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Overview of the European Tokamak Programme in the new European Framework Programme

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In the new European framework Programme (FP9), EUROfusion has gathered the experimental tokamak activities under a single structure called tokamak exploitation (TE). This Task Force is developing the scientific EUROfusion Programme on four devices: ASDEX Upgrade, MAST-U, TCV and WEST. JET is also included but will first complete the DT campaign in 2021 separately. Within the headlines of the European Road Map, the overarching priorities of the task force is to: prepare ITER exploitation, guide the DEMO design, and exploit the recent machine enhancements, such as those related to plasma exhaust in all four devices.

Taking advantage of the capabilities of each machines, the Task Force experiments Programme has focused its priorities on: i) the development of the H-mode with ITER operational constraints: dominant electron heating, the control of transients (ELMs, disruption and run-aways), pedestal-SOL compatibility and fast particle physics ii) the exploration of DEMO scenarios (QH-mode, I-mode, EDA-mode) and iii) a strong Programme on heat and particle exhaust: detachment physics and control, the validation of the plasma facing components for ITER and the exploration of alternative divertor concepts (snow-flake, super-X divertor).

Along those lines, in the recent 2021 campaigns in ASDEX Upgrade, the EDA and QCE no-ELM scenario is developed further extending its domain of existence to different shaping and lower toroidal field strength (1.8T). On its side, transient QH mode have been produced transiently in the ASDEX Upgrade metallic wall with good confinement. Detachment properties are also studied in these scenarios but is prevented when small ELM activity remains. Detachment studies have also achieved low ELM regime whilst maintaining high confinement (H~1.03) close to the density limit. In addition, comparison between nitrogen and Argon seeding have been achieved featuring good ELM buffering properties. ELM active mitigation is also explored in the standard ELMy H-mode ITER scenario and density control has been successfully achieved during resonant magnetic perturbation (RMP) phase using pellet injection. In this scenario, the pedestal quality has been extended to high triangularity shape (d=0.4) which is an important step towards the ITER parameters. The operation of the ITER baseline scenario also depends on mastering the discharge start-up studied with ECRH assist and extrinsic impurity injections to widen the operational window of the plasma initiation. In addition, run-away generation after disruptions in high electron temperature plasma is investigated to determine the role of the so-called hot tail mechanisms in performant plasmas.

About plasma exhaust, first TCV experiments are investigating in L-mode and H-mode the alternative divertor configurations like the snow-flake versus the single null configuration using the existing baffles. These discharges shall be compared this year with identical discharges without the baffles and later with a new more closed set of baffles. MAST-U is also starting its campaign with the first investigation of the super X divertor. On its side, WEST completes now the installation of the new tungsten actively cooled components for their qualification for ITER in high fluence long pulse discharges. These experiments will provide eventually the elements for selecting and designing the most optimised divertor for future fusion reactor.

Beyond 2021, the tokamak European Programme will develop further with the addition of power upgrades in TCV and WEST and divertor upgrade in ASDEX Upgrade and the potential extension of JET until 2023. Tight links are being built with ITER and the DEMO EU teams to ensure that experiment and modelling results are in line with their requests.