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Long-pulse no-ELM H-mode operation with feedback-controlled detachment and H98,y2~1.1 under boronized metal wall in EAST

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Metallic impurities induced by divertor heat load and ELM filaments are the main challenges in achieving long-pulse high-performance H-mode operations. Long-pulse (>50s) no-ELM H-mode discharges with feedback-controlled divertor detachment by nitrogen seeding from outer horizontal target plate of the lower divertor have been achieved under boronized metal wall in the EAST tokamak. Figure 1 shows such a discharge with n_{el}~$4\times10^{19}m^{-3}$, I_p=400kA, B_t=2.45T, q_{95}~6.2, β_N~1.35, β_p~1.55, lower signal null configuration (dRsep~-2cm), favorable Bt direction, heated by ~2.5MW ECRH at 140GHz and ~2MW LHCD at 4.6GHz. Good electron density feedback control is achieved through SMBI from the outer midplane. Divertor detachment control is achieved through feedback to the electron temperature measured by a divertor Langmuir probe at the outer target plate of lower divertor in this discharge. Detachment control through feedback to XUV radiation near the divertor X-point has also been achieved in other discharges. The electron temperature near the outer strike point of the lower divertor is maintained at ~2eV as measured by divertor Langmuir probes, indicating the achievement of divertor detachment. The divertor peak surface temperature measured by infrared camara is reduced from ~500 to ~250℃ by the nitrogen seeding. Good energy confinement with H_{98y2}~1.10 is maintained for ~20s, then decreasing to H_{98y2}~1.05 until 50s when the discharge is terminated due to depletion of the volt-seconds. Long-pulse discharges of >70s (limited by volt-seconds) have been achieved with plasma current I_p reduced to 350kA with q_{95}~7.0. However, the energy confinement is lower (H_{98y2}~1.0). Before the nitrogen seeding, grassy-ELM-like perturbations appear in the divertor Dα signals as shown in Fig.1(d). Then, the perturbations are completely suppressed and a no-ELM regime is maintained till the end of the discharge. Tangsten and molybdenum impurity line emission saturate after 40s as well as the core radiation. Carbon impurity line emission keeps nearly constant. A broadband turbulence peaking at ~600kHz appears during the nitrogen seeding in the pedestal steep-gradient region near the pedestal top, which may be responsible for the ELM suppression. The improved particle confinement leads to a continuous decrease in the divertor Dα signal, as well as a decrease in the SOL density, and more neutral particles are ionized in the pedestal region, resulting in an increase in the pedestal density gradient. This plasma regime has also been obtained at I_p=500kA and q_{95}~5.2 in 10s short pulses with H_{98y2} up to 1.2. In summary, these experiments demonstrate a metal-wall compatible plasma regime for tokamak long-pulse operation with good energy confinement, stationary divertor detachment and no ELM, which are desired operational conditions for future fusion reactors.

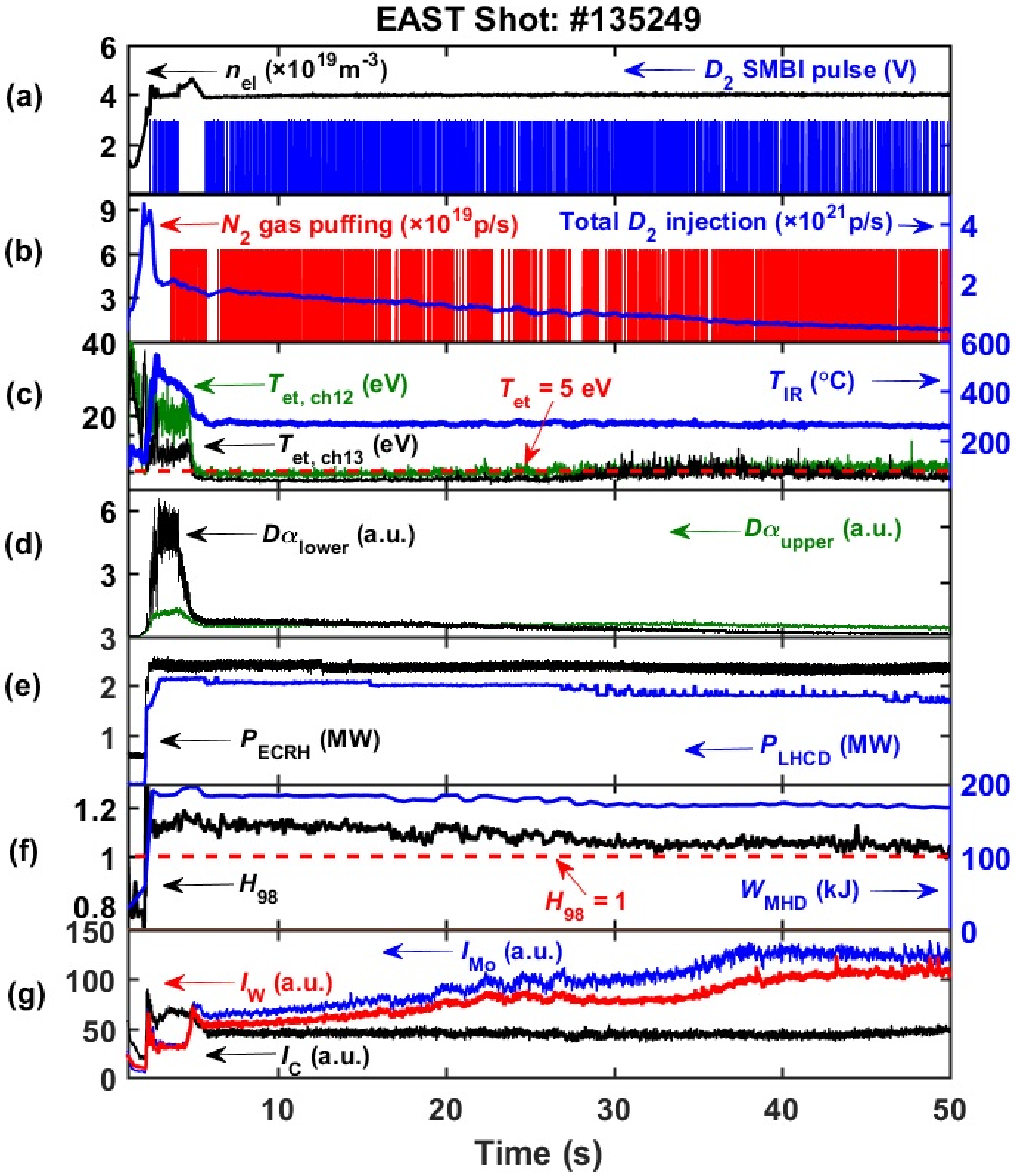

Figure 1: enter image description here

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