§26. Development of Faraday Cup-type Lost Fast-Ion Probe for Heliotron J

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Good confinement of energetic particles (EPs) in magnetically confined fusion is essential in realizing a fusion reactor since energetic alpha particles generated by fusion reactions play an essential role as a primary heating source in the future burning plasmas. For this reason, deep understanding for interplay between EPs and EP-driven magnetohydrodynamic (MHD) instabilities is required. To investigate transport and/or loss of energetic ions due to EP-driven MHD instabilities, development of Faraday cup-type lost fast-ion probe (FLIP) is ongoing in Heliotron J in the collaboration between Institute of Advanced Energy, Kyoto University and National Institute for Fusion Science[1)]. The FLIP functions as a magnetic spectrometer having apertures on the one side of detector box and has been employed in NSTX[2)], JET[3)], CHS[4)] and so on.

The Lorentz orbit code[5)] treating gyromotion has been set up for Heliotron J to find a diagnostic port suitable for our purpose. Fig. 1 shows typical Poincaré plots of co- and counter-going beam ion orbits (H^+) having energy of 30 keV at the corner section and straight section. Note that Heliotron J is equipped with two neutral beam injectors oriented in parallel and anti-parallel direction an the beam injection energies are typically 30 keV. Fine dots represent the shape of the vacuum vessel. As can be seen, measurement at the corner section will allows us to catch both co- and counter-going beam ions. Therefore, we decided to use upper diagnostics port at the corner section.

Fig. 2 shows a schematic drawing of whole view of FLIP constructed for Heliotron J. The probe shaft is made of a stainless steel. The position of probe head can be changed vertically by using a linear bellows driving system. The movable length of the driving system is 600 mm. We employ a so-called rotary stage to rotate the probe shaft. Because of this, we can change the angle between the aperture and magnetic field line so as to change detectable pitch-angle region widely.

The schematic drawing of Faraday cup section and block diagram of signal transfer and data acquisition systems for the Heliotron J FLIP are depicted in Fig. 3. There are thin Faraday films on the bottom of the detector box. Faraday film is aluminum vapor deposited onto one face of the quartz substrate. The thickness of the films is about 0.2 mm. There is a set of apertures on the one side of the detector box. The front aperture has ~5 mm width and ~4 mm height. This aperture size is determined using the grid calculation program so as to obtain an aimed particle whose energy is up to 30 keV. An electric current from each foil is fed into a current amplifier (NF Corp. LI-76). Subsequently, the voltage signals are transmitted to the isolation amplifier (NF Corp. P64) and are digitized finally using analog to digital converter having sampling rate of 1 MHz, (COMEX Corp./Dasmini, 16 bit resolution).

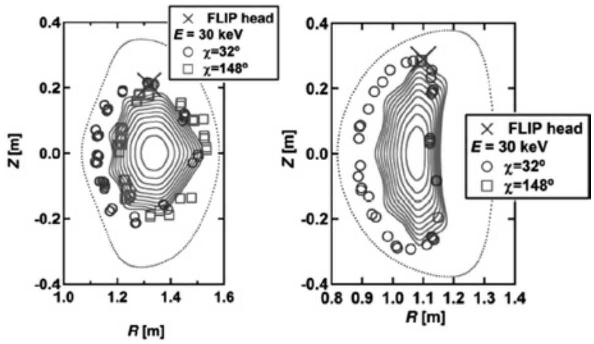

Fig. 1. Poincaré plots of co- and counter-going beam ion orbits (H^+) having energy of 30 keV at the corner section (left) and straight section (right).

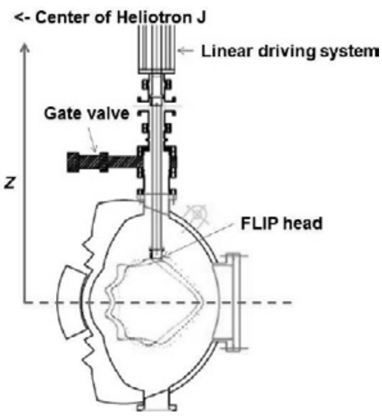

Fig. 2. Schematic drawing of the FLIP placed at the innermost position with last closed magnetic flux surface.

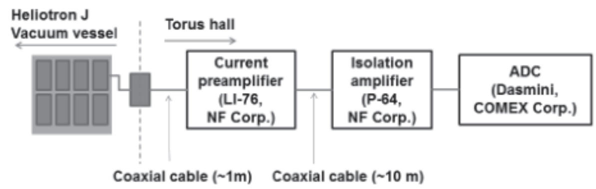

Fig. 3. Block diagram for signal transfer and data acquisition systems of the FLIP.

1) Ogawa, K. et al. : submitted to Plasma and Fusion Research.
2) Darrow, D.S. et al. : Rev. Sci. Instrum. **72** (2001) 784.
3) Darrow, D.S. et al. : Rev. Sci. Instrum. **75** (2004) 3566.
4) Isobe, M. et al. : Rev. Sci. Instrum. **77** (2006) 10F508.
5) Isobe, M. et al. : J. Plasma Fusion Res. SERIES **8** (2009) 330.