Sanford Underground Research Facility Overview

January 19, 2012

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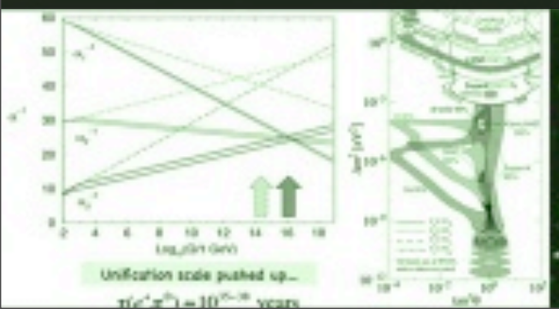
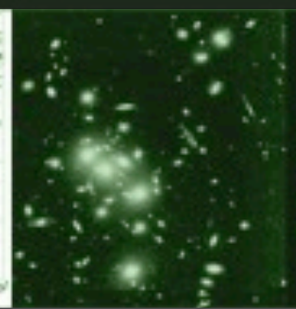
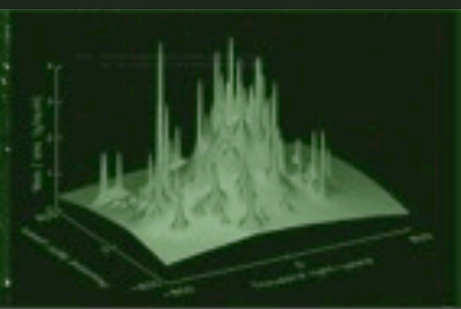
UC Berkeley







Sanford Underground Research Facility SURF

Overview Outline

- DOE Support of Homestake
- FY12 Activities
- SURF Science Programs and US Long Range Plans
- Conclusions and Summary

Sanford Underground Research Facility (SURF)

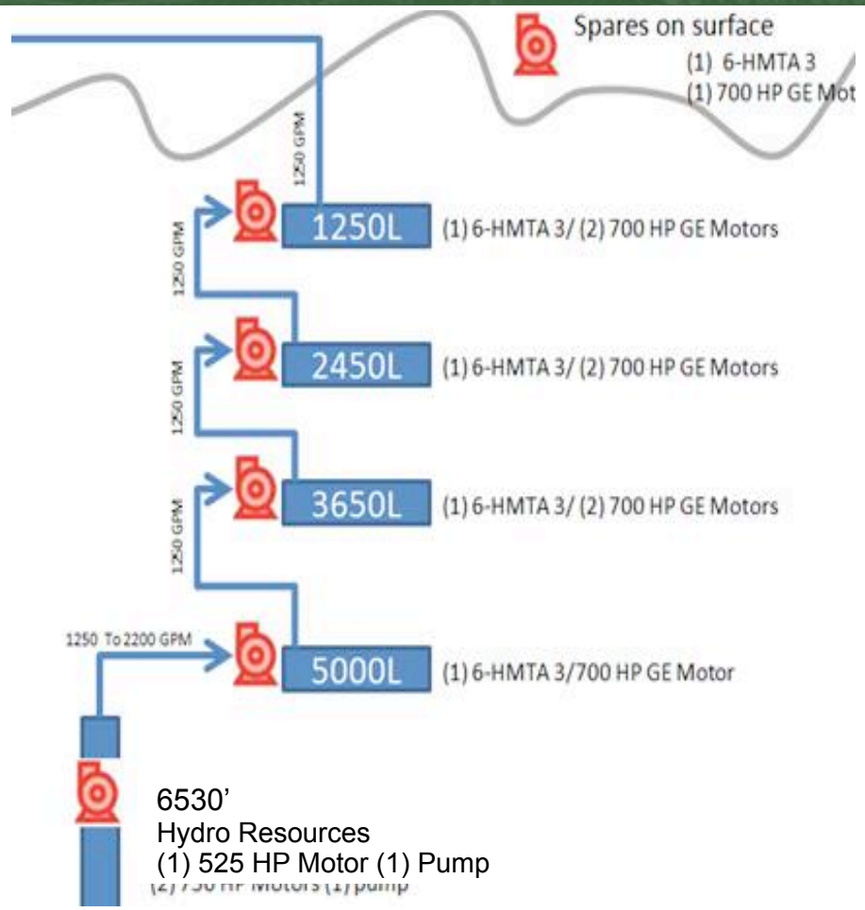
- Customized and dedicated facility to address DOE's underground research areas: Dark Matter, Neutrinoless Double-Beta Decay, and Long-Baseline Neutrinos
- Facility ownership and operations are well established
  - dedicated science facility
  - no competition and associated risks from mining, transportation, or tourism
  - well assessed facility and low risk: just completed the NSF's PDR with full assessments and plans for a much more comprehensive facility
    - much of PDR design is applicable to LBNE
    - LBNE using PDR A/E Design Contractors
    - as well as planning for G3 DM and 1-tonne scale DBD experiments
  - facility design is readily expandable and adaptable
  - customized designs for modern experimental requirements
- Facility improvements & enhancements underway
- Initial (early) science program underway
  - Integration and Oversight of Science Program and Facility

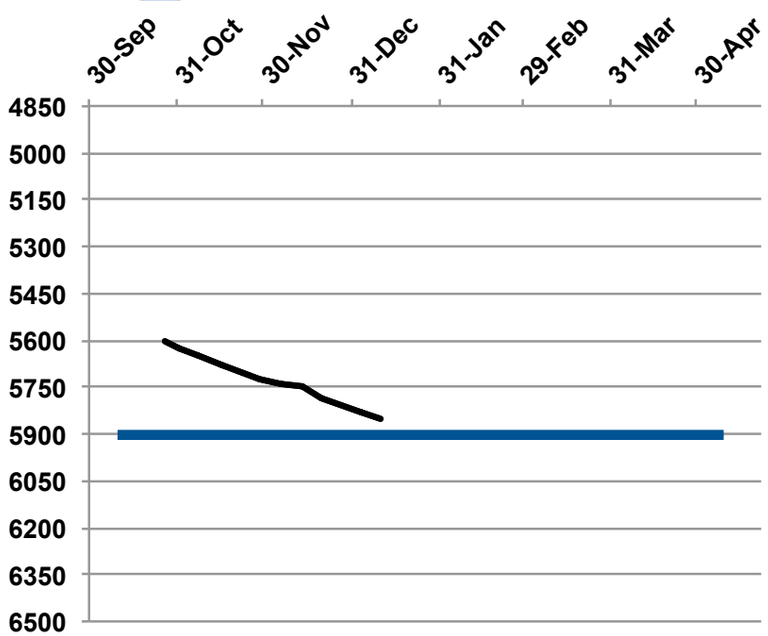
FY12 Activities – four main areas

- Minimal sustaining maintenance and operations
  - –pumping water
  - –safe access to the underground
  - –site security
  - –maintaining investments

- Facility Improvements and Rehabilitation
  - –with significant SDSTA funding
- Facilitating and Integrating Early Science program
  - –Davis Campus
  - –LUX and MAJORANA DEMONSTRATOR
- LBNE Design Activities

Facility Maintenance and Dewatering Activities





– SURF maintaining infrastructure on the Surface and Underground

- Redundant Safe Access
- Shaft maintenance, ground control, ...
- Ventilation
- Utilities
- Pumping accumulated water ~ 1100 gpm
  - –Water treated and disposed in local stream meeting EPA regulations and monitoring requirements
  - –See Headley's talk for details

Facility Rehabilitation and Improvement Projects

- SURF is accomplishing a list of facility rehabilitation and improvement projects with existing funds with the Davis Campus and shaft rehabilitation being the most significant. These include:
  - Davis Campus construction and outfitting
  - Yates & Ross Shaft Furnishing Rehabilitation and Improvements
  - Building Upgrades
  - Utilities (ventilation, water, power distribution, ...)
  - IT (cyber, communications, ...)
  - Safety items

Access to the 4850L obtained with Independent Shafts and Conveyances - Ross and Yates

✦ Ross Shaft – for Construction and Maintenance Activities (see Mike Headley's talk for details, schedule)

– Design for Shaft Steel Furnishings Rehabilitation and Other Improvements

- Complete steel replacement, new bearing beams, ground support

✦ Yates Shaft – rehabilitate for Primary & Redundant Access

– Wooden shaft furnishings regularly maintained

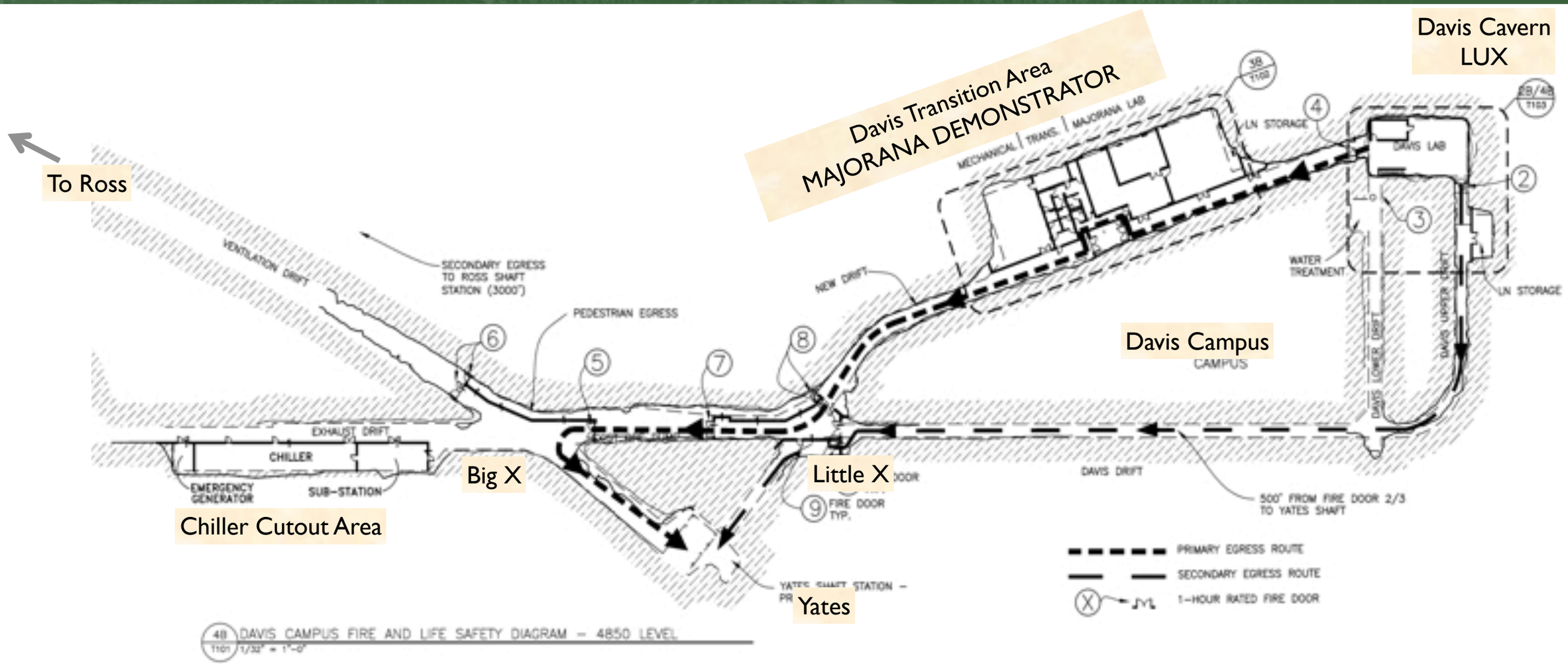
– Hybrid design for rehabilitating likely (incrementally replacing wood with steel)

– Design for new emergency braking system complete

SURF Science Programs

- Supported within the Davis Campus are:
  - Large Underground Xenon (LUX) Dark Matter Experiment (DOE/NSF)
  - MAJORANA DEMONSTRATOR (MJD) Neutrinoless Double-Beta Decay Experiment (DOE/NSF)
  - Center for Ultralow Background Experiments at DUSEL (CUBED) (EPSCoR/SD)
- Distributed through the Facility
  - site characterization efforts, background measurements (e.g. *arXiv*:1007.1921v3)
  - future Gravity Wave Detector site characterization DUGL (e.g. *arXiv*:1006.0678)
  - Transparent Earth
  - Geomicrobiology
  - GEOX^TM
  - Rock Core Archive
  - several existing, low-impact Bio-Geo-Eng efforts

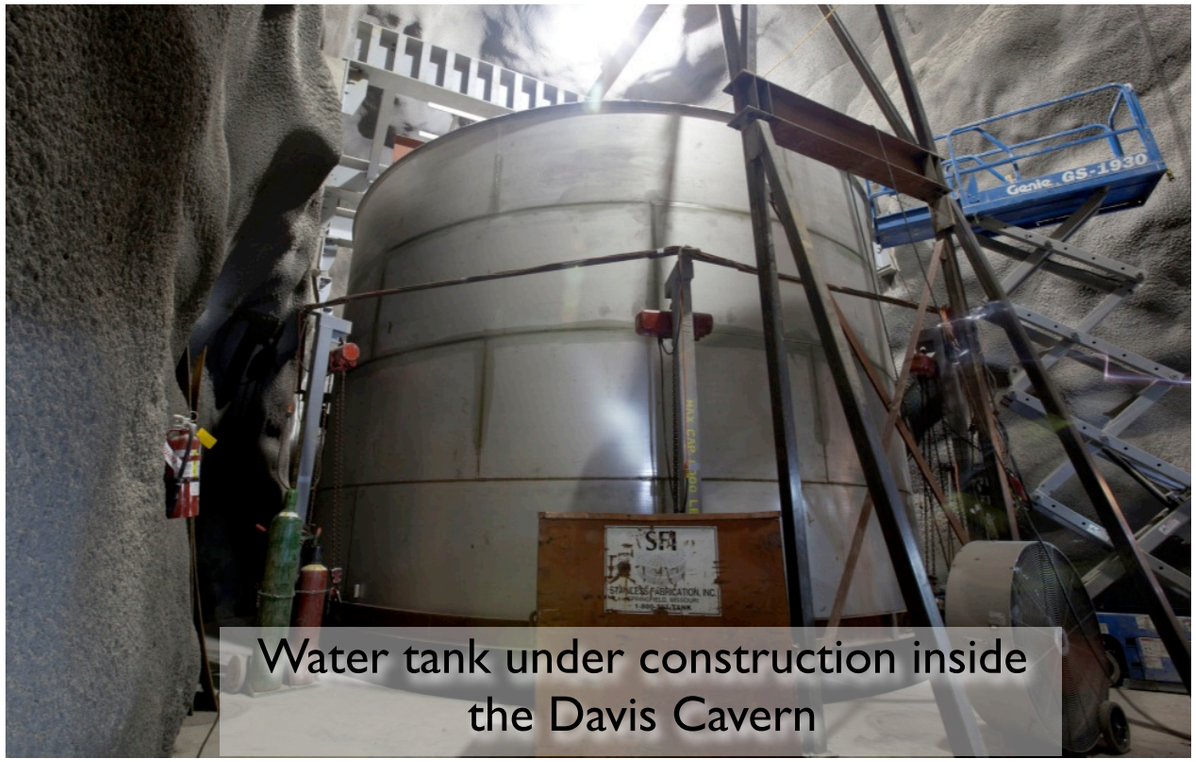
Davis Campus Supporting Early Science Efforts



- Highpoint of South Dakota's $125M Investment
- On budget and on schedule for March 22, 2012 beneficial occupancy
  - LUX Dark Matter Experiment
  - MAJORANA DEMONSTRATOR Neutrinoless Double-Beta Decay

Davis Campus Outfitting

Looking at the North end of the chiller cutout area



Water tank under construction inside the Davis Cavern

Looking South down the access drift inside the transition area

View of the Davis Cavern

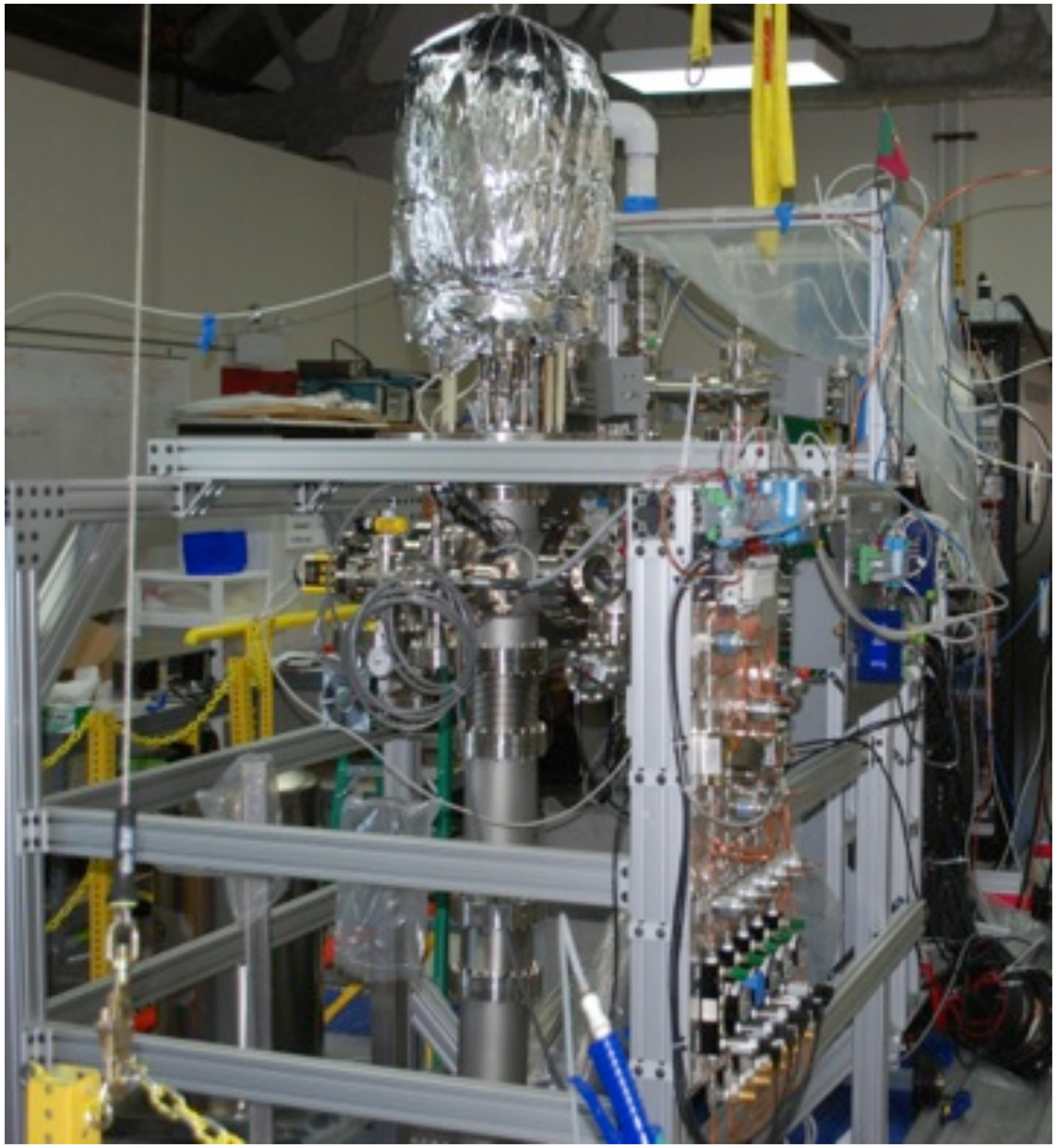
MAJORANA DEMONSTRATOR

- Electroforming clean room near Ross shaft: fully operational

LUX Dark Matter

LUX Collaboration meet at Sanford on October 22 – 23, 2011

LUX Underground Readiness Review held at Sanford on October 24 – 25, 2011



Thermosyphon Dewar Prior to Outer Can Installation

Facilitating and Integrating Science Efforts

- Experimental Readiness and Safety Reviews
- Experimental Integration
- Facility Design and Construction
- EH&S functions
- NEPA Requirements
  - Categorical Exclusion for LUX and MJD experiments obtained December 2011
    - Includes facility operations for water pumping, treatment and disposal as well as on-going maintenance activities for the facility

Supporting LBNE Design Efforts

- SURF staff and organization has been effectively assisting in the creation of the LBNE Conceptual Design
- Developed three distinct Conceptual Designs
- LBNE using DUSEL's Architectural/Engineering and Construction Management contractors (HDR, ARUP, Golder, McCarthy-Kiewit) to develop specific design for LBNE
- SURF Engineering and Design Staff continue to manage the A/E contracts for LBNE
  - Headley
  - Willhite
  - DeVries
  - Vardiman
  - Systems Engineering, Contract management, Administration, ...

SURF's Science Programs and US Long Range Plans: Dark Matter and Neutrinoless Double-Beta Decay

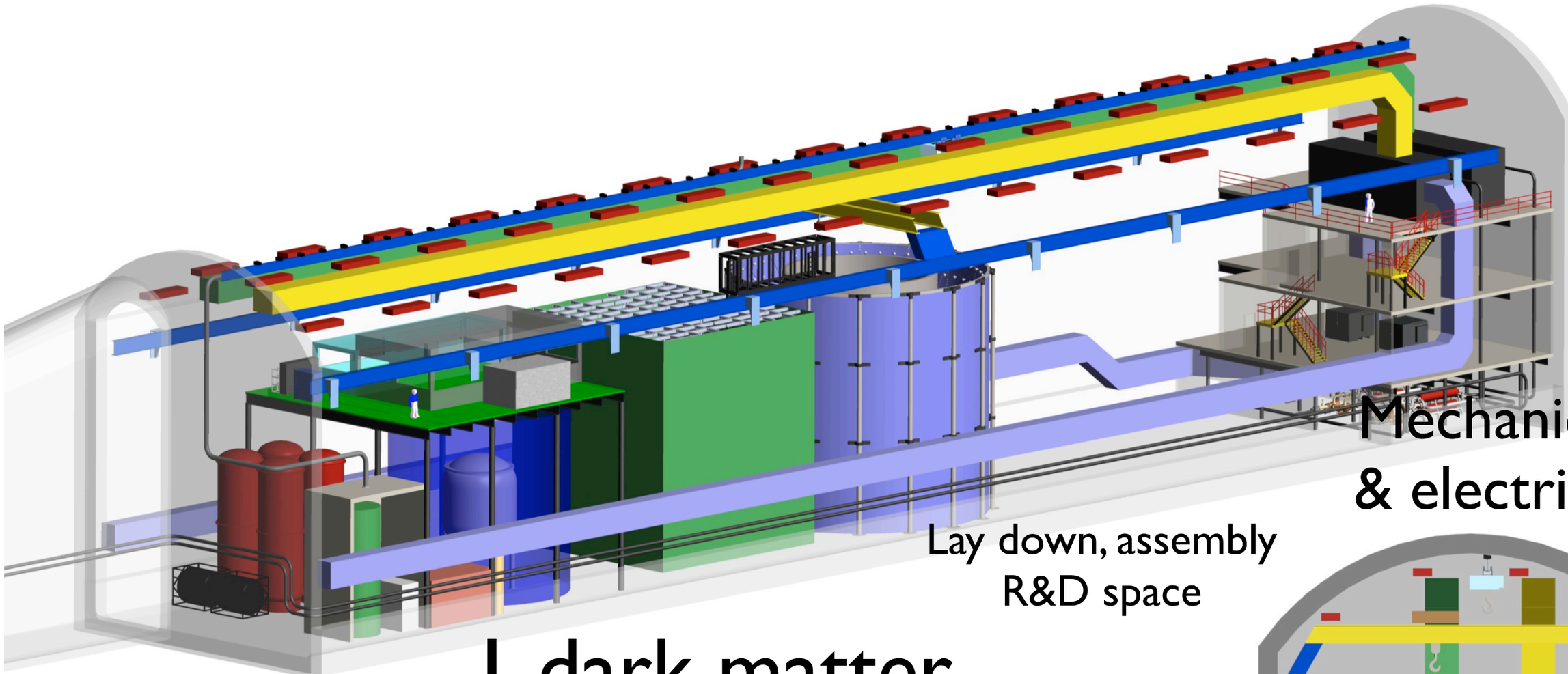
- NRC and Marx/Reichanadter report emphasized the importance and benefits of collocating physics experiments in a single facility.
- We have prepared and presented conceptual design options to host DM and DBD at the 4850 and 7400L. Plans now focused on the 4850L (Plan B).
- The incremental cost for the Lab Module at 4850L would be ~$100M. Module could host multiple experiments. Cost and schedule estimates have been validated.
- More recently we have prepared a pre-conceptual estimate for the 4850L lab module independently developed from LBNE and with minimal facility improvements. *Plan B-prime*

Sanford Underground Research Facility SURF

Plan B (Minimum Scope Facility at 4850L)

- Reduce Facility Scope (from DUSEL PDR) to a minimum that supports:
  - LBNE
  - Early Science in the Davis Campus (DLM, DTA) (LUX, MAJORANA Demonstrator, and perhaps a G2 Dark Matter Experiment, some Low Background Counting (CUBED))
  - A single Laboratory Module (LM) at 4850L supporting both
    - a single G3 Dark Matter experiment
    - a 1 tonne-scale neutrinoless double beta decay experiment
- Facility Design
  - LBNE and Single Laboratory Module (20m x 24m x 115m: 100m science, 15m MEP)
  - Safe, redundant, but not-significantly modified, access
  - Preserves options for deeper LMs, additional LMs, and facility improvements
  - Sanford supported Education & Outreach on the surface
  - Preserves option for NSF participation in the science (and associated infrastructure)
    - 2nd DM experiment - share the cost of the LM?
    - Nuclear Astrophysics Facility and LM
    - participation in Long Baseline Neutrinos and/or Proton Decay, Neutrinoless Double Beta Decay
    - Biology, Geology, & Engineering program (0 to 4850L) as stand-alone efforts

Plan B - 20m wide x 24m high x 115m

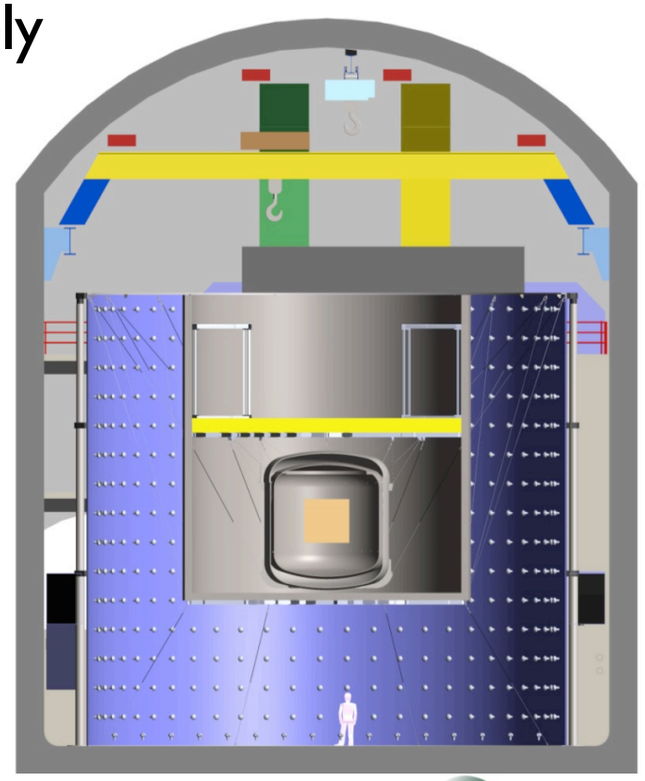


Mechanical & electrical

Lay down, assembly R&D space

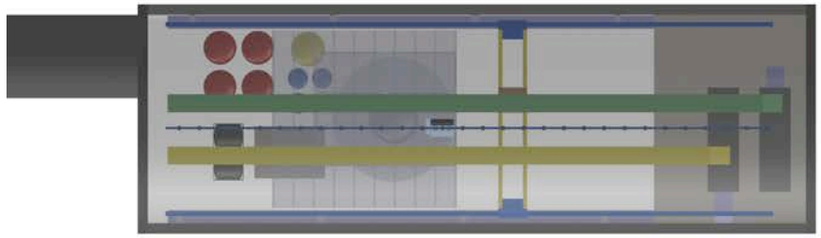
1 dark matter target

1 0νββ expt & support



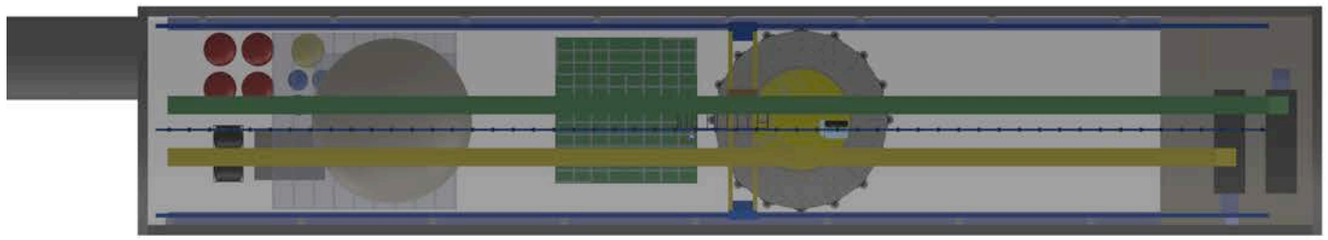
Plan B - Options

Cost/schedule compared in Backup



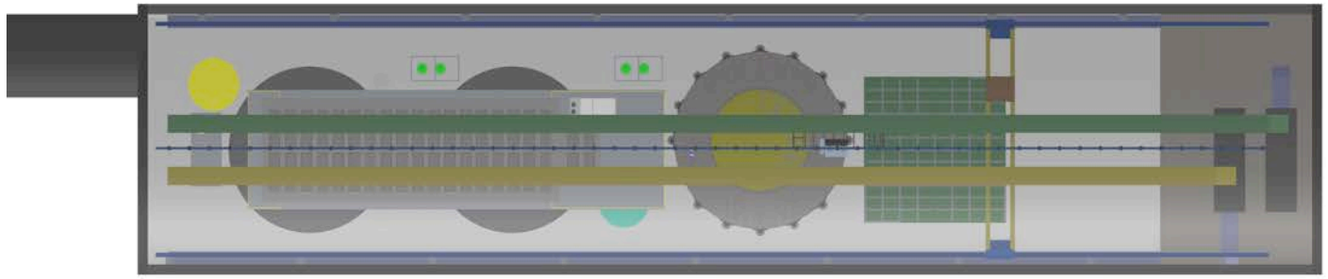
Shorter Module

20x24x65



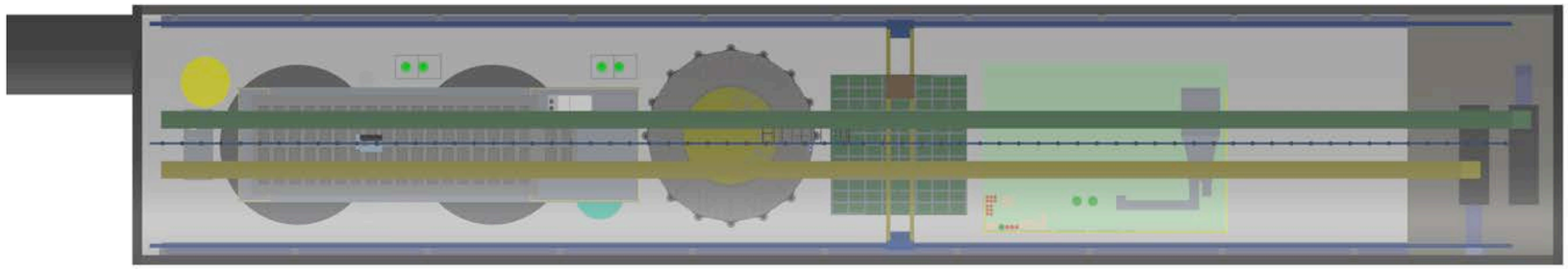
Baseline

20x24x115



Wider/Taller Module

24x28x115



Wider/Taller & Longer Module

24x28x145

Developing concepts for a 4850L Lab Module independently developed from LBNE (Plan B prime)

- Customized and scaled for Gen-3 DM and 1-tonne DBD
- Use Operations Staff for some Rehab/Facility Improvement Projects
- Reduced facility infrastructure, utilities, and support would be required

PAC comments on Science Program

- SURF Program Advisory Committee met: 14-16 December
  - full report posted on SURF website (www.dusel.org)
  - focused on the physics in the Davis Campus and facility readiness
  - *SURF:*
    - *The SURF management team has done a superb job of advancing the project under very difficult conditions, with uncertain funding prospects. Every attempt should be made to capture their talent, experience, and spirit in forming the organization that will continue to build SURF in the future.*
  - LUX
    - *The experiment has made great progress in commissioning the full detector system on the surface. The goal is to have the detector fully commissioned and taking science data by the end of calendar 2012. The surface testing facility has been a major asset.*
  - MAJORANA DEMONSTRATOR
    - *The PAC was presented with evidence, both documentary and physical, of impressive progress on MJD, and it appears that data taking can begin in 2013-2014. A major goal for MJD will be to try to achieve a background below 4 counts/ton-year in a 4-keV-wide spectral region of interest. This would be an important step in reaching the background levels necessary for a ton-scale experiment.*
  - LBNE
    - *We are very impressed with the rigorous and thoughtful approach that the Collaboration has taken in reaching its [technology] recommendation. We look forward to a formal decision on the detector technology choice and rapid movement toward achieving approval of CD-1 in FY 2012.*

SURF: Establish, support and maintain world-class research programs

- Dark Matter
  - G1 LUX (350kg) and potential upgrades
  - G2 (~2T) experiments using existing infrastructure
  - G3 (~10T) in a new Lab Module
- Neutrinoless Double-Beta Decay
  - G1 & Electro-forming Lab MAJORANA DEMONSTRATOR
  - On-going material generation, assay
  - 1 tonne-scale experiment in a new LM
- Identifying additional space suitable for G2-scale and R&D
- Long Baseline Neutrinos, Proton Decay, and ancillary neutrino measurements

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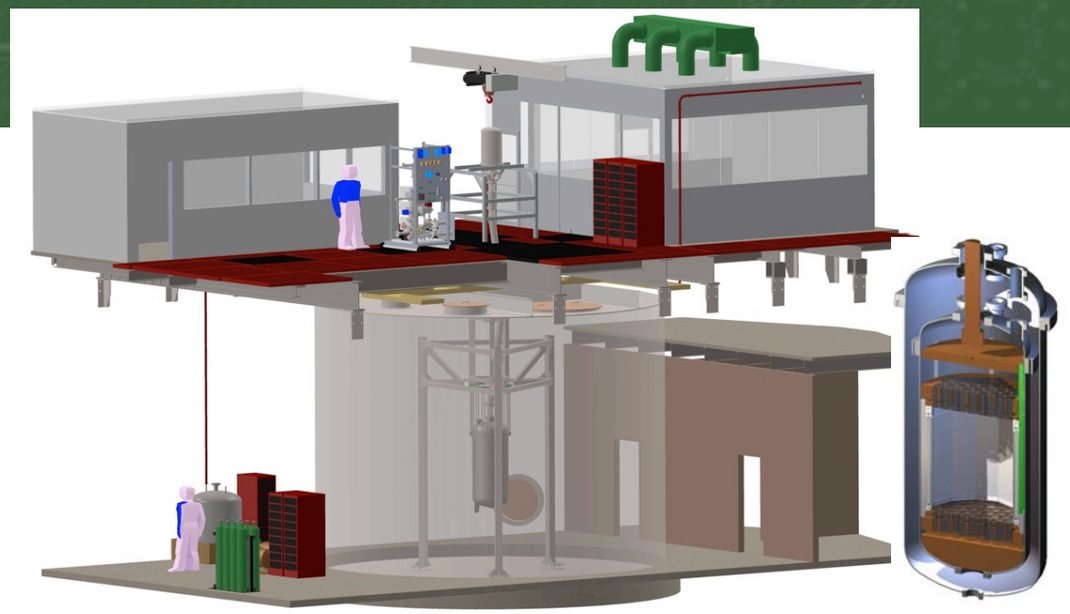

LUX – 350kg

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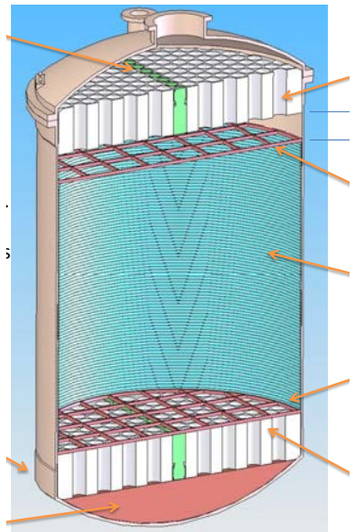

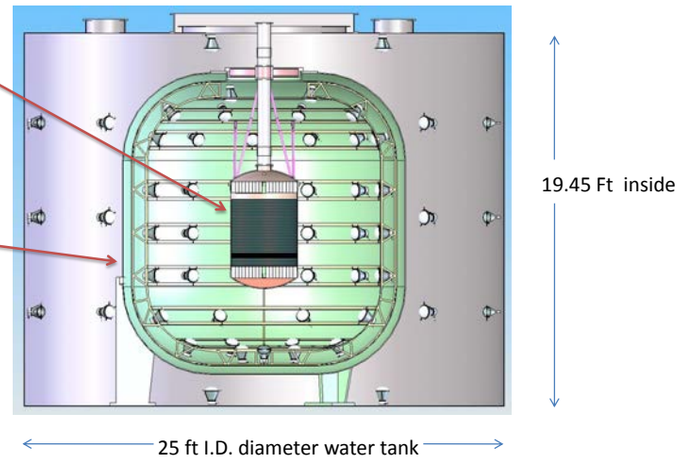

G2 ~ 2 tonne

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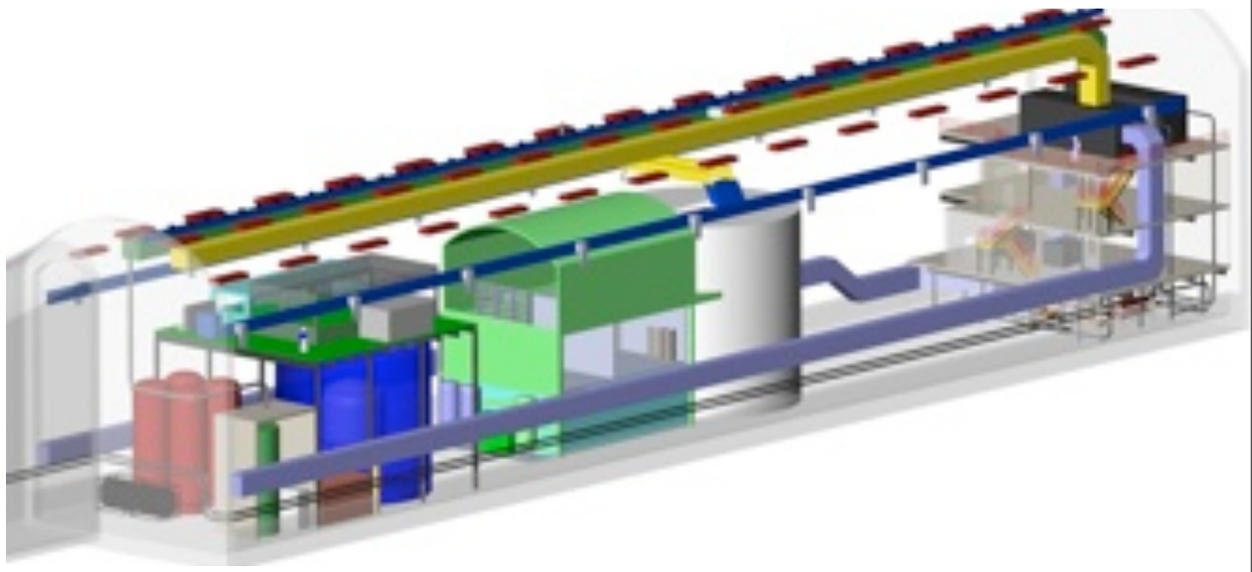


G3 ~ 10tonne

Experimental Timelines at SURF

Year	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
Dark Matter	Davis Campus											
Gen-1		LUX		(Upgrades?)								
Gen-2					Generation-2							
R&D Efforts								R&D and Prototypes				
						Construction				Lab Module 4850L		
Gen-3									Generation-3			
0νββ												
MJD Electroforming	Temporary Clean Room											
Majorana Demonstrator		Davis Campus										
LBNE (possible timeline)												
CD - Approvals			CD1									
				CD2/3a								
					CD3							
						Construction						
									Outfitting, Liner, etc			
										LBNE		

Generation-2 Dark Matter Experiments

- Multiple technologies are being developed and showing promise for scalability and exquisite sensitivity
- DOE have recently announced plans to develop a *roadmap* for Dark Matter and a Funding Opportunity Announcement is being prepared for the near future: {at least one G2 experiment, coupled with additional smaller R&D efforts}. NSF presented plans for a solicitation to continue their underground physics efforts initiated with the DUSEL S-4
- The Davis Campus Infrastructure is likely suitable for one G2 Dark Matter experiment without significant modification
- We believe that hosting a G2 experiment at Homestake is critical for the domestic program

Additional Research Areas in Homestake

- Responding to community interest and world-wide pressures to identify deep underground research space, the SURF team has reviewed existing space at or near the 4850L suitable or expeditiously adaptable for R&D or G2 efforts

- Further emphasizes the synergistic nature of hosting multiple efforts and sharing infrastructure at SURF – as highlighted in the NRC DUSEL science assessment and the Marx/Reichanadter report

- Pursuing a variety of avenues to fund the development of these areas including philanthropic and non-federal sources

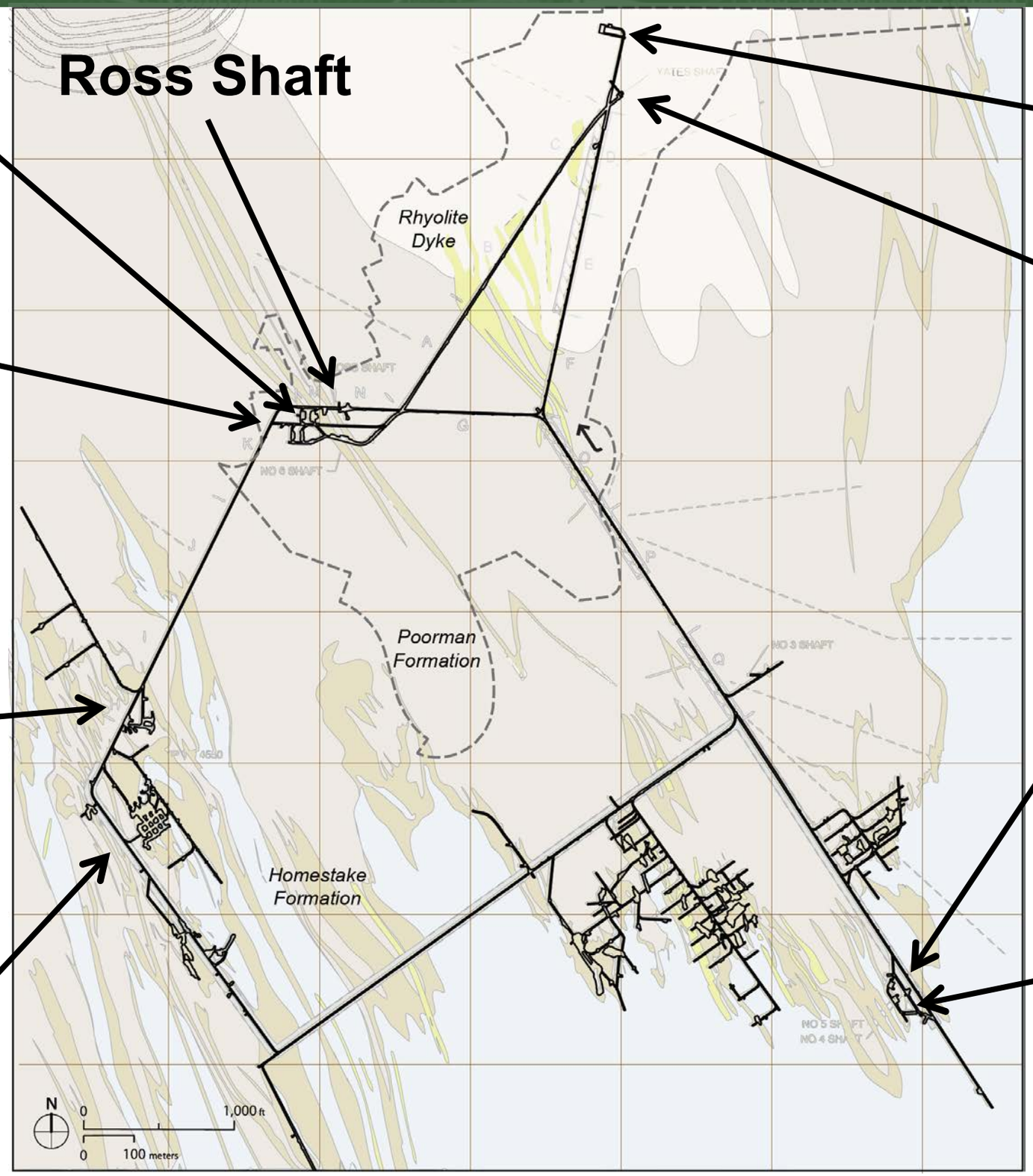
4550 & 4850 Levels

Option #1
4550L #6 Winze

Option #3
Ross Shaft Shop Area

Option #2
17 Ledge Shop Area

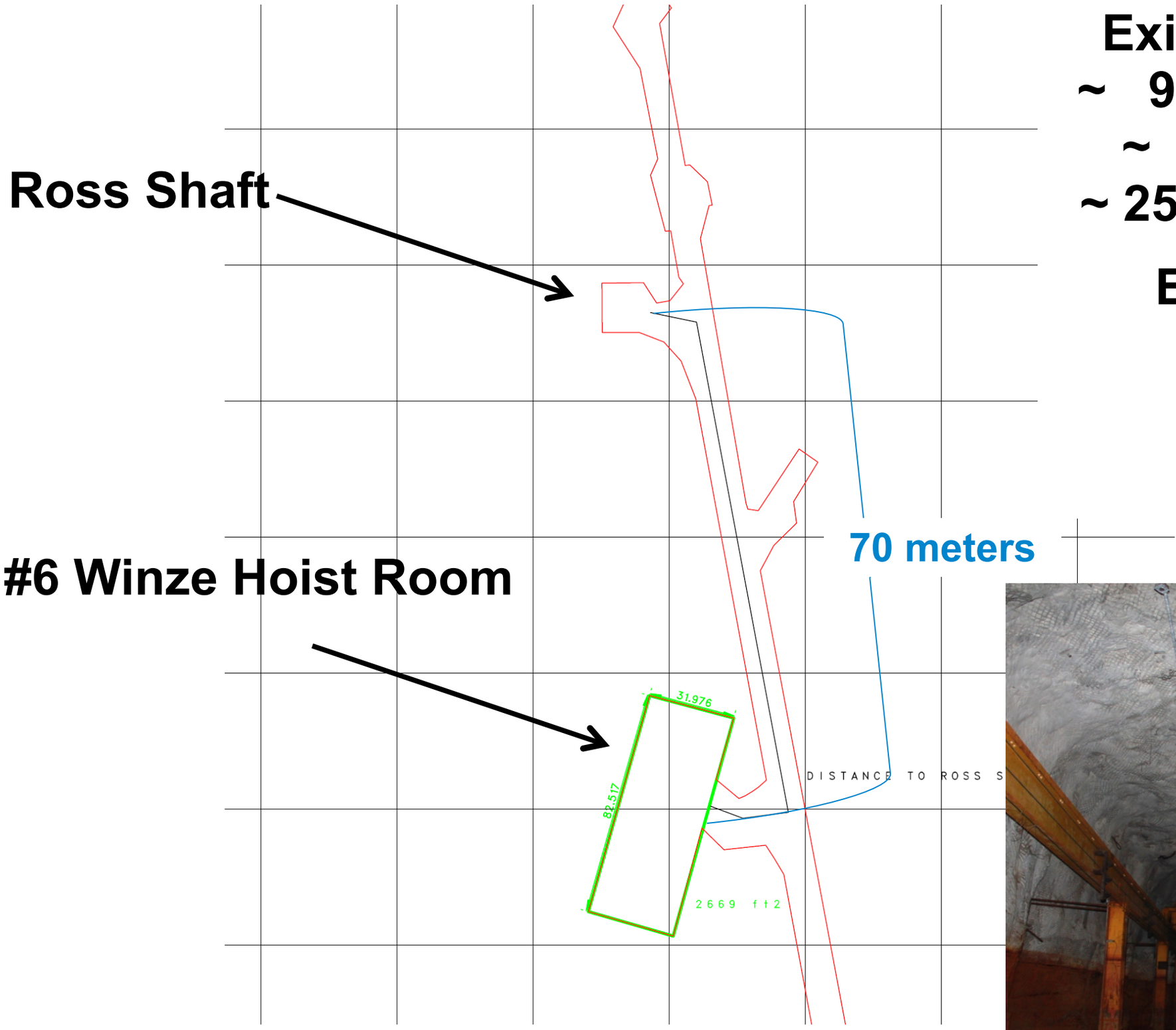
Option #6
Stope Areas



Option #4
#4 Winze Cage Hoist Room

Option #5
#4 Winze Skipping Hoist Room

Option #1 - #6 Winze Hoist Room Location



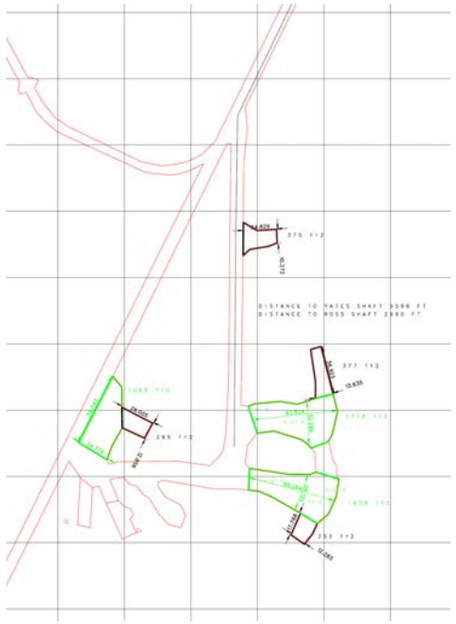
Existing Dimensions:
~ 9.7m (31.9 feet wide)
~ 6m (20 feet high)
~ 25.1m (82.5 feet long)

Existing Volume:
~ 1491 m^3
(~ 52,635 ft^3)

Examples – Ross Shaft Shop Area and 17 Ledge

Existing Rooms Approximate Dimensions

Room	Width meters	Height meters	Length meters	Area m^2	Volume m^3
A	10.3	2.7	16.2	167.9	460.5
B	10.8	2.7	20.0	215.1	590.2
C	7.3	2.7	18.6	134.9	370.0
D	6.2	2.7	21.9	136.9	375.6
E	55.7	2.7	0.5	25.5	69.9



2 existing rooms
~ 7.6m (25 feet wide)
~ 2.9m (9.5 feet high)
~ 19.5m (64 feet long)
Volume:
~ 1048 m^3 (~ 37,012 ft^3)

Basis of Estimate for New Excavation

- ~2550 meters^3 (90,000 cubic feet) of laboratory space ~ Davis Cavity
  - 9m wide (30 feet)
  - 15m high (50 feet)
  - 18m long (60 feet)

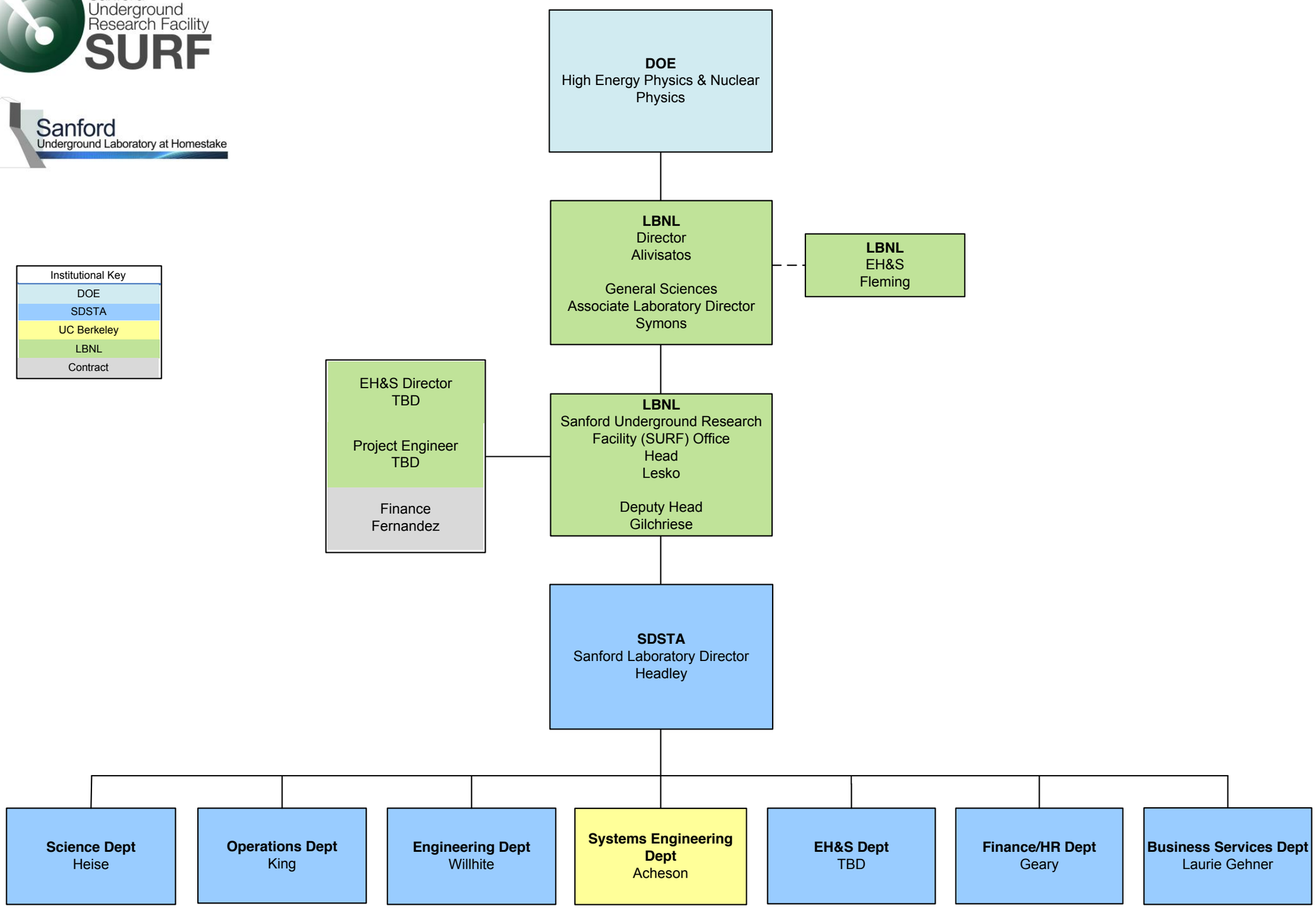
- Infrastructure requirements - assume 2 km length
  - 1.5 megawatt electrical
  - 30,000 cfm ventilation
  - 500 gpm water
  - 12 strand fiber optic cable

- Costs based on Davis Campus unit cost
  - Volume excavation \$630/m^3 total cost
  - Access drift rehabilitation (pattern bolting) \$300 per meter – assume 1 km length
  - Electrical and Fiber optic line \$995 per meter – plus transformers
  - Water supply 500 gpm \$215 per meter
  - Ventilation allowance – case by case assumption
  - Rehabilitation costs – case by case assumption

Sanford Underground Research Facility SURF

Summary – SURF and Homestake

- Low-risk, well-assessed site for DOE's efforts in LBNE, Dark Matter and Neutrinoless Double-Beta Decay
- Significant site preparation and design work completed, at a Preliminary Design Level, much of this applicable to the DOE facility
  - NSF invested $54M in the DUSEL design
  - SDSTA invested $125M in preparation of Homestake
- Science program established at SURF and provides a path for significant results while community assesses LBNE, next generation Dark Matter and Neutrinoless Double-Beta Decay roadmaps and plans
  - Generation 1 Dark Matter and Neutrinoless Double-Beta Decay initiated
  - Generation 2 Dark Matter could be hosted in existing facilities at the 4850L
  - Identifying additional potential areas for R&D and experimental efforts
  - Lab Module at 4850L could host both Generation 3 Dark Matter and 1-tonne Neutrinoless Double-Beta Decay experiments and maximize the synergisms with LBNE
- Efficient and stable operations, maintenance, EH&S programs and organizations exist

backup slides

SURF Organization for FY12