§1. Development of a Heavy Ion Beam Probe for LHD

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In the last campaign (2000 - 2001), the beam transport system was tested and some problems were revealed. One of them is that the beam was not transported to the injection port of LHD because of the stray field of LHD. Another is that the electric fields between the sweepers could not be controlled because the radiation light from a plasma triggered the breakdown on the electrostatic sweepers plates. We took measures against these problems before this campaign.

Two additional electrostatic steerers are installed in the system in order to compensate the deflection of the beam orbit due to the stray field. The 100 kV single-end accelerator was used to test the beam transport system because the operation of the 3 MV tandem accelerator had not yet be licensed.

Figure 1 shows the beam intensities in the beam line when the beam energy is 80 keV and the strength of the magnetic field (B) is 0.75 T. The beam can go through the beam line and reached to the injection port. The trajectory of 80 keV Tl^+ in B of 0.75 T is equivalent to that of 6 MeV Au^+ in B of 6.6 T, thus the probe beam can be injected into LHD plasmas with B of 3 T, probably.

The radiation-triggered breakdown of the sweepers is one of the most important and difficult problems. As it is triggered by the radiation light from plasmas, we should reduce the radiation power coming into the beam line and/or develop a sweeper in which the generation of photoelectrons is suppressed. We had no positive solution, so we planned to advance the development step by step. At first, the aperture between the sweeper and the plasma was planned to be narrowed down to reduce the radiation light and not to block the probe beam. The diameter of the aperture is decreased so that the radiation light does not strike the front edges of the sweepers electrodes. The breakdown voltage of the sweeper in the extraction port increases by about 2 kV compared with the previous sweeper. Although the performance is not sufficient for LHD plasmas, we can probably use it for low-density plasmas with low radiation power which are target in the first stage of measurement of plasmas.

Apertures with various size of the opening were not tested due to a vacuum-related problem in the beam line, so the aperture has not been optimized. Moreover, the sweeper in the injection port was not tested at all because the gate valve can not be opened owing to a leakage on the seal of the valve and a vacuum-related problem in the beam line, unfortunately. We will continue the test in the next campaign, and development of a new type of sweeper on the basis of the results will be required before long.

A development of an energy analyzer also progressed simultaneously. Although Green-Proca type electrostatic analyzers have been used in conventional HIBPs, that requires unrealistic voltage for the 6 MeV LHD-HIBP. Therefore, we invented an electrostatic analyzer with tandem anodes [1]. It has been designed for the most part and it is under construction. Its performance will be test in the fiscal year of 2002.

The remote-control system for the beam transport system is being developed by using COACK (Compornent Oriented Advanced Control Kernel), that is a kind of programing language developed to control various hardwares in the High Energy Accelerator Research Organization (KEK). Almost all system has been programed and it has been tested by using virtual instruments.

With regard to the tandem accelerator, the operation has not been permitted by the authorities concerned yet. The legal process including the construction of the radiation controlled area is a pending issue to the next year.

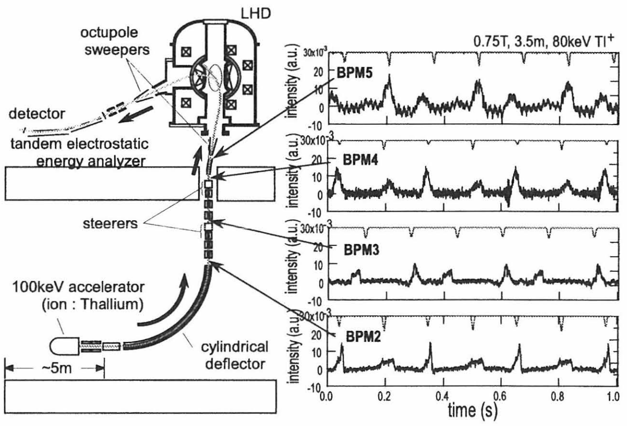

Fig. 1. Schematic view of LHD-HIBP and the beam intensities by the beam profile monitor(BPM)s. The strength of the magnetic field is 0.75 T and the beam energy is 80 keV. The BPMs scan the beam in two directions. The lower wave form in each graph shows the beam intensity. The spikes of the upper wave form in each graph shows the timing when the BPM cuts across the central axis of the beam line, and the scan direction is recognized by the magnitude of the spike. The beam are transported to BPM5 which is just in front of the injection port.

Reference
1) Y. Hamada, et al., Rev. Sci. Instrm., 68, 2020 (1997)