STATUS OF THE SEPARATED SECTOR BOOSTER AT GRENOBLE

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Introduction

A separated sector booster cyclotron is under construction at the Institut des Sciences Nucléaires de Grenoble. This facility named SARA (Système Accélérateur Rhône-Alpes) has been studied and is realized by the institutes of Lyon and Grenoble. The first studies of the basic parameters of the machine have been developed in 1976 (ref. 1) and the final authorization to build the machine was given in 1977 by the C.N.R.S. In August 1978 the first magnet is under mapping, the R.F. cavity is under testing and the injection optical elements are under construction.

The general characteristics of the beam are summarized in Table 1. Fig. 1 shows a layout of the cyclotron and the Post Accelerator.

Ion	Input Energy MeV/amu	Output Energy MeV/amu	Intensity 10^{12}p/s
^{12}C	5.5	30	4
^{16}O	5.5	30	3
^{20}Ne	5.5	30	1
^{40}Ar	2.6	15	.3

Table 1: Project characteristics.

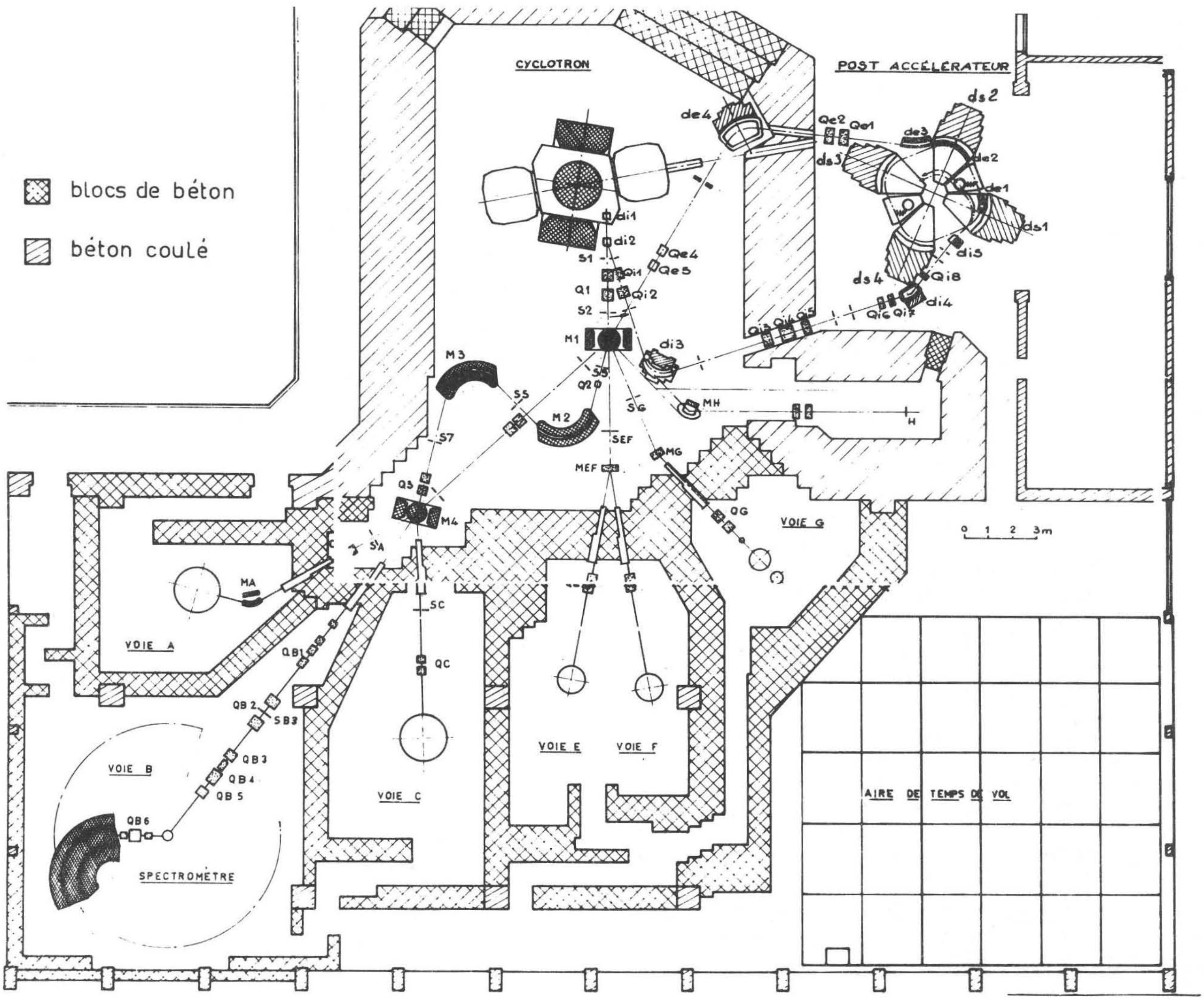

Fig. 1: Layout of SARA system.

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The stripping is done on the first orbit inside the Post Accelerator at a radius which may be varied in order to change the energy gain and stripping ratio. Generally the two machines work on synchronous modes.

As shown in Fig. 1 the Post Accelerator is situated in an existing building. The existing beam lines may be fed either by the beam from the cyclotron or from the Post Accelerator.

The total cost of the new machine was estimated at $1.5 million in 1976.

Magnet Design

Sector angle	48^o
Field at K = 120 MeV	14.5KG
Gap	6 cm
Ampere-turns	90000
Beam radius:	
inner	.66 m - .88m
outer	2.10 m
Total weight	10^5kg
Number of sectors	4

Table II: Principal characteristics of one sector magnet

(a) Technology (Fig. 2)

The yoke of one magnet is divided into 5 parts of less than 20000 kg. Each part is made of low carbon laminated steel plates 140 mm thick. These plates are cut out, then machined and welded together.

The poles are machined from 290 mm thick laminated steel (.06% carbon). A stainless steel flange is welded all around the pole tip in order to receive the vacuum seal. The pole face itself is under vacuum.

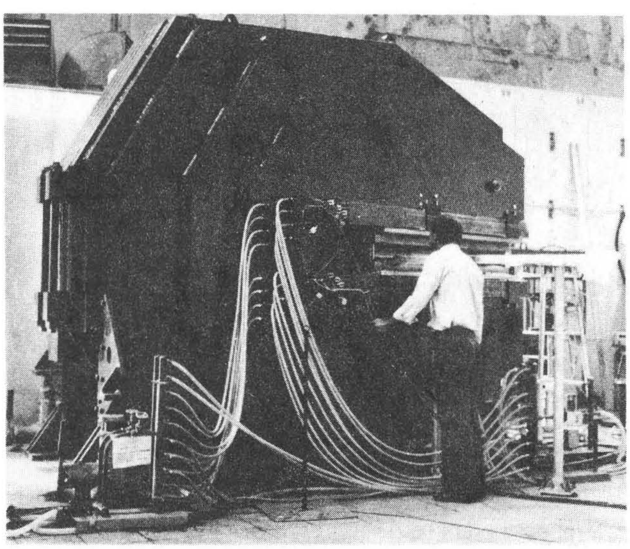

Fig. 2: The first sector magnet under mapping.

The main coils are made of 64 turns of 14 mm square hollow copper conductor with a 7 mm bore for water cooling. Each conductor is insulated by a fiberglass tape and the whole coil is impregnated with an epoxy resin. The coil winding is done at the laboratory (Fig. 3).

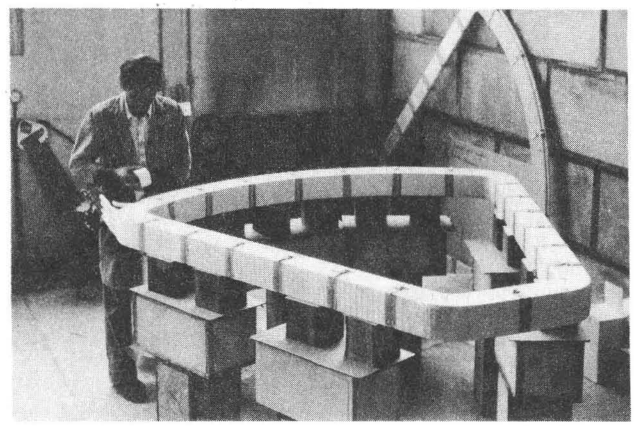

Fig. 3: Main coil before impregnation.

(b) Shimming, Trimming

The shimming is designed to reduce the trim coils power. Owing to the small energy range (10 to 30 MeV/amu), it provides an almost correct field at the maximum energy. A constant width slot is machined radially on the pole face. It is filled with a shim whose height is a function of the radius. This technique was first proposed by J.A. Martin et al. for the Oak Ridge project (Ref. 2). 15 correcting coils enclosed in vacuum tight containers provide the small dynamic corrections. Each consists of only one flat copper wire and is concentric with the beam path.

(c) Model Measurements

A .14 scale model was made in order to verify the properties of the magnet and the shimming. Fig. 4 and 5 show an R, θ field map with the shim and corresponding calculations of ν_r, ν_z.

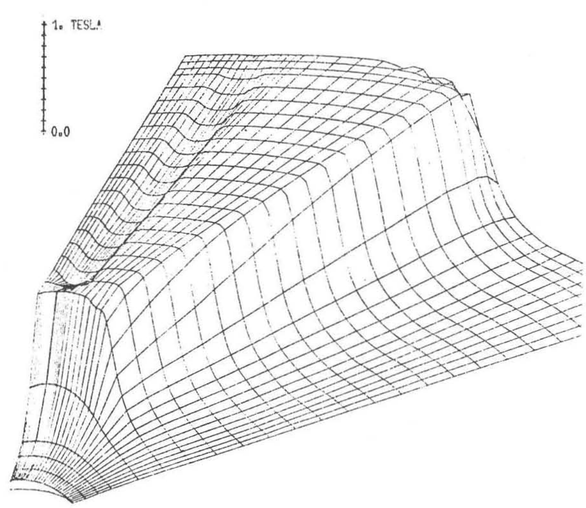

Fig. 4: Field map of the .14 scale model showing shimming effect.

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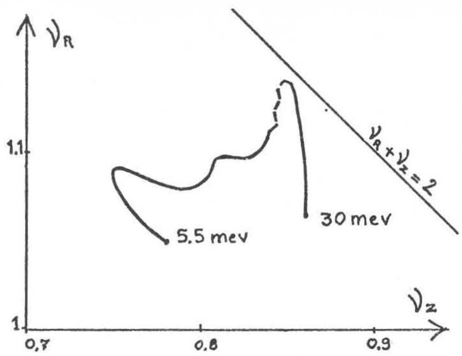

Fig. 5: ν_R, ν_z calculated from the Fig. 4 field map.

Radio Frequency System

Dee Angle	34°
Tuning range	15.5 to 26 MHz
Peak RF voltage	100 KV at 26 MHz 70 KV at 15.5 MHz
Coarse tuning	Two moving panels
Fine tuning	One moving panel
Phase regulation	.1°
Amplitude regulation	10^{-4}
Maximum power	60 KW

Table III - RF Characteristics.

The resonator is a Δ type having two vertical coaxial lines with fixed short circuits. The tuning is done by two movable panels at the rear part of the Dee. The coupling to the RF amplifier is capacitive. The expected Q is from 6000 at 26 MHz to 4000 at 15.5 MHz. A ½-scale model has been built and was tested by the beginning of 1977 — the measurements showed a good agreement with calculations. A first resonator and its test chamber has been designed and built (Fig. 6).

The power supply (12 kV, 20 A), RF amplifier, and control systems have been constructed at the lab.

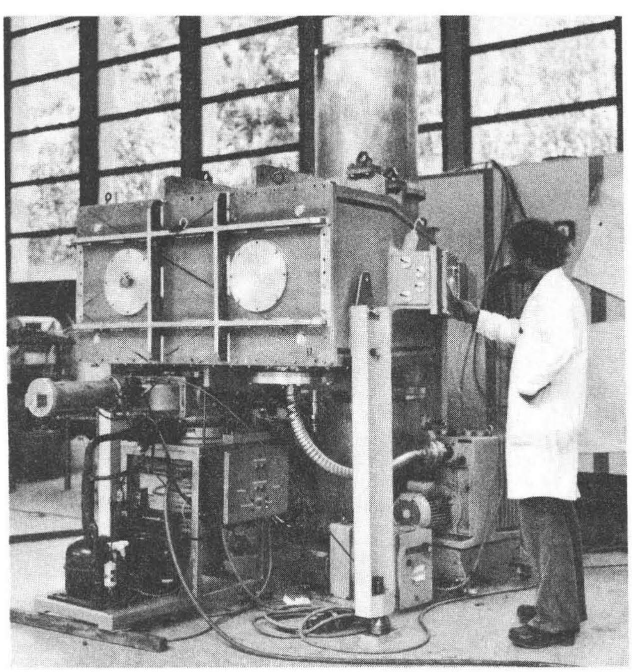

Fig. 6: Resonator and its test chamber.

Flat Topping

A flat topping cavity on the third harmonic of the main resonator has been studied, and a full scale model is under construction. It will be tested with the first resonator.

Vacuum System

Very classical, it is fitted out with four 5200 l/s oil diffusion pumps with freon-cooled baffles. The expected vacuum is 1×10^{-6} torr using viton seals.

Injection line; Stripping

The stripping by a carbon foil is done inside one magnet in the first trajectory. The stripping foil may be moved in order to choose the energy gain of the machine (several energy gains are possible, depending upon the chosen running mode). The injection line between the cyclotron and the Post Accelerator is calculated in order to be achromatic and partly isochronous. It includes 4 dipoles and 8 quadrupoles.

Extraction system

Two systems have been studied: the first one uses a 1.4 m electrostatic deflector, followed by a 27° septum magnet. The second one (Fig. 7) uses a .6 m electrostatic deflector, followed by two electromagnetic channels and a septum magnet. Table IV summarizes the two systems.

The first system is simpler and more attractive, but it is not easy to build a reliable electrostatic deflector in a 6 cm magnet gap. Experiments will be done soon to test such a deflector.

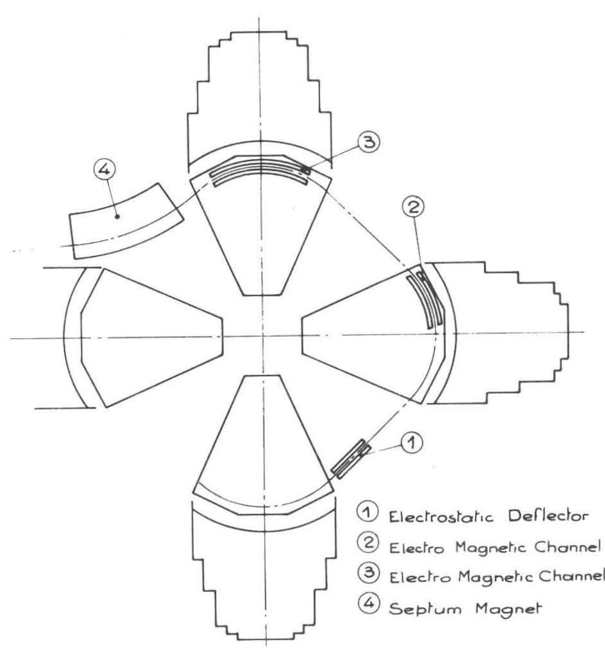

Fig. 7: Second extraction system.

System	1	2
Electrostatic Channel		
Length	1.4m	.6m
Field at K=120 MeV	30 KV/cm	42 KV/cm
Location	Gap	Free space
Electro Magnetic Channel		
Length		.59m
Field reduction		550 G
Electro Magnetic Channel		
Length		1.82m
Field reduction		650
Septum Magnet		
Angle	27°	27°
Field	9400 G	9400 G

-- Table IV - Extraction characteristics

Conclusion

Since 1973, the Grenoble cyclotron has been successively equipped with an internal heavy ion source and an external one using axial injection. The Post Accelerator project is the logical continuation to procure a good tool for nuclear heavy ions physics. The first beam at 30 MeV/amu is expected in 1980.

References

1) Project Post Accelerator Grenoble, Internal Report, March 1976.

2) J.A. Martin et al., Design status of a separated-sector cyclotron booster accelerator for the Holifield Heavy Ion Research Facility, IEEE NS 24, no. 3.