10 GHz ECRIS FOR WARSAW CYCLOTRON

K.Sudlitz, E.Kulczycka

Heavy Ion Laboratory, Warsaw University, Pasteura 5A, 02093 Warsaw, Poland

Abstract

Cusp type, 10 GHz ECRIS [1] [2] has been built and tested earlier. For obtaining intensive beams, more relevant for cyclotron, cusp geometry has been replaced by hexapole. Discharge chamber (stainless steel, 50 mm diameter, 250 mm long) is an extension of a coaxial line, feeding RF (9,6 GHz, up to 200 W) to the plasma. The NdFeB hexapole (0,52 T on the surface) has been used. The axial magnetic field is created by water cooled coils.

The axial injection line dedicated to K160 isochronous heavy ion cyclotron has been constructed. The line consists of Glaser lenses, double focusing magnet, solenoid and mirror type inflector. The system provides sufficient transmission of the beam from ECR ion source to the firsts orbits of the cyclotron for m/q ranging from 7 to 2. After successful initial tests which were done in July 1997 the ECRIS serves as an external source for Warsaw Cyclotron.

Ion source.

For obtaining relevant beam for cyclotron a small ECR ion source has been built (Fig.1). ECR discharge take place in the stainless steel chamber, 50 mm inner diameter, 250 mm long. This chamber is an extension of a coaxial line, feeding RF to the plasma, similarly to Nanogan [3]. The magnetic confinement of the plasma in radial direction is obtained by the hexapol surrounding the chamber (0,52 T on the surface).The hexapol consists of 12 segments made of NdFeB permanent magnets [4]. Trough the 1mm gap between the hexapol and the chamber tube a cooling oil is pumped. The axial magnetic field is created by 8 water cooled coils. Each two coils are supplied with a current from separate power supply. This configuration allows to obtain relevant magnetic profile, tuned for the maximum of a beam current.

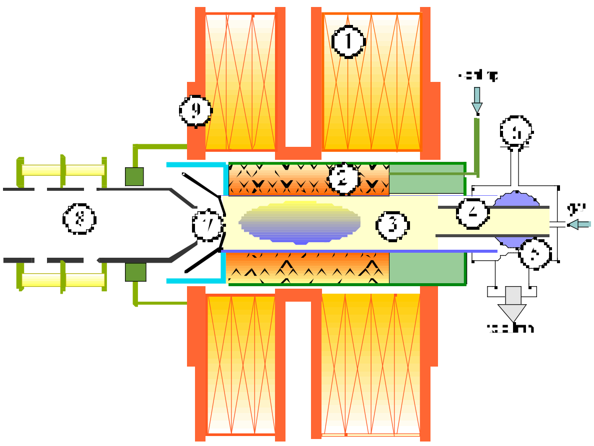

Fig. 1. ECR ion source.
1. coils 2. hexapol 3. plasma chamber 4. coaxial line 5. tuner 6. RF injection 7. exit hole 8. Einzel lens 9. yoke

Injection line.

The injection line (Fig.2) has been designed with minimum number of optical elements. Only axial symmetry elements , Glaser lenses and solenoid, are used [5] [6].

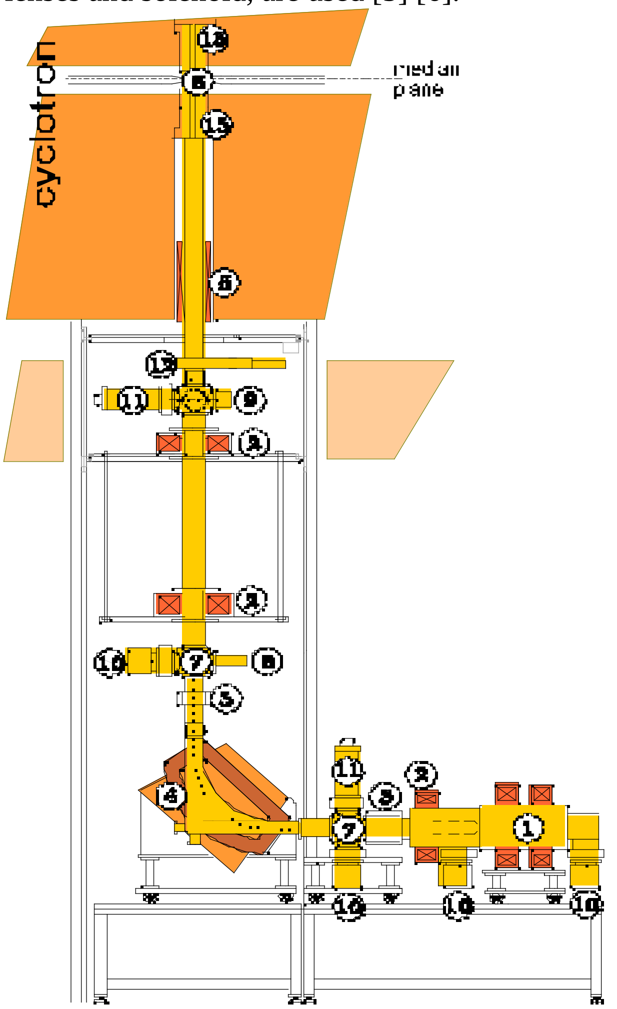

Fig. 2 The injection line.
1. ECR ion source 2. Glaser lenses 3. steering coils 4. analysing magnet 5. solenoid 6. inflector 7. slits 8. Faraday cup 9. wire detector 10. turbomolecular pumps 11. cryogenic pumps 12. main valve 13. plugs

The first order calculation have been done using TRANSPORT and POISSON code for the beam with the emmitance of 300 mm mrad and m/q ranging from 8 to 2.
The injection line is about 6 m. long. The ion beam created in the source is focused by both Einzel and magnetic lenses on entrance slit of the 90_ magnet. The magnet plays the role of bending and analysing element. The bent beam is directed trough two Glaser lenses (3-4,5 and 2 kGs) to the magnetic channel in the yoke of the cyclotron's magnet. A magnetic field in the channel is tuned by solenoid (1,3 kGs) and passive magnetic elements. In the median plane of the cyclotron the beam is strongly focused by this field on the inflector (beam diameter approximately 3 mm).
To decrease and compensate the influence of a stray magnetic field (50-800 Gs) the ion guides are made from magnetic steel and two sets of steering coils and one moved correcting coil (under the cyclotron magnet) are used.
The vacuum system of the line, consisting of two cryogenic (400 l/s) and four turbomolecular pumps (240 l/s), provides an operating pressure 10^{-7} Torr.
All mechanical elements of the line, apart from analysing magnet (Danfysik), have been made in the HIL workshop.

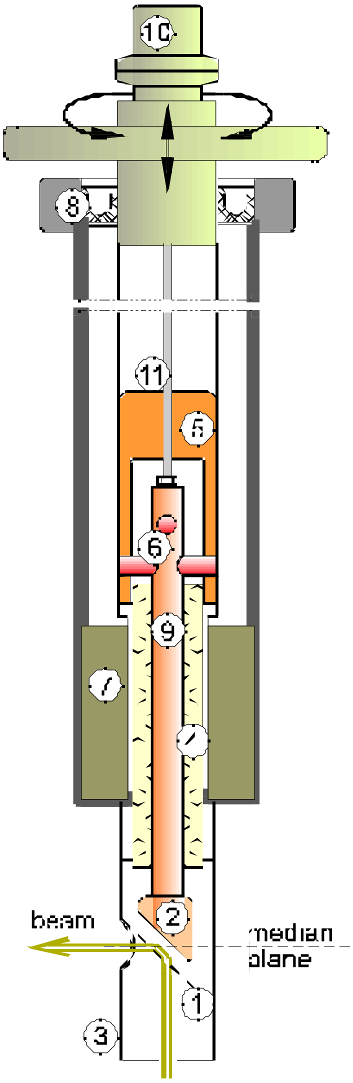

Fig.3 Inflector
1. grid 2. electrode 3. shield 4. BN insulator 5. radiator 6. ruby insulator 7. plug 8. seal 9. rod 10. lead-in 11. conductor

<u>Centre region.</u>

For the beginning the gridded electrostatic mirror [7] has been used for inflection of the beam (Fig.3). The mirror consists of the electrode inclined at about 45_ with respect to median plane and the grounded grid, parallel to the electrode. The best results has been obtained when the voltage on the electrode was about 7 kV and distance between electrode and grid was about 3 mm. For tuning, the inflector is movable (2,5 mm up and down) and rotational. After leaving the mirror the beam enters the housing of the inflector, placed in the centre of the cyclotron (Fig.4) The housing, together with the dee insert (puller), plays the role of the electrostatic lens.
The spiral inflector is planned to be used later.

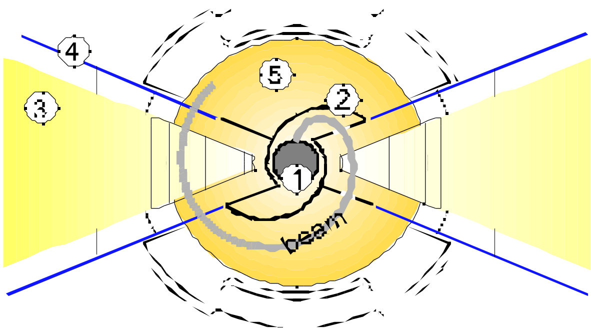

Fig.4 Centre region
1. inflector 2. housing 3. dees 4. counterdees 5. plug

Results.

	+3	+4	+5	+6	+7	+8	+9	+10
C		**55**	**6**					
N	**100**	**85**	**65**					
O	**130**	**150**	**85**	**32**	**10**			
F	**65**	**75**	**47**	**22**	**10**	**2**		
Ne	**120**	**115**	**70**	**22**	**8**	**2**		
S			**50**		**60**	**30**	**10**	**4**

	+6	+7	+8	+9	+10	+11	+12	+13
Ar	**70**	**65**	**58**	**15**		**5**		
Kr		**30**	**32**	**27**	**20**	**14**		**4**

Tab.1. Ion beams currents in e_A.

Above currents were measured on the Faraday cup (see Fig.2, item 8). Transmission between the Faraday cup and the inflector is about 85%.

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