**Introduction**

SNOLAB is an international particle astrophysics laboratory located 6800ft below the surface in Creighton Mine in Sudbury, Ontario Canada. The laboratory is a class 2000 clean-lab, meaning there are less than 2000 particles per cubic feet that are greater than 0.5 μm in size.

**Why go to such great lengths?**

The 2km thick layer of rock helps to block millions of muons coming from the sun and cosmos. The combination of rock shielding and ultra-low background environment in SNOLAB helps to reduce background particle noise and allows for the existence of extremely sensitive detectors.

**SNO+**

SNO+ is one of the detectors located in SNOLAB. The detector is the largest in SNOLAB. It’s 6m acrylic vessel and 9m stainless steel structure (PSUP) supports ~9800 photomultiplier tubes (PMTs) located in an ~85ft by ~72ft cavern. The low background environment of SNOLAB and the size of the SNO+ detector makes it extremely sensitive.

It is the successor of the SNO experiment whose contributions won the 2015 Nobel Physics prize for demonstrating that neutrinos have mass. SNO+ hopes to continue to contribute significantly to neutrino physics.

**Physics goals and Phases of SNO+**

- Neutrinoless double beta decay (0νββ)
- Geo- and Reactor Antineutrinos
- Solar neutrinos
- Supernova neutrinos
- Nucleon Decay

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**AmBe Source and Reactor Antineutrino**

In order to measure the reactor antineutrinos the detector must be calibrated to make accurate measurements and estimate how many antineutrino signals are detected and where they occur.

The Americium-Beryllium (AmBe) neutron source was selected to mimic the antineutrino signal. The AmBe source was deployed in 23 different positions in the detector over a 3 day period.

**Analysis Goals:**
- Measure Neutron Capture Efficiency and Capture Time
- Calibrate energy and position reconstruction (future work)

**AmBe Signal**

**Primary Signal**

Initial neutron from AmBe scatters off a hydrogen atom which produces a 4.4 MeV gamma.

**Secondary Signal**

Neutron is then captured in the UPW which produces a secondary 2.2 MeV gamma.

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**Identifying AmBe events**

We use two quantities to identify and tag AmBe events

1. Nhit Cut
   - Number of PMTs hit in the detector
   - Related to the energy
2. Time Window Cut (Δt)
   - Time after the prompt event in which we look for a candidate delayed event.

Events are iterated through. When an event passes the prompt nhit cut, events within a coincident time period are investigated for potential candidate delayed events.

**Neutron Capture Efficiency and Capture Time**

- **True-True**
  - Prompt event is the 4.4 MeV γ
  - Delayed event is the 2.2 MeV γ

- **Fake-Fake**
  - Prompt event is background
  - Delayed event is background

- **True-Fake**
  - Prompt event is the 4.4 MeV γ
  - Delayed event is background

Using the fit function to solve for the neutron capture time (Δt) and efficiency (P · E). We can plot the values over all runs.

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**Neutron Capture Efficiency and Capture Time**

- **Neutron Capture Time**
- **Neutron Capture Efficiency**
- **Rate of candidate prompt events**
- **Rate of candidate delayed events**