SNO+ Tellurium Loading for Neutrinoless Double Beta Decay

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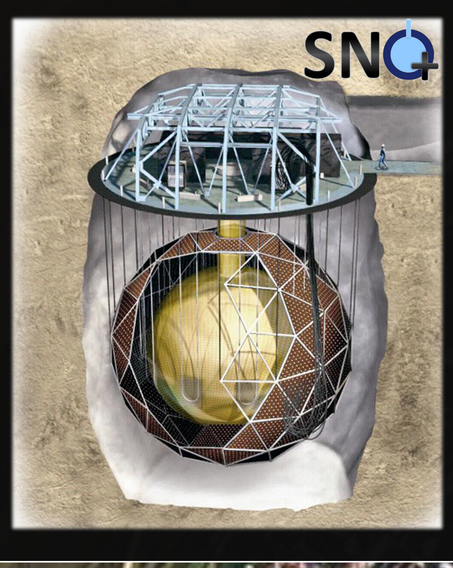
Introduction

SNO+ is a new experiment that incorporates the existing SNO detector. By replacing the heavy water used in the SNO detector with a tellurium loaded liquid scintillator, the experiment will focus on the search for neutrinoless double beta decay. In order to enable this search, novel metal-loading and purification techniques capable of achieving the required levels of radiopurity and optical quality have been developed.

Design and Location

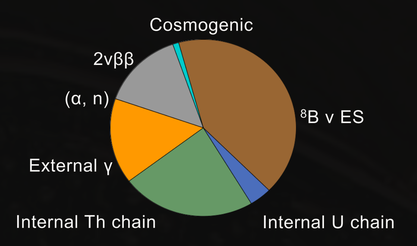


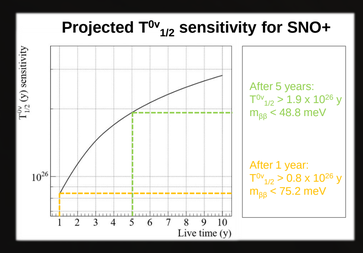
SNO+ is located in the SNOLAB underground Facility in Sudbury, ON. This is equivalent to 6000 m.w.e. of shielding from cosmic rays.

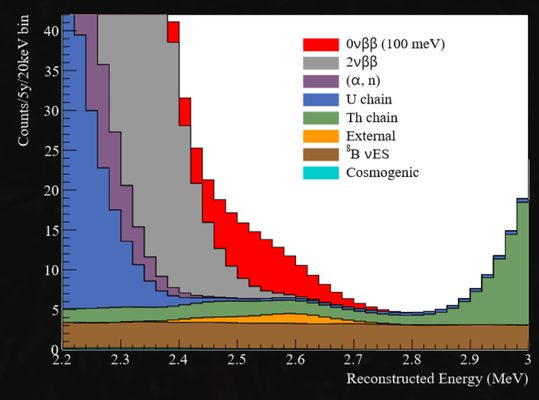
Double Beta Decay Physics

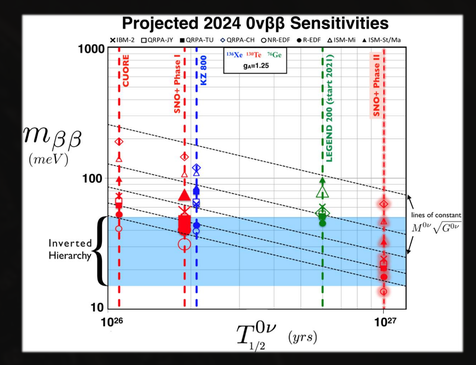
SNO+ will be a kilo-tonne scale liquid scintillator-based experiment located at SNOLAB in Sudbury, Canada. The main advantages of this technology for the (0νββ) physics are:

- High Te target mass at fractional loading (1.3 tonnes of ^{130}Te @ 0.5%Te by mass)
- Self-shielding and active discrimination (due to a large detector volume)
- Low internal backgrounds (effective purification techniques)





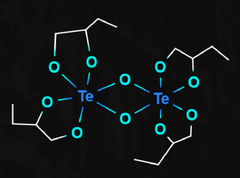


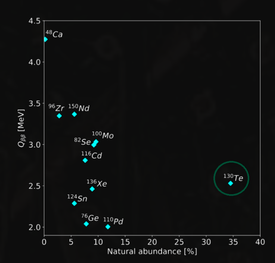


SNO+ Scintillator Cocktail

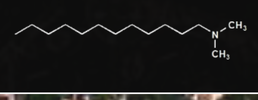
780 T Linear Alkylbenzene (LAB)
+ 2 g/L PPO (Primary Fluor)
+ 15 mg/L bisMSB (WS)

Tellurium Butanediol (TeDiol)
0.5%Te in LAB



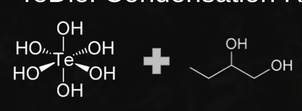


DDA (stabilizing amine)
0.4% in LAB

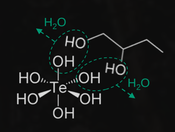


Tellurium Butanediol Synthesis

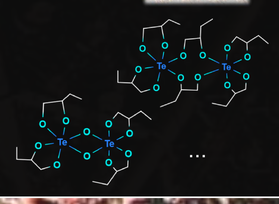
TeDiol Condensation Reaction



"Diolization"
(Consdensation)



"Polymerization"
(dimeric and poly-nuclear complex structures formed)



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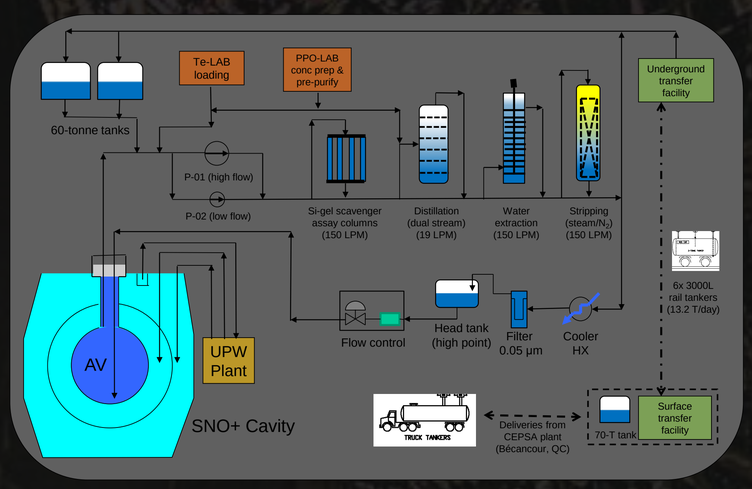
Main Advantages

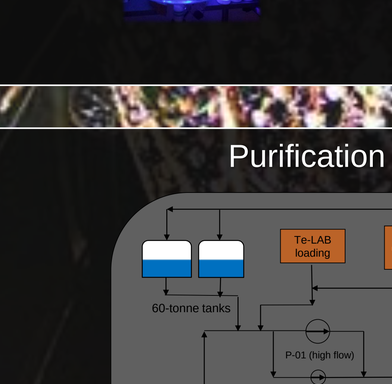
- High light levels at 0.5% loading
- Minimal optical absorption
- Low radioactivity levels
- Distillable reagents
- Easily scalable

Purification and Production Techniques



LAB Target Levels
U: 10^{-17} g/g
Th: 10^{-18} g/g

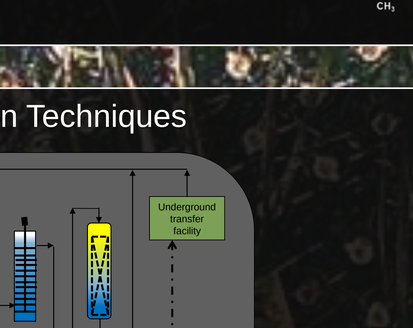
The Telluric Acid Plant



Telluric Acid target requirement:
^{232}Th ~10^{-14} g/g, and ^{238}U ~10^{-13} g/g
Reduction factor of ~10^3 w.r.t. raw Te

Cosmogenic daughters of Tellurium:
(^{60}Co, ^{110m}Ag, ^{126}Sn, ^{88}Zr, ^{88}Y, ^{124}Sb)
Reduction factor of ~10^4-10^6

The TeDiol Production Plant

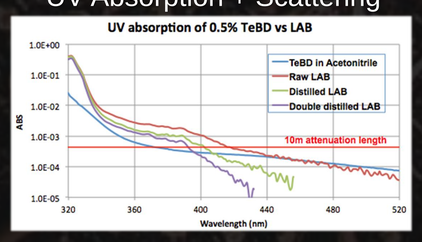


Butanediol target requirement:
^{232}Th 3.5x10^{-15} g/g, ^{238}U 3.5x10^{-14} g/g
Reduction factor of ~10^5 w.r.t. raw BD

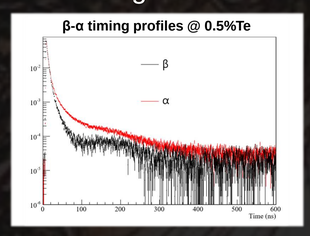
DDA amine target requirements:
^{232}Th 2x10^{-14} g/g, ^{238}U 5x10^{-15} g/g
Reduction factor of ~10^5 w.r.t. raw DDA

TeDiol Scintillator Properties

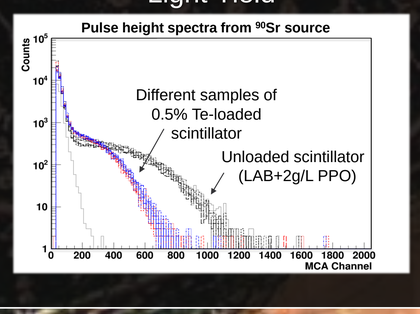
UV Absorption + Scattering



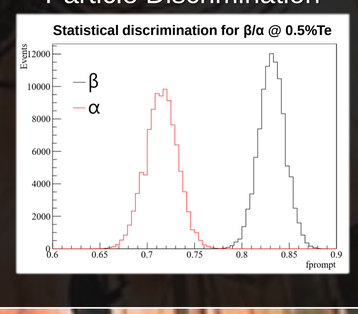
Timing Profiles



Light Yield



Particle Discrimination



Loading Technique Mature and Well-tested

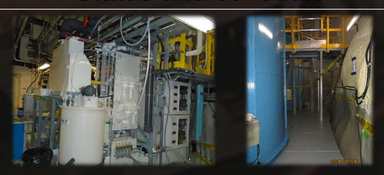
Acrylic compatible & Stable

Complex stable and tested under a variety of conditions

Compatible with acrylic and materials of the experiment

Robust synthesis technique developed

Status and schedule



LAB plant commissioning – first LAB fill imminent

Telluric Acid plant entering commissioning phase

TeDiol plant construction underway

U of Alberta, Queen's U
TRIUMF, SNOLAB
Laurentian U

U of Chicago, BNL, LBL, UNC-CH
UC Davis, UC Berkeley, UPenn
Boston University

Lancaster U, U of Liverpool
Queen Mary U of London
U of Oxford, U of Sussex

Technische Universitat
Dresden

Laboratório de Instrumentação e Física
Experimental de Partículas

Universidad Nacional
Autónoma de México