

Dear SURF Readers,

Welcome to the February 2013 Sanford Underground Research Facility (SURF) monthly newsletter. The newsletter is also posted online, and a pdf copy is available. You can read recent and archived newsletters at our new website at 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

February 27-March 2: LUX ZEPLIN (LZ) Collaboration Meeting – College Station, TX

March 4-6: EHSOC meeting - Lead, SD

**March 5, 2013: DURA meeting and
March 6-8: Cosmic Frontier Meeting - SLAC, Menlo Park, CA**

Major Milestone Reached: LUX Fills Its Detector

On January 30, 400 kilograms of compressed xenon was delivered to the Sanford Lab Underground Research Facility (SURF) Davis Campus 4850 Level. SURF Science Director Jaret Heise credited the safe delivery to Science Integration Engineer Wendy Zawada and Facilities Tech Oren Loken (shown in Figure 1), who worked with Infrastructure Tech Shane Heydon to move the xenon underground.



Figure 1: Facilities Techs Calob O'Grady, left, and Shane Heydon, center, along with Infrastructure Tech Oren Loken and were on the crew delivering ultra-pure xenon underground to the 4850 Level

On Thursday, February 7, the LUX experiment team began condensing the gaseous xenon in the LUX detector. (Several reporters came on site to report the event. To reference these, please see *SURF in the News* on page 3.)

In the weeks leading up to this event, researchers slowly began cooling down the LUX detector in preparation for liquefying liquid xenon inside the detector. Progress was tracked on a chart (shown in Figure 2). To ensure that everything cooled evenly, the LUX team used thermosyphons—liquid-nitrogen cooled, gravity-driven heat pumps—which controlled cooling to various components in the detector.



Figure 2: Chart tracking the progress of cooling the LUX dark matter detector. Time was tracked on the horizontal axis (starting January 24), and temperature in Kelvin was tracked on the vertical axis

By Sunday, LUX researchers had finished filling the dark matter detector with liquid xenon – about a third of a ton. The next step will involve the purification process, which researchers expect to take several weeks.

LUX Behind the Scenes

Such events occur only with a great deal of effort on the part of many people: LUX collaboration members from several institutions as well as Sanford Lab staff. Postdocs and graduate students mentored by senior physicists carry out much of the hard work.

Carter Hall, Professor of Physics at the University of Maryland, leader of its LUX group, reports on its contribution:

The LUX dark matter detector was designed to observe the extremely faint signal of WIMP dark matter, buried within the ordinary cosmic ray cacophony of events. To accommodate this, the LUX collaboration moved the detector to the 4850

Level of Sanford Lab in the summer of 2012. The quest to escape from ordinary background events caused by radioactive-material decays began several years ago, when the LUX detector was first being designed and constructed. Each component of the detector, from its photomultiplier tubes to its titanium vessel, was screened to make sure that any trace quantities of radioactivity in the detector would not obscure the WIMP events during data taking.

A key component of the materials screening campaign lies at the heart of the LUX detector: 370 kilograms of liquid xenon that LUX will use to search for dark matter scattering events. While liquid xenon is a very good particle detection medium, the xenon gas that is sold on the commercial market is also commonly contaminated with about 100 parts-per-billion of krypton (a noble gas). Krypton, unfortunately, includes trace quantities of the problematic radioactive isotope ^{85}K . (This isotope was essentially non-existent on earth prior to the atomic age, but it is now present in the atmosphere in modest quantities introduced in atmospheric weapons-tests and nuclear fuel reprocessing). Although ^{85}K presents no danger to people, an extremely sensitive detector like LUX could be rendered blind to dark matter even by modest quantities. To meet the LUX dark-matter sensitivity goal, the krypton concentration in the LUX xenon had to be reduced to a level of several parts-per-trillion, a reduction factor of more than 10,000!



Figure 2: LUX scientists monitor the flow of xenon. From left: Dan McKinsey (Yale professor), Richard Knoche (University of Maryland-UM-grad student), Patrick Phelps (Case Western Reserve University grad student), and Attila Dobi (UM grad student)

This purification work was performed over several months in the fall of 2012 at Case Western Reserve University (CWRU) in Cleveland, Ohio. CWRU Physics Professor Dan Akerib and colleagues, including graduate student Chang Lee, set up a system that removed krypton to less than 5 parts per trillion. The usual “off-the-shelf” xenon gas might contain as much as 100 parts per billion, an impurity that the sensitive LUX detector cannot tolerate. The Case Western team followed a careful process, drop by drop, using about 60 kilograms of charcoal in a column slightly shorter than the 6.5-foot high LUX detector. (More on this process in a future issue of the SURF newsletter.)

To keep a close eye on the krypton concentration of the LUX xenon, the University of Maryland group built an online xenon sampling system for LUX that is capable of routinely detecting krypton at the level of one part-per-trillion using a common vacuum mass spectrometer. The system is seen in Figure 2, with graduate students Attila Dobi and Richard Knoche, who played the primary role in constructing, installing, and testing it. A similar system was successfully used by LUX during its commissioning run in the surface lab during the winter of 2012. Dobi and Knoche automated the device over the summer to allow frequent and reliable observations of xenon gas impurities to be made with minimal human intervention during the LUX underground run. The measurement technique was developed for LUX by the Maryland group in 2009-2011; it is also useful for monitoring not just krypton concentration but also that of other important impurities species such as argon, helium, oxygen, and nitrogen. The LUX materials-screening campaign will continue for the foreseeable future and beyond, as LUX collects data.

SURF Newsletter Supplement Articles

The second in the series of SURF Newsletter Supplement articles, “The MAJORANA DEMONSTRATOR Project at the 4850 Level Davis Campus” is available at:

<http://www.sanfordlab.org/lbnl/1198>

SURF website: <http://www.sanfordlab.org/>

Like SURF on Facebook:

<http://www.facebook.com/SURFatHomestake>



SURF IN THE NEWS

KELO TV: [Dark Matter Experiment Almost Ready to Begin](#) (Derek Olson, February 7)

KOTA News: [A rare decay could help scientists at the Sanford Lab answer universal questions](#) (Taisha Walker, February 12)
[Scientists make advancement with underground dark matter experiment](#) (Taisha Walker, Feb. 12)

LBNL news: [LUX ZEPLIN Primed to Take the Next Step Forward in the Search for Dark Matter](#) (Paul Preuss, February 7)

Symmetry.com: [Illuminating the dark universe](#) (Glennnda Chui, January 28)

PhysicsToday: [Dark matter search gets started deep in Sanford Lab](#) (Toni Feder, February 2013)

Fermilab Today: [DOE launches Environmental Assessment for LBNE](#) (Andre Salles, January 22)

Yale Daily News: [Scientists hunt for dark matter](#) (Anisha Suterwala, January 29)

NCYT (Noticias de la Ciencia y la Tecnologica): [El detector de materia oscura más sensible del mundo](#) (February 5)

Rapid City Journal: [Homestake Opera House hosts Inside the Higgs Boson](#) (February 2)
[Reporter's notebook: Touring the depths of the earth](#) (Aaron Orłowski, January 21)

Black Hills Pioneer (with Wendy Pitlick): [Higgs-like Boson science lecture draws crowd](#) (February 16)
[SHS Students get involved with Sanford Lab research](#) (February 13)
[Senior Science](#) (February 5)
[Ready to flip the switch on dark matter](#) (January 31)
[Science at Sanford Lab touches lives](#) (January 22)
[Reporter recounts personal tours of lab progress](#) (January 21)

For twitter updates see: www.sanfordlab.org

Reports Available

Prepublication version of the report of the decadal study by the Committee on the Assessment and Outlook for Nuclear Physics (NP2010 Committee):
http://sites.nationalacademies.org/BPA/BPA_069589

The National Research Council report – “An Assessment of the Deep Underground Science and Engineering Laboratory”:
http://www.nap.edu/catalog.php?record_id=13204

Marx-Reichanadter Committee report to DOE:
http://science.energy.gov/~media/np/pdf/Review_of_Underground_Science_Report_Final.pdf

LBNE Reconfiguration Report:
http://www.fnal.gov/directorate/lbne_reconfiguration

Paper: *The Large Underground Xenon (LUX) Experiment* will be published in *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, Vol. 704, 11 March 2013, pp. 111–126. Available soon!

DURA Election and meeting

The Underground Research Association Executive Committee (DUREC) called for nominations and held an election before the next annual DURA meeting on March 5, 2013 at SLAC in Palo Alto, prior to the *Cosmic Frontier Meeting and Workshop* of March 6-8. DURA welcomes Bill Roggenthen (SDSMT), Jason Detwiler (University of Washington), and Peter Sorensen (LLNL) who have recently joined with other members of the executive committee. DUREC now has seven members from Physics experiments, and two members from Bio-Geo-Engineering (BGE) backgrounds. If you wish to comment on DURA, please contact chair Richard Gaitskell (Richard_Gaitskell@brown.edu). For further information on DURA, see: <http://sanfordlab.org/dura>

SANFORD UNDERGROUND LABORATORY NEWS

MAJORANA DEMONSTRATOR (MJD) Update

The first purified Germanium (Ge) crystals arrived at SURF on Monday, February 11. David Radford and Brandon White (shown in Figure 5) of Oak Ridge National Laboratory drove from its storage in

Cherokee Caverns, a commercial cave near Oak Ridge, Tennessee to Sanford Lab in Lead, South Dakota over a two-day period. Due to a winter blizzard close to Interstate 90, they were forced to take a slight detour with their valuable cargo, estimated to be worth about \$1 million. Their freight also included five of the 30 enriched germanium detectors that MJD will use in the experiment. The isotopically-enriched germanium oxide was produced in Russia and shipped to Oak Ridge a few months ago in 20-foot sea containers inside steel-shielded vessels to protect it from cosmic radiation.



Figure 4: Facilities Tech Oren Loken pulls the cart and helps MAJORANA scientists move germanium crystals off the Yates Shaft cage



Figure 5: David Radford holds a cryostat containing ^{76}Ge crystals. Brandon White (left)

Safety at Sanford Lab

The Yates Shaft Risk Assessment Group met in Lead during the week of January 28 to discuss safety and maintenance of the Yates Shaft. A similar process took place in relation to the Ross Shaft. However, the Yates Shaft supports are made of timber rather than steel.

Risk mitigation measures include additional ground controls, rock bolts, installation of barriers,

replacement of some timber, and a detailed, thorough inspection program.

Geotechnical engineering consultant Tony Iannacchione of *ATI Consulting*, who also directs the Mining Program at the University of Pittsburgh, is working with the group. He helped conduct a similar risk assessment of the Ross Shaft last year. The group is looking at how to refine work processes as well as identifying hazard controls and finding new ways to reduce risks.

During the Ross Shaft replacement, scheduled to take about four and a half years, the Yates Shaft provides the main access to the underground. This includes access to experiments at the Davis Campus on the 4850 Level.

EDUCATION AND OUTREACH

Recent Activities:

K-12 Outreach

Spring in South Dakota is Science Fair time in many schools, and judging is always a rewarding experience. This month, Education and Outreach Director Ben Sayler and Deputy Director Peggy Norris judged the Spearfish Middle School Science Fair, hosted by Black Hills State University. Peggy also judged physics and electrical engineering projects for the Northeast Wyoming regional fair at Newcastle, Wyoming. At the high school level, students have the opportunity to move on to the regional fair in Rapid City, and if they win there, possibly the national science fair sponsored by *Intel*. One of the projects from Newcastle High School utilized Quarknet muon detectors borrowed from Sanford Lab to try to find a correlation between sunspot activity and cosmic ray intensity.

Science Education Specialist Julie Dahl and Peggy Norris attended the annual South Dakota Science Teachers Association meeting in Huron, South Dakota on February 7-9. An update on activities at the Sanford Underground Research Facility was presented and materials were made available to teachers at an exhibit table.

Senior Derrick Morrison of Lead-Deadwood High School (shown in Figure 6) is doing a senior research project with John Scheetz, Jim Whitlock, and Duane Ennis. They are constructing a working

model of the sand filters at the Waste Water Treatment Plant. The goal is to gain a better understanding of the mechanism that makes the sand filters so successful in removing the iron from the mine water. The working model will also allow for testing of chemical additives, such as detergents, that might be introduced as part of the science activities underground. Their work was featured in the February 5 *Black Hills Pioneer*.



Figure 6: Lead-Deadwood High School senior Derrick Morrison stands behind one of his pilot sand filters next to the actual filters used at the water treatment plant at the Sanford Underground Research Facility. (Photo courtesy of Wendy Pitlick, Black Hills Pioneer)

Public Outreach

On February 12, 130 members of the northern Black Hills community attended a *Deep Science for Everyone Lecture* at the Historic Homestake Opera House in Lead, South Dakota. The lecture, given by Professor Beate Heinemann of UC Berkeley and LBNL, was on the search for and discovery of a Higgs-like particle at the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland. Dr. Heinemann is a member of the ATLAS collaboration, one of the experiments hunting the Higgs-like Boson at the LHC. Thanks to a generous donation by *Versatile Carpets and Interiors* of Spearfish, South Dakota, and the sponsorship of the Lead Chamber of Commerce and the Homestake Opera House, a reception was held preceding the lecture.



Figure 7: Physicist Beate Heinemann of UC Berkeley gives talk at Historic Homestake Opera House on February 12

ENVIRONMENT, HEALTH & SAFETY



Winter Sports Safety

- Dress appropriately for winter sports of sledding, ice skating, skiing, or snowboarding: layer in warm clothes, hats, gloves, goggles, or helmets. Make sure that long scarves are tucked in so they don't get entangled in lifts, ski poles or other equipment.
- Keep hydrated and watch for signs of hypothermia: cold hands or feet, shivering, drowsiness, confusion, or shallow breathing.
- In spite of their winter coats, some pets are susceptible to the cold. If they get wet, dry off their coats and paws right away. Signs of hypothermia in dogs are similar to those seen in humans.

If you are visiting South Dakota, contact (605) 722-0002 for road closure and weather information.

UPCOMING CONFERENCES AND WORKSHOPS

DURA meeting, SLAC, Menlo Park, CA. March 5, 2013 before the Cosmic Frontier Workshop.

Cosmic Frontier Workshop 2013, SLAC, Menlo Park, CA. March 6-8, 2013.

<http://www-conf.slac.stanford.edu/cosmic-frontier/2013/>

Workshop in Low Radioactivity Techniques, Laboratori Nazionali del Gran Sasso (LNGS), Italy. April 10-12, 2013. The workshop will examine topics in low radioactivity materials and techniques. This conference is intended to be wide in scope to include all aspects of the development of low background detectors and techniques.

<http://lrt2013.lngs.infn.it>

INPAC/MRPI General Meeting - New Directions in Nuclear/Particle Astrophysics and Cosmology, Asilomar Conference Grounds, Pacific Grove, CA, April 26-28, 2013. Program and meeting details still in development. For an overview of the 2011 meeting: <http://cosmology.berkeley.edu/inpac-mrpi/>

SINOROCK Third Symposium, Tongji University, Shanghai, China. June 13-16, 2013. A URL workshop will be held on June 12.

<http://www.sinorock2013.org>

ARMA, 47th US Rock Mechanics/Geomechanics Symposium, Westin San Francisco Market Street, San Francisco, CA. June 23-26, 2013.

<http://armasymposium.org/>

Community Summer Study 2013 (SNOWMASS on the Mississippi). Minneapolis, MN, July 29-August 6, 2013. Sessions on five particle physics frontiers: cosmic energy, facilities, instrumentation, and intensity.

<http://www.snowmass2013.org>

EUROCK 2013, ISRM International Symposium, Congress Centre, Wroclaw University of Technology, Wroclaw, Poland. September 21-26, 2013. Rock Mechanics for resources, energy, and environment.

<http://www.eurock2013.pwr.wroc.pl/index.php?id=0>

Underground Science Experiments & Research Seminars (USERS) continue bi-weekly on Thursdays, 1:30-2:30 PM. Alternate sessions will be held at LBNL and UC Berkeley, 325 Old LeConte Hall. If you are interested in attending these seminars please subscribe to this email list for future announcements:

<http://dusel.org/mailman/listinfo/ugsseminars>

DURA Events: Please send information regarding upcoming meetings of interest to DURA members to Richard_Gaitskell@brown.edu or jswang@lbl.gov.



JOBS

Tenure track faculty position in Experimental Particle Physics, UC Davis. Research on LUX and Double Chooz experiments, building a small reactor neutrino detector in Canada, and campaign to measure backgrounds for future underground dark matter and neutrino experiments. Experimental Particle Physics Search Committee Chair, Dept. of Physics, Univ. of California, Davis, CA 95616. dmnu@physics.ucdavis.edu. Deadline: 2/15/13.

<https://recruit.ucdavis.edu/apply/JPF00050>

PhD Graduate Research Assistant in Deep Life Study, DRI Las Vegas and UNLV School of Life Sciences, Nevada. Interface with NASA Astrobiology Institute and Life Underground. Focus

on deep drilling programs associated with Death Valley National Park, Nevada National Security site, and other underground locations. Interdisciplinary team includes USC, Caltech, Rensselaer, and JPL. Duane Moser, Desert Research Institute, 755 E. Flamingo Rd., Las Vegas, NV 819119. Duane.moser@dri.edu.

NAI: <https://astrobiology.nasa.gov/nai/>

Life Underground:

<http://www.astrobio.net/pressrelease/5073/seeking-life-underground>

Postdoctoral Researcher, LLNL, Livermore. Research in Experimental Nuclear Physics (ENP) Group/Nuclear and High Energy Physics. Support of CUORE. Nicholas Scielzo (scielzo1@llnl.gov)

[https://careers-](https://careers-prd.llnl.gov/psp/careers/EMPLOYEE/HRMS/c/HRS_HRA_M.HRS_CE.GBL?Page=HRS_CE_JOB_DTL&Action=A&JObOpeningId=11017&SiteId=1&PostingSeq=1)

[prd.llnl.gov/psp/careers/EMPLOYEE/HRMS/c/HRS_HRA_M.HRS_CE.GBL?Page=HRS_CE_JOB_DTL&Action=A&JObOpeningId=11017&SiteId=1&PostingSeq=1](https://careers-prd.llnl.gov/psp/careers/EMPLOYEE/HRMS/c/HRS_HRA_M.HRS_CE.GBL?Page=HRS_CE_JOB_DTL&Action=A&JObOpeningId=11017&SiteId=1&PostingSeq=1)

Postdoctoral researcher, Experimental Astroparticle Physics, IU South Bend, IN. Work on COUPP direct dark matter search experiment. Prof. Ilan Levine, ilevine@iusb.edu. Dept. of Physics & Astronomy, IUSB, 1700 Mishawaka Ave., South Bend, IN, 46634. Deadline: 3/1/13.

<https://www.iusb.edu/academic-affairs/searches.shtml.php-postdoc>

Tenure track faculty position at University of South Dakota. Prefer background in theoretical/computational physics and research interests including dark matter searches, neutrino experiments, or materials science focused on detectors utilized in an underground environment. Review begins 2/1/13.

<https://yourfuture.sdbor.edu>

Tenure track faculty positions in Physics at South Dakota School of Mines. New SURF-related research program in particle physics, neutrino physics, dark matter, proton decay, and related research that requires deep underground shielding and low-background counting; also seeking a specialist in computational physics. Job #: 0004996.

<http://www.sdsmt.edu/employment>

Professor and Assistant Professor positions, Physics Dept., Temple University. The tenure-track positions are open to theoreticians and experimentalists in all fields of Physics. Deadline: 1/31/13.

<http://phys.cst.temple.edu/professor>

<http://phys.cst.temple.edu/assis-professor>

Research Assistant/Associate in High Energy Physics, Imperial College, London. Work on laboratory R&D and design development for the next-generation LUX-ZEPLIN (LZ) dark matter experiment. Job ref: NS2013003NT. Dr H. Araujo, H. Araujo@imperial.ac.uk.

Postdoc Position, T2K Experimental High Energy Physics, York University, Toronto. Work on the T2K neutrino oscillation experiment. Prof. Sampa Bhadra, bhadra@yorku.ca, Dept. of Physics & Astronomy, York University, 4700 Keele St., Toronto, ON M3J 1P3, Canada.
<http://inspirehep.net/record/1203399>

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Contributors: Kevin Lesko; Bill Harlan (Sanford Lab local news); Carter Hall, University of Maryland (LUX: Behind the scenes); Peggy Norris, Ben Saylor (Education and Outreach)

Photo Credits: Fig. 1: Jaret Heise; Fig. 2: LUX Collaboration; Fig. 3: Bill Harlan; Figs. 4,5: Matt Kapust; Fig. 6: Wendy Pitlick, *Black Hills Pioneer*.

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