

# Update on Recent Cl-35(n,p) LENZ Measurements into the RRR

**Kenneth Hanselman**  
*XCP-5 Nuclear Data Team*  
khanselman@lanl.gov

## Outline:

- Review of “Fast” Improvements
- Extending the Measurements
- Analysis & FP Characterization
- Looking Ahead Toward ENDF/B-IX

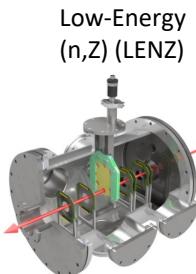
LA-UR-25-30757

>>> CSEWG 2025 <<<

# Review: Fast Improvements

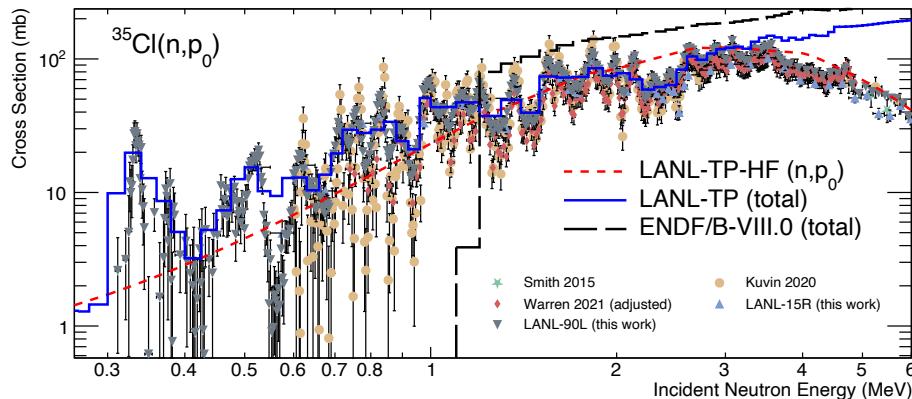


+ **TerraPower**  
A Nuclear Innovation Company

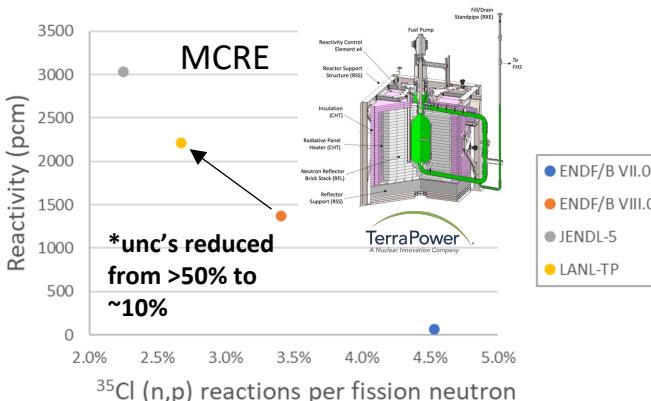


**GAIN** Gateway for Accelerated Innovation in Nuclear  
(Voucher NE-22-28590)

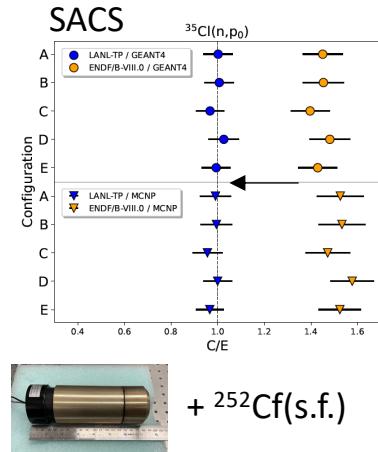
- prior focus was on fast-spectrum region for MSR applications, with experiments run over the 2022-2023 LANSCE run cycles
- LENZ instrument @ WNR (unmoderated “fast” spectrum of spallation neutrons)
- the resulting LANL-TerraPower evaluation for  $(n + {}^{35}\text{Cl}, {}^{37}\text{Cl})$  using the latest data is available by request or on the NNDC GitLab  
 >> covariances for major channels  
 >> working w/ ORNL to update RRR more formally



## FAST “VALIDATION” EFFORTS:



T. Cisneros et al., PHYSOR 2024, proc., San Francisco, CA, 2024 pp. 1549–1559



+  ${}^{252}\text{Cf}(\text{s.f.})$

see my ND-2025 presentation, or upcoming pub. in Nature Sci. Rep. (in review)

# Motivation for New Experiments

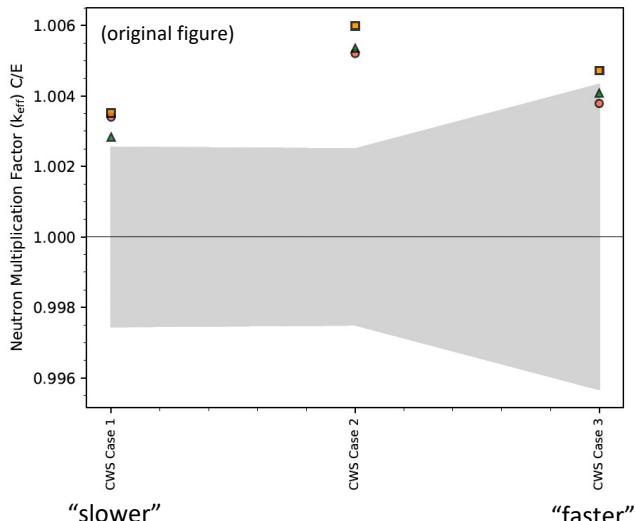
Most actual “benchmarks” are in the low-energy regime – we’ve tested two so far:

## Chlorine Worth Study

(Pu-based, (C)PVC + HDPE)

N. Thompson *et al.*, OSTI ID: 2345728 (2024)

- ENDF/B-VIII.1
- ENDF/B-VIII.1 with LANL-TP  $^{35}\text{Cl}$
- ▲ + LANL-TP  $^{35}\text{Cl}(n,\gamma)$  max unc.



- Discrepancies observed between benchmarks that can’t be explained by adjustments to fast-energy Cl alone.

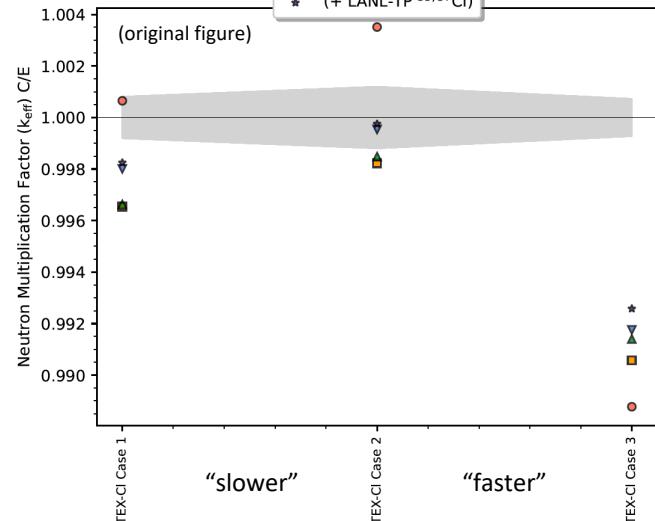
- Now that the fast evaluation is well uncertainty-constrained, re-evaluation can proceed into the RRR and thermal for further impact studies (with M. Pigni, ORNL)

## TEX-Cl

(U-based, NaCl + HDPE)

E. Aboud *et al.*, OSTI ID: 2202542 (2023)

- ENDF/B-VII.1 Base
- ENDF/B-VIII.0 Base
- ▲ (+ LANL-TP  $^{35,37}\text{Cl}$ )
- ▼ ENDF/B-VIII.1 Base
- ★ (+ LANL-TP  $^{35,37}\text{Cl}$ )



\*\*\*huge thanks to Eric Aboud (LLNL) for providing simplified MCNP files, prelim. results, and general guidance

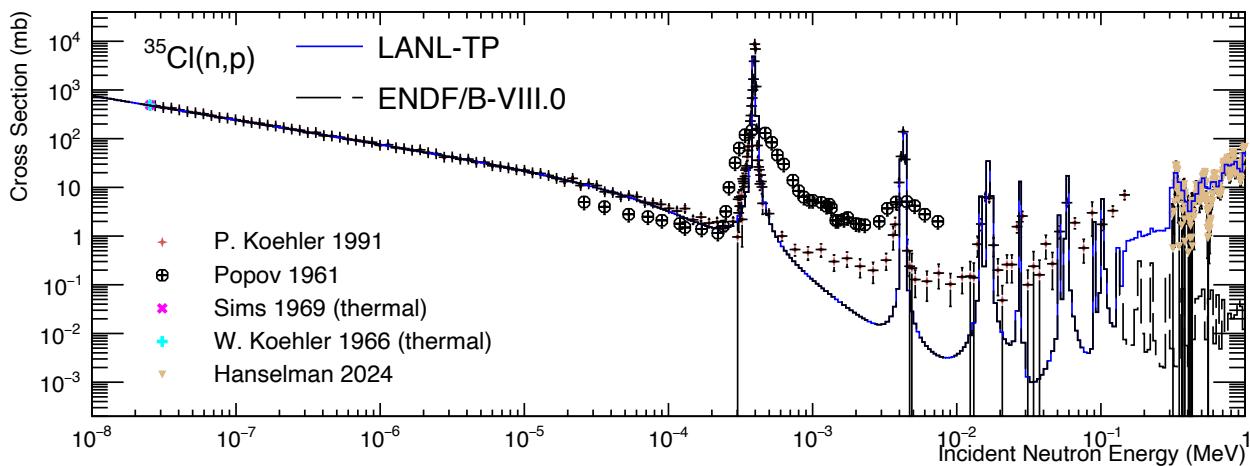
# Motivation for New Experiments

The LENZ (n,p) measurements can be extended down to thermal by running at the **Lujan Scattering Center** (moderated source of spallation neutrons)

- energies from thermal up to ~few hundred keV
- current RRR differential data are poorly resolved
- mainly important for **criticality safety**, with some astrophysics interests
- continued collaboration with ORNL to update resonance region evaluation

\* flux in the intermediate region recently bolstered by **Mark IV upgrade to Lujan spallation target**

L. Zavorka, M. J. Mocko, and E. R. Olivas,  
Nucl. Instrum. Meth. Phys. Res. A 1040,  
167210 (2022)



# Bird's eye view of LANSCE

- Uniquely capable of accelerating  $H^+$  and  $H^-$  simultaneously
- Can deliver 100 kW of  $H^-$  and 800 kW of  $H^+$  beam
- 120 pulses per second shared among 5 facilities
- $H^-$  beam:
  - Lujan Center (NNSA)
  - Weapons Neutron Research Facility (NNSA)
  - Proton Radiography (NNSA)
  - Ultra-Cold Neutron Source (DOE-Office of Science)
- $H^+$  beam:
  - Isotope Production Facility (DOE-Office of Science)

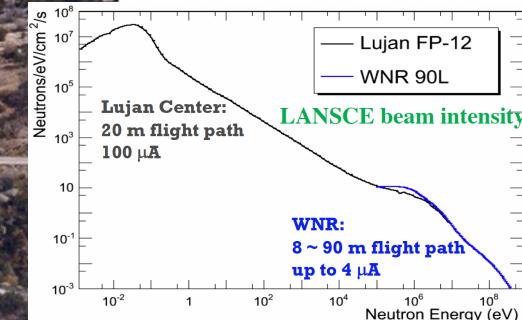


Experiment @ Lujan  
Sep-Oct 2025

Moderated white  
neutron source (W  
spallation)

FP12 @ ~20.8 m

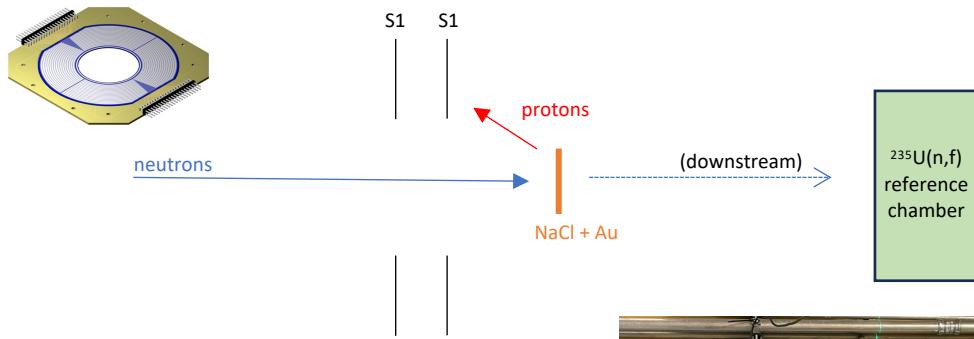
Total of ~45,236 uA-hrs  
(~4000 in 2023)



# Experimental Details

Two 65um Micron S1 DSSDs covering backward lab angles: 116-134° and 143-159°

## Al 6-way cross chamber



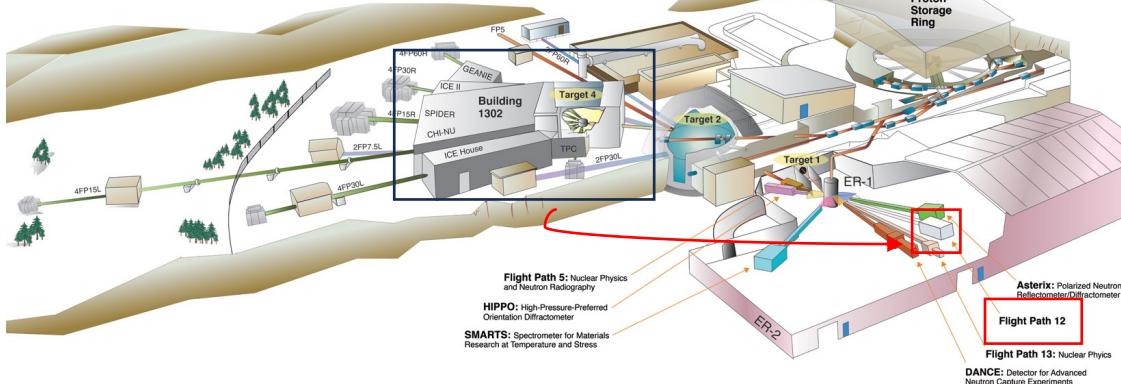
Three foil targets:

NaCl + Au (35,351 uA-hrs)

LiF + Au (2,880 uA-hrs)

Au (7,006 uA-hrs)

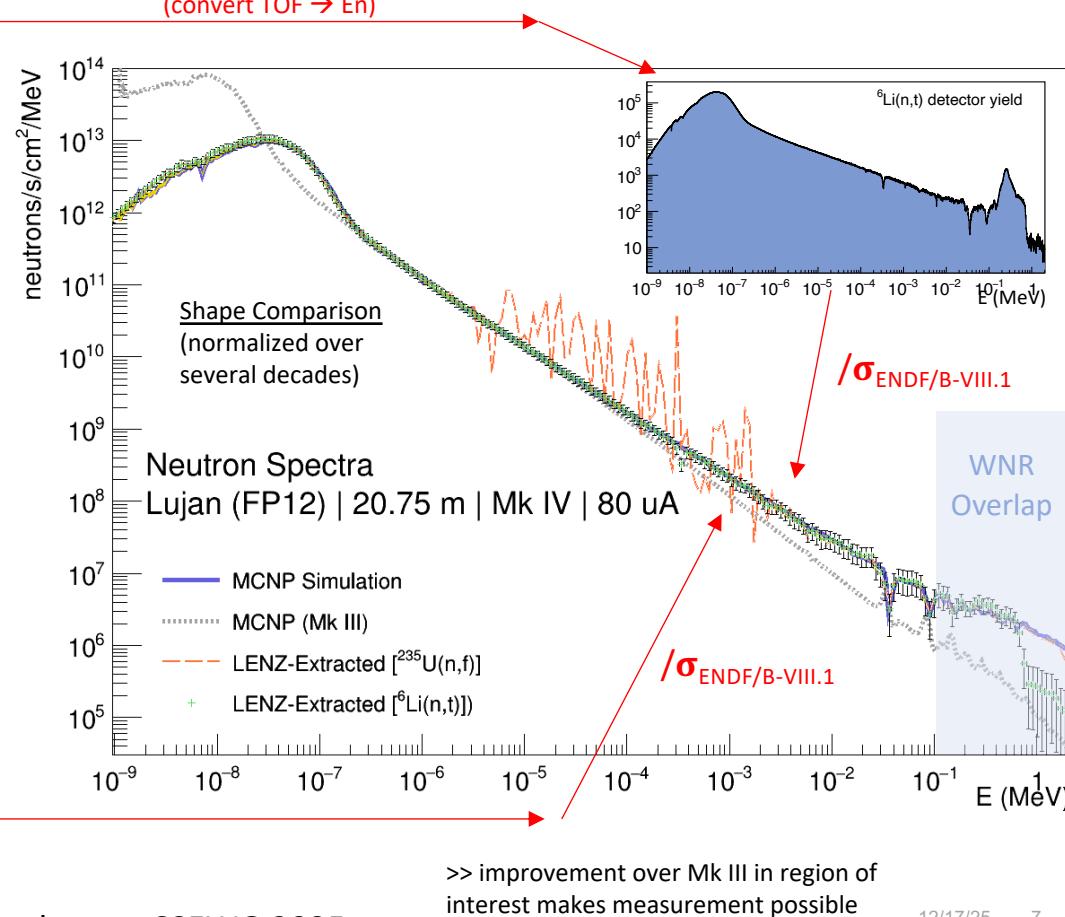
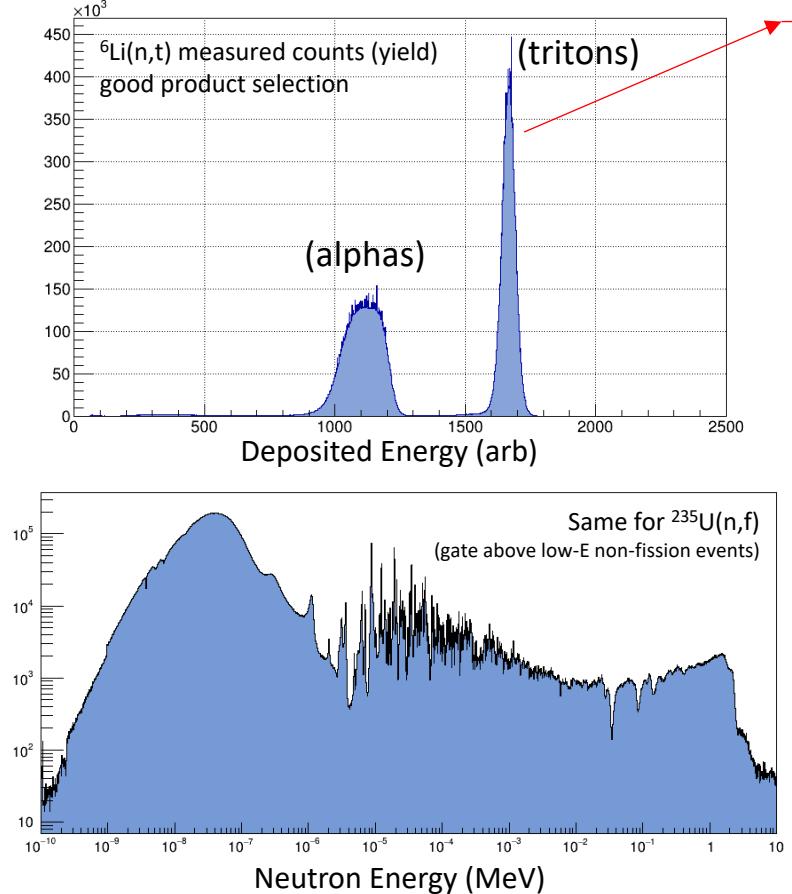
Avg of ~80 uA



Data processed through CAEN V1730  
500 MHz digitizers & MIDAS software

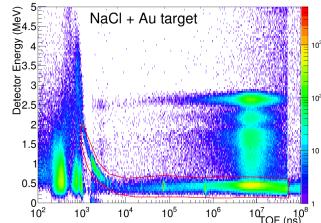
# Beam Characterization via Measured ${}^6\text{Li}(\text{n},\text{t})\alpha$ & ${}^{235}\text{U}(\text{n},\text{f})$

(convert TOF  $\rightarrow$   $E_n$ )

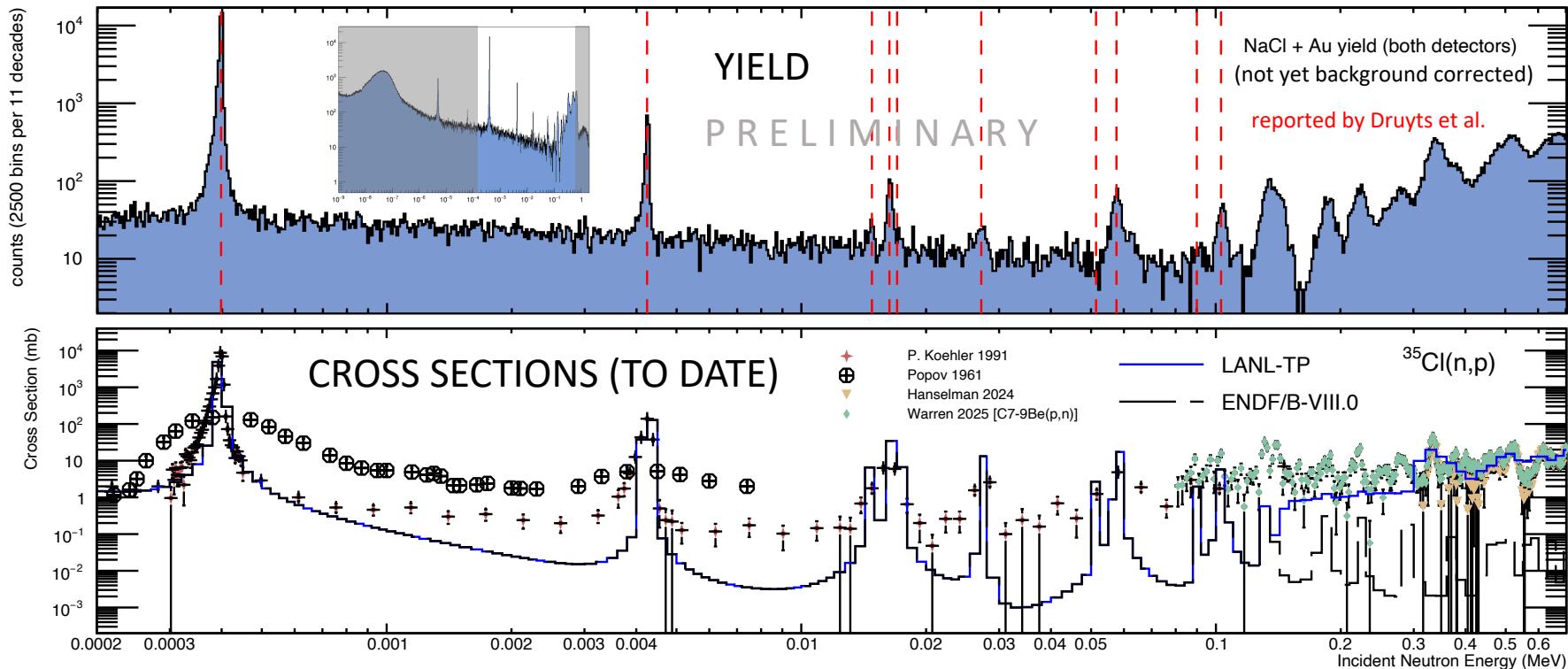


# PRELIMINARY Yield Spectrum for NaCl + Au

first-order calibration using known resonances  
(Druyts *et al.* Nucl. Phys. A 573, 291 (1994))

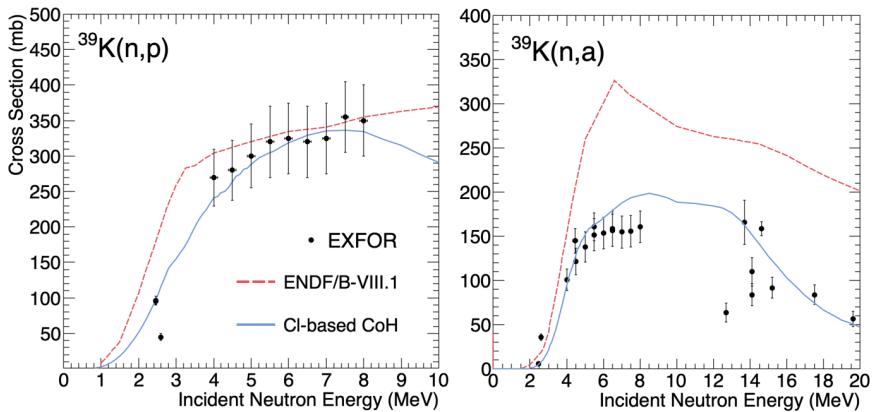
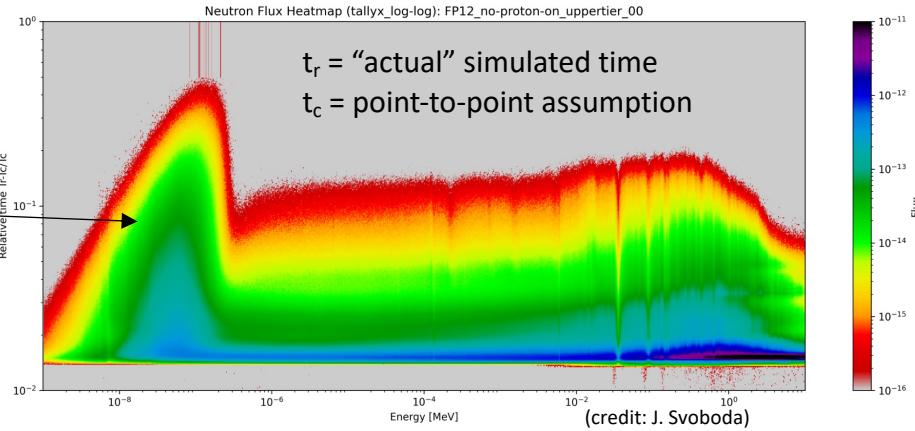


\* resolution above ~10 keV  
impacted by 290ns width of  
proton pulses



# Summary & Future Work

- For actual cross section extraction, simulations of the facility-based timing resolution and moderation delay (right) will be incorporated.
- Once cross section is extracted, will work closely with ORNL evaluators to incorporate it into RRR re-evaluation and continue to test against benchmarks.
- Final product is eventually intended for ENDF/B-IX.
- Also for ENDF/B-IX, we plan to push updates to stable potassium isotopes ( $^{39,41}\text{K}$ ) in the fast range based on lessons learned from chlorine, relevant for MSRs using K-based salts. New measurements would aid this effort.



# THANK YOU

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LANL (P-2): **Josef Svoboda** (MCNP simulations & facility characterization)

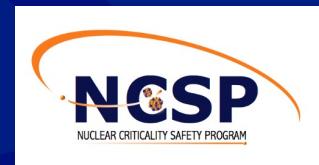
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U.S. DEPARTMENT OF  
**ENERGY**

**NNSA**<sup>SM</sup>  
National Nuclear Security Administration



K.H. contact: khanselman@lanl.gov