

# Sanford Underground Research Facility America's Underground Research Laboratory

Dr. Markus Horn, Research Scientist  
Sanford Underground Research Facility (SURF)



 **Sanford**  
Underground Research Facility  
South Dakota Science and Technology Authority





# Dr Markus Horn

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More than 15 years in Underground physics / laboratories

- PhD Astroparticle Physics University of Karlsruhe (KIT), GER
- Scientist at Imperial College London, Oxford University, Yale and UC Berkeley / LBNL
- Underground laboratory experience in France, United Kingdom and USA

2016-present: Research Scientist, SDSTA

- Experiment point-of-contact (MJD, Bio-Geo-Eng & others)
- Member of LUX-ZEPLIN collaboration



This is SURF



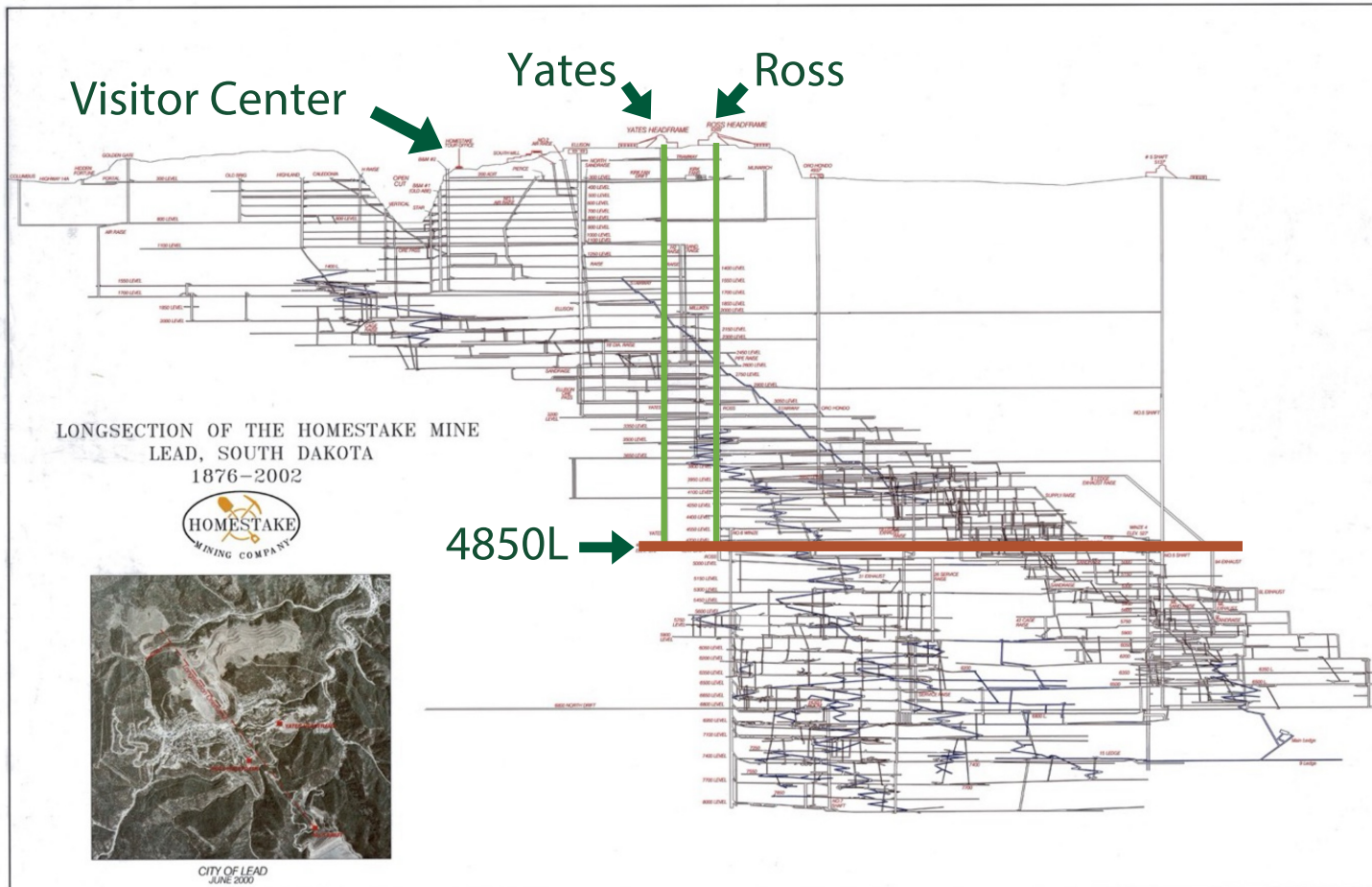


# Sanford Underground Research Facility





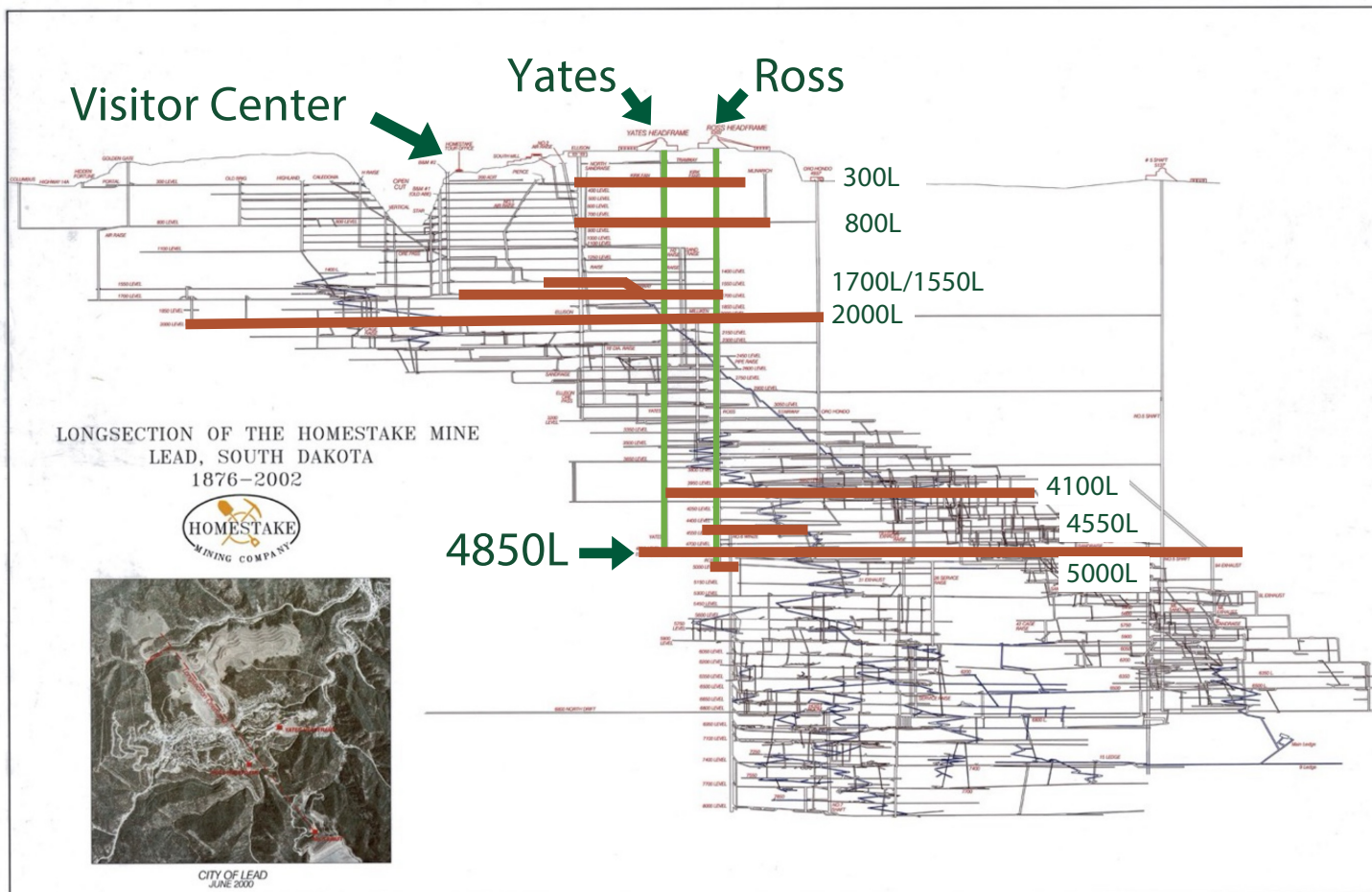
# Homestake Mine Legacy



- ~ 600 km / 380 miles of tunnels from surface to 2.4 km / 8000 ft deep, 63 total elevations, 29 currently accessible
- ~ 20 km / 12 miles maintained for science and facility operations

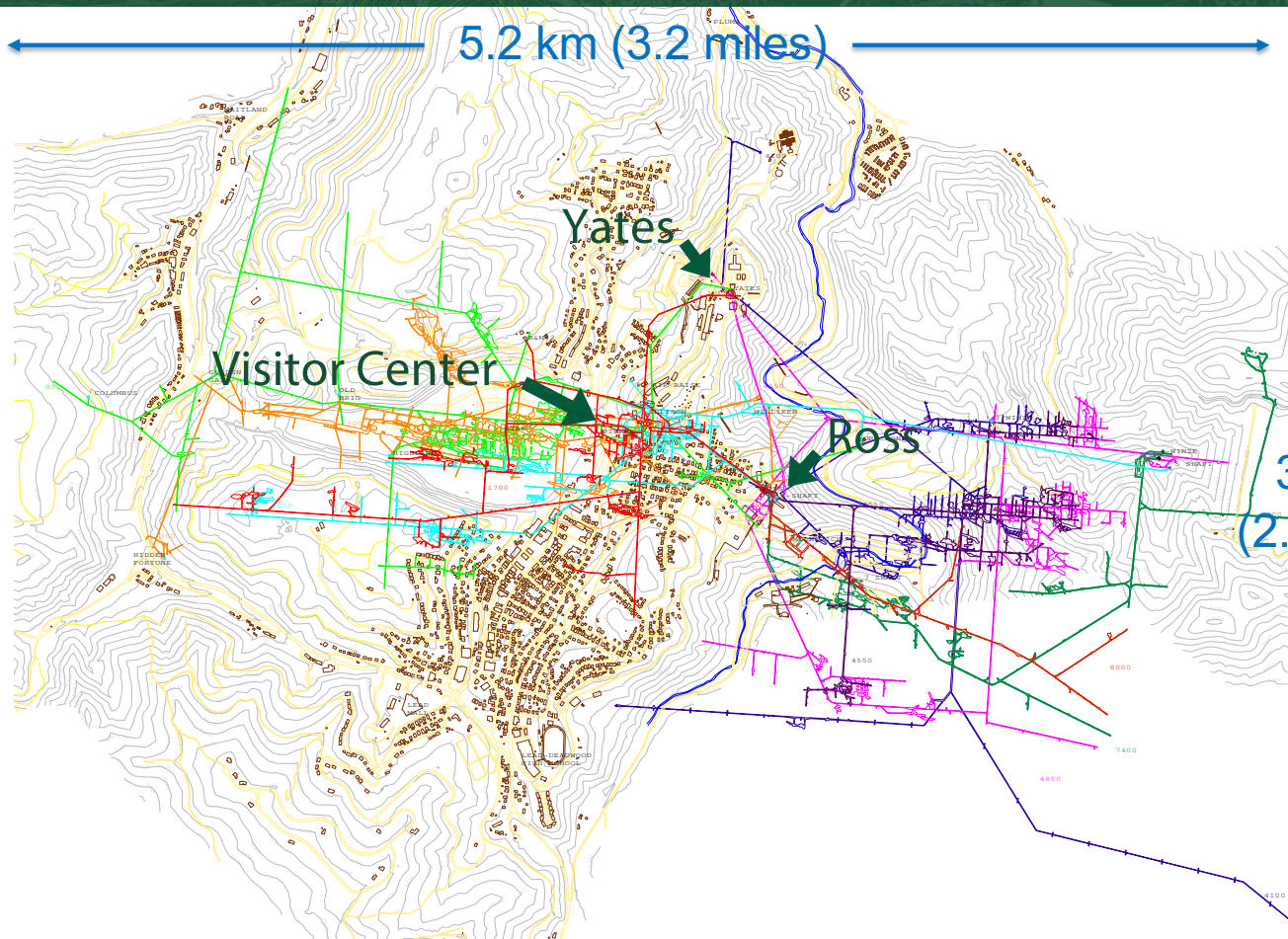


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# Homestake Mine Legacy

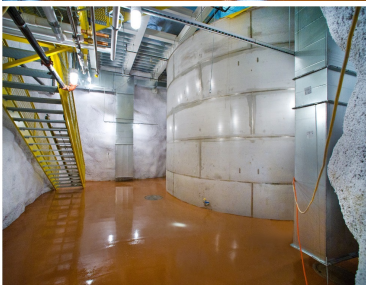


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# 4850L Science Facilities

YATES SHAFT



ROSS SHAFT



ROSS  
CAMPUS

LBNF  
DUNE

#6 WINZE

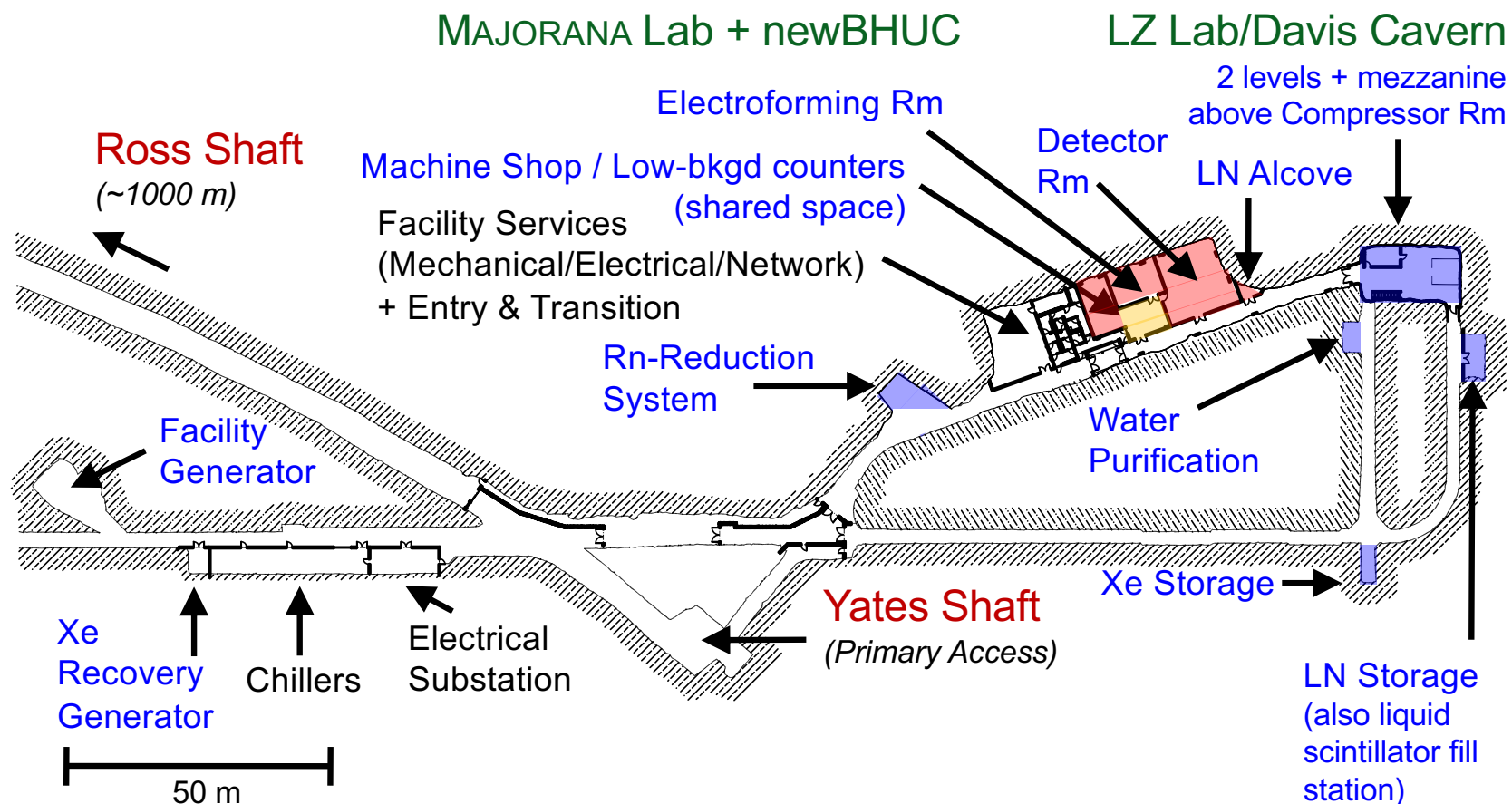
Existing Facilities  
LBNF Excavation

DAVIS  
CAMPUS



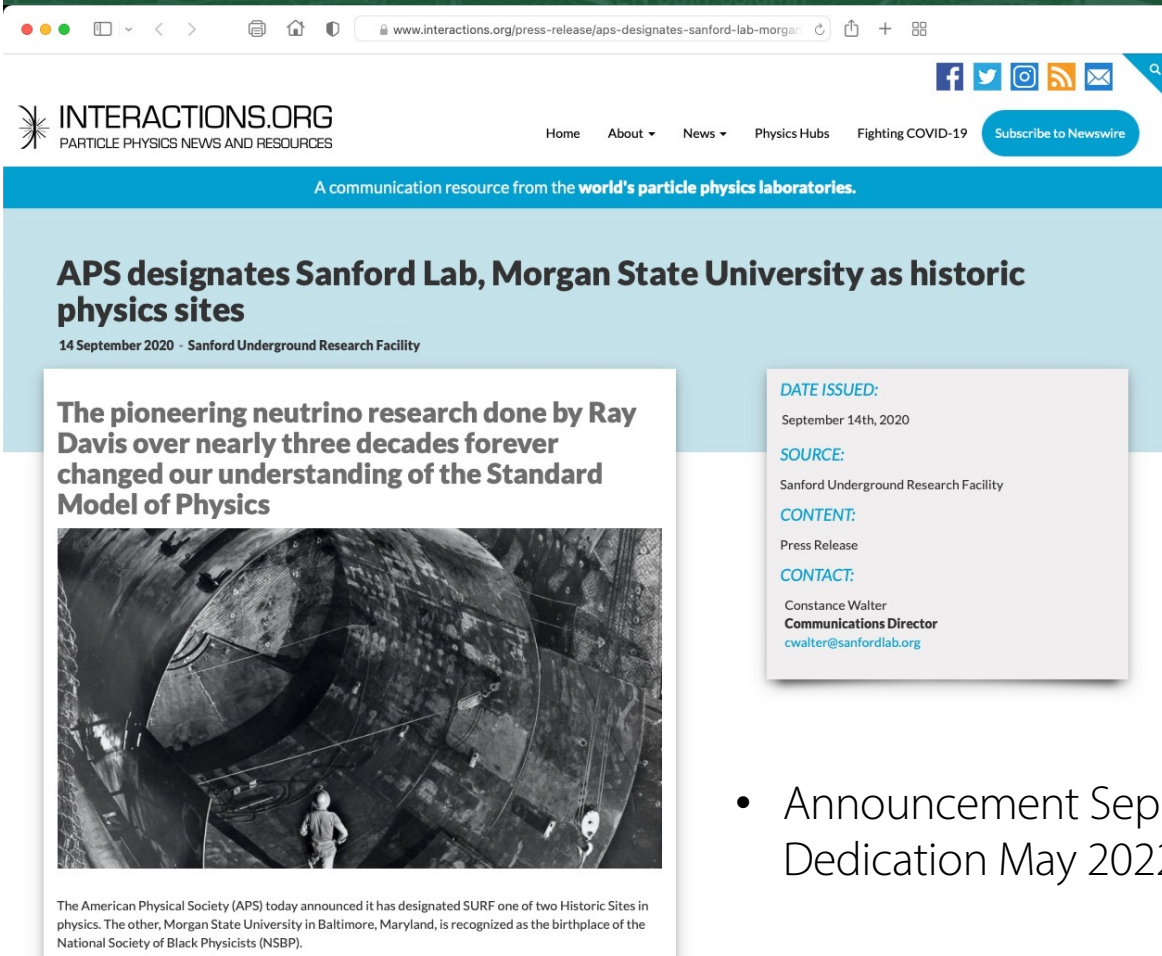


# 4850L Science Facilities – Davis Campus





# SURF Designated APS Historical Site



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

INTERACTIONS.ORG  
PARTICLE PHYSICS NEWS AND RESOURCES


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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

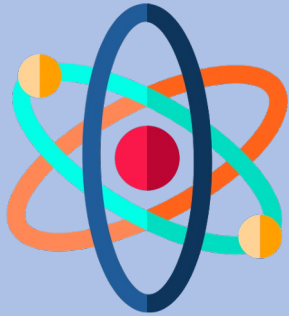
**CONTENT:**  
Press Release

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

- Announcement Sep 2020, Dedication May 2022







**PHYSICS**

MAJORANA DEMONSTRATOR •

LUX-ZEPLIN •

CASPAR •

LBNF/DUNE •

BHUC •

- DoD – Pedestrian Dead Reckoning
- Caterpillar\*
- Xilinx (AMD)\*
- GEOX™
- Thermal Breakout
- Shotcrete
- Blast Monitoring



**ENGINEERING**

# Science Program



**BIOLOGY**

- Astrobiology / DeMMO •
- BuG ReMeDEE •
- Biodiversity •
- Liberty BioSecurity\* •
- Biofuels •
- Chemistry •
- 2D BEST •
- Carbon Sequestration •

- EGS Collab – SIGMA-V
- DEMO-FTES
- 3D DAS
- BH Seismic
- Core Archive\*
- Transparent Earth
- Hydro Gravity



**GEOLOGY**

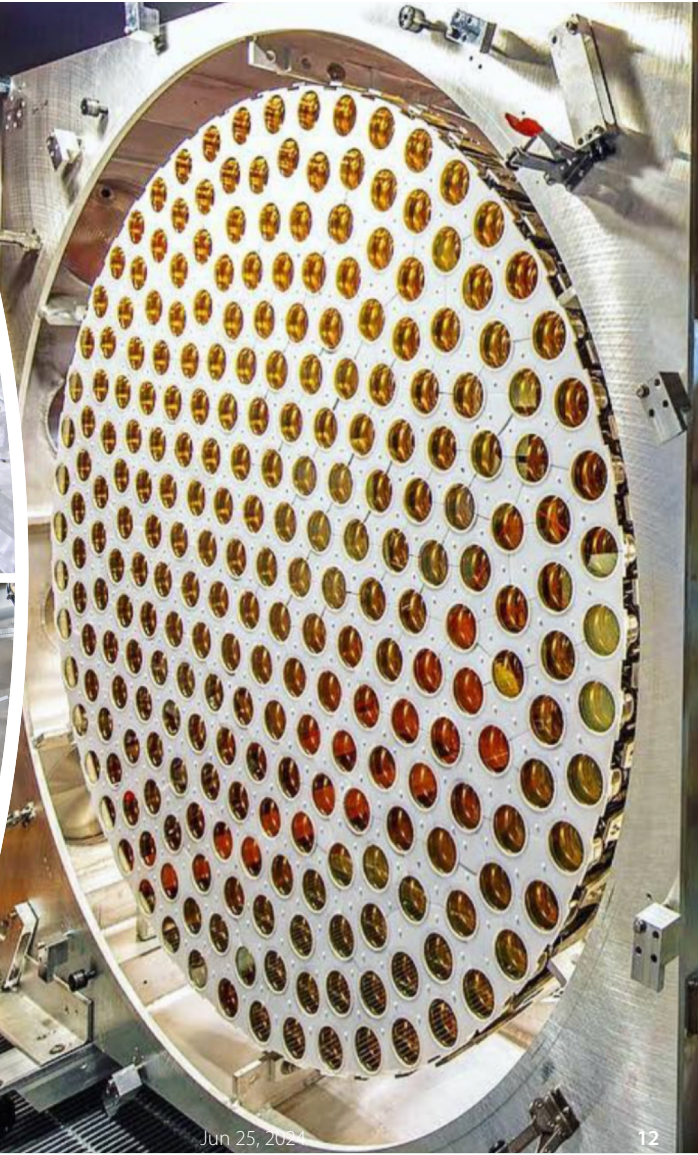
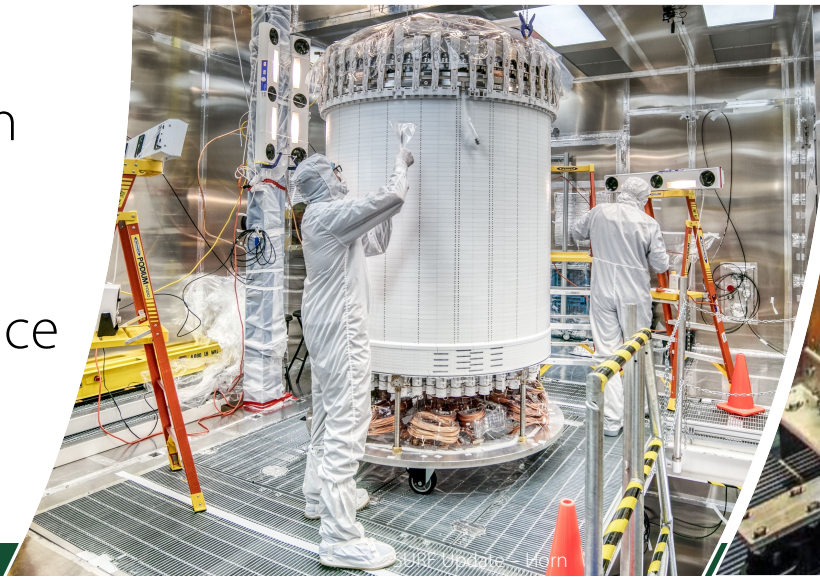
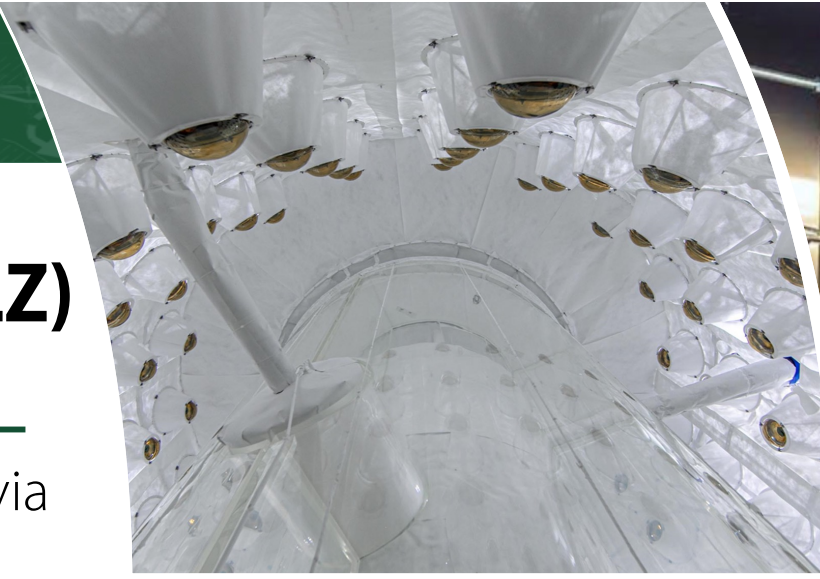
CURRENTLY  
**31** GROUPS  
 21 active  
 64 total  
 since 2007



# Physics

## LUX-ZEPLIN (LZ)

- Direct detection via nuclear recoil
- Recoiling nucleus produces signal in detector (light, charge, heat)
- World-leading since July 2022





# Physics

- Studying neutrino mass & matter/antimatter imbalance, proving technique for tonne-scale exp.
- ~40kg Germanium (44 detectors)
- Electro-formed ultrapure copper

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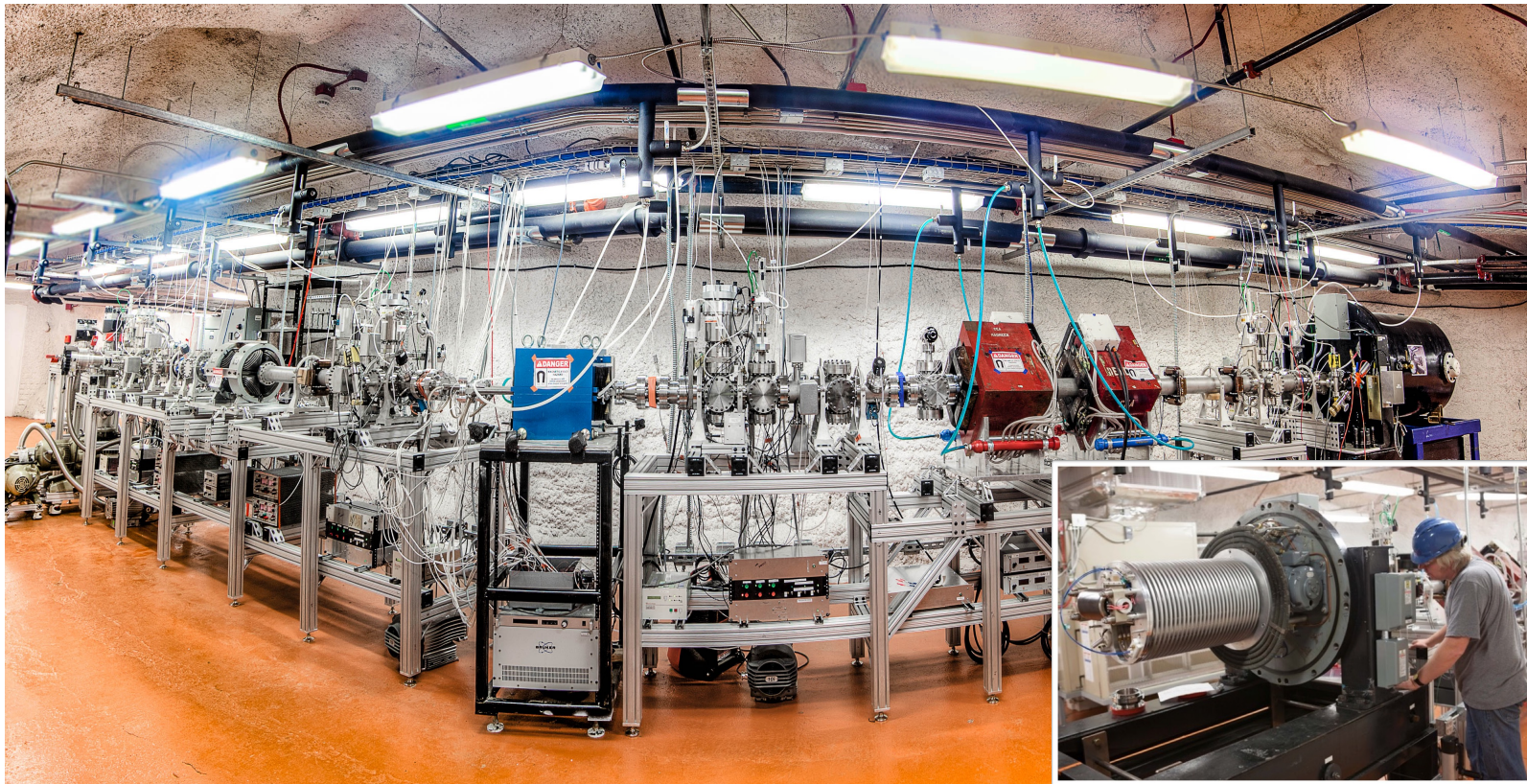
## MAJORANA DEMONSTRATOR





# Physics

## **CASPAR** Compact Accelerator System for Performing Astrophysical Research



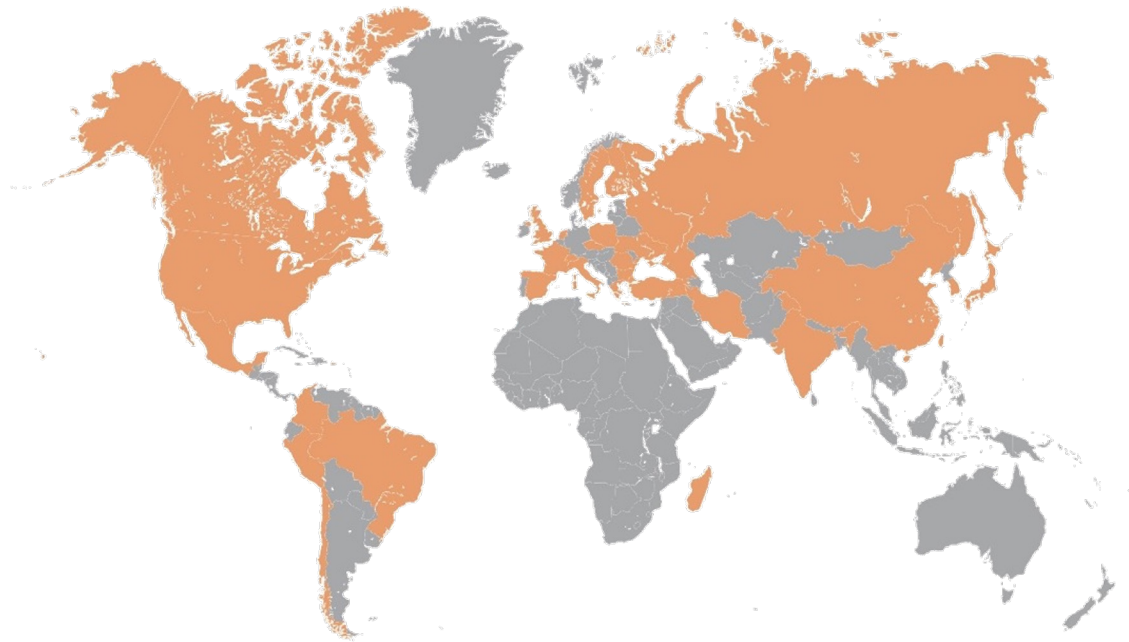
- Study of stellar nuclear fusion reactions, esp. of heavier elements in Supernovae - “star stuff”
- At SURF since 2015, planning next phase of operation in 2024





# International DUNE Collaboration

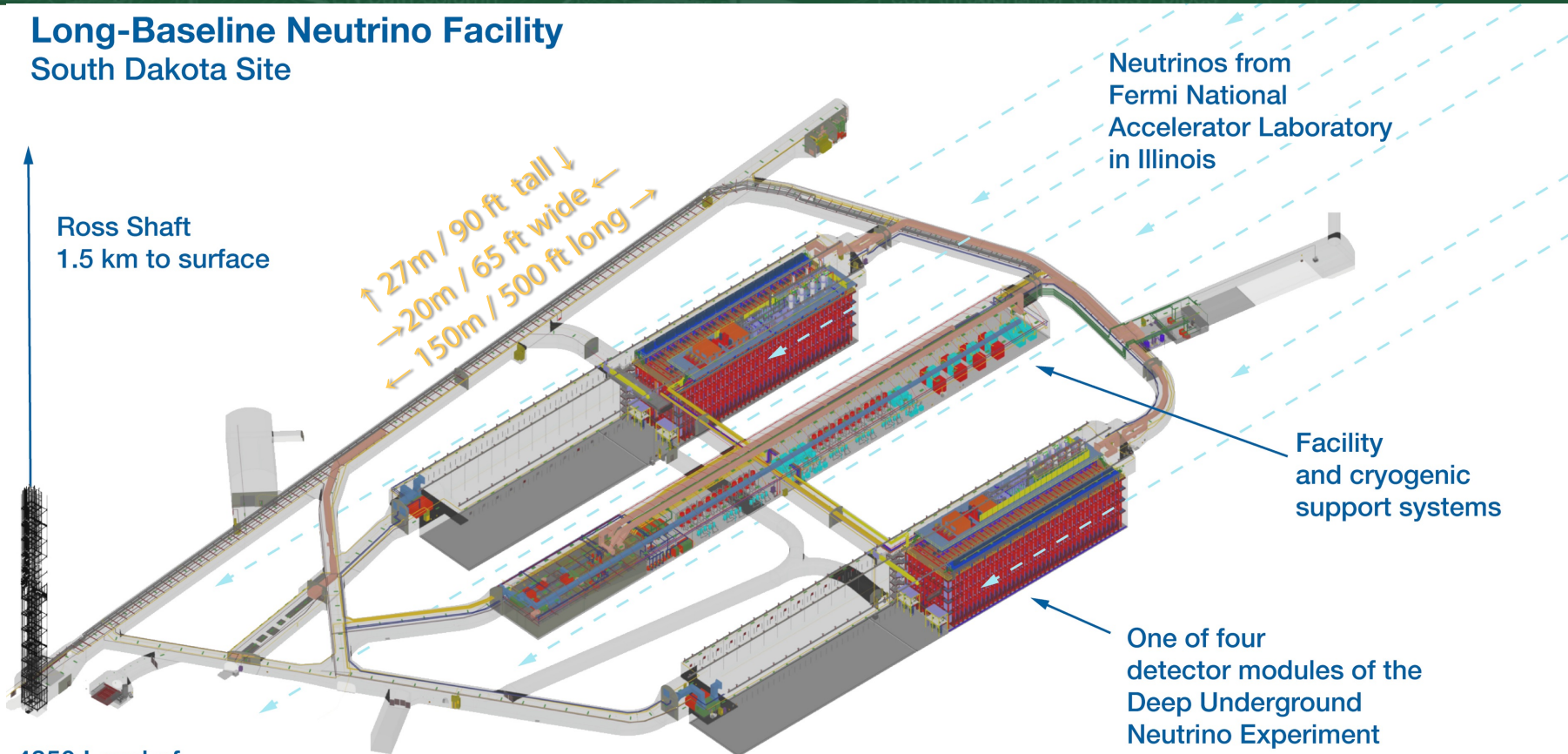
1689 collaborators from 243 institutions in 39 nations + CERN  
52% non-US



The LBNF/DUNE project will be the first internationally conceived, constructed, and operated mega-science project hosted by the Department of Energy in the U.S.

# DUNE @ LBNF

## Long-Baseline Neutrino Facility South Dakota Site



4850 Level of  
Sanford Underground  
Research Facility



# DUNE @ LBNF – Status 2024



SURF Update – Horn

Jun 25, 2024

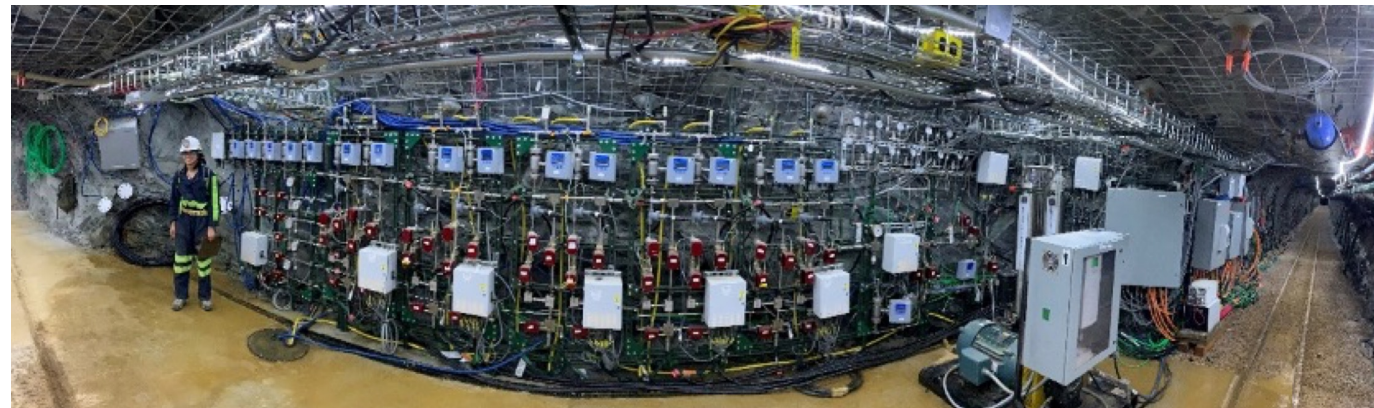
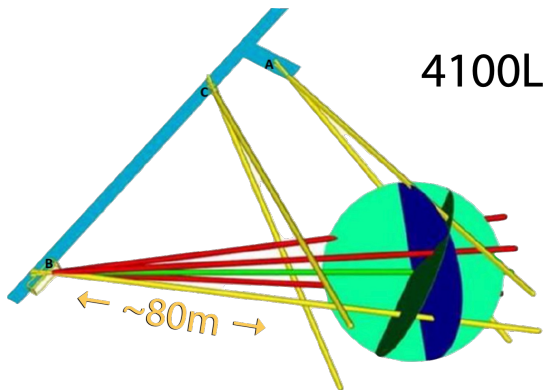
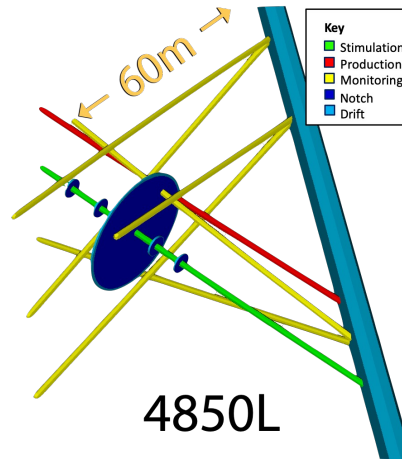
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# Geology

## EGS Collab

- Enhanced Geothermal Systems
- Study geothermal effects and fluid flow in a controlled testbed; also biology sampling
- Stimulation, Flow and Monitoring to validate simulation models
- Onsite since 2017, decommissioned on 4100L Dec 2022. Returning collaboration Oct 2023





# Engineering

\*industrial partnership

- Support u/g R&D and customer experience for MineStar™ tracking technology
- Over 1 mile of MineStar™ technology distributed over 1700L and ramp to 1550L
- 6 utility vehicles currently UG at SURF using MineStar technology
- Site-wide tracking system in development for SURF



**CATERPILLAR®**



# Biology

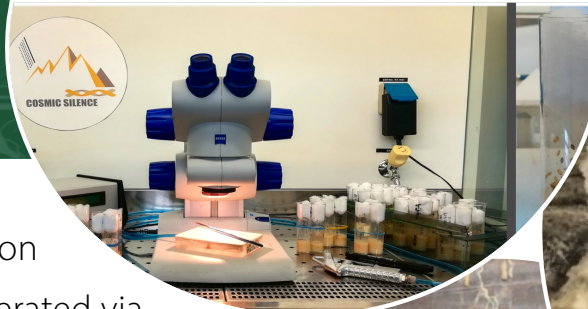
- “Extreme” underground environment
  - Geo-chemical
  - Light
  - Humidity
  - Temperature
  - Pressure
  - pH-Level
  - Salinity
  - Scarcity of nutrients





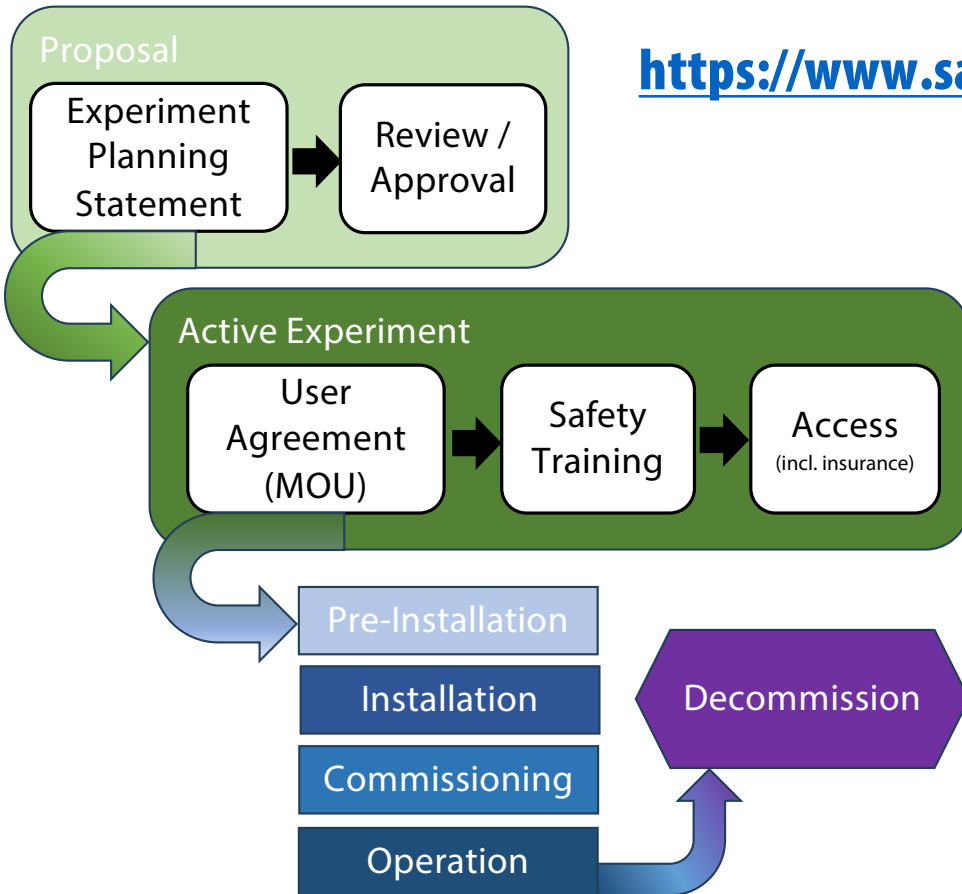
# Biology

- Extremophiles
  - Methane regulation/oxidation
  - Carbon sequestration accelerated via microbial enzymes
  - Bioplastics and biofuels
- Biofilms
  - Corrosion-resistant coatings
  - Biological nitrogen-fixing
  - Microplastics
- Microbial "dark matter" - Omnitrophota
- Astrobiology
  - In-situ cultivation
  - Mars-rover (@Boulby)
- Radiation effects
  - Plant life – Arabidopsis
  - Drosophila (@LNGS & @SNO)





# Experiment Implementation Program



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

The screenshot shows the Sanford Underground Research Facility's Research Proposal Guidelines webpage. The page features a navigation bar with links for EVENTS, NEWS, SUBSCRIBE, WORK WITH US, LOG IN, and SEARCH. The main heading is "RESEARCH PROPOSAL GUIDELINES". Below the heading, it states "All proposals must follow these guidelines". The page is divided into sections for "RESEARCHER RESOURCES" and "PROPOSAL DOCUMENTS".

**RESEARCHER RESOURCES**

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

**PROPOSAL DOCUMENTS**

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



# SURF Organization – Science Department



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



**Gavin Cox (MS)**  
Expt Support Scientist  
- LZ Operations

**Jaret Heise (PhD)** - Director  
- Manage dept and experiment implementation program



**Mark Hanhardt (MS)** Expt  
Support Scientist  
- Surface + UG Campuses



**Julia Delgaudio (BS)**  
Expt Support Scientist  
- LZ Operations



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



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

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

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





# SURF User Association

<https://www.sanfordlab.org/researchers/surfuserassociation>

## Purpose

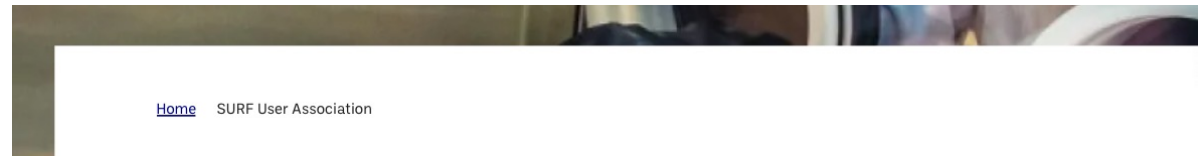
- Two-way communication on topics important to researchers.
- Promotes a sense of community amongst SURF exp. & researchers
- Articulates and promotes scientific case for UG science and significance to society, provides channel for advocacy.

## Organization

- Membership open to all UG science community
- Exec. Comm. of 9 individuals across disciplines, incl. early career

## Meetings

- General Meetings annually
- Topical workshops, incl. community planning (next 2024/5)



# SURF USER ASSOCIATION

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

## RESEARCHER RESOURCES

[Proposal Guidelines](#)

[Science Liaison Office](#)

[SURF User Association](#)

[Visitor information](#)

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

## Membership

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

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





## Mission of SURF

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





The banner features a logo consisting of four rounded, teardrop-like shapes arranged in a cross pattern. Each shape has a color gradient: top-left is yellow to orange, top-right is orange to red, bottom-left is red to pink, and bottom-right is pink to purple. Below the logo, the text "neutrino day" is printed in a dark blue, sans-serif font. The banner is set against a background of a stone wall on the left and a dimly lit interior space on the right, where a white van is visible.

**neutrino** day

# Neutrino Day – July 13, 2024

SURF's free science festival starts in: 17:23:42:13



[About](#)

[Neutrino Day 2024](#)

[Get Involved](#)

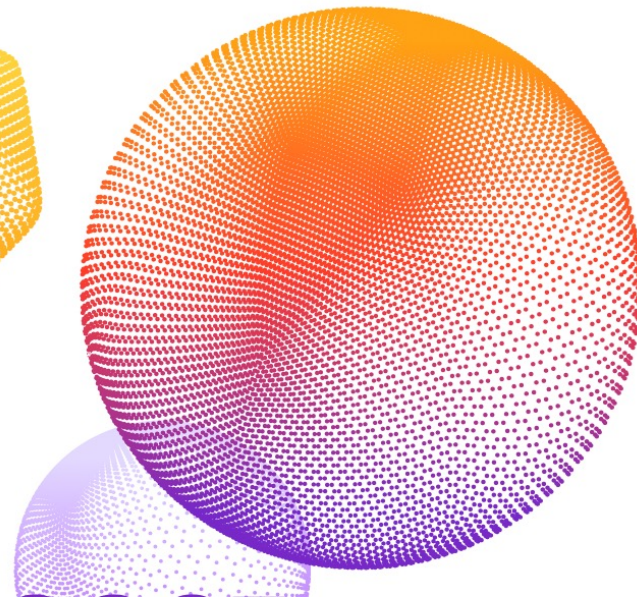
[News](#)

## Neutrino Day

Where Science & Fun **Collide**

Mark your calendars for SURF's 16th annual Neutrino Day celebration on Saturday, July 13, 2024. Activities run from 9:00 a.m. to 3:30 p.m. and a final presentation by Mr. Freeze at 4:00 p.m.—we'll see you there!

Planning for Neutrino Day is under way! Check back often for event updates.



<https://www.neutrinoday.com>





# K-12 Programming





Everything a Teacher Needs in One Box



## Education Leaders

- Professional development offerings
- Curriculum resources
- Science content support

Education impacts 2022-2023:

- 17,000 K-12 students
- 700 teachers supported





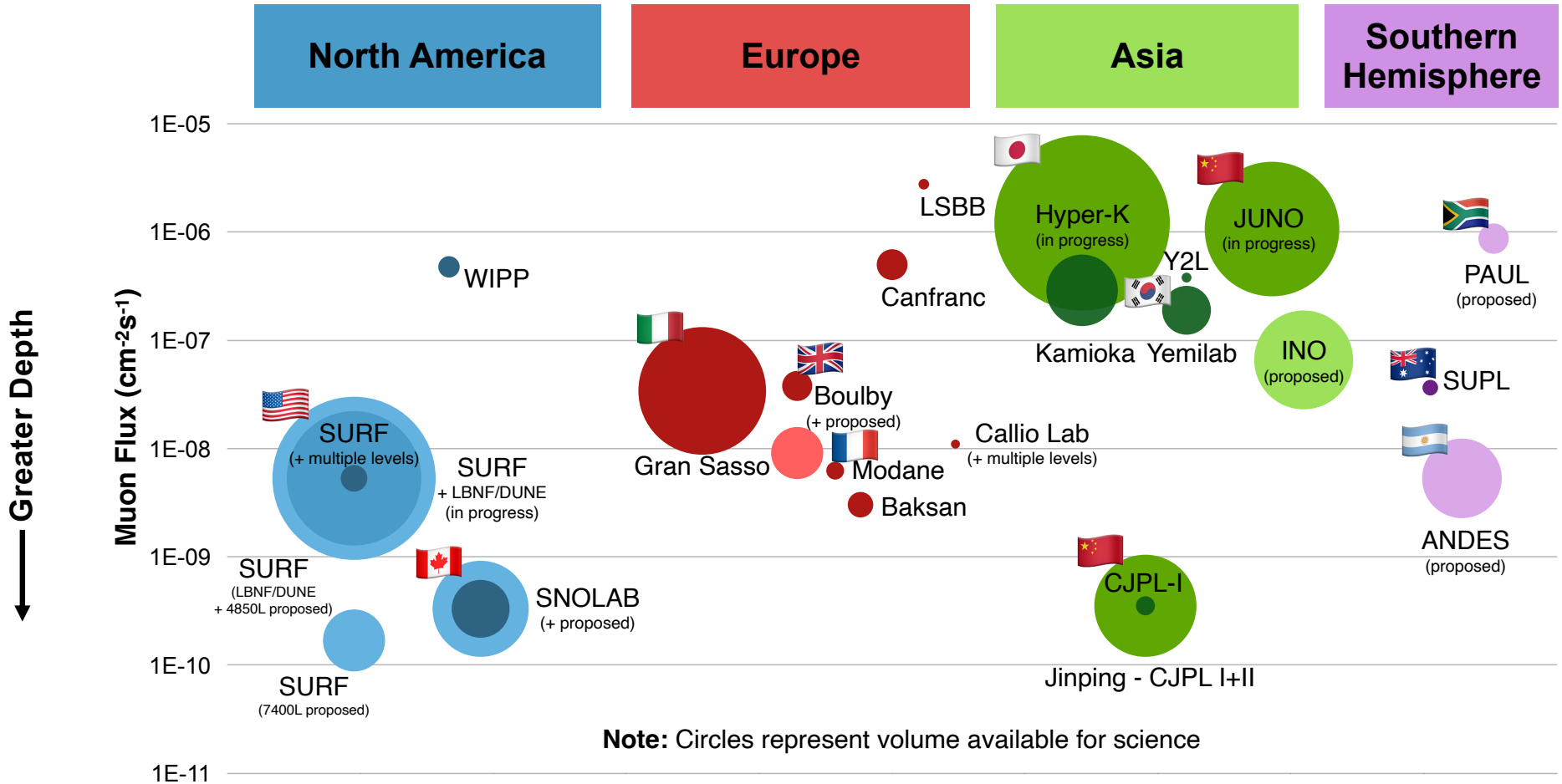
## Internships and Davis-Bahcall Scholars



# The Future



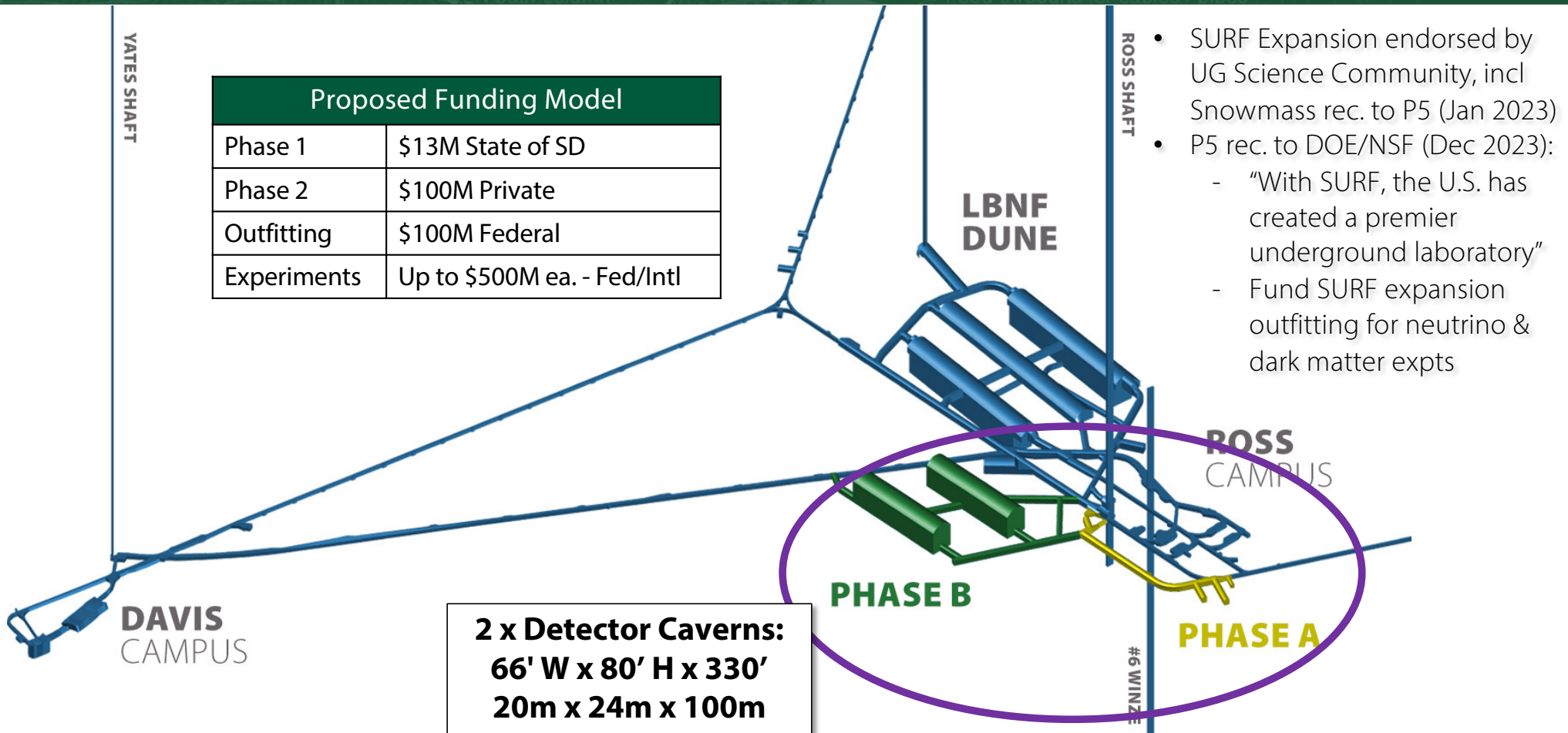
# Competing Underground Facilities





# 4850L expansion for future experiments

Space needed for U.S. world leadership. Science community endorsed expansion.





**THE INSTITUTE**  
FOR UNDERGROUND SCIENCE  
AT SURF

[PROGRAMS](#)

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[CONTACT ↗](#)

# KNOWLEDGE. PEOPLE. PLACE.

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

[▶ SEE OUR FUTURE PROGRAMS](#)





An aerial photograph of a town nestled in a valley, surrounded by rolling hills and mountains. The sky is filled with dramatic, colorful clouds in shades of orange, red, and purple, suggesting a sunset or sunrise. The town below features a mix of green trees and buildings, with a prominent white tower on the left side.

**Thank you!**

**Subscribe to Deep Thoughts**  
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