# MAGNETIC EXTRACTION CHANNELS FOR 1ST RING CYCLOTRON

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## ABSTRACT

The extraction system was designed to extract the accelerated beam completely without deterioration of optical properties of beams and to match the optical condition for the beam transport system to the next accelerator or experimental facilities. Two magnetic extraction channels were designed and their magnetic field strength was calculated.

## EXTRACTION SYSTEM

Extraction elements and their positions were determined by the orbit analysis for 300 MeV protons[1]. The 1st ring cyclotron and the extraction elements are shown in Fig. 1. The 300 MeV proton beams can be

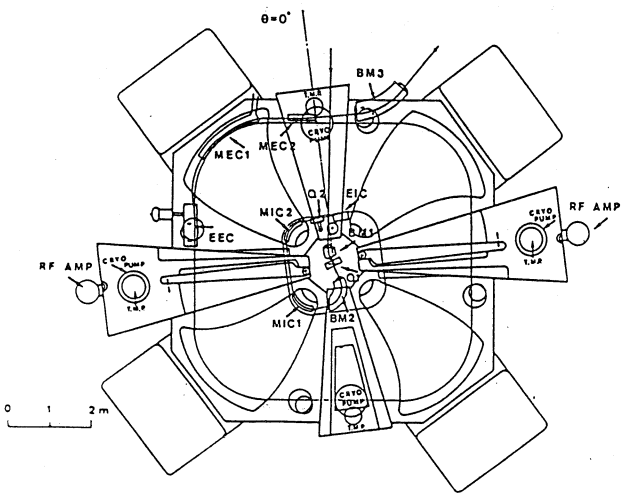



Fig.1 Layout of the first ring cyclotron

extracted in single turn mode through an electrostatic extraction channel (EEC) and a magnetic extraction channel (MEC-1) with very high extraction efficiency (100%) as shwon in Fig. 2. The elements of the extraction system are closely arranged in a quarter section of the ring as shown in Fig. 1 since the radial betatron frequency becomes near to 2 on the outermost radius for the acceleration of 300 MeV protons. Fig. 3 shows radial phase ellipses for various azimuth on the final orbit and the position of EEC is most profitable in this azimuthal position. After EEC1, magnetic extraction channel (MEC-1) is placed into a sector magnet gap.

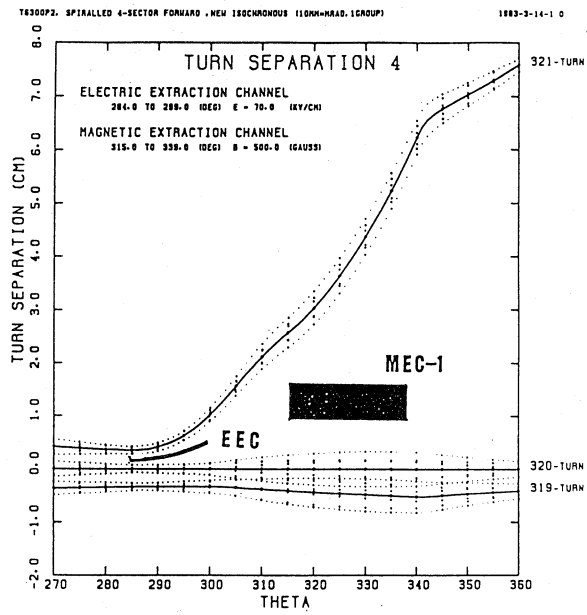



Fig. 2 Radial extent of the beams on the extraction region

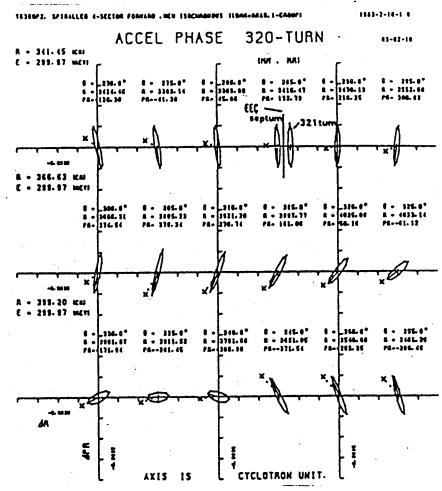
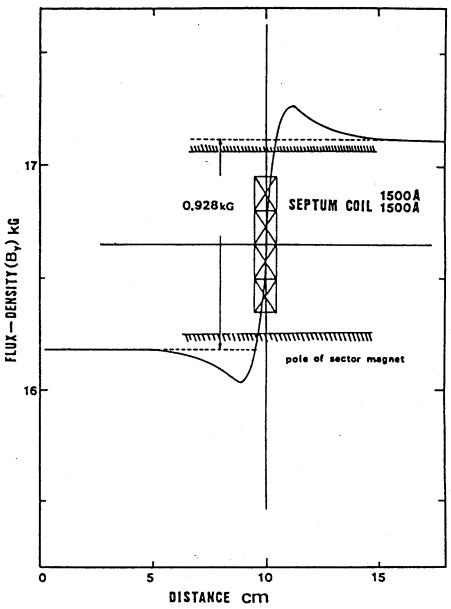



Fig. 3 Radial phase ellipses for various azimuth on the final orbit

## MEC-1 FIELD COMPUTATION

As shown in Fig. 2, the required magnetic field is -500 gauss (- means the magnetic field opposite to the sector magnet field). The magnet which produces its maximum field of -900 gauss has been calculated with the computor code TRIM. Four turns coil carrying 1500A makes about -900 gauss inside the MEC-1 but it makes some disturbance arround the channel, especially near the septum coil. If the four turns coil carrys the same current of 1500A the difference between calculated magnetic field and the ideal step field becomes more the 150 gauss as shown in Fig. 4. This is mainly affected by the position of septum coil located at 14mm apart from the pole surface of the sector magnet. We calculated it by varing the current on each coil. If the outer coil carrys a larger current than middle, overshoot or undershoot can be reduced to 60 gauss.

Simultaneously we plot the magnetic field at 1cm from median plane and the disturbance is abour 90 gauss. Since these inhomogenieties in the magnetic extraction channel makes hurmful effect on the final beam orbit or extracted beam quality, the value must be reduced much more. Another method to reduce these disturbance is now calculating by applying trim coil located up and down the MEC-1. By this method the trim coil must carry the proper current for isochronous field superimposed with the required as for the magnetic extraction channel.




## MAGNETIC EXTRACTION CHANNEL 2

MEC-2 is the ellement which has the purpose of matching between the ring cyclotron and the transport system. It produce both a dipole field for bending and a quadrupole field for focusing. As shown in Fig. 1, MEC-2 is located in valley section between two sector magnets. The design value for two performances are 3 kgauss of dipole field and 0.5 kgauss/cm of quadrupole field.

## MAGNETIC FIELD COMPOTATION

As shown in Fig. 5, it consists of 4 turns coils, quadrupole current sheets and iron frame. The beam duct pass through between the dipole coils and the end of these coils and current sheet become a window frame type. Taking 3cm as the magnet gap of iron yoke, the magnetic motive force needs 7500 AT and the coil current is about 1900A. If we use 5mm 10mm rectangular cupper hollow conductor with 3mm diameter hole the current density is about 42 ampere/$mm^2$. Total power is about 7.7 kwatts. As for quadrupole, 0.5 kgauss/cm is generated by 3112a per face, the current density becomes 17.7ampere/$mm^2$. Since the MEC-2 must be set inside the vacuum chamber, to separate the coil apart from the vacuum and to fill the helium gas into the minute gaps between coils.

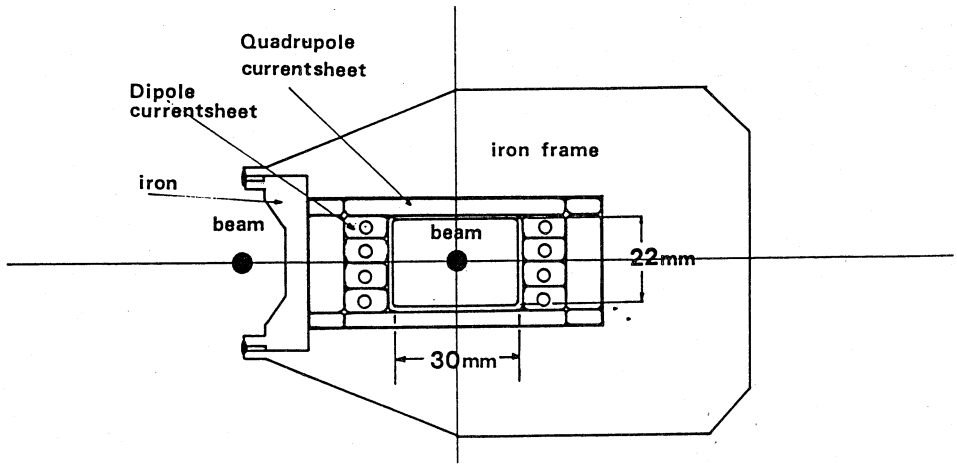



Fig. 5 MEC-2

## Reference

1. I. Miura et al., Proceedings of the 10th International Conf. on cyclotron and their applications, to be published.