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Neutrino and Dark matter detection with CLEAN: Preliminary studies

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CLEAN is an approach to the detection of weakly interacting particles of astrophysical significance, combining large mass and low energy threshold. Preliminary measurements have been made of the time response of the scintillation light due to β energy deposition. We have measured two distinct time constants corresponding to the singlet and triplet states of liquid neon.

Keywords: Neutrino; Dark Matter

The "Cryogenic Low Energy Astrophysics with Noble gases" (CLEAN) project is a proposed [1] 135 tonne liquid neon particle detector that will push the boundaries of neutrino detection, particularly for $p-p$ produced solar neutrinos. The low energy threshold required to detect these neutrinos implies that CLEAN should also be able to set significant limits in dark matter searches [2].

Neon is a relatively inexpensive element that has several advantages over other scintillation media. There are no radioactive isotopes of neon and because its surface binding energy is so low, most contaminants can be removed with an activated charcoal cold trap. Liquid neon has a high scintillation yield, is dense, and is transparent to its own scintillation light, making it practical for use in a large self-shielding apparatus. Furthermore, we expect very good pulse shape discrimination between electron and nuclear recoil type events that make neon a good choice for dark matter exploration.

Preliminary studies have been carried out on liquefied neon scintillation[3], as well as on related systems such as the wavelength shifters[4] that are necessary to convert the 77 nm scintillation light to the visible. Here we are presenting data from experiments looking at the time dependence of the scintillation light. Figures 1 and 2 contain plots of oscilloscope traces collected from 1 MeV β scintillation events in liquid neon. Figure 1 provides a clear view of the time scale corresponding to the singlet excitation. Figure 2 is an expansion of the time scale to show the triplet component.

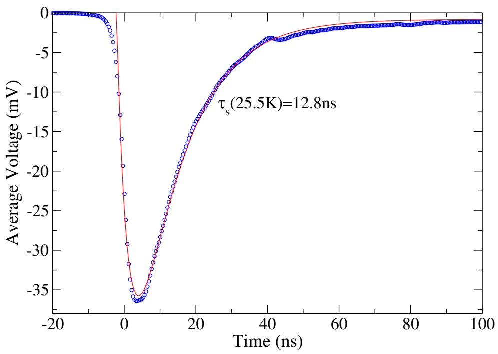

Fig. 1. Trace average showing the prompt light component (singlet).

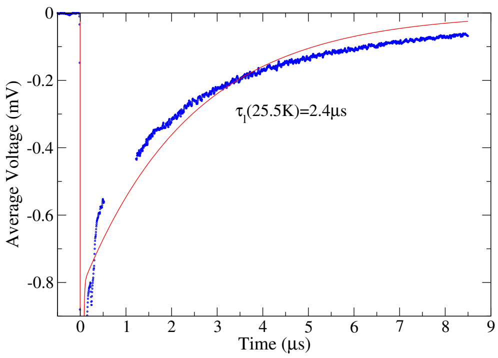

Fig. 2. Trace average showing the extended light component (triplet).

The solid line in figures 1 and 2 is a fit to the data using this function:

$$\begin{aligned}\bar{V} &= A\left(e^{-t/\zeta} - e^{-t/\tau_s}\right) \\ &+ B\left(e^{-t/\zeta} - e^{-t/\tau_l}\right)\end{aligned} \tag{1}$$

where A and B are the respective amplitudes of the short (singlet) and long (triplet) time components, and τ_s and τ_l are the single and triplet time constants.

From this model we find that the triplet to single light production ratio is about 2.8. It should be stressed that this result is for essentially unpurified neon containing unknown contaminants. With greater purity, we expect this ratio to increase as the slow component is prone to quenching by contaminants. Ongoing research includes neon purification and measurements of scintillation due to nuclear recoils.

References

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