LA-UR-21-20448

Evaluation of Energy Dependent Fission Product Yields

Status Report 2021

T. Kawano, LANL

PIs: A. Sonzogni (BNL), L. Bernstein (LBNL),
L. Wood (PNNL), and N. Schunck (LLNL)

Energy-Dependent FPY Project Funded by NA22

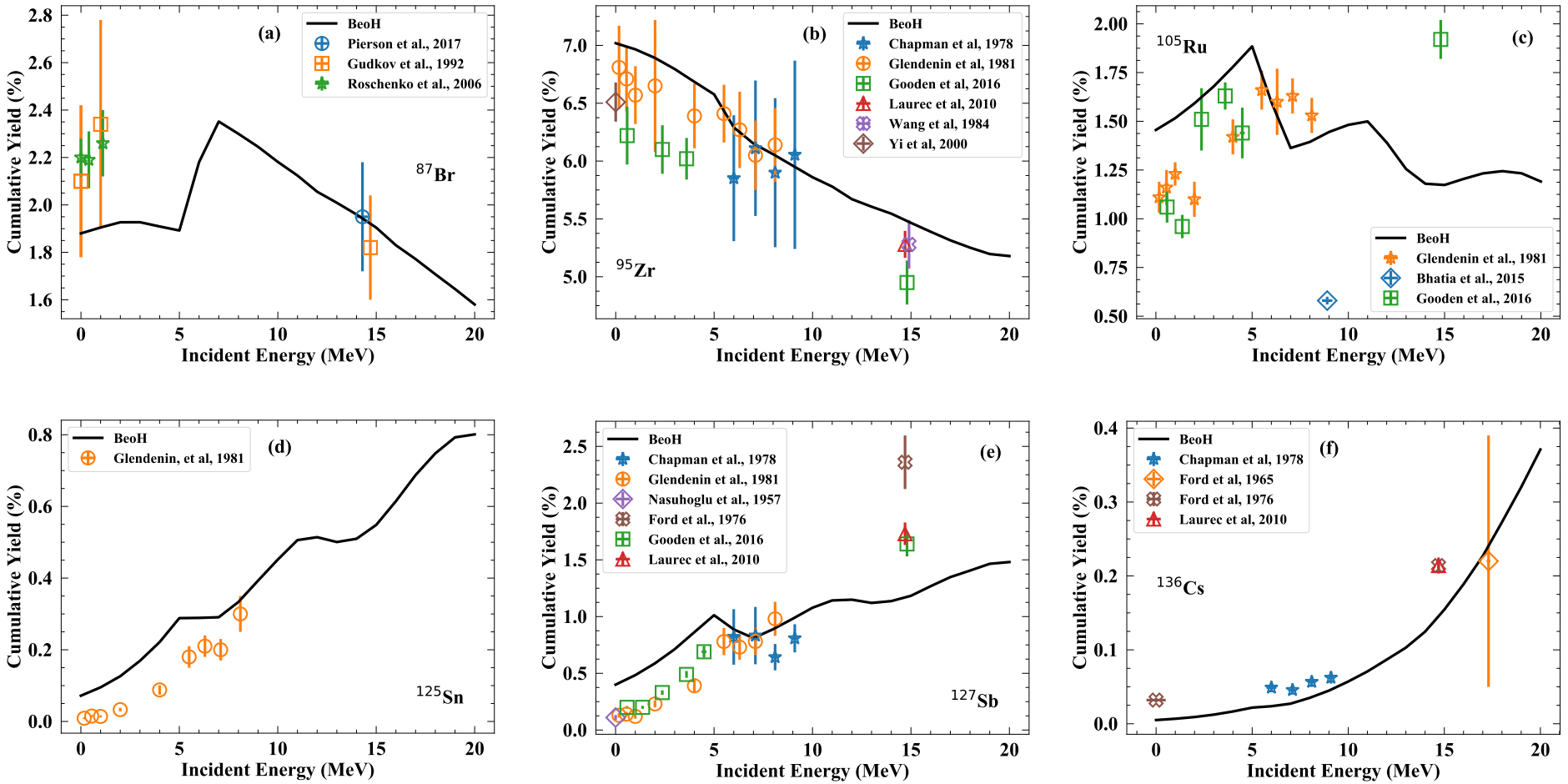
Joint effort by 5 laboratories (LANL, BNL, LBNL, PNNL, and LLNL)

Recent Relevant Meetings

- CSEWG (virtual, hosted by BNL, 11/30 – 12/3, 2020) FPY and covariance sessions
  - N. Schunck, R. Vogt, C. Sears, A. Mattera, A. Lovell, R. Lorek, E. Matthews
- IAEA Fission Yield CRP (virtual, hosted by IAEA, 8/31 – 9/4, 2020)
  - Meeting report, INDC-NDS-0817, prepared by T. Kawano, B. Pritychenko, R. Vogt, et al.
- EPJ Web of Conferences: International Workshop on Fission Product Yields
  - Vol.42 (2020), Santa Fe, New Mexico, USA, 9/30 – 10/4, 2019
  - All papers are available at:

https://www.epj-conferences.org/articles/epjconf/abs/2020/18/contents/contents.html

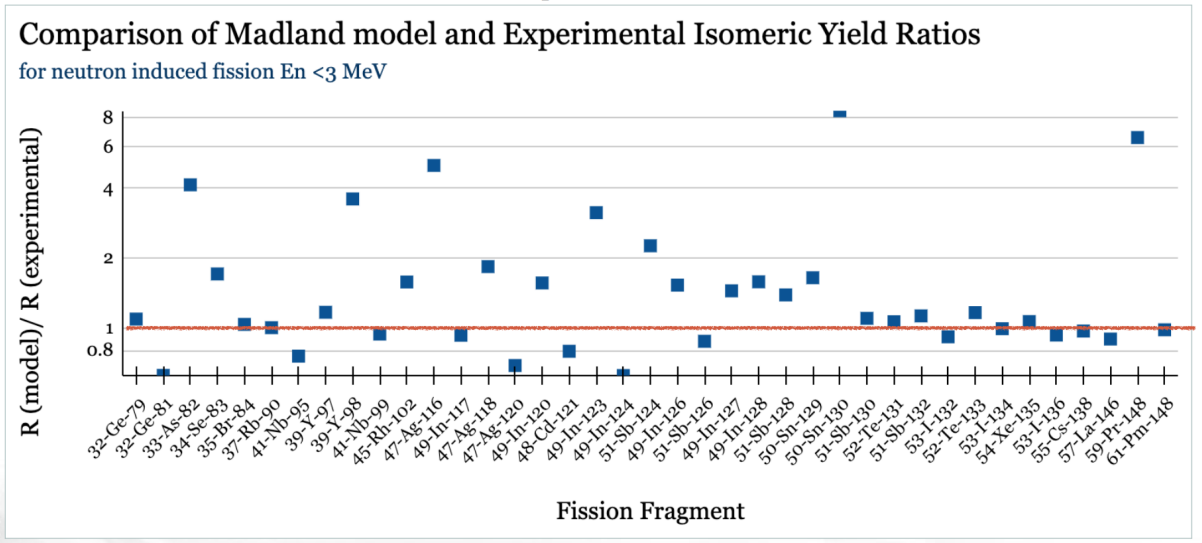
LANL FPY model: Multi-Chance Fission

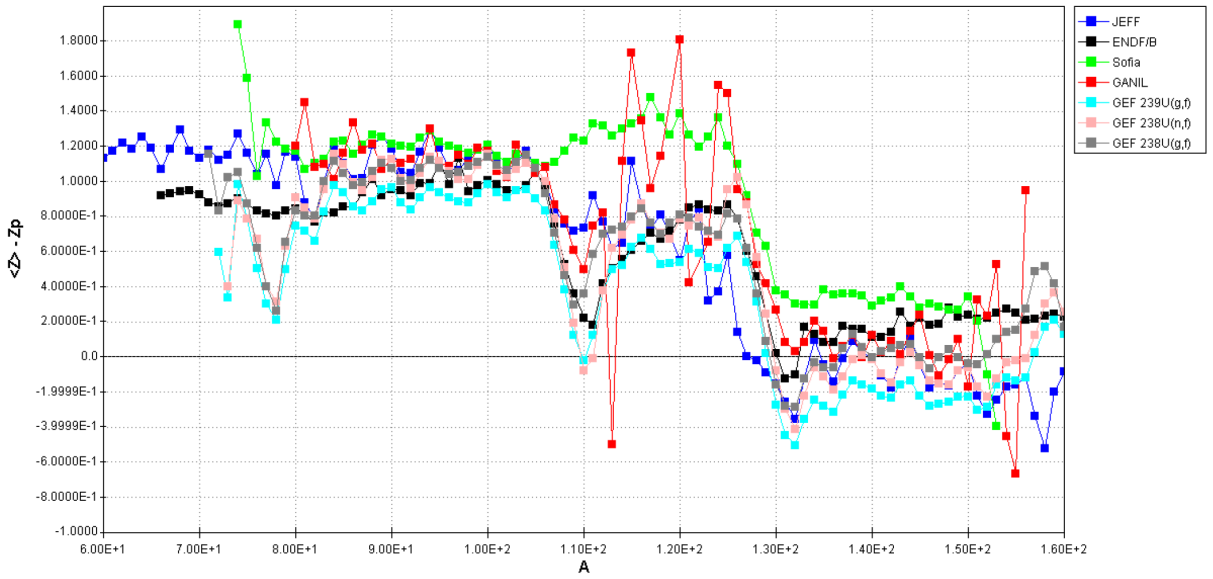


A. Lovell, et al. PRC to be published

BNL/NNDC Activities

- Searched and compiled all fission yield data in **NSR** and **EXFOR**, including non-journal references in the England & Rider report as well as the Robert Mills' thesis.
- Developed JSON format for fission yields.
- Corrected ^{238}U yields measured using activation technique with current decay data.
- Compiled all Isomeric Ratio data and compared with Madland-England model.
- Studied surrogate potential of inverse kinematics data from GANIL and GSI.
- Compared ^{238}U yields with GEF calculations for outlier identification.

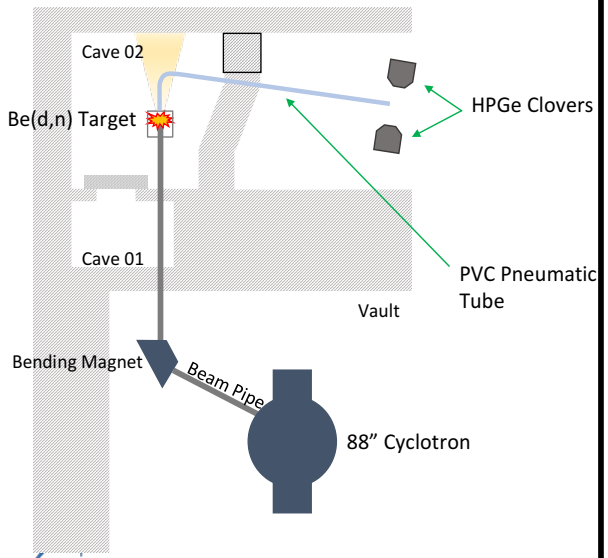




Fission Yield Measurements @ LBNL (FLUFFY)

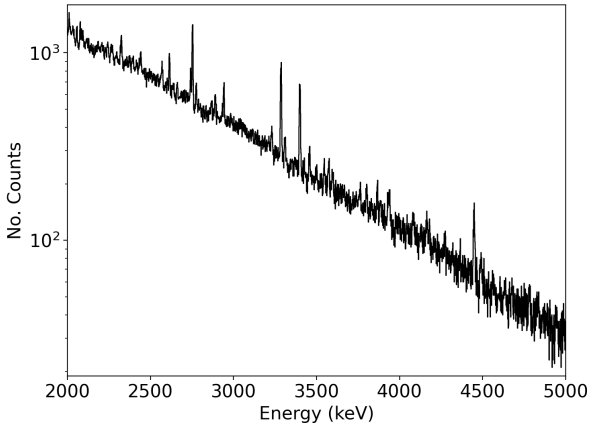
Experimental Apparatus

- Fast Loading User Facility for Fission Yields at the LBNL 88-inch cyclotron transports samples between beam in < 1 second.
- ^{235,238}U data taken – 7/20
- ^{235}U,^{239}Pu planned for 21



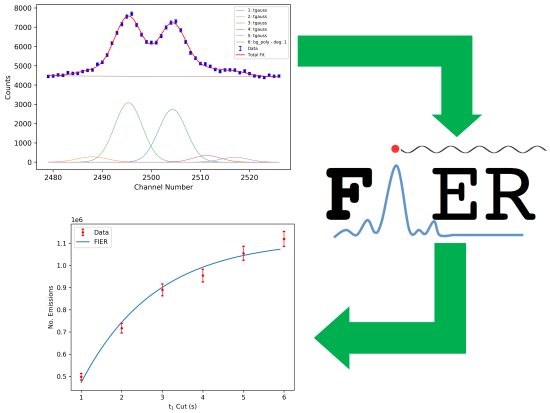
High-Energy Gammas

- Rapid transport times allow for short-lived high Q_β FP's to be seen.
- Characterization of high-energy gammas from these products with relevance to safeguards and security.



Data Analysis

- FIER is used to model the irradiation scheme of the experiment in order to handle complex decay corrections.
- Minimization between FIER and experimental data allows simultaneous determination of FPY, $t_{1/2}$, BR, and I_γ's.



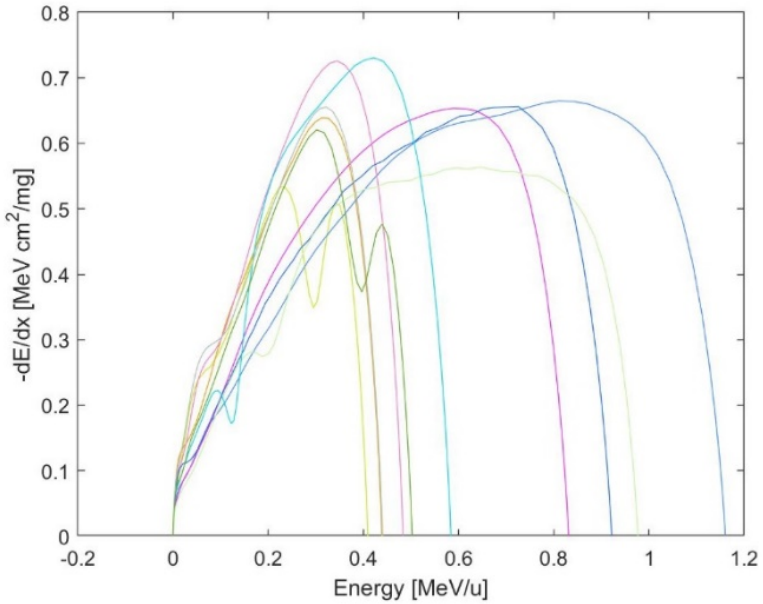
Independent FPY Measurements @ PNNL

Looking at energy loss in MeV-cm^2/mg for improved Z discrimination

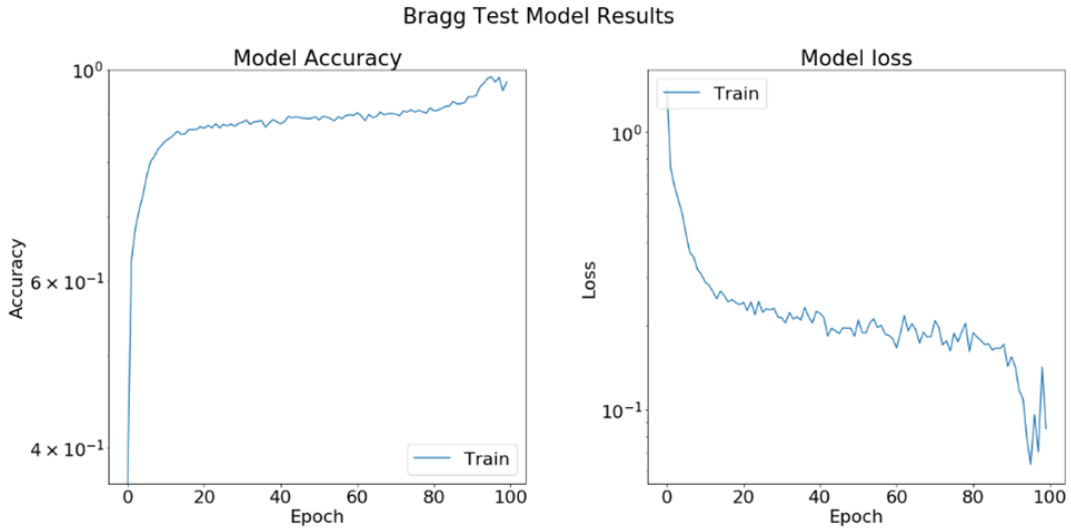
- Fitting low-order polynomial to energy-normalized tail of the areal density stopping power
- Strong nuclear recoils are a challenge; exploring methods of generalizing track data for identification

Machine-learning based Bragg curve identification

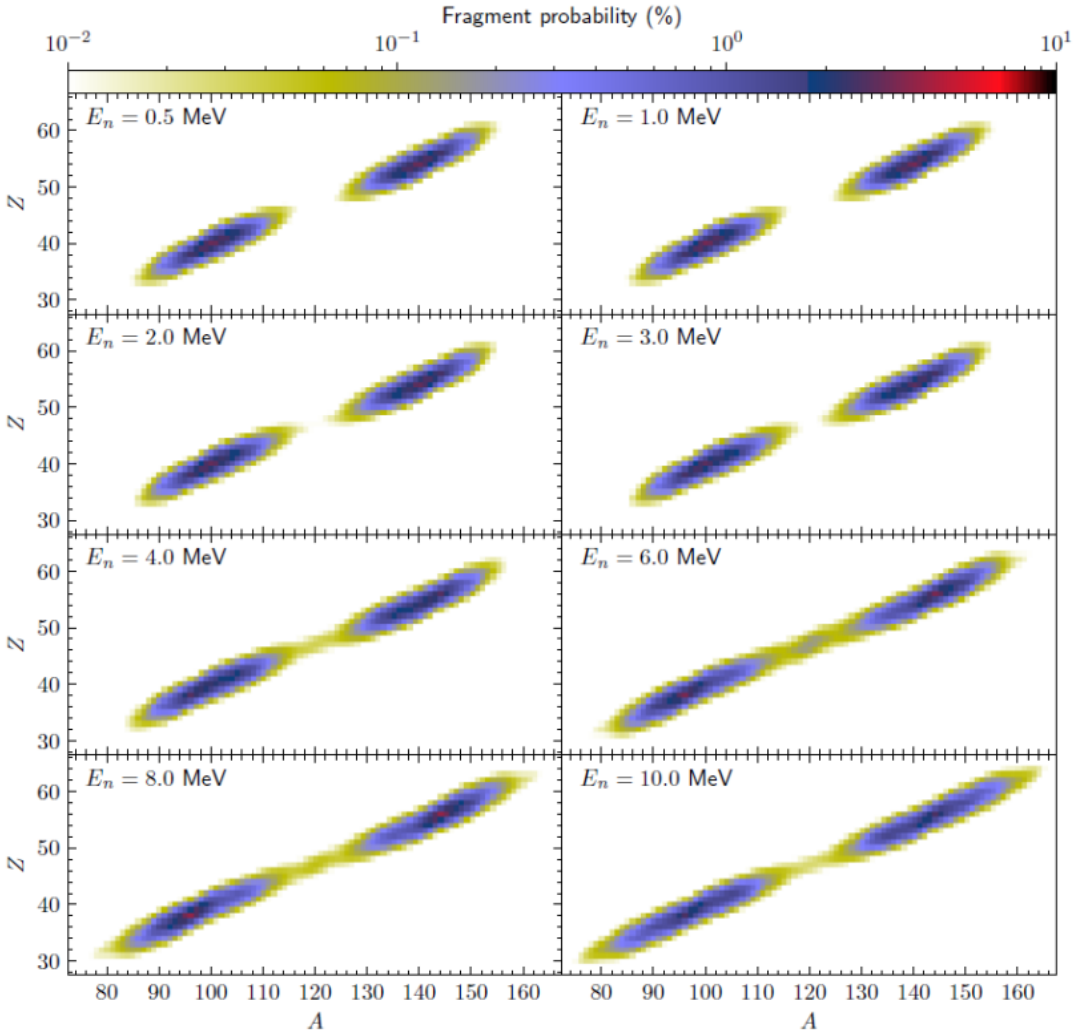
- Initial model has shown promising results
- Generating significantly larger data set now
- Working with ML experts at PNNL on using "semi-supervised" learning methods to mix simulation and experimental data



Areal density stopping power for 10 fissionTPC tracks

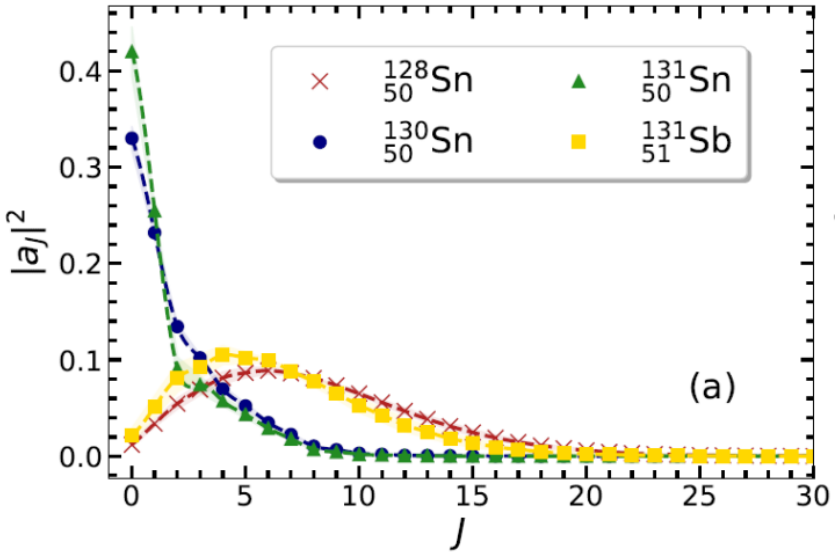


LLNL Activities



Particle number projection gives Y(Z,A) as a function of neutron energy

- Angular momentum projection techniques predict spin distributions consistent with FF deformations
- Initial FREYA calculations suggest visible impact in photon multiplicities



Predictions from microscopic results can provide guidance to improve phenomenological models built in statistical reaction codes