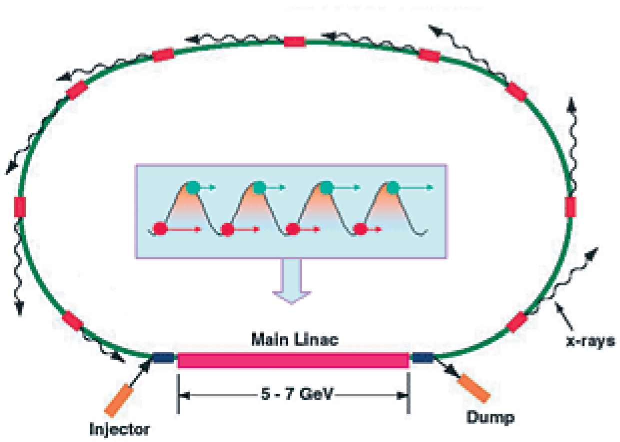
NSF awards Cornell $18 million to develop a new source of X-rays

By Simeon Moss

The National Science Foundation (NSF) has awarded Cornell $18 million to begin development of a new, advanced synchrotron radiation X-ray source, called an Energy Recovery Linac (ERL). The ERL, based on accelerator physics and superconducting microwave technology in which Cornell's Laboratory of Elementary Particle Physics (LEPP) is a world leader, will enable investigations of matter that are impossible to perform with existing X-ray sources.



In the proposed Energy Recovery Linac facility, electrons are pushed to almost the speed of light, "surfing" on the crest of microwaves in a linear accelerator (linac). The accelerated electrons make one trip around the Cornell Electron Storage Ring (CESR), and returning electrons feed back into the linac and give up their remaining energy to the microwaves. When the full-scale facility is built, the 1.3 kilometer-long linac will occupy a tunnel underneath campus parking lots.

"The X-ray beams produced by the new source will be roughly a thousand times better in brightness, coherence and pulse duration than currently is possible," said Sol Gruner, Cornell professor of physics, who is the principal investigator of the ERL project.

The NSF award to Cornell funds prototyping of critical components of the ERL at Cornell's Wilson Synchrotron Laboratory. According to Maury Tigner, LEPP director and co-principal investigator on the project, the design of the prototype is nearly completed. Scientists from the Thomas Jefferson National Accelerator Facility, a U.S. Department of Energy facility in Newport News, Va., worked with Cornell on the initial design. Prototype construction and testing is expected to be completed in 2008. Cornell then will seek funding for a full-scale ERL facility.

The facility will be a major upgrade of the national-user synchrotron radiation facility, Cornell High Energy Synchrotron Source (CHESS), which provides service to scientists and technologists from around the world, as well as to many departments at Cornell. The ERL will have value across the board, Gruner said, from research in biology and medicine to materials science and nanotech-nology development.

Synchrotron radiation is generated when fast-moving electrons are forced to change direction. In the CHESS facility, bundles of electrons are accelerated to very high energies by repeated trips around the Cornell Electron Storage Ring (CESR), a doughnut-shaped instrument about a kilometer in circumference, buried under the Cornell campus. At various points around the ring magnets induce a wobble in the electron beam, generating X-rays.

In the proposed facility, electrons will be pushed to within a fraction of the speed of light by a microwave beam in a linear accelerator (linac), made up of two straight tubes each about 1.3 kilometers long. The energetic electrons will be fed into CESR to make only one trip around the circle; then they will return to the linac where their energy will be recovered and used to push the next batch of electrons out.

In traveling many times around CESR, beams of electrons tend to spread out, diminishing the brightness and focus of the beam. By supplying energy in one long straight-line push followed by only one trip around the ring, the ERL will produce a brighter, narrower beam. The small beam will enable researchers to probe nanometer-sized structures, and its brightness means that very short pulses -- as short as one-thousandth of one-billionth of a second -- can still contain enough energy for useful experiments.

The ERL radiation may be used to determine the structure of cells and biological molecules that cannot be determined with current sources, information important both to basic science and the pharmaceutical industry.

It also will make possible new study of advanced materials on a nano scale, giving more insight into how to make stronger metals and composites, better drug delivery systems and more efficient optoelectronics. And the very fast pulses will make it possible to follow the structural changes that happen during important chemical reactions, both of life and chemical manufacturing processes.

Cornell constructed the world's first beam line to study synchrotron radiation in the early 1950s. Today, CHESS, which is directed by Gruner, is one of five national hard X-ray synchrotron radiation facilities funded by the NSF and the National Institutes of Health and is the only such facility in the United States located on a central university campus.

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