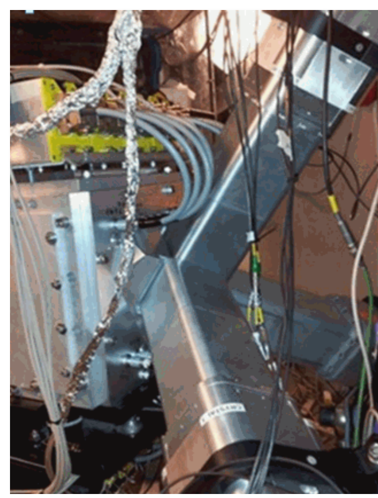
Nuclear Science Division Newsletter

In this issue: **April, 2015**

Higher intensity beams, more data at the 88-Inch Cyclotron

A new generation of experiments, exploiting recent upgrades at the 88-Inch Cyclotron and the Berkeley Gas Filled Separator (BGS), is addressing the fundamental issue of the maximum limit of nuclear mass and charge. This can be done by either populating the heaviest nuclei directly, or with indirect approaches via detailed spectroscopy of the heaviest systems for which such studies are possible. Both approaches are used at the BGS but the Feb. 2015 landmark experiment was a study of detailed level structure of ^{255}Lr (Z=103, N=152) following the electromagnetic decay of high-lying meta-stable (isomeric) states.

More than an order-of-magnitude more data was collected relative to earlier experiments. This was made possible from the exploitation of high intensity beams from the cyclotron and a new focal-plane detector system at the BGS. Thanks to the concerted effort of the cyclotron operations staff, a series of incremental improvements, especially at the initial ion injection, allowed the accelerator to run with up to 2 particle μA of ^{48}Ca on target. Part of the beam time was devoted to exploring new methods to allow the BGS targets to survive intense ^{48}Ca beams of >1 particle μA. Also, the new Clover Corner Cube (C^3) focal plane detector system (pictured in the photograph), which uses Double-Sided Silicon Strip Detectors (DSSSD's) for recoil, alpha, and electron identification and Clover-type Germanium detectors for gamma-rays, provided much higher efficiency then previous set-ups.



The new Berkeley Gas-filled Separator focal plane detector called C3 (Clover-Corner-Cube) was built in the shape of the corner of a cube. Each of the 3 faces of the cube are occupied by a 64x64 mm^2 DSSD and a similar-sized punch-through detector.

The data will form part of the PhD thesis of graduate student Nick Esker, (UC Berkeley Chemistry). A preliminary analysis has already shown that the data can be used to identify and characterize single- and multi-quasiparticle excitations and rotational sequences in ^{255}Lr. This study, and others like it, should soon be able to pin-down the microscopic level structure of nuclei in this region and help determine which combination of protons and neutrons will form the heaviest atomic nucleus.

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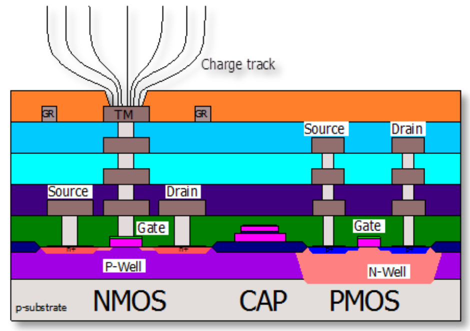
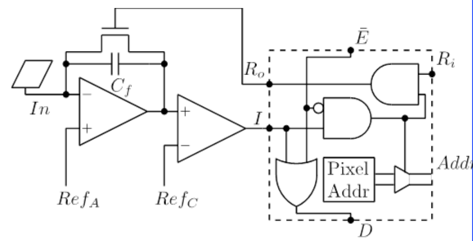
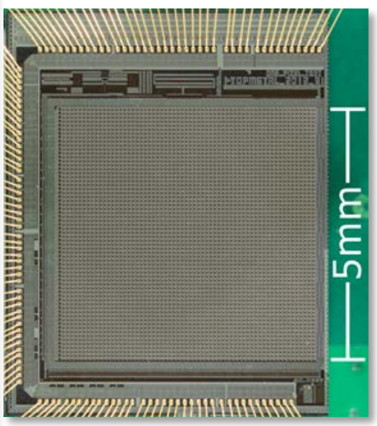
Topmetal CMOS pixel sensors detect charge directly



Imaging charged particle tracks is the ultimate goal of many generations of charge readout schemes in particle detectors. Familiar examples are wires and strips in a gas chamber, frontend application-specific integrated circuits (ASICs) bonded to silicon strip detectors, etc. The idea of using complementary metal-oxide-semiconductor (CMOS) integrated circuits (ICs) to collect charge directly has also been considered. However, existing ICs, commonly optimized for high luminosity collider applications, do not have the right specifications for the task.





In 2012, NSD postdoc Yuan Mei was looking for a way to measure the position of trapped ions in an electrostatic trap; the traps allow physicists to study beta decay symmetries using trapped radioisotopes. Mei and former NSD postdoc Xiangming Sun (a faculty member at Central China Normal University (CCNU)) started to develop their own CMOS pixel sensor, named *Topmetal*, to image charge from these ions. Using industrial standard 0.35µm CMOS technology, by placing a metal patch on the top of each pixel, exposed to air, the sensor can directly collect and measure the amount, location, and time-of-arrival of external charge drifting towards the sensor. Leveraging the mature and inexpensive industrial standard technology, and a high integration level of circuits, charge collection, amplification, and data processing are unified right at the point of charge measurement. Two versions of *Topmetal* have been produced successfully. Both feature a square array of pixels with 80µm pitch size between pixels, and they are optimized for different applications.

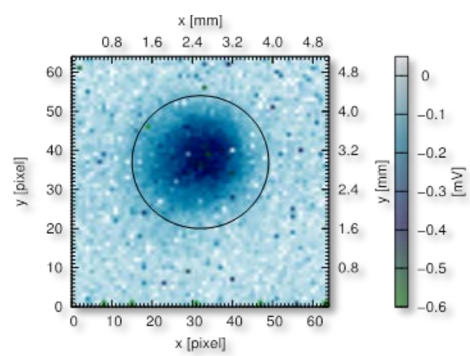
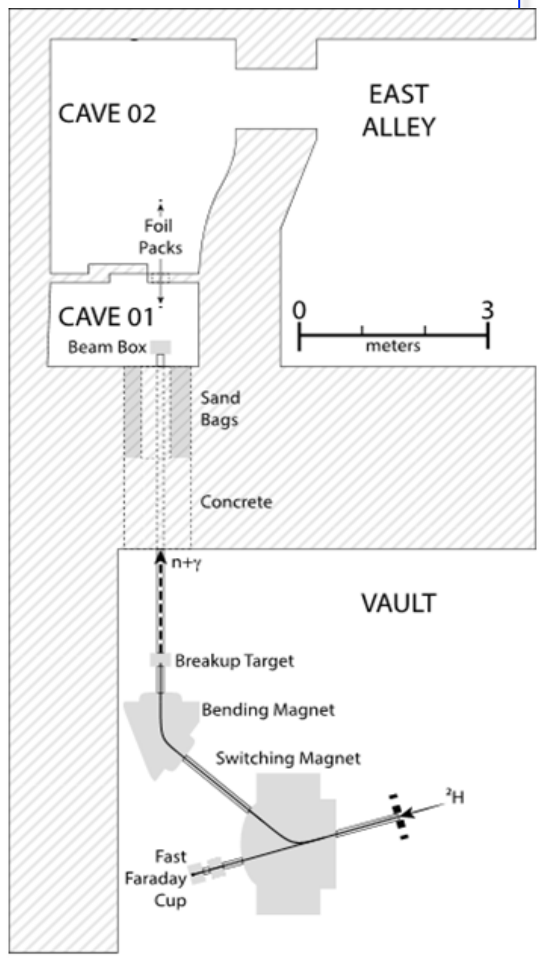


Figure 1 (a) Cross-section view of a CMOS pixel. (b) Internal circuitry of a pixel. (c) Photograph of a Topmetal sensor. (d) Charge cloud induced by alphas ionizing air, imaged by the Topmetal sensor.

The first version of *Topmetal* was tested at the 88-inch cyclotron to perform in-air proton beam positioning using ionization, and in-vacuum heavy ion beam measurement based on charged beam induction. The second version is being tested for electron-track gamma-ray imaging. Possible future applications include gaseous Time Projection Chamber charge readout without gas gain, medical imaging, nondestructive beam tomography measurement at JLAB and BELLA, as well as charge transfer observation in chemical reactions at ALS.

88-Inch Cyclotron forges new paths for neutrons



Energetic (1-30 MeV) neutron beams are of central importance for a wide range of applied and basic science ranging from medical isotope production to the developments of novel detector materials to materials damage studies for nuclear energy systems to national security and nuclear forensics to the structure of atomic nuclei. However, intense collimated neutron beams are hard to generate due to the inability to focus them using magnets.

A team of LBNL, LLNL and UCB-Nuclear engineering department researchers has commissioned an intense pulsed neutron time-of-flight capability at the LBNL 88-Inch Cyclotron. A figure showing the experimental set-up at the cyclotron is shown on the right. The source utilizes the break-up of high current (≤20 μA) deuteron beams with energies ranging from 12-60 MeV on thick (≈1 cm) targets to produce a neutron beam with a broad energy spectrum centered at approximately half of the incident deuteron beam energy. The flux of the resulting neutron beam can be adjusted from 10^1-10^7 n/s/cm^2 by varying both the beam current and the material used in the break-up target. The energy of "tagged" neutron-induced events can be determined by time-of-flight from the deuteron beam (Δt≥2 ns).

Recent experiments include the first absolute light-yield measurements of the neutron detector detectors that comprise the time-of-flight detector system at the National Ignition Facility (NIF). The beam is now also being used to measure inelastic neutron scattering cross sections relevant to the design of nuclear energy systems.

International Symposium Marks Opening of New Institute

What does it take for a city to recover from a radiological disaster? That question was at the heart of the April 10 inaugural International Symposium on Radiological Resilience & Beyond. The symposium offered discussions and talks on the current needs for increasing societal resilience to radiological events and brought to Berkeley Lab experts from Japan and colleagues from around the world.

The daylong symposium also marked the opening of the Institute for Resilient Communities. The brainchild of the Nuclear Science Division's Kai Vetter (who is also a Professor in the Nuclear Engineering Department on Campus), this new lab-wide effort is "…dedicated to providing tools that enhance resilience in communities locally and globally." The Institute provides a "framework for research, education, and community involvement to minimize the physical and psychological impact of future disruptive events and provides a forum for dialogue among researchers, educators, decision makers, and communities locally and globally."

Besides Berkeley Lab, UC and the city of Berkeley, other partners in the new Institute include the Japan Atomic Energy Agency, Japan's National Institute of Radiological Sciences and National Institute of Advanced Industrial Science and Technology, the University of Tokyo, as well as Koriyama City, a city hard-hit by the events in Japan 4 years ago.

The photo at right was taken at the opening ceremony for the Institute. From left to right: Tom Bates, Mayor of Berkeley; Kai Vetter of NSD; Masato Shinagawa, Mayor of Koriyama City; Horst Simon, Deputy Laboratory Director.

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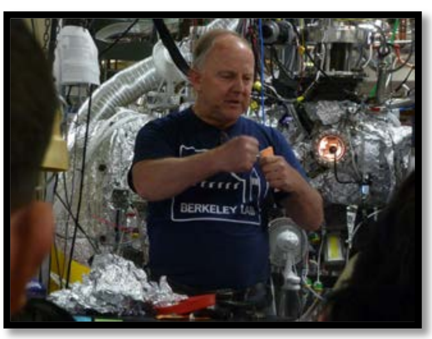
Fragments

The NSD is happy to welcome Heather Crawford back to the nuclear structure group. After receiving her PhD from Michigan State in 2010, Dr. Crawford spent her postdoc years at LBNL, before leaving for a faculty position at Ohio University in Athens, OH. She is returning as a career-track scientist. Her scientific interests are focused on the nuclear structure of the most neutron-rich nuclei, which can be studied with using radioactive ion beams produced at NSCL, TRIUMF in Canada or RIKEN in Japan. At LBNL, she will also be heavily involved with GRETINA and GRETA.



On April 4, 180 girl scouts and boy scouts, along with their leaders, participated in the 5th annual Nuclear Science Day event. Nuclear Science Day is an opportunity for teens to learn about nuclear science, and get some hands-on experience with radiation detectors. NSD director Dr. Barbara Jacak opened the day with a lecture on the "ABC" of radiation (alpha, beta and gamma radiation), followed by a talk on the RadWatch program by graduate student Ryan Pavlovsky. Numerous questions on the atomic nuclei and radiation safety were asked after these illuminating lectures. Following the lectures, the youths and their leaders participated in a number of activities, including the use of Geiger counters to do radiation survey, building an electroscope and understanding how different radiation detectors work, building an atomic model, and a tour of the ALS accelerator. The youths also participated in a career forum where panelists discussed their career paths in nuclear science and policy. All of the participants received a patch. This years patch (right) featured a picture of GRETINA. The event was co-hosted by NSD, Advanced Light Source (ALS) and Workforce Development & Education office.

Newsletter Notes

Please send any comments, including story suggestions to Spencer Klein at srklein@lbl.gov. Newsletter layout of current and previous issues by Sandra Ritterbusch.

Previous issues of the newsletter are available at:
https://commons.lbl.gov/display/nsd/NSD+Newsletter