Minfang Yeh and Richard Hahn for Braidwood Collaboration

In 2004, the Solar-Neutrino/Nuclear-Chemistry Group in BNL began to center its efforts on developing the Gd-loaded liquid scintillators for the newly proposed, high-precision theta-13 experiments. This work was an expansion of our R&D of chemical techniques for synthesizing metal-loaded organic liquid scintillator for LENS-Sol (~10% of indium by weight in LS), which we had been studying since 2000. In late 2004, samples of 0.1%~0.2% of Gd by weight in LS with excellent optical transparencies (~15 meters of *1/e* attenuation length) and high light output (~95% of pure pseudocumene, PC) were successfully prepared. From the experience learned from recent reactor experiments (for example, CHOOZ had to be shut down because its detector deteriorated at a rate of 0.4% per day or >100% per year), it is clear that the most critical ingredients for a long-term (>3 years) antineutrino detector are the stability of its key characteristics: optical transparency and light output. To examine the long-term stability of the BNL Gd-LS, a quality control program (QC) has been implemented to monitor periodically the changes of attenuation length and light output of selected Gd-LS samples since their synthesis. Analogous to the previously presented BNL data of the variation of optical absorbance vs. time (see Figure 1, which shows up-to-date absorbance values), the light yields for selected Gd-LS samples are shown in the Figure 2 as a function of time. It should be noted that any trends of observed degradation of the optical transparency do not necessarily translate into degradation of the light yield. For example, the Palo Verde experiment reported a slow deterioration rate of its scintillator transparency of 0.03% per day or ~10% per year, while no significant degradation of the corresponding light yield and the Gd loading was observed.

To date, BNL samples with 1.2% and 0.2% of gadolinium in PC have been stable over a period of ~220 days. We know that the stability of the Gd-LS will also depend on any chemical interactions that it may have with the material of the detector vessel in which it is stored, e.g., in acrylic. Palo Verde reported that the dilution of its PC solvent with other inert organic solvents, such as mineral oil, could slow down the chemical attack of the vessel. To evaluate this possibility of preventing chemical degradation of the Gd-LS and the detector vessel, a sample of the BNL 1.2% gadolinium solution, which was originally synthesized in PC, was diluted with pure dodecane. The final formulation of this Gd-LS is ~0.2% of gadolinium by weight in a mixture of 20% PC and 80% dodecane. To date, its light yield has shown no variation since its preparation, a period of ~50 days. A comparison of the optical stability for this mixed-solvent 0.2% Gd-LS with values reported by Palo Verde and CHOOZ is presented in Figure 3.

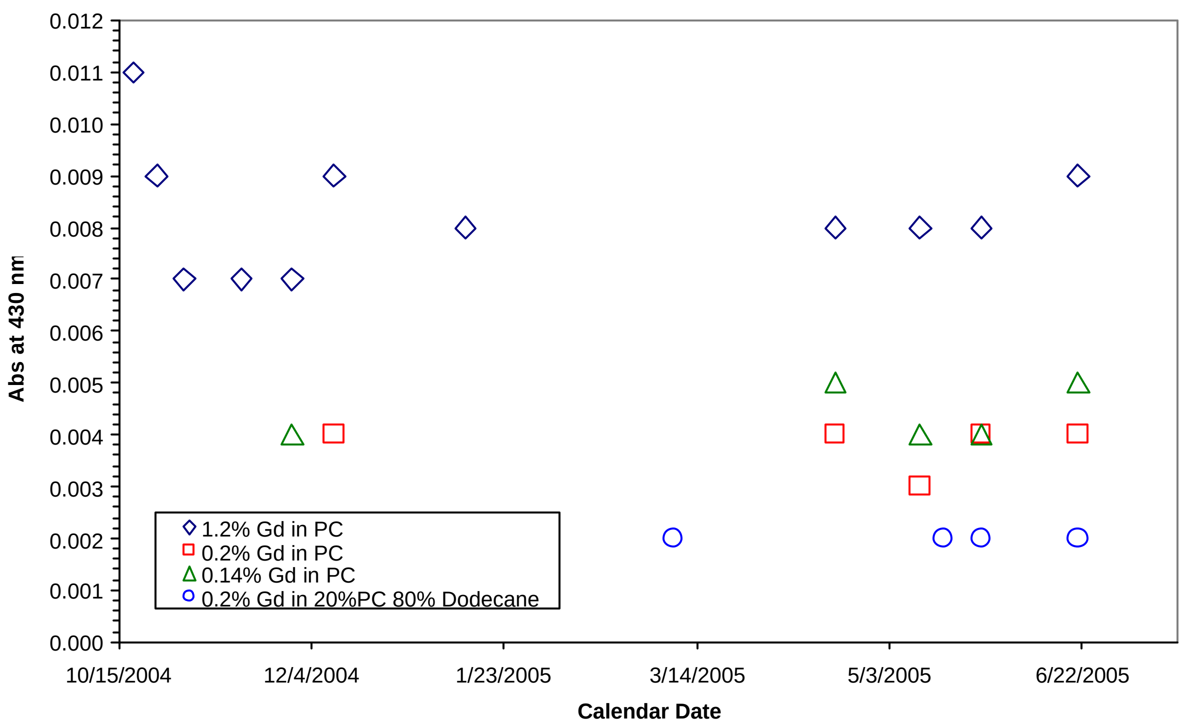

Figure 1. Variation of absorbance vs. time to date for BNL samples.

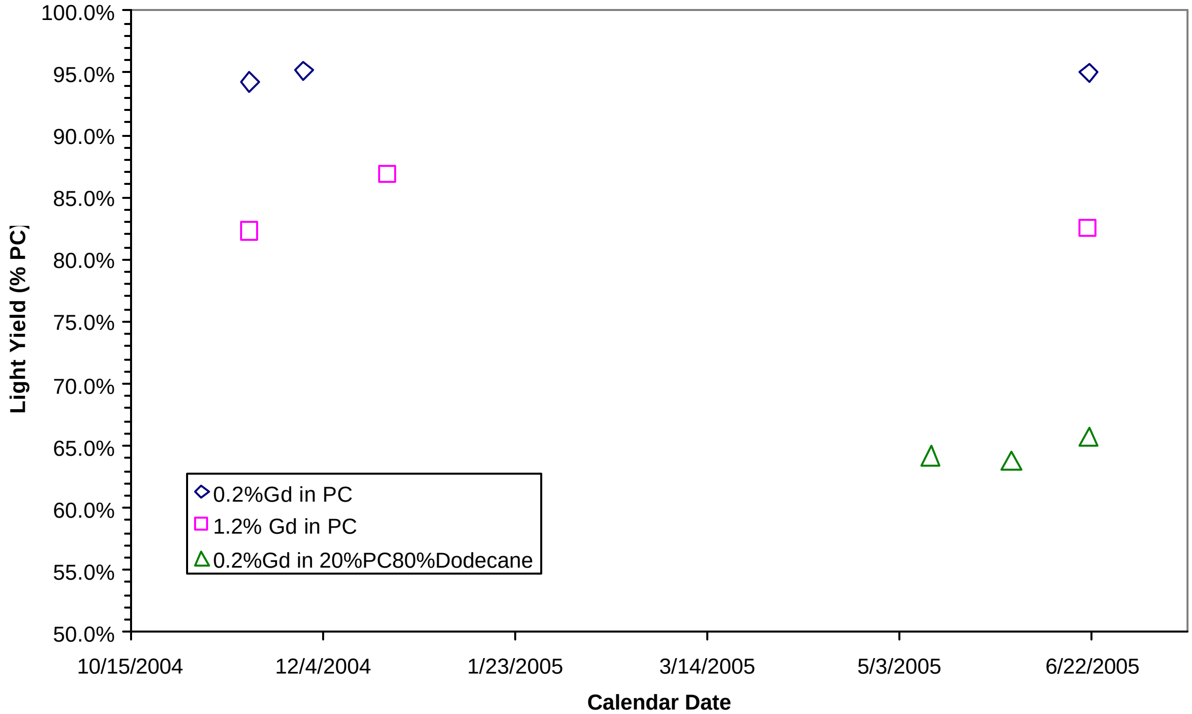

Figure 2. Variation of light output vs. time to date for BNL samples.

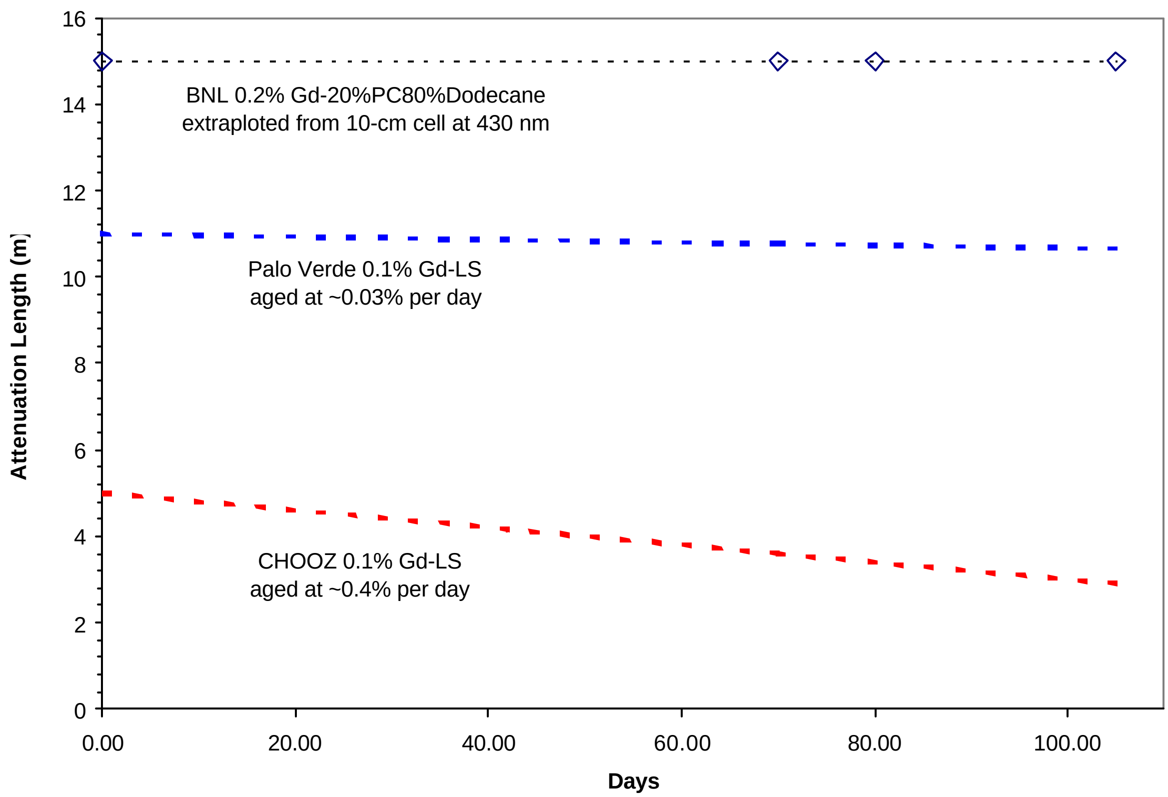

Figure 3. A comparison of the BNL 0.2% Gd-LS with Palo Verde and CHOOZ Gd-LS.