Progress in H^- Ion Source Development at TAC*

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Abstract

A program has been started at the Texas Accelerator Center to develop H^- ion sources for its 500 keV RFQ program. The group is working on both magnetron and volume ion sources. A tilted extraction system has been designed for the magnetron source which corrected a 25 mrad angular offset in the extracted beam. An LBL type volume H^- ion source has been designed and constructed. To date, the plasma generator of the source has been tested, with extracted beam tests beginning during Summer 1991.

I. INTRODUCTION

The linac program at the Texas Accelerator Center (TAC) has been centered on developing an RFQ as a preinjector for the SSC. To support the RFQ program, a parallel ion source development program had been started. The first ion source built at TAC was a magnetron H^- ion source. Within the past year, a volume H^- ion source program has been started. Both of these ion source development programs are aimed at providing H^- currents of up to 50 mA for the TAC RFQ.

II. MAGNETRON DEVELOPMENT

A BNL[1] type magnetron H^- ion source has been built at TAC as a part of a project to construct a 500 keV RFQ accelerator[2]. The design and performance of this source have been previously reported[3]. The source regularly achieves 10 mA of H^- current within a normalized emittance of 0.29 π mm–mrad, horizontal, and 0.36 π mm–mrad, vertical. The emission current density is routinely 1.3 A/cm^2 or better. There has been a continuing effort to refine individual components of the system, particularly the cesium transfer line and the extraction system.

The cesium system has been generally designed following the BNL example: an external cesium boiler and vacuum insulated transfer line entering the back of the source body. Several modifications are currently being developed for the system. First, the cesium boiler is connected to the valve by means of an EVAC[4] CF fitting instead of the Mini-conflat which is typically used. These fittings use a clamping chain and conflat type flange to make the seal, and will simplify the process of making a connection inside a glove bag. The second development is to remove the axial heater from the transfer line and place it in direct thermal contact with the outside of the transfer line. A vacuum insulating jacket surrounds the transfer line back to the elbow.

Magnetron ion sources use an externally generated magnetic field to confine the discharge plasma to the gap between the anode and cathode. Unfortunately, the magnetic field extends far beyond the plasma generator into the extraction gap. This field causes the beam to deflect upwards during extraction. A 30 keV beam of H^- ions was deflected upwards by 25 mrad during extraction across a 4.5 mm gap[3]. Usually this deflection causes few problems when the beam is injected into a large aperture beam transport line; however, when it is injected into the TAC Helical Electrostatic Quadrupole (HESQ) lens[5], the deflection causes the beam to impact on the electrodes along the length of the lens.

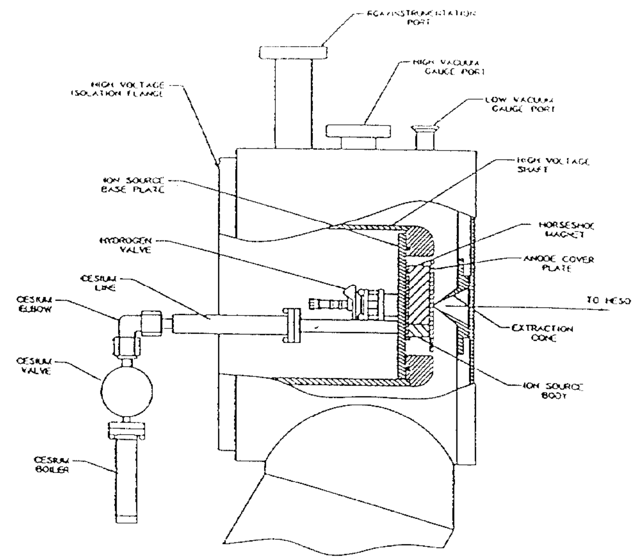

Figure 1. Original TAC magnetron ion source geometry from Ref 6.

A new extraction system was designed and constructed which corrected the trajectory of the ion beam. Figure 1 shows the old extraction geometry. In the modified system, the high voltage isolation flange, which holds the re-entrant high voltage shaft and source mounting flange, and the extraction cone were tilted upwards by

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25 mrad while still maintaining the same extraction gap geometry. The emittance of the beam was remeasured after installation. It showed that the beam was now travelling in a direction parallel to the center of the center of the beam line.

III. VOLUME SOURCE DEVELOPMENT

Volume ion sources are becoming increasingly wide spread as H^- ion sources for accelerators. The lower ion temperature can result in significantly smaller emittances than those obtained from magnetron ion sources, making them attractive for low emittance accelerator systems. Within the past year the ion source group at TAC has initiated a two phase volume ion source development program aimed towards developing a volume H^- source for the TAC 500 keV RFQ. Phase 1 is to build a LBL type multicusp volume H^- ion source[7] to gain basic experience with volume sources. Phase 2, starting during Summer 1991, will be to develop a compact toroidal volume source[8] to supply 10 mA of H^- to the 500 keV RFQ. The toroidal geometry was chosen for the final source geometry since it is capable of producing an electron-to-H^- density on the order of 2–5[9], thereby simplifying a pulsed extractor system by reducing the capacitance and switching currents needed to drive the electrodes.

The Phase 1 TAC volume ion source is a small LBL type source. The entire source is constructed modularly to provide an easy means of testing differentc source configurations. The plasma generator is a copper cylinder with an inside diameter of 7.6 cm and a total length of 11.5 cm. Twelve 7.6 cm long longitudinal rows of Sm-Co magnets form the plasma confinement field. The magnetic field at the surface of the copper has 1.0 kG. The back flange of the ion source is magnetically insulated with line cusps. A tungsten filament and PFN are used to drive the discharge. Two filter magnets are used to provide the magnetic filter. The separation between the magnets is 3.8 cm resulting in a magnetic field of 300 G in the center, and a surface field of 1 kG. Water cooling is used to protect the filter and longitudinal cusp magnets.

Initial testing of the plasma generator is underway at this time. Figure 2 shows the I–V characteristic of the measured at a pressure of 27 microns. The discharge power was varied from 0.7–29 kW. H^- yield was not determined. The filament was heated by a DC current which was not interupted during the plasma pulse. The characteristic curve appears to quite linear over the entire range. The pressure was varied on either side of 27 microns, and we had observed a substantial decrease in arc current at all voltages when compared to the 27 micron data.

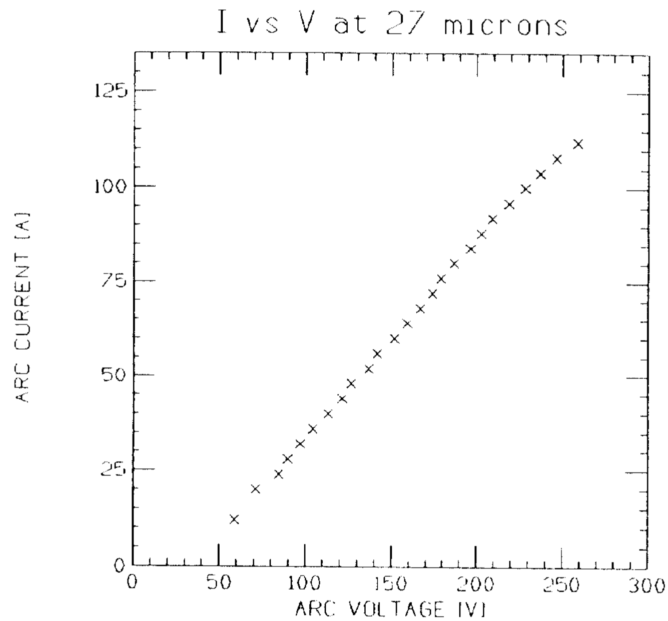

Figure 2. Characteristic curve of the plasma at a filling pressure of 27 microns.

IV. SUMMARY

The ion source development program at TAC has been actively involved in attempting to develop several ion sources. The magnetron program has reached its design goals and is undergoing engineering refinement. The volume source development at TAC is still in its beginning stages and is devoted to pursuing the toroidal volume source technology first developed at Brookhaven.

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VI. REFERENCES

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