Beam Homogeneity Dependence on the Magnetic Filter Field at the IPP Test Facility MANITU

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The homogeneity of large RF driven negative hydrogen ion sources relevant for the ITER neutral beam system is a critical issue for the transmission of the negative ion beam through the accelerator and the beamline components. As a first test, the beam homogeneity at the IPP long pulse test facility MANITU [1] is measured by means of the divergence and the stripping profiles obtained with a spatially resolved Doppler-shift spectroscopy system. Since MANITU is typically operating below the optimum perveance, an increase in the divergence corresponds to a lower local extracted negative ion current density if the extraction voltage is constant. The beam H_α Doppler-shift spectroscopy is a rather simple tool, as no absolute calibration — both for the wavelength and the emission — is necessary. Even no relative calibration of the different LoS is necessary for divergence and stripping profiles as these quantities can be obtained by the line broadening of the Doppler-shifted peak and the ratio of the integral of the stripping peak to the integral of the Doppler-shifted peak, respectively. The stripping peak in the Doppler spectrum is caused by excitation of hydrogen atoms with less than the full energy, i.e. originating from ions that have been stripped within the accelerator.
First initial results have been already presented in [2]. The paper describes the H_α MANITU Doppler-shift spectroscopy system which is now operating routinely and the evaluation methods of the divergence and the stripping profiles. Beam homogeneity measurements are presented for different extraction areas and magnetic filter field configurations both for Hydrogen and Deuterium operation; the results are compared with homogeneity measurements of the source plasma.
The Doppler-shift spectroscopy system at MANITU consists of 20 channels, 7 horizontal channels, viewing in vertical direction and 13 vertical channels, viewing in horizontal direction. The optic heads are located about 1.2 to 1.5 m downstream of the grounded grid; they have a viewing angle of about 50°.
Generally, the beam homogeneity depends on the strength of the horizontal magnetic filter field in the source, the lower the field near the plasma grid, the more homogeneous the vertical divergence profile is. This behavior is associated with plasma drifts in the source: the main part of the extracted negative ion current is generated opposite to the plasma drift direction, i.e. if the magnetic filter field causes a plasma drift to the bottom of the plasma grid, then the negative ions are predominantly extracted from the top part of the plasma grid. The homogeneity of Deuterium beams is better than for Hydrogen; this is consistent with measurements of the homogeneity of the source plasma [2]. The stripping fraction, however, is larger by roughly a factor of 2 for Deuterium. The long term stability of the beam homogeneity is rather good: no major change could be observed for several 100 s long pulses, if at all, the homogeneity improves during the pulse.

[1] W. Kraus, this conference
[2] U. Fantz et al. AIP Conf. Proc. 1097 (2008) 265-274