Contribution ID: **551** Type: **Overview**

DIII-D Research Towards Establishing the Scientific Basis for Future Fusion Reactors

Monday, October 22, 2018 12:00 PM (25 minutes)

DIII-D research is addressing critical challenges in preparation for ITER and the next generation of fusion devices through a focus on scientific investigation of plasma physics fundamentals, integration of disparate core and boundary plasma physics, and development of attractive scenarios. Fundamental studies show that including the energetic particle "kick"model in transport codes dramatically improves agreement with the measured beam ion profile during strong Alfvénic activity, while dimensionless parameter scaling studies of intrinsic rotation lead to a predicted ITER rotation profile with significant turbulence stabilization. Hard X-ray spectra measurements show that anomalous dissipation of runaway electron (RE) beams is strongest for low energy RE populations, likely due to interactions between the low energy RE population and RE-driven kinetic instabilities. Core-boundary integration studies show that the small angle slot divertor achieves detachment at lower density and extends plasma cooling across the divertor target plate, which is essential for controlling heat flux and erosion. A rotating n=2 RMP combined with a stationary n=3 RMP has demonstrated access to ELM suppression with lower 3D field strength, while at the same time dynamically controlling the divertor heat and particle flux. Other edge studies show that the higher L-H power threshold with RMP fields is potentially due to both 3D density gradient modifications and changes in ExB shear layer topology. Super H-mode experiments in the presence of ELMs have achieved near-record pedestal pressures and record stored energies for the present DIII-D configuration with βN,ped≈1.3, H98y2≈1.6-2.4 and IP≤2.0 MA. In scenario work, the ITER baseline Q=10 scenario has been advanced by adjusting the early current density profile evolution to obtain reproducibly stable operation with ≈0 external torque and without n=1 tearing modes. In the wide pedestal QH-mode regime that exhibits improved performance, the startup counter torque has been eliminated so that the entire discharge uses ≈0 applied torque and the operating space is more ITER-relevant. Finally, the high βP scenario with large-radius ITB has been extended to IP˜1 MA (q95˜6) with high confinement H98y2˜1.6 from both Shafranov shift and negative magnetic shear. Work supported by the USDOE under DE-FC02-04ER54698.

Country or International Organization

United States of America

Paper Number

OV/1-4

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Session Classification: OV/1 Overview Magnetic Fusion

Track Classification: OV - Overviews