STATUS REPORT OF THE COMPACT CYCLOTRON C-30 FOR MEDICAL ISOTOPES PRODUCTION

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The present state of the C-30 INS cyclotron installation is given. Details of iron shiming, preliminary test results of internal ion source are discussed.

The C-30 INS cyclotron described in papers[1,2] is in the course of assembling in the shielded vault. Figure 1 shows the electromagnet during assembling.

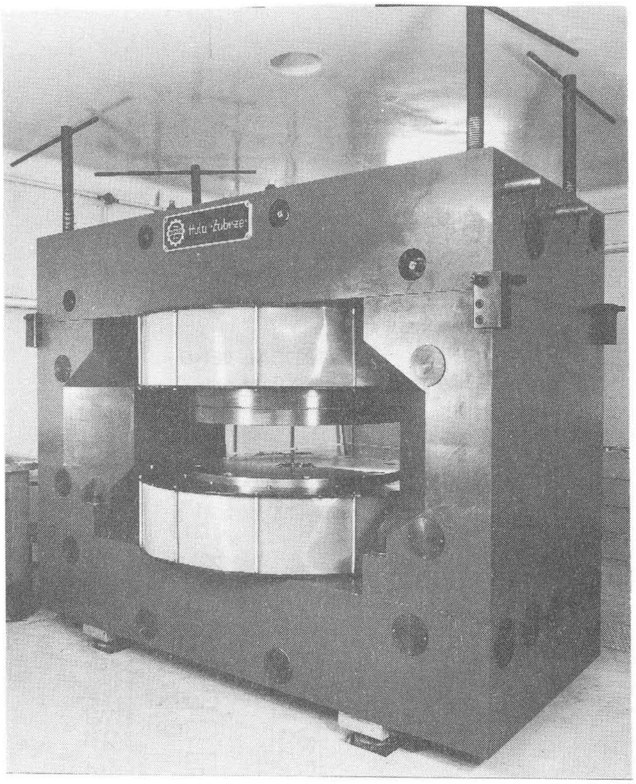


Fig. 1. The C-30 electromagnet with all sectors and the bottom pole face removed for corrections.The hole in the ceiling was drilled for the axial injection system.

The main procedure upon the magnetic structure involves the correction of hill profiles in order to get the isochronous fields for H^- and D^- particles at slightly different field levels /in the center 1.743T and 1.765T respectively/ without any correcting coils. The saturation effect in the sectors, where the magnetic field reaches 2.5 T, leads to the field redistribution by these two levels of excitation. However, the appropriate isochronous fields for H^- and D^- particles can only be found by an iterative procedure in sector profiles precise machining. The first profile determined by model measurements, shown in Fig. 2, is not accurate enough. The lathe and machining errors reach 0.1 mm at different radii, although all sectors were cut from one plate. To correct these errors it was decided to cut in the sectors radial grooves and to put iron trims, after each field measurement. The preparations are going on to determine the sizes of grooves. It is hoped, that this procedure together with additional shims in the 5 mm gaps between the sectors and pole faces will result in the sufficient mean field accuracy better than 10 Gs.

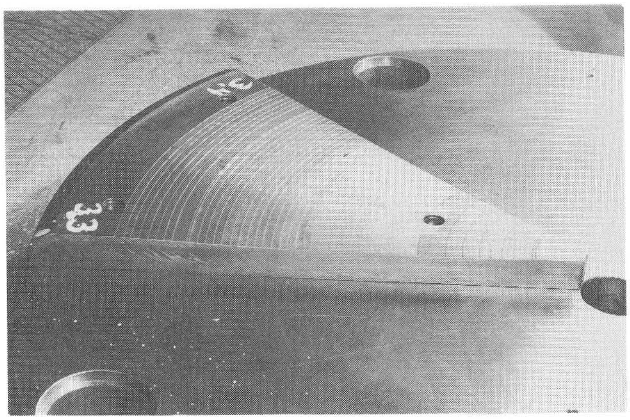


Fig. 2. One of the sectors dismantled on the bottom pole face. The step-profile before any corrections can be seen. The outer sector edge is Rogowski shaped.

The accelerating system is close to be completed according to the results of full scale model measurements. The fixed freguency system resonates in the range of 53-54 MHz tuned by two inductive loops of the size about $50 \times 150\ mm^2$ turned around their axes by 90 degrees. The loops are placed near the end walls of the rectangular resonators above the square stems of dees. The two 45 degrees dees are bridged in the center. This system permits to run at harmonics 2 /H^-/ and 4/D^-/ using only one RF coupling loop.

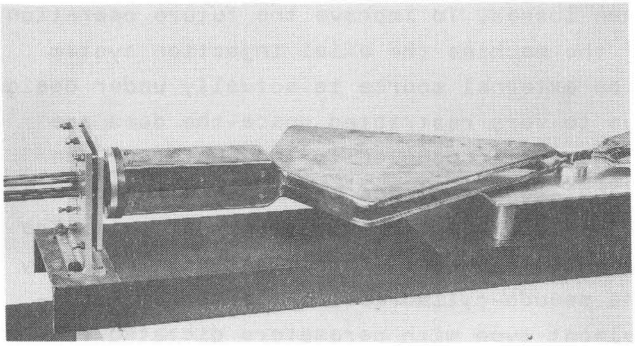


Fig. 3. The dee on an assembling bank.

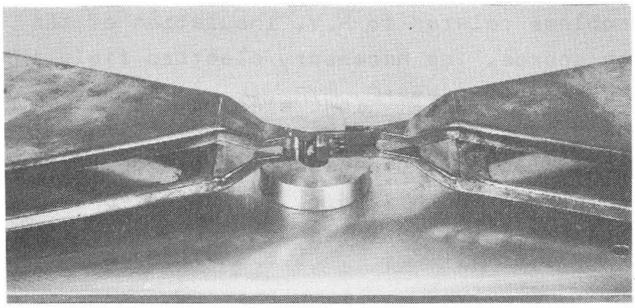


Fig. 4. The shorting bridge connecting the two dees. The bridge carries the puller, in this case the puller for harmonic mode 2.

The prospect of the C-30 INS cyclotron is to run with an external ion source and an appropriate axial injection system to avoid vacuum problems in the small gap design. This system is under developement / goal 1988 /. For this reason an internal ion source was designed and built and recently tested /september 1986/, Fig. 5.

The new built H^- PIG-type was designed mainly from the low-gas consumption point of view. The design of the source and the test arrangement are shown in Fig. 6.

The test of this ion souce was performed using the test stand of the Heavy Ions Laboratory at Warsaw University[3]. The stand consists of an electromagnet with 90 cm pole diameter and 10 cm gap, capable to achieve magnetic field up to 1.6 T, and of suitable measuring equipement. The ion source is installed inside a vacuum chamber located in the electromagnet gap. The pressure $5 \cdot 10^{-7}$ Torr in the vacuum chamber was achieved by a 6000 l/s diffusion pump.

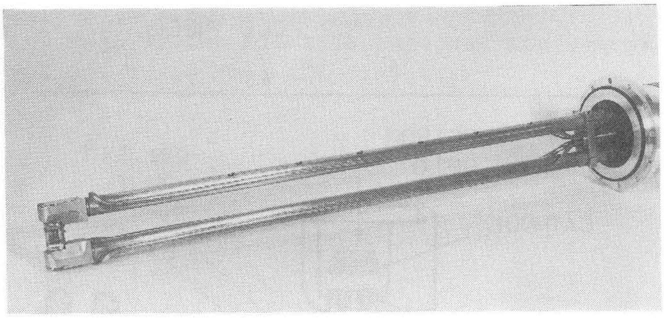
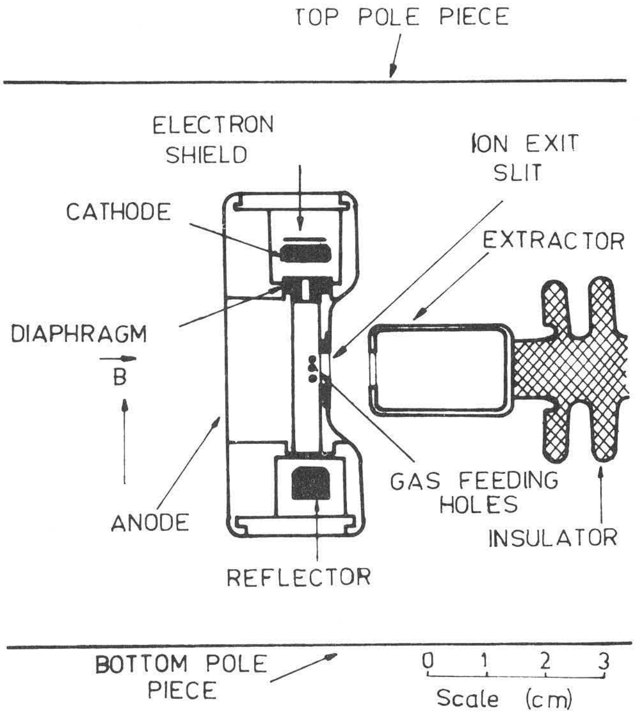


Fig. 5. The PIG-type internal ion source for the first C-30 configuration.

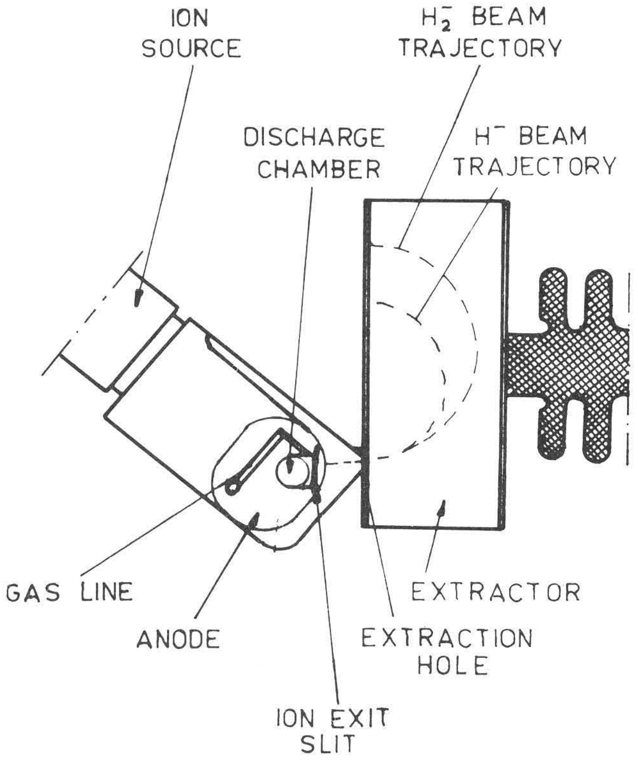
The design of this ion source is similar to the cold cathode ion source previously developed by Ehlers[4]. The ion source consists of a tantalum arc diaphragm 2.5 mm in diameter located on the top of the copper anode cylinder of 5 mm diameter. The gas feed line is connected to the anode by three 1 mm diam. holes. The ion exit slit 0.5x6 mm have been milled in a 1 mm thick tantalum sheet insert. The anode is hold by two copper blocks which are tap-water cood by external water lines electrically insulated. The cold tantalum cathode is located at the top of the anode and at the bottom of the anode is placed the tantalum anticathode. Both cathode and anticathode are maintained at the same potential. The cathode and anticathode are specially shaped to keep a thermal balance between heat conductive losses and stable cathode temperature.

During the first test of the ion source a total negative ion current 50 μA was obtained. The source was operated at an arc current of 20 mA and arc voltage of 2000V The magnetic field during operation was 1.23 T and an extracting potential of 11 kV was applied. At above conditions the gas flow rate was about 0.8 cm^3/min and the pressure in the vacuum chamber $2 \cdot 10^{-6}$ Torr.

Since the gap in our cyclotron is relatively small the vacuum pumping of the central part is limited to value not



SIDE VIEW



PLAN VIEW

Fig. 6. Experimental arrangement for the preliminary measurements of the extraction current H^- and H_2^-.

exceeding 1500 l/s. In the operation with the internal source reported above, the processes involving charge transfer, radiative capture and collisional detachment will lead to H^- beam losses. To improve the future operation of the machine the axial injection system from external source is actually under design. Due to very restricted space-the dees are mechanically coupled in the center of the magnet-we are forced to displace the axis of injection from the axis of magnet pole. The beam is to be guided to the median plane by the pseudo-cylindrical inflector of Pabot-Belmont type with parameters dictated by nominal magnetic field fixed at 1.74 T and space available in the center. The feasible solution which we have got gives $R_{magn}=1.1$cm and $R_{el.}=1.32$ cm corresponding to 17.6 keV injection energy of H^- ions. This last value is sufficiently high for good beam handling and does not create serious technological problems related to H.V. insulation of the ion source. The necessary electric field in the inflector $E=2\cdot E_{inj}/R_{electr.}=26,8$ kV/cm which is also admissible. The position of the inflector and necessary modification of center are shown in Fig. 7. The off-axis displacement is

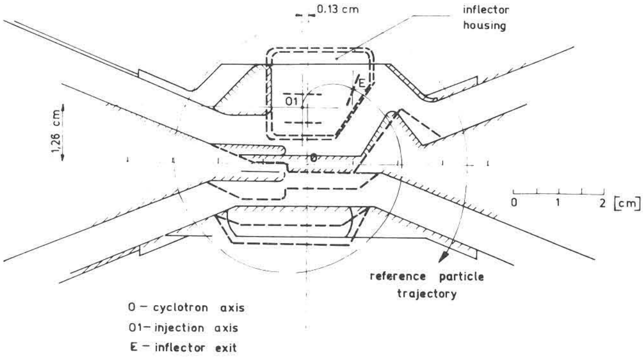


Fig. 7. Central region configuration of the C-30 cyclotron. Already existing parts are shown in continous line; axial injection modification in dashed line.

equal to r=1.27 cm. We are encouraged to adopt this solution by succesfull operation of GANIL injector cyclotron[5] emploing off--axis injection. The beam envelopes in the axial hole of the magnet down to the inflector entrance were computed using the

TRANSPORT Code and necessary data concerning magnetic field were derived using POISSON /TRIM/ Codes. The results for nominal value of B_c=1.74 T are illustrated in Fig. 8. To arrive to good focusing it is sufficient to use one additional solenoidal lens with $l_{mech.}$=17.5 cm and 18000 Amper·turns max /B= 0.12 T/. These results will be verified by the measurement of magnetic field distribution in the axial hole and if necessary suitable corrections will be introduced. The vacuum pipe in the axial hole will have 5.4 cm inner diameter which should guarantee the pressure below $1\cdot10^{-5}$ Torr under the most unfavorable conditions. To allow for the correction of beam axis, two small steering coils will be installed between the solenoidal lens and the central plug.

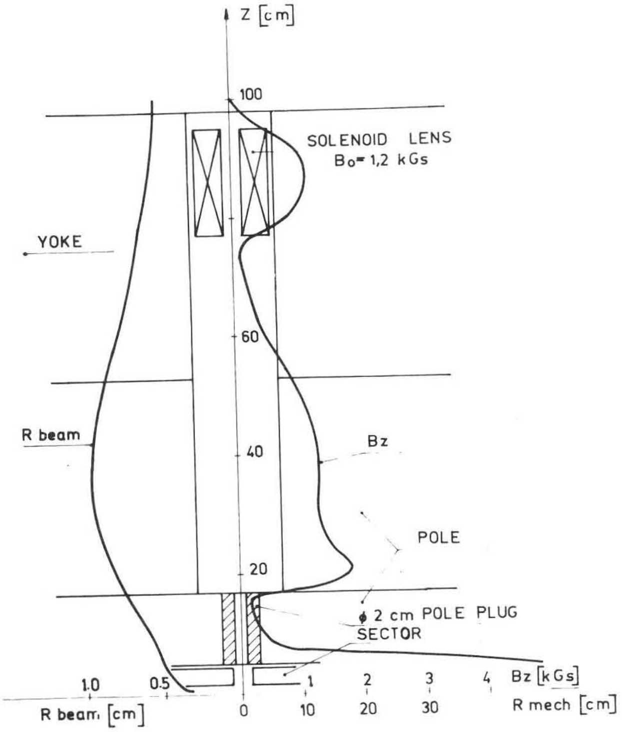


Fig. 8. The calculated magnetic field distribution and H^- 17.6 keV beam envelope in axial hole of the cyclotron.

The rest of the system is standard. It consists of 90° analysing double focusing magnet of 30 cm radius bending the horizontal beam in the ion source room vertically into cyclotron axis. The 1 m thick heavy concrete ceiling separating the cyclotron vault from the ion source room makes this last radiation free. The 25 cm diameter hole in it cut right on the axis of cyclotron accomodates the set of four magnetic uncooled guadrupoles for emitance adaptation to the cyclotron acceptance. The overall length of the axial injection system will be about 4.6 m. Two oil diffusion pumps 800 l/s will be used to keep the vacuum on the 10^{-6} Torr level.

The overall layout of the system is shown in Fig. 9.

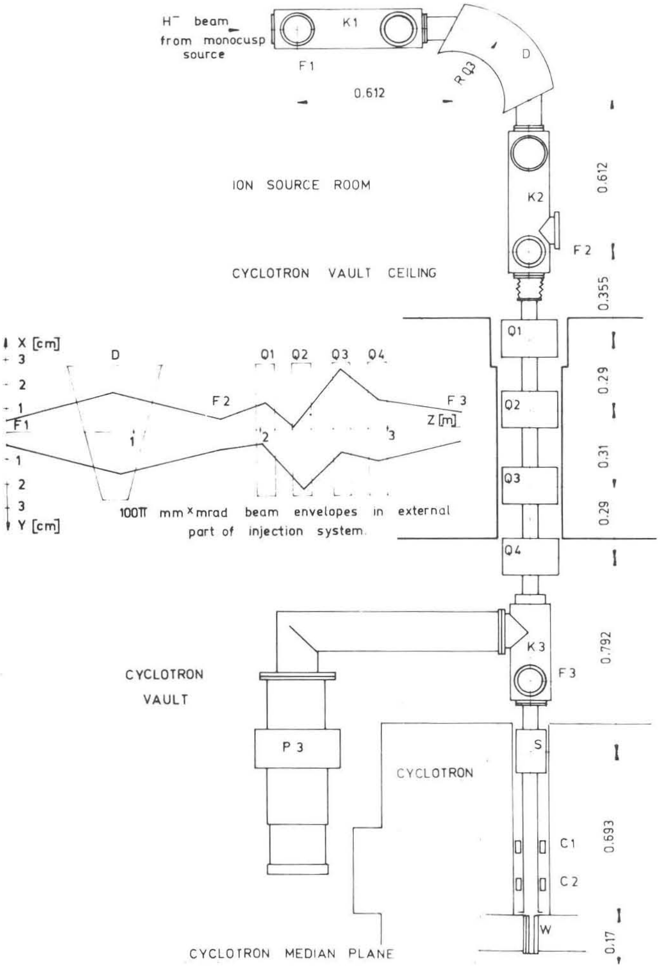


Fig. 9. General lay-out of injection from external source. K1-K3-beam diagnostic boxes, D-analysing magnet, Q1-Q4-matching magnetic quadrupoles, S-focusing solenoid, C1-C2-steering coils, W-central plug.

References.

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