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A tightly-baffled, long-legged divertor concept for DEMO and its potential test in TCV

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Safe plasma exhaust with high core performance is one of the remaining challenges on the development path towards a fusion reactor. Alternatives to conventional single-null divertors are assessed as risk mitigation. While multiple null divertors face severe technological challenges, long-legged divertors emerge as a promising option [1] where combination with tight baffling may further increase the heat exhaust potential [2].
A proposed upgrade of the TCV tokamak aims at proof-of-principle experiments of such a tightly-baffled, long-legged divertor (TBLLD). In a first phase, new in-vessel components and diagnostic enhancements will provide a well-diagnosed, tightly baffled outer divertor leg to assess TBLLD's ability to increase the plasma neutral interaction and impurity radiation and, thereby, facilitate detached divertor operation. Experiments will also investigate the stability margin between divertor re-attachment and over-mitigation together with passive mechanisms and active technologies to operate within those margins. Initial SOLPS-ITER simulations predict that the first phase should demonstrate a significant increase in the power handling capability. Relying upon intrinsic carbon radiation alone or employing nitrogen seeding should both lead to at least a 5-fold increase of the power handling capability over the unbaffled TCV divertor. Experiments in the first phase will test the divertor models that are used to prepare the second upgrade phase and assess the plasma exhaust potential of the TBLLD concept in DEMO. In this second upgrade phase, the TBLLD concept will be applied to the entire TCV divertor in combination with a promising high-performance plasma core with up-down symmetric configurations and negative triangularity shaping being currently considered as options.
Initial scoping studies investigate the application of such a TBLLD concept into the EU DEMO design without significant changes to the conventional single-null equilibrium solution. This is achieved by using the full depth of the space defined by the tritium breeding blanket, similar to the proposed ARC fusion pilot plant design, but without the challenging, and costly, complications of that magnetic topology [3].
[1] F. Militello, et al., Nucl. Mater Energy 26 (2021) 100908.
[2] M. Umansky, et al., Nucl Fusion 60 (2020) 016004.
[3] A.Q. Kuang, et al., Fusion Eng. Des. 137 (2018) 221.

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