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Towards reactor relevant alternative concepts in the TCV Tokamak

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Plasma exhaust is a crucial issue for future fusion reactors, where the heat flux deposited on the divertor targets will exceed material limits if unmitigated. The most promising solution to date is to operate in the detached divertor regime. In a reactor operating in H-Mode, an additional complexity emerges from the presence of Edge Localized Modes (ELMs), which are unacceptable from the power exhaust point of view and require ELM mitigation and/or ELM buffering. In view of the extrapolation towards a reactor, the TCV tokamak has embarked on a journey to test reactor relevant alternative concepts, namely the negative triangularity (NT) and the tightly baffled, long-legged divertor.

Experimental observations on TCV and DIII-D have shown that negative triangularity L-Mode discharges can exhibit H-mode grade confinement [1,2], with discharges reaching up to β_N=2.8 (2 in steady-state) in L-Mode, thus opening the possibility for high confinement reactors that side-step the challenges associated with H-mode such as ELMs, removing the need for ELM mitigation or ELM buffering. Negative triangularity discharges appears to enter H-mode at significantly higher power than the L-H threshold for positive triangularity discharges, which offers a wider parameter space for stable plasma operations for future reactors where the alpha heating is not directly controlled. Experiments show that the density limit is similar in NT as compared to PT, and that detachment is generally harder to attain in NT, where sufficient cooling (< 5eV) of the outer target is not achieved in core density ramps and, with N2 seeding, only at the cost of confinement degradation. This reveals that while NT represents a promising solution towards ELM-free, high confinement, scenarios, core-edge integration remains challenging.

Building upon the success of the divertor gas baffles installed in the framework of the Plasma EXhaust (PEX) European program [3,4], a proposed upgrade to the Swiss Plasma Center installations, the Swiss Fusion Hub, plans to equip the TCV divertor with a tightly baffled, long-legged divertor geometry, which was inspired by simulations for the ADX tokamak concept [5]. Preliminary simulations suggest that such configuration should demonstrate substantially improved detachment access and a large detachment window, while being relevant for a reactor. Understanding divertor physics in this new configuration will employ an extended suite of divertor diagnostics, providing two-dimensional measurements of kinetic, fluctuation, and spectroscopic quantities across TCV's divertor volume. In parallel, an upgrade of the ECRH system will allow accessing operation at higher heat flux levels and higher upstream separatrix pressures.

References

[1] S. Coda et al 2022 *Plasma Phys. Control. Fusion* **64** 014004.
[2] A. Marinoni et al. *Rev. Mod. Plasma Phys.* 5, 6 (2021).
[3] A. Fasoli et al 2020 *Nucl. Fusion* **60** 016019.
[4] H. Reimerdes et al 2021 *Nucl. Fusion* **61** 024002.
[5] M. Umansky, et al., *Nucl Fusion* **60** 016004.