SuperCDMS SNOLAB

Materials and Assay

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Pacific Northwest
NATIONAL LABORATORY
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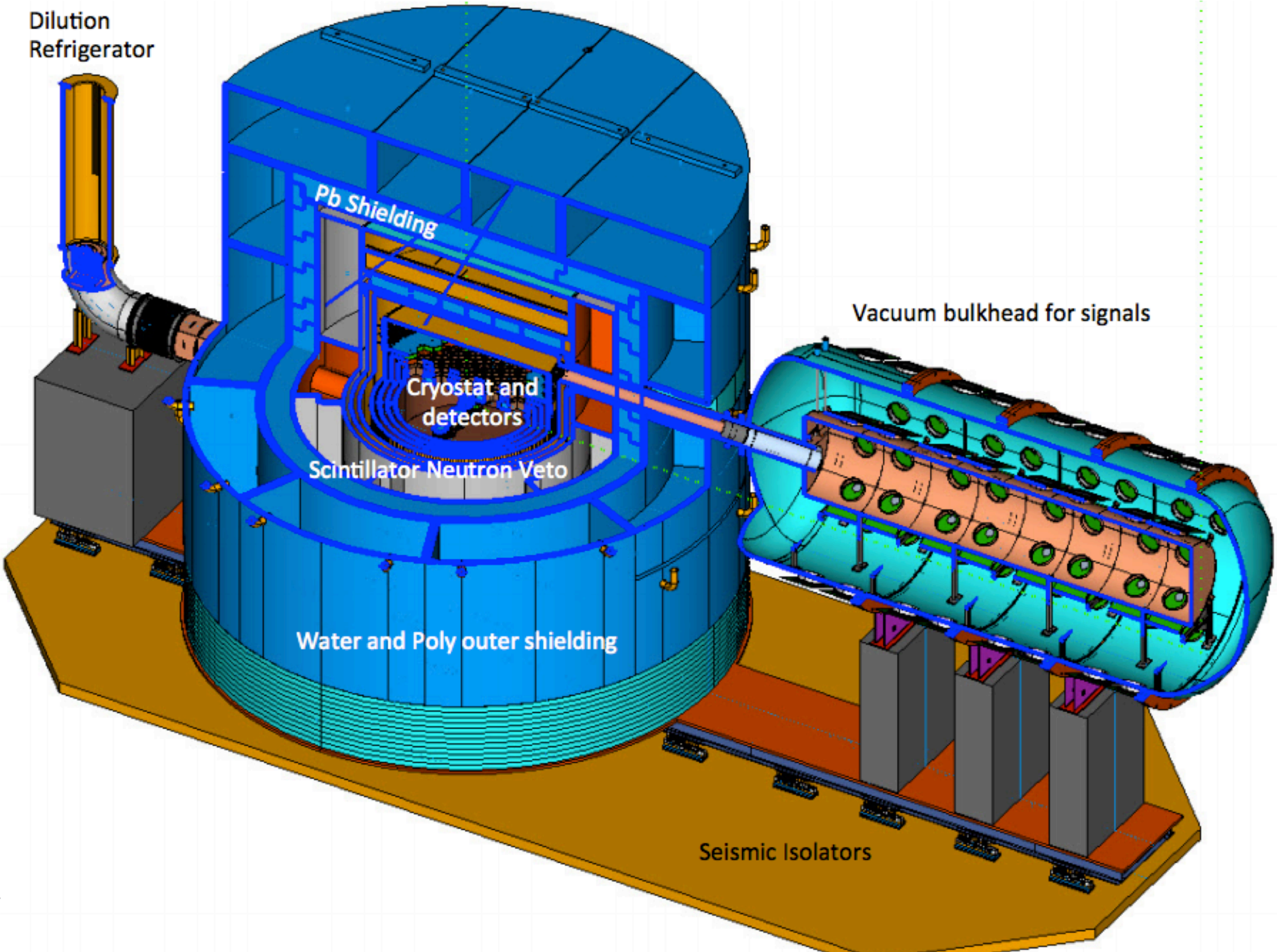
SuperCDMS SNOLAB

- Proposed detector at SNOLAB based on the mature CDMS technology
- 200 kg array of cryogenic germanium and silicon bolometers (iZIPs)
- Aiming for <1 event in 4 years
- Backgrounds are reduced through
  - Enhanced position resolution (fiducialization)
  - Nuclear/electronic recoil separation
  - Neutron veto
  - Deeper location
  - **Lower backgrounds through materials selection and assay**
    - Lower intrinsic background rates are a cornerstone of the proposal to move to SNOLAB

Apparatus Overview



Detectors

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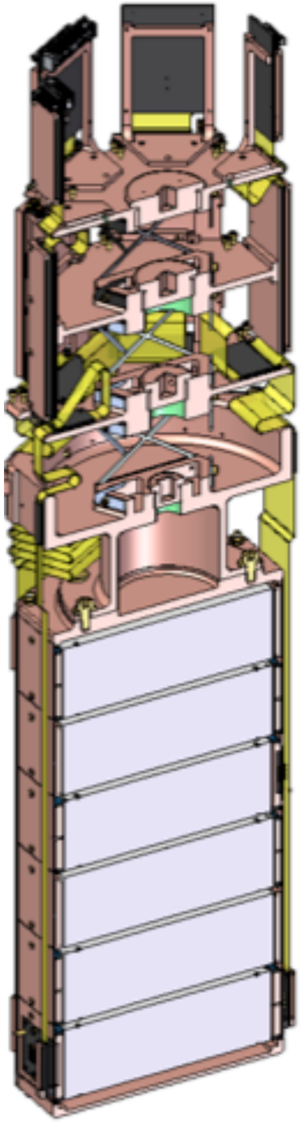
- Detectors are kept in a radon purged/reduced environment and any exposure is tracked
  - No direct assay of residual ^{210}Pb planned
  - SuperCDMS Soudan experience shows we can achieve our radon exposure goals

- Don’t forget about cosmic ray activation of the detectors
- Not as important if using the nuclear/electronic recoil separation
- Much of the germanium activation is relatively short-lived and monochromatic
  - ^{3}H is probably the limiting intrinsic, cosmogenic isotope
- Silicon will include trace ^{32}Si from cosmic ray spallation in the atmosphere
  - Difficult to measure, although has been proposed for age dating so there is active research in developing the methods

Electronics and Cold Hardware



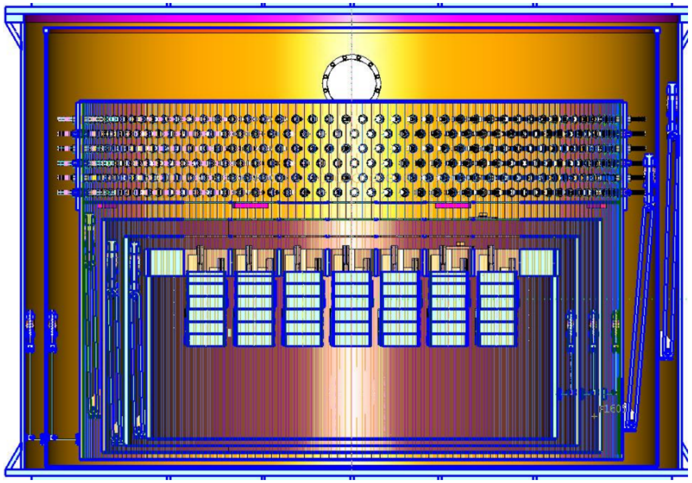
- Detectors are close packed in stacks, or towers, to limit direct shine from copper detector holders
- Custom flex cable carries detector signals to the top of the tower
- The front end amplification is done at the top of the towers using cryogenic SQUID and HEMT amplifiers
- Cabling then exits the shielding

Electronics and Cold Hardware Background Tally

- Gopher HPGe detector at Soudan has been the workhorse for qualifying materials for the tower design
- Cabling connectors at the top of the towers appears problematic
  - Working with vendors to identify clean thermoplastics for their processes
- Also concerned about the critical components that cannot be changed
  - Only 1 SQUID vendor, 1 HEMT vendor and we currently have access to only a few pieces
  - In process of using ICP-MS to assay for U, Th
  - These devices are critical so we will have to design around any intrinsic radioactivity
    - However, these are fabricated in ultra-clean nano-fabrication facilities and the masses are extremely small, so we are hopeful
  - Ultra-cold feedback components are silicon/germanium resistors
    - Also will be assayed with ICP-MS
- With these caveats, the cold hardware is expected to be subdominant to the massive cryostat and shield

Cryostat

- The cryostat within the shield consists of a series of nested copper cans to conduct and shield the various temperature stages
  - During operation, heat is conducted from the detectors
  - Cans may be as thick as ¼" to shield gamma rays from the outer shielding
  - Inner, coldest can is removable so detector installation can be completed in a controlled environment before installation
- These copper cans are contained within a stainless steel vacuum vessel
- Some heat exchangers under investigation for the initial cool down from room temperature

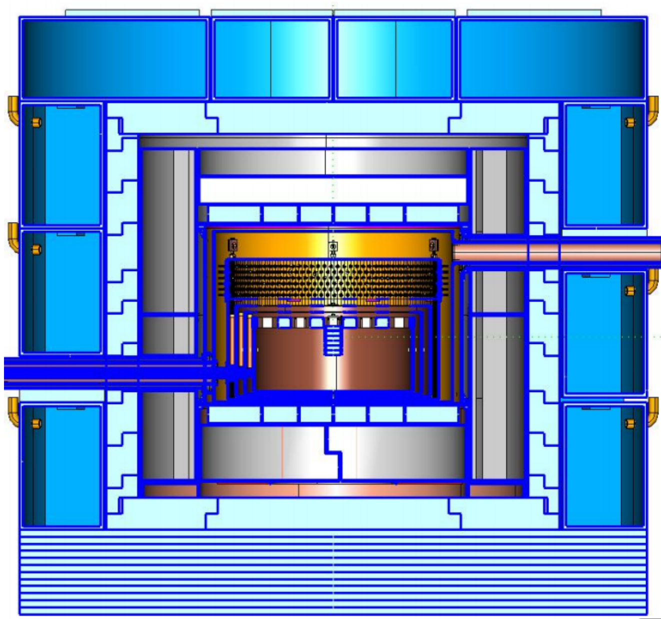


Cryostat Background Tally

- Conservative estimates were used to baseline the background expectation from the cryostat copper
  - 70 microBq/kg U
  - 20 microBq/kg Th
  - 40 microBq/kg K
- Currently copper is the largest background contributor in the background budget of 0.52 counts
- These copper levels are not stringent, so spot checking of the copper using ICP-MS and HPGe is planned
- We are in the process of costing out lower background copper options

Shielding

- Water/Plastic based outer layer to moderate neutrons from the SNOLAB environment
- Lead shielding to attenuate the gamma-ray flux from the SNOLAB environment
- Neutron veto*,** of neutron capture (Li, B, Gd) doped scintillator
  - Moderates any neutrons from the lead/water shield
  - Vetoes neutron events in coincidence with detector events
  - Possibility to monitor the inner neutron flux
  - Will tag muons inside the shield
  - * Either solid plastic scintillator
  - ** Still carrying the option of an all passive shield
    - The neutron veto would be replaced by passive plastic



Shielding Background Tally

- Most background estimates are based on the passive shielding option
- Lead is the next largest contributor to the background budget of 0.35 events (compared to 0.52 for copper)
  - This background estimate was based on 660 microBq/kg U
  - Currently leveraging a multi-project lead campaign (E. Hoppe)
    - Results are comining in consistently at <50 microBq/kg U
  - Loss of Doe Run lead source is under active study
- Copper can thicknesses are being revisited for neutron veto efficiency
  - Would reduce the copper background, but may require a ^{210}Pb specification for lead
- Plastic/water shield is expected to be subdominant to the lead by more than an order of magnitude
- The materials assay team aiming to respond quickly to down selection of the shielding options

Summary

- Detector exposure to radon has historically best been done with in-situ alpha counting
  - R&D work being done with XIA large area alpha counter at SMU
- Plan is to screen all apparatus materials with HPGe
  - A number of shielded surface detectors
  - Shallow 14 crystal array at PNNL
  - UMN operating a crystal deep underground at Soudan
- Small critical components will be measured with ICP-MS
- Major materials will be spot checked with ICP-MS
  - ICP-MS done by Hoppe group at PNNL
- SuperCDMS has a number of design choices that will impact the screening program
- Copper cryostat (0.52 events) and lead shield (0.37 events) are currently the largest expected background sources