§21. Flux Difference between Co- and Counter Neutral Beams Injection

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In the helical devices, the particle orbit of the NBI co-injection beam against the direction of the torus magnetic field is different from that of the counter injection. According to the calculation, the guiding center of the particle orbit is close to the magnetic axis and shifted to the high magnetic field side in the co-injection and counter-injection, respectively. The tendency is remarkable in the low magnetic field.

In the 4th experimental campaign, NBI#1 as the counter-injection and NBI#2 as the co-injection are

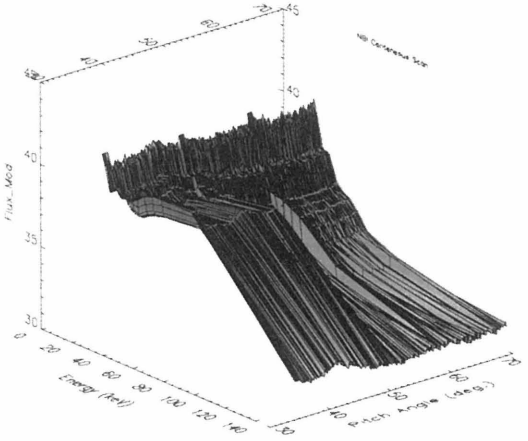

Fig.1. The spatial-resolved neutral particle energy spectrum in NBI long discharge (co-injection).

prepared. In 5th cycle, NBI#3 is added as the counter injection beam. NBI#1 and #3 change to the co-injection and #2 changes to the counter-injection by the inversion of the magnetic field direction in some shots on the 5th cycle. The time-of-flight type NPA has the capability of a high S/N ratio against the radiation including soft/hard X-rays from plasmas[1]. The analyzer and the movable stage are installed at the mid-plane of LHD on the 10-O port.

The accurate comparison between the co- and counter injection can be expected so the horizontal scan of the analyzer during long discharge is also done in the inverse magnetic field. The spatial resolved energy spectra can be observed during a long discharge of NBI plasma by continuously scanning the neutral particle analyzer. Figure 1 shows the time evaluated (=angular distributed) three dimensional spectrum obtained by overlapping of three NBI plasma discharges. The scanned pitch angle is from 44 degrees to 74 degrees. The injected hydrogen neutral beam energy of NBI#2 is only 130 keV because the original ion source polarity is negative. The shape of spectra is almost similar from 44 degrees to 53 degrees. However the spectra from 55 degrees are strongly varied. It reflects the injection pitch angle of the beam according to the simulation (53 degrees at Rax=3.75 m in simulation). The beam keeps the pitch angle at incidence until the beam energy becomes to the energy, which the pitch angle scattering is occurred by the energy loss due to the electron collision

The pitch angle distribution is shown in Fig. 2 when the magnetic field is inversely applied. The

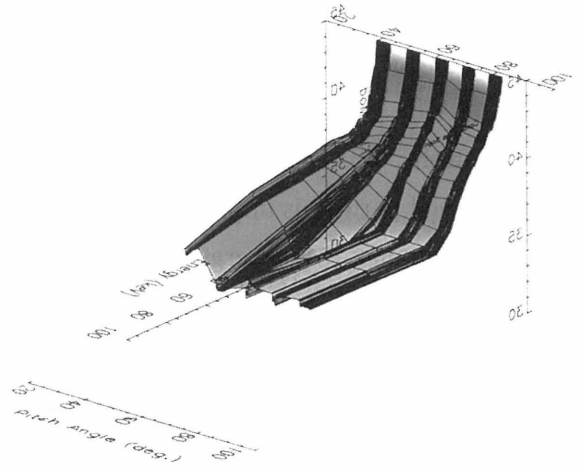

Fig.2. The spatial-resolved neutral particle energy spectrum in NBI long discharge (counter-injection).

large variation at 48 degree can be observed. The pitch angle of the particle is almost conserved in high-energy region because the pitch angle scattering occurs near the energy of the 15 times the electron temperature. It is not believed that only the particles with large pitch angle are localized near the plasma center where the back ground neutrals is not rich. Therefore it is reasonable that the particles with the pitch angle between 48 to 53 degrees are lost. The neutral particle flux in the counter injection is less than that in the co-injection. The main reason is that the particle orbit in the counter injection is inside of the plasma. The part of the decrease comes from the particle loss with large pitch angle. However the loss of the counter injected particle does not strongly affect to the heating efficiency and the stored energy because the contribution of the particles with large pitch angle is not so much.

References

1) T. Ozaki, *Rev. of Sci. Instrum.*, 71(7), 2698-2703 (2000)