ISBN: 978-3-95450-184-7 doi:10.18429/JACoW-IPAC2018-THPML080

PRELIMINARY RESULTS OF A NEW HIGH BRIGHTNESS H$^-$ ION SOURCE DEVELOPED AT TRIUMF

K. Jayamanna, F. Ames, I. Byelinskii, J. Cheng, M. Lovera, and B. Minato
TRIUMF, 4004 Wesbrook Mall, Vancouver BC Canada

Abstract

This paper describes the preliminary results of a high brightness ion source developed at TRIUMF, which is capable of producing a negative hydrogen ion beam (H$^-$) of up to 5 mA of direct current. A 1.7 mm-mrad and 5 mm-mrad rms emittance is achieved for 500 µA and for 1 mA H$^-$, respectively. Characteristics as well as a brief description regarding extraction issues of the source to date are also presented.

INTRODUCTION

Since the 1980s TRIUMF has developed several types of H$^-$ ion sources. They are currently being utilized in cyclotrons developed by manufacturers like ACSI, BEST, and CYCIAE. Large hospitals like Vancouver General Hospital [1] (VGH) and radiopharmaceutical producers like Nordion [2, 3] also use the TRIUMF-built ion sources for the injection into their cyclotrons. These ion sources can produce up to 60 mA of H$^-$ beam with relatively larger emittance [4]. TRIUMF's 500 MeV requires a brighter beam than these ion sources can produce therefore a necessity arose to develop a new ion source, which can produce 1 mA H$^-$ beam with less than 5 mm-mrad rms emittance.

TEST SETUP

The source consists of a 50 mm diameter, 75 mm long plasma volume, a magnetic confinement designed to minimize emittance of the H$^-$ beam and an extraction system. The extraction system consists of 3 electrodes: a first electrode, a second electrode and the ground electrode. After optimizing, this will be converted in to a four electrode system. A new electron filter was also designed specifically for this ion source in order to minimize the emittance. Figure 1 shows an artistic drawing of the ion source.

The high voltage terminal is equipped with filament, arc, first electrode and extraction power supplies as well as controls and is elevated up to 60 kV. Two separate transformers provide two separate ground circuits, one for controls and another for high current and high voltage circuits for stable and reliable operation. Even though the high voltage terminal is equipped to run high power ion sources the ion source described in this paper utilizes only a fraction of the total power.

The beam line consists of two emittance scanners [5], a permanent magnet focusing solenoid [6], a graduated Faraday cup and the necessary steering elements. The vacuum system is equipped with four turbo pumps backed by two dry pumps and ion gauges.

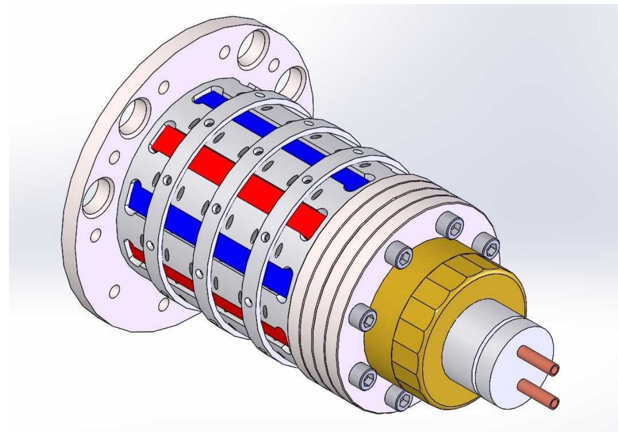

Figure 1: An artistic view of the 50mm (2”) ion source.

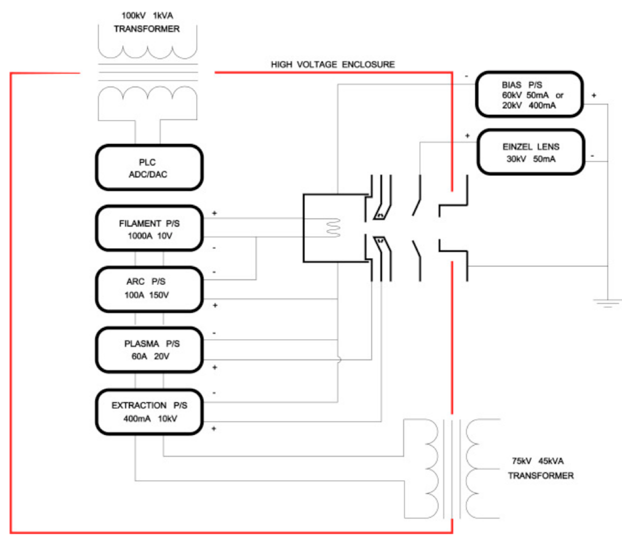

Figure 2: Electrical schematics of the high voltage terminal.

BEAM CURRENT AND EMITTANCE STUDIES

The source has only been in operation for a few weeks and the measured rms emittance for 500 nA and for 1 mA were found to be 1.7 and 5 mm-mrad. Emittance plot and the fractional emittance curve are shown in Figure 3 and Figure 4. Emittance versus the beam energy is shown in Figure 5.

We found that 60% of the beam was transferred to the Faraday cup thus far. Five apertures, each 1.5 mm in diameter, vertically aligned and spaced at 1 mm apart were installed at the plasma electrode to study the newly designed extraction system as well as the electron filters. Beams from only three out of five apertures reached the scanner after

ISBN: 978-3-95450-184-7 doi:10.18429/JACoW-IPAC2018-THPML080

passing through the electron filter (see Figure 5). Beams from the other two apertures were noted at the ground electrode but no further. Steps are being taken to improve the extraction efficiency.

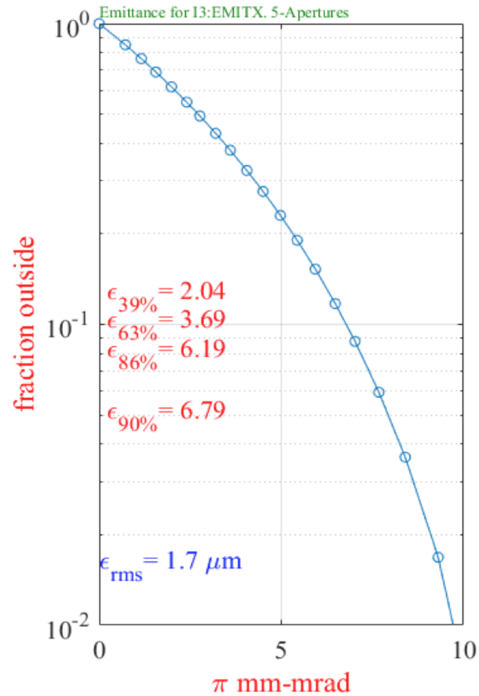

Figure 3: Fractional emittance for 500 nA H$^-$.

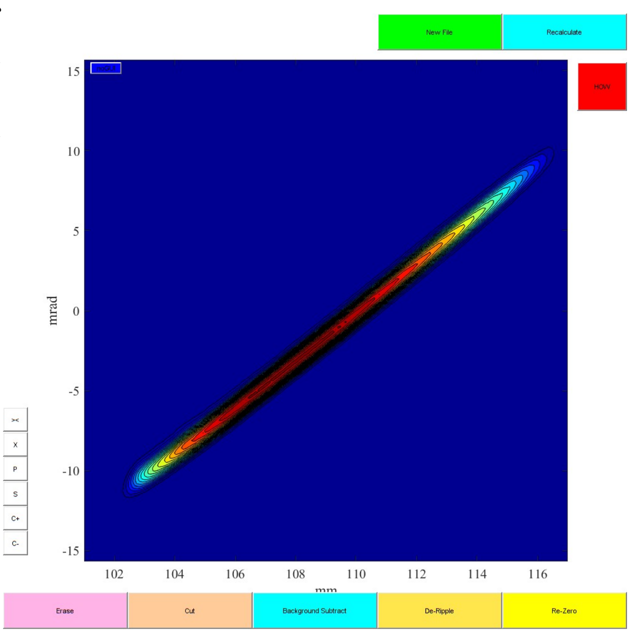

Figure 4: Emittance plot for 500 nA OF H$^-$.

CONCLUSION

A 5 mm-mrad rms emittance is achieved for 1 mA of H$^-$ beam. The preliminary results of the ion source produced promising results, surpassing previous ion sources

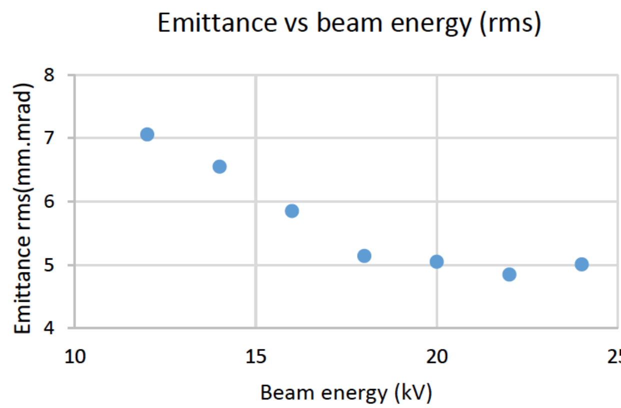

Figure 5: Emittance vs beam energy for 1 mA H$^-$.

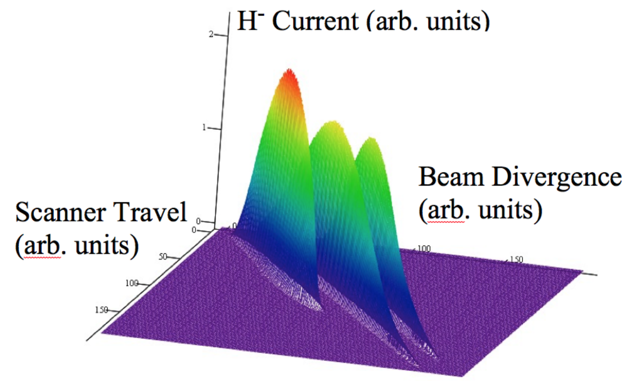

Figure 6: Emittance surface plot with 3 out of 5 apertures.

for similar currents. Its extraction system and the magnetic confinement are being optimized for the beam efficiency as well as beam brightness.

ACKNOWLEDGMENTS

TRIUMF receives federal funding via contribution agreement through the National Research Council of Canada.

REFERENCES

[1] F. Benard, in *Journal of Nuclear Medicine* **55**, p. 1017, 2014.

[2] B. Milton, in *International Conference on High Energy Accelerators*, Dallas, **28** no. 19.

[3] G. Cojocaru, in *Proc. of Cyclotrons 2013*, Vancouver, BC, Canada, p. 446, 2013.

[4] K. Jayamanna, *NIMA* **895**, p. 150, 2018.

[5] R. Simpson, "Single ring permenant magnet lens", in *Proc. of IPAC'18*, Vancouver, Canada, 2018, paper TUPMK011, these proceedings.

[6] P.W. Allison, *IEEE Trans. Nucl. Sci.* **30**, p. 220, 1983.