§31. ARMS and CNPA Signals during NBI-heating in Large Helical Device

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We compare the decay times of charge exchange neutral particle fluxes in various NBI plasmas after switching-off NBI by using the Compact Neutral Particle Analyzer in Large Helical Device. Here the decay times at co-, counter and perpendicular injections are observed at the magnetic axis of Rax=3.65. The decay times are determined mainly by the electron drag in tangential NBI. The decay time decreases by the weak magnetic field same as the simulation. The decay time at the perpendicular beam NBI is several ten ms, which is less than one tens of that at the tangential injections. The decay time determined by the ion-ion collision, which is the main process of the energy loss and the pitch angle scattering at the injection energy of 40 keV, is about 10-20 ms. The observed decay times are still several times smaller than those values. The results are compared with the results from Angular Resolved Multi-Sight line neutral particle.

Figure 1 shows the neutral particle angular distribution around the pitch angle of 90 degrees obtained by ARMS when the perpendicular NBI is applied. The horizontal and vertical velocities of the neutral particles are on the horizontal and vertical axes. Therefore the radial axis means the particle speed. The logarithmic flux of the particle is colored. In Fig. 1, the flux near 90 degrees is observed slightly intensive but broad because the NBI is applied to the perpendicular direction. This means the trapped particle near 90 degrees is well confined. The particle, which is injected to the perpendicular, is decreasing its energy and pitch angle by the ion-ion collision. In decreasing of the total particle flux over 15 keV at the pitch angle of 85 degrees or less, the effect from the loss cone or loss from the chaotic region may be involved. The uniform angular distribution can be obtained from short ion-ion collision time of 10 ms.

Figure 2 shows the pitch angle distribution when the tangential NBI is applied. When the tangential NBI is applied, the beam energy decreases by the electron drag, it has the large pitch angle at the low energy by the beam ion collision. Therefore the angular distribution of the beam is uniform at the low energy. However we find that the beam with the pitch angle over the 85 degrees strongly decreases (dent) from the measurement by ARMS. This suggests there is the loss region around there.

It is very important to know where is the loss region and it is serious or not. For this purpose, we check the change of the dent near the pitch angle of 85 degrees by the plasma density. The experiments has been performed at density profiles of two different discharges with same NBI heating. Here we assume that the dent is due to the particle loss from the loss region. Usually the dent should change by the electric field in the plasma. The negative electric field enhances the loss, this means, makes deep dent. If the plasma density is high, the electric field becomes negative. Therefore the dent should be deep. But the dependence between the density and electric field is not so strong at the density over 10-19 m-3. Actually the electric fields may be almost the same. On the other hand, the flux will decrease because the background neutral, which is source of the charge exchange, cannot invade to the plasma at high-density case. The fluxes at the high and low-density plasmas come from the plasma outer and the whole region, respectively. Therefore by the comparison of the flux from between the high- and low-density plasma, we can estimate where the charge exchange occurs. Figure 2 shows the spectra of two different sight lines at the high and low-density plasmas. At one sight line (No.15), the energetic particle is well confined. Another sight line (No. 19) reflects the loss region. We compare the discrepancy between the No.15 and No.19 at the high- and low- density plasmas. The discrepancy at the high-density plasma is larger than that at the low-density plasma. This means that the loss region is localized at the outer plasma. According to Aurora code calculation, the penetration depth of the background neutral is changed at ρ=1/3. Therefore there may be the loss region out of ρ=1/3 same as the original design of LHD.

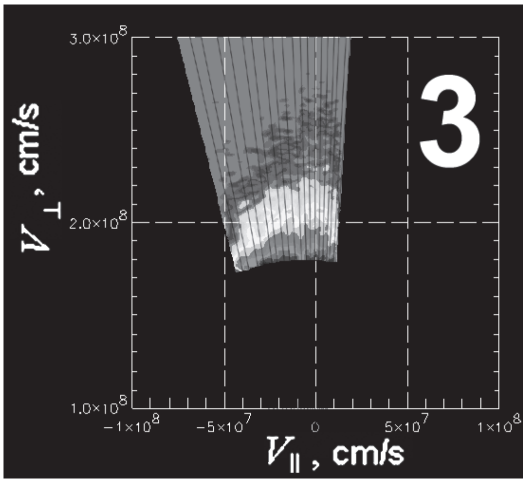

Fig.1. The ARMS signal in NBI#4 plasma. The intensity of the flux is colored. The analyzer is covered from 70 to 100 degrees of the pitch angle.

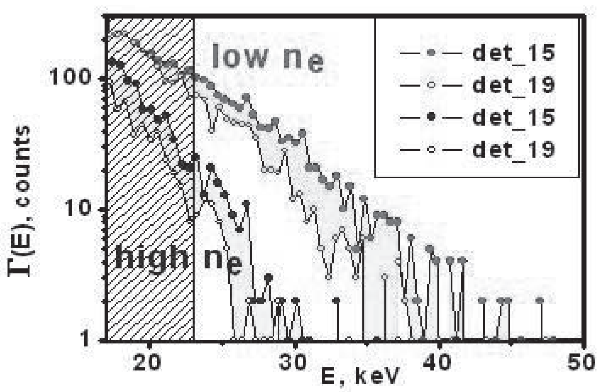

Fig. 2. The spectra of ARMS signals in chords, No.15 and No.19. The spectra of two different chords are compared at the high- and low-density case. At less than 30 keV, the particle loss is large in the high-density plasma.