EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-EP/81-132
23 October 1981

ELECTROSTATIC IMAGING OF MINIMUM IONIZING PARTICLES

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(Submitted to Nuclear Instruments and Methods)

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A recent work at CERN¹⁾ has demonstrated the feasibility of charged-particle trajectory imaging in gases by measuring the electric charges stored on insulating surfaces. This was illustrated with α -particles and with an amplification of the primary ionization by a factor of close to 10^3 with the help of a single-step parallel grid gap.

In view of the great interest attached to the accurate localization of minimum ionizing particles or single electrons liberated, for instance, by VUV radiation, we have verified the same concept of detection with a two-step gated avalanche chamber²⁾.

Minimum ionizing electrons from a ^{106}Ru source are detected by a scintillation counter after having traversed a conversion gap C, and triggered the gating grid G separating two amplifying gaps A₁ and A₂ (Fig. 1), with delays adjusted to the drift times in C, in D, and in A₁.

The electrons are collected on a 125 μm mylar foil F backed by a conductive layer of Sn_2O_3 . The experiments were performed in two gas mixtures: argon (97.5%) + propane (2.5%), and helium (93%) + methane (4%) + triethylamine (3%).

The gain permitted by the two-step amplification is sufficient for the convenient detection of minimum ionizing particles, and even single electrons as can be seen from our results.

1. Trajectories in argon-propane. When we trigger the gating grid after detection of one electron in the scintillation counter, we observe (Fig. 2) a rather wide track of 2.5 mm FWHM along the 5 cm of the sensitive length of the foil. The width is much larger than the resolution of our scanning device, which is the same as in Ref. 1: an electrostatic probe with a 0.6 mm hole, set at about 0.5 mm from the foil.

2. Trajectories in helium-methane-triethylamine. This gas presents the greatest interest; the primary ionization being only 6 ions/cm in helium, the distance between avalanches should make it possible to test the capability of detecting single avalanches. It is also used, in practice, for the imaging of VUV Čerenkov light.

This gas is favourable for high multiplications before reaching breakdown (which is a very great nuisance in our set-up, since every spark deposits a very broad splash of electrons on the mylar). Figure 3a shows the transverse scanning of a typical electron track over the total length of 5 cm of the sensitive region of the chamber. We observe gaps due to the low primary ionization power.

Figure 3b shows a transverse scanning of one avalanche in steps of 0.25 mm. We observe a FWHM of about 1 mm in both the lateral and the longitudinal dimension, which can be considered as the size of the image of a single avalanche in our set-up. The signal-to-noise ratio is still favourable enough to make the detection of single electrons easy, even if several electrons of a δ -ray contributed to the avalanche. Figure 3c shows the charge distribution along an electron track, clearly displaying the primary ionization distribution. The number of avalanches along a track is compatible with the expected primary ionization of 6 ions/cm, taking into account the limited resolution of our scanning set-up.

In conclusion, this further work confirms that at the present stage of electrostatic imaging, the detection of relativistic ionizing particles, in helium mixtures at atmospheric pressures, can be made feasible by combining it with multi-step amplification. The considerable accuracy of position measurement in a stored image could make this detector of interest for some specific applications.

However, the greatest prospects for this detector are still in the detection of particle trajectories in dense media, without any amplification. This requires some further new steps in the charge detection methods and is being actively investigated.

REFERENCES

- 1) G. Charpak, R. Bouclier, A. Breskin, R. Chechik and J. Lewiner, preprint CERN-EP/81-89 (1981), submitted to Nucl. Instrum. Methods.
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Figure captions

- Fig. 1 : Experimental set-up. The fast β -particles liberate electrons in the gas of space C. The electrons are multiplied in A_1 , drift in D, and are transmitted through the control grid G to A_2 , where they are again multiplied, transferred to T, and collected by F. The voltages V_1 to V_6 for the helium-methane-triethylamine gas mixture are -5400, -4400, -1800, 0, +2600, +3100, respectively; G is gated by pulses of ± 150 V on alternating wires. The mean voltage of G is -700 V.
- Fig. 2 : Electron track in argon. Argon (97.5%)-propane (2.5%) mixture. Transverse scanning of an electron track. The width (FWHM) is 2.5 mm. larger than the resolution of the scanning device (~ 0.6 mm).
- Fig. 3 : Electron track in helium. Helium (93%)-methane (4%)-triethylamine (3%) mixture.
- a) Transverse scanning in steps of 2 mm. Many holes are observed.
 - b) Transverse scanning, in steps of 0.25 mm, of an isolated avalanche.
 - c) Longitudinal scanning of an electron track. The longitudinal track over a length of 2 cm shows a number of separated avalanches, compatible with the scanning resolution and the primary ionization.

Fig. 1

Fig. 2

Fig. 3a

Fig. 3 (cont.)