§12. High Beta Experiments in LHD

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In the 10th experimental campaign in F.Y.2006, in order to extend the operation range of the beta value, we finely study the confinement properties on the magnetic axis positions, and the heating efficiency of perpendicular NBI in the high beta discharges. By the calculation, the heating efficiency of perpendicular NBI is quite sensitive to the magnetic axis position of the configurations and it suddenly decreases as the magnetic axis shift torus- outwardly. Up to last experimental campaign, the contribution of the perpendicular NBI to the beta value was small in the high beta discharges where the large magnetic axis shift was observed. On the contrary, in the high beta and low-density discharges, the beam component is fairly large. Then, it is expected that, just after the pellet injection, the beam pressure suddenly decreases, and that the magnetic axis shift decrease. Moreover, the reduction of the NBI power leads to the reduction of the magnetic axis shift due to beta. Then, in order to control the magnetic axis position, we apply the pellet injection and a short break down of the parallel NBI. By the pellet injection, a short break down of the NBI power and the perpendicular NB injection under the high power parallel NBI, we obtain a $<\beta_{dia}>=5.0\%$ plasma, where plasma with more than 90% of max $<\beta>$ is maintained for a short time, $\sim 10\tau_E$. Here τ_E is the energy confinement time. It should be noted that $<\beta_{dia}>=5.0\%$ corresponds to the reactor relevant parameter and it was a target value before the construction [1].

Figure 1 shows the waveform of the $<\beta_{dia}>=5.0\%$ plasma. In Fig.1(a), the averaged beta value and the line averaged electron density are shown, the normalized magnetic axis shift in Fig.1(b), and the port-through NBI power in Fig.1(c), where #1+2+3 corresponds to the sum of the parallelly NB injected power and #4 to the perpendicularly NB injected power. The pellets are injected during t=0.6-0.8s. Before the pellets inject, the normalized shift of the magnetic axis exceeded 40%. During pellet injections and a NBI line break down for 0.1s, the shift of the magnetic axis approaches to zero. The perpendicular NB injection starts just after all pellet injections. After the last pellet injection, the electron density suddenly decreases and the beta value increases and reaches the maximum value of the beta, when the shift of the magnetic axis is more than 40% of the minor radius. After the beta maximum it decreases gradually. It should be noted that according to the comparison the discharges with and without perpendicular NBI, the perpendicular NBI to the beta value is ~10% of the total beta value.

Figure 2 shows the waveform of the $<\beta_{dia}>=4.8\%$ plasma, which corresponds to the maximum beta value without pellet injection and the perpendicular NBI. The extension of the beta range is mainly due to the increment of the parallel NBI power comparing with last experimental campaign. In Fig.2(a), the averaged beta value and the beam component are shown, the magnetic fluctuations in Fig.2(b)-(d). The high beta plasma with $<\beta_{dia}>$ > $0.9\text{x}<\beta_{dia}>_{max}$ is maintained for around 100 times of τ_E (in quasi-steady). And the MHD activities corresponding to the peripheral rational surfaces are observed and its levels are not so large.

Reference

[1] A.Iiyoshi et al., Fusion Technol. 17 (1990) 169.

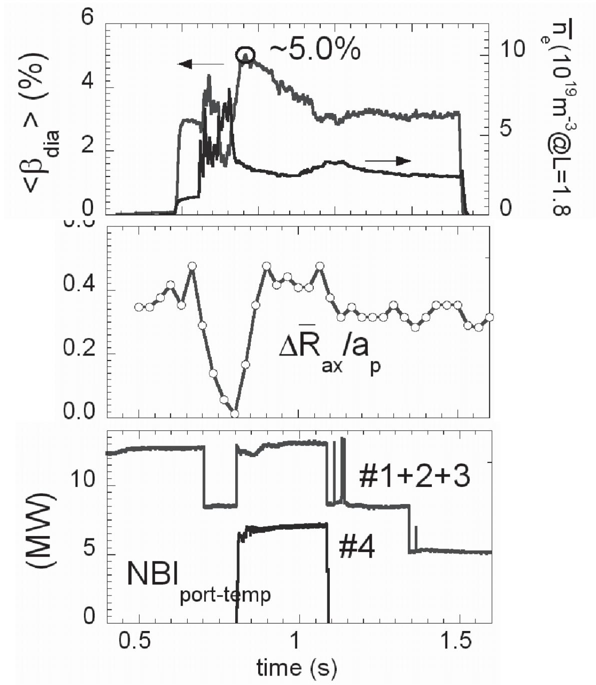

Fig.1 The waveform of the $<\beta_{dia}>=5.0\%$ plasma. (a) the averaged beta value and the line averaged electron density. (b) the normalized magnetic axis shift. (c) the port-through NBI power.

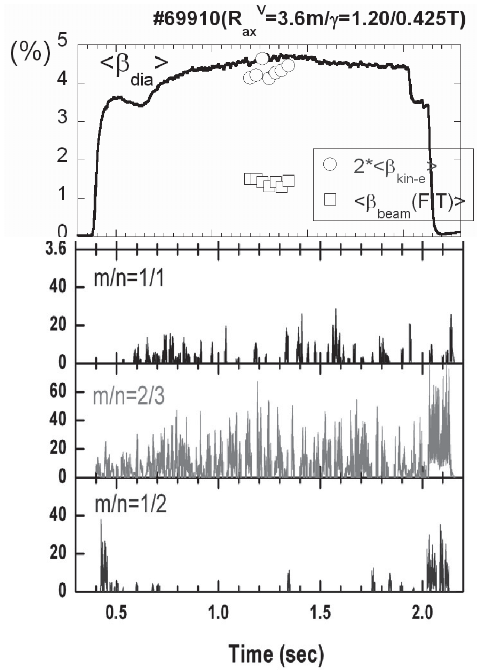

Fig.2 The waveform of the $<\beta_{dia}>=4.8\%$ plasma. (a) the averaged beta value and the beam component. (b)-(d) the mode amplitude of the magnetic fluctuations.