

Cryogenic Facilities @ Fermilab and SNOLAB

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- Facilities for next-generation cryogenic experiments
 - NEXUS prototyping and testing facility
 - CUTE testing and science facility
 - SuperCDMS SNOLAB
 - Conclusions

NEXUS @ Fermilab

Northwestern Experimental Underground Site at Fermilab

- Operated by Northwestern SuperCDMS Group.
- Idea is to use the NuMI access tunnel at Fermilab (300 m.w.e.) to set up a clean, low-background, accessible testing facility for prototyping and testing next-generation cryogenic crystal experiments.
- At this depth you stop all muon-induced hadronic showers. The muon rate is dropped to 3.4 muons/cm²/day.
- The depth allows for testing of G2+ detectors without risk of cosmogenic activation.

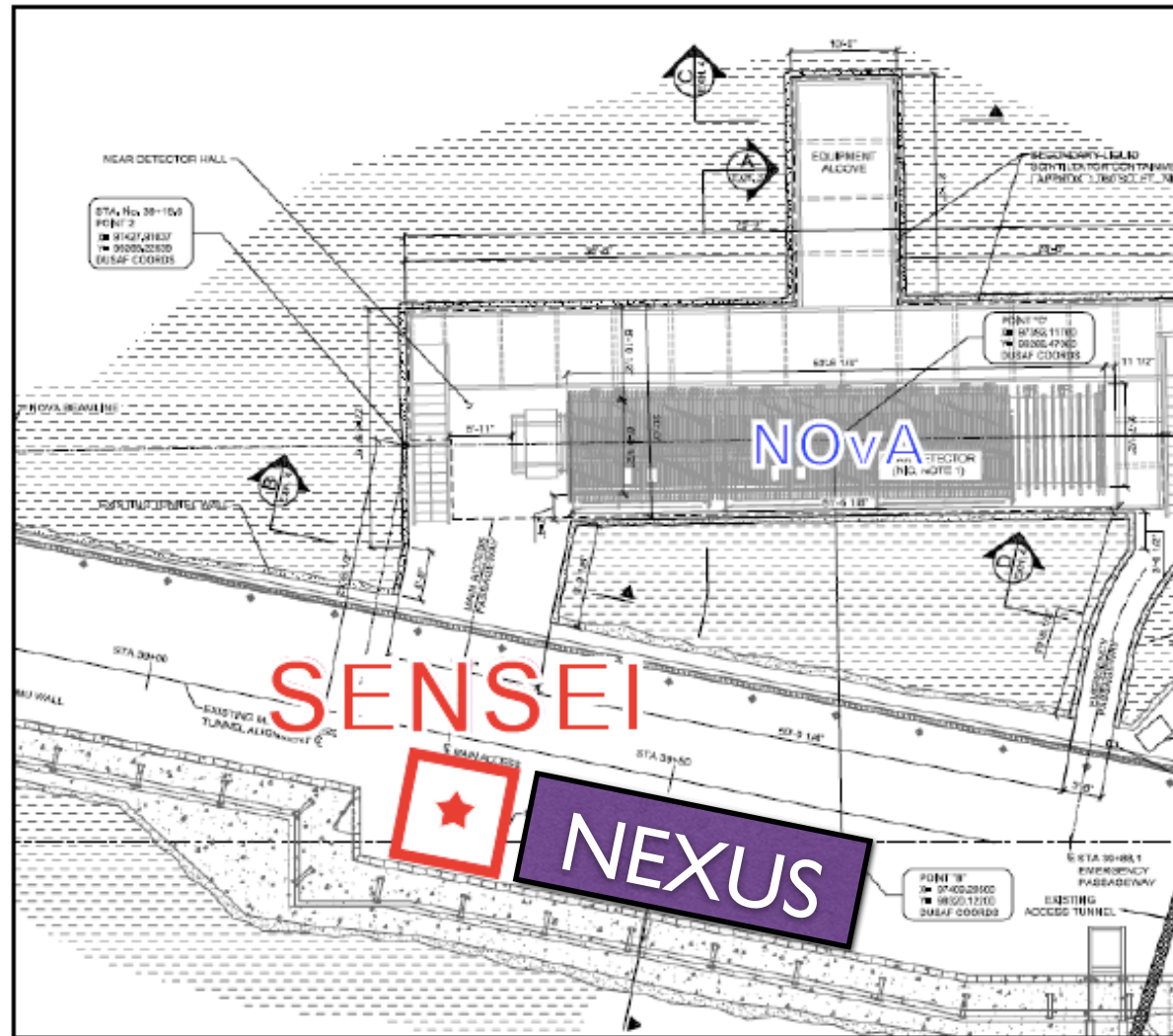




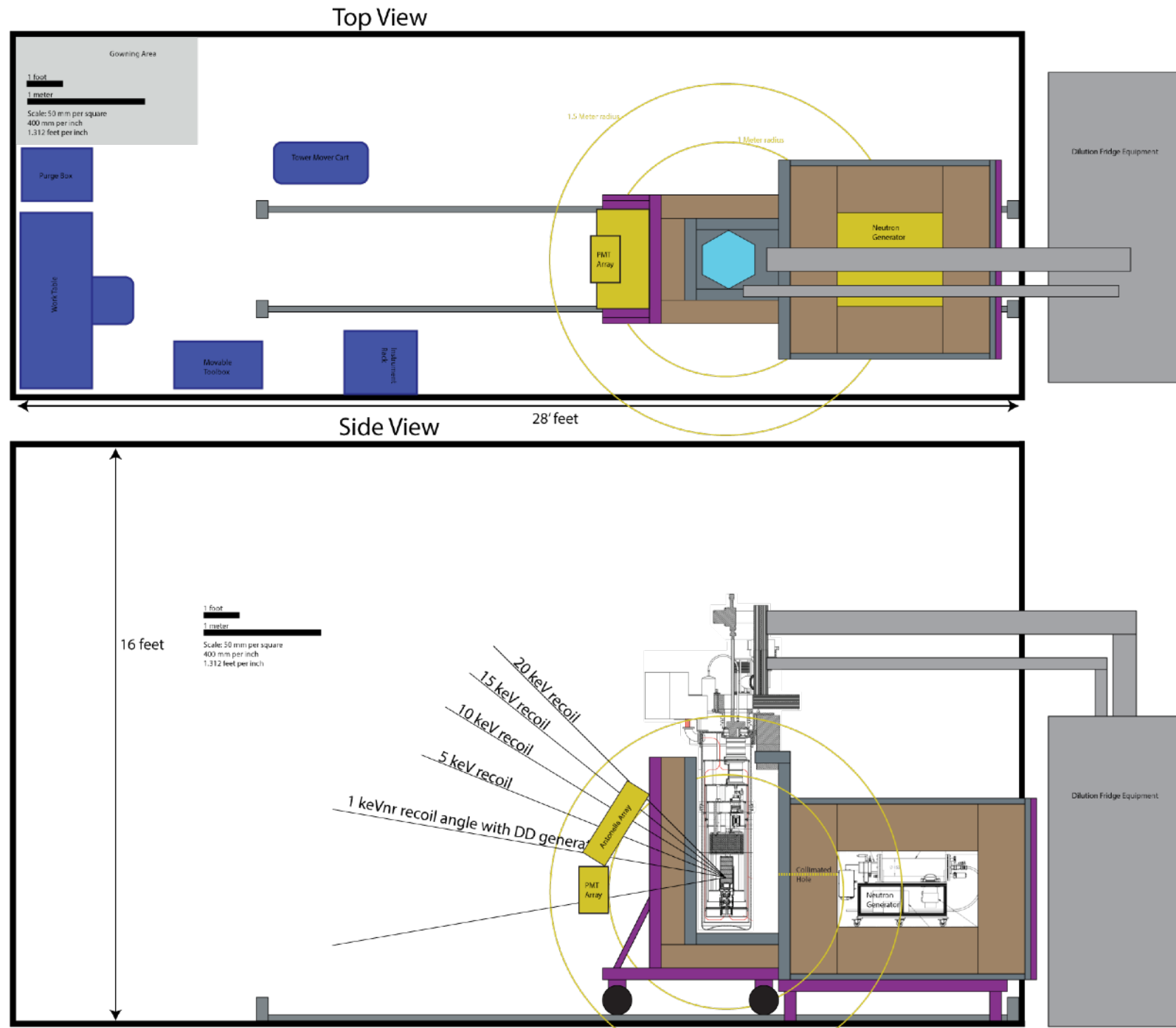
NoVA Near
Detector Hall

Proposed
Cleanroom
Location

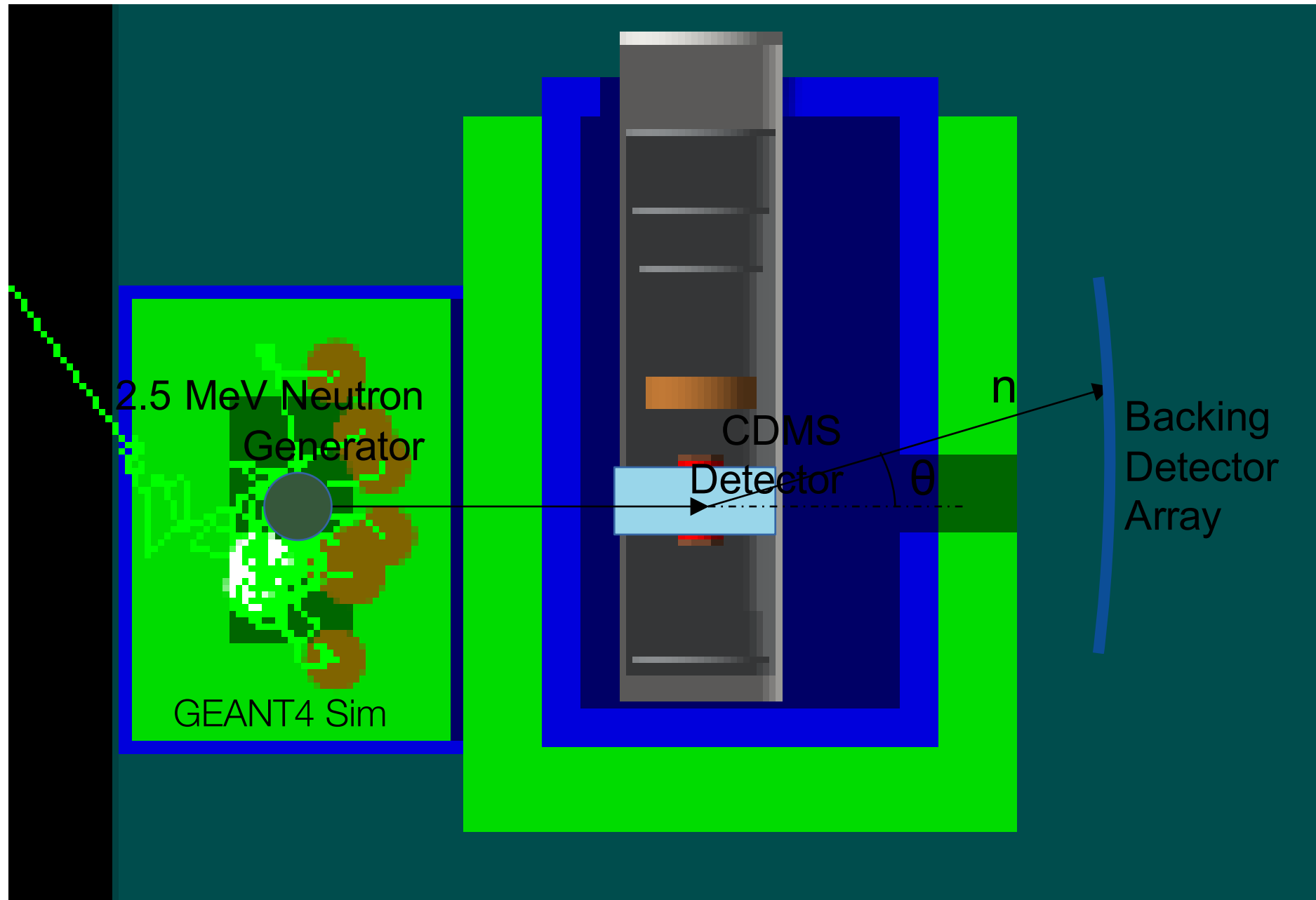
The diagram illustrates the MINOS experiment setup. On the left, the NuMI building is shown with two tall, white, conical structures. A horizontal line connects the NuMI building to the MINOS Hall. The MINOS Hall is a rectangular structure located 107 m away from the NuMI building, as indicated by a double-headed arrow. A red star is located inside the MINOS Hall. The background is a blue sky and a green field.



NEXUS Layout: DD neutron generator built in



NEXUS Neutron Calibration with DD Generator



NEXUS CAD

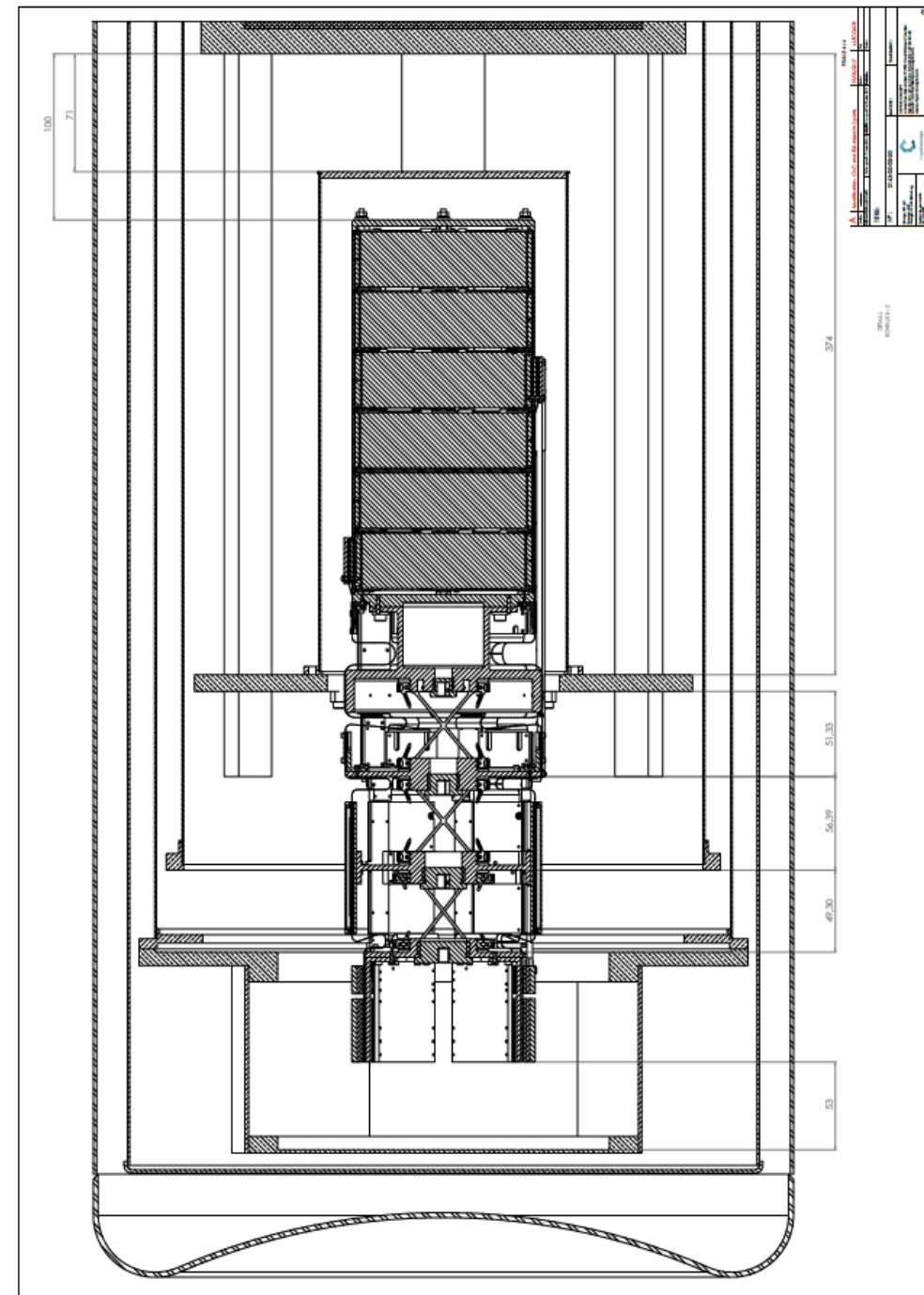


NEXUS CAD



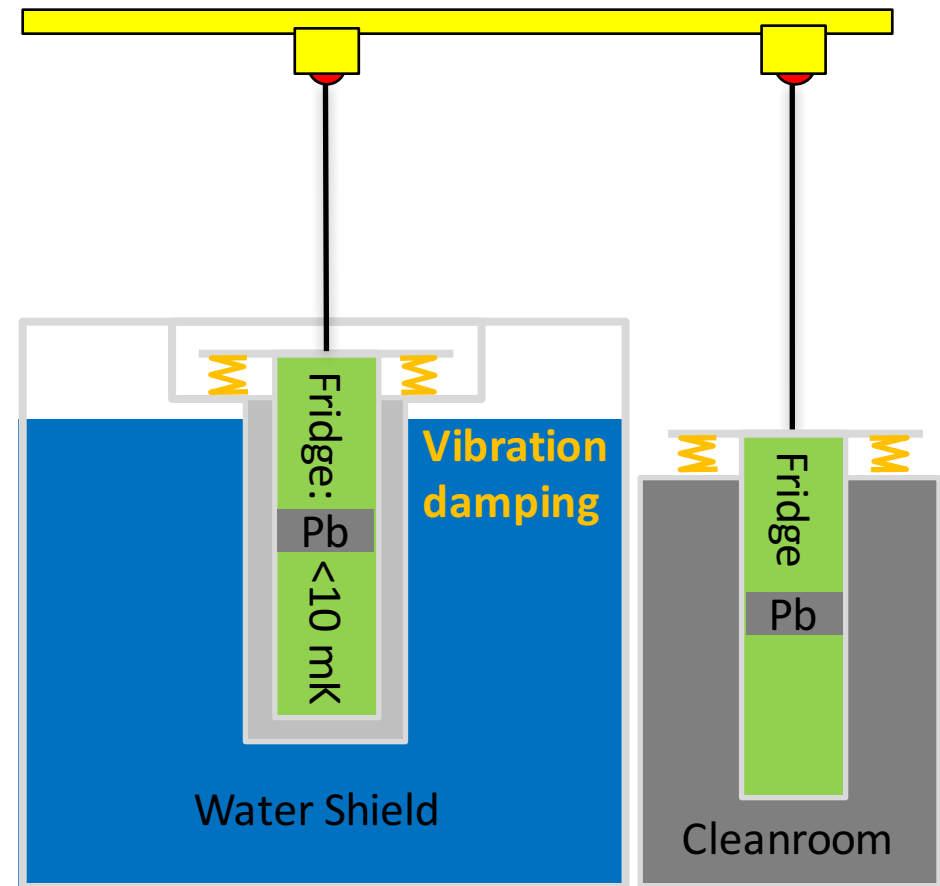
NEXUS Specs

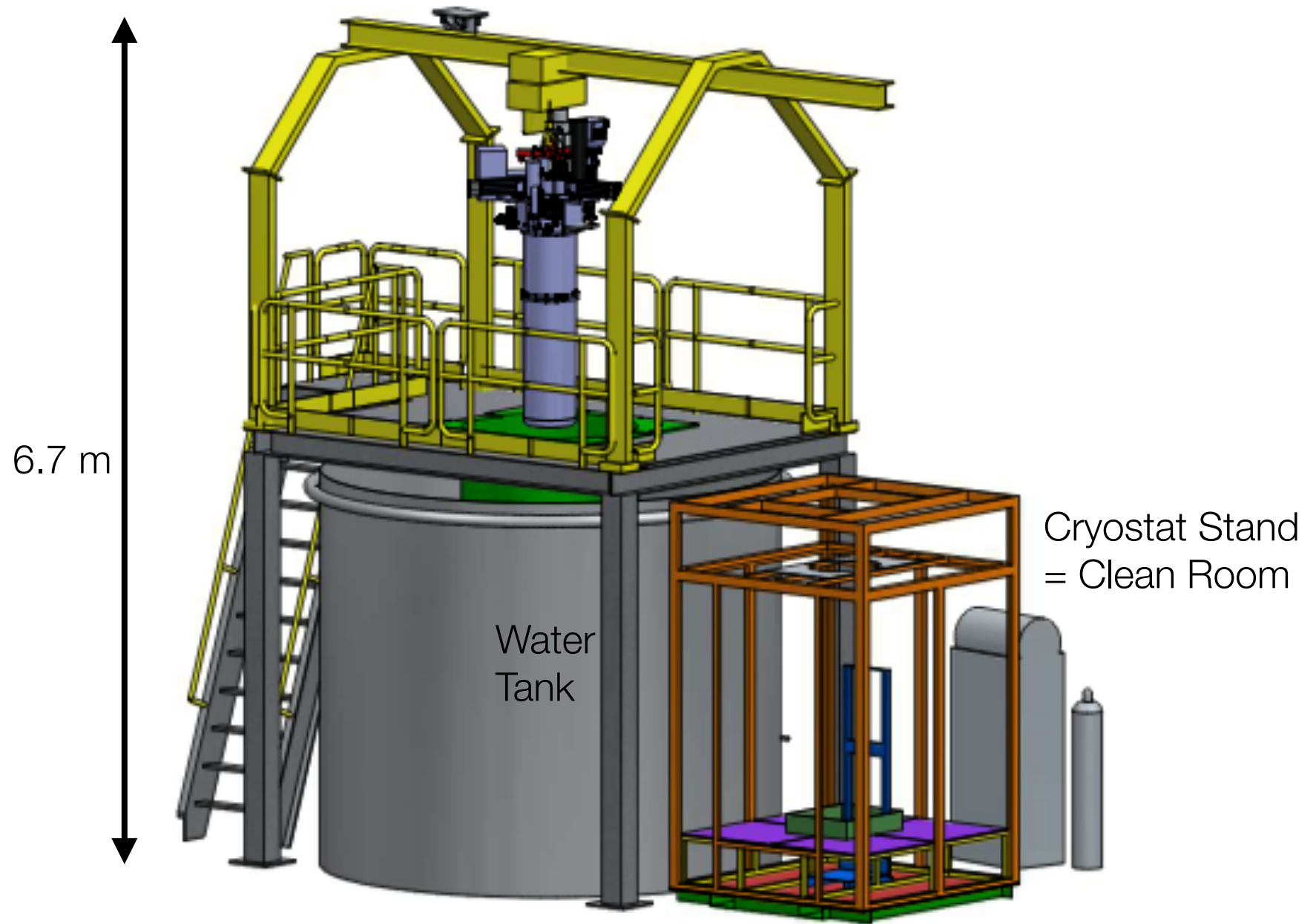
- Large Experimental Space:
33 cm diam x 53 cm tall,
typical payload ~10 kg
- 150 μW @ 100 mK
- <10 mK base temp
- Backgrounds ~100 dru
(evnt/keV/kg/day)
- Muon Rate: 3.4 muons/cm²/day
- Several day turn around time



CUTE @ SNOLAB

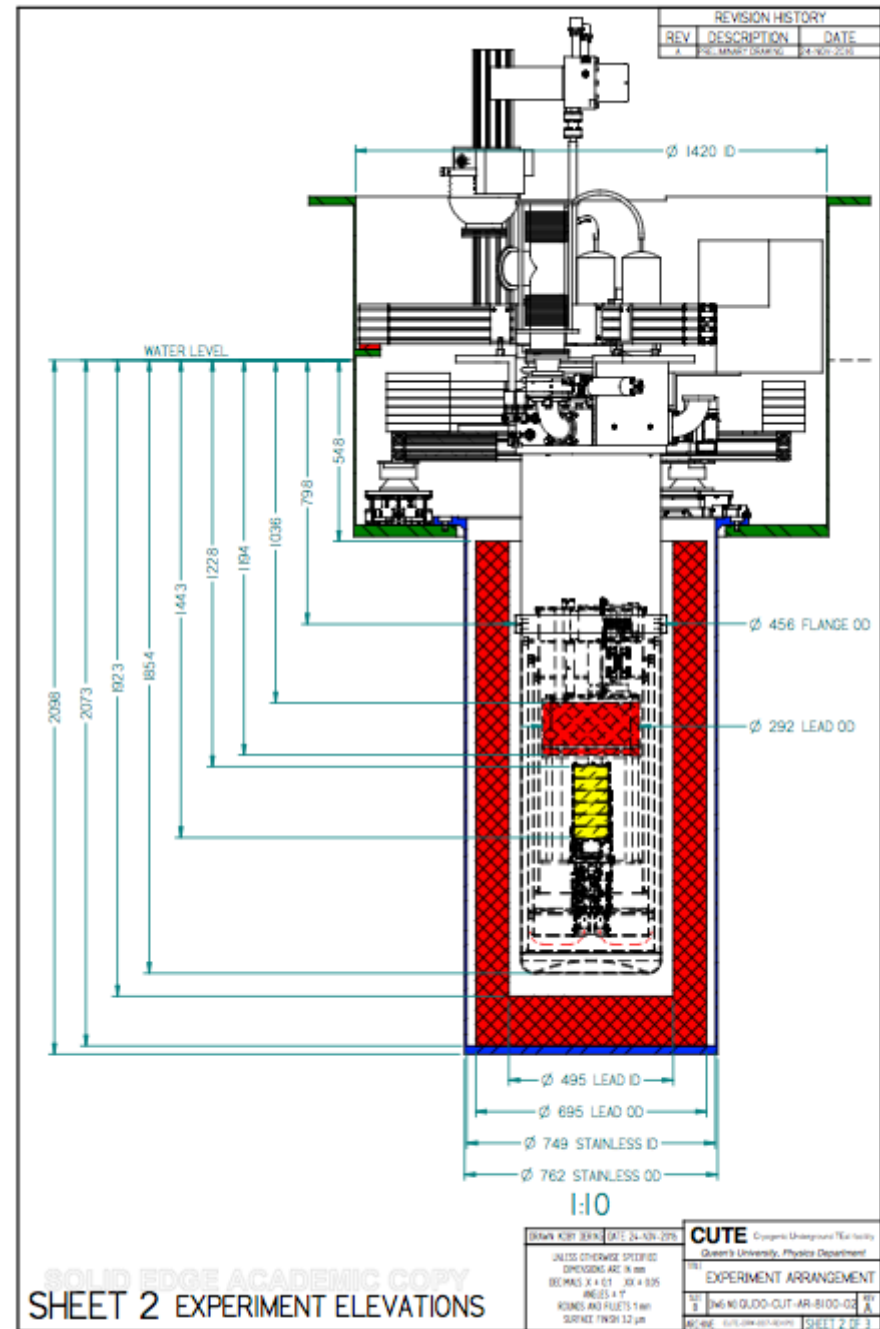
- Operated by Queen's SuperCDMS Group
- Very low background test facility
- Located underground at SNOLAB, next to SuperCDMS
- Perform basic tests that are impacted by presence of background, check backgrounds (^{32}Si , ^3H in Si, surface background, etc.)
- DM science platform!



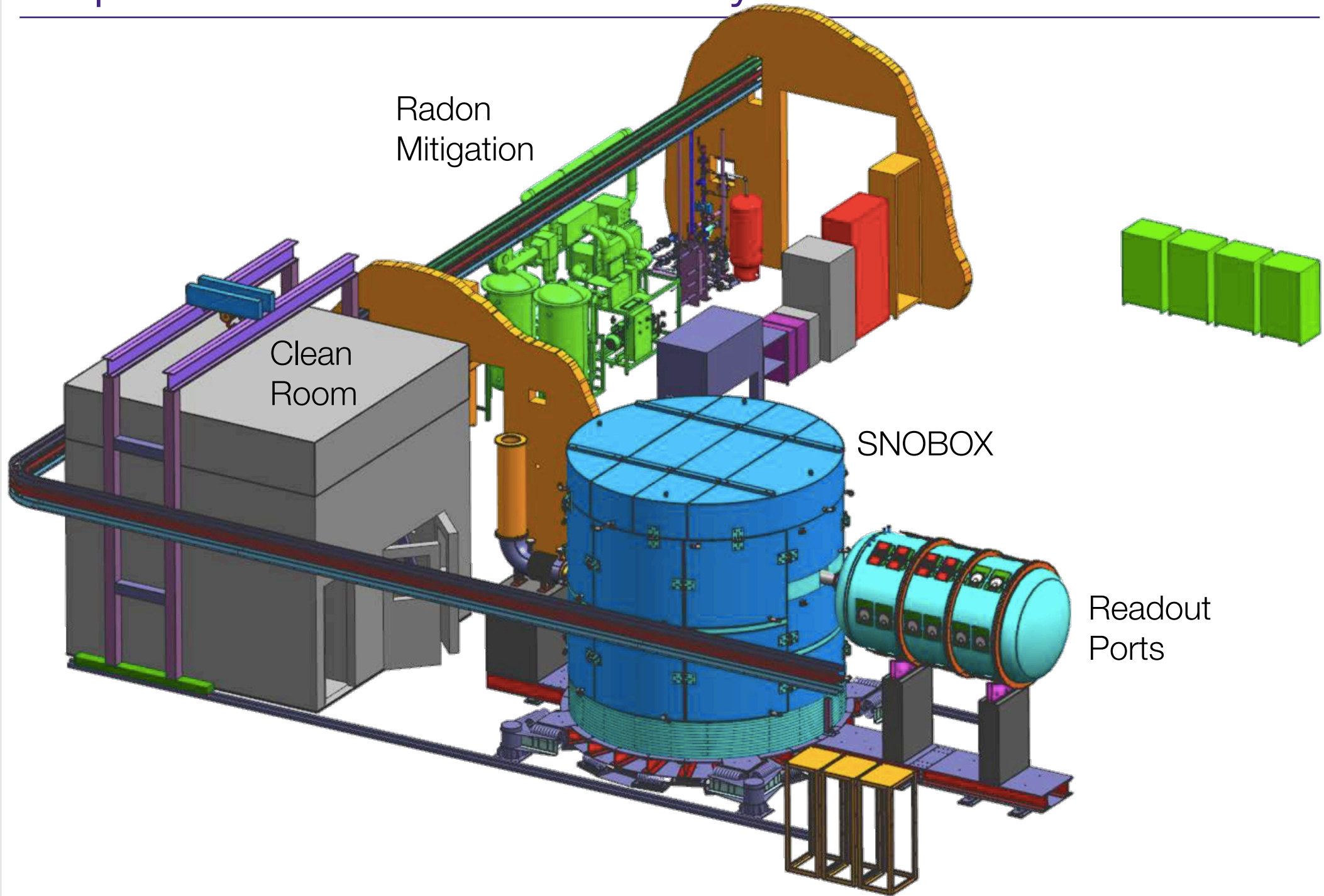


CUTE Specs

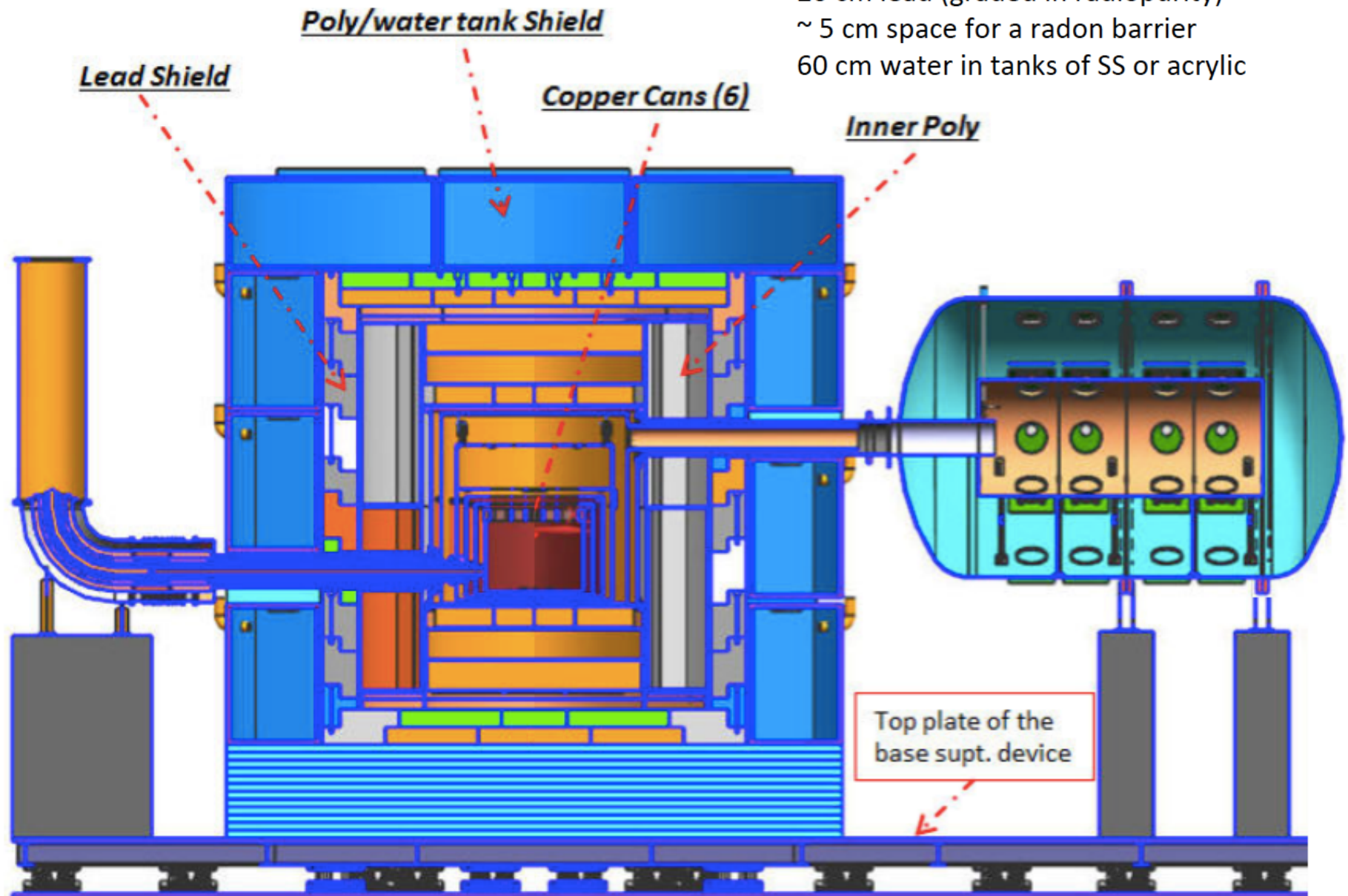
- Same vendor and specs as NEXUS fridge
- Ensures easy movement of payloads between the two facilities.
- Background between 3-30 dpm (with/without external lead shield)
- Low radon concentration inside clean room: 10 Bq/m³
- Several day turn around time



SuperCDMS SNOLAB Facility

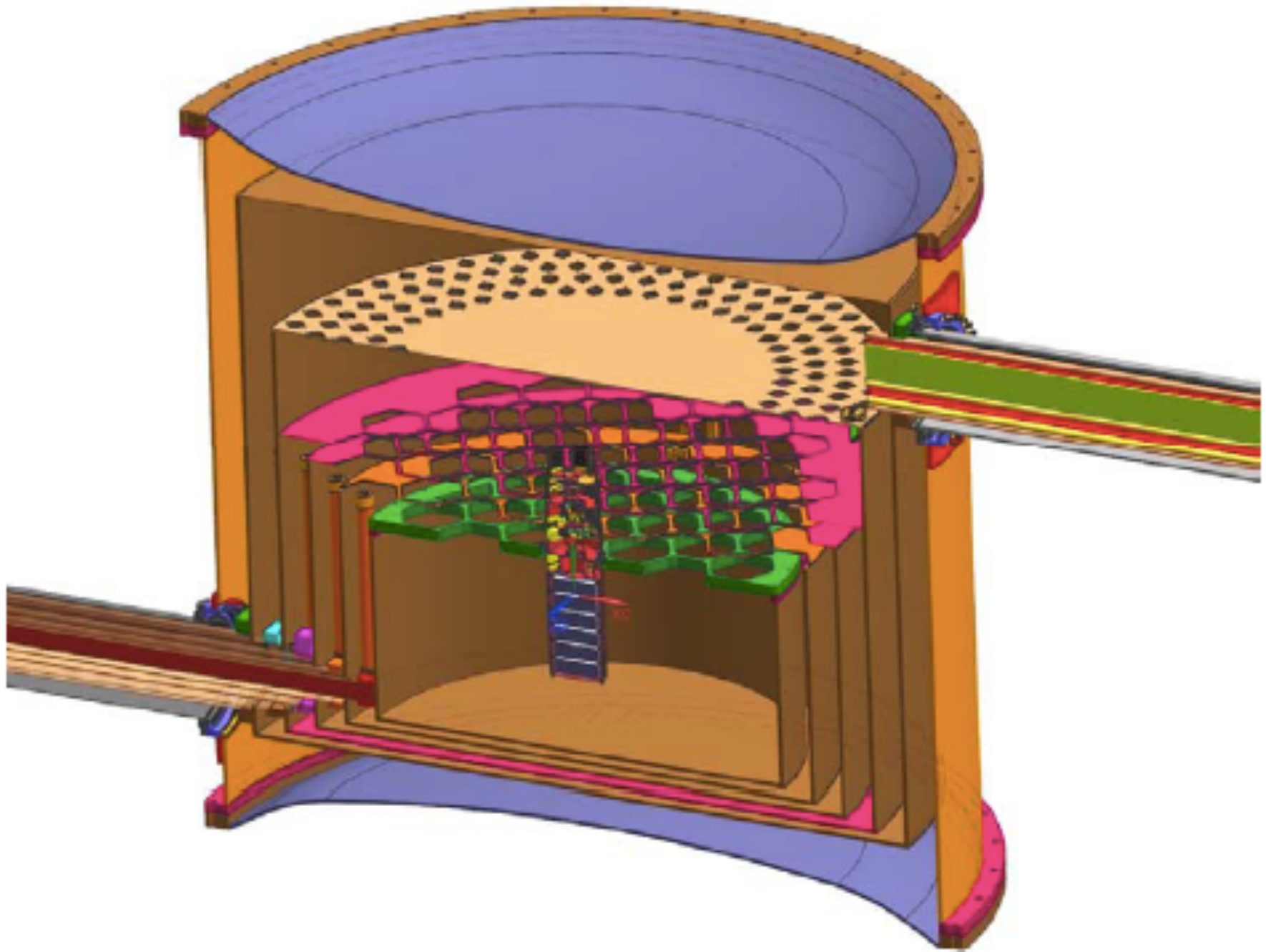


SuperCDMS SNOLAB



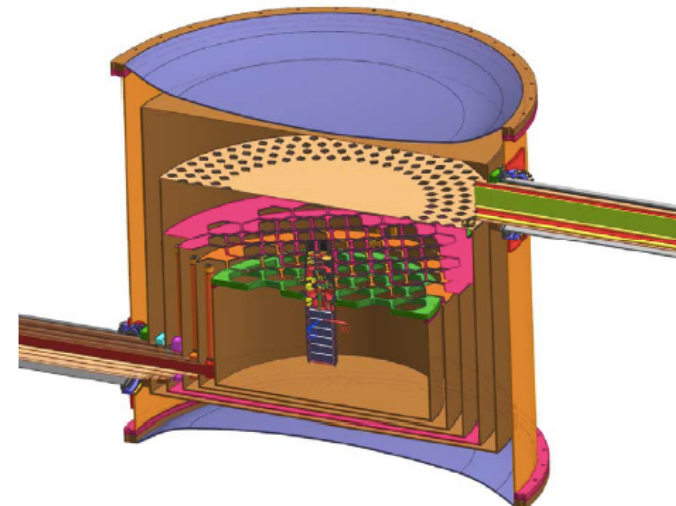
1 mm + for the mu metal shield (attached to OVC)
30 cm HPDE (interlocking and no line of sight)
20 cm lead (graded in radiopurity)
~ 5 cm space for a radon barrier
60 cm water in tanks of SS or acrylic

SuperCDMS SNOBOX



SuperCDMS SNOLAB Facility

- Class 100 Clean room, 14'x14'x12', <1 BqRn/m³
- SNOBOX has room for 31 towers, experimental space is approximately 90 cm diameter x 40 cm tall
- 5 μ W cooling power @ 15 mK
- Background ~ 0.1 evt/keV/kg/day (for Ge target)



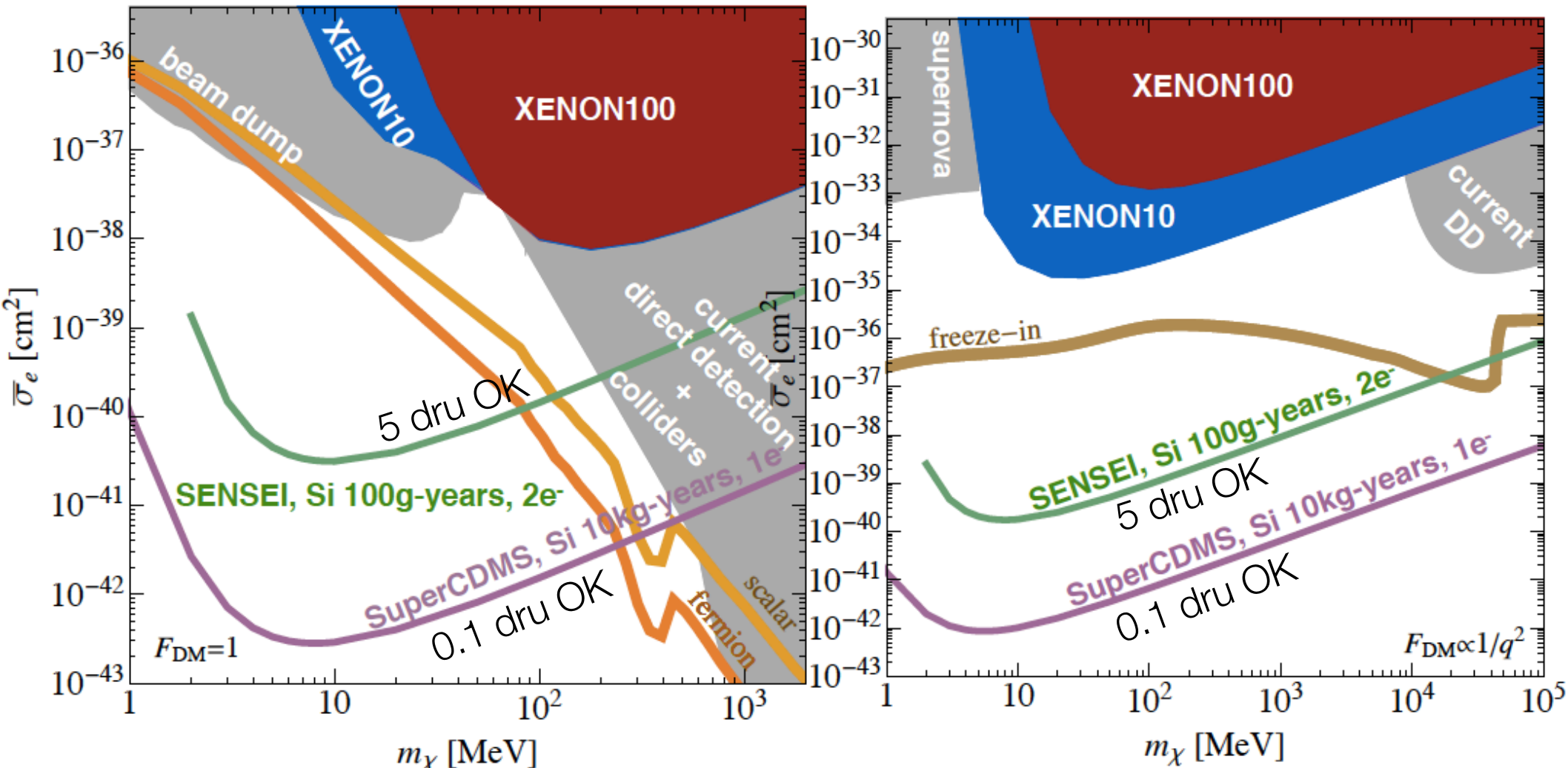
Conclusions

- NEXUS is convenient low-background location for prototyping, ironing out operations, taking initial quick science.
 - Online early 2018
- CUTE is a promising location for next-generation cryogenic searches, up to $\sim x30$ lower background than NEXUS, same interfaces, easy transfer from NEXUS to CUTE.
 - Online early 2018
- SuperCDMS SNOBOX will have up to $\sim x30$ lower background than CUTE; its the ultimate location for either a large payload or a super-low background measurement.
 - G2 experiment scheduled to start science operations in 2020 with a 4 tower payload, potential collaborations with other experiments possible after G2 data taking.
- All these facilities are open to partnerships!

Backup

How low a background do you need?

SuperCDMS projections



Slide from Tien-Tien Yu

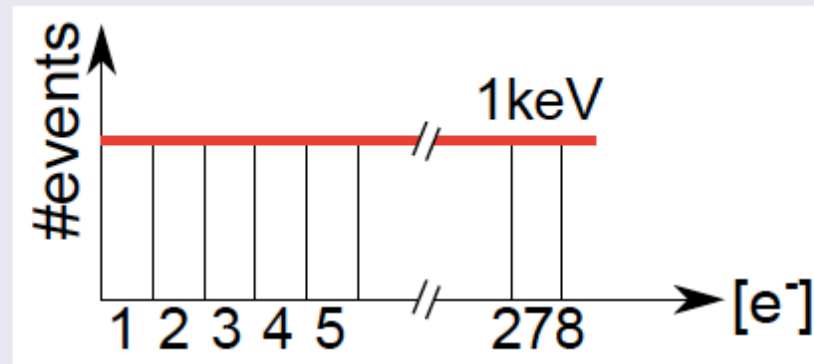
SENSEI Background Estimate

Back of the envelope calculation

A 100g detector that takes data for one year \rightarrow **Expo = 36.5kg · day**

Assuming same background as in DAMIC:

- **5 DRU** ($\text{events} \cdot \text{kg}^{-1} \cdot \text{day}^{-1} \cdot \text{keV}^{-1}$) in the 0-1keV range
 $\rightarrow N_{\text{bkg}} = 36.5 \text{ kg} \cdot \text{day} \times 5 \text{ DRU} = 182.5 \text{ events}$
- Dominated by external gammas \rightarrow **flat Compton spectrum**



182.5 events over the 278 charge bins in the 0-1keV range

Expect 0.65 bkd events in the lowest ($2 e^-$) charge-bin

Slide from Javier Tiffenberg

SuperCDMS Compton Backgrounds Rough Estimate

- Background expectation is on the order of 0.1 dru
- SENSEI estimates 0.65 events in 0.1 kg-yr @ 5 dru
- SuperCDMS estimate: 10 kg-yr @ 0.1 dru = 1.3 events
- Of course these are just back-of-the-envelope estimates of Compton backgrounds, at these low energies other backgrounds, especially from the detectors, may dominate.

