Updates on the CoGNAC Neutron Scattering Project at LANL

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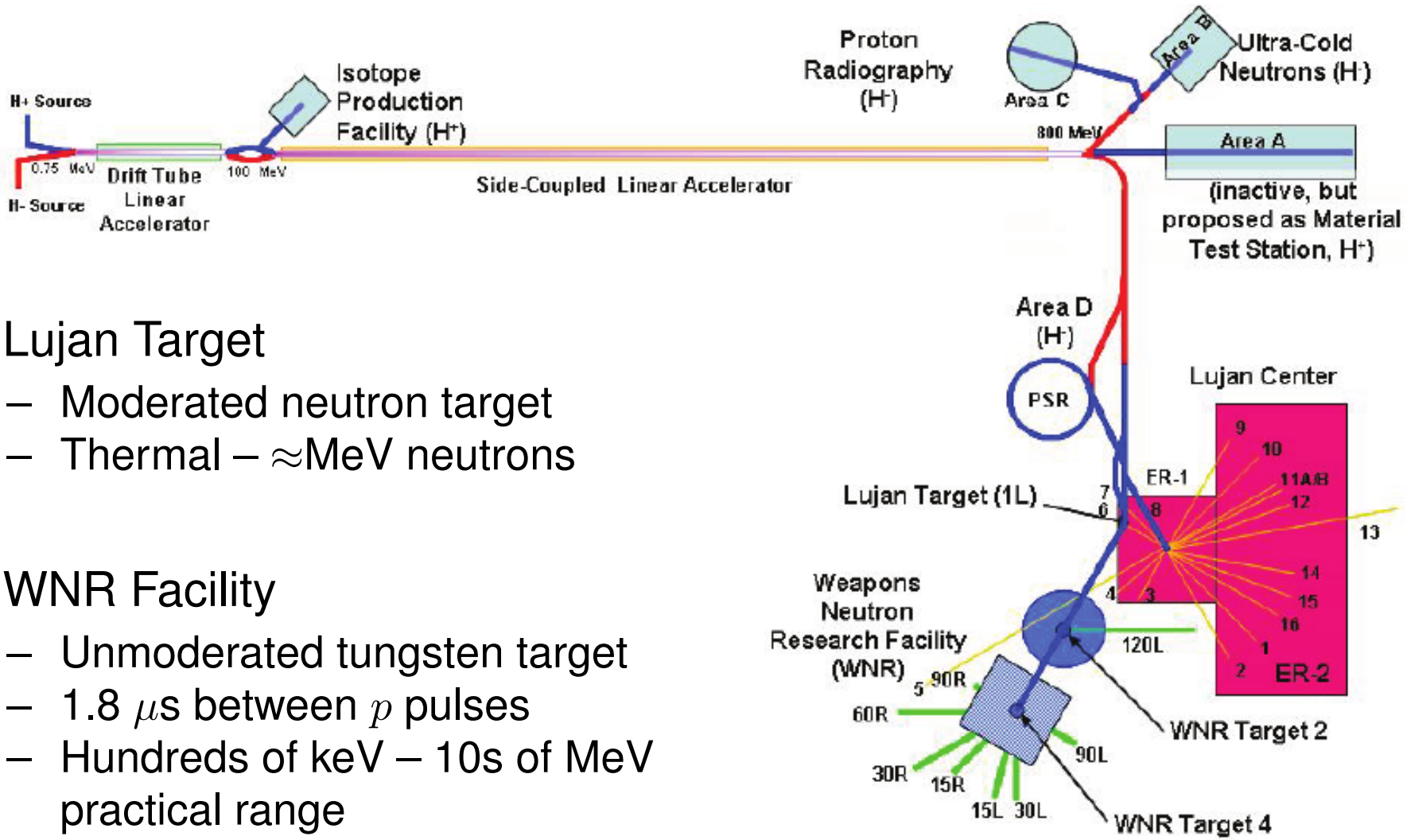
Outline

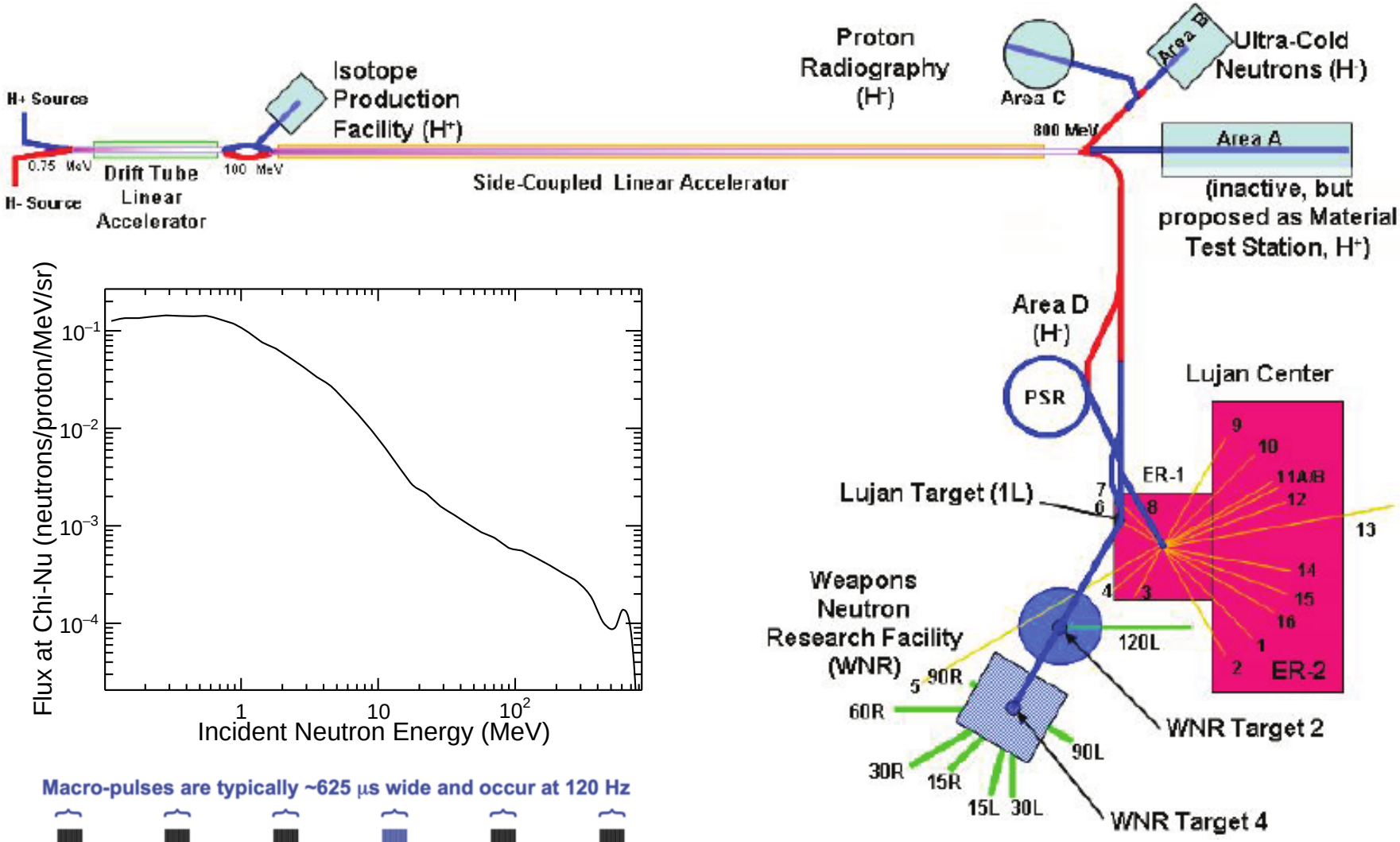
- LANSCE
- CoGNAC
- BeO ^{16}O(n,$n'\gamma$) γ-only Measurements
- Pure ^{28}Si(n,$n'\gamma$) γ-only and n-γ Measurements
- Elastic Scattering Approach
- Preliminary ^{12}C(n,n), ^{28}Si(n,n), and ^{16}O(n,n) Results
- Future Work with (n,2n) and (n,3n) Measurements

The LANSCE Facility: Pulsed White n Source



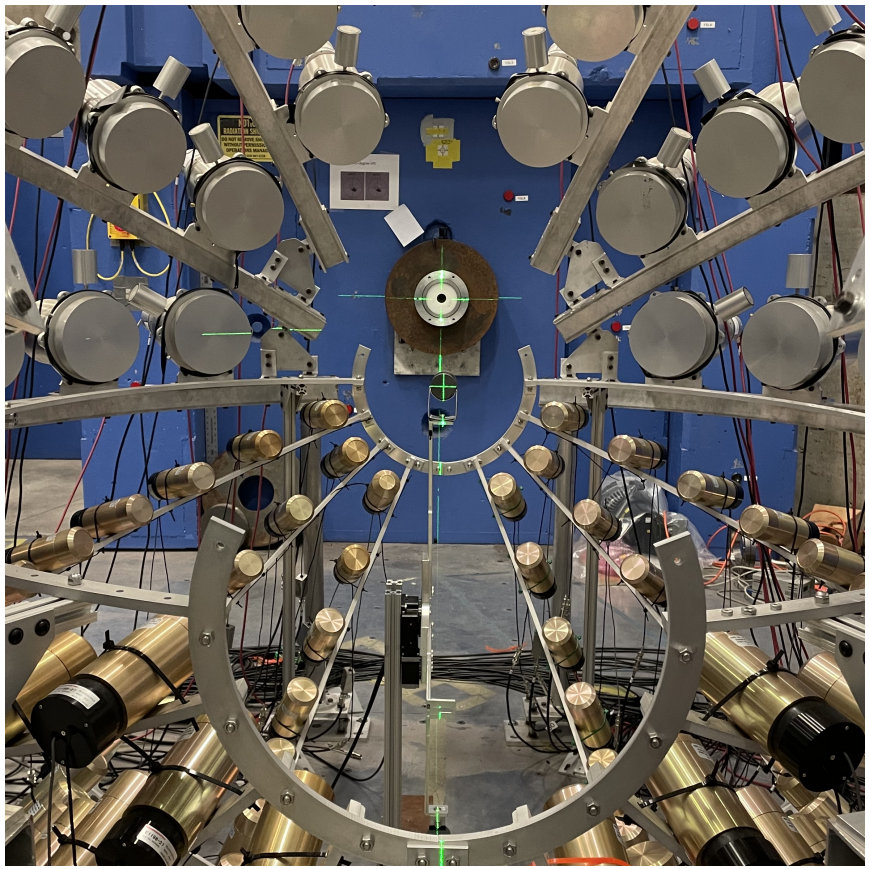
- Lujan Target
  - Moderated neutron target
  - Thermal – ≈MeV neutrons
- WNR Facility
  - Unmoderated tungsten target
  - 1.8 μs between p pulses
  - Hundreds of keV – 10s of MeV practical range

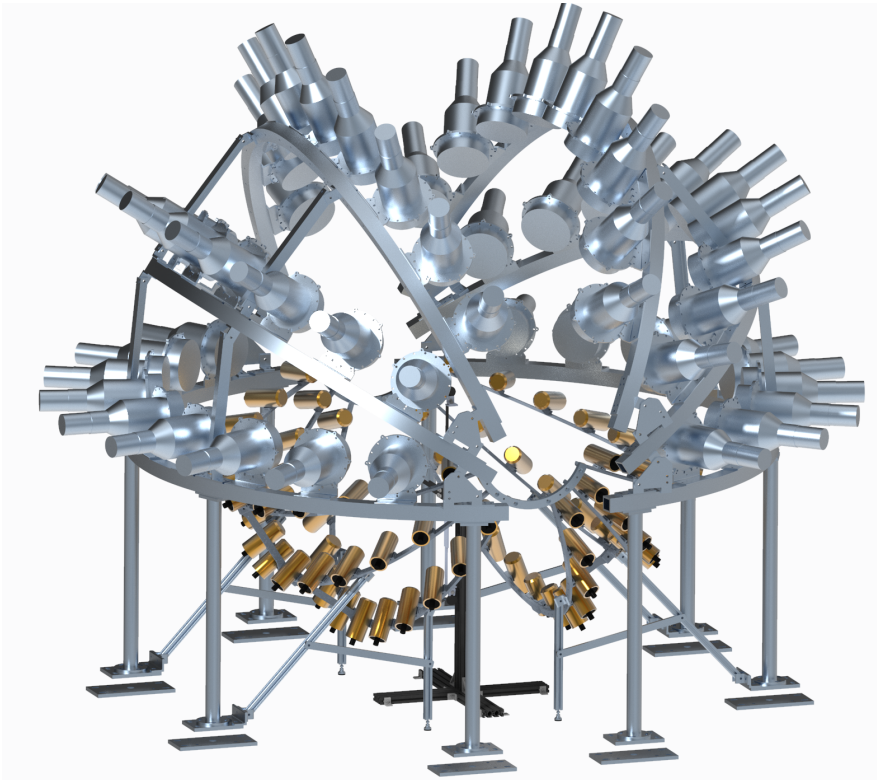
The LANSCE Facility: Pulsed White n Source



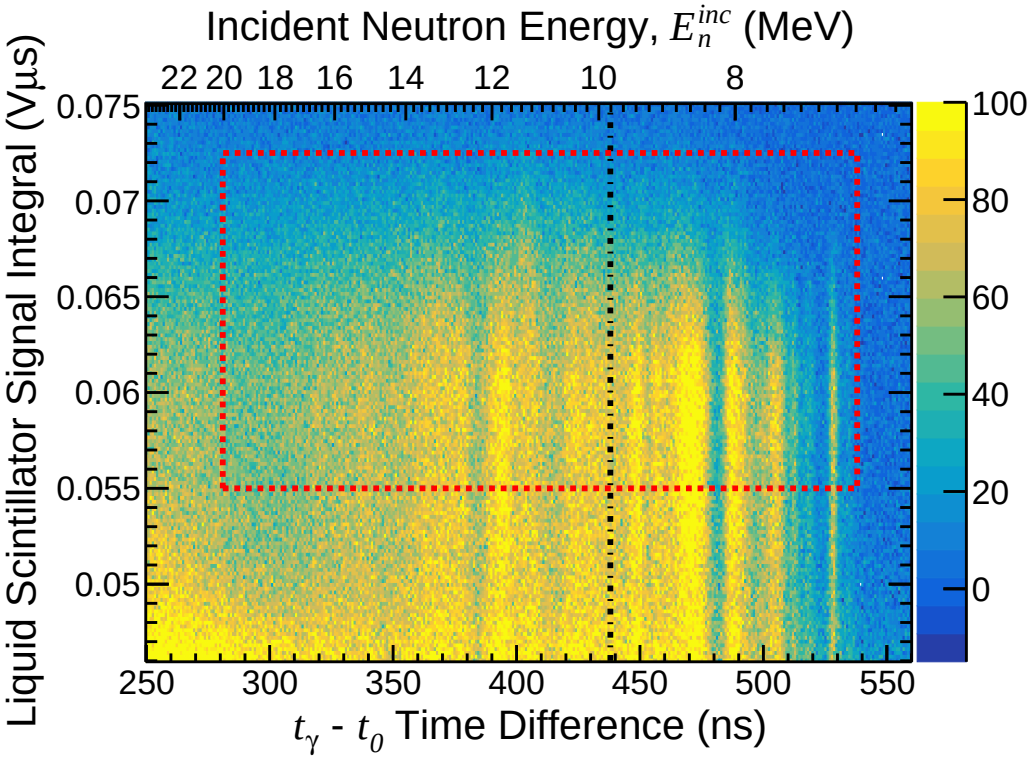
Correlated Gamma-Neutron Array for sCattering

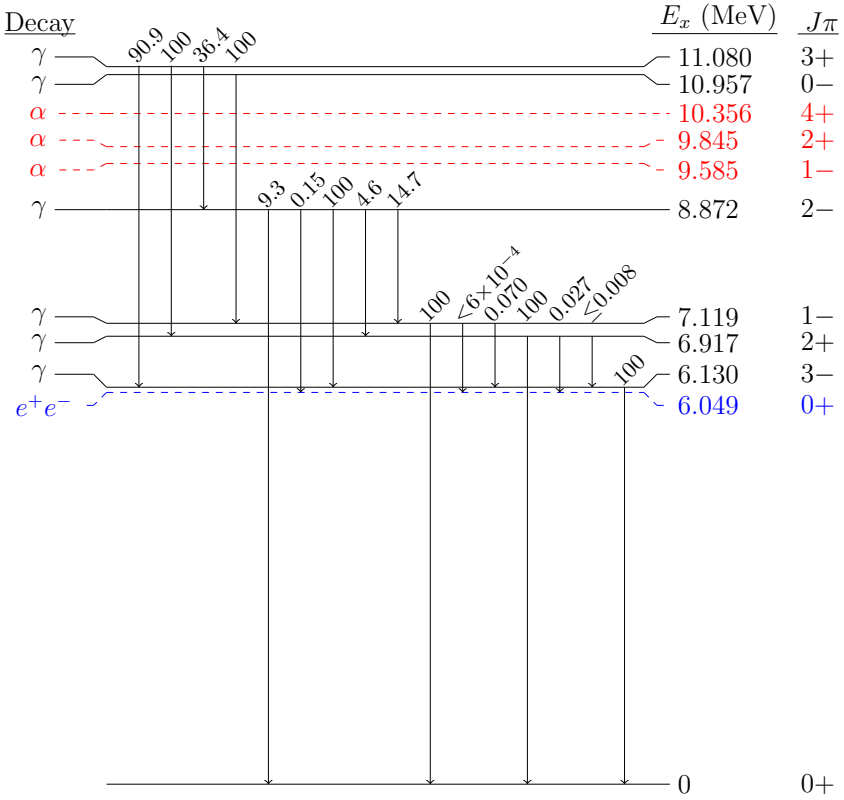
- Pulse-shape discrimination for n-γ separation
  - Only focusing on liquid scints (upper) here
  - CLYCs (lower) availability for similar analyses
- Can use n-γ coincidence for E_n^{inc} and E_n^{out} from (n,$n'\gamma$)
- Can't use γ-rays for elastic (n,n) reaction timing!





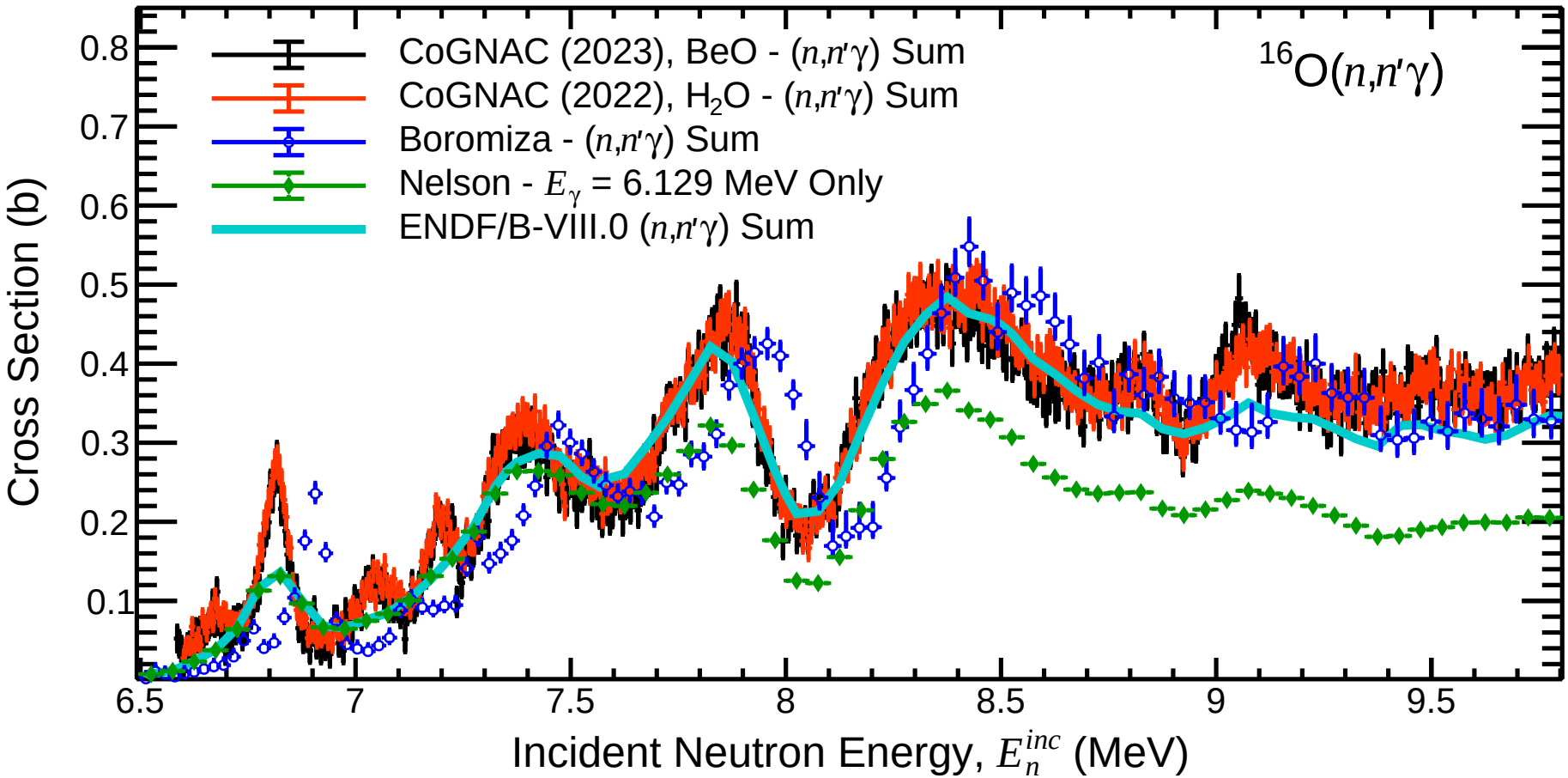
γ-only Analysis of ^{16}O(n,$n'\gamma$)





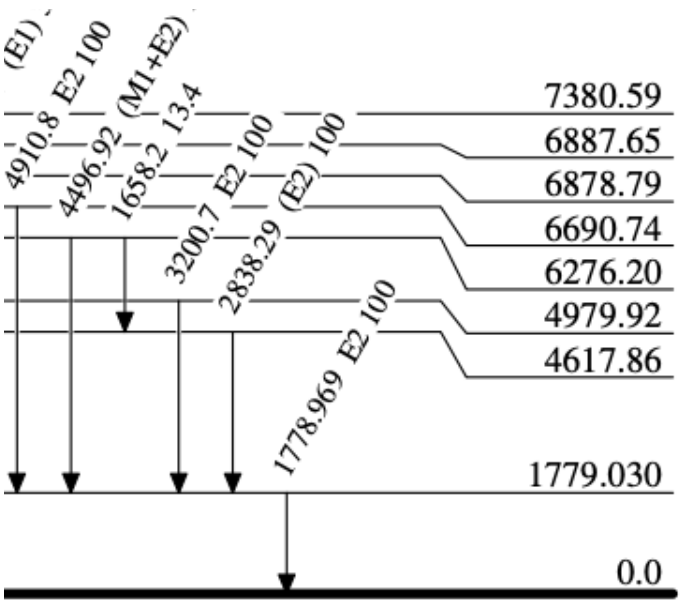
- States 2-4 in ^{16}O decay via γ-ray emission to the ground state
  - only ≈3% difference in γ efficiency from E_γ = 6.1–7.1 MeV
- 8.872 keV 5th state decays 93% through first 4 states
- States 6-8 decay via α, higher decay through first 4 states

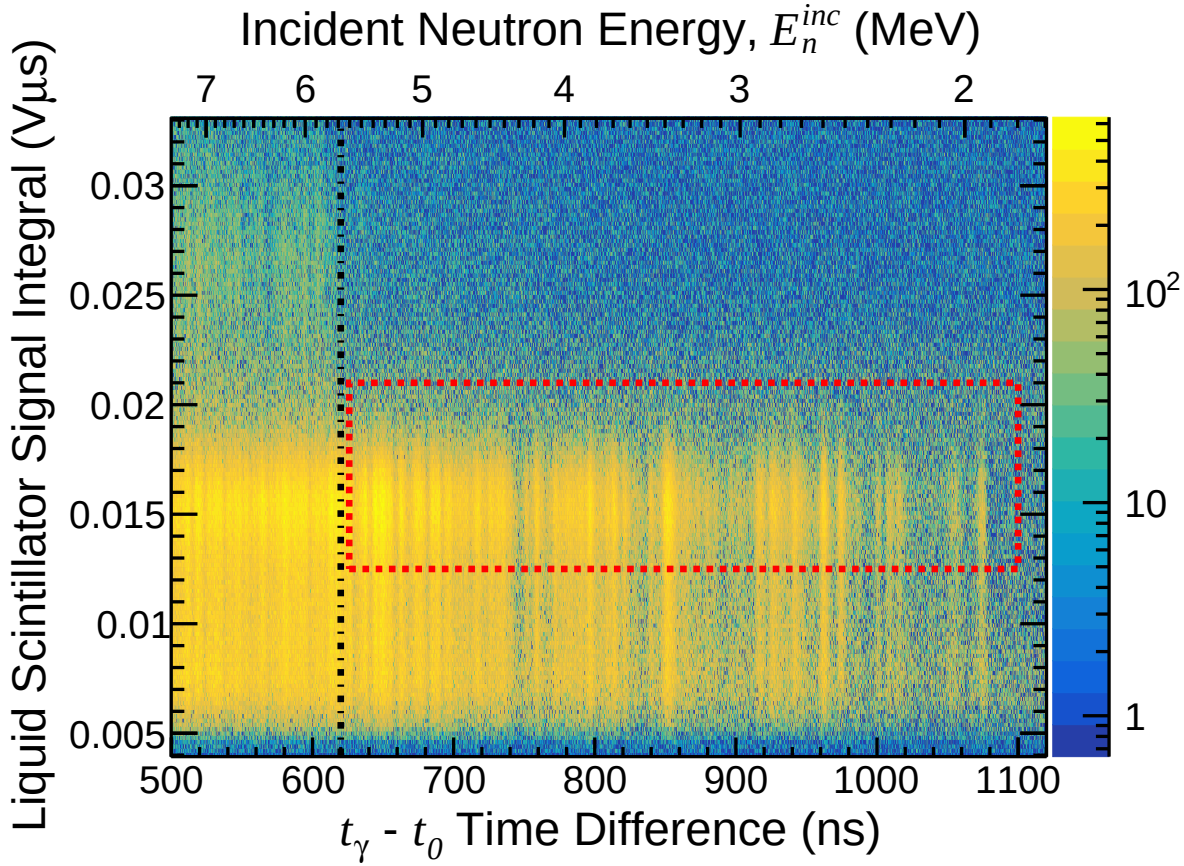
γ-only $^{16}O(n,n'\gamma)$ H_2O and BeO Results



Results submitted for publication in Nuclear Data Sheets

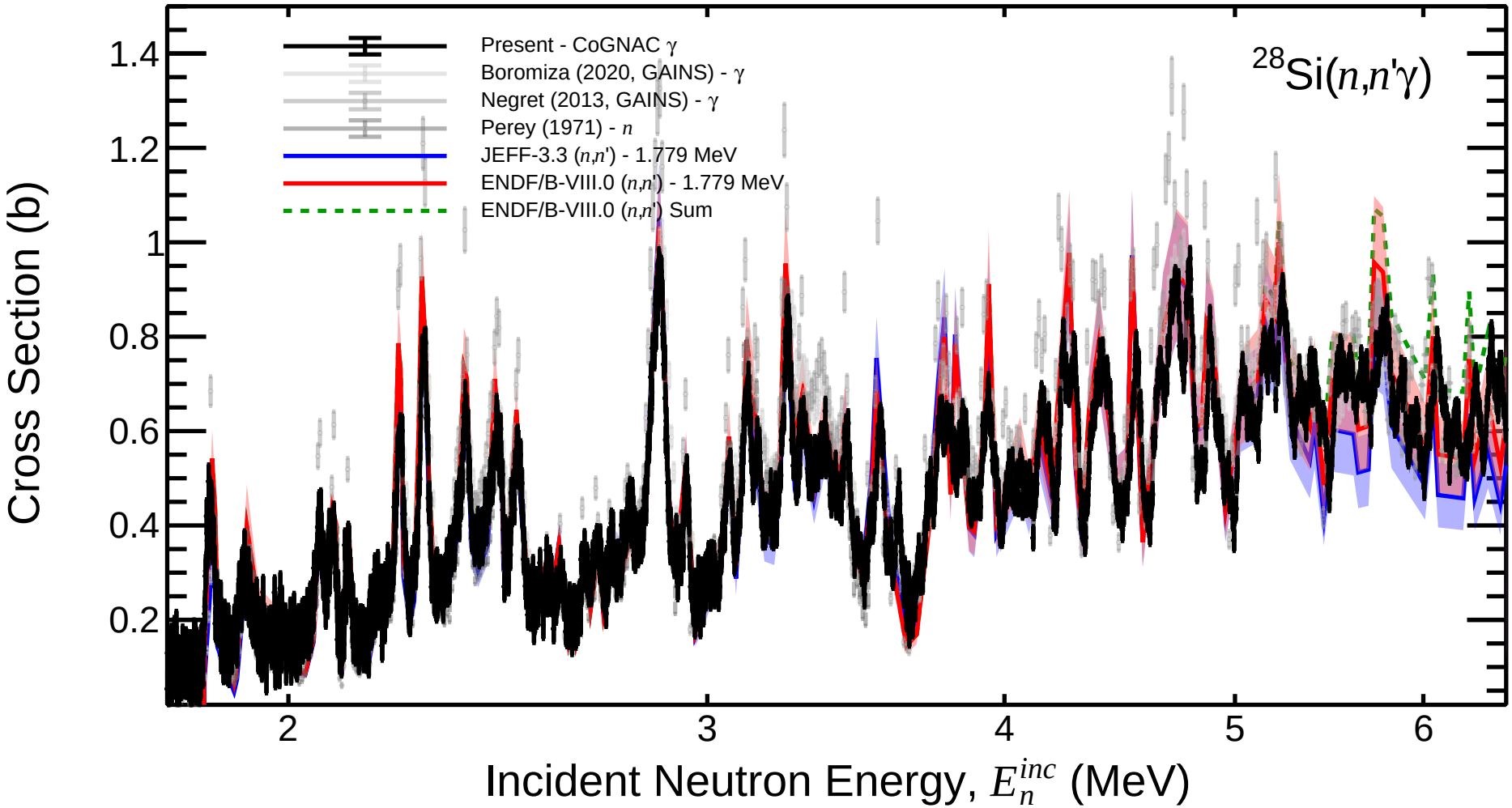
γ-only Analysis of ^{28}Si(n,$n'\gamma$)





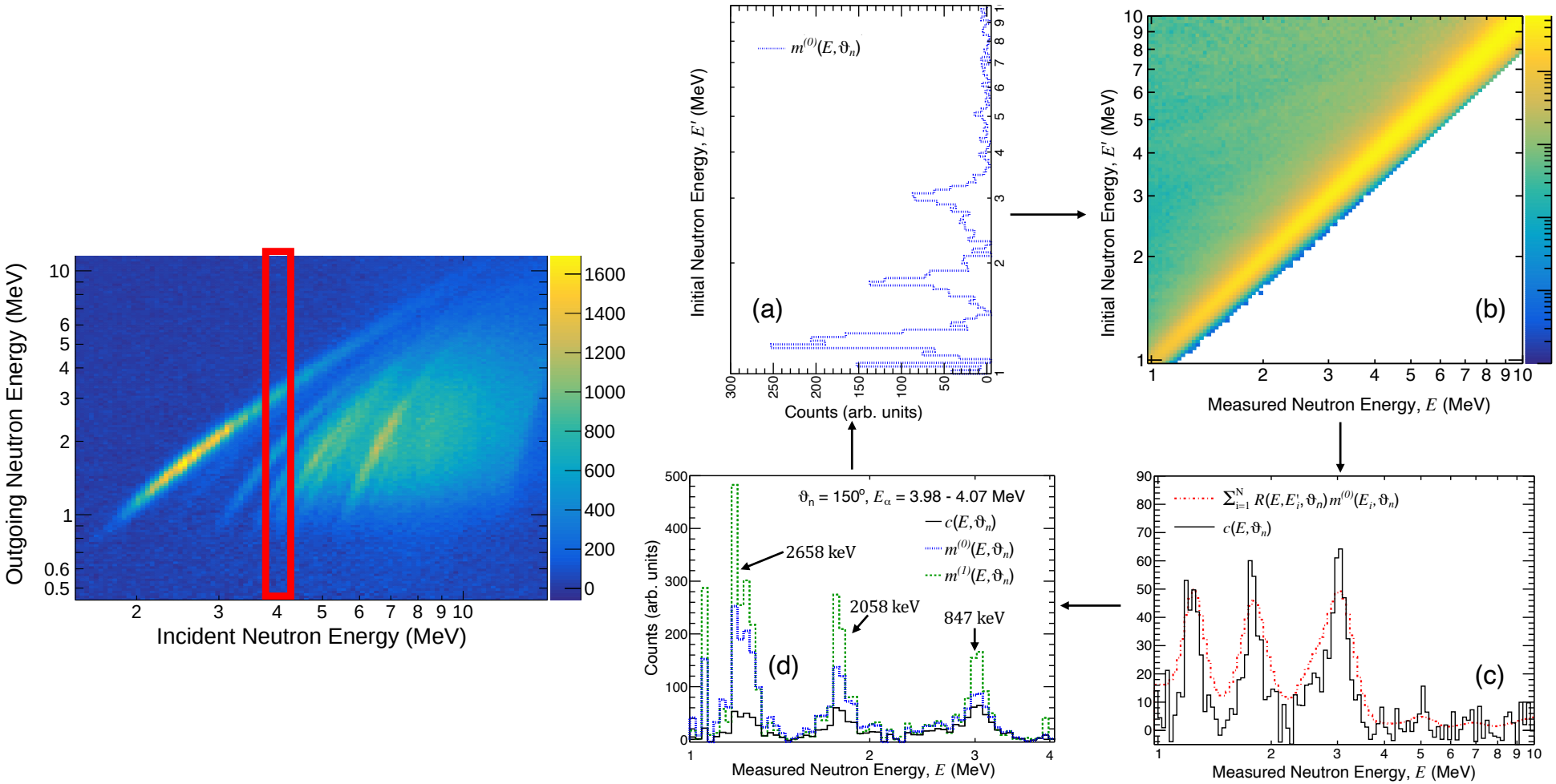
- 1st state (dominant) easily accessible in n-γ, and γ-only
  - Can extract n-γ correlation pattern (first measurement)
- 2nd and 4th are next dominant contributors

γ-only ^{28}Si(n,$n'\gamma$) Results

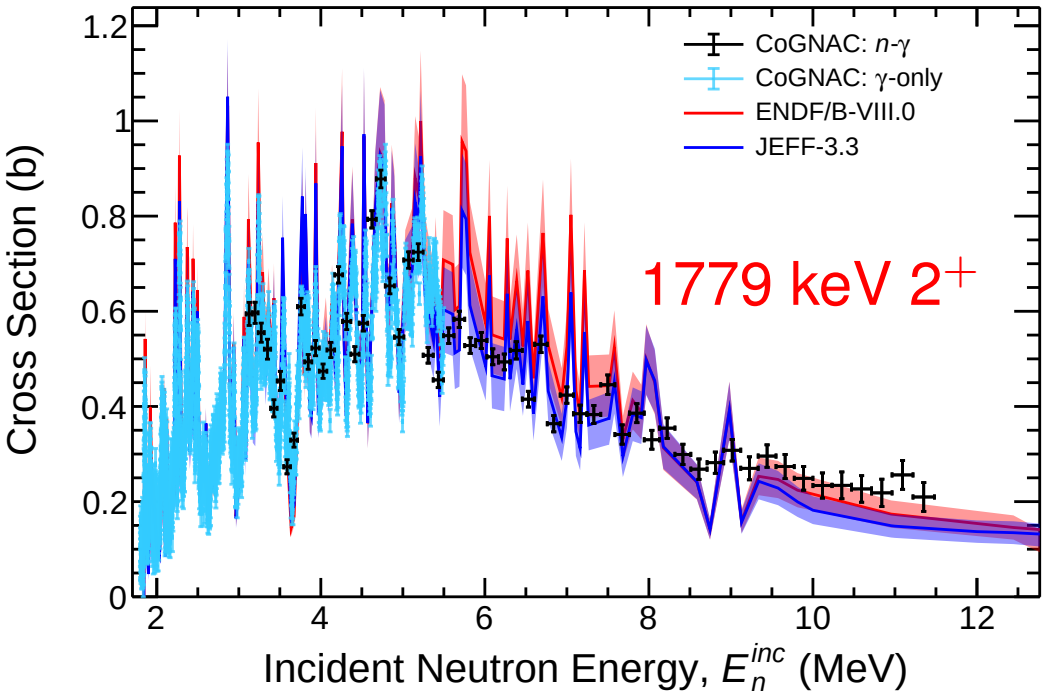


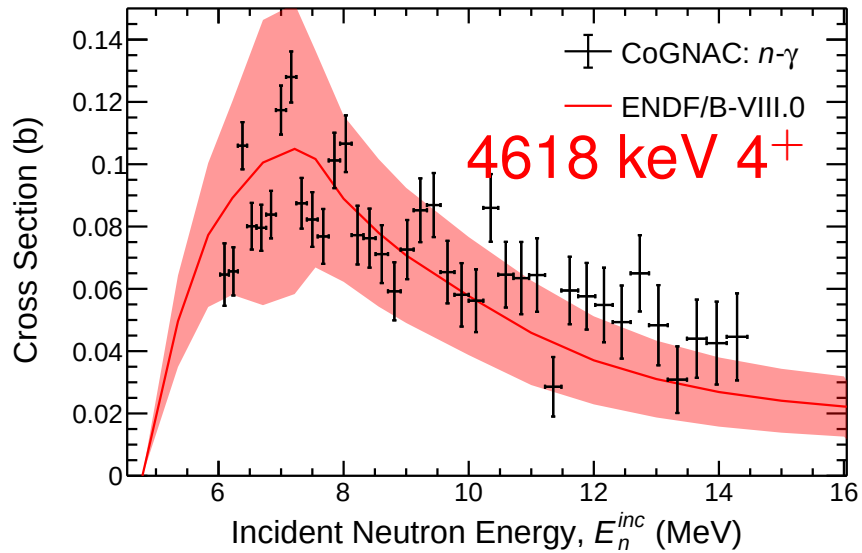
n-γ Analysis: Isolate and Unfold

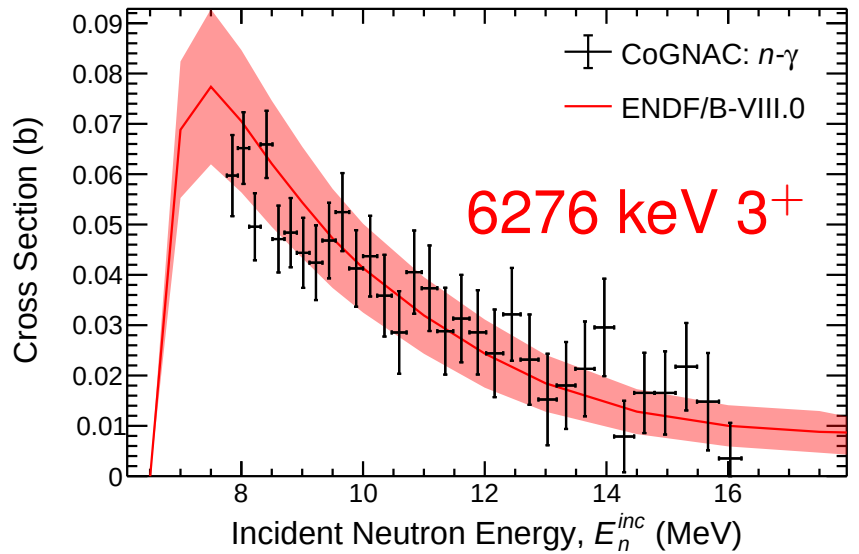
See: Kelly *et al.* (2023) PRC **108** 014603



n-γ ^{28}Si(n,$n'\gamma$) Results

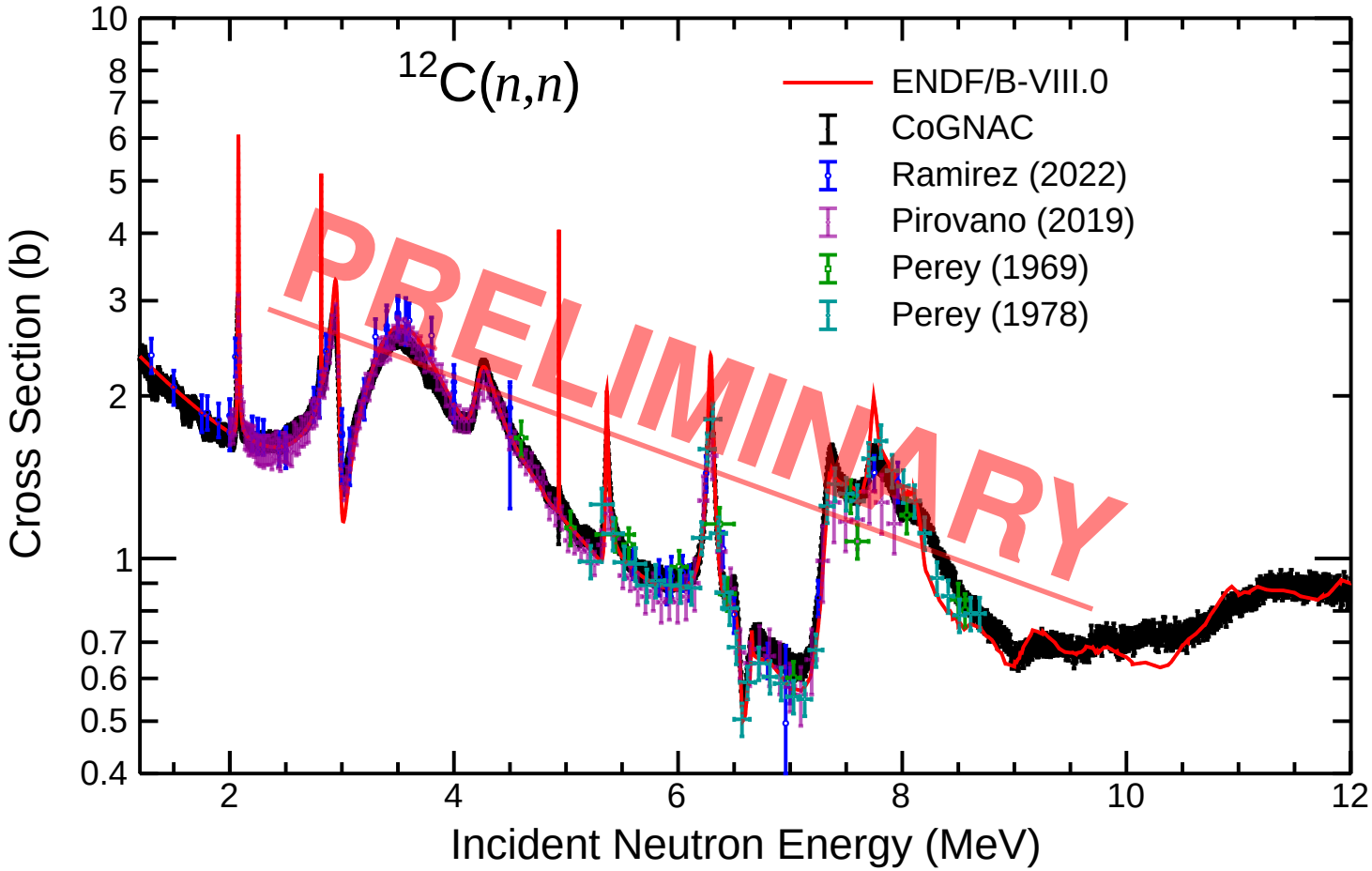






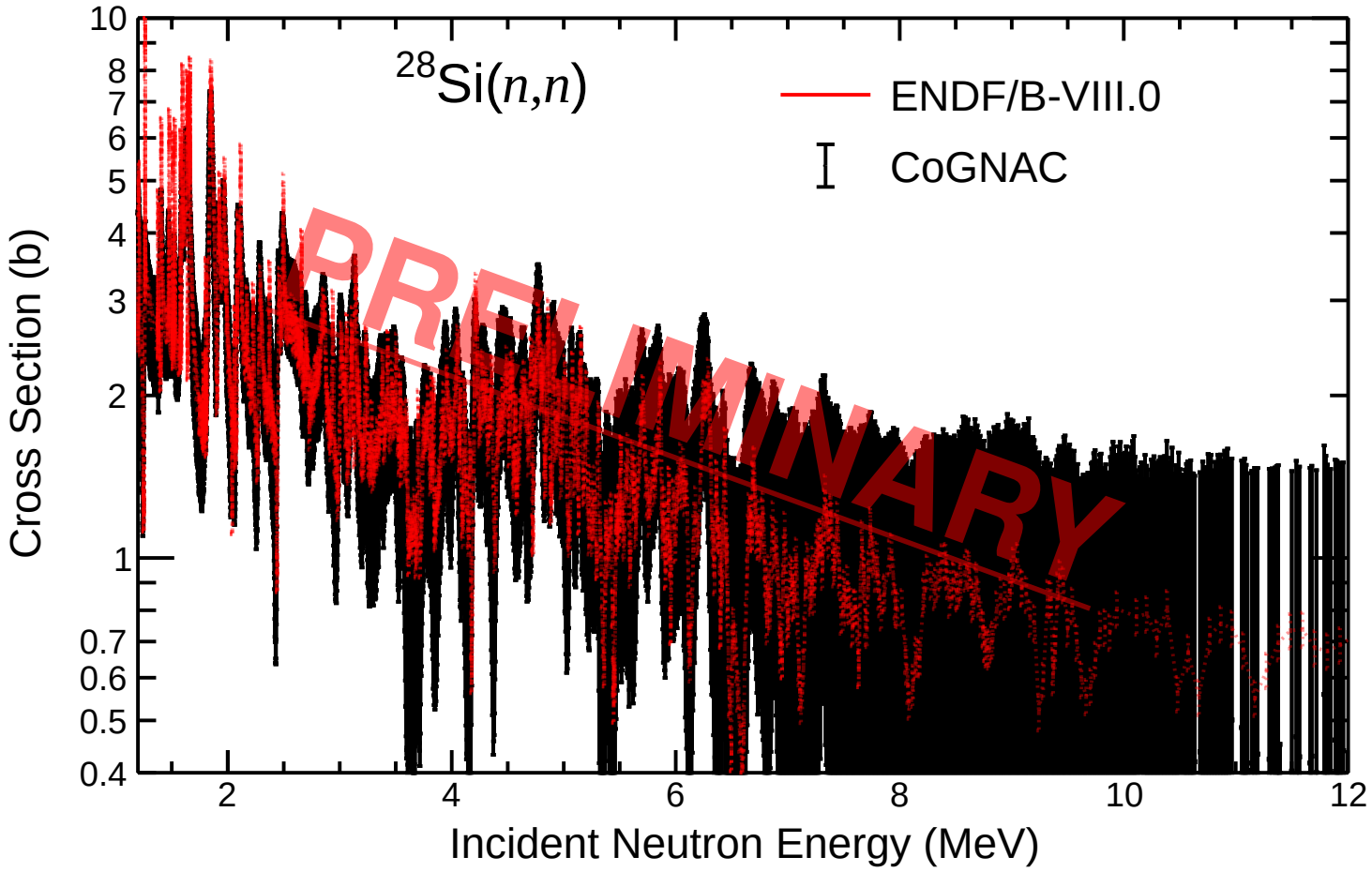
To be submitted to PRC in Q1FY25

CoGNAC (n,n) Methods Have Evolved



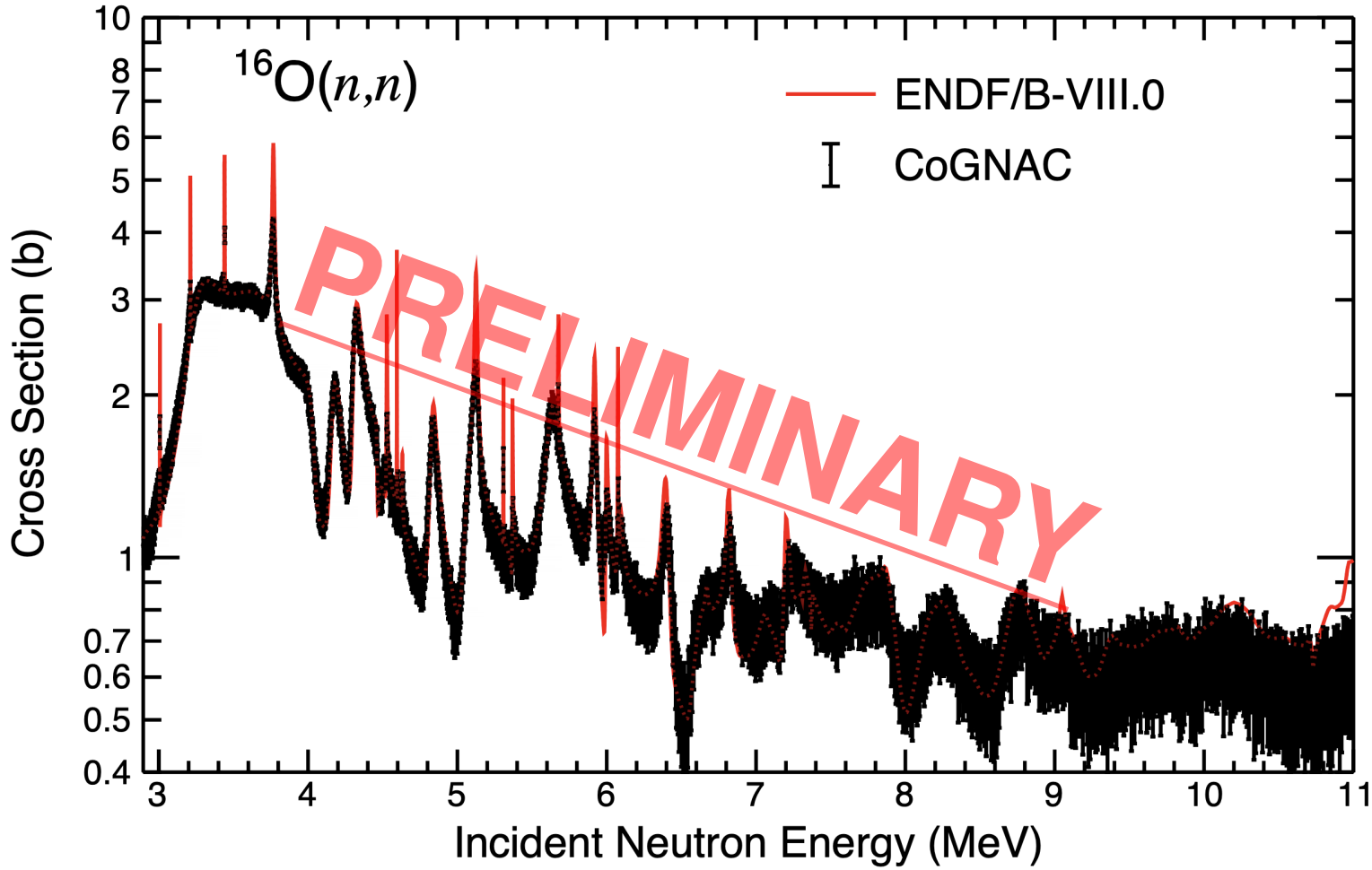
- Only one combination of E_n^{out}, E_n^{inc}, and ϑ_n can produce a total TOF
- Utilize other scattering targets or ^{252}Cf(sf) as a reference
  - These results were obtained using ^{9}Be(n,n) as a reference

Technique is Validated w/ ^{28}Si(n,n) Analysis



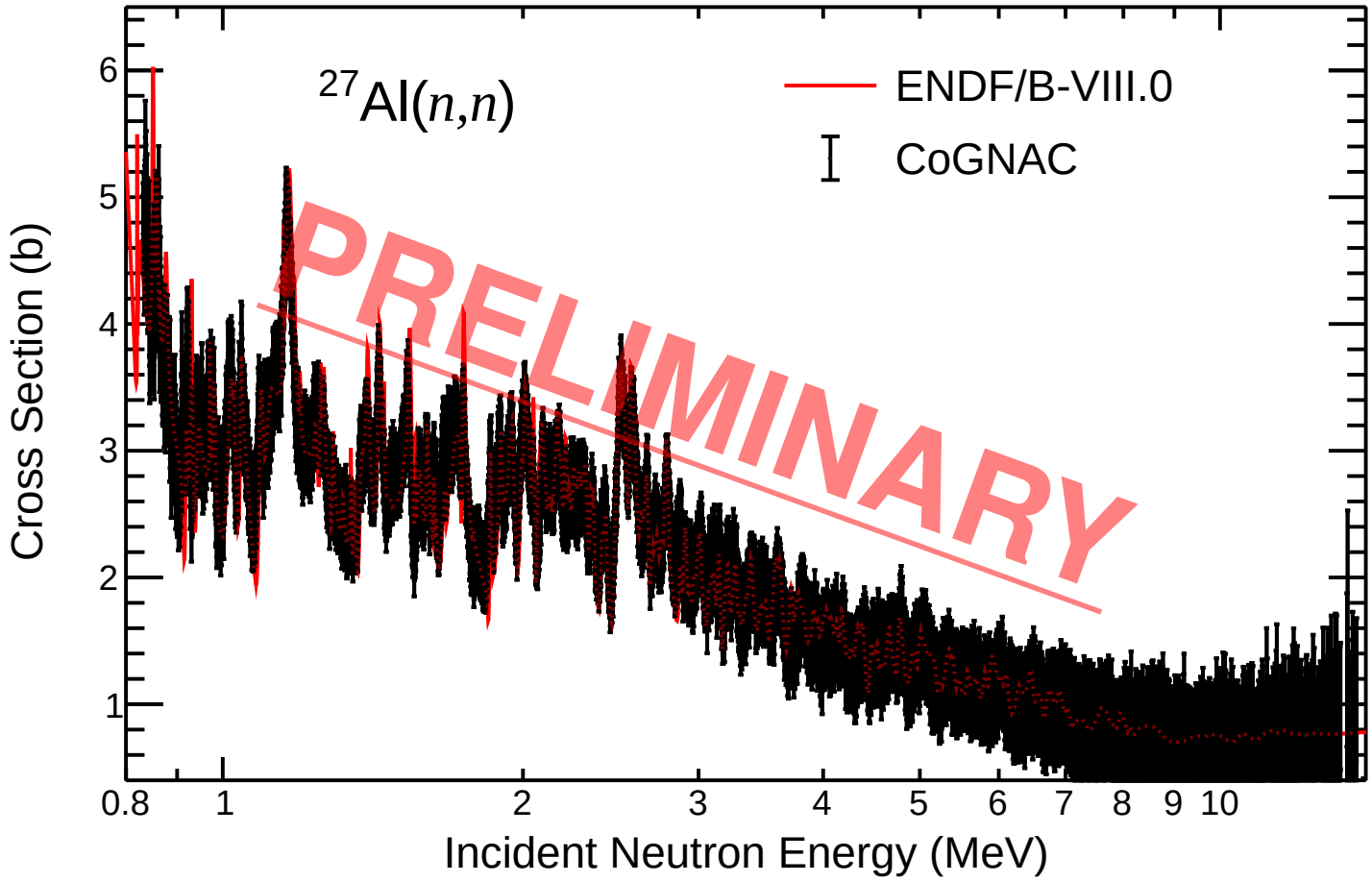
- Quick, preliminary analysis ... Also measured high-res. ^{28}Si(n,$n'\gamma$)
- ^{28}Si-based efficiency produces near-identical ^{12}C(n,n) results

Technique is Also Validated w/ ^{16}O(n,n) Analysis



- Quick, preliminary analysis ... Also measured high-res. ^{16}O$(n,n'\gamma)$
- Structure of ^{16}O(n,n) is not appropriate for efficiency

Technique is *ALSO* Validated w/ ^{27}Al(n,n) Analysis



- Quick, preliminary analysis ... Also measured ^{27}Al(n,$n'\gamma$)
- Structure of ^{27}Al(n,n) also likely not appropriate for efficiency

Future Work

Inelastic Scattering:

- ^{16}O(n,$n'\gamma$) manuscript under review at Nuclear Data Sheets
- ^{28}Si(n,$n'\gamma$) results manuscript in preparation

Elastic Scattering:

- Finalize systematic uncertainties and propagate to covariances
  - Reliance on ENDF/B-VIII.0 ref. data implies baseline systematic
  - Relative efficiency method needs to be rigorously understood

(n,2n) and (n,3n) Measurements:

- An expansion of CoGNAC to allow for the extraction of (n,2n) and (n,3n) reactions recently funding under the DOE Early Career Research Program
- 5-year project timeline to develop detection system and analysis techniques

THANK YOU!

Send questions to Keegan Kelly: kkelly@lanl.gov

^{12}C(n,n) liquid scintillator analysis funded by OES/Secondary Assessment Technologies Data collection on ^{27}Al, ^{16}O, and ^{28}Si for γ-production measurements funded by NNSA Defense Nuclear Nonproliferation Research and Development (DNN R&D; NA-22), leveraged for (n,n) cross validation in this work.

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