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model of particle physics. The facility is widely recognized as unique in terms of its energy range and purpose. And although some pieces of the science might get picked up by Japan's J-PARC or other hadron facilities, most would be lost.

The LRP's second priority was FRIB. Based on a superconducting linear accelerator, FRIB will be able to make thousands of different isotopes, including many unstable ones that have never been produced in usable quantities (see PHYSICS TODAY, February 2009,

page 25). The isotopes will be used to address questions in astronomy; study atomic nuclei; test fundamental symmetries of nature; and research potential applications in, for example, medicine, national security, and condensed-matter physics.

A site at Michigan State University is ready for FRIB, and the university and state are jointly paying \$94 million of the facility's \$680 million tab. A handful of rare-isotope facilities are in the works around the world, but FRIB—designed to be 1000 times more powerful than its

First seeded free electron laser shines for users

A free electron laser (FEL) in Trieste, Italy, began producing 40- to 150-fs pulses at soft x-ray and extreme-UV wavelengths last year, and commissioning began this fall on a second FEL that will reach shorter wavelengths. Based on a conventional linac operating at 10 Hz and 1.2 GeV, the €160 million (\$210 million) FERMI@Elettra source is the first user facility to implement seeding. The result: high-gain light pulses that are coherent; are stable in intensity, photon energy, and bandwidth; and have tunable energy and polarization that can be switched from linear to circular.

In seeding, an external laser imprints its coherent field and narrow bandwidth on a relativistic electron beam as the electrons enter a series of undulators. The technique overcomes the drawbacks of relying, as most FELs do, on spontaneous electron organization. The Trieste beam shows a "spectacular degree of both transverse and longitudinal coherence and will allow experiments that could not be performed in any other manner," says MIT's William Barletta, a consultant for the FEL design team. "We can generate a detectable FEL signal at wavelengths down to about 4 nm," says Fulvio Parmigiani, coordinator of the FERMI@Elettra scientific program. But the shortest wavelength with sufficient intensity for experiments is about 20 nm.

The three beamlines at the Trieste FEL are dedicated to spectroscopy of gases and beams of mass-selected clusters of atoms or molecules; coherent dynamic imaging of such things as nanostructures and biological systems; and inelastic and elastic scattering experiments. Two additional beamlines for magnetic dynamics and pump-probe experiments are planned. The experimental hall is shown in the bottom photo; the top one shows an aerial view of the site.

The second FEL is designed to get down to a fundamental emission of 4 nm, with harmonics providing even shorter usable wavelengths. The linac is also being upgraded to 50 Hz and 1.5 GeV next year, with hopes of going to 1.8 GeV in 2014. One aim of the upgrades is to provide sufficient intensity for experiments needing 1-nm radiation.

Says Barletta, "Most future machines in the soft x-ray region will have some seeded beams." The FEL in Trieste "is important to see how well seeding works." **Toni Feder**



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