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Studies of High- and Low-δ Divertor Operation on DIII–D*

S.L. Allen[1] for the Divertor and Advanced Tokamak Task Force on DIII–D

General Atomics, P.O. Box 85608, San Diego, CA 92186-5608

[1]*Lawrence Livermore National Laboratory, Oak Ridge National Laboratory, Sandia National Laboratories, Albuquerque, University of California, San Diego*

A useful tokamak divertor must not only reduce the heat flux and erosion, but also play a role in controlling the core electron density and impurity content. An additional geometry constraint is that several Advanced Tokamak (AT) modes depend on high- triangularity (δ ~ 0.7) plasma shapes at high plasma current. On DIII–D, we have used a lower divertor which can pump low-δ shapes(SL); we can also operate high-δ (unbaffled, unpumped) SN or DN operation We have recently added a single null, outer single-baffle high-δ divertor on the top of the machine. (Single null High-δ Outer Baffle, or SHO). A summary of experimental data with SL and SHO operation, and comparisons with computational models will be presented in this paper (primarily ELMing H–mode). Experiments to date have demonstrated density control with the SHO configuration that is similar to previous SL operation. In both cases, we have operated at n_e/n_{GW} ~ 0.35, which is less than unpumped or "natural" H–mode operation by about a factor of two. To first order, the shape of the n_e and T_e profiles remains constant. The precise control of the plasma shape and wall conditioning were important in achieving these results. The total particle balance and 2-D bolometer radiated power profiles (focusing near the upper baffle) determined the progress of the conditioning. The impurity density remains roughly constant as n_e decreases, so the impurity concentration increases. Currently, the impurity behavior in SHO is an active research topic, both with experiments and computational modeling underway. UEDGE modeling has predicted changes in the plasma flow near the separatrix as the separatrix is moved towards the baffle, which could in turn promote impurity flows toward the pump. These predictions will be tested by varying the divertor geometry of the SHO (the baffle shape can also be changed in a vent by changing carbon tiles).

We have completed preliminary experiments to determine the effect of baffling: unpumped, high-δ SN discharges with(top divertor)– and without(bottom)–baffling were used. Experimental data from an array of tangential H_α monitors at the midplane and a transport analysis using detailed edge n_e and T_e profiles from Thomson Scattering were used to estimate the ionization current in each case. Comparisons indicate that the baffle reduces the ionization by 2–3×, in rough agreement with predictions from UEDGE and DEGAS modeling. No significant difference in τ_E has been observed, but the density at which the divertor detaches is reduced by ~20%.

We have also started high-δ DN experiments (with pumping at only the upper null), using a magnetic configuration favoring the upper divertor to enhance density control. This will guide the design of future divertor modifications on DIII–D, including a tightly-baffled top– and bottom– DN divertor. Modeling predicts a reduction of core ionization by nearly an order of magnitude in this case. Pumping at all four strike points also provides increased particle exhaust.

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