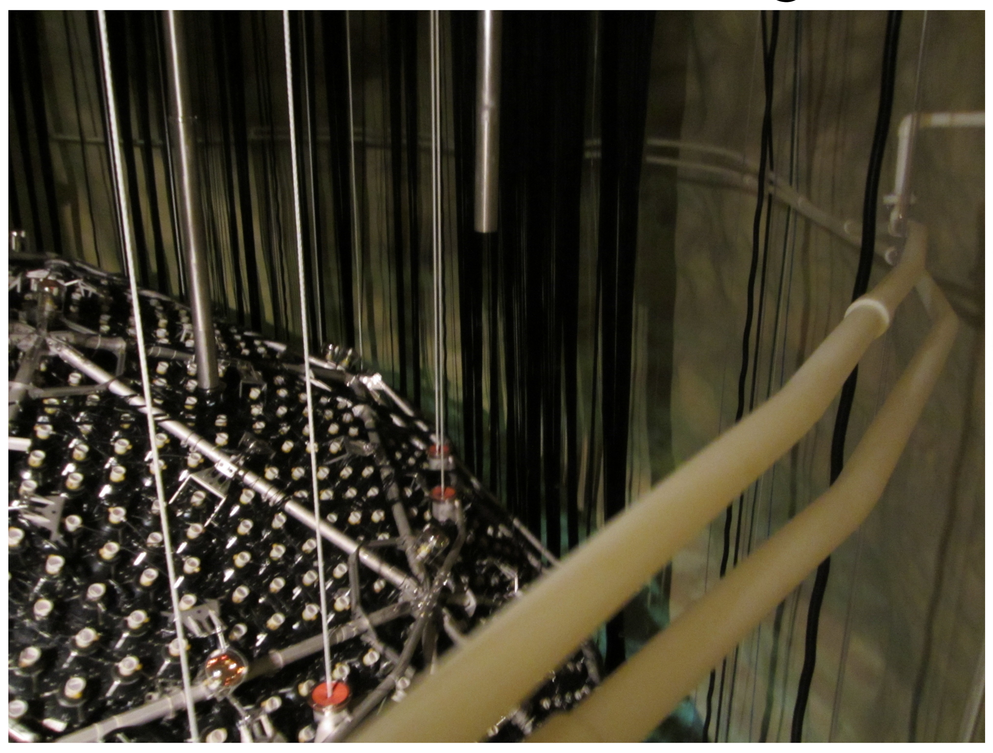
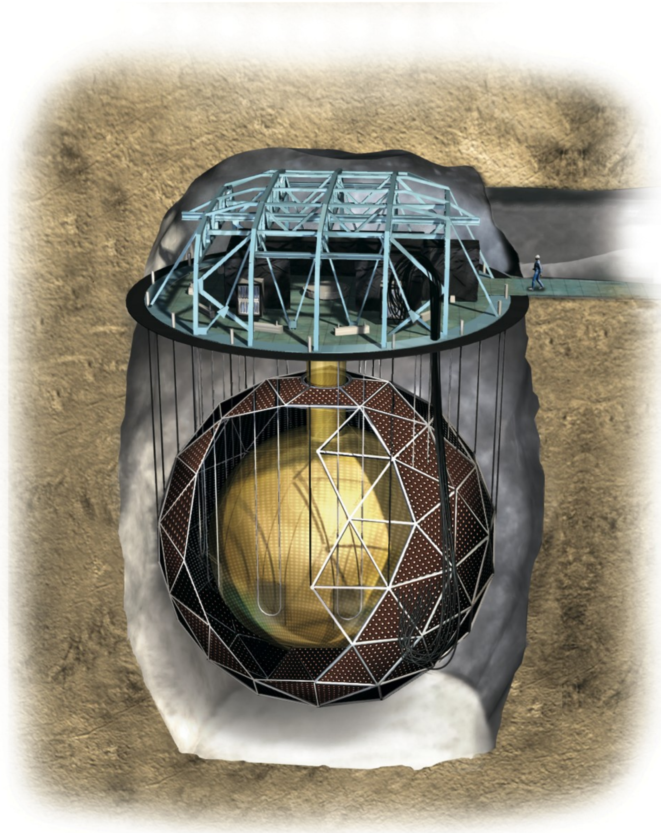
University of Sussex

From SNO to SNO+
Upgrading a Neutrino Experiment

Gwenaëlle LEFEUVRE, for the SNO+ Collaboration

The SNO+ experiment is the follow up of SNO, completed in 2006. The detector is being upgraded to replace the SNO heavy water target by liquid scintillator (LS). The lower energy threshold will turn SNO+ into a new experiment with a new set of technical challenges.

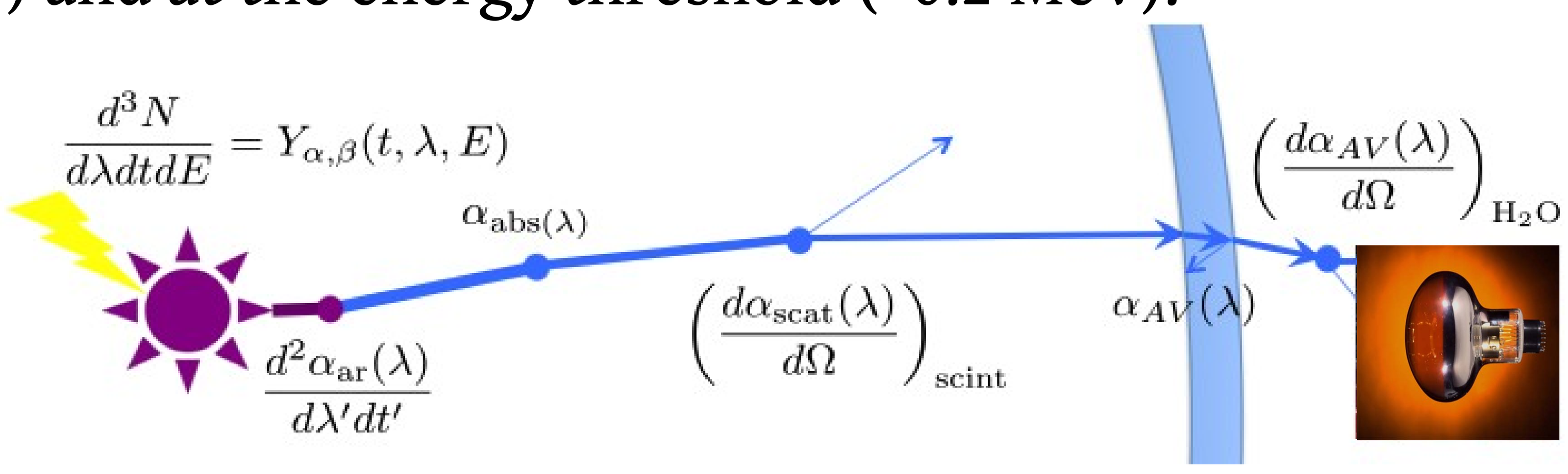




Calibration

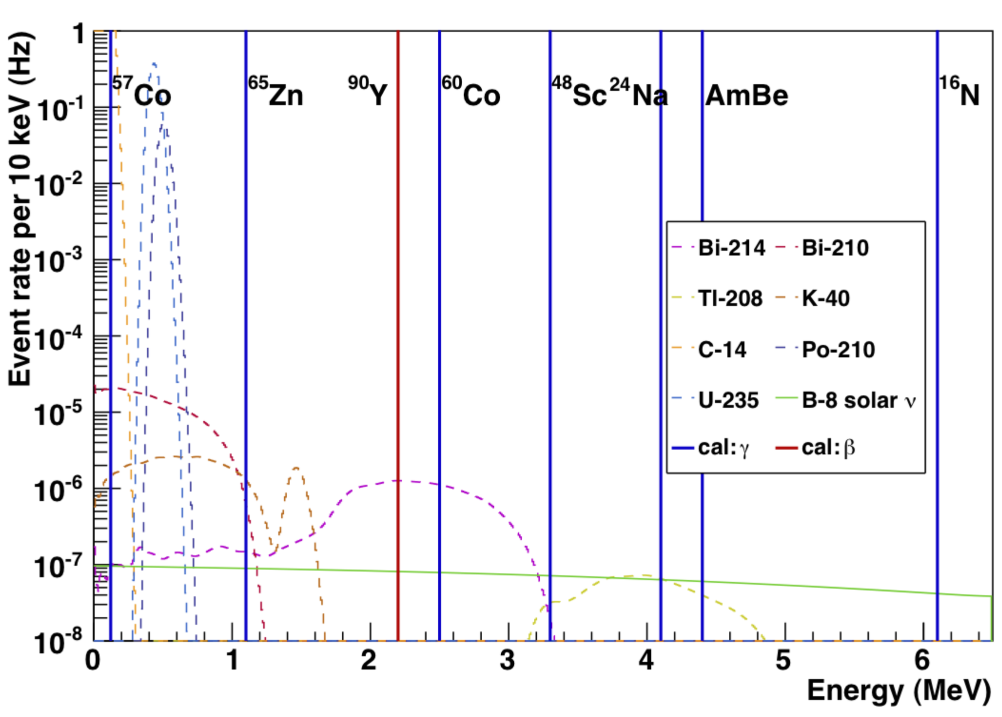
The calibration and monitoring programme is a very delicate task: it must provide a comprehensive understanding of the entire detector over a wide energy range (0.1 to 10 MeV). Among the most important parameters, it must establish:

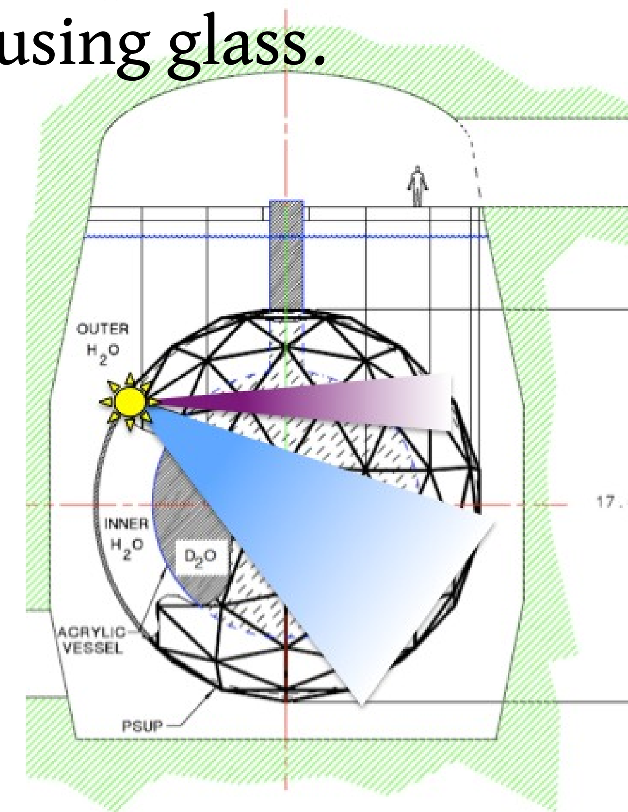
- The **optical response** in all media, ie scattering and absorption in LS, acrylic and water ;
- The **optical and electronic response of the PMTs**: gain and timing, light propagation in PMT and reflector set ;
- The **position reconstruction** ;
- The **energy response**, resolution, reconstruction bias, and stability, especially at the double beta decay end-point (3.7 MeV) and at the energy threshold (~0.2 MeV).



All these parameters will be measured by more than one system to reduce the systematics and model the short and long term behaviour of the detector:

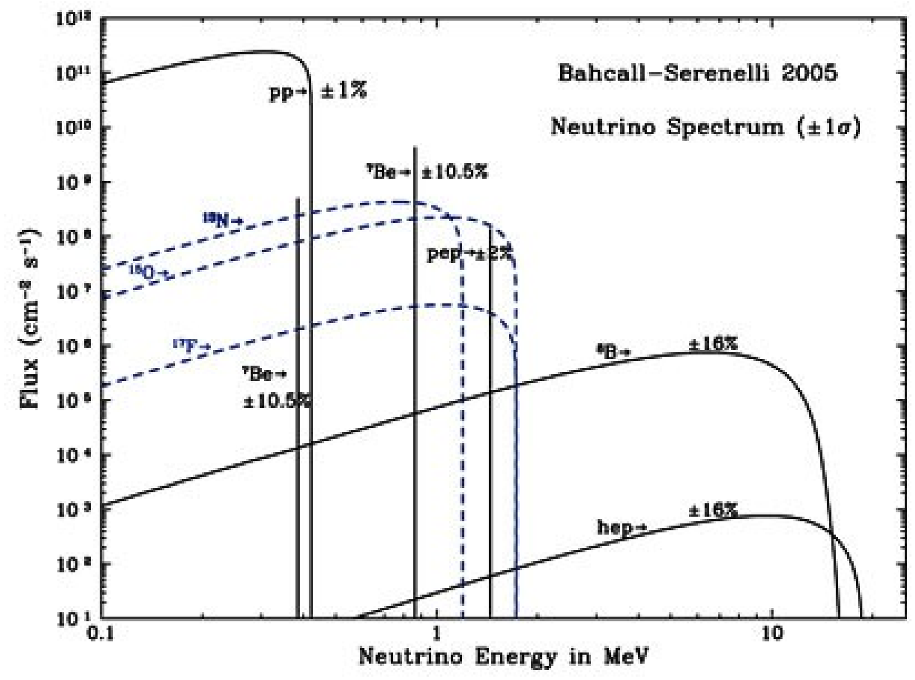
- The energy calibration will be addressed using a set of deployed **radioactive sources** (^{16}N, ^{60}Co, AmBe, ^{48}Sc...) ;
- The absolute optical calibration will be done with a **Cherenkov** source ;
- The **ELLIE** system (see right) will be used for the long term optical calibration and monitoring. It will be complemented by the **laserball**, a quasi-isotropic light source made by injecting laser light into a quartz diffusing glass.



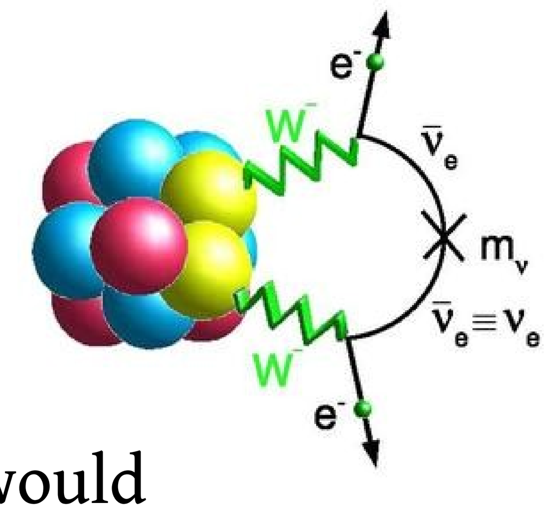


Physics Goals

SNO+ is a **multi-purpose neutrino detector** composed of a 12m diameter acrylic vessel filled with liquid scintillator and surveyed by ~9.500 photomultiplier tubes. It will address several aspects of neutrino physics, linking to particle physics, astrophysics and cosmology:



Low Energy Solar Neutrinos: SNO+ will detect the pep and CNO solar neutrinos, helping to understand better the mechanisms at work within the Sun.



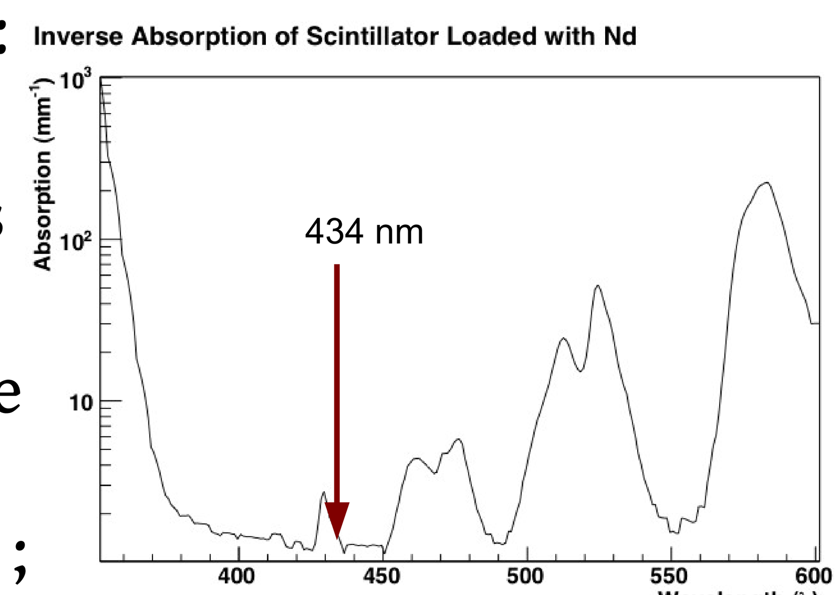
Neutrinoless Double Beta Decay: the detection of this decay would prove that neutrinos are their own antiparticles, and would help determining the absolute mass scale of the neutrino. For this, Neodymium will be added in the liquid scintillator.

But also... SNO+ will study the heat generation within the Earth by detecting geo-neutrinos, characterise neutrino oscillations with reactor neutrinos, search for nucleon decay, and look out for supernovae neutrinos.

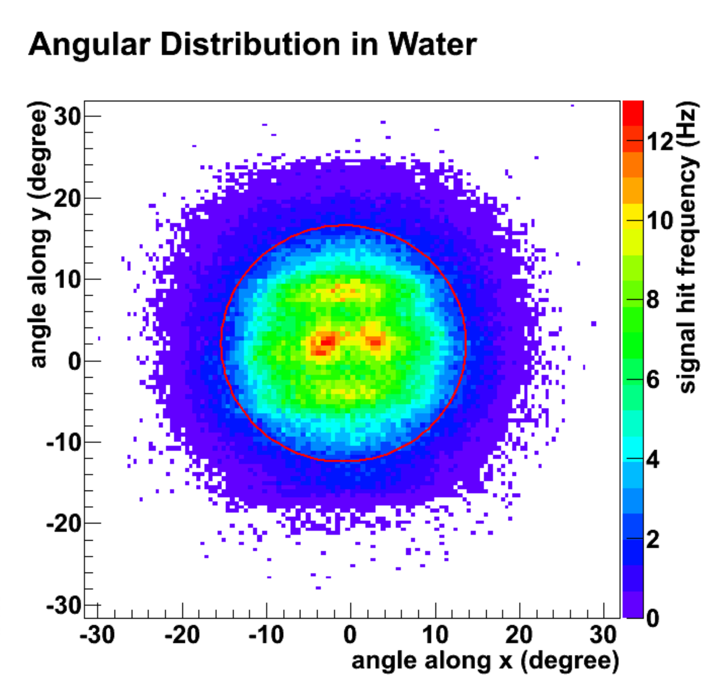
ELLIE

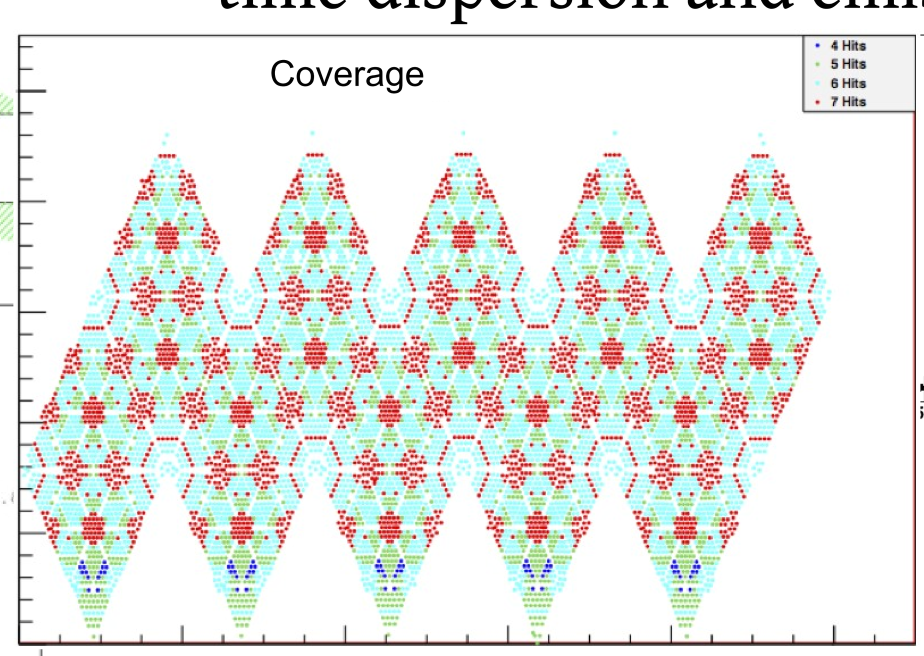
The low energy detection goal subjects the experiment to stringent radio-purity requirements, that the calibration must also meet, by limiting the access to the acrylic vessel.

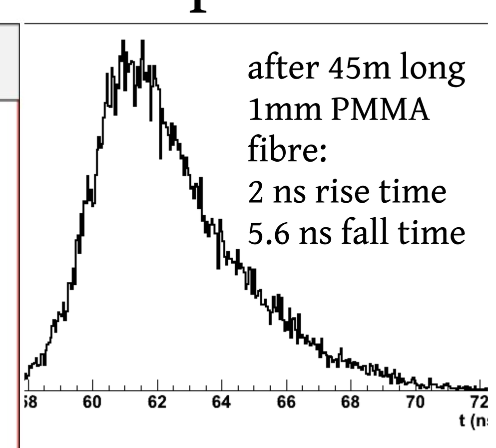
The **Embedded Led Light Injection Entity** is a set of 120 optic fibres installed on the nodes of the PMT support structure in the water. The electronics (LED/lasers, drivers) will sit on deck above the detector. ELLIE will offer a quasi-continuous monitoring of the PMT time response, the attenuation and the scattering. The following elements were carefully designed and studied for the Timing module:



- Design and productions of ~100 **LED driver units** delivering sub-ns rise time pulses into optical fibres ;
- The **LED selection** factored in the absorption spectrum of Nd-loaded LS, LED intensity and time stability ;
- The **1mm PMMA fibres** were fully characterised in terms of attenuation, time dispersion and emission profile.







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