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IER 153 PFUNS: Preliminary Spectral Adjustment Results

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Outline

- Background
- Introduction to Spectrum Adjustment
- Method
- Status Update
- What's Next?

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Background: IER 153 PFUNS

- Prompt Fission Uranium Neutron Spectrum (PFUNS) aims to reduce uncertainty in the ^{235}U PFNS energies, specifically above 8 MeV
- Performed at the National Criticality Experiments Research Center (NCERC) in 2024
- Critical assembly using Rocky Flats HEU hemishells (~93% ^{235}U) on the Planet vertical-lift assembly machine
- Activation foils exposed in central sample chamber

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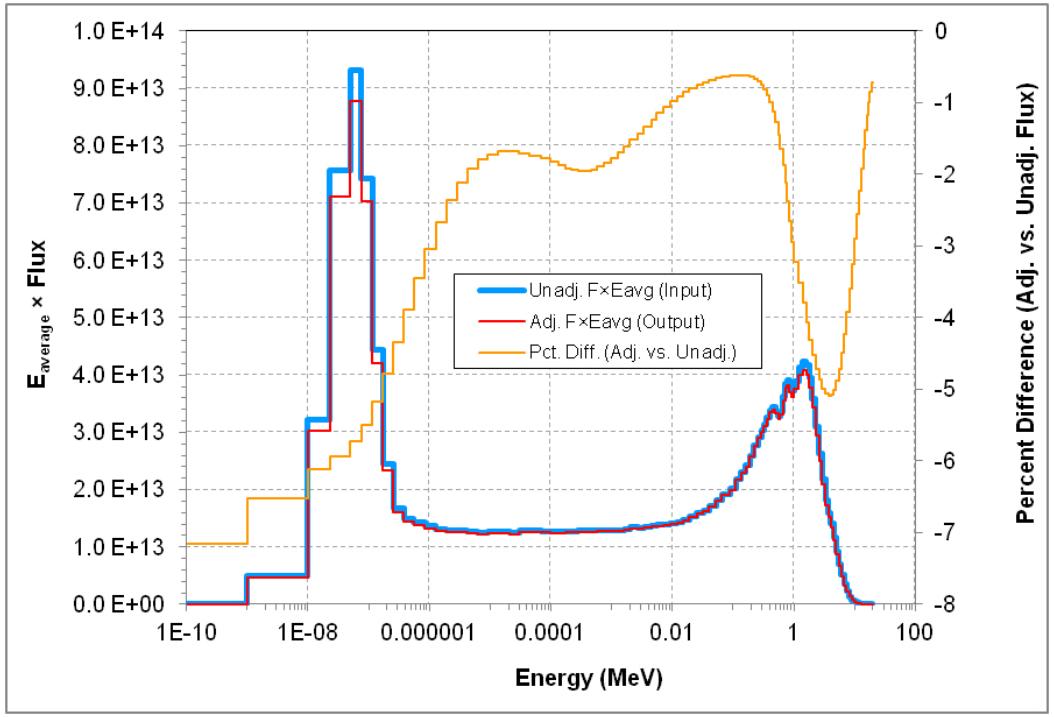
Introduction to Spectrum Adjustment

- Spectrum adjustment uses reaction rates captured by fission foils to adjust a physics-based *a priori* spectrum (usually generated by Monte Carlo transport)
- Adjusted spectrum is used to attain precise estimate of the flux
  - Adjusts for experimental conditions not captured in the theoretical spectrum
- Using foils with threshold reaction cross sections, energy-dependent fluences are captured
  - Reactions with a high neutron energy threshold captures flux data in high energy ranges



Example adjustment from the STAYSL homepage

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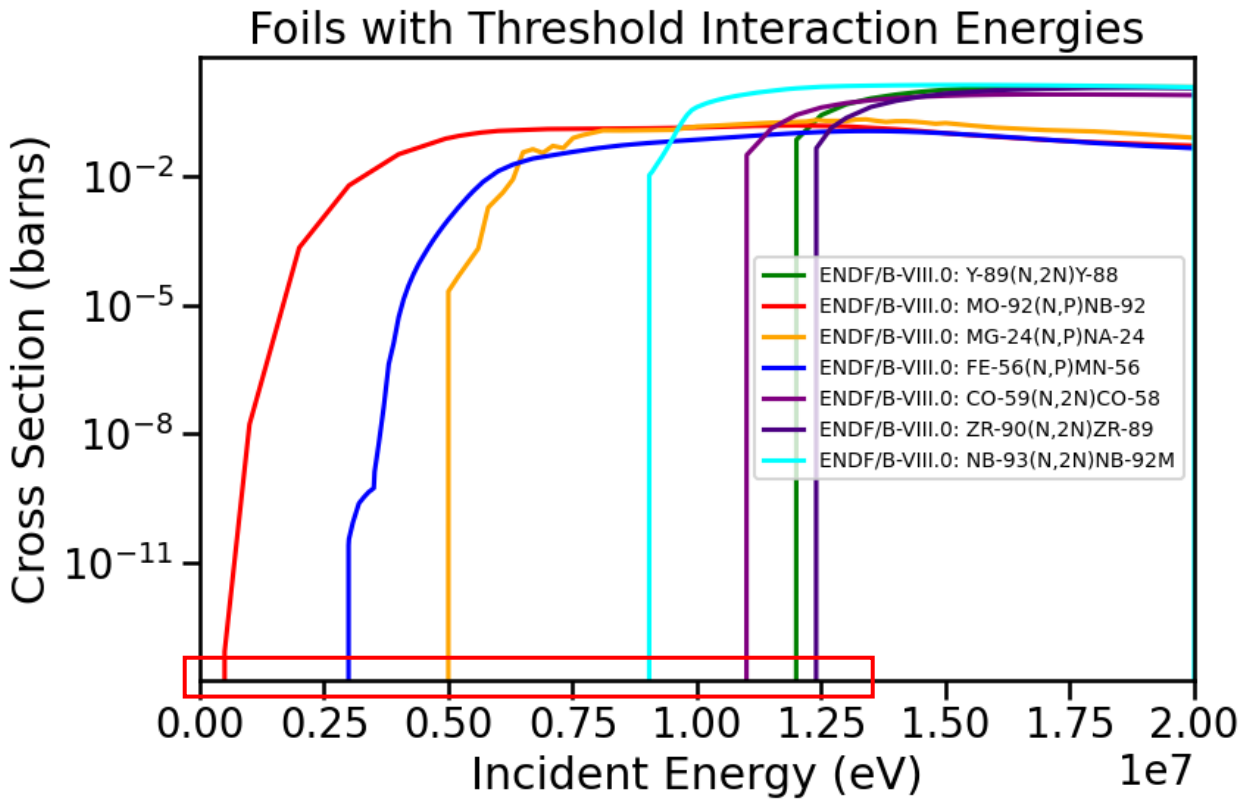
Threshold Reactions

- Choosing foils with various energy thresholds for interaction
  - High energy thresholds necessary for PFUNS (i.e., Y-89 and Zr-90 for high energies)
- Relates measured reaction rates to neutron energy regions



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Spectrum Adjustment with Activation Foils

- Better representation of the actual neutron distribution in energy
- Primary method for estimating an in-core measurement of the neutron flux with full spectrum coverage
- Can validate previous representations of the spectrum for reactor systems
- **Reduced uncertainties**
  - Of particular importance for PFUNS

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Method: STAYSL PNNL

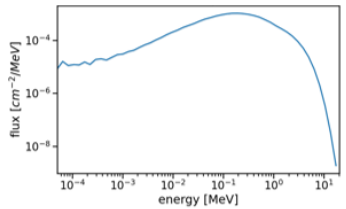
- Approximately 40 reactions captured during PFUNS irradiation
  - Measured at NCERC-CL DAF, NCERC-CL NISC, and TA-48's count room (gamma spec)
  - Validation between the three counting laboratory locations for long-lived reactions
- Prior spectrum calculated with MCNP®6.3
  - F4 tally on foil volume in the sample chamber
  - SAND-II 640-group structure

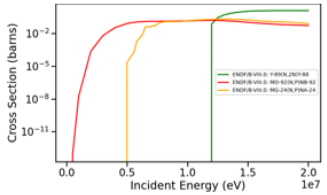
Simplified STAYSL Flow Chart

a priori spectrum

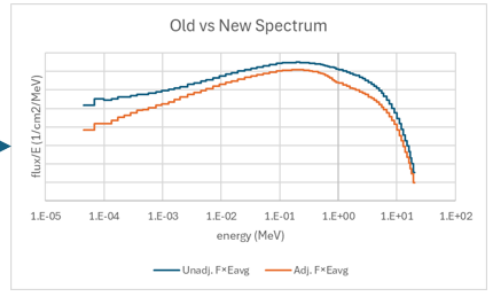
measured reaction rates

cross section data





STAYSL PNNL
Least Squares Adjustment



adjusted spectrum

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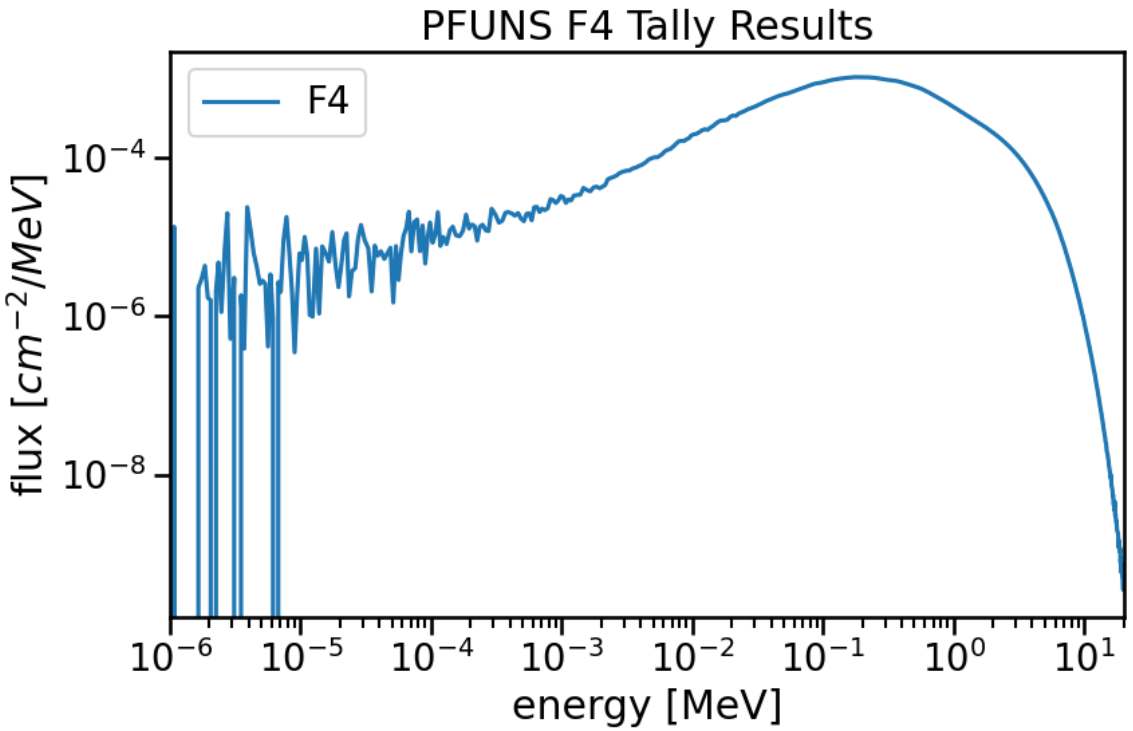
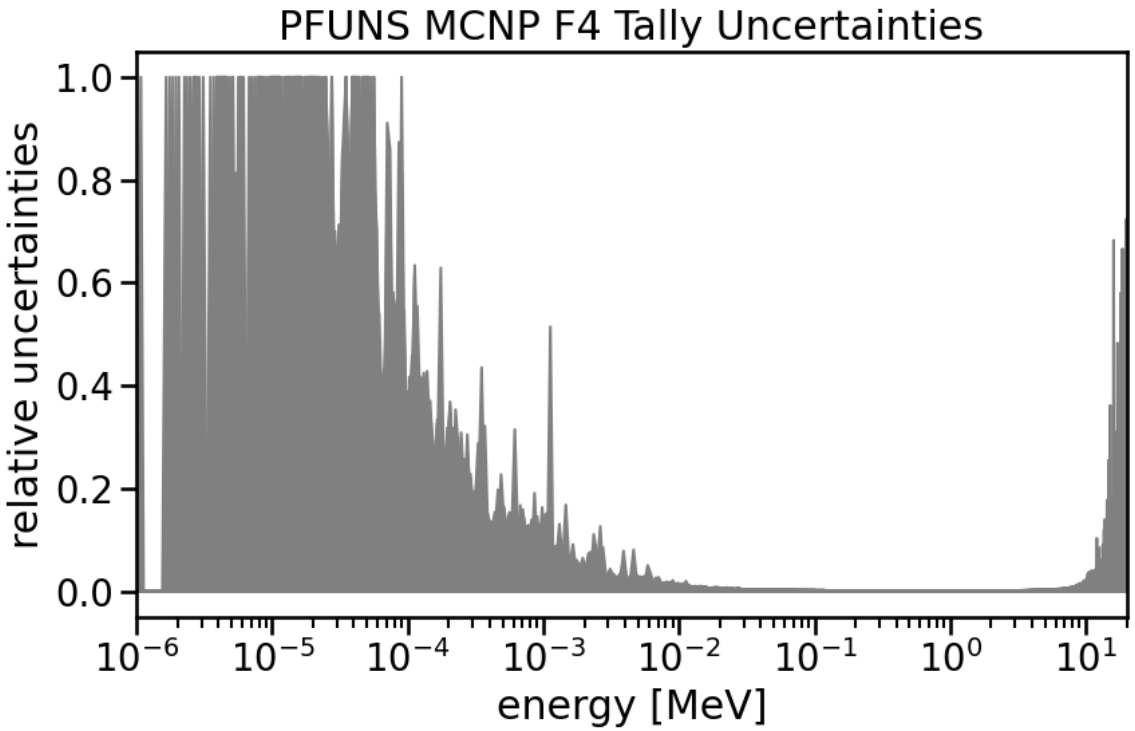
Status Update: SAND II Prior Spectrum

- Good representation of theoretical flux in the fast region
- Low tally counts and poor uncertainty in low energies (thermal and epithermal) and energies approaching 20 MeV





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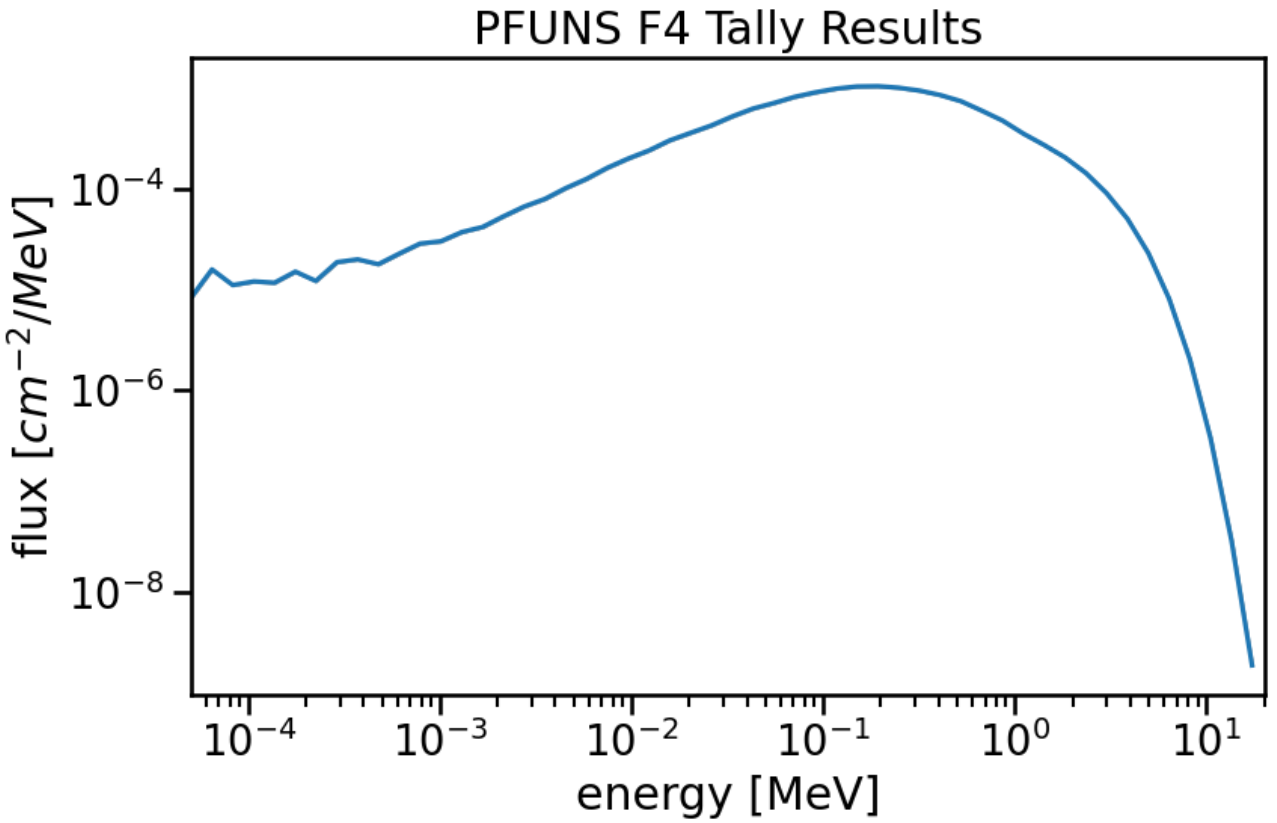
Status Update: Truncated Prior

- Truncated spectrum to constrain the prior to energies of interest

Neutron Energy	Percentage of Fissions Caused in MCNP Simulation
Thermal (<0.625 eV)	0.00%
Intermediate (0.625 eV - 100 keV)	5.24%
Fast (>100 keV)	94.76%



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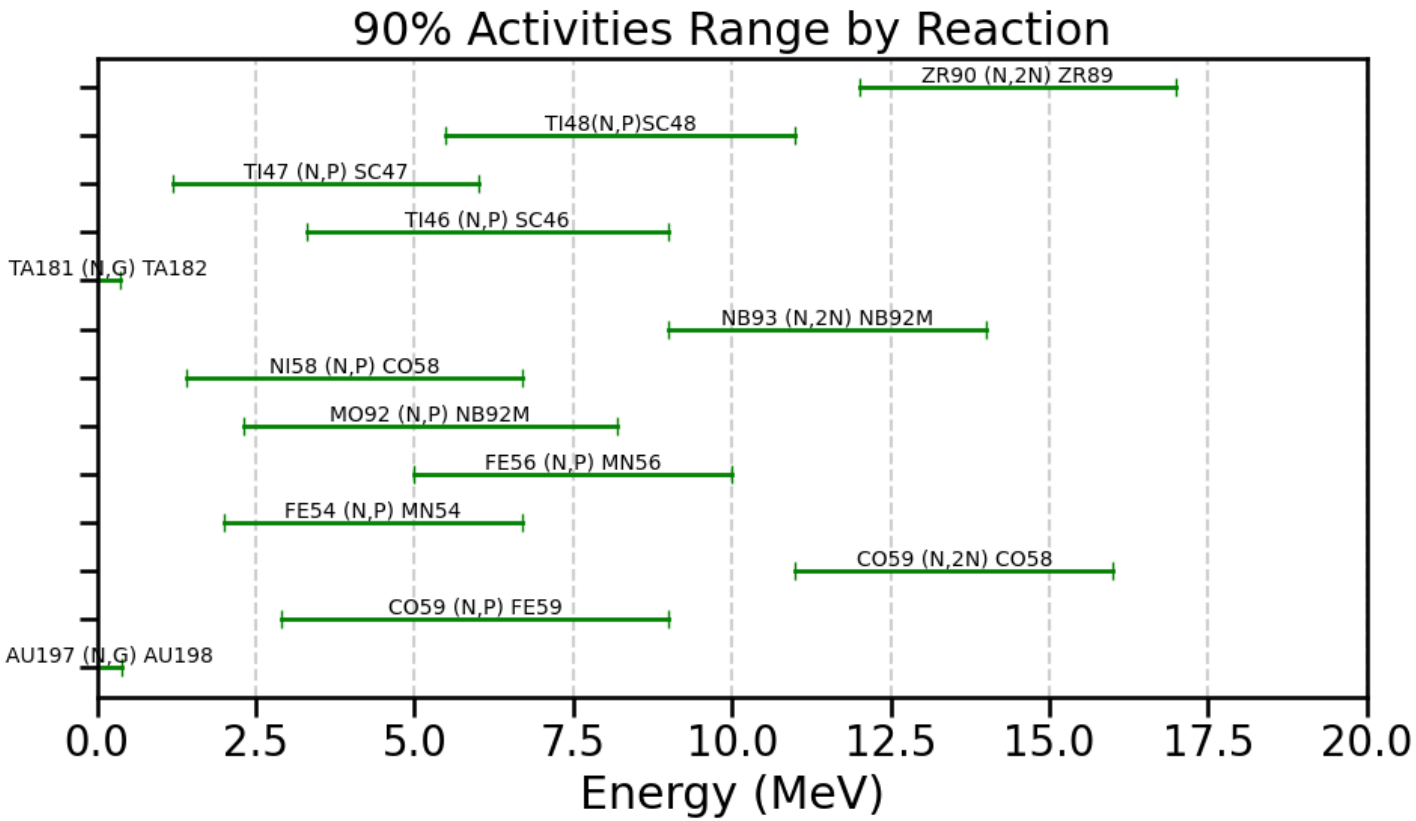
Status Update: Reactions

- Shown are some of the reactions considered for the preliminary adjustment
- The plot shows the 90% activities range for each reaction



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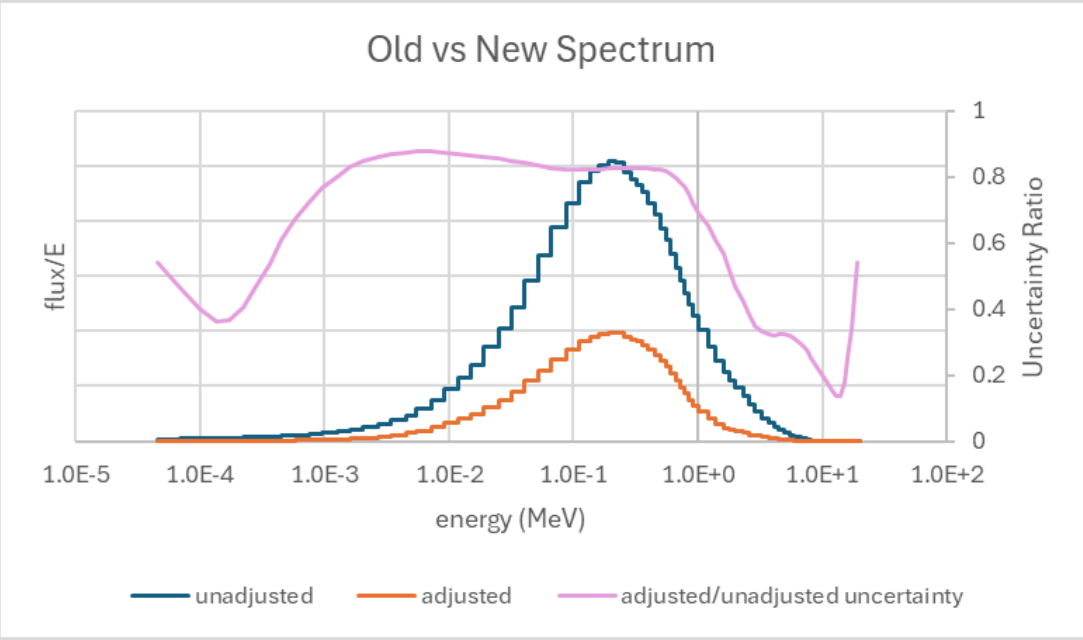
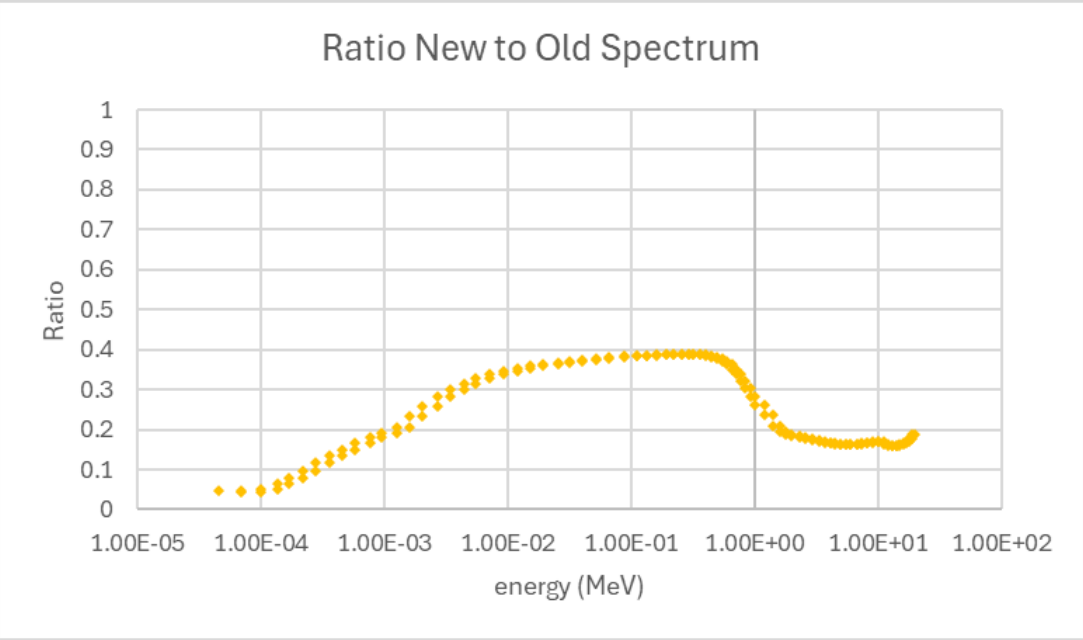
Status Update: Preliminary Adjustment

- STAYSL calculated least-squares adjustment of PFUNS irradiation (preliminary results)





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What's Next?

- Conduct thorough and finalized spectral adjustment using STAYSL PNNL
- Employ more robust techniques to capture statistics, physics-based, and systematic uncertainties
  - Need to be able to address prior covariance
- Develop independent spectral adjustment process to verify STAYSL PNNL output and for future use at the NCERC Counting Laboratory

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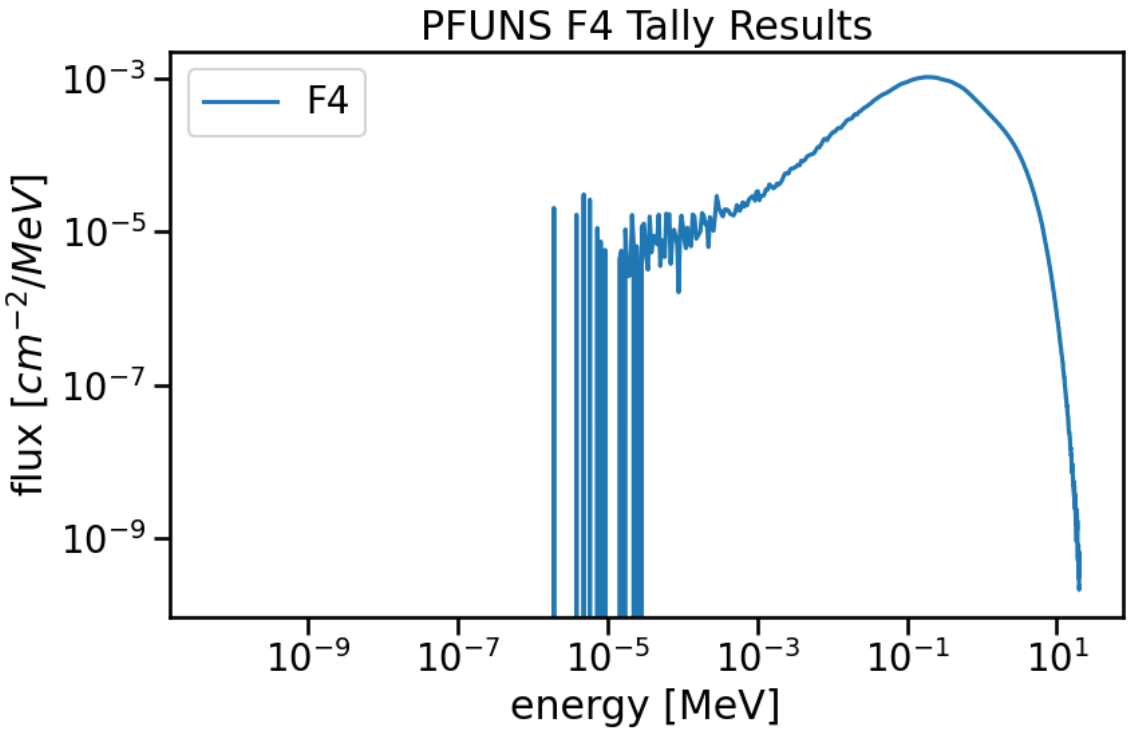
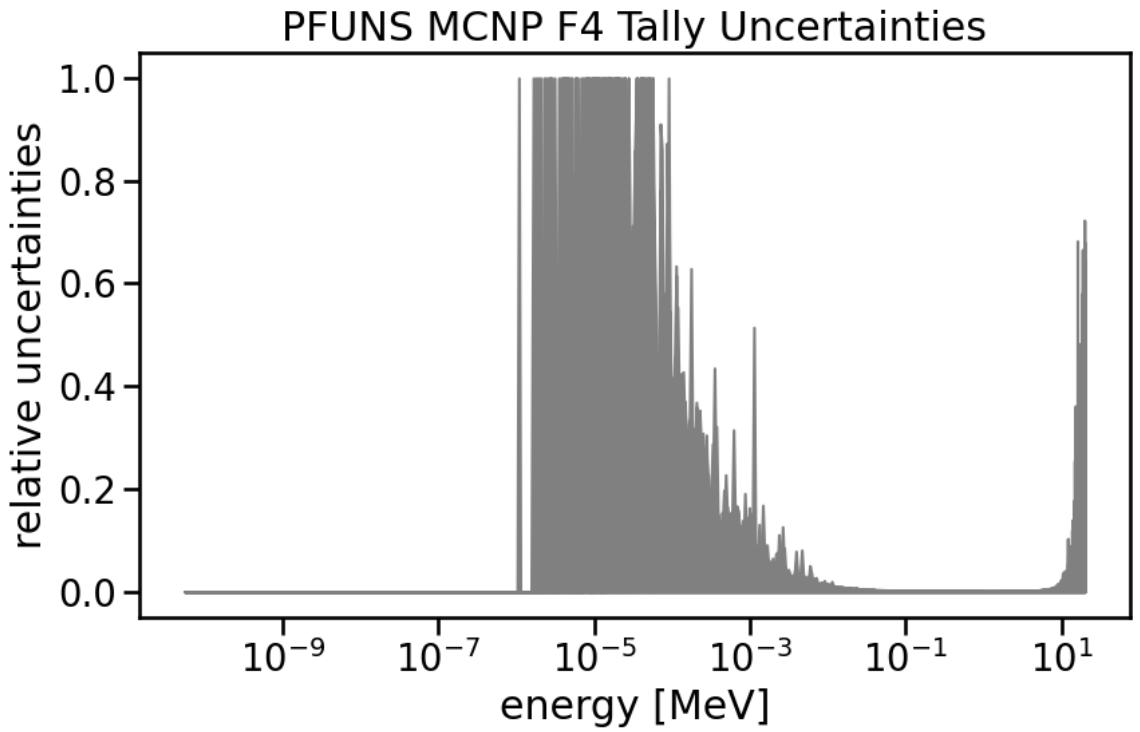
Backup Slides

MCNP Tally & Uncertainty – Full Energy Range





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