§16. Energy and Pitch Angle-resolved Measurements of Escaping Fast Ions in CHS

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Losses of fast ions (fusion products, ICRF produced ions, neutral beam particles) lead to not only degradation of heating efficiency but also localized damage of a first wall. A time-resolved neutral beam ions loss from the Compact Helical System (CHS) is measured by a scintillator-based lost particle probe (TFTR-type) to investigate the loss mechanism in a helical system[1]. A scintillator plate (ZnS) fixed in a metal box which has a pair of apertures is installed as a detector. Fast ions whose gyroradii are comparable with approximately 40 keV protons are allowed to pass through the apertures. The probe has a feature that positions hit by the fast ions on the scintillator plate have information of the energy and the pitch angle of the ions. Therefore the energy distribution and the pitch angle distribution of the ions are obtained by analysis of light distribution on the plate. The orbits of the ions are computed with their energy and pitch angle using a orbit code which is based on that used for TFTR. A numerical model integrating the Lorentz force to follow motion of ions is used in the code.

The light distribution is detected by a CCD camera and a nine channel array of photomultiplier tubes (PMT) with sampling frequencies of 30 Hz and 20 kHz. The array has been installed on the probe to detect lights on divided region for the each channel separately, while a single channel PMT which detects the light integrating over the whole region was installed on the previous probe. Thus, it is possible to investigate behavior of losses for different orbits. Figure 1 shows view of the array on the scintillator, together with the grid obtained by the orbit calculation. Here, the gyroradius centroid is given by $\rho = (2mE)^{0.5}/qB$ and the pitch angle is $\chi = \arccos(v_{//}/v)$. The position of the each circle was determined by a method transmitting laser light from the output of the optical fibers to the scintillator, i.e. the light was transmitted reversely relative to usual use.

Figure 2 shows a time evolution of particle losses detected at two different channels. The vacuum magnetic axis position R_{ax}, the toroidal field strength B_T and the line averaged electron density n_e were 99.5 cm, 0.88 T and 6 x 10^{12} cm^{-3}, respectively. The signals show quite different behavior. The signal of channel 6 has the huge peak around 50 ms which a mechanism has not been understood yet although no peak is seen in the that of channel 7. The two group of spikes synchronizing with magnetic fluctuation due to MHD activity are observed during the period 70 ms to 110 ms and 115 ms to 130 ms. In the former a burst of 50 kHz is observed on the magnetic probe, while that of 100 kHz is observed in the latter. Relationship between fast ion losses and MHD activity would be understood by further analysis.

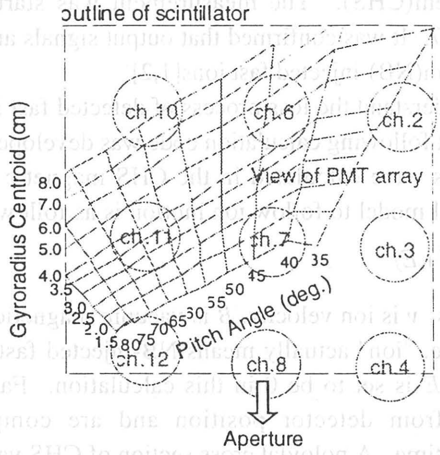

Fig.1 View of the PMT array on the scintillator with the calculated grid.

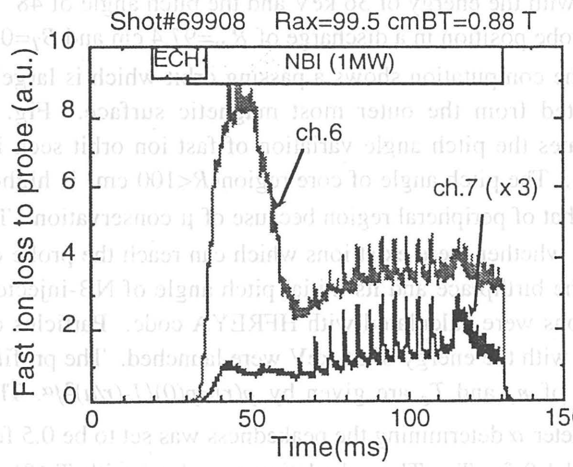

Fig. 2 Time evolution of fast ion loss to probe. Different behavior of loss for different channels of the PMT array are seen.

References

[1] D. S. Darrow et al., J. of Plasma Fusion Res. SERIES, Vol. 1, (1998) 362-365.