Sanford Underground Research Facility
FroST - THEIA Detector Workshop

David Vardiman

Project Engineer

October 22-24, 2016

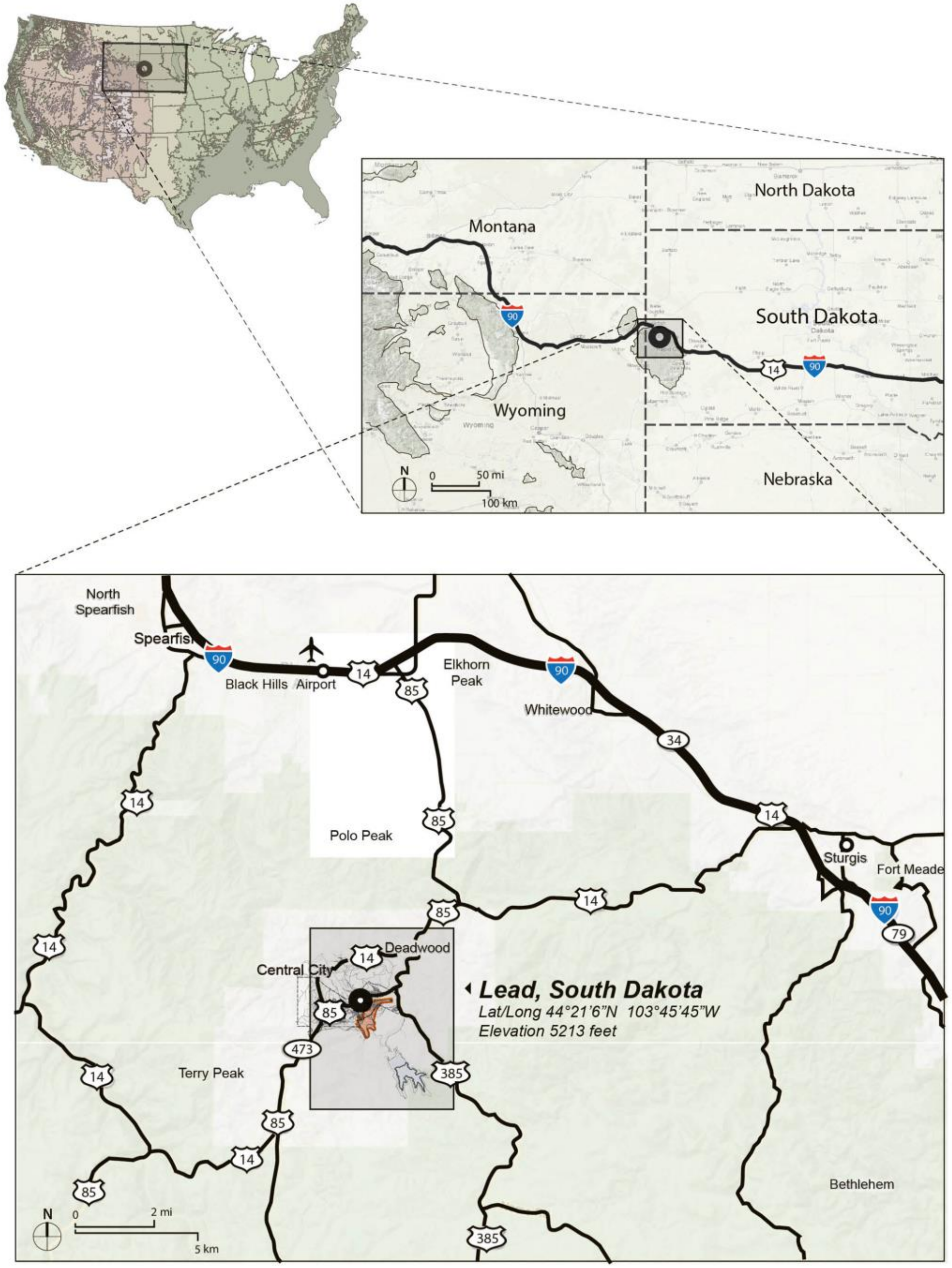
Sanford Underground Research Facility
South Dakota Science and Technology Authority

Agenda

- SURF Facilities
- Existing Science
- Future Science
- 4850L Geotechnical Site Investigations
- THEIA Basis of Design
- THEIA Basis of Estimate

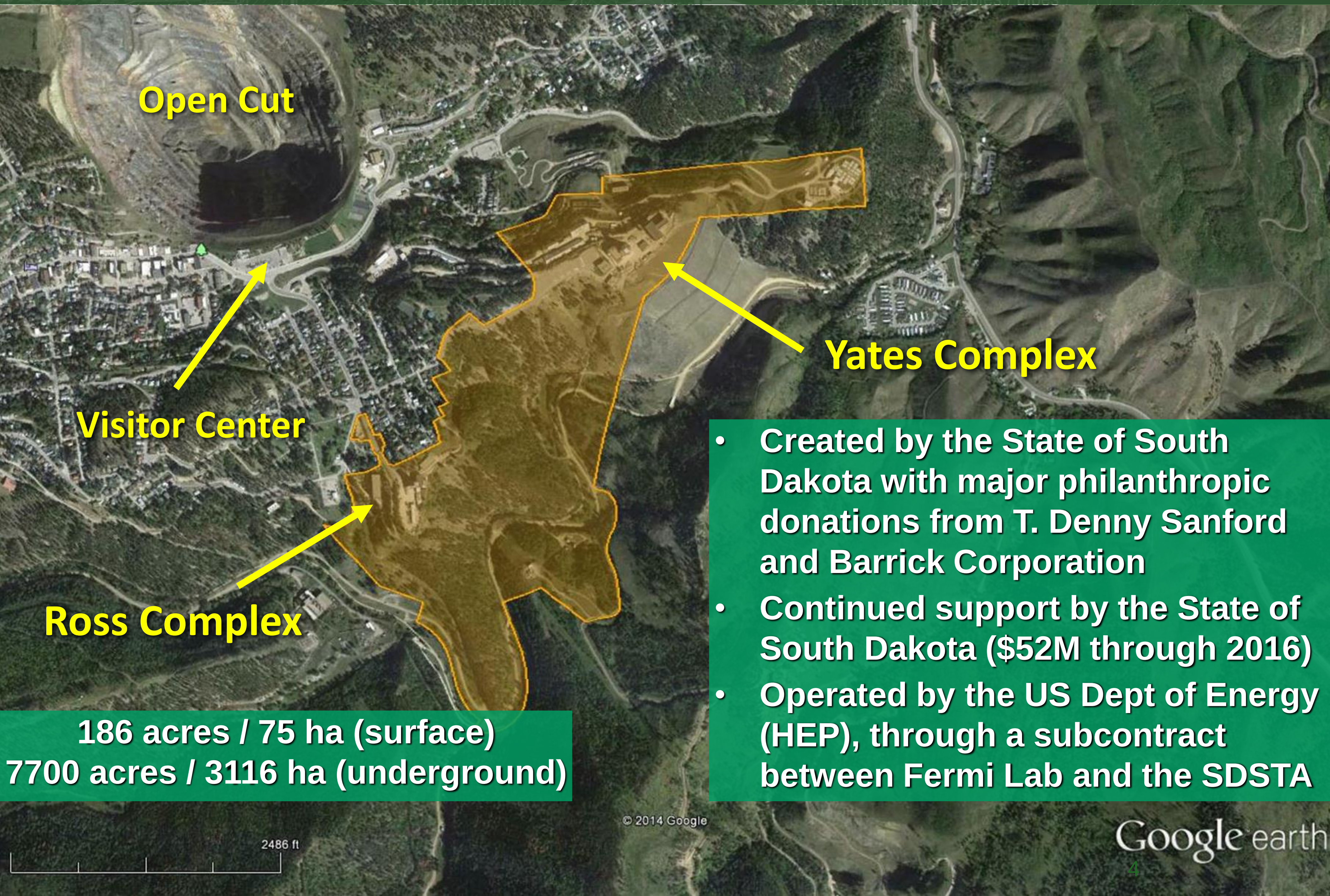
Sanford Underground Research Facility

Dedicated facility for underground scientific research



Sanford Underground Research Facility

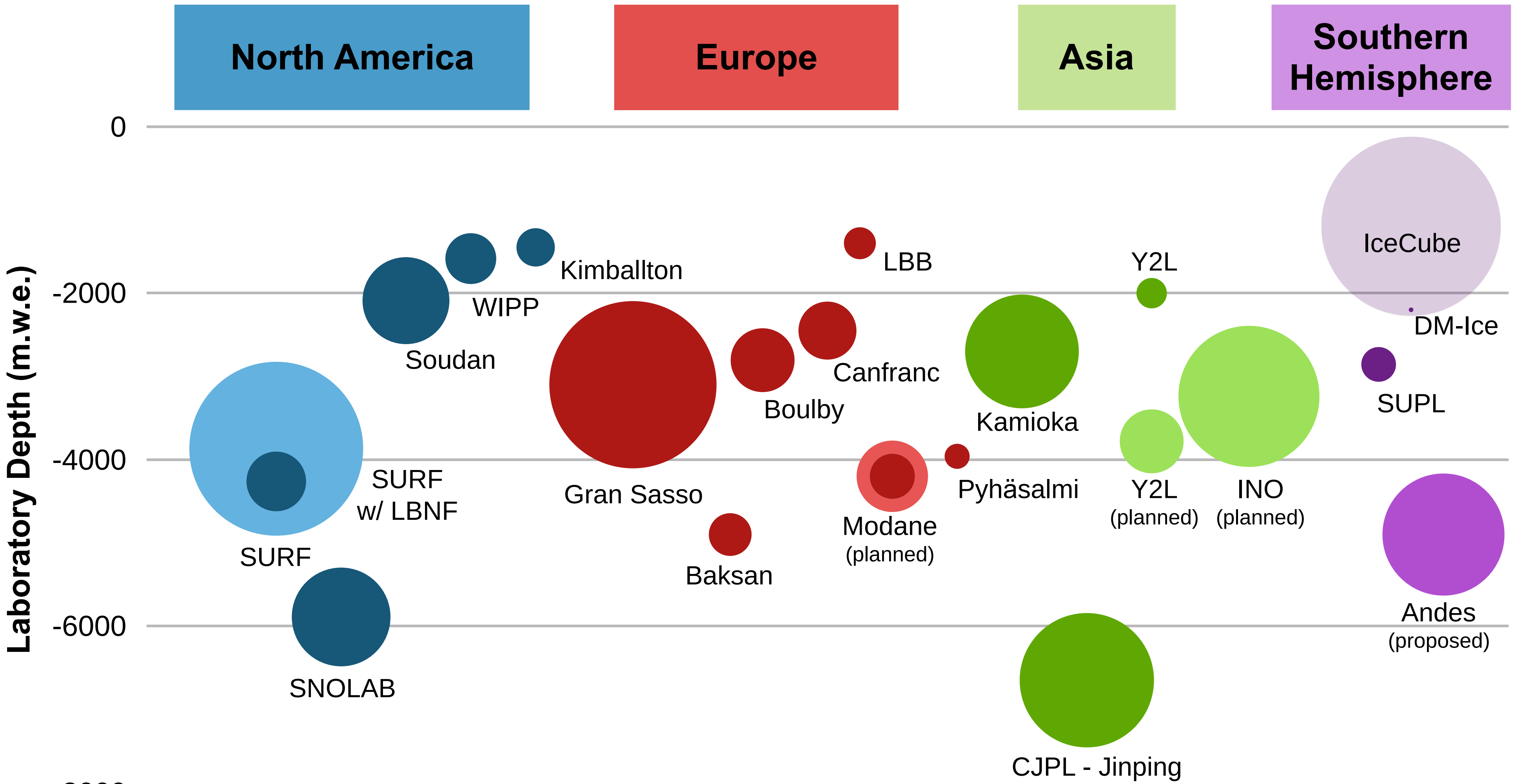
Dedicated facility for underground scientific research



186 acres / 75 ha (surface)
7700 acres / 3116 ha (underground)

- Created by the State of South Dakota with major philanthropic donations from T. Denny Sanford and Barrick Corporation
- Continued support by the State of South Dakota ($52M through 2016)
- Operated by the US Dept of Energy (HEP), through a subcontract between Fermi Lab and the SDSTA

Global Underground Laboratories



SURF Science Institutions

Current Researchers From All Around the World (60 institutions)

United States

- Bigelow Laboratory, East Boothbay, MA
- Brown University, Providence, RI
- **Black Hills State University, Spearfish, SD**
- Caltech, Pasadena, CA
- Case Western Reserve University, Cleveland, OH
- Colorado School of Mines, Golden, CO
- **Dakota State University, Madison, SD**
- Desert Research Institute, Las Vegas, NV
- Duke University/TUNL, Durham, NC
- Fermi National Accelerator Lab, Batavia, IL
- Idaho National Laboratory, Idaho Falls, ID
- Indiana University, Bloomington, IN
- Jet Propulsion Laboratory, Pasadena, CA
- Lawrence Berkeley National Lab, Berkeley, CA
- Lawrence Livermore National Lab, Livermore, CA
- Los Alamos National Lab, Los Alamos, NM
- National Energy Tech Lab, Albany, OR / Morgantown, WV
- North Carolina State University, Raleigh, NC
- Northwestern University, Evanston, IL
- Oak Ridge National Lab, Oak Ridge, TN
- Pacific Northwest National Lab, Richland, WA
- Princeton University, Princeton, NJ
- Rensselaer Polytechnic Institute, Troy, NY
- Sandia National Laboratory, Albuquerque, NM
- **South Dakota School of Mines & Tech, Rapid City, SD**
- **South Dakota State University, Brookings, SD**
- Spearfish School District, Spearfish, SD
- SLAC National Accelerator Lab, Menlo Park, CA
- Stanford University, Stanford, CA
- State University of New York, Albany, NY

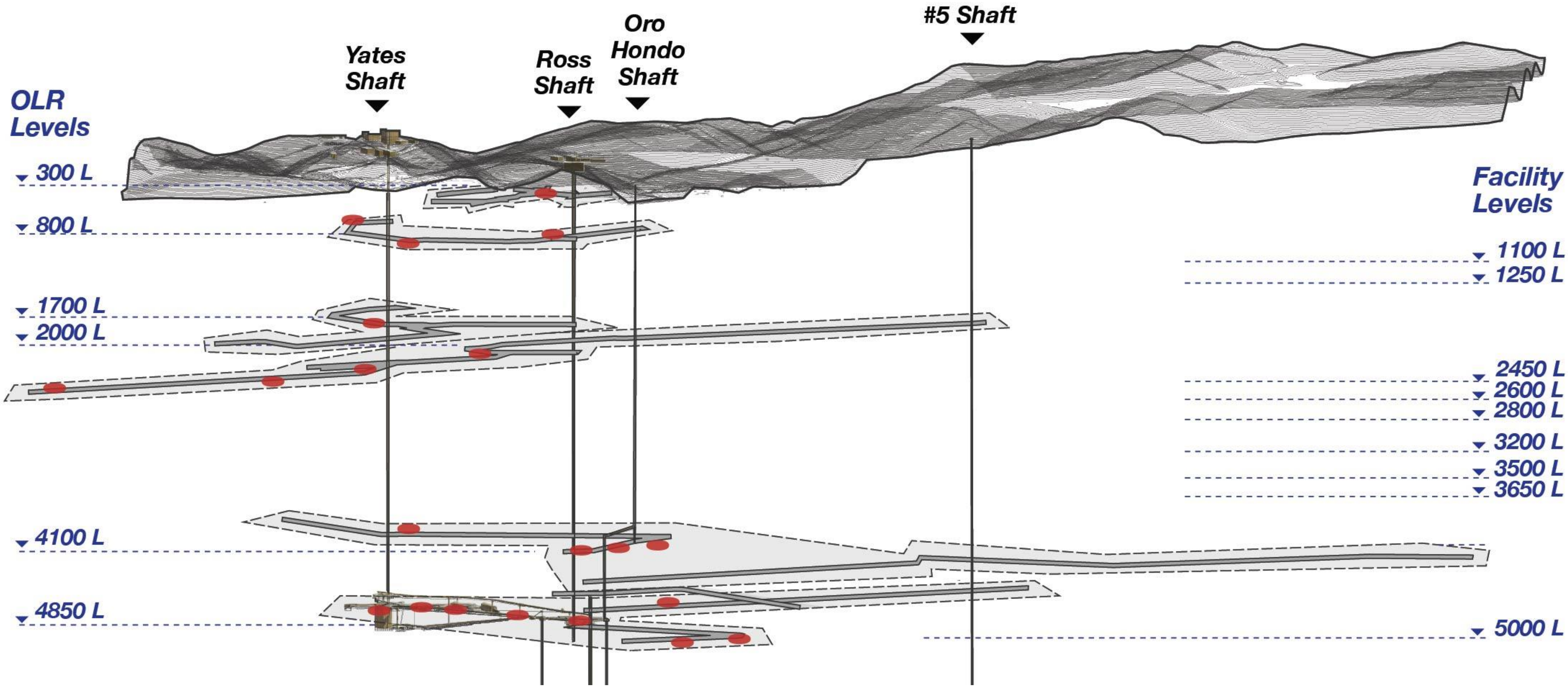
US – continued

- Tennessee Tech University, Cookeville, TN
- Texas A&M University, College Station, TX
- US Geological Survey (AZ/SD), Tucson, AZ
- University of California Berkeley, Berkeley, CA
- University of California Davis, Davis, CA
- UC Santa Barbara, Santa Barbara, CA
- University at Albany/SUNY, Albany, NY
- University of Maryland, College Park, MD
- University of Minnesota, Minneapolis, MN
- University of North Carolina, Chapel Hill, NC
- University of Notre Dame, Notre Dame, IN
- University of South Carolina, Columbia, SC
- **University of South Dakota, Vermillion, SD**
- University of Southern California, Los Angeles, CA
- University of Rochester, Rochester, NY
- University of Tennessee, Knoxville, TN
- University of Wisconsin, Madison, WI
- University of Washington, Seattle, WA
- Yale University, New Haven, CT

World

- Joint Institute for Nuclear Research, Dubna, Russia
- Imperial College London, London, Britain
- LIP– Coimbra, Coimbra, Portugal
- NRC Institute for Theoretical and Experimental Physics, Moscow, Russia
- Osaka University, Osaka, Japan
- Queen’s University, Kingston, Canada
- University College London, London, Britain
- University of Edinburgh, Edinburgh, Scotland
- University of Tasmania, Tasmania, Australia

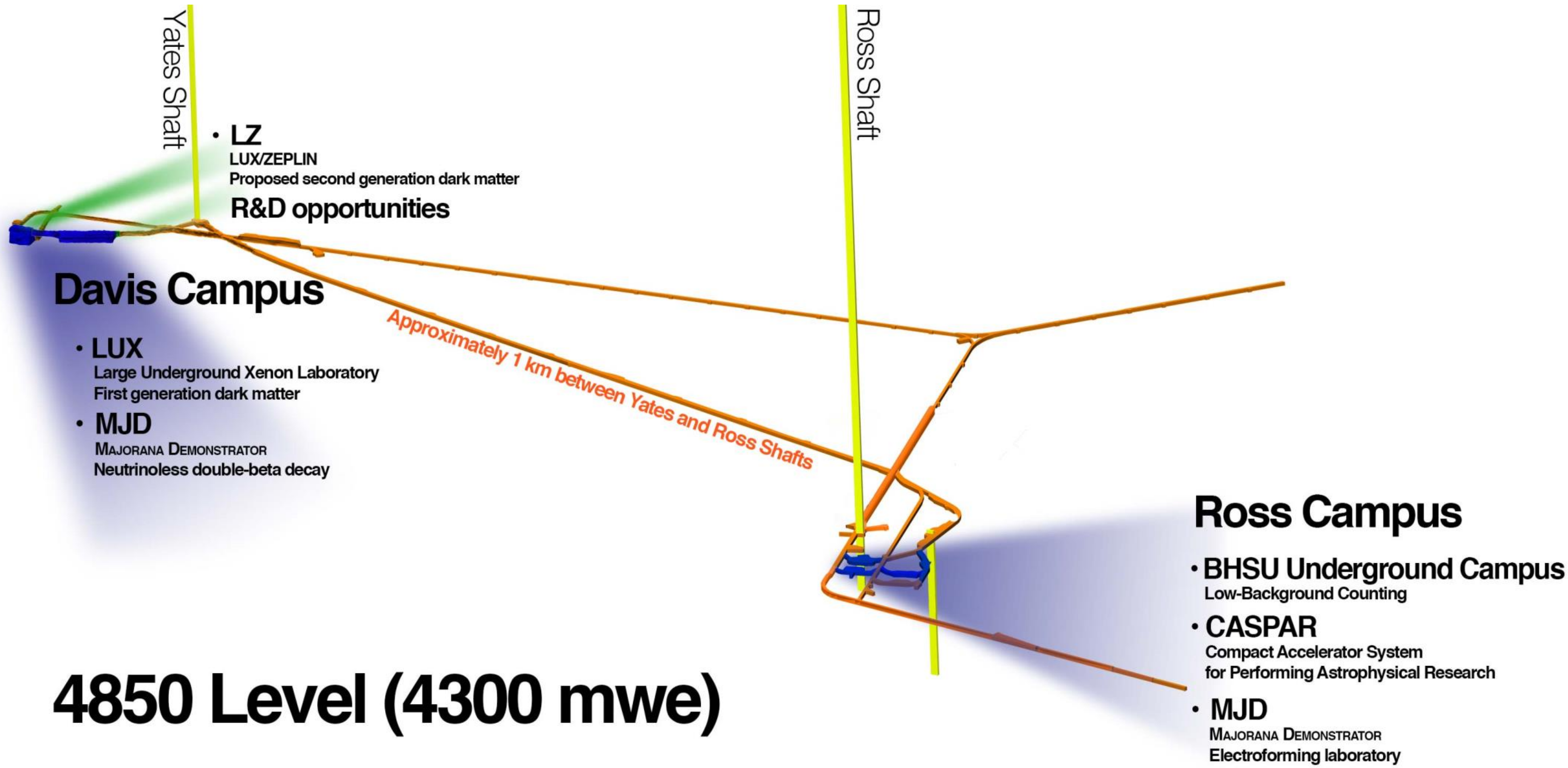
Sanford Lab Existing Science Facilities



- ~600 km of tunnels from Surface to 8000 feet deep
(63 total elevations, 29 currently accessible)
- ~20 km maintained for science and facility operations

Existing Facility-Wide Facilities

4850L Existing Science Facilities



Existing 4850L Facilities

Existing 4850L Physics Program

MAJORANA DEMONSTRATOR (MJD):
Studying the neutrino's mass and the imbalance of matter/antimatter in the universe.
First module installed in the lead/copper shield. Module 2 detector strings assembled and in the shield. Physics data expected 2016.

Large Underground Xenon (LUX):
Direct detection of dark matter.
300-day data completed in May 2016.
4x improvement and still the most sensitive.

Compact Accelerator System for Performing Astrophysical Research (CASPAR):
Studying nuclear reactions in stars.
Assembly in process. Operations planned for 2016.

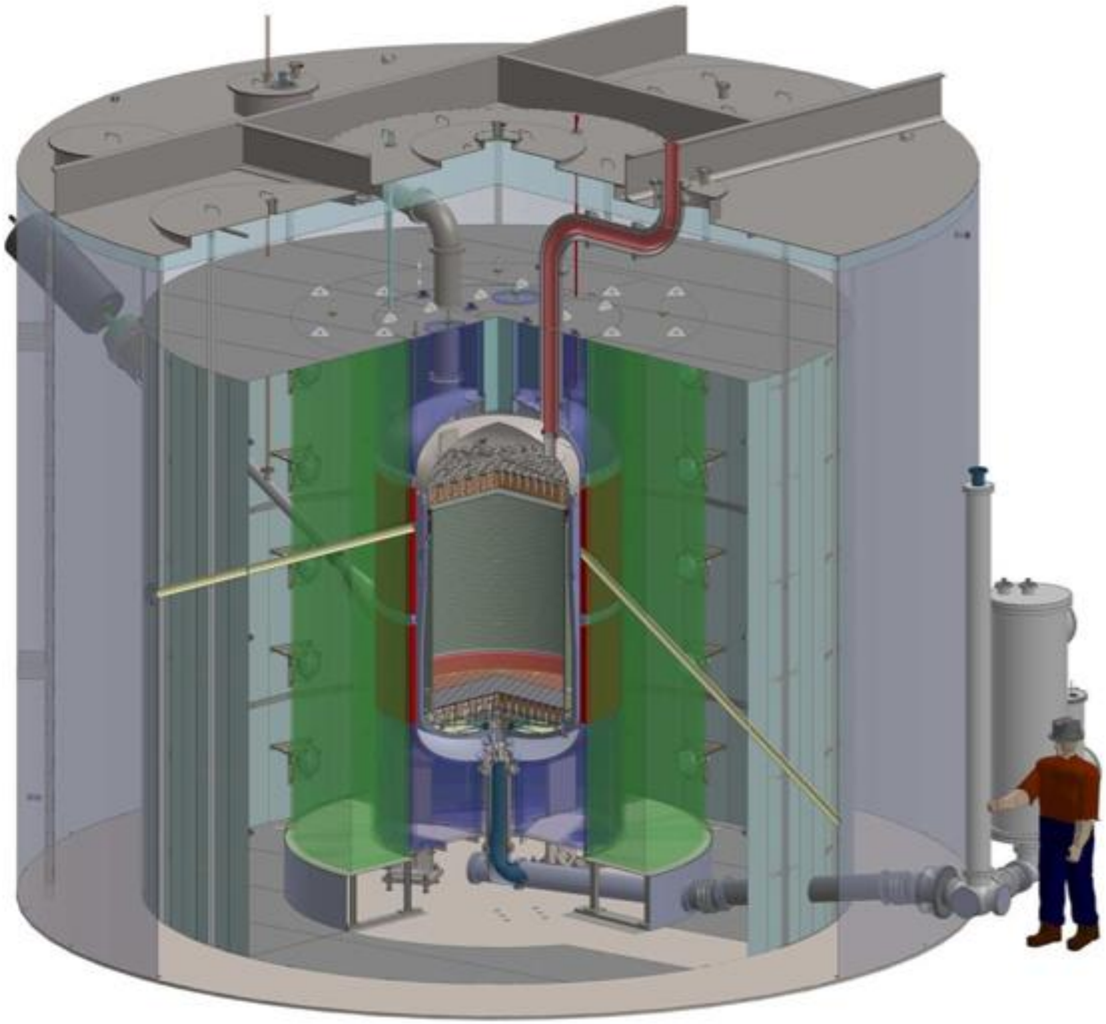
Black Hills State Univ. Underground Campus:
Low Background Assay and Measurement
Installed 4 Low Background Counters. More planned.

LUX Detector Deployed in Water Shield Tank

300 live day run concluded in May 2016. 4x improvement in sensitivity

LUX-ZEPLIN (LZ) Dark Matter Experiment

LZ will be located in the Davis Cavern on the 4850 foot level

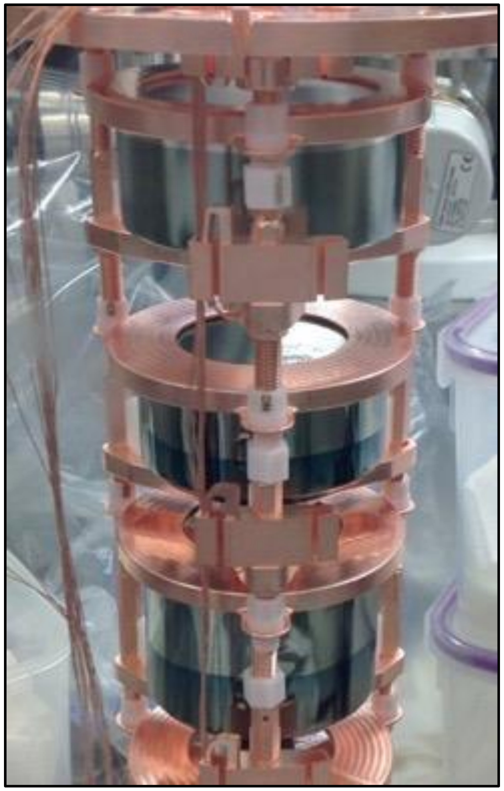


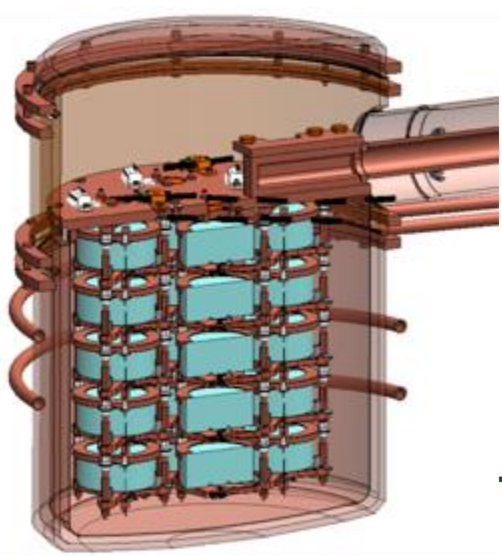
LZ Detector and Shielding

- 30x larger mass than the LUX experiment. 100x more sensitive.
- LBNL leading experiment design and development
- SDSTA to refurbish the existing Surface Laboratory and Davis Campus to host LZ
- Experiment and facility design work currently underway
- DOE recenlty received CD-2/3b
- Facility modifications to occur in 2016 (surface) and 2017 (4850L)
- Experiment installation underground planned for 2018-19
- 5 years of operations envisioned

MAJORANA Shield and Detector Assembly

2 detector modules. 40kg total enriched Ge^{76} . Scheduled start Dec. 2016





Sanford Underground Research Facility

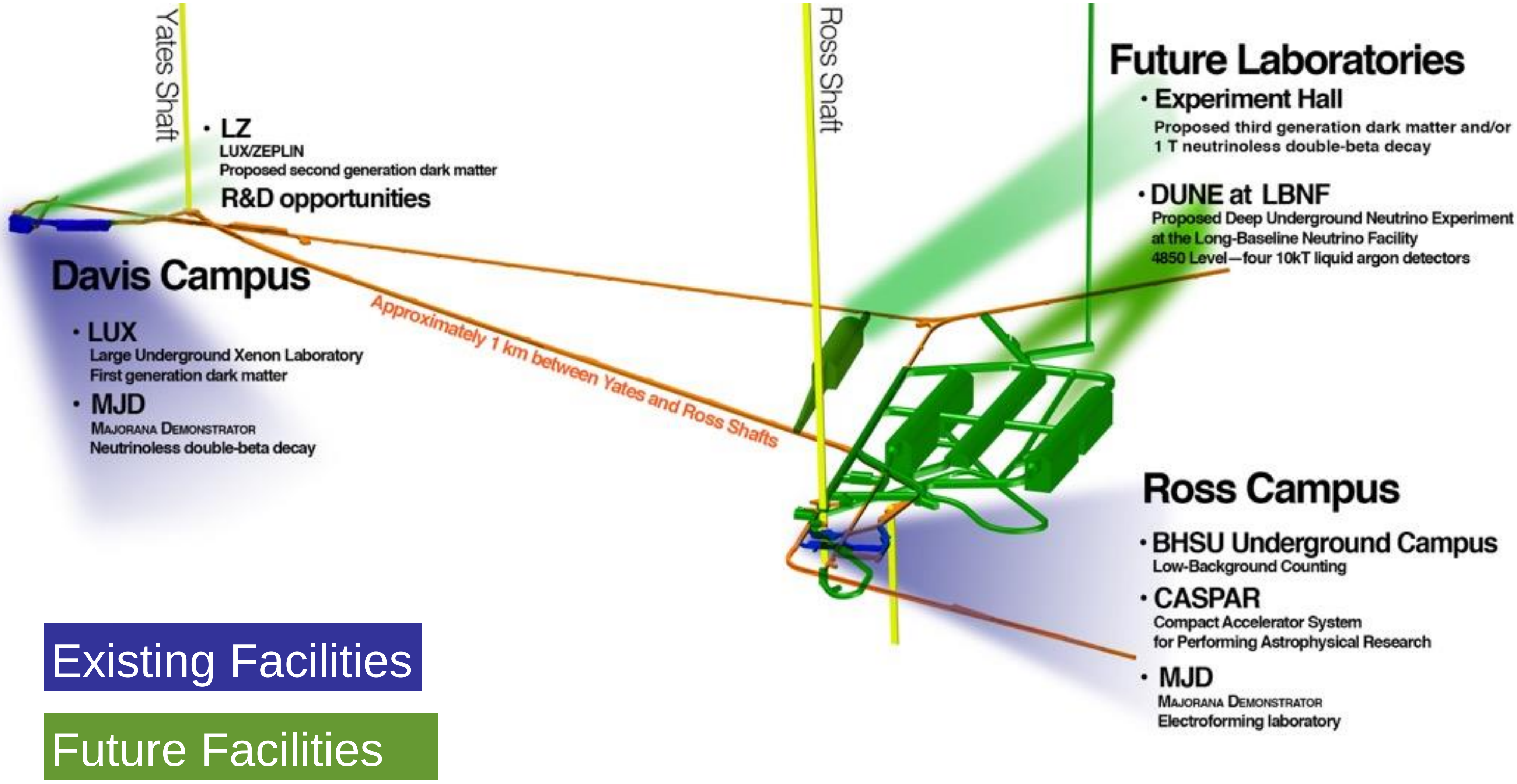
4850L Ross Campus: CASPAR

Compact Accelerator System for Performing Astrophysical Research

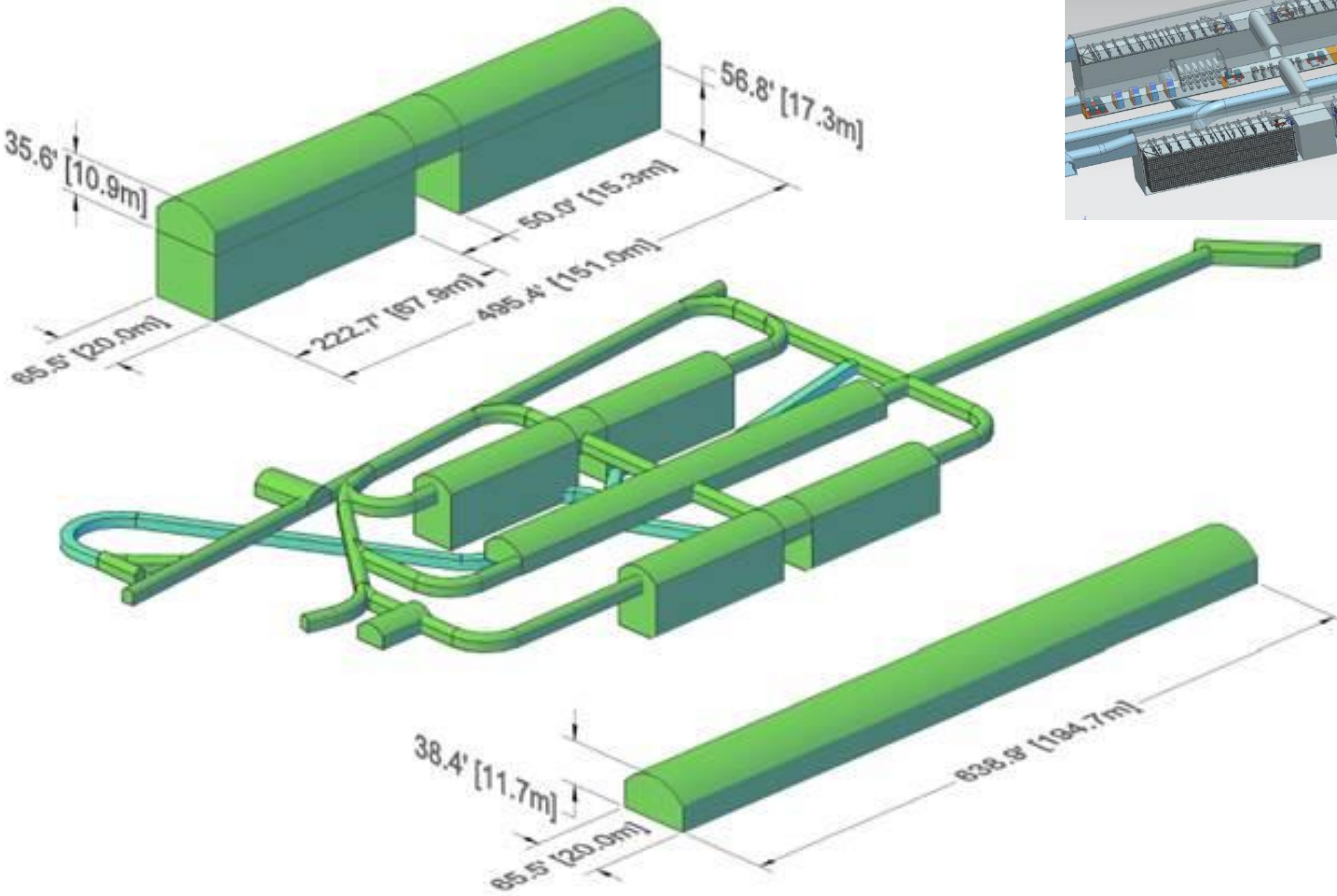
SURF Low-Background Counting

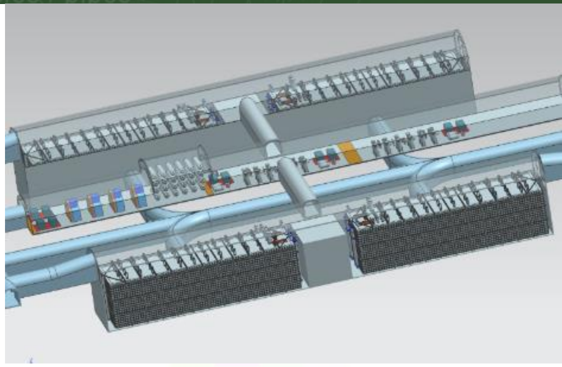
Establishing national-level capability in BHUC Cleanroom at SURF

4850L Future Science Facilities



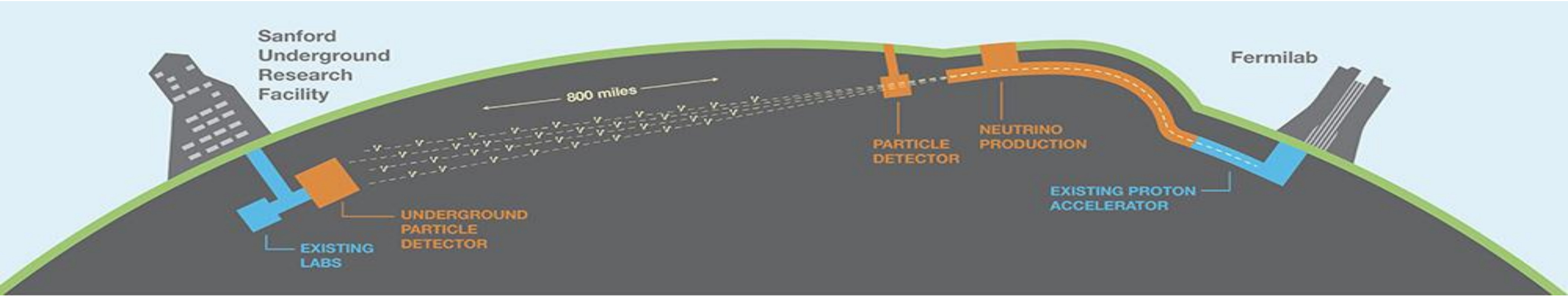
Underground Excavation



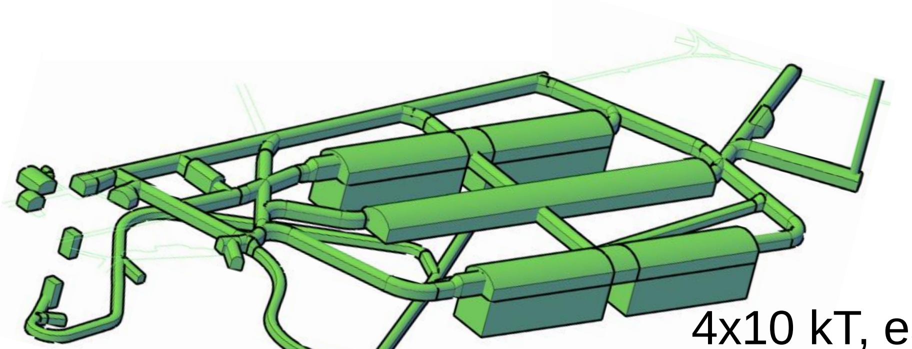


Long Baseline Neutrino Facility

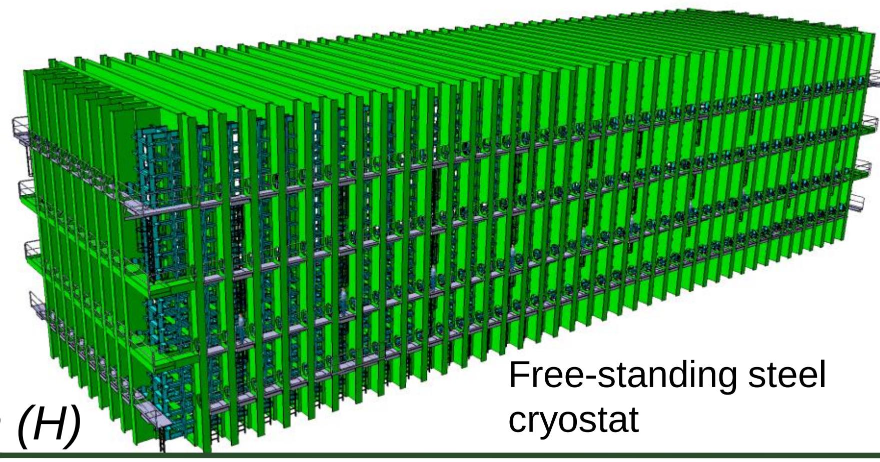
LBNF will host Deep Underground Neutrino Experiment (DUNE)



- LBNF is DOE project led by FNAL, SDSTA leading design for SD facilities
- 2 caverns on 4850L will accommodate 70 kT (total) / 40 kT (fiducial) LAr
- Design optimized to allow parallel excavation/outfitting, geotechnical studies completed 2014, test blast program completed spring 2016
- CD-3a held Dec 2015. Construction approval pending for 2017 start in SD
- Excavation start 2019, ~3 year duration

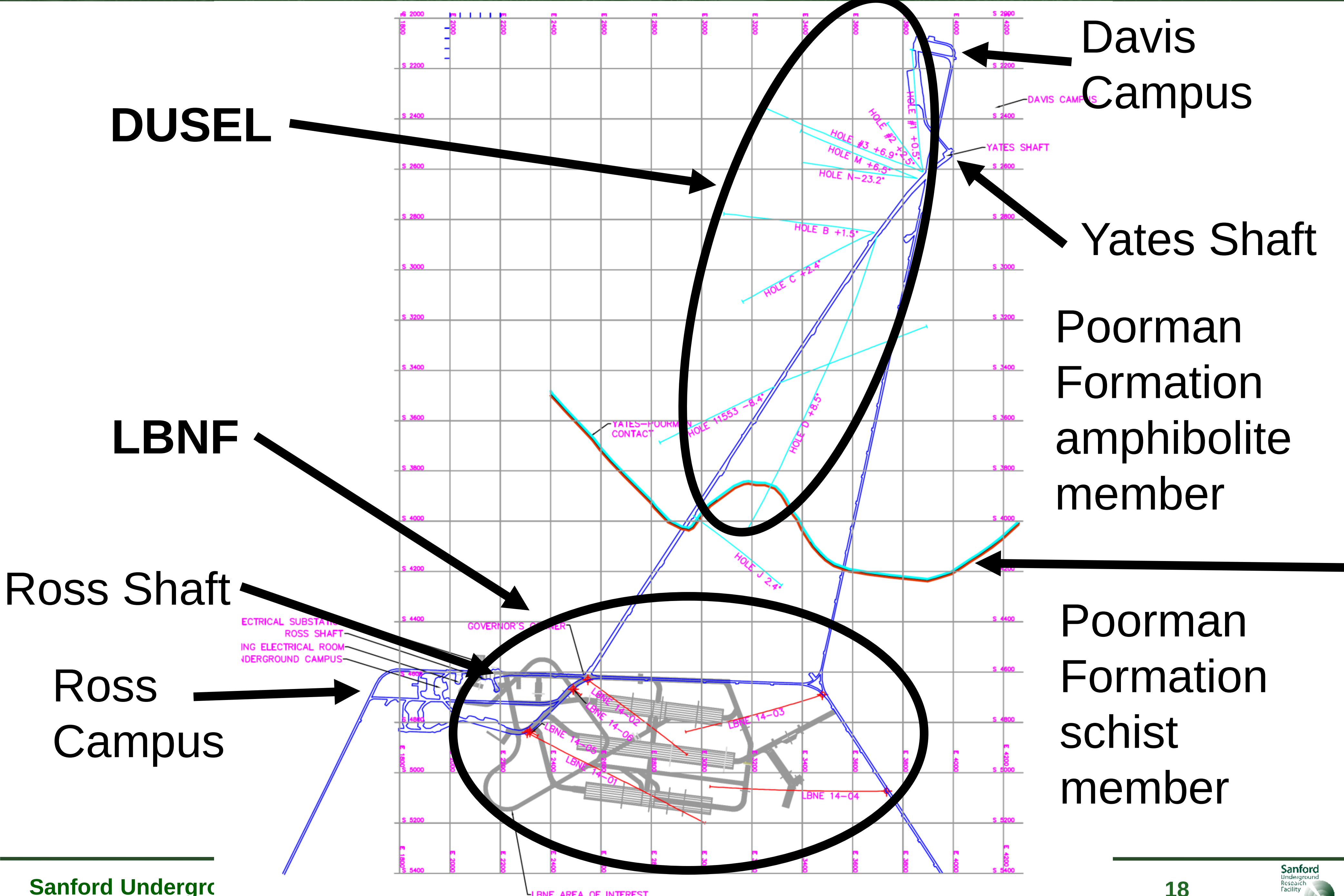


4x10 kT, each chamber:
70m (L) x 20m (W) x 29m (H)



Free-standing steel cryostat

4850L Geotechnical Site Investigations



Phase 1 – Geotechnical Site Investigation

Phase 1 Field Data Collection

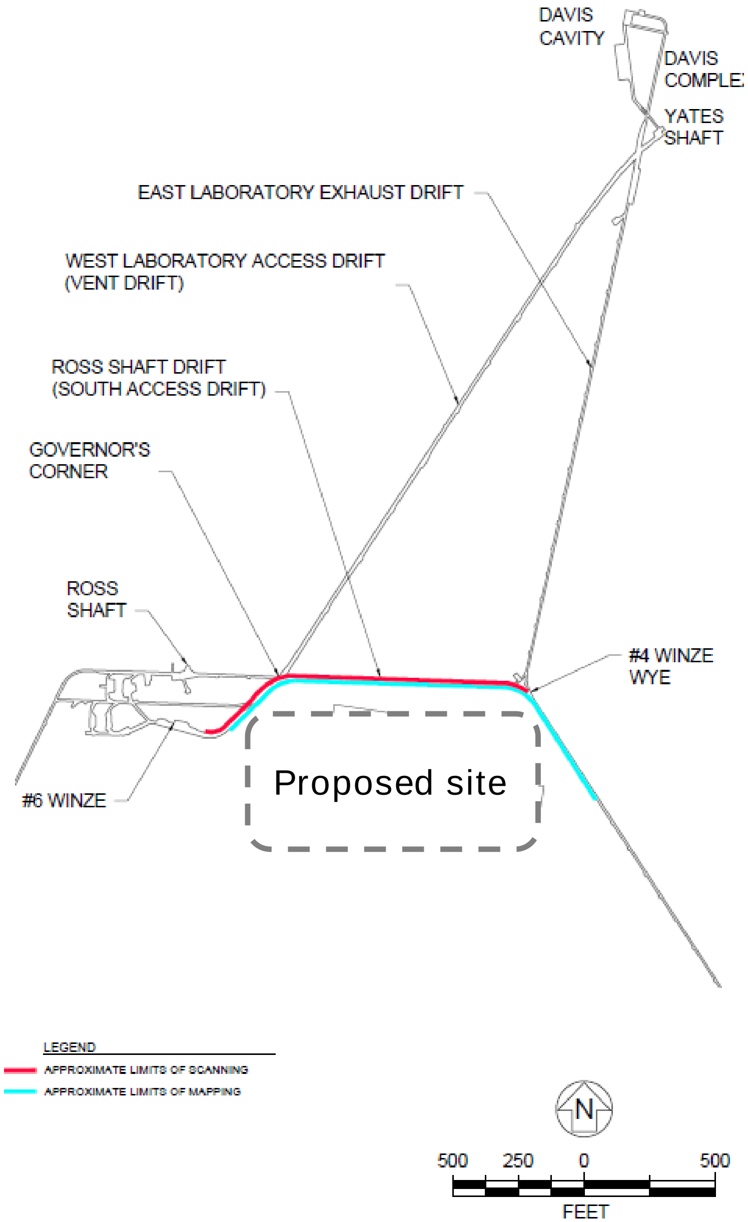
Phase 2 Borehole Investigation

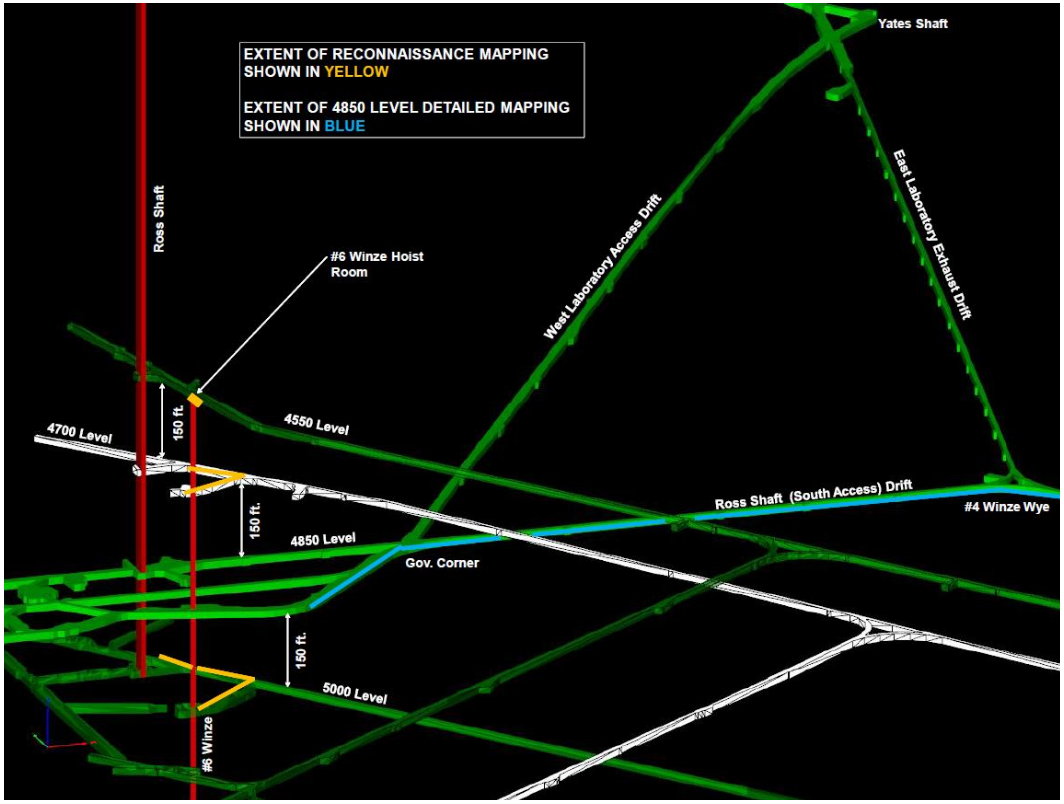
Timeline: Aug. 2013 – July 2014

- Geotechnical site investigation goals and timeline
- Mine drift mapping
- Rock Mass Response and Performance
- Modes of failure

- Core drilling
- In situ stress measurements
- Hydrology
- Lab analyses
- Interpretation of Rock Mass Rated domains
- Modeling

Phase 1 - Mapping Extents





- 1600 ft. (488m) mapped
- 1200 ft. (366m) laser scanned
- Mapped limited areas above (4700 L) and below (5000 L)
- 4550 L hoist room

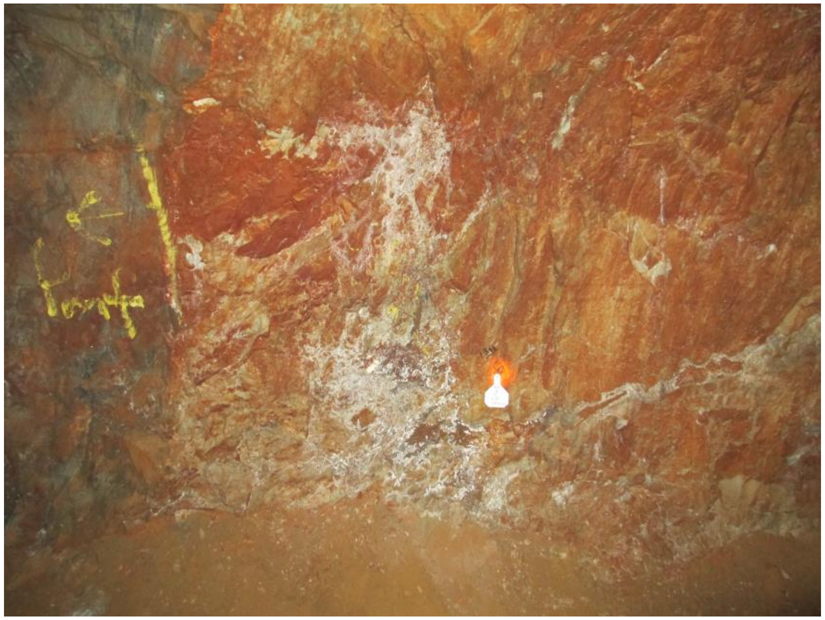
Phase 1 - Drift Mapping

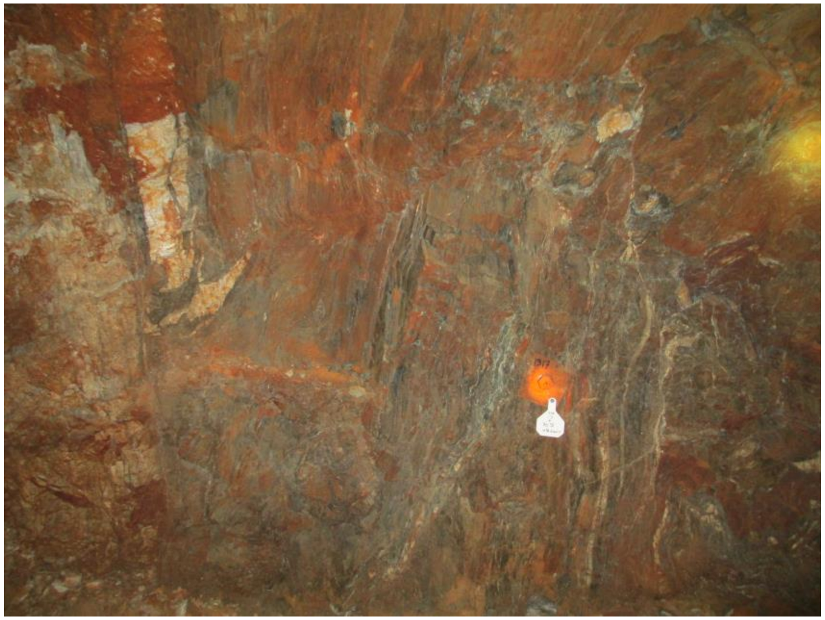
- **Detailed geological mapping of existing mine drifts – both lateral and vertical extents considered**
- **Laser scan drifts to collect as-constructed geometric info for uploading into SURF's Vulcan 3D mine model**
- **Characterize the rock mass and discontinuities for design purposes**

4850L Geological Mapping Observations

Tertiary rhyolite dikes

- Not foliated
- 2 ft. (0.6m) to 40 ft. (12m) wide along drifts
- Contact between the two is generally intact
- Important to map / project as difference in engineering properties may (and has previously been observed) result in adverse behavior during excavation (e.g. spalling)

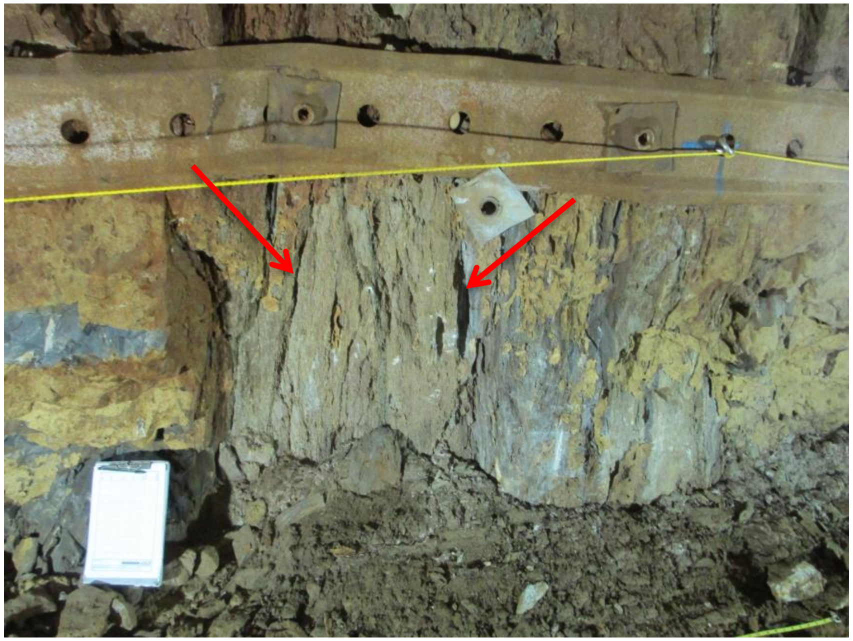




4850L Geological Mapping Observations

Faults and Shears

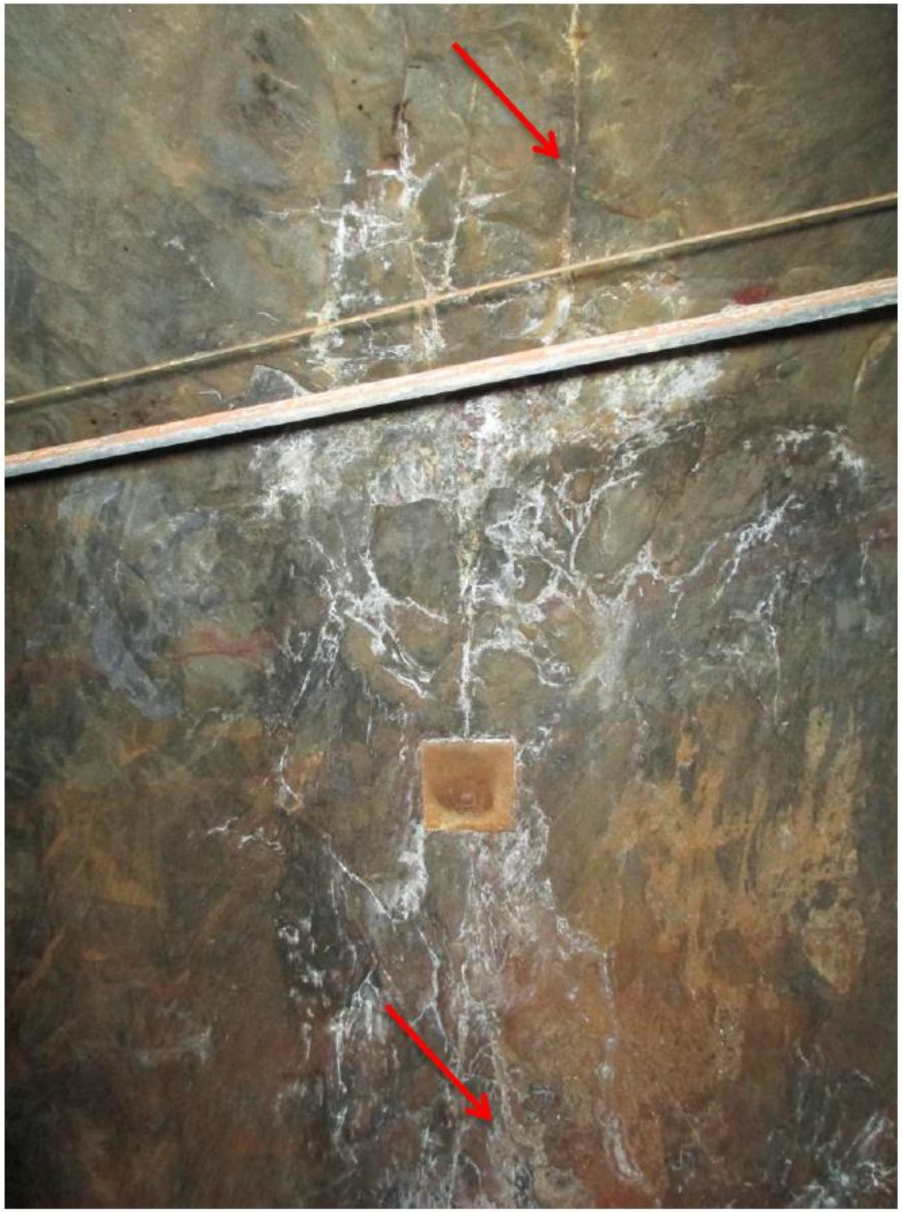
- Limited structures
- Majority well healed
- Some apparent ductile shear zones, mica and quartz rich
- Relatively continuous structure



4850L Geological Mapping Observations

Joint Veins

- Mineralized veins, through-going and high persistence, up to several inches thick
- Occasionally acting as kinematic release plane for wedge fallout
- J/Vs crosscut rhyolite dikes, suggesting they are manifestation of recent tectonic activity
- Filled to partially filled with quartz and pyrite, often vuggy or voided
- Often associated with white **"effervescence"** where groundwater seepage had/is occurring and dried out. (White residue is dissolved solids precipitated out)
- Suggests these features are the main conduit for groundwater flow, where present



4850L Geological Mapping Observations

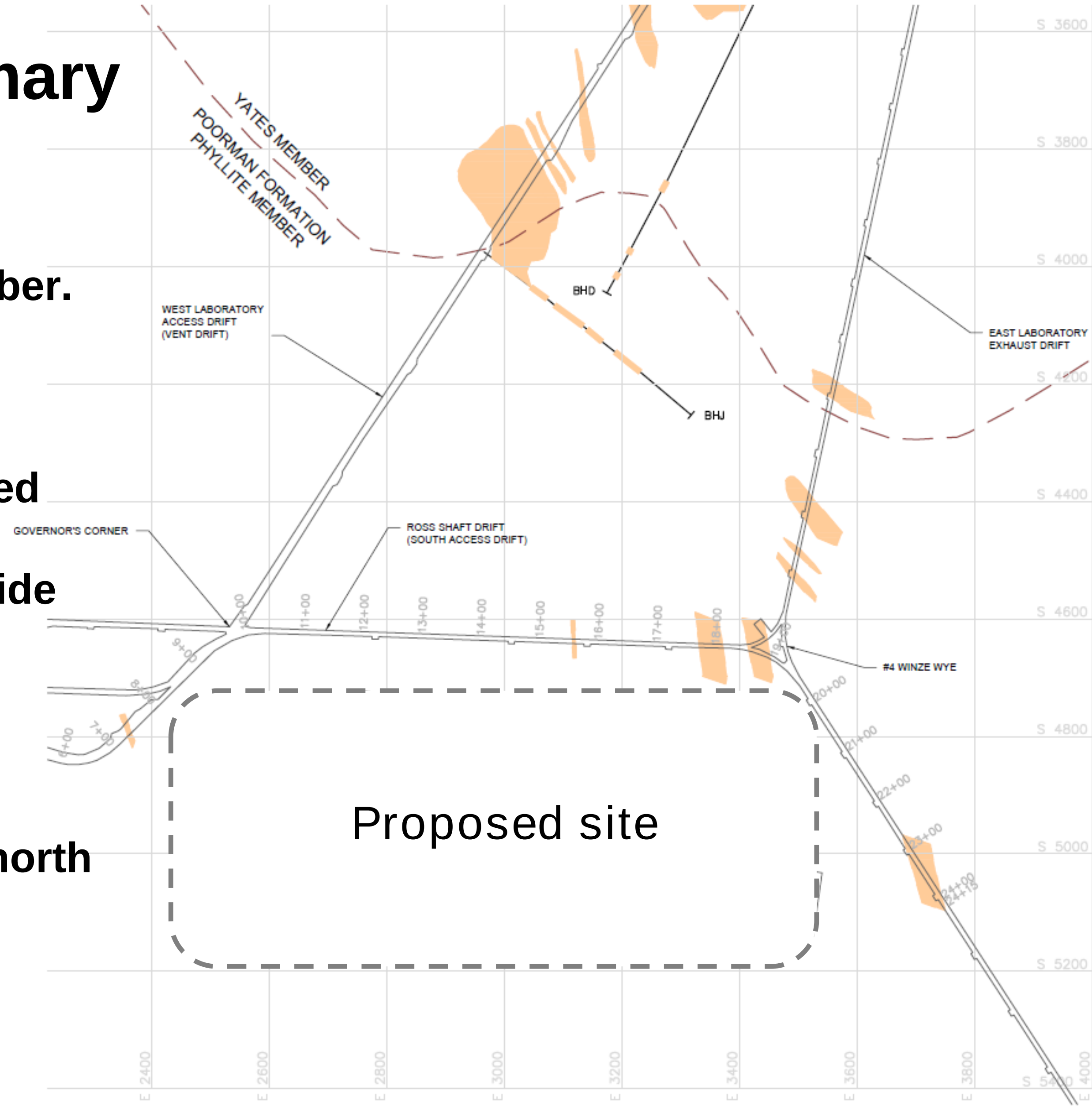
Other observations

- **Limited kinematic failures**
- **Some slabbing past #4 Winze Wye where drift is subparallel to foliation**
- **Modes of failure**

4850L LBNF Site Geologic Map

General Phase 1 Summary

- Project area dominated by Poorman Formation schist member.
- Complexly foliated and folded
- Rhyolite dikes and lower GSI rated domain predominately on east side of proposed site
- Poorman Formation schist and amphibolite member contact to north



Phase 2 – Borehole Investigation

Phase 1 Field Data Collection

Phase 2 Borehole Investigation

Timeline

Aug. 2013

July 2014

- ➢ **Geotechnical site investigation goals and timeline**
- **Mine drift mapping**
- **Rock Mass Response and Performance**
- **Modes of failure**

- **Core drilling**
- **In situ stress measurements**
- **Hydrology**
- **Lab analyses of rock characteristics**
- **Interpretation of Rock Mass Rated domains**
- **Modeling**

Phase 2 - Borehole Investigation

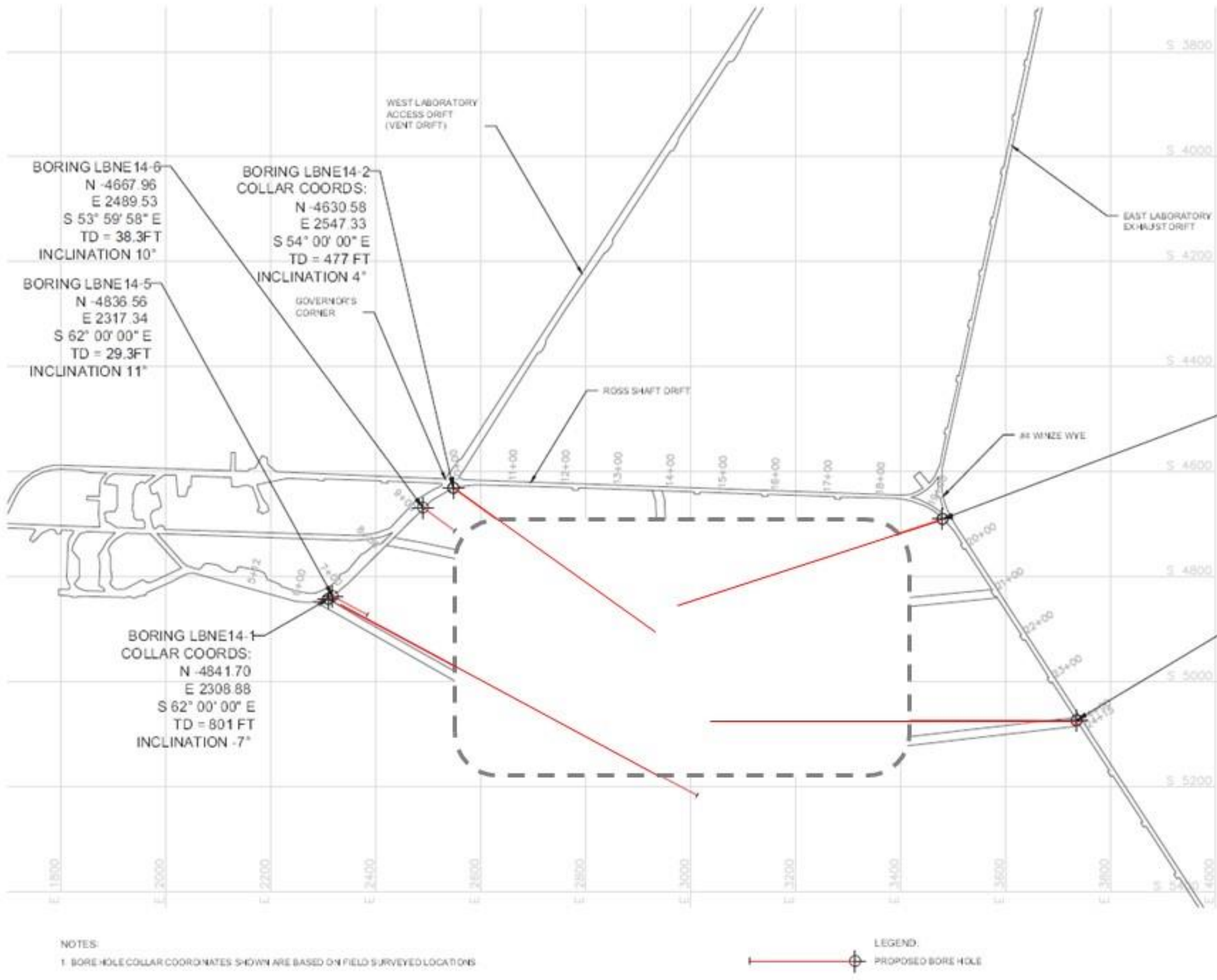
Primary goal was to evaluate different cavern configurations within the area of interest

Investigation Included:

- **771 meters of HQ-size (64 mm) core drilled in four drill holes**
- **20.6 meters of PQ-size (152 mm) core drilled in two drill holes**
- **Packer testing in two longest boreholes**
- **Downhole imaging of HQ Boreholes**
- **In-situ stress testing in PQ Boreholes**

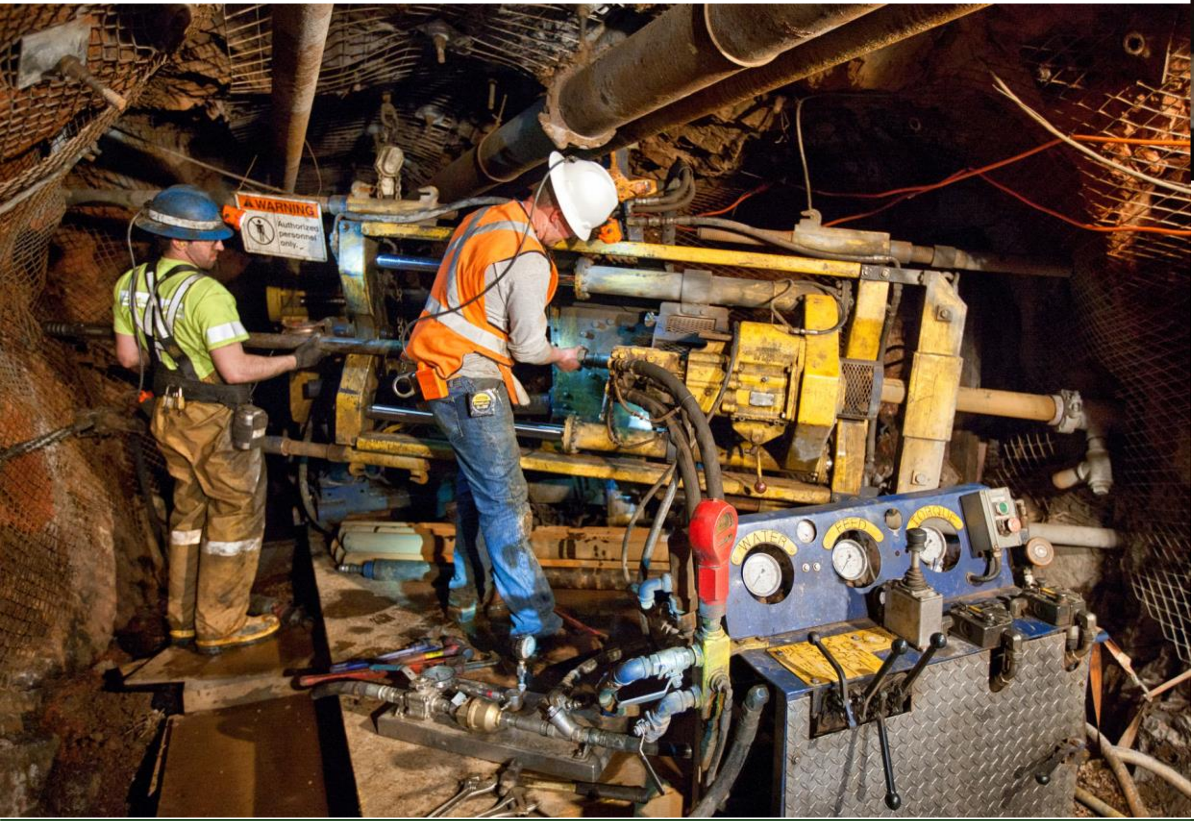
Phase 2 - Borehole Investigation

- **Potential for different cavern configurations covered by investigation**
- **771 meters of HQ-size (64 mm) core drilled**
- **20.6 meters of PQ-size (152 mm) core drilled for CSIRO hollow inclusion cell (HI cell)**



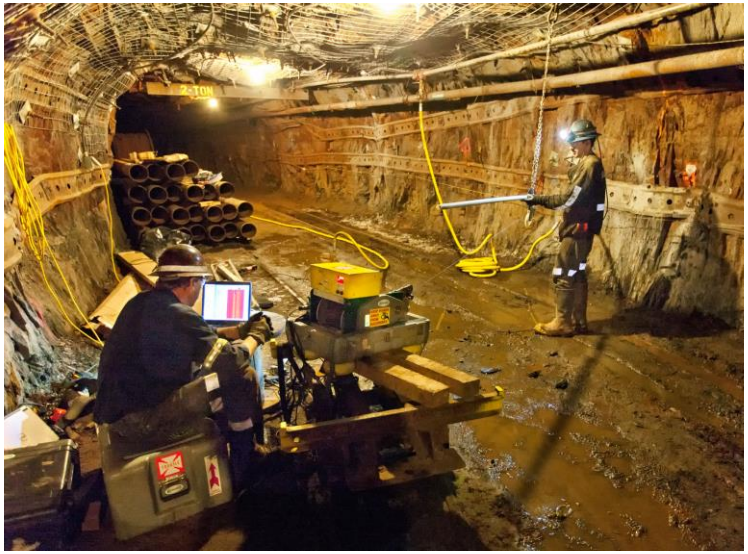
HQ (96/64 mm) Core Drilling Program

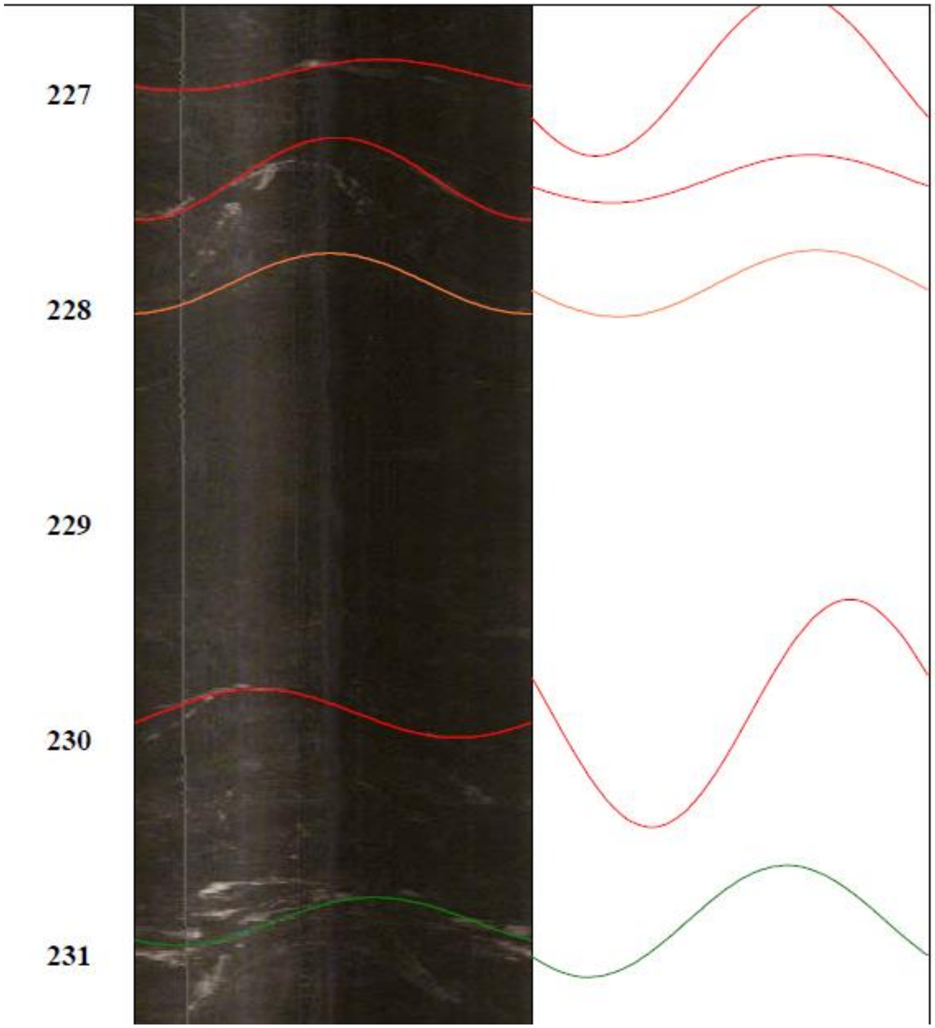
- 20HH Underground Electric / Hydraulic Core Drill
- Large equipment for existing drifts
- Significant setup efforts



Downhole Imaging

- **Applied both acoustical and video**



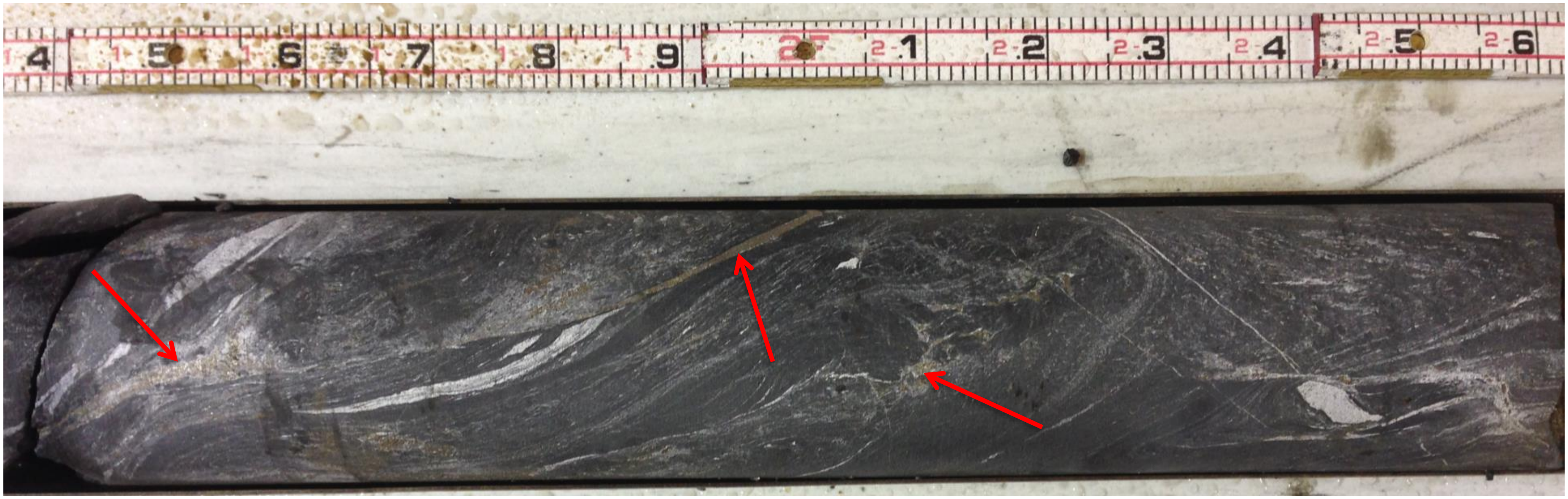


LBNE 14-3

Phase 2 Investigation Results

Sulfides

- Primarily in low carbonate, graphite-rich rock
- Blebs and stringers
- Locally magnetic



Phase 2 Investigation Results

Foliation

- Contorted versus planar
- Present at all scales

Phase 2 Investigation Results

Faults and Shears

- **1-2 zones encountered in each borehole, except LBNE 14-2 (none)**
- **Typically 100mm wide or less, weakly cemented, brecciated shears, micaceous**
- **Lower overall strength compared to surrounding rock mass (~50% lower)**
- **Maximum thickness of 0.6m in LBNE 14-3. Altered, weak to very weak. Clay infilled and chlorite infilled, smooth joints.**
- **Core demonstrates localized destressing (nickeling) weeks after drilling**

Phase 2 Investigation Results

Hydrologic Investigation

- **Pumped packer system down borehole**
- **Packer injection testing**
- **Borings LBNE 14-1 and LBNE 14-2 interval testing & full borehole testing**
- **Rhyolite vs Poorman Formation Schist**
- **Three holes encountered less then 0.1 liter per minute flows from fractures**
- **Fourth hole encountered no flow and remains dry today**

Phase 2 Summary Investigation Results

- (3) lithologies of Poorman Formation Schist depending on mineralogy
  - Sericite carbonate quartz schist (74.3 Percent)
  - Graphitic quartz sericite schist (16.3 Percent)
  - Biotite carbonate quartz schist (3.3 Percent)
- Tertiary Rhyolite (6.1 Percent)
- All lithologies contain graphite, just in varying percentages
- Sulfides (pyrite, pyrrhotite) occur in blebs or stringers along foliation up to 20-30 percent in graphitic schist
- Foliation varied from planar and intense to wavy and contorted

In-Situ Testing

- **Completed in LBNE 14-5 and LBNE 14-6**
- **CSIRO hollow inclusion cell (HI cell)**
- **Completed by Agapito Associates**
- **6 tests scheduled, 5 successfully completed.**

In-Situ Testing

Table 3.15: Summary of In situ Stress Design Parameters

Reference System	Component		Design Value
Resolved cartesian (as modeled 2D/3D stresses)	σx (E-W)		3988 psi (27.5 MPa)
	σy (N-S)		4176 psi (28.8 MPa)
	σz (vert.)		6221 psi (42.9 MPa)
	τxy		406 psi (2.8 MPa)
	τxz		-595 psi (-4.1 MPa)
	τyz		14.5 psi (-0.1 MPa)
Full principal stress tensor	σ1	Magnitude	6380 psi (44.0 MPa)
		Trend	175o
		Plunge	75o
	σ2	Magnitude	4408 psi (30.4 MPa)
		Trend	309o
		Plunge	10o
	σ3	Magnitude	3640 psi (25.1 MPa)
		Trend	040o
		Plunge	11o

In-situ Testing

Biaxial Load Cell Tests

- **4 successful tests**
- **Sample broke during overcore of 5th test**

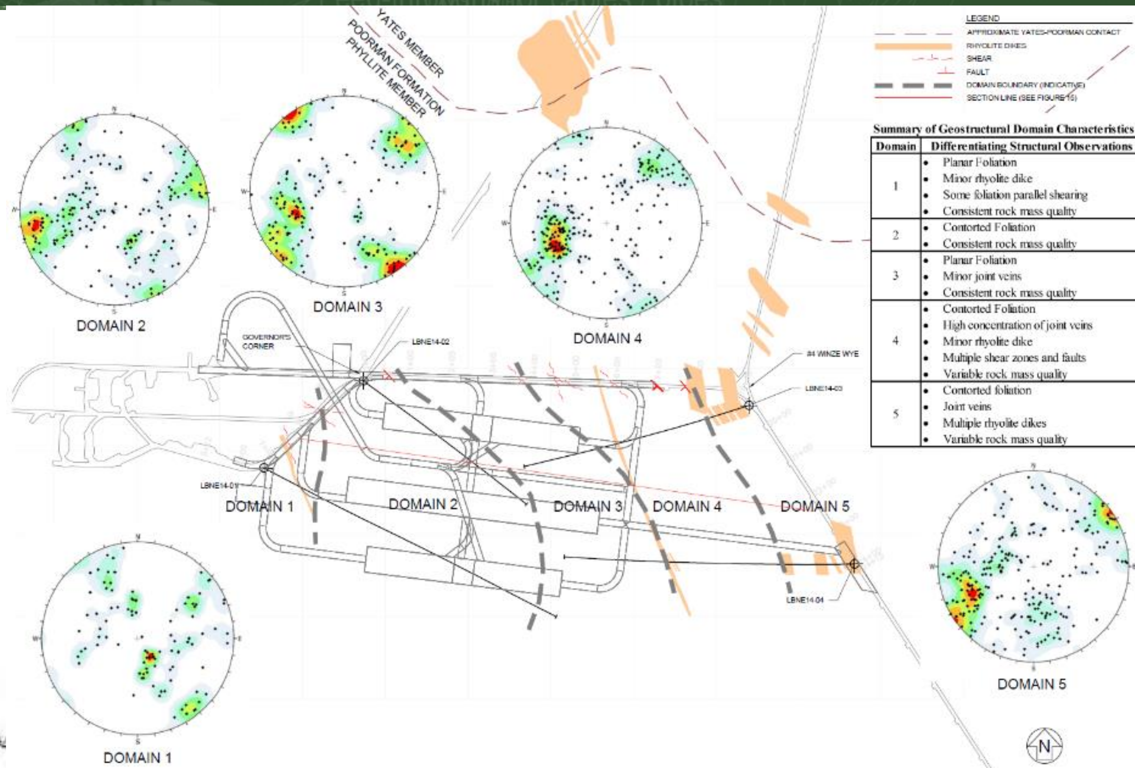
Laboratory Analysis

- Laboratory testing of rock core including uniaxial compression strength tests, tensile strength tests, triaxial compression strength tests, uniaxial creep test, and direct shear tests on joints.
- Laboratory chemistry testing of groundwater including pH and conductivity.
- Observations of groundwater inflow and long term monitoring of groundwater (shut-in) pressure build-up in boreholes.
- The density ranged from 169 pcf (26.5 kN/m3) to 191 pcf (30.0 kN/m3) with a mean of 176 pcf (27.6 kN/m3). For numerical modeling, a unit weight of 175 pcf (27.5 kN/m3) is recommended.
- Twelve UCS tests were performed on the schist and test results ranged between 3.68 ksi (25.4 MPa) up to 17.16 ksi (118.3 MPa). Typically “non-structural” failures ranged between 10.22 ksi (70.5 MPa) and 17.16 ksi (118.3 MPa) while “structural” failures had lower strengths that ranged between 3.68 ksi (25.4 MPa) and 12.87 ksi (88.7 MPa).
- It is anticipated that the rock strength of intact rock will typically range between 7 ksi (48.3 MPa) and 18 ksi (124.1 MPa) with the majority of the rock having strength around 13 ksi (89.6 MPa).
- Two UCS tests were performed on the rhyolite and indicate a much higher strength when compared to the schist. Test results ranged between 20.26 ksi (139.7 MPa) and 26.46 ksi (182.4 MPa).

4850L Geotechnical Conclusions

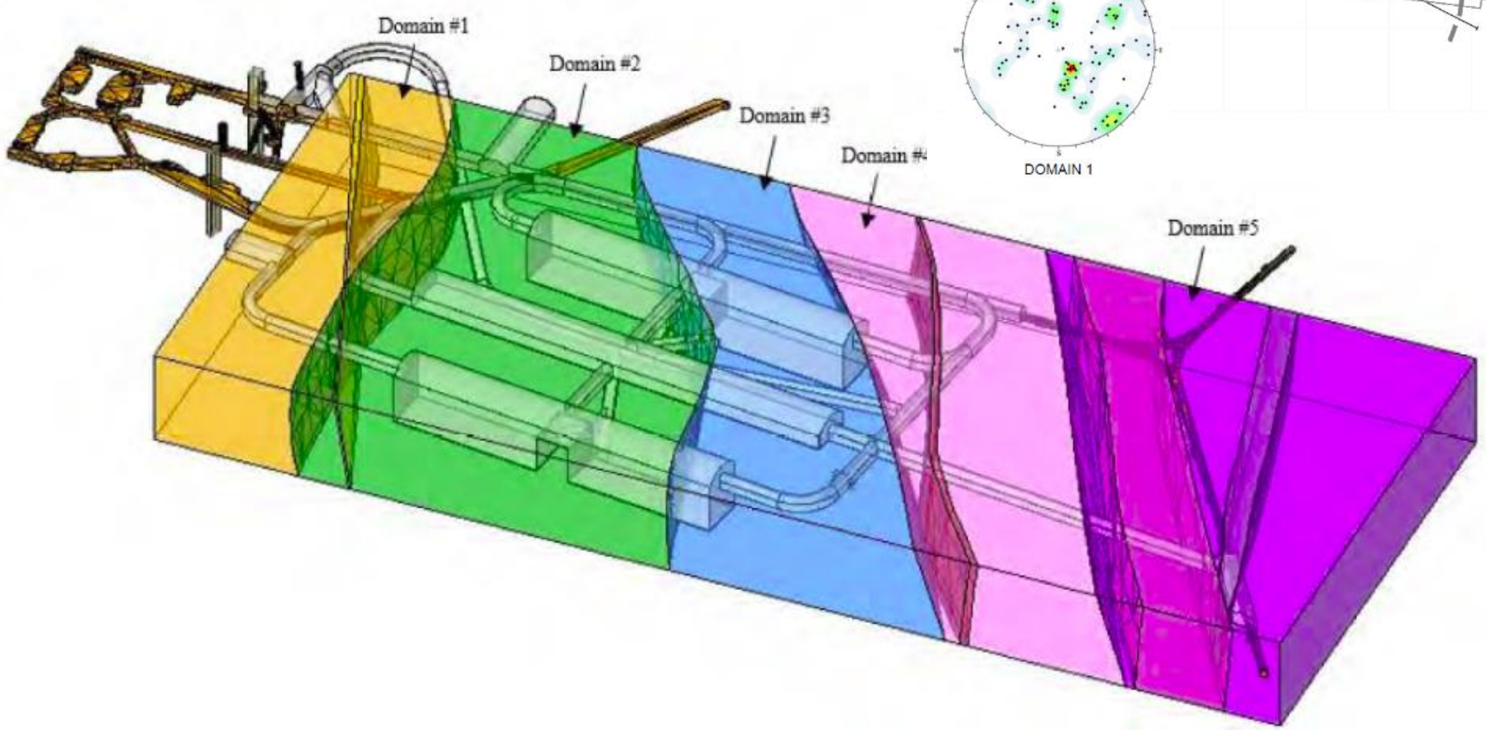
- Three distinct rock mass types;
  - ✓ Poorman Formation schist member
  - ✓ Poorman Formation amphibolite (Yates) member
  - ✓ Tertiary-age rhyolite dikes
- Poorman Formation rock masses highly deformed, foliated and variously jointed depending on rock type
- Rock densities similar for Poorman Formation rocks, rhyolite lighter
- Rock strength character varies by rock type, see previous slide
- In-Situ Stresses: Sigma 1 sub-vertical and K ratios near parity
- Poorman Formation schist member amiable for upright cylinder cavern spans of 66 meter diameter and for mailbox caverns 34 meter spans. "Heroic" ground support measures are required beyond these limits of standard ground support 16 meter cable bolt lengths
- The Poorman Formation Schist is a "very good" to "extremely good" quality rock based on the rock mass characterization performed using the results of the geotechnical exploration program. The rhyolite tends to exhibit lower quality and ranges from "fair" to "very good" quality and is influenced by presence of fracture-born ground water, based on results presented by Golder Associates (2011).
- Tertiary-age rhyolite dikes occupy older sheared rock domains, these dikes crosscut all older rock types, and act as through going, joint-controlled water conduits. Recommend avoiding these domains if possible.

Cavern Locations



Summary of Geostructural Domain Characteristics

Domain	Differentiating Structural Observations
1	• Planar Foliation • Minor rhyolite dike • Some foliation parallel shearing • Consistent rock mass quality
2	• Contorted Foliation • Consistent rock mass quality
3	• Planar Foliation • Minor joint veins • Consistent rock mass quality
4	• Contorted Foliation • High concentration of joint veins • Minor rhyolite dike • Multiple shear zones and faults • Variable rock mass quality
5	• Contorted foliation • Joint veins • Multiple rhyolite dikes • Variable rock mass quality



Upright Cylinder Trade Study Conclusions

Advanced Conceptual Engineering
Task#5: Upright Cylinder Trade Study
REP/005/ACON/0
Final Issue | May 15, 2015

The results of the analyses are summarized in the following points:

- The 20 kT and 50 kT upright cylindrical caverns are technically feasible with practical, rather than "heroic", rock support measures based on a limiting cable bolt length of 53 ft. (16m).
- Maximum cable bolt lengths of approximately 48 ft. (14.5m) would be required in the crown of the 50 kT cavern and sidewall of the 20 kT cavern to control / limit joint separation and dilation as the excavation is enlarged.
- There is not a clear differentiation in preferred cavern geometry (20 or 50 kT) based on anticipated ground support requirements.
- Significantly larger span cylinder geometries are likely not feasible within the limitations of practical ground support.
- Mailbox shaped caverns with spans up to 125 ft. (38m) and with vertical walls up to 82 ft. (25m) are feasible using practical ground support measures.

It should be kept in mind that due to the complex geological conditions of the 4850 Level, and lack of detail in the numerical models (i.e. construction sequence, ground support), nothing beyond "general" conclusions can be stated with confidence. Further detailed study would be required if the upright cylinder geometry was to be adopted as the LBNF preferred shape.

Upright Cylinder Trade Study Conclusions

Figure 7.3 has been developed to summarize the overall feasibility of the various shaped caverns in the Poorman Formation Schist. As described in **Section 2.3**, 'practical' ground support includes cable bolts up to 16m in length, while 'heroic' support, which adds significant cost, schedule, and risk, has cable bolts up to 25m in length. Primary rock reinforcement (shorter, fully grouted rock dowels) installed in between the cables has not been discussed, but should be mentioned as it will play a very important role in maintaining surface integrity and confinement around the cable bolt heads and preventing shallow key blocks from unravelling, especially within the excavation disturbance zone.

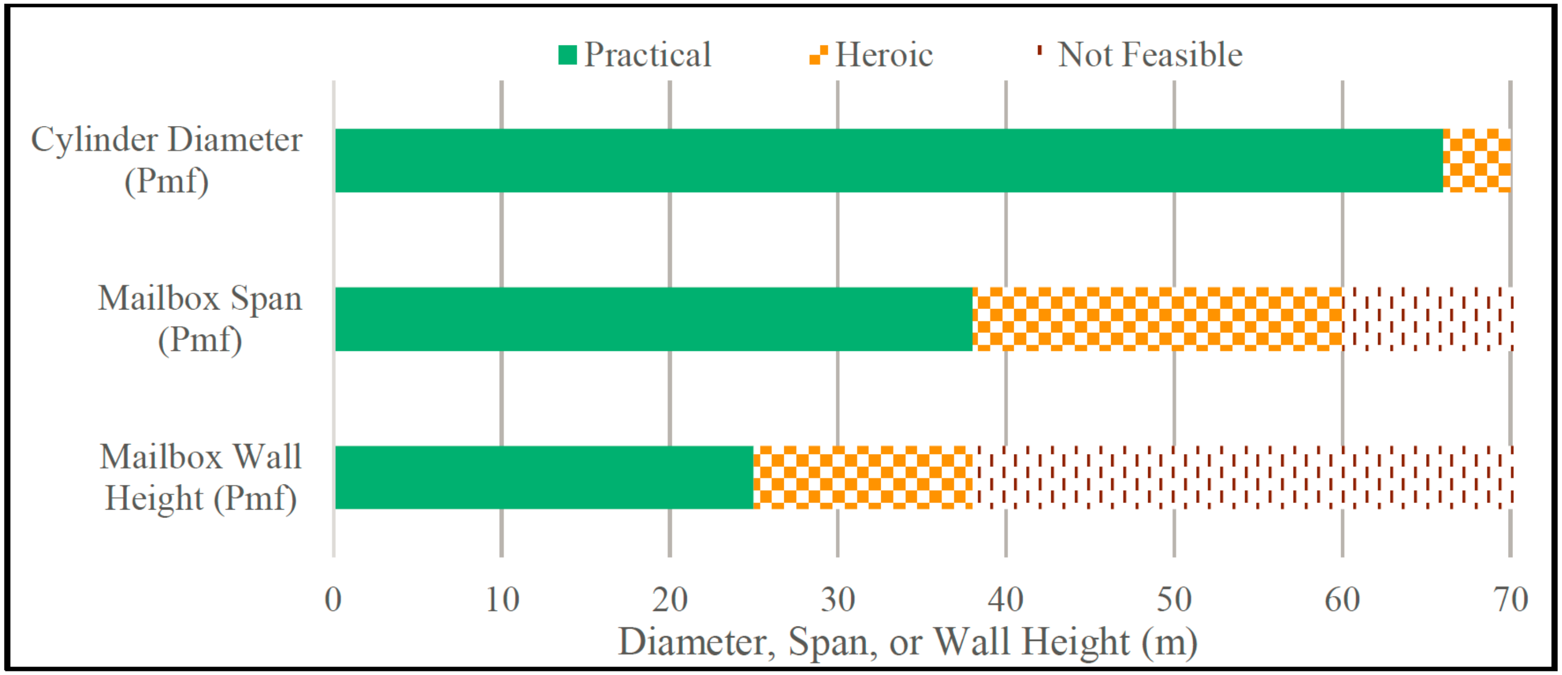


Figure 7.3: Feasible cavern dimensions for the Poorman Formation Schist (Pmf) based on required ground support length.

Upright Cylinder Trade Study Conclusions

The cost comparison was compiled by determining a ‘cost’ for each of the major items of work – excavation, bolting, shotcreting etc. The ‘cost’ was not based on a dollar value but a proportional value relative to the other items. The relative values were developed based on the previous Trade Study (Golder, 2010). Using this method, comparative costs were developed for the 20kT and 50kT caverns, as well as the 10kT mailbox configuration being studied for the LBNF 30% Preliminary Design.

The cost comparison, for excavation and support only, showed that:

• The cost of the 20kT cavern is approximately 1.2 to 1.4 times the cost of the LBNF 30% Preliminary Design 10kT configuration

• The cost of the 50kT cavern is approximately 1.7 to 1.9 times the cost of the LBNF 30% Preliminary Design 10kT configuration

• The cost of excavating the 50kT cavern is approximately 1.3 to 1.4 times the cost of the 20kT cavern.

It should be noted that this cost comparison is very high level and only intended to provide an indication of relative costs.

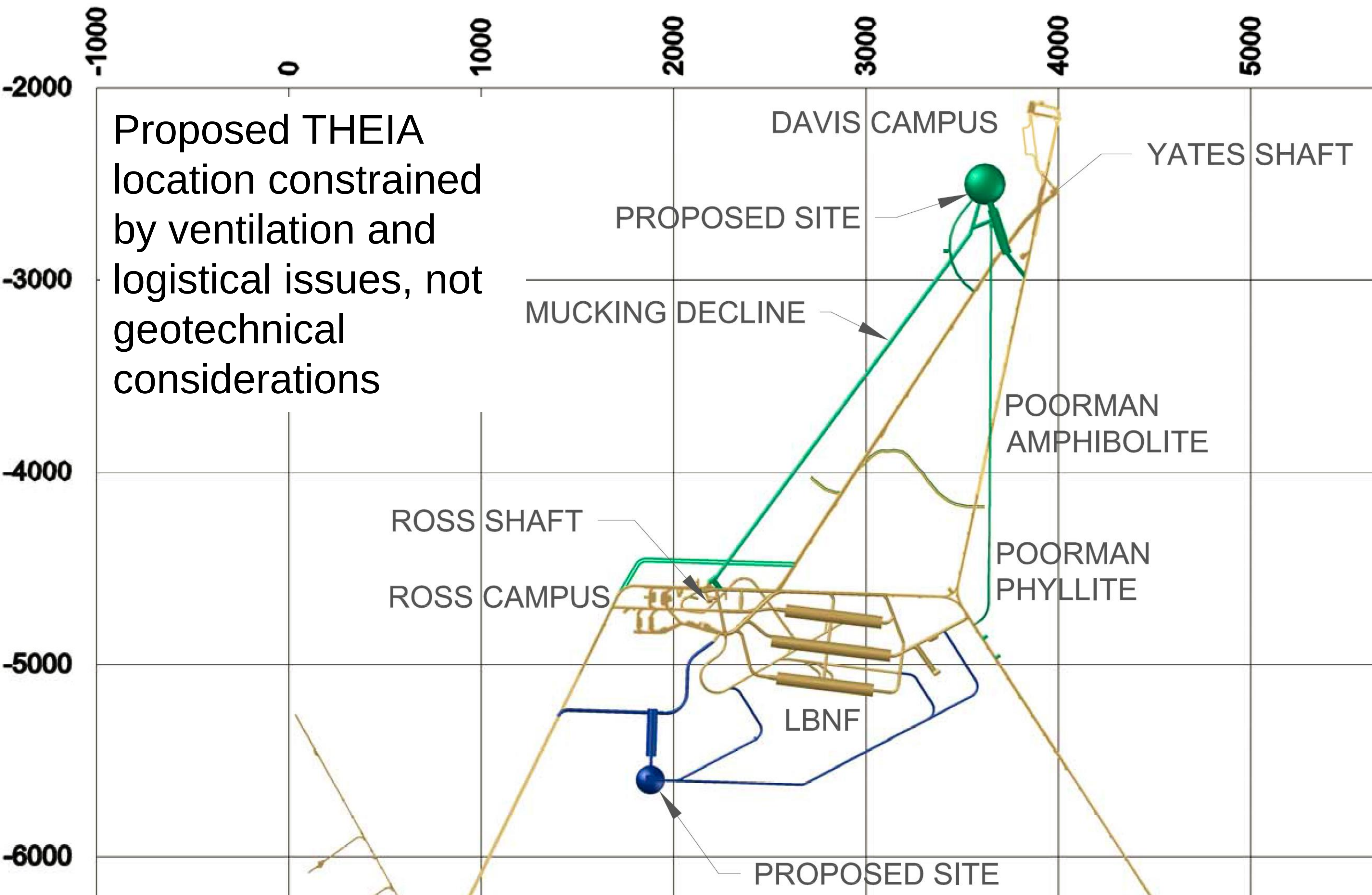
THEIA BOE Assumptions

Disclaimer:

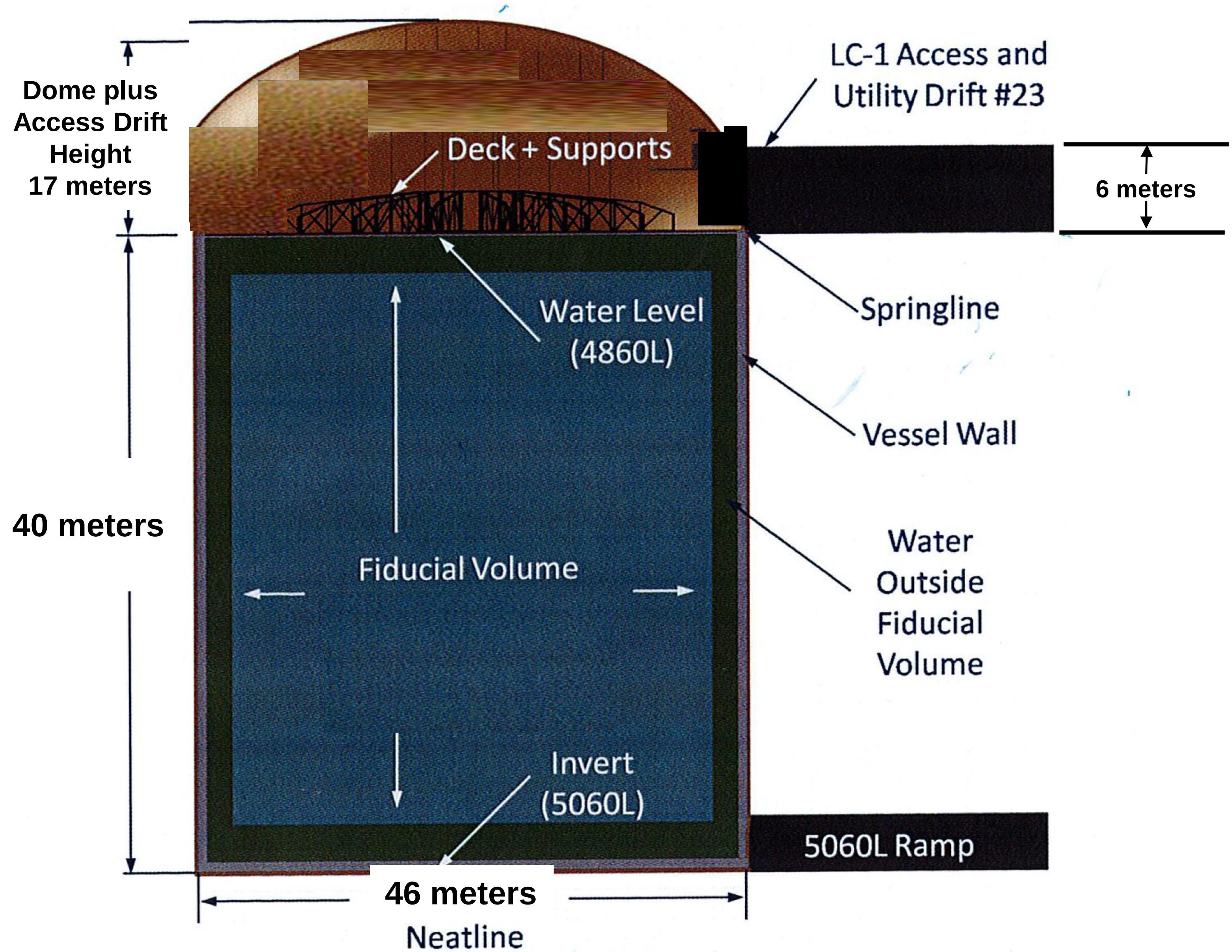
The following BOE is an initial, high-level design and cost estimate premised upon SURF's current level of understanding of the THEIA Project requirements. It is known that further maturation of project related requirements will significantly alter cost and schedule estimates.

THEIA Project BOE Design

Proposed THEIA location constrained by ventilation and logistical issues, not geotechnical considerations



THEIA Project BOE Design



THEIA Project BOE Schedule Estimate

ACTIVITY	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
CD-0 Review	*									
Conceptual Design & BOE										
30% EXC & BSI	*									
75% EXC & BSI	*									
100% EXC & BSI	*									
CD-1 Review		*								
Geotechnical Site Investigation		* * *								
Preliminary Design (CMGC)										
30% EXC & BSI		*								
60% EXC & BSI			*							
90% EXC & BSI			*							
100% EXC & BSI			*							
CD-2 Review			*							
Final Design (CMGC)										
30% EXC & BSI				*						
60% EXC & BSI				*						
90% EXC & BSI				*						
100% EXC & BSI				*						
CD-3 Review					*					
Procurement (CMGC)					* * *					
Construction										
Excavation						* * * *	* * * *			
BSI							* *	* * * *		
Beneficial Occupancy									* * * *	* * * *
CD-4 Review									*	

THEIA Project BOE Cost Estimate

ACTIVITY	2017 $US million	
Excavation Direct Cost	$	26.4
BSI Direct Cost	$	20.0
EXC & BSI Direct Cost Subtotal	$	46.4
Indirect Cost (50% of Directs)	$	23.2
EXC & BSI SUBTOTAL	$	69.6
Geotechnical Site Investigation	$	1.5
Conceptual Design & BOE (3-5%)	$	3.5
Preliminary Design (5%)	$	3.5
Final Design (5%)	$	3.5
Procurement (5%)	$	3.5
DESIGN SUBTOTAL	$	15.4
PROJECT SUB TOTAL	$	85.0
CONTINGENCY (50%)	$	42.5
PROJECT GRAND TOTAL	**$**	**127.5**

Sanford Underground Research Facility

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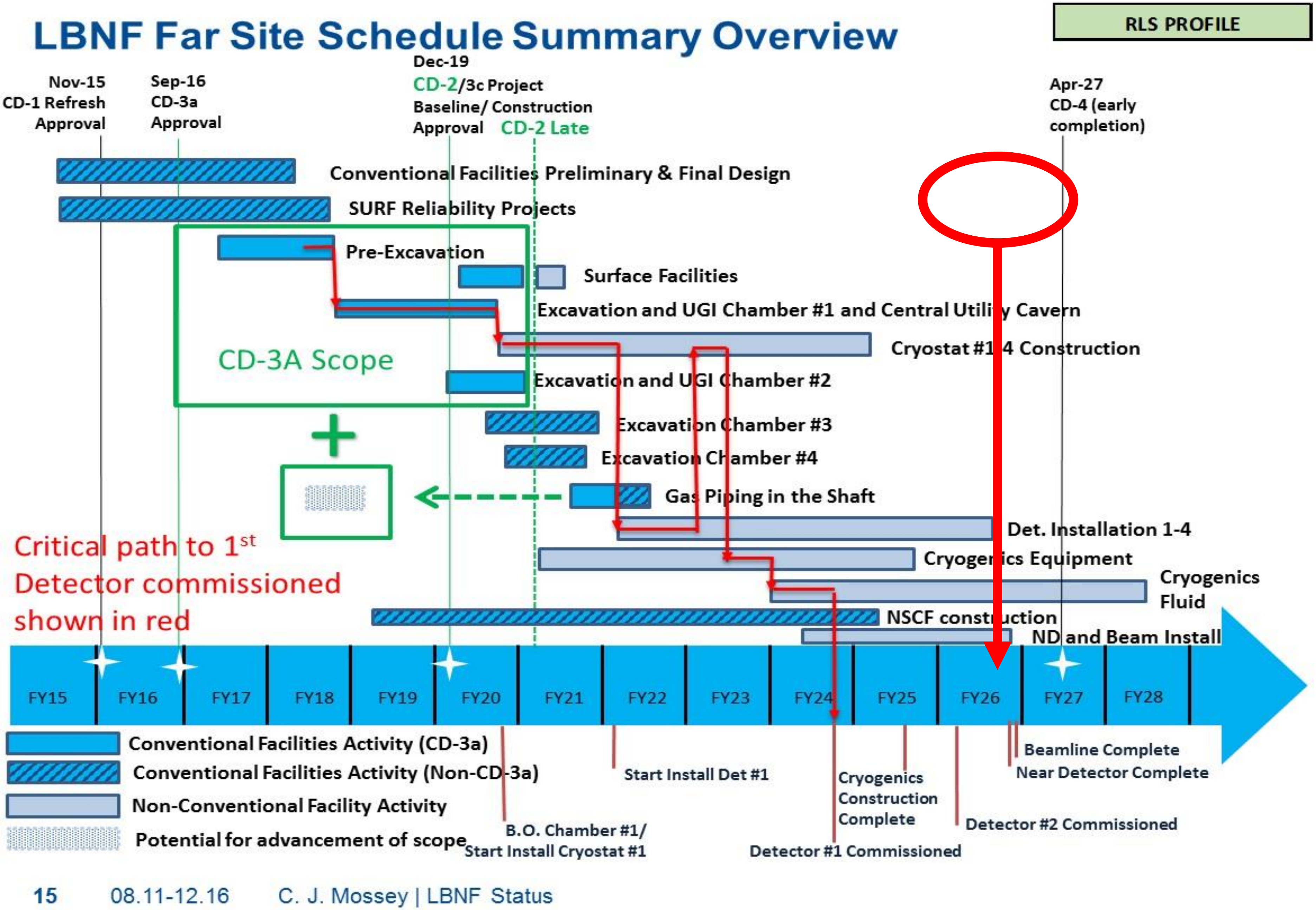
Long Baseline Neutrino Facility Schedule



Sanford Facility

THEIA Budgetary Rough Order of Magnitude Cost Estimate

Prepared by: Arup

10/13/2016

ARUP

Excavation Volume	119,848	m3

Description		Quantity	Unit	Unit Cost	Total Cost
Drifts		10,375	m3	$ 294	3,054,000
4850-01	Drift #1	4,938	m3	$ 294	$ 1,453,000
4850-02	Drift #2	4,375	m3	$ 294	$ 1,288,000
4720-02	Entrance Drift	1,062	m3	$ 294	$ 313,000
Mucking Ramps		15,081	m3	$ 229	3,452,000
4950-01	Muck #1	3,926	m3	$ 229	$ 899,000
4720-01	Muck #2	6,825	m3	$ 229	$ 1,562,000
4850-05	Muck #3	1,500	m3	$ 229	$ 343,000
4850-06	Muck #4	2,830	m3	$ 229	$ 648,000
Mid-Chamber		8,002	m3	$ 294	2,355,000
4850-03	Mid Chamber	8,002	m3	$ 294	$ 2,355,000
Large Dome Cavern		86,390	m3	$ 203	17,519,000
4850-07	Drop Raise	95	m	$ 13,120	$ 1,246,000
4850-07	Dome	9,819	m3	$ 300	$ 2,946,000
4850-08	Above Sill	10,142	m3	$ 160	$ 1,623,000
4850-09	Below Sill	66,429	m3	$ 160	$ 10,629,000
	Cable Bolts	1,676	ea	$ 520	$ 872,000
	Rock Bolts	2,539	ea	$ 80	$ 203,000
Subtotal Direct Costs		**119,848**	**m3**	**$ 220**	**$ 26,380,000**
Excavation Contractor Indirects:					**$ 13,536,000**
Indirect Equipment / Ownership				4%	$ 1,005,000
General Mobilization				1%	$ 290,000
Demobilization / Punch list				1%	$ 233,000
General Plant Operation / Maintenance				1%	$ 319,000
Field Supervision				8%	$ 2,119,000
Overhead & Maintenance / Service				8%	$ 2,181,000
Bonds, Insurance, and Taxes				3%	$ 696,000
Finance Charges				1%	$ 132,000
Contractor Profit / Mark-up				19%	$ 5,121,000
Contractor Contingency				5%	$ 1,440,000
Subtotal Direct + Indirect Costs		**119,848**	**m3**	**$ 333**	**$ 39,916,000**

*bcy = Bank Cubic Yards