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Title: Measurement of Neutron-Induced Nuclear Reaction Cross Sections on Fission-Product Nuclides

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Neutron-Induced Cross Sections on Fission Product Nuclei (P163)

70 YEARS OF CREATING TOMORROW

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CEA/NNSA Collaboration on Fundamental Science
May 30, 2013

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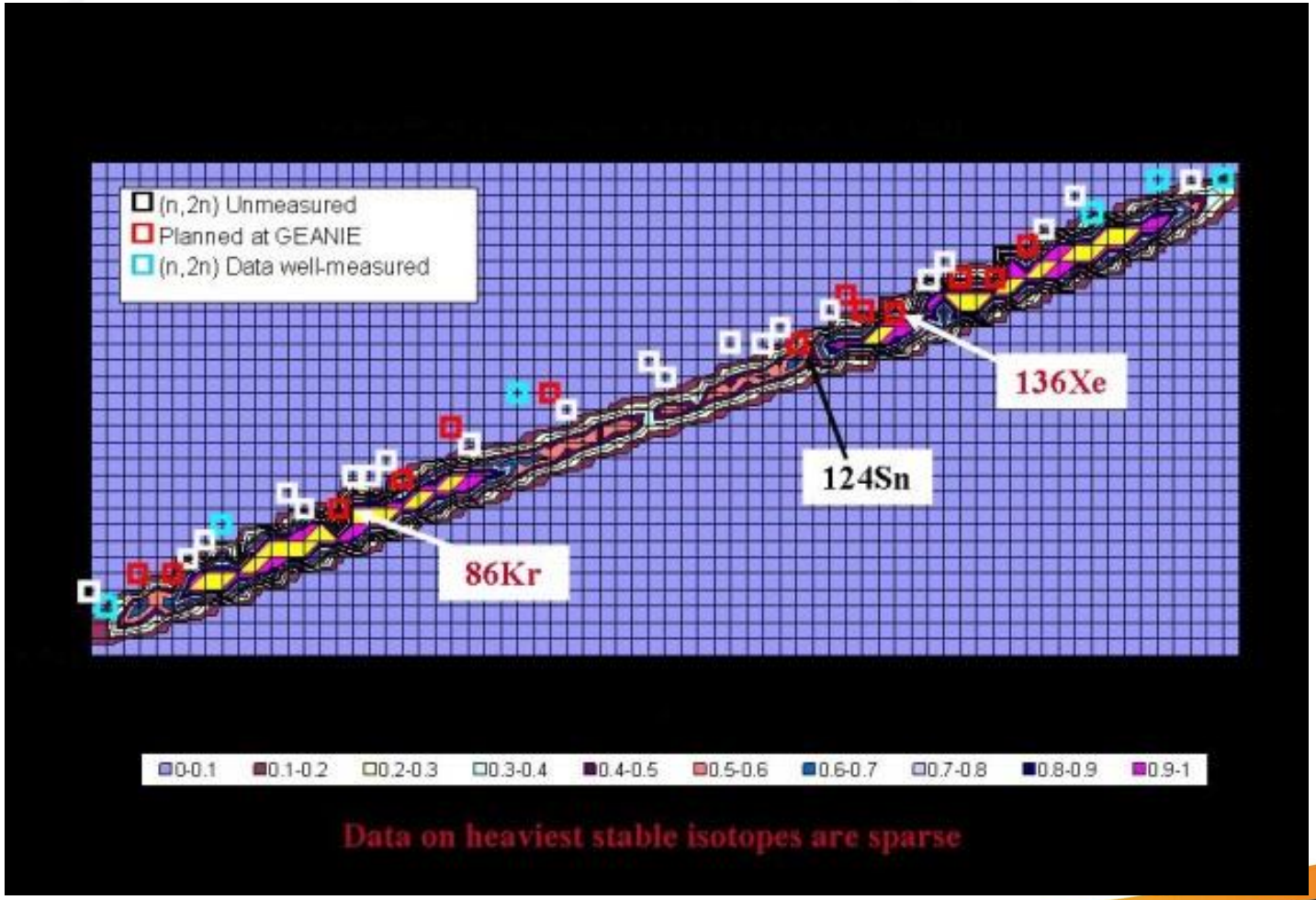
Providing nuclear data to test and benchmark reaction models in relation to neutron economy in the fission environment

- Goals
  - Determine significant (n,n'), (n,2n), (n,3n), (n,p) and (n,α) cross sections on stable fission product nuclei
  - Provide data to serve as benchmarks for nuclear reaction model calculations
  - Improve neutron economy and transport calculations
  - Add levels and gammas to nuclear database

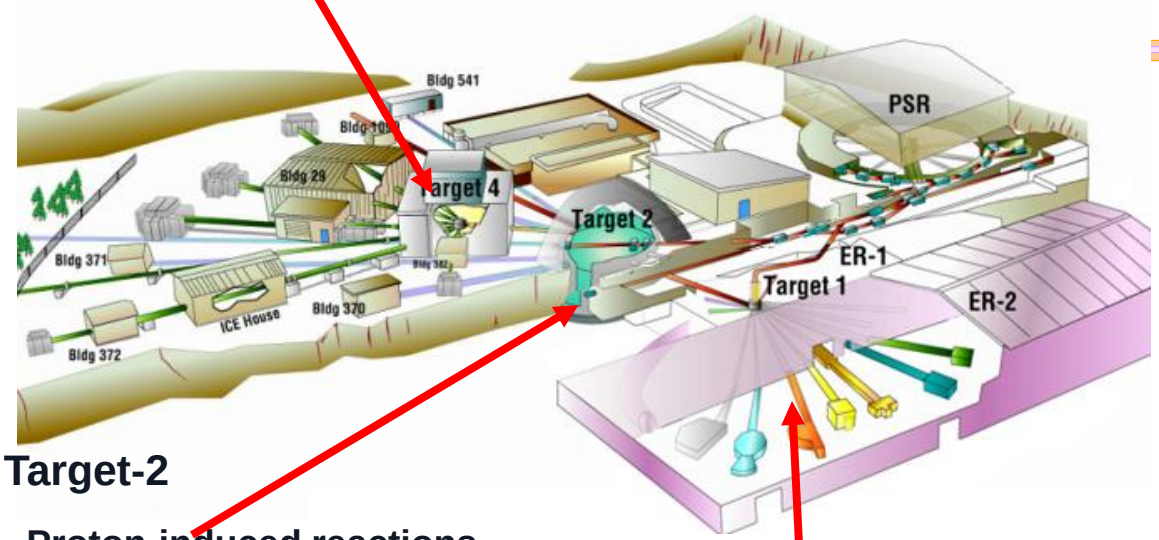
Chart of the Nuclides Showing Fission Products for E_n=14 MeV



Nuclear Science research is performed at many experimental areas at LANSCE

Weapons Neutron Research Facility

Target-4
High-energy neutron research



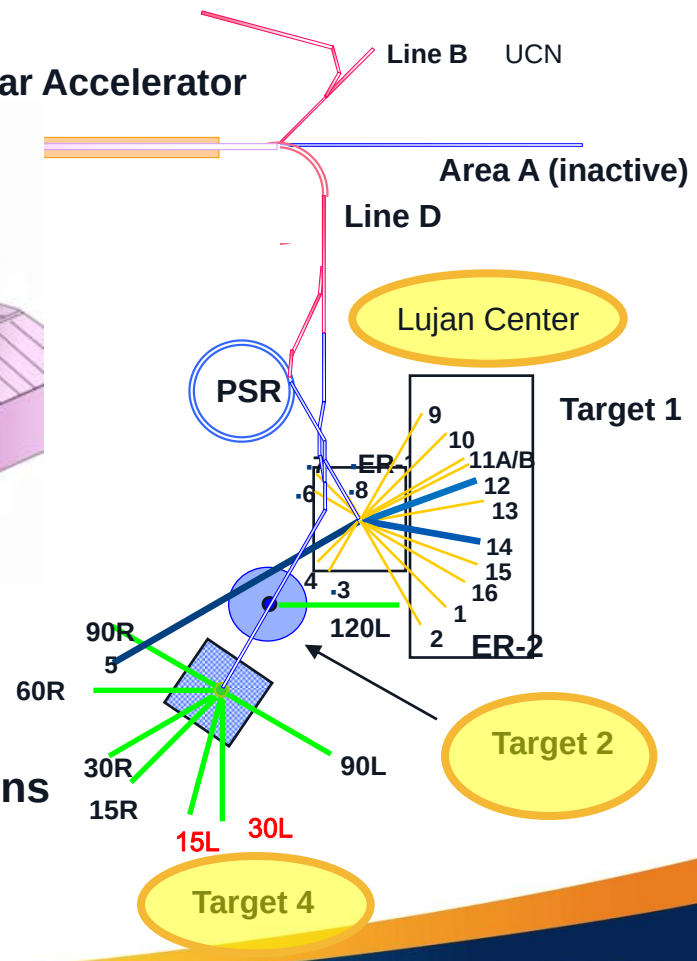
Target-2

- Proton-induced reactions
  - Single-pulse experiments (Sandia)
  - Lead Slowing-Down Spectrometer
  - SNS target testing
  - Isotope production testing
  - 99Mo production tests

Lujan Center

Low-energy neutrons
- Material science
- Nuclear science

Proton Radiography



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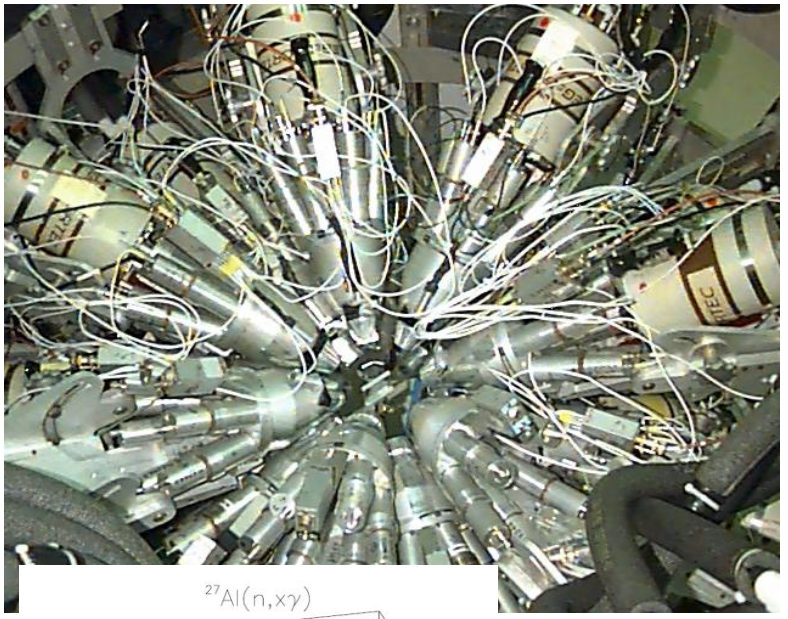
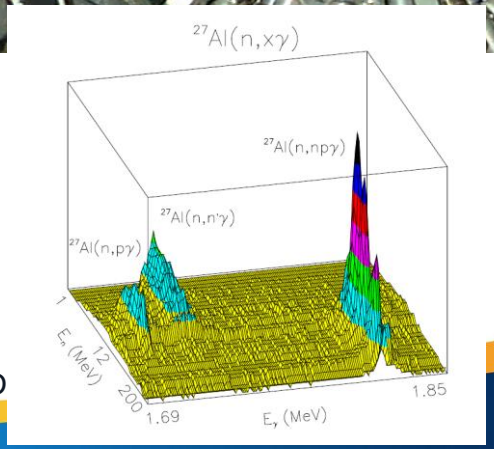
GEANIE is an Array of High-Resolution Gamma-Ray Detectors

- Combination of planar Ge (x-ray and γ) detectors and coaxial Ge detectors – 20 total
- Photon energy range 15 keV < E_γ < 9 MeV
- BGO background suppression shields
- Measure gamma-ray pulse height, neutron time of flight, 100 keV < E_n < 400 MeV
- Built using elements of the former HERA array from LBL
- Collaboration with LLNL and CEA Bruyères-le-Châtel

GEANIE γ-ray Spectrometer Array





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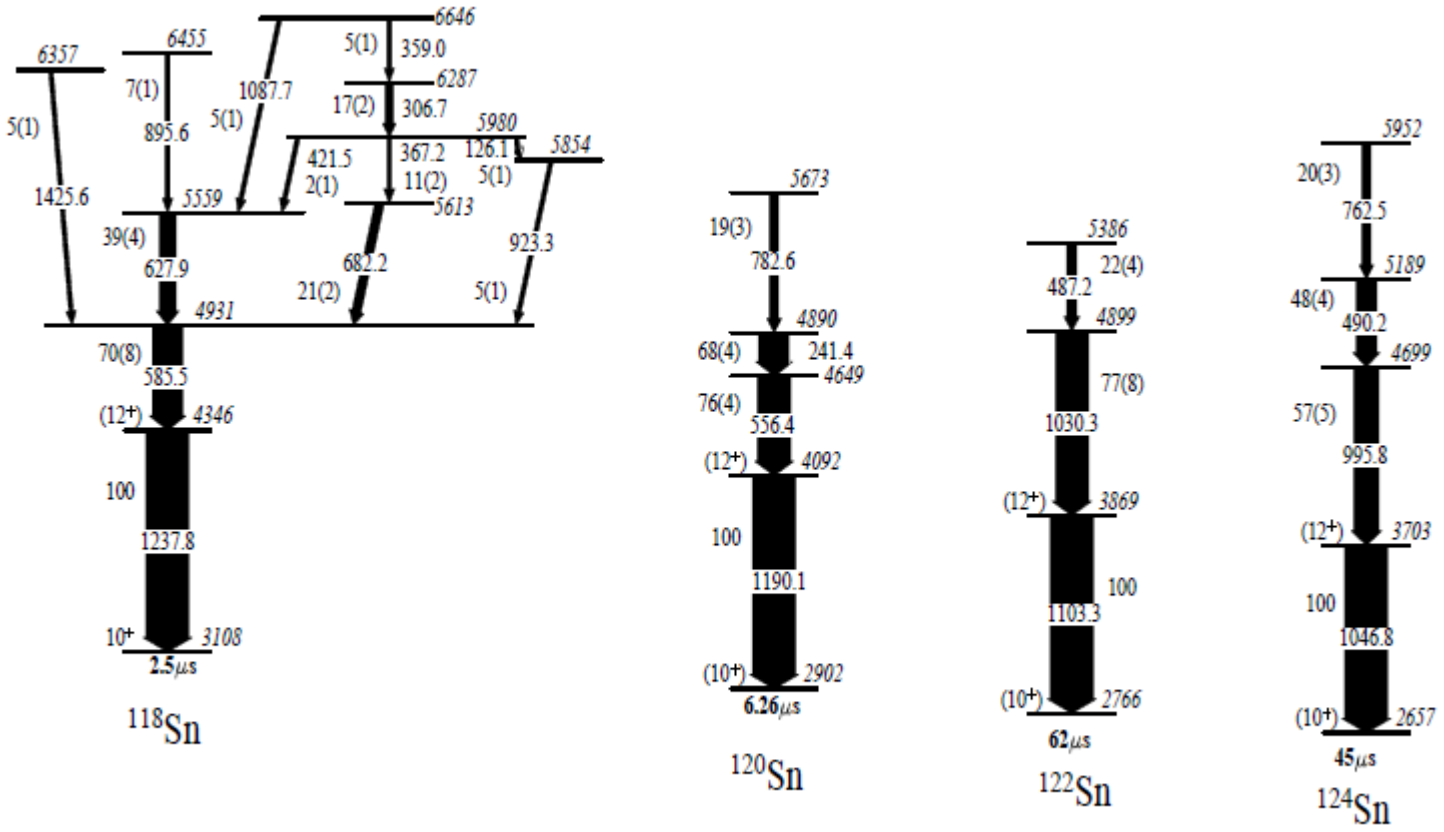
GEANIE Experiments at LANSCE with Samples from Bruyeres-le-Chatel

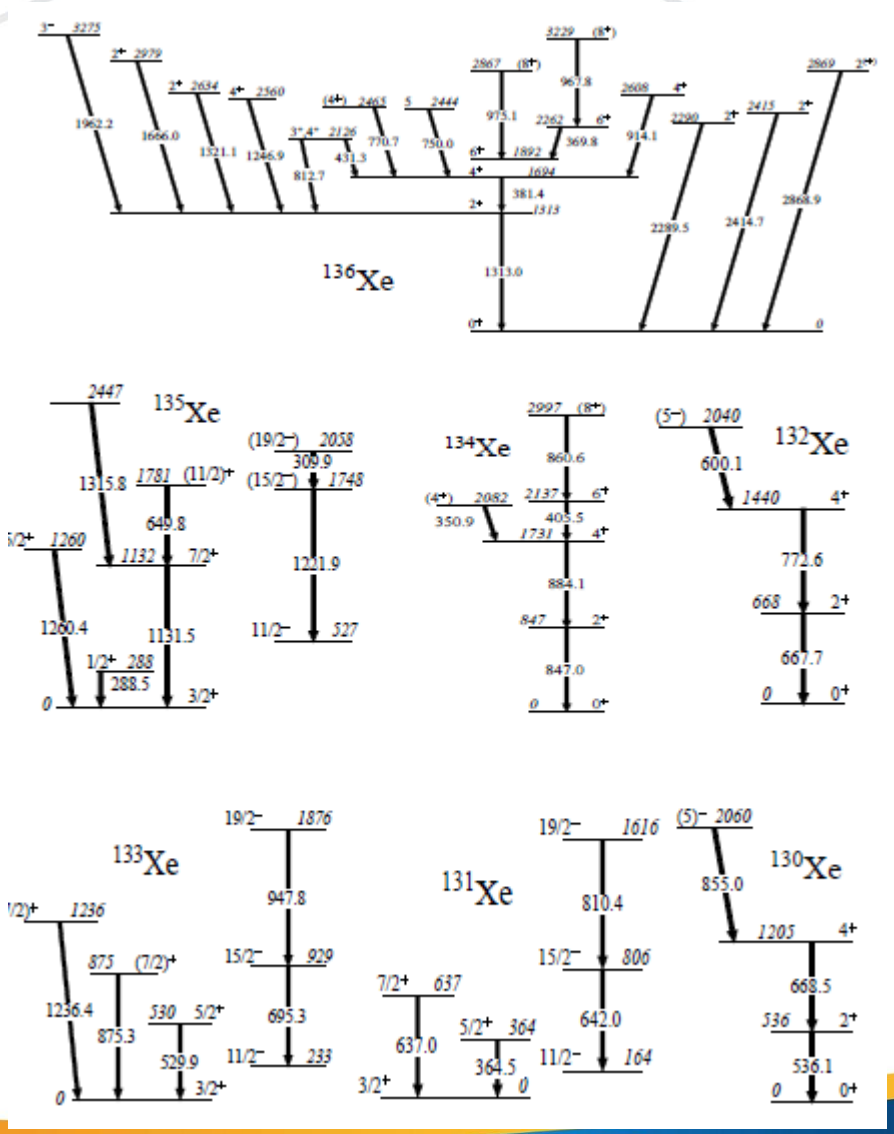
- Measurements on fission fragments
  - Light: ^{86}Kr, ^{93}Nb, ^{100}Mo
  - Symmetric:^{112,124}Sn
  - Heavy:^{127}I, ^{130}Te, ^{136}Xe, ^{138}Ba
- Data on lightest and heaviest Sn isotopes can test reaction models
  - Surprisingly little data on heaviest stable nuclei
- ^{124}Xe – ^{136}Xe planned

CEA gas cell for Xe and Kr samples

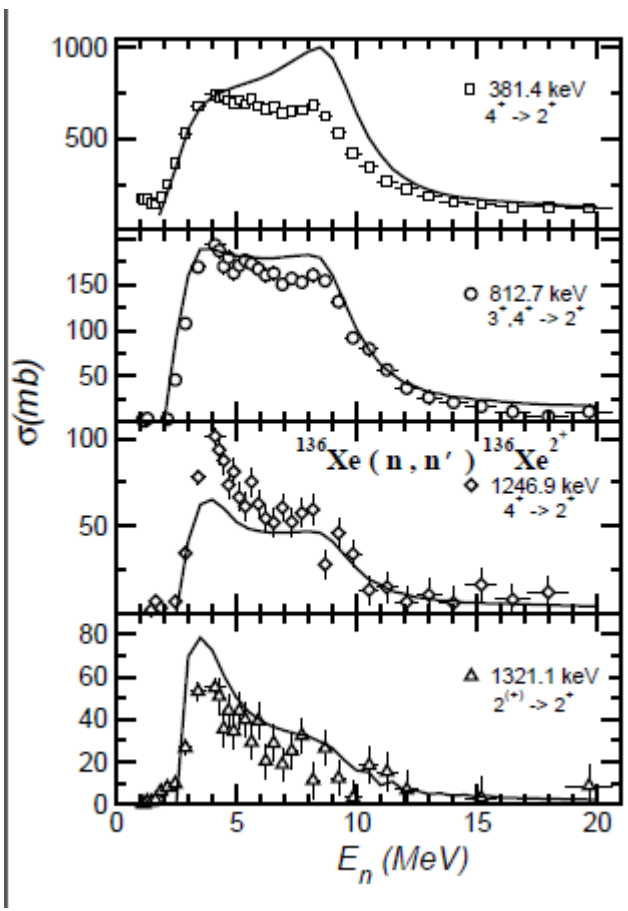
Measured Feeding of 10^+ Isomers in Tin Isotopes – from GEANIE and Gammasphere Data

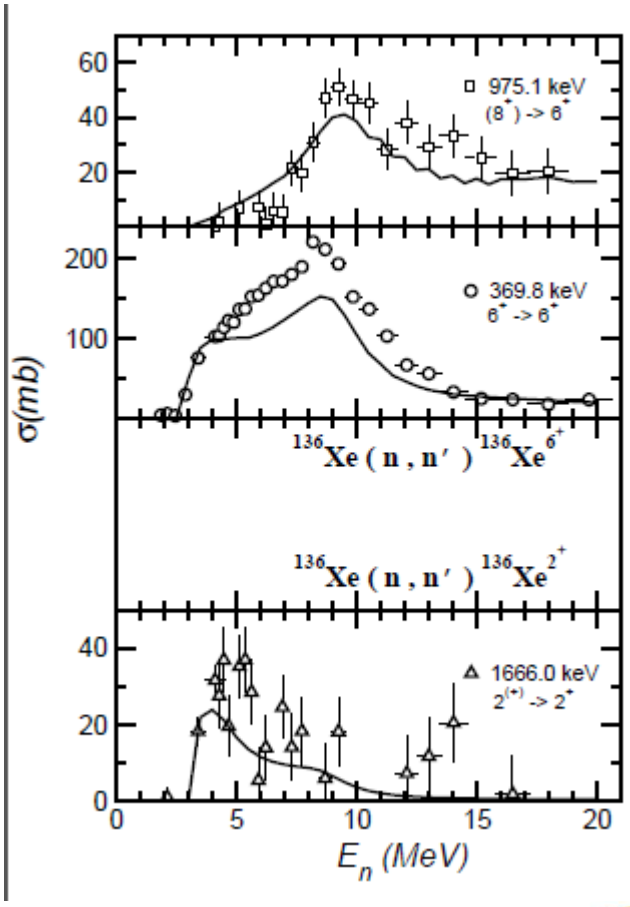


^{135}Xe Levels and Gammas



^{136}Xe(n,n') Excitation Functions Compared to Model Calculations

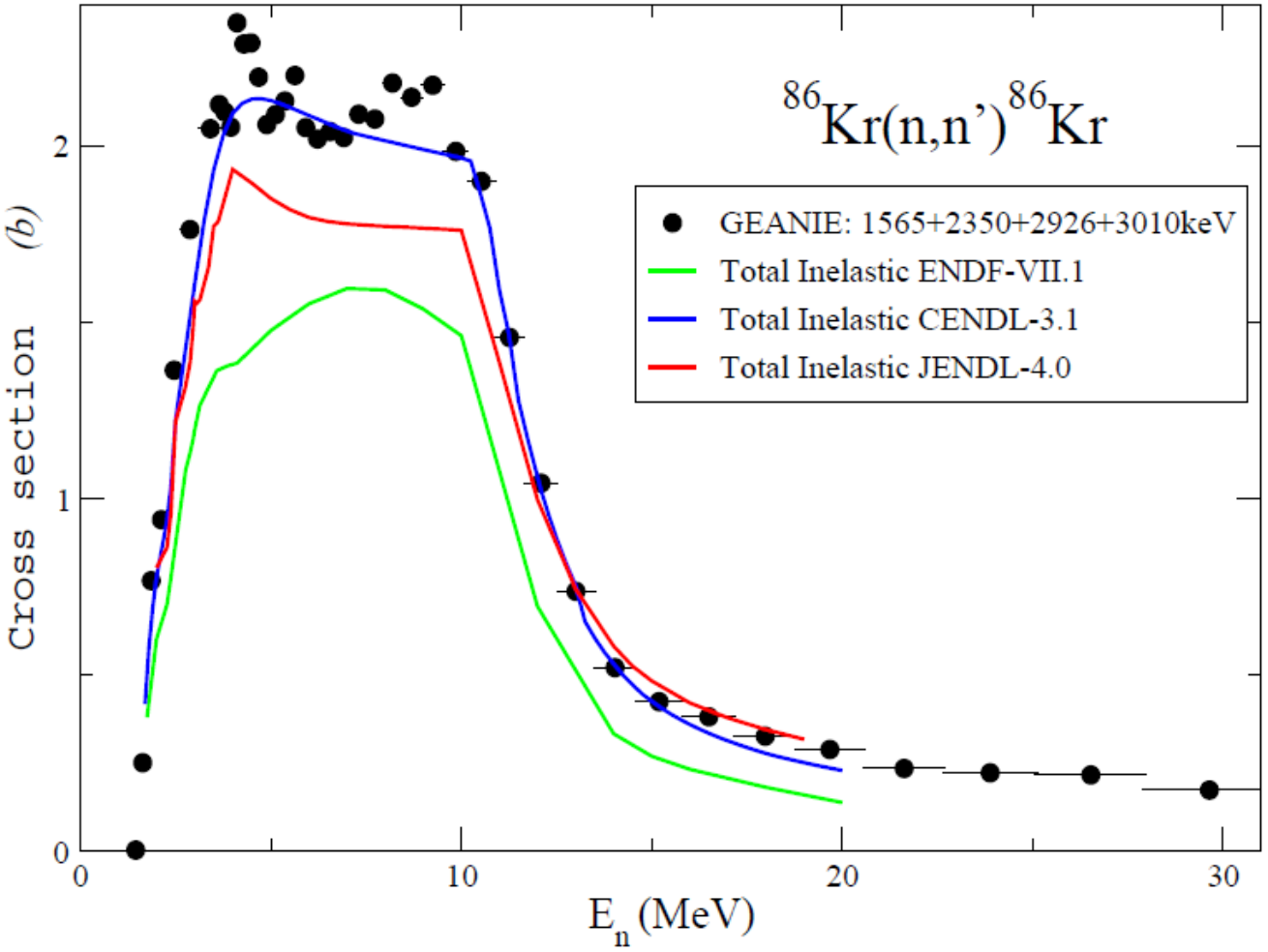




New gammas and levels

- ^{86}Kr
  - 10 gamma rays observed for the first time
  - 1 previously unknown energy level identified
- ^{124}Sn
  - Many new levels and gammas
- Will be sent to evaluators for inclusion in databases

^{86}Kr summed inelastic gamma-ray data compared with total inelastic evaluations



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GEANIE Is Providing Valuable Data for Neutrino-less Double-Beta Decay and Dark Matter Search Experiment Designs

- ^{136}Xe is a $0\nu\beta\beta$ decay detector candidate
- Liquid Argon detectors are one detector design for dark matter searches
- In deep underground experiments, cosmic ray produced neutrons may create backgrounds in critical energy regions
- GEANIE data provide limits on those backgrounds

Publications

- "Low-spin states in ^{86}Kr from the (n,n′) reaction," N. Fotiades, M. Devlin, R. O. Nelson, and T. Granier, Phys. Rev. C **87**, 044336 (2013)
- "States built on the 10^{+} isomers in ^{118,120,122,124}Sn," N. Fotiades, M. Devlin, R. O. Nelson, J. A. Cizewski, R. Krücken, R. M. Clark, P. Fallon, I. Y. Lee, A. O. Macchiavelli, and W. Younes, Phys. Rev. C **84**, 054310 (2011)
- "High-Spin States in ^{135}Xe," N. Fotiades, R. O. Nelson, M. Devlin, J. A. Cizewski, J. A. Becker, W. Younes, R. Krücken, R. M. Clark, P. Fallon, I. Y. Lee, A. O. Macchiavelli, T. Ethvignot, and T. Granier, Phys. Rev. C **75**, 054322 (2007)

Summary

- Good progress on data acquisition
- Analysis is continuing
- Work with reaction modelers on these data sets is starting
- New nuclear structure and reaction data has been obtained – 3 journal articles
- Gas sample work benefiting neutrinoless double beta decay/dark matter searches