MC32 MULTIPARTICLE NEGATIVE ION CYCLOTRON

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INTRODUCTION

The MC32 is a fixed field isochronous cyclotron for acceleration of negative ions currently under development as an isotope production machine. The design is based on the well established MC40 series of positive ion cyclotrons modified to accelerate H^- and D^-. The MC32 NI version utilizes an internal dual mode hot filament ion source while the MC32 NE is equipped with an external multi CUSP ion source capable of $>2\,\mu A$ d.c. output and uses axial injection to introduce the particles into the cyclotron.

Two beam ports are available 180 degrees apart allowing simultaneous extraction of two beams by means of the carbon stripping foil technique. With the internal source $100\,\mu A$ of protons from 15 to 32 MeV and deuterons from 8 to 15 MeV can be extracted. Otherwise the external source permits extraction of up to $500\,\mu A$ of each particle.

The MC32 operation is automated using a programmable logic controller which provides such functions as run programming, monitoring of interlocks and fault finding.

MAGNET

The rectangular magnet yoke allows convenient access to all cyclotron components. The pole gap varies from a minimum of 10 cm to a maximum of 18 cm which does not impose constrictions on system designs and provides good conductance for pumping vacuum. Four spiral shaped sectors are used to ensure 180^0 symmetry of the extracted beams. (Figure 1)

The main coils are wound from glass fibre insulated, hollow copper conductors cast in epoxy and are directly water cooled. To ensure the isochronicity conditions for H^- and D^- three concentric pole face windings provide the necessary radial gradient to the magnetic field. A set of harmonic coils are provided and serve to center the beam and vary the first harmonic content of the field. The harmonic coils are wired in such a manner that the amplitude and the azimuth of the first harmonic disturbance can be independently set.

Ion Sources

The MC32 can be equipped with either of two ion sources depending on the desired extracted beam current. In the case of the MC32NI version the ion source is of hot filament type featuring low gas consumption. The source is inserted vertically from the top of the magnet through an airlock system which enables anodes, cathodes and slits to be inspected or replaced without the need to break machine vacuum. The hot filament source will provide $> 100\,\mu A$ of extracted beam for both particles.

The high current version MC32NE uses an external multi CUSP source to permit beam currents of up to $500\,\mu A$ of each particle. The source provides $> 2\mu A$ d.c. output which is introduced into the cyclotron from below through an axial injection system. A bunching system will allow 30% of d.c. beam to be accelerated in the cyclotron. The spiral inflector in the central region is vertically inserted from above. The ion source system is equipped with an oil diffusion pump to minimize any influence on the main machine vacuum. (Figure 2)

Figure 1: As the regions of maximum yield and maximum electronic heating (maximum stopping power) are separated in space, there is an optimum length of containment where the density reduction is minimized without significantly affecting the yield.

by Henry Blosser and coworkers[6] has become an interesting alternative to d-T neutron generators. However, the dosimetric quality and operational reliability of this new device remain to be proven.

RFQs: radiofrequency quadrupoles are compact and powerful sources of charged particles.[35-37,45] Originally designed as injectors, RFQs are limited to low energies. This reduces the spectrum of applications to special cases of RP, like zero threshold nuclear reactions, e.g. $^{18}O(p,n)^{18}F$, $^{16}O(^{3}He,p)^{18}F$, $^{14}N(d,n)^{15}O$. The ^{3}He RFQ[45] is not able to deliver carrier- free ^{11}C and ^{15}O. The combination with a linac can compensate for the deficiency in energy but increases size and cost.

The TCA[44] represents as a light weight and relatively inexpensive device for PET radioisotope production. However, it has to be shown if enduring operation is as uncritical as compared to a small cyclotron.

The high brightness of linear accelerators has to be adapted to manageable power densities. The compensation of low energy by high beam currents, as stated, has its limitations in the quality of target design.

RFQs and TCA as well as the very small cyclotron cyclone-3D[43] may be useful for reducing load of a busy main accelerator and may have an important role as specialized secondary radionuclide production systems.

SUMMARY AND CONCLUSIONS

In general, high current low energy accelerators deliver surplus beam power in view of most of today's local needs within a research or hospital setting. The demands of commercial radionuclide production for proton beam currents higher than 300 μA will soon be met by H^- cyclotrons.

The crucial point in compensating low energies by high beam currents is the suitable design of targetry to withstand the high loads. Extending the beam spot decreases power density and helps to preserve long term reliable operation so necessary for all clinical or commercial applications.

New types of compact accelerators will become effective only in combination with intelligent design of specialized target systems and, of course, if they are competitive with respect to dimensions and weight as well as costs both for purchase and operation.

REFERENCES

(ARI = Int.J.Applied Radiation and Isotopes)

1. Lambrecht RA, Sajjad M, 1988: ARI 39, 1081-1083

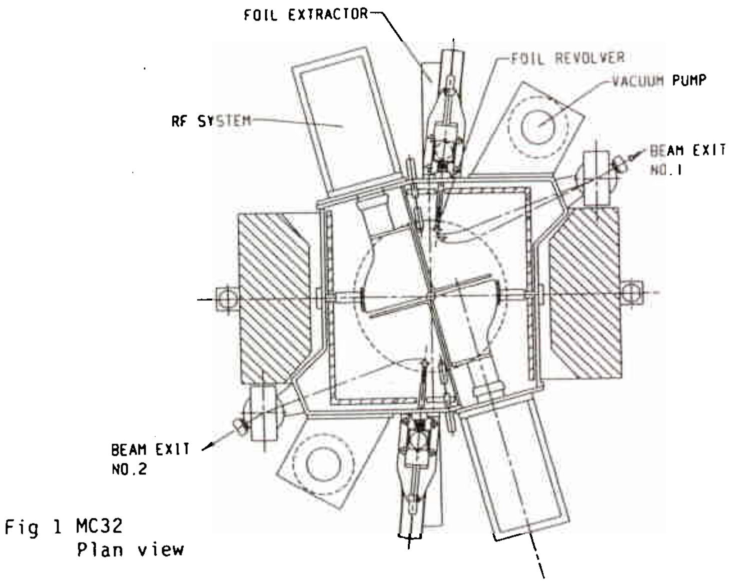

Figure 1 MC32 Plan View

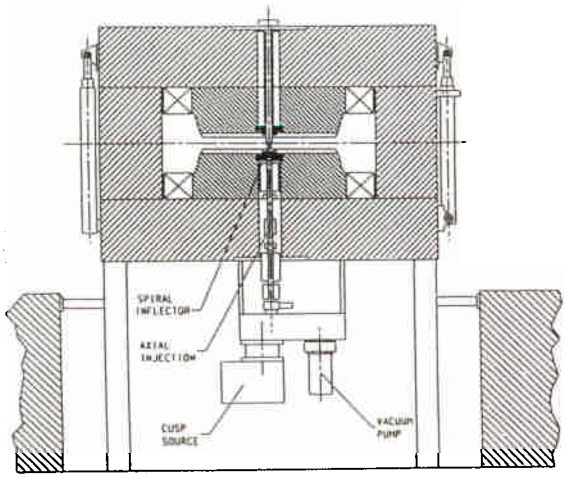

Figure 2 MC32 Side View

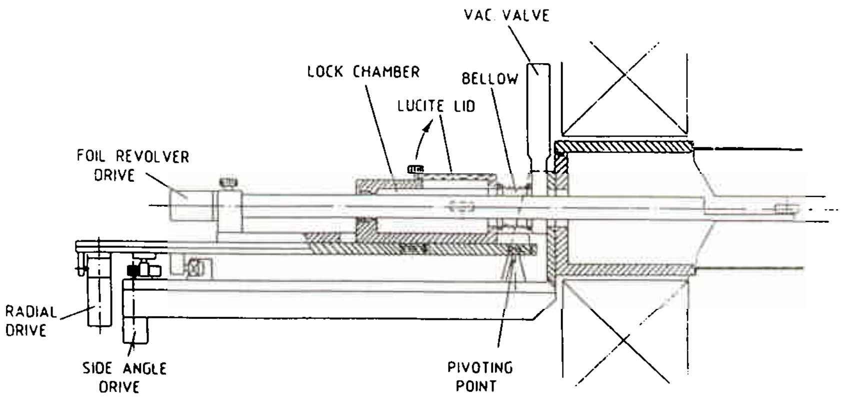

Figure 3 Extraction System

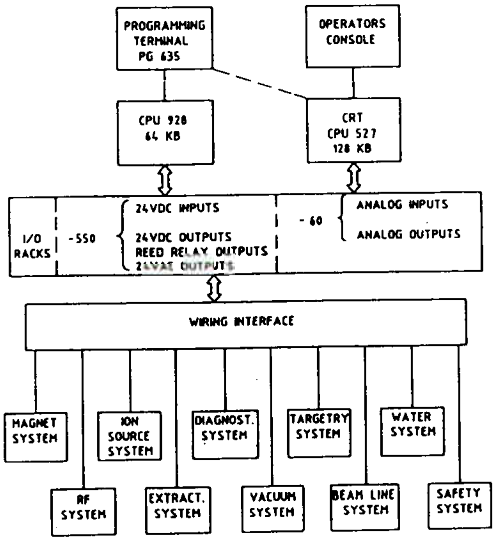

Figure 4 Control System Overview

Ancillary Systems

A complete facility as shown in Figure 5 will include beam transport lines and targetry. An improved solid target and transport system based on earlier versions is under development capable of withstanding at least 8 kW beam power. All ancillary systems can be incorporated in the Simatic control system to facilitate operation.

Performance Specifications:

Type of ions:	Protons	Deutrons
Energy range:	15-32 MeV	8-16 MeV
Beam intensities: MC32NI	> 100 μA	> 100 μA
: MC32NE	> 500 μA	> 500 μA
Number of simultaneous beams:	2, beam ports 180° apart	
Energy spread:	< ± 1.0 %	
Foil package lifetime:	> 100 μAh	
Beam emittance: normalized	< 5π mm x mrad	

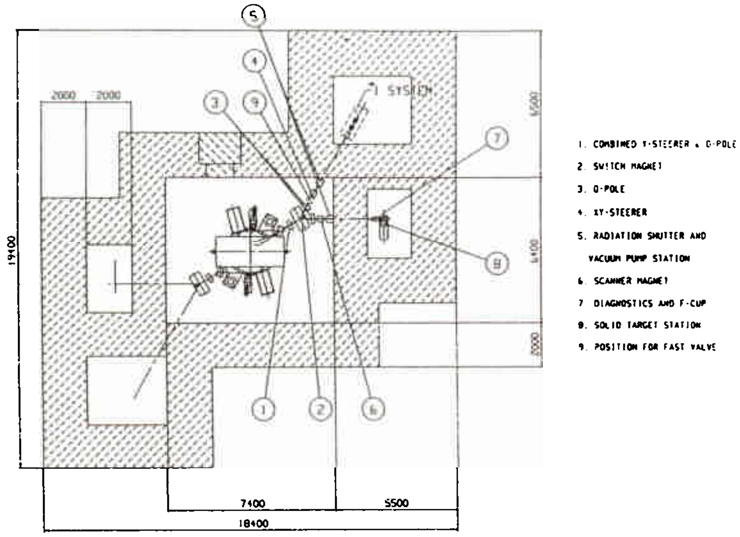

Figure 5 Facility Layout

CONCLUSION

The first of the MC32 series is currently under construction and will be assembled in the fall of 1989. The project is described in more detail in another contribution to this workshop.[3] Beam tests will be performed from April to July 1990 with delivery scheduled for September 1990 to the DKFZ (Deutsches Krebsforschungszentrum), Heidelberg, FRD.

REFERENCES

1. Larsson J.D., Bergström J.O. and Kjellström R. Fully Automated Control System for an MC17F Medical Cyclotron, Proceedings of the Twelfth Intl Conf on Cyclotrons and Their Applications, Berlin, May 8-12, 1989.
2. Kjellström R., Recent Developments in Targetry and Radioisotope Processing Systems, Proceedings of the Second Workshop on Targetry and Target Chemistry, DKFZ publications, Heidelberg, September 22-25, 1987.
3. Wolber G., A Biomedical Negative Ion Compact Cyclotron for the German Cancer Research Center, in these Proceedings.