

Update on Recent $\text{Cl-35}(\text{n,p})$ LENZ Measurements into the RRR

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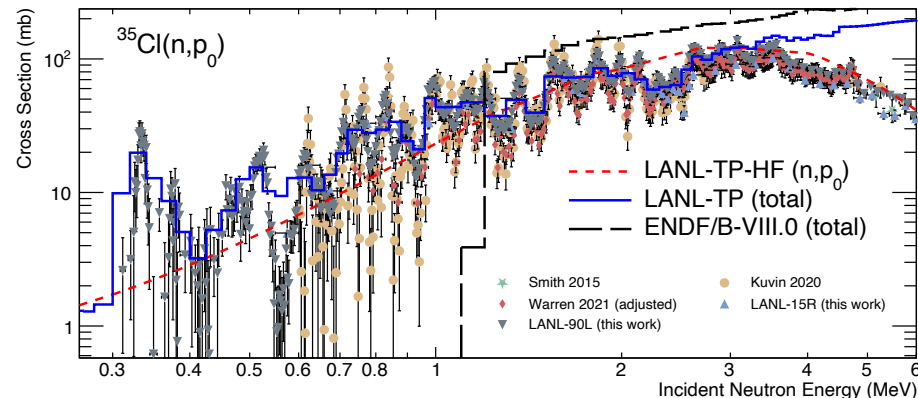
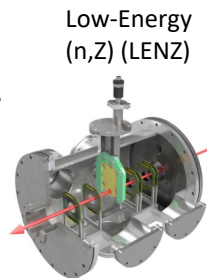
Outline:

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

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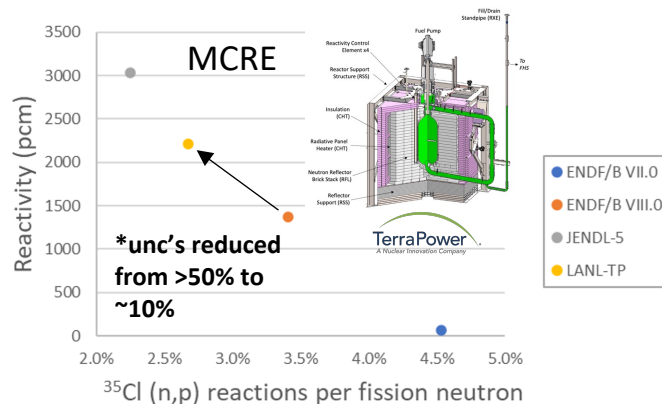
Review: Fast Improvements

Phys. Rev. C **110** 024609 (2024)



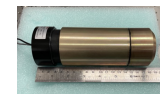
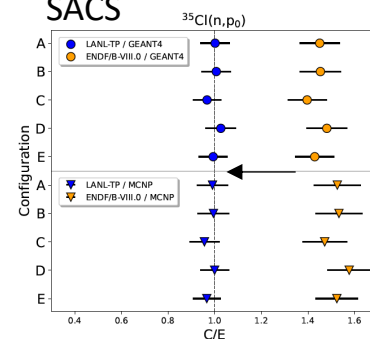
- prior focus was on fast-spectrum region for MSR applications, with experiments run over the 2022-2023 LANSCE run cycles
 - LENZ instrument @ WNR (unmoderated “fast” spectrum of spallation neutrons)
 - the resulting LANL-TerraPower evaluation for ($n + {}^{35}\text{Cl}, {}^{37}\text{Cl}$) using the 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

SACS



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

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

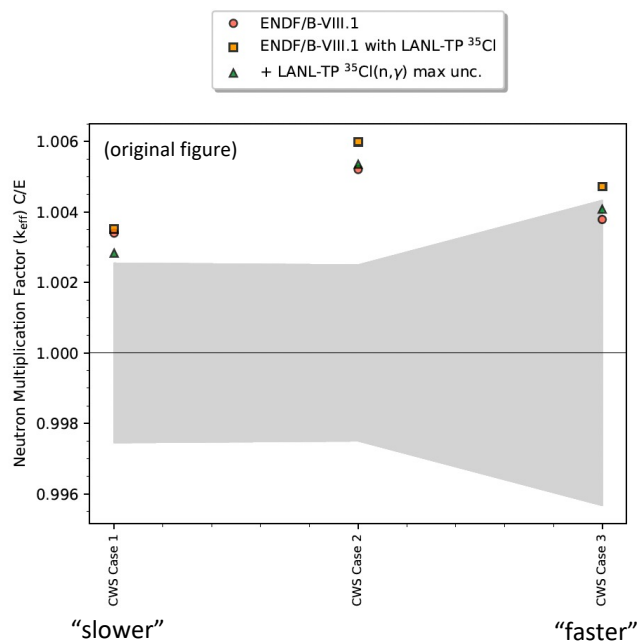
Motivation for New Experiments

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)



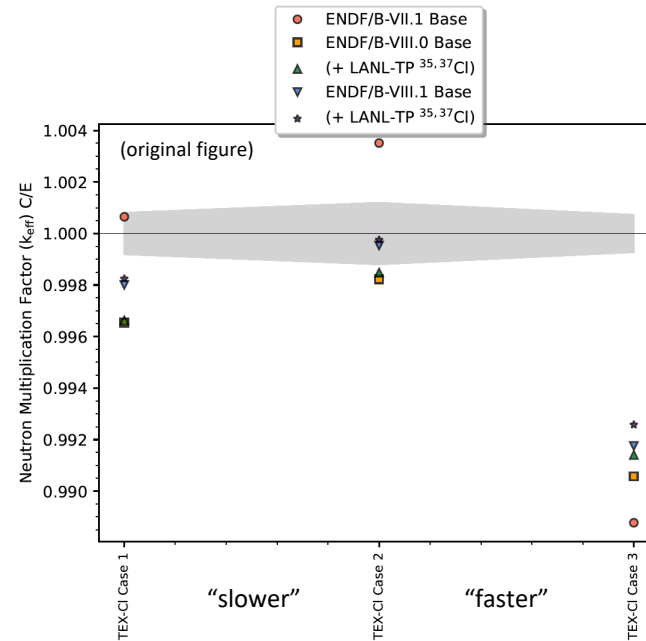
- Discrepancies observed between benchmarks that can’t be explained by adjustments to fast-energy CI alone.

- 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-CI

(U-based, NaCl + HDPE)

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



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

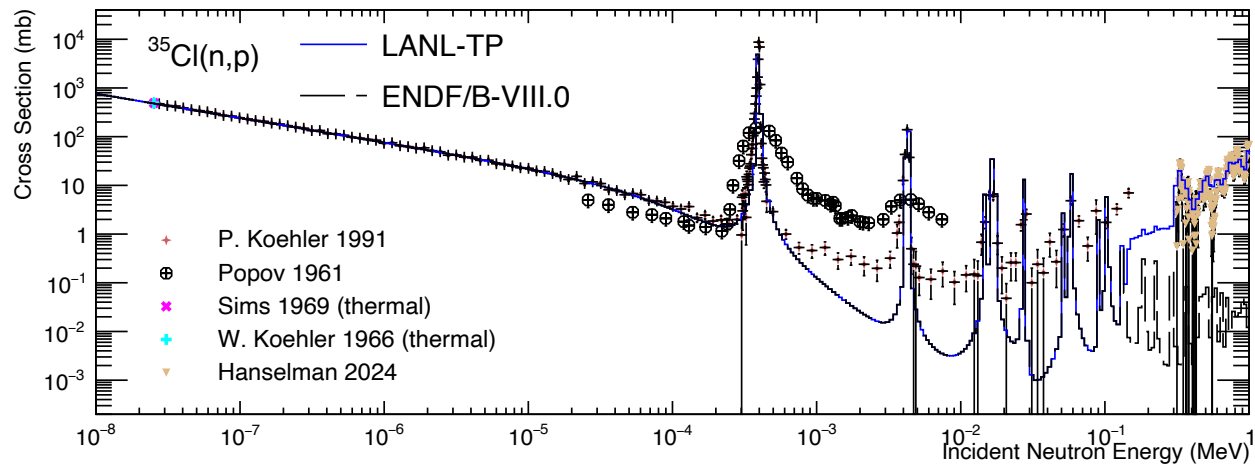
Motivation for New Experiments

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

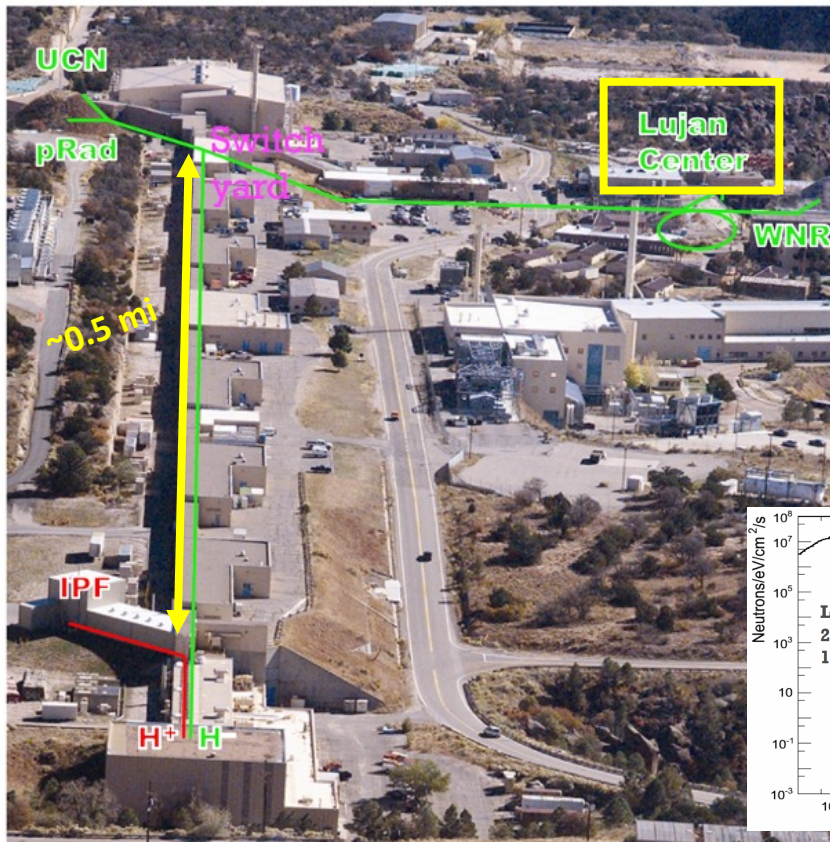
* flux in the intermediate region recently bolstered by **Mark IV upgrade** to Lujan spallation target

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)

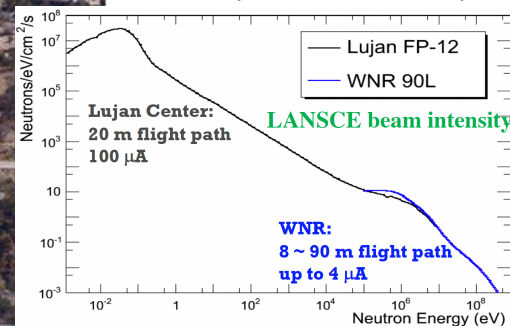


Experiment @ Lujan
Sep-Oct 2025

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

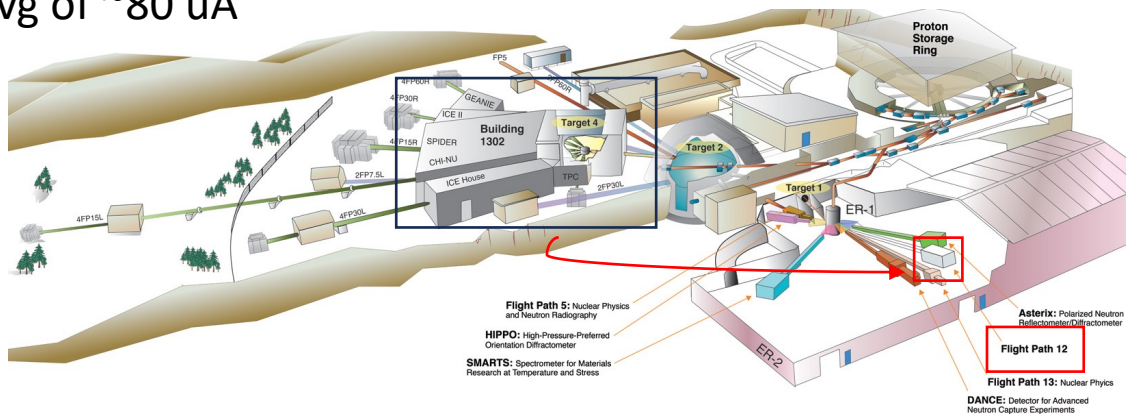
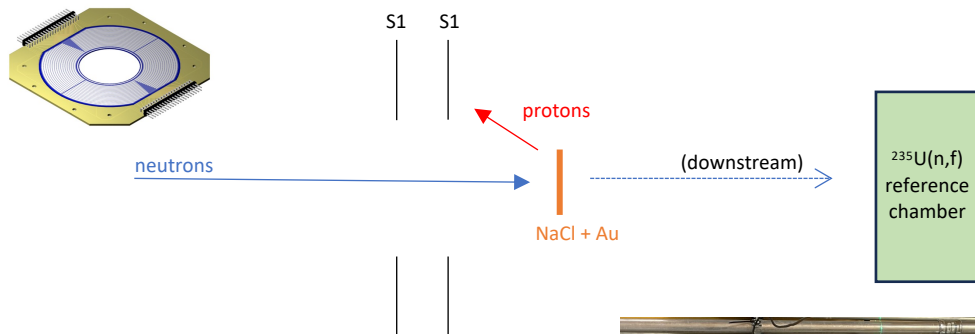
Three foil targets:

NaCl + Au (35,351 uA-hrs)

LiF + Au (2,880 uA-hrs)

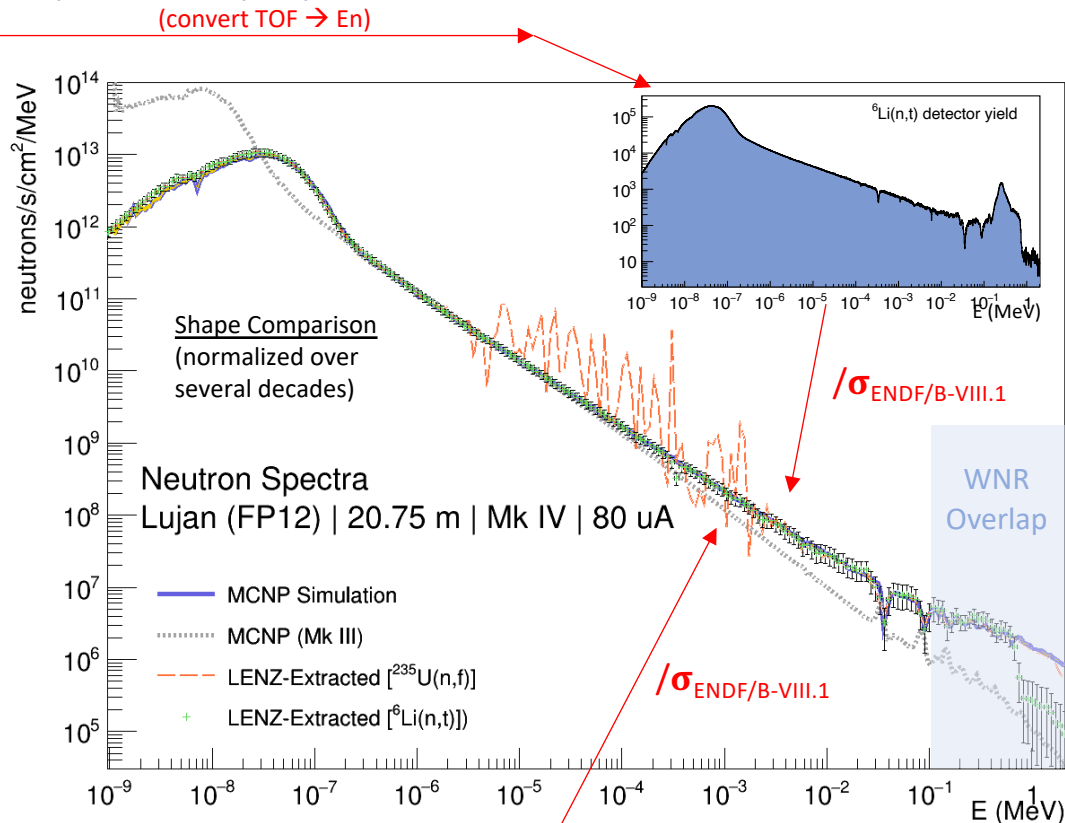
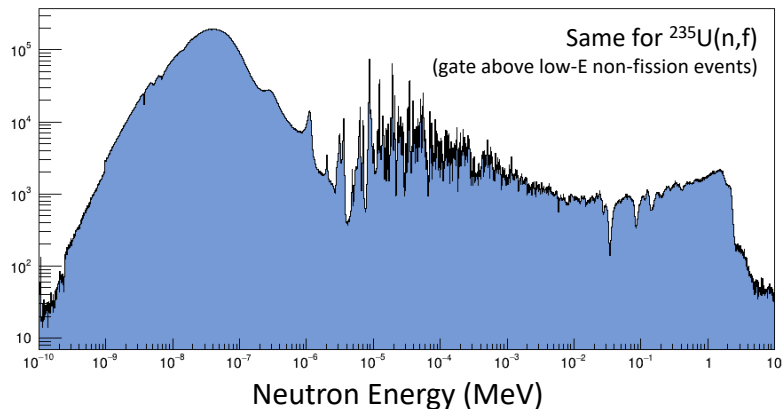
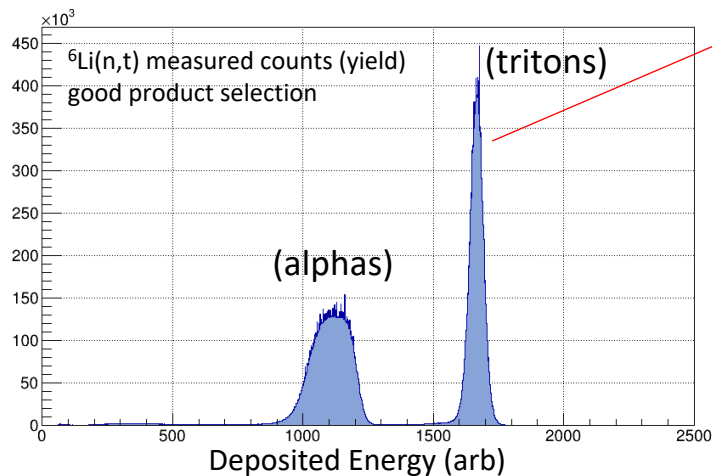
Au (7,006 uA-hrs)

Avg of ~80 uA



Data processed through CAEN V1730
500 MHz digitizers & MIDAS software

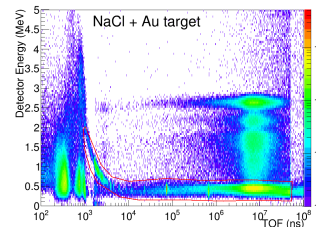
Beam Characterization via Measured ${}^6\text{Li}(n,t)\alpha$ & ${}^{235}\text{U}(n,f)$



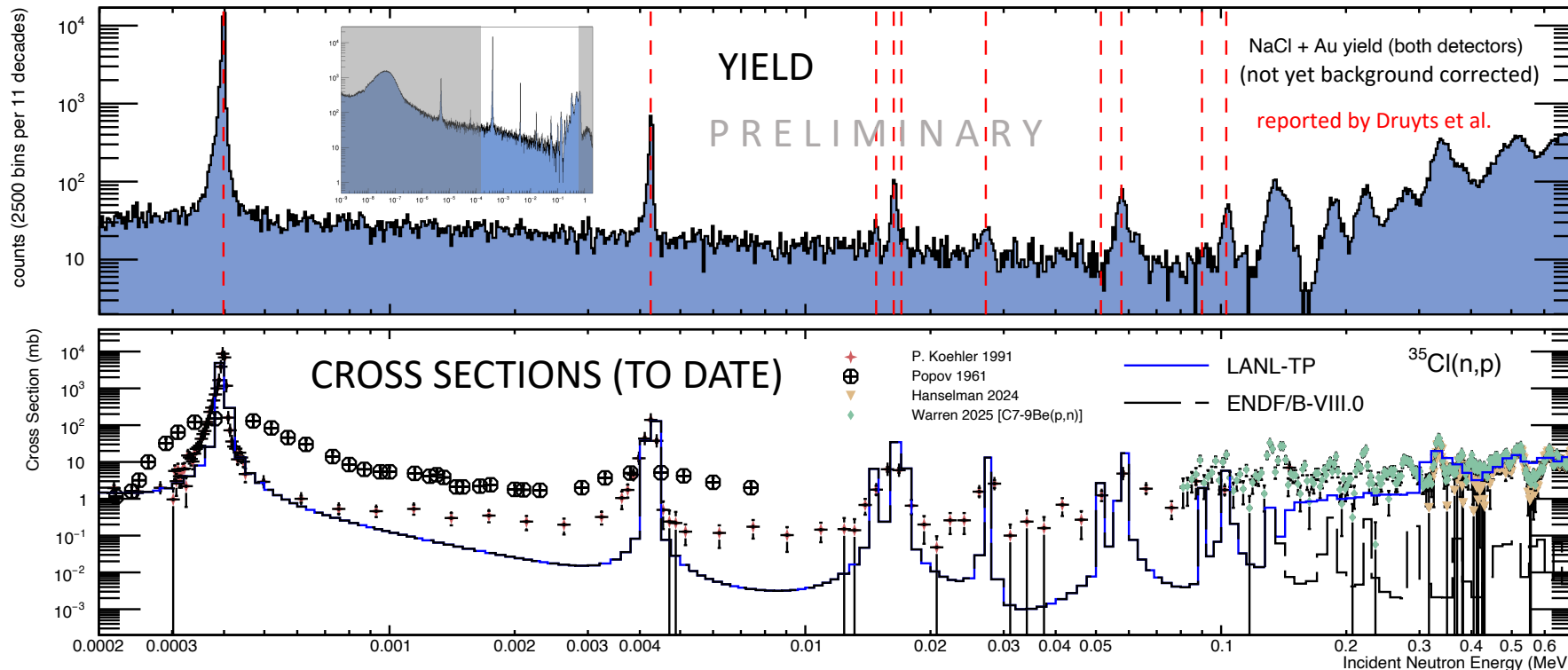
>> improvement over Mk III in region of interest makes measurement possible

PRELIMINARY Yield Spectrum for NaCl + Au

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

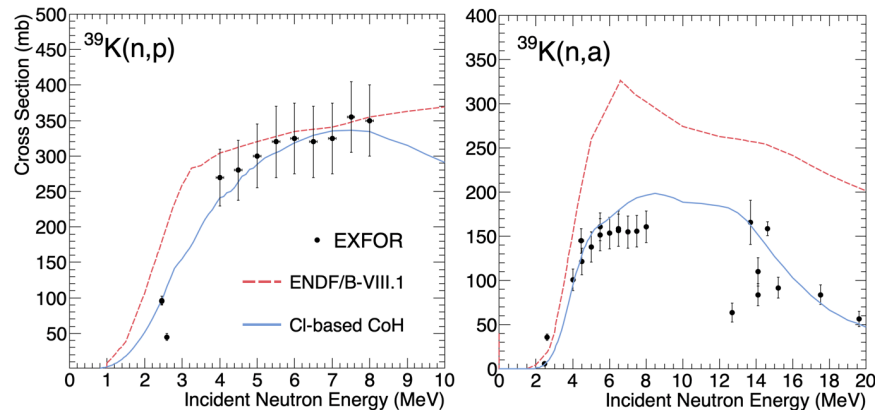
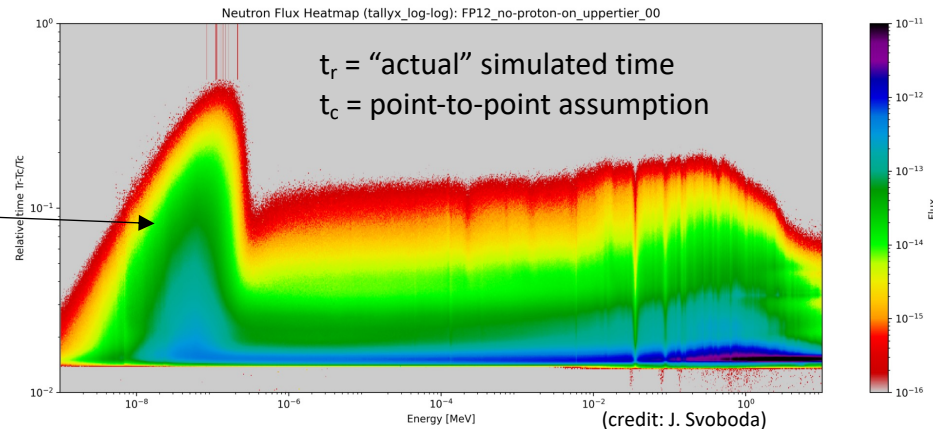


* resolution above ~ 10 keV
impacted by 290ns width of
proton pulses



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.



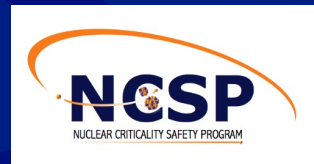
THANK YOU

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Indiana U: **Gabe Munoz** (experimental assistance)

Validation efforts: **India Allan** (NCSU), **Noah Kleedtke** (LANL), **Eric Aboud** (LLNL), and the **TerraPower Team** (T. Cisneros, B. Harper, M. Wargon)