§10. Development of a Strongly-Focusing High-Intensity He^+ Ion Source for Fusion-Produced Alpha Particle Diagnostics

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Measurement of velocity distributions and spatial profiles of fusion-produced alpha particles in a next-stage magnetic plasma-confinement device is a challenging topic in thermonuclear fusion research. An active beam probe diagnostic method based on an energetic neutral beam of ^3He is considered as one of the most promising candidates. The energetic He beam is produced by spontaneous electron detachment from He^- ions which are converted from He^+ ions through a double charge exchange reaction with an alkali metal vapor in a small-aperture gas cell.

A strongly-focusing high-intensity He^+ ion source has been designed and constructed as a beam source for the energetic He^0 beam probe system. It consists of a plasma chamber of 300 mm in diameter and 280 mm in length with the cylindrical wall surrounded by 9 rows of Sm-Co permanent magnets forming a cusp magnetic field to confine He plasma, 8 tungsten filaments as hot-cathodes and a beam extraction system made of three concaved electrodes. Across the 100 mm diameter extraction area, 300 beamlets are formed through 4 mm apertures. The beamlets are designed to be converged by the electrodes with the focal length of 750 mm.

The He^+ ion source was installed with a beam diagnostic chamber on the Neutral Beam Injection (NBI) test stand at NIFS. A photograph of the He^+ ion source with the beam diagnostic chamber on NBI test stand at NIFS is shown in Fig. 1. In the beam diagnostic chamber, a Rogowski coil beam current monitor, a carbon plate beam target movable in the direction of the beam axis and ports for CCD cameras to measure the beam envelope and the beam profile were installed. A photograph showing inside of the beam diagnostic chamber is in Fig. 2.

He^+ beam was extracted from the He^+ ion source at the acceleration voltage of 18-22 kV. The acceleration current about 3 A, which is enough to diagnose the alphas at ITER, was achieved at the acceleration voltage of 20 kV with an arc power of 14 kW. The infrared radiation from the carbon plate irradiated by the He^+ beam was observed by an IR camera installed outside of the chamber. The measured beam diameter was about 30 mm at the focal point. However the measured focal length was shorter than the design one presumably due to the deformation of the electrodes caused by the heat radiation from the He plasma.

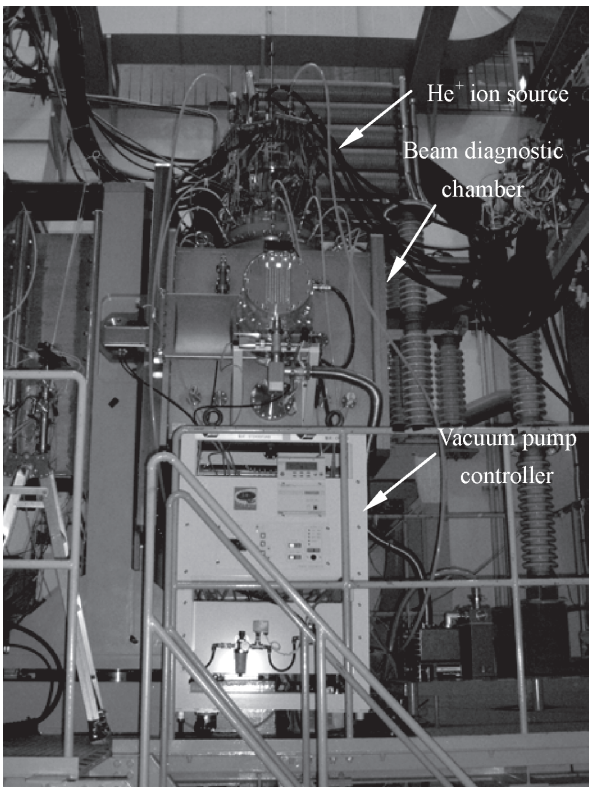

Figure 1 Photograph of the He^+ ion source with a beam diagnostic chamber on NBI test stand at NIFS.

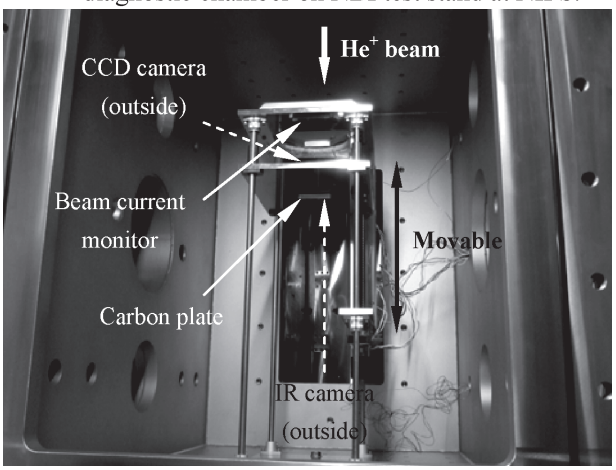

Figure 2 Photograph showing inside of the beam diagnostic chamber.

References

1) Shinto, K. *et al.*, Proc. of PAC05 (2005) 2630.
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3) Shinto, K. *et al.*, Proc. of EPAC2006 (2006) 1726.