Fission-energy neutron response of CLYC

T.A. Laplace[1], B.L. Goldblum[1,2], J.A. Brown[1], J.M. Gordon[1], P. Kerr[3], R.L. Mannino[3], V. Mozin[3], P.R. Thompson[1]

[1]University of California Berkeley, Berkeley, California, USA
[2]Lawrence Berkeley National Laboratory, Berkeley, California, USA
[3]Lawrence Livermore National Laboratory, Livermore, California, USA
Corresponding Author Email: lapthi@berkeley.edu

$Cs_2LiYCl_6:Ce^{3+}$ (CLYC) has emerged as a scintillator of interest for its ability to detect both fast and slow neutrons as well as gamma rays. Neutrons are detected through ^{6}Li(n,αt), ^{35}Cl(n,p) and ^{35}Cl(n,α) reaction channels. Efforts to use this material as a neutron spectrometer or multimodal detector have been frustrated by the inability to separate signals originating from proton and alpha recoils using the traditional charge integration method for pulse shape discrimination (PSD). This has led to the limited use of CLYC enriched in ^{7}Li, which provides no response to neutrons below 400 keV.

A recent breakthrough in separating signals from protons and alpha recoils was presented at the last SCINT meeting [1], paving the way for neutron spectroscopy using CLYC. To produce an accurate detector response matrix for use in spectroscopy, understanding of the light output as a function of particle recoil energy for protons, alphas and tritons is essential. A series of measurements were conducted using a Cf-252 source and a tagged time-of-flight setup along with measurements using DD and DT neutron generators in a low room return facility. Measurements were performed using eight 1.5-inch right cylinders of CLYC enriched in Li-6. Data were acquired using a DT-5730 500 MS/s 14-bit digitizer.

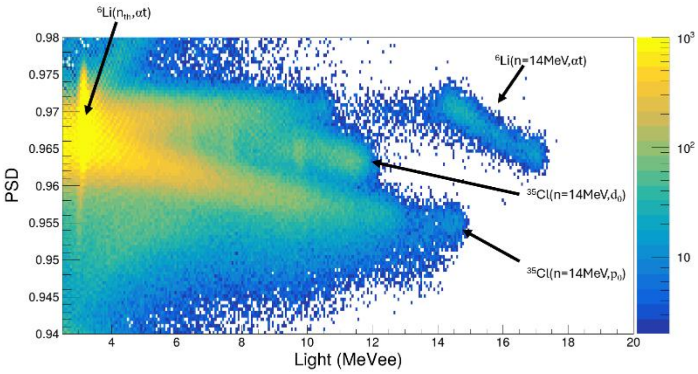

Figure 1. PSD as a function of light produced in a 1.5-inch CLYC scintillator irradiated with 14.1 MeV neutrons. Several features are showcased, enabling extraction of particle specific light output at key energies. The distribution of events from 14.1 MeV neutrons undergoing capture by Li-6 is broadened due to kinetic boost in the energy sharing of the alpha and triton and their difference in ionization quenching.

Figure 1 shows a PSD metric as a function of light output for neutron-induced signals obtained using the DT generator. Features corresponding to 14 MeV neutrons undergoing different reactions channels are shown. The broad response corresponding to ^{6}Li(n,αt) events is due to both the kinematic energy sharing between alphas and tritons, which depends upon the angle of emission relative to the incoming neutron, and different amounts of ionization quenching for each particle type. Progress towards fission-energy neutron spectroscopy with CLYC will be discussed, including the measurement and benchmarking of a 3D response matrix (neutron energy – light – PSD).

[1]. J. A. Brown, et al. "Proton discrimination in CLYC for fast neutron spectroscopy," *Nucl. Instrum. Methods A* 1069 (2024).

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