STATUS OF THE VERSATILE ION SOURCE VIS*

F. Maimone#,G. Ciavola, L. Celona, S. Gammino, D. Mascali, N. Gambino, R. Miracoli, F. Chines, S. Passarello, G. Gallo, E. Zappalà, INFN-LNS, Via S. Sofia 62, 95123 Catania, Italy

Abstract

The characteristics of the ideal injector for high power proton accelerators has been studied at INFN-LNS, Catania with the TRIPS ion source. The source must obey to the request of high brightness, stability and reliability. The new Versatile Ion Source (VIS) is a permanent magnet version of the TRIPS source with a simplified and robust extraction system. It may operate up to 80 kV without a bulky high voltage platform to produce multi-mA beams of protons and H_2^+. The source status and description along with the forthcoming developments are hereinafter presented.

VIS DESCRIPTION

The source TRIPS (TRasco Intense Proton Source) has been built at INFN-LNS in the framework of the TRASCO project [1]. In 2003 the source completely fulfilled all the requirements for an high intensity proton injector [2]. In fall 2005 it has been moved to INFN-LNL where it will be used in the SPES facility. The TRIPS source operates at 80 kV with on-line movable solenoid coils magnetic system and a five electrodes extraction structure. These features permitted to perform many tests to optimize the extracted beam current characteristics (current, emittance) and source reliability as a function of the magnetic field profile. However it was observed that the large number of control devices placed at high potential affected the reliability requirement.

Therefore, in order to further enhance such important parameter and to maintain at the same time all the characteristics of the TRIPS ion source, a proton source, called PM-TRIPS was built in 2006 [3,4]. During the first operations of this new source, some Penning discharges occurred, due to the high stray magnetic field values measured in the extraction region. In order to avoid this phenomenon the magnetic system has been redesigned by using the OPERA calculation suite (figure 1). The magnetic field measurements on axis confirmed a good matching between simulated data and experimental measures. Figure 2 shows the magnetic field profile on the chamber axis: the drastic decrease of magnetic field at the extraction permits to avoid undesidered effect on the extracted beam. The off axis magnetic field measurements in the extraction area (figure 3) revealed relatively low values with an important decrease with respect to the ones of the PM-TRIPS source. The VIS source employs also a more compact extraction column by using a four electrodes extraction system. It consists of a plasma electrode at 80 kV voltage, two water-cooled copper grounded electrodes and a negatively biased electrode between them (figure 4). Particular care has been paid to design the electrodes geometry by means of AXCEL code. A remote control is used to set the main source parameters and monitor the source status and performances, thus ensuring safe source operations. The use of permanent magnets reduces the number of components at high voltage simplifying the controls because all the devices are placed at ground potential.

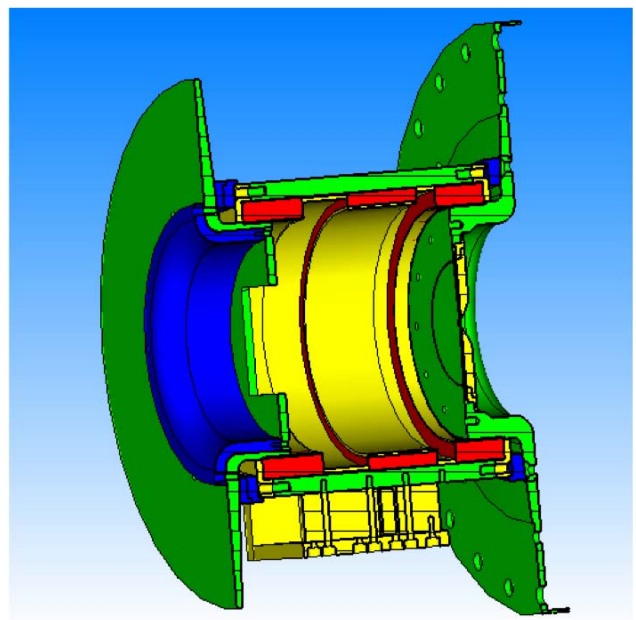

Figure 1: 3D view of the VIS magnetic system (in red the NdFeB magnets, in yellow the stainless steel components, in blue the aluminum ones and in green the ARMCO iron parts).

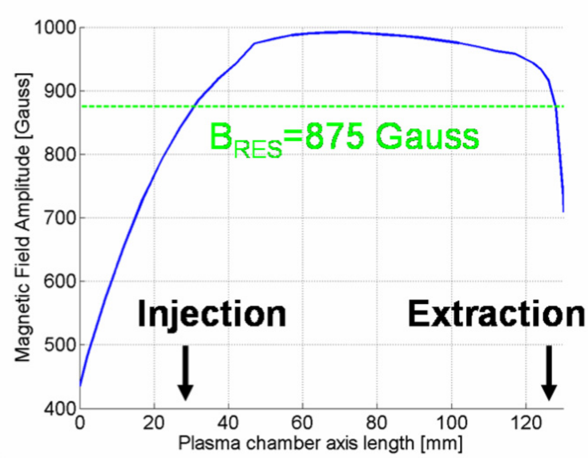

Figure 2 :The VIS magnetic field measured on the plasma chamber axis.

*Work supported by INFN through the NTA-HPPA project
#maimone@lns.infn.it

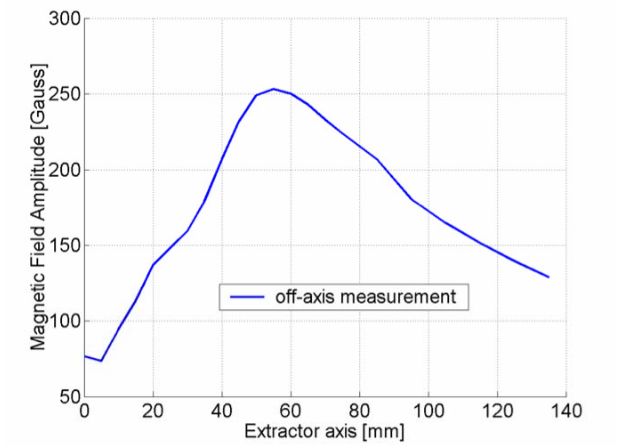

Figure 3: Stray magnetic field values in the extraction area (56 mm off axis). The plasma electrode is located at x=0.

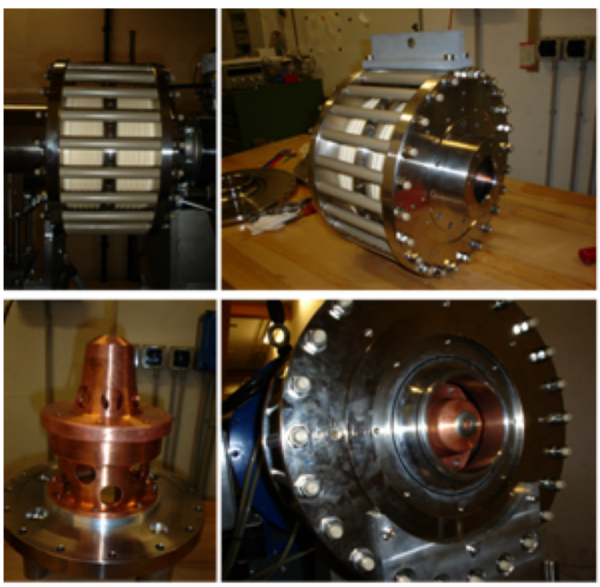

Figure 4 : VIS extraction column.

MICROWAVE LINE

The microwave feeding the plasma is provided by a 2 kW Magnetron operating at 2.45 GHz. An automatic tuning unit adjusts the modulus and phase of the incoming wave to match the plasma chamber impedance and a dual-arm directional coupler is used to measure the forward and the reflected power.

To insulate the waveguide line (figure 5) from the high voltage region, a new waveguide DC-break has been designed with the HFSS elecromagnetic simulator [5] and built. It consists of 31 aluminum disks separated one from each other with fiberglass disks. This structure's performances have been measured (figure 6) and the results in terms of insertion loss reveal a good agreement with the simulation data, compatible with the tolerances of the construction process [6]. It can be observed that the insertion loss is 1.4 dB at 2.45 GHz.

A quartz window is placed before the WR284 water-cooled copper bend in order to protect it from the back-streaming plasma electrons. A maximally flat macthing transformer connects the microwave line to the plasma chamber (figure 7). It is an optimized version of the one used in the TRIPS source. It realizes a matching impedance with the plasma chamber and it concentrates also the electromagnetic field in its inner part. This feature enhances the electromagnetic field excited in the plasma chamber cavity [7] with beneficial effects on the ion beam brightness.

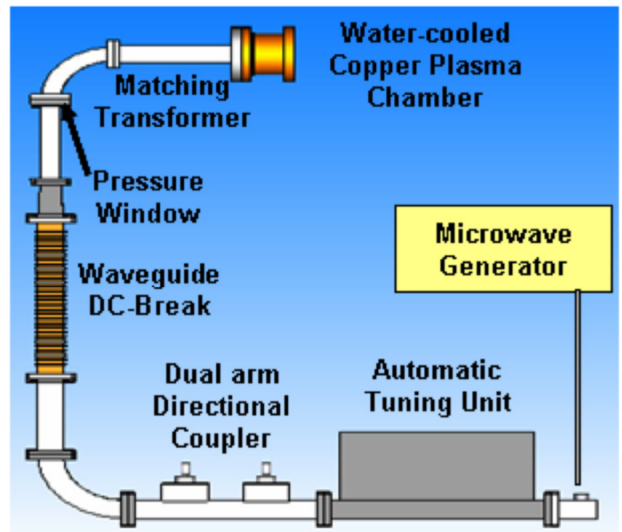

Figure 5 : VIS microwave line.

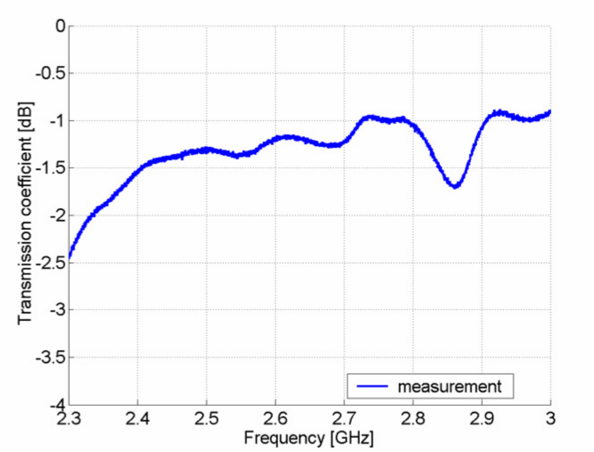

Figure 6: DC-break measured transmission coefficient.

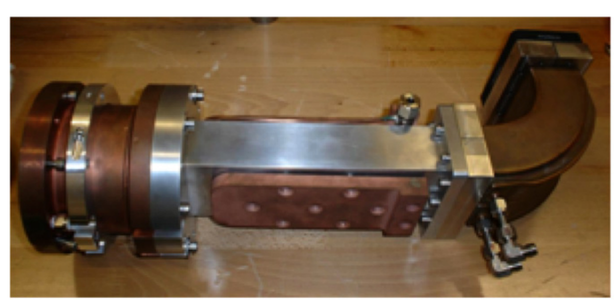

Figure 7 : Assembly of microwave line parts on the high voltage side (from left to right VIS plasma chamber, matching transformer and the water-cooled bend).

STATUS AND PERSPECTIVES

In figure 8 the source body is shown. The permanent magnet has been connected to the extractor and the plasma chamber was inserted inside it. The microwave line has been connected to the plasma chamber and to the Magnetron. The vacuum system has been tested and a value of 10^{-7} mbar is now routinely achieved inside the LEBT and just after the extraction region. The gas injection system has been connected to the matching transformer and tested. The water cooling system has been tested and no leak was also observed. A low conductance water has been used. A first plasma was produced three weeks ago, even in absence of plasma diagnostic tools. The plasma formation was monitored by means of the absorbed microwave power measured at directional coupler and by the pressure gauge.

The microwave diagnostics permits also to observe the change of the plasma characteristics during the conditioning phase. This phase is now concluded and we are now ready to produce the first beam except for few minor safey issues for high voltage shielding that have been modified and for the completion of the computer control system.

At the end of June the control system will be able to set the main source parameters and to monitor the source status and performances. The first H^+ beam is planned for middle July. After the optimization of the H^+ beam, also the H_2^+ beam will be optimized. Then several measurements will be carried out in order to characterize the produced ion beams in terms of emittance and brightness, by means of an EMU (Emittance Measurement Unit). A long run test (>200 h) will be then executed in order to match the reliability requirement. Further improvements of the source performances will be achieved by using a Traveling Wave Tube Amplifier operating in the 2.3÷7.5 GHz frequency range with a 500 W maximum output power, instead of the Magnetron, according with the “frequency tuning effect “, already demonstrated in ECRIS [8].

After the tests with protons and H_2^+, light ions of interest for material science will be produced.

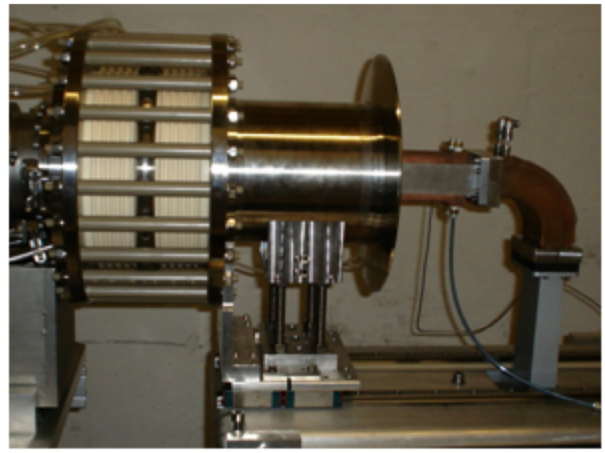

Figure 8 : The source body.

ACKNOWLEDGEMENTS

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