Nuclear Science Division Newsletter

In this issue: **October, 2014**

Heino Nitsche, 1949 - 2014

On July 15, Professor Heino Nitsche died unexpectedly and peacefully in his sleep.

Heino was born in Munich, Germany on July 24, 1949. In 1980, he earned his Ph.D. in nuclear chemistry from the Freie Universität Berlin. Heino first came to LBNL in 1980 as a staff scientist, staying until 1993. During that time, his good friend, mentor, and colleague, Bob Silva, introduced him to his future wife, Martha Boccalini; they married in 1989. In 1993, he and Martha returned to Germany, where Heino was appointed as the head of Forschungszentrum Dresden-Rossendorf, a radiochemistry research institute. Heino decided to return to Berkeley when offered positions as a full professor in the Department of Chemistry at UC Berkeley, a senior research scientist at LBNL, and the founding director of LBNL's Glenn T. Seaborg Center. Heino was the group leader of the Heavy Element Nuclear and Radiochemistry Group at LBNL.

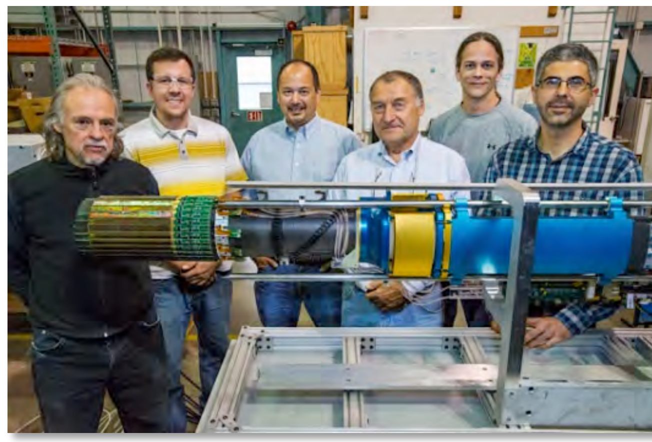
Over the years, Heino's research has encompassed a number of topics in nuclear and radiochemistry. His work was focused in two main areas: the production and chemistry of the heaviest elements, and chemistry of the actinide elements. In 2014, Heino was awarded the Hevesy Medal and shortly before passing, he was notified that he also won the 2015 Glenn T. Seaborg Award for Nuclear Chemistry.

In the College of Chemistry at UC Berkeley, Heino taught Chem 1A, a general chemistry course for non-majors, and Chem 146, the introductory nuclear and radiochemistry class. He had a passion for teaching and loved interacting with students. He was active in other organizations on campus including the Graduate Life Committee and those aimed at improving student mental health.

On August 22, there was a celebration of Heino's life at the Faculty Club at UC Berkeley. A number of fellow professors, current and former students, and friends spoke of Heino's energy, loyalty, kindness, and creativity. People stayed at the celebration of his life long into the evening, telling stories, drinking wine, and laughing hysterically, just as Heino would have wanted. Heino's students will strive to live life, and continue in science, with the passion and enthusiasm they learned from him.

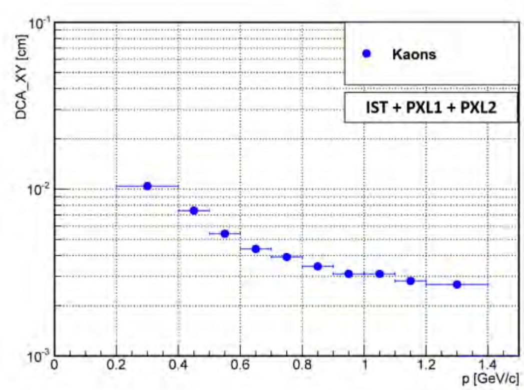
The STAR Heavy Flavor Tracker sees "first light" at RHIC

The STAR Heavy Flavor Tracker (HFT) was installed at the detector in January, 2014, and took data in the run that followed. The detector recorded 1.2 billion gold-gold collision events at a center of mass energy of 200 GeV per nucleon. The data are still being calibrated, but the preliminary data (see the figure) shows that the sensors already achieve 30 μm pointing resolution at the collision point, meeting the HFT requirements.



The data will be used for precision measurements of the cross section for D-meson formation, to measure the collective flow of D-mesons (v_2), and to measure the nuclear modification factor for D-mesons (R_{AA}). The data will also be used to explore charm-charm correlations.

The HFT is a high precision silicon pixel detector. The first two layers (PXL) of the HFT use state-of-the-art thinned (50 μm thickness) CMOS Monolithic Active Pixel sensors from the IPHC Laboratory in Strasbourg, France. There are 356 million pixels in the PXL detector; each 20 μm on a side. Both the high resolution and the low mass of the detector represent a breakthrough in pixel technology. The PXL layers can be retracted and if necessary replaced with a spare detector within a 24 hour period … and still maintain its pointing accuracy.



The pointing resolution of the STAR Heavy Flavor Tracker as a function of particle momentum for the sensors with aluminum substrates. The impact parameter resolutions for kaons observed in 200 GeV Au+Au collisions are shown on the plot.

Two additional Si-detector systems complete the HFT. One system consists of a double-sided Silicon Strip Detector (SSD) and the other is a layer of single-sided strip-pixel detectors at intermediate radius (IST). The PXL and SSD detectors were designed and built at LBL while the IST was fabricated at MIT. The HFT is a Major Item of Equipment project for the US Department of Energy Office of Nuclear Physics. It achieved Critical Decision 4 (CD4) on September 25, 2014.

Majorana Demonstrator passes tests

The MAJORANA group in Nuclear Science Division led the work in completing several important milestones in the MAJORANA DEMONSTRATOR (MJD) project in recent months.

The MJD is an experiment to search for neutrinoless double-beta decay in ^{76}Ge. In November 2012, the project delivered the first batch of germanium, enriched to 87% of ^{76}Ge, to the detector manufacturer AMETEK/ORTEC in Oak Ridge, TN (NSD newsletter January, 2013). Since then, the NSD team, collaborators from other institutions and the company coordinated the production, testing and delivery of 30 p-type point-contact (P-PC) detectors, which were chosen for their low-noise and high-energy-resolution characters. The total detector mass is 25.2 kg. The delivery of these detectors marked a significant milestone for the project — the completion of detector production from "virgin" enriched germanium (^{enr}Ge) material. In normal operation at detector manufacturers, shavings mixed with cutting fluids in the detector cutting process are not saved for reprocessing. Because of the high cost of ^{enr}Ge, this sludge was saved, and is being recycled and re-purified by a processing company in Tennessee. Up to 4 kg of additional detectors will be fabricated from the reprocessed materials very soon.

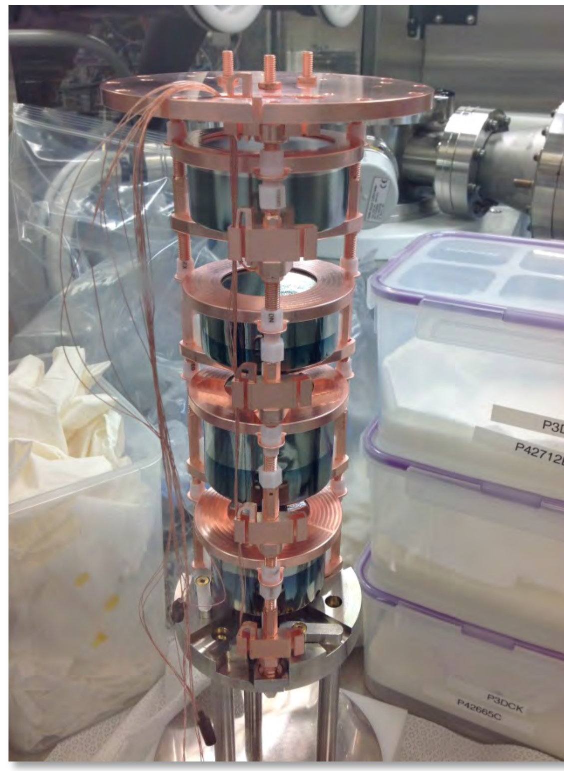


Figure 1. MJD's first string of 76-Ge detectors. The top detector is a natural Ge detector, while the bottom three are enriched in 76-Ge. The NSD team leads the work of detector production, testing and assembly in the project.

The NSD team has also completed the delivery of signal readout electronics for the MJD prototype cryostat (PC). The PC was constructed out of clean oxygen-free high-conductivity (OFHC) copper (instead of the ultra-clean copper that the MJD project electroforms in the underground facility at Sanford Underground Research Facility, SURF). Its main purpose is to allow the design and operation of different subsystems tested before the assembly of the two ultra-clean cryostats, which will house the ^{enr}Ge detectors in the experiment. Three strings of natural detectors are mounted in the PC, and have been integrated with the vacuum, cryogenic, data-acquisition, passive shield and active muon veto subsystems at SURF. Based on the operating characteristics of the delivered readout electronics in the PC, refinements to their designs have been made by the Engineering Division. The production of readout electronics for the two ultra-clean cryostats is in progress. NSD postdoctoral fellow Nicolas Abgrall is the MJD deputy task lead for the production and qualification of the electronics.

The NSD team led the assembly and the testing of the assembled detector strings. ^{enr}Ge detectors, encapsulated in vendor's test cryostats, were first transported to SURF by ground (to avoid cosmogenic activation). Once they have been tested for performance underground, they are removed and assembled in a string in a dry-nitrogen environment. The assembly of ^{enr}Ge detector strings for the two ultra-clean cryostats began in July. Figure 1 shows MJD's first assembled ^{enr}Ge detector string. After a string is assembled, it is mounted in a string-test cryostat, where its performance is evaluated. NSD postdoctoral fellow Susanne Mertens coordinates the underground assembly and string testing work. Figure 2 shows the calibration spectrum of a ^{enr}Ge detector in the string-test cryostat. The full-width-at-half-max (FWHM) resolution at 1.33 MeV is 1.95±0.02 keV, demonstrating good performance of the string assembly and the associated production readout electronics.

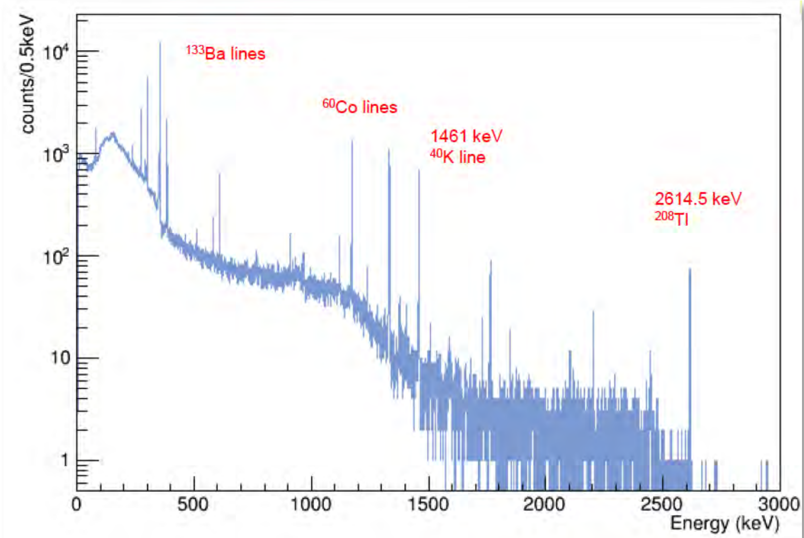


Figure 2. Calibration spectrum of an enriched detector in an assembled string. The string was installed in a string-test cryostat, which was not shielded from environmental gamma-ray backgrounds.

Low Background Facility digs deep in South Dakota

The Berkeley Low Background Facility (BLBF) at LBNL maintains gamma-ray counting stations in two unique locations: a surface site at LBNL and an offsite underground location for high-sensitivity radiometric counting.

The Berkeley Low Background Facility remote counting station at SURF.

In January of 2014, the remote counting station of the BLBF was shut down to begin relocating the detector and associated equipment from its home of 25-plus years in the powerhouse of the Oroville Dam in Oroville, CA to the Sanford Underground Research Facility (SURF) in Lead, SD. The process took approximately 6 months, and as of July 2014 we began screening our first samples underground in the detector's new location.

The counting station is situated 4850 feet underground in the east counting room of the Davis Cavern. The figure shows the spectrometer and the counting room. The detector shielding is outfitted with a gaseous N_2 line to purge and exclude radon from interfering with sample counting. The outer shield was reconstructed and contains an inner cavity that is taller than in its previous configuration at Oroville by 15 cm. The higher depth at SURF leads to a reduction in background, compared to Oroville

Over the years, the BLBF has provided low-background counting services to quantify concentrations of uranium, thorium, potassium, and other radioisotopes in a wide variety of candidate construction materials for experiments, including SNO, KamLAND, Double CHOOZ, Daya Bay, CUORE, LUX, LZ, MAJORANA, KATRIN, SURF, and more. A sample sent to BLBF for counting will be counted in the surface system at LBNL first. If the user requires higher sensitivity, the sample would then be sent underground where it is loaded into the spectrometer by a trained SURF personnel. LBNL experts evaluate the counting results from both systems. Current and future underground experiments will benefit from the expertise and the improved setup of the BLBF.

Studying radiation in its environment

Figure 1 A cutaway view of the RadMAP vehicle showing the radiation sensors inside.

The Radiological Multisensor Analysis Platform (RadMAP) vehicle has recently been upgraded to fuse radiation data with information from environmental sensors. RadMAP has its home at Building 88 and has been operated by a team of postdocs and students from the Applied Nuclear Physics program.

Figure 2 A gamma-ray image (colors) fused with a 3D lidar point cloud and visual imagery allows for accurate localization of a radioactive source (in this case, it is inside the vehicle).

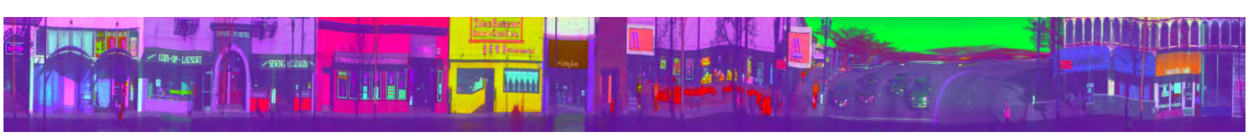
RadMAP is equipped with state-of-the-art tools for nuclear detection as well as environmental sensing. The goals of RadMAP are the systematic mapping of background radiation and the study of potential correlations with features in the environment. For example, the on-board weather station measures atmospheric conditions that can affect the radon and neutron background levels. Two panoramic video cameras in combination with rotating laser ranging ("lidar") sensors are producing 3D "point clouds" as the basis for reconstructing the visual environment in 3D.

In collaboration with a group in the EECS department at UC Berkeley, new techniques for semantic segmentation of the 3D environment into buildings, cars, people, trees, and other classes are being pioneered with this large dataset.

The fusion of imagery and lidar data with gamma-ray detectors enables the time-dependent identification, localization, and tracking of radioactive objects in their 3D environment. Only the combined modality enables sufficiently unambiguous detection and tracking in complex real-world environments.

In addition, hyperspectral cameras were recently installed to study correlations between spectral components in the visual and near-infrared domain (i.e., 400 — 1700 nm) with nuclear signatures.

NERSC is being utilized to manage the large amount of multidimensional data being collected. In collaboration with researchers from the Computational Research Division, a software framework has been developed that allows users from different research communities easy and fast access to the data. This framework is flexible enough to be extended to other scientific data as well.



A false color hyperspectral image taken in downtown Berkeley. Each pixel has hundreds of times the color information of a typical RGB image and can be used to identify materials near the vehicle.

Nuclear Science Division Newsletter

Fragments

A number of new post-docs joined the division in the past few months. The MAJORANA group welcomes new postdoctoral fellow Adam Bradley, from Case Western Reserve University, where he worked on low-energy radioactivity and dark matter in the LUX experiment. Postdocs Markus Fasel, Andrew Manion and Jochen Thader have joined the Relativistic Nuclear Collisions program, where they will work on new high-rate, high-throughput approaches to tracking (aimed at ALICE upgrades), STAR spin physics and computing infrastructure and STAR physics, respectively. New graduate student Guannan Xie has also joined the RNC program, to work on the STAR heavy flavor tracker. Shanshan Cao has joined the nuclear theory program, where he is studying heavy flavor physics in heavy ion collisions. Nidhi Patel has joined the Applied Nuclear Physics program, where she is working on a project to optimize radiation detection systems in environments where the backgrounds are highly variable. Tenzing Joshi has joined the ANP program, where he is working on new radiation detection algorithms for complex detection systems. Finally, Gopakuma Kamalakshakurup has joined the nuclear chemistry group, where he will develop microfluidic liquid-liquid extraction system for fast single-atom chemistry with heavy elements.

NSD post-docs take a break from their research to share pizza with NSD leadership.

Newsletter Notes

Please send any comments, including story suggestions to the Editor, Spencer Klein, at: srklein@lbl.gov. Previous issues of the newsletter are available at:

https://commons.lbl.gov/display/nsd/NSD+Newsletter.

Newsletter layout of current and previous issues by Sandra Ritterbusch.