Effect of divertor poloidal leg length on SOL turbulence and transport

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A key feature of several alternative divertor concepts, explored to address the open issue of power exhaust in a tokamak fusion reactor, is an increased poloidal length of the outer divertor leg with respect to a standard Lower Single Null. This feature is being explored in current tokamaks as MAST-U [1], and it is considered for the design of future machines as DTT [2], ARC [3] and DEMO-EU [4, 5]. The expected benefits include reduced peak target heat fluxes due to increased cross-field transport, higher radiation levels, and a facilitated access to detachment. Among these phenomena, the effect on cross-field transport and the role of turbulence are the least understood, and probably the key missing pieces for reliable extrapolations of advanced divertor concepts to future devices.
The nature of turbulence in the divertor is still debated [6]. Past experiments [7] and isothermal simulations [8] suggested that turbulence, active along the outer divertor leg, can lead to a substantial broadening of the Scrape-Off Layer (SOL) heat flux width at the target. New TCV experiments at lower toroidal field, though, surprisingly show only a weak effect of the leg length [9].
In order to understand these observations, the poloidal length of the outer divertor leg has been scanned with the GBS edge turbulence code [10], for the first time with a realistic TCV diverted geometry and for non-isothermal conditions. These simulations allow us to elucidate the nature of the turbulence in the divertor region and to disentangle the roles of turbulence and background drifts, showing a remarkable and unexpected importance of the latter in determining the SOL width. The results of these simulations are then also compared in detail with dedicated TCV experiments, taking advantage of a wide range of edge plasma diagnostics, including a unique Reciprocating Divertor Probe Array that provides 2D plasma measurements along the divertor leg and at the turbulence timescales [11].

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