§8. Multibeamlet Focusing of Intense Negative Ion Beams by Aperture Displacement Technique

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Multibeamlet focusing of intense negative ion beams has been performed using beamlet steering by aperture displacement. An external-filter-type large negative-ion source was used, where 16.2 A of H^- ion current was obtained and 13.6 A of a H^- ion beam was accelerated to 125 keV with a grid area of $25\text{ cm} \times 50\text{ cm}$ [1,2]. In this experiment, the plasma grid was masked, resulting in 270 (18×15) apertures of 11.3 mm in diameter, giving a total area of $25\text{ cm} \times 26\text{ cm}$. The apertures of the grounded grid were displaced as all 270 beamlets are steered to a common point (a focal point) in both the two-stage and the single-stage accelerators, as shown in Figs. 1 (a) and (b). The multi-beamlets were successfully focused, as shown in Figs. 2 (a) and (b), which show the vertical beam profiles measured 5 m and 11.2 m downstream from the ion source, respectively. An e-folding half width of 10 cm was achieved 11.2 m downstream in both accelerators, corresponding to a gross divergence angle of 9 mrad. The negative ion beamlets are deflected by the electron deflection magnetic field at the extraction grid and the deflection direction reverses line by line, resulting in the beam splitting in the deflection direction, as shown in Fig. 3 (a). This beamlet deflection was well compensated also using beamlet steering by the aperture displacement of the grounded grid, as shown in Fig. 3 (b).

The aperture displacement technique is effective to the multibeamlet focusing of intense negative ion beams, and can be also used to compensate the beamlet deflection by the magnetic field generated at the extraction grid. These results enable the efficient beam injection into the LHD plasma.

[1] Y. Takeiri, *et al.*, Rev. Sci. Instrum. 66 , 2541 (1995).
 [2] Y. Takeiri, *et al.*, J. Plasma and Fusion Research 71 , 605 (1995).

Fig. 1. Grid arrangements along the beam axis in (a) the two-stage accelerator and (b) the single-stage accelerator.

Fig. 2. Vertical beam profiles measured (a) 5 m and (b) 11.2 m downstream, respectively.

Fig. 3. Horizontal beam profiles measured 11.2 m downstream (a) without compensation of the beamlet deflection by the magnetic field at the extraction grid, and (b) with compensation of it by the aperture displacement technique.