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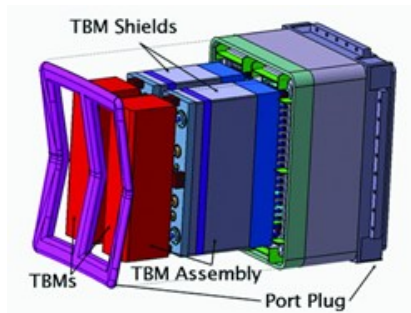
High performance operation compatible with test blanket modules

-Joseph Snipes, Stability & Control Section leader

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Focus On

Recent experiments performed by a team of international scientists on the **DIII-D tokamak** in San Diego, California, USA, indicate that the magnetic field errors introduced by the **Test Blanket Modules** (TBMs) in ITER can be corrected using non-axisymmetric control coils so that the impact on high performance plasma operation is reduced to a tolerable level.

Present TBM designs for ITER position nearly a ton of ferromagnetic steel close to the plasma surface to test the feasibility and efficiency of producing tritium fuel in the physical structures surrounding the plasma itself. Tritium will be produced within ITER's TBMs by exploiting the neutrons generated by the nuclear reactions occurring in the plasma, which will interact with lithium inside the TBMs.



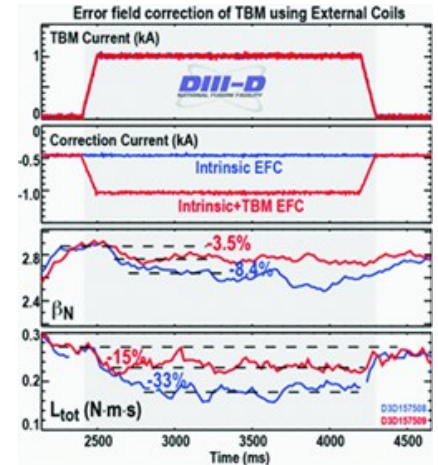
Schematic exploded view of a pair of TBMs to be installed in three equatorial ports in ITER. The components shown in red must be made of a special reduced-activation ferromagnetic steel that can withstand high neutron fluence and heat flux from the plasma.

Previous DIII-D experiments in 2009 and 2011 with a set of electromagnetic coils that were specifically designed to mimic the magnetic error field from a pair of TBMs in ITER **suggested** that high performance operation in ITER might be significantly degraded by the additional magnetic fields produced by the TBMs. Those experiments indicated that as plasma performance increased, the magnetic fields produced by the TBMs significantly reduced energy and particle confinement, making it increasingly difficult to sustain high plasma performance.

The latest experiments used sets of both internal and external control coils to correct the magnetic field errors introduced by the TBM mockup in DIII-D. Sophisticated methods of scanning the magnetic fields produced by the correction coils allowed the optimum correction to be made to specific components of the error field.

With the optimum correction fields, it was possible to run the DIII-D plasmas at high performance with almost no degradation in performance due to the TBM mockup. In the graph above, the normalized energy confinement of the plasma (denoted by βN) hardly decreases with optimized error field corrections, though a more sensitive measure of the effects of error fields—the total angular momentum of the plasma—drops by about 15 percent when a single row of external coils is used. Similar results were found using internal correction coils.

The results of these experiments indicate that it should be possible for ITER to compensate for a significant fraction (>60 percent) of the TBM-induced performance degradation in high performance ITER scenarios using either internal or external correction coils. Although a rigorous extrapolation of the DIII-D results to ITER remains to be confirmed, this is very important and timely information for ITER so that the conceptual designs of the TBMs can be finalized before the design reviews of the six test blanket systems begin in July 2014.



Error field correction of both the intrinsic magnetic field errors in DIII-D and the magnetic field errors produced by the TBM mockup (red) show that plasma performance (denoted by βN) drops by only 3.5% when error field corrections are optimized. The plasma rotation is an even more sensitive measure of the effect of error fields and the total angular momentum of the plasma (L_{tot}) is reduced by 15% with optimized error field correction.



The team of international scientists that worked on the TBM mockup experiments on the DIII-D tokamak in San Diego included Joseph Snipes (5th from right), Stability & Control Section leader from the ITER

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