§7. High-Central-Beta Configuration

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High-beta regime in the LHD has been extended to ~5% by optimizations of the magnetic configuration; the heating efficiency is kept high-level when the Shafranov-shift is reduced by making the aspect ratio higher ($A_p \sim 6.6$). Here, a new approach to the high-beta configurations with a peaked density profile (i.e. larger Shafranov-shift) is investigated.

From an MHD point of view, there are many advantages in the peaked profile plasmas; the magnetic well is deeper in the core region from the larger Shafranov-shift and the pressure gradient in the edge region is smaller. Therefore, overall MHD stability will be improved significantly. We started to study peaked pressure profiles in the LHD as an alternative approach to obtain the high-beta plasma. A peaked profile is formed in the recovery phase after sequentially injected hydrogen pellets. While the electron density decreases after the pellets, the electron temperature recovers quickly. In this recovery phase, the pressure profile becomes peaked; high-central-beta plasma is formed in this phase[1,2]. Though the final plasma with peaked pressure is stable, MHD stability is important in the process of the formation. When the vacuum magnetic axis Rax_{vac} is located inward (e.g. Rax_{vac} = 3.6m), larger levels of MHD fluctuations and sawtooth-like instabilities are activated when the pressure profile is being peaked[3]. The peaking of the plasma is thereby disturbed and the degree of peaking is small. On the contrary, in the outward-shifted cases (Rax_{vac} > 3.7m), the achieved electron density is higher and the density / pressure profile becomes fairy peaked. Therefore, a higher central-beta β_0 can be achieved. However, the increase of β_0 is limited by the so-called core density collapse (CDC) events[4]. It is an abrupt event where the core density is collapsed within 1 ms. CDC appears when the magnetic axis position exceeds 4.1m. So far, we do not have understood the mechanism fully. The magnetic reconnection in the region where the magnetic surfaces are heavily compressed by the large Shafranov shift is promising candidate since the time scale of the events suggests that the transport along the magnetic field lines is important. In order to avoid the CDC events, the vacuum magnetic axis should locate inward since there is much space for the Shafranov-shift. Therefore, the best way to achieve the high central beta is to keep the magnetic axis between 3.7m and 4.1m in the formation phase of the peaked profile, avoiding these two unstable regions. The magnetic configuration suitable for the peaked profile is thus different from the one in the standard averaged-high-beta discharges. The highest β_0 (80586, shown in Fig.1) is obtained with Rax_{vac} = 3.65m (Bt = 0.65T), which is the smallest value where the peaked pressure profile can be formed at the present. The central beta (~9.9 %) is comparable to the value in the highest averaged-beta discharge (69910, Rax_{vac} = 3.6m and Bt = 0.425T) with a higher toroidal magnetic field (Fig. 3). We continue the optimization of the configuration in order to get the higher value of the beta at the plasma core.

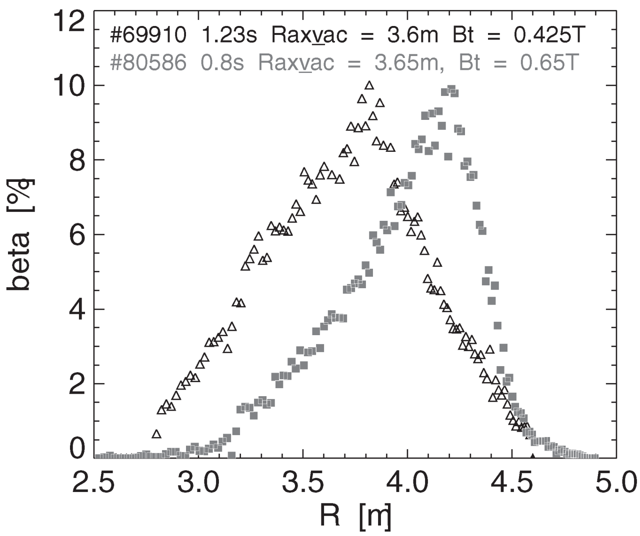

Fig.1: Comparison of the beta profile between an averaged-high-beta discharge ($<\beta>\sim 4.8\%$) and a peaked profile discharge ($<\beta>\sim 3.0\%$).

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