§36. Energetic Particle Mode Induced Fast-ion Loss in Heliotron J

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Good confinement of fast particles (FPs) in fusion plasmas is essential in realizing a fusion reactor since alpha particles generated by a fusion reaction play an essential role as a primary heating source. Deep understanding of the interplay between FPs and FP-driven MHD instabilities such as Alfvén eigenmodes (AEs) is required. We have developed a Faraday-cup-type lost fast-ion probe (FLIP) [1] for Heliotron J, which is helical axis Heliotron device with the medium size (major and minor radii of $R \sim 1.2$ m/$<a> <$ 0.25 m). Measurement of FILP is based on the magnetic spectrometer concept, and can simultaneously measure the energy and the pitch angle of detecting ions with high time resolution.

We measured energetic particle mode (EPM) induced fast ion loss by means of FLIP. It shows that the EPM enhance the loss of fast ion having the pitch angle of 110 to 125 degrees. We compared the pitch angle of EPM induced fast ion loss with numerical simulation. First, we calculate the deposition profile of neutral beam. Figure 1 shows the neutral beam deposition profile on Heliotron J with standard magnetic configuration.

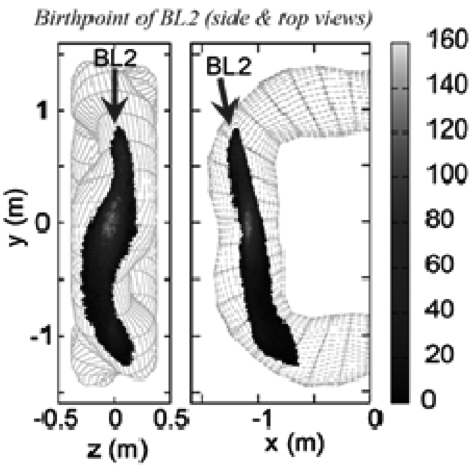

Fig. 1 Deposition profile of neutral beam on standard configuration in Heliotron J.

Therefore, we follow the orbit of fast ion deposited in the plasma by means of DELTA5D code with magnetic fluctuation [2]. The frequency of EPM is 80 kHz and the radial profile of EPM magnetic fluctuation is based on the fluctuation profile measured by soft-x ray and beam emission spectroscopy. Figure 2 shows the time evolution of number of confined particle inside the plasma. Note that number of fast ion considered in this calculation is 2700. We found that the number of confined particle decreases with the increase of the magnetic perturbation amplitude and the increase of the width of magnetic perturbation.

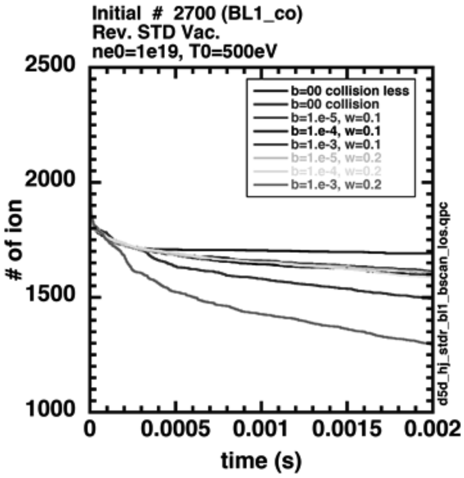

Fig. 2. Time evolution of number of confined fast particle. The number changed according to magnetic fluctuation profile and amplitude.

Finally, we investigate the pitch angle of fast ion pass through the last closed flux surface (LCFS) and exit points of fast ion on LCFS (Fig. 3). Color of points shows the classification of orbit; red, blue, and gray correspond to reentering (co-going) fast ion, trapped or transition ion, and counter going fast ion, respectively. Note that, the installation position of FLIP is θ_B of 0.25 and ζ_B=0.75.

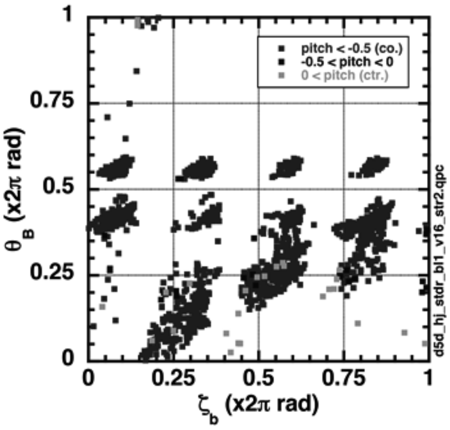

Fig. 3. Exit points of the fast ion on the LCFS calculated by the DELTA5D code. The color shows the orbit of fast ion.

We found that no fast ion reach FLIP position without magnetic fluctuation, however, with magnetic fluctuation finite fast ion can be measured by FLIP; this is consistent with experimental results.

1) Ogawa, K. et al,: Plasma and Fusion Res. **8** (2013) 2402128.
2) Spong, D.: Phys. Plasmas **18** (2011) 056109.