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LHD における重イオンビームプローブ(HIBP)による電位の二次元構造の計測
Two-Dimensional Measurement of Electric Potential by Heavy Ion Beam Probe (HIBP) in LHD

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Heavy ion beam probes (HIBPs) are unique diagnostic tools for directly measuring the profile of the electrostatic potential and its temporal evolution in high-temperature magnetically confined plasmas. In the Large Helical Device (LHD), a HIBP has been developed to study confinement physics related to electrostatic potential [1]. Recently, two-dimensional measurement is tried to study detail of transport physics related to magnetic islands, spatial structures, fluctuation profiles and so on.

The observation point of LHD-HIBP can be changed one-dimensionally by sweeping an injection angle of probe beam. The two-dimensional potential profile can be obtained by changing the probe beam energy (E_b) as shown in Fig.1, where the each measurement position is projected on the poloidal cross section by tracing the vacuum magnetic field line from the actual observation point. However, it is difficult to change E_b practically because it spends much time (about 30 minutes) to optimize the beam trajectory by adjusting more than 20 control parameters after changing the E_b. Now, we have been developing a PC-based fast automatic trajectory optimization system, and apply it to measure the two-dimensional potential profiles on a poloidal plain on shot-to-shot basis in the LHD.

In the optimization process, the deviation of the probe beam from the center of beam-transport line is adjusted to be 0 by controlling voltage of steerer electrodes installed in the beam-transport system. The beam deviation is measured by rotating wire called Beam Profile Monitors (BPMs) at five positions in the beam-transport line, and measured in the two axis perpendicular to the beam line by each BPM. The applied voltages on the steerers are automatically optimized, using deviations measured by BPMs. The matrix of conversion factor from the deviations to the required voltages has been calibrated in advance.

In the 2013 campaign on LHD, the automatic optimization system has been applied on LHD-HIBP. As a result, the optimization of beam trajectory has been completed within 30 seconds on average, which is shorter than the interval between discharges (3 minutes). Figure 2 shows the two-dimensional potential profile measured by HIBP using the automatic optimization system. The magnetic surfaces with β of 0.69% are also shown. The potential profile in Fig.2 seems to be on non-uniform on the magnetic surfaces. One of the reasons is that finite β effect is not taken into account when the measurement positions are projected on a poloidal plane. The effect will shift the measurement positions in Fig.2 downward, qualitatively. The validation of the measurement with the automatic optimization system will be discussed in the presentation.

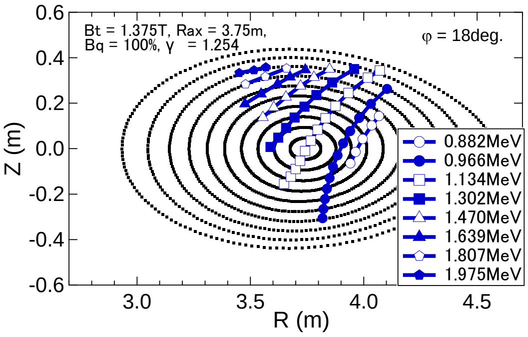

Fig.1. The Observable regions of LHD-HIBP in B_t = 1.375T, R_{ax} = 3.75m, B_q = 100%, γ = 1.254. The measurement position traces a marked curve during an injection-angle-sweep of the probe beam for each E_b.

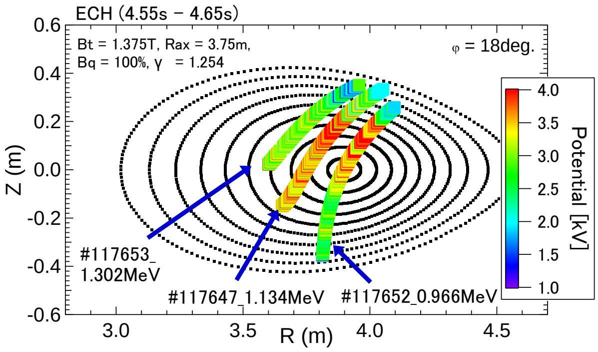

Fig.2. Two-dimensional potential profile measured with HIBP by applying automatic optimization system. Magnetic surfaces are plotted under β = 0.69%, φ = 18deg. B_t = 1.375T, R_{ax} = 3.75m, B_q = 100%, γ = 1.254.

[1] Ido,T.,Shimizu,A.,Nishiura,M.: Journal of Plasma and Fusion Research Vol86, No9(2010) 507-516