SANFORD UNDERGROUND RESEARCH FACILITY

(More) SURF Overview

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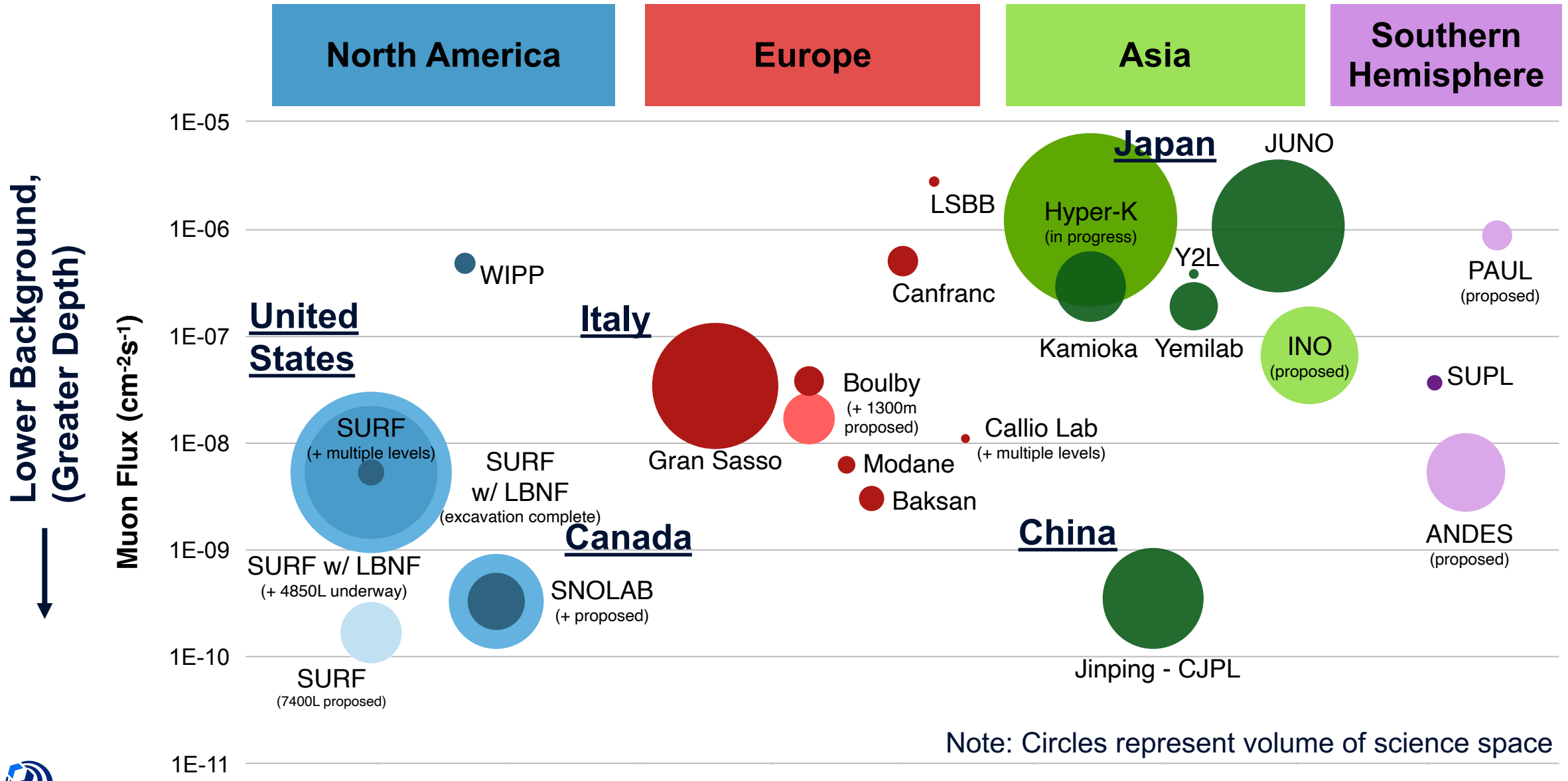
Sanford Underground Research Facility

Where in the world is SURF?

Sanford Underground Research Facility

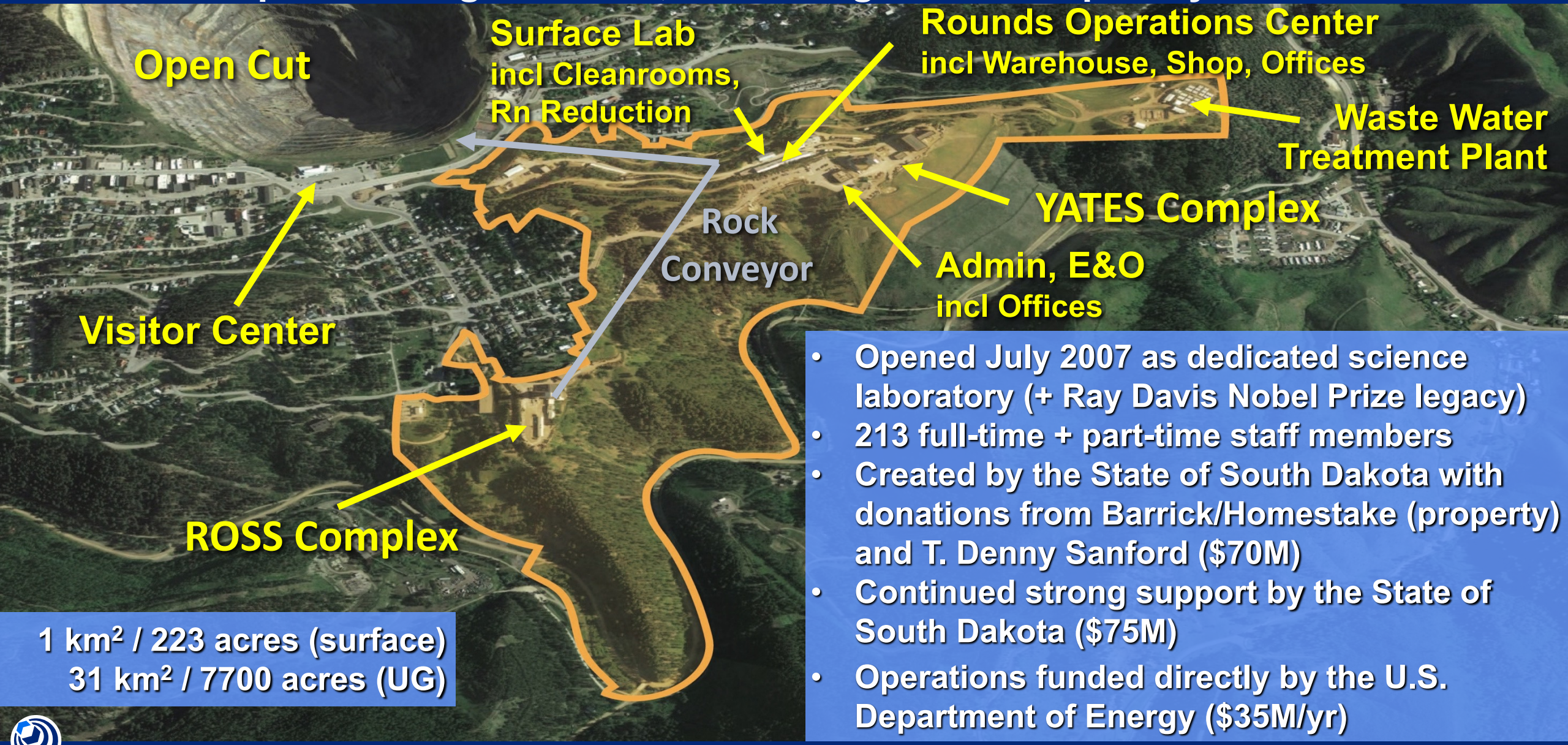
Lead, South Dakota, USA

SURF in the Global Context



Sanford Underground Research Facility

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



- Opened July 2007 as dedicated science laboratory (+ Ray Davis Nobel Prize legacy)
- 213 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 ($35M/yr)

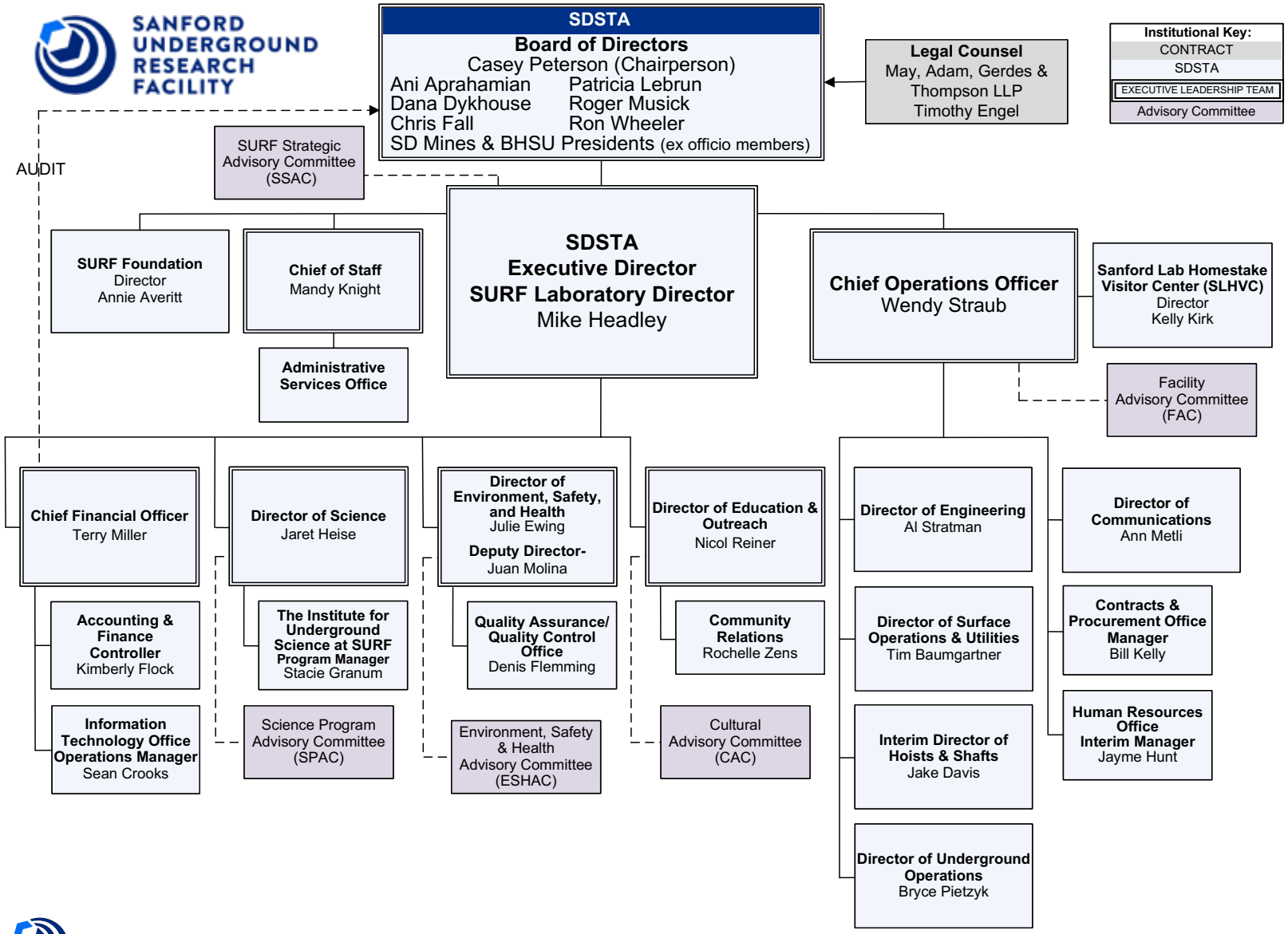
1 km² / 223 acres (surface)
31 km² / 7700 acres (UG)

Sanford Underground Research Facility

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

SDSTA Organization Structure

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

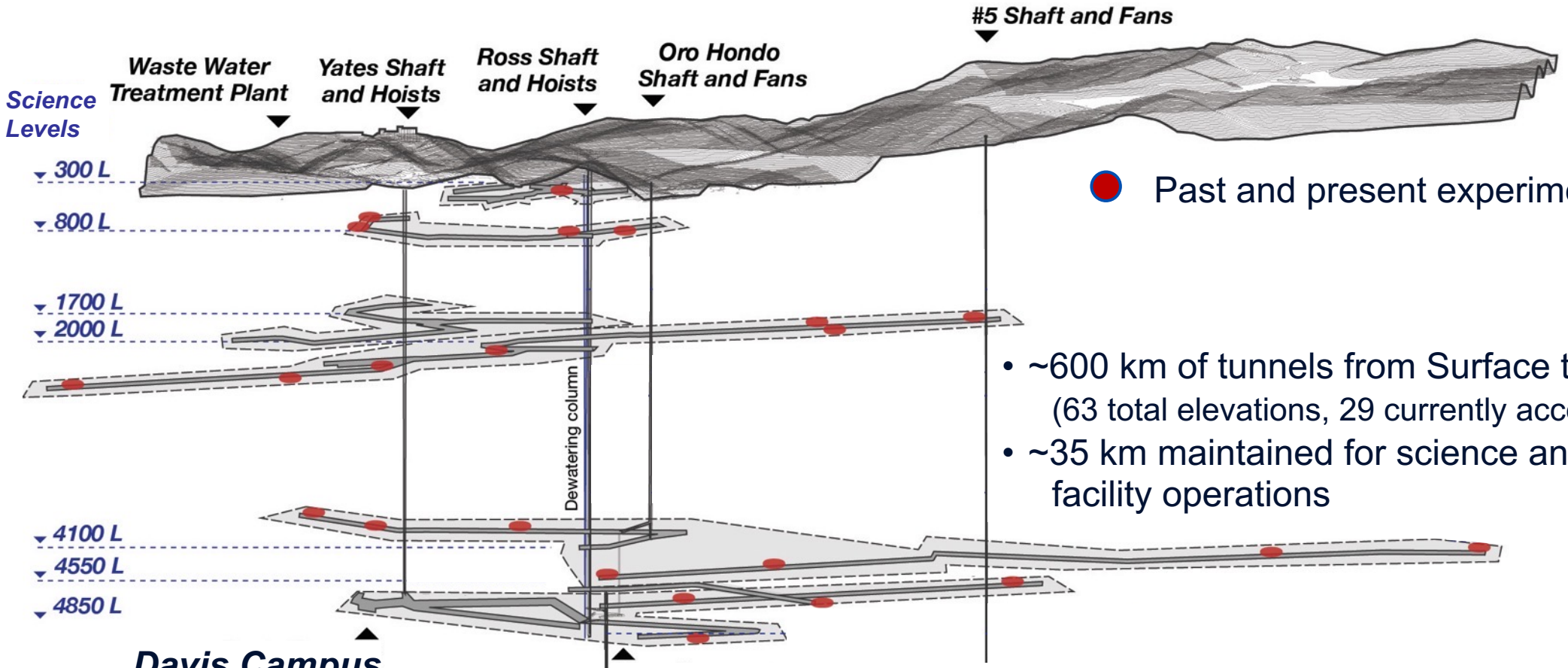


Staffing Area	FY25 FTE (%)	FY29 FTE (%)
Admin / Mgmt	22 (10%)	22 (9%)
Engineering	12 (6%)	12 (5%)
ESH	19 (9%)	22 (9%)
Outreach	26 (12%)	26 (11%)
Scientific	5 (2%)	6 (3%)
Technical / Operations	133 (61%)	148 (63%)
TOTAL	**217**	**236**

FY25 Science Direct Support = ~17 ppl

SURF Underground Lab Geography

Yates & Ross Shafts + ventilation shafts, multiple levels for science



Past and present experiment sites

- ~600 km of tunnels from Surface to 2.4 km deep
  (63 total elevations, 29 currently accessible)
- ~35 km maintained for science and facility operations

Davis Campus

LUX-ZEPLIN (LZ)

MAJORANA DEMONSTRATOR (MJD), incl Copper Electroforming

BHSU Underground Campus, incl Low-Background Counting

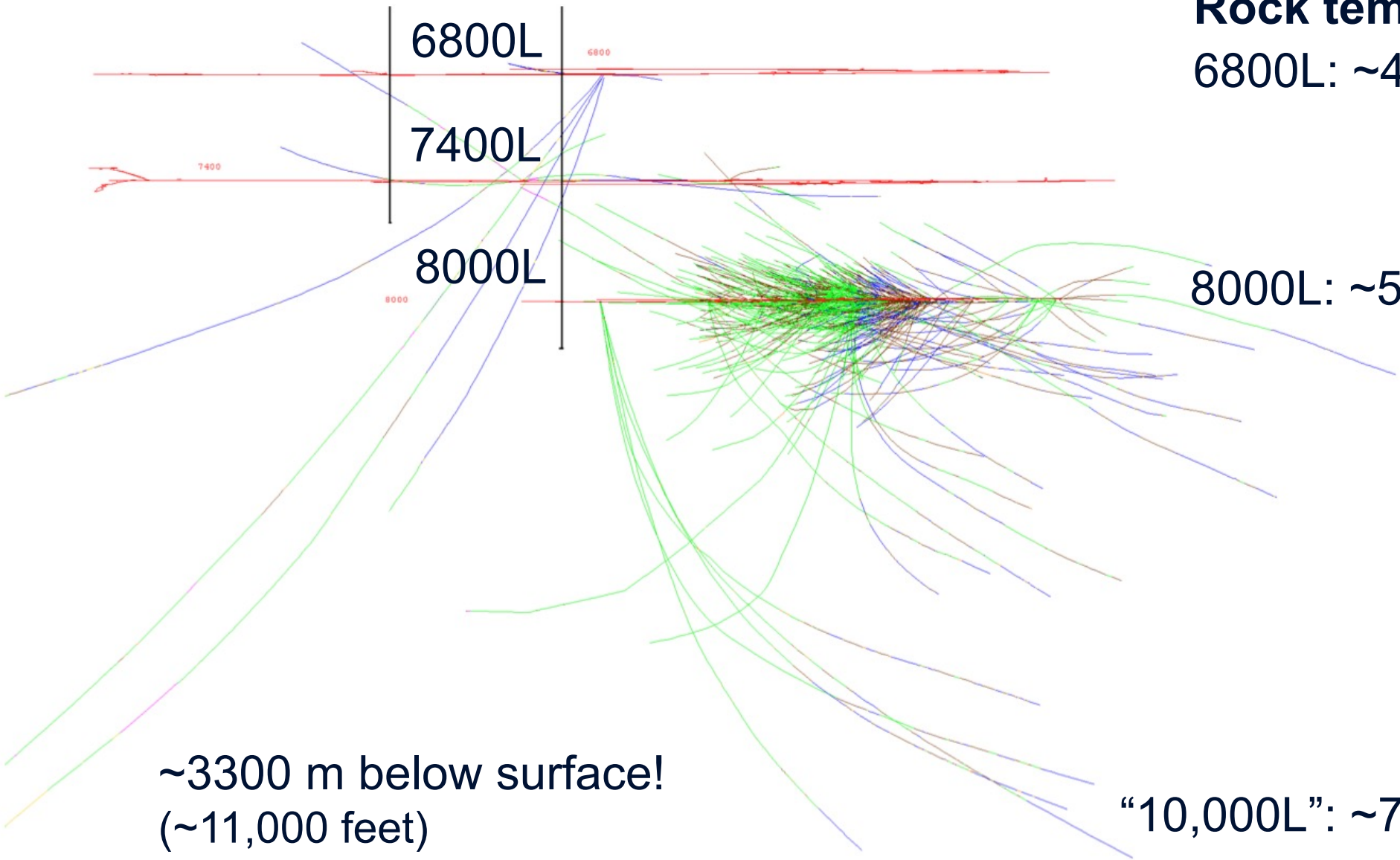
Ross Campus

CASPAR
(temporarily mothballed Spring 2021, operatios resuming summer 2025)

BHSU Underground Campus
(temporarily decommissioned Summer 2020, operations resuming summer 2025)

SURF Underground Lab Geography

Future possibilities to access existing deep holes?



Rock temperature

6800L: ~48 C / 119 F

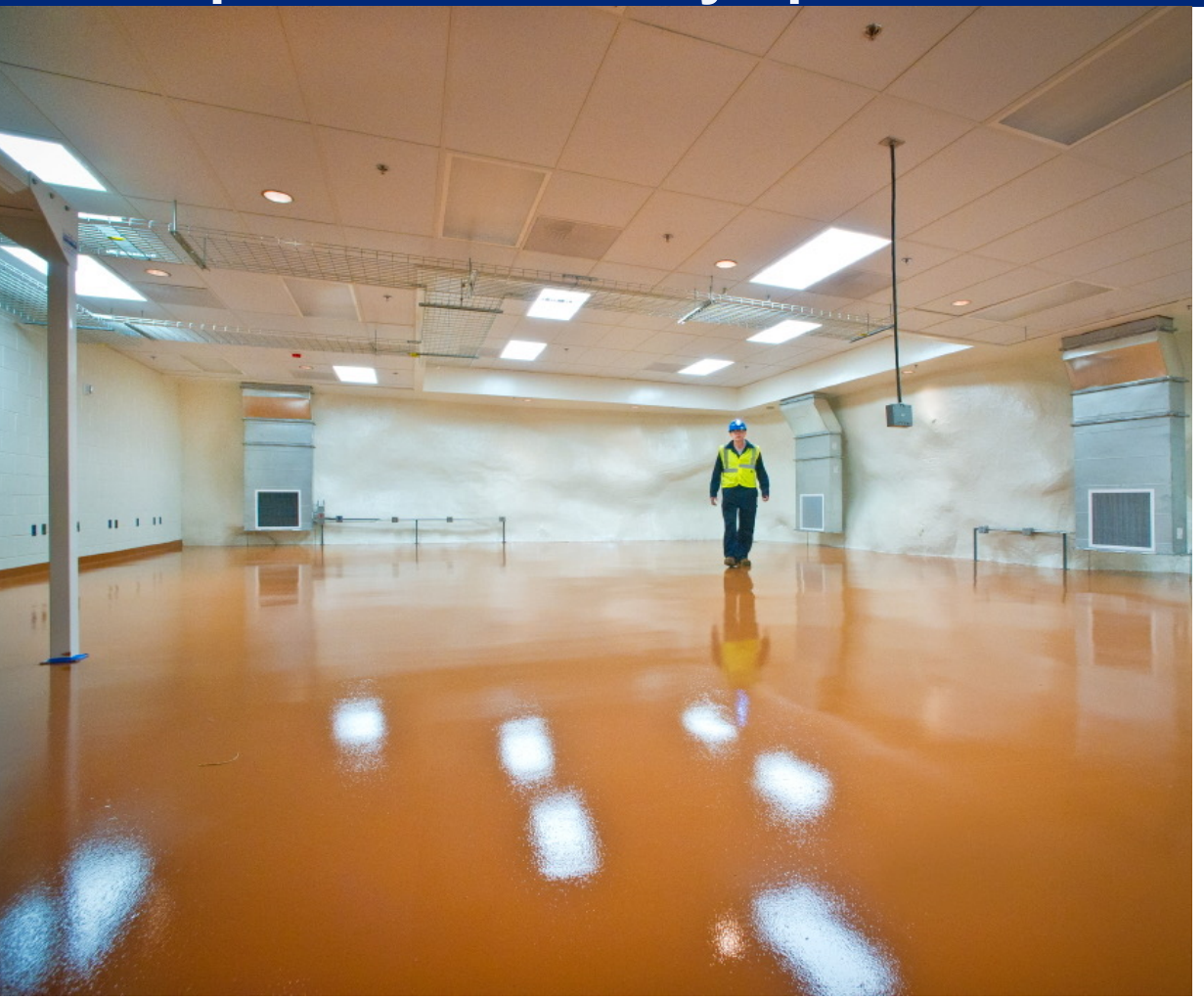
8000L: ~56 C / 133 F

~3300 m below surface!
(~11,000 feet)

“10,000L”: ~74 C / 165 F

SURF 4850L Davis Campus

Examples of laboratory space



Detector Room (MJD):

Area =140 m^2, 11 m × 9.8-12.8 m × 2.7 m (H)
(raised section: 5.9 m × 5.8 m × 3.2 m (H))

Davis Cavern, Lower (LZ):

Area =142 m^2, 13.7 m × 9.1 m × 6.4 m (H)
(incl tank: 7.6 m dia. × 6.4 m H). Total Cavern H = 10.8 m

Geology and Engineering

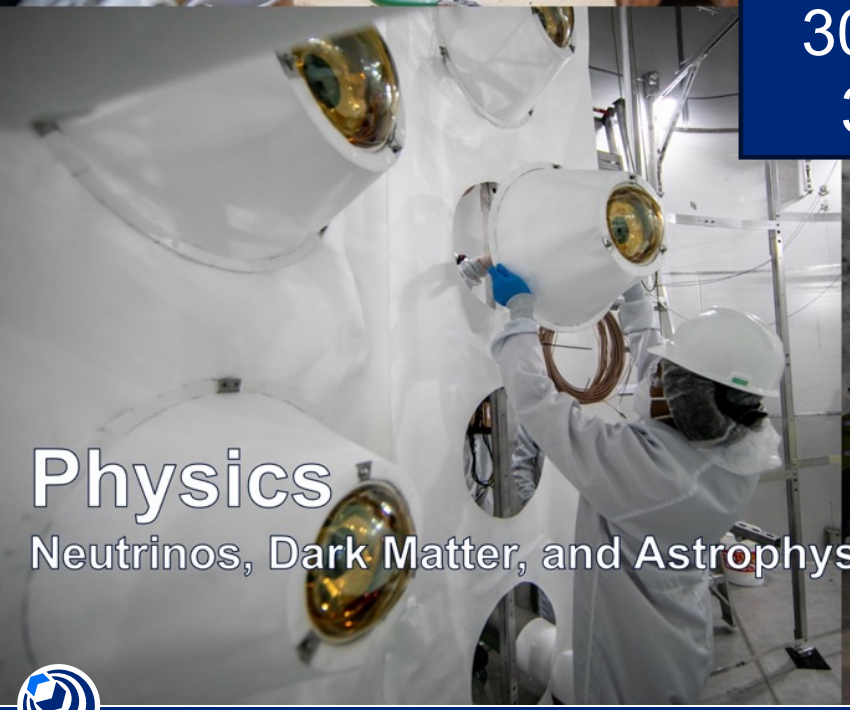
Enhanced Geothermal Systems
Mining Technology

Biology

Extremophiles, Biodiversity

Science Program

30 Expts with 2387 Collaborators,
310 Institutions in 49 Countries



Physics

Neutrinos, Dark Matter, and Astrophysics

Partnerships

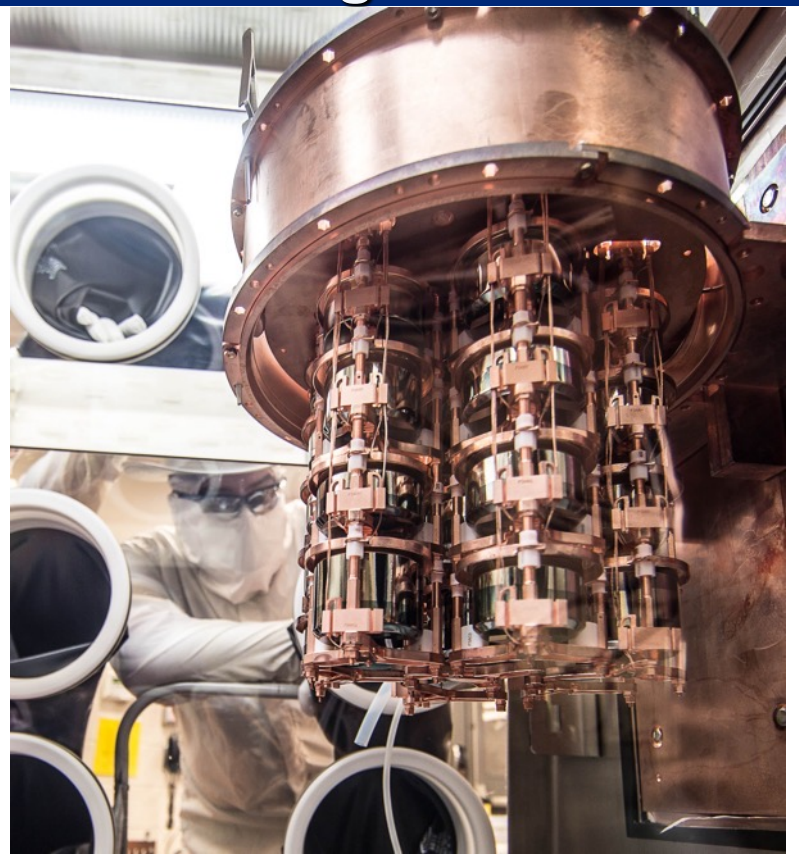
Commercial, Technology,
Industrial, Workforce development

SURF Science Program – Current Physics Highlights

Strong and diverse program with exciting future

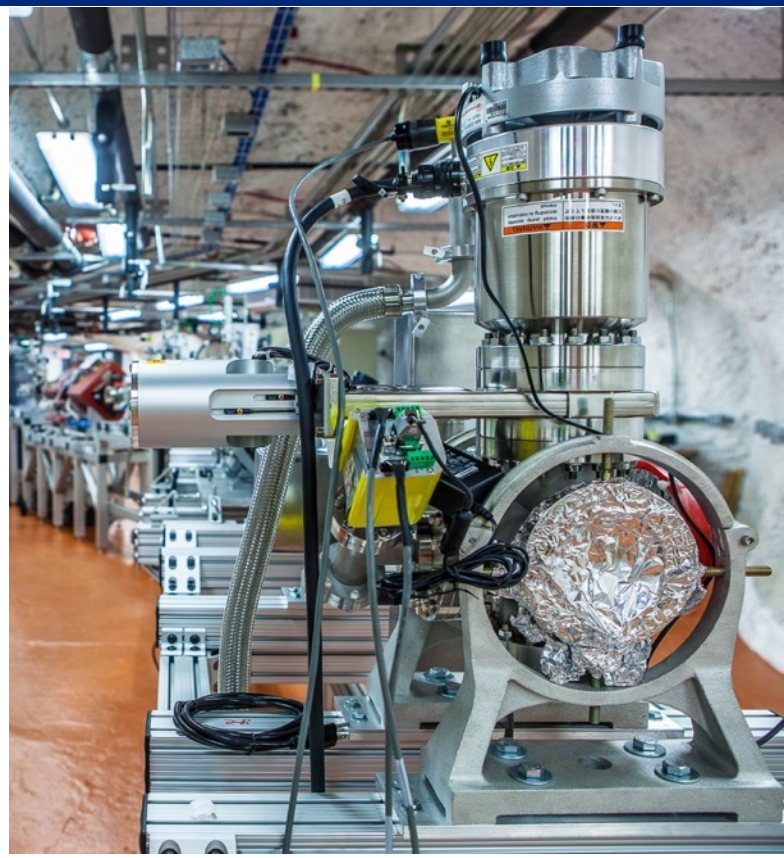
LUX-ZEPLIN (LZ)

- Direct search for **dark matter** using 10 tonnes xenon
- World-leading WIMP-search results announced July 2022 + Aug 2024



MAJORANA DEMONSTRATOR (MJD)

- Investigate **neutrinoless double-beta decay** using 44 kg Ge
- Final Ge result July 2022, Ta-180 decay search first results June 2023

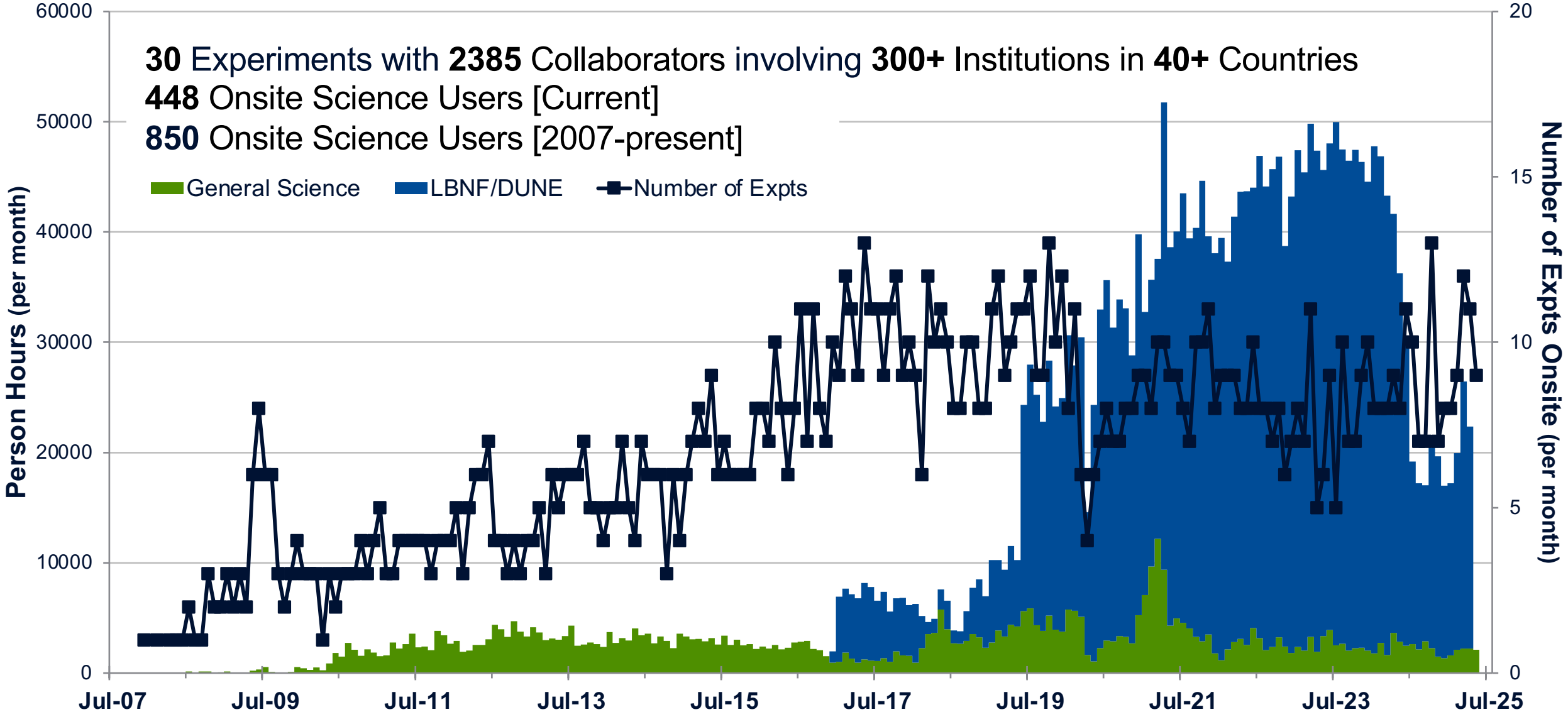


CASPAR

- Stellar fusion reactions to study **nucleosynthesis** using accelerator
- Initial phase 2015-2021, next phase starting in 2025, last for 3+ years

SURF Science Program

Hosting world-leading experiments and researchers from diverse scientific communities



SURF High-Impact Science

Hundreds of papers have been published on science at SURF

- Characterization of thermostable cellulases produced by *Bacillus* and *Geobacillus* strains, G. Rastogi, A. Bhalla, A. Adhikari, K. M. Bischoff, S. R. Hughes, L. P. Christopher, R. K. Sani *Bioresource Technology* **101**, 8798 (2010) doi: 10.1016/j.biortech.2010.06.001.
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- Insights into the phylogeny and coding potential of microbial dark matter, Rinke C, Schwientek P, Sczyrba A, Ivanova NN, Anderson IJ, Cheng JF, Darling A, Malfatti S, Swan BK, Gies EA, Dodsworth JA, Hedlund BP, Tsiamis G, Sievert SM, Liu WT, Eisen JA, Hallam SJ, Kyrpides NC, Stepanauskas R, Rubin EM, Hugenholtz P, Woyke T. *Nature* **499**:431-437 (2013) doi: 10.1038/nature12352.
- Obtaining genomes from uncultivated environmental microorganisms using FACS-based single-cell genomics, Rinke C, Lee J, Nath N, Goudeau D, Thompson B, Poulton N, Dmitrieff E, Malmstrom R, Stepanauskas R, Woyke T. *Nature Protocols* **9**:1038-1048 (2014) doi: 10.1038/nprot.2014.067.
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- Results on the Spin-Dependent Scattering of Weakly Interacting Massive Particles on Nucleons from the Run 3 Data of the LUX Experiment, D. S. Akerib *et al.* (LUX Collaboration) *Phys. Rev. Lett.* **116**, 161302 (2016) doi: 10.1103/PhysRevLett.116.161302.
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- New limits on Bosonic Dark Matter, Solar Axions, Pauli Exclusion Principle Violation, and Electron Decay from the MAJORANA DEMONSTRATOR, N. Abgrall *et al*. (MAJORANA Collaboration) *Phys. Rev. Lett.* **118**, 161801 (2017) doi: 10.1103/PhysRevLett.118.161801.
- First Searches for Axions and Axionlike Particles with the LUX Experiment, D. S. Akerib *et al*. (LUX Collaboration) *Phys. Rev. Lett.* **118**, 261301 (2017) doi: 10.1103/PhysRevLett.118.261301.
- Search for Neutrinoless Double-ß Decay in ^{76}Ge with the MAJORANA DEMONSTRATOR, C. E. Aalseth *et al*. (MAJORANA Collaboration) *Phys. Rev. Lett.* **120**, 132502 (2018) doi: 10.1103/PhysRevLett.120.132502.
- First Limit on the Direct Detection of Lightly Ionizing Particles for Electric Charge as Low as e/1000 with the MAJORANA DEMONSTRATOR, S. I. Alvis *et al*. (MAJORANA Collaboration) *Phys. Rev. Lett.* **120**, 211804 (2018) doi: 10.1103/PhysRevLett.120.211804.
- Measurement of Low-Energy Resonance Strengths in the ^{18}O(α,γ)^{22}Ne Reaction, A.C. Dombos *et al*. (CASPAR Collaboration) *Phys. Rev. Lett.* **128**, 162701 (2022) doi: 10.1103/PhysRevLett.128.162701.
- Geological activity shapes the microbiome in deep-subsurface aquifers by advection, Y. Zhang, R.N. Horne, A.J. Hawkins, J.C. Primo, O. Gorbatenko, A.E. Dekas, *PNAS* **119**, 2113985119 (2022) doi: 10.1073/pnas.2113985119.
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- Final Result of the MAJORANA DEMONSTRATOR's Search for Neutrinoless Double-β Decay in ^{76}Ge, I. J. Arnquist *et al*. (MAJORANA Collaboration) *Phys. Rev. Lett.* **130**, 062501 (2023) doi: 10.1103/PhysRevLett.130.062501.
- First Dark Matter Search Results from the LUX-ZEPLIN (LZ) Experiment, J. Aalbers *et al*. (LZ Collaboration) *Phys. Rev. Lett.* **131**, 041002 (2023) doi: 10.1103/PhysRevLett.131.041002.
- Constraints on the Decay of ^{180m}Ta, I. J. Arnquist *et al*. (MAJORANA Collaboration) *Phys. Rev. Lett.* **131**, 152501 (2023) doi: 10.1103/PhysRevLett.131.152501.
- Exotic Dark Matter Search with the MAJORANA DEMONSTRATOR, I. J. Arnquist *et al*. (MAJORANA Collaboration) *Phys. Rev. Lett.* **132**, 041001 (2024) doi: 10.1103/PhysRevLett.132.041001.
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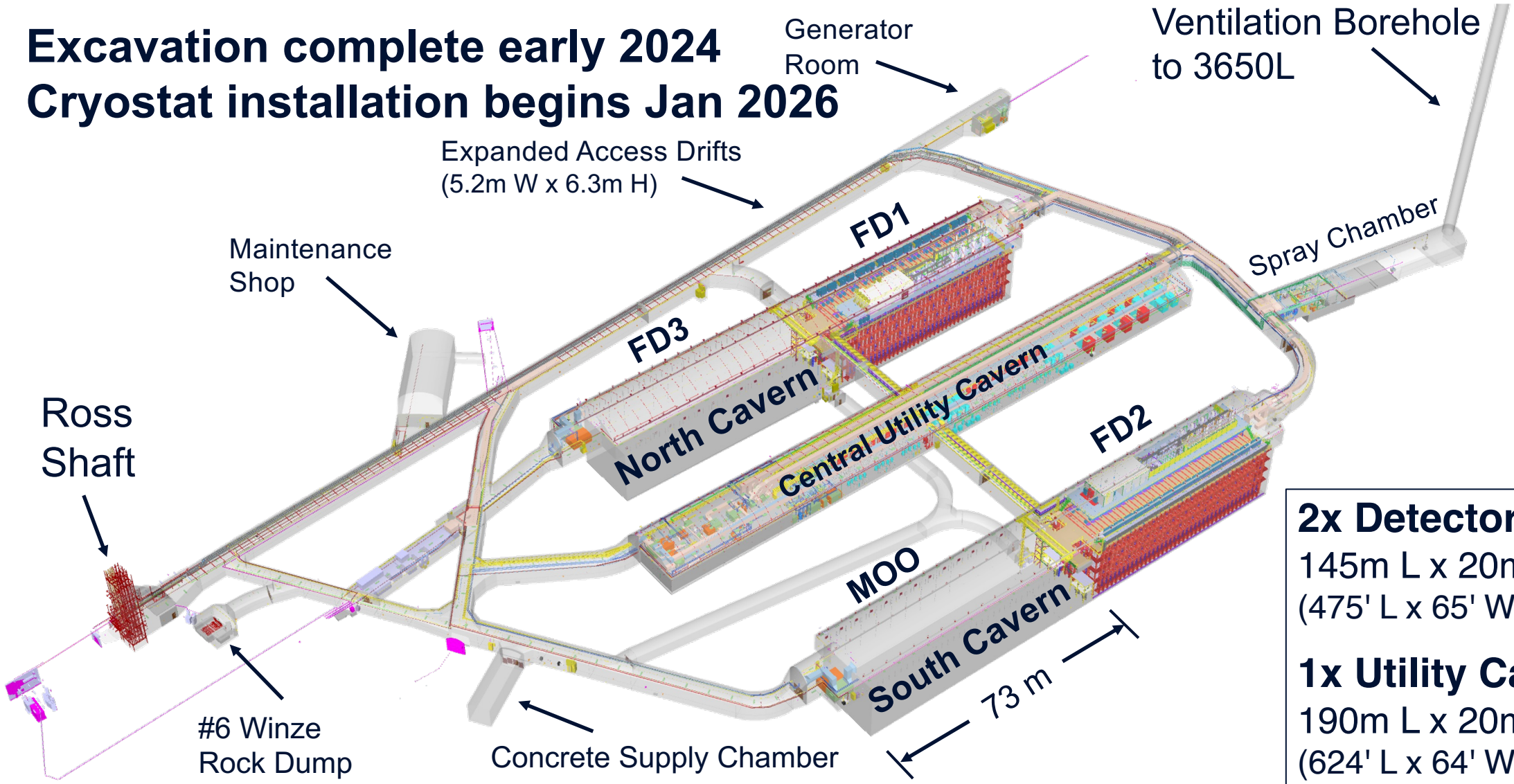
- Transportability of exogenous microbial community correlateswith interwell connectivity in deep aquifers, Y. Zhang, A.E. Dekas, A.J. Hawkins, J.C. Primo, O. Gorbatenko, T. Huang, Z. Pang, R.N. Horne, *Water Res.* **285** 124008 (2025) doi: 10.1016/j.watres.2025.124008.
- New constraints on cosmic ray-boosted dark matter from the LUX-ZEPLIN experiment, J. Aalbers *et al*. (LZ Collaboration) *Phys. Rev. Lett.* **134** 241801 (2025) doi: 10.1103/nr92-jvt3.
- Final Results of the MAJORANA DEMONSTRATOR's Search for Double-Beta Decay of ^{76}Ge to Excited States of ^{76}Se, I. J. Arnquist *et al*. (MAJORANA Collaboration) *Phys. Rev. Lett*. **134** 242501 (2025) doi: 10.1103/PhysRevLett.134.242501.
- Dark Matter Search Results from 4.2 Tonne-Years of Exposure of the LUX-ZEPLIN (LZ) Experiment, J. Aalbers *et al*. (LZ Collaboration) *Phys. Rev. Lett*. **135** 011802 (2025) doi: 10.1103/4dyc-z8zf.

Long-Baseline Neutrino Facility (LBNF)

LBNF will host the Deep Underground Neutrino Experiment (DUNE)

Excavation complete early 2024
Cryostat installation begins Jan 2026



2x Detector Caverns:
145m L x 20m W x 28m H
(475' L x 65' W x 92' H)

1x Utility Cavern:
190m L x 20m W x 11m H
(624' L x 64' W x 37' H)

LBNF North Cavern

SURF User Association

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

Purpose

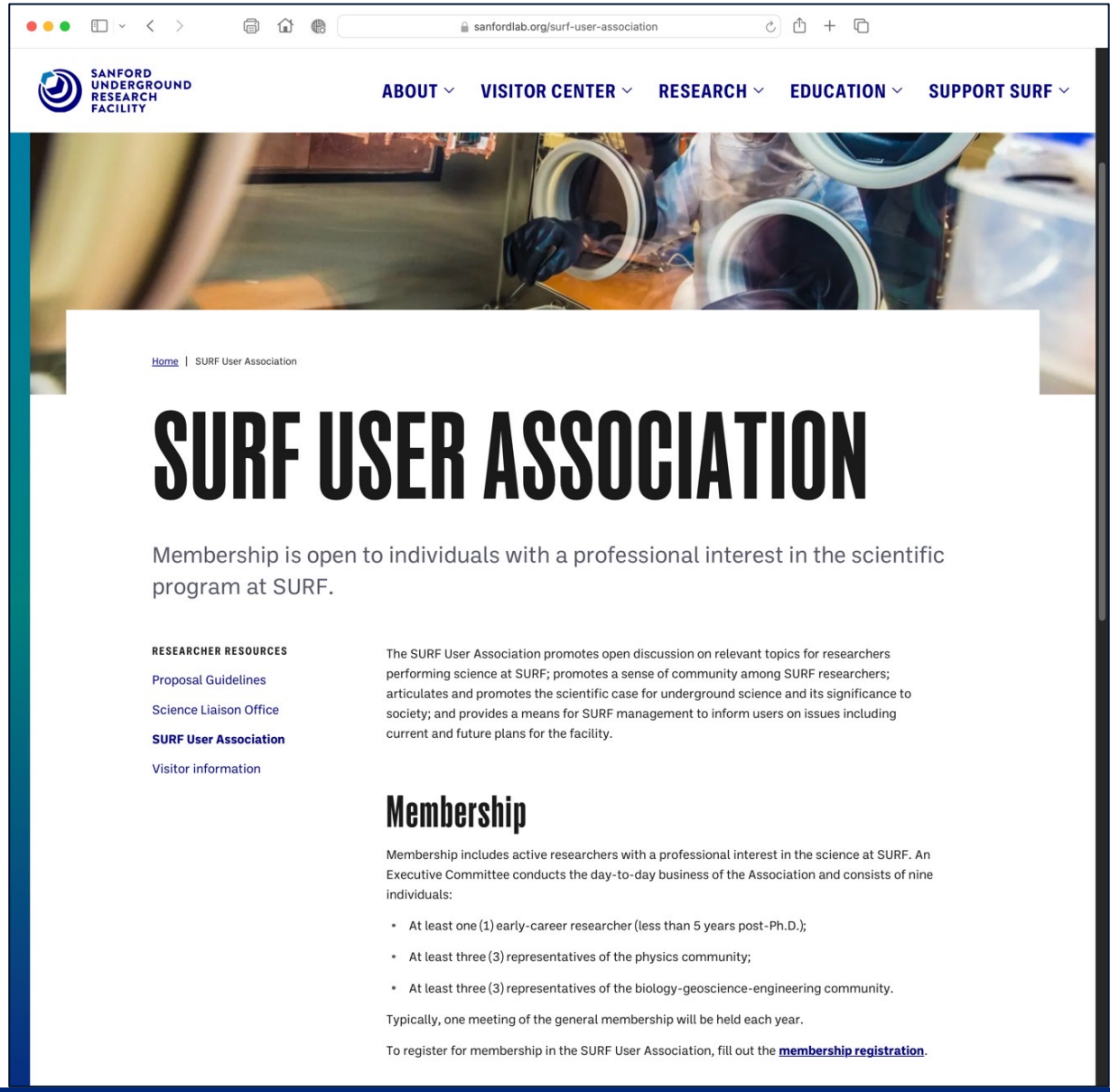
- **Two-way communication** on topics important to researchers.
- Promotes a **sense of community** amongst SURF experiments and researchers.
- Articulates and promotes **scientific case for UG science** and significance to society, provides channel for **advocacy**.

Organization

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

Meetings

- **General meetings** typically held annually, last session held at CoSSURF 2024.
- **Topical workshops**, incl community planning (e.g., Vision Workshop 2021). Next workshops in 2025/26.



4850L Space Needed for Future Experiments

U.S. strategic plan recognized need for more UG space, endorsed expansion

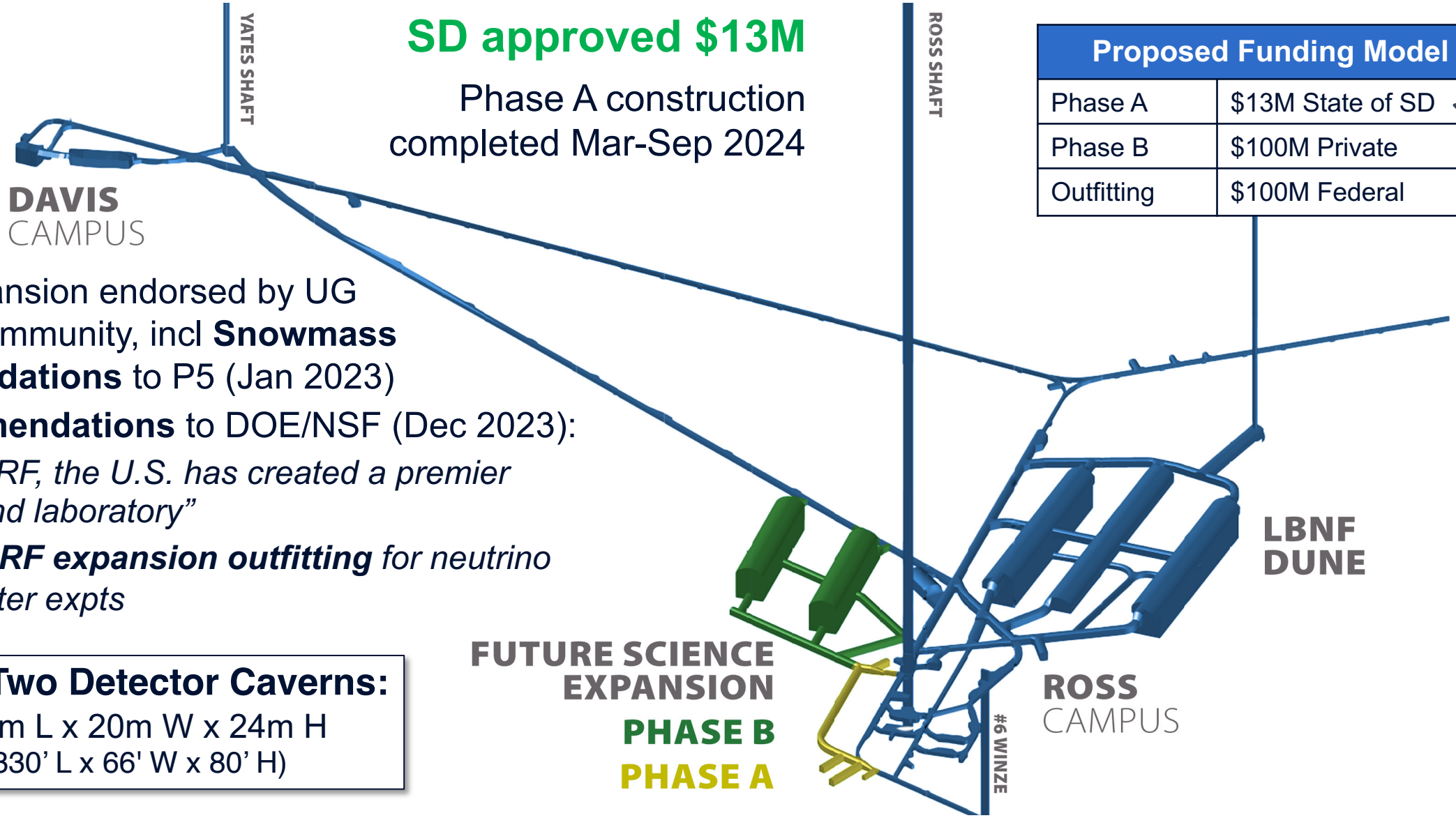
SD approved $13M

Phase A construction completed Mar-Sep 2024

Proposed Funding Model	
Phase A	$13M State of SD ✓
Phase B	$100M Private
Outfitting	$100M Federal

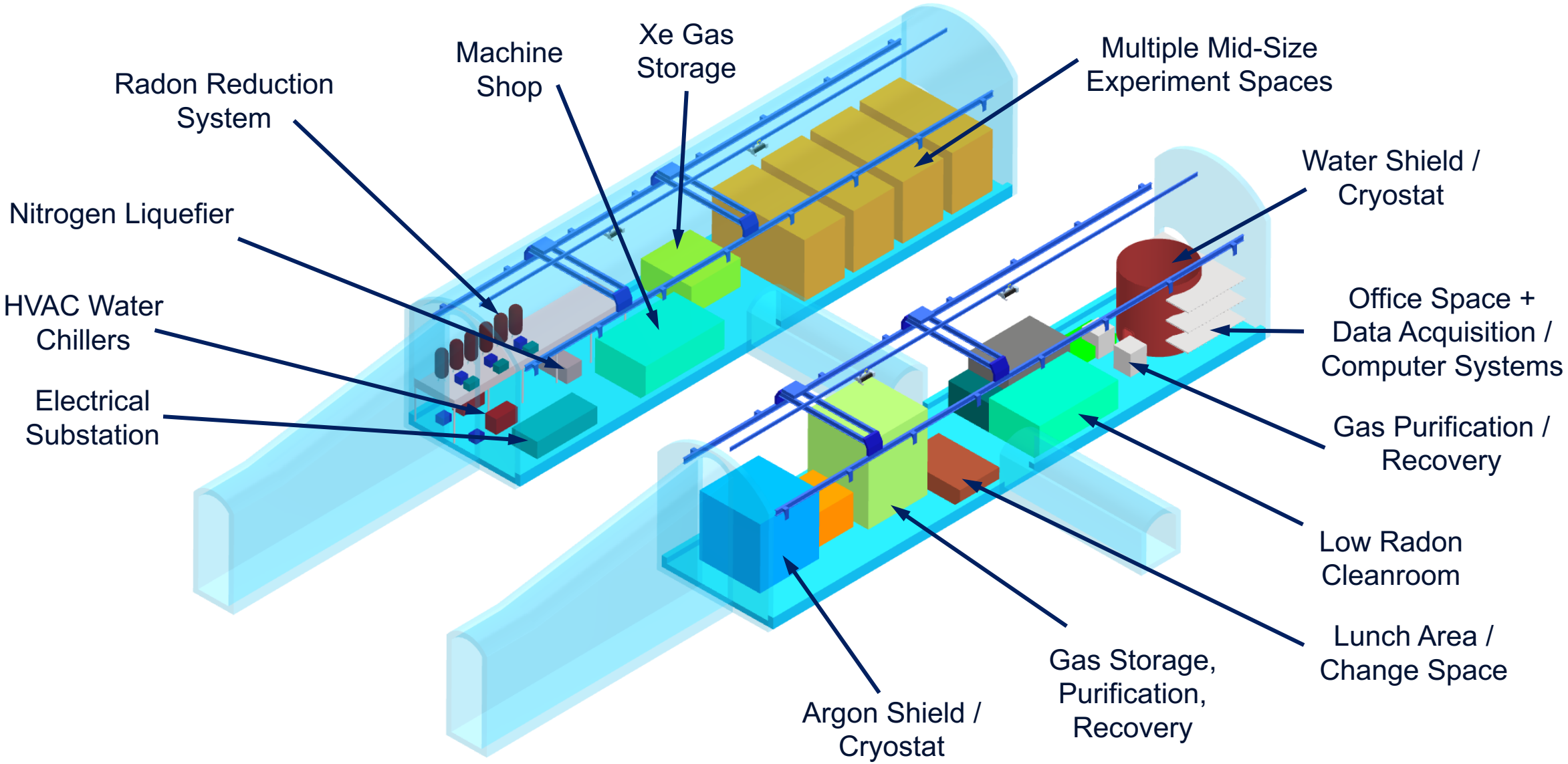
- SURF Expansion endorsed by UG Science Community, incl **Snowmass recommendations** to P5 (Jan 2023)
- **P5 recommendations** to DOE/NSF (Dec 2023):
  - *"With SURF, the U.S. has created a premier underground laboratory"*
  - ***Fund SURF expansion outfitting*** *for neutrino & dark matter expts*

Up to Two Detector Caverns:
100m L x 20m W x 24m H
(330' L x 66' W x 80' H)



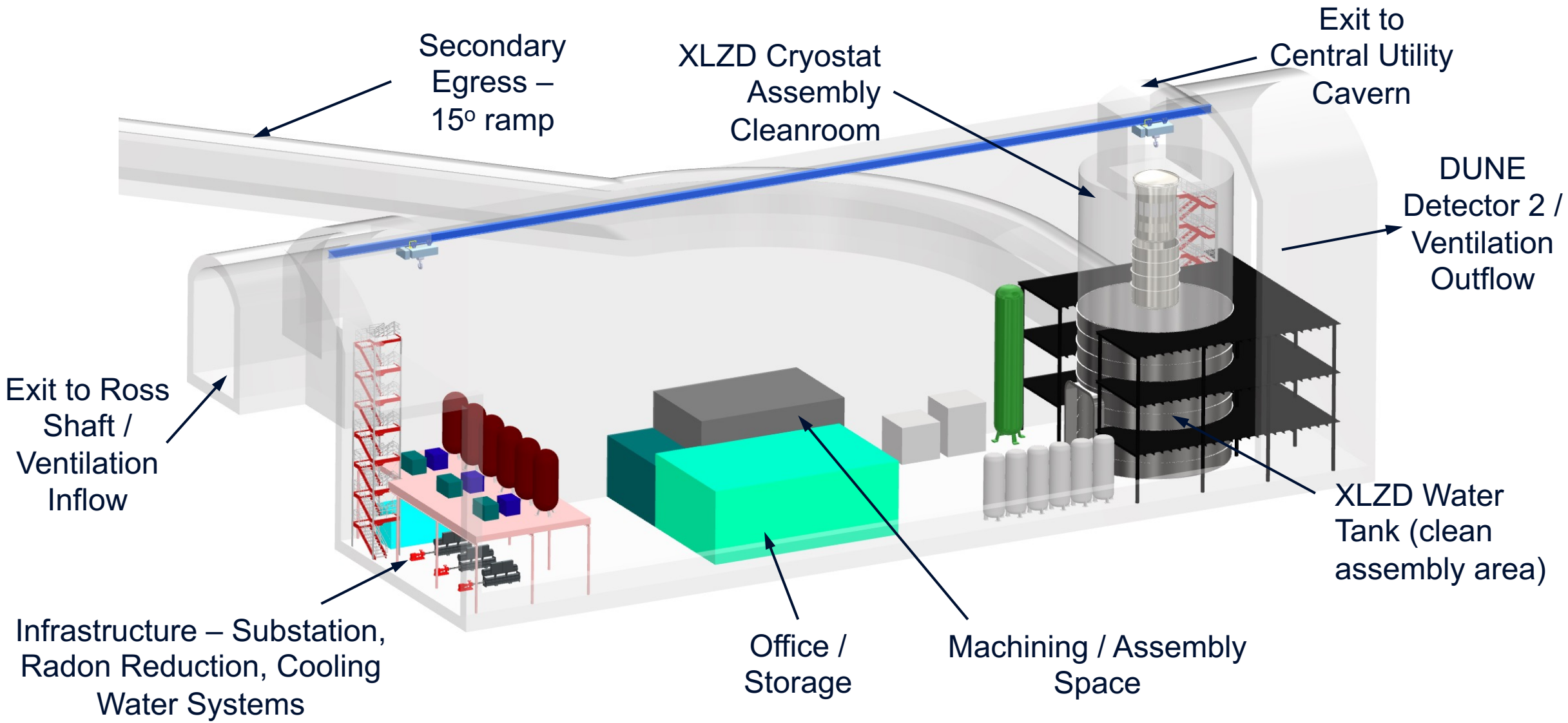
Big Science at SURF

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



Big Science at SURF

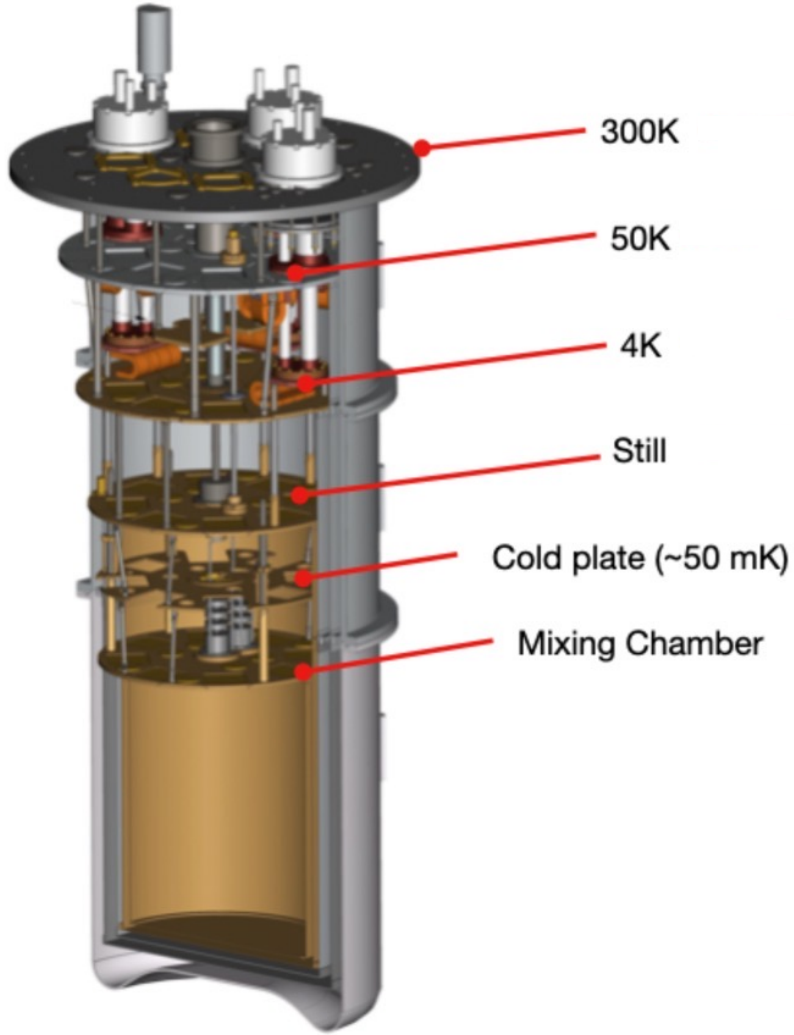
Conceptual layout (FD4/MOO), informed by DUSEL PDR, ARGO/XLZD, LZ



SURF Cryogenic User Facility

Proposal inline with becoming DOE scientific user facility

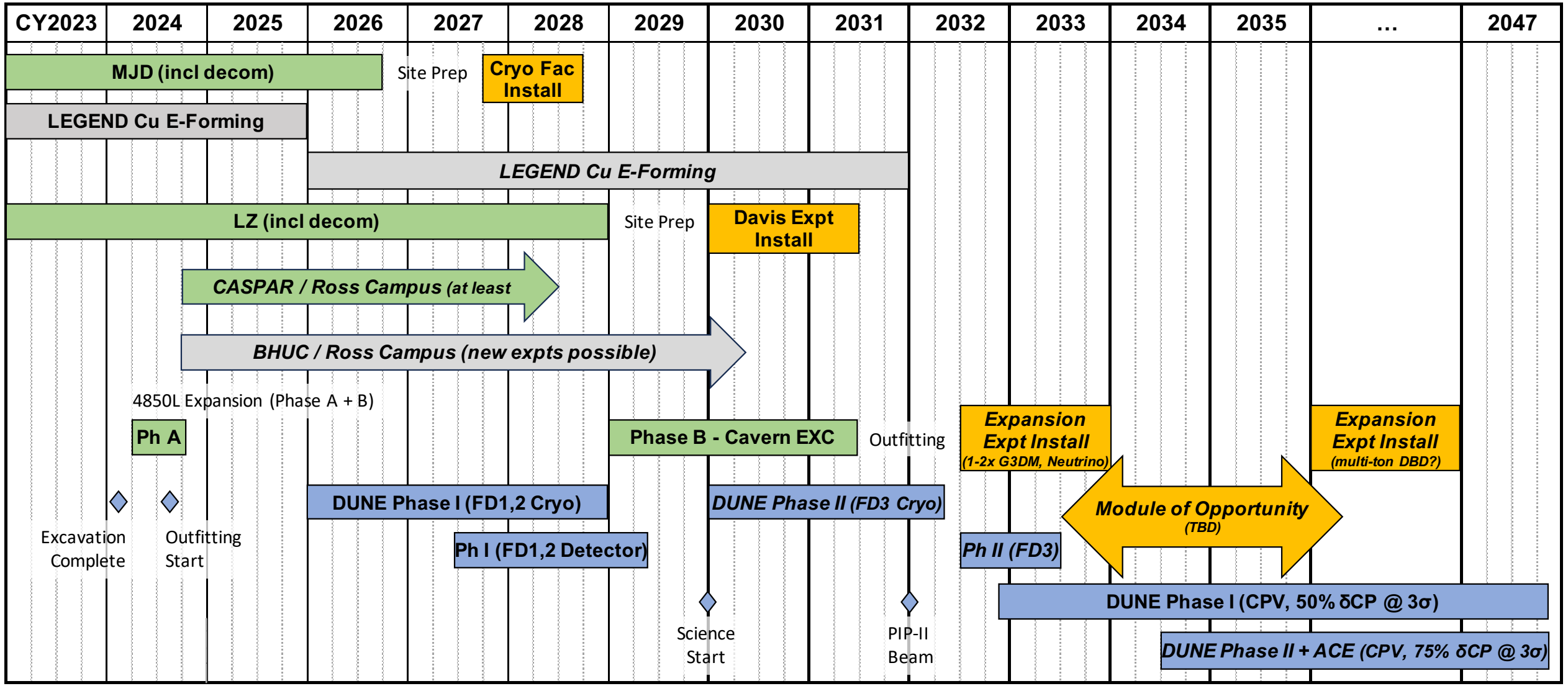
- **Multi-user, low-background, ultra-low temperature test facility for cryogenic detectors:**
  - Applications in **fundamental nuclear and particle physics research** (neutrinos and dark matter)
  - Detectors with extremely low energy thresholds and excellent energy resolution require **isolation from ionizing radiation** at deep facility like SURF to be effective
  - Detectors often rely on quantum thermal sensors with operating **temperatures in milli-Kelvin range** requiring dilution refrigerator
- **Cryogenic User Facility at SURF:**
  - **No deep underground cryogenic test facility in U.S.** (recent shallow sites addressing general shortage of underground cryogenic test infrastructure in U.S. – PNNL & FNAL)
  - **Significant interest from U.S.-based groups**: Low-mass dark matter (TESSERACT, SPLENDOR), neutrinoless double-beta decay (CUPID), quantum information systems (MIT, UIUC); collaborating with Virginia Tech
  - Underground cleanroom, cooling infrastructure available; clean shielding Pb and surface lab space possible.



Proposing Bluefors XLD1000SL dilution refrigerator to accommodate large payload (detectors/shielding)

SURF Science Strategic Planning

Timeline



SURF Summary

- SURF has strong relationship with DOE that benefits UG science community:
  - DOE funding for SURF operations incl **mandate to support experiments**; anticipating DOE User Facility designation.
  - DOE funding for SURF infrastructure ensuring **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 experiments to deliver high-impact science, incl leveraging strong partnerships with U.S. national laboratories.
- SURF is playing a strong role in the UG science community:
  - **User Association** serving as catalyst for community discussions: https://sanfordlab.org/surf-user-association.
  - **Strong recognition** and support for SURF by community and in recent **P5 report for U.S. strategic planning**.
- SURF wants to host future world-leading experiments:
  - LBNF excavation done, outfitting started in 2024. **DOE** "**Module of Opportunity**" expanded physics program.
  - Construction underway to **increase underground laboratory space**, plans advancing for new large caverns on 4850L (1500 m, 4100 mwe) on **timeframe of next-generation experiments (~2030)**.
  - **Call for Letters of Interest (LOIs)** underway to ensure existing and future space used to its fullest scientific potential, incl options for **neutrinos and dark matter** in existing laboratory space.
  - **SURF offers multiple deep laboratory options to host future new initiatives!**

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)

Sanford Underground Research Facility

SURF Mission:

We advance world-class science and inspire learning across generations.

SURF Vision:

The world's preferred location for underground science and education.

SURF serves the entire underground science community

SURF welcomes and encourages research from all disciplines that are able to take advantage of the unique attributes of our laboratory

Sanford Underground Research Facility
General summary

Site: Deepest underground lab in U.S., dedicated to science (former Homestake Gold Mine). Significant footprint with multiple tunnels, access from surface to ~1500 m (total depth = 2450 m).

Science Program:

- **Past:** Davis Solar Neutrino Experiment, LUX, MAJORANA DEMONSTRATOR (0νββ)
- **Current:** LZ, MAJORANA DEMONSTRATOR (^{180m}Ta), CASPAR, Low-bkgd counting (BHUC), Geomicrobiology, Geoengineering (esp. geothermal), other industry/engineering
- **Future** (no funding/site decisions yet):
  - Dark Matter: Low-mass (SPLENDOR, HydroX), next-generation WIMP (XLZD, Argo), other (CrystaLiZe)
  - Neutrino: Water-based liquid scintillator (Theia), Multi-ton-scale 0νββ (LEGEND 6000), etc
  - QIS, atom interferometry – gravitational waves, dark matter (km-scale vertical or horizontal), etc

Facility:

- **4850L Existing:** Davis Campus operating well, re-open Ross Campus in 2024 (closed due to LBNF)
- **4850L LBNF/DUNE:** Excavation complete for all caverns, outfitting expected complete in 2026
- **4850L Expansion:** Up to 2x caverns (100m L x 20m W x 24m H), develop in 2 phases (Phase A fully funded), excavation complete by ~2030, outfitting by DOE-HEP (or private)
- **7400L Expansion:** One or more caverns (75m L x 15m W x 15m H), funding/schedule TBD

Sanford Underground Research Facility
Physical characteristics

- **Property:** 1 km^2 (surface) with ~1600 m^2 storage (incl drill core) and 355 m^2 staging/assembly space; 31 km^2 (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 currently undergoing extensive maintenance). 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 = 5.31×10^{-5} μ/m^2/s (4.6 μ/m^2/d). Several other UG elevations for science: 300L, 800L, 1700L, 2000L, 4100L, 4550L.
- **Space:**
  - Surface (science space, as low as class 10-100): 210 m^2 (cleanrooms = 92 m^2 / 914 m^3)
  - 4850L (science space, as low as class 100): Davis Campus (1018 m^2 / 4633 m^3), Ross Campus (920 m^2 /3144 m^3)
  - Radon-reduction: Surface = 2200x reduction @ 300 m^3/h (Ateko), Davis = 700x reduction @ 150 m^3/h (SD Mines)
- **Bkgds** (4850L): Radon* = 170-570 Bq/m^3, gamma = 1.9 **γ**/cm^2/s, neutron = 1.7×10^{-2} n/m^2/s.

* Studies conducted Summer 2024, expect to reduce Rn concentration

- **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.

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 (~10 μBq/kg U/Th)
- **Material production/purification:** One of only a few labs where UG Cu electroforming is performed (average U, Th decay chain ≤ 0.1 μBq/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**

SURF Science Strategic Plan

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

Scope:

- Organize science strategic plan in two parts: Physics and Non-Physics

Physics (closely aligned with top U.S. national priorities):

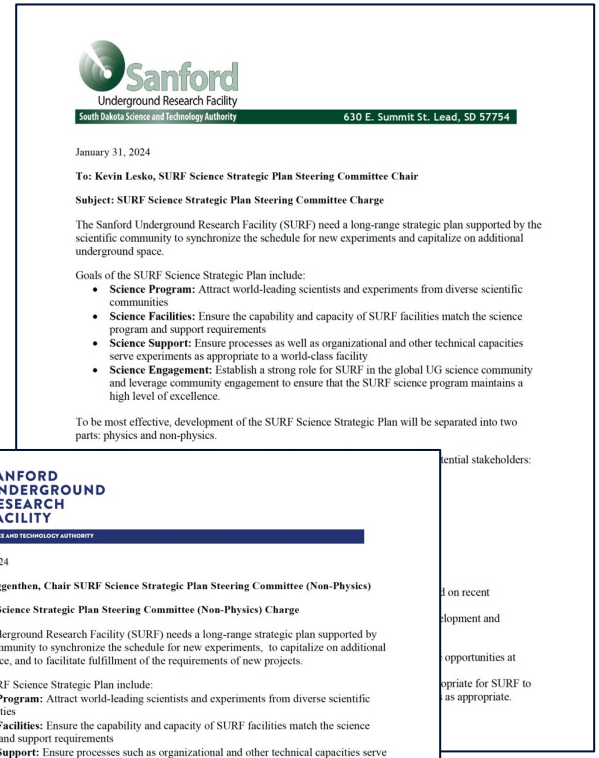
- DUNE support (Phase 1 and Phase 2)
- Generation 3 Dark Matter (XLZD and/or ARGO)
- 'Agile' Experiments / Low-Mass Dark Matter
- General R&D facility

} **Cryogenic User Facility w/ dilution refrigerator**

- Generation 2 Dark Matter upgrade (LZ → HydroX, CrystaLiZe, etc)

Non-Physics:

- Several expert panel discussions so far, aim for report in late 2025



Sanford Underground Research Facility
South Dakota Science and Technology Authority 630 E. Summit St. Lead, SD 57754

January 31, 2024

To: Kevin Lesko, SURF Science Strategic Plan Steering Committee Chair

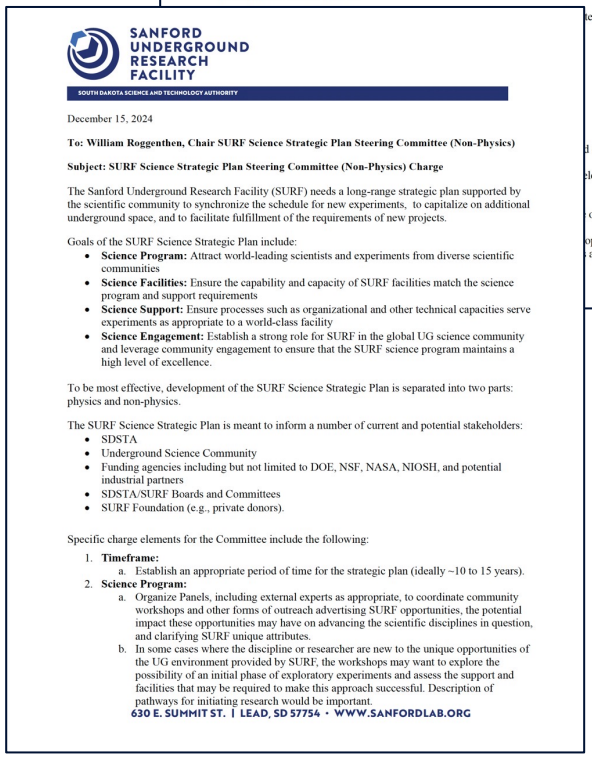
Subject: SURF Science Strategic Plan Steering Committee Charge

The Sanford Underground Research Facility (SURF) need a long-range strategic plan supported by the scientific community to synchronize the schedule for new experiments and capitalize on additional underground space.

Goals of the SURF Science Strategic Plan include:

- **Science Program:** Attract world-leading scientists and experiments from diverse scientific communities
- **Science Facilities:** Ensure the capability and capacity of SURF facilities match the science program and support requirements
- **Science Support:** Ensure processes as well as organizational and other technical capacities serve experiments as appropriate to a world-class facility
- **Science Engagement:** Establish a strong role for SURF in the global UG science community and leverage community engagement to ensure that the SURF science program maintains a high level of excellence.

To be most effective, development of the SURF Science Strategic Plan will be separated into two parts: physics and non-physics.



SANFORD UNDERGROUND RESEARCH FACILITY
SOUTH DAKOTA SCIENCE AND TECHNOLOGY AUTHORITY

December 15, 2024

To: William Roggenthen, Chair SURF Science Strategic Plan Steering Committee (Non-Physics)

Subject: SURF Science Strategic Plan Steering Committee (Non-Physics) Charge

The Sanford Underground Research Facility (SURF) needs a long-range strategic plan supported by the scientific community to synchronize the schedule for new experiments, to capitalize on additional underground space, and to facilitate fulfillment of the requirements of new projects.

Goals of the SURF Science Strategic Plan include:

- **Science Program:** Attract world-leading scientists and experiments from diverse scientific communities
- **Science Facilities:** Ensure the capability and capacity of SURF facilities match the science program and support requirements
- **Science Support:** Ensure processes such as organizational and other technical capacities serve experiments as appropriate to a world-class facility
- **Science Engagement:** Establish a strong role for SURF in the global UG science community and leverage community engagement to ensure that the SURF science program maintains a high level of excellence.

To be most effective, development of the SURF Science Strategic Plan is separated into two parts: physics and non-physics.

The SURF Science Strategic Plan is meant to inform a number of current and potential stakeholders:

- SDSTA
- Underground Science Community
- Funding agencies including but not limited to DOE, NSF, NASA, NIOSH, and potential industrial partners
- SDSTA/SURF Boards and Committees
- SURF Foundation (e.g., private donors).

Specific charge elements for the Committee include the following:

1. **Timeframe:**
   a. Establish an appropriate period of time for the strategic plan (ideally ~10 to 15 years).
2. **Science Program:**
   a. Organize Panels, including external experts as appropriate, to coordinate community workshops and other forms of outreach advertising SURF opportunities, the potential impact these opportunities may have on advancing the scientific disciplines in question, and clarifying SURF unique attributes.
   b. In some cases where the discipline or researcher are new to the unique opportunities of the UG environment provided by SURF, the workshops may want to explore the possibility of an initial phase of exploratory experiments and assess the support and facilities that may be required to make this approach successful. Description of pathways for initiating research would be important.

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SURF Plans to Become DOE User Facility

Benefits:

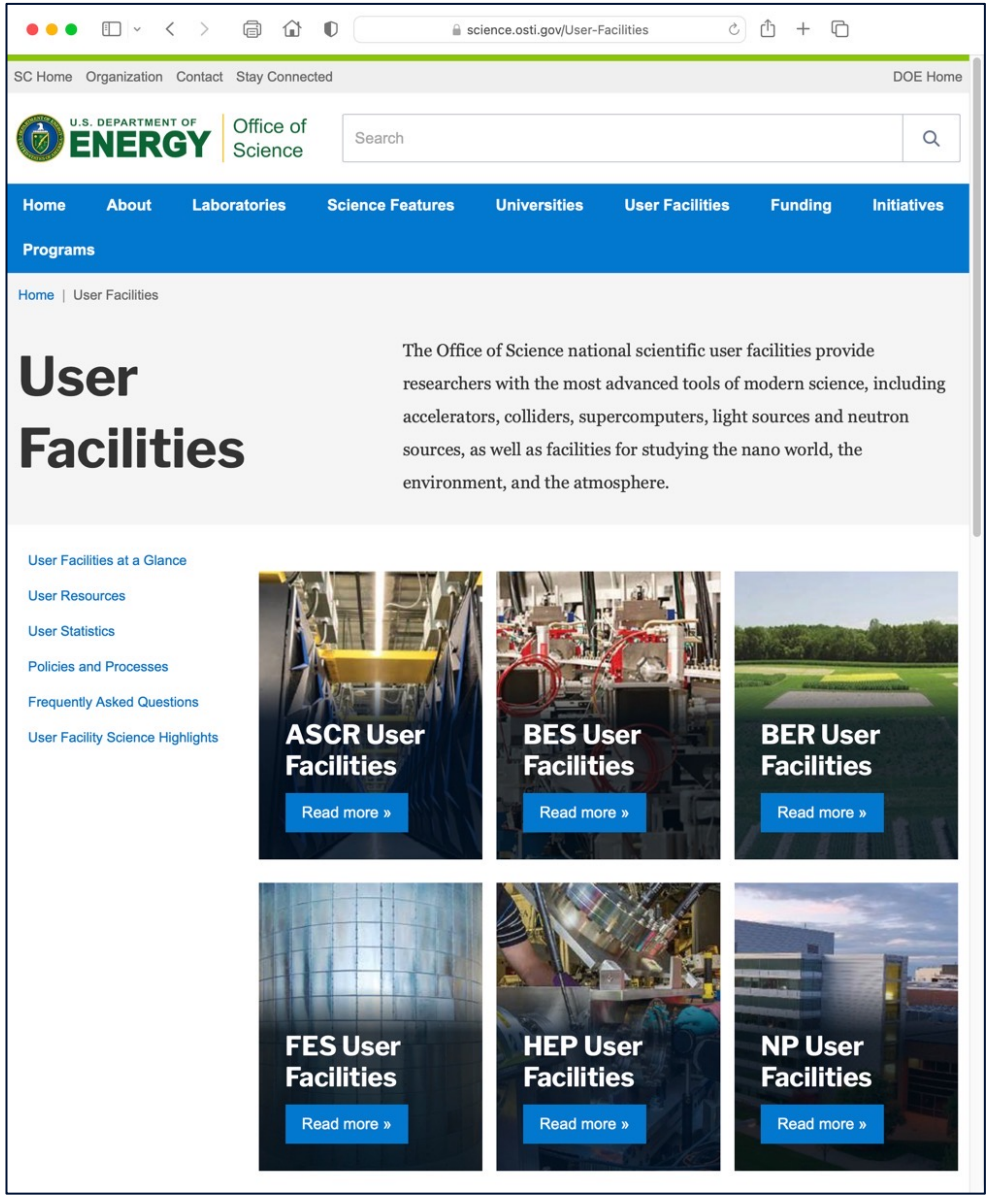
- Expands DOE User Facility portfolio to incl underground lab, raises SURF's stature within DOE community.
- Promotes underground science in U.S., increases funding opportunities.
- Enhances SURF's role in global science community.
- Communicates SURF is open to a broad range of science and users and that we have a standard process, accepted by DOE, for hosting science.

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 and Science Program Advisory Cttee established.
- Application draft near final, expect DOE invitation to submit soon.



SURF Organization – Science Staffing

Resources to enable safe and successful implementation of experiments

Markus Horn (PhD)
Research Scientist
- Surface + UG Campuses

SURF has robust organization:
9 Depts + 5 Offices + Institite

Gavin Cox (MS)
Expt Support Scientist
- LZ Operations

Jaret Heise (PhD) - *Director*
- Manage dept and experiment implementation program

Mark Hanhardt (MS)
Expt Support Scientist
- Surface + UG Campuses

Julia Delgaudio (BS)
Expt Support Scientist
- LZ Operations

Robyn Weis - *Lab Custodians (Surface + UG)* - Dee Espinosa

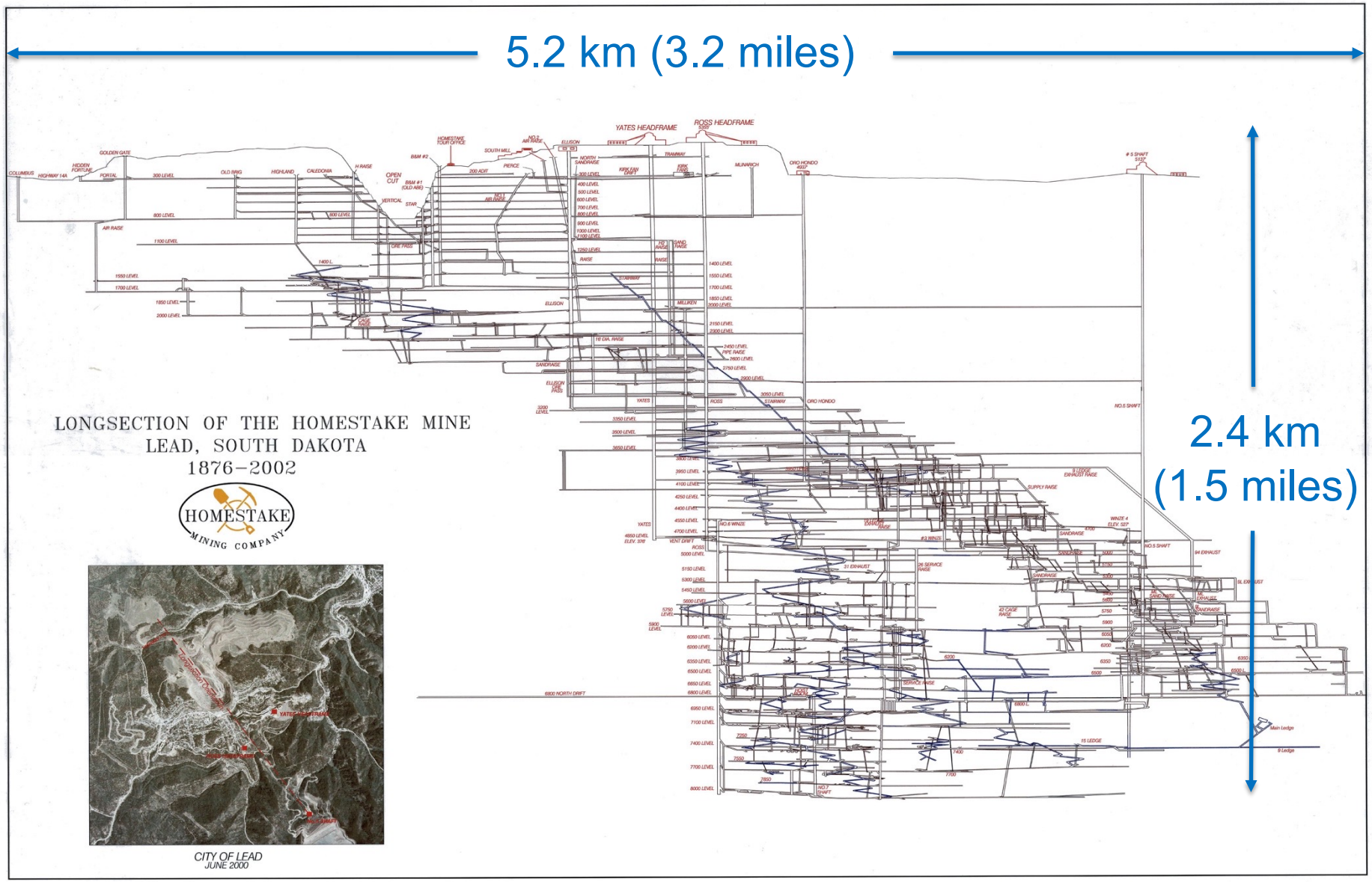
Doug Tiedt (PhD)
Research Scientist
- Surface + UG Campuses

+ Many Others!
Engineering, ESH, OPS…

Christopher Kreitzinger
Support Associate
- Admin, User Association

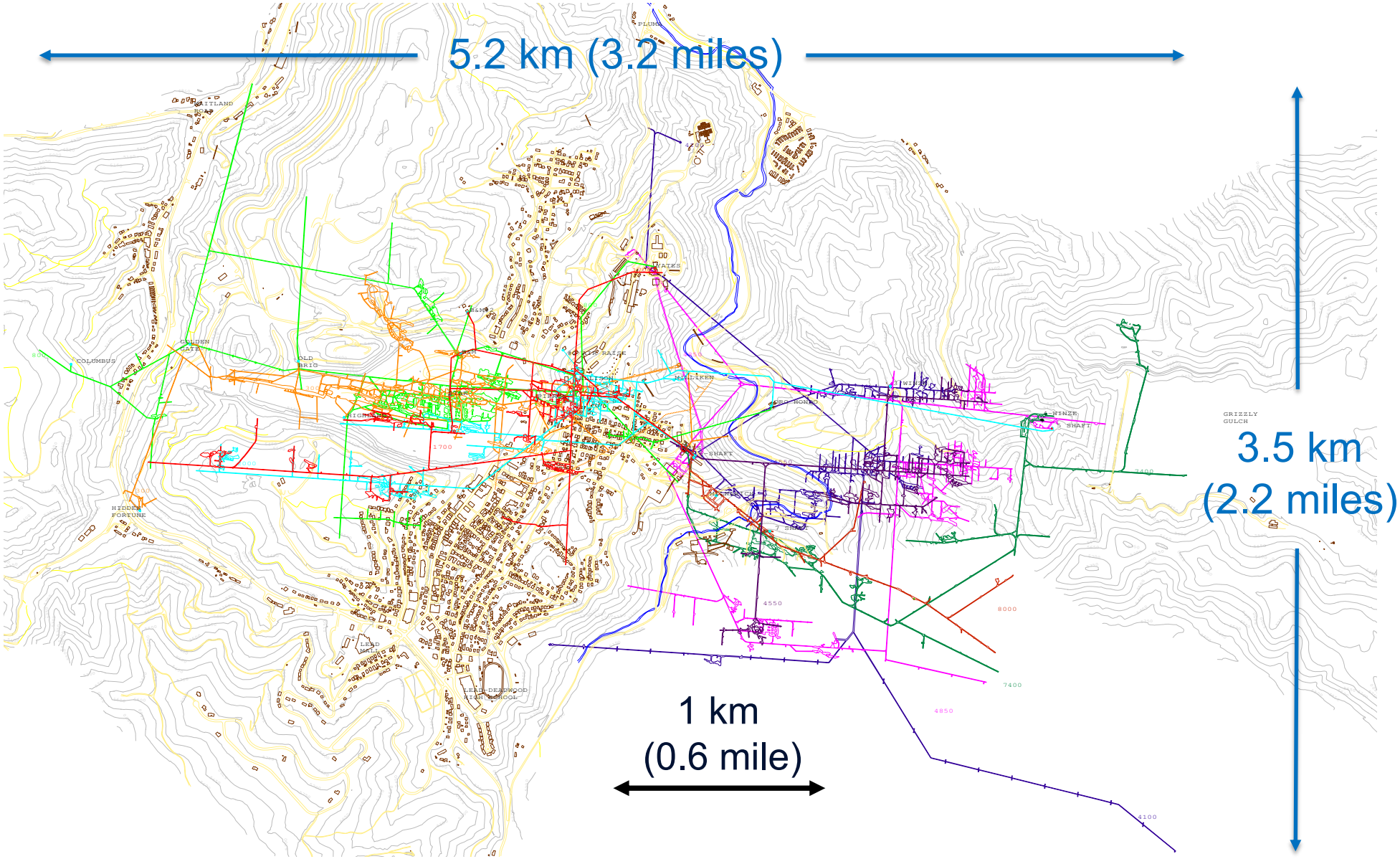
SURF Underground Lab Geography

Significant underground footprint for science



SURF Underground Lab Geography

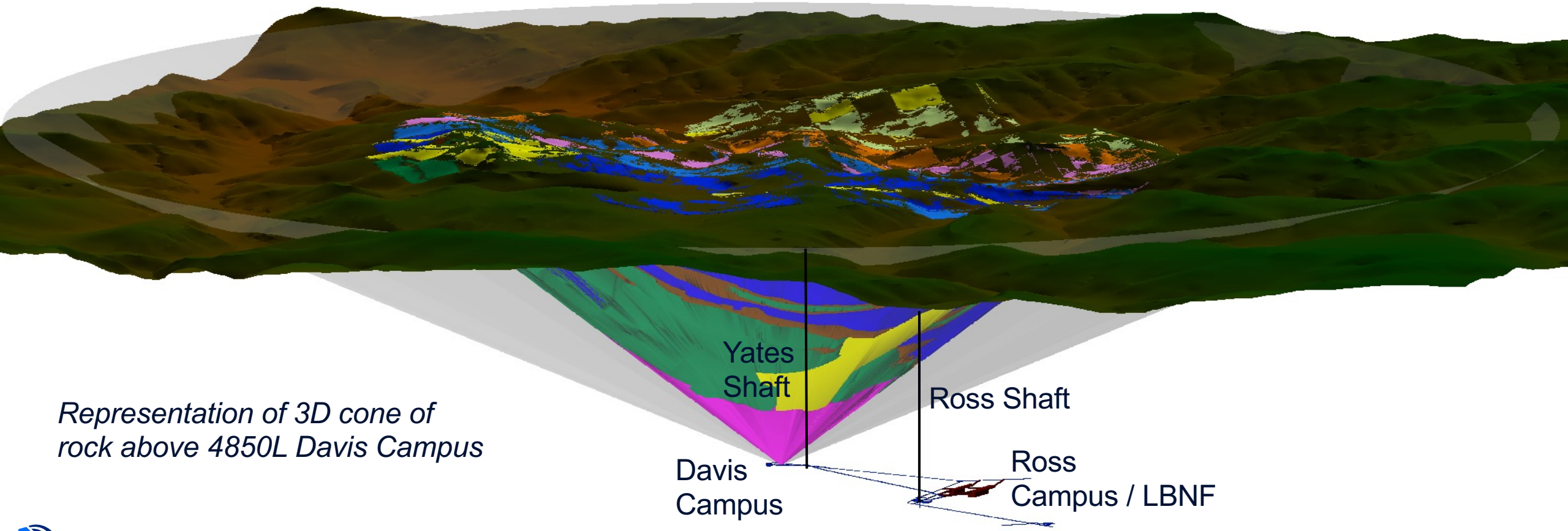
Significant underground footprint for science



SURF Science Support – Geology Model

Site well understood, including drill core & logs

- 3D model of seven main rock formations + Rhyolite 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: Hart, Trancynger, Roggenthen, Heise, SD Acad Sci **93**, 33 (2014)



Representation of 3D cone of rock above 4850L Davis Campus

SURF Experiment Implementation & Support

Main Science documents under IMS/ISO document control

Experiment Implementation Program

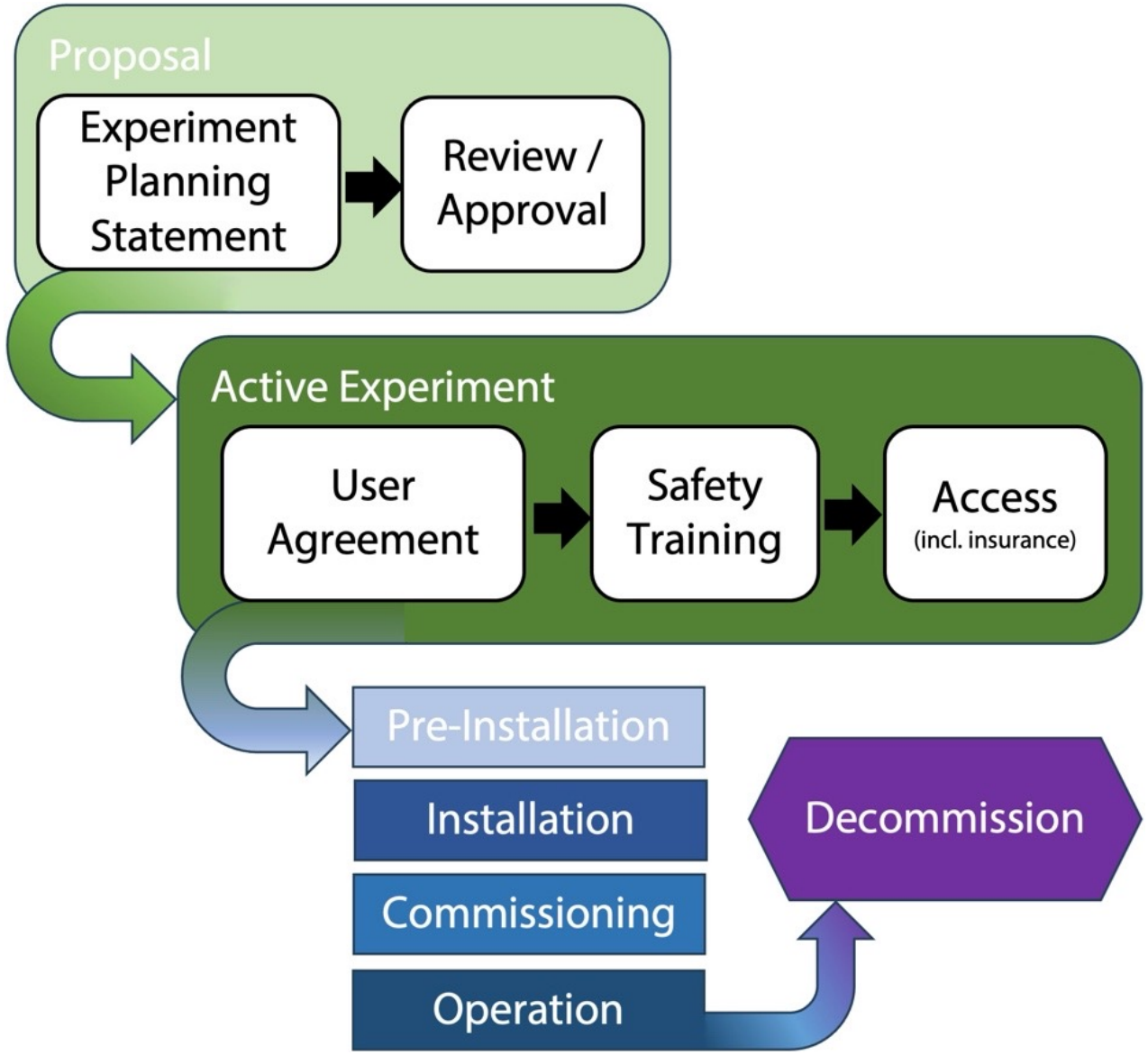
- Integral to the SDSTA institutional mission is advancement of compelling underground, multidisciplinary research
- EIP framework allows experiments to be implemented at SURF in effective and efficient manner
- References several key elements:
  - Experiment Planning Statement
  - User Agreement (was MOU)
  - Publication Policy
  - Experiment Decommissioning Statement

Experiment Integration & Support

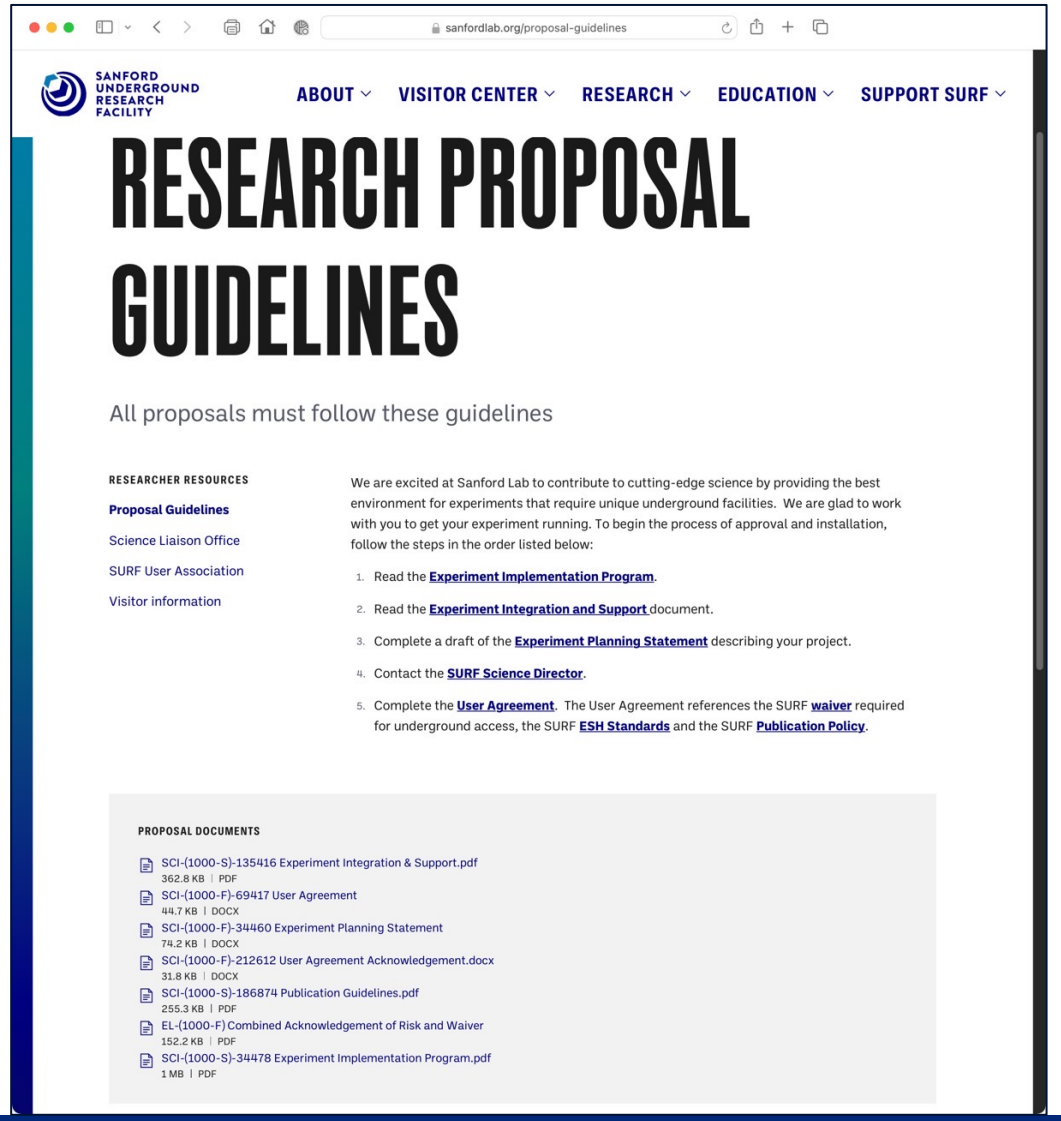
- In partnership with research groups, SDSTA aims to maintain a robust organization with resources to promote safe and successful experiment operations at SURF
- References several key elements:
  - Several specific ESH Standards (incl WPC)
  - SURF Applications/Databases (TAP, SARF, etc)
  - Table of responsibilities (SDSTA and Experiment)
  - Perception Survey, Information for Researchers Wiki, etc

SURF Experiment Implementation Program

Identify interfaces and hazards within approval framework



https://sanfordlab.org/proposal-guidelines



SURF Science Program

Research activities ranging from the surface to 1500+m underground

Physics

LZ – *Dark matter, 2-phase Xe TPC*

MAJORANA DEMONSTRATOR / LEGEND – *Neutrinoless double-beta decay, Ge-76, Ta-180m, also Cu e-forming*

CASPAR – *Nuclear astrophysics with 1 MV accelerator*

LBNF/DUNE – *Neutrino properties, etc*

BHUC – *BHSU Underground Campus, mainly material screening*

Berkeley LBF – *Low-bkgd counter (x3);* also CUBED – *Low-bkgd counter (x1) (possibly future Crystal Growth)*

nEXO – *Low-bkgd counter (x1)*

LLNL – *Low-bkgd counter (x1)*

SDSMT – *Neutron bkgds*

Biology

Astrobiology/DeMMO – *In-situ culture, isolate DNA*

2D Best – *Biofilms*

Biodiversity – *Microbial communities*

Biofuels – *Extremophile bioprospecting*

m-sense – *Microbes and environment*

Chemistry – *Env characterization*

Liberty BioSecurity* – *Extremophiles*

Geology

CUSSP – *Geothermal*

DEMO-FTES – *Geothermal*

3D DAS – *Seismic monitoring using fiber*

Core Archive* – *Mainly gold deposits*

Hydro Gravity – *Gravity for water tables*

BH Seismic – *Global monitoring*

Transparent Earth – *Seismic arrays*

Engineering

AMD (was Xilinx, Inc)* – *Chip error testing*

Thermal Breakout – *In-situ stress*

Shotcrete – *Mining safety*

Enviro Monitoring – *Ventilation airflow*

Caterpillar* – *Mining technology*

MAP – *Microbe-assisted phytoremediation*

Metalurgy – *WWTP product uses*

Total = 30 groups

22 Active Projects

70 Total Groups Since 2007

* Denotes proprietary group

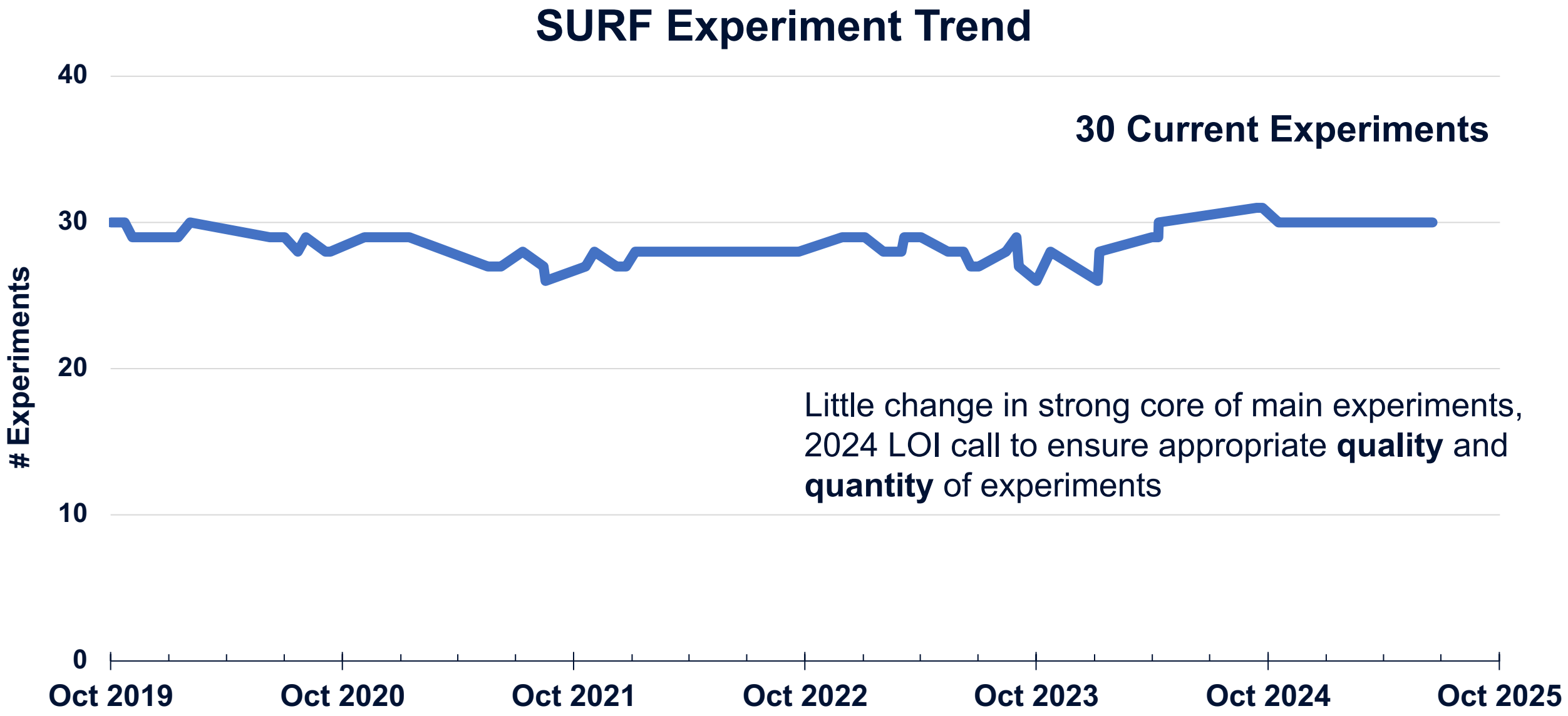
Significant interest from others

(28 groups in 2024)

Also Science Programs for Students: 2x DOE RENEW, 1x NSF REU

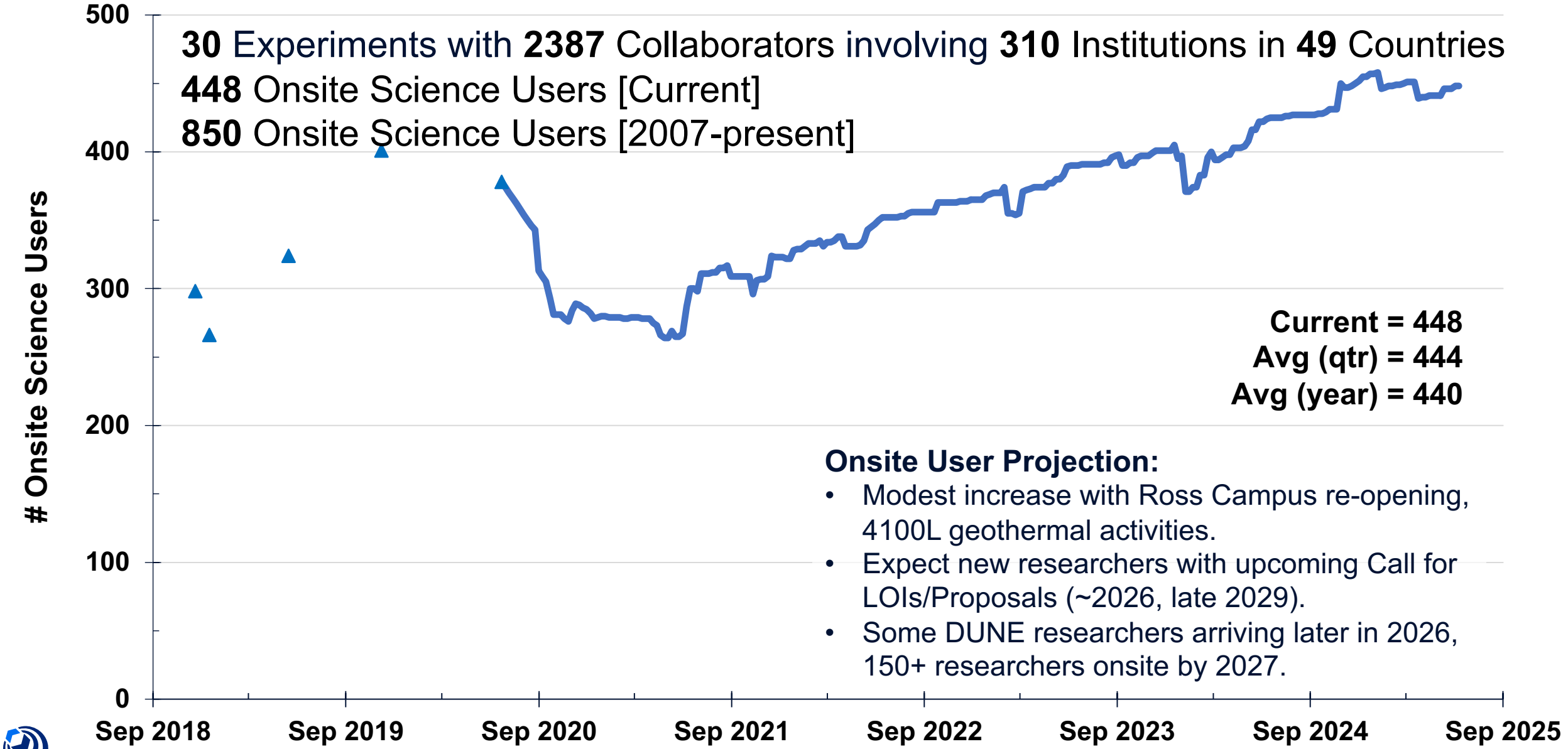
SURF Science Program

Hosting world-leading experiments and researchers from diverse scientific communities



SURF Onsite Users

Significant user base, expect more engagement with UG science community

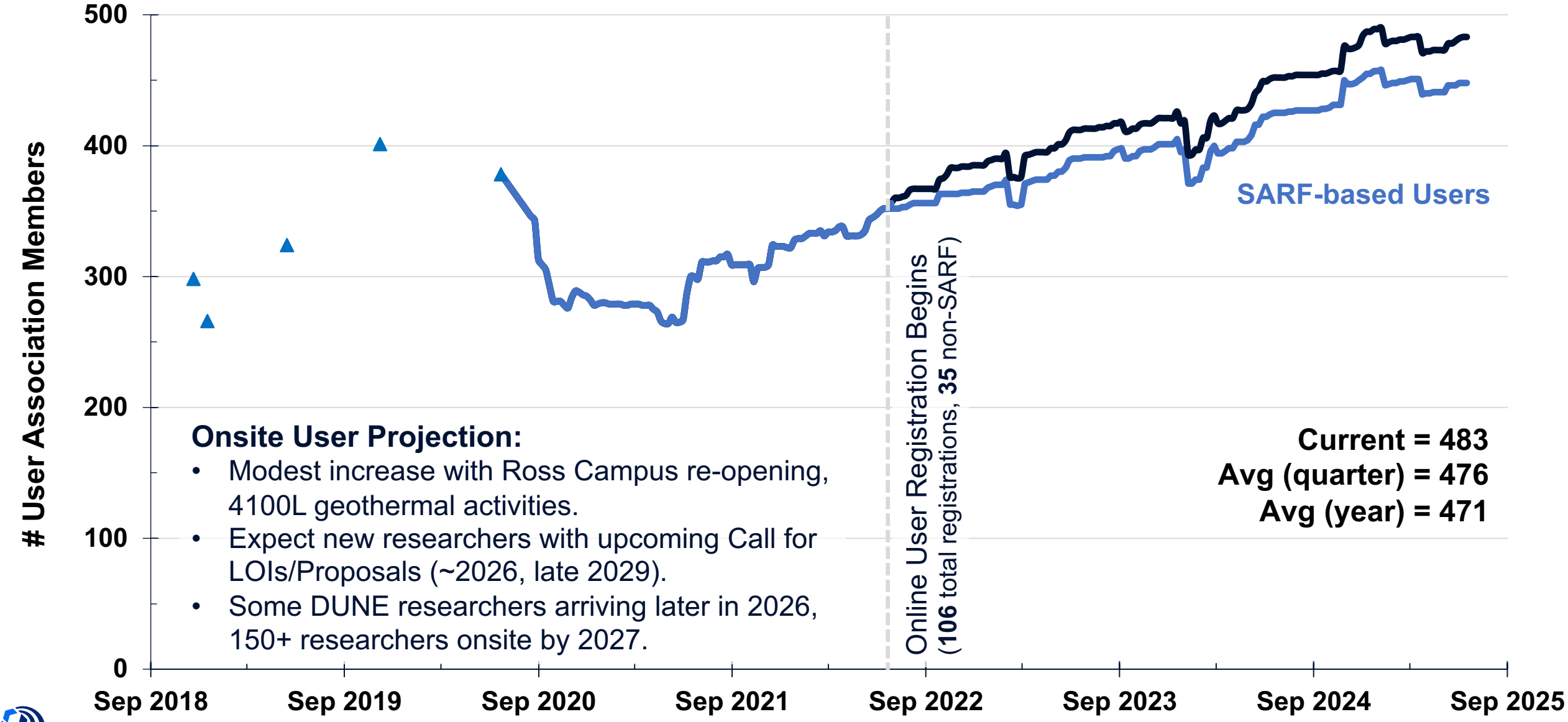


Onsite User Projection:

- Modest increase with Ross Campus re-opening, 4100L geothermal activities.
- Expect new researchers with upcoming Call for LOIs/Proposals (~2026, late 2029).
- Some DUNE researchers arriving later in 2026, 150+ researchers onsite by 2027.

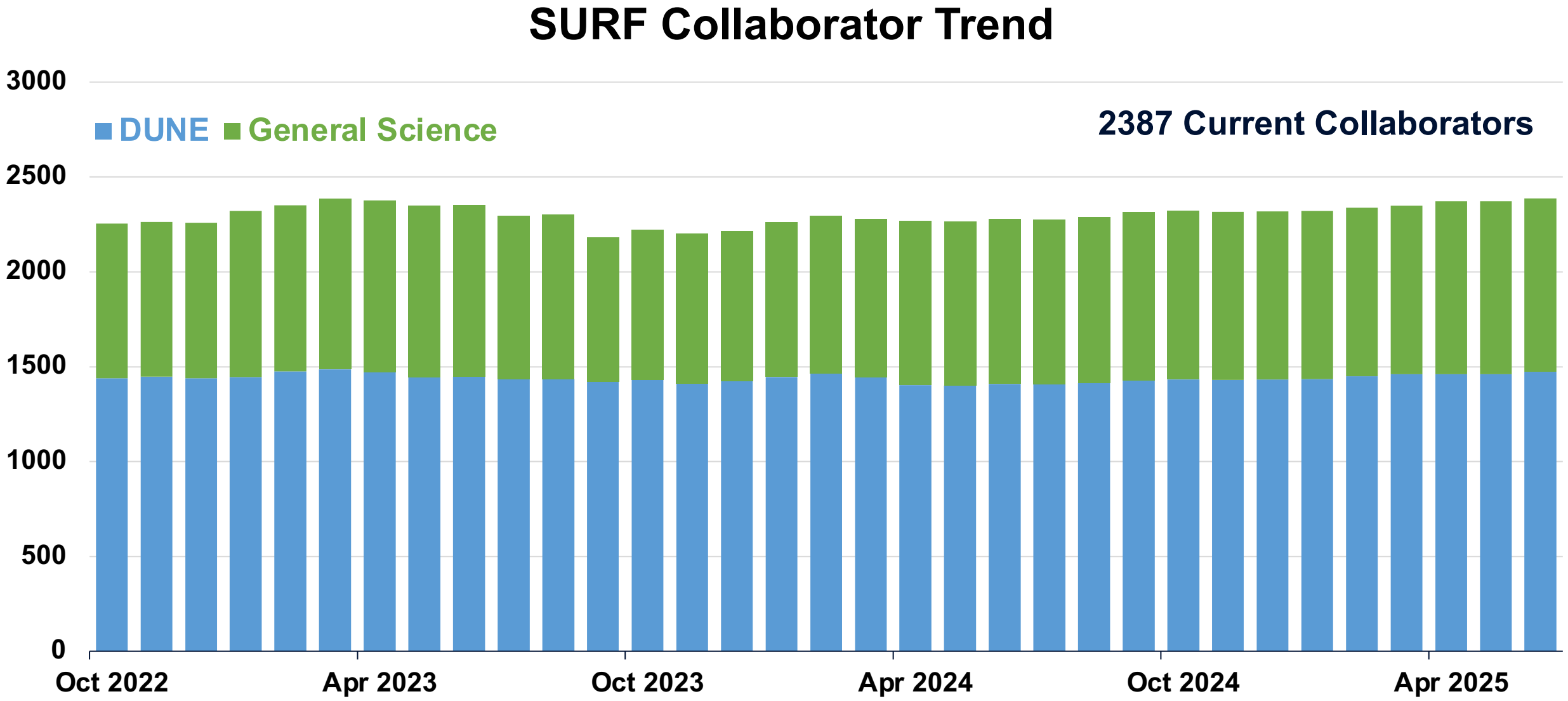
SURF User Association Members

Significant user base, expect more engagement with UG science community



SURF Science Program

Hosting world-leading experiments and researchers from diverse scientific communities



LUX-ZEPLIN (LZ)

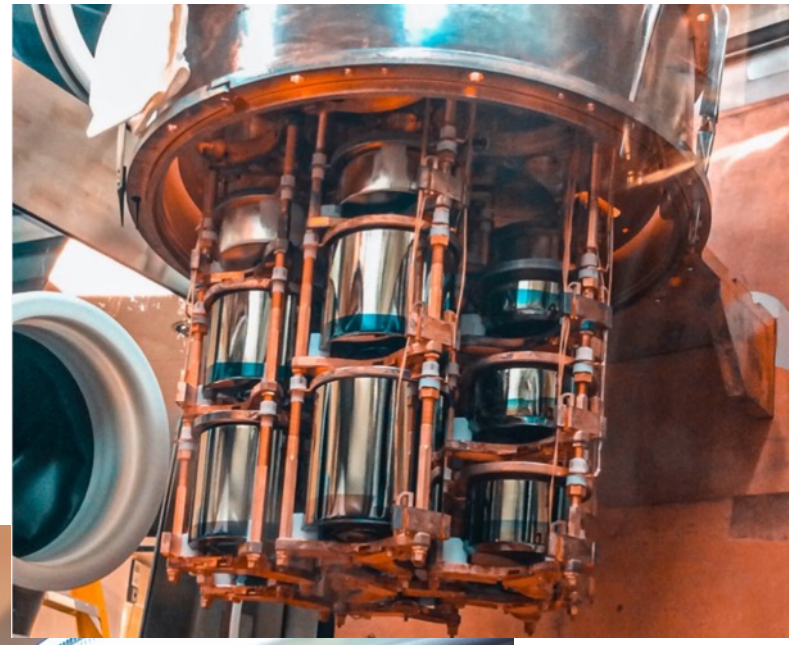
Large Underground Xenon - ZonEd Proportional scintillation in Liquid Noble gases

- **Science Goal:** Direct dark matter search using dual-phase xenon (10 tonnes) in Ti cryostat surrounded by ultra-pure water and Gd liquid scintillator veto.
- **Collaboration:** 197 members, 36 institutions, lead = LBNL [DOE HEP].
- **Status:**
  - Onsite since Jul 2017 (as LUX since Nov 2009).
  - Production data started Dec 2021. WIMP-search results: 10.1103/PhysRevLett.131.041002 (2022, world-leading), latest results 10.1103/4dyc-z8zf (2024, world-leading).
  - WIMP-search data taking continuing (> 600 live days).
- **Future:**
  - Complete science data early 2028, then decommission. SURF Xe inventory available through Sep 2028.
  - Meetings with next-generation liquid Xe collaboration (XLZD): http://arxiv.org/abs/2203.02309. Proposing up to ~100 tonnes Xe. Site TBD, SURF expansion would work (size and nominal schedule ~2030); also for Argo (argon).
  - Low-mass dark matter projects potential follow-ons to LZ.

MAJORANA DEMONSTRATOR (MJD)

Also Large Enriched Ge Experiment for Neutrinoless ββ Decay (LEGEND)

- **Science Goal:** Neutrinoless double-beta decay using 44 kg Ge in two cryostats, 30 kg enriched ^{76}Ge inside compact shield (poly + Pb + Cu); also LEGEND R&D and more recently rare decays (^{180m}Ta).
- **Collaboration:** 62 members, 20 institutions, lead = ORNL [DOE NP].
- **Status:**
  - Onsite at SURF since Nov 2010.
  - Achieved 65 kg-yr exposure (2015-2021), final 0νββ result published Feb 2023: 10.1103/PhysRevLett.130.062501.
  - Ta-180m rare decay search May 2022 - Jun 2025, first results published Oct 2023: 10.1103/PhysRevLett.131.152501.
  - Four Cu electroforming baths operating at Davis Campus.
- **Future:**
  - Decommissioning underway, completed by Oct 2026 (some Pb/Cu materials shipping to DAMIC-M).
  - Cu e-forming to continue, expected to expand to 8+ baths for LEGEND (and UG science community).
  - Ton-scale: CD-1 in fall 2025 for LEGEND-1000 (nEXO paused). Data taking ~2031-2044 → $T_{1/2}$ ~ 10^{28} yrs.
  - "Multi-ton-scale" experiment (in 2040s) possible at SURF.



CASPAR

Compact Accelerator System for Performing Astrophysical Research

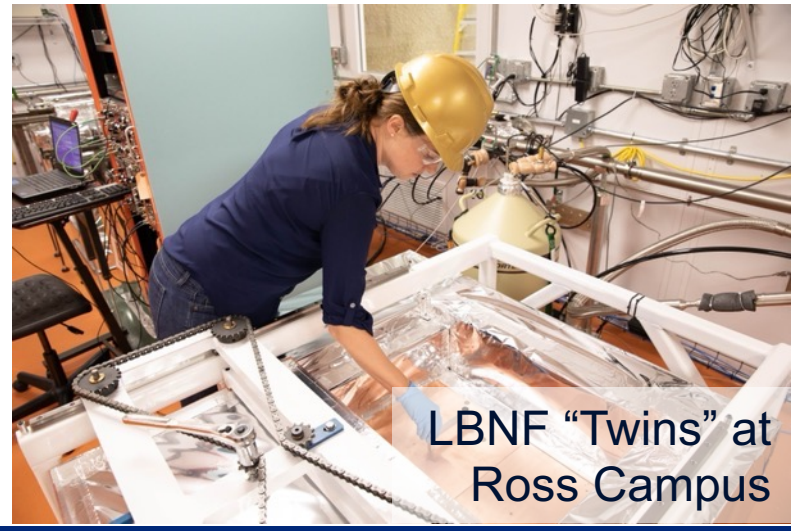
- **Science Goal:** Study of stellar nuclear fusion reactions, esp. neutron production for slow neutron-capture nucleosynthesis using 1-MV electrostatic accelerator for protons or alpha particles.
- **Collaboration:** 26 members, 2 institutions, lead = SD Mines [NSF MPS/PHY].
- **Status:**
  - Onsite at SURF since mid-2015, beam since 2017.
  - Data collected 2017-2021 with targets: ^{7}Li, ^{11}B, ^{14}N, ^{18}O, ^{20}Ne, ^{22}Ne (gas, solid), ^{27}Al.
  - Bkgd characterization, incl liquid scintillator neutron detectors (ORNL), ^{3}He and NaI arrays (Notre Dame).
  - Laboratory mothballed Apr 2021 due to LBNF construction.
  - 5 scientific papers, incl PRL: 10.1103/PhysRevLett.128.162701.
  - NSF funding for operations started FY25.
- **Future:**
  - 4 more papers planned. Also: 4 students graduated, 2 in queue.
  - Next phase of operation starting 2025 (4850L Ross Campus lab), targets incl ^{19}F (CNO solar neutrinos) and ^{7}Li, ^{10}B (JWST data).

SURF Material Assay at BHUC

Black Hills State University Underground Campus

- **Science Support Goal:** Characterize radiopurity of experiment components; also multi-disciplinary science support at Ross Campus.
- **Collaboration:** 14 members, 7 institutions, lead = BHSU [institutional funding, some DOE support via experiments like LZ]; also 2 Student Science Programs
- **Status:**
  - Onsite since Sep 2015 (previous low-bkgd efforts with CUBED starting Apr 2013 at Davis Campus).
  - Ross Campus operations Sep 2015 – Jul 2020. Laboratory mothballed Mar 2021 due to LBNF construction.
  - Initial operations at Davis Campus starting Nov 2020 after SURF-supported cooling upgrades. Sample counting resumed Mar 2021.
  - Five counter systems operating, incl two dual-crystal systems. Recent samples incl protoDUNE, also IceCube, CUPID, NEXT, nEXO.
- **Future:**
  - Possible addition of 7th (Ge-V) and 8th (UCLA) detectors.
  - Limited space for expansion and multi-disciplinary activities at Davis Campus. Return to Ross Campus starting underway in 2025 following LBNF/DUNE excavation phase.

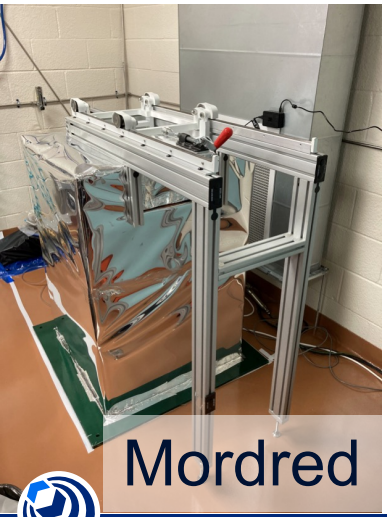
LLNL detector commissioning at Davis Campus

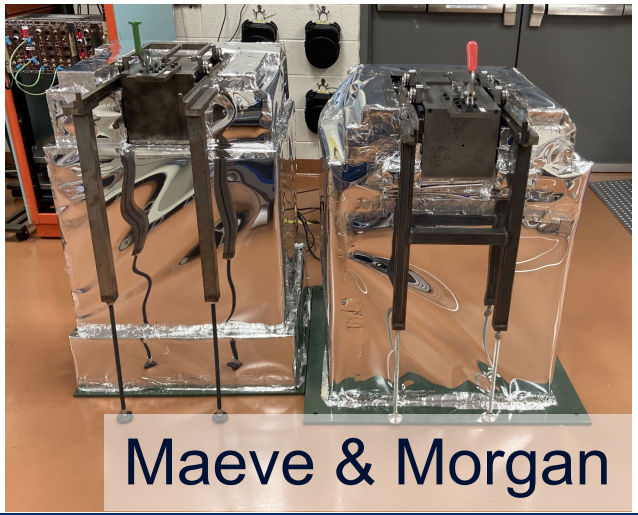


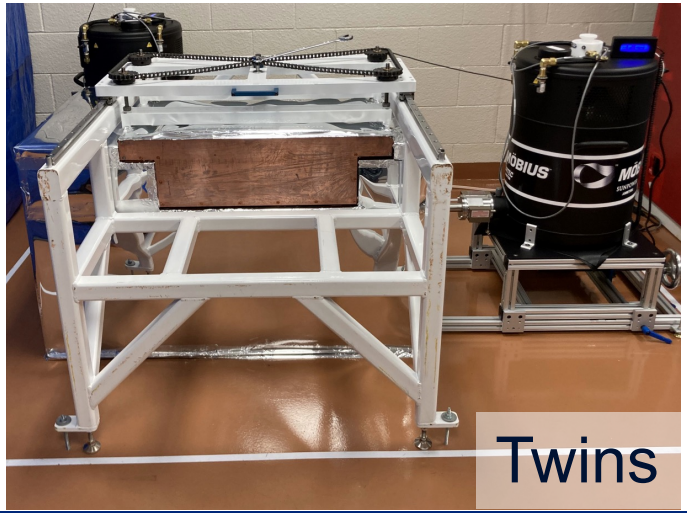
LBNF “Twins” at Ross Campus

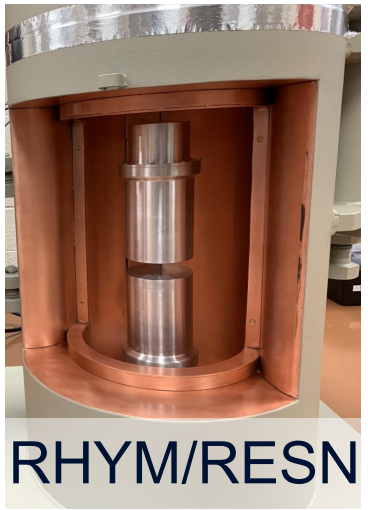
SURF Material Assay at BHUC: Davis Campus

Low-background counting capabilities serving national & international community


Mordred


Maeve & Morgan


Twins


RHYM/RESN


Ge-IV

Geology: DEMO-FTES

Demonstration of Fracture Thermal Energy Storage

- **Science Goal:** Study enhanced geothermal system (EGS) and fracture thermal energy storage (FTES) effects on 10-meter scale. Pressure systems used to isolate sections of holes and flow water between holes.
- **Collaboration:** DEMO-FTES (12 members, 4 institutions) [DOE Office of Energy Efficiency and Renewable Energy (EERE), Geothermal Technology Office (GTO)]; previous kISMET (35 members / 12 institutions), EGS Collab/SIGMA-V (128 members / 23 institutions).
- **Status:**
  - Onsite starting Dec 2023 (EGS Collab/SIGMA-V Oct 2017 – Dec 2022 and kISMET since Jun 2016).
  - Leveraging 4100L site: 11 drill holes (180-265 m long) and some existing instrumentation (no new drilling planned); future groups may use five 4850L kISMET holes (4x 50m, 1x 100m (72m useable)).
  - Electrical upgrade for water heater (source of stored heat).
- **Future:**
  - DEMO-FTES activities at SURF thru Dec 2025 (was Dec 2024).
  - DOE-SC Basic Energy Sciences funding CUSSP 2024-2027; other community interest in testbed (e.g., Eden)

SIMFIP tool installed for EGS/SIGMA-V

DOE-SC BES program manager visit

Biology: DeMMO
Deep Mine Microbial Observatory

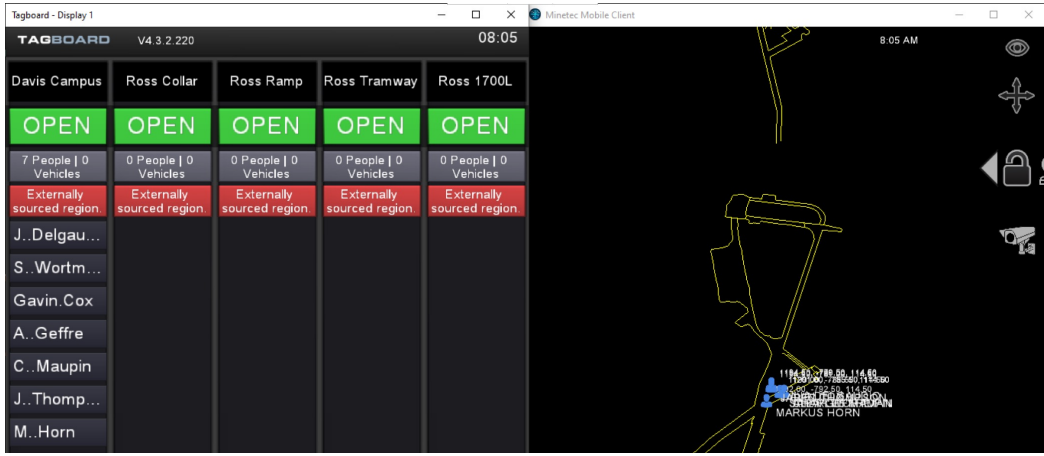
- **Science Goal:** Explore and understand rock-hosted microbial ecosystems by performing long-term water sampling from drill core holes (new and legacy), testing for life in drill core (new); also test various substrates, incl electrode-assisted cultivation (bioreactor).
- **Collaboration:** DeMMO (7 members, 2 institutions; lead = Northwestern) [Institutional]; previous Life Underground: NASA Astrobiology Institute (15 members, 6 institutions; lead = USC)
- **Status:**
  - Onsite since 2014 (NASA funding 2014-2018).
  - Synergistic collaboration between biology, geology & physics.
  - Outfitted 6 holes for long-term monitoring: 2x 800L, 1x 2000L, 1x 4100L, 2x 4850L.
  - Collected and analyzed LBNF drill core, incl JPL's *in situ* laser spectrometer SHERLOC, technology concept used on Perseverance rover (part of Mars 2020 mission).
- **Future:**
  - Continue sampling indefinitely (and somewhat infrequently).
  - One 4850L site impacted by 4850L Expansion (waste rock).

NAI collected LBNF core


Sampling water from legacy drill hole

CAT
Caterpillar Underground Research Center

- **Industrial Partnership Goal:** Provide real-world, interactive environment for customer experiences, training and new product implementation.
- **Collaboration:** 12 core members (total of 296 ppl, incl customer groups), 46 institutions, lead = Caterpillar [institutional funding]; proprietary group requires full DOE cost recovery
- **Status:**
  - Onsite since Aug 2020 (initial inspections Feb 2019).
  - Former motor & loader barns (~925 m^2), ~1000-m ramp. Total of 17,000+ rock bolts, 3000+ mesh panels, new rail.
  - Over 1.5 km of MineStar tracking technology distributed throughout 1700L and ramp to 1550L.
  - 6 utility vehicles currently UG at SURF using tracking technology.
  - Site-wide tracking system in development, currently in test mode (4850L, 1700L, surface) w/ Science, UMC, ERT, et al.
- **Future:**
  - Complete Ross Shaft fiber installation and deployment.
  - 10-year agreement through Sep 2030.



SURF Potential Vertical Facility

Long-baseline atom interferrometry:

Promising technique for probing aspects of fundamental physics, astrophysics and cosmology

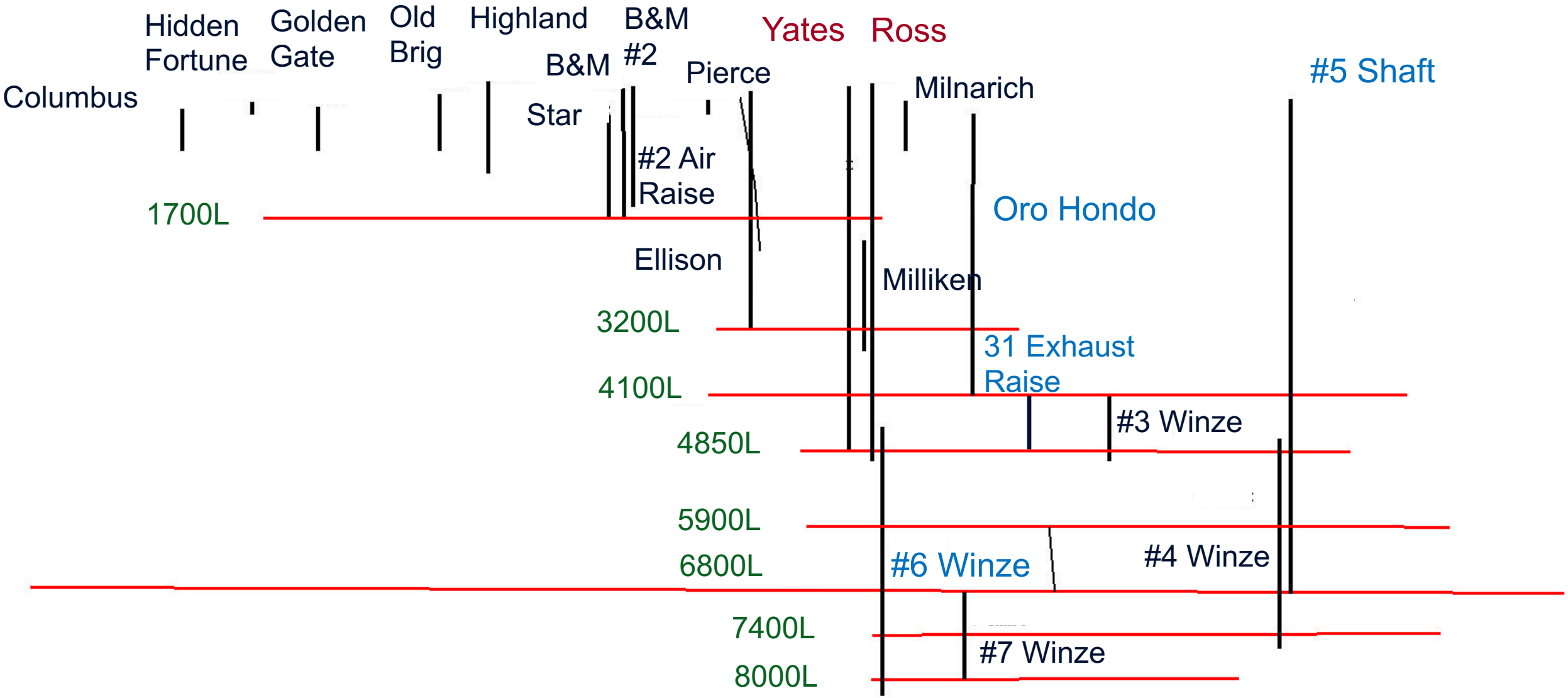
- **Ultralight Dark Matter**:
  - Mass range ~10^{-19} to 10^{-11} eV
  - Sensitive to waves of dark matter interacting with atomic constitutents
  - Complementary to direct and other searches, signal would provide direct evidence of dark matter through non-gravitational interactions
- **Gravitational Waves**:
  - Signals in frequency range 0.1-10 Hz, characteristic of mergers of intermediate-mass black holes (100 to 100,000 solar masses), important role in assembly of supermassive black holes in cores of galaxies
  - Complementary to laser interferometry with current LIGO / VIRGO / KAGRA as well as future Einstein Telescope and Cosmic Explorer and space-based LISA

Facility requirements (https://arxiv.org/pdf/2503.21366):

- Two possible geometrical configurations: **horizontal or vertical**
- Vertical requirements: **1.5-m diameter** shaft (minimum), **15-cm diameter** pipe for ultra-high vacuum
- **Current:** AION (Oxford/UK – 10 m), MAGIS (Fermilab/USA – 100 m vertical), MIGA (LSBB/France – 150 m horizontal arms), ZAIGA (China – 300 m vertical and 1000 m horizontal arms)
- **Future km-Scale:** Porta Alpina/Switzerland, Boulby/UK, SURF/USA

SURF Potential Vertical Facility

Depth layout



SURF Potential Vertical Facility

Initial SURF study completed March 2023 (presented at 2022 TVLBAI workshop)

Vertical Facility design assumptions:

- Significant length: Medium scale (100 m), large scale (1000 m)
- Cross-section: 1.5 m *[2.4 – 5 m original requirement from 2021 SURF Vision Workshop]*
- Access required to top and bottom
- Surface (or near surface) access preferred (for constructability and cost considerations)
- Availability of existing supporting infrastructure and utilities

SURF Evaluation:

- 12 shafts/winzes/raises considered, 6 sites feasible for further study:

  Large Scale (1000-m Candidates):
  - #5 Shaft – Available from surface to 4850L (1500 m) and extends to 6900L
  - Ellison Shaft – Available from surface to 3200L (need to remove top ~100 m concrete plug)

  Medium Scale (100-m Candidates):
  - #6 Winze – Available from 4550L to 5000L (extends further to 8000L)
  - Milliken Winze – Available from 2000L to 3500L
  - Milnarich Shaft – Available from surface to 800L (if top concrete plug removed), verify dimensions
  - 31 Exhaust Raise – Available from 4100L to 4850L, verify dimensions
- O ($100k) needed to refine requirements and initial evaluation

SURF Potential Vertical Facility

Feasibility based on requirement assumptions (incl >2-m diameter)

Name	Current Use	Length	Cross Section/ Diameter	Ownership	Feasible? (Y/N)	Comment
#5 Shaft	Secondary Lab Ventilation Pathway	2103 m (6900 ft)	5.2 m diameter (17 ft diameter)	SDSTA	Yes	Rehabilitation required (debris at 208 m/683 ft), sustain current use
Ellison Shaft	None	985 m (3233 ft)	6.1 m x 3.7 m (20 ft x 12 ft)	SDSTA	Yes	Limited access, concrete plug at 90 m/ 300 ft
#6 Winze	Dewatering column to deep pool (future access to 7400L?)	1083 m (3552 ft)	5.2 m x 4.3 m (17 ft x 14 ft)	SDSTA	Yes	Rehabilitation required, currently 137 m / 450 ft useable
Milliken Winze	None	459 m (1505 ft)	3.7 m x 3.7 m (12 ft x 12 ft)	SDSTA	Yes	UG access, travel distance for access, 2000L to 3500L
Milnarich Shaft	None	182 m (596 ft)	Unknown	SDSTA	Yes	Surface access, surface to 800L (concrete plug)
31 Exhaust Raise	Connection to primary ventilation	229 m (750 ft)	5.5 m diameter (18 ft diameter)	SDSTA	Yes	UG access, long travel but both ends accessible

SURF Potential Vertical Facility

Yates Shaft Refurbishment:

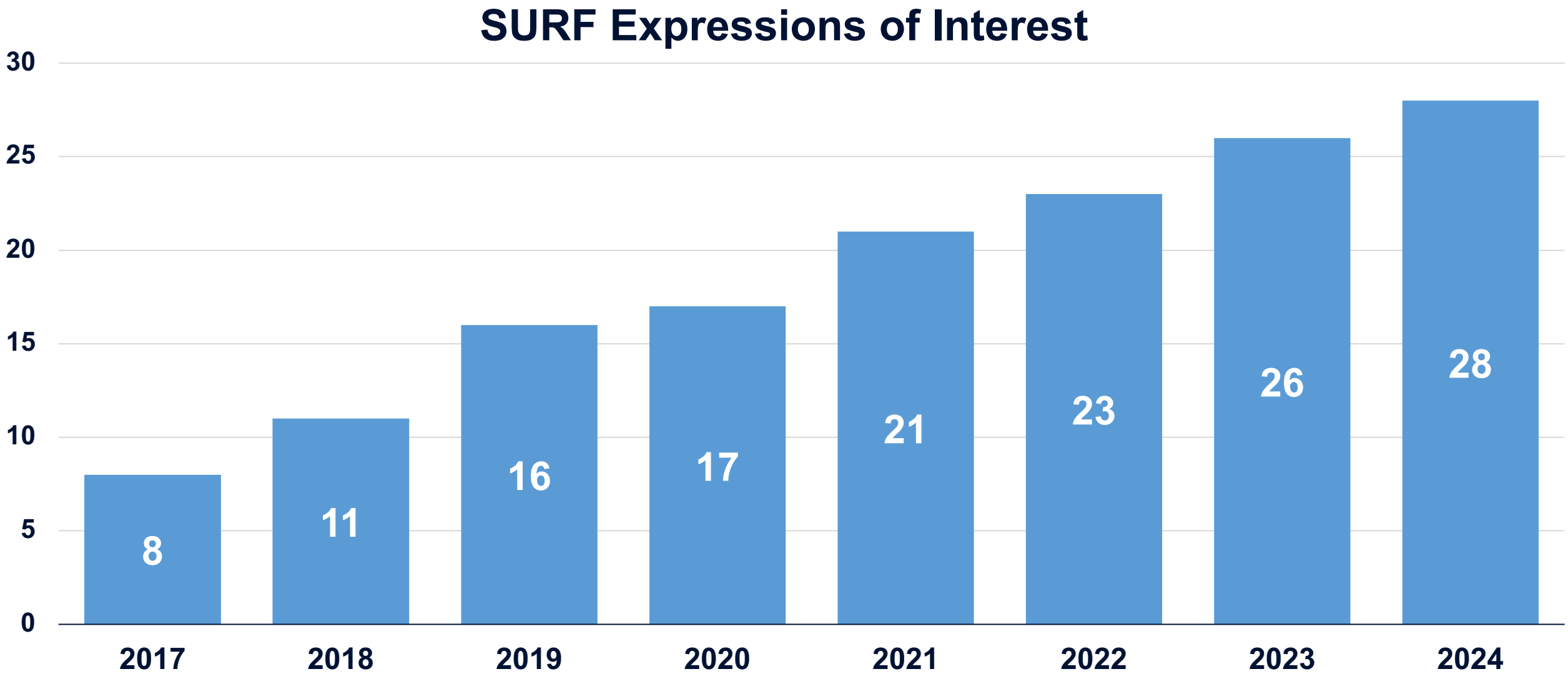
- DOE recognizes investment necessary to ensure safe and redundant access in coming decades, developing CD-0-like “mission need” and cost & schedule profile
  - Design (leverages recent Ross Shaft design): ~2026-2027 (earliest)
  - Construction: ~2027-2030 (earliest)
- Potential for shaft to accommodate 1.3-m diameter cross-section (maybe 1.75-m diameter with reconfiguration or different compartment)
- *Note: Yates Shaft is one of two main shafts and would be in regular daily operation*

Additional Considerations:

- Survey underway to ensure underground ventilation capacity for LBNF/DUNE (FD1,2,3) and 4850L Expansion laboratories
  - May preclude use of #5 Shaft as well as other uses for Yates Shaft compartments
- SURF call for LOIs soliciting facility requirements from potential future experiments (incl 4850L Expansion laboratories)
  - Needs such as low-Rn air from surface may place demand on Yates Shaft compartment(s)
- LBNF/DUNE DOE “Module of Opportunity” design and needs currently unknown

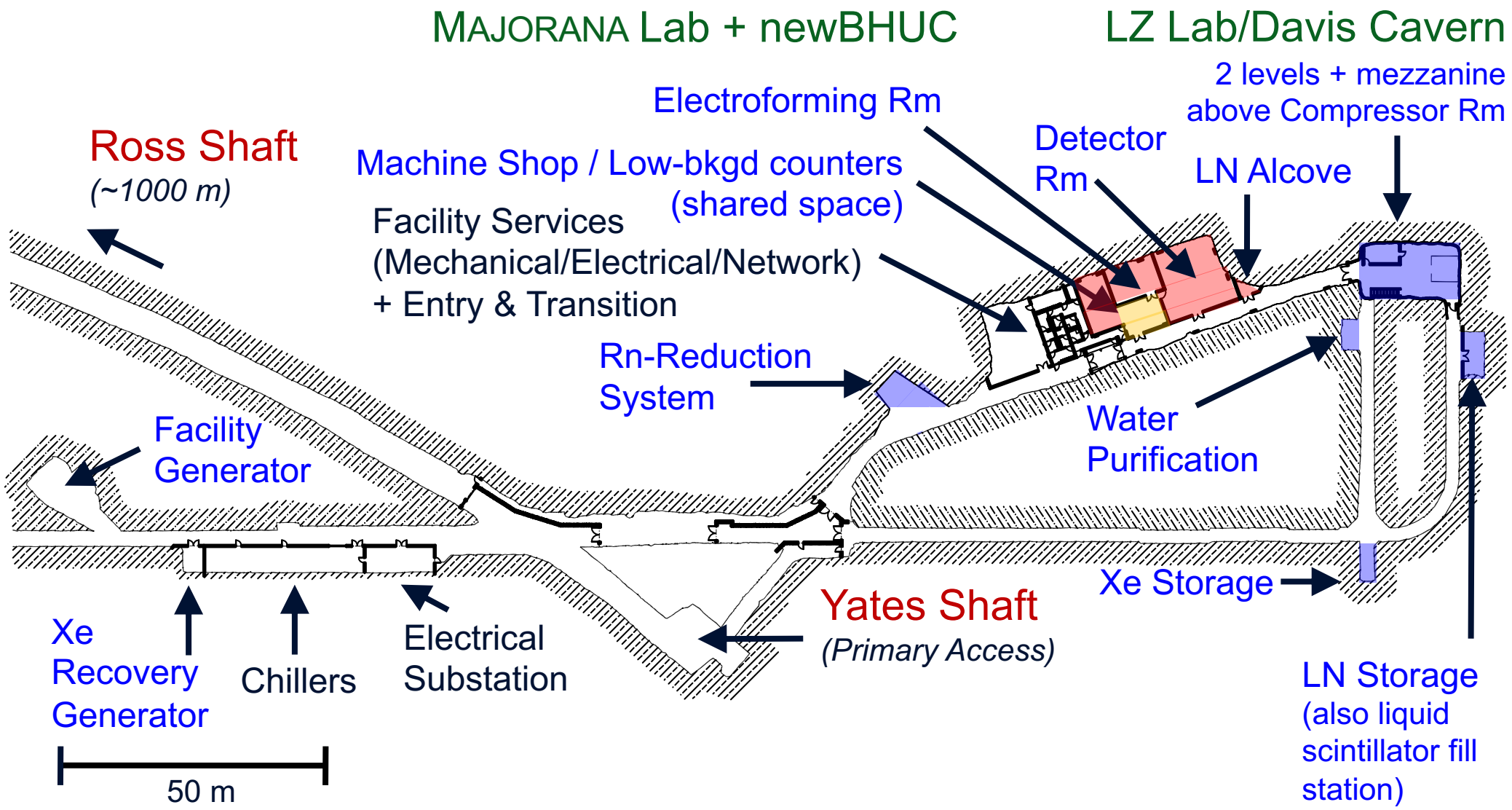
SURF Science Program

Growing interest from the underground science community



4850L Davis Campus

3,017 m² (Total) / 1,018 m² (Science)



SURF Designated APS Historical Site

Announcement Sep 2020, Dedication May 2022

www.interactions.org/press-release/aps-designates-sanford-lab-morgan

INTERACTIONS.ORG
PARTICLE PHYSICS NEWS AND RESOURCES

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A communication resource from the **world's particle physics laboratories.**

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 ional Society of Black Physicists (NSBP).

DATE ISSUED:
September 14th, 2020

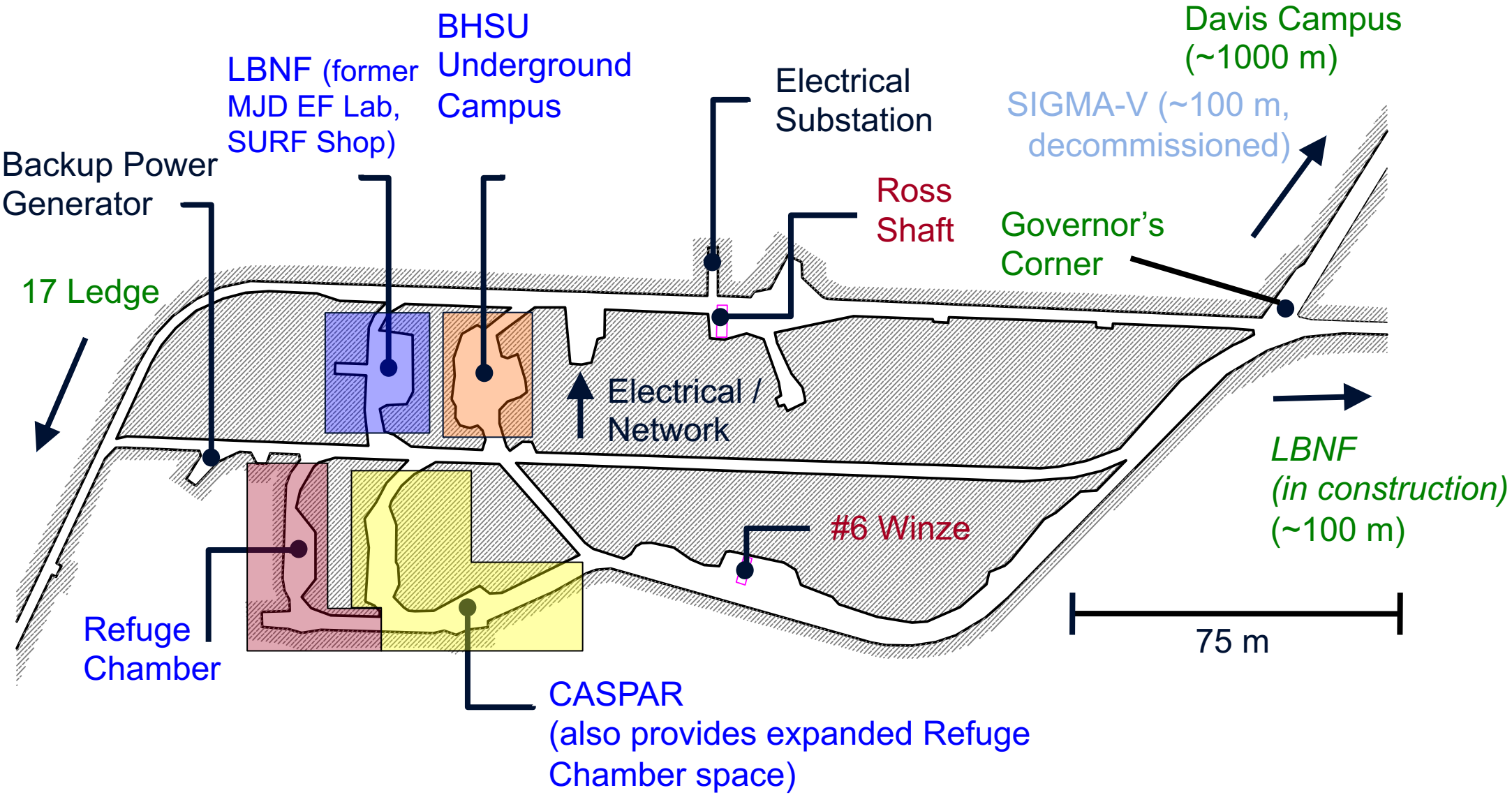
SOURCE:
Sanford Underground Research Facility

CONTENT:
Press Release

CONTACT:
Constance Walter
Communications Director
cwalter@sanfordlab.org

4850L Ross Campus

2,653 m² (Total) / 920 m² (Science)



SURF 4850L Ross Campus

Examples of laboratory space

2010-2017

Copper Electroforming

2015-2020, resume 2024

Former MJD Electroforming:
Area = 228 m^2
(Cleanroom removed,
current construction office)

2015-2021, resume 2024

BHUC Cleanroom:
Cavern Area = 268 m^2,
Cleanroom = 12.1 m × 6.1 m ×
2.4 m (H)

CASPAR Hall:
Area = 236 m^2,
30 m × 3 m (min) × 2.8 m (H)

SURF Current & Future Facilities

Summary for various science campuses, including timelines

Location	Laboratory	Existing/*Planned* Space		Available (CY)	Comments
		Area (m^2)	Vol (m^3)		
Surface	Surface Lab (+ RRS)	210	600	2021	LZ use ~complete, allowing use by others
Davis Campus (4850L)	LZ Lab – Davis Cavern (2 levels)	372	1,956	~2028	LZ data complete early ~2028 + decommissioning
	MJD Lab – 2 Rooms + BHUC share	300	1,279	2026 / ~2032	Ge-76 DBD completed 2021, Ta-180m data 2022-25 + decommissioning; Cu e-forming through ~2031
	Cutout Rooms (4)	100	412	~2028	LZ timeframe for most spaces
Ross Campus (4850L)	Former E-forming	228	742	?	LBNF use currently, likely unavailable for several yrs
	BHUC (BHSU cleanroom)	266	773	N/A	Mothballed, equip and systems relocated to Davis Campus; re-occupy 2024 after LBNF excavation
	CASPAR	395	1,130	2027+	Mothballed, equip remains, re-occupy 2024 after LBNF excavation. (Also expanded Refuge Chamber)
	Refuge Chamber	258	866	?	Long-term use TBD
LBNF (4850L)	LBNF	9,445	191,863	?	Excavation complete early 2024; MOO/FD4 available
4100L	Geoscience Lab	334	11 drill holes	2025	DEMO-FTES use 2023-2025, CUSSP 2025-2027
4850L	*Expansion (2 proposed)*	*4,022*	*94,608*	*Earliest new: excavation 2028, complete ~2031*	*Each 20m (W) x 24m (H) x 100m (L)*
7400L	*New Labs (2 proposed)*	*4,178*	*42,440*		*Each 15m (W) x 15m (H) x 75m (L) + other supporting*

SURF Electrical and Standby Power

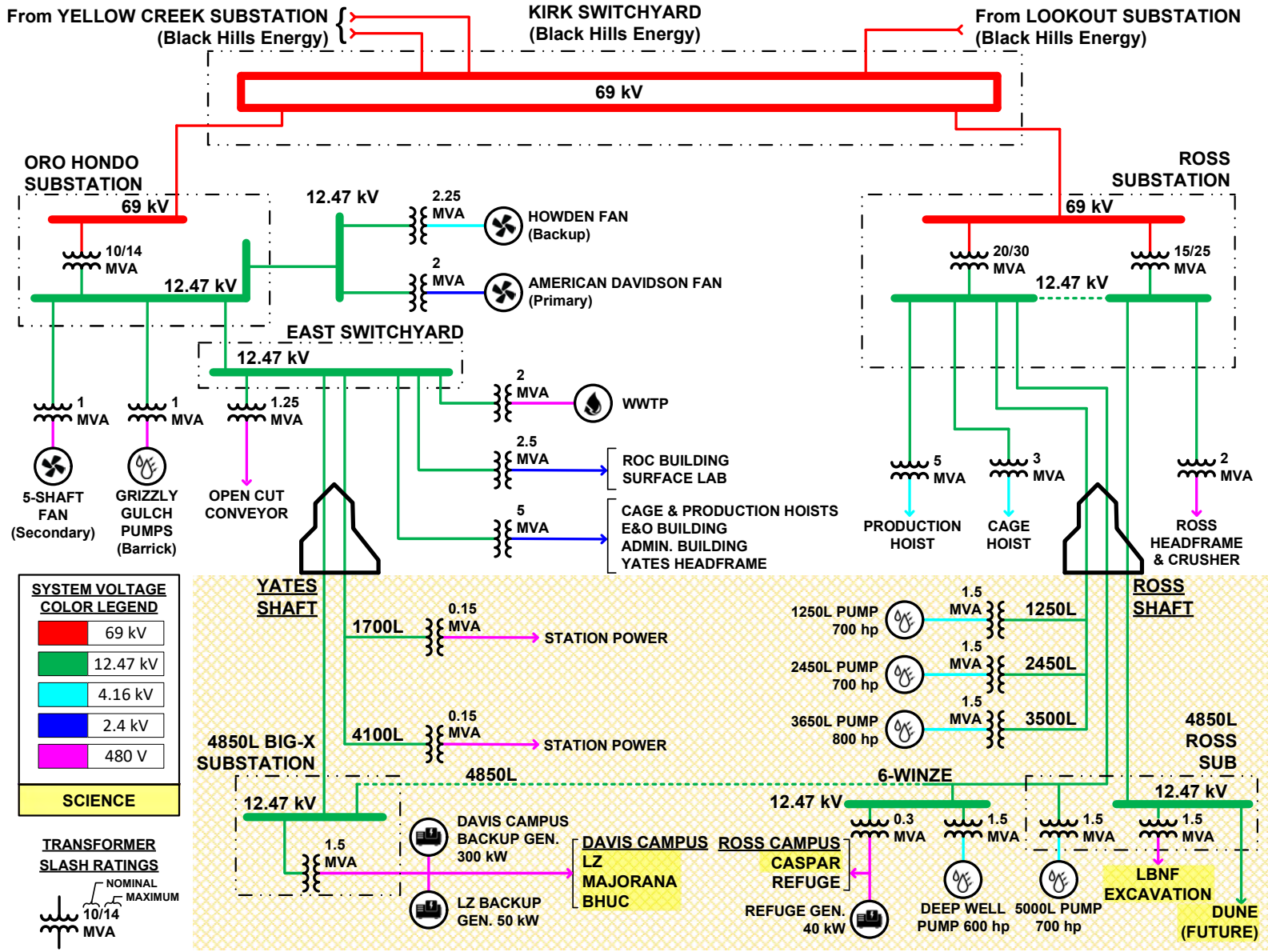
Current SDSTA + LBNF	Total Capacity	Available Capacity
Electrical Power [kW]	24,000	20,000
Standby Power [kW]	390	80

Future (FY27) SDSTA + LBNF	Total Capacity	Available Capacity
Electrical Power [kW]	24,000	15,000

LBNF/DUNE Operations = ~6 MW

(4 detectors)

- Nitrogen generators ~3 MW
- Chillers/cooling ~1.6 MW
- Detector power ~1.4 MW



The Institute for Underground Science at SURF

Goal: The Institute for Underground Science at SURF constructed by Sep 2035

World-leading center for

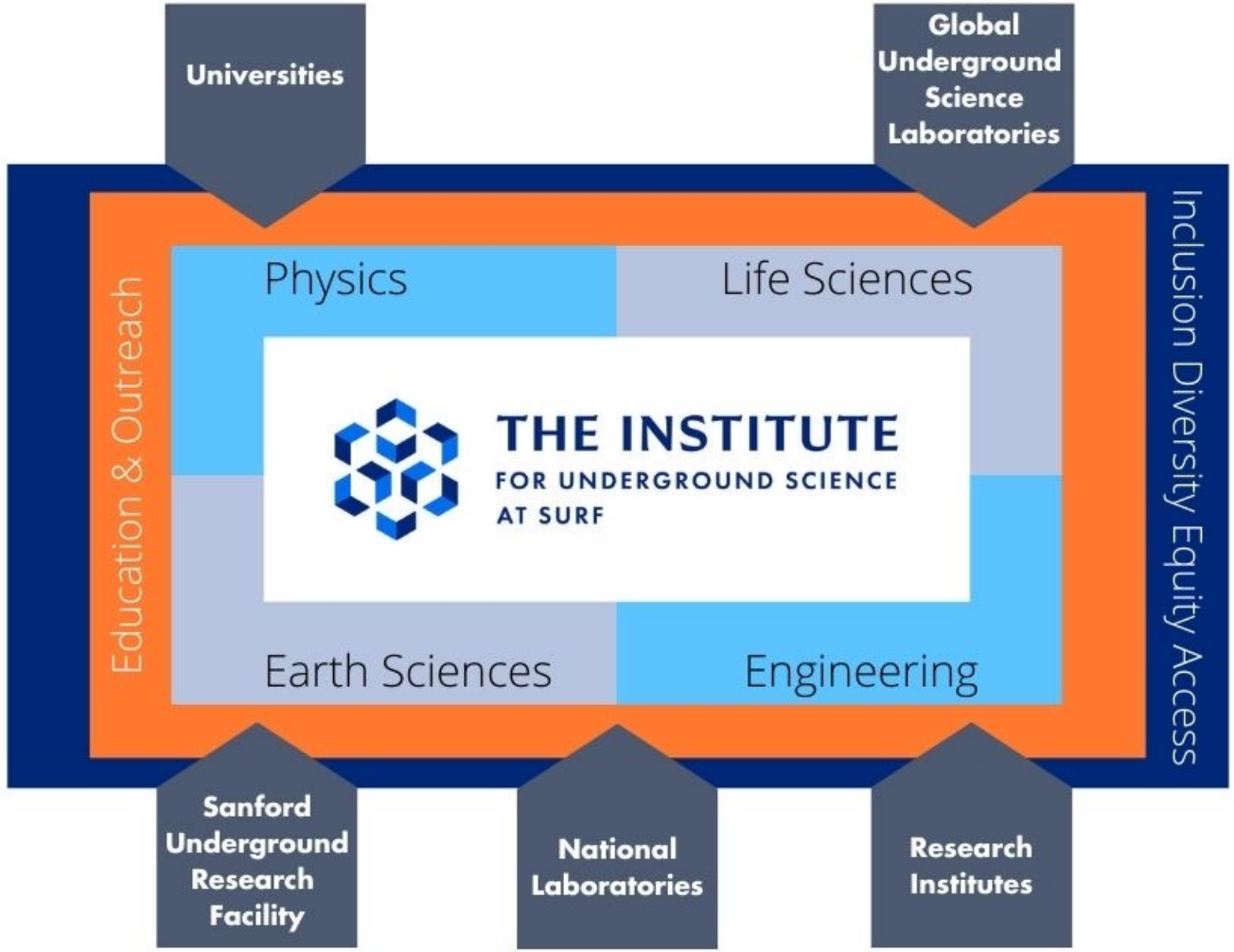
- **Underground science collaboration and intellectual community**
- **K-12 and public education & outreach programs**

THE INSTITUTE
FOR UNDERGROUND SCIENCE
AT SURF

Institute for Underground Science at SURF

Activities since June 2023, formally launched December 2023

- World-leading center for underground science collaboration and intellectual community.
- Leadership in long-term science community planning.
- Global community for vision and leadership in multidisciplinary research.
- “Hub” for information on global underground science.
- Close collaboration and integration with the science and outreach programs.
- World leadership in K-12 and public education and outreach programs.



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Institute for Underground Science at SURF

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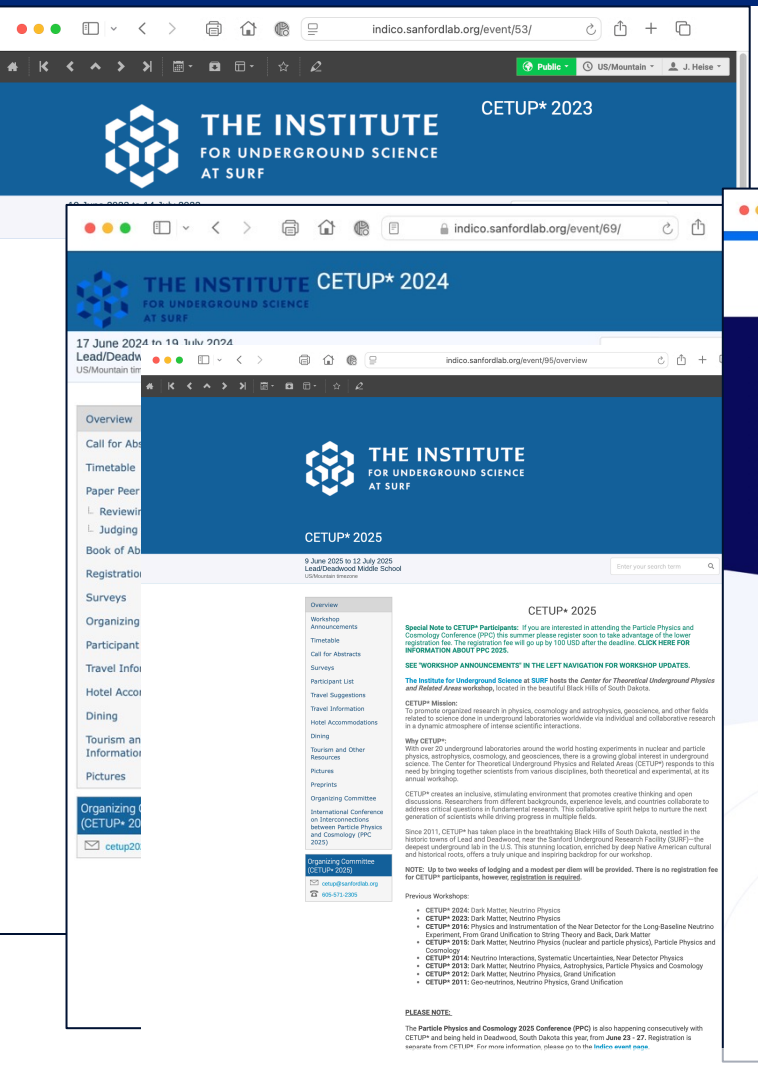
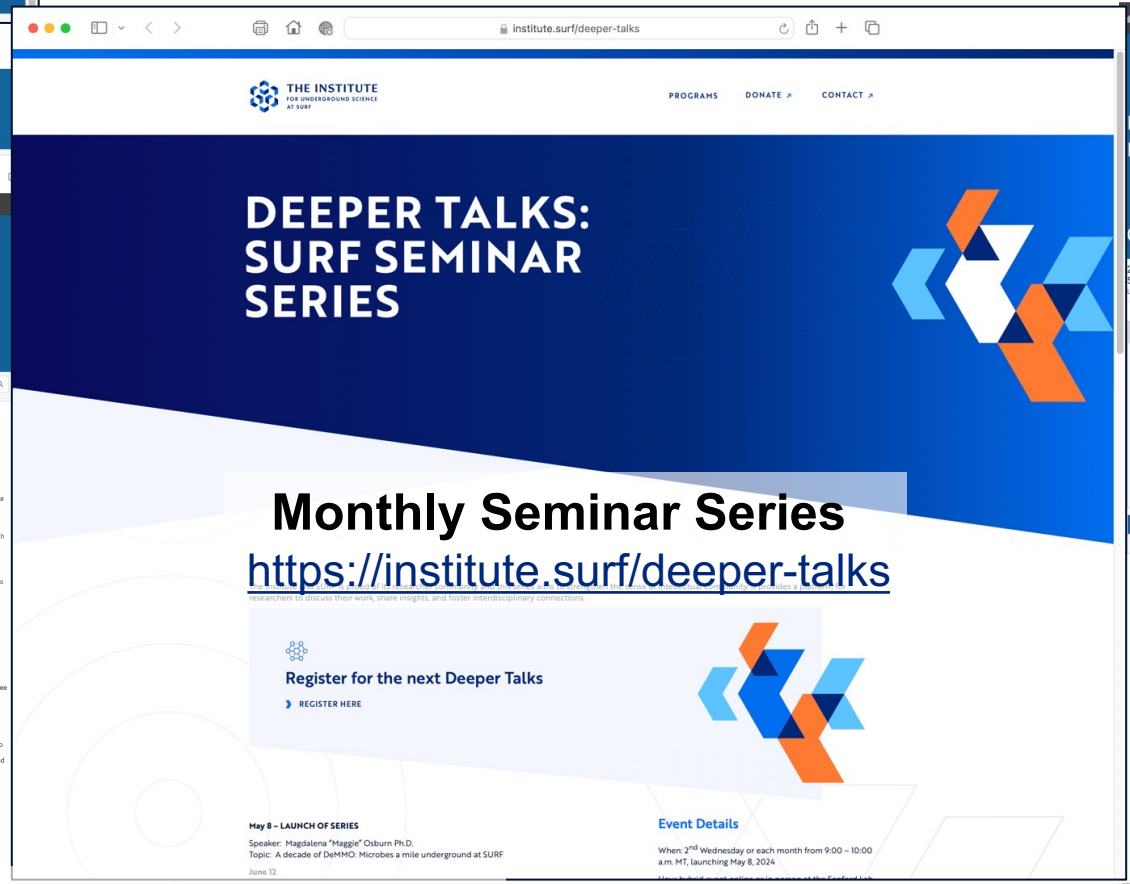
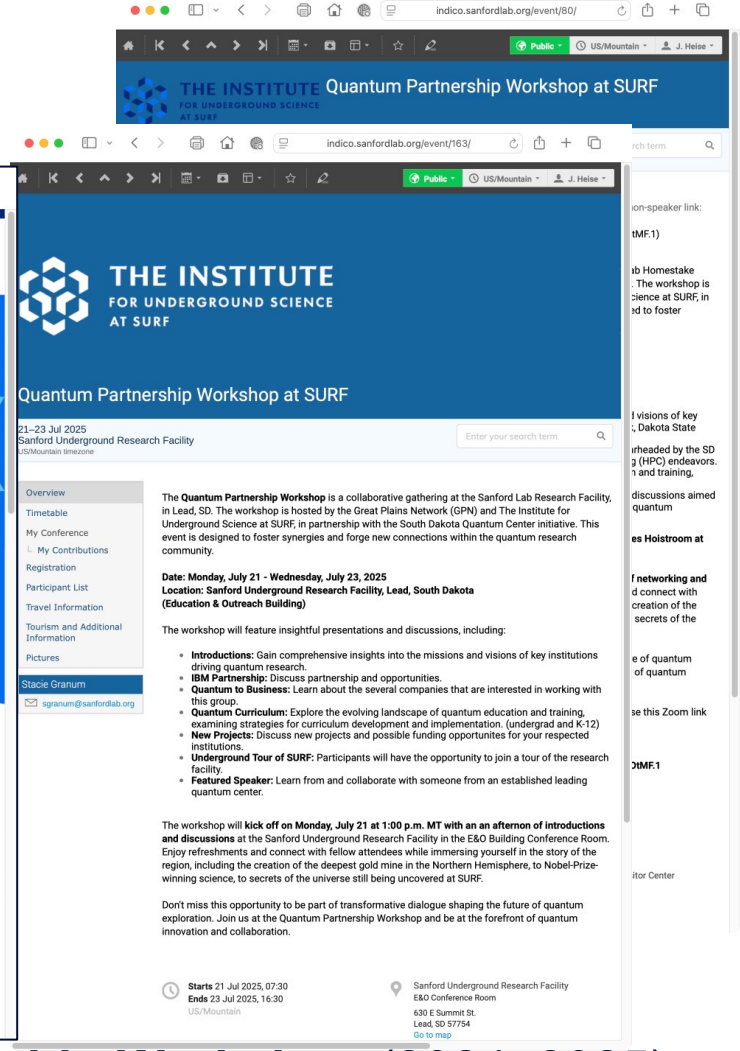




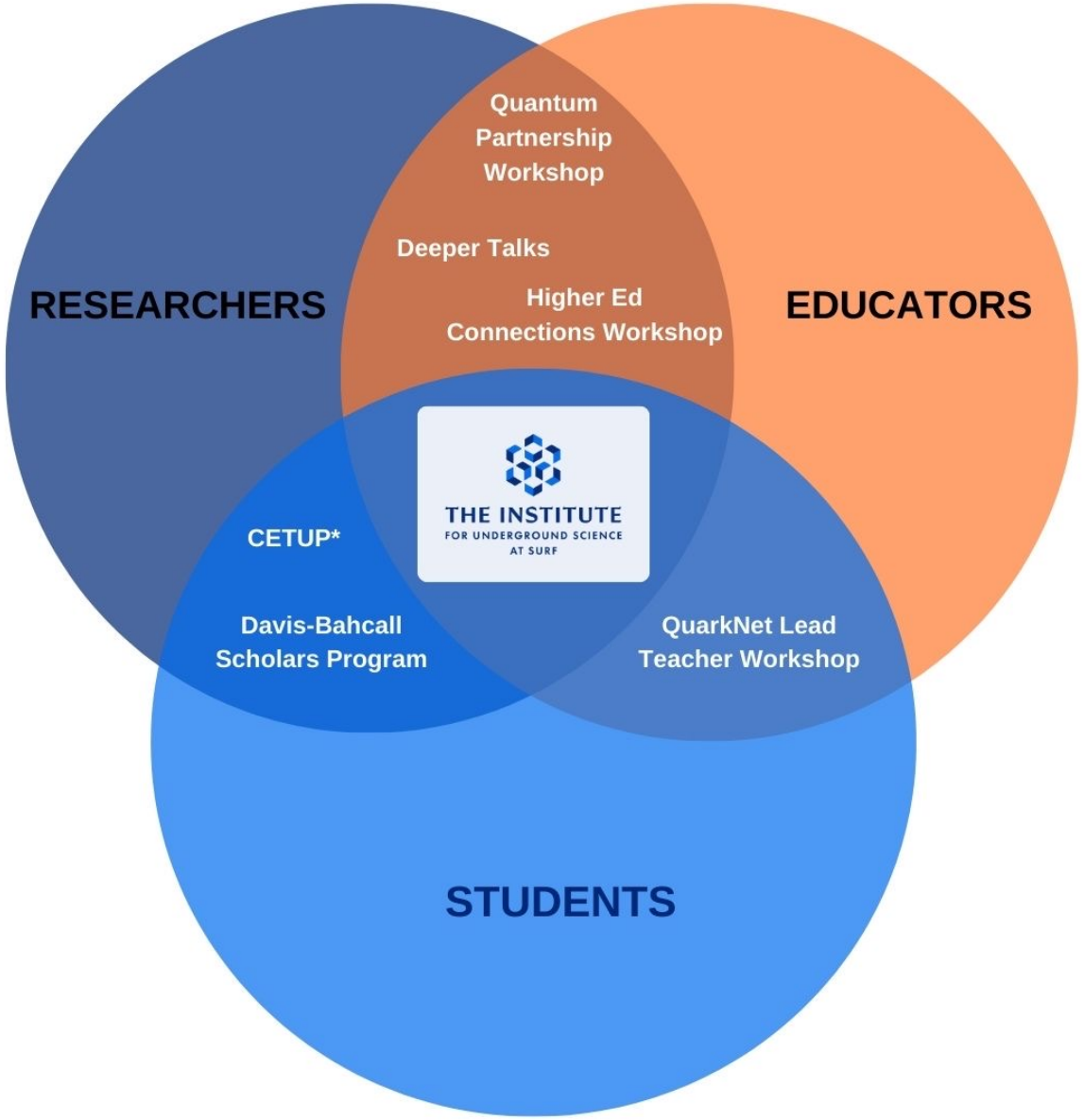


CETUP* (2023, 2024, 2025)
https://indico.sanfordlab.org/e/CETUP2023 / 2024 / 2025

Quantum Partnership Workshop (2024, 2025)
https://indico.sanfordlab.org/e/QPW2024 / QPW2025

Institute for Underground Science at SURF

Activities since June 2023, formally launched December 2023



6 Programs

360+ Participants

24 Countries

SURF Science & Education Opportunities

SURF Programs

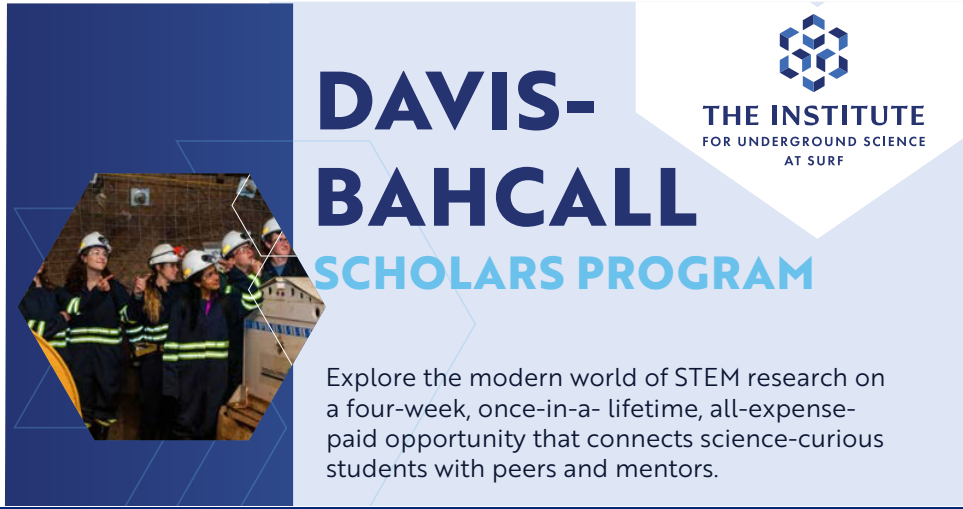
- **Summer Internships** (Bozied/Bauer/Headley)
  - Science, engineering, operations, environmental science and communications, incl underrepresented groups https://sanfordlab.org/internships
- **Davis-Bahcall Scholars Program**
  - Multidisciplinary studies at U.S. & European labs/industries https://sanfordlab.org/dbs

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:** SD Mines, BHSU, RESPEC; also USD, SDSU, DSU



SURF Education and Outreach Efforts

Presentations and Field Trips	Curriculum Units and Resources	Career Exploration and Development	Supporting Teachers
• K12 presentations • Face-to-face • Virtual options • Field trips	• 17 unique curriculum units available for checkout • 5-15 hours of fully designed and resourced science curriculum	• Davis-Bahcall Scholars Program • Summer internship opportunities • Pre-service educator program support	• 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	1,437
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	1,689
Total Student Contacts	8,112	5,745	19,709	17,921	16,580	22,009

*Includes data from June 1, 2024 through May 30, 2025

Provide professional development and support to **more than 400** educators during the school year.

Sanford Lab Homestake Visitor Center

Acquired January 2022. Greatly expands public outreach opportunities.

Sanford Lab Homestake Visitor Center (SLHVC)

Building Meaningful Relationships with Diverse Audiences

Diverse 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 Čhaŋgléška Wakȟáŋ

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
Visitors	57,317	58,136
States	*50*	*50*
Countries	*33*	*42*
Buses	139	137
Events	121	124

Čhaŋgléška Wakȟáŋ, the Ethnobotanical Garden at SURF

Public tours started summer 2024, expect 2-3 years for native plant growth

Volunteer for Neutrino Day!

neutrino day

WHERE SCIENCE & FUN **COLLIDE**

SATURDAY, JULY 12
9AM-4PM

Join us for a day of science fun! Sign up to volunteer using the link here:

SCAN HERE TO VOLUNTEER

neutrinoday.com/volunteer/signup

Jaret Heise – Science Director

- **16 years** SDSTA Science Director
- **21 years** science management experience
- **28 years** experience in underground science

  Participation in Sudbury Neutrino Observatory (SNO) experiment (6800-ft level of active nickel mine, now SNOLAB), which resolved Solar Neutrino Problem first posed by Ray Davis Homestake Chlorine Experiment
  - **University of British Columbia** PhD Student at SNO (detector construction, supernova neutrino search)
  - **Los Alamos National Lab** Postdoctoral Researcher at SNO (led neutron detector installation)
  - **Queen's University** SNO Detector Operations Manager (member of onsite management team)