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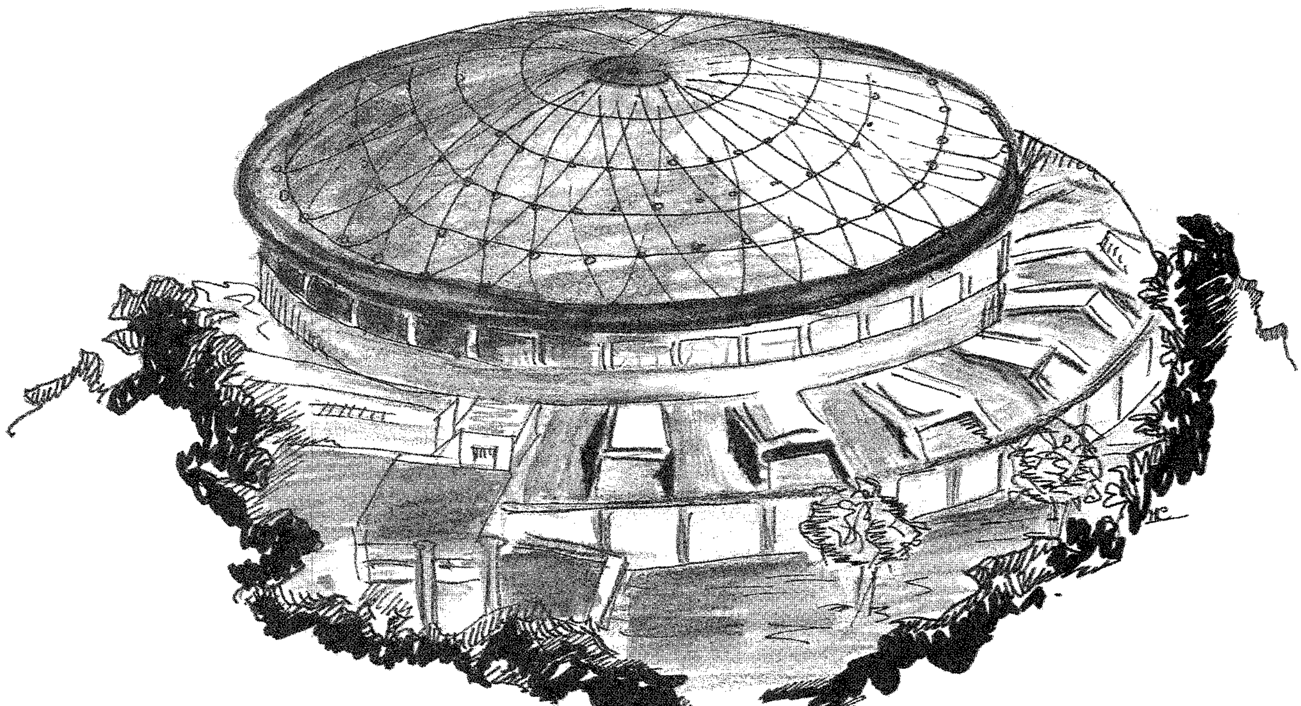
GLASS ELECTRODE SPARK COUNTERS



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GLASS ELECTRODE SPARK COUNTERS

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ABSTRACT

We have developed and investigated the behaviour of a spark counter based on low cost resistive glass electrodes.

INTRODUCTION

The need of large area detectors with a time accuracy of the order of only a few nanoseconds is foreseen in apparata for extensive air showers. They could also be used as external muon detectors in high rate environment, like future collider experiments.
In both cases the proposed detector must have uncritical conditions concerning high voltage, a high reliability, low cost of both the detector and front-end electronics.

Planar spark counters with very good time resolution (≤50ps) using semiconductive glass ($\rho \cong 10^9$-$10^{10}\Omega\cdot$cm) as electrodes have been developed in Novosibirsk(1). They are mainly used for particle identification at energies around 1GeV, but their relatively high cost and construction difficulty, due to the strict technological requirements (i.e. mechanical problems correlated with gaps of 100 - 200 μm and high gas pressure operation), make them unfeasible for very large area detectors.

A more simple (gaps of 1.5 - 2 mm and gas mixtures at atmospheric pressure) to construct planar counter, with a lesser time resolution has been developed(2) using bakelite

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[1] This work has been done in the framework of TESTE group activities.

($\rho \cong 10^{11} \Omega \cdot cm$) as resistive electrodes. However, a serious problem of this kind of detector is its noisy operation, probably due to the material used.

To overcome these problems we have developed a new type of detector with a gap of about 2 mm operated at atmospheric pressure and based on low cost resistive glass electrodes.

SPARK COUNTER PROTOTYPE DESCRIPTION

Two spark counter prototypes have been built; their cross section is shown in Fig. 1. The parallel electrodes are made of resistive glass with a volume resistivity of $6 \cdot 10^{11}$ $\Omega \cdot cm$, and a thickness of 2 mm. The external side of the glass is varnished by a solution of graphite in water, in order to supply high voltage. A glass-epoxy frame, 1.6 mm thick, 10 mm wide delimits an active surface of $10 \cdot 10$ cm^2. Due to the small dimensions and the good mechanical characteristics of the material used the chambers do not need extra spacers. The electrode transparency effect (3) allows the induced pulses to be read by pick-up electrodes (surface of $10 \cdot 10$ cm^2) placed on both sides of the chambers.

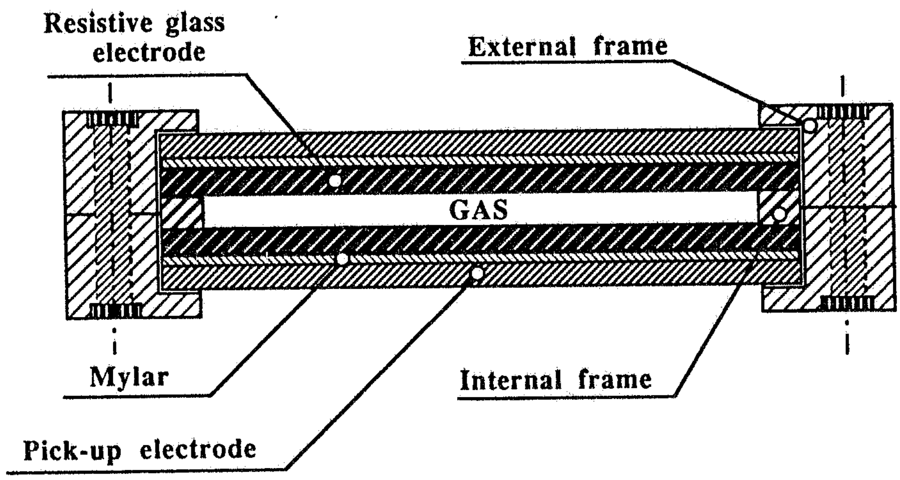

FIG. 1 - Cross section of the glass electrode spark counter prototype.

EXPERIMENTALS RESULTS

Fig. 2 shows the singles counting rate plateau as a function of high voltage, obtained with one of the two prototypes after a very short time of burning-in (some hours). The gas mixture used during these measurements is an Argon (60%) + C_4H_{10} (38%) + Freon 13B1 (2%). The discriminator threshold applied on the signal is 20 mV/50 Ω and the electronic dead time is 5 μs. A plateau width of about 700 - 800 V is obtained, showing the possibility of a wide noiseless operating range. It must be stretched in accordance with the main requirement for safe and uncritical operation. A spark threshold around 5.4 KV and a plateau knee near values of 5.9 KV are observed with both prototypes.

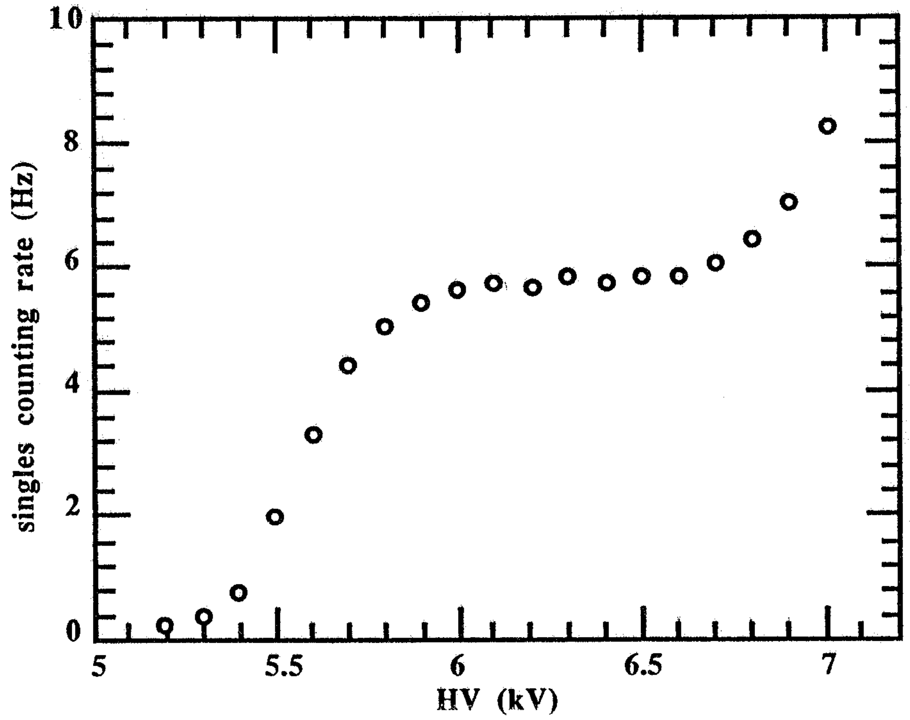

FIG. 2 - Singles counting rate as a function of high voltage obtained with a Ar(60%) + C_4H_{10}(38%) + Freon 13B1(2%) gas mixture, a 20 mV/ 50 Ω threshold and a 5 μs electronic dead time.

In Fig. 3 the average induced pulse on one pad at 6.4 KV is shown. The pulse amplitude is about 0.4 Volt on 50 Ω impedance. Due to the pad capacitance integration a pulse duration of about 100 ns with a rise time of about 5 ns is observed.

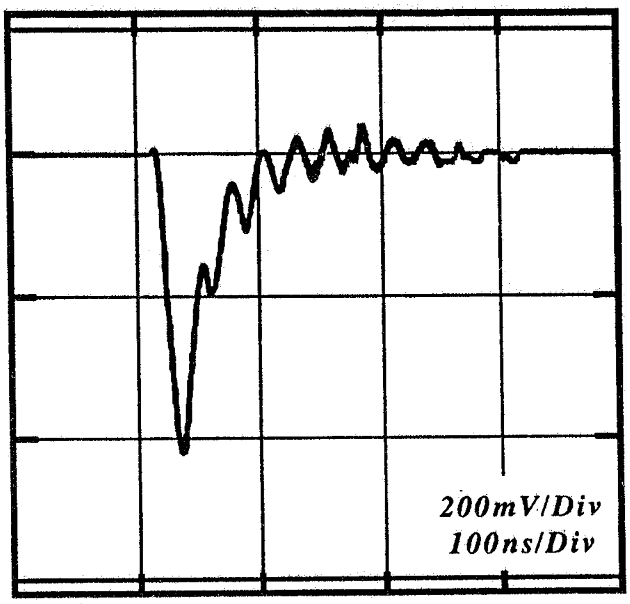

FIG. 3 - Average induced pulse on a pick-up pad; C_{pad} ~ 0.4 nF, HV = 6.4 KV.

The efficiency measurements were performed by using a cosmic rays trigger telescope consisting of three scintilator counters. The lowest one was shielded by 5 cm Pb layer in order to cut-out most of the cosmic ray soft component. The efficiency as a function of high voltage is plotted in Fig. 4. The knee of the plateau is around 5.9 KV, where a value of about 100% is reached.

A rough estimation of the glass electrode spark counter time resolution was obtained with cosmic rays by measuring the time difference between the discriminated pulses (5 mV / 50 Ω threshold) from a plastic scintillator (with a measured time jitter of 1.25 ns) and our detector prototype. Fig. 5, where the time resolution as a function of high voltage is reported, shows that in the plateau region a time resolution of the order of nanosecond is easily obtained. As expected the time resolution decreases very rapidly when the high voltage increases even though at higher voltages, due to the after-pulse production, a worsening in time performances can be observed. Further improvements in time resolution can be obtained using gas mixtures with higher photon quenching capabilities.

A quantitative measurement of the maximum tolerable rate, a more precise evaluation of the time of flight resolution and a detailed study of the influence of gas composition on the detector performances must be done in the near future, along with the construction and testing of a large area prototype.

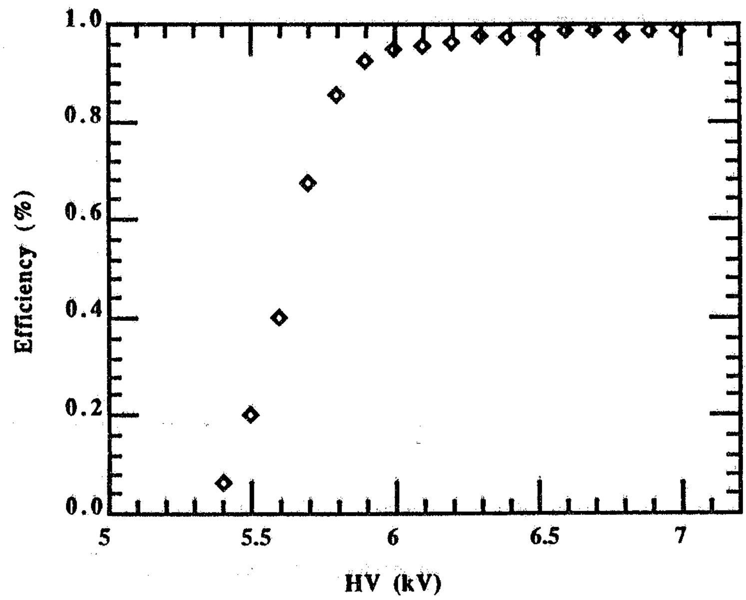

FIG. 4 -.Detection efficiency as a function of high voltage.

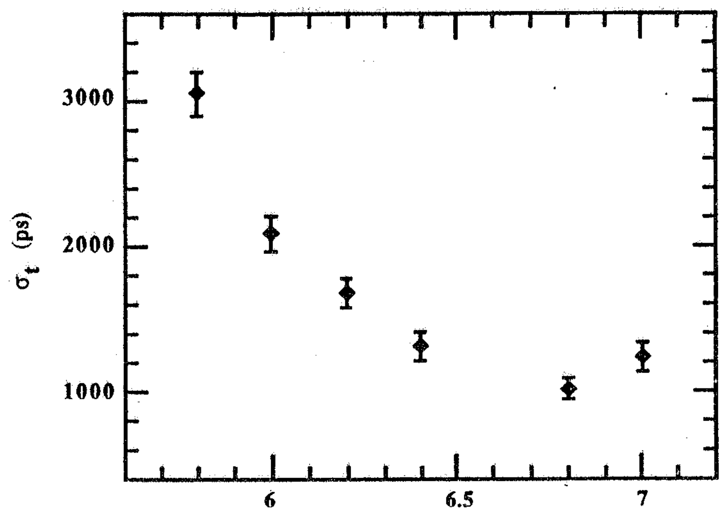

FIG. 5 - Time of flight resolution as a function of high voltage.

CONCLUSIONS

Our investigation demonstrates that it is possible to obtain noiseless spark counters with localized discharge using resistive glass as electrodes.

The advantages of this choice are manifold:

i) a wide and stable plateau region is obtained;

ii) a relatively short burning-in time compared with other materials is observed;

iii) since glass is characterized by good planarity therefore the mechanical support requirements are minimum.

Taking into account that the dead time τ of the spark counter with resistive electrodes depends on the electrode volume resistivity ρ and dielectric costant ε by means $\tau \equiv \rho\varepsilon$, an estimation of the maximum rate at which our spark counter prototypes could be operated is 10^3 - 10^4 Hz/m^2. That is they can be used in cosmic rays apparata as EAS array or in underground experiments.

For relatively high rate environments as the external parts of proton-antiproton collider detectors, resistivity at least one order of magnitude smaller are required. This can be done by adjusting in a suitable way the glass composition. In this respect work is in progress.

ACKNOWLEDGEMENTS

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