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A Study of Fission Modes to Improve Nuclear Forensics

June 2019

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Idaho National Laboratory

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A Study of Fission Modes to Improve Nuclear Forensics

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IMPACT

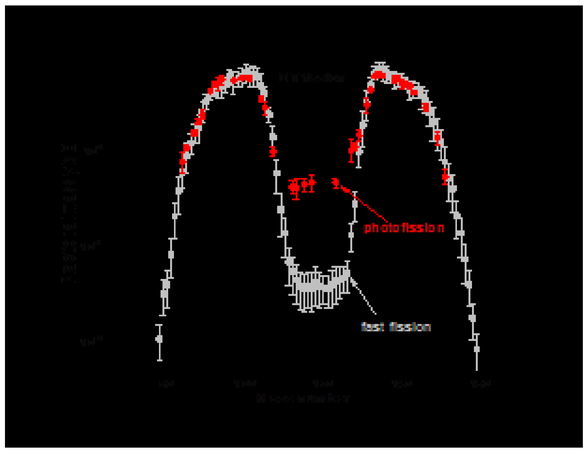
- ***New or improved production methods for isotopes of interest to nuclear forensics***
- ***Methods to provide improved nuclear data of isotopes of interest to the science and nuclear forensics communities***

BACKGROUND

The nuclear forensics community continues to seek timely and cost-effective methods for producing low-fission yield isotopes, in particular isotopes with masses that fall within the valley of the fission fragment mass distribution. One such method that is generating interest is the use of photofission-based isotope production. To utilize photofission to its greatest extent, the contribution of the various fission modes and their influence on mass distributions, and consequently their influence on valley isotope production, warrants an in-depth examination.

OUTCOMES

- Generate a relatively unique method for producing fission-valley isotopes
- New method to provide publishable nuclear data



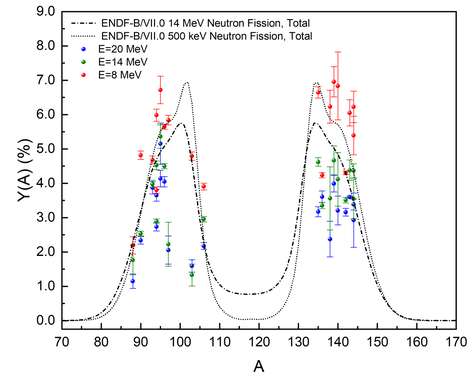
APPROACH

- Obtain and evaluate charge and mass distributions from various databases and the literature
- Establish the mathematical formulism to decompose the selected mass distributions into their respective components of the multimodal fission models
- Compare and evaluate the results with prior work available from the literature
- Obtain, evaluate/validate experimentally-measured, photofission mass distributions using complementary INL-led research
- Apply decomposition methods to the photofission mass distributions
- Evaluate peak-to-valley ratios and specific isotopic ratios as a function of excitation energies
- Report and publish appropriate findings

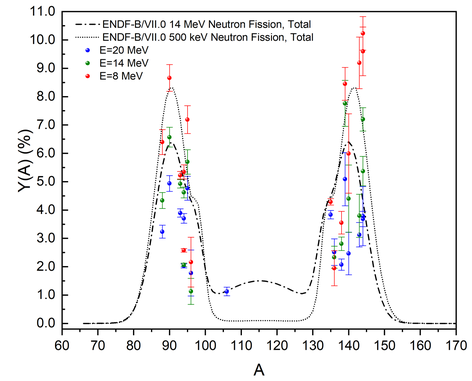
RESULTS

- Assessment of empirical neutron- and photon-induced fission data
- Fitting routines implemented based on Levenberg-Marquardt least squares fitting algorithms - each fission mode of the multimode-fission model is assumed to be a Gaussian function, with the total fragment yield, as a function of mass number represented by:

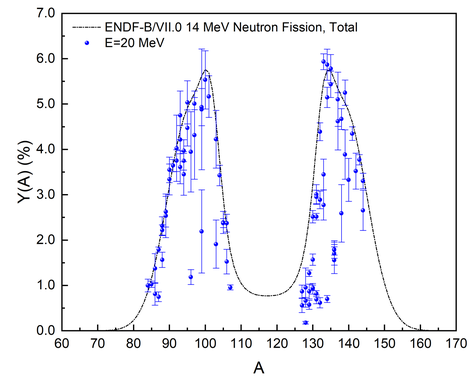
- Suite of computational tools developed from which empirical data sets are generated
- Software interfaces with Origen-S and MCNP to produce empirical, simulated data
- Fission fragment mass distributions provide “ground truth” values
- Evaluation of analysis methodologies and optimization of experimental measurements



Experimentally measured short-lived CFPY for ^{238}U at bremsstrahlung X-ray endpoint energies 8, 14 and 20 MeV with respect to the multimode-fission model fit to ENDF-B/VII.0 fast (500 keV) and DT neutron fission fractional mass yields[3].



Experimentally measured short-lived CFPY for ^{232}Th at bremsstrahlung X-ray endpoint energies 8, 14 and 20 MeV with respect to the multimode-fission model fit to ENDF-B/VII.0 fast (500 keV) and DT (14 MeV) neutron fission fractional mass yields[3].



Experimentally measured long-lived CFPY of ^{238}U at bremsstrahlung X-ray endpoint energy 20 MeV with respect to the multimode-fission model fit to ENDF-B/VII.0 DT (14 MeV) neutron fission fractional mass yields[3].

[1]Belyshev, S. S., Ishkhanov, A. A. and Stopani, K. A.; “Mass yield distributions and fission modes in photofission of ^{238}U below 20 MeV,” Phys Rev C **91**, 034603 (2015).
[2]England, T. R. and Rider, B. R.; “Evaluation and Compilation of Fission Product Yields,” ENDF-349, LA-UR-94-3106, Los Alamos National Laboratory (1994) [available at http://t2.lanl.gov/publications/yields/apxA.txt].
[3]ENDF-B/VII.0: Accessed from Janis 4.0, Nuclear Energy Agency, Organization for Economic Co-operation and Development. [Accessed from: https://www.oecd-nea.org/janis/].

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