

Dear SURF Readers,

Welcome to the February 2016 Sanford Underground Research Facility (SURF) monthly newsletter. The newsletter is posted online; a pdf copy is available as well. You can read recent and archived newsletters at our website -- www.sanfordlab.org. We are glad to receive your input on news, links to news articles, upcoming workshops, conference notices, scientific updates, information concerning SURF, employment opportunities, and other highlights relevant to underground science.

Important Dates

March 2-3: LZ Infrastructure Reviews – Lead, South Dakota
April 26-28: LZ CD-2/3b Independent Project Review – LBNL, Berkeley

CAPTAIN

The Cryogenic Apparatus for Precision Tests of Argon Interactions with Neutrinos (CAPTAIN) program endeavors to make measurements of importance to the Deep Underground Neutrino Experiment (DUNE). The program has two detectors that researchers plan to use to make these measurements. The Mini-CAPTAIN prototype detector is a 1000-channel liquid argon time-projection chamber (TPC) with a 400kg instrumented mass. The detector is currently undergoing commissioning at Los Alamos National Laboratory (LANL). The CAPTAIN detector is a five ton instrumented mass liquid argon TPC with 2000 channels, and is under construction at LANL.

The CAPTAIN program addresses important scientific questions associated with the long-baseline, atmospheric and supernova neutrino science of DUNE. Specifically, CAPTAIN will run at Fermilab in the NuMI beamline as part of the CAPTAIN MINERvA program to measure cross-sections and reaction topologies at few-GeV neutrino energy. Further, Mini-CAPTAIN will run in the high-energy neutron beam at LANL in order to measure the response of liquid argon TPC's to high-energy neutrons. This is crucial for understanding how to reconstruct few-GeV neutrino interactions. Finally, the CAPTAIN detector will be deployed near Fermilab's Booster Neutrino Beam (BNB) source in

an off-axis position to measure the low-energy charged-current electron-neutrino cross sections that are important for DUNE's supernova-neutrino detection capability.

In addition, the CAPTAIN detectors can test systems for DUNE including the laser calibration system and the use of photon detection to improve the reconstruction of events. Mini-CAPTAIN (Figure 1) is currently in the neutron beamline at the Los Alamos Neutron Science Center (LANSCE) and will be making crucial measurements of neutron interactions with liquid argon.

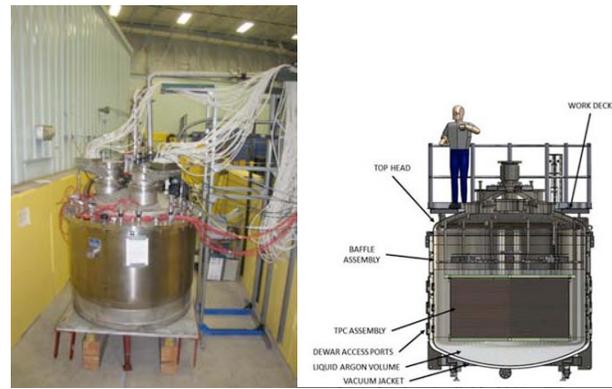


Figure 1: (Left) Mini-CAPTAIN detector deployed in the LANSCE neutron beam line in February 2016. (Right): The CAPTAIN detector (Images Courtesy: CAPTAIN collaboration)

The facility for the experiment, the Long-Baseline Neutrino Facility (LBNF) will consist of the world's highest-intensity neutrino beam from Fermilab and provide the infrastructure necessary to support massive, cryogenic *far detectors* installed deep underground at SURF, 800 miles away. LBNF will be responsible for the facilities to house the experiment's *near detectors* on the Fermilab site.

The CAPTAIN collaboration is a 70-member team from twenty different universities and laboratories. DUNE will be a dual-site experiment. CAPTAIN is supported by the Department of Energy through the LANL LDRD program and the Office of Science High Energy Physics, and the University of California Institute for Nuclear/Particle, Astrophysics and Cosmology.

Congratulations to LIGO

On February 11, the Laser Interferometer Gravitational-Wave Observatory (LIGO) Scientific

Collaboration announced that gravitational waves had been observed for the first time ever on September 14, 2015 by two LIGO detectors (Figure 2). See <https://lsc.ligo.org/events/GW150914/> for more details.

“This detection is the beginning of a new era. The field of gravitational wave astronomy is now a reality,” said Gabriela Gonzalez, spokesperson for the LIGO Scientific Collaboration (LSC), and Professor of Physics and Astronomy at Louisiana State University. The event confirms Albert Einstein’s general theory of relativity, first published in 1915.

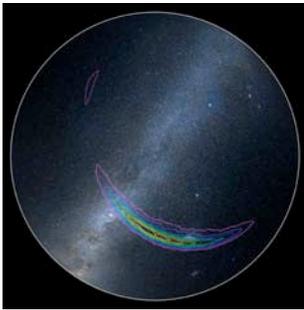


Figure 2: LIGO scientists believe the signal came from the Southern Hemisphere of the sky (Image Courtesy LIGO)



Figure 3: DUGL monitoring site on the 2000 Level at SURF

“This is a whole new way of looking at the universe,” said Vuk Mandic, Associate Professor of Physics and Astronomy at the University of Minnesota. Mandic has been involved with several LIGO-related projects, including the Deep Underground Gravity Laboratory (DUGL) at SURF. DUGL consists of 24 seismometer stations located on several levels of Sanford Lab and on the surface (Figure 3). Placed in a grid that probes approximately 1 cubic mile, the seismometers measure ground movement—to velocities less than a micron per second. Mandic said one goal of DUGL is to inform the design of the

next-generation interferometer gravitational wave detectors that are even more sensitive, deep underground.

The observation underscores the importance of the work being done by DUGL scientists at Sanford Lab. “We’ve been sharing LIGO’s journey since 2008,” said Jaret Heise, SURF Science Liaison Director. “I look forward to seeing how our partnership evolves as the scientific community peers further into the newly opened window to gravitational waves. LIGO’s results show us that nature is willing to share more of her secrets and, hopefully, the experiments at Sanford Lab are next on her list.”

LZ Directors Review

A "Director's Review" of the LZ Project organized by the LBNL Office of Project Management was conducted on February 9-11, chaired by Daniel Lehman (DOE retired). Other members of the review committee included Elaine McCluskey (FNAL), Robert McKeown (JLab), Jay Marx and Jim Tarpinian (PMAB), David MacFarlane and Pam Utley (SLAC), Mark Thomson (Univ. of Cambridge, UK), and from LBNL: Chris Bebek, Dan Dwyer, John Joseph, Matt Johnson, Daniela Leitner, Alan Poon, Dave Rodgers, Rick Larson, and Russ Wells. The thorough review will help prepare the LZ collaboration for a DOE CD-2/3b review scheduled for April 26-28 at LBNL.

REPORTS/PAPERS AVAILABLE

Forward Momentum 2025, a 5-year strategic plan based on a 10-year vision for SURF: www.sanfordlab.org/sites/sanfordlab.org/files/.../Forward_Momentum.pdf

All four volumes of the Deep Underground Neutrino Experiment (DUNE) for Conceptual Design Report DUNE/LBNF are now available on arXiv: Vol. 1. Overview 1601.05471, Vol. 2 Physics 1512.06148, Vol. 3 LBNF 1601.05823, Vol. 4 DUNE detector 1601.02984. <http://arxiv.org/>

[The Sanford Underground Research Facility at Homestake \(SURF\)](#). (K.T. Lesko, Phys.Procedia 61 (2015) 542-551.)

[P5 report \(Print quality\)](#) The full Particle Physics Project Prioritization Panel report as accepted by the High Energy Physics Advisory Committee

For news, *twitter* updates, and other features, see the SURF website: www.sanfordlab.org
Like Sanford Lab Visitor Center on Facebook: <https://www.facebook.com/sanfordlabhomestake/>



SURF IN THE NEWS

Scientific American: [Last Call: Will WIMPs Show Their Faces in the Latest Dark Matter Experiment](#) (Clara Moskowitz, February 1)

The Guardian: [Gravitational waves: breakthrough discovery after a century of expectation](#) (Tim Radford, February 15)

Symmetry: [Test of DUNE tech begins](#) (Lauren Biron, February 16)

[LIGO sees gravitational waves](#) (Lauren Biron, February 11)

[Neutrinos on a Seesaw](#) (Matthew Francis, February 9)

[A mile-deep campus](#) (Shannon Hall, January 28)

Christian Science Monitor: [No longer blind: Why that gravitational wave discovery is so heavy](#) (Calla Cofield, February 15)

SLAC: [Three Ways to Bust Ghostly Dark Matter](#) (Communications, February 8)

Forth Worth Star Telegram: [UT Arlington helping with \\$1 billion project to study ghostly particles](#) (Patrick Walker, February 13)

Duluth News Tribune: [Work winding down on 2 big experiments in Soudan mine](#) (Lisa Kaczke, February 13)

Rapid City Journal: [BHSU hosting conference for women in Physics](#) (Tom Griffith, January 16)

Black Hills Pioneer: [A whole new way to see the universe](#) (Constance Walter, February 15)

DURA News

To comment on DURA, please contact its chair Richard Gaitskell (Richard_Gaitskell@brown.edu). For Bio-Geo-Engineering matters, contact Bill Roggenthen (William.Roggenthen@sdsmt.edu).

For further information on DURA, see: <http://sanfordlab.org/dura>

SANFORD UNDERGROUND LABORATORY NEWS

Black Hills State Underground Campus

The Black Hills State University Underground Campus (BHUC) is now open for operation, with a class-1,000 cleanroom that houses ultra-sensitive low background counters that assay materials for sensitive physics experiments. Currently, two counters from U.C. Berkeley are in operation; another four more are expected to be installed this year. BHUC collaborators plan to eventually house their 10 counters from different collaborators, including LBNL, the University of South Dakota, Brown University, and BHSU. Most of the counters look for gamma rays, while others will be sensitive to surface alpha particles. One instrument proposed by the South Dakota School of Mines and Technology will look for beta-decay contaminants.



Figure 4: Dr. Brianna Mount and Black Hills State University undergraduate students Rachel Williams and Madison Jilek hold lead bricks used to shield low-background counters in the BHSU Underground Campus cleanroom

“Low background materials are vital to nearly all underground physics experiments,” said Brianna Mount, Research Assistant Professor at BHSU and Lab Director of the underground campus (Figure 4). Assaying backgrounds of different materials also helps model the background of the detectors, while offering students the opportunity to work with experts on gamma-ray spectroscopy.

BHSU manages the campus, but it is open to students across the state and across disciplines. While physics students work with the low background counters, students from other

disciplines can work on research in two areas adjoining the counting cleanroom

“We’re very excited that students have access to Sanford Lab and the unique environment of the 4850 Level,” Mount said. Not only college students will benefit from the underground campus; a pilot program will pair 16 middle school students with BHSU students to create robots for an underground competition. The college students will take the robots to an underground obstacle course where the robots must complete a mission. The middle school students will be able to watch via videoconferencing. K-12 students can also learn more about the science at Sanford Lab through videos and games that will be offered on the BHSU website.

For more info on research and education and outreach opportunities, visit the website at www.bhsu.edu/underground or contact Mount directly at brianna.mount@bhsu.edu.

Traffic: Check for detours through Deadwood en route to Lead: <http://www.highway85lead.com/traffic>

EDUCATION AND OUTREACH

Dark Matter for Middle School Students

The Education and Outreach Department gave workshops using their middle and high school curriculum units at the South Dakota Science Teachers Association conference in Huron in early February. Teachers have been recruited to pilot units this spring, as well as to sign up for training this summer in preparation for using the units next year.

The hands-on units are aligned to the newly-adopted South Dakota science standards (Figure 5). Several of the units have been piloted in multiple classrooms thus far, with good success; this month, E&O will feature one middle school unit, *What’s the ‘Matter’ with the Big Bang*.

The unit starts with the theme song from the popular television show *The Big Bang Theory*. The material introduces students to the scale of the universe, properties of matter, and the electromagnetic and gravitational interactions. Students then explore the evidence for dark matter, ending with a talk about Sanford Lab and when possible, a virtual tour of the LUX experiment. The unit has been used at three schools thus far:

- West Middle School (Rapid City) Grade 8 (112 students)
- Sanborn Central School (Forestburg) Grades 6-8 (35 students)
- Chamberlain Middle School Grade 8 (54 students)

The unit is currently at the middle school in Mobridge. Initial feedback from teachers has been positive. Based on their detailed feedback, revisions will be made this summer before the program is expanded next year.



Figure 5: SURF E&O Director June Apaza demonstrates “Exploring the Unseen”, an activity in which students are given a tub full of water and a cup stuffed with a paper towel



Figure 6: STEM Careers, a presentation for the middle school age group

The E&O Department is testing other platforms for virtual tours. The videoconference system at the Davis campus—with its high resolution and cameras in the MAJORANA DEMONSTRATOR (MJD) cleanroom—is excellent, but the technology is not always available to schools. Recently, Skype was used for a talk and virtual tour of LUX for 40 middle school students in Florida. Experiment Support Scientist Mark Hanhardt and E&O Deputy Director Peggy Norris participated from the Davis Campus. The students had previously watched the *Science Friday* video about Sanford Lab (a Public Radio International program that runs on NPR) and had done a hands-on activity about indirect evidence.

They came up with many great questions about dark matter. Here are a few random ones:

- Do we hypothesize that dark matter is hazardous?
- If you could harness dark matter, what could it be used for?
- Would dark matter be affected by black holes and if so, how?
- Would regular matter and dark matter interact, and how?
- Since light is massless, why it is affected by gravity, specifically how it can't escape black holes?
- Does dark matter have a color?
- What properties do you hypothesize dark matter to have, i.e., does it have a smell?
- How do gravitational waves interact with dark matter?

Deep Talks

A Deep Talks assembly takes place the second Thursday of each month at Sanford Lab, and will continue through May. On February 11, E&O Director June Apaza and other members of the E&O team presented "Exploring the Unseen," an interactive experience relating to dark matter and the Large Underground Xenon (LUX) experiment. Over the past year, the E&O team, assisted by six South Dakota teachers, has developed curriculum units for use in schools across the state—two each for grades 3-5, 6-8 and 9-12. The units focus on the active science at SURF. Apaza is also director of the Center for Math and Science Education at Black Hill State University. A reception preceded the talk, with sample craft brews from Crow Peak Brewing, along with light refreshments sponsored by First National Bank.

ENVIRONMENT, HEALTH & SAFETY



Energy Conservation

- Turn things off when you're done, whether computers, room lights, or televisions. Set your computer to Sleep or screensaver mode.
- Unplug appliances that you rarely use. Use appliances efficiently.
- Buy energy-efficient compact fluorescent or LED light bulbs.

STAFF NEWS

We note that Will McElroy is stepping up to a new position in the South Dakota region. As SURF Underground Access Director, Will has played a large role in planning and conducting the Ross Shaft rehabilitation as well as the maintenance of the Yates Shaft, which has enabled the simultaneous safe use and rehabilitation of Shaft furnishings. Will's extremely positive and 'can do' attitude, so prevalent over the past many years, will be missed. Bryce Pietzyk, current SURF Senior Underground Operations Engineer, will be filling Will's boots in the interim.



Figure 7: Historic photo (2009) with Will McElroy (center) during excavation of 4850 Level Davis Campus



South Dakota Gov. Dennis Daugaard recently appointed Dr. Robert Wilson to the South Dakota Science and Technology Authority (SDSTA). A professor of experimental high energy physics at Colorado State University in Fort Collins, Colorado, Wilson replaces Tom Adam who retired earlier this year.

UPCOMING CONFERENCES AND WORKSHOPS

RAM 2016: Robotics & Autonomous Systems in Mining, Sheffield, England, March 2, 2016. Organized by Boulby Underground Lab with Sheffield Robotics.
<http://ram2016.eventbrite.com/>

Cosmology 2016 Rencontres de Moriond Conference, La Thuile (Valle d'Aosta, Italy), March 19-26, 2016. Topics devoted to Cosmology and dark matter. For registration and more details:
<http://moriond.in2p3.fr/J16>

APS April meeting 2016, Salt Lake City, April 16-19. **The Cold Universe**, April 25-July 15, UC Santa Barbara.

<http://www.aps.org/meetings/calendar.cfm>

Geoneutrino summer school, Gran Sasso, Italy, July 11-21, 2016. Bring together nuclear/particle physicists and geologists, with the aim to contribute and build up a new geoscience community.

<https://agenda.infn.it/conferenceDisplay.py?confid=10519>

ICHEP 2016 Chicago: 38th International Conference on High Energy Physics, August 3-10, Chicago. Physicists will share latest advancements in particle physics, astroparticle physics, cosmology, and accelerator science. Deadline for abstract submission: Feb. 7, 2016.

<http://ic hep2016.org/>

NuFACT 2016, Quy Nhon, Vietnam, August 21-27, 2016. Workshop on neutrino physics beyond the PMNS matrix.

<http://vietnam.in2p3.fr/2016/nufact/>



JOBS

Postdoctoral Research Associate Positions, Stony Brook, New York. Research with Nucleon decay and Neutrino Experiments. Contact: Prof. Chang Kee Jung chang.jung@stonybrook.edu. Closing: 2/5/16.

Postdoctoral Position, Brown University. Research on LUX-ZEPLIN (LZ) in Astroparticle Physics group led by Rick Gaitskell. Review begins: 2/6/16. Contact: richard_gaitskell@brown.edu
<https://academicjobsonline.org/ajo/jobs/6834>

Lecturer, Liverpool University, Physics Dept. Experimental Particle Physicist in Particle Physics Group. Contact: Prof. Ronan McGrath, email: mcgrath@liverpool.ac.uk. Closing: 2/22/16.
<https://www.liverpool.ac.uk/working/jobvacancies/currentvacancies/academic/a-590132/>

Lindemann Trust Fellowships, 2016-17. Three grants per year for postdocs to carry out scientific research in the USA. Closing: 2/15/16.
www.esu.org/lindemann

Postdoctoral positions, University of Zurich. Work with Experimental Astroparticle group in GERDA neutrinoless double beta decay experiment. Contact: Prof. Laura Baudis, Physics Institute of the University of Zurich, Winterthurerstr. 190, CH-8057 Zurich, Switzerland. Closing: 2/29/16.

<http://www.physik.uzh.ch/jobs.shtml>

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Photo Credits: Fig. 1: CAPTAIN collaboration; Fig. 2: LIGO collaboration; Figs. 3,7: SURF; Figs. 4,5: Matt Kapust; Fig. 6: Lynn Arnold, Julie Dahl

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