§5. Study on High Energy Particles Escaped from LHD Using Lost Ion Probe

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For understanding fast ion behaviors, a scintillator type lost ion probe is newly developed and installed into 2.5U port of LHD. 1, 2) The lost ion probe has measured the loss signals of fast ions near the edge region throughout the 9th campaign.

The location of the lost ion probe was determined using the collision less orbit code of single particle and Delta5d code taking into account the particle collisions inside plasmas. Both results are crosschecked. The Delta5d code calculates the fast ion behaviors using NB deposition profile. In the case of the magnetic axis Rax=3.75m and Bt=3T, the ion loss points across the last closed flux surface of ρ=1 are mapped on the θ-Φ space, where θ and Φ are the poloidal and the toroidal angles, respectively.

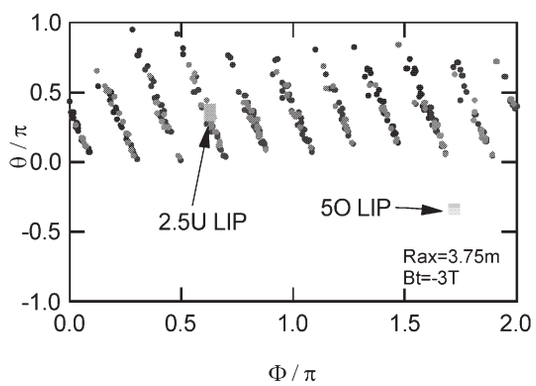

Fig. 1. Maps of ion loss points and detector positions (2.5U:new location, 5O:location before 8th campaign)

The lost ion probe measures the pitch angles and the gyro radii of fast ions directly and simultaneously by observing the ion strike points on the scintillator plate passing through the entrance slit and the collimator slit. The emitted light from the scintillator plate is detected by a CCD camera for relatively slow signals of 33 msec/frame and by a 3x3 photomultiplier array for fast signals from dc to 20 kHz. Figure 2 shows that the gyro radius estimated from the peaks of striking points on the scintillator plate becomes small as the toroidal magnetic field increases.

The confinement time of fast ions can be obtained from the ICRF power modulation experiments. The phase delay between the ICRF sine wave and the detected signal is used to estimate the confinement time of fast ions. 3) From this result, the phase delay is found to be 20.7 degrees. In the previous experiments, the neutral particle analyzer is used as a detector. However since a direct detection of fast ions is possible without the effect on a sight line integration, the confinement time would be obtained more precisely.

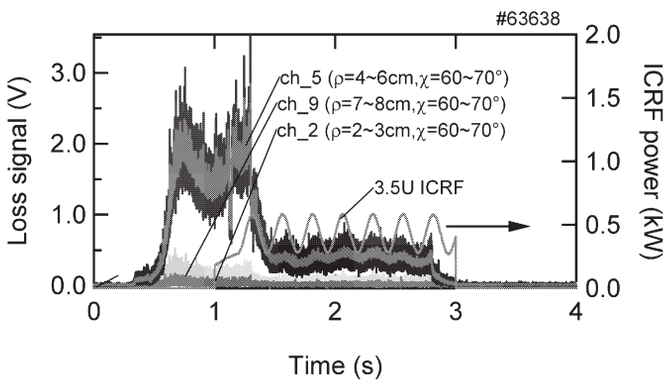

Fig. 2. Fast ion losses for gyro radii. The signal of Ch5 corresponds to the ion energy with more than 30 keV. The ICRF power is modulated with a sine wave of 4 Hz.

The spatial distribution of lost fast ions is measured in the vicinity of the LHD plasmas, shown in Fig. 3. At Z=1000 mm, the intensity of lost fast ions has almost disappeared. These data are important, and can use the estimations of deposition profile of NB with the combination of HFREYA code.

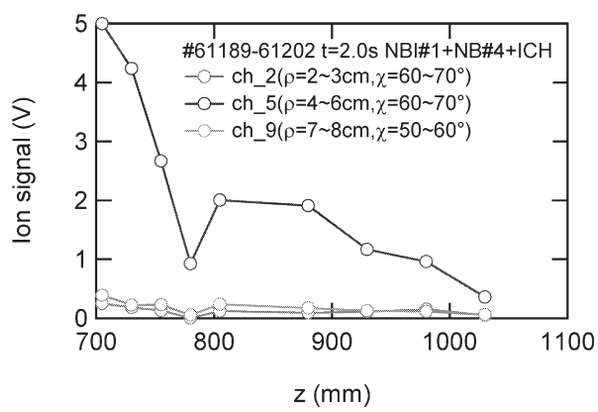

Fig. 3. Spatial distribution of lost fast ions is measured in the edge region at R=3.45m. Plasma parameters are n_e(FIR)=0.75x10^{19} m^{-3}, Rax=3.6m, and Bt=-1.375m.

References

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2) Nishiura, M., Isobe, M., et al. NIFS-PROC-63, (2006)194-198.
3) Mutoh, T., et al. Nucl. Fusion **43**(2003)738-743.