Los Alamos NATIONAL LABORATORY

Chlorine at Lujan: Extending the LANSCE Measurements Down to Thermal

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Outline:

- Motivation
- Preliminary Experiment
- Analysis & FP Characterization
- Future Work

PHYSICS SINCE 1943

THEORETICAL DIVISION Since 1943

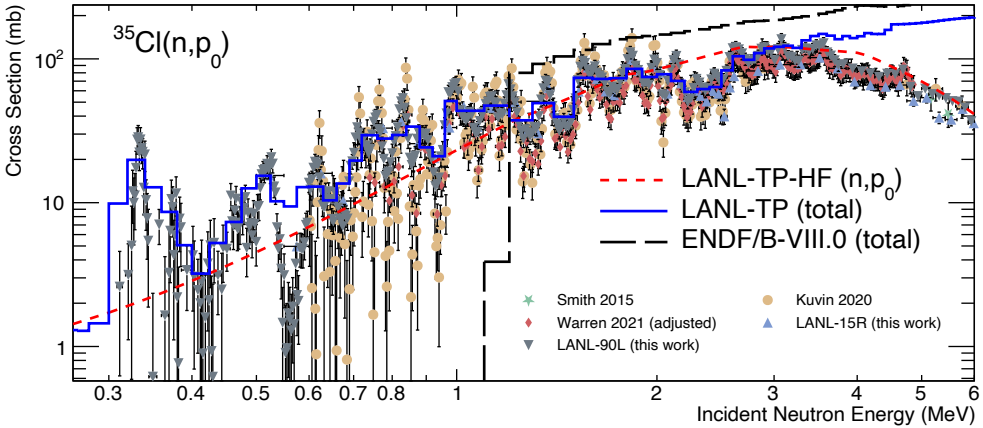
TerraPower A Nuclear Innovation Company

NCSP NUCLEAR CRITICALITY SAFETY PROGRAM

LA-UR-24-31759

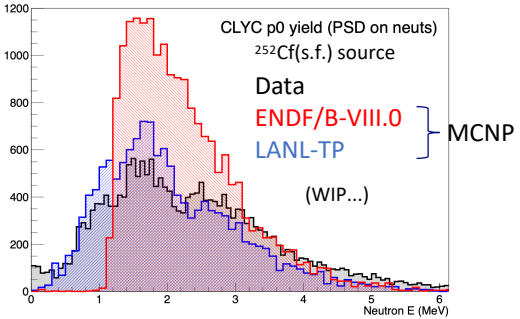
Status of Evaluation after LANL-TP GAIN collaboration

- the LANL-TerraPower evaluation for (n + ^{35}Cl) using the latest data is available by request or on the NNDC GitLab
  >> covariances for major channels
  >> direct fitting to fluctuations



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

- ongoing data testing:
  >> UC Berkeley (J. B. Valentin master's thesis) for MCRE/TP
  >> MIT (S. Collins) for fusion neutronics
  >> Tyler Nagel (now LANL postdoc) on UCB GENIE data
  >> CLYC + ^{252}Cf source with SULI summer student (I. J. Allen, NCSU)



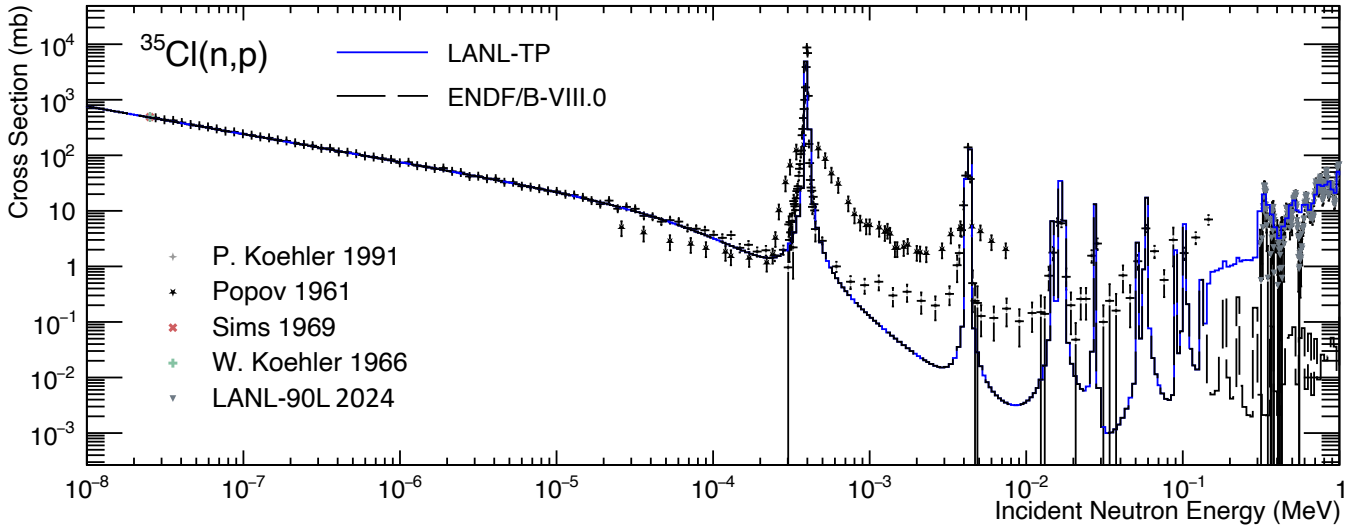
Motivation for New Experiments

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

Then energies from thermal up to ~few hundred keV may be probed, particularly in the resonant region where existing differential data are poorly resolved and discrepant
→ important for criticality safety, astrophysics, etc.

* 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

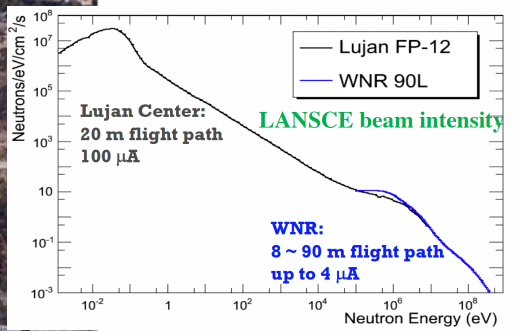
- Uniquely capable of accelerating H^+ and H^- simultaneously
- Can deliver 100 kW of H^- and 800 kW of H^+ beam
- 120 pulses per second shared among 5 facilities
- H^- beam:
  - Lujan Center (NNSA)
  - Weapons Neutron Research Facility (NNSA)
  - Proton Radiography (NNSA)
  - Ultra-Cold Neutron Source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

Experiment @ Lujan during Feb 2024

Moderated white neutron source (W spallation)

FP12 @ ~20.8 m

Total of ~4000 uA-hrs



Experimental Details

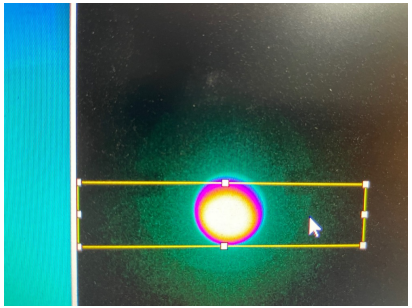
"Mini-LENZ" Chamber

Three foil targets:
NaCl + Au (816 uA-hrs)
Au (305 uA-hrs)
LiF (158 uA-hrs)

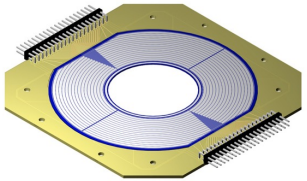
Avg of ~80 uA

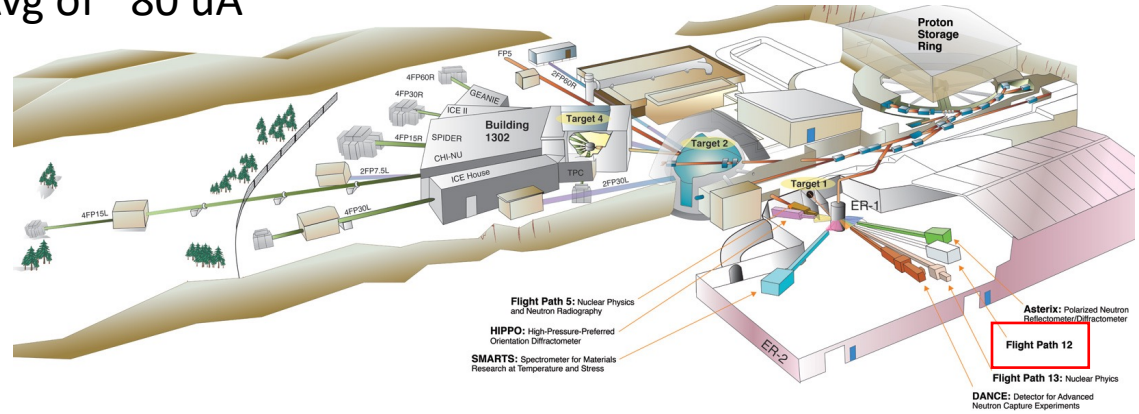
Setup at FP12

0.6" diameter beamspot, fairly uniform



Single Micron S1 DSSD covering backward lab angles ~117-136°

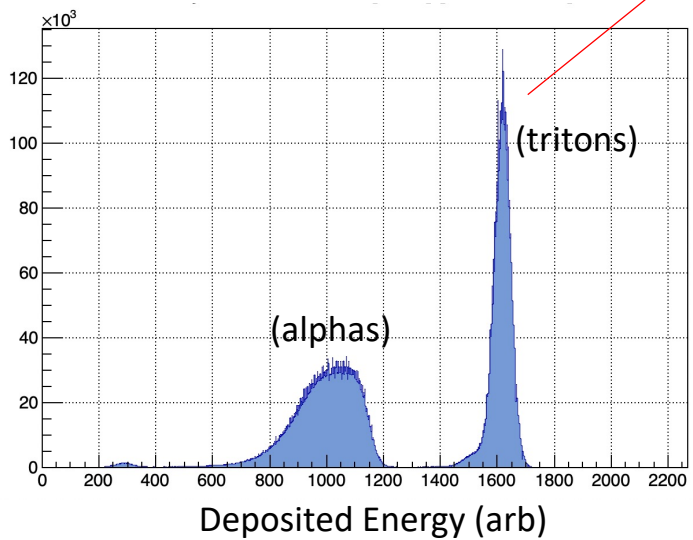




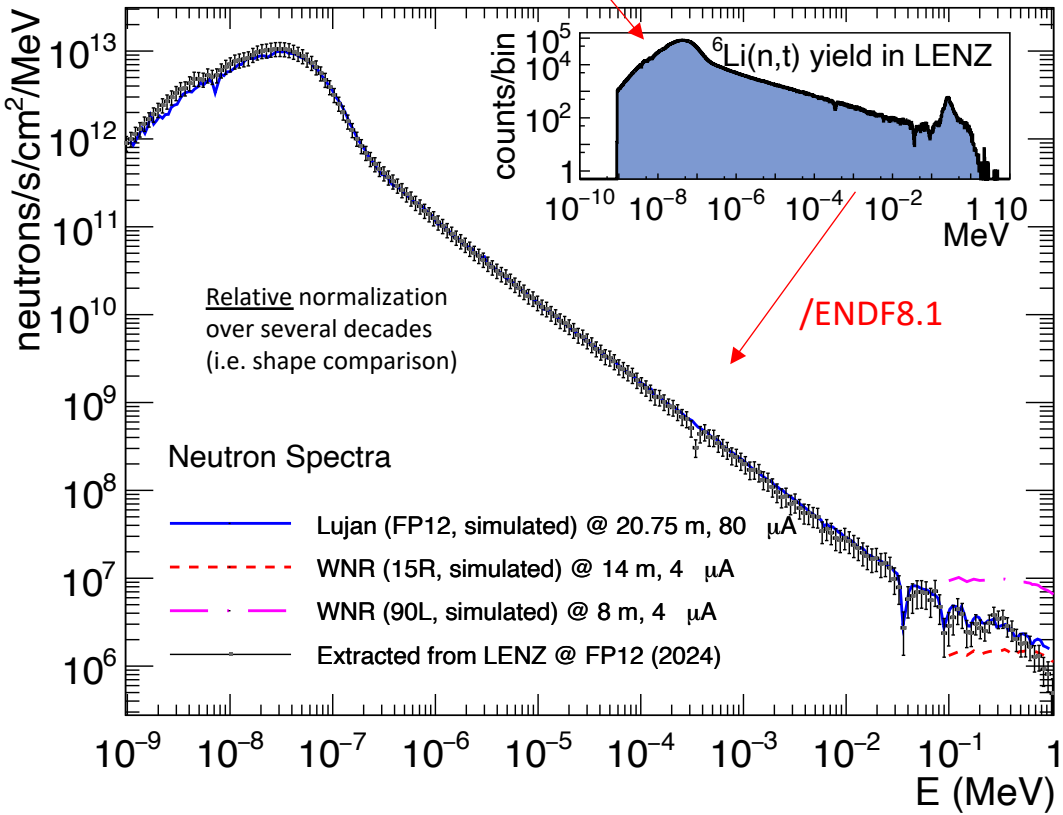
Data processed through CAEN V1730 500 MHz digitizer & COMPASS software

Beam Characterization via Measured ^{6}Li(n,t)α

Can cleanly select:



(convert TOF->En)



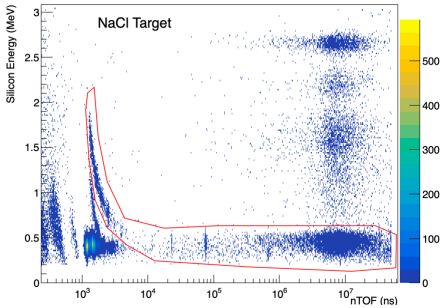
Using latest ENDF/B-VIII.1 angular distributions (channel by channel) & covariances

PRELIMINARY Yield Spectra for NaCl & Au

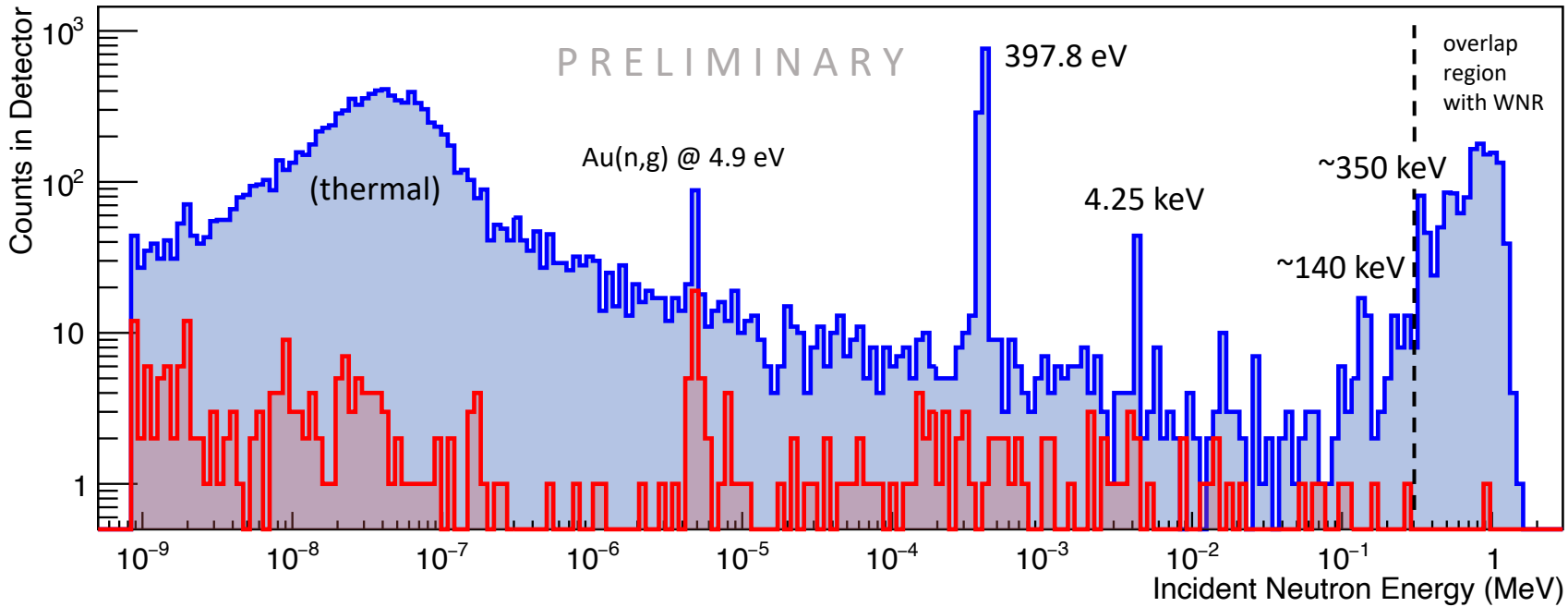
NaCl on Au backing | ~10 hrs @ 80 uA

Au backing only | ~4 hrs @ 80 uA

(planning for a lighter backing for next run, e.g. Al)



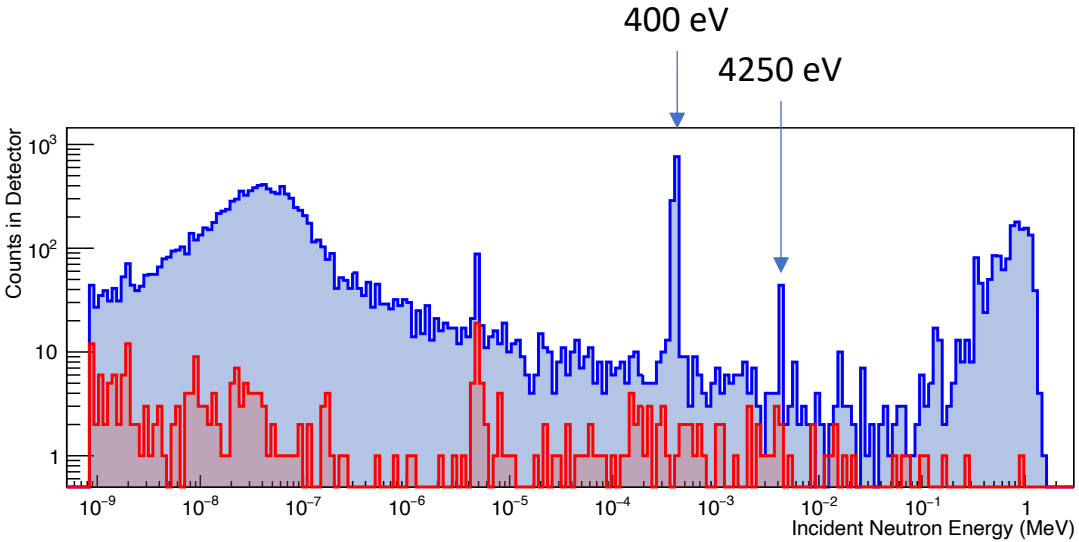
- identifiable resonances, plus some not in current evaluation (~140 keV)
- good coverage up into WNR overlap region
- HOWEVER, statistics an issue for quantitative analysis



PRELIMINARY Quantitative Comparisons

Can at least compare quantities for strongest resonances:

→ resonance strengths: $(\omega\gamma) = 2*\text{Area}/\lambda^2$
(see e.g. Druyts *et al.* NP **A573** (1994) 291-305)



From literature (relative to thermal value of 440(10) mb), in meV:

Ref.	400 eV	4250 eV
P. Koehler (1991)	9	32
Popov (1961)	6.5(21)	23(12)
Gledenov (1989)	9.7(14)	36(07)
Druyts (1994)	7.9(04)	38(03)
Mughabghab (1981)	7.1	14.4

Relative normalization factors (arb → barns) using thermal region vs the above (after background subtraction):

Thermal	400 eV	4250 eV
0.349(94)	0.393(31)	0.390(31)

→ very consistent within uncertainty
→ fast region still under investigation (efficiency complications due to strength of Lujan gamma flash)

Summary & Future Work

So far, preliminary ^{35}Cl(n,p) data measured at Lujan are promising, but limited.

Still, much has been learned about LENZ + Lujan, enough to begin preparation for next run cycle to optimize the setup:

- New chamber & DAQ under design to maximize solid angle coverage (more detectors at more angles) & minimize efficiency losses
- Flight path characterization continuing through MCNP simulations (J. Svoboda) and measured reference data
- Estimated ~40 days run time for next cycle, including production and reference runs, to populate the low-yield ~10-300 keV region with sufficient statistics (<10% unc. per bin)

THANK YOU

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National Nuclear Security Administration