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THE SATURNE POLARIZED PARTICLE SOURCE

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1. Description

The source is represented on fig.1. We have increased the intensity of the atomic jet (Ref.1, 2, 3), making profit of the pulsed regime. Notice that :

1. Just one skimmer is used,it is far away from the bottle, according to Dr.Campargue's remarks (Ref.4).
2. Turbo molecular vacuum pumps provide a good secondary vacuum
3. The cooling device takes advantage of the two stages of the cryo-generator.
4. The hydrogene gas is fed through a pulsed piezo electric valve, located very closed to the bottle.

2. Characteristics and performances

The source is currently running with protons or deuterons. In order to ease the presentation we will just quote the results obtained with protons.

The piezo valve is opened during 2 ms in advance of 1.5 ms regarding to the RF power pulse.

The 50 cm long sextupole magnet is tapered and its radial aperture has been enlarged from 7. mm to 10.8 mm at the input and 14. mm to 21. mm from the middle to the end, in order to take advantage of the expected cooled atomic jet.

The maximum beam intensity stands at 230 μA (1 μA of background)

3. Experimental results

In order to have a better understanding of the way, the source is running and consequently to improve its performances, the following measurements have been carried out.

3.1 Study of the cooling of the atomic jet. Measurement of the particle velocity

(i) The jet is cooled down in order to increase the intensity of the polarized proton beam (density of the atomic jet). A notable gain has been observed immediately after having enlarged the sextupole aperture as said before. The maximum beam current was reached for a temperature of 100 K and a sextupole current of 120 A. It is worthwhile to notice that the nozzle-skimmer distance, the pressure of the piezo valve and the sextupole current were systematically tuned.

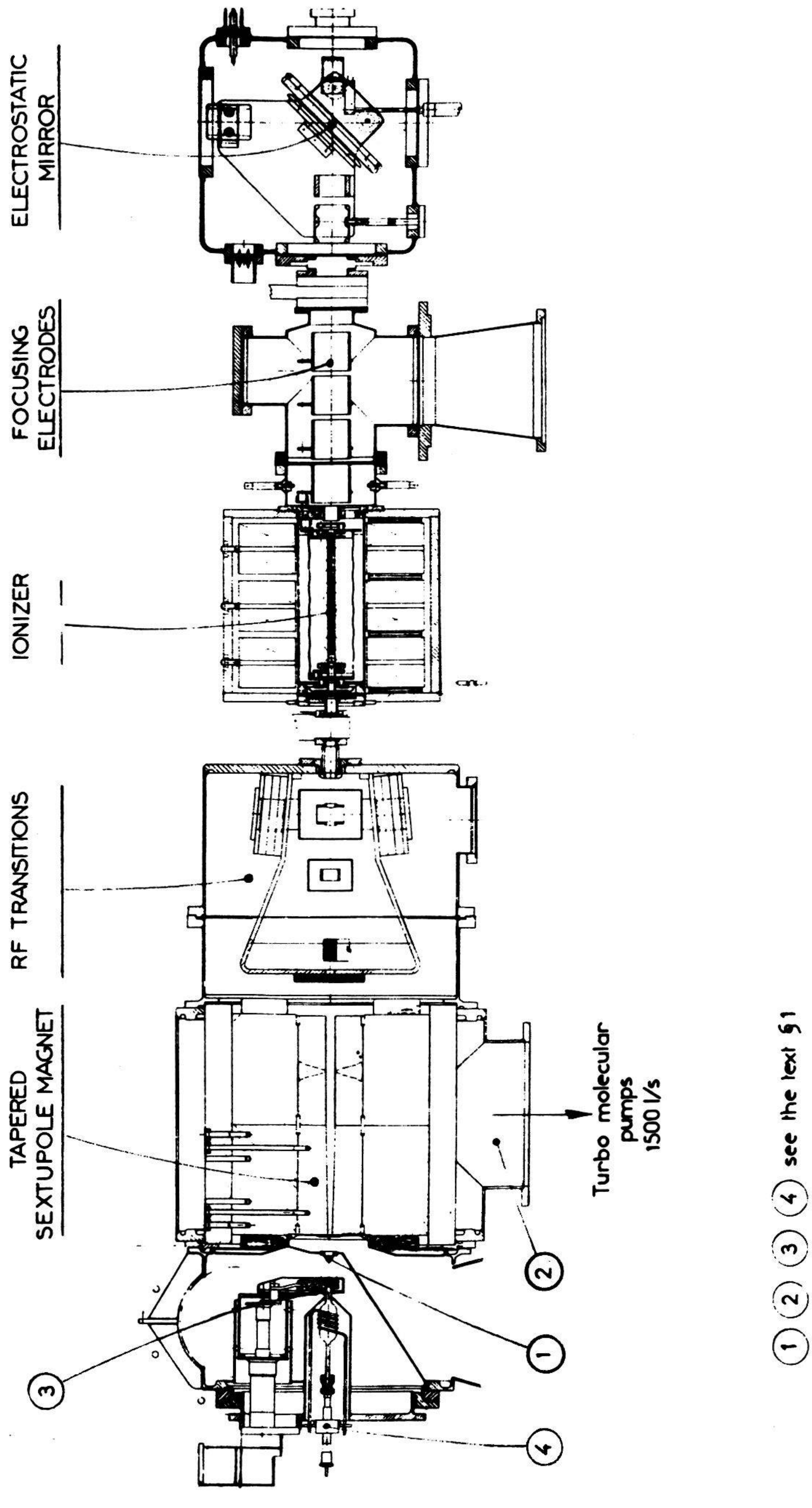

FIG.1: THE SATURNE POLARIZED BEAM SOURCE

(ii) Measurement of the particle velocities. It has been found with a pyrex nozzle, velocities of 2500 m/s corresponding to an optimum at a temperature of 70 K and a sextupole current of 85 A.These velocities were higher than the ones measured at SIN and as suggested by Dr.JACCARD we have removed the pyrex nozzle and replaced it by a sapphire nozzle (coarse surface).
One can see under those new conditions that the optimum stands at a temperature of 160 K and a sextupole current of 120 A; the velocities beeing now of the order of 2750 m/s.

A measurement of the total intensity of the jet is then carried out, taking use of an hydrogene pulsed flow without RF discharge during the cooling duration. In this measurement we warm up from 40 K to 300 K. On the curve (fig.2.1), the intensity drops rapidly when the temperature decreases.

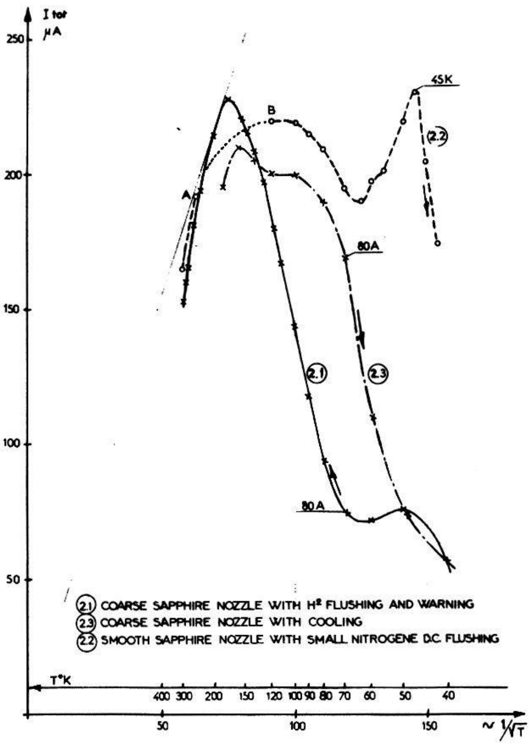

Fig.2 - Comparison between coarse and smooth sapphire nozzle.

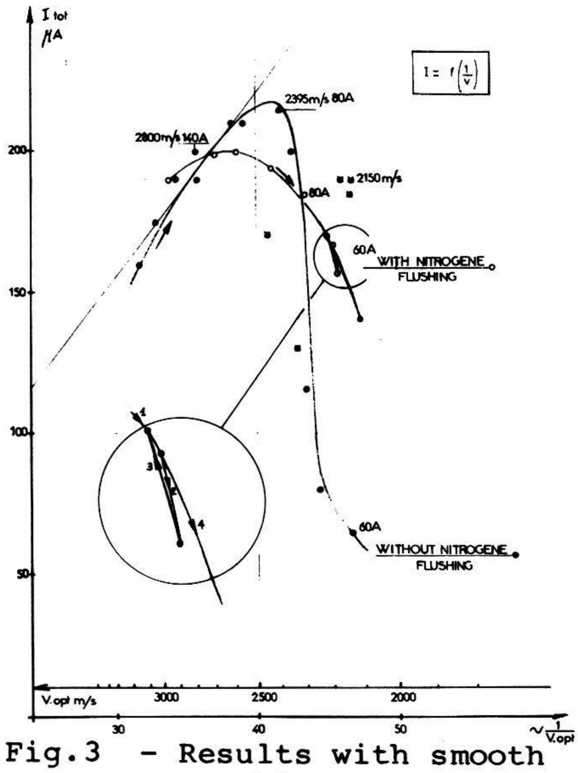

Fig.3 - Results with smooth sapphire nozzle.

If we use now a smooth machined nozzle instead of the previous coarse nozzle and if we add a nitrogen gas flow at a low DC pressure, the intensity does not fall so rapidly and shows a second maximum. This second maximum is not higher than the maximum obtained with the coarse sapphire nozzle at a higher temperature (fig.2.2).
These curves show that at this time the velocities are, with no doubt slower, since the temperature is lower and this should allow us to enlarge again the sextupole aperture and consequently increase the beam intensity due to the larger acceptance of the sextupole. One was expecting velocities of :

$$2750.\sqrt{\frac{45}{160}} = 1460 \text{ m/s}$$

Before machining the poles, we have made more measurements and improved the method of measuring the velocities, after having made some tests with some other exotic gas, unfortunately leading to worse results. The final measurements are carried out with a DC flow of nitrogen gas, on fig.3 we plot the total beam intensity versus the inverse of the measured particle velocity i.e. the jet density, and this, for different experimental conditions.

One experimentaly sees that :

- Lowering the temperature from a value of the order of 80K, it is worthwhile to have a DC nitrogen flow along with the temperature decrease.

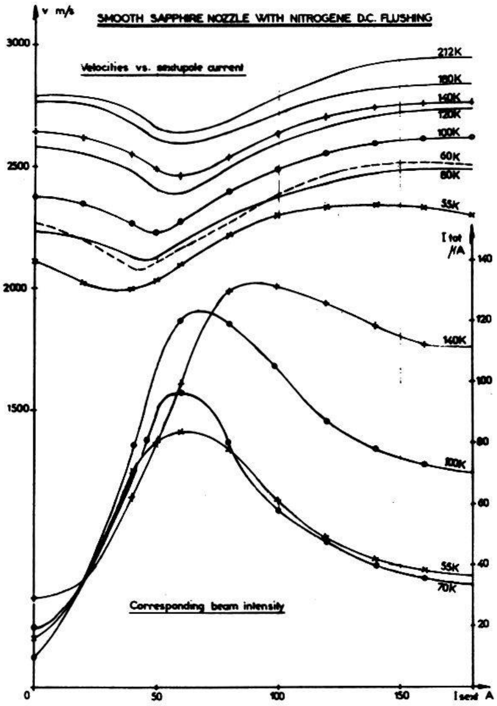

Fig.4 - Velocity measurements

- The surface of the nozzle keeps memory of the previous flow of nitrogen gas (conditioning). This can explain the discrepancies between some experimental points. Let us recall that on fig.2 we obtained different results regarding the path we chose (cooling down from 300 K or warming up from 40 K) fig.2.3 and fig.2.1

The velocities at this second maximum are now 2150 m/s instead of 1460 m/s expected. As seen on fig.4 from the measured velocities one can optimize the sextupole aperture.

A recombination effect seems to take place for particles having a velocity slower than 2000 m/s.

4. **Conclusions**

At a velocity of 2150 m/s corresponding to a current of 60 A in our sextupole, one can get with an additional nitrogen gas DC flow, an intensity of 190 µA polarised protons after 12 hours of stabilization instead of 65 µA without nitrogen, at the same velocity. Taking account of the performances at 2850 m/s, where the sextupole is well matched to the particle trajectories, one can find easily that with particles having a velocity of 2150 m/s the sextupole aperture might be increased by the factor $\frac{2850}{2150} = 1.33$. The corresponding beam intensity will be $190 \times \left(\frac{2850}{2150}\right)^2 = 335\ \mu A$

The sextupole current would be 120 x 1.33 = 160 A

At last, we recall that before making measurement with a sapphire nozzle, we used a pyrex nozzle having one bottle-neck and two tiny balls inside in order to generate turbulence. Comparable results to those with sapphire and nitrogen gas flow were obtained.

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