Calibrations of the SNO+ PMTs

Authors: Freija Descamps*, Max Beaug, Kimia Haghighi, Matt Jaffe, Katayan Kamdin, Tannier Kaptanoglu, Sylvia Lewin, Gabriel Orebi Gann and Darius Roohani for the SNO+ collaboration

SNOLAB

SNOLAB is located in the Creighton mine near Sudbury, Canada. It contains several neutrino and dark matter experiments. At its depth of about 2200m the flat overburden equals about 6000m.w.e.

SNO+

The SNO+ experiment uses the existing Sudbury Neutrino Observatory (SNO) detector. The main physics goal of SNO+ is to search for the neutrinoless double beta decay, solar & supernova neutrinos and reactor & geo antineutrinos.

SNO+ PMTs

9,522 sensitive photomultiplier tubes are attached to a geodesic sphere. They provide a solid angle coverage of about 54%. Accurate calibration of the PMT response is essential for the success of SNO+.

Understanding the PMTs

SNO+ calibrates the PMTs in-situ by using calibration sources. These sources can be fixed, like the LED system, or deployable, like the Cherenkov source. In SNO data, a change over time in angular response was observed. Different aging models are simulated and compared to data.

Hit-level PMT calibration

For each single PMT, we need to determine • what charge corresponds to a single photoelectron, • the total cable + electronics delay, • the effect of the discriminator level on timing.

SNO+ has two sources of optical calibration data: • ELLIE: external LED & lasers injected via fibers, • laserball: near-isotropic single-wavelength photon source that can be deployed inside the acrylic vessel.

Cherenkov calibration source

Cherenkov principle:
• ⁸Li carried at high speed by helium gas through a tube into decay chamber
• ⁸Li → ⁸Be + β + v (Q~13 MeV); ⁸Be → ²α,
• β enters acrylic wall of decay chamber, produces Cherenkov light, and stops in the acrylic.
• α produces scintillation light in the helium gas which can be used to tag the event.
• Use of UV absorbent acrylic minimizes scintillation effects.

Relative angular response

R&D underway for the Cherenkov source includes:
• Choice of chamber lining to absorb alpha scintillation photons.
• Application of wavelength shifter coating.
• Methods of bonding two acrylic hemispheres together.

Conclusion

A detailed microphysical understanding of the SNO+ PMT response is a requirement for any high-precision, robust physics result. LBNL/ U.C. Berkeley is leading the effort to calibrate the SNO+ PMTs and characterize them in simulations.