Joint DIII-D/EAST experiment on high β_P scenario optimization

Teams of EAST (China) and DIII-D (USA) scientists carried out a successful second joint experiment, aimed at developing the high beta-poloidal regime of plasma operation toward higher beta for a more reactor-relevant operational scenario.

Background: The First joint DIII-D/EAST experiment (Aug. 2013) developed a prototype fully non-inductive scenario for extension to steady-state operation on EAST.

- The plasma current (Ip), toroidal field (Bt), Ip ramp rate, plasma cross section shape, and injected power were consistent with recently upgraded EAST capabilities
- Approach to fully non-inductive operation was based on the high β_P regime, yielding a bootstrap current fraction>80%
- Excellent energy confinement quality was observed, associated with the formation of an internal transport barrier (ITB) at large minor radius

The second joint experiment (Aug. 2014) was aimed at increasing β_N (and β_T) in this high β_P regime, in order to progress toward a more attractive reactor scenario. Relaxation oscillations limit the maximum β_N in the high β_P regime. Previously, these relaxation oscillations had been attributed to repetitive build-up and collapses of the ITB. However, analysis of the first joint experiment suggested that these relaxation oscillations might instead be caused by external modes amenable to wall stabilization.
The recent experiment tested this hypothesis by implementing a reduced plasma-wall separation at the outboard midplane. Originally, the plasma-wall gap in these experiments was particularly large in order to prevent over-heating of the wall by fast ion losses, which are large in the high β_P regime (low plasma current). An optimized waveform of the plasma-wall gap was developed, with large outer gap until high density (which limits fast ion losses) is established, and reduced outer gap afterwards. Use of this optimized outer gap waveform enabled a significant (up to ~30%) performance increase (in terms of β_N and β_T) relative to earlier work, demonstrating that ITB plasmas can be compatible with high beta limits, and opening the path to future performance improvements.

These results build the foundation for follow-up experiments to be conducted on EAST, where the superconducting coils enable extension to very long pulse, and verification of compatibility of this regime with reactor relevant boundary conditions.

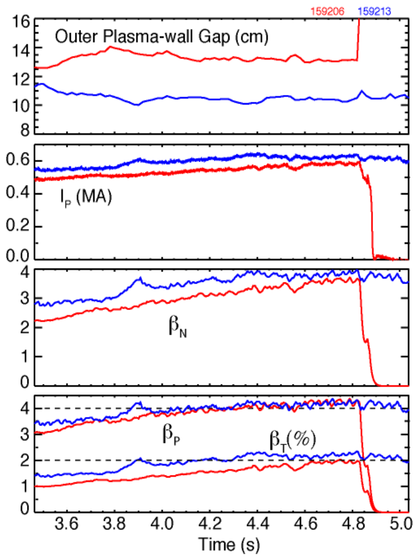

Figure 1: Comparison of two discharges with only input difference in the programmed waveform for the plasma-wall outer gap. Discharge with larger gap (red) suffers a beta collapse and disruption at $\beta_N \sim 3.6$. Discharge with reduced gap (blue) exceeds this β_N value, and sustains higher β_N and β_T values until the high heating power phase ends.

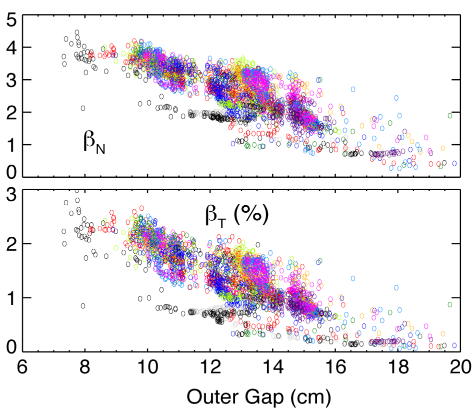

Figure 2: Database plots show plasma performance strongly improving with smaller outer gap.