§3. Potential Profile Measurements with HIBP in the Low Density Plasma of LHD

Shimizu, A., Ido, T., Nishiura, M., Nakamura, M., Yokoyama, M., Takahashi, H., Igami, H., Yoshimura, Y., Kubo, S., Shimozuma, T., Kato, S., Yokota, M.

In toroidal magnetized plasma, the radial electric field is an important parameter because the plasma confinement property is modified by this parameter. In helical device, the strong non-ambipolar diffusion flux in 1/ν regime is predicted from the neoclassical theory, and the radial electric field is determined by the ambipolar condition. This radial electric field can suppress the large ripple loss in the 1/ν regime of helical device. In LHD, a heavy ion beam probe (HIBP) was developed to measure the profile of potential and its temporal evolution [1]. In this report, an example of experimental result of potential profile measurement with HIBP is reported.

This experiment was done in the following parameters of magnetic field configuration: the magnetic field strength is 1.375 T, the major radius of magnetic axis is 3.6 m, the pitch parameter is 1.254, and the quadropole field is 100%. The acceleration energy of probe beam is 1.302 MeV for this configuration. In Fig.1, temporal evolutions of line averaged density and heating methods are shown. Plasma is produced and sustained by NB heating. NBI #1 is a counter-injection beam line and #2 is a co-injection beam line. NBI#2 is turned off at 3.6 s, so only counter-injection beam is injected after this time. ECH (77GHz) is applied from 3.8 s to 5.0 s additionally. Line averaged density is 0.5×10^{19} m^{-3} at 3.7 s and it is ramped up to 1.2×10^{19} m^{-3}. The probe beam incident angle of HIBP is changed in the frequency of 10 Hz in order to measure the radial profile of potential. The potential profile in the periods (a) 4.20~4.25 s, (b) 4.80~4.85 s, (c) 5.10~5.15 s measured with HIBP are shown in Fig.2. In the period (a), the density is low, 0.5×10^{19} m^{-3}, while in the period (b) the density is higher than in (a), 0.8×10^{19} m^{-3}. In these two cases, ECH is additionally applied to NB heated plasma. In the period (c), the density is higher than in (a) and (b), 1.0×10^{19} m^{-3}, and no ECH is applied (only NB heating sustains the plasma). The potential at the plasma center is 3.3 kV in the period (a), 2.1 kV in the period (b), and about 0.5 kV in the period (c). The radial profiles of electron temperature in these 3 periods are shown in Fig. 3. Due to the intensive central heating of ECH, the internal transport barrier (ITB) is seen in the center of plasma in the period (a) and (b). The strong shear of radial electric field at ρ ~ 0.2 in the period (a) is deduced from the measured potential profile in Fig.2, and this strong shear is one possible reason for the formation of electron ITB. In the period (b), the potential profile is flat in the region from ρ ~ 0.2 to ρ ~ 0.6 as shown in Fig. 2. The reason for this flattening of potential profile is considered to be magnetic islands, and in the temperature profile the flattening is also seen as shown in Fig.3. In the period (c), the potential is almost zero. The comparison of experimental data to the neoclassical theory is in progress.

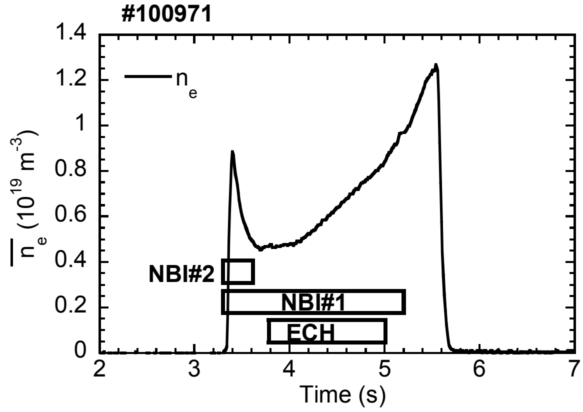

Fig. 1. Temporal evolution of line averaged density and heating

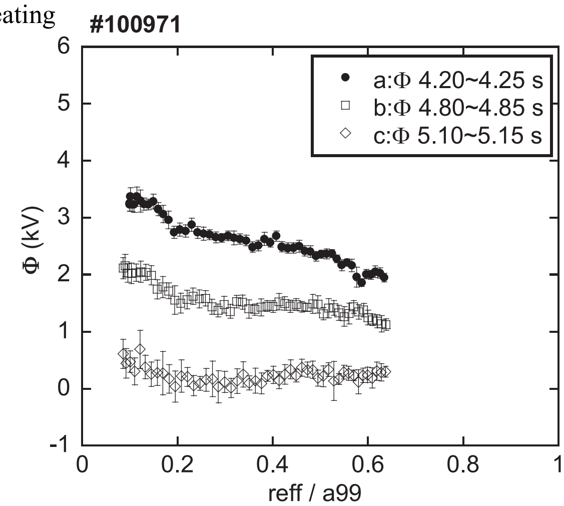

Fig. 2. Radial profiles of potential measured with HIBP in periods a) 4.20~4.25 s, b) 4.80~4.85 s and c) 5.10~5.15 s

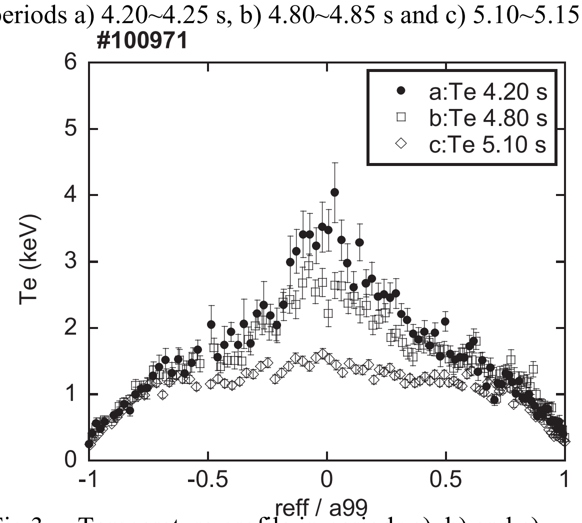

Fig.3. Temperature profile in periods a), b) and c)

1) Shimizu, A. *et al.*: 23rd IAEA Fusion Energy Conference 2010. (http://www-pub.iaea.org/MTCD/meetings/PDFplus/2010/cn180/cn180_papers/exc_p4-11.pdf)