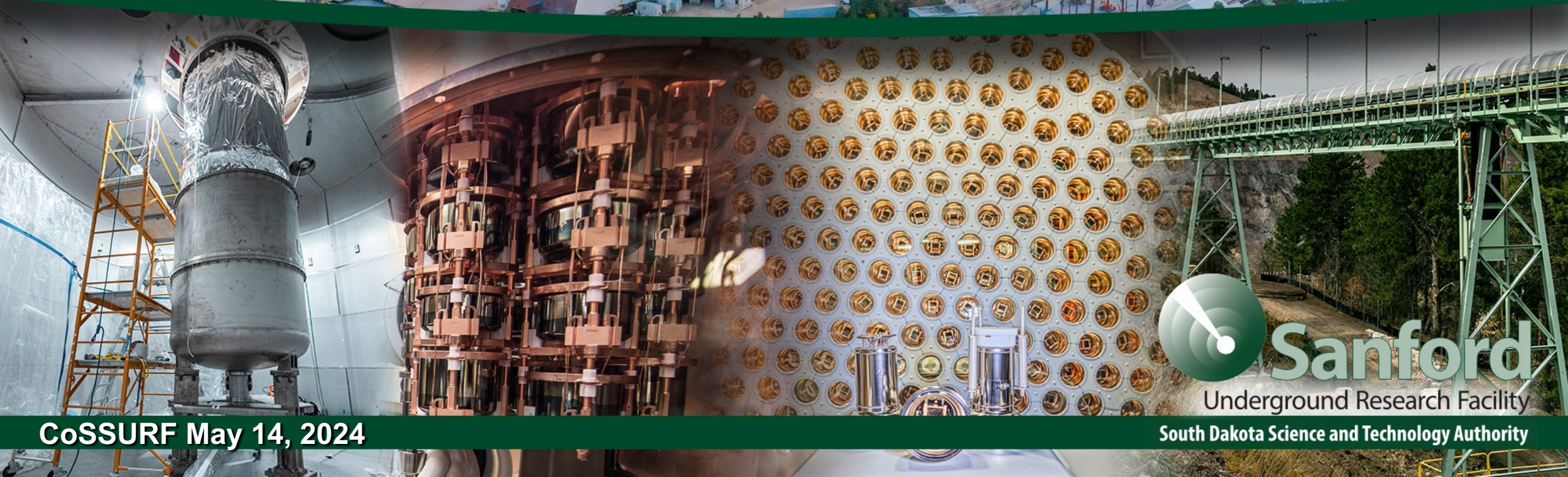


# The Sanford Underground Research Facility

Jaret Heise, Science Director

[jaret@sanfordlab.org](mailto:jaret@sanfordlab.org)



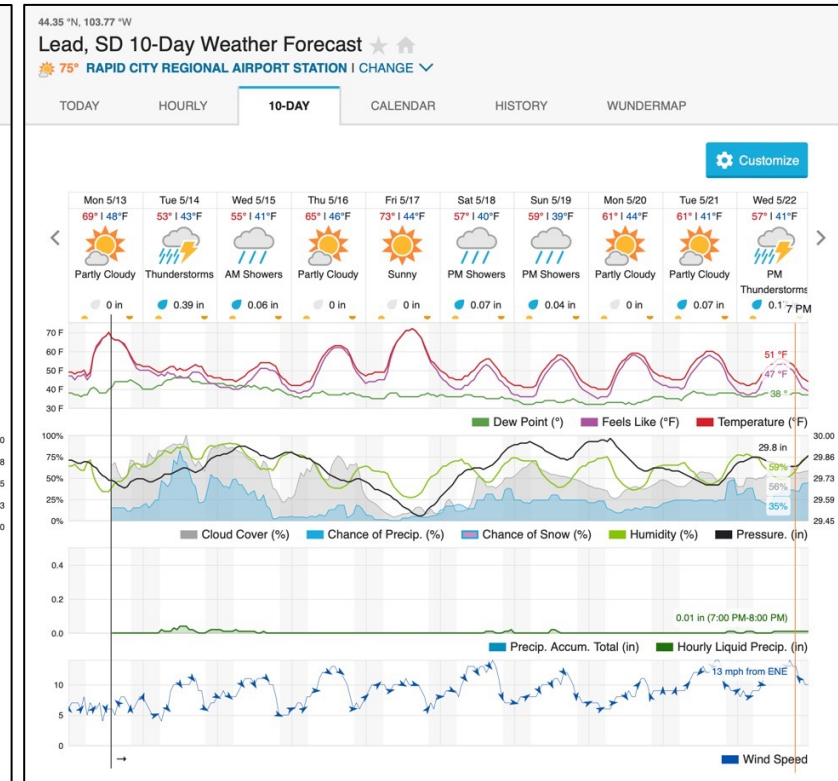
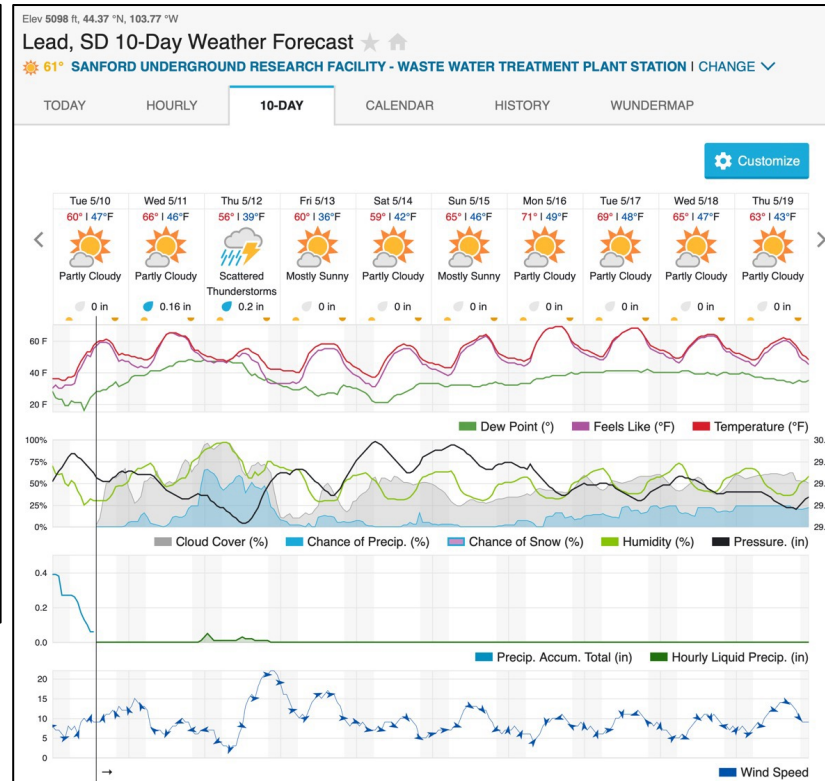
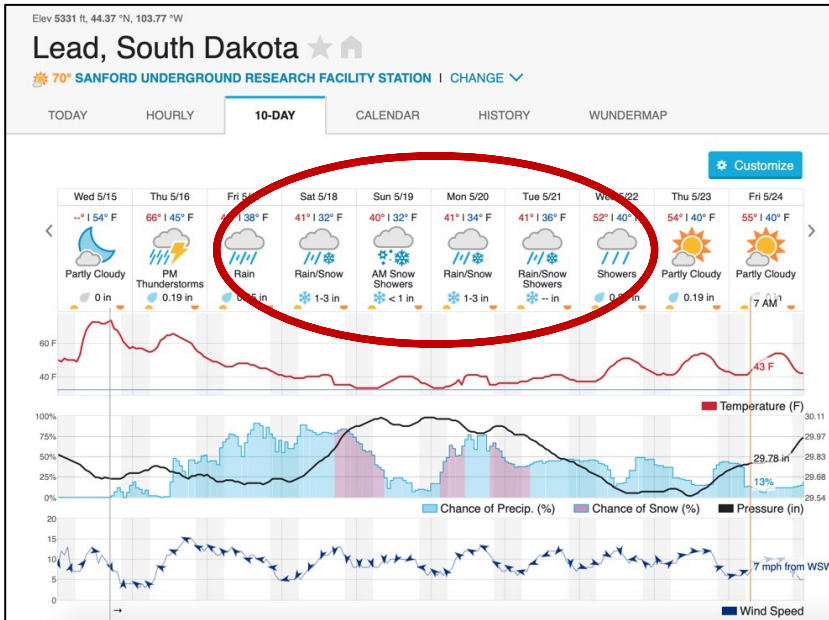
# Sanford Underground Research Facility

Welcome to South Dakota!

CoSSURF 2019  
May 15-17  
[Snow!]

CoSSURF 2022  
May 11-13  
[No snow!]

CoSSURF 2024  
May 14-16  
[No snow!]



# 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.

# SURF Science Program

## SURF serves a diverse community:

- Physics
  - Low-background environment to study rare processes
- Biology
  - Isolation from surface microorganisms
  - Variety of environmental conditions (temperature, humidity, etc)
  - Variety of niches (materials/rock geochemistry, water from different locations, trace gases, etc)
- Geology
  - Variety of geologic environments / rock formations (permeability, porosity, chemistry); also drill core archive
- Engineering
  - Real-world environments for technology development, mining, etc

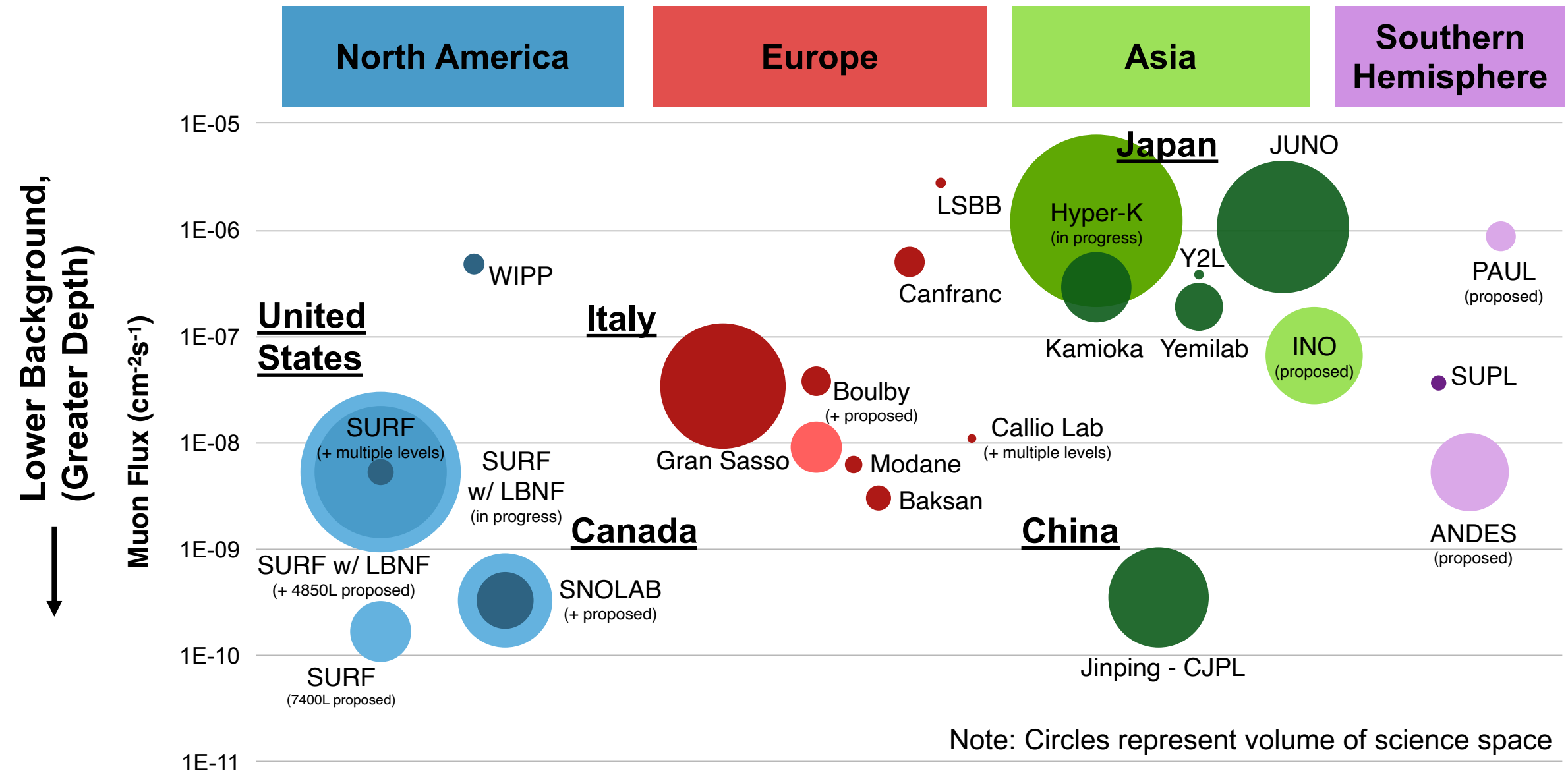


# Sanford Underground Research Facility

## Where in the world is SURF?

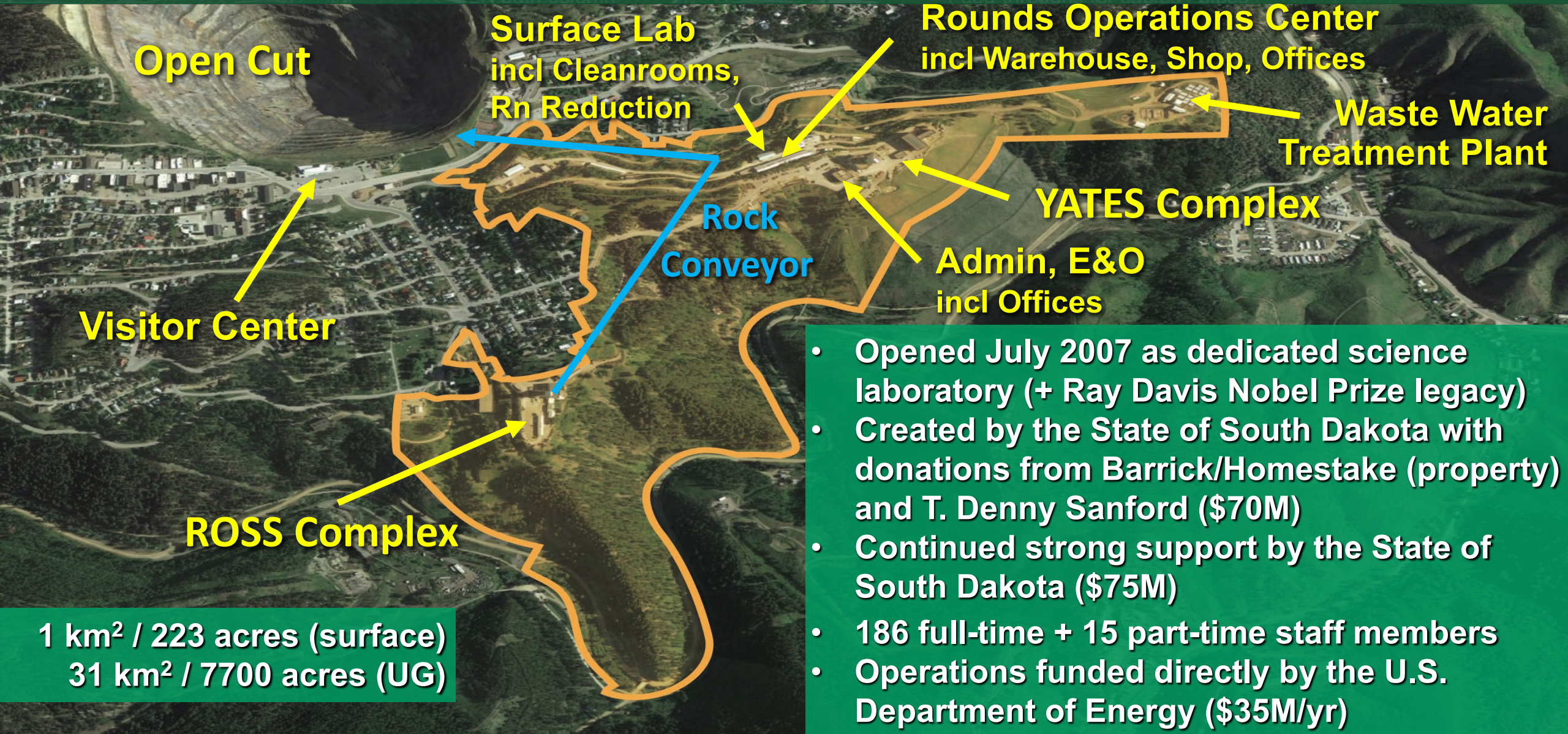


# SURF in the Global Context



# Sanford Underground Research Facility

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

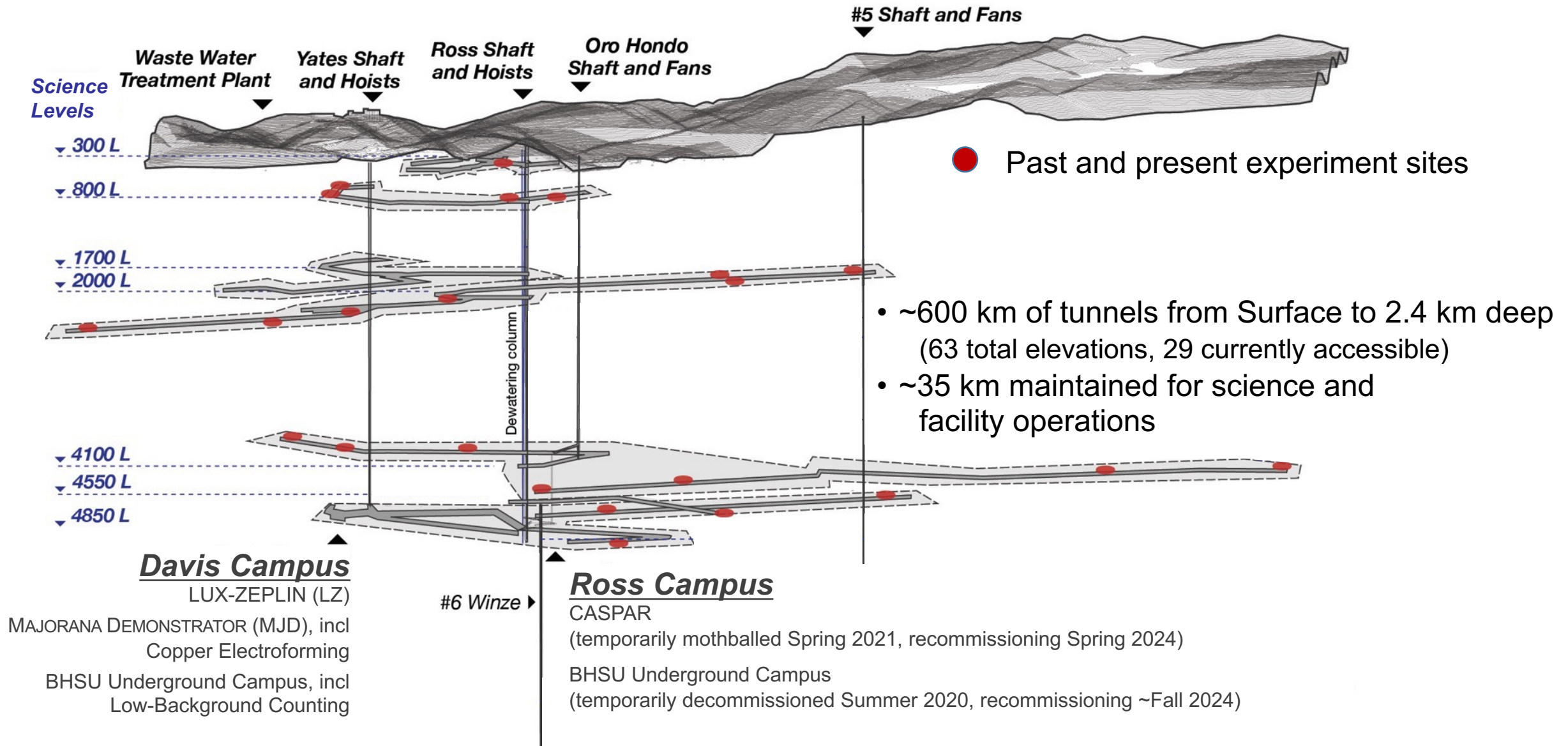


1 km<sup>2</sup> / 223 acres (surface)  
31 km<sup>2</sup> / 7700 acres (UG)

- Opened July 2007 as dedicated science laboratory (+ Ray Davis Nobel Prize legacy)
- 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)
- 186 full-time + 15 part-time staff members
- Operations funded directly by the U.S. Department of Energy (\$35M/yr)

# SURF Underground Lab Geography

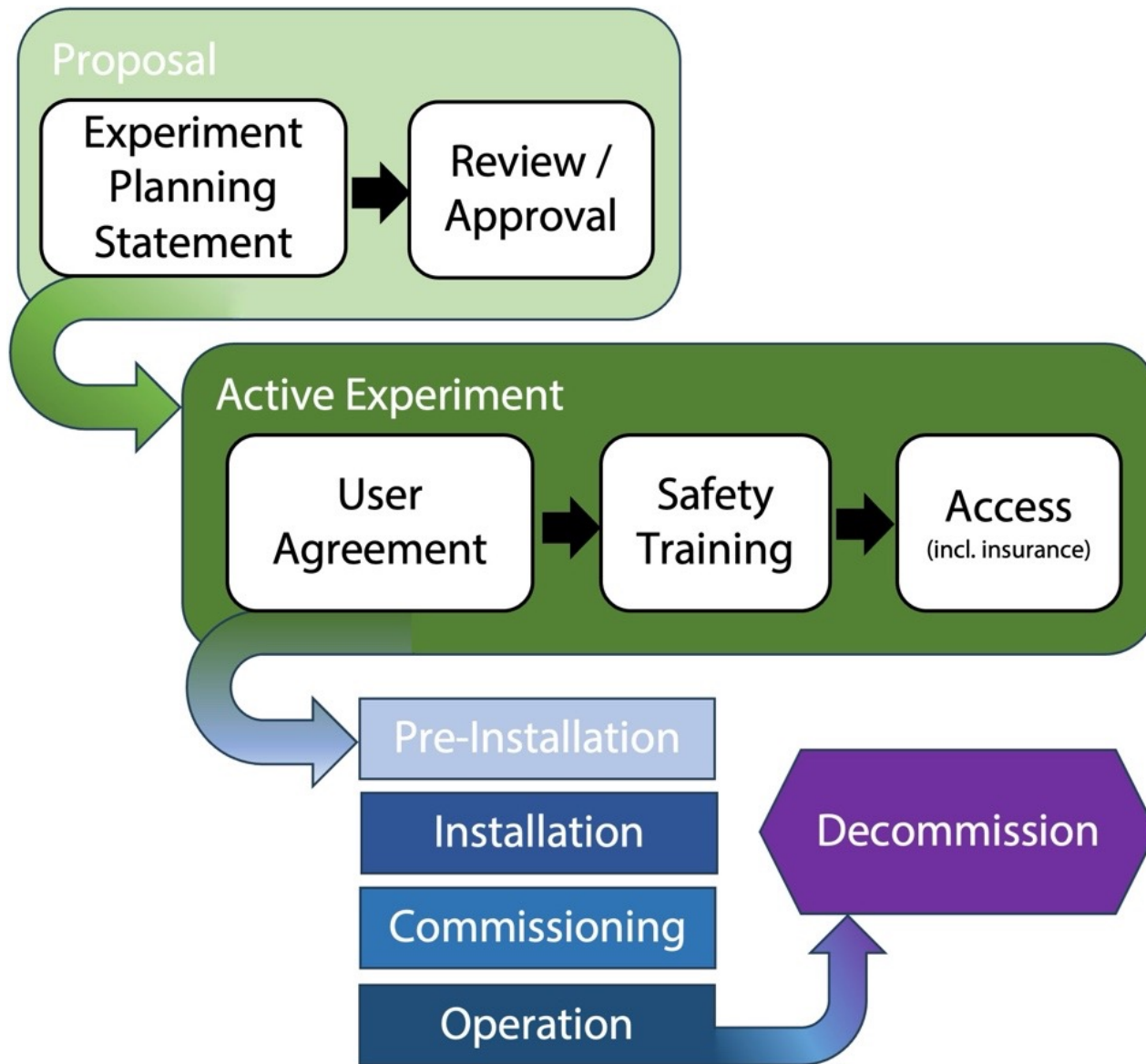
Yates & Ross Shafts + ventilation shafts, multiple levels for science





# 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's Research Proposal Guidelines webpage. The page title is "RESEARCH PROPOSAL GUIDELINES" and it states that all proposals must follow these guidelines. It lists researcher resources such as Proposal Guidelines, Science Liaison Office, SURF User Association, and Visitor information. A list of five steps is provided for the approval process, starting with reading the Experiment Implementation Program and ending with completing the User Agreement. A section for Proposal Documents lists various files with their sizes and formats, including Experiment Integration & Support.pdf, User Agreement.docx, Experiment Planning Statement.docx, User Agreement Acknowledgement.docx, Publication Guidelines.pdf, Acknowledgement of Risk and Waiver.pdf, and Experiment Implementation Program.pdf.

# SURF Organization – Science Staffing

Resources to enable safe and successful implementation of experiments



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

**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



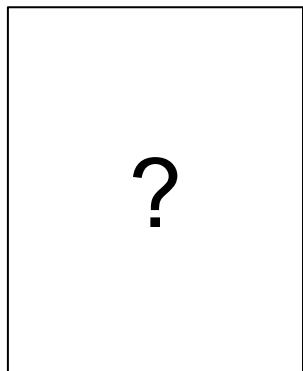
**Robyn Weis - Lab Custodians (Surface + UG) - Dee Espinosa**



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

**+ Many Others!**  
**Engineering, ESH, OPS...**

**TBD**  
*Support Associate*  
- Admin, User Association





**Dark Matter**  
LUX-ZEPLIN



**Neutrinos**  
MAJORANA DEMONSTRATOR  
LBNF /DUNE

**Science Program**



**Biology**  
Extreme Life  
Astrobiology



**Geology**  
Geothermal Energy  
Seismic Studies

# 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** 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

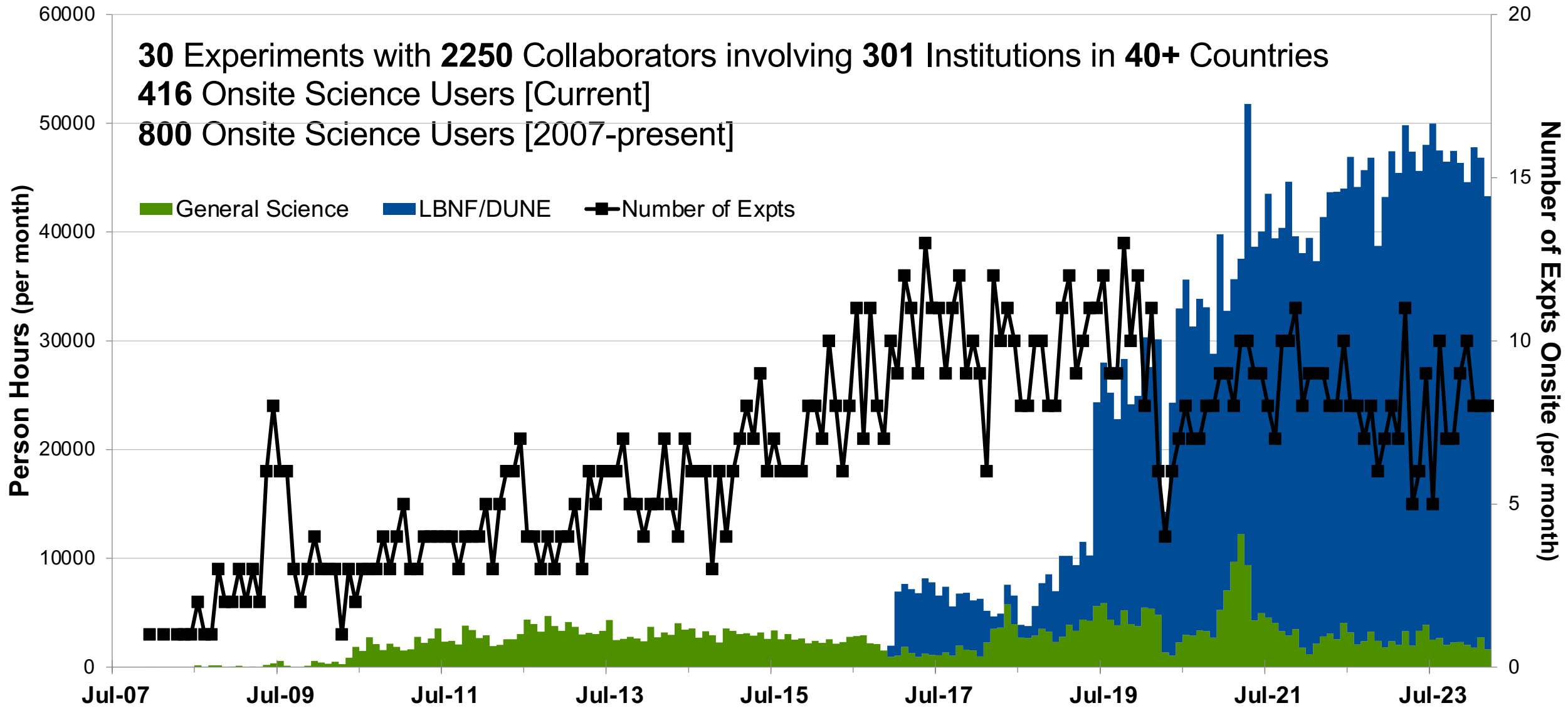
# SURF High-Impact Science

## 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).

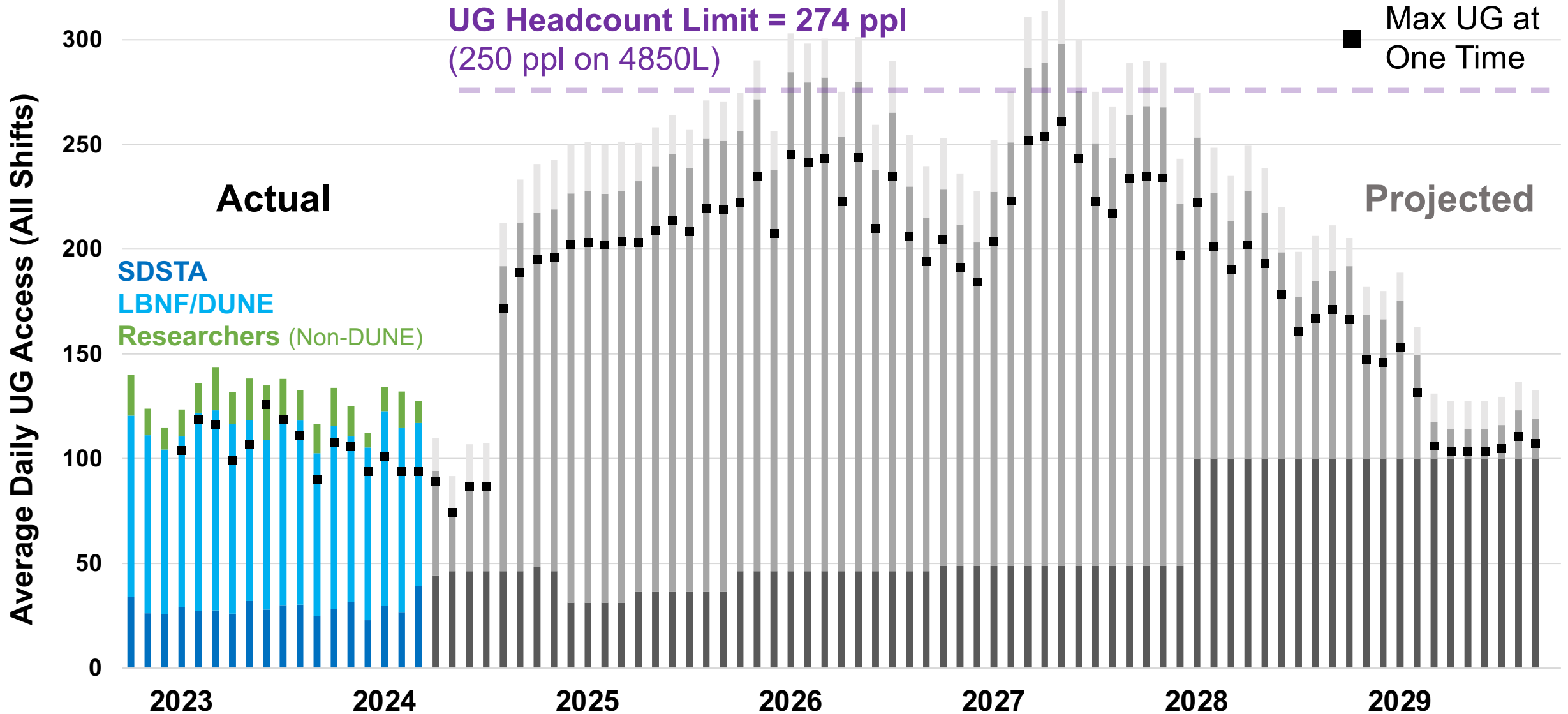
# SURF Science Program

Hosting world-leading experiments and researchers from diverse scientific communities



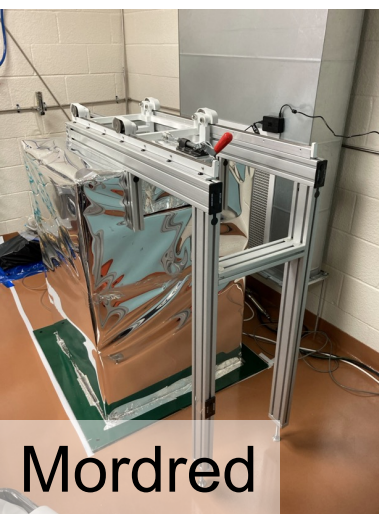
# SURF Average Daily Underground Access

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

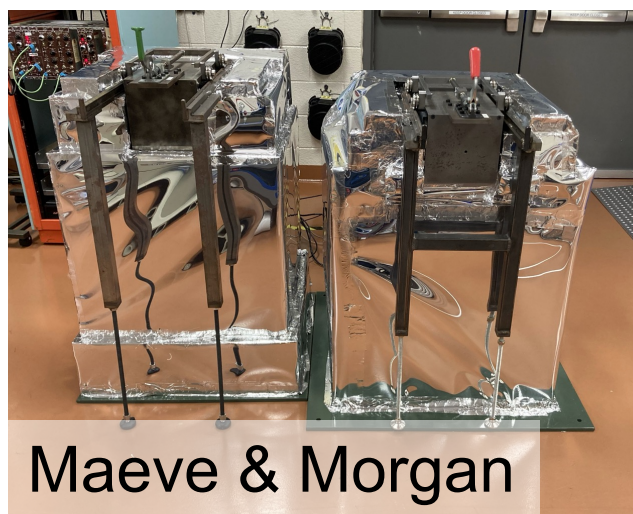


# SURF Material Assay at BHUC: Davis Campus

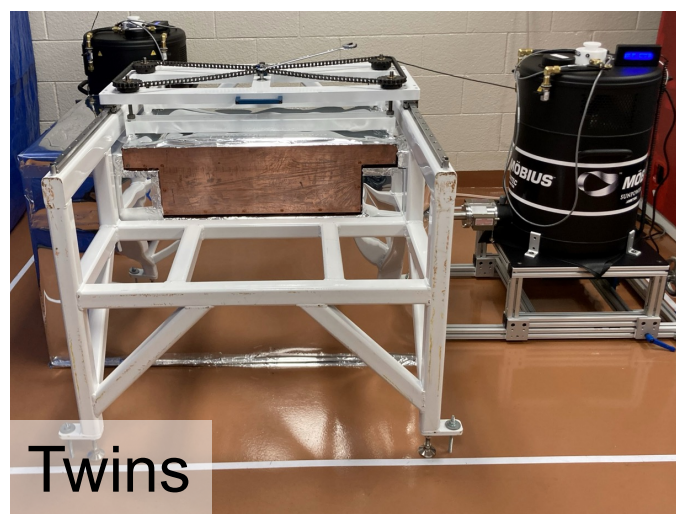
Low-background counting capabilities serving national & international community



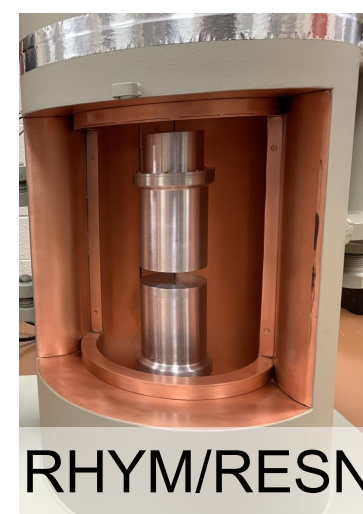
Mordred



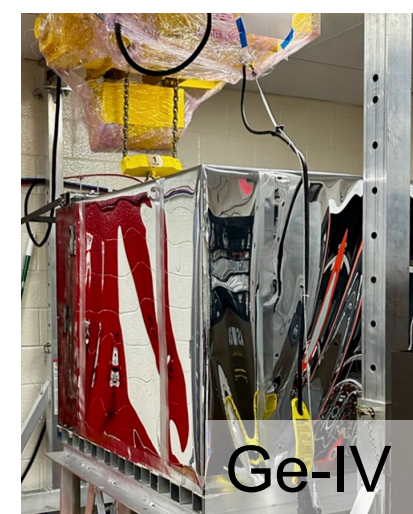
Maeve & Morgan



Twins



RHYM/RESN



Ge-IV



# SURF Material Assay at BHUC

Low-background counting capabilities serving national & international community

Detector	Crystal		[U] mBq/kg	[Th] mBq/kg	Install Date	Status	Comments
	Type	Size					
<b>Maeve</b> (BLBF)	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> (BLBF)	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, BLBF)	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> (BLBF, 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))	Operating until recently due to cryocooler issues	Vertical design, requires 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).

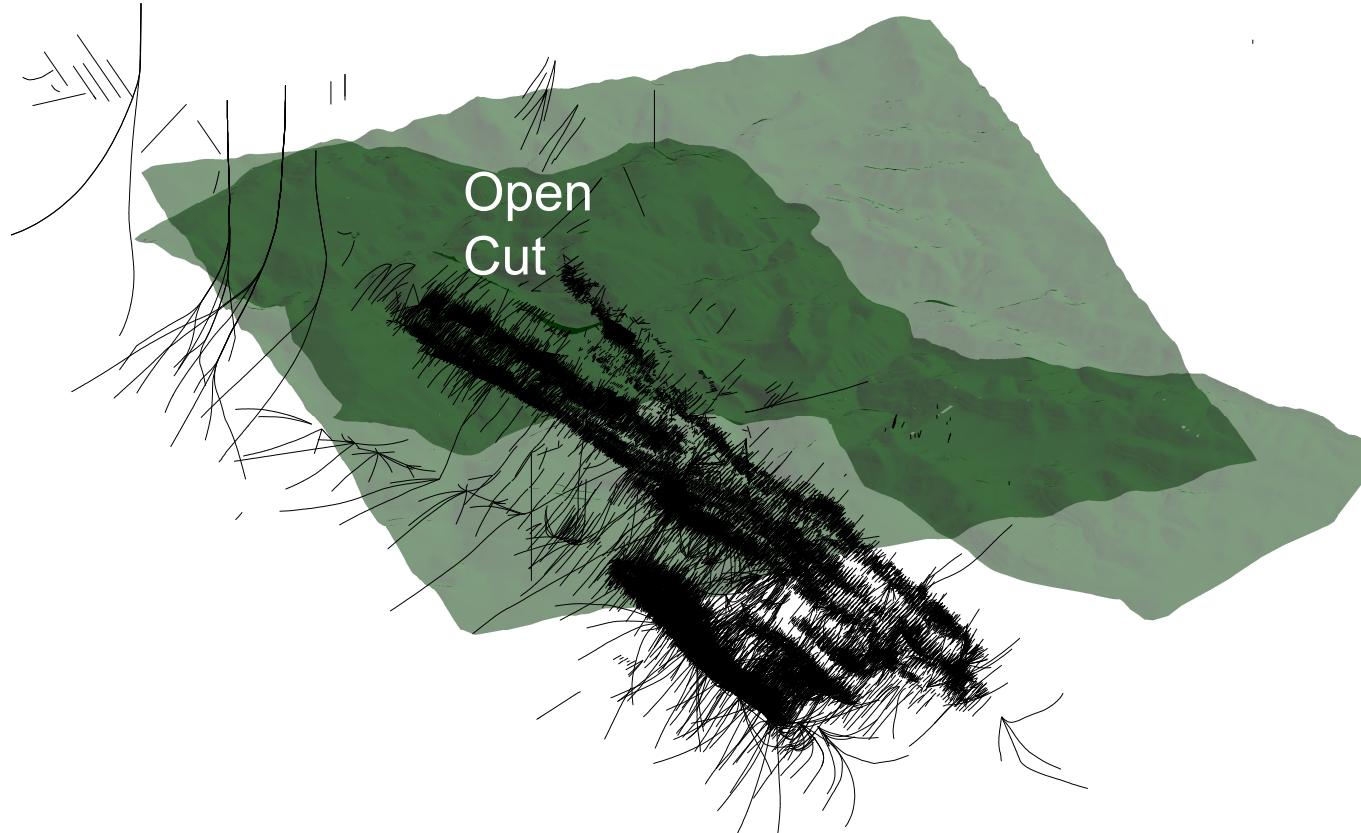
Also see: LZ Assay Paper <https://arxiv.org/pdf/2006.02506>

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 Opportunities – Drill Core

## Core repository

- Total of 27,870 drill holes (+ others) on Homestake property
- Portion of core retained and donated to SDSTA: 39,760 boxes of core for 2,688 drill holes (91 km!), SDGS initial help with stewardship
- SDGS database with 58,000+ entries, representing 1,740 drill holes:  
<http://cf.sddenr.net/homestake/>



# SURF User Association

<https://www.sanfordlab.org/researchers/surfuserassociation> (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 planned for CoSSURF (May 16, 2024).
- **Topical workshops**, incl community planning (e.g., Vision Workshop 2021). Next workshops 2024/2025.

The screenshot shows a detailed timetable for an event on May 16, 2024. The 'SURF User Association Meeting' is highlighted with a red circle. The meeting is scheduled for 14:00 at the Surbeck Center, SD Mines, and is presented by Frank Strieder. Other events include a lunch session from 12:00 to 14:00, a coffee break from 15:40 to 16:20, and several scientific presentations and workshops.

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

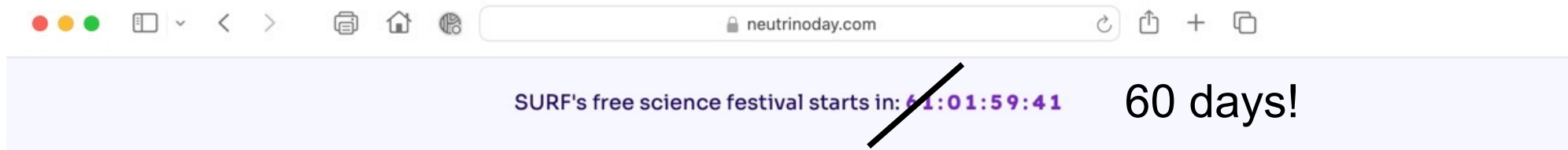
**May 16, 2024:**

SURF User Association Session During CoSSURF

<https://indico.sanfordlab.org/event/68/timetable/-20240516.detailed>

# Upcoming Events – Neutrino Day

July 13, 2024 (<http://www.neutrinode.com>)



The screenshot shows a web browser window with the URL [www.neutrinode.com](http://www.neutrinode.com). A light blue banner at the top of the page contains the text "SURF's free science festival starts in: ~~61:01:59:41~~ 60 days!". The timer is crossed out with a diagonal line, and the new count is "60 days!".

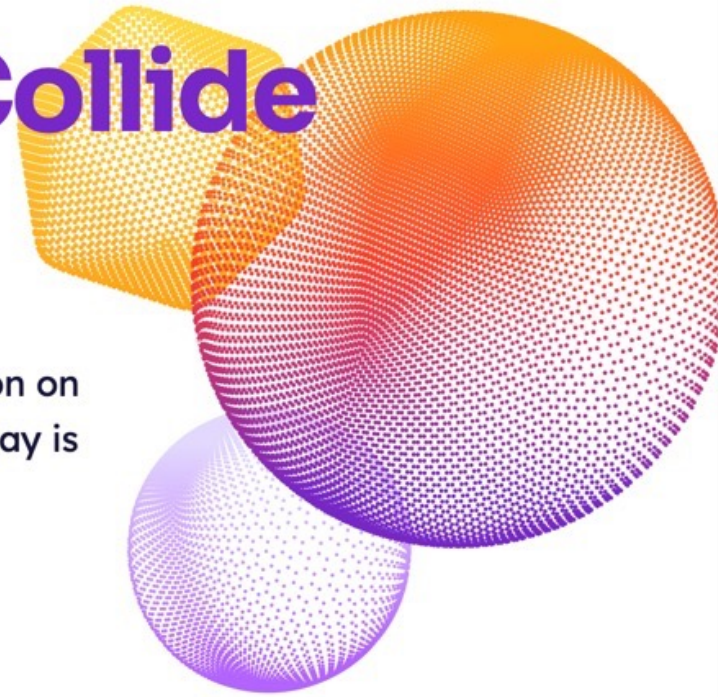


[About](#) [Neutrino Day 2024](#) [Get involved](#) [Volunteer](#) [News](#)

## Where Science & Fun Collide

**JUL 13 2024**  **Lead, South Dakota & Everywhere Else**

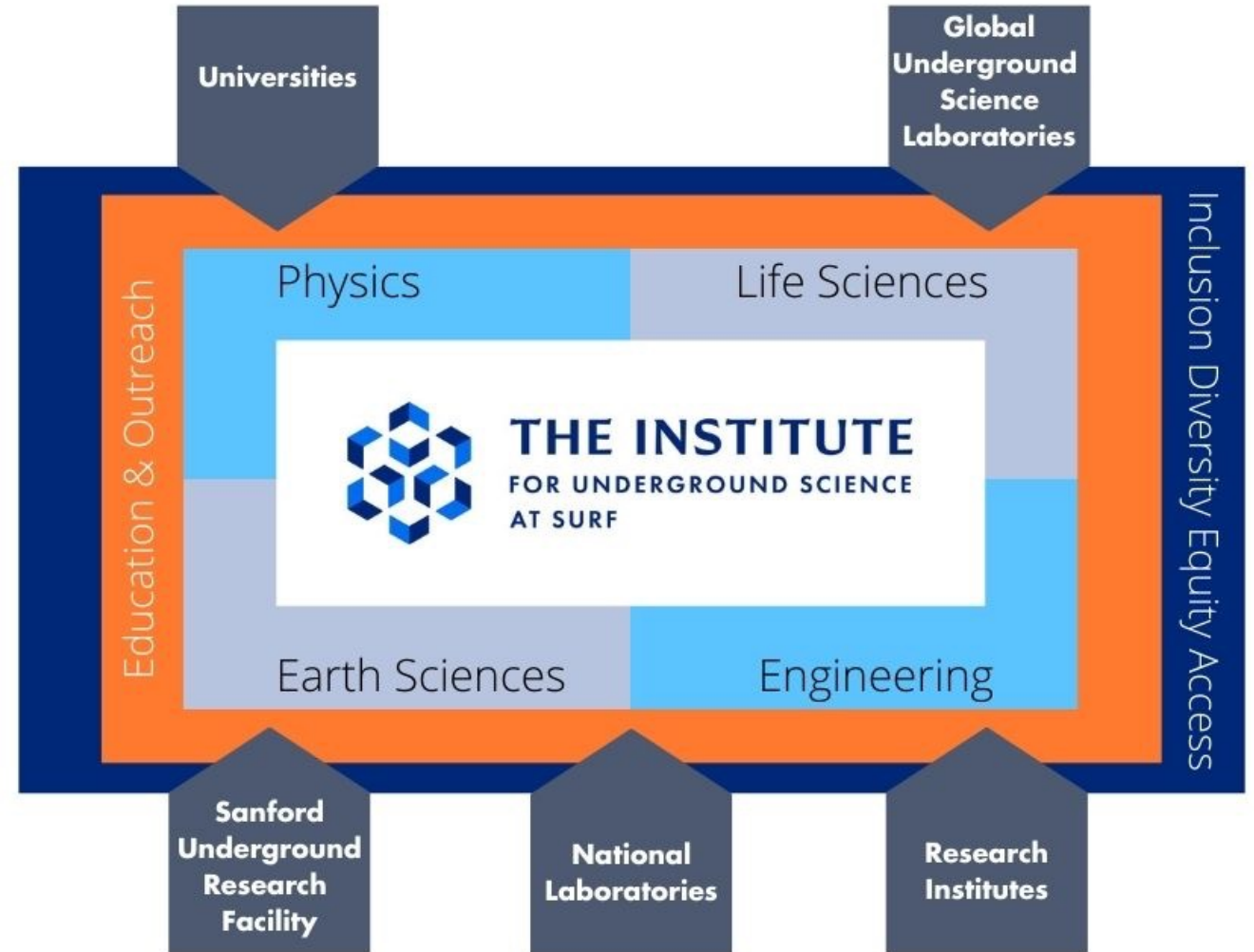
Mark your calendars for SURF's 16th annual Neutrino Day celebration on Saturday, July 13, 2024—we'll see you there! Planning for Neutrino Day is under way! Check back often for event updates.



# Institute for Underground Science at SURF

Kick-off held December 14, 2023

- Establish a world-leading center for underground science collaboration and intellectual community.
- Provide leadership in long-term science community planning.
- Engage with the global community for vision and leadership in a range of disciplines.
- Serve as a “hub” for information on global underground science.
- Foster close collaboration and integration with the science and outreach programs.
- Establish world-leading programs in K-12 and public Education & Outreach.



# Upcoming Events – Workshops

The screenshot shows the Indico event page for CETUP\* 2024. The page title is "CETUP\* 2024" and the dates are "17 June 2024 to 19 July 2024" at "Lead/Deadwood Middle School". The mission statement is: "To promote organized research in physics, cosmology and astrophysics, geoscience, and other fields related to science done in underground laboratories worldwide via individual and collaborative research in a dynamic atmosphere of intense scientific interactions." The page lists previous workshops from 2011 to 2023, including topics like Dark Matter, Neutrino Physics, and Grand Unification. A sidebar on the left contains navigation links such as "Overview", "Call for Abstracts", "Registration", and "Organizing Committee".

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

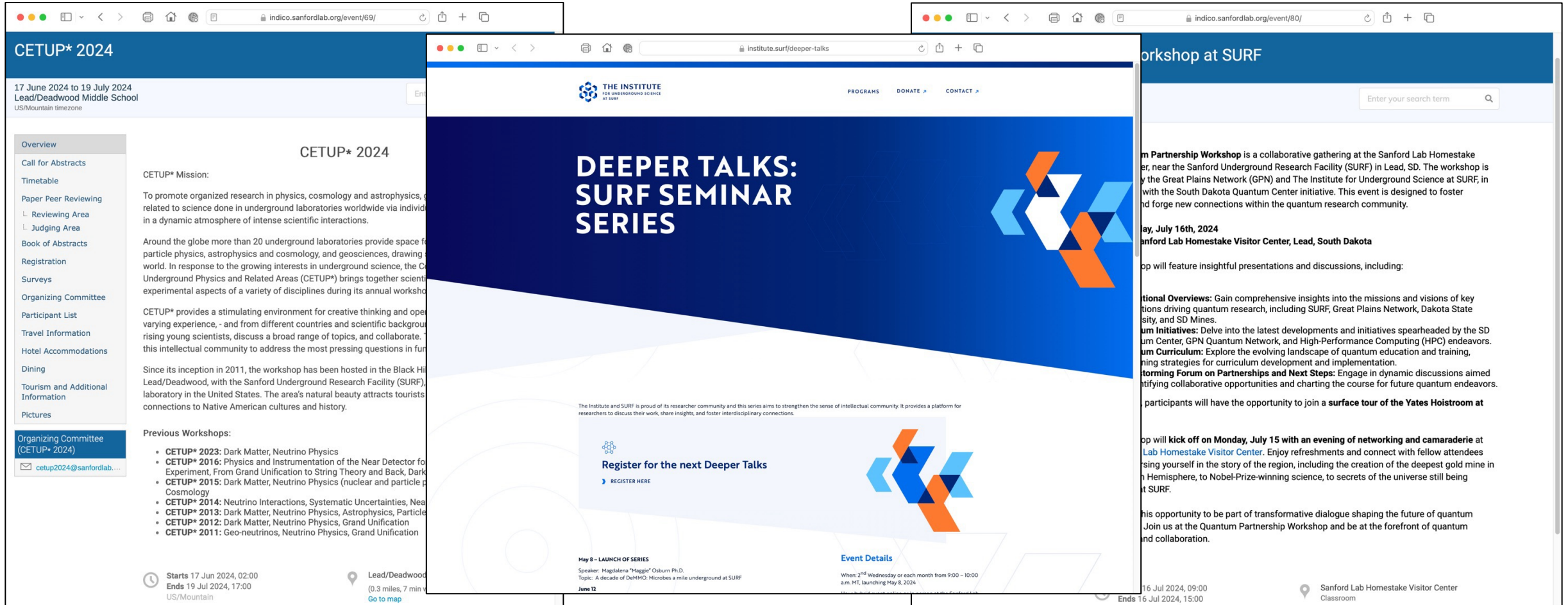
<https://indico.sanfordlab.org/e/CETUP2024>

The screenshot shows the Indico event page for the Quantum Partnership Workshop at SURF. The page title is "Quantum Partnership Workshop at SURF" and the date is "16 July 2024" at "Sanford Lab Homestake Visitor Center". The description states: "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." The date is "Tuesday, July 16th, 2024" and the location is "Sanford Lab Homestake Visitor Center, Lead, South Dakota". The page lists key features like "Institutional Overviews", "Quantum Initiatives", and "Quantum Curriculum". A sidebar on the left contains navigation links such as "Overview", "Registration", and "Stacie Granum".

**Jul 16, 2024:**  
**Quantum Partnerships Workshop**

<https://indico.sanfordlab.org/event/80>

# Upcoming Events – Workshops



**Jun 17-Jul 19, 2024:**  
**CETUP\* 2024**  
<https://indico.sanfordlab.org/e/CETUP2024>

**Monthly Seminar Series**  
<https://institute.surf/deeper-talks>

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

# SURF Long-Term Goals

**By 9/30/2035, SURF will have world-leading multi-disciplinary experiments in operations with proposed experiments actively competing for newly developed underground laboratory space including:**

1. The Long-Baseline Neutrino Facility (LBNF) and Deep Underground Neutrino Experiment (DUNE) have been constructed and are fully operational.
2. Yates Shaft and Hoists have been fully reconstructed and modernized.
3. Two additional large lab modules on the 4850L have been constructed and are fully operational.
4. The Institute for Underground Science at SURF has been constructed and is fully operational with compelling, vibrant science and education programs.
5. Foster commercial partnerships to advance technology development in the region, increase facility operations efficiency and safety, and expand workforce development opportunities.



# 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

DRAFT Report of the 2023 Particle Physics Project Prioritization Panel

A strategic plan for the High Energy Physics Advisory Panel

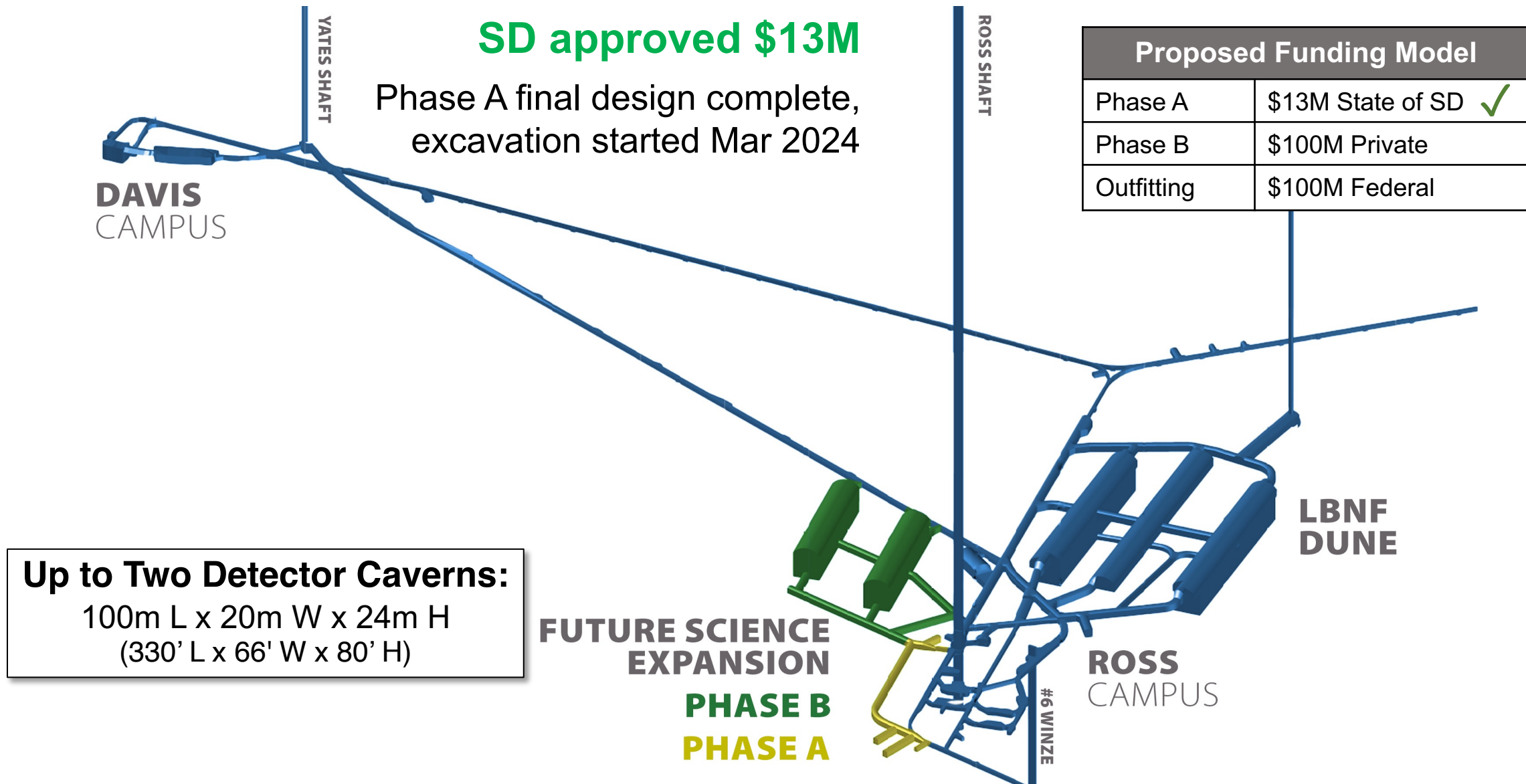
## 2023 P5

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

# 4850L Space Needed for Future Experiments

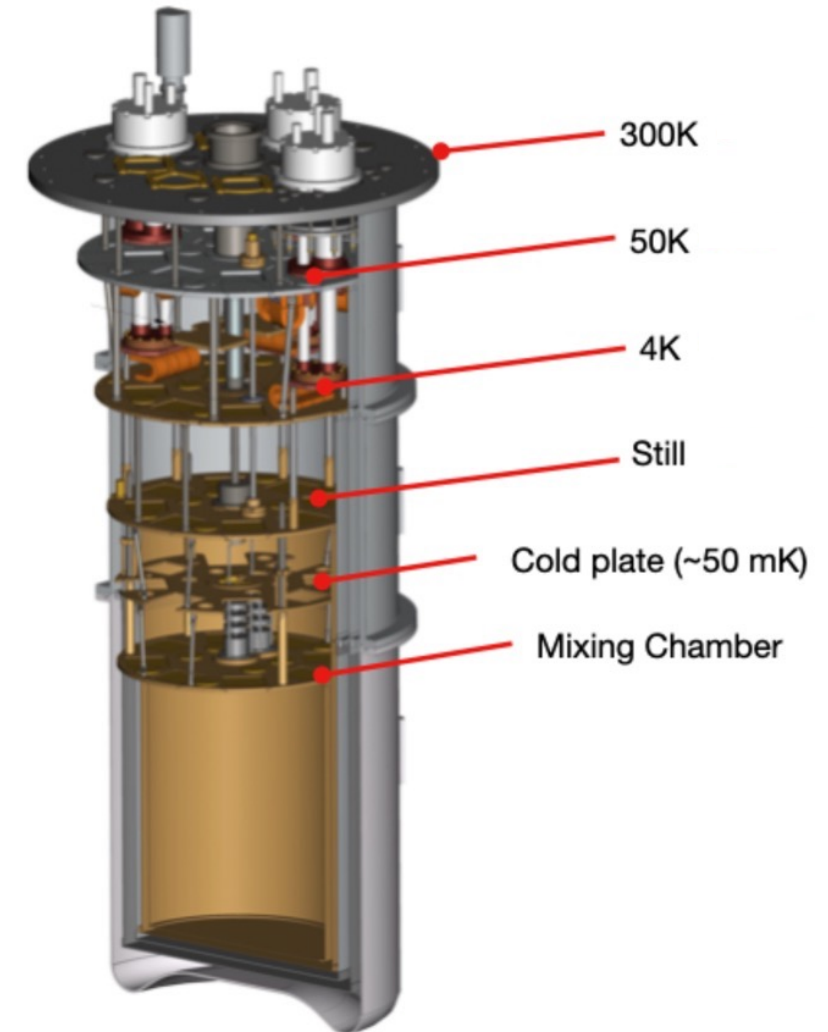
U.S. strategic plan requires more space, community has endorsed expansion



# SURF Cryogenic User Facility

## Preliminary step to becoming national 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
- **Need for Cryogenic User Facility at SURF:**
  - **No deep underground cryogenic test facility in U.S.** (generally, shortage of underground cryogenic test infrastructure in U.S.)
  - Due to strategic scientific value, many **other countries operate cryo facilities** (Europe, Canada) or are planning to build them (several countries in Asia)
  - **Significant interest from U.S.-based groups:** low-mass dark matter (TESSERACT, SPLENDOR), neutrinoless double-beta decay (CUPID), quantum information systems (MIT, UIUC)



# SURF Call for Letters of Interest

## Ensuring SURF used to its fullest scientific potential

### Significance:

- First formal call to UG science community since March 2008! (Note: 2008 call strongly leveraged earlier 2005 call for LOIs)
- Initial calls selected strong physics anchors for Davis Campus: MJD and LUX (which led to current LZ)
- 2024 call is opportunity for SURF to refine science strategic plan development currently underway

### Summary:

- 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: 100m L x 20 m W x 24 m H, LOIs and subsequent discussions will inform final design)
- Submissions will be reviewed by SURF Science Program Advisory Committee
- Deadline for LOIs (+ EPS): **Fri May 17, 2024 at 11:59 PM MT**



South Dakota Science and Technology Authority 630 E. Summit St. Lead, SD 57754

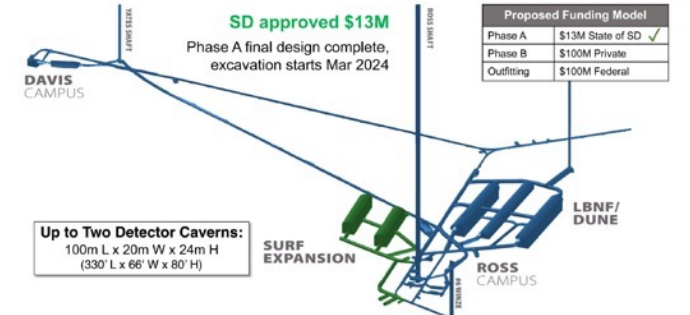
March 22, 2024

#### 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.



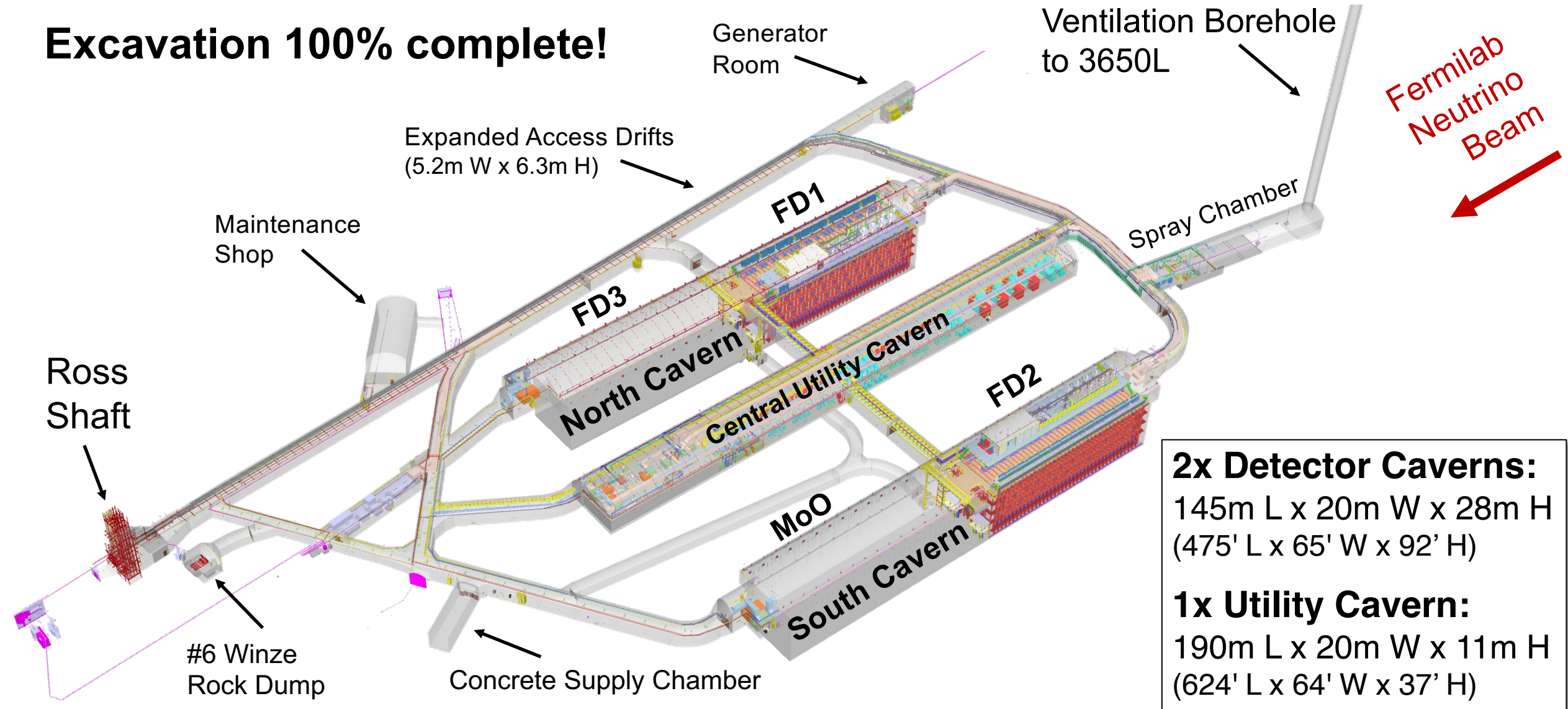
Leading into recent U.S. long-range planning, the SURF User Association held a Vision Workshop (<https://indico.sanfordlab.org/e/Vision2021>) and SURF participated in nuclear physics town halls and the particle physics Snowmass community input processes. As a result, SURF featured prominently in the 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>.

# Long-Baseline Neutrino Facility (LBNF)

LBNF will host the Deep Underground Neutrino Experiment (DUNE)

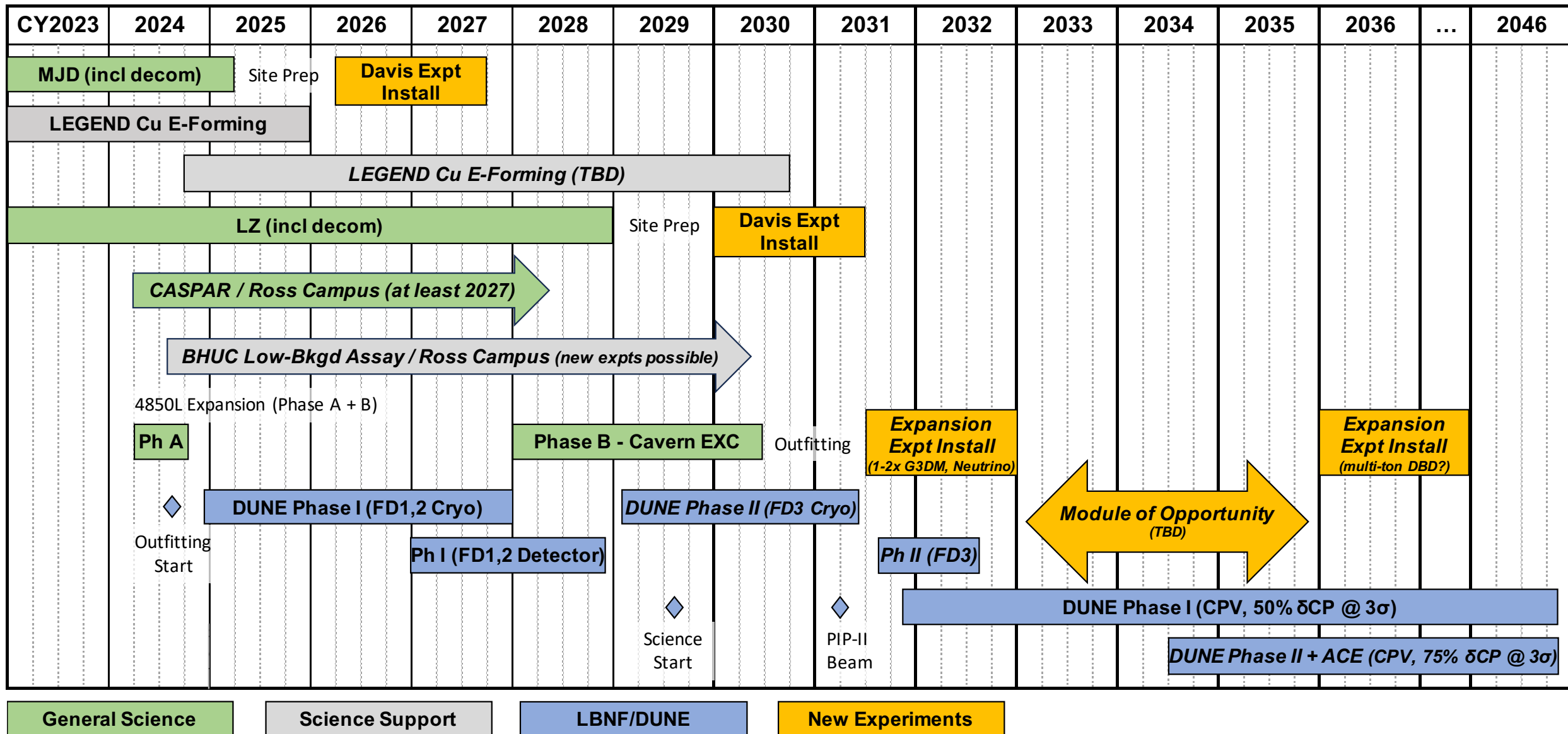
**Excavation 100% complete!**





# 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 ensures **safety and reliability**.
- SURF offers world-class service to the underground science community:
  - SURF breadth and depth enables **diverse and transformational science**.
  - SURF has attracted **world-leading** experiments and scientists from **diverse scientific communities**.
  - SURF has **proven track record** of enabling experiments to deliver high-impact science.
  - **LBNF/DUNE is SURF's top priority**.
- SURF wants to host other future world-leading experiments:
  - All existing and near-term lab space at SURF is **fully subscribed**.
  - Leveraging LBNF/DUNE excavation contractor offers **significant development advantages**.
  - SURF is preparing to **increase underground laboratory space**, plans advancing for new large caverns on 4850L (1500 m, 4100 mwe) on **timeframe of next-generation experiments (~2030)**.
- SURF is playing a strong role in the UG science community:
  - **User Association** serving as catalyst for community discussions and will leverage for future planning.
  - **Strong community support** endorsing more space at SURF (Vision Workshop 2021, Snowmass 2021/2022).
  - **Strong recognition** and support for SURF in recent **P5 report for U.S. strategic planning**.



# Sanford Underground Research Facility

Thank You!



# 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 (TESSERACT, HydroX), next-generation WIMP (XLZD, Argo), other (CrystaLiZe)
  - Neutrino: Water-based liquid scintillator (Theia), Beyond-ton-scale  $0\nu\beta\beta$ , etc
  - QIS, gravitational waves/atom interferometry, etc

## Facility:

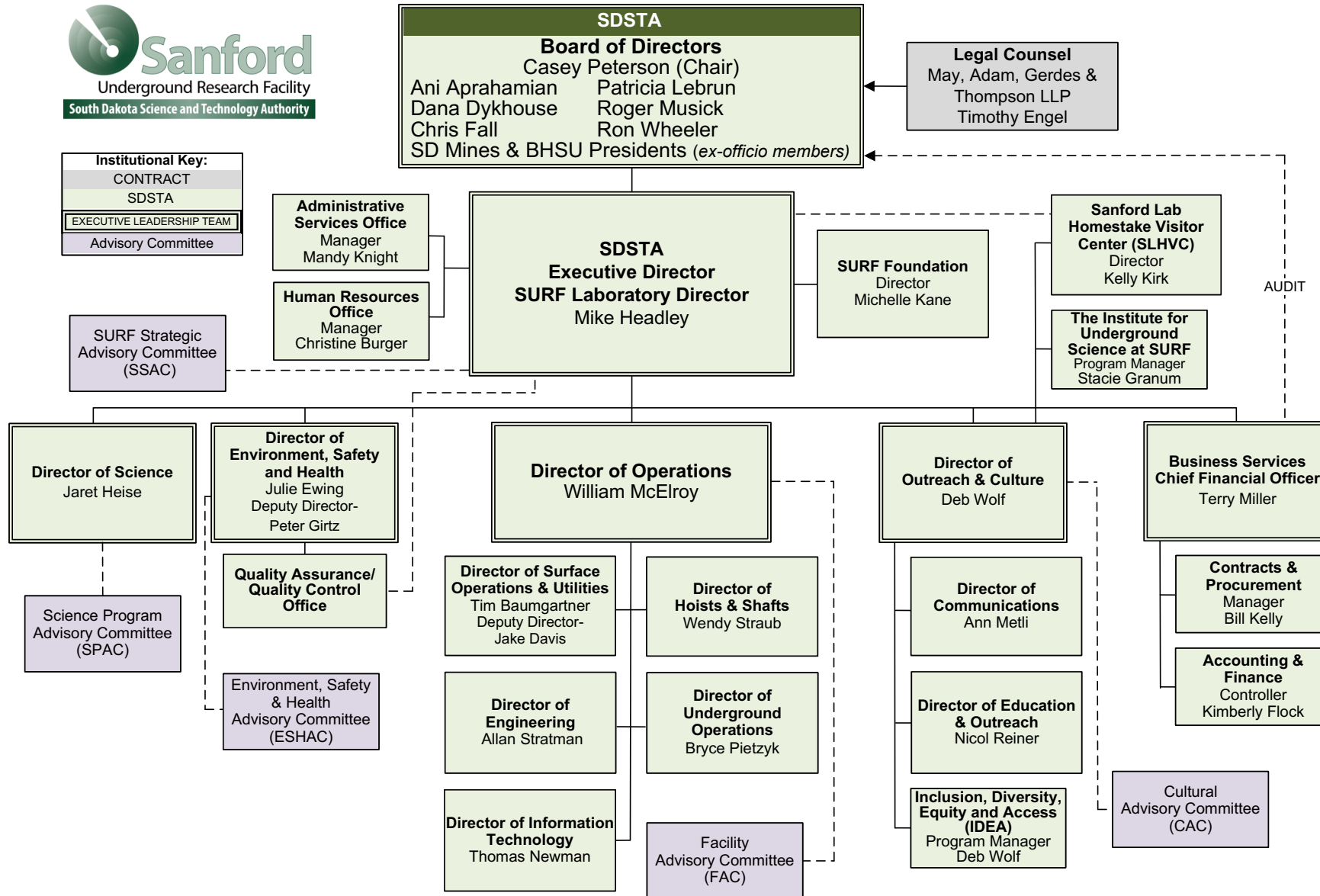
- **4850L Existing:** Re-open Ross Campus in 2024 (CASPAR, BHUC labs temporarily closed due to LBNF)
- **4850L Construction:** LBNF/DUNE (excavation 100% complete, science starts mid-2029)
- **4850L Expansion:** Up to 2x caverns (100m L x 20m W x 24m H), develop in 2 phases (funding for first phase in-hand), excavation complete by ~2030
- **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)
- **Depth:** Deepest lab in U.S. Main UG level = 4850L (1490 m, 4300 mwe), muon flux =  $5.31 \times 10^{-5}$   $\mu/\text{m}^2/\text{s}$ . 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 = 300 Bq/m<sup>3</sup>, gamma = 1.9  $\gamma/\text{cm}^2/\text{s}$ , neutron =  $1.7 \times 10^{-2}$  n/m<sup>2</sup>/s.
- **Utilities:**
  - Power = 24,000 kW capacity (20,000 kW available now, 15,000 kW in FY27); Standby = 3 diesel generators (390 kW)
  - Chilled water (2x 246 kW), purified water (37.8 lpm), compressed air (up to 1100 scfm, 140 scfm at Davis Campus)
  - Network = 20 Gbps internally, 10 Gbps externally (100 Gbps planned). WiFi available surface + underground.

# SDSTA Organization Structure



# SURF's Road to Multi-Disciplinary Science

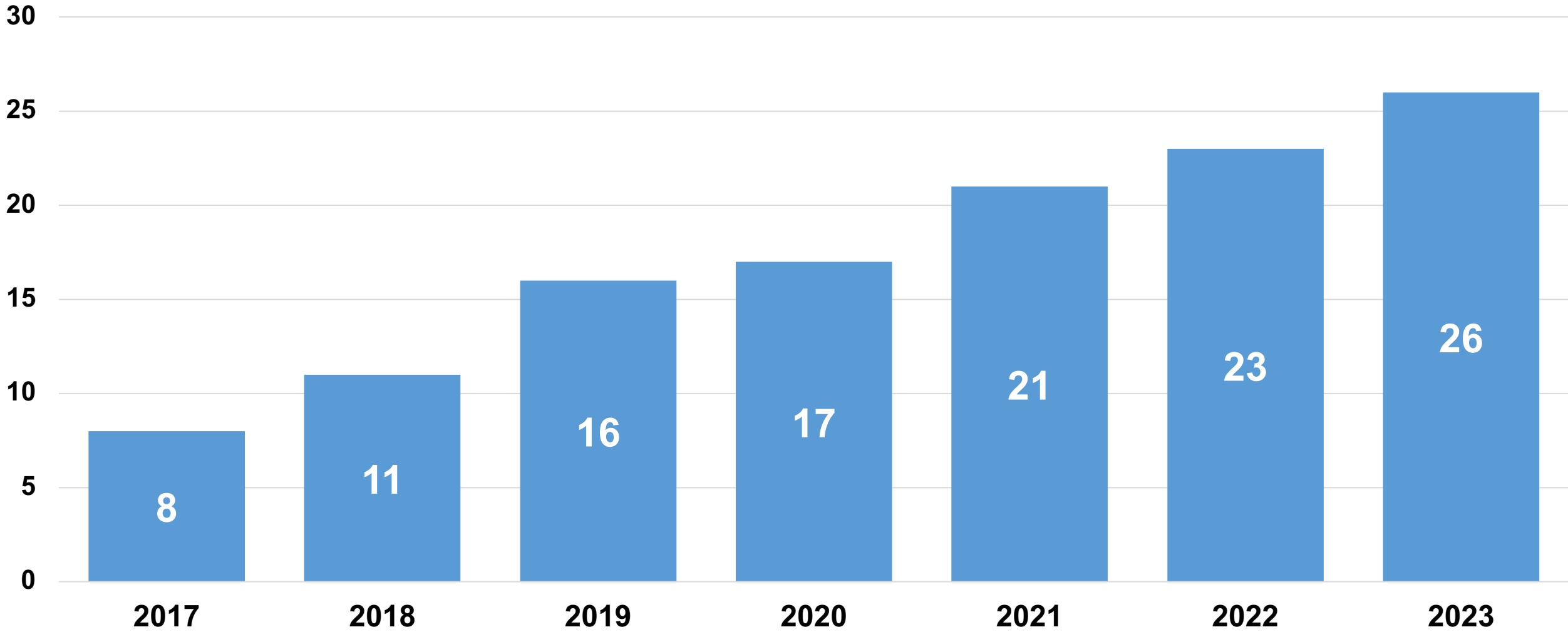
## Broad science program right from the start

- South Dakota and Black Hills Roots:
  - **Agriculture** is largest economic sector in state, many universities have strong biology departments & faculty
  - Locally, Black Hills region has strong ties to **mining/geology**; leveraged some industrial connections, also some early biology sampling during Homestake operations
  - Geographically near other interesting sites (e.g., Yellowstone National Park, well-known to researchers)
- DUSEL Roots:
  - Funding strategy for national UG lab was via National Science Foundation with **broad science mandate**
  - Strong leadership from U.S. national laboratory, LBNL, with **multi-disciplinary science portfolio**
- SURF Opportunities:
  - Significant footprint with access to **variety of environments** (range of temperature and humidity, rock formations/materials, water, depth, etc)
  - Drill core **repository**, access to underground **drill holes** (and **expertise** to modify), areas of **isolated water**
- SURF Multi-Disciplinary Science:
  - Biologists on SURF User Association (incl recent chair) and Science Program Advisory Committee
  - Planning at least one biology/geology Research Scientist hire in next 2 years
  - SURF Vision Workshop 2021: “No one has successfully created a true multi-disciplinary underground lab.”  
**SURF [and other laboratories] aspire to this goal!**

# SURF Science Program

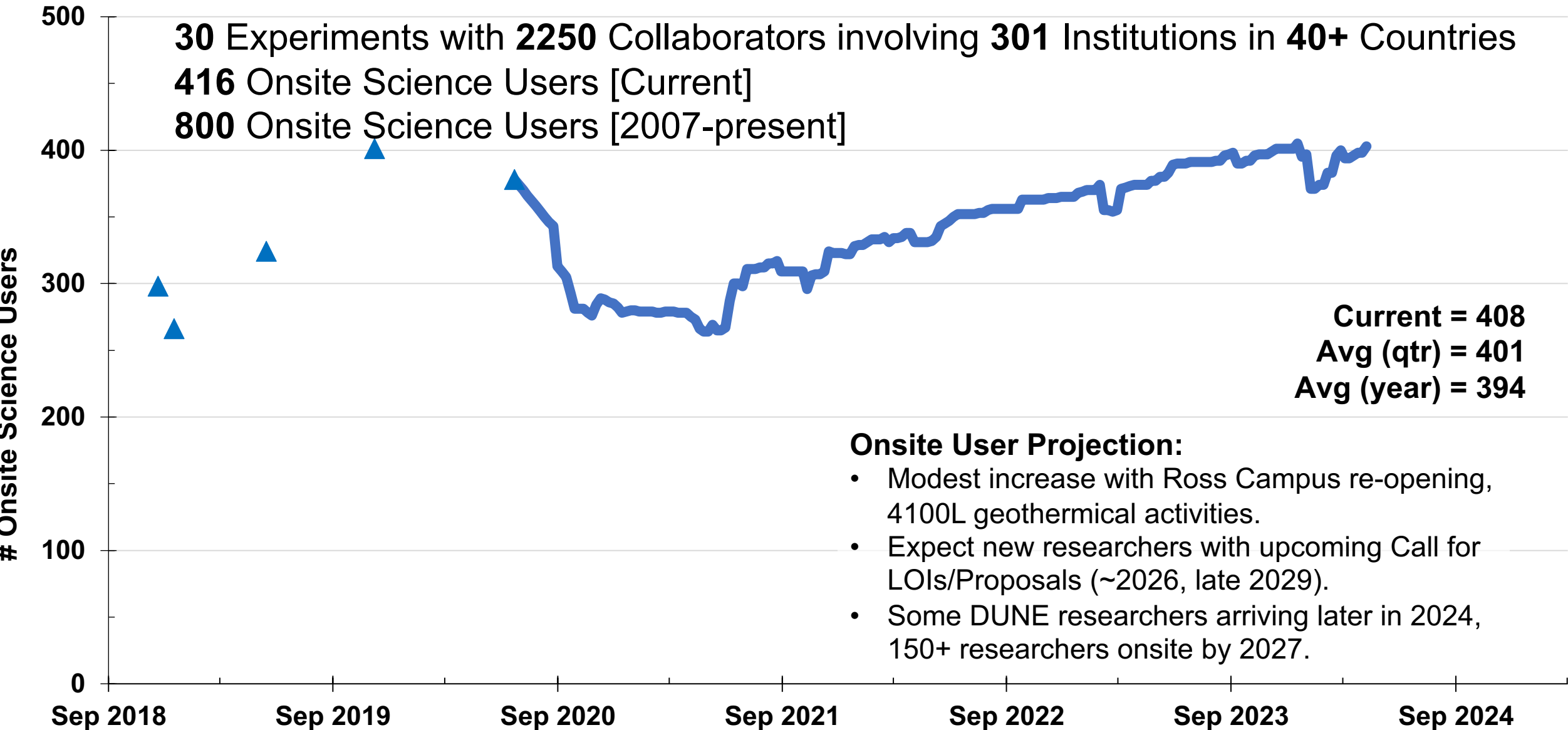
Hosting world-leading experiments and researchers from diverse scientific communities

## SURF Expressions of Interest



# SURF Onsite Users

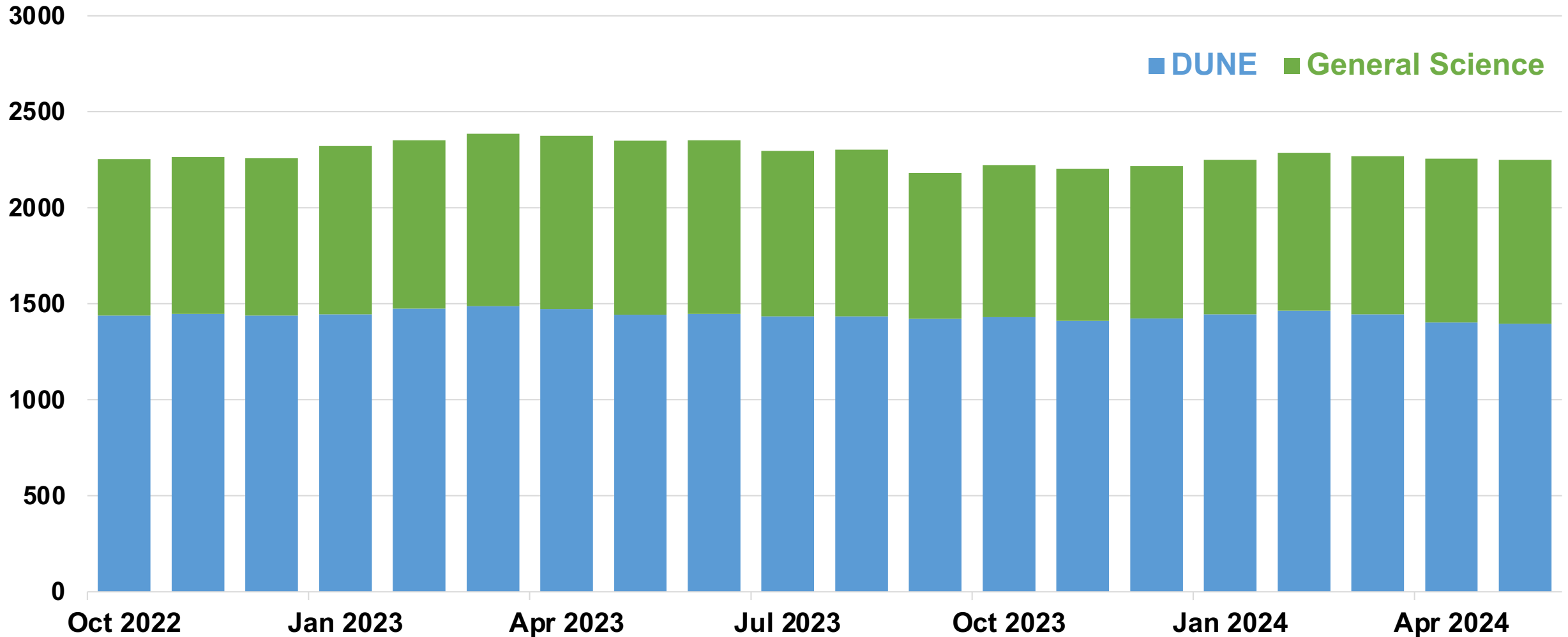
Opportunity for more engagement with UG science community



# SURF Science Program

Hosting world-leading experiments and researchers from diverse scientific communities

## SURF Collaborator Trend





# Sanford Underground Research Facility

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



Ross Shaft

Yates Shaft



Administration Bldg



Rounds Operations Center

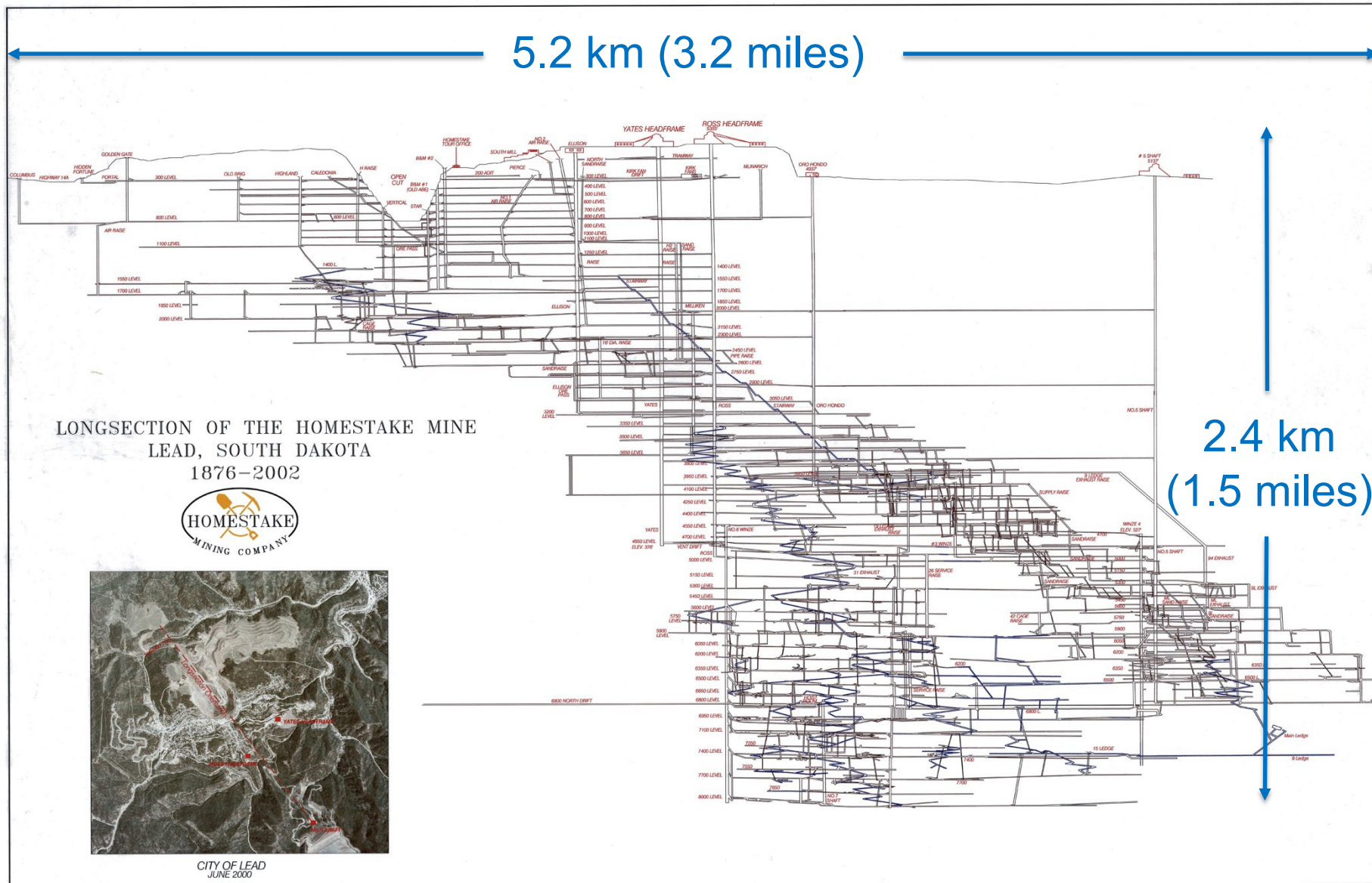
Surface Lab + RRS



Yates Hoistroom

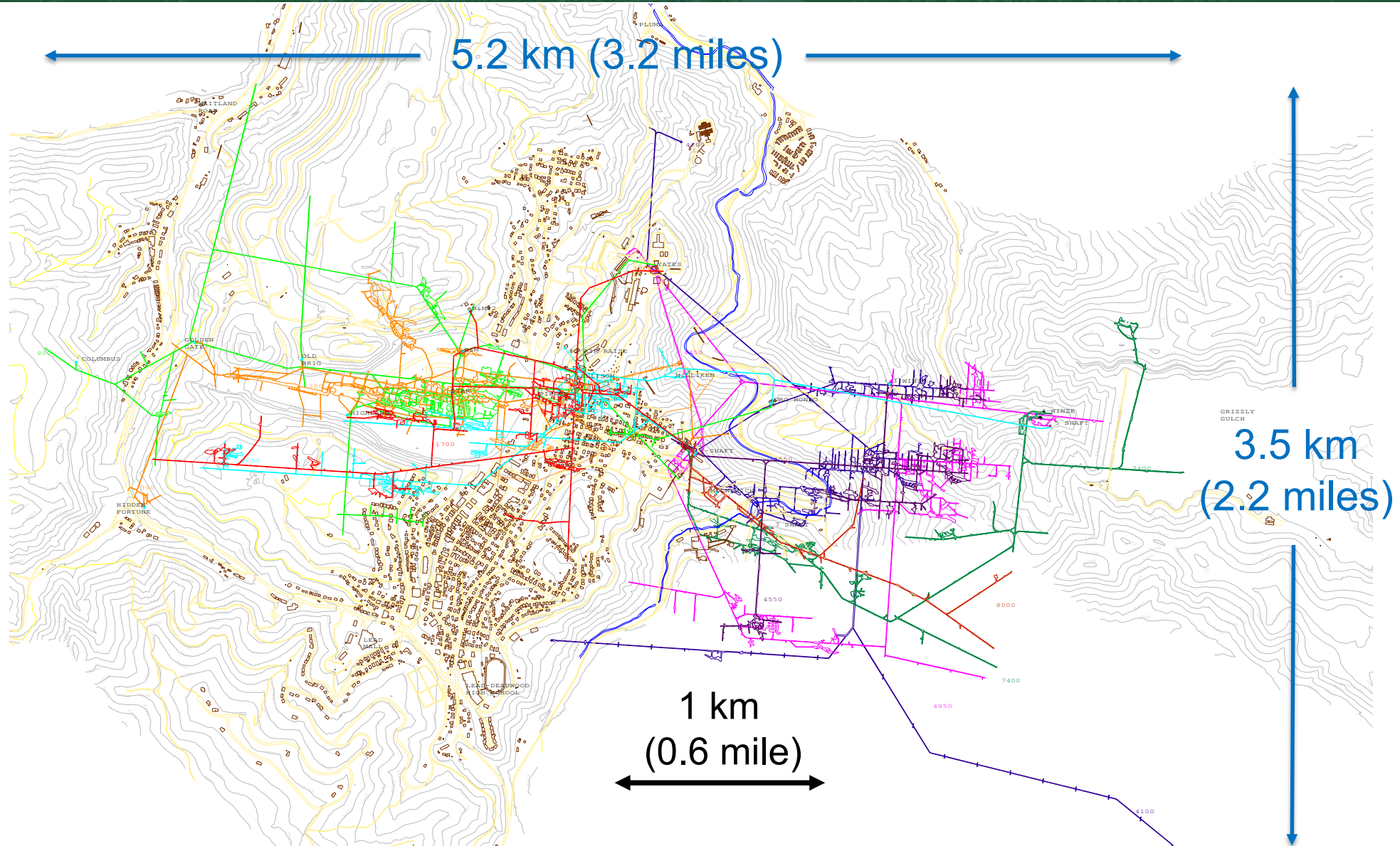
# SURF Underground Lab Geography

Significant underground footprint for science



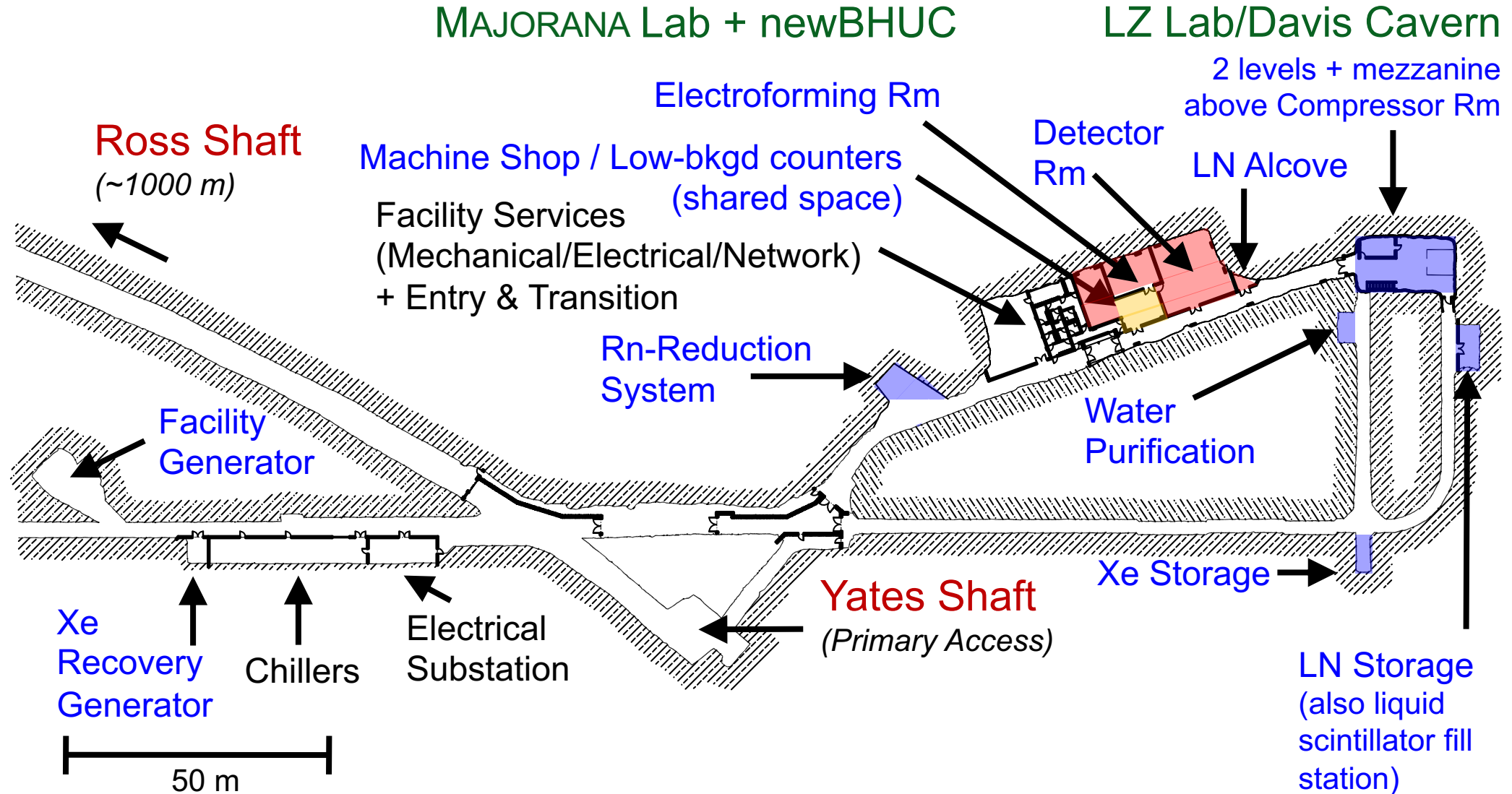
# SURF Underground Lab Geography

Significant underground footprint for science



# 4850L Davis Campus

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

Sanford Underground Research Facility



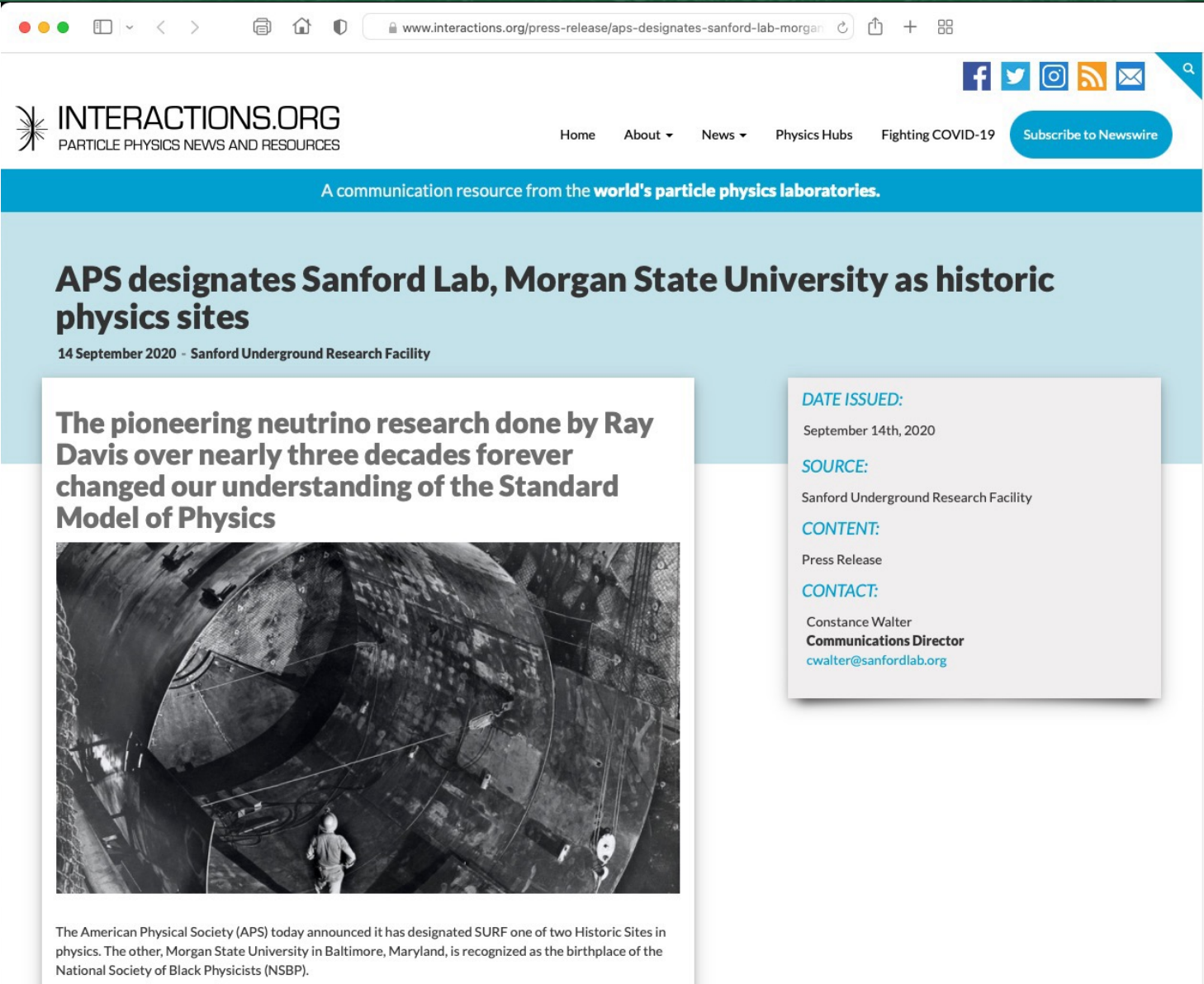
### Davis Cavern, Lower (LZ):

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

SURF Overview | May 2024

# 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


Home About News Physics Hubs Fighting COVID-19 [Subscribe to Newswire](#)

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 National Society of Black Physicists (NSBP).

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

**SOURCE:**  
Sanford Underground Research Facility

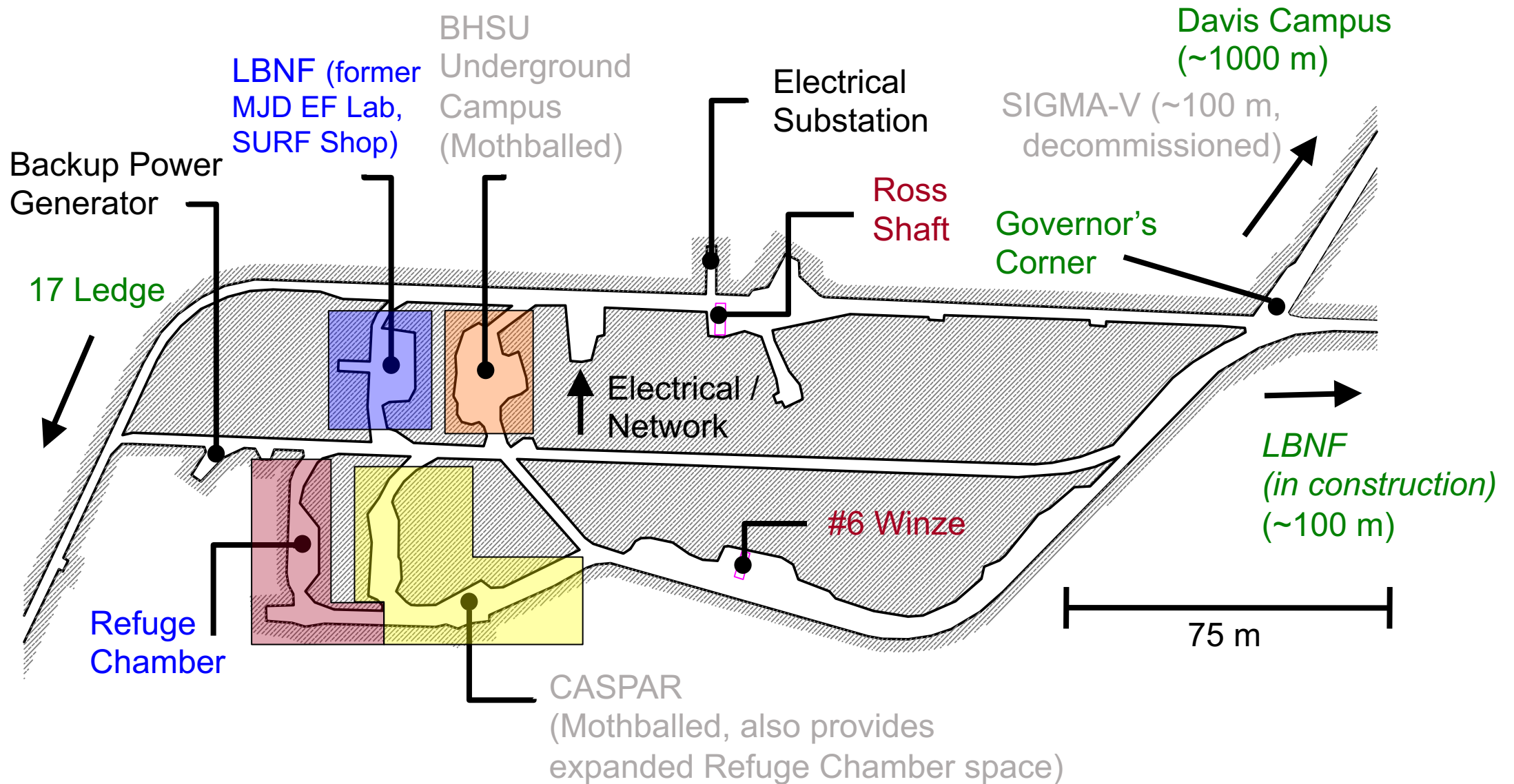
**CONTENT:**  
Press Release

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



# 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)



# 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
<i>LBNF (4850L)</i>	<i>LBNF</i>	<i>9,445</i>	<i>191,863</i>	<i>?</i>	<i>Excavation complete in Mar 2024</i>
4100L	Geoscience Lab	334	11 drill holes	2025	DEMO-FTES use 2023-2024, CUSSP 2024-2027
4850L	<i>New Labs (2 proposed)</i>	<i>4,022</i>	<i>94,608</i>	<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>	<i>4,178</i>	<i>42,440</i>		<i>Each 15m (W) x 15m (H) x 75m (L) + other supporting</i>

# SURF Experiment Implementation Program

## Identify interfaces and hazards within approval framework

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

Rev. 02  
SCI-(1000-F)-34460  
SURF Experiment Planning Statement

**Project Name** \_\_\_\_\_ Date Submitted: mm/dd/yyyy

Status:  Preliminary (Expression of interest, Support letter request)  Formal implementation request  Update

**1. Project Summary**

Discipline:  Physics  Biology

**Project Description**  
Provide a brief project description, including purpose, scientific merit

**IDEA – Inclusion, Diversity, Equity and Access**  
SDSTA is committed to creating a culture that centers on inclusion, and stakeholders embody SDSTA's commitment to IDEA as both a consideration in these areas.

South Dakota Science and Technology Authority

Rev. 02  
SCI-(1000-F)-34460  
SURF Experiment Planning Statement

**9. SDSTA Review Section – to be completed by SDSTA personnel**

**Research Category** (SDSTA determination based on user input)  Non-proprietary  Proprietary

**Experiment Implementation Program Requirements**  
Additional documentation requirements.

Required for all Experiments:  User Agreement (UA)  Insurance (General Liability, Workers' Compensation)

Services Agreements:  General Services Agreement (GSA)  Contract

**Environment, Safety & Health Requirements**  
Based on the information provided in the Experiment Planning Statement, the following training, documentation, and reviews are warranted.

Hazard Analysis:  (JHA/SOP required for most activities)

Minimum Training:  Orientation (surface and/or underground)  General Safety – Basic (and subsequent Annual Refresher Training (ART))

Other Training:  SDSTA: \_\_\_\_\_  Non-SDSTA: \_\_\_\_\_

Inventories:  Chemicals  Electrical  Hoisting & Rigging  Pressure Vessels  Radioactive Materials

Assessment Documents:  Experiment Hazard Assessment Summary (EHAS), incl additional training  Quantitative Analysis – Mechanical  Quantitative Analysis – ODH  Quantitative Analysis – Pressure

Reviews:  Walk-through Inspection(s)  Readiness Review(s)  Merit Review

SDSTA Review	Name	Date	Signature
SCIENCE			
ENVIRONMENT, SAFETY & HEALTH			
ENGINEERING			
INFORMATION TECHNOLOGY			
HOISTS AND SHAFTS			
SURFACE OPERATIONS & UTILITIES			
UNDERGROUND OPERATIONS			

**Other Review** (If applicable)

Name	Date	Signature

**SDSTA Acceptance**

Name	Date	Signature

**SURF LABORATORY DIRECTOR**

South Dakota Science and Technology Authority Page 11 of 12 Form

Expt Planning Statement (EPS)

sanfordlab.org/proposal-guidelines

**SANFORD UNDERGROUND RESEARCH FACILITY** MENU

# RESEARCH PROPOSAL GUIDELINES

All proposals must follow these guidelines

**RESEARCHER RESOURCES**

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

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

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

**PROPOSAL DOCUMENTS**

- SCI-(1000-S)-135416 Experiment Integration & Support.pdf 362.8 KB | PDF
- SCI-(1000-F)-69417 User Agreement 44.7 KB | DOCX
- SCI-(1000-F)-34460 Experiment Planning Statement 74.2 KB | DOCX
- SCI-(1000-F)-212612 User Agreement Acknowledgement.docx 31.8 KB | DOCX
- SCI-(1000-S)-186874 Publication Guidelines.pdf 255.3 KB | PDF
- Acknowledgement of Risk and Waiver 101.2 KB | PDF
- SCI-(1000-S)-34478 Experiment Implementation Program.pdf 1 MB | PDF

# SURF Experiment Implementation & Support

## Main Science documents under IMS document control

### Experiment Implementation Program (EIP)

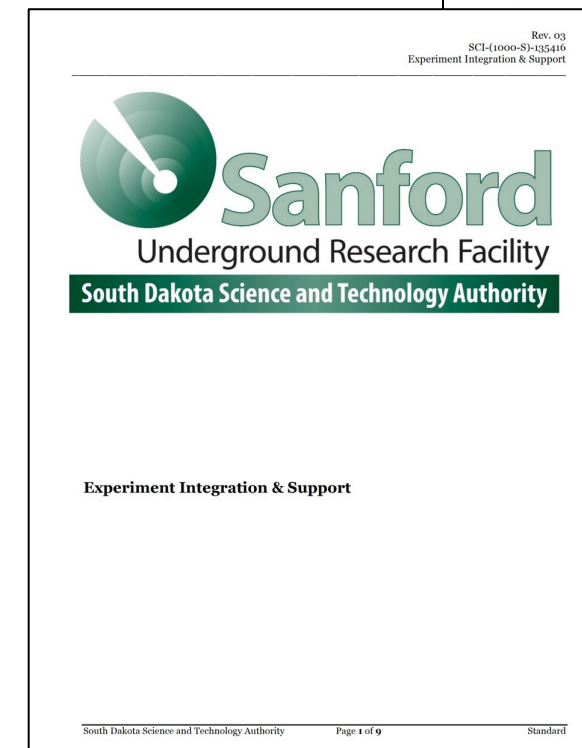
- Integral to the SDSTA institutional mission is advancement of compelling underground, multidisciplinary research
- EIP framework allows experiments to be implemented at SURF in effective and efficient manner
- References several key elements:
  - Experiment Planning Statement
  - User Agreement
  -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



Experiment Implementation Program



Experiment Integration & Support

# 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 displays '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 'Programs' section. The main content area is titled 'User Facilities' and includes a paragraph describing the facilities: 'The Office of Science national scientific user facilities provide researchers with the most advanced tools of modern science, including accelerators, colliders, supercomputers, light sources and neutron sources, as well as facilities for studying the nano world, the environment, and the atmosphere.' Below this text, there is a list of links: 'User Facilities at a Glance', 'User Resources', 'User Statistics', 'Policies and Processes', 'Frequently Asked Questions', and 'User Facility Science Highlights'. The page also features six featured facility cards, each with a 'Read more' button: ASCR User Facilities, BES User Facilities, BER User Facilities, FES User Facilities, HEP User Facilities, and NP User Facilities.

# The Institute for Underground Science at SURF



**THE INSTITUTE**  
FOR UNDERGROUND SCIENCE  
AT SURF

**KNOWLEDGE.**  
**PEOPLE. PLACE.**

BENEATH THE BLACK HILLS of South Dakota, researchers advance the future of world-leading science. The Institute for Underground Science at SURF will unite today's research and tomorrow's discoveries.



# The Institute for Underground Science at SURF

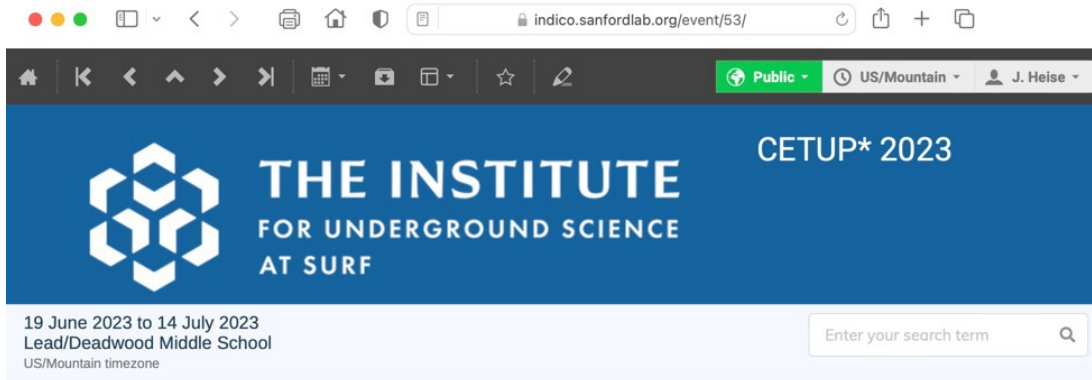
Goal: The Institute for Underground Science at SURF constructed by Sep 2035

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



# Institute for Underground Science at SURF

## CETUP\* Topical Workshop held summer 2023! Registration underway for 2024



- Overview
- Call for Abstracts
- Timetable
- Contribution List
- Book of Abstracts
- Registration
- Organizing Committee
- Participant List
- General Information
- Travel Information
- Accommodations
- Dining
- Organizing Committee (CETUP\* 2023)
- ✉ cetup2023@sanfordlab...

### CETUP\* 2023, Hosted by The Institute for Underground Science at SURF

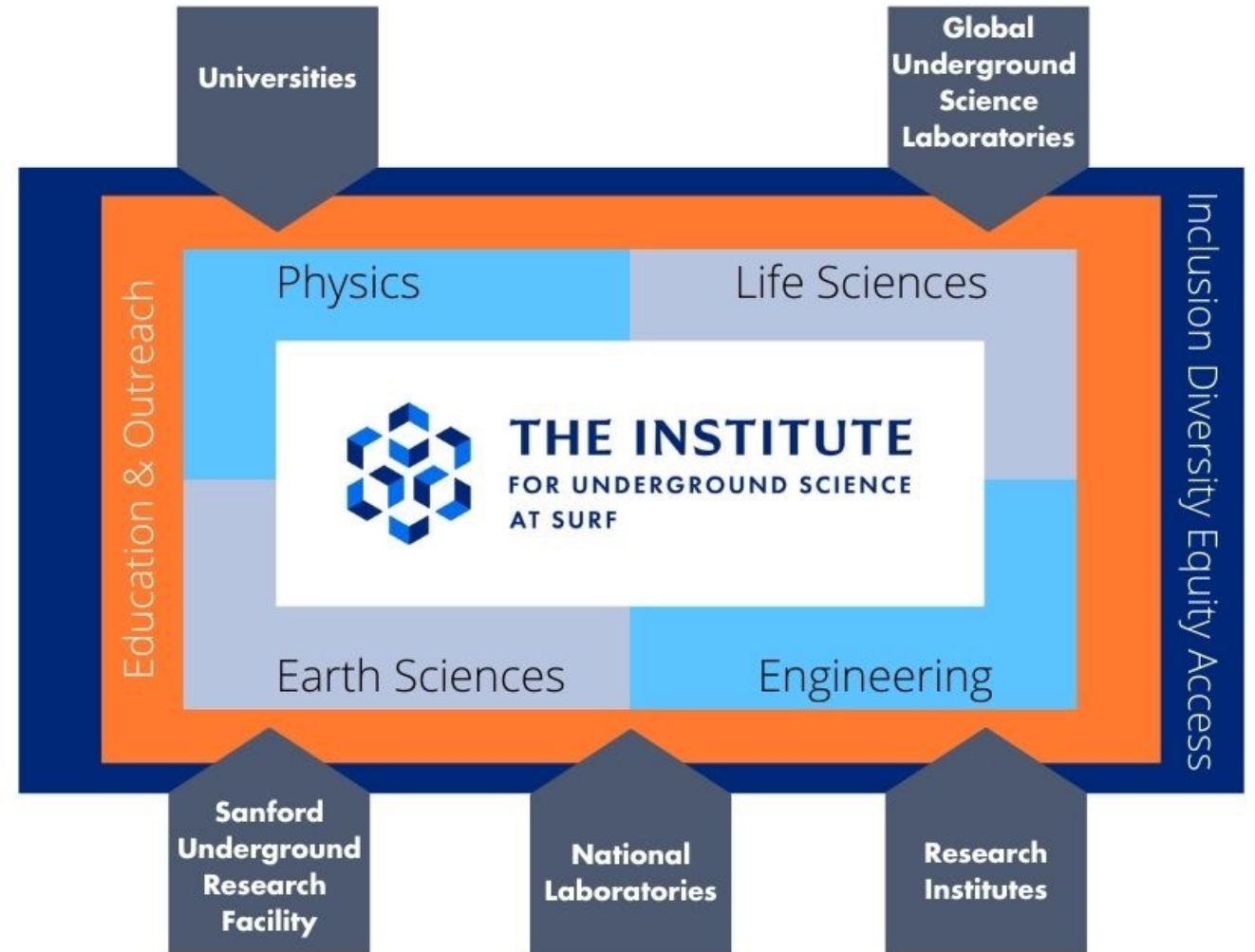
Around the globe more than 20 underground laboratories provide space for experiments in nuclear and particle physics, astrophysics and cosmology as well as geosciences, drawing scientists from all over the world. In response to the growing interests in underground science, the Center for Theoretical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

CETUP\* provides a stimulating environment for creative thinking and open discussion. Researchers with varying experience, and from different countries and scientific backgrounds collaborate to attract rising young scientists to participate. The combined expertise allows this intellectual community to address the most pressing questions in fundamental research:

- What is the nature of dark matter?
- What is the origin of neutrino masses?
- How have neutrinos shaped the evolution of the universe?
- How do supernovae explode?
- What is the origin of the matter-antimatter asymmetry in the Universe?

Since its inception in 2011, the workshop has been hosted in the Black Hills of South Dakota in Lead/Deadwood, near the Sanford Underground Research Facility (SURF), which is the deepest underground laboratory in the United States. The area's natural beauty attracts tourists year-round, and has strong connections to Native American culture and history.

This year CETUP\* returns under the auspices of the Institute for Underground Science at SURF. The Institute will be a global center for collaboration and intellectual community focused on underground science for the international underground research community. CETUP\* is one of the Institute's first science-focused endeavors.



# 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 Čhangeléška Wakħánj

### 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

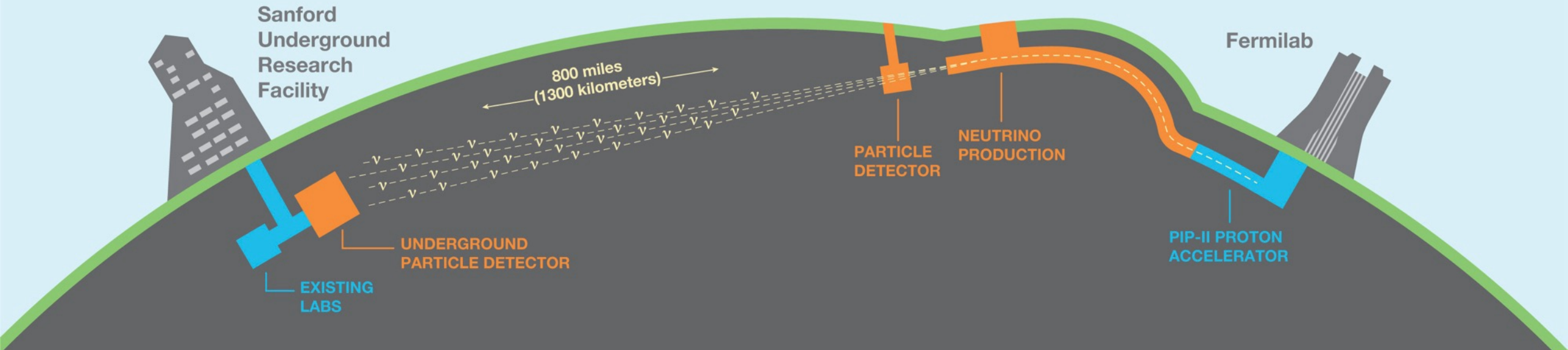
- Visitors from 35 countries
- 57,317 visitors in 2023
- 130 bus tours



# Long-Baseline Neutrino Facility (LBNF)

LBNF will host the Deep Underground Neutrino Experiment (DUNE)

## U.S. DOE's Flagship Neutrino Study Experiment



**Origin of matter:** Investigate CP violation. Are neutrinos the reason the universe is made of matter?



**Supernova explosions and black hole formation:** Ability to observe neutrinos from supernovae events and neutron star (or possibly black hole!) formation in real time.



**Unification of forces:** Investigate nucleon decay, advance unified theory of energy and matter.