

Dear SURF Readers,

Welcome to the May 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](http://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**

**July 6-8: EHSOC Review – Lead, South Dakota**

**July 9: Neutrino Day – Lead, South Dakota**

**LUX Reaches Significant Milestone**

On May 2, LUX, the Large Underground Xenon dark matter experiment located on Sanford Lab's 4850 Level, reached a significant milestone: the successful completion of its final dark matter run with over 300 live days of quiet, low-background operation searching for dark matter interactions. "I would describe the mood as exciting, joyous, and electric," said Mark Hanhardt, Sanford Lab support scientist.

This is the culmination of many years of effort. The construction and testing of the full LUX detector started at the Sanford Lab surface level in 2010 (Figures 1-2). This activity was done in parallel with the excavation of the new Davis Campus at Sanford Lab, which included the enlargement of the original Davis Cavern.



Figure 1: 2010 photo of researchers, grad students, and technicians with LUX cryostat cylinder



Figure 2: 2010 photo taken during the move

The LUX detector was moved underground in the summer of 2012, amid great excitement about its future prospects (Figures 3-4). LUX would be the first major particle astrophysics experiment at the new Sanford Lab in South Dakota.



Figure 3: 2012 photo of the LUX detector being moved by forklift into the Yates Shaft headframe



Figure 4: 2012 photo of researchers, engineers, and technicians maneuvering the LUX dark matter detector at SURF's 4850 Level

The LUX dark matter detector was much more sensitive than other existing detectors. Within a few weeks of the LUX experiment starting its first dark matter run in 2013, it had surpassed the sensitivity of all previous direct detection experiments for dark matter masses--above six times that of a proton. First results were announced in late 2013, using the first three months of dark matter search data from LUX.

In October 2013, after a 90-day live run, LUX announced that it was the most sensitive dark matter detector in the world. Since then, researchers have improved the detector's sensitivity level, increasing its ability to detect WIMPS (weakly interacting massive particles), the leading contender in the dark matter search.

"LUX was so much larger than existing detectors, that within a few weeks of starting its first run in 2013, it had surpassed all previous direct detection experiments," said Richard Gaitskell, Brown University Physics professor and LUX co-spokesperson (Figures 5-6).



*Figure 5: In 2013, LUX co-spokespersons Dan McKinsey (left) and Rick Gaitskell (right) pose on the top deck of the LUX experiment*



*Figure 6: 2013 photo of LUX researchers in a cleanroom at the Sanford Lab surface, working on the interior of the detector before it is inserted into its titanium cryostat*

LUX released new findings in December 2015, which were a reanalysis of all the data taken in 2013. These results showed the tremendous progress that LUX has been able to make in analysis algorithms, and also demonstrated the significantly improved understanding of two-phase xenon detector response based on new calibration techniques. LUX was able to reach a minimum cross-section sensitivity of  $6 \times 10^{-46} \text{ cm}^2$ , which beat the sensitivity goal (a spin independent cross-

section of  $7 \times 10^{-46} \text{ cm}^2$ ) that was contained in the original funding proposals for LUX.

The new calibration techniques include injecting neutrons, which act as stand-ins for dark matter particles, into the detector, and then tracking them to learn details about the recoil. The nature of the interaction between neutrons and xenon atoms is thought to be very similar to the interaction between dark matter and xenon. Refined techniques included the use of tritiated methane, krypton-83 and a neutron generator, and were used in the most recent run.

Since November 2014, the LUX collaboration has been searching for dark matter again, with the detector in WIMP search mode or calibration mode. There have been many challenges throughout each phase of the experiment. The challenge during any dark matter search is to ensure that the detector is taking data in a completely stable mode where the operating conditions are very well understood. In order to maximize the potential of the dark matter search, regular high statistics calibrations were carried out. A major team effort has ensured that LUX was able to deliver extremely high levels of live time.

At regular intervals, calibrations were carried out for two weeks every four months to ensure a high level of accuracy in measuring responses to backgrounds and potential dark matter signals.

After 19 months, the run officially ended on May 2. "That is a long time to operate a detector without a significant break," said Simon Fiorucci, LBNL scientist and LUX science operations manager. "But it was critical to demonstrate our ability to do so as we prepare to run LZ for more than three years."

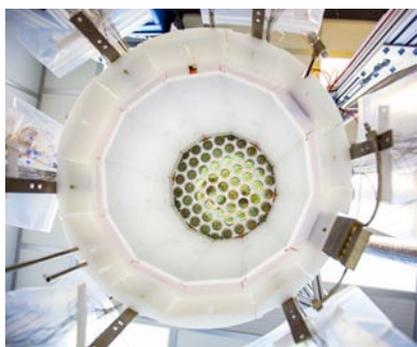
The new 2014-2016 LUX dark matter run live time is well over three times longer than LUX's previous search, and the LUX collaboration will be able to use this to significantly improve sensitivity for the elusive particles. These new data will be used to further probe for new dark matter models. The LUX collaboration plans to announce new search results before the end of 2016.

In late 2016, LUX will be decommissioned in preparation for the LUX-ZEPLIN (LZ) experiment. This second-generation dark matter detector will have a 10-ton liquid xenon target and will be up to 100 times more sensitive than LUX. LZ will be

located inside the same 72-gallon water tank that currently shields LUX (Figure 7).



*Figure 7: LUX is housed in a 72,000-gallon tank 4850 feet underground*



*Figure 8: Photomultiplier tubes can pick up tiny bursts of light when a particle interacts with xenon atoms*

LUX consists of one-third of a ton of liquid xenon inside a titanium vessel. On the very rare occasions when a dark matter particle collides with a xenon atom inside the detector, the xenon atom will recoil and emit a tiny flash of light, which will be detected by the light sensors (Figure 8).

The work on LUX is not yet over, in spite of all the significant milestones that have been reached. A final round of very high accuracy calibrations on LUX will be acquired in the summer of 2016. This will ensure that maximum use can be made of the dark matter search data that has been collected since 2014. LUX will also be taking new calibration data to best understand techniques that will be directly applicable to the LZ experiment that follows. Paving the way for the LZ experiment—a detector over twenty times as large—LUX will begin to be removed from the Davis Lab in September 2016. LZ is scheduled to begin arriving at Sanford Lab in the summer of 2017.

## LUX-ZEPLIN (LZ) Review

A Department of Energy CD-2/3b independent project review of the LUX-ZEPLIN (LZ) Project was held at Lawrence Berkeley National Laboratory on April 26-28, 2016. About two dozen reviewers from US and non-US institutions, along with members from the Department of Energy, thoroughly reviewed the design, plans, costs and schedule for the LZ Project. The LZ experiment will contain about 10 tonnes of liquid xenon and will be located at the 4850 Level at SURF, replacing the Large Underground Xenon (LUX) detector, which will be decommissioned and removed by spring of 2017. This CD-2/3b independent project review was a critical step in continuing to move forward on the LZ Project.

## REPORTS/PAPERS AVAILABLE

[The Sanford Underground Research Facility at Homestake](#). Jaret Heise, J.Phys.Conf.Ser. **606** (2015) no. 1, 012015; [arxiv: 1503.01112](#) (2015)

*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](http://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** 542 (2015)

[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](http://www.sanfordlab.org)  
**Like Sanford Lab Visitor Center on Facebook:** <https://www.facebook.com/sanfordlabhomestake/>



**SURF IN THE NEWS**

*US News & World Report:* [South Dakota's Black Hills State University Opening Underground Campus](#) (Associated Press, May 6)

*Symmetry:* [Five Fascinating Facts about DUNE](#) (Laura Biron, April 14)

*Fermilab:* [By the numbers: LBNF/DUNE continues to make progress](#) (Chris Mossey, May 3)

*KOTA TV:* [BHSU goes deep underground](#) (Yassir Kishk, April 26)

*SDPB.org:* [Innovation: DUNES project](#) (Cara Hetland, May 13)

*Black Hills Knowledge Network:* [BHSU Opens Underground Campus at Sanford Lab](#) (May 17)

*Black Hills Travel Blog.com:* [How to Make the Most of Four Hours in Lead, SD](#) (Alicia, May 24)

*Rapid City Journal:* [Scientists gather in Rapid City to discuss neutrinos](#) (Staff, May 18)

[Lead grants SURF easement for elevated conveyor](#) (Tom Griffith, May 11)

[BHSU students will soon be mining nuggets of wisdom](#) (Tom Griffith, April 27)

*Black Hills Pioneer:* [BHSU cuts ribbon on Sanford Science Education Center, Underground Campus](#) (Adam Hurlburt, May 10)

[Lead grants SDSTA easements for elevated conveyor system](#) (Adam Hurlburt, May 6)

[Hands-on, cutting-edge student research opportunities](#) (Kaija Swisher, May 5)

[Black Hills State University opening underground campus](#) (Associated Press, May 4)

**DURA**

To comment on DURA, please contact its chair Richard Gaitskell ([Richard.Gaitskell@brown.edu](mailto:Richard.Gaitskell@brown.edu)). For Bio-Geo-Engineering matters, contact Bill Roggenthen ([William.Roggenthen@sdsmt.edu](mailto:William.Roggenthen@sdsmt.edu)). For further information on DURA, see: <http://sanfordlab.org/dura>

**SANFORD UNDERGROUND LABORATORY NEWS**

**Lead Chamber of Commerce Award**

The Lead Chamber of Commerce presented awards on April 29 at the Historic Homestake Opera House, following a public process of nomination and voting. SURF won the "Lead the Way" award, given to a business in recognition of a significant investment made in their business through expansion or improvement, demonstrating their belief in the future of Lead (Figure 9). This year's prize recognized SURF's investment in the Sanford Lab Homestake Visitor Center.



*Figure 9: Mike Headley, SDSTA Executive Director, second on right, accepts award on behalf of SURF*

**Safety Matters**

To promote and ensure safety, SURF and its Emergency Response Team regularly carries out evacuation drills so that safety team members are prepared for possible emergencies. In mid-May, the team staged and participated in a multi-agency emergency drill.

"You train to be prepared for any emergency and we're prepared because we train," said John Emick, ERT lead.

The team started with a tabletop exercise, with all agencies involved discussing the emergency scenario and determining who would be involved if the scenario was an actual event. This is a critical step in the procedure. "In any emergency, communication is the most important thing," said Emick.

The tabletop was followed by a functional exercise that involved key personal at SURF, Lawrence County Emergency Planning, and the National Guard's 82<sup>nd</sup> Civil Support team.

“We wanted to show that we can respond to an emergency, put our processes into practice, and integrate with outside entities,” said SURF Environmental, Safety and Health Director Neil Schroeder.

The scenario, developed by Emick and others, involved a simulated release of nitrogen gas on Sanford Lab’s 4850 Level. This triggered a simulated evacuation of the underground and a real-life practice of a medium incline rope rescue, in which the team attached ropes to both victim and a Stokes, or rescue basket, and then pulled both up the incline (Figure 10).

“Our team did great,” Schroeder said. “We found opportunities for improvement—both in how we respond to an emergency and in how we integrate with other groups. But overall, the exercise shows that our team is ready for any emergency.”



*Figure 10: Members of the National Guard’s 82<sup>nd</sup> Civil Support Team perform a steep-incline rope rescue during the emergency drill held at Sanford Lab*

Another important element of the drill was to exercise Sanford Lab’s incident command system and emergency operations center (EOC), said Lab Director Walter Weinig. In an emergency, an incident commander oversees the event. On a facility level, there is much more to deal with. “We need to also focus on families, employees, and the media,” said Weinig. “The incident commander can’t do all of that and also focus on saving lives.”

Overall, Weinig was pleased with the efforts of everyone involved. “Our team integrated well and every agency involved benefitted from the exercise,” he said. “Working with the other agencies was great.”

## EDUCATION AND OUTREACH

### K-12 Student Outreach

The Education and Outreach team has been working all year to provide students across South Dakota a taste of Sanford Lab science and engineering, through the use of the newly developed curriculum units and assembly programs. During the 2015-2016 school year, E&O programs reached a total of over 870 students with the curriculum units and 8,488 students with the assembly programs. These students ranged from pre-kindergarten to high school seniors, attending 60 schools in 27 counties across the state. Many of the schools were rural so this outreach is of particular significance to those students.

For most students, one of the E&O programs raises awareness about something that is happening within their state. For some students, it is life-changing. Figure 11 illustrates a theory submitted by 13-year old Khristian Beek from Alcester-Hudson Middle School, a small community in the southeast corner of South Dakota. After exploring the Big Bang model and dark matter in a two-week unit, Eighth Grade students were asked--as a post-assessment--to draw their idea of the universe. This student carried out his assignment, and then added his own theory on the back. He called it the Hourglass Theory, and he used it to explain why our universe is all matter and no antimatter. Khristian wants to become a theoretical astrophysicist when he grows up. Are there any physics departments out there ready to recruit him?



*Figure 11: Illustration from Eighth-Grade student Khristian Beek on his “hourglass theory of the universe”*



### Deep Talks

On May 12, a Deep Talks event took place at the Sanford Lab Homestake Visitor Center in Lead with David Vardiman, Project Engineer at Sanford Lab, speaking on “1.8 Billion Years of Geologic History.” He covered the geologic stratigraphy of Lead’s Open Cut and the Northern Black Hills, its various styles of gold- and silver-bearing ore bodies, and the dramatic effect climate has had on the region during its nearly 2-billion year history. A reception preceded the talk, with sample craft brews from Crow Peak Brewery and light refreshments from The Lodge at Deadwood. To view the talk on vimeo: <https://www.facebook.com/sanfordlabhomestake/>

### ENVIRONMENT, HEALTH & SAFETY



### Summer Safety

- Use sunscreen with SPF of 15 or greater. Reapply sunscreen every two hours, or after swimming. Wear lightweight, light-colored clothing.
- Keep well hydrated; drink plenty of fluids. Don’t leave children or pets in a hot car.
- To repel insects: avoid strong scents; try insect repellent pads or spray.
- Keep a first aid kit handy.

### UPCOMING CONFERENCES AND WORKSHOPS

**The Cold Universe, April 25-July 15, UC Santa Barbara.** Program will present the role of molecules, heavy elements and dust for star formation. <https://www.kitp.ucsb.edu/activities/colduniv16>

**PhysStat2016 workshop, Kavli IPMU University of Tokyo,** May 30-June 1. A second workshop will follow at Fermilab, September 19-21. <http://indico.ipmu.jp/indico/conferenceDisplay.py?confid=82>

**Neutrino 2016, London, England,** July 4-9. Programs on neutrino physics, the impact of neutrino physics on astronomy and cosmology, and future development. <http://neutrino2016.iopconfs.org/home>

**Geoneutrino summer school, Gran Sasso, Italy,** July 11-21. Bring together nuclear/particle physicists and geologists, with the aim to contribute and build up a new geoscience community. <http://agenda.infn.it/conferenceDisplay.py?confid=10519>

**ICHEP 2016 Chicago: 38<sup>th</sup> International Conference on High Energy Physics,** August 3-10, Chicago. Physicists will share latest advancements in particle physics, astroparticle physics, cosmology, and accelerator science. <http://ichep2016.org/>

**NuFACT 2016, Quy Nhon, Vietnam,** August 21-27. Workshop on neutrino physics beyond the PMNS matrix. <http://vietnam.in2p3.fr/2016/nufact/>



### JOBS

**Postdoctoral Research Assistant, Oxford.** Work on SNO+ experiment in Particle Physics. Contact: Stephen Biller, [stephen.biller@physics.ox.ac.uk](mailto:stephen.biller@physics.ox.ac.uk). Closing: 7/4/16. [https://www.recruit.ox.ac.uk/pls/hrsliverecruit/erq\\_jobspec\\_version\\_4.jobspec?p\\_id=123659](https://www.recruit.ox.ac.uk/pls/hrsliverecruit/erq_jobspec_version_4.jobspec?p_id=123659)

**Postdoctoral Researcher, LLNL.** Research focus on R&D on the nEXO neutrinoless double beta decay experiment. Contact: Samuele Sangiorgio, [sangiorgio1@llnl.gov](mailto:sangiorgio1@llnl.gov). Job ID: 101011. <http://careers-ext.llnl.gov/jobs/5386296-postdoctoral-research-staff-member>

**Postdoctoral Fellow (Nuclear Science), LBNL.** Work on experiments to search for lepton number violation and to probe the absolute neutrino mass scale. Contact: Alan Poon, [awpoon@lbl.gov](mailto:awpoon@lbl.gov). <https://lbl.taleo.net/careersection/2/jobdetail.ftl?lang=en&job=82113>

**Postdoctoral research scientist, South Dakota School of Mines & Technology, Rapid City.** Research in experimental underground physics, direct dark matter searches. Closing: 6/15/16. Richard Schnee, [Richard.Schnee@sdsmt.edu](mailto:Richard.Schnee@sdsmt.edu); Juergen.Reichenbacher@sdsmt.edu <http://inspirehep.net/record/1430055>

**Postdoctoral researcher, LLNL.** Research on fission TPC project in Nuclear and Particle Physics

## SURF MONTHLY NEWSLETTER

Group. Contact: Lucas Snyder ([snyder35@llnl.gov](mailto:snyder35@llnl.gov)) or Samuele Sangiorgio ([sangiorgio1@llnl.gov](mailto:sangiorgio1@llnl.gov)). Job ID: 100894.

<http://careers-ext.llnl.gov/jobs/search?q=100894>

**Postdoctoral Associate, Dark Matter and Neutrino Physics, Northwestern University.** Join group of Prof. Enectali Figueroa-Feliciano. Research SuperCDMS and other experiments. Closing: 7/31/16. Contact: [enectali@northwestern.edu](mailto:enectali@northwestern.edu)  
<http://inspirehep.net/record/1430991>

**Lab tech positions, South Dakota School of Mines & Technology, Rapid City.** Work with construction of systems including LZ dark matter experiment at SURF.  
<https://www.higheredjobs.com/details.cfm?JobCode=176244745>

**Postdoctoral position, University of Michigan.** Research with neutrino group. Opportunities to work on JSNS2 experiment in Japan, SBND, and MicroBooNE experiments at Fermilab. Contact: Joshua Spitz, [spitzj@umich.edu](mailto:spitzj@umich.edu). Closing: 7/15/16.  
<http://inspirehep.net/record/1423248>

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

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