§1. Characteristics of High-temperature High-beta Plasma

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Plasma performance of the future Helical reactor is being estimated based on the present parameters of LHD. One of the concerns about this extrapolation process is that the high-beta plasma in LHD is so collisional that the reactor plasma might behave differently. For example, when the plasma becomes less collisional, the plasma reacts to the topology of the magnetic field more sensitively. It is therefore possible that the pressure or temperature gradient cannot be sustained in the magnetic stochastic region surrounding the main plasma of LHD.

In order to evaluate the plasma behavior in high-temperature regime, trials for producing the high-beta plasma with higher magnetic field ($B_t = 1.0$T) are made. Since the heating efficiency of the NBI heating degrades drastically with the outward-shifting of the magnetic axis, configurations with small Shafranov shift (plasma aspect ratio Ap = 6.6 and the ellipticity k = 1.1 (Bq = 72%)) are selected[1). Also, the optimum vacuum axis position smaller than Rax = 3.6m is investigated with Ap = 6.6. Figure 1 shows the achieved beta value, the central density and the central temperature in this series of experiments. Achieved beta is higher with configurations with smaller Shafranov shift. However, the inward-shifteding is not effective for realizing the high-beta plasma. The peak value of the electron density decreases with the decrease of the vacuum magnetic axis position. Phenomenologically, this saturation of the density limits the increase in the plasma beta. Though the highest beta value is not obtained, the high-beta plasma (beta $\sim$ 3.2%) with the central electron temperature upto 1.5keV is realized with Rax(vac) = 3.575m configuration. The temperature in the edge magnetic stochastic region is increased as well. The electron temperature in the stochastic region varies from 100eV to 300eV at beta $\sim$ 3.0%. Figure 2 shows the scale length of the electron temperature profile in the stochastic region (R=4.4m, 4.5m and 4.6m) as a function of the electron mean free path at R= 4.5m. The scale length does not change so much, even though the plasama becomes more colisionless and the mean free path exceeds the circumference of a LHD ($2\pi R \sim 25$m) or the connection length ($\sim$ 100m) to the wall estimated by the HINT2 equilibrium code. The effects of the reduction of the collisionality in the magnetic stochastic region do not appear with present plasma parameters in high-beta experiments. Further confirmation of this characterisitic with more collisionless plasma is required.

1) K. Y. Watanabe et.al., Fusion Sci. and Tech., (2011) vol.58 pp.160-175.

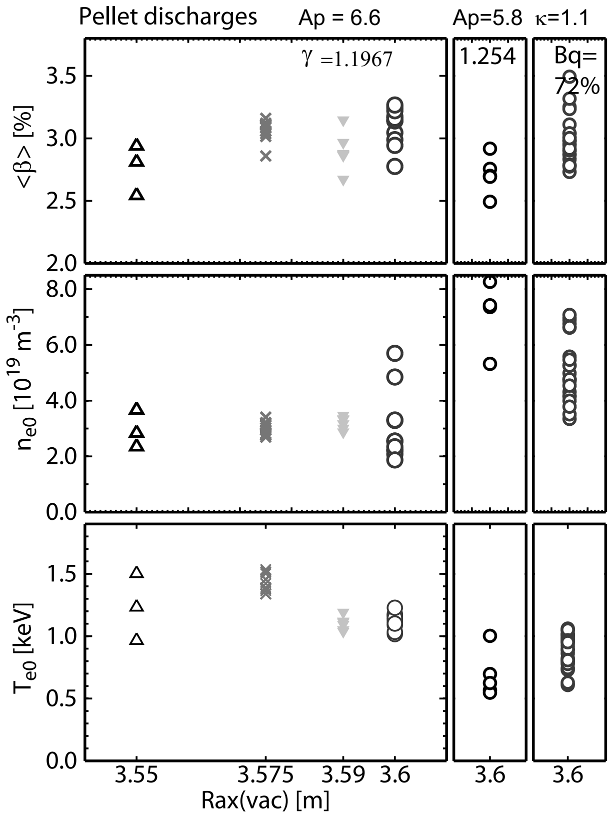

Fig. 1: Achieved beta, the maximum central electron density and the central electron temperature at highest beta are shown together. Results of the optimization of the vacuum magnetic axis position with $A_p = 6.6$ is also shown.

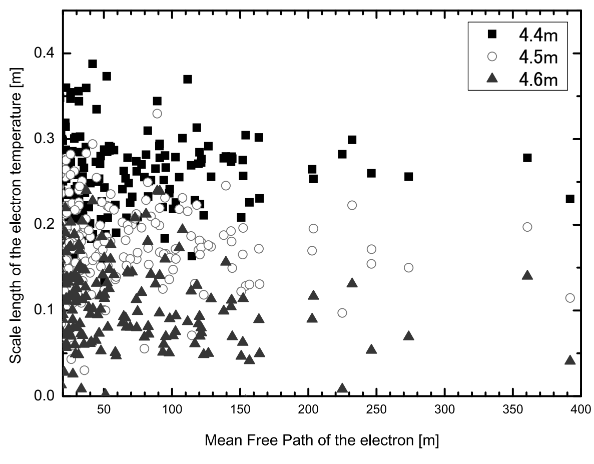

Fig. 2: The scale length of the electron temperature profile in the stochastic region (R=4.4m, 4.5m and 4.6m) as a function of the electron mean free path at R= 4.5m.