Today at Berkeley Lab

Friday, Aug. 4, 2006

FERMI@Elettra, A First-of-its-Kind Free Electron Laser:

Berkeley Lab Scientists and Engineers Complete Initial Stages of Design

The managers of Sincrotrone Trieste, operators of Elettra, the Italian light source located near Trieste, chose members of the Accelerator and Fusion Research Division's Center for Beam Physics, working with experts from the Engineering Division, to lead in designing a state-of-the-art free electron laser facility called FERMI@Elettra, in collaboration with scientists at Trieste, the Massachusetts Institute of Technology, and the Stanford Linear Accelerator Center.

FERMI@Elettra, a user facility, will be the world's first free electron laser facility employing "seeded harmonic cascades." This system allows exquisite control over both electron and photon beams to achieve high peak-power photon pulses.

Free electron lasers generate coherent beams of light (laser light) by sending bunches of electrons traveling at near light speed through the alternating magnetic fields of a wiggler or undulator magnet. The electrons slalom rapidly through the undulator, converting some of their energy into photons with each swerve. Coherent radiation is produced when electrons within a bunch travel together in short packages, each package radiating en masse in the slalom ride through the undulator.

The packaging and bunching of electrons needed for coherence can be "seeded" by initially shooting a separate laser of chosen wavelength through the electron beam, causing radiation at the seed laser frequency and, when the packages enter a second undulator, at higher harmonics (e.g., two or three times the seed laser frequency). These two-undulator stages can be arranged in series so that each emits outgoing radiation at a harmonic of the incoming radiation—thus, a seeded harmonic cascade.

While all free electron lasers can be tuned by adjusting magnetic field strength or electron beam energy, seeded harmonic cascades provide much greater control over pulse length, energy, and other beam characteristics of the emitted laser light. The Center for Beam Physics has historically led Berkeley Lab efforts in physics design studies for this kind of machine.

FERMI@Elettra will be capable of providing intense, tunable coherent light in the vacuum ultraviolet (VUV) and soft x-ray region of the spectrum. It will be able to provide ultrafast photon pulses of 100 femtoseconds and shorter (a femtosecond is a quadrillionth of a second), or longer pulses of up to 1,000 femtoseconds. These capabilities are expected to allow FERMI@Elettra users to make significant scientific advances.

There are many components of FERMI@Elettra, and the Berkeley Lab team is providing leadership and technical contributions in all major aspects of the project. These include:

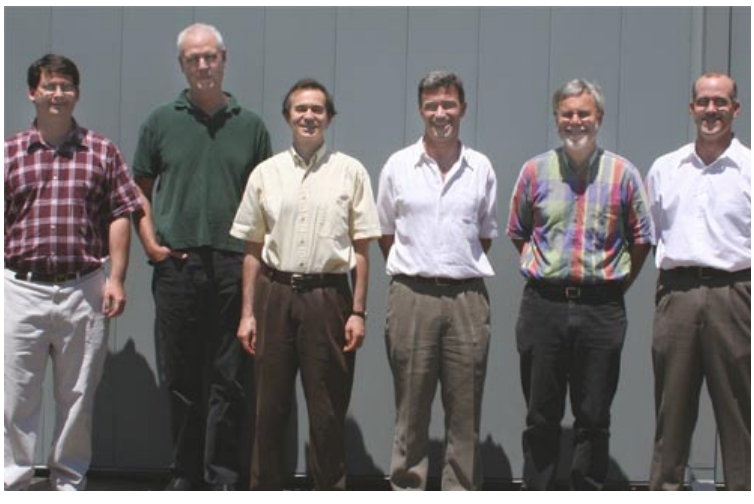
- the high-brightness radio-frequency photocathode gun, which emits electrons when illuminated by laser;
- the main linear accelerators that accelerate the electron bunches to near light speed;
- the electron bunch compressors;
- the beam spreader that distributes the electron bunches to two separate free electron lasers;
- optimizing the physics of all systems to produce electron bunches tailored for the free electron laser process;
- producing the laser beams in the free electron lasers.

The facility requires ultrastable timing and synchronization, instrumentation, and radiofrequency power systems, all areas in which Berkeley Lab excels.

Lab personnel have also gained new understanding from the present study. Advances include learning how to obtain high-quality electron bunches in the presence of strongly perturbative electromagnetic fields, how to optimize bunch compression for specific free electron laser requirements, and how to optimize the performance of seeded harmonic cascades. These new skills will be applicable to present and future accelerator projects within the Office of Science.

Berkeley Lab has provided technical notes and reports to Sincrotrone Trieste for use in compiling the FERMI@Elettra conceptual design report, which is nearing completion, under a one-year, $1.4 million contract; support to Sincrotrone Trieste in critical physics and engineering of FERMI@Elettra will continue under a new contract.

"We expect to remain involved in this project through commissioning of the free electron lasers in 2009 and onward," says John Corlett, head of the Center for Beam Physics.



A few members of Berkeley Lab's FERMI@Elettra team: from left, Gregg Penn, John Staples, Sasha Zholents, John Corlett, Bill Fawley, and Steve Lidia

More information on Elettra is at
http://www.elettra.trieste.it/index.php

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