

USNDP LANL Report

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Personnel Changes and National / International Activities

■ Staff Members and Post-Docs

- M. Herman joined T-2 in Sept. 2018
- H.I. Kim visiting scientist in P-27/T-2 started in Jul. 2018
- A. Georgiadou joined P-27 in Nov. 2018
- L. Zavorka joined P-27 in Apr. 2018

■ Summer Students (not all funded by USNDP)

- A. Lewis (UC Berkeley), P. Fanto (Yale U.), and T. Chadwick (LAHS)
- M. Grinder (MSU) and P. Tsintari (Central Michigan U.)

■ Conference Organized and Plans

- Int. Conf. Nuclear Reaction Mechanisms, Varenna, Italy, June 2018
- Int. Workshop Compound Nuclear Reactions and Related Topics, CNR2018, Berkeley, CA, Sep. 2018
- Workshop on Fission Product Yield Experimental Data, Los Alamos, NM, Aug. 2018

■ IAEA CPRs and Meetings

- R-matrix (G. Hale)
- Strength function and photo-nuclear data library (T. Kawano)
- Reference input parameter library (T. Kawano, no meeting in this FY)
- INDC (M. Herman, T. Kawano)

■ FIRE (Fission In R-process Elements) Topical Collaboration

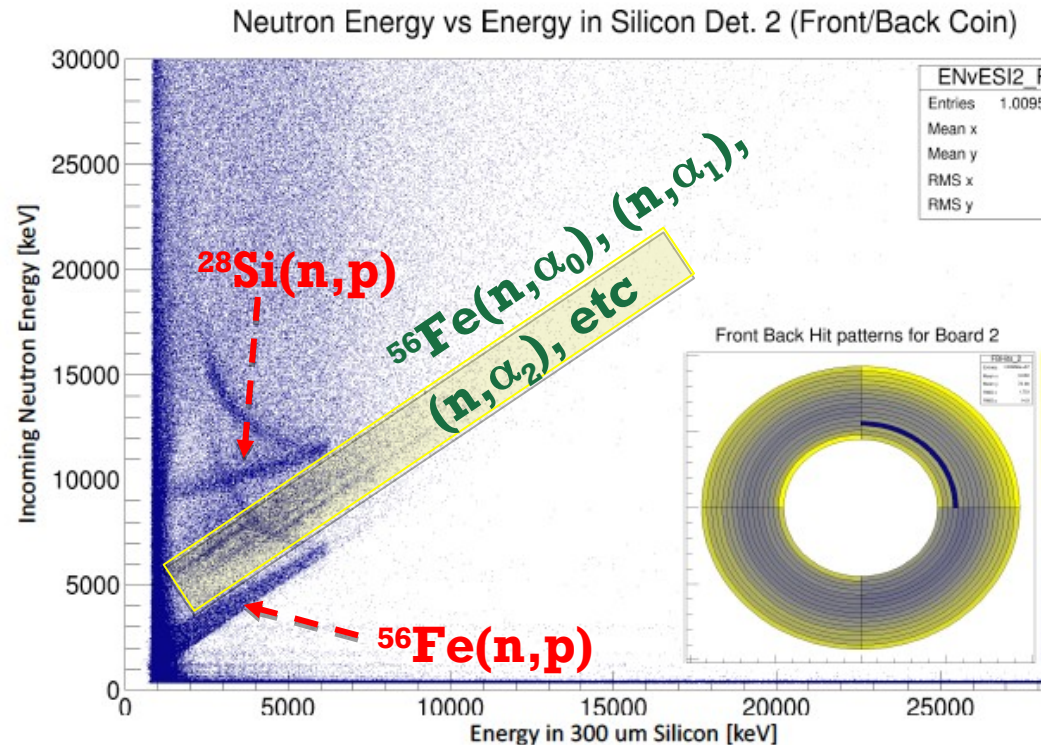
- Funded by DOE/SC and NNSA
- Collaboration meeting at NCSU in May 2018



Fission In R-process Elements

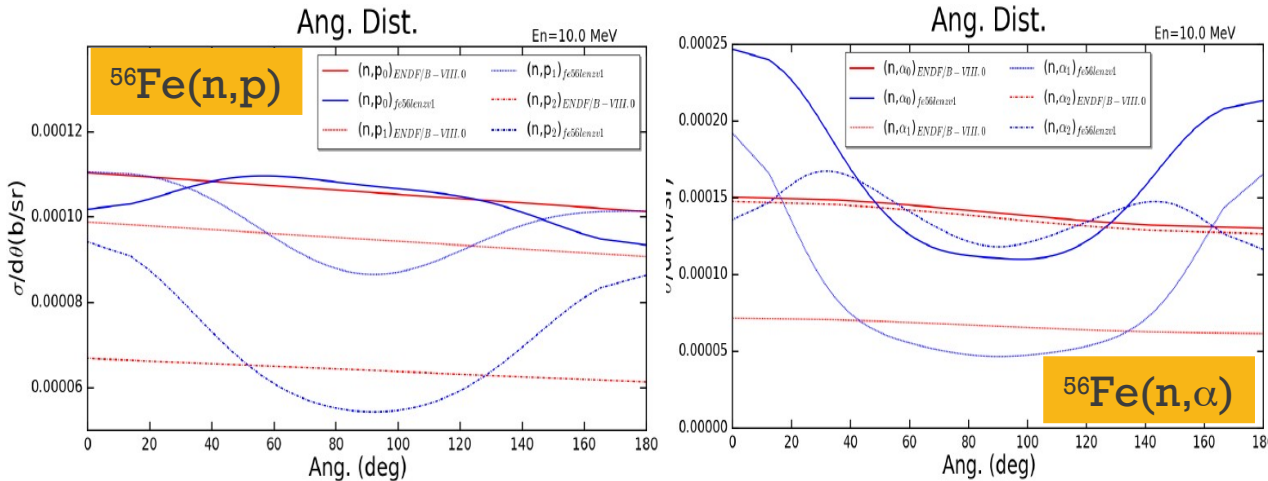
The FIRE collaboration explores the role of fission in the rapid neutron capture or r-process of nucleosynthesis

LENZ Campaign on Gas-Production Cross-Sections Measurements on Cr, Mn, Fe, Co, Ni, etc.



- Interested in the neutron energy range up to 20 MeV as a broad coverage
- Used self-supporting, thin, and enriched targets with Ohio U. collaboration
- ΔE -E telescope in forward and backward angles are utilized
- LENZ is sensitive to differential cross sections to discrete levels and angles

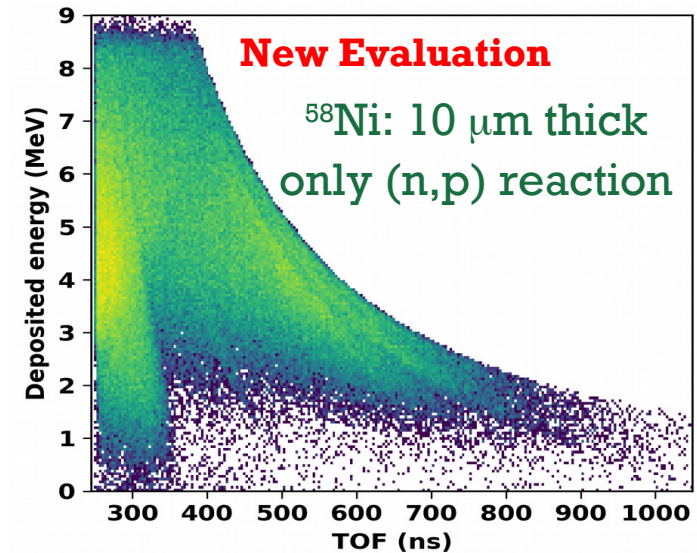
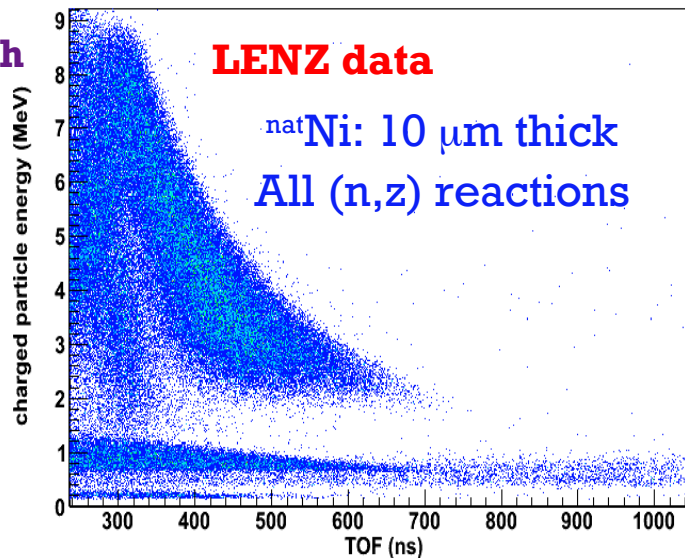
New Angular Distributions at $E_n=10$ MeV



Cross sections are same with those of ENDF/B-VIII.0 by using same incident neutron energies and fitting to cross sections of ENDF/B-VIII.0

Red: ENDF/B-VIII.0 and **Blue: Present evaluation**

MCNP6 simulation with the new evaluation by H.I. Kim



Nuclear Reaction Theory and Modeling Highlights

■ Nuclear-Astrophysics

- Californium-254 and Kilonova Light Curves, Zhu et al. *Astrophys. J. Lett.* **863**, L23 (2018).
- Short-Lived Radioisotope ^{98}Tc Synthesized by the Supernova Neutrino Process, Hayakawa et al., *Phys. Rev. Lett.* **121**, 102701 (2018).

■ Statistical Model and Fission

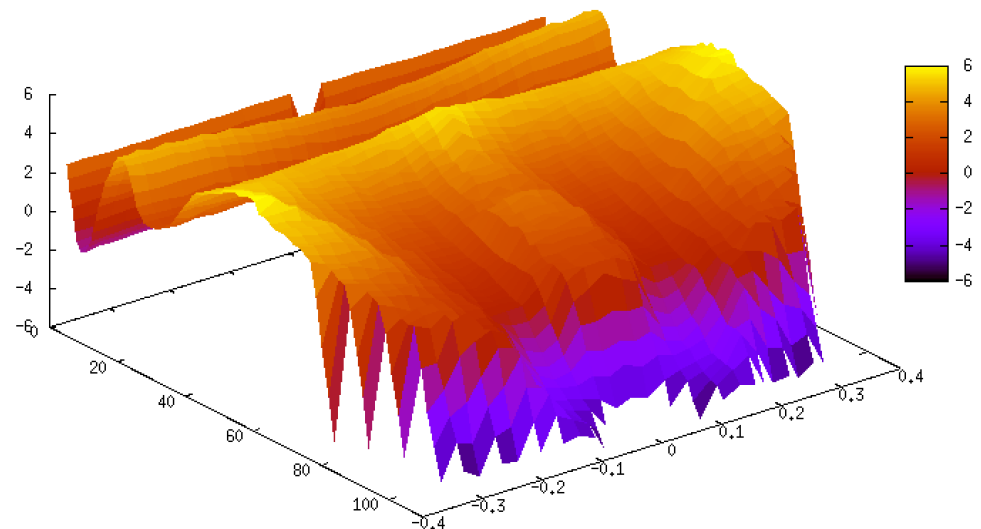
- Exit-Channel Suppression in Statistical Reaction Theory, Bertsch and Kawano, *Phys. Rev. Lett.* **119**, 222504 (2017).
- Angular momentum of fission fragments, Bertsch, Kawano, Robledo, ArXiv 1810.13429
- Fission potential energy surface and dynamics, Verriere et al.

■ Deterministic Hauser-Feshbach statistical decay of fission fragments

- $^{235}\text{U}(n, f)$ Independent fission product yield and isomeric ratio calculated with the statistical Hauser-Feshbach theory, Okumura et al., *J. Nucl. Sci. Tech.* **55**, 1009 (2018)

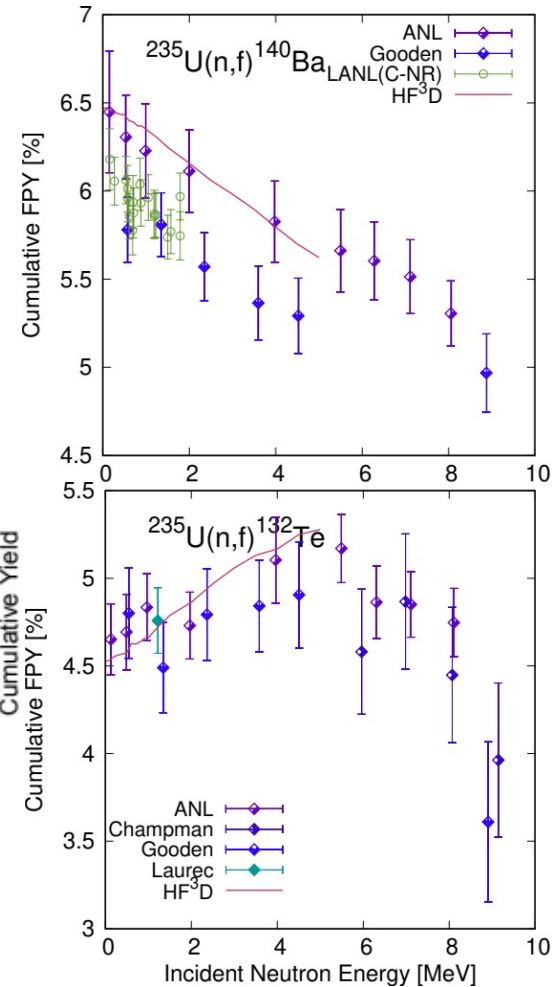
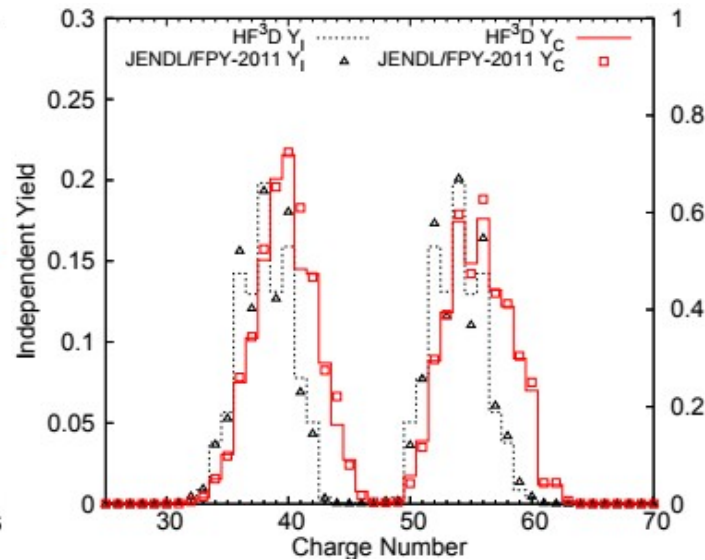
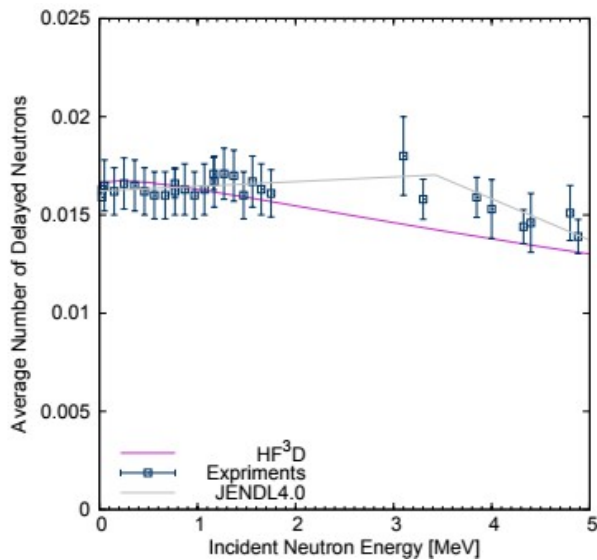
■ Connecting IFPY and CFPY

- Presentations at WONDER and Verenna by Okumura

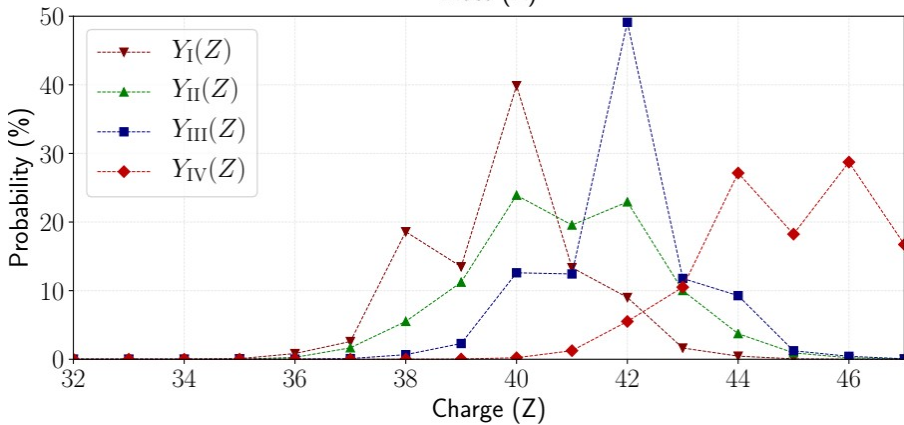
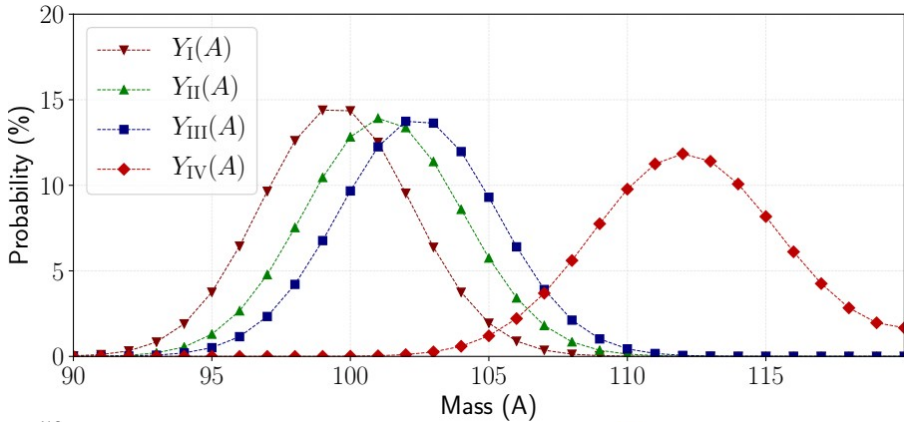


Hauser-Feshbach Fission Fragment Decay, HF³D Model

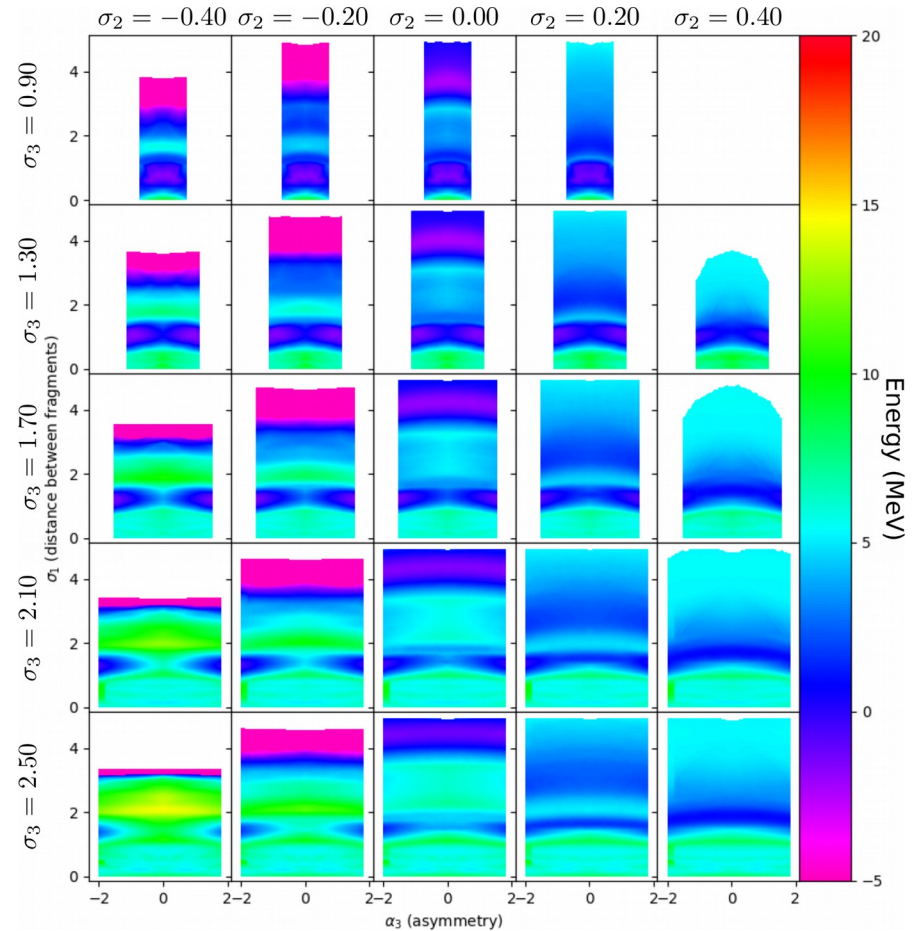
- Hauser-Feshbach decay of fission fragments
 - neutron and photon multiplicity distributions and spectra
 - independent fission product yield, incl. isomeric state
- beta-decay calculation connected
 - cumulative fission product yield
 - decay heat and delayed neutrons



Fission Work Under FIRE Collaboration, Pu240



Mass and Charge Distributions



FRLDM potential Energy Surface

Perspective

■ Fission Theories

- Fission potential energy surface for dynamical fission process
 - random walk, Langevin, GCM
 - realistic fission path in the fission cross section calculation
- Hauser-Feshbach fission fragment decay
 - independent and cumulative fission product yields
 - prompt fission neutron and photon spectra
 - in connection with the LANSCE programs, SPIDER and ChiNu, as well as other fission measurements

■ Statistical Theories in collaboration with UW and Yale

■ LENZ

- Resolve $^{16}\text{O}(n,\alpha)$ issue: provide LANL final cross sections with uncertainties with “forward propagation analysis using the MCNP6 response functions”
- Finalize experimental (n,p) and (n,α) cross sections on ^{58}Ni and ^{60}Ni over $0.5 \text{ MeV} < E_n < 20 \text{ MeV}$, including angular distributions and discrete level cross sections