THE BEAM TRANSPORT SYSTEM FOR THE MODIFIED ORSAY SYNCHROCYCLOTRON

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Abstract

The beam transport system and the detection apparatus for the modified Orsay synchrocyclotron are described. The main characteristics of the expected performance and a survey of the experimental proposals are given.

Introduction

The Orsay synchrocyclotron was completely shut down on 17-5-75 and will be modified to get more intensity and to increase the extracted proton beam energy from 155 to 200 MeV[1]). The technical options and the present status of the realization of the machine are presented by A. LAISNE in the poster session I, paper A33 [2]). The main characteristics of the expected extracted beams are summarized in Table I.

Table I - Machine Characteristics

Beam Characteristic		Previous Machine	Future Machine
	p Energy	156 MeV	200 MeV (170)*
	d Energy	82 MeV	108 MeV (91)
	τ Energy	217 MeV	283 MeV (238)
	α Energy	166 MeV	218 MeV (182)
PROTON BEAM	Internal Intensity	3.50 μA	10 μA
	Extracted Intensity	0.35 μA	7 μA
	Horizontal Emittance	$\pi \times 70\ 10^{-6}$ rad.m	$\pi \times 9\ 10^{-6}$ rad.m
	Vertical Emittance	$\pi \times 40\ 10^{-6}$ rad.m	$\pi \times 19\ 10^{-6}$ rad.m
	Total $\Delta E/E$	1%	1) 0.25% 2) 1%
	Macro Duty Cycle	1%	1) 70% 2) 2%
	Micro Duty Cycle	30%	1) 10% 2) 30%

* In parenthesis is given the second energy value at which the machine can also operate.
1) With Cee extraction
2) With normal extraction

Here I will discuss mainly the experimental areas and the transport system which are planned to get the best use of the beam. A general view of the layout is shown in Figure 1.

1. Experimental areas

It will be possible to transfer the particles to three experimental areas ; the first one (hall I) will be designed with a large magnet spectrometer for an achromatic system ; a second one (hall II) will receive a less intense beam, the intrinsic resolution of which will be greatly improved by means of analysing slits (F_3) ; and the third one (hall III) will be specially built for high intensity spectroscopy experiments with an on-line mass separator.

2. Beam transport system

The extracted beam will be at 8° of the H.F. line. Four beam steerers will permit alignment of the beam with the theoretical optical axis. A quadrupole doublet Γ_1 will doubly focus on the point F_1. The beam will be then deviated back towards the experimental halls by means of two magnets (A_1 and A'_1). These spectrometers will deliver a dispersed beam to be analyzed in F_3. The magnet A_1 will also be used as a switching device for the line of hall III and the one of halls I and II. On the latter line a quadrupole doublet Γ_2 will ensure a horizontal focusing in F_4 and a vertical focusing in F_5 which will be a double focusing point due to the effect of the magnet A_2. This magnet will be also used to switch the beam between halls I or II.

The main beam line (hall I) will be built so that the energy spread on the target in point C_1 can be exactly compensated by the dispersion of the detection spectrometer (S), realizing an achromatic system. A double focusing in C_1 is obtained through a quadrupole triplet Γ_3. The dispersing device A_2 will permit separate adjustment of the dispersion and linear magnification. Different operating conditions of Γ_2-Γ_3 will allow a focused analyzed beam in C_1.

The analyzed beam in C_2 will be of small horizontal size because the dispersion of A_2 is subtracted from the one of A_1 A'_1. The focusing in Γ_2 will be obtained with a quadrupole doublet Γ_4.

The maximum intensity will be transferred in hall III through two quadrupole doublets Γ_5 and Γ_6 and a small magnet A_3.

The required stabilities for each element are as follows : $\pm\ 3.10^{-5}$ on A_1, $\pm\ 10^{-4}$ on A'_1; $\pm 2.10^{-5}$ on A_2 ; $\pm\ 10^{-5}$ on S ; $\pm\ 2.10^{-4}$ on all the lenses and $\pm\ 10^{-3}$ on the beam steerers.

This beam transport system will include several slits. The most important are : D_1 and D'_1 to adjust the emittance, F_1 to define the object of the achromatic system and F_3 to analyze the dispersed beam. Because of activation these slits must be remotely controlled and cooled.

The beam qualities depend directly on the vacuum in the beam lines. The limit of 10^{-4} Torr is sufficient for handling p, d, τ and α and will be obtained with turbomolecular pumps.

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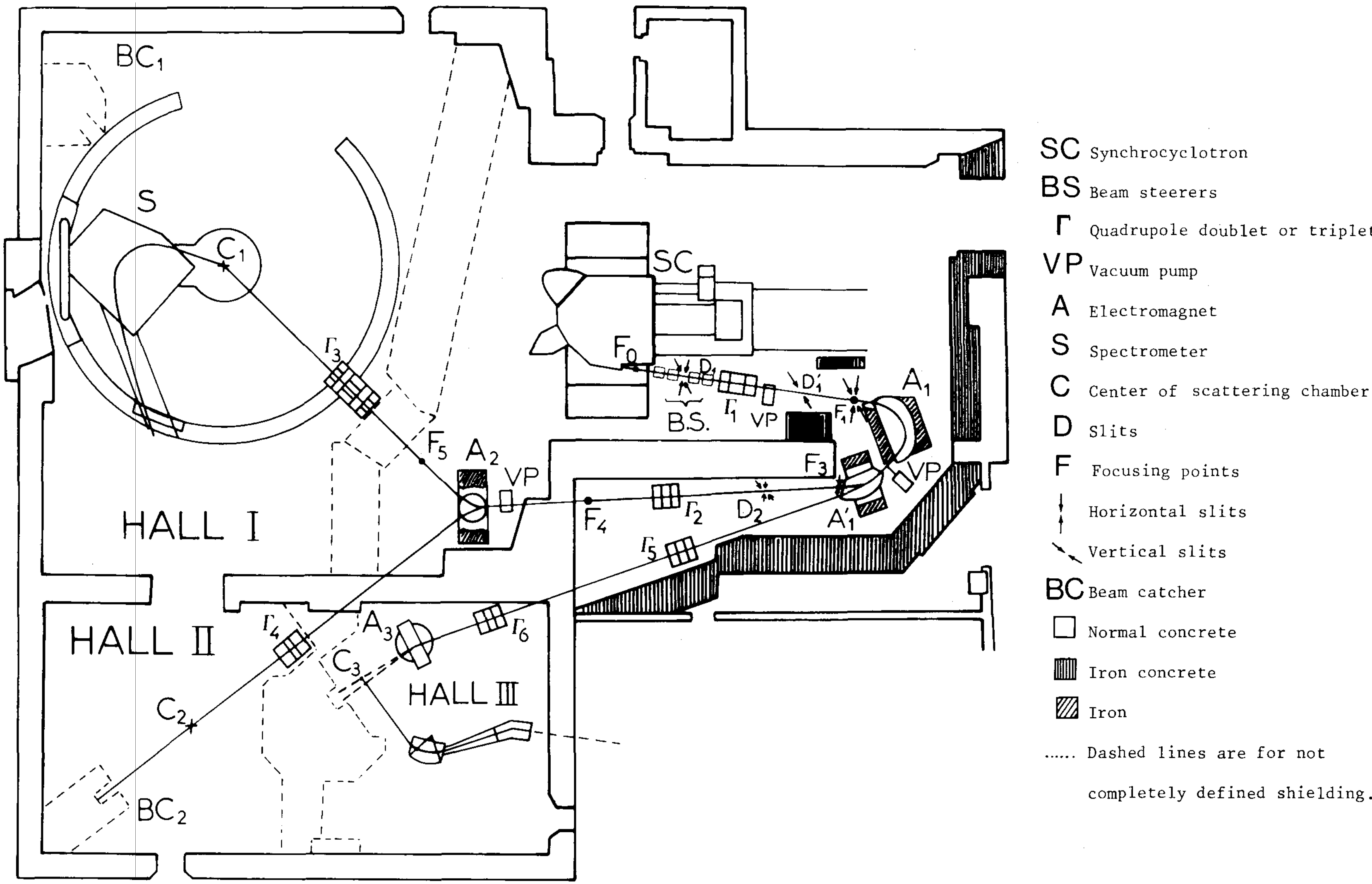

Fig. n°1. Layout of the Orsay synchrocyclotron experimental areas.

The high intensity requires an improvement of the shielding. The choice of local devices, principally in F_1 and F_3 will reduce the total mass of screening. In each hall the transferred beam will be stopped in such a way as to reduce the background inside and ensure radiological protection outside.

Many points of beam control are also planned : in the center of beam steerers, before Γ_1, at the level of F_1, between A_1 and A'_1, after F_3, in F_4 and F_5, in front and in the center of the scattering chambers. Precise beam profile observations will be made by a charge measurement on a wire scanner driven by a stepping motor and giving a digitalized spectrum of horizontal or vertical profile. Other coarse information will be given by fixed cameras focused on a remotely controlled retractable scintillator. Absolute intensity will be measured with Faraday cups placed inside the beam catchers. The pulsed beam will allow induction rings to be also used as non-destructive intensity monitors which will be very useful in front of scattering chambers.

In Table II we show the expected improvement in performance.

Table II - Expected proton beam characteristics

Experimental Area	Previous Machine	Future Machine
Hall I Achromatic System $F_1 = 1$ mm ΔE^* limit $\Delta\theta_H \times \Delta\theta_V$ H mm × V mm (size of beam spot on the target) I_{max}	 150 keV 0°5 × 0°5 32 × 12 0.05 µA	 40 keV 0°6 × 0°1 1) 8 × 13 2) 32 × 13 4.6 µA
Hall II Analyzed Beam $F_1 = F_3 = 1$ mm ΔE^* limit $\Delta\theta_H \times \Delta\theta_V$ H mm × V mm I_{max}	 1.5 MeV 0°5 × 0°4 5 × 10 0.05 µA	 130 keV 0°20 × 0°15 2 × 10 1) 1.2 µA 2) 0.35 µA
Hall III High Intensity Beam H mm × V mm I_{max}	 10 × 10 0.3 µA	 7 × 7 6.5 µA

* This performance includes neither target effects nor second order aberrations, and supposes the above defined regulations.

1) With Cee extraction
2) With normal extraction

3. Computer role

The complexity of the beam transport system and the desired high performance require the use of a computer. At first it will be used to drive the magnets and lenses, to adjust them to the best values and to survey the stability of these units (with an alarm when given limits are not respected). We will have for this purpose a IBM 1130 computer linked to automatic Micralspa devices[3]). The computer will also store many parameters and corresponding beam characteristics to optimize for the operating conditions. All the software and hardware are now being studied.

4. Detection apparatus

The greatest improvement of the accelerator will be the 40 keV resolution obtained with the achromatic system for 200 MeV protons. Such a limit will require a special 0.2 mm spatial resolution detection device on the focal plane of the spectrometer. The useful range will be 30 cm perpendicularly to the optical axis. A knowledge of the trajectories of the emitted particles will be necessary to reject spurious events and to check the optical qualities of the achromatic beam. Taking into account the time structure of the beam and the computer treatment of the data it seems possible to reach a mean counting rate of 1000 events.sec^{-1}. This performance should be obtained with multi-wires chambers with measurement of the center of gravity of the induced current on the cathode[4]). Three of these chambers will be used, 50 cm apart and in coincidence with plastic scintillator detectors. Each chamber will give the horizontal and vertical position with respectively 0.2 and 2 mm accuracy.

The analyzed beam (hall II) will be equipped with a scattering chamber for semiconductor detector and with a small magnet spectrometer apparatus allowing π meson detection in the same way as in previous experiments[5]).

In the experimental area III the on-line mass separator ISOCELE[6]) will be improved for extended spectroscopy purposes.

5. Experimental proposals

The realization of this project will take about twenty months and future experiments are not yet well defined. However one can state the general trend. With the achromatic beam, high resolution experiments are planned, especially on inelastic scattering and transfer reactions. The analyzed beam hall will be used partially for π-production experiments with an interesting extension of previous work done at 155 [5]) and 185 MeV [7]) and for which many problems remain to be settled.

The realization of Isocele II, a new high current on-line isotope separator permitting the use of many targets, and the high intensity of the beam will give this apparatus a powerful efficiency for spectroscopic studies of level schemes and nuclear shapes as already done with the previous machine[8]).

Conclusion

I have tried to give an extensive but not complete description of what the future Orsay synchro-cyclotron facilities will be. Some points are not yet well defined but we anticipate a rapid completion of the project and we hope that the final characteristics will give us a good competitive tool. Further improvements will also be possible and I will note some of them to conclude : modification of the ion source to get polarized beams and possibly heavier ions ; creation of a neutron beam ; equipment for an external irradiation point, and eventually the acquisition of a large solid angle spectrometer for the hall II.

References

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