



**SANFORD
UNDERGROUND
RESEARCH
FACILITY**

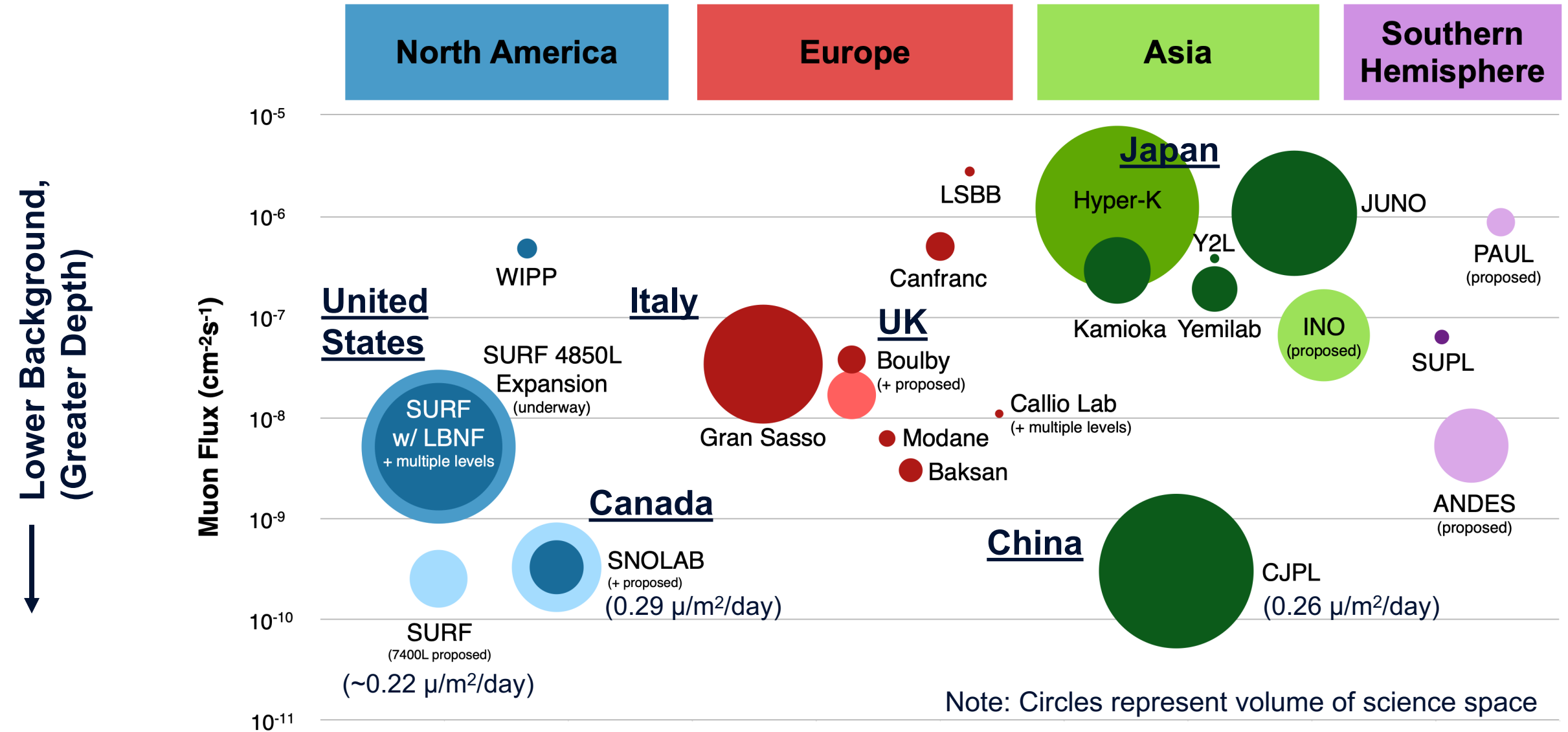
Opportunities at the Sanford Underground Research Facility

Jaret Heise, Science Director
jaret@sanfordlab.org

Coordinating Panel on Advanced Detectors
University of Washington, Seattle, WA
October 20-23, 2026

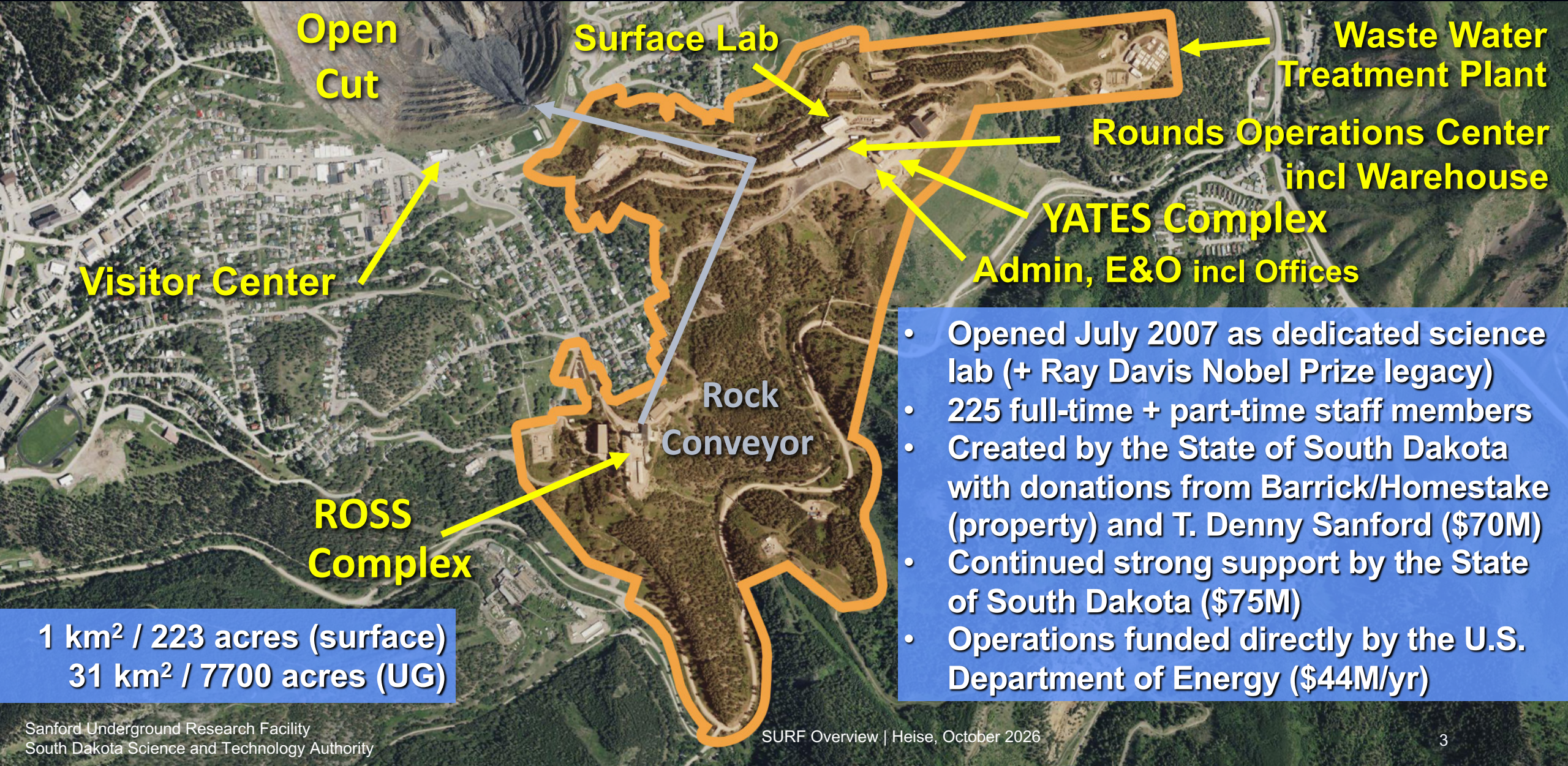
SURF in the Global Context

Deep site ($4.5 \mu\text{m}^2/\text{day}$) with significant expansion potential, max depth 2450 m



Sanford Underground Research Facility

Nation's deepest underground lab, advancing multi-disciplinary research



1 km² / 223 acres (surface)
31 km² / 7700 acres (UG)

- Opened July 2007 as dedicated science lab (+ Ray Davis Nobel Prize legacy)
- 225 full-time + part-time staff members
- Created by the State of South Dakota with donations from Barrick/Homestake (property) and T. Denny Sanford (\$70M)
- Continued strong support by the State of South Dakota (\$75M)
- Operations funded directly by the U.S. Department of Energy (\$44M/yr)



Geology and Engineering

Enhanced Geothermal Systems
Mining Technology

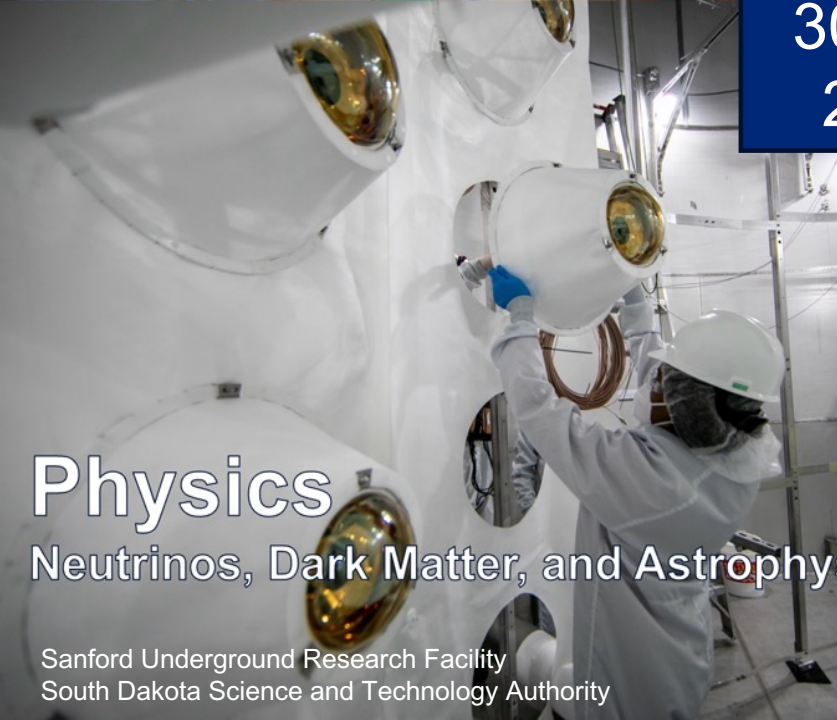


Biology

Extremophiles, Biodiversity

Science Program

30 Expts with 2,250 Collaborators,
280+ Institutions in 47 Countries



Physics

Neutrinos, Dark Matter, and Astrophysics



Partnerships

Commercial, Technology,
Industrial, Workforce development

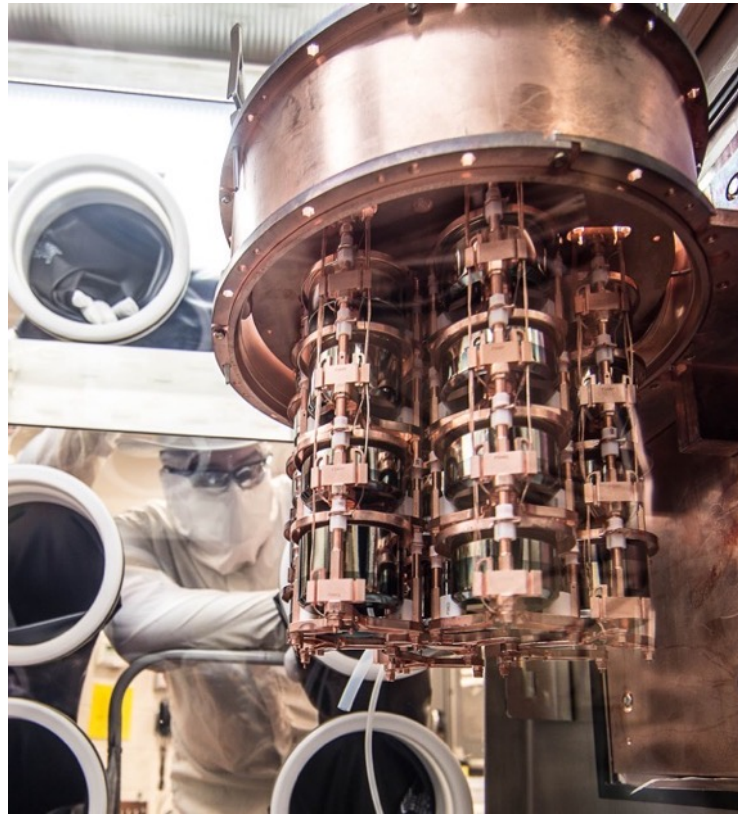
SURF Science Program – Current Physics Highlights

Strong and diverse program with exciting future



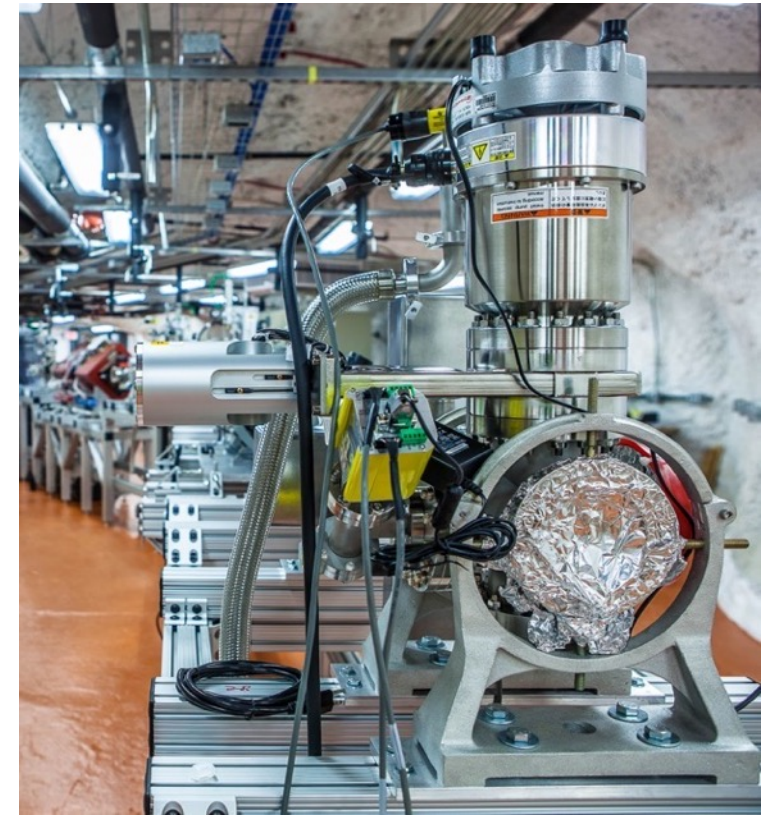
LUX-ZEPLIN (LZ)

- Direct **dark matter** search using 10 t Xe
- World-leading WIMP-search results since 2022, Sep 2026 HENR event (!)
- Proposal: LZ + HydroX into ~2034



MAJORANA DEMONSTRATOR (MJD)

- Searches complete: **neutrinoless double-beta decay** w/ Ge-76, Ta-180
- LEGEND-focused support continuing: UG Cu electroforming, clean materials



CASPAR

- Stellar fusion reactions to study **nucleosynthesis** using accelerator
- Initial phase 2015-2021, physics data resumed 2026 (^{19}F underway)



SURF Material Assay at BHUC

Low-background counting capabilities serving national & international community



Long-Baseline Neutrino Facility (LBNF)

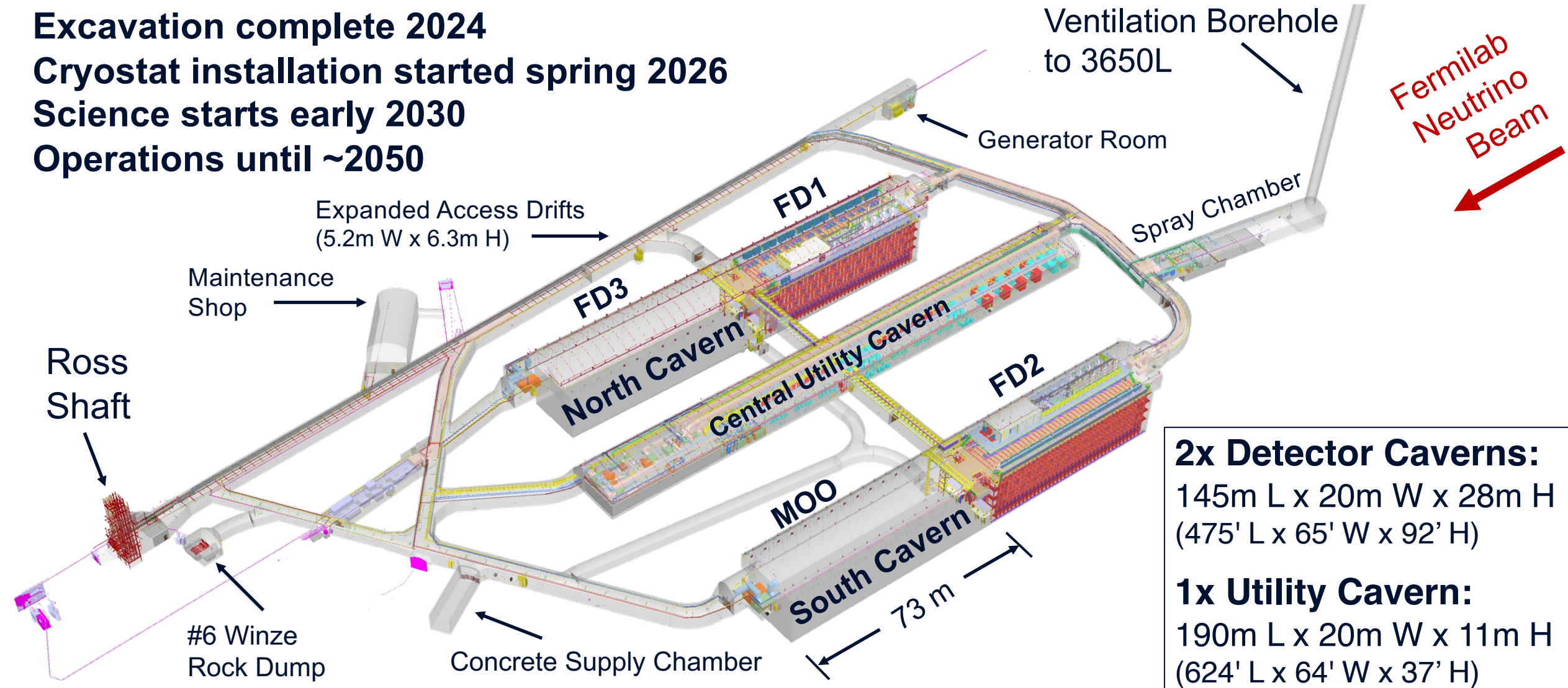
LBNF will host the Deep Underground Neutrino Experiment (DUNE)

Excavation complete 2024

Cryostat installation started spring 2026

Science starts early 2030

Operations until ~2050



LBNF South Cavern



Long-Baseline Neutrino Facility (LBNF)

LBNF will host the Deep Underground Neutrino Experiment (DUNE)

LBNF South Cavern



SURF Science Strategic Plan

Long-term vision to ensure SURF continues to serve scientific community

Goals

- **Program:** Attract world-leading scientists and experiments
- **Facilities:** Ensure SURF facilities support science program
- **Support:** Ensure organizational capabilities serve experiments
- **Engagement:** Establish strong SURF role in global UG science community

Physics (closely aligned with top U.S. priorities c. 2023; revisit with SCAC)

- DUNE support (Phase 1 and Phase 2)
- Generation 3 Dark Matter (XLZD and/or ARGO)
- ‘Agile’ Experiments / Low-Mass Dark Matter
- General R&D facility
- Generation 2 Dark Matter upgrade (extend LZ ops + low-mass dark matter)

Quantum User Facility
w/ dilution refrigerator

Non-Physics (based on community expert input)

- SURF is critical hub for innovation and discovery:
 - Geology and geomechanics (geothermal, real-time sensing, etc)
 - Biology and microbial systems (extremophiles, incl CO₂ sequestration)
 - Industrial and academic partnerships (e.g., CAT, NSF REU programs, etc)

Sanford Underground Research Facility Scientific Strategic Plan
24 June 2024

Executive Summary

The US High Energy Physics and Nuclear Physics communities recently completed their long-range planning exercises: [Particle Physics Project Prioritization Panel](#) and [Long Range Plan](#), respectively. Underground physics experiments remain central to the future of the US High Energy Physics program. These plans present opportunities for Sanford Underground Research Facility (SURF) to identify future users and advance plans for hosting their experiments in the coming decade.

For the High Energy Physics community, SURF is a critical host for the future of multiple highest priority experiments for the coming decades. The DUNE Phase I and Phase II are recommended as the highest priority and present an opportunity for the US HEP program to host a world-class, international, neutrino program at SURF. Under all budgetary scenarios considered in the P5 report, dark matter experiments are recommended in the coming decades. The G3 dark matter experiment XLZD or ARGO represents an important opportunity for SURF to host experiments in their planned expansion or in DUNE's Module of Opportunity. It is imperative that SURF engineering and physics staff actively engage with these collaborations in the coming year to develop conceptual plans, requirements, and installation plans. These plans can be matured to Memoranda-Of-Understanding (or other vehicles) with additional work by the experimental

Strategic Assessment of Research and Collaborative Opportunities Beyond Physics at the Sanford Underground Research Facility

October 5, 2026 (Draft submitted January 31, 2026)

Executive Summary:

The Sanford Underground Research Facility (SURF) has successfully transitioned from its history as a gold mine into a leading international hub for deep underground science and technology. SURF offers a suite of environmental conditions well-suited for a variety of geology, biology, and engineering research, unlike physics labs that use the subsurface mainly for radiation shielding. The facility's primary value comes from its four unique attributes: its depth, its breadth, varied geochemical composition, and its long-term access that facilitates investigations of the subsurface requiring longer periods of time. SURF offers access to a rock mass volume of ~35 km³ and, with approximately 34 km maintained for access on 29 underground levels reaching up to 1.5 km deep, provides the largest geography for scientific purposes of any global underground laboratory.

Research and Partnerships

SURF hosts diverse research projects that leverage its stable rock, high in-situ stress, and extreme subterranean habitats.

- **Geology and Geomechanics:** Projects like the EGS Collab initiative aim to advance geothermal energy by studying hydraulic fractures in crystalline rock. Other projects, such as GEOXTM and portions of the EGS Collab project, focus on developing and deploying advanced sensing technologies to measure rock movement in real time, which is critical for underground construction and safety.
- **Biology and Microbial Ecosystems:** Research in this area explores life in extreme environments. For example, the Deep Mine Microbial Observatory (DeMMO) studies how microbes survive in harsh conditions through time. A separate, groundbreaking project discovered extremophiles at SURF that can convert CO₂ gas into a stable solid mineral in just ten days, which normally takes years. The discovery has a pending patent, highlighting its commercial potential.
- **Industrial and Academic Partnerships:** SURF serves as a valuable testbed for industries. Caterpillar (CAT) used the facility to develop its MineStar technology, a Wi-Fi-based system for tracking equipment and personnel in GPS-denied environments. SURF's in-house staff and expertise in deep underground work make it a strategic partner that can mitigate the risks and complexities of such projects. SURF continues to be an



SURF Quantum User Facility

Multi-user, low-background, ultra-low temperature test facility

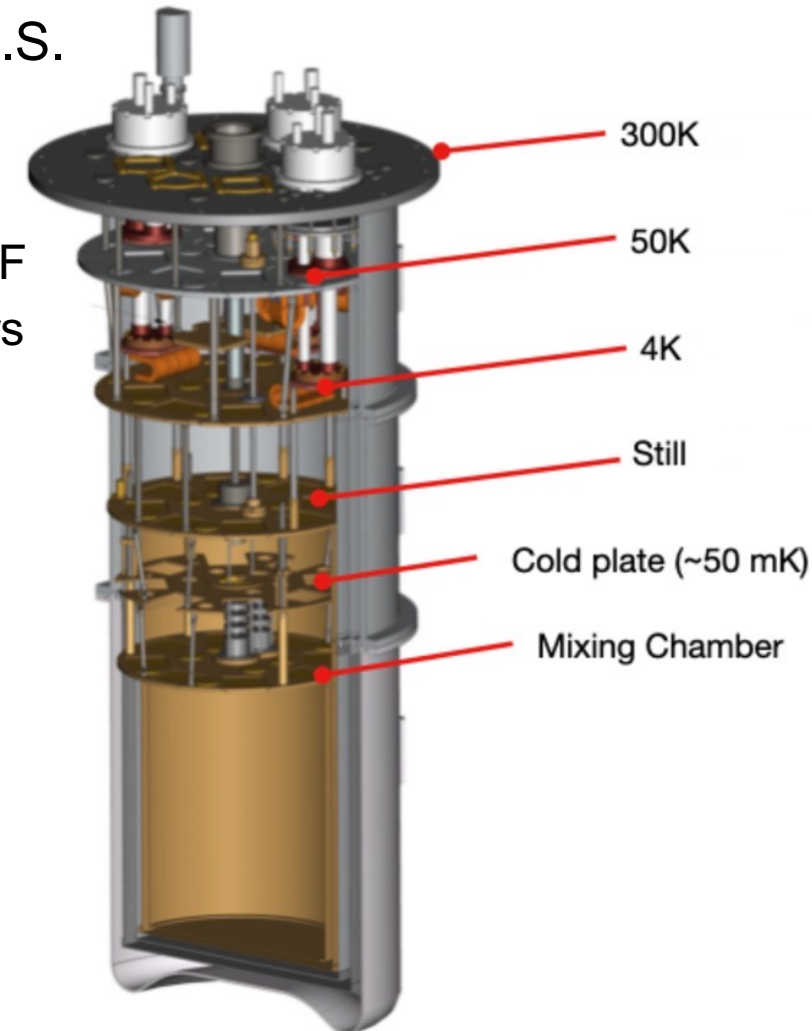
No deep underground quantum user facility currently exists in the U.S.

Establish internationally-competitive research resources

- Detectors with extremely low energy thresholds and excellent energy resolution require isolation from ionizing radiation at deep facility like SURF
- Serve experiments using cryogenic calorimeters, quantum phonon sensors for applications in particle astrophysics, incl dark matter, $0\nu\beta\beta$, $CE\nu NS$
- Attract industry leaders in quantum computing (Google, IBM, D-Wave)
- Bolster \$3M investment in SD Center for Quantum Information Science & Technology

Planning underway

- Quantum Partnership Workshop (2026 event 3rd in series: <https://indico.sanfordlab.org/e/Quantum2026>) enhancing synergies with state QIS initiatives as well as broader interest in topics such as quantum communication networks
- Basic facility upgrades understood (mainly power, cooling)
- Cleanroom space available, also Pb shielding
- Exploring state-of-the-art electrical, vibrational requirements

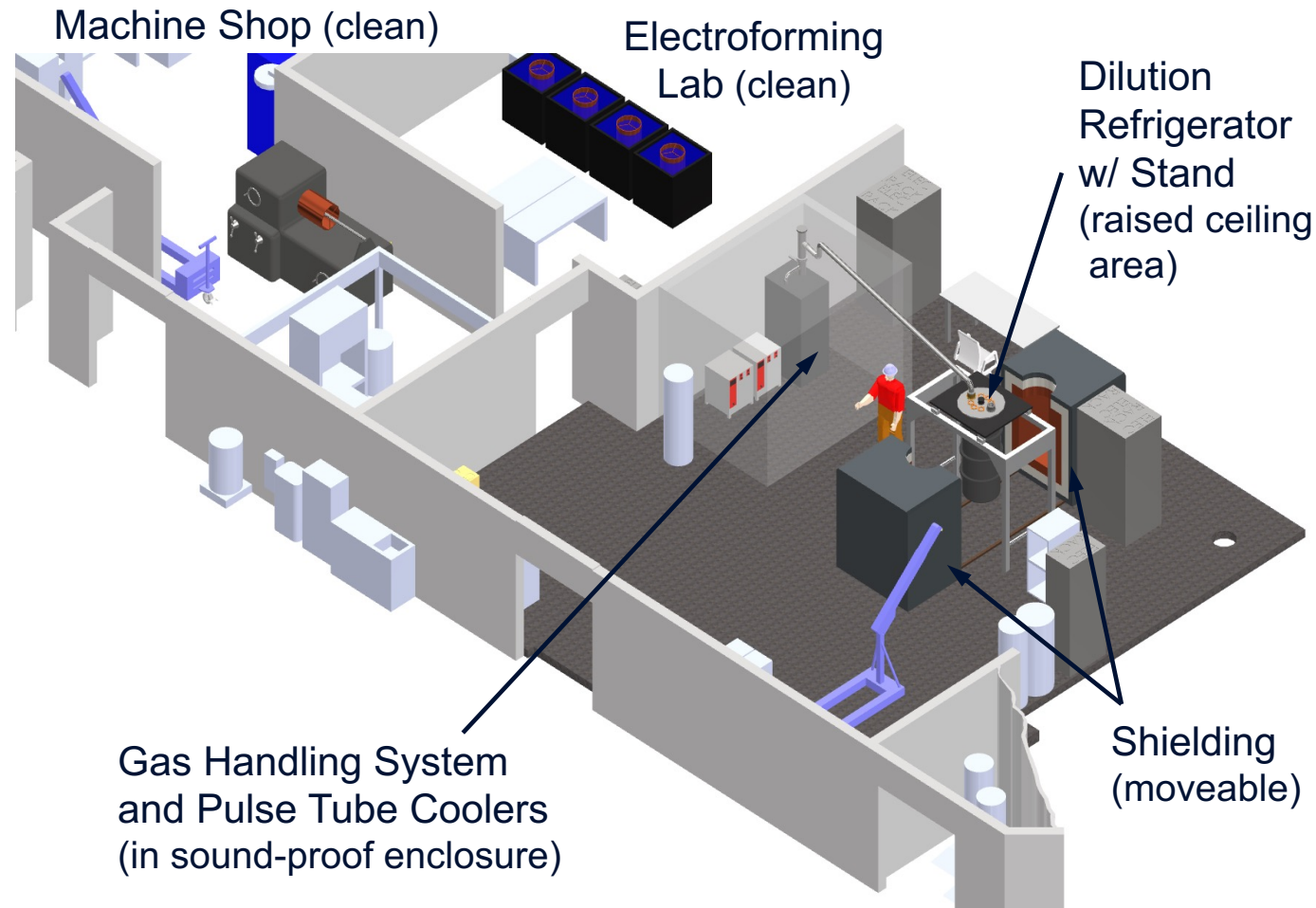


Evaluating commercial dilution refrigerator options that would meet user needs



SURF Quantum User Facility

Deep site at 4850L Davis Campus planned to support range of quantum science



Area (total = **140 m²**): 11 m × 9.8-12.8 m × 2.7 m (H)

Area (raised section): 5.9 m × 5.8 m × 3.2 m (H)



SURF Vertical Facility

Unique facility would serve broad range of science communities

Science

- Atom interferometry using quantum sensors (ultralight dark matter, gravitational waves)
- Quantum communication network; also atmospheric cloud chamber, microgravity studies, isotope separation, etc

Community Interest

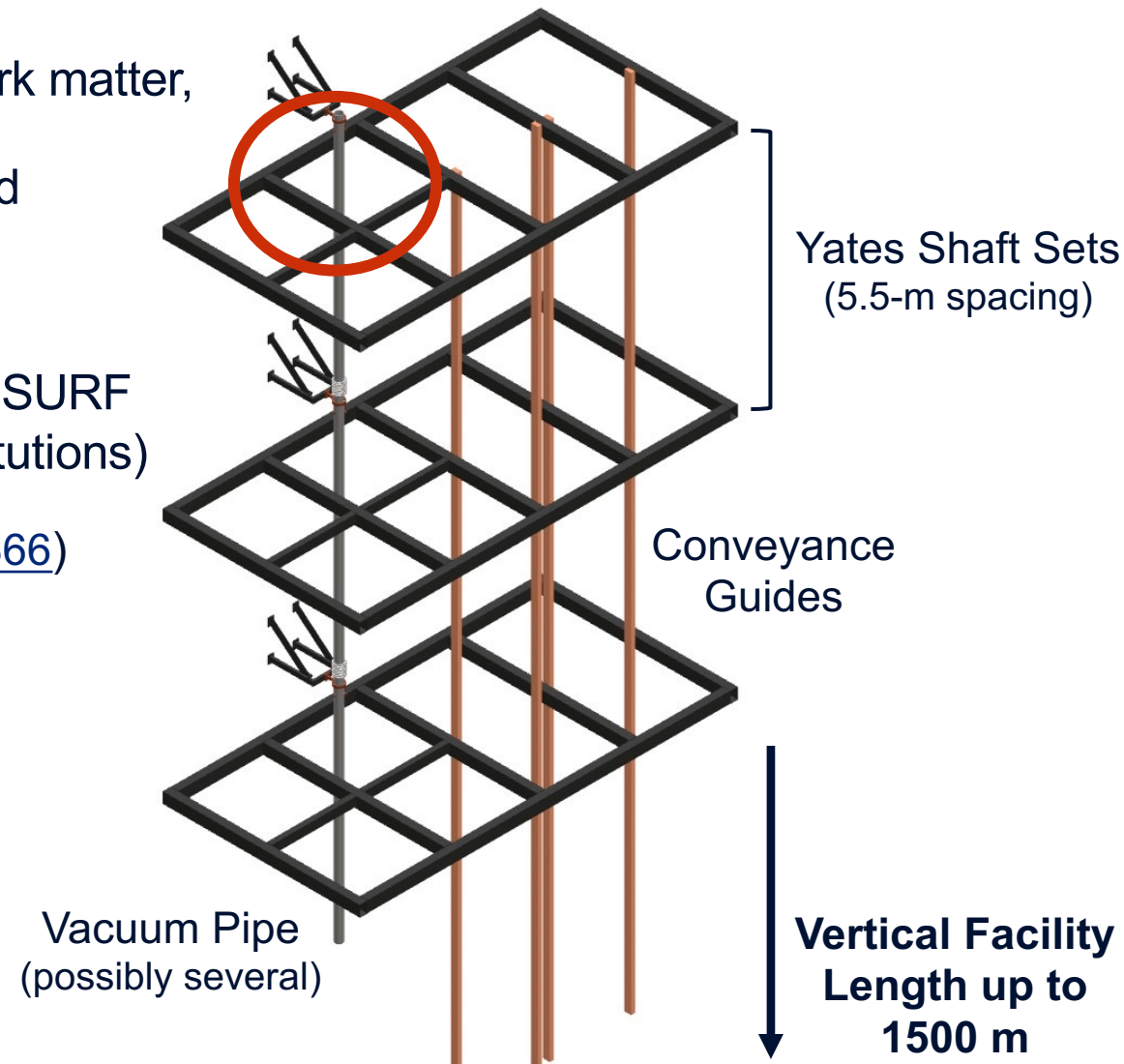
- Various workshops since 2008 to explore opportunities a SURF
- SURF joined TVLBAI collaboration in Oct 2025 (50+ institutions)

Expt Requirements (TVLBAI <https://arxiv.org/pdf/2503.21366>)

- **1.5-m diameter shaft** (minimum), **15-cm diameter pipe** for ultra-high vacuum
- Possibly separate pipes for separate applications

SURF Facility

- Initial shaft study completed March 2022
- **Yates Shaft refurbishment** in 2030s after related upgrades complete (electrical, incl hoists)
- Potential use of “Runabout” compartment **1.75m x 2.0m**



Deep Space Needed for Future Experiments

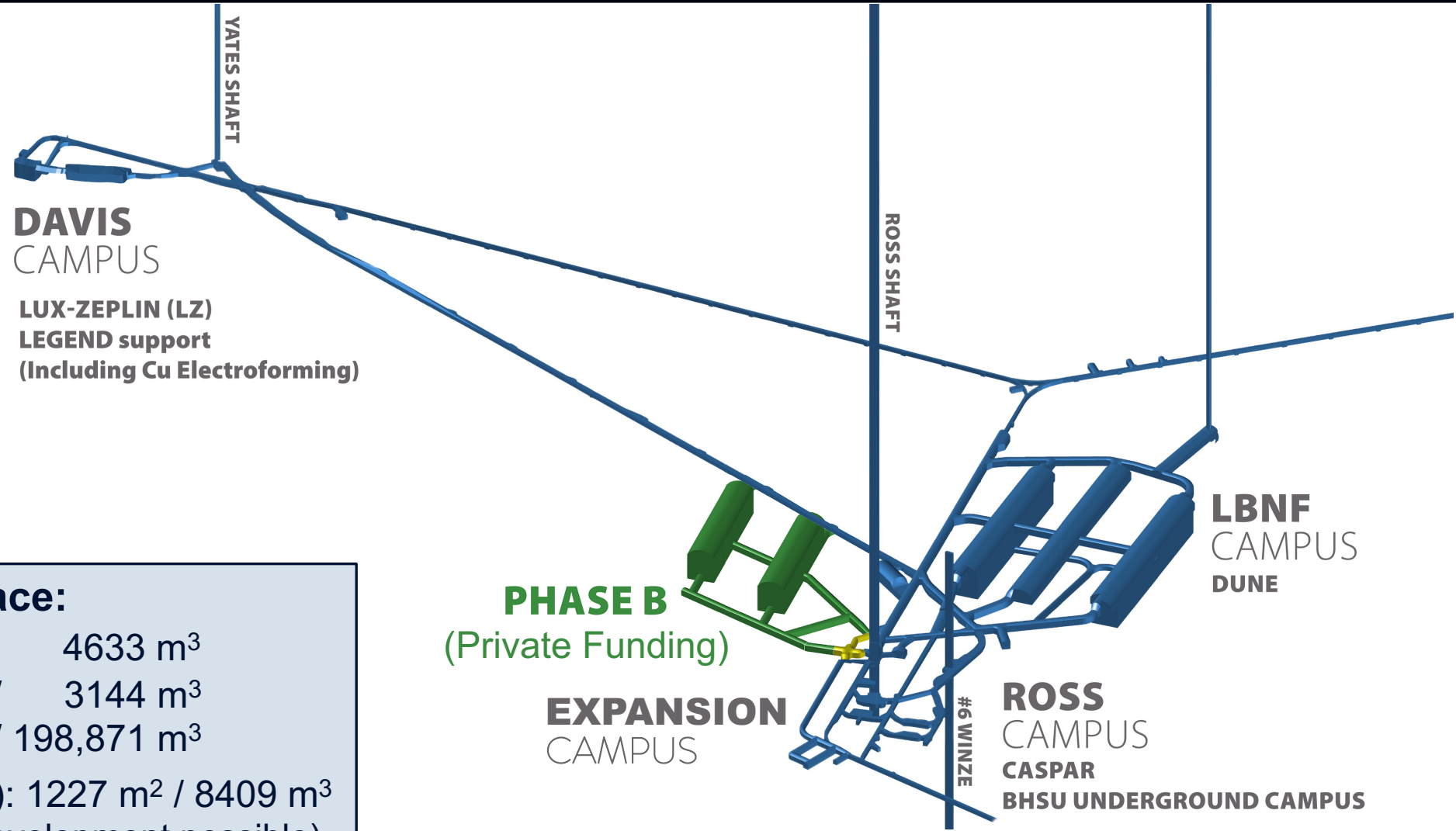
U.S. strategic plan endorsed SURF expansion for neutrino and dark matter expts

4850L:

1400-1500 m depth
3900-4300 m.w.e.

Existing Laboratory Space:

- Davis Campus: 1018 m² / 4633 m³
- Ross Campus: 920 m² / 3144 m³
- LBNF Campus: 9958 m² / 198,871 m³
- Expansion Campus (new): 1227 m² / 8409 m³
(some amenities, further development possible)

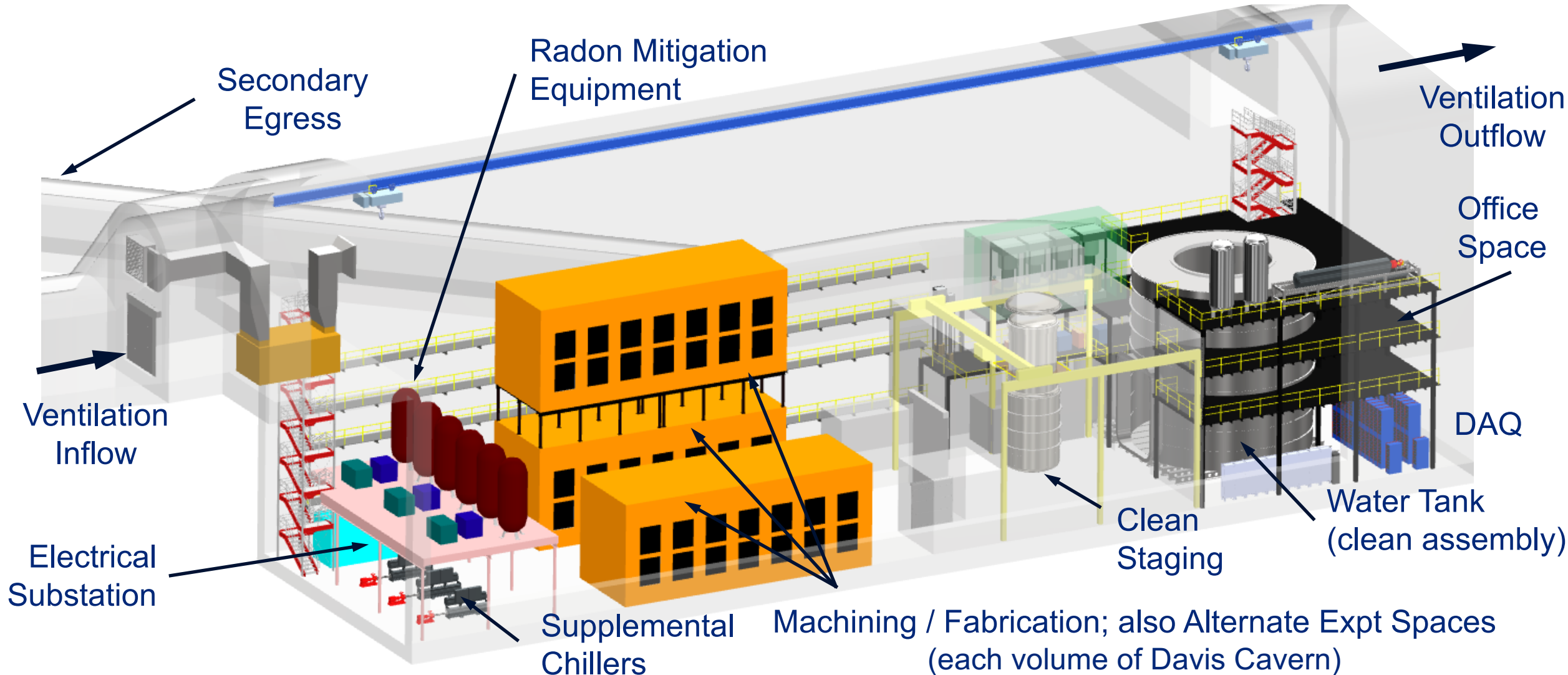


See also: [Annu. Rev. Nucl. Part. Sci. 76 69-95 \(2026\)](#)



Next-Generation Science at SURF

Several deep options available



SURF Aspires to Become DOE User Facility

Important to have deep underground user facility in the U.S.

Benefits

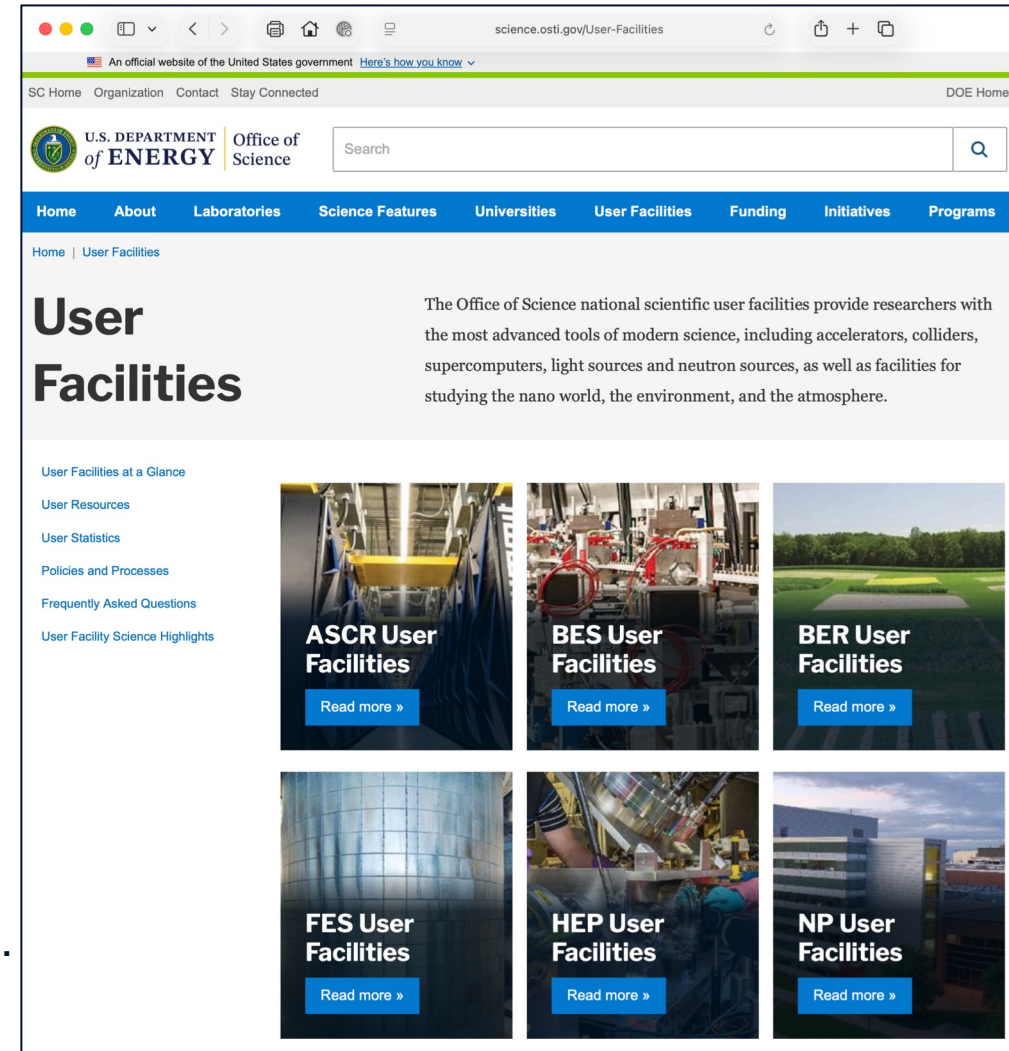
- Expands DOE User Facility portfolio to incl underground lab, raises SURF's stature within DOE community.
- Promotes underground science in U.S., increases SURF funding opportunities (FOAs encourage partnerships w/ User Facilities)
- Enhances SURF's role in global science community.
- Communicates SURF is open to a broad range of science and users, SURF processes for hosting science accepted by DOE.

Main Requirements

- Facility open to users regardless of nationality or institution. ✓
- Allocation of facility resources determined by merit review. ✓
- Facility resources for users to conduct work safely and efficiently. ✓
- The facility supports a formal user organization. ✓

Status

- User Association + Science Program Advisory Committee established.
- Significant maintenance for Yates Shaft completed March 2025.
- Application drafted, revisit following DOE HENP re-organization.



SURF Summary

- SURF has strong relationship with DOE that benefits UG science and CPAD community:
 - SURF has mandate to **support experiments** and ensure **safe and reliable access for decades**.
- SURF offers world-class service to the underground science community:
 - SURF attributes attract **world-leading** experiments and scientists from **diverse scientific communities**.
 - SURF has **proven track record** of enabling high-impact science by leveraging strong **institutional partnerships**.
- SURF is playing a strong role in the UG science community (see backup):
 - **User Association** serving as catalyst for community discussions: <https://sanfordlab.org/surf-user-association>.
 - **Institute** has had significant impact with initial programming that is building intellectual community.
- SURF wants to host future world-leading experiments. SURF is *your* deep underground lab!



Sanford Underground Research Facility

Thank You!



Agency Acknowledgement:

The Sanford Underground Research Facility (SURF) is a federally sponsored research facility under DOE-SC HEP Award Number DE-SC0020216 (cooperative agreement)



The Institute for Underground Science at SURF

World-leading center for

- **Underground science collaboration and intellectual community**
- **Science education and engagement** (K-12 and public education & outreach programs)



THE INSTITUTE
FOR UNDERGROUND SCIENCE
AT SURF

<https://institute.surf>
(Also: <https://vimeo.com/834559440>)



Institute for Underground Science at SURF

Advancing program vision using existing resources to build constituency

Vision

Create a dynamic intersection of KNOWLEDGE, PEOPLE, and PLACE, dedicated to building an unparalleled intellectual community and serving as a world-leading center for underground science and technology

Priorities



Build Intellectual Community



Foster Interdisciplinary Collaboration



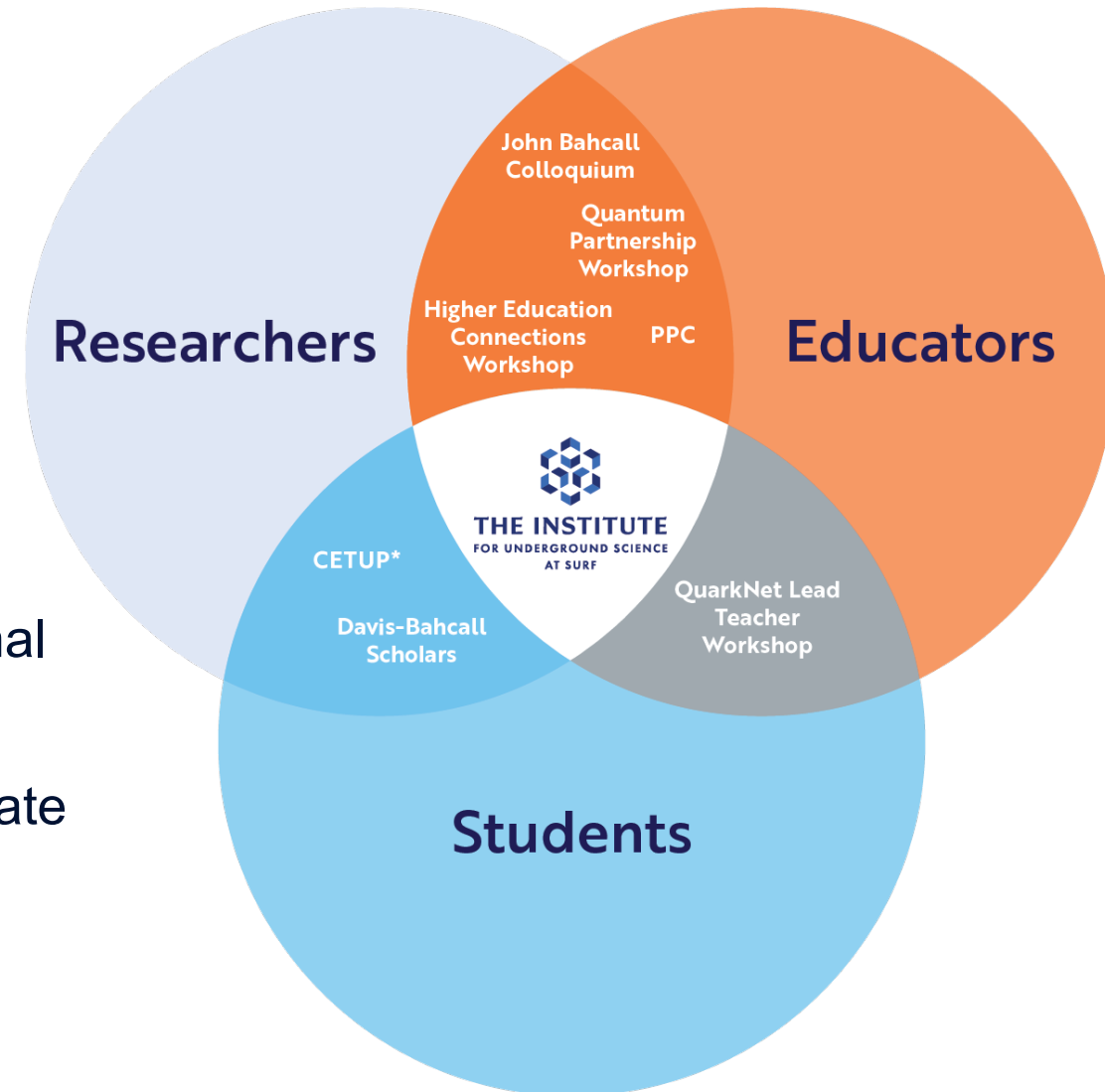
Construct a Path for Future Generations



Expand Educational Opportunities

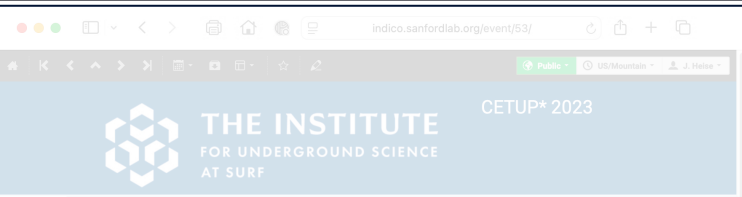
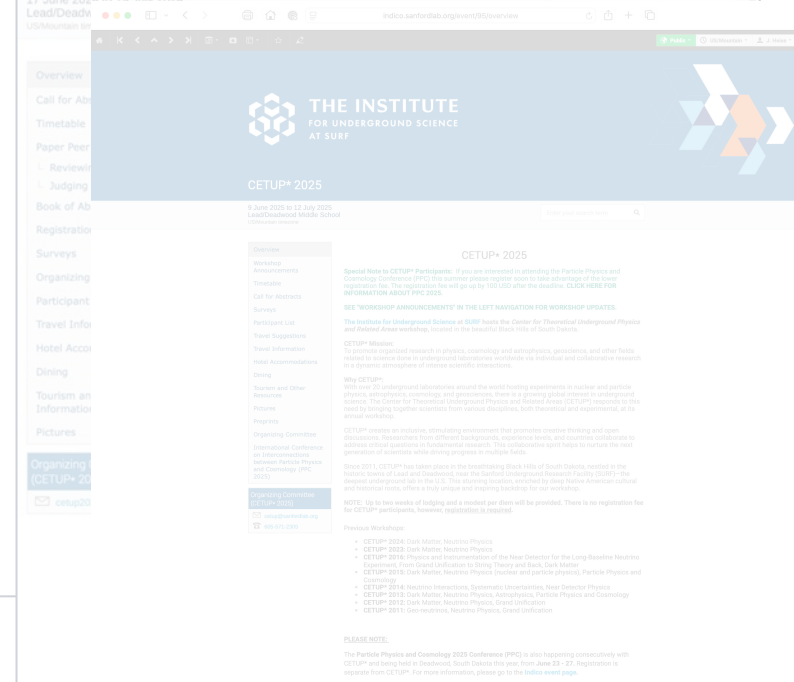


Establish Passionate Partnerships



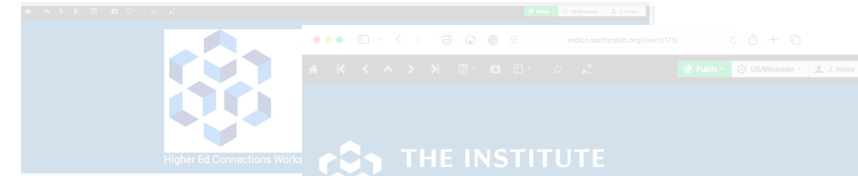
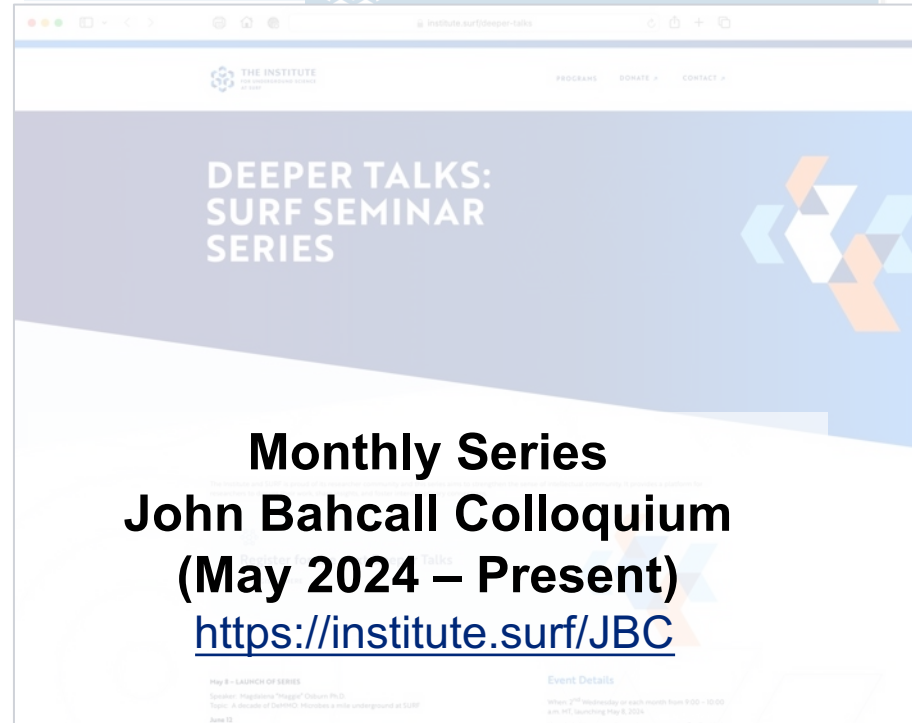
Institute for Underground Science at SURF

Activities since June 2023, formally launched December 2023



Higher Ed Connection Workshop (2024, 2025)

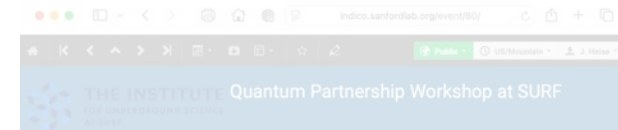
<https://indico.sanfordlab.org/event/76> / [175](https://indico.sanfordlab.org/event/175)



Monthly Series

John Bahcall Colloquium (May 2024 – Present)

<https://institute.surf/JBC>



CETUP* (2023, 2024, 2025, 2026)

<https://indico.sanfordlab.org/e/CETUP2023> / [2024](https://indico.sanfordlab.org/e/CETUP2024) / [2025](https://indico.sanfordlab.org/e/CETUP2025) / [2026](https://indico.sanfordlab.org/e/CETUP2026)

Quantum Partnership Workshop (2024, 2025, 2026)

<https://indico.sanfordlab.org/e/QPW2024> / [2025](https://indico.sanfordlab.org/e/QPW2025) / [2026](https://indico.sanfordlab.org/e/QPW2026)



SURF User Association

<https://sanfordlab.org/surf-user-association> (incl registration)

Purpose

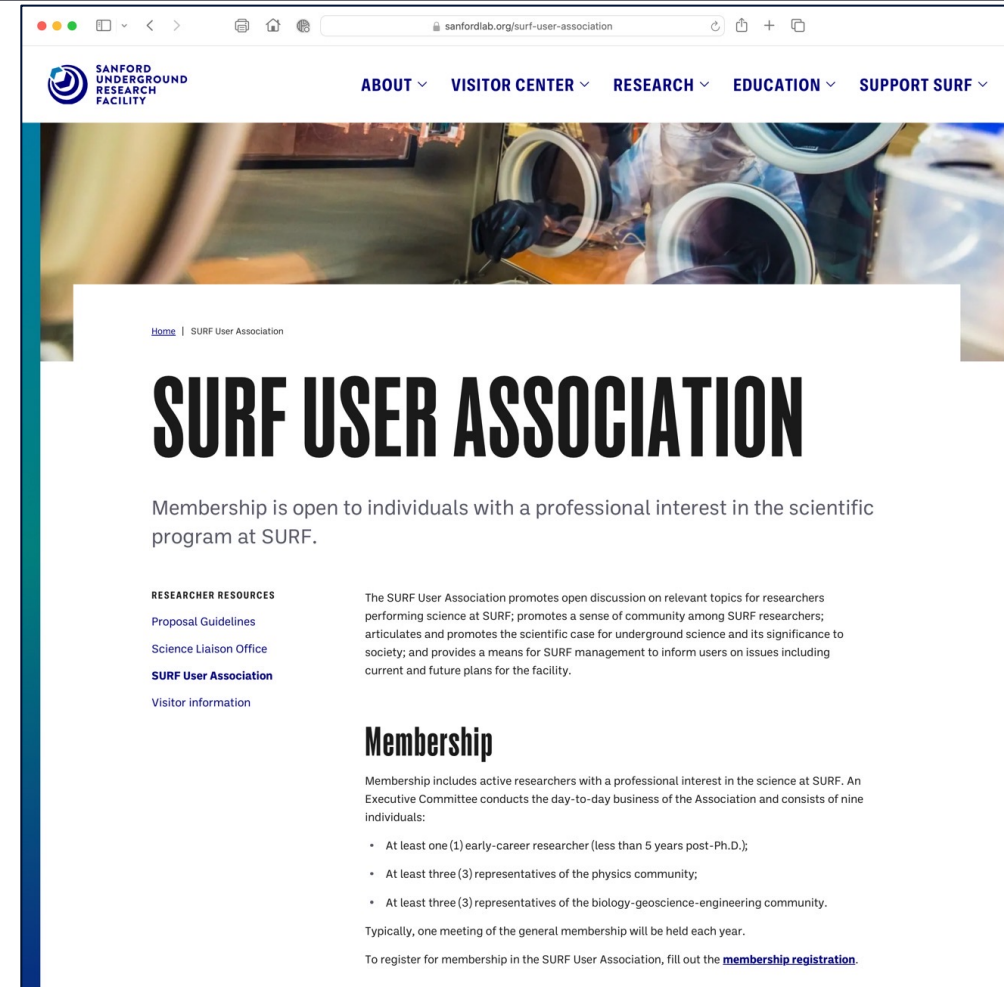
- **Two-way communication** on topics important to researchers
- Promotes a **sense of community** amongst SURF experiments and researchers
- Articulates and promotes **scientific case for UG science** and significance to society, provides channel for **advocacy**

Organization

- **Membership = 567** (open to all UG science community)
- **Executive Committee** consists of 9 individuals across scientific disciplines, incl early career. Quarterly meetings with SURF Management

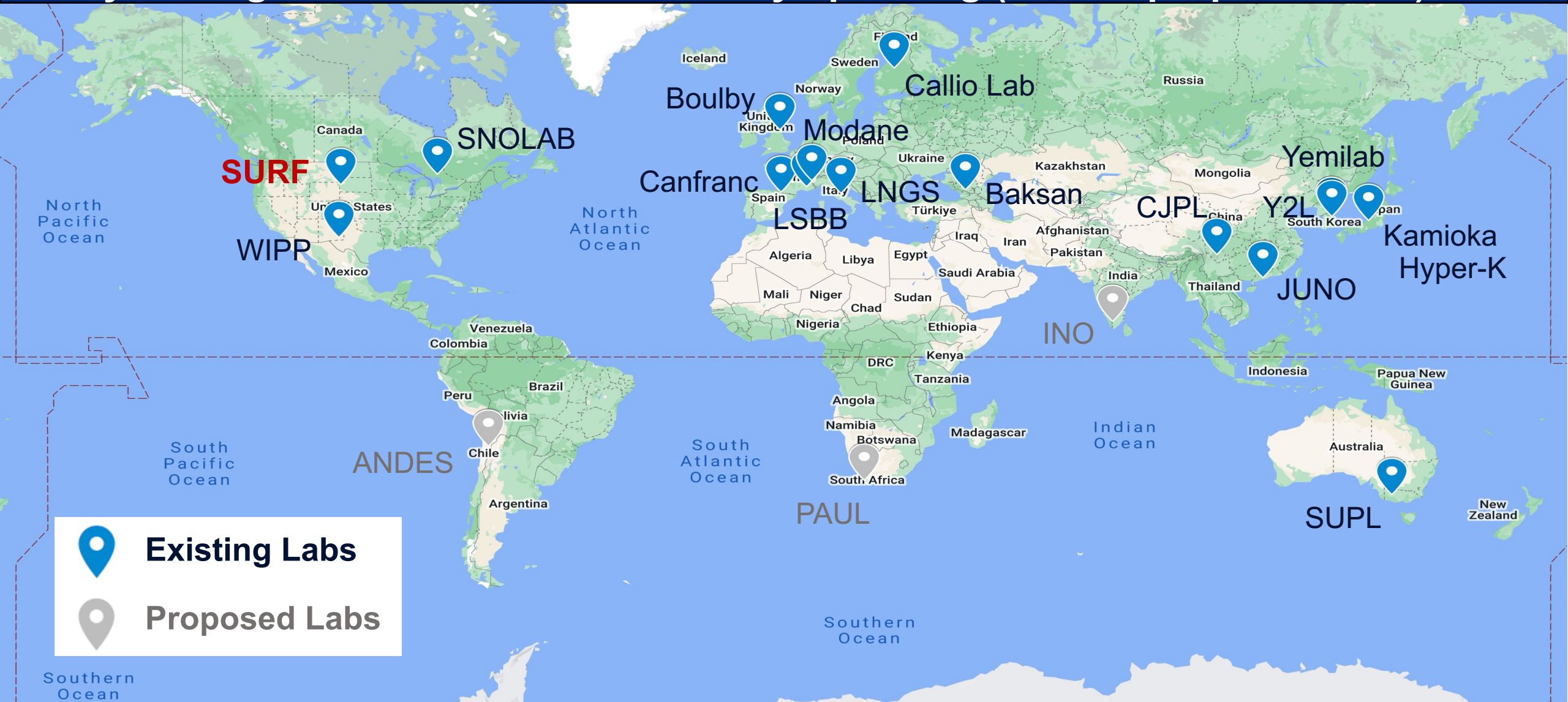
Events

- **Engagement** initiatives in progress, stay tuned in 2026
- **General meetings** typically annually, next @ CoSSURF 2027
- **Topical workshops**, incl community planning (e.g., Vision2021)
- **Advocacy**, with participation in 2026 HEP DC Visit (interactions with 27 congressional offices + OSTP)



Where in the World is SURF?

Many underground laboratories currently operating (+ more proposed labs)



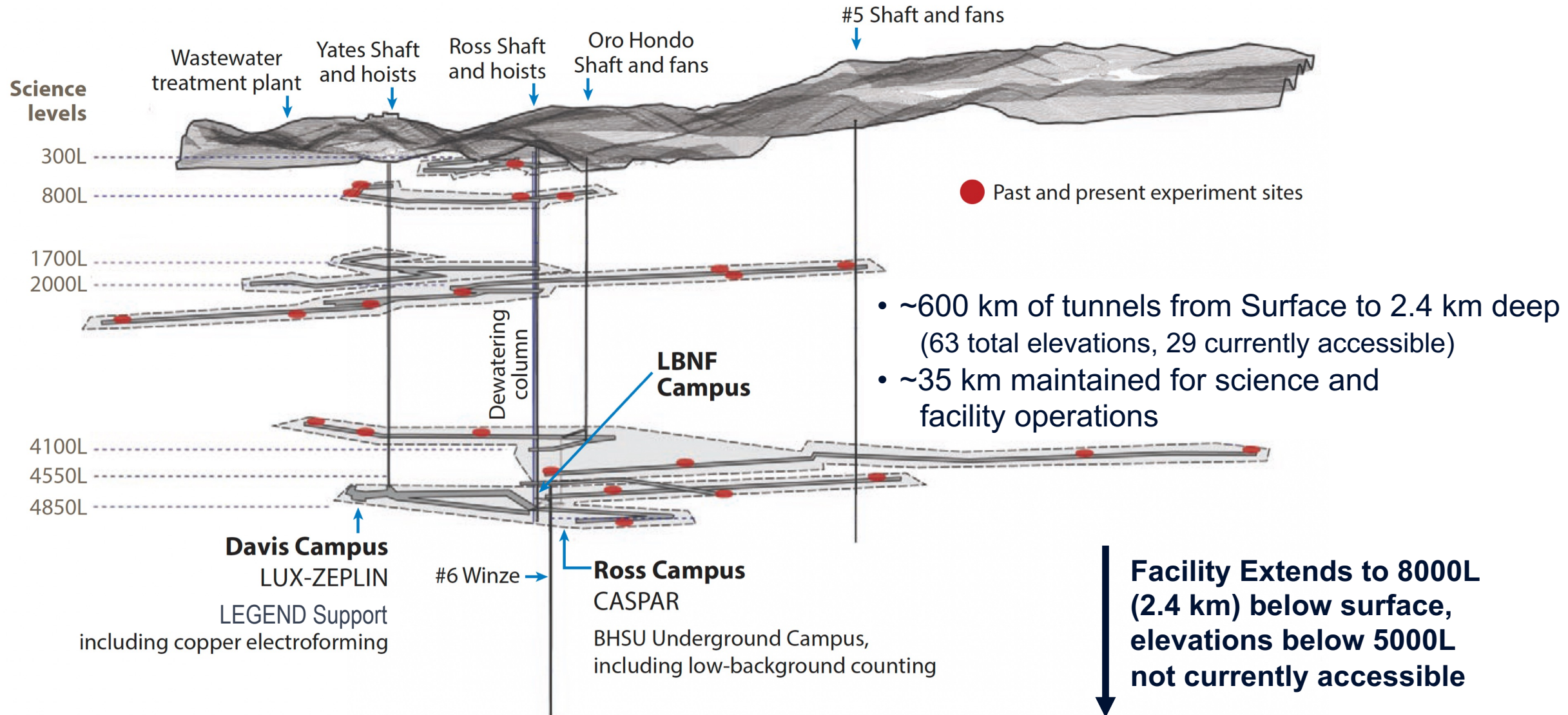
Sanford Underground Research Facility

Lead, South Dakota, USA



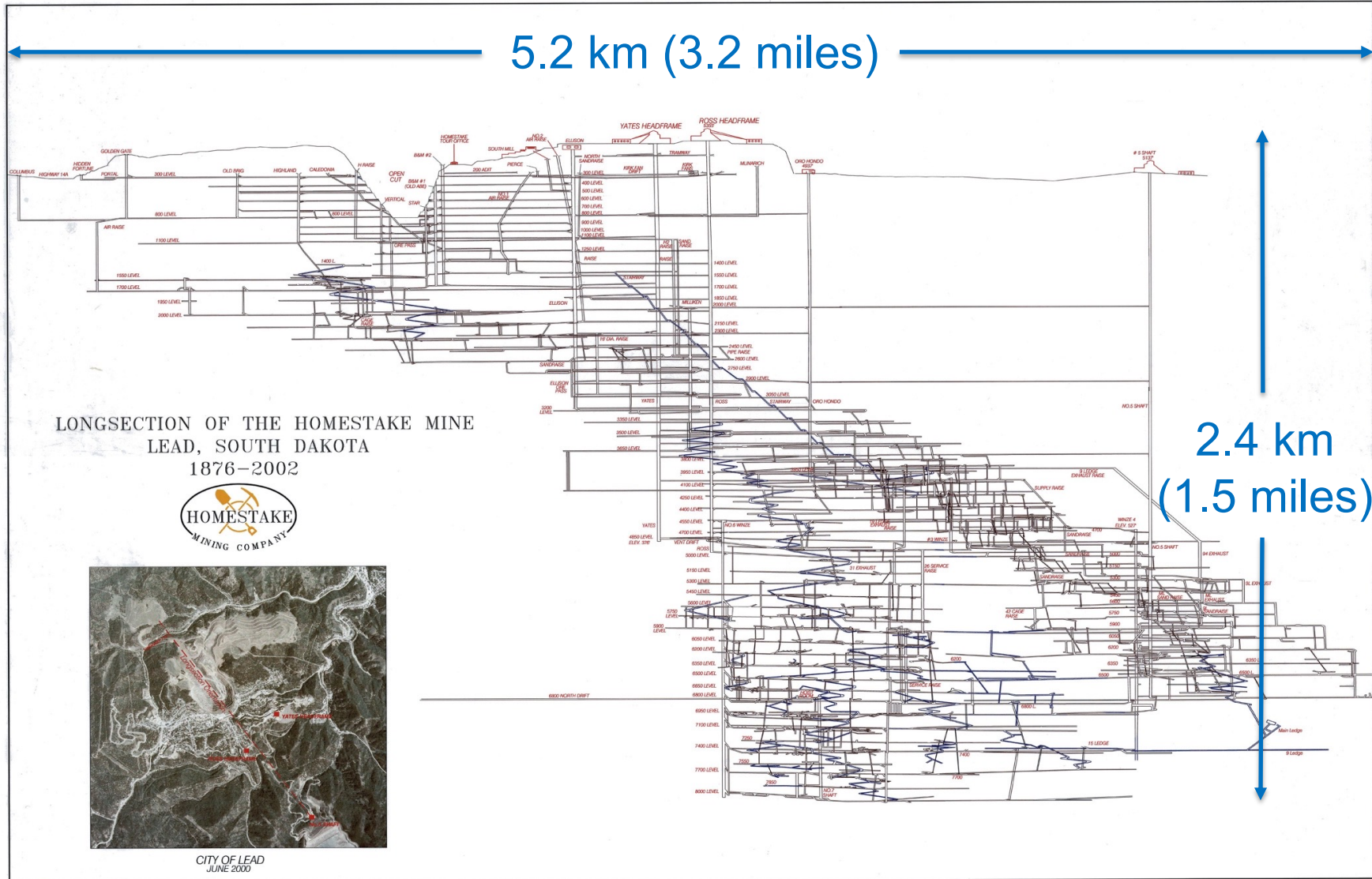
SURF Underground Lab Geography

Largest footprint for science: access to rock mass of $\sim 35 \text{ km}^3$, 35 km of tunnels



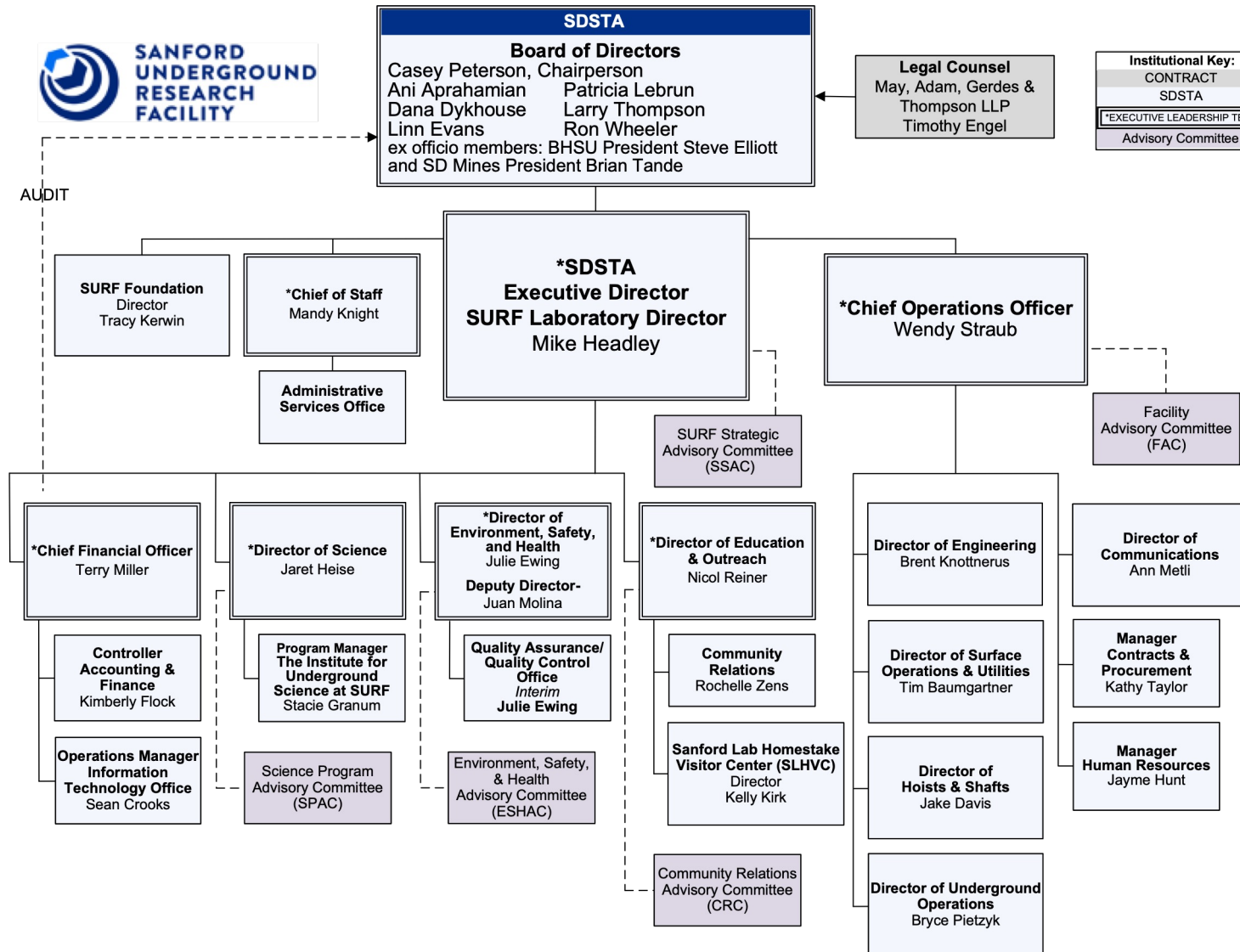
SURF Underground Lab Geography

Significant underground footprint for science



SDSTA Organization

Robust organization: 9 depts, 5 offices + Institute, Visitor Center and Foundation



Staffing Area	Current # ppl (%)	FY29 # ppl (%)
Admin / Mgmt	30 (13%)	30 (13%)
Engineering	13 (6%)	13 (6%)
ESH	21 (9%)	21 (9%)
Outreach	23 (10%)	23 (10%)
Scientific	5 (2%)	5 (2%)
Technical / Operations	133 (59%)	140 (60%)
TOTAL	225	232 *

* More LBNF/DUNE support possible

Current Science Direct Support = 19 ppl



SURF Science Program

Research activities ranging from surface to 1500+m underground

Physics

LZ – Dark matter, 2-phase Xe TPC
LEGEND Support – Cu e-forming, machining for neutrinoless double-beta decay
CASPAR – Nuclear astrophysics with 1 MV accelerator
Expt Bkgds – Neutrons, gamma-rays
LBNF/DUNE – Neutrino properties, etc
BHUC – BHSU Underground Campus, mainly material screening

Berkeley LBF – Low-bkgd counter (x4); also CUBED – Low-bkgd counter (x1)
AL/KY (was nEXO) – Low-bkgd counter (x1)
LLNL – Low-bkgd counter (x1)
NEMESIS – Neutron detectors, dark matter

Total = 30 groups

24 Active Projects

24 Groups with SD Involvement

79 Total Groups Since 2007

Significant interest from others
(34 groups in 2025)

* Denotes
proprietary
group

Biology

Astrobiology/DeMMO – In-situ culture, DNA isolation
Biodiversity – Microbial communities
Biofilms – Deep biosphere methane cycling
Carb EnZero – Microbes for carbon capture, bio-leaching
Chemistry – Env characterization
Delavie Sciences* – Extremophiles
DULIA-Bio/REPAIR – Yeast in low-radiation (multi-lab)
m-sense – Microbes and environment
SDSU Mesonet – Climate station/modeling

Geology

CUSSP – Geothermal
3D DAS – Seismic monitoring using optical fiber
Black Hills Seismic – Global monitoring
Core Archive* – Mainly gold deposits
Biosignatures – Life signs for exobiology
Transparent Earth – Seismic arrays
USGS Seismic – Earthquake, nuclear monitoring

Engineering

Environment Monitoring – Ventilation airflow
Safety Robotics – Mining safety
Shotcrete – Mining safety
Water – Geothermal and resources



SURF Material Assay at BHUC

Low-background counting capabilities serving national & international community

Detector	Crystal		[U] mBq/kg	[Th] mBq/kg	Status	Comments
	Type	Size				
Maeve (LBNL)	p-type (85%)	2.2 kg	0.1 (10 ppt)	0.1 (25 ppt)	Production assays	Relocated from Oroville. Old Pb (200-yr old) inner shielding.
Merlin (LBNL)	n-type (115%)	2.2 kg	~0.2 (~20 ppt)	~0.2 (~50 ppt)	Operating	Installed 2025.
Morgan (LBNL)	p-type (85%)	2.1 kg	0.2 (20 ppt)	0.2 (50 ppt)	Production assays	Low-bkgd upgrade 2015.
Mordred (USD/CUBED, LBNL)	n-type (60%)	1.3 kg	0.7 (60 ppt)	0.7 (175 ppt)	Production assays	Low-bkgd upgrade 2015-2016, shield access upgrade.
Twins (Dual HPGe) (LBNL, BHSU, UCSB)	p-type (2x120%)	2x 2.1 kg	~0.01 (~1 ppt)	~0.01 (~1 ppt)	Operating	Low-bkgd upgrades 2016-2017; flexible shield configuration.
RHYM+RESN (Dual HPGe) (LLNL)	p-type (2x65%)	2x 1.1 kg	<0.1 (<10 ppt)	<0.1 (<25 ppt)	Production assays	Cryocooler, low-E ²¹⁰ Pb (<2 mBq/kg).
Ge-IV (Alabama, Kentucky)	p-type (111%)	2 kg	0.04 (3 ppt)	0.03 (8 ppt)	Offline	Gantry + hoist for vertical design. Awaiting relocation to Ross Campus.

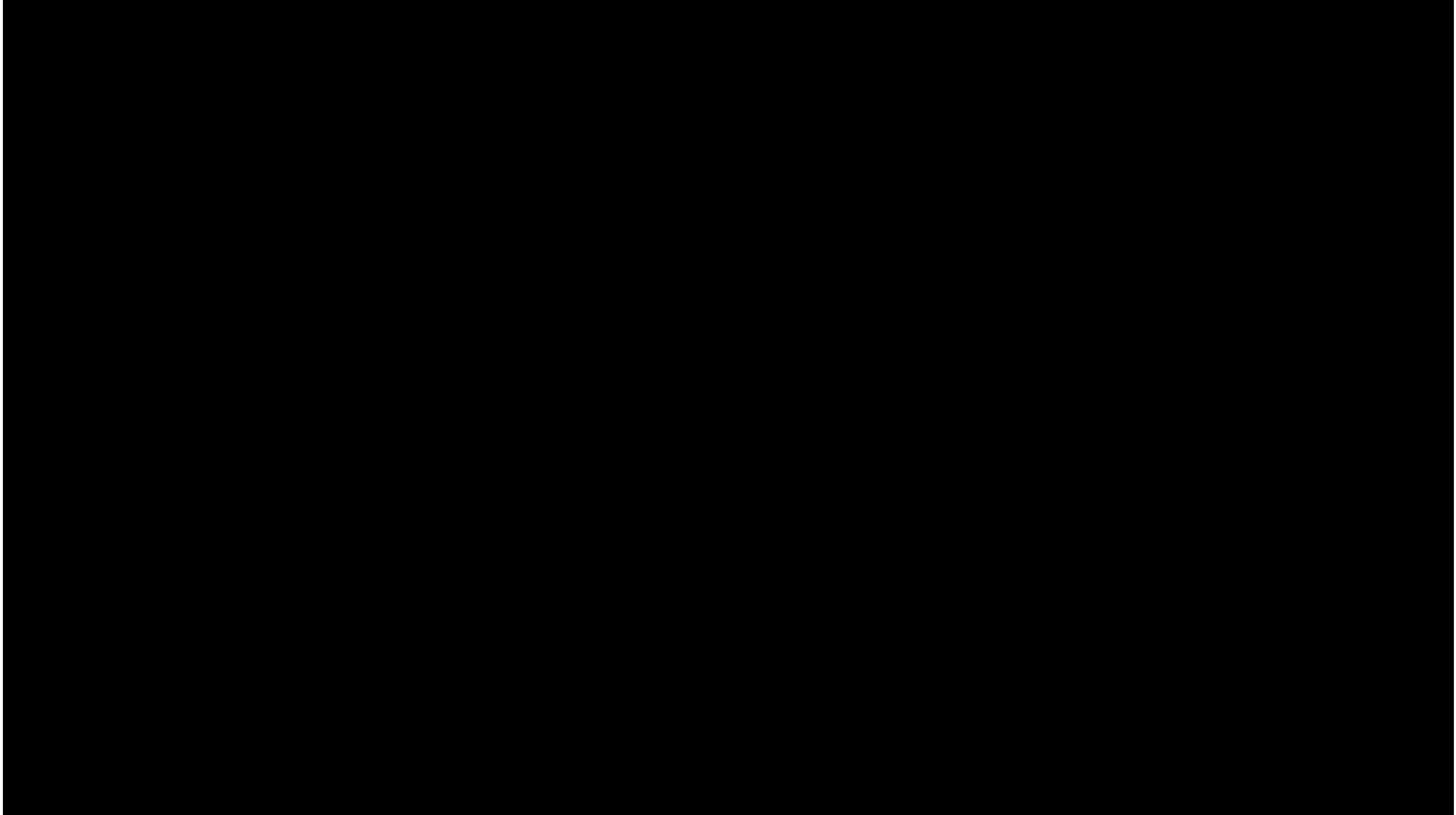
Also see: LZ Assay Paper <https://arxiv.org/pdf/2006.02506>

Local universities have some additional material screening capabilities: **HPGe** ([0.2-0.4 kg]/SD Mines), **ICP-MS** (BHSU), **Rn emanation** characterization (0.1 mBq/SD Mines), **Alpha** (1 mBq/m² ²¹⁰Po/SD Mines; XIA UltraLo-1800/LZ purchased)

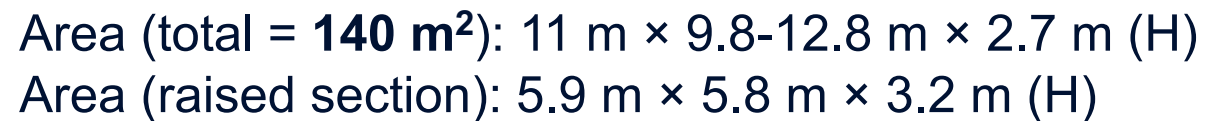


4850L Laboratory Expansion – Phase A

Expansion blasting video: <https://vimeo.com/982238458>

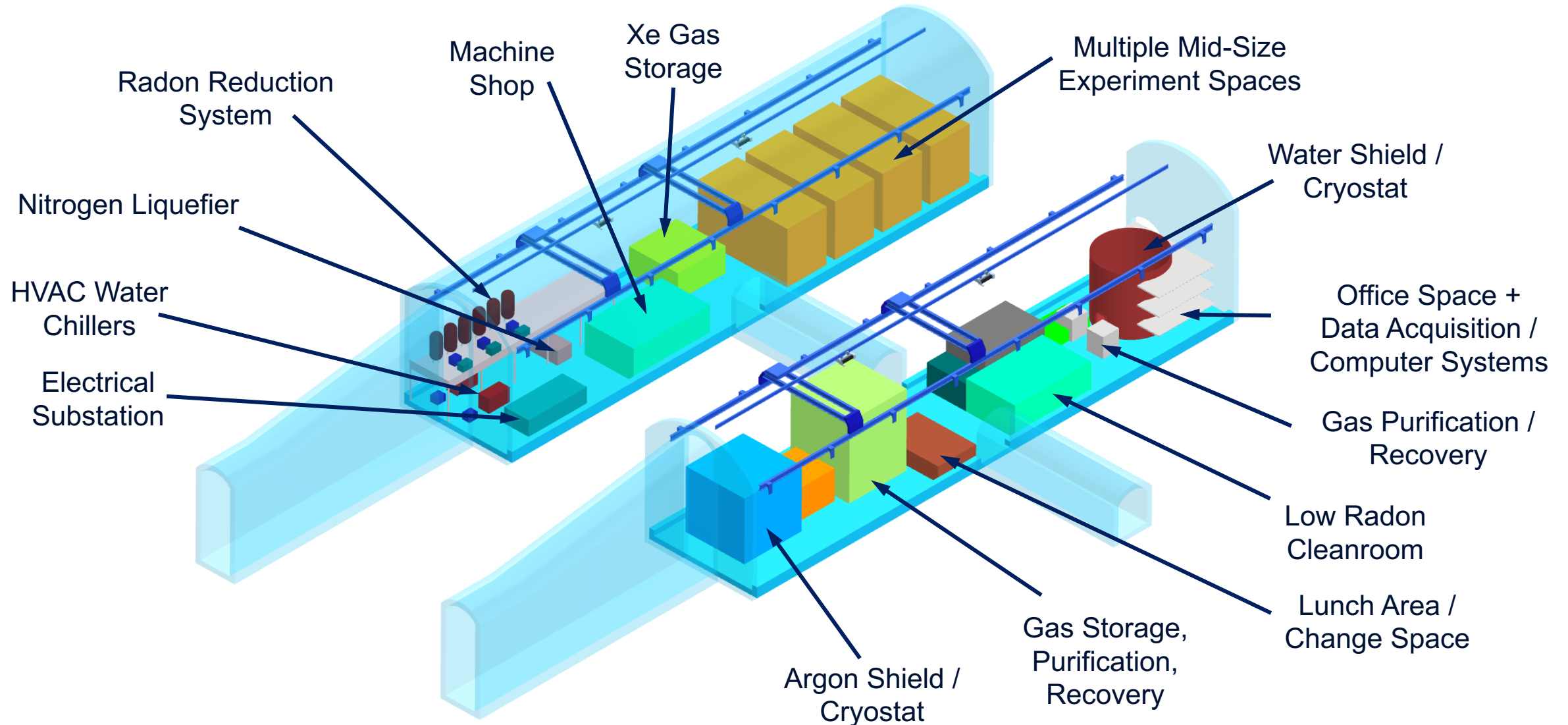


Deep site at 4850L Davis Campus planned to support range of quantum science



Next-Generation Science at SURF

Conceptual layout (2x 100m caverns), informed by DUSEL PDR, ARGO/XLZD, LZ



Next-Generation Science at SURF

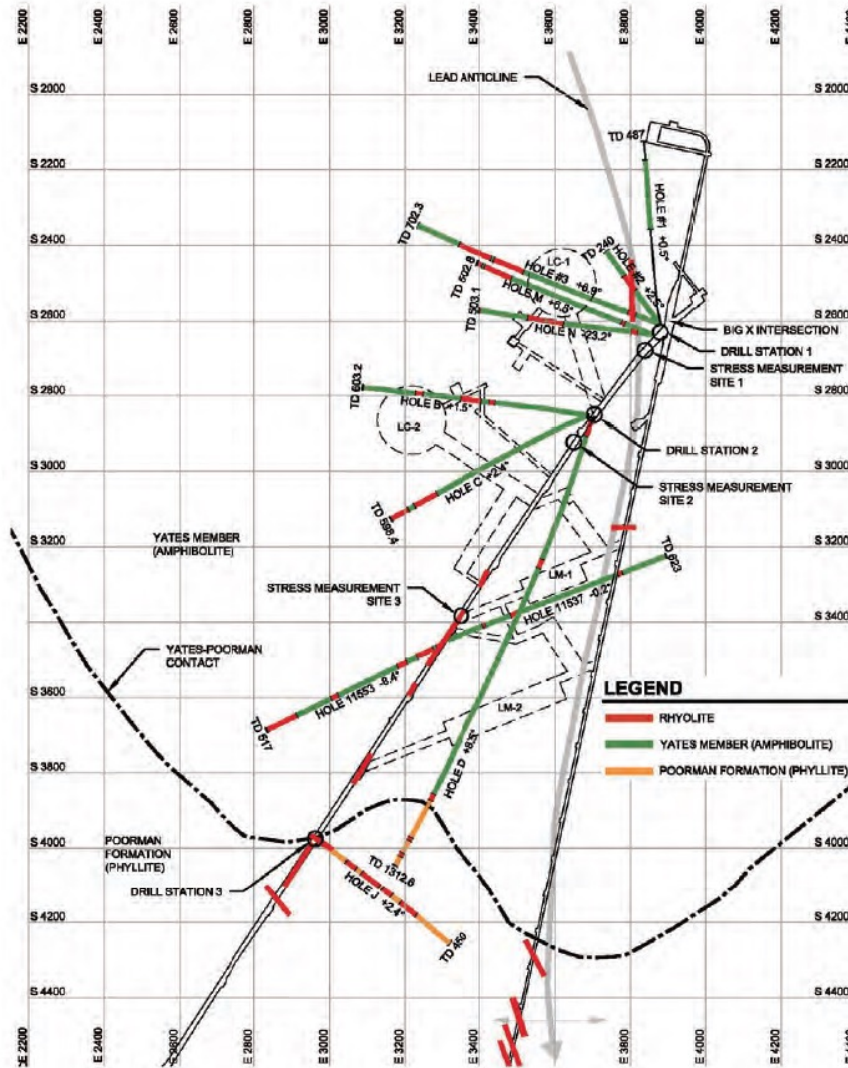
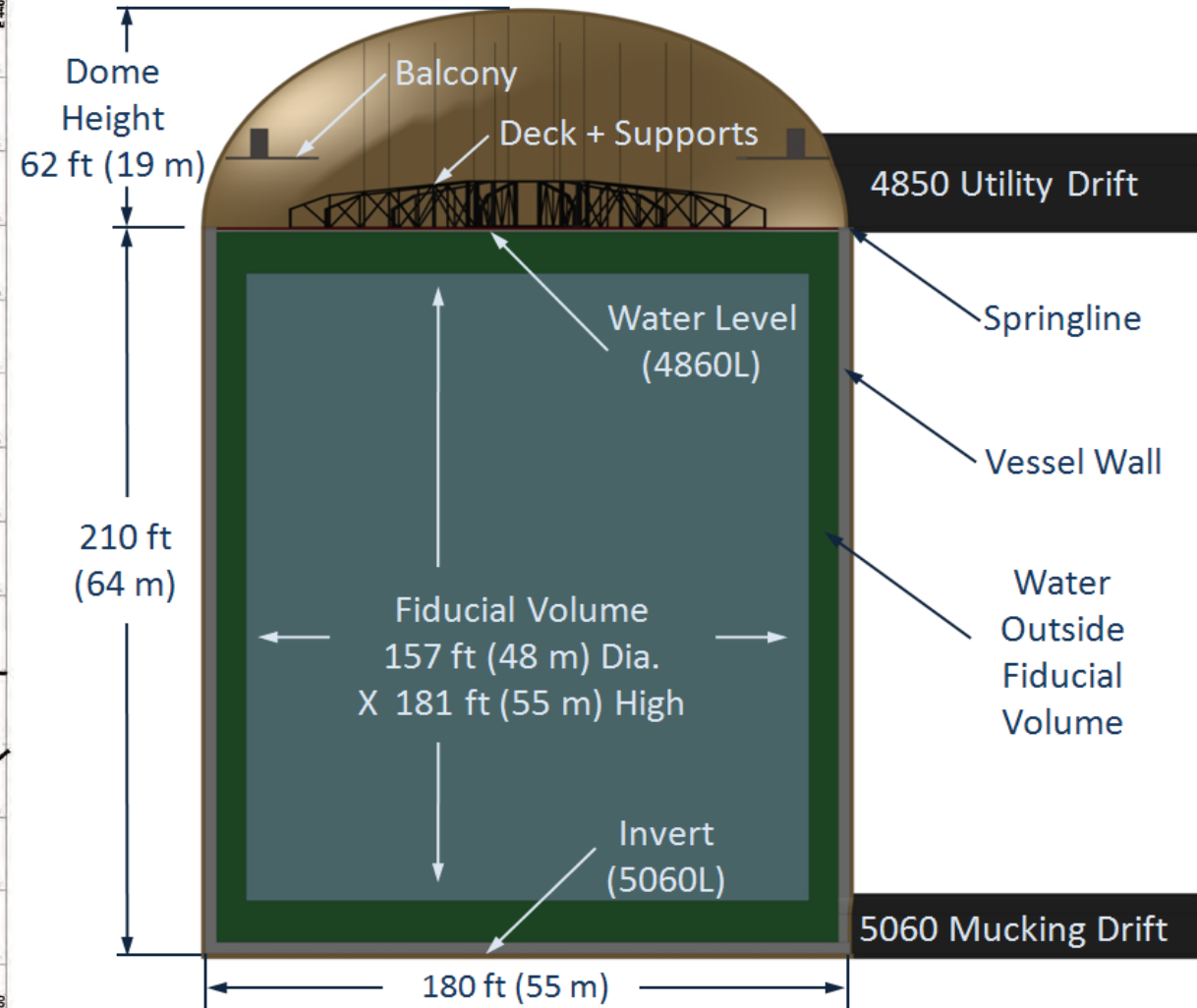
Several deep options available, alternate geometries possible

4850L Right Cylinder Studied

LBNE 100 kT
Water Cherenkov
(see DUSEL PDR:
[arxiv:1108.0959](https://arxiv.org/abs/1108.0959))

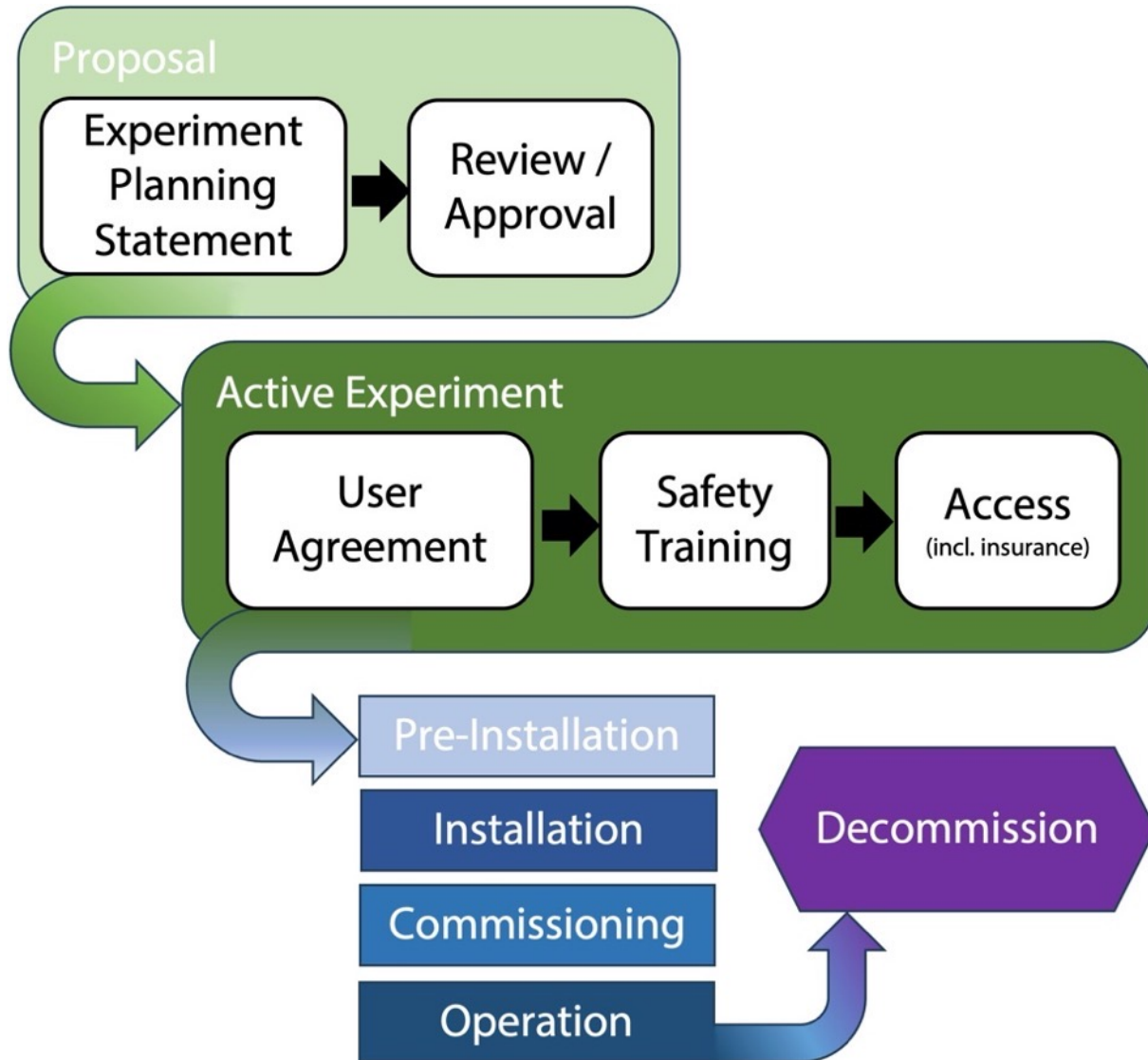
Ventilation

- **Exhaust:**
170,000 m³/h
(via raise to
4700L)
- **Fresh Air:**
30,600 m³/h
via Yates Shaft
(1 exchange/hr)



SURF Experiment Implementation Program

Identify interfaces and hazards within approval framework



<https://sanfordlab.org/proposal-guidelines>

The screenshot shows the **RESEARCH PROPOSAL GUIDELINES** webpage from the Sanford Underground Research Facility. The page includes a navigation bar with links for **ABOUT**, **VISITOR CENTER**, **RESEARCH**, **EDUCATION**, and **SUPPORT SURF**. The main heading is **RESEARCH PROPOSAL GUIDELINES**, followed by the text: "All proposals must follow these guidelines".

RESEARCHER RESOURCES

- Proposal Guidelines**
- Science Liaison Office
- SURF User Association
- Visitor information

We are excited at Sanford Lab to contribute to cutting-edge science by providing the best environment for experiments that require unique underground facilities. We are glad to work with you to get your experiment running. To begin the process of approval and installation, follow the steps in the order listed below:

1. Read the [Experiment Implementation Program](#).
2. Read the [Experiment Integration and Support](#) document.
3. Complete a draft of the [Experiment Planning Statement](#) describing your project.
4. Contact the [SURF Science Director](#).
5. Complete the [User Agreement](#). The User Agreement references the SURF [waiver](#) required for underground access, the SURF [ESH Standards](#) and the SURF [Publication Policy](#).

PROPOSAL DOCUMENTS

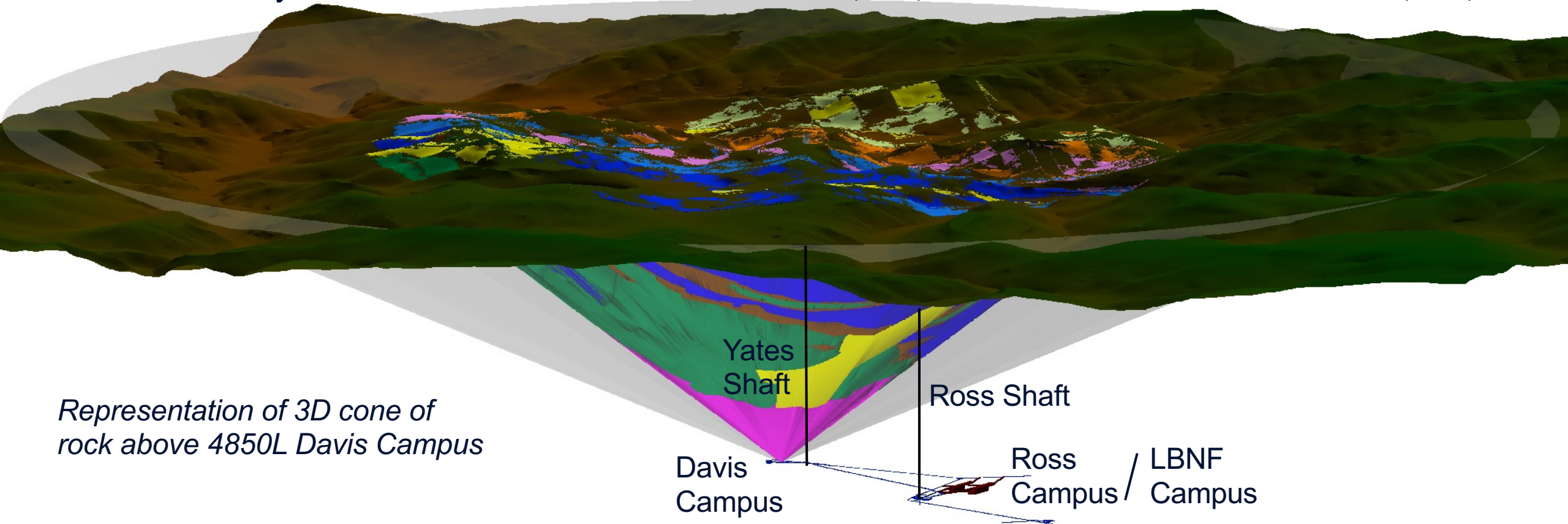
- SCI-(1000-S)-135416 Experiment Integration & Support.pdf
362.8 KB | PDF
- SCI-(1000-F)-69417 User Agreement
44.7 KB | DOCX
- SCI-(1000-F)-34460 Experiment Planning Statement
74.2 KB | DOCX
- SCI-(1000-F)-212612 User Agreement Acknowledgement.docx
31.8 KB | DOCX
- SCI-(1000-S)-186874 Publication Guidelines.pdf
255.3 KB | PDF
- EL-(1000-F) Combined Acknowledgement of Risk and Waiver
152.2 KB | PDF
- SCI-(1000-S)-34478 Experiment Implementation Program.pdf
1 MB | PDF



SURF Science Support – Geology Model

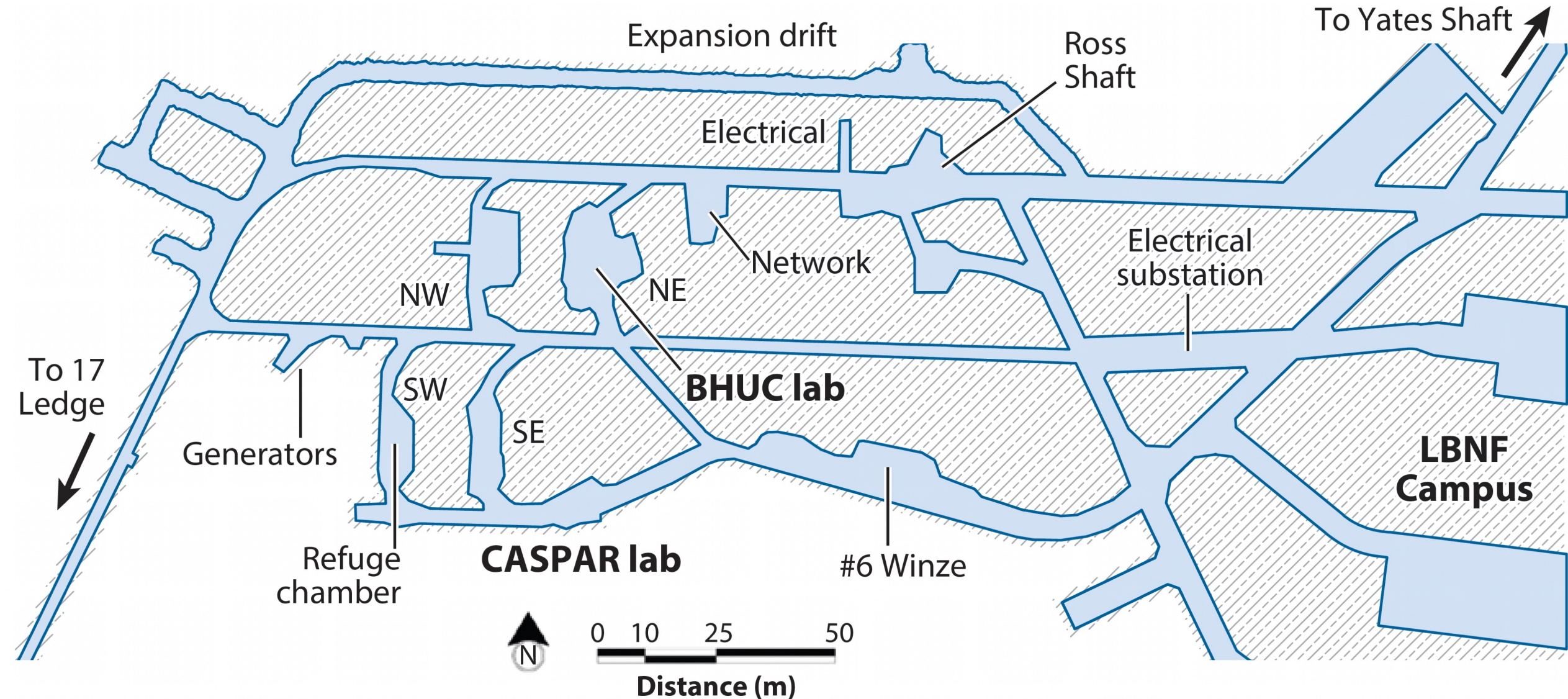
Site well understood, including drill core & logs

- 3D model of 12 rock formations (including rhyolite/phonolite intrusives)
- Detailed surface topology: Aerial survey for site performed 2011 (1' contours)
- Global coordinates: Survey performed summer 2016 (incl world's longest plumb bob)
- Rock density data: KH, TCT, WR, JH, *SD Acad. Sci.* **93**, 33 (2014); JH *Annu. Rev. Nucl. Part. Sci.* **76** 69-95 (2026)



SURF 4850L Ross Campus

2,653 m² (Total) / 920 m² (Science)



SURF 4850L Ross Campus

Examples of laboratory space



2010-2017

Former MJD Electroforming:

Area = 228 m²
(Cleanroom removed,
current construction office)

CASPAR Hall:

Area = 236 m²,
30 m × 3 m (min) × 2.8 m (H)



2015-2021, resumed 2025



2015-2020, resumed 2025

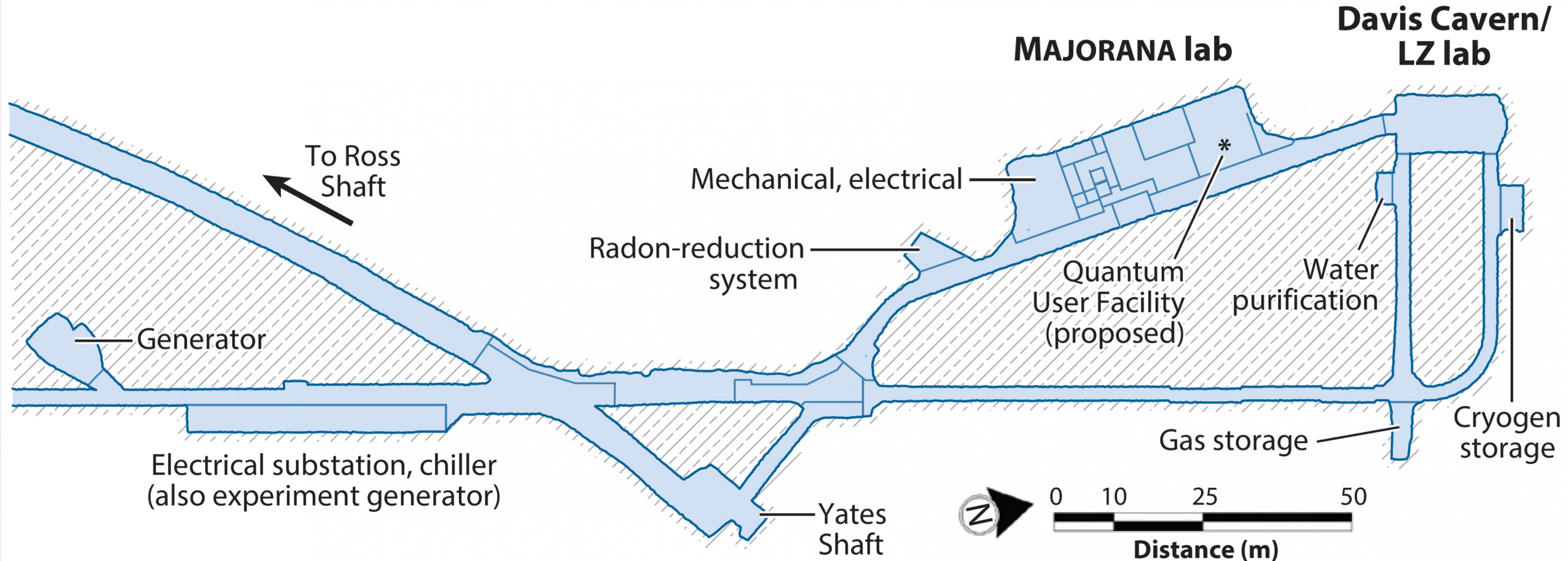
BHUC Cleanroom:

Cavern Area = 268 m²,
Cleanroom = 12.1 m × 6.1 m ×
2.4 m (H)



SURF 4850L Davis Campus

3,017 m² (Total) / 1,018 m² (Science)



SURF 4850L Davis Campus

Examples of laboratory space



Detector Room (MJD):

Area = 140 m^2 , $11 \text{ m} \times 9.8\text{-}12.8 \text{ m} \times 2.7 \text{ m (H)}$
(raised section: $5.9 \text{ m} \times 5.8 \text{ m} \times 3.2 \text{ m (H)}$)



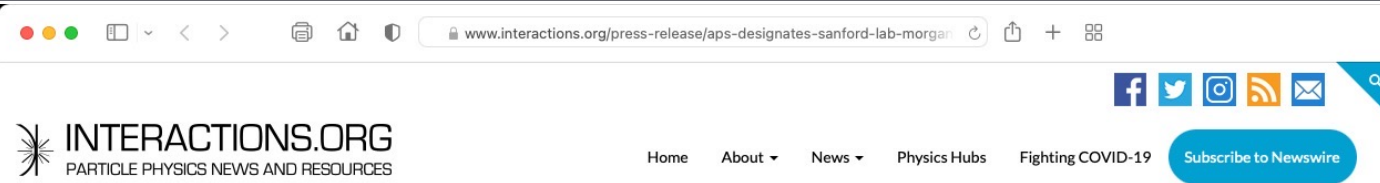
Davis Cavern, Lower (LZ):

Area = 142 m^2 , $13.7 \text{ m} \times 9.1 \text{ m} \times 6.4 \text{ m (H)}$
(incl tank: $7.6 \text{ m dia.} \times 6.4 \text{ m H}$). Total Cavern H = 10.8 m



SURF Designated APS Historical Site

Announcement Sep 2020, Dedication May 2022



APS designates Sanford Lab, Morgan State University as historic physics sites

14 September 2020 - Sanford Underground Research Facility

The pioneering neutrino research done by Ray Davis over nearly three decades forever changed our understanding of the Standard Model of Physics



The American Physical Society (APS) today announced it has designated SURF one of two Historic Sites in physics. The other, Morgan State University in Baltimore, Maryland, is recognized as the birthplace of the National Society of Black Physicists (NSBP).

DATE ISSUED:

September 14th, 2020

SOURCE:

Sanford Underground Research Facility

CONTENT:

Press Release

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Communications Director
cwalter@sanfordlab.org



From 1962 to 1994, Raymond Davis Jr. built and operated the first successful detector for solar neutrinos using John N. Bahcall's theoretical model and working with William A. Fowler, Maurice Goldhaber, and numerous engineers and crew members on the 4850 Level of the Homestake Mine, now the Davis Campus at the Sanford Underground Research Facility. The result of Davis's observations, just one third the theoretical expected flux, led to fundamental advances in particle physics and astrophysics. For his work, Davis received a share of the 2002 Nobel Prize in Physics, along with Masatoshi Koshiba for his research into the detection of cosmic neutrinos.



HISTORIC PHYSICS SITE, REGISTER OF HISTORIC SITES
AMERICAN PHYSICAL SOCIETY



SURF Science & Education Opportunities

SURF Programs

- **Summer Internships** (Bozied/Bauer/Headley)
 - Science, engineering, operations, environmental science and communications, incl underrepresented groups <https://sanfordlab.org/internships>
- **Davis-Bahcall Scholars Program**
 - Multidisciplinary studies at U.S. & European labs/industries <https://sanfordlab.org/dbs>

National Programs

- NSF Research Experiences for Undergraduates (REU):
 - **BHSU** multidisciplinary program since 2016 (physics, chemistry, biology) <https://bhsu.edu/academics/programs/physics.html>
 - **SD Mines Li-SMART** (Lithium, Mining, Recycling and Technology) started 2025 <https://www.sdsmt.edu/news/releases/Li-SMART.html>
- DOE Reaching a New Energy Sciences Workforce (RENEW):
 - **RENEW-Midwest**: From the Underground to the Cosmos, student diversity in STEM (BHSU, UMich, Benedictine) <https://www.pathwaystoscience.org>
 - **NuPUMAS**: Neutrino Physics for Undergraduate Minority Advancement in Science, student diversity in STEM (UHouston / Texas Physics Consortium) <https://nupumas.physics.uh.edu>

Other Opportunities

- **BHSU Underground Campus**: Promoting undergraduate research
- **Local Researchers**: BHSU, SD Mines, RESPEC; also USD, SDSU, DSU



SURF Science Interns



DAVIS-BAHCALL SCHOLARS PROGRAM

THE INSTITUTE
FOR UNDERGROUND SCIENCE
AT SURF

Explore the modern world of STEM research on a four-week, once-in-a-lifetime, all-expense-paid opportunity that connects science-curious students with peers and mentors.



STEM Education at SURF



- SURF Education & Outreach team reaches **22,000+** K-12 students per year
 - Presentations and field trips
 - Curriculum units
- Professional development for more than **400** educators per year
- **Davis-Bahcall Scholars** program and **summer internship** opportunities (Apply this fall!)



K-12 Education & Outreach

Presentations and Field Trips	Curriculum Units and Resources	Career Exploration and Development	Supporting Teachers
<ul style="list-style-type: none">• K12 presentations• Face-to-face• Virtual options• Field trips	<ul style="list-style-type: none">• 17 unique curriculum units available for checkout• 5-15 hours of fully designed and resourced science curriculum	<ul style="list-style-type: none">• Davis-Bahcall Scholars Program• Summer internship opportunities• Pre-service educator program support	<ul style="list-style-type: none">• Professional development offerings• Curriculum resources• Science content support• Just-in-time support
			



Education & Outreach – By the Numbers

School Year	2019-2020 (covid begins)	2020-2021 (during covid)	2021-2022	2022-2023	2023-2024	2024-2025
Field Trips	254	58	485	972	966	1,501
Classroom Presentations	3,704	2,005	14,038	12,799	10,281	14,712
Curriculum Units	3,236	3,384	3,718	2,554	3,965	4,171
Other	918	298	1,468	1,596	1,368	1,729
Total Student Contacts	8,112	5,745	19,709	17,921	16,580	22,113

August 2024 – July 2025: Developed and facilitated more than 6000 people hours of professional development for more than 400 educators



Sanford Lab Homestake Visitor Center

Acquired January 2022. Greatly expands public outreach opportunities.



Sanford Lab Homestake Visitor Center (SLHVC)

Building meaningful relationships with range of audiences

Audiences

- Intergenerational year-round programming
- Venue space for SURF and its affiliates
- Local community
- Tourists

Engaging Content

- Docent tours
- Ask-a-Scientist events
- *Deep Talks* lecture series
- *Deep Roots* cultural events
- Tours to hoist room and Čanglěška Wakhánj

Accessible Opportunities

- Accessibility strategic plan in process
- Serves as SURF's public "front door"
- Multi-use space
- Community partner:
 - Voter polling site
 - Visitor center for tourists
 - Exploring public EV charging station



By the Numbers

	2023	2024	2025
Visitors	57,317	58,136	55,484
States	50	50	50
Countries	33	42	41
Buses	139	137	158
Events	121	124	140



Čanġlěška Wakħán, the Ethnobotanical Garden at SURF

Public tours started summer 2024



Sanford Underground Research Facility

General summary

Site: Deepest underground lab in U.S., largest footprint for scientific pursuits (former Homestake Gold Mine). Operations funded directly by U.S. Department of Energy (\$44M/yr). Robust org, total staff = 228 ppl.

Science Program:

- **Past:** Davis Solar Neutrino Experiment, LUX, MAJORANA DEMONSTRATOR ($0\nu\beta\beta$, $^{180\text{m}}\text{Ta}$), others (incl Deep Underground Gravity Lab, affiliated w/ LIGO collaboration; Industry/engineering w/ Caterpillar)
- **Current:** LZ, CASPAR, Low-bkgd counting (BHUC), Geoengineering (esp. geothermal, seismic), Geomicrobiology, Engineering
- **Future** (no funding/site decisions yet):
 - Dark Matter: Low-mass (SPLENDOR, HydroX), next-generation WIMP (XLZD, Argo), other (CrystaLiZe)
 - Neutrino: Liquid scintillator (Theia), multi-ton-scale $0\nu\beta\beta$ (LEGEND 6000), XLZD, etc
 - QIS, atom interferometry – gravitational waves, ultra-light dark matter: km-scale vertical or horizontal

Facility:

- **4850L Existing:** Davis Campus and Ross Campus operating well
- **4850L Quantum User Facility:** Fridge(s) for QIS at Davis Campus/Expansion (exploring funding)
- **4850L LBNF/DUNE:** Excavation complete, “Module of Opportunity” for expanded science program (DOE)
- **4850L Expansion:** Up to 2x caverns (100m L × 20m W × 24m H), complete in early 2030s (private/DOE?)
- **Vertical Facility:** Accommodate during Yates Shaft refurbishment, schedule TBD / ~2030s (DOE/other?)



Sanford Underground Research Facility

Physical characteristics

- **Property:** 1 km² (surface) with ~1600 m² storage (incl drill core) and 355 m² staging/assembly space; 31 km² (total underground) with ~600 km of tunnels extending to over 2450 m below ground.
- **Access:** Vertical; personnel and materials via one of two main shafts (Yates Shaft extensive maintenance campaign completed, DOE funding discussions for full refurbishment). Facility dedicated to science.
 - Yates Shaft: 1.39 × 3.77 × 2.58 m, 4.8 tonnes (lengths up to 7.3 m possible at reduced payload mass)
 - Ross Shaft: 1.40 × 3.70 × 3.62 m, 6.1 tonnes (lengths up to 8.2 m possible at reduced payload mass; new cage soon)
- **Depth:** Main UG level = 4850L (1480 m, 4300 mwe), muon flux = $(5.18 \pm 0.27) \times 10^{-5} \mu/\text{m}^2/\text{s}$ (4.5 $\mu/\text{m}^2/\text{d}$). Several other UG elevations for science: 300L, 800L, 1700L, 2000L, 4100L, 4550L.
- **Space:**
 - Surface (science space, as low as class 10-100): 210 m² (cleanrooms = 92 m² / 914 m³)
 - 4850L (science space, as low as class 100): Davis Campus (1018 m² / 4633 m³), Ross Campus (920 m² / 3144 m³)
 - Radon-reduction: Surface = 2200x reduction @ 300 m³/h (Ateko), Davis = 700x reduction @ 150 m³/h (SD Mines)
- **Bkgds** (4850L): Radon* = 210-330 Bq/m³, gamma = 1.9 $\gamma/\text{cm}^2/\text{s}$, neutron (thermal) = $1.7 \times 10^{-2} \text{ n}/\text{m}^2/\text{s}$.
- **Utilities:**
 - Power = 24,000 kW capacity (20,000 kW available now, 15,000 kW in FY27); Standby = 3 diesel generators (390 kW)
 - Chilled water (2x 246 kW), purified water (37.8 lpm), compressed air (up to 1100 scfm, 140 scfm at Davis Campus)
 - Network = 20 Gbps internally, 10 Gbps externally (100 Gbps planned), WiFi available surface + underground

* Studies conducted Summer 2024, expect to reduce Rn concentration



Sanford Underground Research Facility

Capabilities

- **Unique environments for multi-disciplinary research:** SURF has attracted world-leading experiments and scientists from diverse scientific communities.
 - **Overburden protection from cosmic-ray muons:** SURF is the deepest underground lab in U.S., one of deepest laboratories in the world (1500 m, 4300 mwe). SURF is expanding to meet the needs of next-generation experiments
- **Local radiation shielding:** Water tank and corresponding water purification system, steel shielding; also selection of low-activity facility construction materials/finishes (e.g., concrete, shotcrete)
- **Assay capabilities:** Low-bkgd counting serving national & international community ($\sim 10 \mu\text{Bq/kg}$ U/Th)
- **Material production/purification:** One of only a few labs where UG Cu electroforming is performed (average U, Th decay chain $\leq 0.1 \mu\text{Bq/kg}$)
- **Environmental control:** Experience w/ HEPA filtration cleanrooms, dehumidifier, Rn-reduction systems
- **Implementation and operations support:** Robust organization with support for planning, execution and coordination of science program activities both planned and ongoing at facility. SURF has proven track record of delivering successful science.
- **Community catalyst:** User Association, incl Vision Workshop 2021. Science Program Advisory Cmttee. Both groups support upcoming SURF application to become **DOE Office of Science User Facility**

