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Towards the Liquid Scintillator Phase of SNO+

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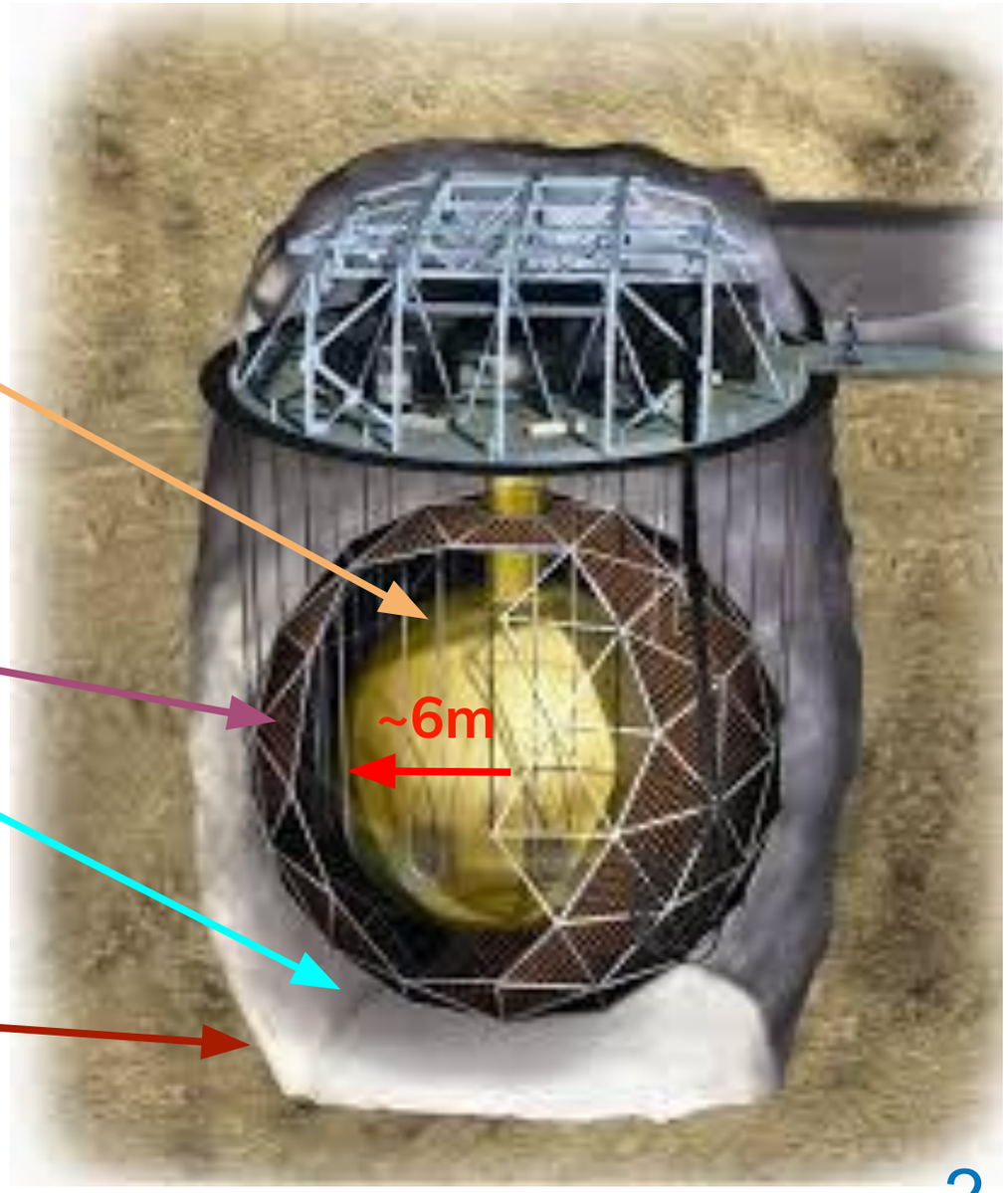
SNOLAB's Summer Student Talk Competition 2019 Delegate

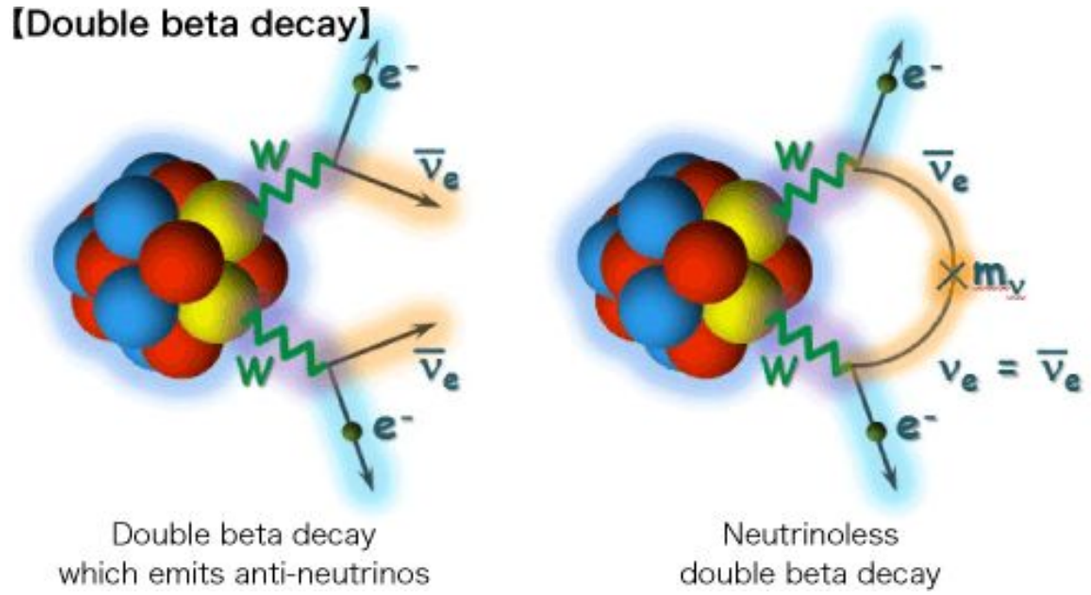
Brief Introduction to SNO+

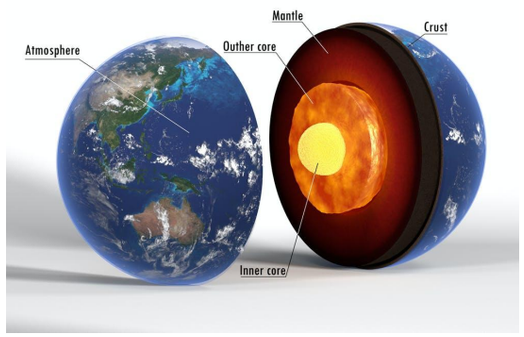
- Located ~2 km underground in Vale's Creighton Mine, Sudbury ON
- Acrylic Vessel (AV) has a thickness of 5 cm, radius of ~6 m, and volume of ~900 m^3
- Surrounded by ~9300 PMTs, giving 54% coverage
- ~7000t ultra pure water (UPW) for shielding
- Urylon liner for radon seal and waterproofing the norite rock cavity

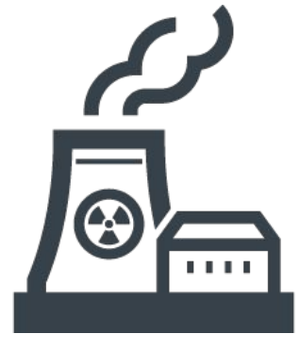


Brief Outline of Physics Goals

- Neutrinoless double beta decay
- Low energy solar neutrinos
- Reactor antineutrinos and geo-antineutrinos
- Supernova neutrinos
- Nucleon decay in UPW

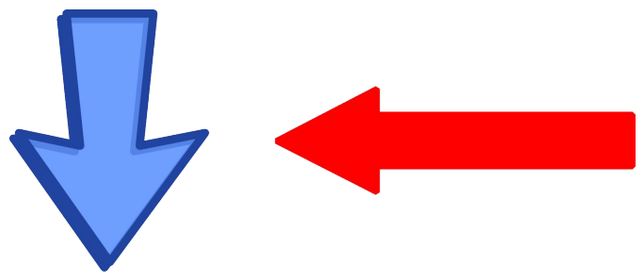






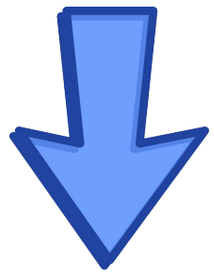
Overview of SNO+ Phases

Ultra-pure water phase



We are here!

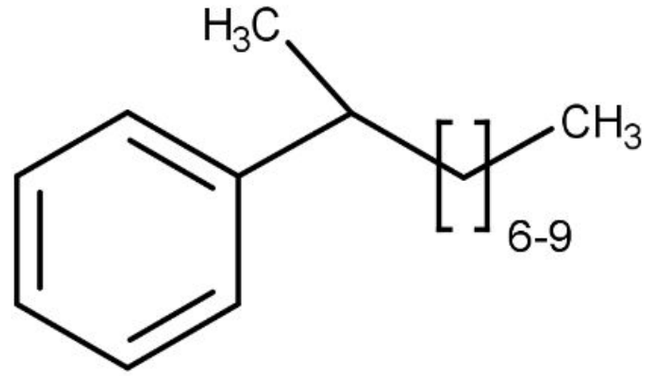
Liquid scintillator phase

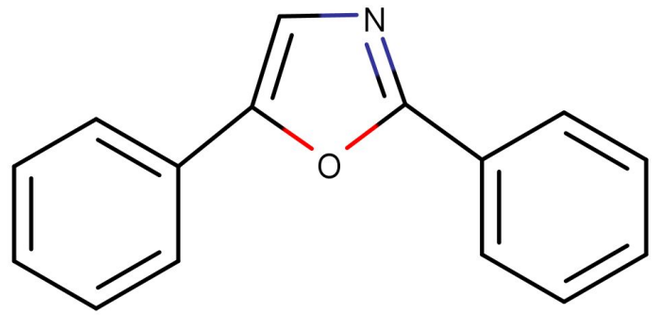


Tellurium-130 loaded,
liquid scintillator phase

Scintillator Details

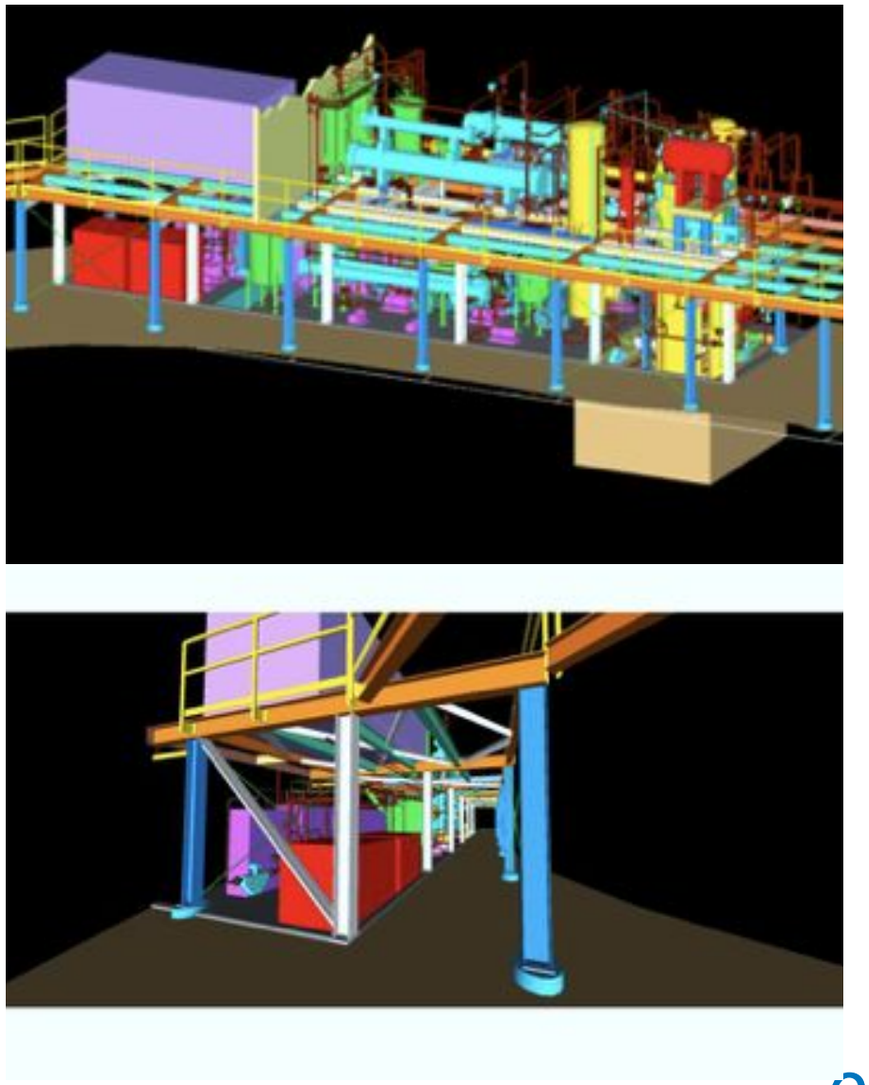
- Linear alkylbenzene (LAB) loaded with 2,5-diphenyloxazole (PPO)
- 0.852 g/cm^3 @ 12℃
- Target PPO concentration of 2 g/L
- PPO shifts photon wavelength to minimize scintillator self-absorption and better match the quantum efficiency of the PMTs





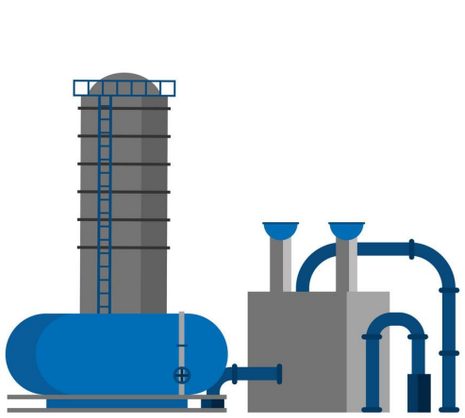
Scintillator Details Continued

- Extensive purification process including multi-stage distillation to ensure purity
- Turbidity, density, and optical/UV-absorption are primary tests of the scintillator quality

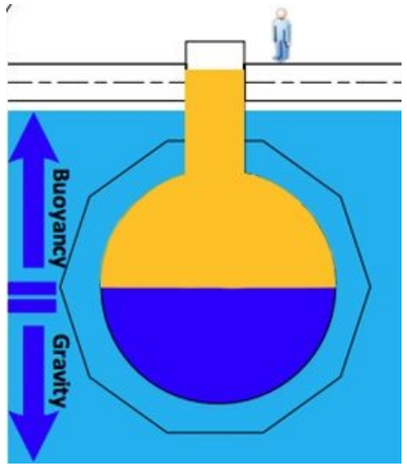


Simplified Flowchart of Scintillator Fill Process

LAB delivered from manufacturer facility to SNOLAB surface, then is transferred underground

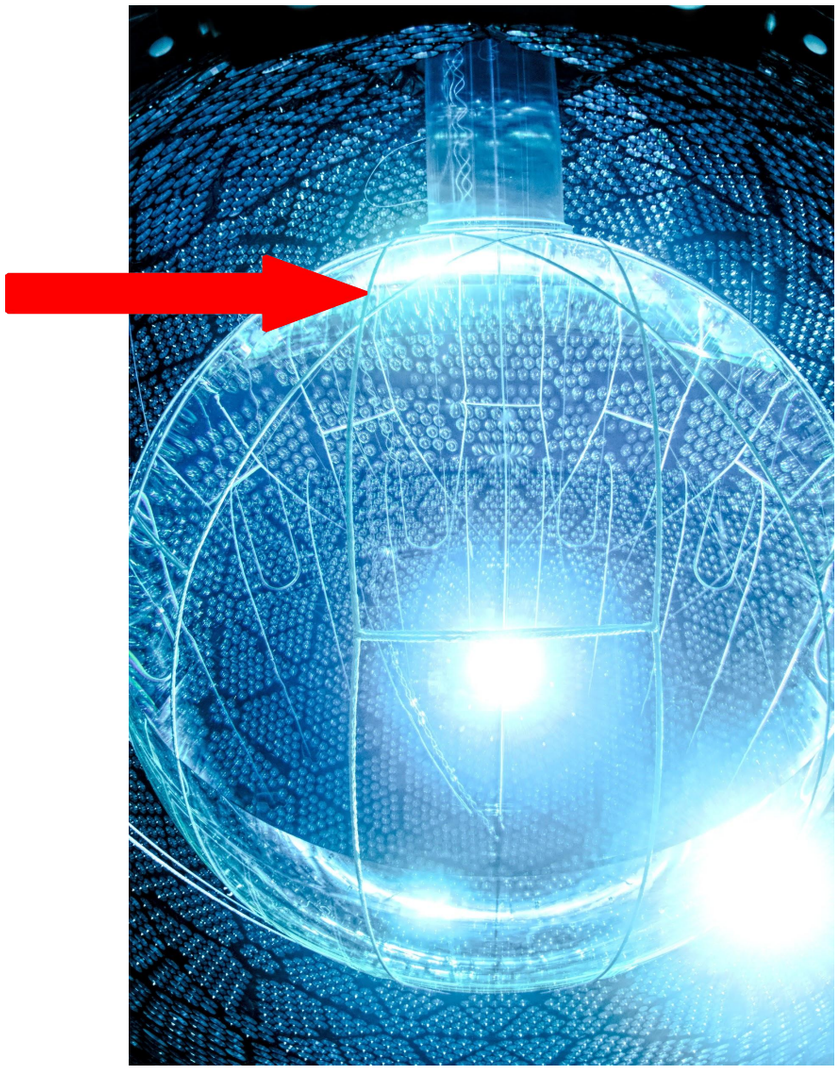


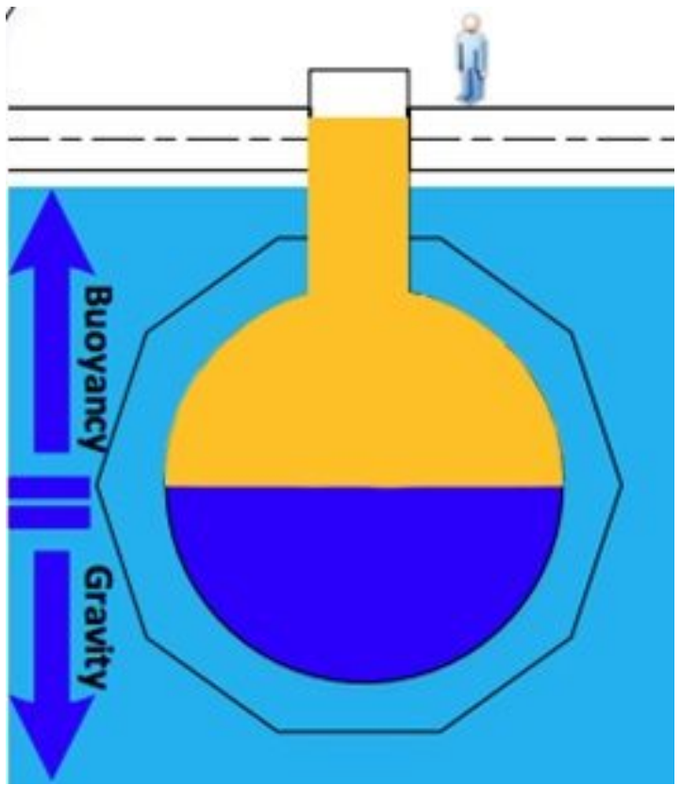
Extensive purification process conducted in underground facility



Removal of UPW from detector and equivalent volume of scintillator added. Continuous monitoring of backgrounds/impurities

Acrylic Vessel Considerations



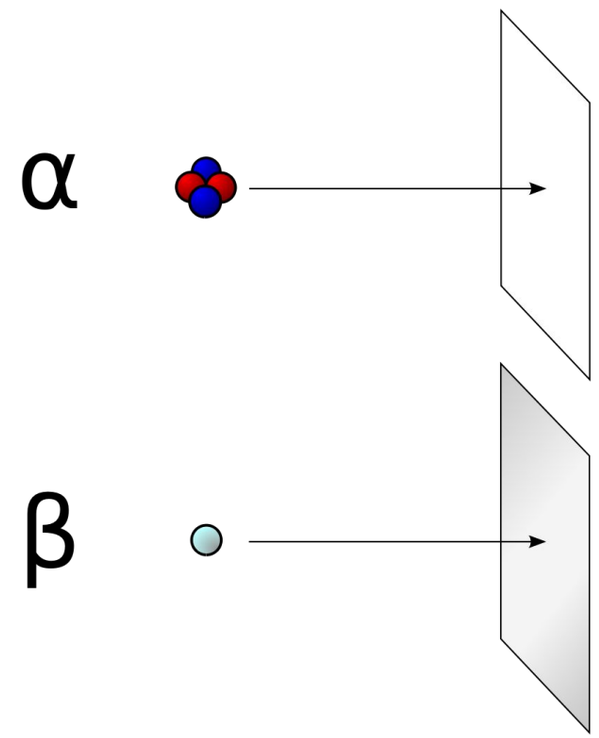


Current Status of Scintillator Fill Phase

- Currently ~365t of scintillator in the AV
- The water/scintillator interface is roughly +0.75 m above AV equator
- PPO concentration is currently 0.52 g/L
- Half way through physically filling the AV!
- This milestone is good opportunity to evaluate backgrounds

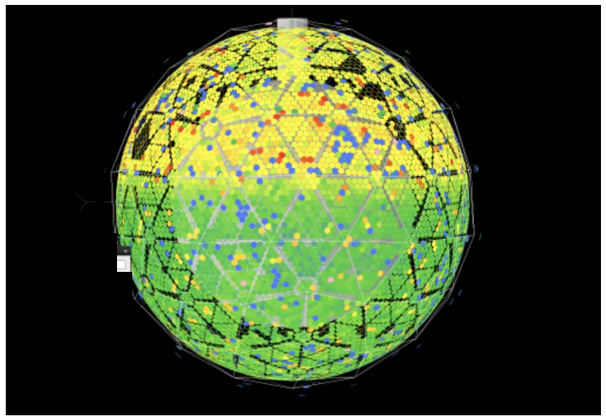
Considerations of the Scintillator Fill Phase

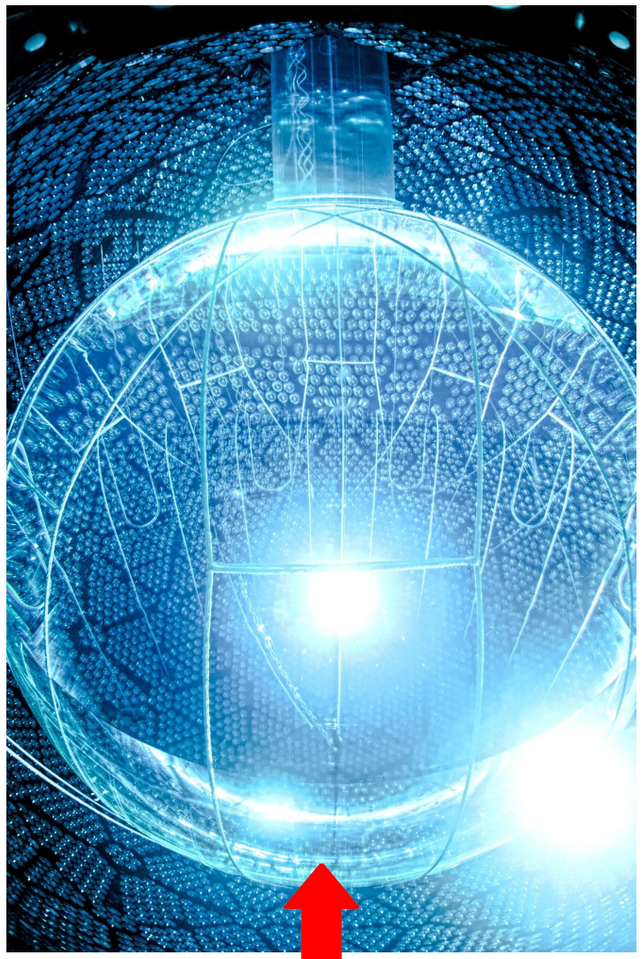
- **Height of the interface between the UPW and LAB**
- Continuing to monitor any impurities/backgrounds in the AV's scintillator
- **Opportunity to develop and test alpha/beta discrimination software**



Water/Scintillator Interface Height Methods

- **Volumetric calculations**
- **Bubblers (using pairs of lines to measure relative liquid level)**
- PSUP Cameras
- PMT Hits





Bubblers

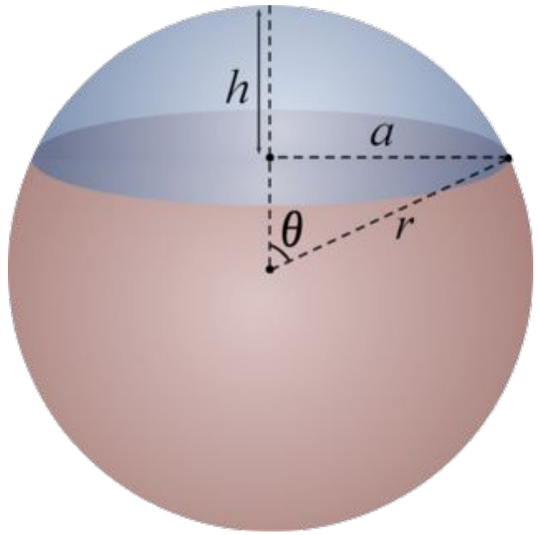
Bubbler/Volumetric Interface Height

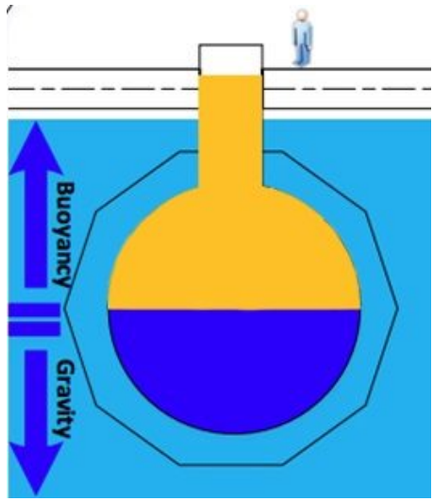
Volumetric:

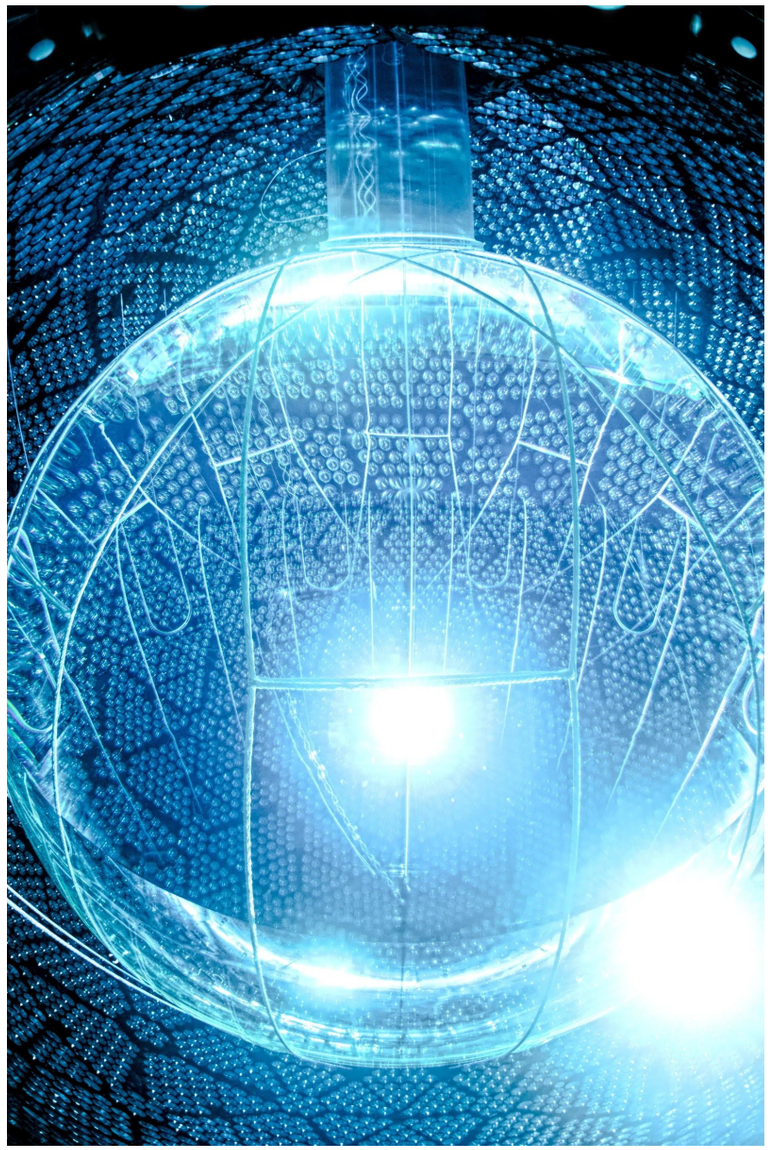
- Based on flow-transmitters
- Makes use of total mass of scintillator added

Bubblers:

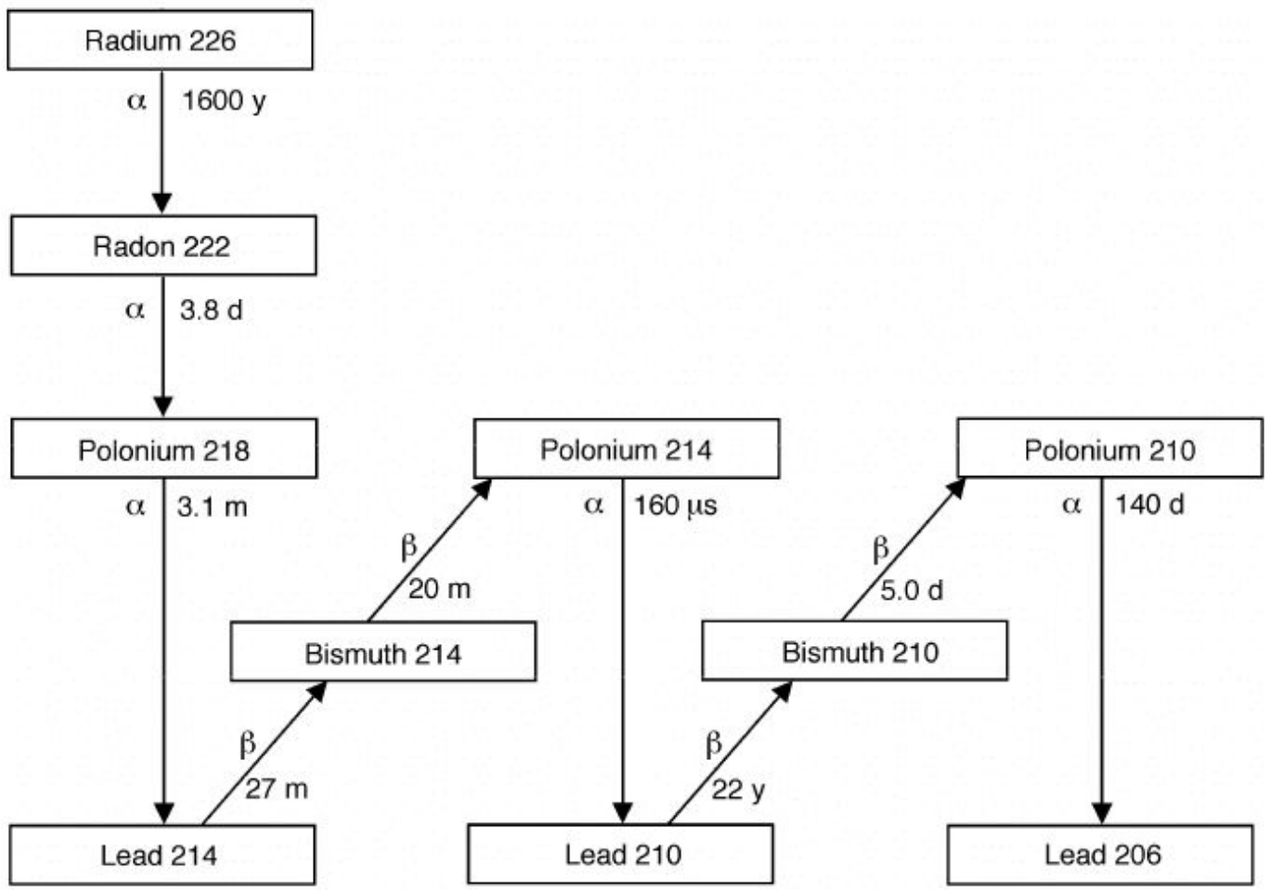
- Relies on detected pressures exerted from column of liquid in the AV







Alpha/Beta Discrimination in Partial Fill



https://www.researchgate.net/figure/The-Basic-Radon-222-Rn-Decay-Chain-The-isotopes-and-their-atomic-masses-are-shown_fig1_51026112

- Alpha and beta events appear statistically similar in terms of the intensity of their signals overtime
- Alpha events present from internal backgrounds

Alpha/Beta Discrimination Development

- In need of a method to reject alpha events with minimum misclassification
- Considering Gatti's weighted average approach for alpha/beta discrimination

$$P_i = \frac{(\overline{\alpha_i} - \overline{\beta_i})}{(\overline{\alpha_i} + \overline{\beta_i})}$$

$$G = \sum_i P_i S_i$$

Pulse-Shape discrimination with the Counting Test Facility, G. Ranucci

Summary

- Nearly halfway through scintillator fill phase
- The underground scintillator purification process is crucial to the reduction of background and the success of the experiment
- Currently analyzing the scintillator's internal backgrounds and improving the understanding of the detector's behaviour with LAB and PPO