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Long-Pulse High Performance Plasmas towards ITER and CFETR Steady-State Operation in EAST

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World-record duration of 403s reproducible H-mode plasmas (H_{98y2}>1.3, n_e/n_{GW}~0.7, f_{BS}>50%) have been recently achieved on EAST, exploiting improved long pulse capabilities, which demonstrate good control of core/edge integration, high-Z impurities, particle recycling and heat exhaust with the ITER-like tungsten divertor and zero injected torque. This achievement sets a milestone on the path to steady-state long-pulse high performance scenarios in ITER and CFETR.

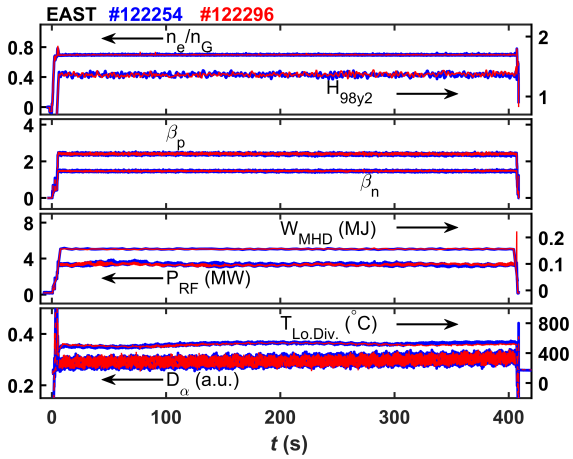

Figure 1. Record duration of 403-second reproducible H-mode plasma achieved with tungsten divertor on EAST.

Important synergistic effects between on-axis electron cyclotron heating and lower hybrid wave leverage the heating and current drive efficiency of radio-frequency (RF) power, enabling fully non-inductive operation at high density (n_e/n_{GW}~0.7) and high poloidal beta (β_P ~2.5). Meanwhile, higher density and β_P enhance the bootstrap current fraction [1] and also self-consistently broaden the current density distribution, leading to increase in confinement. Transport analysis indicates that the high energy confinement quality (H_{98y2}>1.3) can be originated from a slightly reversed magnetic shear and an internal transport barrier (ITB) in the T_e channel, at $\rho \sim 0.3$, and suggests that TEM turbulence dominates in the core region. A high frequency small ELM regime [2] facilitates the RF power coupling to the H-mode edge and reduces divertor sputtering/erosion. Tungsten concentration in the core is well controlled at C_w<10^{-5}, benefiting from strong central EC-heating in this high β_P plasmas.

Key technical and scientific challenges including robust plasma shape control, improvement of magnetic measurements, particle and heat load have also been addressed. EAST will further extend high performance regime with available heating power and demonstrate the core-edge integration with full metal walls.

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