§ 15. Two-dimensional Lithium Beam Probe for Edge Plasma Diagnostics

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Two-dimensional plasma structures near and outside of the last closed flux surfaces (LCFS) have been measured by the use of the two-dimensional lithium beam probe (LiBP). The beam injection angle is variable and observation points covers edge and separatrix region of heliotron type helical magnetic configuration.

A lithium neutral beam with the energy up to 15 keV and with the equivalent beam current of a hundred microamperes is injected from the M-port (located upside of the torus). Light emission from the beam due to electron impact excitation (670.8 nm) is collected through a window mounted on the O-port (located outside of the torus).

Experiments have been carried out with magnetic axis at Rax = 0.921 m, which is the inboard limiter configuration. The LCFS is touching the inboard vacuum chamber wall at 8 locations. The magnetic filed line thus lose ergodicity outside of the LCFS. Plasmas in this region is considered to be scrape off plasmas. The magnetic field strength is 0.95 T on the axis. Hydrogen plasmas are produced by electron cyclotron resonance (ECR) heating with a 53.2 GHz, 170 kW gyrotron and additionally heated by two neutral beam injectors (both in co-direction) with beam energy of 40 keV and total power of 1.3 MW. ECH is applied from t = 20 ms to 120 ms and NBI from t = 80 ms to 180 ms, where t = 0 is the start of data acquisition for diagnostics. Average electron density in ECH phase is about $1x10^{19}$ m^{-3} and in NBI phase is $4x10^{19}$ m^{-3} respectively.

The Li beam injection angle is varied every 2° between 0 ° and -18° in the present experiments. Figure 1 shows an example of the light emission signal. Signal from a killer puff, which is introduced to prevent high-energy electron production during the turn off phase of the helical coils, is also detected at around t = 450 ms. Expanded signal at this phase is shown in the same figure. The emission signal comes from the collision of Li beam with neutral gas. Since the gas distribution becomes uniform in a short time, relative sensitivity between channels can be calibrated.

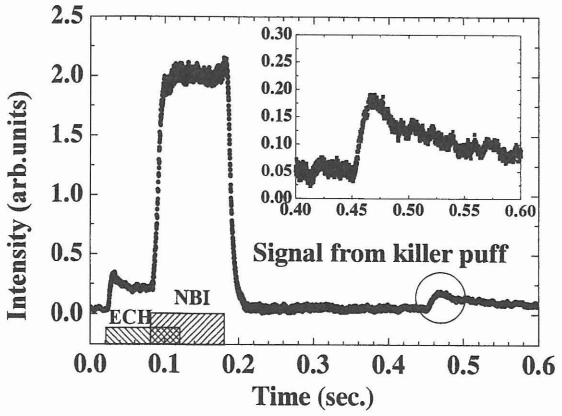

Fig.1. An example of the light emission signal.

Two-dimensional beam emission profiles are shown for ECH phase (Fig. 2a) and NBI phase (Fig. 2b). Smooth contour of the emission intensity along the LCFS is shown in the ECH phase. This is due to the low electron density at the edge and beam attenuation is negligible. However the contour in the core region deviates from the flux surfaces due to beam attenuation. Small shift of the contour downward from the closed flux surface structure is observed. It is primarily explained by the finite lifetime of the excited state. On the other hand, the peak of the beam emission intensity roughly follows the LCFS in NBI phase and rapidly decreasing toward the core, suggesting higher density plasma within the LCFS. It is also noted that significant amount of surface plasmas are confined outside the LCFS and they are spreading toward the separatrix region. Two-dimensional density reconstruction is necessary for further discussions, which is underway.

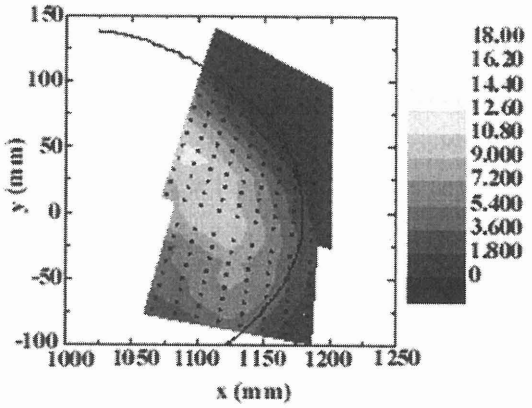

Fig. 2a). Two-dimensional beam emission profile for ECH phase. Solid line is the LCFS.

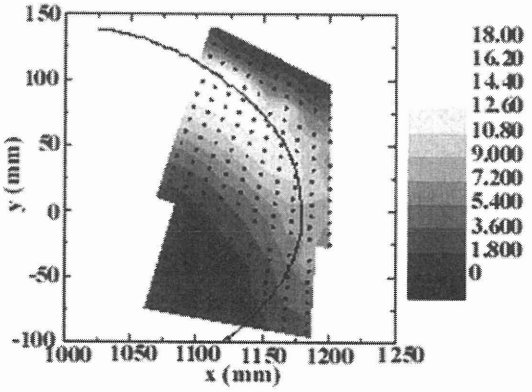

Fig. 2b). Two-dimensional beam emission profile for NBI phase. Solid line is the LCFS.