
Nuclear Cross Section Measurements within the Advanced Fuel Cycle Initiative

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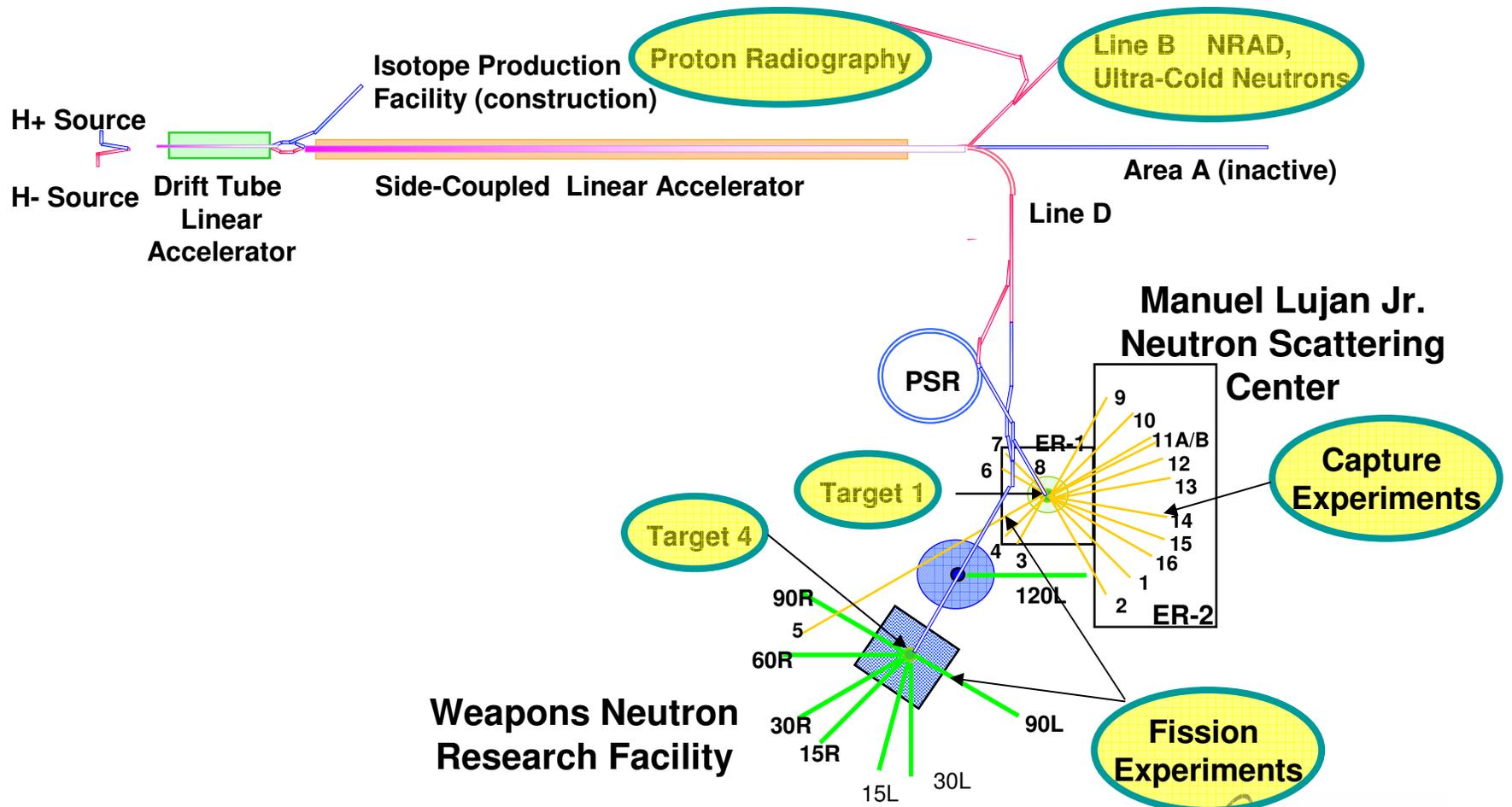


AFCI's nuclear data program is motivated by the different actinide content in recycled fuels

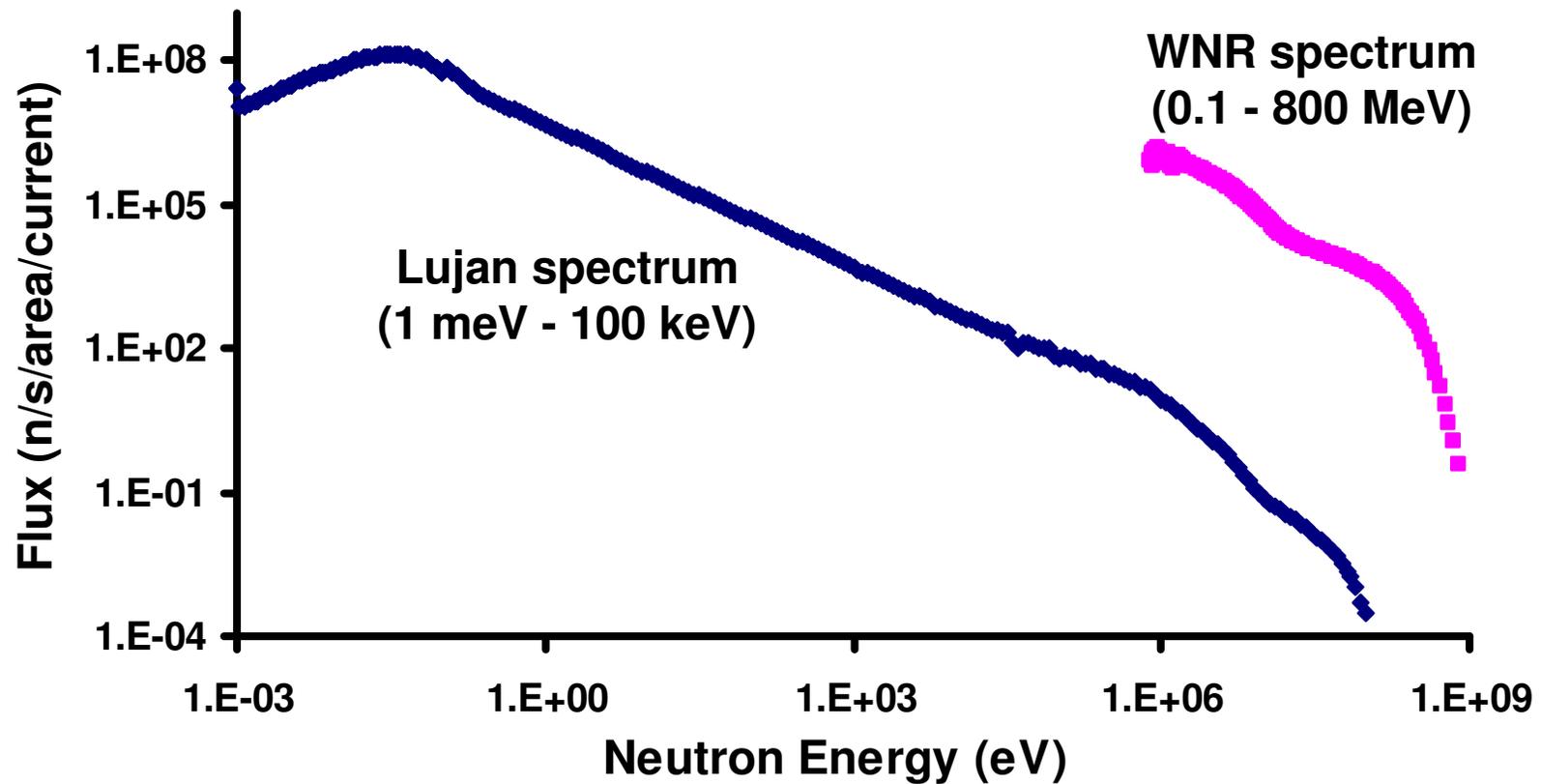
- **The higher minor actinide (MA) content of fuels that undergo multiple recycles places a greater demand on the quality of cross section data for MA's.**
- **For some isotopes, nuclear data evaluators need new experimental data to guide the production of new evaluations.**
- **The DOE's Advanced Fuel Cycle Initiative (AFCI) has developed a multi-year program plan to address these needs, taking into account the nuclear data needs of GEN IV as well.**
- **The measurement program utilizes the unique capabilities that exist at the Los Alamos Neutron Science Center (LANSCE).**



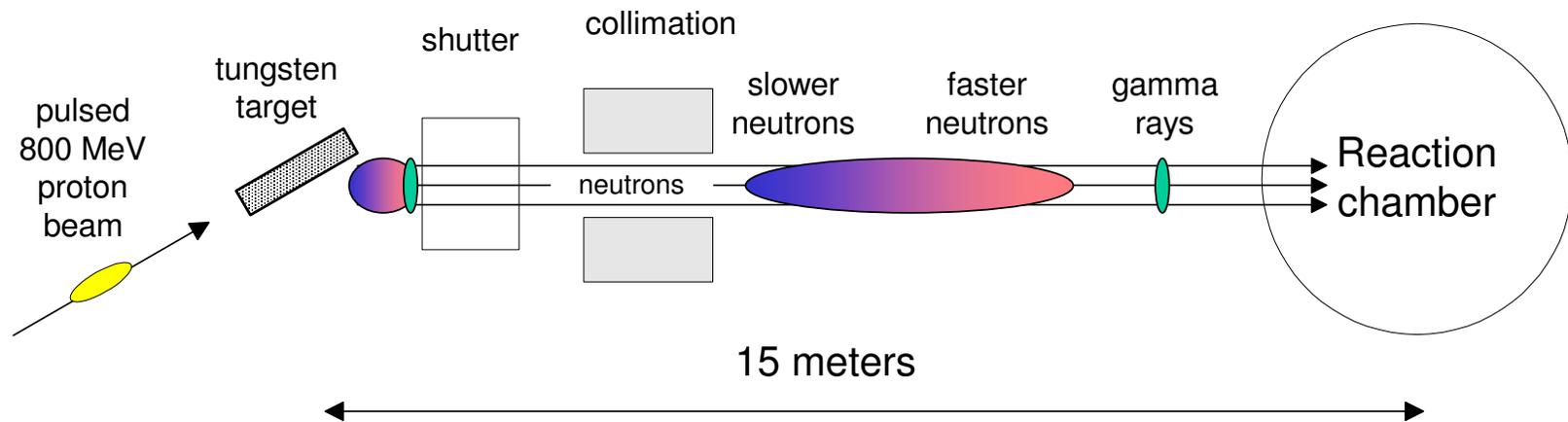
LANSCCE delivers 800-MeV proton pulses to two spallation targets for neutron production



The neutron sources at LANSCE span 12 decades in energy



Time of flight over the flight path identifies the energy of the neutron that induces the reaction



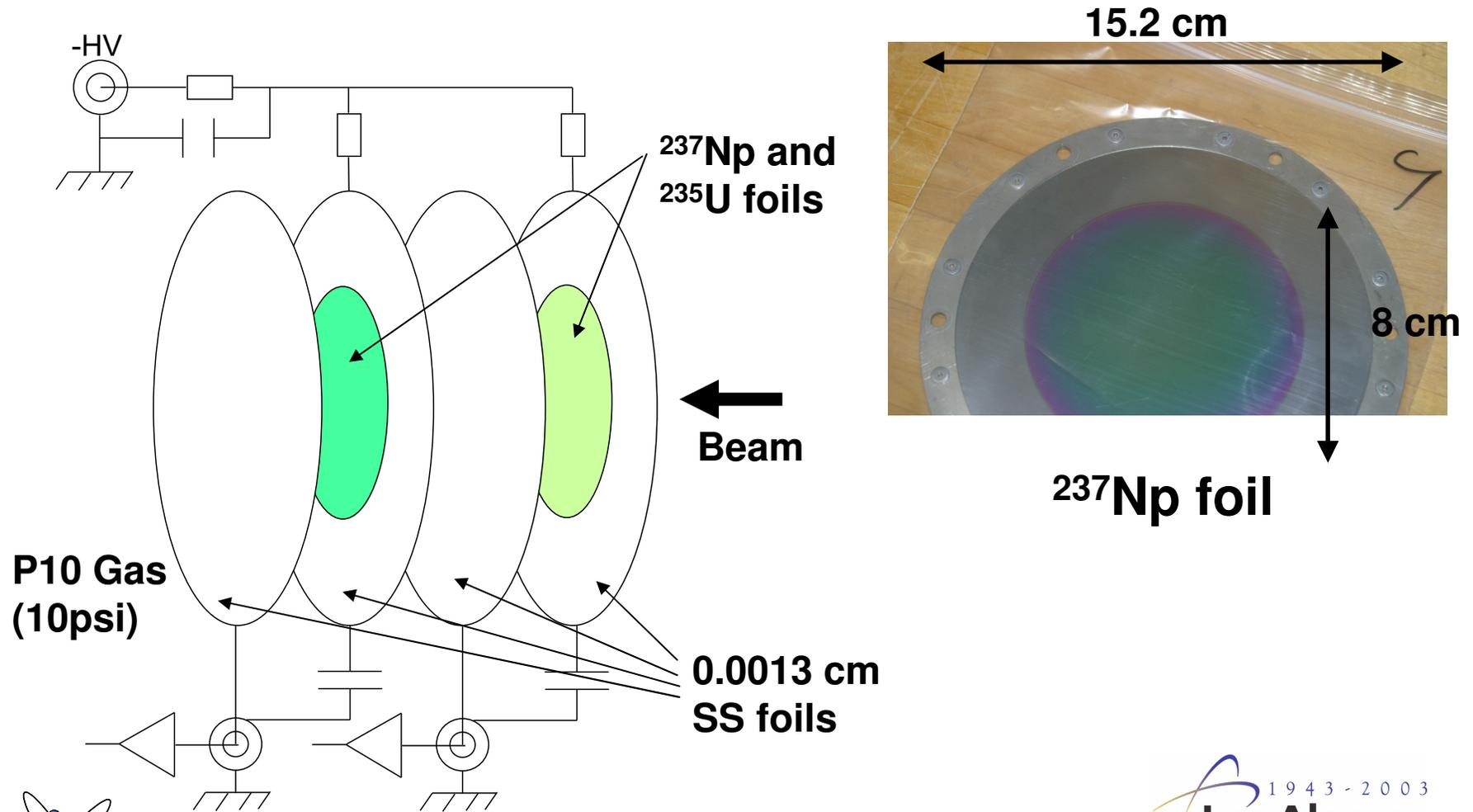
$$E_n \sim v^2 \sim 1/t^2 \quad (\text{non-relativistic})$$

To cover a broad energy spectrum, fission measurements are made at both Lujan and WNR

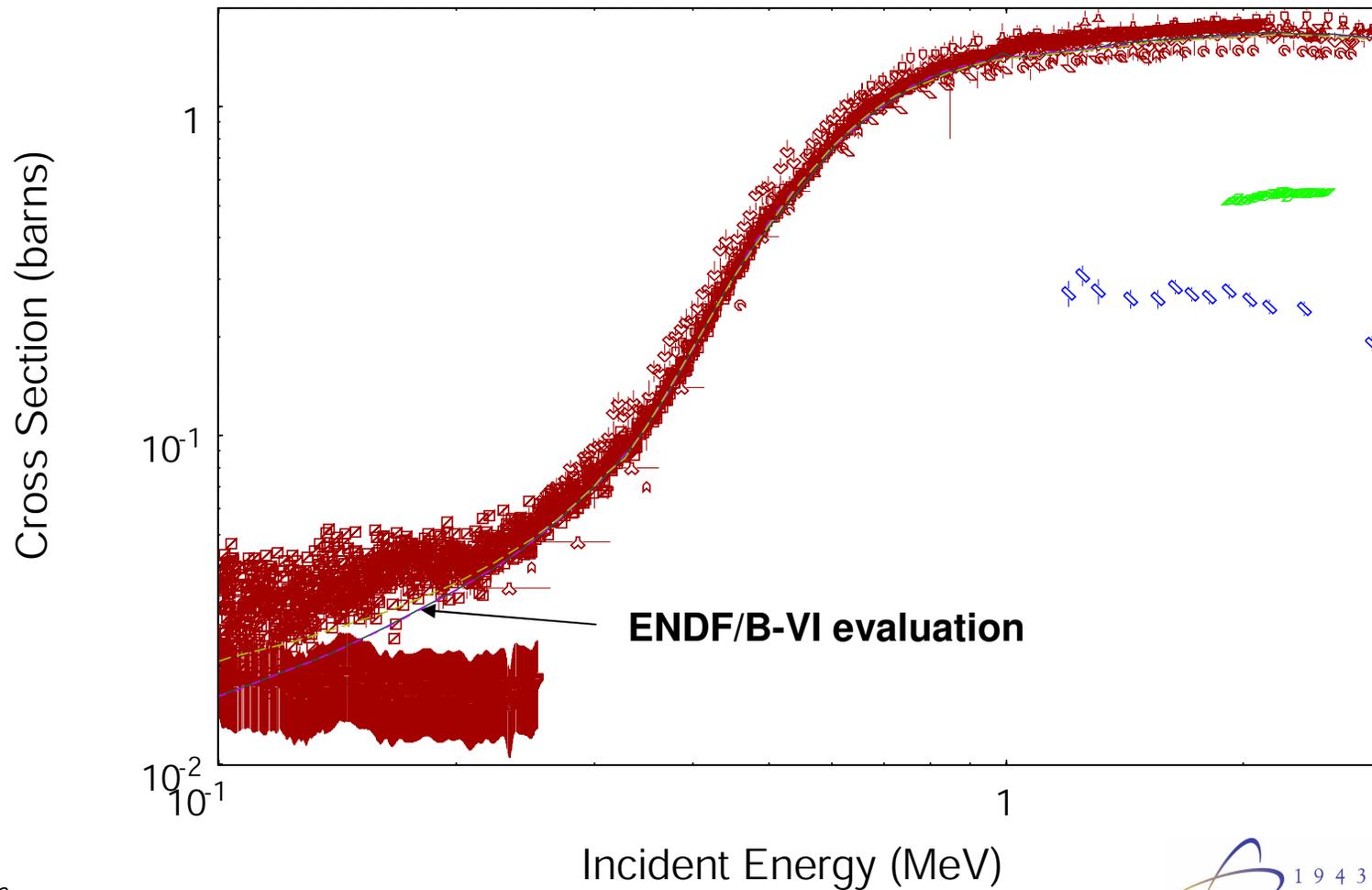
- Lujan covers energies <100 keV, WNR energies >100 keV
- The goal is to measure fission cross sections, relative to a U-235 or U-238 standard, with 2% accuracy, placing stringent criteria on:
 - Counting statistics
 - Sample characterization (purity, uniformity, thickness)
 - Beam characterization (purity, profile)
 - Detector performance (efficiency, dead time)
 - Backgrounds (wrap arounds, dark current, decays)
- To accomplish this, we have designed and built a single system that collects data at both facilities (WNR and Lujan)
- Np-237 was chosen for the first measurement because:
 - Current measurements are discrepant
 - High-quality, well-characterized foil was in hand



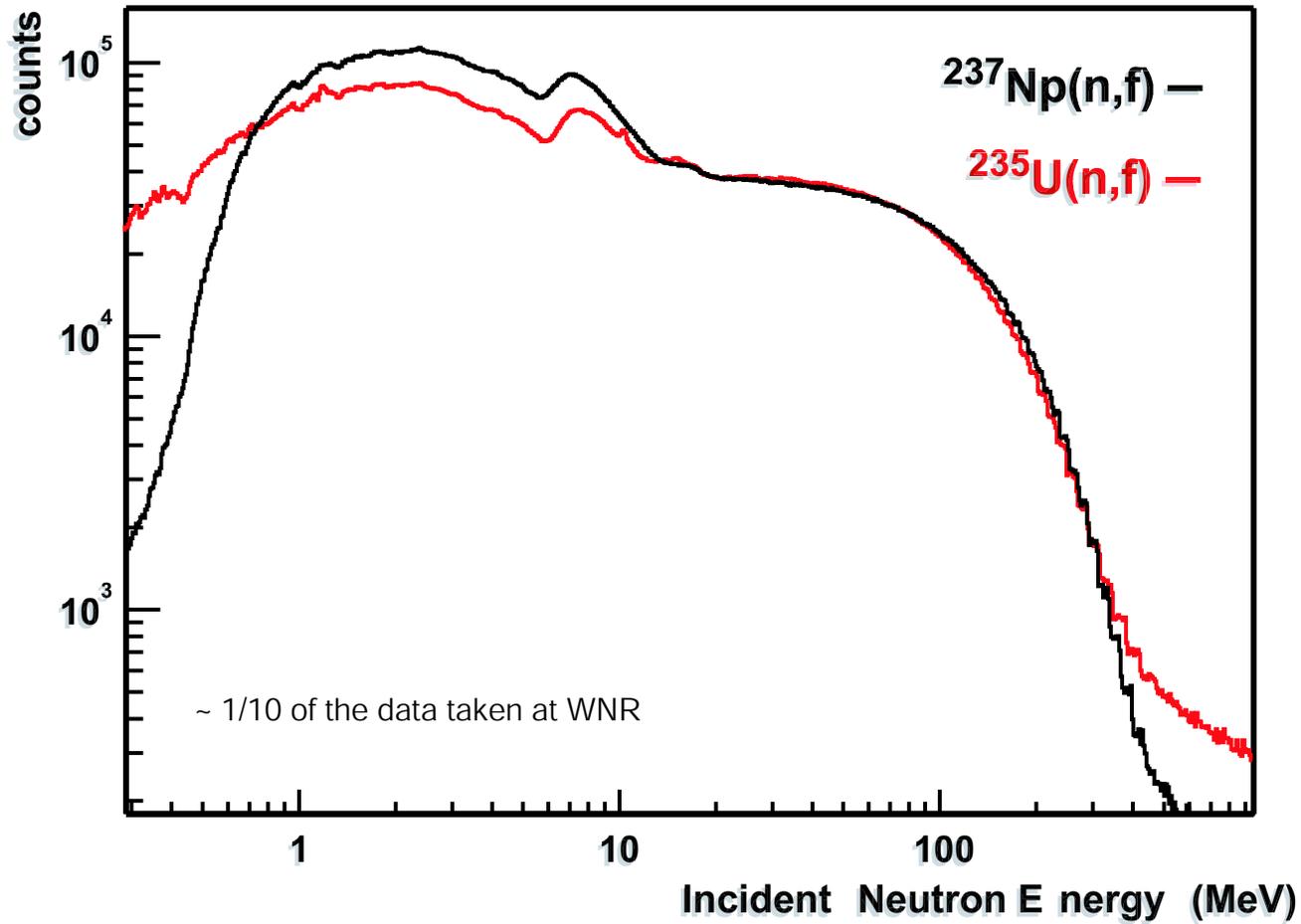
A double fission chamber is used to acquire data on the ^{237}Np sample and ^{235}U standard simultaneously



Current $^{237}\text{Np}(n,f)$ experimental data are discrepant

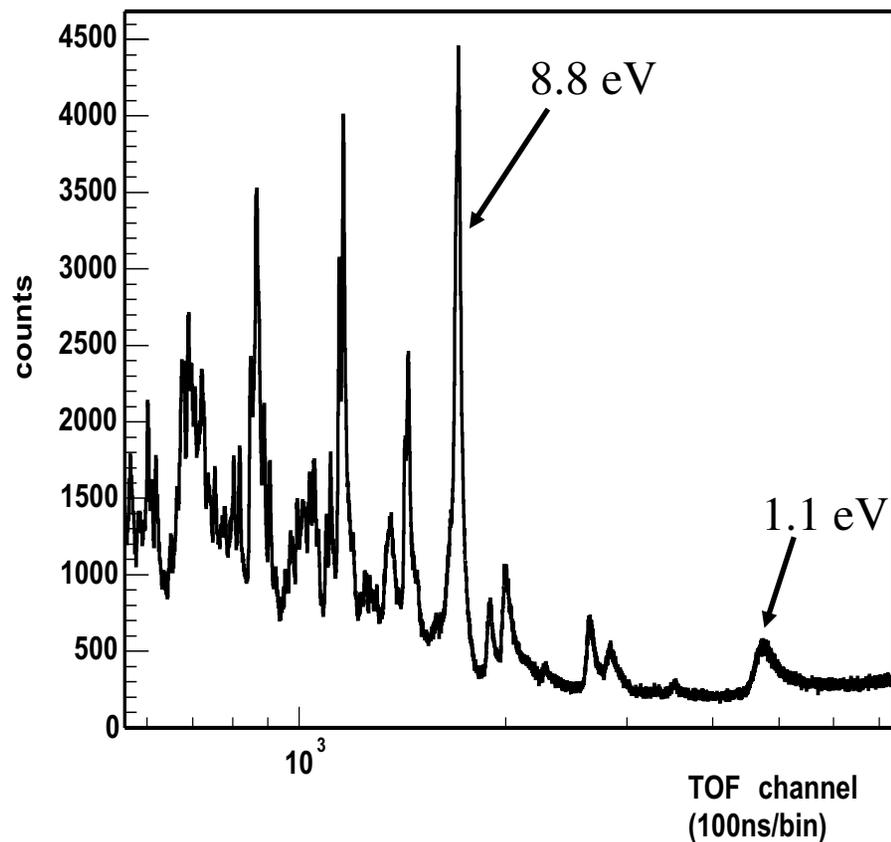


First $^{237}\text{Np}(n,f)$ data were acquired in January 2004

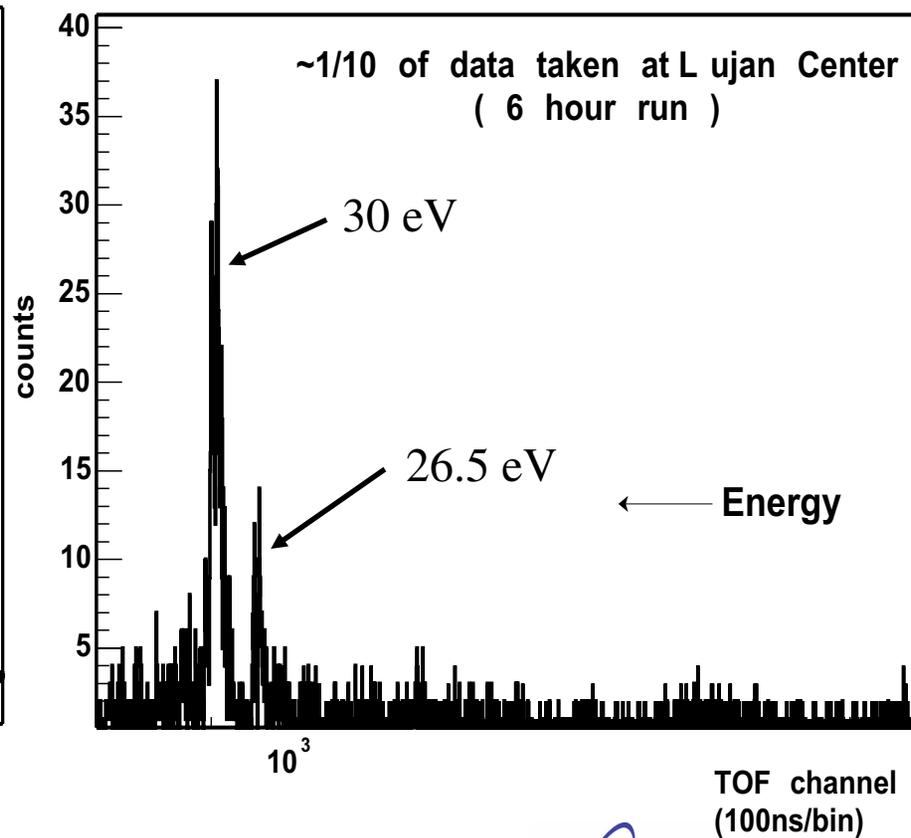


Some data have recently been acquired at low energy

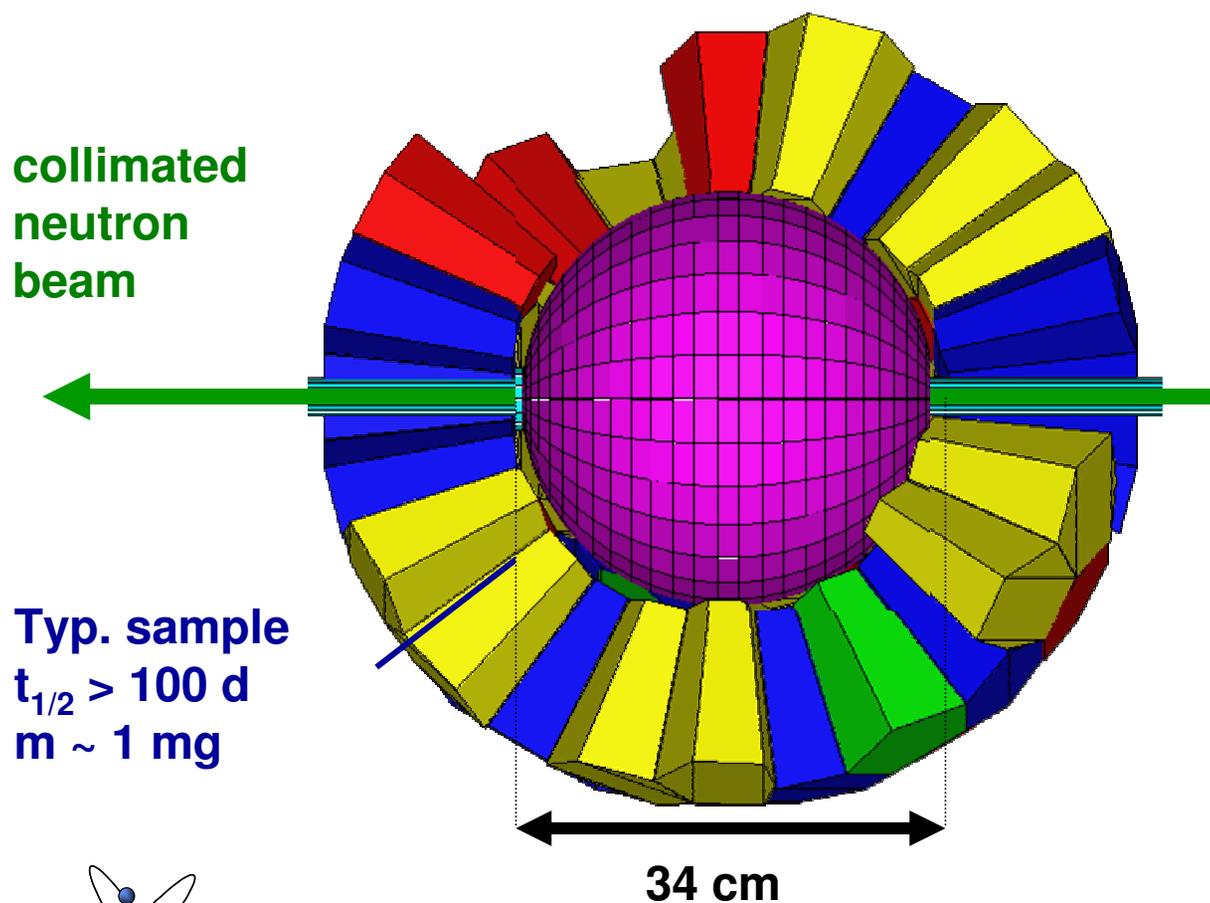
$^{235}\text{U}(n,f)$ Raw TOF Distribution



$^{237}\text{Np}(n,f)$ Raw TOF Distribution



Capture cross sections are made on the newly commissioned DANCE instrument: **D**etector for **A**dvanced **N**eutron **C**apture **E**xperiments



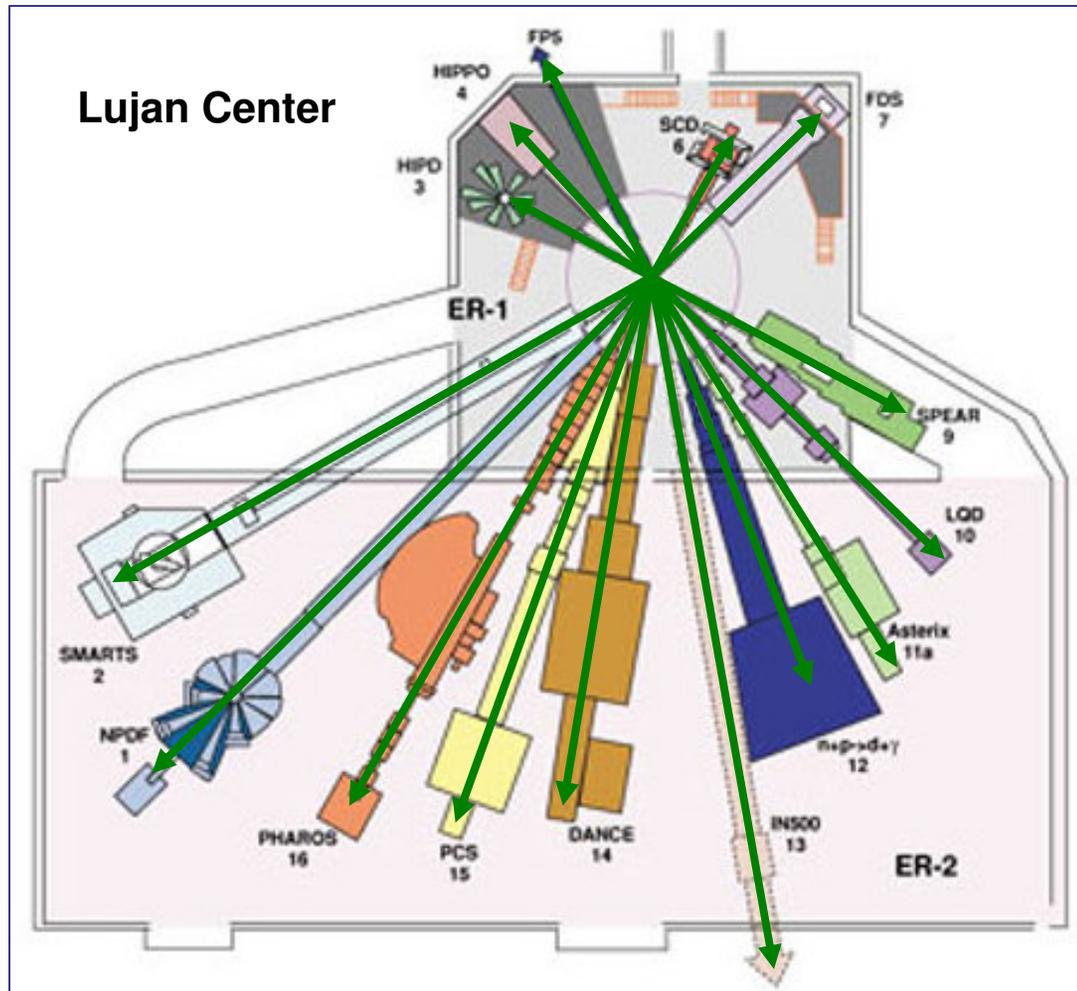
neutrons:

- spallation source
- thermal .. 500 keV
- 20 m flight path
- 3×10^5 n/s/cm²/decade

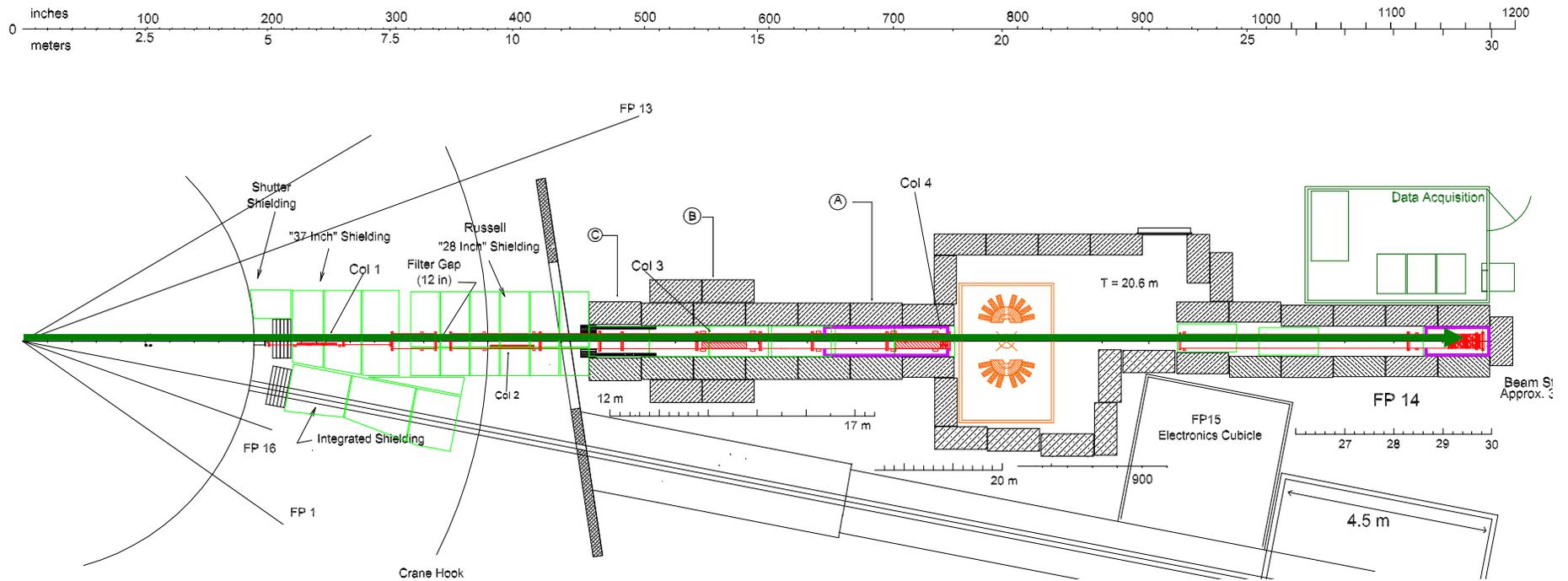
γ detector:

- 160 BaF₂ crystals
- 4 different shapes
- $R_i=17$ cm, $R_a=32$ cm
- 7 cm ⁶LiH inside

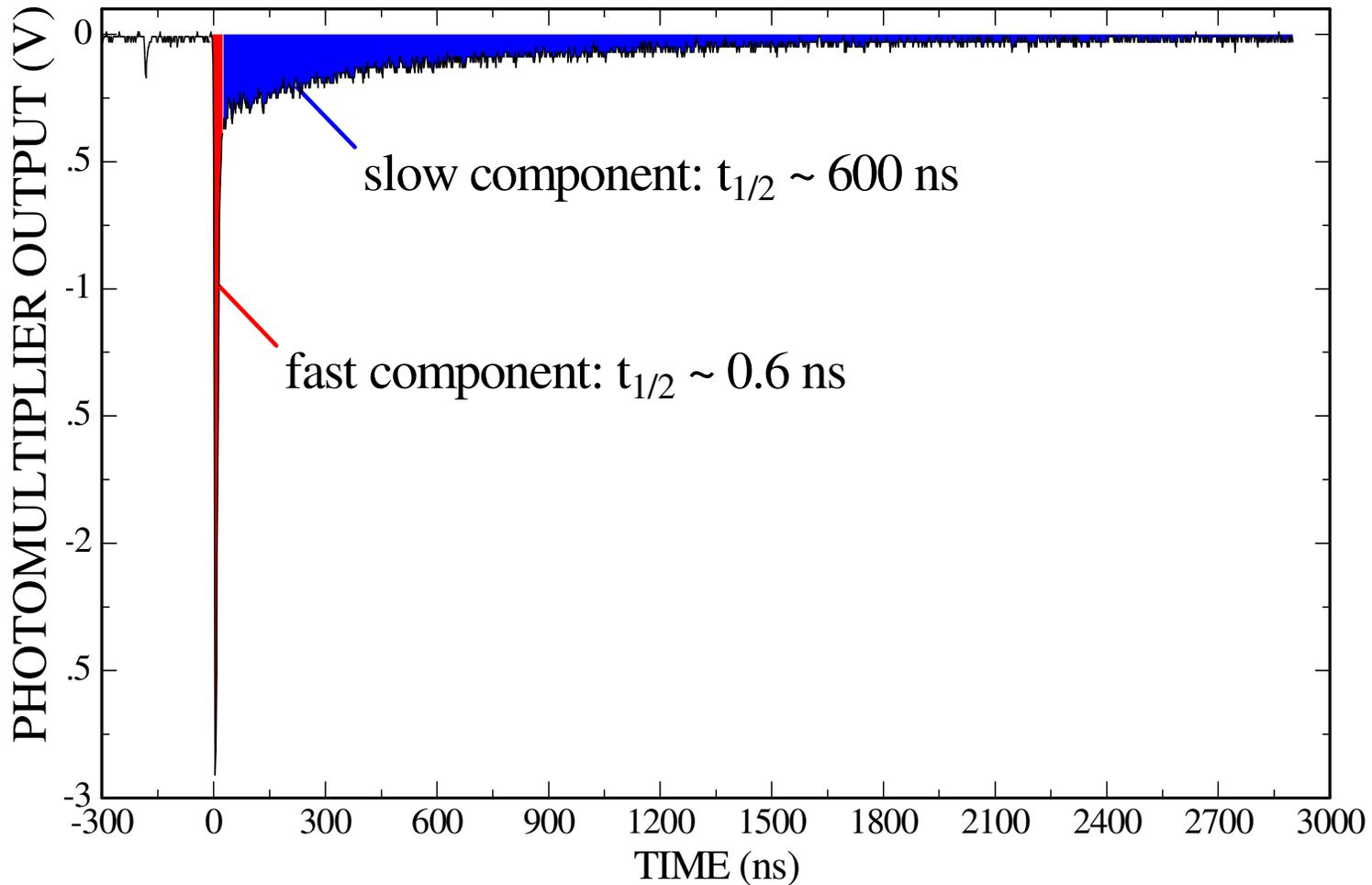
DANCE occupies Flight Path 14 at the Lujan Center



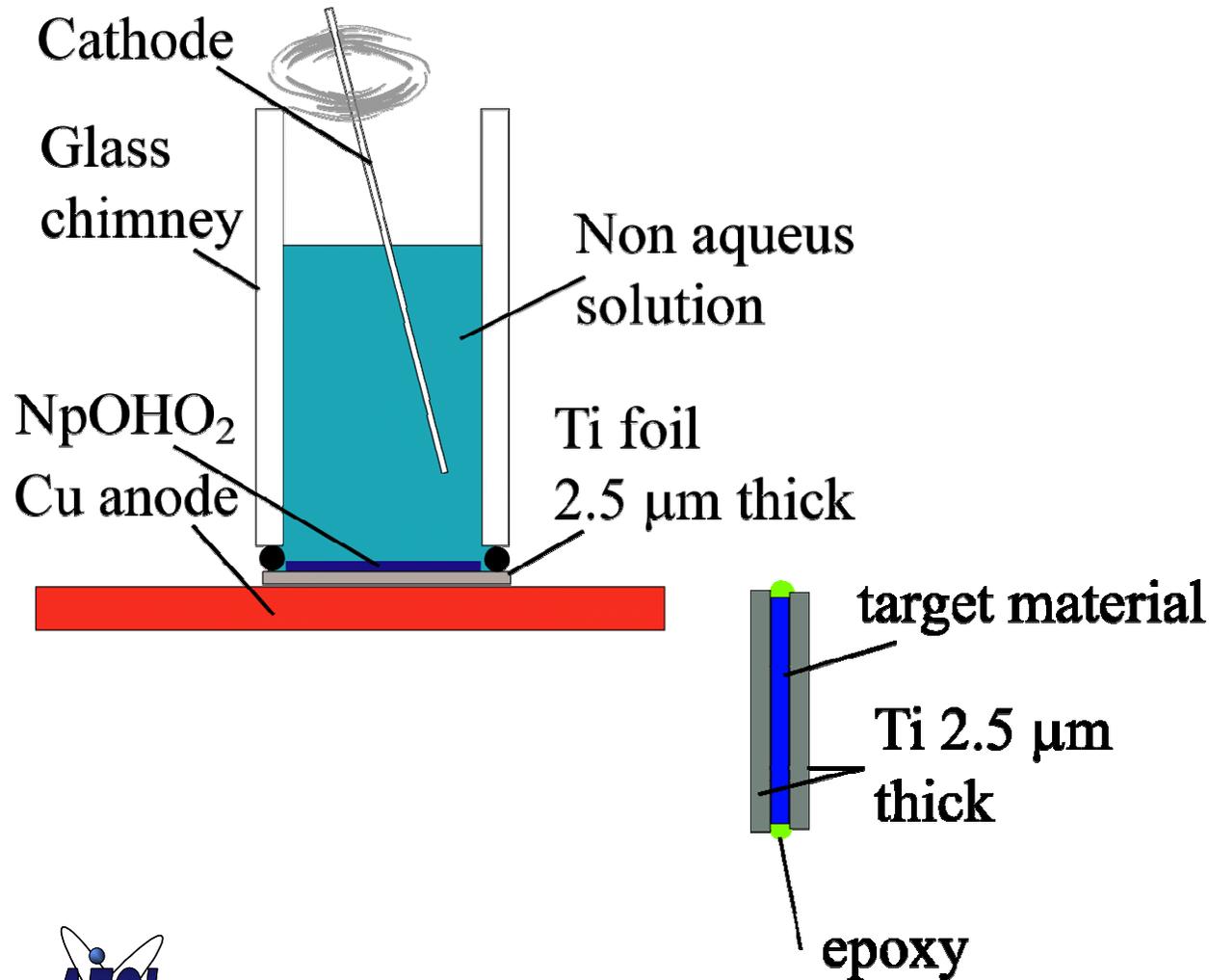
The DANCE sample position is 20 m from the neutron source



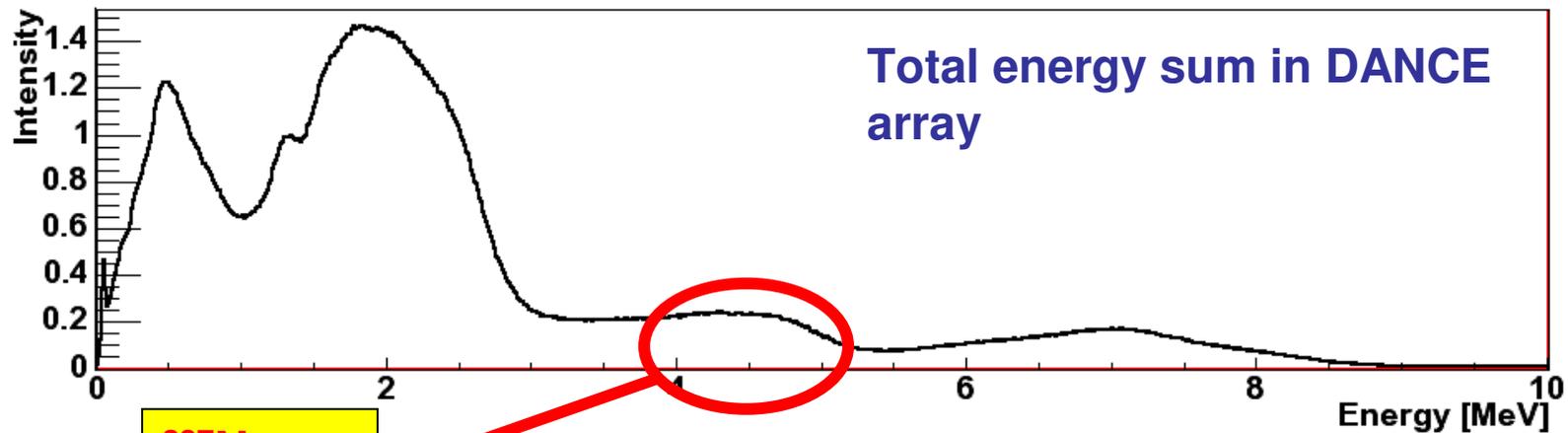
The BaF₂ waveform has characteristic fast and slow components



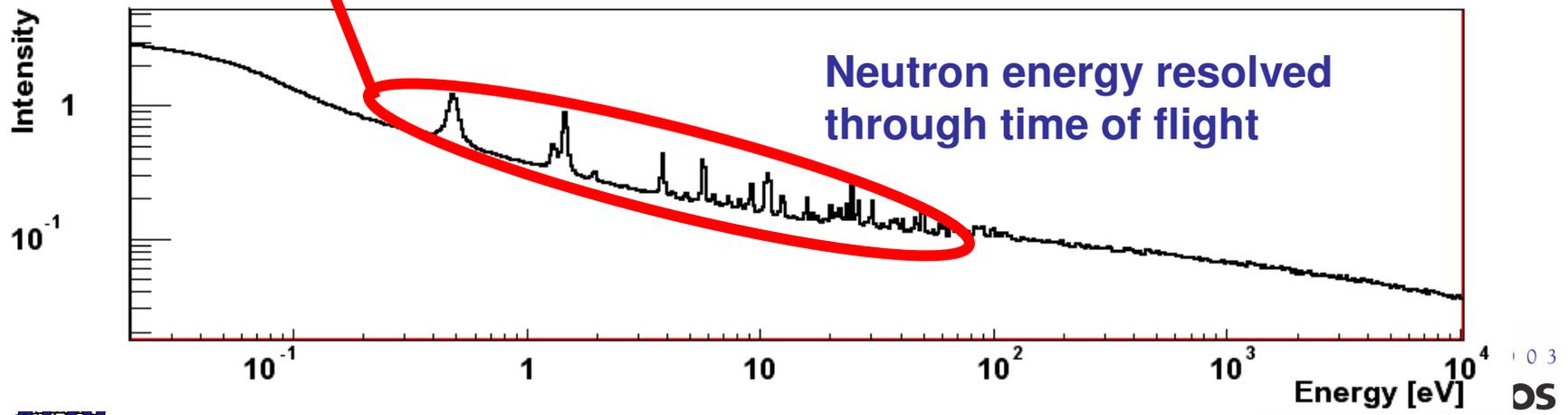
The ^{237}Np foil for DANCE was fabricated by LANL group C-INC using an electroplating process



The capture gamma signal is a small part of the total signal detected by the BaF₂ detectors



²³⁷Np
Signal

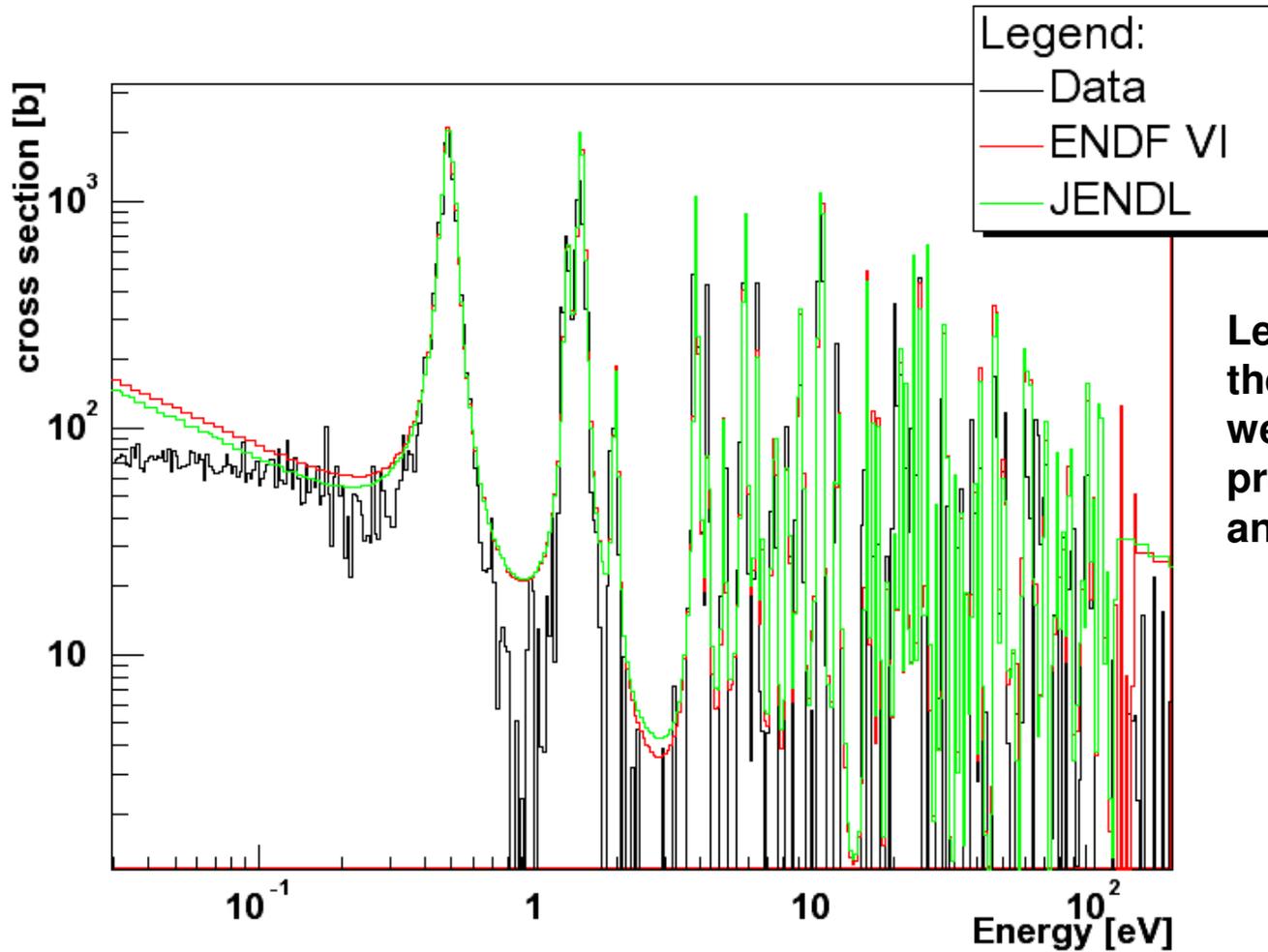


Background subtraction is accomplished by careful analysis

- **Sources of background include:**
 - **Intrinsic alpha signal from Ra contamination in the Ba**
 - **Neutron elastic scattering from the Ti backing, Kapton windows, and Np-237**
 - **Neutron capture in the Ti backing and Kapton windows**



A preliminary $^{237}\text{Np}(n,\gamma)$ cross section is the first measured cross section from DANCE



Less than 10% of the data acquired were used in the preliminary analysis.

The AFCl has mapped out a long-term plan to measure key MA reaction cross sections

- Capture:

^{241}Am , ^{239}Pu , ^{241}Pu , ^{242}Pu , ^{238}Pu , ^{243}Am , ^{244}Cm

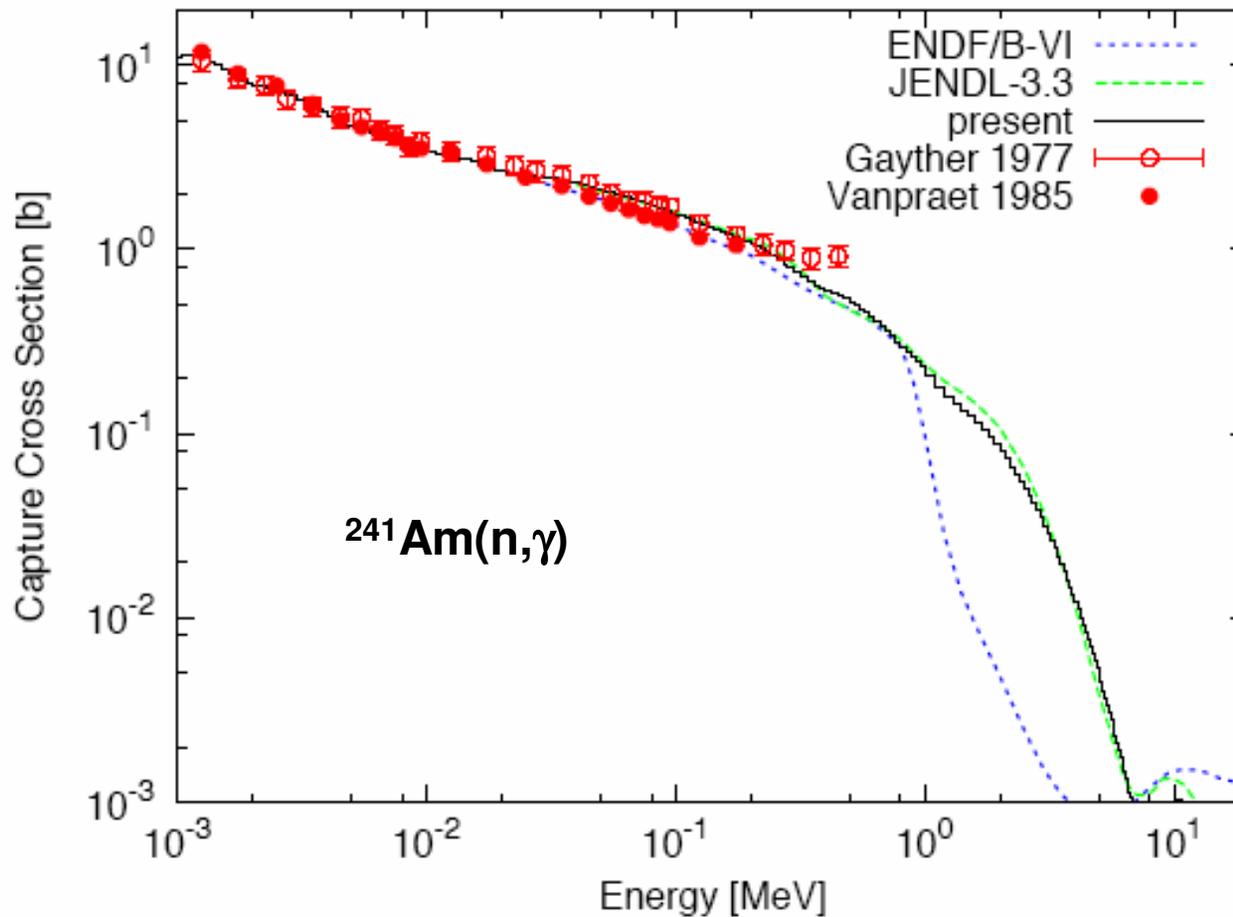
- Fission:

^{237}Np , ^{238}Pu , $^{242\text{m}}\text{Am}$, ^{243}Am , ^{241}Pu , ^{243}Am , ^{244}Cm



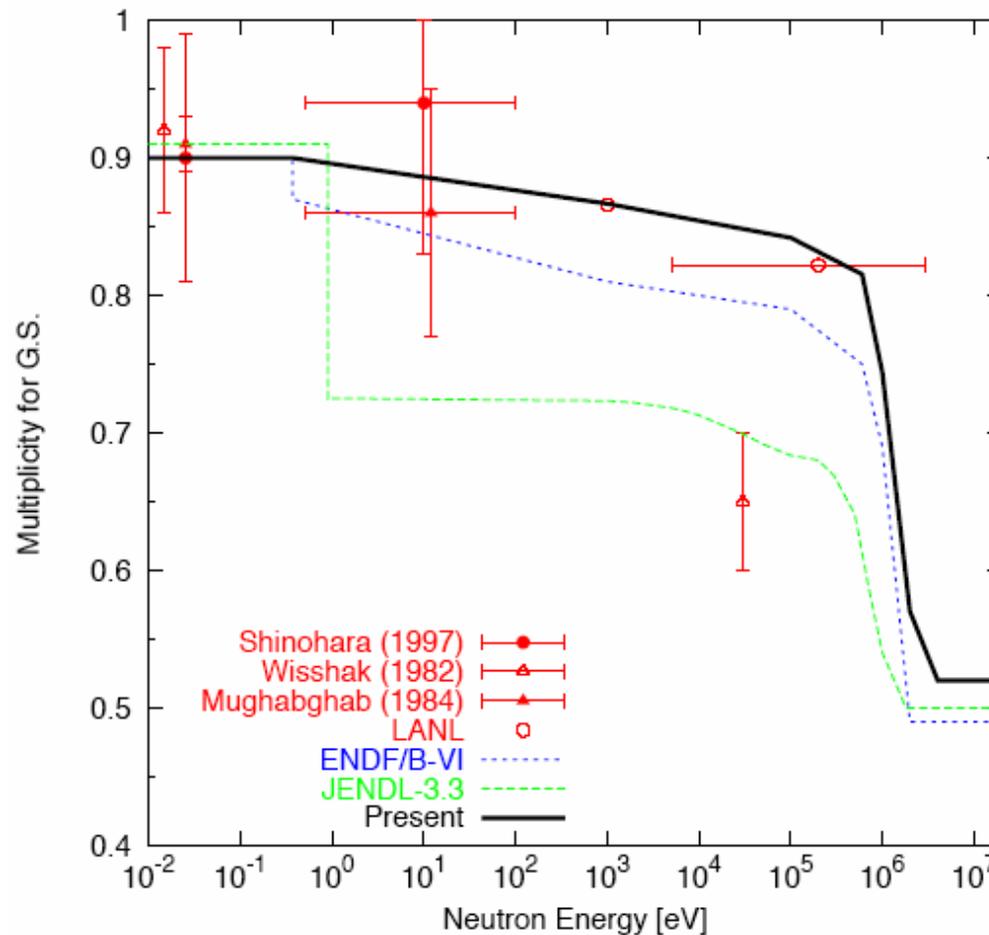
AFCI couples this experimental program with a program to develop improved evaluations

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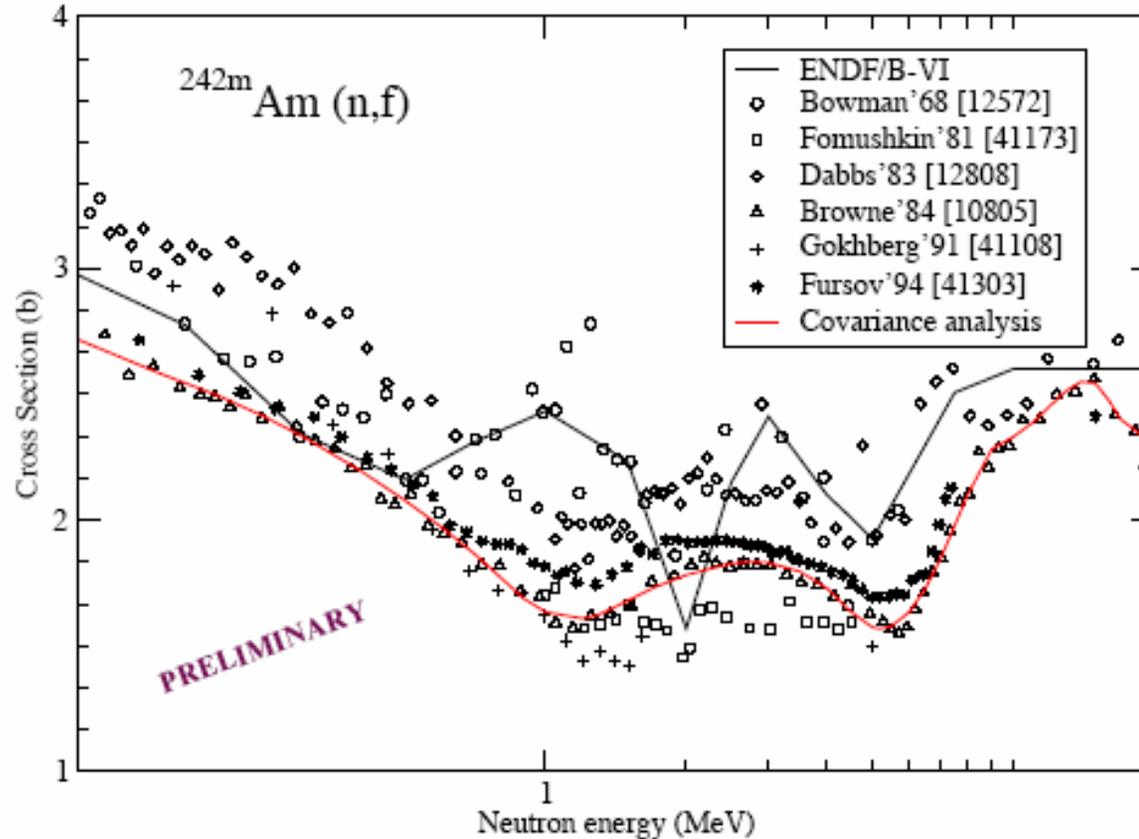


Branching ratio to ^{242}Am ground state



AFCI couples this experimental program with a program to develop improved evaluations

- FY03: completed new ^{241}Am evaluation
- FY04: working on $^{242\text{m}}\text{Am}$ evaluation



AFCI is in the process of establishing collaborative agreements with European colleagues

- **A draft DOE-EURATOM agreement with the Institute for Reference Materials and Measurements (IRMM) at Geel, Belgium for the loan of a double-gridded Frisch chamber for fission measurements**
- **A draft DOE-EUROTRANS agreement under DM5 NUDATRA**



Summary

- **The AFCI has initiated a long-range program to measure capture and fission cross sections of key minor actinides important in the transmutation and GEN IV missions.**
- **Preliminary successes have been achieved recently in measuring the capture and fission cross sections of ^{237}Np .**
- **We welcome collaboration with similar activities worldwide.**

