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Measurements of the Prompt Fission Neutron Spectra of ^{235}U and ^{239}Pu at Chi-Nu

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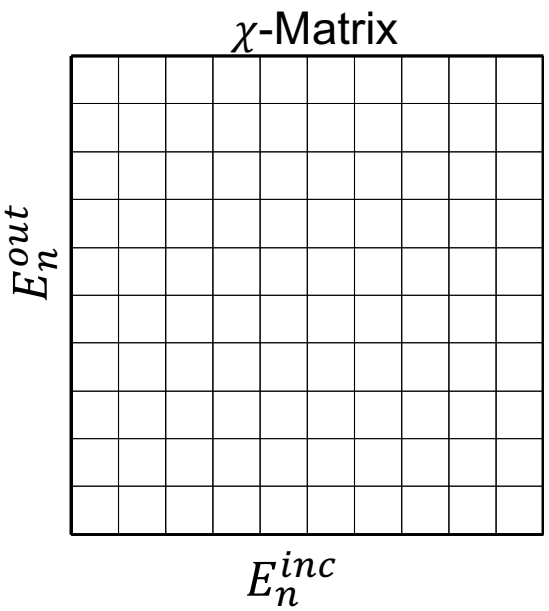
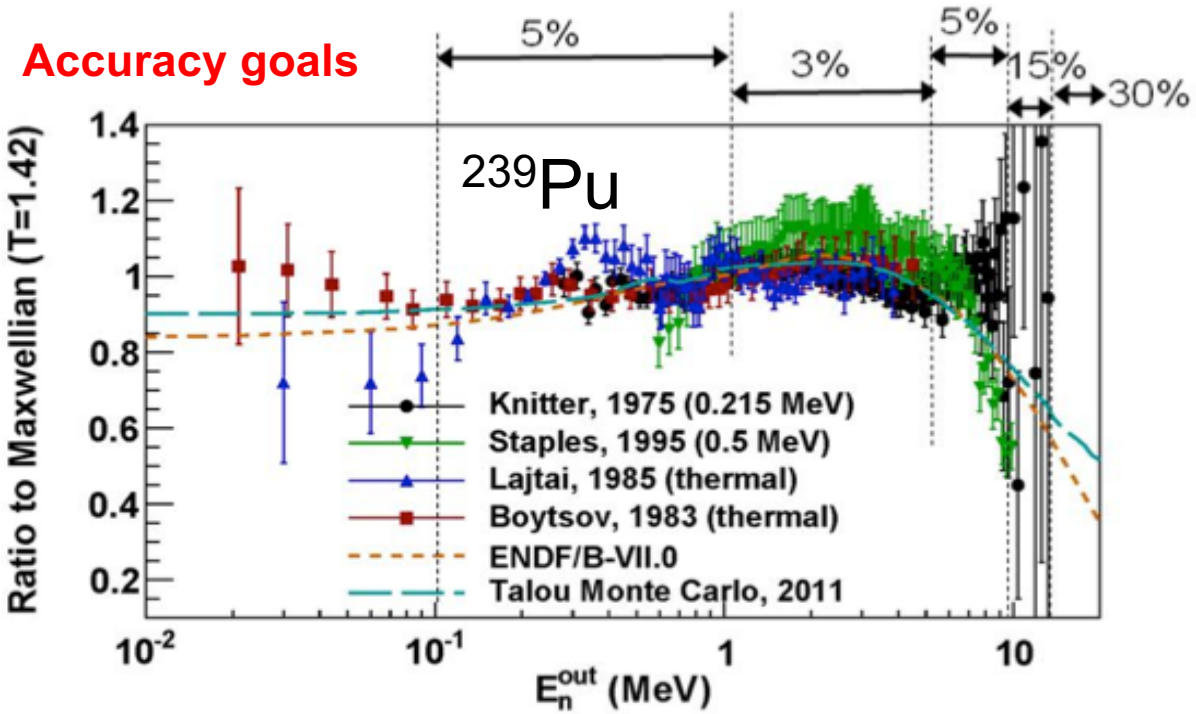
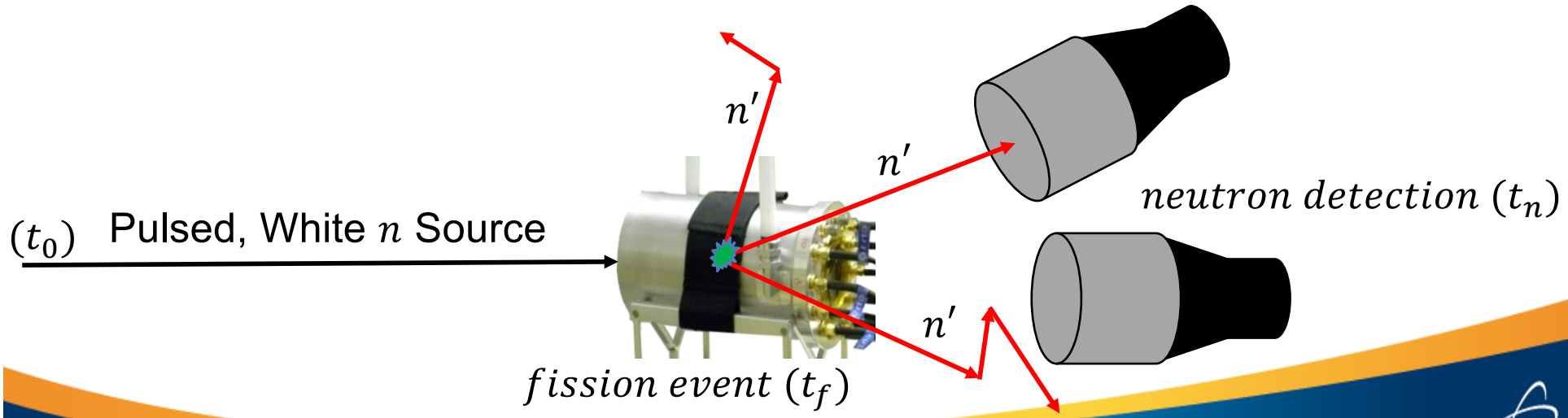
The Chi-Nu Experiment

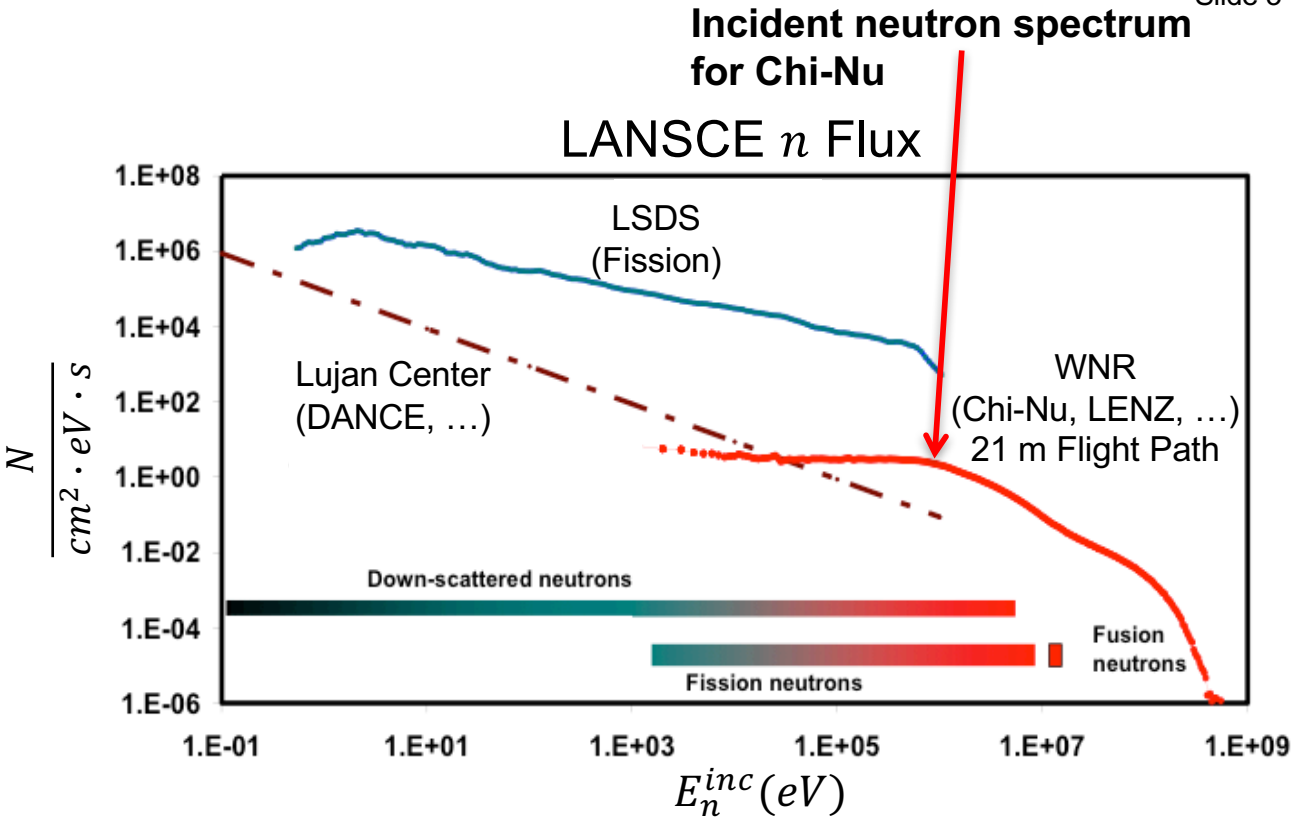
- Purpose: Measure the χ-matrix for neutrons (χ_v-matrix) incident on actinides







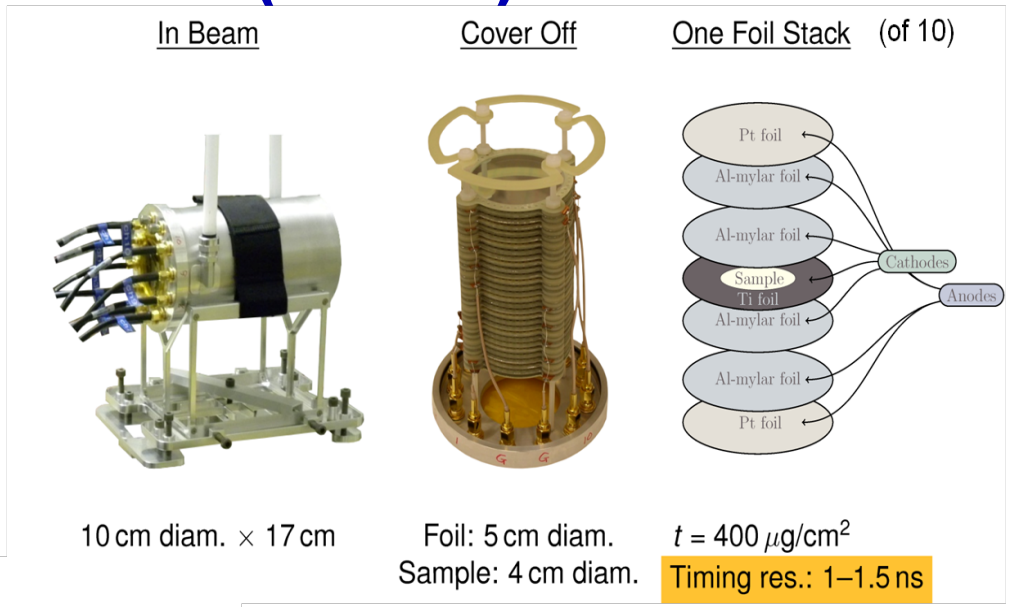
Incident Neutrons: LANSCE and WNR

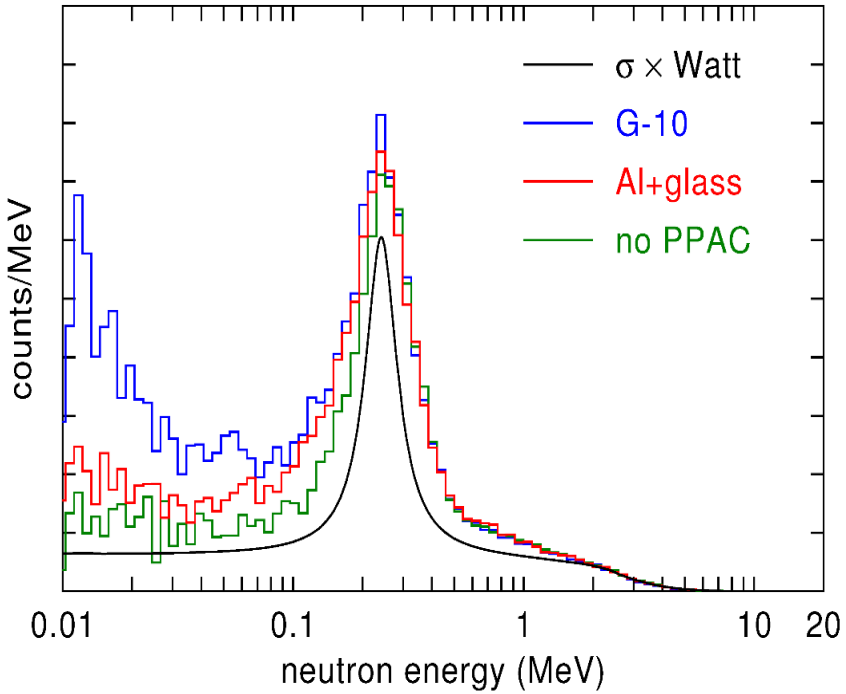


- LANSCE: Los Alamos Neutron Science Center
- WNR: Weapons Neutron Research
  - Receives high-energy n's via spallation on a tungsten target
  - 0.5 MeV $\lesssim E_n^{inc} \lesssim$ 100 MeV is of interest for Chi-Nu

Fission Detection: Parallel-Plate Avalanche Counter (PPAC)

- 6 Total PPACs:
  - ^{252}Cf: Two, with different activities
  - ^{235}U: One, with 50 mg total mass
  - ^{239}Pu: Three, one with 50 and two with 100 mg total mass
- ^{235}U and ^{239}Pu PPACs contain 10 Ti target foils

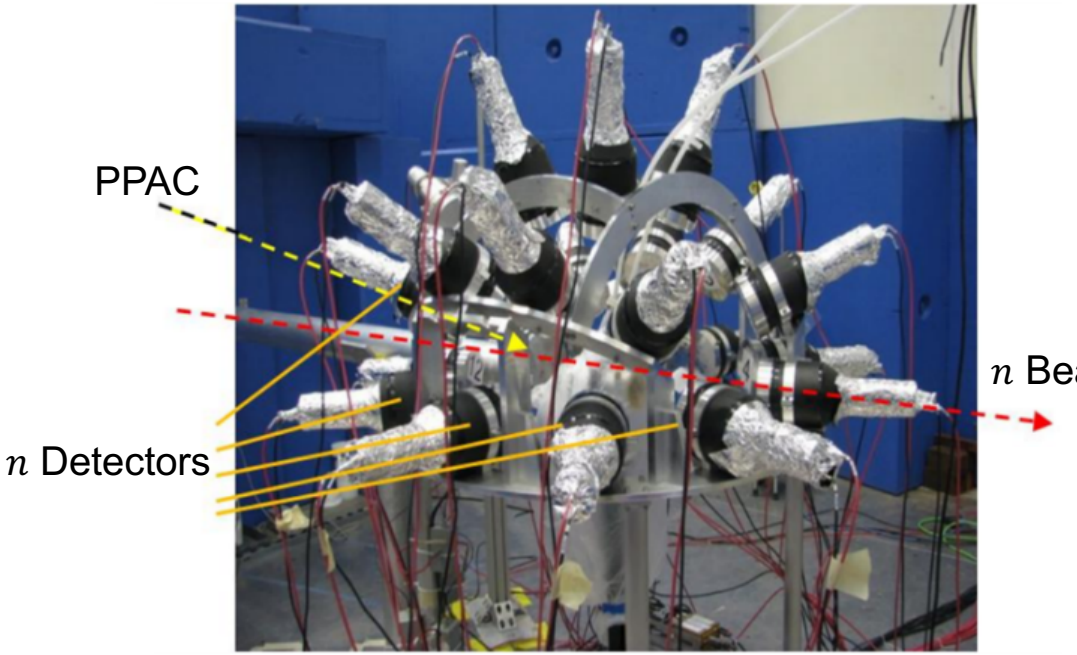


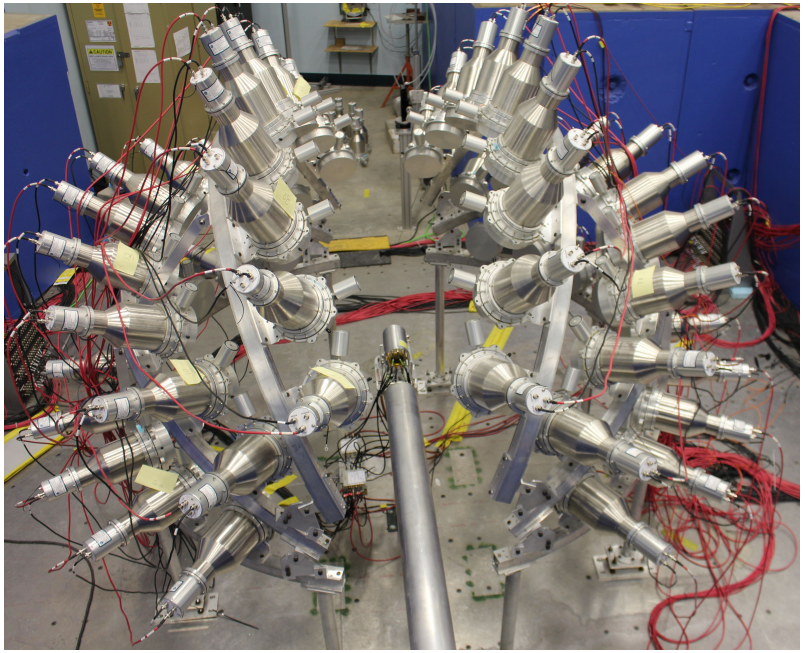


- Significant modifications made to initial PPAC design to reduce n scattering
  - G-10 is an issue
  - Change from G-10 to Al and glass improved PPAC performance
  - Other H-rich materials have also been reduced

Outgoing Neutron Detection: Chi-Nu n-Detector Arrays

- Low E_n^{out}: 22 ^{6}Li-glass (LiGl) Detectors
  - $E_n^{out} \leq 1$ MeV
  - Operate via $^6\mathrm{Li}(n,\alpha)\mathrm{t}$ reaction
- High E_n^{out}: 54 Liquid Scintillators
  - $E_n^{out} \geq 0.5$ MeV
  - Good PSD for n-γ separation

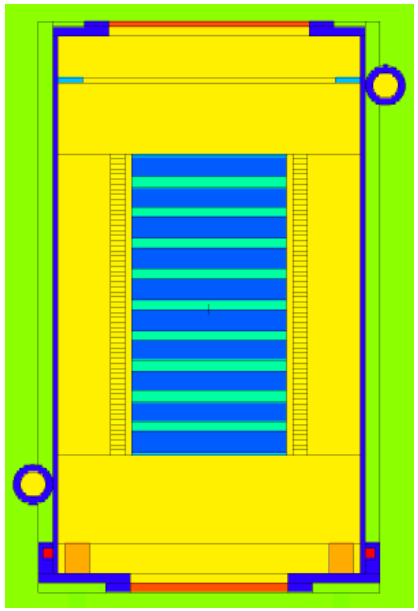




Overlap region allows for a high- and low-energy measurements to be combined into a single PFNS result

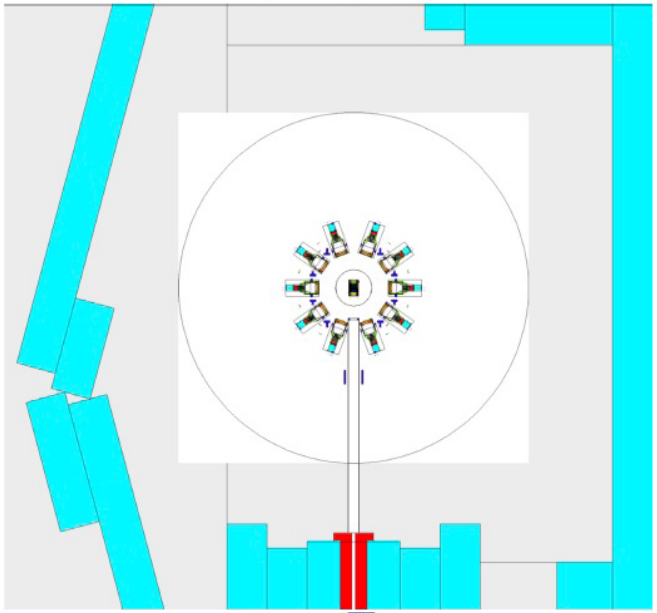
Detailed Models of the Chi-Nu Experiment

PPAC

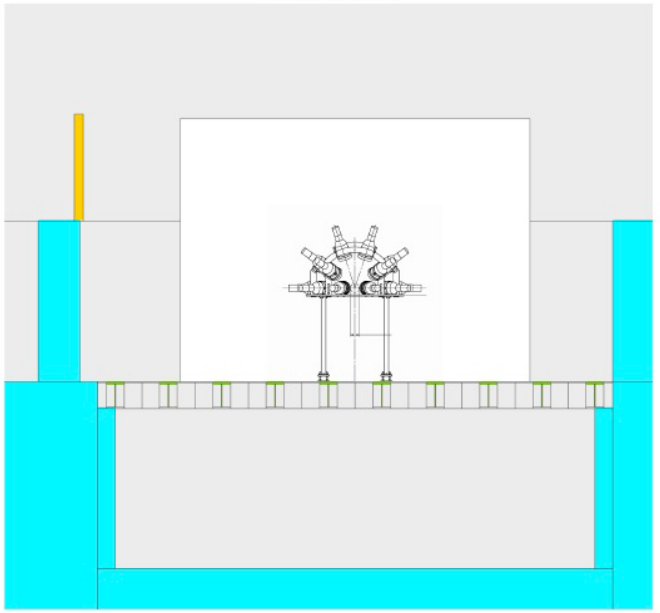


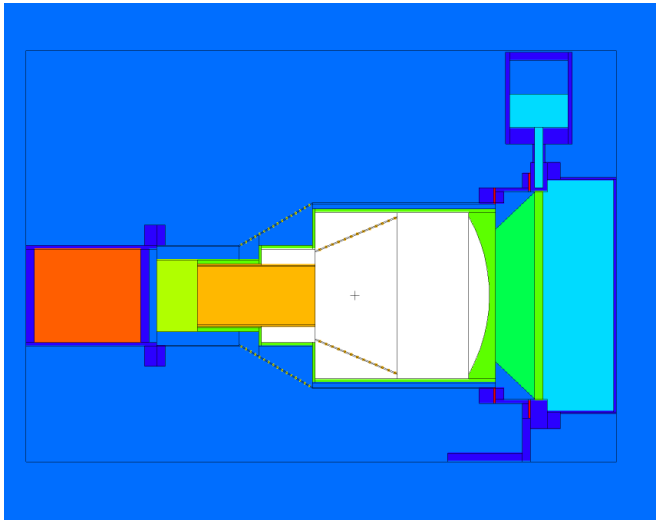
^{6}Li-glass Array

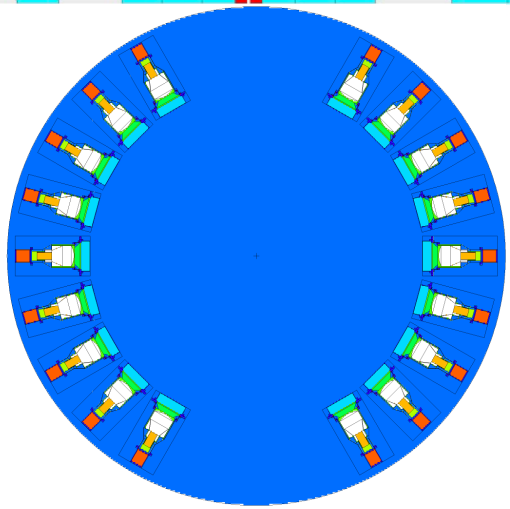
top view

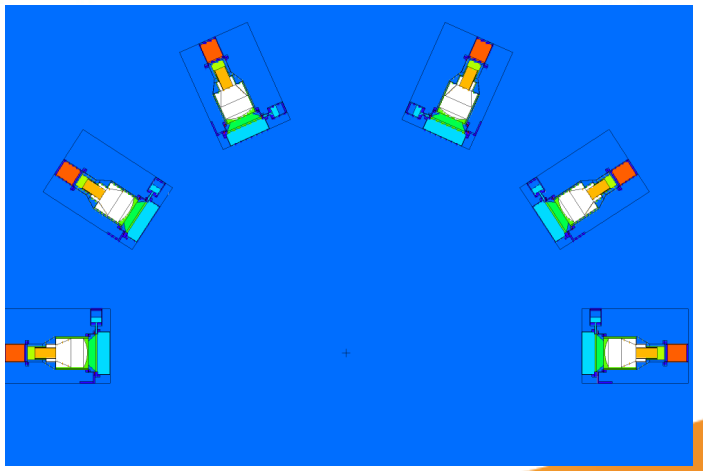


front view









Liquid Scintillator Array

Time-Dependent Background Measurements

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

A new method to reduce the statistical and systematic uncertainty of chance coincidence backgrounds measured with waveform digitizers

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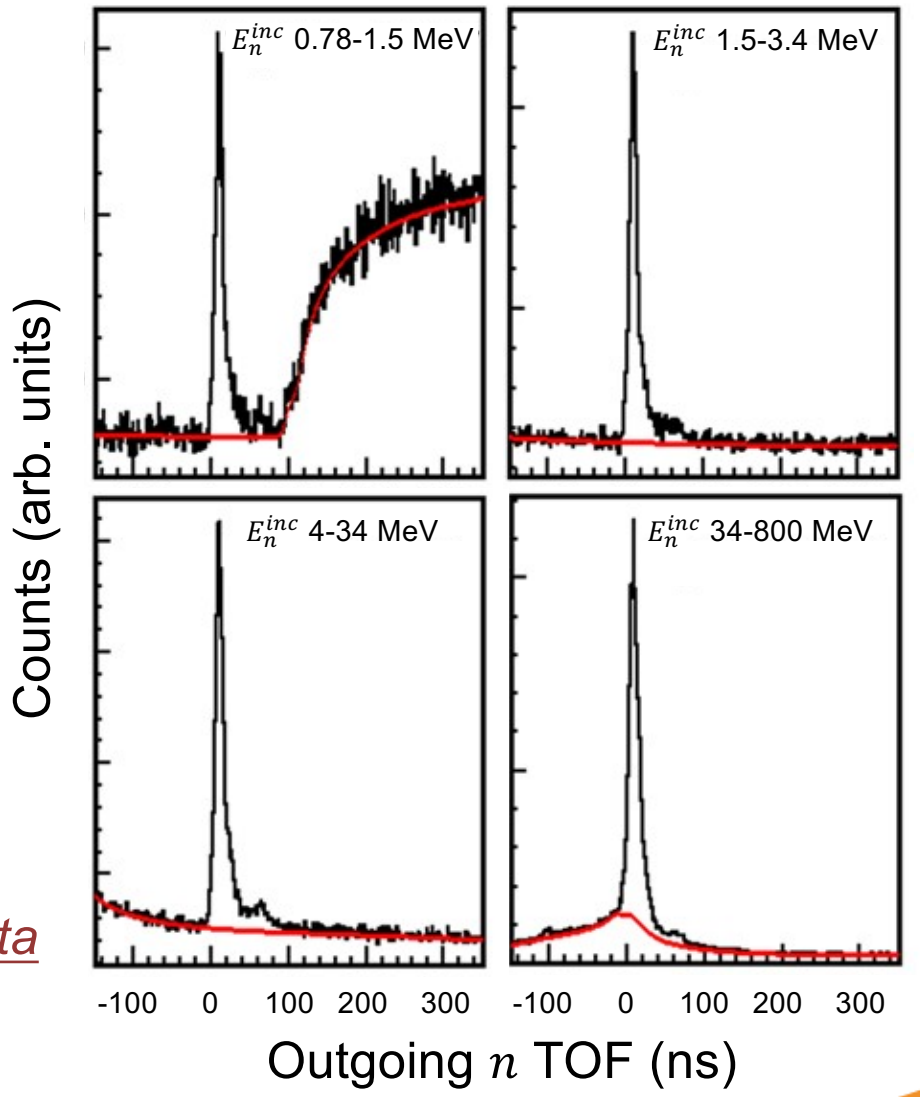
Los Alamos National Laboratory, Los Alamos, NM 87544, USA

J.M. O'Donnell, Nucl. Instrum. and Methods **A 805** (2016), 87

- Background changes shape based on the chosen E_n^{inc}
- Chance coincidence rate is measured using the *singles* rates of the PPAC and n detectors



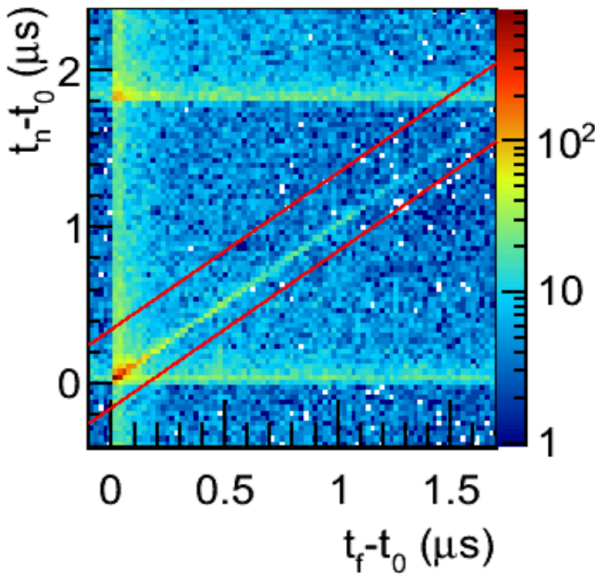
No Need to Collect Separate Background Data

Collect Background as Data are Taken

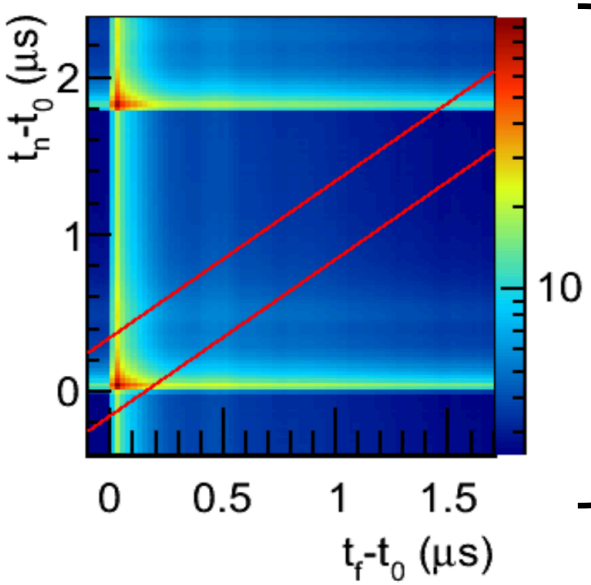
Factor of 4 Improvement in use of Beam Time

Measurement of the χ-Matrix

Foreground + Background

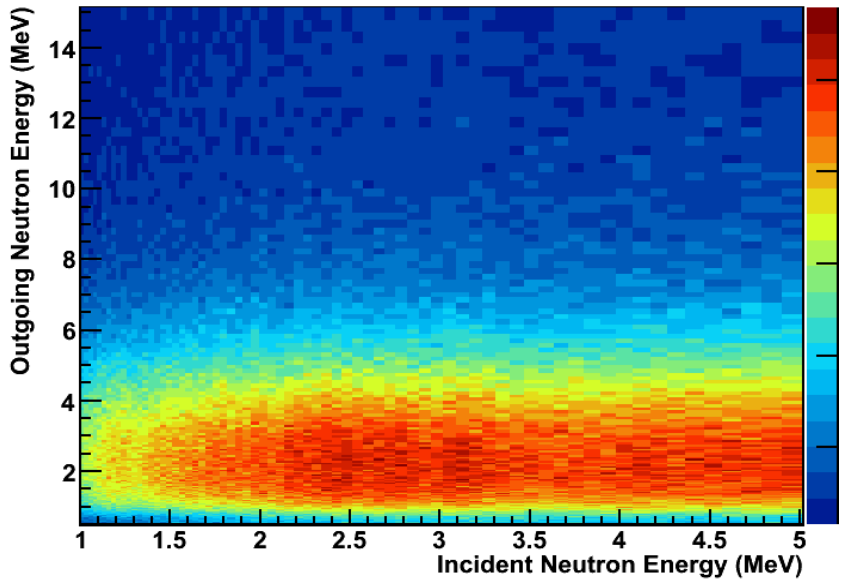


Background



^{239}Pu

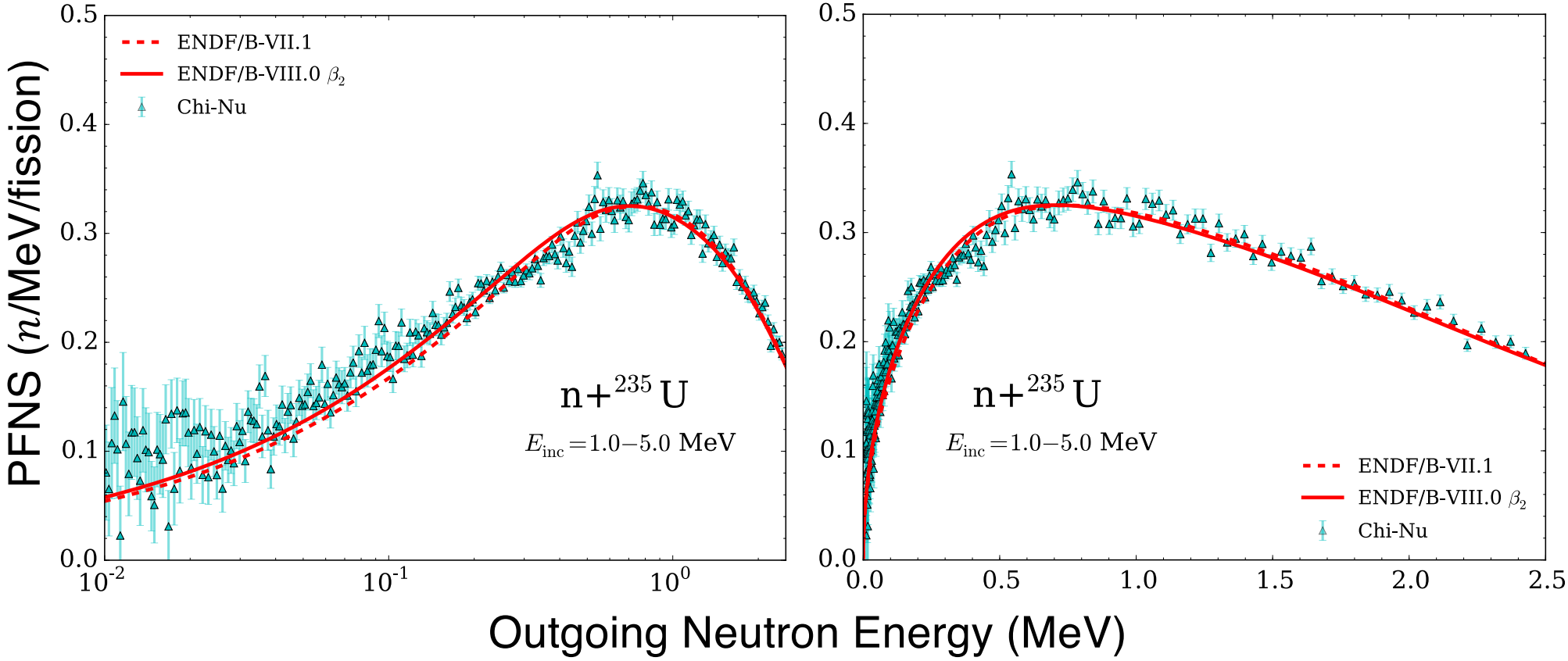
The data for any combination of E_n^{inc} and E_n^{out} is simply projected out



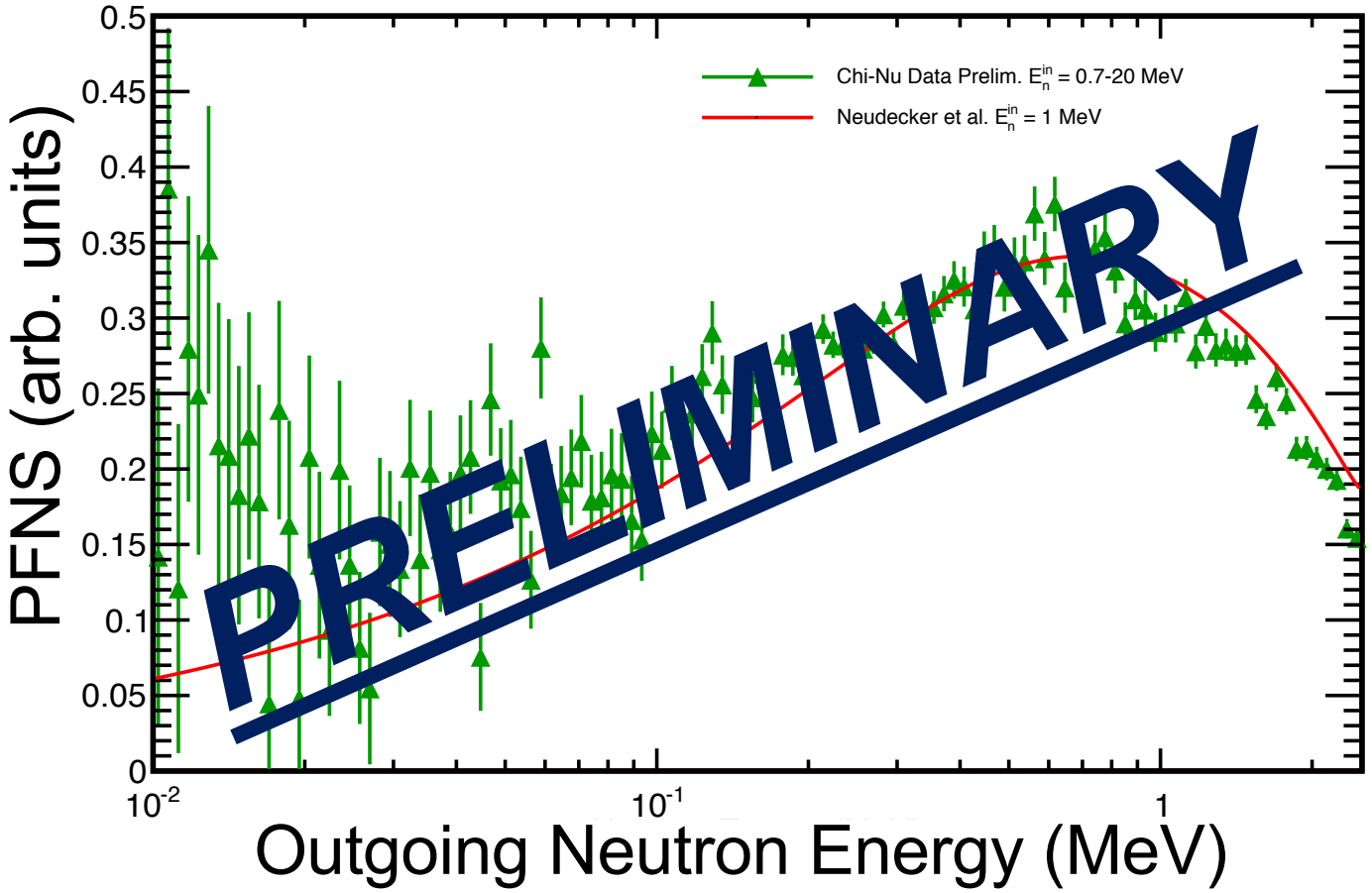
^{235}U

Preliminary Low-Energy ^{235}U Results

PRELIMINARY



Preliminary Low-Energy ^{239}Pu Results



Only 1 Week of Low-Energy Data

- High α-background rate is a serious problem
- Techniques have been developed to ensure that the highest precision result is obtained

Past and Future Milestones for Chi-Nu

- ^{235}U Data Collected to Date:
  - 3 months of data collected with the low-energy array
  - 1.5 months of data collected with the high-energy array
    - *^{235}U data collection is complete*

- ^{239}Pu Data Collected to Date:
  - 2.5 Months of data collected with the low-energy array
  - Short high-energy data set collected to confirm ability to handle data rate

- Future Data Collection Plans:
  - Collect another ~1 month of low-energy ^{239}Pu data before 2017
  - Collect high-energy ^{239}Pu data in the spring/summer of 2017

- Future Results Plans:
  - Final high- and low-energy ^{235}U results by mid-to-late 2017
  - Publication of ^{235}U results shortly after final results are obtained
  - Initial low-energy ^{239}Pu results by mid 2017
  - Initial high-energy ^{239}Pu results by late 2017

The Chi-Nu Collaboration

- Los Alamos National Lab:

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M. E. Rising, M. C. White, C. J. Solomon

- Lawrence Livermore National Lab:

C.-Y. Wu, B. Bucher, M. Q. Buckner, R. A. Henderson