

STATUS REPORT ON THE CATHOLIC UNIVERSITY OF LOUVAIN CYCLOTRON

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ABSTRACT

This paper describes the 80 MeV (protons) cyclotron built for the University of Louvain. The machine features variable energy and can also accelerate deuterons, ^3He and alpha particles. Design and construction were completed within 40 months and first operational results are reported.

INTRODUCTION

As was reported earlier¹ the UCL cyclotron is an intermediate machine between the cyclotrons of the Faculty of Science of Grenoble and of the University of Maryland, basically on the same design, with an electromagnet with four spiralled sectors on the poles and two accelerating electrodes of 90° . It was built for an intermediate energy between the 60 MeV protons of Grenoble and 100 MeV of MUSIC, selected as 80 MeV protons, but as the others with provisions to exceed these limits. The RF system is on the same principle of two amplifier chains applying RF power to two resonant cavities tuned by moving panels. This design is also used in the construction of the cyclotrons for the National Institute of Radiological Science in Tokyo and for the National Scientific Research Center of Orleans.

CONSTRUCTION

The order was received in March 1969 and the assembly of the elements, sub-contracted for most of them in Belgium, was completed at the end of 1971. The first internal beam was obtained on October 13, 1971 less than 40 months after the contract was received. The complete range of operation and the beam handling system was tested with a beam. Some measurements remain to be made to have the complete precise characteristics of the beams available.

CHARACTERISTICS

The characteristics of the UCL cyclotron can be summarized as follows:

• Proton energy range	10-80 MeV
• Deuteron energy range	10-40 MeV
• $^3\text{He}^{++}$ energy range	20-120 MeV
• Alpha particle energy range	20-80 MeV
• Extracted beam current	20 μA
• Energy spectrum width	0.5 per cent

but it was designed for a maximum possible proton energy of 100 MeV.

The electromagnet characteristics are:

• Weight	200 metric tons
• Pole diameter	2.15 m
• Gap maximum	40.5 cm
• minimum	16.6 cm
• Maximum average induction at the extraction radius	16 kG (100 MeV)
• 12 pairs of circular trimming coils	
• 8 pairs of harmonic coils	
• Number of ampere-turns in the main coils	400,000

The radio-frequency with two cavities and two electrodes (dees) of 86° extension can be tuned in the 11 to 23 MHz range, the dee voltage is 50 kV, the RF maximum power 70 kW for each cavity. Completely automatic tuning and phase control is achieved by solid-state systems giving stabilities better than 10^{-6} in frequency, 0.1° in phase between dees and 10^{-3} in dee voltage.

The extraction uses an electrostatic deflector of 55° , a magnetic channel of 2.5 kG maximum and a gradient correction system.

Extreme care was taken in the design of the power supplies to ensure the highest possible stability of operation, which is a dominant feature of this machine.

TEST RESULTS

The machine was operated on both fundamental and second harmonic modes, over the complete energy range. Presently the following extracted beams have been obtained:

protons 20,30,43,50,60 and 70 MeV

alphas 96 MeV

This last test was made to confirm the possibility of operation at the maximum energy of the design. All beams were obtained exactly at the computed settings of the parameters.

The extracted beam was used to test the beam handling system, and a focal spot of very small dimensions was obtained on the final target. No precise measurements of emittance and energy dispersion have as yet been made but with the transmission of the extracted beam it has been verified that the energy dispersion does not exceed a few parts in one thousand.

The tests at maximum beam current have been avoided up to the present time of final adjustments to prevent activation of elements, but it was easily shown on the first internal beam test that currents in excess of 50 μ A were easily accelerated.

REFERENCES

1. P. Macq et al., Proc. Fifth Int. Cyclotron Conf. (Butterworths, London, 1971) 124

DISCUSSION

NEED: What types of power have you handled to date on your deflector assembly?

DUPUIS: We have already obtained at the target 5 μ A of alpha and, as I say, we limited the power to not activate too much the machine. So the 50% efficiency is measured directly from this target vs the internal beam. We made some check-up on the efficiency of the deflector and we found very easily 60% at the beams we obtained.

NEED: But you haven't power tested it yet?

DUPUIS: No, we have not yet gone to full power. We intend to do it in the coming months. We think that with the new septum we have that there is a possibility to handle about between 1000 and 1500W.

RESMINI: Did I get you right, if I understood that maximum proton energy can be extended higher than 80 MeV? If so, what exactly do you have to do to extend the maximum proton energy?

DUPUIS: From the measurement of the magnetic field it showed that the machine is stable up to 100 MeV, as far as magnetic field is concerned. Now we think that to achieve the 100 MeV it would be necessary to have some modification, and the first we can see is to increase the power to the magnetic channel. Extraction with the deflectors and reducing the distance of the septum will enable us to handle the voltage for 100 MeV. But for the magnetic channel, which is now 2500 G, we would probably have to increase the power supply, which is a limiting factor. As far as the RF system is concerned, for 80 MeV we need 50 kV at 20 Mc/s. We have already achieved it. And for 100 MeV we would need to have a frequency of about 22 to 22.5 Mc. We have already obtained 40 kV, and we have plenty of power reserve so maybe a slight modification in the driving of the final amplifier.

WARREN: Have you taken any special precautions to deal with the violently radioactive components when you get up to full current? For the handling and maintenance inside the machine?

DUPUIS: We have not yet made the mapping of radiation at full power. From the experience at Grenoble and Maryland we expect that there is no major problem.