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HIGH ENERGY LOW INTENSITY BEAM PROFILE MONITOR

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Summary

The principle of this monitor - used in beam emittance measurements on transport lines - is based on secondary emission phenomenon in dielectric layers. Thin aluminium strips covered with low density KCl layer are used.

Measurements with electron beams in the range 150 to 400 MeV are made with foils and strips in the region of stable operation. Observations upon avalanche multiplications encountered are also reported.

1. Introduction

The high secondary emission yield reported by Goetze, Boerio and Green[1], and others[2],[3],[4] for low density KCl dynodes make their application interesting for the detection of low intensity beams. This yield as noted by different authors is dependent on collector potential, primary beam energy and intensity. The dependence of the secondary emission on these factors as well as its behaviour with high collector potential where avalanche multiplication processes build up, are observed. Results obtained on a low density KCl strip-monitor are presented.

2. Description of the monitor

The secondary emitter consists of a 5 cm diameter aluminium disk on which a half-micron thick aluminum conductive backing has been deposited. Low density KCl has then been deposited by evaporation at 4 Torr argon pressure. Quantities of KCl between 25 mg and 80 mg have been evaporated in order to compare different types of emitters. The emitter is introduced in an ion-pumped system with an aluminum foil to which it will be compared. The distance between the emitter and the collector is about 5 mm (fig. 1).

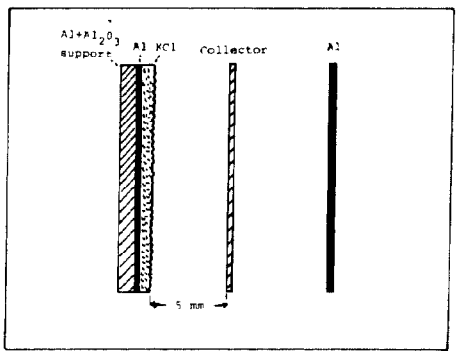


Fig. 1 : Cross-section of the monitor

3. Measurement technique

Measurements have been carried out in the 500 MeV end-station of the Orsay linac. A Faraday cup was used to measure the primary beam intensity. The secondary emission yield δ was obtained from the quotient of the integrated current leaving the KCl layer to the integrated current leaving the Faraday cup. When comparisons were made between emitters of different KCl weight, these emitters were installed in the same system.

4. Discussion on experimental results

Measurements made with up-stream and down-stream configurations did not show great differences in the results.

4.1 Dependence of δ on collector potential

As shown in fig. 2, we observed a nearly linear increase of δ with collector potential up to 120 volts. Above this value, the increase of δ could not be well defined : we observed avalanches phenomena. Observations within a fixed time on layers of different weights showed that :

- the avalanches observed as steps in the layer response (volts) during time integration are quite regular (fig. 3)
- the collector voltage at which avalanche multiplications occurred seems to depend on the thickness of the layers
- the average number of avalanches is an increasing function of the beam intensity and of the collector potential (fig. 4 and 5)
- the amplitude of the avalanches (volts) is a linear increasing function of the collector potential. It weakly depends on beam intensity (fig. 4 and 5).

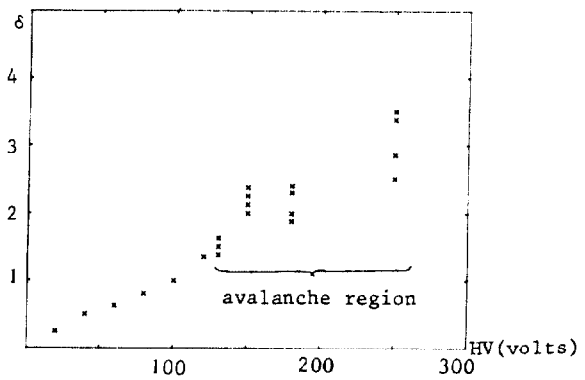


Fig. 2 : Dependence of the secondary emission yield δ on collector potential HV

4.2 Dependence of δ on primary beam energy

To observe the influence of KCl layer on this dependence, we measured the quotient K of the integrated current leaving the KCl layer to the integrated current leaving a 20-foils aluminum secondary emitter. Fig. 6 shows that KCl layer response slowly increases with beam energy.

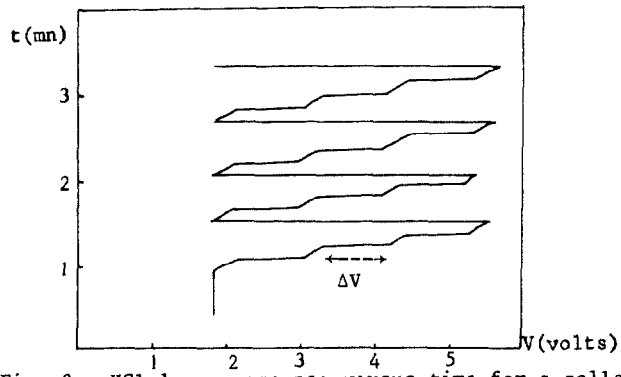


Fig. 3 : KCl layer response versus time for a collector potential of 350 V, a beam energy of 360 MeV and a beam average current of 200 nA.

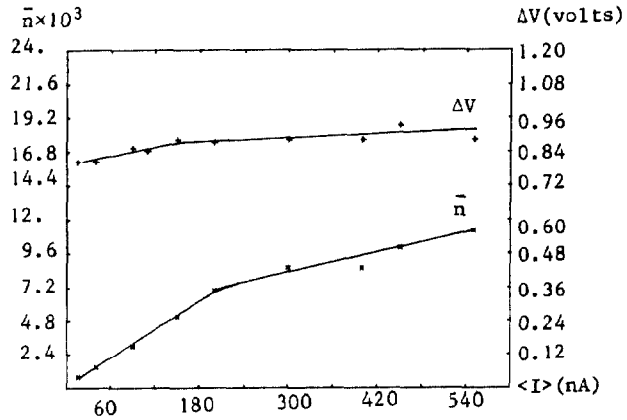


Fig. 4 : Influence of the average beam current on :
- average number of avalanches $\bar{n}$(×)
- avalanche step amplitude ΔV(+)

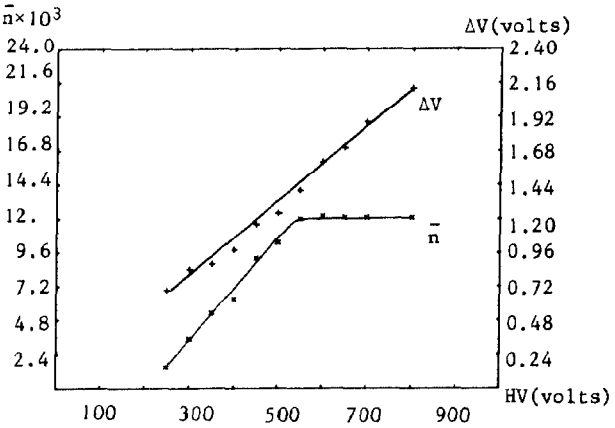


Fig. 5 : Influence of the collector potential HV, on :
- average number of avalanches $\bar{n}$(×)
- avalanche step amplitude ΔV(+)

4.3 Dependence of δ on beam intensity

Measurements made with beam average intensities between 1nA and 200 nA (fig. 7) show a very weak dependence of δ upon <I>. However, for very low intensities of the order of some nA the secondary emission yield seems to increase slightly as well as we are lowering the primary beam intensity

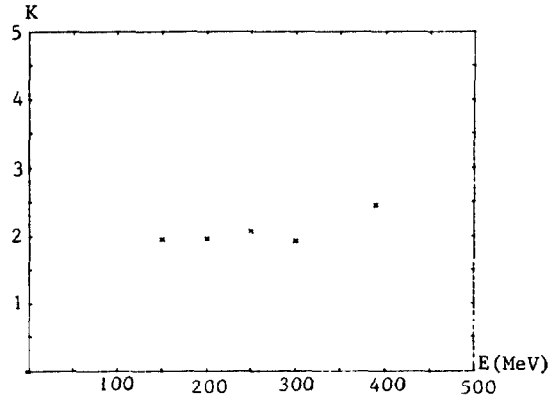


Fig. 6 : Beam energy dependence of the low density KCl monitor.

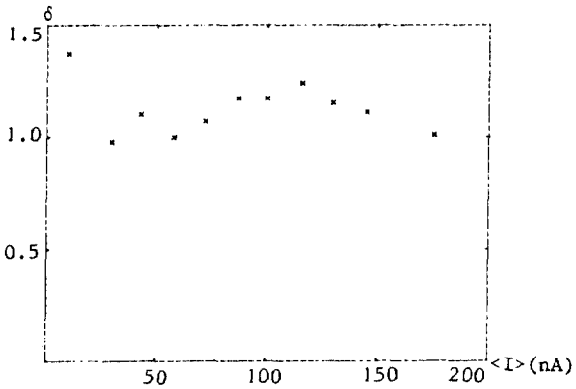


Fig. 7 : Beam intensity dependence of the KCl secondary emission yield.

5. Beam profile monitor

. Beam profile is measured with a secondary strip-emitter. This emitter consists of a 20 microns thick mylar disk on which 15 strips of half-micron thick aluminum conductive backing have been deposited. Low density KCl has then been deposited on the strips with the same method described above. Strip width as well as separation between strips is taken about two millimeters. The distance between KCl layer and collector is still five millimeters.

. For present electronic facilities, only five strips are connected to integration circuits. The integrated current leaving the KCl layer has been compared to the integrated current leaving the Faraday cup. The measurements are obtained as the strips are vertical ; profiles reported here concern horizontal distribution of charges in the beam. Potential collector has been maintained at 100 volts, integration capacities at 1 nF.

. Fig. 8 shows the beam profiles obtained for a weak current (10^8 e⁻/pulse) at two different positions of the strip-emitter. These positions are separated by 4 mm which is the distance between the middles of two neighbour strips. Part of differences between the two curves is due to the beam instability observed during the measurements. These results may be compared with the profile obtained with one strip removed in a

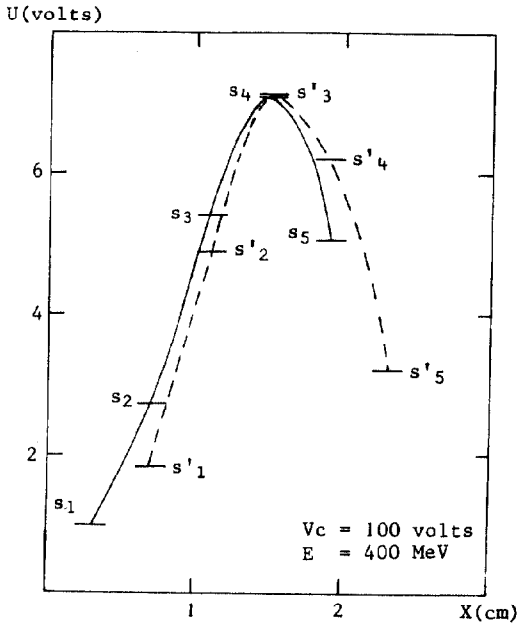


Fig. 8 : Beam profiles obtained at two different positions of the strip-emitter with an average beam current of 1 nA.

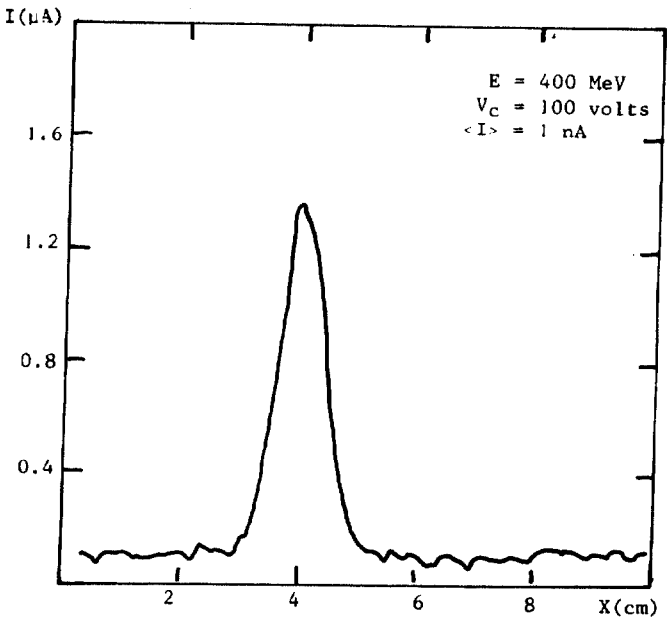


Fig. 9 : Integrated current record on one strip removed in the beam. One centimeter in this figure represents 1.6 cm of displacement. Integration gain is about 104.

direction perpendicular to the beam (fig. 9). Widthes measured on both types of profiles are in agreement with values obtained with slit measurements. It is obvious that large values of strip width chosen for present technological opportunity do not allow great precision in these comparisons.

6. Conclusions

Unfortunately we have not obtained with our KCl layers secondary emission yields as high as expected. This yield is measured between the unity and 1.5 in the region of stable operation. Layer thickness which is not well controlled is probably under its optimum value. However these yields make that monitor quite sensitive for low intensities and the results reported above clearly indicate that a strip-emitter of that kind is very promising for beam profile measurements. The bad resolution due to large strip width as well as large strip separation can be improved by the diminution of these quantities which is possible with the deposition method on mylar foil. The resolution can also be considerably enhanced by the use of camera tube techniques[6] replacing discontinuous strip lecture by electronic scanning of KCl target. This solution is up to now, under examination.

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References

1. G.W. GOETZE et al., Journal of Applied Physics, 35, 3 (1964).

2. D.McMULLAN et al., Advance in Electronics and Electron Physics, 28 A (1969).

3. E.L. GARWIN et al., Advance in Electronics and Electron Physics, 22 A (1966).

4. E.L. GARWIN et al., SLAC-PUB-623, July 1969.

5. C. NGUYEN NGOC, R. CHEHAB, M. PLAGES - Beam Profile Monitor - Report in preparation - Laboratoire de l'Accélérateur Linéaire, Orsay.

6. C. NGUYEN NGOC - NI/28-72 - "Anneaux de Collisions" Laboratoire de l'Accélérateur Linéaire, Orsay (1972)