A Compact Injector for Energies up to 400 keV

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Abstract

We have constructed a very compact 400 kV injector for a small mass 3 accelerator. Due to restrictive boundaries, the whole system has been optimized. For example, a Disktron[1] as high voltage power supply, power transfer to the high voltage platform by a motor generator system, a bi-cycled frigen water cooling system and fibre optics control. As ion source a duoplasmatron is used. In first runs ions are accelerated up to 400 keV at beam currents of about 80 μA.

Description of the High-Voltage Platform

Figure 1 shows a side view of the injector while figure 2 displays a top view of the whole accelerator system. Because of the limited height of the room and the required injection energy, the height of the source platform has to be kept rather low (50 cm). The distance between the top of the platform to the ceiling and from the bottom of the platform to the floor was chosen 110 cm. The radius of the corona shields is 25 cm, and each curvature is in any case 25 cm. The platform support insulators are purchased commercially and are rated for 260 kV. Four insulators are used to support the platform. Three of them support housing while the fourth insulator is situated below the generator in order to decouple vibrations from the generator to the housing. The total volume available inside the platform is about 2.2 m^3. The housing covers the generator, the secondary cooling system with a heat exchanger, the power supplies at platform potential, a small 30 kV insulating platform for the source, two 30 kV insulating transformers, a gas handling system, a 1000 l/s turbo pump and a roughing pump, and the power supply for the disktron high-voltage source.

The component parts of the platform

The ion source. We use a duoplasmatron that has been made available by GSI[2]. The duoplasmatron is well known for high ionization efficiency for gases. During a test performed on a 90° test bench the following results were achieved (dc beam):

$$
\begin{aligned}
H^+ &= 200\mu A\\
H_2^+ &= 150\mu A\\
H_3^+ &= 300\mu A\\
H_4^+, H_5^+ &< 1\% \text{ of the total beam.}
\end{aligned}
$$

The results for the high H_2^+ and H_3^+ can be understood by the reaction mechanism and the differences in the binding energies. The different components can be reduced considerably for certain discharge operating conditions.

Principles of the gas handling system. The main parts are a 1000 l/s turbo pump, a roughing pump, a hydrogen reservoir and a needle valve.

The high voltage generator. A disktron is used for supplying the high voltage to the platform. Detailed information is given in ref.1.

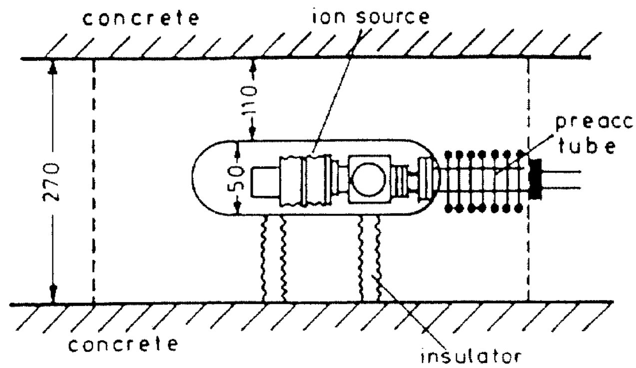

Fig. 1: Side view of the injector. Dotted lines represent the Faraday cage.

The platform power supply. A motor-generator system is used for the power supply at platform potential. The arrangement is shown in fig. 2. An asynchronous motor drives a three-phase generator with a total output power of 10 kW. The torque of the motor is transmitted to the generator by a dynamically balanced insulating pipe with an outside diameter of 30 cm.

The cooling system. Because of the low current load capability of the disktron (2 mA) a freon cooling system, situated on ground potential, is used. The cooling capacity is about 4–6 kW. In order to have the possibility of frequent openings which are needed due to source maintenance, we have installed a secondary cooling system. This cooling system uses a demineralized water-glycol mix. The heat exchanger to the freon system is placed on the platform.

The preacceleration tube. The preacceleration tube is a 400 kV Dowlish tube with deeply dished aluminum electrodes. The resistor chain along the electrodes can be adjusted to meet the drain current demands. Each third electrode is equipped with a corona ring.

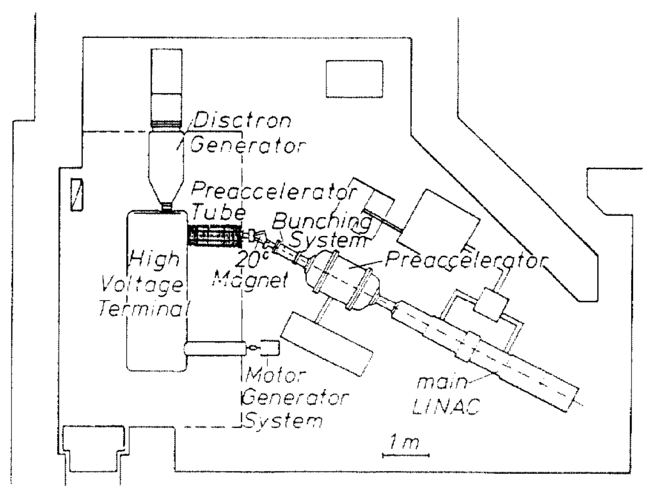

Fig. 2: Top view of the whole accelerator system.

[1] A. Isoya, Y. Miyake, K. Takagi, T. Uchiyama, K. Yui, R. Kikuchi, S. Komiya and C. Hayashi: Nucl. Instr. Meth., B 6, 1985, 250-257

[2] Gesellschaft für Schwerionenforschung in Darmstadt

The control supplies. In order to operate the power supplies we use a fibre optic system. The fibres directly connect the control system at ground potential with the appropriate power supplies at platform potential.

First Results

The high voltage behavior of the injector is very stable with no occurrence of corona or sparking up to a voltage of 380 kV. The fibre optic system for control of the source ran without failure. The motor-generator power supply and the freon-destilled water cooling system has performed very well. During these tests we have accelerated a total beam of about 80 μA with the platform at 380 kV and source extraction potential of 20 kV. Minor problems occurred at ion currents in excess of about 100 μA. As the disktron is a constant current machine, source instabilities leed to voltage fluctuations of the platform. An improved stabilizing system should however overcome this.

Acknowledgements

We would like to thank Dr. N. Angert and Dr. M. Müller of GSI for leaving us the duoplasmatron. We would also like to acknowledge the skilfull help of several talented students who were also involved in construction of the injector system.

References

[1] A. Isoya, Y. Miyake, K. Takagi, T. Uchiyama, K. Yui, R. Kikuchi, S. Komiya and C. Hayashi: Nucl. Instr. Meth., B 6, 1985, 250-257