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Development of gaseous particle detectors based on semi-conductive plate electrodes

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Summary. — A new kind of particle detector based on a Resistive Plate Chamber structure is under development. Semi-conductive electrodes with resistivity up to $10^8\,\Omega\,\mathrm{cm}$ are introduced to improve the Rate Capability performance. In this paper some results on the configurations under test are described. The DC Voltamperometric characterization of a SI-GaAs sample measured applying metal electrodes on the substrate is also reported.

1. – Increasing the rate capability

When a particles flux Φ passes through an RPC detector [1], the simultaneous ignition of many unit cells occurs, whose cumulative effect causes a voltage drop on the electrodes described by eq. (1), with $\langle Q\rangle$ mean charge involved in a single process, Φ_{eff} number of process occurring in the detector per unit time and surface, ρ electrode resistivity, d electrode thickness

$$V - V_{\mathrm{gas}} = 2\rho d\langle Q\rangle\Phi_{\mathrm{eff}}. \tag{1}$$

To prevent the detector from losing efficiency as the flux rises, it is necessary to minimize the voltage drop on the electrodes. For this purpose in this test the combination of two strategies was used:

- Reduction of the average charge $\langle Q\rangle$ using a high Signal-to-Noise ratio charge amplifier [2].
- Replacement of standard insulating electrodes with Semi-Insulating electrodes with lower resistivity and thickness of $400\,\mu$m.

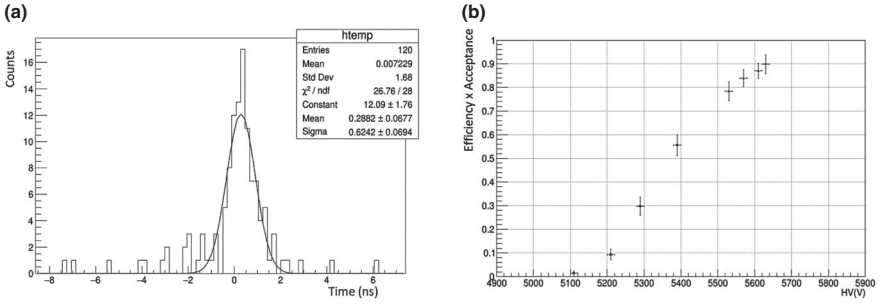

Fig. 1. – (a)Time difference with respect to the trigger detector [3] corrected for the Time Walk effect ($HV = 5630\,\mathrm{V}$) (b) Efficiency × acceptance, 450 MeV electrons, 1 mm gas gap.

2. – Experimental test

The prototype is made of two SI-GaAs electrodes spaced by a PET circular crown 1 mm thick. Both electrodes are 400 μm thick and have a resistivity on the order of $10^8\,\Omega\,\mathrm{cm}$. The gas gap is filled with a gas mixture consisting of TFE-iC4H10-SF6 (95%/4.5%/0.5%). The detector is placed in series with a 100 MΩ resistance in order to avoid that the power dissipated in the electrode, due to any shock related to edge defects, damage the crystal. The signal is read on a pad placed under the low-voltage electrode. The prototype characterization was carried out at the BTF of the National Laboratories of Frascati, using 450 MeV electron beam. The average multiplicity of particles per bunch was fixed at 0.3 for the whole duration of the test. In fig. 1 the experimental observations are shown. Taking into account the trigger time resolution of (180 ± 4) ps, a time resolution of (590 ± 90) ps was measured.

A second prototype with 1.5 mm gas gap, one silicon electrode and one SI-GaAs electrode, has been investigated with atmospheric muons. In this case a time resolution of (1.10 ± 0.09) ns was measured. These results provide a solid foundation for the development of new prototypes. Efficiency × acceptance curves, as well as the time resolution, are consistent with what observed in a standard RPC detector. For an experimental confirmation of the increase in terms of Rate Capability, a test with a source of photon has been planned.

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