Chi-Nu ^{235}U and ^{239}Pu PFNS Measurements

November 8th, 2017: CSEWG 2017, BNL

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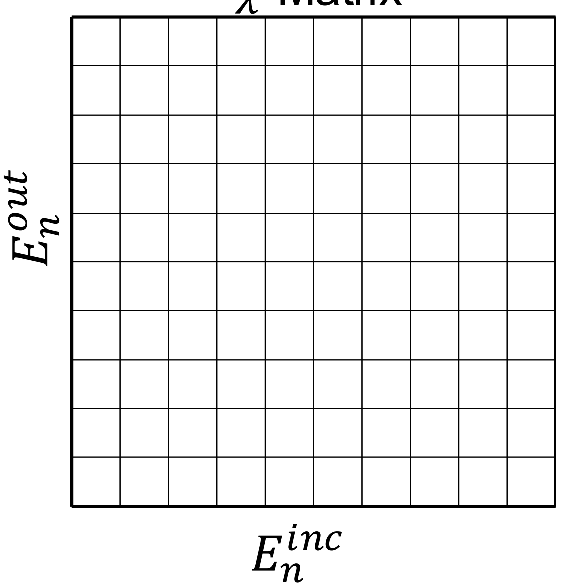
Work performed under the auspices of
U.S. DOE by LANL under contract DE-AC52-06NA25396
and LLNS, LLC under contract DE- AC52-07NA27344

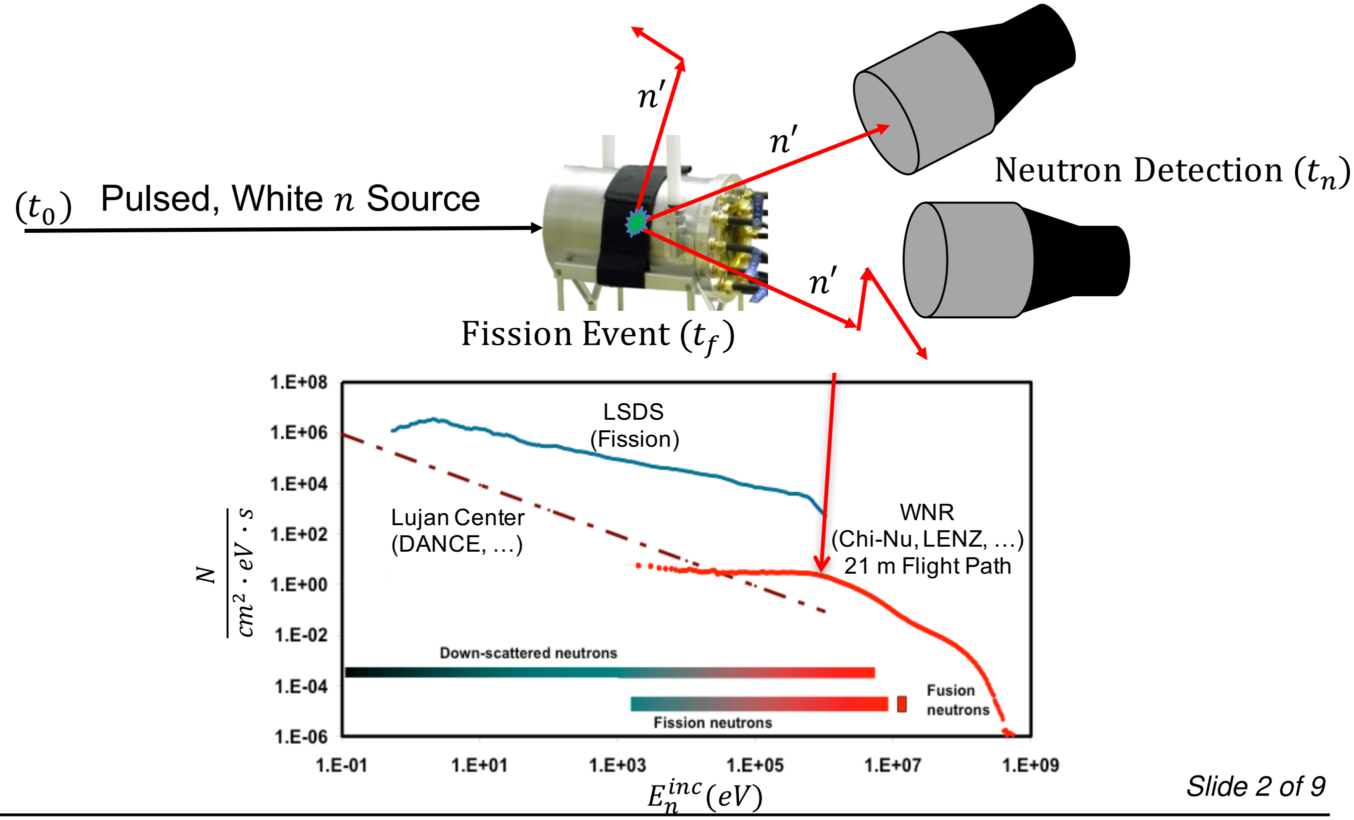
LA-UR-17-XXXXX (DC Reviewed)

Chi-Nu Goals, Method, and Challenges

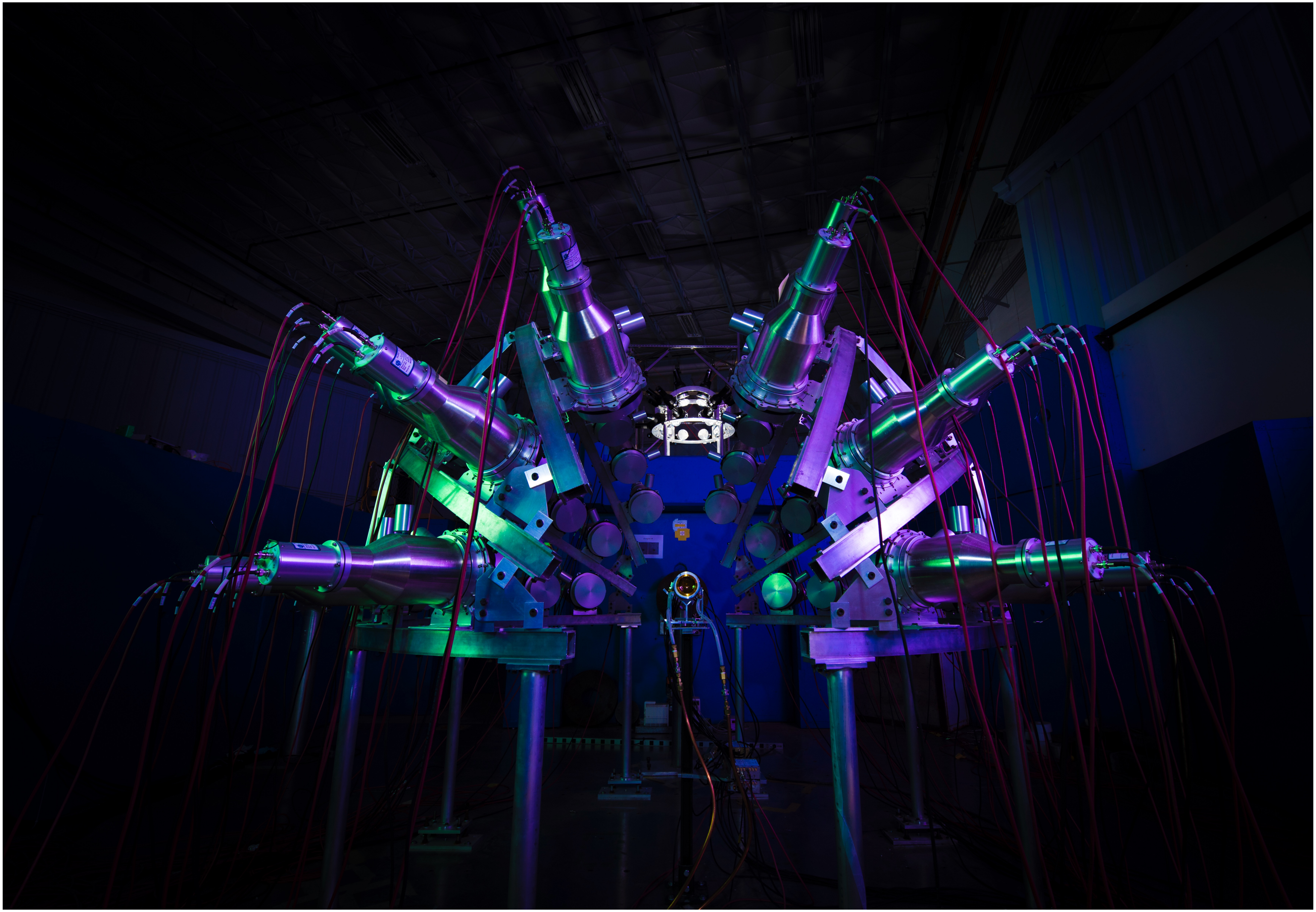
- Goals
  - Measure the neutron χ-matrix
  - ^{252}Cf, ^{235}U, ^{239}Pu
  - PFNS for ranges of E_n^{inc}
- Method
  - Double TOF
  - PPAC target
  - $E_n^{out} < 2$ MeV
    - 22 ^{6}Li-glass
  - $E_n^{out} > 800$ keV
    - 54 Liquid Scint.
- Challenges
  - $E_n^{inc} \geq 0.7$ MeV ≤ 20 MeV
  - $E_n^{out} \geq 0.01$ MeV ≤ 10 MeV
  - Detailed Uncertainties

χ-Matrix



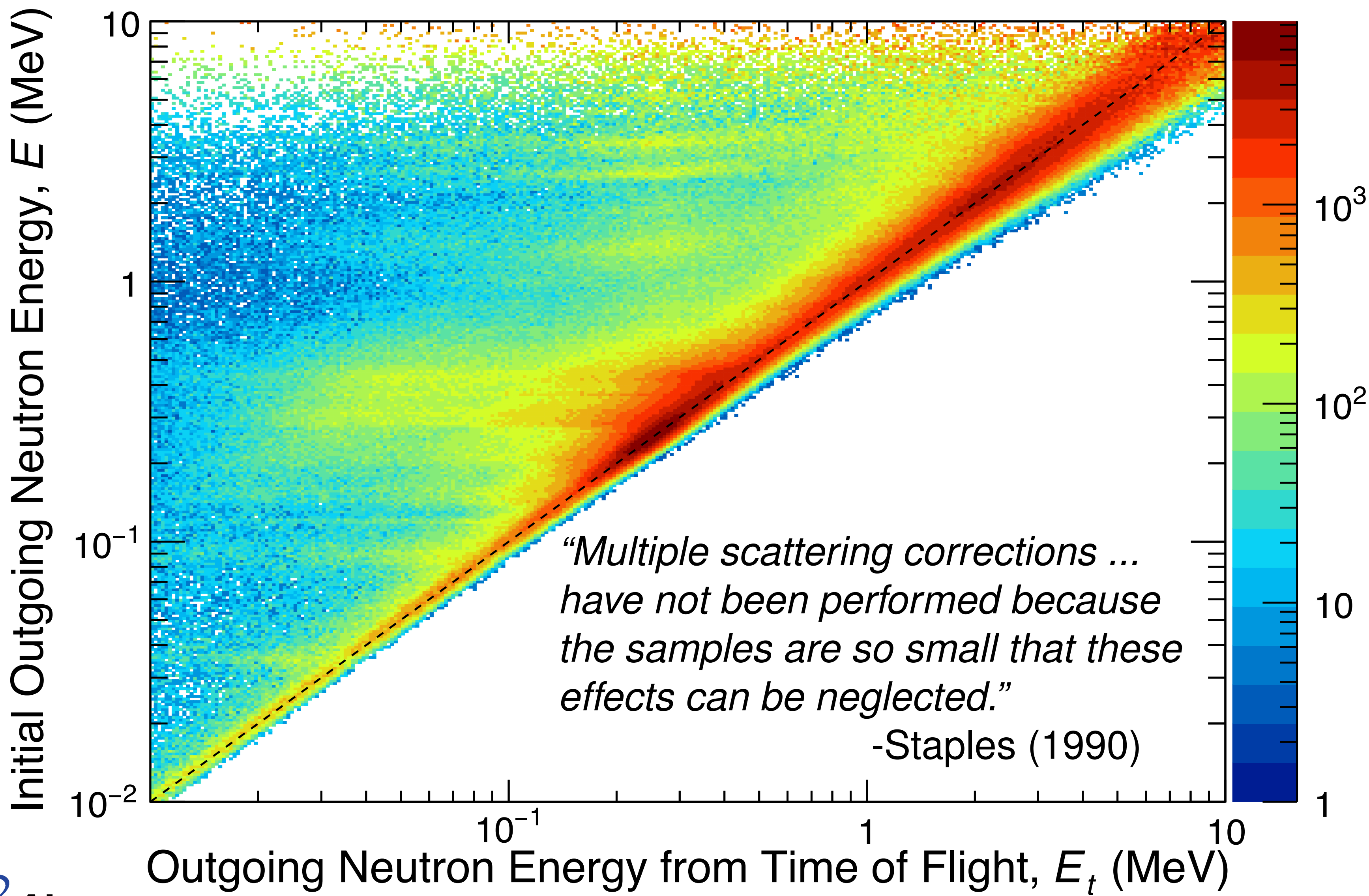


The Chi-Nu Arrays



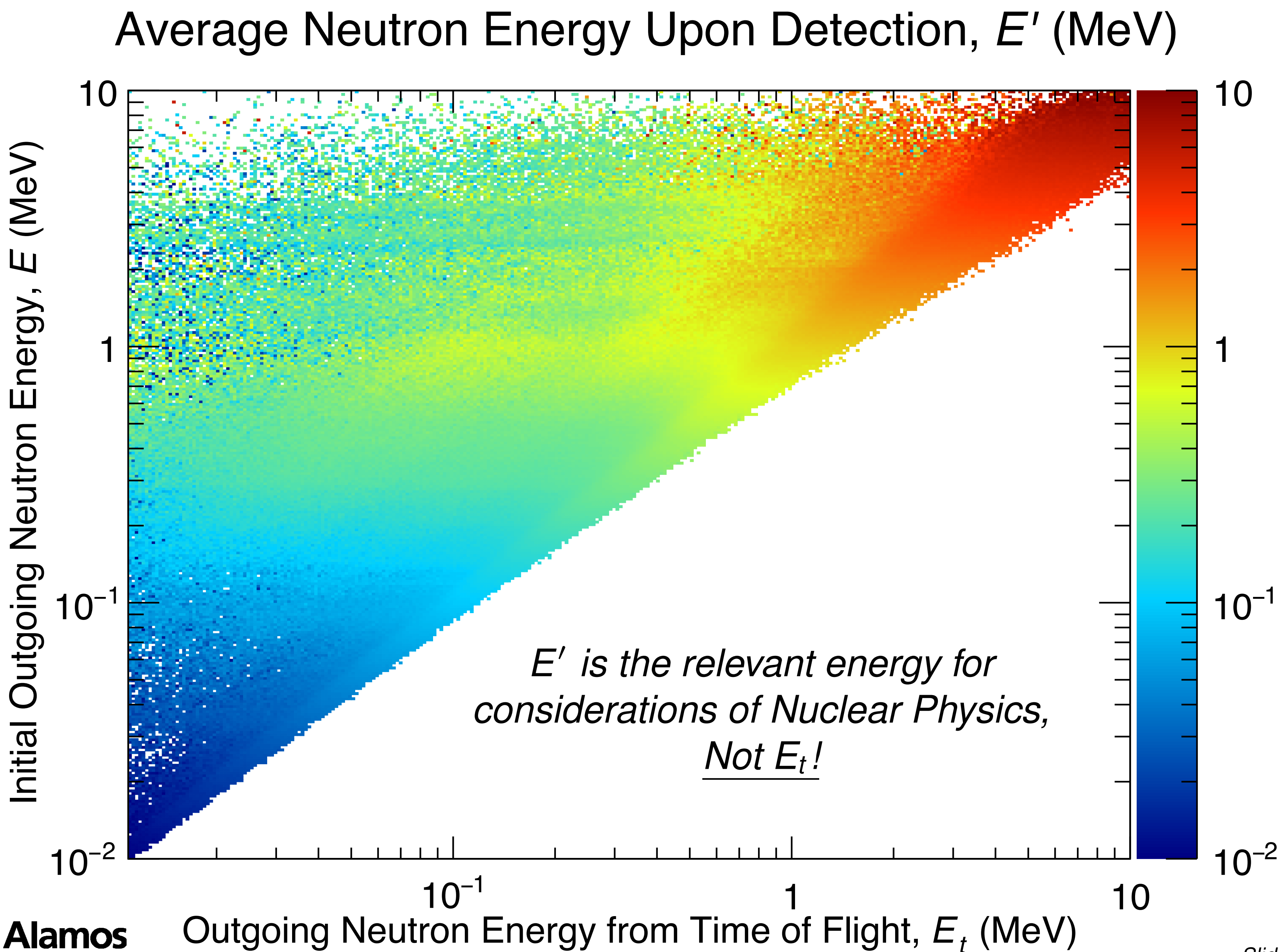
MCNP® ^{6}Li-glass Detector Response Matrix

Detector Response Changes with Experimental Environment



K.J. Kelly *et al.*, Nucl. Instrum. and Methods A, **866** 182

What is the Average n Energy Upon Detection?

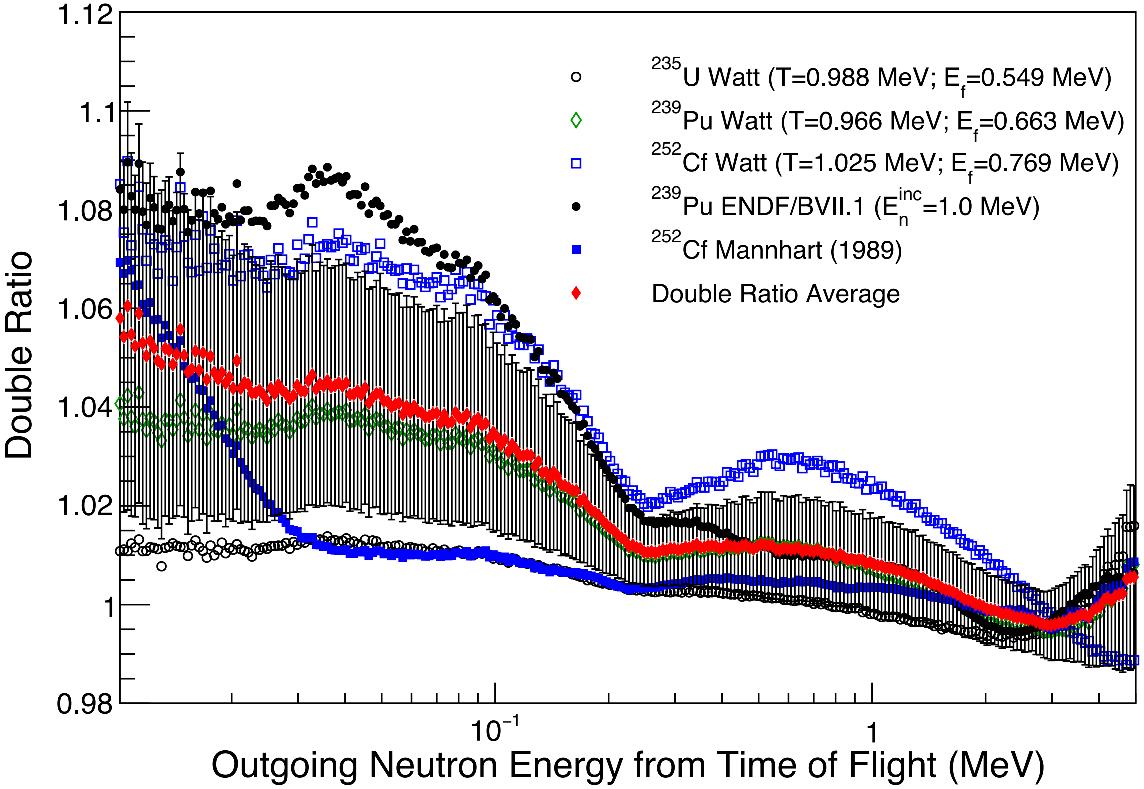


Method of PFNS Extraction: Ratio-of-Ratios Method†

- Based on the approximate equality of

$$\frac{C(p_\alpha(E),E_t)}{p_\alpha(E_t)} \approx \frac{C(p_\beta(E),E_t)}{p_\beta(E_t)}$$

- True within ∼5–10% for a typical PFNS



$$\begin{aligned} D_\alpha &= \text{Double Ratio} \\ &= \frac{C(p_\alpha(E),E_t)/p_\alpha(E_t)}{C(p_{maxw}(E),E_t)/p_{maxw}(E_t)} \end{aligned}$$

Average over reasonable PFNS range and set equal to the experimental ratio

$$\frac{1}{\kappa}\sum_{\alpha=1}^{\kappa}\frac{C(p_\alpha,E_t)}{p_\alpha(E_t)} = \frac{C(p_{exp},E_t)}{p_{exp}(E_t)}$$

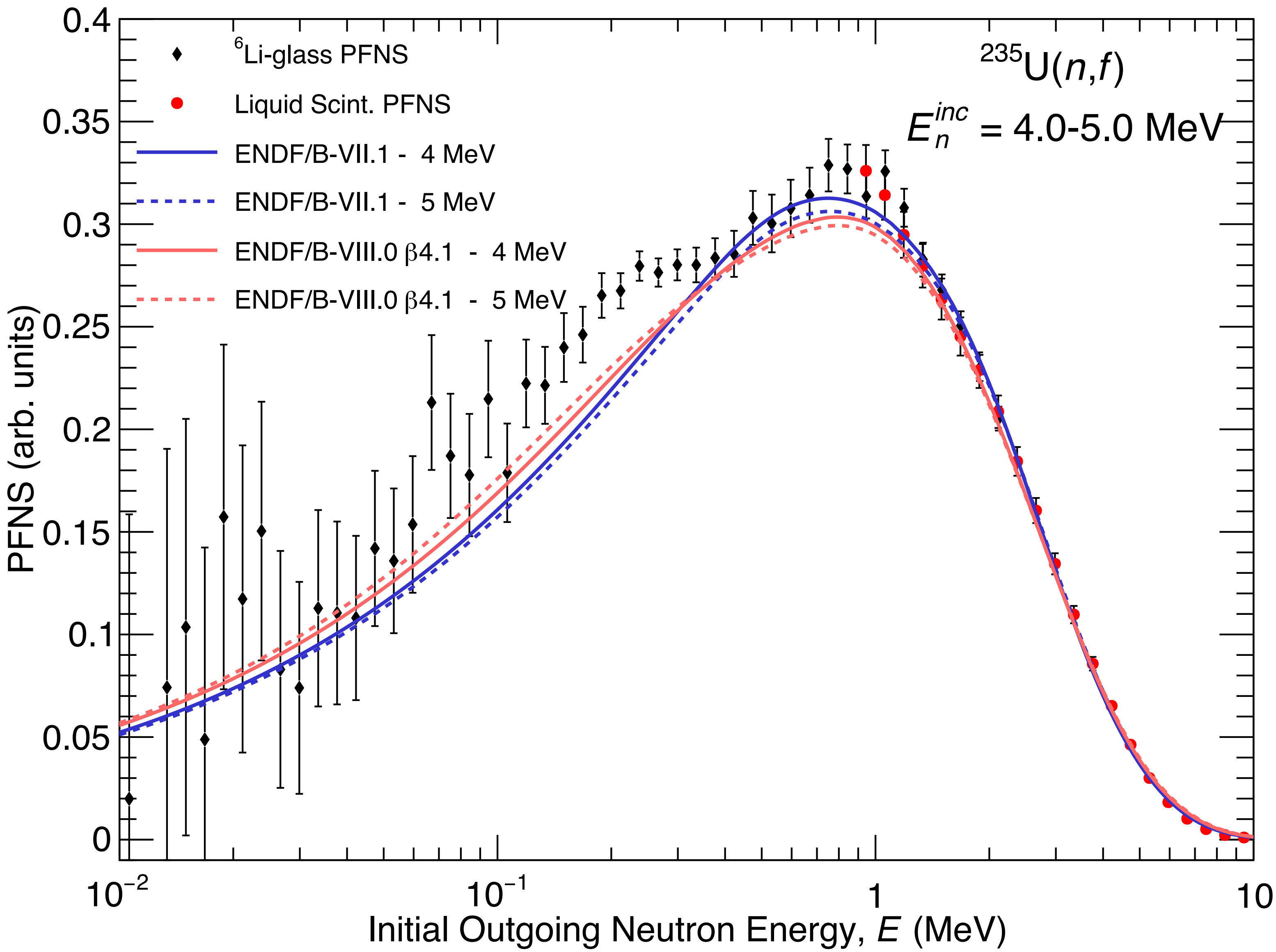
$$\Rightarrow \boxed{p_{exp}(E) = \frac{C(p_{exp},E_t)}{\frac{1}{\kappa}\sum_{\alpha=1}^{\kappa}\frac{C(p_\alpha,E_t)}{p_\alpha(E_t)}}}$$

→ Quickly extracts PFNS

→ Uncertainties are increased to account for bias towards average PFNS

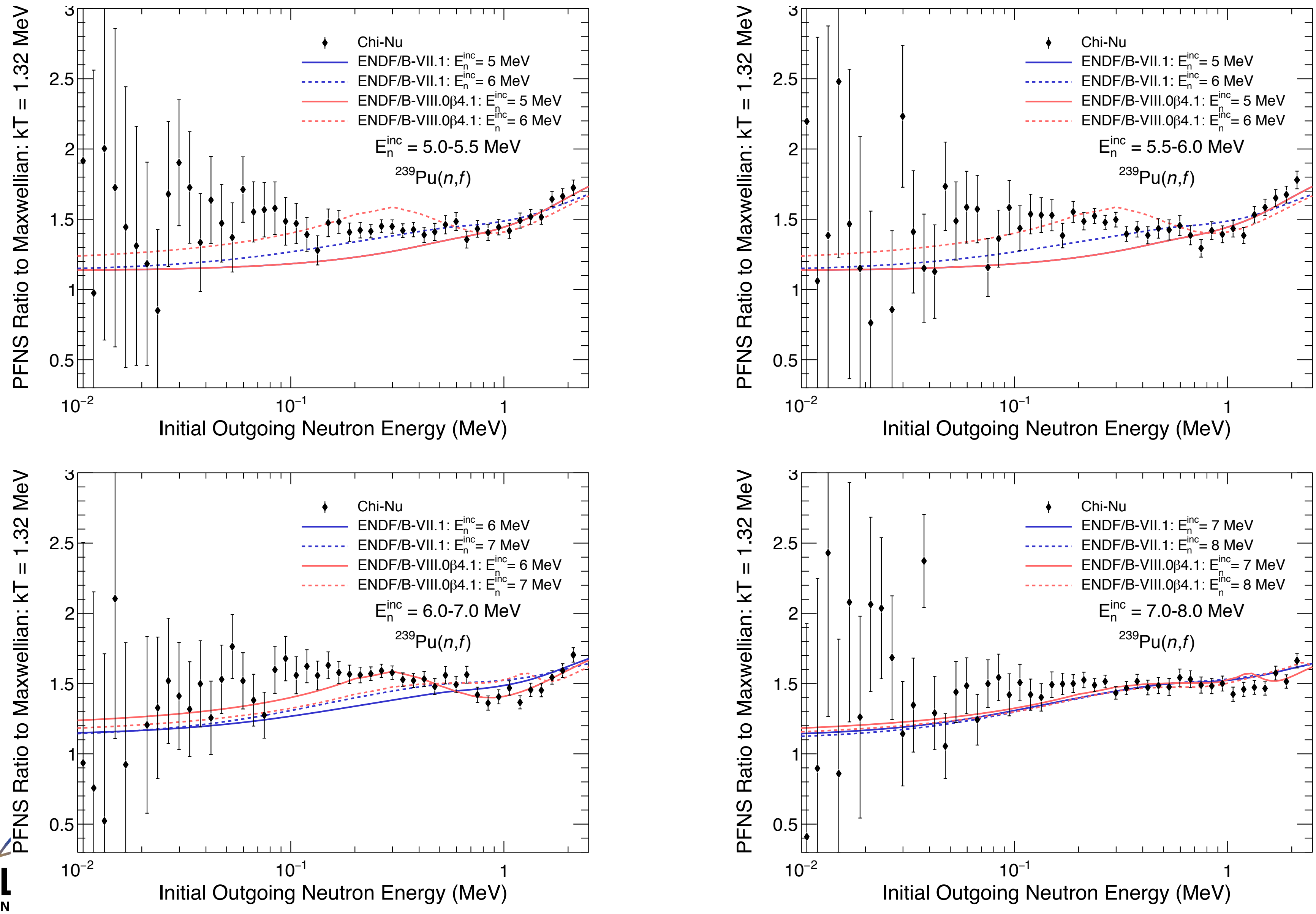
†T.N. Taddeucci *et al.*, Nucl. Data Sheets, **1232** (2015) 135

^{235}U Combined ^{6}Li-glass and Preliminary L.S. Results



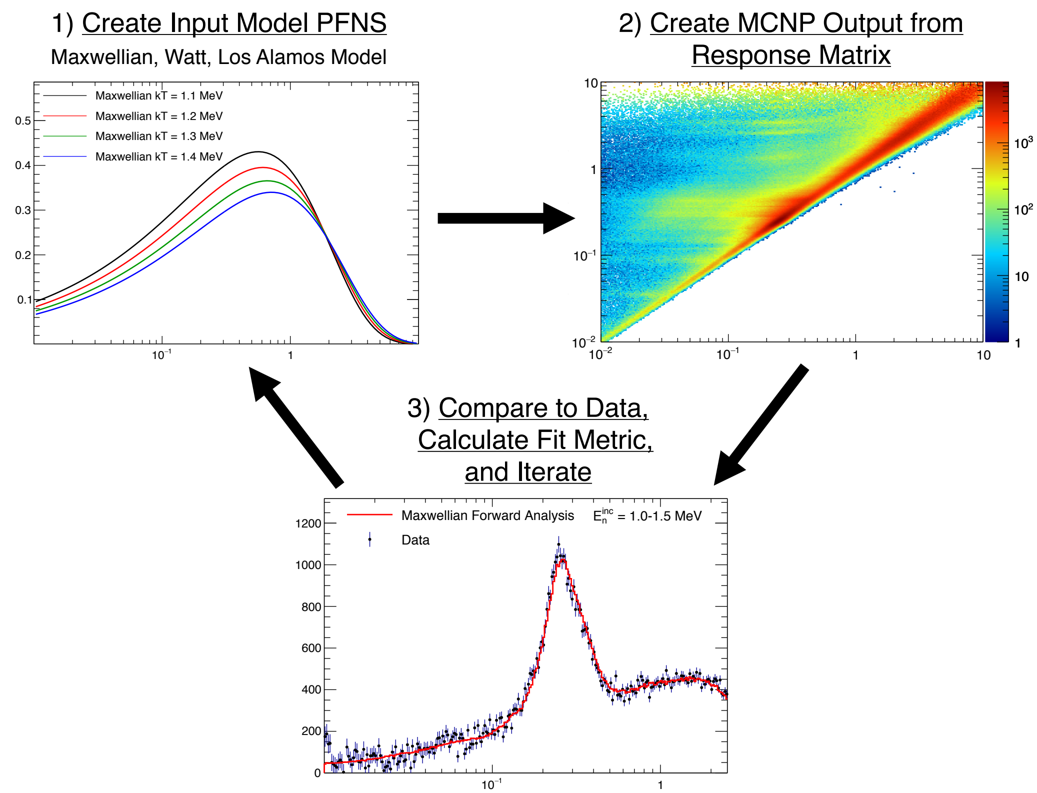
Data processed by J.A. Gomez

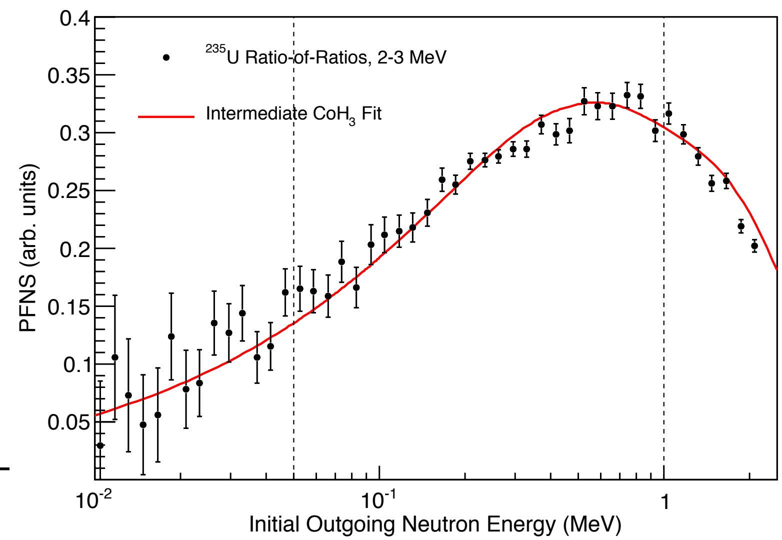
Preliminary ^{239}Pu PFNS: 2nd-Chance Fission Region



Future Directions

- Systematic Uncertainties:
  - MCNP® nuclear physics
  - Background normalization
  - Other sources
- More sophisticated analyses
  - Forward Analysis
    - max($\mathcal{L}$) or min(χ^2)
    - Maxwellian & Watt PFNS
    - CoH_3 (LAM), CGMF
  - Unfolding
    - MCMC p(E) Variations
    - ROOT routines
    - SVD, Bayesian Analysis
- Finalize HE analysis of ^{235}U
- Finalize LE analysis of ^{239}Pu
- Analyze HE ^{239}Pu data





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