Predicting Angular Momentum of Fission Fragments Using Machine Learning

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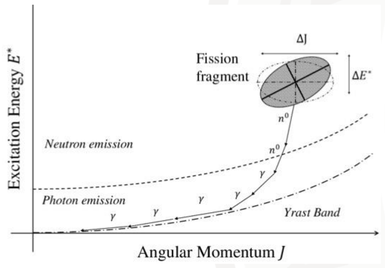
Introduction and Motivation

Daughter fragments in fission are observed to have angular momentum. Understanding the production of angular momentum contributes to:

- Insights on gamma-ray production
- Isotope identification
- NDA screening techniques
- Directional distribution of a particle

The **Manchester Spin Method** is used to determine angular momentum of a fragment using *discrete* gamma spectra.

Incorporating machine learning techniques will expand analysis to *statistical/continuum* gamma-rays.



Mission Relevance

NNSA Mission: Preventing nuclear weapons proliferation and reducing the threat of nuclear and radiological terrorism around the world.

Analyzing the gamma ray spectra from the rotation of fission observables will further our understanding of fission in SNM, particularly when it comes to isotope identification and NDA screening techniques. This will contribute to NNSA's nonproliferation objectives.

Technical Approach

1. Verify the MSM initial level and spin population distribution

Inputs: ENSDF level scheme, gamma spectrum

Outputs: E_γ matrix, GSF matrix, initial level/spin population distribution

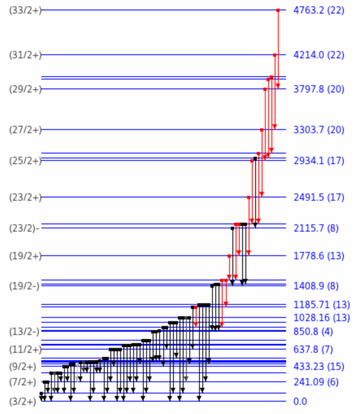
Verified by simulated and experimental data

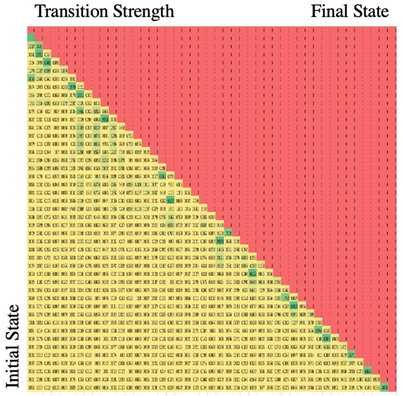
2. Use RAINIER to isolate and analyze statistical gamma-ray data

RAINIER generated gamma spectrum, neutron and gamma-ray energy/multiplicity

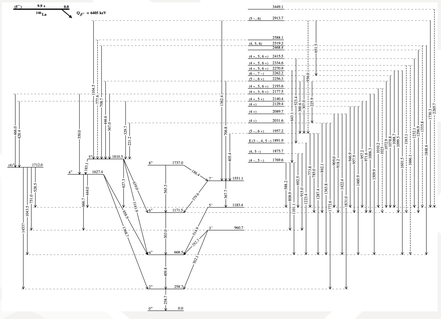
3. Develop machine learning script to reconstruct angular momentum distributions

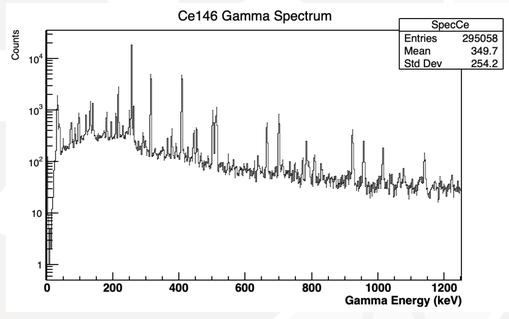
Training set: RAINIER generated time-dependent event list

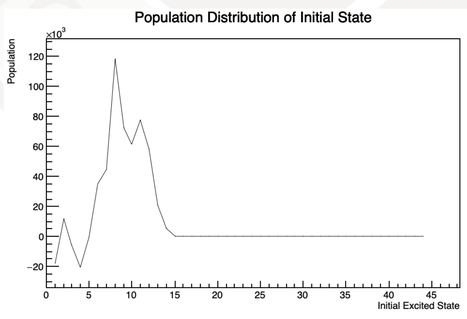


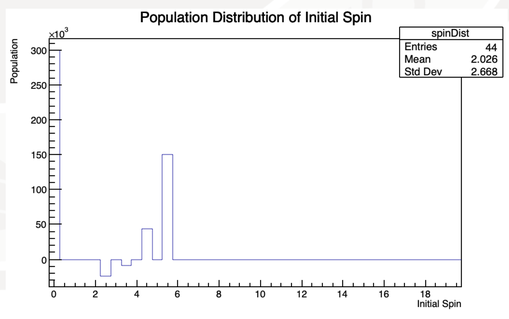


Results









Experimental data from ANL Gammasphere using ^{146}La beta-decay to ^{146}Ce

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MTV Impact

National Laboratory Collaborations:

- Argonne National Laboratory
  - Gammasphere
- Lawrence Berkeley National Laboratory
  - RAINIER Simulation Tool

MTV MCNP/MCNPX-PoliMi Workshop

Conclusion

This work shows the validity of the MSM to determine a fragments initial spin distribution, and includes preliminary work that incorporates statistical contributions towards the angular momentum of fission fragments

Future work includes:

- Modifying RAINIER for event-by-event analysis
- Creating analysis algorithms to determine spin distributions of fragments

National Nuclear Security Administration