Horizontal and vertical structure of the high-energy particle distribution in large helical device

T.Ozaki[1], P.Goncharov[1], S.Murakami[2], E.Veschev[3], S.Sudo[1], T.Seki[1], H.Sanuki[1], T.Watanabe[1] and LHD Experimental Group[1]

1)National Institute for Fusion Science, Toki, Gifu 509-5292, Japan

2) Kyoto University, Kyoto, Japan

3) Graduate University for Advanced Studies, Hayama, Kanagawa, 240-0193, Japan

There are two neutral particle analyzers, the time-of-flight (TOF-NPA) and the silicon detector (SD-NPA), which are scannable horizontally and vertically. In horizontal scan, it is interesting to measure the pitch angle distribution and to investigate the loss cone feature obtained by it. It is very important to control the trapped particle by the helical ripple to realize the helical type plasma fusion device. Here the charge exchange neutral particle between the high-energy ion and the background neutral is measured to obtain the pitch angle of the high-energy ion in the plasma. Tangential injected NBI heating in long discharge is suitable for this purpose in LHD. The energy of the high-energy ion supplied from NBI decreases by the plasma electron. The pitch angle scattering is occurred by the collision of the plasma ion with several times energy of the electron temperature. Therefore we can easily compare the experimental pitch angle distribution with the simulation result, which is obtained by considering the initial pitch angle distribution and the atomic process. The pitch angle distribution from 40 to 100 degrees can be obtained by horizontal scanning the TOF-NPA during the long discharge over 100 seconds sustained by the NBI#2 (co-injection) at the magnetic axis (R_{ax}) of 3.6 m. The trapped particle by the helical ripple can be clearly observed around the pitch angle of 90 degrees. The loss cone feature is agreed with the result. It is interesting to investigate the dependence of R_{ax} of the loss cone feature. However it is not suitable to use the scanning of TOF-NPA during NBI plasma discharge although it can provide the precise structure of the loss cone because it is very difficult to sustain the long discharge at different magnetic axis. We use SD-NPA, which has ability of 6 different pitch angle measurement at R_{ax} =3.5, 3.6 and 3.75 m. More trapped particle can be observed at Rax=3.5 m because the large helical ripple can be expected at inner magnetic axis.

In vertical scan, the heating deposition profile of the ion cyclotron resonance heating (ICH) has been discussed. In LHD, the long discharge over 30 minutes with the total energy of 1GJ can be sustained by the ICH. The deposition profile can be obtained by the vertical scan of the SD-NPA. The region where the high-energy particle is generated, is agreed with the resonance region of ICH. Similar result can be obtained by the pellet charge exchange measurement in the short discharge.