Update on CIELO Related Nuclear Data Measurements at the Gaerttner LINAC Center at RPI

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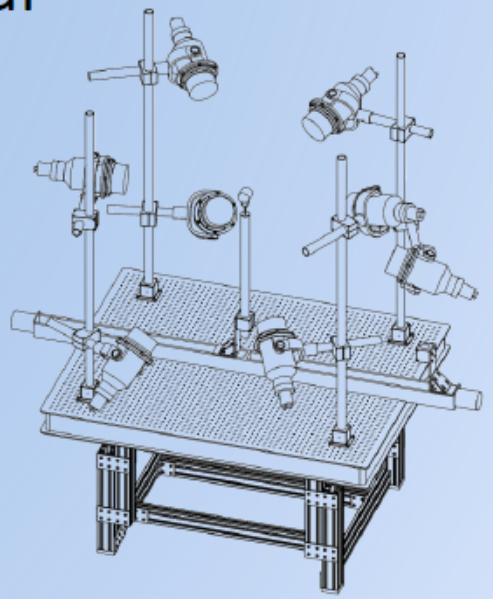
linac The Gaerttner LINAC Center

Summary of Related Activity

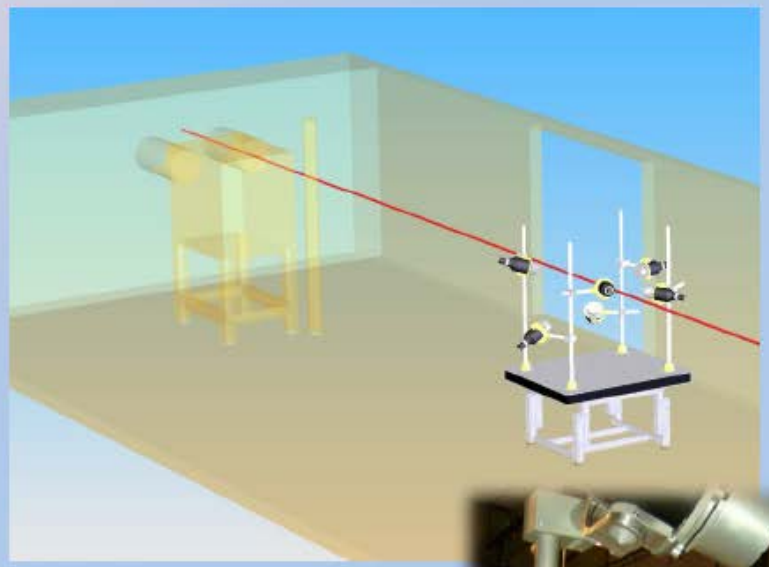
- ^{235}U fission and capture yield up to 3 keV.
  - Data was delivered to Leal (ORNL) for inclusion in the evaluation.
- ^{56}Fe - high resolution transmission, 0.5-20 MeV
  - Data was delivered to Leal (ORNL) for inclusion in the evaluation.
- Neutron scattering 0.5-20 MeV
  - Data on ^{238}U published.
  - Data on Fe finalized, publication in process.
- Prompt fission neutron measurements
  - Data on ^{238}U in progress.

Neutron Scattering

- Provide accurate benchmark data for scattering cross sections and angular distributions in the energy range from 0.5 to 20 MeV
- Can be developed to provide differential elastic and inelastic scattering cross section measurements
- Design a flexible system: now also used for fission neutron spectra measurements



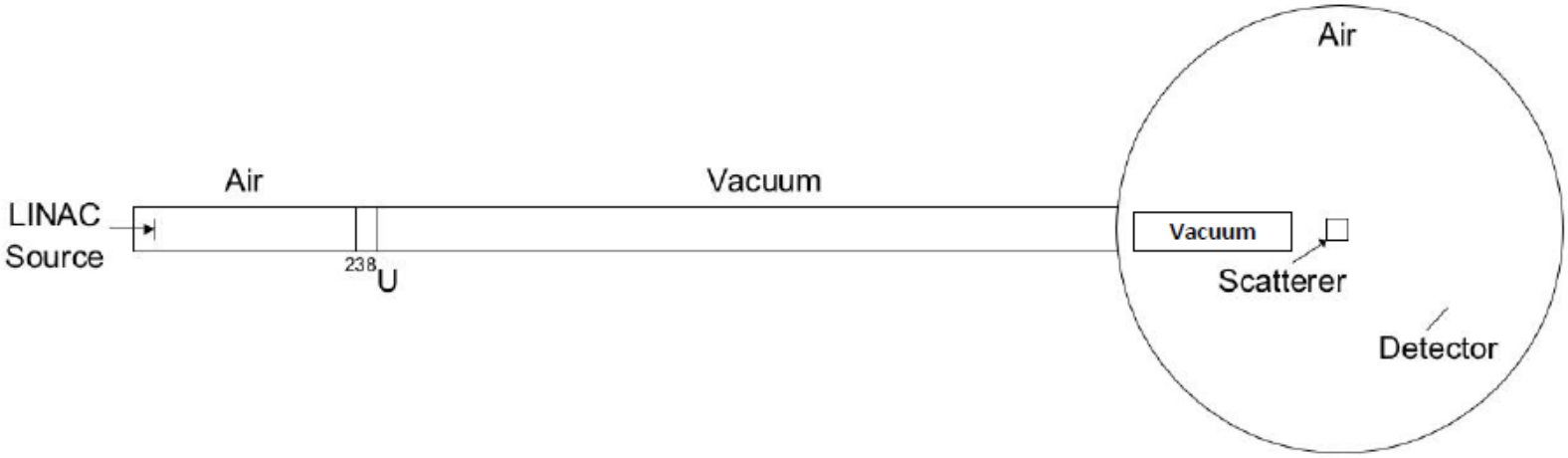
Scattering Detection System: Experimental Setup



Low mass sample holder

MCNP Simulation Geometry

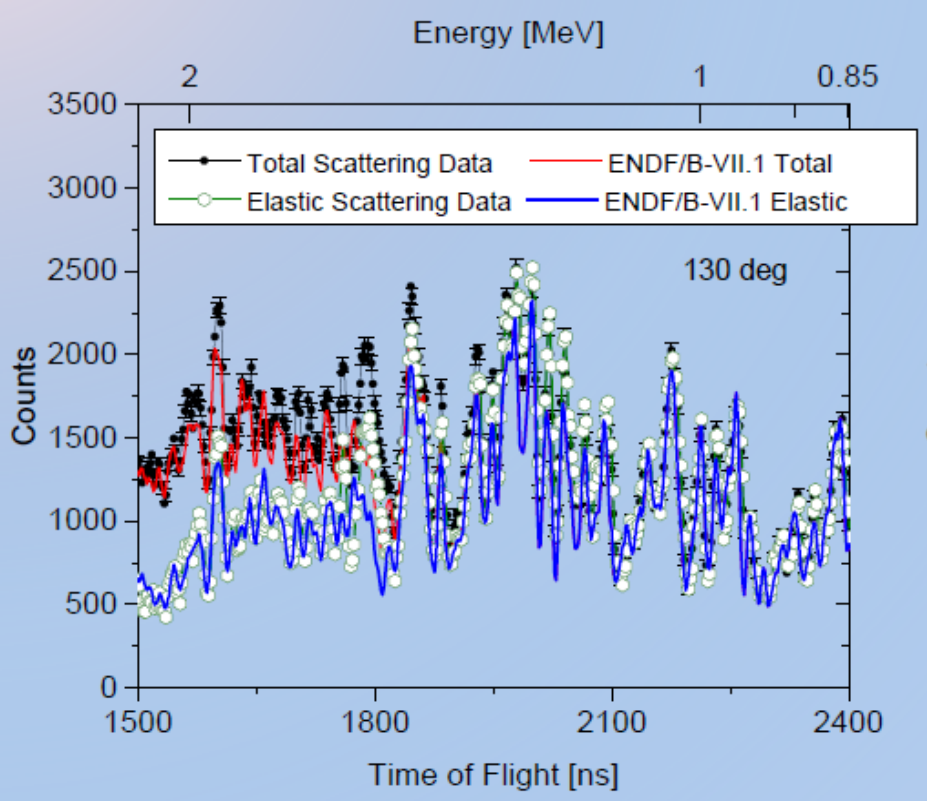
- Use ASAP (As Simple As Possible) approach
- Use array of point detector tally F5 to model the EJ301 detector
  - Convolute the tally with the detector efficiency
- Include ¾" Depleted U filter in the simulation
- Include windows (Al)
- Include recent improvements of vacuum tube near the sample

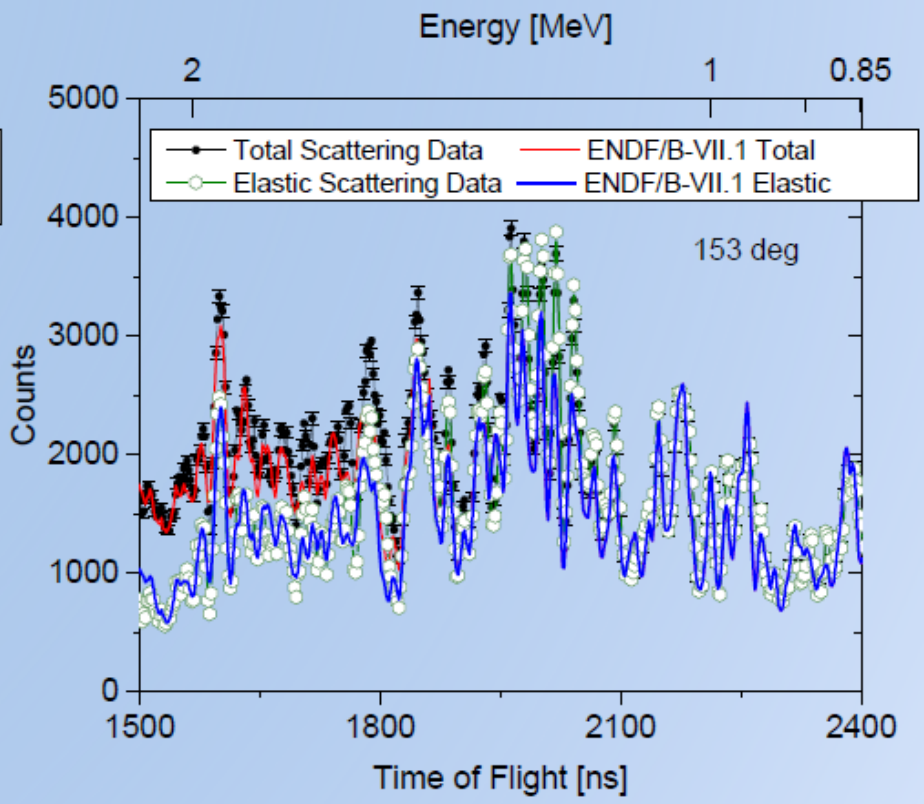


Observations for ^{nat}Fe

- The JENDL-4.0 evaluation had best overall agreement with experimental data from 0.5 to 20 MeV for all angles.
- Experimental data can be analyzed further to provide:
  - Inelastic to Elastic Scattering Ratios
  - Elastic (only) Scattering Contribution

Elastic Scattering vs MCNP simulation





- Elastic scattering can be measured from 0.5 to 2.0 MeV
- Only elastic scattering contribution measured and simulated
- Collaborating with ORNL to improve new ^{56}Fe evaluation

Summary

- Neutron scattering in the energy range from 0.5-20 was measured for Fe and ^{238}U at several scattering angles.
  - Data and MCNP simulation were used as benchmark for cross section and angular distribution evaluations.
  - Based on FOM the ^{238}U and ^{nat}Fe data is in best agreement with the JENDL-4 evaluations.
  - Inelastic to elastic scattering ratio were obtained for the 1st excited state and compared with evaluations. All evaluations agree with experimental data within 1-2 times the experimental uncertainty.
- Prompt fission yields were measured using the gamma tag method
  - ^{252}Cf measured fission neutron spectrum below 1 MeV is in good agreement with evaluations
  - Experimental results for ^{238}U provide some information about the change in the PFNS as a function of energy.

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Quasi-differential neutron scattering from ^{238}U from 0.5 to 20 MeV

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ABSTRACT

The Rensselaer Polytechnic Institute Linear Accelerator was used to produce a pulsed neutron beam that was incident on a ^{238}U scattering sample 30 m from the source. Eight liquid scintillator (EJ-301) proton recoil fast neutron detectors located at several angles surrounding the sample were positioned at a distance 0.5 m. Neutrons resulting from elastic scattering, inelastic scattering, and fission reactions were recorded as a function of time-of-flight. Pulse shape analysis including a new gamma misclassification correction was used to reduce erroneous counts from gamma events produced from fission and inelastic scattering reactions. The experimental data were simulated using an improved model of the Rensselaer Polytechnic Institute neutron scattering system that included individual detector efficiencies and neutron flux shape. The experimental data were compared with several evaluated nuclear data libraries using a figure-of-merit. Overall, the JENDL-4.0 evaluation provided the best agreement with the ^{238}U experimental data. Furthermore, the Rensselaer Polytechnic Institute scattering model was used to constrain uncertainties that allowed for improvements to a new ^{238}U evaluation.

1. Introduction

^{238}U is a significant component of the nuclear fuel cycle that includes nuclear fuel enrichment facilities, nuclear powered light water reactors, and spent fuel storage. To safely design these systems, accurate ^{238}U nuclear properties are required. Nuclear properties of ^{238}U, including neutron interaction probabilities and angular distributions of secondary particles, are found in evaluated ^{238}U nuclei. Experimental nuclear data provide a means to measure interaction probabilities and validate nuclear models.

Nuclear data can be obtained from many different experimental techniques designed to isolate and measure specific reactions. Smith et al. produced near mono-energetic neutron beams to perform double differential scattering experiments with a thin sample at discrete angles to determine the energy dependent angular distribution (Smith et al., 1978). Integral critical bench-

Message from Yaron Danon:

- **The actual U-238 experimental data is in final review that I need to do before it will be released by our sponsor. This includes the experimental data and MCNP input files that were used for the simulation of the detector responses.**
- **A publication for the Fe data is almost ready and once published the experimental data and simulations will be released as well.**