Examining and Modeling Gamma Emission from Quasi-Differential High Energy Scattering Measurements

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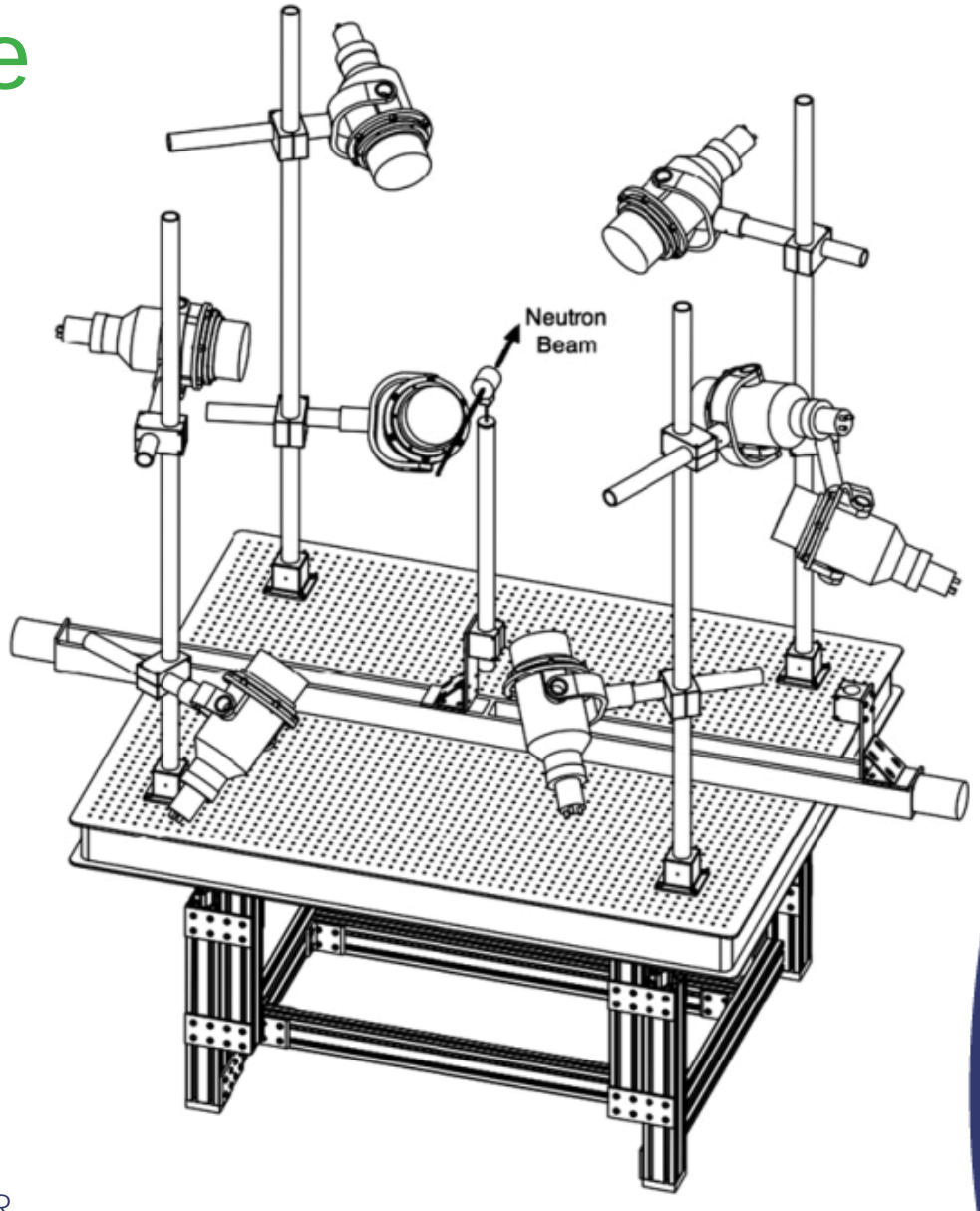
Outline

- Motivation
- RPI Gaerttner LINAC Center
- High Energy Scattering System
- Modeling Detector Efficiency
  - Energy calibration
  - Upper and lower-level discriminators
- High Energy Scattering Measurements
  - Iron – primarily 847 keV
  - ^{238}U – Inelastic and fission gammas
- Next Steps



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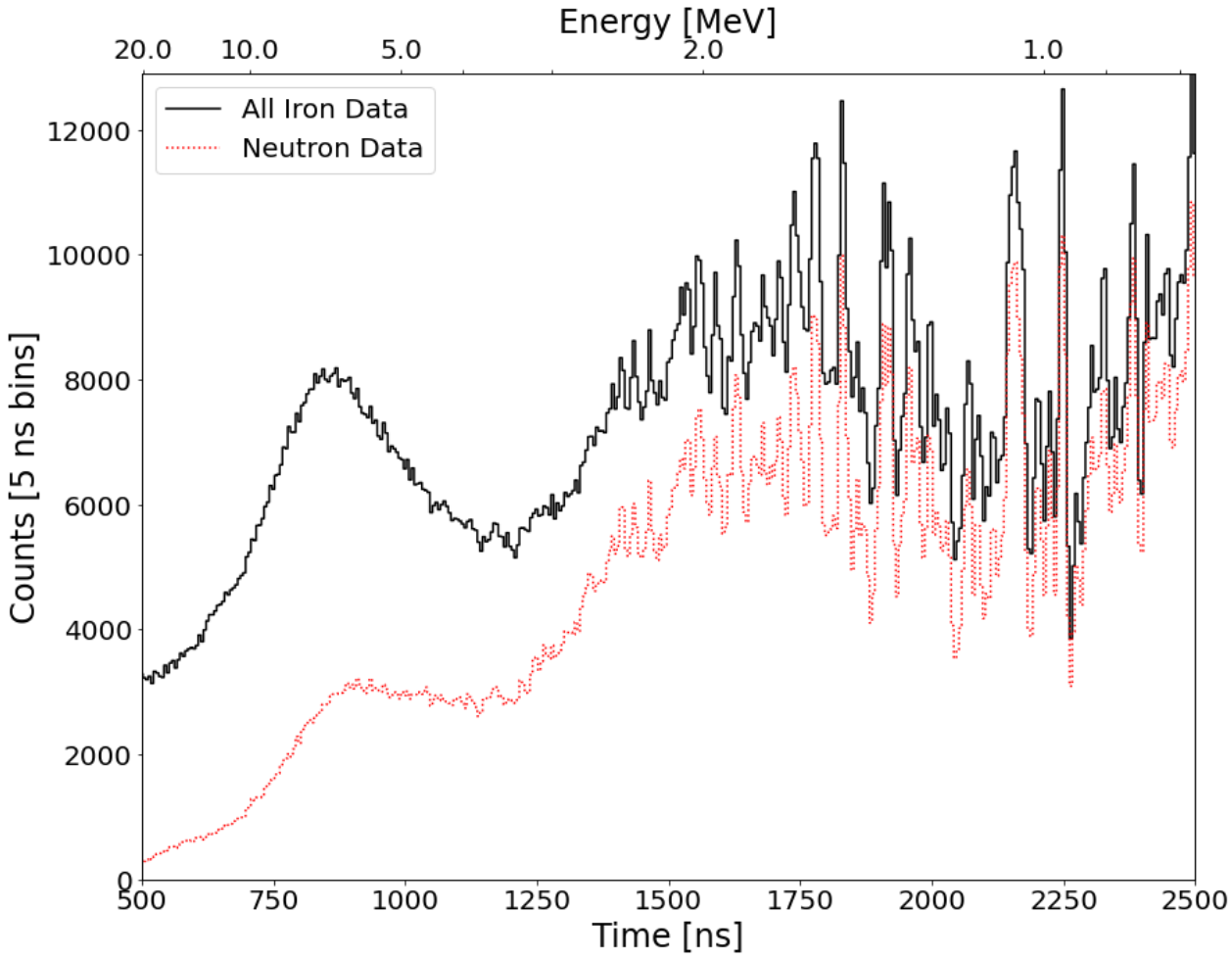
Motivation

- Both neutrons and gammas are measured during experiments
  - Neutron data is used for total quasi-differential scattering, inelastic-to-elastic ratios, elastic-only, etc.
  - Gamma data are typically ignored
- Develop methods to analyze gamma data to be used as additional tools for validation



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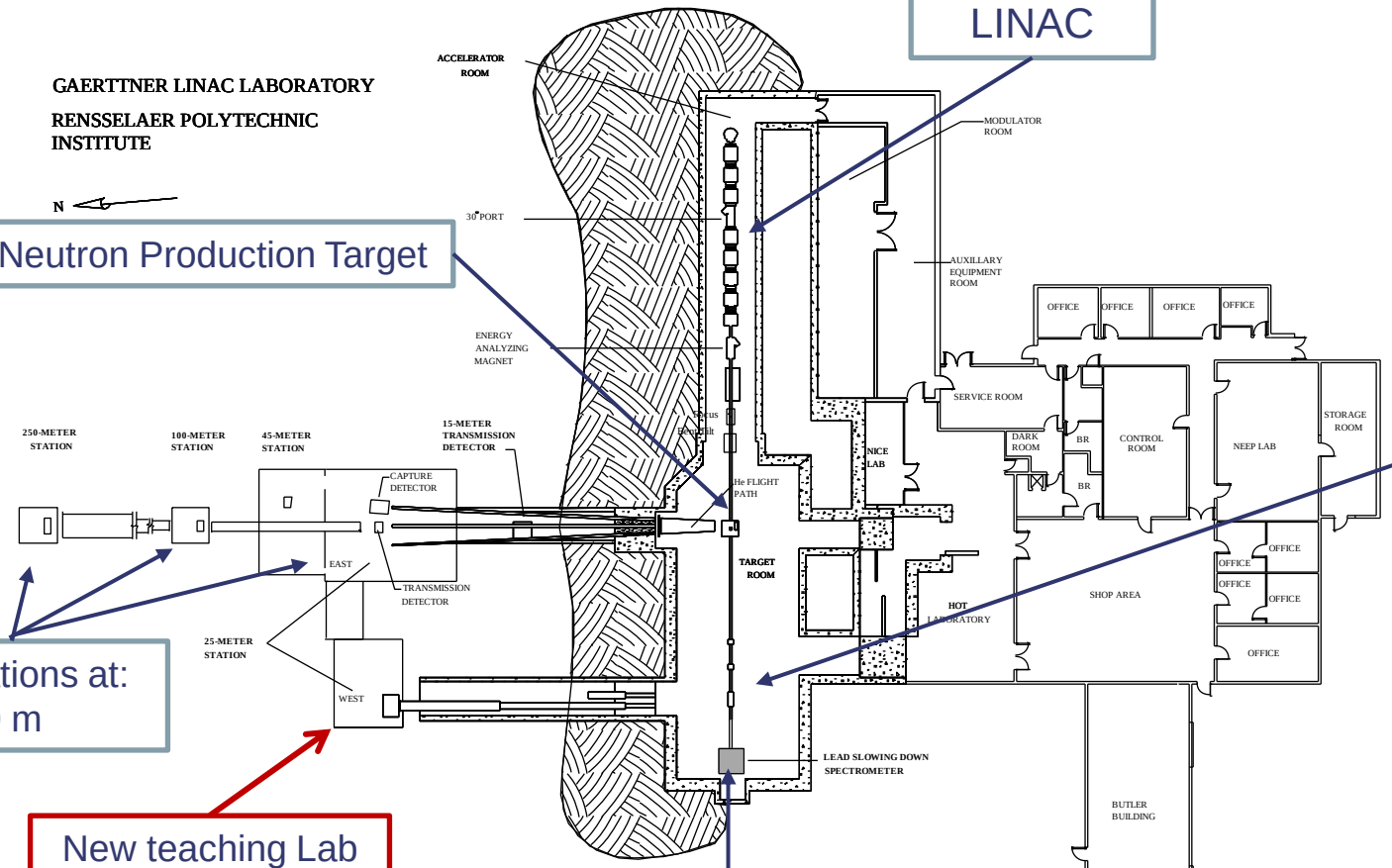
The RPI Gaerttner LINAC Center

Electron LINAC

Target room



Neutron Production Target

Detection Stations at:
15 - 250 m

New teaching Lab

Lead Slowing Down Spectrometer

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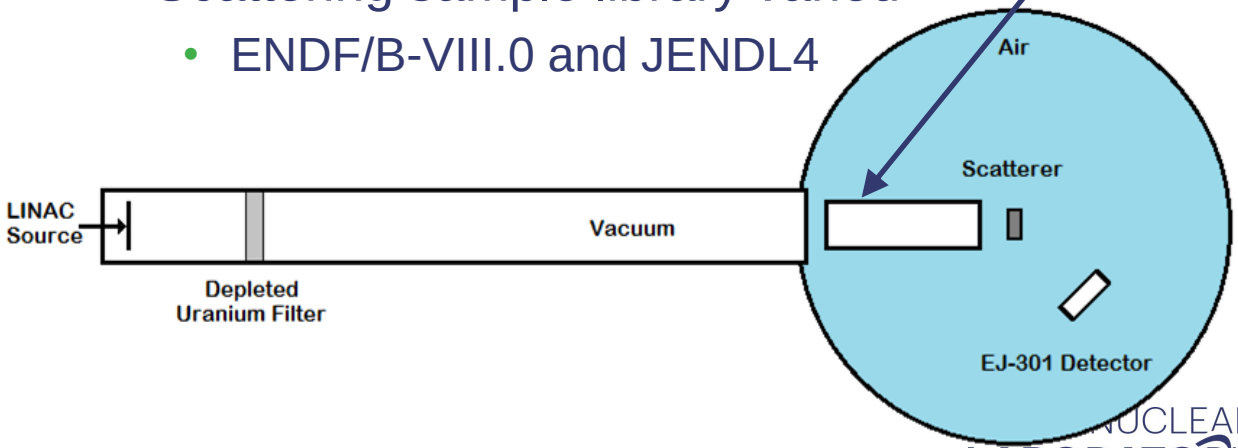
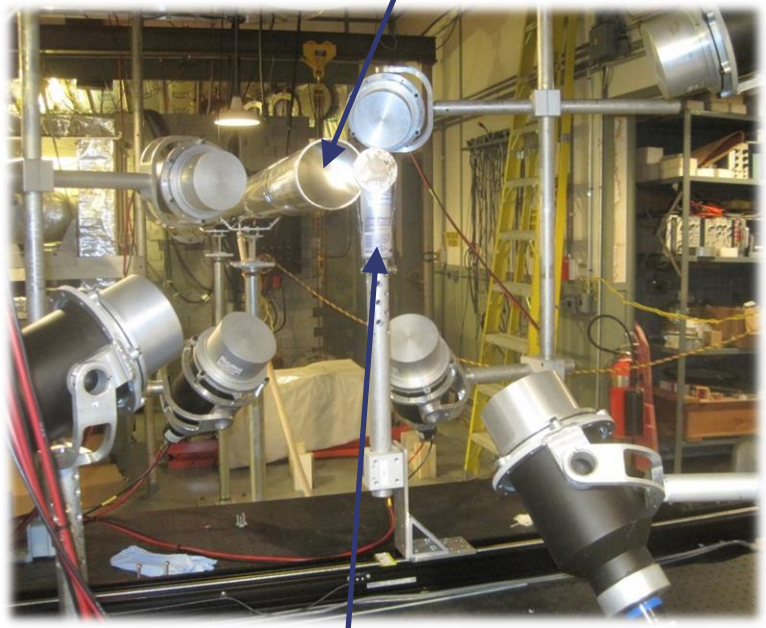
High Energy Scattering System

- Each experiment collected three sets of data:
  - Sample of Interest, e.g., ^{238}U or Iron
  - Graphite Reference Sample
  - Open Beam
- Fluctuations in neutron intensity recorded by beam monitors
- Experiments were modeled in MCNP
  - Scattering sample library varied
    - ENDF/B-VIII.0 and JENDL4



Upstream vacuum reduced open beam contribution‡

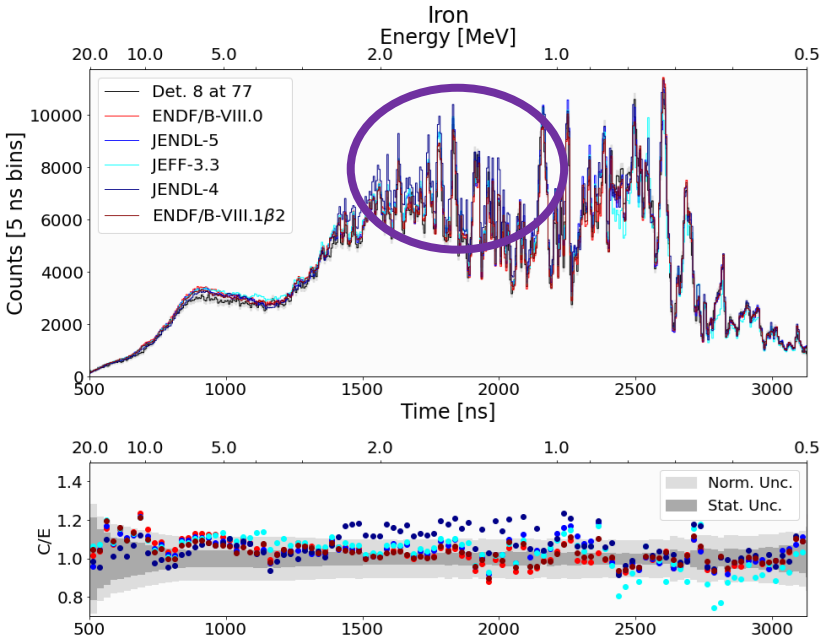


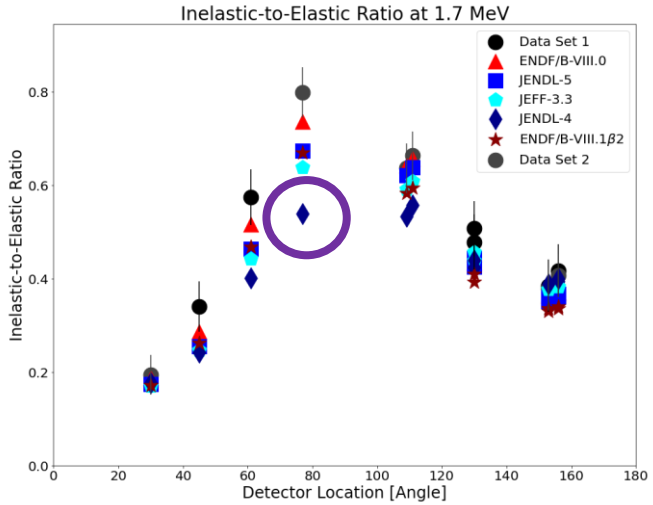
Low mass sample holder

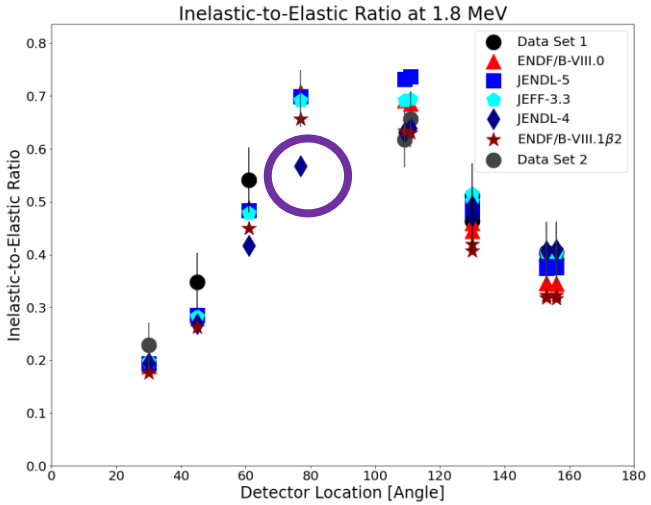
‡ Present after 2011

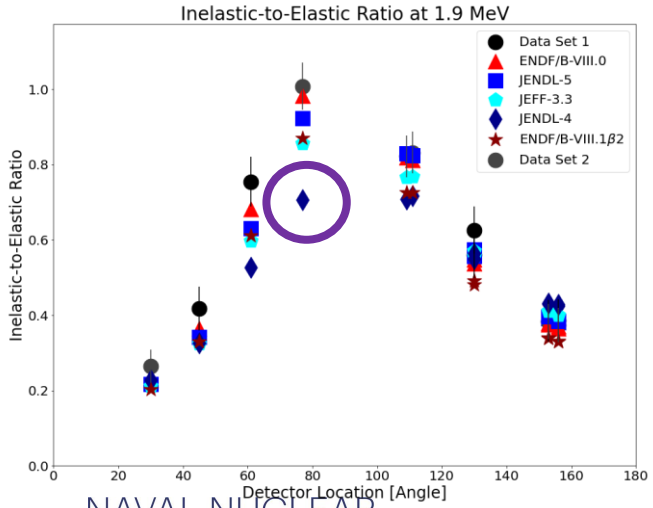
Revisiting Discrepancies with Iron and JENDL4

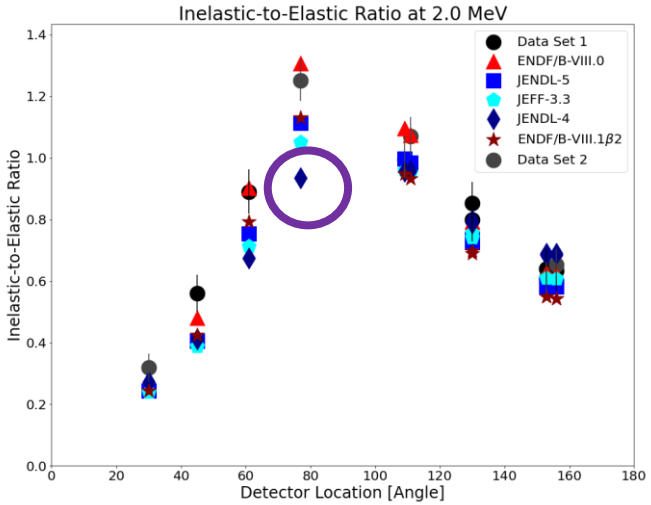
- Recall that JENDL-4 had poor agreement with measured data
- Inelastic-to-elastic ratios











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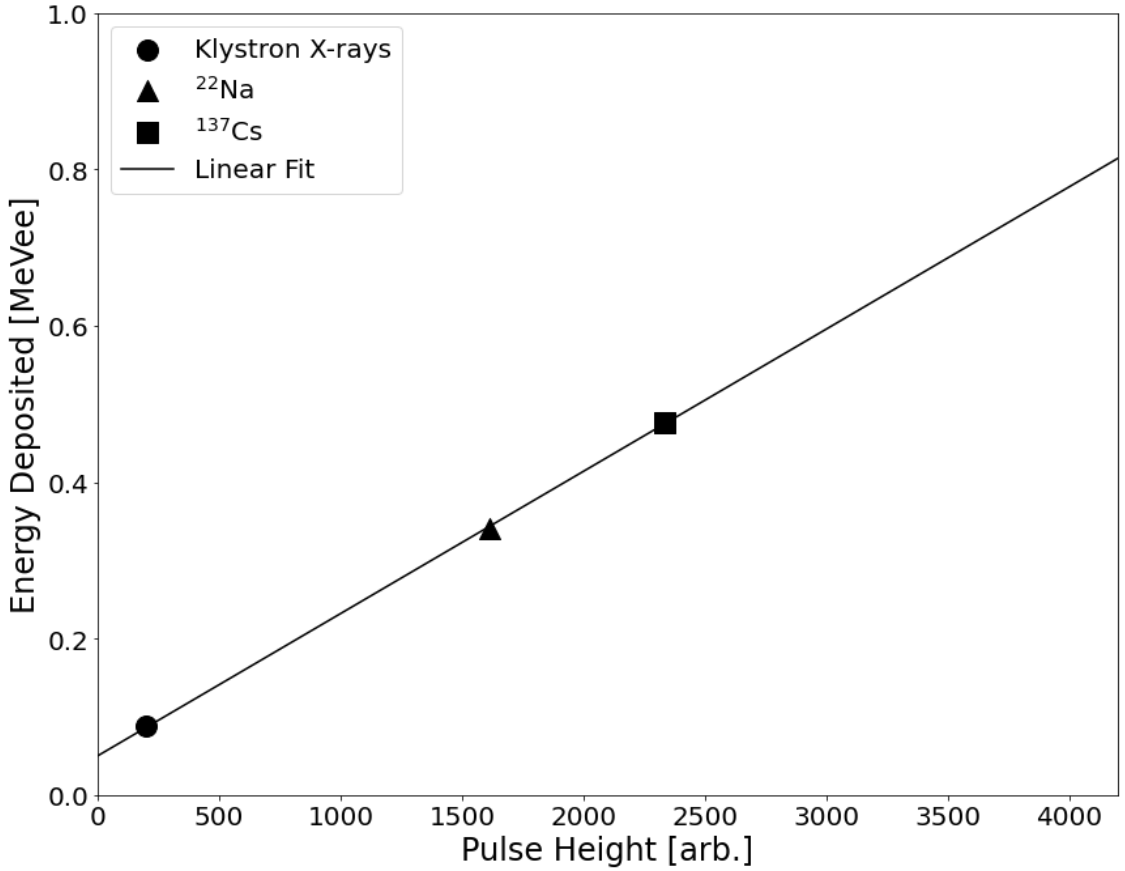
Energy Calibration

- Gamma and x-rays used to calibrate detector
  - Klystron X-rays ~200 keV
  - ^{22}Na - 511 keV
  - ^{137}Cs – 661 keV
- Maximum pulse height ~4200
- 8-bit resolution prevents fitting above ~1 MeV



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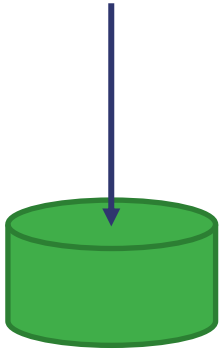
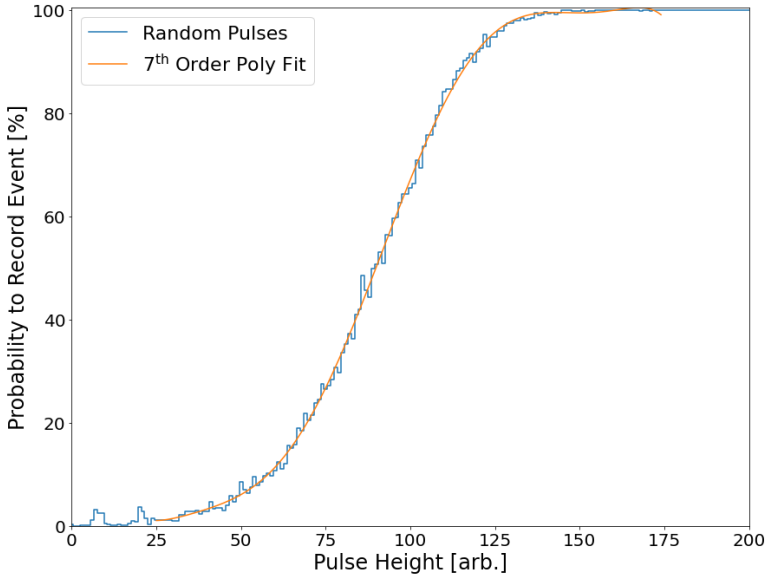
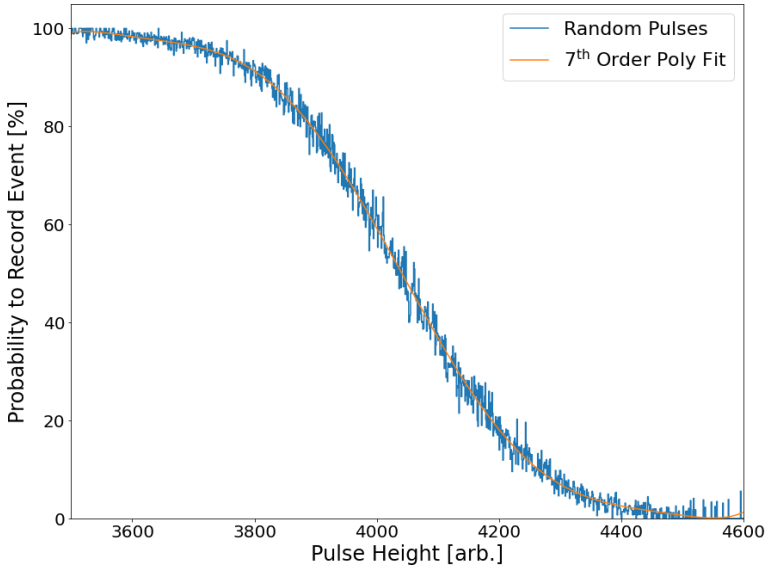
Detector Efficiency

- Simple gamma response
  - EJ301, $H_{1.212}C$, 5-inch diameter by 3-inch thick
  - Monoenergetic gammas normal to surface
  - Energy deposited tallied with MCNP
- Low amplitude events limited amplitude
  - Not recorded if an event's amplitude does not exceed the digitizer's threshold
- Large events limited by digitizer (8-bit) resolution
  - Saturated pulses







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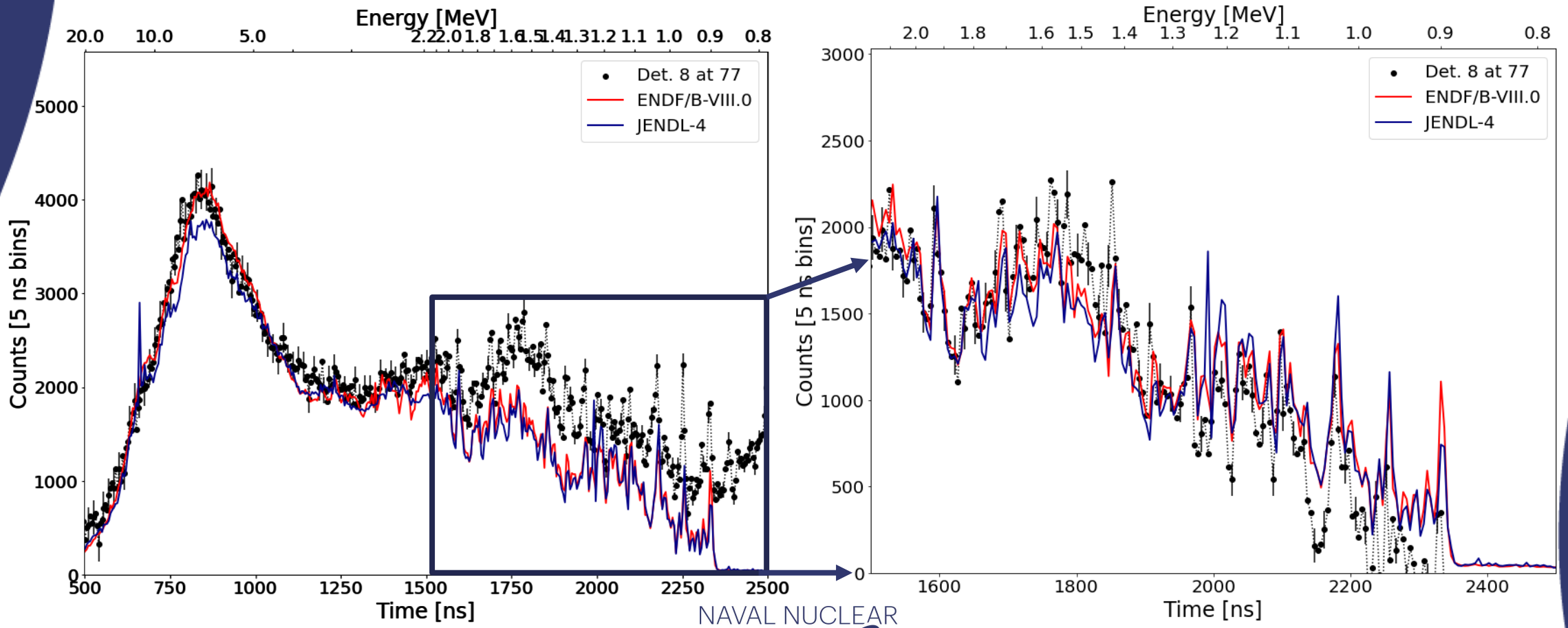
Iron – Gamma response

- First attempt showed decent agreement between evaluations and measured data above 3 MeV
- Correction applied to gamma data based on Graphite



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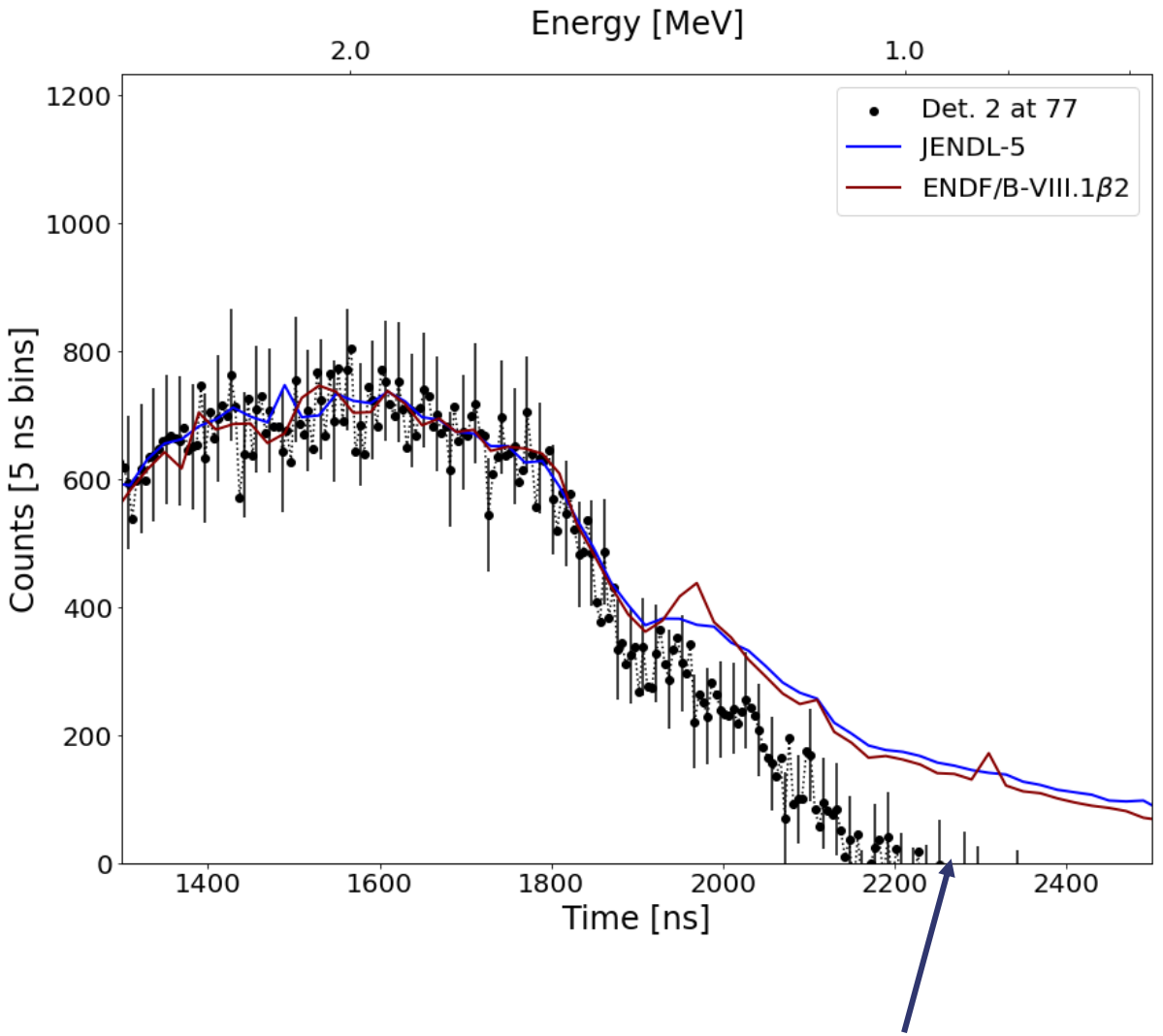
^{238}U

- Many different gamma energies
  - Disagreement between data and simulations
    - Gamma overcorrection
    - Gamma efficiency
- Large uncertainties
  - Limited number of events
  - Correction factors



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Next Steps

- Detector efficiency model
  - Unique for each detector
  - Upper and lower-level discriminators
  - Gaussian broadening
- Investigate pulse classifications
  - Overcorrection
- Examine time-of-flight pulse height distributions
  - Iron – 0.85 to 2 MeV
  - ^{238}U – 0.5 to 3 MeV
  - 5 to 10 MeV
- Expand efforts and methods to 10-bit data

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