Cleaning program for SNO+ internal calibration sources

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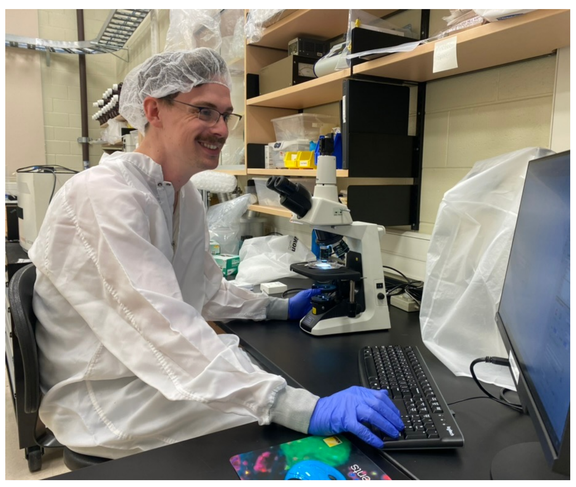
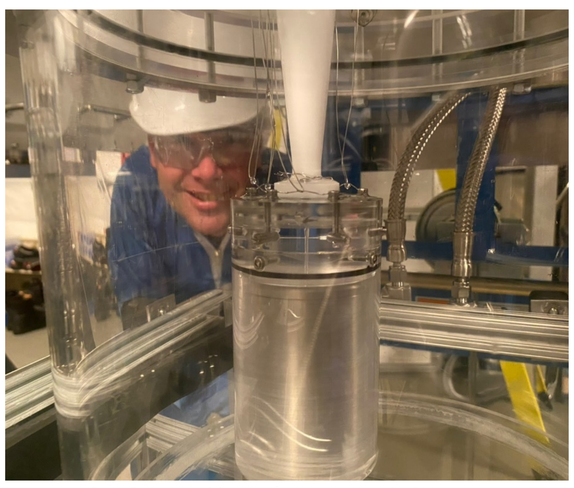
Introduction

Internal calibration sources used in SNO+ have been deployed last year (2025). In order to maintain the quality of the liquid scintillator in the SNO+ Acrylic Vessel (AV), calibration sources must be cleaned and confirmed to be at the desired cleanliness/background levels for SNO+ scintillator. The Source Cleaning Vessel (SCV) was developed for this task, recirculating a closed-loop volume of high-quality SNO+ liquid scintillator, linear alkyl benzene (LAB). Liquid Particle Counting (LPC) and UV-Vis spectroscopy was used to evaluate the cleaned source.



Matt Depatie scanning a sample for particles



Ryan Bayes admiring the freshly cleaned AmBe source

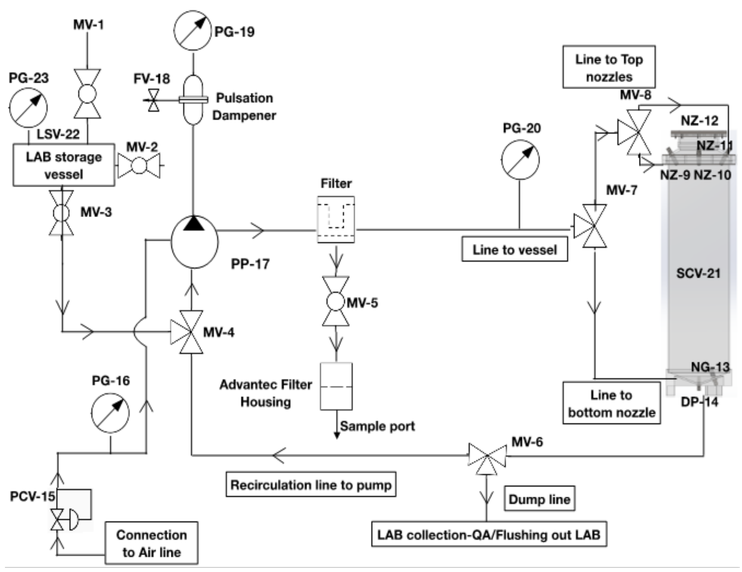
Equipment

Source Cleaning Vessel (SCV)

- Acrylic cylinder with **machined acrylic flanges** at the ends.
- Opening on top flange interfaces and **seals** with the SNO+ calibration deployment system.
- Two pairs of selectable **spray nozzles** at the top, one spray nozzle at the bottom.
- Bottom flange has **drain port** for the LAB.

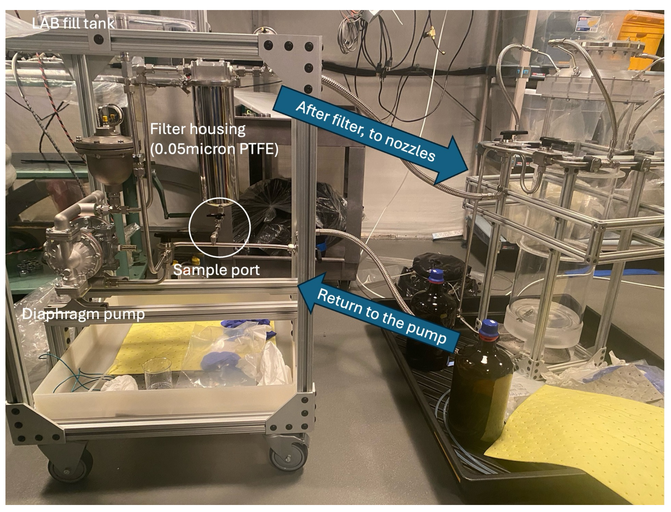
Pump skid:

- SCV connects to pump skid with two flexible stainless steel hoses.
- **Fill tank** on top of skid to load clean LAB.
- **Diaphragm pump** feeds the system, either filling SCV from tank or recirculating.
- Pump outlet connected to filter housing containing **0.5μm PTFE filter**.
- **Sample port** at bottom of filter housing.
- Filter outlet feeds the SCV spray nozzles.

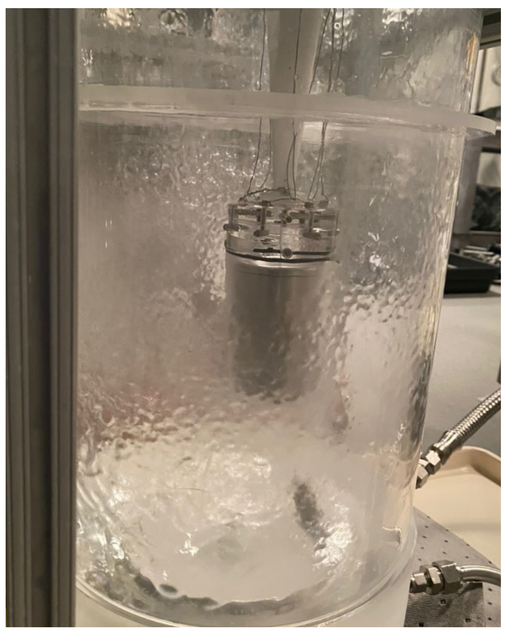


Flow diagram for the Source Cleaning Vessel skid

A source deployed into the SCV can be moved up and down through the nozzle's spray pattern to wash particulates from the source. As the scintillator recirculates, particulates are filtered by the PTFE cartridge.



Annotated picture of the Source Cleaning Vessel



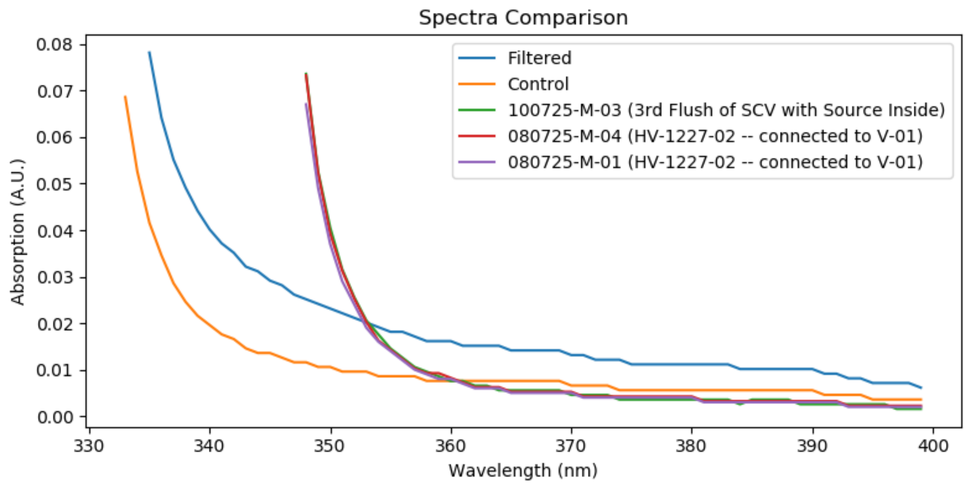
SNO+ Americium-Beryllium (AmBe) source inside the Source Cleaning Vessel (SCV)

Sampling

Samples are collected from the bottom of the filter housing. Before a sample is taken, the sample port is cleaned with methanol, and then some LAB is flushed out to remove and trapped particulates. Samples collected after flushing represent the cleanliness level of the SCV as it's recirculating.**125mL samples are collected for UV-Vis spectroscopy, followed by a 500mL sample LPC.**

UV-Vis Spectroscopy

SNO+ uses UV-Vis Spectroscopy of the LAB to confirm optical clarity. Chemical contaminates can increase light absorption in unwanted regions of the UV-Vis spectrum. For source cleaning, a sample of the LAB is taken before filling the SCV to compare after the cleaning is completed. We also compare to pre-measured LAB standards. **If no changes in the UV-Vis spectrum are observed, we determine there to be no chemical contaminates originating from the source.**



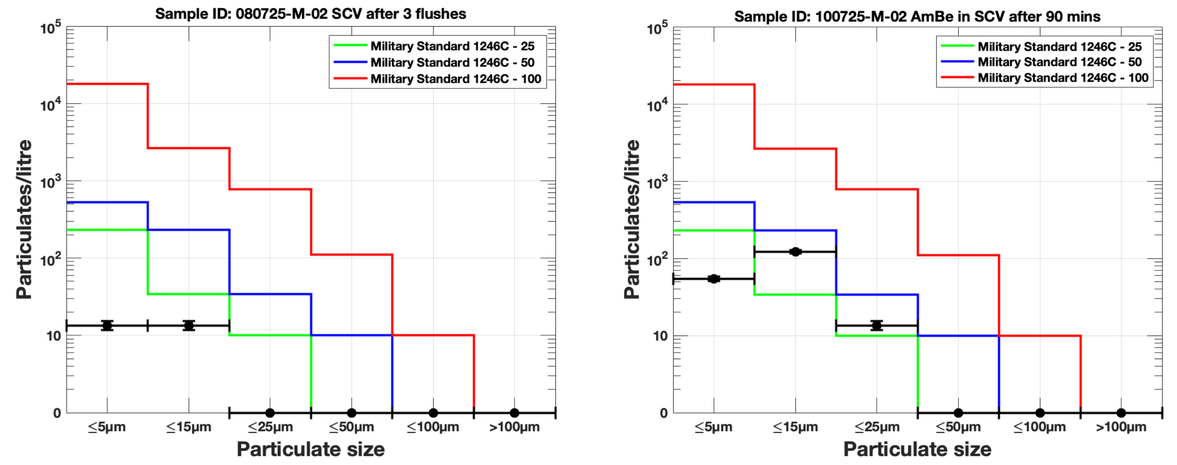
UV-Vis Spectra of samples, comparing starting LAB sample to LAB used to clean the AmBe source

Liquid Particle Counting

For source cleaning, we set a liquid particle count limit determined by Military Standard 1246C–50. This limits the allowable number of particles under certain sizes within a litre of liquid. This standard has also been used in the SNO+ scintillator plant. After recirculating LAB onto the source within the SCV, a passing sample must show particle counts under this limit.

The 500mL sample taken for LPC is brought to the SNOLAB surface lab for analysis. The sample is pulled through a 10μm filter paper, collecting the particles from the sample. The filter paper is then analyzed under a microscope with a 10x magnification connected to a computer for image capture. A random and non-overlapping set of photos of the filter paper is taken. This image set is run through a MATLAB analysis code to extract the particles from the background of the filter paper, then measured and counted.

If samples collected after source cleaning pass both UV-Vis Spectroscopy and Liquid Particle Counting, the source is determined to be at the cleanliness standard required to be deployed into the SNO+ AV.



Acknowledgement

This process was developed at the University of Alberta. This equipment was shipped from Edmonton to SNOLAB early 2024, where the system was recommissioned in the SNOLAB surface labs, then shipped to the SNOLAB underground facility. UofA commissioning lead by Ankit Gaur, underground commissioning and operations were then led by me. I would like to thank Ryan Bayes for his mentorship and hardware support, and the SNOLAB scientific support group for their help with sample analysis.

Ankit Gaur with the Source Cleaning Vessel in the SNOLAB surface labs