

## Dear Homestake Collaboration,

Welcome to the May 2011 monthly newsletter for Homestake DUSEL and South Dakota's Sanford Laboratory. We gladly receive your input on news, links to news articles, upcoming workshops, conference notices, scientific updates, information concerning DUSEL, employment opportunities, and other highlights relevant to our shared goal.

### Important Dates

**Week of June 6: DUSEL PDR Review Dry Runs**

**June 21-22 – Joint FNAL and DUSEL Program Advisory Committee Meeting, Aspen CO**

**June 22-24 – HEPAP Meeting, Washington, DC**

**July 19-21: Final PDR review – Lead, So. Dakota**



## Re-engaging the NSF in a DOE-led DUSEL Facility

by Kevin T. Lesko (*DUSEL Principal Investigator*)

A frequent topic of discussion among the DUSEL Management and the funding agencies since the National Science Board (NSB) action in December 2010 which denied further funding for the development of the DUSEL facility and its suite of experiments (ISE), has been how to best re-engage the National Science Foundation in DUSEL's scientific programs. The NSB strongly endorses DUSEL's scientific goals and has encouraged Project Management and scientific leaders to actively pursue avenues for involving the NSF in these science programs. [1,2]

The DOE is proactively seeking to understand the scientific opportunities and implications of DOE oversight of the DUSEL facility. The DOE *Office of Science* Independent Review of Options for Underground Science Committee, co-chaired by Jay Marx and Mark Reichenadter, has engaged the scientific community and DUSEL Project Management in soliciting input to assess the options for DOE's principal underground Science Missions:

Long Baseline Neutrinos, Dark Matter Searches, and Neutrinoless Double Beta Decay experiments. The DOE focused on these three topics to determine the future of activities that are already in progress for the DOE [3].

The *National Academy of Sciences* is expected to complete its assessment of Underground Science in the near future [4]. It is widely anticipated that their report will further inform the DOE Office of Science Independent Review. The National Academy study will address DUSEL's full spectrum of research including additional physics topics, notably Nuclear Astrophysics, additional neutrino research, the biology, geology and engineering topics discussed in the Project's Conceptual and Preliminary Design Reports, as well as Education and Public Outreach opportunities associated with DUSEL.

The DUSEL Project completed its Preliminary Design in March 2011. The Design was successfully reviewed by the Project's internal review committee, chaired by Mike Witherell. The Project has completed its final edits to the Preliminary Design Report (PDR) for a May 2011 submission and is now preparing for an agency review of the Preliminary Design in July 2011. The PDR includes a thorough discussion of the full spectrum of science opportunities considered by the DUSEL Project. The Facility design is responsive to this wide spectrum of science included in the ISE to ensure that the design enables a wide range of intellectually exciting and scientifically transformational experiments.

Furthermore, DUSEL's science missions were reviewed by the DUSEL Program Advisory Committee (PAC) in 2010 and again in 2011 [5]. The selection of near-term science goals for the NSF's DUSEL was informed by discussions with the funding agencies, the DUSEL PAC as well as engaging the scientific community through comprehensive workshops and through the DUSEL Research Association (DuRA) [6].

Subsequent to the NSB actions, the Project and its NSF program officers have responded to the DOE's requests to consider "cost-effective options for implementing a world class program of underground science assuming only DOE resources". Using the PDR as the basis of estimate, the Project has developed facility design options responsive to DOE's Office of Science Independent Review charge. The Project produced advanced cost and schedule estimates for these options. These

options, Plans B and C, would host the LBNE project at Homestake using the 4850L for the Water Cherenkov Detector LBNE option and/or this level or perhaps a higher level, 800L, to host the Liquid Argon Detector option. Plans B and C are distinguished in providing laboratory space at the 4850L or the 7400L, respectively, to host Dark Matter or Neutrinoless Double Beta Decay Experiments. The Project has continued to refine these options in discussion with scientific collaborations, the Project's advisory boards and committees, the DOE's LBNE Project, as well as the funding agencies.

In parallel with these developments, the NSF's Geosciences Directorate independently assessed the geosciences scientific opportunities provided by DUSEL [7]. In addition to endorsing DUSEL's geosciences ISE projects, this assessment highlighted further scientific opportunities including some mentioned in DUSEL's Conceptual Design and PAC reports, but which were not subsequently actively developed by scientific collaborations.

While the Project's Plans B and C are focused on addressing the DOE's three primary physics experimental areas, other experiments and disciplines can be re-introduced into the core facility design – the Project has taken steps ensuring that additional experiments could be integrated to the facility – when their plans have been adequately advanced and their project sponsors are identified. Included in all versions of the Project's response to the DOE's assessment are 1) the Early Science program including a Generation-1 Dark Matter Experiment, LUX, the MAJORANA DEMONSTRATOR neutrinoless double beta decay project, nearly a dozen biology, geology and engineering efforts and 2) a significant education and outreach effort strongly supported by South Dakota and T. Denny Sanford.

It is important for us to recognize that the process for introducing science deployments into the core facility design is evolving with the proposed change of facility leadership from the NSF to the DOE. As a proposed NSF MREFC-funded project we effectively included the ISE under a single funding umbrella and developed the entire science program as a single proposal. This original MREFC-funded process introduced some tension among experiments and disciplines: some experiments were more advanced in their development than others; some were more accustomed to using

experimental user facilities; and, a single MREFC approach constrained the scope for the experiments within the MREFC project's total cost and schedule. Relaxing the single MREFC-only funding constraint may benefit DUSEL's science programs. This introduces a wider variety of funding paths, many more appropriate for the variety of project scales being considered: everything from PI-driven proposals to NSF Major Research Equipment and NSF Major Research Instrumentation proposals, to stand-alone MREFC applications, to additional DOE-sponsored Projects. These projects can individually develop and mature as appropriate and seek to be integrated into the facility as their plans become sufficiently mature. The collaborations will be expected to develop their plans and make their scientific arguments in a more autonomous fashion. Communication with the facility design team will require an additional effort both from the collaborations and the DUSEL team. This new approach will benefit from strong scientific leadership arising from the scientific communities and collaborations. DUSEL management stresses, however, that the development of concepts in isolation from the facility designers will likely lead to delays and complications in integrating the requirements into the facility plans. Close collaboration between the various collaborations and the Project will be required to ensure other science opportunities are adequately addressed in DUSEL plans as we move forward.

The wide spectrum of science identified by the DUSEL project, endorsed by the PAC, and addressed in earlier National Academy and agency reports, long range plans, and community efforts all benefit from full integration into the facility design. While some efforts are more clearly aligned with one agency rather than the other, all the efforts involve DOE- and NSF-supported scientists and engineers and we have not identified projects that were exclusively "DOE-science" or "NSF-science". The Project considers it among its highest priorities to re-engage the NSF to ensure that all US scientists will have an opportunity to benefit from DUSEL's transformational science and to help ensure that the most exciting opportunities are advanced. Through the active involvement of both the DOE and NSF we foresee the greatest benefits to the entire underground science program, the maximum realization of synergistic benefits, and greatest reduction of overall costs through the increased sharing of infrastructure and facilities. The DUSEL Project has made great strides in producing a

cohesive and integrated community of multidisciplinary users of the DUSEL facility. The Project Management is committed to continuing to work with all scientific, engineering, and educational users to ensure the development of the optimum research program matched to the facility. We look forward to working with scientific collaborations as they develop scientific plans and would be pleased to proactively engage the NSF seeking ways to support of these experiments within DUSEL's suite of scientific experiments.

## References

1. Ray Bowen, chair of the NSB:  
<http://www.aps.org/publications/apsnews/201101/nsffunding.cfm>
2. Barry Barish, consultant to the NSB:  
[http://sites.nationalacademies.org/BPA/BPA\\_060036](http://sites.nationalacademies.org/BPA/BPA_060036)
3. Charge Letter to the Committee can be found at:  
[http://lbne2-docdb.fnal.gov/0035/003501/001/DUSEL\\_Charge\\_Letter.pdf](http://lbne2-docdb.fnal.gov/0035/003501/001/DUSEL_Charge_Letter.pdf)
4. National Academy of Sciences site addressing DUSEL Science can be found at  
[http://sites.nationalacademies.org/BPA/BPA\\_058955](http://sites.nationalacademies.org/BPA/BPA_058955)
5. The DUSEL PAC reports can be found at  
<http://www.dusel.org/html/pac.html>
6. The DuRA website can be accessed from  
<http://www.dusel.org/html/dura.html>
7. The NSF Geosciences Advisory Committee report can be down loaded from  
[http://www.nsf.gov/geo/geoac\\_subcomm\\_rpts.jsp](http://www.nsf.gov/geo/geoac_subcomm_rpts.jsp)



*Figure 1: At Sanford Lab, LUX Principal Investigator Rick Gaitskell inspects dark matter detector*

## LUX and Dark Matter – Part I *Why search for Dark Matter?*

Ever since the idea of a major underground science laboratory at DUSEL was first proposed several years ago, physicists involved in one particular category of experiment have always expressed great interest in being a part of it. These experiments are Dark Matter Searches.

Dark matter has been an important topic in particle physics and cosmology for almost 80 years, ever since Swiss astronomer Fritz Zwicky first observed in 1933 a discrepancy between the amount of light emitted by a cluster of far-away galaxies, and the total amount of mass contained within that cluster as inferred from the relative motions of those galaxies, and simple application of Isaac Newton's theory of gravitation.

The surprising result from Zwicky's observation was that the vast majority of the mass in the galaxy cluster did not emit any visible light or other electromagnetic radiation. This went contrary to the instinctive assumption that in such a large collection of galaxies most of the mass would be carried by the stars. For instance, within our own solar system the Sun is more than 700 times heavier than all of the planets and known orbiting objects together. It is not unreasonable to assume that the same would be true at the galactic and super-galactic scale.

Over 80 years of further observations, covering a wide range of cosmic scales and experimental techniques, continue to point out the same result as well as refining it. We now know with certainty that in the entire Universe, all the matter we know—the stars, planets, intergalactic gases, and other cosmic objects such as black holes—can only account for less than 5% of the mass we know to be there. Five times more abundant is an unknown: a kind of matter that needs to be there to explain the gravitational behavior of galaxies that we have never been able to see. It could be everywhere, permeating our galaxy and others like it, surrounding us at any given time with incredible density, yet stubbornly avoiding detection despite more than twenty years of dedicated efforts from particle physicists all over the world. Scientifically, this is both very frustrating and very exciting.

Many theories have been crafted to try to predict what this dark matter really is, and more are being proposed nearly every week. Many of the most compelling predict the existence of a new kind of elementary particle which would possess significant mass and interact with ordinary matter exclusively through gravity and through the weak force, one of the four fundamental forces of nature, which governs processes such as radioactivity. The weak force has an extremely short range, smaller than the size of a single nucleon, which would explain why dark matter particles are so difficult to detect: one has to literally bump head-on into an atomic nucleus of ordinary

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matter in order to leave any sign of its passage. Because an atom is essentially empty space (a nucleus surrounded by its electronic cloud is equivalent to a marble sitting at the center of a kilometer-wide sphere), and because a dark matter particle, albeit massive, is still extremely small, this is a very rare occurrence.

It is still statistically possible; the trick to dark matter detection is then to design a detector sensitive enough to register the tiny bump of a dark matter particle into an ordinary nucleus, but also discriminating enough to avoid confusing any other interaction with that of a dark matter particle. The latter part is extremely difficult due to the overwhelming amount of radiation that every object is constantly subjected to or emits. The average human body emits thousands of gamma rays every second through natural radioactivity; an unacceptable background when one is looking for one tiny event, possibly as rare as a few per year in hundreds of kilograms of material.

Thankfully, most radiation can be stopped given a sufficient amount of shielding material, such as lead or even pure water. If one takes great care to select the materials used to build the detector (and the shield) for their very low radioactivity levels, pays attention to minimizing exposure during construction, and designs a shield of appropriate thickness, it is possible to build a very quiet detector.

(To be continued in June 2011 issue)

## DuRA Survey and DuRA Charter

The DUSEL Research Association (DuRA) Executive Committee (DuREC) is conducting a second email survey among members of DUSEL.org to ratify the Charter. For colleagues who are not DuRA members yet, please take the first DuRA survey to become voting members. Membership in DuRA is open by request, and all are welcome. Given the research specific focus of DuRA, emails regarding DuRA business may not be of interest to all and this is the reason for the separate membership request from DuRA. The request is in the form of a brief survey, and response to this survey will automatically establish membership.

DuRA Charter survey:

<https://spreadsheets.google.com/spreadsheet/viewform?formkey=dDZ3cjRGdS1DY3ViYmFreklzNnFnS1E6MQ>

DuRA Charter: [http://www.dusel.org/PDFs/dura-docs/DuRA\\_charter\\_20101202.pdf](http://www.dusel.org/PDFs/dura-docs/DuRA_charter_20101202.pdf)



## DUSEL IN THE NEWS



Figure 2:  
SDSTA Executive Director Ron Wheeler (right) and Jim Benning of Ainsworth-Benning Construction sign an \$8 million contract to create a research campus on the 4850 Level

For more details on this story: *Lab moving closer to science 4,850 feet deep* - <http://www.sanfordlab.org>

KOTA Territory News: *Sanford Lab at Homestake signs contract* (May 18)

KEVN Black Hills FOX news: *Sanford Underground Lab starts construction* (Brendyn Medina, May 18)

News Center 1: *Contract signed for Sanford Laboratory project* (Justin Wickersham, May 18)

Rapid City Journal: *Spearfish contractor inks agreement with Sanford Lab; Homestake project important for South Dakota* (Gov. Dennis Daugaard, May 9)

Black Hills Pioneer: *Ainsworth-Benning signs \$8.1 million lab contract* (Wendy Pitlick)

## To read other DUSEL news items:

Science Insider, Science AAAS: *Chu calls NSF's Decision to Abandon DUSEL 'Disappointing'* (Jeffrey Mervis). For more details: <http://bit.ly/ChuDUSELcomment>

DUSELwatch.com: *Why DUSEL?* (Wendy Pitlick)

Argus Leader: *Sioux Falls students to spend summer with top scientists* (May 6)

## SANFORD UNDERGROUND LABORATORY AT HOMESTAKE

### Red Cloud School Pilot Project



*Figure 3: Lawrence Livermore National Laboratory researcher Peter Sorenson (back to camera) explains the LUX dark matter detector to middle school and high school students from Red Cloud Indian School*

A pilot project to connect Sanford Lab scientists with students from the Red Cloud Indian School on the Pine Ridge Reservation in South Dakota was declared “*lila wašte*” by Red Cloud senior Franklin Sioux Bob.

*Lila wašte* (LEE-la wash-TAY) means “very good” in the Lakota language. “We should go back so we could go underground,” Franklin told Karl Eagle Bull, a reporter with the school newspaper, *The Blue Pages*.

Franklin and Karl were among 19 students and four faculty members from Red Cloud who visited the Sanford Lab as part of a project to develop and test ways Sanford Lab scientists and other professionals can work with students in isolated rural schools.

Communications Director Bill Harlan coordinated the program. He worked with E&O Deputy Director Peggy Norris, Science Education Specialist Julie Dahl, Multimedia Specialist Matt Kapust, Science Liaison/Laboratory Supervisor Connie Giroux and Cultural and Diversity Coordinator KC Russell.

Principal Jim Mattern, science teacher Wendell Gehman and AP English teacher Mike Sunderland handled logistics and preparation on the Red Cloud side. This project originated with a 2010 trip to Red Cloud by Bill Harlan and George Campbell. Campbell has since retired as cultural Outreach Director for the project but still serves as chairman of the DUSEL/Sanford Lab Cultural Advisory

Committee. The committee and the Sanford Lab/DUSEL staff have been working for more than two years to establish relationships on all nine South Dakota reservations.

Red Cloud’s field trip to the lab on April 19 started early in the morning for the students with a three-hour bus ride to the Sanford Lab. Twelve of the students, who were members of the Red Cloud Science Club participated in a workshop on radiation, directed by Norris and Dahl. All 19 students visited the LUX surface laboratory, where researchers explained the dark-matter detector under construction.

Seven of the students, including Karl Eagle Bull, were studying journalism in their English class. Harlan and Kapust coached them on how to report on the trip for the school paper. Three students were also taking a photography class, so we loaned them digital single-lens reflex cameras and gave them a short introduction to news photography.

Later in the month, Harlan, Kapust and Dahl visited the school. Kapust showed the students how he used design software to turn their eight-page paper into a four-page product.

The May edition of *The Blue Pages* included six stories about the Sanford Lab. “What is dark matter, first of all?” wrote Stanford University-bound senior DeAndrea McLaughlin. “Dark matter could be tiny particles called ‘weakly interacting massive particles,’ or ‘WIMPS,’ that are all over in space around us, though we never feel them.” (She also wrote, “Scientists are excited about this project and enjoy their work a little too much.”)

Red Cloud’s school paper usually is printed in black and white. For this edition, Dahl arranged for the paper to be printed in color at Black Hills State University, which already has a Memorandum of Understanding to work with Red Cloud.

The Sanford Laboratory’s Communications department and the Education and Outreach Department are planning to work with the school next year in an expanded program. Sanford Lab staff also hopes to add a school from another reservation.



*Figure 4: Students from Red Cloud visit Sanford Lab. Three of the visiting students and six others from Red Cloud were named 2011 Gates Millennium Scholars and will receive major college scholarships*

**Sanford Lab's wastewater treatment team** earned an Excellent Operation and Maintenance award for 2010 from the South Dakota Department of Environment and Natural Resources. This is the second year that they have won this award. It recognizes compliance with Sanford Lab's surface-water discharge permit as well as outstanding wastewater system operations. The treatment plant crew includes water treatment plant operators George Krebs, Patrick Hasson, Ken Noren, and Jackson Pahl; facilities technicians Duane Ennis and Gary Larson; consultant Jim Whitlock; Environmental Manager John Scheetz; and Surface Operations Foreman Dan Regan.



*Figure 5: Project Engineer Bryce Pietzyk (left) has been named underground supervisor for the Davis Campus outfitting project. Engineering Tech Kip Johnson (third from left) and Infrastructure Tech Sion Hanson will manage logistics. Engineering Director Rick Labahn will continue as project manager.*

## EDUCATION AND OUTREACH

### Early Programming

As the school year draws to a close, Sanford Laboratory has increasingly become a destination for classroom field trips. This gives education staff

valuable opportunities to test content and tours related to DUSEL science with students in a wide range of age groups covering a range of curriculum and standards. Whenever possible, activities are tied directly into what the students are studying in the classroom. Recent on-site activities include:

- **Wall School Science Classes.** Three different science classes-eighth grade earth science, high school earth science and high school physics-visited Sanford Lab on April 27. After an overview video and discussion, eighth graders toured the Waste Water Treatment Plant (WWTP) while the high school earth science and physics classes talked about cosmic rays, and then visited the hoist room. After lunch, the eighth graders built water filters to filter and test mine water, while the high school earth science students heard from graduate student Jason Van Beek about geoscience experiments underground, and the physics students learned about dark matter and toured the LUX surface lab. Thanks to Jim Whitlock and the crew at the WWTP, Julie Dahl, Jason Van Beek, and Peter Sorenson and the LUX crew for all their help to make this day run smoothly.
- **Spearfish High School Physics Class.** Teacher Steve Gabriel, who is an active part of the GEOXDM collaboration, brought his physics class to Sanford Lab on May 4. The group heard a talk about Sanford Lab/DUSEL science from Jaret Heise, and then talked about dark matter before touring the LUX Surface lab.
- **Rapid City elementary students.** Approximately 60 fourth graders from Elizabeth Seton School in Rapid City were the first group to visit Lead under a new integrated effort of several cultural institutions in the town of Lead. The morning theme focused on science, and Jason Van Beek presented a geology lesson with students at the Open Cut/Homestake Visitors' Center while Julie Dahl and Ben Sayler worked with students on electric motors at the Yates Education Building. After lunch students visited the Black Hills Mining Museum, Homestake Opera House, and Black Hills/Ft. Pierre Roundhouse for history and social studies themed programs.
- **Lead area home schoolers.** Fifteen students, ranging from kindergarten to eighth grade, from

a local home schooling group visited the Yates Education Building on May 24. The younger students made marshmallow nuclei and DNA bracelets (popular activities at Neutrino Day every year) with Julie Dahl while the older students explored properties of light using atomic spectrometers.

## Cultural activities

On April 28, KC Russell visited Crow Creek High School, Lower Brule High School and Crow Creek Community College and talked to administrators about the Sanford Lab/DUSEL project and the potential for partnering on some activities.

**The APS April 20-May 3, 2011 meeting** in Anaheim celebrated 100 years of sub-atomic physics – the atomic nucleus was “invented” by Lord Rutherford 100 years ago - with more than 100 contributed sessions, plus poster sessions. One session noted the 100<sup>th</sup> birthday of Luis Alvarez, with reminiscences including underground cosmic ray measurements below the Egyptian pyramid detecting the empty chamber. Peggy Norris organized one education session. An international physics session focused on uses of antineutrino detectors for applications to detect proliferation of nuclear materials, talks on education in developing countries, and a talk on collaborations by Joe Wang. For more on this meeting, see: <http://www.aps.org/meetings/april/index.cfm>

## ENVIRONMENT, HEALTH & SAFETY



### Summer Safety

Summer is a time for picnics, weddings, graduation parties, and barbecues.

Keep an eye on the grill, especially if children or pets are playing nearby. Be sure the hamburgers are completely cooked. Known sources of *E. coli* include undercooked beef, sausage, and contaminated produce.

Keep perishable food in a cooler stored in the shade and pack in ice or freezing gels. Don't leave food out for more than 1 hour, especially as the temperature gets up to 90 degrees. Bacteria grow

faster in warmer weather. Potato salad and deviled eggs are not the only sources of concern. Other foods include melons, tomatoes, and lettuce.

**Safety pages on Sanford Lab website:** [www.sanfordlab.org](http://www.sanfordlab.org) - Use the left hand menu to open individual pages

## UPCOMING EVENTS AND ANNOUNCEMENTS

### Workshops

**12<sup>th</sup> International Conference on Topics in Astroparticle and Underground Physics, Münchner Künstlerhaus** (Munich House of Artists), Munich, Germany, September 5-9, 2011. Topics covered by the conference: Cosmology and particle physics, Dark matter and its detection, Neutrino physics and astrophysics, Gravitational waves, High-energy astrophysics and cosmic rays. For more info: <http://taup2011.mpp.mpg.de/>

**Third International Workshop on Baryon and Lepton Number Violation (BLV-2011)**, Gatlinburg (Edgewater Hotel), Great Smoky Mountains, Tennessee, September 22-24, 2011. The Workshop purpose is to discuss state-of-the-art of B, L, and B-L violation search, stimulate experimental and theoretical developments in this area, and attract new and young researchers to this field. Other topics will include: proton decay, n-nbar transformations, Majorana neutrinos and their role in physics beyond the standard model and in Cosmology. For more info: <http://www.phys.utk.edu/blv2011/>

### DuRA Events

Presentations that may be of interest to DuRA members are scheduled in the following meetings:

**45<sup>th</sup> U.S. Rock Mechanics/Geomechanics Symposium** with sessions on Geology and Geophysics, Mining Engineering, DUSEL Rock Mechanics, Civil Engineering, and underground construction, San Francisco, CA, June 26-29, 2011. <http://www.armsymposium.org/>

**2011 XXV International Union of Geodesy and Geophysics (IUGG) General Assembly**, workshops and business meetings, Melbourne, Australia, June 28-July 8, 2011. <http://www.iugg2011.com/>

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**GeoProc 2011 4<sup>th</sup> International Conference on Coupled THMC Processes in Geosystems**, Perth, Australia, July 6–9, 2011. <http://www.mech.uwa.edu.au/research/geoproc>

**Meeting of the Division of Particles and Fields of the APS**, Brown University, Providence, RI, August 9-13, 2011. <http://www.hep.brown.edu/~DPF2011/>

**12<sup>th</sup> International Congress on Rock Mechanics**, with workshop WS-5 on Networks of underground research laboratories for international disciplinary innovations, Beijing, China, Oct. 17-21, 2011. <http://www.isrm2011.com/page.asp?id=100>

**AGU Fall Meeting**, San Francisco, December 5–9, 2011. <http://www.agu.org/meetings/>

Please send information regarding upcoming meetings of interest or presentations from DuRA members, as well as other related events to Steve Elliott ([elliotts@lanl.gov](mailto:elliotts@lanl.gov)) or Duane Moser ([Duane.Moser@dri.edu](mailto:Duane.Moser@dri.edu)).



## JOBS

Visiting Assistant Professor, Dept. of Physics, Univ. of South Dakota. Candidate will participate in 2010 DUSEL Research Center (CUBED) activities and in planned DUSEL experiments. Apply at: <https://yourfuture.sdbor.edu>, contact Chair of Physics Search Committee, Dept. of Earth Science & Physics, University of South Dakota, 414 East Clark, Vermillion, SD 57069 or [physics@usd.edu](mailto:physics@usd.edu).

Senior Tenured Faculty, Physics Dept., Temple University, in all areas of Astrophysics. Applicants must have a high-quality research program with substantial research funding, and teaching experience. To apply, send CV, research plan, current grant support, statement of teaching philosophy and 5 references to: <http://www.temple.edu/physics/news/positions.html> or Search Committee, Dept. of Physics, Temple University, 1900 N 13<sup>th</sup> Street, Philadelphia, PA 19122-6082.

Postdoctoral Fellow with PhD in Microbiology or Geology to work on NSF PIRE-funded project with

focus on microbial community structure and diversity, biogeography, and genomics, Tengchong Geothermal Field, Yunnan Province. Send CV and research statement, to: Dr Hailiang Dong, Dept of Geology, Miami University, Oxford, OH 45056, or [dongh@muohio.edu](mailto:dongh@muohio.edu).

Postdoctoral Position, UC Santa Barbara, Particle Detector Development, Dept. of Physics. Lead detector R&D program, building ultra-high-resolution particle detectors for future neutrino and dark matter detectors. Contact: [bmonreal@physics.ucsb.edu](mailto:bmonreal@physics.ucsb.edu), Professor Ben Monreal or <http://hep.ucsb.edu/>

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**Photo Credits:** Figs. 1-5: Matt Kapust.

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