LANSCE Measurements and Detector Development Update

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Outline

- Introduction
- Los Alamos Neutron Science Center
- Fission activities
- Neutron capture activities
- Neutron output activities
- Conclusions

LANL is funded through FCR&D for nuclear data measurements

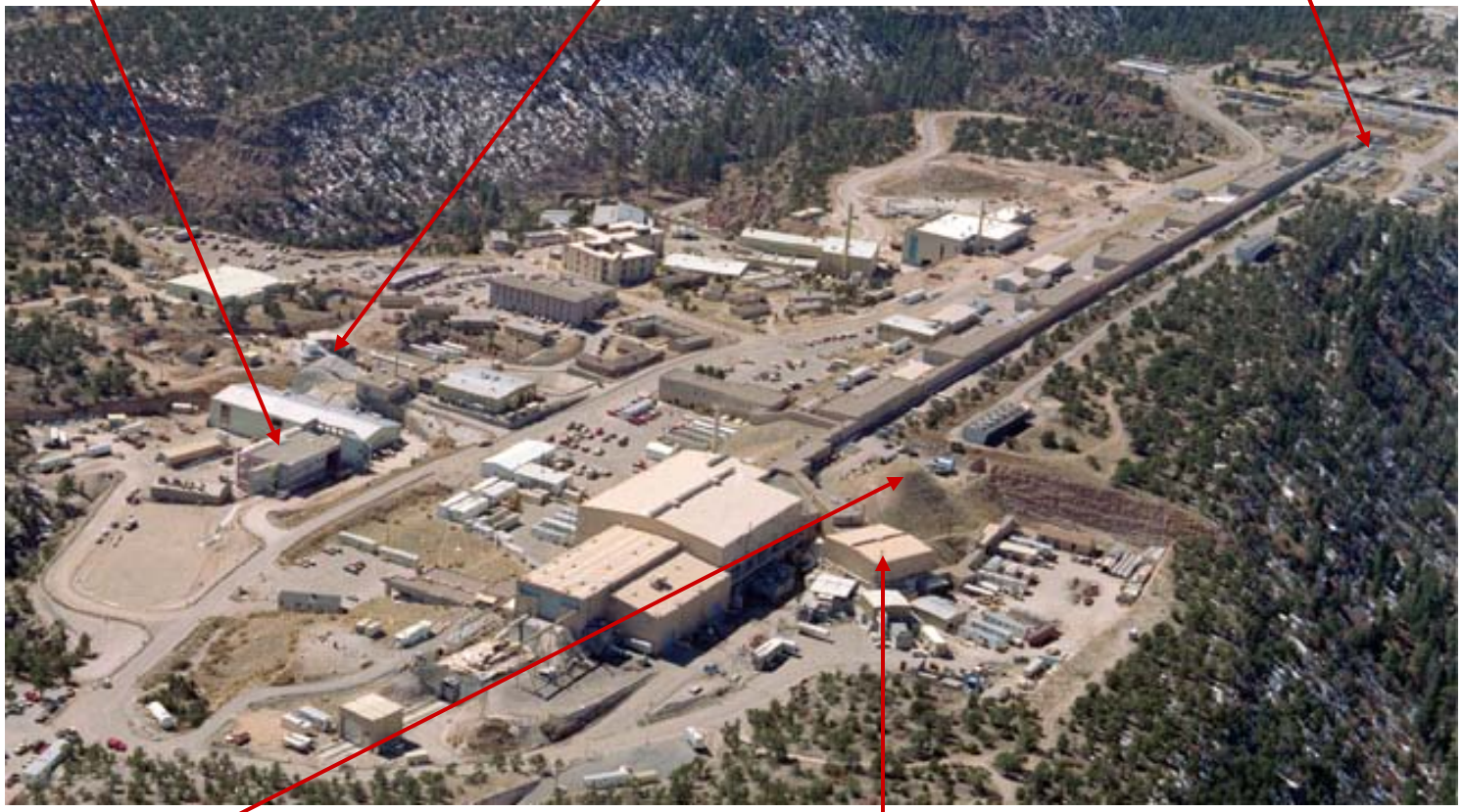
- **Two FCR&D work packages**: measurements and detector development
- **Three research areas**: fission, neutron capture, and neutron output
- **Capture** is studied with the Detector for Advanced Neutron Capture Experiments (DANCE) at the Lujan Center.
  - Incident neutron energies: sub-thermal to ~0.5 MeV
  - High efficiency 4-pi array: measures Q-value, gamma-cascades
- **Fission** is studied with parallel-plate ionization chamber at WNR and Lujan Center.
  - Incident neutron energies: sub-thermal to hundreds of MeV's
  - Parallel plate ionization chambers will be replaced by TPC
- **Neutron output** is measured with the Fission Gamma-Ray Observer (FIGARO) at WNR.
  - Incident neutron energies: 1- 400 MeV
  - Successfully measured the fission neutron spectrum from Pu-239
  - Being upgraded to better cover the low and high end of the fission neutron spectrum. The new instrument is called Chi-nu

The Los Alamos Neutron Science Center (LANSCE)

Lujan Center

Weapons Neutron Research (WNR)

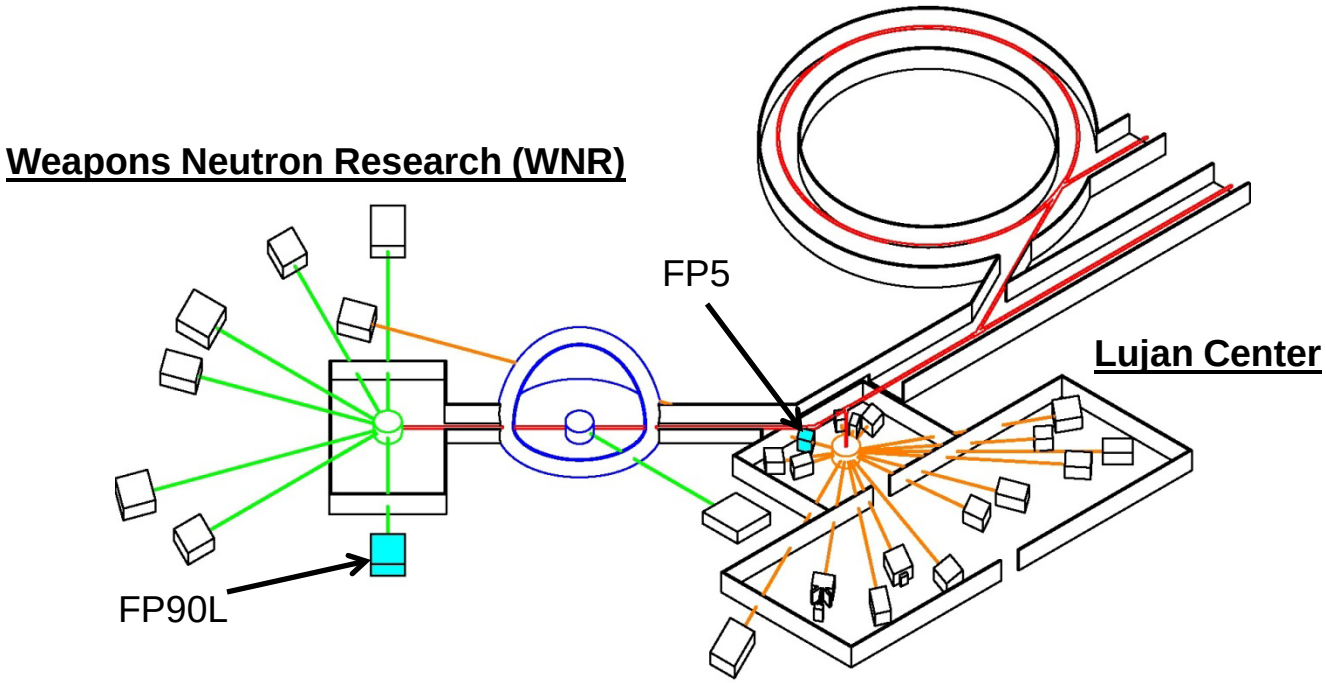
Isotope Production



Proton Radiography

UCN Experiment

Weapons Neutron Research (WNR) and Lujan Center

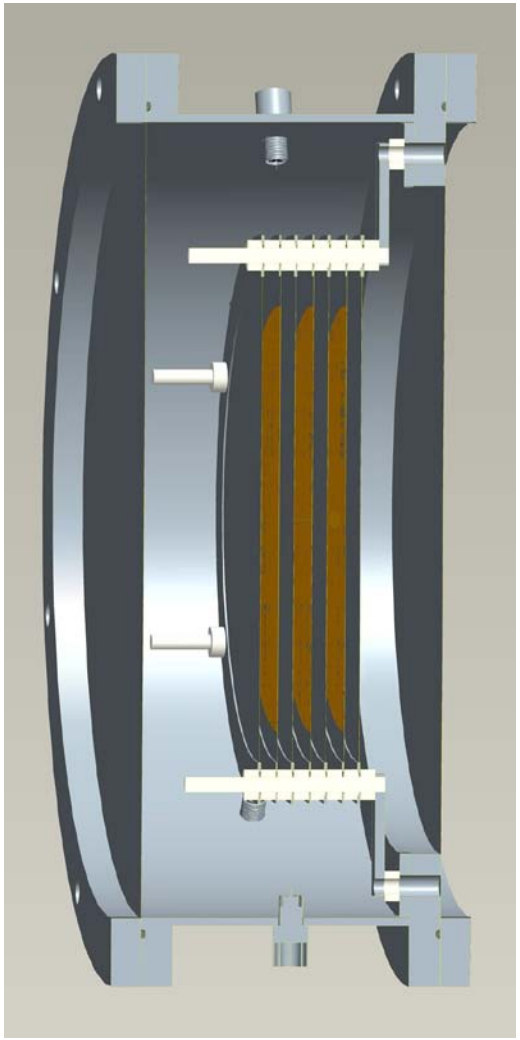


- The 800-MeV proton accelerator at LANSCE produces neutrons through spallation
- Moderated and un-moderated spallation neutron spectra available
- White source – neutron energies measured using time-of-flight
- Lujan Center and WNR cover neutron energies from sub-thermal to hundreds of MeV

The fission program: current status

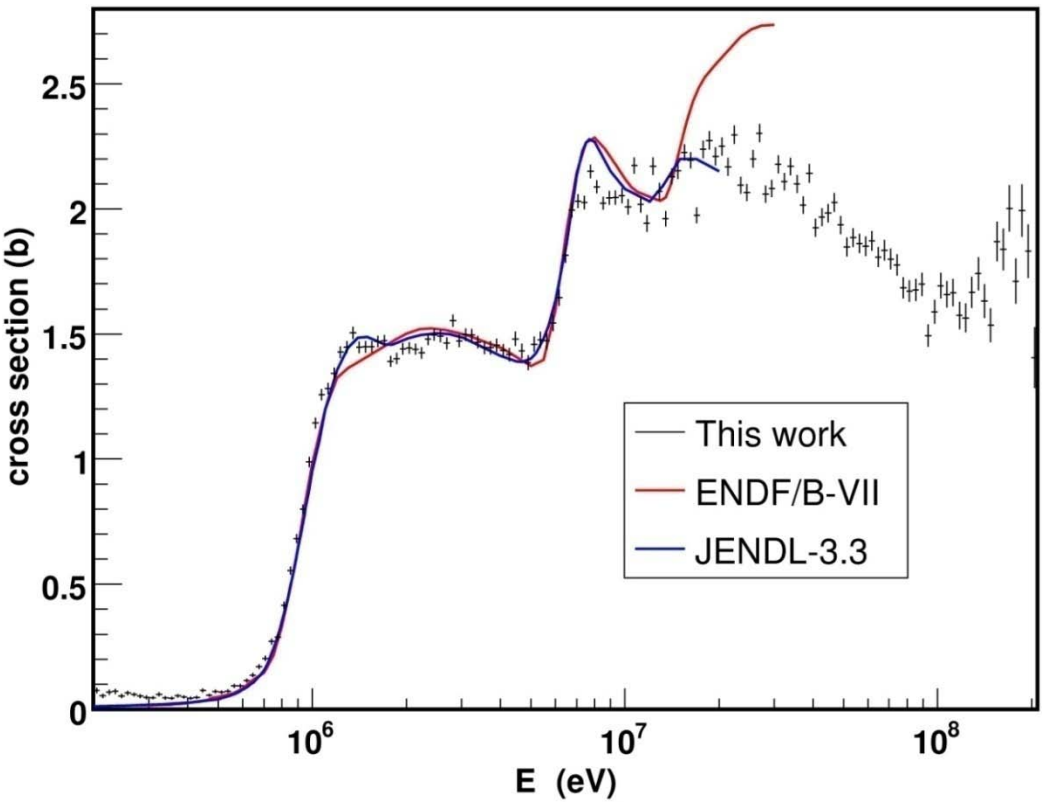
- The Am-243 measurement was improved, uncertainties reduced.
- U-233 and U-238 have been measured, analysis is ongoing. Preliminary results available.
- Facility preparations at LANSCE/WNR for prototype TPC commissioning.
- Proof of principal for new digital DAQ for fission measurements. Full system commissioning planned for FY2011.
- Pulse stacking test was completed. Report was delivered on June 1, meeting level 3 milestone.

Parallel-plate ionization chambers are used for fission detection



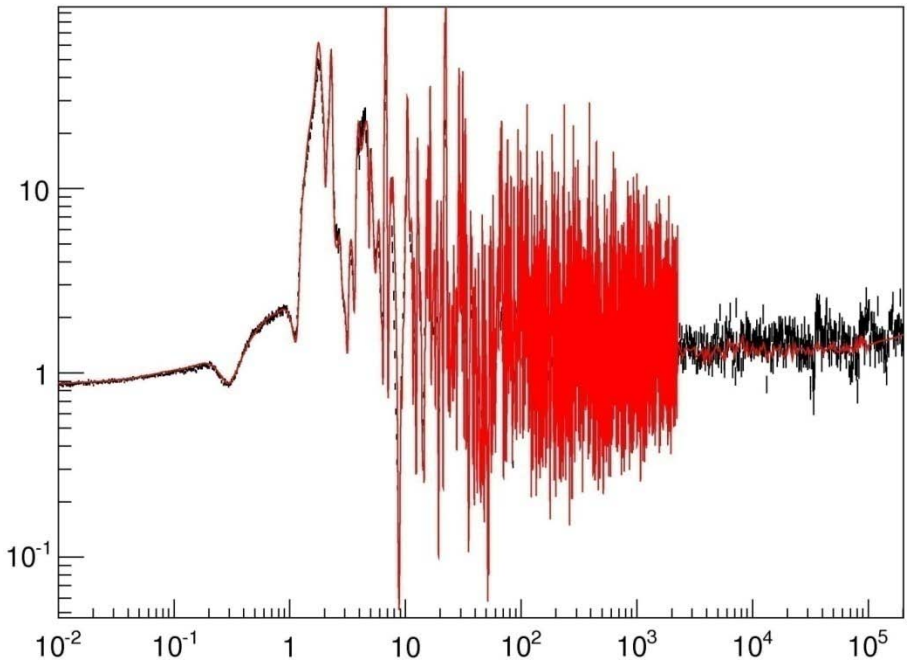
- Parallel-plate ionization chambers are the currently used fission detectors
- High efficiency
- Fast timing properties
- Reasonable fission identification
- Easy to operate and insensitive to radiation damage

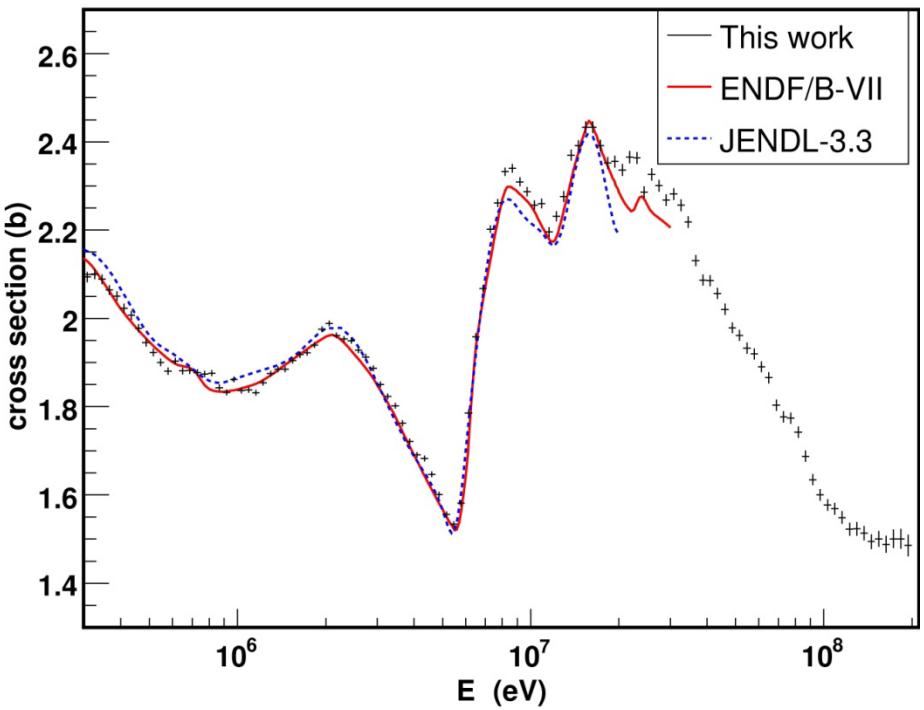
The Am-243 fission cross section shape was recently measured at LANSCE



- **Am-243 (n,f) was measured with target that needs to be characterized. This is a shape measurement at this point. The absolute cross section is of most interest for this isotope.**
- **There is an obvious problem with the ENDF evaluation above ~15 MeV.**

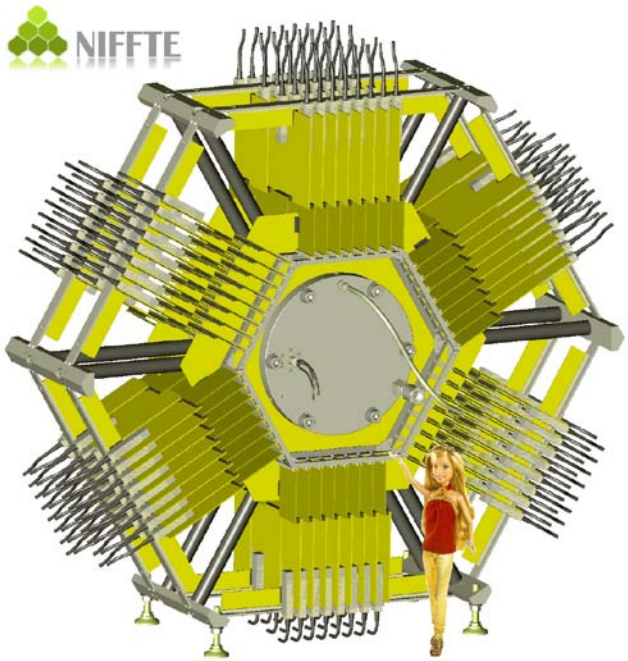
The U-233 neutron induced fission cross section





- **The U-233 fission cross section was measured from sub-thermal to 200 MeV**
- **Current evaluations are accurately representing the data**

The Fission Time Projection Chamber (TPC) will provide cross sections with unprecedented accuracy



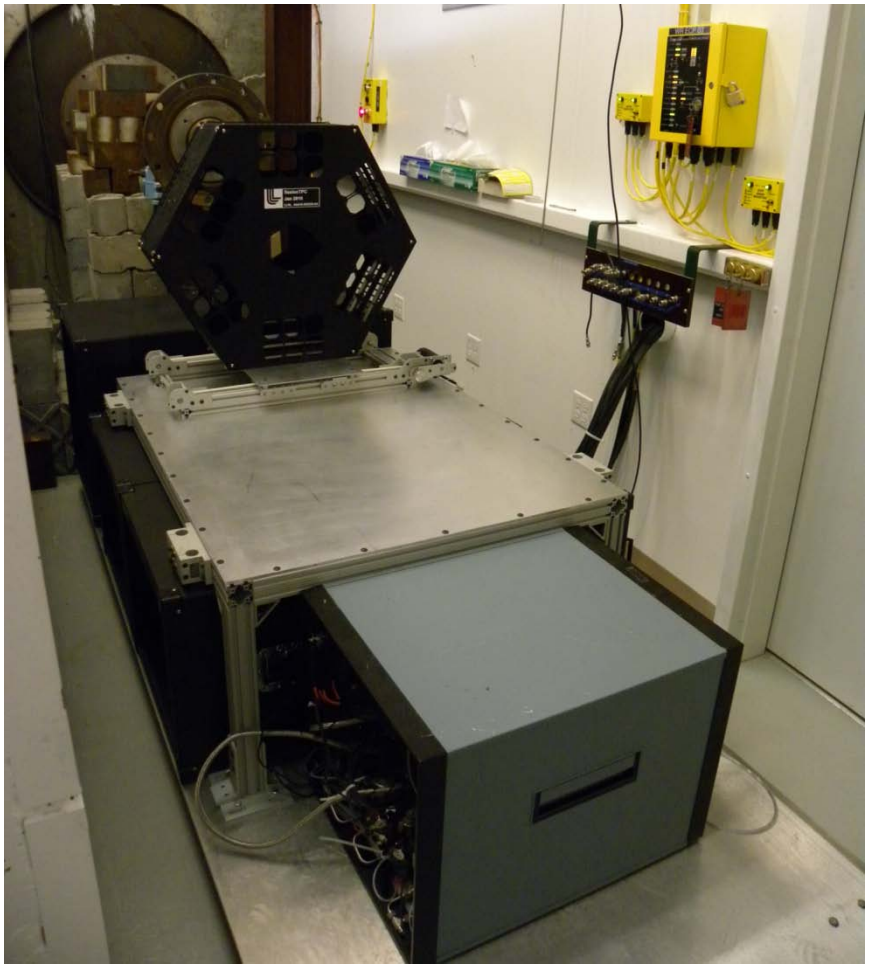
- **3D pictures of the particle tracks**
  - sample uniformity
  - beam uniformity
  - efficiency
  - erases decay / light charged-particle background
- **"Absolute" fission cross sections**
- **Fission studies**

NERI-C is funding 6 participating universities (FY8-10)
- **Abilene Christian University** (*Rusty Towell, Donald Isenhower*)
- **Cal Poly San Luis Obispo** (*Jenn Klay*)
- **Colorado School of Mines** (*Uwe Greife*)
- **Georgia Tech (PI)** (*Nolan Hertel, Eric Burgett*)
- **Ohio University** (*Tom Massey, Steve Grimes*)
- **Oregon State** (*Walt Loveland*)

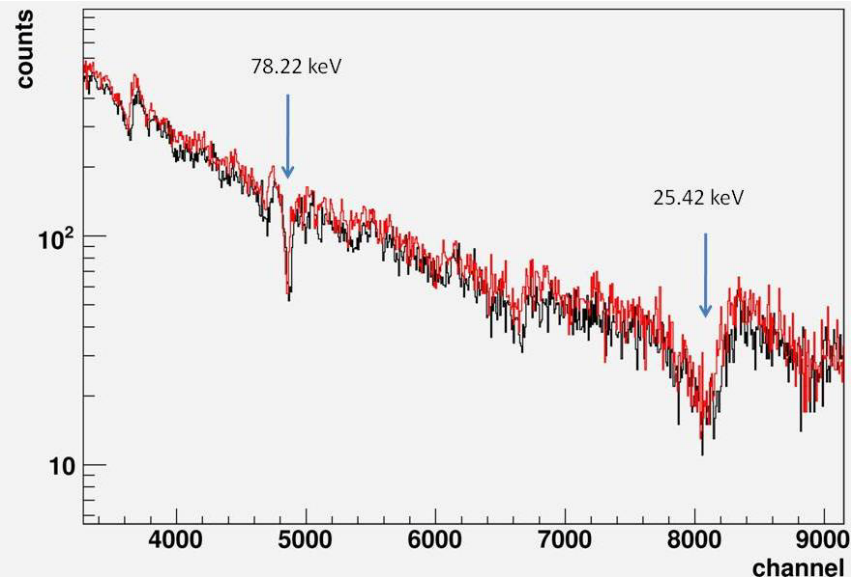
FCR&D & NNSA provides lab funding
– **Lawrence Livermore National Laboratory** (*Mike Heffner*)
– **Los Alamos National Laboratory** (*Fredrik Tovesson*)
– **Idaho National Laboratory** (*Tony Hill, Chris McGrath*)

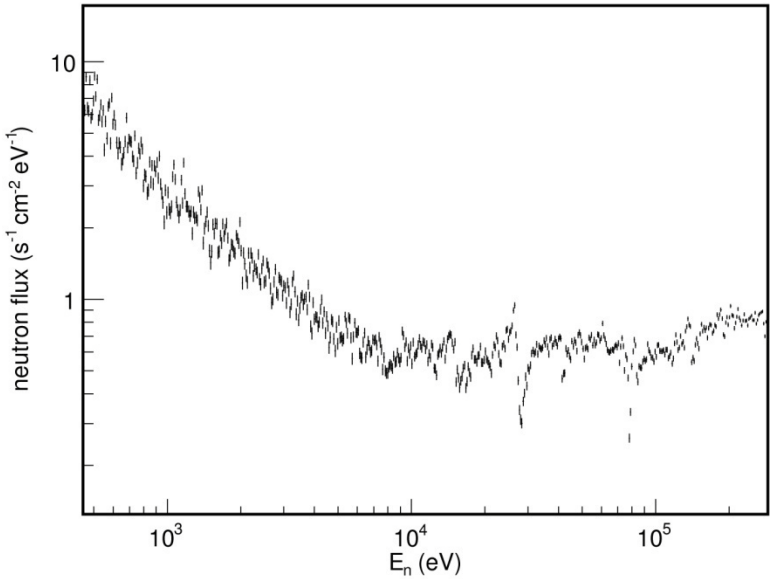
The necessary preparations at LANSCE for the TPC commissioning have been made

- The TPC stand was constructed. Positioning table is being assembled.
- Gas handling system (designed and built by CSM) installed on flight path.
- Gas delivery system installed.
- Clean bench installed in lab for TPC operations
- Feasibility of using BioSafety cabinet for radioactive sample loading was investigated. This type of bench will likely be used.
- Summer students are working on slow control, positioning table remote control.



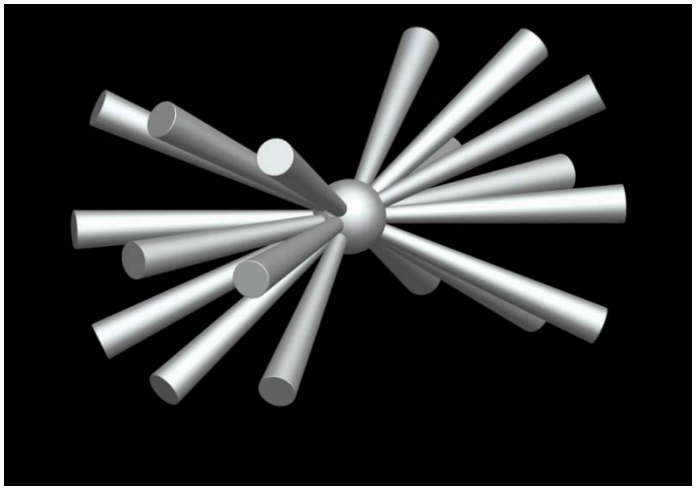
Analysis of pulse stacking tests from 2009 was completed

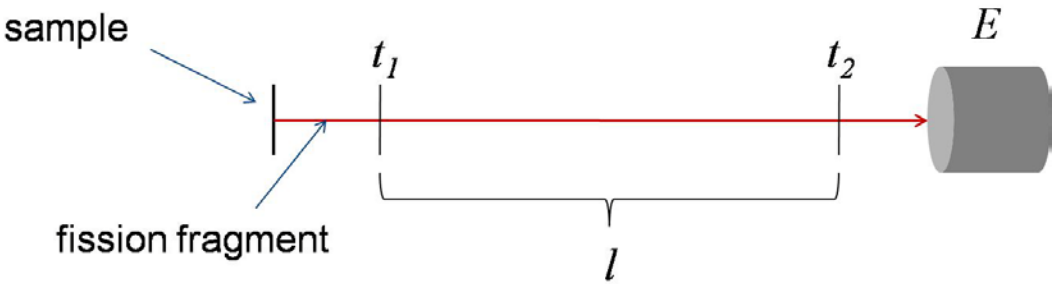




- A 0.5% energy resolution was observed by fitting resonances in the 550-650 eV region, close to the calculated resolution of 0.4%
- Room background was shown to dominate the measurement below 10 keV
- The gamma flash causes significant ionization in the chambers at these high instantaneous proton currents

Spectrometer for ion detection in fission experiments (SPIDER)





- Fission product yields vs. neutron energy is important for defense applications, possibly for advanced reactors.
- A spectrometer based on the 2E-2v method could provide this data with ~1 amu resolution
- Approach was successfully demonstrated in the 80's at the ILL reactor, but no data exists for fast neutrons.

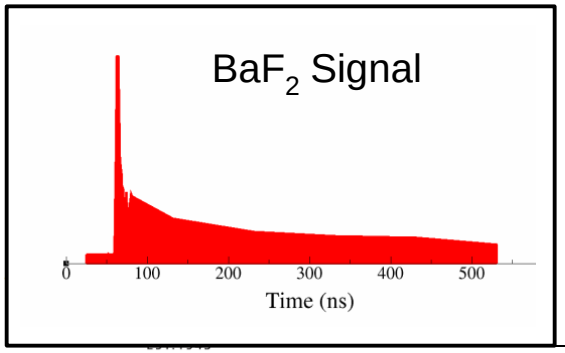
The Detector for Advanced Neutron Capture Experiments (DANCE)

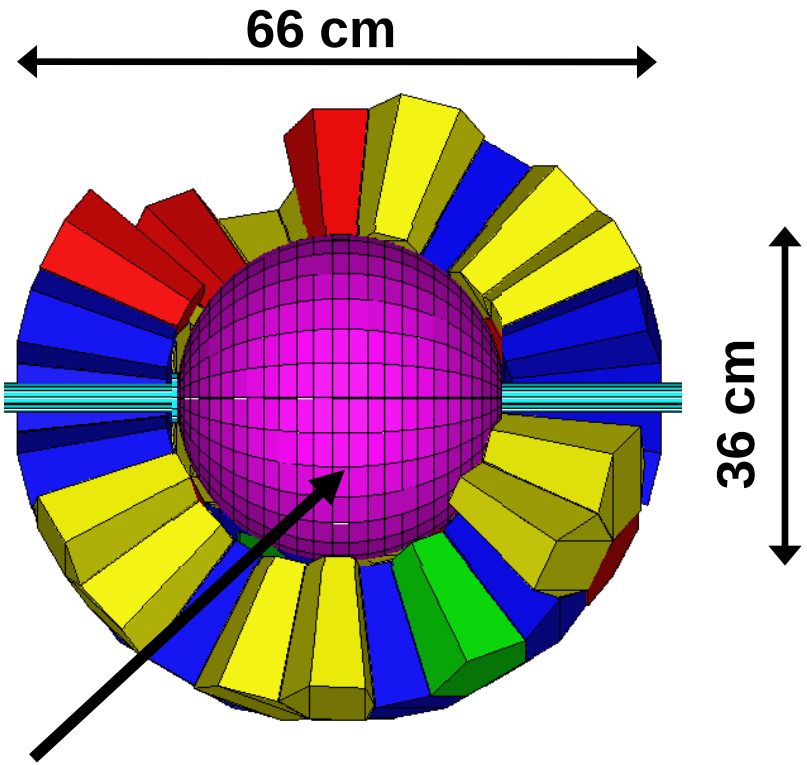
160 BaF_2 Scintillators

4 Detector Shapes each covering the same solid angle

$\varepsilon_{\text{clock}} \approx 90\ \%$

$\varepsilon_{casc} \approx 98\ \%$





^{6}LiH Shell Surrounds Sample (6 cm)

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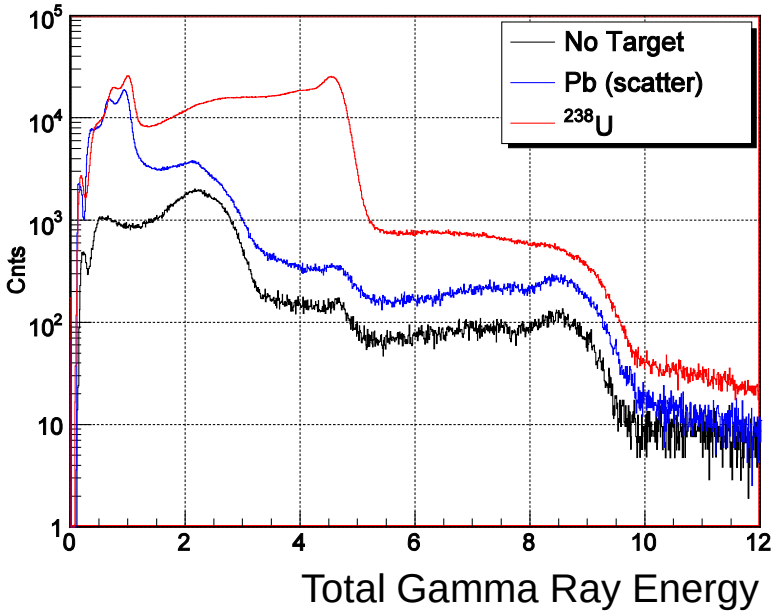
- For details see: Heil *et al*, NIM A 459 (2001) 229-246

Total Gamma Energy Discriminates based on Q-Value

10 eV < E_n < 100 eV M>=2



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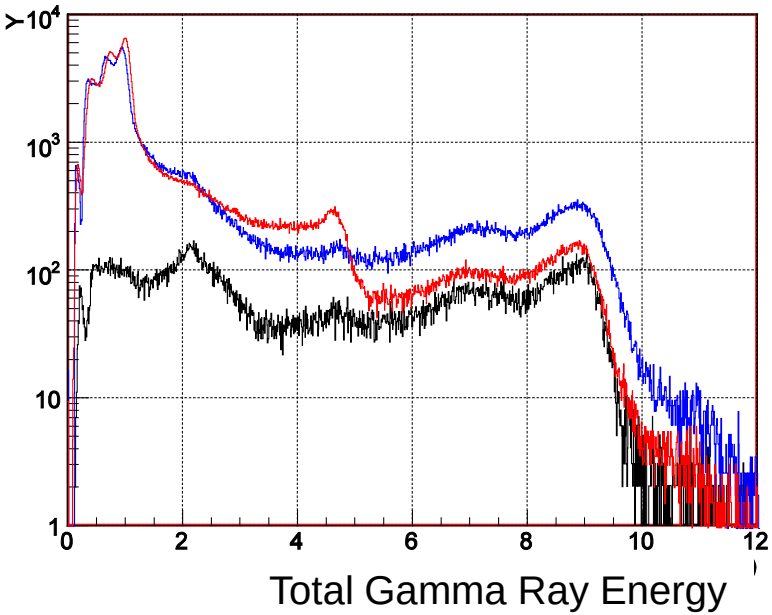
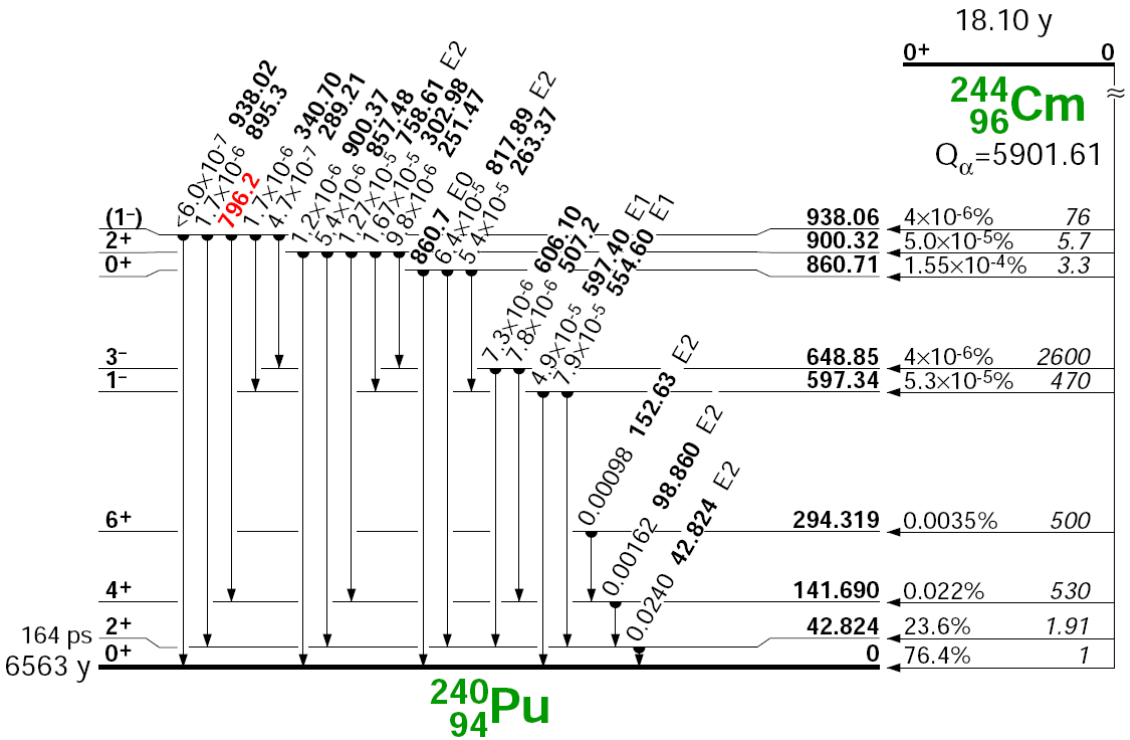


The Sensitivity of DANCE to Radiogenic Decays are being Studied

A 1 mg sample of ^{244}Cm has an activity of 80 mCi, or 3x10^{9} decays/s.

Simulations were performed to estimate the response of DANCE to the decays.

Background rates of up to 10^{7}/s are tolerable

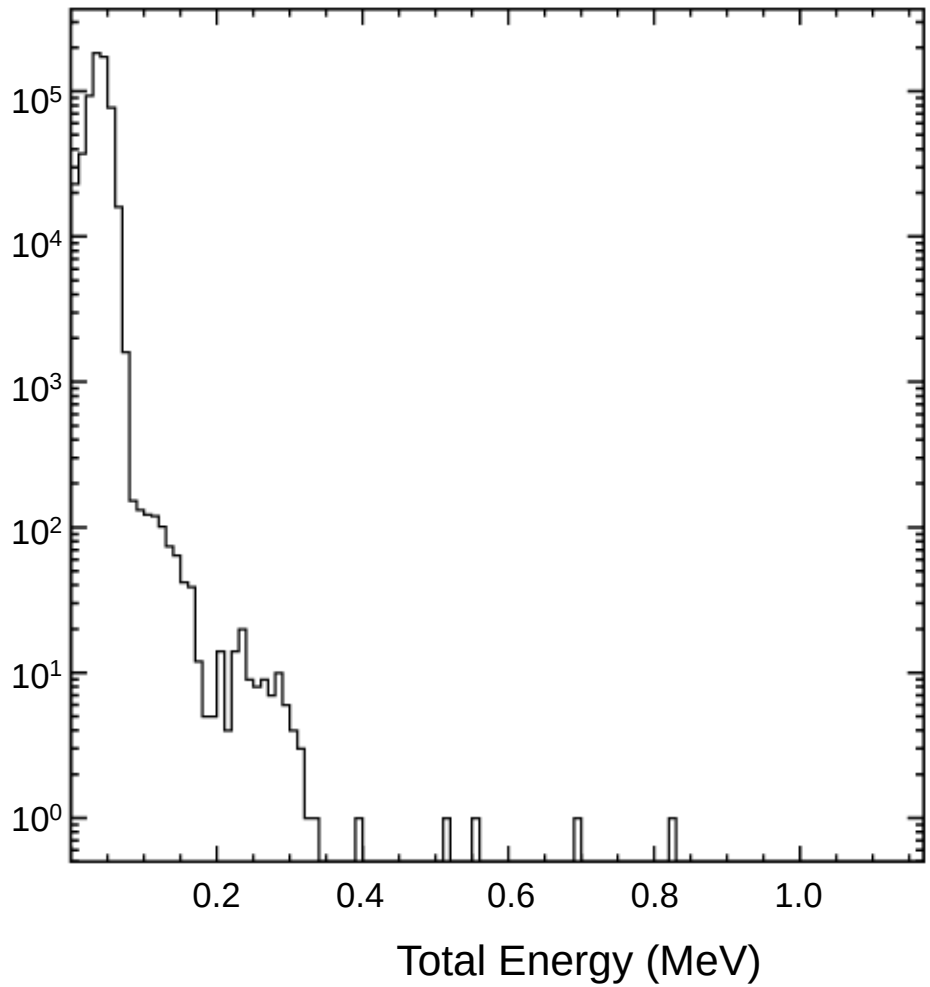


Simulations of ^{244}Cm in DANCE

5×10^6 decays were simulated.

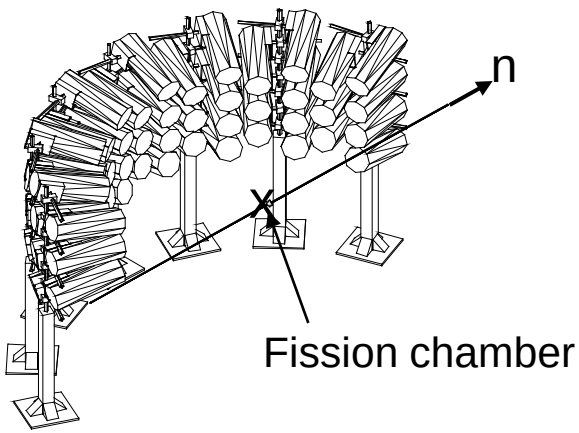
A sample of up to 1.4 mg could be used with 0 threshold. With a more reasonable 100 keV threshold, a 2.2 g sample is tolerable.

Simulations for all actinides and long lived ($t_{1/2} > 1$ d) are underway



Chi-Nu array of fast neutron detectors detects the fission neutrons

Chi-Nu (n,xn+γ)



22.7 m from
WNR source

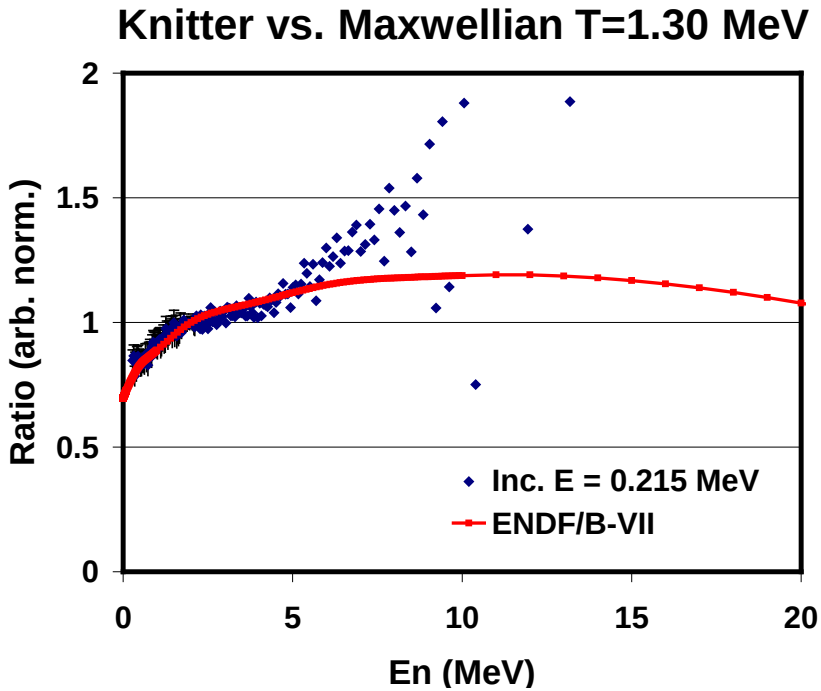
20 liquid scintillator neutron detectors

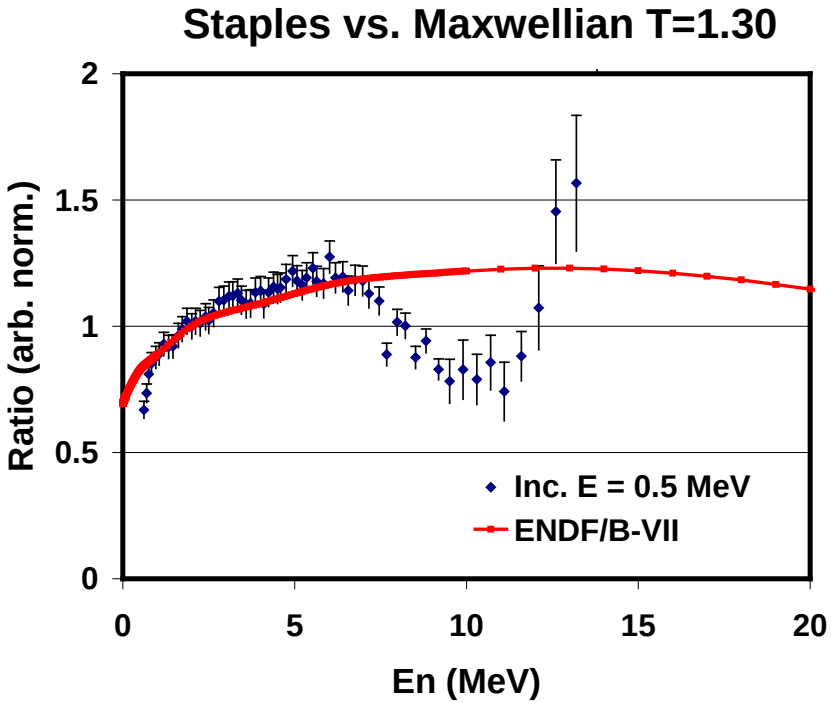
2 gamma-ray detectors

Double time-of-flight experiment

Previous data on fission neutron spectra are inconsistent (and also very incomplete)

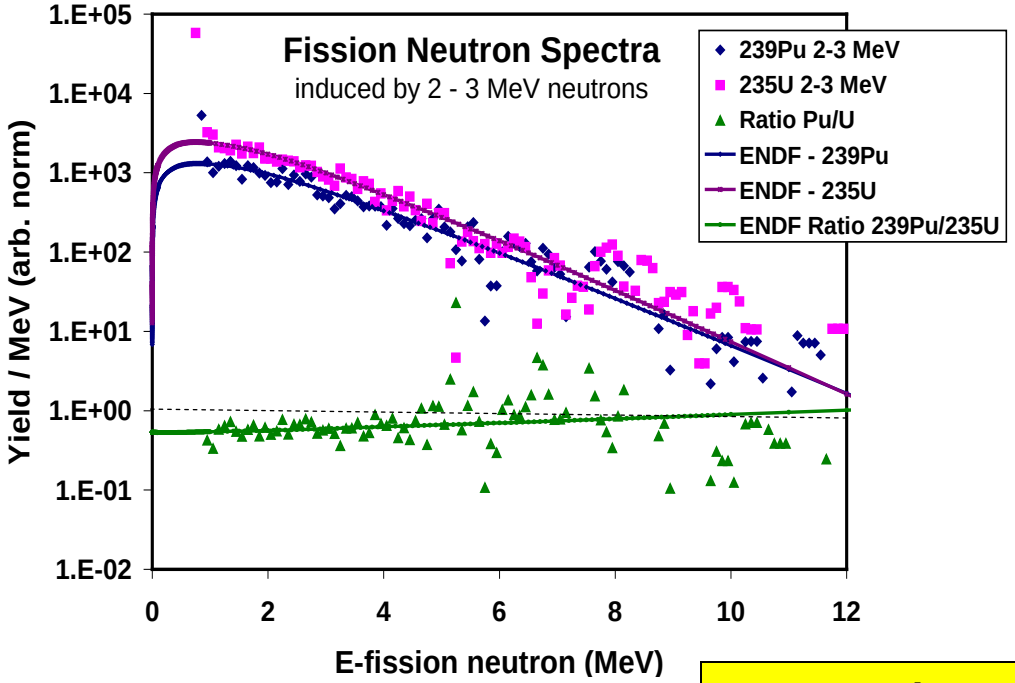
^{239}Pu(n,f)





We measure the shapes of fission neutron spectra and ratios of spectra for $^{235}U(n,f)$ and ^{239}Pu (n,f)

Example: Incident E_n = 2 to 3 MeV

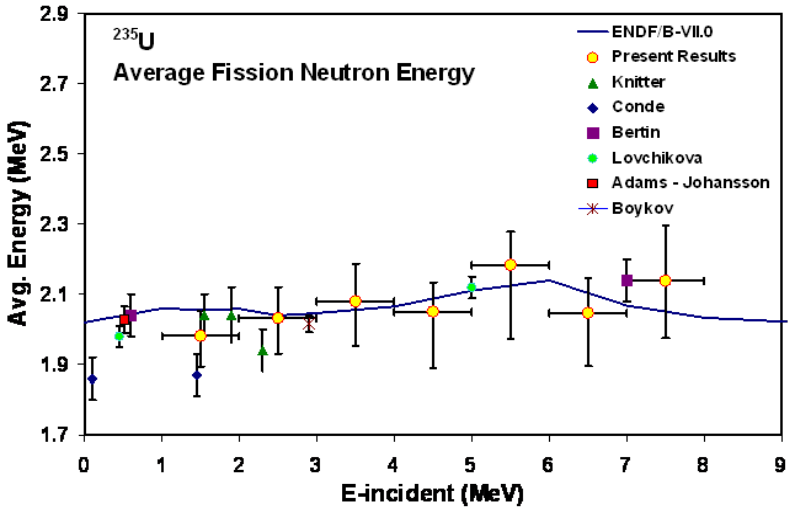


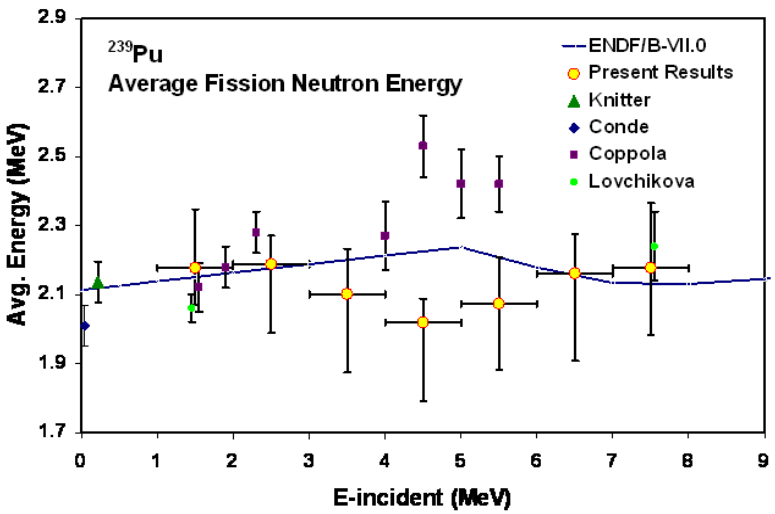
Spectra show no significant difference from ENDF in 1-7 MeV region.. But..

Measurements of spectra below ~1 MeV and better measurements above 6 MeV emitted neutron energy are necessary!

Recent progress - publication

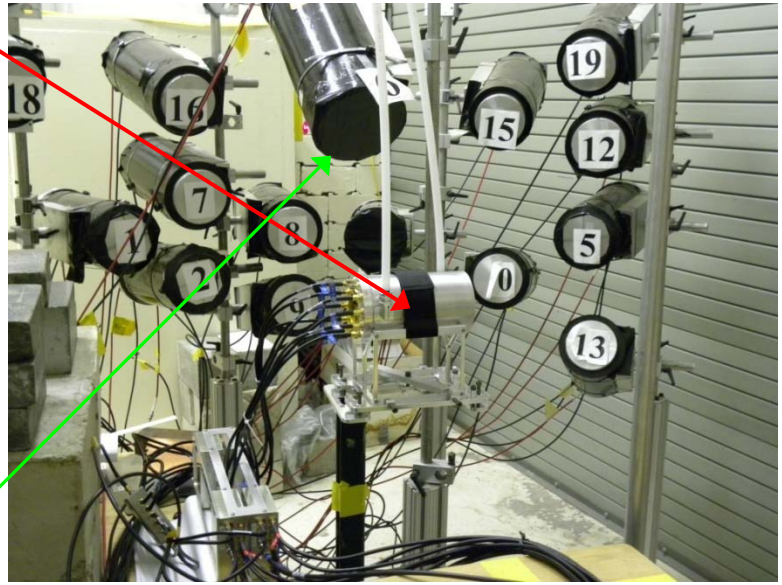
- **Article submitted to Physical Review C**
  - LA-UR-10-03762
  - Spectral data fitted by Los Alamos model with adjusted Total Kinetic Energy
  - Average fission energies reported and compared with literature results

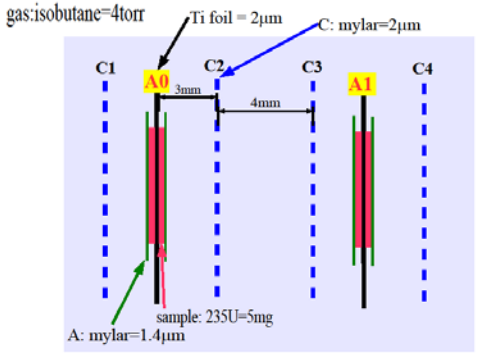




Present experimental progress

- **New fission chamber from LLNL**
  - 112 mg of ^{235}U on 10 double-sided Parallel Plate Avalanche Counters (PPAC)
  - Thin backing foils → less neutron scattering unrelated to fission
  - Lower mass of chamber body (less multiple scattering correction)
- **^{6}Li-glass detectors soon to be deployed for fission neutrons below 1 MeV.**
  - One is installed in this picture
- **LANSCE beam is up and running**
  - (since June 15)





Future directions for this Fiscal Year

- **Take data on 235U(n,f) fission neutrons**
- **Develop prototype data acquisition with waveform digitizers (first units being purchased now)**
- **Develop concepts to increase number of organic scintillators for neutron detection**
- **Implement several ^{6}Li-glass detectors for fission neutrons below 1 MeV**
- **Design detectors (such as those above) for neutron inelastic scattering experiments**

Conclusions

- **Active measurement program for fission, capture and neutron output**
- **The Time Projection Chamber will reduce uncertainties in fission cross section measurements**
- **Feasibility study to determine which isotopes can be measured at DANSCE is ongoing**
- **The new Chi-Nu instrument will better cover full energy range of fission neutrons**