

§55. Fast Ion Charge Exchange Spectroscopy on Tangential Viewing Geometry in LHD

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A tangential viewing geometry for fast ion charge exchange spectroscopy(FICXS) has been established in LHD[1]. FICXS is a kind of charge exchange recombination spectroscopy for the measurement of fast ion distributions such as energy and its spatial location. The basic scheme of the diagnostic has been pioneered in DIII-D tokamak[2]. The FICXS measures the Doppler-shifted $H\alpha$ spectra from fast neutrals produced by the charge exchange(CX) processes between the fast ions and the neutral beams(NB). An advantageous of the diagnostic is that the measurement area can strictly be determined by the cross point of the NB and its observation LOS.

In the early stage of the development of FICXS in LHD, the radial LOSs were installed to investigate the trapped particle behavior[3]. Although the radial LOS has good sensitivity and resolution in the direction perpendicular to magnetic field line in the velocity space (v_{\perp}) of fast ion, this LOS is not suitable for the measurement of the passing particle which has its large velocity component parallel to the field line(v_{\parallel}). It is necessary to investigate the behavior of passing particles because it can easily interact with MHD modes such as Alfvén eigenmodes(AE) which can become unstable by the energy transfer from the particle.

To ensure better sensitivity for the v_{\parallel} component of fast ion in FICXS measurement, we have added the tangential LOSs as shown in Fig.1. The LOSs are horizontally aligned in the horizontally-elongated poloidal cross section of LHD plasma where the diagnostic NB is injected. The LOS is directed to the counter clockwise(CCW) of the torus. The observation area covers from inboard edge of LHD plasma to magnetic axis along the probe beam which radially injected from outboard side to inboard side of the plasma passing through magnetic axis. This corresponds to the major radius $R \sim 2.8\text{m}$ to $\sim 3.8\text{m}$. The tangential injectors NBI#1 and NBI#3 are directed to counter clockwise(CCW). The injector NBI#2 is directed to clockwise(CW). In this viewing geometry, the radial injector(NBI#4) is used as a source of probe beam.

The observed spatial density profiles of fast ions are shown in Fig. 2. The figure shows two spatial profiles obtained by the extraction of FICX component in the two wavelength ranges 664.2-665.5nm and 662-663nm corresponding to the energy ranges 35-55keV and 70-100keV for the passing particles moving to the CCW direction. The evaluated FICX component profiles from GNET simulation are also shown in the figure. Because

of the uncertainty from the calculation of fast ion distribution, the simulation can not obtain the result outer than $R=3.5\text{m}$. The spatial profiles of fast ion density derived by the simulation and the observation are well agreed for the available region. Both density profile for the two energy ranges increase toward the magnetic axis $R_{ax}=3.8\text{m}$ except for the small difference between their tendencies.

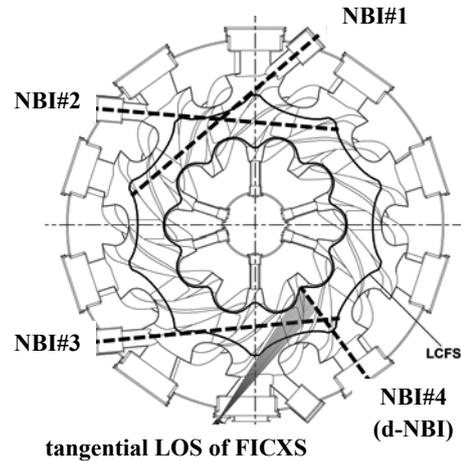


Fig. 1 Hardware apparatus of tangential FICXS diagnostic on the midplane of LHD.

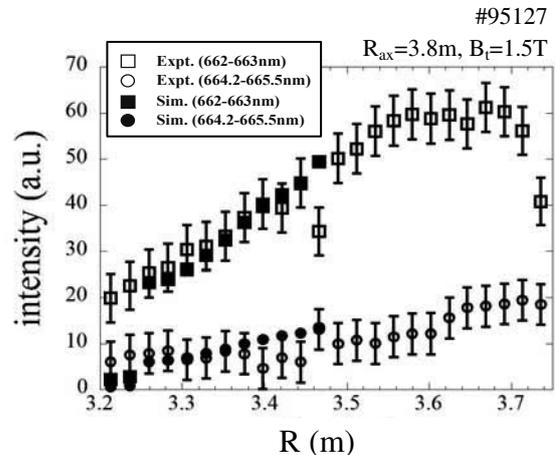


Fig. 2 Spatial intensity profiles of FICX component for each wavelength range derived by the experimental observation and the calculation.

[1] Ito, T., et al.: Rev. Sci. Instrum. **81** (2010) 10D327.
 [2] Heidbrink, W.W., et al.: Plasma Phys. Control. Fusion **46** (2004) 1855.
 [3] Osakabe, M., et al.: Rev. Sci. Instrum. **79** (2008) 10E519.