AmBe Source Calibration in SNO+ Water Phase

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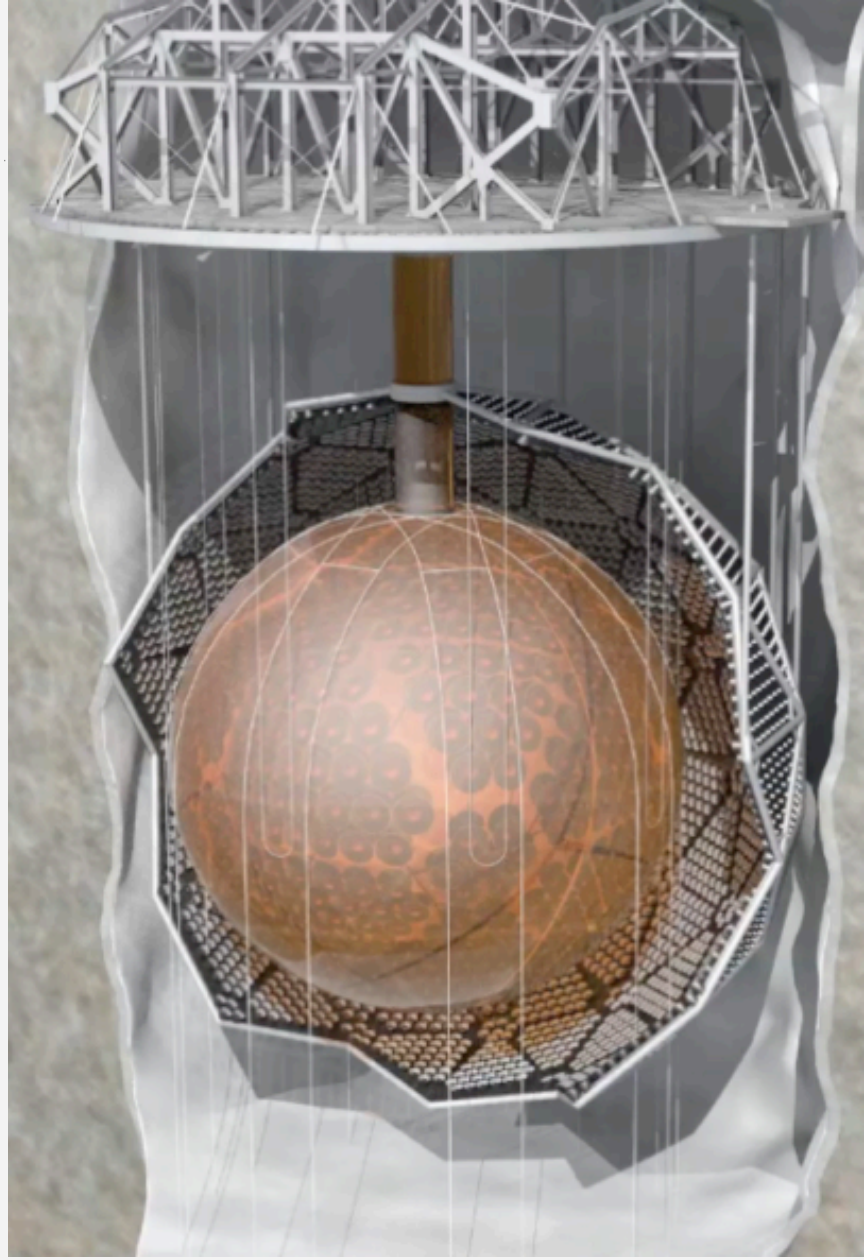
Queen's UNIVERSITY

Overview

- SNO+ detector & its water phase
- Calibration hardware
- AmBe source calibration
  - Physics motivation(s)
  - Calibration progress
- First look at the calibration data

SNO+ water phase

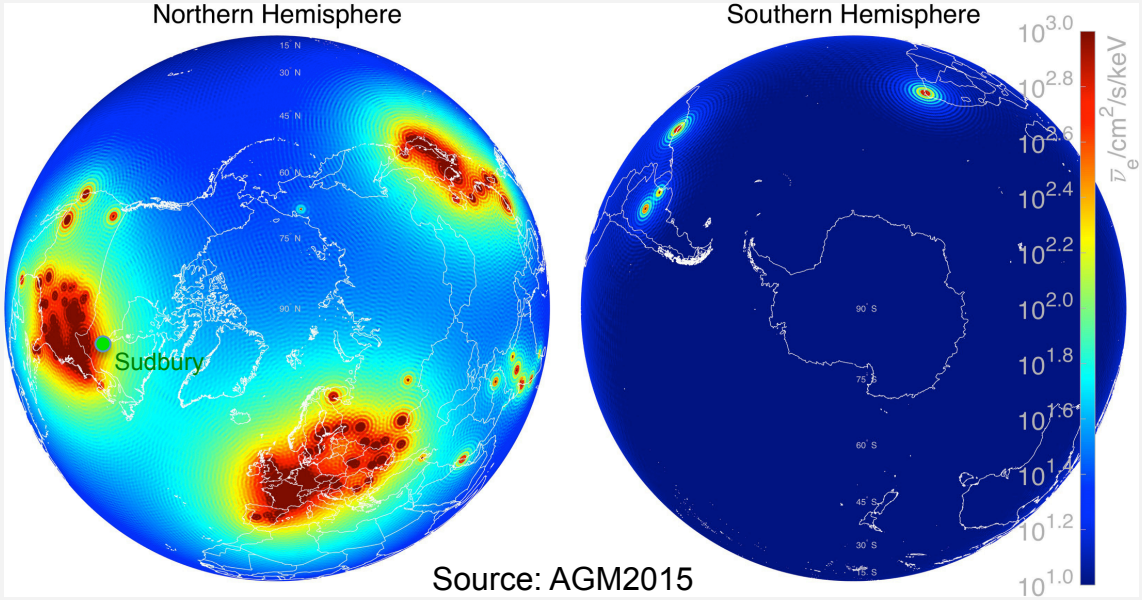
- Started May 4th, 2017.
- Background analysis and various performance tests in preparation for the Liquid Scintillator phase.
- Physics topics including invisible nucleon decay and reactor antineutrinos are being explored.



Invisible nucleon decay

- Invisible nucleon decay as a channel where baryon number violation occurs was predicted by some Grand Unified Theories (GUT) to explain the matter-antimatter asymmetry of the universe.
- One example: n->ννν (in a nucleus)
- No visible energy deposited via the nucleon decay itself, while the remaining nucleus is left in an excited state.
- In SNO+: $^{16}O \rightarrow ^{15}O^{*} + \nu\nu\nu$, $^{15}*O \rightarrow ^{15}O + \gamma$ (~6 MeV)
- Expect to surpass the current best limit with 3 months worth of data, thanks to the ultra-low background in SNO+.

Reactor antineutrino search



$$\bar{\nu}_e + p \longrightarrow n + e^+$$

Inverse beta decay

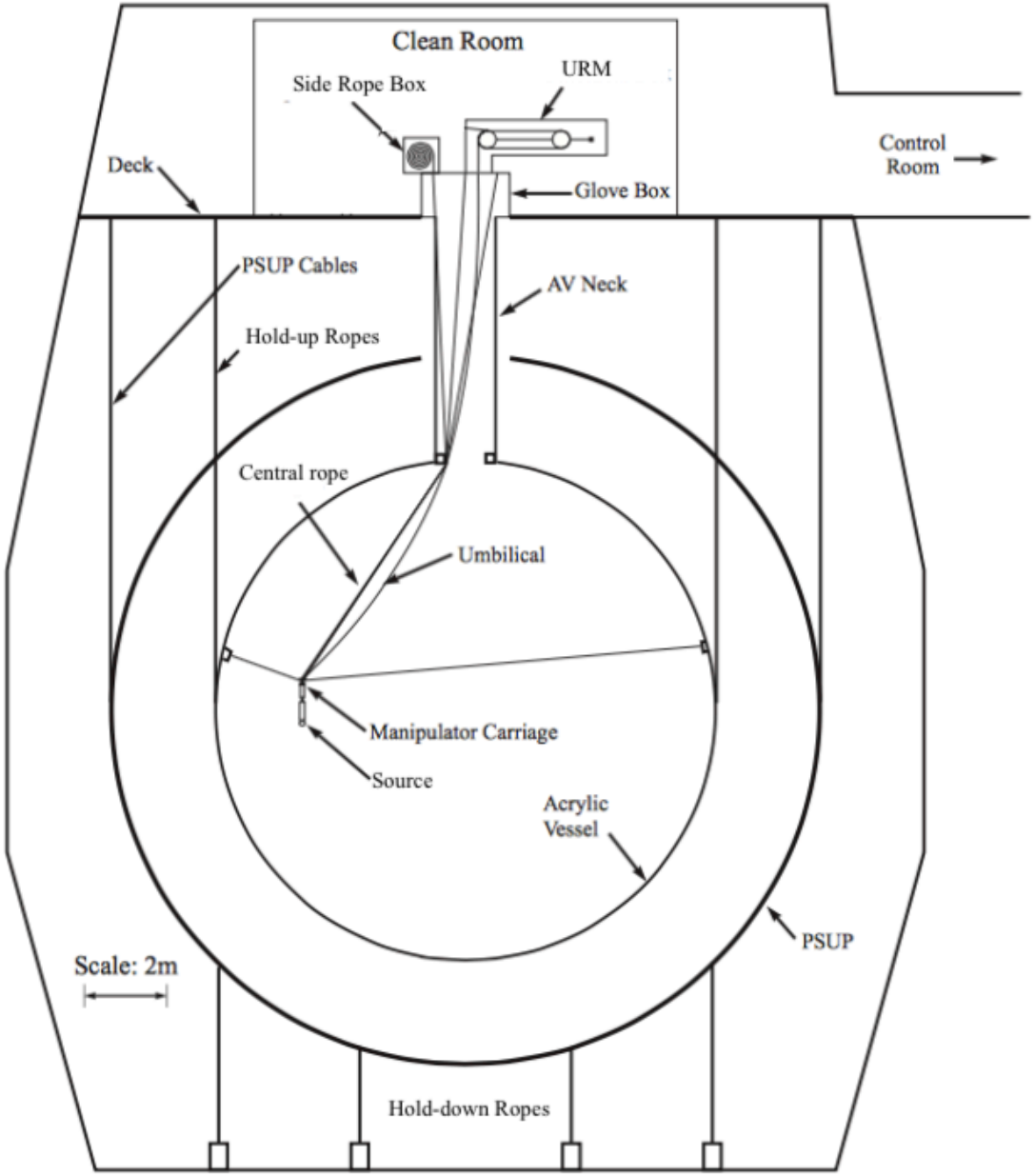
- Positron signal: Cherenkov radiation from positron & Compton scattering -> gammas with corresponding energy
- Delayed signal: neutron captured on protons -> 2.2 MeV gammas

Position and time coincidences

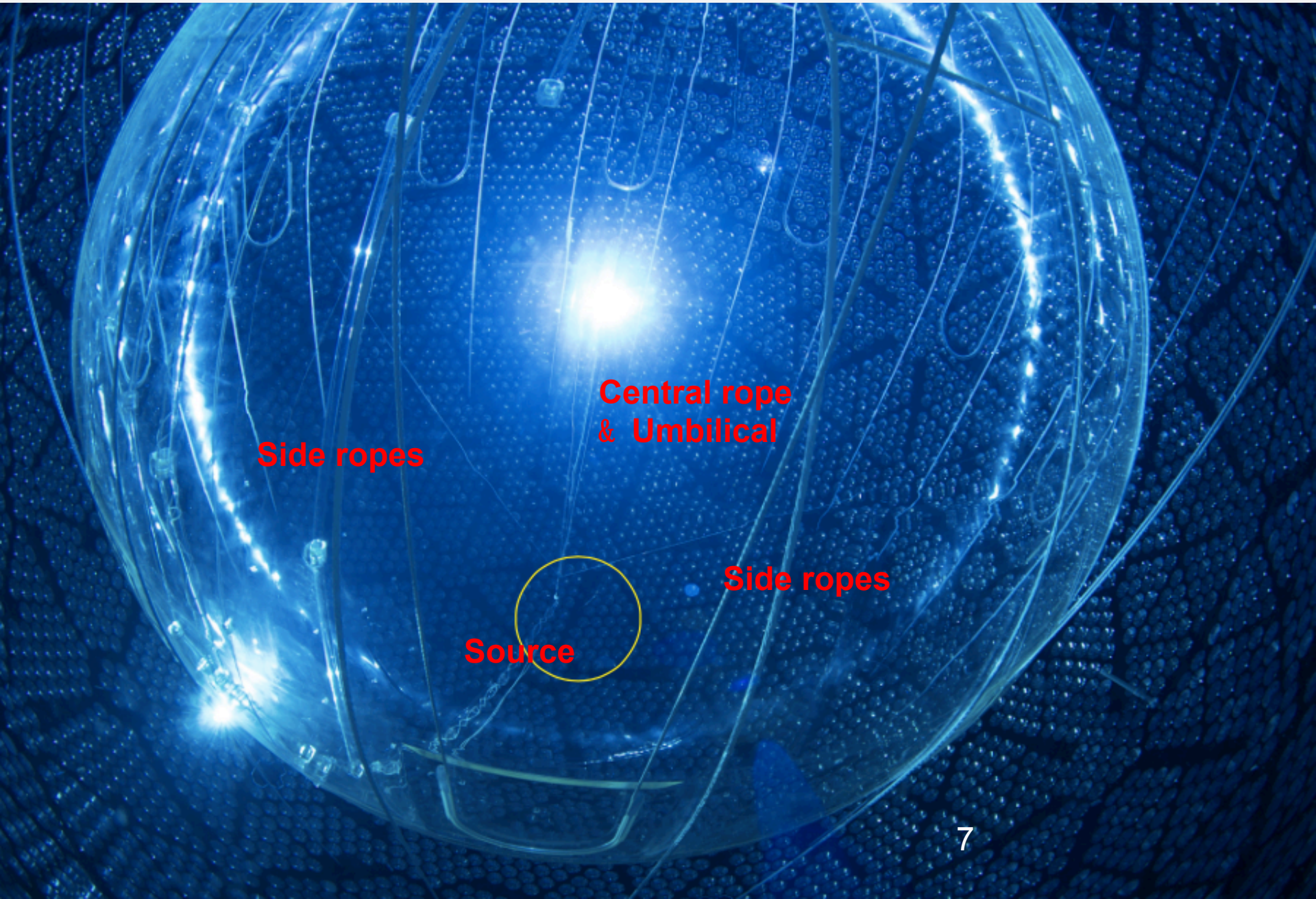
Accidental Background rejection factor > 10^6

SNO+ Calibration system

- URM: Umbilical Retrieval Mechanism which controls the central rope and the umbilical.
- Four Side Rope Boxes enable source deployment in three axes mode.
- All ropes operate in tension range 3 – 120 N.



Source deployment



AmBe source calibration:

$$\alpha + {}^{9}Be \longrightarrow {}^{12}C + n(\sim 40\%),$$

$$\alpha + {}^{9}Be \longrightarrow {}^{12}C^{*} + n(\sim 60\%),$$

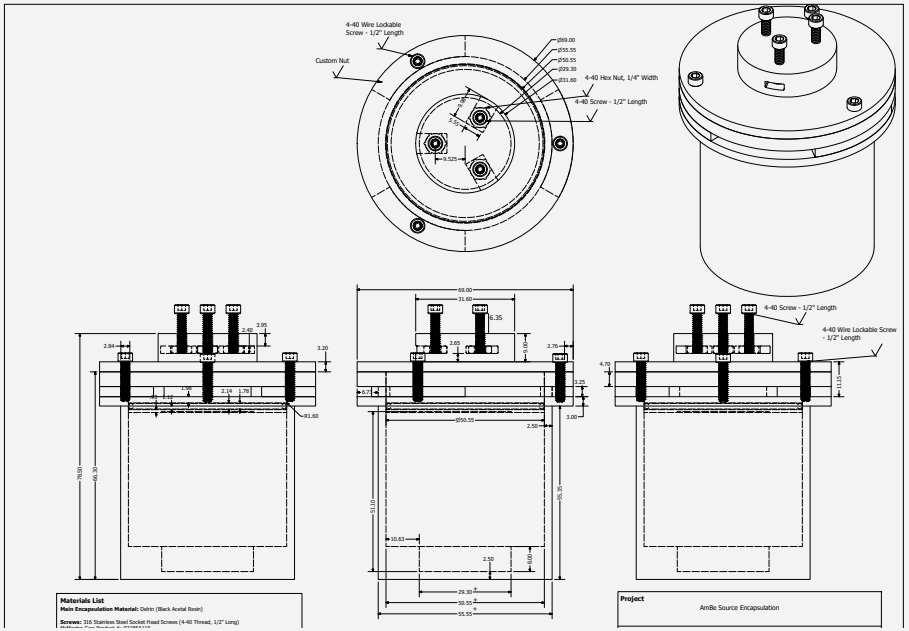
$${}^{12}C^{*} \longrightarrow {}^{12}C + \gamma(4.4MeV).$$

Good Cherenkov light yield enables seeing this low energy!

- Prompt signal: 4.4 MeV gammas
- Delayed signal: neutron captured on protons: 2.2 MeV gammas
  - Mimics antineutrino signals
- Provide another two energy calibration points (4.4 MeV, 2.2 MeV) along with 6.1 MeV from ^{16}N source calibration.
  - Check energy linearity
  - Help background analysis (Bi/Tl)

AmBe source calibration: Source preparation

- The old SNO AmBe source was identified at SNOLAB
- A new encapsulation needed for cleanliness of the detector
  - Design & fabrication
  - Leak test & bubble test
  - Detailed cleaning procedure



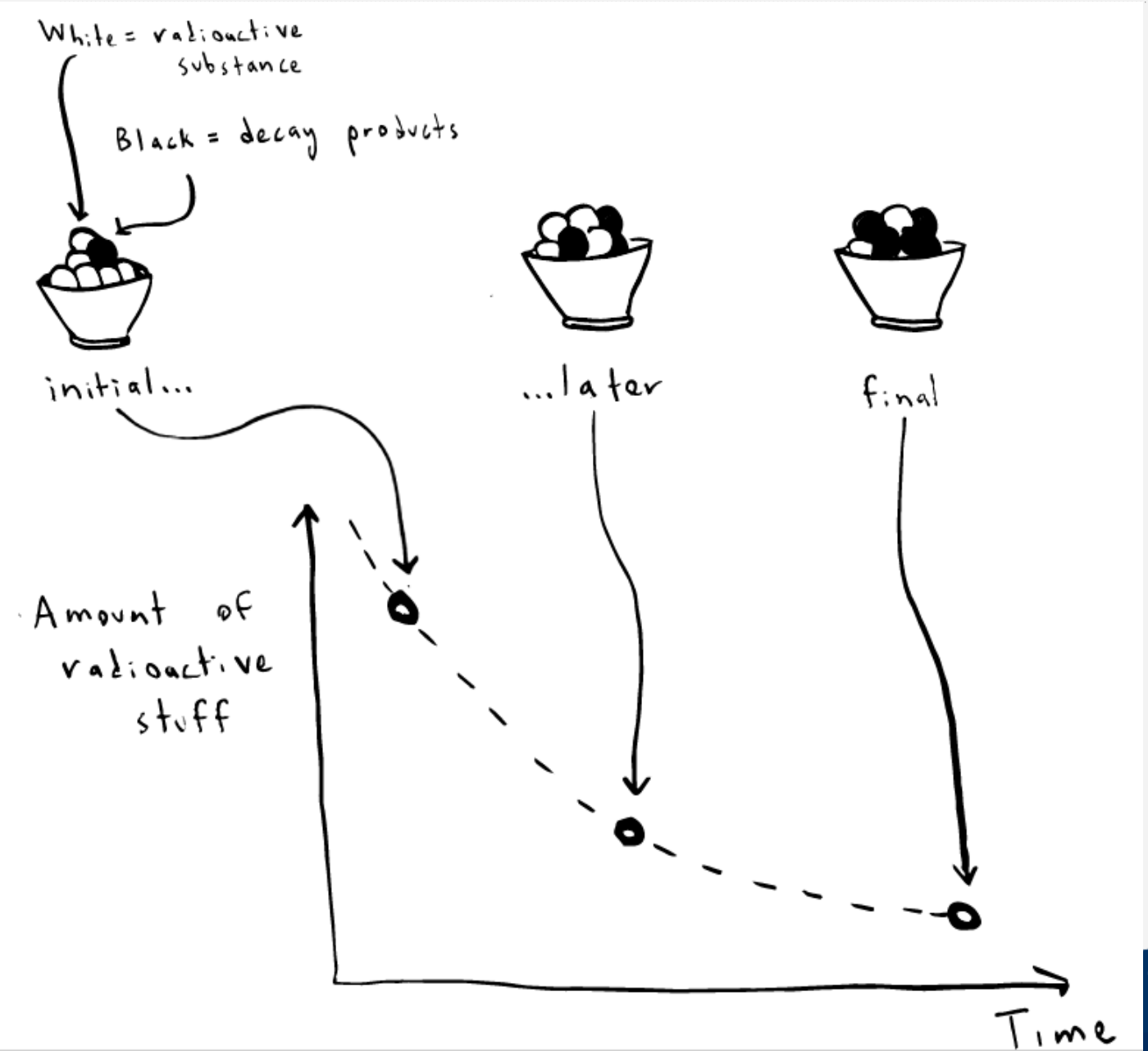
AmBe source calibration: Source deployment

- Source deployed on Jan. 19th, 2018.

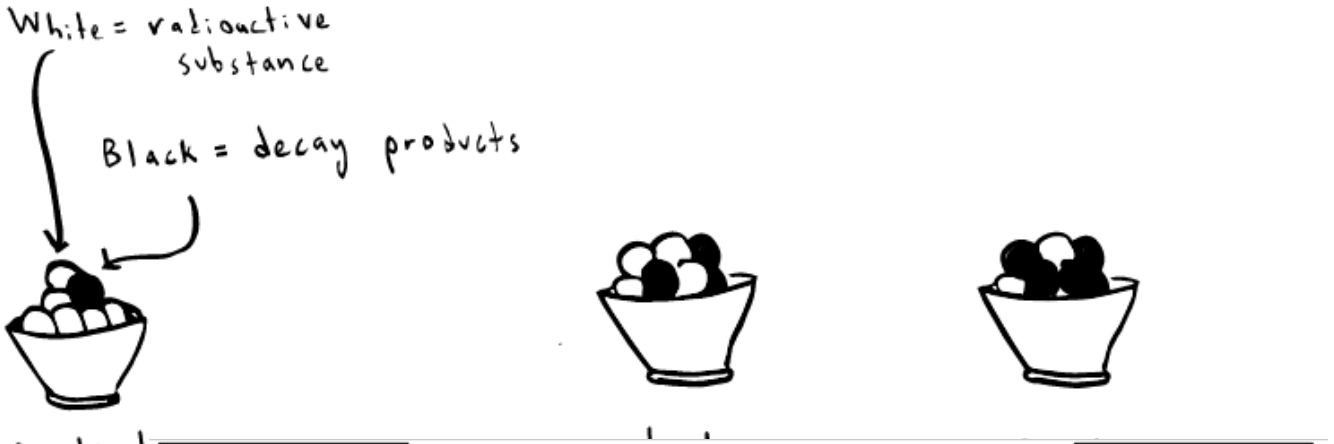
AmBe source calibration: Source deployment

- 15 hrs of calibration data was taken at various locations of the detector.
- Detailed inspection after source retrieval showed no sign of leakage.

First look at AmBe calibration data



First look at AmBe calibration data



initial

Amoun
radio
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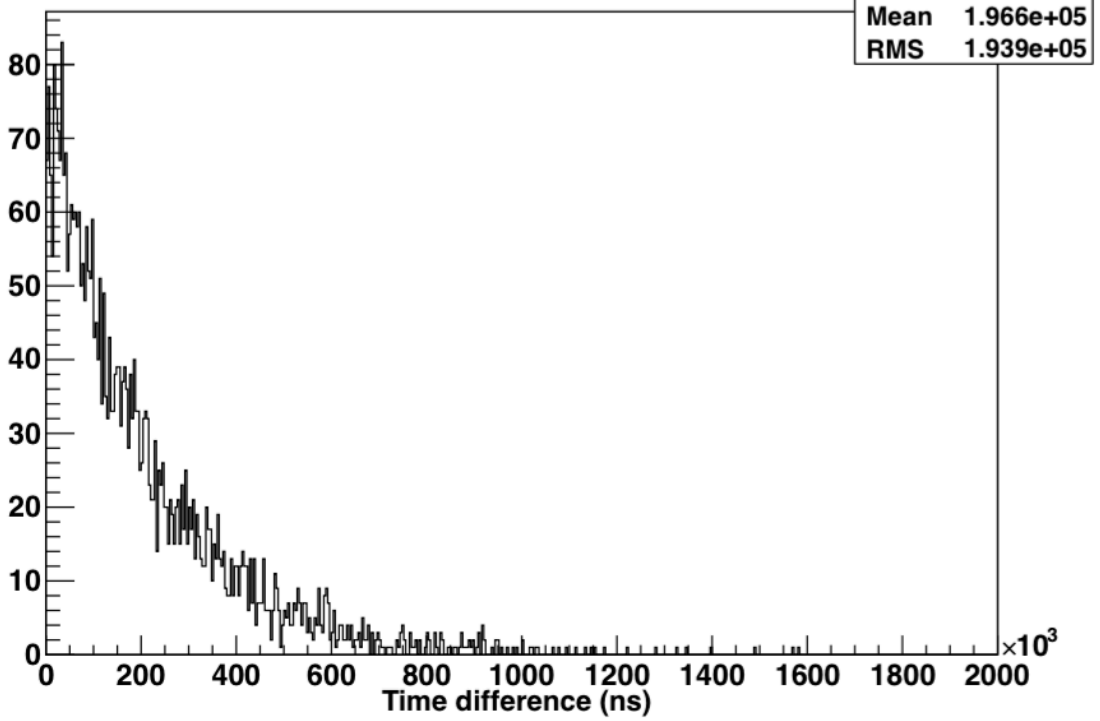
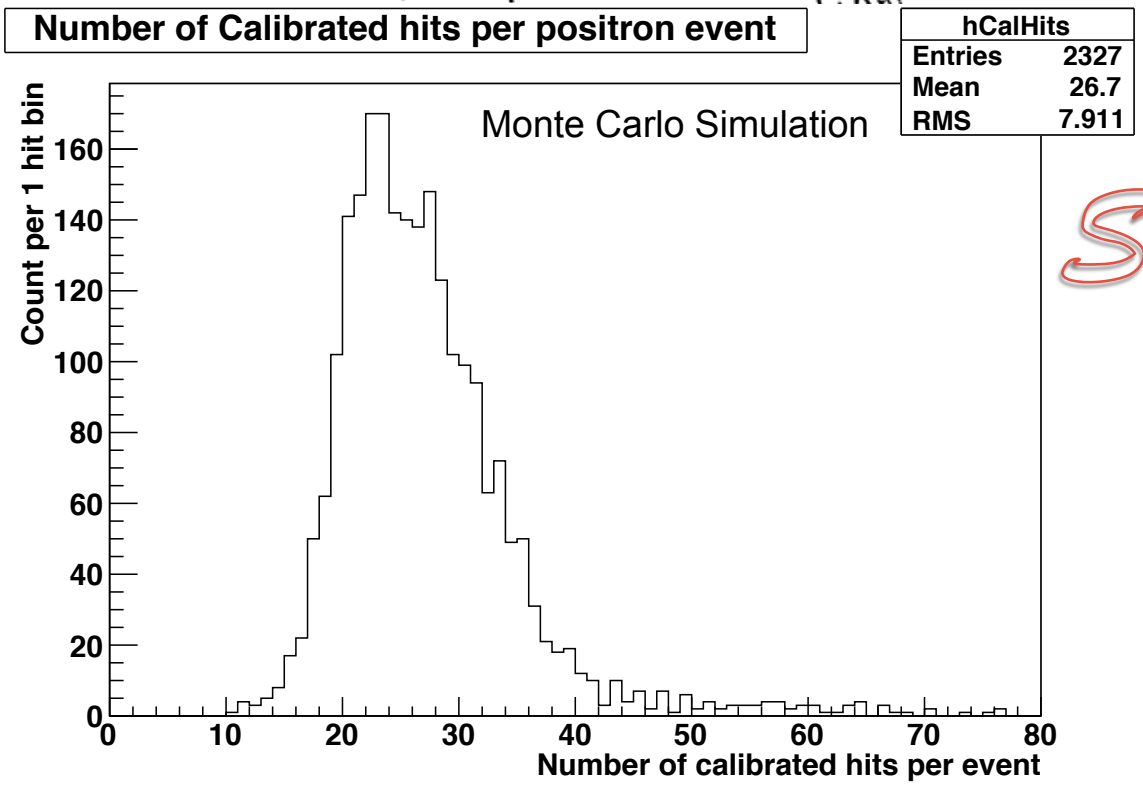
time difference

Monte Carlo Simulation



time

First look at AmBe calibration data



Amount radioac stu

Stay tuned!

Thanks!