LA-UR- 08-7141

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Title: ~~Twenty-five~~ 25 years of Sillicon Detector Research in Physics Division at Los Alamos

Author(s): Kapustinsky, Jon S.

Intended for: Talk : Compact Muon Solenoid Experiment, Geneva Switzerland

Los Alamos
NATIONAL LABORATORY
EST. 1943

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Form 836 (7/06)

25 Years of Silicon Detector Research in Physics Division at Los Alamos

Jon S Kapustinsky
18/October/2008
CERN - CMS

Physics Division

Biophysics

Neutron Physics and Applications

Plasma Physics

Subatomic Physics

P-25 Org Chart

Subatomic Physics

Group Leader Scott Wilburn
Deputy Group Leader Jon Kapustinsky
Deputy Group Leader Frank Merrill

Ops Officer Steve Greene

Admin Team
Irene Martinez
Miquela Sanchez

Theory
Ivan Vitev (T)
Mikkel Johnson (R)

PHENIX Team
TL Melynda Brooks
Dave Lee
Jon Kapustinsky
Mike Leitch
Pat McGaughey
Ming Liu
Hubert Van Hecke
Xiaodong Jiang
Walt Sondheim
Gerd Kunde
Sergey Butsyk (PD)
Camelia Mironov (PD)
Zhengyun You (PD)
Lei Guo (PD)
Han Liu (PD)

Neutrino Team
TL Geoff Mills
Richard Van de Water
Gabe Powers (S)
Geralynn Zeller (PD)
Zarko Pavolic (PD)
Gerry Garvey (R)
Hywel White (R)

EDM Team
TL Martin Cooper
Takeyasu Ito
John Ramsey
Mark Makela
Chris Mauger
Shigeuiki Tajima (PD)
Raul Hennings-Yeomans (PD)
Steven Clayton (PD)

Radiography Team*
TL Andy Saunders
Frank Merrill
Feeseha Mariam
Dale Tupa (LSO)
Gary Hogan
Debbie Clark

***includes UCN**

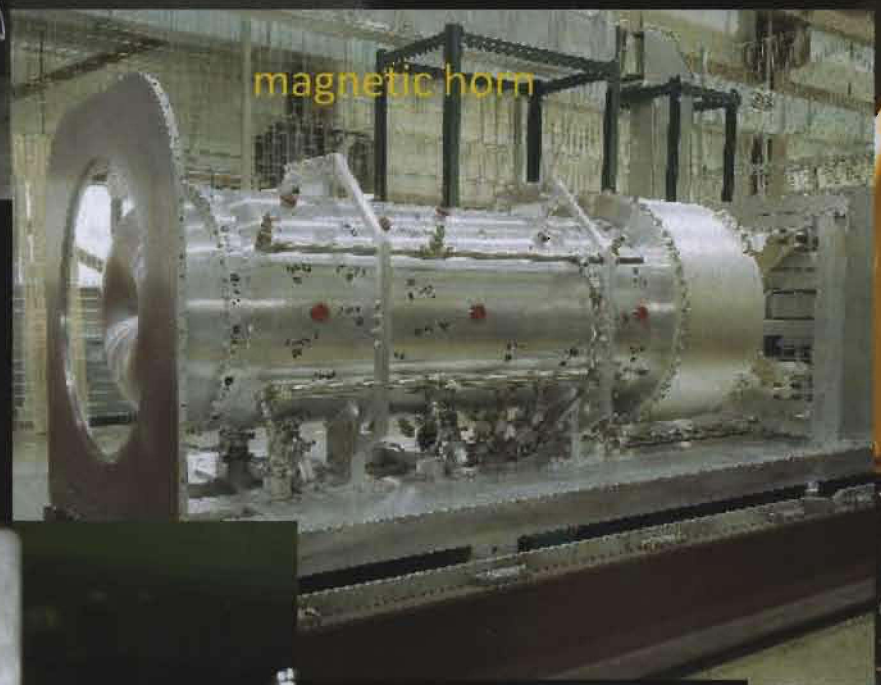
Threat Reduction Team
ATL Chris Morris
Cynthia Schwartz
Matthew Murray
Steve Greene
Andrew Green (LTSM)
Fawn Pazuchanics (S)

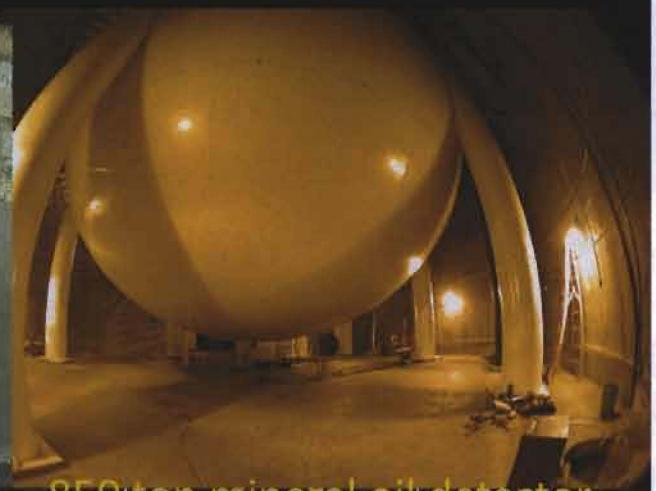
Tech Team
TL Neil Thompson
Jeff Bacon
Scott Currie
Camilo Espinoza
Jackie Gonzales (ESO)
Todd Womack
Brian Hollander (alt LSO)
Julian Lopez
Jason Medina
Eduardo Campos (S)
Jose Dominguez (S)
Joshua Valdez (S)
James Harrison (S)

TL = Team Leader
ATL = Acting Team Leader
LTSM = Limited Term Staff Member
(PD) = postdoc
(S) = student
(R) = retired
(T) = Theory Div.
(ESO) = Electrical Safety Officer
(LSO) = Laser Safety Officer

Booster Neutrino Experiment

P-25 LANL Team:
G. Garvey, W. Louis, G. Mills, Z. Pavlovic, R. Van de Water, D. H. White, G. Zeller

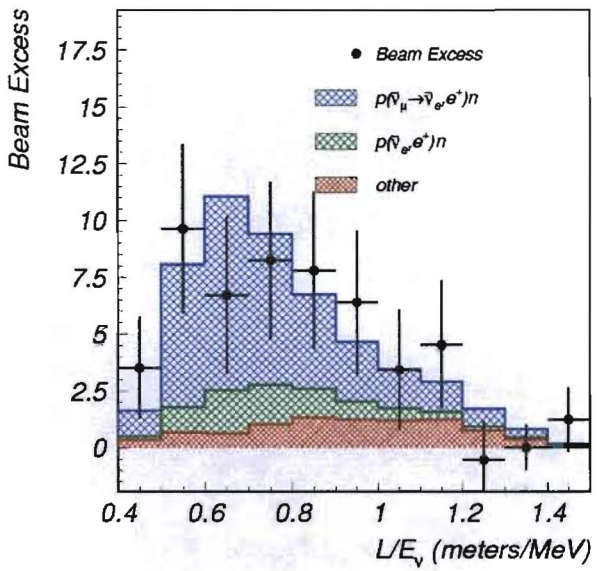




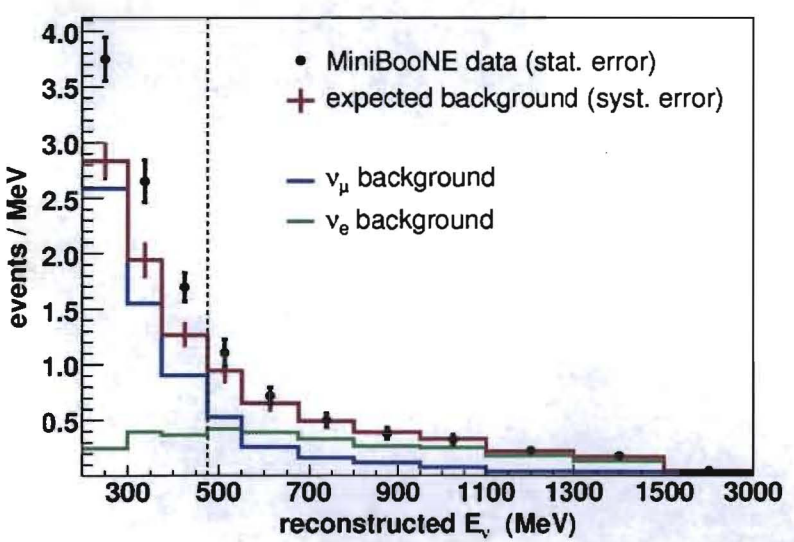
Highlights of results:

- Electron (anti)neutrino appearance

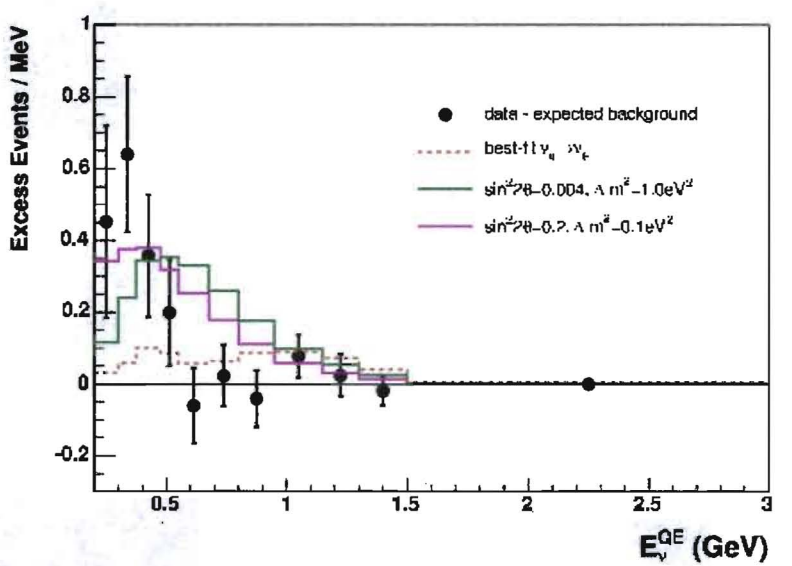
LSND final : Phys. Rev. D 64, 112007 (2001)



MiniBooNE I : PRL 98, 231801 (2007)

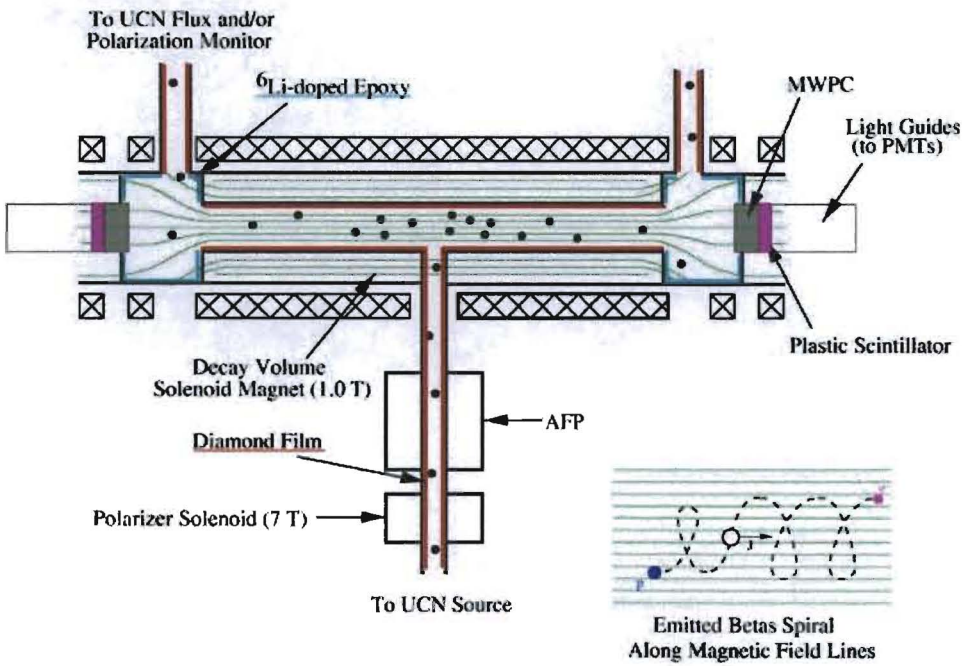


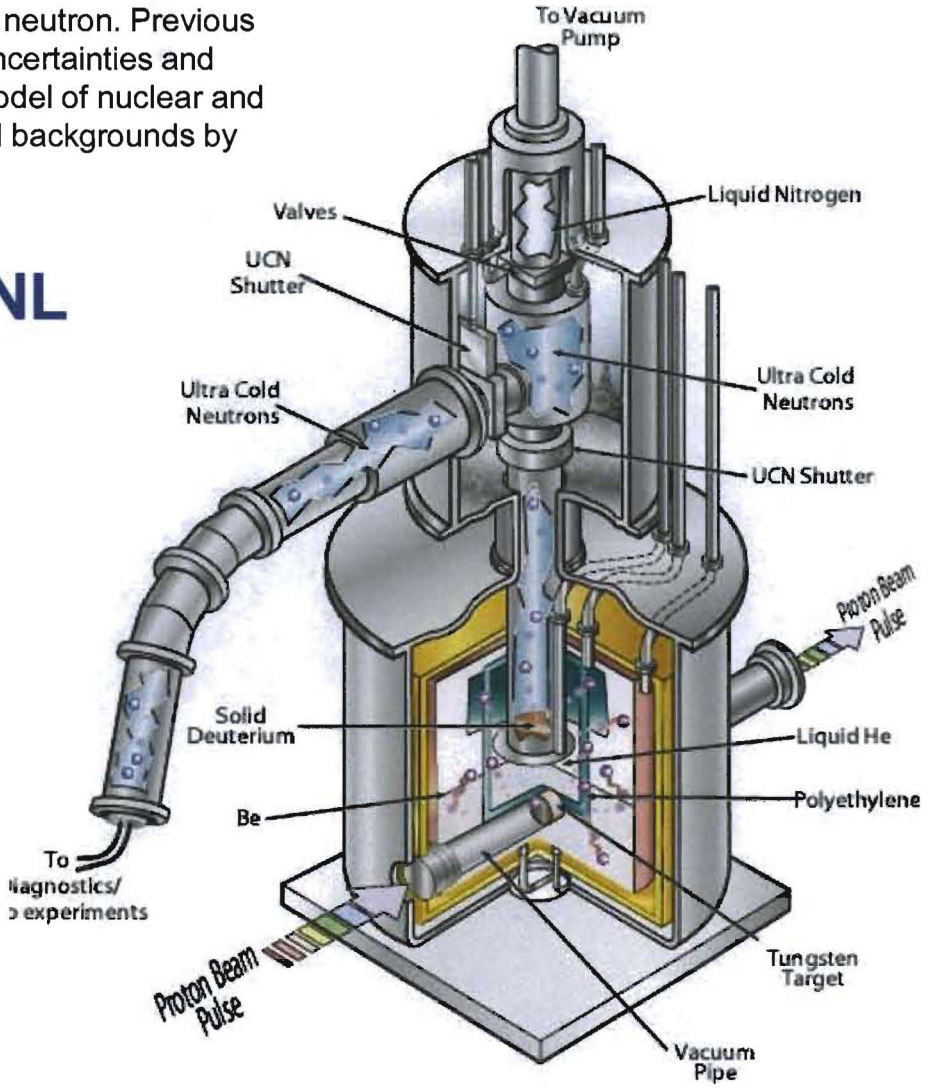
MiniBooNE II : 2008, 20% additional data, reanalysis (preliminary)



When a neutron decays, it emits a proton, an electron, and a neutrino in a process known as beta decay. Measurement of the correlations between these outgoing particles and the initial polarization of the neutron reveals details of the weak nuclear force, which is one of the four fundamental forces of nature. The Ultra-Cold Neutron (UCN) A experiment at LANSCE completed a first measurement of the A correlation parameter, which relates the outgoing electron's momentum to the polarization of the decaying neutron. Previous measurements of this parameter have been plagued by systematic uncertainties and backgrounds, but have hinted at new physics beyond the standard model of nuclear and particle physics. The UCNA experiment reduces the uncertainties and backgrounds by using ultra-cold neutrons to perform the measurement.

Ultracold neutron facility at LANL





LANSCE UCNA Beta Decay Spectra
12/2007

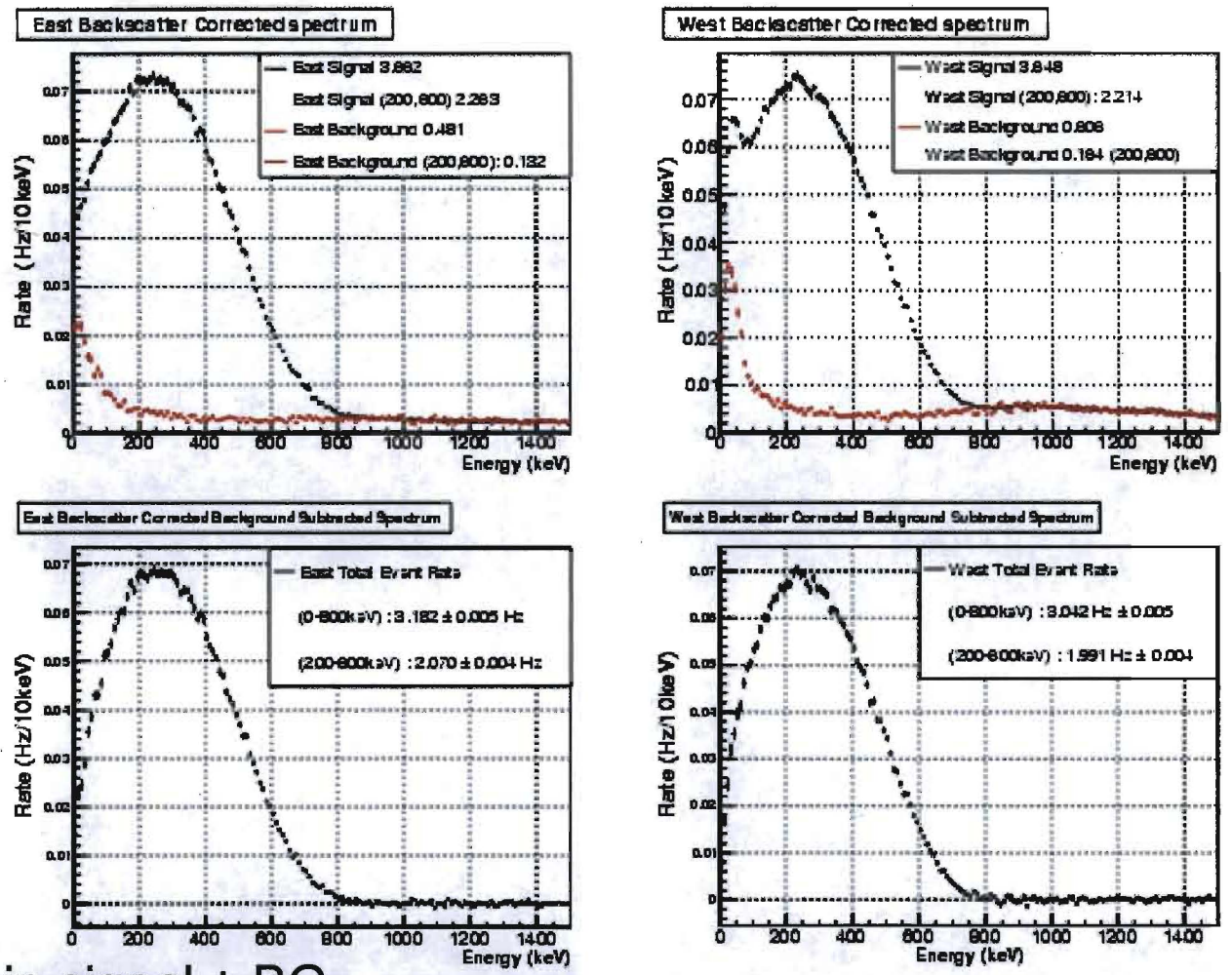
East Detectors

West Detectors

Signal + BG

Preliminary

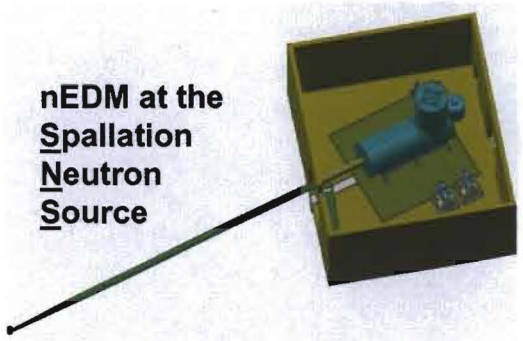
Signal

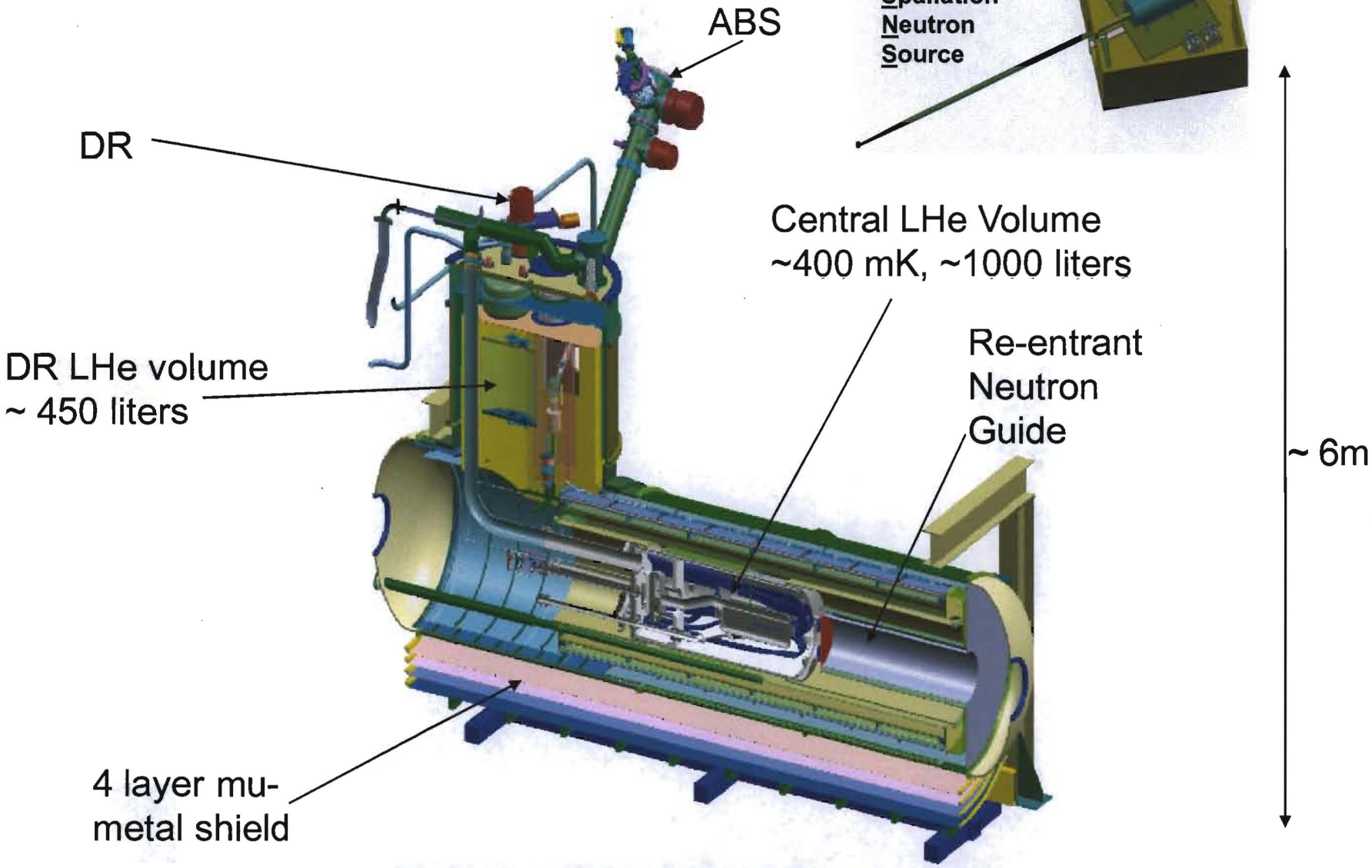


800,000 counts in signal + BG
36 hours of live acquisition

Summed over detectors, not spins

nEDM Experiment – vertical section

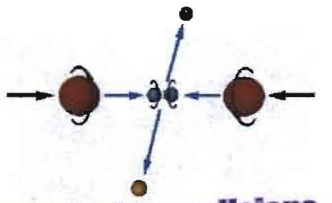




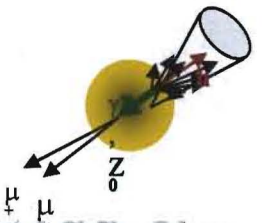
- **The current value is < 3 x 10-26 e•cm (90% C.L.)**
- **We hope to obtain roughly < 2 x 10-28 e•cm with UCN in superfluid He**

PHENIX Team Highlights

Au-Au collsions



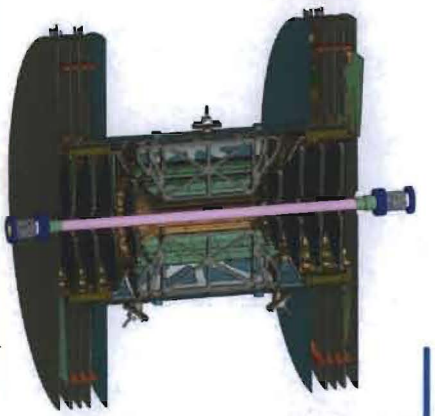
polarized p-p collsions

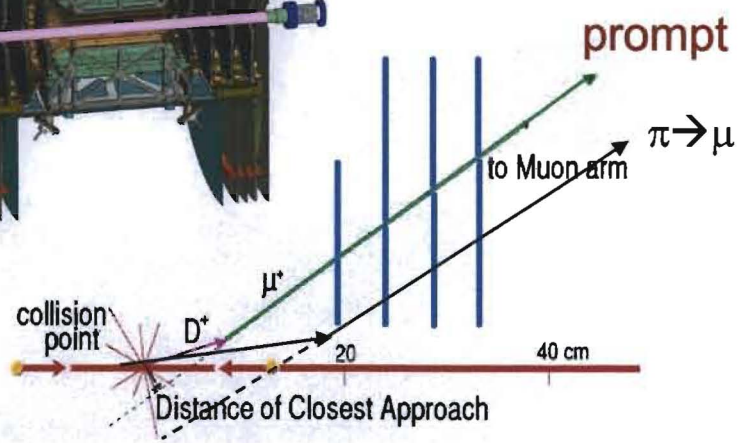


Jets in Pb-Pb collisions

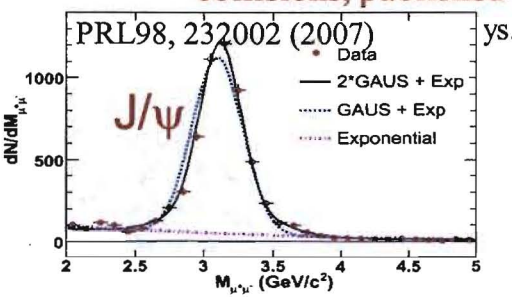
- PHENIX Experiment at Relativistic Heavy Ion Collider at BNL
  - Over 550 scientists from 13 countries
- LANL leading Unique Muon Measurements at RHIC
  - Studying the properties of Quark-Gluon-Plasma in high energy heavy ion collisions
    - The world best measurements of charm suppression in heavy ion collisions
  - Studying the polarized nucleon structure to solve the 20-year old "spin crisis"
    - World best measurement of J/ψ production in polarized p-p collisions
- CMS Experiment at the Large Hadron Collider at CERN
  - LDRD-ER to pioneer the study of a new plasma probe - Z^0 tagged Jets - in PbPb collisions, published in CMS Physcis TDR

- Future: New Muon Program with State of the Art Silicon Vertex Detectors
  - LANL-launched $5M upgrade project funded by DOE
  - Measure Heavy Flavor to extract Quark Gluon Plasma energy loss mechanisms

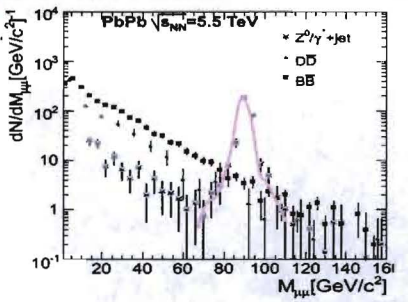




PRL98, 232002 (2007)

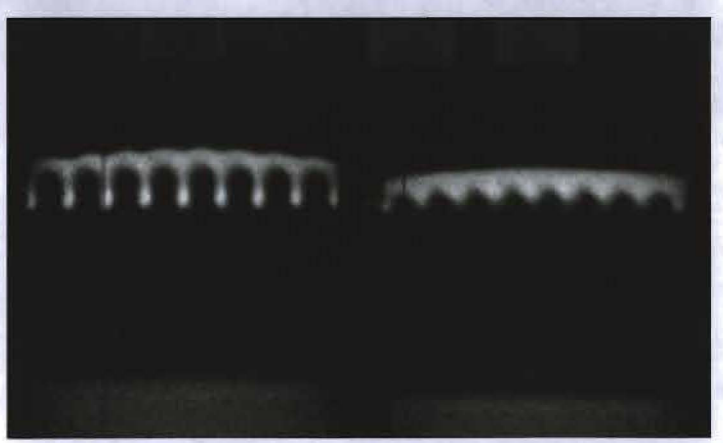


vs.



PHENIX

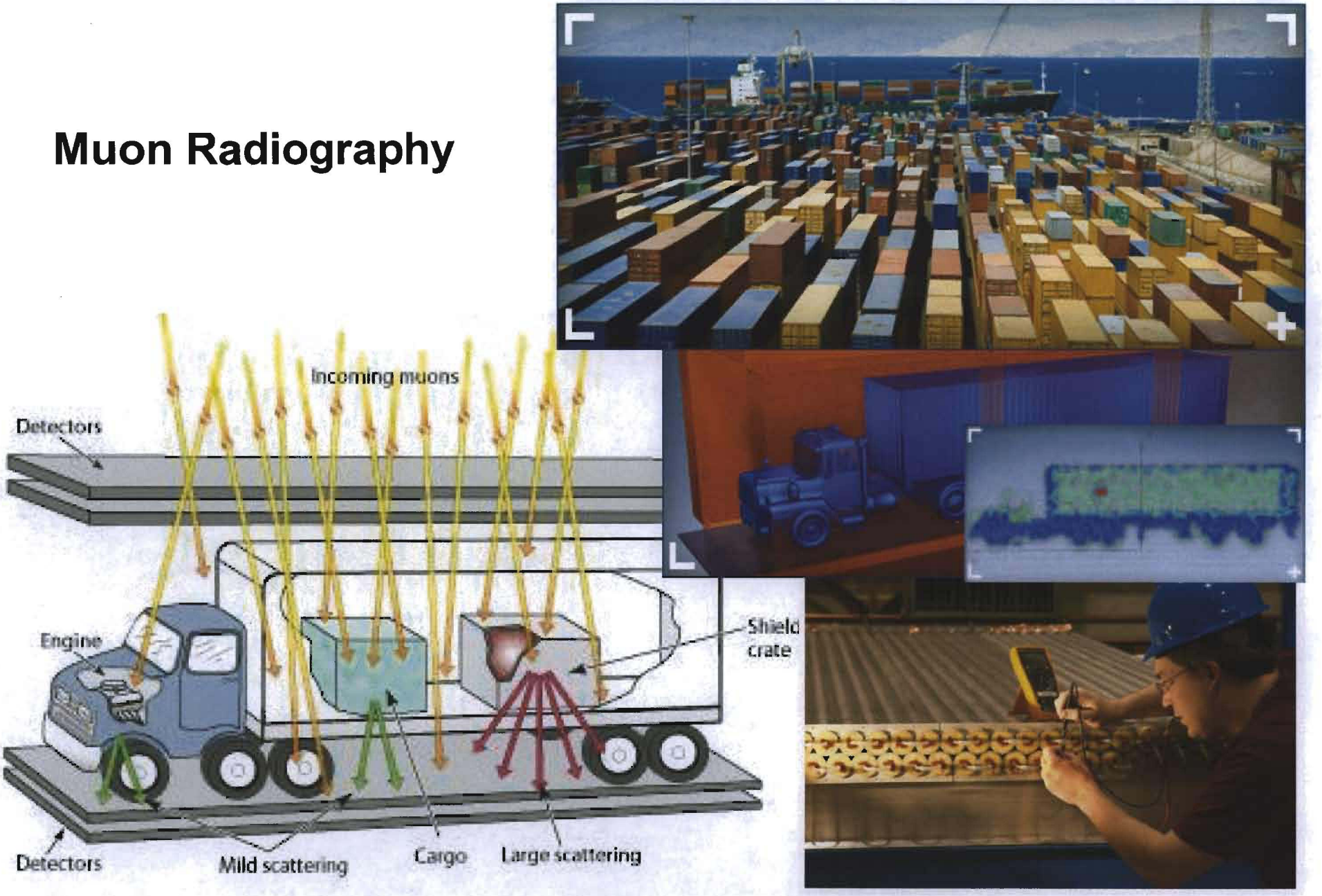
2007 Run Cycle Proton Radiography at LANSCE



40 Dynamic Experiments in 08

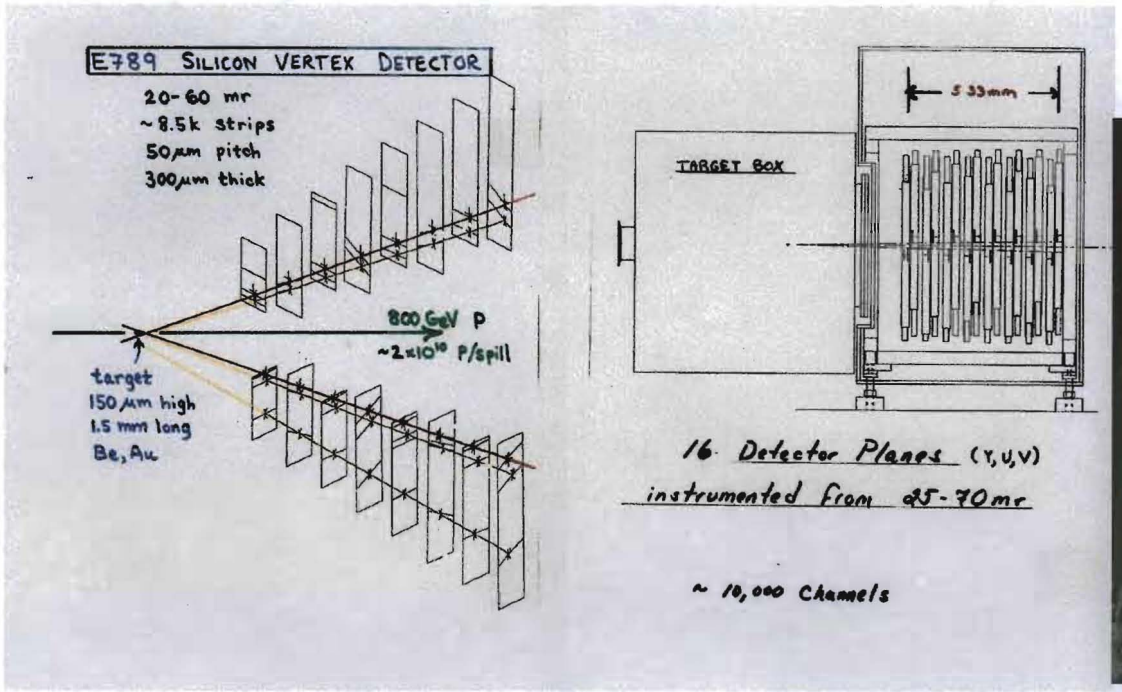
6 High Strain Rate Strength Measurements (Cu,Ta,Va, LLNL, LANL)
6 HE burn studies
7 HE Detonation-to-Deflagration Transition Studies
2 RRW HE Initiation System Studies (LLNL configuration)
4 Solid-Solid Phase Transition Measurements in iron and cerium
3 Thermos confirmatories
3 Thermos Pu experiments
4 Spall/Material Failure Recovery Experiments
1 Cylindrical Implosion Studies
1 Timing Verification Tests
3 Klex Series

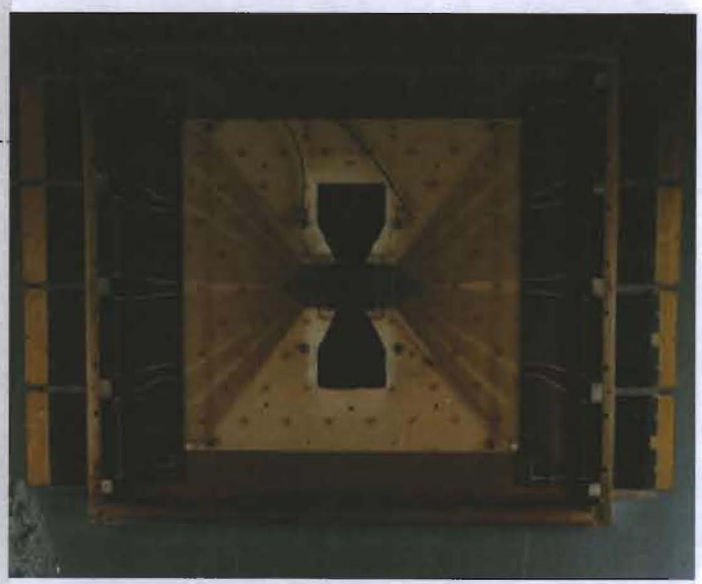
Muon Radiography



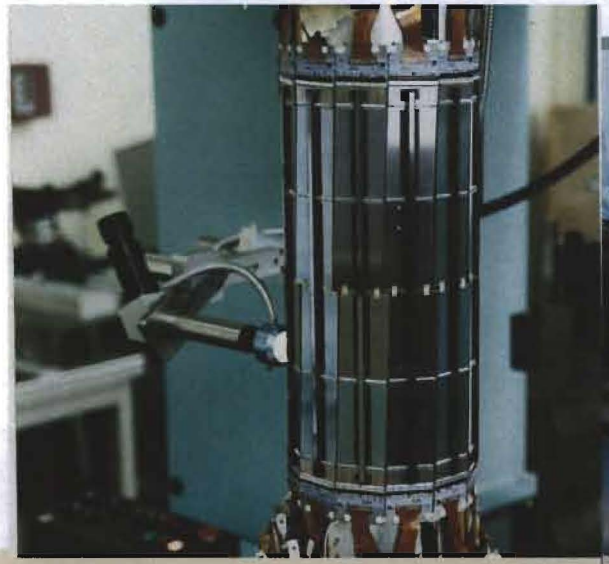
Silicon Projects in P25 Subatomic Physics

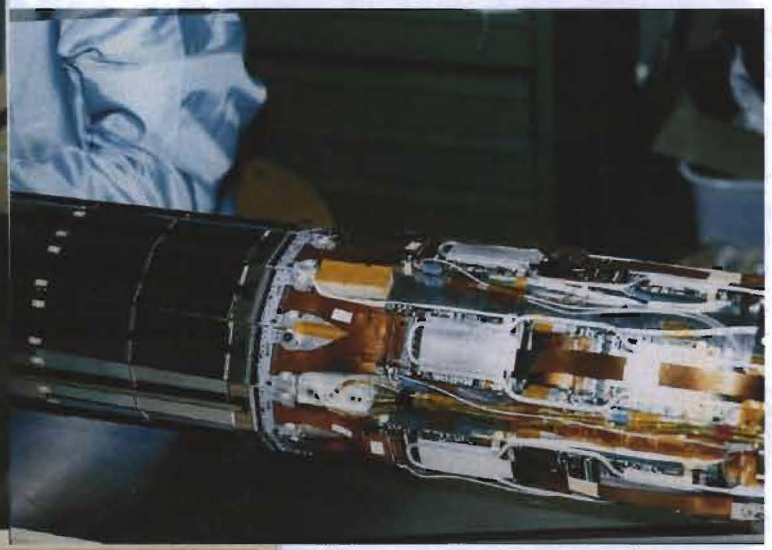
- **Experiment E789 at FNAL – Rare Beauty Decay, 800 GeV protons on fixed target**
- **SSC R&D (L*, SDC)**
  - ❖ **Radiation Damage Studies – leakage current, pulse height, type reversal, temperature effects (Ziock, Kapustinsky)**
  - ❖ **Low mass composite support structures, thermal management techniques (Miller, Thompson ⟶ Hytec)**

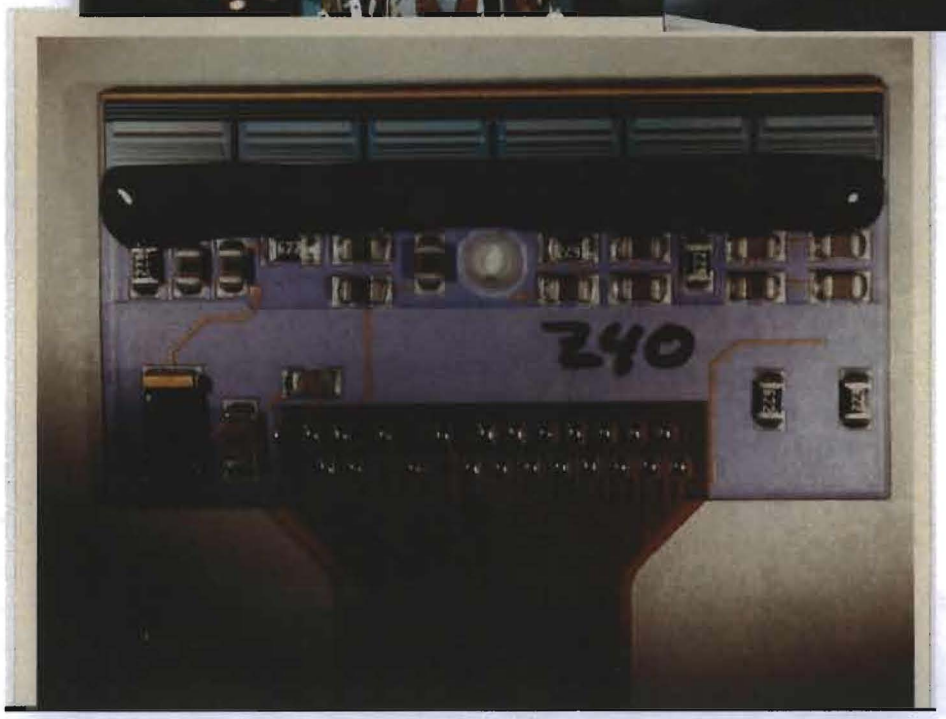


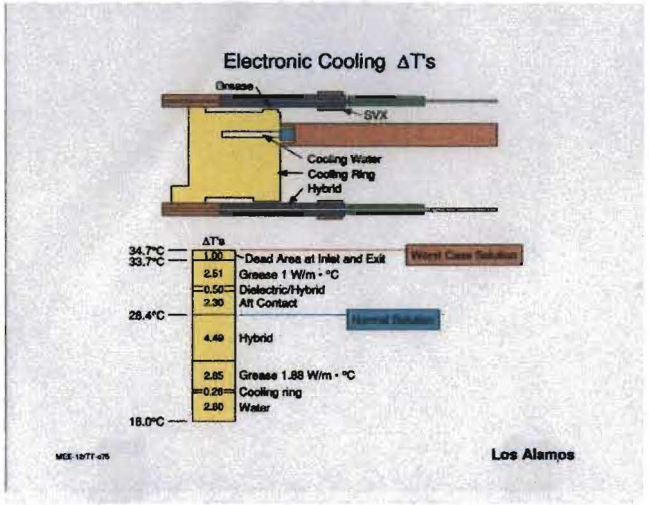


L3 Silicon Microvertex Detector (SMD)







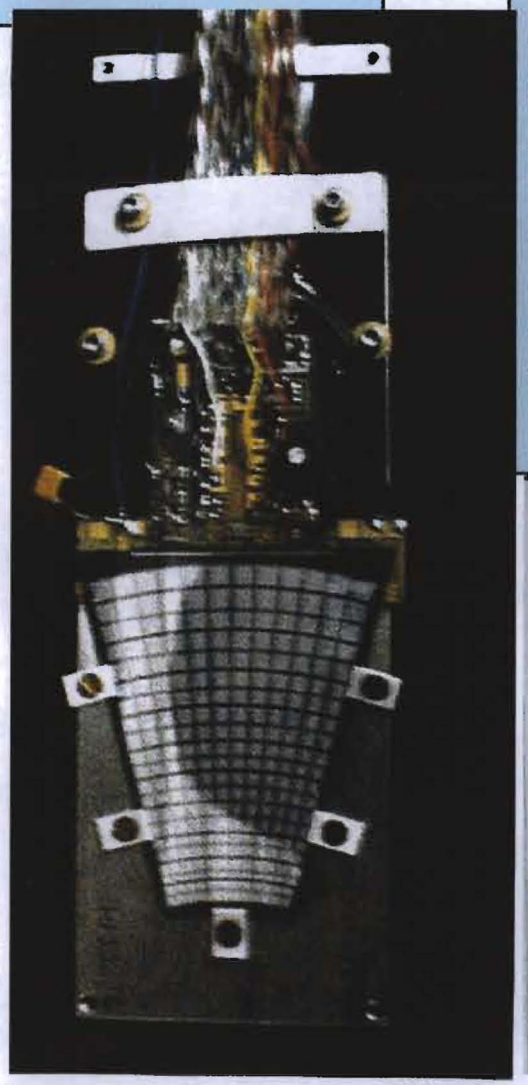


PHENIX Multiplicity Vertex Detector (MVD)

30 degree wedge

12 x 21 pads

2 x 2 mm to 4.5 x 4.5 mm



Barrel ac-coupled strips

Endcaps ac-coupled, double metal pads

Multichip module for readout

Rohacell support structure

PHX-1 MCM

Substrate:

The substrate is 48mm x 40mm rectangular and 1.524 (60 mils) thick, fired, white alumina (AL_2O_3, 96%). It has 14 milled wells for 12 Custom Asic die and 2 Xilinx die.

Components:

12 Custom Asic, die
Xilinx Component, die
29 Chip Capacitors, surface mount

I/O Contacts

Inputs - 34 contact pads ((1.5mm x 0.45mm pad) 0.7mm pitch)
Outputs - 208 contact pads ((1.5mm x 0.1mm pad) 0.2mm pitch)

Circuitry:

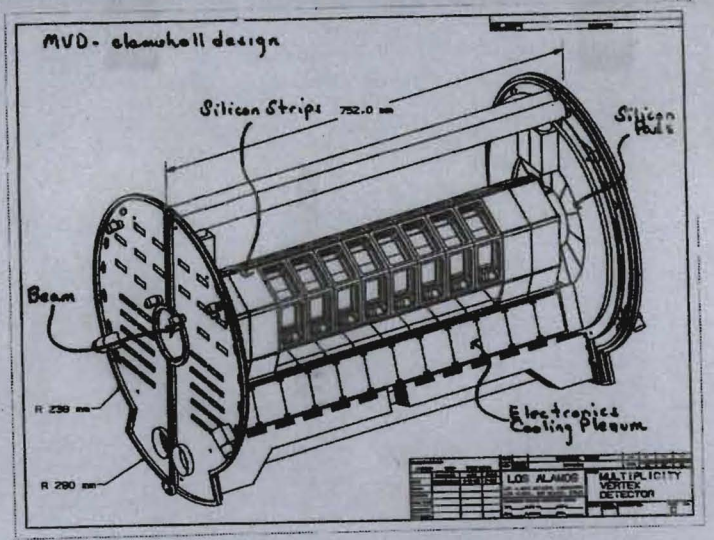
Basemetal - I/O pads, IC die backside metal contact, and 2 high-speed clock lines.
1st metal - Analog signal layer
2nd metal - Power plane
3rd metal - Digital signal layer
4th metal - Ground plane

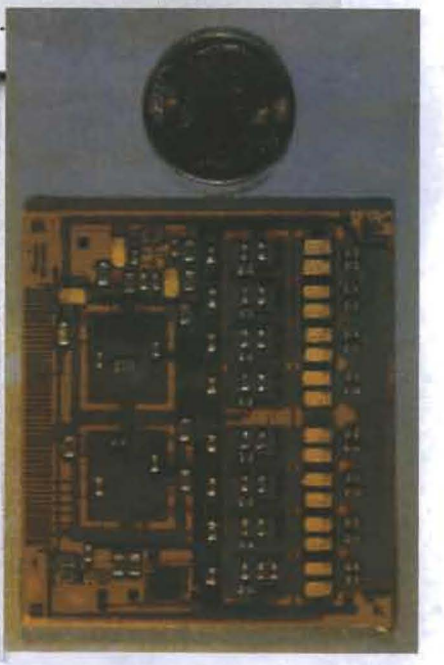
General Information:

950 connections (approx.)

Number of Vias	3624
Via Pad Size	0.072mm
Via Laser Drill Size	0.045mm
Minimum Trace Size	0.048mm
Minimum Trace Spacing	0.048mm

SCALE: 1:1





iFVTX

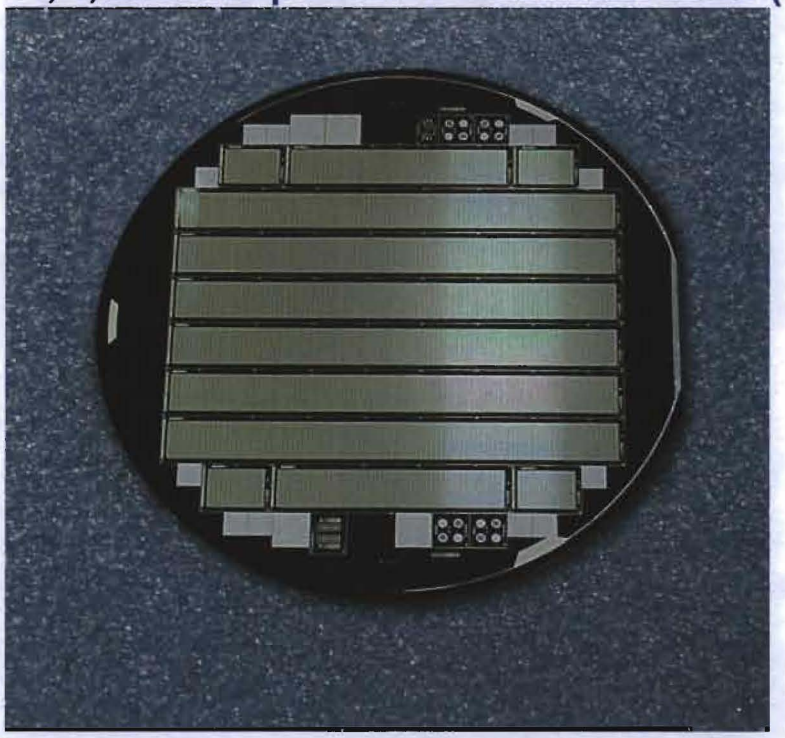
Atlas style pixel sensors

FPIX readout chip from BTeV

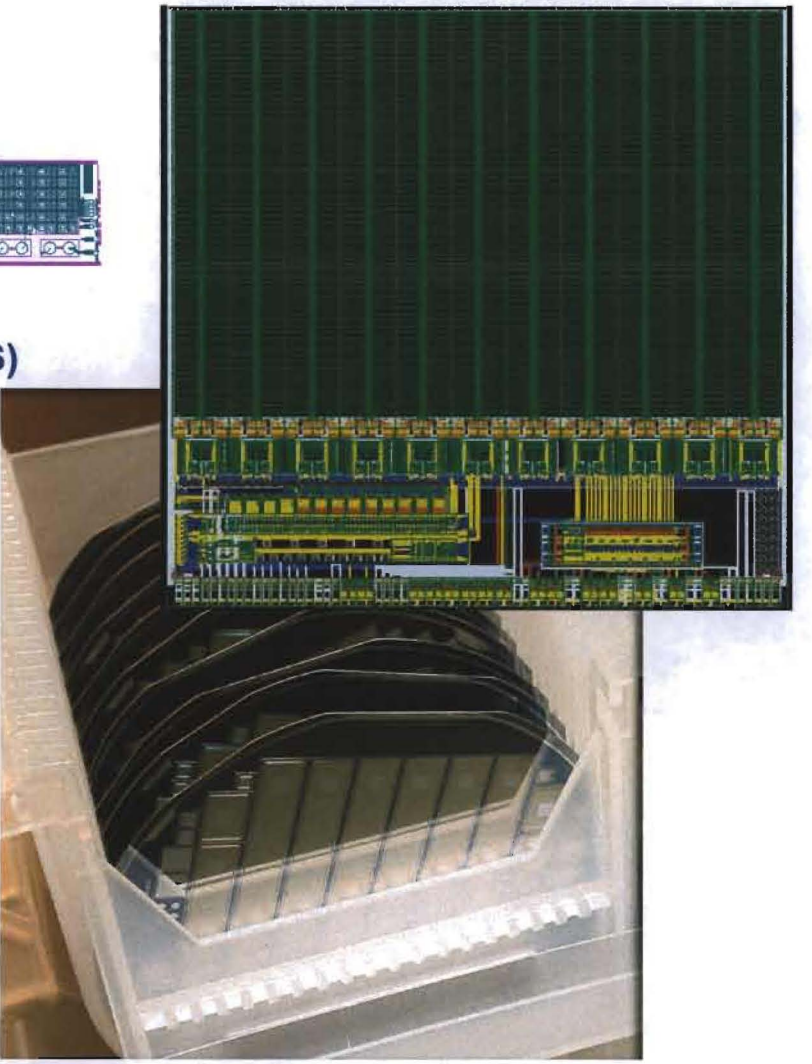
~1M channel picture frame for PHENIX R&D

8-chip ladder

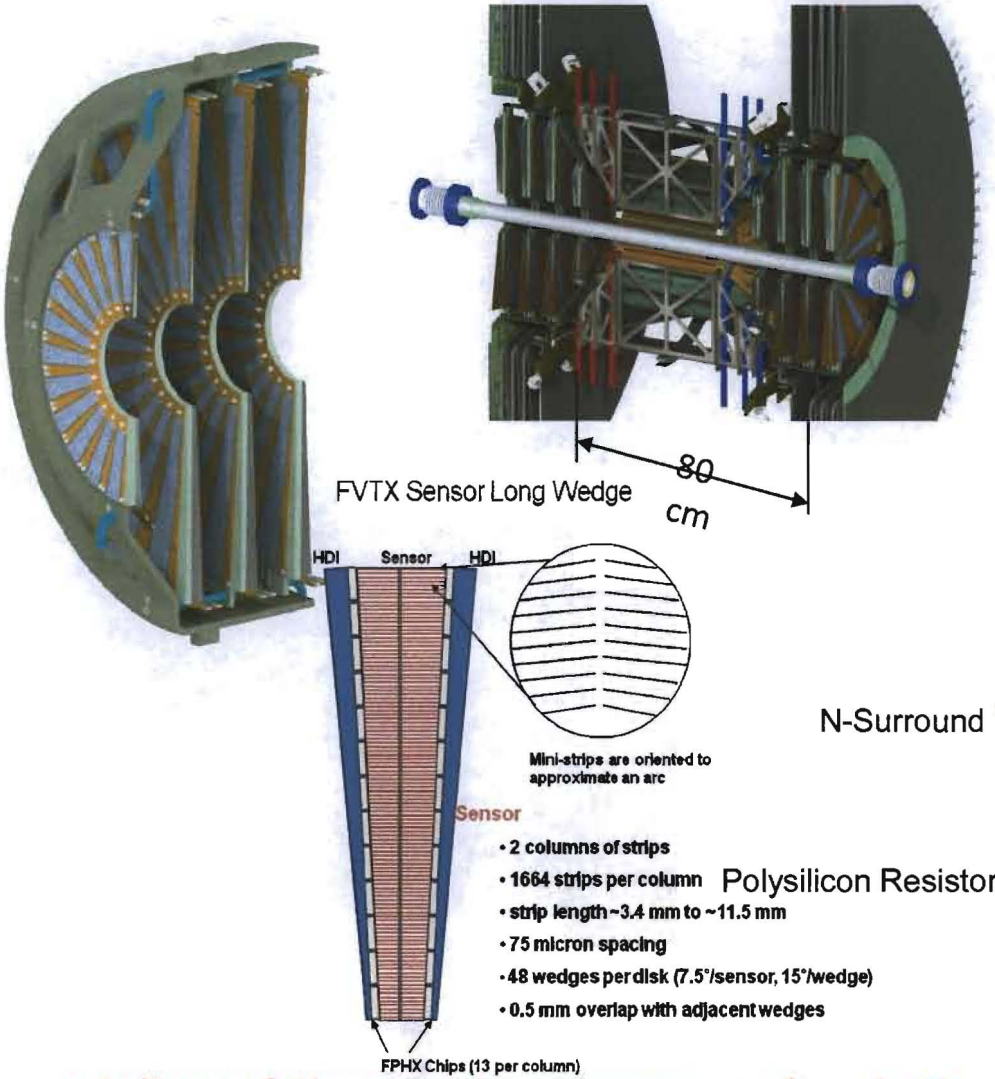
1, 4, and 8 chip sensors on a 4-inch wafer (CiS)



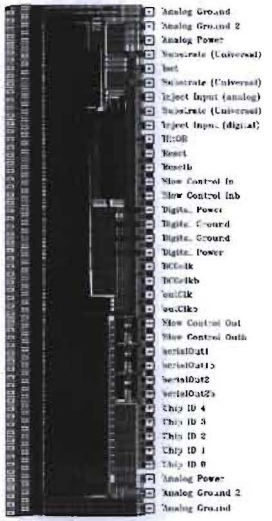
FPIX readout chip

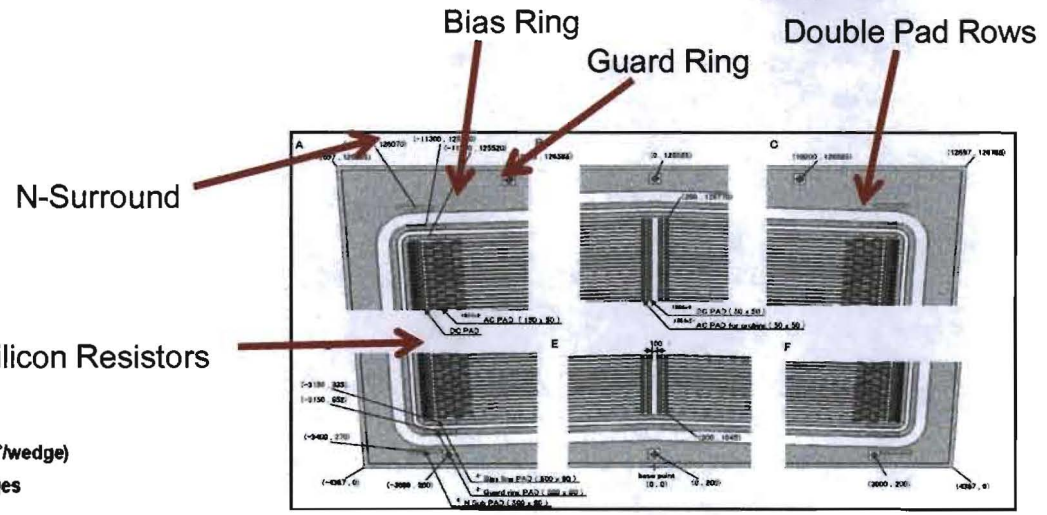


FVTX Upgrade



FPHX readout chip





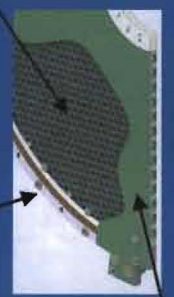
ac-coupled p-on-n

75 micron pitch

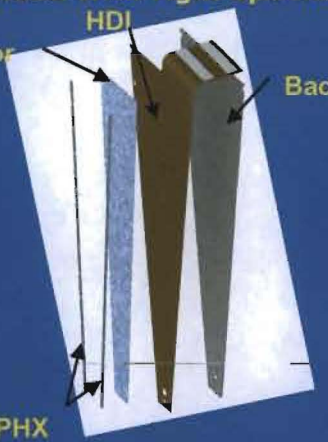
- 4 discs of Si sensor in acceptance of each Muon Arm
- Microstrips to accurately measure R coordinate of track
- > 1M channels
- Scheduled to be installed in FY11

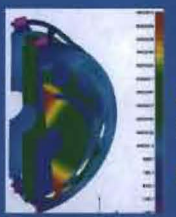
Jon S. Kapustinsky

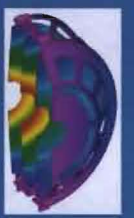
The wedge is the basic assembly unit of the FVTX. Each 15° wedge is comprised of a thermally conductive backplane, a kapton high density interconnect (HDI) signal and power router, a 7.5° silicon sensor, and two columns of FPHX readout chips. Design and modeling of the wedge assembly, the disk assembly, and the endcap enclosure is ongoing at Hytec Inc. Finite element analysis predicts acceptable results for thermal and mechanical distortions.

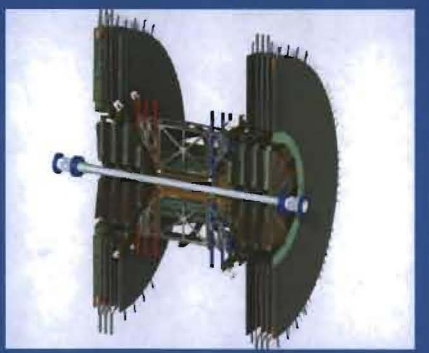


All bonded with rigid epoxies



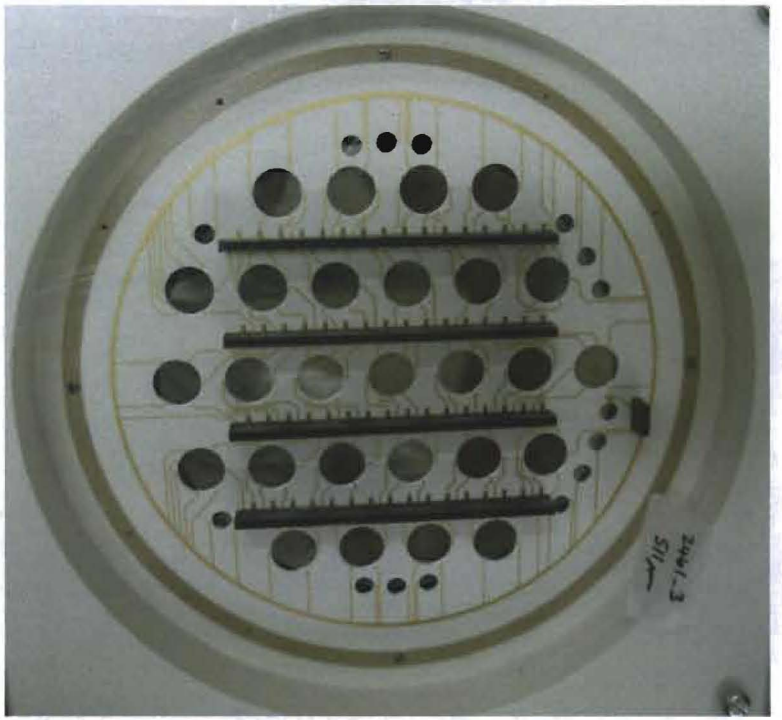


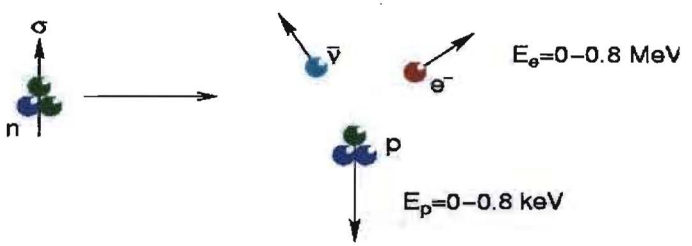
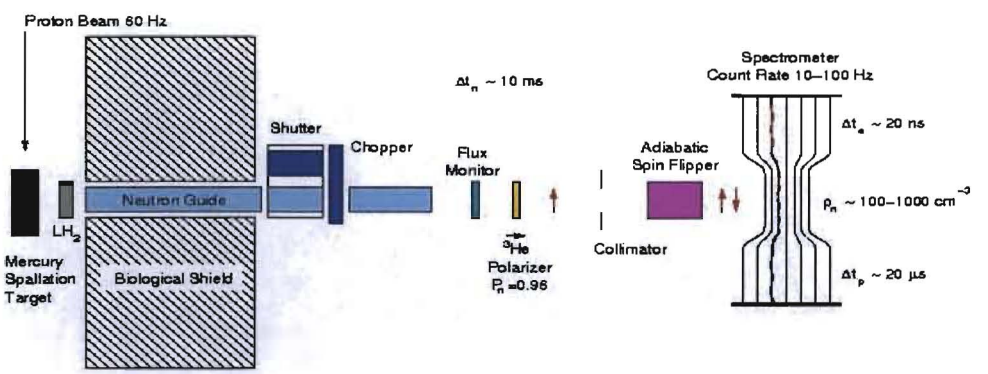




Large Area Ion-Implanted Si Detector

Neutron β -Decay with Polarized Cold Neutrons - abBA



PI - Scott Wilburn

- 89 cm^2 active area
- 2 mm thick (0.5 mm prototype)
- <100 nm thick entrance window
- Hermetic detection of charged particles
- Coincident detection of e^- and *p*
- Precision (10^{-4}) determination of *a, b, A, B*