What, spend your summer vacation doing physics at CHESS?

E. Fontes (9/27/2006)

Ithaca, NY -- Sixteen college students had very non-traditional summer vacations – opting to fill the halls of Cornell's Newman and Wilson laboratories with their smiling faces and ten weeks of intense discussion about – of all things – physics!

These students join 137 before them who visited the Cornell campus under a Research Experiences for Undergraduates (REU) program funded by the National Science Foundation (NSF), according to Richard Galik. Galik, a professor of physics, is one of the principal investigators of interlocking REU grants between Cornell and Wayne State University in Detroit, Michigan. He gathered mentors from the Cornell faculty and research staff to guide students through a diverse set of projects covering elementary particle theory, accelerator physics and x-ray and materials sciences.

This was a summer of "big science," with a majority of students focused on cutting-edge projects such as the future ERL x-ray source, the Compact Muon Solenoid experiment at CERN, and a future particle physics center called the International Linear Collider.

Five of the sixteen worked closely with physicists to help design a new type of particle accelerator called an Energy Recovery Linac, or ERL. An ERL will be an exciting new source of high-energy x-rays, and will spur new types of science based on nanometer-sized beams, coherent x-ray imaging and ultra-short pulses. Cornell is planning to upgrade its existing x-ray facility, the Cornell High Energy Synchrotron Source (CHESS), with an ERL accelerator in the near future.

"I learned about the Cornell program at a physics conference last summer where I spoke with prior students and saw papers that looked very professional," recalled Elise Novitski, physics major from Yale's class of 2008. "I had spent the prior summer doing nuclear physics research and wanted to get closer to particle physics." Elise worked with Matthias Liepe, assistant professor of physics, and Valery Shemelin, research associate in the superconducting radio frequency research group, on a project "Design Optimization of a HOM Broadband Absorber for the Cornell ERL." HOMs ("higher order modes") are high frequency oscillations in the electromagnetic waves inside superconducting radiofrequency (RF) cavities. These cavities are commonly used to accelerator electrons to the high energies (and velocities) needed by particle accelerators such as the ERL x-ray source. Because they disturb the acceleration of tightly bunched electron beams, HOMs are undesirable and special materials are placed inside the cavities to absorb them.

Elise wrote computer code to model the complex waves and cavities using special analysis programs Microwave Studio and CLANS. She learned quickly that computer processing speed is a major limitation to creating realistic models. "One model took two weeks to process, and just finished running only one half hour ago," she told an audience during her final project report before the ERL technical design group.

Adra "Tory" Carr, a rising senior at the University of Arizona and an aspiring experimental scientist, has participated in summer research programs in astronomy and dabbled in laser and quantum optics. She came to Cornell "with no preconceived notions" about a project to study coherent synchrotron radiation (CSR) with Georg Hoffstaetter, associate professor of physics. CSR is an effect seen in dense beams of charged particles (such as electrons) when x-rays emitted by the particles induce micro-bunching; that is, they break up the original bunch into smaller bunches, which in turn radiate more x-rays that cause still more severe micro-bunching. This effect destabilizes highly focused beams and can become so severe that it limits the bunch charge that a particle accelerator can provide. Tory used an accelerator modeling program, written by senior research associate David Sagan, to examine CSR in various parts of the proposed ERL design. Comparing her results to those from other CSR simulation tools, she has helped define an accurate model of the future ERL x-ray source.

Besides their intense physics work and mixing with a variety of professional staff, the students did have time to develop a sense of community at work and in the dormitory. “The sixteen physics REUs all clicked and have been a cohesive group since the start,” Tory added with satisfaction. Organizer Galik gave some attention to the social aspects of the summer but avoided micromanaging the students’ free time. Introductory sessions, tours, and student-faculty lunches involved students in the colorful research fabric of the lab. Several REU programs on campus coordinated with each other to show students the wide variety of scientific research at Cornell. Other highlights were lunchtime “Fun Talks” and weekend trips to New York City and Niagara Falls organized by the Cornell Center for Materials Research REU program.

Elise had an unexpected opportunity to share lunch with NSF Director Arden Bement, Jr., during his visit to Wilson Laboratory to learn about the particle physics and x-ray science programs. Elise joined three Cornell graduate students who gave five minute presentations on their work. She demonstrated nicely the high level of complexity undergraduate projects could achieve, as well as how excited and grateful she was for research opportunities afforded by the NSF-funded REU program.

In total, five REU undergraduates worked on this first-of-its-kind ERL x-ray source. In addition to Elise and Tory, Michael Antosh, from the University of New Hampshire, spoke at the technical design meeting about “Design of a Multicell Superconducting Cavity for the Cornell ERL Main Linac.” Michael also worked with mentor Liepe. Ivan Bazarov, research associate and head of the diagnostics team for the ERL prototype construction project, was mentor to two undergraduates: Michael Rosenman, from Carnegie Mellon University, studied “In-situ Modeling of the ERL Injector” and Colwyn Gulliford, from New College of Florida, developed “Study of Interceptive Emittance Diagnostics.”

Hoffstaetter, who supervised Tory Carr, also organizes the weekly technical design group meeting where the students presented their reports. He opened the meeting admitting that he started the summer with “some doubts” about the merits of having so many

undergraduates working at once. Over the course of the summer, he confessed, his doubts have been cleanly erased.

--

Elise Novitski, 2006 REU student from Yale University.

Tory Carr, 2006 REU student from the University of Arizona.