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# Overview of Exhaust Physics Results from MAST-U

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The particle and power exhaust solution in fusion reactors needs to produce tolerable power loads on plasma-facing-components and be compatible with the high-performance fusion core. Alternative divertor configurations should be explored to mitigate the risk that the ITER solution, a single null divertor with a high radiation fraction in the scrape-off-layer (SOL), does not extrapolate to future higher power devices. MAST-U was designed to explore the comparative benefits of conventional and alternative configurations, in particular the Super-X configuration [1] with tightly baffled divertor chambers. The Super-X configuration increases the outer strike point major radius by a factor of ~2, which increases the connection length and total flux expansion by roughly the same factor. This reduces the heat flux to the outer target and improves access to the detached divertor regime due to the combined effect of increased wetted area and enhanced volumetric power losses and cross-field transport.

During the first MAST-U campaign, the aim of the main exhaust experiments was to demonstrate the expected advantages of the Super-X configuration compared with a conventional divertor. An ohmic heated L-mode scenario in double-null configuration with plasma current of 600-750 kA and elongation of ~2 was developed for both conventional and Super-X configurations. Midplane electron temperature and electron density profiles were similar for the two configurations, which shows that the core plasma conditions were not adversely affected by the Super-X configuration or the presence of detached divertors. The ion flux rollover at the outer target measured by Langmuir probes was 50% lower for the Super-X configuration in terms of midplane line average density, in agreement with previous SOLPS and analytic modelling predictions [2]. During attached divertor conditions, the peak heat flux measured by IR thermography was a factor of ~10 lower for the Super-X configuration. Multi-wavelength imaging and spectroscopy diagnostics identified distinct regions of ionisation, molecular activated recombination and electron-ion recombination in the divertor chamber during the detachment evolution. Results from the SOLPS-ITER code indicate (i) particle drifts do not seem to play a major role in the outer scrape-off-layer; (ii) the outer target ion flux rollover in the conventional configuration is driven by power loss from the core, rather than from the divertor; (iii) unlike our expectations for a reactor, the core and main SOL particle sources are significant compared to the target flux. This motivates going to higher heating powers in future experiments.

The aim of this contribution is to give an overview of exhaust physics results from MAST-U and discuss the implications for future reactors (enhanced role of plasma-molecular interactions, simulation-experiment comparison in current devices is essential for credible extrapolation to more reactor relevant conditions). Results from the first campaign will be presented along with preliminary analysis from the second campaign, starting in September 2022. The main exhaust objective for the second campaign is to study the compatibility of high-confinement core scenarios with optimised conventional and Super-X configurations.

[1] P. M. Valanju et al Phys. Plasmas 16 056110 (2009)
[2] B. Lipschultz et al Nucl. Fusion 56 056007 (2016)

## Speaker's Affiliation

UKAEA, Oxon

## Member State or IGO

United Kingdom

**Primary authors:** Dr KIRK, Andrew (UKAEA); Dr THORNTON, Andrew (UKAEA); Dr LIPSCHULTZ, Bruce (University of York); Dr THEILER, Christian (Ecole Polytechnique Fédérale de Lausanne, Swiss Plasma Center ); Dr MOULTON, David (UKAEA); Dr FEDERICI, Fabio (University of York); Dr LOVELL, Jack (Oak Ridge National Laboratory); Mr CLARK, James (University of Liverpool); Dr HARRISON, James (UKAEA); Dr ALLCOCK, Joseph (UKAEA); Dr VERHAEGH, Kevin (UKAEA); Mr NICHOLAS, Osborne (University of Liverpool); Dr RYAN, Peter

(UKAEA); Dr HENDERSON, Stuart (UKAEA); Dr CHRISTIAN, Theiler (Ecole Polytechnique Fédérale de Lausanne, Swiss Plasma Center ); Mr DAMIZIA, Yacopo (University of Liverpool)

**Presenter:** Dr RYAN, Peter (UKAEA)

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