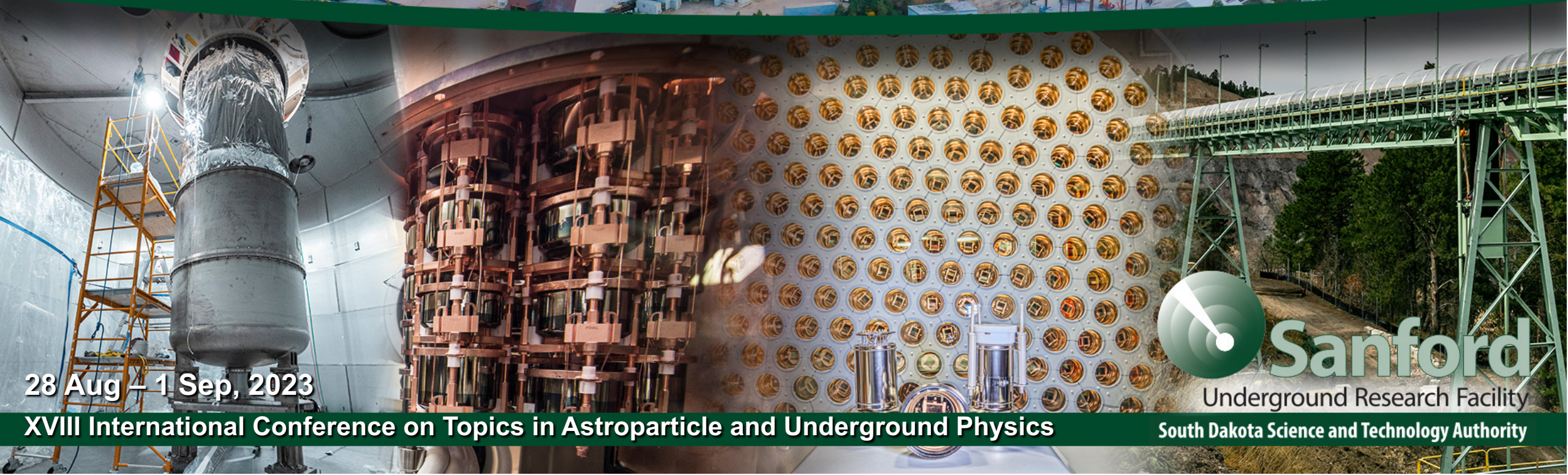


Opportunities at the Sanford Underground Research Facility

Jaret Heise, Science Director

jaret@sanfordlab.org



28 Aug – 1 Sep, 2023

XVIII International Conference on Topics in Astroparticle and Underground Physics



Sanford

Underground Research Facility

South Dakota Science and Technology Authority

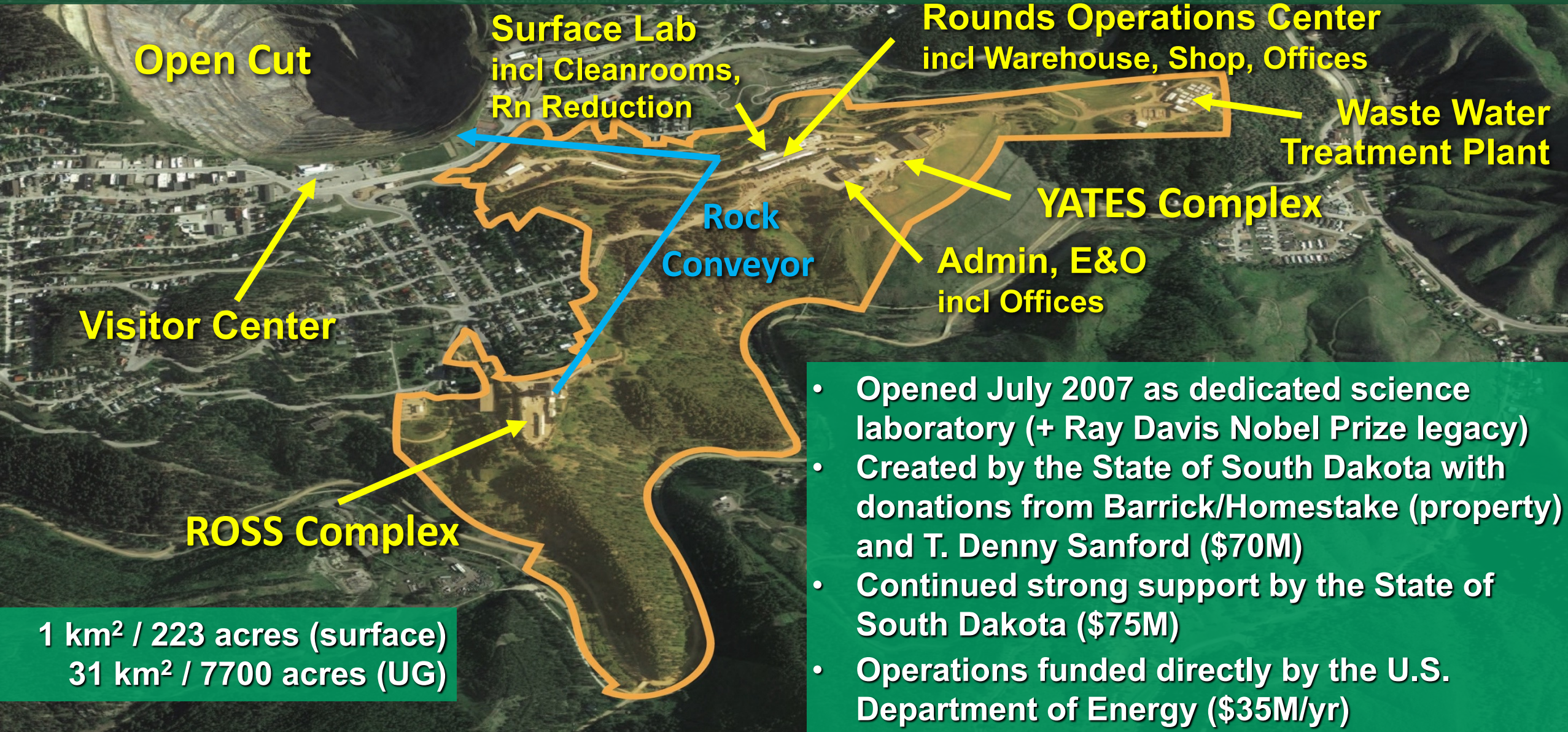
Sanford Underground Research Facility

Where in the world is SURF?



Sanford Underground Research Facility

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



Sanford Underground Research Facility

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



Ross Shaft

Yates Shaft



Administration Bldg



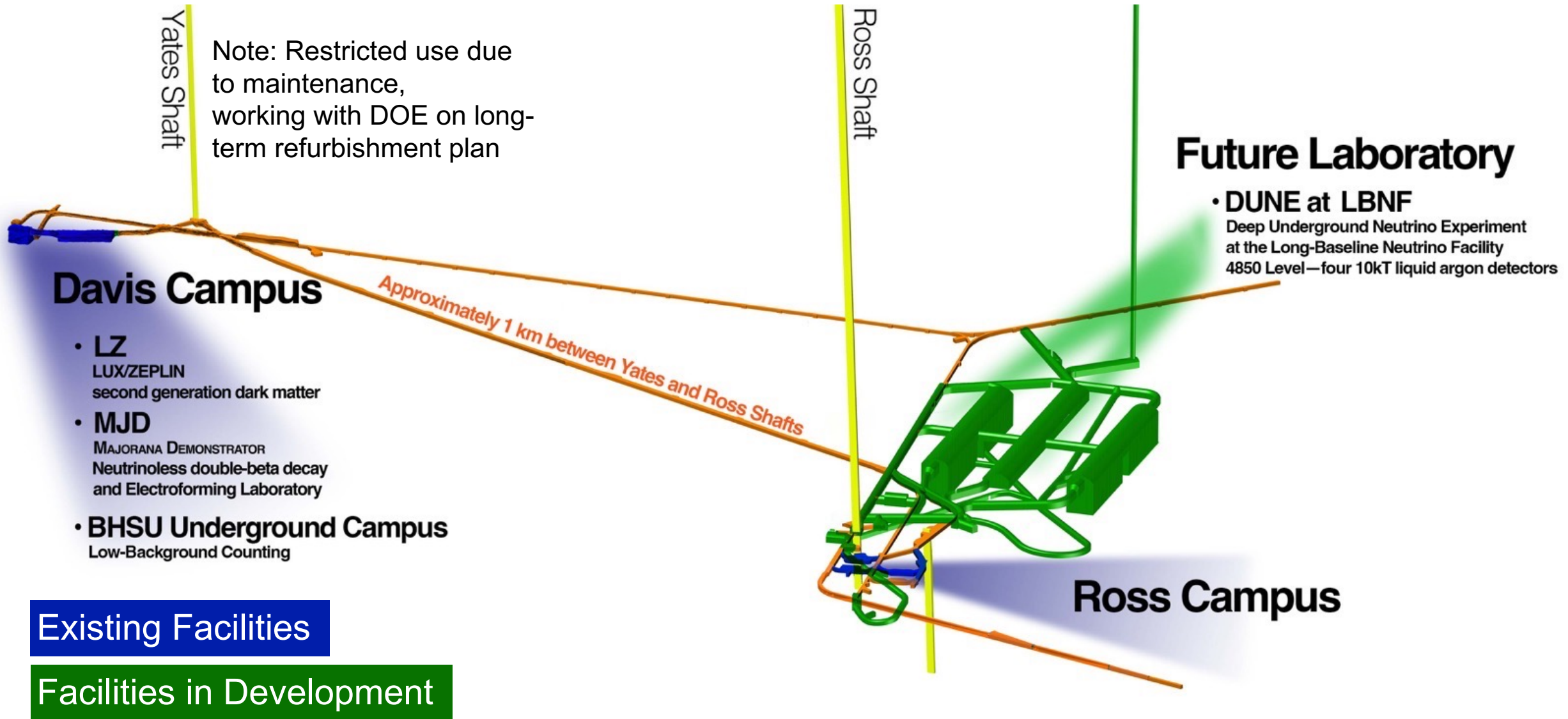
Rounds Operations Center

Surface Lab + RRS



Yates Hoistroom

4850L Science Facilities





Dark Matter
LUX-ZEPLIN



Neutrinos
MAJORANA DEMONSTRATOR
LBNF /DUNE



Biology
Extreme Life
Astrobiology

Science Program



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

Total = 31 groups

22 Active Projects

63 Total Groups Since 2007

Significant interest from others
(23 groups in 2022)

* Denotes proprietary
group

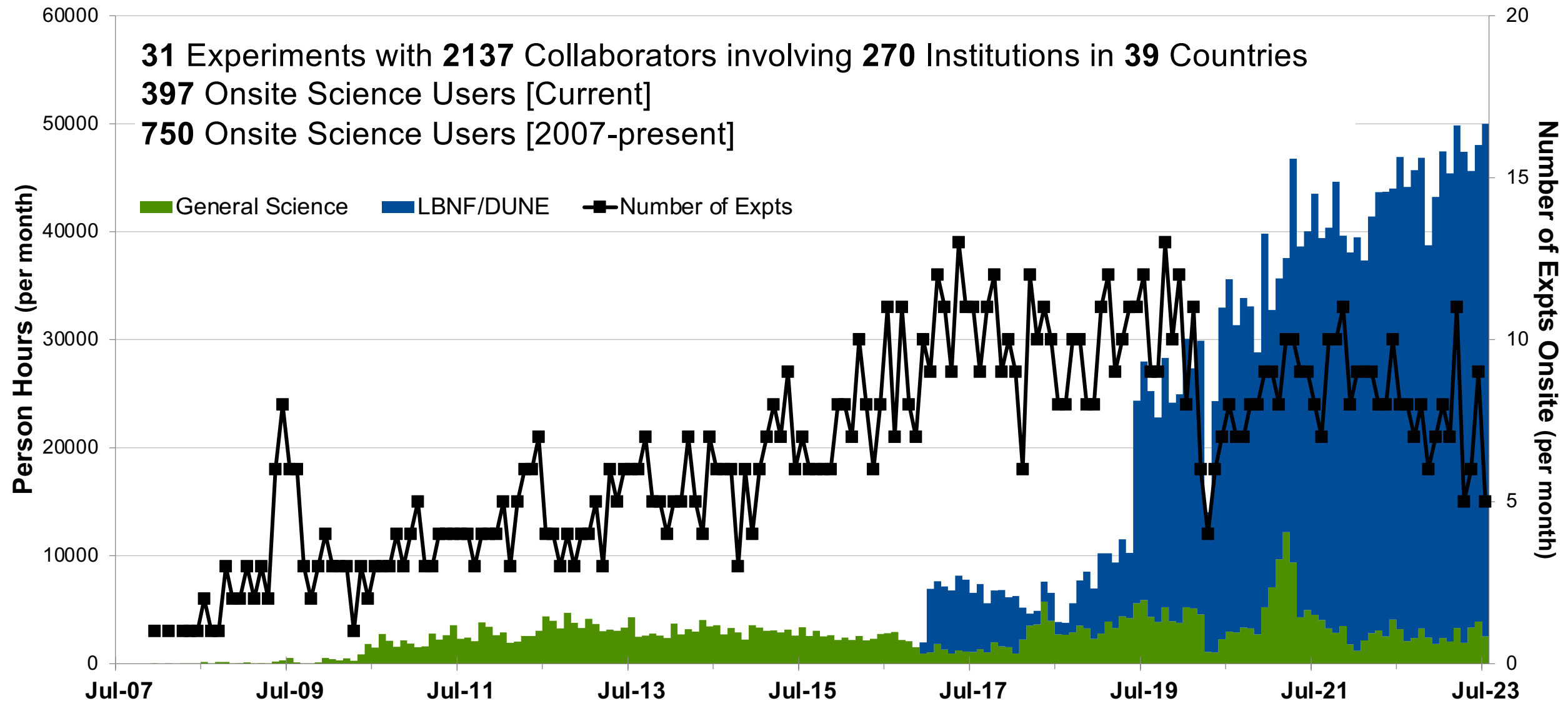
Biology Astrobiology/DeMMO – In-situ
cultivation, DNA isolation
2D Best – Biofilms
Biodiversity – Microbial communities
Biofuels – Extremophile bioprospecting
BuG ReMeDEE – Methane oxidation
Chemistry – Env characterization
Liberty BioSecurity* – Extremophiles

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

Engineering Xilinx, Inc* – Chip error testing
Thermal Breakout – In situ stress
Shotcrete – Mining safety
Env Monitoring – Ventilation airflow
Caterpillar* – Mining processes
Blast Monitoring – LBNF-related
PDR – Sensors

SURF Science Program

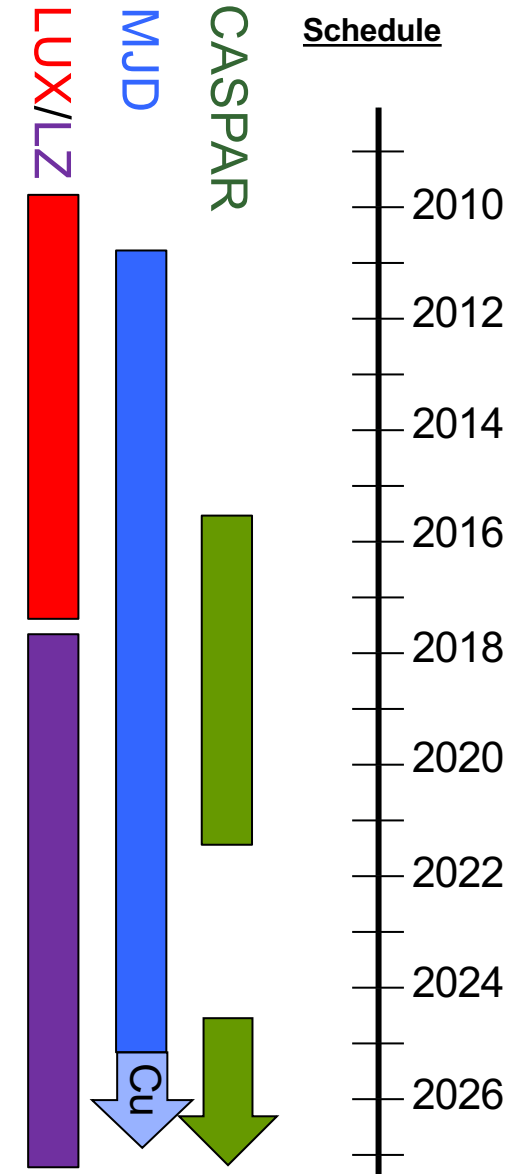
Hosting world-leading experiments and researchers from diverse scientific communities



SURF Science Program – Current Physics Highlights

Strong and diverse program with exciting future

- **LZ:** Direct search for **dark matter** using 10 tonnes xenon within ultra-pure water shield + Gd liquid scintillator veto
Status: WIMP search ongoing, first results announced Jul 2022 (PRL Jul 2023), run for 5 years (~2027).
- **MAJORANA DEMONSTRATOR:** Investigate **neutrinoless double-beta decay** using 44 kg Ge in two cryostats, 30 kg enriched ^{76}Ge inside multi-layer compact shield
Status: Data 2015-2021 (exposure goal achieved), final $0\nu\beta\beta$ result announced Jul 2022 (PRL Feb 2023). Ultra-pure electroformed Cu production continues for LEGEND. Rare decay search $^{180\text{m}}\text{Ta}$ underway, first result Jun 2023, complete in 2024.
- **CASPAR:** Study of stellar nuclear fusion reactions, esp. neutron production for **slow neutron-capture nucleosynthesis** using 1-MV accelerator
Status: Beam operation 2017-2021, targets incl ^7Li , ^{11}B , ^{14}N , ^{18}O , ^{20}Ne , ^{22}Ne (gas, solid), ^{27}Al . $^{18}\text{O}(\alpha,\gamma)^{22}\text{Ne}$ PRL Apr 2022. Next phase starting FY24, incl ^{14}N (relevant for CNO solar neutrinos).
- **BHUC:** 6x **low-bkgd assay** counters operating (~10s ppt sensitivity)



SURF Science Program – Current Physics Highlights

Strong and diverse program with exciting future

- **LZ:** Direct search for **dark matter** using 10 tonnes xenon within ultra-pure water shield + Gd liquid scintillator veto

Status: WIMP search ongoing, first results announced Jul 2022 (PRL Jul 2023), run for 5 years (~2027).

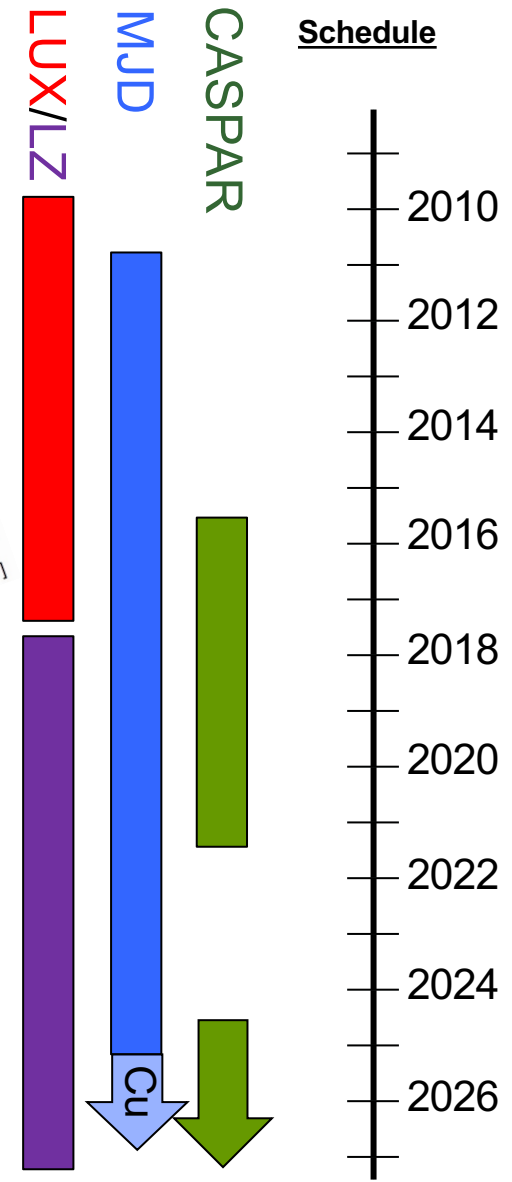
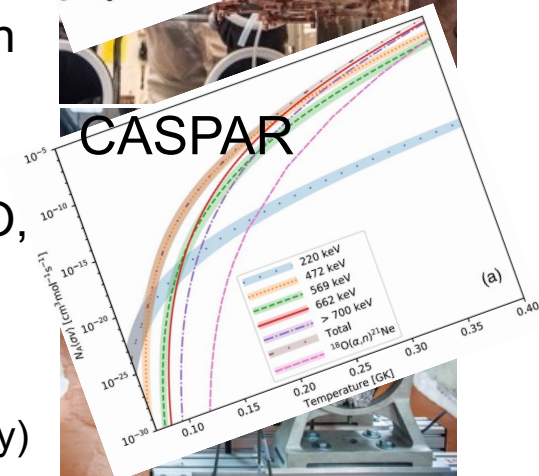
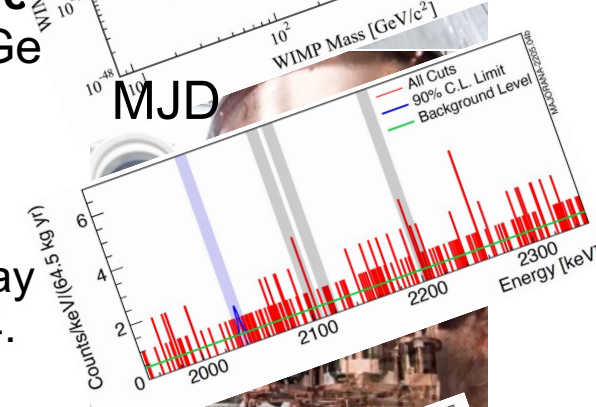
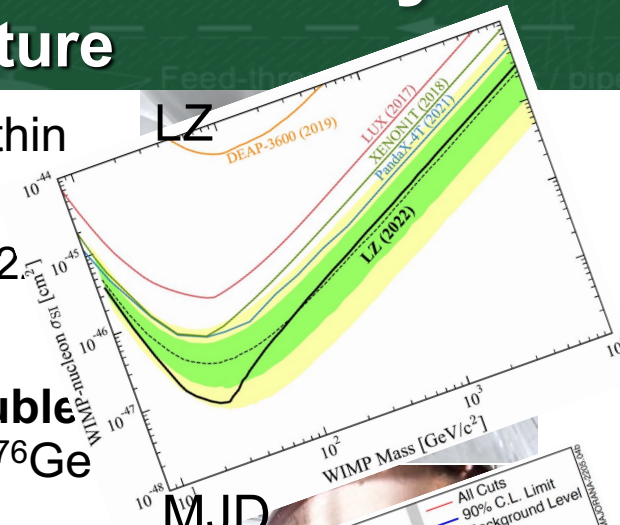
- **MAJORANA DEMONSTRATOR:** Investigate **neutrinoless double beta decay** using 44 kg Ge in two cryostats, 30 kg enriched ^{76}Ge inside multi-layer compact shield

Status: Data 2015-2021 (exposure goal achieved), final $0\nu\beta\beta$ result announced Jul 2022 (PRL Feb 2023). Ultra-pure electroformed Cu production continues for LEGEND. Rare decay search $^{180\text{m}}\text{Ta}$ underway, first result Jun 2023, complete in 2024.

- **CASPAR:** Study of stellar nuclear fusion reactions, esp. neutron production for **slow neutron-capture nucleosynthesis** using 1-MV accelerator

Status: Beam operation 2017-2021, targets incl ^7Li , ^{11}B , ^{14}N , ^{18}O , ^{20}Ne , ^{22}Ne (gas, solid), ^{27}Al . $^{18}\text{O}(\alpha,\gamma)^{22}\text{Ne}$ PRL Apr 2022. Next phase starting FY24, incl ^{14}N (relevant for CNO solar neutrinos).

- **BHUC:** 6x low-bkgd assay counters operating (~10s ppt sensitivity)



SURF Science Program – Current Physics Highlights

Strong and diverse program with exciting future

- **LZ:** Direct search for **dark matter** using 10 tonnes xenon within ultra-pure water shield + Gd liquid scintillator veto

Status: WIMP search ongoing, first results announced Jul 2023 (PRL Jul 2023), run for 5 years (~2027).

- **MAJORANA DEMONSTRATOR:** Investigate **neutrinoless double beta decay** using 44 kg Ge in two cryostats, 30 kg enriched inside multi-layer compact shield

Status: Data 2015-2021 (exposure goal achieved), final 0 $\nu\beta\beta$ result announced Jul 2022 (PRL Feb 2023). Ultra-pure electroformed Cu production continues for LEGEND. Rare decay search ^{180m}Ta underway, first result Jun 2023, complete in 2024

- **CASPAR:** Study of stellar nuclear fusion reactions, esp. neutron production for **slow neutron-capture nucleosynthesis** using 1-MV accelerator

Status: Beam operation 2017-2021, targets incl ^7Li , ^{11}B , ^{14}N , ^{18}O , ^{20}Ne , ^{22}Ne (gas, solid), ^{27}Al . $^{18}\text{O}(\alpha,\gamma)^{22}\text{Ne}$ PRL Apr 2022. Next phase starting FY24, incl ^{14}N (relevant for CNO solar neutrinos).

- **BHUC:** 6x low-bkgd assay counters operating (~10s ppt sensitivity)

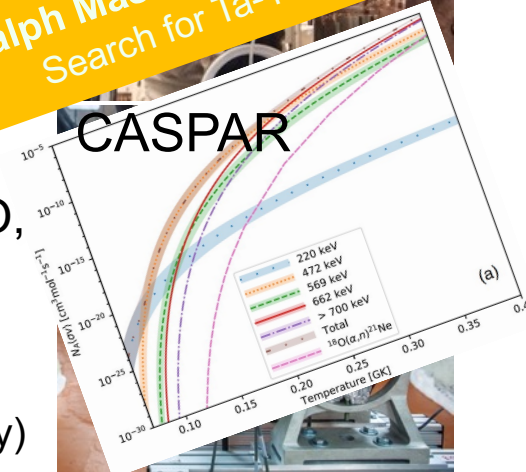
Billy Boxer, Mon Aug 28 @ 16:30
Status of the LZ Experiment

Michael Williams, Mon Aug 28 @ 17:30
Effective Field Theory DM Searches w/ LZ

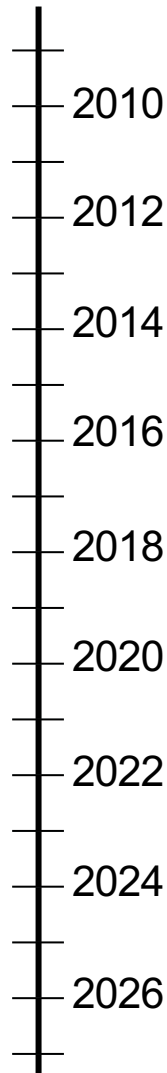
Chris Haufe, Wed Aug 30 @ 14:00
Final MJD Results, Improved Bkgd Model

Ian Guinn, Wed Aug 30 @ 14:15
MJD Ge-76 to Se-76 excited states

Ralph Massarczyk, Tue Aug 29 @ 16:15
Search for Ta-180m decay with MJD

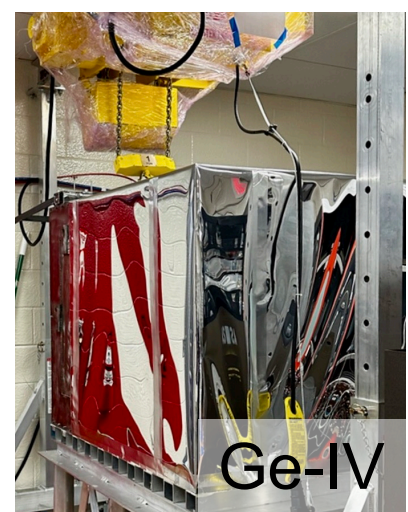
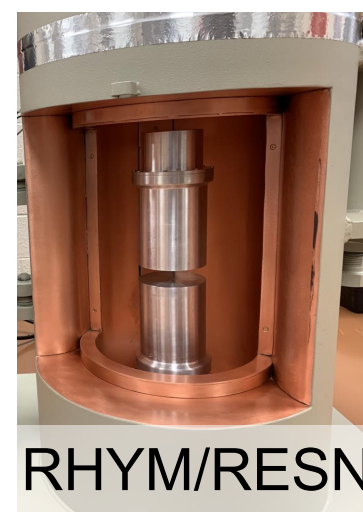
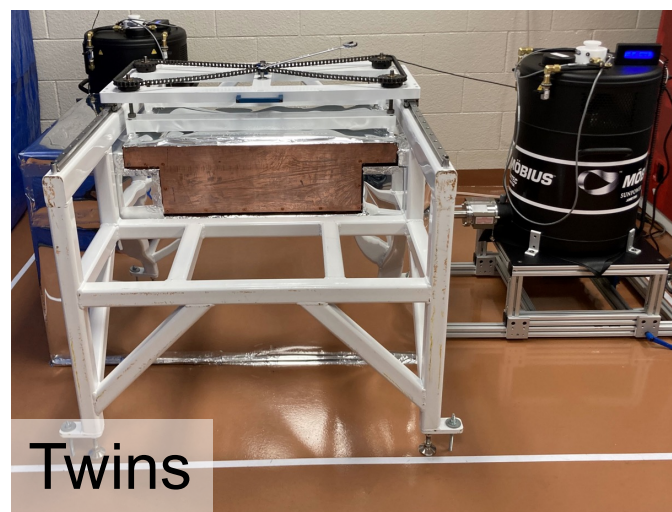
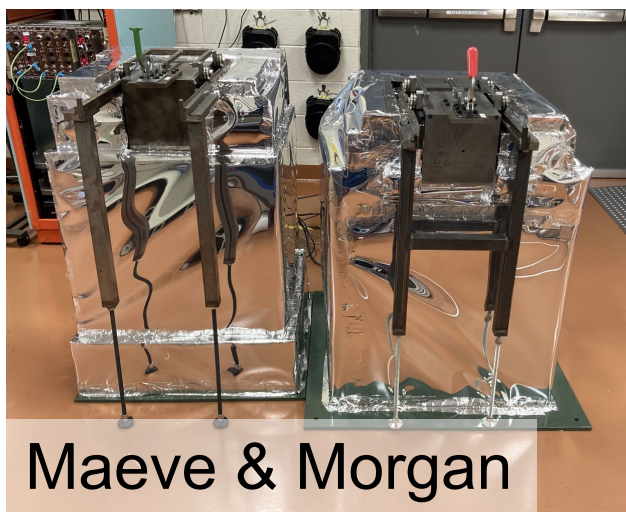
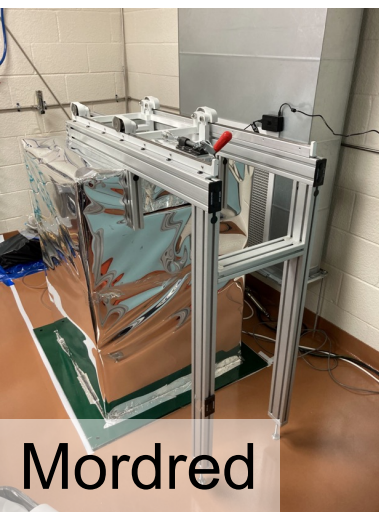


Schedule



SURF Material Assay at BHUC: Davis Campus

Low-background counting capabilities serving national & international community



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					
Maeve (BLBF)	p-type (85%)	2.2 kg	0.1 (10 ppt)	0.1 (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.
Morgan (BLBF)	p-type (85%)	2.1 kg	0.2 (20 ppt)	0.2 (50 ppt)	Davis Campus: Nov 2020 (Ross Campus: Nov 2015; Davis Campus: May 2015)	Production assays	Low-bkgd upgrade 2015. Cooling system upgrades 2020.
Mordred (USD/CUBED, BLBF)	n-type (60%)	1.3 kg	0.7 (60 ppt)	0.7 (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.
Dual HPGe (“Twins”) (BLBF, BHSU, UCSB)	p-type (2x120%)	2x 2.1 kg	~0.01 (~1 ppt)	~0.01 (~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.
Ge-IV (Alabama, Kentucky)	p-type (111%)	2 kg	0.04 (3 ppt)	0.03 (8 ppt)	Davis Campus: May 2023, Nov 2020 (initial) (Ross Campus: Jul 2018, Oct 2017 (initial))	Commissioning	Vertical design, requires gantry + hoist. Cooling system upgrades 2020.
Dual HPGe (“RHYM+RESN”) (LLNL)	p-type (2x65%)	2x 1.1 kg	<0.1 (<10 ppt)	<0.1 (<25 ppt)	Davis Campus: Feb 2022, Sep 2020 (initial)	Operating	Cryocooler, low-E ²¹⁰ Pb (<2 mBq/kg).

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

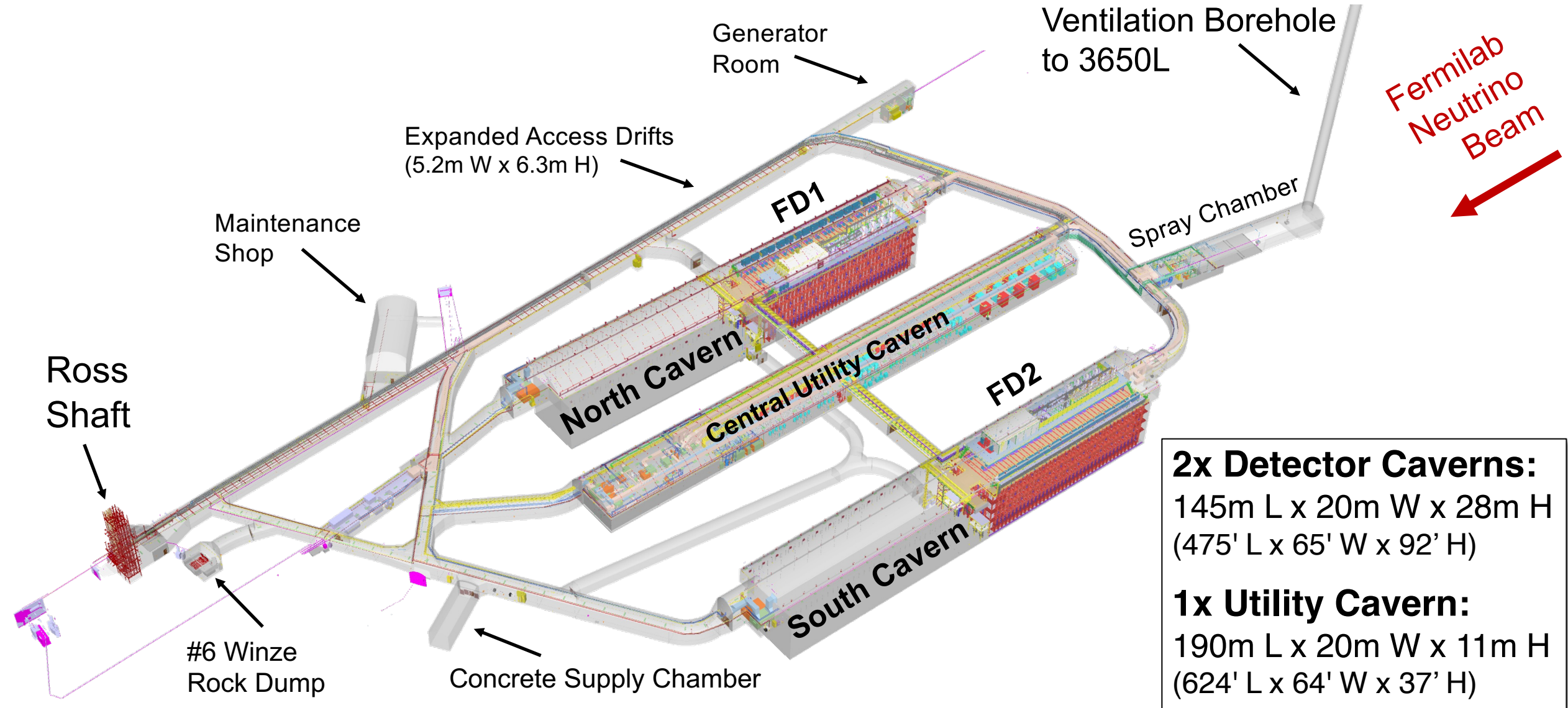
Local universities have some additional material screening capabilities: **HPGe** (SOLO [0.6 kg]/BHSU, [0.2-0.4 kg]/SD Mines), **ICP-MS** (BHSU), **Rn emanation** characterization (0.1 mBq/SD Mines), **Alpha** (1 mBq/m² ²¹⁰Po/SD Mines; XIA UltraLo-1800/LZ purchased)

SURF High-Impact Science

- 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- β Decay in ^{76}Ge with the MAJORANA DEMONSTRATOR, C. E. Aalseth *et al.* (MAJORANA Collaboration) *Phys. Rev. Lett.* **120**, 132502 (2018) [doi: 10.1103/PhysRevLett.120.132502](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).
- 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- β Decay in ^{76}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).
- Exotic dark matter search with the MAJORANA DEMONSTRATOR, I. J. Arnquist *et al.* (MAJORANA Collaboration) submitted to *Phys. Rev. Lett.*
- Constraints on the Decay of $^{180\text{m}}\text{Ta}$, I. J. Arnquist *et al.* (MAJORANA Collaboration) submitted to *Phys. Rev. Lett.*

Long-Baseline Neutrino Facility (LBNF)

LBNF will host the Deep Underground Neutrino Experiment (DUNE)



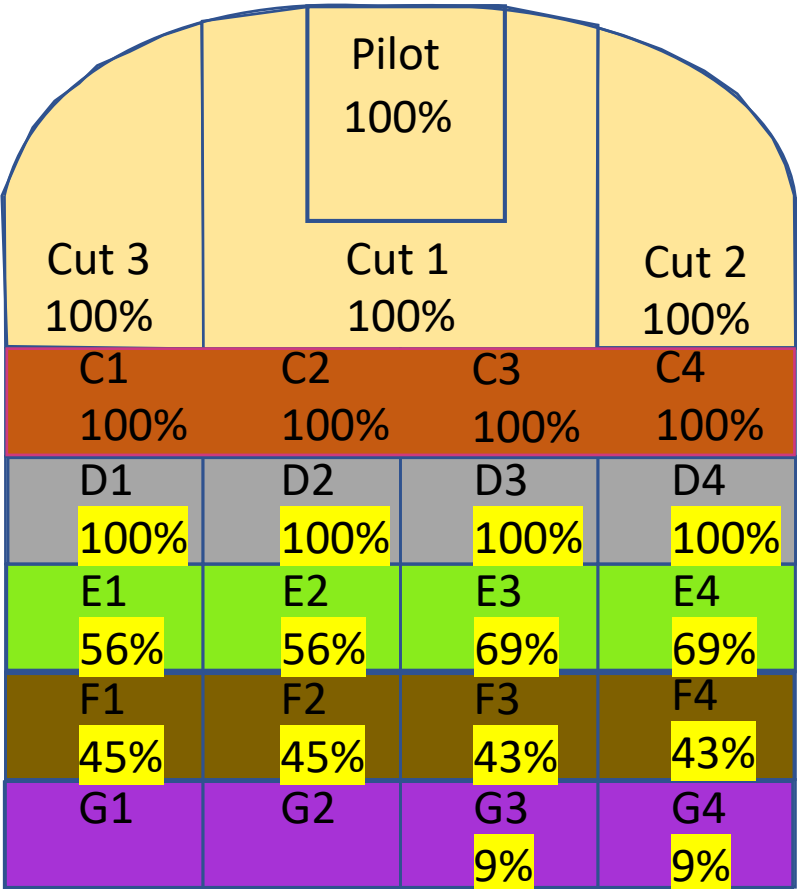
77% completed by volume. Excavation phase continues through mid-2024.



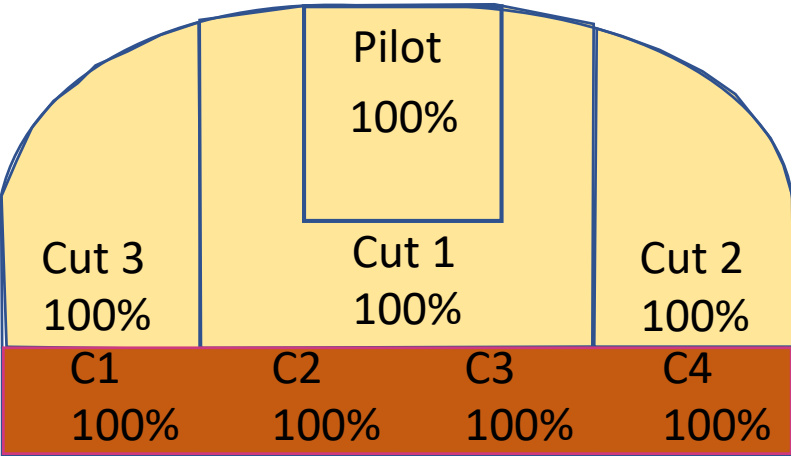
LBNF Excavation Progress

77% completed by volume. Excavation phase continues through mid-2024.

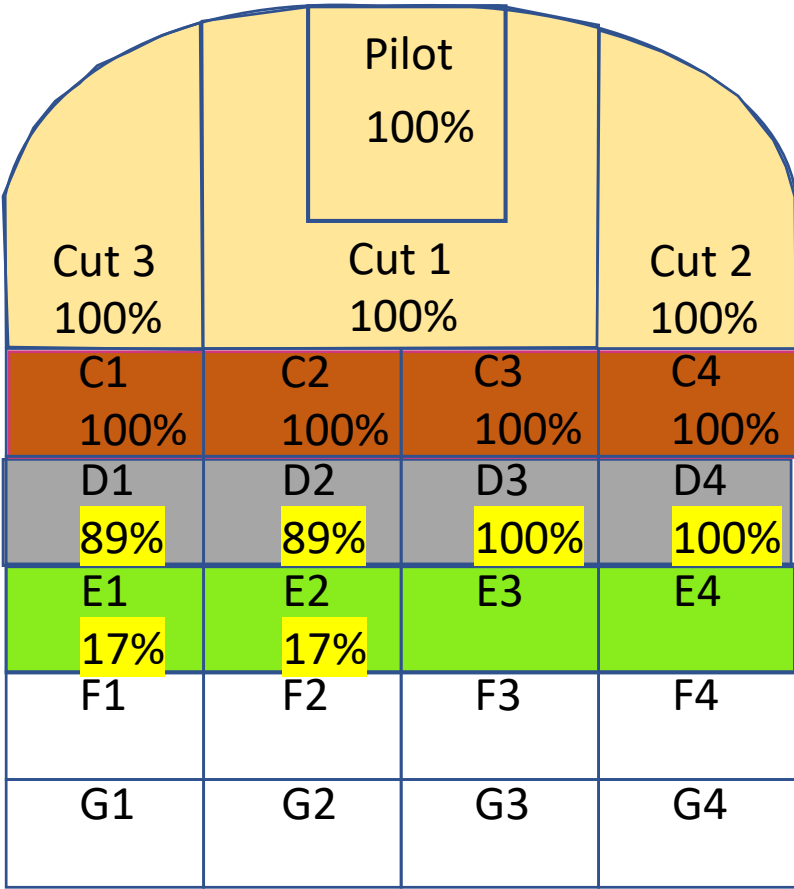
August 28, 2023



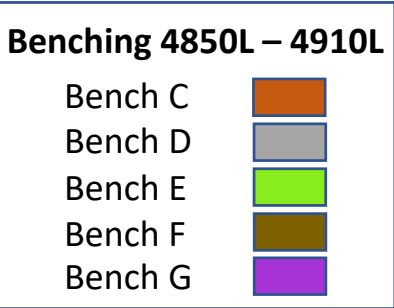
North Cavern



CUC Cavern



South Cavern



LBNF Excavation Progress

North Detector Cavern – August 23, 2023



Particle Physics Strategic Planning Underway

Establishing a new 10-year vision

Building for Discovery

Strategic Plan for U.S. Particle Physics in the Global Context



Report of the Particle Physics Project Prioritization Panel (P5)

May 2014

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” completed Jul 2022
- Recommendations outlined in Jan 2023 final report to P5:
 - Construction and operation of **LBNF/DUNE Phase I & II** and **PIP-II**
 - New experiments and R&D require **more underground space**
- SURF-specific recommendations to ensure world-class facility:
 - Leverage the LBNF excavation enterprise to **increase underground space at SURF**
 - Designate SURF as a formal U.S. **DOE User Facility**
- 2023 P5 report expected Late 2023 / Early 2024

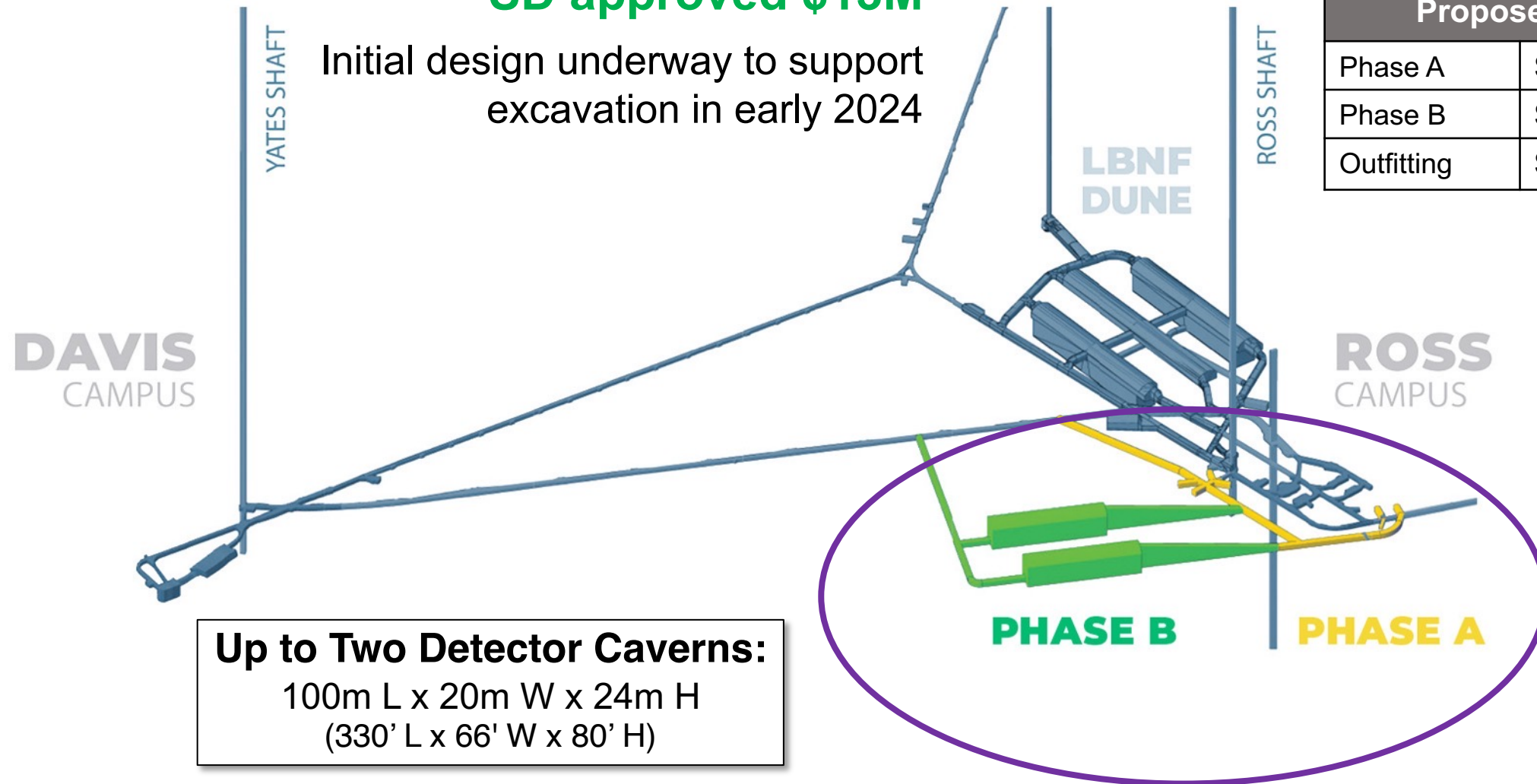
4850L Space Needed for Future Experiments

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

SD approved \$13M

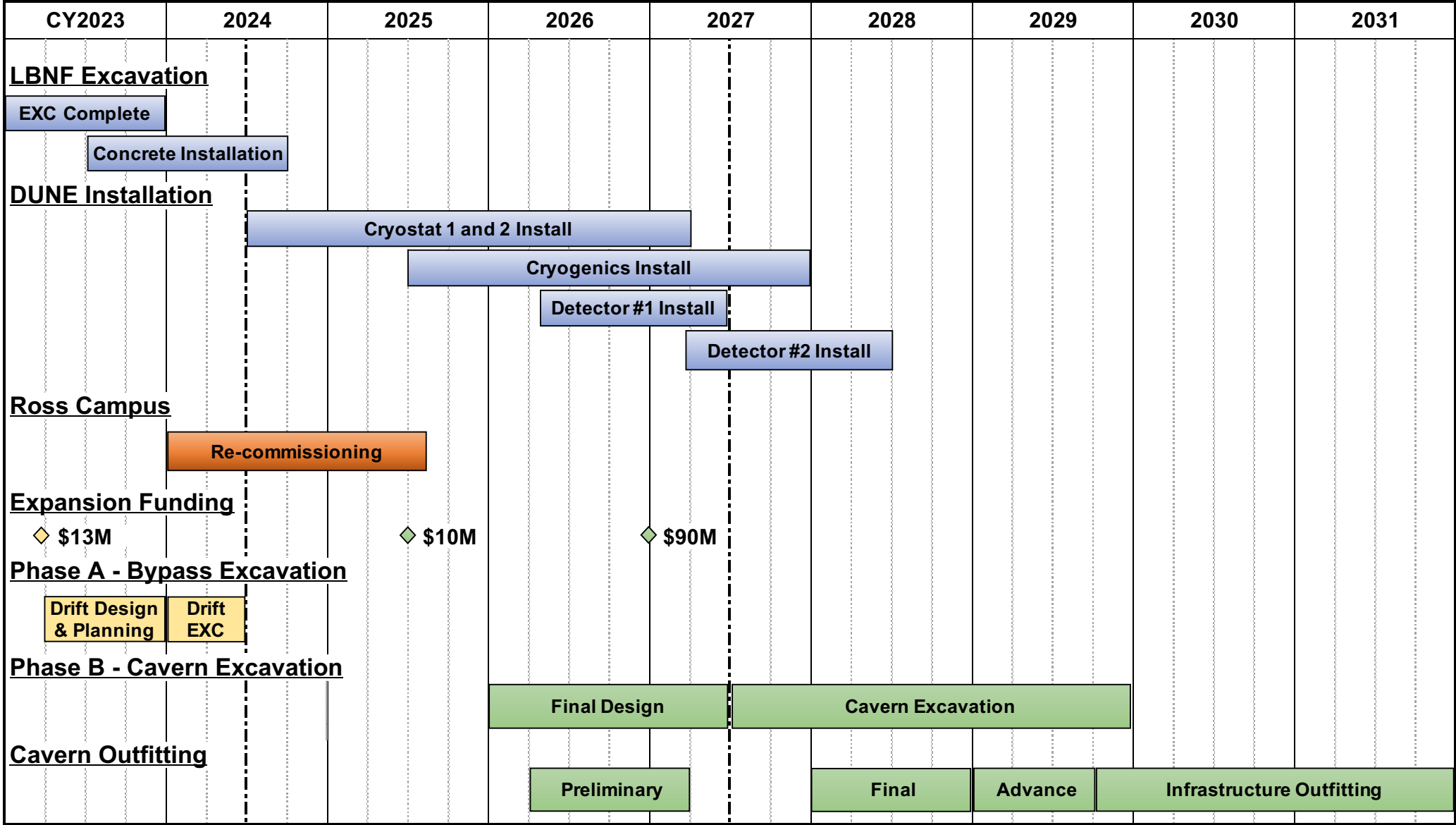
Initial design underway to support excavation in early 2024

Proposed Funding Model		
Phase A	\$13M State of SD	✓
Phase B	\$100M Private	
Outfitting	\$85M Federal	



SURF 4850L Expansion Schedule

Next-generation experiments need underground space in early 2030s



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.
- **Topical workshops**, incl community planning (e.g., Vision Workshop 2021). Next workshops following P5, SURF lab expansion funding (2024).

2022 SURF User Association Annual General Meeting

26-27 Oct 2022
Zoom
US/Mountain timezone

Overview
Timetable
Contribution List
My Conference
My Contributions
Participant List

Timetable

Wed 26/10 Thu 27/10 All days

Print PDF Full screen Detailed view Filter

Session legend

- Active science updates
- Potential new research areas
- Q&A/discussion
- SURF facility overview and updates

10:00	Greeting	Mike Headley
10:00 - 10:30	Zoom	
10:30	Facility Overview and Updates	Janet Heise
10:30 - 10:45	Zoom	
10:45	SURF Outreach and Culture	Deb Wolf
10:45 - 11:00	Zoom	
11:00	SURF User Association Updates	Billey Kruger
11:00 - 11:15	Zoom	
11:15	DUNE Update	Chris Marshall
11:15 - 11:30	Zoom	
11:30	BIO Update	Ralph Sev
11:30 - 11:45	Zoom	
11:45	CASPARI	Frank Strecker
11:45 - 12:00	Zoom	
12:00	DARWIN	Magdalena Ostera
12:00 - 12:15	Zoom	
12:15	MID	Ralph Messerschmidt
12:15 - 12:30	Zoom	
12:30	BHUC	Brianne Moore
12:30 - 12:45	Zoom	
12:45	Break	
12:45 - 13:00	Zoom	
13:00	Q&A/discussion	
13:00 - 13:15	Zoom	
13:15	Q&A/discussion	
13:15 - 13:30	Zoom	
13:30	Q&A/discussion	
13:30 - 13:45	Zoom	
13:45	Q&A/discussion	
13:45 - 14:00	Zoom	

2022 SURF User Association Annual General Meeting

26-27 Oct 2022
Zoom
US/Mountain timezone

Overview
Timetable
Contribution List
My Conference
My Contributions
Participant List

Timetable

Wed 26/10 Thu 27/10 All days

Print PDF Full screen Detailed view Filter

Session legend

- Initiating, expanding, funding science
- Physics community planning updates
- SURF Institute for Underground
- SURF Long Term Planning

10:00	Summary of the 2021 SURF User Association Vision Workshop	Kevin Lesko
10:00 - 10:30	Zoom	
10:30	Expanding SURF's Underground Footprint	Allen Strahan
10:30 - 10:40	Zoom	
10:40	Discussion/Q&A	
10:40 - 11:00	Zoom	
11:00	Physics community planning updates	
11:00 - 11:30	Zoom	
11:30	Break	
11:30 - 11:45	Zoom	
11:45	Getting Started with a Project at SURF	Janet Heise
11:45 - 12:40	Zoom	
12:40	Maintaining Work and Funding for Projects of Various Sizes	Billey Kruger
12:40 - 12:55	Zoom	
12:55	Q&A	
12:55 - 13:15	Zoom	
13:15	Institute: Overview and Future Plans	Mike Headley
13:15 - 13:45	Zoom	

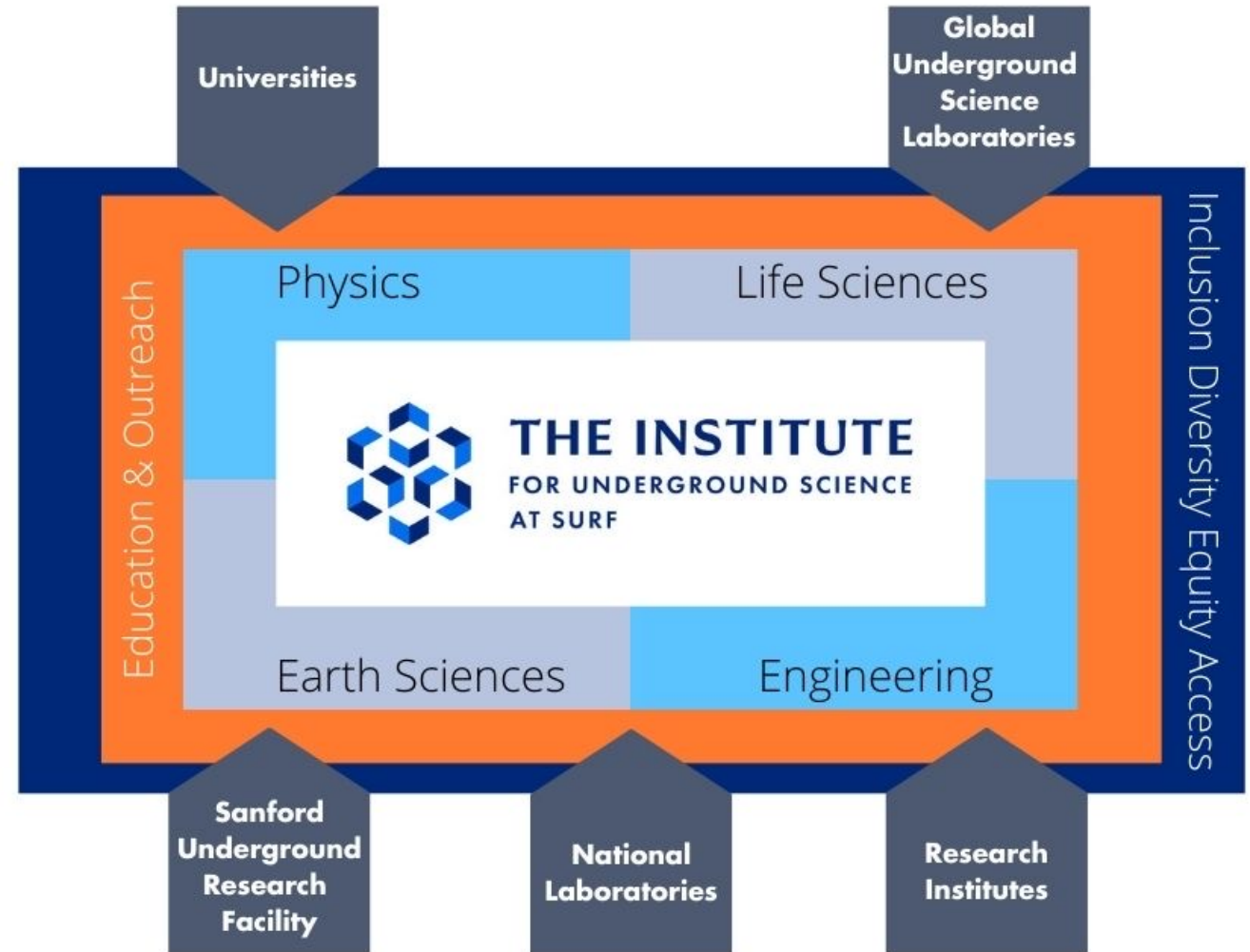
Oct 26-27, 2022:

SURF User Association General Meeting
<https://indico.sanfordlab.org/e/SUA-Oct2022>

Institute for Underground Science at SURF

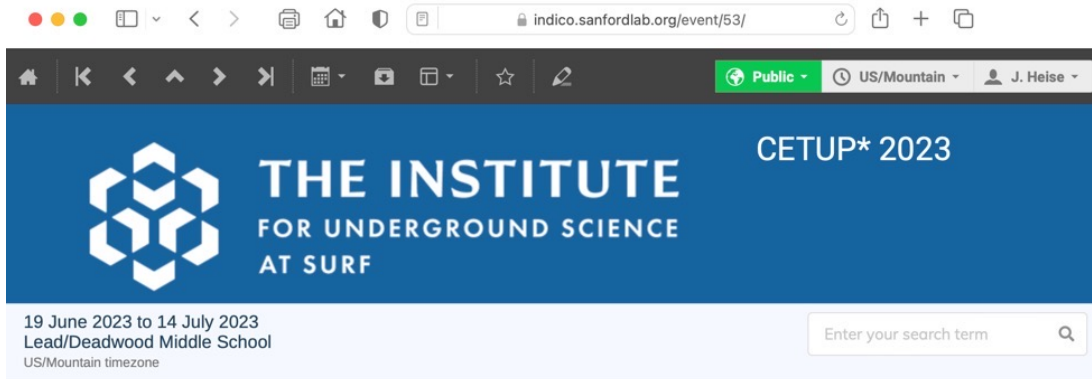
Kick-off planned for December 2023

- 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.



Institute for Underground Science at SURF

CETUP* Topical Workshop held this summer!



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

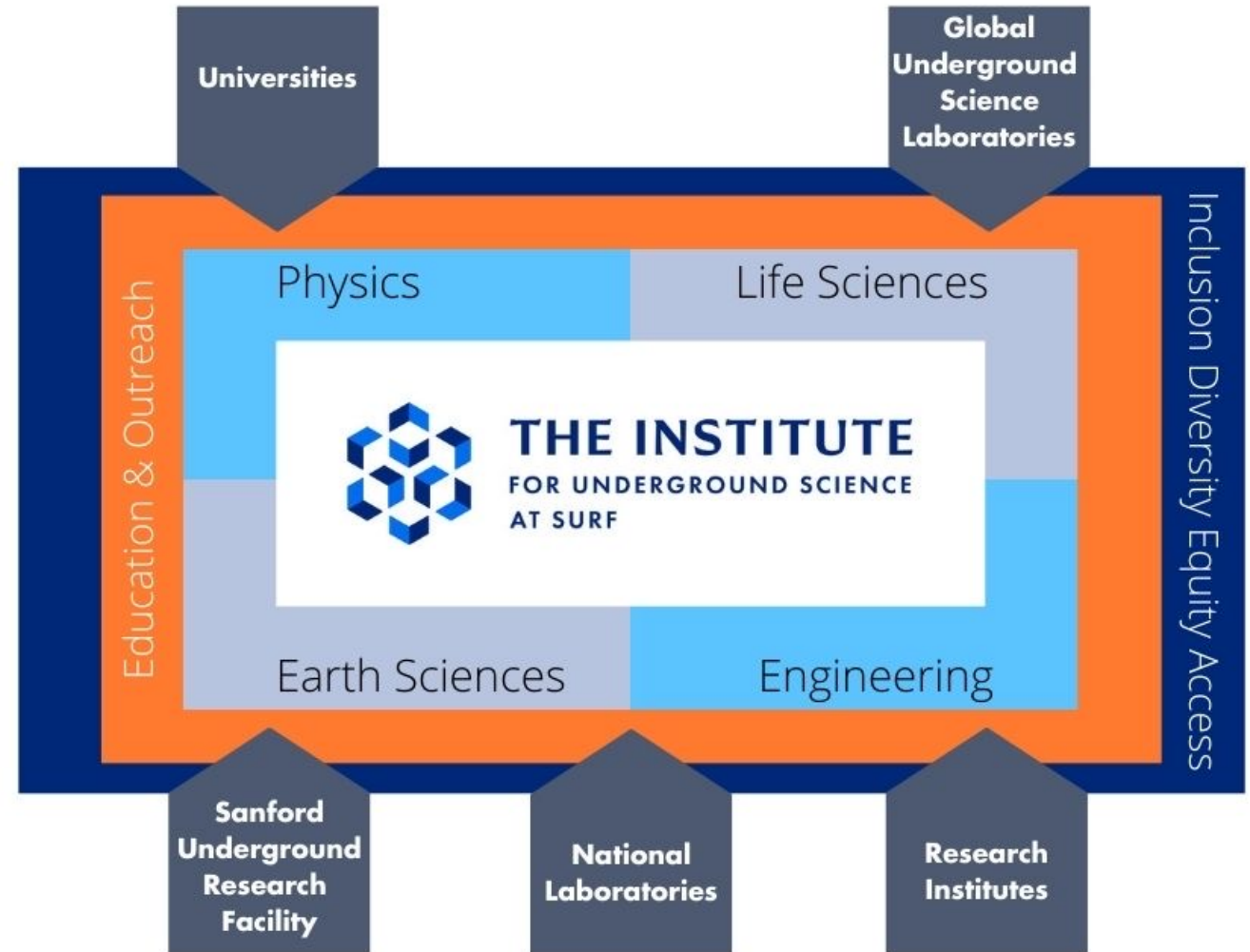
Around the globe more than 20 underground laboratories provide space for experiments in nuclear and particle physics, astrophysics and cosmology as well as geosciences, drawing scientists from all over the world. In response to the growing interests in underground science, the Center for Theoretical 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?

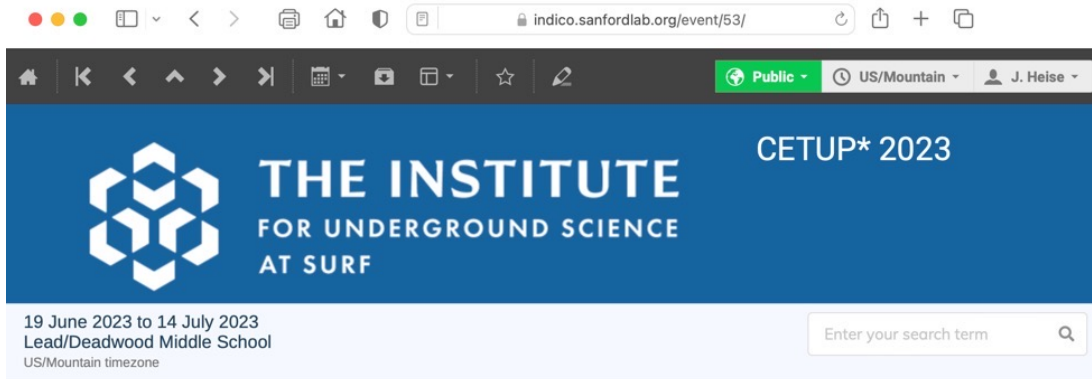
Since its inception in 2011, the workshop has been hosted in the Black Hills of South Dakota in Lead/Deadwood, near the Sanford Underground Research Facility (SURF), which is the deepest underground laboratory in the United States. The area's natural beauty attracts tourists year-round, and has strong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



Institute for Underground Science at SURF

CETUP* Topical Workshop held this summer!



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

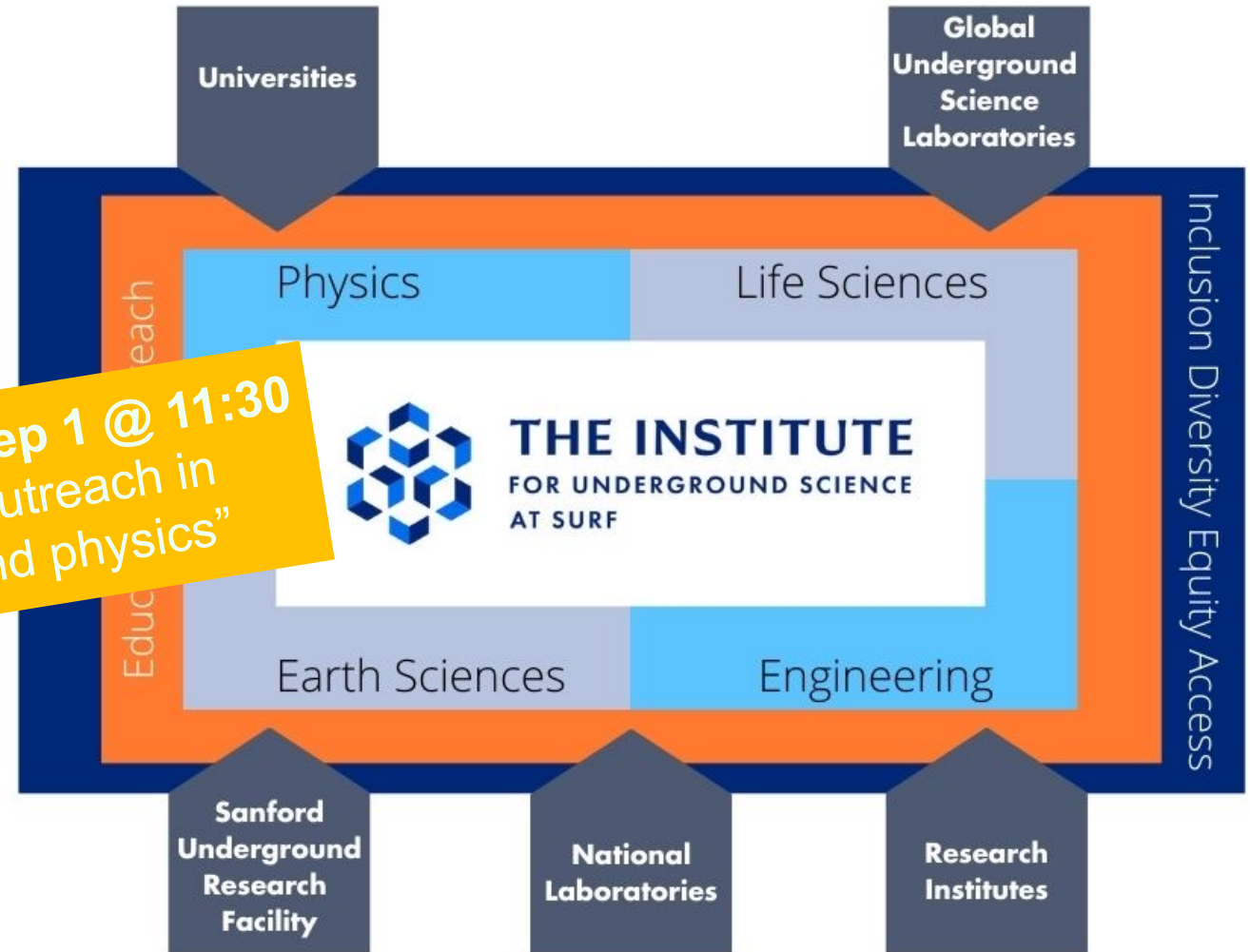
Around the globe more than 20 underground physics experiments in particle physics, astrophysics, and geophysics are operating over the world. In response to this, Theoretical Underground Physics (TUP) provides a stimulating environment for theoretical and experimental physicists to address the most pressing questions in underground 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.

Constance Walter, Fri Sep 1 @ 11:30
"Accessible science outreach in astro and underground physics"



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.
 - **SURF existing science program and LBNF/DUNE remain top priorities**.
- SURF wants to host other future world-leading experiments:
 - All existing and near-term 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, 4200 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).
 - Anticipating strong recognition and support for SURF in upcoming **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 ~70% complete, science starts late 2028)
- **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

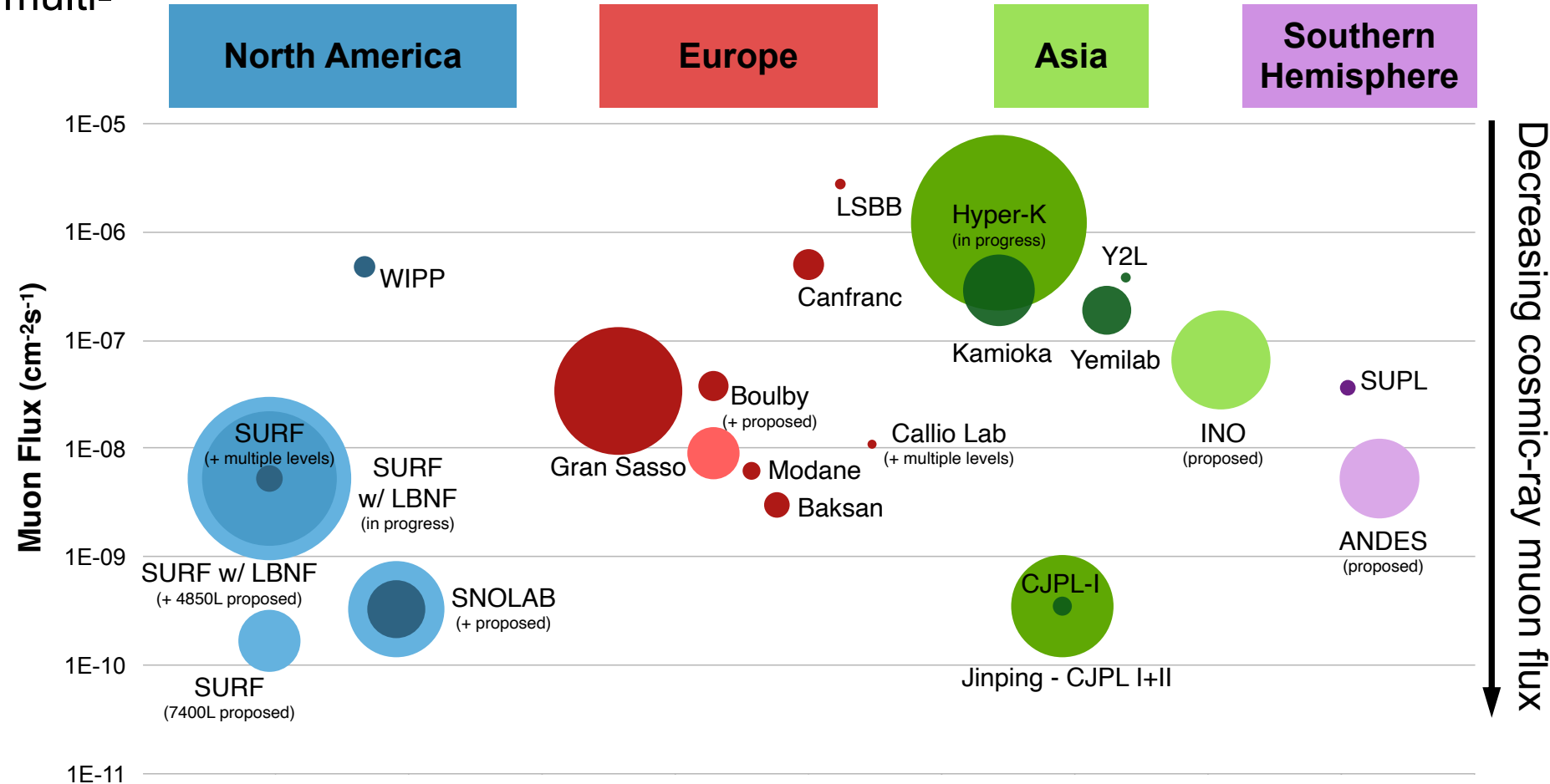
Physical characteristics

- **Property:** 1 km² (surface) with ~1600 m² storage (incl drill core) and 355 m² staging/assembly space. 31 km² (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 = 5.31×10^{-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 m² (cleanrooms = 92 m² / 914 m³)
 - 4850L (science space, as low as class 100): Davis Campus (1018 m² / 4633 m³), Ross Campus (920 m² / 3144 m³)
 - Radon-reduction: Surface = 2200x reduction @ 300 m³/h (Ateko), Davis = 700x reduction @ 150 m³/h (SD Mines)
- **Bkgds** (4850L): Radon = 300 Bq/m³, gamma = 1.9 $\gamma/\text{cm}^2/\text{s}$, neutron = 1.7×10^{-2} n/m²/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.

Worldwide Underground Facilities

UG Facilities can provide:

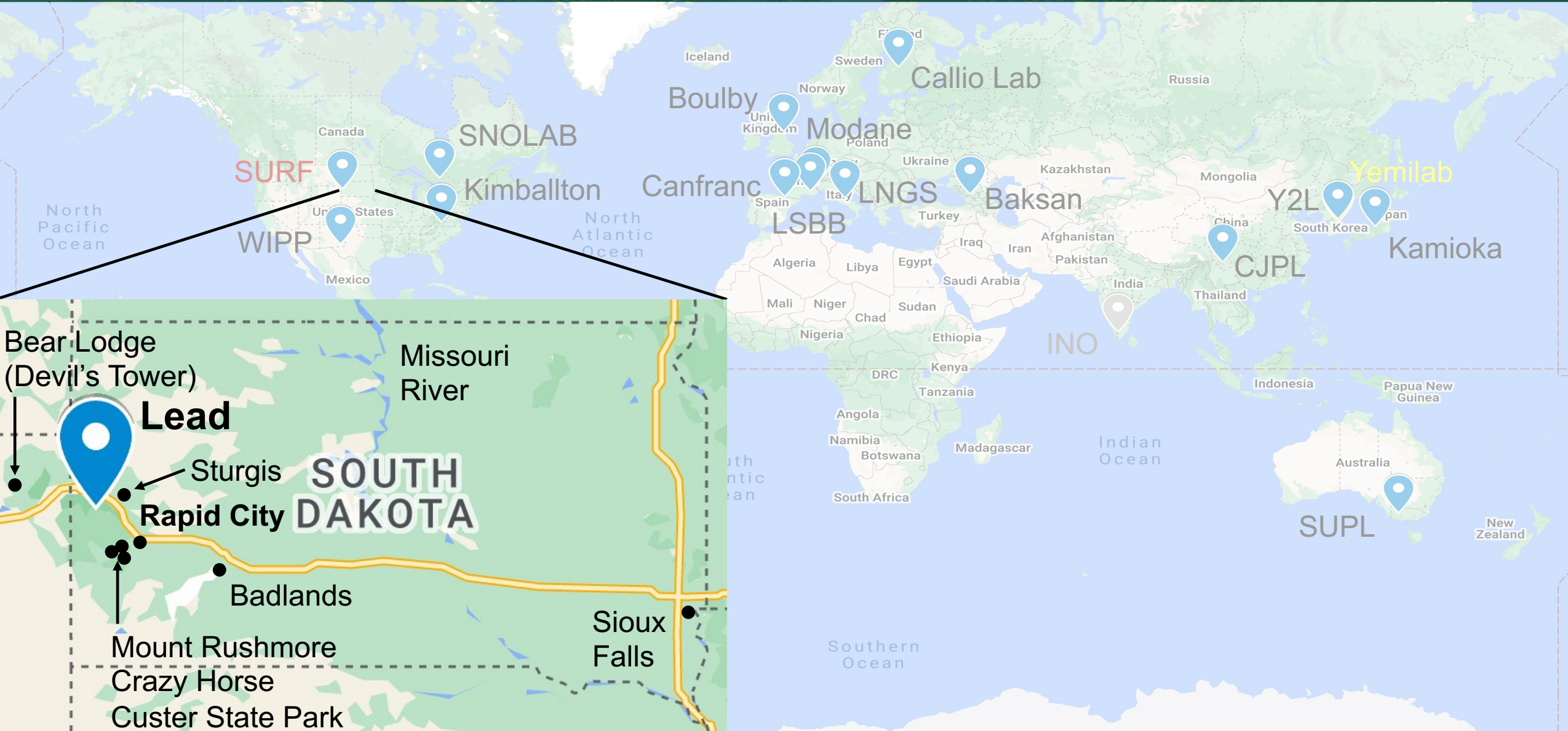
- Unique environments for multi-disciplinary research
 - Overburden protection from cosmic-ray muons
- Local radiation shielding
- Assay capabilities
- Material production/purification
- Environmental control
- Implementation and operations support
- Community catalyst



Note: Circles represent volume of science space

Sanford Underground Research Facility

Where in the world is SURF?



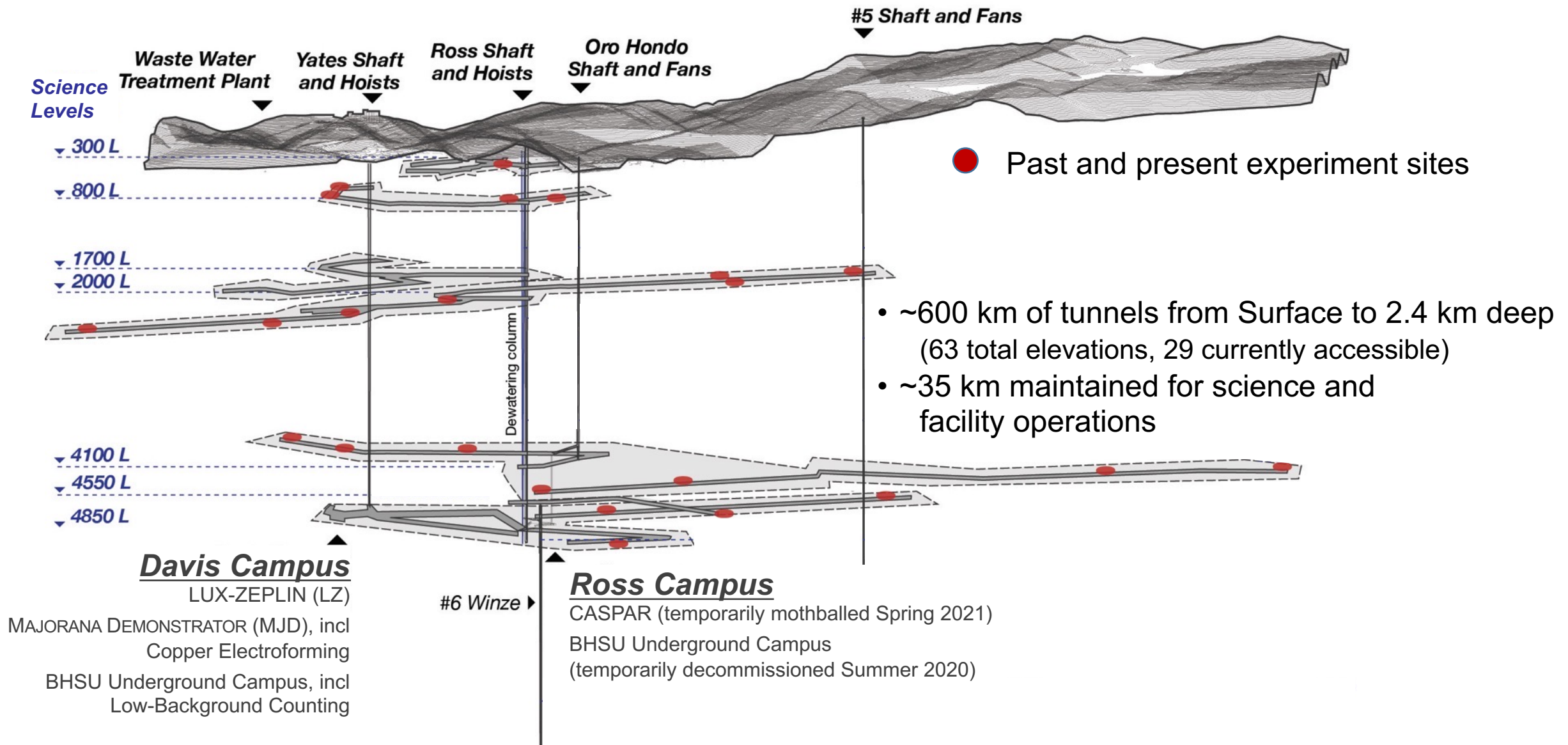
SURF Science Program

Hosting world-leading experiments and researchers from diverse scientific communities



SURF Underground Lab Geography

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



SURF Current & Future Facilities					
Summary for various science campuses, including timelines					
Location	Laboratory	Existing/ <i>Planned</i> Space		Available (CY)	Comments
		Area (m²)	Vol (m³)		
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 in ~2027 + 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 FY24 after LBNF excavation
	CASPAR	395	1,130	2029-2031?	Mothballed, equip remains, re-occupy FY24 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 2023</i>
4100L	Geoscience Lab	334	11 drill holes	2025	DEMO-FTES use 2023-2024
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>
Sanford Underground Research Facility			J. Heise TAUP @ Vienna, Aug 29, 2023		
34					

Sanford Lab Homestake Visitor Center

Acquired January 2022. Greatly expands public outreach opportunities.



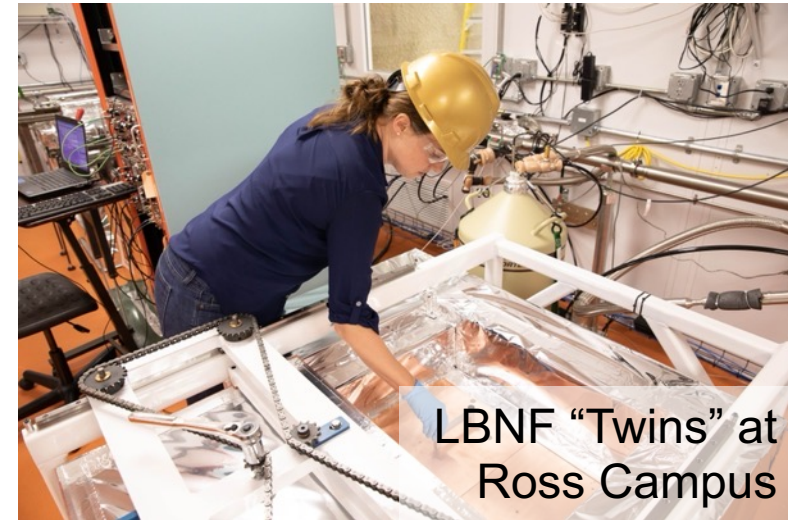
SURF Material Assay at BHUC

Black Hills State University Underground Campus

- **Science Support Goal:** Characterize radiopurity of experiment components; also multi-disciplinary science support at Ross Campus.
- **Collaboration:** 14 members, 7 institutions, lead = BHSU (institutional funding, some DOE support via experiments like LZ).
- **Status:**
 - Onsite since Sep 2015 (previous low-bkgd efforts with CUBED starting Apr 2013 at Davis Campus).
 - Ross Campus operations Sep 2015 – Jul 2020. Laboratory mothballed Mar 2021 due to LBNF construction.
 - Initial operations at Davis Campus starting Nov 2020 after SURF-supported cooling upgrades. Samples resumed Mar 2021.
 - All six counter systems operating, incl LLNL dual-crystal system. Recent samples incl protoDUNE, also IceCube, CUPID, NEXT-100.
- **Schedule:**
 - Fully commission LBNL dual-crystal system. Possible addition of 7th detector (Ge-V).
 - Limited space for expansion at Davis Campus. Return to Ross Campus in ~FY24 following LBNF construction.



LLNL detector commissioning at Davis Campus



LBNF "Twins" at Ross Campus

LBNF Excavation Progress

North Detector Cavern



LBNF Excavation Progress

North Detector Cavern



LBNF Excavation Progress

Large drilling equipment



LBNF Excavation Progress

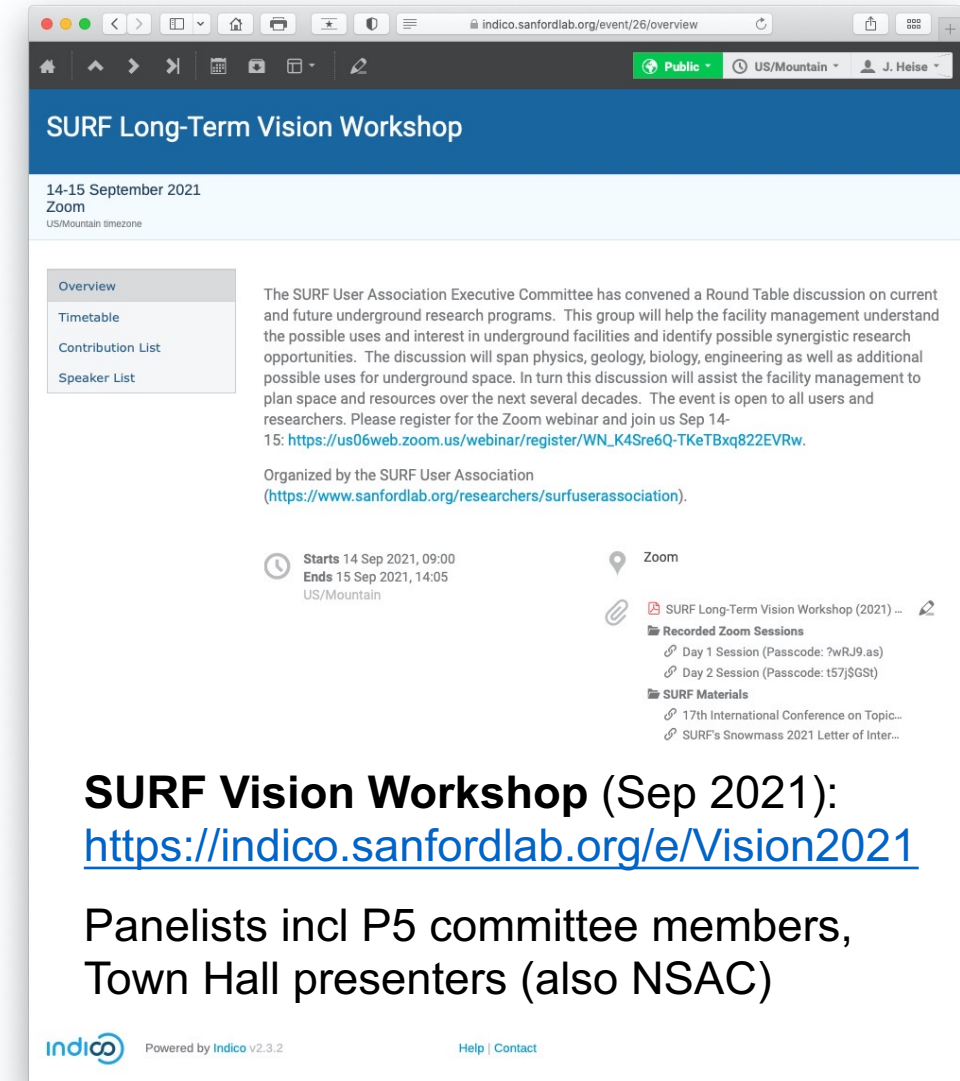
Total of 800,000 tons of excavated rock going to Open Cut



SURF Community Engagement

SURF Long-Term Vision Workshop

- **All Science Disciplines:** Significant interest in additional underground space. Additional excavation both scientifically motivated and cost effective (if following LBNF/DUNE) even if precise details re: specific experiments not worked out yet
- **Physics:**
 - **LBNF/DUNE:**
 - Community interest in “Module of Opportunity” (now Phase 2)
 - Other expts benefit from LBNF/DUNE neutrino beam at SURF
 - Prediction of DUNE+ (follow-on expt to DUNE) beyond 2050
 - **Dark Matter:** Generation-3 detector for direct WIMP search
 - **Neutrinoless Double-Beta Decay:** Prediction of generation beyond ton-scale
 - **QIS:** Quantum sensors (dark matter, gravitational waves, etc), quantum computing
 - **Nuclear Astrophysics:** Physics niche complementing other UG accelerators
- **Science Support:** Long-term access, assay, materials, etc
- **Misc:** UG labs promote synergies, advocacy for diversity of projects



The screenshot shows the Indico event page for the SURF Long-Term Vision Workshop. The page is titled "SURF Long-Term Vision Workshop" and is scheduled for 14-15 September 2021. It is a Zoom event in the US/Mountain timezone. The page includes a sidebar with links to Overview, Timetable, Contribution List, and Speaker List. The main content area describes the workshop as a Round Table discussion on current and future underground research programs, organized by the SURF User Association. It provides a registration link and a list of recorded Zoom sessions, including Day 1 and Day 2 sessions, SURF Materials, and the 17th International Conference on Topic... and SURF's Snowmass 2021 Letter of Inter... The page also includes a footer with the Indico logo and version information.

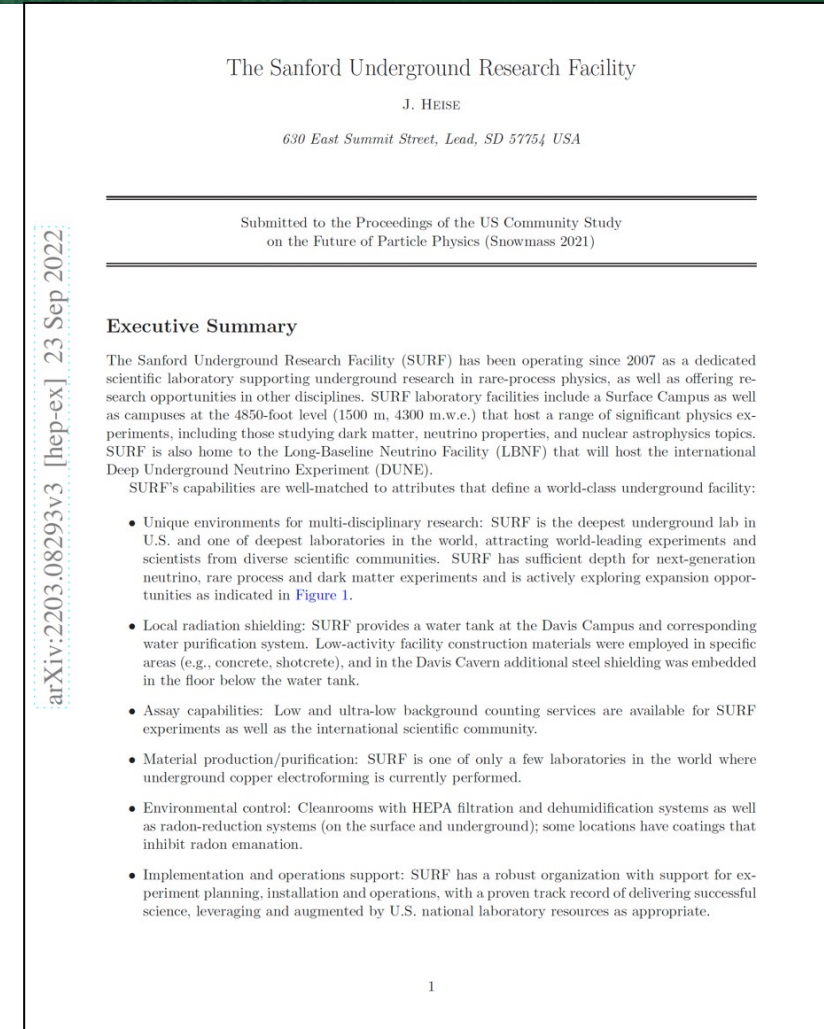
SURF Vision Workshop (Sep 2021):
<https://indico.sanfordlab.org/e/Vision2021>

Panelists incl P5 committee members,
Town Hall presenters (also NSAC)

SURF at Snowmass

SURF contributions reflect UG science community input and engagement

- SURF documents submitted for UG Facilities Frontier:
 - LOI: <https://www.snowmass21.org/docs/files/?dir=summaries/UF/>
 - Whitepaper: <https://arxiv.org/abs/2203.08293>
- Additional underground space proposed at SURF:
 - **4850L** (1500 m, 4200 m.w.e), **7400L** (2300 m, 6500 m.w.e.)
 - Initial engineering designs completed
 - Excavation for **100-m caverns** could begin as early as 2027, **complete by ~2030**
- SURF advocated for recommendations, including:
 - Mission need for **additional deep laboratory space** in U.S. in U.S. to support compelling future science
 - Establish process to **optimize scientific use of UG spaces** at SURF (i.e., LBNF/DUNE)
 - Endorse value of **multi-disciplinary underground science** at a dedicated laboratory in U.S.

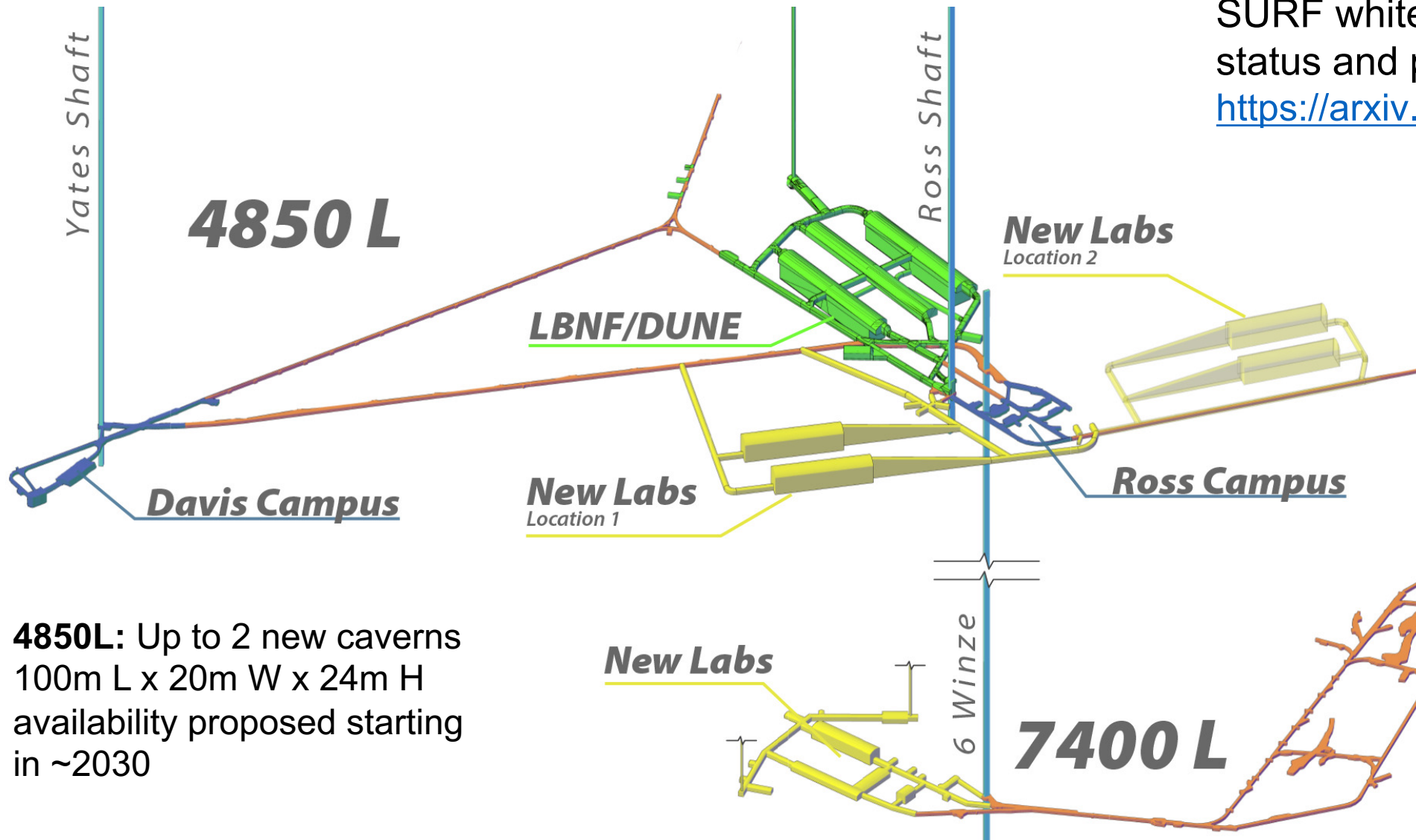


UG science community input from SURF
Vision Workshop held Sep 2021,
<https://indico.sanfordlab.org/e/Vision2021>

SURF Current & Future Underground Facilities

Strategic plan incl additional 4850L labs + deeper access

SURF whitepaper describing current status and proposed future facilities:
<https://arxiv.org/abs/2203.08293>



4850L: Up to 2 new caverns
100m L x 20m W x 24m H
availability proposed starting
in ~2030

7400L: Caverns (nominal)
75m L x 15m W x 15m H
schedule TBD

Snowmass Underground Facilities Frontier

Strong community support for SURF and UG experiments

Executive Summary:

- New experiments and enabling R&D require **more UG space**.
- Endorsed **SURF 4850L expansion** (and possible future 7400L) for next-generation dark matter, neutrinoless double-beta decay expts

Recommendations:

1. Leverage **LBNF excavation** enterprise to **increase underground space at SURF** in timely and cost-effective way to permit siting of next-generation UG high energy physics research experiments.
 - **Excavate and outfit one or more new underground caverns at SURF 4850[†]** to house at least one large next-generation expt plus mid-size & small expts.
2. Designate SURF as a U.S. **DOE User Facility**.
3. Provide full support for **LBNF/DUNE UG facilities**.
4. R&D and decision making for a **third-generation direct-detection dark matter program** should commence immediately to enable a construction start in the late 2020s.
5. To ensure a robust collection of scientific programs in underground facilities, support the **enabling capabilities, technique development, and expertise** required for UG experiments.

FERMILAB-CONF-23-008
SLAC-PUB-17717

Report of the 2021 U.S. Community Study on the Future of Particle Physics (Snowmass 2021)

organized by the APS Division of Particles and Fields

Snowmass 2021 Study Conveners: Marina Artuso, K  t  vi A. Assamagan, Phillip S. Barbeau, Laura Baudis, Robert Bernstein, Aaron S. Chou, Nathaniel Craig, Csaba Cs  ki, Aida X. El-Khadra, V. Daniel Elvira, Julia Gonski, Steven Gottlieb, Stephen Gourlay, Jeter Hall, Patrick Huber, Kevin T. Lesko, Petra Merkel, Benjamin Nachman, Meenakshi Narain[†], John L. Orrell, Alexei A. Petrov, Breece Quinn, Fernanda Psihas Tor Raubenheimer, Laura Reina, Kate Scholberg, Vladimir Shiltsev, Marcelle Soares-Santos, Sara M. Simon, Tim M. P. Tait, Alessandro Tricoli, Elizabeth E. Worcester, Jinlong Zhang

Snowmass 2021 Steering Group: Joel N. Butler, R. Sekhar Chivukula, Andr   de Gouv  a, Tao Han, Young-Kee Kim, Priscilla Cushman, Glennys R. Farrar, Yury G. Kolomensky, Sergei Nagaitsev, Nicol  s Yunes

Editorial Committee: Robert H. Bernstein, Sergei Chekanov, Michael E. Peskin

[†]deceased, Jan. 1, 2023.

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.

SURF plans to become DOE User Facility

Benefits:

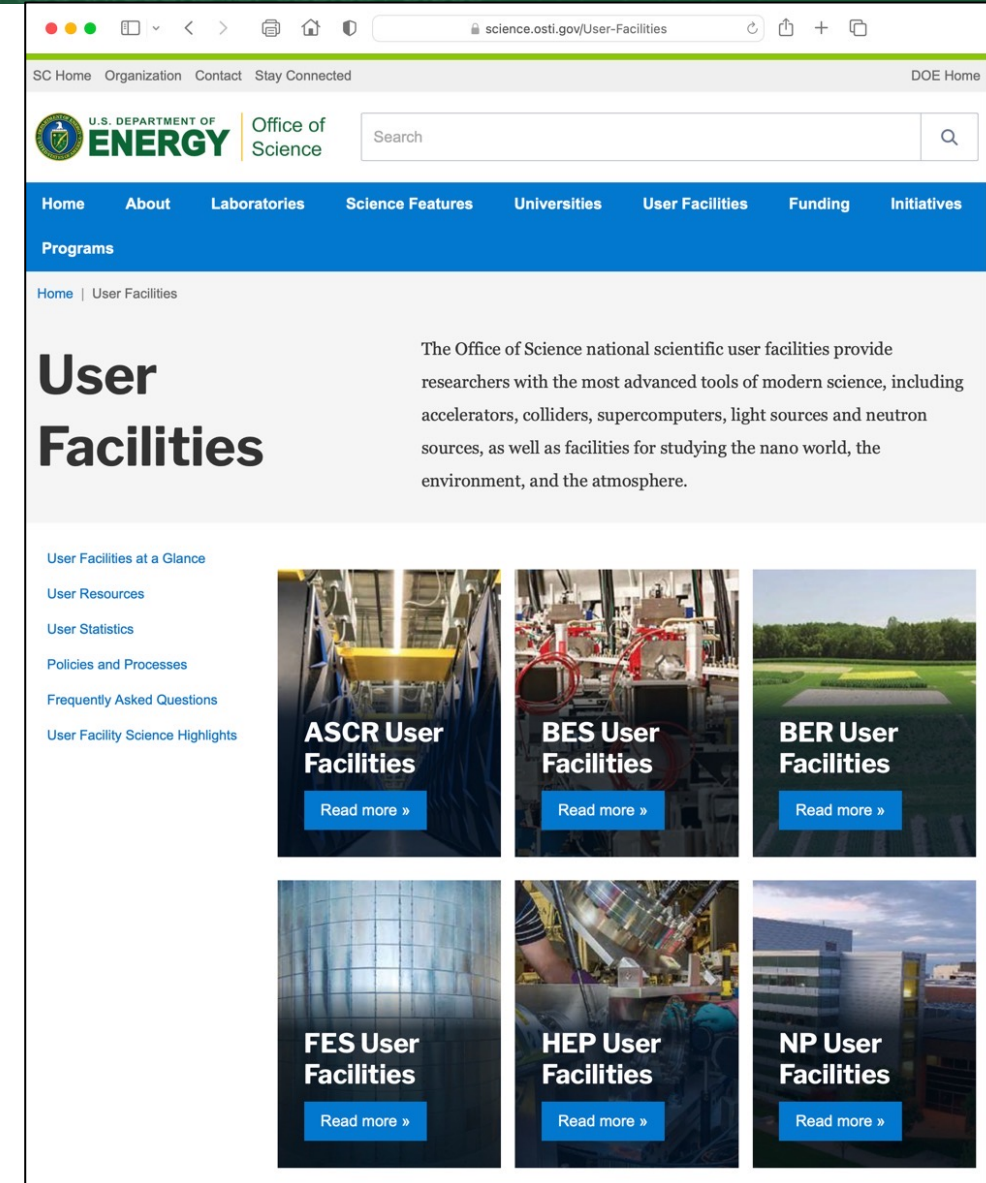
- Expands DOE User Facility portfolio to incl underground lab, raises SURF's stature within DOE community.
- Promotes underground science in U.S., increases funding opportunities.
- Enhances SURF's role in global science community.
- Communicates SURF is open to a broad range of science and users and 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 4850L Expansion – South Dakota Support

4850L space needed for next-generation experiments

United States Senate
WASHINGTON, DC 20510

February 18, 2023

South Dakota State Legislators
c/o Joint Committee on Appropriations
500 East Capitol Avenue
Pierre, SD 57501

Dear Members of the South Dakota State Legislature,

We write to emphasize our strong and continued commitment to support ongoing and additional federal funding for the Sanford Underground Research Facility (SURF).

We understand the South Dakota State Legislature is considering a \$13 million appropriation for the South Dakota Science and Technology Authority (SDSTA), owner and operator of SURF. This is a significant investment of state resources, and we appreciate the thoughtfulness and due diligence required in your deliberations.

SURF is the deepest underground research facility in the United States, which makes it uniquely positioned to conduct cutting-edge research in a range of fields, including physics, biology, and engineering. The facility has attracted internationally-leading researchers and has made significant contributions to our understanding of the universe and the advancement of science. SURF is only a reality due to past support, including the bold, historic support of the State of South Dakota.

In 2004, the South Dakota State Legislature appropriated \$14.3 million to create the SDSTA and cover expenses incurred in the agreement with Barrick Mining Corporation and the Homestake Mining Company to donate the mine. Then, in an October 2005 special session, the State of South Dakota appropriated \$19,887,630 to begin facility operations, which included pumping water out of the mine. At that time, the South Dakota delegation secured federal resources in the form of a \$10 million grant. This combined funding was matched by a generous \$70 million donation from philanthropist T. Denny Sanford, who believed in the dream of converting the mine into a world-class research facility.

The legacy of SURF is a story of South Dakotans investing in South Dakota, and the investments have paid off. To date, South Dakota has cumulatively spent \$62 million in support of SURF; that money has yielded \$932 million in direct federal and private investment, a 15:1 return. SURF provides good jobs and state-wide economic benefits. Between federal fiscal year 2007 and 2022, SURF has spent over \$135 million in South Dakota payroll and over \$170 million in contracts with South Dakota vendors.

Now, South Dakota is again at a crossroads. Our state leaders will determine whether or not the current appropriation request is a merited and wise use of our citizens' tax dollars. Likewise, we will need to make the case to our federal counterparts that further investment in this facility is a wise use of federal taxpayer dollars.

Phase I of the expansion will be used to fund the design and construction of a drift (a tunnel) at the 4850-foot level, necessary to facilitate the later construction in 2027 of two caverns to house future experiments. The timing of the state appropriation for phase I is critical to eliminate the need to demobilize and remobilize the excavation contractor that is already on site (a savings of \$15 million) and to avoid interference with the over \$1 billion LBNF/DUNE Project currently being undertaken at SURF.

For phase II of the expansion, the SDSTA has been working diligently to raise private funds to cover the cost of the excavation of the two caverns. We are committed to working to secure federal funding as needed to resolve any unexpected shortfalls in private funding and to cover the cost of outfitting the caverns to make them suitable to house future experiments.

SURF's future objectives are supported by national academic partners and federal agency stakeholders. Those entities are well aware of SURF's expansion plans. The U.S. Department of Energy recently commissioned a panel of experts from other national laboratories to perform an independent review of SDSTA's operations. In June 2022, the panel found SDSTA's planning and management of operations to be excellent. SURF has sound management and strong business-minded board members.

SURF's partners are eagerly anticipating this expansion because there is nowhere else in the United States capable of conducting this research. Our nation recently lost two U.S.-funded research projects to underground labs in Canada and Italy. Without the new caverns, future experiments funded by U.S. taxpayers will continue to go to underground laboratories in other countries.

SURF's potential is tremendous. With additional space to house more research projects, more federal funding opportunities will exist. The newly-excavated spaces could attract experiments with investments of up to \$1 billion or more per cavern. Equally important, additional research capacity increases opportunities to keep our next generation, the best and the brightest in the world, at home.

This is again a historic time for SURF. The actions the state and the federal government take will have long-lasting effects for South Dakota. We hope this additional information is helpful as you consider this budget request.

Sincerely,



M. Michael Rounds
United States Senator



John Thune
United States Senator

SURF 4850L Expansion – South Dakota Funding

4850L space needed for next-generation experiments

sdlegislature.gov/Session/Bill/23993

LEGISLATORS | SESSION | INTERIM | LAWS | ADMINISTRATIVE RULES | BUDGET | STUDENTS | REFERENCES | MYLRC

Senate Bill 35

BACK TO FULL LIST

RSS SHARE TWEET

Title: make an appropriation to expand laboratory space at the Sanford Underground Research Facility and to declare an emergency.

Sponsors: Senators Maher (prime), Castleberry, Crabtree, Davis, Diedrich, Duhamel, Foster, Johnson, Kolbeck (Steve), Larson, Nesiba, Novstrup, Otten (Herman), Rohl, Schoenbeck, Stalzer, Tobin, and Zikmund and Representatives Reimer (prime), Blare, Cammack, Chaffee, Chase, Donnell, Drury, Duba, Duffy, Emery, Fitzgerald, Kasson, Krull, Kull, Lesmeister, Massie, Moore, Nelson, Olson, Peterson (Drew), Schneider, Shorma, St. John, Tordsen, and Venhuizen

Subjects: Appropriation, Emergency Clause, Procurement of Public Improvements, State Affairs and Government
Want to add this bill to one of your tracking lists? [Logon to MyLRC](#)

Date	Action	Audio	Location
01/10/2023	First read in Senate and referred to Senate Commerce and Energy S.J. 13	N/A	
01/17/2023	Scheduled for hearing	▼	1:19:31
01/17/2023	Referred to Joint Committee on Appropriations , Passed, YEAS 9, NAYS 0.	▼	1:19:31
02/22/2023	Scheduled for hearing	▼	1:19:11
02/22/2023	Joint Committee on Appropriations Do Pass , Passed, YEAS 15, NAYS 3.	▼	1:19:11
02/24/2023	Senate Deferred to another day, Passed S.J. 338	N/A	
02/27/2023	Senate Do Pass, Passed, YEAS 29, NAYS 4. S.J. 353	▼	1:03:45
02/28/2023	First read in House and referral to committee waived pursuant to JR 6D-1 H.J. 400	N/A	
03/01/2023	House of Representatives Do Pass, Passed, YEAS 55, NAYS 13. H.J. 442	▼	2:52:16
03/02/2023	Signed by the President S.J. 417	N/A	
03/06/2023	Signed by the Speaker H.J. 491	N/A	
03/07/2023	Delivered to the Governor on Tuesday, March 07, 2023 S.J. 442	N/A	
03/27/2023	Signed by the Governor on Thursday, March 23, 2023	N/A	

23.405.12 2 35

An Act to make an appropriation to expand laboratory space at the Sanford Underground Research Facility and to declare an emergency.

I certify that the attached Act originated in this 7 day of March, 2023 at 10:00 AM.

Senate as Bill No. 35

Larry Johnson Secretary of the Senate By Judy Davis for the Governor

Tom Doonan President of the Senate The attached Act is hereby approved this 30 day of March, A.D., 2023

Attest:

Larry Johnson Secretary of the Senate Steve Nouri Governor

Hyatt M. Stalzer Speaker of the House

Attest:

Patricia Miller Chief Clerk Monae L. Johnson Secretary of State

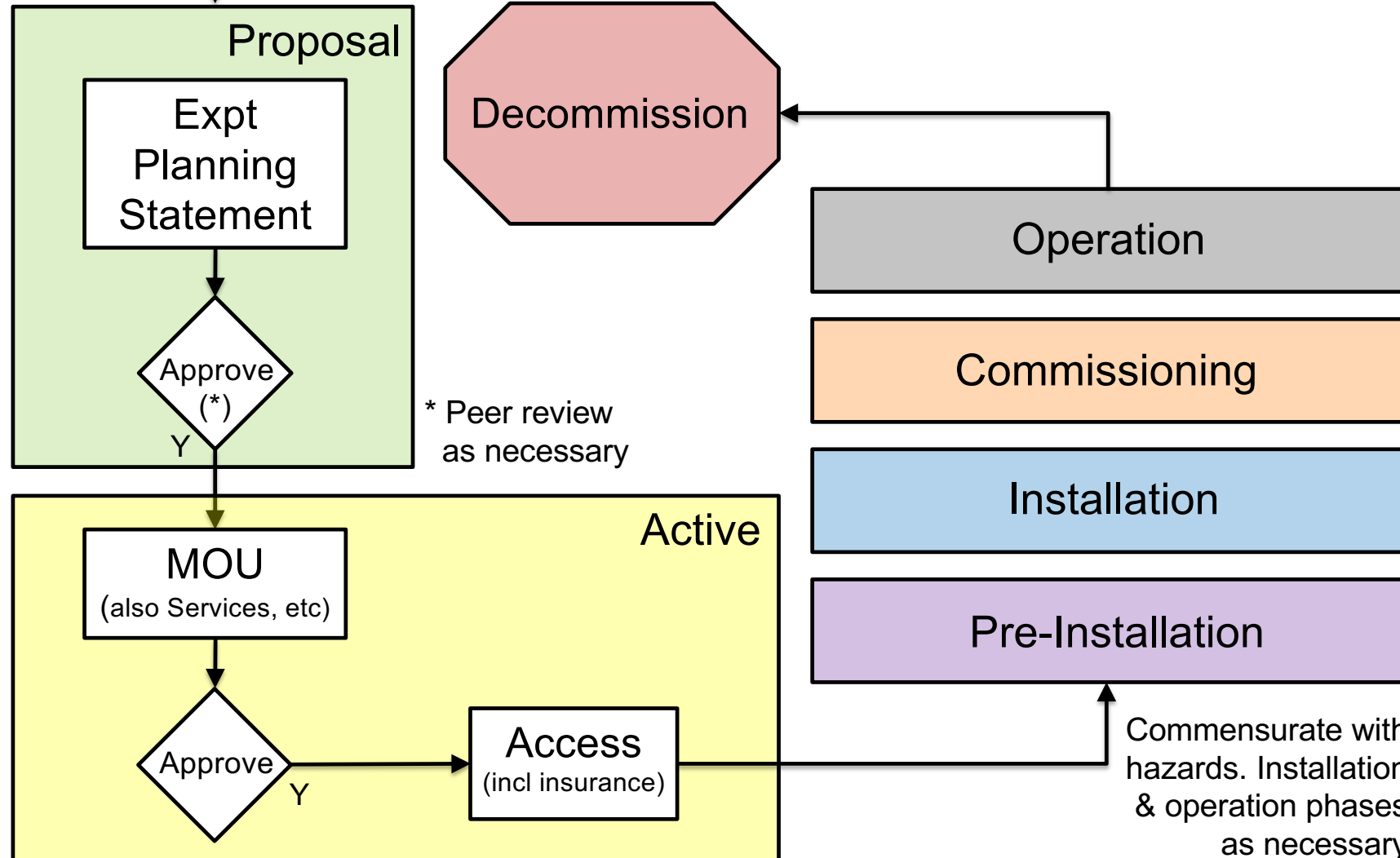
Senate Bill No. 35 By _____ Asst. Secretary of State
File No. _____
Chapter No. _____

SB35 ENROLLED

SURF Experiment Implementation Program

Identify interfaces and hazards within approval framework

Expt Concept

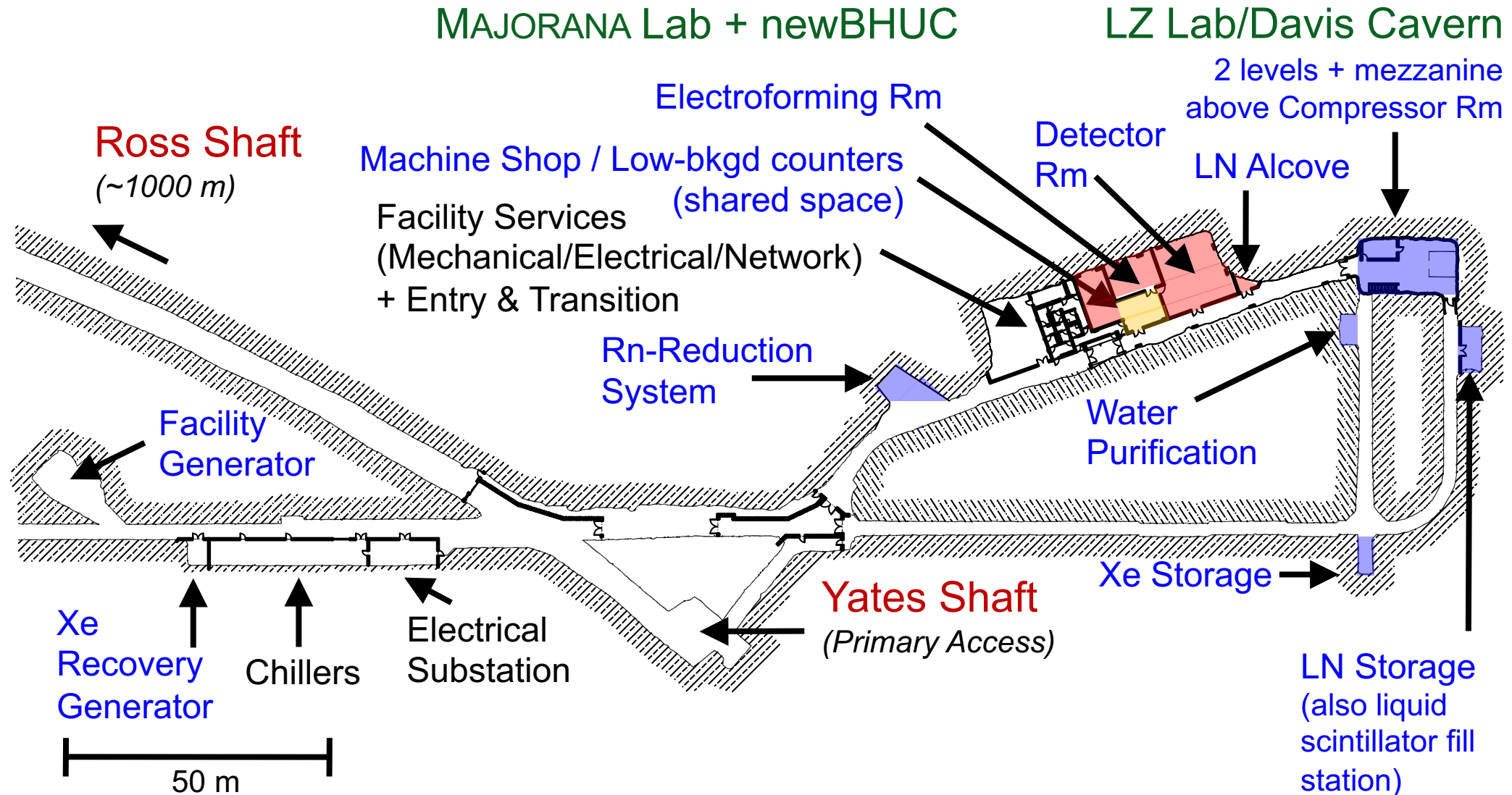


<https://www.sanfordlab.org/researchers/proposal-guidelines>

The screenshot shows the Sanford Underground Research Facility website. The header includes navigation links: Visitor Center, SDSTA, The Facility, News and Events, Contact Information, SURF Foundation, and DONATE. The main content area is titled **Proposal Guidelines** and states: "All proposals must follow these guidelines". It provides a list of steps for the approval process, including reading the **Experiment Implementation Program**, **Experiment Integration and Support** document, completing a draft of the **Experiment Planning Statement**, contacting the SURF Science Director, and completing the **Memorandum of Understanding (MOU)**. A table lists various documents for download, such as the **Experiment Implementation Program** (660.31 KB), **Experiment Integration and Support Standard** (337.86 KB), **Experiment Planning Statement** (274.98 KB), **MOU Template** (49.37 KB), **Publication Policy** (275.69 KB), and **Acknowledgement of Risk and Waiver** (98.83 KB). The footer contains links to job opportunities, social media, and legal information.

4850L Davis Campus

3,017 m² (Total) / 1,018 m² (Science)



SURF 4850L Davis Campus

Examples of laboratory space



Detector Room (MJD):

Area = 140 m², 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 m², 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

J. Heise | TAUP @ Vienna, Aug 29, 2023

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

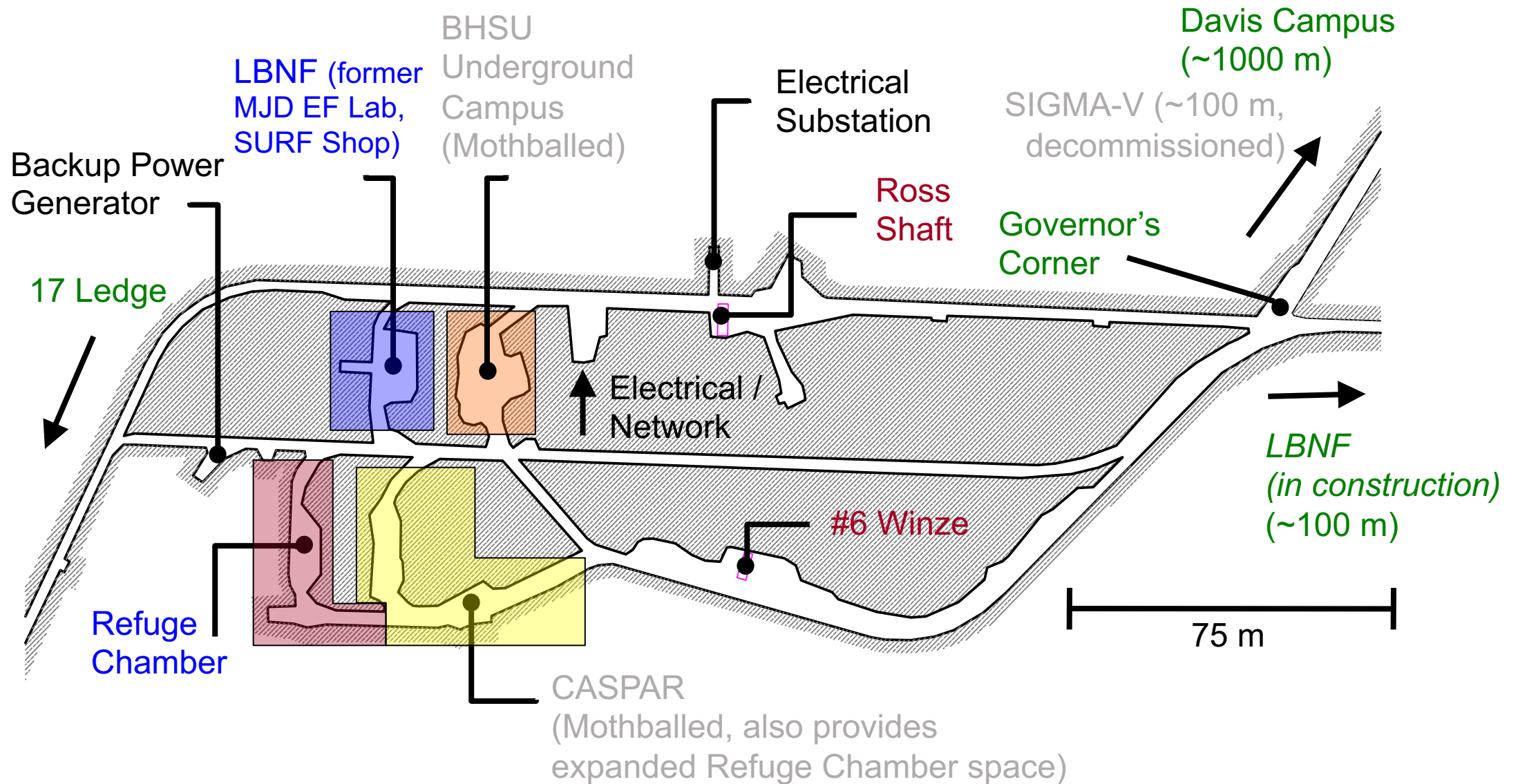
CONTENT:
Press Release

CONTACT:
Constance Walter
Communications Director
cwalter@sanfordlab.org



4850L Ross Campus

2,653 m² (Total) / 920 m² (Science)



SURF 4850L Ross Campus

Examples of laboratory space



2010-2017

Former MJD Electroforming:

Area = 228 m²
(Cleanroom removed, future UG WWTP)

CASPAR Hall:

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



Copper Electroforming



2015-2021, resume FY24



2015-2020, resume FY24

BHUC Cleanroom:

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

SURF Underground Facility Expansion

Feasibility study conducted for new 4850L caverns

- Feasibility considerations:
 - Space (up to 100 m long), geotechnical conditions
 - Ventilation for excavation, outfitting, and operation
 - Waste rock handling
 - Access to and separation from existing operations
 - Ability to excavate, construct, and expand in phases
- Assessment results:
 - Current **ventilation** plan adequate for proposed expansion
 - Proposed laboratory expansion locations provide adequate **isolation and separation** from existing Science operations
 - Access to Ross waste dump, blast isolation doors for excavation
 - Positive **geotechnical** site locations based on preliminary info
 - Suggest additional geotechnical study at specific site locations to verify
 - Cost and schedule provided for **phased construction**
 - Excavation for **two 100-m caverns ~2.5 years**, incl mobilization & de-mob

Document No. RPT-21531-0001

4850 Level Expansion Project Final Report

South Dakota Science and Technology Authority
Sanford Underground Research Facility
Yates Feasibility Study
Project No. 182921531

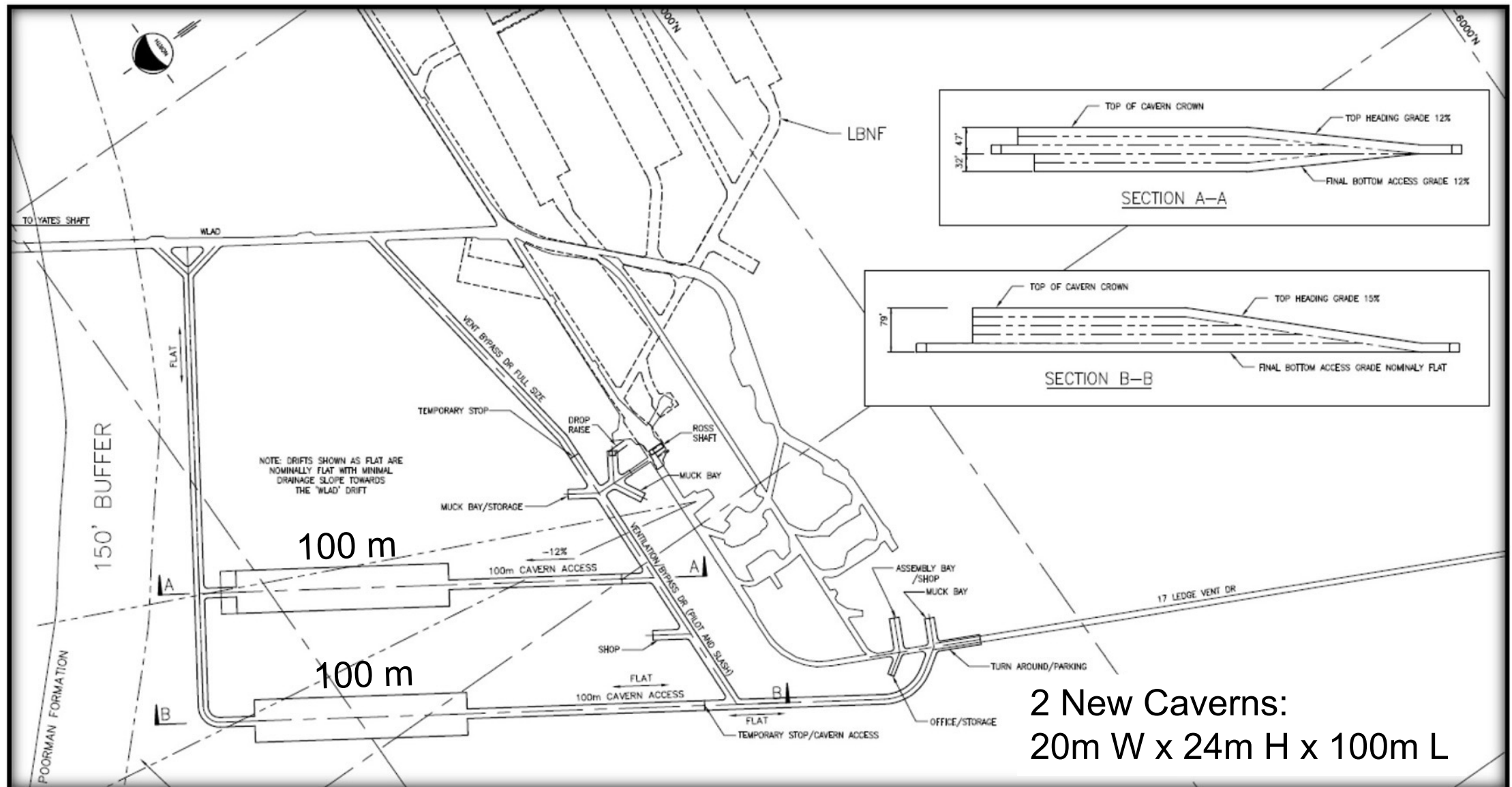
02 February 2022



Stantec Consulting International LLC
3133 West Frye Road, Suite 300
Chandler, Arizona 85226
USA

SURF Underground Facility Expansion

Feasibility study conducted for new 4850L caverns



SURF Radon Reduction System – Surface

Commercial continuous-cooled Rn mitigation system

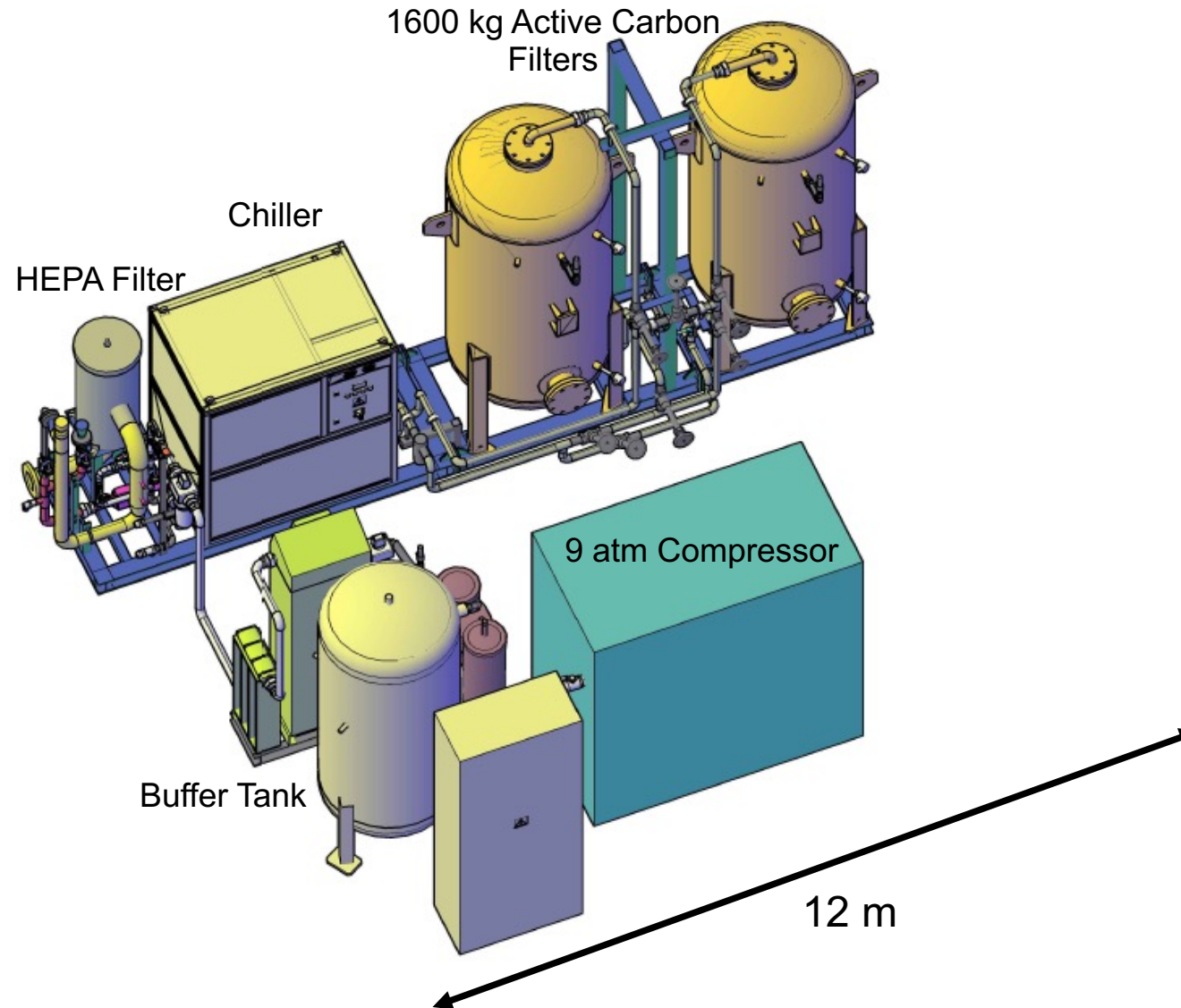


- **Specs:** 1000x Rn reduction, 300 m³/hr
- **Supplier:** Ateko, Czech Republic (same as Y2L, Gran Sasso, etc)
- **Design:** Compress air to 9 bar, cool to -60C dew point, flow air through carbon adsorption columns, reduce pressure, reheat as desired
- **Space:** Dedicated bldg, 74 m²
- **Status:** 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 m², 240 m³
- **Status:** Operating as Class 100, **770x Rn reduction** inside cleanroom

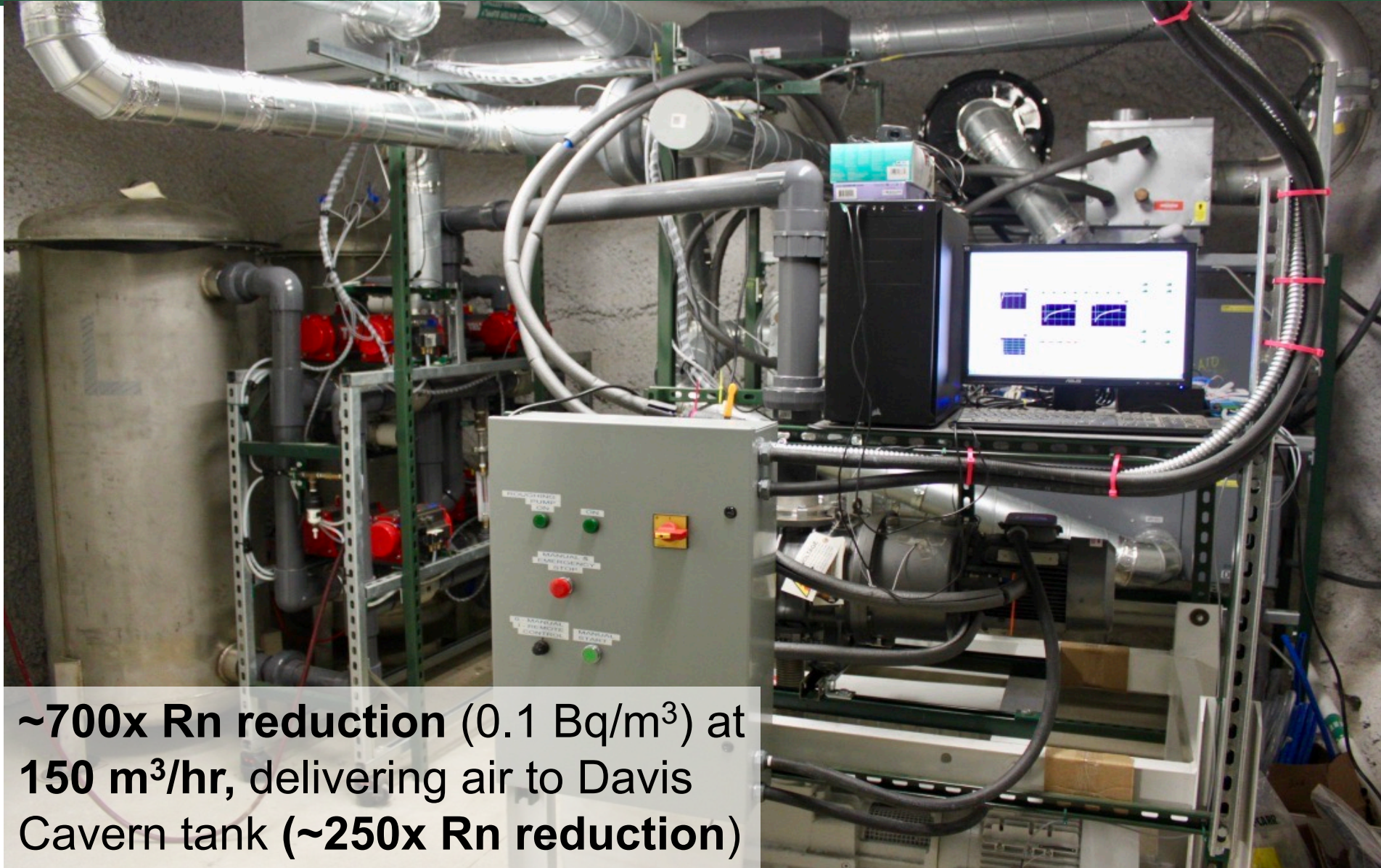
SURF Radon Reduction System – Surface

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)**

SURF Water Purification System

Davis Campus

