Scintillating Counter of Uranium and Thorium (SCOUT)

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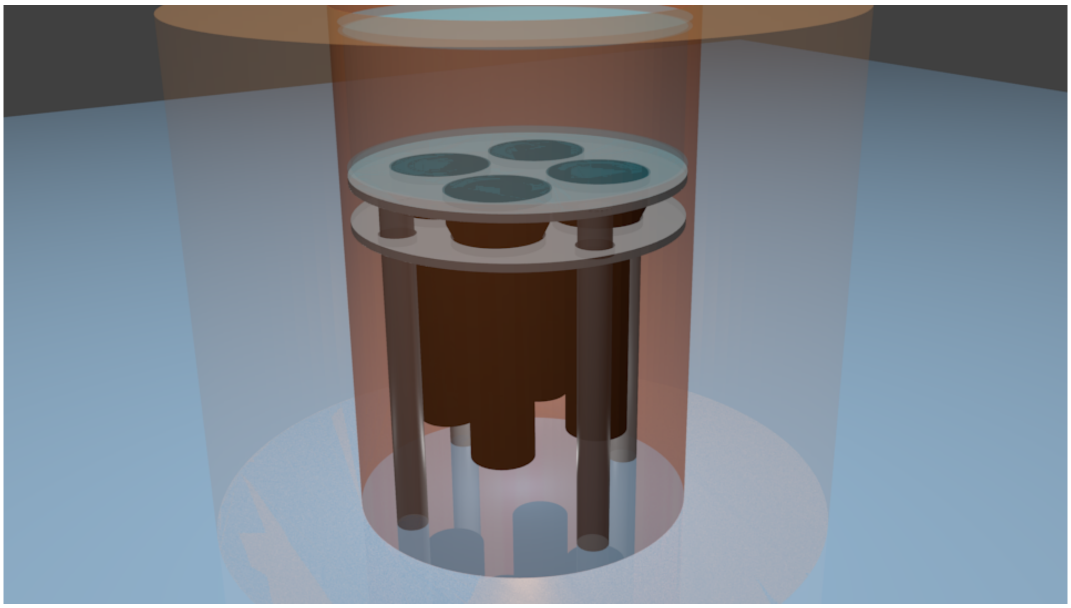
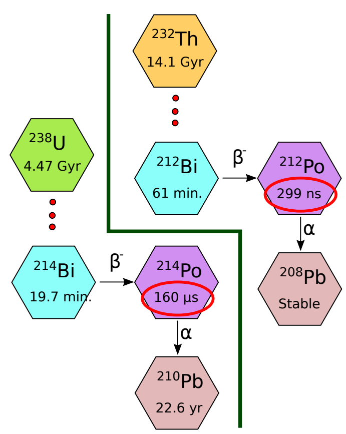


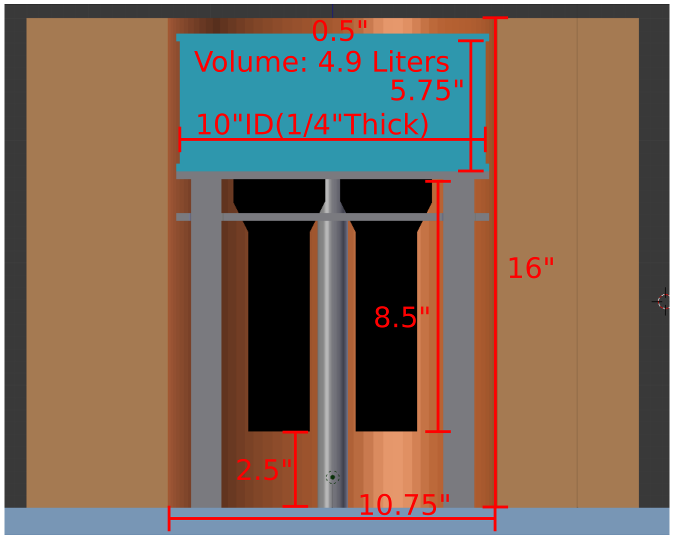
1 Introduction

Scout is an alpha beta coincidence counter designed to assess the radiopurity of the SNO+ liquid scintillator (Linear Alkylbenzene + 2 g/L 2,5 diphenyloxazole) that arrives at the surface transfer facility at Snolab. By counting the decays of $^{214}Bi \rightarrow^{214} Po \rightarrow^{210} Pb$ in the Uranium decay chain and $^{212}Bi \rightarrow^{212} Po \rightarrow^{208} Pb$ in the Thorium decay chain, the radiopurity can be determined. The expected sensitivity for each of these is of order 10^{-10} g/g for a 24 hour measurement.



2 Design

The design for Scout consists of a lead shield from a previous Germanium counter at UCDavis roughly 4.5" thick. The shield is copper lined on the inside. The inner vessel is made of acrylic with UV-Transparent acrylic used for the bottom portion which is coupled to the PMTs. The vessel holds roughly 5 liters of fluid in a short, but wide cylindrical volume. Room is left at the bottom for high voltage and signal cables to run from the voltage dividers out the hole in the bottom to the DAQ. Room is left at the top to accommodate quick-connect ports for gas and liquid exchange.



3 Data Acquisition

The four photomultipliers are powered by a desktop CAEN high voltage power supply. The supply has four channels, so the voltage can be individually adjusted for proper gain matching. The voltage dividers are negative with a BNC and SHV connector coming directly from them. The BNC will convert to LIMO and plug into the 16-channel SIS3316 250MHz ADC where only four channels will be used. The trigger scheme in software can either be set to sum the four channels or trigger on individual channels. There is not currently a way to require two channels to go above threshold, but this may be looked into in the future. The coincidence trigger will be done offline using timing and energy cuts.

4 Sensitivity

With the assumption that the LAB is clean to begin with, limtis will be set based on the background rates, detector volume, and live time. The coincidence window for Bi-Po will help to reject most single events except those that fall in the same random coincidence window. Based on the energy resolution of the final design, an energy cut can help to further reduce the background event rate. For a detector volume of about 5 liters, the sensitivity for a 1 hour run would be about 10^{-10} g/g for each isotope, with ^{238}U having a slightly better result due to the shorter half-life.

5 Procedure

1. Assuming we use 5 liters of LAB, measure out PPO at 2g/L (10 grams total) into the mixing vessel.
2. Seal the mixing vessel and connect the nitrogen supply line to the vessel.
3. Set the pressure just above atmosphere and open the fluid exit port slightly.
4. Close the fluid exit port, then turn off and disconnect the nitrogen supply.
5. Fill the mixing vessel with 5 liters of LAB, keeping track of the mass of LAB added on a scale.
6. Place the mixing vessel on the magnetic stirrer for 5 minutes (bar should be in there from the start).
7. While the PPO mixes, prepare the measurement vessel as follows.

8. Seal the vessel and connect the nitrogen supply line.
9. Turn off and disconnect the nitrogen supply. This time keep both hoses attached and filled with nitrogen.
10. Quick-connect the hoses to the exchange vessel, then open all valves.
11. Tilt the vessel in such a way that fluid flows freely through the fluid port, and gas flows freely through the gas port.
12. Close and disconnect the fluid and gas lines.
13. Begin data acquisition (procedure to be written).
14. Once DAQ is finished, connect fluid hose to the drain port of the measurement vessel
15. Open both gas ports to the atmosphere and drain the vessel.
16. Close and disconnect all hoses.
17. Empty the mixing vessel into the waste drum.
18. Clean the hoses and mixing vessel.
19. [It may be possible to clean the AV by filling and rinsing with UPW or LAB]

6 Component List

- 1 metric tonne lead shield on Stand: 2'x2'x5' tall
- Waste drum (55 Gallon)
- Acrylic Measurement Vessel (5 liters)
- Acrylic mobile mixing vessel
- Fluid transfer hose with hand valves on both ends
- Gas transfer hose with hand valves on both ends
- 4x3" Photomultipliers
- Desktop High Voltage Supply (Caen)
- VME Crate
- VME Waveform Digitizer (sis3316 ADC)
- VME USB interface (sis3150)
- Intel NUC for data recording
- External backup storage
- Magnetic Stirrer
- Chemical Spill Kit
- Tubing to connect