Liquid Scintillator for the PROSPECT Antineutrino Detector

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PROSPECT: 4-ton segmented ⁶Li-loaded liquid scintillator detector

PROSPECT will probe short-baseline oscillations & spectral distortions using a compact, segmented, high-resolution antineutrino detector

Liquid scintillator developed is composed of:
- ⁶Li-doped liquid scintillator-like base (DIPN)
- anionic surfactant
- purified 10 M LiCl, with a total loading of 0.1% Li by mass

LS properties yielded tight engineering constraints:
Cover gas system. Extensive material compatibility studies: long-term soak tests followed by light yield and absorption measurements. Material strength tests:
- All materials in contact with LS qualified
- dominant materials, acrylic, PTFE, PLA, Viton
- Microemulsion based LS allows precise stable doping of radionuclides

Over 2 years of R&D to develop a new water-based technique to load hydrophobic elements (i.e. Li) in liquid scintillator

Li capture peak as a function of time for the 2 cell P50X prototype, change in peak position and PSD consistent with oxygen quenching.

Production, QA/QC, mixing, filling, and environmental control.

Base materials purified, and then mixed in stages to produce final LS

Extensive QA/QC performed on each batch, with very good consistency observed between batches.

28 x 200L drums shipped from BNL to ORNL in a temperature controlled truck, ultimately mixed in a PTFE lined ISOtank prior to AD filling.

Microemulsion based LS allows precise stable doping of radionuclides

0.5 Bq of dissolved ¹²⁷Ac, yields a Re-Po chain that is easily separated from backgrounds. Excellent calibration source and determines relative cell volume

Scintillator performance

Ultimate energy resolution requires high light yield and efficient collection.

Capture peaks demonstrate excellent energy resolution (∼ 4.5%/sqrt(E))

Li capture peak as a function of time for the 2⁶Li doping shows expected purely exponential behavior

Li capture peak as a function of time for the 2⁶LiLS optical absorbance at 420nm wavelength. All drums had a better absorbance than the requirement

Li shows sensitivity to oxygen quenching, but with proper handling has shown excellent stability.

PSD as a function of energy from in situ measurement (with selective cuts), right plot shows PSD in the energy region of the neutron capture peak

PSD consistent with oxygen quenching.

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