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A 2.5 T, 1.25 m free bore superconducting magnet for the Magnum-PSI linear plasma generator

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The interplay between a nuclear fusion plasma and the reactor wall determines the performance and lifetime of fusion reactors. DIFFER's main experiment Magnum-PSI is the only laboratory setup in the world capable of exposing materials to plasma conditions similar to those of future fusion reactors. The success of the Magnum-PSI experiment depends on the generation of a 2.5 T magnetic field without restricting the diagnostic access and operational aspects of the experiment. This has been achieved with a magnet consisting of five superconducting solenoids wound on a 2.5 m long stainless steel coil former positioned in a cryostat offering a 1250 mm warm bore. A copper stabilized (Cu/Sc.: 8.7) multifilamentary NbTi conductor with a 3.48 mm2 cross section has been used, thus the magnet exhibits a total inductance of 500 H and a stored energy of 15 MJ. This presents some challenge for the protection scheme that has been implemented using a mix of back-to-back cold diodes and an external dump resistor. The coils generate a plateau shaped magnetic field adjustable up to 2.5 T over a distance of 1750 mm between the exit of the plasma source and the end of the target plate, while the distance between the coils allows for 16 room temperature view-ports. Taking advantage of these, the large warm bore provides an excellent access to the experiment for diagnostics and maintenance. The coils are cooled with liquid helium using a re-condensing system operated with cryocoolers, while the magnet system cycles between zero and full field every day. The magnetic stray field is shielded down to 1 mT outside the experimental area by iron walls that flank the magnet. Design, assembly and testing of the magnet system are described, and the Magnum-PSI experiment and its capabilities will be introduced.

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