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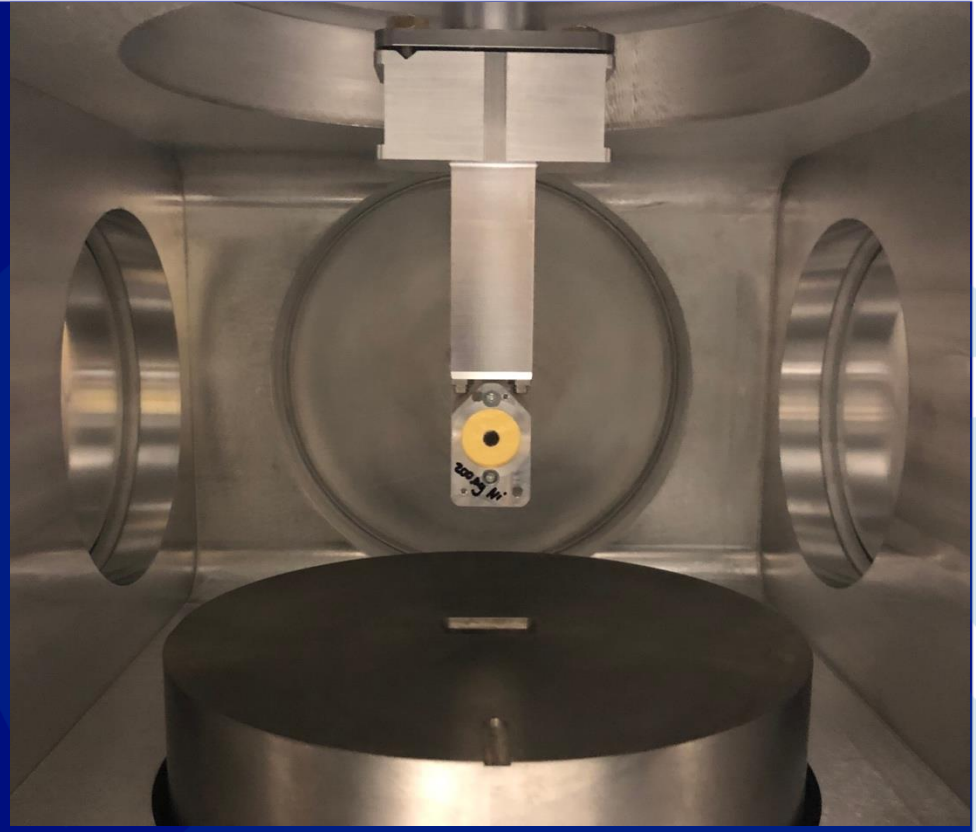


USNDP FY24 report on LANL program

Hye Young Lee and Toshihiko Kawano

Los alamos National Laboratory

US Nuclear Data Program Annual Meeting 2024

October 1-4, 2024

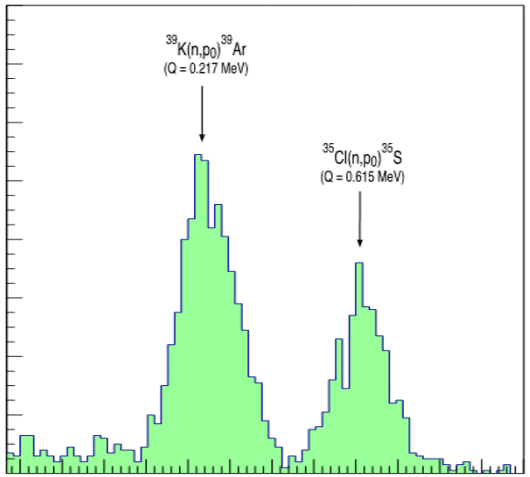
Triangle Universities Nuclear Laboratory (TUNL), Durham, NC

Directly measured (n,p) and (n,α) cross sections on ^{40}K ($T_{1/2}$= 1.3 Gy)

(Led by P. Gastis)

- For the interest of radiometric dating and radiogenic heating of exoplanets as destruction mechanism for ^{40}K
- total 13.8 mg of ^{40}KCl material was procured from Isoflex (97 % chemical enrichment, 12.8% isotopic enrichment)
- Thin film was fabricated using electrospray deposition technique by S. Dede and K. Manukyan at U. of Notre Dame

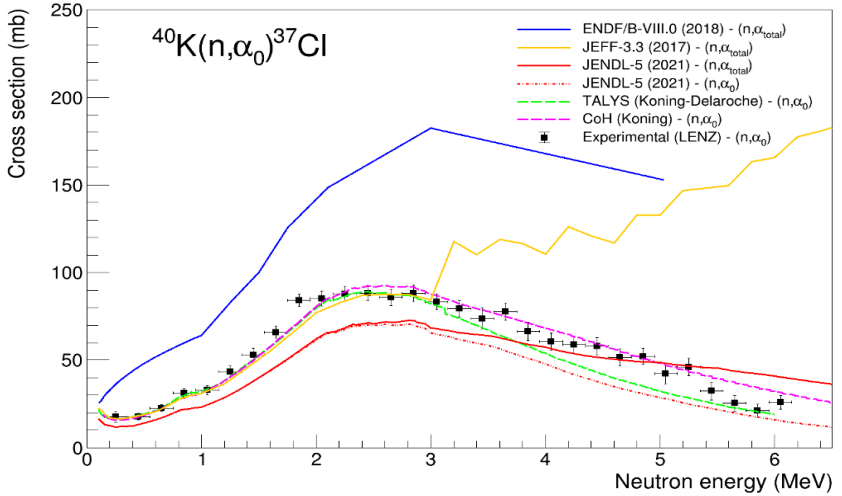
Ratios of partial cross sections of ^{39}K(n,p_0) and ^{35}Cl(n,p_0) reactions in the enriched and natural KCl targets confirm the atomic percentages between Cl and K of the enriched targets

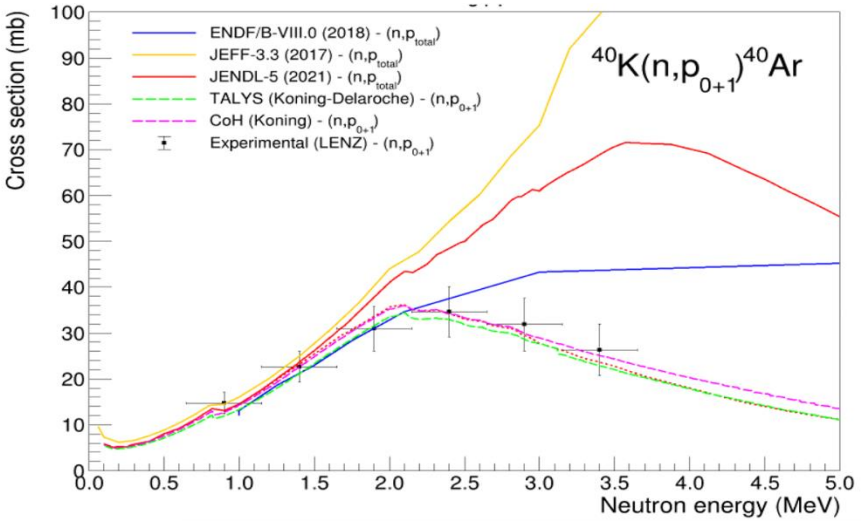


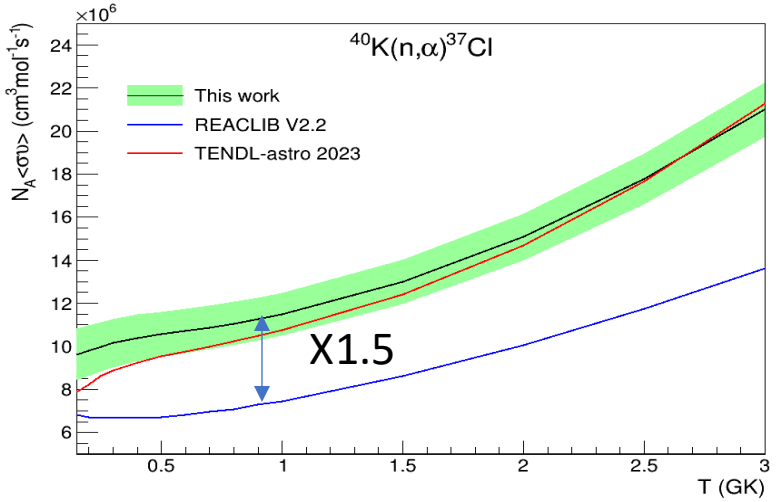
Reconstructed Q-values for (n,p) reactions of ^{39}K(n,p_0) (Q = 0.217 MeV) and 35Cl(n,p_0) (Q = 0.615 MeV)

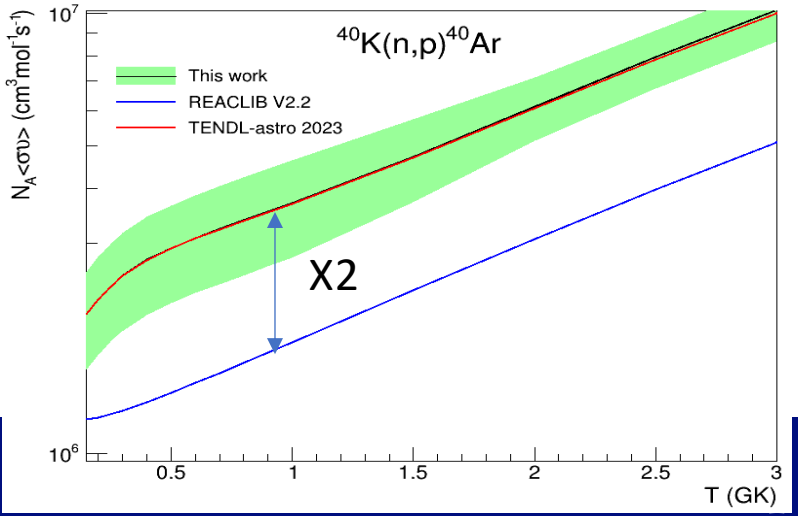
"Electrospraying Deposition and Characterizations of Potassium Chloride targets for Nuclear Science Measurements", S. Dede, S. D. Essenmacher, et al., Nucl. Instr. Meth. A (2023)

LANSCE cross sections and experimentally determined reaction rates

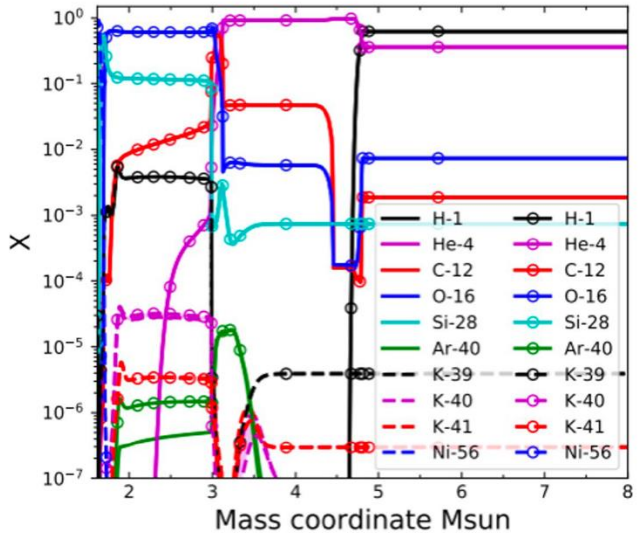


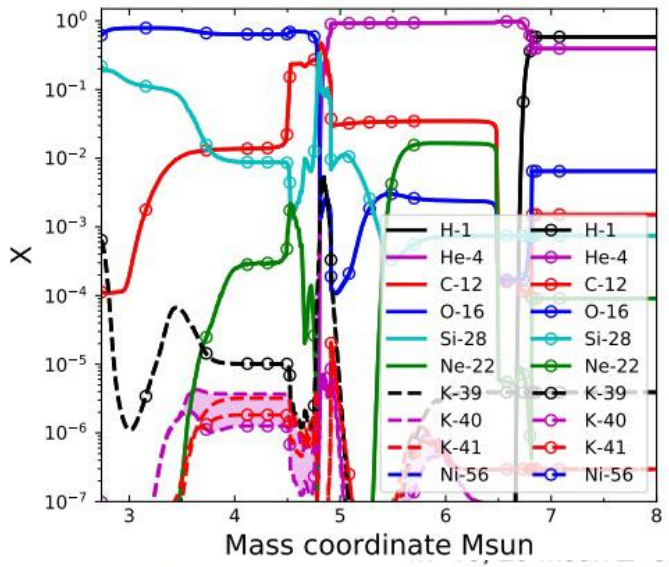


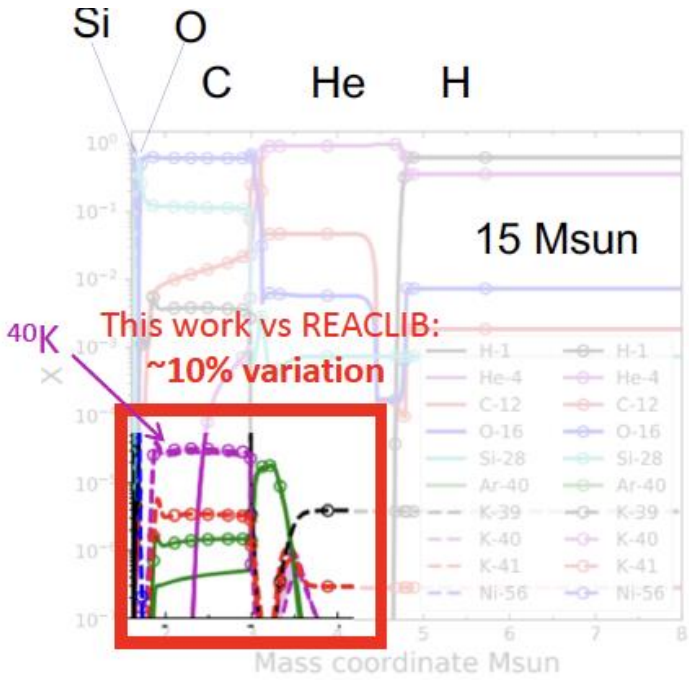


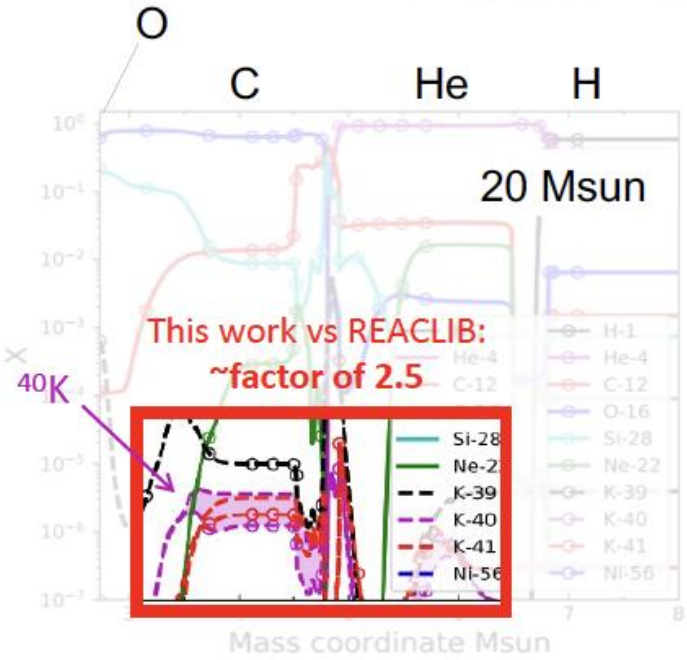


Impacts on astrophysics based on updated (n,p) and (n,α) reaction rates of ^{40}K



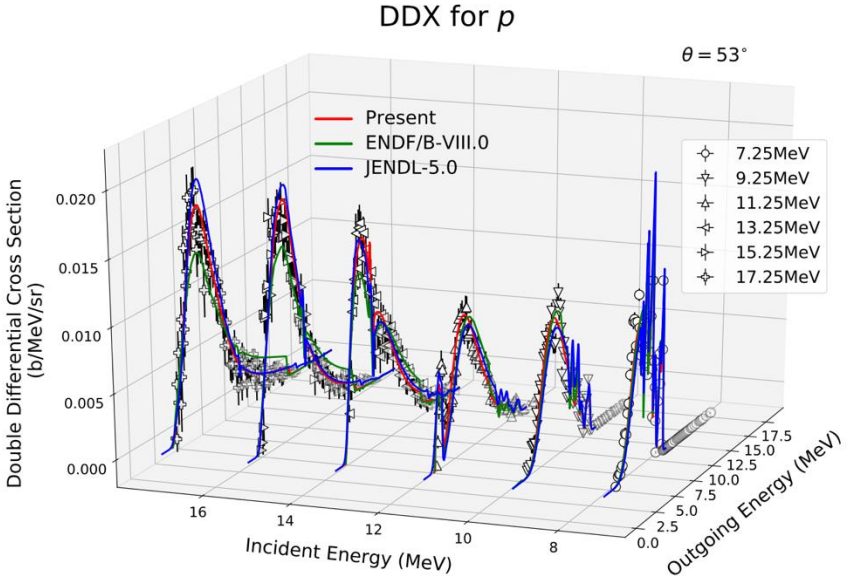


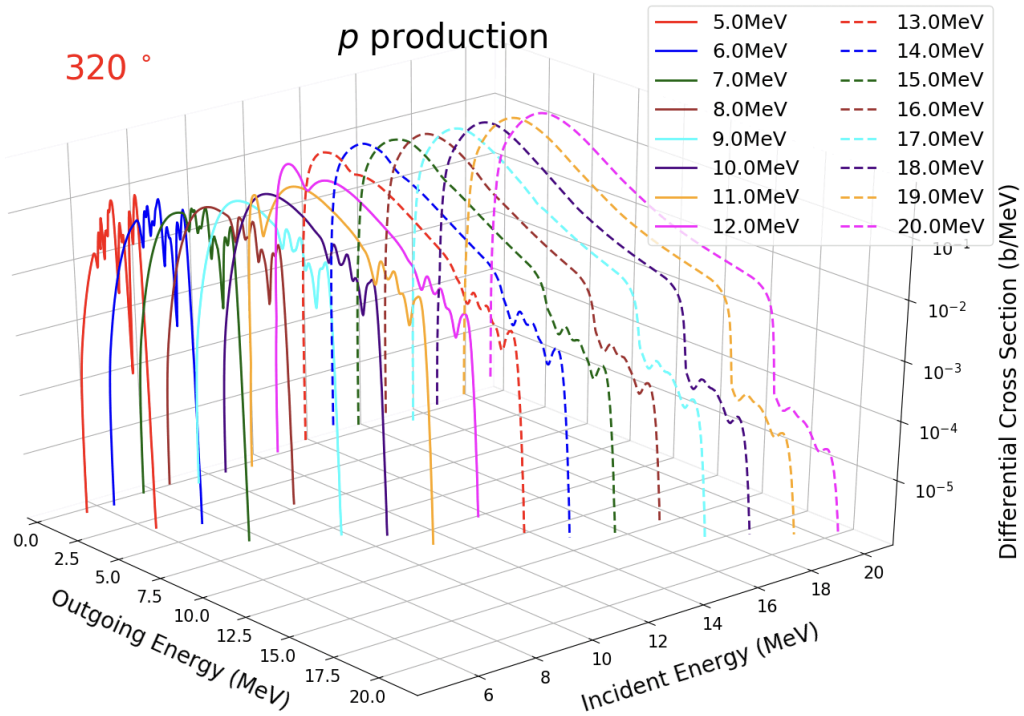


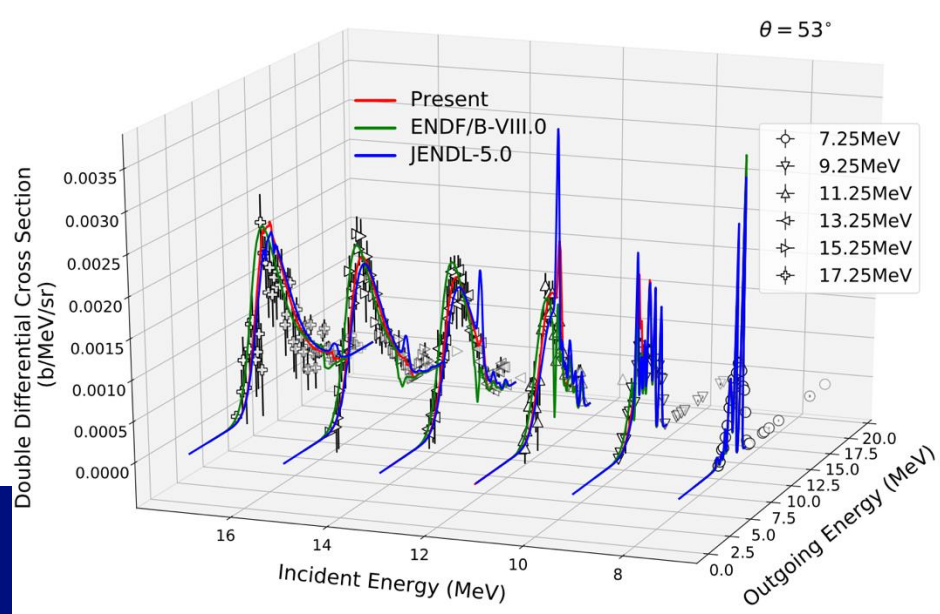


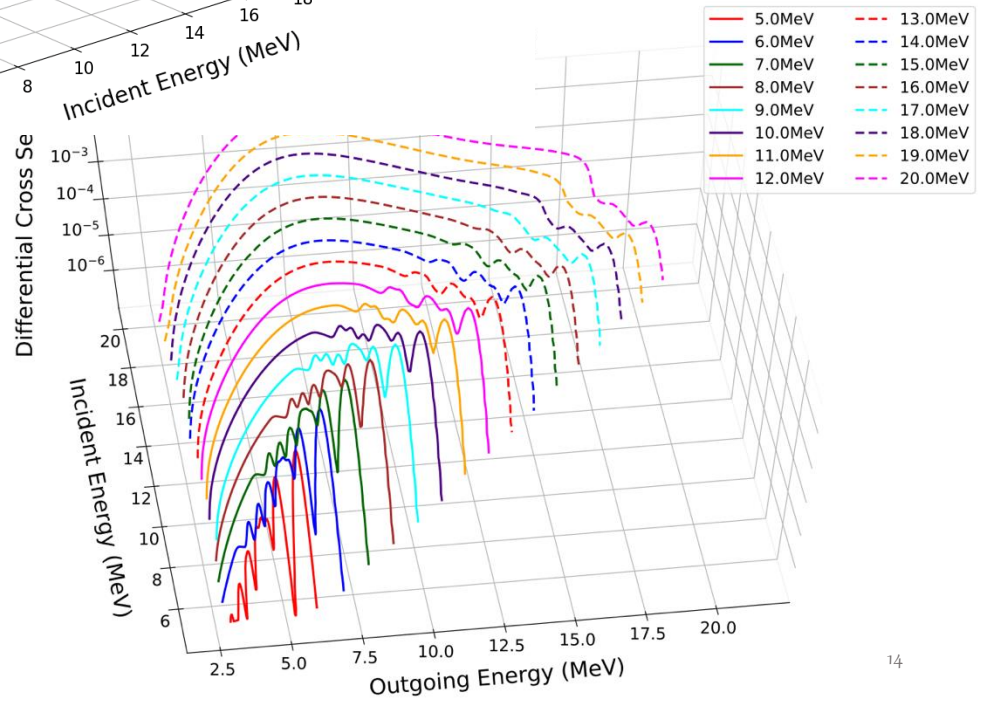
^{40}K yields calculated using the Core Collapse Supernova simulations. The horizontal axis shows the mass coordinate in the solar mass unit and the vertical axis shows the mass fraction. The bottom panels show the yield differences between the LANSCE rate and REACLIB.

Energy spectra (left) and angle-integrated differential cross sections (right) for neutron induced reactions on ^{54}Fe





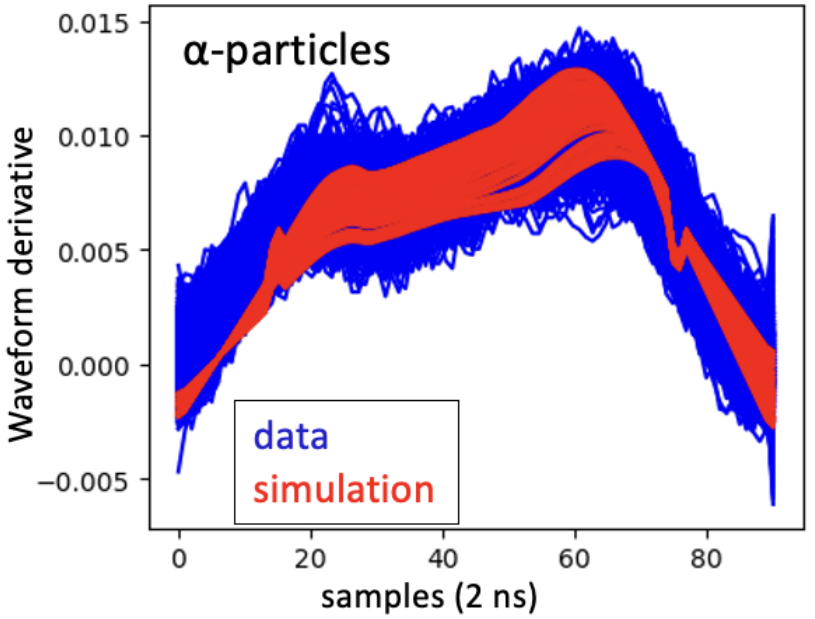


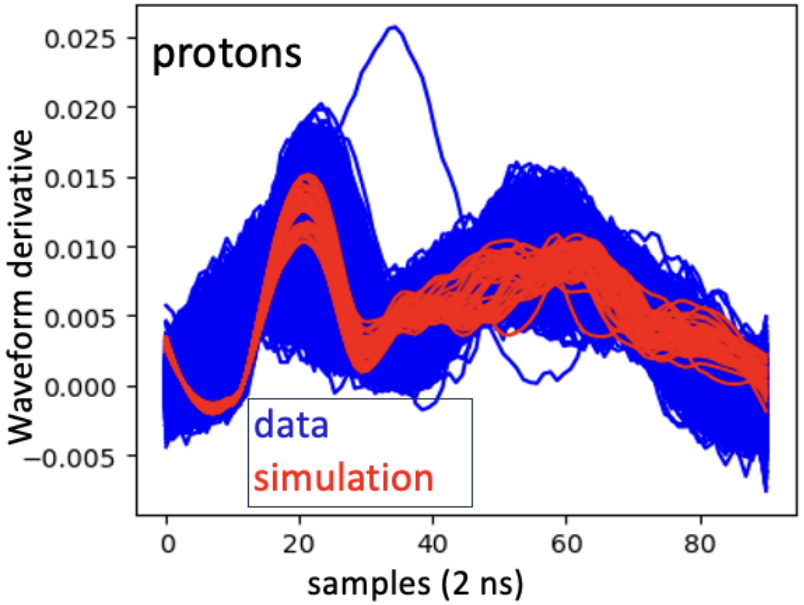


Developed advanced analysis tools using AI/ML algorithm to recover low-level data from LENZ measurements

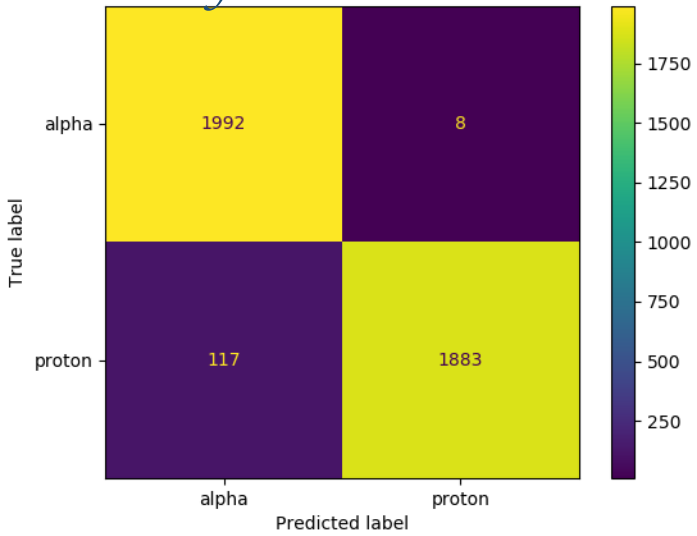
Charged particles waveform derivatives are compared between data and simulation

- Trained ML models soslely on simulated data and test on actual data.
- AI/ML tools are developed for simulated data analyses in order to
  -improve the signal to background ratios
  -enhance good signal identification
  -reduce systematic uncertainties





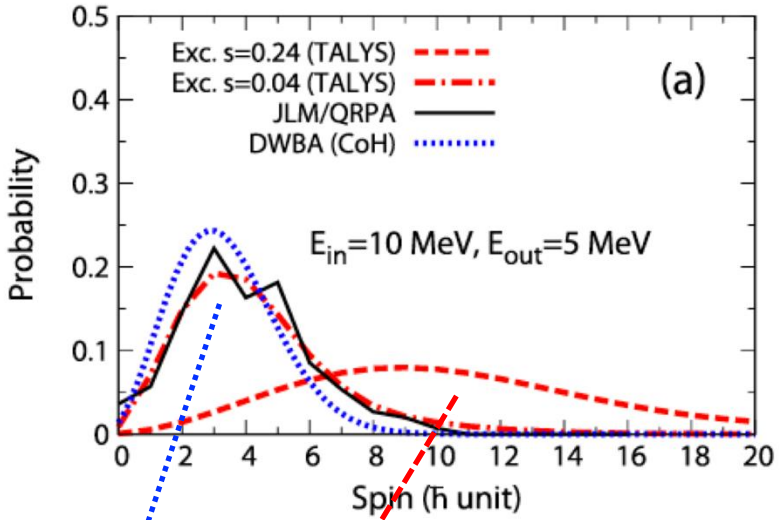
Confusion matrix

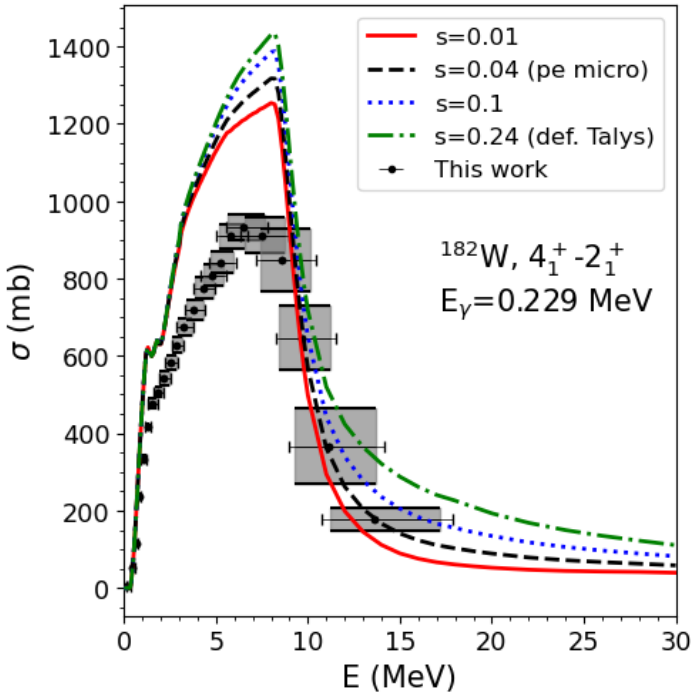


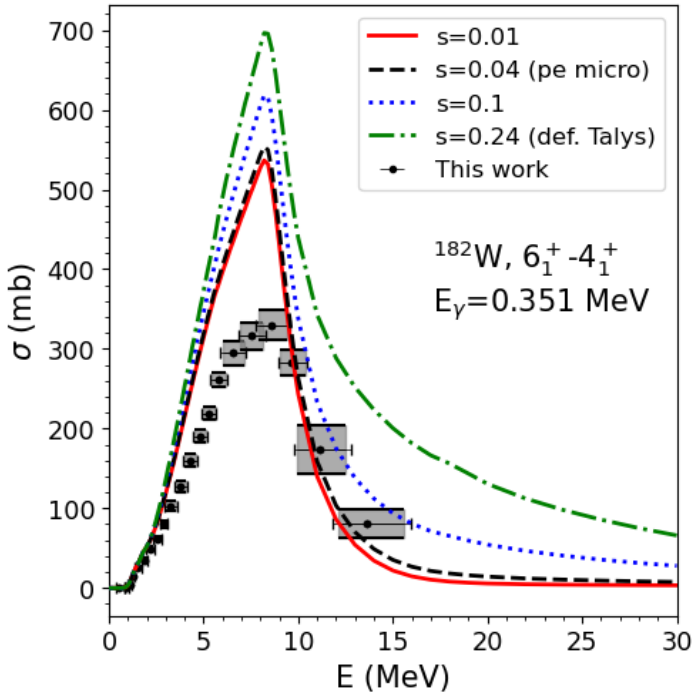
"Machine-learning aided pulse shape analysis in silicon semiconductor detectors", J.R. Randhawa, S.A. Kuvin, A. Khatiwada, and H.Y. Lee, Nucl. Instr. Meth. A (submitted)

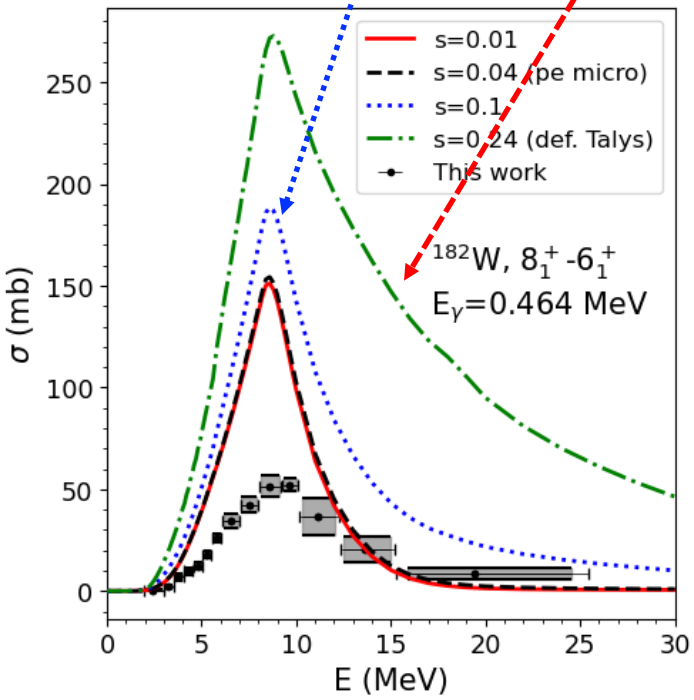
Inelastic scattering for tungsten isotopes

- Inelastic scattering cross section can be inferred by gamma-ray production data
- Proper model calculations must be performed
  - We test the statistical Hauser-Feshbach model with pre-equilibrium emission for the tungsten data
  - Data taken by IPHC/CNRS (Strasbourg) group at Geel
- Angular momentum transfer in the pre-equilibrium process significantly modifies the high-spin trar
  - The exciton model is not capable for calculating the angular momentum, since it is classical
  - Quantum mechanical model is essential



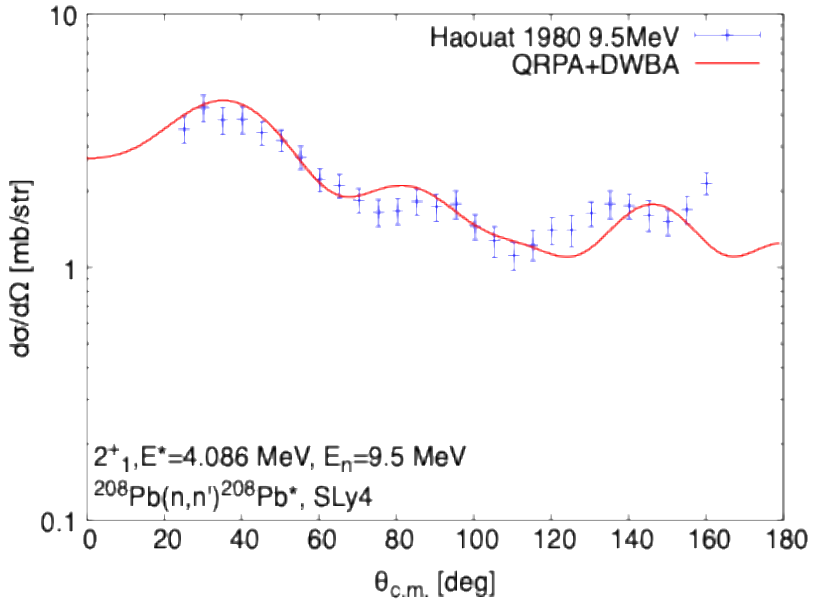


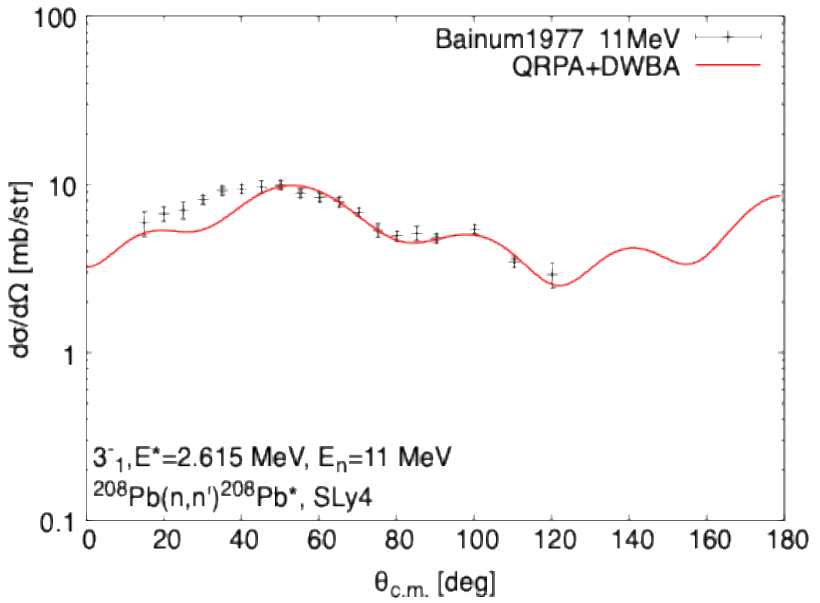


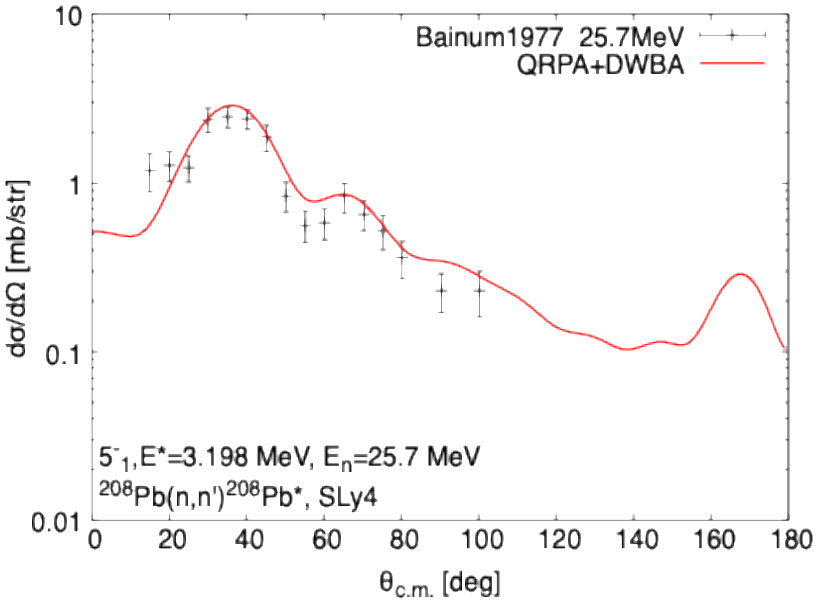


Microscopic calculations for inelastic scattering process, which could be applicable for wider mass and energy ranges

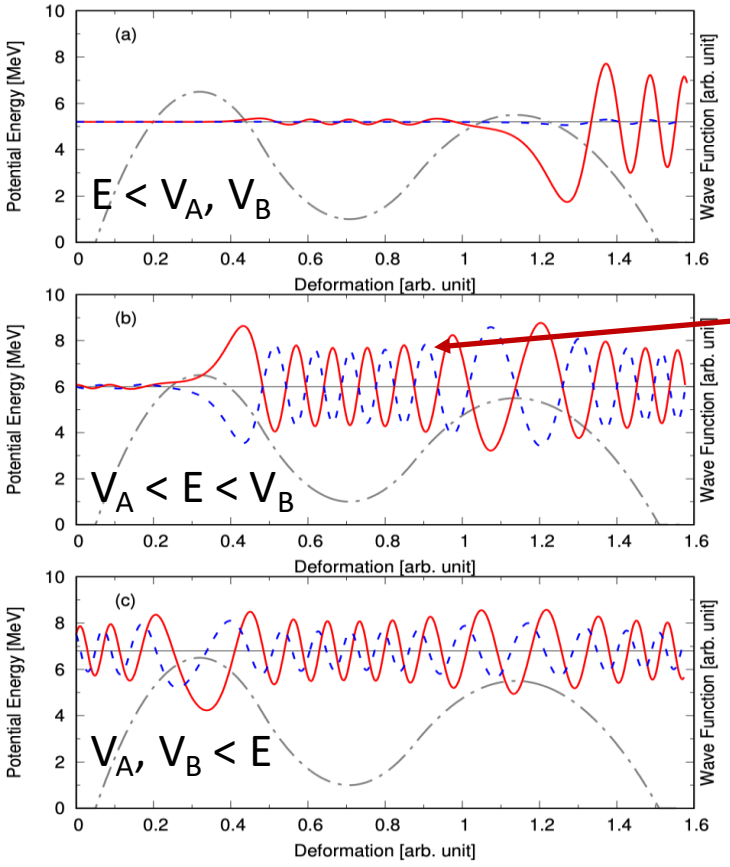
- Energy Density Functional Theory to describe the target single-particle states
- Finite Amplitude Method (FAM) to describe nuclear interaction
  - FAM proposed by Nakatuskasa, is a powerful and efficient technique to solve Quasi-particle Random Phase Approximation (QRPA) equations
  - H. Sasaki of LANL developed a non-iterative technique of FAM, which is even faster than regular FAM calculations
  - FAM applied to the neutron inelastic scattering process for ^{208}Pb to study angular momentum transfer (presented at CNR2024 in Vienna)
    - an effective nucleon-nucleon interaction is given, no adjustable parameters
    - the final states are discrete levels, but will be extended to the continuum



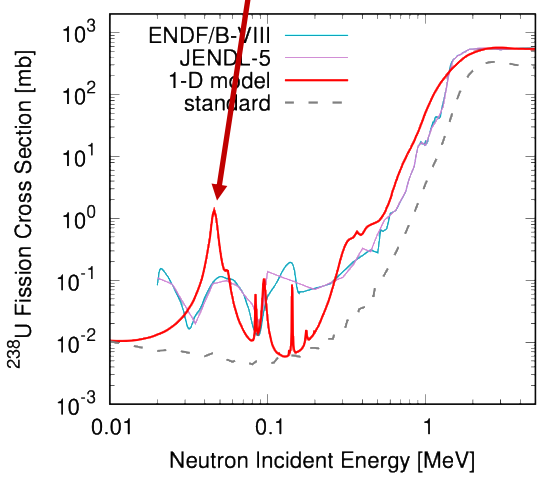


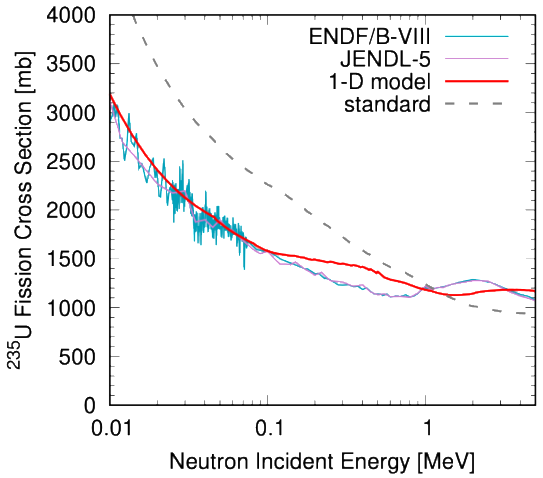


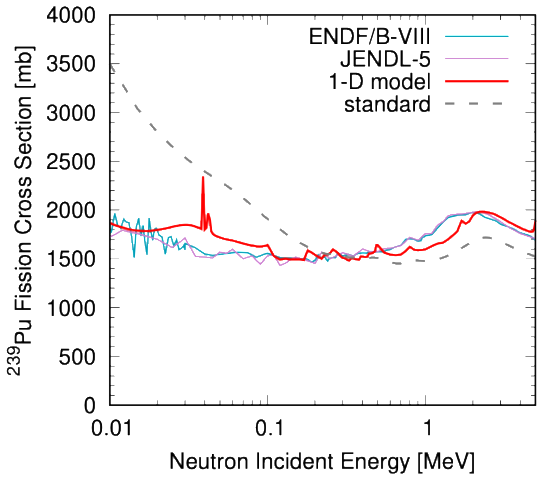
Solving one-dimensional fission potential for calculation fission penetrabilities in the statistical Hauser-Feshbach model



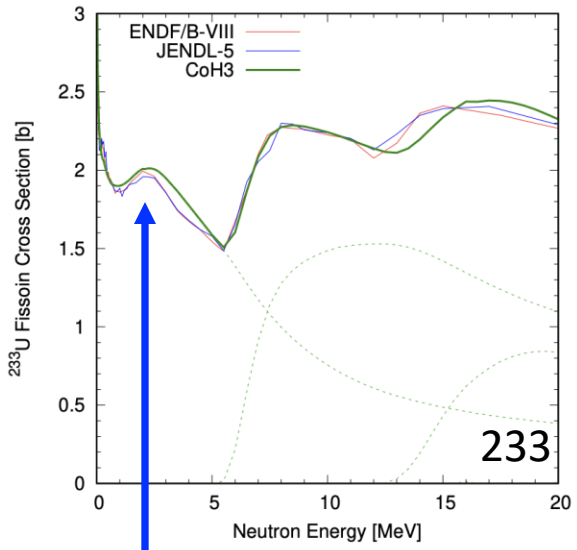
- New fission model developed at LANL, where fission transmission coefficients (penetrabilities) are calculated by solving the one-dimensional Schrodinger equation
  - no WKB approximation, instead realistic fission path is defined
  - there are 4 parameters – 2 for fission barrier heights, 2 for fission trajectory compression
  - T. Kawano, P. Talou, S. Hilaire, Phys. Rev. C 109, 044610 (2024)
- Standing wave between the barriers make resonances

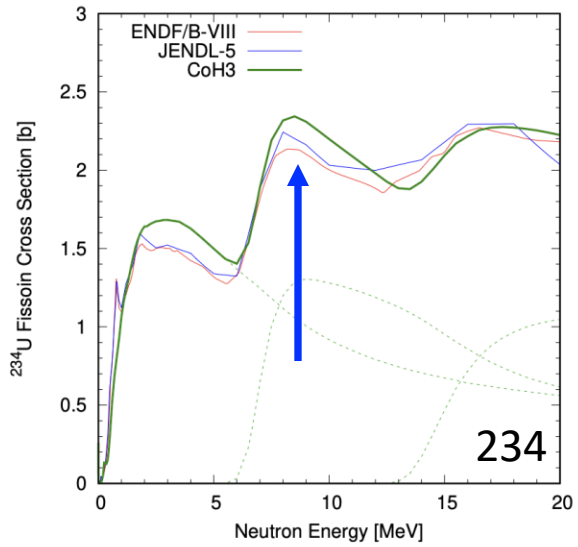


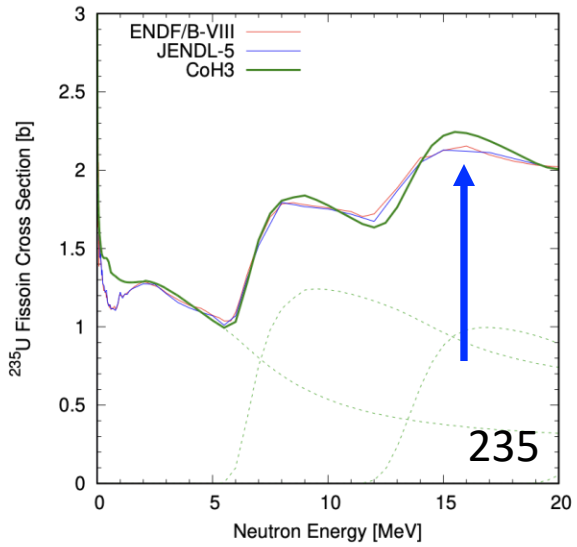


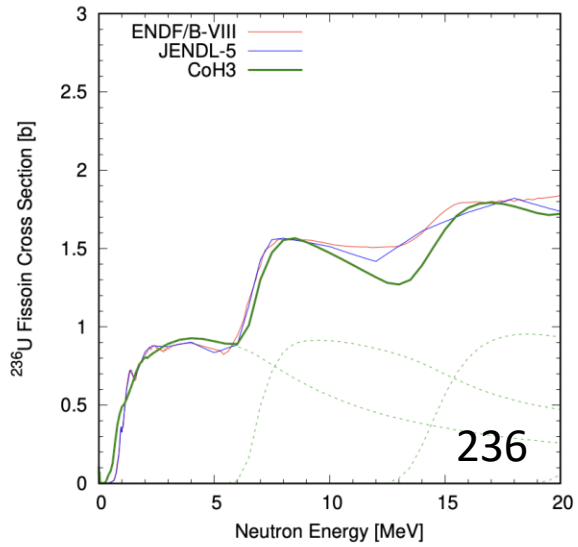


Consistent calculation of fission cross sections for all uranium isotopes (first time!)

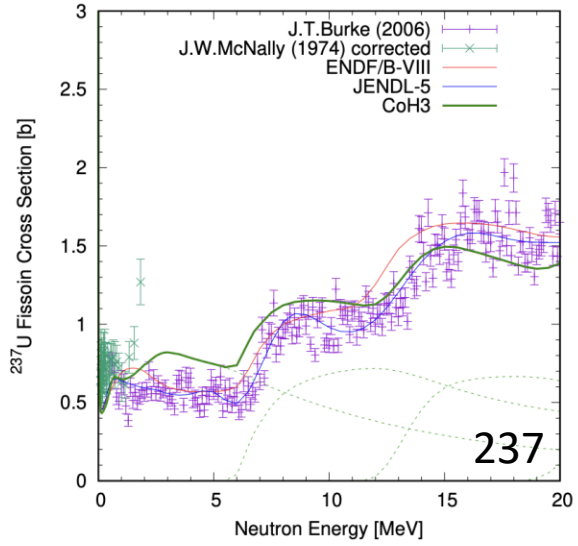


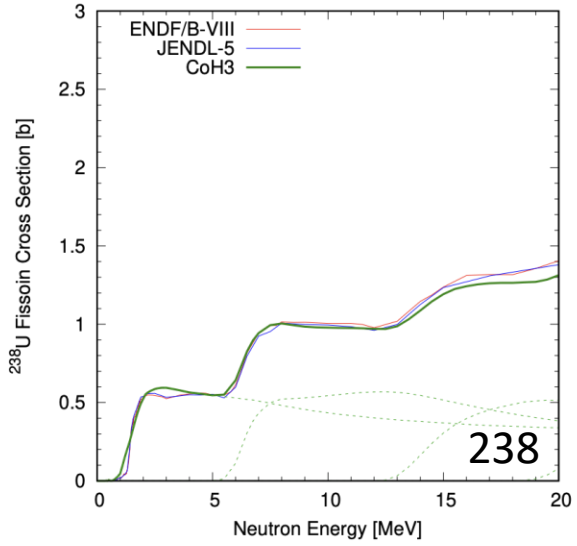


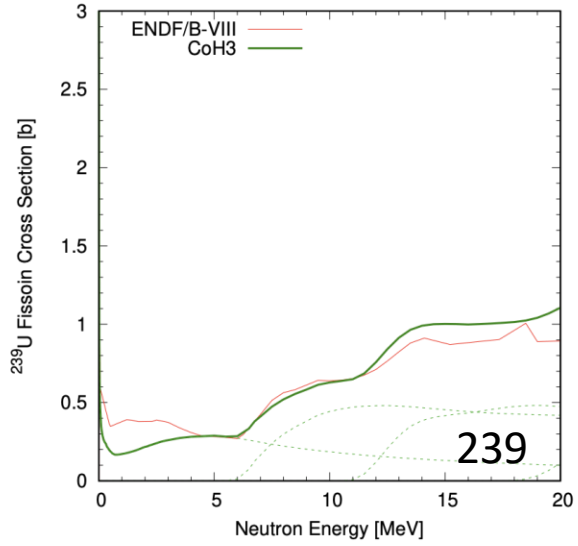




Same fission parameters for ^{234}U userd







Summary on USNDP-LANL program in FY24

Awards

- Technology Development Award 2023, Japan Atomic Energy Society for T. Kawano "Development of comprehensive calculation technique for nuclear data in the fission process"
- 2024 R&D 100 Special Recognition Silver Award for H. Y. Lee as a team of "NDα: Nondestructive Alpha Spectrometer", under Software/Services category

Conference Organization

DIMER: Direct Measurements of neutron reactions on radionuclides

- ~~Sept. 16 – 19, 2024~~ New Dates: Dec. 16-19, 2024
- Santa Fe, New Mexico
- Local Organizers: H.Y. Lee, R. Reifarth, and T. Stamatopoulos
- International Co-Organizers: M. Wiescher from University of Notre Dame, USA
- *https://exp-astro.de/meetings/dimer/organizers.php*

Open-source Software

LANL ND program provides two software packages to support the wider nuclear data communities, such as nuclear data evaluation, processing, and applications. LANL released the ENDF-6 data interface and nuclear data evaluation assist code DeCE [8] in 2016 at

`https://github.com/toshihikokawano/DeCE`

and the CENS code in 2021 at

`https://github.com/toshihikokawano/CENS`

which converts Evaluated Nuclear Structure Data File (ENSDF) into other application specific formats, such as RIPL. We maintain these software updates to help nuclear data evaluators and end users.

Hauser Feshbach calculation code, CoH3, will be on the public GitHub soon