§1. Extension of Operational Regime in High-T_i Plasmas in the LHD

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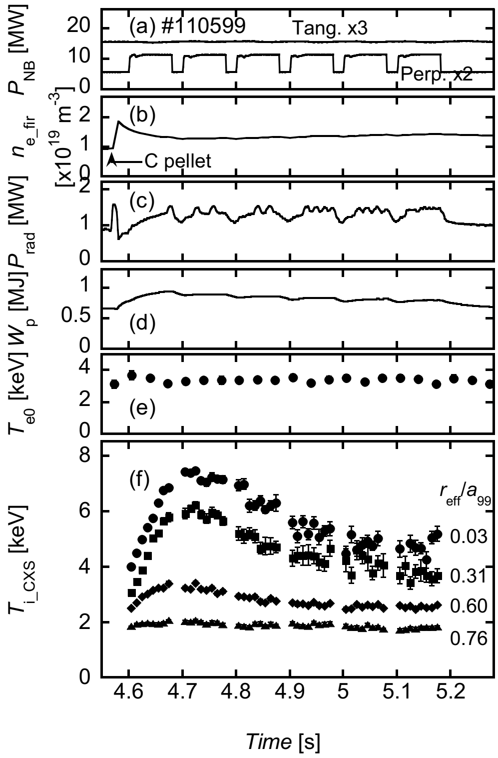
Realization of high-T_i plasmas is one of the most important issues in helical plasmas, which have an advantage for steady-state operation comparison with tokamak plasmas. Since 2010, newly installed perpendicular-NBI with the beam energy of 40 keV has been operational in the LHD and the total-heating power of perpendicular-NBIs increased from 6 MW to 12 MW. Such low-energy NBIs are effective for ion heating and enabled us to achieve a higher T_i than that obtained previously [1]. In the last experimental campaign, ICRH-discharge cleaning was adopted to reduce particle recycling from the wall. As a result, NBI-heating-power profile became peaked and the density-normalized ion heating power in the core region increased by 18%.

In the LHD, high-T_i plasmas have been realized in combination with a carbon pellet [1-3]. The kinetic-energy confinement was improved by a factor of 1.5 after the pellet injection. Figure 1 shows the typical time evolution of (a) the port-through NB power, (b) line-averaged-electron density, (c) the radiation power, (d) the plasma stored energy, (e) T_{e0}, (f) T_i, (g) the radial profiles of T_i, T_e and n_e in the high-T_i discharges, which recorded the highest T_{i0} and (h) the progress of the achieved T_{i0} in the LHD as the dependence of T_{i0} on the density-normalized ion heating power $P_i/<n_i>$. The plasma was sustained by three tangentially injected NBs and two perpendicularly injected NBs with the total-port-through power of 27 MW and the column-shaped C pellet (ϕ = 1.0 mm, l = 1.0 mm) was injected at t = 4.57 s. One line of the perpendicular NBIs was modulated for T_i measurement by CXRS. After the pellet injection, the central T_i, dT_i/dr_{eff} at the core region clearly increased indicating the formation of the ion-ITB. On the other hand, there was little change in T_{e0}. The radiation power increased just after the pellet injection but went back to the previous level due to the formation of the impurity hole. Ion temperature of 7 keV at the plasma center was successfully obtained and the achieved T_{i0} has been increasing approximately linearly with $P_i/<n_i>$.

ICRH-discharge conditioning exerted a preferable effect also on quasi-steady-state operation of high-T_i discharges without C-pellet injection. The sustain time of the plasma with T_{i0} > 4.5 keV has been successfully extended to 1 s from 0.5 s, which is the previous record, even the P_{NB} was 4 MW lower than that of the previous one.

1) O. Kaneko *et al.*:Plasma Fusion Research **4** (2009) 027.
2) K. Ida *et al.*: Nucl. Fusion, **49** (2009) 095024.
3) K. Nagaoka *et al.*: Nucl. Fusion, **51** (2011) 083022.



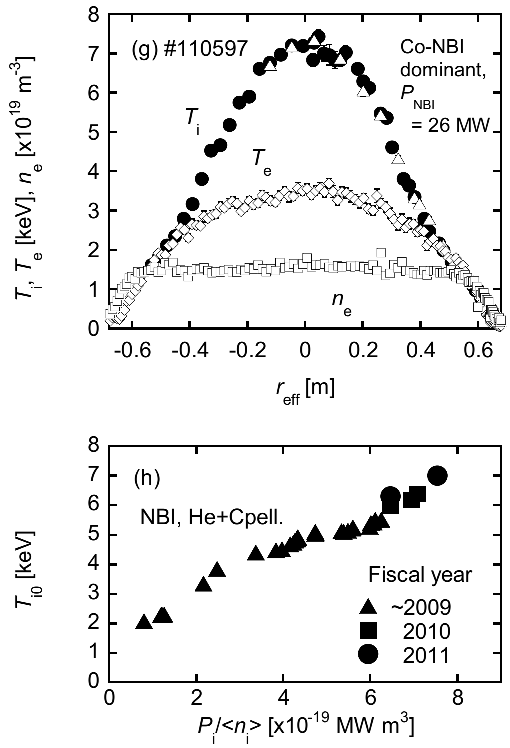


Fig. 1. The typical time evolution of (a) the port-through NB power, (b) line-averaged-electron density, (c) the radiation power, (d) the plasma stored energy, (e) T_{e0}, (f) T_i, (g) the radial profiles of T_i, T_e and n_e in the high-T_i discharges, which recorded the highest T_{i0} and (h) the progress of the achieved T_{i0}.