FAST NEUTRON EVALUATIONS FOR ADVANCED LEAD SYSTEMS

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NCSP TPR 2023 | Albuquerque, NM

Work supported by DOE-NEUP | Project Number: 19-16739.

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PROJECT OVERVIEW

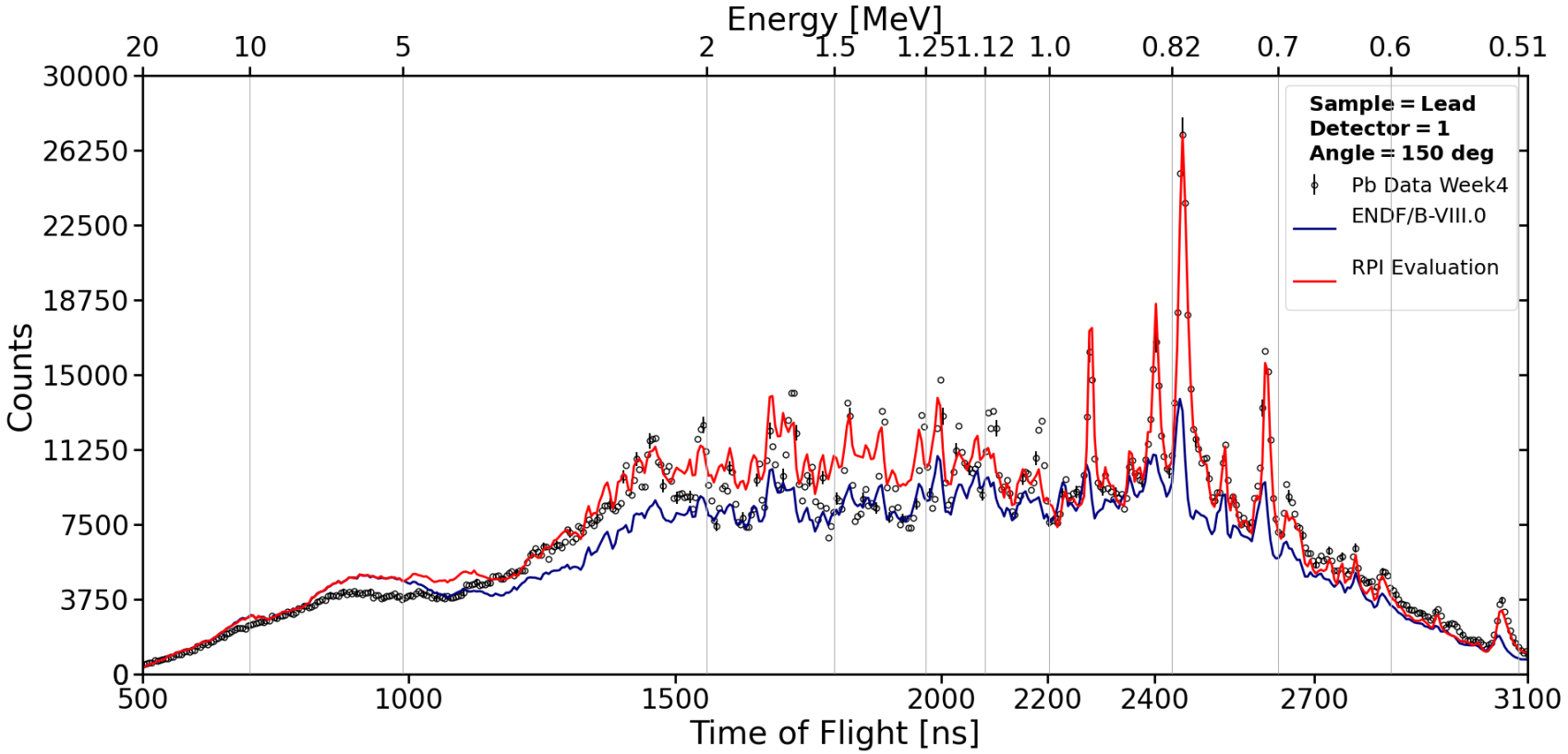
- Motivation
  - Hydromine and Westinghouse are developing Lead Fast Reactors (LFR) as a part of GEN IV reactors
  - In Belgium, MYRRHA, a Pb-Bi cooled accelerator driven system (ADS) being designed for T&H validation
  - Niowave - Pb cooled fast spectrum testbed
  - DOE-NEUP supporting LFR development through material and cross section validation

- Project Goals
  - Evaluate Pb isotopes with focus of improving predictive capabilities of fast systems
  - Benchmark available critical and shielding experiments with sensitivity to Pb
  - Utilize RPI Quasi-Differential Scattering experiment for scattering reactions
  - Performed Resolved Resonance Region (RRR) and fast region evaluations for natural Pb isotopes with differential data on EXFOR
  - Submit evaluations to ENDF/B-VIII.1 library

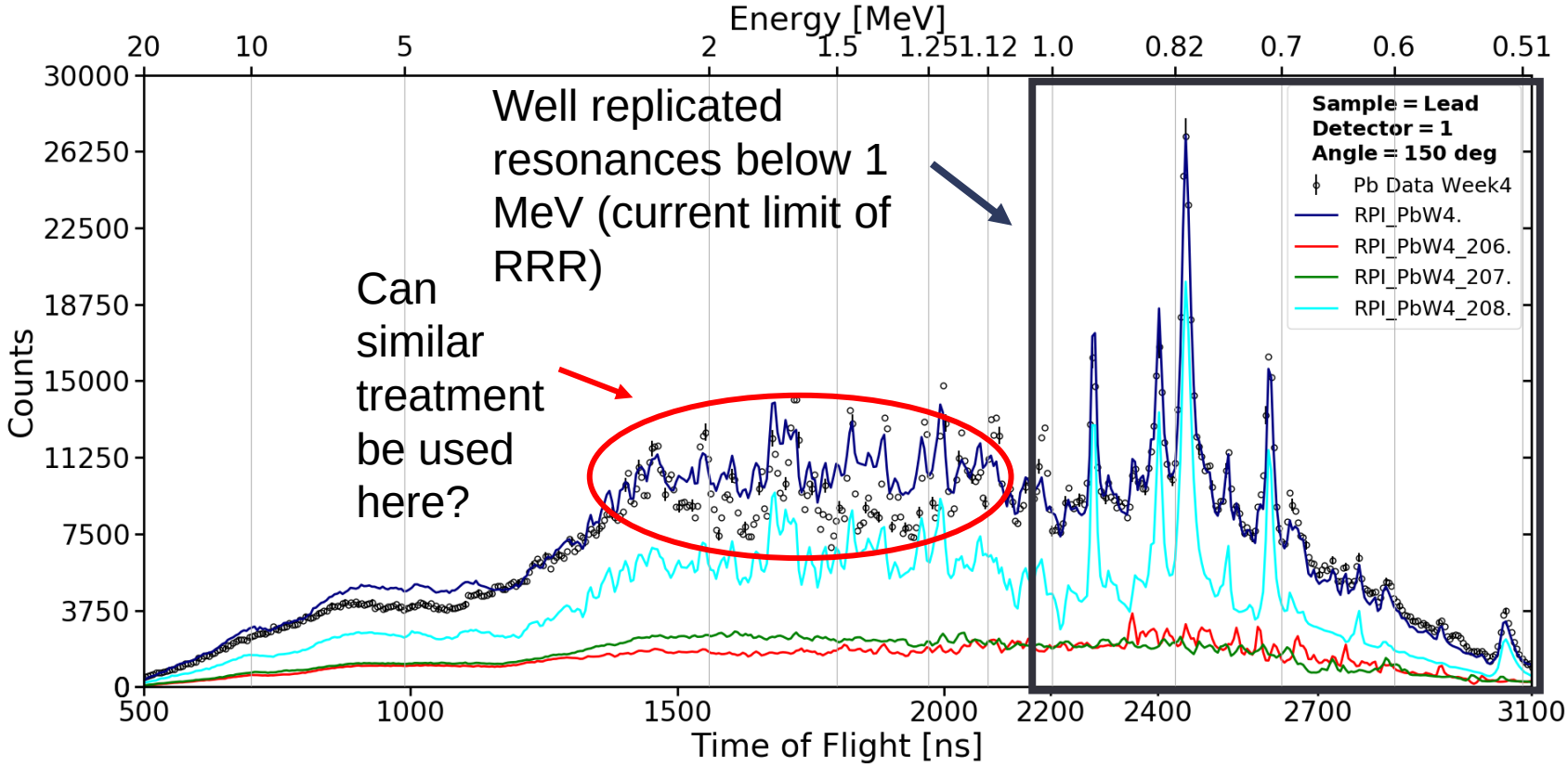
MAJOR ACCOMPLISHMENTS

- Performed pre-validation and pre-evaluation for natural lead (FY20)
  - All evaluations fit ORELA (n,tot) measurements by D.J. Horen, J. Harvey, and R. Carlton – Same total cross sections for JEFF-3.3, JENDL-5.0 and ENDF/B-8.0
  - Elastic Scattering Angular Distributions deemed to be largest difference in libraries, quasi-differential scattering, critical benchmarks
- RRR Evaluations (FY21)
  - Update resonance parameters with most current capture data
  - Use new resonance parameters to calculate ESAD with Blatt-Biedenharn Formalism
- Fast Region Evaluations (FY22+)
  - Extended the RRR of Pb-208 and fast region evaluations of Pb-208
  - Fast region evaluations of Pb-206 cross section
  - Covariance development

Once the RRR was done for Pb-206/7/8, NJOY16 used to recalculate ESAD

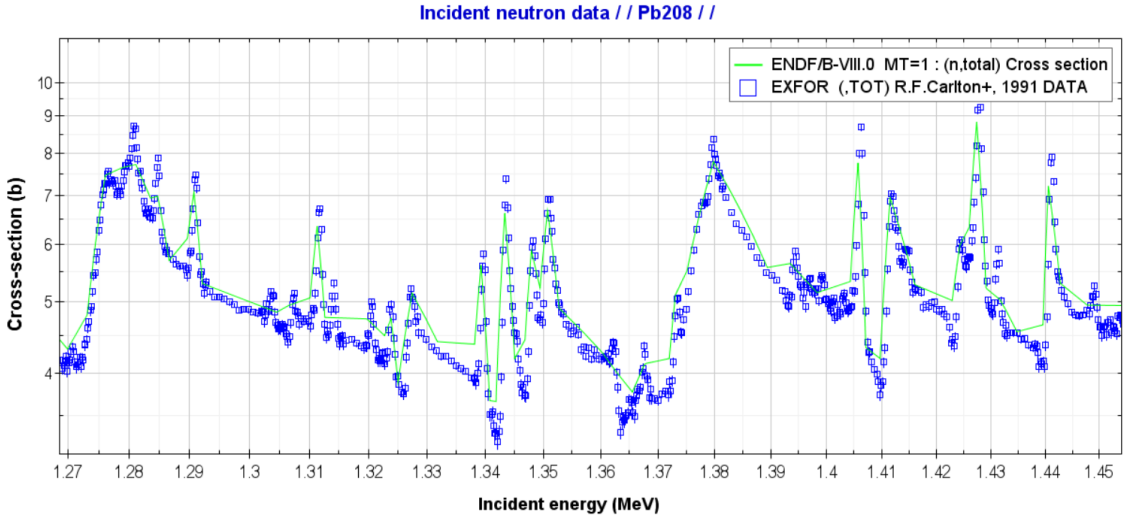


ANALZYED ISOTOPIC SCATTERING CONTRIBUTIONS

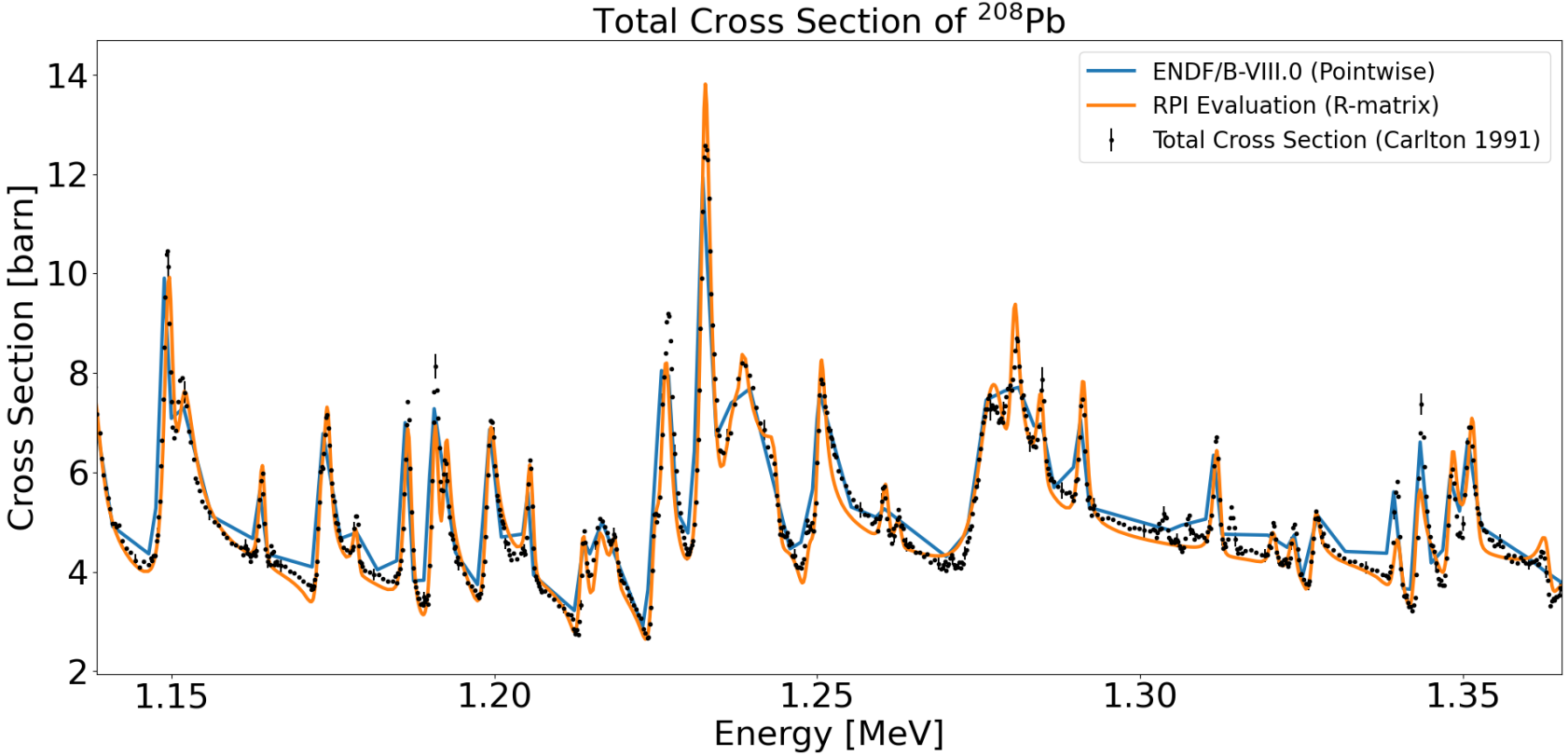


Pb-208 RRR EXTENSION

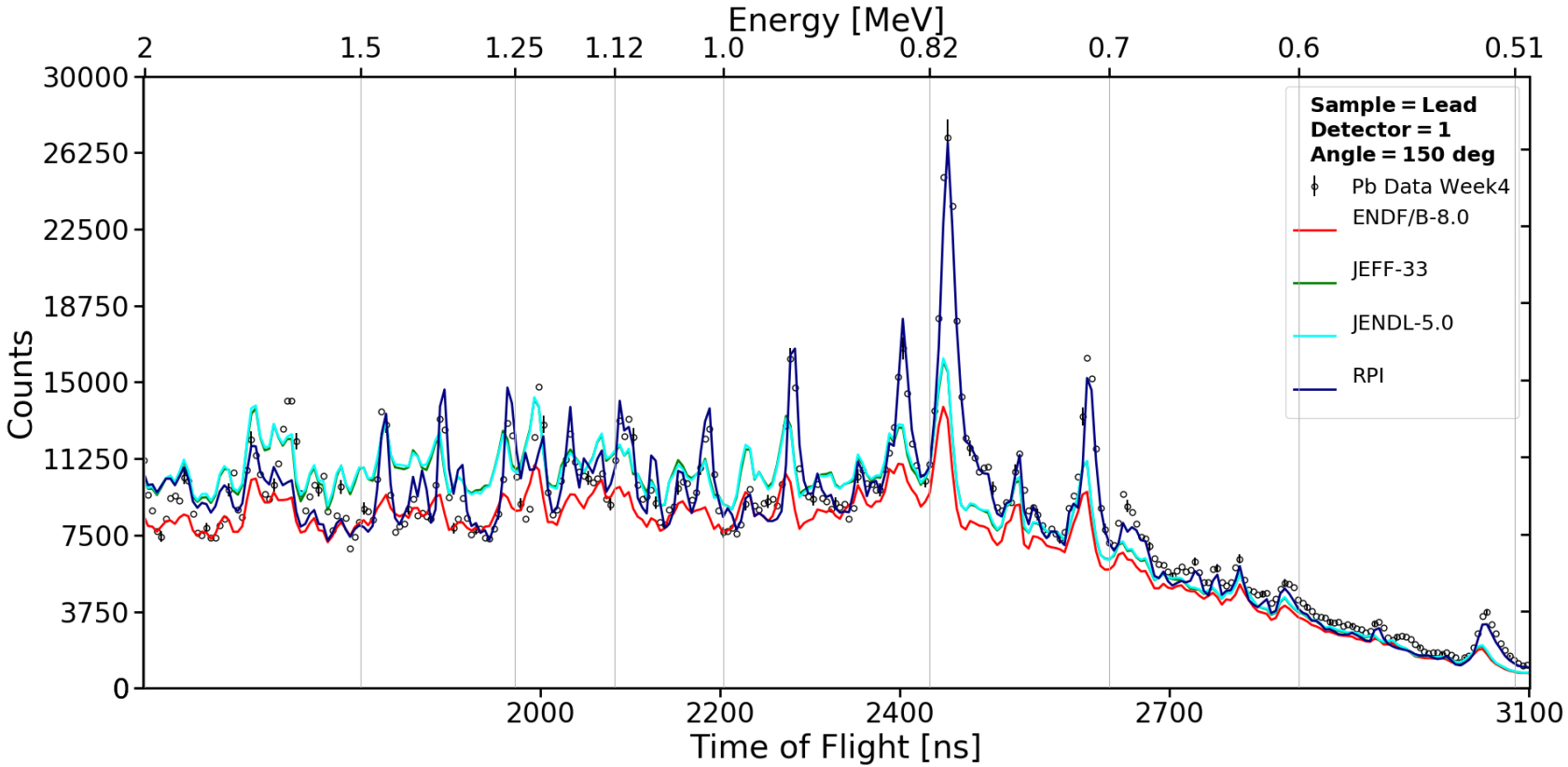
- Expanded on previous evaluations by parameterizing the differential data past 1 MeV using R-matrix theory
- Increased information for angular momenta of resonances
- Validate spin assignments of resonance with RPI Quasi-Differential Scattering while fitting transmission in SAMMY



R-Matrix Parameterized Cross Section RRR extended 1.0 → 1.5 MeV

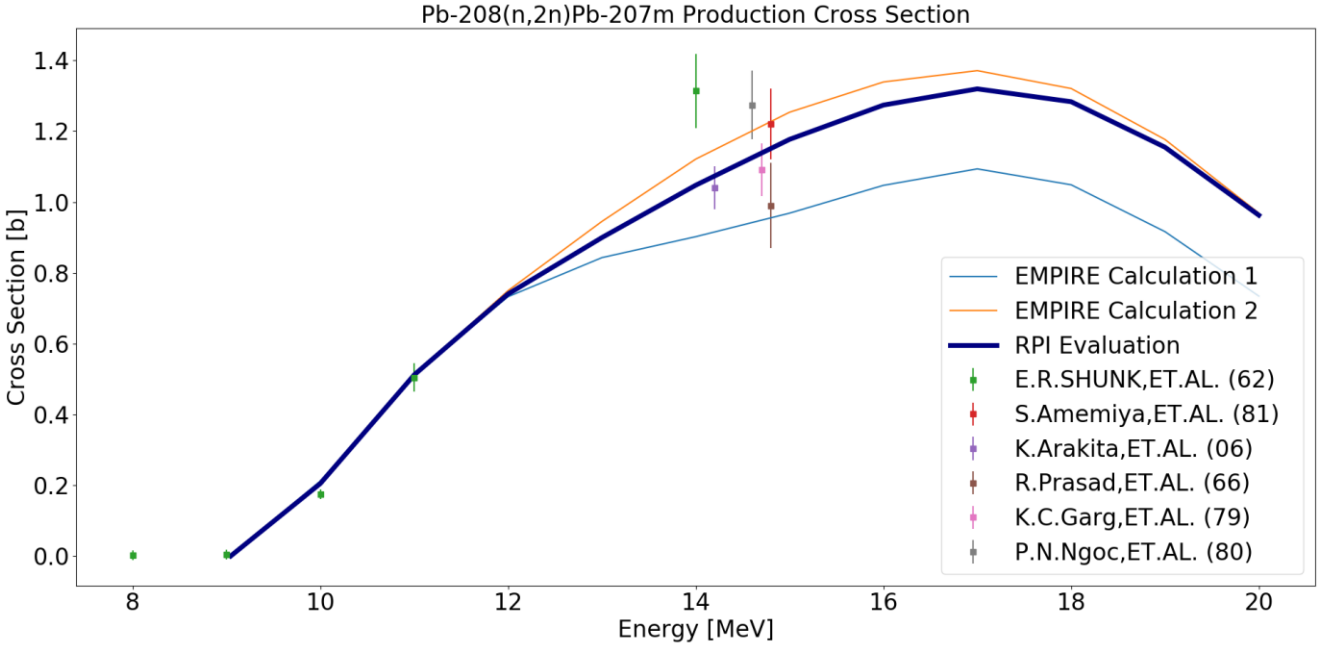


RPI Scattering Simulations



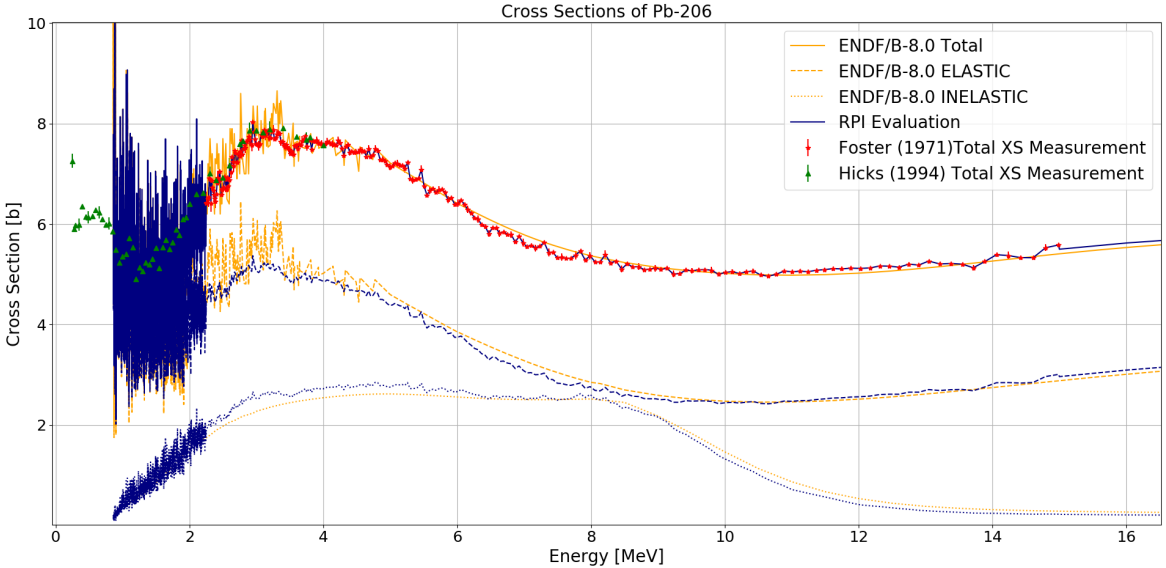
Pb-208 Fast Region Evaluation

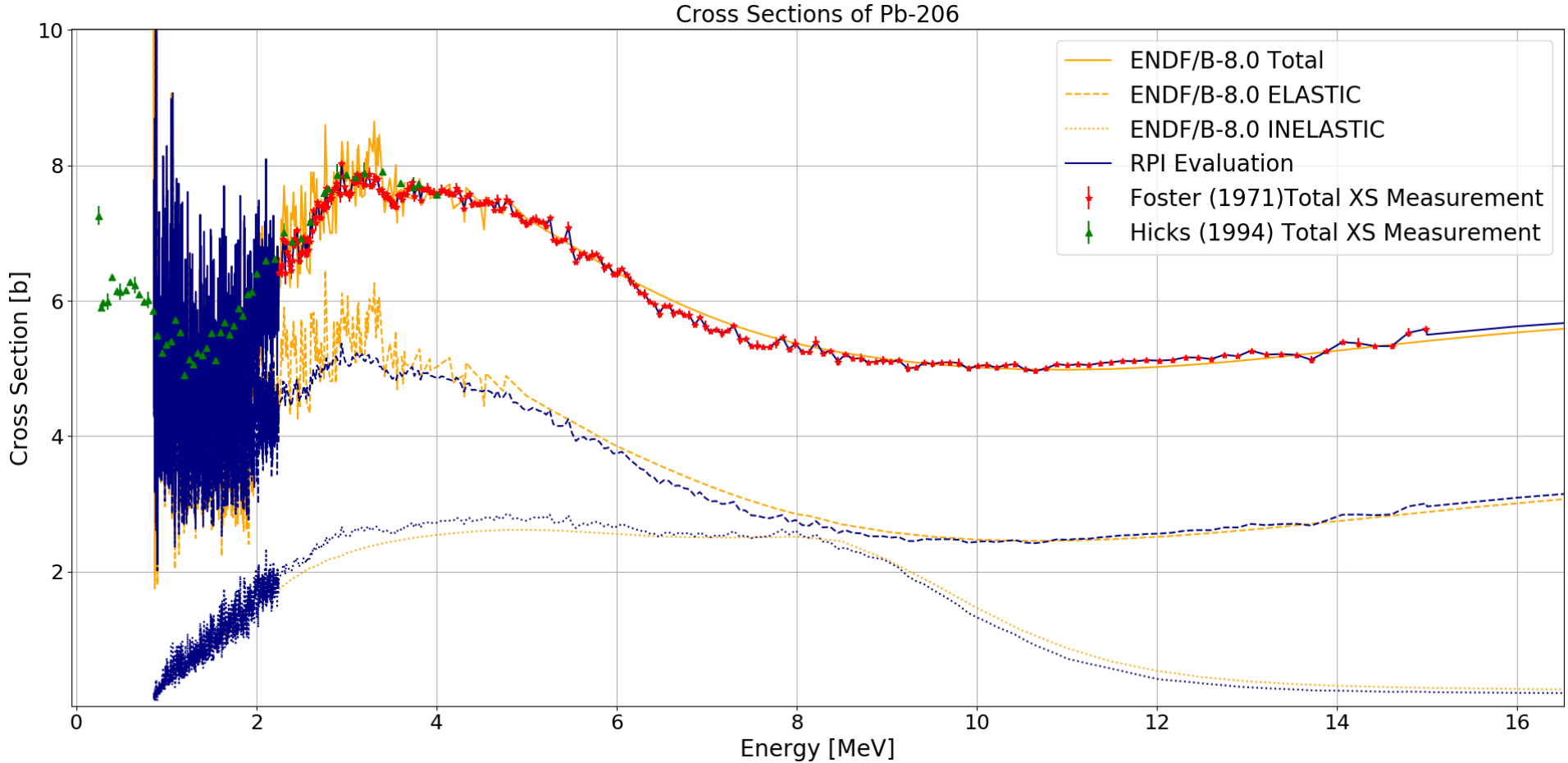
- Assisted SNL with Pb-208(n,2n) 207m production, using EMPIRE the ENDF files were produced for SNL
- Unfortunately, needed to use tally multipliers in MCNP as MF10 isn't supported in ACE



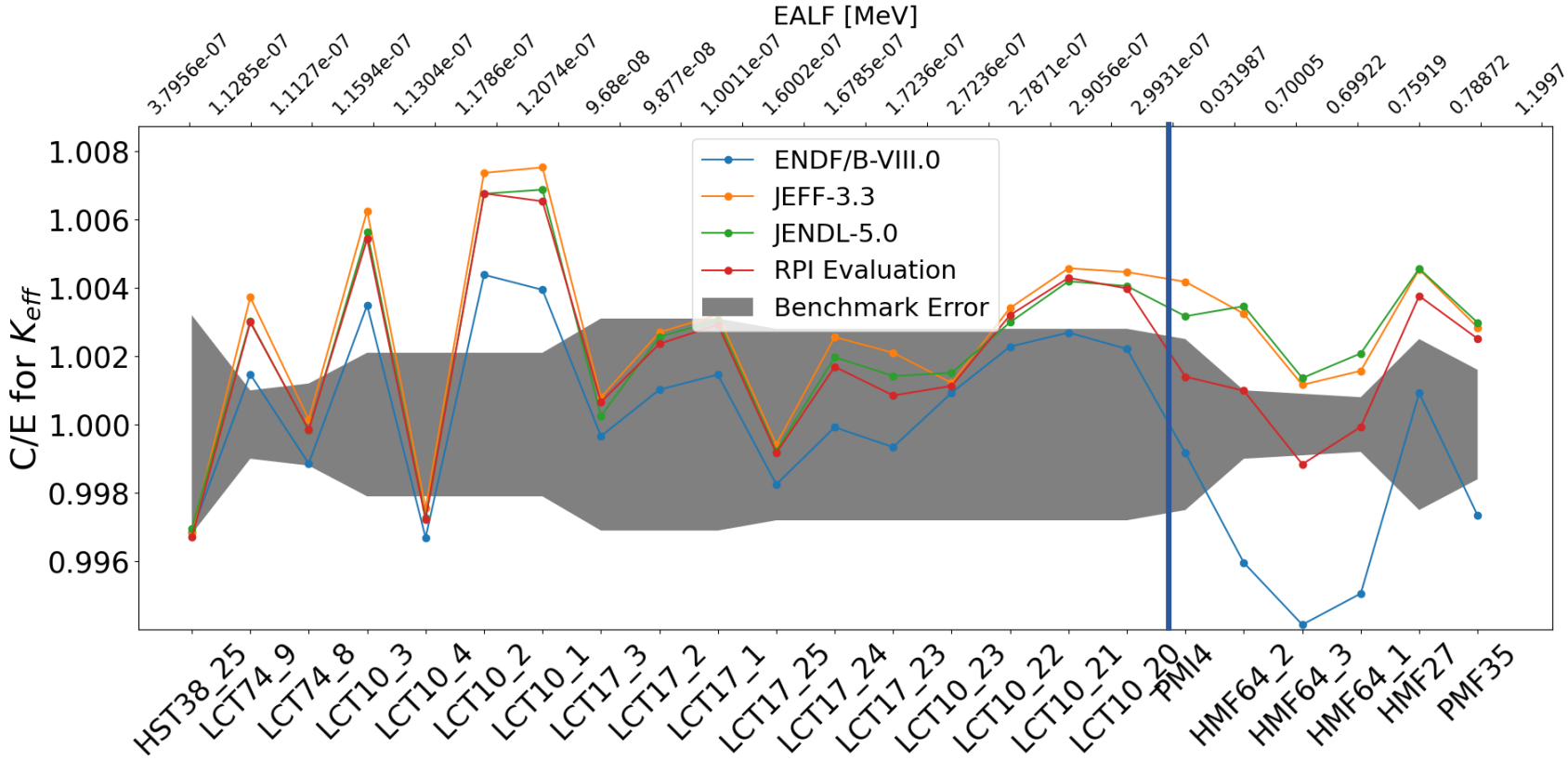
Pb-206 Fast Region Evaluation

- Reformatted the Pb-206 cross sections with more physically accurate presentation
- Removed legacy structure from natural lead measurement preserved in ENDF/B-VIII.0's Pb-206




Cross Sections of Pb-206
ENDF/B-8.0 Total
ENDF/B-8.0 ELASTIC
ENDF/B-8.0 INELASTIC
RPI Evaluation
Foster (1971)Total XS Measurement
Hicks (1994) Total XS Measurement
Cross Section [b]
Energy [MeV]
0
2
4
6
8
10
12
14
16
2
4
6
8
10

BENCHMARK PERFORMANCE



- FY-22 Summary
  - Extended RRR for Pb-208 using new methodology with spin validation from Quasi-differential scattering
  - Pb-208 cross sections finished with collaboration from T. Kawano, (n,2n) reaction updated for isomeric production per SNLs' request
  - Pb-206 cross sections finished with reformatted inelastic cross sections
  - Improved predictive capabilities of fast critical assemblies and RPI scattering experiments
- Future Work
  - Covariance update for MF-32, MF-33, and MF-34
  - Pb-207 fast region cross sections

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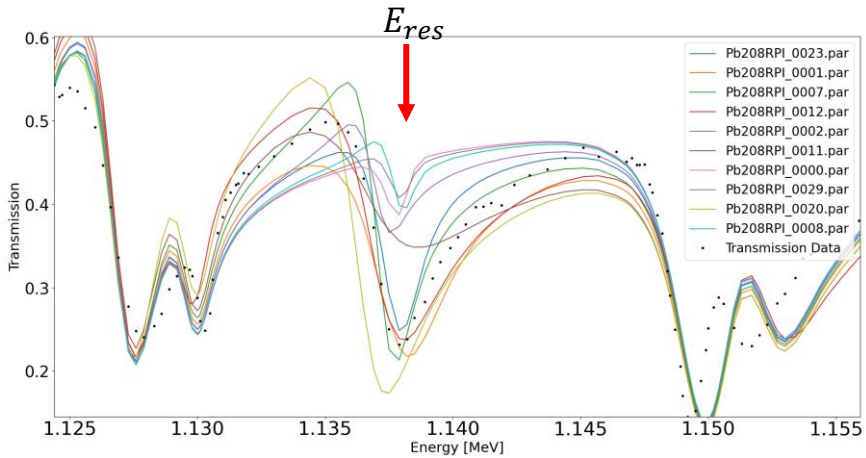
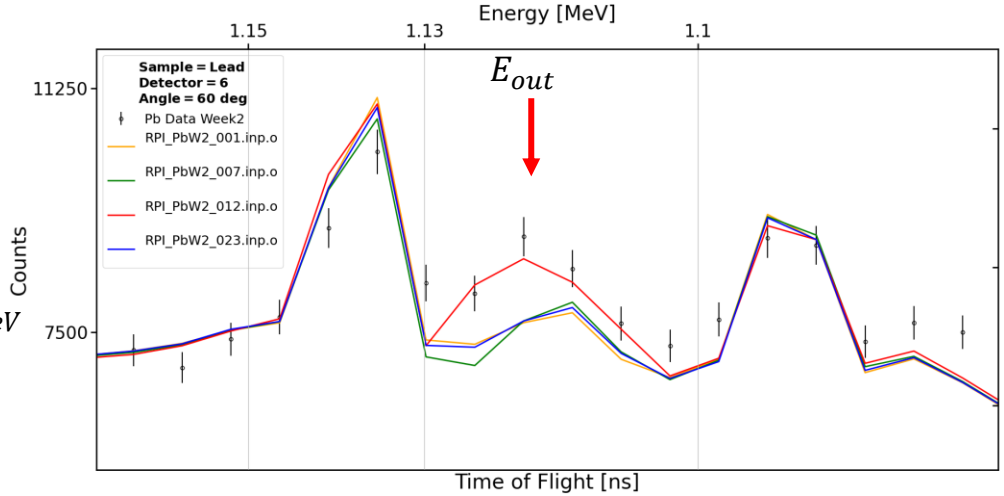
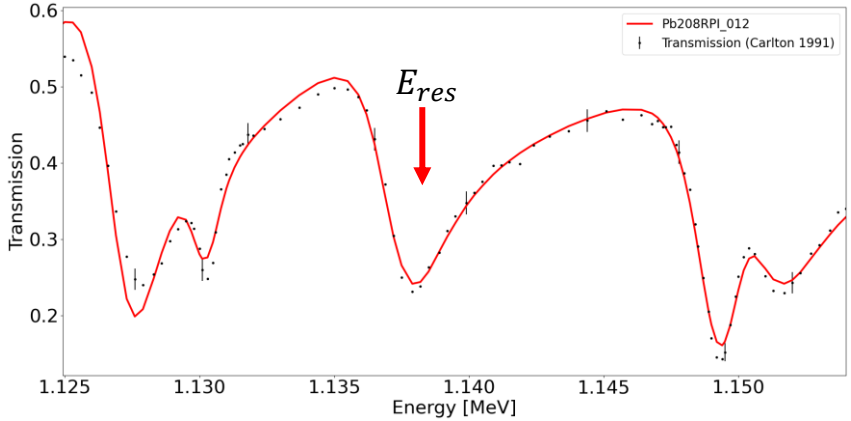


1. Generate and fit all available angular momenta (spin assignments) for 3 decades worth of Γn, have SAMMY fit both E and Γn, Γγ assumed constant



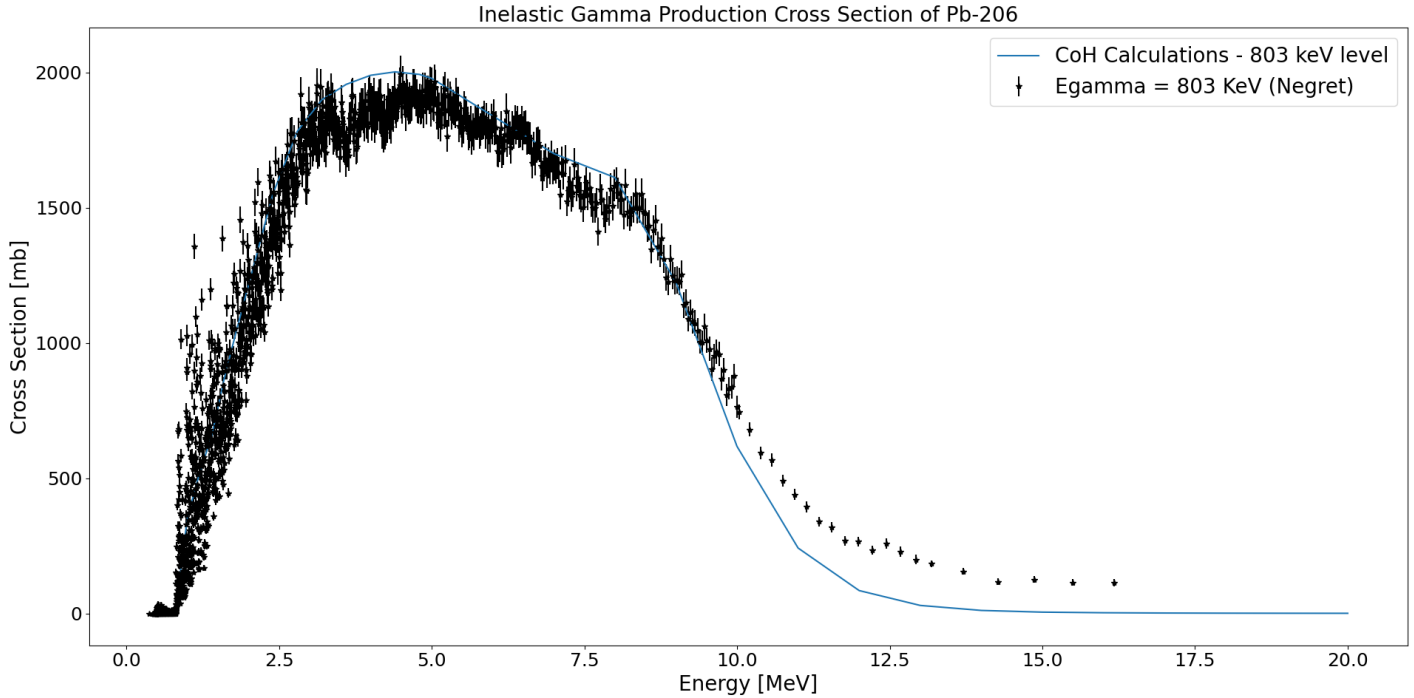
2. Run scattering simulations using resonance parameters derived scattering cross sections

$E_{out} = E_{res}(1 - \frac{4A}{(1+A)^2} cos^2(\theta))$ $E_{out}(1.137\ MeV, 60°) = 1.116\ MeV$



3. Pick spin assignment and resonance parameters which match transmission and scattering simulations the best

Inelastic Gamma Production from 1st Level of Pb-206(n,n')



- Data from Negret (GELINA) show structure on first inelastic state, need to apply resonances structure to inelastic states.