SANFORD UNDERGROUND RESEARCH FACILITY

SURF Experiment Implementation and Integration Support

Jaret Heise, Science Director
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Theia Site Visit
December 1, 2025

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 [space commitment] (references Publications)
  - Access (Request form, risk waiver, insurance)
  - 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 Work Planning)
  - SURF Applications/Databases (TAP, SARF, etc)
  - Table of responsibilities (SDSTA and Experiment)
  - Perception Survey, Information for Researchers, etc

SURF Experiment Implementation & Support

Main Science documents under IMS/ISO document control

Experiment Implementation Program

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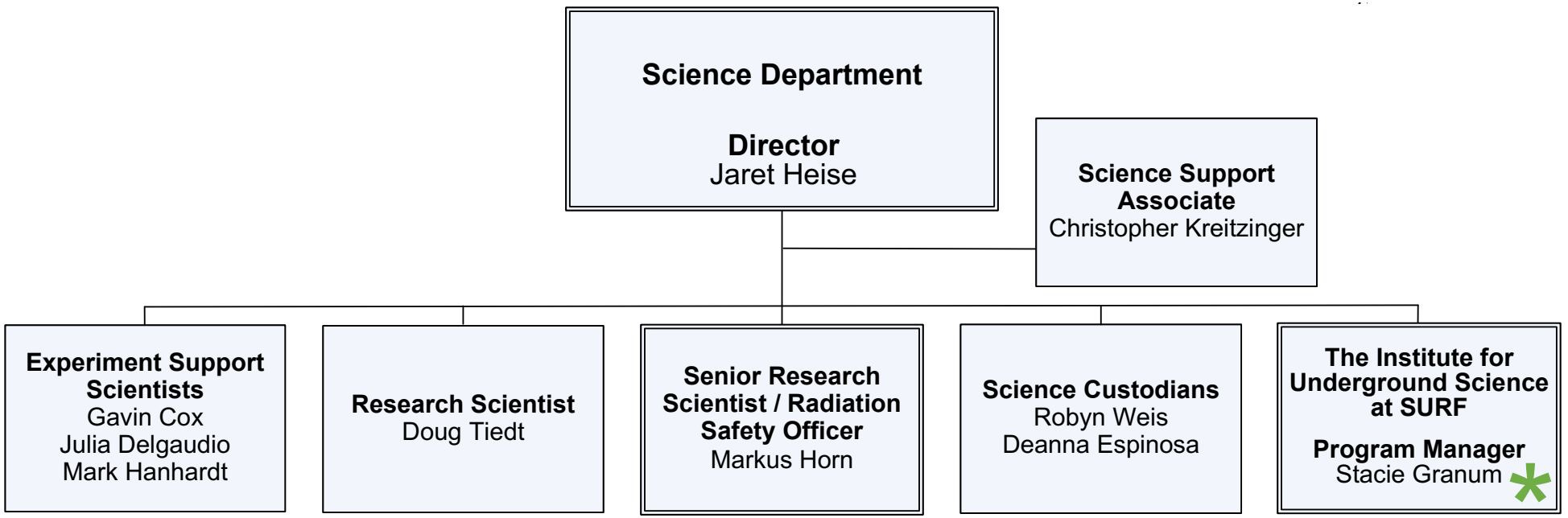
For more details, see CoSSURF 2024, User Association Session: https://indico.sanfordlab.org/event/68/sessions/160/#20240516

Science Organization & Scope

Resources to enable safe and successful implementation of experiments



- **Main point of contact** for experiments and researchers
- **Experiment implementation process** management, incl coordination of review and authorization processes
- **Scientific support,** incl participation as collaboration members and technical experiment support
- **Science facility support**, incl lab coordination and oversight, specialized custodial support
- **Represent SURF** (facility and science), incl public presentations, scientific conferences, etc
- **Build intellectual community** *

SDSTA Organization – Science Staffing

Resources to enable safe and successful implementation of experiments

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

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

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

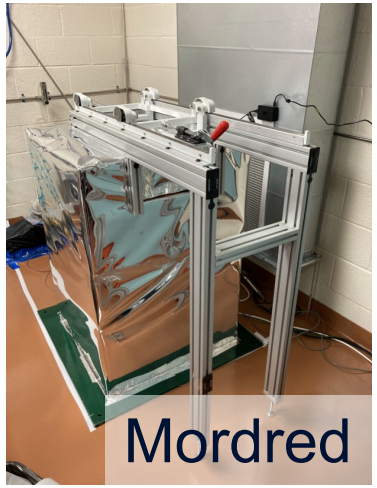
Doug Tiedt (PhD)
Research Scientist
- Surface + UG Campuses

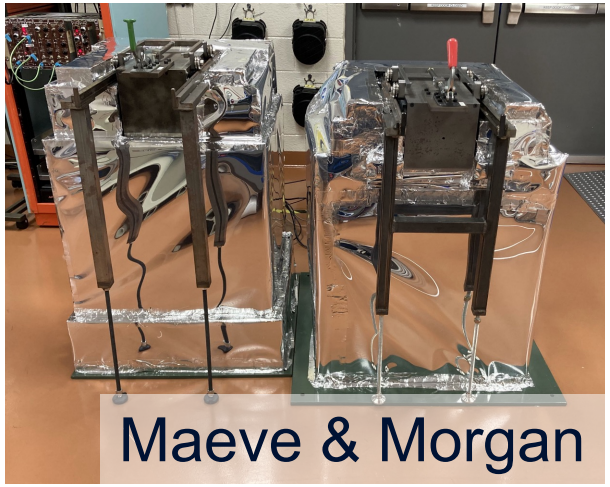
+ Many Others!
Engineering, ESH, OPS…

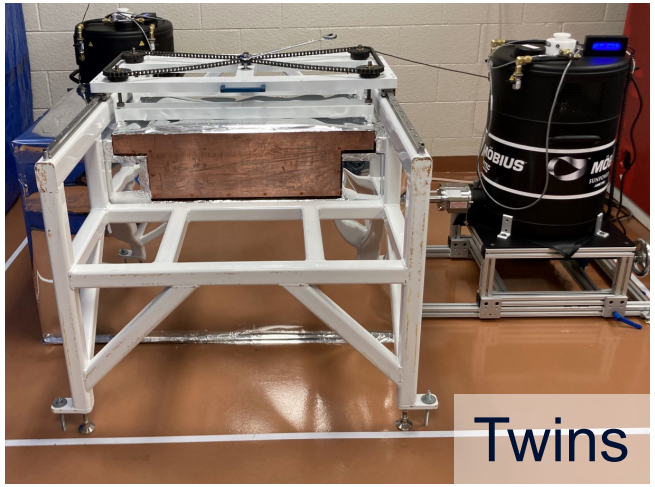
Christopher Kreitzinger
Support Associate
- Admin, User Association

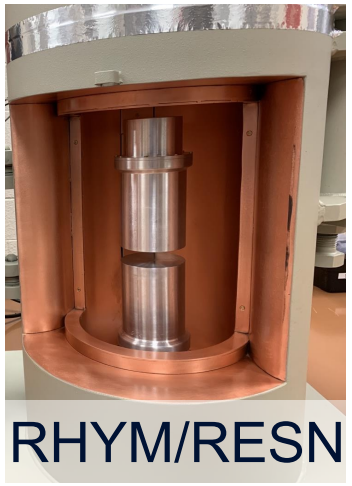
SURF Material Assay at BHUC

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

SURF User Association

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

Purpose

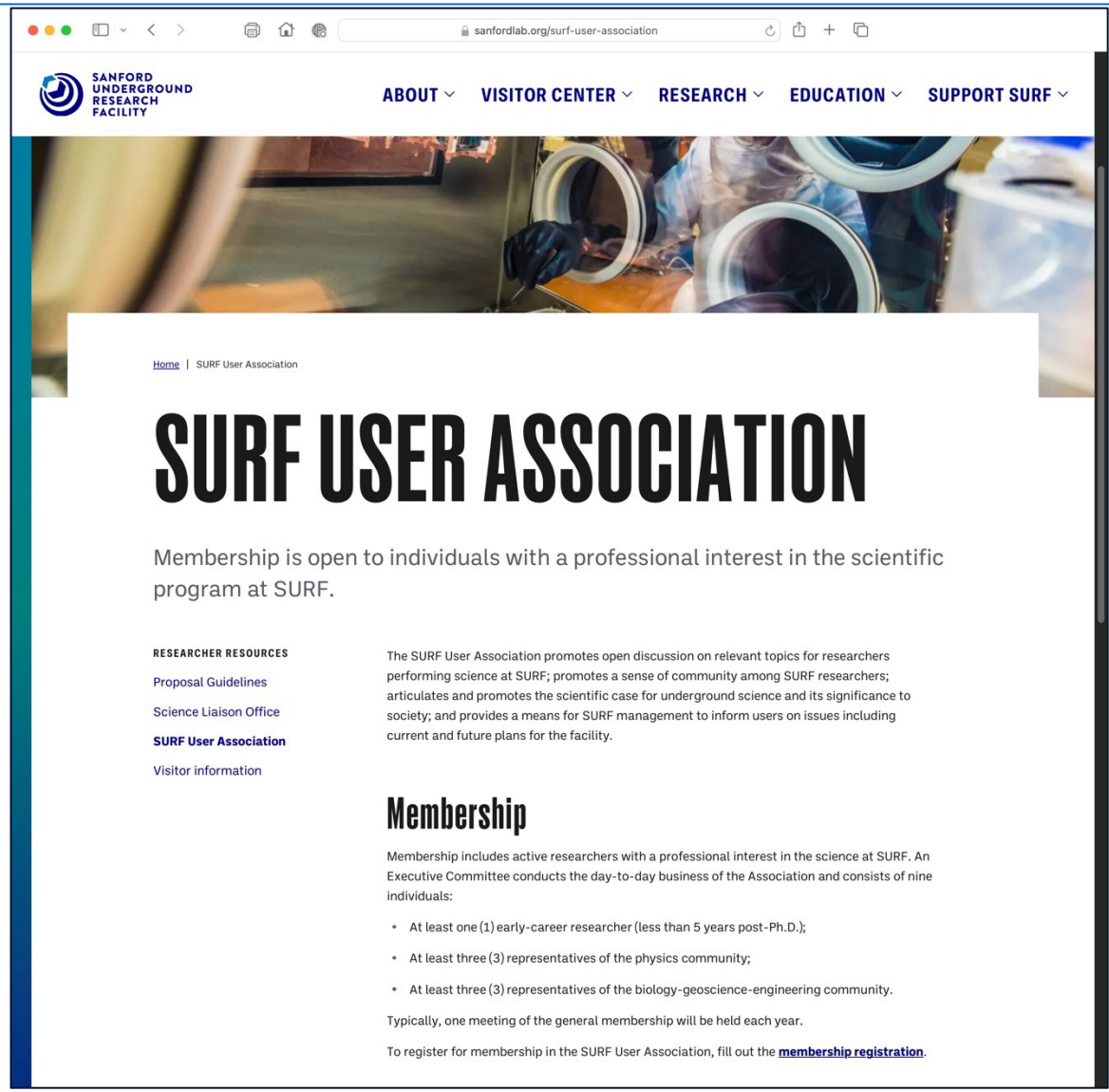
- **Two-way communication** on topics important to researchers.
- Promotes a **sense of community** amongst SURF experiments and researchers.
- Articulates and promotes **scientific case for UG science** and significance to society, provides channel for **advocacy**.

Organization

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

Meetings

- **General meetings** typically held annually, last at CoSSURF 2024 (no CoSSURF 2026 planned).
- **Topical workshops**, incl community planning (e.g., Vision Workshop 2021). Next workshops in 2026.



SURF Call for Letters of Interest

Ensuring SURF used to its fullest scientific potential

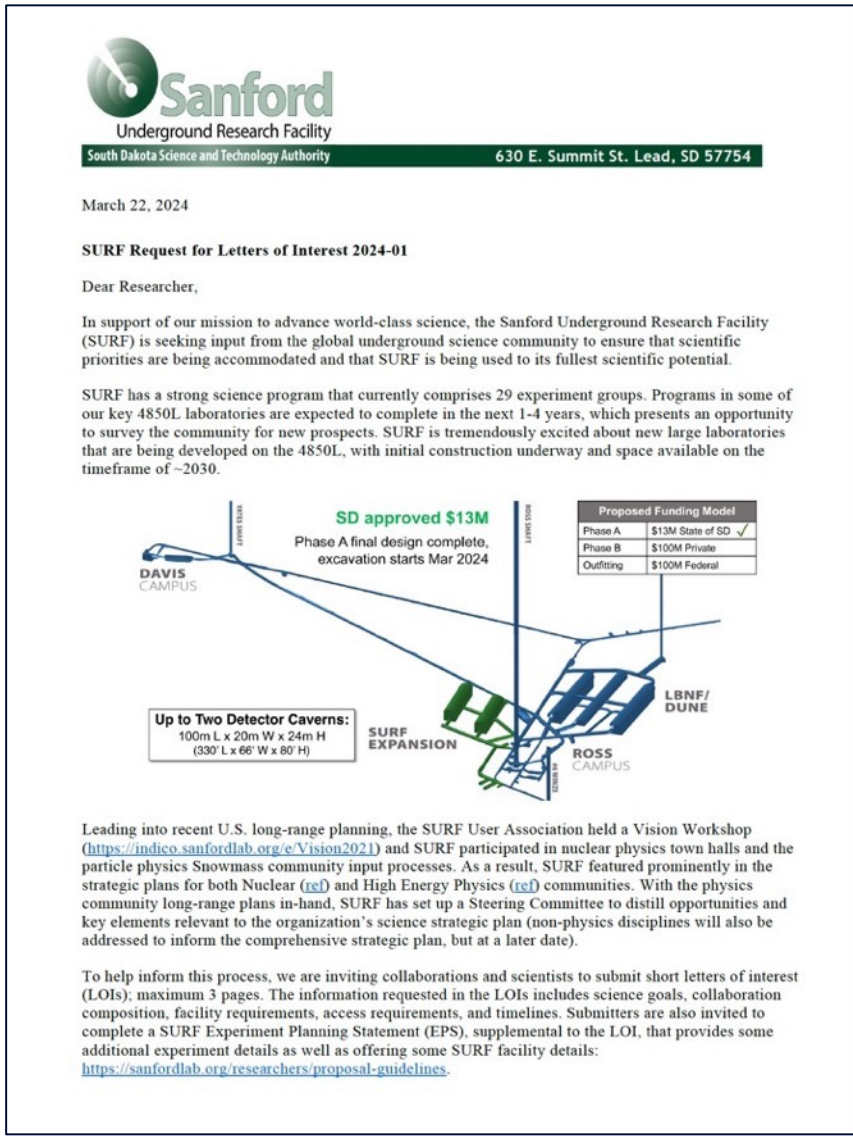
Significance of 2024 LOI Call:

- 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**

15 responses received, initial SPAC review complete



Sanford Underground Research Facility

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 (ref) and High Energy Physics (ref) 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 Call for Letters of Interest

Theia LOI received

Theia: Letter of Interest for space at SURF

Science goals

We propose the "Theia" detector: a novel, "hybrid" neutrino detector, which will be able to observe both directional photons of the Cherenkov light signature ("chertons"), and isotropic photons from the much brighter scintillation signature, ("scintons"), facilitati cutting-edge, interdisciplinary science. Theia's hybrid technology will interr of neutrino physics aligned with community priorities, with world-leading se complementarity to other large-scale neutrino experiments.

Bright scintillation light provides the necessary energy resolution for low-er physics, including measurements of the CNO solar neutrinos, antineutrinos Earth (geo neutrinos), and eventually a search for neutrinoless double beta sensitivity beyond the inverted neutrino mass ordering. The ability to detec directional chertons will allow measurements of CP violation using the LBN neutrino beam, with comparable sensitivity to the baseline liquid argon (LA the equivalent cavern size. The combination of chertons and scintons will a backgrounds to signals such as the diffuse supernova relic neutrinos (DSN

Theia would enable a unique multi-messenger astronomical measurement neutrinos, by detecting anti-electron neutrinos while simultaneously DUNE observe electron neutrinos—a literally complementary data set. Similarly fo neutrino physics, deploying Theia at SURF, with the same beam and base LArTPC modules, would offer risk reduction and facilitate a critical test via of water-based liquid scintillator, should DUNE and Hyper-Kamiokande ha measurements of the CP-violating phase δ. For these reasons, Theia is a DUNE's "Module of Opportunity". However, Theia would achieve an even physics if deployed in a dedicated, custom cavern with size and shape cho physics program.

Table I shows the full breadth of the Theia physics program, including a co results achieved in a DUNE-like cavern (25-kton total mass) or a custom, 1 Table II outlines the requirements for each physics topic, which can potenti with a phased approach. Figure 1 shows the reach for long-baseline physic neutrinoless double beta decay (NLDBD). Full details can be found in the [1].

TABLE I: THEIA physics reach. Exposure is listed in terms of the fiducial vol analysis. For NLDBD the target mass assumed is the mass of the candidat fiducial volume.

Primary Physics Goal	Reach	Exposure /
Long-baseline oscillations	$> 5\sigma$ for 30% of δ_{CP} values	524 kt-MW-y
Supernova burst	$< 1(2)^\circ$ pointing accuracy 20,000 (5,000) events	100(25)-kt de
DSNB	5σ discovery	125 kton-yr
CNO neutrino flux	< 5 (10)%	300 (62.5) kt
Reactor neutrino detection	2000 events	100 kton-yr
Geo neutrino detection	2650 events	100 kton-yr
NLDBD	$T_{1/2} > 1.1 \times 10^{28}$ yr	211 ton-yr [13
Nucleon decay $p \to \bar{\nu}K^+$	$T > 3.80 \times 10^{34}$ yr (90% CL)	800 kton-yr

TABLE II: THEIA physics goals and phased program. Each successive phase adds to the breadth of the physics program. The configuration column lists potential approaches to each phase, rather than a finalized detector design.

Phase	Primary Physics Goals	Detector capabilities	Configuration options
I	Long-baseline oscillations	High-precision ring imaging	Low-yield WbLS
	^{8}B flux		Low photosensor coverage
	Supernova burst, DSNB		Fast timing
II	Long-baseline oscillations	Low threshold	High-yield WbLS or slow LS
	^{8}B MSW transition	Cherenkov/scintillation	Potential ^{7}Li loading
	CNO, *pep* solar	separation	High photosensor coverage
	Reactor and geo $\bar{\nu}$	High light yield	Potential dichroicon deployment
	Supernova burst ($\bar{\nu}_e$ and ν_e),		
	DSNB (ν_e and $\bar{\nu}_e$)		
III	$0\nu\beta\beta$	Low threshold	Inner vessel with
	^{8}B MSW transition	Cherenkov/scintillation	LAB+PPO+isotope
	Reactor and geo $\bar{\nu}$	separation	High photosensor coverage
	Supernova burst and DSNB ($\bar{\nu}_e$)	High light yield	Potential dichroicon deployment

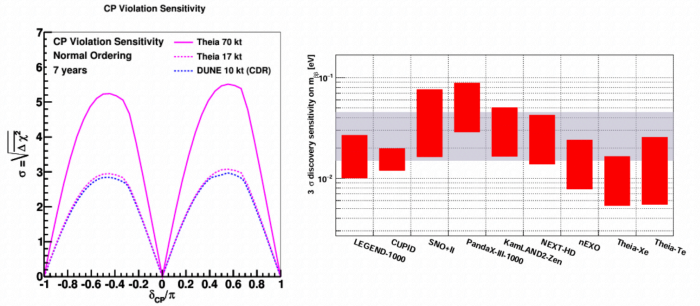


Figure 1: (Left) Sensitivity to CP violation as a function of the true value of δ_{CP}, for a 70-kton fiducial detector (pink solid), and for a 17-kton fiducial (pink dashed) in comparison to a 10-kton fiducial LArTPC (blue dashed). Seven years of exposure to the LBNF beam, with equal running in neutrino and antineutrino mode is assumed [1].

(Right) Discovery sensitivity (3σ) for proposed future neutrinoless double beta decay experiments. The grey shaded region corresponds to the parameter region allowed in the Inverted Hierarchy of the neutrino mass. The red error bars show the mββ values such that an experiment can make at least a 3σ discovery, within the range of the nuclear matrix elements for a given isotope [1].

Collaboration composition

The Theia collaboration includes over 100 members from 46 institutions around the world. Members participate from: Canada, China, Finland, Germany, Italy, Japan, South Korea, Portugal, Turkey, the United Kingdom, and the United States, with the latter including both

SCI-(1000-F)-34460
SURF Experiment Planning Statement

Theia: hybrid Cherenkov+scintillation next-generation neutrino detection Date Submitted: **05/17/2024**

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

1. Project Summary

Discipline: ☐ Biology ☐ Engineering ☐ Geology x Physics

Project Description
Provide a brief project description, including purpose, scientific merit and scope. Add relevant citations or references as appropriate. If necessary, add additional space to this form.

We propose the "Theia" detector: a novel, "hybrid" neutrino detector, which will be able to observe both directional Cherenkov light ("chertons"), and bright scintillation light, ("scintons"), facilitating a rich program of cutting-edge, interdisciplinary science. Theia's hybrid technology will interrogate a broad range of neutrino physics aligned with community priorities, with world-leading sensitivities and complementarity to other large-scale neutrino experiments.

Bright scintillation light provides the necessary energy resolution for low-energy neutrino physics, including measurements of the CNO solar neutrinos, antineutrinos from the crust of the Earth (geoneutrinos), and eventually a search for neutrinoless double beta decay with sensitivity beyond the inverted neutrino mass ordering. The ability to detect and identify directional chertons will allow measurements of CP violation using the LBNF neutrino beam with comparable sensitivity to the baseline liquid argon (LAr) detector design, for the equivalent cavern size. The combination of chertons and scintons will allow THEIA to reject backgrounds to signals such as the diffuse supernova relic neutrinos.

Theia is a candidate for DUNE's "Module of Opportunity", but would achieve an even stronger program of physics if deployed in a dedicated, custom cavern. Sitting proximate to the DUNE LArTPC detectors, Theia would enable a unique multi-messenger astronomical measurement for supernova burst neutrinos, by detecting anti-ves while simultaneously DUNE's LAr detectors observe ves—a literally complementary data set. Similarly, for long-baseline ν physics, Theia's low-Z target of water-based liquid scintillator will provide a critical test should DUNE and Hyper-Kamiokande have different measurements of the CP-violating phase δ.

IDEA – Inclusion, Diversity, Equity and Access
SDSTA is committed to creating a culture that centers on inclusion, diversity, equity and access (IDEA); see https://sanfordlab.org/sdsta/inclusion-diversity-equity-and-access. It is critical that all partners and stakeholders embody SDSTA's commitment to IDEA as both a moral imperative and a necessary ingredient for a successful collaborative scientific environment. Describe project efforts and considerations in these areas.

We propose to contribute to developing and nurturing a diverse workforce by presenting an inspiring and challenging design problem accessible to students from under-represented backgrounds. The goal of creating a diverse and representative workforce is integrated throughout our collaboration and plans. South Dakota, where Theia would be sited, is an EPSCoR state, and 10% of the population is Native American. Poverty, racism, and low expectations, mistrust, disenfranchisement, and geographic isolation have led to a high-school graduation rate of 50% compared to 90% for local White students. As part of a recent NSF proposal we, working closely with staff at SURF, developed a plan to integrate a cutting-edge science and engineering program within classrooms and provide support for a cohort of educators that will serve as science teacher-leaders, to improve the exposure these students get to topics that they might otherwise never see. Further, we designed an IDEA program that can leverage the proposed work on Theia to facilitate a more open and inclusive culture and community in our field. The program would be managed and assessed by an IDEA committee created within Theia, comprised of members from within the collaboration at all career levels, from PIs to Undergraduates. Its charge would be to set policies to promote and grow IDEA within the Theia project team, evaluate the success of this effort by studying and documenting the process and outcomes, and be a resource and offer advice. In addition to our IDEA efforts, Theia's physics program has impacts across an extensive range of science, from Earth science to astrophysics to particle physics to cosmology. Some of the technologies that may be used, such as spectral photon-sorting dichroicons, could even help improve the efficiency per unit area of solar-energy-generating farms.

Sanford Underground Research Facility

Thank You!

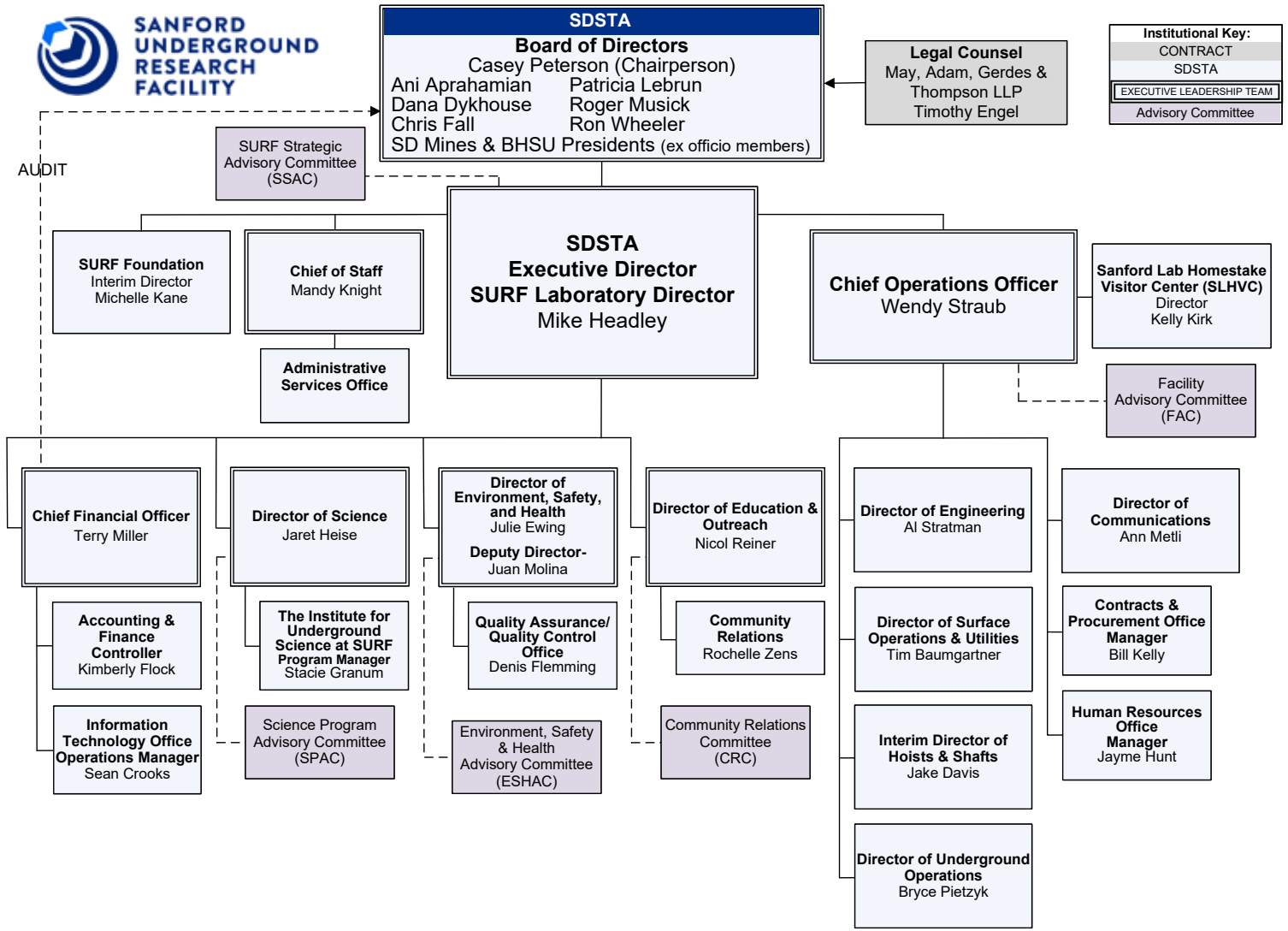
Agency Acknowledgement:
The Sanford Underground Research Facility (SURF) is a federally sponsored research facility under DOE-SC HEP Award Number DE-SC0020216 (cooperative agreement)

SURF Summary

- SURF has strong relationship with DOE that benefits UG science community:
  - SURF has mandate to **support experiments** and ensure **safe and reliable access for decades**.
- SURF offers world-class service to the underground science community:
  - SURF attributes attract **world-leading** experiments and scientists from **diverse scientific communities**.
  - SURF has **proven track record** of enabling high-impact science by leveraging strong **institutional partnerships**.
- SURF is playing a strong role in the UG science community:
  - **User Association** serving as catalyst for community discussions: https://sanfordlab.org/surf-user-association.
  - **Institute** has had significant impact with initial programming, advancing intellectual community building.
- SURF wants to host future world-leading experiments:
  - LBNF excavation done, outfitting started in 2024. **DOE** "**Module of Opportunity**" expanded physics program.
  - Construction underway to **increase underground laboratory space**, plans advancing for new large caverns on 4850L on **timeframe of next-generation experiments (~2030)**.
  - Call for **Letters of Interest (LOIs)** re-affirmed prospective experiments and identified **new avenues**. New facilities in planning (Cryogenic User Facility) and consideration (Vertical Facility).
  - SURF is **deep laboratory** site and offers **largest footprint** in the world for scientific pursuits. **Many options to host future initiatives – big or small!**

SDSTA Organization

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

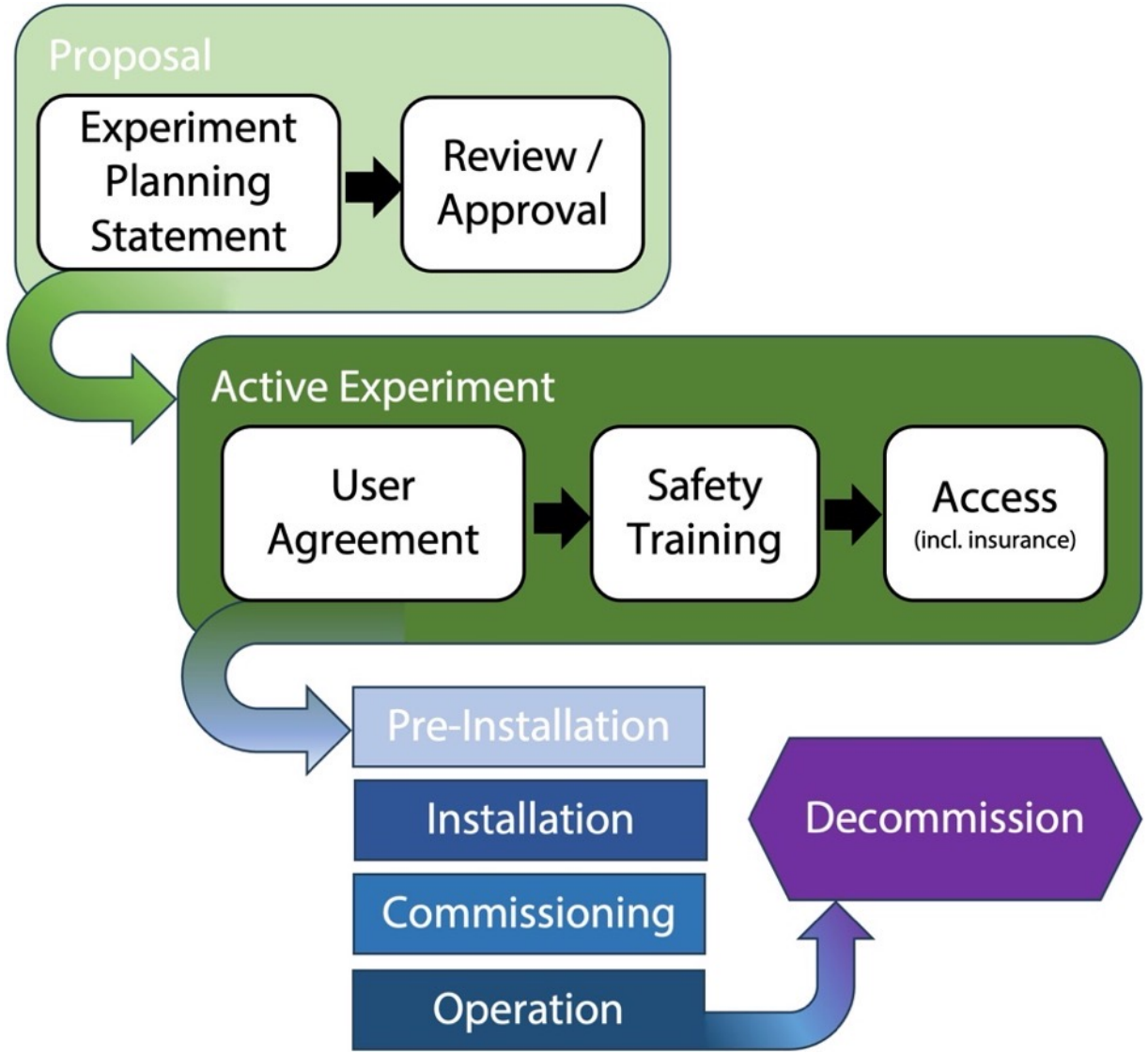


Staffing Area	Current # ppl (%)	FY29 # ppl (%)
Admin / Mgmt	31 (15%)	31 (13%)
Engineering	12 (5%)	12 (5%)
ESH	21 (10%)	23 (10%)
Outreach	23 (11%)	24 (10%)
Scientific	5 (2%)	6 (3%)
Technical / Operations	128 (58%)	142 (60%)
TOTAL	**220**	**235**

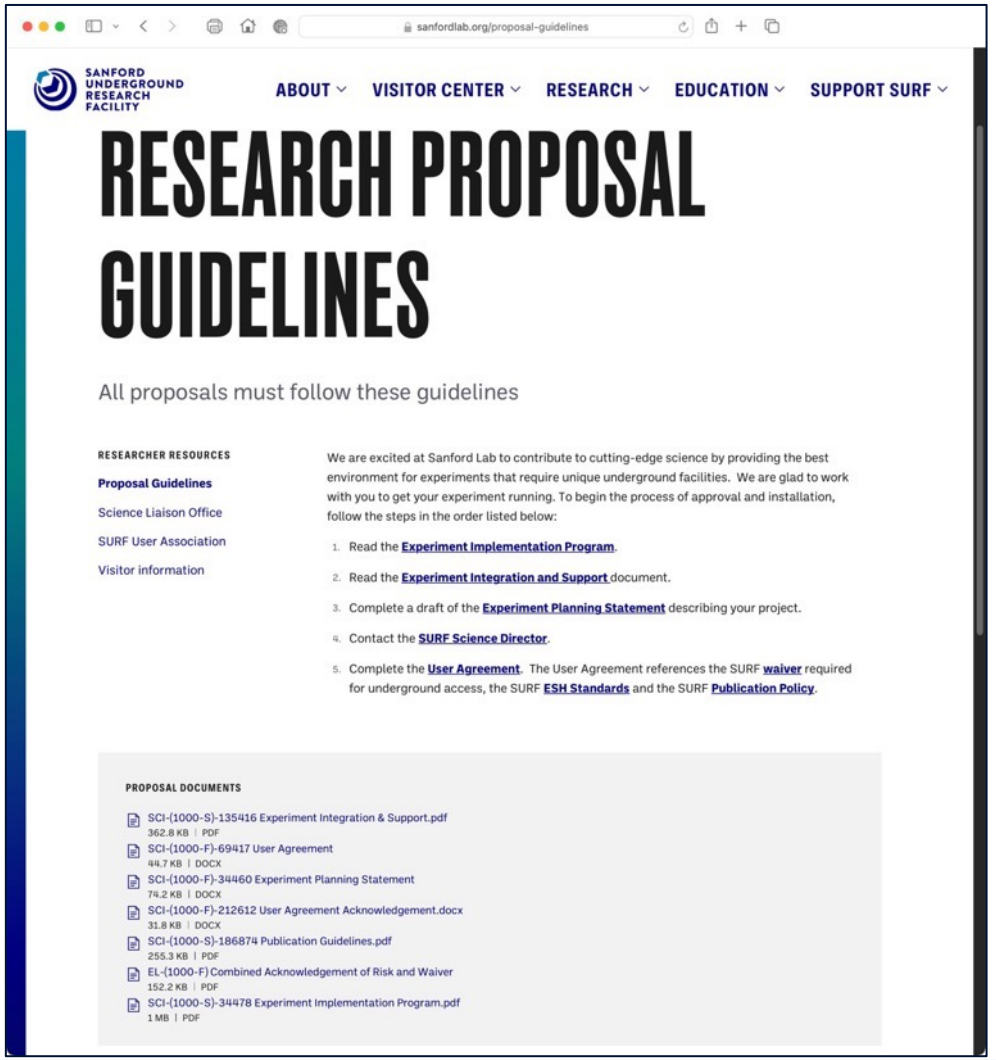
Current Science Direct Support
= ~19 ppl

SURF Experiment Implementation Program

Identify interfaces and hazards within approval framework



https://sanfordlab.org/proposal-guidelines



SURF Experiment Implementation Program

Identify interfaces and hazards within approval framework

Rev. 04
SCI-(1000-F)-34460
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 ☐ Geology ☐ Engineering ☐ Other: _____

Project Description
Provide a brief project description, including purpose, scientific merit and scope. Add relevant citations or references as appropriate. If necessary, add additional space to this form.

Community
SDSTA is committed to creating a welcoming and collaborative
SURF's core values (Safety Focus, Care for Others, Profession
considerations in these areas.

South Dakota Science and Technology Author

Rev. 04
SCI-(1000-F)-34460
Experiment Planning Statement

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

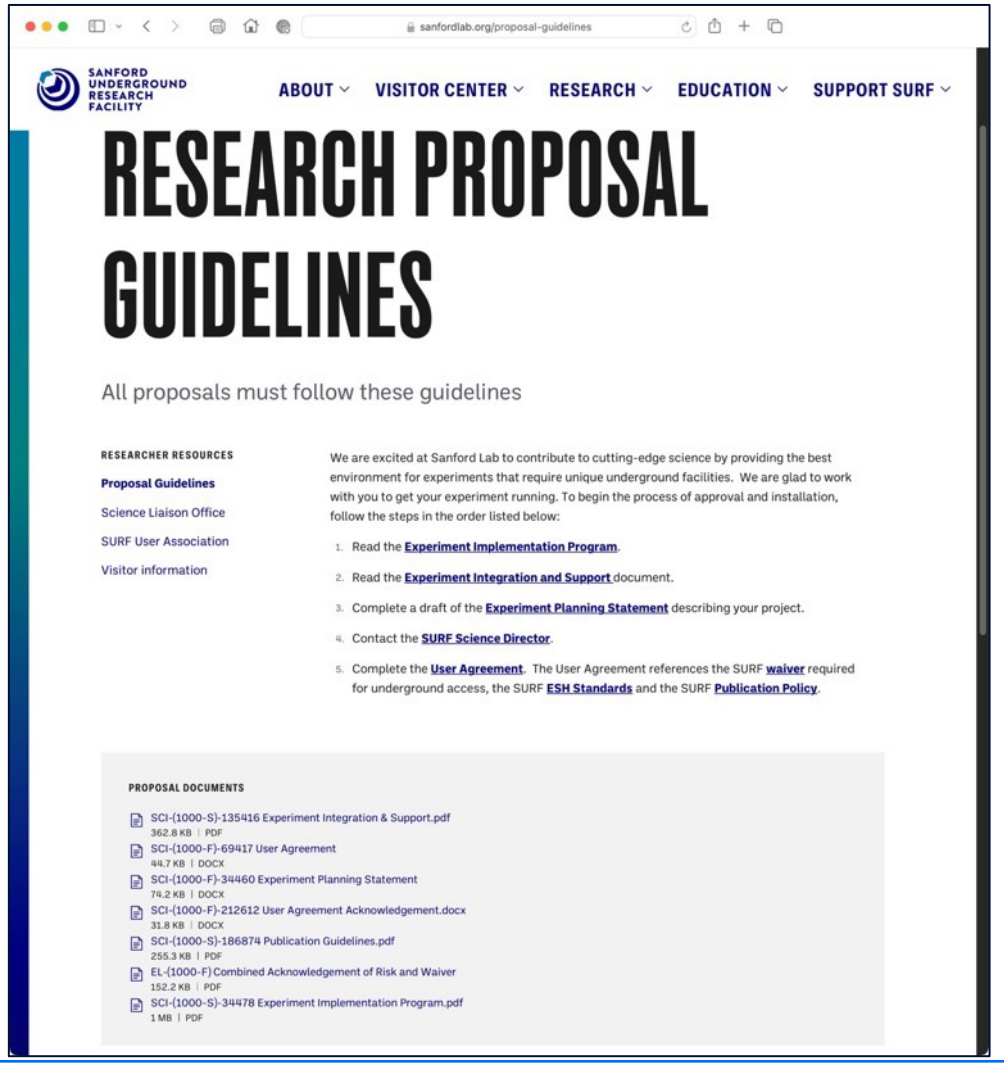
Research Category (SDSTA determination based on user input)	☐ Non-proprietary	☐ Proprietary		
Experiment Implementation Program Requirements Additional documentation requirements.				
Required for all Experiments:	☐ User Agreement (UA)	☐ Insurance (General Liability, Workers' Compensation)		
Services 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)

https://sanfordlab.org/proposal-guidelines




Geology and Engineering
Enhanced Geothermal Systems
Mining Technology
Biology
Extremophiles, Biodiversity
Science Program
30 Expts with 2,457 Collaborators,
319 Institutions in 55 Countries
Physics
Neutrinos, Dark Matter, and Astrophysics
Partnerships
Commercial, Technology,
Industrial, Workforce development

SURF Science Program

Research activities ranging from 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*

Total = 30 groups
20 Active Projects
71 Total Groups Since 2007

Significant interest from others
(33 groups in 2025)

* Denotes proprietary group

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*
- Delavie Sciences* – *Extremophiles*
- DULIA-Bio/REPAIR – *Yeast in low-radiation (multi-lab)*

Geology

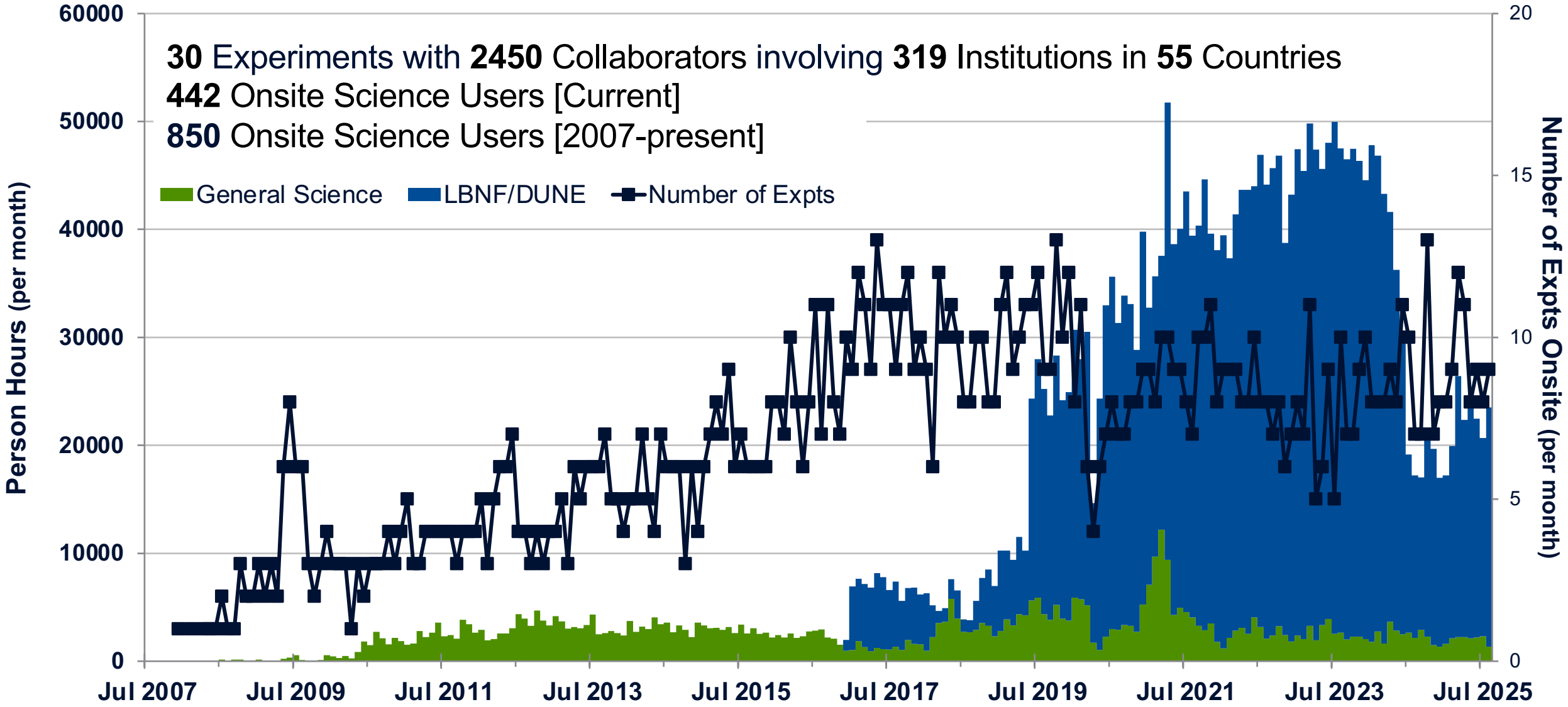
- CUSSP – *Geothermal*
- DEMO-FTES – *Geothermal*
- 3D DAS – *Seismic monitoring using fiber*
- Core Archive* – *Mainly gold deposits*
- Hydro Gravity – *Gravity for water tables*
- BH Seismic – *Global monitoring*
- Transparent Earth – *Seismic arrays*

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*

SURF Science Program

Hosting world-leading experiments and researchers from diverse scientific communities



SURF Science Strategic Plan

Physics elements incorporated into organization long-term vision

Goals:

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

Scope:

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

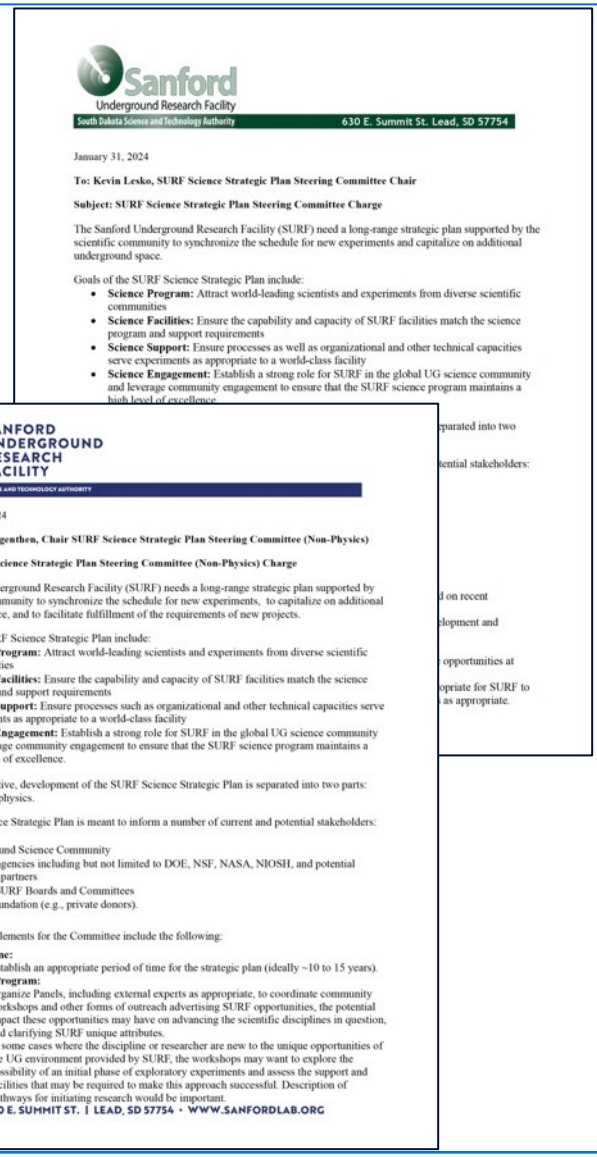
Physics (closely aligned with top U.S. national priorities):

- DUNE support (Phase 1 and Phase 2)
- Generation 3 Dark Matter (XLZD and/or ARGO)
- 'Agile' Experiments / Low-Mass Dark Matter
- General R&D facility
- Generation 2 Dark Matter upgrade (LZ → HydroX, CrystaLiZe, etc)

Cryogenic User Facility w/ dilution refrigerator

Non-Physics:

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



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

January 31, 2024

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

Subject: SURF Science Strategic Plan Steering Committee Charge

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

Goals of the SURF Science Strategic Plan include:

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

SANFORD UNDERGROUND RESEARCH FACILITY
SOUTH DAKOTA SCIENCE AND TECHNOLOGY AUTHORITY

December 15, 2024

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

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

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

Goals of the SURF Science Strategic Plan include:

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

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

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

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

Specific charge elements for the Committee include the following:

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

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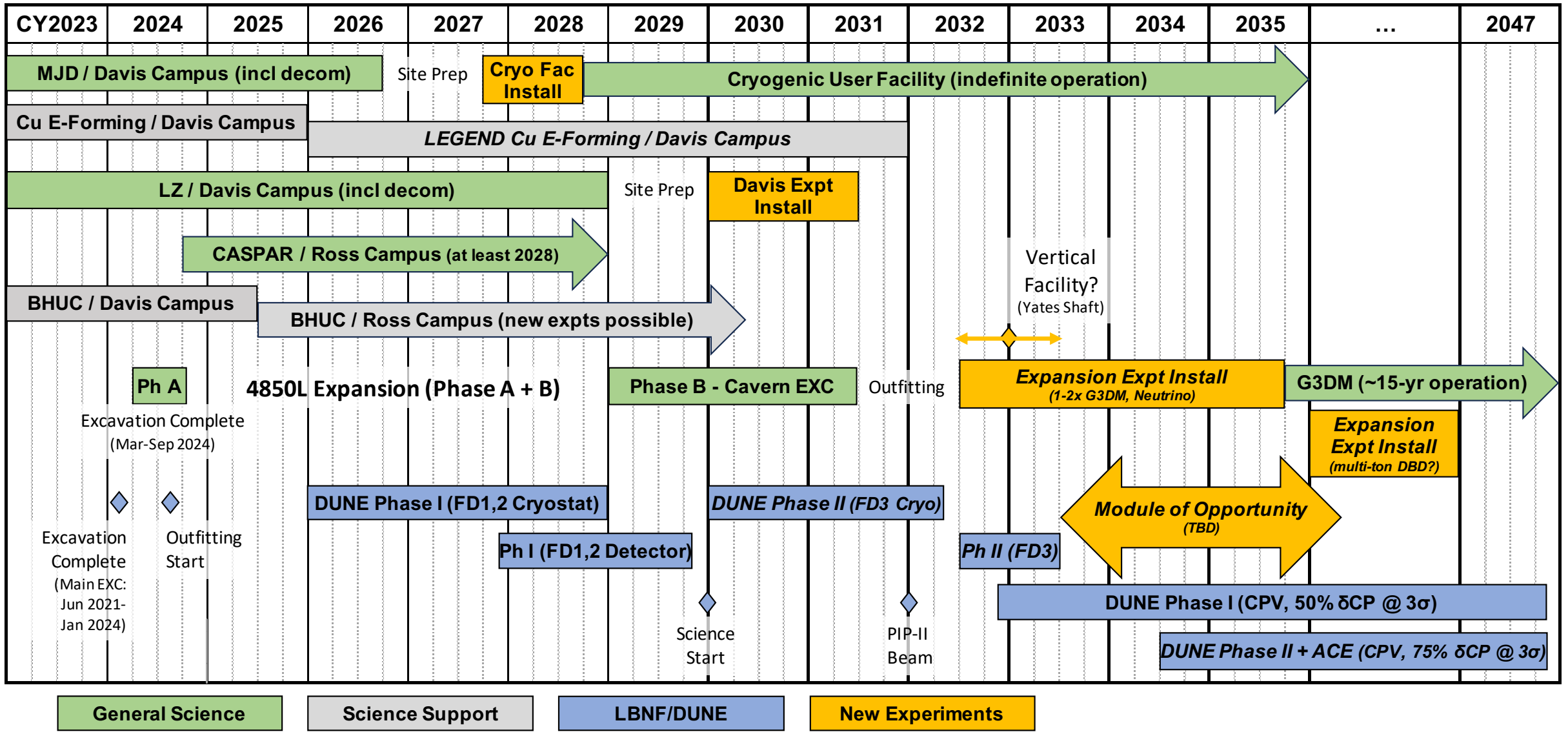
SURF Science Strategic Planning

Timeline



SURF Plans to Become DOE User Facility

Benefits:

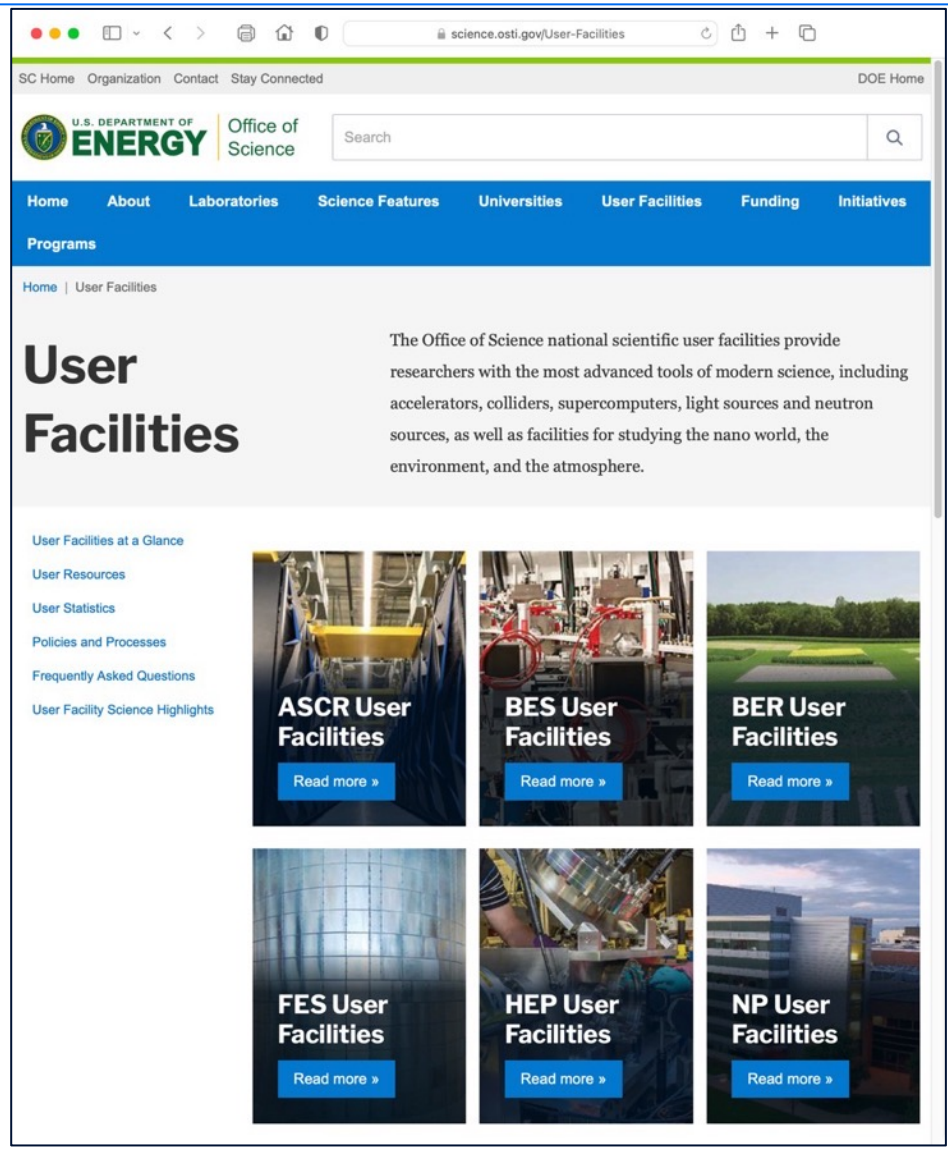
- Expands DOE User Facility portfolio to incl underground lab, raises SURF's stature within DOE community.
- Promotes underground science in U.S., increases funding opportunities.
- Enhances SURF's role in global science community.
- Communicates SURF is open to a broad range of science and users and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

Main Requirements:

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

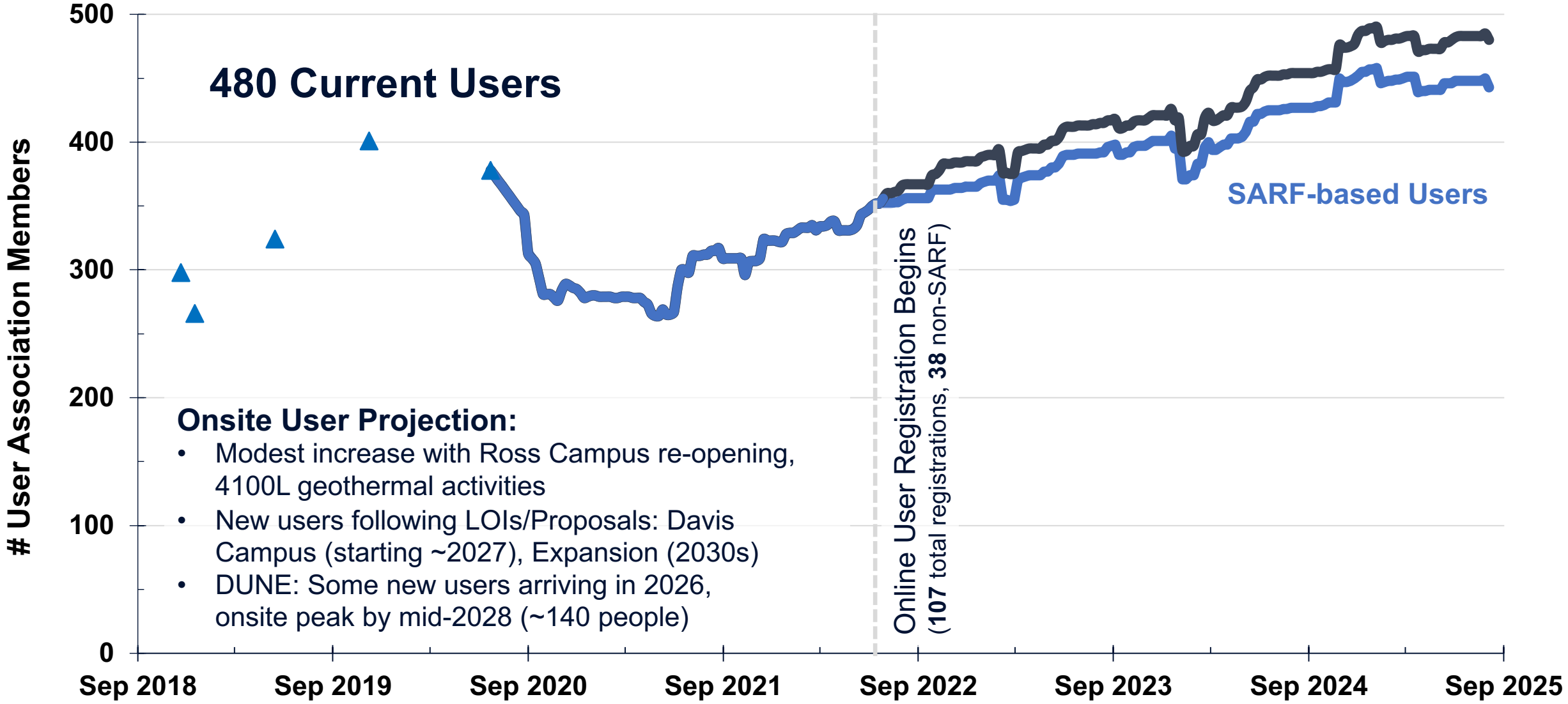
Status:

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



SURF User Association Members

Significant user base, expect more engagement with UG science community



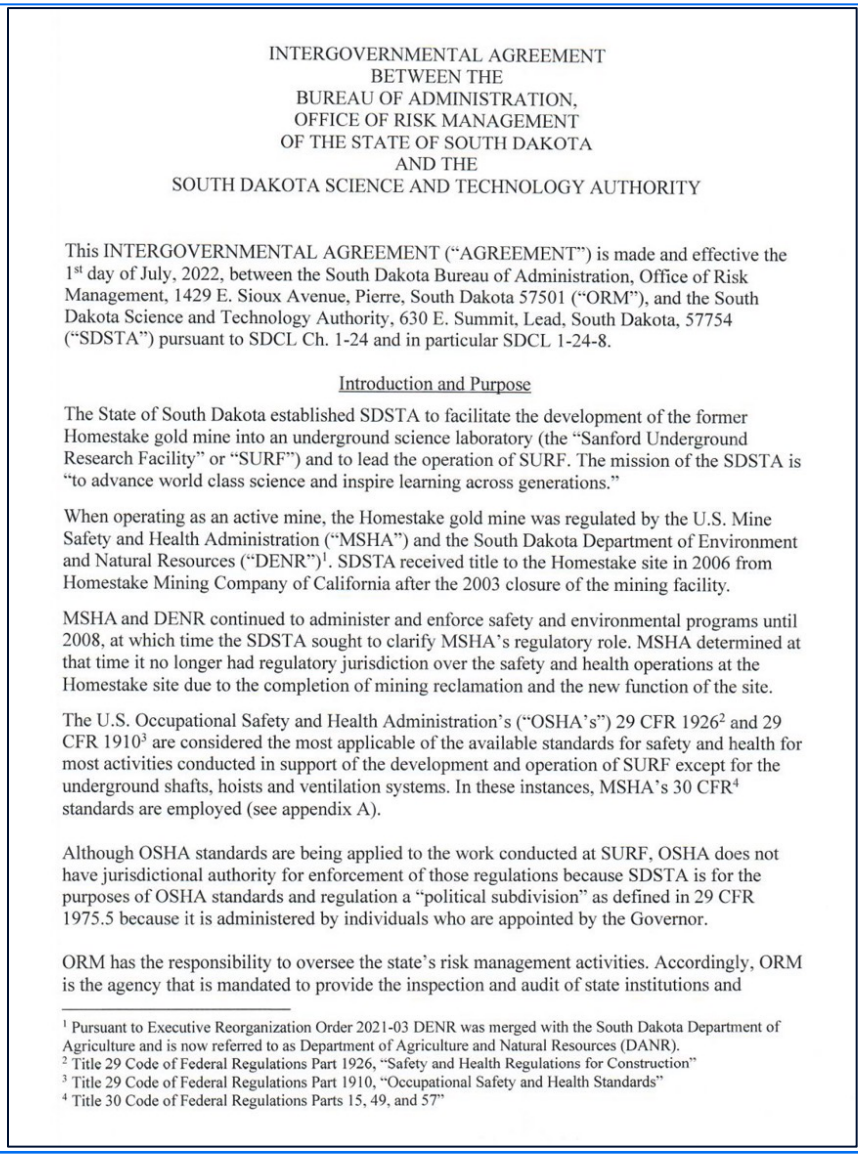
Onsite User Projection:

- Modest increase with Ross Campus re-opening, 4100L geothermal activities
- New users following LOIs/Proposals: Davis Campus (starting ~2027), Expansion (2030s)
- DUNE: Some new users arriving in 2026, onsite peak by mid-2028 (~140 people)

SURF Governance

Informs SURF ESH Manual

- **Intergovernmental Agreement (IGA)** created in 2011 between SDSTA and state of South Dakota **Office of Risk Management (ORM)** for worker health and safety oversight at SURF:
  - Roles & responsibilities, incl site inspections and enforcement authority
  - Agreement on specific regulations, codes and standards that best support safe operations at SURF
  - Reviewed and approved annually
- Key IGA regulations include:
  - **OSHA:** General worker health (1910) and safety/construction activities (1926)
  - **MSHA:** Shaft and hoisting operations, ventilation, ground control (30 CFR Part 57), diesel particulate (Part 7), mine rescue (emergency response team)
  - **NFPA:** Electrical (70E), fire alarm (72), life safety (101), etc
  - **NEPA:** (10 CFR 1021)
  - **DANR:** South Dakota Dept of Agriculture and Natural Resources oversees environmental regulation compliance, also ionizing radiation-producing machine registration
  - **City of Lead** is AHJ for building, fire and life safety codes
- NRC regulates radioactive material:
  - License since 2013, amended 2018 for broad scope



INTERGOVERNMENTAL AGREEMENT
BETWEEN THE
BUREAU OF ADMINISTRATION,
OFFICE OF RISK MANAGEMENT
OF THE STATE OF SOUTH DAKOTA
AND THE
SOUTH DAKOTA SCIENCE AND TECHNOLOGY AUTHORITY

This INTERGOVERNMENTAL AGREEMENT ("AGREEMENT") is made and effective the 1st day of July, 2022, between the South Dakota Bureau of Administration, Office of Risk Management, 1429 E. Sioux Avenue, Pierre, South Dakota 57501 ("ORM"), and the South Dakota Science and Technology Authority, 630 E. Summit, Lead, South Dakota, 57754 ("SDSTA") pursuant to SDCL Ch. 1-24 and in particular SDCL 1-24-8.

Introduction and Purpose

The State of South Dakota established SDSTA to facilitate the development of the former Homestake gold mine into an underground science laboratory (the "Sanford Underground Research Facility" or "SURF") and to lead the operation of SURF. The mission of the SDSTA is "to advance world class science and inspire learning across generations."

When operating as an active mine, the Homestake gold mine was regulated by the U.S. Mine Safety and Health Administration ("MSHA") and the South Dakota Department of Environment and Natural Resources ("DENR")[1]. SDSTA received title to the Homestake site in 2006 from Homestake Mining Company of California after the 2003 closure of the mining facility.

MSHA and DENR continued to administer and enforce safety and environmental programs until 2008, at which time the SDSTA sought to clarify MSHA's regulatory role. MSHA determined at that time it no longer had regulatory jurisdiction over the safety and health operations at the Homestake site due to the completion of mining reclamation and the new function of the site.

The U.S. Occupational Safety and Health Administration's ("OSHA's") 29 CFR 1926[2] and 29 CFR 1910[3] are considered the most applicable of the available standards for safety and health for most activities conducted in support of the development and operation of SURF except for the underground shafts, hoists and ventilation systems. In these instances, MSHA's 30 CFR[4] standards are employed (see appendix A).

Although OSHA standards are being applied to the work conducted at SURF, OSHA does not have jurisdictional authority for enforcement of those regulations because SDSTA is for the purposes of OSHA standards and regulation a "political subdivision" as defined in 29 CFR 1975.5 because it is administered by individuals who are appointed by the Governor.

ORM has the responsibility to oversee the state's risk management activities. Accordingly, ORM is the agency that is mandated to provide the inspection and audit of state institutions and

[1] Pursuant to Executive Reorganization Order 2021-03 DENR was merged with the South Dakota Department of Agriculture and is now referred to as Department of Agriculture and Natural Resources (DANR).
[2] Title 29 Code of Federal Regulations Part 1926, "Safety and Health Regulations for Construction"
[3] Title 29 Code of Federal Regulations Part 1910, "Occupational Safety and Health Standards"
[4] Title 30 Code of Federal Regulations Parts 15, 49, and 57"

SURF Radon Reduction System – Surface

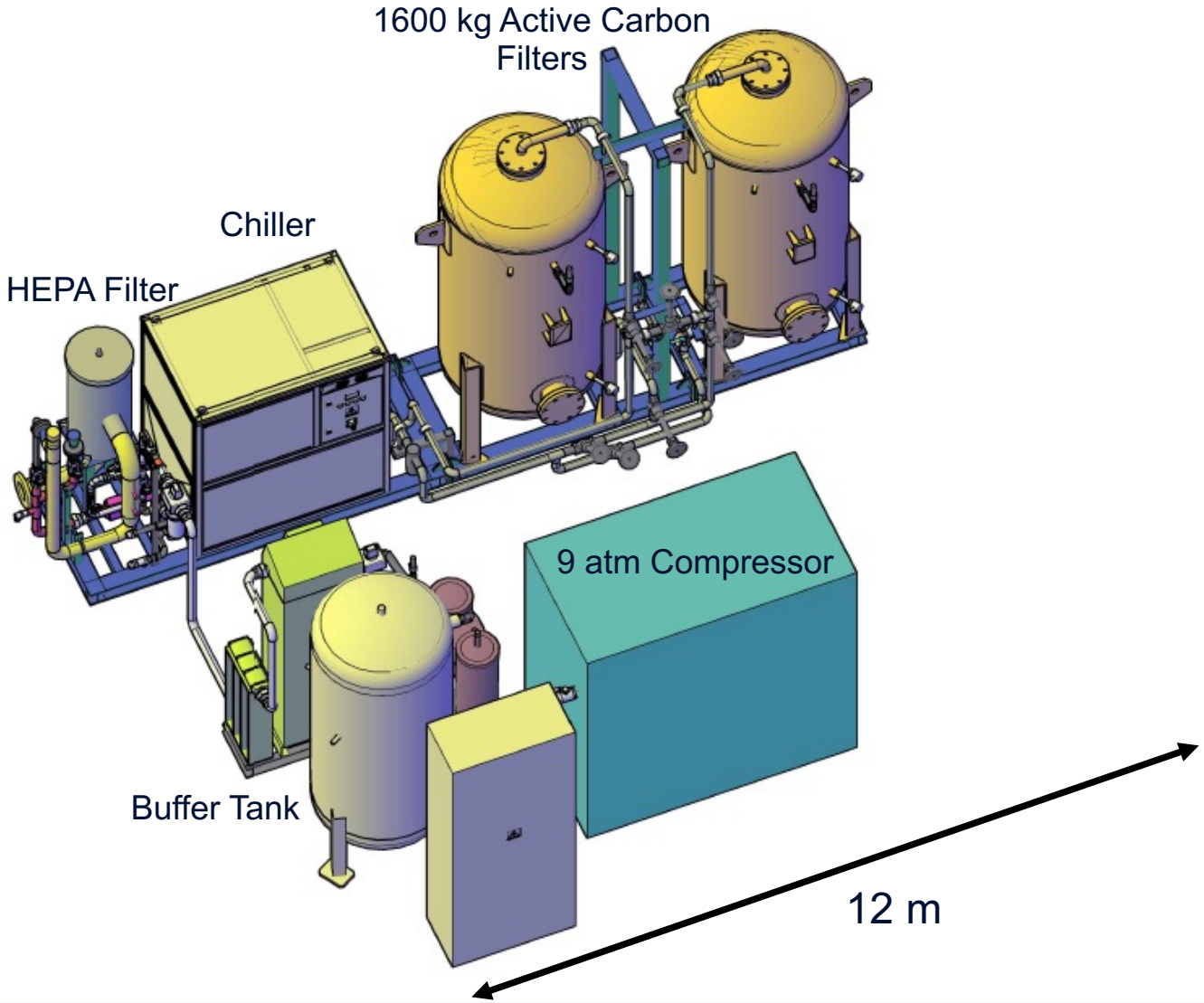
Commercial continuous-cooled Rn mitigation system

- **Specs:** 1000x Rn reduction, 300 m^3/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^2
- **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^2, 240 m^3
- **Status:** Operating as Class 100, **770x Rn reduction** inside cleanroom

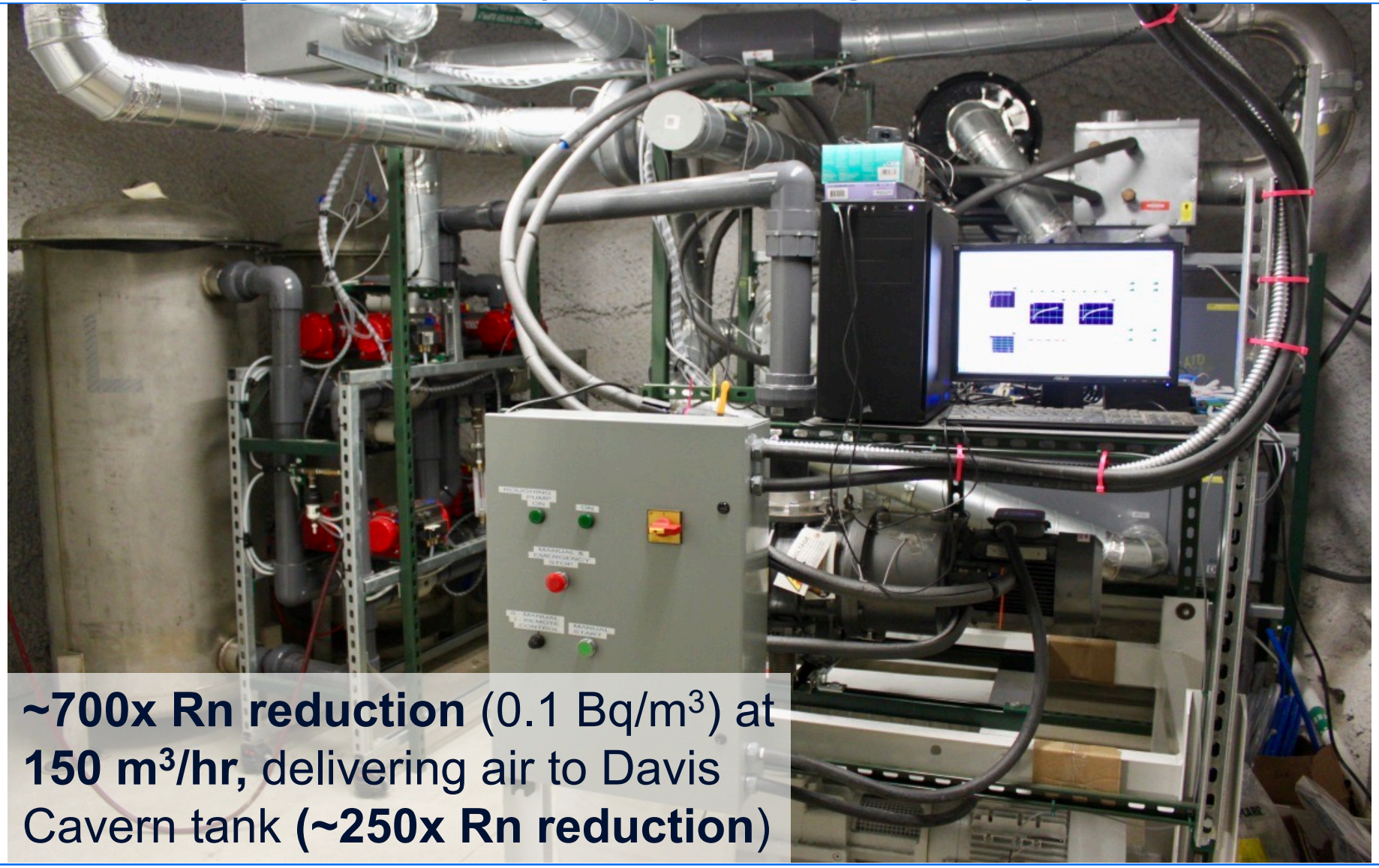
SURF Radon Reduction System – Surface

Commercial continuous-cooled Rn mitigation system



SURF Radon Reduction System – Underground

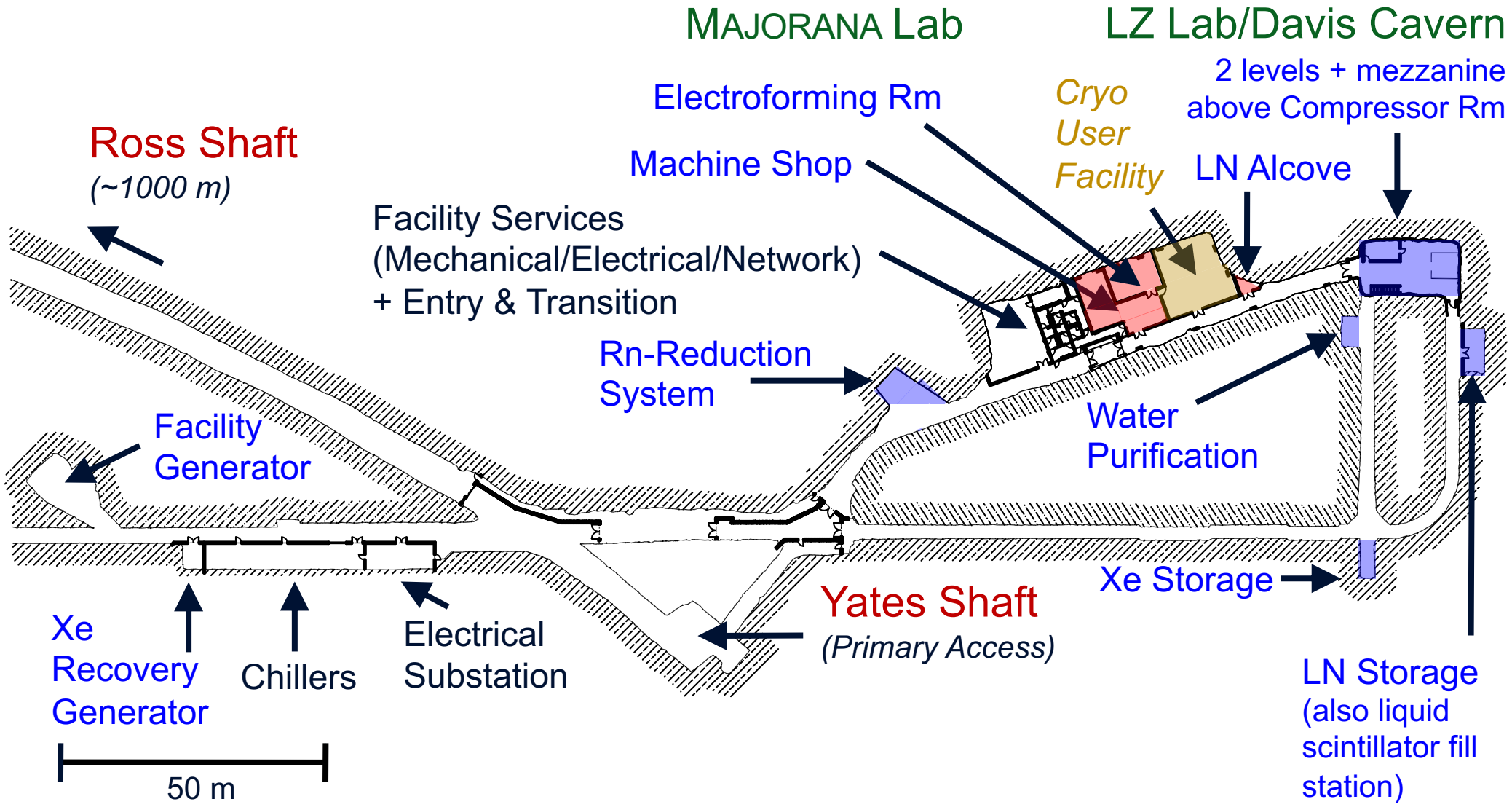
SDSMT vacuum-swing adsorption (VSA) Rn mitigation system



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

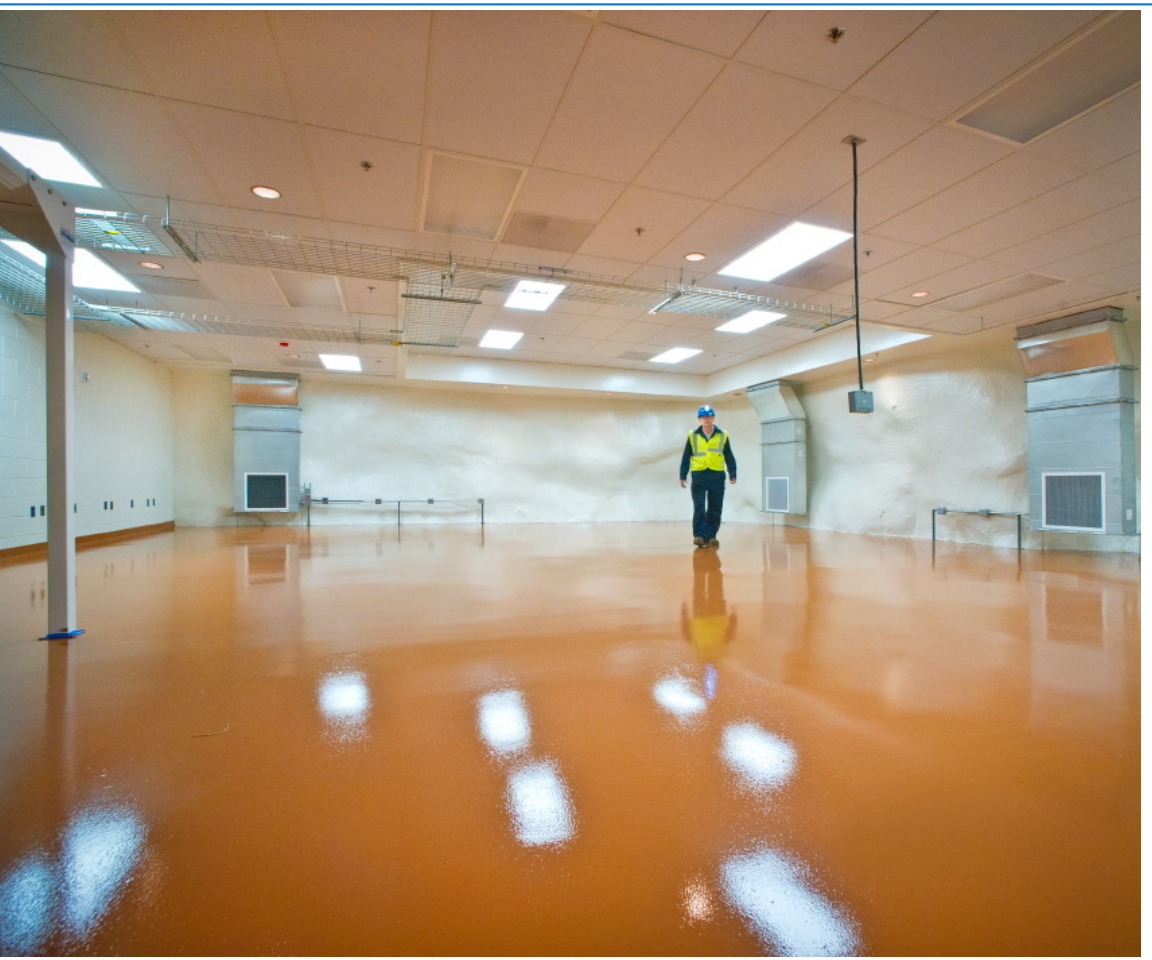
4850L Davis Campus

3,017 m² (Total) / 1,018 m² (Science)



SURF 4850L Davis Campus

Examples of laboratory space



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

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

SURF Designated APS Historical Site

Announcement Sep 2020, Dedication May 2022

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

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

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

14 September 2020 - Sanford Underground Research Facility

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

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

DATE ISSUED:
September 14th, 2020

SOURCE:
Sanford Underground Research Facility

CONTENT:
Press Release

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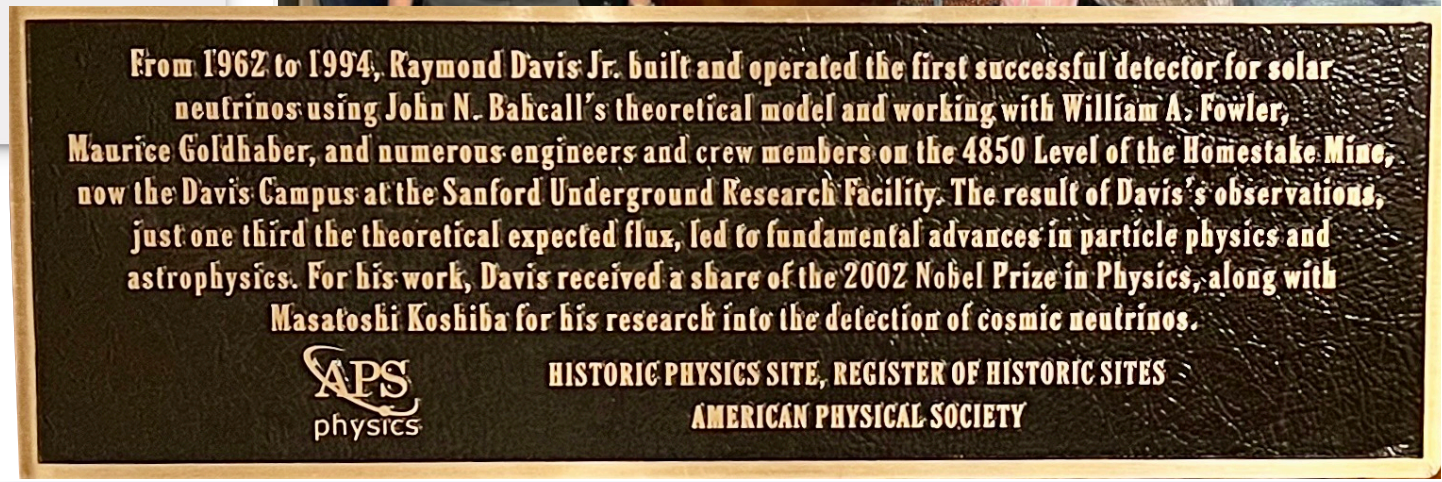
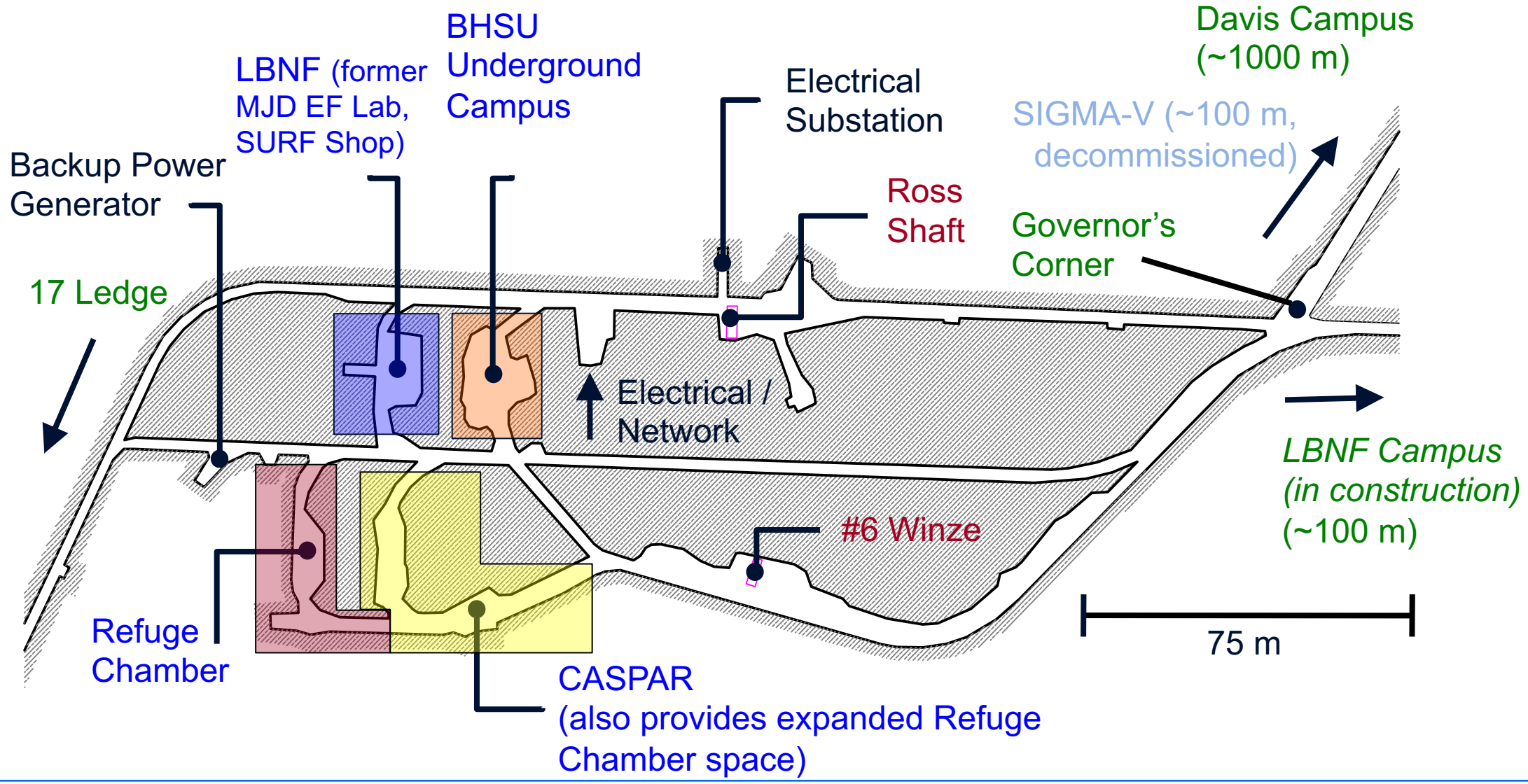
Communications Director
cwalter@sanfordlab.org



4850L Ross Campus

2,653 m² (Total) / 920 m² (Science)



SURF 4850L Ross Campus

Examples of laboratory space

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

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

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

SURF Current & Future Facilities

Summary for various science campuses, including timelines

Location	Laboratory	Existing/*Planned* Space		Available (CY)	Comments
		Area (m^2)	Vol (m^3)		
Surface	Surface Lab (+ RRS)	210	600	2021	LZ use ~complete, allowing use by others
Davis Campus (4850L)	LZ Lab – Davis Cavern (2 levels)	372	1,956	~2028	LZ data complete early ~2028 + decommissioning
	MJD Lab – 3 Rooms *(1 Rm for Cryo Facility)*	300	1,279	2027 / ~2032	Ge-76 DBD + Ta-180m completed, decommissioning complete in 2026; Cu e-forming through ~2031
	Cutout Rooms (4)	100	412	~2028	LZ timeframe for most spaces
Ross Campus (4850L)	Former E-forming	228	742	?	LBNF use currently, likely unavailable for several yrs
	BHUC (BHSU cleanroom)	266	773	N/A	Low-bkgd counting operations resumed summer 2025. Indefinite use.
	CASPAR	395	1,130	2027+	Phase II program underway until at least 2028. Proposals for Phase III (Also expanded Refuge)
	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	2028	DEMO-FTES use 2023-2025, CUSSP 2025-2027
4850L	*Expansion (2 proposed)*	*4,022*	*94,608*	*Earliest new: excavation 2029, complete ~2031*	*Each 20m (W) x 24m (H) x 100m (L)*
7400L	*New Labs (2 proposed)*	*4,178*	*42,440*		*Each 15m (W) x 15m (H) x 75m (L) + other supporting*

Institute for Underground Science at SURF

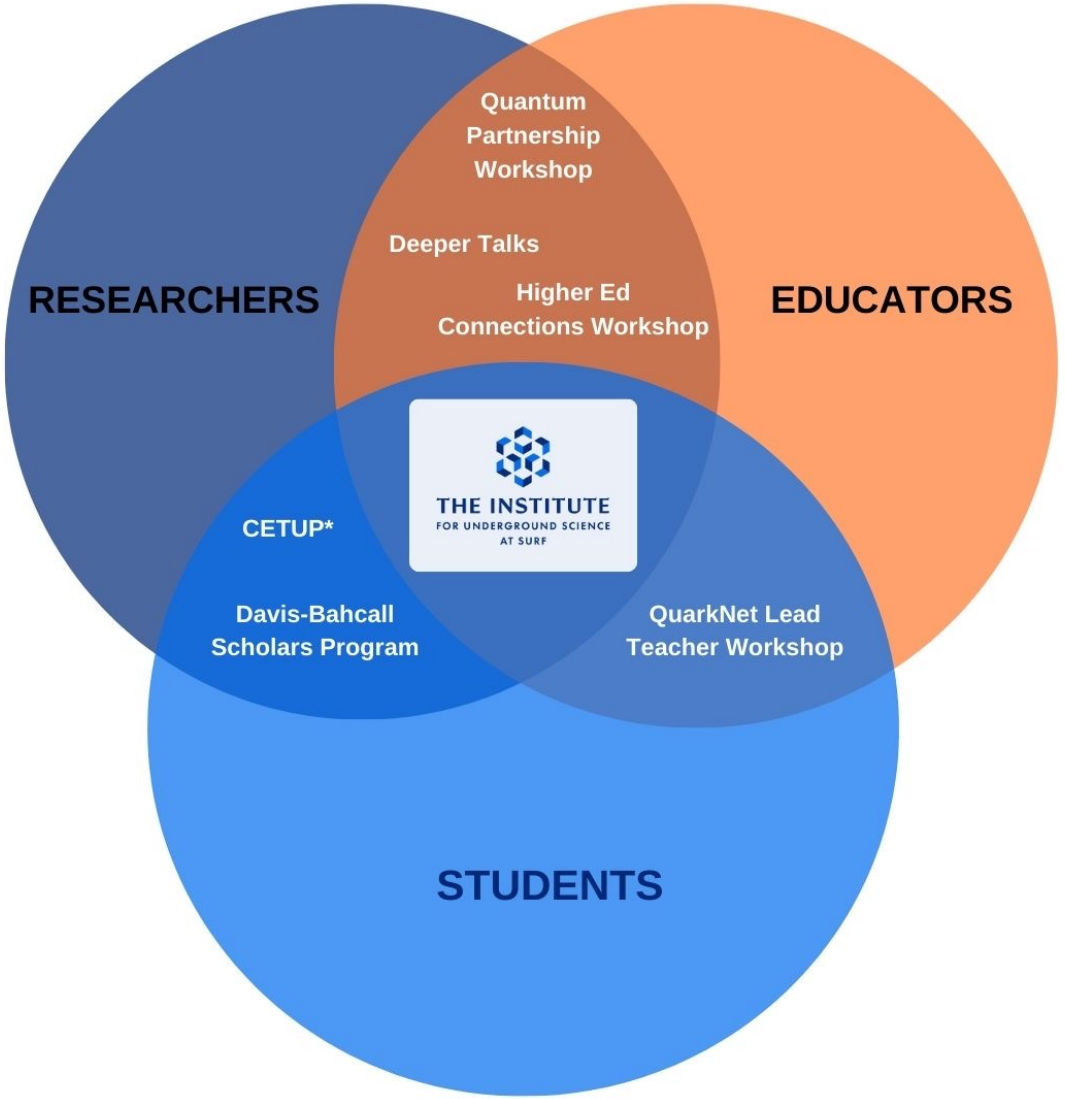
Advancing program vision using existing resources to build constituency

Vision

Foster a globally recognized intellectual community by scaling impactful programs, engaging researchers, educators, and students to support underground science initiatives.

Priorities

- Build Intellectual Community
- Expand Educational Opportunities
- Foster Interdisciplinary Collaboration
- Establish Passionate Partnerships
- Construct a Path for Future Generations



The Institute for Underground Science at SURF

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

World-leading center for

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

THE INSTITUTE
FOR UNDERGROUND SCIENCE
AT SURF

Sanford Underground Research Facility

General summary

Site: Deepest underground lab in U.S., largest footprint for scientific pursuits (former Homestake Gold Mine). Operations funded directly by U.S. Department of Energy ($35M/yr). Robust org, total staff = 213 ppl.

Science Program:

- **Past:** Davis Solar Neutrino Experiment, LUX, MAJORANA DEMONSTRATOR ($0\nu\beta\beta$, ^{180m}Ta), others (incl Deep Underground Gravity Lab, affiliated with LIGO collaboration)
- **Current:** LZ, CASPAR, Low-bkgd counting (BHUC), Geoengineering (esp. geothermal, seismic), Geomicrobiology, Industry/engineering (Caterpillar)
- **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, ultra-light dark matter (km-scale vertical or horizontal)

Facility:

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

Sanford Underground Research Facility

Physical characteristics

- **Property:** 1 km^2 (surface) with ~1600 m^2 storage (incl drill core) and 355 m^2 staging/assembly space; 31 km^2 (total underground) with ~600 km of tunnels extending to over 2450 m below ground.
- **Access:** Vertical; personnel and materials via one of two main shafts (Yates Shaft extensive maintenance campaign completed, DOE funding discussions for full refurbishment). Facility dedicated to science.
  - Yates Shaft: 1.39 × 3.77 × 2.58 m, 4.8 tonnes (lengths up to 7.3 m possible at reduced payload mass)
  - Ross Shaft: 1.40 × 3.70 × 3.62 m, 6.1 tonnes (lengths up to 8.2 m possible at reduced payload mass; new cage soon)
- **Depth:** Main UG level = 4850L (1480 m, 4300 mwe), muon flux = 5.31×10^{-5} $\mu/m^2/s$ (4.6 $\mu/m^2/d$). Several other UG elevations for science: 300L, 800L, 1700L, 2000L, 4100L, 4550L.
- **Space:**
  - Surface (science space, as low as class 10-100): 210 m^2 (cleanrooms = 92 m^2 / 914 m^3)
  - 4850L (science space, as low as class 100): Davis Campus (1018 m^2 / 4633 m^3), Ross Campus (920 m^2 /3144 m^3)
  - Radon-reduction: Surface = 2200x reduction @ 300 m^3/h (Ateko), Davis = 700x reduction @ 150 m^3/h (SD Mines)
- **Bkgds** (4850L): Radon* = 180-402 Bq/m^3, gamma = 1.9 $\gamma/cm^2/s$, neutron = 1.7×10^{-2} $n/m^2/s$.
- **Utilities:**
  - Power = 24,000 kW capacity (20,000 kW available now, 15,000 kW in FY27); Standby = 3 diesel generators (390 kW)
  - Chilled water (2x 246 kW), purified water (37.8 lpm), compressed air (up to 1100 scfm, 140 scfm at Davis Campus)
  - Network = 20 Gbps internally, 10 Gbps externally (100 Gbps planned), WiFi available surface + underground

* Studies conducted Summer 2024, expect to reduce Rn concentration

Sanford Underground Research Facility
Capabilities

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