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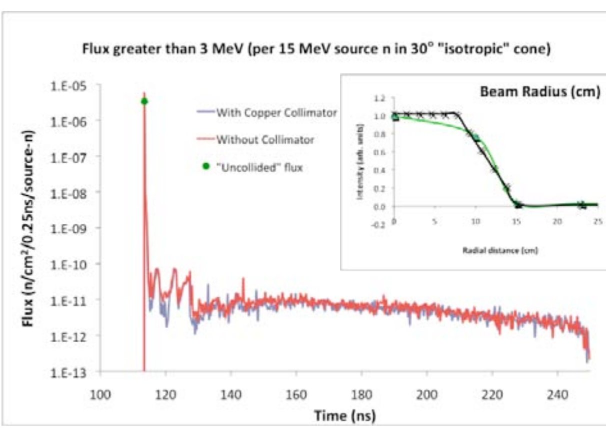
Intense neutron beams for neutron scintillator development

A collaboration of staff from LLNL, LBNL, and UCB has developed an intense high-energy neutron source in Cave 0 at the 88-Inch Cyclotron. This was done by breaking up a deuteron beam in a thick target located in the cyclotron vault. In this configuration the cyclotron vault wall acts as a “collimator” for the forward-going breakup neutrons, letting a relatively intense neutron beam through to Cave 0. The 1 ns wide intrinsic timing of the cyclotron allows the neutron energy to be determined using time-of-flight .

Neutron fluxes in excess of 10^3 n/s/cm^2/MeV have been demonstrated for a deuteron beam energy of 29 MeV and intensity of 100 nA incident on a Ta break-up target in the vault. Increasing the intensity to 10 µA and moving to a Be break-up target would yield a flux of more than 10^6 n/s/cm^2/MeV, significantly larger than the average current of most user beam lines at the LANL LANSCE/WNR neutron source.



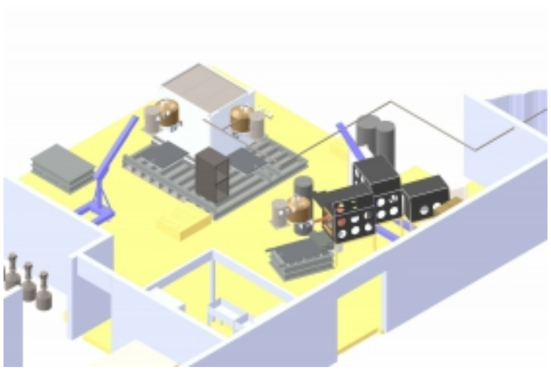
A numerical (MCNP) simulation of the neutron source in Cave 0 showing that the uncollided flux (the green dot) is more than 10^5 times larger than the scattered flux. The inset shows the spatial profile of the beam.

The neutron source has been used to develop a new class of organic crystal scintillators with “tunable” neutron/gamma pulse shape discrimination capabilities. These new scintillators will be used for the highly segmented Low-Energy Neutron Spectrometer (LENS) at NIF and a proposed Neutron And Silicon Coincidence Array (NASCAR) at LBNL.

Suitable neutron dosimetry is being developed to allow these neutron beams to be used as part of the BASE (Berkeley Accelerator Space Effects) Facility for radiation effects testing of satellite equipment. These neutrons could also be used for testing terrestrial-based equipment for radiation hardness.

Majorana Demonstrator detector units being assembled

In December 2012, working nearly a mile underground in the cleanest space in South Dakota, NSD physicist Ryan Martin and his team, began assembling the 70-some detector units for the Majorana Demonstrator experiment, which will look for the rare (and as of yet undetected) neutrino-less double beta decay process nearly 5,000 feet underground in the recently opened Davis Campus of the Sanford Underground Research Facility located in the former Black Hills Homestake gold mine.



The floor plan of the MJD experiment in the Davis Campus of the Sanford Underground Research Facility and the LBNL-led team working on assembling of the prototype detector.

The milestone assembly of the first MJD detector took only about two hours, but Martin had practiced the task many times at his LBNL home base, attaching a polished germanium-crystal detector the size of a hockey puck to a wafer-thin glass electronics board. But he had never assembled a detector unit while wearing four pairs of protective gloves. The gloves serve to protect the equipment which must be kept ultra-clean to eliminate all sources of background radiation. The germanium detectors ultimately will be placed in cryostats made of ultra-pure copper that, in turn, will be inside a copper shield inside a lead igloo—all of which will protect them from the ever-present radiation from the surrounding rock.

Each germanium crystal must be precisely connected to the fused silica glass low-mass front end board (LMFE) which holds the electronic circuits that will relay the signals from the crystal. The LMFE in turn is mounted on a copper leaf spring and connected to the germanium crystal by a pin.

The first detectors were made from natural germanium and these prototypes were merely used for testing before the installation of those made from enriched germanium having a significantly higher proportion of ^{76}Ge (and carry a much higher price tag). Since the first assembly back in December, the enriched detectors have already begun arriving from ORTEC, the contractor in Tennessee, keeping the team busy.

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Nuclear Science Day for Girl Scouts and Boy Scouts

The third annual *Nuclear Science Day for Girl Scouts and Boy Scouts* was held on March 2. A total of 118 Boy Scouts and 78 Girl Scouts (drawn from over 700 applicants from all around the greater Bay Area) spent a science-packed Saturday at the Lab. After an introductory lecture on radiation by Senior Faculty Chemist Heino Nitsche, the scouts were divided into groups and rotated among six activity stations.

One station dealt with the electroscope and its use for studying radiation; the Scouts built their own which they could keep to share with others. At another station, the Scouts learned about fission and also built models of hydrogen isotopes, complete with quark-filled nucleons and surrounding electrons.

In the Career Forum, three nuclear scientists from different areas discussed their various career paths, including working and studying abroad, serving as a reactor operator in the Navy, and using radiation in the treatment of disease. The Scouts questioned the scientists about the best and worst parts of their jobs, what motivated their career choices, the opportunities for internships and work experience, and studying nuclear science in high school and college.

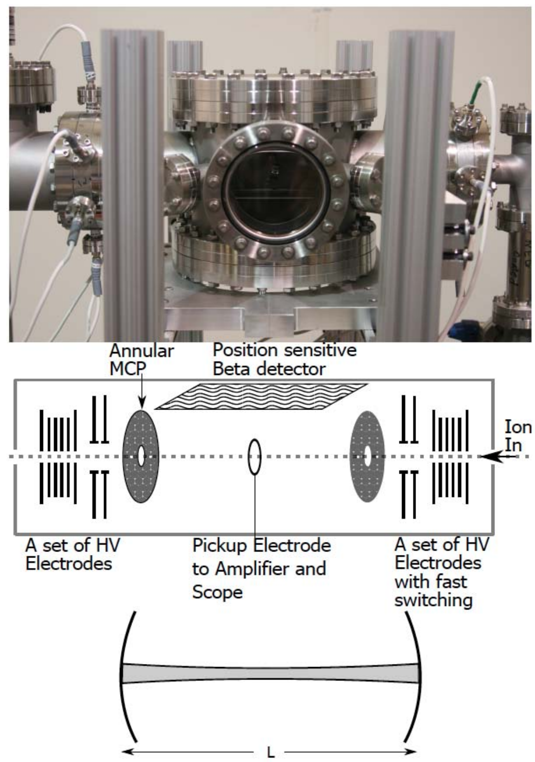
Because the 88-Inch Cyclotron was not accessible, there was a tour of the Advanced Light Source which was conveniently shut down so it was possible for the Scouts to see its interior, which generally made a big impression on everybody. Tireless Lab volunteers explained how the ALS generates X-rays for the users and described a variety of the science that this facility is being used for.

The event was a huge success among everyone and it was especially gratifying that the *Boy Scouts of America* Diablo Council awarded the NSD its 2013 Partnership Award for hosting the Nuclear Science Day the past three years, stating "*Your community outreach has sparked a growing interest in the Boy Scouts' new Nova program to introduce STEM [science, technology, engineering, and mathematics] subjects to youth …*".

Electrostatic Ion Trap for beta-neutrino correlation measurements

The correlation between the two leptons resulting from nuclear beta decay is a powerful tool for testing the Standard Model *V-A* theory of weak interactions. Due to its sensitivity to scalar and tensor current interactions, deviation of the measured value from the Standard Model prediction would indicate additional physics beyond the Standard Model.

The LBNL Electrostatic Ion Trap (ESIT) is the latest addition to the quest of precision measurements of the beta-neutrino correlation. The ESIT is an electrostatic analogue to the optical Fabry-Pérot interferometer, using two opposing sets of electrodes to create a parallel pair of electrostatic mirrors to confine ions (illustrated in the figure). In the trap, the ion bunches are reflected by the electrostatic mirrors. When an ion undergoes beta decay, the position sensitive beta detector records the energy and position of the beta. The annular Micro-Channel Plates register the recoiling daughter nucleus. Combined with the timing information, which tells the position where beta decay occurred, the momenta of both beta and daughter nucleus are determined, from which the neutrino momentum is constructed. The ESIT provides a large field free area for the beta decay to occur.



The Electrostatic Ion Trap (ESIT) and its internal structure. It is an electrostatic analogue of the optical Fabry-Perot interferometer.

This experiment is located at the Ion Source for Radioactive Isotopes (IRIS) facility at the 88-inch Cyclotron where the cyclotron is used for isotope production and the IRIS Electron Cyclotron Resonance ion source is used for high efficiency isotope ionization and transport. The unique combination of the 88-inch Cyclotron and IRIS will enable the trapping of short lived isotopes, such as ^{6}He. The commissioning of the trap and the ECR source is currently underway. The detectors and isotope production will be added at the second stage.

This project was initiated by Stuart Freedman and Paul Vetter. It is currently led by NSD postdoc Yuan Mei and the Weak Interactions Group, in collaboration with Guy Ron from the Hebrew University of Jerusalem and Michael Haas from the Weizmann Institute.

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NSD Fragments

NSD Scientist Awarded Honorary Professorship by Polish President

NSD physicist **Grazyna Odyniec**, a native of Poland, was awarded an honorary professorship on January 23 by the President of Poland, Bronislaw Komorowski, at the Presidential Palace in Warsaw. The title is awarded to Polish citizens for exceptional accomplishment in science or the arts, as determined by a stringent selection process. It is the highest and most prestigious rank in Polish academia and is rarely given to non-residents of Poland. Grazyna came to LBL in 1982 and has played a leading role in several generations of experiments in the ever expanding field of high-energy nuclear collisions, most notably the STAR experiment at the BNL Relativistic Heavy Ion Collider, and she has coauthored over 300 research publications. She spearheaded the initiative a decade ago to establish US participation in the heavy-ion program at the CERN LHC and she is currently leading the STAR search for the critical point of strongly interacting matter.

The NSD Deputy torch has been passed on

In January, Senior Physicist **Jørgen Randrup**, long-time member and former Scientific Director of the Nuclear Theory Program, took over as Deputy Director of the Nuclear Science Division from Senior Physicist **Spencer Klein**, who had served in that role for about two and a half years. During his tenure, Spencer started the NSD Newsletter, led the development of the NSD strategic plan, improved divisional communication , organized the recent divisional review, and worked on space and safety issues, while somehow still managing to find time to pursue his research in neutrino astrophysics.

Hao Qiu has joined the Relativistic Nuclear Collisions Group as a postdoc. He will work on the STAR Heavy Flavor Tracker and on heavy-flavor analysis with STAR.

Please send any comments, including story suggestions to Jørgen Randrup at: JRandrup@LBL.gov

The NSD Newsletter (including previous issues) may be found on the NSD home page: https://commons.lbl.gov/display/NSD/home/