§16. Experiment Study of 2-D Potential Fluctuation Profile with HIBP

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In the study of plasma confinement physics, measurement of radial electric field, E_r, is very important. In helical system, the particle flux of low collisional regime, so called $1/\nu$ regime, is reduced by E_r, which is determined by the neoclassical context. Moreover, poloidal flow is correlated to $E \times B$ flow, and shear flow structure is important because the turbulence suppression by it can improve the plasma confinement. To study those physics, heavy ion beam probe (HIBP) has been developed on the LHD. In recent study, the method to measure 2-D potential profile is developed and applied to measure potential fluctuation of MHD mode.

Usually, on HIBP diagnostic, the probe beam energy, E_b, is fixed and the injection/ejection angle of probe beam, α, β is changed to vary the observation point. For 2-D profile measurement, the beam probe energy is changed in addition to α, β. However, this is not easy task, because the beam transport line of LHD-HIBP system is long (~20 m), and many electro-static deflectors have to be adjusted to optimize the beam orbit on the beam transport line, when E_b is changed. To reduce the required time for this adjustment, a PC-based automatic beam adjustment system was developed and applied to 2-D equilibrium potential profile measurement experiments [1]. Now, 2-D potential fluctuation profile data from these experiments is analyzed.

Temporal evolutions of typical discharge's parameters of our experiments are shown in Fig.1. The plasma is produced by balance NBI heating, NBI #1 (counter-injection) and NBI #2 (co-injection). The short pulse of ECH is applied in the duration 4.5 - 4.9 s. At 5.3 s, NBI #1, #2 are turned off and NBI #3 (counter-injection) is turned on. The line averaged density is about ~ 0.4×10^{19} m^{-3}, and the central electron temperature in NBI period is ~ 1.5 keV. In the duration 5.5 - 6.5 s, the high frequency mode (~200 kHz) is observed in HIBP potential signal as shown in Fig.2. This signal is correlated to signals from magnetic probes. To obtain 2-D fluctuation profile, the probe beam energy, E_b, is changed shot to shot. By using the signal from magnetic probe as a reference, the phase between the potential fluctuation and magnetic field fluctuation is estimated and 2-D structure of phase shift is obtained. In Fig. 3, this structure is shown with vacuum magnetic surfaces. From this figure, the poloidal mode number of this fluctuation is considered to be 1 or 2.

2-D phase structure of potential fluctuation is successfully measured with our HIBP system, although the interpretation of the physical aspect is not studied yet. In the future, signal to noise ratio will be improved, and more detail structure of the mode will be analyzed to understand the physical mechanism.

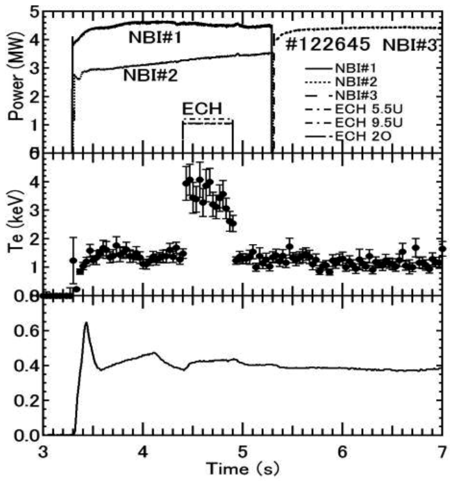

Fig. 1. Time evolutions of plasma parameters of typical discharge are shown.

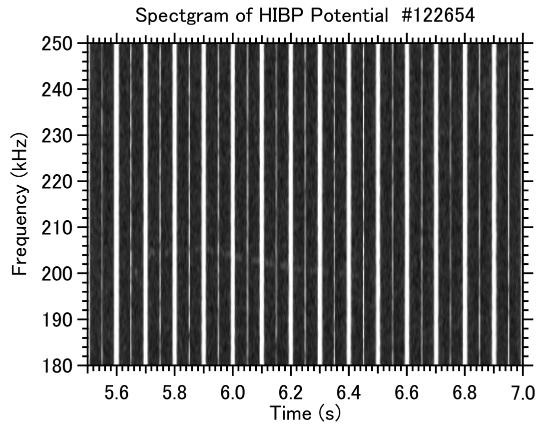

Fig. 2. Spectgram of HIBP potential signal in the duration 5.5 - 7.0 s is shown . High frequency mode (~200 kHz) can be seen in the duration 5.5 - 6.5 s.

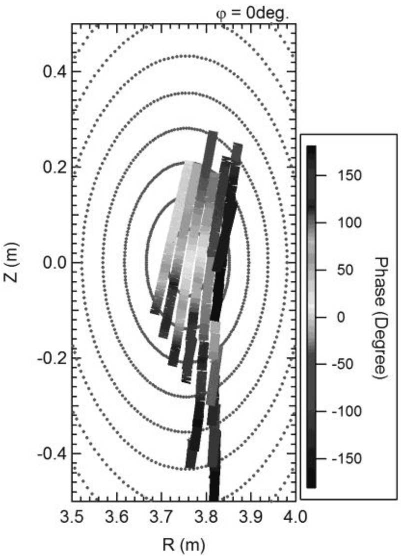

Fig. 3. 2-D phase structure of potential fluctuation is shown. As a reference signal, magnetic field fluctuation from magnetic probe is

1) Shimizu, A., Ido, T. et al.: Rev. Sci. Instrum. **85** (2014) 11D853.