Nuclear Data Measurements at LANSCE

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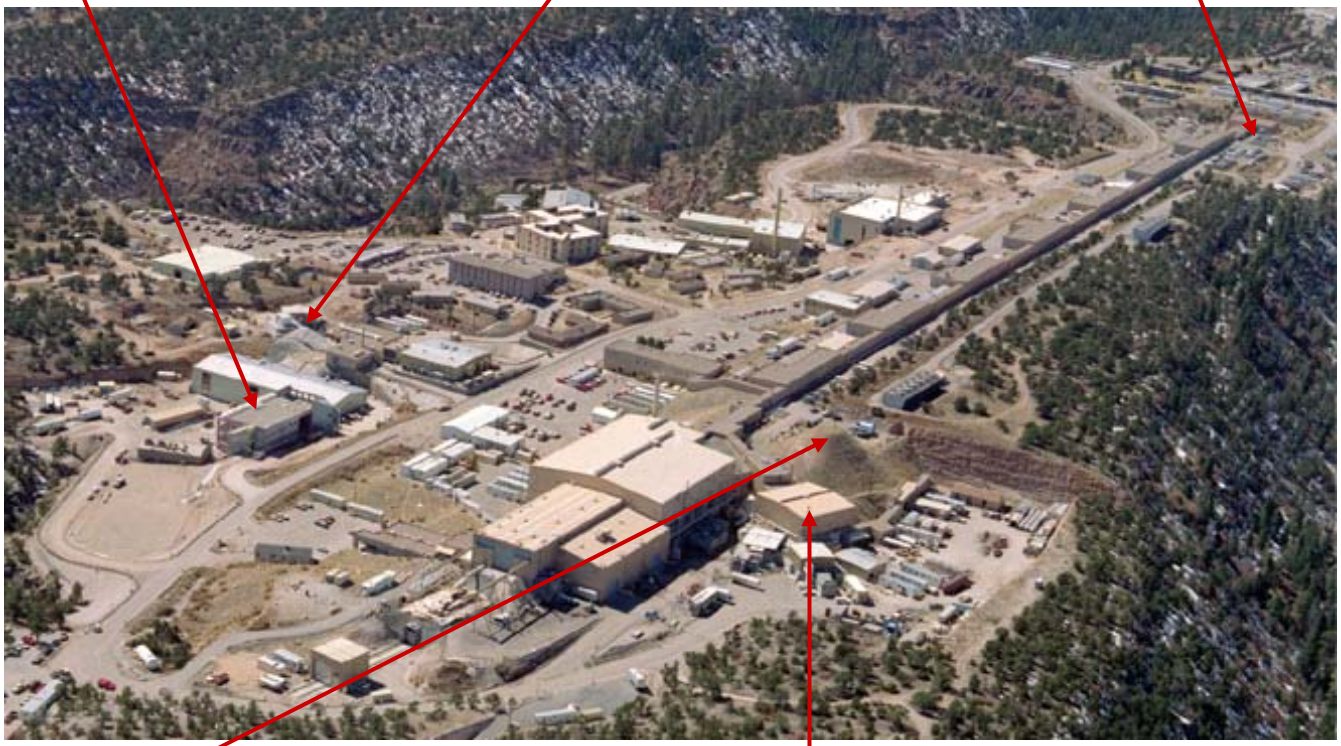
Introduction

- **Nuclear data measurements at LANSCE support nuclear energy, the weapons program and basic science**
- **Fission cross sections are measured from thermal energies to 200 MeV using fission chambers**
- **Neutron capture is studied with the Detector for Advanced Neutron Capture Experiments (DANCE) at the Lujan Center from sub-thermal to ~0.5 MeV**
- **Neutron output is measured with the Chi-Nu detector at WNR.**

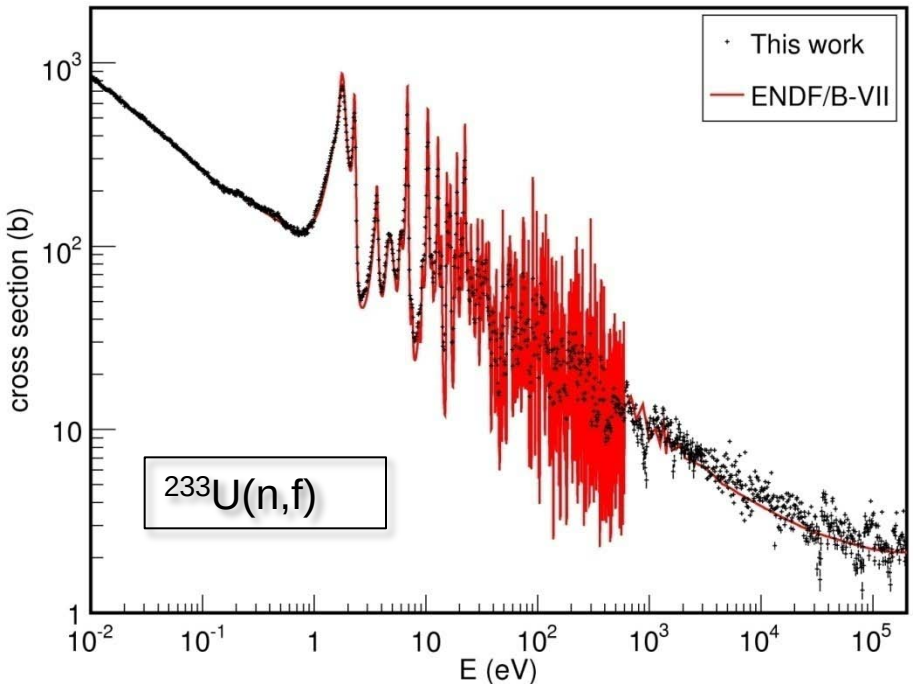
The Los Alamos Neutron Science Center (LANSCE)

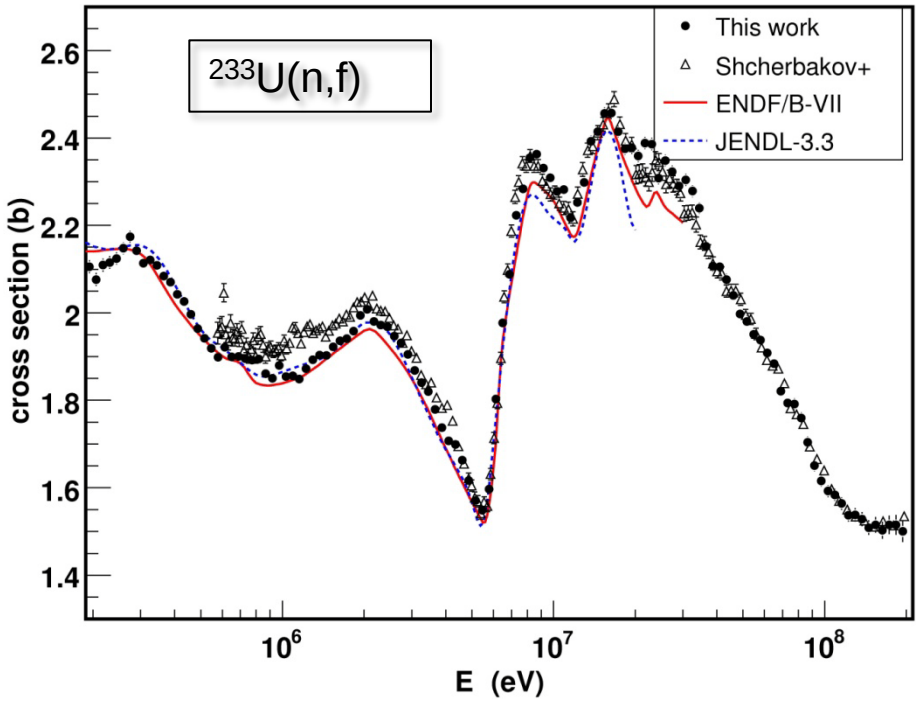


The fission program

- **U-233 and U-238 measurements completed, delivered to evaluators.**
- **Facility preparations at LANSCE/WNR for prototype TPC commissioning completed.**
- **Beam experiments with prototype TPC at LANSCE are in progress.**
- **Proof of principal for new digital DAQ for fission measurements. Full system commissioning planned for FY2011.**

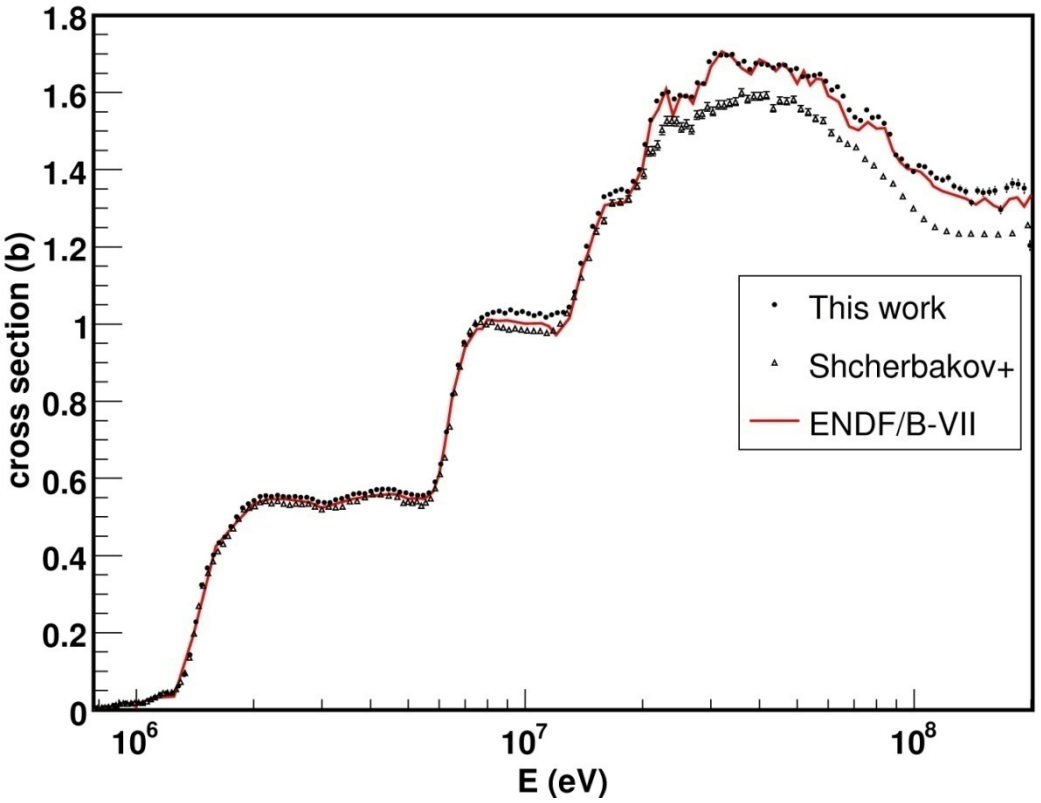
The U-233(n,f) cross section measurement is finalized





- **The neutron energies below 200 keV are measured at Lujan Center. Structures in the unresolved resonance region observed, missing from the evaluation.**
- **The data set extends to 200 MeV. The only other measurement extending beyond 20 MeV is from PNPI (Shcherbakov et al.)**

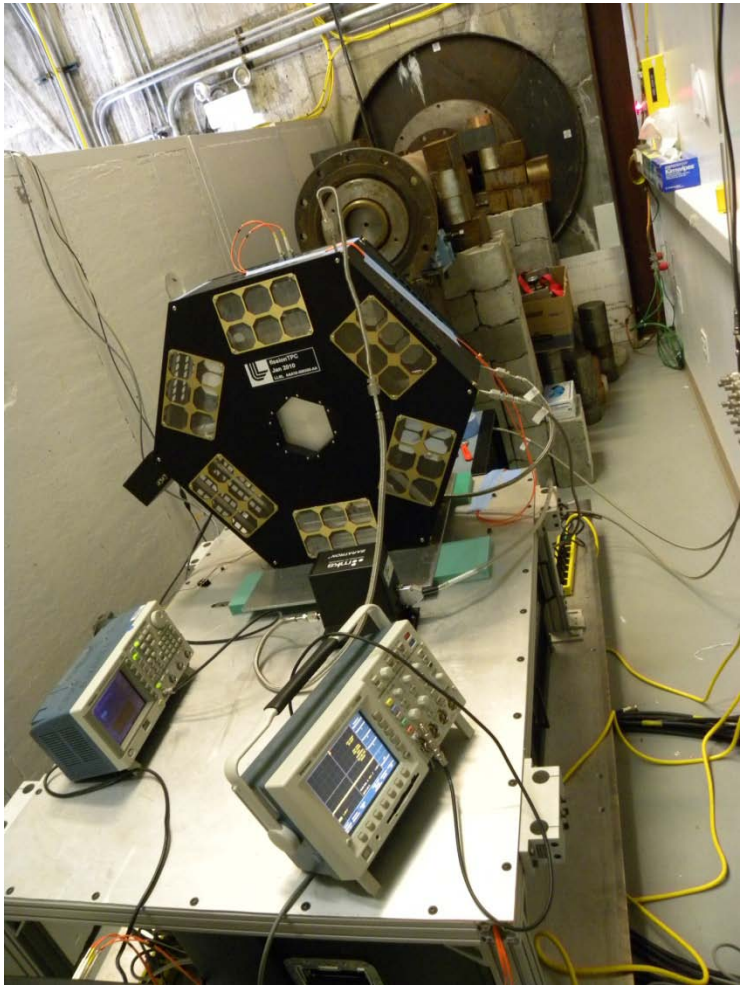
The U-238 (n,f) cross section was measured from 0.2 to 200 MeV



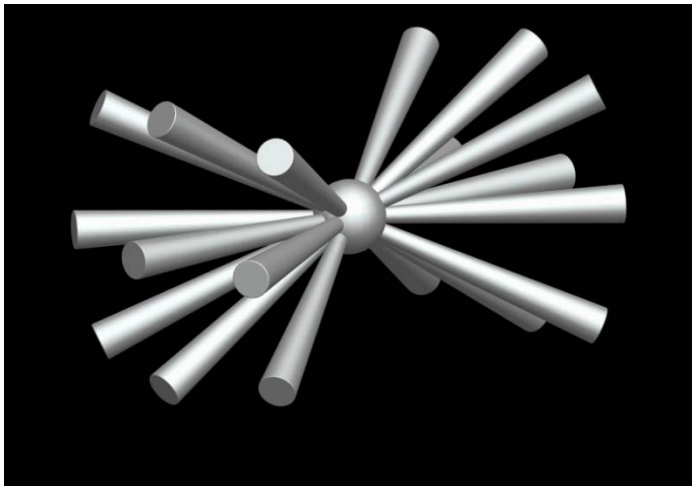
- U-238 (n,f) is a standard up to 200 MeV. The standard evaluation above 20 MeV is mainly based on one experimental data set (Lisowski et al.)
- The new data agrees with Lisowski, and does not support the lower cross section measured by Shcherbakov et al.

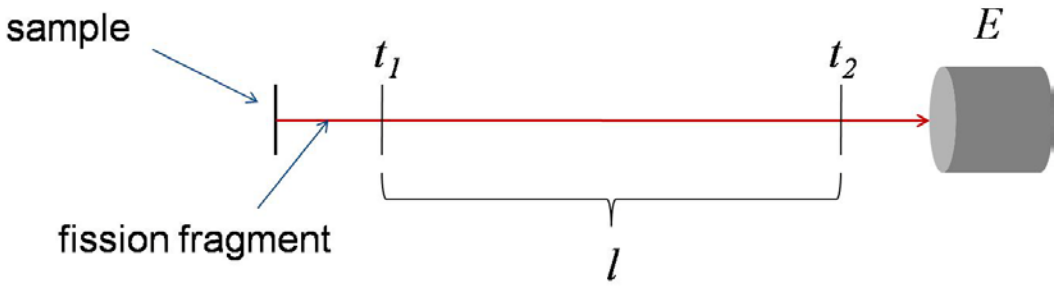
The prototype TPC was delivered to LANL late July

- The prototype was loaded with a thin carbon backing for the initial beam tests
- Beam tests provide noise levels, gains, first beam-induced tracks
- The prototype has two preamp cards and digital cars, allowing 64 channels to be read out



Spectrometer for ion detection in fission experiments (SPIDER)





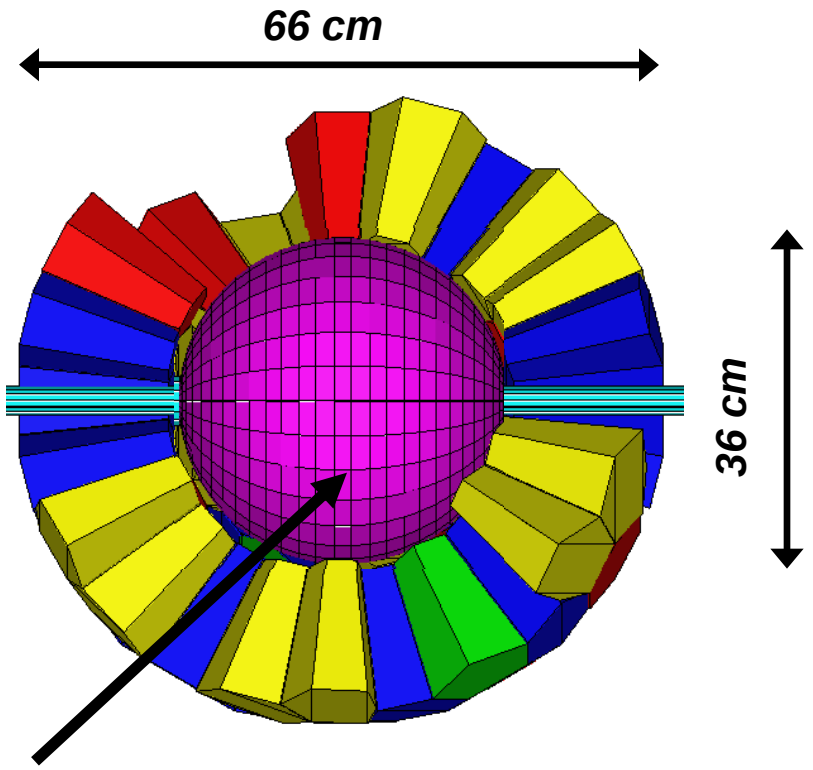
- **Fission product yields vs. neutron energy is important for defense applications, possibly for advanced reactors.**
- **A spectrometer based on the 2E-2v method could provide this data with ~1 amu resolution**
- **Approach was successfully demonstrated in the 80's at the ILL reactor, but no data exists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

The neutron capture program

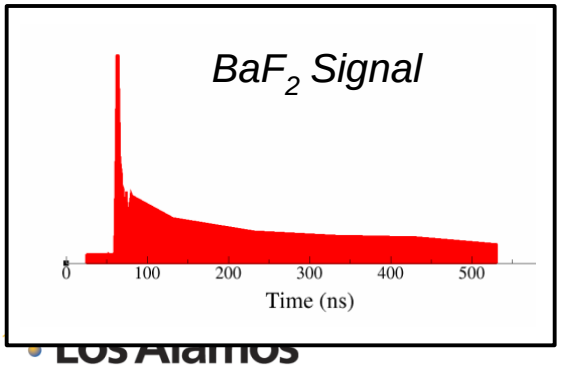
- A Pu-239 target was delivered and acceptance tested.
- Preliminary data on the capture cross section of Pu-239 was collected.
- Preliminary data on the capture cross section of U-238 was collected.
- A newly designed parallel plate avalanche counter (PPAC) for fission triggering was delivered. The complete characterization of the PPAC is ongoing, and the completion was delayed into FY11.
- A feasibility study on measuring highly active samples at DANCE was completed.

The Detector for Advanced Neutron Capture Experiments (DANCE)

160 BaF_2 Scintillators
4 Detector Shapes each covering the same solid angle
$\varepsilon_\gamma \approx 90$ %
$\varepsilon_{casc} \approx 98$ %

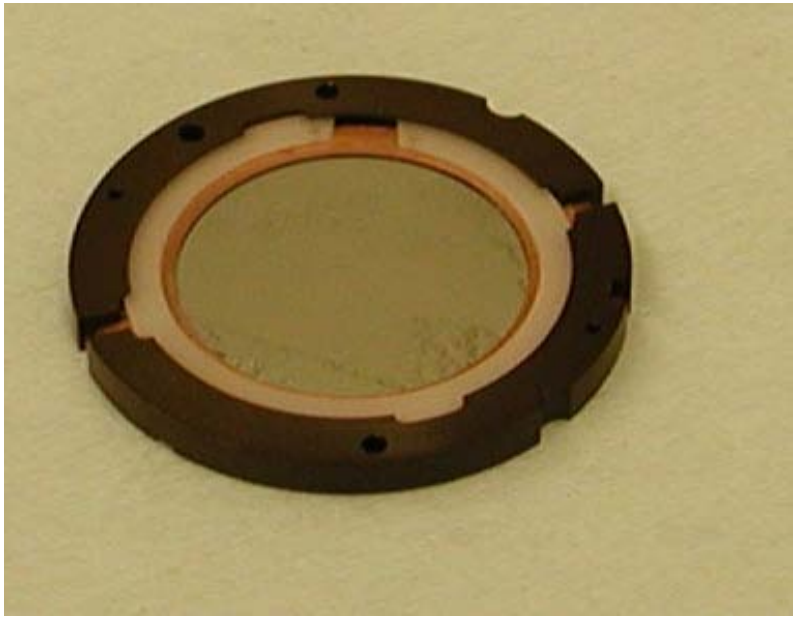


^{6}LiH Shell Surrounds Sample (6 cm)



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

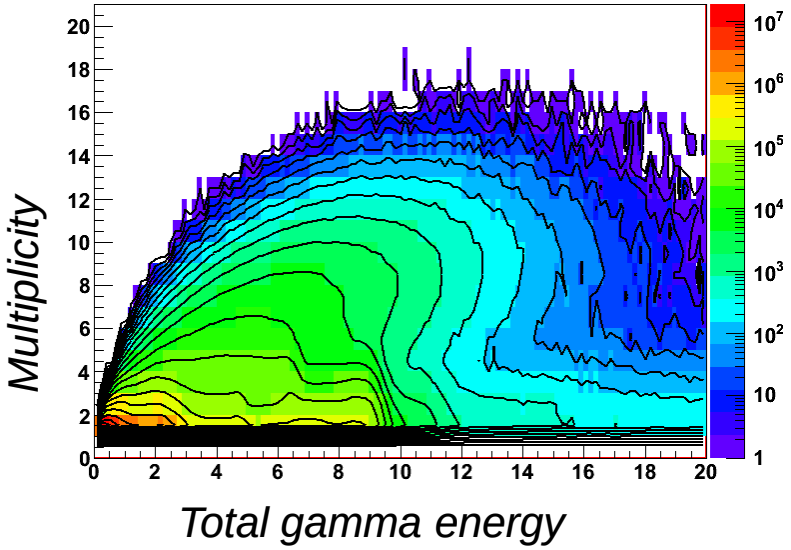
Fission triggering is required for measuring capture in fissile target



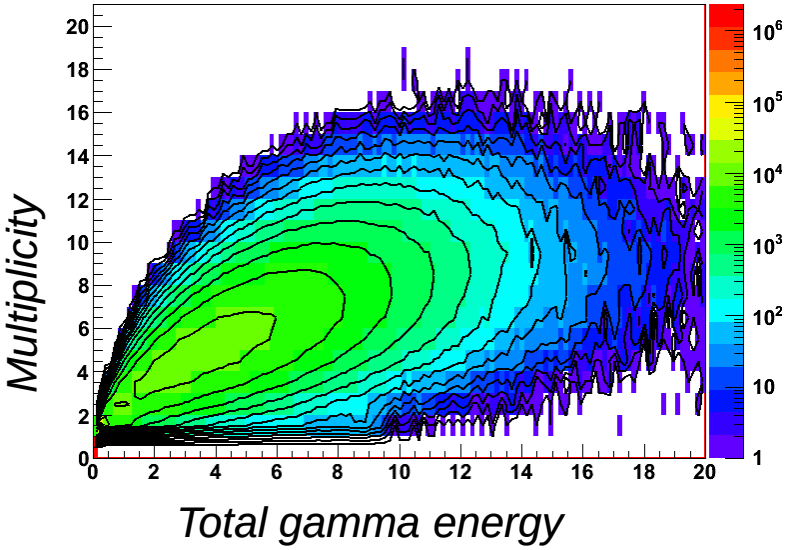
- The fissile sample is loaded into the PPAC, which in turn is inserted into DANCE
- By triggering on fission the DANCE response to fission is measured, and the capture cross section can be measured by subtracting off the fission events

DANCE Gamma-ray Spectrum from fission can be identified with Fission Tagger

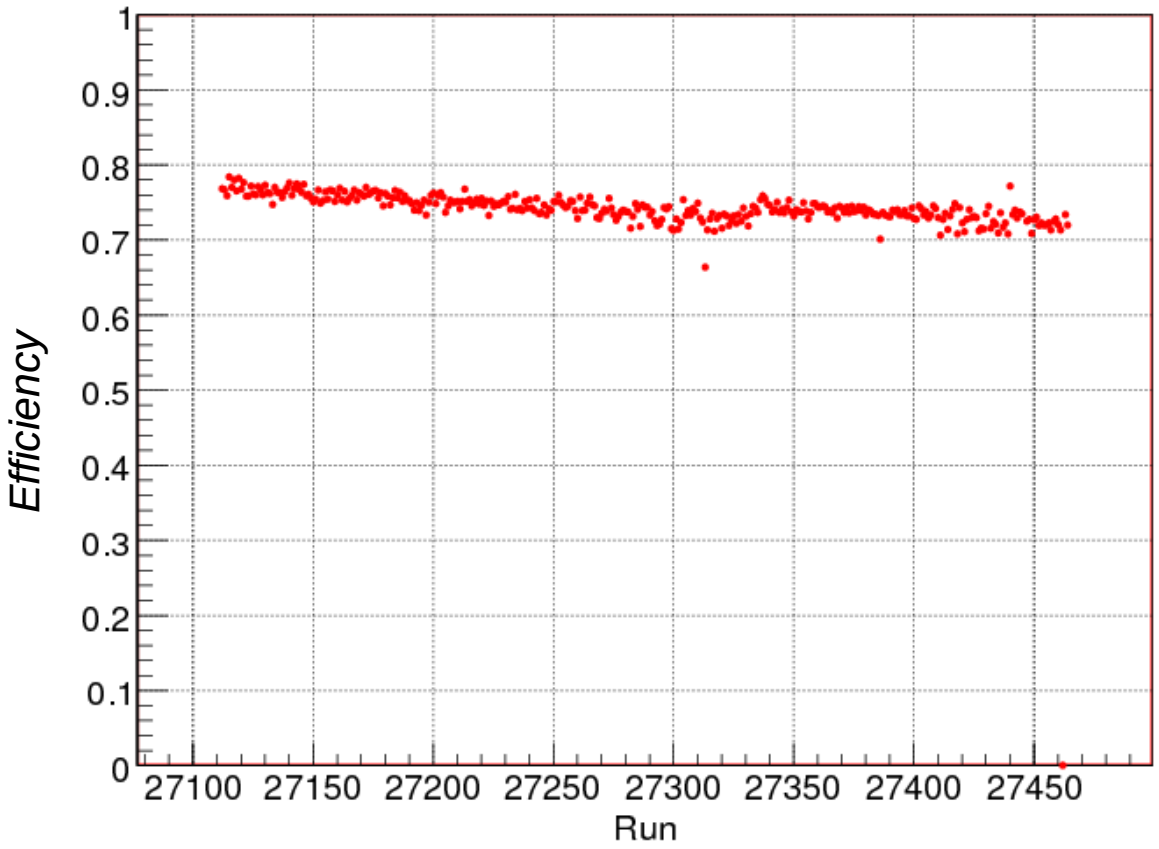
Raw DANCE gammas



Fission-gated DANCE gammas



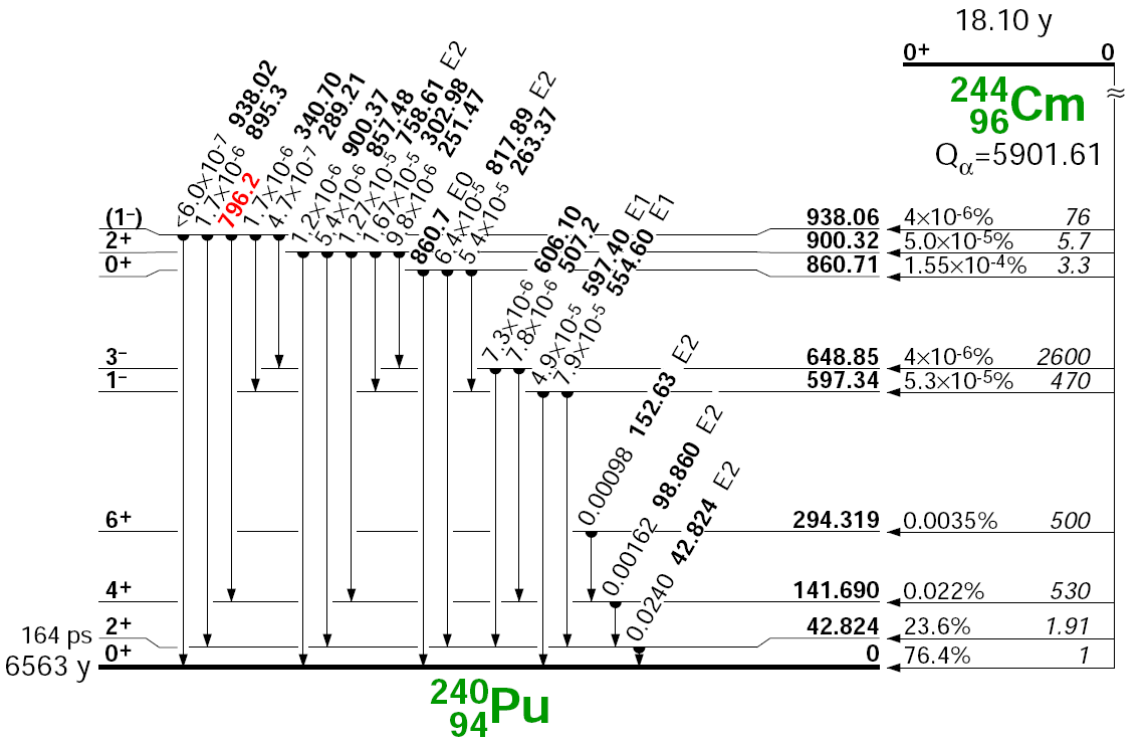
PPAC Efficiency



- **Some degradation over running time**
  - Changing amplifier channels restores efficiency
- **Efficiency shown for a 2.59 mg/cm2 239Pu sample**

A feasibility study on measuring highly active samples at DANCE was completed

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

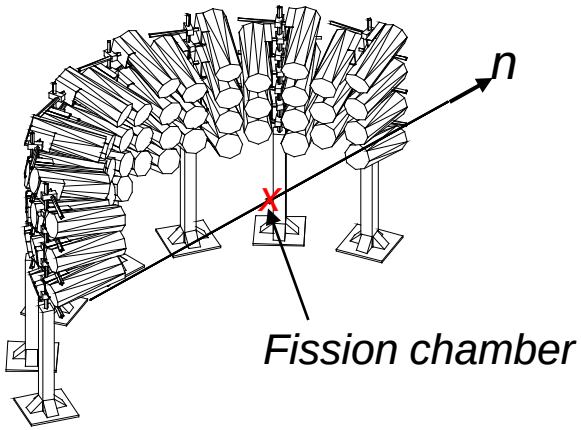


The neutron output program

- The Chi-Nu instrument has been designed for high precision neutron output measurements.
- The approach to measure the two extremes of the neutron spectrum was determined.
- The PPAC fission trigger was extensively tested
- Li-glass detectors will measure low energy (<0.5 MeV) neutrons.
- More detectors will be added to provide sufficient count rates for high energy neutrons
- A new building will be installed at the WNR facility in 2011, which will help reduce background at Chi-Nu

Chi-Nu array of fast neutron detectors

Chi-Nu (n,xn+γ)



22.7 m from WNR source

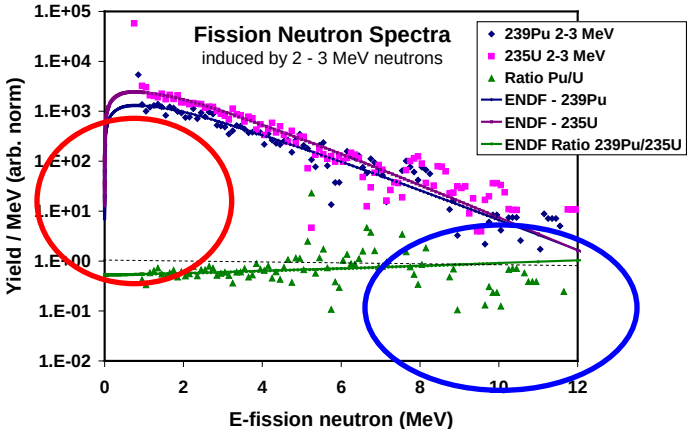
20 liquid scintillator neutron detectors

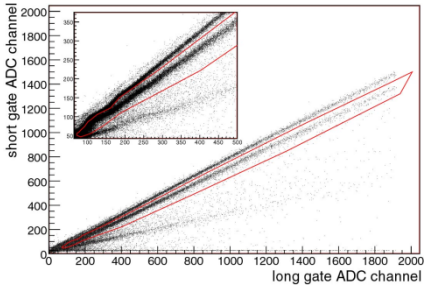
2 gamma-ray detectors

Double time-of-flight experiment

Measurement of fission neutron spectra needs detector and technique development

- **Measure fission neutrons below 1 MeV**
  - **Need better n-gamma discrimination**
  - **^{6}Li-glass detectors**
- **Measure fission neutrons better above 8 MeV**
  - **Better timing on fission chamber (LLNL-LANL collaboration)**
  - **More efficient neutron detectors (larger solid angle for detection)**
- **Reduce background**
  - **Room scattering**
  - **Neutron scattering (not from fission)**

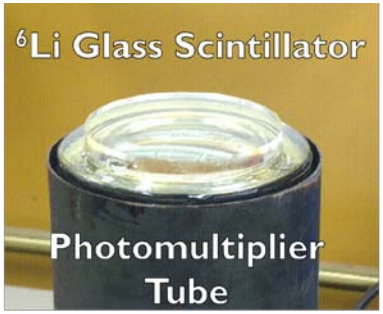




Pulse-shape discrimination differentiates neutrons and gamma rays

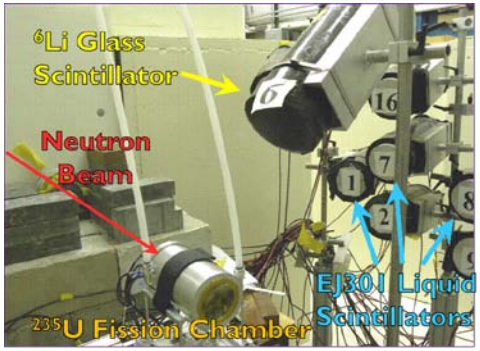
^{6}Li-glass scintillators were assembled, characterized and used in preliminary measurement

^{6}Li-glass on PM tube

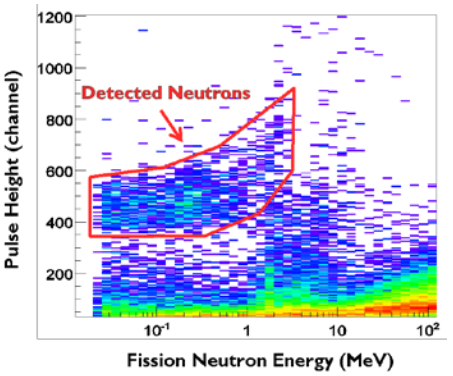


Several types of reflector were tested

Setup in beam

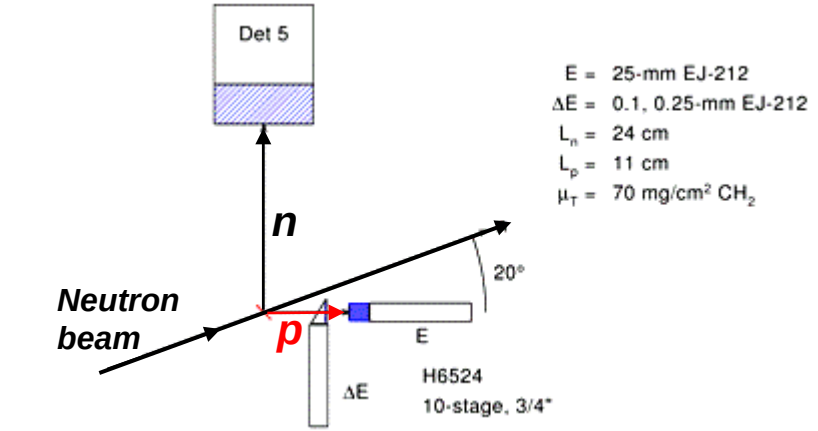


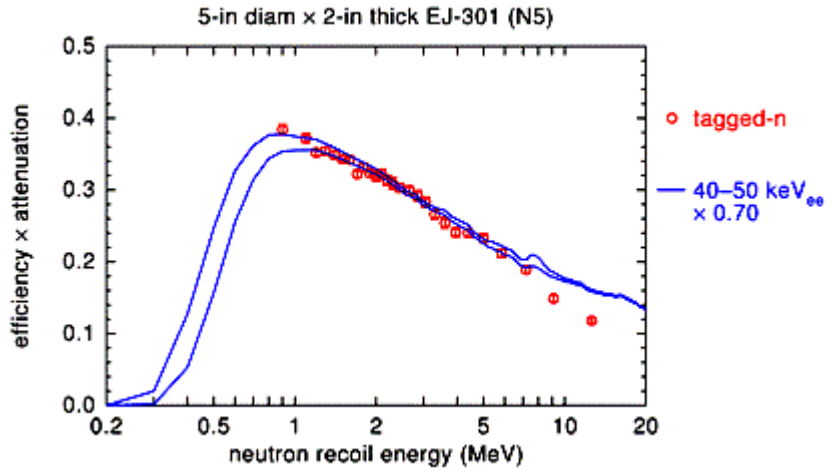
Low energy neutrons were detected cleanly



“Tagged neutrons” are used to measure detector efficiency for neutrons from 1 MeV to 20 MeV

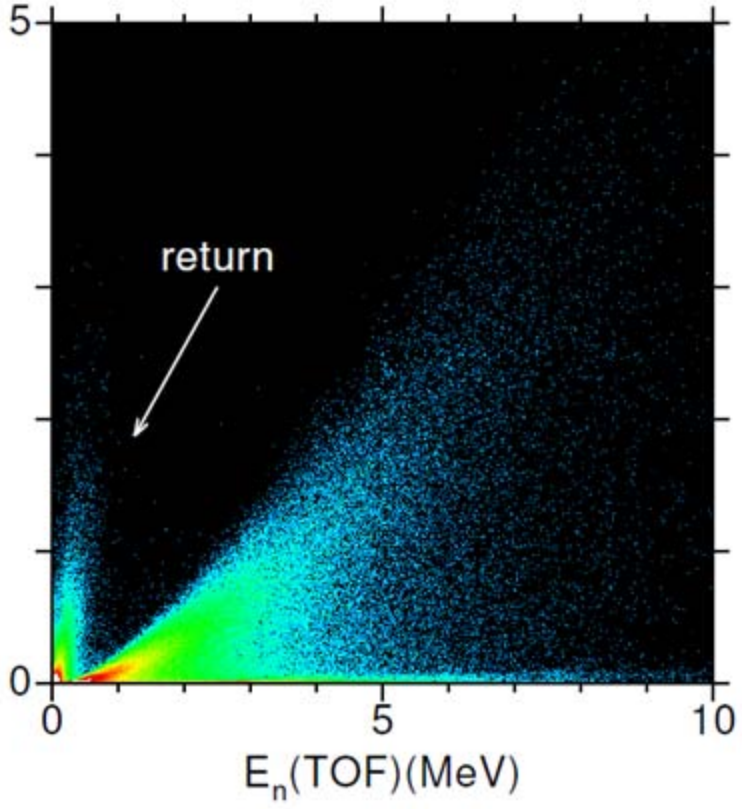
- Scatter neutrons from CH_2
- Detect recoil protons from n-p scattering
- Scattered neutrons go at the complementary angle on the other side of the beam
- For each detected proton, there is exactly one neutron incident on the detector



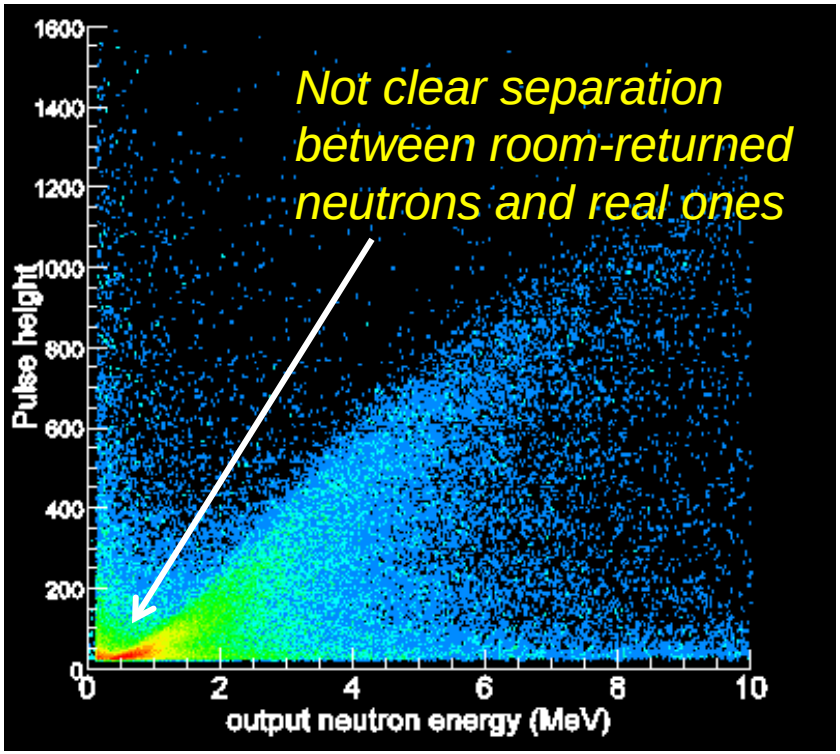


“Room-return” neutrons in Liquid Scintillators

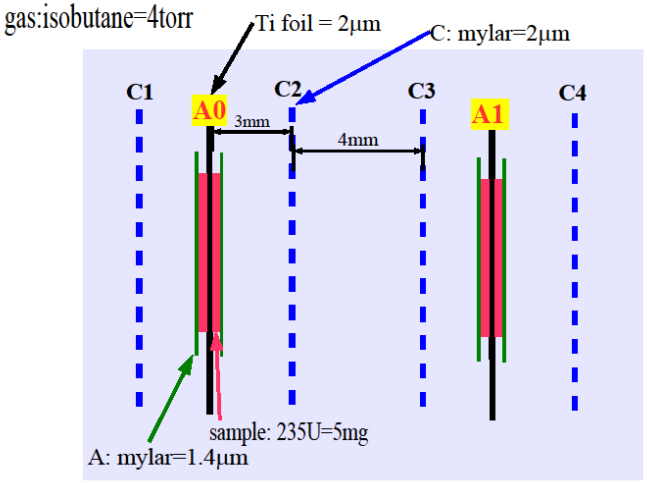
MCNPX calculation

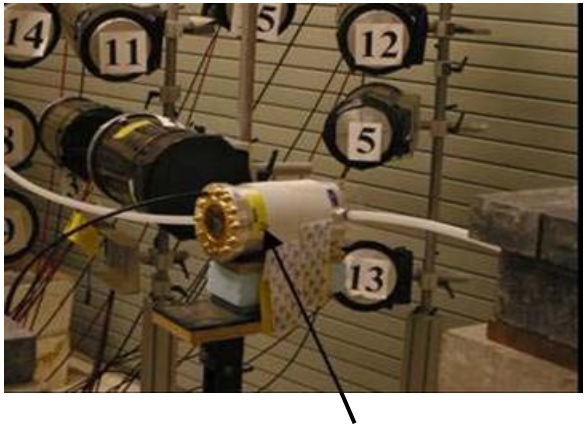


Data taken in N#1 detector



Parallel-plate avalanche counter (PPAC) was used for first production runs in 2010

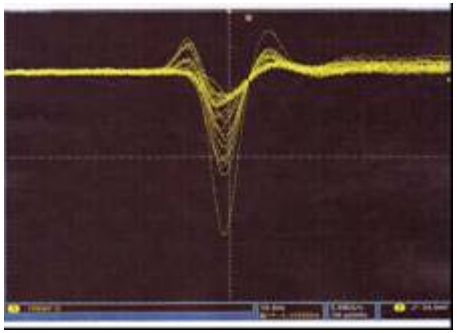




PPAC

Features of PPAC

- *Gas gain for larger signal*
- *Fast (~ 1ns)*
- *Developed by LLNL*



First production runs for $^{235}U(n,f)$ in 2010

-- data being analyzed now

Conclusions

- New measurements of fission cross sections were completed this year: U-233 and U-238
- The Time Projection Chamber delivered first beam data in FY10, will provide unprecedented accuracy
- Initial neutron capture data for Pu-239 and U-238 was collected this FY.
- The new PPAC will significantly improve accuracy in (n,γ) measurements of fissile isotopes
- The PPAC developed for neutron output measurements performs well
- The ^{6}Li glass detector tests showed the capability of measuring fission neutrons below 0.5 MeV
- The scattering background will be significantly reduced on the Chi-Nu flight path when the new WNR building is installed