Directionally Dependent Event-by-Event Neutron-Photon Multiplicity Correlations in ^{252}Cf

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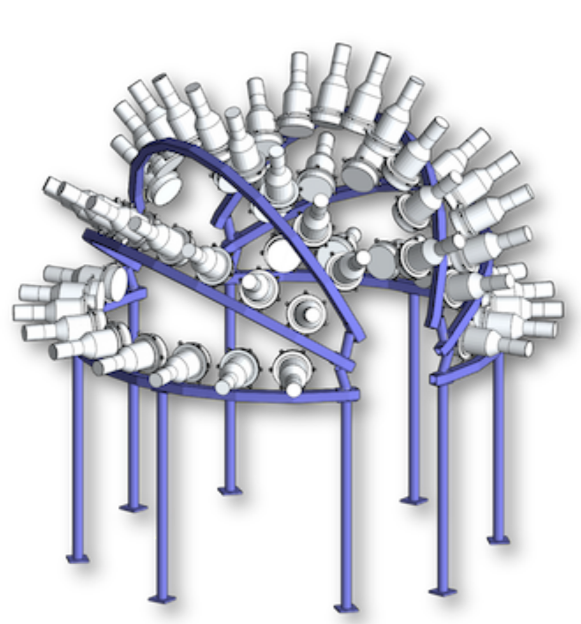
Introduction and Motivation

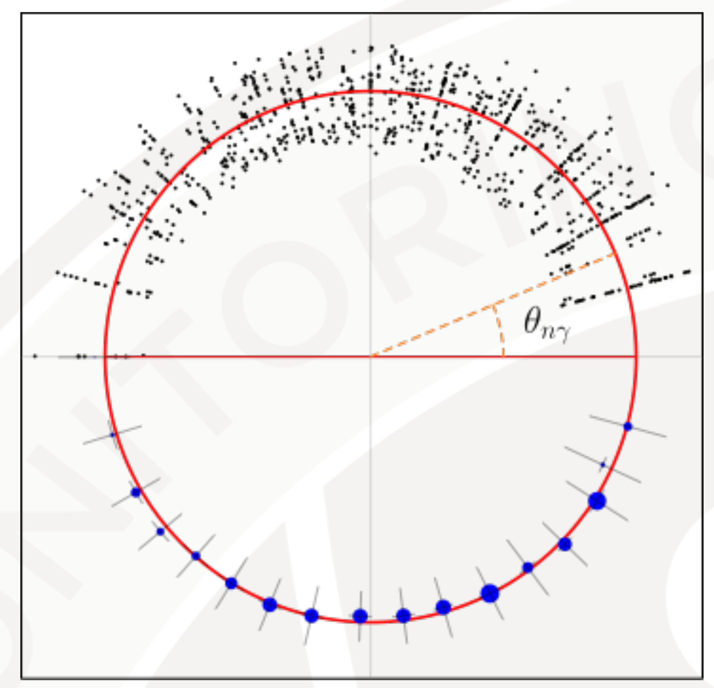
- Radiation emitted from fission interactions contain unique identifying signatures that can be used for source identification and characterization.
- Want to study cross correlations in energy, multiplicity, and angle, which are expected from de-excitation physics, for the purpose of improving detection capabilities.
- These higher correlations can additionally probe fission fragment observables, such as angular momentum and excitation energy, for research in fission dynamics.

Technical Approach

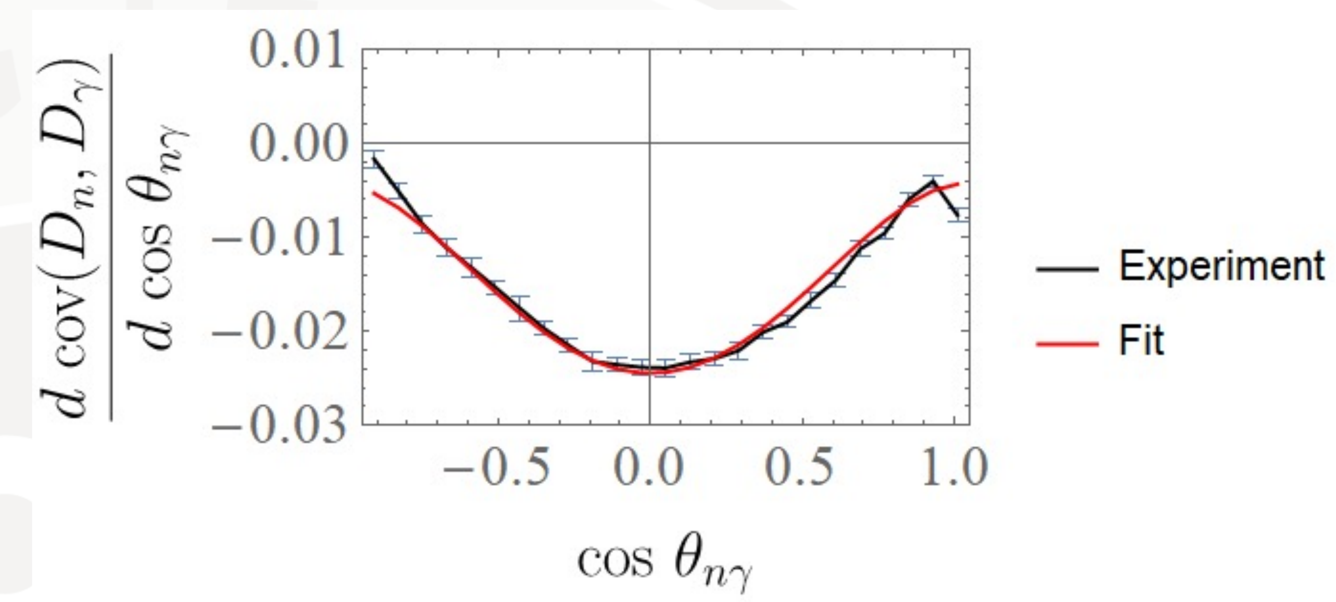
- Source: ^{252}Cf(sf), fabricated at Oak Ridge National Laboratory
- Geometry: Chi Nu Array (1 meter radius hemisphere)
- Detectors: 42 EJ-309, 3 fission chamber
- Quantity of interest:
  - Event-by-Event neutron-photon multiplicity covariance (dependent on particle energies and the angle they make wrt each other)



Results



Angular Response of experimental system. Radial distance represents efficiency, and angle from the horizontal represents the angle between detectors.

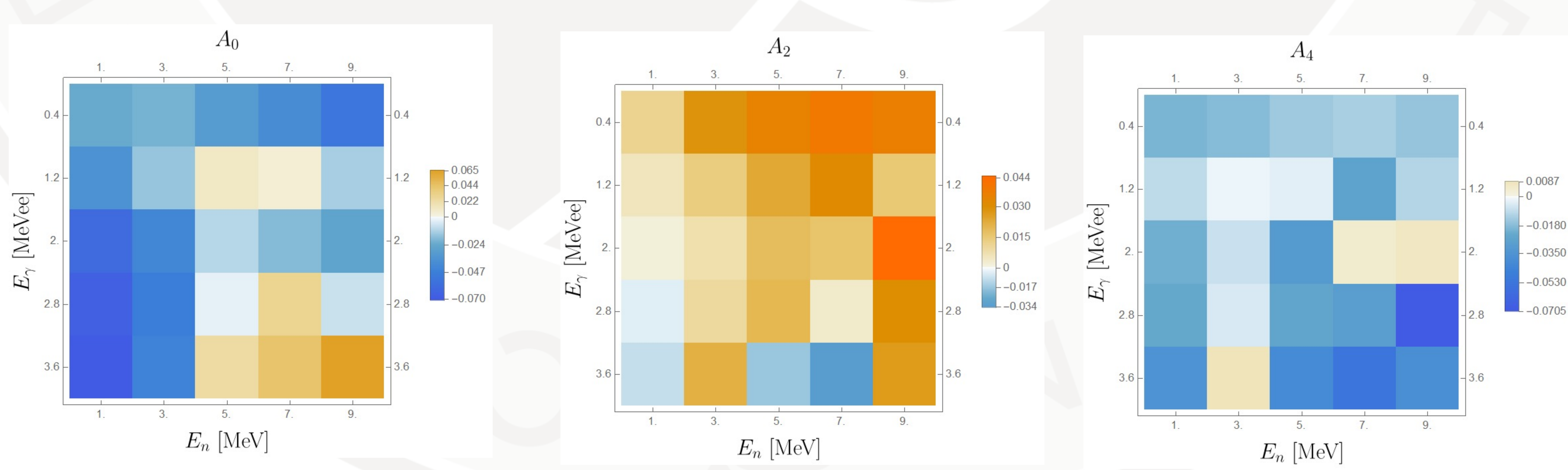


Energy independent neutron-photon multiplicity bicorrelation. The angle is between the detections of the two particles.

We fit the correlation with a sum of legendre polynomials typically used to represent the photon angular distribution from fission:

$$f(\cos\theta_{n,\gamma}) = A_0P_0(\cos\theta_{n,\gamma}) + A_2P_2(\cos\theta_{n,\gamma}) + A_4P_4(\cos\theta_{n,\gamma})$$

Using these fits, we examine the neutron and gamma energy dependence of the coefficients A_0, A_2, and A_4. This dependence is shown in the plots below:



Variation of the fit parameters with both neutron and photon energies.

Discussion

1. A_0 captures the **vertical shift** of the correlation.
   - Change in sign of the multiplicity covariance at high E_n , E_γ
2. A_2 captures the **curvature** (approx.) of the correlation.
   - Curvature can be used to infer qualitative tendencies of specific gamma transitions (i.e., dipole, quadrupole radiations)
3. A_4 is an additional parameter that is varied to best fit the measured data.

Impact

- The study of higher order correlations and connections to fission fragment observables is a way to study fission dynamics experimentally.
- Personally, my experience as a student with MTV has been an opportunity to learn many new skills within scientific research.

Conclusion and Next Steps

- Overall, the change in sign of the N-P multiplicity covariance indicates different statistical behavior in different particle energy regions.
- The variation of the curvature coefficient seems to indicate higher tendencies of dipole radiations at higher photon energies.
- We next want to correlate the statistical behavior of the particles with the fragment characteristics

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