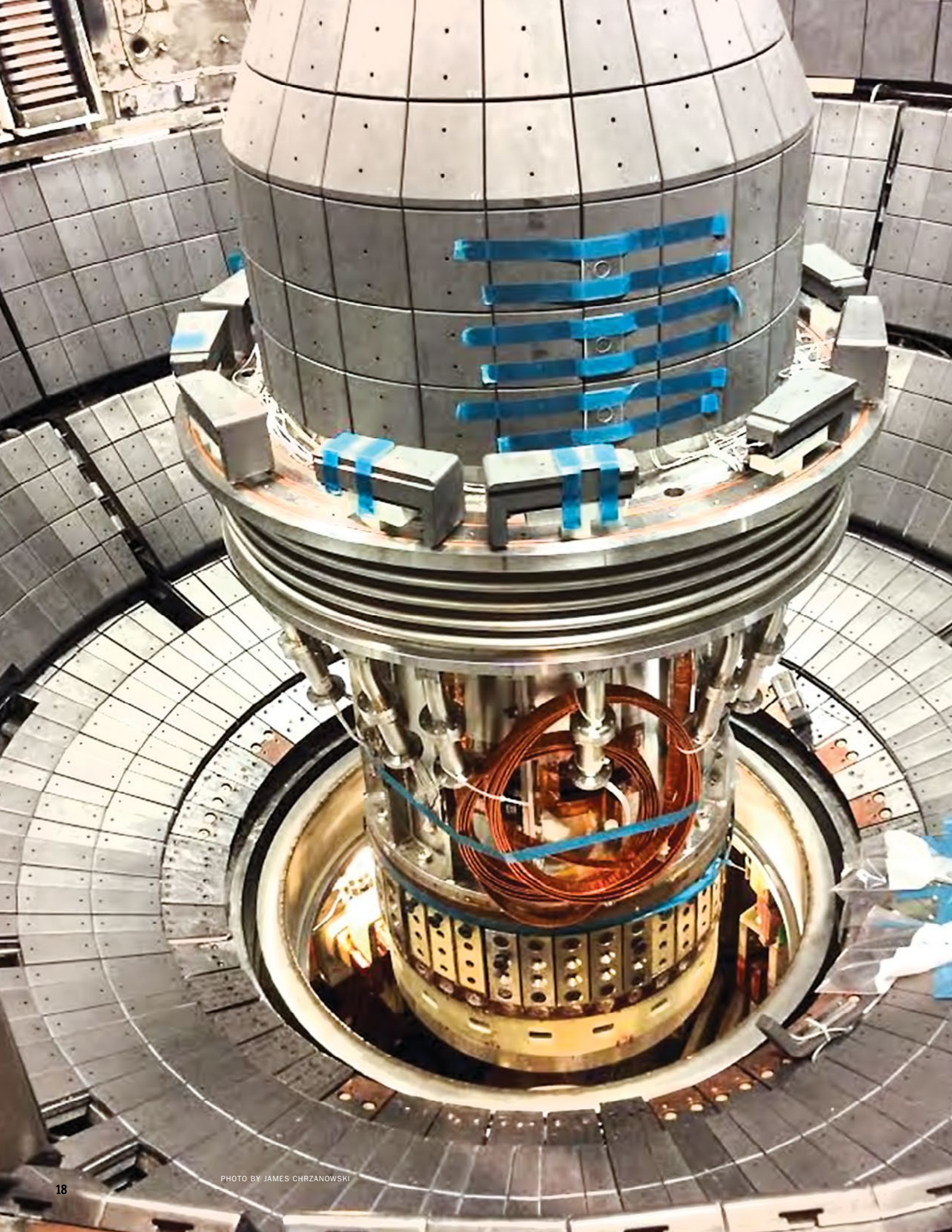

PHOTO BY JAMES CHRZANOWSKI

The Princeton Plasma Physics Laboratory

The quest for clean energy continues

FUSION — the energy-making process that powers the sun — could provide us with a near limitless source of energy, ending our dependence on fossil fuels for making electricity.

This summer, after a nearly three-year overhaul, the world-leading fusion research facility at the Princeton Plasma Physics Laboratory (PPPL) switched on its newly outfitted flagship reactor, the National Spherical Torus Experiment-Upgrade (NSTX-U). The reactor uses electrical current and heat to create a hot, charged state called a plasma, which is encased by powerful magnets so that parts of the atoms can collide and fuse, releasing massive quantities of energy in the process.

The $94 million upgrade has made the NSTX-U the world's most powerful spherical tokamak — the name given to donut-shaped fusion reactors — while doubling its heating power and magnetic fields, and making it the first major addition to the U.S. fusion program in the 21st century.

"The upgrade boosts NSTX-U operating conditions closer to those to be found in a commercial fusion power plant," said Stewart Prager, director of PPPL, which is managed by Princeton University for the U.S. Department of Energy and is located some three miles from the campus. "Experiments will push into new physics regimes and assess how well the spherical design can advance research along the path to magnetic fusion energy."

The key feature of the design is its compact, cored apple-like shape, as compared with the bulkier, donut-like form of conventional tokamaks. The compact shape enables spherical tokamaks to confine highly pressurized plasma gas — the hot, charged fuel for fusion reactions — within comparatively low magnetic fields. This capability makes spherical tokamaks a cost-effective alternative to conventional tokamaks, which require stronger and thus more expensive magnetic fields.

Building the NSTX-U posed novel challenges for engineers and technicians throughout PPPL. Tasks ranged from flying a 70-ton neutral beam machine over a 22-foot wall to building a 29,000-pound center stack. These huge components fit alongside and inside an existing facility — the original NSTX — with hair-thin precision, requiring an effort that one engineer likened to rebuilding a ship in a bottle.

Researchers now plan to test whether the NSTX-U can continue to produce high-pressure plasmas under the hotter and more powerful conditions that the upgrade allows. Also on the research agenda are tests of how effectively the NSTX-U can keep temperatures approaching 100 million degrees centigrade from dissipating, and whether its spherical design can be a strong candidate for a major next step in the U.S. fusion program. **–By John Greenwald**

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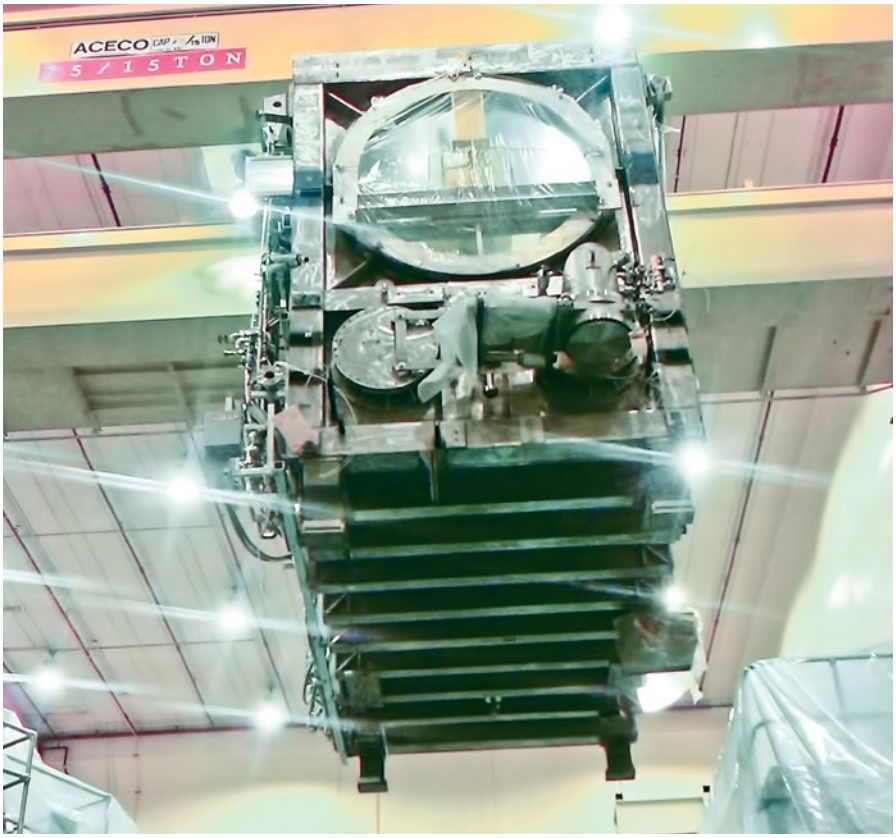
PHOTO BY MICHAEL VIOLA



After a three-year, $94 million overhaul, the Princeton Plasma Physics Laboratory's primary fusion reactor has resumed the quest for clean energy. The fusion of parts of the atom inside the reactor could release a near limitless amount of energy and reduce our dependence on fossil fuels, while generating minimal hazardous waste. The upgrade included replacing the center of the apple-shaped reactor with a new 29,000-pound magnetic core (left) and bringing in a 70-ton machine (above) that produces beams that heat the plasma.