Evaluation work for ^{139}La

I. Stetcu, T. Kawano, A. E. Lovell, and M. Herman

November 7, 2024

LA-UR-24-31639

Prepared for CSEWG meeting
Brookhaven National Laboratory, November 4-7

Outline

- Evaluation procedure
- n+^{139}La evaluation
- Summary

General procedure for consistent evaluations

- If standard cross sections are available for given channels, we take those cross sections from standards and adjust transmission coefficients in the respective channels to exactly reproduce the required cross sections. Because we are aware that the models included in CoH_3 rely on drastic approximations and we have problems reproducing the available data, even if standards are not available, we will first determine the cross section by performing a generalised least square fit that takes into account the available measurements, and then we reproduce the cross section in our model by adjusting the transmission coefficients. This is mostly the case with the fission channel for actinides.
- If data on total cross section are available, we start with an optical potential appropriate for target-projectile combination and readjust the parameters via a Monte-Carlo search, or using a Bayesian approach, to provide the best reproduction of the data. If no experimental data are available (for example, there is no total cross section data for ^{234}U), we use an appropriate global optical potential.
- Statistical HF models must be carefully tuned to available data and oftentimes the evaluation of select channels must be further adjusted such that critical assemblies remain within physical bounds
- All other channels are obtained from CoH_3 calculations. For the channels where experimental data are available, we further determine whether we can adjust parameters to better reproduce the data.
- Don't trust the data (unless good reasons), and trust the modeling codes even less

CoH_3: Coupled-Channels Hauser-Feshbach code

- ❑ Hauser-Feshbach-Moldauer theory for compound nuclear reactions
  - 45,000 lines C++ code (~ 140 C++ source files, ~60 headers, ~80 classes)
  - maintain by GNU Autotools package

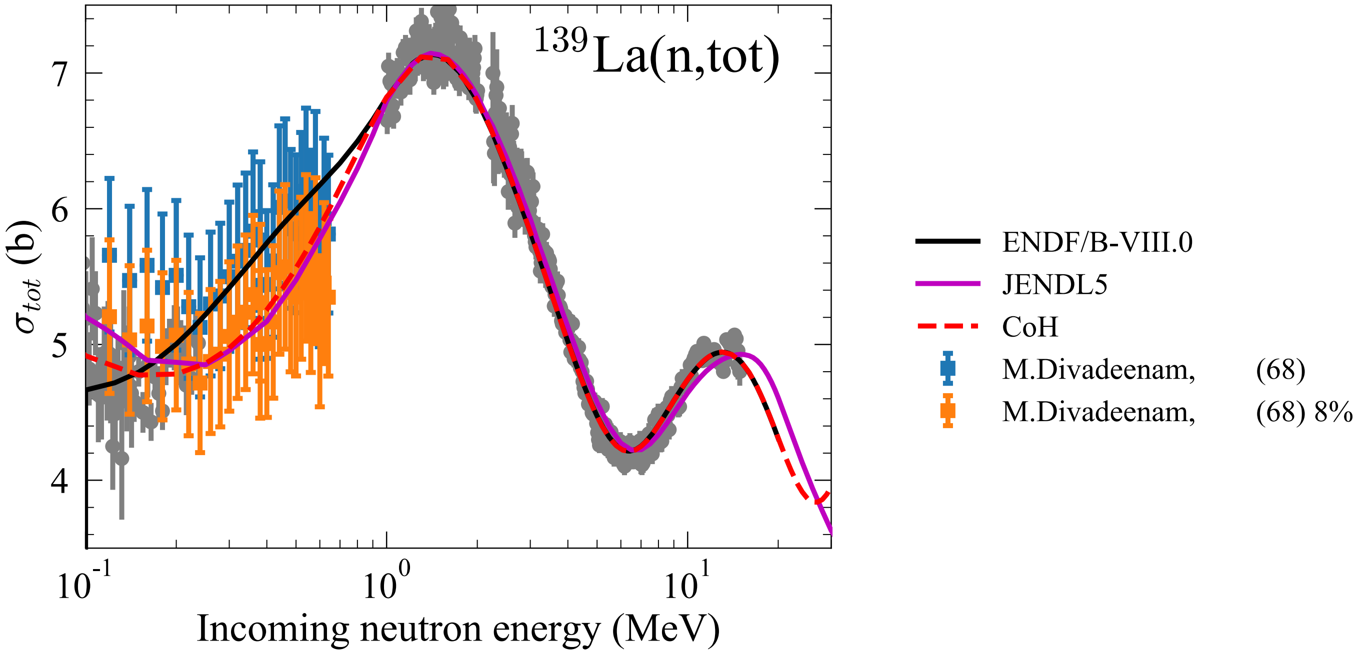
- ❑ Modules and Models employed

- spherical and deformed optical models
- DWBA for direct inelastic scattering
- Moldauer's width fluctuation correction with LANL parametrization
- Gilbert-Cameron level density with updated parameters
- pre-equilibrium 2-component exciton model
- Madland-Nix prompt fission neutron spectrum including pre-fission emission
- direct/semidirect capture model
- mean-field models (FRDM and Hartree-Fock BCS)

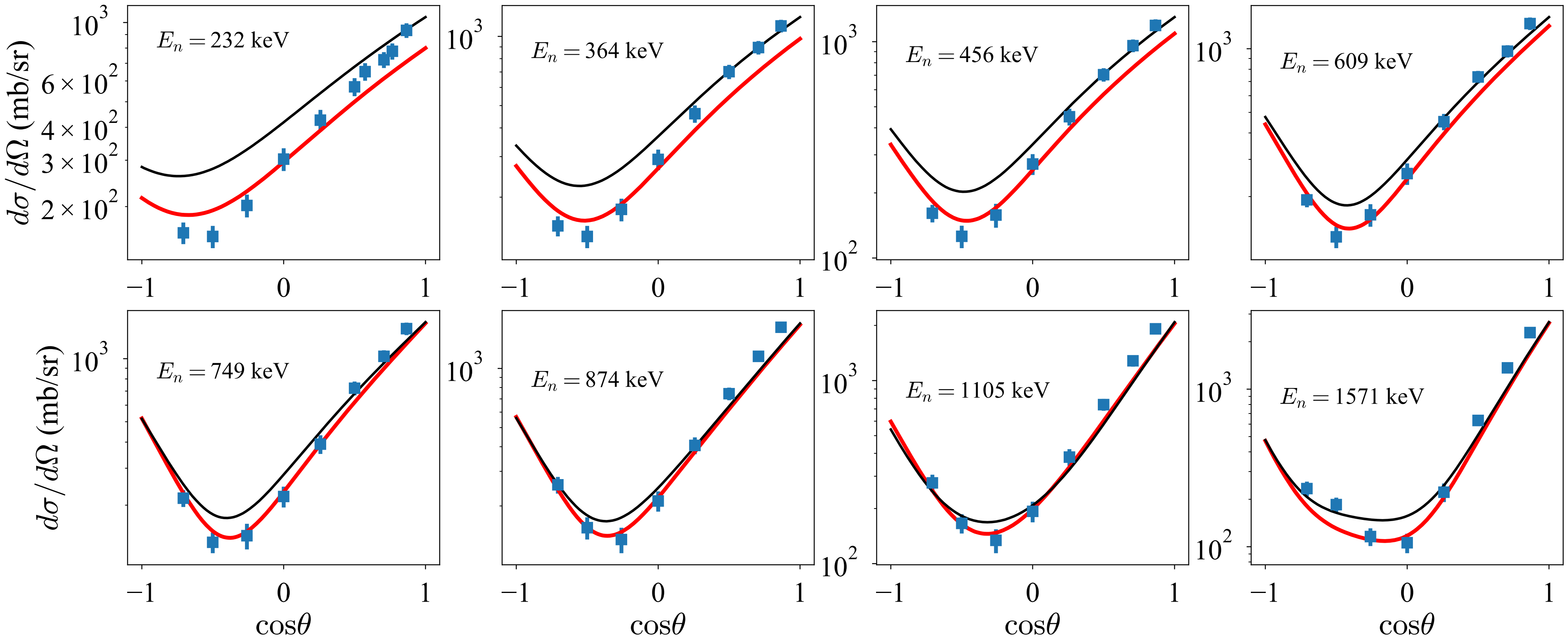
Consistent evaluations in all channels

^{139}La(n,tot) evaluation

- Good agreement with ENDF/B-VIII.0/CENDL-3 and JENDL5 above 1 MeV
- ENDF/B-VIII.0 follows Divadeenam data below 1 MeV
- Could there be problem with the Divadeenam data? Not enough information
- New evaluation: better matching of the low-energy data
- Waiting for the resonance analysis from ORNL to see whether we should adjust the low-energy cross section



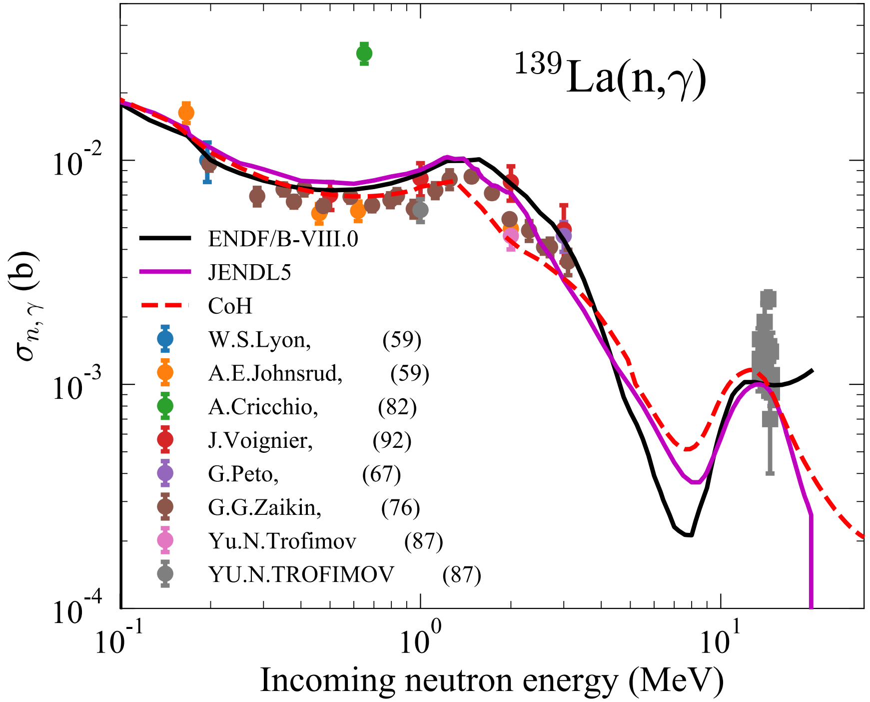
^{139}La angular dependence

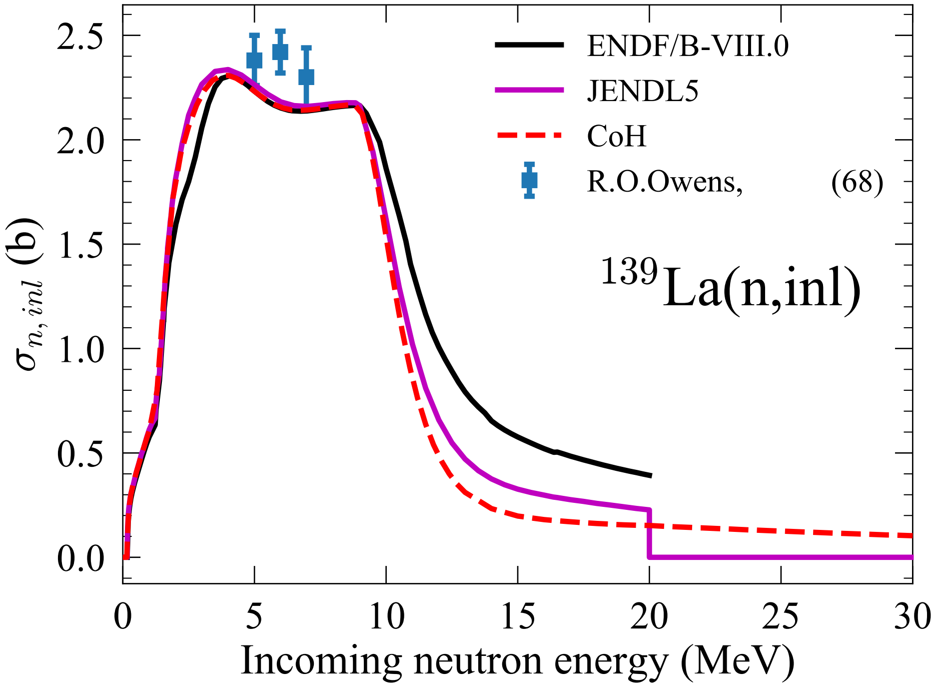


Fairly good reproduction of experimental data (no adjustments)

Blac curves: ENDF-B/VIII.0; Red curves: CoH (current evaluation)

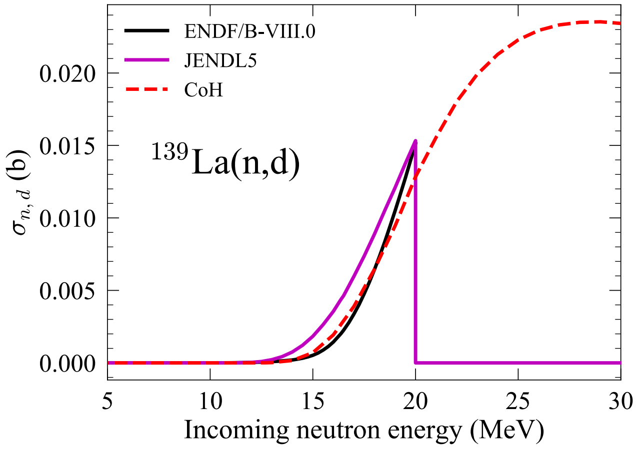
^{139}La(n,g) and ^{139}La(n,inl)

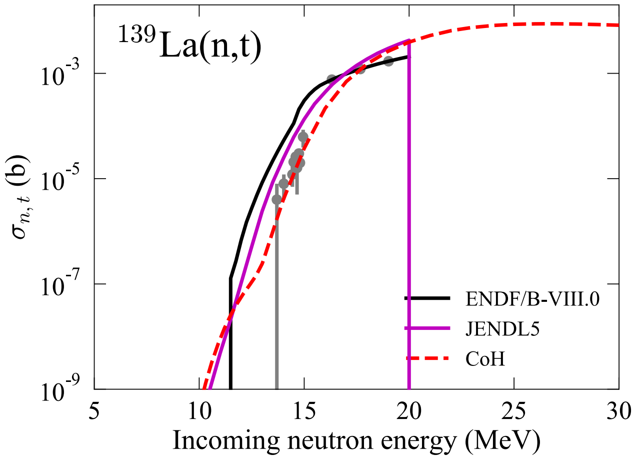




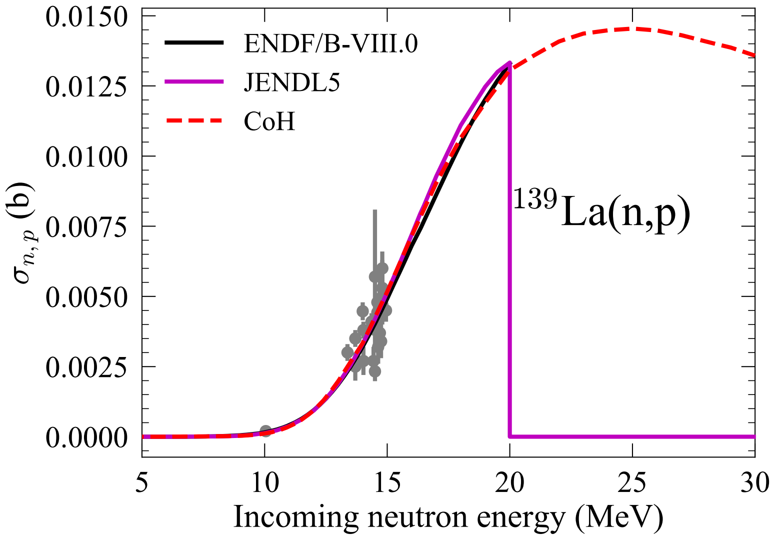
- At energies above 1 MeV, the capture data can be less reliable
- Inelastic channel very close to the previous evaluation

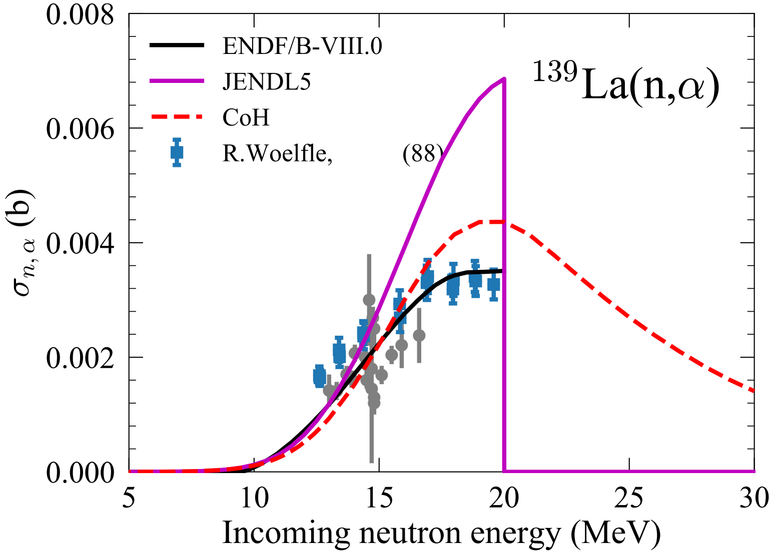
n+^{139}La: charged particles





(n,p): Koning Delaroche



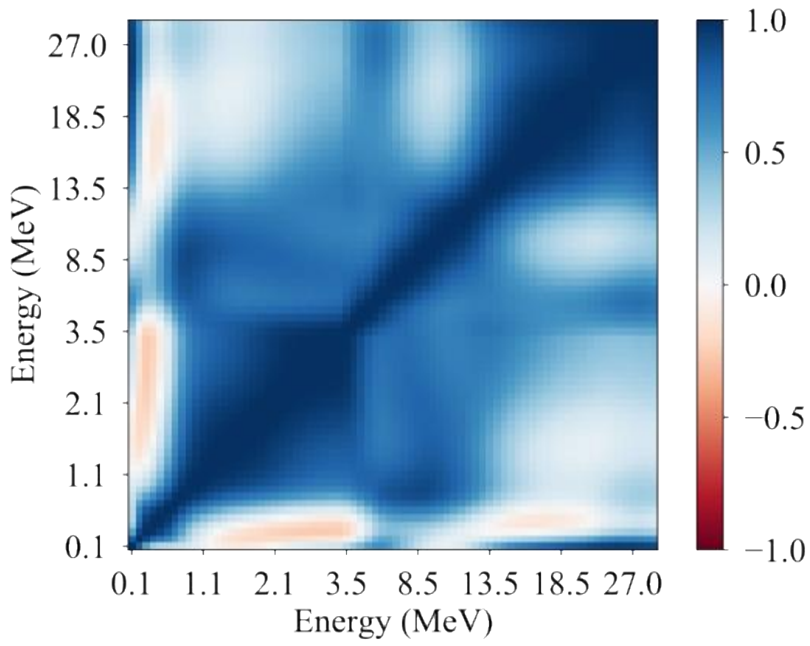


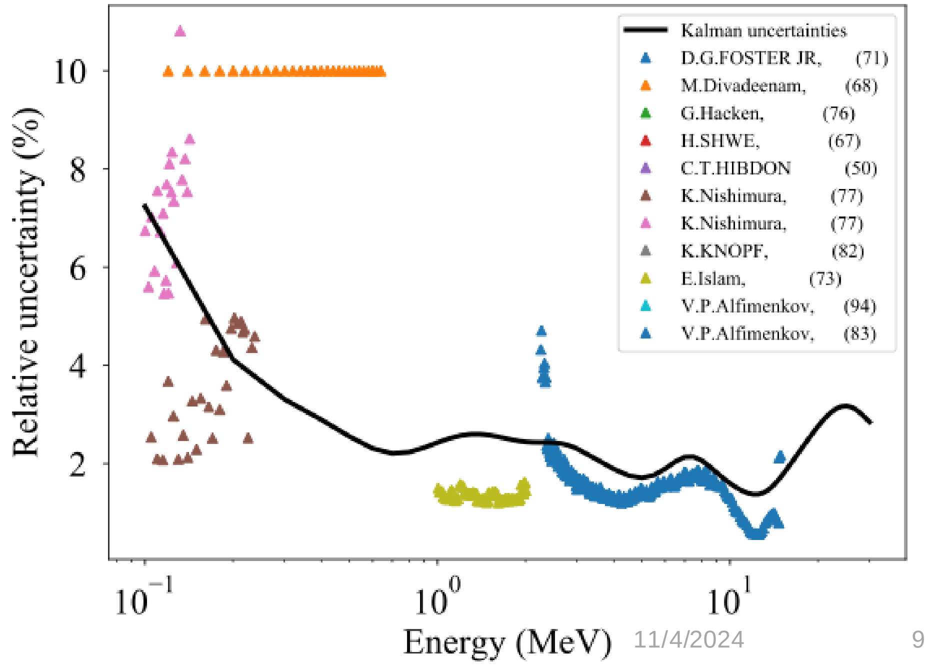
(n,α): Avrigeanu 2009 OM

- Adjustment in the s.p. state density for (n,p) and (n,α) channels to match available data
- No adjustment for (n,t)

Covariance evaluation

- Based on CoH_3 calculations
- Calculated sensitivities with respect to all parameters
- Kalman filter to evaluate covariances





Correlations and uncertainties for the total cross section.
Covariance for MT=1 is missing in ENDF/B-VIII.0

Summary

- Emphasis on producing consistent evaluations for all reactions and channels
- CoH_3 is our go to evaluation tool which has been updated with several theoretical enhancements
- Evaluation: evaluated all open channels
- Evaluation: evaluated the covariance based on CoH_3, Kalman filter, data uncertainties
- ^{139}La evaluation: close to submitting an evaluation file to NNDC (see also previous talk)

This work was carried out under the auspices of the National Nuclear Security Administration of the U.S. Department of Energy at Los Alamos National Laboratory under Contract No. 89233218CNA000001. This work was supported by the Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.