PPPL PRINCETON PLASMA PHYSICS LABORATORY

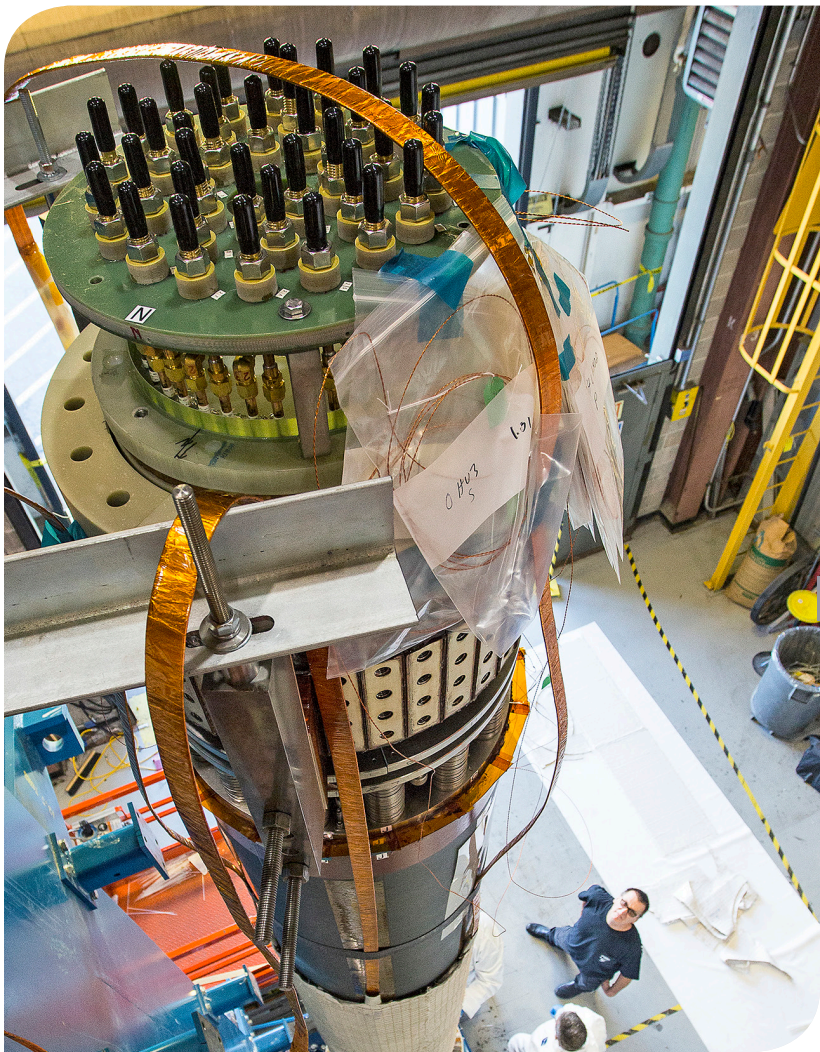
PRINCETON UNIVERSITY

U.S. DEPARTMENT OF ENERGY

Building the Most Powerful Spherical Tokamak

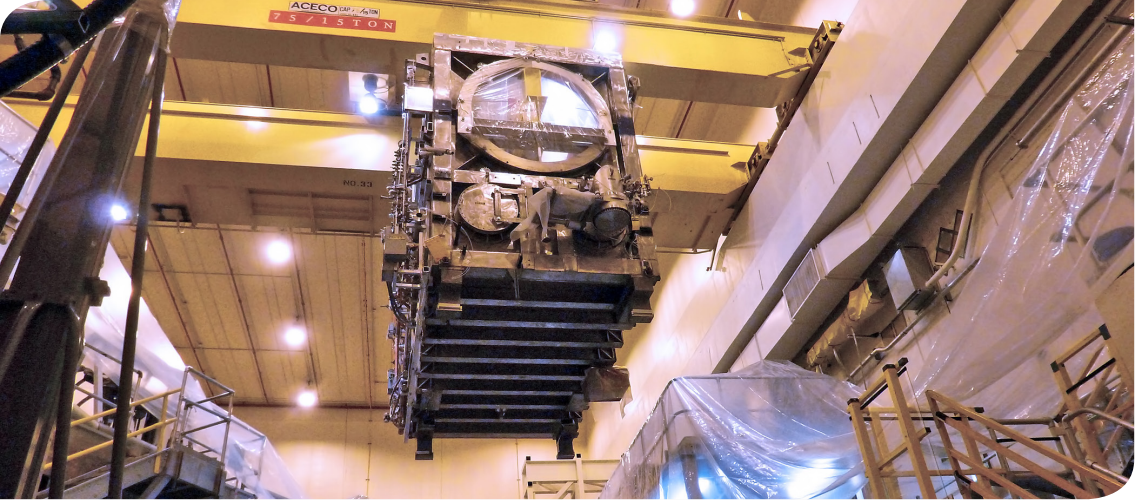
Two major new components power the National Spherical Torus Experiment-Upgrade: A widened center stack that doubles the magnetic field strength and plasma current and quintuples the length of fusion experiments, and a second neutral beam injector that doubles the tokamak's heating power. Taken together, the new parts boost the NSTX-U operating conditions closer to those that will be found in a commercial fusion power plant.

"This project was more complex than building the NSTX in the first place," says Mike Williams, head of engineering and infrastructure and associate director of the Laboratory. "We had to figure out how to reinforce the existing facility to withstand the increased electromagnetic forces produced by the upgrade."



Here is a look at the major steps in the NSTX-U construction:

Creating the new center stack meant sanding, brazing, welding and applying insulation tape to each of the 36 copper conductors that make up the 21-foot-long magnet. Technicians then bound the conductors together through repeated applications of vacuum pressure impregnation — a potentially volatile process. They next fabricated a coil that winds around the bundle to induce current into the plasma.



The final step called for using an overhead crane to lift the magnet over a 22-foot shield wall, which the bundle cleared by inches, and carefully lower it into the center of the spherical tokamak. “This was really a watershed moment,” Williams said of the installation, which completed the center stack construction.

Installing the new neutral beam injector required even heavier lifting. Technicians first spent months taking apart, decontaminating and refurbishing the truck-sized, 70-ton device, which was originally used with the Lab’s now-dismantled Tokamak Fusion Test Reactor. They then towed the injector into the NSTX-U test cell, attached it to the overhead crane and hoisted it over the shield wall.

Workers next hooked up the device and its power supplies, cables, cooling-water pipes and other equipment in the already crowded test cell. Last came the task of cutting a window into the NSTX-U vacuum vessel and aligning the beam to within 80 thousands of an inch of a target inside the vessel. “The whole thing was fraught with challenges and difficulties,” said engineer Tim Stevenson, who headed the beam box project. “It was a monumental team effort that took a great deal of preparation. And when it was show-time, everyone showed up.”