

## MULTI-CHANNEL WATER STEAM $H^-$ SOURCE FOR INTERNAL INJECTION TO A CYCLOTRON

P. Kunznetsov, V. Parkhomchuk and G. Silvestrov

*Budker Institute of Nuclear Physics, Siberian Division of Russian Academy of Science (BINP RAS), Novosibirsk*

The  $H^-$  source is based on Penning discharge in water steam providing high concentration of  $H^-$  ions in the discharge channel. The source is a 20 mm diameter cylinder placed at the cyclotron center and has a number of small holes equal to the cyclotron sector number. The source design is described. Results of investigations of the source under various conditions and injection dynamics in a full-scale model of the three-sector cyclotron central part are presented.

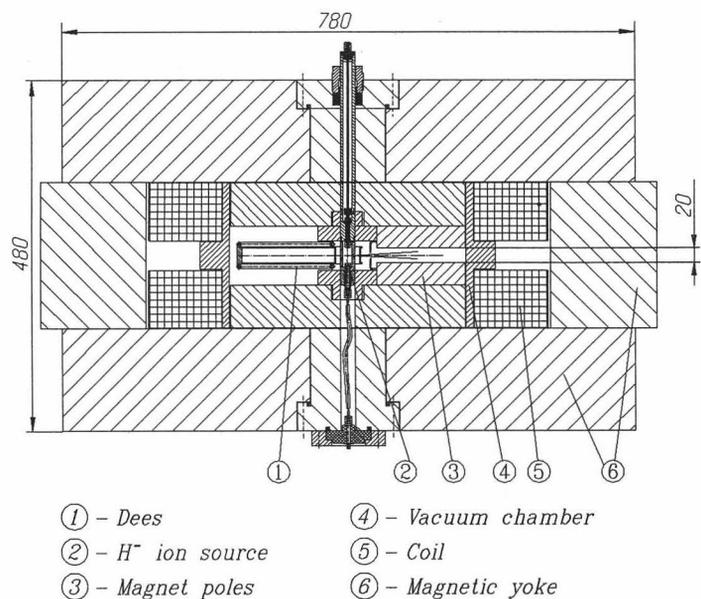
### INTRODUCTION

At present time there is a project of 12 MeV  $H^-$  cyclotron under development at BINP [1]. Two variants of injection into the cyclotron are under consideration : external injection and internal one. Internal version is more simple since it uses for ion generation internal cyclotron magnetic and electric fields and no needs for transport injection line. The water-steam  $H^-$  source has the following advantages in comparison with hydrogen one :

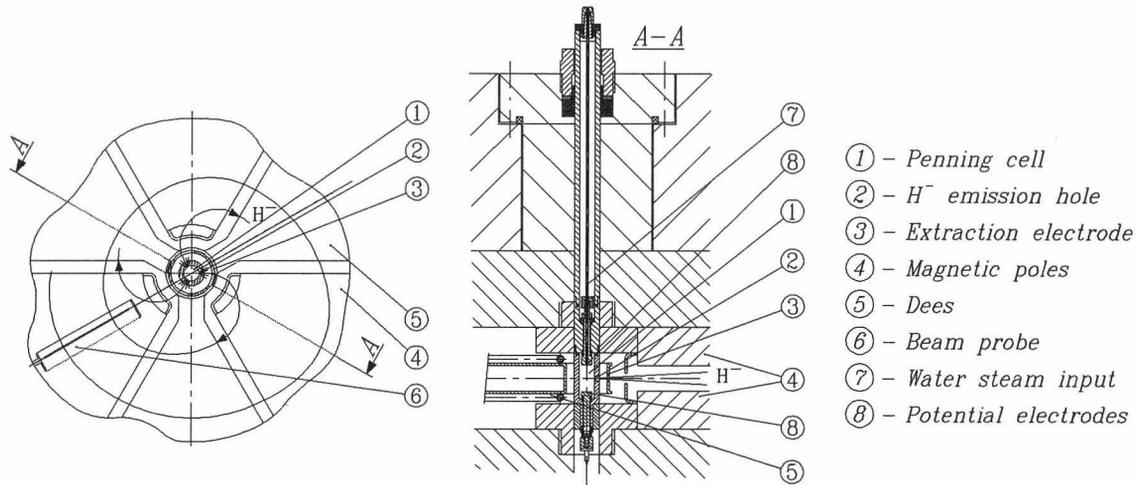
- The cross-section of  $H^-$  production ( $4.8 \cdot 10^{-18} \text{ cm}^2$ ) is by two orders higher then that with  $H_2$  molecules [2]
- The products of discharge in water steam form dielectric cover on aluminium electrodes outside discharge region thus increasing electric firmness of the electrodes. On the contrary, the products of discharge in hydrogen cause erosion of electrodes, reducing electric firmness and the source life time [3], see also Figure 4.

### SOURCE CONSTRUCTION

The source is a Penning cell of cylindrical geometry (20 mm diameter, all electrodes are made of aluminium) which will be placed at center of three-sector cyclotron. At present time a full-scale model of three-sector cyclotron was designed and produced to investigate the system of internal injection. General cross-section of the model is shown in Figure 1, more detailed views are presented in Figure 2. The source has three (one in each sector) emission holes of 1 mm diameter and uses for ion extraction dees voltage.



**Figure 1** : Full-scale model of cyclotron central part with water-steam  $H^-$  source.



**Figure 2 :** Horizontal and vertical cross-sections of the cyclotron model center with internal water-steam  $H^-$  ion source.

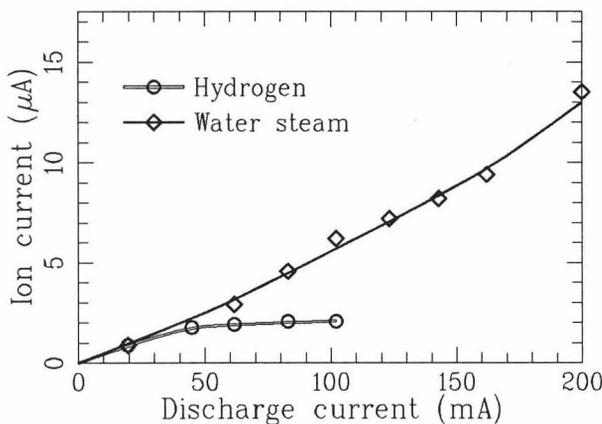
**The designed parameters of the source :**

Extraction voltage (amplitude value of RF voltage)	30 kV
Pulse discharge current	10 A
Discharge current pulse duration	1÷2 msec
Ion current (from each hole)	500 $\mu A$

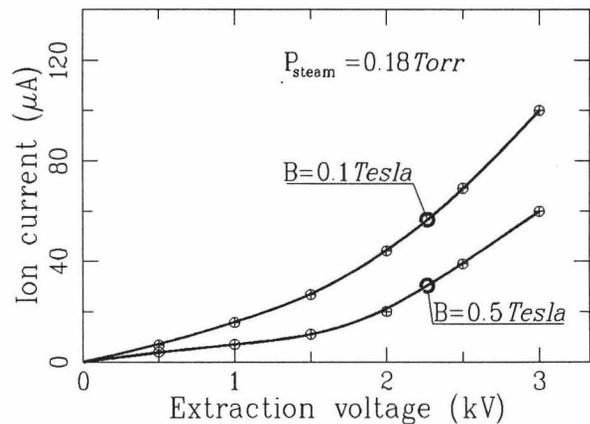
**EXPERIMENTAL RESULTS**

The first stage of the source investigation was carried out with one emission hole in continuous mode using DC extraction voltage up to 4 kV, magnetic field and pressure in discharge chamber also was varied. The results of the investigation are as follows :

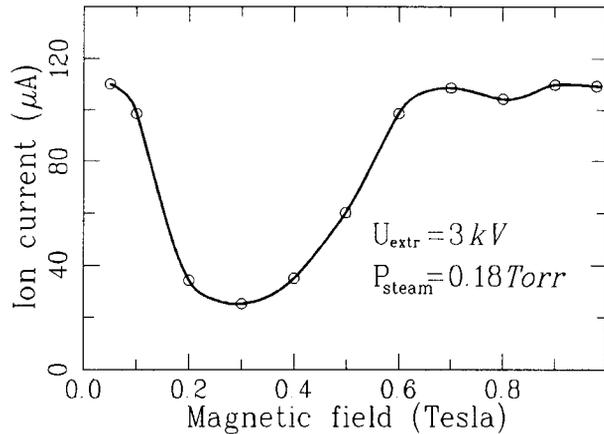
- The microperveance of the source is equal to 10÷20  $\mu A/kV^{3/2}$  (Figure 4)
- The ion current versus magnetic field is near constant with field higher then 0.6 Tesla (Figure 5). This result is very important in order to use the source for internal injection in cyclotron.
- The optimal pressure in discharge chamber is ~0.18 Torr (Figure 6)



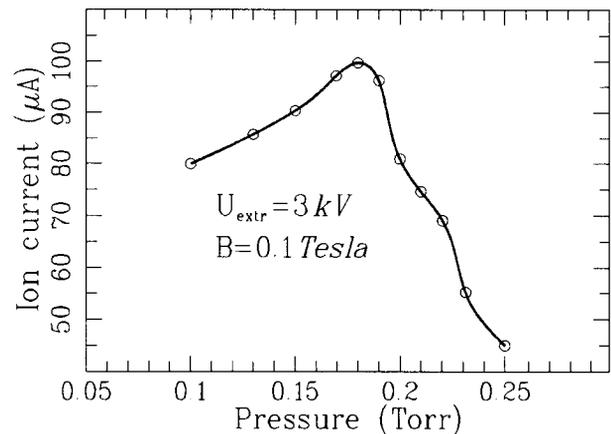
**Figure 3 :** Dependence of  $H^-$  ion current on the discharge current [Ref.3]



**Figure 4 :** Dependence of  $H^-$  ion current on extraction voltage.



**Figure 5 :** Dependence of  $H$  ion current on magnetic field.



**Figure 6 :** Dependence of  $H$  ion current on pressure in discharge chamber

In the second stage of the source investigation it was displaced in full-scale model of central part of three-sector cyclotron, dees was supplied by AC voltage.

**Measurements were carried out with the following conditions :**

Extraction voltage (amplitude value of RF voltage)	4 kV
Extraction voltage frequency	8.57 MHz
Magnetic field in the source region	0.4 Tesla
Pulse discharge current	15 A
Discharge current pulse duration	1 msec

For the beam observation a grid covered with luminophore was placed between magnetic poles. The grid size allows to observe two separate beam orbits. Beam current was measured by means of screened electrode located behind the grid.

There was obtained  $H$  ion current of 30  $\mu A$  from one hole under such conditions. Extrapolation to extraction voltage of 30 kV (designed value) gives the ion current value of 600  $\mu A$ , that meet to requirements on ion source for internal injection in cyclotron.

**REFERENCES**

- [1] V.Karasyuk, G.Kurkin, P.Kuznetsov et. al., *H Cyclotron for Charge-Exchange Injection into a Synchrotron* - this conference.
- [2] Harrie Massey, *"Negative ions"* - Cambridge University Press, London-New York-Melbourne, 1976.
- [3] V.Parkhomchuk, N.Kot, *Three-beam H water steam ion source* - PTE, n.1, 1985, p.34-36, Russia.