



Opportunities at the Sanford Underground Research Facility

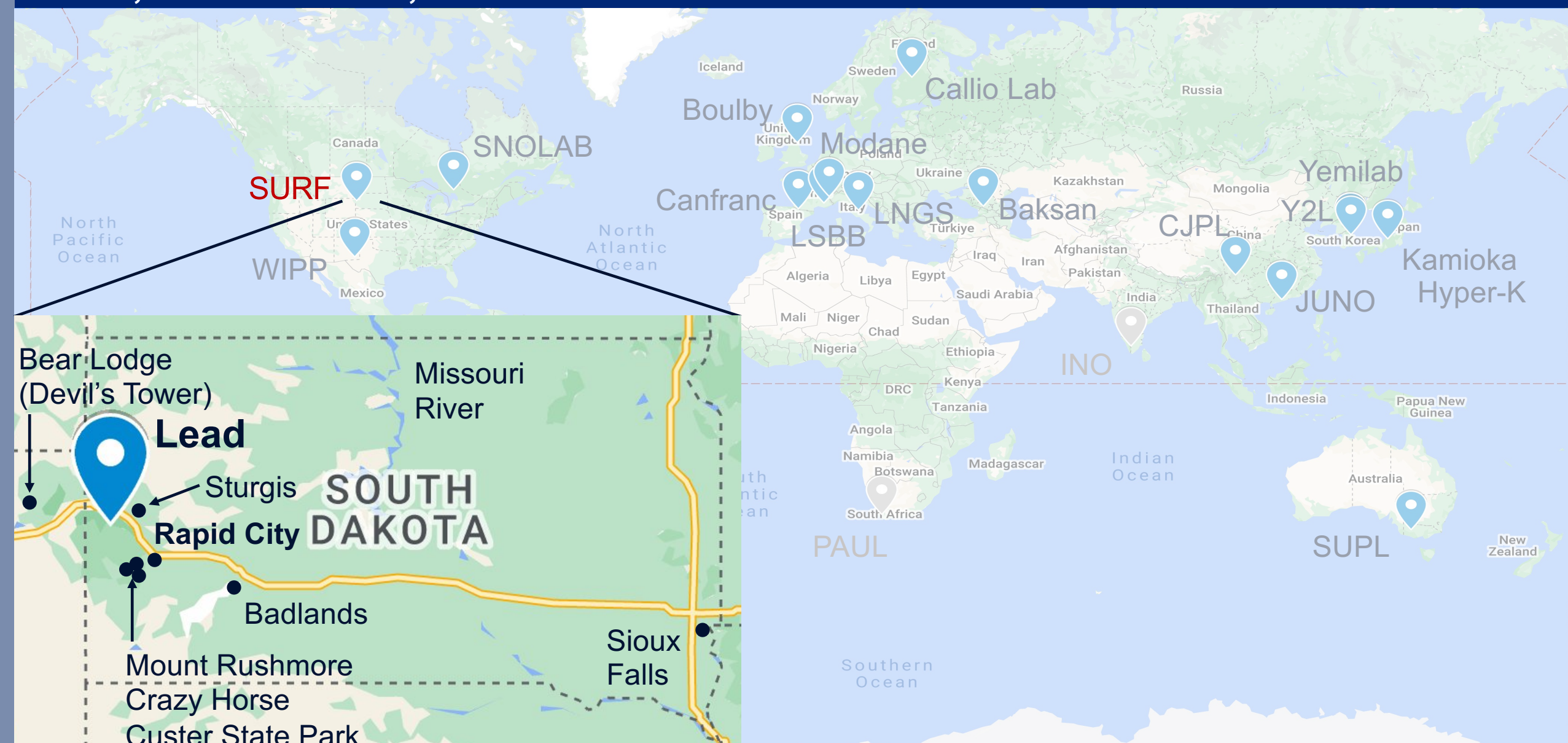
J. Heise

Abstract: The Sanford Underground Research Facility (SURF) began operation in 2007 as a facility dedicated to advancing compelling multidisciplinary scientific research. SURF is one of the deepest laboratory sites and offers the largest footprint in the world for scientific pursuits, including physics campuses at a depth of 1.5 km where the LUX-ZEPLIN dark matter, CASPAR nuclear astrophysics and DUNE neutrino experiments are located. SURF provides ultra-low background environments, low-background assay capabilities, and electroformed copper is produced at the facility.

SURF is eager to host new experiments. In addition to preparations for new deep laboratory caverns, SURF is actively investigating modifications to existing infrastructure to host a Quantum User Facility and a Vertical Facility, both of which would support quantum information science and additional particle astrophysics opportunities.

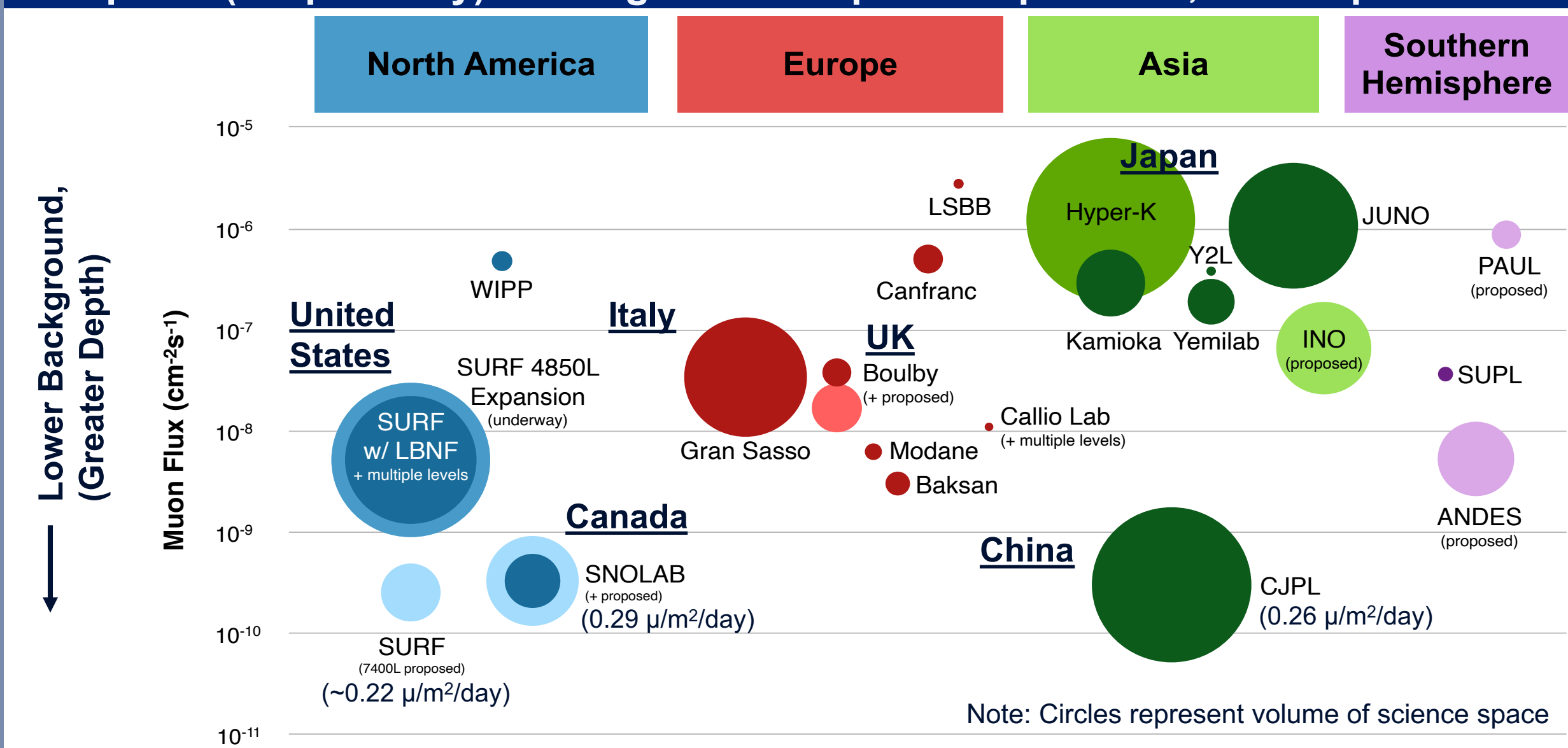
1. Sanford Underground Research Facility

Lead, South Dakota, USA



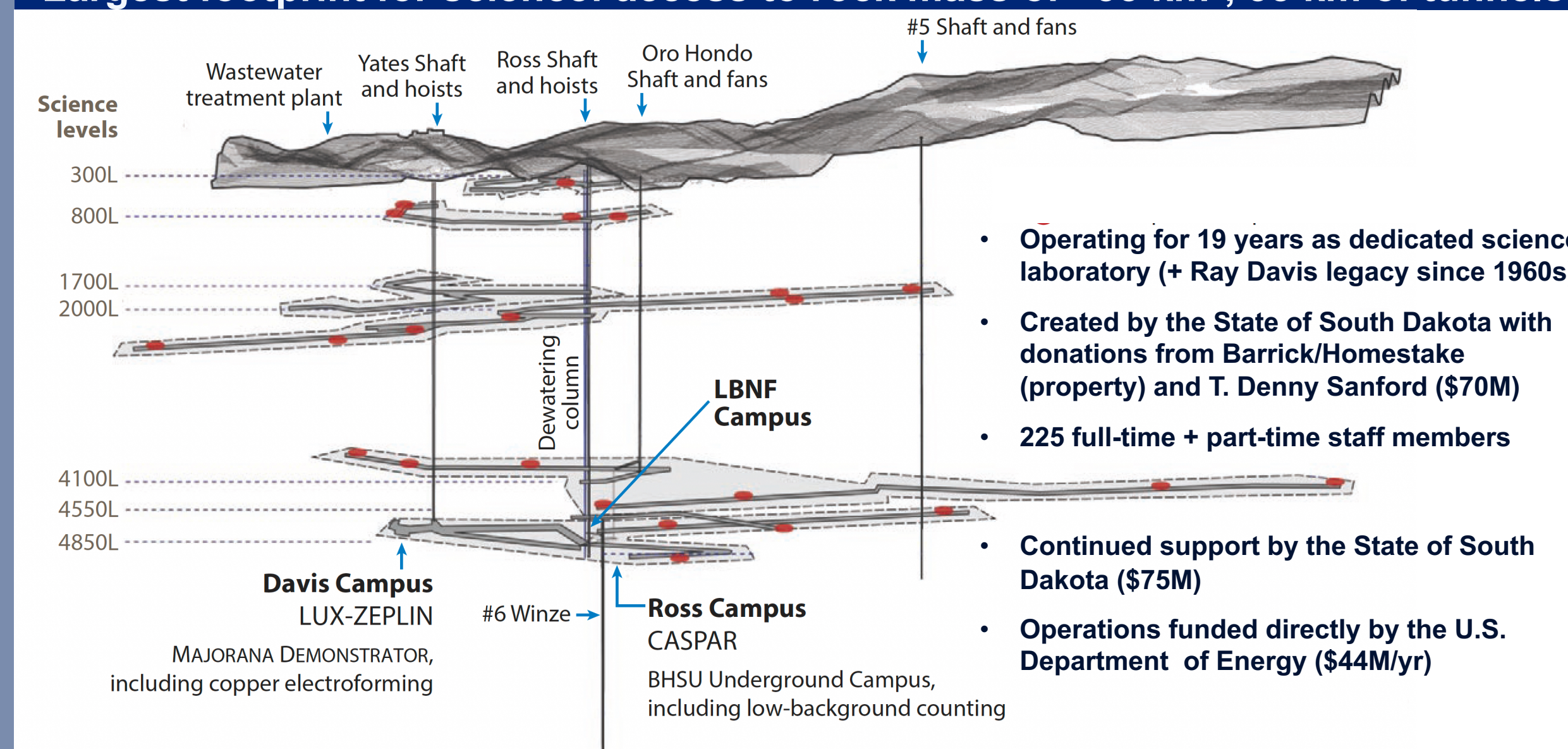
2. SURF in the Global Context

Deep site (4.5 $\mu\text{m}^2/\text{day}$) with significant expansion potential, max depth 2450 m



3. SURF Underground Laboratory Geography

Largest footprint for science: access to rock mass of $\sim 35 \text{ km}^3$, 35 km of tunnels



Geology and Engineering

Enhanced Geothermal Systems
Mining Technology

Biology

Extremophiles, Biodiversity

4. Science Program

31 Expts with 1,850 Collaborators,
280+ Institutions in 47 Countries

Physics

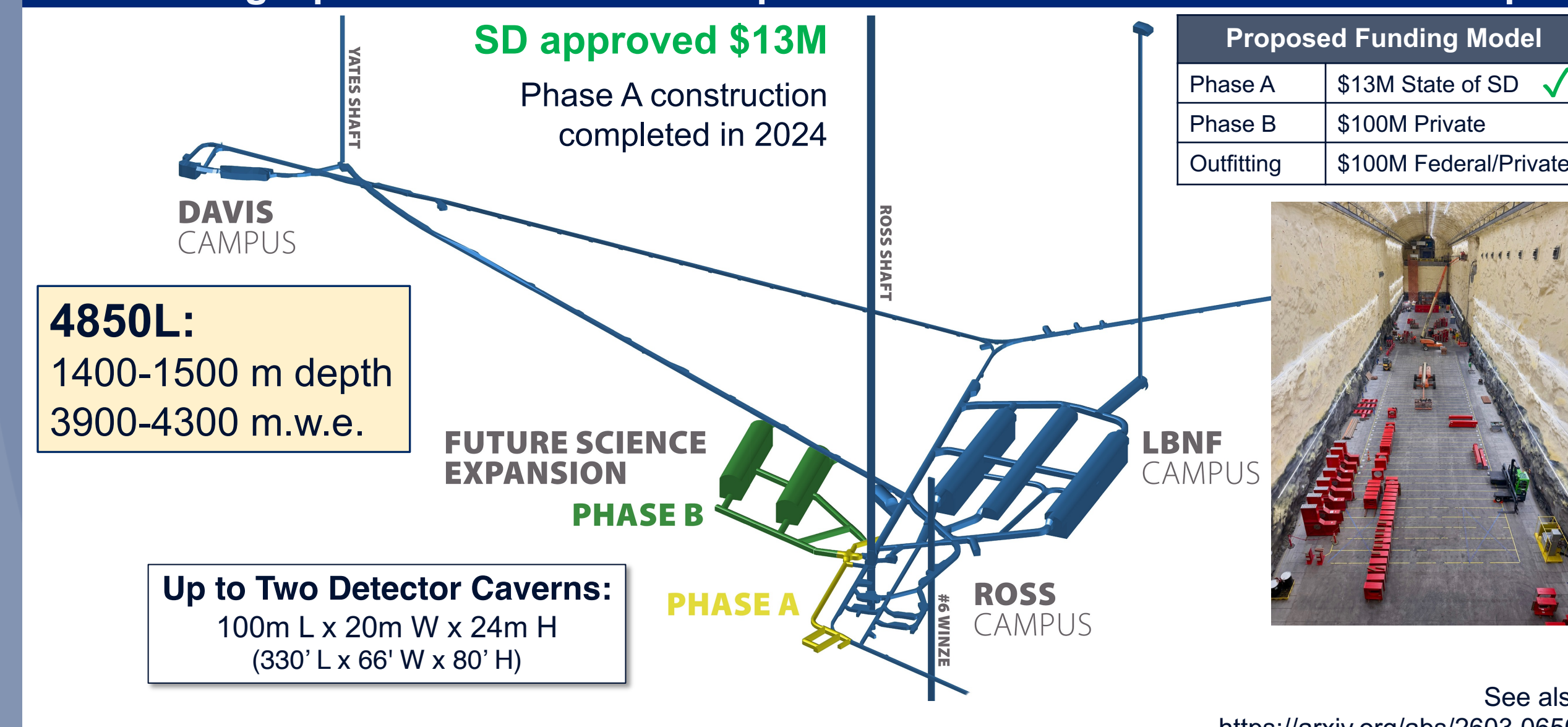
Neutrinos, Dark Matter, and Astrophysics

Partnerships

Commercial, Technology,
Industrial, Workforce development

5. Deep Space Needed for Future Experiments

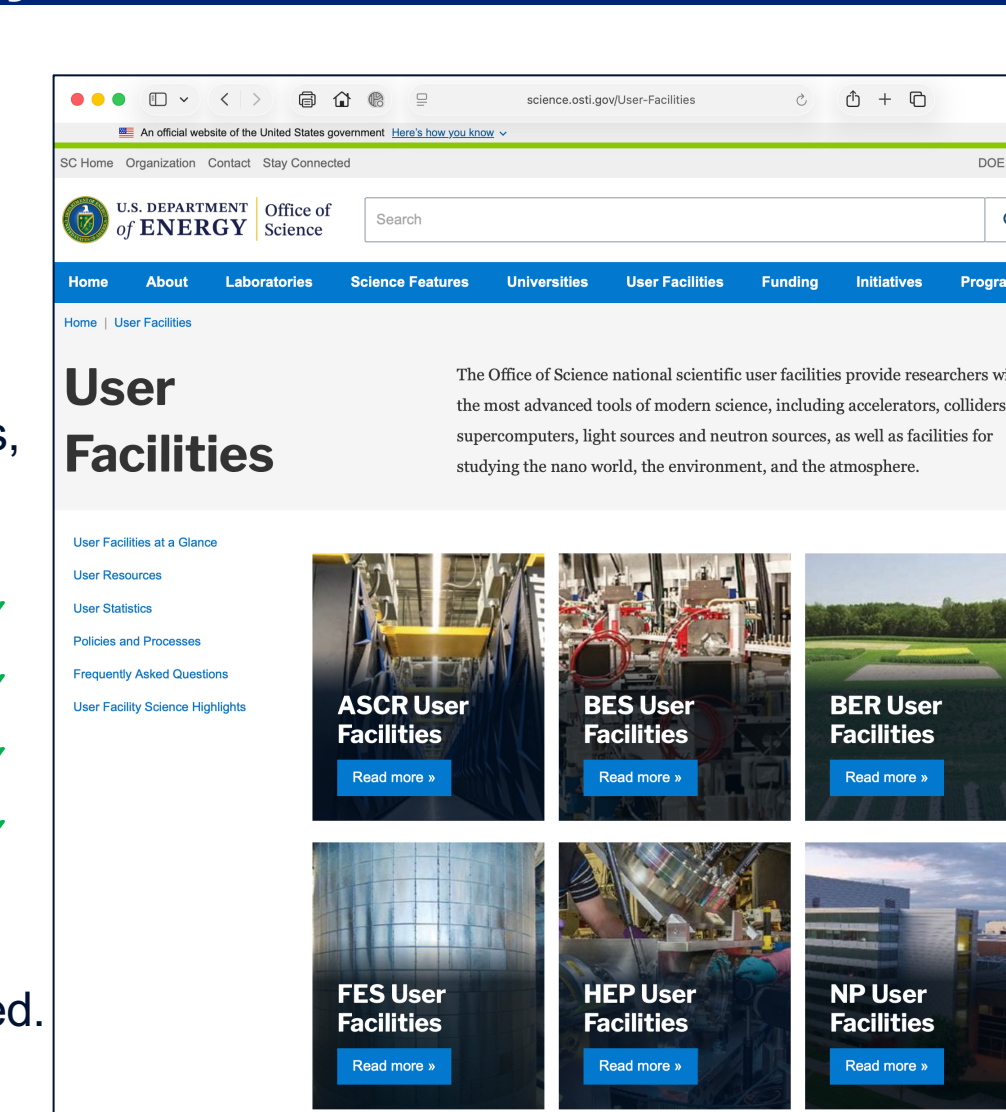
U.S. strategic plan endorsed SURF expansion for neutrino and dark matter expts



6. SURF Aspires to Become DOE User Facility

Important to have deep underground user facility in the U.S.

- Benefits**
- Expands DOE User Facility portfolio to incl underground lab, raises SURF's stature within DOE community.
 - Promotes underground science in U.S., increases SURF funding opportunities (FOAs encourage partnerships w/ User Facilities)
 - Enhances SURF's role in global science community.
 - Communicates SURF is open to a broad range of science and users, SURF processes for hosting science accepted by DOE.
- 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 + Science Program Advisory Committee established.
 - Significant maintenance for Yates Shaft completed March 2025.
 - Application draft near final, awaiting DOE invitation to submit.



7. SURF Quantum User Facility

Multi-user, low-background, ultra-low temperature test facility

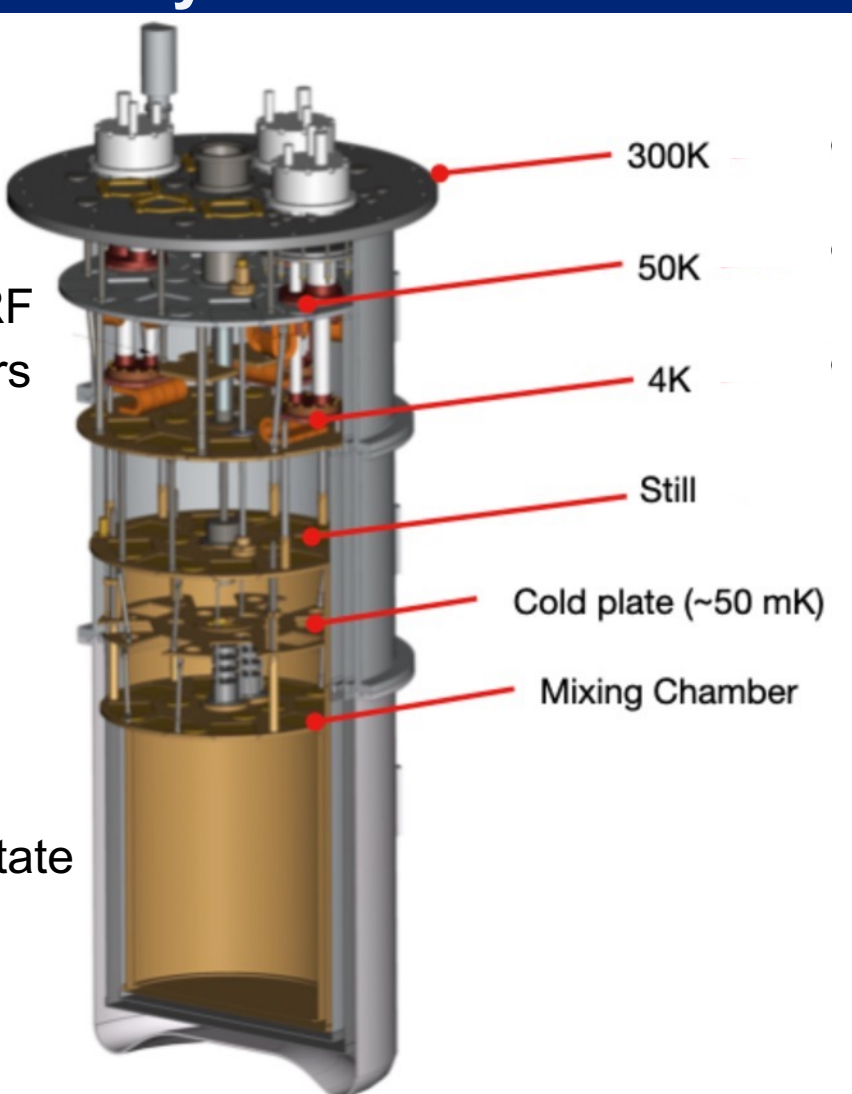
No **deep** underground cryogenic facility currently exists in the U.S.

Establish internationally-competitive research resources

- Detectors with extremely low energy thresholds and excellent energy resolution require isolation from ionizing radiation at deep facility like SURF
- Serve experiments using cryogenic calorimeters, quantum phonon sensors for applications in particle astrophysics, incl dark matter, $0\nu\beta\beta$, CEvNS
- Attract industry leaders in quantum computing (Google, IBM, D-Wave)
- Bolster \$3M investment in SD Center for Quantum Information Science & Technology

Planning underway

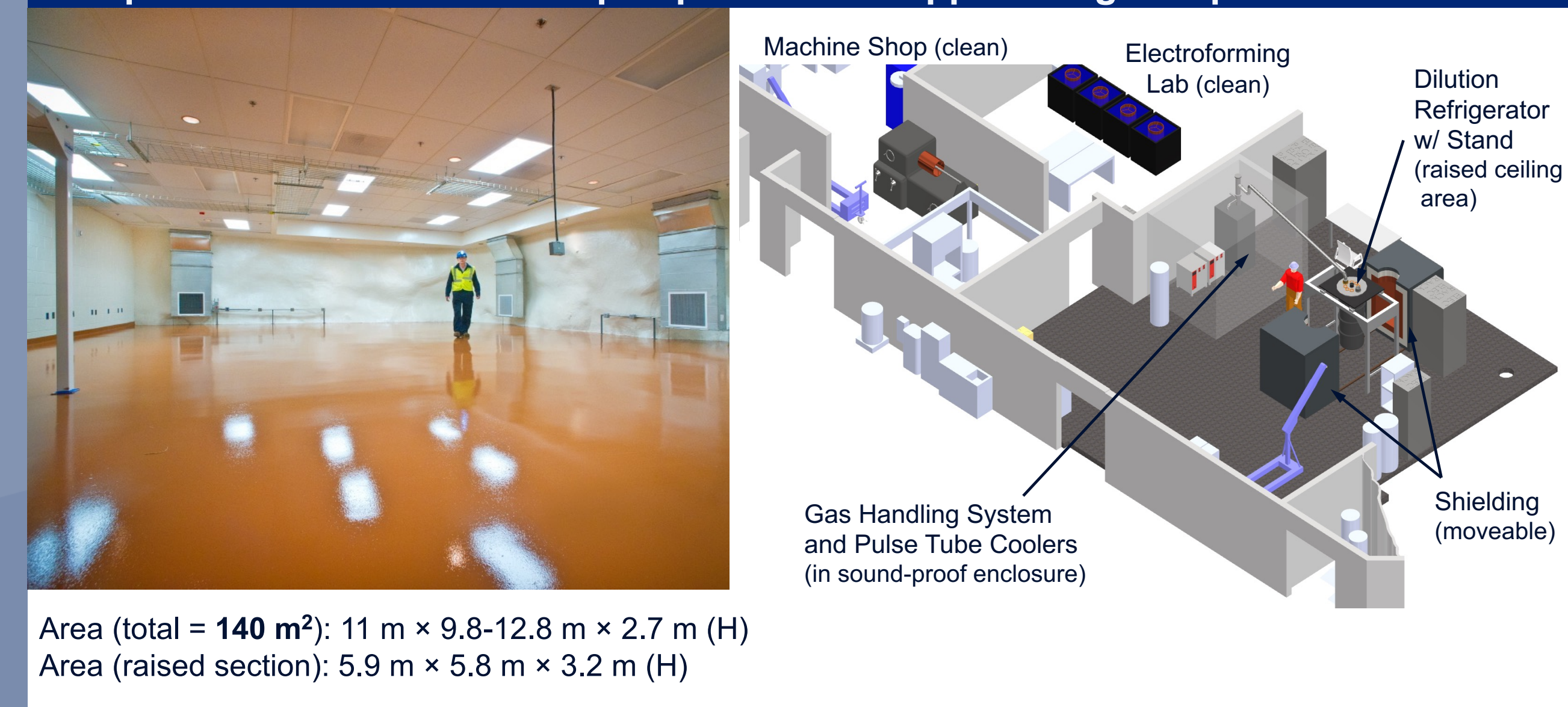
- Quantum Partnership Workshop (2026 event 3rd in series: <https://indico.sanfordlab.org/e/Quantum2026>) enhancing synergies with state QIS initiatives as well as broader interest in topics such as quantum communication networks
- Facility upgrades understood (mainly electrical, cooling)
- Cleanroom space available, also Pb shielding



Several options for commercial dilution refrigerator that would meet facility needs

8. SURF Quantum User Facility

Deep site at 4850L Davis Campus planned to support range of quantum science



9. SURF Vertical Facility

Unique facility would serve broad range of science communities

Science

- Atom interferometry using quantum sensors (ultralight dark matter, gravitational waves)
- Quantum communication network; also atmospheric cloud chamber, microgravity studies, isotope separation, etc

Community Interest

- Various workshops since 2008 to explore opportunities a SURF
- SURF joined TVLBAL collaboration in Oct 2025 (50+ institutions)

Expt Requirements (TVLBAL <https://arxiv.org/pdf/2503.21366>)

- 1.5-m diameter shaft (minimum), 15-cm diameter pipe for ultra-high vacuum
- Possibly separate pipes for separate applications

SURF Facility

- Initial shaft study completed March 2022
- Yates Shaft refurbishment in 2030s after related upgrades complete (electrical, incl hoists)
- Potential use of "Runabout" compartment 1.75m x 2.0m

