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Testing LRS01: Two Takes on the Large Hadron Collider's Accelerator Research Program

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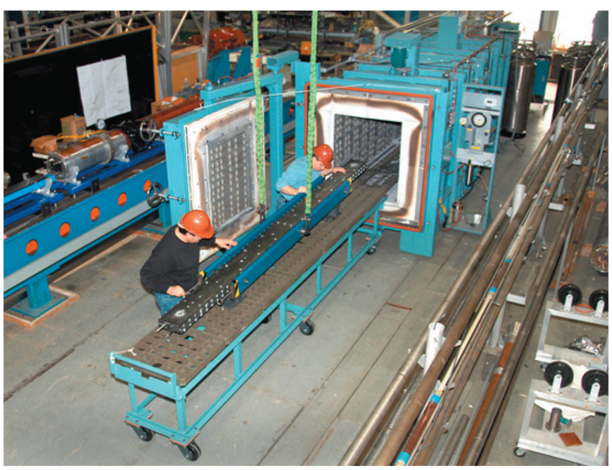
The first item below is by Katie Yurkewicz, Ph.D. in nuclear physics, who handles press and public inquiries for United States participation in the Large Hadron Collider (US/LHC) at CERN, the European Organization for Nuclear Research near Geneva, Switzerland. Following her story is Science@Berkeley Lab's take on the Lab's participation in the LHC magnet upgrade project, first published in our inhouse magazine, Today at Berkeley Lab.

Long Racetrack Magnets go the Distance

The Large Hadron Collider won't start up until next year, but physicists and engineers in Europe, Japan and the U.S. are already working toward collider upgrades. In a major milestone for the U.S. LHC Accelerator Research Program (LARP), the first "Long Racetrack Shell" magnet, a precursor of an upgraded superconducting quadrupole magnet, was successfully tested the week of 23 July, 2007 at Brookhaven National Laboratory (BNL).



One coil of the Long Racetrack magnet is moved into the reaction oven at BNL. (Photo Brookhaven National Laboratory)

The U.S. group is working toward upgrades for the "inner triplet" quadrupole magnets that perform the final focusing of the particle beams prior to collision. Due to the magnets' proximity to the interaction points, the inner triplets are built to withstand high doses of radiation without failing. An upgraded, higher-luminosity LHC will mean a hotter environment for the magnets.

Because upgraded inner triplets will need to operate at a higher temperature and higher magnetic field, the U.S. team from BNL, Fermilab, and Lawrence Berkeley National Laboratory is evaluating niobium-tin (Nb3Sn) technology for the magnet coils, rather than the well-established niobium-titanium used in current LHC magnets.

"Nb3Sn magnets would be an advantage because they can run at a higher temperature and higher magnetic field gradient, but the material is really hard to work with," explained BNL's Peter Wanderer, LARP's magnet systems leader. A European project, CARE/NED, is also investigating Nb3Sn conductors for use in upgraded LHC magnets.

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The Long Racetrack Shell magnet, so called because of its shape, is the first accelerator-style Nb3Sn magnet to be fabricated significantly longer than one meter. The 3.6-meter-long magnet approaches the length that will be needed for the LHC. BNL fabricated the coils for the LRS, Berkeley Lab designed and fabricated the support structure, and Fermilab contributed project management and insulated cable for a practice coil.

The first of these magnets, LRS01, was tested the week of July 23 at BNL. "Training" of the magnet -- subjecting it to repeated quenches -- started above 80 percent of the magnet's estimated maximum current density of 10.6 kA (kilo-amperes, or thousand amperes). After five quenches the current reached 91 percent of the estimated maximum, corresponding to a coil peak field of 11 tesla.

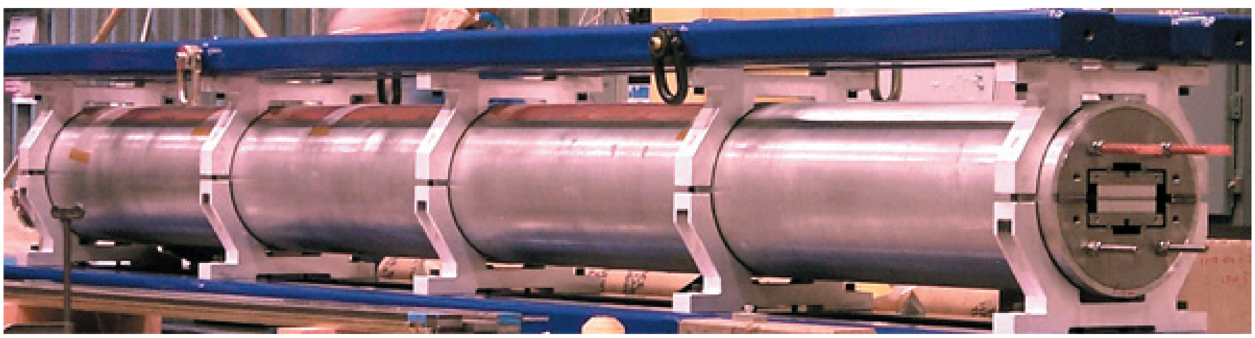
"The LRS01 magnet is providing key information for the fabrication of long niobium-tin coils and the optimization of shell-based support structures," said Paolo Ferracin from Berkeley Lab.

Added Fermilab's Giorgio Ambrosio, who coordinated the activities at the three labs, "the next step for LARP is to build the Long Quadrupole, the first-ever four-meter-long Nb3Sn accelerator magnet model."

—Katie Yurkewicz

Super Test Results for a Superconducting Magnet

Spectacular physics results are expected to follow in short order once CERN's Large Hadron Collider turns on next year, but accelerator physicists are already getting ready to upgrade the machine for higher luminosities. In the US's LHC Accelerator Research Program, Berkeley Lab, Brookhaven, and Fermilab are collaborating on the development of a new generation of powerful superconducting magnets for the LHC's two main interaction regions, those that house the ATLAS and CMS experiments.



The support structure of the Long Racetrack Shell magnet. (Photo Paolo Ferracin)

At Brookhaven during the week of July 23, 2007, members of Berkeley Lab's Accelerator and Fusion Research Division (AFRD) and their Brookhaven and Fermilab collaborators successfully tested LRS01 -- LRS stands for Long Racetrack Shell -- which at 3.6 meters (almost 12 feet) is the longest magnet model of its kind ever built. The superconducting magnet uses niobium-tin "racetrack" windings in the long supporting structure.

AFRD's Paolo Ferracin, who led the Berkeley Lab effort, calls the tests "a major milestone in the development of superconducting magnets for the Large Hadron Collider's Interaction Regions, beyond the current design." He emphasizes "the successful partnership between the labs," including Berkeley Lab's "magnet design and analysis, cable fabrication, coil technology transfer, and structure design and fabrication."

LRS01 is the first niobium-tin accelerator-type magnet model of significantly more than one meter in length, approaching the length of the real magnets that will be needed for the LHC upgrade. The two racetrack coils were fabricated at Brookhaven; the supporting shell structure was designed and built by Berkeley Lab's Superconducting Magnet Group. Ferracin describes the support structure as "an extension of Berkeley Lab's Subscale Common-Coil Magnet design, based on an aluminum shell pretensioned over iron yokes using pressurized bladders and locking keys." (The model magnet's coils and their supports are called "cold masses" because the coils must be kept at very low temperatures for superconductivity.)

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Superconducting magnets must be "trained" to reach their optimum field strengths by repeated deliberate quenchings, or losses of superconductivity. The training of LRS01 started above 80 percent of the magnet's estimated maximum current density, and after only five quenchings the current had reached 91 percent of its target. This corresponds to a peak magnetic field of 11 tesla, surpassing the 10-tesla limitation of accelerator-type coils based on niobium-titanium technology.

This and other results are evidence, says Ferracin, that "the LRS01 magnet is providing key information for the fabrication of long niobium-tin coils and the optimization of shell-based support structures."

In addition to Ferracin, members of the superconducting magnet group also include Paul Bish, Brad Bingham, Shlomo Caspi, Dan Cheng, Dan Dietderich, Helene Felice, Arno Godeke, Ray Hafalia, Roy Hannaford, Hugh Higley, Daryl Horler, Alan Lietzke, Nate Liggins, Juan Lizarazo, Gary Ritchie, Gianluca Sabbi, and Jim Swanson.

—Paul Preuss

Additional information

More about CERN is at http://public.web.cern.ch/Public/Welcome.html.

More about the Large Hadron Collider is at http://lhc.web.cern.ch/lhc/.

More about the U.S. at the Large Hadron Collider is at http://www.uslhc.us/.