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Improved understanding and performance of power exhaust of alternative divertor discharges on MAST Upgrade

K. Verhaegh[1], J.R. Harrison[1], B. Lipschultz[2], D. Moulton[1], N. Lonigro[2,1], N. Osborne[3,1], P. Ryan[1], T. Wijkamp[4,5], C. Theiler[6], D. Brida[7], C. Cowley[2,1], G. Derks[5,4], R. Doyle[8], F. Federici[9], S. Henderson[1], B. Kool[5,4], H. Reimerdes[6], L. Xiang[1], N. Vianello[10]

[1]United Kingdom Atomic Energy Authority, [2]University of York, [3]University of Liverpool, [4]Eindhoven University of Technology, [5]Dutch Institute for Fundamental Energy Research, [6]Ecole Polytechnique Fédérale Lausanne, [7]Max Planck Institute Garching, [8]Dublin City University, [9]Oak Ridge National Laboratory, [10]Consorzio RFX

e-mail (speaker): kevin.verhaegh@ukaea.uk

MAST Upgrade supports a range of Alternative Divertor Configurations (ADC), including a Super-X Divertor (SXD), in a strongly baffled divertor chamber. Our results show that the SXD (B_t/B_{xpt} = 2.3 (ratio of magnetic field at target to X-point)) exhibits numerous advantages over the Conventional Divertor (CD) (B_t/B_{xpt} = 1.1), including enhanced detachment access and reduced particle & heat fluxes through increased ion & power sinks. The SXD remains detached in beam-heated scenarios (up to P_{NBI}=2.5 MW) between 25-50% Greenwald fraction (n_{GW}), while the CD only detaches at 45% n_{GW} without extrinsic seeding. An intermediate strike point radius (B_t/B_{xpt} = 1.7) configuration, the Elongated Divertor (ED), retains many of the SXD benefits.

The MAST-U SXD and ED demonstrate a reduced detachment front location sensitivity during heating/fueling perturbations and transients; whilst the conditions in the core and upstream of the detached region are identical between the SXD, ED and CD (Figure 1a,b,c). The downstream-end of the ionisation region (*detachment front*) remains at a constant poloidal distance from the X-point, independent of the magnetic geometry below the detachment front, according to both experiments (Figure 1 a,b) and simulations. Therefore, the enhanced power/particle exhaust capabilities of the longer legged baffled divertors (SXD & ED) are caused by the additional volume downstream of the detachment front up until the strike point. In this *detached region* (Figure 1a, b), plasma-molecular interactions involving molecular ions lead to Molecular Activated Recombination (MAR) ion sinks, enhancing particle removal capabilities [1]. Such molecular interactions have an unprecedented impact on the detachment physics in the strongly baffled MAST-U SXD [2,3] & ED (Figure 1a,b) and their treatment requires modifications to exhaust modelling [4].

Initial H-mode results show that the MAST-U SXD and ED remains detached during the inter-ELM period. H-mode operation and a larger range of ADCs will be investigated in the upcoming experimental campaign (07/2023-) including studies on ELM power dissipation using novel ultrafast spectroscopy.

References

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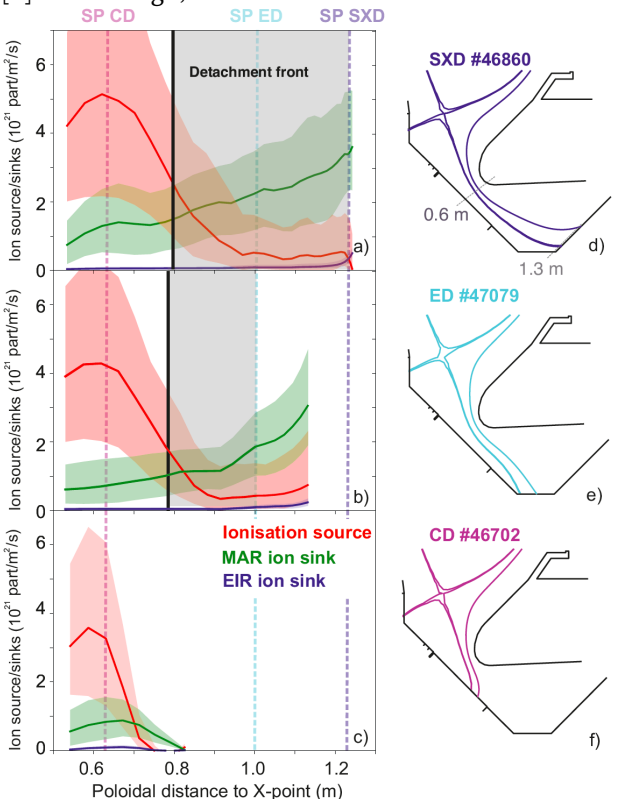

Figure 1: Ion source & sink profiles in the divertor chamber as function of poloidal distance to the X-point for the SXD (a,d), ED (b,e) and CD (c,f) configurations at 35 % n_{GW}. The detached region is shaded black (a,b) and the strike point (SP) position for the three configurations is highlighted (a,b,c)