linac The Gaerttner Laboratory

Nuclear Data at Rensselaer

Report to CSEWG November, 2009

Y. Danon, N. Francis, M. Lubert, M. Rapp, F. Saglime, R. Bahran, J. Thompson

Rensselaer Polytechnic Institute, Troy, NY, 12180

and

D.P. Barry, R. C. Block, J.G Hoole, G. Leinweber, J. Geuther

KAPL Inc., Lockheed Martin Corporation, Schenectady, NY 12301-1072

Rensselaer

KAPL Neutron Spectroscopy Group

Measurements Completed This Year

- Ta - High energy (0.5-20 MeV) transmission
- Zr - High energy (0.5-20 MeV) neutron scattering
- ^{155,156,157,158,160}Gd - Epi thermal (2-2000 eV) capture measurements
- ^{nat}Eu ^{153}Eu - Thermal (0.01-20 eV) capture measurements
- ^{147}Sm and ^{149}Sm - (n,α) cross section measurements with the LANL LSDS
- ^{95,96,98,100}Mo - First batch of transmission measurements at 100 m and 31 m flight paths completed
- ^{235}U - Thermal (0.01-20 eV) capture and fission cross measurement to support development of an α (capture to fission ratio) measurement technique

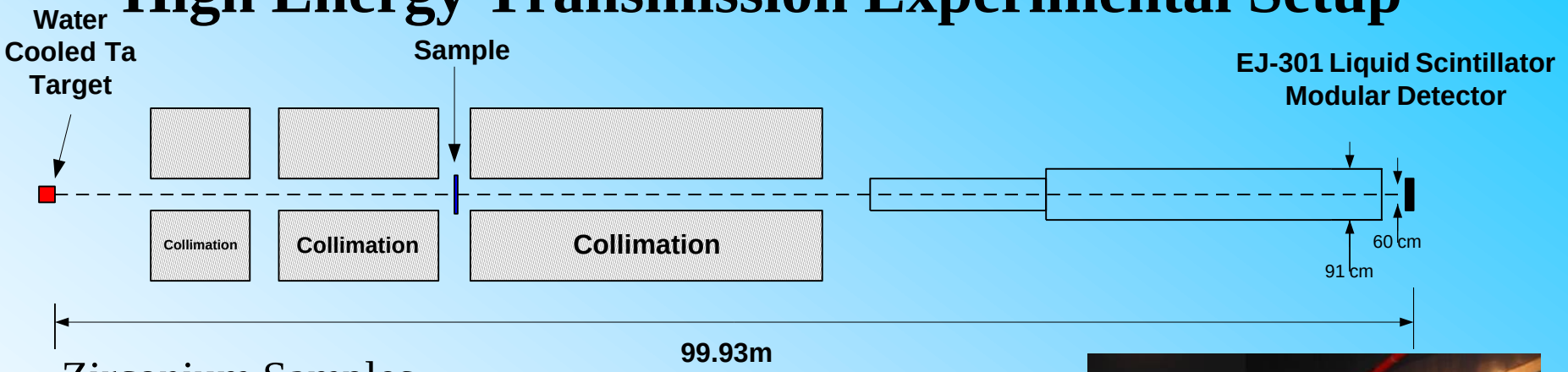
Planned Measurements

- High energy (0.5-20 MeV) neutron scattering from ^{238}U.
- Complete resonance region (1 eV- 400 keV) transmission measurements for $^{95,96,98,100}Mo$ isotopes
- Complete capture measurements of $^{155,156,157,158,160}Gd$ and Dy isotopes (NCSP).
- $^{149}Sm(n,\alpha)$ and $^{50}V(n,\alpha)$ cross section measurements at the RPI and LANL LSDS

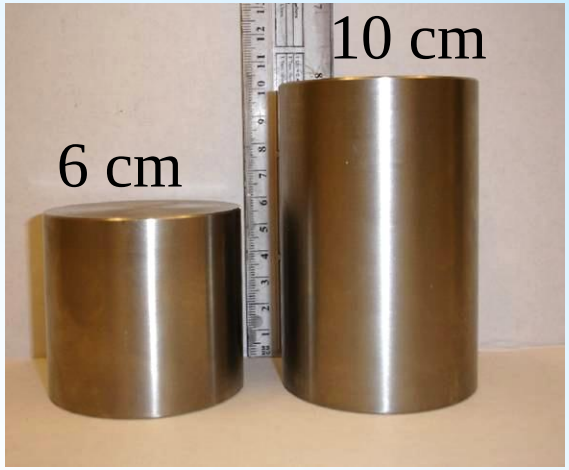
Data Analysis

Sample	Status
Be, Mo, Zr, Ti, Ta	High energy (0.5-20MeV) transmission analysis in progress
Zr	High energy (0.5-20MeV) scattering data analysis in progress
Be, C	High energy (0.5-20MeV) scattering paper submitted to NIM
Mo	"Resonance Parameters and Uncertainties Derived from Epithermal Neutron Capture and Transmission Measurements of Natural Molybdenum", accepted for publication in NS&E
Rh	SAMMY analysis pending
Cd	REFIT analysis pending (Moxon has our data)
Re	Data analysis suspended
Eu	Data analysis started
U-236	New samples and a transmission measurement required for completion of this task

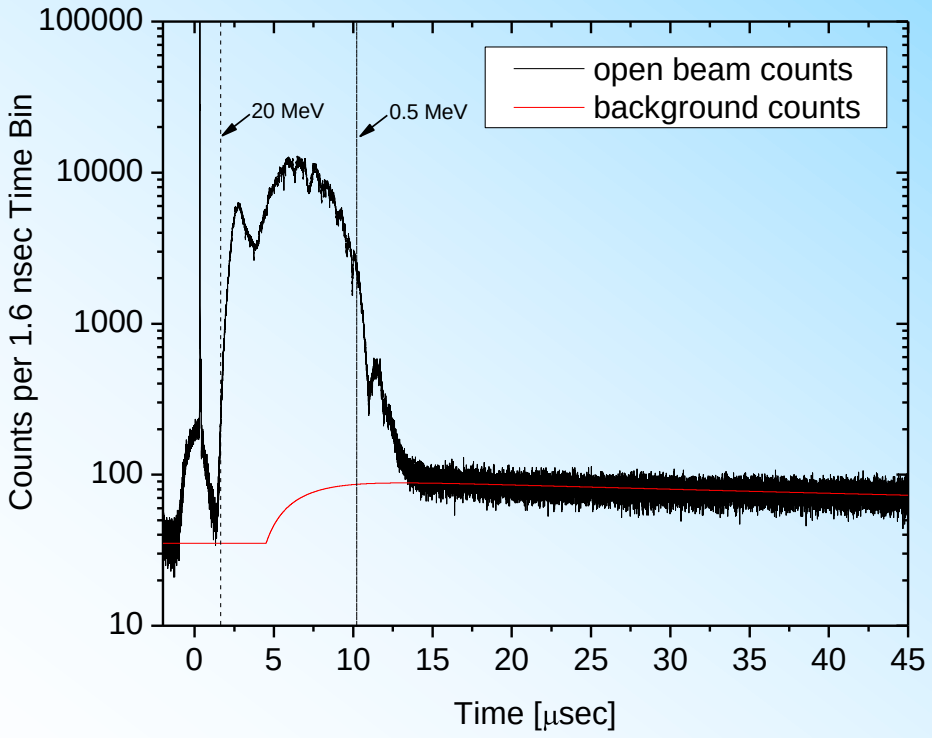
High Energy Transmission Experimental Setup



Zirconium Samples

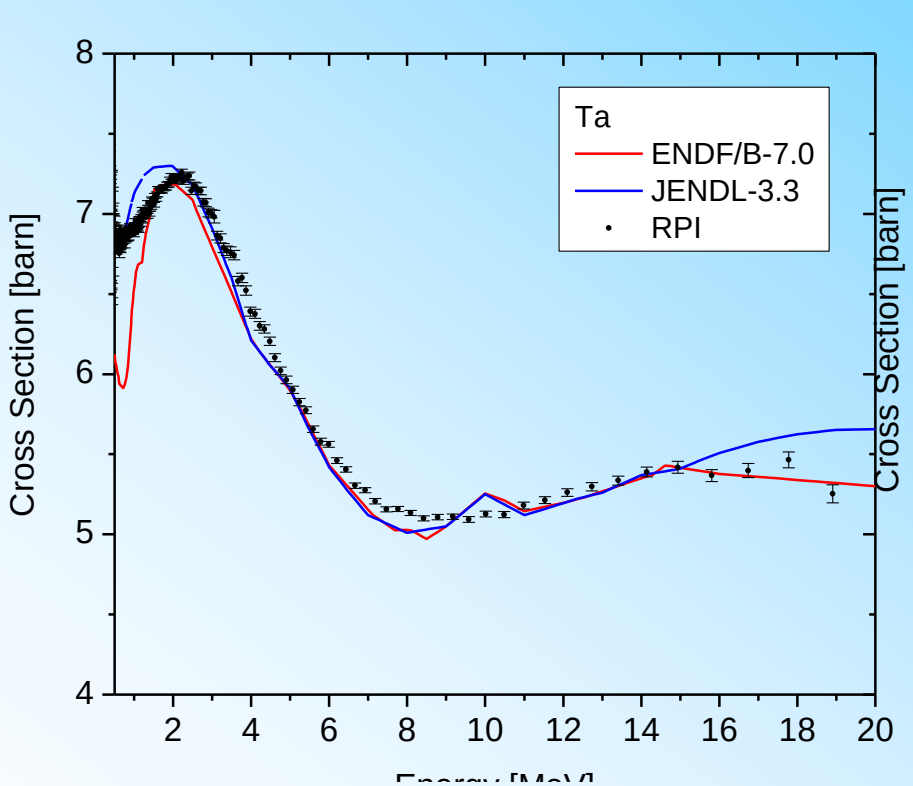


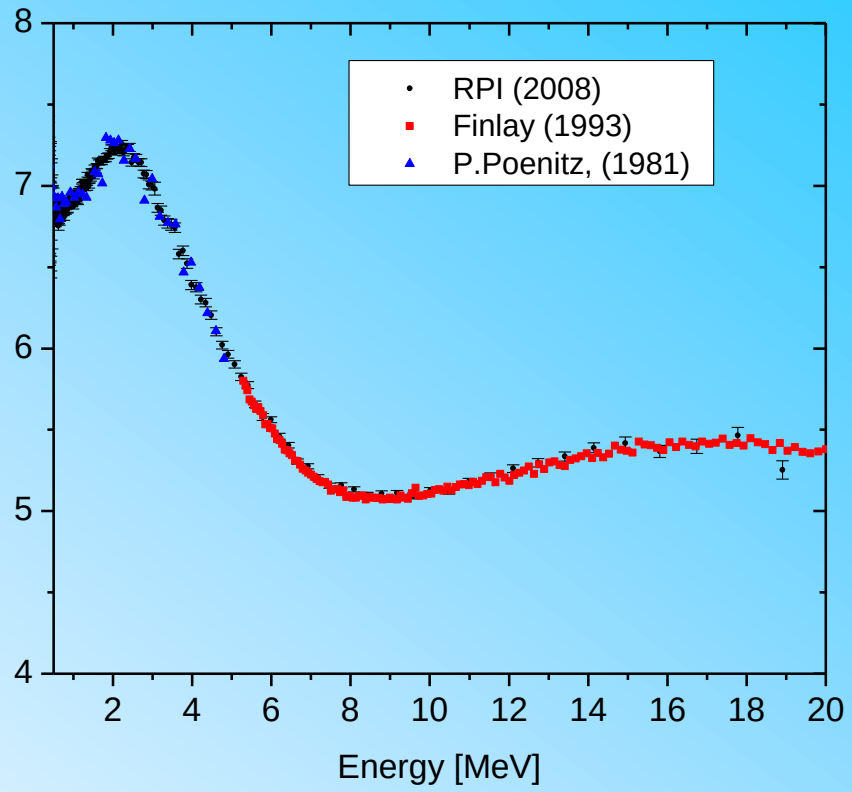
Background Determination



- MCNP was used to simulate background due to neutron capture interactions with the detector
- 2.2 MeV photons from hydrogen neutron capture were tallied in the detector volume as a function of time
- The MCNP tally was normalized to the exponentially decaying portion of the collected data (t>20 μs)
- The MCNP results were fitted to a pulse shape curve
- **18<(Signal-Bkg)/Bkg <200**

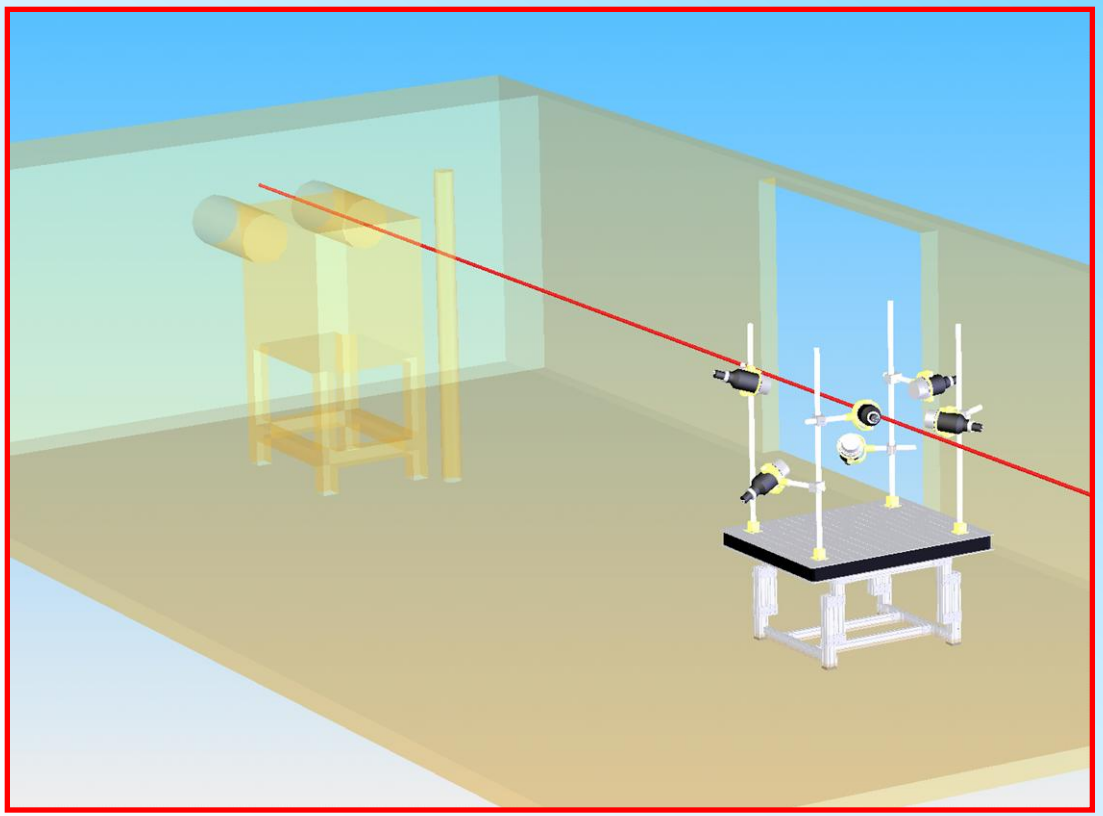
Tantalum

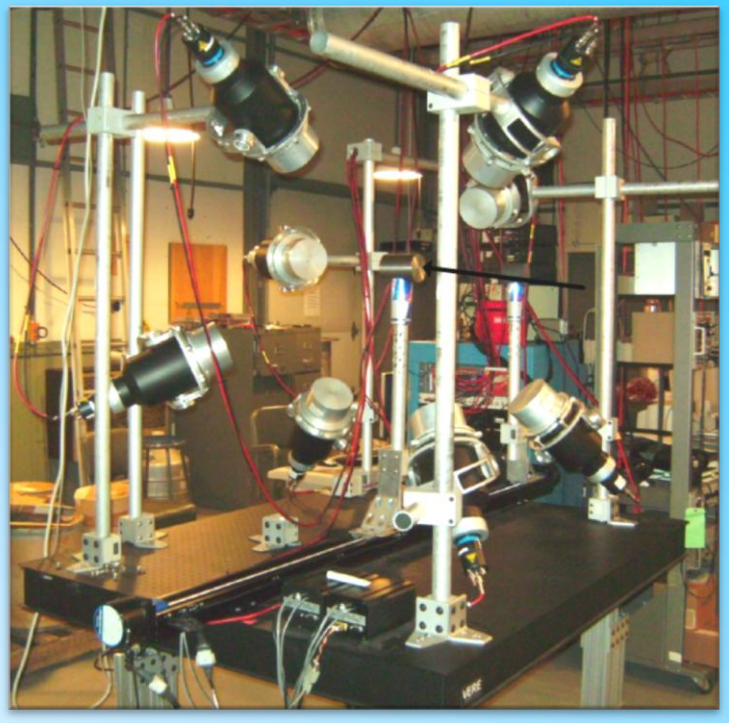




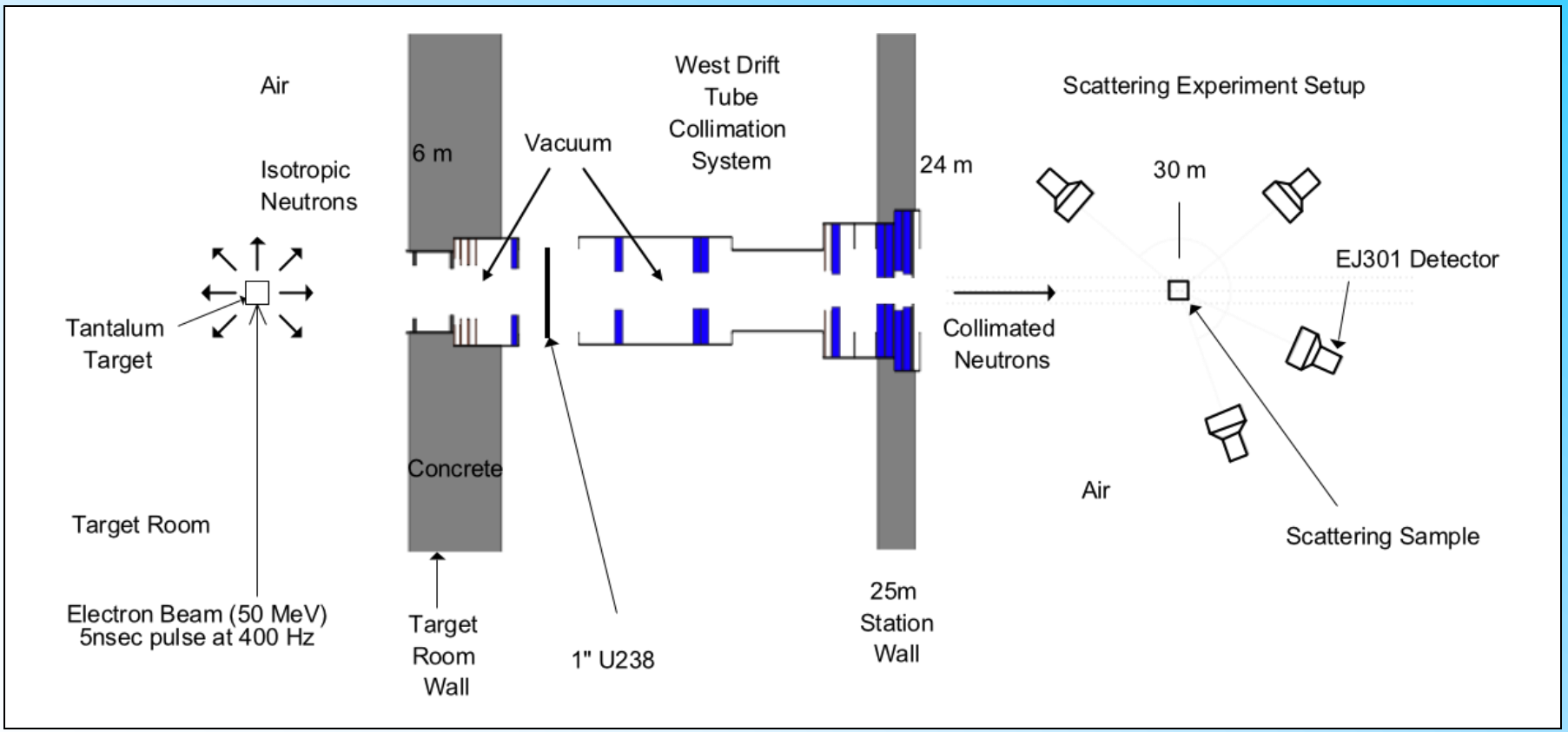
- Deviations from ENDF/B-7.0 and JENDL-3.3 below 3 MeV
- RPI measurement agrees with other experimental data

Fast Neutron Scattering Detector Array



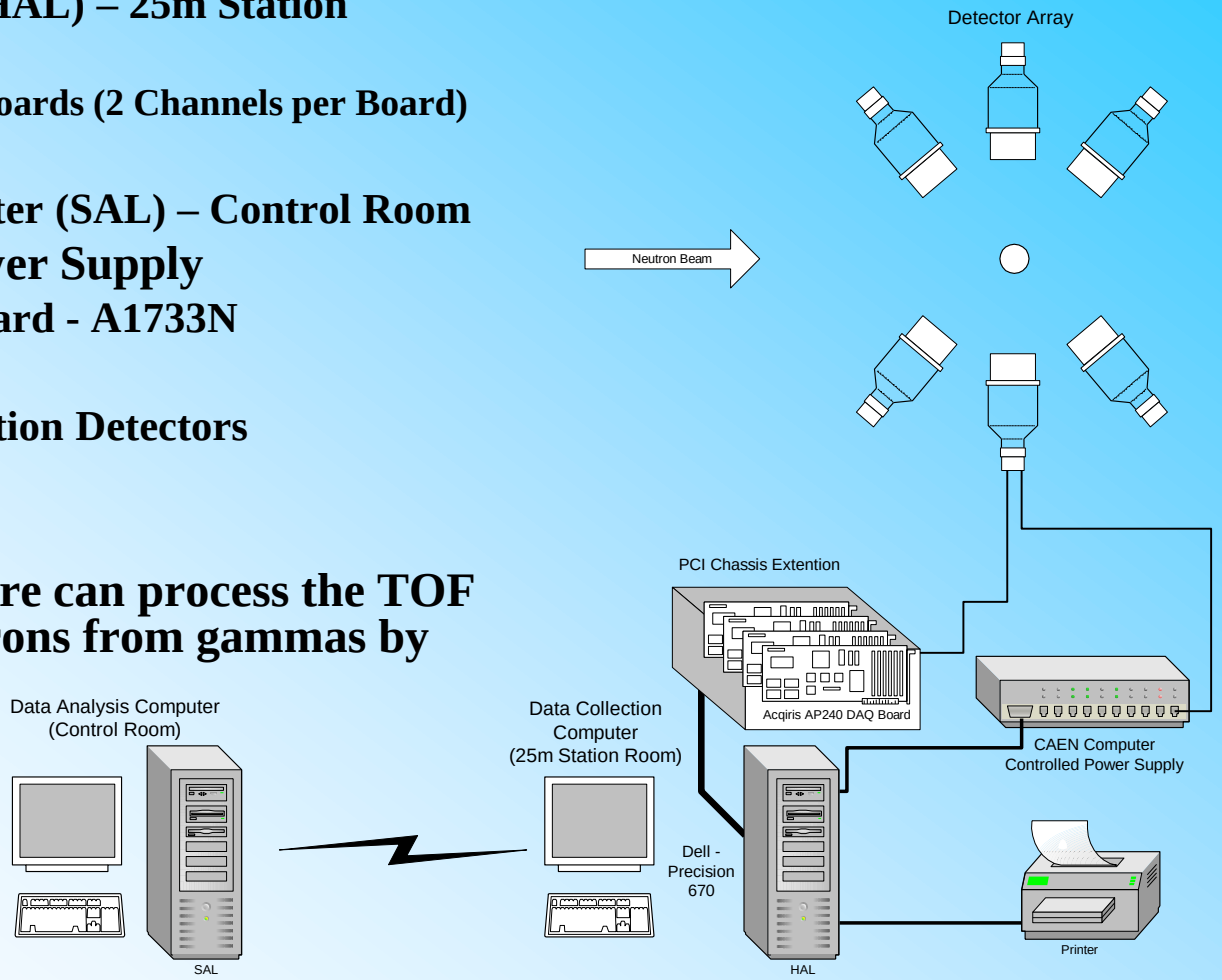


Scattering Experiment Setup Overview



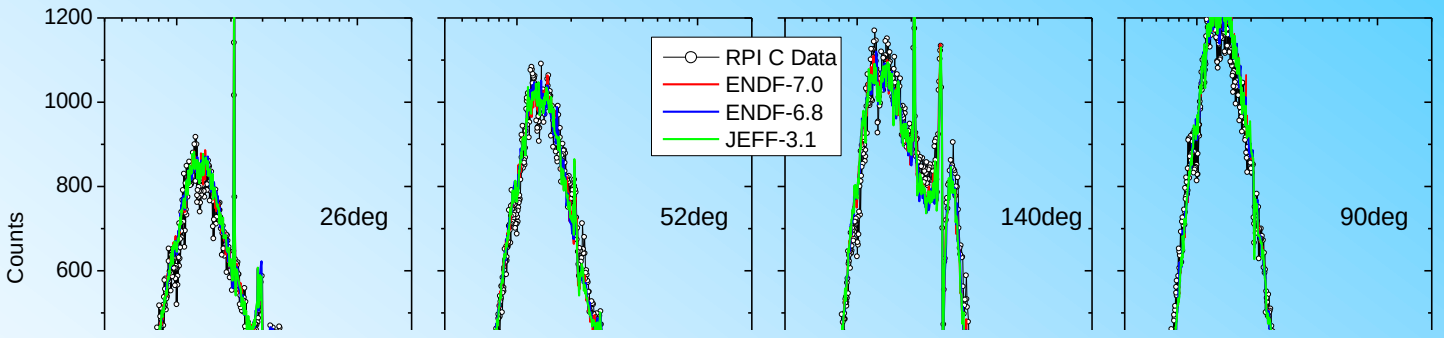
Scattering Detection System: Experimental Setup

- **Data Acquisition System**
  - **Main DAQ Computer (HAL) – 25m Station**
  - **PCI Extension Chassis**
    - **Acqiris AP240 DAQ Boards (2 Channels per Board)**
- **Data Processing System**
  - **Data Processing Computer (SAL) – Control Room**
- **Computer Controlled Power Supply**
  - **Chassis - SY 3527 Board - A1733N**
- **Detector Array**
  - **8 EJ301 Liquid Scintillation Detectors**
  - **Detector Stands**
- **Sample Holder / Changer**
- **The RPI developed software can process the TOF data and distinguish neutrons from gammas by pulse shape analysis**

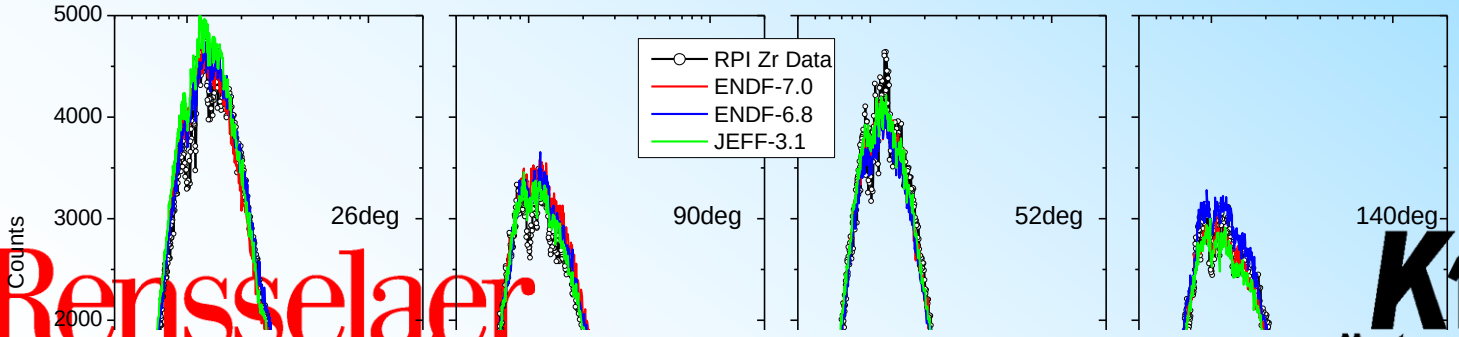


Zr Scattering Preliminary Results

C-7 cm

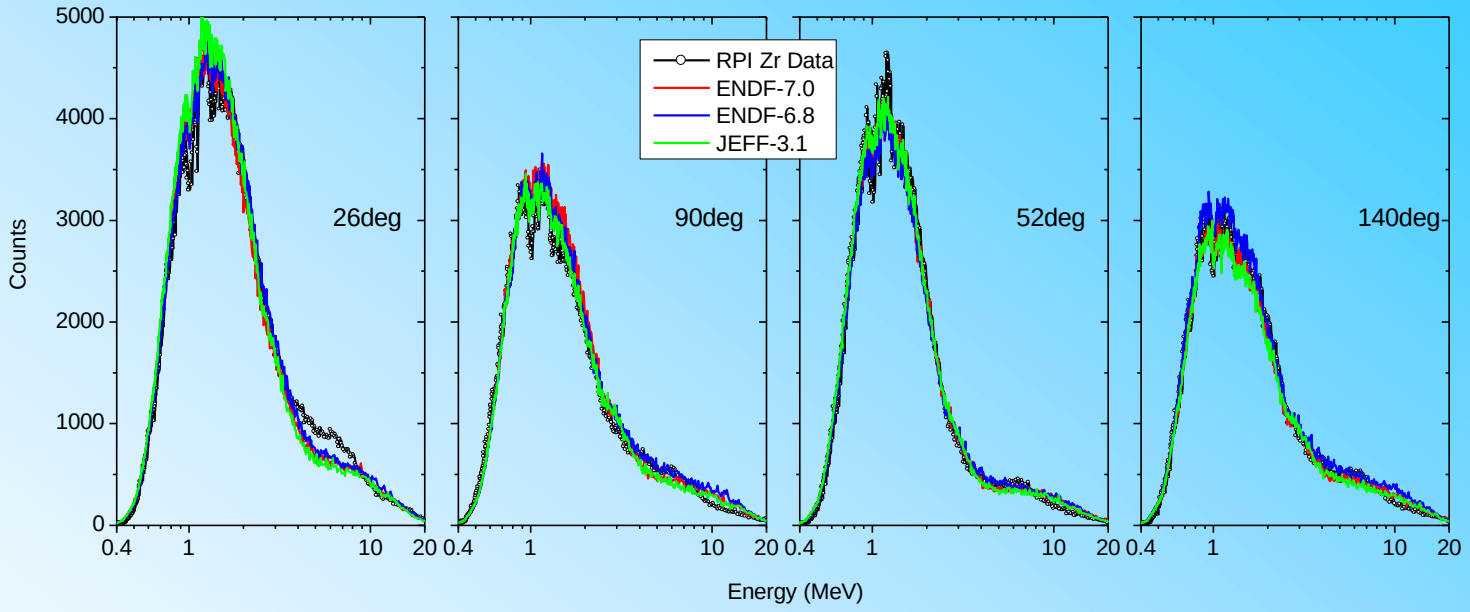


Zr-6 cm

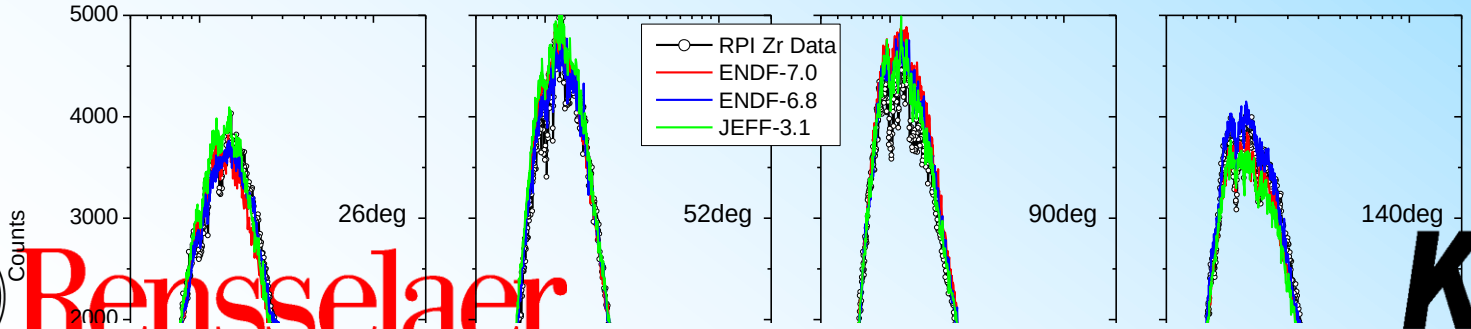


Zr Scattering Preliminary Results

Zr-6 cm

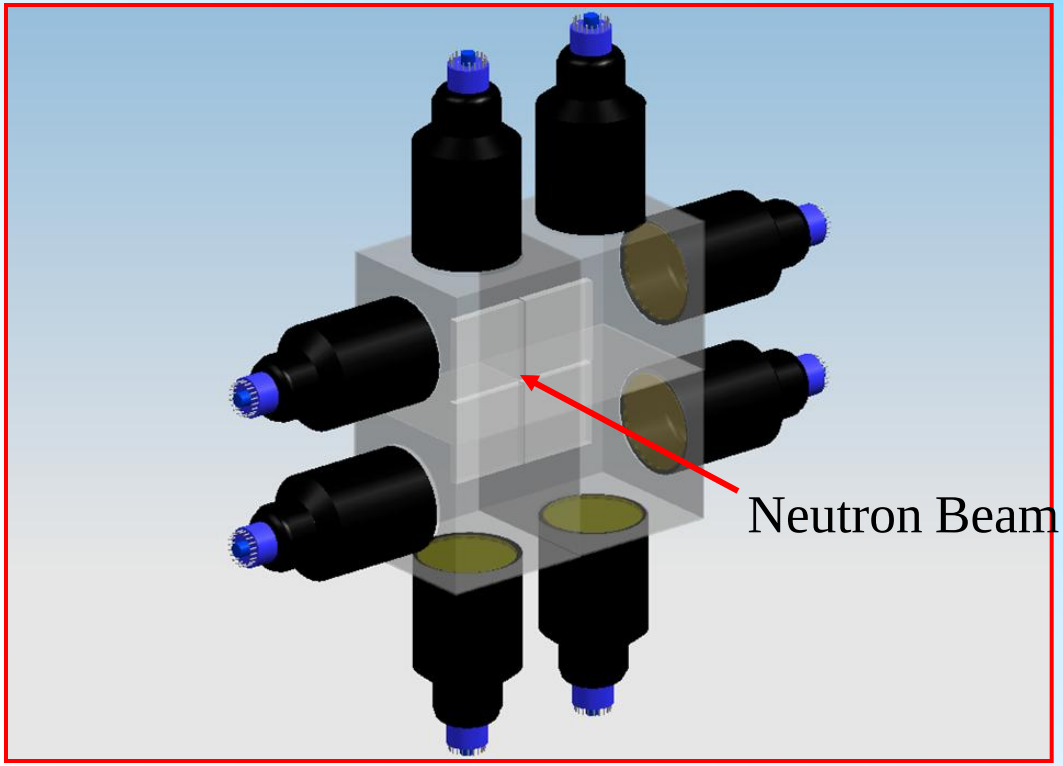


Zr-10 cm



High Resolution Transmission Detector

- Modular Li-Glass detector at 100m flight path
  - Extends our capabilities to the unresolved resonance region
  - Qualification measurements in progress.

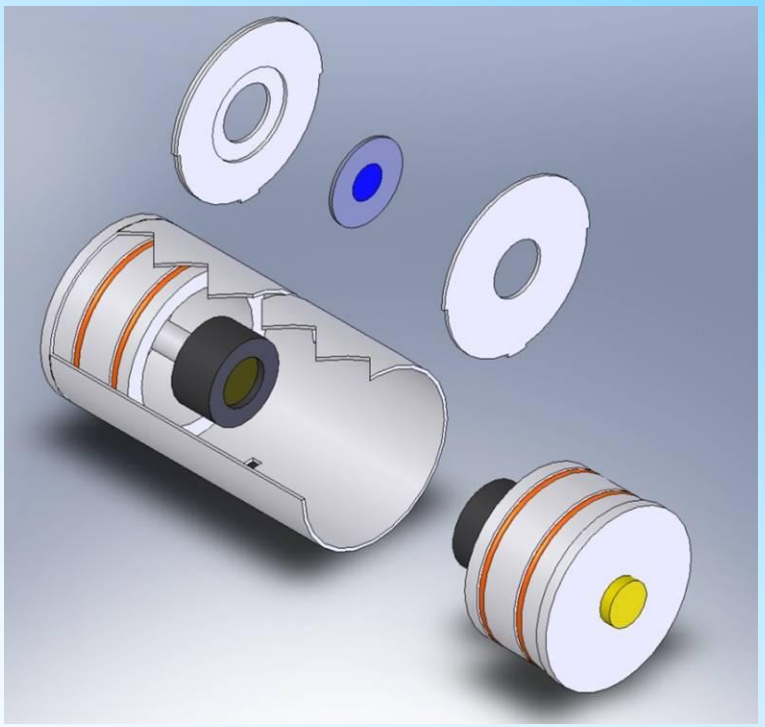


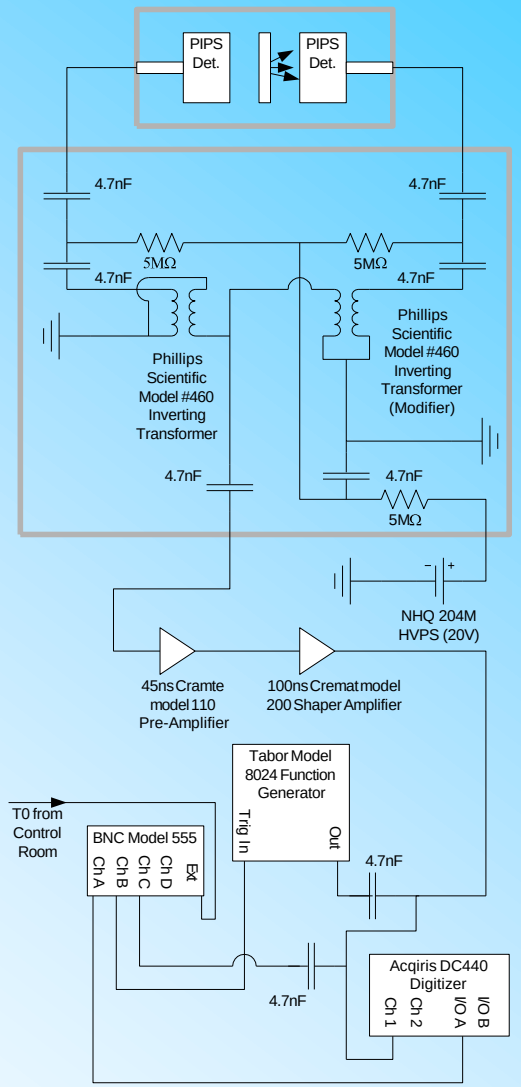
Lead Slowing Down Spectrometer

- Fission cross section and fission fragment spectroscopy
  - Measured ^{235}U and ^{239}Pu.
  - ^{248}Cm is planned.
  - Cathy Romano PhD topic.
- Detectors for (n,α) and (n,p) measurements are under development
  - Compensated Solar Cells
  - Compensated PIPS detectors
  - Compensated GEM amplified detectors

Working hard with the LANL LSDS

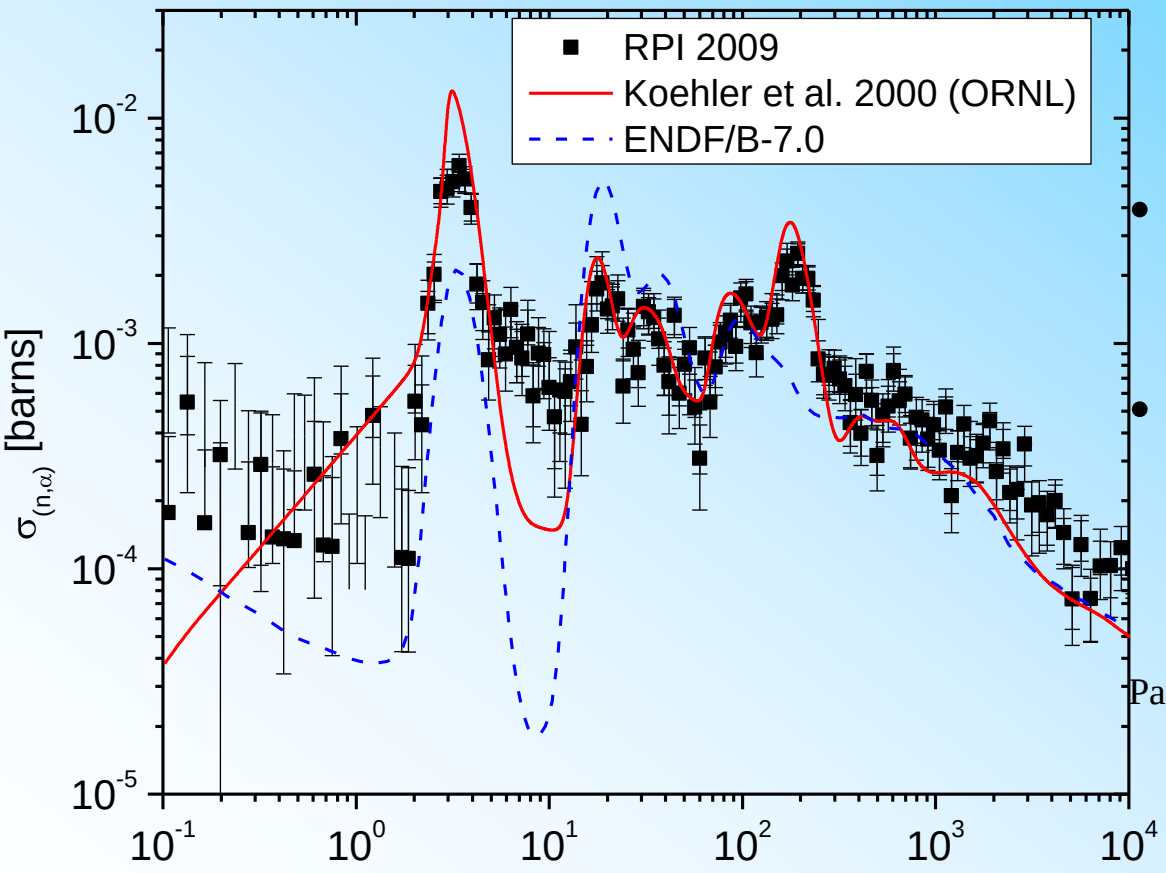
Compensated PIPS Detector





Gamma discrimination by recording the gamma spectra on face to face detectors

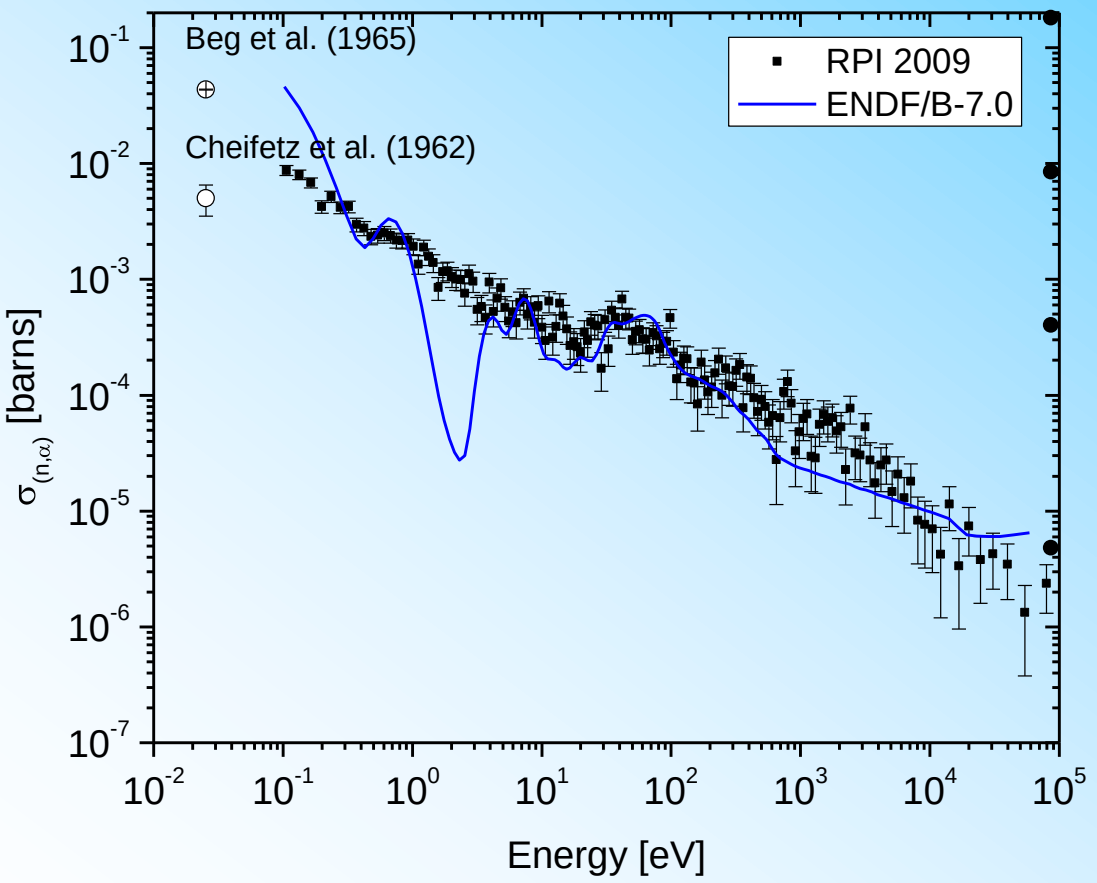
Measurement of (n,α) cross section of ^{147}Sm



- The motivation was to demonstrate the ability to measure small cross section of small sample with the LSDS
- Used 9.6 0.05 mg of 98.03% enriched ^{147}Sm sample
- Our data agrees with the resolution broadened Koehler measurement better than ENDF/B 7.0

Paul E. Koehler et al. Phys. Rev. C 69,015803,2004

Measurement of (n,α) cross section for ^{149}Sm



- This is the only measured data for this reaction
- Used 9.4±0.05 mg of 97.67 % enriched ^{149}Sm
- The data are in reasonable agreement with the ENDF/B-7.0 estimate
- Extrapolation of the thermal value is in better agreement with the Beg et al. (1965) measurement

Gd Resonance Parameters

- Published
  - G. Leinweber, D.P. Barry, M.J. Trobovich, J.A. Burke, N.J. Drindak, , HD Knox, RV Ballad, R.C. Block, Y. Danon, L.I. Severnyak, "Neutron Capture and Total Cross-Section Measurements and Resonance Parameters of Gadolinium",. NS&E, **154**, 261-279 (2006).
- Show reduction of 11% in the thermal value of ^{157}Gd
- New benchmark is in agreement with our data
  - G. Perret, M. F. Murphy, F. Jatuff, J-Ch. Sublet, O. Bouland, R. Chawla, "Impact of New Gadolinium Cross Sections on Reaction Rate Distributions in 10 10 BWR Assemblies, NS&E, **163**, 1, 17-25 (2009)
  - "**The PROTEUS results support the new thermal and epithermal gadolinium data measured by Leinweber et al**."
- Consider revising the ^{157}Gd evaluation.

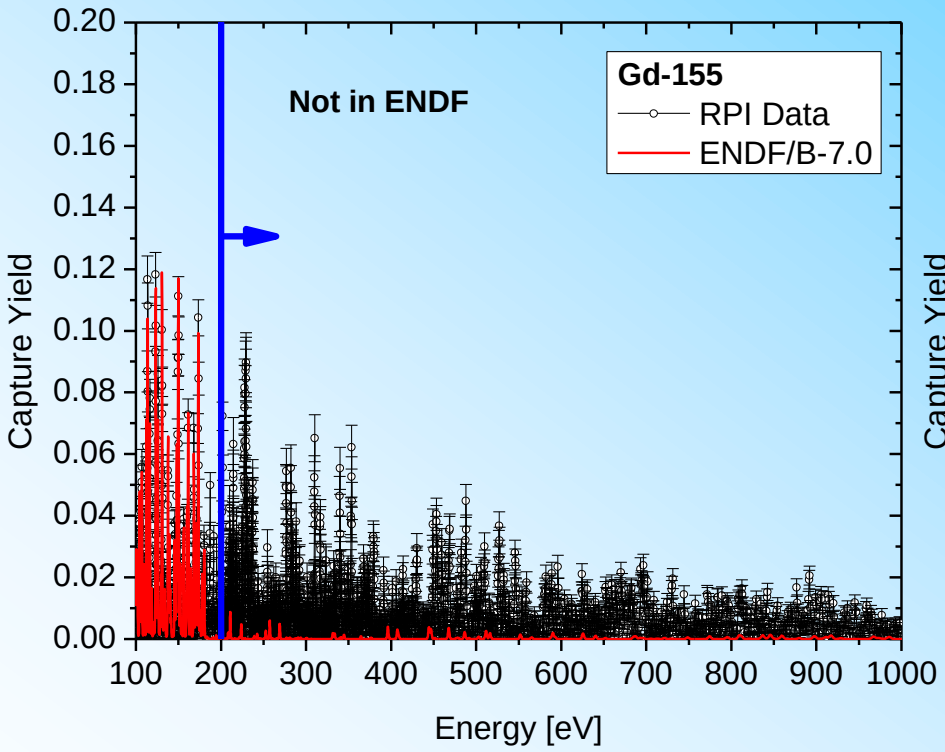
New Gd Resonance Region Measurements

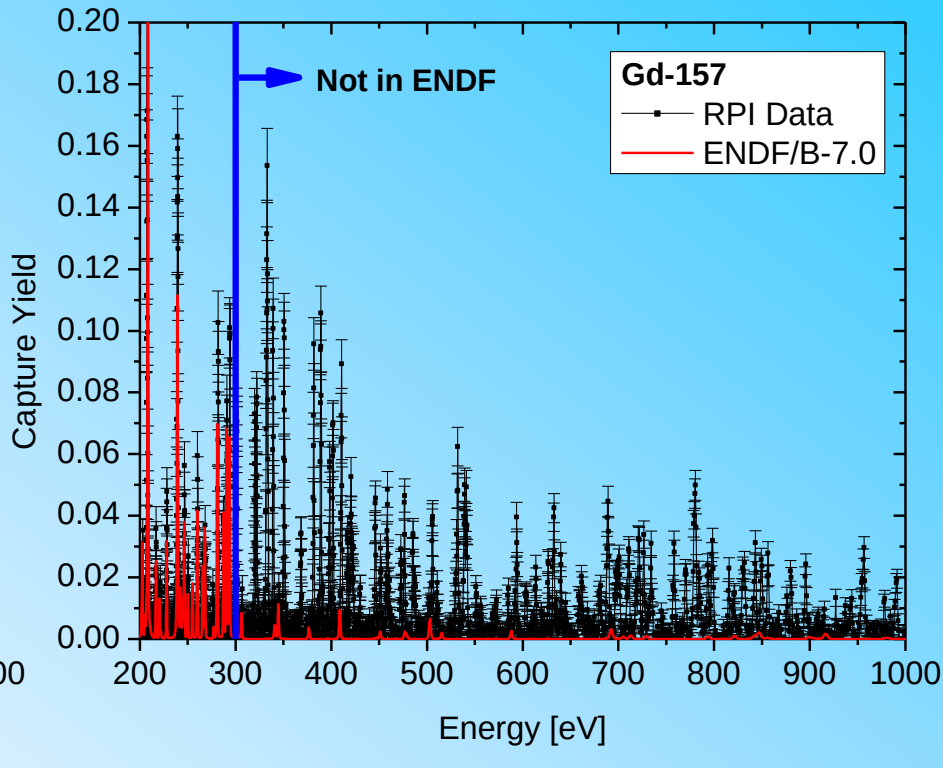
- Obtained enriched isotopes of ^{155,157,156,158,160}Gd form Korea
- Measurements were funded by NCSP through ORNL and were done during Feb 2009

Gd enriched samples

- Small samples
  - Round samples dimensions: ~ 18 mm diam x 0.1 mm thick
  - Square samples dimensions: ~ 15 mm x 15 mm x 0.2 mm thick
- Measured for ~70 hours

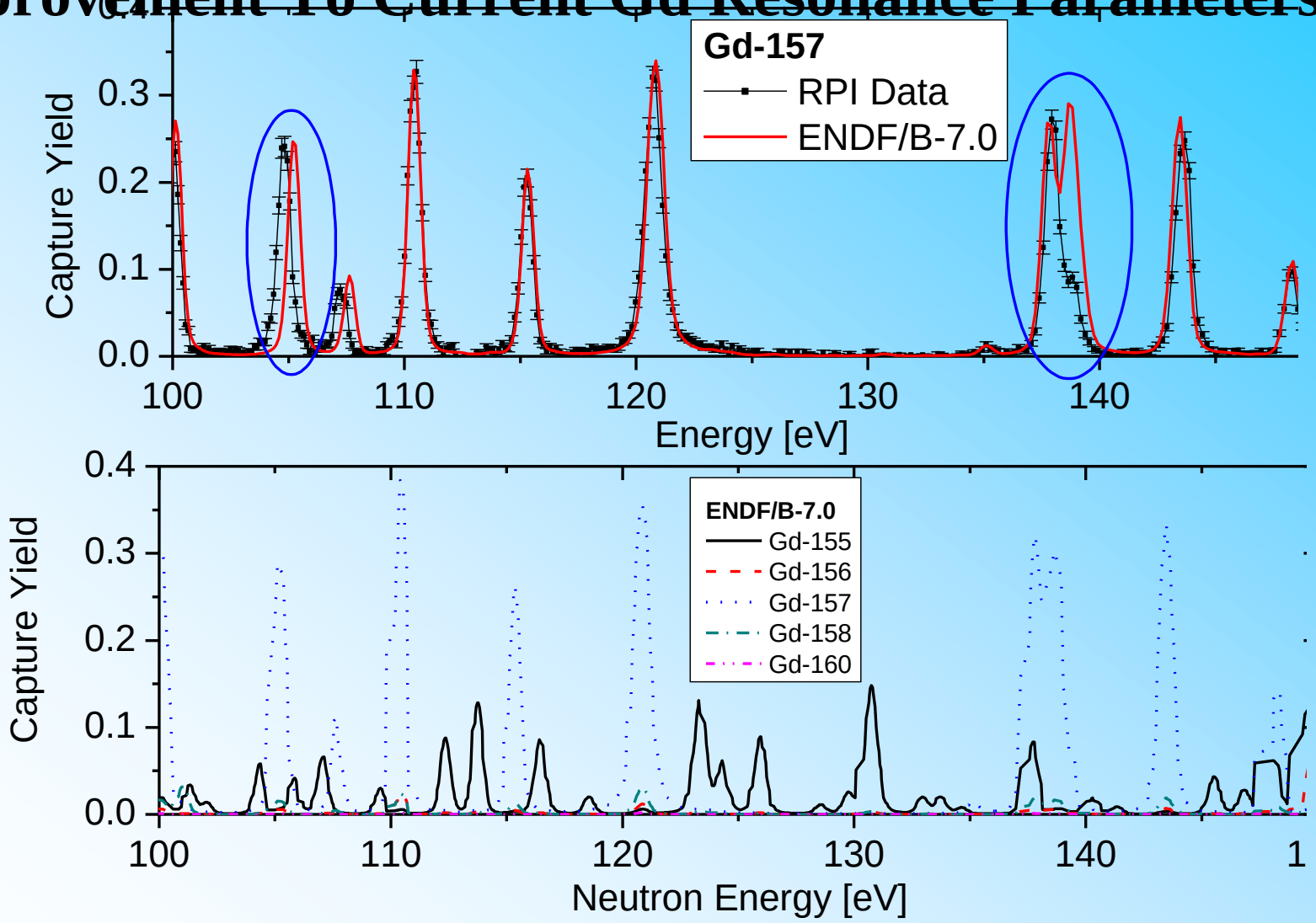
^{155}Gd and ^{157}Gd





- Many new resonances were observed

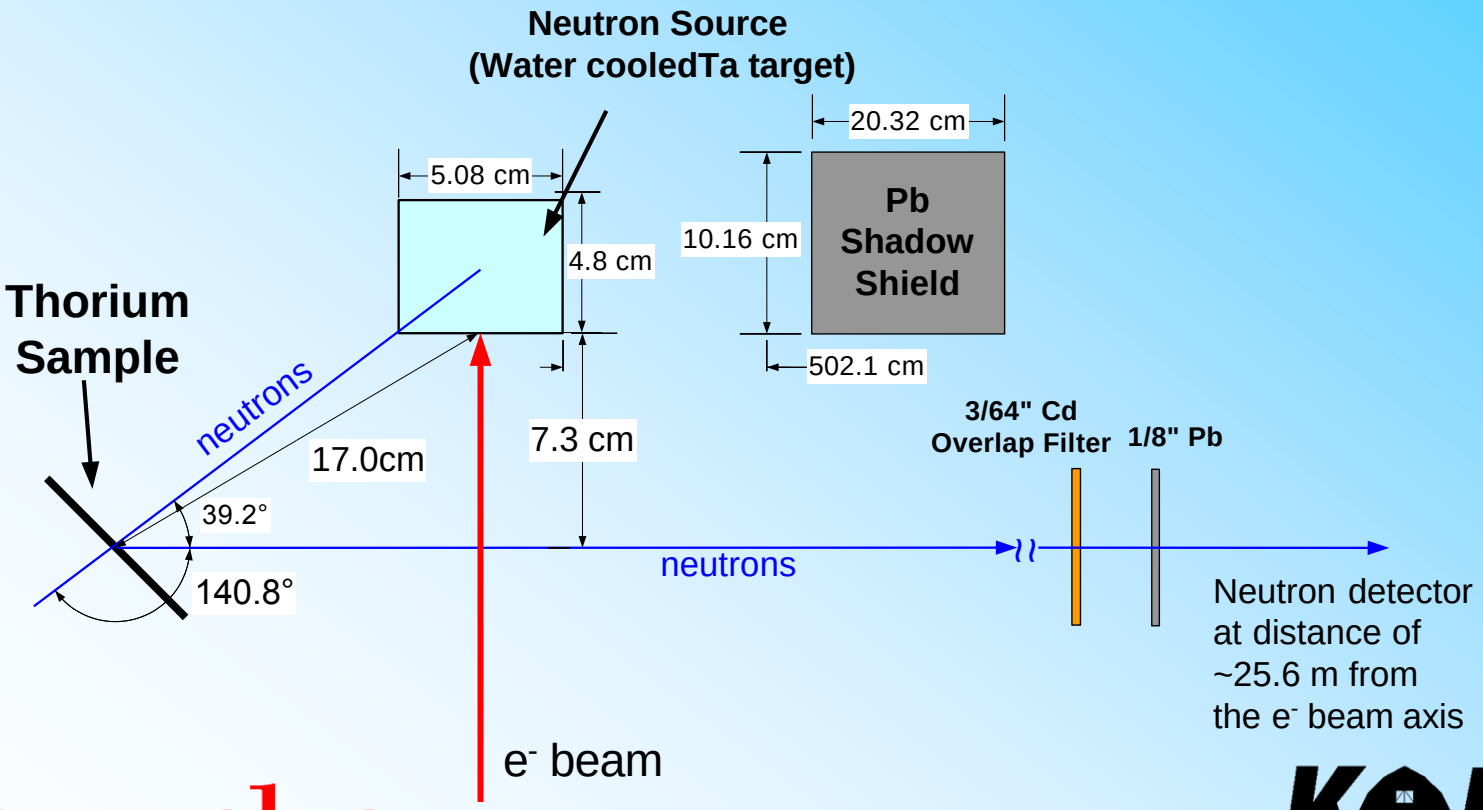
Improvement To Current Gd Resonance Parameters



Thorium Resonance Scattering - Experimental Setup

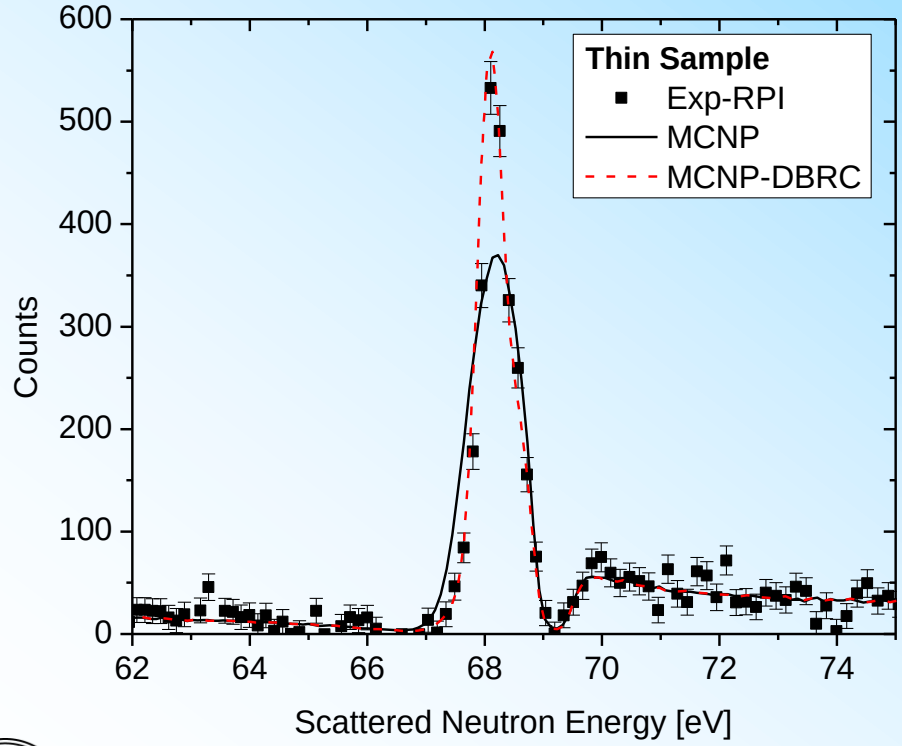
- Compare experiments and calculations for neutron backscattering
- The backscattering angle was **140.8**

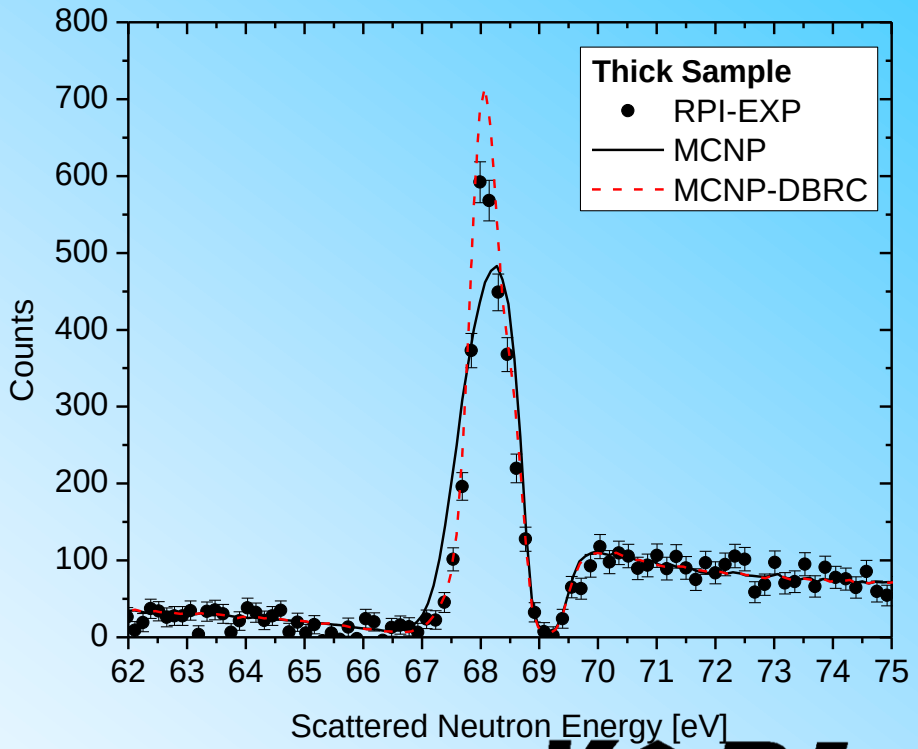
Back Scattering Geometry



Thorium Backscattering Experimental Results

- Two sample thicknesses were used
- Experimental data was compared to current MCNP Doppler broadening and the new Doppler Broadening Rejection Correction (DBRC) method implemented by Dagan in MCNP 5
- The DBRC method is in good agreement with the experiments





linac The Gaerttner Laboratory

Nuclear Data at Rensselaer

Report to CSEWG November, 2009

Y. Danon, N. Francis, M. Lubert, M. Rapp, F. Saglime, R. Bahran, J. Thompson

Rensselaer Polytechnic Institute, Troy, NY, 12180

and

D.P. Barry, R. C. Block, J.G Hoole, G. Leinweber, J. Geuther

KAPL Inc., Lockheed Martin Corporation, Schenectady, NY 12301-1072

Rensselaer

KAPL Neutron Spectroscopy Group

Depleted ^{238}U Discs for Scattering Experiments

- Obtained from Y-12 with the support of NCSP and facilitation by ORNL