

Sanford Underground Research Facility Joint Appropriations Committee Update

Mike Headley
Executive Director
SD Science and Technology Authority

January 2016



SD FY2017 Major Goals

- Support safe underground access and operation of the current experiments deployed underground
 - LUX Dark Matter experiment and MAJORANA Demonstrator Neutrino experiment
- Advance the Ross Shaft Rehabilitation Project to the 4850 foot level
- Complete the installation and commissioning of new experiment systems on 4850 foot level (CASPAR accelerator and the BHSU Underground Campus)
- Complete the final facility designs and begin construction for the LUX-ZEPLIN (LZ) Generation 2 Dark Matter experiment. Acquire xenon for LZ.
- Advance final facility designs for the Long-Baseline Neutrino Facility (LBNF) experiment facilities planned for South Dakota and begin early construction
- Continue to support strong partnerships with the South Dakota Universities, American Indian Tribes, and State and Federal Agencies, Industry Partners

Budget Highlights

SDSTA budget outlined on pages 11-15 of FY17 Budget Briefing

- FY16 to FY17 budget changes
 - Overall budget reduction of \$6.75M and 32.3 FTE
 - Ross Shaft refurbishment transitioning from state funding to Department of Energy (DOE) funding. Salary reduction of \$2,844,783 and 32.3 FTE.
 - Decrease of operating expenses of \$3,904,653 due to Ross Shaft transition to DOE funds and completion of various construction projects
 - New Ross Shaft refurbishment contract in place between Lawrence Berkeley National Lab and SDSTA in January 2016
- SDSTA workforce
 - 128 full time staff, 16 part time staff
 - No major changes in SDSTA staffing anticipated

Budget Highlights

Ross Shaft Refurbishment Update

Surface	Schedule
Tramway	
300 L	
800 L	
1250 L	Q1 CY2014
1400 L	
1550 L	
1700 L	
1850 L	
2000 L	
2150 L	
2300 L	Q1 CY2015
2450 L	
2600 L	
2750 L	
2900 L	
3050 L	
3200 L	
3350 L	Q1 CY2016
3500 L	
3650 L	
3800 L	
3950 L	
4100 L	
4250 L	
4400 L	
4550 L	Q1 CY2017
4700 L	
4850 L	
5000 L	Mid CY2017

Completed

- Ross Shaft refurbishment required to support construction of the Long-Baseline Neutrino Facility (LBNF) Project
- Legislature appropriated \$3.95M last session (FY15 funds)
 - Funds expended from June 2015 through December 2015
 - 95.4% of funds spent in South Dakota on SDSTA labor, shaft steel fabrication, materials, and supplies
 - 427 vertical feet of the Ross Shaft was refurbished
 - 75 old steel sets were removed
 - 25 new steel sets installed equaling 267 tons of shaft steel
- Overall, the Ross Shaft has been refurbished to 3,383 feet from surface (66% completed)
- Ross Shaft refurbishment is on track for a 2017 completion and a transition to LBNF construction
- *SDSTA is grateful to the Legislature and Governor Daugaard for \$3.95M to bridge the project to DOE funding*

Ross Shaft Refurbishment Progress

Examples of old shaft steel



1 AM

Ross Shaft Refurbishment Progress

New steel recently installed



Current Underground Physics Program

MAJORANA DEMONSTRATOR (MJD):

Studying the neutrino's mass and the imbalance of matter/antimatter in the universe. First module (29 detectors) installed in the lead/copper shield. Module 2 detector strings being assembled. Physics data expected 2016.

Large Underground Xenon (LUX):

Direct detection of dark matter. 300-day data run to complete in mid-2016.

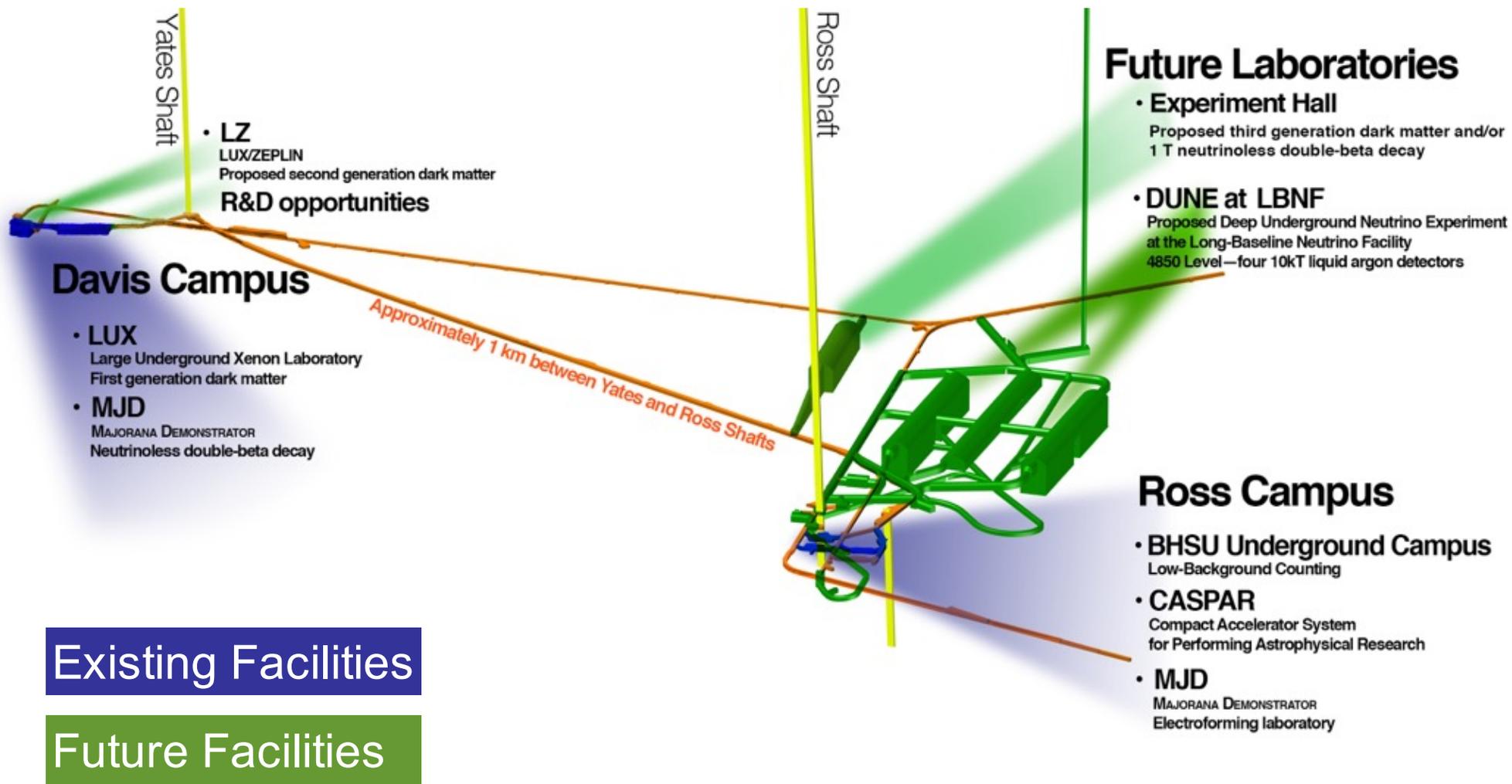


Compact Accelerator System for Performing Astrophysical Research (CASPAR):

Studying nuclear reactions in stars. Accelerator assembly in process. Operations in 2016.

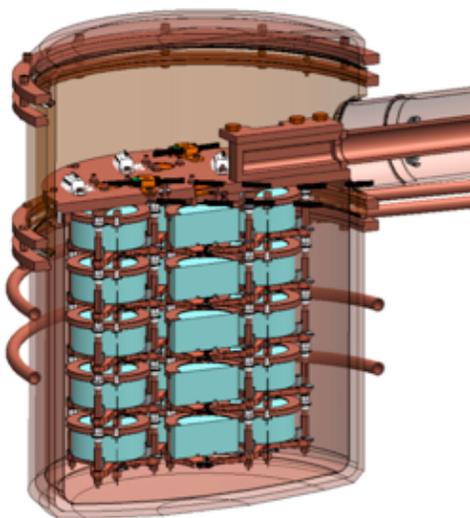
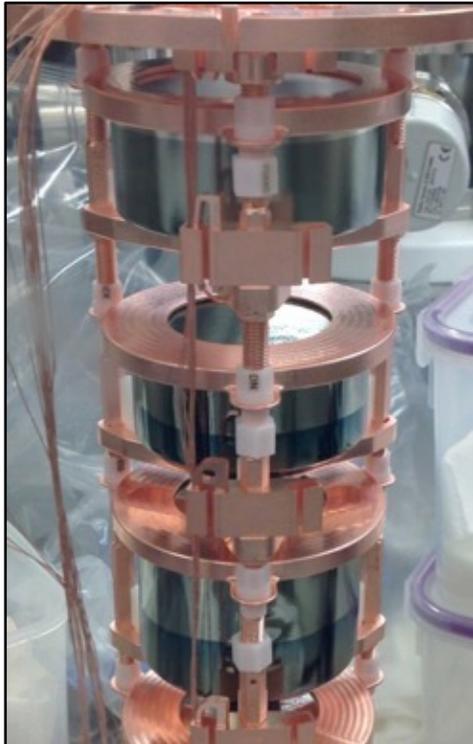
Black Hills State Univ. Underground Campus:
Low Background Assay and Measurement
Installing / commissioning Low Background Counters

4850L Science Facilities



MAJORANA Shield and Detector Assembly

2 detector modules planned. 40kg total enriched Ge^{76}



Module 1 Final Assembly



Module 1 Integration with Pb/Cu Shield

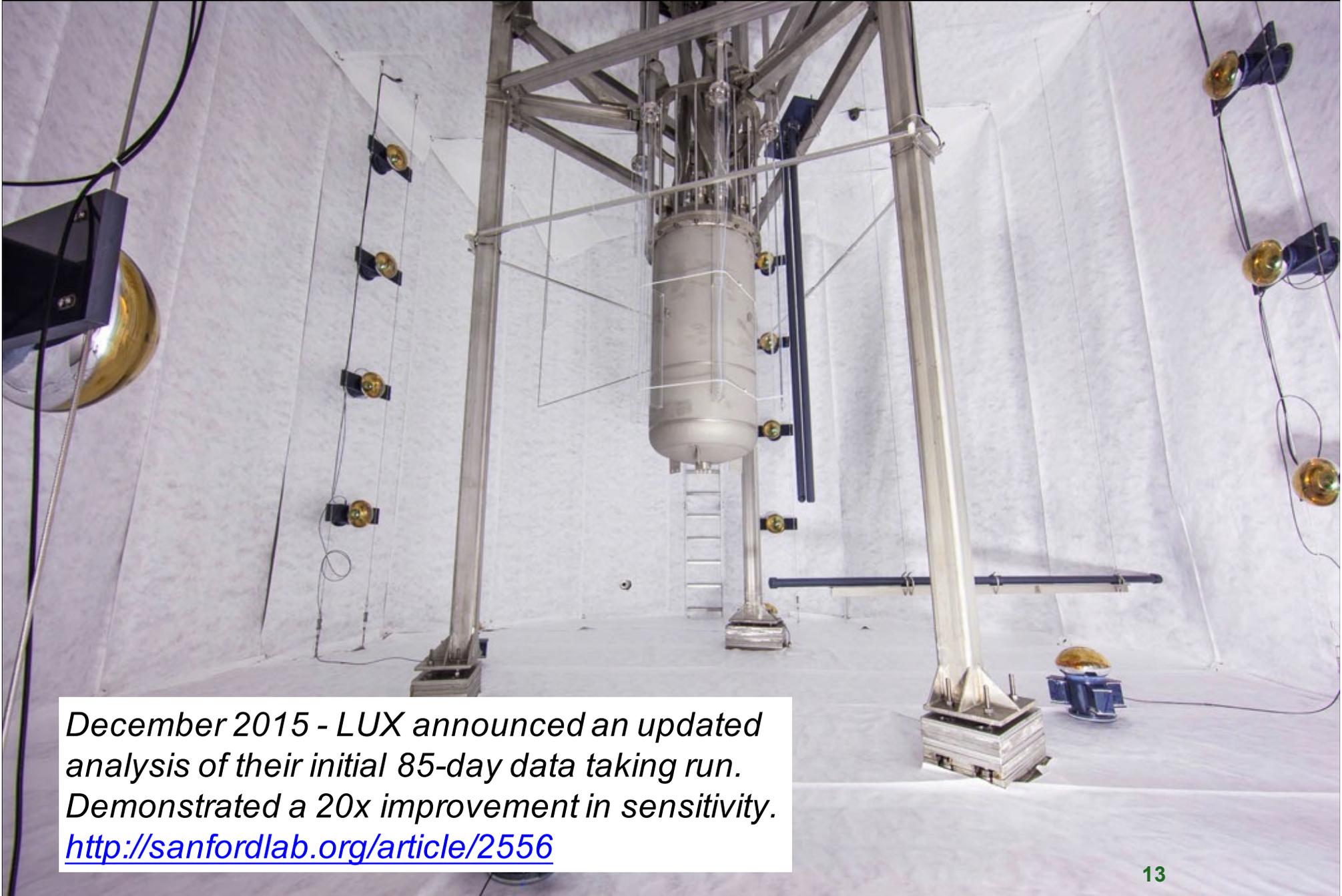


Module 1 installed in the Shield



LUX Detector Deployed in Water Shield Tank

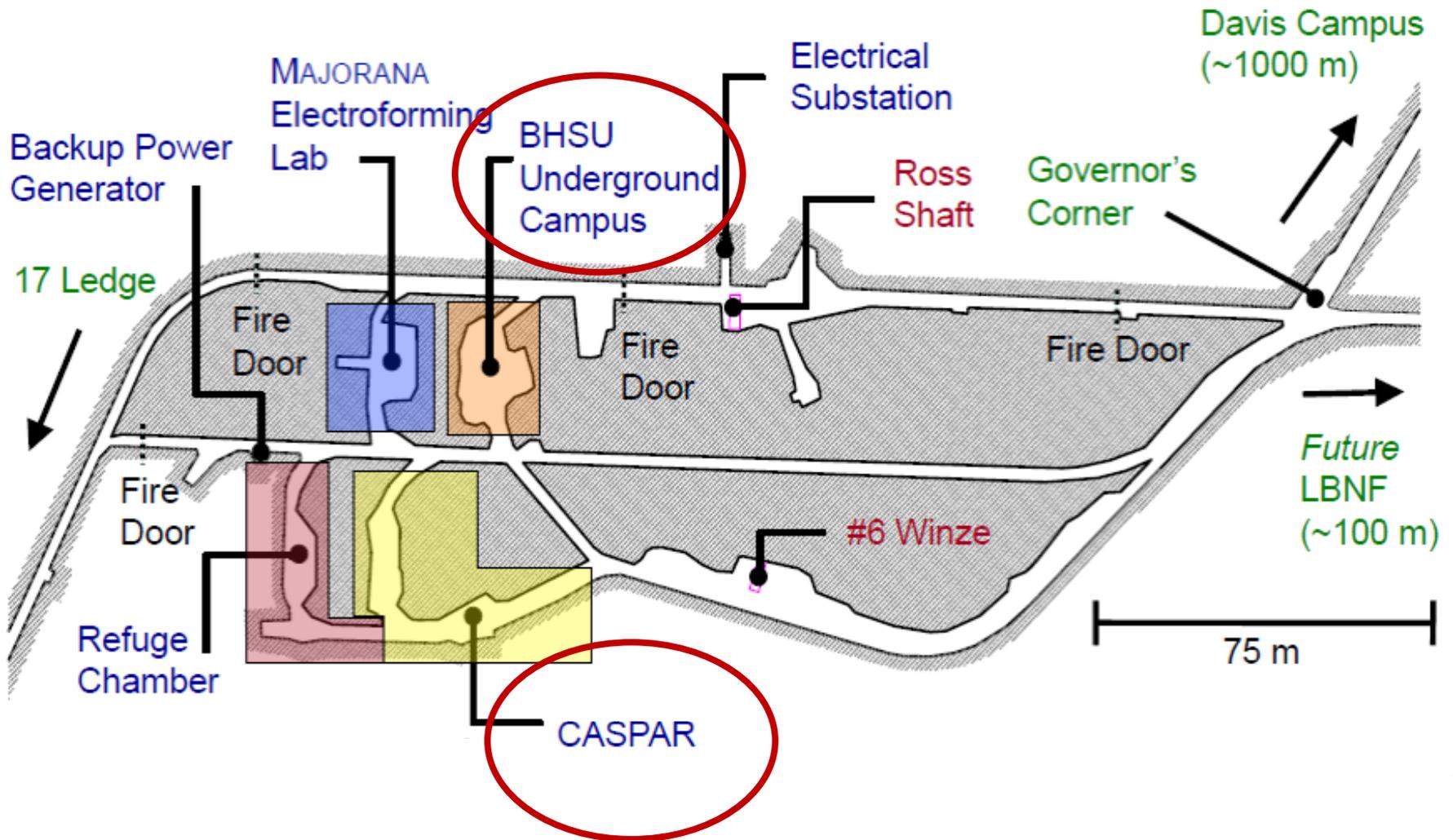
300 day live data taking run to conclude mid-2016



December 2015 - LUX announced an updated analysis of their initial 85-day data taking run. Demonstrated a 20x improvement in sensitivity.
<http://sanfordlab.org/article/2556>

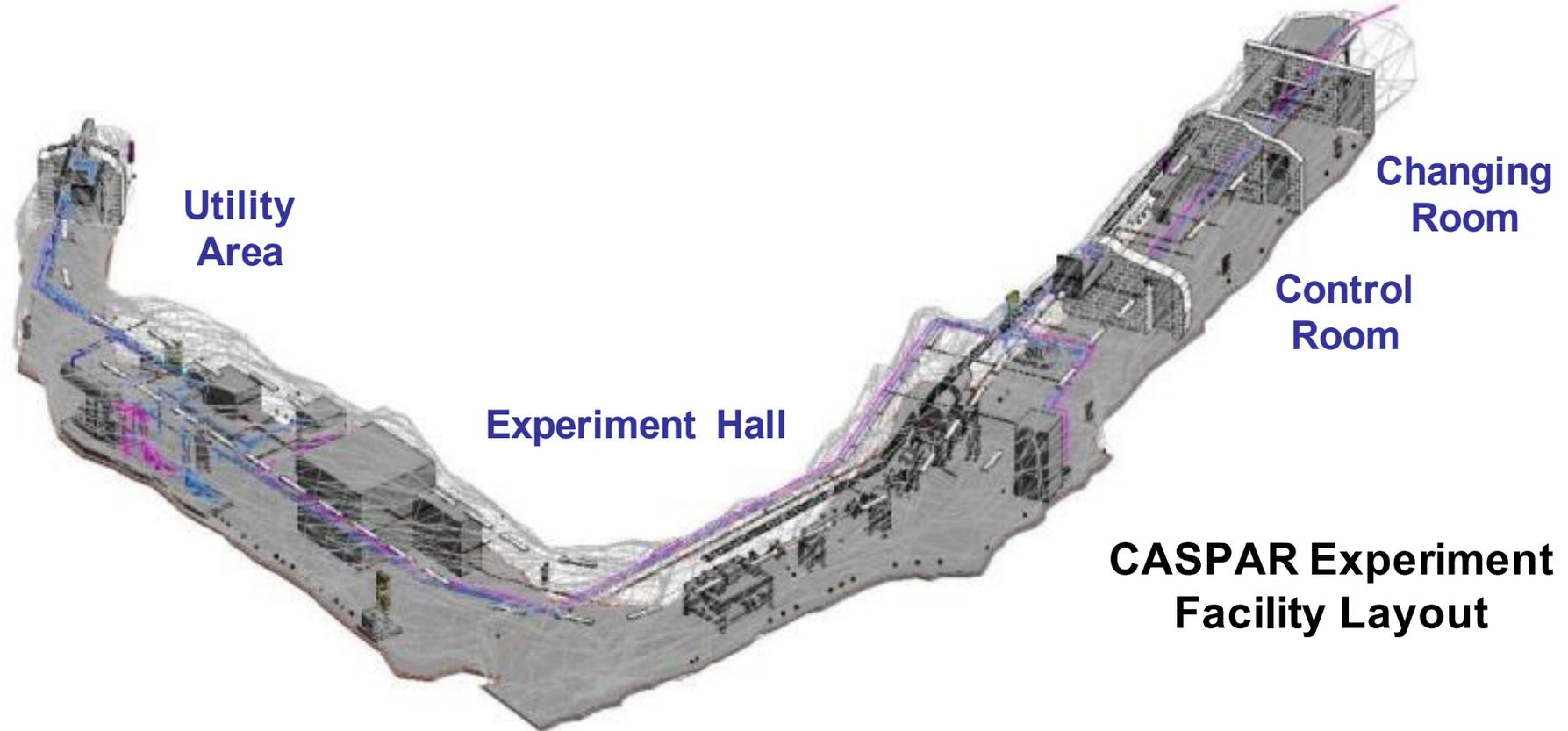
4850L Ross Campus

Two new laboratory facilities were completed August 2015



CASPAR Experiment Facility Completed

Compact Accelerator System for Performing Astrophysical Research



CASPAR Experiment Facility Layout

- CASPAR is a low-powered accelerator that replicates nuclear reactions in stars at the end of their life. These processes generate ~50% of elements on periodic table
- Collaboration includes SDSM&T, Univ. of Notre Dame, CO School of Mines
- CASPAR will operate 10+ years. SDSM&T will lead CASPAR operations.
- Facility construction completed and experiment installation began in August 2015
- Accelerator operations planned for mid-2016

CASPAR Experiment Hall

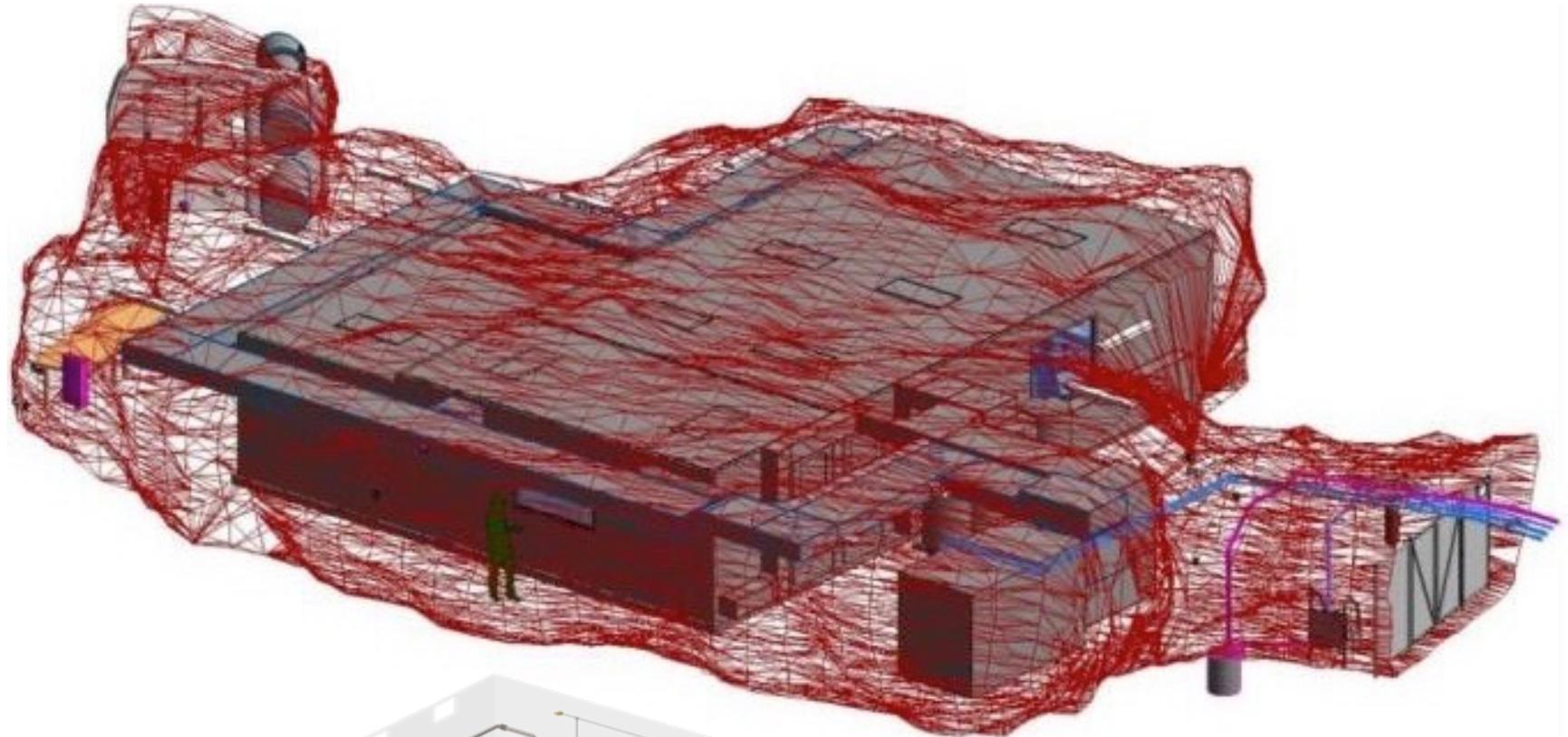


CASPAR Accelerator



BHSU Underground Campus (BHUC)

Building a national-level capability for low-background counting



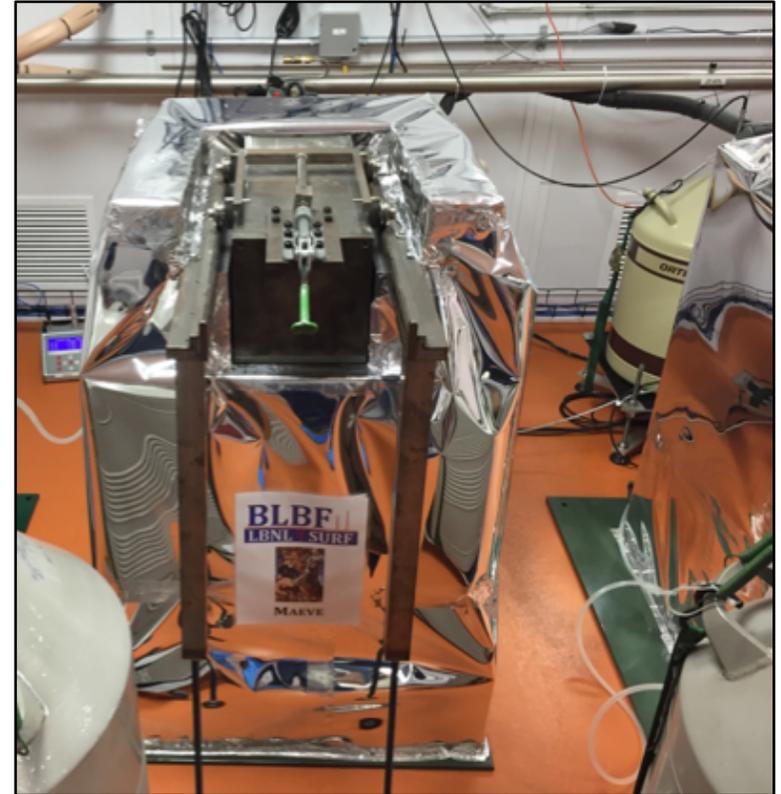
Class 1000 clean room: 20' x 30'
Room for 9 low background counting detectors

Class 10,000 clean room: 20' x 10'
Biology, Geology, and education and outreach
including university-level student experiences

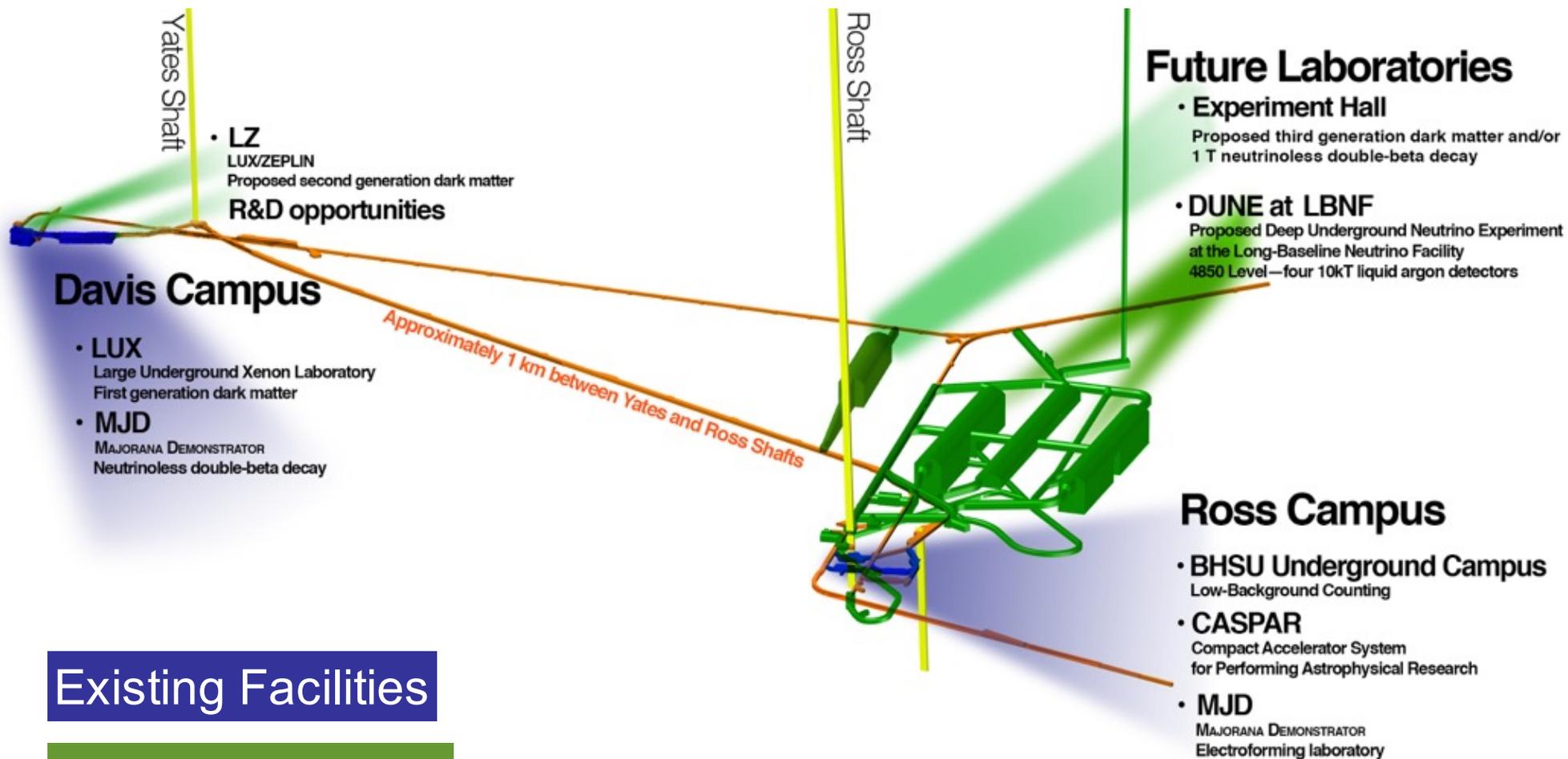
BHUC Cleanroom Entrance



Low Background Counter Installation



4850L Science Facilities

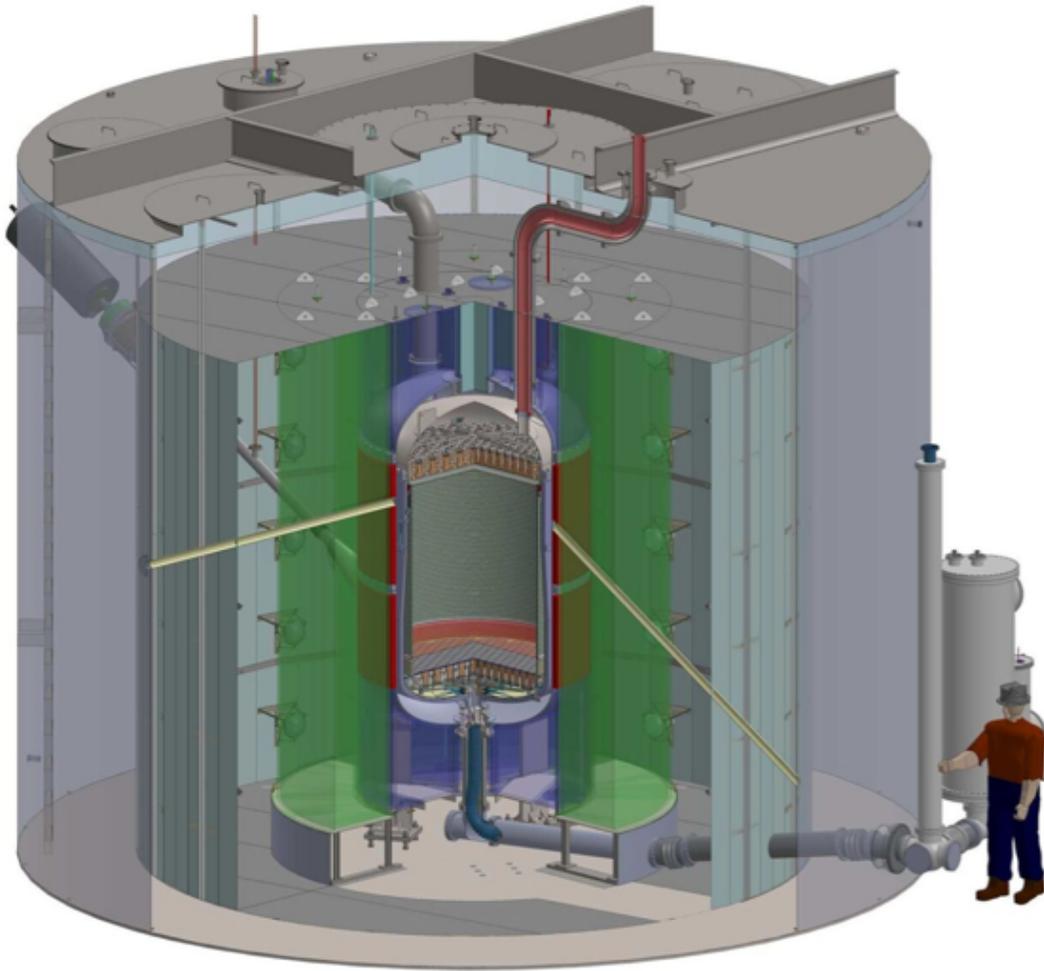


Existing Facilities

Future Facilities

LUX-ZEPLIN (LZ) Dark Matter Experiment

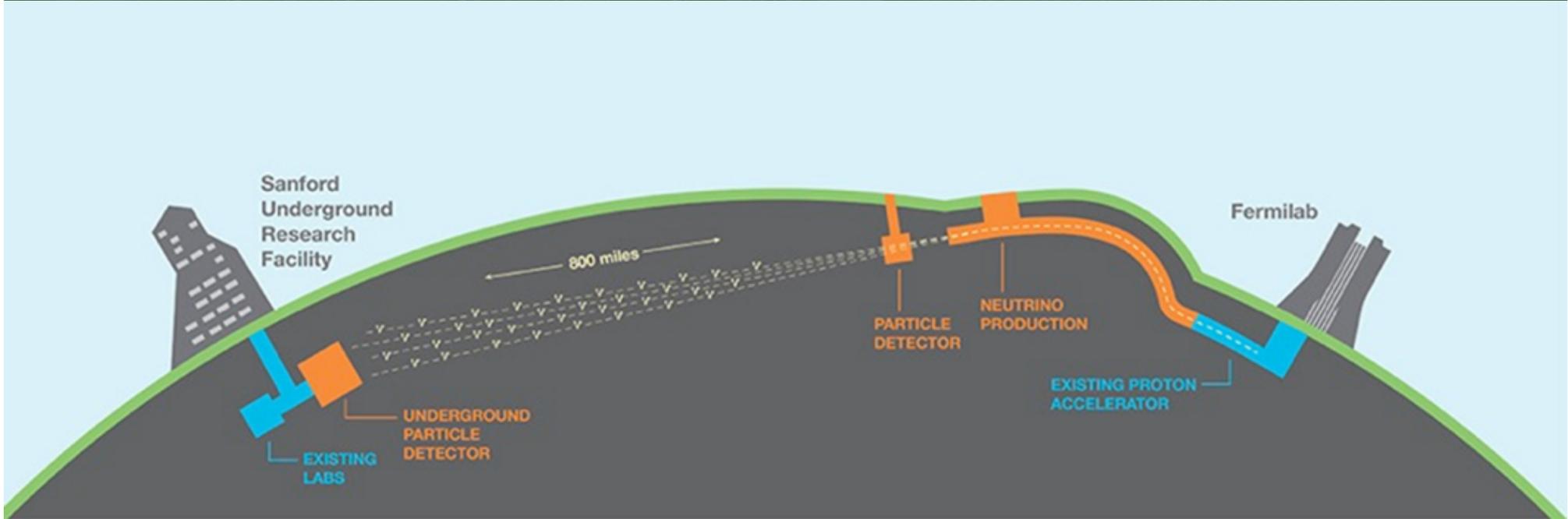
LZ will be located in the Davis Cavern on the 4850 foot level



LZ Detector and Shielding

- 30x larger mass than the LUX experiment. 100x more sensitive.
- LBNL leading experiment design and development
- SDSTA to refurbish the existing Surface Laboratory and Davis Campus to host LZ
- Experiment and facility design work currently underway
- DOE “baseline” review planned for April 26-28, 2016
- Facility modifications to occur in 2016 (surface) and 2017 (4850L)
- Experiment installation underground planned for 2018
- 5 years of operations envisioned

Long-Baseline Neutrino Facility (LBNF) and the Deep Underground Neutrino Experiment (DUNE)



- LBNF: provides facilities at two locations to support DUNE
 - Near Site: Fermilab, Batavia, IL – facilities to create a neutrino beam
 - Far Site: Sanford Underground Research Facility, Lead, SD – facilities to support DUNE detectors
- DUNE: large liquid argon detectors to study neutrino oscillations
 - Near and Far Site neutrino detectors: U.S. as partner in international project
 - DUNE Collaboration includes 144 institutions world-wide and ~800 collaborators

International Particle Physics Community Convergence

- **2013: European Strategy for Particle Physics updated**

- Endorsed high priority of neutrino physics
- Bottom line: CERN should help the European neutrino community participate in a long-baseline program ***outside of Europe***



Building for Discovery

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

Report of the Particle
Physics Project
Prioritization Panel (P5)

- **2014: “P5” Plan**

- A strategic plan for U.S. particle physics maximizing opportunities for breakthrough science
- Explicit prioritization, hard choices made within realistic budget scenarios
- Particle physics community unified behind the plan: 2,331 signatures on letter sent to DOE Secretary Moniz

International Particle Physics Community Convergence

2015: New DOE-CERN-NSF partnership agreement is signed

Allows CERN to support science initiatives **outside of Europe** for first time in 60 year history



“A model for the kinds of international scientific collaborations that can enable breakthrough insights and innovations.” **John Holdren, President’s Science Advisor**



“This agreement is also historic since it formalizes CERN’s participation in U.S.-based programs such as prospective future neutrino facilities for the first time.” **Rolf Heuer Director General, CERN**

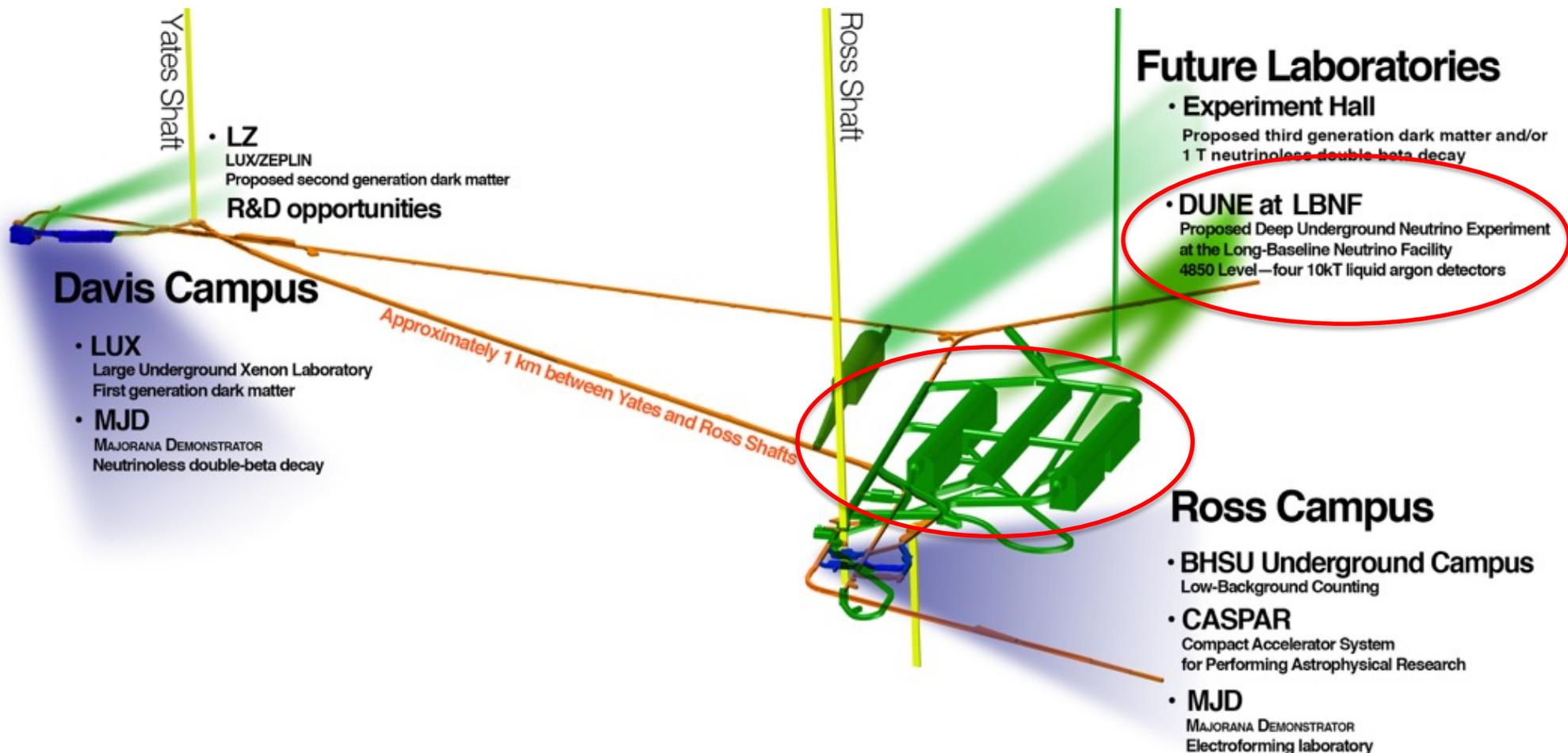
LBNF / DUNE Progressing Quickly

“This project will be the first time the U.S. has hosted a truly international mega-science project on U.S. Soil” ... DOE Office of Science Director

- Fermilab leading LBNF/DUNE. Partnerships with CERN & South Dakota
- DUNE Collaboration formed in January 2015. International science community response impressive: 144 institutions and 800 collaborators
- Facility preliminary designs for the SD facilities completed in August 2015
- DOE approved the Project’s conceptual designs in November 2015
- DOE review held in December 2015 to evaluate Project’s facility designs and readiness for early construction activities at the Far Site in SD
- DOE currently considering LBNF’s readiness for early construction activities
- If DOE construction approval received, early construction could begin in 2017
- DOE’s FY16 appropriation included \$26M to advance LBNF/DUNE designs

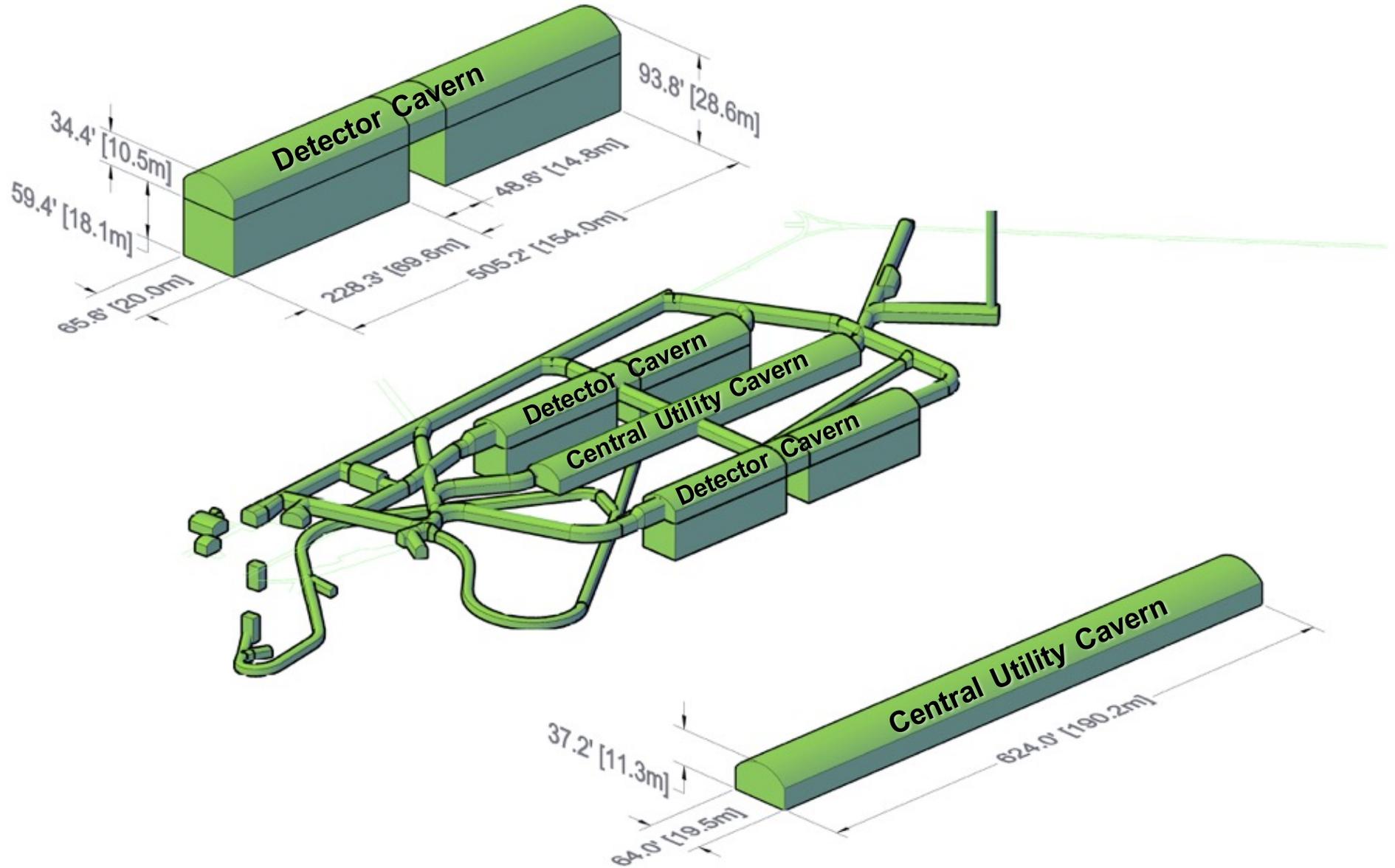
LBNF 4850L Facilities Design

Four 10kt detector pits, central utility cavern, and connecting drifts

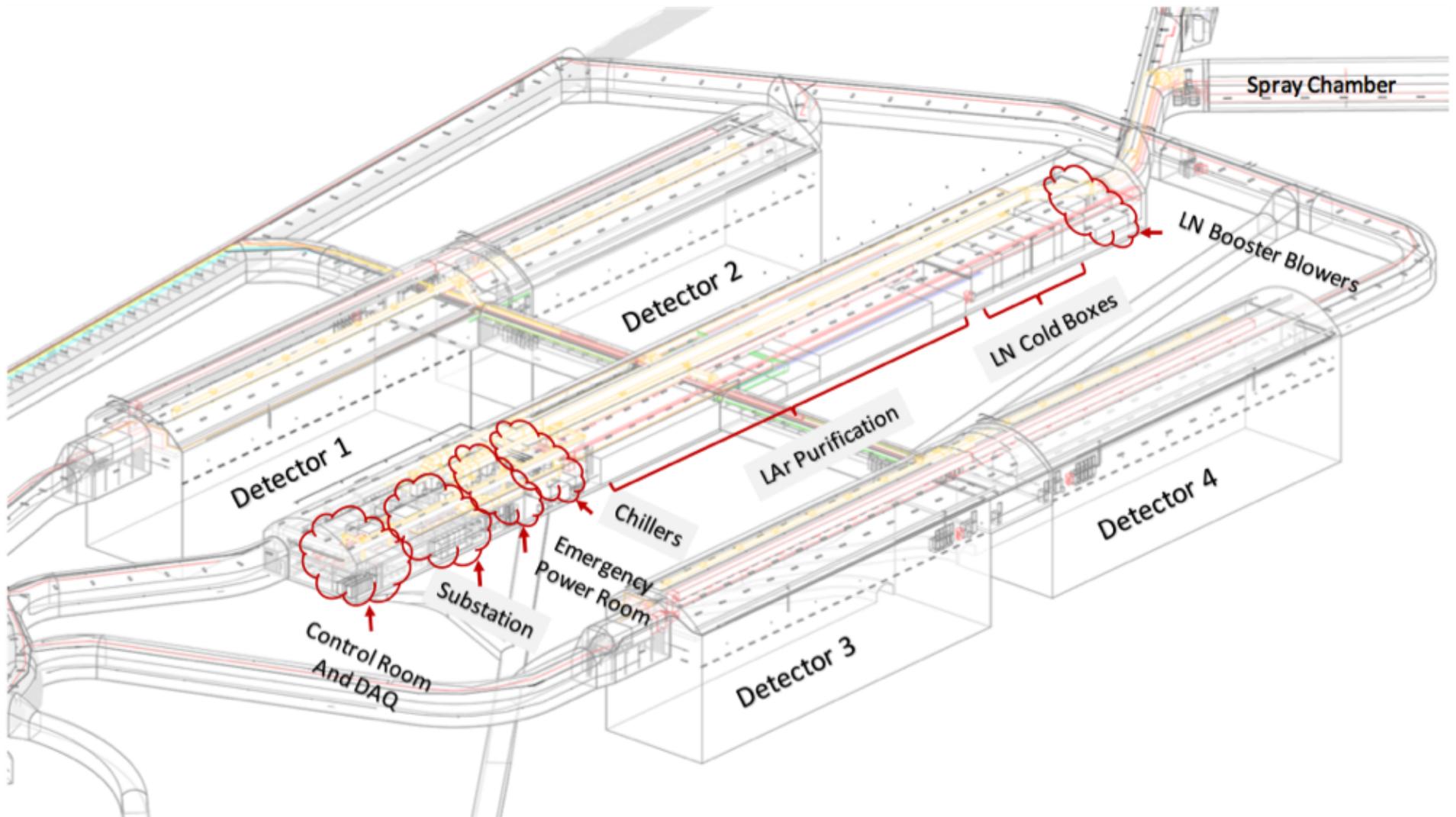


LBNF Excavations Planned for Sanford Lab

Excavated material ~800,000 tons

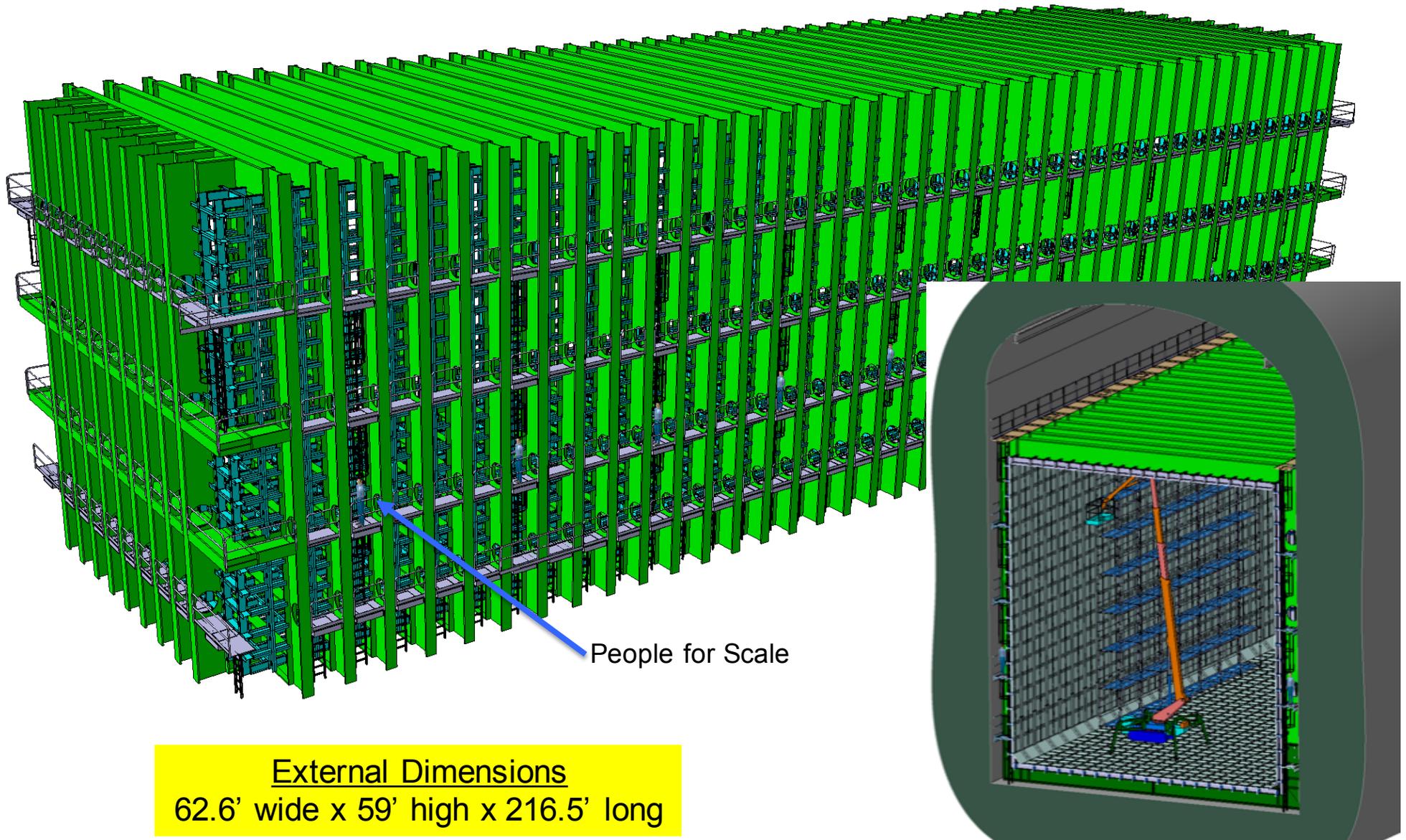


LBNF Facilities



LBNF Free-Standing Steel Cryostat

CERN leading Cryostat design and development



External Dimensions
62.6' wide x 59' high x 216.5' long

Economic Impacts in South Dakota

As of January 2016

Spending in South Dakota to date	\$170 million
Annual total budget (all sources & activities)	\$22.4 million
Annual SURF operations budget (DOE funds) (includes Berkeley and South Dakota activities)	\$15 million
Annual payroll in SD	\$12.9 million
Annual non-payroll expenses in SD	\$6.6 million
Jobs in South Dakota	165
Active research groups	21
Research groups with SD members	17



Education and Outreach Impacts

2008 through 2015

**K-12 students
participating
in programs** **15,451**

**Teachers
participating in
programs** **2,697**

**General public
attending programs** **19,210+**



Funding Commitments as of January 2016

State Appropriated Funding*

2004	\$14.3M
2005	\$19.9M
2010	\$5.4M
2014	\$2.0M
2015	\$3.9M
Total	\$45.5M

*\$12M in restricted accounts

Other Funding

T. Denny Sanford	\$70.0M
HUD Grant	\$10.0M
NSF	\$81.4M
DOE	\$79.5M
LBNF (THROUGH FY16)	\$15.0M
Interest earnings	\$13.7M
Total	\$269.6M

Experiments

LUX	\$5.0M (+ \$650k/yr ops)
MAJORANA	\$25.3M (+ \$2M/yr ops)
LBNF	\$107.6M (Ops TBD)

DOE Operations Funding Ongoing Today

Funds work at Lawrence Berkeley National Lab and Sanford Lab

- Federal FY2012* - \$11M (SDSTA allocation \$9.3M)
 - Federal FY2013 - \$14M (SDSTA allocation \$12.97M)
 - Federal FY2014 - \$15M (SDSTA allocation \$13.4M)
 - Federal FY2015 - \$15M (SDSTA allocation \$13.5M)
 - Federal FY2016 - \$15M (SDSTA allocation \$13.9M)
-
- DOE funded operations oversight transitioning from Lawrence Berkeley National Laboratory to Fermilab by October 1, 2016
-
- * FY2012 was a transition year from NSF to DOE operations funds. NSF funded first four months due to a continuing resolution.

SD University Involvement Highlights

	<p>BHSU</p>	<ul style="list-style-type: none"> • Joint Sanford Science Education Center with SDSTA. Remodel of the Jonas Science Hall was completed in October 2015. • BHSU leads Sanford Lab education and outreach activities. • Joint development and operation of the BHSU Underground Campus on 4850L.
	<p>DSU</p>	<ul style="list-style-type: none"> • DSU supports Sanford Lab information technology security program. • DSU leads <i>Center for Theoretical Underground Physics and Related Areas</i> (CETUP) conference. (2016 program will be the 6th year held. Over 200 participants and many publications).
	<p>SDSM&T</p>	<ul style="list-style-type: none"> • SDSM&T and USD are lead SD institutions for physics PhD program. • SDSM&T has 19 physics PhD students. 13 involved in SURF projects. • 12 faculty members in Physics Department. 6 of them working on SURF projects (DUNE, CASPAR, LUX, LZ and MAJORANA DEMONSTRATOR). • SDSM&T faculty in leadership roles for DUNE, CASPAR, LZ and MAJORANA. • In May 2015, SDSM&T held first science conference on <i>Science at the Sanford Underground Research Facility</i>. • SDSM&T has 3 Master Students (2 involved with SURF projects), also 16 undergraduate students are involved in SURF related research projects.
	<p>SDSU</p>	<ul style="list-style-type: none"> • Discussions underway between DUNE leadership and SDSU on research to test DUNE detector electronics to function in very cold environments and on modeling of liquid argon behavior and purity in the DUNE detector.
	<p>USD</p>	<ul style="list-style-type: none"> • USD and SDSM&T are lead SD institutions for physics PhD program. • USD has 3 scientists involved in SURF projects. • SDSTA scientist enrolled in PhD program at USD. • USD leads CUBED collaboration with scientists on site at Sanford Lab.

New Sanford Lab Homestake Visitor Center Open

Located at the Open Cut in Lead, SD



Visitor Center Grand Opening

June 30, 2015 – Over 700 people in attendance



Visitor Center Exhibits

Attracted over 34,000 people in first four months of operation



Celebrated 50 years of science in 2015



- 2015 Neutrino Day attracted 1,800 people. A record setting event – even with road construction in Lead and Deadwood.
- Dedicated tribute “Davis Ring” to honor Dr. Ray Davis’ work at Homestake in August



The Governor Studying 3D Underground Model



Recent “Deep Talk” at Visitor Center

Dr. Jaret Heise describing work on the Nobel Prize-Winning “SNO” experiment



New Strategic Plan Released



- Released December 2015
- 5 year plan based on 10 year vision
- Developed with input from National Laboratories, science experiments, SDSTA staff and Board of Directors
- Major Focus Areas
 - Infrastructure
 - Science Support
 - Environment, Safety & Health
 - Education & Outreach
 - Communications
 - Organizational Capacity
 - Business Model
- Hardcopies mailed to all Legislators

Available at: http://www.sanfordlab.org/sites/sanfordlab.org/files/docs/SDSTA/Foward_Momentum.pdf



Thank You!

E&O Update: Piloting New STEM Curriculum Modules Based on the Science of the Sanford Lab

<u>Grade Band</u>	<u>Title</u>	<u>Synopsis</u>
3-5	May the Force Be With You	Students explore magnets and magnetic forces, and rotational and linear motion induced by magnets.
	Exploring the Unseen	Students gather and use indirect evidence to reason about things too small to see, too remote to reach and otherwise difficult to detect.
6-8	Monster Waves	Students explore wave properties, how energy is transferred through waves and how waves moving through media give information which can be used for a variety of purposes.
	What's the 'Matter' with the Big Bang	Students explore matter and interactions through a variety of activities focusing on the very big (galaxies) and the very small (neutrinos and other subatomic particles).
9-12	Perplexing Puddles	This unit, designed for high school biology classes, highlights a NASA-funded research project at Sanford Lab called 'Life Underground'.
	'We are Made of Star-stuff'	This unit, designed for high school chemistry classes, uses nucleosynthesis in the cosmos to introduce the structure of matter, the periodic table and nuclear processes.

Federal Funding FY2016

Federal Contract / Project	Total \$\$
LBNL / SURF Operations	\$13,984,422
LBNL / Ross Rehabilitation	\$4,776,815
FNAL / Long Baseline Neutrino Facility	\$2,258,001
LBNL / LUX	\$119,305
LBNL / LZ	\$323,621
Total	\$21,732,163

- Total does not include LBNF Final Design contracts that are expected in January, \$3.6M.

Federal Funding FY2016

Funding Source	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Grand Total
DOE Operations													
Planned Budget	\$ 1,139,482	\$ 1,151,866	\$ 1,338,364	\$ 1,165,695	\$ 1,164,070	\$ 1,219,124	\$ 1,148,200	\$ 1,191,263	\$ 1,121,097	\$ 1,086,303	\$ 1,146,287	\$ 1,112,671	\$ 13,984,422
FTEs	76.55	76.55	76.55	77.55	77.55	77.55	77.55	77.55	77.55	77.55	77.55	77.55	
Ross Rehab - LBNL													
Proposed Budget				\$ 495,342	\$ 495,342	\$ 515,948	\$ 495,986	\$ 506,251	\$ 508,105	\$ 498,326	\$ 518,625	\$ 508,995	\$ 4,542,918
FTEs				28.90	28.90	28.90	28.90	28.90	28.90	28.90	28.90	28.90	
LBNF Support													
Planned Budget	\$ 683,067	\$ 638,748	\$ 726,287	\$ 50,648	\$ 51,950	\$ 55,262	\$ 51,950	\$ 53,501	\$ 54,751	\$ 51,223	\$ 57,084	\$ 53,530	\$ 2,528,001
FTEs	2.40	2.40	7.30	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	
LUX													
Planned Budget	\$ 9,742	\$ 9,652	\$ 9,832	\$ 9,652	\$ 12,152	\$ 9,832	\$ 9,652	\$ 9,742	\$ 9,742	\$ 9,652	\$ 9,874	\$ 9,782	\$ 119,305
FTEs	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
LZ													
Planned Budget	\$ 17,780	\$ 16,973	\$ 23,748	\$ 24,760	\$ 26,510	\$ 27,116	\$ 49,760	\$ 25,939	\$ 32,439	\$ 24,814	\$ 27,487	\$ 26,294	\$ 323,621
FTEs	1.25	1.25	1.65	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	
MJD													
Planned Budget	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 2,500	\$ 30,000
FTEs	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	