§21. Development of an H⁻ Beam Probe System for a High Intensity Positive Ion Beam Profile Measurement

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We have proposed a negative ion beam probe system as a new scheme to diagnose beam profiles of high intensity positive ion beams.[1)]

IFMIF (International Fusion Materials Irradiation Facility) is an accelerator driven neutron source consisting of two linacs each of which provides a continuous-wave (CW) deuteron (D^+) beam with the beam energy and beam current of 40 MeV and 125 mA, respectively. In condition of the extreme high intensity and the severe radiation environments, the beam diagnostics by conventional techniques in the beam transport line seems almost impossible. A widely used wire-scanning-type beam profile monitor (BPM) can cause severe scattering of D^+ ions to damage beam line components. After a certain period of operation, the components including the wire-scanning-type BPM become radioactive. As another type BPM, a gas-cell-type BPM can deteriorate not only vacuum condition of the beam line but also the optics for the D^+ beam transportation. In order to perform the beam diagnostics in the severe condition, we have proposed and an active beam probe system to diagnose the beam profiles of the high power positive ion beams.

We have started an experimental study with a low energy intense ion beam system being tested at NIFS to validate the capability of the negative ion beam probe system. A strongly focusing He^+ ion source developed for measurement of spatial profile and velocity distribution of α particles produced by D-T nuclear reactions in fusion plasmas is employed as a target beam source for the proof-of-principle (PoP) experiment. For the probe beam source, we have designed and assembled an H^- ion source as shown in Fig. 1. This source chamber of 120 mm in inner diameter and 160 mm in length is made from an aluminum alloy and designed to produce the H^- beam with a rectangular shape of 70 mm × 2 mm. The source has tungsten-filament hot cathodes and permanent magnets forming a tent-shaped magnetic filter[2)] to confine the hydrogen plasma. The magnetic field strengths at the center and that on the inner wall of the source chamber are 20 G and 1500 G, respectively. Fig. 2 shows an experimental result of H^- beam profile measurement performed at a small test bench. About 90 % of the total H^- beam current is detected along the long side of the rectangular. After the H^- beam extraction test, the H^- ion source was transported to the NBI test stand at NIFS. Fig. 3 shows an experimental setup of a PoP H- probe beam system for a He^+ beam diagnostics. The beam test will be started in 2011 summer.

1) Shinto, K. et al.: Proc. of IPAC'10 (2010) 999.
2) Tobari, H. et al.: Rev. Sci. Instrum. **79** (2008) 02C111.

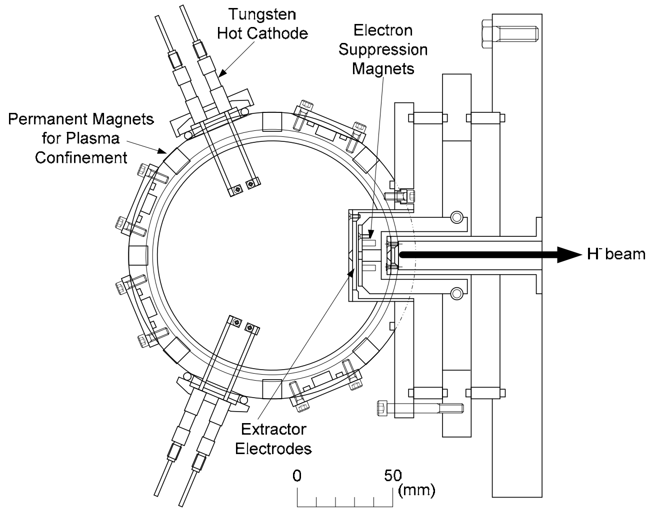

Fig. 1. A schematic drawing of the H^- ion source for a negative ion beam probe system.

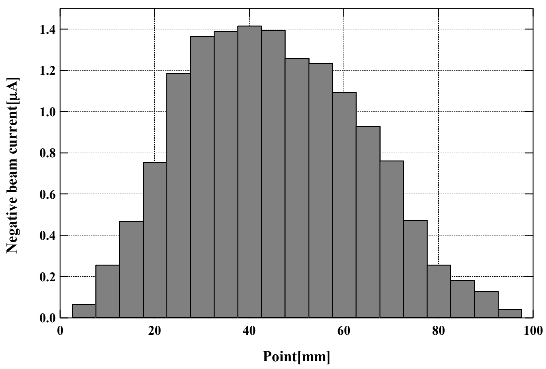

Fig. 2. Experimental result of the H^- beam profile measurement.

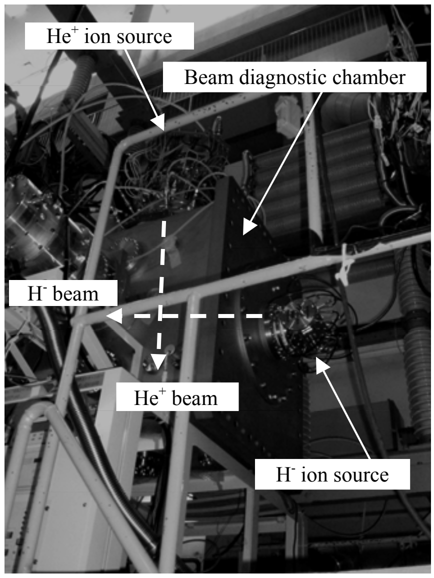

Fig. 3. Experimental setup of a proof-of-principle H^- probe beam system for a high-intensity positive-ion beam diagnostics.