§23. Line of Sight from 6O port to NB#3 for Beam Emission Spectroscopy on LHD

Nakano, H., Yoshinuma, M., Ida, K.

Beam emission spectroscopy (BES) is one of the powerful diagnostics to measure local density fluctuation for turbulence and transport studies. In the BES, the density fluctuation is evaluated from the fluctuation of Doppler-shifted H-alpha emission (beam emission) by the interaction between the neutral beam and the plasma. The BES systems have been installed on several toroidal devices with the neutral beam lines (PBX-M, DIII-D, CHS, LHD, etc.). Some LHD-BES systems (6T-NB#3, 10.5L-NB#1 and 9O-NB#4) have been performed to obtained the density fluctuation with less than 10 kHz, although the other systems on other devices detected the fluctuation with more than several ten kHz[1),2)]. One of the reasons of this difference is the spatial resolution and the sensitivity which depend on the position and the shape of the sample volume (SV) defined by the cross region of the line of sight (LOS) and the beam emission area. The high spatial resolution of minor radius can be performed by aligning the LOS along magnetic flux surface. To detect small scaled with high frequency fluctuations across the magnetic field lines, the LOS has to be also aligned with magnetic field line. It is not easy to supply these demands in the LHD because the magnetic field line curvature changes along toroidal direction and the accessibility of the LOS to the plasma is not high due to complicate vacuum chamber and large distance between the plasma and ports.

A new BES system was designed to detect the high frequency fluctuations in the periphery region of core plasma[3)]. In this system, the beam emission from the tangential neutral beam from 7-T port (BL3) in the plasma was viewing from the end of the 6-O port through mirrors (Fig. 1). The LOS design was performed in the vacuum magnetic configuration. The LOS targets set at the 6.5 direction of the LHD because not only the magnetic flux surfaces are comparably flat but also the magnetic field lines are relatively straight (Fig. 2). The LOS goes from upside to the mid plane at 6.5 direction with 8 to 10 degree which almost correspond to the magnetic field line angle (Fig. 2(b)). The angle between the LOS and BL3 is 32 degree. When the beam is injected with energy of 188 keV which is maximum beam energy, the Doppler shift is 11 nm which is enough far to separate the beam emission from the background H-alpha emission. The measurement area is limited to $r/a = \rho > 0.8$ due to prevent the plasma facing mirror (2nd mirror) from touching the core plasma. The spatial resolution and relative emission intensity were calculated in following parameter: the vacuum magnetic configuration, the magnetic axis of 3.6 m, plasma density profile $n(\rho)$ defined by $n(\rho) = (2 - 1.8\,\rho^8)\,10^{19}\mathrm{m}^{-3}$, and electron temperature profile $T_e(\rho)$ defined by $T_e(\rho) = (2 - 1.8\,\rho^2)$ keV. The diameter of 20 mm of the LOS was assumed. The spatial resolution was calculated to be approximate 0.03 in normalized minor radius.

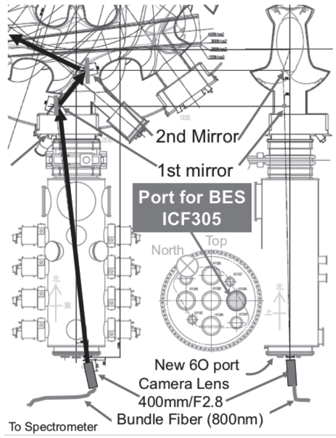

Fig. 1 The LOS of the new designed BES from the end of the 6O port to the NB#3

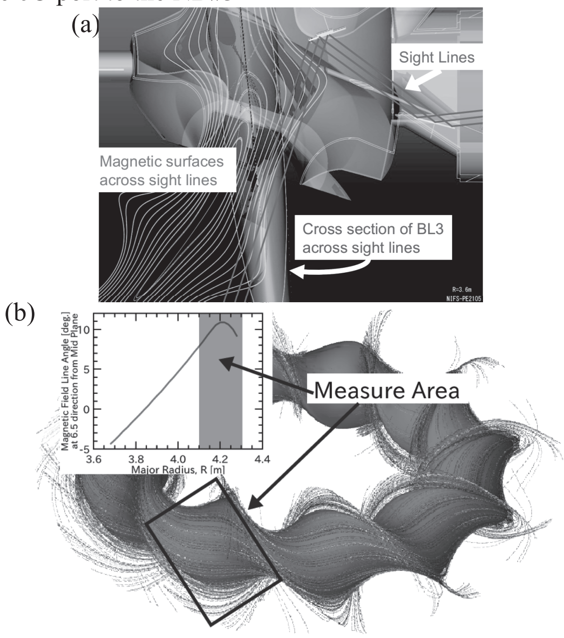

Fig. 2 (a) The LOS and the flux surface at R=3.6m. (b) The field line and its angle from the mid plane.

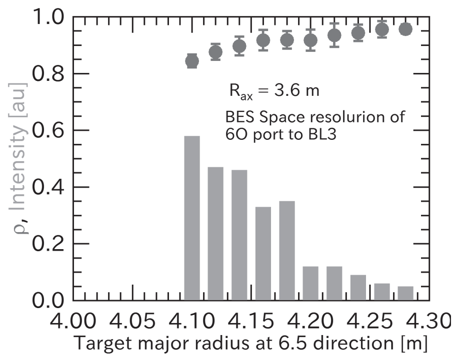

Fig. 3 The spatial resolution and relative signal intensity.

1) G R. McKee et al., Plasma and Fusion Research **2** (2007) S1025.
2) Kobayashi S., et al Review of Scientific. Instrument **83** (2012) 10D535.
3) Nakano, H. et al.: 25th International Toki Conference P1-87, 3rd-6th November 2015, Toki, Japan.