WANDA 2023 Update:
White Source $n-\gamma$ Measurements of $\gamma$-Production Cross Sections at LANSCE

K. J. Kelly, M. Devlin (presenting), E.A. Bennett, J.M. O’Donnell, M. Paris

2023 WANDA
Outline

• Project Motivation

• Analysis Methods

• $^{27}$Al and $^{16}$O Measurements, and $^{12}$C

• Future Work
Motivation: Active Interrogation

- Identify contents of a container via neutron irradiation
- $\gamma$-ray emission used for ID
- Requires knowledge of $\gamma$-prod. XS
  - Effectively equal to $(n,n'\gamma)$ XS for many nuclei
- Also require understanding of neutron transport
CoGNAC $n$-$\gamma$ Approach to Scattering

- PSD $n$-$\gamma$ separation $\Rightarrow$ treat each detector as both $n$ and $\gamma$ detector
  - Incident Neutron Energy, $E_{inc}^n$, from $t_0$-$t_\gamma$ time difference
  - Outgoing Neutron Energy, $E_{out}^n$, from $t_\gamma$-$t_n$ time difference

- Chi-Nu liquid scintillator array and nearly complete CL YC-6 detector array
Iterative Unfolding of Neutron Spectra

\[ m^{(n+1)}_{\alpha|\beta}(E) = \frac{m^{(n)}_{\alpha\beta}(E)c_{\alpha}(E)}{\sum_{i=1}^{N} R(E, E_i)m^{(n)}_{\alpha|\beta}(E_i)} \]

- Improves resolution of state excitations
- Corrects for environmental \( n \) scattering effects
- Extract full strength of each excited state
  - Demonstrated with continuous PFNS in MCNP

Kelly et al., NIMA 1010 (2021) 165552
Kelly et al., NIMA 866 (2017) 182
Gold, Report ANL-6984 (1964)

Data
Unfolded

Peak Assignments: Known; Likely; Unsure

Nat. Fe, \( E_{n}^{inc} = 1.950-7.943 \) MeV

One or more states around 5100 keV
One or more states around 5500 keV
4085 (1,2+)
54Fe
Data Unfolded Peak Assignments: Known; Likely; Unsure

• Improves resolution of state excitations
• Corrects for environmental \( n \) scattering effects
• Extract full strength of each excited state
  - Demonstrated with continuous PFNS in MCNP

Kelly et al., NIMA 1010 (2021) 165552
Kelly et al., NIMA 866 (2017) 182
Gold, Report ANL-6984 (1964)
Preliminary $^{12}\text{C}(n,n'\gamma)$ Cross Section

- Correlated $n-\gamma$ Distributions: Kelly et al., PRC 104 (2021) 064614
- $\gamma$-Production XS motivated liq. scint. $\gamma$-ray Investigations
- No competing $\gamma$ rays $\Rightarrow$ high-res, high-stats $^{12}\text{C}(n,n'\gamma)$ XS

\[ \text{Cross Section} (b) \]

\[ \text{Incident Neutron Energy, } E_{n}^{\text{inc}} \text{ (MeV)} \]
**$^{27}\text{Al}(n,n'\gamma)$ Cross Sections**

- All data normalized to 4.0 MeV data point at $E_x = 2212$ keV
Preliminary Results for $^{16}\text{O}(n,n'\gamma)$

![Graph showing cross section vs. incident neutron energy]

- CoGNAC - Liqd. $\gamma$
- Boromiza - GAINS $\gamma$
- Nelson - $E_\gamma = 6.129$ MeV
- ENDF/B-VIII.0 ($n,n'$)

Incident Neutron Energy, $E_n^{inc}$ (MeV)

Cross Section (b)
Future Work

- $^{27}\text{Al}(n,n'\gamma)$ data under review
- $^{16}\text{O}(n,n'\gamma)$ results preliminary, but promising
- $^{28}\text{Si}(n,n'\gamma)$ data, and likely more $^{16}\text{O}$ data, to be collected during the 2023 run cycle