Correlations Between Fission Fragment Properties and γ-Ray Emission

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Introduction and Motivation

As detection technology and techniques improve, nonproliferation instrumentation has become sensitive to increasingly complex signatures of fission. We intend to elucidate the origins of those signatures by measuring correlated fission neutrons and gamma rays.

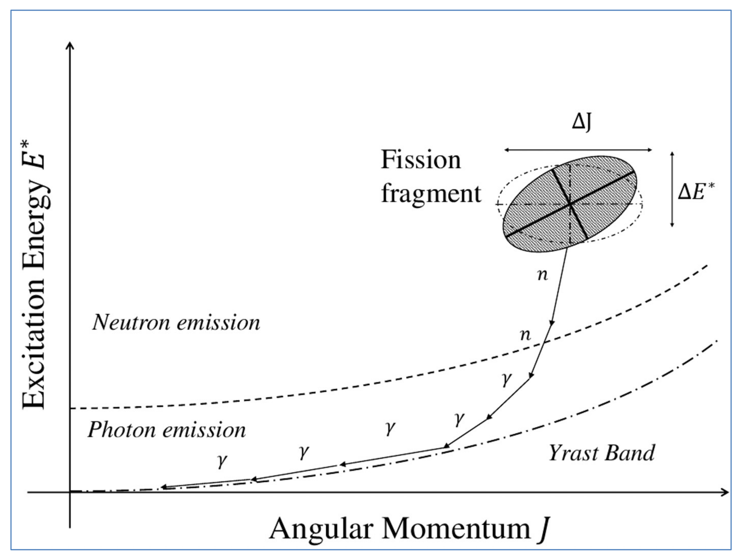

Fig. 7. Cartoon of fission fragment de-excitation [1]

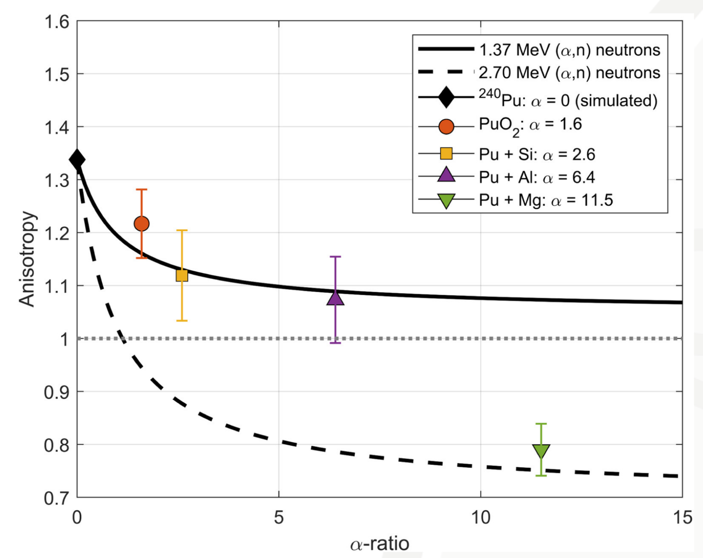

Fig. 1. Pu metal can be distinguished from oxides with neutron anisotropy [2]

Nuclear Data: Improving evaluated data libraries

Modeling Fission: More accurate signatures in simulations for instrument development for nonproliferation, e.g., **CGMF** (LANL), **FREYA** (LLNL)

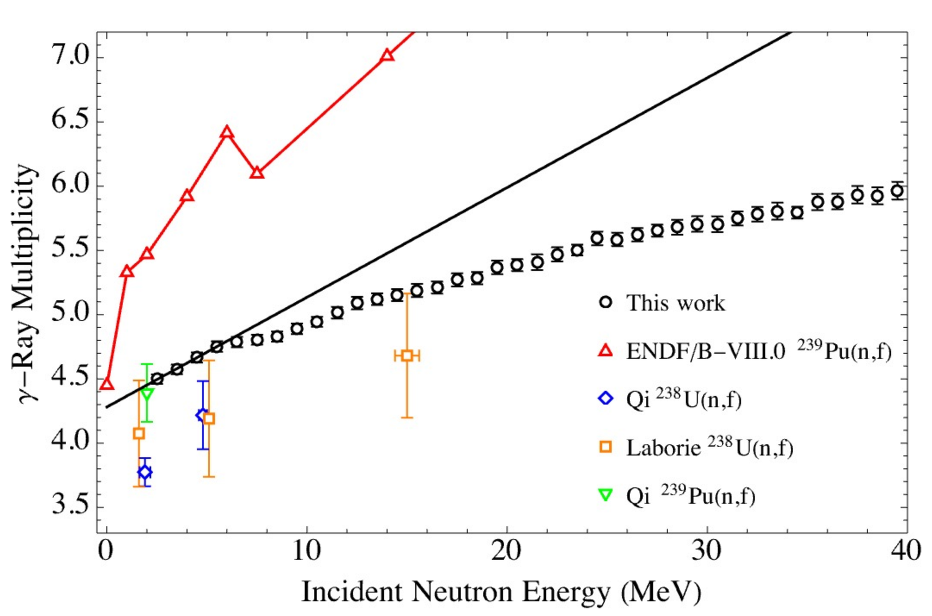

Fig. 2. Gamma-ray multiplicity in ^{239}Pu(n,f) as a function of incident neutron energy [3]

Technical Approach

Twin Frisch-Gridded Ionization Chamber (TFGIC)

- Built with collaborators at Argonne National Lab (ANL) [4]
- Cf-252 spontaneous fission source inside
- Measures fragment masses and total kinetic energy (TKE) with the *2E* method [5]

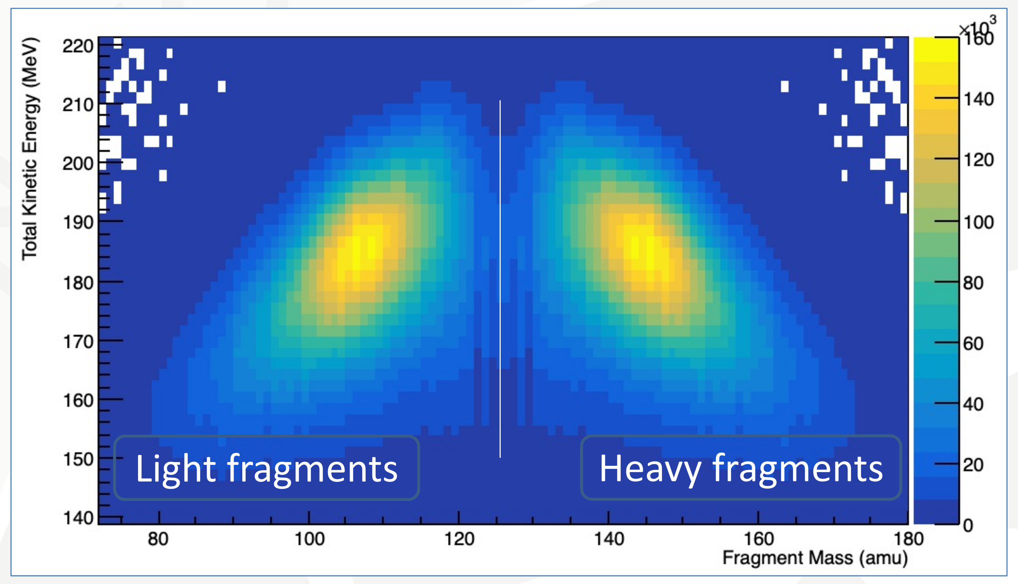

Fig. 3. Measured histogram of total kinetic energy vs. fragment mass

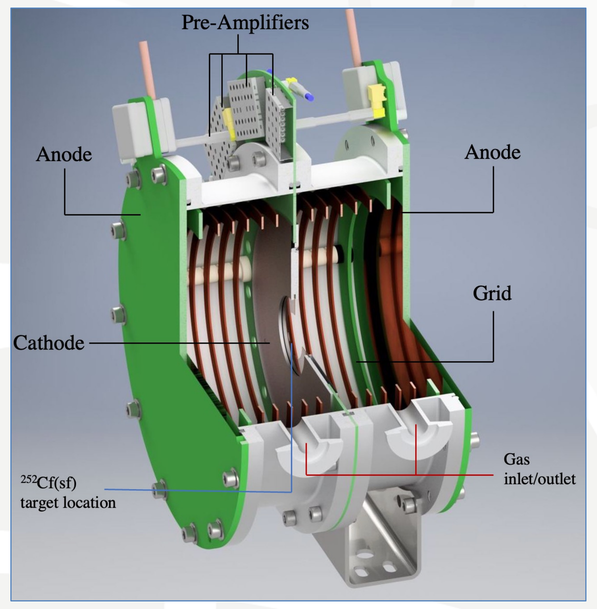

Fig. 4. CAD drawing of our TFGIC at ANL [4]

Gammasphere + FS-3

- Gammasphere: 110 HPGe spectrometers, arranged in 4π
- FS-3: Neutron- and gamma-ray-sensitive stilbene detectors
- Objective: combine with TFGIC to correlate fragment properties with neutron and gamma-ray emission

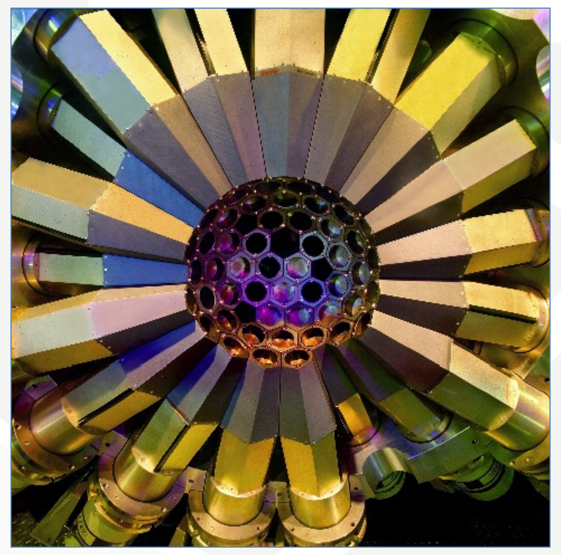

Fig. 5. The Gammasphere array at ANL

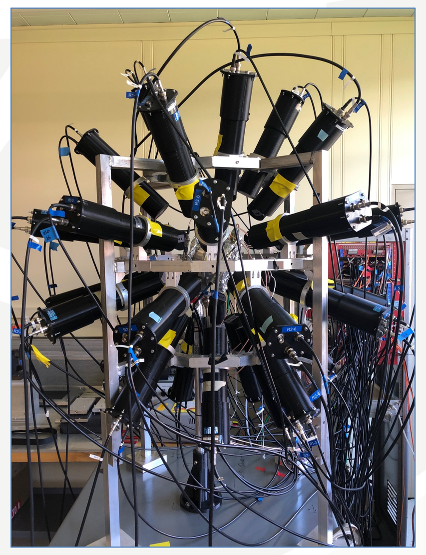

Fig. 6. The FS-3 array from UM [4]

Results

- We built a TFGIC that is mostly transparent to fission neutrons and gamma rays and has TKE and mass resolutions that are comparable to literature values
- We benchmarked our TFGIC + FS-3 setup against existing fragment + neutron/gamma data (see Fig. 8 [4])
  - *Simultaneously* measured both quantities for the first time

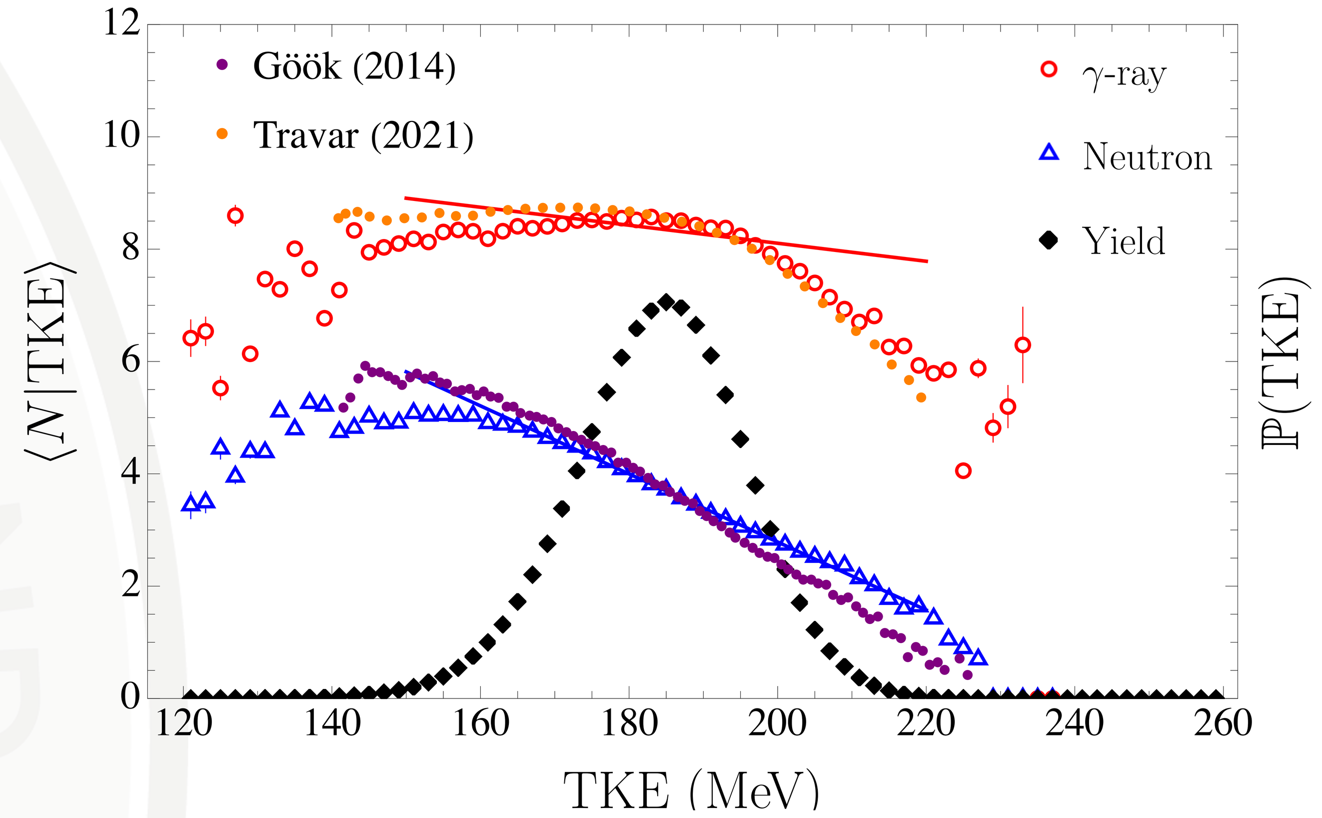

Fig. 8. Neutron and gamma-ray multiplicity vs. TKE [4]

Conclusion & Impact

- We built a twin Frisch-gridded ionization chamber at ANL and validated its performance with FS-3 from UM
- Combination of TFGIC + Gammasphere + FS-3 will produce world-leading experimental results
- These results will (1) improve nuclear data and (2) help theorists improve predictive fission models to advance the NNSA's nuclear safeguards and nonproliferation mission by elucidating new signatures and correlations

Mission Relevance

- Improve fission gamma-ray nuclear data libraries, where experimental data is limited
- Discovering new signatures of fission could substantially improve nuclear material accountancy

MTV Impact

- Extensive collaboration with experimental scientists and engineers at Argonne National Lab
  - Constructing ionization chamber
  - Gammasphere experiment
- Collaborations with fission theorists at LANL (P. Talou, I. Stetcu, A.E. Lovell), LLNL (R. Vogt), and LBNL (J. Randrup)

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References

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