Abstract for an Invited Paper
for the DPP10 Meeting of
The American Physical Society

Scaling of the power exhaust channel in Alcator C-Mod[1]

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Physics-based transport models that can accurately simulate the heat-flux power widths in tokamaks are lacking at the present time. Yet this parameter is fundamentally important for ITER and more critically important for DEMO. In order to improve our understanding, Alcator C-Mod has recently installed an extensive array of divertor heat flux diagnostics to explore power exhaust channels over its wide range of accessible conditions, including reactor-level parallel heat fluxes (> 0.5 GW/m2) with high neutral opacity in an ITER-like vertical divertor plate geometry. This research is part of a coordinated science program with DIII-D and NSTX [1]. C-Mod's divertor heat flux "footprints" are found to exhibit a two zone structure: a narrow channel at the strike point location and a tail feature that extends into the far scrape-off layer. The balance in power carried by these two features can change depending on core radiation levels. In EDA H-mode discharges, the narrow feature is typically 2-3 mm wide mapped to the outer midplane; integral heat flux widths (λ_p) are 3.5 to 5 mm. These data stand in contrast to the empirical scalings used to estimate λ_p for ITER [2], which predict 0.5 mm for C-Mod. λ_p are found to systematically decrease with increasing plasma stored energy, which is in turn linked to the height of the edge pedestal and the strength of the quasi-coherent mode that accompanies EDA H-modes. These correlations yield an inverse relationship between λ_p and plasma current for discharges that attain the same normalized pressure gradient in the pedestal. Thus pedestal physics appears to be strongly coupled to the width of the power exhaust channel on adjacent open field lines.

[1] DoE Joint Facilities Research Target for FY2010 http://www.science.doe.gov/ofes/performancetargets.shtml.
[2] Kirnev, et al., Plasma Phys. Control. Fusion 49 (2007) 689-701.

[1]Supported by U.S. D.o.E. Coop. Agreement DE-FC02-99ER54512.