STATUS REPORT ON THE C.N.R.S. ORLEANS'CYCLOTRON

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1. Introduction

The variable energy isochronous cyclotron of the CNRS in ORLEANS was put in use on January 3rd 1977.

This status report summarily describes the cyclotron, the beam lines and the irradiation systems used, and shows the results after the first year of exploitation.

2. The cyclotron

Performances and characteristics of the machine can be summarized as follows in table 1 and table 2.

Table 1 : Performances

ENERGY :		
	Proton energy range	: 5 - 36 MeV
	Deuteron energy range	: 5 - 25 MeV
	α particle energy range	: 10 - 50 MeV
	$^3He^{++}$ energy range	: 8 - 60 MeV
INTENSITY BEAM :	Maximum extracted beam intensity for protons and deuterons	: 100 μA
	Maximum extracted beam intensity for α particles and helium 3	: 40 μA

Table 2 : Characteristics

Electromagnet characteristics :	
Weight (metric ton)	110
Pole diameter (m)	1.60
Number of spiralled sectors	4
Gap maximum (cm)	27
Gap minimum (cm)	13
Maximum average induction at the extraction radius 67,5 cm (kG)	15
Number of ampere turns in the mains coils	250.000
Number of trim coils (pair)	8
Number of harmonic coils (pair)	4
Radiofrequency : Range from 20 to 40 MHz	
Number of dees	2
Number of cavities	2
Dee angle	60°
Maximum dee voltage (kV)	50
RF power available (kW)	2 x 50
Frequency stability	10^{-6}
Dee voltage stability	10^{-3}
Phase stability	0,1°
Extraction :	
Electrostatic deflector :	
Maximum field (kV/cm)	110
Angular span	58°
Magnetic channel	passive
Gradient corrector	
Ion source : Type : Livingstone	
Location : internal, vertically introduced	
Maximum arc power (W)	800
The center region is designed for 2,3,4 harmonic operations with a single orbit for all energies and particles.	

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3. The beam lines and the irradiation systems

The beam handling system was designed and built by the cyclotron group. It consists of a main line connecting the cyclotron to a switching magnet (Figure 1) which directs the beam to one of the 2 separate (3 and 4) shielded rooms.

3.1. Irradiation room n° 3

In this room the end of the 0° beam line can be equipped as required by two different devices :

- An irradiation system in the vacuum. Target assembly is cooled by thermal contact with a water-cooled copper target holder. Maximum irradiated area is 7 cm^2.
- A Be target for fast neutrons production resulting in the following nuclear reactions :

$^9Be(p,n)^9B$ 36 MeV protons or
$^9Be(d,n)^{10}B$ 25 MeV deuterons

3.2. Irradiation room n° 4

In this room irradiation is carried out at atmospheric pressure and beam line is closed by a 25 μm titanium foil. Ahead of this foil, an automatic irradiation system allows irradiation of solid targets with high intensity beams.

A pneumatic transfer system connects this irradiation system with a hot cell located in the high activity laboratory n° 8. A control unit in the hot laboratory allows all the irradiation and handling operations. When the rabbit in which there is the target has reached its irradiation position, two jacks automatically connect it with a water circuit : 8 bar pressure, 4 l/min, and the back surface of the target is water cooled while the front surface of the target and the titanium foil are cooled by air.

The irradiated area on the target is about 5 cm^2.

4. Results achieved so far

During year 1977, the cyclotron has been run 9 hours a day, and 5 days a week. It has been in the charge of the technical staff, which has to see to its maintenance and further improvements. The total beam time, 1931 hours, was divided as follows (Table 3).

Table 3

	Hours	%
Operating time....................	1.217,5	63
Scheduled shut downs..............	294	15,5
Maintenance and minor developments	274	14
Break downs.......................	145,5	7,5

4.1. Operating time

The operating time is the time during which the cyclotron is running. This time can be divided into two parts :

- The time related to the machine development 378 h, that is 19,5 % of the total time.
- The irradiation time : the time when the beam is actually on the experimenters'targets.

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839 h 50, that is 43,5 % of the total time.

4.1.1. Machine development

- The developing of new beams with helium 3 ions mainly.
- Power tests of the ions source α.
- Power tests of the RF system between 30 and 40 MHz.
- Studies of the beam structure on the targets located at the end of the 0° beam line, with and without low frequency sweeping of the beam on these targets.

4.1.2. Irradiation time

This time can be divided as follows according to the type of ions (Table 4)

Table 4

Particles	Irradiation time (hours)	%
Protons	391,50	46,5
$^{3}He^{++}$ particles	260,00	31
Deuterons	122,50	14,5
α particles	65,50	8

For each particle, this distribution of the irradiation time according to the type of experiments is (Tables 5 and 6) :

PROTONS

Table 5

Energy (MeV)	Irradiation time (hours) 391 h 50	Percentage of the total irradiation time	Research field
11	328	39	Activation. Analysis, Archaeometry. Diffusion under irradiation.
32	45	5	^{137}Ce and ^{139}Ce. Production for nucleus study. ^{77}Br preparation by reaction $^{79}Br(p,3n)^{77}Kr \to {}^{77}Br$
27	3		Iodine production by reaction $^{124}Te(p,2n)^{123}I$
25	15,50	2	

HELIUM 3

Table 6

Energy (MeV)	Irradiation time (hours) 260 h	Percentage of the total irradiation time	Research field
13	101,50	12	Activation analysis.
17	26,50	3	Semiconductors.
20	85,50	10	Diffusion under irradiation.
25	21,50	3	
48	6	1	Iodine production by reaction $^{124}Te(^{3}He,4n)^{123}Xe \to {}^{123}I$
50	10	1	
53	9	1	

For deuterons most beam hours, 101 h 50, that is 12 % of the irradiation time, were spent using a beam of 25 MeV energy, on the thick beryllium target for fast neutron activation and dosimetry.

For α particles, most beam hours were used for ^{84} Rb production by the following nuclear reaction

$^{81}Br(\alpha,n)^{84}Rb$ with 20 MeV α energy and for simulation of radiation damage in reactor materials with a 30 MeV α energy.

4.2. Scheduled shut downs

These scheduled shut downs were necessary for :

- The installation and testing of irradiation systems and steering magnets.
- The installation of a post for intercepting $_{3}^{+}He$ ions in the center of the machine when the cyclotron is running with $_{3}^{++}He$ ions in harmonic 2 mode.

4.3. Break downs

are mainly due :

- to the arc and filament power supplies of the ion source,
- from the high voltage electrode of the electrostatic deflector whose input was damaged by the beam, as the protecting copper finger was not properly fixed.
- to the power tube socket of cavity n° 2.

These last 2 devices were removed.

4.4. Maintenance and minor developments

This last item mainly deals with the ion sources, the radio-frequency system and the electronic racks of the beam transport.

5. Future developments

- Study and achievement of two beam plugs in the separation wall of the cyclotron vault and irradiation rooms.
- Building and installation of a shielded gate for irradiation room n° 4.
- Study and achievement of an emittance measuring device which could be used for measuring the beam density as well.
- Installation of an energy measurement system.
- Study and installation of a gas target for short lived radioisotopes production.

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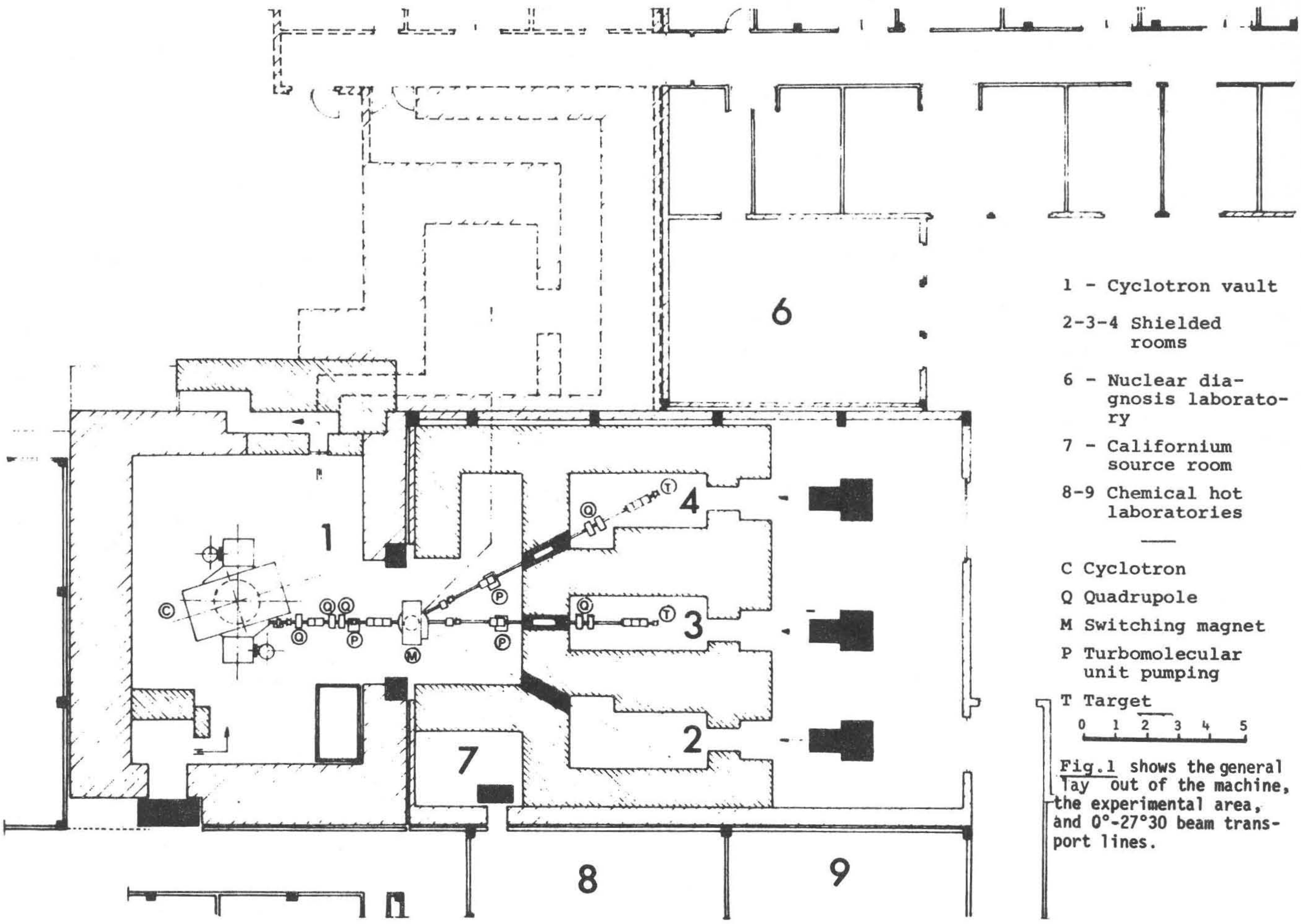

Fig.1 shows the general lay out of the machine, the experimental area, and 0°-27°30 beam transport lines.