NEW CORRELATIONS AND METHODS FOR ACTINIDE MEASUREMENTS AT ANL-IPNS BY INL GROUP

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OVERVIEW: Measurements at IPNS

GOAL:

Measurement of fission parameters and neutron TOF using neutron induced reactions with a multi-parameter coincidence system of several detector types. Produce correlated data for neutron induced reactions on actinide targets.

FACILITY:

The facility used is Argonne National Laboratory – Intense Pulsed Neutron Source. This work demonstrates the capability of IPNS as a neutron source for cross section measurements.

INL MEASUREMENTS:

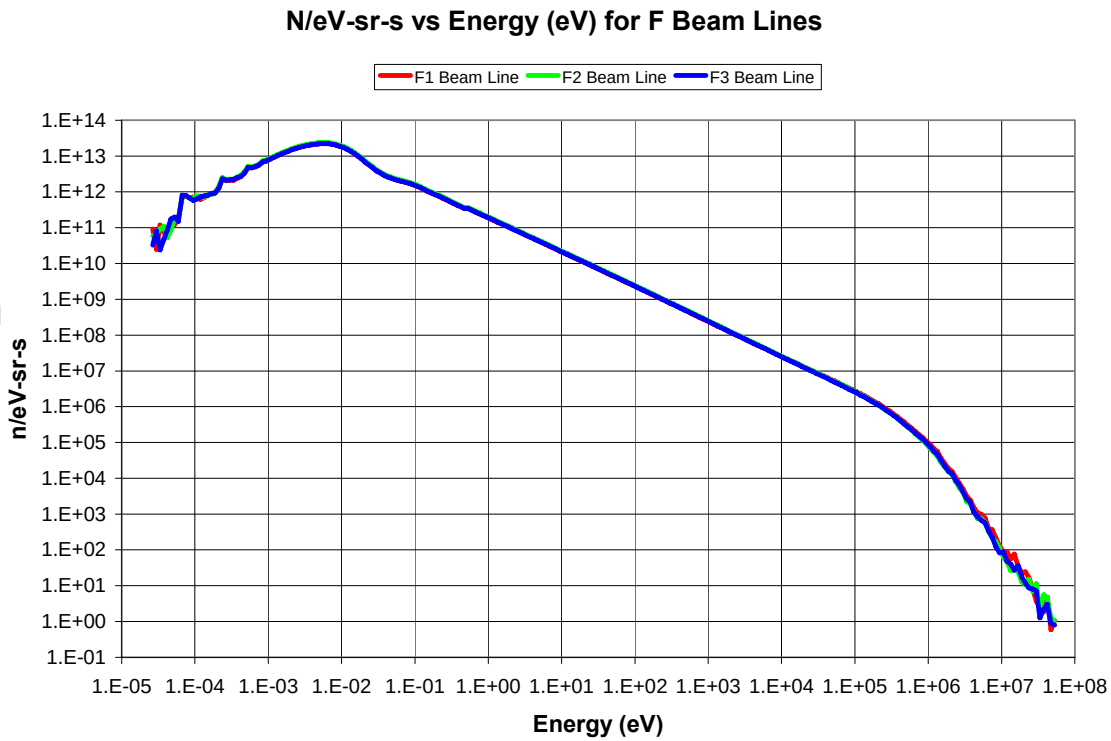
Use multi-detector arrays and coincidence methods developed in other areas of low-energy nuclear physics in the past decades with a target of ^{239}Pu. Show that these methods result in high quality, low error results.

RECENT RESULTS:

LDRD funds were used to take data with the INL system at ANL-IPNS and these preliminary results are presented as a demonstration of the capability that has been developed.

IPNS - a spallation neutron source

- A usable neutron energy from ~1 meV to ~2 MeV.
- An integrated flux of ~5.3 x 10^6 n-cm^{-2}-s^{-1} at 12 m.
- Beam is available ~23 weeks per year.
- Neutron beam is moderated with a cryogenic methane moderator.
- The incident proton pulse width is ~70 nanoseconds.
- IPNS is a user facility, versus a cost recovery facility.
- Gram quantities of most actinides can be used in IPNS.



In-beam physics methods are employed

Arrays of detectors - multiple detectors of multiple types.

Fast electronics are capable of short time resolution, ~1 ns.

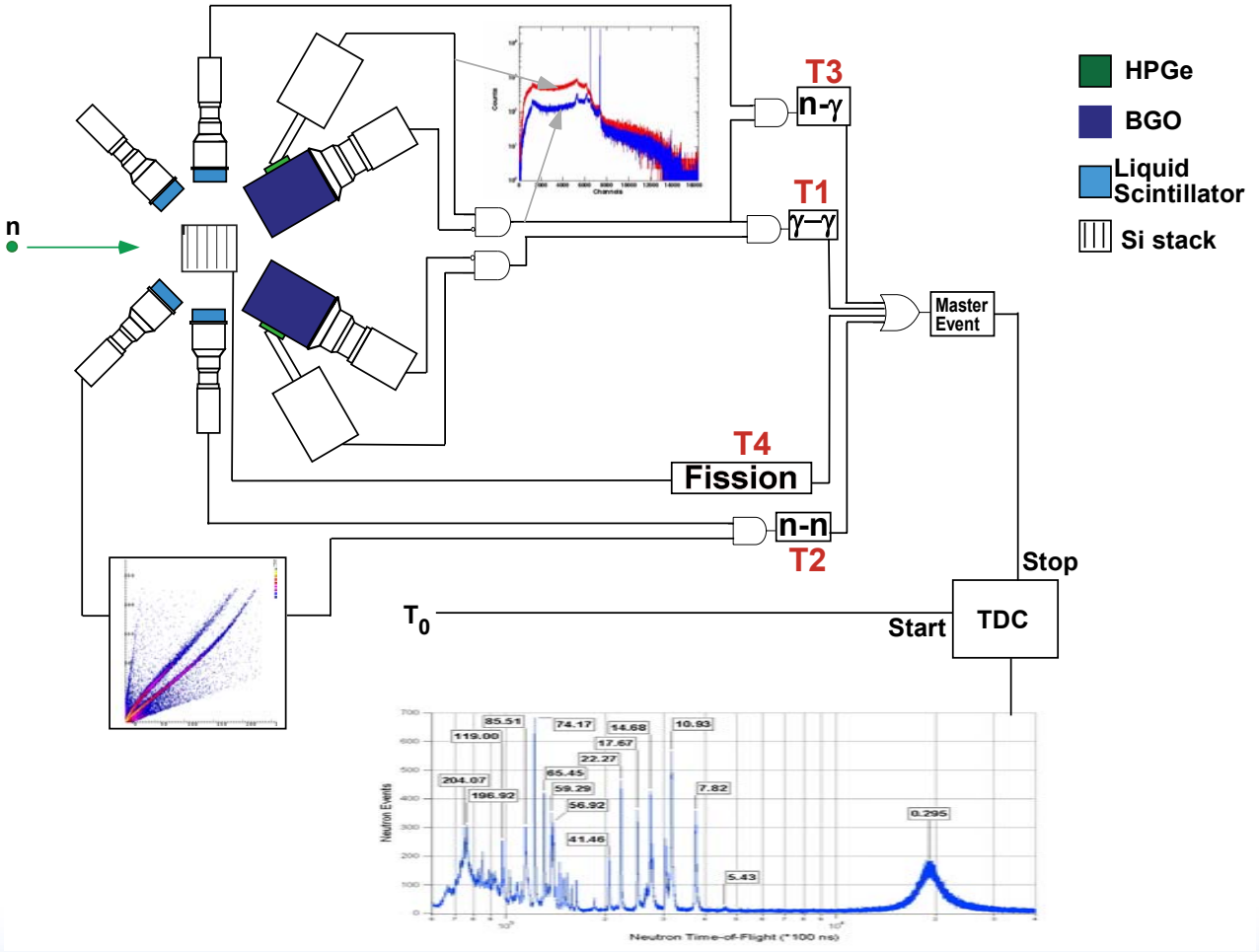
Detectors and electronics are operated in fast coincidence mode.

Data are collected on an event-by-event basis.

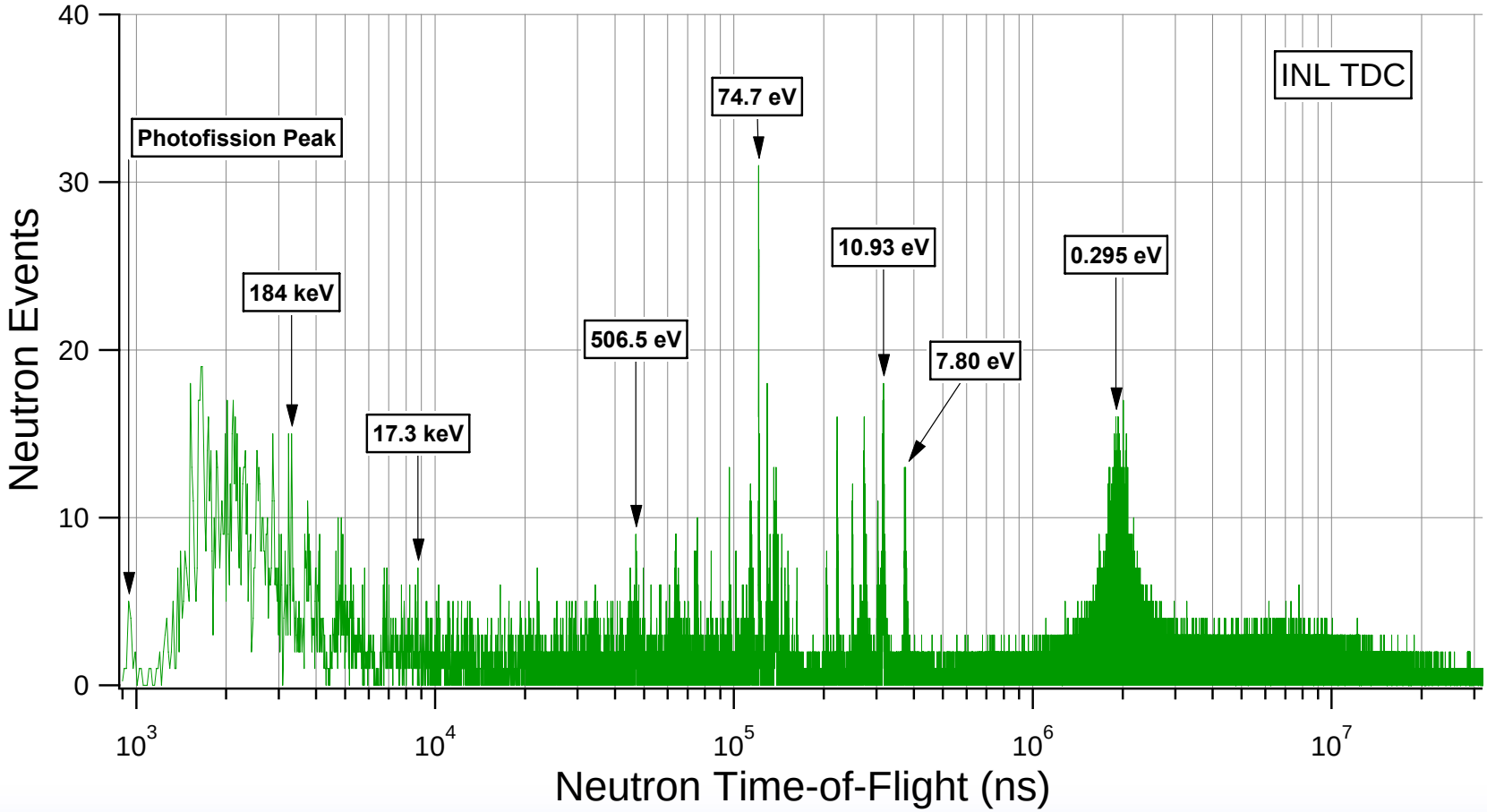
Data are stored in list mode for offline sorting- or gating-based analysis.

Determine decay products of resonances.

Event Triggers



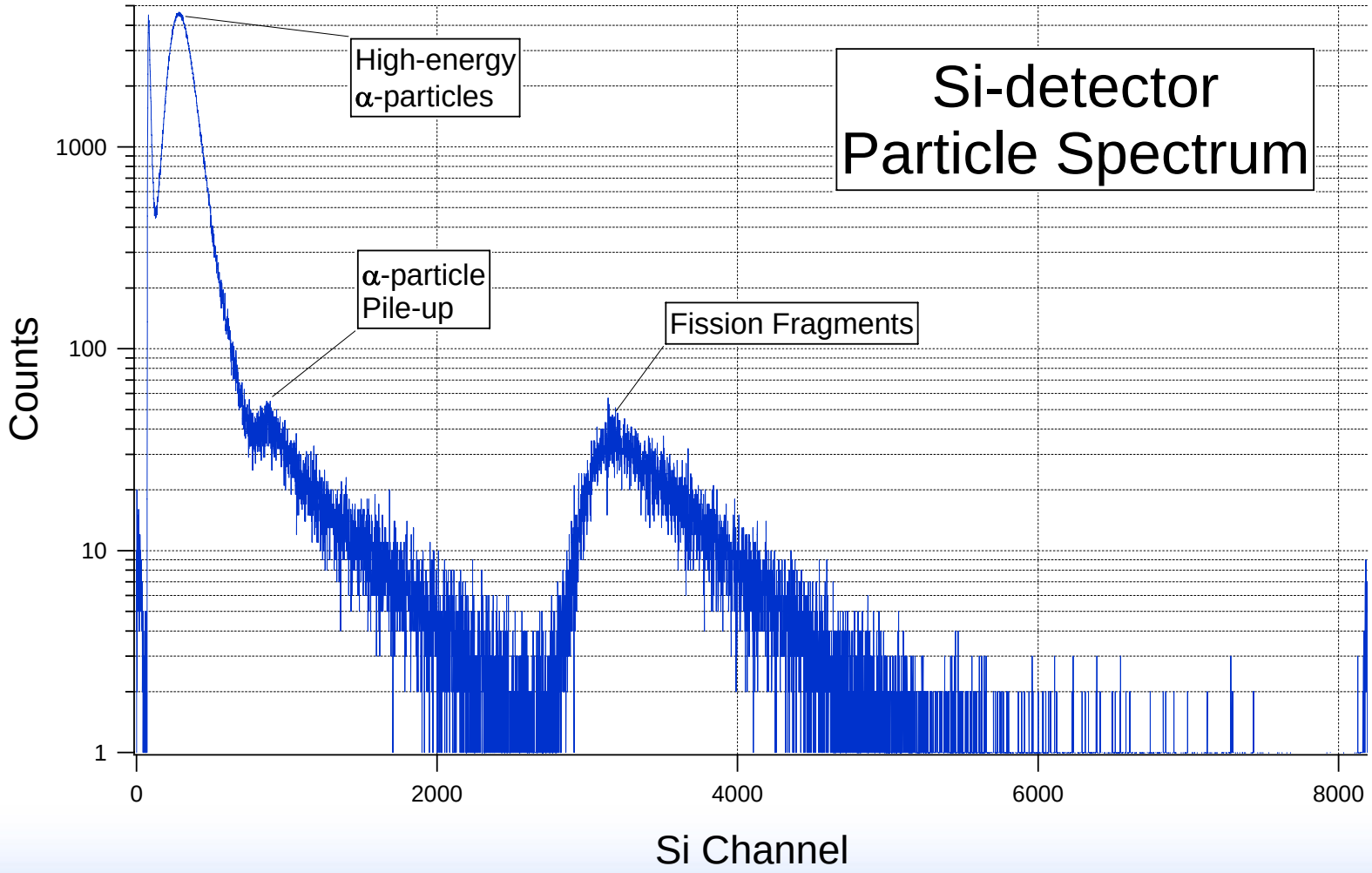
Multi-stop Neutron Time-Of-Flight TDC Spectrum



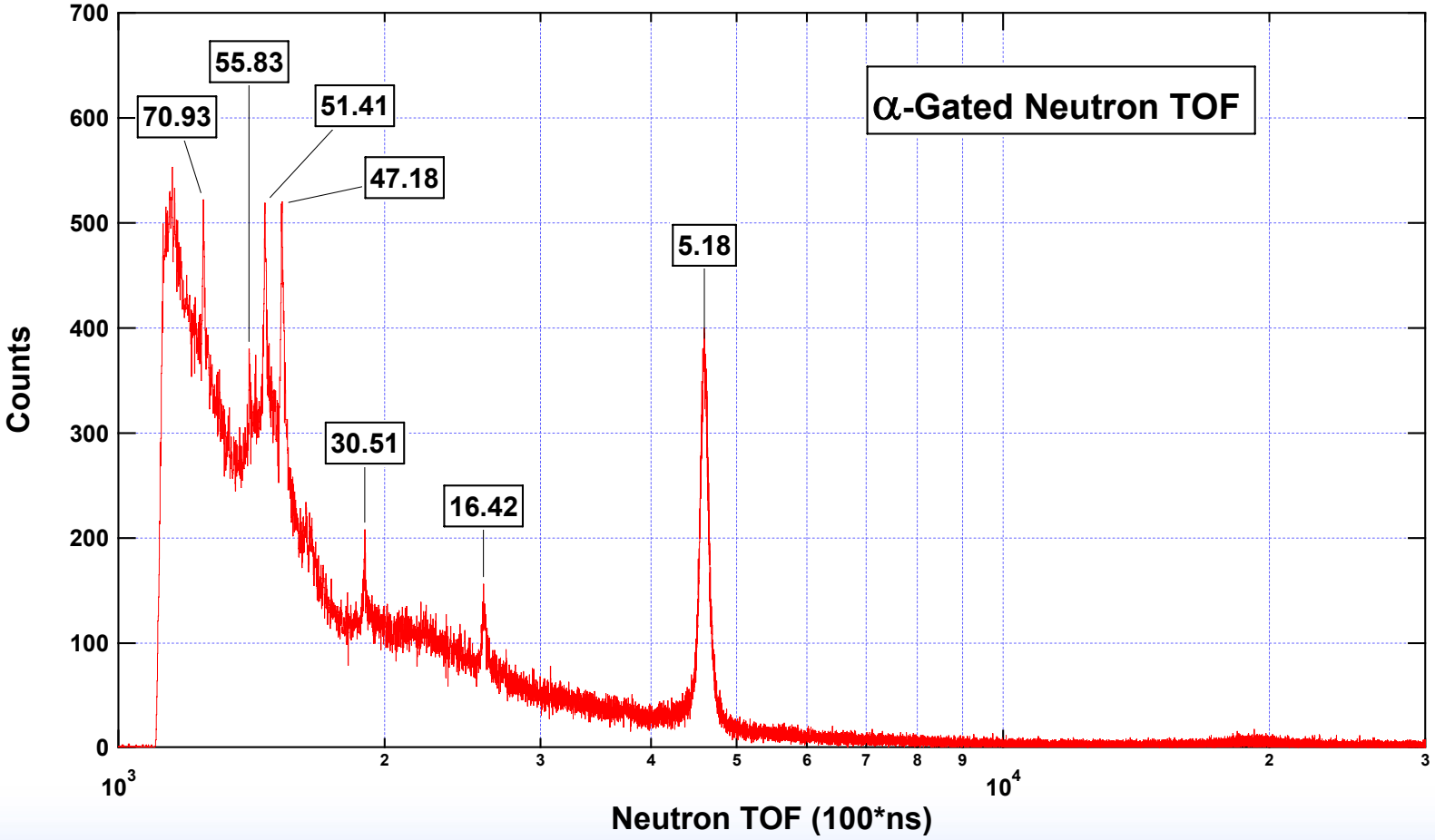
Separation of Reaction Channels

Competition between charged particle, capture, and induced fission reaction channels are extremely difficult to separate for the actinides.

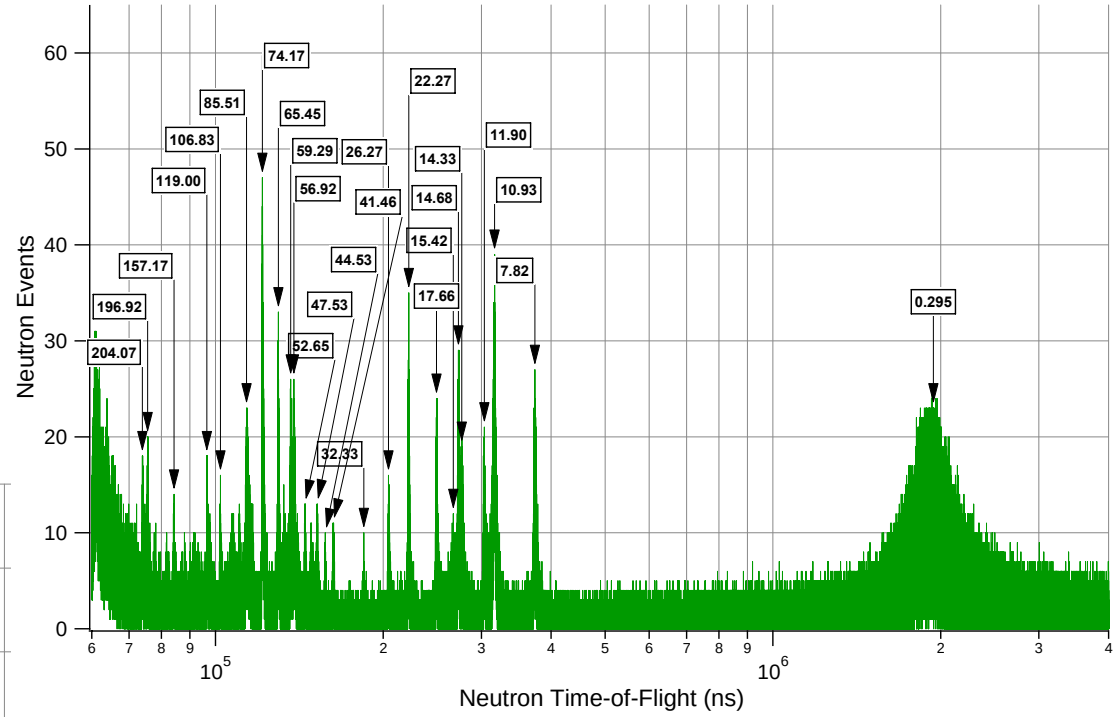
Three reaction modes (charged particle, gamma ray, and fission) are observable with the INL system.

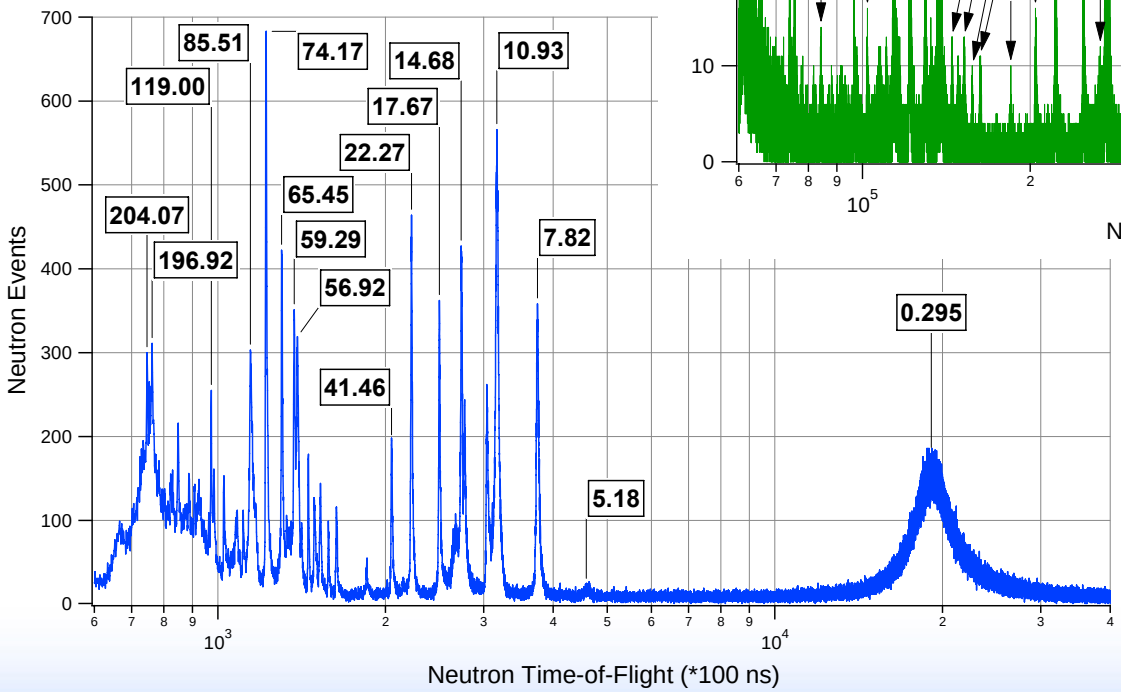

Si-detector
Particle Spectrum
High-energy
α-particles
α-particle
Pile-up
Fission Fragments
Counts
1000
100
10
1
0
2000
4000
6000
8000
Si Channel

New resonances from n,α reaction



Fission





Capture

Recommendations:

Use IPNS, a neutron spallation source located at ANL, that has not been previously used for nuclear physics experiments. It has good characteristics for high quality measurements.

Use new methods for measurements as with the INL setup. These methods have been proven successful in other low energy nuclear physics measurements and the present work has demonstrated applicability to cross sections and fission parameters.

Determine branching ratios perform capture, fission, and alpha-out results for neutron induced reactions. Also, neutron multiplicity and fission yields are determined.

Data show high resolution and clean neutron event spectra over an energy range of ~0.001 eV to ~2 MeV at IPNS, as a single continuous measurement.

Address high-priority actinides, even those with high specific activity, in the near future.