§9. Development of a Large Negative Ion Source and a Photo-neutralizer for the Continuous Operation

Ando, A., Matsuura, K., Sasaki, Y., Komuro, A., Takahashi, K. (Dept. Electrical Eng. Tohoku Univ.)

A Neutral beam injection system (NBI) is a powerful and promising tool for heating of magnetically-confined thermonuclear fusion plasmas. A high power hydrogen negative-ion (H^-) source has been successfully developed for a beam source and operated as a major heating device in LHD. For a long pulse or continuous operation, it is requisite to develop radio-frequency (RF)-driven H^- sources. Our previous studies have shown that a field effect transistor (FET)-based high power RF amplifier with the frequency below 0.5 MHz enables us to operate RF ion sources. As a next step, we have developed a large-scaled ion source consisting of Alumina ceramic tube with 230 mm in inner diameter and 300 mm in length, which are wound by a RF loop antenna, as shown in Fig. 1.. Characteristics of plasma production in the source were measured in hydrogen gas in order to clarify the high density plasma production with this source.

Fig. 2 show the axial distributions of electron density and temperature in different magnetic filter field configurations at the hydrogen pressure of 0.3 Pa. When a strength of the magnetic filter field increases, the electron density increased and electron temperature decreases downstream. These plasma parameters are suitable for negative hydrogen production and beam extraction. Now we are preparing a cesium evapolation to the source to increase the production of negative hydrogen.

In addition to the experiments, we modeled a gas and photo neutralization system by using two-dimensional PIC (Particle In Cell)/MC (Monte Carlo) simulation. In our simulation, the electrostatic model is applied to an r-z cylindrical coordinates. The electrostatic code consists of establishing charge assignment, integration of a Poisson equation, and employing a time integration of momentum equation. Monte Carlo scheme is used to simulate the interaction between charged particles and neutral particles. Computation domain is 5 cm in r-direction and 4.2 m in z-direction. Spatial step is 6.0×10^{-4} m in both directions

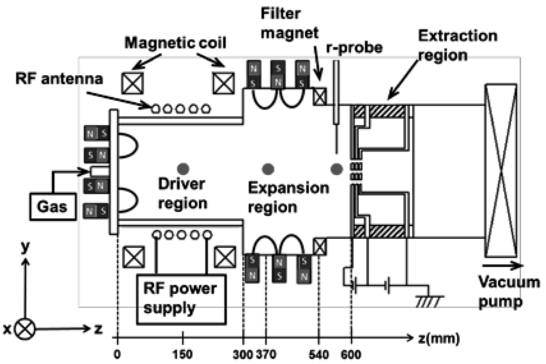

Fig.1 Experimental setups.

and a simulation time step is 3.0×10^{-11} s. The injected beam is composed of negative ions D^- , which is uniformly distributed in a 6 mm in radius. Figure 3 shows one of the simulation results of spatio-temporal variation of beam and plasma particles in gas and photo neutralization system. Our simulation results indicate that a beam plasma formed in the neutralizer prevents the beam from diverging due to self-charge. The beam convergence rate is evaluated as a one of the important parameters for the net-neutralization efficiency.

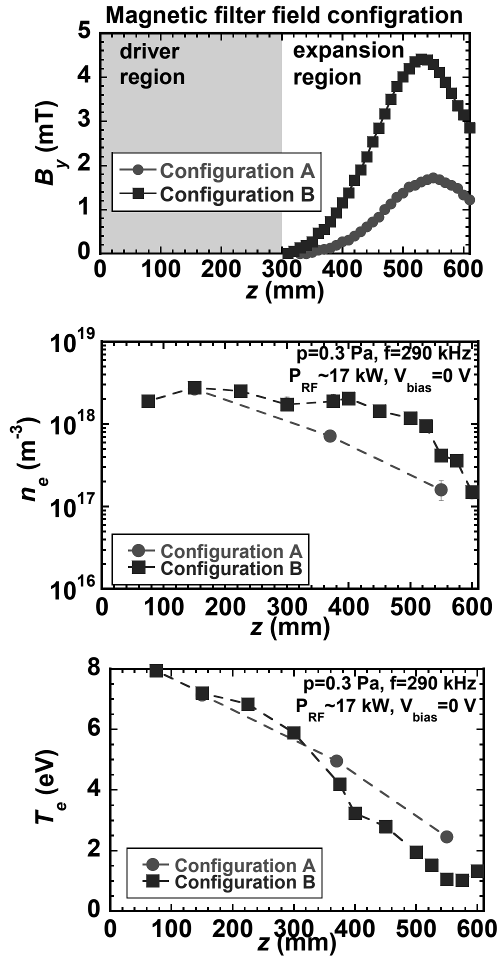

Fig. 2 Axial distributions of applied magnetic field, electron density, and electron temperature.

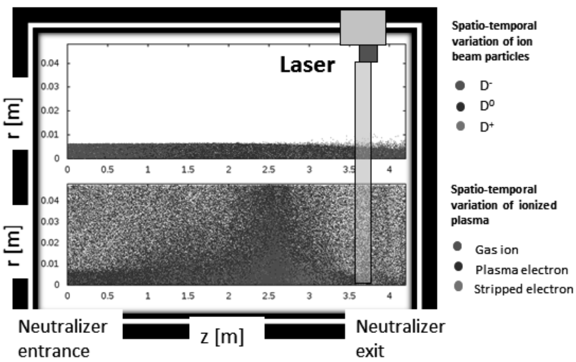

Fig. 3 Simulation results of spatio-temporal variation of beam and plasma particles in gas and photo neutralization system.