§ 17. Beam Characteristics of New Accelerator with Multi-Slit Grounded

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In order to increase neutral injection power an originally designed beam accelerator has been introduced to the negative ion source of LHD-NBI beam line #1. A schematic view of the new accelerator is shown in Fig. 1. The accelerator consists of four electrode grids, which are a plasma grid (PG), an extraction grid (EG), a steering grid (SG) and a multi-slit grounded grid (MSGG). Extraction voltage (Vex) and acceleration voltage (Vac) are applied between the PG and the EG, and between the SG and the GG, respectively. The EG and the SG are in a common potential. By introducing the accelerator, the maximum injection power reached 4.4 MW in FY2002.

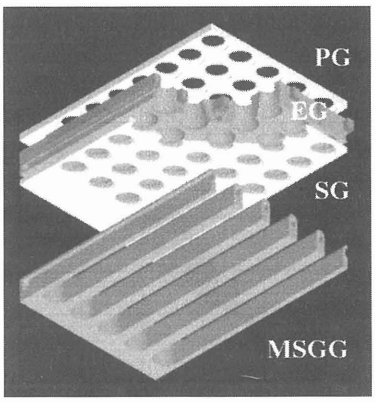

Fig. 1. A schematic view of the new beam accelerator with the MSGG. The H- beam is accelerated from upward to downward direction in this view.

There, however, is a problem on its beam focusing. The problem is that a part of neutral beam touches on the injection port of the beam line. The port is a connecting tube between the beam line and LHD, and molybdenum plates for beam heat protection cover the inner wall of the port. The beam touching decreases the injection power and also damages the port.

Vertical and horizontal beam profile is measured by using a calorimeter array installed inside the beam line. The distance between the array and the ion source is 8,6 m. The typical profiles are indicated in Figs. 2a and 2b. In the Figures profiles obtained from an accelerator with multi-aperture grounded grid (MAGG) is also plotted for comparison. The intensities are normalized in both cases, and the profiles are measured in the conditions that the maximum port-through power is obtained. In the horizontal profile, whose direction is parallel to the long side of the MSGG slits, beam width in the MSGG is narrower than the width in the MAGG. In contrast, the width in the MSGG is wider than the width in the MAGG.

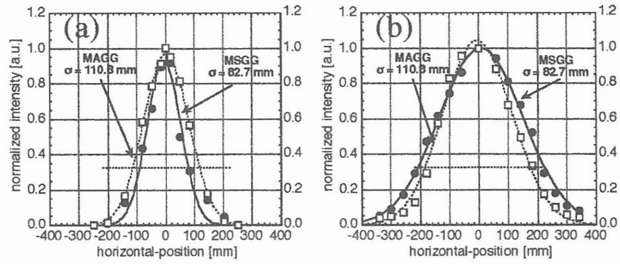

Fig. 2. Horizontal (a) and vertical (b) beam profiles at a calorimeter array installed in beam line #1 of LHD-NBI. The plots with closed circles and open squares indicate the profiles in the MSGG and in the MAGG, respectively.

The beam focal characteristic is similar to the optics. A pair of electrodes with single apertures on the sides of beam upstream and downstream corresponds to a pair of convex and concave lenses. Changing the voltage ratio is similar to changing the curvatures of those lenses. Figure 3 indicates the beam widths in horizontal and vertical directions as functions of the voltage ratio. As shown in the figure, the voltage ratios at the minimum beam widths in both directions are not coincident with each other. A coincidence of the ratio is observed in case of previous accelerator with the MAGG.

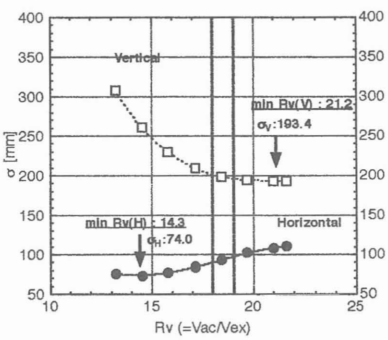

Fig. 3. Horizontal and vertical beam width as functions of the voltage ratio R_V. The plots with closed circles and open squares are changes of horizontal and vertical changes of beam widths, respectively.

This focal characteristic is a nature of the accelerator with the MSGG. The reason why mismatching of the focal condition is as follows; the focal condition in perpendicular to the slit is close to that of the previous set of grids with the MAGG, while the condition along slit direction corresponds to a set of a convex lens and a much weaker concave lens. The horizontal beam width, which is along a long side direction of the slit, is much narrower than that in the MAGG, fortunately. The narrow width has an advantage to port-though efficiency. It is available to coincident the focal condition by modifying the SG on beam upstream side. Numerical analysis on beam trajectory has started to correct the vertical focusing structure on the SG. On the basis of the analysis, experiments on the focal conditions are scheduled to investigate by using a small-scaled negative ion source for development.