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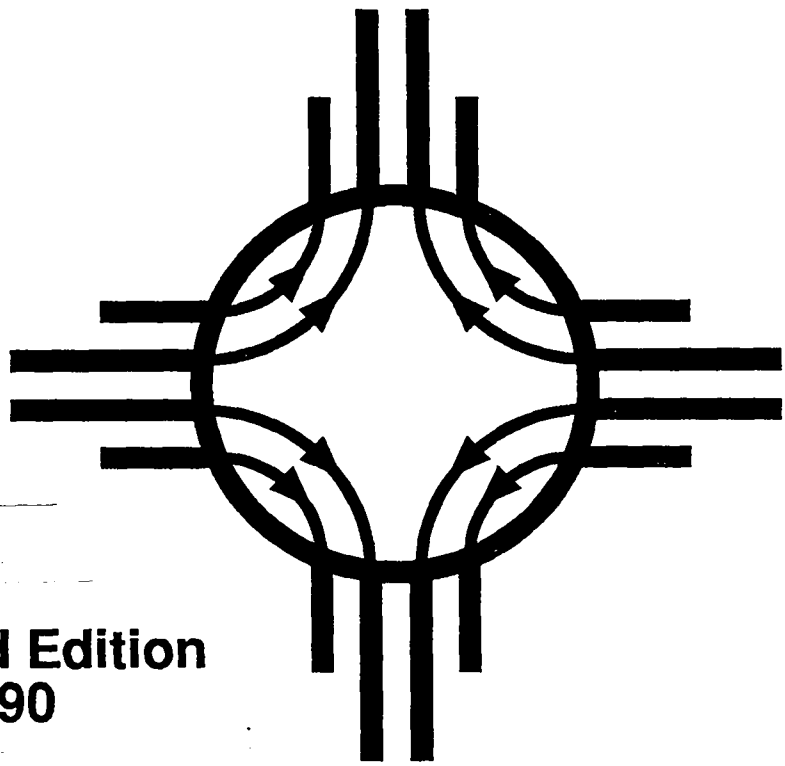
Los Alamos Accelerator Code Group

Computer Codes for Particle Accelerator Design and Analysis:

A Compendium



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Second Edition
May 1990

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Computer Codes for Particle Accelerator Design and Analysis:

A Compendium

LOS ALAMOS NATIONAL LABORATORY
3 9338 00165 5926

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Computer Codes for Particle Accelerator Design and Analysis:

A Compendium

by Helen Stokes Deaven and
Kwok Chi Dominic Chan

Los Alamos Accelerator Code Group

Second Edition, Revised and Expanded

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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Introduction

Excerpts from the First Edition, January 1987

Computer codes and code compilations share the common problem of obsolescence. This compilation will probably be almost useless in three years or less. Useful codes become widely distributed. Users make improvements in distributed code and the original author loses control over the evolution of the code as variations proliferate. Many times authors tire of maintaining, documenting, and distributing their codes. Every generation of accelerator physicists produces code-builders, persons who feel that they can design more comprehensive or easier-to-use codes to do the tasks done by previous codes.

On the whole this environment of change is healthy, but when the number of codes and the variations on the same code become too large, there is a legitimate concern about duplication of effort and confusion in comparing the outputs of different codes that supposedly do nearly the same calculations.

It might be useful to establish a mechanism for evaluating and making comparisons between codes. Such a mechanism would also be useful in maintaining and guiding the evolution of codes abandoned by the original authors and in setting standards for types of input, output, and documentation.

The design of the next generation of high-energy accelerators will probably be done as an international collaborative effort and it would make sense to establish, either formally or informally, an international center for accelerator codes with branches for maintenance, distribution, and consultation at strategically located accelerator centers around the world.

This arrangement could have at least three beneficial effects. It would cut down duplication of effort, provide long-term support for the best codes, and provide a stimulating atmosphere for the evolution of new codes. It does not take much foresight to see that the natural evolution of accelerator design codes is toward the development of so-called Expert Systems, systems capable of taking design specifications of future accelerators and producing specifications for optimized magnetic transport and acceleration components, making a layout, and giving a fairly impartial cost estimate. Such an expert program would use present-day programs such as TRANSPORT, POISSON, and SUPERFISH as tools in the optimization process. Such a program would also serve to codify the experience of two generations of accelerator designers before it is lost as these designers reach retirement age.

It is our hope that this compilation will stimulate some thought in this direction.

In searching the accelerator literature, we have come across only two previous comprehensive surveys of useful accelerator codes. The first was a book by John Colonias, *Particle Accelerator Design: Computer Programs*, Academic Press (1974). The second was a review article by Eberhard Keil, "Computer Programs in Accelerator Physics," in *AIP Conference Proceedings No. 105: Physics of High Energy Particle Accelerators, SLAC Summer School, 1982*, edited by Melvin Month, pp. 651–690 (1983). Colonias gives a comprehensive discussion of 35 codes. Keil mentions 21 codes. There are only 3 codes that are mentioned in both surveys. This is perhaps an indication of how rapidly codes become obsolete and new codes are written.

In addition to these surveys, there are four other sources worth mentioning:

1. *Lecture Notes in Physics 215: Computing in Accelerator Design and Operation, Proceedings of the Europhysics Conference held at the Hahn-Meitner-Institut für Kernforschung, Berlin GmbH*, W. Busse and R. Zelazny, Eds. (Springer-Verlag, Berlin, New York, 1984).
2. *Lecture Notes in Physics 247: Nonlinear Dynamics Aspects of Particle Accelerators, Proceedings of the Joint US-CERN School on Particle Accelerators,*

Held in Santa Margherita di Pula, Sardinia, 31 January - 5 February, 1985, J.M. Jowett, M. Month, S. Turner, Eds. (Springer-Verlag, Berlin, 1986).

3. "Proceedings of the Workshop on Accelerator Orbit and Particle Tracking Programs, May 3–6, 1982," Brookhaven National Laboratory informal limited-distribution report BNL-31761.
4. "Workshop on Orbital Dynamics and Applications to Accelerators, March 7–12, 1985, Lawrence Berkeley Laboratory," *Particle Accelerators* **19** (1), 1–262 (1986).

Certainly there are useful codes that we did not find. We solicit the readers of this document to write to us about our omissions as well as any errors in content.

John L. Warren

Special Acknowledgments

This document describes 203 codes that originate from 10 countries and are currently in use. We feel that this compendium will contribute to the dialogue supporting the international collaborative effort that is taking place in the field of accelerator physics today. This document was made meaningful through the time, effort, and patience required by the 145 individuals who filled out our forms describing the current codes included in this book. We are extremely grateful for their contributions, and on behalf of the accelerator community, we would like to thank them.

Funding for this project was received from the Office of High Energy and Nuclear Physics, U.S. Department of Energy. We thank Dave Sutter, Dave Hendrie, Jerry Peters, and John Erskine for their continued interest in and support for the Los Alamos Accelerator Code Group and this project.

Preface

Second Edition, May 1990

Three years have passed since *Computer Codes Used in Particle Accelerator Design*, the first edition of this document, was presented at the 1987 Particle Accelerator Conference. It has achieved a wide circulation and we have received some favorable feedback. Although the first edition has proven to be a useful tool for the accelerator community, some of the codes are now obsolete and many new codes and newer versions of old codes are now being used. There is now enough new information to justify a second edition.

In this second edition, we have updated and corrected the information in the first edition, we have improved its look and organization, and we have added many new codes.

To begin with, we changed the title. The word *Analysis* was added to the title to reflect the wider scope of the codes. The first edition's title was long, and as a result, the document became known informally as *The Compendium*. We have included the word *Compendium* in the new title so that when the formal title is shortened, the familiar title will have some similarity to the actual title.

It was important to us that this document would function well as a reference tool. We hoped to improve the classification system for the codes. Because of the variety of codes collected in this compendium, developing a proper classification system was a difficult task. We have made an attempt and we will appreciate any comments so that an improvement can be made in the future. We have included the concept of key terms to help readers find the codes they need. Although many key terms could be appropriate for each code, for practical reasons, the contributors were asked to choose three key terms that best described their code. A few codes have more than three key terms because we thought it would be helpful to tag a three-dimensional code and to indicate if a PC version was available. We have also provided four indices.

In the first edition, the inclusion of obsolete codes with the descriptions of the current codes proved to be misleading to some readers. In this edition, we have listed the obsolete codes in an appendix and we have decided not to include descriptions of them. For the most part, it was the authors who made the decision that the code had become obsolete and would no longer be of interest. This list also includes some codes that we assumed were obsolete because we could not find an author or a user willing to provide the information we needed to make a current description.

For each entry, the **Author** section should state the affiliation of the author when the code was written and being worked on. In some cases, the time period is indicated as well.

The following is a brief overview of the process of compiling this document to give the reader a perspective on the code descriptions in this document.

We included a letter about the upcoming edition and a questionnaire in the registration packets of the 1989 Particle Accelerator Conference. We had a display of the first edition at the Conference and passed out many more forms. We also mailed questionnaires to people who we believed might have a code that should be included or who were recommended by persons who contacted us. We received replies from authors, maintainers, distributors, and interested parties. A few codes were not included in this edition because the information we received came too late. Some codes were omitted because we could not gather enough information to create a significant entry (these codes are not listed among the obsolete codes).

Once we had the replies, the work of compiling the information began. We wanted the code entry to convey exactly the technical information supplied to us with a minimum of editorial changes. This involved many phone calls, letters, and electronic mail messages, requiring a great deal of patience by many contributors. We did not make any critical evaluations of the codes. We relied on the contributors for the accuracy of the information; all contributors have had an opportunity to verify their entries for correctness and completeness.

We are extremely grateful to Richard Cooper, leader of our Accelerator Theory and Simulation Group, for his insightful direction, perceptive editorial comments, the design of the Los Alamos Accelerator Code Group's logo, and the PostScript file that produced our front cover.

Members of our group helped make this large project possible. We would like to thank Jean Merson for the time that she took to help us with the endless proofreading. We also appreciate the considerable assistance of Paul Channell and the appreciable help of Tai-Sen Wang. We would like to thank Rosemary Wallace for her help with the typing and proofreading. We would also like to acknowledge the patience of all those who tolerantly waited while we monopolized the printer queue.

We would like to thank the research librarians at the Los Alamos National Laboratory Library for their help in verifying and completing references, especially Donna Berg, Marie Harper, and Jackie Stack. We would like to thank the Computing and Communications Division consultants for providing technical information and advice, especially David Kratzer and Bob Wheat. We would like to thank the editors of the Information Services Division for their guidance and technical support. We would also like to thank Donald E. Knuth for providing us with the opportunity to enjoy his powerful and convenient TEX typesetting system.

Functions: COMPONENT DESIGN: RF cavities

BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: impedance, wakefield, time-domain

Abstract: ABCI solves Maxwell's equations for a longitudinally-distributed Gaussian bunch passing through an axisymmetric structure. The code also computes wake functions.

Author: Yong Ho Chin, CERN, Switzerland

Reference: Yong Ho Chin, "ABCI User's Guide," CERN report LEP-TH/88-(report number is unavailable) (1988).

Status: ABCI was last modified in October 1989. The code is maintained and distributed, without charge, by Yong Ho Chin. It has approximately 1600 lines of FORTRAN source code and 10 known users. The code has been run on VAX/VMS and IBM/VM systems. The program is being distributed through the computer networks.

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ACCSIM

Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: space charge/high current, tracking, injection

Abstract: ACCSIM is an **AC**Celerator tracking and **SIM**ulation code that is primarily used to study multiturn charge-exchange injection into an accumulator ring. This code has also been used for other tracking studies. Monte Carlo techniques are used to generate a variety of incoming beam distributions and to simulate scattering and energy loss in the stripping foil. The accumulating ensemble of particles is tracked using first-order matrices (generated by the code DIMAD) and first-order longitudinal difference equations, making the code efficient enough to study injection cycles of thousands of turns. Space-charge effects can be included in both longitudinal and transverse planes. "Painting" schemes can be specified for achieving the desired final distributions. This program produces various statistics and illustrates trends such as losses, emittances, form factors, tune shifts, as well as scatterplots showing the beam distributions. Recent additions to the code include thin multipoles and collimation systems.

Authors: F.W. Jones and G.H. Mackenzie, TRIUMF, Canada; H.O. Schönauer, CERN, Switzerland

Reference: F.W. Jones, G.H. Mackenzie, and H.O. Schönauer, "ACCSIM — A Program to Simulate the Accumulation of Intense Proton Beams," XIV International Conference on High-Energy Accelerators, Tsukuba, Japan, August 1989.

Status: ACCSIM was last modified in April 1990. This code is maintained and distributed, without charge, by Frederick W. Jones. It has approximately 10 000 lines of FORTRAN source code. There is only one distributed version of this program. It is for the VAX/VMS system. A 70-page user's guide and examples are available. This code is being distributed on magnetic tape reels and through the computer networks.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: misalignment, optimization, corrector

Abstract: ALIGN simulates survey misalignments of magnetic elements in a circular accelerator. It constructs a closed orbit corresponding to the misalignment errors and finds corrector strengths needed to sustain a particle beam within the vacuum chamber. ALIGN is a Monte Carlo-type program that performs a collection of misalignments over an ensemble of machines.

History: ALIGN was developed and used for the construction of PEP at SLAC. It has been exported to CERN where it was used in the design of LEP and also used in the design of the Superconducting Super Collider (U.S.A.). This code has been incorporated into the program MAD.

Authors: Dick Sah and Elon Close, Lawrence Berkeley Laboratory, U.S.A.

Reference: E. Close, M. Cornacchia, A. King, and M.J. Lee, "A Proposed Orbit and Vertical Dispersion Correction System for PEP," *IEEE Transactions on Nuclear Science* **NS-26** (3), 3502–3504 (1979), also SLAC internal report PEP Note 271.

Status: ALIGN was last modified in July 1989. This code is maintained and distributed, without charge, by Elon R. Close. It has approximately 3000 lines of FORTRAN source code. The original version of this code was written for a CDC 7600. There are two distributed versions of this program. They are for the VAX/VMS and IBM 3080X/CMS systems. A 20-page user's guide and examples are available. A reference manual is being prepared. This code is being distributed on magnetic tape reels, through the computer networks, and on high-density 3.5-inch diskettes for IBM-compatible personal computers.

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AMOS

Function: COMPONENT DESIGN: RF cavities, induction linac cavities

Key Terms: impedance, wakefield, special boundary condition

Abstract: AMOS (Azimuthal MOde Simulator) is a two-and-one-half-dimensional finite-difference time-domain code. The azimuthal mode number, m, to be used in the simulation is chosen by the user (the fields vary as $e^{im\phi}$). This code may be used to calculate wake potentials and impedances of complex accelerator cells, which include dielectrics, magnetic materials, and a variety of boundary conditions.

Authors: John F. DeFord, George Craig, and Robert McLeod, Lawrence Livermore National Laboratory, U.S.A.

Reference: J.F. DeFord, G.D. Craig, and R. McLeod, "The AMOS (Azimuthal Mode Simulator) Code," 1989 IEEE Particle Accelerator Conference, Chicago, Illinois, March 20–23.

Status: AMOS was last modified in March 1990. This code is maintained and development is continuing. Although this code is not currently being distributed, it is available for use at the Beam Research Group, Lawrence Livermore National Laboratory (U.S.A.). If interested, contact George Craig at (415) 422-4683 or Mail Code L-626, LLNL, Livermore, California 94550. This code consists of approximately 50 000 lines of FORTRAN source code. There are nine known users. There are four versions of this program. They are for the Sun-3 (Floating Point System), VAX/VMS, CRAY/LTSS, and CRAY/CTSS (FORTLIB) systems. A 25-page user's guide, a 15-page reference manual, and examples are available.

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Function: COMPONENT DESIGN: RF cavities

Key Terms: three dimensions, wakefield, special boundary condition

Abstract: ANDY is the field solver from the code IVORY with source terms and diagnostics designed for wakefield calculations. A general impedance boundary condition is used to model RF absorption. The code has been used to compute wake potentials in induction accelerators.

Author: Brendan B. Godfrey, Mission Research Corporation, U.S.A.

Reference: T.P. Hughes and B.B. Godfrey, "Electron Beam Stability in Compact Recirculating Accelerators," Mission Research Corporation, Albuquerque, report MRC/ABQ-R-1040 (1988).

Status: ANDY was last modified in April 1989. This code is maintained and distributed, for a negotiable fee, by Thomas Hughes. It has approximately 3500 lines of FORTRAN source code. There are three known users. There is only one distributed version of this program. It is for the CRAY/CTSS (CFTLIB) system. Although there is no formal documentation, there are some examples available. This code is being distributed on high-density 5.25-inch diskettes for IBM-compatible personal computers.

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ARCHSIM

Function: BEAM DYNAMICS: proton synchrotrons

Key Terms: tracking, injection, painting

Abstract: ARCHSIM simulates the acceleration cycle of a rapid-cycling proton synchrotron. A lattice can consist of up to 100 cells and RF cavities. The first-order tracking during H^- injection is performed including all the physics of beam-foil interaction (coulomb scattering, energy loss, nuclear reactions). Transport of the beam in six dimensions includes all second-order optical terms. The RF field and proton velocity are treated exactly. Longitudinal space charge is handled in a self-consistent manner. The fluctuations resulting from the finite number of particles are handled by a Gaussian smoothing algorithm. The program can track 100 particles without space charge through the full acceleration cycle, from 0.8 to 32 GeV on a VAX 11/780 in 49 minutes (approximately 5000 turns). A thousand particles with space charge takes about 10 hours of computer time.

The motivation for writing this tracking program was the need to explore the effect of various rf accelerator-cavity parameters on the beam dynamics and stability of a proposed 32-GeV rapid-cycling synchrotron.

The program uses second-order transport matrices generated by another program like DIMAT. These matrices are checked to see if they are symplectic before doing the simulation.

The graphics (phase-space plots and particle-distribution histograms) and the number as well as type of optical elements available have been improved.

The program is presently arranged as two programs: SIMIIC, which executes the time-consuming simulation, and ASIMPLT, which does the postprocessing.

Authors: H. Arch Thiessen 1981-1989, John Warren 1984-1985, and Danling Shi 1986, Los Alamos National Laboratory, U.S.A.

References: H. Arch Thiessen, "A Primer for ARCHSIM," Los Alamos National Laboratory report LA-UR-89-1034 (March 1989).

H. Arch Thiessen and John L. Warren, "ARCHSIM: A Proton Synchrotron Tracking Program Including Longitudinal Space Charge," in *Lecture Notes in Physics 215: Computing in Accelerator Design and Operation, Proceedings of the Europhysics Conference held at the Hahn-Meitner-Institut für Kernforschung Berlin GmbH*, W. Busse and R. Zelazny, Eds. (Springer-Verlag, Berlin, New York, 1984) pp. 225–260.

Status: ARCHSIM was last modified in March 1989. This code is maintained and distributed, without charge, by H. Arch Thiessen. It has approximately 46 000 lines of FORTRAN source code. There are two distributed versions of this program. One is a vectorized version for the CRAY/CTSS (CFTLIB) system and the other is for the VAX/VMS system. A 50-page primer is available as well as sample input and output files. The sample output files document the input data. This code is being distributed through the computer networks.

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ARGUS

Functions: COMPONENT DESIGN: ion and electron sources, RF cavities

BEAM DYNAMICS: general

Key Terms: impedance, particle-in-cell, three dimensions

Abstract: ARGUS is a family of three-dimensional codes with a modularized architecture. The current system includes three-dimensional models for particle-in-cell simulation in either transient or steady-state mode, time-domain and frequency-domain electromagnetics and electrostatics.

Authors: A. Drobot, A. Mankofsky, L. Seftor, C. Chang, K. Ko, and J. Petillo, Science Applications International Corporation (SAIC), U.S.A.; S. Brandon, J. Moura, and D. Nielsen, Lawrence Livermore National Laboratory, U.S.A.

Reference: A. Mankofsky, "Three-Dimensional Particle Codes and Applications to Accelerators," in *AIP Conference Proceedings 177: Linear Accelerator and Beam Optics Codes, La Jolla Institute 1988*, Charles R. Eminhizer, Ed. (American Institute of Physics, New York, 1988), pp. 137–160.

Status: ARGUS is maintained and distributed, without charge, by Science Applications International Corporation (SAIC). There is a charge for code installation and for instruction in the use of the code. ARGUS has approximately 40 000 lines of FORTRAN source code. It is being used at about 10 sites. There is only one distributed version of this program. It is for the CRAY/CTSS (FORTLIB) system. A UNICOS version is expected to be released before April 1990. A 100-page user's guide is available. This code is being distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: magnets

Key Terms: nonlinear/higher order, eddy current

Abstract: The program ASEM (Analytic System for ElectroMagnetic fields) is an analytical system for two-dimensional and axisymmetric magnetic fields. This interactive program uses a Galerkin-type finite-element technique with backward time-difference to time-dependent terms and an upwind method to velocity terms in order to acquire stable calculations. ASEM can deal with nonlinear magnetic properties and a quadrilateral hysteresis loop for magnetization. It also has an interactive preprocessor/postprocessor for automatic mesh generation and for displaying the results of the analysis (contour lines, vector diagrams, etc.) in full color. Helpful interactive command systems were designed to make these processors easy to use.

History: The original type of ASEM program was developed in the Hitachi Research Laboratory, Hitachi, Ltd., and has been used in mainframe computers (HITAC M-series) for designing various kinds of magnetic equipment. This program was installed on an Engineering Work Station (Hitachi 2050/32) in 1988, adding the functions for interactive preprocessors and postprocessors.

Author: Motoya Ito, Hitachi Research Laboratory, Hitachi, Ltd., Japan

References: none

Status: ASEM was last modified in March 1989. This code is maintained and distributed, for a fee, by the Hitachi Engineering Company. The charge for this code is $30 000, a nonproliferation agreement is required, and the program's documentation is written in Japanese. There are approximately 10 known users. There are two distributed versions of this program. One is in FORTRAN and the other is in C. The C version has 25.8 kilosteps and the FORTRAN version has 19.6 kilosteps. Both the FORTRAN and the C versions have only been run on a Hitachi Creative Work Station 2050/32 running UNIX (HI-UX). There is a 106-page manual that describes the input data and the operation of the preprocessor and postprocessor. This code is being distributed on high-density 3.5-inch diskettes for IBM-compatible personal computers.

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AXCEL - GSI

Function: COMPONENT DESIGN: ion and electron sources

Key Terms: space charge/high current, plasmas, plasma boundaries

Abstract: AXCEL - GSI is an interactive, two-dimensional code that looks at plasma boundaries, electrons and ions, and symmetric magnetic fields in structures with cylindrical symmetry. Cathode and plasma simulation is handled. This code has a Poisson solver, a Laplace solver, and a Vlasov solver based on the finite-difference method.

History: The original AXCEL was written in 1975 by John H. Whealton, Oak Ridge National Laboratory, U.S.A. The first version from Gesellschaft für Schwerionenforschung (GSI), mbH, Germany, came out in 1983. INP is a commercial version of this code.

Author: Peter Spädtke, Gesellschaft für Schwerionenforschung (GSI), mbH, Federal Republic of Germany, 1980 to present

References:

Peter Spädtke, "AXCEL - GSI," Gesellschaft für Schwerionenforschung (GSI), mbH, report, Darmstadt GSI-83-9 (1983).

Peter Spädtke, "Computer Simulation of High-Current DC Ion Beams," in "Proceedings of the 1984 Linear Accelerator Conference: Lufthansa-Schulungszentrum, Seeheim, May 7–11, 1984," N. Angert, Ed., Gesellschaft für Schwerionenforschung (GSI), mbH, report, Darmstadt GSI-84-11 (1984), pp. 356–358.

J. Klabunde, P. Spädtke, A. Schönlein, "High Current Beam Transport Experiments at GSI," *IEEE Transactions on Nuclear Science* **NS-32**, 2462–2464 (1985).

Status: AXCEL is being maintained and distributed, without charge, by Peter Spädtke. It has approximately 6000 lines of standard FORTRAN-77 source code. There are three distributed versions of this program. They are for the VAX/VMS, CRAY, and IBM/MVS systems. A 66-page user's guide and examples are available. The author will attempt to provide the code on whatever media the requester requires.

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Function: BEAM DYNAMICS: general

Key Terms: stability, impedance, beam breakup

Abstract: BALTIC evaluates the linear growth of the beam breakup, image displacement, and resistive-wall instabilities in multigap induction and RF accelerators.

Author: Brendan B. Godfrey, Mission Research Corporation, U.S.A.

Reference: T.P. Hughes and B.B. Godfrey, "Electron Beam Stability in Compact Recirculating Accelerators," Mission Research Corporation, Albuquerque, report MRC/ABQ-R-1040 (1988).

Status: BALTIC was last modified in February 1989. This code is maintained and distributed, for a negotiable fee, by Thomas Hughes. It has approximately 400 lines of FORTRAN source code. There are three known users. There is only one distributed version of this code. It is for the CRAY/CTSS (CFTLIB) system. There is no user's guide or reference manual but some examples are available. This code is being distributed on high-density 5.25-inch diskettes for IBM-compatible personal computers.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: stability, intrabeam scattering

Abstract: BBI (Bunched-Beam Instability) calculates bunch lengthening, synchrotron-frequency shifts, longitudinal and transverse coupled bunch modes, resistive-wall effects, tune shifts, intra-beam scattering, and transverse mode coupling ("fast head-tail effect")

History: Work began on the code EBI (Electron Beam Instabilities) in 1978. The original authors were Albert Hofmann, Kurt Huebner, and Bruno Zotter, while the actual coding was done by Monica Gygi. Expansion to the code BBI (i.e., including protons) occurred in approximately 1980.

Author: Bruno Zotter, CERN, Switzerland, 1978 to present

References:

Albert Hofmann, Kurt Hübner, and Bruno Zotter, "A Computer Code for the Calculation of Beam Stability in Circular Electron Machines," *IEEE Transactions on Nuclear Science* **NS-26**, 3514–3516 (1979).

M. Gygi-Hanney, A. Hofmann, K. Hübner, and B. Zotter, "PROGRAM BBI : Bunched-Beam Instabilities in High-Energy Storage Rings," CERN, LEP Divisional report 83-2 (1983).

P.M. Gygi, "User's Guide for BBI on MVS Wylbur," CERN internal report, LEP Theory note 88-60 (1988).

P.M. Gygi, "User's Guide for BBI on VM," CERN internal report, LEP Theory note 88-61 (1988).

B. Zotter, "BBI — a Program to Compute Bunched Beam Instabilities in High Energy Particle Accelerators and Storage Rings," CERN, LEP Divisional Report LEP/TH 89/74 (December 1989).

Status: BBI was last modified in the latter part of 1988. This code is maintained and distributed, without charge, by Bruno Zotter. A nonproliferation agreement is required. It has approximately 4000 lines of FORTRAN-77 source code. There are about 20 known users. The original version of this code was written for a CDC machine. Although a VAX/VMS version exists, it is not available at CERN. There is also a version that runs on an IBM/CMS and IBM/VM system. In the present version of BBI on the IBM/VM system, GKS graphics are used. GKS can be addressed directly or via the graphics package TOPDRAWER. The output from TOPDRAWER is then converted to GKS by the utility GXPLOT. TOPDRAWER was developed at SLAC by Roger Chaffee. It is available, without charge. Contact Bill Johnson, Bin 97, SLAC, Post Office Box 4349, Stanford, California 94309. His phone number is 1 (415) 926-2660; on FTS: it is 462-2660. A 25-page user's guide for BBI is available. This code is being distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: induction linac cavities

Key Term: wakefield, beam breakup, impedance

Abstract: BBU evaluates the wake potential for the Beam-BreakUp instability for a radial line of arbitrary width and depth terminated by a lumped impedance. Numerical output can be used by the accelerator transport code BALTIC.

Author: Brendan B. Godfrey, Mission Research Corporation, U.S.A.

Reference: B.B. Godfrey, "Transverse Wake Potentials for Wide Radial Lines," Mission Research Corporation, Albuquerque, report MRC/ABQ-R-1046 (1988).

Status: BBU was last modified in March 1989. This code is maintained and distributed, for a negotiable fee, by Thomas P. Hughes. There is only one distributed version of this program. It is for a CRAY/CTSS (CFTLIB) system. No documentation is available but there are some examples that might prove to be helpful. This code is being distributed on high-density 5.25-inch diskettes for IBM-compatible personal computers.

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Function: BEAM DYNAMICS: linacs

Key Term: wakefield, beam breakup

Abstract: BBUNS stands for **B**eam **B**reak-**U**p **N**umerical **S**imulator. The code uses an nth-order integration scheme and a fourth-order Runge-Kutta to solve for the displacement of a beam due to the wakefield in any cavity. The wake is accepted as an input file (it may be generated by any suitable code). The beam growth is then calculated.

History: BBUNS was originally called TWA.

Author: Gil A. Travish, Lawrence Berkeley Laboratory, U.S.A., 1988 to present

References: G.A. Travish, "The Beam Break-Up Numerical Simulator," Lawrence Berkeley Laboratory report LBL-28029 (1989).

Status: BBUNS was last modified in January 1990. The code is maintained, distributed, and kept current, without charge, by Gil Travish. It has approximately 2000 lines of FORTRAN source code. The program will run on the CRAY computer series with the CFT77 (CRAY FORTRAN) compiler and uses the DISSPLA graphics library. The code is fully documented: a 62-page user's guide (LBL-28029 cited in the **References** section above) is available. The program is being distributed through the computer networks.

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Function: COMPONENT DESIGN: ion sources

Key Terms: space charge/high current, plasmas

Abstract: Starting from the unperturbed plasma in an ion source, BEAM (Beam Extraction and Acceleration Modeling) calculates ion trajectories, electrostatic potentials, and the sheath location. Electrode boundaries need not be on mesh lines and mesh density is variable to permit finer resolution in critical locations. Both extraction and injection simulations are possible, with variable current density, variable ion-injection energy and angle, and nonzero ion-temperature effects. Two-dimensional rectangular and cylindrical geometries are handled.

History: BEAM was based on the Oak Ridge National Laboratory (U.S.A.) code AXCEL with some features from SNOW. Major changes were made to some of the convergence routines, the start conditions in the plasma, and the emittance-plot output. The code has been extensively commented.

Authors: M.R. Shubaly and R.A. Judd, Chalk River National Laboratories, Canada; R.W. Hamm, Los Alamos National Laboratory, U.S.A.

Reference: M.R. Shubaly, R.A. Judd, and R.W. Hamm, "BEAM, an Improved Beam Extraction and Acceleration Modeling Code," *IEEE Transactions on Nuclear Science* **NS-28**, 2655–2657 (1981).

Status: BEAM was last modified in January 1986. This code is maintained and distributed, without charge, by Murray Shubaly. The code is currently being revised. It has approximately 7000 lines of FORTRAN source code. There are about 10 known users. At this time, VAX/VMS, CYBER, IBM, CDC 6600, and CDC 7600 versions exist. A user's guide is being prepared. This code is being distributed on magnetic tape reels and through the computer networks.

Maintained and Distributed by:

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: tracking, stability, beam-beam interaction

Abstract: BEAMBEAM is a multiparticle two-beam (strong-strong) simulation program that has been written for investigation of the beam-beam effect in LEP at CERN. The motion of the superparticles is treated in six-dimensional phase space and the effects of quantum excitation and radiation damping are included. Non-zero dispersion at the RF cavities allows the computation of single-beam synchro-betatron resonances.

After each revolution, the parameters influencing the beam-beam force (e.g., the beam dimensions and the beam current) are reevaluated in order to simulate a real situation. For the beam-beam force, an elliptical beam with Gaussian charge distribution has been assumed. The computation of this force is speeded up by using tabulated values of the complex error function and a fast interpolation procedure.

The initial distribution of a large number of particles (typically 200) in each of the three phase planes is random with prespecified variances. Each particle in each beam is 'tracked' through (i) a RF cavity, (ii) a beam-beam interaction, and (iii) a traversal of a machine arc. This procedure is repeated until each beam has completed one run. The position of each particle is then compared with aperture limitations (typically 10 σ) and those particles that fall outside are excluded from further tracking. The remaining particles are then used to recalculate the beam current, the specific luminosity, the beam variances, and hence the new beam-beam kick parameters. This cycle is repeated until the 'beam' has been circulating for about 1.5 damping times.

Author: Steve Myers, CERN, Switzerland, 1982 to present

References: S. Myers, "Beam-Beam Simulation for LEP," *IEEE Transactions on Nuclear Science* **NS-28**, 2503–2505 (1981).

S. Myers, "Simulation of the Beam-Beam Effect During Injection, Accumulation, and Acceleration in LEP," *IEEE Transactions on Nuclear Science* **NS-30**, 2466–2468 (1983).

S. Myers, "Simulation of the Beam-Beam Effect for e^+e^- Storage Rings," *Nuclear Instruments and Methods in Physics Research* **211**, 263–282 (1983).

Status: BEAMBEAM was last modified in February 1989. This code is maintained and distributed, without charge, by Lindsay Wood. It has approximately 12 000 lines of FORTRAN source code. The code has been modified to conform to ANSI standard FORTRAN-77, so the program should run on any system. At this time, the program is running on an IBM/VM/CMS system and an Apollo workstation. HBOOK, a largely obsolete graphics package from CERN, is used. There are four known users. A three-page user's guide is available. This code is being distributed through the computer networks.

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Function: BEAM DYNAMICS: linacs

Key Terms: nonlinear/higher order, space charge/high current, three dimensions

Abstract: BEDLAM is a fourth-order moment simulation code. The beam at the input to a linear accelerator is specified as a collection of moments of the phase-space distribution. Then the moment equations, which describe the time evolution of the moments, are numerically integrated. No particles are traced in this approach. The computed distribution and the external forces are computed consistently to a given order of accuracy. Although BEDLAM includes moments to fourth order only, it could be systematically extended to any order. An important feature of this method is that physically interesting and intuitive quantities, such as beam sizes and rms emittances, are computed directly.

A new version is under development that includes space-charge effects, uses Lie–Poisson integration, and has other improvements that were developed as a result of new work on moment methods, moment invariants, and Lie-Poisson integration by P. Channell, D. Holm, W. Lysenko, and J.C. Scovel.

Authors: Walter Lysenko, Paul Channell (author of the soon-to-be-released new version), and Liam Healy, Los Alamos National Laboratory, U.S.A., 1983 to present

References: P.J. Channell, L.M. Healy, and W.P. Lysenko, "The Moment Code BEDLAM," *IEEE Transactions on Nuclear Science* **NS–32**, pp. 2565–2566 (1985).

W.P. Lysenko and P.J. Channell, "New BEDLAM," Conference on Computer Codes and the Linear Accelerator Community, Los Alamos, New Mexico, U.S.A., January 22–25, 1990.

Status: The new version of BEDLAM will be available in mid-1990. It is maintained and distributed, without charge, by Walter Lysenko. This new version is available in two source languages: 29 000 lines of standard FORTRAN-77 or 36 000 lines of Pascal. An approximately 50-page user's guide and an example are available with the code. This program is being distributed on magnetic tape reels, .25-inch magnetic tape cartridges for Sun workstations, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

Maintained and Distributed by:

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: tracking, beam-beam interaction

Abstract: BMBMI (BeaM-BeaM Interaction) simulates beam-beam interaction, taking into account horizontal and vertical betatron oscillation and synchrotron oscillation. Kicks due to beam-beam interaction are calculated using a table and interpolating quadratically. Between interaction points, transformation is linear. Quantum fluctuation, damping, and a crossing angle are included. Cases for both weak-strong and strong-strong are considered.

Author: Anton Piwinski, Deutsches Elecktronen-Synchrotron (DESY), Federal Republic of Germany

References: A. Piwinski, "Computer Simulation of the Beam-Beam Interaction," in *11th International Conference on High Energy Accelerators*, W.S. Newman, Ed. (Birkhäuser Verlag, Basel, 1980) pp. 751–762.

A. Piwinski, "Computer Simulation of the Beam-Beam Interaction at a Crossing Angle," *IEEE Transactions on Nuclear Science* **NS-32**, pp. 2240–2242 (1985).

A. Piwinski, "Computer Simulation of the Beam-Beam Interaction and Measurements with Petra," *IEEE Transactions on Nuclear Science* **NS-28**, pp. 2440–2442 (1985).

Status: BMBMI is not suitable for unfamiliar users. It has approximately 400 lines of FORTRAN source code. There is only one version of this program. It is for an IBM/MVS system.

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Function: BEAM DYNAMICS: general

Key Terms: particle-in-cell, three dimensions, ion-focused regime

Abstract: BUCKSHOT is a three-dimensional, gridless, magnetostatic, particle code in the paraxial approximation. It is primarily used to study relativistic electron beam (REB) dynamics in the presence of a pre-ionized plasma channel in the ion-focused regime, including a user-defined applied magnetic field. Simple foil focusing and gap physics are included. This code is menu driven and includes a postprocessor for graphics that has the capability of producing movies.

Author: J.S. Wagner, Sandia National Laboratories, U.S.A., 1987

References: J.S. Wagner, "BUCKSHOT, a 3-D Gridless Magnetostatic Particle Code," Sandia National Laboratories report SAND 87-2019 (1987).

J.S. Wagner, "Analysis and Benchmarking of the BUCKSHOT Code," Sandia National Laboratories report SAND 87-2015 (1987).

J. S. Wagner, "BUCKSHOT-MAGIC Comparison for RADLAC Conditioning Cell Parameters," Sandia National Laboratories report SAND 88-1119 (1988).

J. S. Wagner, "BUCKSHOT Simulations of Beam Injection on the Recirculating Linac," Sandia National Laboratories report SAND 89-0523 (1989).

Status: BUCKSHOT is maintained. In general, this code is not publically available. Exceptions to this rule have been made and they are decided on a case-by-case basis. It has approximately 10 000 lines of standard FORTRAN-77 source code. There are six known users. There are two versions of this program. They are for the VAX/VMS and CRAY/CTSS (CFTLIB) systems. A user's guide is being written.

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Function: COMPONENT DESIGN: ion and electron sources, magnets

Key Terms: eddy current, three dimensions, finite element

Abstract: The CARMEN package is a well-proven integrated suite of programs for three-dimensional analysis of eddy currents. The package includes powerful preprocessing and postprocessing modules linked to an analysis module using state-of-the-art finite-element techniques. CARMEN solves the three-dimensional time-varying magnetic-field equations. The time variation can either be transient or alternating. The established total and reduced-potential method used in the code TOSCA is used in nonconducting media. This method reduces the solution time and corrects the cancellation errors associated with the simple reduced-potential method. In conducting media, the program uses the vector potential and this is directly coupled with the scalar potentials in the exterior.

History: CARMEN originated at the Rutherford Appleton Laboratory, England, and has been further developed and marketed by Vector Fields, a company that distributes the code and provides support, including training, from offices in England and the U.S.A.

Authors: C.W. Trowbridge, J. Simkin, C.S. Biddlecombe, and C.R.I. Emson, Rutherford Appleton Laboratory, England, 1982 to present

References:

C.R.I. Emson, J. Simkin, and C.W. Trowbridge, "Further Developments in Three-Dimensional Eddy Current Analysis," *IEEE Transactions on Magnetics* **MAG-21**, 2231–2234 (1985).

"Carmen: 3D Eddy Current Computation," Vector Fields, Ltd., data reference sheet 118771 (1987).

Status: CARMEN was last modified in August 1988. This code is maintained and distributed, for a fee, by Vector Fields. A nonproliferation agreement is required. It has approximately 181 000 lines of standard FORTRAN-77 source code. It is being used at 12 sites. It has been run on VAX/VMS, CRAY/COS, CRAY/UNICOS, IBM/CMS, Sun, and Apollo systems. A 220-page user's guide, a 224-page reference manual, examples, and an on-line help facility are available. This code is being distributed on magnetic tape reels.

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CASCADE

Function: COMPONENT DESIGN: RF cavities

Key Terms: ferrite/dielectric, special boundary condition

Abstract: CASCADE uses a scattering-matrix method to compute complex resonant frequencies or the transmission spectrum in complex dielectric-loaded cylindrical cavities. Dielectric constants and/or permeabilities can be complex. A cavity consists of sections of length $l_i, i = 1, 2, ..., n$. Each section can be divided into two cylindrically symmetric regions with different dielectric constants and permeabilities. For example:

$$r < r_0, \quad \varepsilon = 2 + 0.5i, \quad \mu = 1 + 0.1i$$

$$r_0 < r < r_1, \quad \varepsilon = 3 + 2i, \quad \mu = 2 + 0.4i$$

If the end sections are not cutoff, outgoing boundary conditions are used when computing the resonant frequencies. This code is easy to run, the input namelist contains approximately 15 lines.

Author: Peter E. Latham, University of Maryland, U.S.A., 1988

Reference: J.M. Neilson, P.E. Latham, M. Kaplan, and W.G. Lawson, "Determination of Resonant Frequencies in Complex Cavities using the Scattering Matrix Formulation," *IEEE Transactions on Theory and Techniques* **37** (8), 1165–1170 (1989).

Status: CASCADE was last modified in March 1990. This code is maintained and distributed, without charge, by Peter Latham. This code is available at the National Energy Research Supercomputing Center (NERSC), formerly NMFECC, at Lawrence Livermore National Laboratory, U.S.A. Requesters should provide their NERSC user number. It has approximately 2000 lines of FORTRAN-77 source code. There are three users. The CRAY/CTSS (FORTLIB) version running at NERSC is the only one that exists. The code uses some math routines from the SLATEC library and the graphics package TV80. Although there is no formal documentation, there are examples available.

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Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, tracking, long elements

Abstract: The purpose of the program CAT (Computer Accurate Tracking) is to generate mappings for multipoles, that are exact to computer accuracy for a specified set of initial conditions around $x_0 = y_0 = 0$. In a preparation run, the maximum order for each element necessary to generate a computer-accurate (17 digits) map is determined. Then manual tracking with these maps is performed.

Authors: Johannes Hagel and Bruno Zotter, CERN, Switzerland

Reference: J. Hagel and B. Zotter, "Comparison of Tracking Methods with Exact Solutions of Non-linear Equations," CERN, LEP Divisional report 88-58 (1988).

Status: CAT was last modified in December 1988. This code is maintained and distributed, without charge, by Johannes Hagel. It has approximately 900 lines of FORTRAN source code. There is only one distributed version of this program. It was written to run on CERN's IBM 3081/VM system. An on-line help facility is available. This code is being distributed through the computer networks.

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Function: COMPONENT DESIGN: RF cavities

Key Terms: three dimensions, resonant mode

Abstract: CAV3D calculates low-frequency modes of any cavity with a three-dimensional cubic mesh to within five per cent accuracy.

Author: Wolfgang Wilhelm, Technische Universität München, Federal Republic of Germany

Reference: W. Wilhelm, "CAVIT and CAV3D — Computer Programs for RF Cavities with Constant Cross Section or Any Three-Dimensional Form," *Particle Accelerators* **12** (3), 139–145 (1982).

Status: CAV3D is maintained and distributed, without charge, by Wolfgang Wilhelm. The code is written in FORTRAN. The program has been run on CYBER, VAX, and PDP-10 machines. A 16-page user's guide is available. The code is being distributed on 3.5-inch diskettes for IBM-compatible personal computers.

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Function: COMPONENT DESIGN: RF cavities

Key Terms: resonant mode

Abstract: CAVIT is a two-dimensional code for cavities with a constant cross section. A square mesh is used. Accuracy is better than one per cent.

Author: Wolfgang Wilhelm, Technische Universität München, Federal Republic of Germany

Reference: W. Wilhelm, "CAVIT and CAV3D — Computer Programs for RF Cavities with Constant Cross Section or Any Three-Dimensional Form," *Particle Accelerators* **12** (3), 139–145 (1982).

Status: CAVIT is maintained and distributed, without charge, by Wolfgang Wilhelm. The code is written in FORTRAN. The program has been run on CYBER, VAX, and PDP-10 machines. A 16-page user's guide is available. The code is being distributed on 3.5-inch diskettes for IBM-compatible personal computers.

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CCRTRACE

Function: BEAM DYNAMICS: linacs

Key Term: optimization, first-order

Abstract: TRACE is an interactive, first-order envelope-tracing code for modeling a beam as it passes through a beam-transport system. TRACE finds transverse beam matching solutions for a beamline that includes accelerating columns, accelerating tanks, solenoids, and Wien filters. Space-charge effects can be included. This code also has the ability to produce rapidly a list of all possible transverse matching solutions for the four-quadrupole matching problem.

A version of TRACE runs at The Los Alamos Meson Physics Facility (LAMPF), Los Alamos National Laboratory, U.S.A. This version is modularized into a library of subroutines with a powerful, simple interface. At LAMPF, TRACE runs on a color CRT and produces a graphics display of the beam displacement relative to the center, phase function for x-x' and y-y' phase space, phase-space ellipses, and the beam profile.

History: TRACE was originally written by Kenneth R. Crandall in 1973 for the SEL-840 that ran the control system at LAMPF. It was later adapted for the VAX 11/780 by Roger Cole. For more information, please refer to the **History** section for the codes TRACE and TRACE 3-D.

Authors: Kenneth R. Crandall and Roger Cole, Los Alamos National Laboratory, U.S.A.

References: K.R. Crandall, D.P. Rusthoi, "Documentation for TRACE: An Interactive Beam-Transport Code," Los Alamos National Laboratory manuscript LA-10235-MS (1985).

J.W. Hurd, J. McGill, "Modification of Accelerator Element in TRANSPORT," in *Proceedings of the 1987 Particle Accelerator Conference: Accelerator Engineering and Technology, March 16–19, 1987, Washington, D.C.*, Eric R. Lindstrom and Louise S. Taylor, Eds., (IEEE, New York, 1987), IEEE catalog number 87CH2387-9, Vol. 2, pp. 1198–1200.

J.W. Hurd, "Derivation of the First-Order Transformation Matrix for a Simple Wien Filter and Comparison to Results of Numerical Integration," *Nuclear Instruments and Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors, and Associated Equipment* **A258** (3), 542–547 (1987).

G. Swain, P. Busch, M. Burns, "Generating Catalogs of Transverse Matching Solutions," 1989 IEEE Particle Accelerator Conference, Chicago, Illinois, March 20-23, Los Alamos National Laboratory report LA-UR-89-944 (1989).

Status: CCRTRACE is maintained but not distributed. This code has approximately 30 000 lines of FLECS source code. There is only one version of this program. It is for the VAX/VMS system. There is a 55-page user's guide.

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CHARGE 2D

Function: COMPONENT DESIGN: electrostatic devices

Key Term: special boundary condition, electric field

Abstract: CHARGE 2D solves electrostatic problems by finding an approximation of charge density induced on equipotential surfaces. Charge density is approximated by a spline function of arc length along curves representing each equipotential surface. Potentials and electric fields can be calculated from the resultant charge density. The user is required to supply several subroutines defining the geometry of the problem.

Author: Kenneth R. Crandall, Los Alamos National Laboratory, U.S.A.

Reference: K.R. Crandall, "Computation of Charge Distribution On or Near Equipotential Surfaces," Los Alamos National Laboratory report LA-UR-3512 (1966).

Status: CHARGE 2D is not maintained or distributed, although it is used by several people at LANL. The program has approximately 2000 lines of FORTRAN source code. There are three versions of this code. They are for VAX/VMS, CRAY/CTSS (CFTLIB), and IBM AT systems. The 48-page Los Alamos report cited above provides examples and can be considered a user's guide and reference manual. It is slightly outdated as the input format has been modified since the report's publication date.

Function: BEAM DYNAMICS: general

Key Terms: control, optimization, closed orbit

Abstract: COMFORT is a lattice program for the analysis and the control of charged-particle beam-transport systems. It uses the same format style for the input data as the code MAD. The code's main features include: Beam and RF calculations for rings, calculations of linear lattice parameters, linear lattice matching, and chromaticity correction.

History: COMFORT is the successor to the program MAGIC. MAGIC is used for the analysis of storage rings and was written by Martin Lee and Alex King.

Authors: Mark D. Woodley, Lou Sanchez Chopitea, and Hamid Shoaee, Stanford Linear Accelerator Center, U.S.A., 1983 to present

Reference: M.D. Woodley, M.J. Lee, J. Jäger, A.S. King, "Control of Machine Functions or Transport Systems," *IEEE Transaction on Nuclear Science* **NS-30**, 2367–2370 (1983).

Status: COMFORT was last modified in September 1988. This code is maintained and distributed, without charge, by Hamid Shoaee. It has approximately 10 000 lines of FORTRAN source code. It is being used at about 20 sites. There are two distributed versions of this program. They are for VAX/VMS and IBM/VM/CMS systems. A 40-page user's guide and examples are available. This code is being distributed on magnetic tape reels and through the computer networks.

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COSY 5.0

Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: nonlinear/higher order, optimization, fringe field

Abstract: COSY 5.0 handles fifth-order matrix transport and tracking using differential algebra. The code handles arbitrary field distributions, fringe fields, and the usual beamline elements as well as having fitting capabilities. The ability to treat space charge is under development. The code's format for input data is closely related to the format used by the code GIOS.

Authors: M. Berz, B. Hartmann, K. Lindemann, and H. Wollnik, University of Gießen, Federal Republic of Germany, 1985 to 1988

References:

M. Berz, H.C. Hofmann, and H. Wollnik, "COSY 5.0, the Fifth-Order Code for Corpuscular Optical Systems," *Nuclear Instruments and Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors, and Associated Equipment* **A258** (3), 402–406 (1987).

H. Wollnik, B. Hartmann, and M. Berz, "Principles of GIOS and COSY," in *AIP Conference Proceedings 177: Linear Accelerator and Beam Optics Codes, La Jolla Institute 1988*, Charles R. Eminhizer, Ed. (American Institute of Physics, New York, 1988), pp. 74–85.

M. Berz and H. Wollnik, "Analytic Solution of Single-Particle Equations of Motion to High Orders: The Formula Manipulator HAMILTON and the Fifth-Order Code COSY 5.0," in *AIP Conference Proceedings 177: Linear Accelerator and Beam Optics Codes, La Jolla Institute 1988*, Charles R. Eminhizer, Ed. (American Institute of Physics, New York, 1988), pp. 301–312.

Status: COSY 5.0 was last modified in 1988. This code is maintained and distributed, generally without charge to nonprofit organizations, by Martin Berz. A nonproliferation agreement is required. It has approximately 50 000 lines of standard FORTRAN-77 source code. There is only one distributed version of this program. It is for the VAX/VMS system. The Graphic Kernel System (GKS) is used. A user's guide is being prepared. This code is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, misalignment, optimization

Abstract: COSY INFINITY is an arbitrary-order thick-element optics and accelerator code, including fringe fields and fitting capabilities. It is based on Differential Algebra. New elements and new features are easily included. This program has a very general object-oriented input language.

Author: Martin Berz, Lawrence Berkeley Laboratory, U.S.A., 1989

References:

M. Berz, "COSY INFINITY, a New Multipurpose Arbitrary Order Beam Dynamics Code," Lawrence Berkeley Laboratory report LBL-28881 (March 1990).

M. Berz, "Differential Algebraic Treatment of Beam Dynamics to Very High Orders," *Particle Accelerators* **24** (2), 109–124 (1989).

M. Berz, "A New Arbitrary Order Optics Code," Conference on Computer Codes and the Linear Accelerator Community, Los Alamos, New Mexico, January 16–19, 1990.

Status: COSY INFINITY was last modified in October 1989. This code is maintained and distributed, generally without charge to nonprofit organizations, by Martin Berz. A nonproliferation agreement is required. It has approximately 10 000 lines of standard FORTRAN-77 source code. There is only one distributed version of this program. It is for the VAX/VMS system. No graphics packages are used. A 40-page user's guide/reference manual and examples are available. This code is being distributed on magnetic tape reels and through the computer networks.

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DA PACKAGE

Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, misalignment, fringe field

Abstract: DA PACKAGE is a toolbox containing elementary differential-algebraic routines, which can be used by other master programs.

Author: Martin Berz, Lawrence Berkeley Laboratory, U.S.A., 1987 to present

References:

M. Berz, "Differential Algebraic Treatment of Beam Dynamics to Very High Orders," *Particle Accelerators* **24** (2), 109–124 (1989).

M. Berz, "Differential Algebraic Treatment of Beam Dynamics to Very High Orders Including Applications to Spacecharge," in *AIP Conference Proceedings 177: Linear Accelerator and Beam Optics Codes, La Jolla Institute 1988*, Charles R. Eminhizer, Ed. (American Institute of Physics, New York, 1988), pp. 275–300.

Status: DA PACKAGE was last modified in October 1989. This code is maintained and distributed, without charge, by Martin Berz. A nonproliferation agreement is required. There are approximately 6000 lines of standard FORTRAN-77 source code. There are about 20 known users. This package has been run on VAX/VMS, CRAY/CTSS (FORTLIB), and CYBER/NOS-VE systems. No graphics packages are used. A 10-page user's guide and examples are available. This code is being distributed on magnetic tape reels, through the computer networks, and on 3.5-inch high-density diskettes for either IBM-compatible and Macintosh personal computers.

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Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, symplectic

Abstract: DALIE can modify a Taylor series representation produced by a differential-algebra-based program into any other useful representation (Lie polynomial, characteristic functions, etc.). This program computes nonlinear quantities (tune shifts, approximate invariants, etc.) related to nonlinear symplectic maps. The code is linked with Martin Berz's differential-algebra package.

Authors: Étienne Forest and John Irwin, Lawrence Berkeley Laboratory, U.S.A.; Martin Berz, University of Gießen, Federal Republic of Germany

References: Étienne Forest, SSC-Central Design Group at Lawrence Berkeley Laboratory, 1988, "Exact Computation of Derivatives with Differential Algebra and Applications to Beam Dynamics," Superconducting Super Collider report SSC-166 (1988).

M. Berz, "Differential Algebraic Description of Beam Dynamics to Very High Orders," *Particle Accelerators* **24** (2), 109–124 (1989).

Étienne Forest, Martin Berz, and John Irwin, "Normal Form Methods for Complicated Periodic Systems: A Complete Solution Using Differential Algebra and Lie Operators," *Particle Accelerators* **24** (2), 91–107 (1989).

Status: DALIE is maintained and distributed, without charge, by Étienne Forest. Users must have a working knowledge of Lie algebra and Martin Berz's differential-algebra (DA) package. There are approximately 2000 lines of FORTRAN source code, not including the DA package. There are five known users. There is only one distributed version of this program. It is for the VAX/VMS system. A six-page user guide is available. This code is being distributed (in most cases) through the computer networks.

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DECAY TURTLE

Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: tracking, particle transmutation

Abstract: DECAY TURTLE tracks particles with first- and second- order matrix formalism. Particle decay is included. This program uses an input format that is very similar to the input formats used in the programs TURTLE, TRANSPORT, and MAD. All four programs use the same format for the beamline specification.

History: DECAY TURTLE evolved from the code TURTLE, written by David C. Carey. Christoph Iselin and K.L. Brown modified the code to include decay in 1973.

Authors: David C. Carey, Fermi National Accelerator Laboratory, U.S.A.; Karl L. Brown, CERN, Switzerland, and Stanford Linear Accelerator Center, U.S.A.; and Christoph Iselin, CERN, Switzerland, 1972 to present

Reference: D.C. Carey, K.L. Brown, Ch. Iselin, "DECAY TURTLE (Trace Unlimited Rays Through Lumped Elements): A Computer Program for Simulating Charged Particle Beam Transport Systems, Including Decay Calculations," SLAC report SLAC-246 (March 1982), also CERN report 74-02 (1974).

Status: DECAY TURTLE was last modified in December 1988. This code is maintained and distributed, without charge, by David C. Carey and Christoph Iselin. There is a nominal charge (about $100 U.S.) to cover the cost of processing a tape, if that is required. The code has approximately 9000 lines of nearly standard FORTRAN-77. The program has been run on CYBER/NOS/BE, IBM/VM/CMS, and IBM/MVS systems. The 50-page user's guide, cited in the **Reference** section above, is available. The code is being distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: electron sources

Key Terms: space charge/high current, deformable mesh

Abstract: DEMEOS is a general-purpose electron optics code useful for the design of electron guns, focusing (transport), and collection systems in linear-beam microwave tubes and linear accelerators. A unique feature of this code is that it solves Poisson's equation on a deformable mesh comprised of irregular triangles. This code can accurately handle relativistic beams having dense space-charge. It is particularly useful in the design of gridded guns and high-convergence sources. Beam diagnostics and the graphic analysis of the code's results are included.

History: DEMEOS was originally written approximately 20 years ago. This code and related versions have been employed extensively in the microwave-tube industry for the design of high-performance diode and gridded electron guns, beam focusing, and collection systems (multistage depressed collectors). It is well-validated and is known to be extremely accurate and reliable.

Author: Richard True, University of Connecticut, Storrs, U.S.A., 1969 to 1972

References:

R. True, "Space-Charge Limited Beam Forming Systems Analyzed on a Deformable Relaxation Mesh," Ph.D. dissertation, University of Connecticut, Storrs, 1972.

R. True, "The Deformable Relaxation Mesh Technique for Solution of Electron Optics Problems," *Technical Digest — International Electron Devices Meeting*, 257–260 (December 1975).

R. True, "A Theory for Coupling Gridded Gun Design with PPM Focussing," *IEEE Transactions on Electron Devices* **ED-31** (3), 353-362 (March 1984).

R. True, "The Design of Gridded Pierce Guns for Accelerators," *IEEE Transactions on Nuclear Science* **NS-32** (5), 2611–2613 (October 1985).

R. True, "Emittance and the Design of Beam Formation, Transport, and Collection Systems in Periodically Focussed TWT's," *IEEE Transactions on Electron Devices* **ED-34** (2), 473–485 (February 1987).

R. True, "Calculation and Design of Grids in Pierce Guns," *Technical Digest — International Electron Devices Meeting*, 215–218 (December 1989).

Status: DEMEOS is maintained and distributed, for a fee, by R. True. A nonproliferation agreement is required, the cost is negotiable, and the distribution is limited (contact the author). The code has approximately 5000 lines of PL/I. The program has been run on VAX/VMS, IBM/MVS, and Unisys systems. An approximately 60-page user's guide and a 322-page reference manual are available. The code is being distributed on magnetic tape reels, TK50 magnetic tape cartridges, and 5.25-inch double-sided double-density 360-kilobyte diskettes for IBM-compatible personal computers.

Maintained and Distributed by: Richard True

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Function: BEAM DYNAMICS: synchrotrons/storage rings, spectrometers/transport lines, general

Key Terms: misalignment, nonlinear/higher order, stability

Abstract: DIMAD is used for the general design of synchrotrons. It performs closed-orbit studies, including stable or unstable special resonance extraction studies. It is based on the code TRANSPORT (second-order). The code has extensive error and misalignment handling capabilities, as well as fitting capability.

Author: Roger Servranckx, University of Saskatchewan, Canada, and Stanford Linear Accelerator Center, U.S.A.

Reference: Roger Servranckx, Karl Brown, Lindsay Schachinger, and David Douglas, "Users Guide to the Program DIMAD," Stanford Linear Accelerator report 285 (1986).

Status: DIMAD was last modified in February 1989. This code is maintained and distributed, without charge, by Roger Servranckx. It has approximately 24 000 lines of FORTRAN source code. There are four distributed versions of this program. They are for the VAX/VMS, VAX/UNIX, IBM/VM, and Sun/UNIX systems. A 25-page user's guide and examples are available. This code is being distributed through the computer networks.

Maintained and Distributed by: Roger Servranckx
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DIPLOT

Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: tracking, graphics postprocessing

Abstract: DIPLOT is a postprocessor used in conjunction with DIMAD (the synchrotron-tracking and lattice-design code written by R. Servranckx and others). The purpose of DIPLOT is to provide additional graphics and facilities for analysis that are not available in DIMAD. This includes the plotting of lattice functions, beam envelopes, machine layouts, etc. The program is interactive and operates by scanning a DIMAD output file, extracting various data, performing additional calculations, and plotting the results. High-quality graphics output is generated for VAX workstations, VT640-compatible terminals, and Hewlett-Packard hard-copy devices. Metafiles can be produced for the graphics editor EDGR, also available from the author. This feature provides support for a number of other printers and plotters, and allows images to be combined, scaled, annotated, and edited in various ways. DIPLOT is constructed in a modular fashion so that new functions and user-written procedures can be added easily.

Author: F.W. Jones, TRIUMF, Canada

References: F.W. Jones, "DIPLOT: A Post-processor for DIMAD," TRIUMF design note TRI-DN-87-22 (1987).

Status: DIPLOT was last modified in April 1990. This code is maintained and distributed, without charge, by Frederick Jones. It has approximately 3000 lines of FORTRAN source code. There is only one distributed version of this program. It is for the VAX/VMS system. A 16-page user's guide is available. This code is being distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: RF cavities

Key Terms: dispersion, special boundary condition, periodic structure

Abstract: The program DISPER does a weighted, nonlinear least-squares-fit to experimentally measured frequencies of mode spectra from arrays of RF cavities. The fit can be for singly or doubly periodic systems with up to second-neighbor coupling constants and various end-cavity terminations. The fit is to a model consisting of coupled RLC circuits.

Author: S.O. Schriber, Chalk River Nuclear Laboratory, Canada

Reference: S.O. Schriber, "Fitting of an Ordered Set of Mode Frequencies," Atomic Energy of Canada, Limited, report AECL-3669 (1970).

Status: DISPER was last modified in 1981. This code is maintained and distributed, without charge, by S.O. Schriber. It has 2573 lines of FORTRAN source code. It has approximately 25 known users. This code has been run on CRAY/CTSS (CFTLIB), CYBER, and IBM systems. A 34-page user's guide and examples are available. This code is being distributed on magnetic tape reels.

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DISPERSION

Function: COMPONENT DESIGN: RF cavities

Key Terms: dispersion, ferrite/dielectric, periodic structure

Abstract: DISPERSION uses the SUPERFISH family of programs to calculate the dispersion curves for axially symmetric TE and TM modes in a periodic structure. This code is a modification of the SUPERFISH code and it also uses a special version of LATTICE which sets up the boundary conditions on the connecting surfaces on the boundaries of the basic cell.

Author: Eric N. Opp, Los Alamos National Laboratory, U.S.A.

References: Robert L. Gluckstern and Eric N. Opp, "Calculation of Dispersion Curves in Periodic Structures," *IEEE Transactions on Magnetics* **MAG-21**, 2344–2346 (1985).

E.N. Opp, "Calculation of Dispersion Curves in Periodic Structures Using SUPERFISH," Los Alamos National Laboratory internal report AT-6:ATN-85-4 (1985).

Status: DISPERSION was last modified in July 1986. This code is not maintained but it is being distributed, without charge, by Eric N. Opp. It has approximately 10 000 lines of FORTRAN source code. It has three known users. There are two distributed versions of this program. They are for the VAX/VMS and CRAY/CTSS (CFTLIB) systems. The Los Alamos National Laboratory internal report cited in the **References** section above and an example from the Stanford Linear Accelerator Center are available. This code is being distributed on small seven-inch magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

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Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, stability, dynamic aperture

Abstract: DYNAP is an interactive program used to estimate **DYN**amic **AP**erture. The lattice structure is given as input:

$$\theta_x = \int \frac{ds}{Q_x \beta_x}, \quad \theta_y = \int \frac{ds}{Q_y \beta_y}, \quad \beta_x, \quad \beta_y, \quad k'(\theta_x, \theta_y)$$

at the sextupole positions.

Authors: Johannes Hagel and Herbert Moshammer, CERN, Switzerland

Reference: J. Hagel, "DYNAP, an Interactive Program for Estimating the Dynamical Aperture," CERN, LEP Divisional report (report number is unavailable) (1986).

Status: DYNAP was last modified in February 1989. This code is maintained and distributed, without charge, by Johannes Hagel. It has approximately 1400 lines of FORTRAN source code. There are four known users. This program has been run on a VAX/VMS system and CERN's IBM 3081/VM system. A 70-page user's guide (please refer to the **Reference** section above) is available; it describes a very old version of the code. There were plans to publish a new guide in 1989, the status of this document is unknown. This code is being distributed through the computer networks.

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EBQ

Function: COMPONENT DESIGN: electron sources

Key Terms: space charge/high current, tracking, particle-in-cell

Abstract: EBQ (electric field **E**, magnetic field **B**, and space charge **Q**) simulates steady-state problems involving the space-charge transport of charged particles in cylindrically symmetric devices. This two-dimensional program accepts data specifying the externally applied electric and magnetic fields. The electric and magnetic self fields of the particles are used to obtain self-consistent azimuthally symmetric charge and current distributions. The code follows particle trajectories and employs a unique method of assigning values of the charge density to grid points. This method provides sufficient accuracy to model the cancellation that occurs between radial electric and magnetic self-forces in a relativistic beam.

History: This code was developed after W. Herrmannsfeldt's code EGUN and before J. Boyd's code DPC.

Author: Arthur C. Paul, Lawrence Berkeley Laboratory, U.S.A.

Reference: A.C. Paul, "EBQ Code – Transport of Space-Charge Beams in Axially Symmetric Devices," Lawrence Berkeley Laboratory report LBL-13241 (1982).

Status: EBQ is maintained by A.C. Paul. The code is being distributed, for a fee, by the National Energy Software Center (NESC). It has approximately 13 000 lines of FORTRAN source code. There are three distributed versions of this program. They are for the VAX/VMS, CRAY/LTSS (FORTLIB), and Sun 3/75 systems. A 299-page user's guide and examples are available. This code is being distributed on magnetic tape reels.

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Function: COMPONENT DESIGN: magnets

Key Term: eddy current, magnetic field

Abstract: EDDYNET uses a wire-grid approach to solve eddy-current problems. The conducting surface is approximated by a quadrilateral mesh of conducting lines. Line resistances and loop inductances are defined in a manner consistent with the approximation. The system of loop equations, with a dense matrix, is solved repeatedly to give the time development of the eddy currents, magnetic field, and dissipated power.

Authors: Larry R. Turner and Robert J. Lari, Argonne National Laboratory, U.S.A., 197'' to present

References: L.R. Turner and R.J. Lari, "Developments in Eddy Current Computations with EDDYNET," *IEEE Transactions on Magnetics* **MAG-19**, pp. 2577–2580 (1983).

L.R. Turner, "Eddy Current Analysis of the ZT-P Shells with EDDYNET," in *Computational Electromagnetics*, Z.J. Cendes, Ed. (Elsevier Science Publishers (North-Holland), New York, 1986), pp. 181–189.

Status: EDDYNET is maintained and distributed, without charge, by Larry Turner. The program has approximately 3000 lines of FORTRAN source code. This code has been run on VAX/VMS, CRAY/CTSS (FORTLIB), and IBM systems. A 70-page user's guide is available. This code is being distributed through the computer networks.

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EGUN

Function: COMPONENT DESIGN: ion and electron sources

Key Terms: space charge/high current, special boundary condition, gun design, PC version

Abstract: EGUN is specifically written to compute trajectories of charged particles in electrostatic and magnetostatic focusing systems including the effects of space charge and self magnetic fields. Starting options include Child's Law conditions on cathodes of various shapes. Either rectangular or cylindrically symmetric geometry may be used. Magnetic fields may be specified using arbitrary configurations of coils, the output of a magnet program such as POISSON, or an externally calculated array of the axial fields. Latest versions are designed for use on IBM-type personal computers. They use up to 16 000 mesh points and have fully integrated graphics support for all CRT monitors and most plotters. Field emitters using Fowler-Nordheim expressions are included.

History: This program was originally written and widely distributed in FORTRAN. The current version is in C and is maintained primarily for use on IBM-type personal computers.

Authors: Glen A. Herrmannsfeldt and W.B. Herrmannsfeldt, Stanford Linear Accelerator Center, U.S.A.

Reference: "EGUN – An Electron Optics and Gun Design Program," Stanford Linear Accelerator Center report 331 (October 1988).

Status: EGUN has been modified recently. This code is maintained by Glen Herrmannsfeldt and W.B. Herrmannsfeldt. It is being distributed, for a fee, by W.B. Herrmannsfeldt. It has approximately 5000 lines of C source code. It is used at more than 100 sites. The latest version is written in C, but a version in FORTRAN is also available. This code has been run on a VAX/VMS, VAX/UNIX, CRAY/CTSS (FORTLIB), and IBM/VM systems, and can be run on any IBM personal computer with 640 kilobytes and a math coprocessor installed. A 125-page user's guide, examples, and an on-line help facility are available. Only the personal computer version is available and it is being distributed on diskettes.

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Function: BEAM DYNAMICS: high-current compact accelerators

Key Terms: space charge/high current, particle-in-cell, three dimensions

Abstract: ELBA is a fully electromagnetic, fully relativistic particle-in-cell code. The program is three-dimensional and has a provision for transporting a beam around bends. Cylindrical geometry is used.

History: ELBA is the fifth in a series of codes developed at the Naval Research Laboratory (NRL) to study the propagation of relativistic high-current electron beams through dense gases, diffuse plasmas, and magnetic fields.

Authors: Glenn Joyce, Jon Krall, and Steven Slinker, Naval Research Laboratory, U.S.A., 1988 to present

References: Glenn Joyce, "ELBA — A Three-Dimensional Particle Code for Relativistic Beam Transport and Propagation," Conference on Computer Codes and the Linear Accelerator Community, Los Alamos, New Mexico, January 16–19, 1990.

Status: ELBA is still being developed by the authors and is not available for distribution. The code has approximately 3000 lines of FORTRAN-77 source code. The program has only been run on a CRAY/COS system with a CFT compiler. The code contains calls to CRAY-specific mathematical routines and uses CRAY-specific asynchronous input/output. The program uses the NCAR (National Center for Atmospheric Research) graphics package that produces some very nice contour plots. This graphics package is available for a fee based on a sliding scale. Contact the Scientific Computing Division's "Graphics Information Customer Line" 1 (303) 497-1201 or write to Post Office Box 3000, Boulder, Colorado 80307-3000. No documentation for ELBA is available at this time.

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Function: COMPONENT DESIGN: magnets

Key Terms: preliminary design, cost estimates

Abstract: EMD is an artificial-intelligence (AI) or expert program for designing medium-sized H-type dipole bending magnets, estimating costs, and generating the most economical input in the proper format for the program POISSON. Given information such as particle type, energy, bend angle, and clear aperture, the program provides a magnet design. The code incorporates details such as minimum end radius of the conductor, layer-to-layer turn transitions, allowance for insulation, and a nominal transverse field uniformity of 1.0%. The design includes the vacuum-chamber cross section, alignment clearance, magnet-core cross section, and a coil configuration using one of Los Alamos Meson Physics Facility's (LAMPF) standard conductors. The solution satisfies the current density, pressure drop, temperature rise, and water velocity constraints. The program uses 10 to 12 formulas and tables, based on the cost of iron and steel in the past, to estimate cost. The program prompts the user at several stages of the design for specific inputs or it can proceed by using the built-in default values that will produce a feasible solution.

The output includes the design parameters, magnetic field, electrical and cooling characteristics, physical dimensions, magnet-core cross sectional sketch, and weight and cost estimates.

The comparison of design solutions with several existing magnets prove the program's accuracy. It has been well received and proved to be of value, providing quick estimates and first-order magnet designs at LAMPF.

Author: Ann Aldridge, Los Alamos National Laboratory, U.S.A.

References: Ann M. Aldridge, Edgar D. Bush, Jr., and Richard L. Hutson, "Computer Program: Expert Magnet Design," *Abstracts the 7th Biennial CUBE (Computer Use by Engineers) Symposium, Lawrence Livermore National Laboratory and the Pleasanton Hilton Hotel October 15–17, 1986* CONF-861070-Abstracts, pp. 69–70, Los Alamos National Laboratory unclassified report LA-UR-86-2264 (copies of the entire paper are available from MP-8, Los Alamos National Laboratory).

Ann Aldridge, "EMD Expert Magnet Designer," Los Alamos National Laboratory internal document (available from MP-8, Los Alamos National Laboratory).

Ann Aldridge and Edgar Bush, Jr., "Notes on the Evolution of Expert Magnet Design," Los Alamos National Laboratory internal document (available from MP-8, Los Alamos National Laboratory.)

Status: EMD was last modified in October 1985. The code is not being maintained, but it is not obsolete. It is available for distribution by Seth Rislove. The code is written in LISP. The program has been run on a VAX/EUNICE system. This interactive code provides prompts that are self-explanatory. A 55-page user's guide is available. There is no need for further documentation unless one really wants to delve into the code. This program is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: tracking, longitudinal

Abstract: ESME is used to calculate the evolution of a distribution of particles in longitudinal phase space in the RF environment of a proton synchrotron. It provides for the modeling of multiple RF systems, feedback control, space charge, and many of the effects of longitudinal coupling impedance. The RF cavities are treated as discrete elements equally spaced around the ring.

Authors: J.A. MacLachlan, Fermi National Accelerator Laboratory, U.S.A.;
S. Stahl, Fermi National Accelerator Laboratory and Northwestern University, U.S.A.

References: J.A. MacLachlan, "Difference Equations for Longitudinal Motion in a Synchrotron," Fermi National Accelerator Laboratory report FN-529 (15 December 1989).

J.A. MacLachlan, "Fundamentals of Particle Tracking for the Longitudinal Projection of Beam Phasespace in Synchrotrons," Fermi National Accelerator Laboratory report FN-481 (15 April 1988).

S. Stahl and J. A. MacLachlan, "User's Guide to ESME v. 7.1," Fermi National Accelerator Laboratory report TM-1650 (May 1990).

Status: ESME was last modified in November 1989. This code is maintained and distributed, without charge, by Steven Stahl. It has approximately 11 000 lines of FORTRAN source code. There are about 20 known users. This program has been run on VAX/VMS, IBM Amdahl 5890/VM/SP, and Sun systems as well as with FPS-124 (floating point accelerator from Floating Point Systems). A 50-page user's guide (Fermi National Accelerator Laboratory report TM-1650 cited in the **References** section above) is available. This code is being distributed on magnetic tape reels and through the computer networks.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: nonlinear/higher order, tracking, beam-beam interaction

Abstract: EVOL is used to track protons in the presence of magnetic and beam-beam nonlinearities, including effects from tune modulation.

Author: Steve Peggs, Fermi National Accelerator Laboratory, U.S.A., 1981 to present

Reference: S. Peggs, "Hadron Collider Behavior in the Nonlinear Numerical Model EVOL," *Particle Accelerators* **17**, pp. 11–50 (1985).

Status: EVOL is maintained and distributed, without charge, by Steve Peggs. It has approximately 2000 lines of nearly standard FORTRAN-77 source code. The only exceptions to the standard are a few nonstandard INCLUDE lines. The code has been run on VAX/VMS and Sun/UNIX systems. The program uses the graphics package TOPDRAWER, developed at SLAC by Roger Chaffee. This graphics package is available, without charge. Contact Bill Johnson, Bin 97, SLAC, Post Office Box 4349, Stanford, California 94309. His phone number is 1 (415) 926-2660, on FTS: it is 462-2660. There is no formal documentation for EVOL. This code is being distributed through the computer networks.

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Function: COMPONENT DESIGN: power sources

Key Terms: space charge/high current, particle-in-cell

Abstract: FCI (Field-Charge Interaction) is a two-and-one-half-dimensional particle-in-cell code that simulates the beam motion inside a klystron by taking into account the fields of space charge, external focusing magnets, and the RF cavities. Using this code, one can analyze the operating mechanism of the high-power klystron. It helps the klystron designer to make a machine that provides optimum performance. This code is applicable to other kinds of high-intensity-beam problems, such as the RF gun, lasertron, and induction linac.

Author: Tsumoru Shintake, National Laboratory for High Energy Physics (KEK), Japan

Reference: T. Shintake, "FCI – Field-Charge Interaction Program for High-Power Klystron Simulations," 1989 IEEE Particle Accelerator Conference, Chicago, Illinois, March 20-23, 1989, KEK preprint 89-18 (May 1989).

Status: FCI is maintained and distributed, without charge, by Masakazu Yoshioka. A nonproliferation agreement is required. It has approximately 10 000 lines of FORTRAN source code. There are about 10 known users. There is only one distributed version of this program. It is for a HITAC-M-280H mainframe, but should be IBM compatible. A user's guide (approximately 10 pages) and a reference manual (approximately 50 pages) were expected to be published by the latter part of 1989. The code is being distributed on magnetic tape reels.

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FEDIF

Function: COMPONENT DESIGN: magnetostatic devices

Key Terms: eddy current, three dimensions

Abstract: FEDIF's two strengths are accuracy and flexibility. This code calculates currents to within 10^{-4}, in relative terms, and the associated fields are calculated to an even greater degree of accuracy.

Finite plate elements are interconnected to three-dimensional networks. The program consists of a set of easily adaptable procedures to cover additional physics such as motional term and three-dimensional body eddy currents.

History: FEDIF was originally written by Helmut Preis at the Max-Planck Institute (MPI) for Plasma Physics, Germany, 1981. That year, it was brought to the Princeton Plasma Physics Laboratory. Interest in the code split in two different directions. Don Weissenburger developed the code into a general utility program, changed the name of the program to SPARK, and installed it at the National Energy Research Supercomputer Center (NERSC), formerly NMFECC, at Lawrence Livermore National Laboratory, U.S.A. Among other modifications, he included subroutines to handle certain generic geometries. Herbert Vogel, on the other hand, was interested in making a raw physics code: a program to be incorporated into other physics programs. He brought the code to Los Alamos National Laboratory, increased the accuracy of the field calculations significantly, and added additional physics as well as graphics.

Author: Herb F. Vogel, Los Alamos National Laboratory, U.S.A., 1983

Reference: H.F. Vogel, H. Preis, "Study on Diffusion of the Vertical Magnetic Field in the Toroidal Stabilizing Shell and Plasma of the ZT-40M Reversed Field Pinch Device," *IEEE Transactions on Magnetics* **MAG-19**, 2482–2485 (1986).

Status: FEDIF was last modified in July 1988. This code is maintained and distributed, without charge, by H.F. Vogel. The code has very limited free support, although more support can be purchased. The code has approximately 4000 lines of standard FORTRAN-77 source code. It has two known users. There is only one distributed version of this program. It is for the CRAY/CTSS (CFTLIB) system. There is no documentation. This code is being distributed on floppy disks for any IBM-compatible personal computer.

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Function: COMPONENT DESIGN: magnets

Key Terms: optimization, ferrite/dielectric, PC version

Abstract: FORCE PC - BNL calculates the forces and torques on coils and iron regions from the potential derived from a POISSON or a PANDIRA run.

History: Ronald Holsinger and Klaus Halbach wrote the original version of FORCE. It is now being distributed by the Los Alamos Accelerator Code Group (LAACG), Los Alamos National Laboratory, U.S.A. Judith Colman modified this original version so that it would run on IBM personal computers, creating FORCE PC - BNL.

Author: Judith Colman, Brookhaven National Laboratory, U.S.A. (please refer to the **History** section above)

References: none

Status: FORCE PC - BNL is only modified when major bugs are discovered. It is distributed, without charge, by Judith Colman. The correct number of pre-formatted diskettes must be supplied. It has approximately 1200 lines of FORTRAN-77 source code. A Ryan-McFarland compiler was used to run the code, but it should work as well with Microsoft 4.1 and Leahy. The code requires a minimum of 640 kilobytes of memory, a math co-processor, and a DOS operating system. The code should run on IBM AT and PS2/60 machines as well as on most IBM clones. It should also compile readily on a VAX/VMS system. The documentation for the original version of the code should still be relevant for the description of data and other technical information in the personal computer version of the code. Examples and a brief description of the personal-computer-specific information are available. The code is being distributed on high- and low-density, 3.5-inch and 5.25-inch diskettes for IBM-compatible personal computers.

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Function: BEAM DYNAMICS: transport lines

Key Terms: space charge, optimization, three dimensions

Abstract: GALOPR is a first-order beam transport code including three-dimensional space charge forces and the beam bunching process. It deals with usual optical devices (bending magnets, lenses, solenoids, drifts, bunchers) and can take into account any special optical device represented by its transfer matrix with space charge (the Müller inflector was recently introduced as one of these devices). The beam can be continuous or undergoing a bunching or a debunching process. The beamline parameters can be optimized in order to fit, at will, the 6×6 transfer matrix and the 6×6 covariance matrix for a maximum beam intensity. The results are presented with useful data tables and graphical displays.

History: GALOPR's history is a long one, it has been evolving for a long time. Work on GALOPR started in 1971 when Bernard Bru worked with Mario Weiss (an engineer at CERN in the MPS Division) to develop the code PREINJ, written to study the Low-Energy Beam Transport System of the actual Proton Linac Injector at CERN. In 1974, Bernard Bru worked at GANIL with René Beck, leader of the Beam Transport Group. In 1976, the code GALOP was written to study the beamlines between the cyclotrons at GANIL. GALOP included dipoles but did not handle bunching. At present, Bernard Bru has been working with Charles Ricaud, in charge of the Operation Augmentation d'Energie (Intensity Boosting Modification) Project, the 100-kilovolt Axial Injection Line at GANIL. GALOPR was written in 1985 to optimize this injection line.

Author: Bernard Bru, CERN, Switzerland, and Grand Accélérateur National d'Ions Lourds (GANIL), France, 1971 to present

References: B. Bru and M. Weiss, "Computational Methods and Computer Programs for Linearized Analysis of Periodic Structures and Beam Transport Systems Under Space Charge Conditions," CERN report CERN/MPS/LIN 72-4 (1972).

M. Weiss, "Bunching of Intense Proton Beams with Six-Dimensional Matching to the Linac Acceptance," *IEEE Transactions on Nuclear Science* NS-20 (3), 877–879 (1973).

R. Beck, B. Bru, and Ch. Ricaud, "L'Inflecteur Hyperboloïde de R. W. Müller," Grand Accélérateur National d'Ions Lourds report GANIL A86-02 a and b.

B. Bru, "GALOPR, a Beam Transport Program, with Space-Charge and Bunching," Grand Accélérateur National d'Ions Lourds report GANIL A88-01.

B. Bru, "Un Programme de Transport de Faisceau Incluant la Charge d'Espace et le Groupement," (to be published).

Status: GALOPR was last modified in October 1989. The code is maintained and distributed, without charge, by B. Bru. The author's authorization is requested. It has approximately 2900 lines of IBM VS FORTRAN-77 (Version 2) source

code The program has about 8 known users. The code has been run on an IBM/VM/XA system and a MODCOMP 32-bit system (MAX32). The NAGRAPH graphics library package is used in the IBM version and DATAPLOT is used in the MODCOMP version. A user's guide, "Un Programme de Transport de Faisceau Incluant la Charge d'Espace et le Groupement," cited in the **References** section above, is being written. Examples and a description of the data set, in French, are available. The code is being distributed on magnetic tape reels, the computer networks, and 5.25-inch double-sided 360-kilobyte or 1.2-megabyte diskettes for IBM-compatible personal computers.

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GEMINI

Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: misalignment, nonlinear/higher order, closed orbit

Abstract: GEMINI is a three-dimensional simulation code for large electron rings, containing a compiler for the implementation of special-purpose algorithms.

Authors: H. Nishimura and É. Forest, Lawrence Berkeley Laboratory, U.S.A.

References: none

Status: GEMINI is maintained and kept current to meet the authors' needs. The code is available to anyone who agrees to collaborate with the authors. The code has 40 000 lines of Pascal source code. It has been run on a VAX/VMS system. No documentation is available.

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Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, fringe field, measured field

Abstract: GENMAP 3.0 is a program to numerically compute transfer maps (through third-order) for arbitrary beamline elements using Lie algebraic methods. The code uses canonical variables (x, p_x, y, p_y, t, p_t). To study a particular beam element or transport system, the user must modify a subroutine to specify the Hamiltonian as a power series around the design trajectory. This involves specifying the electromagnetic fields in question (and various derivatives) by analytic approximations or interpolation tables. The output of GENMAP 3.0 is the Lie algebraic transfer map for the system under study. GENMAP 3.0 is generally used to compute transfer maps for beamline elements with fringe fields. These maps can be utilized by MARYLIE 3.0 for tracking and analysis of transport systems with realistic fringe fields. GENMAP 3.0 can also be incorporated as a subroutine in MARYLIE 3.0 for optimization of systems with fringe fields. It is currently available in this form for Rare Earth Cobalt (REC) quadrupoles, including overlapping fringe-field effects. A new version of GENMAP 3.0, GENMAP 5.0, is a program that treats REC quadrupoles through fifth-order and is available on a developmental basis.

Authors: Alex J. Dragt and Filippo Neri, Center for Theoretical Physics, Department of Physics and Astronomy, University of Maryland, U.S.A.; Robert D. Ryne, Lawrence Livermore National Laboratory, U.S.A.

References:

R. Ryne, "Numerical Computations of Transfer Maps using Lie Algebraic Methods," Los Alamos National Laboratory internal report AT-6:ATN-86-21 (June 1986).

R. Ryne, "Numerical Computation of the Transfer Map for a Magnetic Dipole with Mid-Plane Symmetry using Lie Algebraic Methods," Los Alamos National Laboratory internal report AT-6:ATN-86-25 (August 1986).

Alex J. Dragt, et al., "MARYLIE 3.0, a Program for Charged Particle Beam Transport Based on Lie Algebraic Methods," a University of Maryland internal document, user's guide (1989).

Alex J. Dragt and H. Moser, "Influence of Strongly Curved Large-Bore Superconducting Bending Magnets on the Optics of Storage Rings," *Nuclear Instruments and Methods in Physics Research. Section B, Beam Interactions with Materials and Atoms* **B24/25**, 877–879 (1987).

Alex J. Dragt, Robert Ryne, "Numerical Computation of Transfer Maps using Lie Algebraic Methods," in *Proceedings of the 1987 Particle Accelerator Conference: Accelerator Engineering and Technology, March 16–19, 1987, Washington, D.C.*, Eric R. Lindstrom and Louise S. Taylor, Eds., (IEEE, New York, 1987), IEEE catalog number 87CH2387-9, Vol. 2, pp. 1081–1083.

Alex J. Dragt, H. Moser, "Nonlinear Beam Optics with Real Fields in Compact Storage Rings," *Nuclear Instruments and Methods in Physics Research. Section B, Beam Interactions with Materials and Atoms* **B30**, 105–109 (1988).

A. Dragt, É. Forest, "Computation of Nonlinear Behavior of Hamiltonian Systems Using Lie Algebraic Methods," *Journal of Mathematical Physics* 24, 2734–2744 (1984).

Étienne Forest, "Lie Algebraic Methods for Charged Particle Beams and Light Optics," Ph.D. thesis, University of Maryland (1984).

Robert Ryne, "Lie Algebraic Treatment of Space Charge," Ph.D. thesis, University of Maryland (1987).

Status: GENMAP 3.0 is still under development, but it is being distributed, for a fee, by Alex J. Dragt. There is a nominal rate for universities and Government laboratories, a reasonable rate for industry. A nonproliferation agreement is required. It has approximately 5000 lines of FORTRAN source code. At this time, VAX/VMS and CRAY/CTSS (CFTLIB) versions exist. While there is no formal documentation, there are examples and publications that might prove to be useful. The code is available on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: magnets

Key Terms: three dimensions, electromagnetic field, finite element

Abstract: The GFUN package is a well-proven suite of programs for three-dimensional analysis of static magnetic fields. The latest version includes powerful preprocessing and postprocessing modules linked to a finite-element analysis module proven over 15 years of application. The method is based on a volume-integral algorithm, the advantage is that the fields are correctly bounded at infinity and free space does not need to be discretised. GFUN is available but has been superceded by the code TOSCA.

History: GFUN originated at the Rutherford Appleton Laboratory, England, and has been further developed and marketed by Vector Fields, a company that distributes the code and provides support, including training, from offices in England and the U.S.A.

Authors: C.W. Trowbridge, J. Simkin, N.J. Diserens, and L.R. Turner, Rutherford Appleton Laboratory, England, 1972 to present

References:

M.J. Newman, C.W. Trowbridge, and L.R. Turner, "GFUN: An Interactive Program as an Aid to Magnet Design," in *Proceedings the Fourth International Conference on Magnet Technology*, Y. Winterbottom, Ed. (National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia, 1972), pp. 617–626.

"GFUN, Three-Dimensional Magnetic-Field Computation System," Vector Fields data sheet (1987).

Status: GFUN was last modified in 1988, this code is maintained and distributed, for a fee, by Vector Fields. A nonproliferation agreement is required. It has approximately 173 000 lines of standard FORTRAN-77 source code. It is used at more than 20 sites. This program has been run on VAX/VMS, IBM/CMS, Sun and Apollo systems. There is a 250-page user's guide, a 200-page reference manual, examples, and an on-line help facility. This code is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: nonlinear/higher order, optimization, fringe field

Abstract: GIOS uses a third-order matrix method. It handles all the usual magnetic and electrostatic beamline elements, fringe-field approximations, and homogeneous space-charge approximations. The code has fitting capabilities (conjugate gradient and simplex method) and a general input language.

History: The first version of GIOS was written in 1958 by H. Wollnik at the Technical University in Münich, Federal Republic of Germany. Besides first-order calculations, this first version, written in Assembler, was able to determine second-order aberrations in the x-direction for angle and energy focusing mass spectrometers where the fringe field effects were only correct to the first-order. In 1962 and 1963, he rewrote the program. This newer version, written in FORTRAN IV, was accurate to second-order in the x- and y- directions, including all fringe-field effects. At the University of Gießen from 1964 to 1968, H. Wollnik, H. Lawin, G. Fiebig, and later G. Amadori and B. Heuser modified this program, introducing the method of transfer matrices and supplying better input and output formats. In 1972 through 1975, GIOS was again largely rewritten by H. Wollnik, T. Matsuo, and E. Kaseckert. All third-order effects in the x-direction, including fringe field effects, and good fitting-procedures were incorporated. T. Matsuo brought this program to Japan where it was modified somewhat and given the name TRIO. In the following years, many useful additions and improvements have been made to GIOS at the University of Gießen. J. Brezina is largely responsible for probably the biggest improvements: the inclusion of homogeneous space-charge effects and the use of algebraic variables.

Authors: H. Wollnik, University of Münich and the University of Gießen, Federal Republic of Germany; T. Matsuo, University of Osaka, Japan; J. Heuser, E. Kasseckert, J. Brezina, K. Becker, C. Geisse, K. Lindemann, S. Meuser, and J. Trötscher, University of Gießen, Federal Republic of Germany; J. Larson, private consultant, U.S.A., 1975 to present

References: H. Wollnik, J. Brezina, M. Berz, and W. Wendel, "GIOS-BEAMTRACE, a Program for the Design of High-Resolution Mass Spectrometers," in *Atomic Masses and Fundamental Constants: Proceedings of the 7th International Conference on Atomic Masses and Fundamental Constants, September 3-7, 1984, Darmstadt-Seeheim*, O. Klepper, Ed. (Technische Hochschule, Darmstadt, 1984) pp. 679–683, Gesellschaft für Schwerionenforschung (GSI), mbH, Darmstadt, report THD-26 (1984).

H. Wollnik, J. Brezina, and M. Berz, "GIOS-BEAMTRACE — A Program Package to Determine Optical Properties of Intense Ion Beams," *Nuclear Instruments and Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors, and Associated Equipment* **A258** (3), 408–411 (1987).

H. Wollnik, B. Hartmann, and M. Berz, "Principles of GIOS and COSY," in *AIP Conference Proceedings 177: Linear Accelerator and Beam Optics Codes, La Jolla Institute 1988*," Charles R. Eminhizer, Ed. (American Institute of Physics, New York, 1988), pp. 74–85.

Status: GIOS is being maintained by Stefan Meuser. The code is being distributed, without charge, by Hermann Wollnik. It has approximately 11 000 lines of FORTRAN-77 source code. There is only one distributed version of this program. It is for the VAX/VMS system. There are only two system calls in the code. One is for clock time and the other is for a random number generator. The FORTRAN source code is able to produce plots on a line printer. The code can produce a graphics metafile, but a metafile-interpreter is needed to make plots from this file. Two hardware-dependent metafile-interpreters are available with GIOS: one can be used with the UGS graphics library and the other with the GKS (Graphic Kernel System) library. The use of these interpreters will require some effort by a knowledgeable person at the site of installation. A 53-page user's guide and 10-pages of examples are available. This code is being distributed on magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks.

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Function: BEAM DYNAMICS: linacs

Key Terms: control, optimization, accelerator start-up/tune-up

Abstract: GROPE calculates an optimized set of operating conditions (energy and phase of the beam at each module entrance) for a stepped-beta linac, which may have errors in tank lengths or spacings. This program provides the parameters needed by the delta-t procedure for setting the rf phase and amplitude for the linac modules. It also provides the corresponding module-to-module phases needed when using the code SIMALAC. Output data from the code GROPE can be used as input data to LINDETS.

History: GROPE was written by Kenneth R. Crandall in the early 1970's when it was found that some of the tank lengths and spacings of the 805-MHz linac at the Los Alamos Meson Physics Facility, Los Alamos National Laboratory, U.S.A., differed significantly from their design values. Extensions and generalizations were added by George R. Swain.

Authors: Kenneth R. Crandall and George R. Swain, Los Alamos National Laboratory, U.S.A., 1975

References: K. Crandall, "805-MHz Linac Design Modifications Due to Length Errors," Los Alamos Scientific Laboratory memorandum, to R.A. Jameson, MP-9 (July 1, 1974), available from G.R. Swain.

Status: GROPE was last modified in November 1989. This code is maintained by George R. Swain but it is not available for regular distribution. GROPE has approximately 1250 lines of FORTRAN IV source code. There is only one version of this program. It is for the VAX/VMS system. There is no documentation.

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Function: COMPONENT DESIGN: RF cavities

Key Term: ferrite/dielectric, finite element

Abstract: H2DB calculates cut-off frequencies, electric lines of force, and magnetic lines of force for waveguides with arbitrary cross sections. A mesh generator and graphics code used to illustrate the code's calculations are included in the package. This code is based on the finite-element method.

History: H2DB was written in 1981 and modified in 1986.

Authors: M. Hara and T. Wada, The Institute of Physical and Chemical Research (RIKEN), Japan, 1981 to 1986

Reference: M. Hara, T. Wada, A. Toyama, and F. Kikuchi, "Calculation of Radio-Frequency Electromagnetic Field by Finite-Element Method," *Scientific Papers of the Institute of Physical and Chemical Research* **75**, pp. 143–175 (1981).

Status: Last modified in June 1987, this code is maintained and distributed, without charge, by M. Hara or T. Wada. However, a nonproliferation agreement is required. It has approximately 1000 lines of IBM-compatible standard FORTRAN-77 source code. It has 10 known users. At this time, it has only been run on a FACOM/OS-IV (F4/MSP) system. A Calcomp device driver is used. While there is no documentation available, there are some examples. This code is being distributed on magnetic tape reels and 5.25-inch diskettes for IBM-compatible personal computers. The source codes take up about 120 kilobytes.

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Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: tracking, particle transmutation

Abstract: HALO calculates muon and neutrino background in muon and hadron beams. Particle positions, angles, momenta, decay parameters, and other quantities may be displayed in one- or two-dimensional histograms. Selected ray histories may also be produced.

Authors: C. Iselin (primary author) CERN, Switzerland; D.C. Carey and J. Cieply, Fermi National Accelerator Laboratory, U.S.A., 1974 to present

Reference: Christoph Iselin, "HALO a Computer Program to Calculate Muon Halo," CERN report 74-17 (1974).

Status: Last modified in November 1988, this code is maintained and distributed, without charge, by David C. Carey. It has approximately 6000 lines of source code. The code was originally written in FORTRAN IV. With all the modifications that have been made, the code contains a fair amount of standard FORTRAN-77, but it still reflects its origins. The only system library call is to a random-number generator. No graphics packages are used, but histograms are generated with standard FORTRAN-77 output routines. More graphics are planned for the future. At this time, the code has been run on CYBER and IBM machines. A 35-page user's guide is available. This code is being distributed on magnetic tape reels and through the computer networks.

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HARMON

Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: nonlinear/higher order, optimization, dispersion

Abstract: HARMON optimizes the strength of sextupole correction magnets to improve beam dynamics. The least-squares method is used to minimize a set of nonlinear functions, including tune shift versus momentum, tune shift versus amplitude, and distortion of phase space. The code, as it stands, will only handle closed machines. The author hopes to extend the code to handle beamlines as well.

A new version of HARMON has been released with the data-based version of MAD (version 7). This new version of HARMON has an input format closely resembling the input format for MAD.

History: HARMON was written by Martin Donald. It was converted to FORTRAN-77 by D. Schofield. The HARMON interface for MAD was written by F. Christoph Iselin.

Author: Martin Donald, SLAC, U.S.A.

References:

M. Donald, "Chromaticity Correction in Particle Accelerators and Storage Rings — Part 1 — A User's Guide to the HARMON Programs," CERN internal report, PEP note 311 (July 1989).

F. Christoph Iselin and James Niederer, "The MAD Program (Methodical Accelerator Design) Version 7 User's Reference Manual," CERN report CERN/LEP-TH/87-33 (April 1987).

M. Donald and D. Schofield, "A User's Guide to the HARMON Program," CERN internal report, LEP note 420 (1982).

Status: HARMON was last modified in July 1988. The code is maintained by Martin Donald. It is being distributed, without charge to nonprofit organizations, by the CERN Program Library. Other organizations are expected to pay a small fee to cover the cost of supplying the program. It has approximately 5000 lines of FORTRAN-77 source code. The program has been run on VAX/VMS, VAX/UNIX, CRAY, and IBM machines. All three documents cited in the **References** section above are needed to use this code. The code is being distributed on magnetic tape reels.

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Function: COMPONENT DESIGN: magnets, RF cavities

Key Term: optimization, stress analysis

Abstract: HAST is a program used to calculate the deformation of magnets and accelerating-structures due to thermal and mechanical loads. It may be used independently but it is more useful when used in conjunction with the programs PRUD-W and TRESCA. HAST is being used to calculate mechanical processes (press loading, cooling, Lorenz-force loading) in the superconducting magnets for UNK, Institute for High-Energy Physics, U.S.S.R.

Authors: A.G. Abramov, A.D. Ryabov, and A.G. Daikovsky, Institute for High-Energy Physics, U.S.S.R.

References: V.K. Grishin, B.S. Ishkhanov, A.V. Tiunov, V.I. Shvedunov, A.G. Abramov, A.G. Daikovsky, A.D. Ryabov, T.D. Ryabova, "Computer Simulation of the RF Properties and Thermal Conditions of the Disk-and-Washer Accelerating Structure for the CW Racetrack Microtron," *Nuclear Instruments and Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors, and Associated Equipment* (Netherlands) **A255** (3), 431–436 (1987).

A.G. Abramov, A.G. Daikovsky, and A.D. Ryabov, "Mathematical Model and Program for SC Magnet Mechanics Studies," Institute for High-Energy Physics, Serpukhov, preprint IFVE 89-104 (1989).

Status: This code is maintained, but not distributed. The code is written in FORTRAN. At this time, only an ICL-1906A version exists. No documentation is available.

Maintained by: A.G. Daikovsky
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Function: COMPONENT DESIGN: RF cavities

Key Term: ferrite/dielectric, finite element

Abstract: The code HAX is used to calculate resonance frequencies and other RF properties for axisymmetric modes. This code is based on the finite-element method. A mesh generator and graphics code used to illustrate the code's calculations are included in the package.

History: HAX was written in 1981 and modified in 1986.

Authors: M. Hara and T. Wada, The Institute of Physical and Chemical Research (RIKEN), Japan, 1981 to 1986

Reference: M. Hara, T. Wada, A. Toyama, and F. Kikuchi, "Calculation of Radio-Frequency Electromagnetic Field by Finite-Element Method," *Scientific Papers of the Institute of Physical and Chemical Research* **75**, 143–175 (1981).

Status: HAX was last modified in June 1987. This code is maintained and distributed, free of charge, by M. Hara or T. Wada. However, a nonproliferation agreement is required. It has approximately 1000 lines of IBM-compatible standard FORTRAN-77 source code. It has 10 known users. At this time, it has only been run on a FACOM/OS-IV (F4/MSP) system. A Calcomp device driver is used. No formal documentation is available, although there are some examples. This code is being distributed on magnetic tape reels and 5.25-inch diskettes for IBM-compatible personal computers. The source codes take up about 120 kilobytes.

Maintained and Distributed by:

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IDA5

Function: BEAM DYNAMICS: synchrotrons/storage rings, spectrometers/transport lines

Key Term: lattice design, PC version

Abstract: IDA5 (Interactive Design of Accelerators) solves most standard accelerator design problems, including two-parameter fitting to adjust tunes, etc. A screen editor approach is used for all entries. Beta-function plots can be generated. Radiation integrals are computed for electron machines. This code is highly interactive. Input-data files for the programs SYNCH, MAD, or PATRICIA can be generated.

History: The origin of IDA5 was a BASIC transport code developed by M. Cornacchia (now at SLAC). The code was converted to the source language Pascal and extended to the present state by the author while employed at Brookhaven National Laboratory, U.S.A. The code was recently upgraded to compile with Borland's TURBO PASCAL-5.

Author: Mark Q. Barton, National Synchrotron Light Source (NSLS), Brookhaven National Laboratory, U.S.A.

Reference: Mark Q. Barton, "Interactive Design of Accelerators IDA," Brookhaven National Laboratory informal report BNL-40011 (June 30, 1987).

Status: IDA5 was last modified in March 1989. This code is no longer maintained, but it is being distributed, with no charge, by Fritz Dell. It has approximately 2500 lines of Pascal source code (compatible with versions four and five of Borland's TURBO Pascal). The code has 10 known users. This code will run on any IBM-compatible personal computer with at least 256 kilobytes of memory and a math coprocessor installed. There is no user's guide or reference manual available. However, an updated version of the Brookhaven report cited above and a complete tutorial is available on the distributed diskette.

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Function: COMPONENT DESIGN: ion and electron sources, magnets

Key Terms: space charge/high current, three dimensions, temperature calculations, PC version

Abstract: INP is a family of codes that interface with each other. The package contains an electrostatic Laplace, Poisson, and Vlasov solver. It performs magnetic field and temperature calculations. It is based on the finite-difference method, the finite-element method, and Biot Savart's Law.

History: INP is derived from the code AXCEL - GSI, also written by Peter Spädtke.

Author: Peter Spädtke, Gesellschaft für Schwerionenforschung (GSI), mbH, Federal Republic of Germany, 1980 to present

References:

P. Spädtke, "Computer Simulation Codes," *Vacuum* **36**, 11–14 (1986).

P. Spädtke, "Computer Modeling," in *The Physics and Technology of Ion Sources*, I.G. Brown, Ed. (John Wiley R. Sons, 1989).

Status: INP is maintained and distributed, for a fee, by Ingenieurbüro für Naturwissenschaft und Programmentwicklung (INP). The cost is $3 000 (U.S.) and up. There are three distributed versions of this program. They are for the IBM/MS-DOS, PS2, and ATARI-ST systems. The code consists of 6000 lines of standard FORTRAN-77 and Assembly language source code. A 20- to 40-page user's guide and examples are available for each code. This code is being distributed on 5.25- and 3.5-inch diskettes for IBM-compatible personal computers.

Maintained and Distributed by:

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62 Wiesbaden
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Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: tracking, optimization

Abstract: INTRAN (INteractive version of TRANSPORT) is a user interface for the code TRANSPORT. Running on a graphics terminal or VAX workstation (VWS or DECWINDOWS), INTRAN greatly improves TRANSPORT's user friendliness and saves a substantial amount of time for anyone designing beam-transport systems. The code includes an interface for the program TRANSPORT, four different versions of TRANSPORT, and a graphics package.

The interface allows the user to select one of the four versions of TRANSPORT: the original version of TRANSPORT by Karl Brown at SLAC, a more modern version from Fermi National Accelerator Laboratory that has the ability to constrain algebraic combinations of matrix elements, a first-order space-charge version from the Swiss Institute for Nuclear Physics (SIN), and finally a third-order version of TRANSPORT.

The graphics package includes an editor that allows the user to produce hard copies on virtually any printer. Publication-quality graphics can be produced by the built-in graphical editor EDGR.

History: INTRAN was originally written for an IBM system in 1975. It was modified to run on a VAX system in the early 1980's.

Authors: A. Haynes and C. Kost, TRIUMF, Canada, 1975 to present

References: none

Status: INTRAN is maintained and distributed, without charge, by Corrie Kost. The interface has approximately 20 000 lines of VAX FORTRAN-77 source code (not including the graphics interface, which is estimated to be at least this size). The four versions of TRANSPORT account for another 25 000 lines of code. Currently, only a VAX/VMS version exists. An 80-page user's guide and an on-line help facility are available. This code is being distributed on magnetic tape reels.

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Function: COMPONENT DESIGN: ion and electron sources

BEAM DYNAMICS: general

Key Terms: space charge/high current, particle-in-cell, special boundary condition

Abstract: ISIS is a multidimensional, fully relativistic, electromagnetic, particle-in-cell code. It uses a charge-conserving algorithm to accumulate currents, eliminating the need for Poisson correction. Other features include body-fitted coordinates and some three-dimensional capability.

History: Originally derived from the code CCUBE by B. Godfrey, Los Alamos National Laboratory (LANL). Extensive modification has been done by LANL personnel, principally, Galen Gisler, Charles Snell, and Michael Jones. Michael Jones is the principal author of the latest version. The system and user interface was written by John Lundsford, also from LANL.

Author: Michael E. Jones, Los Alamos National Laboratory, U.S.A.

References:

R.K. Cooper and M.E. Jones, "The Physics of Codes," in *AIP Conference Proceedings 184: Physics of Particle Accelerators, Fermilab Summer School, 1987, Cornell Summer School, 1988*, Melvin Month and Margaret Dienes, Eds. (American Institute of Physics, New York, 1989), Vol. 1, pp. 1084–1105.

M.E. Jones, R.K. Keinigs, W. Peter, and S.E. Wilks, "Cerenkov Wakefield Accelerators: Rippled Wave Guides," Advanced Accelerator Concepts Workshop, Lake Arrowhead, California, January 9–13, 1989, Los Alamos National Laboratory document LA-UR-89-1230 (1989).

Status: ISIS was last modified in July 1989. This code is maintained and distributed, without charge, by Michael Jones. It has approximately 35 000 lines of FORTRAN source code and some CRAY assembly language. The code has about 20 known users. There is only one version of this program. It is not easily transportable because it has been optimized for LANL's CRAY/CTSS (CFTLIB) system. There is a rough draft of a user's guide and an on-line help facility. Although the code is used extensively, both the user's guide and the help facility have become obsolete as there has not been enough time or funding for their upkeep.

Maintained and Distributed by:

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Function: BEAM DYNAMICS: general

Key Terms: wakefield, space charge/high current, particle-in-cell

Abstract: ITACA stands for Integration of Transients in Axisymmetric Cavities for Accelerators. The code is a self-consistent two-dimensional particle-in-cell code that integrates the wave equation for the H-field in time-domain (with a second-order approximation in space and time) and the generalized Ampere law for the E-field plus the relativistic equation of the motion for the particles (with a fourth-order approximation in time). Using the Rician assignment algorithm with two-dimensional particles for the driving current and an accurate treatment of the boundary conditions on the cavity surface, ITACA can describe the interactions between the particles and the self fields (space charge and wakefields). These interactions are of relevance for the beam-dynamics (space charge induced emittance growth, beam break-up, beam plasma interaction, etc.).

ITACA can handle up to 200 000 mesh points, allowing a quite good discretization for a large number of problems. The package includes an eigenvector-finder able to compute the field distribution of a resonating mode in an axisymmetric cavity. The code simulates the laser-driven emission of electrons by a photocathode for the study of RF guns. A number of beam distributions with their self-fields are generated. The package contains a postprocessor for the electromagnetic field propagation plots, the phase spaces and all the other related beam dynamics quantities.

Work is in progress to extend the code to a two-and-one-half-dimensional simulation.

Authors: Luca Serafini, Istituto Nazionale di Fisica Nucleare, University of Milan, Italy; et al.

References: L. Serafini and C. Pagani, "ITACA: A New Computer Code for the Integration of Transient Particle and Field Equations in Axi-Symmetrical Cavities," in *EPAC European Particle Accelerator Conference Rome, June 7–11, 1988*, S. Tazzari, Ed. (World Scientific, Singapore, 1989) Vol. 2, pp. 866–868.

L. Serafini, C. Pagani, L. Ferrucci, L. Muda, and A. Peretti, "Numerical Integration of Transient Particle and Field Equations in Axi-Symmetrical Cavities," in *High Gain, High Power Free Electron Laser; Physics and Application to TeV Particle Acceleration: Proceedings of the Istituto Nazionale di Fisica Nucleare (INFN) International School on Electromagnetic Radiation and Particle Beams Acceleration, Varenna, Italy, June 20–25, 1988*, R. Bonifacio, L. De Salvo Souza, and C. Pellegrini, Eds. (North-Holland, New York, 1989), pp. 293–305.

Status: ITACA is maintained and distributed, without charge, by Luca Serafini. The code is written in FORTRAN. The program has been run on a VAX machine. Documentation is being written and is not available at this time. The code is being distributed on magnetic tape reels and through the computer networks.

Maintained and Distributed by: Luca Serafini
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IVORY

Function: BEAM DYNAMICS: general

Key Terms: space charge/high current, particle-in-cell, three dimensions

Abstract: IVORY is a general purpose, relativistic, electromagnetic plasma simulation code. Electrostatic and two-dimensional versions also exist. Extensive diagnostics are provided. IVORY has been used to study beam-plasma interactions, beam acceleration, and microwave generation.

Authors: Brendan B. Godfrey and Mark M. Campbell, Mission Research Corporation, U.S.A.

Reference: Mark M. Campbell and Brendan B. Godfrey, "A Three-Dimensional PIC Code for Study of Relativistic Beam Propagation," in "Proceedings of the Tenth Conference on Numerical Simulation of Plasmas," available from Joanne Helton, General Atomics Technologies, Inc., 10955 John Jay Hopkins Drive, San Diego, California 92121, (1983), paper 2B9.

Status: IVORY was last modified in November 1989. This code is maintained by Mark Campbell. It has approximately 20 000 lines of FORTRAN source code. There are about 10 known users. There is only one distributed version of this program. It is for the CRAY/CTSS (CFTLIB) system. This code is being distributed on high-density 5.25-inch diskettes for IBM-compatible personal computers.

Maintained by: Mark M. Campbell
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1720 Randolph Road, Southeast
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U.S.A.

PHONE: 1 (505) 768-7600

Distributed by: Thomas P. Hughes
same address and phone number as above

Function: BEAM DYNAMICS: general

Key Terms: stability, particle-in-cell, three dimensions

Abstract: KMRAD was written to analyze the linear stability of beams and plasmas whose equilibria have azimuthal symmetry. The radial direction is represented by a spatial grid, while axial and azimuthal perturbations are Fourier transformed. The code has been used to study electron-beam stability in a resistive background, as well as electron-electron and electron-ion instabilities.

Authors: Thomas P. Hughes and Brendan B. Godfrey, Mission Research Corporation, U.S.A.

Reference: Thomas P. Hughes, "KMRAD: A Linearized Particle Code for the Study of Resistive Instabilities," Mission Research Corporation, Albuquerque, report AMRC-R-364 (1982).

Status: KMRAD was last modified in 1987. This code is maintained and distributed, for a negotiable fee, by Thomas Hughes. It has approximately 3500 lines of FORTRAN source code. There are three known users. There is only one distributed version of this code. It is for the CRAY/CTSS (CFTLIB) system. No documentation is available. This code is being distributed on high-density 5.25-inch diskettes for IBM-compatible personal computers.

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Function: COMPONENT DESIGN: disk-loaded waveguide

Key Terms: impedance, wakefield

Abstract: KN7C finds the resonant frequencies, the field pattern, and the longitudinal loss factors for axisymmetric waveguide modes propagated at $v = \beta c$ in disk-loaded waveguide by field matching using matrix techniques.

History: Work began on KN7C in 1972 and has continued to the present. There were spells of activity: the CDC version in 1972, the IBM version in the early 1980's, and the CRAY version in 1989. In all cases, these new versions contained modifications to improve the code, in addition to modifications necessary to accommodate the new system.

Author: Eberhard Keil, CERN, Switzerland, 1972 to present

References:

E. Keil, "Diffraction Radiation of Charged Rings Moving in a Corrugated Cylindrical Pipe," *Nuclear Instruments and Methods* 100 419–427 (1972).

E. Keil, "Computer Programs in Accelerator Physics," in *AIP Conference Proceedings Number 105: Physics of High Energy Particle Accelerators*, Melvin Month, Ed. (American Institute of Physics, New York, 1983), pp. 651–690, CERN internal report, LEP Theory note 84-01 (1984).

Status: KN7C was last modified in January 1989. This code is distributed and maintained, without charge to nonprofit organizations, by Eberhard Keil. Other organizations are expected to pay a small fee to cover the cost of supplying the program. It has approximately 1500 lines of FORTRAN-77 source code. KN7C conforms to the full set of ANSI standard FORTRAN-77, apart from three statements related to NAMELIST input and output. It has ten known users. This code has been run on VAX/VMS, CRAY/UNICOS, and IBM/VM/XA systems. No graphics packages are required. While there is no formal documentation, there are examples available. This code is being distributed on magnetic tape reels and through the computer networks.

Maintained and Distributed by:

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Function: COMPONENT DESIGN: ion and electron sources

Key Terms: misalignment, tracking, plasmas, three dimensions

Abstract: KOBRA is a three-dimensional code that has a Laplace solver, a Poisson solver, and a Vlasov solver.

Author: Peter Spädtke, Gesellschaft für Schwerionenforschung (GSI), mbH, Federal Republic of Germany, 1983 to present

References:

P. Spädtke, "KOBRA3 – Three-Dimensional Ray Tracing Including Space Charge Effects," *IEEE Transactions on Nuclear Science* **NS-32**, 2465–2467 (1982).

Peter Spädtke and Susan Wipf, "KOBRA3, A Code for the Calculation of Space Charge Influenced Trajectories in 3 Dimensions," Gesellschaft für Schwerionenforschung (GSI), mbH, Darmstadt, report GSI-89-9 (1989).

Status: KOBRA is maintained and distributed, without charge, by Peter Spädtke. It has approximately 20 000 lines of standard FORTRAN-77 source code. There are three distributed versions of this program. They are for the VAX/VMS, CRAY/CTSS (CFTLIB), and IBM/MVS systems. An 80-page user's guide and examples are available. The author will attempt to provide the code on whatever media the requester requires.

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Function: COMPONENT DESIGN: RF cavities

Key Terms: finite element, nonlinear/higher order

Abstract: LACC (Linear Accelerator Cavity Code) solves the classical electromagnetic-field problem of the empty, axially symmetric resonator with conducting walls. The program algorithm is based on a variational formulation coupled with the high-order polynomial, triangular finite-element method for the magnetic-field calculation. Various other numerical methods such as one- and two-dimensional Newton-Cotes integration are used to obtain the performance measuring quantities (e.g., transit-time factor, stored energy, power loss, shunt impedance, Q-factor).

History: LACC is a modification of a program, written in 1973, called AXISYMM - VECTOR - HELMHOLTZ - FINTEL6.

Author: Adalbert Konrad, McGill University, Canada, 1973 to 1978

References:

A. Konrad, "Linear Accelerator Cavity Field Calculation by the Finite Element Method," *IEEE Transactions on Nuclear Physics* **20** (1), 802–808 (1973).

A. Konrad, "A Linear Accelerator Cavity Code Based on the Finite Element Method," *Computer Physics Communications* (Netherlands) **13** (5-6) 349-362 (1978).

A. Konrad, "Evaluation of the LACC Program," *Computer Physics Communications* (Netherlands) **14** (3-4) 177-184 (1978).

Status: LACC was last modified in 1977 or 1978. This code is not maintained, but it is being distributed, for a nominal fee, by the Computer Physics Communications (CPC) Program Library. The distribution services of the Program Library are described in detail in the back of any Computer Physics Communications journal. LACC has approximately 4000 lines of IBM FORTRAN IV source code. There is only one distributed version of this program. It is for the IBM 360/75/MVT system. A VAX/VMS conversion is possible. Although no formal documentation exists, the code is well commented and has a CPC program description. This code is being distributed on magnetic tape reels, floppy disks for IBM-compatible personal computers, and through the computer networks.

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Function: COMPONENT DESIGN: target and radiation shielding design

Key Terms: Monte Carlo, particle transmutation

Abstract: LAHET is a part of LAHET Code Systems (LCS). LAHET is a Monte Carlo code for the transport and interaction of nucleons, pions, muons, light ions, and antinucleons in complex geometry. New features include the option of using either the Bertini intranuclear cascade model or the VEGAS/ISABEL intranuclear cascade model. Other new features are the Fermi breakup model for excited light nuclei (instead of the evaporation model) and a multistage pre-equilibrium exciton model functioning between the intranuclear cascade model and the evaporation (or Fermi breakup) model. LAHET may also be used without particle transport to generate particle production cross sections.

For low-energy neutron and gamma transport, LAHET couples to MCNP (version 3B), a Monte Carlo code developed and maintained at Los Alamos National Laboratory.

History: LAHET is the new release of the Los Alamos National Laboratory's adaption of the Oak Ridge National Laboratory's code HETC.

Author: R.E. Prael, Los Alamos National Laboratory, U.S.A.

References: Richard E. Prael and Henry Lichtenstein, "User Guide to LCS: The LAHET Code System," Los Alamos National Laboratory report LA-UR-89-3014 (September 1989).

Status: A new version of LAHET was released in the early part of 1990. The code is maintained and distributed, without charge, by Richard Prael. LCS has a total of 75 000 lines of FORTRAN source code: LAHET has approximately 36 000 lines, HMCNP has approximately 29 000 lines, and auxiliary codes have 10 000 lines. LCS has been run on CRAY/CTSS (CFTLIB and FORTLIB) and CRAY/UNICOS systems. The family of codes has been installed and is being maintained at the National Energy Research Supercomputer Center (NERSC), formerly NMFECC, at Lawrence Livermore National Laboratory, U.S.A. A 76-page user's guide is available. The system is being distributed on magnetic tape reels that the requester is expected to supply.

Maintained and Distributed by:

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LANS

Function: COMPONENT DESIGN: RF cavities

Key Terms: impedance, dispersion, finite element

Abstract: LANS evaluates the electromagnetic fields and resonance frequencies of axisymmetric modes of axisymmetric RF cavities. The mathematical basis of this code is the finite-element method and the method of inverse iterations with a shift. The method of inverse iterations with a shift is a good method to find the eigenfrequencies and fields of the cavities. This code has some advantages when compared to the code SUPERFISH. For example, it requires a smaller number of operations necessary for calculations and it gives better resolution of resonance modes with close frequencies.

Author: V.P. Yakovlev, Institute for Nuclear Physics (INP), Novosibirsk, U.S.S.R.

Reference: B.M. Fomel, V.P. Yakovlev, M.M. Karliner, and P.B. Lysyansky, "LANS — A New Code for Evaluation of the Electromagnetic Fields and Resonance Frequencies of Axisymmetrical RF Cavities," *Particle Accelerators* 11 (3), 173–179 (1981).

Status: LANS was last modified in 1987. This code is maintained and distributed, without charge, by B.M. Fomel and V.P. Yakovlev. A nonproliferation agreement is required. It has approximately 2500 lines of FORTRAN source code. It has about 10 known users. There is only one distributed version of this program. It is for the ICL-1900 system. An on-line help facility and examples are available. This code is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: synchrotrons/storage rings, beam transport

Key Terms: interactive, first-order, tracking

Abstract: LATTICE is a simple interactive program used in the lattice design of synchrotrons. It provides correct chromaticity, geometry, small-amplitude tune shift, acceptance, and the optimization of many parameters. A new version was released in the latter part of 1989. It now includes a tracking module, can handle high-order elements with errors, and calculates dynamic aperture. The program QUICKTRAN has the same capabilities as LATTICE, but QUICKTRAN has been optimized for beam transport studies. LATTICE is a user-friendly code and provides very good graphics, including Tektronix and PostScript graphics drivers. All updates are backwards compatible. Users are informed about new versions and receive new source code.

History: LATTICE was first written in 1976, borrowing ideas from both TRANSPORT and SYNCH. These codes have been developed through several versions and new features continue to be added.

Author: John Staples, Lawrence Berkeley Laboratory, U.S.A., 1976 to present

References:

John Staples, "LATTICE...A Beam Transport Program," Lawrence Berkeley Laboratory internal document, available from John Staples or Ed Sheena (September 1988).

John Staples, "QUICKTRAN...A Beam Transport Program," Lawrence Berkeley Laboratory internal document, available from John Staples or Ed Sheena (April 1988).

Status: LATTICE and QUICKTRAN were last modified in August 1989. These codes are maintained and distributed, without charge, by John Staples. LATTICE has approximately 4000 lines of Pascal source language in addition to the drivers. The current version of the code has been designed to run on the VAX/VMS system. A 55-page user's guide/reference manual, an on-line help facility, and many sample files are available for LATTICE. These codes are only being distributed through the computer networks.

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Function: BEAM DYNAMICS: linacs

Key Terms: beam-beam interaction, particle-in-cell, three dimensions

Abstract: LINBBEAM was written to study the interaction of electron and positron beams in high-energy linear colliders. A particle-in-cell (PIC) method is used to describe the interaction. The program has been developed for the CERN Compact Linear Collider (CLIC) design study. It includes the important physics of the beam-beam interaction, i.e., beam disruption due to pinching of the bunches and the energy loss this pinching induces. The interaction of multi-bunch systems are handled.

Initial particle distributions are defined from function generators or from user-specified input data. This user-defined data can be from a previous interaction study. These particle distributions are mapped onto a three-dimensional Cartesian grid. At each time step, the electric fields at each grid point are calculated by solving Poisson's equation for the charge distribution of each species. The Poisson solver was chosen such that nonuniformly spaced grids could be used. It is possible to redefine the grid during execution, thus ensuring that the particle distributions are described to the highest precision with the available number of mesh points.

The output includes luminosity (the contribution per time step and the integrated value), particle densities in (x, y, z) versus time, and trace-particle trajectories. A comprehensive package to display these results visually has been written.

Author: Lindsay Wood, CERN, Switzerland, 1989

References: none

Status: LINBBEAM was last modified in June 1989. This code is maintained by Lindsay Wood, but it is not being distributed because it is still under development. It has approximately 15 000 lines of strictly standard FORTRAN-77 source code. The program has been run on CERN's IBM/VM/CMS system as well as on an Apollo workstation. The part of the code that performs the graphics analysis uses NAG routines which interface onto the Graphics Kernel System (GKS). At this point, no documentation has been written.

Maintained by: Lindsay Wood
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Function: COMPONENT DESIGN: magnets

Key Terms: nonlinear/higher order, iron saturation

Abstract: LINDA uses a combination of scalar potential (in air and copper) and vector potential (in iron) to model two-dimensional magnetostatic problems. Iteration uses over-relaxation in a uniform rectangular mesh. The program's input format is much simpler than the input format for the code POISSON. LINDA will handle iron with nonuniform permeability. The code produces accurate results and can handle up to 30 000 mesh points. The code's main limitation is that the problem can only have one region of iron.

Author: Richard S. Christian, Purdue University, U.S.A., 1969

Reference: John S. Colonias, *Particle Accelerator Design: Computer Programs* (Academic Press, New York, London, 1974), pp. 6, 39–63, 84, 86–91, 288.

Status: LINDA is not maintained and could be considered to be obsolete. However, it is useful in obtaining preliminary results. The code is being distributed, without charge, by Stanley Snowdon. It has approximately 3000 lines of FORTRAN source code. The program has been run on CYBER/NOS (limited utility) and IBM/OS systems. Although no formal documentation has been written, the code contains many useful comments. It is being distributed on magnetic tape reels.

Distributed by: Stanley C. Snowdon
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Function: BEAM DYNAMICS: linacs

Key Terms: control

Abstract: LINDETS calculates estimates of beam energy and phase errors due to a specified measurement uncertainty of time-of-flight when using the delta-t procedure to set the RF phase and amplitude for linac modules. Output data from the code GROPE can be used as input data to LINDETS.

Author: George R. Swain, Los Alamos National Laboratory, U.S.A., 1989

References: none

Status: LINDETS was last modified in March 1989. This code is maintained by George R. Swain, but it is not available for regular distribution. It has 410 lines of FORTRAN-77 source code. This code has been running on a VAX/VMS system.

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LONG1D

Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: space charge/high current, tracking, impedance

Abstract: The LONG1D family of codes is capable of tracking many thousands of particles in synchrotrons and storage rings. The main code (LONG1D) simulates synchrotron longitudinal dynamics, including acceleration. The package includes an interactive ensemble generator (DISTRIB) and graphics display. The ensemble generator is a piece of code that sets up the phase-space initial coordinates for the many thousands of particles in the initial configuration. The on- and off-line graphic display (GRAFIX, MTNRANGE) programs give phase-space plots and demonstrate bunch-shape versus time. Arbitrary voltage and magnetic field laws, etc., are allowed. The model includes space charge with a second-order symplectic integration. There are options for injection and painting studies, for phase- and radial-control loops, and for exact modeling of beam-loading, assuming an LCR representation for the RF cavity.

History: Much of LONG1D was written at Rutherford Laboratory, Oxford, U.K., in 1985. The code has been validated through comparison with experimental measurement of the time evolution of bunches in the ISIS fast-cycling high-current synchrotron. The code was transported to TRIUMF, Canada, in 1987 where it has been significantly modified to allow the simulation of various processes in the proposed KAON Factory. The code is being actively worked on to allow the study of coupled-bunch oscillations.

Author: Shane R. Koscielniak, Rutherford Appleton Laboratory, England, 1985 to present

References:

Shane Koscielniak, "Longitudinal Beam Dynamics Studies on the ISIS Synchrotron," Ph.D. thesis, University of Oxford, unpublished (1987).

Shane Koscielniak, "LONG1D User Guide," TRIUMF report TRI-DN-88-20 (1988).

Jon. Spencer, "BEAM-LOAD," TRIUMF report TRI-DN-88-30 (1988).

Shane Koscielniak, "GRAFIX User Guide," TRIUMF report TRI-DN-89-13 (1989).

Status: LONG1D was last modified in February 1989. This code is maintained and distributed, without charge, by Shane Koscielniak. A nonproliferation agreement is required. The source code is written in VAX FORTRAN-77. There are four known users. The code has been run on VAX/VMS and IBM/CMS systems. The graphics plots can either be sent to a line printer or displayed on a terminal using the graphics library GPLOT. GPLOT was written at TRIUMF and is available, without charge, from Corrie Kost (please refer to the entry for the code INTRAN or the code OPDATA-PLOTDATA-EDGR). A few very common system calls are used in LONG1D: a call for the current date, the current time (clock), and a random-number generator. A 54-page user's guide is available. The code is being distributed on magnetic tape reels.

Maintained and Distributed by: Shane R. Koscielniak

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LOOPER

Function: COMPONENT DESIGN: RF cavities

Key Terms: stability, impedance, periodic structure

Abstract: LOOPER calculates the RF characteristics of coupled RF resonators using coupled RLC-circuit theory. Input data, consisting of cavity Q values and impedance, permits calculation of power losses and average on-axis fields that agree very well with multicell SUPERFISH calculations. This program handles off-resonance characteristics and all passband modes.

Author: S.O. Schriber, Chalk River Nuclear Laboratory, Canada

References: none

Status: LOOPER was last modified in 1981. This code is maintained and distributed, without charge, by S.O. Schriber. It has 1523 lines of FORTRAN source code. There are about 25 known users. This program has been run on CRAY/CTSS (CFTLIB), CYBER, and IBM systems. An eight-page user's guide is available. This code is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: linacs

Key Terms: misalignment, tracking, wakefield

Abstract: LTRACK is a first-order-matrix beam-transport code that takes into account the wake forces of the monopole, dipole, and quadrupole modes. Provision is made for error analysis, including orbit correction. This program has been used in the study of wake effects in the Stanford Linear Collider at SLAC and in the Free-Electron Laser Projects, Los Alamos National Laboratory, U.S.A.

Author: Karl Bane, Stanford Linear Accelerator Center, U.S.A., 1984

Reference: K.C.D. Chan and R. K. Cooper, "LTRACK — Beam Transport Calculation Including Wakefield Effects," in *AIP Conference Proceedings 177: Linear Accelerator and Beam Optics Codes, La Jolla Institute 1988*, Charles R. Eminhizer, Ed. (American Institute of Physics, New York, 1988), pp. 37–44.

Status: LTRACK was last modified in 1987. This code is maintained and distributed, without charge, by Kwok-Chi Dominic Chan. It has approximately 7000 lines of FORTRAN-77 source code. The program has been run on CRAY/CTSS (CFTLIB) and IBM/VM systems. It uses the graphics package, PLOT10, written and owned by Tektronix. A user's guide and examples are available for LTRACK as well as instructions describing the code installation. This code is being distributed on small seven-inch magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

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Function: BEAM DYNAMICS: linacs

Key Terms: nonlinear/higher order, tracking, optimization

Abstract: LYRAN was written to analyze the beam dynamics in superconducting heavy-ion linacs, as in QWR and/or SLR. The program transports a group of particles, given as input and randomly distributed on a selected distribution function, through linac elements. These elements include RF accelerating and bunching elements, dipoles, quadrupoles, electrostatic lenses, drift spaces, and foil charge strippers. Second-order corrections to dipole and quadrupole fields are included. A nonlinear optimization routine has been incorporated. Beam characteristics are displayed through the generation of beam envelope plots.

Authors: Jian-Qin Lu, Ilan Ben-Zvi, and John G. Cramer, Nuclear Physics Laboratory, University of Washington, U.S.A.

Reference: J.-Q. Lu, I. Ben-Zvi, J.G. Kramer, "LYRAN: A Program for the Analysis of Linac Beam Dynamics," *Nuclear Instruments and Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors, and Associated Equipment* **A262**, 200–206 (1987).

Status: LYRAN was last modified in April 1988. This code is maintained and distributed, without charge, by Jian-Qin Lu. It has approximately 8000 lines of FORTRAN source code. There are five known users. There is only one distributed version of this program. It is for the VAX/VMS system. A user's guide is available. This code is being distributed on magnetic tape reels that the requester is expected to supply.

Maintained and Distributed by: Jian-Qin Lu
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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: misalignment, tracking, beam-beam interaction

Abstract: MAD stands for Methodical Accelerator Design. The program is a general-purpose tool for the design of synchrotrons and the study of charged-particle optics in alternating-gradient accelerators and beamlines. The code handles very large and very small accelerators. Features of the code include linear lattice parameter calculation, linear lattice matching, survey calculations, particle tracking, chromatic effects, and resonances.

Authors: Ch. Iselin and H. Grote, CERN, Switzerland; J. Niederer, Brookhaven National Laboratory, U.S.A.

References: Christoph Iselin, "The MAD Program Methodical Accelerator Design Reference Manual," CERN report CERN/LEP-TH/85-15 (May 1985).

Christoph Iselin and James Niederer, "The MAD Program Methodical Accelerator Design Version 7.2 User's Reference Manual," CERN report CERN/LEP-TH/88-28 (July 1988).

Ch. Iselin, E. Keil, J. Niederer, and J.M. Veuillen, "The MAD Program Methodical Accelerator Design Version 6 Programmer's Reference Manual," CERN report CERN/LEP-TH/87-60 (December 1987).

Status: MAD 8.0 was last modified in 1989. This code is maintained by Christoph Iselin and distributed, without charge to nonprofit organizations, by the CERN Program Library. Other organizations are expected to pay a small fee to cover the cost of supplying the program. It has approximately 50 000 lines of FORTRAN source code. The program has been run on VAX/VMS, VAX/UNIX, CRAY, and IBM systems. A 120-page user's guide is available. This code is being distributed on magnetic tape reels.

Maintained by: Christoph Iselin
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MADEST

Function: COMPONENT DESIGN: magnets

Key Terms: coil, cost estimates, PC version

Abstract: MADEST is an interactive program used to develop geometric designs for the cores and conventional coils of various types of magnets. It does *not* involve magnetic field calculations. In addition to developing magnet designs, this program can be used to develop cost estimates for fabricating and installing systems of magnets. The code is still under development.

History: In 1970, MADEST was written in a machine language. It was converted to BASIC in 1980 and largely converted to FORTRAN-77 in 1984.

Author: Kenneth M. Thompson, Argonne National Laboratory, U.S.A., 1970 to present

Reference: K.M. Thompson, "An Interactive Computer Program for the Design and Costing of Magnets," *Journal de Physique Colloque* C1, 871–874 (January 1984).

Status: MADEST was last modified in January 1989. This code is operational and is being distributed, without charge, by K.M. Thompson. It has approximately 13 000 lines of nearly standard FORTRAN-77 or Hewlett-Packard BASIC source code. There are six known users. This program has been run on the VAX/VMS system as well as Hewlett-Packard personal computers running UNIX: HP 9845, HP 200, and HP 300. However, only the executable form of the VAX/VMS version is available. The code is being distributed on magnetic tape reels and through the computer networks. The requester is expected to supply the tape reel if a non-network transfer is required.

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Function: COMPONENT DESIGN: magnets

Key Terms: plasmas, three dimensions, special boundary condition

Abstract: MAFCO-W has been written for calculating magnetic fields of finite-size conductors of general configuration that can be approximated by arc segments or straight segments of rectangular cross section. The magnetic field components were obtained by integrating the Biot-Savart law over the volume of the conductor. Their mathematical expressions were first reduced to single integration analytically and then integrated numerically. The magnetic fields for the conceptual Tokamak fusion reactors, UWMAK-I and II, were calculated and analyzed. The Lorentz force is computed as well. A three-dimensional spline interpolation was used to save calculations and therefore increase speed. This code was used in the magnetic fusion design at the Plasma Fusion Center, MIT, for 1988 and 1989. This code has been well tested.

Author: Ted F. Yang, Plasma Fusion Center, Massachusetts Institute of Technology (MIT), U.S.A.

Reference: T.F. Yang, "Magnetic-Field Code for Handling General Current-Carrying Conductors in 3-D," in *Fifth International Conference on Magnet Technology (MT-5), Roma (EUR) - Italy, April 21-25, 1975*, N. Sacchetti, M. Spadoni, and S. Stipcich, Eds. (Comitato Nazionale per l'Energia Nucleare, Frascati, 1975), pp. 203-209.

Status: MAFCO-W was last modified in 1987. This code is maintained and distributed, without charge, by Ted Yang. It has approximately 2000 lines of FORTRAN source code. It has 12 known users. There are two distributed versions of this program. They are for the CRAY/CTSS (FORTLIB) and CDC/UNIVAX systems. A 50-page user's guide is available. This code is being distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: ion and electron sources, magnets, RF cavities, power sources

Key Terms: impedance, particle-in-cell, three dimensions

Abstract: MAFIA Release 2.03 (MAxwell's equations solved by the Finite Integration Algorithm) is a family of codes that solves Maxwell's equations for static, resonant, and transient fields. The mesh generator, postprocessor, and the units that handle the physics are separate modules within the family of codes.

Authors: A collaboration among Technische Hochschule, Darmstadt, Federal Republic of Germany; Deutsches Elecktronen-Synchrotron (DESY), Federal Republic of Germany; Kernforschungs Anlage-Jülich (KFA), Federal Republic of Germany; and Los Alamos National Laboratory, U.S.A. Thomas Weiland, Technische Hochschule (principal author).

References: R. Klatt, F. Krawczyk, W.-R. Novender, C. Palm, T. Weiland, B. Steffen, T. Barts, M.J. Browman, R. Cooper, C.T. Mottershead, G. Rodenz, and S.G. Wipf, "MAFIA – A Three-Dimensional Electromagnetic CAD System for Magnets, RF Structures, and Transient Wake-Field Calculations," in "1986 Linear Accelerator Conference Proceedings," Stanford Linear Accelerator Center report 303 (September 1986) pp. 276–278.

F. Ebeling, R. Klatt, F. Krawzcyk, E. Lawinsky, T. Weiland, S.G. Wipf, B. Steffen, T. Barts, J. Browman, R.K. Cooper, and G. Rodenz, "Status and Future of the 3D MAFIA Group of Codes," in *AIP Conference Proceedings 177: Linear Accelerator and Beam Optics Codes, La Jolla Institute 1988*, Charles R. Eminhizer, Ed. (American Institute of Physics, New York, 1988), pp. 117–130.

Status: MAFIA was last modified in January 1989. This code is maintained and distributed, generally for a nominal charge, by Thomas Weiland. It has approximately 83 500 lines of FORTRAN source code. Sample interfaces are available for the VAX/VMS, CRAY/CTSS (CFTLIB), CRAY/CTSS (FORTLIB), and IBM/MVS systems. Examples are sent as part of the package. This code is being distributed on magnetic tape reels.

Although one must get the source code directly from Thomas Weiland, the executable form of the code is installed at Los Alamos National Laboratory and at the National Energy Research Supercomputer Center (NERSC), formerly NMFECC, at Lawrence Livermore National Laboratory, U.S.A. For more information about these executable files, contact Therese Barts, Los Alamos Accelerator Code Group (LAACG). Her BITNET address is AT6TCB@LAMPF.

A 190-page user's guide may be obtained from the Los Alamos Accelerator Code Group, Mail Stop H829, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, U.S.A.

Maintained and Distributed by: Thomas Weiland
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MAG-PC

Function: COMPONENT DESIGN: air-core coil

Key Terms: magnetic field, three dimensions, PC version

Abstract: MAG-PC computes the three-dimensional fields of an air-core coil, using the Biot-Savart law. Coils are specified as a series of arcs, lines, and general coil elements. The basic version allows up to 1011 segments. The advanced version allows up to 5477 elements, provides a preview of the three-dimensional coil geometry, and permits the specification of significant digits of accuracy.

Author: SRI International, U.S.A.

References: "MAG-PC Product Guide," Infolytica Corporation data reference sheet (1988).

Status: MAG-PC was last modified in 1989. The code is maintained by SRI International and distributed, for a fee, by Infolytica Corporation. The basic version of the program is $489 (U.S.) and the advanced version is $899 (U.S.). The code is written in C. Its size is unavailable. The program has about 60 known users. A 45-page user's guide and examples are available. The code has been run with IBM 8088, 8086, 80286, and 80386 chips. This statement means that this program should run on IBM XT, AT, and PS/2 machines as well as most IBM-compatible machines. The code is being distributed on one 360-kilobyte diskette.

Maintained by: SRI International

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Function: COMPONENT DESIGN: magnets

Key Terms: coil, magnetic field

Abstract: MAGFOR calculates electromagnetic fields and forces in coil systems with arbitrary geometry. The coils may be modeled by using 20-node isoparametric hexahedrons; eight-node rectangular cross-sectional straight segments; rectangular cross-sectional circular arcs; and/or filamenting circular loops. A combination of analytical and numerical integration of the Biot-Savart law for a volume distribution of current is used for calculating magnetic fields. Volumetric body forces are calculated for the 20-node isoparametric brick by numerically integrating the vector product $J \times B$ over its volume, where the magnetic field at each Gauss point is obtained by interpolating the magnetic field at the node points by using shape functions. The force is distributed to the node points of the element, again using the shape functions in a consistent manner that maintains inter-element torsion. Body forces obtained from MAGFOR were compared with body forces from the computer code EFFI for several coil configurations considered in the design of the Advanced Toroidal Facility (ATF), Oak Ridge National Laboratory.

Author: William D. Cain, Oak Ridge National Laboratory, U.S.A.

Reference: W.D. Cain, "MAGFOR: A Magnetics Code to Calculate Field and Forces in Twisted Helical Coils of Constant Cross Section," *Fusion Engineering* **2**, 1223-1227 (1983).

Status: MAGFOR was last modified in June 1988. This code is maintained and distributed, without charge, by William Cain. It has approximately 2500 lines of FORTRAN IV source code. It has three known users. There are two distributed versions of this program. They are for the CRAY/CTSS (FORTLIB) and VAX/VMS systems. No graphics packages are used. A six-page user's guide is available. This code is being distributed on high-density 3.5-inch diskettes for IBM-compatible personal computers.

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Function: BEAM DYNAMICS: general

Key Terms: space charge/high current, plasmas, particle-in-cell

Abstract: MAGIC (MAGnetic Insulation Code) is a two-dimensional, finite-difference, time-domain, self-consistent particle-in-cell code for simulating physical processes. Powerful boundary conditions are included to represent structural geometries, material properties, incident and out-going electromagnetic waves, field emission, beam injection, and so forth.

Phenomena with characteristic time scales ranging from fractions of picoseconds to tens of nanoseconds have been studied. Typical applications include plasmas, pulsed power, magnetic insulation, diodes, switches, vacuum electronics tubes, microwave sources, charged particle and neutral particle beams, and fusion. The code can also study characteristic times limited only by the availability of computer resources.

MAGIC handles Cartesian, spherical, and cylindrical coordinates, allowing for a variety of possible invariant coordinates. It can also exploit inherent mirror and periodic symmetries in a problem, thus broadening the class of configurations that can be simulated. Transmission lines may be modeled separately and then connected to the simulation in a variety of ways.

MAGIC includes a variety of field and particle algorithms that may be independently selected for individual problems. Algorithms for damping numerical noise are available for simulations of high-density conditions. Multiple species of charged particles may be simultaneously specified. External magnetic fields may be applied. Special particle-pushing algorithms are available for high B-field conditions. Options for relativistic and nonrelativistic particle-pushing are available.

There is a solver is available to compute initial electromagnetic fields for a user-specified configuration of particles, voltages, surfaces, etc. It may be used as a Poisson solver to obtain fields for static configurations and to set initial electromagnetic fields for the first time step. In this manner, the user may specify a complex initial configuration from which to begin a time domain simulation.

MAGIC belongs to a family of codes that contains a number of modules to perform a variety of tasks. SOS is a three-dimensional counterpart to MAGIC that also includes three-dimensional frequency-domain capabilities. POSTER is a postprocessor that has the ability to generate movies.

Output capabilities of the code include a variety of plots (vector, contour, perspective, trajectory, etc.), time histories, and tables. Data may be dumped for further analysis and movie generation by other codes or for continuation at a later time.

Authors: Bruce Goplen, Larry Ludeking, James McDonald, Gary Warren, and Richard Worl, Mission Research Corporation, U.S.A.

References: Bruce Goplen, Larry Ludeking, James McDonald, Gary Warren, and Richard Worl, "MAGIC Reference Manual - Algorithms," Mission Research Corporation technical report MRC/WDC-R-201 (October 1989).

Bruce Goplen, Larry Ludeking, James McDonald, Gary Warren, and Richard Worl, "MAGIC User's Manual," Mission Research Corporation technical report MRC/WDC-R-216 (October 1989).

Bruce Goplen, "MAGIC Exercise Workbook," Mission Research Corporation technical report MRC/WDC-R-223 (October 1989).

Bruce Goplen, Larry Ludeking, James McDonald, Gary Warren, and Richard Worl, "MAGIC User's Group," Mission Research Corporation technical report MRC/WDC-R-222 (October 1989).

L. Ludeking, G. Warren, J. McDonald, and B. Goplen, "POSTER User's Manual - Version May 1989," Mission Research Corporation technical report MRC/WDC-R-166 (May 1989).

Status: MAGIC was last modified in January 1990. The code is maintained by James McDonald and distributed, for a fee, by Bruce Goplen. A nonproliferation agreement is required. There are about 15 known users. It has approximately 150 000 lines of FORTRAN source code. The program has been run on VAX/VMS, VAX/ULTRIX, CRAY/COS, CRAY/CTSS (CFTLIB and FORTLIB), and CRAY/UNICOS systems. The code uses NCAR/GKS (National Center for Atmospheric Research/Graphic Kernel System) or DISSPLA graphics packages. A 350-page user's guide (MRC/WDC-R-216), a 150-page reference manual (MRC/WDC-R-201), a 30-page tutorial (MRC/WDC-R-223), and examples are available. The code is being distributed on streamer tape.

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Distributed by: Bruce Goplen
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Function: COMPONENT DESIGN: magnets

Key Terms: optimization, fringe field, three dimensions, PC version

Abstract: MAGIC stands for Magnet Analysis for Government, Industry, and Colleges. It is a powerful family of concise computer programs for solving axisymmetric and nonaxisymmetric three-dimensional problems in electromagnetics.

MAGIC calculates: magnetic fields, field derivatives, field indexes, and the "error-coefficients" of the Taylor-series expansion of the magnetic field; magnetic fluxes and vector potentials; integrated Lorentz ($J \times B$) body forces and nodal loads, and the resulting local and average stresses; self and mutual inductances, L/R time constants, and inductive-coupling coefficients; and eddy current losses and other eddy current phenomena.

Unique analytic formulas and ingenious algorithms combine to make MAGIC far faster, more accurate, more concise, and easier to use than competing codes. To ensure an accuracy of better than one part per million, all computations are done in 64-bit double precision. For any system of uniform-current-density planar coils, the codes can easily yield this accuracy, even at any point within the conductors or on the coil boundaries. Extensive use of our proprietary analytic formulas and ingenious algorithms make MAGIC extraordinarily concise – the entire MAGIC family of codes is only a few thousand lines of code.

The MAGIC package includes the following programs for axisymmetric systems (systems of coaxial circular coils): BEAMLINE, UNIFORM, COILS, INDEX, COILSJ, LOCATE, FORCES, COILSL, COILSM, and EDDY. The package includes the following codes for nonaxisymmetric systems of uniform-current-density and planar coils with parallel axes (systems of rectangular bore coils): RCOILS, REDDY, and TAYLOR. Codes for systems of circular and noncircular coils with nonparallel axes are included: TORUS, TFSTRESS, and TFCOOL. Codes for nonlinear magnetic systems, axisymmetric and nonaxisymmetric permanent magnets, and ferromagnetic problems are included: RING and TETRA.

Author: Carl F. Weggel, Magnet Analysis for Government, Industry, and Colleges, U.S.A.

References: C.F. Weggel, R.J. Weggel, and D.P. Schwartz, "New Analytic Formulas for Calculating Magnetic Fields, Flux, and Vector Potential," 11th International Conference on Magnet Technology, August 28–September 1, 1989, Tsukuba, Japan.

Status: MAGIC is maintained and distributed, for a fee, by Carl F. Weggel. The cost for this code is negotiable. It has fewer than 3000 lines of ANSI standard FORTRAN source code. MAGIC has been run on several 386-based personal computers as well as VAX minicomputers.

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Function: COMPONENT DESIGN: magnets, power sources

Key Terms: nonlinear/higher order, eddy current, three dimensions, PC version

Abstract: MAGNET is a two-dimensional and three-dimensional Computer Aided Engineering (CAE) design tool for simulating and analyzing electromagnetic and electrostatic devices, such as the following: motors, recording heads, actuators, levitators, transformers, NMR magnets, and other devices. MAGNET can improve product quality, reduce development/production costs and decrease development time.

MAGNET uses the finite-element method to calculate magnetic field values throughout a device. MAGNET also calculates flux densities, stored energies, Maxwell stresses, inductances, capacitances, torques, or other characteristics. These results can be directed to a CRT screen with the capability of using multiple windows or to a printer or plotter in the form of tables, graphs, or plots.

History: MAGNET 2D was first released commercially in 1978. By this time, MAGNET 2D has been substantially updated and annual or biannual updates are available to customers. MAGNET 3D was released in November 1988. Eddy current effects in three dimensions were added in September 1989.

Author: Infolytica Corporation, Canada

References: none

Status: MAGNET is maintained, kept current, and distributed, for a fee, by Infolytica Corporation. A nonproliferation agreement is required. The cost depends on the machine/software configuration. Prices start at under $4000 (U.S.) for a one-year lease on a personal computer and $9500 (U.S.) for a one-year lease on a work station. Licenses can also be purchased. The code has more than 500 000 lines of FORTRAN and C source code. The source code is not available; only the executable code is distributed. The program has been run on VAX/VMS, CRAY, and IBM systems; Hewlett-Packard/HP-UX, Sun/(Sun-OS), and Apollo/DN 10 workstations; and IBM AT, IBM 386, IBM PS/2, and Macintosh personal computers. A user's guide of approximately 400 pages, a reference manual of approximately 300 pages, examples, detailed tutorials, and telephone support are available. The code is being distributed on magnetic tape reels; .25-inch magnetic tape cartridges for Sun, Hewlett-Packard, and Apollo workstations; TK50 magnetic tape cartridges; 360-kilobyte, 720-kilobyte, and 1.2-megabyte diskettes for IBM-compatible machines; and diskettes for Macintosh machines.

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Function: COMPONENT DESIGN: magnets

Key Terms: iron saturation, magnetic field

Abstract: MAGNET computes two-dimensional static magnetic fields, including saturation effects. The code accepts one air region and one iron region having a common boundary of arbitrary shape. Neither of the two regions is allowed to be doubly connected. This program is suited for low-field magnets as well as for highly saturated magnets.

Author: Christoph Iselin, CERN, Switzerland

References: Ch. Iselin, "Two dimensional Magnetic Fields Including Saturation," CERN short write up T600 (1977), a long write up is also available.

R. Perin, S. van der Meer, "The program MARE for the Computation of Two-Dimensional Static Magnetic Fields," CERN report 67-7 (1967).

Status: MAGNET was last modified in May 1977. This program is maintained and distributed, without charge to nonprofit organizations, by the CERN Program Library. Other organizations are expected to pay a small fee to cover the cost of supplying the program. It has approximately 2000 lines of FORTRAN source code. It has been run on CYBER and IBM systems. A 22-page user's guide and examples are available. This program is being distributed on magnetic tape reels.

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Function: COMPONENT DESIGN: magnets

Key Terms: nonlinear/higher order, fringe field, three dimensions

Abstract: The MAGNUS-3D family of programs for three-dimensional nonlinear magnetic-field calculations consists of the preprocessor KUBIK, the MAGNUS solver, the postprocessor EPILOG, and the graphical postprocessor MAGNUS-GKS. The programs can solve any problem of linear or nonlinear magnetostatics, with any combination of ferromagnetic materials, permanent magnets, and electric conductors in space. The programs can also calculate derived quantities (such as magnetic forces, energy and harmonic coefficients) and display three-dimensional plots (the magnetic bodies, conductors, and field lines) on a wide range of supported devices.

MAGNUS-3D employs the finite-element method with a total scalar potential in regions with iron and a partial scalar potential in regions with electric current. The use of the total potential in iron avoids the severe round-off errors that arise if a reduced potential is used.

The mesh generator KUBIK employs a divide-and-conquer technique. The model is divided into parts, a mesh is automatically created inside each part, and the parts are assembled into the final structure. KUBIK is a truly three-dimensional mesh generator, where the complexity of the model is never a limiting factor since a more complicated model only requires some more work to provide the input data.

MAGNUS has a library of conductor elements. The user uses the elements to construct conductors of practically any shape in space. Commands exist to duplicate conducting structures by reflection, translation, or rotation and to produce tables and plots. The conductors are completely independent of the mesh created by KUBIK, and can be changed or displaced without modifying the mesh. MAGNUS also has a library of magnetization tables for ferromagnetic materials, including several industrial American and Japanese steels used for magnets. The user can give additional tables as input. The independent program WIRE can be used to calculate the field of the conductors alone (no iron or boundary conditions) at any point of space; WIRE uses the same conductor data as MAGNUS for input.

The MAGNUS solver obtains a solution in the mathematical sense: the magnetic potential given as a function of the coordinates at every point in the solution domain. High efficiency and surprisingly short execution times are achieved by means of sophisticated programming and the use of sparse-matrix technology. The solver runs for a specified number of iterations or until the desired accuracy is achieved. The solver can be restarted for more iterations if needed.

Once the solution is available, EPILOG is used for postprocessing. EPILOG accepts commands, will print tables, make plots, or calculate field lines, harmonic coefficients, energy, flux, field integrals, force, or torque. The plots include views of the mesh, magnetic bodies, field lines, and function graphs of the field components along any line in space.

The graphics postprocessor displays color plots, when color is available, that can be seen from any point-of-view in space with optional wireframe or full hidden-surface removal options.

Author: Sergio Pissanetzky, Texas Accelerator Center, U.S.A., 1975 to present

References:

S. Pissanetzky, "KUBIK: an Automatic Three-Dimensional Finite-Element Mesh Generator," *International Journal of Numerical Methods in Engineering* **17**, 255–269 (1981).

S. Pissanetzky, "Automatic Three-Dimensional Finite-Element Mesh Generation using the Program KUBIK," *Computer Physics Communications* **32**, 245–265 (1984).

S. Pissanetzky, "The New Version of the Finite-Element 3-D Magnetostatics Program MAGNUS," *Computational Electromagnetics*, Z.J. Cendes, Ed. (Elsevier Science Publishers (North-Holland), New York, 1986), pp. 121–132.

S. Pissanetzky, "The Interpolation of Magnetization Tables," *COMPEL — International Journal for Computation and Mathematics in Electrical and Electronic Engineering* (Ireland) **5** (1), 41-56 (1986).

M. Fan and S. Pissanetzky, "Three-Dimensional Magnetic Engineering: the Programs MAGNUS and EPILOG," *Nuclear Instruments and Methods in Physics Research. Section A: accelerators, spectrometers, detectors and associated equipment* **A272** (1,2) 606–609 (1988), Proceedings of the Ninth International Free Electron Laser Conference, Williamsburg, Virginia, September 14-18, 1987.

A. Ferrari and S. Pissanetzky, "Recent Extensions of the Program MAGNUS-3D for Three-Dimensional-Accelerator Magnetic Engineering," in *EPAC European Particle Accelerator Conference Rome, June 7-11, 1988*, Vol. 2, S. Tazzari, Ed. (World Scientific, Singapore, 1989) Vol. 2, pp. 1315–1317.

S. Pissanetzky, M. Fan, and W. Schmidt, "MAGNUS and the Design of Shielded Nuclear-Magnetic Resonance Magnets," Seventh Annual Meeting of the Society of Magnetic Resonance in Medicine, San Francisco, California, U.S.A. August 22-26, 1988. Published in the Book of Abstracts.

S. Pissanetzky and P. Tompkins,"3-D Magnetic-Field Calculations for Wigglers Using MAGNUS-3D," 10th. International Free Electron Laser Conference. Jerusalem. Israel. August 29 - September 2, 1988. Proceedings to be published by Elsevier Science Publishers (North-Holland).

N. Mahale and S. Pissanetzky, "Recent Advances in MAGNUS Computational Technology for 3D Nonlinear Magnetostatics," *IEEE Transactions on Electron Devices* **35** (11), 2034–2038 (1988).

Status: MAGNUS was last modified in March 1989. This code is maintained and distributed, for a fee, by Sergio Pissanetzky. The codes, including a graphics postprocessor, have approximately 58 900 lines of ANSI standard FORTRAN-77 source code. These codes are extremely portable and should run on practically

any computer with the necessary resources: a virtual-memory operating system of sufficient speed and memory (16 megabytes of core memory) for a reasonable run. A typical run requires 10 to 30 gigaflops (10 to 30 billion floating point operations). This is not a program for a personal computer. It has been run on VAX/VMS, VAX/UNIX, CRAY XMP, CRAY 2, CYBER 205, IBM/DOS, Apple Macintosh II A/UX, and NEC SX-2 systems. The graphics postprocessor is interfaced with the international Graphic Kernel System (GKS). A 144-page user's guide, a 98-page reference manual, examples, an on-line help facility, training courses, consultants, and a telephone hot line are available. This code is being distributed on magnetic tape reels, 800-kilobyte or 1.4-megabyte single- or double-sided diskettes, and 0.25-inch tape cassettes.

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MAPRO

Function: BEAM DYNAMICS: linacs

Key Terms: space charge/high current, tracking, three dimensions

Abstract: MAPRO tests the beam dynamics in drift-tube linacs through multiparticle simulation.

Author: authors' names are unavailable

References: none

Status: MAPRO is maintained and distributed, without charge, by Michael Pabst. A nonproliferation agreement is required. The program was written in FORTRAN and has been run on CRAY and IBM systems. There is no documentation available. The code is being distributed through the computer networks.

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Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, tracking, fringe field, symplectic

Abstract: MARYLIE employs algorithms based on a Lie-algebraic formulation of charged-particle trajectory calculations. It is able to compute transfer maps for and trace rays through single or multiple beamline elements. These computations are performed for the full six-dimensional phase space. The code handles all nonlinearities, including chromatic effects, through third-order (octupole). In addition, MARYLIE is symplectic (canonical) through all orders.

MARYLIE may be used both for particle tracking around or through a lattice and for analysis of linear and nonlinear lattice properties. Tracking can be performed element to element, lump to lump, or any mixture of the two. A lump is a collection of elements combined together and treated by a single transfer map. The speed for element to element tracking is comparable to that of other codes. When collections of elements can be lumped together to form single transfer maps, tracking speeds can be orders of magnitude faster. Up to 10 000 particles may be tracked at one time.

MARYLIE has powerful analytic tools. They include the calculation of first-, second-, and third-order dispersion; tunes and first- and second-order chromaticities; the other linear lattice functions and their energy dependence through second-order; the dependence of tune on betatron amplitude; nonlinear lattice functions; nonlinear phase-space distortion; transfer map normal forms; nonlinear resonance driving terms; and nonlinear invariants. MARYLIE can be used to give an explicit representation for the linear and nonlinear properties of the total transfer map of a system. This information can be used to evaluate or improve the optical quality of a single pass system such as a beam-transport line or linear collider. Finally, MARYLIE may be used to transport second- and higher-order beam moments directly, without particle tracking.

MARYLIE also has extensive fitting and optimization tools. Essentially, all quantities computed by MARYLIE, both linear and nonlinear, can be fit or optimized. Up to 20 quantities can be fit or optimized at one time.

Authors: Alex J. Dragt, Filippo Neri, and Johannes van Zeijts, Center for Theoretical Physics, University of Maryland, U.S.A.; David R. Douglas, Continuous Electron Beam Accelerator Facility, U.S.A.; Étienne Forest, Lawrence Berkeley Laboratory, U.S.A.; Robert D. Ryne, Lawrence Livermore Laboratory, U.S.A.; Liam M. Healy, Naval Research Laboratory, U.S.A.; C. Thomas Mottershead, Los Alamos National Laboratory, U.S.A.; Petra Schuett, Technische Hochschule Darmstadt, Federal Republic of Germany, 1985 to present

References: Alex J. Dragt and John Finn, "Lie Series and Invariant Functions for Analytic Symplectic Maps, " *Journal of Mathematical Physics* **17**, 2215–2227 (1976).

Alex J. Dragt, "A Method of Transfer Maps for Linear and Nonlinear Beam Elements," *IEEE Transactions on Nuclear Science* **NS-26** (3), 3601–3603 (1979).

Alex J. Dragt and David R. Douglas, "Charged Particle Beam Transport Using Lie Algebraic Methods," *IEEE Transactions on Nuclear Science* **NS-28**, 2522–2524 (1981).

David R. Douglas, "Lie Algebraic Methods for Particle Accelerator Theory," Ph.D. thesis, University of Maryland, unpublished (1982).

Alex J. Dragt, "Lectures on Nonlinear Orbit Dynamics," in *AIP Conference Proceedings No. 87: Physics of High Energy Particle Accelerators*, R.A. Carrigan, F.R. Huson, and Melvin Month, Eds. (American Institute of Physics, New York, 1982), pp. 147–313.

Alex J. Dragt and David Douglas, "Lie Algebraic Method for Charged Particle Beam Transport and Particle Tracking," in "Proceedings of the Workshop on Accelerator Orbit and Particle Tracking Programs, May 3–6, 1982," Brookhaven National Laboratory informal limited distribution report BNL-31761, pp. 346–356 (1982).

Alex J. Dragt and Étienne Forest, "Computation of Nonlinear Behavior of Hamiltonian Systems Using Lie Algebraic Methods," *Journal of Mathematical Physics* **24**, 2734–2744 (1983).

Alex J. Dragt and David R. Douglas, "MARYLIE: The **Maryland Lie** Algebraic Transport and Tracking Code," *IEEE Transactions on Nuclear Science* **NS-30**, 2442–2444 (1983).

David R. Douglas and Alex J. Dragt, "Lie Algebraic Methods for Particle Tracking Calculations," in *Proceedings of the 12th International Conference on High-Energy Accelerators*, Francis T. Cole and Rene Donaldson, Eds. (Fermi National Accelerator Laboratory, Batavia, Illinois, 1983), pp. 369–371.

Étienne Forest, "Lie Algebraic Methods for Charged Particle Beams and Light Optics," Ph.D. thesis, University of Maryland, unpublished (1984).

Alex J. Dragt and David R. Douglas, "Particle Tracking Using Lie Algebraic Methods," in *Lecture Notes in Physics 215: Computing in Accelerator Design and Operation, Proceedings of the Europhysics Conference held at the Hahn-Meitner-Institut für Kernforschung Berlin GmbH*, W. Busse and R. Zelazny, Eds. (Springer-Verlag, Berlin, New York, 1984), pp. 122–127.

Alex J. Dragt, "Nonlinear Lattice Functions," in *Proceedings of the 1984 Summer Study on the Design and Utilization of the Superconducting Super Collider, Snowmass, Colorado*, R. Donaldson and J. Morfin, Eds. (Division of Particles and Fields of the American Physical Society, New York, 1984), pp. 369–372.

Alex J. Dragt, Liam M. Healy, Filippo Neri, Robert D. Ryne, David R. Douglas, and Étienne Forest, "MARYLIE 3.0 — A Program for Nonlinear Analysis of Accelerator and Beamline Lattices," *IEEE Transactions on Nuclear Science* **NS-32**, 2311–2313 (1985).

Alex J. Dragt, "Elementary and Advanced Lie Algebraic Methods with Applications to Accelerator Design, Electron Microscopes, and Light Optics," *Nuclear Instruments and Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors, and Associated Equipment* **A258** (3), 339–354 (1987).

Alex J. Dragt, "Lie Algebraic Methods for Charged Particle Optics," in *AIP Conference Proceedings 177: Linear Accelerator and Beam Optics Codes, La Jolla Institute 1988*, Charles R. Eminhizer, Ed. (American Institute of Physics, New York, 1988), pp. 261–264.

F. Neri, A.J. Dragt, G. Rangarajan, D.R. Douglas, L.M. Healy, and R.D. Ryne, "Lie Algebraic Treatment of Linear and Nonlinear Beam Dynamics," *Annual Review of Nuclear and Particle Science* **38**, 455–496 (1988).

Alex J. Dragt and Filippo Neri, "Analysis of Tracking Data Using Normal Forms," in *EPAC European Particle Accelerator Conference, Rome, June 7–11, 1988*, S. Tazzari, Ed. (World Scientific, Singapore, 1989), Vol. 1, pp. 675–679.

Alex J. Dragt, Filippo Neri, et al., "Release of MARYLIE 3.0," 1989 IEEE Particle Accelerator Conference, Chicago, Illinois, March 20–23.

Alex J. Dragt, et al., "MARYLIE 3.0, A Program for Charged Particle Beam Transport Based on Lie Algebraic Methods," University of Maryland internal document, user's guide (1989).

Status: MARYLIE was last modified in April 1989. This code is maintained and distributed, for a fee, by Alex J. Dragt. There is a nominal rate for universities and government laboratories and a reasonable rate for industry. A nonproliferation agreement is required. MARYLIE has approximately 30 000 lines of standard FORTRAN-77 source code. There are about 20 known users. This code has been run on VAX/VMS, VAX/UNIX, CRAY/CTSS (CFTLIB), IBM/MVS, and DECstation 3100/ULTRIX systems. The only system calls that are used in MARYLIE are used for timing. A 350-page user's guide, examples, and an on-line help facility are available. This code is being distributed on magnetic tape reels and through the computer networks. The requester is expected to supply the tape reel if a non-network transfer is required.

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MASK

Functions: COMPONENT DESIGN: ion and electron sources, RF cavities

BEAM DYNAMICS: general

Key Terms: space charge/high current, impedance, particle-in-cell

Abstract: MASK is a family of codes consisting of two-dimensional field solvers (electrostatic or electromagnetic) and two-and-one-half-dimensional particle-in-cell simulation. It allows impedance boundary conditions to be used to represent ports through which particles do not enter. MASK has been applied to model microwave sources (such as klystrons and lasertrons) and accelerator components (such as subharmonic bunches).

Authors: Adam Drobot, Larry Seftor, Kwok Ko, and John Petillo, Science Applications International Corporation (SAIC), U.S.A.; Alan Palevsky, Massachusetts Institute of Technology, U.S.A.

References: K. Eppley, S. Brandon, A. Drobot, H. Hanerfeld, W. Herrmannsfeldt, R. Melendes, D. Nielsen, and S. Yu, "Results of Simulations of High-Power Klystrons," *IEEE Transactions on Nuclear Science* **NS-32**, 2903–2905 (1985).

S.S. Yu, A. Drobot, and P. Wilson, "Two and One-Half Dimension Particle-in-Cell Simulation of High-Power Klystrons," *IEEE Transactions on Nuclear Science* **NS-32**, 2918–2920 (1985).

H. Hanerfeld, "Computational Needs for Modeling Accelerator Components," in *Computing in High Energy Physics*, L.O. Hertberger, W. Hoogland, Eds. (North Holland, Amsterdam, 1986), pp. 319–321, Stanford Linear Accelerator Center preprint SLAC–PUB–3708 (1985).

Status: MASK was last modified in August 1989. This code is maintained and distributed, without charge, by Science Applications International Corporation (SAIC). There is a charge for code installation and for instruction in the use of the code. MASK has approximately 45 000 lines of FORTRAN source code. It has approximately 50 known users and is being used at 20 sites. This code has been run on VAX/VMS, CRAY/CTSS (FORTLIB), CRAY/UNICOS, and IBM 3090 systems. A 100-page user's guide is available. This code is being distributed on magnetic tapes and through the computer networks.

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Distributed by: Alfred Mondelli, same address as above
PHONE: 1 (703) 734-4066

Function: COMPONENT DESIGN: magnets, RF cavities, general

Key Terms: impedance, optimization, stress analysis, PC version

Abstract: MASTER is a family of codes used to calculate distributions of magnetic, electrostatic, and electromagnetic fields, as well as temperature, stress and deformation in two-dimensions. All the codes are fully compatible so that consistent calculations can be made throughout the hardware development. The finite-element method is used. Although this program will run with fewer resources, it is preferable to use this program on computers with at least one megabyte of core memory.

Authors: I.V. Gonin, V.P. Gorbul, and V.V. Paramonov, Institute for Nuclear Research (INR), Academy of Sciences, U.S.S.R.

Reference: I.V. Gonin, et al., "Code Package for Field Distribution Calculation in Accelerator Hardware," Proceedings of the 11th All Union meeting on Particle Accelerators.

Status: MASTER was last modified in April 1989. This code is maintained and distributed, for a fee, by Valentin V. Paramonov. It has approximately 24 000 lines of FORTRAN source code. It is being used at three installations in the U.S.S.R. This program has been run on VAX/VMS, VAX/UNIX, and IBM/OS systems, as well as IBM AT personal computers. A 112-page user's guide and examples are available. This code is being distributed on magnetic tape reels.

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CABLE: moscow meson

Function: COMPONENT DESIGN: target and radiation shielding design

Key Terms: three dimensions, Monte Carlo, radiation transport, PC version

Abstract: MCNP is the internationally recognized standard Monte Carlo (statistical) radiation transport code for neutrons, photons, and electrons. The program is three-dimensional, time-dependent, and continuous energy or multigroup.

History: MCNP is the original Monte Carlo particle transport code first developed during the Manhattan Project.

Authors: 350-person years of development by dozens of people, Los Alamos National Laboratory, U.S.A., 1945 to present

References: Judith F. Briesmeister, Ed., "MCNP — A general Monte Carlo Code for Neutron and Photon Transport," Los Alamos National Laboratory report LA-7396-M, revision 2 (September 1986).

R.A. Forster, et al., "MCNP Capabilities for Nuclear Well Logging Calculations," (to be published in *IEEE Transactions on Nuclear Science*).

Status: MCNP was last modified in July 1988. The code is maintained by John Hendricks and Judi Briesmeister. It is distributed, without charge, by the Radiation Shielding Information Center, Oak Ridge National Laboratory. MCNP has approximately 30 000 lines of ANSI standard FORTRAN-77 source code. It has about 350 known users. The code has been run on VAX/VMS, VAX/UNIX, CRAY/CTSS (CFTLIB), CRAY/UNICOS, CRAY/COS, CYBER/NOS, IBM/MVS, and PRIME systems; Apollo and Sun workstations; and IBM personal computers. Graphical output is available through GRAFLIB, CGS, DISSPLA, PLOT10 (Textronix), and DI3000 options. A 583-page user's guide and a 106-page reference manual is available. The program is being distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: diagnostics

Key Terms: emittance measurement, phase-space distribution

Abstract: The program name MEBT stands for Maximum Entropy Beam Tomography. Intense particle beams require noninterceptive diagnostics. The measured profile of a beam may be interpreted as a tomographic projection of its density distribution. With a small number of such projections and appropriate transfer matrices connecting them, Minerbo's maximum entropy (MENT) algorithm may be used to construct an estimate of the beam density distribution in both coordinate and phase space. The author plans to rewrite this code as a set of portable mathematical subroutines.

History: Gerry Minerbo, from Los Alamos National Laboratory, originally developed this algorithm on the CDC 7600 in 1979. Tom Mottershead, from EG & G at the time and now from Los Alamos, adapted and rewrote the code for the PDP-11/RSX-11M in approximately 1980 as part of an integrated on-line diagnostic system for the Fusion Materials Irradiation Test (FMIT) facility accelerator. The current version is written for the VAX/VMS system.

Authors: Gerry Minerbo, Los Alamos National Laboratory, U.S.A.;
C. Thomas Mottershead, EG & G, U.S.A., 1979 to present

References: C.T. Mottershead, "Maximum Entropy Beam Diagnostic Tomography," *IEEE Transactions on Nuclear Science* **NS-32**, 1970–1972 (1985).

G.N. Minerbo, "MENT: A Maximum Entropy Algorithm for Reconstructing a Source from Projection Data," *Computer Graphics and Image Processing* **10**, 48–68 (1979).

O.R. Sander, G.N. Minerbo, R.A. Jameson, and D.D. Chamberlin, "Beam Tomography in Two and Four Dimensions," in "Proceedings of the 1979 Linear Accelerator Conference," Brookhaven National Laboratory report BNL-51134 (1980), pp. 314–318.

Status: As of 1989, MEBT is dormant although current interest may revive it soon. The code needs to be rewritten to isolate the mathematical algorithm from the FMIT data acquisition system. When the code is rewritten, it will be it will be available for distribution, by Tom Mottershead. It has approximately 1000 lines of VAX FORTRAN IV source code. A home-brew graphics package is used by the program and can be distributed with it. The package uses VAX FORTRAN to perform Tektronix primitives. If you are not using a Tektronix terminal or a Tektronix emulator on a VAX system, this package will have to be replaced. There is no documentation available. The code is being distributed on magnetic tape reels and through the computer networks.

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Function: BEAM DYNAMICS: linacs

Key Terms: space charge/high current, particle-in-cell, wakefield

Abstract: MESH simulates the dynamics of short electron bunches at the injection stage. The Lax-method for solving Maxwell's equations was used, as well as the particle-in-cell method for simulating beam dynamics.

Author: V.P. Yakovlev, Institute for Nuclear Physics (INP), Novosibirsk, U.S.S.R.

Reference: B.M. Fomel, M.M. Karliner, I.N. Meshkob, and V.P. Yakovlev, (title is unavailable), Institute for Nuclear Physics, Novosibirsk, preprint INP 86-81 (1986).

Status: MESH was last modified in 1987. This code is maintained and distributed, without charge, by B.M. Fomel and V.P. Yakovlev. A nonproliferation agreement is required. It has approximately 2000 lines of FORTRAN source code. It has two known users. There is only one distributed version of this program. It is for the ICL-1900 machine. Although there is no formal documentation, there are some examples available. This code is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: misalignment, optimization, closed orbit

Abstract: MICADO is a solver of rectangular systems of linear equations. It is recommended for over-determined systems. The solution is iterative and gives at each iteration the most efficient solutions to reduce the norm of the residual vector. It has been extensively tested for orbit correction. The code has been used to calculate dynamic aperture corrections. This method is also used to correct (on-line) the orbit for different machines.

Authors: B. Autin and Y. Marti, CERN, Switzerland

References: B. Autin and Y. Marti, "Closed orbit correction of A.G. Machines Using a Small Number of Magnets," CERN report CERN/ISR_MA/73-17 (1973).

G. Guignard and Y. Marti, "PETROC User's Guide," CERN report CERN/ISR_BOM_TH/81-32 (1981).

Status: MICADO is maintained and distributed, without charge, by Yolande Marti. The program has approximately 400 lines of FORTRAN-77 source code. There is only one distributed version of this code. It for the IBM/XA system. It is being distributed on magnetic tape reels and through the computer networks.

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Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, tracking, optimization, PC version

Abstract: MIRKO is an interactive program for designing synchrotrons and beamlines. The program uses a linear matrix formalism and optimization in first-order. Investigation of nonlinear effects is made with particle tracking through linear matrices and thin nonlinear lenses.

Interactive graphics allow the user a choice between the use of a mouse or cursor. Graphic display of envelopes, ellipses, and particle distributions are possible.

Author: Bernhard J. Franczak, Gesellschaft für Schwerionenforschung (GSI), mbH, Federal Republic of Germany

Reference: B. Franczak, "MIRKO — An Interactive Program for Beam Lines and Synchrotrons," in *Lecture Notes in Physics 215: Computing in Accelerator Design and Operation, Proceedings of the Europhysics Conference held at the Hahn-Meitner-Institut für Kernforschung Berlin GmbH*, W. Busse and R. Zelazny, Eds., (Springer-Verlag, Berlin, New York, 1984), pp. 170–175.

Status: MIRKO was last modified in May 1989. This code is maintained and distributed, with a charge for the personal computer version, by Bernhard J. Franczak. It has approximately 20 000 lines of FORTRAN source code. The code has about 25 known users. This code has been run on VAX/VMS, IBM/MVS, and Atari/ST systems. A 21-page user's guide, an 80-page reference manual, examples, and an on-line help facility are available. This code is being distributed on magnetic tape reels and through the computer networks.

Maintained and Distributed by: Bernhard J. Franczak
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Function: BEAM DYNAMICS: accumulator rings

Key Terms: tracking, closed orbit, particle-in-cell

Abstract: MISAR stands for Multiturn Injection Studies in Accumulator Rings. MISAR is a PARMILA-like multiparticle simulation code that follows the transverse coordinates of a collection of macroparticles from the inflector, around the lattice of a circular machine for a number of turns, incorporating the space-charge forces of the beam as modified by the image effects in the walls. No longitudinal structure in the beam is allowed. After each turn around the machine, the number of particles in the beam is increased by the addition of a new quantity of beam from the inflector. Provisions are made for time-dependent pulsed bumps that can move the equilibrium orbit in the vicinity of the inflector to establish the multiturn injection process. As in PARMILA, there are a variety of options for generating the initial coordinates of the inflected beam and a variety of options for displaying the properties of the accumulated beam. The space-charge effects are supplied by a subroutine that is called one or more times during each basic period of the lattice.

Authors: Donald A. Swenson and Kenneth R. Crandall, Los Alamos National Laboratory, U.S.A.

Reference: Donald A. Swenson and Kenneth R. Crandall, "MISAR: A Particle Tracking Code for Multiturn Injection Studies in Accumulator Rings," Los Alamos National Laboratory report LA-UR-82-1585 (1982).

Status: MISAR was last modified in 1983. The code is not being maintained, but it is available for distribution, without charge, by Donald Swenson. It has 2058 lines of FORTRAN IV (FORTRAN-77 compatible) source code. The program has been run on CDC 7600 and CRAY/CTSS (CFTLIB) systems. The nine-page Los Alamos report, cited in the **Reference** section above, is used as a user's guide and reference manual. The code is being distributed on magnetic tape reels.

Distributed by: Donald A. Swenson
Scientific Applications International Corporation (SAIC)
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San Diego, California 92121
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PHONE: 1 (619) 458-3854

Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: stability, impedance, wakefield

Abstract: MOSES is a computer program that computes (complex) coherent betatron tune shifts as a function of the bunch current for a Gaussian beam and provides their graphical representation on a line printer. The threshold of stored current due to the mode-coupling instability is calculated. The betatron tune may have a spread.

History: The first version of MOSES was published in 1986. It was then incorporated into the program BBI in 1988. A second version of MOSES was published in 1988. This new version included two new features: the capability of giving the betatron tune spread as input and variation of the synchrotron tune as a user-defined function of current.

Author: Y.H. Chin, CERN, Switzerland, 1986 to present

References:

Y.H. Chin, "MOSES User's Guide, Version 1.0,". CERN report SPS/86-2 (DI-MST) (1986).

P.M. Gygi, "User's Guide for New BBI," CERN internal report, LEP Theory note 60 (1988).

Y.H. Chin, "User's Guide for New MOSES, Version 2.0" CERN report CERN/LEP-TH/88-05 (1988).

Status: MOSES was last modified in April 1988. This code is distributed and maintained, without charge, by Yong Ho Chin. It has approximately 1700 lines of standard FORTRAN-77 source code. It has 20 known users. This program was written for the IBM/VMS system at CERN, so it uses two of CERN's system libraries: GENLIB and KERNLIB. These libraries are not essential and other system libraries can be substituted easily. This program has also been run on a VAX/VMS system. A 26-page user's guide, which includes examples, is available. This code is being distributed through the computer networks.

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Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: optimization, raytracing

Abstract: MOTER is a ray-tracing program intended for the analysis and the optimization of a system of magnetic elements. Several unique features are included in MOTER, among these are the following: Monte Carlo simulation of the beam phase space; a sophisticated definition of the performance, including the possibility of computer correction of aberrations based on measurements of the trajectory of each event; the automatic optimization of any parameter of the magnet system; the possibility of using field maps for dipoles, quadrupoles, and multipoles; and the availability of several new element types, including an $E \times B$ separator, an RF accelerating gap, a wedge degrader, and various slits and scatterers.

To the greatest possible extent, MOTER makes use of parameter definitions that are identical to the program RAYTRACE, from which MOTER evolved. In order to minimize the pitfalls involved in setting up a problem, the user should first study the problem with the standard codes TRANSPORT, TURTLE, and RAYTRACE, in that order, before using MOTER.

Authors: H. Arch Thiessen and Morris M. Klein, Los Alamos National Laboratory, U.S.A., approximately 1977 to present

Reference: H.A. Thiessen and M.M. Klein, "Spectrometer Design at LASL," in *Proceedings of the Fourth International Conference on Magnet Technology, Brookhaven, 1972*, Y. Winterbottom, Ed. (Brookhaven National Laboratory, Upton, Long Island, New York, 1972) NTIS CONF-720908-12, pp. 8–17.

Status: MOTER was last modified in March 1989. This code is maintained and distributed, free of charge, by Al Zeller. It has approximately 11 000 lines of standard FORTRAN-77 source code. The only system library call is for a random-number generator. Although the code was originally written for the CRAY/CTSS (CFTLIB) system at Los Alamos National Laboratory, U.S.A., it was moved over to a VAX/VMS system. The lines that were necessary to make the random-number generator calls were commented out and lines necessary for the calls on a VAX/VMS system were inserted. It has 3 known users. There are two pieces of documentation available that are needed to run the program MOTER in addition to the manual for the program RAYTRACE. One is about 10 pages long and the other is about 30 pages long. This documentation will be combined and updated in the near future. There are also some examples available. This code is being distributed on magnetic tape reels and through DECNET.

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Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: space charge/high current, tracking, three dimensions

Abstract: MOTION is a macroparticle tracking code. It is fully relativistic. It integrates equations of motion through any user-defined external (electric and/or magnetic) field. The program has a variety of built-in components: quadrupoles, solenoids, dipoles, bunching cavities, octupoles, RF gaps, full three-dimensional space charge, and dipole magnets with no edge forcusing. Three initial distributions are available: four-dimensional waterbag, four-dimensional K-V, and user defined. This code is highly specialized and consumes a lot of CPU time. It is good for the design and analysis of beamlines.

Authors: K. Mittag and D. Sanitz, Kernforschungszentrum Karlsruhe, Federal Republic of Germany

Reference: K. Mittag and D. Sanitz, "MOTION — A Versatile Multiparticle Simulation Code," in "Proceedings of the 1981 Linear Accelerator Conference Held at Bishop's Lodge, Santa Fe, New Mexico October 19–23, 1981," R.A. Jameson and Louise S. Taylor, Eds., Los Alamos National Laboratory report LA-9234-C, pp. 156–158 (1982).

Status: MOTION was last modified in April 1987. This program is maintained and distributed, without charge, by K. Bongardt. The source code is written in FORTRAN-77. It has about 10 known users. This code has been run on CRAY and IBM 3081 systems. A 30-page user's guide is available. This program is being distributed on magnetic tape reels.

Maintained and Distributed by: Klaus Bongardt
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MSC/EMAS

Function: COMPONENT DESIGN: magnets, RF cavities

Key Terms: eddy current, fringe field, three dimensions

Abstract: MSC/EMAS™ is an ElectroMagnetic Analysis System. It is a general-purpose two- and three-dimensional finite-element analysis program for electromagnetic problems with linear, nonlinear, and anisotropic materials. It includes DC, AC, transient, and modal analysis.

MSC/EMAS™ is based on a new unified formulation of Maxwell's equations. The user can mix three-, two-, and one-dimensional finite elements plus circuit elements to model sources. The program includes a powerful graphics preprocessor and postprocessor called MSC/XL.

History: MSC/EMAS™ is based on the analytical engine of the world's leading finite-element program, MSC/NASTRAN™. The numerical algorithms at the heart of MSC/EMAS™ have been rigorously tested and proven at over 1000 installations worldwide. MSC/EMAS™ has replicated the data-processing efficiencies of MSC/NASTRAN™ while incorporating MSC's new formulation of Maxwell's equations.

Authors: Development team including B.E. MacNeal, J.R. Brauer, L.A. Larkin, V.D. Overbye, J.J. Ruehl, N.J. Lambert, P.L. Allaud, D.T. Putnam, S.M. Schaefer, and others at MacNeal-Schwendler Corporation, U.S.A., 1967 to present

References:

B.E. MacNeal, J.R. Brauer, and L.A. Larkin, "Analysis of Cavities and Waveguides Using MSC/EMAS™," Conference on Computer Codes and the Linear Accelerator Community, Los Alamos, New Mexico, U.S.A., January 22–25, 1990.

B.E. MacNeal, R.H. MacNeal, and R.N. Coppolino, "Spurious Modes of Electromagnetic Vector Potential Finite Elements," *IEEE Transactions on Magnetics* **MAG-25**, 4141–4143 (September 1989).

J.R. Brauer, E.A. Aronson, K.G. McCaughey, and W.N. Sullivan, "Three-Dimensional Finite Element Calculation of Saturable Magnetic Fluxes and Torques of an Actuator," *IEEE Transactions on Magnetics* **MAG-24**, 455–458 (1988).

A.B. Bruno and J.R. Brauer, "Scattering from an Infinite, Finitely Conducting Cylinder by Finite Element Analysis," *Journal of Applied Physics* **63**, 3200–3202 (1988).

What Every Engineer Should Know About Finite Element Analysis, John R. Brauer, Ed. (Marcel Dekker, Inc., New York, 1988).

Status: The first-release of MSC/EMAS™ came out in October 1989. The code is maintained and distributed, for a fee, by the MacNeal-Schwendler Corporation. A nonproliferation agreement is required. It has approximately one million lines of FORTRAN-77 source code and some Assembler. Less than two per cent of the total number of lines are in Assembler to increase speed.

There are about 20 known users of the code as of January 1990 and the number is rapidly increasing. The code has been run on VAX/VMS, CRAY/UNICOS 5.0, and IBM/MVS/XA SP2.20 systems as well as Apollo/Aegis 9.7 and CONVEX/UNIX 7.0 workstations. No additional graphics package is necessary. An approximately 1000-page user's guide, an approximately 200-page application manual, and examples are available. The program is being distributed on magnetic tape reels.

Maintained and Distributed by:

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MULTIMODE

Function: COMPONENT DESIGN: magnets, RF cavities

Key Terms: stability, impedance, optimization, PC version

Abstract: MULTIMODE is a two-dimensional code that calculates 1) the eigenfrequencies and field distributions of modes with and without angular dependence in axisymmetric cavities, 2) cutoff frequencies and mode field distributions in wave guides, and 3) mode information of periodic structures. The finite-element method with high-order approximation is used. Subspace iterations are used to solve eigenvalue problems.

Authors: M.S. Kaschiev, Joint Institute for Nuclear Research (JINR); V.V. Gusev and A.I. Fedoseev, Institute for High-Energy Physics (IHEP), U.S.S.R.; I.V. Gonin and V.V. Paramonov, Institute for Nuclear Research (INR), U.S.S.R.

Reference: M.S. Kaschiev, V.A. Kashcheeva, I.V. Puzynin, V.V. Gusev, A.I. Fedoseev, I.V. Gonin, and V.V. Paramonov, "Calculating the Oscillation Total Spectrum in Axially Symmetric Longitudinally Homogeneous Resonators, Waveguides, and in Periodic Accelerating Structures in the Modes of Traveling and Standing Waves," in *Proceedings of the 9th All-Union Conference on Charged Particle Accelerators, Dubna, U.S.S.R., 16 October, 1984*, INIS-SU-352, CONF-8410203, Vol. 1, pp. 137–141.

Status: MULTIMODE was last modified in June 1988. This code is maintained and distributed, for a fee, by V.V. Paramonov. The source code is written in FORTRAN. There are about 50 known users at 11 installations. The program has been run on VAX/VMS, VAX/UNIX, IBM/OS systems, as well as the IBM AT personal computer. A 25-page user's guide and examples are available. This program is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: cyclotrons

Key Terms: space charge/high current, tracking, three dimensions

Abstract: NAJO is a general three-dimensional multiparticle code for studying particle motion in cyclotrons. Related to the geometry of the GANIL (Grand Accélérateur National d'Ions Lourds) four separated-sector cyclotrons, it can easily be adapted to other configurations. The most general version includes space-charge effects. The program's simulations agreed perfectly with the behavior of the GANIL beam as detected through the use of probes. At least five laboratories have derived codes from NAJO.

History: NAJO was used in the design of GANIL.

Authors: A. Chabert, M. Prome, and J. Sauret, GANIL (Grand Accélérateur National d'Ions Lourds), France, 1975 to present

References: J. Sauret, A. Chabert, and M. Prome, "Multiparticle Codes Developed at GANIL," *Lecture Notes in Physics 215: Computing in Accelerator Design and Operation, Proceedings of the Europhysics Conference held at the Hahn-Meitner-Institut für Kernforschung Berlin GmbH*, W. Busse and R. Zelazny, Eds. (Springer-Verlag, Berlin, New York, 1984) pp. 164–169.

Le Groupe Theorie Parametres, "Les Programmes ANJO, JOAN, NAJO," Grand Accélérateur National d'Ions Lourds internal report GANIL 80R/132/TP/06.

Status: NAJO is maintained and distributed, without charge, by André Chabert. It has less than 1000 lines of FORTRAN-77 source code. It has been run on IBM/VM/SP and MODCOMP 2385 systems. The program does not perform any graphical analysis of the data and there are no system calls. Although there is no formal documentation, there are examples available. This program is being distributed on magnetic tape reels and through the computer networks.

Maintained and Distributed by: André Chabert
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Function: COMPONENT DESIGN: RF cavities

Key Terms: electron loading, tracking

Abstract: NEWTRAJ simulates electron loading in TM modes of axially symmetric RF cavities. It uses the RF fields obtained by the code OSCAR2D to compute the trajectories of electrons starting from the cavity walls. When an electron strikes the cavity wall, secondary emission and backscattering are simulated. NEWTRAJ was successfully used to design multipacting-free cavities.

History: NEWTRAJ was derived from a program that was given to the Istituto Matematica Applicata by J. Halbritter, Institut für Kernphysik, Kernforschungszentrum Karlsruhe (KfK) GmbH, Federal Republic of Germany.

Authors: Paolo Fernandes, Istituto per la Matematica Applicata, Consiglio Nazionale delle Ricerche, Italy; Renzo Parodi, Istituto Nazionale di Fisica Nucleare (INFN), Italy

References: P. Fernandes and R. Parodi, "OSCAR2D, a Computer Code for the Design of RF Cavities and Structures," in "1986 Linear Accelerator Conference Proceedings," SLAC report 303 (September 1986), pp. 330–332.

P. Fernandes and R. Parodi, "NEWTRAJ, a Computer Code for the Simulation of the Electron Discharge in Accelerating Structures," in *Proceedings of the 1987 Particle Accelerator Conference: Accelerator Engineering and Technology, March 16–19, 1987, Washington, D.C.*, Eric R. Lindstrom and Louise S. Taylor, Eds., IEEE catalog number 87CH2387-9, Vol. III, pp. 1857–1859.

R. Boni, V. Chimenti, P. Fernandes, R. Parodi, B. Spataro, and F. Tazzioli, "Design and Operation of a Multipacting-Free 51.4 MHz RF Accelerating Cavity," *Nuclear Instruments and Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors, and Associated Equipment* **A274**, 49–55 (1989).

Status: This code is maintained by Renzo Parodi, but it is not available for distribution. It has approximately 3000 lines of FORTRAN source code. There is only one version of this program. It is for the VAX/VMS system. No documentation is available.

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Function: BEAM DYNAMICS: general

Key Terms: graphics postprocessing

Abstract: OPDATA-PLOTDATA-EDGR is a package for generalized manipulation and graphical display of data with such capabilities as curve fitting, smoothing, integration, differentiation, interpolation, sorting, binning, convoluting, filtering, peak finding, etc. Publication-quality graphics can be produced for many devices. This package is highly recommended for any VAX installation involved in scientific research.

History: This package resulted from the need to perform many various analyses and displays of data in the field of accelerator design, commissioning, and operation. This package is the result of some 20 man-years of programming, starting in 1975, and is extensively used by accelerator design groups.

Authors: P. Bennet, J. Chuma, A. Haynes, F. Jones, and C. Kost, TRIUMF, Canada

References:

P. Bennett and C.J. Kost, "OPDATA Reference Manual," TRIUMF internal Computing Design note TRI-CD-87-04 (September 1989).

F.W. Jones, "EDGR: Graphics Editor User's Guide," TRIUMF internal Computing Design note TRI-CD-87-01 (February 1989).

J.L. Chuma, "PLOTDATA Reference Manual," TRIUMF internal Computing Design note TRI-CD-87-03 (August 1989).

C.J. Kost, "Computational Tools for Cyclotron Design, Commissioning, and Operation," 12th International Conference on Cyclotrons and their Applications, Berlin, May 1989, World Scientific, in press.

Status: OPDATA-PLOTDATA-EDGR are maintained and distributed, without charge to academic and nonprofit institutions, by Corrie Kost. A nonproliferation agreement is required. It has approximately 100 000 lines of FORTRAN source code. There are more than 1000 known users. There is only one version of this program. It is for a VAX/VMS system. A 500-page user's guide is available. This code is being distributed on large magnetic tape reels that the requester is expected to supply.

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OPTIC II

Function: BEAM DYNAMICS: electrostatic accelerators

Key Terms: optimization, tracking, PC version

Abstract: OPTIC II is a general beam transport code, using matrix methods with special provisions for electrostatic accelerators.

Authors: T.J. Devlin, Lawrence Berkeley Laboratory, U.S.A.; J.D. Larson, Brookhaven National Laboratory and private consultant, U.S.A.; plus a cast of thousands

References: none

Status: OPTIC II was last modified in late 1988. This code is maintained and distributed, without charge, by James Larson. The source code is written in FORTRAN. This program has been run on VAX/VMS, IBM, and many kinds of older mainframe systems as well as the personal computer XPC Model 1. The user's guide for this program is about 100 kilobytes on the diskette that the program is distributed on. There are also examples available. The code is being distributed on 5.25-inch, 360-kilobyte diskettes for IBM-compatible personal computers.

Maintained and Distributed by:

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Function: COMPONENT DESIGN: RF cavities

Key Terms: RF field, resonant mode

Abstract: OSCAR2D computes the TM and TE modes of axially symmetric or constant cross-section RF cavities. The boundary of the cavity section in the $r - z$ or $x - y$ plane may consist of straight segments and circular or elliptical arcs. It can compute the n lowest modes in a single run or directly the n-th mode given an approximation of its frequency and some qualitative information about its field. The problem is discretized by finite differences and the resulting matrix eigenvalue problem is solved by a Rayleigh quotient iteration where the algebraic system is solved by the biconjugate gradient method.

History: OSCAR2D was derived from the program LALA. An older version of OSCAR2D was LALAGE.

Authors: Paolo Fernandes, Istituto per la Matematica Applicata, Consiglio Nazionale delle Ricerche, Italy; Renzo Parodi, Istituto Nazionale di Fisica Nucleare (INFN), Italy

References: P. Fernandes and R. Parodi, "LALAGE - A Computer Code to Calculate the TM01 Modes of Cylindrically Symmetrical Multicell Resonant Structures," *Particle Accelerators* **12** (3), 131–137 (1982).

P. Fernandes and R. Parodi, "Computation of Electromagnetic Fields in Multicell Resonant Structures for Particle Acceleration," *IEEE Transactions on Magnetics* **MAG-19**, 2421–2424 (1983).

P. Fernandes and R. Parodi, "Computation of Electromagnetic Fields in TE and TM Resonators and in Waveguides," *IEEE Transactions on Magnetics* **MAG-21**, 2246–2249 (1983).

P. Fernandes and R. Parodi, "OSCAR2D, a Computer Code for the Design of RF Cavities and Structures," in "1986 Linear Accelerator Conference Proceedings," SLAC report 303 (September 1986), pp.330–232.

P. Fernandes and R. Parodi, "Higher Order Modes Computation in RF Cavities," *IEEE Transactions on Magnetics* **24**, 154–157 (1987).

Status: OSCAR2D is maintained and distributed, without charge, by Paolo Fernandes. A nonproliferation agreement is required. It has approximately 8000 lines of FORTRAN source code. There is only one version of this program. It is for a VAX/VMS system. A 24-page user's guide and examples are available. The program is being distributed on magnetic tape reels.

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Function: COMPONENT DESIGN: magnets

Key Term: ferrite/dielectric, permanent magnet

Abstract: PANDIRA calculates static magnetic fields in two Cartesian dimensions or cylindrically symmetric configurations in three dimensions. The code solves ferroelectric problems and handles permanent magnet materials as well as permeable iron and current-carrying coils. The program uses the "direct" method to solve a generalized Poisson's equation in two dimensions.

History: The POISSON/PANDIRA group of codes were originally derived from a diffusion calculation code written by Alan Winslow at Lawrence Livermore National Laboratory. In the late sixties, Jim Spoerl at Lawrence Berkeley Laboratory modified this code to develop the TRIM codes, MESH and FIELD. MESH constructed an irregular mesh to fit the geometry of the magnet and FIELD solved Poisson's equation for the potential function over the mesh. Ronald Holsinger, Klaus Halbach, and other associates at Lawrence Berkeley Laboratory made extensive changes to the TRIM codes and introduced the use of conformal transformations. They renamed the codes LATTICE, TEKPLOT, and POISSON. Holsinger improved the existing codes and wrote the codes FORCE and MIRT with theoretical assistance from Klaus Halbach while he was at the Swiss Institute for Nuclear Research (SIN) and at CERN. Holsinger worked at Los Alamos National Laboratory from 1975 to 1977 developing the codes AUTOMESH, PANDIRA, and SUPERFISH, with Klaus Halbach's continued support. Holsinger left Los Alamos in 1977 and continued to update and maintain the programs until 1982. Since 1986, the Los Alamos Accelerator Code Group (LAACG) has received funding from the U.S. Department of Energy to maintain a standard version of these codes.

Authors: Ronald Holsinger, Lawrence Berkeley Laboratory, U.S.A., Swiss Institute for Nuclear Research (SIN), Switzerland, CERN, Switzerland, and Los Alamos National Laboratory, U.S.A.; Klaus Halbach, Lawrence Berkeley Laboratory, U.S.A.

Reference: K. Halbach, "Design of Permanent Multipole Magnets With Oriented Rare Earth Cobalt Materials," *Nuclear Instruments and Methods* 169, 1-10 (1980).

Status: PANDIRA was last modified in August 1988. A new version will be released in the latter part of 1990. This code is maintained and distributed, without charge, by the Los Alamos Accelerator Code Group (LAACG).

The source and executable forms of this code are installed at Los Alamos National Laboratory and at the National Energy Research Supercomputer Center (NERSC), formerly NMFECC, at Lawrence Livermore National Laboratory, U.S.A. For more information about these files, contact Therese Barts, Los Alamos Accelerator Code Group. Her BITNET address is AT6TCB@LAMPF.

The POISSON/PANDIRA and SUPERFISH family of codes are distributed as a package. There are 10 source files containing approximately 19 500 lines of FORTRAN IV source code. Sample runs for all the programs are sent with the source code.

There are two distributed versions of this program. They are for VAX/VMS and CRAY/CTSS (CFTLIB and FORTLIB) systems. The program uses the graphics package, PLOT10, written and owned by Tektronix.

The POISSON/PANDIRA codes are fully documented. A 224-page user's guide and a 300-page reference manual are available. The code is being distributed on small seven-inch magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

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PAR2DOPT

Function: COMPONENT DESIGN: magnets

Key Terms: optimization, coil

Abstract: PAR2DOPT is used to optimize the placement of turns in cylindrical coils by minimizing a weighted function of field errors. This program operates upon coils composed of partially keystoned conductors.

Authors: P.A. Thompson, R.C. Fernow, and G. Morgan, Brookhaven National Laboratory, U.S.A.; S. Caspi, Lawrence Berkeley Laboratory, U.S.A.

References: none

Status: PAR2DOPT was last modified in May 1989. This code is maintained and distributed, without charge, by Pat Thompson. It has approximately 4000 lines of FORTRAN source code. The program has between five and ten known users. There is only one distributed version of this program. It is for a VAX/VMS system. There is no formal written documentation. However, there is documentation within the source code and some examples. This informal documentation enables most first-time users to run the program within an hour. The program is being distributed on magnetic tape reels and through the computer networks.

Maintained and Distributed by:

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Function: BEAM DYNAMICS: linacs

Key Terms: space charge/high current, tracking, three dimensions, PC version

Abstract: PARMELA stands for Phase And Radial Motion in Electron Linear Accelerators. It is a variation of PARMILA that applies to standing-wave electron linacs and transport lines. The user must supply information about the linac structure and the fields in the basic RF cell. Multiparticle tracking is done with space-charge forces. The independent variable is time as opposed to distance along the beamline. The code will generate several types of initial electron distributions. The output is a file of particle distributions in six-dimensional phase space at the exit of each RF cell.

PARGRAF is a postprocessor that will make "phase-space scatter plots".

Authors: Kenneth R. Crandall and Lloyd Young, Los Alamos National Laboratory, U.S.A.

References: none

Status: PARMELA was last modified June 1989. This code is maintained and distributed, without charge by Lloyd Young. PARMELA has 6000 lines of FORTRAN source code and PARGRAF has 3000 lines of FORTRAN source code. This program has been run on the CRAY/CTSS (CFTLIB) system and will run on any IBM-compatible personal computer. The code PARGRAF requires the Hercules display graphics package. Although the code is only partially documented, there is an 11-page user's guide available. This program is being distributed on magnetic tape reels and double-sided, high-density 360-kilobyte diskettes for IBM-compatible personal computers.

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PARMILA - AT1

Function: BEAM DYNAMICS: drift-tube linacs

Key Terms: misalignment, space charge/high current, tracking

Abstract: PARMILA stands for Phase And Radial Motion in Ion Linear Accelerators. Given the electric and magnetic fields in one RF cavity and the gap-length-to-cell-length function for the cavity design from a code like SUPERFISH, PARMILA will generate the layout for a multicell drift-tube linac. The code performs multiparticle tracking, with space charge, through the linac or through a transport line. The independent variable is the distance along the beam line. There are several choices for initial particle distributions: Kapchinskij-Vladimirskij (KV), Gaussian, waterbag, uniform, rectangular, and experimental data. The default space-charge subroutine assumes a circular beam and makes the impulse approximation once per RF cell. Other subroutines can be substituted if desired. The output is a file with the phase-space distribution at the exit of each RF cell.

OUTPROC is a postprocessor that plots beam profiles as a function of the beam direction z and particle distribution for cross sections of phase space, e.g., (x, x'), (y, y'), (ϕ, E), etc. OUTPROC also calculates moments of the distribution.

Author: Donald A. Swenson, Midwestern Universities Research Association (MURA), U.S.A.

References: none

Status: PARMILA - AT1 is maintained by Bob Garnett and distributed, without charge, by the Los Alamos Accelerator Code Group (LAACG). No support is available for this code. It has approximately 7000 lines of FORTRAN source code. The only version that exists was written for the CRAY/CTSS (CFTLIB) system. The program uses the DISSPLA graphics package. Although the code is only partially documented, a 32-page user's guide is available. This code is being distributed on small seven-inch magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

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PARMILA - AT6

Function: BEAM DYNAMICS: ion linacs

Key Terms: misalignment, space charge/high current, tracking

Abstract: PARMILA - AT6 is a multiparticle simulation code. The program generates a drift-tube linac and an input beam. Movement of the beam through the linac is then simulated. The code is modularized and uses the chain-matrix method to pass collections of particles through the system under study. Except for the space-charge calculation, the code is six-dimensional. For the space-charge calculation, the ion beam is treated as if it were a function of radius and longitudinal position only. Each particle is assumed to be a ring of charge that contributes to the electric field on a two-dimensional $R - Z$ mesh. This is sometimes termed a two-and-one-half-dimensional treatment. The mesh can be held fixed for an entire run or may be readjusted at fixed intervals set by the user.

PARMILA - AT6 contains detailed nonlinear modeling. Its independent variable is the accelerator's longitudinal coordinate. It can be considered an essentially second-order code.

PARMILA - AT6 is used for the design of drift-tube linacs (DTLs) and the design of low- and high-energy beam-transport lines (LEBTs and HEBTs). It is also used for beam-dynamic studies of beams in DTLs, LEBTs, and HEBTs.

History: Many people have contributed to the development of PARMILA over the years. In the discussion following Don Swenson's presentation, Fred Mills indicated that the starting point for PARMILA was a report by W.K.H. Panofsky. Mills credits himself, Phil Morton, Don Swenson, and Don Young for extending Panofsky's work. In its original form, PARMILA was written by Don Swenson at Midwestern Universities Research Association (MURA) about 1963. It was brought to Los Alamos National Laboratory (LANL) by Don Swenson about 1964. At LANL, PARMILA was expanded and improved. Major contributors to this effort included K.R. Crandall, R.A. Jameson, R.S. Mills, J.E. Stovall, and D.A. Swenson.

Authors: D.A. Swenson, Midwestern Universities Research Association (MURA) and Los Alamos National Laboratory, U.S.A; K.R. Crandall, R.A. Jameson, R.S. Mills, and J.E. Stovall, Los Alamos National Laboratory, U.S.A.

References:

D.A. Swenson, "Application of Calculated Fields to the Study of Particle Dynamics," in "Conference on Proton Linear Accelerators," Midwestern Universities Research Association report MURA-714, pp. 328–340.

W.K.H. Panofsky, "Linear Accelerator Beam Dynamics," University of California Radiation Laboratory, Berkeley, report UCRL-1216 (February 1951).

P.L. Morton, "Particle Dynamics in Linear Accelerators," Midwestern Universities Research Association MURA-679 (December 1963).

B. Austin, T.W. Edwards, J.E. O'Meara, M.L. Palmer, D.A. Swenson, and D.E. Young, "The Design of Proton Linear Accelerators for Energies Up to 200 MeV," Midwestern Universities Research Association MURA-713 (July 1965).

D.A. Swenson and J. Stovall, "PARMILA," Los Alamos National Laboratory internal report MP-3-19 (January 1968).

L. Smith and R.L. Gluckstern, "Focusing in Linear Accelerators," *Review of Scientific Instruments* **26** (2), 220–228 (1955).

J.E. Stovall, "Selection of Quadrupole Strengths for Drift-Tube Linac," Los Alamos National Laboratory internal report MP-3-38 (July 1968).

R.A. Jameson, "PARMILA Input Subroutine, and Particle Distribution Fitting Techniques," Los Alamos National Laboratory memorandum MP-9 (June 22, 1978), available from Jean Merson.

G.P. Boicourt, "PARMILA - An Overview," in *AIP Conference Proceedings 177: Linear Accelerator and Beam Optics Codes, La Jolla Institute 1988* Charles R. Eminhizer, Ed. (American Institute of Physics, New York, 1988) pp. 1-21.

G. Boicourt and J. Merson, "PARMILA Users and Reference Manual," Los Alamos National Laboratory unclassified report LA-UR-90-127 (January 1990).

Status: PARMILA - AT6 was last modified in December 1989. This code is maintained and distributed, without charge, by Jean Merson. Support for this code is minimal. It has approximately 5500 lines of FORTRAN-77 source code. This version has been extensively modified to vectorize on Los Alamos National Laboratory's CRAY/CTSS (CFTLIB) computers (X/MP and Y/MP). It uses the following libraries: CALMATH, CFTMATH, DISCFT, INTCFT, CGSCFT. There are three known users. An approximately 140-page combined user's guide and reference manual was published in January 1990. The code is being distributed on small seven-inch magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

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PARMTEQ

Function: BEAM DYNAMICS: RFQ accelerators

Key Terms: space charge/high current, tracking

Abstract: PARMTEQ is a version of PARMILA that will generate a design for an RFQ ion accelerator and also do multiparticle tracking with space charge through the linac. Several types of initial distributions can be used.

In PARMTEQ(B), distance along the beam (z) is the independent variable. In PARMTEQ(C), time is the independent variable. The program produces a file describing particle distributions over six-dimensional phase-space at the end of each RFQ cell.

History: This version of PARMTEQ was developed and is being used in the Accelerator Technology Division of the Los Alamos National Laboratory, U.S.A.

Author: Kenneth R. Crandall, Los Alamos National Laboratory, U.S.A.

References: none

Status: PARMTEQ is not really maintained, but it is available, without charge, from Tarlochan Bhatia. It has approximately 24 000 lines of FORTRAN IV source code. At Los Alamos, it is being used on CRAY/CTSS (CFTLIB) and VAX/VMS systems. There is no documentation available. The code is being distributed on small seven-inch magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

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Function: BEAM DYNAMICS: linacs

Key Terms: misalignment, space charge/high current, optimization, PC version

Abstract: PARTRACE combines the input format and linac generation of PARMILA with the beam dynamics of TRACE 3-D. The result is an extremely fast-running version of PARMILA that can be used for error studies or for optimizing linacs and transport lines.

Author: Kenneth R. Crandall, AccSys Technology, Inc., U.S.A.

Reference: K.R. Crandall, "Error Studies Using PARTRACE, a New Program that Combines PARMILA and TRACE 3-D," in "1988 Linear Accelerator Conference Proceedings," Continuous Electron Beam Accelerator Facility (CEBAF) report CEBAF-89-001, pp. 335–337 (June 1989).

Status: PARTRACE was last modified June 1989. This code is maintained by Kenneth R. Crandall. It is being distributed, for a fee to cover administrative costs and consultation, by M.E. Hamm. The code has 2765 lines of FORTRAN source code. It has 3 known users. The program has been run on a CRAY/CTSS (CFTLIB) system and will run on any IBM AT clone. There is no formal documentation, although there are some examples available. The code is being distributed on double-sided, double-density, 5.25-inch diskettes for IBM-compatible personal computers.

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PATH

Function: BEAM DYNAMICS: spectrometers/transport lines, linacs

Key Terms: space charge/high current, nonlinear/higher order, raytracing

Abstract: PATH is a group of interactive computer programs used for simulating charged-particle beam-transport systems. It was developed for evaluating the effects of some aberrations without a time-consuming integration of trajectories through the system. PATH contains all the features available in DECAY TURTLE (including the input format) plus additional features such as a more flexible random-ray generator, longitudinal phase space, some additional beamline elements, and space-charge routines. One of the programs also provides a simulation of an Alvarez linear accelerator.

History: The beam-transport portion of PATH is derived from the well-known program DECAY TURTLE.

Authors: John Farrell, Ann Aldridge, and Dan P. Rusthoi, Los Alamos National Laboratory, U.S.A.

Reference: John A. Farrell, "PATH - A Lumped Element Beam Transport Simulation Program with Space Charge," in *Lecture Notes in Physics 215: Computing in Accelerator Design and Operation, Proceedings of the Europhysics Conference held at the Hahn-Meitner-Institut für Kernforschung Berlin GmbH*, W. Busse and R. Zelazny, Eds. (Springer-Verlag, Berlin, New York, 1984), pp. 267–272.

Status: PATH was last modified in February 1990. This code is maintained and distributed, without charge, by Dan Rusthoi. The code has 8000 lines of FORTRAN source code. Although the original version of the code was written for a CYBER machine, at this time, there are only two versions of the code available: one is for the VAX/VMS and the other is for the CRAY/CTSS (CFTLIB) system. If space-charge calculations are required, it is best to run this code on a CRAY machine. Although there is no formal documentation of this code available, all of the programs in this package are interactive and use helpful and easy-to-understand prompts. There is also an on-line help facility available. The program is being distributed on small seven-inch magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: misalignment, tracking, closed orbit, PC version

Abstract: PATPET is a combination of the codes PATRICIA and PETROS. It is a tracking program that takes into account multipoles, systematic field errors, and misalignments. This code also does closed-orbit calculations. It produces dynamic apertures in one run based on tracking 400 particles.

Authors: Louis Emery and Helmut Wiedemann, Stanford Synchrotron Radiation Laboratory, U.S.A; J. Kewisch and K.G. Steffen, Deutsches Elektronen-Synchrotron (DESY), Federal Republic of Germany; Michael Borland and James Safranek, Stanford Synchrotron Radiation Laboratory, U.S.A., 1985

Reference: L. Emery, H. Weidemann, and J. Safranek, "User's Guide for PATPET Version 88.2," Stanford Synchrotron Radiation Laboratory internal report, ACD-NOTE 36 (June 21, 1988).

Status: The last version of PATPET came out in February 1988. It is maintained and distributed, without charge, by Louis Emery. It has approximately 20 000 lines of VAX FORTRAN source code. The only system calls are for the date, time of day, and time elapsed. They are located in two subroutines and are easily changed. No graphics packages are used. The code has been run on VAX/VMS and IBM/VM systems, as well as IBM-compatible personal computers. A 35-page user's guide is available. This code is being distributed on magnetic tape reels, through the computer networks, and on diskettes for IBM-compatible personal computers.

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PATRAC

Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: nonlinear/higher order, tracking, misalignment

Abstract: PATRAC is a tracking program using matrix formalism and thin-lens approximation for multipoles with up to 20 poles. The program uses 5×5 matrices to include coupling. Misalignment errors can be included as well as modulation and synchrotron motion. During a closed-orbit simulation, the displacements for the accelerator elements can be specified explicitly or with reference to a measured closed orbit.

History: PATRAC was first written between 1980 and 1982. The code was completely rewritten in 1986 and some additions were made up until 1989.

Authors: A. Hilaire and A. Warman, CERN, Switzerland, 1980 to present

References:

P. Faugeras, A. Hilaire, and A. Warman, "PATRAC, Particle Tracking Program," in "Proceedings of the Workshop on Accelerator Orbit and Particle Tracking Programs, May 3–6, 1982," Brookhaven National Laboratory informal limited distribution report BNL-31761, pp. 162–169 (1982).

A. Hilaire and A. Warman, "A Program for Single Particle Tracking," CERN internal report SPS/AMS 88-8 (1988).

Status: PATRAC was last modified in January 1989. This code is maintained and distributed, without charge, by A. Hilaire. It contains approximately 5000 lines of FORTRAN-77 source code. The program can be run on IBM/VM systems and Apollo workstations. The code contains some calls to the Graphic Kernel System (GKS) routines as well as calls to higher level routines from the CERN library and from NAGLIB that, in turn, call GKS routines. The part of the program that contains these calls to graphics routines is independent of the rest of the program and can be suppressed. A pseudo graphic alternative exists in the form of print commands. There is only one system call; it is for the creation of the metafile in graphics mode. A 16-page user's guide is available. The code is being distributed through the computer networks.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: nonlinear/higher order, tracking, stability, PC version

Abstract: PATRICIA is designed to track particles in circular accelerators in the presence of sextupoles and systematic multipoles. It tracks either individual particles or establishes dynamic aperture based on 400 particles. Tracking may include synchrotron oscillations and damping.

History: Written in 1976, PATRICIA is the first tracking code developed to study the stability of particles in highly nonlinear circular accelerators.

Authors: Helmut Wiedemann and Louis Emery, Stanford University, U.S.A., 1976 to present

References:

H. Wiedemann, "Users Guide for PATRICIA Version 85.5," Stanford Synchrotron Radiation Laboratory (SSRL) internal report ACD-NOTE 29 (May 1985).

H. Wiedemann, "Chromaticity Correction in Large Storage Rings," SLAC internal report PEP-NOTE 220 (September 1976).

S. Kheifets, "Tracking Studies in PEP and Description of the Computer Code PATRICIA," in "Proceedings of the Workshop on Accelerator Orbit and Particle Tracking Programs, May 3–6, 1982," Brookhaven National Laboratory informal limited distribution report BNL-31761, pp. 89–125 (1982); SLAC publication SLAC-PUB-2922 (May 1982).

Status: PATRICIA underwent a major revision in 1985. Minor modifications have been made since, as required. This code is maintained and distributed, without charge to national laboratories, by H. Wiedemann. It has 4972 lines of FORTRAN source code. There are about 100 known users. The code has been run on VAX/VMS and IBM/VM systems as well as IBM AT personal computers. The SSRL ACD-NOTE cited in the **References** section above can be considered as a user's guide. This program is being distributed through the computer networks and on 3.5-inch diskettes for IBM-compatible personal computers.

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PC - POISSON

Function: COMPONENT DESIGN: magnets, electrostatic/magnetostatic devices

Key Terms: ferrite/dielectric, PC version

Abstract: PC - POISSON is an IBM-compatible personal computer version of a code used in the design of magnets, high-voltage systems, and other two-dimensional applications of Poisson's equations with dielectrics and ferromagnetic materials. This program contains the familiar POISSON codes AUTOMESH, LATTICE, POISSON, and FORCE and provides extensive support for screen and hardcopy graphics.

History: PC - POISSON is a version of the original POISSON codes by Ronald Holsinger and Klaus Halbach that are maintained and distributed by the Los Alamos Accelerator Code Group, Los Alamos National Laboratory, U.S.A., with funding by the U.S. Department of Energy. S. Humphries, Jr., is responsible for the personal computer graphics support and menu organization.

Author: S. Humphries, Jr., Acceleration Consultants, U.S.A. (please refer to the **History** section above), 1988 to present

References: none

Status: PC - POISSON was last modified in March 1990. This code is maintained and distributed, for a fee of $585 (U.S.) for the site license, by S. Humphries, Jr. The graphics package supports several graphics screens, pen plotters, and laser printers. PC - POISSON runs on all IBM-compatible personal computers and will automatically sense a mathmatics coprocessor. Extensive examples are available on the diskette with the source code. A 60-page tutorial and complete documentation (portions of the POISSON Reference Manual and User's Guide, written by the Los Alamos Accelerator Code Group and used with their permission) are also supplied with the code. The executable code is being distributed on 5.25-inch (360-kilobyte or 1.2-megabyte) and 3.50-inch (720-kilobyte) diskettes for IBM-compatible personal computers, running the MS-DOS operating system.

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Functions: COMPONENT DESIGN: ion and electron sources, magnets, electrostatic and magnetic lens

Key Terms: eddy current, finite element, electromagnetic design

Abstract: The PE2D package consists of a suite of programs for electrical engineering design in two dimensions. The package includes a powerful preprocessing and postprocessing module linked to three finite-element analysis modules.

Geometric-data input is very easy, with automatic finite-element mesh generation, and material data can be either linear or nonlinear. The analysis modules use either first- or second-order triangular finite elements with selection by the user independent of the geometric data. PE2D analyses static fields as well as transient and steady-state AC fields. Comprehensive postprocessing facilities allow the results to be displayed in graphical or tabular form with error analysis for accuracy predictions.

History: PE2D originated at the Rutherford Appleton Laboratory, England, and has been further developed and marketed by Vector Fields, a company that distributes the code and provides support, including training, from offices in England and the U.S.A.

Authors: C.W. Trowbridge, S. Simkin, C.S. Biddlecombe, and M.J. Newman, Rutherford Applelon Laboratory, England, 1976 to present

References:

A.G.A.M. Armstrong and C.S. Biddlecombe, "The PE2D Package for Transient Eddy Current Analysis," *IEEE Transactions on Magnetics* **MAG-18**, 411–415 (1982).

C.S. Biddlecombe and J. Simkin, "Enhancements to the PE2D Package," *IEEE Transactions on Magnetics* **MAG-19**, 2635–2638 (1983).

"PE2D: CAE of Electromagnetic Devices," Vector Fields, Ltd., data reference sheet 118721 (1987).

Status: PE2D was last modified in August 1989. This code is maintained and distributed, for a fee, by Vector Fields, Ltd. A nonproliferation agreement is required. It has 121 000 lines of standard FORTRAN-77 source code. The code is being used at over 50 sites. The program has been run on VAX/VMS, IBM/CMS, Sun, and Apollo systems. A 108-page user's guide, a 135-page reference manual, examples, and an on-line help facility are available. This code is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: misalignment, closed orbit, synchrotron integrals

Abstract: PETROC computes betatron and dispersion functions as well as synchrotron frequencies. The code calculates the radiation integrals, damping partition numbers, beam emittances, bunch length, and energy spread. The effect of given or random distortions (misalignments) on the closed orbit and betatron motion is determined (with or without radiation losses). Different algorithms for correcting the orbit are included (amplitude minimization, successive bumps, and iterative method using a small number of correctors). In the presence of radiation losses and energy variations, the total orbit length is kept constant.

Authors: G. Guignard and Y. Marti, CERN, Switzerland

Reference: G. Guignard and Y. Marti, "PETROC User's Guide," CERN report CERN/ISR-BOM-TH/81-32 (1981).

Status: PETROC was last modified in August 1987. This code is maintained and distributed, without charge, by G. Guignard and Y. Marti. The code has approximately 7300 lines of FORTRAN-77 source code and about 30 known users. There is only one version of this program. It is for an IBM/VM/XA system. A 43-page user's guide (please refer to the citation in the **Reference** section above) and examples are available. The code is being distributed on magnetic tape reels and through the computer networks.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: misalignment, closed orbit, coupled motion

Abstract: PETROS performs all the computations of a fully coupled storage-ring optics system. Five-dimensional matrices are used throughout the code. The distorted closed orbit is found in the presence of magnet misalignments and field errors (prescribed or random), the sextupole fields, and the energy deviation of a considered particle.

With respect to the distorted closed orbit, the following items are calculated for electrons: the linear transformation matrices, the corresponding betatron and dispersion functions, the betatron and synchrotron frequencies, the radiation losses due to bending, the five synchrotron radiation integrals, the damping partition numbers, the damping times, the beam emittances, the bunch length, the relative energy spread, and the synchrotron lifetime. The momentum compaction factor, the linear chromaticities, and the compensation by the sextupoles are also calculated.

The code simulates closed orbit corrections and gives the corresponding kick amplitudes.

Author: Jörg Kewisch, Deutsches Elektronen-Synchrotron (DESY), Federal Republic of Germany

References:

G. Ripken, "Untersuchungen zur Strahlführung und Stabilität der Teilchenbewegung in Beschleunigern," Deutsches Elektronen-Synchrotron (DESY) report R1-70/4 (1970).

F. Willeke and G. Ripken, "Methods of Beam Optics," Deutsches Elektronen-Synchrotron (DESY) report DESY 88-114 (1988).

Jörg Kewisch, "Berechnung der linearen, gekoppelten Optik und der Strahlparameter," Diploma Thesis, Deutsches Elektronen-Synchrotron (DESY), 1977.

K. Steffen and J. Kewisch, "Study of Integer Difference Resonance in Distorted PETRA Optics," Deutsches Elektronen-Synchrotron (DESY) report PET-76/09 (1976).

B. Zotter, "A Short Guide for the Use of Program PETROS at CERN," CERN report LEP-70/37 (1978).

G. Guignard and Y. Marti, "Numerical Simulations of Orbit Correction in Large Electron Rings," in *Lecture Notes in Physics 215: Computing in Accelerator Design and Operation, Proceedings of the Europhysics Conference Held at the Hahn-Meitner-Institut für Kernforschung Berlin GmbH*, W. Busse and R. Zelazny, Eds. (Springer-Verlag, Berlin, New York, 1984), pp. 237–242.

Status: PETROS was last modified in June 1989. This code is maintained and distributed, without charge, by Jörg Rossbach. The code has approximately 10 000 lines of FORTRAN-77 source code and about 20 known users. The program has been run on VAX/VMS and IBM/MVS/XA systems. Although no formal documentation has been written, examples are available. The code is being distributed on magnetic tape reels and through the computer networks.

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PISCES

Function: COMPONENT DESIGN: RF cavities

Key Terms: impedance, optimization, finite element

Abstract: PISCES calculates a complete set of electromagnetic modes in an axisymmetric cavity. The finite-element method is used with up to third-order shape functions. Although two components are enough to express these modes, three components are used as unknown variables to take advantage of the symmetry of the element matrix. The unknowns are taken to be either the electric field components $\vec{E} = (E_r E_\phi E_z)$ or the magnetic field components $\vec{H} = (H_r H_\phi H_z)$. The zero-divergence condition is satisfied by the shape function within each element.

Author: Yoshihisa Iwashita, Institute for Chemical Research, Japan

Reference: Y. Iwashita, "Calculation of RF Fields in Axisymmetric Cavities," Los Alamos National Laboratory report LA-UR-85-1892 (May 1985).

Status: PISCES will not be supported until 1991. The code has approximately 5000 lines of FORTRAN source code. At this time, only a VAX/VMS version exists.

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Function: COMPONENT DESIGN: magnets

Key Terms: magnetic field, electric field

Abstract: POISSON - BNL contains major modifications to the AUTOMESH and LATTICE programs that are included in the original POISSON group of codes written by R. Holsinger and K. Halbach. With these modifications, the user has more control over the type of mesh to be generated; different mesh sizes can be used at any number of places anywhere in the problem's geometry. These improvements allow the user to describe the finer details of a complicated geometry with a reasonable number of mesh points. New curves have been added to define elliptical and multipole boundaries. Any arbitrary curve can be defined. In LATTICE, one can interactively correct any negative area triangles. In POISSON, one now has access to the intermediate results while the original run is progressing. This allows for more control over convergence. With these modifications, there is a lesser chance that a solution will diverge.

History: POISSON - BNL is derived from the 1981 version of the original POISSON codes written by Holsinger and Halbach and maintained by the Los Alamos Accelerator Code Group (LAACG).

Author: Ramesh C. Gupta, Brookhaven National Laboratory, U.S.A. (see **History** section above)

References:

R.C. Gupta, "Modifications in the AUTOMESH and other POISSON Group Codes," Brookhaven National Laboratory report BNL-38943 (1986); CONF-8510190-1.

R.C. Gupta, "Improved Mesh Generator for the POISSON Group Codes," in *Proceedings of the 1987 Particle Accelerator Conference: Accelerator Engineering and Technology, March 16–19, 1987, Washington, D.C.*, Eric R. Lindstrom and Louise S. Taylor, Eds., (IEEE, New York, 1987), IEEE catalog number 87CH2387-9, Vol. 3, pp. 1449–1451.

Status: POISSON - BNL was last modified in May 1989. This code is maintained and distributed, without charge, by R.C. Gupta. A nonproliferation agreement is required. The code has approximately 20 000 lines of FORTRAN source code. The program has only been run on a VAX/VMS system. Although there is no formal documentation, there are some examples available. The code is being distributed through the computer networks.

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POISSON - CERN (POISCR)

Function: COMPONENT DESIGN: magnets

Key Terms: ferrite/dielectric, elliptic boundary value problems

Abstract: POISSON - CERN (POISCR) is a finite-element triangular-mesh code that performs two-dimensional calculations for electrostatic, magnetostatic, and temperature distribution problems.

History: POISSON - CERN (POISCR) is derived from the original POISSON code (POISSON - LAACG) written by Ronald Holsinger, Klaus Halbach, and other associates at Lawrence Berkeley Laboratory. POISSON - LAACG was originally derived from a diffusion calculation code written by Alan Winslow at Lawrence Livermore National Laboratory. In the late sixties, Jim Spoerl at Lawrence Berkeley Laboratory modified this code to develop the TRIM codes MESH and FIELD. MESH constructed an irregular mesh to fit the geometry of the magnet and FIELD solved Poisson's equation for the potential function over the mesh. Holsinger, Klaus Halbach, and other associates at Lawrence Berkeley Laboratory made extensive changes to the TRIM codes and introduced the use of conformal transformations. They renamed the codes LATTICE, TEKPLOT, and POISSON. Holsinger worked at the Swiss Institute for Nuclear Research (SIN) and at CERN from 1973–1975. This is when the CERN version of the POISSON codes was developed.

Authors: Ronald Holsinger and Klaus Halbach, Lawrence Berkeley Laboratory, U.S.A.; Christoph Iselin, CERN, Switzerland

Reference: Ron Holsinger and Christoph Iselin, "Solution of Poisson's or Laplace's Equation in Two-Dimensional Regions," CERN long write up T604 (publication date is unavailable).

Status: POISSON - CERN (POISCR) was last modified in about 1980. This code is maintained and distributed, without charge to nonprofit organizations, by the CERN Program Library. Other organizations are expected to pay a small fee to cover the cost of supplying the program. The code has approximately 7000 lines of FORTRAN-77 source code. The program has been run on CYBER/NOS/BE and IBM/MVS systems. The current version runs on the IBM/CMS/XA system. It would not be a serious problem to run these codes on a CRAY, although there has been no particular effort in the direction of vectorization. The graphics calls are concentrated in one program. A CERN written GKS plot package is used. A 64-page user's guide is available. The code is being distributed on magnetic tape reels.

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POISSON - LAACG

Function: COMPONENT DESIGN: magnets

Key Terms: optimization, ferrite/dielectric

Abstract: POISSON - LAACG calculates static magnetic fields in two Cartesian dimensions or cylindrically symmetric configurations in three dimensions. The code solves electrostatic problems and will handle problems with permeable iron, but not permanent magnets. Permanent magnets are handled by the program PANDIRA. POISSON - LAACG uses an over-relaxation method to solve generalized Poisson's equation in two dimensions.

History: The POISSON/PANDIRA group of codes were originally derived from a diffusion calculation code written by Alan Winslow at Lawrence Livermore National Laboratory. In the late sixties, Jim Spoerl at Lawrence Berkeley Laboratory modified this code to develop the TRIM codes MESH and FIELD. MESH constructed an irregular mesh to fit the geometry of the magnet and FIELD solved Poisson's equation for the potential function over the mesh. Ronald Holsinger, Klaus Halbach, and other associates at Lawrence Berkeley Laboratory made extensive changes to the TRIM codes and introduced the use of conformal transformations. They renamed the codes LATTICE, TEKPLOT, and POISSON. Holsinger improved the existing codes and wrote the codes FORCE and MIRT with theoretical assistance from Klaus Halbach while he was at the Swiss Institute for Nuclear Research (SIN) and at CERN. Holsinger worked at Los Alamos National Laboratory from 1975 to 1977 developing the codes AUTOMESH, PANDIRA, and SUPERFISH, with Klaus Halbach's continued support. Holsinger left Los Alamos in 1977 and continued to update and maintain the programs until 1982. Since 1986, the Los Alamos Accelerator Code Group (LAACG) has received funding from the U.S. Department of Energy to maintain a standard version of these codes.

Authors: Ronald Holsinger, Lawrence Berkeley Laboratory, U.S.A., Swiss Institute for Nuclear Research, Switzerland, Los Alamos National Laboratory, U.S.A.; Klaus Halbach, Lawrence Berkeley Laboratory, U.S.A.

Reference: K. Halbach, "A Program for Inversion of System Analysis and Its Application to the Design of Magnets," Lawrence Livermore National Laboratory report UCRL-17436 (1967); CONF-670705-14.

Status: POISSON - LAACG was last modified in August 1988. A new version will be released in the latter part of 1990. This group of codes is maintained and distributed, without charge, by the Los Alamos Accelerator Code Group (LAACG).

The source and executable forms of this code are installed at Los Alamos National Laboratory and at the National Energy Research Supercomputer Center (NERSC), formerly NMFECC, at Lawrence Livermore National Laboratory, U.S.A. For more information about these files, contact Therese Barts, Los Alamos Accelerator Code Group. Her BITNET address is AT6TCB@LAMPF.

The POISSON/PANDIRA and SUPERFISH family of codes are distributed as a package. There are 10 source files containing approximately 19 500 lines of FORTRAN IV source code. Sample runs for all the programs are sent with the source code.

There are two versions currently being distributed. They are for VAX/VMS and a CRAY/CTSS (CFTLIB and FORTLIB) systems. The codes use the graphics package, PLOT10, written and owned by Tektronix. A 224-page user's guide, a 300-page reference manual, and examples are available. The code is being distributed on small seven-inch magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

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POISSON - LBL

Function: COMPONENT DESIGN: magnets

Key Terms: fringe field, special boundary condition, magnetic field

Abstract: POISSON - LBL replaces simple constant Neumann/Dirichlet boundary conditions by more general conditions expressible in the form of a series of harmonic functions giving the physically correct behavior of the potential at large distances. The code can handle the superposition of an externally applied field as well. The changes that were made to the original POISSON codes to create POISSON - LBL are described in the citations listed in the **References** section below.

History: POISSON - LBL is derived from the original POISSON code written by R. Holsinger and K. Halbach (POISSON - LAACG).

Authors: Shlomo Caspi, Mike Helm, and Jackson Laslett, Lawrence Berkeley Laboratory, U.S.A. (please refer to the **History** section above)

References:

S. Caspi, M. Helm, and L.J. Laslett, "Incorporation of a Circular Boundary Condition into the Program POISSON," Lawrence Berkeley Laboratory internal report LBL-17064 SSC-MAG-5 (February 1984).

S. Caspi, M. Helm, and L.J. Laslett, "The Generalization of a Circular Boundary Condition in the Program POISSON to Include No Symmetry and Axis-Symmetry of Revolution," Lawrence Berkeley Laboratory internal report LBL-18063 SSC-MAG-12 (July 1984).

S. Caspi, M. Helm, and L.J. Laslett, "Incorporation of an Elliptical Boundary Condition into the Program POISSON," Lawrence Berkeley Laboratory internal report LBL-18798 SSC-MAG-28 (December 1984).

S. Caspi, M. Helm, and L.J. Laslett, "Incorporation of Superposition into the Program POISSON," Lawrence Berkeley Laboratory internal report LBL-19050 SSC-MAG-31 (January 1985).

S. Caspi, M. Helm, and L.J. Laslett, "The Application of Program POISSON to Axially-Symmetric Problems – Magnetostatic and Electrostatic – with Use of Prolate Spheroidal Boundary," Lawrence Berkeley Laboratory internal report LBL-20893 SSC-MAG-68 (January 1986).

S. Caspi, M. Helm, and L.J. Laslett, "Numerical Solution of Boundary Condition to Poisson's Equation and its Incorporation into the Program POISSON," *IEEE Transactions on Nuclear Science* **NS-32**, 3722–3724 (1985).

S. Caspi, M. Helm, and L.J. Laslett, "Incorporation of Toroidal Boundary Condition in the Program POISSON," Lawrence Berkeley Laboratory internal report LBL-22985 (July 1987).

Status: POISSON - LBL is maintained and distributed, without charge, by Shlomo Caspi. The source code is written in FORTRAN. Although the original version was written for the HP1000, the program has been run on VAX/VMS, VAX/UNIX,

Sun/UNIX, and CRAY/CTSS (FORTLIB) systems. There is no documentation available that is specifically for POISSON - LBL. Documentation for the original POISSON codes will be helpful. The program is being distributed on magnetic tape reels.

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POISSON PC - BNL

Function: COMPONENT DESIGN: magnets

Key Terms: optimization, ferrite/dielectric, PC version

Abstract: POISSON PC - BNL calculates static magnetic fields in two Cartesian dimensions or cylindrically symmetric configurations. The code will handle problems with permeable iron but not permanent magnets. This version will only handle up to 4000 mesh points. This package includes the following codes: AUTOMESH, LATTICE, TEKPLOT, and POISSON.

History: Ronald Holsinger and Klaus Halbach wrote the original version of POISSON. It is now being distributed by the Los Alamos Accelerator Code Group (LAACG), Los Alamos National Laboratory, U.S.A. Judith Colman modified a 1985 version of this code so that it would run on IBM personal computers.

Author: Judith Colman, Brookhaven National Laboratory, U.S.A. (please refer to the **History** section above)

References: none

Status: POISSON PC - BNL is only modified when major bugs are discovered. It is distributed, without charge, by Judith Colman. The correct number of pre-formatted diskettes must be supplied. It has approximately 7000 lines of FORTRAN-77 source code. A Ryan-McFarland compiler was used to run the code, but it should work as well with Microsoft 4.1 and Leahy. The code requires a minimum of 640 kilobytes of memory, a math co-processor, and a DOS operating system. The code should run on IBM AT and PS2/60 machines as well as on most IBM clones. It should also compile readily on a VAX/VMS system. The documentation for the original version of the code should still be relevant for the description of data and other technical information in the personal computer version of the code. Examples and a brief description of the personal-computer-specific information are available. The code is being distributed on high- and low-density, 3.5-inch and 5.25-inch diskettes for IBM-compatible personal computers.

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Function: COMPONENT DESIGN: magnets

Key Terms: nonlinear/higher order, superferric, iron dominated

Abstract: POISSON - TAC is an improvement over the original code in that the magnetization table is accurately interpolated, the table truncation errors are avoided, and the input format for data is simpler. Imagine the field at a point in a magnet as given by the sum of contributions from each little element of magnetized iron plus a contribution from the currents. The field can be accurately calculated only if the magnetization is accurately known at each point. In the original POISSON, the magnetization is calculated by interpolating a table with the assumption that $1/\mu$ is a linear function of B^2 in each interval. It is now known that such an assumption produces errors as large as 5% in some intervals of the original POISSON internal table (1010 steel), which are larger than the experimental errors in the measurement of μ.[1] To solve this difficulty, a table with 195 points has been generated for 1008 steel using accurate interpolation techniques.[2] This table has been implemented as the internal table of POISSON - TAC. The points are so close that the assumption of $1/\mu \propto B^2$ does not introduce any appreciable errors and good field accuracy can be obtained. POISSON - TAC will issue a warning when truncation of the magnetization table occurs as a consequence of high fields during iteration. It has been shown that convergence to an incorrect solution takes place when truncation errors are present.[2] However, if truncation appears only during the initial iterations, convergence is to the correct solution.

History: POISSON - TAC is a modification of the original POISSON code (POISSON - LAACG) developed by R. Holsinger and K. Halbach.

Authors: W. Schmidt and S. Pissanetzky, Texas Accelerator Center, Texas A & M University, U.S.A. (see **History** section above)

References:

1. S. Pissanetzky, "The Interpolation of Magnetization Tables," *COMPEL International Journal for Computation and Mathematics in Electrical and Electronic Engineering* 5, 41–56 (1986).

2. R. Carcagno and S. Pissanetzky, "A Smooth Magnetization Table for 1008 Steel at 4.2K," Texas Accelerator Center report TAC–257/85 (1985).

Status: POISSON - TAC was last modified in January 1989. This code is maintained and distributed, without charge, by William Schmidt. It has approximately 10 000 lines of FORTRAN source code. There are two distributed versions of this program. One for a VAX/VMS system and one for a Sun/SunOS 4.x system requiring an FPS-264 floating point accelerator from Floating Point Systems. There are about 20 known users. The original POISSON documentation is available. The code is being distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: magnets

Key Terms: nonlinear/higher order, eddy current, three dimensions

Abstract: PROFI calculates the two- and three-dimensional magnetic fields for permanent magnets and two-dimensional eddy-current fields. Three-dimensional eddy current fields will be available in the near future. A combination of eddy current and temperature calculations can be handled. The finite-difference method is used instead of the finite-element method.

Author: W. Müller, Technische Hochschule Darmstadt, Federal Republic of Germany

References: W. Müller, W.-R. Novender, U. Hamm, J. Krueger, A. Jacobus, R. Winz, T. Weiland, and H. Euler, "Numerical Solution of 2- or 3-Dimensional Nonlinear Fields Problems by Means of the Computer Program PROFI," *Archiv für Elektrotechnik* **65**, 299–307 (1982).

A. Knoblauch and W. Müller, "Finite Difference Solution of 3-Dimensional Eddy-Current Distributions," *IEEE Transactions on Magnetics* **MAG-19**, 2393–2396 (November 1983).

Hp. Eulenberg and H. Thyssen, "Die rechnerunterstützte Auslegung eines Strahl-Choppers für Linearbeschleuniger," *Archiv für Elektrotechnik* **69**, 367–377 (1986).

E. Ch. Andresen, J. Heil, and S. Russenschuck, "Influence of Magnet Configurations and Dimensions on the Power Output of Synchronous Machines with Rare Earth Magnet Excitation," Proceedings ICEM Pisa, Italy (1988), Part 1, pp. 467–472.

M. Schäfer-Jotter and W. Müller, "Optimization of Electrotechnical Devices Using a Numerical Laboratory," COMPUMAG Conference, Tokyo, Japan, 1989.

S. Russenschuck and W. Müller, "Mathematical Optimization Techniques for the Design of Permanent Magnet Synchronous Machines Based on Numerical Field Calculation," COMPUMAG Conference, Tokyo, Japan, 1989.

M.P. Dobberstein, "Solution of Large Electrostatic Problems by Means of the Finite Difference Code PROFI," Deutsches Elektronen-Synchrotron report DESY M-89-01, pp. 1–23 (January 1989).

Status: PROFI is maintained and distributed, for a fee, by PROFI Engineering. It has approximately 240 000 lines of FORTRAN source code. The program has between 250 and 300 known users. The code has been run on VAX/VMS, VAX/UNIX, CRAY/CTSS (CFTLIB), IBM/MVS, IBM/MVS/XA, IBM/VM/CMS, and IBM/AIX systems as well as Sun, Apollo, and Hewlett-Packard workstations. There are eight documentation manuals (each approximately 150 pages long), a hot-line telephone service, and about 150 examples are available.

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Function: COMPONENT DESIGN: RF cavities

Key Terms: dispersion, resonant mode, periodic structure

Abstract: PRUD-W calculates eigenfrequencies and electromagnetic fields with and without azimuthal variation in axially symmetric cavities of arbitrary shape. It presents fundamental possibilities for obtaining the dispersion characteristics of periodic structures. The code uses a subspace iteration method with unconditional and fast convergence (independent of the initial approximation) and with the possibility of obtaining simultaneously up to 10 eigenvectors. Setting the phase advance and the number of vectors to be iterated, one can obtain points on several branches of dispersion characteristics. It also enables the user to calculate modes in H^- structures (RFQ in a two-dimensional approximation).

Authors: Yu. I. Portugalov, A.D. Ryabov, and A.G. Daikovsky, Institute for High Energy Physics, Serpukhov, U.S.S.R.

Reference: A.G. Daikovsky, Yu. I. Portugalov, and A.D. Ryabov, "PRUD-W: A New Code to Compute and Design Accelerating Structures," *Particle Accelerators* **20** (1) 23–43 (1986).

Status: PRUD-W is maintained by A.G. Daikovsky, but not distributed. The code is written in FORTRAN. The program has only been run on a ICL-1906A system. No documentation is available.

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QUICKTRAN

Function: BEAM DYNAMICS: synchrotrons/storage rings, beam transport

Key Terms: interactive, first-order, optimization

Abstract: QUICKTRAN is a simple interactive program used in the design of beam transport systems. Similar to a first-order version of TRANSPORT, it includes multiparameter optimization, geometry, phase-space acceptance, a complete set of correlations and excellent graphics output. QUICKTRAN has the same user interface, commands, and file structure as LATTICE and is maintained as a variant of LATTICE. The fundamental difference between the codes is that in QUICKTRAN, the beam is represented by a 6×6 σ matrix so that solenoids and rotations are correctly handled. Higher-order multipoles are not included in QUICKTRAN and are included in LATTICE only in the tracking module. Both Tektronix and Postscript graphics drivers are available and are included in the source code with the program.

History: QUICKTRAN was first written in 1988, borrowing ideas from both TRANSPORT and SYNCH. These codes have been developed through several versions and new features continue to be added.

Author: John Staples, Lawrence Berkeley Laboratory, U.S.A., 1976 to present

References:

John Staples, "LATTICE...A Beam Transport Program," Lawrence Berkeley Laboratory internal document, available from John Staples or Ed Sheena (September 1988).

John Staples, "QUICKTRAN...A Beam Transport Program," Lawrence Berkeley Laboratory internal document, available from John Staples or Ed Sheena (April 1988).

Status: QUICKTRAN and LATTICE were last modified in August 1989. These codes are maintained and distributed, without charge, by John Staples. QUICKTRAN has approximately 3300 lines of Pascal source language in addition to the drivers. The current version of the code has been designed to run on the VAX/VMS system. A 20-page user's guide/reference manual, an on-line help facility, and many sample files are available for QUICKTRAN. These codes are only being distributed through the computer networks.

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RACETRACK

Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: tracking, closed orbit, wigglers and undulators

Abstract: RACETRACK performs linear optics calculations. The code handles closed orbit distortions and corrections, tracking in thin magnet approximations (up to 20 poles), and the effect of wigglers and undulators on beam dynamics.

Author: Albin Wrulich, Sincrotrone Trieste, Italy

References: A. Wrulich, "RACETRACK — A Computer Code for the Simulation of Nonlinear Particle Motion in Accelerators," Deutsches Elektronen-Synchrotron (DESY) report DESY-84-026 (1984).

A. Wrulich, "The Simulation of Insertion Device Effects on Single Particle Motion with RACETRACK," Sincrotone Trieste report ST/M-88/12 (1988).

Status: RACETRACK was last modified in March 1989. This code is maintained and distributed, without charge, by Albin Wrulich. The source code is written in FORTRAN. The program has about 20 known users. There is only one distributed version of this program. It is for a VAX/VMS system. An updated description of the program can be found as comments in the program. The program documentation is the DESY report listed in the **References** section above. The code is being distributed on magnetic tape reels.

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Function: COMPONENT DESIGN: ion and electron sources

BEAM DYNAMICS: transport lines

Key Terms: tracking, PC version

Abstract: RAY is a two-dimensional interactive program that simulates ions and electrons within electrostatic and magnetostatic fields. Electrostatic potentials are calculated exactly. The program is menu-driven. High-resolution colored graphics are available. The code handles cylindrically symmetric geometries. This code has been replaced by the INP package by the same author.

Author: Peter Spädtke, Gesellschaft für Schwerionenforschung (GSI), mbH, Federal Republic of Germany

Reference: Presentation on low-energy ion beams, conference in Great Britain, 1986.

Status: RAY is not maintained, but it is available for distribution, without charge, by Peter Spädtke. The code is written in machine language for the Commodore C64 and C128. Documentation is available and may be obtained on request from the author. The program is being distributed on 5.25-inch diskettes for IBM-compatible personal computers.

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RAYTRACE

Function: BEAM OPTICS: spectrometers, beamlines, accelerators

Key Terms: nonlinear/higher order, fringe field, raytracing, PC version

Abstract: RAYTRACE is an ion-optical computer code that numerically integrates the particle differential equations of motion through real fields and can be used to trace rays one-by-one through a sequence of electromagnetic devices. The main types of elements that are presently supported include dipoles (six versions), multipoles (four through twelve poles), electrostatic deflector, velocity filter, lens, solenoid, accelerator section, and Einzel lens. For an ion-optical system with a symmetry plane, the accuracy of the trajectory calculations in this plane is comparable to the accuracy of the description of the electric and magnetic fields, i.e., RAYTRACE computes to essentially infinite order. The field components for trajectories off this median plane for dipoles are described by a fourth-order Taylor series; the field in off-axis multipoles is described by a Taylor series carried to at least fifth-order.

Users of RAYTRACE practically always start with TRANSPORT to determine first- and second-order parameters, the basic layout of the system. RAYTRACE is then used to fine-tune the system. First- and second-order parameters generally have to be readjusted slightly, and when dipoles are involved, there are also zeroth-order adjustments, i.e., centerline offsets. The major function of RAYTRACE, however, is to calculate higher-order aberrations in the optics and to aid in correcting these aberrations, whenever possible. The program does not have a built-in automatic fitting routine for minimizing image aberrations, etc., but it has been used as a subroutine for such programs.

Since the program traces one ray at a time, it is not readily adaptable to handle space-charge forces as they occur in systems with intense beams.

Authors: S. Kowalski and H. Enge, Massachusetts Institute of Technology, U.S.A.

Reference: S. Kowalski and H.A. Enge, "The Ion-Optical Program RAYTRACE," *Nuclear Instruments and Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors, and Associated Equipment* **A258** (3), 407 (1987).

Status: RAYTRACE is maintained and distributed, without charge, by S. Kowalski. The code has approximately 6500 lines of FORTRAN source code. The code has been run on VAX/VMS, VAX/UNIX, CRAY, and IBM systems as well as personal computers. An 80-page User's Guide is available. The program is being distributed on magnetic tape reels and through the computer networks.

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Function: BEAM OPTICS: spectrometers, beamlines, accelerators

Key Terms: nonlinear/higher order, fringe field, PC version

Abstract: RAYTRACE PC - BNL is an ion optics code that numerically integrates the particle differential equations of motion through real fields and can be used to trace rays one-by-one through a sequence of electromagnetic devices. For more detail, please refer to the RAYTRACE entry.

History: S. Kowalski and H. Enge, Massachusetts Institute of Technology, U.S.A., wrote the original version of RAYTRACE. Judith Colman modified this original version so that it would run on IBM personal computers, creating RAYTRACE PC - BNL.

Author: Judith Colman, Brookhaven National Laboratory, U.S.A. (please refer to the **History** section above)

References: none

Status: RAYTRACE PC - BNL is only modified when major bugs are discovered. It is distributed, without charge, by Judith Colman. The correct number of pre-formatted diskettes must be supplied. It has approximately 6500 lines of FORTRAN-77 source code. A Ryan-McFarland compiler was used to run the code, but it should work as well with Microsoft 4.1 and Leahy. The code requires a minimum of 640 kilobytes of memory, a math co-processor, and a DOS operating system. The code should run on IBM AT and PS2/60 machines as well as or most IBM clones. It should also compile readily on a VAX/VMS system. The documentation for the original version of the code should still be relevant for the description of data and other technical information in the personal computer version of the code. Examples and a brief description of the personal-computer-specific information are available. The code is being distributed on high- and low-density, 3.5-inch and 5.25-inch diskettes for IBM-compatible personal computers.

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RELAX3D

Function: COMPONENT DESIGN: cyclotron central region, electrostatic devices

Key Terms: three dimensions, electric field

Abstract: RELAX3D is a user-friendly interactive program that solves the Laplace/Poisson equation in a three-dimensional Cartesian or a two-dimensional cylindrical coordinate system with dielectrics (two-dimensional only) by the method of successive over-relaxation (finite difference). Problem cases are dynamically loaded from a user-written subroutine describing the geometry. Contour plots of the potential distribution along any slice can be produced.

Authors: H. Houtman, F. Jones, and C. Kost, TRIUMF, Canada

References: C.J. Kost and F.W. Jones, "RELAX3D: User's Guide and Reference Manual," TRIUMF design note, TRI-CD-88-01 (1988).

H. Houtman and C.J. Kost, "A FORTRAN Program (RELAX3D) to Solve the 3-Dimensional Poisson (Laplace) Equation," in *Lecture Notes in Physics 215: Computing in Accelerator Design and Operation, Proceedings of the Europhysics Conference held at the Hahn-Meitner-Institut für Kernforschung Berlin GmbH*, W. Busse and R. Zelazny, Eds. (Springer-Verlag, Berlin, New York, 1984), pp. 98–103.

Status: RELAX 3D was last modified in 1988. This code is maintained and distributed, without charge, by Corrie Kost. The program has approximately 12 000 lines of FORTRAN source code. It has about 20 known users. There is only one distributed version of this program. It is for a VAX/VMS system. A 46-page user's guide, examples, and an on-line help facility are available. This code is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: nonlinear/higher order, tracking, particle transmutation

Abstract: REVMOC is a second-order Monte Carlo beam-transport program that looks at the effects of multiple scattering, decay, nuclear scattering, and energy loss. The program cannot optimize beamline elements and is thus primarily used to perform detailed checks on a TRANSPORT-designed beamline. Aberration coefficients (transfer matrices) can be calculated for the full beamline.

Authors: W. Hsieh, P. Kitching, C. Kost, P. Reeve, and G. Stinson, TRIUMF, Canada

References: C.J. Kost and P.A. Reeve, "A Monte Carlo Beam-Transport Program, REVMOC," in *Lecture Notes in Physics 215: Computing in Accelerator Design and Operation, Proceedings of the Europhysics Conference held at the Hahn-Meitner-Institut für Kernforschung Berlin GmbH*, W. Busse and R. Zelazny, Eds. (Springer-Verlag, Berlin, New York, 1984), pp. 158–163.

C. Kost and P. Reeve, "REVMOC a Monte Carlo Beam Transport Program," TRIUMF design note TRI-DN-82-28 (1982).

Status: REVMOC was last modified in 1989. This code is maintained and distributed, without charge, by Corrie Kost. The code has approximately 14 000 lines of FORTRAN source code. It has approximately 10 known users. The program has been run on VAX/VMS and VAX/UNIX systems. A 60-page user's guide is available. The code is being distributed on magnetic tape reels.

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RFQLIB

Function: BEAM DYNAMICS: linacs

Key Terms: space charge/high current, nonlinear/higher order, particle-in-cell

Abstract: The RFQLIB system performs particle tracing simulations for RFQ linear accelerators. The particle equations of motion are numerically integrated using time as the independent variable. The forces on the particles are computed in two subroutines. Subroutine FOR computes the external electric forces of the RF field in the RFQ. The RFQ parameters are stored in a table as a function of the longitudinal coordinate. Interpolation is used to get the parameters at given values of the synchronous particle position. Subroutine SCFOR computes the space-charge forces by a particle-in-cell method using the electrostatic approximation. An $r - z$ Poisson solver is used with a conducting boundary at $r =$ const and with periodic boundary conditions in the z-direction. An important feature of RFQLIB is the availability of facilities to generate and maintain various versions of the code generated by the user.

Author: Walter P. Lysenko, Los Alamos National Laboratory, U.S.A.

References: W.P. Lysenko, "An RFQ Simulation Code," in "Proceedings of the 1984 Linear Accelerator Conference: Lufthansa-Schulungszentrum, Seeheim, May 7–11, 1984," N. Angert, Ed., Gesellschaft für Schwerionenforschung (GSI), mbH, report, Darmstadt GSI-84-11 (1984), pp. 327–329.

W. Lysenko, "The RFQ Simulation Code Library RFQLIB and Associated Codes," Los Alamos National Laboratory technical note AT6: ATN-84-1 (1984).

Status: RFQLIB was last modified in 1985. This code is maintained and distributed, without charge, by W. Lysenko. The code has approximately 2000 lines of FORTRAN source code. There is only one distributed version of this code. It is for a CRAY/CTSS (CFTLIB) system. A 30-page user's guide/reference manual is available. The code is being distributed on magnetic tape reels, .25-inch magnetic tape cartridges for Sun workstations, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: control, optimization, closed orbit

Abstract: RING is a modeling program that can be used off-line as a design program (e.g., SYNCH, MAD, etc.) or on-line as a control program. When RING is used as a control code, the program-microprocessor interface is specific to the installation.

The program has two major modules: one for tune and chromaticity optimization/control and one for orbit calculation/correction/control. The code uses MICADO's algorithm for minimizing the orbit displacements around the ring.

In addition to the standard lattice elements (drifts, bends, quadrupoles, and sextupoles), undulators can also be included. Edge focusing is calculated as in TRANSPORT. Chromaticity due to dipoles is calculated as in SYNCH.

Machine and beam parameters, synchrotron integrals, damping partitions, rate of change of damping partitions, energy spread, spatial beam size with and without coupling, bunch length, quantum and Touschek lifetime, etc., are calculated on demand.

Author: Eva S. Bozoki, Brookhaven National Laboratory, U.S.A.

References: Eva S. Bozoki, "High Level Control Programs at NSLS," in *Lecture Notes in Physics 215: Computing in Accelerator Design and Operation, Proceedings of the Europhysics Conference held at the Hahn-Meitner-Institut für Kernforschung Berlin GmbH*, W. Busse and R. Zelazny, Eds. (Springer-Verlag, Berlin, New York, 1984), pp. 420–424.

Eva Bozoki, "High Level Computer Control," Brookhaven National Laboratory informal report BNL-31361 (1982).

Eva Bozoki, "Front-End for the Ring Control Program," Brookhaven National Laboratory informal report BNL-35507 (1984).

Status: RING was last modified in 1988. This code is maintained and distributed, without charge, by Eva Bozoki. The code has approximately 6000 lines of FORTRAN source code. The program is being used by the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory. The code has been run on VAX/UNIX and Data General systems. Documentation is available, please refer to the **References** section above. The program is being distributed through the computer networks.

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RMKT

Function: COMPONENT DESIGN: power sources

Key Term: klystron, tracking

Abstract: RMKT is a large-signal klystron simulation code.

Authors: Bruce Carlsten and Paul Tallerico, Los Alamos National Laboratory, U.S.A.

References: P. Tallerico and B. Carlsten, "Computer Modeling of the Klystron," *IEEE Transactions on Nuclear Science* **NS-30**, 2170–2172 (1983).

B. Carlsten and P. Tallerico, "Self-Consistent Klystron Simulations," *IEEE Transactions on Nuclear Science* **NS-32**, 2837–2839 (1985).

B. Carlsten, "A Self-Consistent Numerical Analysis of Klystrons Using Large-Signal Beam-Wave Interaction Simulations," Ph.D. thesis, Stanford University (1985).

Status: RMKT was last modified in 1985. This code is not maintained, but it is being distributed, without charge, by Bruce Carlsten. The code has approximately 4000 lines of FORTRAN source code. There are three known users of the code. The program has been run on CRAY/CTSS (CFTLIB) and CYBER/LTSS systems. The documentation for this code is Bruce Carlsten's thesis, cited in the **References** section above. The program is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: linacs

Key Term: wakefield, beam breakup

Abstract: RWALL follows the transverse beam break-up of a high-current relativistic electron beam in a smooth pipe due to the resistive-wall instability. Variation of λ_β within a beam slice, along the beam, and along the beam-pipe can be accommodated.

The wake integral is computed using a fourth-order Gaussian algorithm that eliminates the singular resistive-wall wake potential. The z-advance uses a fourth-order Runge-Kutta algorithm.

The code is specifically configured to study the two-beam accelerator.

Author: David H. Whittum, Lawrence Berkeley Laboratory, U.S.A.

Reference: D.H. Whittum and A.M. Sessler, "Transverse Resistive Wall Instability in the Two-Beam Accelerator," Lawrence Berkeley Laboratory internal report, Collider Physics note 40, (unpublished but available from the author) (May 1988).

Status: RWALL was last modified in July 1989. This code is maintained and distributed, without charge, by David Whittum. The code has 1944 lines of FORTRAN source code. It has two known users. The code has only been run on a VAX/VMS system. Documentation is available from the author. The program is being distributed on 3.5-inch diskettes for Macintosh personal computers.

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Function: COMPONENT DESIGN: electron sources

Key Terms: space charge/high current, special boundary condition, electron gun

Abstract: SAM performs calculations for axially symmetric electron guns. The boundary integral equation method and current tubes model are used.

Author: M.A. Tiunov, Institute for Nuclear Physics, Novosibirsk, U.S.S.R.

References:

M.A. Tiunov, B.M. Fomel, V.P. Yakovlev, "Computer-Aided Electron Gun Design," Abstracts of XIII International Conference on High Energy Accelerators, Novosibirsk, 1986.

M.A. Tiunov, B.M. Fomel, V.P. Yakovlev, "SAM - The Interactive Program for Calculation of Electron Guns," Institute for Nuclear Physics, Novosibirsk, preprint 87-35 (1987).

Status: SAM was last modified in 1988. This code is distributed and maintained, without charge, by B.M. Fomel and M.A. Tiumov. A nonproliferation agreement is required. SAM has approximately 6000 lines of FORTRAN source code. It has 4 known users. The code has only been run on a PDP-11. Although there is no formal written documentation, examples and an on-line help facility are available. The program is being distributed on magnetic tape reels.

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Function: COMPONENT DESIGN: magnets

Key Terms: iron saturation, magnetic field

Abstract: SATDSK calculates the median-plane magnetic field due to fully saturated iron poletips. Optionally, SATDSK calculates the magnetic field due to disks of magnetic charge, which can simulate the effect of holes in the iron poletip or circular trim rods embedded in the poletip. SATDSK is intended for poletip geometries that are both symmetric about the median plane, and have azimuthal sector symmetry. Thus, the program is primarily designed to simulate the magnetic field due to iron poletips in superconducting cyclotrons.

Author: G.S. McNeilly, Oak Ridge National Laboratory, U.S.A.

Reference: Gregory S. McNeilly, "SATDSK: A Numerical Simulation of the Magnetic Field Due to Saturated Iron in Cyclotron Poletips," *Computer Physics Communications* **23**, pp. 199–207 (1981).

Status: SATDSK was last modified in 1981. It is not being maintained. The code is being distributed, for a nominal fee, by the Computer Physics Communications (CPC) Program Library. The distribution services of the Program Library are described in detail in the back of any CPC journal. The catalog number for this program is ABKI. The code has approximately 1200 lines of FORTRAN source code. This program has been run on VAX/VMS and IBM systems. The only documentation for this code that is available is listed in the **Reference** section above. This program is being distributed on magnetic tape reels, floppy disks for IBM-compatible personal computers, and through the computer networks.

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SCHAR

Functions: COMPONENT DESIGN: ion sources

BEAM DYNAMICS: general

Key Terms: misalignment, space charge/high current, three dimensions

Abstract: SCHAR traces macrofilaments or macroparticles through electromagnetic fields with or without space charge. Fields may be analytical or tabulated grid values. Input options for the particle distribution include: measured, Kapchinskij-Vladimirskij (KV), and four-dimensional or six dimensional phase space.

History: SCHAR was initially developed to predict space-charge effects in the Los Alamos Meson Physics Facility's H^+ injector line. Recently, it has been used for optical-pumped polarized ion source modeling.

Authors: R.J. Hayden and M.J. Jakobson, University of Montana, U.S.A.

References:

R.J. Hayden and M.J. Jakobson, "The Space Charge Computer Program SCHAR," *IEEE Transactions on Nuclear Science* **NS-30**, 2540–2542 (1983).

R.J. Hayden and M.J. Jakobson, "Macrofilament Simulation of High Current Beam Transport," *IEEE Transactions on Nuclear Science* **NS-32**, 2519–2521 (1985).

R.J. Hayden and M.J. Jakobson, *Nuclear Instruments and Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors, and Associated Equipment* **A258** (3), 536–541 (1987).

R.J. Hayden and M.J. Jakobson, "Shaping Solenoid Fields to Reduce Emittance Degradation of Polarized H^- Ion Beams," *Nuclear Instruments and Methods in Physics Research. Section A, Accelerators, Spectrometers, Detectors, and Associated Equipment* **A278** (2), 394–396 (1989).

Status: SCHAR was last modified in February 1989. This code is maintained and distributed, without charge, by R.J. Hayden and M.J. Jakobson. It has approximately 2000 lines of FORTRAN source code. It has 5 known users. The code has been run on VAX/VMS and CRAY systems. Although no formal written documentation is available, there are some examples. This program is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: linacs, synchrotrons/storage rings

Key Terms: space charge/high current, stability, particle-in-cell

Abstract: SCOP-2 is a two-dimensional (x, y Cartesian) particle-in-cell code used for space-charge-dominated beam-transport studies. This code has been used recently for resonance crossing studies in storage rings under space-charge-dominated conditions. SCOP-2 generates two-dimensional trajectories and performs tracking.

Authors: I. Bozsik and I. Hofmann, Institut für Plasmaphysik, Federal Republic of Germany

Reference: I. Bozsik and I. Hofmann, "Space Charge Effects in the Focusing of Intense Ion Beams," *Nuclear Instruments and Methods in Physics Research* **187**, 305–311 (1981).

Status: SCOP-2 was last modified in 1986. This code is not being maintained, but it is being distributed, without charge, by Ingo Hofmann. The source code is written in FORTRAN. The program has only been run on an IBM system. There is no documentation available. The program is being distributed on magnetic tape reels.

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SCOP-RZ

Function: BEAM DYNAMICS: linacs, synchrotrons/storage rings

Key Terms: stability, particle-in-cell, three dimensions

Abstract: SCOP-RZ is a particle-in-cell simulation code with three-dimensional trajectories and a two-dimensional Poisson solver ($r - z$). The program uses a conducting cylindrical pipe as a boundary condition. A user-defined impedance can be included. The code has been used to study RF bunching and the longitudinal microwave instability.

Authors: I. Bozsik and I. Hofmann, Institut für Plasmaphysik, Federal Republic of Germany

Reference: I. Hofmann and I. Boszik, Proceedings of the Symposium on Accelerator Aspects of Heavy Ion Fusion, Gesellschaft für Schwerionenforschung (GSI), mbH, Darmstadt, p. 181 (1982).

Status: SCOP-RZ was last modified in 1986. This code is not being maintained, but it is being distributed, without charge, by I. Bozsik and I. Hofmann. The source code is written in FORTRAN. This program has only been run on an IBM system. There is no documentation available. This code is being distributed on magnetic tape reels.

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Function: COMPONENT DESIGN: RF cavities

Key Terms: frequency calculation

Abstract: SHRIMP is a postprocessor for the program SUPERFISH. SHRIMP computes the cavity frequency by a variational technique, using the fields calculated by SUPERFISH. The frequency computed by SHRIMP has an error of $\delta f/f \propto 1/N^4$ for an $N \times N$ mesh. Thus, by using SHRIMP as a postprocessor, one can make the SUPERFISH mesh coarser and still obtain comparable accuracy in f.

Author: Robert D. Ryne, Los Alamos National Laboratory, U.S.A.

Reference: R.L. Gluckstern, R.D. Ryne, R.F. Holsinger, "Numerical Programs for Obtaining Accurate Resonant Frequencies of Modes in Azimuthally Symmetric Electromagnetic Cavities," in *COMPUMAG Conference on the Computation of Electromagnetic Fields Digest of Summaries: Genoa, Italy, 30 May, 2 June, 1983*, 141–143 (1983).

Status: SHRIMP was last modified in August 1985. This code is maintained and distributed, without charge, by Robert Ryne. SHRIMP has 1000 lines of FORTRAN source code. It has been run on CRAY/CTSS (CFTLIB and FORTLIB) systems. There is no graphical display of the code's calculations. A 13-page unfinished technical note serves as a user's guide. It is available from the code's author. The program is being distributed on magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks.

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SIMALAC

Function: BEAM DYNAMICS: linacs

Key Terms: misalignment, tracking

Abstract: SIMALAC is a particle-tracing code for stepped-beta linacs with quadrupole singlets or doublets between tanks. In a stepped-beta linac, all the cells in a tank are the same length. Alignment errors and field distribution errors may be included. Particle coordinates may be imported/exported from/to the PARMILA particle tracing code.

History: SIMALAC was developed by Kenneth R. Crandall to model the Los Alamos Meson Physics Facility's (LAMPF) 805-megahertz linac in 1970. Extensions and generalizations were added by G. Swain and others.

Authors: Kenneth R. Crandall and George R. Swain, Los Alamos National Laboratory, U.S.A.

References: none

Status: SIMALAC was last modified in February 1990. This code is maintained by George R. Swain. It is not available for distribution. SIMALAC has 3514 lines of FORTRAN IV source code converted to work with FORTRAN-77 compilers. It has three known users. There is only one version of this program. It is for a VAX/VMS system. A 43-page user's guide is available.

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Function: BEAM DYNAMICS: storage rings

Key Terms: stability, impedance, wakefield

Abstract: SIMTRAC is a simulation program for tracking longitudinal and transverse single-bunch effects in a circular electron machine, using N superparticles. The program includes damping, collective effects, beam-loading of RF cavities, and wakefields. Applications include the evaluation of bunch lengthening, thresholds for longitudinal and transverse instabilities, synchro-betatron resonances, and fit of an impedance model to reproduce either the measured tune shifts or the observed thresholds.

A typical run of 1000 superparticles can be followed for around 5000 turns. Output includes the beam dimensions after a user-defined number of turns, phase-space plots, and averages over a given number of turns.

Author: Daniel Brandt, CERN, Switzerland

Reference: D. Brandt, "SIMTRAC - A Simulation Program for Tracking Longitudinal and Transverse Single Bunch Effects," CERN internal report, LEP Note 512 (1984).

Status: SIMTRAC is maintained and distributed, without charge, by Daniel Brandt. SIMTRAC has approximately 2300 lines of FORTRAN source code. It is being used at 5 laboratories. The code currently runs on IBM/MVS, IBM/CMS, and IBM/XA systems. A 32-page user's guide and examples are available. This code is being distributed through the computer networks.

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SIXTRACK

Functions: COMPONENT DESIGN: magnets

BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: nonlinear/higher order, tracking, stability

Abstract: SIXTRACK is designed to perform long-term tracking, finding the dynamical aperture with the help of the Lyapunov exponent. This code treats the full six-dimensional phase space in a symplectic manner and acceleration can also be considered. One-turn maps can be calculated using M. Berz's Differential Algebra techniques.

History: SIXTRACK is based on the code RACETRACK, by Albin Wrulich, with only minor changes to the input structure. Fixed-format input is changed to free format input, etc.

Authors: Albin Wrulich, Deutsches Elektronen-Synchrotron (DESY), Federal Republic of Germany; Frank Schmidt, CERN, Switzerland

Reference: F. Schmidt, "SIXTRACK, Single Particle Tracking Code, Treating Transverse Motion with Synchrotron Oscillations in a Symplectic Manner," CERN internal report SL/90-11 (AP) (1988).

Status: SIXTRACK was last modified in May 1989. This code is maintained and distributed, without charge, by F. Schmidt. SIXTRACK has approximately 10 000 lines of FORTRAN source code. It has four known users. This code has been run on VAX/VMS and IBM systems. There are plans to install the code on an Apollo workstation. The CERN report, cited in the **Reference** section above, is the user's guide. This program is being distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: magnets

Key Term: eddy current

Abstract: SKIN performs eddy current calculations for axially symmetric systems. The equivalent circuits method is used.

Author: M.A. Tiunov, Institute for Nuclear Physics, U.S.S.R.

Reference: M.A. Tiunov, "The Evaluation Quasi-Static Magnetic Fields in Axially Symmetric Systems," Institute for Nuclear Physics (INP), Novosibirsk, preprint INP 82-59 (1982).

Status: SKIN was last modified in 1989. This code is maintained and distributed, without charge, by B.M. Fomel and M.A. Tiunov. A nonproliferation agreement is required. SKIN has approximately 2500 lines of FORTRAN source code. It has four known users. The code has only been run on a PDP-11/32 machine. Examples and an on-line help facility are available. This program is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: nonlinear/higher order, stability, spin polarization

Abstract: SMILE calculates radiative spin polarization (including higher-order depolarizing resonances) to arbitrary order. The program only treats linear orbital dynamics with arbitrary machine geometry including imperfections. SMILE uses perturbation theory to calculate spin action-angle variables of a ring, to arbitrary order in principle.

History: SMILE is an extension of an earlier code SLIM that calculates only first-order resonances. SMILE's name was chosen to reflect this fact. SLIM was written by A. W. Chao of Lawrence Berkeley Laboratory (LBL), U.S.A., and was optimized and reorganized by D. Barber and J. Kewisch, Deutsches Elektronen-Synchrotron (DESY), Federal Republic of Germany.

Author: Sateesh R. Mane, Cornell University, U.S.A.

Reference: S. R. Mane, "Electron-Spin Polarization in High-Energy Storage Rings. II. Evaluation of the Equilibrium Polarization," *Physics Review A* **36**, 120–130 (1987).

Status: SMILE was last modified in January 1990. SMILE is maintained by Sateesh R. Mane, Desmond Barber, and Hans Grote. It is being distributed, without charge, by Hans Grote. The code has approximately 5000 lines of FORTRAN source code. It has about 10 known users. The program has been run on VAX/VMS, VAX/UNIX, CRAY, and IBM/VM systems. Although there is no formal written documentation, there are some examples available. The code is being distributed through the computer networks.

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SNOW 2D

Function: COMPONENT DESIGN: ion sources

Key Terms: space charge/high current, nonlinear/higher order, optimization

Abstract: SNOW is a digital computer program that has been developed for the simulation of dense ion beams. The program simulates the plasma expansion cup (but not the plasma source itself), the acceleration region, and a drift space with neutralization, if desired. The ion beam is simulated by computing representative trajectories through the device. The potentials are simulated on a large rectangular matrix that is solved by iterative techniques. Poisson's equation is solved at each point within the configuration using space-charge densities computed from the ion trajectories combined with background electron and/or ion distributions.

History: The two-dimensional version of SNOW was brought to Los Alamos National Laboratory from Sandia National Laboratories by Robert Hamm, Medium Energy Physics (MP) Division, about 1978. The program was transferred to Accelerator Technology (AT) Division and a CRAY/CTSS (CFTLIB) version was installed in about 1983. This version of the code was "frozen" at that time. However, plotting routines, rms beam parameters, and post-processing programs have been added. From 1987 to the present, Jack Boers, VARIAN Associates, has extended the two-dimensional version to three dimensions.

Author: Jack E. Boers, Sandia National Laboratories, U.S.A.

Reference: Jack E. Boers, "SNOW - A Digital Computer Program for the Simulation of Ion Beam Devices," Sandia National Laboratories internal report SAND 79-1027 (1980).

Status: SNOW 2D is maintained and distributed, without charge, by Joe Sherman. Note that some changes have been made to the code recently that have not been documented. It may be difficult to run the code without personal help from someone who is familiar with the code. The code has approximately 2200 lines of FORTRAN source code. There are two versions available: a VAX/VMS and a CRAY/CTSS (CFTLIB). A 64-page user's guide, the SAND 79-1027 cited in the **Reference** section above, is available. The program is being distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: ion sources

Key Terms: space charge/high current, nonlinear/higher order, optimization

Abstract: SNOW 3D is a digital computer program that has been developed for the simulation of dense ion beams. The program simulates the plasma expansion cup (but not the plasma source itself), the acceleration region, and a drift space with neutralization if desired. The ion beam is simulated by computing representative trajectories through the device. The potentials are simulated on a large rectangular matrix that is solved by iterative techniques. Poisson's equation is solved at each point within the configuration using space-charge densities computed from the ion trajectories combined with background electron and/or ion distributions.

History: The SNOW program, two dimensional version, was brought to Los Alamos from Sandia Laboratories by Robert Hamm, Medium Energy Physics (MP) Division, in approximately 1978. The program was transferred to Los Alamos National Laboratory and installed on a CRAY/CTSS (CFTLIB) system about 1983. The version being maintained by AT-10 at Los Alamos was "frozen" at that time. However, plotting routines, rms beam parameters, and post-processing programs have been added. From 1987 to present, Jack Boers has extended the two-dimensional version to three dimensions.

Author: Jack E. Boers, Sandia National Laboratory, Varion-Extrion, U.S.A.

Reference: J.E. Boers, Rosmarie H. Frederickson, J. Sherman, and Ken Smith, 'Programmer's Manual for SNOW 3D," informal publication (April 1988).

Status: SNOW 3D is maintained and distributed, for a fee, by VARIAN Associates. Note that some changes have been made to the code recently that have not been documented. It may be difficult to run the code without personal help from someone who is familiar with the code. The program has approximately 10 000 lines of FORTRAN source code. A 70-page reference manual is available. The code is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: general

COMPONENT DESIGN: general

Key Terms: space charge/high current, particle-in-cell, three dimensions

Abstract: SOS is a three-dimensional, finite-difference, time- and frequency-domain, self-consistent particle-in-cell code for simulating physical processes. Powerful boundary conditions are included to represent structural geometries, material properties, incident and out-going electromagnetic waves, field emission, beam injection, and so forth. The algorithm in SOS has been used to analyze a variety of structures including coupled-cavity traveling wave tubes, klystron cavities, and helical structures. The code has often been used to compute the sensitivity of the cavity modes to various aspects of the device shape. The mode information has been used to compute dispersion curves and R/Q.

SOS is member of the MAGIC family of codes. SOS is not only a three-dimensional counterpart to the code MAGIC, but also includes three-dimensional frequency-domain capabilities. A description of the time-domain algorithm in SOS can be found in the description of the code MAGIC. The frequency-domain algorithm computes cavity response frequencies and their modes. The frequency-domain treats many, but not all, of the models available in the time-domain.

SOS handles Cartesian and cylindrical coordinates. It allows user-defined structure, symmetries, dielectrics, and some of the sub-grid models. It computes the lowest one to ten or more modes of a device. Symmetries, when available, can be used to simplify and accelerate the process substantially.

The name SOS is derived from the Self-Optimized-Sector memory management technique it uses for large problems. μSOS is a subset of SOS without particles.

Output capabilities from SOS are similar to MAGIC. A variety of plots (vector, range, trajectory, and phase-space) as well as time histories are available. Data may be dumped for further analysis with other codes.

Authors: Bruce Goplen, Gary Warren, and James McDonald, Mission Research Corporation, U.S.A.

References:

Bruce Goplen, James McDonald, and Gary Warren, "SOS Reference Manual Version October 1988," Mission Research Corporation final report MRC/WDC-R-190 (March 1989).

Bruce Goplen, Kevin Heaney, James McDonald, Gary Warren, and Richard Worl, "SOS User's Manual Version October 1988," Mission Research Corporation technical report MRC/WDC-R-158 (March 1989).

Gary Warren and Bruce Goplen, "SOS Exercise Workbook," Mission Research Corporation technical report MRC/WDC-R-205 (August 1989).

Bruce Goplen, Larry Ludeking, James McDonald, Gary Warren, and Richard Worl, "MAGIC User's Group," Mission Research Corporation technical report MRC/WDC-R-222 (October 1989).

L. Ludeking, G. Warren, J. McDonald, and B. Goplen, "POSTER User's Manual - Version May 1989," Mission Research Corporation technical report MRC/WDC-R-166 (May 1989).

Status: SOS was last modified in October 1989. The code is maintained by James McDonald and distributed, for a fee, by Bruce Goplen. A nonproliferation agreement is required. There are about 4 known users. SOS has approximately 70 000 lines of nearly standard FORTRAN-77 source code. The program has been run on VAX/VMS, VAX/ULTRIX, CRAY/COS, CRAY/CTSS (CFTLIB and FORTLIB), and CRAY/UNICOS systems. The code uses NCAR/GKS (National Center for Atmospheric Research/Graphic Kernel System) or DISSPLA graphics packages. A 275-page user's guide (MRC/WDC-R-158), a 220-page reference manual (MRC/WDC-R-190), a 50-page tutorial (MRC/WDC-R-205), and examples are available. The code is being distributed on streamer tape.

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Distributed by: Bruce Goplen
same address and phone number as above

Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: nonlinear/higher order, tracking, fringe field

Abstract: SOTRM numerically calculates the orbit of a reference ray and several infinitesimally displaced trajectories to evaluate the first- and second-order transformation matrices. The output format is suitable as input to the TRANSPORT program.

The magnetic field data can be stated as a one-dimensional array, a two-dimensional polar or rectangular array, or synthesized as the product of a radial and azimuthal field profile. Alternatively, several built-in field modules for drift space, bending magnet, quadrupole and sextupole magnets are also provided.

Author: Elon R. Close, Lawrence Berkeley Laboratory, U.S.A., 1970

References:

Elon R. Close, "SOTRM: A Program to Generate First- and Second-Order Matrix Elements by Tracking Charged Particles in a Specified Magnetic Field," Lawrence Livermore National Laboratory report UCRL-19823.

Elon R. Close, "Generation of First- and Second-Order Transformation Elements From a Given Magnetic Field," Lawrence Livermore National Laboratory report UCRL-19182.

John S. Colonias, *Particle Accelerator Design: Computer Programs*, (Academic Press, New York, London, 1974), pp. 194–203.

Status: SOTRM is maintained and distributed, without charge, by Arthur C. Paul. The source code is written in FORTRAN. The program has been run on CRAY/CTSS (FORTLIB) and Sun 3/75 systems. Although there is no formal written documentation, examples and an on-line help facility are available. The program is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: space charge/high current, tracking

Abstract: SPEAM VI calculates and plots the rms beam envelopes of a continuous nonrelativistic proton beam through various magnetic and electrostatic elements. Space-charge forces are included. Either the generalized Kapchinskij-Vladimirskij (KV) equations or those of Emigh may be used.

Authors: C. Kost and W. Joho, TRIUMF, Canada, 1973

References: W. John and C. Kost, "SPEAM a Computer Program for Space Charge Envelopes," TRIUMF design note TRI-DN-73-11 (1973).

L. Root, "Modifications to SPEAM," TRIUMF design note TRI-DN-74-31 (1974).

S. Foster and L. Root, "SPEAMTEK an Interactive Version of SPEAM," TRIUMF design note TRI-DN-74-32 (1974).

Status: SPEAM VI was last modified in 1986. It is maintained and distributed, without charge, by Corrie Kost. The code has approximately 2000 lines of FORTRAN source code. The program has less than ten known users. At this time, there is only a VAX/VMS version. An 18-page user's guide, TRIUMF design note TRI-DN-73-11, cited in the **References** section above, is available. The code is being distributed on magnetic tape reels.

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SUPERFISH - LAACG

Function: COMPONENT DESIGN: RF cavities

Key Terms: impedance, ferrite/dielectric

Abstract: SUPERFISH - LAACG evaluates the eigenfrequencies and fields for arbitrarily shaped two-dimensional waveguides in Cartesian coordinates and three-dimensional axially symmetric RF cavities in cylindrical coordinates. The package contains codes to generate the mesh, to plot the fields and to evaluate auxiliary quantities of interest in the design of drift-tube linacs. For example, transit-time factors, power losses, and the effect of perturbations are calculated.

History: Several of the programs in the SUPERFISH group of codes were originally derived from a diffusion calculation code written by Alan Winslow at Lawrence Livermore National Laboratory. For more information, please refer to the **History** section for the code POISSON - LAACG. Ronald Holsinger worked at Los Alamos National Laboratory from 1975 to 1977 developing, with Klaus Halbach's support, the codes AUTOMESH, PANDIRA, and SUPERFISH. Holsinger left Los Alamos in 1977 and continued to update and maintain the programs until 1982. Since 1986, the Los Alamos Accelerator Code Group (LAACG) has received funding from the U.S. Department of Energy to maintain a standard version of these codes.

Authors: Ronald Holsinger Lawrence Berkeley Laboratory, U.S.A., Swiss Institute for Nuclear Research, Switzerland, Los Alamos National Laboratory, U.S.A.; Klaus Halbach, Lawrence Berkeley Laboratory, U.S.A.

References: K. Halbach and R.F. Holsinger, "SUPERFISH – A Computer Program for Evaluation of RF Cavities with Cylindrical Symmetry," *Particle Accelerators* **7** (4), 213–222 (1976).

K. Halbach, R.F. Holsinger, W.E. Jule, and D.A. Swenson, "Properties of the Cylindrical RF Evaluation Code SUPERFISH," in "Proceedings of the 1976 Proton Linear Accelerator Conference September 14 to 17, 1976," S.O. Schriber, Ed., Chalk River Nuclear Laboratories report AECL-5677, pp. 122–128.

Status: SUPERFISH - LAACG was last modified in August 1988. A new version of the code will be released in the latter part of 1990. The code is being maintained and distributed, without charge, by the Los Alamos Accelerator Code Group. A nonproliferation agreement is required. The program is being distributed on small seven-inch magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required. For more information about the code, please refer to the **Status** section for POISSON - LAACG.

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Function: COMPONENT DESIGN: RF cavities

Key Terms: impedance, ferrite/dielectric, PC version

Abstract: SUPERFISH PC - BNL evaluates the eigenfrequencies and fields for arbitrarily shaped two-dimensional waveguides in Cartesian coordinates and three-dimensional axially symmetric RF cavities in cylindrical coordinates. The package contains codes to generate the mesh, to plot the fields, and to evaluate auxiliary quantities of interest in the design of drift-tube linacs. For example, transit-time factors, power losses, and the effect of perturbations are calculated. The package contains the following programs: AUTOMESH, LATTICE, TEKPLOT, SUPERFISH, and SFOUT.

History: Ronald Holsinger and Klaus Halbach wrote the original version of SUPERFISH. It is now being distributed by the Los Alamos Accelerator Code Group (LAACG), Los Alamos National Laboratory, U.S.A. Judith Colman modified a 1985 version of this code so that it would run on IBM personal computers.

Author: Judith Colman, Brookhaven National Laboratory, U.S.A. (please refer to the **History** section above)

References: none

Status: SUPERFISH PC - BNL is only modified when major bugs are discovered. It is distributed, without charge, by Judith Colman. The correct number of pre-formatted diskettes must be supplied. It has approximately 8400 lines of FORTRAN-77 source code. A Ryan-McFarland compiler was used to run the code, but it should work as well with Microsoft 4.1 and Leahy. The code requires a minimum of 640 kilobytes of memory, a math co-processor, and a DOS operating system. The code should run on IBM AT and PS2/60 machines as well as on most IBM clones. It should also compile readily on a VAX/VMS system. The documentation for the original version of the code should still be relevant for the description of data and other technical information in the personal computer version of the code. Examples and a brief description of the personal-computer-specific information are available. The code is being distributed on high- and low-density 3.5-inch and 5.25-inch diskettes for IBM-compatible personal computers.

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SUPERSAM

Function: COMPONENT DESIGN: electron sources

Key Terms: space charge/high current, electron gun

Abstract: SUPERSAM calculates axisymmetric electron guns with high beam compression. The finite-element method and current-tubes model are used.

Authors: D.G. Myakishev, M.A. Tiunov, and V.P. Yakovlev, Institute for Nuclear Physics, Novosibirsk, U.S.S.R.

References: none

Status: SUPERSAM was last modified in 1989. This code is maintained and distributed, without charge, by B.M. Fomel and D.G. Myakishev. A nonproliferation agreement is required. It has approximately 5000 lines of FORTRAN source code. This program was written to run on a PDP-11. Although no formal written documentation is available, there are examples and an on-line facility. The code is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: general

Key Terms: impedance, dispersion, wakefield

Abstract: SYBILLE is an interactive code that analytically calculates the synchro-betatron motion in the presence of wakefields (longitudinal) and dispersion in cavities. It works *between* and *on* resonances. The input data includes the angular position of cavities, voltage, frequency, twiss-parameters at cavity positions $(\alpha_y, \beta_y, \eta_y, \eta'_y)$, impedance (broad-band), sigma of bunch, etc. The output is the amplitude growth due to coupled synchro-betatron motion.

Authors: Johannes Hagel, CERN, Switzerland; Toshio Suzuki, National Laboratory for High Energy Physics (KEK), Japan

Reference: J. Hagel and T. Suzuki, "Analytic Theory of the Coupled Synchro-Betatron Motion in (Electron) Storage Rings," CERN, LEP Divisional report 88-57 (December 1988).

Status: SYBILLE was last modified in March 1989. This code is not maintained, but it is being distributed, without charge, by Johannes Hagel. It has approximately 1400 lines of FORTRAN source code. There is only one distributed version of this program. It is for CERN's IBM 3081/VM system. Some CERNLIB routines (Bessel functions) are used. An on-line help facility is available. This code is being distributed through the computer networks.

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SYMP3

Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: nonlinear/higher order, tracking, beam-beam interaction

Abstract: SYMP3 simulates the colliding beam dynamics in e^+e^- storage rings. The first version of the program did not incorporate sextupoles but showed some of the characteristics measured in various machines in the past. The focus of the present work is to understand the effects of sextupoles on these results. To accomplish this understanding, thin sextupoles are added in two ways. The first employs a linear-transfer/nonlinear-kick algorithm for each lattice cell. While this method is exact, it is slow for machine lattices with many sextupoles. The second method is to create a symplectic second-order transfer map for the entire machine. The luminosities, beam sizes, and tune shifts from these programs are calculated. In addition, the shapes of the time-averaged transverse distributions are obtained. The beam-beam interaction is accomplished each turn by first calculating the beam centroids and rms sizes, and then using this information to determine the transverse kicks received by each test particle. The bunch positions and sizes are output each turn. In addition, the test particles' positions are binned and accumulated in 1000 turn intervals.

Radiation excitation and damping are added to each test particle at each turn in order to maintain the initial (noncolliding) horizontal and vertical emittances. Since there are no energy oscillations, the contribution to the horizontal beam size from the horizontal off-energy function at the interaction region is replaced by additional betatron emittance.

Authors: Gerald P. Jackson, Fermi National Accelerator Laboratory, U.S.A.

Reference: G.P. Jackson and R.H. Siemann, "A Computer Simulation Study of e^+e^- Storage Ring Performance as a Function of Sextupole Distribution," *IEEE Transactions on Nuclear Science* **NS-32**, 2541–2543 (1985).

Status: SYMP3 was last modified in 1985. The program is not being maintained, it is *not* supported, but it is available. The code is not obsolete but it has been largely forgotten. The code has approximately 200 lines of FORTRAN source code and FPS Assembly language source code that would not be portable to other machines. The latest version has been optimized for the IBM supercomputer at Cornell University, U.S.A. The code has been designed to use the Floating Point System's FPS-164/264 vector subroutines. There are approximately ten users. The program is available on magnetic tape reels and through the computer networks.

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Function: BEAM DYNAMICS: synchrotrons/storage rings, beam transport

Key Terms: betatron functions, closed orbit, dispersion, lattice design

Abstract: SYNCH is used to design and to analyze synchrotrons, storage rings, and transport lines. Lattices are defined by statements describing the beamlines and their components: drifts, dipoles, quadrupoles, sextupoles, other beamlines, etc. Betatron functions and closed orbit distortions, due to momentum deviation or misalignments, can be obtained. Orbits and beam ellipses can be tracked. Emittances, damping time, etc., can be calculated.

Authors: Alper A. Garren, Ardith S. Kenney, Lawrence Berkeley Laboratory, U.S.A., 1960 to present

References: A.A. Garren, A.S. Kenney, E.D. Courant, and M.J. Syphers, "A User's Guide to SYNCH," (1985).

A.A. Garren, A.S. Kenney, E.D. Courant, M.J. Syphers, and A.D. Russell, 'SYNCH User's Manual," Superconducting Super Collider/Fermi National Accelerator Laboratory report (to be published) (1990).

Status: SYNCH was last modified in March 1990. The code is maintained by Ardith S. Kenney and distributed, without charge, by Ed Sheena and A.D. Russell. It has approximately 16 500 lines of ANSI standard FORTRAN-77 source code. This program has about 50 users. The code has been run on VAX/VMS, CRAY, CYBER, IBM systems as well as Sun workstations. Graphical output is currently available through the use of the DISSPLA graphics package; other options are being developed. A newly updated approximately 175-page user's guide is available (Fermi report cited in the **References** section above). The code is being distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: general

Key Terms: stability, impedance, wakefield

Abstract: By calculating wake fields, TBCI analyzes the electromagnetic interaction between bunched beams of charged particles moving through cylindrically symmetric cavities. The default Gaussian shape function for the bunch may be replaced by a shape of the user's choice.

There are several postprocessors for TBCI. WAKCOR subtracts a tube wake field from the total wake. WAKFLS reads fields and wakes as saved at every time step and does a Fourier transformation. WAKOUT reads the wake field, prints it, and calculates the impedance.

History: TBCI is an extension of a code called BCI, written by the same author. The extension allows the nonaxially symmetric mode to be calculated for axially symmetric structures.

Author: Thomas Weiland, Deutsches Elecktronen-Synchrotron (DESY), Federal Republic of Germany

References:

T. Weiland, "Transient Electromagnetic Fields Excited by Bunches of Charged Particles in Cavities of Arbitrary Shape," in *11th International Conference on High Energy Accelerators*, W.S. Newman, Ed. (Birkhäuser Verlag, Basel, 1980) pp. 570–575.

T. Weiland, "Transverse Beam Cavity Interaction," *Nuclear Instruments and Methods in Physics Research* **212**, 13–34 (1983).

Status: TBCI is maintained and distributed, generally for a nominal charge, by Thomas Weiland. It has approximately 20 500 lines of FORTRAN source code. Sample interfaces are available for the VAX/VMS, CRAY/CTSS (CFTLIB), CRAY/CTSS (FORTLIB), and IBM/MVS systems. Examples are sent as part of the package. This code is being distributed on magnetic tape reels.

Although one must get the source code directly from Thomas Weiland, the executable form of the code is installed at Los Alamos National Laboratory and the National Energy Research Supercomputer Center (NERSC), formerly NMFECC, at Lawrence Livermore National Laboratory, U.S.A. For more information about these executable files, contact Therese Barts, Los Alamos Accelerator Code Group (LAACG). Her BITNET address is AT6TCB@LAMPF.

A 16-page user's guide may be obtained from the Los Alamos Accelerator Code Group, Mail Stop H829, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, U.S.A.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: misalignment, nonlinear/higher order, tracking

Abstract: TEAPOT was developed for design work on the Superconducting Super Collider. It is a tracking code that treats all elements as thin elements. TEAPOT uses the same input format as the program MAD and then converts all thick elements to a user-defined number of thin ones. Tracking is exact and therefore symplectic. A Twiss analysis can be performed in the presence of multipole errors and misalignments. The tune and chromaticity can be fit to arbitrary values. All elements can be misaligned and rotated. Multipole field errors can be added to any element. Momentum offsets are handled exactly. Decoupling is available as well as orbit correction.

Authors: L. Schachinger, Central Design Group for the Superconducting Super Collider, U.S.A.; R. Talman, Central Design Group for the Superconducting Super Collider and Cornell University, U.S.A.; V. Paxson, Central Design Group for the Superconducting Super Collider and Lawrence Berkeley Laboratory, U.S.A.; and T. Sun, Central Design Group for the Superconducting Super Collider, U.S.A.

References: L. Schachinger and R. Talman, "TEAPOT: A Thin Element Accelerator Program for Optics and Tracking," *Particle Accelerators* **22** (1), 35–56 (1987).

Étienne Forest, "Lie Algebraic Maps and Invariants Produced by Tracking Codes," Superconducting Super Collider report SSC-78, (1986).

Status: TEAPOT was last modified in January 1989. The code is maintained and distributed, without charge, by L. Schachinger. It has approximately 12 000 lines of FORTRAN source code. A version in C is available with dynamic storage allocation. The code has about 30 users. The code has been run on VAX/VMS, VAX/UNIX, CRAY/CTSS (FORTLIB), Hewlett-Packard/UNIX, and Sun/UNIX systems. A 15-page users guide, a 100-page reference manual, and examples are available. The code is being distributed on .25-inch magnetic tape cartridges for Sun workstations written using the UNIX utility tar and through the computer networks.

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TOPAZ2D

Function: COMPONENT DESIGN: electrostatic/magnetostatic devices

Key Terms: nonlinear/higher order, finite element

Abstract: TOPAZ2D is a nonlinear finite-element code for electrostatic and magnetostatic analysis on planar and axisymmetric geometries. Material properties can be isotropic or orthotropic and can be nonlinear functions of the electric field or magnetic flux. Dirichlet and Neumann conditions can be specified on the boundaries. TOPAZ3D is available for three-dimensional electrostatic problems.

Author: A.B. Shapiro, Lawrence Livermore National Laboratory, U.S.A., 1982 to present

References: A.B.Shapiro, "TOPAZ2D, A Two-Dimensional Finite Element Code for Heat Transfer Analysis, Electrostatics, and Magnetostatics Problems," University of California report, Lawrence Livermore National Laboratory UCID-20824 (1986).

Status: TOPAZ2D was last modified in March 1990. The code is maintained, kept current, and distributed, with no charge, by Arthur B. Shapiro. It has approximately 7000 lines of ANSI standard FORTRAN-77 source code. The only exceptions are two to three system calls to clock, etc. The program has about 300 users. The code has been run on VAX/VMS, CRAY/CTSS, CRAY/UNICOS, and IBM/VM systems and should run on just about any UNIX system. The preprocessors and postprocessors for TOPAZ use the graphics package DIGLIB, developed at Lawrence Livermore National Laboratory, distributed with the processors, without charge. A 110-page user's guide and examples are available. The program is being distributed on magnetic tape reels.

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Function: COMPONENT DESIGN: electrostatic devices

Key Terms: nonlinear/higher order, three dimensions, finite element

Abstract: TOPAZ3D is a nonlinear finite-element code for electrostatic analysis on three-dimensional geometries. Material properties can be isotropic or orthotropic and can be nonlinear functions of the electric field. Dirichlet and Neumann conditions can be specified on the boundaries. TOPAZ2D is available for two-dimensional planar and axisymmetric geometries.

Author: A.B. Shapiro, Lawrence Livermore National Laboratory, U.S.A., 1982 to present

References: A.B. Shapiro, "TOPAZ3D — A Three-Dimensional Finite Element Heat Transfer Code," University of California report, Lawrence Livermore National Laboratory, UCID-20484 (1985).

Status: TOPAZ3D was last modified in March 1990. The code is maintained, kept current, and distributed, without charge, by Arthur B. Shapiro. It has approximately 7000 lines of ANSI standard FORTRAN-77 source code. The only exceptions are two to three system calls to clock, etc. The program has about 300 users. The code has been run on VAX/VMS, CRAY/CTSS, CRAY/UNICOS, and IBM/VM systems and should run on just about any UNIX system. The preprocessors and postprocessors for TOPAZ use the graphics package DIGLIB, developed at Lawrence Livermore National Laboratory, distributed with the processors, without charge. A 62-page user's guide and examples are available. The program is being distributed on magnetic tape reels.

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Function: COMPONENT DESIGN: ion and electron sources, magnets, RF cavities, general

Key Terms: nonlinear/higher order, three dimensions, electromagnetic field

Abstract: The TOSCA package is a well proven suite of programs for three-dimensional analysis of magnetostatic and electrostatic fields. The latest version of the package includes powerful preprocessing and postprocessing modules linked to an analysis module renowned for its accuracy and recently improved to reduce solution time using state-of-the-art finite-element techniques. The TOSCA method is to compute the total potential in the magnetic material and the reduced potential in the regions where source currents have been specified. The reduced potential represents only that portion of the field produced by magnetization, the remainder of the field is computed directly by source currents. By using this method, TOSCA avoids the drawbacks of other methods that rely on the difference between two large quantities. As a result, the accuracy of the TOSCA computation is far higher than alternative methods and is proven by many years of comparison with measured results.

History: TOSCA originated at the Rutherford Appleton Laboratory, England, and has been further developed and marketed by Vector Fields, a company that distributes the code and provides support, including training, from offices in England and the U.S.A.

Authors: C.W. Trowbridge and J. Simkin, Rutherford Appleton Laboratory, England, 1980 to present

References:

J. Simkin and C.W. Trowbridge, "Three-Dimensional Nonlinear Electromagnetic Field Computations, Using Scalar Potentials," *IEEE Proceedings* **127** (6), Part B, 368–374 (1980).

"TOSCA: 3D Electromagnetic Computations," Vector Fields, Ltd., data reference sheet 118711 (1987).

Status: TOSCA was last modified in August 1989. The code is maintained and distributed, for a fee, by Vector Fields, Ltd. A nonproliferation agreement is required. It has approximately 187 000 lines of ANSI standard FORTRAN-77 source code. The program is being used at over 60 sites. The code has been run on VAX/VMS, CRAY/COS, CRAY/UNICOS, and IBM/CMS systems as well as Sun and Apollo workstations. A 220-page user's guide, a 224-page reference manual, examples, and an on-line help facility are available. The program is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: space charge/high current, optimization, permanent magnet quadrupoles

Abstract: TRACE is an interactive, two-dimensional, first-order, envelope-tracing, beam-dynamics computer code with space charge. It includes some unique features as well as a number of elements not commonly found in other beam-transport programs, such as the permanent-magnet quadrupole (PMQ), RFQ, RF gap, accelerator column, and accelerator tank. The code also has a number of fitting capabilities, allowing almost any element parameter in the beamline to be varied, including space charge. TRACE calculations provide immediate graphic display, including the beam envelope and the phase-space ellipses in the transverse dimensions. The program is easy to use and contains its own help package that lists all instructions necessary for input, calculations, and graphic output.

History: The original version of TRACE was written in 1973 and was developed for use on the control computer for the accelerator at the Los Alamos Meson Physics Facility (LAMPF), U.S.A. It facilitated beam-transport calculations, starting with measured properties of the LAMPF beam, and served as an aid in tuning the beam transport. A modified version was written for the controls computer for the CERN linac in 1977; in 1979, the CERN version was adapted to the PIGMI controls system, and was used in tuning the transport for the test of the RFQ linac. Because of its usefulness as a design tool as well as a tuning aid, it was expanded and adapted for use on the CDC 7600 and the VAX-11/750 computers. For more information, please refer to the **History** section in the entries for the codes CCRTRACE and TRACE 3-D.

Authors: Kenneth R. Crandall and Dan P. Rusthoi, Los Alamos National Laboratory, U.S.A.

References: K.R. Crandall and D.P. Rusthoi, "TRACE: An Interactive Beam-Transport Code," in "Proceedings of the 1984 Linear Accelerator Conference: Lufthansa-Schulungszentrum, Seeheim, May 7–11, 1984," N. Angert, Ed., Gesellschaft für Schwerionenforschung (GSI), mbH, Darmstadt GSI-84-11 (1984), pp. 371–373.

K.R. Crandall, D.P. Rusthoi, "Documentation for TRACE: An Interactive Beam-Transport Code," Los Alamos National Laboratory report LA-10235-MS (1985).

Status: TRACE was last modified in April 1987. The code is maintained by Dan Rusthoi and distributed, without charge, by the Los Alamos Accelerator Code Group (LAACG). It has approximately 4600 lines of FORTRAN source code. Although the program has been run on CDC 6600 and CDC 7600 systems, there are only two distributed versions of TRACE. These versions are for the VAX/VMS and CRAY/CTSS (CFTLIB) systems. A 66-page user's guide and an on-line help facility is available. The code is being distributed on small seven-inch magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

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Function: BEAM DYNAMICS: linacs

Key Terms: space charge/high current, optimization, three dimensions

Abstract: TRACE 3-D is an interactive program that calculates the envelopes of a bunched beam (including linear space-charge forces) through a user-defined transport system. The transport system may consist of the following elements: drift, thin lens, quadrupole, permanent-magnet quadrupole (PMQ), solenoid, doublet, triplet, bending magnet, edge angle (for bend), RF gap, RFQ cell, RF cavity, coupled-cavity tank, coordinate rotation, and user-defined elements.

The beam is represented by a 6×6 σ-matrix (introduced by the TRANSPORT program) defining a hyperellipsoid in six-dimensional phase space. The projection of this hyperellipsoid on any two-dimensional plane is an ellipse that defines the boundary of the beam in that plane. Using a sequence of matrix transformations, the beam can be "followed" between any two elements. The user can change any parameter and observe the effect on the beam envelopes and on the output beam ellipses. Several matching options are available that determine values for the ellipse parameters or for specified transport-system parameters (such as quadrupole gradients) to meet specified objectives.

History: TRACE 3-D was derived from TRACE. TRACE is a two-dimensional (DC beam) code without coupling between x and y, using two two-dimensional transport matrices. TRACE 3-D is a three-dimensional (RF beam) version of TRACE with a six-dimensional transport matrix. TRACE 2-D, derived from TRACE 3-D, is a two-dimensional (DC beam) version of TRACE 3-D with a five-dimensional transport matrix.

Author: Kenneth R. Crandall, Los Alamos National Laboratory, AccSys Technology, Inc., U.S.A.

Reference: K.R. Crandall, "TRACE 3-D Documentation," Los Alamos National Laboratory report LA-11054-MS (August 1987).

Status: TRACE 3-D was last modified in the Spring of 1988. It is not currently being maintained although bugs have been fixed. It is being distributed, without charge, by the Los Alamos Accelerator Code Group (LAACG). It has 4,668 lines of FORTRAN source code. The program has more than 100 users. There are two versions of TRACE 3-D. One is for the CRAY/CTSS (CFTLIB) system and the other is an enhanced user-friendly version with an on-line help package for the VAX/VMS system. TRACE 3-D uses the graphics package, PLOT10, written and owned by Tektronix. The report, cited in the **Reference** section above, can be used as a user's guide and a reference manual. The document also contains examples. The code is being distributed on small seven-inch magnetic tape reels, TK50 magnetic tape cartridges, and through the computer networks. The requester is expected to supply the magnetic tape if a non-network transfer is required.

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TRACE 3-D PC

Function: BEAM DYNAMICS: linacs

Key Terms: space charge/high current, optimization, three dimensions, PC version

Abstract: TRACE 3-D PC is an interactive program that calculates the envelopes of a bunched beam (including linear space-charge forces) through a user-defined transport system. The transport system may consist of the following elements: drift, thin lens, quadrupole, permanent-magnet quadrupole (PMQ), solenoid, doublet, triplet, bending magnet, edge angle (for bend), RF gap, RFQ cell, RF cavity, coupled-cavity tank, coordinate rotation, and user-defined elements.

The beam is represented by a 6×6 σ-matrix (introduced by the TRANSPORT program) defining a hyperellipsoid in six-dimensional phase space. The projection of this hyperellipsoid on any two-dimensional plane is an ellipse that defines the boundary of the beam in that plane. Using a sequence of matrix transformations, the beam can be "followed" between any two elements. The user can change any parameter and observe the effect on the beam envelopes and on the beam ellipses that are provided as output. Several matching options are available that determine values for the ellipse parameters or for specified transport-system parameters (such as quadrupole gradients) to meet specified objectives.

History: TRACE 3-D was derived from TRACE. TRACE is a two-dimensional (DC beam) code without coupling between x and y, using two two-dimensional transport matrices. TRACE 3-D is a three-dimensional (RF beam) version of TRACE with a six-dimensional transport matrix. TRACE 2-D, derived from TRACE 3-D, is a two-dimensional (DC beam) version of TRACE 3-D with a five-dimensional transport matrix.

Author: Kenneth R. Crandall, Los Alamos National Laboratory, AccSys Technology, Inc., U.S.A.

References: K.R. Crandall, "TRACE 3-D Documentation," Los Alamos National Laboratory report LA-11054-MS (August 1987).

Status: TRACE 3-D PC is being maintained and distributed, for a nominal fee, by Kenneth R. Crandall. It has approximately 5000 lines of nearly standard FORTRAN-77 source code. This code should run on any IBM-compatible personal computer. The report cited in the **Reference** section above can be used as a user's guide and a reference manual. This document also contains examples. The code is being distributed on diskettes for IBM-compatible personal computers.

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Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: nonlinear/higher order, tracking, fringe field

Abstract: TRAJECTORY simultaneously integrates the equations of motion for a charged particle in a magnetic field and solves the differential equations for the ion optic matrix representing small motion about the paraxial trajectory. The orbit calculation is carried out in the median plane with the vertical transformation matrix calculated from a Taylor-series expansion of the magnetic field off the median plane. When the matrix is calculated in this manner, it is readily used with the ion-optic transport code, TRANSPORT. The trajectory data can be used to obtain internal target positioning for a given beamline.

Author: A.C. Paul, Lawrence Berkeley Laboratory, U.S.A.

References: A. C. Paul, "TRAJECTORY - An Orbit and Ion Optic Matrix Program for the 184-inch Cyclotron," Lawrence Berkeley Laboratory report UCRL-19407 (1969).

John S. Colonias, *Particle Accelerator Design: Computer Programs* (Academic Press, New York, London, 1974), pp. 203–210.

Status: TRAJECTORY is maintained and distributed, without charge, by A.C. Paul. The code is written in source language FORTRAN IV. The program has been run on the CRAY/CTSS (FORTLIB) system as well as the Sun 3/75 workstation. A 17-page user's guide, examples, and an on-line help facility are available. The code is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: transport lines

Key Terms: control, optimization, phase-space ellipse

Abstract: TRANCO provides a tool to examine and control transport lines in terms of beam and machine parameters, using the mathematical model of the system.

It is a modeling program that can be used off-line as a design program (e.g., TRANSPORT) or on-line as a control program. When TRANCO is used as a control program, the program-microprocessor interface is specific to the installation.

The program can perform ellipse matching (calculate/control the orientation and shape of the phase-space ellipses), ellipse positioning (calculate/control the position of the center of the phase-space ellipses), and beam steering.

A colored graphic display program for GENESCO GCT-300 display system is also available.

Although input data required for the lattice generation is read from files, TRANCO is an interactive program designed to facilitate the input of data using data validation procedures and default options.

Author: Eva S. Bozoki, Brookhaven National Laboratory, U.S.A.

References: Eva S. Bozoki, "High Level Control Programs at NSLS," in *Lecture Notes in Physics 215: Computing in Accelerator Design and Operation, Proceedings of the Europhysics Conference held at the Hahn-Meitner-Institut für Kernforschung Berlin GmbH*, W. Busse and R. Zelazny, Eds. (Springer-Verlag, Berlin, New York, 1984) 420–424.

Status: TRANCO was last modified in 1985. The code is maintained and distributed, without charge, by Eva Bozoki. It has approximately 2000 lines of FORTRAN source code. The code has only been run on a Data General machine. A 20-page user's guide that includes examples is available. The program is being distributed on magnetic tape reels and through the computer networks.

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Function: BEAM DYNAMICS: general

Key Terms: space charge/high current, tracking, optimization

Abstract: TRANSOPTR is a beam transport design code with parametric optimization in first- and second-order. In first-order calculations, space charge may be included either in two dimensions, treating transverse forces only, or in three dimensions, treating both transverse and longitudinal forces. In cases where space charge is not included, the standard matrix formalism is used. Space charge is treated by directly integrating the linear differential equations for the beam sigma matrix.

Authors: E.A. Heighway and M.S. de Jong, Chalk River Nuclear Laboratories, Canada

References: R.M. Hutcheon and E.A. Heighway, "TRANSOPTR — A Second-Order Beam Transport Design Code with Optimization and Constraints," *Nuclear Instruments and Methods in Physics Research* **187**, 89–95 (1981).

M.S. de Jong and E.A. Heighway, "A First Order Space Charge Option for TRANSOPTR," *IEEE Transactions on Nuclear Science* **NS-30**, 2666–2668 (1983).

E.A. Heighway and M.S. de Jong, "TRANSOPTR — A Beam Transport Design Code with Space Charge, Automatic Internal Optimization and General Restraints," Chalk River Nuclear Laboratories report AECL-6975, Revision A (June 1984).

Status: TRANSOPTR is maintained and distributed, without charge, by M.S. de Jong. The code has approximately 3000 lines of FORTRAN source code. The program has been run on a CDC-900/NOS/VE system. A 56-page user's guide (AECL-6975, cited in the **References** section above) is available. The preferred method of distribution for this code is through the computer networks. It is also being distributed on standard 5.25-inch personal computer diskettes for IBM-compatible personal computers.

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TRANSPORT PC - BNL

Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, optimization, matrix representation, PC version

Abstract: TRANSPORT PC - BNL is a beamline transfer-matrix calculation and fitting program. It calculates floor coordinates, beam matrix, and first- and second-order transfer matrices. Elements include arc-bending-magnet, quadrupole, sextupole, octupole, solenoid, and accelerating cavity. The program can simulate misalignments, beam steering, and random errors for any beamline parameter. This program uses an input format that is very similar to the input formats used in the programs TURTLE, DECAY TURTLE, and MAD. These programs use the same format for the beamline specification. This version of TRANSPORT includes TRPLOT.

History: David C. Carey, Fermi National Accelerator Laboratroy, U.S.A., wrote the original version of TRANSPORT (please refer to the **History** section for TRANSPORT - FERMI). Judith Colman modified this original version so that it would run on IBM personal computers, creating TRANSPORT PC - BNL.

Author: Judith Colman, Brookhaven National Laboratory, U.S.A. (see the **History** section above)

References: none

Status: TRANSPORT PC - BNL is only modified when major bugs are discovered. It is distributed, without charge, by Judith Colman. The correct number of pre-formatted diskettes must be supplied. It has approximately 25 000 lines of FORTRAN-77 source code. A Ryan-McFarland compiler was used to run the code, but it should work as well with Microsoft 4.1 and Leahy. The code requires a minimum of 640 kilobytes of memory, a math co-processor, and a DOS operating system. The code should run on IBM AT and PS2/60 machines as well as on most IBM clones. It should also compile readily on a VAX/VMS system. The documentation for the original version of the code should still be relevant for the description of data and other technical information in the personal computer version of the code. Examples and a brief description of the personal-computer-specific information are available. The code is being distributed on high- and low-density, 3.5-inch and 5.25-inch diskettes for IBM-compatible personal computers.

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Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, optimization, matrix representation

Abstract: TRANSPORT - FERMI is a beamline transfer-matrix calculation and fitting program. It calculates floor coordinates, beam matrix, and first-, second-, and some third-order transfer matrices. Elements include arc-bending-magnet, quadrupole, sextupole, octupole, solenoid, and accelerating cavity. The program can simulate misalignments, beam steering, and random errors for any beamline parameter. This program uses an input format that is very similar to the input formats used in the programs TURTLE, DECAY TURTLE, and MAD. All four programs use the same format for the beamline specification.

History: The original version of TRANSPORT was written in BALGOL in the early 1960's by Chuck Moore, Hal Butler, and Sam Howry at SLAC. It was translated into FORTRAN by Stan Kowalski at the Massachusetts Institute of Technology (MIT) around 1965. Improvements in the late 1960's were made by Barbara Kear at SLAC. From 1972 to the present, it has been maintained and developed by David C. Carey at Fermi National Accelerator Laboratory. Several significant contributions during this period were made by Christoph Iselin at CERN.

Authors: David C. Carey, Fermi National Accelerator Laboratory, U.S.A.; Christoph Iselin, CERN, Switzerland, early 1960's to present (please refer to the **History** section above).

References: Karl L. Brown, "TRANSPORT/360 a Computer Program for Designing Charged Particle Beam Transport Systems," Stanford Linear Accelerator Center report SLAC-91, revision 2 (May 1977), also Fermi National Accelerator Laboratory report NAL-91.

K.L. Brown, F. Rothacker, D.C. Carey, and Ch. Iselin, "TRANSPORT: A Computer Program for Designing Charged Particle Beam Transport Systems," CERN report CERN 80-04 (May 1977).

D.C. Carey, "Third-Order TRANSPORT with MAD Input," Fermi National Accelerator Laboratory report TM-1546 (September 1988).

Status: TRANSPORT - FERMI was last modified in March 1989. This code is maintained and distributed, without charge, by David C. Carey. There is a nominal charge (about $100 U.S.) to cover the cost of processing a tape, if that is required. It has approximately 25 000 lines of nearly standard FORTRAN-77. The code has been run on VAX, CYBER, and IBM machines. The only system library call is for the initialization of a random-number sequence for error simulation. No graphics packages are used, but work in that area is under way. There are at least hundreds of TRANSPORT - FERMI users. The reports cited above can be used as documentation. The first report that is cited, SLAC-91, is 125 pages long and the second report, TM-1546, is 61 pages long. The code is being distributed on magnetic tape reels and through the computer networks.

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Function: BEAM DYNAMICS: spectrometers/transport lines, beam transport

Key Terms: misalignment, space charge/high current, six dimensions

Abstract: TRANSPORT - LBL calculates properties of charged-particle beam transport systems using the matrix method in a six-dimensional phase space.

This version of TRANSPORT reflects some improvements over the original version of TRANSPORT from SLAC (now TRANSPORT - FERMI). TRANSPORT - LBL includes many additional elements, options, and procedures that are documented. Some of these important additions are the ability to transform polygons, perform ray tracing, separate particles, handle space charge, create plots, perform interactive on-line calculations, and manage flexible data manipulations.

History: The original version of TRANSPORT was written in the early 1960's by Hal Butler, Chuck Moore, and Sam Howry at SLAC, in the source language BALGOL. It was translated into FORTRAN IV by A.C. Paul in 1975.

Author: Arthur C. Paul, University of California, Los Angeles, U.S.A.

References: A. C. Paul, "TRANSPORT, an Ion Optic Program, LBL Version," Lawrence Berkeley Laboratory report LBL-2697 (1975).

John S. Colonias, *Particle Accelerator Design: Computer Programs* (Academic Press, New York, London, 1974), pp. 140–164.

Status: TRANSPORT - LBL was last modified in 1978. The code is maintained and distributed, without charge, by A.C. Paul. It has 12 740 lines of FORTRAN IV source code. This version of the code has been run on a CRAY/CTSS (FORTLIB) system and a Sun 3/75 workstation. A 173-page user's guide (LBL-2697, cited in the **References** section above) and examples are available. The program is being distributed on magnetic tape reels.

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TRANSVRS

Function: BEAM DYNAMICS: linacs

Key Terms: impedance, wakefield

Abstract: TRANSVRS calculates the frequencies and R/Qs of a large number of deflecting modes in a simple disk-loaded structure. Using these results, one can calculate the transverse wakefield forces generated by an ultra-relativistic bunch.

Authors: Karl Bane, SLAC, U.S.A.; and Bruno Zotter, CERN, Switzerland, 1980.

References: K. Bane and B. Zotter, "Transverse Modes in Periodic Cylindrical Cavities," in *11th International Conference on High Energy Accelerators*, W.S. Newman, Ed. (Birkhäuser Verlag, Basel, 1980) pp. 581–591.

Status: TRANSVRS was last modified in 1980, it is in its original form. The code is being distributed, without charge, by Karl Bane. It has approximately 2500 lines of FORTRAN source code. It was written for an IBM/CMS/VM system. There is no formal written documentation, but input is simple. The code is being distributed through the computer networks.

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Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: control

Abstract: TRBEJ corrects beam trajectories along complicated beam transport systems. Using the data from the beam position monitors and the information on the magnetic structure of the lattice, all necessary corrections to the values of currents can be calculated. The statistical problem of finding these corrections is solved using the least-squares technique. TRBEJ has been used in the proton ion control system of the synchrotron at the Institute for High Energy Physics.

Authors: A.G. Afonin and B.S. Volkov, Institute for High Energy Physics (IHEP), U.S.S.R.

References: A.G. Afonin, B.S. Volkov, A.V. Maximov, et al., "Correcting the Fast and Slow Extraction Trajectories at IHEP Proton Synchrotron." in *Proceedings of the VIth All-Union Seminar*, 12-15 April, 1987, Zvenigorod, Moscow, 1987.

Status: TRBEJ was last modified in 1988. The code is maintained by B.S. Volkov. It is not available for distribution. The program is written in FORTRAN. The code has only been run on an SM-4 machine. A 5-page reference manual has been written.

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TRESCA

Function: COMPONENT DESIGN: magnets

Key Terms: three dimensions, special boundary condition, iron saturation

Abstract: The new code TRESCA implements the hybrid FEM-BEM method that enables one to compute typical accelerator magnets in two and three dimensions with open boundary conditions, high fields, and iron saturation. The code is designed for computers having a throughput of approximately 1 megaflop and limited core storage. The program takes three to ten minutes to solve two-dimensional problems and two to four hours to solve a problem in three-dimensions. This interactive code was designed to be easy to use.

Authors: S.Yu. Ershov, A.D. Ryabov, and A.G. Daikovsky, Institute for High Energy Physics (IHEP), U.S.S.R.

References: (authors' names are unavailable), "TRESCA: A New Code for 2D and 3D Magnetostatic Problems," COMPUMAG Conference, Tokyo, Japan, 1989.

Status: TRESCA is maintained and distributed, for a fee, by A.G. Daikovsky. It has approximately 25 000 lines of FORTRAN source code. The program was written to run on a VAX/VMS system.

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Function: COMPONENT DESIGN: magnets

Key Term: eddy current

Abstract: TRIDIF is a time-dependent diffusion version of the well-known PANDIRA-POISSON-TRIM triangular-mesh magnet code. Modifications allow TRIDIF to treat field diffusion in materials with time-varying permeabilities. Good agreement between the measured and computed magnetic fields was found for a simple test experiment.

Author: J.R. Freeman, Sandia National Laboratories, U.S.A., 1980 to present

References: J.R. Freeman, "TRIDIF, a Triangular Mesh Diffusion Code," *Journal of Computational Physics (U.S.A.)* **41** (1), 142–153 (May 1981).

M.L. Hodgdon and J.R. Freeman, "Transient Magnetic-Field Calculations with TRIDIF," Sandia National Laboratory report number SAND 81-2001C (1981); CONF-810954-1.

Status: TRIDIF is maintained by Rebecca S. Coats. The code is being distributed, without charge, by J.R. Freeman and Rebecca S. Coats. It has approximately 10 000 lines of FORTRAN source code. TRIDIF has about six users. The program was written to run on the CRAY/CTSS (CFTLIB) system. TRIDIF has a postprocessor that produces contour plots. This postprocessor uses the graphics package WEASEL that was written at Sandia National Laboratories and is available free of charge. If requested, WEASEL can be included in the TRIDIF package or it is available by contacting Peter Watterberg at PAWATTE@SANDIA.GOV. There are only a handful of very basic calls to this package so the translation to another graphics package would be a relatively easy job. Although there is no formal written documentation, there are a few examples. The code is being distributed on magnetic tape reels.

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Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: nonlinear/higher order, fringe field, dispersion

Abstract: TRIO has been mainly used for mass spectrometer design. The code calculates the third-order ion trajectory by transfer matrix method for any system consisting of drift space, cylindrical and toroidal electric sector and quadrupole and homogeneous/inhomogeneous magnetic sector and quadrupole. The fringing field effect is taken into consideration.

Authors: T. Matsuo, H. Matsuda, and Y. Fujita, College of General Education, Osaka University, Japan; and H. Wollnik, University of Gießen, Federal Republic of Germany

References: T. Matsuo, H. Matsuda, Y. Fujita, H. Wollnik, "Computer Program TRIO for Third-Order Calculation of Ion Trajectory," *Mass Spectroscopy* **24**, 19–61 (1975).

Status: TRIO was last modified in 1975. The code is maintained and distributed, for a nominal fee to cover postage, by T. Matsuo. A nonproliferation agreement is required and acknowledgement is requested when any paper is published using information derived through the use of this code. The program is written in FORTRAN. It has about 50 users. The code was written to run on an IBM system. An eight-page user's guide and examples are available. The program is being distributed on magnetic tape reels.

Maintained and Distributed by: Takekiyo Matsuo
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Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, optimization, PC version

Abstract: TROPIC stands for **TR**ansport **OP**timization with Interactive Calculation. TROPIC is a first-order version of TRANSPORT with on-line graphics and the ability to change parameters and constraints interactively.

Author: Judith Colman, Brookhaven National Laboratory, U.S.A.

References: none

Status: TROPIC is maintained and distributed, without charge, by Judith Colman. The correct number of pre-formatted diskettes must be supplied. It has approximately 25 000 lines of FORTRAN-77 source code. A Ryan-McFarland compiler was used to run the code, but it should work as well with Microsoft 4.1 and Leahy. The code requires a minimum of 640 kilobytes of memory, a math co-processor, and a DOS operating system. The code should run on IBM AT and PS2/60 machines as well as IBM clones. It should also compile readily on a VAX/VMS system. EGA or HERCULES versions are available. Documentation is available. Examples and a brief description of the personal-computer-specific information are available. The code is being distributed on high- and low-density, 3.5-inch and 5.25-inch diskettes for IBM-compatible personal computers.

Maintained and Distributed by:

Judith Colman
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Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, tracking

Abstract: TURTLE simulates single-pass charged-particle beam lines and spectrometers. The program includes geometric terms and all-order chromatic effects for individual quadrupoles, bending magnets, sextupoles, and solenoids. The code accumulates effects regardless of order. The user can specify one- and two-dimensional histograms of particle coordinates at any beamline location. This program uses an input format that is very similar to the input formats used in the programs DECAY TURTLE, TRANSPORT, and MAD. All four programs use the same format for the beamline specification.

Author: David C. Carey, Fermi National Accelerator Laboratory, U.S.A., 1971 to present

Reference: D.C. Carey, "TURTLE (Trace Unlimited Rays Through Lumped Elements A Computer Program for Simulating Charged Particle Beam Transport Systems," Fermi National Accelerator Laboratory report NAL-64 (May 1978).

Status: TURTLE was last modified in November 1989. This code is maintained and distributed, without charge, by David C. Carey. There is a nominal charge (about $100 U.S.) to cover the cost of processing a tape, if that is required. It has approximately 16 000 lines of nearly standard FORTRAN-77. This program has been run on CYBER, IBM, and CDC machines. The only system call is to initialize a random-number sequence for error simulation. No graphics package is used. There are probably hundreds of TURTLE users. The only documentation is the 45-page report cited above. This code is being distributed on magnetic tape reels and through the computer networks.

Maintained and Distributed by:

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Function: BEAM DYNAMICS: general

Key Terms: nonlinear/higher order, tracking, PC version

Abstract: TURTLE-PC is a version of TURTLE modified to write a file describing particles at specific points along the beamline and to keep statistics on the number of particles lost at each point along the beamline. TURTPLOT is a graphics code for EGA-board personal computers to generate scatter plots ($X - X', Y - Y'$, and $X - Y$) from the TURTLE-PC output file. The code also plots the X and Y distributions. More plot types may be added. Both TURTLE-PC and TURTPLOT are still being developed but the current versions are operational.

History: TURTLE-PC is derived from the original version of TURTLE written by David C. Carey, Fermi National Accelerator Laboratory, U.S.A.

Author: Judith Colman, Brookhaven National Laboratory, U.S.A. (please refer to the **History** section above)

References: none

Status: TURTLE-PC is maintained and distributed, without charge, by Judith Colman. The correct number of pre-formatted diskettes must be supplied. The source code is written in FORTRAN. A Ryan-McFarland compiler was used to run the code, but it should work as well with Microsoft 4.1 and Leahy. The code requires a minimum of 640 kilobytes of memory, a math co-processor, and a DOS operating system. The code should run on IBM AT and PS2/60 machines as well as on most IBM clones. It should also compile readily on a VAX/VMS system. The documentation for the original version of the code should still be relevant for the description of data and other technical information in the personal computer version of the code. Examples and a brief description of the personal-computer-specific information are available. The code is being distributed on high- and low-density, 3.5-inch and 5.25-inch diskettes for IBM-compatible personal computers.

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Function: COMPONENT DESIGN: RF cavities

Key Terms: impedance, special boundary condition, PC version

Abstract: TWAP calculates properties such as frequency, Q, shunt impedance, etc., for traveling-wave accelerator structures with a fairly arbitrary boundary shape. The code employs functional expansions: space-harmonics in an inner region and cavity functions in an optional outer region. The program uses a minimization method to find expansion coefficients and frequency to fit boundary conditions.

History: TWAP was originally developed to investigate a possible superconducting accelerator for SLAC.

Author: Richard H. Helm, SLAC, U.S.A., 1970 to present

References: R.H. Helm, "Computation of the Properties of Traveling Wave Structures," in "Proceedings of the 1970 Proton Linear Accelerator Conference, September 28th through October 2, 1970," Fermi National Accelerator Laboratory report (report number is unavailable); CONF-700929-(Vol. 1), pp. 279–309 (1970).

Status: TWAP was last modified in March 1989. The code is maintained and distributed, without charge, by Richard Helm. It has approximately 2000 lines of nearly standard FORTRAN-77 source code. The program has been run on an IBM/VM operating system as well as an IBM PS-2 (50). It should run on any IBM/AT compatible personal computer. The code uses the TOPDRAWER graphics package developed at SLAC by Roger Chaffee. The graphics package is available, without charge. Contact Bill Johnson, Bin 97, SLAC, Post Office Box 4349, Stanford, California 94309. His phone number is 1 (415) 926-2660, on FTS: it is 462-2662. TWAP is poorly documented. A seven-page reference manual that includes an example is available. The program is being distributed through the computer networks and on 3.5-inch or 5.25-inch double-sided high-density diskettes for IBM-compatible personal computers.

Maintained and Distributed by: Richard H. Helm
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Function: COMPONENT DESIGN: RF cavities

Key Term: impedance, resonant mode

Abstract: URMEL computes symmetric ($m = 0$) and asymmetric ($m > 0$) resonant modes in cavities and frequencies of longitudinally homogeneous fields in waveguides for cylindrically symmetric accelerating structures. Instead of H_ϕ and E_ϕ, only the electric field components in the (r, z) plane are used for the calculation of the transverse modes. The discretization is based on finite-integration techniques described in the references. Many modes are found on one pass. URMEL uses a rectangular mesh instead of the triangular mesh used by URMEL-T.

Author: Thomas Weiland, Deutsches Elecktronen-Synchrotron (DESY), Federal Republic of Germany

References: T. Weiland, "A Discretization Method for the Solution of Maxwell's Equations for Six Component Fields," *Electronics and Communication (AEÜ)* **31**, 116–120 (1977).

T. Weiland, "On the Computation of Resonant Modes in Cylindrically Symmetric Cavities," *Nuclear Instruments and Methods in Physics Research* **216**, 329–248 (1983).

J. Tückmantel, "An Improved Version of the Eigenvector Processor SAP Applied in URMEL," CERN report CERN/EF/RF 85-4 (July 1985).

Status: URMEL was last modified in 1988. This code is maintained and distributed, generally for a nominal charge, by Thomas Weiland. It has approximately 14 000 lines of FORTRAN source code. Sample interfaces are available for the VAX/VMS, CRAY/CTSS (CFTLIB), CRAY/CTSS (FORTLIB), and IBM/MVS systems. Examples are sent as part of the package. This code is being distributed on magnetic tape reels.

Although one must get the source code directly from Thomas Weiland, the executable form of the code is installed at Los Alamos National Laboratory and the National Energy Research Supercomputer Center (NERSC), formerly NMFECC, at Lawrence Livermore National Laboratory, U.S.A. For more information about these executable files, contact Therese Barts, Los Alamos Accelerator Code Group (LAACG). Her BITNET address is AT6TCB@LAMPF.

A 70-page user's guide for URMEL and URMEL-T may be obtained from the Los Alamos Accelerator Code Group, Mail Stop H829, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, U.S.A.

Maintained and Distributed by: Thomas Weiland
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Function: COMPONENT DESIGN: RF cavities, waveguide

Key Terms: impedance, ferrite/dielectric, resonant mode

Abstract: URMEL-T computes symmetric ($m = 0$) and asymmetric ($m > 0$) resonant modes in cavities and frequencies of longitudinally homogeneous fields in waveguides for cylindrically symmetric accelerating structures. Instead of H_ϕ and E_ϕ, only the electric field components in the (r, z) plane are used for the calculation of the transverse modes. The discretization is based on Finite Integration Techniques described in the references. Many modes are found on one pass. URMEL-T uses a triangular mesh instead of the rectangular mesh used by URMEL.

Authors: Ursula van Rienen, Deutsches Elektronen-Synchrotron (DESY), Federal Republic of Germany; Thomas Weiland, Deutsches Elektronen-Synchrotron (DESY), Technische Hochschule Darmstadt, Federal Republic of Germany

References: T. Weiland, "A Discretization Method for the Solution of Maxwell's Equations for Six Component Fields," *Electronics and Communication (AEÜ)* **31**, 116-120 (1977).

U. van Rienen and T. Weiland, "Triangular Discretization Method for the Evaluation of RF-fields in Waveguides and Cylindrically Symmetric Cavities," *IEEE Transactions on Magnetics* **MAG-21**, 2317–2320 (1985).

Status: URMEL-T was last modified in 1989. This code is maintained and distributed, generally for a nominal charge, by Thomas Weiland. It has approximately 29 000 lines of FORTRAN source code. Sample interfaces are available for the VAX/VMS, CRAY/CTSS (CFTLIB), CRAY/CTSS (FORTLIB), and IBM/MVS systems. Examples are sent as part of the package. This code is being distributed on magnetic tape reels.

Although one must get the source code directly from Thomas Weiland, the executable form of the code is installed at Los Alamos National Laboratory and the National Energy Research Supercomputing Center (NERSC) at Lawrence Livermore National Laboratory, U.S.A. For more information about these executable files, contact Therese Barts, Los Alamos Accelerator Code Group (LAACG). Her BITNET address is AT6TCB@LAMPF.

A 70-page user's guide for URMEL and URMEL-T may be obtained from the Los Alamos Accelerator Code Group, Mail Stop H829, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, U.S.A.

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Function: COMPONENT DESIGN: RF cavities

Key Terms: impedance, three dimensions, wakefield

Abstract: VARGUS is a three-dimensional code that computes electromagnetic fields in either the frequency-domain or time-domain and allows the user to embed structures on the computational grid.

Authors: Larry Seftor, Kwok Ko, John Petillo, Adam Drobot, Alfred Mondelli, Science Applications International Corporation (SAIC), U.S.A.; and Mike Kress, City University of New York (CUNY), Staten Island, U.S.A.

References: none

Status: VARGUS was last modified in October 1989. The code is maintained and distributed, without charge, by Science Applications International Corporation (SAIC). There is a charge for code installation and for instruction in the use of the code. VARGUS has approximately 35 000 lines of FORTRAN source code. The program has about 25 users. The code was written to run on a VAX/VMS system. A 100-page user's guide is available. The program is being distributed on magnetic tape reels.

Maintained and Distributed by:

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VISTA CONTROL SYSTEM

Function: CONTROL SYSTEM

Key Terms: design, graphical user interface

Abstract: VISTA CONTROL SYSTEM is a multi-computer, network-based control and data acquisition system especially suitable for accelerators and beam transport systems. Various input and output systems are supported. Many systems can be implemented with very little conventional programming and in a very short time using easy-to-use drawing and system configuration packages.

History: VISTA CONTROL SYSTEM was directly derived from Particle Beam Telescope control system at Los Alamos National Laboratory, U.S.A.

Authors: J. Hill, R. Rothrock, V. Martz, R. Westervelt, D. Kersteins, L. Trease, S. Bair, M. Zander, Los Alamos National Laboratory, U.S.A.

References: none

Status: VISTA CONTROL SYSTEM is being expanded continually. The code is maintained and distributed, for a fee, by Vista Control Systems, Inc. A nonproliferation agreement is required. It has approximately 60 000 lines of C source code. The code has about 25 known users. The program was written to run on a VAX/VMS system. An approximately 100-page user's guide, an approximately 50-page reference manual, and examples are available. The code is being distributed on TK50 magnetic tape cartridges.

Maintained by: Richard Rothrock
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Distributed by: Peter Clout
same address and phone number as above
CLOUT@VISTANM.COM

Function: BEAM DYNAMICS: linacs

Key Terms: space charge/high current, particle-in-cell, three dimensions

Abstract: WARP is a three-dimensional electrostatic particle-in-cell code for heavy-ion fusion accelerator studies. The program contains an envelope solver, used for initialization. The program uses a three-dimensional FFT (sine-sine-periodic) field solver. The code is being optimized for speed and size.

Authors: Alex Friedman, David Grote, Debra Callahan, and A. Bruce Langdon, Lawrence Livermore National Laboratory, U.S.A.; and Irving Haber, Naval Research Laboratory, U.S.A., 1989 to present

References: Alex Friedman, "WARP: A 3D (+) PIC Code for HIF Simulations," Conference on Computer Codes and the Linear Accelerator Community, Los Alamos, New Mexico, January 22–25, 1990.

P.F. Dubois, et al., "The BASIS System," Lawrence Livermore National Laboratory report M-225 (March 29, 1990).

Status: WARP is still somewhat incomplete and is under active development. The code is being maintained by the authors listed above. At this point, it has approximately 10 000 lines of FORTRAN IV and MPPL preprocessor source code. MPPL is a structured super set of FORTRAN. The code has been built atop the BASIS Development/Run-Time System (see the BASIS bulletin board on the National Magnetic Fusion Energy Computer Center, U.S.A., and the Lawrence Livermore report cited in the **References** section above for information on BASIS.) The program has been run on CRAY/CTSS, CRAY/LTSS, and CRAY/NLTSS systems. It may be installed on a Sun workstation in the future. Two graphics packages are used. One is within the BASIS package and the other is GRAFL-3, built atop GRAFLIB and GRAFCORE. Although no formal written documentation is available, there are examples and an on-line help facility. The source code is largely self-documenting via FORTRAN comment cards and the BASIS variable description file.

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Function: BEAM DYNAMICS: general

Key Terms: plasmas, particle-in-cell

Abstract: WAVE is a general-purpose two-dimensional relativistic electromagnetic plasma simulation on a Cartesian mesh.

History: WAVE was first developed by R.L. Morse and C.W. Nielson in 1971. It has been extensively modified and augmented by E.L. Lindman and D.W. Forslund.

Authors: R.L. Morse, C.W. Nielson, E.L. Lindman, and D.W. Forslund, Los Alamos National Laboratory, U.S.A.

References: R.L. Morse and C.W. Nielson, "Numerical Simulation of the Weibel Instability in One and Two Dimensions," *Physics of Fluids* **14** (4), 830–840 (April 1971).

D.W. Forslund, "Fundamentals of Plasma Simulation," *Space Science Reviews* **42**, 3–16 (1985).

Status: The latest released version of WAVE came out in 1986. This code is maintained and distributed, without charge, by David Forslund. It has approximately 6000 lines of FORTRAN source code. The program has been run on CDC 7600 and CRAY/UNICOS systems as well as Sun 3, Sun 4, and Apollo workstations. A 10-page user's guide and examples are available. The code is being distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: waveguide

Keyword: ferrite/dielectric

Abstract: WAVEGIDE is an interactive, self-documenting program used in the design of waveguides. The code solves for hybrid, TM, or TE modes in any arbitrary two-dimensional cross section with a conducting boundary and with varying, even discontinuous, permittivity and permeability. WAVEGIDE produces an input file for IMSL's program PDE/PROTRAN. Waveguide problems can be solved directly by PDE/PROTRAN, but it is much easier when WAVEGIDE is also used. PDE/PROTRAN is not distributed in this package.

History: Both WAVEGUIDE and PDE/PROTRAN were developed by Granville Sewell for IMSL.

Author: Granville Sewell, University of Texas at El Paso, U.S.A.

References: G. Sewell, "An Interactive Waveguide Program," Fifth Annual Review of Progress in Computational Electromechanics, Monterey, California, U.S.A., March 1989.

Granville Sewell and Serba Cvetkovic, "WAVEGIDE — An Interactive Waveguide Program," *Advances in Engineering Software* **11** (4), 169–175 (1989).

Status: WAVEGIDE is being maintained and distributed, without charge, by Granville Sewell. Granville Sewell has agreed to do this only for the near future. No long-range commitment has been made. WAVEGIDE has approximately 2000 lines of portable FORTRAN-77 source code. The program has been run on an IBM/MUSIC system. As an interactive program, it is totally self-documenting. The code is being distributed through the computer networks or 5.5-inch diskettes for IBM-compatible personal computers.

Maintained and Distributed by: Granville Sewell
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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: beam-beam interaction, optimization, wigglers

Abstract: WIGWAM is a multi-purpose design and performance evaluation program for electron storage rings. The parameters and performance are evaluated in a very flexible way. The optics may be specified in two ways: through a TWISS file generated by MAD or in a skeleton description useful in early stages of design. The code allows performance to be optimized in many ways, using "controls" such as wiggler excitations, damping partition variation, RF voltage, coupling, etc. The performance of "pretzel" schemes are evaluated as well as some beam-transfer functions. The input format allows for a wide variety of plots, including the graphical display of all the optics information, many beam parameters as functions of energy, etc.

History: WIGWAM was originally written to include the effects of nonlinear wigglers (non-Gaussian beam distributions) in storage ring parameter calculations. The code has grown into a multi-purpose design and performance evaluation program. It has recently been interfaced to the program MAD via the RDTWISS package and TWISS files.

Author: J.M. Jowett, CERN, Switzerland

References: J.M. Jowett, "WIGWAM, A Description of the Program," CERN internal report, LEP Theory note 47 (June 1987).

J.M. Jowett, "Luminosity and Energy Spread in LEP," CERN report CERN-LEP-TH/85-4 (1985).

Status: WIGWAM was last modified in January 1990. The code is maintained and distributed, without charge by J.M. Jowett. The program requires the CERN Library Programs package, the NAGLIB (Numerical Algorithms Group Library) routines, and the TOPDRAWER graphics package.

The distribution policy for the CERN Library Programs package is listed here only to give the reader an idea of who might be able to receive the codes. There are 14 European countries that contribute to CERN's budget, they are considered member states. The package is not available to commercial enterprises in nonmember states or for any purpose related to military applications. Organizations collaborating with CERN, national laboratories, and physics departments in member state universities may receive the programs freely and without charge. Nonprofit-making organizations in member states and academic physics departments in nonmember states may receive the library for 500 Swiss Francs. Commercial enterprises in member states may receive the library for 1000 Swiss Francs. For up-to-date distribution policies and to receive the codes, contact the Program Library, Division SL, CERN, CH-1211 Geneva 23, Switzerland. The telephone number is 41 (22) 767 6643.

Only one of the NAGLIB routines is used in WIGWAM and only in one part of the program. It is used to perform a Cauchy principal value integration. Most of the program and 99% of its applications would run without it. The NAGLIB routines are available from Numerical Algorithms Group, Ltd., Mayfield House,

256 Banbury Road, Oxford OX2 7DE, Great Britain. There telephone number is 44 (865) 511245.

The TOPDRAWER graphics package was developed at SLAC by Roger Chaffee. The graphics package is available, without charge. Contact Bill Johnson, Bin 97, SLAC, Post Office Box 4349, Stanford, California 94309. His phone number is 1 (415) 926-2660, on FTS: it is 462-2662.

WIGWAM has approximately 10 000 lines of FORTRAN source code. The code has about five users. The program has been run on IBM/VM/CMS and IBM/MVS systems. Although there is no formal documentation, examples and various notes are available from the author. The CERN report, CERN-LEP-TH/85-4, cited in the **References** section above, is useful for examples of output from the program. The code can be distributed on magnetic tape reels and through the computer networks.

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Function: COMPONENT DESIGN: ion sources

Key Terms: space charge/high current, optimization, plasmas

Abstract: WOLF solves Poisson's equation within a user-defined boundary of arbitrary shape. The code uses a two-dimensional Cartesian coordinate geometry represented on a triangular lattice. The vacuum electric fields and equipotential lines are calculated for the input problem. The user may then introduce a series of emitters from which particles of different charge-to-mass ratios and initial energies can originate. These nonrelativistic particles are then traced by WOLF through the user-defined region. Effects of ion and electron space charge are included in the calculation. A subprogram, PISA, forms part of this code and enables optimization of various aspects of the problem. The WOLF package also allows detailed graphics analysis of the computed results.

Authors: Klaus Halbach and Steve Magyary, Lawrence Berkeley Laboratory, U.S.A.

References: K. Halbach, "Mathematical Models and Algorithms for the Computer Program WOLF," Lawrence Berkeley Laboratory internal report LBL-4444 (1979).

D.L. Vogel, "WOLF: A Computer Code Package for the Calculation of Ion Beam Trajectories," Lawrence Berkeley Laboratory internal report LBL-18871 (1985).

Status: WOLF was last modified in July 1989. The code is being maintained and distributed, without charge, by Oscar Anderson. There is very minimal support available for this code. It has approximately 8000 lines of ANSI standard FORTRAN-77 source code. Although this program was written to run on CDC 6400 and CDC 7600 machines, the only distributed version of this code is for the CRAY/CTSS (FORTLIB) system. A 100-page user's guide is available, but it is out of date. It is the LBL-18871 report cited in the **References** section above. The code is being distributed through the computer networks.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: stability, intrabeam scattering, Touschek lifetime, gas-scattering lifetime, PC version

Abstract: ZAP can be used to calculate single-bunch instability thresholds and instability growth rates from coupled-bunch instabilities in storage rings, bunch lengthening, Touschek and gas scattering lifetimes, equilibrium emittances for electron beams in the presence of radiation damping, quantum fluctuations, and intrabeam scattering. It is an interactive, self-prompting code.

Authors: M.S. Zisman, S. Chattopadhyay, and J. Bisognano, Lawrence Berkeley Laboratory, U.S.A.

References: Michael S. Zisman, "ZAP and Its Application to the Optimization of Synchrotron Light Source Parameters," *Particle Accelerators* **23** (4), 289–307 (1988).

Michael S. Zisman, Swapan Chattopadhyay, and Joseph Bisognano, "ZAP User's Manual," Lawrence Berkeley Laboratory internal report LBL-21270 (December 1986).

Status: ZAP was last modified in March 1989. The code is maintained and distributed, without charge, by Michael Zisman. It has approximately 10 000 lines of FORTRAN source code. The program has been run on VAX/VMS and IBM/VM systems as well as IBM and Macintosh personal computers. A 188-page user's guide that includes examples is available. Sample input files to run examples are also available. The code is being distributed on magnetic tape reels, through the computer networks, and on DEC RX50 diskettes. The requester is expected to supply the tape or diskette if a non-network transfer is required.

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ZFIELD

Function: BEAM DYNAMICS: linacs

Key Terms: space charge/high current, tracking

Abstract: ZFIELD, a trajectory computer code for a linac beam, was written as a design aid to complement the TRANSPORT code. It includes space charge, plots the emittance ellipse at axial values, and plots beam radius. Comparing ZFIELD and TRANSPORT in drift regions, significant differences in beam-radius predictions are found in the two-megavolt region for currents above 200 amps and above 400 amps in the four-megavolt region. Using ZFIELD, beam-envelope growth for beams with different emittances can be compared and the effect of space charge on emittance growth can be shown graphically.

Author: Curry Sawyer, EG & G Measurements, Inc., U.S.A.

Reference: C. Sawyer and N. Norris, "Estimation of Space Charge and Emittance Growth Effects in a Drift Region," in "Proceedings of the 1984 Linear Accelerator Conference: Lufthansa-Schulungszentrum, Seeheim, May 7–11, 1984," N. Angert, Ed., Gessellschaft für Schwerionenforschung (GSI), mbH, Darmstadt, report GSI-84-11 (1984), pp. 349–351.

Status: ZFIELD was last modified in 1986. The code is not being maintained and has been put in moth balls. It is being distributed, with a small charge to cover costs, by Stan Kocimski. The program has approximately 1000 lines of FORTRAN source code. The paper, cited above in the **References** section, together with some memorandums serve as documentation for this code. The program is being distributed on magnetic tape reels.

Distributed by: Stan Kocimski
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PHONE: 1 (805) 681-2319

Function: BEAM DYNAMICS: spectrometers/transport lines

Key Terms: raytracing, optimization, fringe field, dispersion

Abstract: ZGOUBI is a ray-trace code for the calculation of spectrometers. The code provides the simulation of particle decay during flight. It works with measured two-dimensional or three-dimensional field maps and/or analytical fields.

History: The basic code of ZGOUBI was written by D. Garetta and J.C. Faivre. It was recently modified by F. Méot and S. Valero, by adding multipole fields, fourth-order, three-dimensional maps, decay, etc. ZGOUBI was used in the calculation of spectrometers SPES I, SPES II, SPES III, and SPES IV at Saturne National Laboratory; SPEG at GANIL (Grand Accélérateur National d'Ions Lourds), Caen, France; as well as the Kaon spectrometer belonging to Gessellschaft für Schwerionenforschung (GSI), Darmstadt, Germany.

Authors: D. Garetta, J.C. Faivre, F. Méot, S. Valero, Saturne National Laboratory, France (please refer to the **History** section above)

References:

F. Méot and S. Valero, "Manuel d'Utilisation de ZGOUBI," Commissariat à l'Énergie Atomique (CEA), Centre d'Études Nucléaires de Saclay (CENS) report, CEA-Saclay LNS 88-13 (1988).

F. Méot and N. Willis, "Raytrace Computation with Monte Carlo Simulation of Particle Decay," Commissariat à l'Énergie Atomique (CEA), Centre d'Études Nucléaires de Saclay (CENS) report, CEA-Saclay LNS 88-18 (1988).

F. Méot, "Raytracing in 3D Field Maps with ZGOUBI," Commissariat à l'Énergie Atomique (CEA), Centre d'Études Nucléaires de Saclay (CENS) internal report LNS/GT 90-01 (1990).

Status: ZGOUBI was last modified in 1989. The code is maintained and distributed, without charge, by F. Méot and S. Valero. It has approximately 6000 lines of FORTRAN source code. The program is being used at many sites. The code has been run on VAX/VMS (the most recent version), CRAY, and IBM systems. An approximately 100-page user's guide is available. The program is being distributed on magnetic tape reels, TK50 magnetic tape cartridges, VAX diskettes, and through the computer networks.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: stability, impedance

Abstract: ZLT calculates and plots the beam coupling impedance versus frequency for various circular accelerator components in order to aid in the analysis of beam stability. Both the transverse impedance Z_T and the normalized longitudinal impedance Z_L/n are found. The impedances are estimated using simplified formulas for the effects of steps, cavities, monitor plates, and other discontinuities in the beam pipe for the ring. Plots may show impedance of individual components or total impedance.

Author: George R. Swain, Los Alamos National Laboratory, U.S.A., 1988 to present

References: G. Swain, "The ZLT Code for Beam Coupling Impedances," Los Alamos National Laboratory internal report, AHF technical note 88-14 (May 1988, revised January 1989).

Status: ZLT was last modified in September 1989. The code is maintained by G. Swain, but it is not available for distribution. It has approximately 3200 lines of FORTRAN-77 source code. About half these lines comprise a user's guide. The code has been run on a VAX/VMS system using the DISSPLA graphics package.

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Function: BEAM DYNAMICS: synchrotrons/storage rings

Key Terms: tracking, optimization, dynamic aperture

Abstract: ZTRACK was developed mainly for fast long-term multi-particle tracking in a storage ring. A thin element machine file (in TEAPOT format) and a command file should be provided by the user. The codes are vectorized for multi-particle tracking in parallel and will keep reducing the particle number to exclude lost particles. This code is best suited for long-term dynamic aperture study. The ZTRACK package includes the code ZMAP that produces a one-turn Taylor-series map using a truncated power-series algebra library, TPALIB, that is a binary library of vectorized mathematical routines, using dynamic memory allocation.

Author: Yiton T. Yan, Superconducting Super Collider Laboratory, U.S.A., 1989 to present

References: L. Schachinger and R. Talman, "TEAPOT: A Thin-Element Accelerator Program for Optics and Tracking," *Particle Accelerators* **22** (1), 34,56 (1987).

Status: ZTRACK was last modified in May 1989. The code is maintained and distributed, without charge, by Y. Yan. A nonproliferation agreement is required. It has approximately 2000 statements of FORTRAN-77 source code. The program was written to run on a CRAY system. A reference manual is being prepared and there are examples available. The code is being distributed through the computer networks.

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BCI
BEAMTRACE

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CODINV
CURE

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DE2D
DIFDIRA

E

EFFI 3D

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FATIMA
FORGY

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GIANT
GO
GOBLIN
GOC3D
GRAPHIC

H

HOPI

I

INTEGRATED TIGER SERIES (ITS)

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