The Chi-Nu Project at LANSCE

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November 8, 2012

LA-UR-12-26069

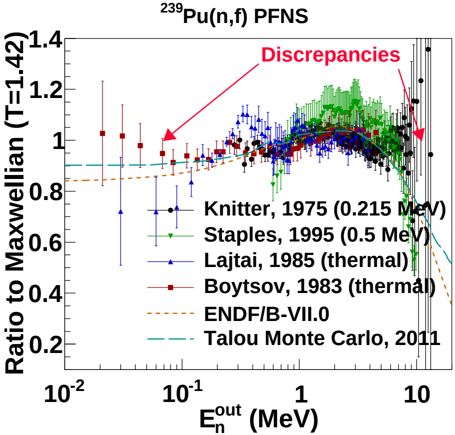
Issues with available data

Issues to be addressed:

- Discrepancies in literature data
  - Lower-energy region
  - Higher-energy region
- Lack of data for incident neutron energies in the MeV range

Our Focus: ^{239}Pu PFNS

- FY2013 - FY2014: $E_{\mathrm{n}}^{\mathrm{inc}}$ = 50 keV – 1 MeV
- FY2015: $E_{\mathrm{n}}^{\mathrm{inc}}$ = 700 keV – 10 MeV



Our Goal and Challenge

Goal: To impact evaluated data libraries, the shape of the PFNS should be measured to 5 % in key portions of the outgoing neutron energy range.

Challenge: Measuring a reaction with low event rates at low outgoing neutron energies while maintaining minimal neutron-scattering backgrounds at a facility that produces neutron beams with a wide range of energies.

Our Facility at LANSCE

Dedicated flight path (15L) at WNR

- Optimized for reducing neutron-scattering backgrounds

Fission sample: Parallel-plate avalanche counter (PPAC)

- Optimized for count rate
- Optimized for timing resolution
- Optimized for reducing neutron-scattering backgrounds

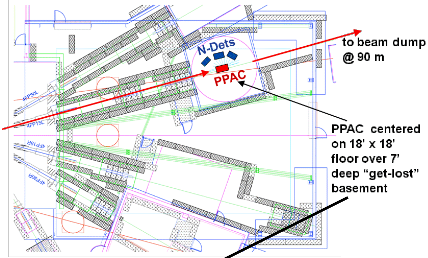
Lithium-glass array

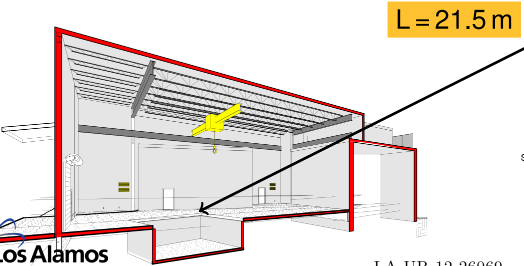
- $E_n^{out} < 1$ MeV

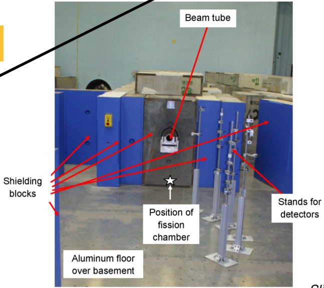
Liquid-scintillator array

- $E_n^{out} > 700$ keV

Chi-Nu Flight Path (15L)







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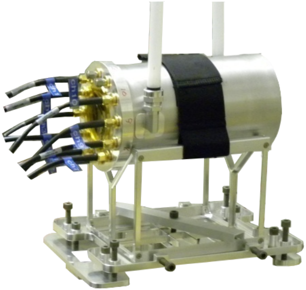
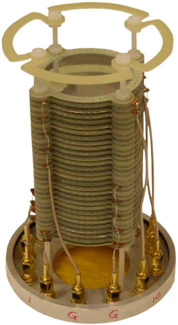
Fission Sample: PPAC (Developed & Built by LLNL)

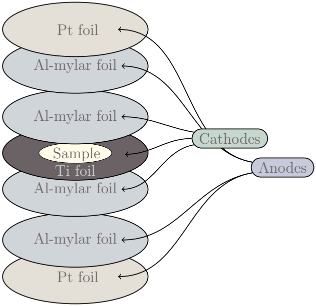
In Beam



Cover Off



One Foil Stack



10 cm diam. $\times$ 17 cm

Foil: 5 cm diam.
Sample: 4 cm diam.

t = 400 μg/cm^2

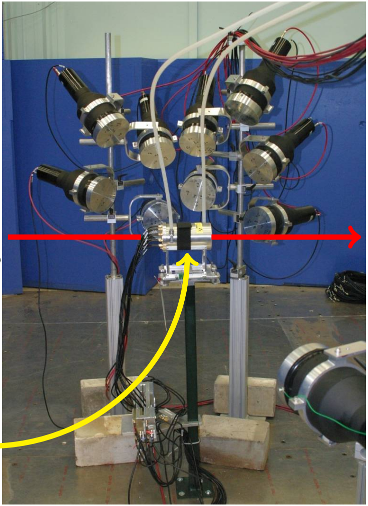
Timing res.: 1–1.5 ns

Lithium-glass Array

Scionix ^{6}Li-glass Detector

10.2 cm diam. × 1.8 cm thick

10 Detectors Viewing PPAC in Beam



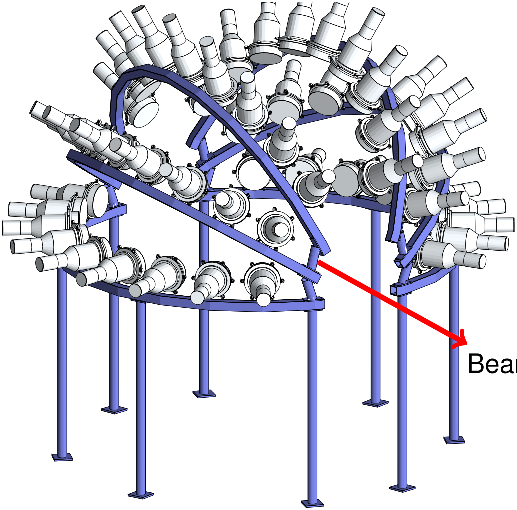
Beam

PPAC

Liquid-scintillator Array

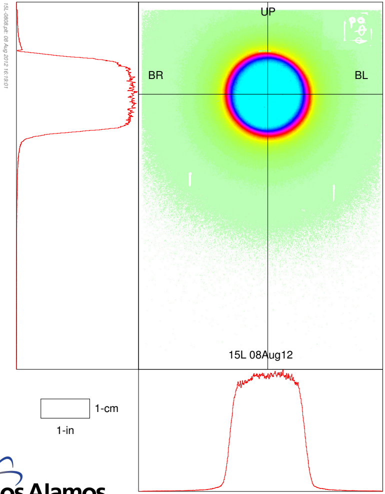
Eljen EJ309 Liquid Scintillator

54 Liquid Scintillators on Stands

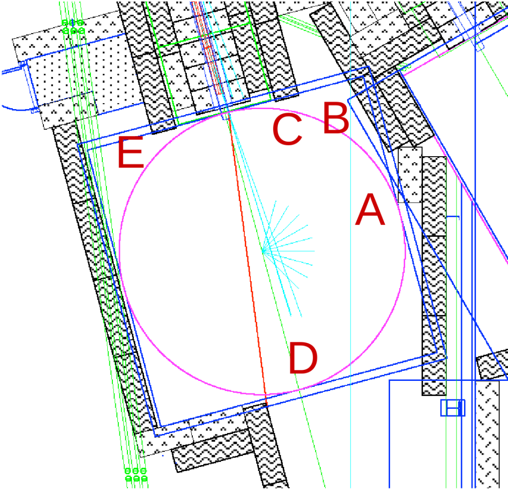


Beam Line Commissioning 2012

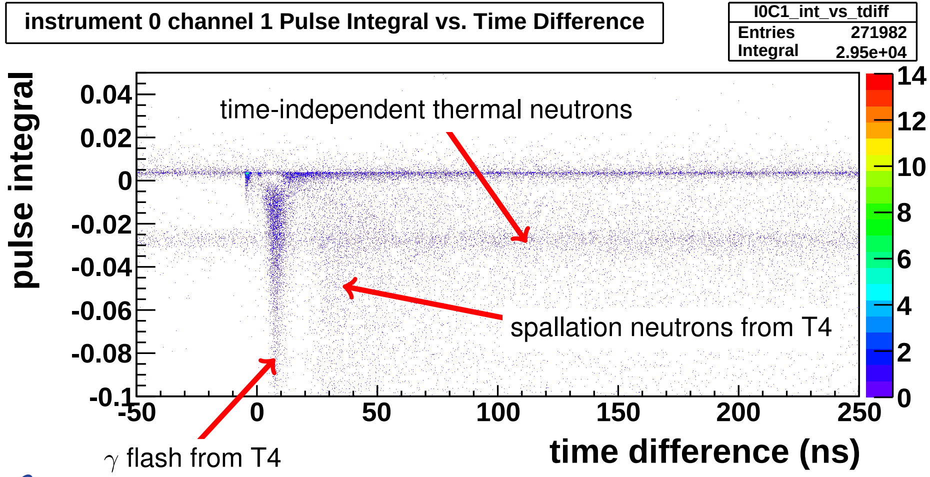
Beam Intensity Profile



Background Survey

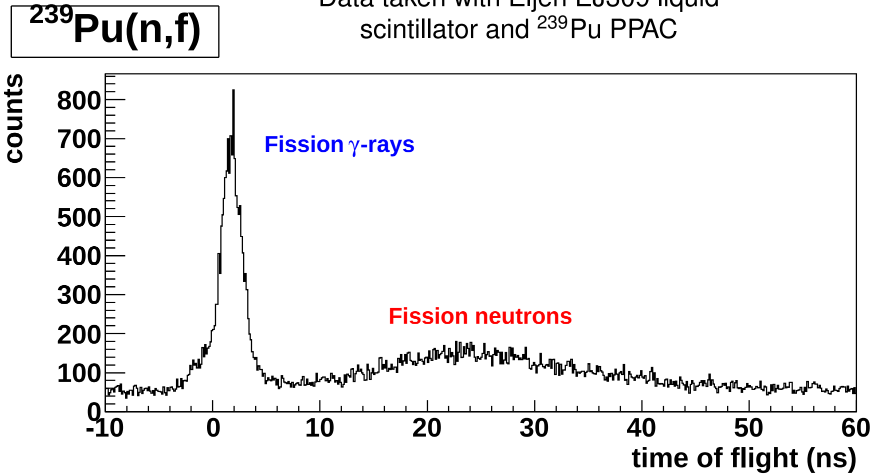


^{6}Li-glass Detector with Beam



Liquid Scintillator with Beam

Data taken with Eljen EJ309 liquid scintillator and ^{239}Pu PPAC



Data Acquisition

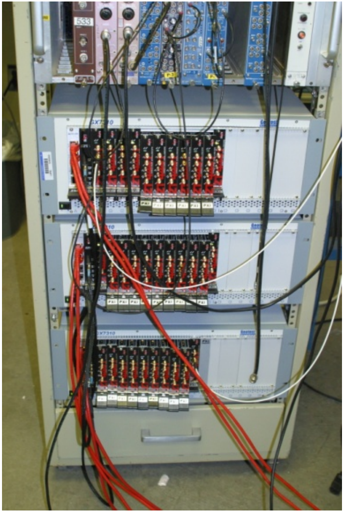
Data Collection

- Frontend Computer
- Waveform Digitizers
- On-board peak processing
- Read out up to 70 channels

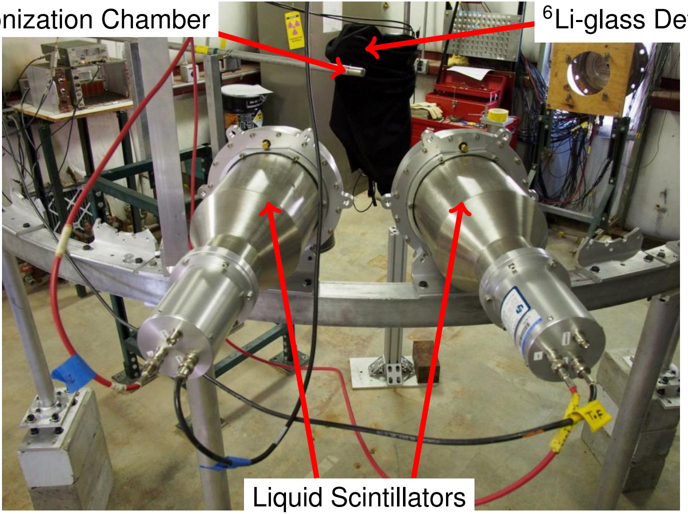
Development

- Close relationship with ZTEC
- Debug digitizer firmware
- Make improvements on acquisition speed

ZTEC Digitizers



Measurements with ^{252}Cf Ionization Chamber



Detector Response and Characterization

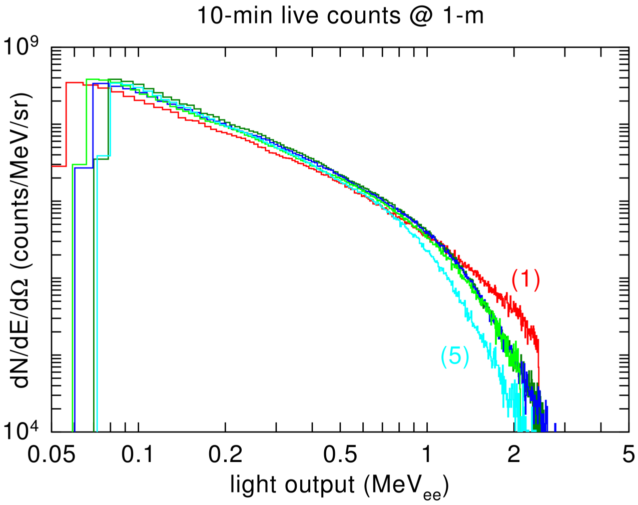
^{6}Li-glass energy spectrum (calculated from TOF)

- Compare measurements with detailed MCNP models
- Understand late-time backgrounds (scattered neutrons returning to detector)
- DAQ development to improve timing
- Analysis algorithms to reduce backgrounds

Liquid-scintillator response to ^{252}Cf neutron spectrum

- Determine light-output curves
- Develop analysis algorithms to improve pulse-shape discrimination (PSD)
- Compare measurements with detailed MCNP and Geant4 models

Gain-matched Dets.: Different ^{252}Cf PH Distributions



(1) Figaro #5 (EJ-301)

(2) Eljen #1 (EJ-309)

(3) Eljen #2 (EJ-309)

(4) Scionix #1 (EJ-309)

(5) Scionix #2 (EJ-309)

conclusion:

different light curves!

Summary and Outlook

Summary

- Challenging Goal: Measure shape of PFNS to 5 % uncertainty
- Commissioned FP, LiGl, and liquid scintillators
- Collected valuable data with ^{252}Cf ionization chamber
- Detailed Monte Carlo models needed

Outlook

- Understand and reduce and backgrounds on 15L flight path
- Improve timing resolution for PPAC and detectors
  $\rightarrow$ Good now, factor of 2–3 better than previous work
  $\rightarrow$ Working to improve
- Characterize ^{239}Pu PPAC fully
- Characterize detectors fully
- Improve DAQ readout speed
- Develop Chi-Nu analysis codes
- New LE & HE data and evaluation by end of FY2016

Publications

- E. Kwan et al., Nucl. Instr. Meth. A, 688 (2012) 55
- R. A. Henderson et al., Nucl. Instr. Meth. A, 655 (2011) 66
- C. Y. Wu et al., Tech. Report LLNL-TR-461044 (2010)
- H. Y. Lee et al., Nucl. Instr. Meth A (Accepted)
- R. C. Haight et al., Proceedings of the 2nd International Workshop on Fast Neutron Detectors and Applications, 2011; JINST 7, C03028 (2012)
- R. C. Haight et al., Proceedings of the 2nd International Workshop on Fast Neutron Detectors and Applications, 2011; JINST_012P_0112, C05002 (2012)
- B. A. Perdue et al., IEEE Trans. Nucl. Phys. (Accepted)

Collaboration and Funding

Chi-Nu Collaboration

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Funding Sponsors

DOE: NNSA, Nuclear Energy, Nuclear Physics