Scaling of Divertor Heat Flux Profile Widths in DIII-D *

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The divertor heat flux profile width $w_{q,div}$ will be important in future large tokamaks and is of interest in many present devices. Previous studies examining the parametric dependence of $w_{q,div}$ show various scalings [1] in JET [2], ASDEX-Upgrade [3], JT60-U [4,5], DIII-D [6,7], and NSTX [8]. We performed new scaling experiments under controlled conditions in DIII-D lower single-null ELMing H-mode diverted configurations without strong pumping. We extracted scaling of the divertor peak heat flux peak and profile width as a function of plasma input parameters.

Peak divertor heat flux scaled linearly with input power, decreased linearly with increasing density, increased linearly with plasma current, and increased linearly with increasing toroidal field magnitude at constant q_{95}. Consistent with the peak heat flux scaling, the width $w_{q,div}$ had a weak linear dependence on input power, was independent of density up to the onset of detachment, inversely proportional to the plasma current, and decreased linearly with toroidal field at constant q_{95}. These results agree with several of the previous scalings and differ from a few others. We show the details of this comparison.

We varied the plasma current I_p at constant toroidal field (B_t) and varied the line-averaged density $\bar{n}_e$ at constant I_p and B_t. The neutral beam injected power P_{inj} was changed at constant I_p and B_t, and B_t / I_p was scanned at constant q_{95}. X-point height was held constant with nearly constant local divertor geometry. Any impact of local divertor geometry (flux-expansion) will be included in more detailed analysis and presented. An IR camera recorded divertor plate surface thermal emission at many-kilohertz frame rates through the whole discharge, so that time-averaged data as well as rapid changes due to ELMs were obtained. Heat flux was calculated using the THEODOR 2D heat flux analysis code. For this analysis the heat flux data was averaged over ELMs. Each averaging interval was chosen for the least variation of parameters over the interval. From these dependencies we extract an overall scaling law. We compare these results with an analysis which excludes ELMs.

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