# §7. Injection of the Probing Beam for a Heavy Ion Beam Probe on LHD

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The beam line has been developed for a heavy ion beam probe (HIBP) which is an important tool to measure space potential and density fluctuation in plasmas. In the last campaign (2002 -2003), we installed all components of the injection-side beam line, but some components didn't work well in the stray field of LHD and the beam was not injected into LHD. In this campaign, we modified the beam line and tried to detect the primary beam in LHD vacuum vessel and the secondary beam in the detector-side beam line.

Three sets of detectors are installed in the LHD vacuum vessel in order to detect the primary beam. They are for 6.0 MeV in 2.37 T, 5.0 MeV in 3.0 T, and 4.0 MeV in 3.0 T, respectively. Two of the primary beam detectors (PBDs) are composed of four detector plates and the other is composed of one plate. Figure 1 shows the detected beam current with a PBD during the sweep in two directions at the injection-side port. The beam energy is 2.34 MeV and the magnetic field strength is 1.8T, that corresponds to the 5.0 MeV in 3.0 T. The beam is detected successfully for the first time in the magnetic field of LHD.

Figure 2 shows the contour of the beam current in the parameter space of the sweep voltage. The result of the trajectory calculation is also shown. Although the parameter region to detect the beam with the PBD is similar in shape, the absolute values of the voltage are different between the experiment and the calculation. That may be due to the error in the alinement of the beam line or the position of PBDs. Anyhow, we got some important information to check the spatial relationship between the beam line and the LHD field.

After that, we tried to detect the secondary beam in the detector-side beam line. But we had no machine time suitable for the HIBP, and the secondary beam could not be detected unfortunately. That remains as a goal in the next campaign.

Other problems also remain. One of the problems is due to the stray field of LHD. The probing beam is deflected in front of the injection port with the electrostatic deflector. We need to apply the voltage of +40 and -40 kV on the positive and negative electrodes, whose gap is 30 mm, in order to deflect 6MeV beam. In the high field operation of LHD, however, the discharge occurred between the positive electrode and the grounded vacuum vessel, and the discharge current exceeded the capacity of the power supply when the voltage is 22 kV or more. Curiously, we can apply the voltage of 30kV or more if the voltage has been applied before the start-up of the LHD field. The range of electrons shortens due to the strong electric field even in the magnetic field and the ionization of neutral gas by the electrons decreases. But the breakdown is often induced by the photoelectron due to the strong radiation from the plasma or by the secondary electron due to the probing beam. Once the break down occurred, we could not apply the voltage in the magnetic field. Therefore, it was difficult to inject 6 MeV beam in the LHD magnetic field of 2.8 T, so we used only the lower energy beam in the lower magnetic field to check the beam trajectory. The deflector should be improved by the next campaign.

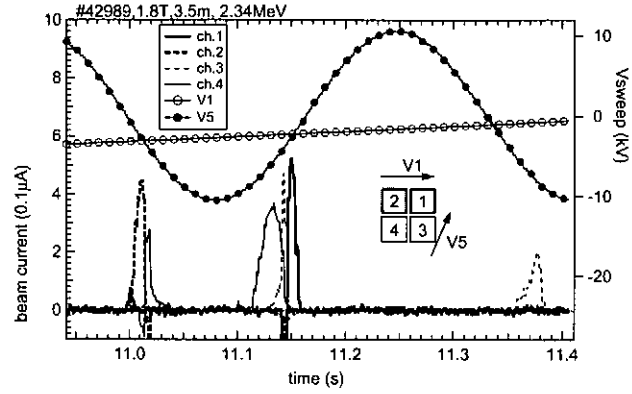


Fig. 1. Beam current on the primary beam detector during the sweep. The beam energy is 2.34 MeV and the magnetic field strength is 1.8T. V1 and V5 is the sweep voltage in toroidal and major radius directions at the injection port, respectively. In the center of the figure, the alignment of the detector plates is shown with the sweep direction.

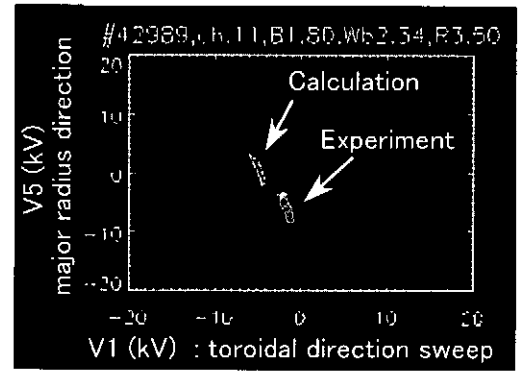


Fig. 2. Contour of the beam current in the parameter space of the sweep voltage. The experimental condition is same as Figure 1.