§14. Measurement of Fast Ion Power Density Outside of the Last Closed Flux Surface on LHD

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In order to reconstruct magnetohydrodynamics (MHD) equilibrium with enough accuracy, the fast ion pressure distribution outside of the last closed flu surface (LCFS) has to be taken in account, because there exists the fast ion orbit going out of the LCFS, then re-entering inside the LCFS, so called "re-enering fast ion orbit". The re-entering fast ions exist outside of the major radius because of outward shifted orbit of co-directed fast ions, while the ctr-directed re-entering fast ions can not exist inboad side of the torus because of much less space between the LCFS and the first wall. It is impossible to remove an uncertainty in determination of boundary in the calculation of fast ion orbits, so far. The experimental determination of boundary of fast ion pressure profile is main target of this research.

The directional probe method was applied to calorimetric measurement of power density of fast ions utilizing hybrid directional Langmuir probe (HDLP) in LHD. The HDLP can measure local heat flux (power density) and local ion saturation current both co- and ctr-directed flux sepalately. The calorimeter head was calibrated using the pulsed lazer injection[1)]. Thus the absolute value of fast ion power density can be obtained by the calorimetric measurement. The HDLP was installed at the outbourd side of almost vertically elongated cross section of LHD plasma, of which schematic view is shown in Fig.1(a). The linear drive can control the probe position in the z direction. The Poincare plots of co-directed fast ions are shown in this figure. The schematics of cross section and sideview of HDLP are shown in Fig.1 (b) and (c), respectively.

The experiment was carried out with the magnetic axis of $R_{\rm ax}$ = 3.75 m and the magnetic strength of $B_{\rm t}$ = −0.75 T. The plasma was sustained by neutral beam injection (NBI) heating. The ctr-directed fast ions can not be observed at the probe position due to inward shifted drift orbit. The power density of co-directed fast ions was observed by the directional probe method. Figure 2 shows the power density profiles normalized by the total energy of co-injected NBI (NBI1 and NBI3), and the observation in 2008 was compared with that in 2007. The difference in 2008 experiment from 2007 is to remove all antenna of ion cycrotron range of frequency (ICRF) heating. The ICRF antenna affect the power density profile of co-directed fast ions and the difference is about 3 cm. The systematic measurement of power density profile of fast ion and the comparison with orbit calculation are left for future study.

1) K. Nagaoka, *et al.*, Rev. Sci. Instrum **79** (2008) 10E523.

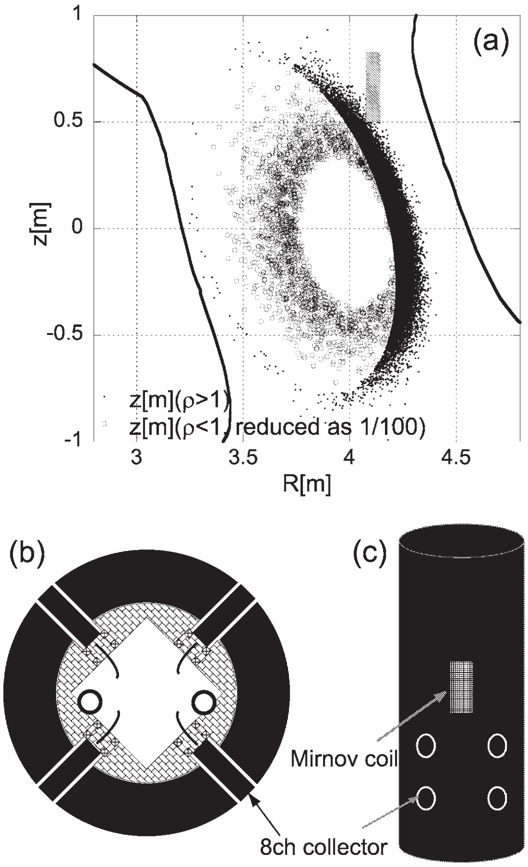

Fig. 1: (a) Poincare plots of co-going fast ions with Rax=3.6m and Bt=0.5T. The Schematics cross section of DLP (b) and DLP head (c).

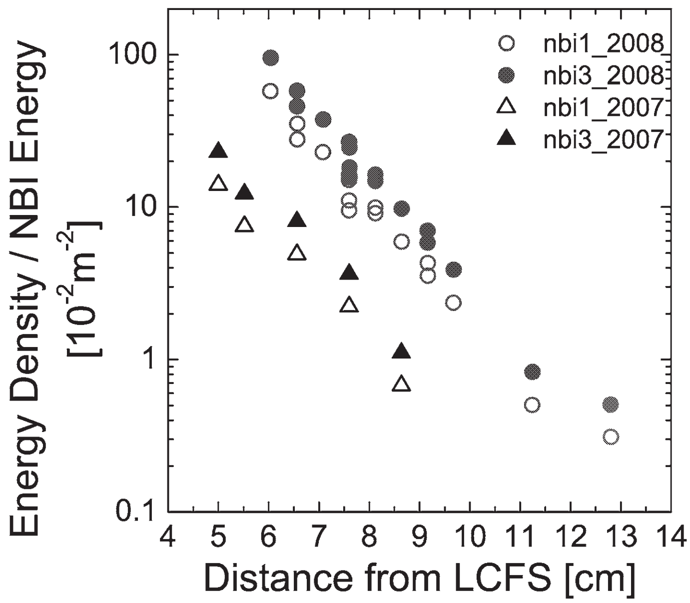

Fig. 2: The power density profiles of co-directed fast ion normalized by co-injected NBI power.