Dear SURF Readers,

Welcome to the August 2012 Sanford Underground Research Facility (SURF) monthly newsletter. In the coming months, this newsletter will be posted online, and a pdf copy will be available. You will also receive an email reminder every month providing the link to the newsletter and SURF news updates. We will still be 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

September 14-16: LUX-ZEPLIN (LZ) meeting - Lead, South Dakota

October 11-13: Community Planning meeting for High Energy Physics - Fermilab, Batavia, Illinois

LUX Experiment Milestones

In July, the Large Underground Xenon (LUX) experiment reached a major milestone. LUX Collaboration Member **Vic Gehman** (seen in Figure 1) was involved in moving the LUX WIMP dark-matter detector from the Sanford Lab surface to the Davis Campus underground. Vic is a Staff Scientist at Lawrence Berkeley National Lab and made several long-term trips to Sanford Lab this summer to participate in the LUX installation process. He details the procedure:

Figure 1: Vic Gehman stands behind the LUX detector during its installation at the 4850 Level

To simplify construction logistics and advance the schedule, the detector was built in a laboratory on the surface over the past several years, and took commissioning data this spring. However, to reach the background levels required for a dark matter search, the detector must collect physics data underground. To protect the outside of the detector, it was carefully wrapped in plastic and foam. The inside of the detector was kept clean during the move by pressurizing it with clean nitrogen gas so that any seals that momentarily opened as a result of bumps or shocks would cause the clean nitrogen to leak out and prevent comparatively dirty mine air from leaking in.

The detector move took place on July 11 and 12, the culmination of months of planning by SURF personnel and members of the LUX collaboration. This included several trial runs with a "mock detector" made of welded steel beams. On the morning of July 11, the LUX detector was loaded onto a steel transport cart. Over the course of two hours that afternoon, it was moved from the surface laboratory to the Yates Shaft Headframe with some forklift assistance from *Donovan Construction* of Spearfish, South Dakota. On the morning of July 12, the detector was moved from the transport cart to a set of six air bearings. The air bearings allowed the detector to slide smoothly over sheet metal that had been set down in the Yates headframe and underground by *Feuillerat Welding* of Rapid City. The detector arrived in the Davis Campus that evening and was installed on the rails in the LUX laboratory. The process of checking out the detector in preparation for installation in the water tank and the start of commissioning began the next day.

The operation was a great success, which is a tribute to the hard work and dedication of all involved. The move was made safely for both the detector and the people who participated. At no point during the move did the detector experience an acceleration greater than 0.15g. The arrival of the LUX detector underground represents a major step forward for Sanford Laboratory, and for low-background physics research in the United States.

Mia Ihm, a Physics graduate student at UC Berkeley, was one of the students participating in the LUX collaboration. She spent a month in June and July living in Lead during LUX's installation underground, her first time spending a long period on-site.

Mia says, "Living in Lead, South Dakota while working on the detector has certainly been a

defining part of the whole experience. It makes for some unique bonds with the experiment, your collaborators, and the town itself."

After an undergrad internship with Professor George Smoot (Nobel Prize in Physics, 2006), Mia knew that she wanted to attend UC Berkeley for her graduate studies. She found dark matter search to be a great blend of her interests in astronomy and detection technique. She is now working with LUX at SURF.

Figure 2: Mia Ihm, underground in the water tank during the PMT installation

Mia's work with LUX has included a bit of everything. She helped with the installation of the photomultiplier tubes (PMTs) in the water tank (shown in Figure 2) that will house and shield the LUX detector. While still on the surface, the LUX crew worked together to put the internal detector pieces together until finally sealing the outer cryostat to bundle the detector down to one neat package. Mia was in charge of numerous electronic and gas system checkouts, ensuring the health of the detector both before and after the big move underground.

"I feel very fortunate to have been part of LUX for the past two years," Mia says. "The timing worked out so that not only was I able to participate in the fun of building up the detector, but I will also be able to look at some of the exciting physics that is soon to come. To finally move underground (and so smoothly) is a milestone that I'm truly proud of, and it was all possible due to the hard work of the SURF staff and my colleagues at LUX."

LUX will soon begin a different mode of operation as researchers finally realize their initial goal: to collect data. Operating underground will be a new experience for many of the LUX scientists and students. There will be some other changes as well. For example, the team is bound to a cage operation schedule so they will not have the flexible hours they previously had working on the surface. Their day will begin at 7:30 a.m. and end at 4 p.m. Each day also will require careful planning ahead of time, as in the past team members could dash off to the hardware store for extra parts or leave the site to buy a sandwich.

As Mia says, "We'll be a little stronger for constantly wearing hard hats and steel toes, but a little weaker from the lack of Vitamin D. It's hard to say exactly what this next phase of LUX will be like, but it's sure to be interesting. I can't wait to find out!"

Copper Electroforming at the SURF 4850 Level

For the past year, Cabot-Ann Christofferson, South Dakota School of Mines and Technology (SDSMT) Instructor and Liaison/Deputy Director of the MAJORANA Project at Sanford Lab, has been supervising Materials Science PhD student Anne-Marie Suriano and Chemical Engineering undergraduate Adam Caldwell of SDSMT, who are part of a team that has been electroforming copper at Sanford Lab's 4850 Level. Project members from *Pacific Northwest National Laboratory (PNNL)* in southern Washington traveled to Sanford Lab to assist the SDSMT team members. Using electroformed copper (it being free of radioactive impurities such as uranium and thorium) in structural components of the MAJORANA DEMONSTRATOR (MJD) apparatus ensures low background in its detector elements. (Elemental copper has no long-lived radioactive nuclei.) Deep underground cosmogenic radiation effects are minimized.

The process was carried out in the ten electrochemical baths in the MAJORANA Temporary Clean Room (TCR) near the Ross Shaft. A thorough multi-stage process is in place to ensure that the copper is produced correctly. Copper slugs are dissolved in acid baths, and then an electric current is run through the baths. Copper atoms adhere to the stainless steel cylindrical forms – mandrels – to a thickness of about 5/8 of an inch. Trace impurities in the original copper remain in the acid bath.

The copper deposits onto stainless-steel cylindrical mandrels at a rate of about 0.002" per day, about one tenth as fast as human hair grows. Measurements were taken of each mandrel (shown in Figure 3) prior to removal to make sure they had reached a minimum thickness of 0.55". The copper-plated mandrels were removed from their

electrochemical baths where they were placed last July. As of mid-August, five mandrels—the first on July 28--had been sent to the newly assembled underground machine shop at the 4850 Level Davis Campus. Copper from one will be used in making a cryostat for the MAJORANA DEMONSTRATOR, and the rest for other detector components or for shielding. The baths will be filled with new mandrels as the second of four production batches gets underway.

Figure 3: Measuring the copper deposited onto a mandrel with a micrometer

While *PNNL* staff were at SURF, the team was able to make several improvements and updates to the TCR. Two additional air conditioning units were installed at the back of the TCR with the help of SURF staff. These units brought the clean room's temperature down from around 86°F to about 74°F. This will improve the efficiency of TCR operations and make the environment more comfortable to work in. A small chemical hood, a "Snorkel", was also installed for use during copper cleaning (Figure 4). The Snorkel is used to reduce fumes in the immediate area when etching the source copper with nitric acid before it is placed into the baths, to provide a much safer work environment.

Figure 4: The newly installed Snorkel, with adjustable arm to move it out of the way when not in use

The first week of August marked the beginning of ultra-pure copper produced on the 4850 Level finally being machined into parts for the MJD experiment. Machinist Randy Hughes of *Adams IFC* in Rapid City (shown in Figure 5) began machining copper in mid-July; the first batches, however, came from *PNNL*. This is taking place in the clean-room machine shop on the 4850 Level.

Figure 5: Machinist Randy Hughes uses a press to flatten one half of a copper cylinder that was electroformed at the MAJORANA Temporary Clean Room

To turn raw copper into components of scientific instruments, Randy Hughes first puts a copper-coated mandrel on a lathe to remove rough spots. He then bakes the mandrel in an oven, and dips it into water. The stainless steel mandrel shrinks in the cool water, allowing its copper coating to drop off in the form of a hollow copper cylinder.

Hughes cuts the cylinders in half, and uses a press to flatten them. He mills the flattened copper to a "one five-thousandth of an inch" under half an inch. Hughes then machines the copper plates into the parts needed. MJD spokesperson Steve Elliott of Los Alamos National Lab said that the machining could take approximately two more years.

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 now available at:
http://www.dusel.org/html/early-science-progress.html

SURF IN THE NEWS

Wall Street Journal (wsj.com): *Physicists Mine Cosmic Answers Deep Underground* (Caroline Porter, July 29)
Minnesota Public Radio (MPR) news: *Search for dark matter in South Dakota* (Tom Weber, August 22) – audio

Symmetrybreaking.com: *Proposed neutrino experiment bounces back, ready to move on* (Kathryn Jepsen, August 10)

NPR.org: *At Old Mine, Hopes of Striking Gold With Dark Matter* (Charles Michael Ray, August 1) - Four-minute story aired on "All Things Considered" South Dakota Public Radio on August 1

Black Hills Pioneer: *LUX scientists look toward future with bigger, better dark matter detector* (Wendy Pitlick, July 31)
We are made from stars (Wendy Pitlick, July 25) – an article on DIANA

Rapid City Journal: *Good, Bad & Ugly* (July 23)

DUSELwatch.com (Wendy Pitlick): *We are made from stars* (July 26)
Making a difference (July 20)

See a time-lapse video of moving the LUX dark matter detector to the 4850 Level on the Sanford Lab YouTube channel.

For twitter updates see: www.sanfordlab.org

Recent 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

SANFORD UNDERGROUND LABORATORY NEWS

Operations Department at Sanford Lab

The past few months have marked several successful milestones at Sanford Lab: the Davis Campus outfitting is complete. The installation of the Large Underground Xenon (LUX) and MAJORANA DEMONSTRATOR (MJD) experiment apparatus is well under way.

World-class science cannot take place without the Sanford Lab Operations Department. Scientific facilities need safe, reliable access to the facility in order to function. The Operations Department supports every activity that takes place at Sanford Lab. As one of many examples, Infrastructure Tech Sion Hanson (shown in Figure 6) supported the scientists and the Education and Outreach team on July 28 (a Saturday morning) during a live videoconference between the Davis campus 4850 Level and a science festival held in Sioux Falls. The Operations team maintains major facility systems such as the Ross and Yates shafts and hoists, the dewatering and water treatment systems, ventilation systems, electrical and cyber-infrastructure systems, hazard mitigation controls, and major safety systems.

Figure 6: Infrastructure Tech Sion Hanson (left) consults with two members of the LUX collaboration—Yale University physicist Markus Horn and Yale undergraduate Mikayla Thompson

Safety at Sanford Lab

As of August 4, the **Yates Shaft** will be the primary access and egress route for operations and science access between Sanford Lab surface and underground. Ross Shaft steel replacement activities have begun. The Ross Shaft rehabilitation conveyances or work decks do not have dogging mechanisms. In case of emergency, if the Yates Shaft is not available, the Ross Shaft can be prepared to support secondary access or egress for a limited time. A refuge area has been constructed at the base of the Ross Shaft on the 4850 Level to support personnel and provide a safe environment for up to 96 hours.

Figure 7: Sanford Lab Supervisor Tom Trancynger demonstrates how to put on the Oxy-K plus S *self-rescuer*

Thirty *Dräger Oxy-K plus S* oxygen-generating self-rescuers are now available at the Davis Campus. These self-contained self-rescuers are rated by NIOSH and MSHA to deliver one hour of oxygen. They have been positioned as part of secondary escape procedure protocols as researchers on the LUX and MAJORANA experiments will still take their *W65* self-rescuer respirator units underground, but these new units will provide additional protection.

Operations Safety Officer Tom Regan recently trained scientists and other staff on the care and usage of the *Dräger Oxy-K* units, and videos of that training session are available from the Sanford Lab EHS Department. Anyone who works regularly at the Davis Campus should receive this training.

Like Sanford Lab on Facebook (and also see Sanford Lab's Photo of the Day):
http://www.facebook.com/SURFatHomestake

EDUCATION AND OUTREACH

2012 Davis-Bahcall Scholars Program

Figure 8: 2012 Davis-Bahcall scholars and mentors on the 4850 Level. Left to right: Erin Yellow Hair (Pine Ridge), Jaysen Spurlock (South Dakota School of Mines), Nicholas Kantack (Brookings), Abe Schwartzrock (Wolsey), Adelyn Crabtree (Pierre), Mark Sperry (Northern State University), Sophia Elia (Rapid City), Stacy Deibert (Sioux Falls); Alex Rickel (Sioux Falls), Sanford Lab Deputy Education Director Peggy Norris, Esteben Rodriguez (Lake Andes), and Steve Gabriel (Spearfish High School)

The 2012 Davis-Bahcall Scholars arrived at Sanford Lab on July 9 for a month-long program that ended on August 4. The program had three components this year: 1) two weeks at Sanford Laboratory, 2) one week in Italy, and 3) one week in the Chicago area. Highlights included:

- A basic lecture series on modern physics
- Lectures from scientists collaborating on LUX and MAJORANA
- Development and presentation of activities for Neutrino Day
- A visit to the 4850 Level to tour the Davis Campus and to measure background in preparation for future cosmic ray muon measurements (see Figure 8)
- Three days at *Laboratori Nazionali del Gran Sasso* (LNGS) which included lectures from five scientists and students working on various experiments, plus a tour of the laboratory
- A tour of the *Laboratori Nazionali di Frascati* (LNF), Italy's largest accelerator laboratory
- A tour of Dr. Andrew Davis' cosmochemistry laboratory at the University of Chicago (Dr. Davis is the son of Ray Davis, namesake of the program - see Figure 9)
- More than two days at Fermilab, including a tour of the accelerators, the D0 detector, and discussions with scientists working on CERN experiments

- A full day at Argonne National Lab, where students toured ATLAS, a nuclear physics accelerator, a laboratory working on new accelerator technology, and the Advanced Photon Source (a source of X-rays to probe the structure of everything from proteins to better fuel injectors)
- A final day at Notre Dame University Nuclear Structure Laboratory, where students toured a tandem accelerator, learned about the DIANA project, and gave their own final presentations of something they had learned during the course of the program. The students chose to talk about a wide range of topics: dark matter, string theory, the Big Bang, neutron and proton therapy for cancer treatment, carbon nanotubes, waste-water treatment, quantum mechanics, space telescopes, and electroforming copper.

Figure 9: Dr. Andrew Davis of University of Chicago (far left) with Davis-Bahcall Scholars. From left: Mark Sperry, Sophia Elia, Abe Schwartzrock, Erin Yellow Hair, Adelyn Crabtree, Esteben Rodriguez, Stacy Deibert, Jaysen Spurlock, Alex Rickel, and Nick Kantack

Davis-Bahcall scholars focus on physics, but they also study other disciplines, and they meet engineers, technicians and others involved in underground research. Abe Schwartzrock, a physics major at South Dakota State University, noted an extraordinary degree of cooperation among various disciplines at the Sanford Lab. “Everyone’s so supportive of each other,” he said. “It’s encouraging for me, going into science, to see everyone so pleasant and patient and willing to answer questions.”

Leading-edge research, however, is not without debate. The young scholars learned that lesson firsthand, when they sat in on a lively working meeting of the Center for Underground Theoretical Physics (CETUP), a program that meets in the Black Hills every summer. “We all kind of know that’s how science works, but it was interesting to see it happen,” said Esteben Rodriguez of Lake Andes, South Dakota. He will study aerospace engineering next year at the University of Colorado at Boulder.

The Education Department thanks the following scientists, students, and staff who gave presentations or tours to the students during the course of the month:

- In the Black Hills: Drew Alton (Augustana), Cynthia Anderson (BHSU), Xinhua Bai (SDSMT), Tom Durkin (SDSMT), Steve Gabriel (Spearfish High School), Rick Gaitskell (Brown), Vince Guiseppe (USD), Bill Harlan (SDSTA), Jaret Heise (SDSTA), Kailas Ledbetter (SDSTA), Jeremy Mock (UC Davis), Harry Nelson (UC Santa Barbara), Tom Regan (SDSTA), Lisa Rebenitsch (BHSU), Tom Trancynger (SDSTA), Jim Whitlock (SDSTA)
- In Italy: Jason Brodsky (Princeton), Stefano Davini (Univ. of Houston), Johnny Goett (LNGS), Chiara Ghiano (LNGS), Matthias Junker (LNGS), and Tamaz Mohayai (Princeton)
- In the Chicago Area: Brendan Casey (Fermilab), Manoel Couder (Notre Dame), Andrew Davis (Univ. of Chicago), Umesh Garg (Notre Dame), Robert Janssens (Argonne), Micha Kilburn (Notre Dame), Don Lincoln (Fermilab), Chris Stoughton (Fermilab), Felicia Svoboda (Fermilab), and Jim Volk (Fermilab)

Teacher-in-Residence Program

Ann Hast (shown in Figure 10), a middle school teacher from West Middle School in Rapid City, was the Sanford Lab Education Department’s first Summer Teacher-In-Residence, joining the staff for ten weeks. During the course of her time at Sanford Lab, she developed material for several activities that can be used at a variety of grade levels, including a ‘Move the LUX’ Engineering Challenge, a unit on Indirect Evidence (Rutherford Scattering), and a unit on Tiltmeters. She worked on a set of webpages with a menu for classroom visits to the laboratory plus pre- and post-visit material. She led activities for Neutrino Day, the Science Festival in Sioux Falls, and Spearfish Friday night. She also assisted with SciGirls, group visits, and multiple teacher workshops. The culmination of her experience at Sanford Lab was a Brown Bag lunch for Sanford Lab staff where she discussed the integration of engineering practices into the Next Generation Science Standards, and field-tested the Move the LUX activity. Everyone in the Education Department appreciates Ann’s enthusiasm, hard

work, and dedication in linking Sanford Lab science and engineering to the K-12 classroom.

Figure 10: Teacher-in-Residence Ann Hast inside a bubble

ENVIRONMENT, HEALTH & SAFETY

Back to School Safety

- Please drive slowly (~10 mph) in the area near Sanford Lab (Summit Street) and watch for the neighborhood kids on bikes.
- Have your child wear a helmet if he or she is riding a bike to school. Make sure the helmet fits correctly.
- Know the rules of the road: ride on the right side of the road single file, and come to a complete stop before crossing the street.
- Wear bright colors during the day. At night, have a white reflector in front of the bicycle and a red reflector in back. You can also put reflective materials on shoes and clothing.

Safety pages on Sanford Lab website:
www.sanfordlab.org - Use the left hand menu

STAFF NEWS

Will McElroy and **Dianna Jacobs** completed PMI Project Management Professional certification in July.

Greg King will lead the newly formed SDSTA Operations Development and Assurance Department. He will focus on the development and advancement of Sanford Lab's operations maintenance program. Greg will take on this major challenge to improve the planning and execution of maintenance efforts that will contribute to a higher level of safety at Sanford Lab. As part of the re-organization, Mike Headley will serve in the Sanford Lab Operations Director role.

UPCOMING CONFERENCES AND WORKSHOPS

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

NNN12: Next Generation Nucleon Decay and Neutrino Detectors - October 4-6, 2012, Fermilab, Batavia, IL.
http://conferences.fnal.gov/nnn12/

IWAA12: International Workshop on Accelerator Alignment - September 10-14, 2012, Fermilab, Batavia, IL.
https://indico.fnal.gov/confLogin.py?returnURL=https%3A%2F%2Findico.fnal.gov%2FconferenceDisplay.py%3FconfId%3D4712&confId=4712

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

JOBS

Assistant Professor position in Experimental Particle Astrophysics, Dept. of Physics & Astronomy, University of South Carolina. Collaborate with ultra-low background searches for dark matter, zero neutrino double beta-decay, and axions. Prof. Frank T. Avignone, Chair of Particle Astrophysics Search Committee, USC Physics & Astronomy, 712 Main St., Columbia, SC 29208. avignone@sc.edu. Deadline: 11/30/12.
http://www.physics.sc.edu

Assistant Professor position in Experimental Nuclear Physics, Duke University. Research in

electroweak interactions, neutrino physics, hadron structure, and nuclear astrophysics. Queries to: Calvin Howell, Chair of the Search Committee, howell@tunl.duke.edu with message subject "NP Search". Deadline: 11/30/12.
http://www.tunl.duke.edu/web.tunl.2011a.jobs.php

Postdoctoral positions – Experimental Particle Astrophysics, Queens University. Research on DEAP-3600 dark matter experiment with possible travel to SNOLAB. Mark Boulay, Associate Prof. & Canada Research Chair in Particle Astrophysics, DEAP Project Director, Dept. of Physics, Queen's University, Kingston, ON K7L 3N6 CANADA, c/o Louise Segsworth. louise.segsworth@queensu.ca
http://www.sno.phy.queensu.ca/group/

Postdoctoral Researcher position – Center for Neutrino Physics, Virginia Tech. Study of neutrino oscillations, working primarily on the Daya Bay Reactor Neutrino Experiment in China. Prof. Jonathan Link, jmlink@vt.edu, Virginia Tech Physics Dept., 317 Robeson Hall, M/C 0435, Blacksburg, VA 24061. Job #0121584. http://www.jobs.vt.edu

Postdoctoral Research Associate in Astroparticle Physics – Purdue University, Indiana. Participate in XENON Dark Matter search. Design calibration systems, analyze data from the XENON100 experiment. Dr. Rafael Long, c/o Emjai Gregory, Purdue University, Dept. of Physics, 525 Northwestern Ave., West Lafayette, Indiana 47907. egregor@purdue.edu. Deadline: 9/28/12.

Process Development Engineer – Fluke Corporation. Knowledge of Physics, Electronics, and Material Science will be relevant. Position is at corporate headquarters in Seattle.
https://danaher.taleo.net/careersection/external/jobdetail.ftl?lang=en&job=FLU000738

Newsletter Editor: Melissa Barclay
Contributors: Kevin Lesko; Bill Harlan (Sanford Lab local news); Vic Gehman and Mia Ihm (LUX Experiment Milestones); Anne-Marie Suriano (Copper Electroforming at the 4850 Level); Peggy Norris, Ben Sayler (Education and Outreach)

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Note: Berkeley Office will be moving September – October !