§13. Initial Experiment on a Compact Toroid Injector SPICA

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SPICA (SPheromak Injector using Conical Accelerator) is a compact toroid (CT) injector developed for LHD. Initial experiments on SPICA have been carried out after the installation of a CT generation bank of which the maximum values of the charging voltage, the stored energy, and the discharge current are 20 kV, 40 kJ, and 300 kA, respectively. Although SPICA is designed as a two-stage plasma gun, a one-state operation has been adopted in the initial experiments. In this one-stage operation, CT is generated and accelerated continuously by the CT generation bank. A small sized vacuum chamber of 0.15 m radius and 2 m length was used at the earlier phase of the experiment, and it was then replaced with the larger vacuum chamber of 0.32 m radius and 3.6 m length.

Typical waveforms of SPICA are shown in Fig. 1. The electron density n_e measured by a He-Ne laser interferometer reaches to the order of 10^{21} m^{-3} and its waveform resembles the magnetic field signal measured at the same location, suggesting that the high density CT is magnetized. The trajectory measured by magnetic signals at various locations indicates that the CT has a velocity exceeding 100 km/s. The CT length estimated from FWHM of n_e signal is about 1 m. Although this is rather longer than expected, we expect that this can be shortened in the two-stage operation, where the CT is compressed axially by acceleration current. Radial profiles of the poloidal magnetic field B_p are depicted in Fig. 2, where the magnetic field strength increases according to the charging voltage of the CT generation bank. The B_p profile has a reversal point, which characterizes the spheromak configuration. The radial location of the reversal point is ~0.06 m, and this is twice larger than that observed when the small vacuum chamber was used. From this observation, the vacuum chamber seems to be working as a shell that determines the CT size. This is an expected, but severe problem, since the port of LHD has a large size of order 1 m. Therefore, a drift tube that can work as a shell is necessary to transfer the CT through the LHD port. The drift tube should be carefully designed, because the stray magnetic field of LHD crossing this drift tube will prevent the CT propagation.

The CT acceleration bank of 40 kV – 96 kJ – 400 kA has been installed on March 2001 and the two-stage operation experiment has just begun since April 2001. After the experiment and the development of the drift tube, SPICA will be installed on LHD as soon as possible.

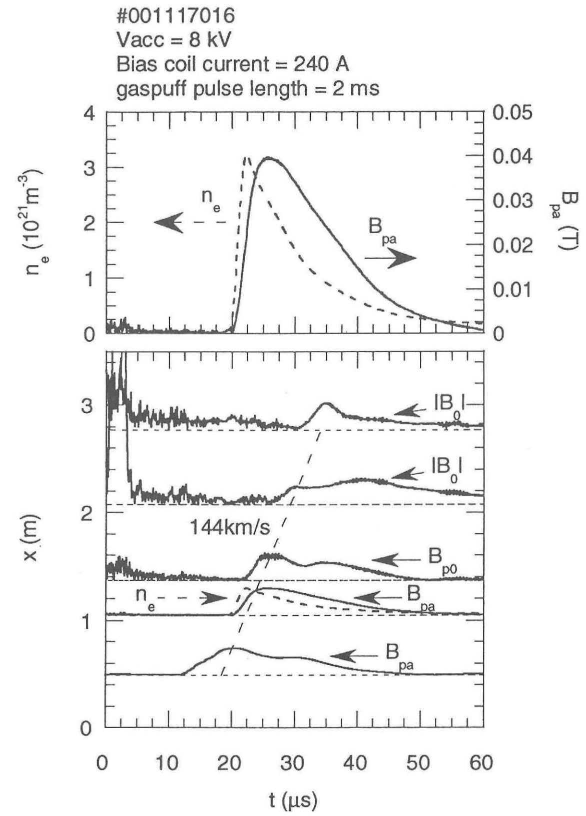

Fig. 1. Waveforms of the electron density n_e, the poloidal magnetic field strength at the plasma edge B_{pa} (top) and magnetic signals at various axial locations (bottom). In the bottom figure, each trace is offset vertically by a distance proportional to the axial location, and the broken line denotes the linear trajectory of a CT having 144km/s of velocity.

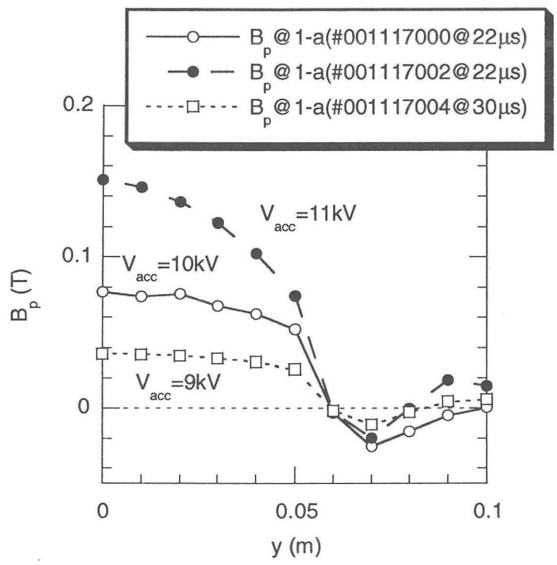

Fig. 2. Radial profiles of the poloidal magnetic field in CTs generated with the charging voltage of 9 kV (open squares), 10 kV (open circles), and 11 kV (closed circles). These profiles are measured at 0.2 m from the exit of the acceleration electrode (x = 1.37 m in Fig. 1).