STATUS REPORT ON THE MEDICYC PROJECT

C.M. LALANNE, P. MANDRILLON*, A. SUSINI**

* *Detached from IN2P3 to Centre Antoine Lacassagne, 06054 Nice Cédex, France.*
** *CERN, 1211 Genève 23, Switzerland.*

Abstract.- Medicyc is a 50 MeV proton medical cyclotron mainly devoted to neutron production for cancer therapy. Design parameters, first measurements on the RF cavity and a new extraction channel are presented. The machine has been designed in such a way that by changing the magnetic field, still with the same RF frequency, it is possible to produce radio-isotopes most commonly used in a hospital.

1. Introduction.- The Nice Cancer Centre under the direction of Professor Lalanne has undertaken a neutron therapy programme based on fast neutrons produced by a 50 MeV proton isochronous cyclotron [1]. Medical and practical requirements for the treatment of patients are the following :

- Depth of 50% dose : $\geqslant$ 14cm
- Dose rate at 140cm SSD : 30rad /minute
- Fields definition : from 5x5cm^2 to 20x20cm^2
- Rotating isocentric gantry

Extrapolating from the existing CGR-680 magnet, modifications of the magnetic field have been studied in order to reach 50 MeV-Proton. A new RF-system has been constructed and a new extraction channel is being designed.

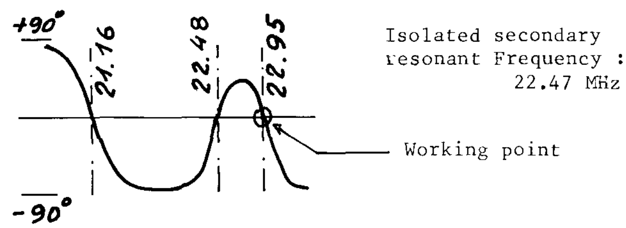
TABLE I

Characteristics :

. Magnet	Length	: 3.7m
	Height	: 2.3m
	Width	: 1.7m
	Sectors	: 4
	Trimcoils	: 8
. Axial Source		
. Radiofrequency system	2 Dees of 75^o aperture	
	Frequency	: 22 MHz
	Peak voltage	: 50 Kvolts
	Power	: 2 CW 25000 Eimac
. Ejection	First Section : electrostatic	E = 100 Kvolts/cm
	Second Section: electromagnetic	B = 2500 gauss
		G = + 400 G /cm
	Third Section : 2 magnetstatic channels	= $\pm$ 1000 G /cm

2. Radiofrequency System.- The nominal fixed frequency is 22 MHz but the mechanical design is such that, via simple manual intervention, it is possible to work between 23.2 and 21.5 MHz. Each one of the 2 Dees is independently excited by its own amplifier which in turn is driven by a master oscillator. Each Dee resonates as a $\lambda/4$ line, the shorting piston being at air by means of an RF vacuum feedthrough of the Philips type. The maximum voltage on the feedthrough is less than 10 kilovolts. This arrangement has been chosen in order to have outside the vacuum the coupling loop, the shorting piston and the fine tuning mechanism which is obtained by slight deformations of the shorting piston. Also the voltage monitor is outside the vacuum.

The characteristic impedance of each Dee resonator is Z_n= 25 ohms. With a Q of about 2500 the required power RF at 50 Kvolts peak is expected to be about 20 Kwatts. The amplifier is 25000 Eimac tetrode driven by 800 Eimac tetrode. The neutralization is obtained by a $\lambda/2$ cable. The coupling is of the detuned primary type and the frequencies where the phase becomes zero are :



Of course we work near the lower peak with an impedance of about 2000 ohm, which can be easily adjusted when detuning the primary [2].

The start-up procedure and the surveying of the status of the system is performed through an ALSPAC H03 programmable automate.

The main power supply is a 180 Kwatts, 12 Kvolts generator from ALSTHOM.

One cavity has been constructed and mounted in a test vacuum chamber in Nice, ready for power test.

3. Central region studies [3].- The double mode of operation of the cyclotron, acceleration on the fondamental for radiotherapy and third harmonic (second harmonic is also possible but has not yet been investigated) for radioisotopes production, with a frequency system, leads us to a special central geometry configuration : one fixed extraction puller on each Dee.

Extensive electrolytic tank measurements have been done in order to find an optimal configuration. Figure 1 shows equipotential lines distribution in this region and the central trajectory for proton (h=1) resulting from the programme AGORA [3]. Centers of curvature motions for both modes of operation are presented on the Figure 2.

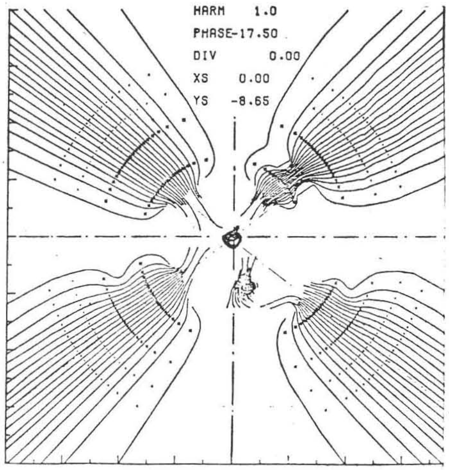


Fig.1: Central region's equipotentials distribution and central trajectory for the fundamental mode.

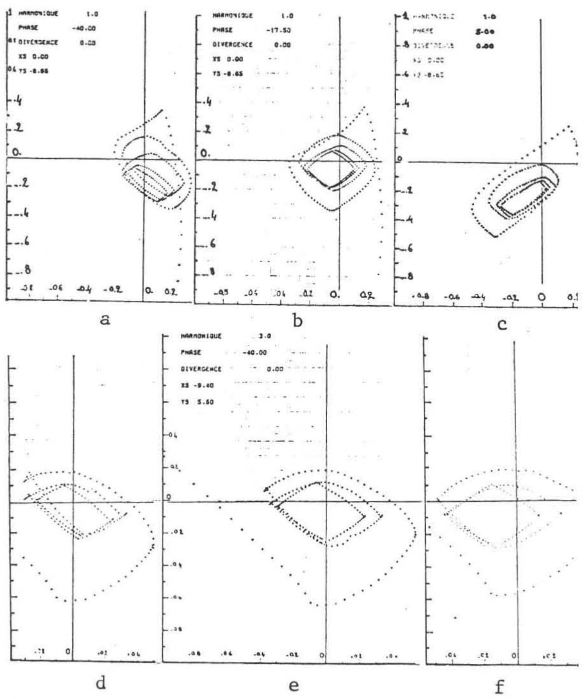


Fig.2: Centers of curvature during the first revolutions : b central phase, a and c extreme accepted phases for the fundamental mode, e, d and f, the same for the third harmonic mode.

Vertical beam losses in the central region after the clearance have been calculated and represent about 60% of the accepted beam.

4. Extraction.-

a) Pre-extraction orbits.- Precessional extraction is used to increase the turn separation of these orbits. Static and dynamic radial phase space studies are presented on the figures 3 and 4. These orbit calculations were carried out in a synthetic magnetic field including data from CGR-MeV and calculated field extrapolations. All accelerated orbit calculations have been performed for the 50 MeV proton goal. They started at 10 MeV where the magnetic field is strictly isochronous and where the effect of the harmonic coils fringe fields is not significant.

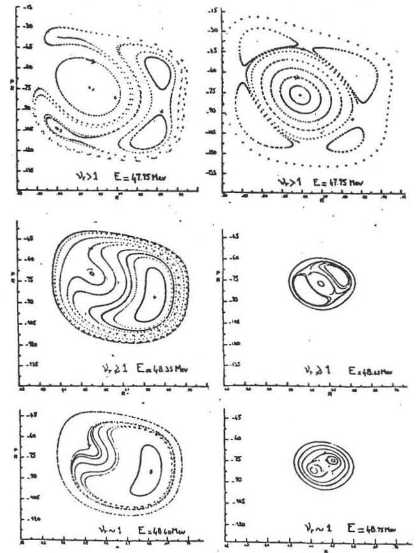


Fig.3: Static radial phase space with and without first harmonic.

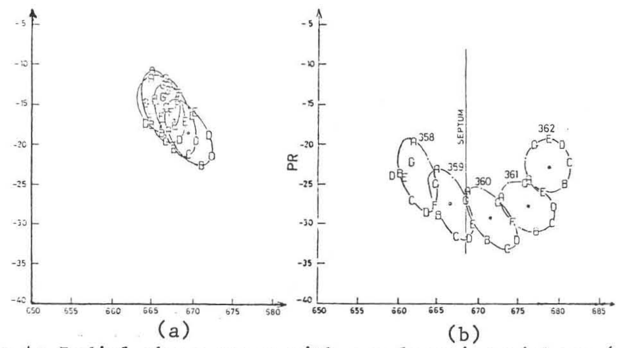


Fig.4: Radial phase space with acceleration without (a) and with (b) first harmonic effect.

With a 5 gauss first harmonic 360 turns are necessary to reach the septum where a 5mm turn separation is obtained without too serious vertical losses (Fig.5).

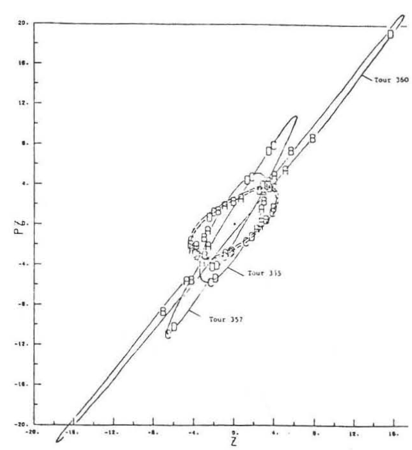


Fig.5: Effects of coupling resonance in the pre-extraction region on vertical beam ellipse.

b) Beam extraction system.- The extraction channel's elements are presented on the figure 6. A short electrostatic section (with a maximum electric field slightly above 100 kV/cm in order to have a reliable medical exploitation) is of course necessary to jump across the electromagnetic septum. This section has the double role of deflection and radial focusing. The maximum current in the septum is about 2750 Amp. This configuration has been found by means of a computer programme written by P. Gara and E. Martin from the IPN-Orsay.

A third section, not yet calculated, consisting of focusing bars is foreseen after the Dee traversal.

5. Acknowledgments.- The Medicyc Project owes much to many discussions with Professor Lalanne who defined the medical requirements of a cyclotron for use in a hospital environment. Also the help of M. Ferrari (Lyon) and A. Lafoux (Orsay) is to be mentioned.

References

1) Rapport Medicyc - Centre Antoine Lacassagne, Nice - Janvier 1980.

2) A. Susini - RF coupling problems - Centre Antoine Lacassagne, Nice - Septembre 1981.

3) P. Mandrillon - La géométrie centrale de Medicyc - Centre Antoine Lacassagne, Nice - Octobre 1981.

4) P. Mandrillon et al.. - L'éjection de Medicyc - Centre Antoine Lacassagne, Nice - Septembre 1981.

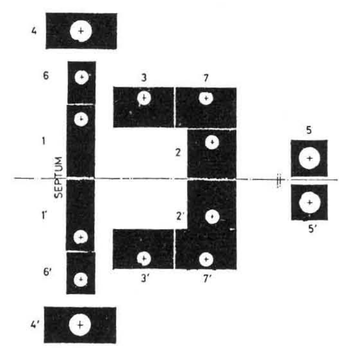


Fig.6: Electromagnetic channel's cross section

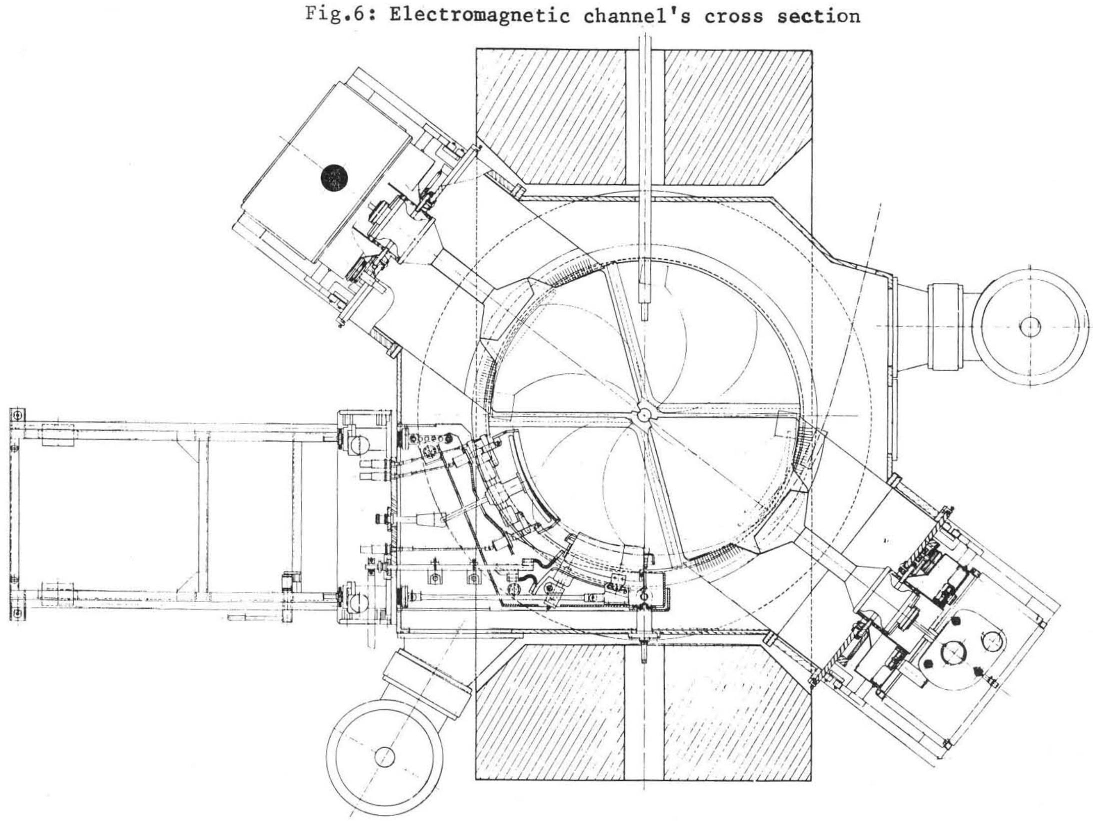


Fig.7: General layout of the cyclotron