Evaluation of Energy Dependent Fission Product Yields
Status Report 2022

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Energy-Dependent FPY Project Funded by NA22

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

FY22 no cost extension at LBNL and PNNL

This report contributed by T. Kawano, A. Lovell, I. Stetcu (LANL), A. Sonzogni and A. Mattera (BNL), L. Bernstein and E. Matthews (UCB/LBNL), N. Schunck, M. Verriere (LLNL), S. Okumura (IAEA)

Recent Relevant Meetings

- Independent project review (5/20, 21), virtual event
  - T. Kawano and A. Lovell (LANL), A. Sonzogni and A. Mattera (BNL), L. Bernstein and E. Matthews (LBNL and UC. Berkeley), L. Wood and M. Moore (PNNL), and N. Schunck (LLNL)

- CSEGW (11/15 - 19, 2021), virtual event
  - A. Lovell helped organizing FPY session
LANL FPY Modeling for Energy Dependence

- Model parameter fitting by applying the KALMAN filter (Bayesian) technique
- Energy-dependent FPYs for $^{235,238}$U and $^{239}$Pu produced
- $^{252}$Cf spontaneous fission, preliminary

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A.E. Lovell, under preparation for publication

S. Okumura et al., JNST 2022
Modeling Spin of Fission Fragments

- Assumptions on the FF spin sensitive to many fission observables, FPY, nu-bar, fission gammas, etc.
  - Recent experimental data need to be interpreted properly
- So far we don’t see any issues in our modeling/assumptions which conflict with experimental findings

I. Stetcu, PRL 127, 222502 (2021)
BNL Evaluation of Experimental FPY data

- JSON-based database to store experimental FY values
- Compilation of $^{238}\text{U}$, $^{239}\text{Pu}$, and $^{241}\text{Pu}$ data updated with new decay data
- Study of the energy-dependence of $^{238}\text{U}$ experimental data
- Isomeric Yields compiled, corrected and new recommended experimental values
BNL FPY Data Benchmarking by Beta-Delayed Electron

- Electron spectrum data in ORNL reports (J.K. Dickens, et al) digitized
  - ENDF/B-VIII.1b decay data JEFF-3.3 FPY data
  - 25 most important contributions identified

Electron Energy (MeV)

**238U**

Electron Energy (MeV)

**239Pu**

Electron Energy (MeV)

**241Pu**
LBNL/UCB Measurements 2020 and 2021

- Fast Loading User Facility for Fission Yields (FLUFFY) at LBNL cyclotron
  - Transport times <0.75 sec allow observation of short-lived fission products
- July 2020 Experiment, $^{238}\text{U}$, $^{235}\text{U}$
  - 14 MeV deuteron breakup on graphite
  - FPY g-emission data analyzed by the FIRE code
  - $A = 86, 98, \text{ and } 136$ mass chains reported in E. Matthews’s dissertation
- May 2021 Experiment, $^{239}\text{Pu}$
  - Data analysis ongoing
LLNL Primary Fission Fragment Yields

- Combining particle-number projection techniques with large-amplitude collective motion
- Particle number projection key to predict isotopic yields $Y(Z,A)$ – including as a function of incident neutron energy
  - deviates from unchanged charge distribution (UCD)
  - good agreement with experimental data for major actinides
Fission Fragment Spin Distribution

- Angular-momentum projection technique gives the spin distributions of primary fission fragments
  - Importance of shell effects at scission
  - No adjustable parameters
  - Used as inputs in statistical decay code such as FREYA to determine photon spectrum

- \(^{238}\text{U}(n,f)\)
- Distribution \(P(\phi_L)\)
- Opening angle \(\phi_L\) (degrees)

- \(J_F(\hbar)\)
- \(A_F\) vs. \(J_F(\hbar)\)

- J. Randrup, R. Vogt, PRL 127 062502 (2021)
Publications


- Advancements in the Nuclear Data of Fission Yields, E. Matthews's Ph.D. thesis,

