Contribution ID: **162**

Type: **Oral**

New Advances in C^{7}LYC

We report on new advances in simulation, characterization and fabrication of the ^{7}Li-enriched dual neutron-gamma scintillator C^{7}LYC. Detailed GEANT4 simulations have been performed, with specific focus on (n,p) and (n,α) reactions on ^{35}Cl that are primarily responsible for the fast neutron response of C^{7}LYC. The simulations are compared to experimental data to separate contributions of the different reaction channels. In addition, new C^{7}LYC crystals with square cross-sections have been fabricated for exploring compact close-packed geometries.

To identify features of the different neutron reaction channels, the neutron and γ response for 1" x 1" and 3" x 3" C^{7}LYC detectors of cylindrical cross-section were simulated in GEANT4 choosing physics models in the code for high precision neutron transport below 20 MeV. The scintillation light output for a 1" x 1" C^{7}LYC was simulated using Birk's equation [1], with Birk's constant for C^{7}LYC deduced from experiment. This allowed a comparison of the quenching of the scintillation light output for protons and α particles. The GEANT4 simulations were compared with initial MCNP results for consistency and subsequently benchmarked against experimental inelastic neutron scattering data from a ^{12}C target.

The experimental data were obtained at the Los Alamos LANSCE facility using a white neutron beam generated by bombarding a thick W spallation target with 800 MeV pulsed protons. An array of 1"x1" C^{7}LYC detectors was placed radially ~20 cm from a ^{12}C scatterer. Incident neutron energies were extracted by measuring their arrival time across a ~20-m flight path from the spallation target to the ^{12}C, and then to the detectors, with appropriate recoil corrections for the different detector angles. The scattered neutron energies were measured as pulse heights in the C^{7}LYC detectors, which reflects the inherent spectroscopic resolution of the scintillator, and allows a mapping of the energy-dependent response of C^{7}LYC to mono-energetic neutrons. Prominent features of the experimental spectra are reproduced remarkably well in the simulations with the primary ^{35}Cl(n,p) and ^{35}Cl(n,α) reactions, and help identify the features where the data overlap from the different neutron reaction channels. In addition, resonances in the ^{35}Cl(n, p) cross-section as a function of incident neutron energy below 3 MeV, recently measured through the detection of the outgoing proton [2], were directly observed in C^{7}LYC with similar resolution.

To assess the efficacy of C^{7}LYC as a viable scintillator for close-packed geometries, four 1" x 1" x 3" C^{7}LYC crystals, with square cross-sections, square photo-tubes and minimal surrounding material, have been acquired. Both efficiency and cross-talk of fast neutrons are being investigated, and initial results will be presented.

The work is supported by the U.S. Department of Energy.

[1] J.B. Birks, The Theory and Practice of Scintillation Counting (Pergamon, New York, 1964).
[2] S.A. Kuvin et al, Phys. Rev. C102, 024623 (2020).

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Session Classification: Poster Session

Track Classification: Poster Presentations