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SECONDARY EMISSION DETECTOR SYSTEM FOR SATURNE II

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Summary

We present a novel approach to beam profile monitoring around a 3-GeV accelerator (Saturne) based on a break-through in secondary emission hardware. Emphasis was set on minimizing multiple scattering so as to preserve the high quality emittance required for nuclear spectroscopy. The secondary emission material is plated by a photographic process as a grid of 0.1 to 0.3 micron thick aluminium or nickel on a Kapton substrate 7 to 10 micron thick. This method represents an order of magnitude improvement over detectors using solid strips of aluminium as far as beam disturbance is concerned.

I. Introduction

We have designed and tested a secondary emission monitor for use in transport of the extracted proton, alpha, or deuteron beam of the Synchrotron Saturne.

This detector provides a non-destructive simultaneous measurement of the vertical and horizontal position distributions of the beam.

The problem is to preserve the quality emittance required for experiences of nuclear spectroscopy, and however to conserve a simple and reliable mechanical technique.

II. Method of operation

The instrument is based on secondary emission effect, that is, the escape of electrons from the surface of materials bombarded with charged particles.

A grid of horizontal or vertical strips is placed in the beam and the number of emitted electrons is measured by integrating the residual charge of each strip with a charge-sensitive amplifier.

A positively biased collector collects the liberated electrons.

III. Design considerations and construction

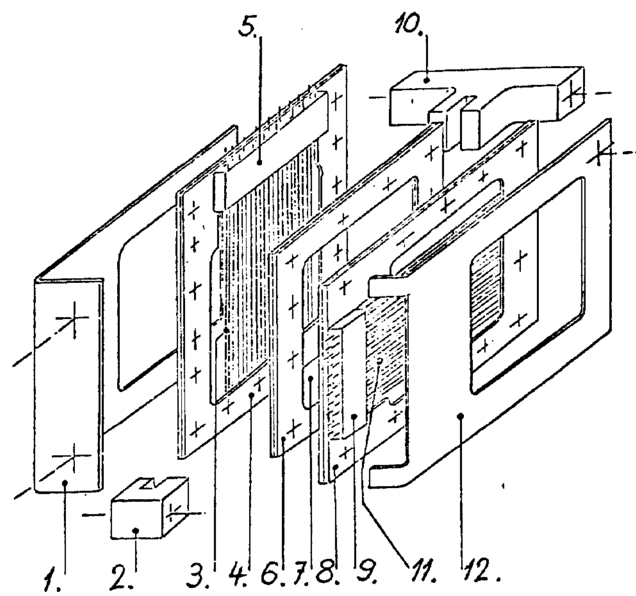
Strips of aluminum or nickel obtained by a photographic system are deposited on a Kapton foil a few microns thick (7). Typically, strips 1.5 mm wide, 0.1 micron to 0.3 micron thick and 0.5 mm spaced are easily obtained.

- Kapton foil is held between two inox pieces one millimeter thick (see fig. 1) To minimize electrostatic charge effects we have almost suppressed all insulating materials except very small pieces holding the three planes (vertical and horizontal strips and collector).

So stretching fragile strips a few microns thick is avoided, precision on strips position and reliability of the device are highly increased.

(We can have some microns of precision on a ten-centimeter strip length).

- The charge information is collected by a simple comb pressed against the end of the printed strips and processed by electronics.



1-12 INOX FRAMES, 2-10 HOLDING INSULATING PIECES, 3-7 KAPTON FOIL, 4-6-8 INOX FRAMES, 5-9 CONNECTOR, 11 ALUMINIUM STRIPS.

FIGURE 1

IV. Electronics

An operational amplifier (Intersil 8007) operates in integrating mode (see fig. 2) Capacitors C are charged by foils currents.

- RC constant is chosen to be shorter than the cycle period of the Synchrotron, and this prevents discharging the capacitors by a particular circuit after each burst.

Integrator outputs are sequentially interrogated, yielding the profile. Several measures can be made during the two-hundred millisecond beam spill.

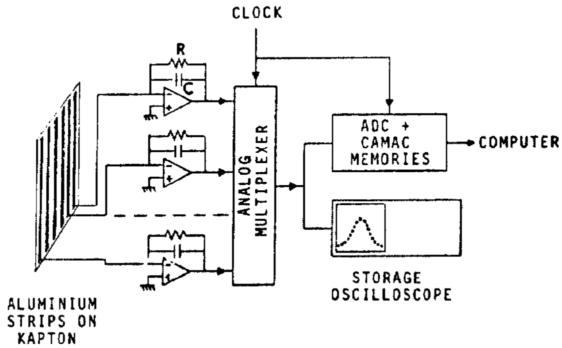


FIGURE 2

V. Performances of the monitor in a beam line

a) The monitor device mainly operates in secondary emission mode for pressures lower than 10^{-2} Torr ; above this pressure, ionization phenomenon becomes preponderant (see fig. 3)

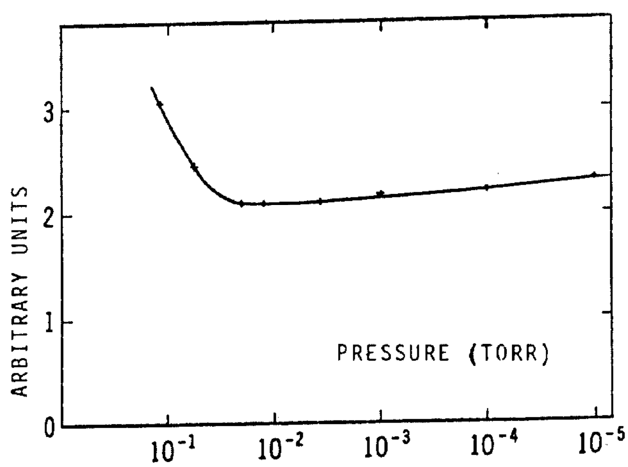


FIGURE 3

b) The monitor operates in a range of 10^9 to 10^{12} particules/burst. Fig. 4 shows beam profiles obtained in a flux of about 5×10^{10} protons of 1.6 GeV energy for differents focusing configurations in agreement with profiles obtained from ionization chambers.

Spatial resolution is about 1 mm.

c) Emittance increase

Fig. 5 shows the divergence increase calculated by Rossi's formula after a passage of the beam through the monitor. For instance, for the nominal emittance of Saturne II and the focusing configuration described here :

$$\begin{cases} \varepsilon_0 = 7.5 \text{ mm mrad} \\ \text{Divergence} = 1.5 \text{ mrad} \\ \text{width} = 5 \text{ mm} \\ \text{Energy} = 1.0 \text{ GeV} \end{cases}$$

The emittance growth is $\Delta\varepsilon/\varepsilon_0 = 2.3\times10^{-3}$.

- This small value allows us to have simultaneously several monitors in the beam to control it : the amount of matter per detector is about 1.8 mg/cm^2.

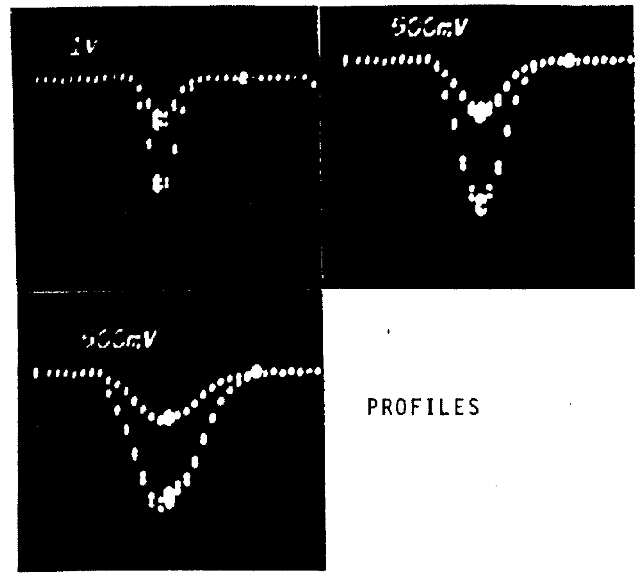


FIGURE 4

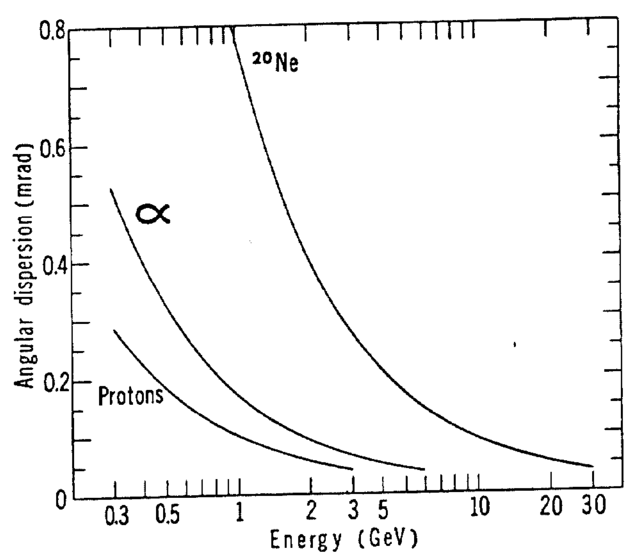


FIGURE 5

Conclusion

The characteristics of this kind of monitor allow their use even for low-energy beams (300 MeV) and medium heavy ions.

Because of the low cost and the simplicity of the device, it will be the basic extracted beam-detection system for Saturne II.