§8. High-beta Profile Data for FFHR-d1 Core Plasma Design

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Core plasma design of a helical fusion reactor FFHR-d1 is based on the direct profile extrapolation (DPE) method [1]. In the DPE method, the density and temperature profiles are assumed to have the same shape as those observed in the experiment. These are multiplied according to the multiplication factors of the magnetic field strength and the heating power, while keeping the so-called gyro-Bohm type relation. Basically, the plasma beta is assumed to be the same in the experiment and the reactor, to apply the same MHD equilibrium. If the plasma beta in the reactor is different from that in the experiment, it is necessary to recalculate the MHD equilibrium for the reactor condition [1]. Therefore, the performance of the reactor core plasma is determined by the experimentally obtained profile data.

In the 18th campaign, an experiment has been carried out with the magnetic configuration similar to that of FFHR-d1 (R_{ax} = 3.55 or 3.60 m, B_0 = 1.0 T, γ_c = 1.20). High-beta profile data as shown in Figs. 1 and 2 have been obtained. The ion temperature profiles have also been taken. Since the high-energy NNB was used as the main heating source, electron heating was dominant in the experiment. This is a similar situation as in the reactor. Because of this, the ion temperature, T_i, is lower than the electron temperature, T_e, at low-density. As the density increases, however, the difference between T_i and T_e becomes smaller and finally, $T_i \sim T_e$ is achieved at high-density. In the DPE method, $T_i \sim T_e$ is basically assumed. Therefore, the equipartition condition of T_i and T_e should be carefully considered in the reactor core plasma design.

A marked difference in the density profiles depending on the magnetic configuration has been observed as shown in Fig. 2(b). In both cases shown in the figure, no fueling was applied and therefore the density was sustained by the particles recycled from the wall. The density profile was peaked in the magnetic configuration with R_{ax} = 3.55 m, while it was hollow with R_{ax} = 3.60 m.

1) J. Miyazawa, et al., Nucl. Fusion **54** (2014) 043010.

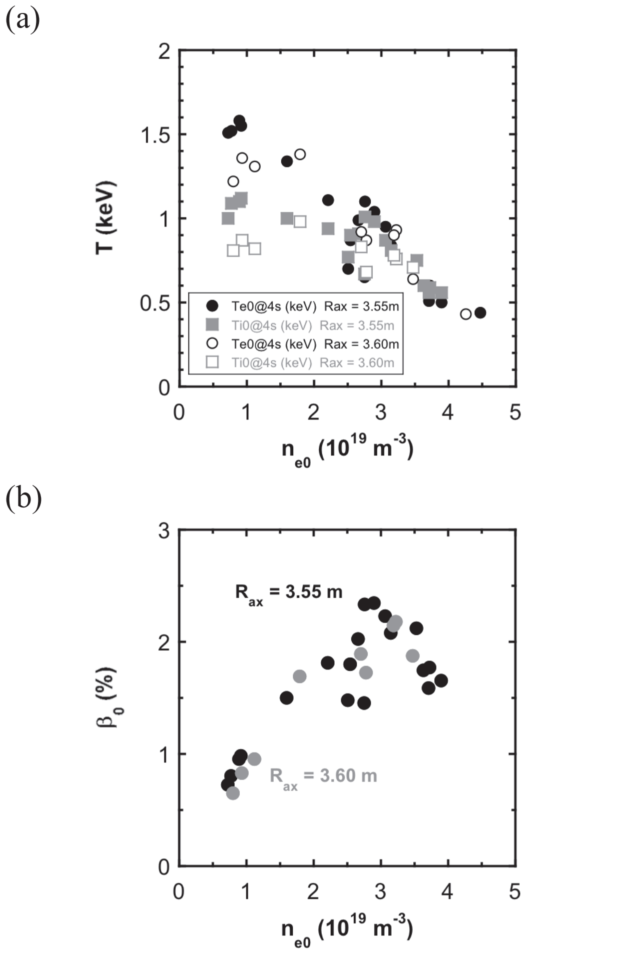

Fig. 1. (a) The central electron temperature, T_{e0}, and (a) the central beta, β_0 (=β_{e0} + β_{i0}), with respect to the central electron density, n_{e0}, obtained in the experiment in LHD to get high-beta profile data for FFHR-d1 core plasma design.

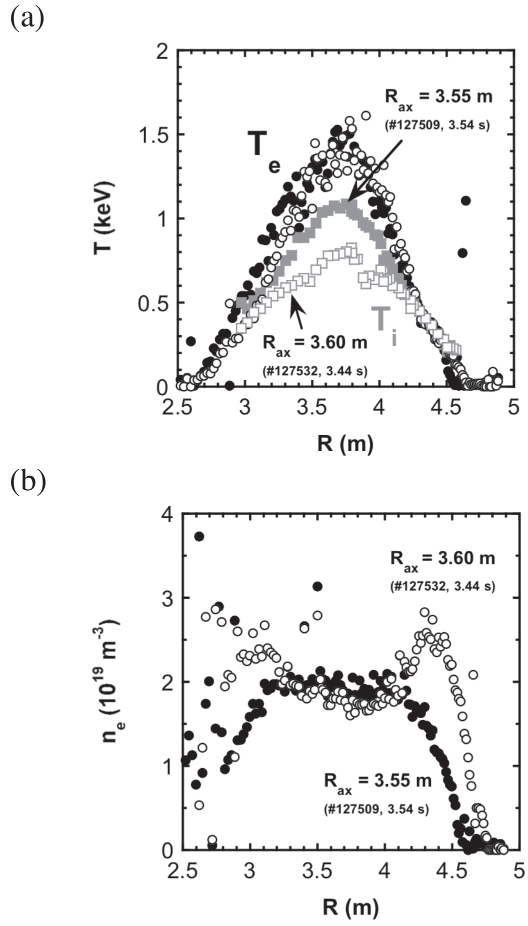

Fig. 2. Radial profiles of (a) the electron temperature, $T_e(\rho)$ (circles), and the ion temperature, $T_i(\rho)$ (squares), and (b) the electron density, $n_e(\rho)$. Closed and open symbols denote the different magnetic configurations of R_{ax} = 3.55 m and 3.60 m, respectively.