



**SANFORD  
UNDERGROUND  
RESEARCH  
FACILITY**

# The Sanford Underground Research Facility

**Jaret Heise, Science Director**

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**CETUP\***

**July 18, 2024**



# Jaret Heise – Science Director

- **15 years** SDSTA Science Director
- **20 years** science management experience
- **27 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

- Univ BC PhD Student at SNO  
(detector construction, supernova neutrino search)
- LANL Postdoctoral Researcher at SNO  
(led neutron detector installation)
- Queen's Univ SNO Detector Operations Manager  
(member of onsite management team)





# Sanford Underground Research Facility



## **SURF Mission:**

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

## **SURF Vision:**

The worlds 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

## Where in the world is SURF?

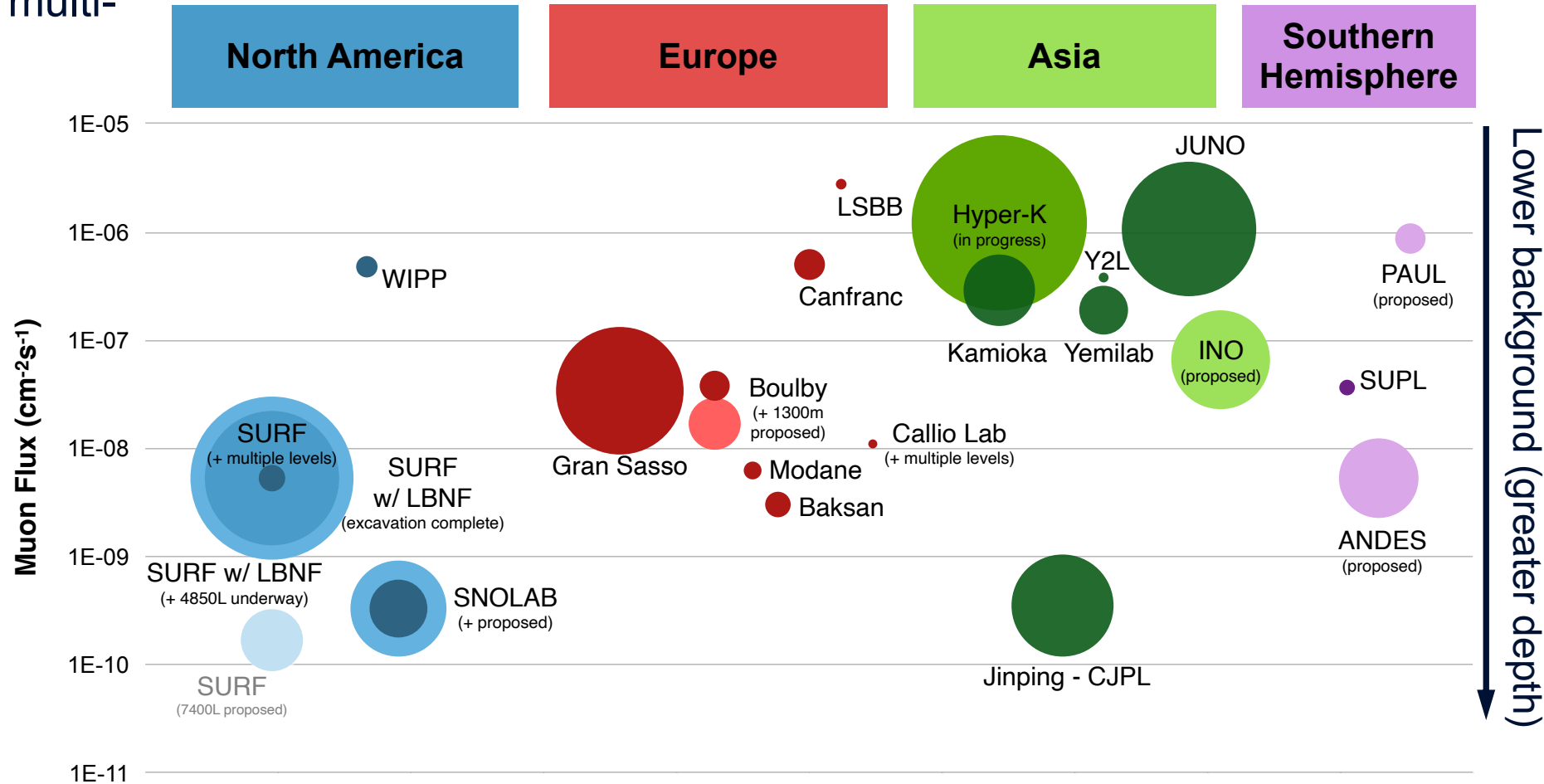




# SURF in the Global Context

## SURF can provide:

- Unique environments for multi-disciplinary research
  - Overburden protection from cosmic-ray muons
- Local radiation shielding
- Assay capabilities
- Material production/purification
- Environmental control
- Implementation and operations support
- Community catalyst



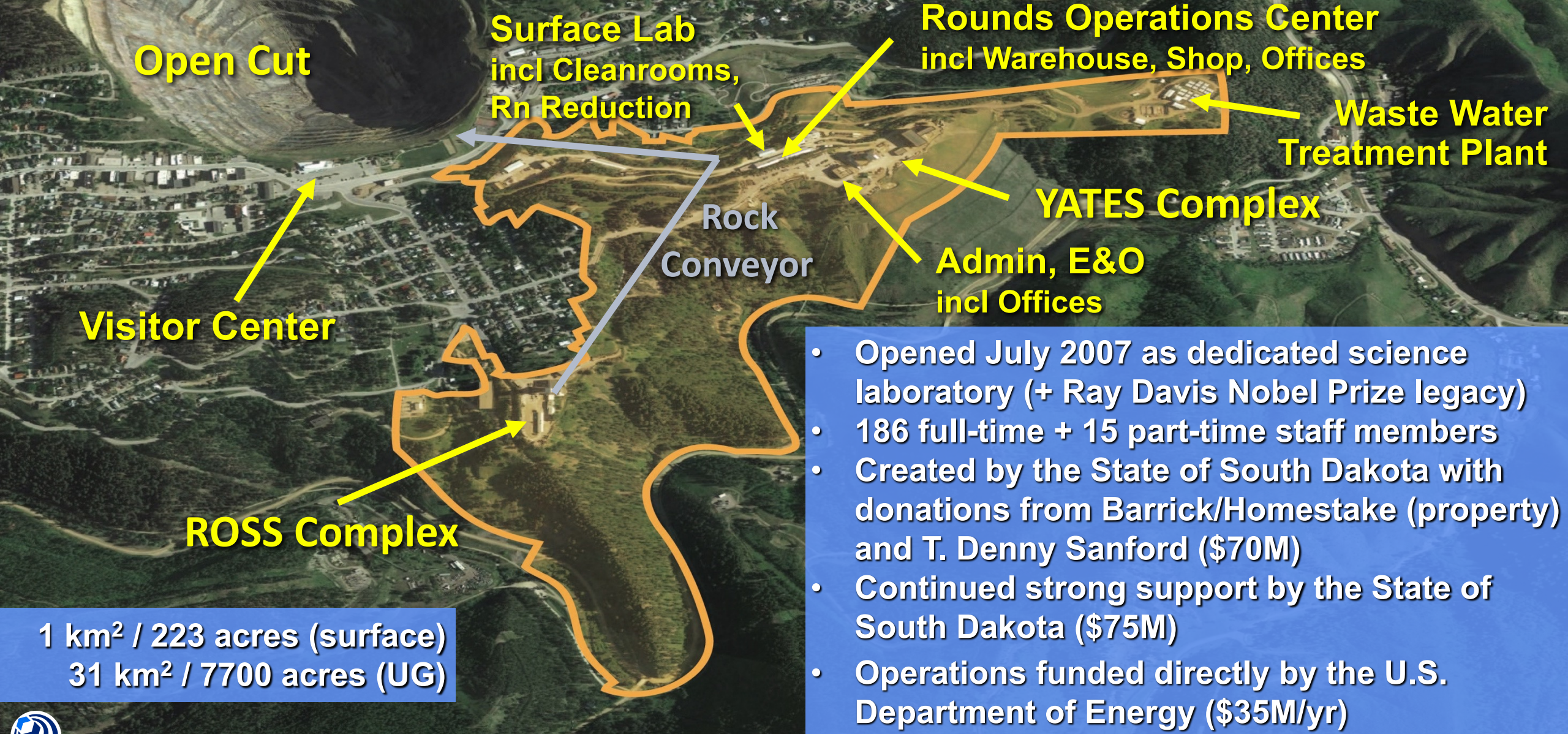
Note: Circles represent volume of science space





# Sanford Underground Research Facility

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



1 km<sup>2</sup> / 223 acres (surface)  
31 km<sup>2</sup> / 7700 acres (UG)

- Opened July 2007 as dedicated science laboratory (+ Ray Davis Nobel Prize legacy)
- 186 full-time + 15 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)





# Sanford Underground Research Facility

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



Ross Shaft

Yates Shaft



Administration Bldg



Rounds Operations Center

Surface Lab + RRS



Yates Hoistroom





# Čanĝléška Wakhán, the Ethnobotanical Garden at SURF

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





# 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:  
11 Depts + 3 offices

**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...

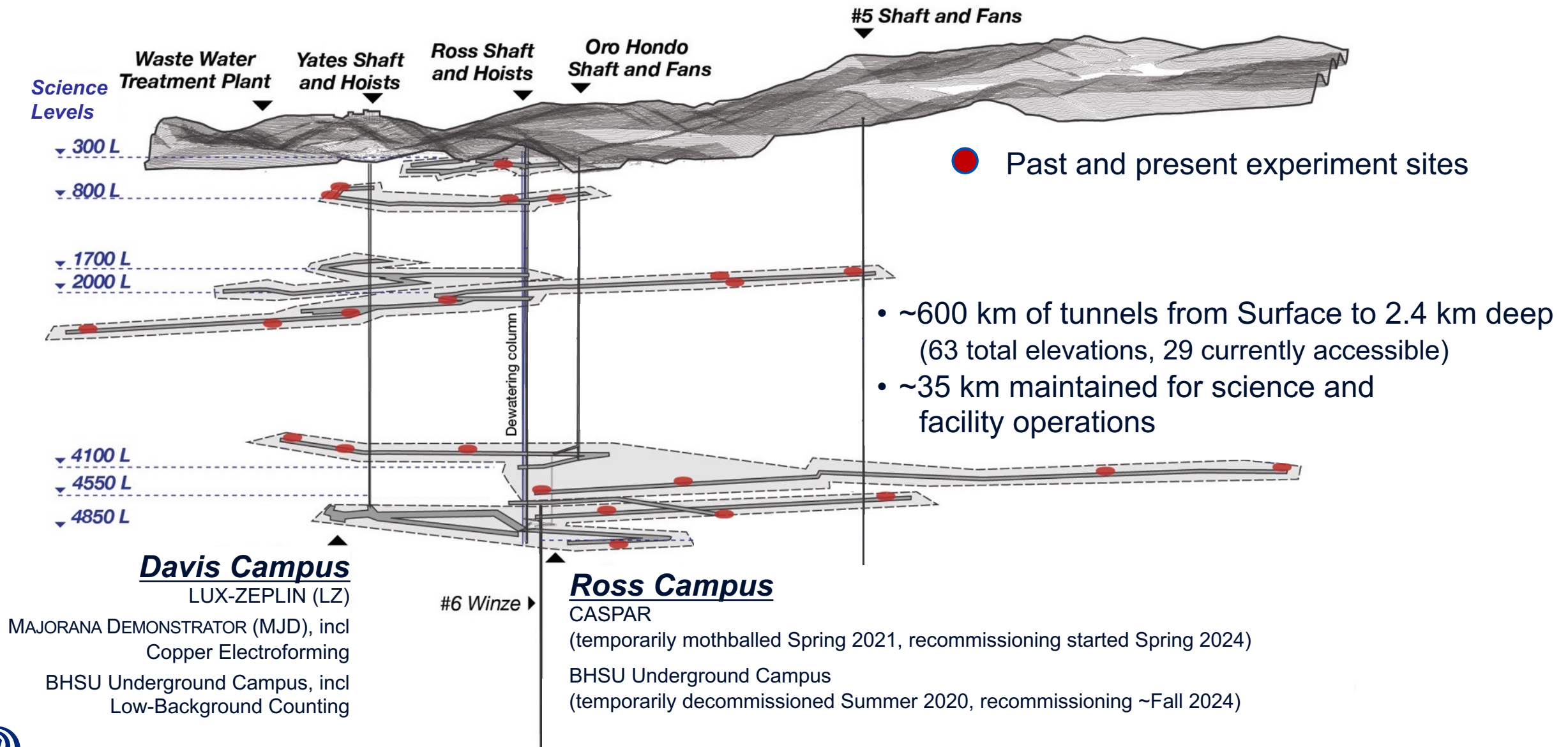
**Christopher Kreitzinger**  
*Support Associate*  
- Admin, User Association





# SURF Underground Lab Geography

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





# SURF 4850L Davis Campus

## Examples of laboratory space



### Detector Room (MJD):

Area = 140 m<sup>2</sup>, 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<sup>2</sup>, 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







**Dark Matter**  
LUX-ZEPLIN



**Neutrinos**  
MAJORANA DEMONSTRATOR  
LBNF/DUNE

**Science Program**  
30 Expts with 2268 Collaborators,  
301 Institutions in 40+ Countries



**Biology**  
Extreme Life  
Astrobiology



**Geology & Engineering**  
Geothermal Energy  
Mining Technologies





# 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:** 184 members, 35 institutions, lead = LBNL [DOE HEP].
- **Status:**
  - Onsite since Jul 2017 (as LUX since Nov 2009).
  - Production data started Dec 2021. First WIMP-search results announced Jul 2022, published Jul 2023: [10.1103/PhysRevLett.131.041002](https://arxiv.org/abs/10.1103/PhysRevLett.131.041002) (world-leading).
  - WIMP-search data taking continuing with run #3 started.
- **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.

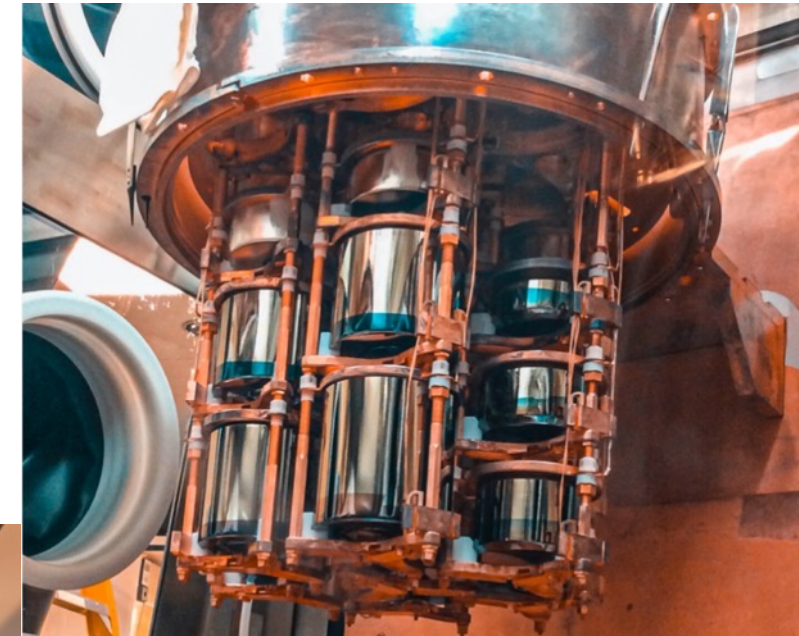




# MAJORANA DEMONSTRATOR (MJD)

## Also Large Enriched Ge Experiment for Neutrinoless $\beta\beta$ Decay (LEGEND)

- **Science Goal:** Neutrinoless double-beta decay using 44 kg Ge in two cryostats, 30 kg enriched  $^{76}\text{Ge}$  inside compact shield (poly + Pb + Cu); also LEGEND R&D and more recently rare decays ( $^{180\text{m}}\text{Ta}$ ).
- **Collaboration:** 62 members, 20 institutions, lead = ORNL [DOE NP].
- **Status:**
  - Onsite at SURF since Nov 2010.
  - Achieved 65 kg-yr exposure (2015-2021), final  $0\nu\beta\beta$  result published Feb 2023: [10.1103/PhysRevLett.130.062501](https://arxiv.org/abs/10.1103/PhysRevLett.130.062501).
  - Ta-180m rare decay search underway, first results published Oct 2023: [10.1103/PhysRevLett.131.152501](https://arxiv.org/abs/10.1103/PhysRevLett.131.152501).
  - Four Cu electroforming baths operating at Davis Campus.
- **Future:**
  - Ta-180m data taking nominally ends in Fall 2024.
  - More discussions needed for decommissioning.
  - Cu e-forming to continue, may expand to ~7-10 baths for LEGEND (and UG science community).
  - Ton-scale: 1 North America + 1 Europe. CD-1 in fall 2024 for LEGEND-1000 and nEXO. No SURF space in 2020s. “Multi-ton-scale” expt at SURF in late-2030s?

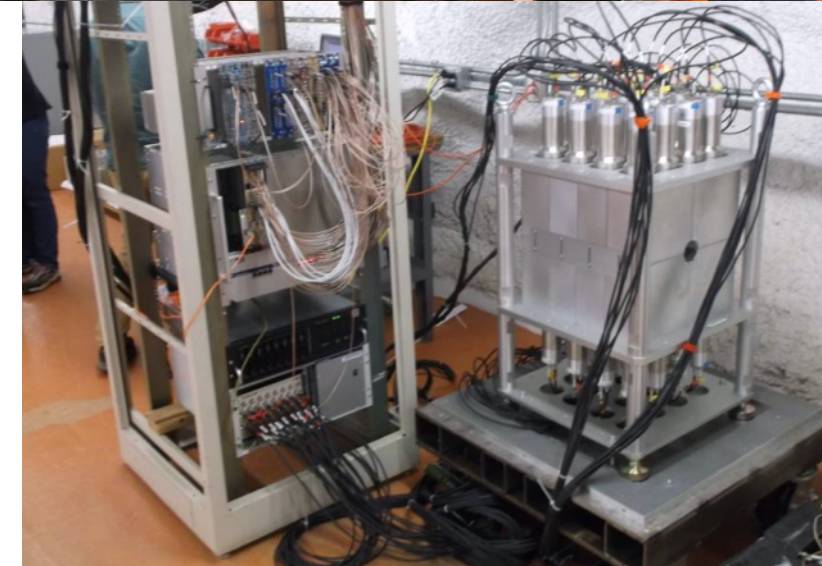




# CASPAR

## Compact Accelerator System for Performing Astrophysical Research

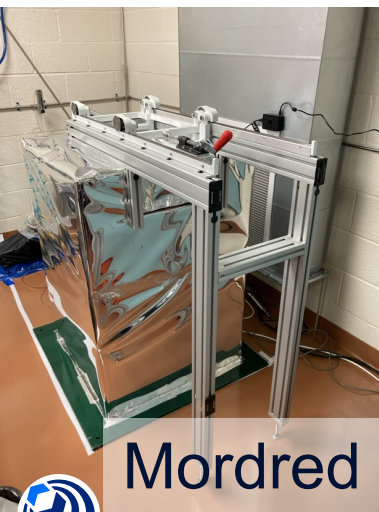
- **Science Goal:** Study of stellar nuclear fusion reactions, esp. neutron production for slow neutron-capture nucleosynthesis using 1-MV electrostatic accelerator for protons or alpha particles.
- **Collaboration:** 26 members, 2 institutions, lead = SD Mines [NSF MPS/PHY].
- **Status:**
  - Onsite at SURF since mid-2015, beam since 2017.
  - Data collected 2017-2021 with targets:  ${}^7\text{Li}$ ,  ${}^{11}\text{B}$ ,  ${}^{14}\text{N}$ ,  ${}^{18}\text{O}$ ,  ${}^{20}\text{Ne}$ ,  ${}^{22}\text{Ne}$  (gas, solid),  ${}^{27}\text{Al}$ .
  - Bkgd characterization, incl liquid scintillator neutron detectors (ORNL),  ${}^3\text{He}$  and NaI arrays (Notre Dame).
  - Laboratory mothballed Apr 2021 due to LBNF construction.
  - 5 scientific papers, incl PRL: [10.1103/PhysRevLett.128.162701](https://doi.org/10.1103/PhysRevLett.128.162701).
- **Future:**
  - 4 more papers planned. Also: 4 students graduated, 2 in queue.
  - Next phase of operation starting FY24 (4850L Ross Campus lab), targets incl Li (JWST data) and  ${}^{14}\text{N}$  (CNO solar neutrinos).
  - NSF funding expected in 2024 (resume ops w/ existing UND funds).



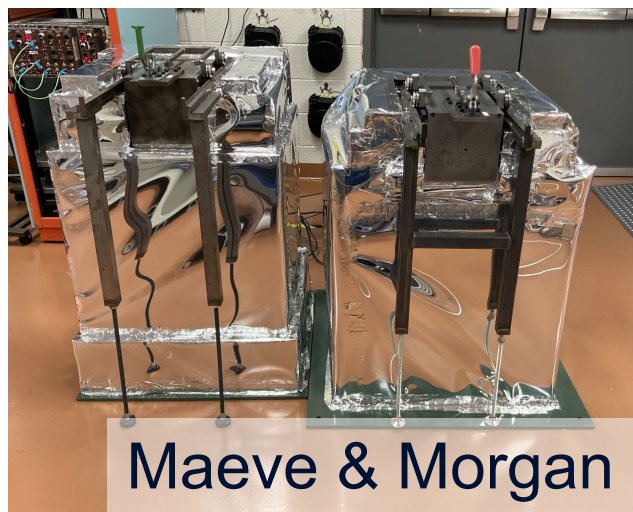


# SURF Material Assay at BHUC: Davis Campus

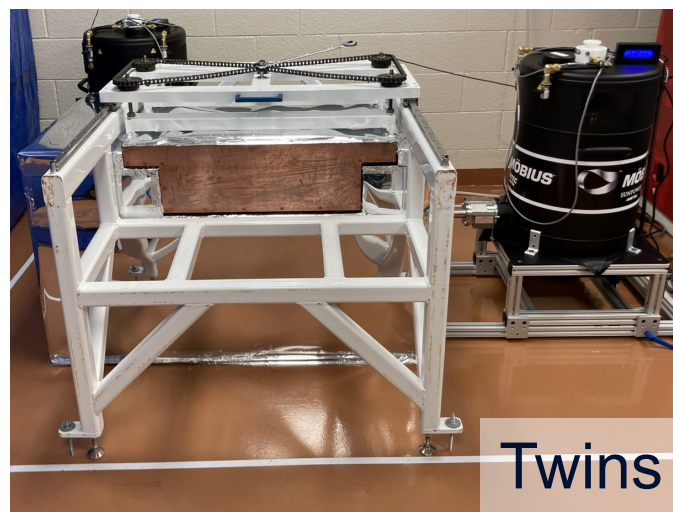
Low-background counting capabilities serving national & international community



Mordred



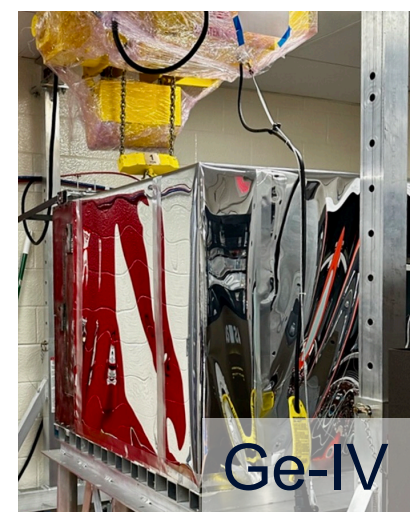
Maeve & Morgan



Twins



RHYM/RESN



Ge-IV

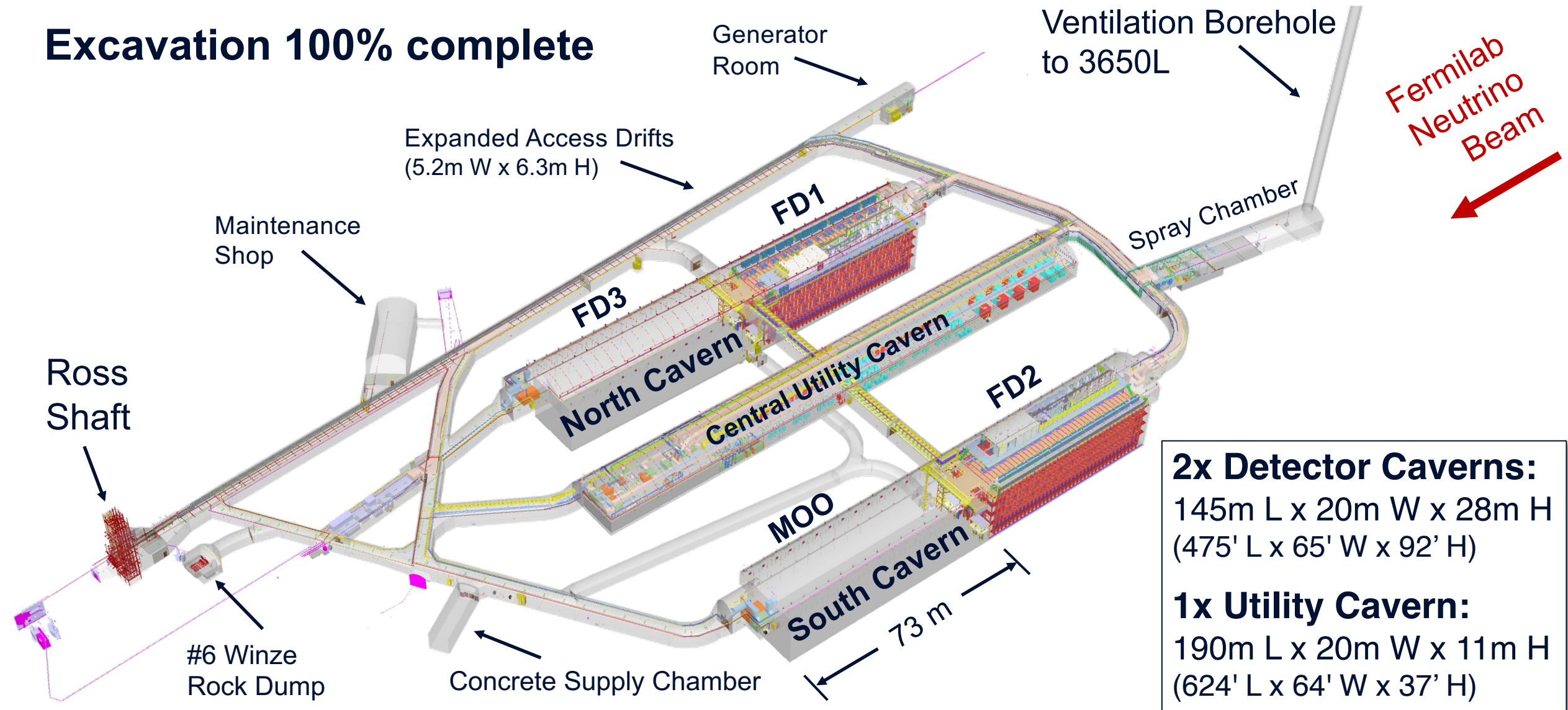




# Long-Baseline Neutrino Facility (LBNF)

LBNF will host the Deep Underground Neutrino Experiment (DUNE)

**Excavation 100% complete**





# LBNF North Cavern





# SURF User Association

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

## Purpose

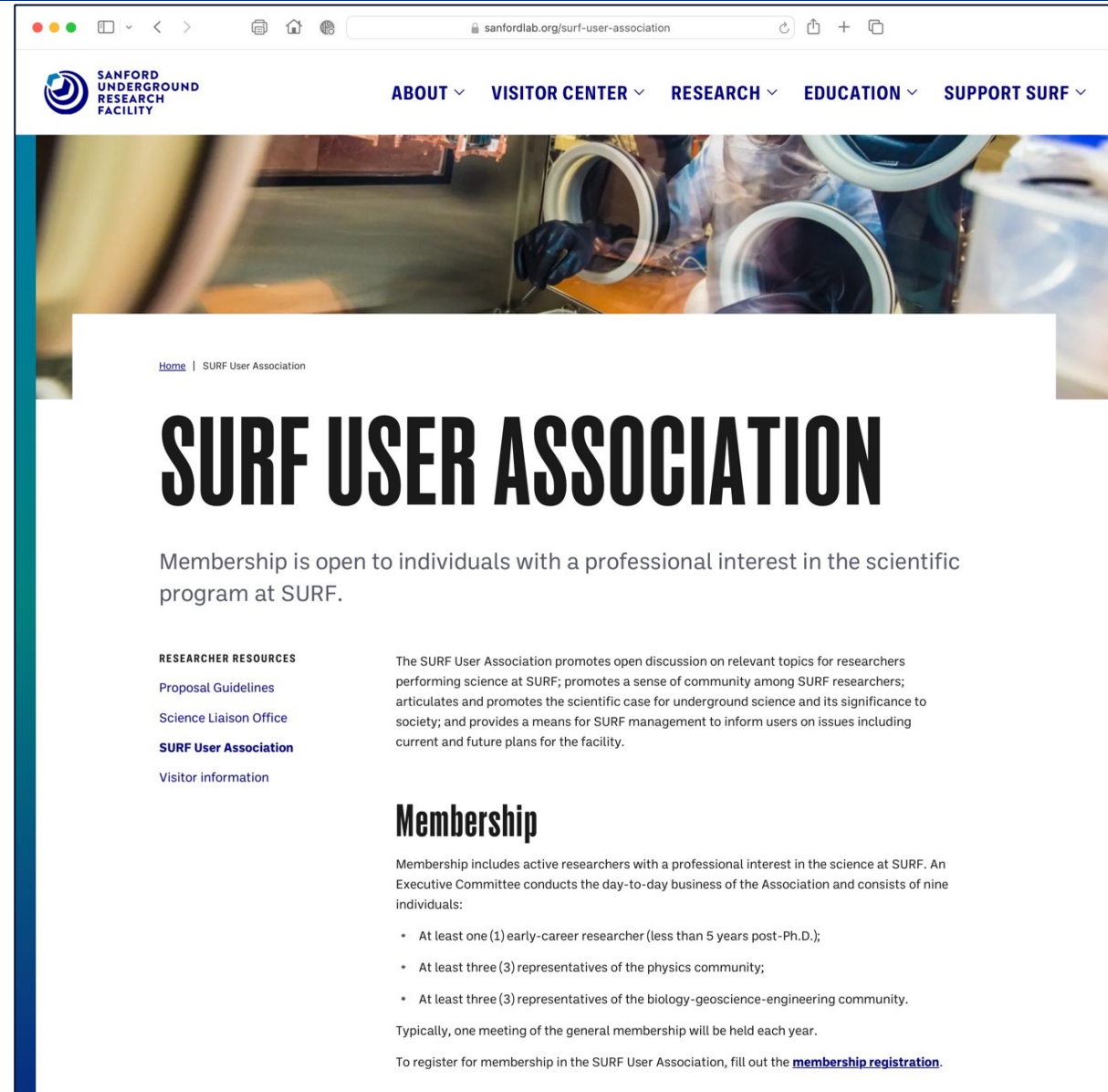
- **Two-way communication** on topics important to researchers.
- Promotes a **sense of community** amongst SURF experiments and researchers.
- Articulates and promotes **scientific case for UG science** and significance to society, provides channel for **advocacy**.

## 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, session held at recent CoSSURF (May 2024).
- **Topical workshops**, incl community planning (e.g., Vision Workshop 2021). Next workshops 2024/2025.



Home | SURF User Association

# SURF USER ASSOCIATION

Membership is open to individuals with a professional interest in the scientific program at SURF.

**RESEARCHER RESOURCES**

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

The SURF User Association promotes open discussion on relevant topics for researchers performing science at SURF; promotes a sense of community among SURF researchers; articulates and promotes the scientific case for underground science and its significance to society; and provides a means for SURF management to inform users on issues including current and future plans for the facility.

## Membership

Membership includes active researchers with a professional interest in the science at SURF. An Executive Committee conducts the day-to-day business of the Association and consists of nine individuals:

- At least one (1) early-career researcher (less than 5 years post-Ph.D.);
- At least three (3) representatives of the physics community;
- At least three (3) representatives of the biology-geoscience-engineering community.

Typically, one meeting of the general membership will be held each year.

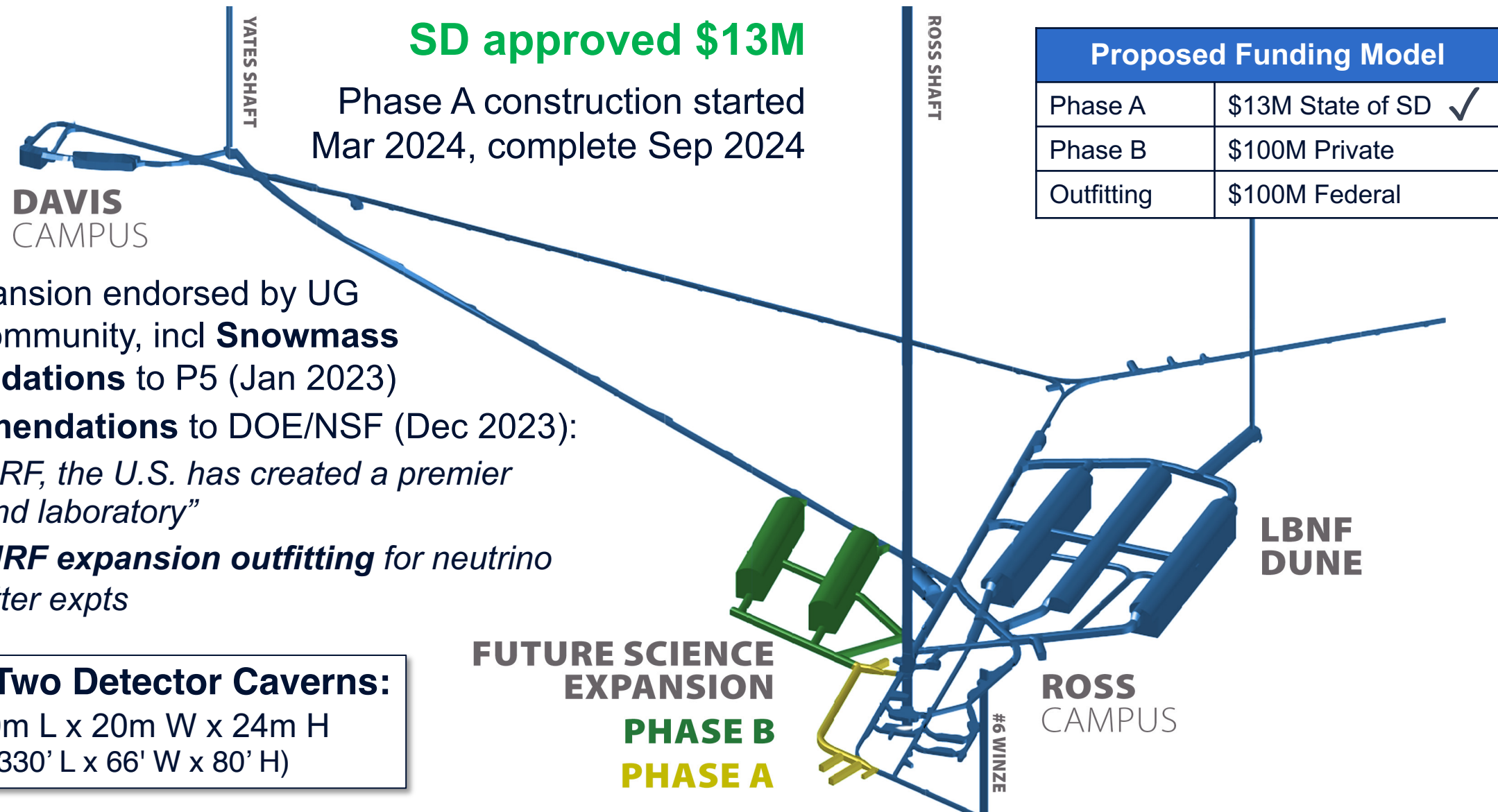
To register for membership in the SURF User Association, fill out the [membership registration](#).





# 4850L Space Needed for Future Experiments

U.S. strategic plan requires more space, community has endorsed expansion



**SD approved \$13M**

Phase A construction started  
Mar 2024, complete Sep 2024

- 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

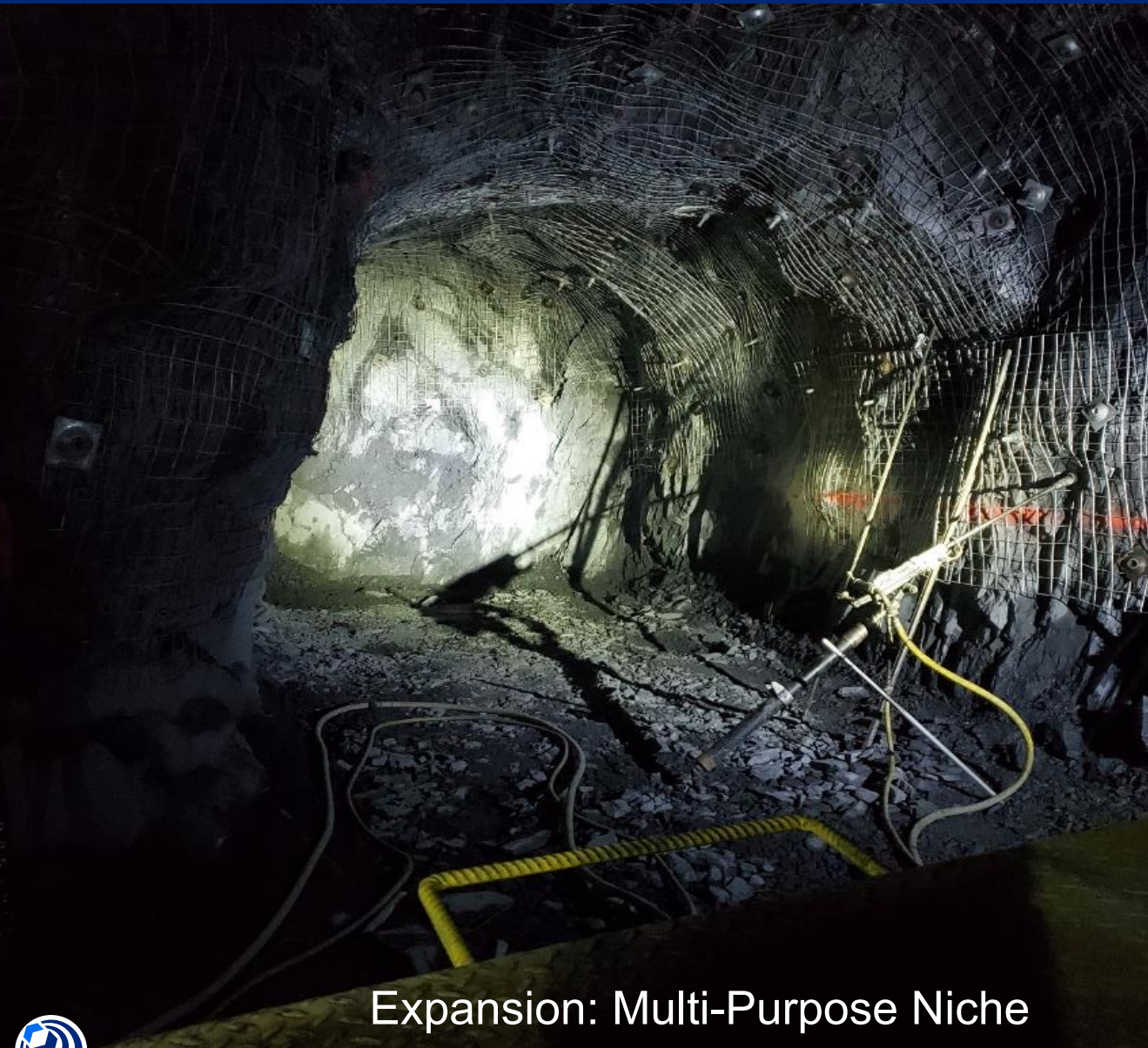
**FUTURE SCIENCE EXPANSION**  
**PHASE B**  
**PHASE A**





# 4850L Laboratory Expansion – Phase A

## Breakout Excavation Phase



Expansion: Multi-Purpose Niche



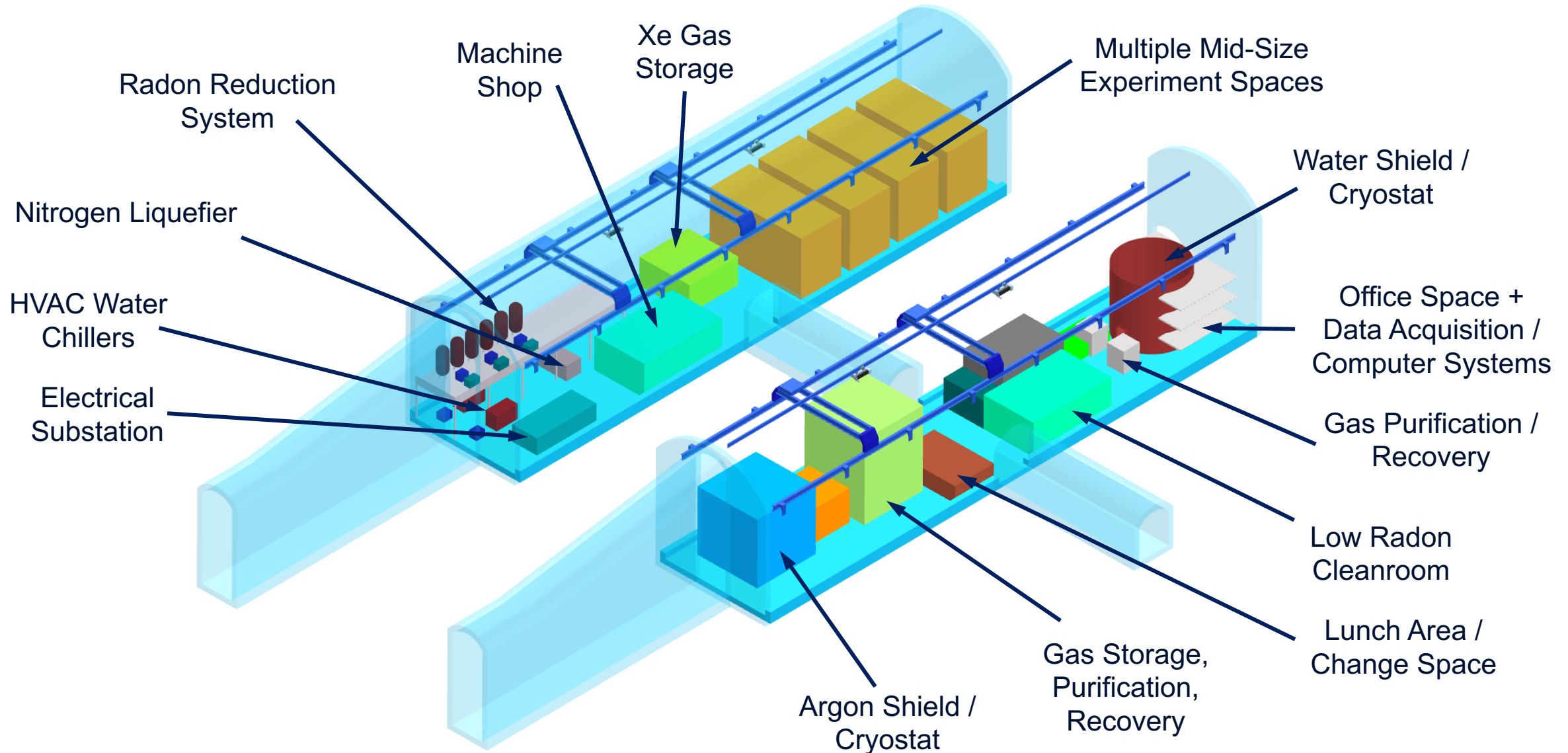
Expansion: Shop Drift





# Big Science at SURF

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





# South Dakota Support for Quantum Initiatives

## Notable state investment attracting interest, also federal congressional support

24.585.12 99th Legislative Session 45



### 2024 South Dakota Legislature Senate Bill 45 ENROLLED AN ACT

**ENTITLED An Act to make an appropriation for the establishment of a Center for Quantum Information Science and Technology and to declare an emergency.**

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF SOUTH DAKOTA:

**Section 1.** There is hereby appropriated from the general fund the sum of **\$3,034,444** to the Board of Regents, for the purpose of establishing a Center for Quantum Information Science and Technology.

## Information Science and Technology



Governor Kristi Noem signed SB 45, which funds the establishment of a Center for Quantum Information Science and Technology.

**THE INSTITUTE FOR UNDERGROUND SCIENCE AT SURF**

15-16 Jul 2024  
Sanford Lab Homestake Visitor Center  
US/Mountain timezone

Enter your search term

- Overview
- Timetable
- Registration
- Participant List
- Travel Information
- Tourism and Additional Information

**Stacie Granum**  
sgranum@sanfordlab.org

The **Quantum Partnership Workshop** is a collaborative gathering at the Sanford Lab Homestake Visitor Center, near the Sanford Underground Research Facility (SURF) in Lead, SD. The workshop is organized by the Great Plains Network (GPN) and The Institute for Underground Science at SURF, in partnership with the South Dakota Quantum Center initiative. This event is designed to foster synergies and forge new connections within the quantum research community.

**Date:** Monday, July 15 - Tuesday, July 16, 2024  
**Location:** Sanford Lab Homestake Visitor Center, Lead, South Dakota

The workshop will feature insightful presentations and discussions, including:

- Institutional Overviews:** Gain comprehensive insights into the missions and visions of key institutions driving quantum research, including SURF, Great Plains Network, Dakota State University, and SD Mines.
- Quantum Initiatives:** Delve into the latest developments and initiatives spearheaded by the SD Quantum Center, GPN Quantum Network, and High-Performance Computing (HPC) endeavors.
- Quantum Curriculum:** Explore the evolving landscape of quantum education and training, examining strategies for curriculum development and implementation.
- Brainstorming Forum on Partnerships and Next Steps:** Engage in dynamic discussions aimed at identifying collaborative opportunities and charting the course for future quantum endeavors.

Additionally, participants will have the opportunity to join a **surface tour of the Yates Hoistroom at SURF**.

The workshop will **kick off on Monday, July 15 at 4:30 p.m. MT with an evening of networking and camaraderie** at the **Sanford Lab Homestake Visitor Center**. Enjoy refreshments and connect with fellow attendees while immersing yourself in the story of the region, including the creation of the deepest gold mine in the Northern Hemisphere, to Nobel-Prize-winning science, to secrets of the universe still being uncovered at SURF.

Don't miss this opportunity to be part of transformative dialogue shaping the future of quantum exploration. Join us at the Quantum Partnership Workshop and be at the forefront of quantum innovation and collaboration.

Starts 15 Jul 2024, 16:30  
Ends 16 Jul 2024, 15:00  
US/Mountain

Sanford Lab Homestake Visitor Center  
Classroom  
160 West Main Street  
Lead, SD 57754

**Jul 15-16, 2024:**  
Quantum Partnership Workshop  
<https://indico.sanfordlab.org/event/80>

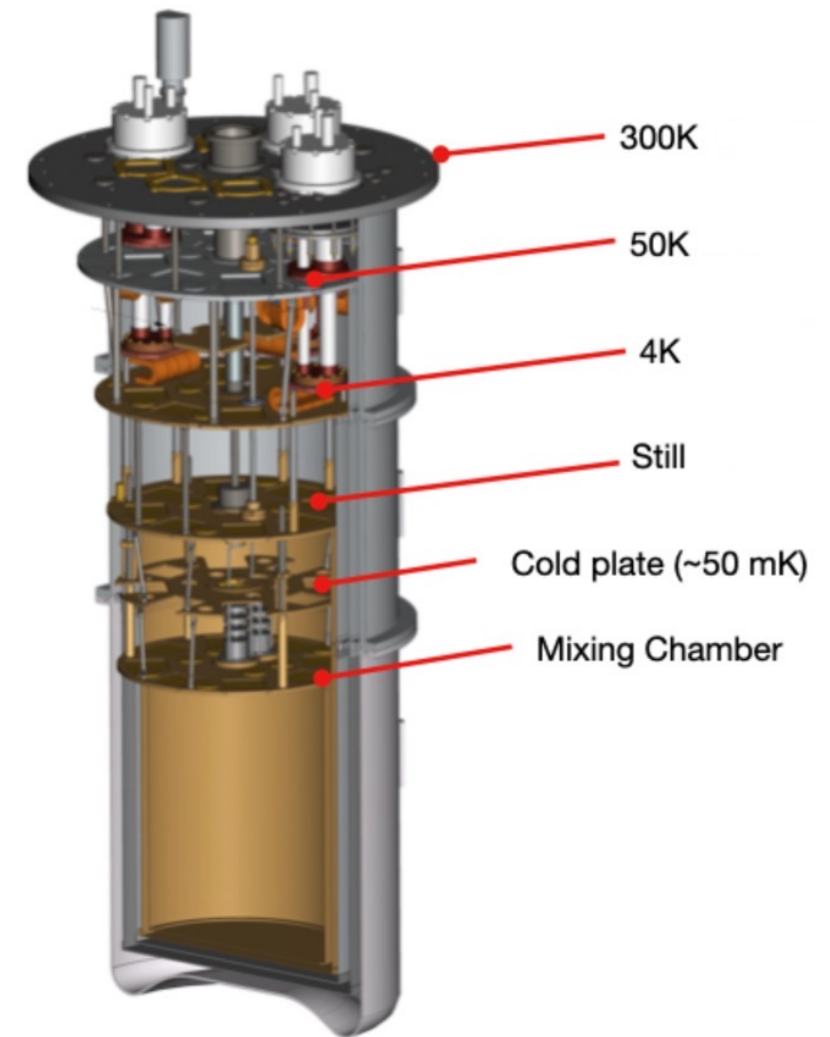




# SURF Cryogenic User Facility

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 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.

The screenshot shows the DOE Office of Science User Facilities website. The browser address bar is science.osti.gov/User-Facilities. The page features a blue navigation bar with links for Home, About, Laboratories, Science Features, Universities, User Facilities, Funding, and Initiatives. Below the navigation bar, there is a search bar and a list of programs. The main content area is titled "User Facilities" and includes a paragraph describing the facilities. Below this, there is a sidebar with links for "User Facilities at a Glance", "User Resources", "User Statistics", "Policies and Processes", "Frequently Asked Questions", and "User Facility Science Highlights". The main content area displays six featured user facilities: ASCR, BES, BER, FES, HEP, and NP, each with a "Read more" button.





# SURF Call for Letters of Interest

## Ensuring SURF used to its fullest scientific potential

### Significance of 2024 LOI Call:

- SURF's first formal call to UG science community since 2005!
- Initial calls selected strong physics anchors for Davis Campus: MJD and LUX (which led to current LZ)
- 2024 call is opportunity for SURF to advance scientific strategic plan goals, ensure strong science program continues

### Overview of 2024 LOI Call:

- Open to all disciplines: Physics, Geology, Biology, Engineering
- Identifies specific existing space on 4850L and 4100L, other undeveloped areas may be available now
- 4850L Expansion started Mar 17, 2024, space available ~2030 (nominally two detector caverns: 100 m L x 20 m W x 24 m H, LOIs and subsequent discussions will inform final design)
- LOIs reviewed by SURF Science Program Advisory Committee
- Nominal deadline May 17, 2024, **LOIs still being accepted**

**If interested, please reach out: [loi@sanfordlab.org](mailto:loi@sanfordlab.org)**



South Dakota Science and Technology Authority

630 E. Summit St. Lead, SD 57754

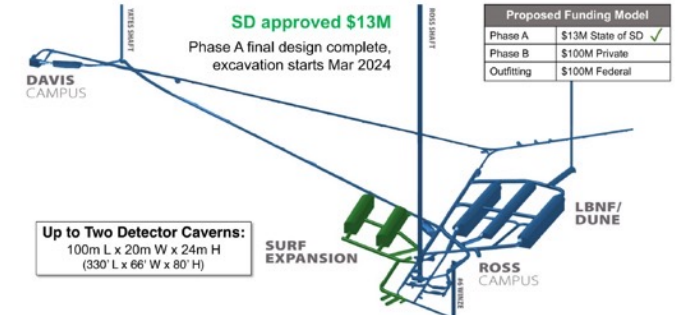
March 22, 2024

#### SURF Request for Letters of Interest 2024-01

Dear Researcher,

In support of our mission to advance world-class science, the Sanford Underground Research Facility (SURF) is seeking input from the global underground science community to ensure that scientific priorities are being accommodated and that SURF is being used to its fullest scientific potential.

SURF has a strong science program that currently comprises 29 experiment groups. Programs in some of our key 4850L laboratories are expected to complete in the next 1-4 years, which presents an opportunity to survey the community for new prospects. SURF is tremendously excited about new large laboratories that are being developed on the 4850L, with initial construction underway and space available on the timeframe of ~2030.



Leading into recent U.S. long-range planning, the SURF User Association held a Vision Workshop (<https://indico.sanfordlab.org/e/Vision2021>) and SURF participated in nuclear physics town halls and the particle physics Snowmass community input processes. As a result, SURF featured prominently in the strategic plans for both Nuclear (red) and High Energy Physics (red) communities. With the physics community long-range plans in-hand, SURF has set up a Steering Committee to distill opportunities and key elements relevant to the organization's science strategic plan (non-physics disciplines will also be addressed to inform the comprehensive strategic plan, but at a later date).

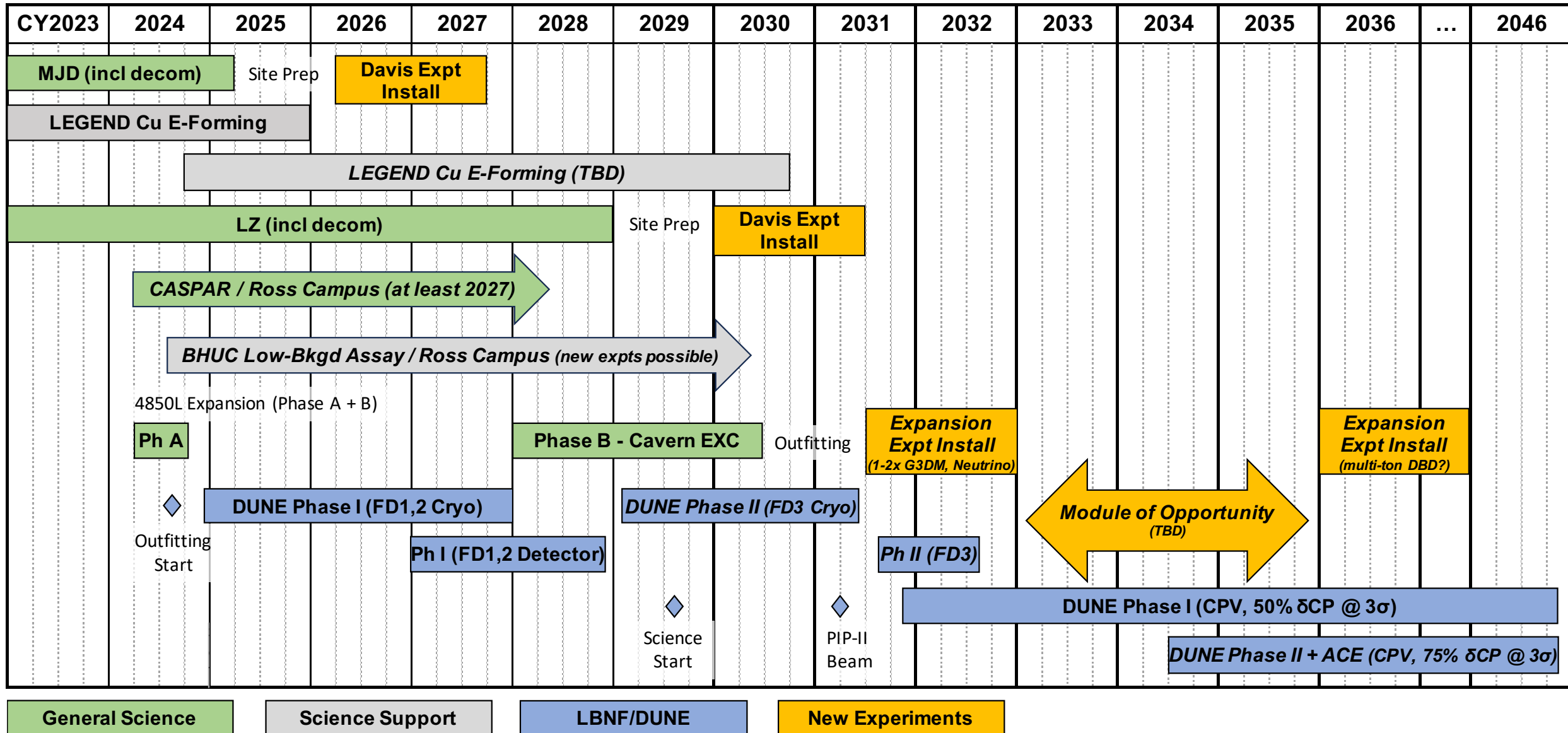
To help inform this process, we are inviting collaborations and scientists to submit short letters of interest (LOIs); maximum 3 pages. The information requested in the LOIs includes science goals, collaboration composition, facility requirements, access requirements, and timelines. Submitters are also invited to complete a SURF Experiment Planning Statement (EPS), supplemental to the LOI, that provides some additional experiment details as well as offering some SURF facility details: <https://sanfordlab.org/researchers/proposal-guidelines>.





# 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://www.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 starting 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

## 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 ( $0\nu\beta\beta$ )
- **Current:** LZ, MAJORANA DEMONSTRATOR ( $^{180\text{m}}\text{Ta}$ ), 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  $0\nu\beta\beta$  (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<sup>2</sup> (surface) with ~1600 m<sup>2</sup> storage (incl drill core) and 355 m<sup>2</sup> staging/assembly space; 31 km<sup>2</sup> (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 =  $5.31 \times 10^{-5}$  μ/m<sup>2</sup>/s (4.6 μ/m<sup>2</sup>/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<sup>2</sup> (cleanrooms = 92 m<sup>2</sup> / 914 m<sup>3</sup>)
  - 4850L (science space, as low as class 100): Davis Campus (1018 m<sup>2</sup> / 4633 m<sup>3</sup>), Ross Campus (920 m<sup>2</sup> / 3144 m<sup>3</sup>)
  - Radon-reduction: Surface = 2200x reduction @ 300 m<sup>3</sup>/h (Ateko), Davis = 700x reduction @ 150 m<sup>3</sup>/h (SD Mines)
- **Bkgds (4850L):** Radon\* = 170-570 Bq/m<sup>3</sup>, gamma = 1.9 γ/cm<sup>2</sup>/s, neutron =  $1.7 \times 10^{-2}$  n/m<sup>2</sup>/s.
  - \* Studies underway 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

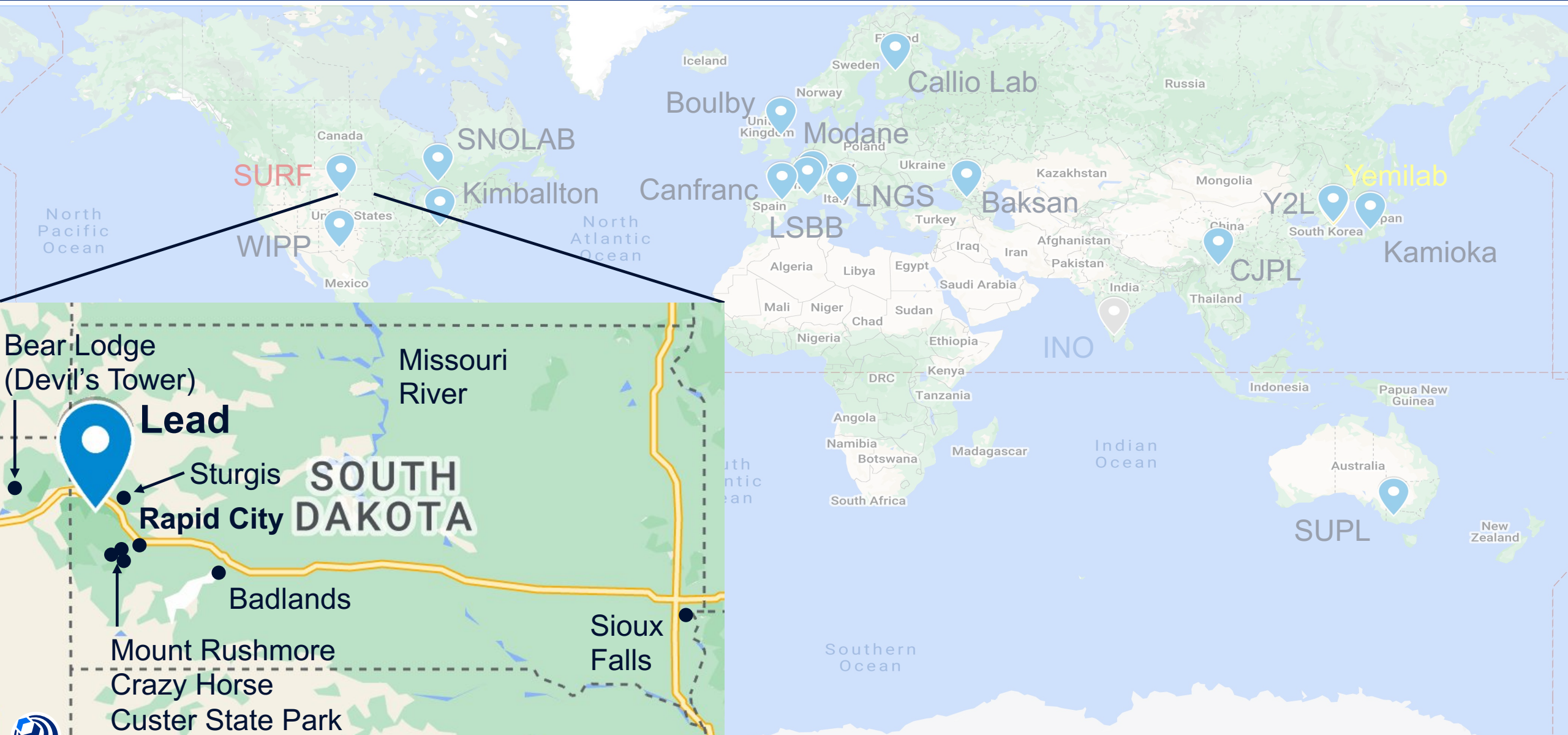
- **Unique environments for multi-disciplinary research:** SURF has attracted world-leading experiments and scientists from diverse scientific communities.
  - **Overburden protection from cosmic-ray muons:** SURF is the deepest underground lab in U.S., one of deepest laboratories in the world (1500 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 ( $\sim 10 \mu\text{Bq/kg}$  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**





# Sanford Underground Research Facility

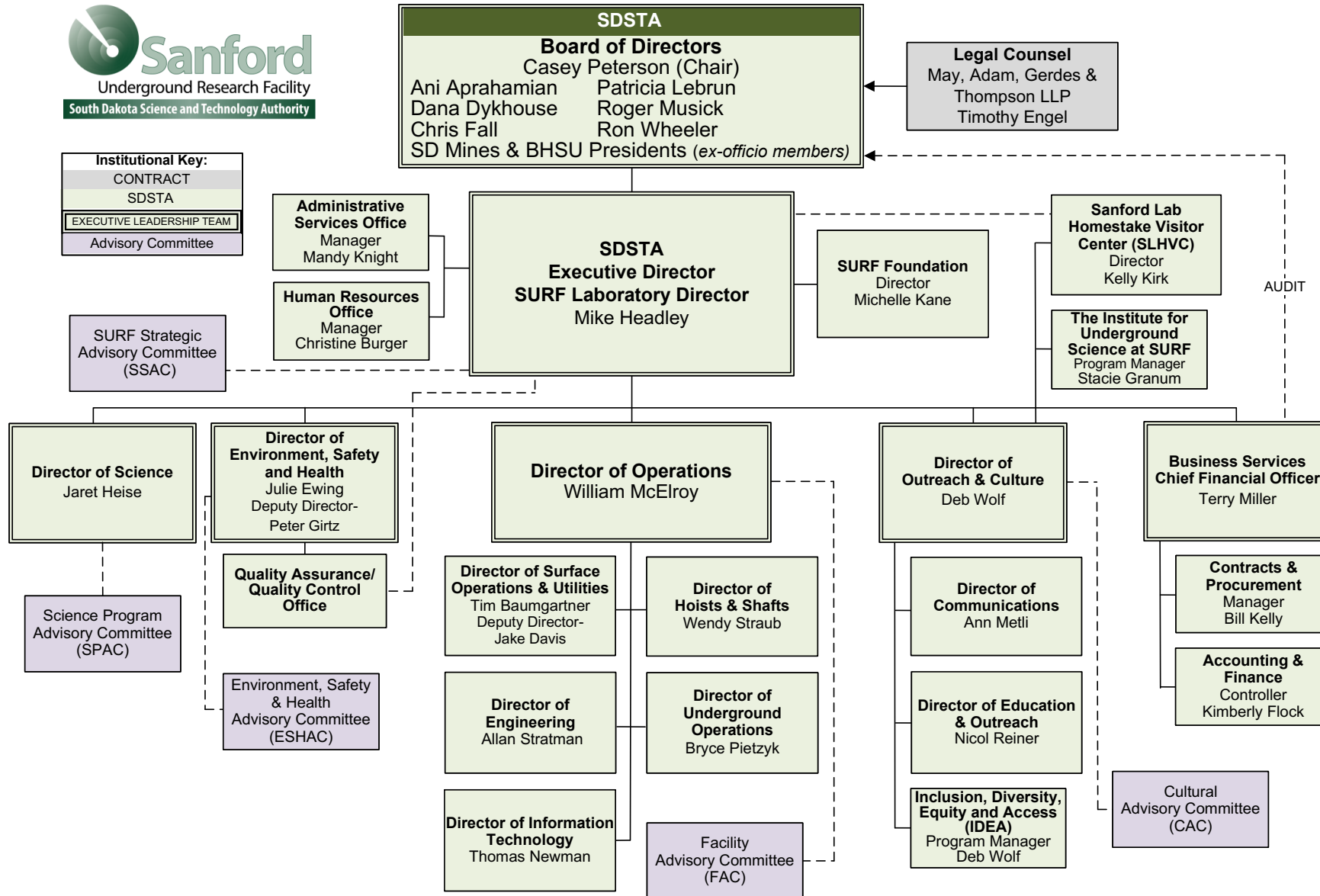
## Where in the world is SURF?





# SDSTA Organization Structure

Robust organization: 11 depts, 3 offices + Visitor Center, Institute, Foundation





# SURF User Association

<https://www.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, session held at recent CoSSURF (May 2024).
- **Topical workshops**, incl community planning (e.g., Vision Workshop 2021). Next workshops 2024/2025.

Time	Event	Location	Presenter
12:00 - 14:00	Lunch	Surbeck Center, SD Mines	
14:00 - 15:40	<b>SURF User Association Meeting</b>	CB 204 E, SD Mines	Frank Strieder
15:40 - 16:20	Coffee Break	CB206 E&W, SD Mines	
16:20 - 17:00	The CYGNOINITIUM project for directional Dark Matter se...		Prof. Elisabetta Baracchini
16:20 - 17:00	DUNE Low Energy Physics with Solar and Supernova Ne...		Gleb Sinev
16:20 - 17:00	Radiopure flexible cables for rare-event physics detectors		Nicole Rocco
16:20 - 17:00	Radiological Backgrounds in DUNE Far Detectors		Dr Shawn Westerdale
17:00 - 17:30	Innovative Purification Techniques for Producing High-Qu...		Austin Warren
17:00 - 17:30	Calibrating DUNE LArTPC Detectors Using Low-Energy ...		Dr Michael Mooney
17:30 - 18:00	Unusual Dielectric Behavior at Low Temperatures: Neutra...		Narayan Budhathoki
17:30 - 18:00	Diffuse Supernova Neutrino Background Search		Linyan Wan

**May 16, 2024:**

SURF User Association Session During CoSSURF  
<https://indico.sanfordlab.org/event/68/timetable/-20240516.detailed>





# SURF Experiment Implementation & Support

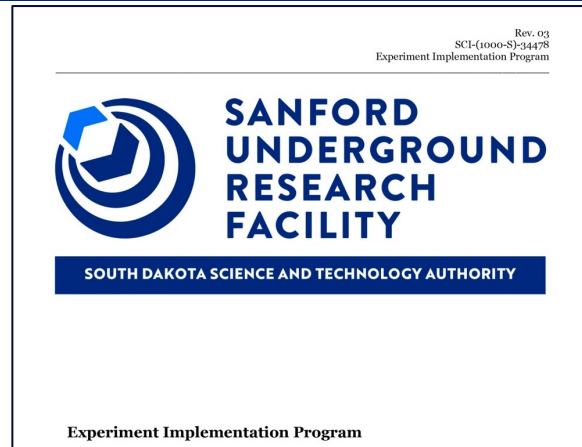
## Main Science documents under IMS/ISO document control

### 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

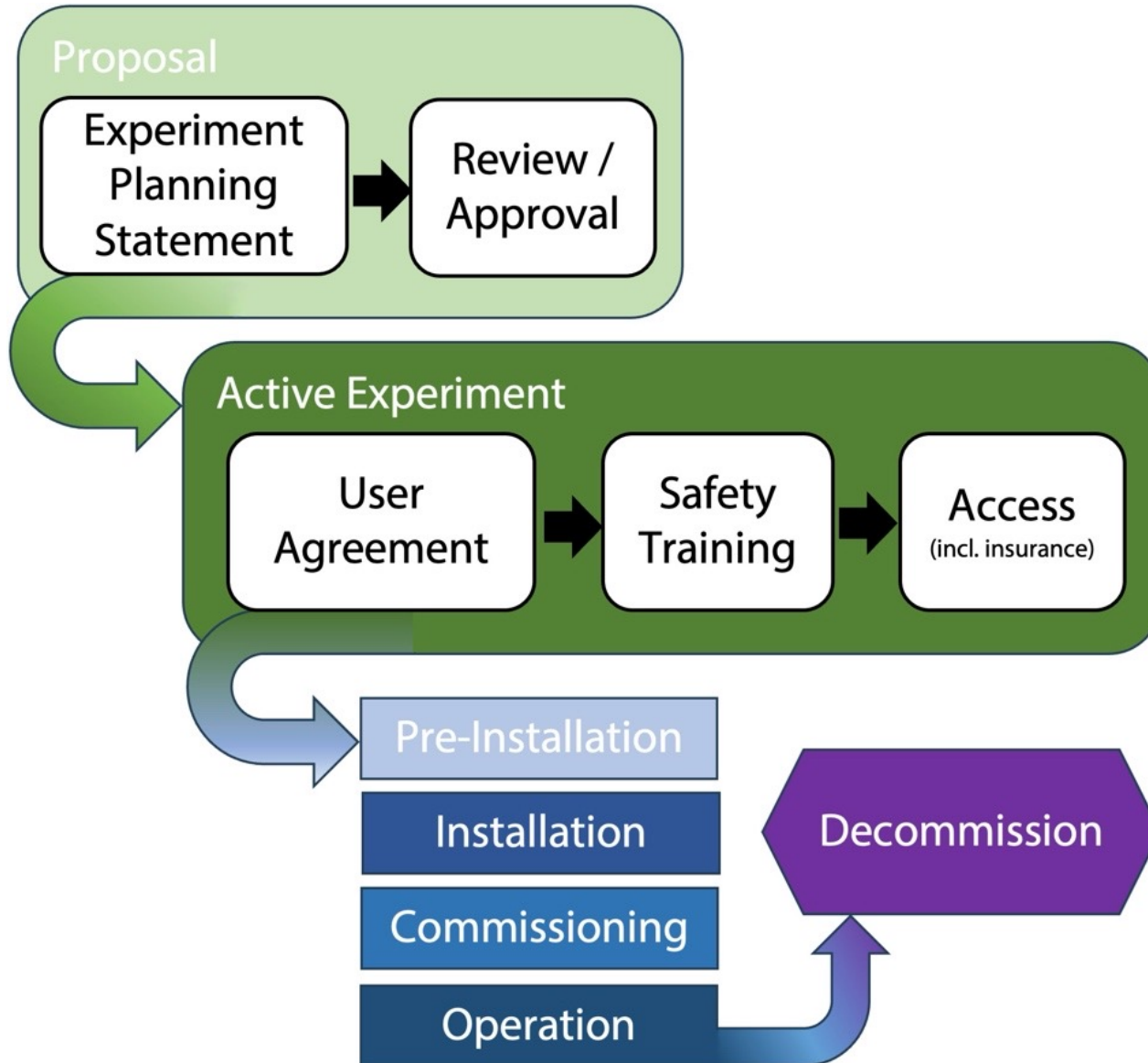
- In partnership with research groups, SDSTA aims to maintain a robust organization with resources to promote safe and successful experiment operations at SURF
- References several key elements:
  - Several specific ESH Standards (incl WPC)
  - SURF Applications/Databases (TAP, SARF, etc)
  - Table of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





# SURF Experiment Implementation Program

Identify interfaces and hazards within approval framework



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

The screenshot shows the Sanford Underground Research Facility Research Proposal Guidelines webpage. The page features a navigation menu with links for ABOUT, VISITOR CENTER, RESEARCH, EDUCATION, and SUPPORT SURF. The main heading is "RESEARCH PROPOSAL GUIDELINES". Below the heading, it states "All proposals must follow these guidelines". The page is divided into two columns: RESEARCHER RESOURCES and PROPOSAL DOCUMENTS. The RESEARCHER RESOURCES section includes links for Proposal Guidelines, Science Liaison Office, SURF User Association, and Visitor information. The PROPOSAL DOCUMENTS section lists various documents with their file names and sizes.

**RESEARCHER RESOURCES**

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

**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 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*  
Plant Growth – *Low EM, cosmic ray muons*

**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*

**Total = 30 groups**

**22 Active Projects**

**68 Total Groups Since 2007**

Significant interest from others  
**(26 groups in 2023)**

\* Denotes  
proprietary group

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





# 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](https://doi.org/10.1016/j.biortech.2010.06.001).
- Improved Lignocellulose Conversion to Biofuels with Thermophilic Bacteria and Thermostable Enzymes, A. Bhalla, N. Bansal, S. Kumar, K. M. Bischoff, R. K. Sani *Bioresource Technology* **128**, 751 (2013) doi: [10.1016/j.biortech.2012.10.145](https://doi.org/10.1016/j.biortech.2012.10.145).
- 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](https://doi.org/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](https://doi.org/10.1038/nprot.2014.067).
- First Results from the LUX Dark Matter Experiment at the Sanford Underground Research Facility, D. S. Akerib *et al.* (LUX Collaboration) *Phys. Rev. Lett.* **112**, 091303 (2014) doi: [10.1103/PhysRevLett.112.091303](https://doi.org/10.1103/PhysRevLett.112.091303).
- 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](https://doi.org/10.1103/PhysRevLett.116.161302).
- Results from a Search for Dark Matter in the Complete LUX Exposure, D.S. Akerib *et al.* (LUX Collaboration) *Phys. Rev. Lett.* **118**, 021303 (2017) doi: [10.1103/PhysRevLett.118.021303](https://doi.org/10.1103/PhysRevLett.118.021303).
- 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](https://doi.org/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](https://doi.org/10.1103/PhysRevLett.118.261301).
- Search for Neutrinoless Double- $\beta$  Decay in  $^{76}\text{Ge}$  with the MAJORANA DEMONSTRATOR, C. E. Aalseth *et al.* (MAJORANA Collaboration) *Phys. Rev. Lett.* **120**, 132502 (2018) doi: [10.1103/PhysRevLett.120.132502](https://doi.org/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](https://doi.org/10.1103/PhysRevLett.120.211804).
- 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](https://doi.org/10.1073/pnas.2113985119).
- Measurement of Low-Energy Resonance Strengths in the  $^{18}\text{O}(\alpha,\gamma)^{22}\text{Ne}$  Reaction, A.C. Dombos *et al.* (CASPAR Collaboration) *Phys. Rev. Lett.* **128**, 162701 (2022) doi: [10.1103/PhysRevLett.128.162701](https://doi.org/10.1103/PhysRevLett.128.162701).
- Search for Spontaneous Radiation from Wave Function Collapse in the MAJORANA DEMONSTRATOR, I. J. Arnquist *et al.* (MAJORANA Collaboration) *Phys. Rev. Lett.* **129**, 080401 (2022) doi: [10.1103/PhysRevLett.129.080401](https://doi.org/10.1103/PhysRevLett.129.080401).
- Search for Solar Axions via Axion-Photon Coupling with the MAJORANA DEMONSTRATOR, I. J. Arnquist *et al.* (MAJORANA Collaboration) *Phys. Rev. Lett.* **129**, 081803 (2022) doi: [10.1103/PhysRevLett.129.081803](https://doi.org/10.1103/PhysRevLett.129.081803).
- Final Result of the MAJORANA DEMONSTRATOR's Search for Neutrinoless Double- $\beta$  Decay in  $^{76}\text{Ge}$ , I. J. Arnquist *et al.* (MAJORANA Collaboration) *Phys. Rev. Lett.* **130**, 062501 (2023) doi: [10.1103/PhysRevLett.130.062501](https://doi.org/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](https://doi.org/10.1103/PhysRevLett.131.041002).
- Constraints on the Decay of  $^{180\text{m}}\text{Ta}$ , I. J. Arnquist *et al.* (MAJORANA Collaboration), *Phys. Rev. Lett.* **131**, 152501 (2023) doi: [10.1103/PhysRevLett.131.152501](https://doi.org/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](https://doi.org/10.1103/PhysRevLett.132.041001).
- Search for Charge Nonconservation and Pauli Exclusion Principle Violation with the MAJORANA DEMONSTRATOR, I. J. Arnquist *et al.* (MAJORANA Collaboration), *Nat. Phys.* (2024) doi: [10.1038/s41567-024-02437-9](https://doi.org/10.1038/s41567-024-02437-9).



# 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)).
  - SURF upgrading electrical infrastructure for water heaters.
- **Future:**
  - DEMO-FTES activities at SURF for ~1 year (until ~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 may be impacted by 4850L Expansion.



NAI collected LBNF core

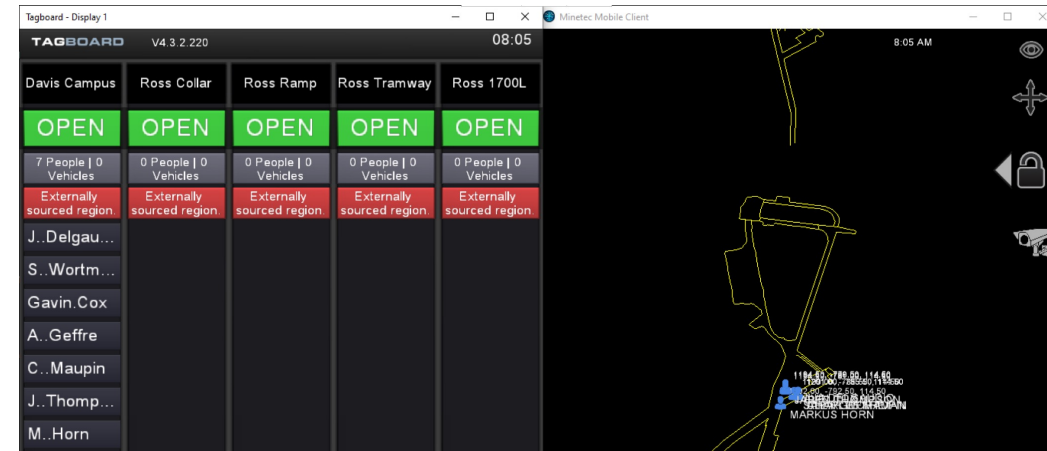


Sampling water from legacy drill hole

# 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 271 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<sup>2</sup>), ~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-yr agreement through Sep 2030.





# SURF Material Assay at BHUC

Low-background counting capabilities serving national & international community

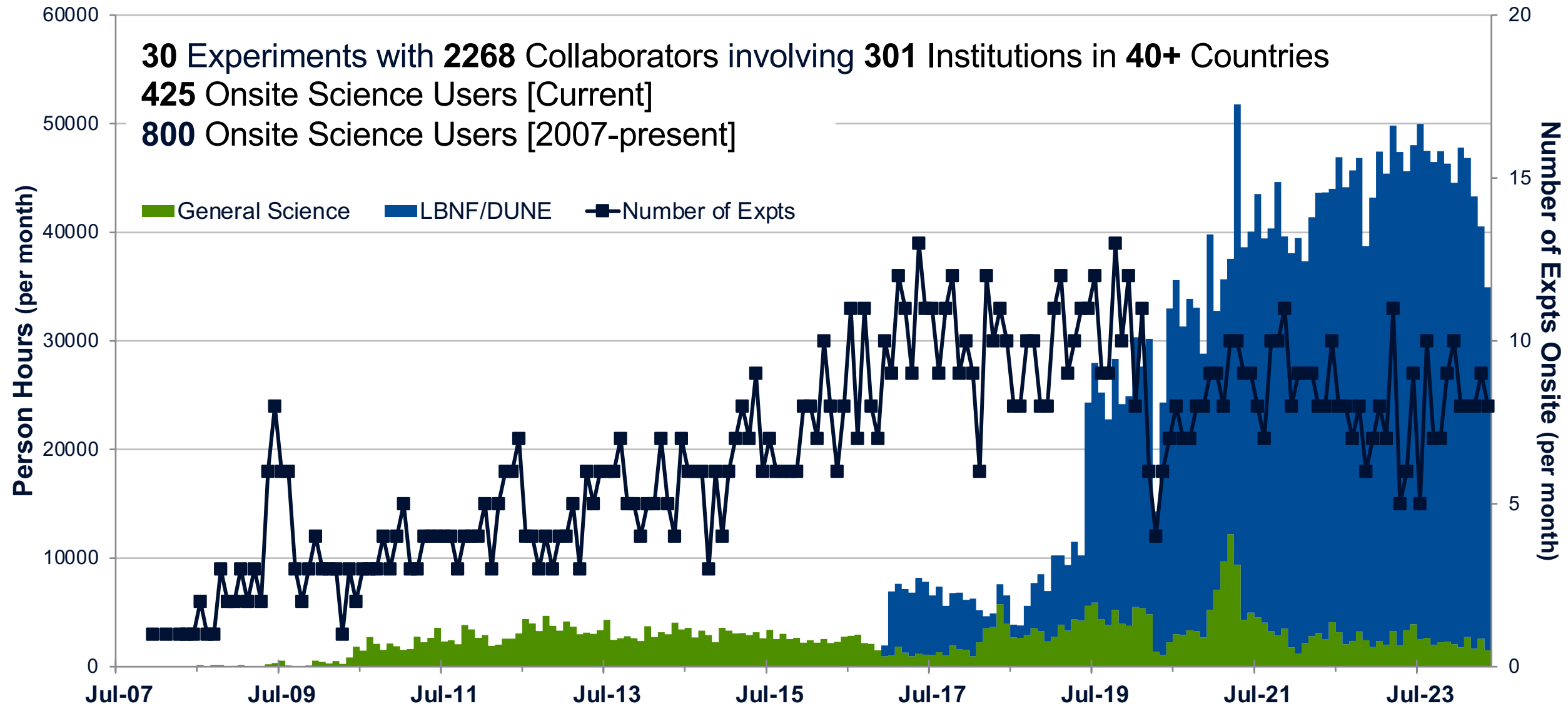
Detector	Crystal		[U]	[Th]	Install Date	Status	Comments
	Type	Size	mBq/kg	mBq/kg			
<b>Maeve</b> (LBNL)	p-type (85%)	2.2 kg	<b>0.1</b> (10 ppt)	<b>0.1</b> (25 ppt)	Davis Campus: Nov 2020 (Ross Campus: Nov 2015; Davis Campus: May 2014)	Production assays	Relocated from Oroville. Old Pb (200-yr old) inner shielding. Cooling system upgrade 2020.
<b>Morgan</b> (LBNL)	p-type (85%)	2.1 kg	<b>0.2</b> (20 ppt)	<b>0.2</b> (50 ppt)	Davis Campus: Nov 2020 (Ross Campus: Nov 2015; Davis Campus: May 2015)	Production assays	Low-bkgd upgrade 2015. Cooling system upgrades 2020.
<b>Mordred</b> (USD/CUBED, LBNL)	n-type (60%)	1.3 kg	<b>0.7</b> (60 ppt)	<b>0.7</b> (175 ppt)	Davis Campus: Nov 2020 (Ross Campus: Jul 2016; Davis Campus: Apr 2013)	Production assays	Low-bkgd upgrade 2015-2016, shield access upgrade. Cooling system upgrades 2020.
<b>Dual HPGe (“Twins”)</b> (LBNL, BHSU, UCSB)	p-type (2x120%)	2x 2.1 kg	<b>~0.01</b> (~1 ppt)	<b>~0.01</b> (~1 ppt)	Davis Campus: Sep 2020 (Ross Campus: Mar 2018, Jul 2017 (initial))	Operating	Low-bkgd upgrades 2016-2017; flexible shield. Cooling system upgrades 2020.
<b>Ge-IV</b> (Alabama, Kentucky)	p-type (111%)	2 kg	<b>0.04</b> (3 ppt)	<b>0.03</b> (8 ppt)	Davis Campus: May 2023, Nov 2020 (initial) (Ross Campus: Jul 2018, Oct 2017 (initial))	Expect repaired cryocooler return Aug 2024	Vertical design with gantry + hoist. Cooling system upgrades 2020.
<b>Dual HPGe (“RHYM+RESN”)</b> (LLNL)	p-type (2x65%)	2x 1.1 kg	<b>&lt;0.1</b> (<10 ppt)	<b>&lt;0.1</b> (<25 ppt)	Davis Campus: Feb 2022, Sep 2020 (initial)	Operating	Cryocooler, low-E <sup>210</sup> Pb (<2 mBq/kg), cylinder shield.

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

Local universities have some additional material screening capabilities: **HPGe** (SOLO [0.6 kg]/BHSU, [0.2-0.4 kg]/SD Mines), **ICP-MS** (BHSU), **Rn emanation** characterization (0.1 mBq/SD Mines), **Alpha** (1 mBq/m<sup>2</sup> <sup>210</sup>Po/SD Mines; XIA UltraLo-1800/LZ purchased)

# SURF Science Program

Hosting world-leading experiments and researchers from diverse scientific communities

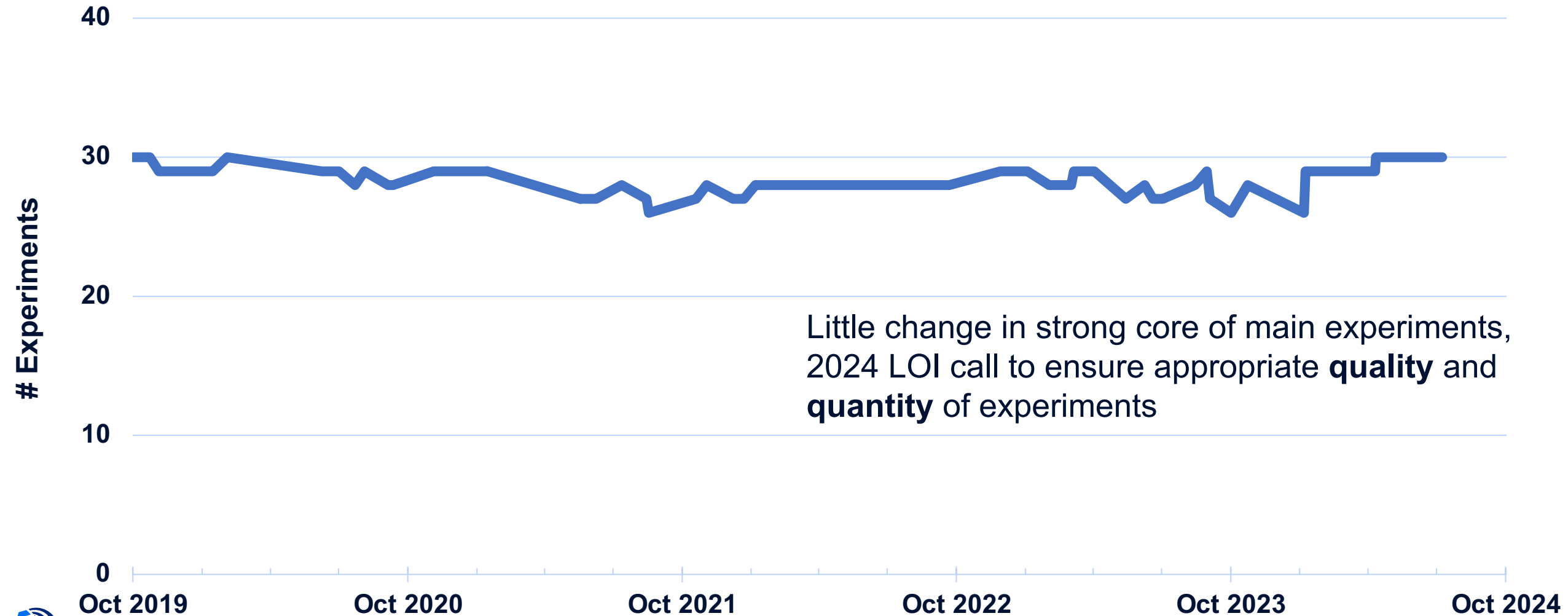




# SURF Science Program

Hosting world-leading experiments and researchers from diverse scientific communities

## SURF Experiment Trend



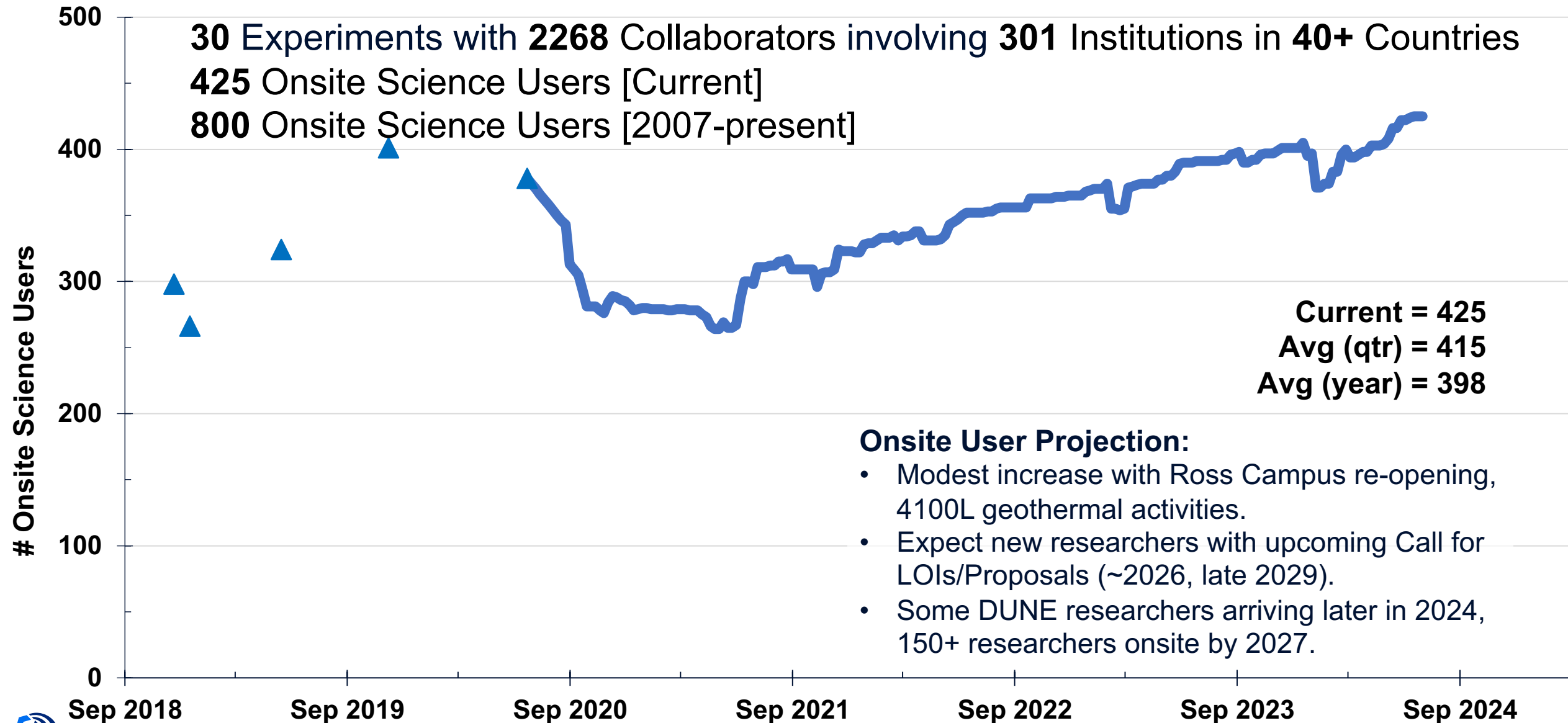
Little change in strong core of main experiments, 2024 LOI call to ensure appropriate **quality** and **quantity** of experiments



# SURF Onsite Users

Significant user base, expect more engagement with UG science community

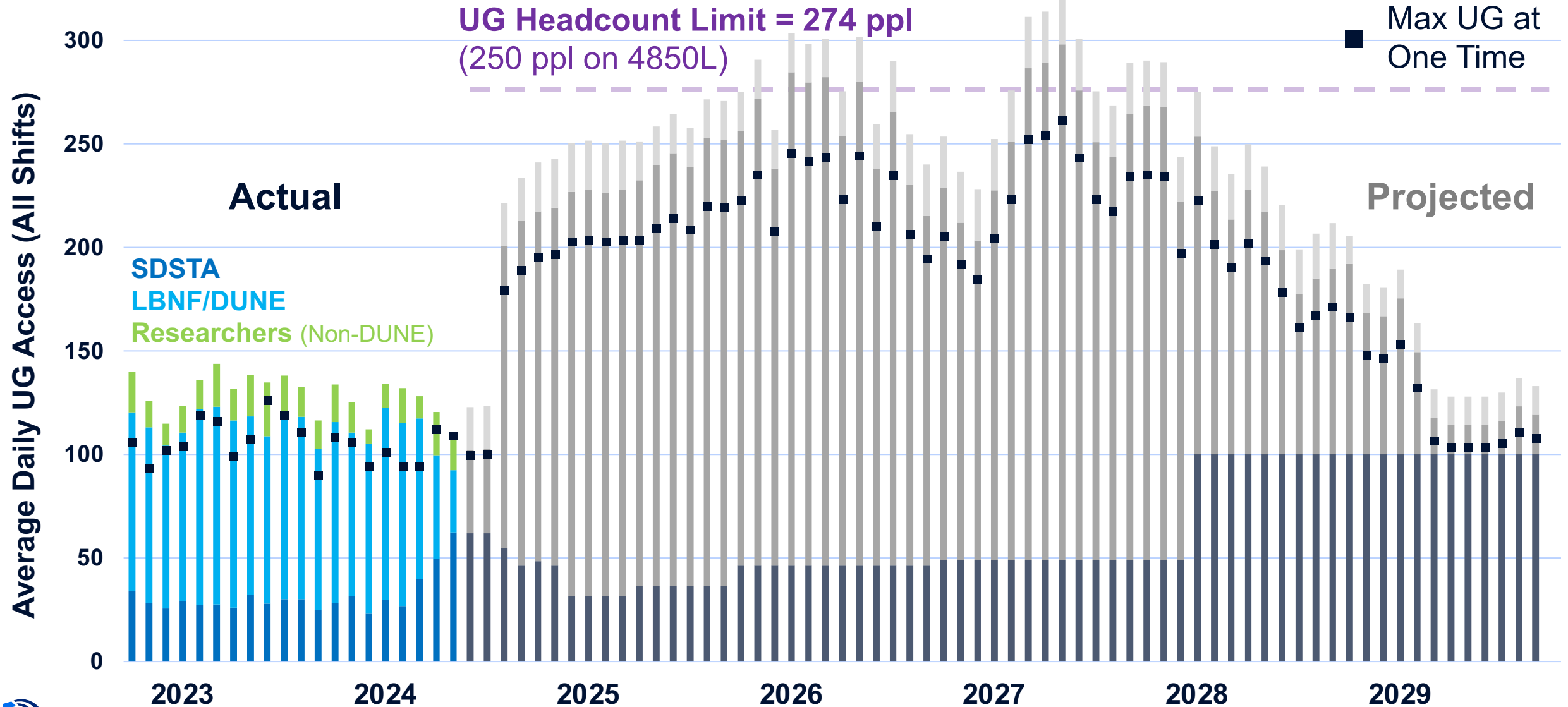
**30 Experiments with 2268 Collaborators involving 301 Institutions in 40+ Countries**  
**425 Onsite Science Users [Current]**  
**800 Onsite Science Users [2007-present]**





# SURF Average Daily Underground Access

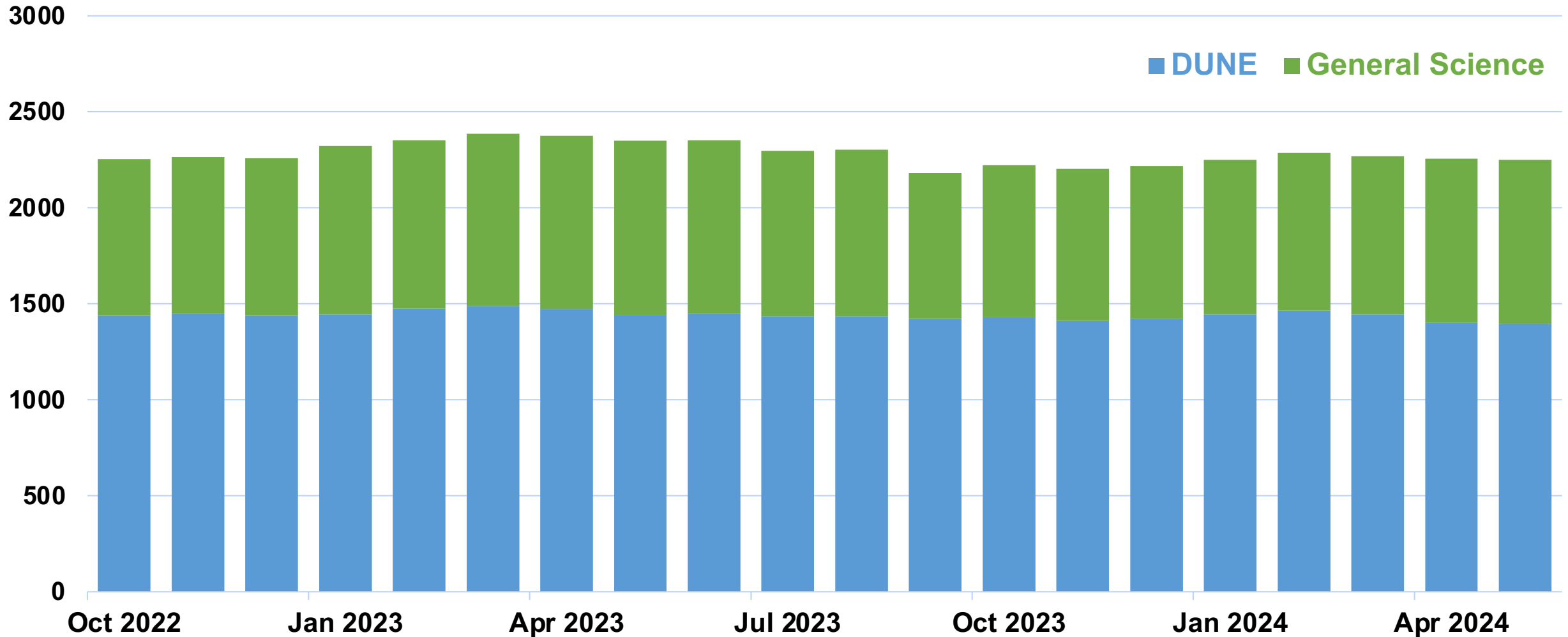
Includes SDSTA + Contractors, Researchers, LBNF/DUNE (BSI, FDC, Consortia)



# SURF Science Program

Hosting world-leading experiments and researchers from diverse scientific communities

## SURF Collaborator Trend

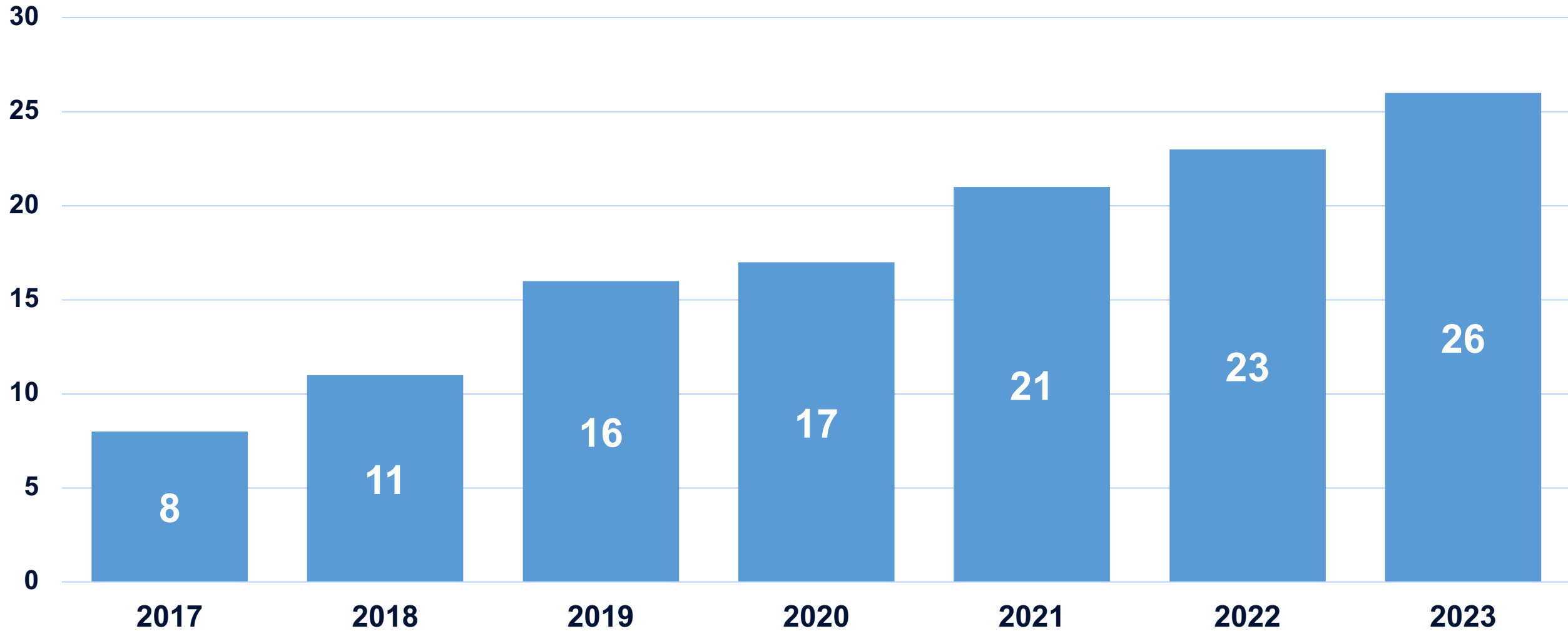




# SURF Science Program

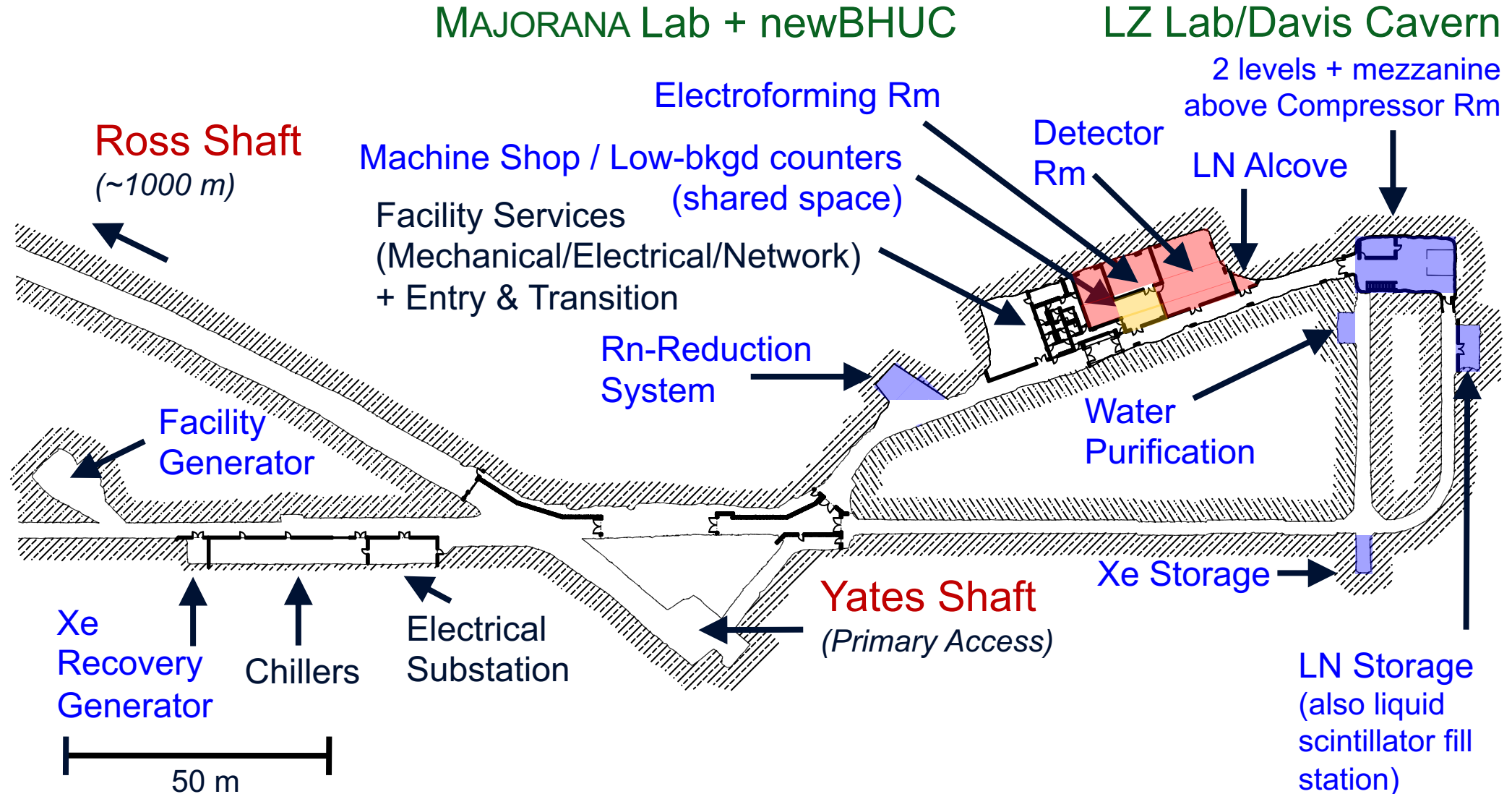
Hosting world-leading experiments and researchers from diverse scientific communities

## SURF Expressions of Interest



# 4850L Davis Campus

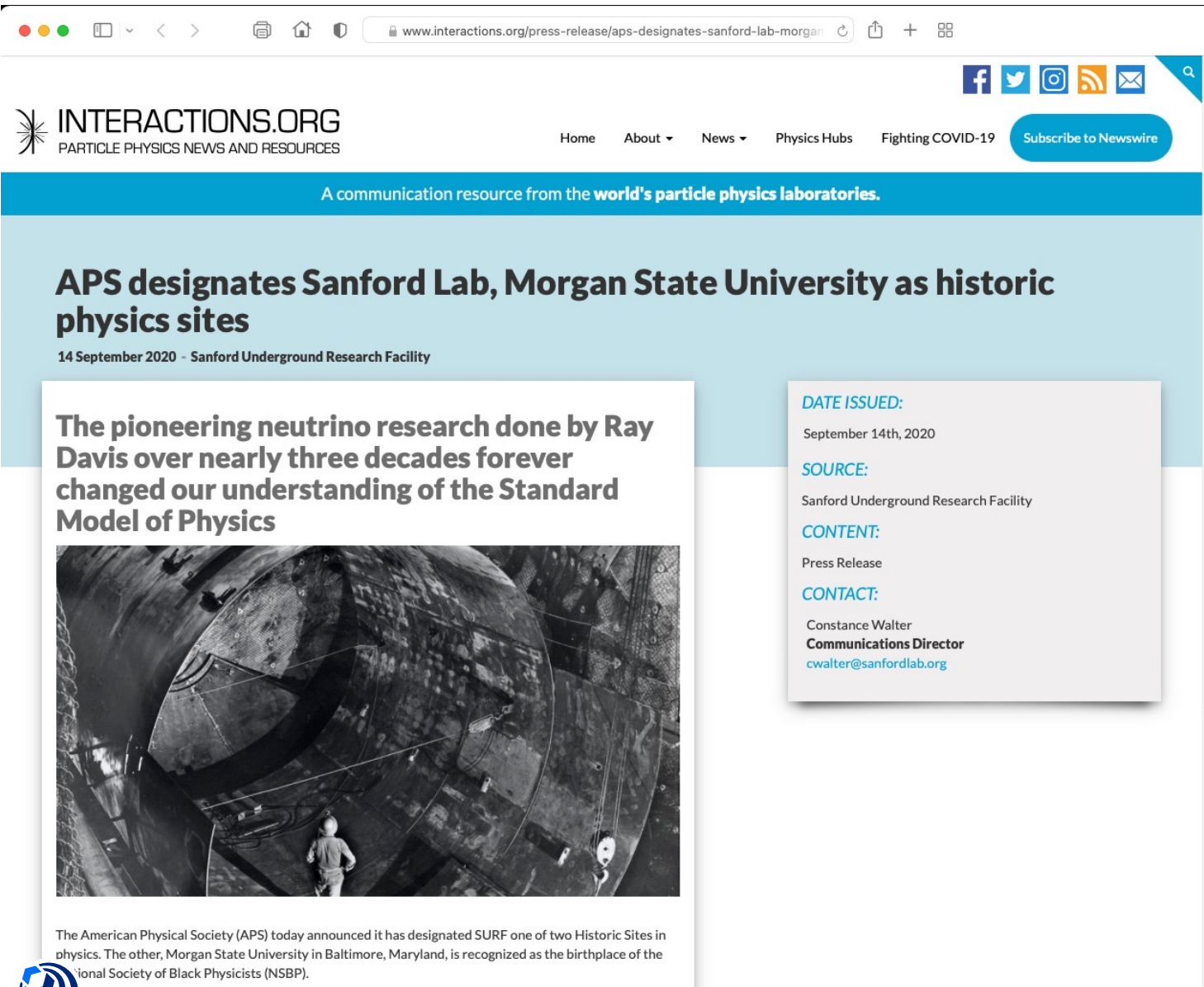
3,017 m<sup>2</sup> (Total) / 1,018 m<sup>2</sup> (Science)





# SURF Designated APS Historical Site

## Announcement Sep 2020, Dedication May 2022



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

INTERACTIONS.ORG  
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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



**DATE ISSUED:**  
September 14th, 2020

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Sanford Underground Research Facility

**CONTENT:**  
Press Release

**CONTACT:**  
Constance Walter  
**Communications Director**  
[cwalter@sanfordlab.org](mailto:cwalter@sanfordlab.org)

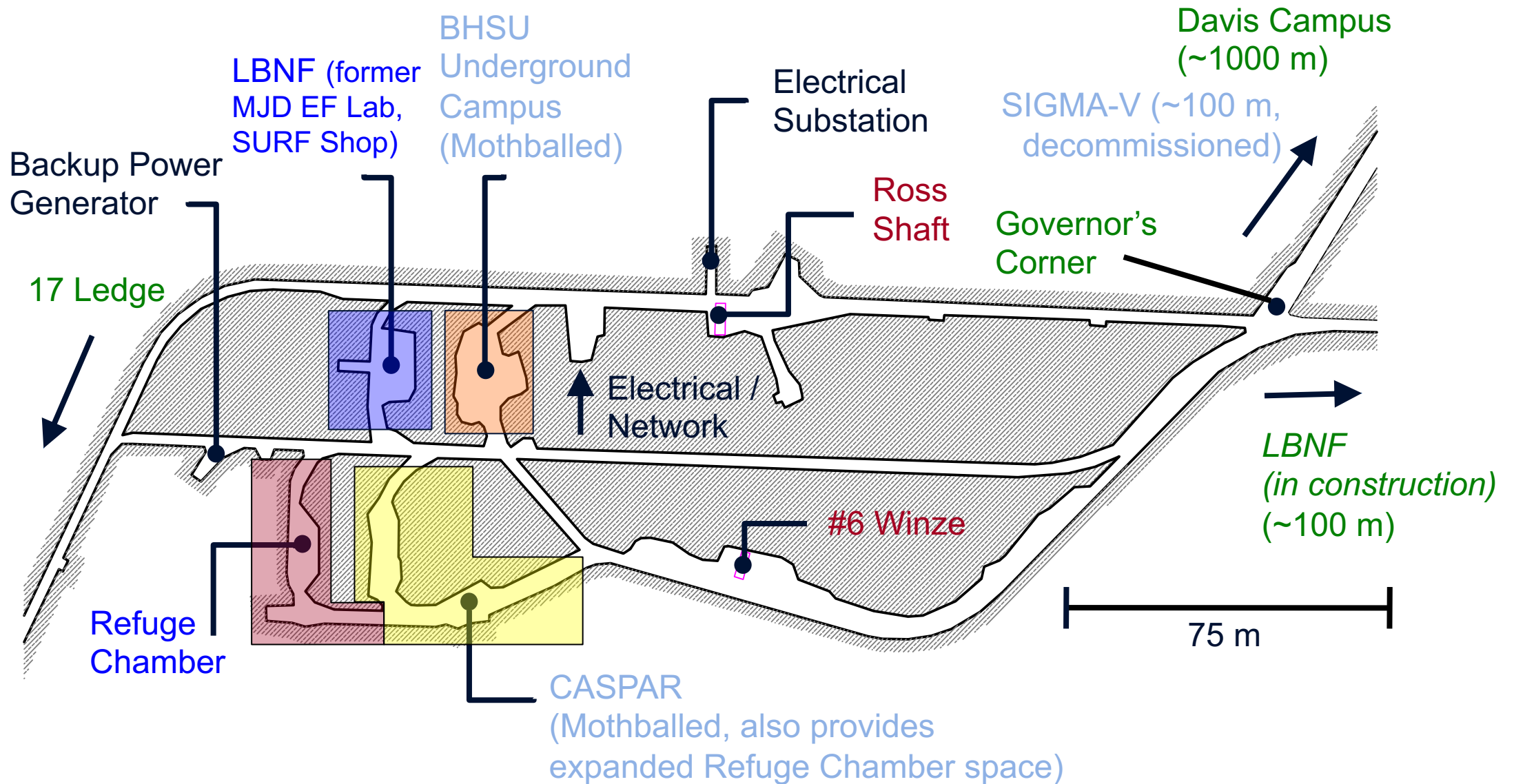
The American Physical Society (APS) today announced it has designated SURF one of two Historic Sites in physics. The other, Morgan State University in Baltimore, Maryland, is recognized as the birthplace of the National Society of Black Physicists (NSBP).





# 4850L Ross Campus

2,653 m<sup>2</sup> (Total) / 920 m<sup>2</sup> (Science)





# SURF 4850L Ross Campus

## Examples of laboratory space



2010-2017



Copper Electroforming



2015-2020, resume 2024

**Former MJD Electroforming:**  
Area = 228 m<sup>2</sup>  
(Cleanroom removed,  
current construction office)



2015-2021, resume 2024

**BHUC Cleanroom:**  
Cavern Area = 268 m<sup>2</sup>,  
Cleanroom = 12.1 m × 6.1 m ×  
2.4 m (H)

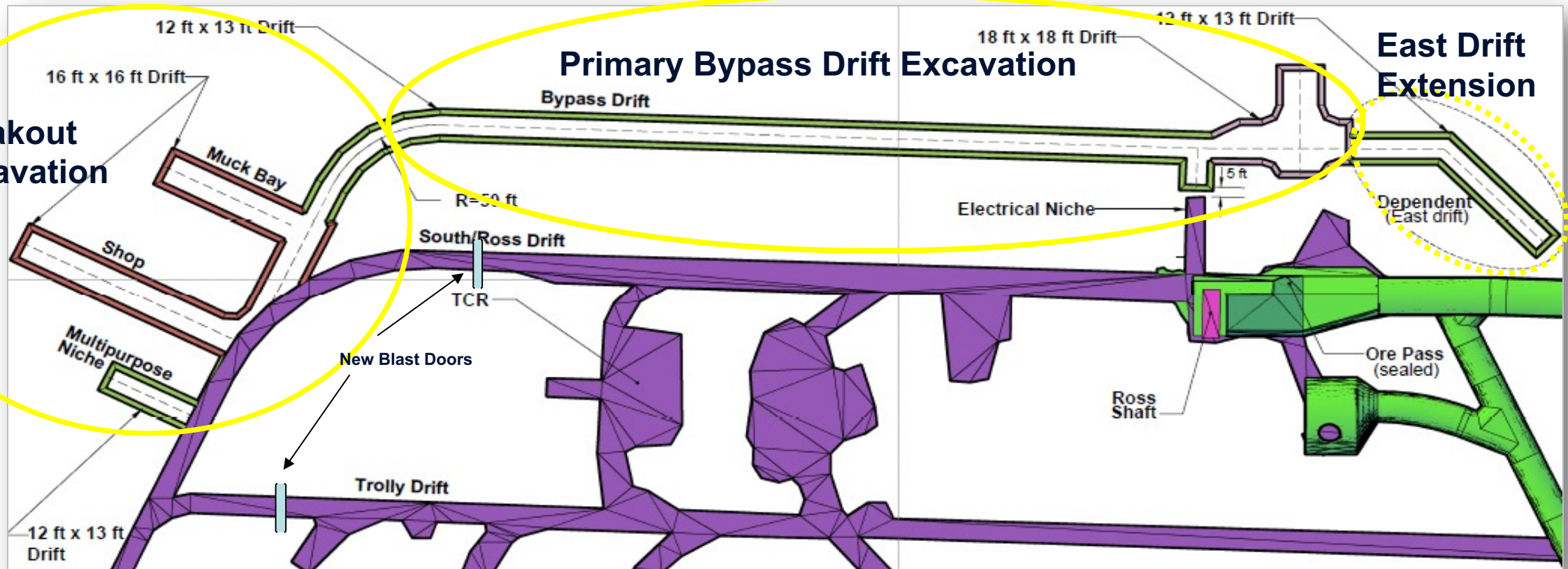
**CASPAR Hall:**  
Area = 236 m<sup>2</sup>,  
30 m × 3 m (min) × 2.8 m (H)





# 4850L Laboratory Expansion – Phase A

## Bypass Drift layout and excavation phases



### Bypass Drift Excavation Phases:

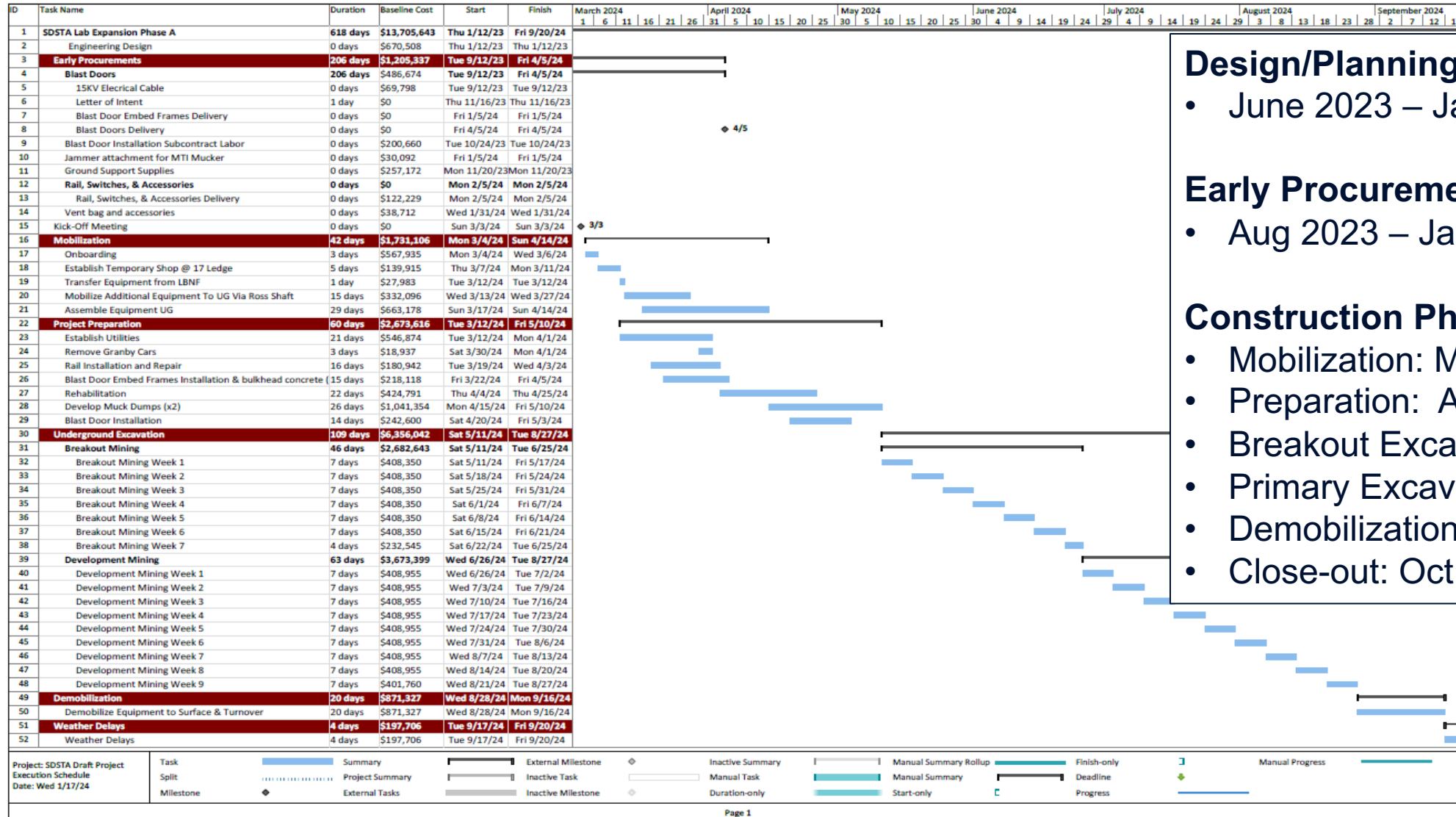
- Breakout Excavations: Shop, Muck Bay, Multi-Purpose Niche
- Main Bypass Drift (3.7m x 4.0m / 12' x 13') & Ore Pass Development (5.5m x 5.5m / 18' x 18')
- East Drift Extension (3.7m x 4.0m / 12' x 13') [funding dependent]

*Excavation muck volume calculated as 8,800 LCY (using 8% overbreak), 4850L storage ~9,300 LCY*



# 4850L Laboratory Expansion – Phase A

## Project Schedule – Summary as of May 31<sup>st</sup>



### Design/Planning Phase – 7 months

- June 2023 – Jan 2024

### Early Procurements – 6 months

- Aug 2023 – Jan 2024

### Construction Phase – 6-7 months

- Mobilization: Mar - Apr
- Preparation: Apr - May
- Breakout Excavation: May-Jun
- Primary Excavation: Jun-Aug
- Demobilization: Sep
- Close-out: Oct

Project: SDSTA Draft Project Execution Schedule Date: Wed 1/17/24

Task Split Milestone

Summary Project Summary External Tasks

External Milestone Inactive Task Inactive Milestone

Inactive Summary Manual Task Duration-only

Manual Summary Rollup Manual Summary Start-only

Finish-only Deadline Progress

Manual Progress

Page 1





**North Cavern**



**South Cavern**





# 4850L Ross Station: LBNF Excavation Phase Ends!

Before



After





# SURF Current & Future Facilities

## Summary for various science campuses, including timelines

Location	Laboratory	Existing/ <i>Planned</i> Space		Available (CY)	Comments
		Area (m <sup>2</sup> )	Vol (m <sup>3</sup> )		
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	~2025+/2026+	Initial scope completed 2021, Ta-180m data 2022-24 + decommissioning; Cu e-forming through 2025+
	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 2023-2024, CUSSP 2024-2027
4850L	<i>Expansion (2 proposed)</i>	4,022	94,608	<i>Earliest new: excavation 2027, complete ~2030</i>	<i>Each 20m (W) x 24m (H) x 100m (L)</i>
7400L	<i>New Labs (2 proposed)</i>	4,178	42,440		<i>Each 15m (W) x 15m (H) x 75m (L) + other supporting</i>



# SURF Planned Infrastructure Improvement

Appropriate capacity for future science with safe and reliable access

## Yates Shaft Refurbishment

- DOE recognizes investment necessary to ensure safe and reliable access in coming decades, developing CD-0 (mission need) and cost & schedule profile:
  - Shaft Design (earliest, leverages recent Ross Shaft design): ~2026-2027
  - Shaft Construction (earliest): ~2027-2030
- Planned refurbishment can accommodate low-Rn surface air supply to UG laboratories (~2030)

## Underground Space

- **4850L Davis Campus** (proposed DOE Infrastructure Improvement Program - IIP):
  - Facility commissioned in 2012, many systems now 12+ years old. Cooling system upgraded using in 2020 using DOE CA funds to accommodate LZ
  - **FY28 IIP** upgrade proposal to ensure facility continues to meet UG science community needs
- **4850L Facility Capacity** (possible IIP in FY26+ as necessary):
  - Ventilation/cooling studies for SURF 4850L Expansion, DOE “Module of Opportunity” (FD4) experiments based on actual LBNF/DUNE and requirements of other experiments

## Surface Space

- **Surface Science Assembly Facility** (proposed IIP):
  - **FY27/28 IIP** design/construction proposal to support new large experiments, incl SURF 4850L Expansion and DOE “Module of Opportunity” (FD4), for dark matter and neutrino experiments (G3DM, Theia, multi-ton  $0\nu\beta\beta$ )



# SURF Infrastructure Improvement Projects (IIP)

Significant ongoing DOE investments ensure safe and reliable facility for science

- **FY20** (\$9.5M)
  - Refuge Chamber
  - Headframe Security
  - Yates Cage MG Set
  - Davis Campus Chillers
  - Ross Complex Waterlines
  - Water Inflow System Replacement (Phase I)
- **FY22** (\$5.3M)
  - 3650L Pumproom Rehabilitation (Phase I)
  - Ross/Yates Hoistroom Roof Drains, Repointing
  - Replace Power Cables East Switchyard
  - WWTP RBC Replacement (Phase I)
- **FY24** (\$8.0 + \$1.0M)
  - WWTP RBC Replacement (Yr 2)
  - Dewatering System PLC
  - 1250L Pumproom Rehabilitation (Design)
  - 4850L Ross Campus Bathrooms
  - Electrical Distribution System Rehabilitation (Yr 1)
- **FY21** (\$5.5M)
  - Water Inflow System Replacement (Phase II)
  - Yates Shaft Concept Study
  - Industrial and Potable Water to Yates Complex (Phase II)
  - WWTP Gravity Flow Upgrades
  - Upgrade Oro Hondo Backup Ventilation System
- **FY23** (\$8.1M)
  - 3650L Pumproom Rehabilitation (Phase II)
  - Replace Yates Hoistroom Roof
  - WWTP RBC Replacement (Yr 1)
- **FY24-31** (TBD)
  - *Yates hoists (IIP?) and shaft refurbishment (DOE 413)*
  - *Surface Science Assembly Facility*
  - *Etc...*



# 2023 Particle Physics Strategic Plan

New 10-year goals established within globally-aware 20-year vision

Exploring  
the  
Quantum  
Universe

Pathways to Innovation  
and Discovery  
in Particle Physics

Report of the 2023 Particle Physics Project Prioritization Panel

## 2023 P5

P5 (Particle Physics Projects Prioritization Panel) reports to HEPAP (High-Energy Physics Advisory Panel) that advises High-Energy Physics of DOE Office of Science and Division of Physics of NSF. We will build on the “Snowmass” community study to hash out priorities for the next 10 years within 20-year context.

- Community input process “Snowmass” conducted through 2022
- Snowmass recommendations to P5 (Jan 2023):
  - **LBNF/DUNE Phase I & II and PIP-II**
  - **Leverage LBNF to increase underground space at SURF**
  - **Designate SURF as a formal U.S. DOE User Facility**
- P5 recommendations to DOE/NSF (Dec 2023):
  - “With SURF, the U.S. has created a premier underground laboratory”
  - **LBNF/DUNE Phase I & II and PIP-II (also “Module of Opportunity”)**
  - **G3 dark matter experiment (at least one), preferably sited at SURF**
  - **Fund SURF expansion outfitting for neutrino & dark matter expts**

A strategic plan for the High Energy Physics Advisory Panel



# SURF Radon Reduction System – Surface

## Commercial continuous-cooled Rn mitigation system



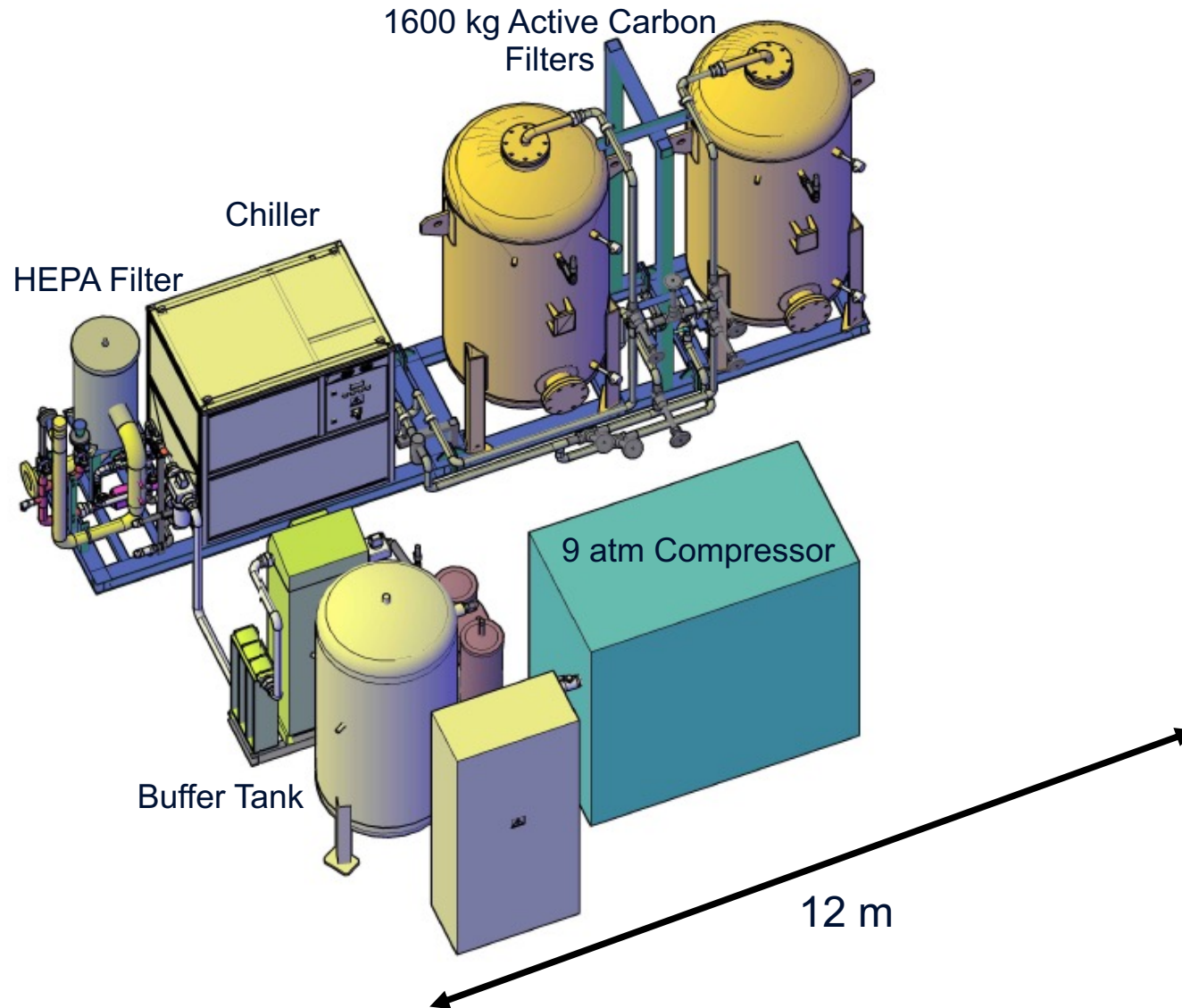
- **Specs:** 1000x Rn reduction, 300 m<sup>3</sup>/hr
- **Supplier:** Ateko, Czech Republic (same as Y2L, Gran Sasso, etc)
- **Design:** Compress air to 9 bar, cool to -60C dew point, flow air through carbon adsorption columns, reduce pressure, reheat as desired
- **Space:** Dedicated bldg, 74 m<sup>2</sup>
- **Status:** Operating, 2200x Rn output reduction

- **Specs:** Design/protocols support Class 100
- **Supplier:** SBB Inc., Syracuse, NY
- **Design:** Metal panels (Al) with careful sealing, balancing differential pressures, special entry ports (air shower, soft-wall for materials, etc)
- **Space:** 54 m<sup>2</sup>, 240 m<sup>3</sup>
- **Status:** Operating as Class 100, **770x Rn reduction** inside cleanroom



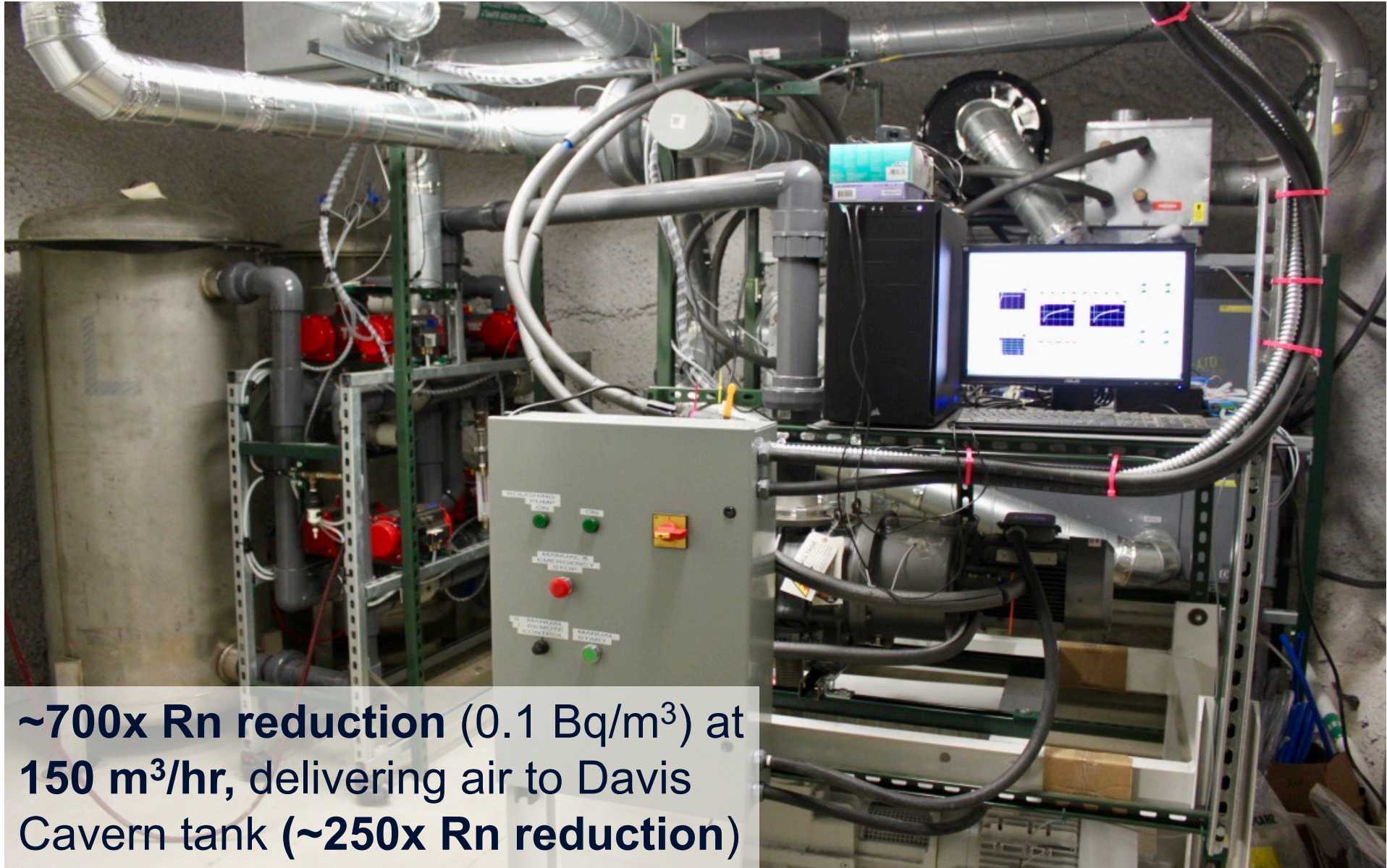
# SURF Radon Reduction System – Surface

Commercial continuous-cooled Rn mitigation system



# SURF Radon Reduction System – Underground

## SDSMT vacuum-swing adsorption (VSA) Rn mitigation system

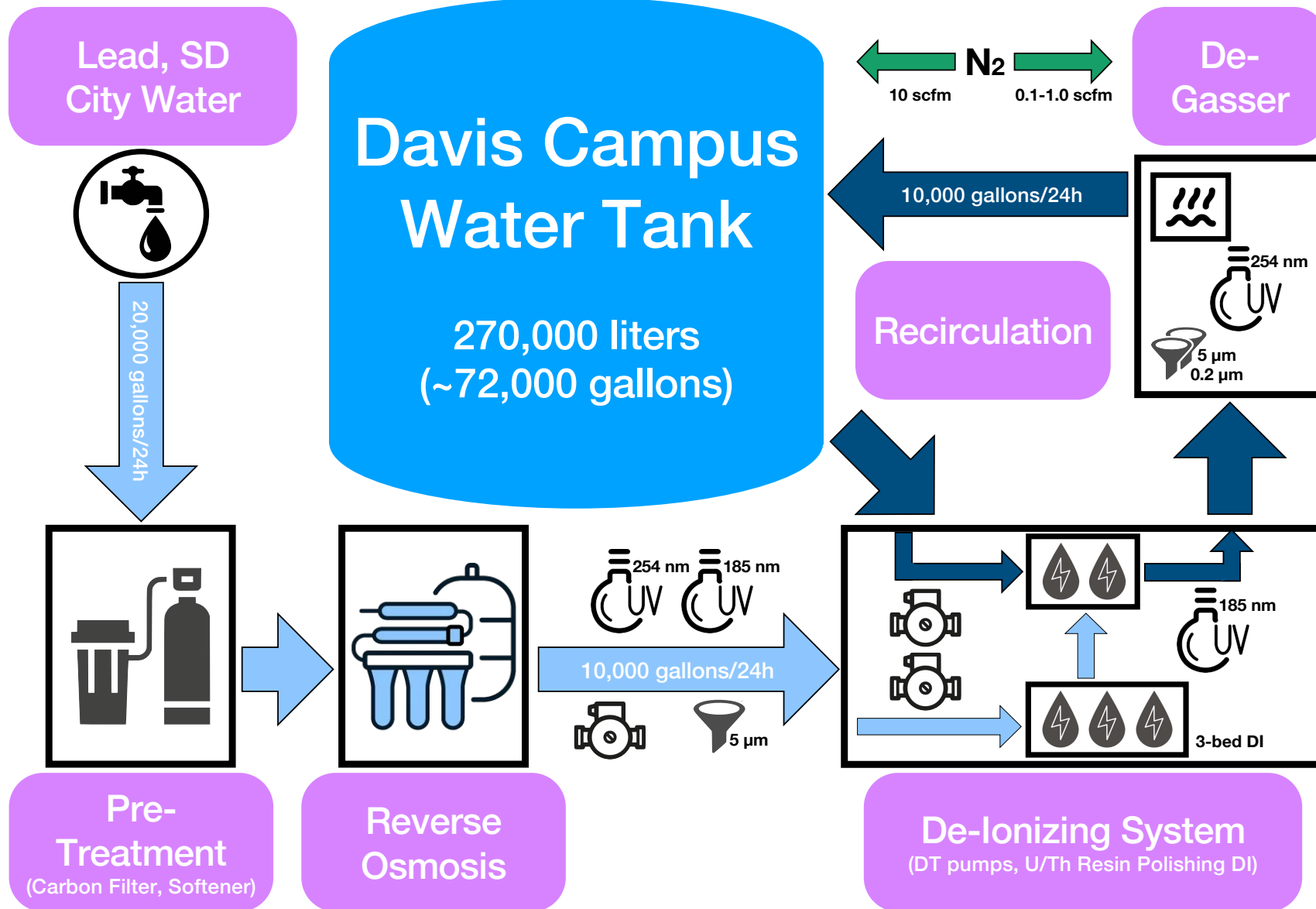


**~700x Rn reduction ( $0.1 \text{ Bq/m}^3$ ) at  
150  $\text{m}^3/\text{hr}$ , delivering air to Davis  
Cavern tank (~250x Rn reduction)**



# SURF Water Purification System

## Davis Campus



# Institute for Underground Science at SURF

## Activities since June 2023, formally launched December 2023

**THE INSTITUTE FOR UNDERGROUND SCIENCE AT SURF**  
CETUP\* 2024

17 June 2024 to 19 July 2024  
Lead/Deadwood Middle School  
US/Mountain timezone

**Overview**

- Call for Abstracts
- Timetable
- Paper Peer Reviewing
  - Reviewing Area
  - Judging Area
- Book of Abstracts
- Registration
- Surveys
- Organizing Committee
- Participant List
- Travel Information
- Hotel Accommodations
- Dining
- Tourism and Additional Information
- Pictures

**CETUP\* Mission:**

To promote organized research in physics, cosmology and astrophysics, related to science done in underground laboratories worldwide via individuals in a dynamic atmosphere of intense scientific interactions.

Around the globe more than 20 underground laboratories provide space for particle physics, astrophysics and cosmology, and geosciences, drawing scientists from all over the world. In response to the growing interests in underground science, the Center for Underground Physics and Related Areas (CETUP\*) brings together scientists to discuss experimental aspects of a variety of disciplines during its annual workshop.

CETUP\* provides a stimulating environment for creative thinking and open discussion, varying experience, - and from different countries and scientific backgrounds, rising young scientists, discuss a broad range of topics, and collaborate. This intellectual community to address the most pressing questions in fundamental physics.

Since its inception in 2011, the workshop has been hosted in the Black Hills National Forest, Lead/Deadwood, with the Sanford Underground Research Facility (SURF), the largest underground laboratory in the United States. The area's natural beauty attracts tourists and provides unique connections to Native American cultures and history.

**Previous Workshops:**

- CETUP\* 2023: Dark Matter, Neutrino Physics
- CETUP\* 2016: Physics and Instrumentation of the Near Detector for the Short-Baseline Neutrino Experiment, From Grand Unification to String Theory and Back, Dark Matter
- CETUP\* 2015: Dark Matter, Neutrino Physics (nuclear and particle physics), Cosmology
- CETUP\* 2014: Neutrino Interactions, Systematic Uncertainties, Near Earth Dark Matter, Neutrino Physics, Astrophysics, Particle Physics
- CETUP\* 2013: Dark Matter, Neutrino Physics, Grand Unification
- CETUP\* 2012: Dark Matter, Neutrino Physics, Grand Unification
- CETUP\* 2011: Geo-neutrinos, Neutrino Physics, Grand Unification

Starts 17 Jun 2024, 02:00  
Ends 19 Jul 2024, 17:00  
US/Mountain

Lead/Deadwood (0.3 miles, 7 min walk)  
Go to map

**Jun 17-Jul 19, 2024:**  
CETUP\* 2024

<https://indico.sanfordlab.org/e/CETUP2024>

**THE INSTITUTE FOR UNDERGROUND SCIENCE AT SURF**

PROGRAMS DONATE CONTACT

## DEEPER TALKS: SURF SEMINAR SERIES

### Monthly Seminar Series

<https://institute.surf/deeper-talks>

Register for the next Deeper Talks

REGISTER HERE

**May 8 - LAUNCH OF SERIES**  
Speaker: Magdalena "Maggie" Osburn Ph.D.  
Topic: A decade of DeMNO: Microbes a mile underground at SURF

**Event Details**  
When: 2<sup>nd</sup> Wednesday of each month from 9:00 - 10:00 a.m. MT, launching May 8, 2024.

**THE INSTITUTE FOR UNDERGROUND SCIENCE AT SURF**  
Quantum Partnership Workshop at SURF

Center

The **Quantum Partnership Workshop** is a collaborative gathering at the Sanford Lab Homestake Visitor Center, near the Sanford Underground Research Facility (SURF) in Lead, SD. The workshop is organized by the Great Plains Network (GPN) and The Institute for Underground Science at SURF, in partnership with the South Dakota Quantum Center initiative. This event is designed to foster synergies and forge new connections within the quantum research community.

**Date:** Monday, July 15 - Tuesday, July 16, 2024  
**Location:** Sanford Lab Homestake Visitor Center, Lead, South Dakota

The workshop will feature insightful presentations and discussions, including:

- **Institutional Overviews:** Gain comprehensive insights into the missions and visions of key institutions driving quantum research, including SURF, Great Plains Network, Dakota State University, and SD Mines.
- **Quantum Initiatives:** Delve into the latest developments and initiatives spearheaded by the SD Quantum Center, GPN Quantum Network, and High-Performance Computing (HPC) endeavors.
- **Quantum Curriculum:** Explore the evolving landscape of quantum education and training, examining strategies for curriculum development and implementation.
- **Brainstorming Forum on Partnerships and Next Steps:** Engage in dynamic discussions aimed at identifying collaborative opportunities and charting the course for future quantum endeavors.

Additionally, participants will have the opportunity to join a **surface tour of the Yates Hoistroom at SURF**.

The workshop will **kick off on Monday, July 15 at 4:30 p.m. MT with an evening of networking and camaraderie at the Sanford Lab Homestake Visitor Center**. Enjoy refreshments and connect with fellow attendees while immersing yourself in the story of the region, including the creation of the deepest gold mine in the Northern Hemisphere, to Nobel-Prize-winning science, to secrets of the universe still being uncovered at SURF.

Don't miss this opportunity to be part of transformative dialogue shaping the future of quantum exploration. Join us at the Quantum Partnership Workshop and be at the forefront of quantum innovation and collaboration.

Starts 15 Jul 2024, 16:30  
Ends 16 Jul 2024, 15:00  
US/Mountain

Sanford Lab Homestake Visitor Center Classroom  
160 West Main Street  
Lead, SD 57754

**Jul 15-16, 2024:**  
Quantum Partnership Workshop  
<https://indico.sanfordlab.org/event/80>





# The Institute for Underground Science at SURF

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

\$115M Projected Budget

- Breakdown:
  - \$65M Main Building
  - \$20M Housing
  - \$22.6M Annual



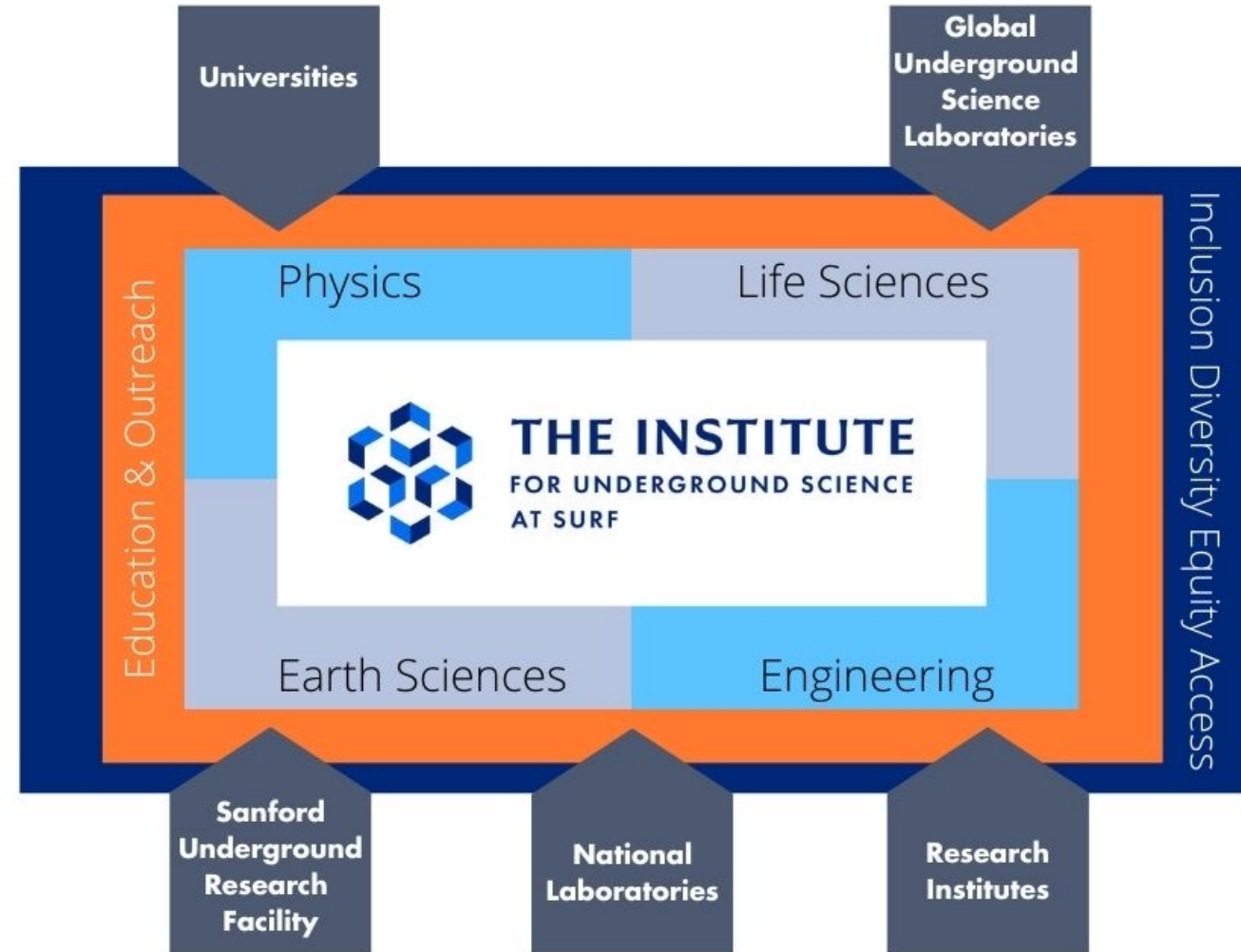
**THE INSTITUTE**  
FOR UNDERGROUND SCIENCE  
AT SURF



# Institute for Underground Science at SURF

Launched December 14, 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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