#### SANFORD UNDERGROUND RESEARCH FACILITY

### Sanford Underground Research Facility America's Underground Lab

Mike Headley SDSTA Executive Director SURF Lab Director January 29, 2025

### **SDSTA** Overview



**SURF Mission:** We advance world-class science and inspire learning across generations.

**SURF Vision:** The world's preferred location for underground science and education.

- SDSTA currently has 190 full time and 12 part time staff members.
- We own, operate, and maintain the SURF facility in support of world-leading science experiments. Currently, 30 science groups and over 2300 collaborators.
- We support the construction of the Long-Baseline Neutrino Facility (LBNF) to host the Deep Underground Neutrino Experiment (DUNE) at SURF.
- We provide leadership in K-12 and public STEM education and outreach.
- SURF operations is federally funded through a five-year Cooperative Agreement (CA) between the U.S. Dept of Energy's (DOE's) Office of Science and the SDSTA.



### **SURF Operations Cooperative Agreement (CA)**

- CA established a direct relationship between DOE and SDSTA.
- Funded 5 years of SURF operations at \$125M total (Federal FY20-24).
- Five year renewal secured Sept 2024 with additional \$203M (Federal FY25-29).
- Under the CA, the SDSTA operates and maintains SURF in support of the science mission. Provides all personnel, facilities, equipment, supplies, and services. Manages the overall effort.
- CA scope includes "Basic Support" to approved Non-Proprietary users without charge. The user will pay for costs incurred for services over and above basic support.
- Costs to support Proprietary users must be fully recovered per DOE direction.
- DOE funds SURF Infrastructure Improvement Projects through the CA to ensure safe and reliable operations.

### **SDSTA Current Budget Overview** FY2026 budget to be approved by SDSTA Board in June

Scope (Source)	Funding
SURF Operations (DOE CA)	\$31.2M
Infrastructure Improvement Projects (DOE CA)	\$3.8M
LBNF construction support (DOE - Fermilab)	\$6.4M
Direct support to other experiments (DOE grant)	\$1.0M
4850L lab expansion excavation (State of SD)	\$4.7M
Institute for UG Science at SURF (SDSTA)	\$0.3M
Board, Exec Office, SLHVC, Foundation (SDSTA)	\$2.0M
Total Budget	\$49.4M

SDSTA funding. Summary provided in the budget book and includes the SURF Foundation, Visitor Center, and the Institute for Underground Science at SURF.

### **Economic Impacts in South Dakota**

- \$75M in South Dakota investments have resulted in \$1.3B in federal (\$1.2B) and private (\$94M) investments (17x ROI for South Dakota).
- SURF activities directly employ 400 FTE (SDSTA, partners, contractors).
- U.S. Dept of Energy has made a 30+ year commitment to SURF ops.

SURF Provides \$2B in Economic Impact in South Dakota, 2020-2029				
Impact Type	Output (Millions)	Earnings (Millions)	Average Annual Employment	
Direct	\$617	\$197	258	
Indirect	\$704	\$454	920	
Total	\$1,321	\$651	1,178	

Source: AEG analysis of base data from SDSTA and Fermilab, U.S. Bureau of Economic Analysis RIMS II Multipliers, U.S. General Services Administration.

Note: Direct and indirect figures may not sum to total figures due to rounding.

### SDSTA Direct Spending within South Dakota Federal FY2007 through FY2024



### **SURF Long-Term Goals**

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

- 1. The Long-Baseline Neutrino Facility (LBNF) and Deep Underground Neutrino Experiment (DUNE) have been constructed and are fully operational.
- 2. Yates Shaft and Hoists have been fully reconstructed and modernized.
- 3. Maximize science with existing space to include a cryogenic user facility and potential LUX-ZEPLIN (LZ) upgrade.
- 4. Additional lab space on the 4850L has been constructed and is fully operational to support next generation science, including at least one Generation 3 Dark Matter experiment.
- 5. Foster commercial partnerships to advance technology development in the region, increase facility operations efficiency and safety, and expand workforce development opportunities.
- 6. The Institute for Underground Science at SURF has been constructed and is fully operational with compelling, vibrant science, and education programs.



### **4850L Science Facilities**





#### Dark Matter LUX-ZEPLIN

### Neutrinos

MAJORANA DEMONSTRATOR LBNF /DUNE

**Biology** Extreme Life Astrobiology

### **Science Program**

Geology

Geothermal Energy Seismic Studies

### **LBNF/DUNE** Overview

Far Site – SURF in Lead, SD Near Site – FNAL in Batavia, IL Facility/Infrastructure and Far Detectors Facility/Infrastructure, Neutrino Beamline, and Near Detectors Sanford Fermilab Underground Research 800 miles 00 kilometers Facility DETECTOR PARTICLE DETECTOR Three subprojects Two subprojects

- FSCF-EXC Far Site Excavation
- FSCF-BSI Far Site Building & Site Infrastructure
- FDC Far Detectors and Cryogenic Infrastructure

- NSCF+B Near Site Conventional Facilities + Beamline
- ND Near Detectors



### LBNF Excavation Scope Cavern excavation completed Feb 2024. Infrastructure construction underway.



### North Caver





# Underground ceremony marks completion of LBNF/DUNE excavation

Dignitaries celebrate with ribbon cutting at SURF

### **2023 Particle Physics Strategic Plan** 10-year strategic plan with a 20-year vision



Pathways to Innovation and Discovery in Particle Physics

RAFT Report of the 2023 Particle Physics Project Prioritization Panel

#### https://usparticlephysics.org/

A strategic plan for the High Energy Physics Advisory Pan

#### 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.

- <u>SURF Summary</u>: "With SURF, the U.S. has created a premier underground laboratory that is built on a decades-old, distinguished history. The realization of this facility adds unparalleled infrastructure capability to the suite of national laboratories in the US. This facility enables the U.S. to be an international host for future neutrino and dark matter experiments."
- SURF-related Recommendations
- <u>Dark Matter</u>: Strong support for the SURF underground lab space expansion to enable siting of a Generation 3 DM experiment in the U.S.
- <u>Neutrinos</u>: Strong endorsement of a 3<sup>rd</sup> DUNE detector and R&D for a 4<sup>th</sup>.
- <u>SURF Expansion</u>: DOE should fund cavern outfitting of SURF 4850L underground space expansion. Estimated at approximately \$100M.

Sanford Underground Research Facility South Dakota Science and Technology Authority



### **More 4850L Space Needed for Future Experiments**



### 4850L Expansion – Phase A Drift Excavation



- Expansion excavation began Mar 2024. Successfully completed in Sept 2024.
- Completed full excavation scope within budget and with high quality.
- ~10,000 cubic yards in total removed and placed underground on 4850L.
- South Drift portal shotcreted in Oct. Electrical install and ventilation improvements are underway. Expect to finish within \$13M budget.

### K-12 Education & Outreach

Presentations and Field Trips	Curriculum Units and Resources	Career Exploration and Development	Supporting Teachers
<ul> <li>K12 presentations</li> <li>Face-to-face</li> <li>Virtual options</li> <li>Field trips</li> </ul>	<ul> <li>17 unique curriculum units available for checkout</li> <li>5-15 hours of fully designed and resourced science curriculum</li> </ul>	<ul> <li>Davis-Bahcall Scholars Program</li> <li>Summer internship opportunities</li> <li>Pre-service educator program support</li> </ul>	<ul> <li>Professional development offerings</li> <li>Curriculum resources</li> <li>Science content support</li> <li>Just-in-time support</li> </ul>



### Education & Outreach – By the Numbers

School Year	2019-2020 (covid begins)	<b>2020-2021</b> (during covid)	2021-2022	2022-2023	2023-2024	2024-2025*
Field Trips	254	58	485	972	966	526
Classroom Presentations	3,704	2,005	14,038	12,799	10,281	7004
Curriculum Units	3,236	3,384	3,718	2,554	3,965	3339
Other	918	298	1,468	1,596	1,368	885
Total Student Contacts	8,112	5,745	19,709	17,921	16,580	11,754*

\* July '24 – January '25

The E&O team also developed and facilitated 1674 people hours of professional development for teachers.





### **SD University Involvement and Partnership Highlights**

	Augustana	<ul> <li>Augustana faculty - DUNE collaborator</li> <li>SDSTA staff serve on Augustana Board of Trustees</li> <li>SDSTA staff supporting Augustana Jr. Science Symposium</li> <li>SDSTA E&amp;O staff support pre-service education undergraduates</li> <li>Faculty attended SURF Higher Ed Connections Workshop</li> <li>Co-collaborators on state E-CORE grant</li> </ul>			OLC	<ul> <li>Co-collaborators on state E-CORE grant</li> <li>SDSTA supported educator professional development at OLC</li> <li>OLC staff served as 2024 SURF Artist-in-Residence</li> </ul>
Ŵ					SD Mines	<ul> <li>SDMines faculty – CASPAR PI, collaborators on DUNE, MJD/ LEGEND, LZ, geology, biology, and engineering experiments</li> <li>SDMines hosted <i>Conference on Science at SURF</i> (CoSURF)</li> </ul>
	BHSU	<ul> <li>Joint development and operation of the BHSU Underground Campus (BHUC) on 4850L</li> <li>BHSU faculty - LZ and biology collaborators</li> <li>NSF REU program (internships) – SURF experience</li> <li>BHSU faculty serve on SURF User Association Executive Committee</li> <li>BHSU faculty - Quantum initiatives partner</li> <li>BHSU president SDSTA Board of Directors (ex-officio)</li> </ul>				<ul> <li>host since 2015</li> <li>SDMines faculty serve on SURF Science Program Advisory Committee and SURF User Association Executive Committee</li> <li>SDMines faculty - Quantum initiatives partner</li> <li>Co-collaborators on state E-CORE grant</li> <li>SDMines president SDSTA Board of Directors (ex-officio)</li> <li>Faculty attended SURF Higher Ed Connections Workshop</li> <li>SDSTA supports the SDMines Women in Science program</li> </ul>
	DIIOO	<ul> <li>SDSTA E&amp;O staff support pre-service education undergraduates</li> <li>BHSU and E&amp;O collaborate on multiple federal grants including EPSCoR, E-CORE, and CIRLCES Alliance</li> <li>BHSU faculty support Davis-Bahcall Scholars program</li> <li>SDSTA supports the BHSU Women in Science program</li> <li>Faculty attended SURF Higher Ed Connections Workshop</li> </ul>		Ś	SDSU	<ul> <li>SDSU faculty - DUNE collaborator, bioengineering collaborator</li> <li>SDSU engineering student projects involving SURF</li> <li>SDSU interest in quantum initiatives</li> <li>SDSU and SDSTA E&amp;O staff co-designed and facilitated K-8 STEM education professional development</li> <li>SDSTA staff support pre-service education undergraduates</li> <li>Co-collaborators on state E-CORE grant</li> </ul>
<b>A</b>	DSU	<ul> <li>Supports SURF information technology security program</li> <li>DSU Faculty - Quantum initiatives partner</li> <li>Co-collaborators on state E-CORE grant</li> <li>Faculty attended SURF Higher Ed Connections Workshop</li> </ul>		<u>No</u>		<ul> <li>Faculty attended SURF Higher Ed Connections Workshop</li> <li>CUBED SD Gov Research Center PI for germanium apps</li> <li>Interest in UG germanium detector lab</li> </ul>
	Northern	<ul> <li>Co-collaborators on state E-CORE grant</li> <li>SDSTA E&amp;O staff support pre-service education undergraduates</li> </ul>			USD	<ul> <li>Interest in quantum initiatives</li> <li>SDSTA E&amp;O staff support pre-service education undergraduates</li> <li>Faculty attended SURF Higher Ed Connections Workshop</li> <li>Co-collaborators on state E-CORE grant</li> </ul>



# **Questions?**

## www.sanfordlab.org

### **Competing Underground Facilities**



**Greater Depth** 



### SURF Science Program – Current Physics Highlights Strong and diverse program with exciting future



#### LUX-ZEPLIN (LZ)

- Direct search for dark matter using 10 tonnes xenon
- World-leading initial result announced in July 2022



#### MAJORANA DEMONSTRATOR (MJD)

- Investigate neutrinoless doublebeta decay using 44 kg germanium
- World-leading final result was announced in July 2022



#### CASPAR

- Stellar fusion reactions to study nucleosynthesis using accelerator
- Initial phase ended in 2021, next phase starting in 2024

### **SDSTA Budget Questions**

- Add, eliminate or restructure any programs? None.
- Changes to your original FY2024 appropriation? None.
- Any special / supplemental appropriation requests?
  - 2023 SB 35 \$13M to fund the first phase of a two-phase underground space expansion.
- Unutilized FTE for the two previous fiscal years? None.
- Instituting any other methods to raise revenue?
  - SURF Foundation raising funds for education and outreach projects.
  - In Oct 2020, signed ten-year partnership with Caterpillar to utilize a portion of the SURF underground area for product R&D and customer product demos.
  - CAT investing in SURF infrastructure and paying yearly lease fees.

