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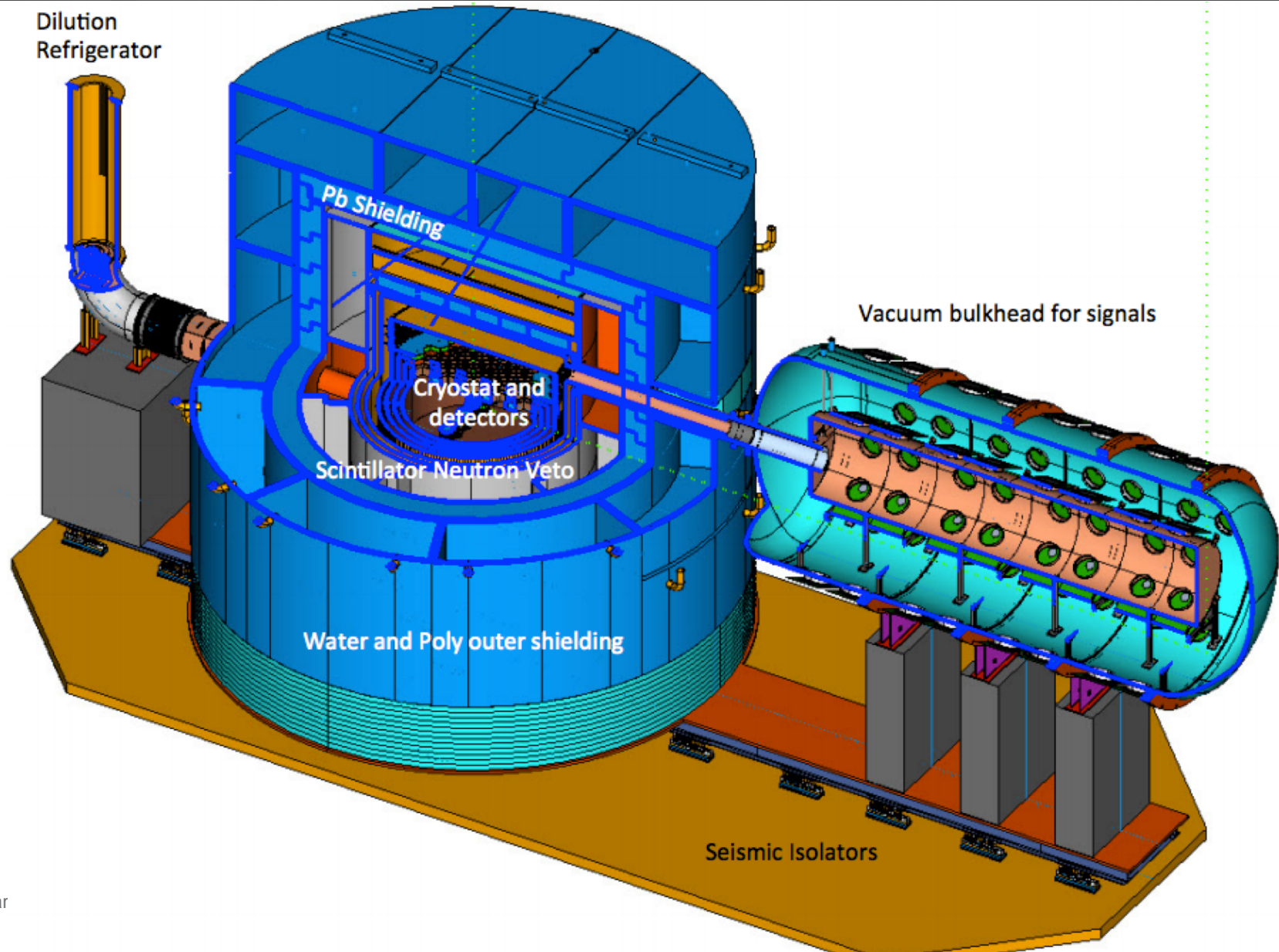
SuperCDMS SNOLAB

Materials and Assay

JETER HALL

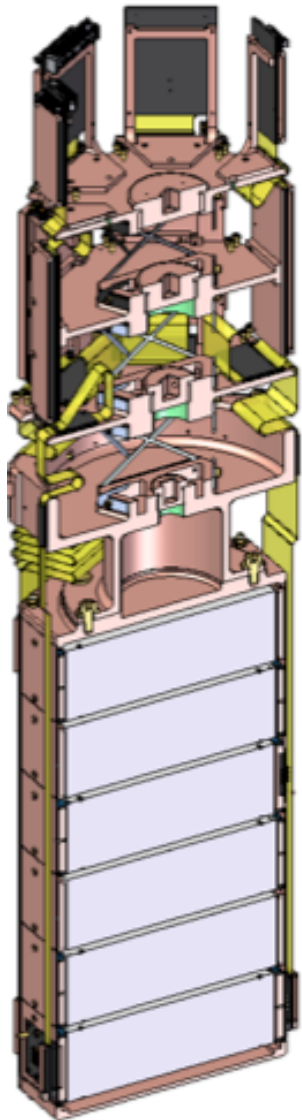
- ▶ Proposed detector at SNOLAB based on the mature CDMS technology
- ▶ 200 kg array of cryogenic germanium and silicon bolometers (iZIPs)
- ▶ Aiming for <1 event in 4 years
- ▶ Backgrounds are reduced through
 - Enhanced position resolution (fiducialization)
 - Nuclear/electronic recoil separation
 - 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 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
 - ^3H 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

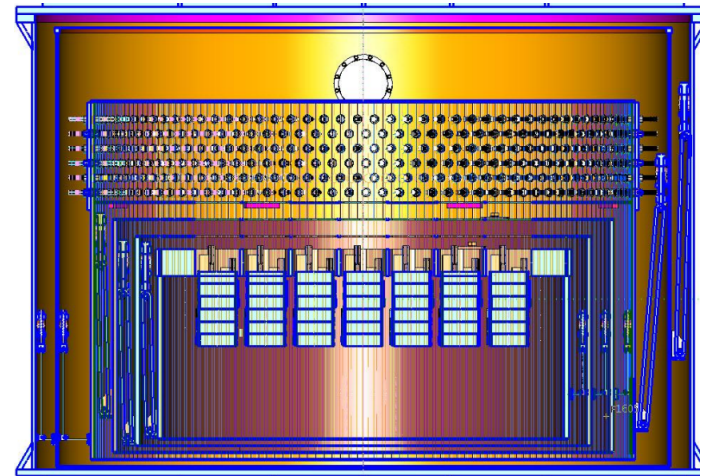


- ▶ Detectors are close packed in stacks, or towers, to limit direct shine from copper detector holders
- ▶ Custom flex cable carries detector signals to the top of the tower
- ▶ The front end amplification is done at the top of the towers using cryogenic SQUID and HEMT amplifiers
- ▶ Cabling then exits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

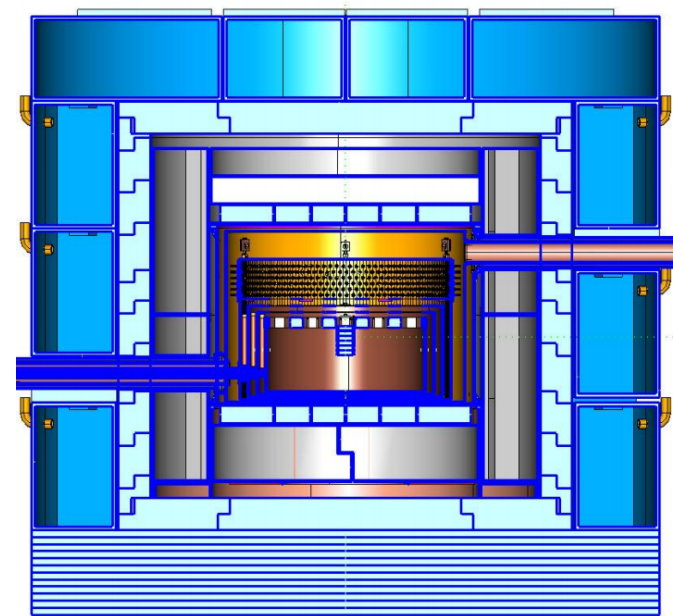
- ▶ The cryostat within the shield consists of a series of nested copper cans to conduct and shield the various temperature stages
 - During operation, heat is conducted from the detectors
 - Cans may be as thick as $\frac{1}{4}$ " to shield gamma rays from the outer shielding
 - Inner, coldest can is 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

- ▶ 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 coming 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

- ▶ Detector exposure to radon has historically best been done with in-situ alpha counting
- ▶ Plan is to screen all apparatus materials with HPGe
- ▶ Small critical components will be measured with ICP-MS
- ▶ Major materials will be spot checked with ICP-MS
- ▶ 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