

The New PEGASUS-III Experiment

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Developing attractive means of initiating current without using magnetic induction from a central solenoid is a critical scientific and technical challenge facing the spherical tokamak (ST). The PEGASUS program has focused on developing the physics basis and predictive models for non-solenoidal tokamak startup using local helicity injection (LHI) and has demonstrated startup to ~ 0.2 MA in a low-field, near-unity aspect ratio (A) ST. Major upgrades are converting the PEGASUS facility into a solenoid-free ST called PEGASUS-III. Major features include: increased toroidal field to 0.6 T for up to 100 ms; improved shape control; and retaining the low aspect-ratio geometry of $A \sim 1.2$. This B_T directly supports the new mission to expand the breadth of solenoid-free research on the facility with multiple reactor-relevant techniques. LHI will be tested at higher field and with new non-circular injectors. A dual-electrode coaxial helicity injection (CHI) system facilitates studies of sustained and transient CHI. Electron cyclotron/electron Bernstein wave RF sources enable startup, sustainment, and HI-RF synergistic studies. The implemented TF upgrade is comprised of a new center rod, outer TF coil system, torque plate assemblies, and integrated divertor coils. The center rod system is comprised of 24 water-cooled, insulated wedge conductors placed inside a new inner vacuum wall. There is no Ohmic solenoid, which allows sufficient copper for the 48 kA/turn toroidal field current (or a current density of 160 MA/m²). The outer TF conductors are 12 pairs of air-cooled, reinforced C-shaped Al plate conductors. Pairwise crossed conductor links connect the outer C-plates to the central rod conductors to eliminate the need for a toroidal compensation wind-back coil. Torque plate assemblies on top and bottom mechanically secure both the outer C-conductors and the interconnecting links; counteract torsional magnetic loads during a pulse; and provide compliance for vertical displacement. The assembly accommodates magnetic and thermal forces, limiting the axial excursion of the central assembly to < 1 mm. PEGASUS-III is powered by 7 MJ of new stored energy and 175 MVA of programmable power systems for the various magnetic coil sets and startup systems.

Work supported by US DOE grants DE-SC0019008 and DE-SC0020402.