FIRST CAMPAIGN WITH ALTERNATIVE DIVERTOR CONFIGURATIONS IN ASDEX UPGRADE

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The exhaust of the power and the He produced by the fusion reactions in a nuclear fusion reactor remains a key challenge. As a possible solution for this problem, alternative divertor configurations (ADCs) have been studied in many tokamaks, like TCV [3, 4], DIII-D [5], NSTX [6] and MAST-U [7], but only at low or moderate heating powers. An outstanding feature of ASDEX Upgrade (AUG) is its high heating power of up to 25 MW compared to its size (R = 1.65 m). In order to study a variety of ADCs [8] under these high power conditions, AUG's upper divertor was equipped with a pair of in-vessel divertor coils, a charcoal coated cryo-pump capable of capturing He, new divertor targets as well as an extended set of diagnostics.
During the two-year long opening, a number of technical challenges were overcome, like the in-vessel winding of the continuous conductor or the installation of the divertor tiles with an alignment accuracy of 0.2 mm. Since April 2025, the new upper divertor is fully operational and more than one hundred ADC discharges were carried out.

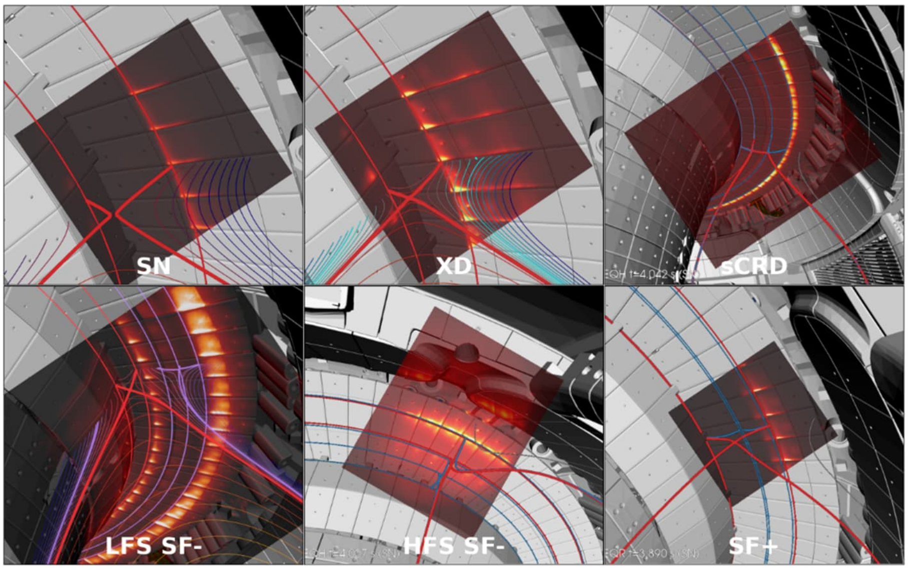
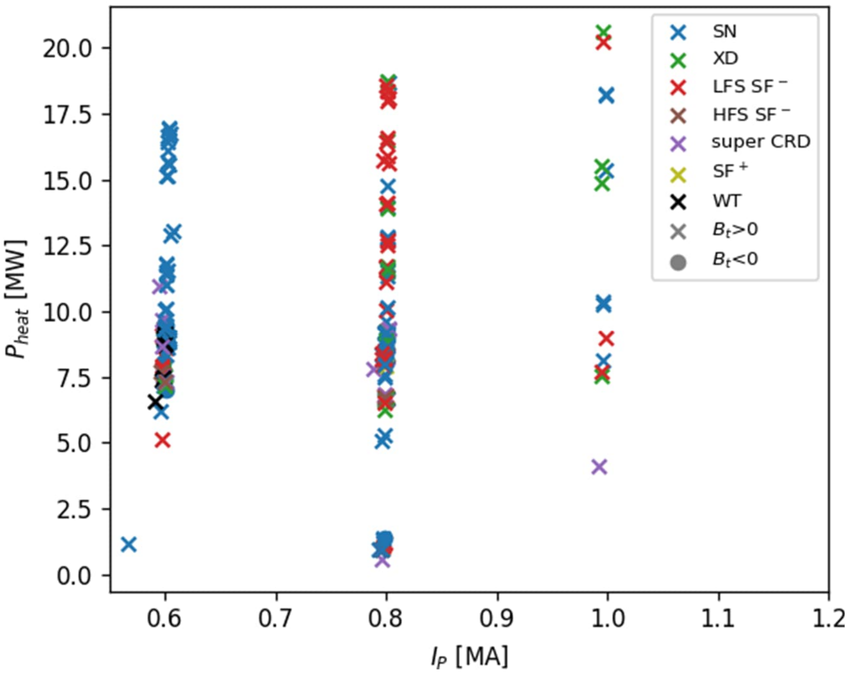


Figure 1: Infrared camera images recorded during different alternative divertor configurations in the new upper divertor of ASDEX Upgrade. The in-vessel components as well as the magnetic equilibrium are overplotted

Figure 1 shows infrared camera images of different AUG discharges overplotted by CAD drawings of the device and the magnetic equilibrium, where the primary separatrix and strike line are shown in red and the secondary ones in purple. Plasma operation has been achieved in all ADCs planed during the design phase of the new upper divertor (cf. Ref. [8]): the X-divertor (XD, Ref. [9]), the Low-Field-Side Snowflake minus (LFS SF^-, Ref. [11, 12]), the High-Field-Side Snowflake minus (HFS SF^-) and the Snowflake plus (SF^+, Ref. [13]) configurations as well as an extreme form of the Compact Radiative Divertor (sCRD, Ref. [10]). Except for the SF^+, stable operation was established in all configurations for seconds, in particular also during the phases with ELMs. Both magnetic field directions and both, low- and high, confinement regimes were established in ADC with plasma currents up to 1 MA and heating powers up to 20 MW (cf. Fig. 2).



In this contribution we will give an overview over the campaign and show first results of the ongoing analysis. As an example, we analyze a 1 MA discharge at 18 MW of total heating power and compare the three phases of the discharge, the SN, XD and LFS SF^- configuration. As expected a splitting of the outer strike line is observed in the XD and LFS SF^- configurations (cf. Fig. 1 bottom left). The peak heat fluxes measured by Langmuir probes decrease by a factor of 1.7 in the LFS SF^- configuration compared to the SN reference.
Another example is a LFS SF^- discharge that facilitates access to an X-point radiator regime [14].
The a large number of high power discharges carried out with very small field line incidence angles at the target did not damage the tiles or provoke hot spots, confirming the benefits of the high alignment accuracy of the target tiles.

ACKNOWLEDGEMENTS

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

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