2009/10 Lead Workshop Deliverables for GEODM

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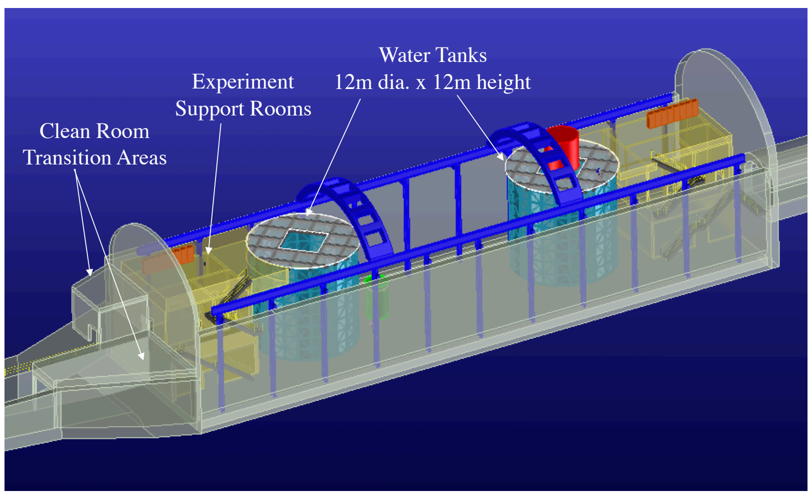
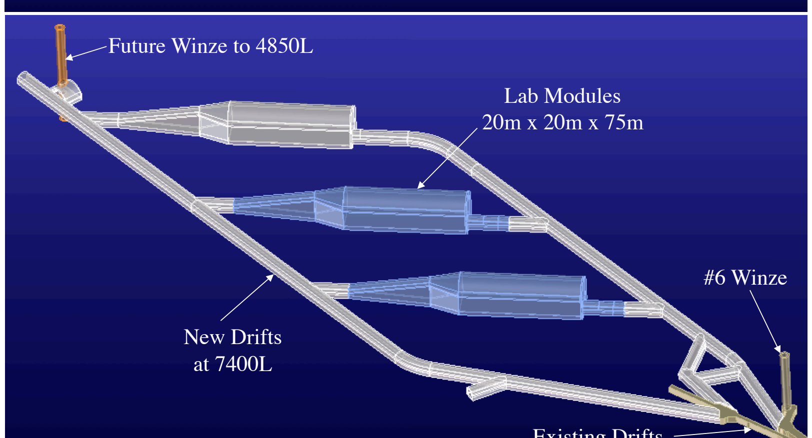
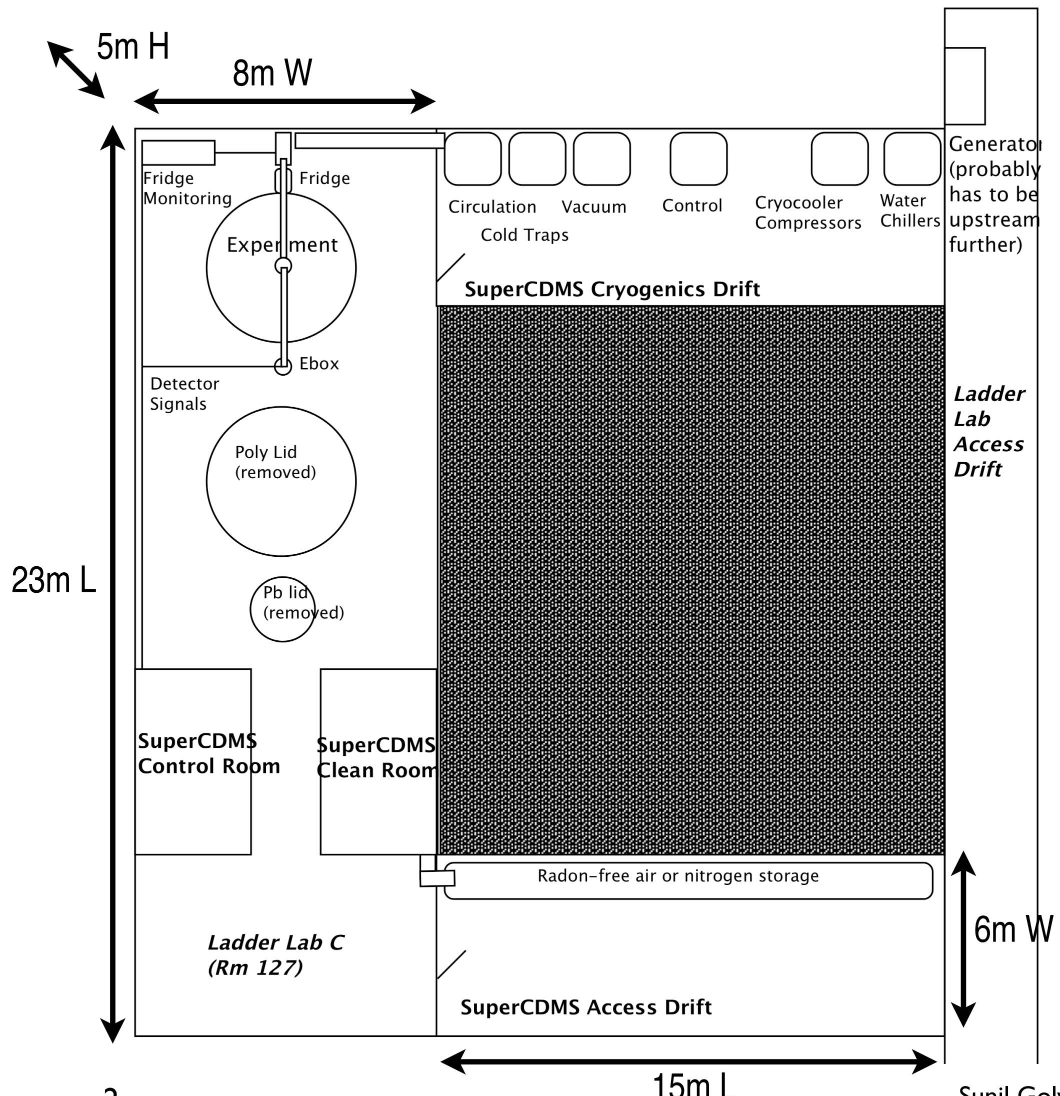
2009/10/03

Experiment Location

- Space constraints:
  - Conceptual design of 7400 ft level (Marks 081219) gives 20m x 20m x 75m labs
  - Scaling of SuperCDMS SNOLAB design by target mass fits this envelope
  - Outstanding issue: conventional vs. water shield; part of S4 study







Experiment Location

- Entry/Exit access
  - Construction
    - Pb/poly option
      - Most challenging single component may be vacuum shell for detector volume if large volume of poly and lead inside; likely will require underground assembly (welding)
      - Pb mass not a challenge in size: ~2 m dimension, ~20-30 cm thickness; but is a challenge in cost: $6M based on scaling from SNOLAB (20 tons, 10 x $0.6M).
    - Water shield option
      - Substantially larger water tank pieces, but not similar to other water shields
      - No cryogen-water safety problem.
  - Operations
    - Non-issue: have demonstrated remote operation in Soudan with non-optimal system
  - Safety
    - *GEODM will use a dry cryogenic system*. Small amounts (100-200L) LN and LHe may be needed for cold traps, radon purge, etc.,
    - Vacuum loss is worst imaginable failure mode
      - Proper system monitoring gives substantial warning (cryogenic plugs do not form quickly); explosive failure only if monitoring ignored or vacuum system design is poor
    - Active neutron veto: plastic or liquid scintillator between 77K and 300K
      - These could pose new challenges, but volumes are small.

Facility Requirements

- Need to be confirmed in detail during S4 phase; preliminary list:
  - Clean areas
    - Class 10000 for cavern containing experimental apparatus
    - Class 100 locally (tent) for work on open cryostat or open water-chamber
    - Class 100 detector payload assembly room
    - Anteroom for gowning, cleaning
  - Ventilation:
    - HEPA filtered fresh or old air to meet cleanliness, radon requirements
    - venting for small amounts of LN, LHe exhaust
  - Radon background:
    - Hall: 100 Bq/m^3 or better (above-ground radon levels)
    - Access to lower radon content air during detector access in payload assembly room and access tent: < 100 mBq/m^3 can in principle be achieved with radon scrubber systems at moderate cost (few x $100k)

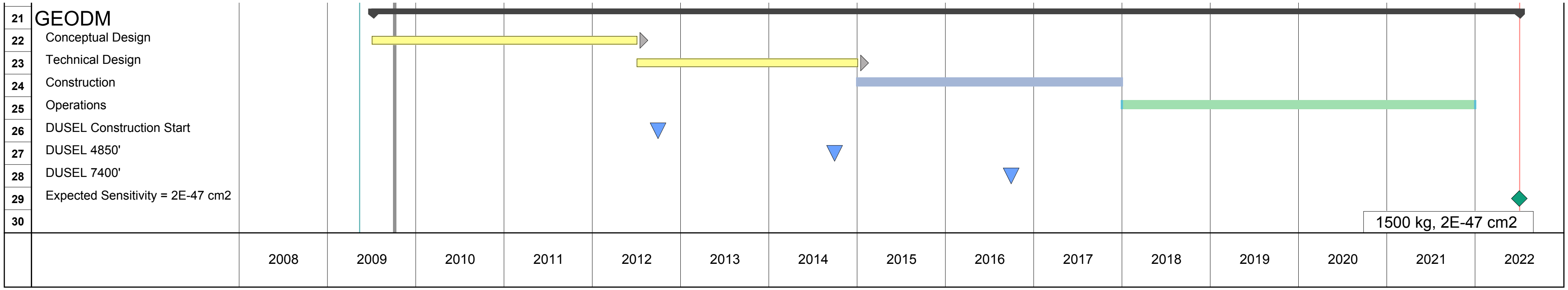
Facility Requirements

- Need to be confirmed in detail during S4 phase; preliminary list:
  - Hazardous materials:
    - 100-200L each of LN and LHe
    - standard lab solvents
    - high-pressure N_2 and He gases
    - shield: hazards either from
      - water tank
      - lead + active neutron veto material
  - RF-tight cavern or enclosure with highly filtered power for electronics
  - Electrical power:
    - 100 kW (pulse tube compressors, dilution unit circulation pumps, electronics/DAQ, HEPA filtering of class 100 regions, radon scrubber operation)
    - UPS for ~25 kW to maintain experiment temperature during switchover to second feed or generator in case of power outage

Facility Requirements

- Need to be confirmed in detail during S4 phase; preliminary list:
  - Hoist capacity:
    - driven by Pb shield: 20 tons total mass
    - large vacuum vessel (3m x 3m) would be more easily transported in larger hoist
  - In-lab crane capacity: similar
  - 24/7/365 emergency access
  - High-speed network (Gb ethernet) for remote access, data transfer
  - Occupancy: 15 peak, 2 steady

Schedule for Occupancy and Deliverables



- 2010: Envelope of DUSEL needs established
  - Largest challenge: choice bet. shield designs, incl. active neutron veto, to set expt. envelope
  - Consider this CD1/CDR for cryostat, shield, and lab interface
- 2012: Baseline detector design established
  - CD1/CDR for detector design and associated subsystems (detectors, cold hardware, electronics)
  - CD2/PDR for cryostat, shield, lab interface
- 2013: Baseline detector cost established
  - CD2/PDR for detector design and assoc. subsystems
  - CD3/FDR for cryostat, shield, lab interface: begin procurement of long lead items (< 25% total expt. construction cost)
- 2014: CD3/FDR for detector design: begin detector construction
  - Start of substantial construction spending

R&D Needs

- R&D to make choice on shield design (base funds, starts now):
  - Pb/poly between 77K and 300K + active neutron veto
  - Water shield + vastly reduced Pb/poly to shield against fridge and water-chamber only
- Detectors (DUSEL R&D, S4)
  - Design
    - ∅7.5 cm x 2.5 cm iZIP *probably* already has sufficient rejection assuming surface-event backgrounds *unchanged* and *already proven* improvement in gamma backgrounds
    - Need to demonstrate multiplicative nature of independent rejection methods underground (SNOLAB test facility, 2010)
    - Need to scale up mass to ∅10 cm x 3.5 cm (1.5 kg) for SNOLAB
    - GEODM goal = ∅15 cm x 5 cm (5.1 kg). Need to confirm bulk event rejection is ok.
  - Production
    - Goal: 300 x ∅15 cm x 5 cm (5.1 kg). Challenges:
      - Substrate acquisition (dislocation-free Ge): demonstrated at ∅3 cm, developing vendors for ∅15 cm
      - Photolith on large detector diameter/thickness
      - Substrate, fab, and testing rate and cost scalable from SNOLAB (100 detectors → 300 detectors)
    - Fallback: 1300 x 10 cm x 2.5 cm (1.1 kg)
      - First tests of ∅10 cm Ortec within months for SuperCDMS SNOLAB
      - Photolith likely to be demonstrated in coming year for SuperCDMS SNOLAB
      - Substrate, fab, and testing rate/cost are most significant challenges (scaling 100 detectors → 1300 detectors requires new paradigm)

Points of Contact

- Spokesperson: S. Golwala (Caltech)
- Project engineer: in process
  - Working toward significant SLAC involvement, including project mgmt and eng.
  - Fallback is LBNL at restricted level of effort during S4 phase + scaling from SNOLAB design (FNAL) leading into more effort during CD2 → CD3 phase.
  - Key point: project engineering is not the major risk with this kind of detector!
    - We have executed smaller-scale designs twice before, once well (CDMS I), once not so well (CDMS II). The key difference was *scientist involvement*, not engineering resources.
    - We are developing x10 smaller volume (x2 smaller length) design for SNOLAB with both engineering and scientist involvement at FNAL now.
    - Water shield may be a new challenge, but it is becoming well understood inside community.
    - Dominant cost/schedule risk is detector production/testing cost/time, where we have a long history of deep engineering and scientist involvement. Focus of S4 effort.