

Dear SURF Readers,

Welcome to the December 2012 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](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**

**March 5, 2013: DURA meeting – SLAC, Menlo Park, CA**

**March 2013: LUX ZEPLIN (LZ) Collaboration Meeting – Lead, So. Dakota**

**FIAT LUX**

*(Report from SURF underground with LUX Graduate Student Mia Ihm and Postdoc Alastair Currie)*

Christmas came early when LUX received the gift of light during the second week of December. After months of rebuilding systems and setting up some new ones, 2 kg of gaseous xenon was finally introduced into the detector. When in its final operating state, LUX will carry over 350 kg of liquid xenon, but this initial batch will allow for some science and characterization of the detector to be done prior to the full cooldown early in 2013. Just a day after LUX was filled, the 122 photomultiplier tubes were fired up and saw their first scintillations from xenon since going underground (See Figures 1 and 2). Photomultiplier tubes, or PMTs, are the light sensors that tell us about the interactions going on in the xenon. On top of that, we also have water circulating in our 250 tonne water tank, which acts as a radiation shield. It's official: we have a working detector!

The concept of light is particularly exciting for one who works underground. Usually the sun will not have yet risen above the Black Hills when we take our morning cage down, and then the sun will have already set when we've resurfaced for the day. We will take any light we can get, but the 178 nm VUV light emitted by xenon might be the most beautiful of all.

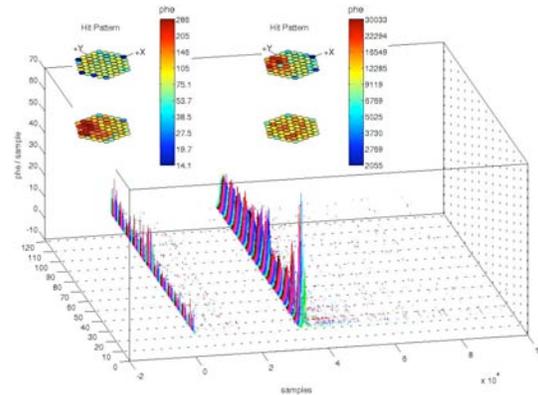


Figure 1: Light seen by the LUX detector from an alpha particle. Individual PMTs and PMT intensities.

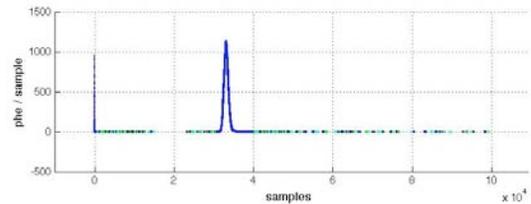


Figure 2: The same alpha event, summed response across all PMTs. The two signal pulses, scintillation followed by ionization, are a feature of LUX and important to informing LUX scientists about the nature of the interactions occurring in the detector.

Despite all the excitement over this important milestone of first light, there is no slowing down at LUX. The task of condensing the rest of the xenon still remains, and now with the detector operational, the data requests come pouring in. A crew of LUX winter warriors will be on site at SURF through Christmas and New Year's to keep things running. Then come January, a swarm of eager scientists will descend upon the Davis cavern to learn how to operate the detector and to push LUX towards completion.

As the advent of a fully finished LUX detector fast approaches, the anticipation over learning some real physics grows. Years of hard work have been leading up to this point, and a new, exciting era for LUX is just around the corner.

**Northwest Mining Convention**

The Northwest Mining Association hosts a convention every year, complete with a trade show, technical presentations, and short courses. Mining

professionals have an opportunity to share and learn new technology and project-based techniques applied in the field from others in the mining industry. This year, the event took place on December 2-7 in Spokane, Washington.

The underground technical session included a discussion from SURF regarding the laser survey performed in the Oro Hondo Shaft. SURF Science Integration Engineer Wendy Zawada teamed with Senior Project Engineer for *Zapata Engineering* Kanaan Hanna (shown in Figure 3) to give a presentation on the 3D laser scan of the Oro Hondo shaft previously completed for the DUSEL Preliminary Design Report. Although SURF is now operating on a smaller scale, the need to understand conditions in the main ventilation exhaust shaft remains important. Mr. Hanna outlined the steps used to create the 3D model from data collected in the field. *Zapata Engineering* and SURF completed the 3D laser survey in July 2010; data generated from this survey were used as a basis to lay out a detailed rehabilitation design.



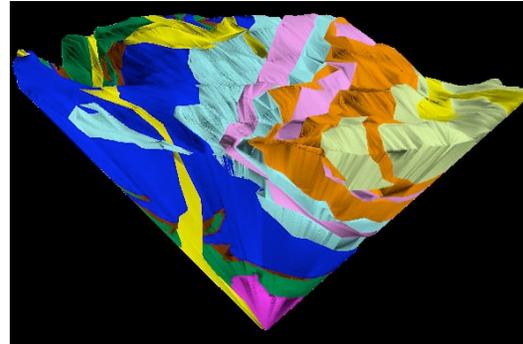
*Figure 3: Kanaan Hanna, Senior Geotechnical Engineer of Zapata Engineering gives a presentation at the Northwest Mining Convention*

**Mapping cone of rock over Davis Campus**

Two geologists working at Sanford Lab have provided a valuable resource for LUX and MAJORANA DEMONSTRATOR experimenters. Kathy Hart, Sanford Lab Consulting Geologist, has been conducting research on a project focused on the cone of rock whose tip rests on the Davis Campus 4850 feet underground. The circular base of the cone is located on the surface of the Black Hills, with the Open Cut to the north, and Kirk Canyon to the south of the Sanford Lab facility.

Hart has entered geological data for all the rock in this cone into a database and has also provided graphic information (shown in Figure 4). Sanford Lab Geologist Tom Trancynger compiled data on rock

density and geochemistry for the study. The rock includes seven major rock formations and various subgroups within those formations. Rock formations include the Ellison (in dark blue), the Northwest (light blue), the rhyolite dike (yellow), amphibolite (lavender), the Flagrock (gold) the Homestake (brown), the Poorman (green), and the Yates Member (hot pink at the bottom).



*Figure 4: This graphic cone represents the 3D mapping of rock above the Davis Campus. The point of the cone is at the 4850 Level, and the Open Cut is at top left, on the surface*

Science Liaison Director Jaret Heise says that their work will help physicists to better predict background noise at experiments on the 4850 Level, as they now know the rock properties and the various formations above the Davis campus. Researchers can use this data to calculate and simulate the muon flux showering down through the rock into the Davis Campus area. Heise chose the 45-degree cone of rock for the study to capture the particles most likely to interfere with potential experiments.

More in-depth details to come in a future issue of the SURF newsletter!

**LBNE updates**

On December 10, LBNE reached an important milestone when DOE approved Critical Decision-1 (CD-1) for the LBNE project. DOE Project Director Pepin Carolan extended congratulations to the LBNE team and collaboration, acknowledging their hard work and cooperation. The LBNE project can now advance into the preliminary design phase, which includes the design for the LBNE far detector and planned facilities at Sanford Laboratory.

*LBNE has a new co-spokesperson:* Robert Wilson of Colorado State University will fill this position for 2013-14, joining Milind Diwan from Brookhaven.



**In Memoriam: Stuart J. Freedman - 1944-2012** (Photo: Courtesy Roy Kaltschmidt, LBNL)

Friends and colleagues of Stuart Freedman were shocked and saddened at his sudden passing on November 9 while he was attending a conference in Santa Fe. Stuart had a distinguished career in experimental physics, having graduated from UC Berkeley with a PhD in Physics in 1972. Most recently, he was a force in underground science as the leader and spokesperson for KamLAND in Kamioka, Japan and also as a member of the collaboration of the CUORE neutrinoless double-beta decay experiment at the Gran Sasso Lab in Italy. After serving in other appointments at Princeton, Stanford, Argonne, and the University of Chicago, Freedman returned to UC Berkeley as a Physics professor and member of LBNL's Nuclear Science Division in 1991.

Throughout his career, Freedman received many honors including appointment to UC Berkeley Physics Department's Luis W. Alvarez Memorial Chair, election to the National Academy of Sciences, and the Bonner Prize for Nuclear Physics from the American Physical Society.

Stuart's family has asked the Physics Department to establish the Freedman Graduate Fellowship, to be given to a top physics graduate student. To contribute or learn more about this fund, contact: Maria Hjelm, Development Officer, UC Berkeley Physics Dept., 366 LeConte Hall, Berkeley, CA 94720 or mhjelm@berkeley.edu.

To read more about Stuart Freedman:  
[LBNL Press release](#) – November 16  
[UC Berkeley Physics – In Remembrance](#)

**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.dusel.org/html/early-science-progress.html>

**New SURF website**

The new SURF website was launched on November 15. <http://www.sanfordlab.org/>

Like SURF on Facebook:  
<http://www.facebook.com/SURFatHomestake>



**SURF IN THE NEWS**

*New York Times* (also MSN.news, Huff Post Science, Washington Post, and other AP): [Dark matter detector nearing activation in SD mine](#) (Amber Hunt, November 20)

*Brown Daily Herald*: [Physicists across nation seek dark matter](#) (Sonia Phene, December 5) – with Kevin Lesko

*Symmetry.com*: [DOE grants CD-1 approval to LBNE project](#) (December 11)

[LUX detector: Search for dark matter underground](#) (November 29)

[East Coasters brave Hurricane Sandy to keep neutrino project on schedule](#) (November 5, Kathryn Jepsen)

*UCL news (London)*: [Dark matter detector installed and submerged in South Dakota](#) (November 15)

*University of Rochester*: [Dark matter detector installed underground and submerged](#) (Leonor Sierra, November 15)

*The Register*: [WIMP-seeking detector flooded](#) (Richard Chirgwin, November 22)

LBNL news: [First purified germanium delivered to MAJORANA DEMONSTRATOR](#) (Paul Preuss, November 15)

LLNL news: [LLNL scientists assist in building detector](#) (Anne Stark, November 16)

KDLT news: [Guard, Sanford Lab train for emergency response](#) (AP, November 16)

*Black Hills Pioneer* (with Wendy Pitlick): [Science and Art](#) (November 29)

[Training for disaster](#) (November 26)  
[LUX ready for testing](#) (November 16)

*Rapid City Journal*: [Doors to discovery to open](#)  
 (Editorial, November 25)

[Dark matter detector submerged in water tank](#) (Bill Harlan, November 21)

For *twitter* updates see: [www.sanfordlab.org](http://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](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](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](http://science.energy.gov/~media/np/pdf/Review_of_Underground_Science_Report_Final.pdf)

LBNE Reconfiguration Report:  
[http://www.fnal.gov/directorate/lbne\\_reconfiguration](http://www.fnal.gov/directorate/lbne_reconfiguration)

### DURA Election and meeting

The Underground Research Association Executive Committee (DUREC) is calling for nominations and will hold an election before the next annual meeting of DURA. The DURA meeting is scheduled to be held on March 5, 2013 at SLAC in Palo Alto, prior to the *Cosmic Frontier Meeting and Workshop* of March 6-8. Please contact chair Richard Gaitskell (Richard\_Gaitskell@brown.edu) to recommend DURA members who are interested in serving on DUREC. Currently, DUREC has seven members from Physics experiments, and two members from Bio-Geo-Engineering (BGE) backgrounds. The terms for DUREC are normally for three years. For further information on DURA, see:  
<http://sanfordlab.org/dura>

### SANFORD UNDERGROUND LABORATORY NEWS

#### MAJORANA DEMONSTRATOR (MJD) Update

On December 6, Lawrence Berkeley National Lab physicist Ryan Martin (shown in Figure 5) and his team assembled the first of 70-plus detector units for

the MAJORANA DEMONSTRATOR experiment. The final assembly took about 2½ hours. Martin had previously simulated the complex process on the surface at LBNL, but this was a first while wearing four pairs of protective gloves. Everyone on the experiment must wear hooded Tyvek coveralls and two pairs of nitrile gloves to protect the experiment from all possible sources of background radiation or outside contamination.



*Figure 5: Ryan Martin assembles a detector unit in the glovebox of the MAJORANA DEMONSTRATOR assembly room at the Davis Campus 4850 Level*



*Figure 6: Fused silica (glass) low mass front-end board, with electronics loaded, is mounted in a copper leaf spring*

The detector units are being assembled inside a nitrogen-filled glovebox inside the clean room. Once Martin has inserted his double-gloved hands into the glovebox gloves, he puts on a fourth pair of gloves that have been positioned inside the box.

A polished germanium crystal produced under pristine conditions is connected to the fused silica (glass) low-mass front-end board (LMFE) upon which is mounted the electronic circuits that will relay signals from the germanium detectors. The LMFE is mounted on a copper leaf spring, and a pin makes the connection with the germanium.

The assembly rate, which involves a meticulous set of procedures, has been averaging about one per day. Much additional work remains. These first detectors consisted of natural germanium, and will

be used in prototype detectors to test the experiment before installation of the enriched germanium—detectors with a higher percentage of the isotope  $^{76}\text{Ge}$ . The first two enriched detectors have already been completed by *ORTEC*, a contractor in Tennessee. Some of the details were reported in the November SURF newsletter. Enriched germanium will begin to arrive at Sanford Lab in early 2013.

### Liquid Nitrogen arrives to LUX

On November 17, Sanford Lab technicians delivered the first load of liquid nitrogen (LN) to LUX, using the new LN cart. The LN cart consists of an 1100-liter Dewar vacuum flask welded to the carriage of a former Granby (3-½ ton side-dump rail car once used to haul rock underground).

Bryce Lutz of *Matheson Gas* (Rapid City) trained SURF Science Liaison Supervisor Connie Giroux and Infrastructure Tech Pat Urbaniak on how to fill the large Dewar. Giroux, who already has a great deal of experience handling LN transport, said that safety procedures include wearing the standard protective equipment of face shields, safety glasses, cryogen gloves, hard-toe boots, and long pants without cuffs.

The LN cart delivered enough liquid nitrogen to fill the LUX experiment's four 450-liter Dewars on the 4850 Level.



*Figure 7: New LN cart with liquid nitrogen to fill the LUX dark matter detector*

### Safety at Sanford Lab

*Sanford Lab's Emergency Response Team (ERT)* conducted its monthly safety drill on November 15. A simulated "disturbing odor" at the Yates Education and Outreach Building was part of the exercise between the ERT and the South Dakota National Guard's 82<sup>nd</sup> Civil Support Team (CST). The latter group includes members of the Army National Guard

and the Air National Guard. Local media were invited to observe the exercise. Some of their reportage links can be found on SURF in the News on Page 3.

The ERT group put on their Dräger BG4 closed-circuit breathing apparatus to check the source of the gas: open unmarked bottles containing unknown substances. ERT Coordinator Woody Hover indicated that team members have been trained to recognize threats that require outside expertise or additional equipment, which was the case here.

About twenty minutes later, two Black Hawk helicopters (shown in Figure 8) arrived from Ellsworth Airforce Base. Ellsworth is about 35 air miles from Sanford Lab. The Black Hawks landed in the Yates parking lot, and 10 CST personnel unloaded equipment. Team members donned Hazmat suits before entering the Yates Education Building.



*Figure 8: Two Black Hawk helicopters land in the Yates parking lot for a joint exercise drill between the Sanford Lab Emergency Response Team and the South Dakota National Guard*

*In another safety drill*, the Davis Campus was evacuated on November 29 due to a low-oxygen level warning. Twenty-five scientists, technicians, and engineers used the simulated event to successfully evacuate their labs. The goal was to set in motion and evaluate the Lab's Emergency Response Plan (ERP). Retired Operations Safety Officer Tom Regan, who continues to serve as a safety consultant and member of the Emergency Response Team (ERT), helped manage the scenario. All members involved in the drill arrived at the Area of Refuge (shown in Figure 9) within 32 minutes. The ERT will evaluate lessons learned and refine the ERP so they will be better prepared in the event of a real emergency.



Figure 9: Davis Campus researchers at the Area of Refuge near the Ross Shaft

## EDUCATION AND OUTREACH

### Moving the LUX

The *Moving the LUX* engineering activity developed by Sanford Lab's Teacher-in-Residence Ann Hast this past summer has proven popular among students of all ages and genders, especially when combined with Multimedia Specialist Matt Kapust's time-lapse video of the actual move of the LUX detector from the surface lab underground. Engineering was the theme for the November SciGirls sessions, so students collaborated on finding a solution to move a model of the LUX detector (a sand-filled film canister) smoothly across a rough surface (a cookie sheet lined with foil and some hidden obstacles). They followed the engineering design process of *Ask, Imagine, Plan, Create, Improve*, and back to *Plan* to come up with many creative solutions. The same activity was used by SURF Science Education Specialist Julie Dahl with Prairie Hills Home Schoolers, ranging in age from kindergarten through eighth grade.

### Sanford Lab Day in Huron, South Dakota

On December 4, Huron, a town of 13,000 in the north-central part of South Dakota, celebrated Sanford Lab Day. A luncheon arranged for local service groups, educators, and the general public attracted over 150 people. Sanford Lab Communications Director Bill Harlan choreographed the program. Bill, along with Executive Director Ron Wheeler, Vince Guiseppe (University of South Dakota, MAJORANA Collaboration) and Jeremy Mock (UC Davis, LUX) gave presentations. Jeremy joined by videoconference from the LUX facility at the Davis Campus. Afterward, teachers and students stayed for an additional hour to ask questions and to discuss educational opportunities with Education and Outreach Director Ben Saylor and Deputy

Director for E&O Peggy Norris. Peggy also participated from the Davis campus.

### 'Lunch and Learn' Brown Bag Seminar

At a Brown Bag Lunch on November 28, Bill Harlan gave staff and community members a tour of the new Sanford Underground Research Facility website, recently launched at [www.sanfordlab.org](http://www.sanfordlab.org). He also showed the group Sanford Laboratory's presence on social media pages such as Twitter (#SanfordLab), Facebook, and YouTube (where you can check out [Matt Kapust's time-lapse video](#)).

### Connecting Science and the Arts Event

Jodi Lomask of *Capacitor Dance* in San Francisco visited Sanford Lab December 3-4. While in the area, Jodi gave two lectures sharing her process of creating dance and acrobatic pieces by bringing scientific experts together with artists. She demonstrated her final products through videos of her dance troupe. Meetings were arranged with local arts groups, and preliminary plans are underway to bring her troupe to the Black Hills in the future. Jodi also toured the Davis campus and talked to scientists and students about the search for dark matter and about neutrinos. We look forward to seeing a future dance piece on these topics. Jodi's visit was hosted in collaboration with the *Science and the Arts* program led by Professor Brian Schwartz of the City University of New York Graduate School.

## ENVIRONMENT, HEALTH & SAFETY



### Holiday Safety

**Fires:** Inspect decorative lights before installing. Do not leave candles unattended. If you have a natural tree, keep it watered. This is a good time to change the batteries on your smoke alarm.

**Drinking:** Appoint a designated driver. Have your drink at the beginning of the party. Know your limit, and eat food while you drink. Don't be afraid to call a cab.

**Pets:** Protect your pets from pine needles, mistletoe, holly, electric lights, candles, and tinsel. Give them their own festive toys and treats.

**Happy Holidays!**

## STAFF NEWS



**Michelle Andresen** has joined the SURF staff as an Administrative Assistant. She will be working mainly with EHS Director Joe Gantos. She has been an Executive Assistant for over 12 years with such companies as *Daktronics* of Brookings, South Dakota, *VeraSun Energy Corp.*, and *Great Western Bank* in Sioux Falls. Her years of experience as an assistant have provided her with strengths such as organizational skills, knowledge of numerous software programs, and the confidence to incorporate her experience into the department. She feels that being part of the EHS department will expand her knowledge and experience unlike any other previous position. Michelle says, "I'm very excited for the opportunity to be a contributing member of the EHS department and SURF!"

Michelle has been married to her husband, Rob for 23 years. He retired from the military after 21 years of service. Rob's career in the Veterans Administration in Ft. Mead, South Dakota was an opportunity for their family to move back to the Black Hills area. They have two children: a daughter, Rachel, who is a sophomore at USD (University of South Dakota) and a son, Reilly, a freshman at Lead-Deadwood High School. A second set of "kids" consists of two yellow labs named Bailey and Remi.

Her personal interests include golfing, trying new recipes, reading, and a new hobby (since moving to the Lead area) of hiking.

Michelle's favorite quotes (which she shares with her children):

*Treat others as you want to be treated*  
*Pray hardest when it's hardest to pray*



**George Krebs**, SURF Water Treatment Plant Operator, has retired. He joined the SURF (then DUSEL) project in 2009.

## UPCOMING CONFERENCES AND WORKSHOPS

**American Physical Society April annual meeting**, International Physics Focus Group, Sheraton Denver Downtown Hotel, Denver, CO. April 13-16, 2013. Abstract due date: January 13, 2013.  
<http://www.aps.org/meetings/april/>

**New Directions in Neutrino Physics**, Aspen Center for Physics, Aspen Colorado. February 3-9, 2013. The emphasis of the conference will be on how new experimental techniques and theoretical ideas will impact the future directions of the field.  
<http://aspenphys.org/physicists/winter/currentconferences.html>

**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>

**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, 47<sup>th</sup> US Rock Mechanics/Geomechanics Symposium**, Westin San Francisco Market Street, San Francisco, CA. June 23-26, 2013.  
<http://armasyposium.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 positions in Physics at South Dakota School of Mines.** New SURF-related research program in particle physics, studying 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. Deadline: 1/7/13.

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

**Postdoctoral Research Assistant for the SNO+ experiment. Department of Particle Physics, University of Oxford, England.** Explore a diverse range of physics, including neutrinoless double beta decay, low energy solar neutrinos, and neutrinos from supernovae. Deadline: 1/11/13.

s.biller1@physics.ox.ac.uk; s.geddes1@physics.ox.ac.uk  
<http://www2.physics.ox.ac.uk/about-us/job-opportunities>

**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>

**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>

**Postdoctoral positions – Experimental Particle Astrophysics, Queens University.** Research on DEAP-3600 dark matter experiment. Mark Boulay, Assoc. Prof. & Canada Research Chair in Particle Astrophysics, DEAP Project Dir., Dept. of Physics, Queen's Univ., Kingston, ON K7L 3N6 Canada, c/o Louise Segsworth. louise.segsworth@queensu.ca  
<http://www.sno.phy.queensu.ca/group/>

**Newsletter Editor:** Melissa Barclay

**Contributors:** Kevin Lesko; Bill Harlan (Sanford Lab local news); Mia Ihm, Alastair Currie (FIAT LUX); Wendy Zawada (Northwest Mining Convention); Peggy Norris, Ben Saylor (Education and Outreach)

**Photo Credits:** Figs. 1-2: Alastair Currie (Imperial College, London); Fig. 3: Wendy Zawada; Fig. 4: Kathy Hart; Figs. 5-6: MAJORANA collaboration; Fig. 7: Bill Harlan; Fig. 8: Matt Kapust; Fig. 9: Tom Regan. Photo of Stuart Freedman, Courtesy of Roy Kaltschmidt, LBNL

**Lawrence Berkeley National Lab**

Kevin T. Lesko: 510-486-7731  
 KTLesko@lbl.gov

Melissa Barclay: 510-486-5237  
 mbarclay@berkeley.edu

**SDSTA/Sanford Lab**

Ron Wheeler, Executive Director  
 Mandy Knight, 605-722-8650, x222  
 MKnight@sanfordlab.org

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

**BERKELEY OFFICE  
 New address**

**SURF Project Office  
 Lawrence Berkeley National Lab (LBNL)  
 One Cyclotron Road  
 MS 50B-5239  
 Berkeley, CA 94720**