LA-UR-23-30290

US Nuclear Data Program review
Los Alamos National Lab overview

Hye Young Lee, LANL
Sept. 13-14, 2023

LANL Nuclear Data Program focuses on improving reaction evaluation via theoretical modeling advancement and differential measurements at LANSCE

- Theoretical Work: *development of accurate nuclear reaction databases, maintained by the National NuclearData Center (NNDC) at BNL, and make these database available for use by researchers in the nuclear physics community, theoretical interpretation of neutron-induced reaction data measured at Los Alamos Neutron Science Center (LANSCE) in terms of nuclear reaction mechanisms and nuclear structure, and nuclear astrophysics, where accurate nuclear data needed for understanding nucleosynthesis can be obtained from theoretical calculations.*

- Experimental Work: *perform experiments at LANSCE to improve our understanding of the nuclear properties for reaction models, analyze the data with a close collaboration with LANL theorists to identify nuclear reactions with high impacts for the DOE nuclear data programs, and work closely with the LANL nuclear data evaluators to ensure the measured data available to the national and international nuclear data communities in timely manner.*

- *Selected highlights on this collaboration:*

  - "New evaluation on angular distribution and energy spectra for neutron-induced charged particle reactions" led to DOE-NE International-Nuclear Energy Research Initiative (I-NERI) funding to incorporate new evaluation of structural materials based on LANSCE data into next ENDF- secondary-particle library; with KAERI

  - ^{35}Cl(n,p) initial work led to DOE-NE GAIN funding; with TerraPower

LANL staff (FY20 – FY23)

- Permanent Staff:
  -Continuous effort: Toshihiko Kawano, Hye Young Lee
  -Variable effort: M. Herman, M. Mumpower, S. Kuvin, P. Gastis

- Postdocs:
  -Theory: M. Verriere, H. Sasaki
  -Experiment: A. Georgiadou, D. Broughton, A. Long, S. Paneru, J. Randhawa, D. Votaw, L. Zavorka

- Students:
  -Pelagia Tsintari (CMU), Scott Essenmacher (MSU, DOE-SCGSR fellowship), Andrew Hannaman (Texas AM), Nikolaos Dimitrakopoulos (CMU)

- External Collaborators:
  - James DeBoer (U. Notre Dame), Mike Febbraro (AFIT), Carla Frohlich (NCSU), H.I. Kim (Korea Atomic Energy Research Institute), Georgios Perdikakis (CMU), Greg Severin (MSU), S. Hilaire, M. Dupuis (CEA), M. Kerveno (U. Strasbourg), S. Nishimura (RIKEN), O. Iwamoto, N. Iwamoto, F. Minato (JAEA), S. Okumura, R. Capote (IAEA), R. Grzywacz (U. Tennessee)

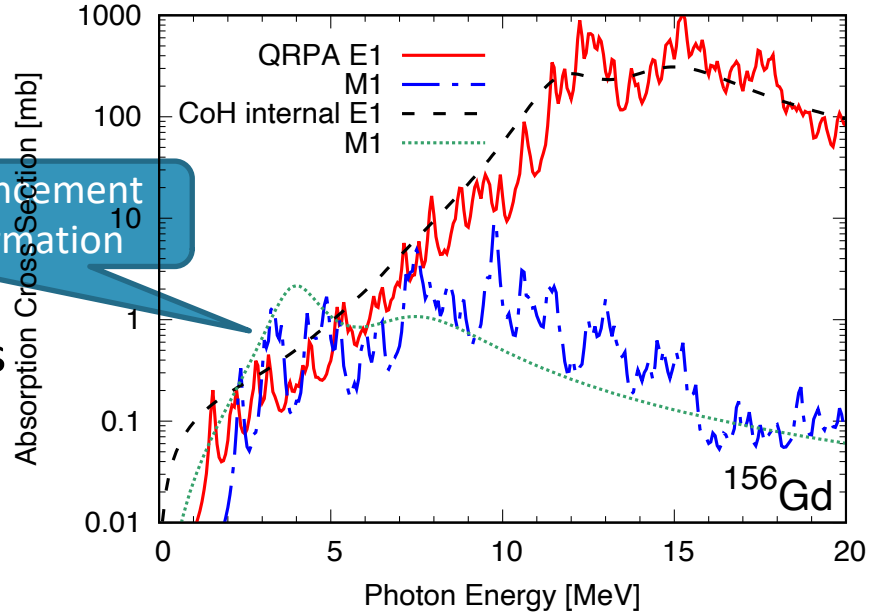
LANL Highlight #1

Nuclear reaction modelling for neutron capture and inelastic scattering by combining nuclear structure inputs

Quasi-particle Random Phase Approximation (QRPA)

- Non-Iterative Finite Amplitude Method (FAM) to solve QRPA
  - an efficient way to calculate microscopic photon strength function (photo-absorption)
    - PRC **105**, 044311 (2022), PRC **107**, 054312 (2023)
- QRPA and particle-hole excitation applied to pre-equilibrium process
  - strong impact on the gamma-ray production cross section, as well as the enhancement of PE emission
    - PRC **104**, 044605 (2021), PRC **107**, 034606 (2023)

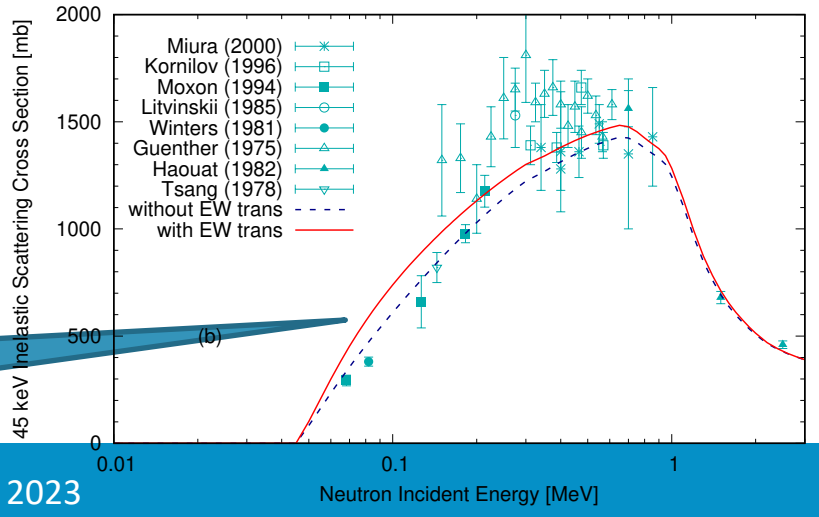
Low energy M1 enhancement due to nuclear deformation



Advances in general theories for compound nucleus reaction

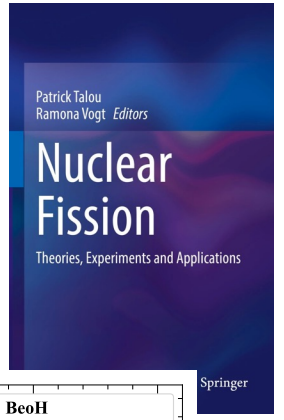
- Coupled-channels Hauser-Feshbach theory
  - consistent treatment of direct reaction channels in compound reaction by applying Gaussian Orthogonal Ensemble (GOE) ensures unitarity of S-matrix
    - EPJA **57**, 16 (2021)

Channel coupling enhances compound inelastic scattering



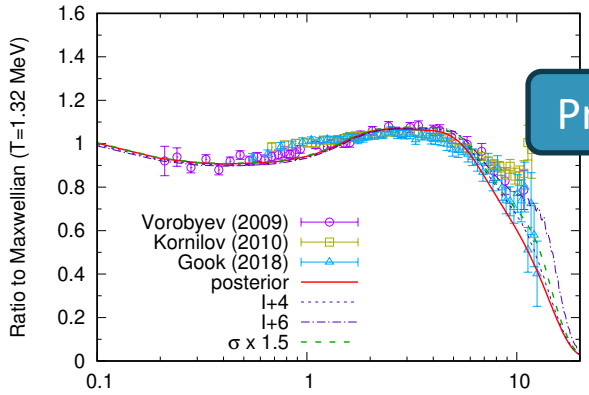
LANL Highlight #2

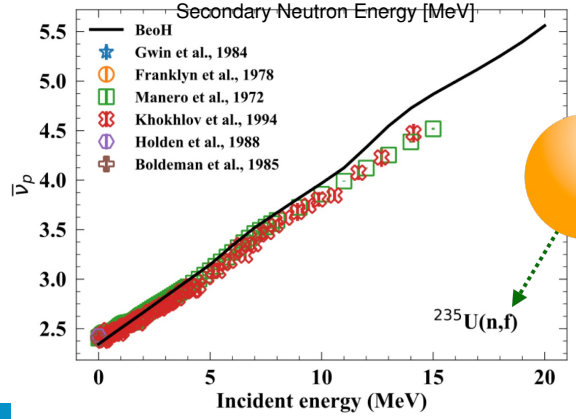
Toward Consistent Calculation of Fission Observables for Improvement of Actinide Nuclear Data



HF³D (Hauser-Feshbach Fission Fragment Decay) Model

- Produces independent and cumulative FPY as well as other fission observables simultaneously
  - 2 codes developed; CGMF for Monte Carlo decay, and deterministic BeoH
  - PRL **127**, 222502 (2021), PRC **103**, 014615 (2021), JNST **59**, 96 (2022), PRC **107**, 044608 (2023)

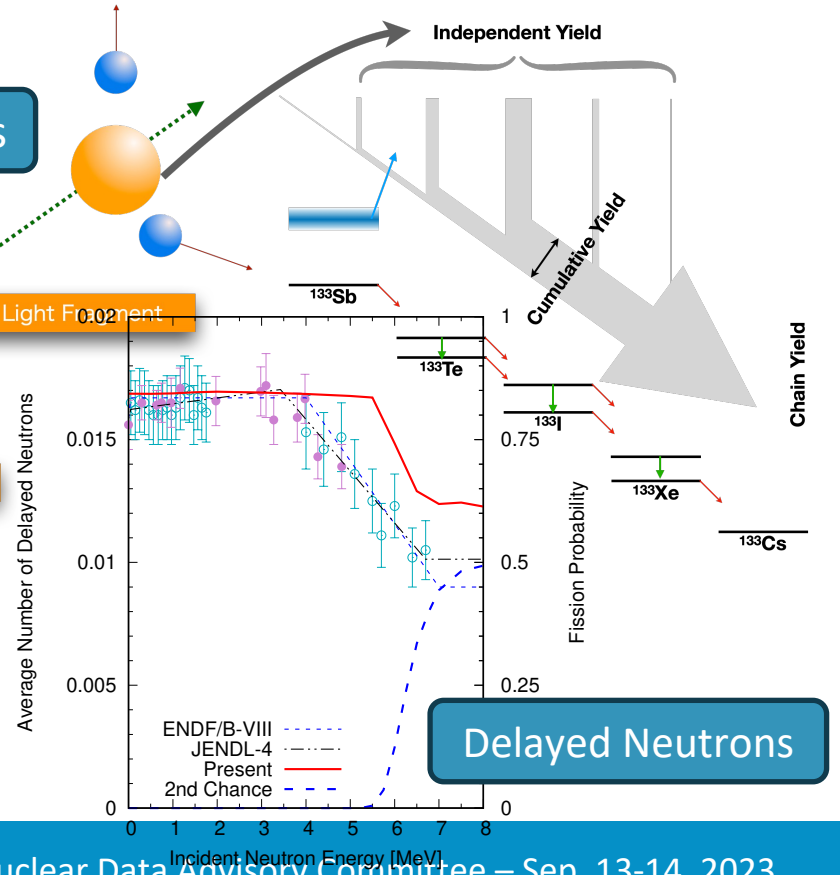




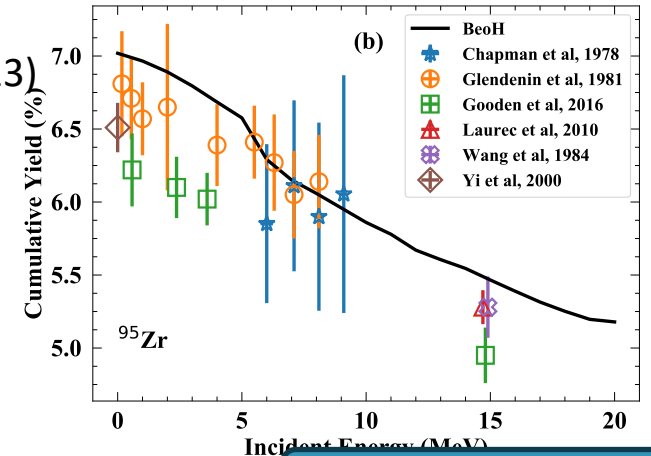
Prompt Neutrons

Light Fragment

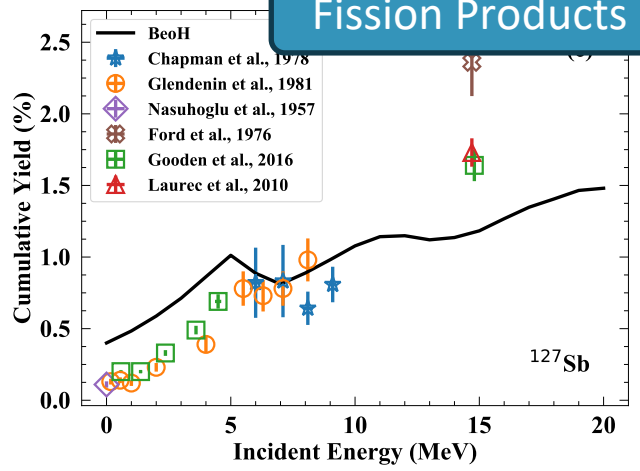
Heavy Fragment



Delayed Neutrons



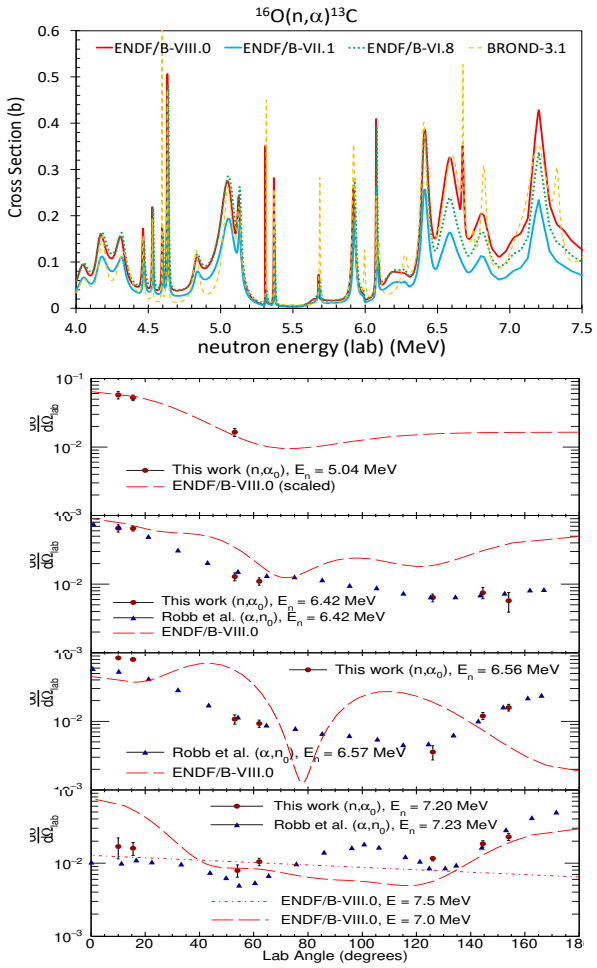
Fission Products



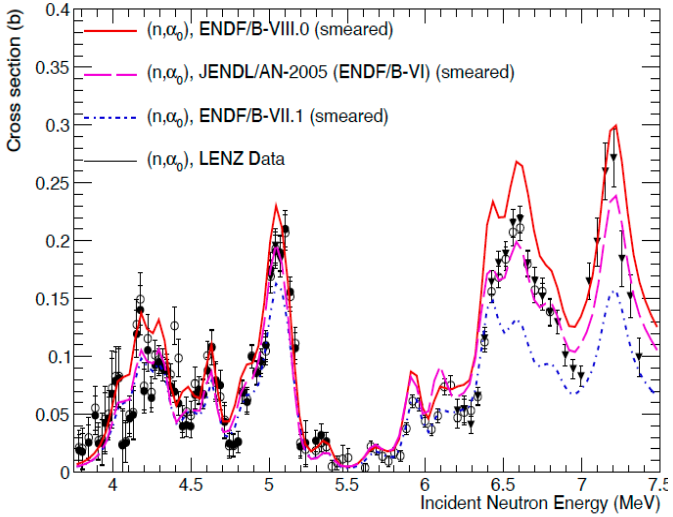
LANL Highlight #3

LANSCE results on $^{16}O(n,\alpha)$ cross sections

Status of available evaluations for $^{16}O(n,\alpha)$ required a new, independent experimental data

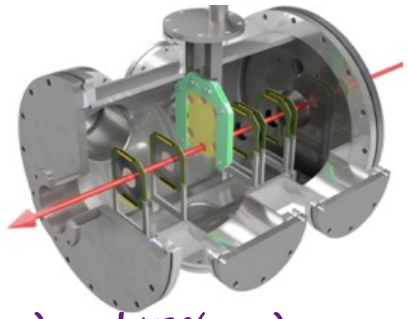


LANSCE measurements (LENZ data), compared with different ENDF releases using the experimental energy resolution function, showed good agreement with ENDF/B-VIII.0 up to 5.5 MeV and ENDF/B-VI above that

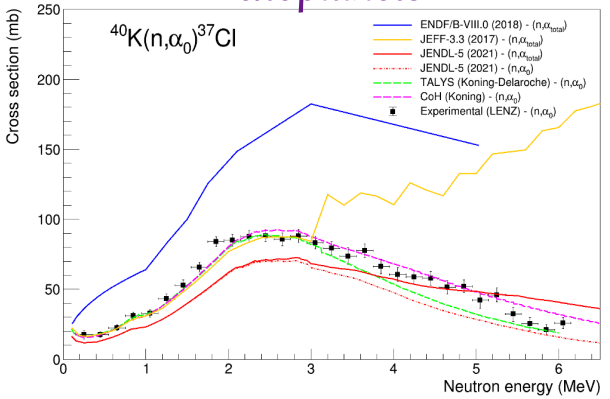


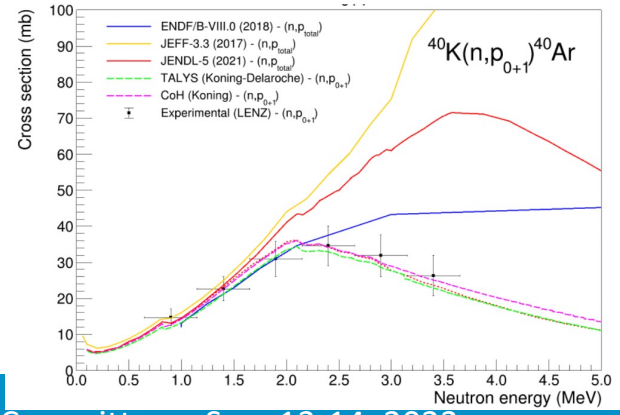
LENZ data: using angular distributions of filled circles - ENDF/B-VIII up to 5.2 MeV
open circles – Notre Dame data (private comm.) up to 6.8 MeV,
filled triangles – Prusachenko data (PRC 2022) up to 7.6 MeV

Angular distributions are compared with energy-averaged ENDF/B-VIII.0, suggesting to improve the angular distribution evaluation at high neutron energy



$^{40}K(n,p)$ and $^{40}K(n,\alpha)$ cross sections for the interest of radiometric dating and radiogenic heating of exoplanets





Microjet Printing was used to provide radioactive V targets under DOE-SC GSR fellowship