§5. High Time-resolved Fast Ion Measurements Affected by Fast-ion-driven MHD Activity

Kobayashi, S., Yamamoto, S., Mizuuchi, T. (IAE, Kyoto Univ.),
Ohtani, Y., Lu, X. (GSES, Kyoto Univ.),
Murakami, S. (Dep. Nucl. Eng., Kyoto Univ.),
Nakashima, Y. (Univ. Tsukuba),
Osakabe, M., Kobayashi, M., Shoji, M., Ida, K., Yoshinuma, M., Du, X.D., Isobe, M., Ogawa, K., Nagaoka, K.

In magnetically confined plasmas, it is important subject to estimate the spatial- and velocity-distribution of fast ions because it is strongly linked to the fast-ion-induced MHD instabilities. Since the MHD instabilities are the physical phenomena having fast time response, a high time-resolved measurements for the fast ions are indispensable to clarify the wave-particle interactions. In this study, we investigate the response of the fast charge exchange (CX) flux with Si-semiconductor based detector (SiFNA) to the MHD activities due to Energetic particle driven InterChange mode (EIC).

Figure 1 shows a setup and sightline of the SiFNA in LHD[1]. The detector is set to observe the CX flux of fast ions produced by a perpendicular NBI (NB#4). The Al filter mounted in front of the SiFNA prevents the soft X-ray and visible radiations. Since the electrical signal from SiFNA is acquired by ADC as "current-mode" with fast sampling (1MHz), the fluctuations of CX flux affected by the EIC mode are detectable. Figure 2 shows the raw signals of the magnetic probe and SiFNA when the EIC mode is occurred. The SiFNA signal increases after turning on NB#4 (t=4.208s), which suggests the SiFNA detects the CX flux of fast ion injected by the NBI. A rapid increase in the SiFNA signal is observed at the same timing of the EIC bursts (t=4.233 and 4.270 s). After each burst, the SiFNA signal decreases gradually. The time evolution of power spectrum of the two signals are also shown in the figure. The EIC has a mode frequency around 10 kHz at initial and it is chirped down to several kHz. However, there is no clear coherent mode in the power spectrum of SiFNA signal at present condition. It has been found that the EIC mode is destabilized by helically trapped fast ions produced by the perpendicular NBI and the mode frequency is determined by the precession frequency of the fast ions [2].

From the Heavy Ion Beam Probe diagnostic, the plasma potential changes due to the EIC bursts, which causes the generation of a significant radial electric field. A transient improvement in the plasma confinement, increase in the ion temperature by charge exchange recombination spectroscopy and reduction in the turbulent fluctuation by phase contrast imaging technique, is observed due to the change in the radial electric field. The increase in the ion temperature is faster (~200μs) than the confinement time, however the plasma toroidal rotation changes more slowly. Although the change in the SiFNA signal due to the EIC burst suggests the transport of the fast ions in the radial directions, it is required to measure the radial displacement of the fast ions directly.

In order to clarify the physical mechanism of the wave-particle interactions and its comparison between experimental devices, we have installed the SiFNA diagnostic system into Heliotron J via a Bilateral Collaboration Research Project [3].

1) M. Osakabe, et al., Review of Scientific Instruments **72**, 788 (2001).
2) X. D. Du, et al., Physical Review Letters. **114**, 155003 (2015).
3) M. Yasueda, S. Kobayashi, et al., Plasma Conference 2014, 2014/Nov/18-21, Niigata, 19PB-062.

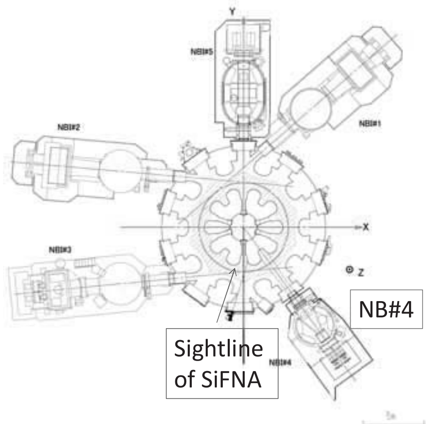

Fig. 1. Schematic view of SiFNA installed in LHD

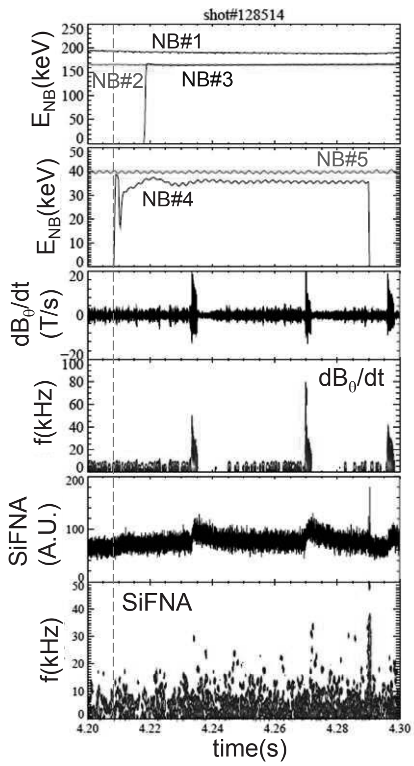

Fig. 2. Time evolution of the NBI heating scenario, raw signals of magnetic probe and SiFNA. The power spectrum of them are also shown in the figure.