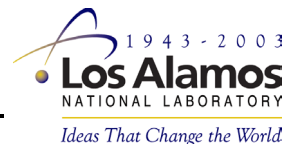


Nuclear Data Experiments at LANSCE: A Brief Summary

**Bob Haight
Los Alamos National Laboratory**

**Cross Section Evaluation Working Group Meeting
Brookhaven National Laboratory
November 4-5, 2003**

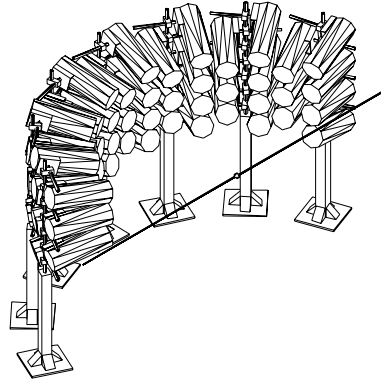


Nuclear data measurements at LANSCE are made with several instruments

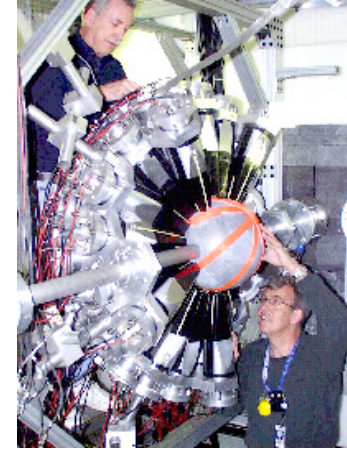
GEANIE ($n, x\gamma$)



FIGARO ($n, xn+\gamma$)



DANCE (n, γ)



N,Z (n , charged particle)



Lead SDS (n, f)



**Other
measurements:
 (p, X)**

Some recent cross section results from GEANIE/WNR: (n,x γ) and (n,x-ray) to infer cross sections

0.5 MeV < E_n < 200 MeV

- $^{193}\text{Ir}(n,n'\gamma)^{193\text{m}2}\text{Ir}$
- $n+^{89}\text{Y}$ for E_n < 20 MeV
- $^{75}\text{As}(n,2n)^{74\text{m,g}}\text{As}$
- $^{238}\text{U}(n,xn\gamma)$
- $^{235}\text{U}(n,n')^{235\text{m}}\text{U}$
- $^{238}\text{U}(n,f)$ x-ray yields

Fotiadis, et al., next slide

Garrett, UCRL-ID-153190 (2003)

Younes, UCRL-ID-154061 (2003)

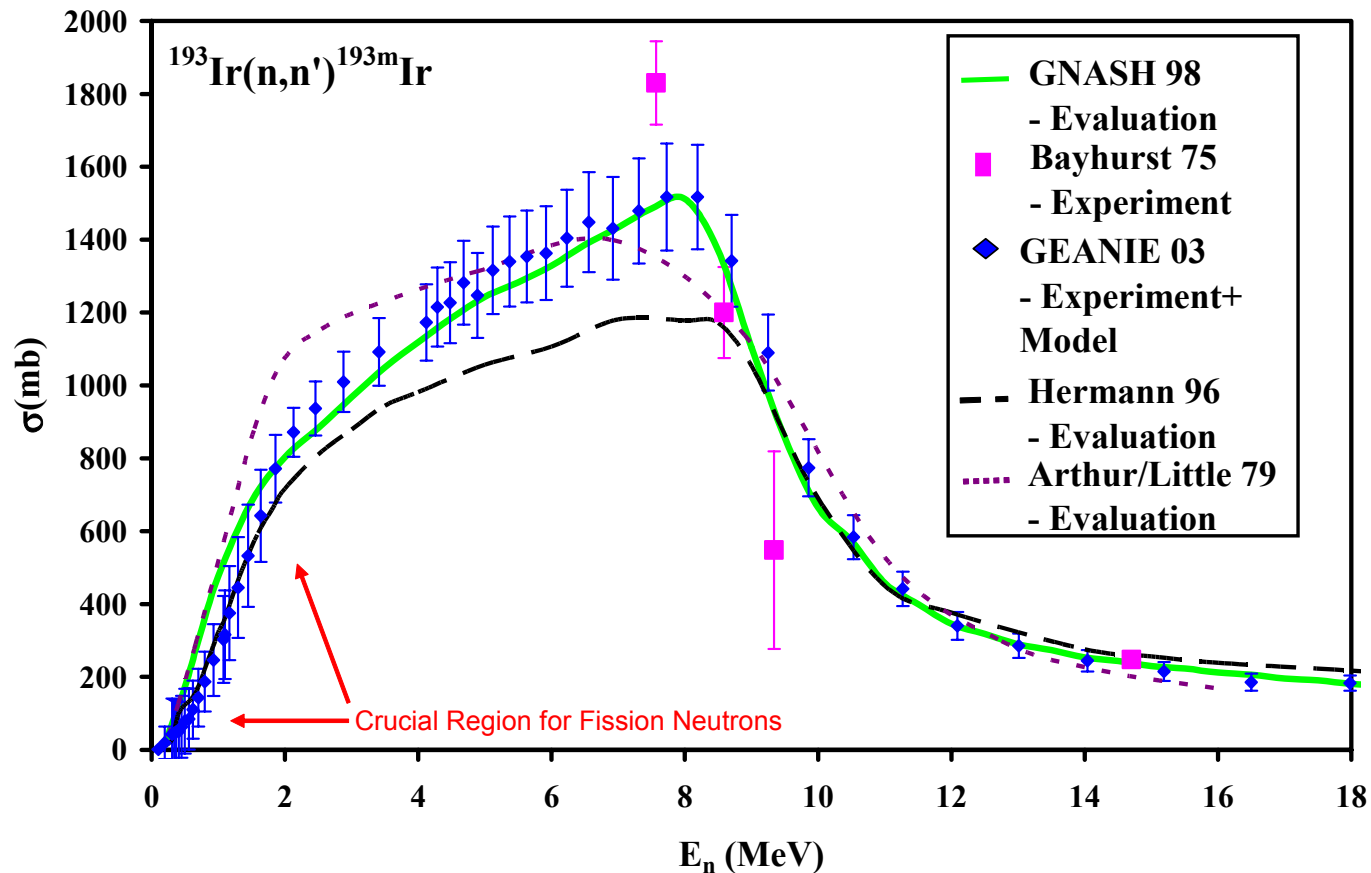
Fotiadis, Phys. Rev. C, in press

Younes, UCRL-ID-151071 (2002)

Granier, Phys. Lett. B, submitted

GEANIE
LLNL/LANL

New GEANIE data significantly improve the $^{193}\text{Ir}(n,n')^{193\text{m}}\text{Ir}$ cross section database

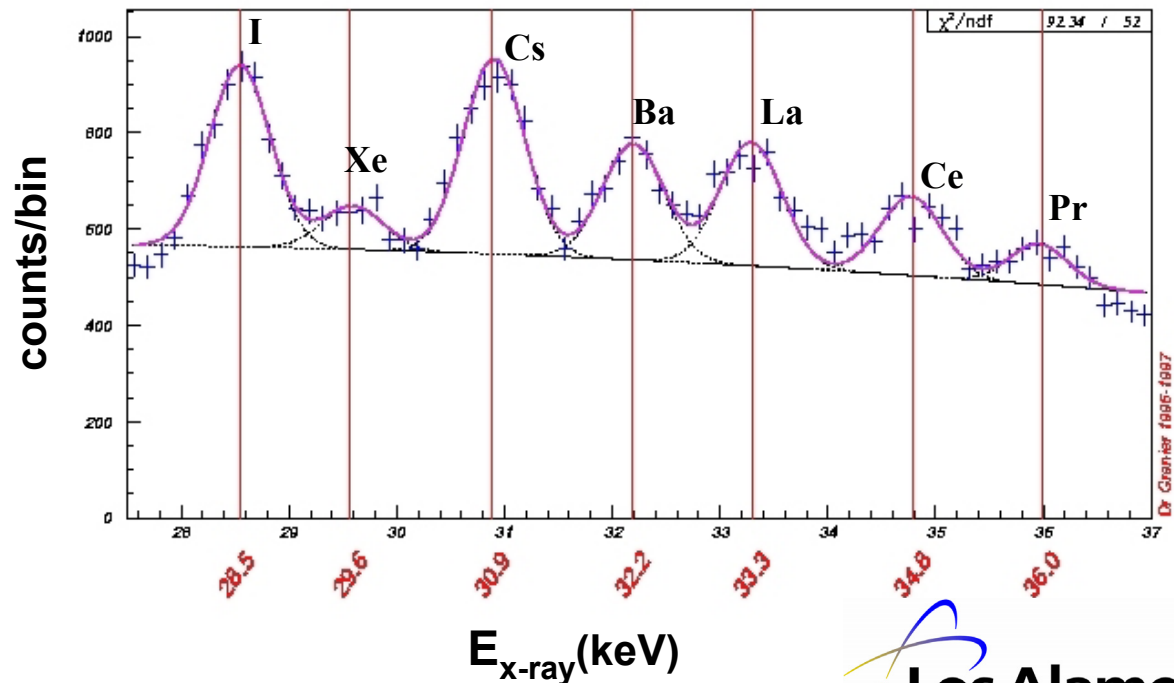


GEANIE
LLNL/LANL

X rays from Neutron-Induced Fission of ^{238}U give elemental yields

- $^{238}\text{U}(n,f)$ fission product mass and charge distributions as a function of incident-neutron energy.
- Measurement of x-rays and gamma-rays with GEANIE following neutron-induced fission at WNR allow a detailed study of the fission products as a function of incident neutron energy.

Plot of the data and fit to the x-ray spectrum showing 7 fission product elements from ^{238}U neutron-induced fission.



Some recent cross section results from FIGARO/WNR: neutron-emission spectra

$$1 \text{ MeV} < E_n < 200 \text{ MeV}$$

Fission Chamber in beam

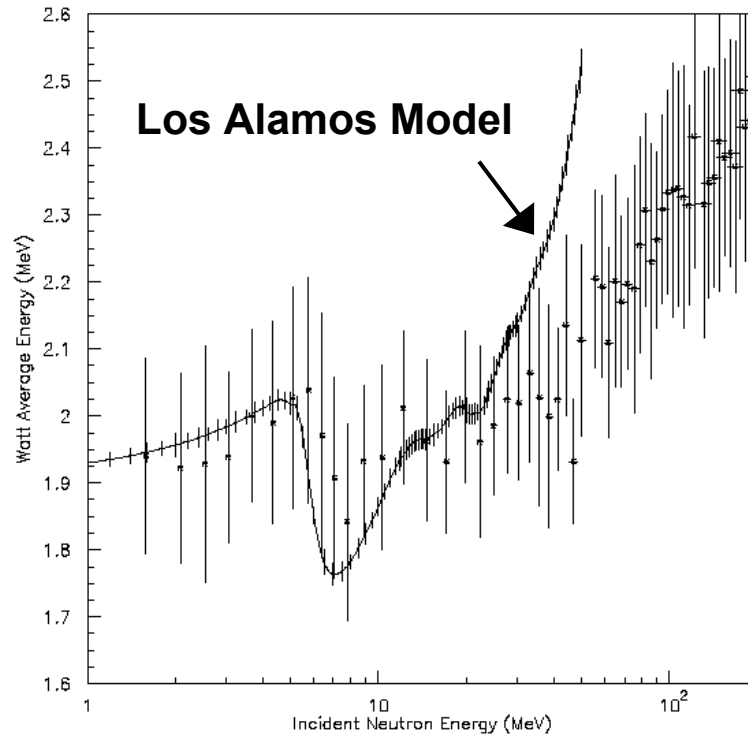
- $^{238}\text{U}(n,f): E_{fn}$ Ethvignot, Phys. Lett. B (in press)
- $^{235}\text{U}(n,f): E_{fn}$ Ethvigot, a.i.p
- $^{235}\text{U}(n,f): E_{f\gamma}$ Nelson, a.i.p
- $^{238}\text{U}(n,f): \nu\text{-bar}$ Ethvignot, paper in prep.

Gamma-ray trigger (HPGe or BaF2)

- $\text{Si}(n,n'\gamma)$ Rochman, submitted to NIM
- Fe, Ni, Mo, Pb Data taken

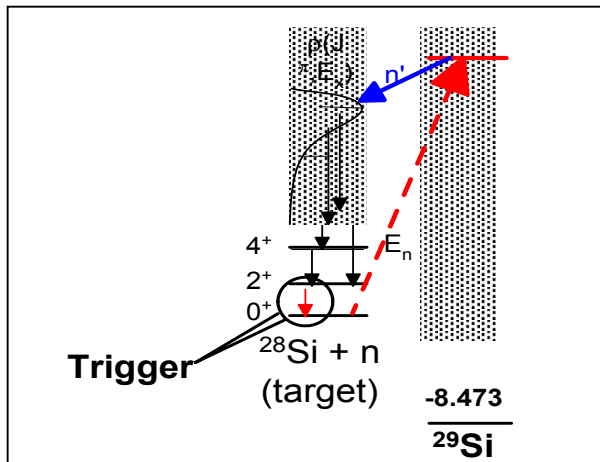
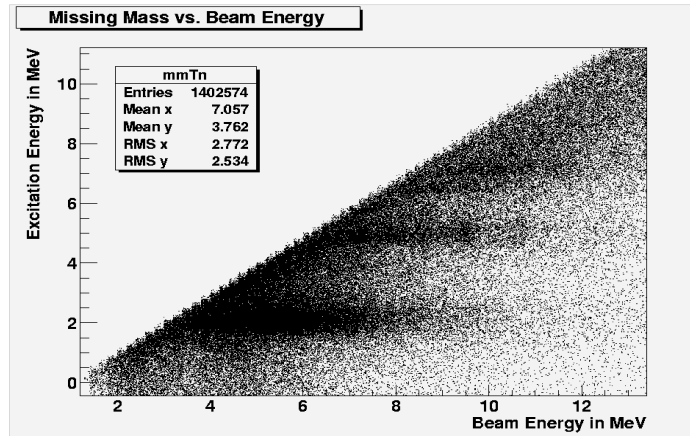
The fission neutron spectrum varies with incident neutron energy

$^{238}\text{U}(n,f)$ average neutron energy

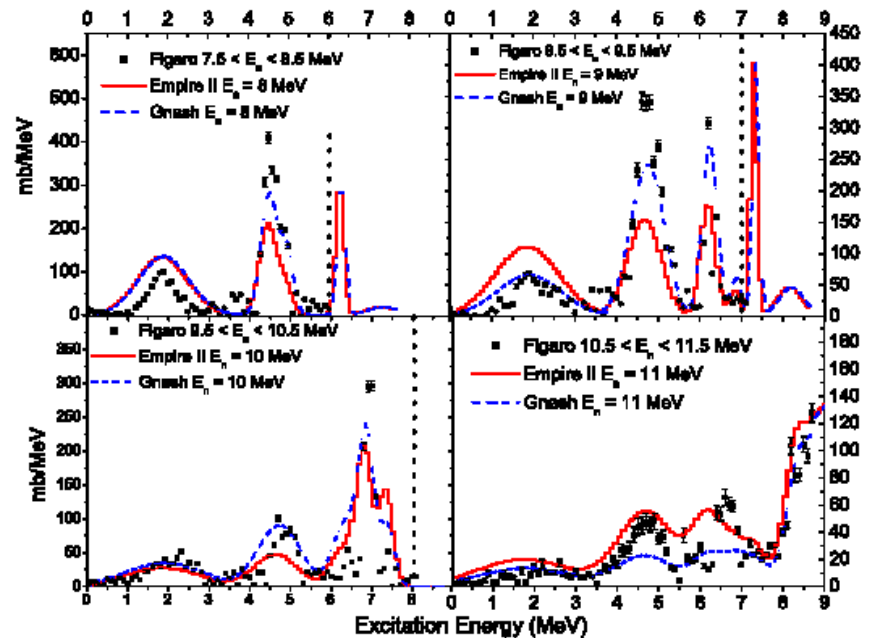


Agreement with Los Alamos Model is good below 20 MeV

Neutron emission from neutron reactions is studied as a function of incident neutron energy



We compare our results with GNASH and EMPIRE calculations

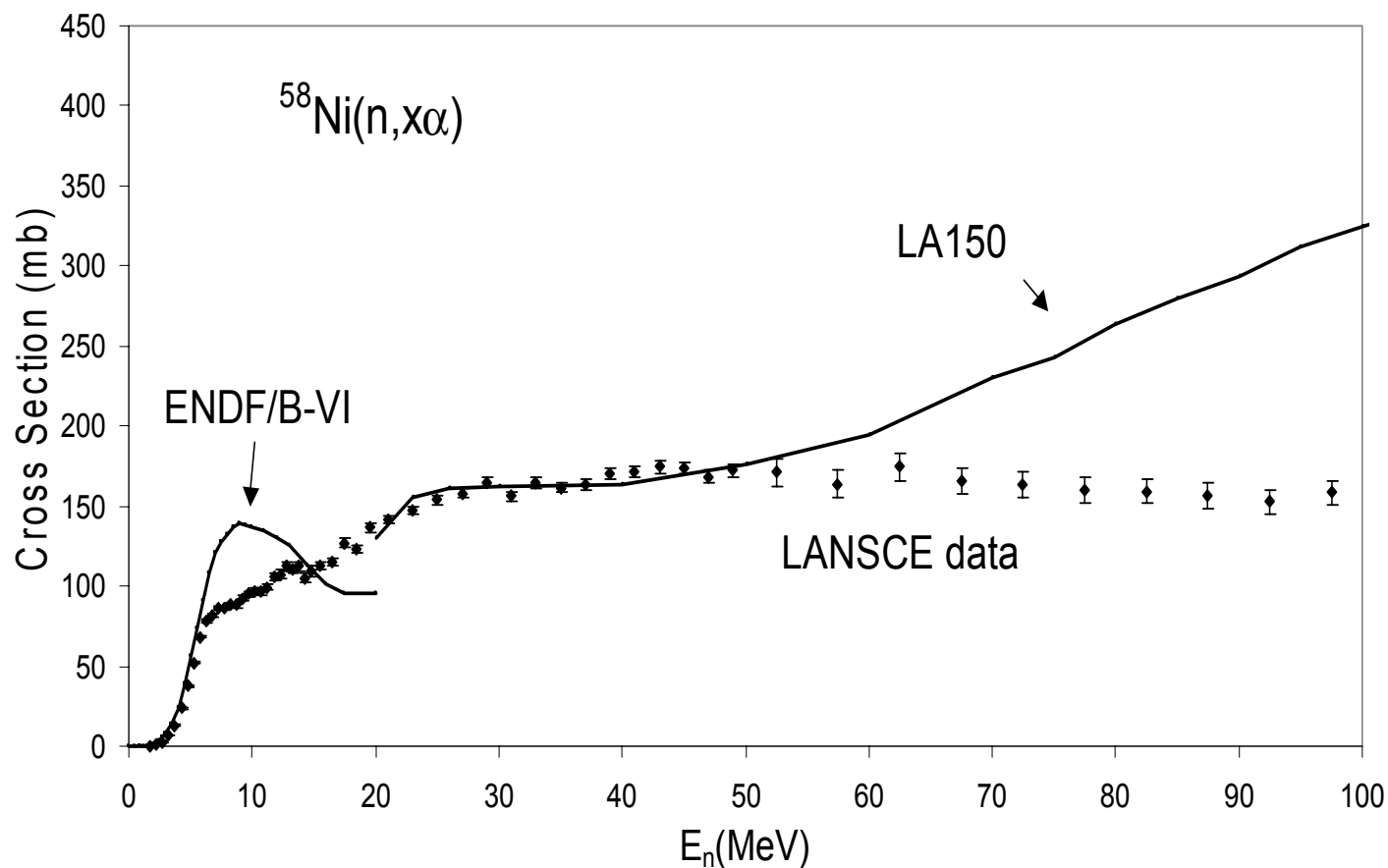


Some recent cross section results from (n,z): proton, deuteron and alpha-particle production cross sections

$1 \text{ MeV} < E_n < 100 \text{ MeV}$

- $^{58,60}\text{Ni}(n, x\alpha)$ Haight, AccApp03
- In progress:
 - $\text{Ni}(n, xp)$
 - $\text{Fe, Cr}(n, xp+x\alpha)$

New data for helium production from neutrons on ^{58}Ni show deviations from LA150



Some recent cross section results from DANCE/MLNSC: neutron capture cross sections

$$1 \text{ eV} < E_n < 200 \text{ keV}$$

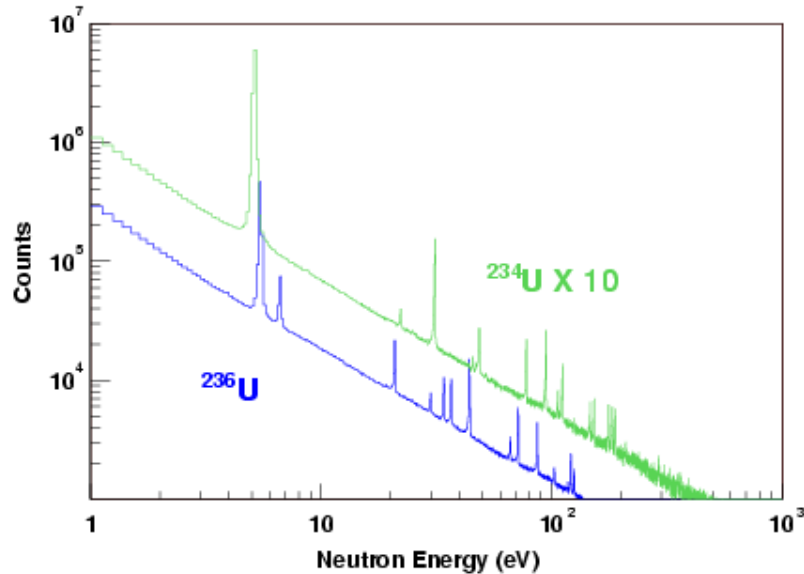
Runs done with 141 crystals

- **Au(n, γ) standard**
- **$^{234}, ^{235}, ^{236}, ^{238}\text{U}(n,\gamma)$ cross section (stewardship)**
- **$^{151}\text{Sm}(n,\gamma)$ cross section (astrophysics)**

Runs done with 159 crystals

- **Au(n, γ) standard**
- **$^{151}\text{Sm}(2003)$ astrophysics**
- **La, Cu, Mn, Co(2003) astrophysics, systematics**

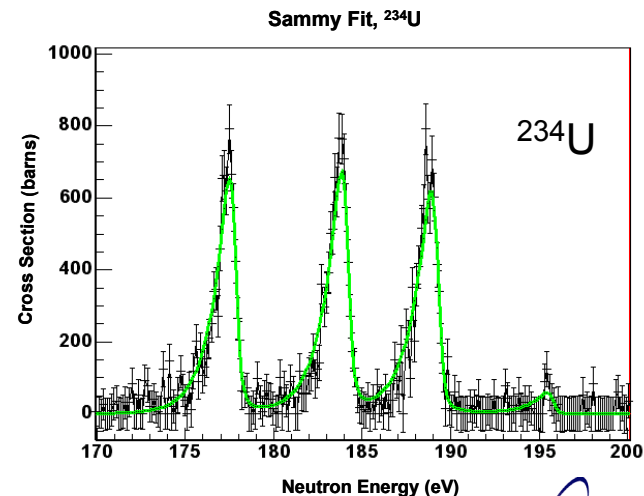
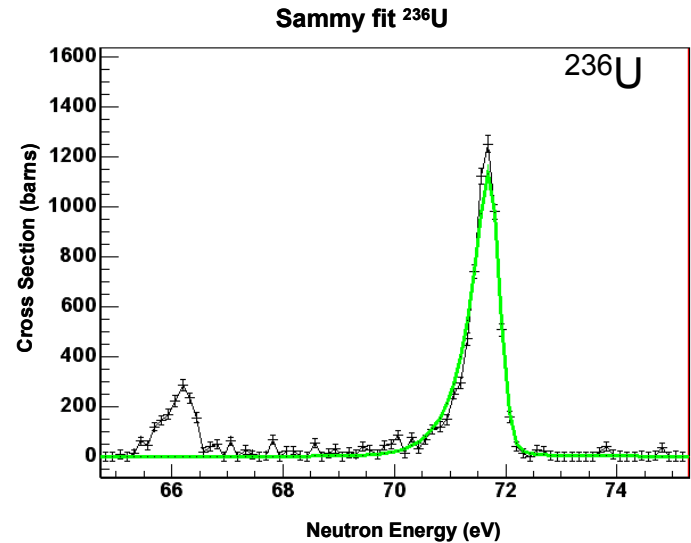
Preliminary Results: $^{234,236}\text{U}$ Resonances



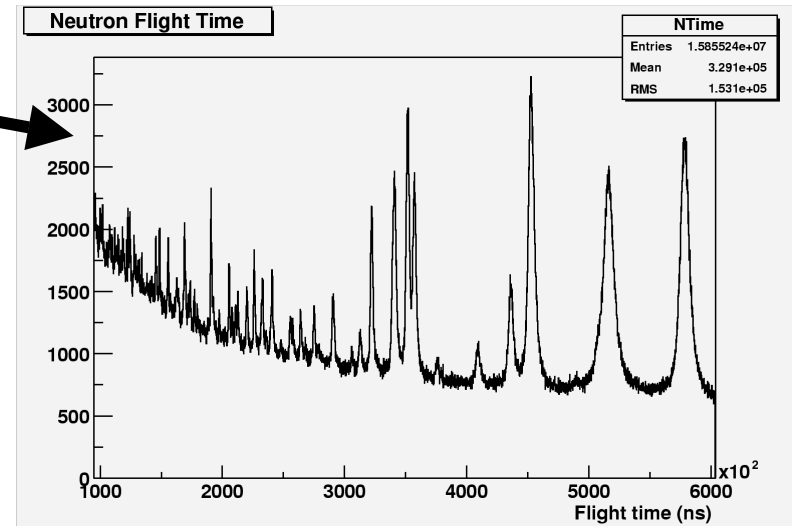
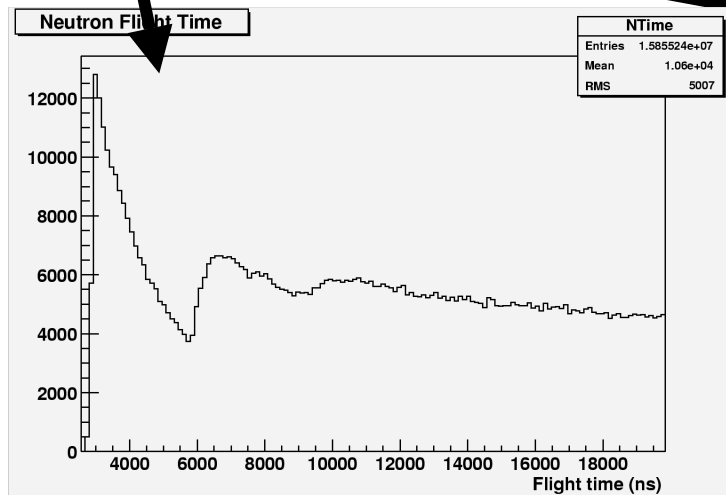
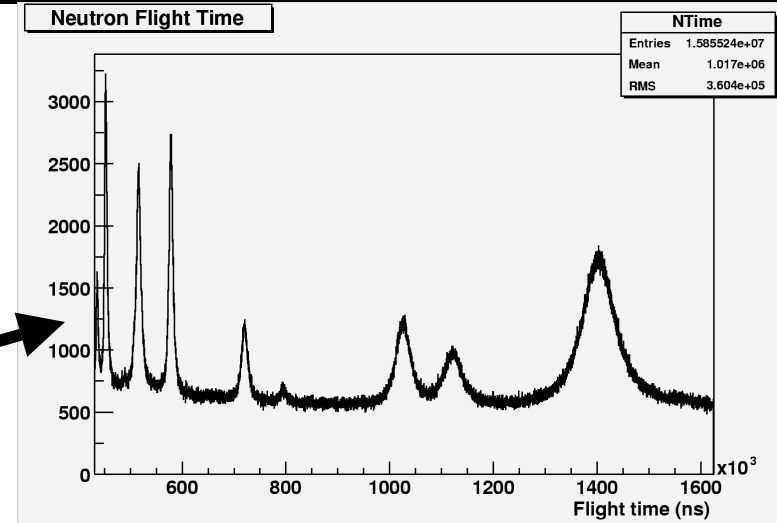
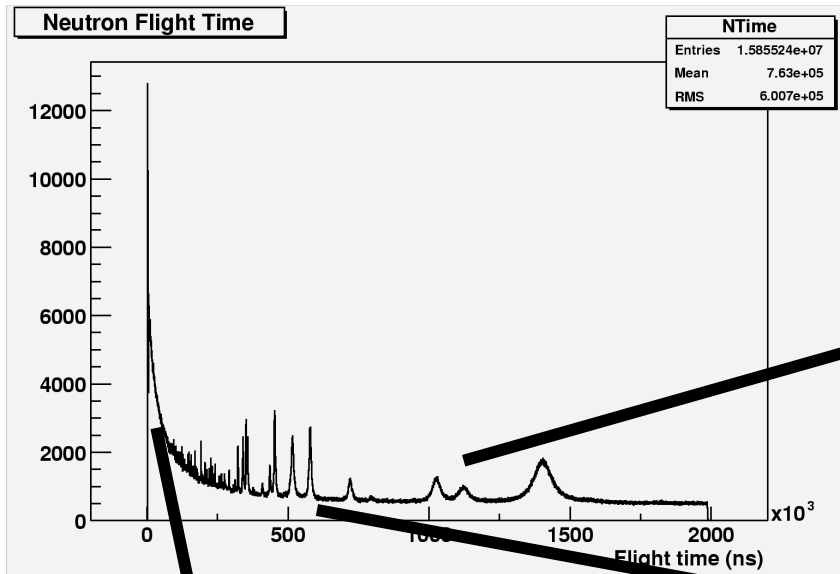
Raw Energy Spectra

Resonances fit using SAMMY code

- Parameters determined from Au resonances
- $T_{\text{eff}} = 300^\circ$ (Doppler Broadening)
- $\Delta L = 0.0109$ m (Moderator thickness)
- $\Delta T_x = 0.390$ μsec (Exp. Tail parameter)
- $T_E = 0.019$ μsec (Gaussian width param.)



0.5 mg of $^{151}\text{Sm}(n,\gamma)$ – TOF spectra show capabilities of DANCE



Some recent cross section results from proton reactions: spallation yields

$E_p = 600, 800 \text{ MeV}$

- Spallation yields on W, Au, Ta

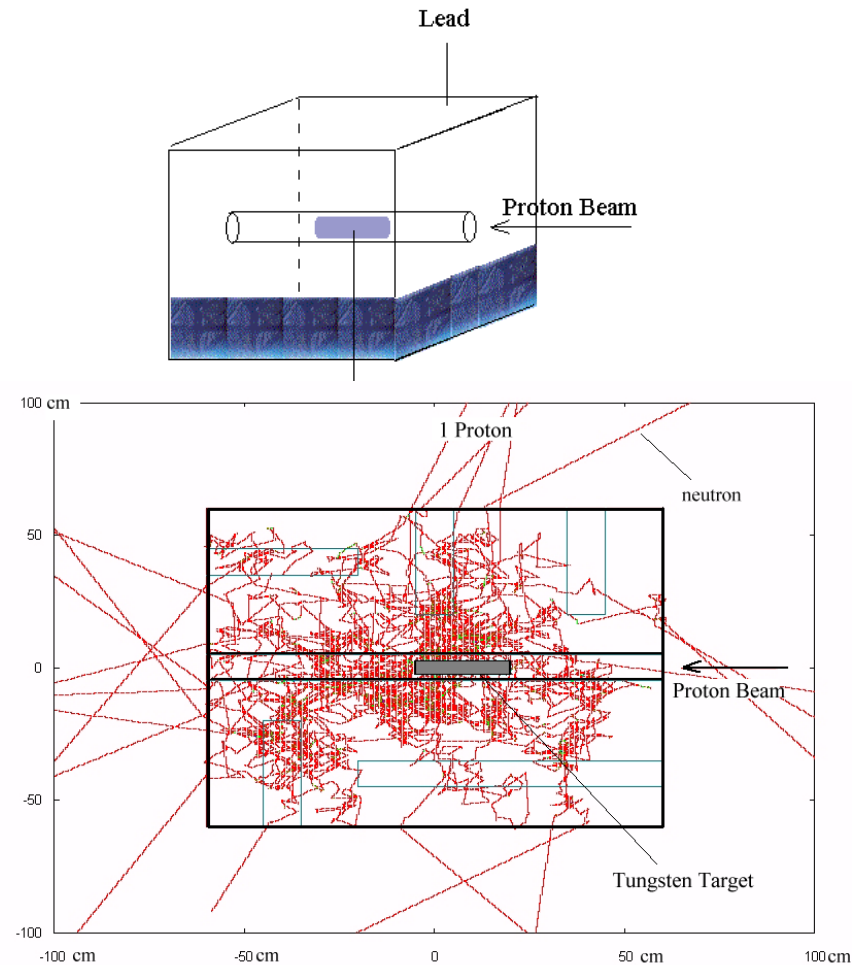
- ^{148}Gd , others

K. Corzine-Kelley, AccApp03

A Lead Slowing-Down Spectrometer is under development, driven by 800 MeV protons from the PSR

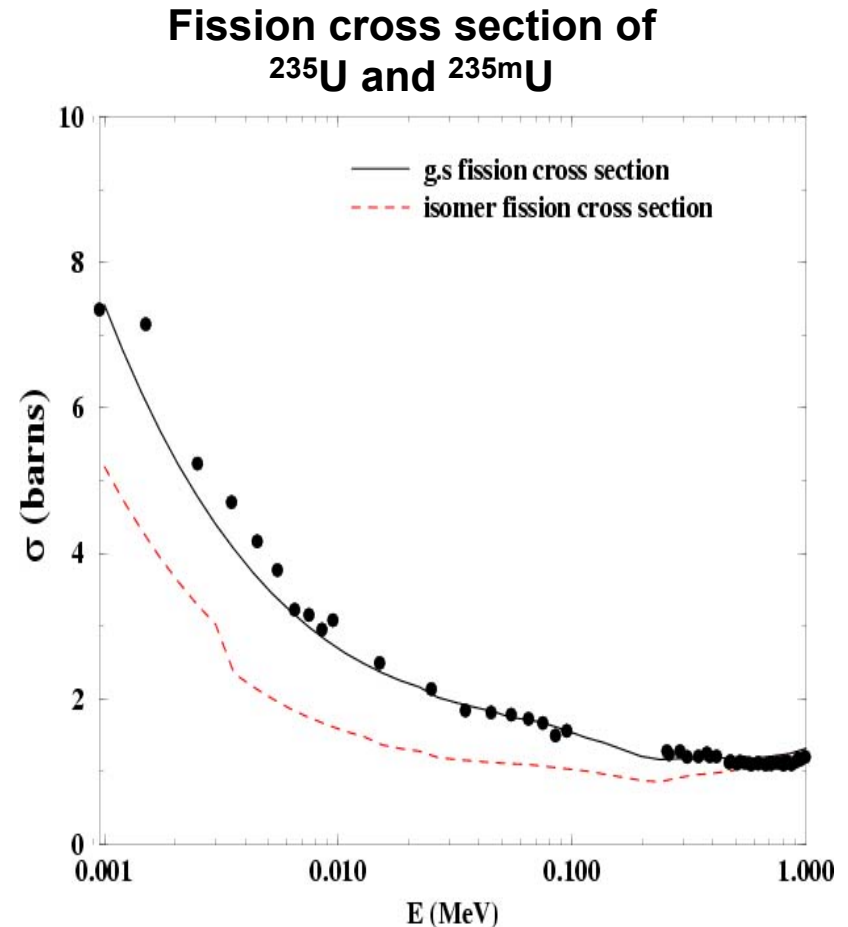


Neutron trajectories following the interaction of 1 proton with the tungsten target in the lead cube



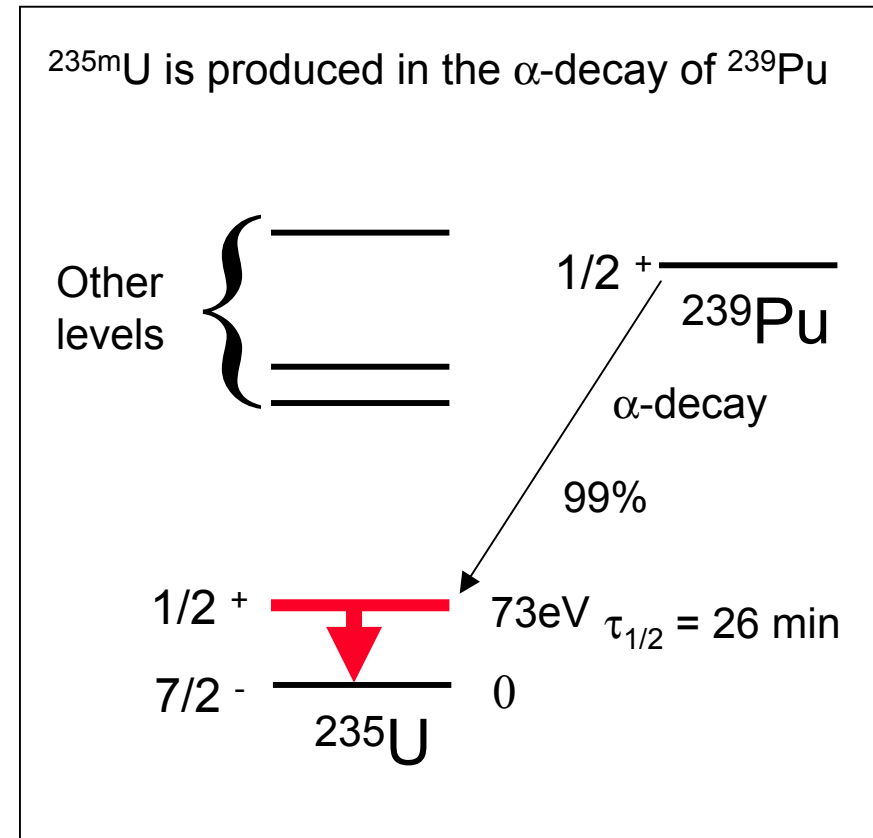
Lead Slowing-Down Spectrometer: To measure fission cross sections of ultra-small samples

- Effort motivated by interest in measuring the fission cross section of isomers and small samples of actinides
- Calculations show that cross section for $^{235\text{m}}\text{U}$ is significantly different than for ground state
- Experiments are in collaboration with LLNL, RPI and CEA/DAM

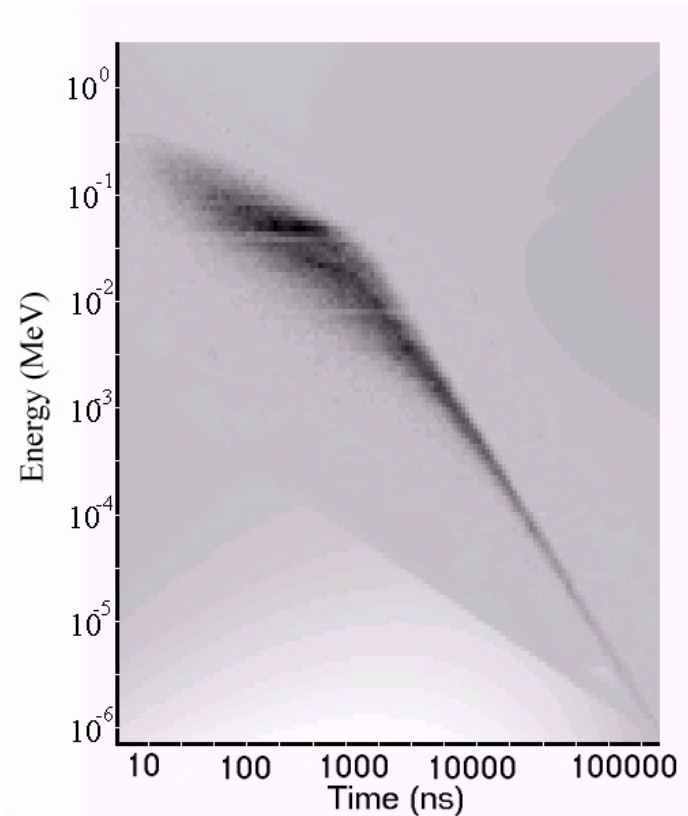


First excited state of ^{235}U is produced in decay of ^{239}Pu

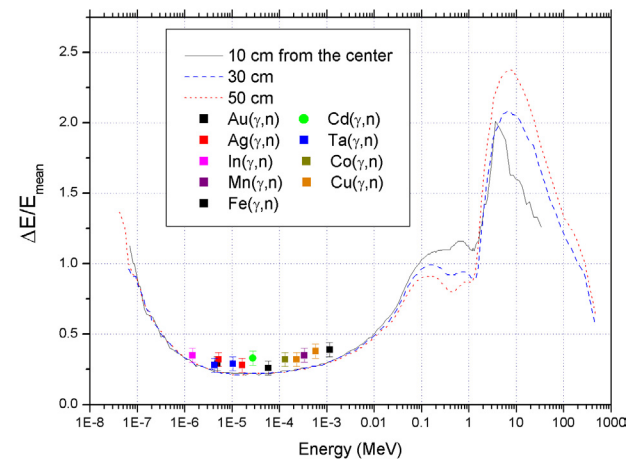
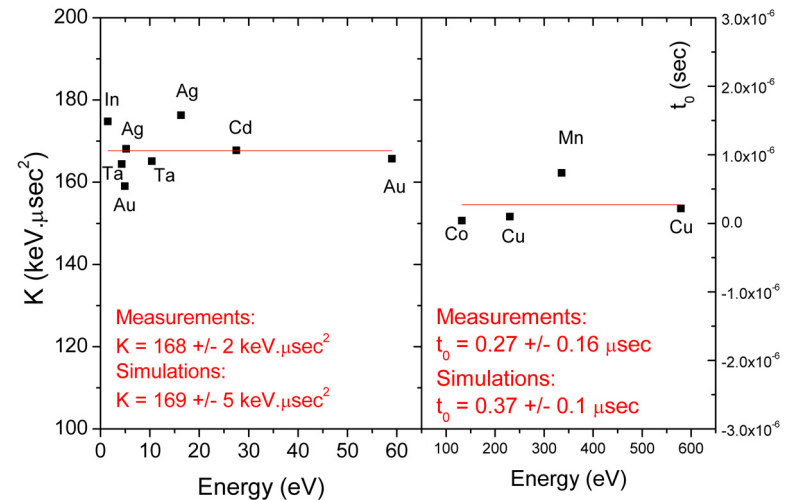
- $^{235\text{m}}\text{U}$
 - 26 min half-life
 - 73eV
 - Decays by internal conversion
 - 99% of ^{239}Pu decays populate $^{235\text{m}}\text{U}$
 - 5 gm of Pu will produce 10ng of $^{235\text{m}}\text{U}$
- Fast extraction of $^{235\text{m}}\text{U}$ will be required
- To measure this small cross section, it is necessary to increase the neutron flux by using a lead-slowing down spectrometer (LSDS)



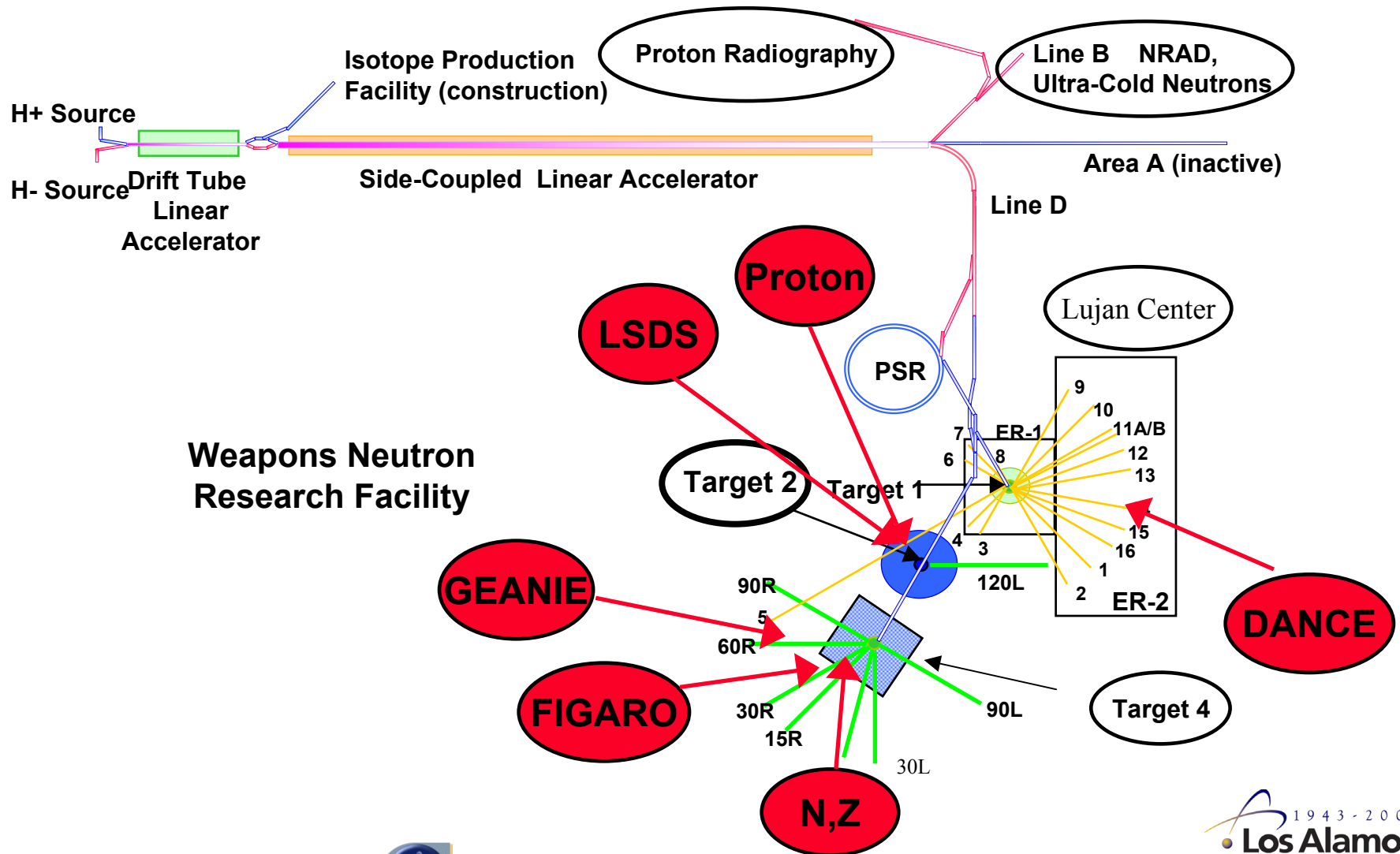
We have characterized the time-energy correlation and measured the resolution in capture resonances



Simulation: $\langle E_n \rangle = K / (t + t_0)^2$
with resolution, $\Delta E/E \sim 30\%$



Nuclear data experiments at LANSCE use neutrons at three locations: Lujan Center, Target 2 and Target 4.



We address the needs of LANSCE sponsors

- **National Nuclear Security Administration**
 - **Program in radchem cross section measurements**
 - » Neutron capture cross sections on radioactive targets (DANCE)
 - » Cross section measurements on high-order $(n,2n)$, (n,xn) reactions (GEANIE)
 - **Program in neutron-induced fission measurements**
 - » Fission product distributions (GEANIE)
 - » Energy output in fission: neutron and γ -ray spectra (FIGARO)
 - » Nuclear properties of fission products and isomers (GEANIE and FIGARO)
- **Office of Nuclear Energy**
 - Measurements in support of the AFCI program include:
 - » Capture and fission cross section on actinides
 - » Gas production: (n,p) , (n,α) reactions in structural materials
- **Office of Science**
 - Support of SNS in understanding pulsed radiation effects on liquid mercury targets
 - Fundamental physics experiments and nuclear data
- **National Resource**
 - Nuclear science User Facility for defense, basic and applied research
 - Industrial testing of semiconductor devices in neutron beams
 - University research in nuclear science

The LANSCE program in nuclear data involves many laboratories

- **GEANIE – LANL, LLNL, Bruyères-le-Châtel, NC State**
- **FIGARO – LANL, Bruyères-le-Châtel**
- **N,Z – LANL, Ohio U**
- **DANCE – LANL, LLNL, ORNL, Colorado School of Mines, FZK Karlsruhe**
- **LSDS – LANL, LLNL, Bruyères-le-Châtel, RPI**
- **Proton – LANL, Georgia Tech**
- **Others – MIT, Kentucky, Kyushu, Harvard,...**