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Accurate timing of gamma photons with high-rate Resistive Plate Chambers

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Timing Resistive Plate Chambers (tRPCs) are planar gaseous detectors made with resistive electrodes, accurately spaced, that define very thin gas gaps. Such detectors are known to provide timing accuracies around 50 ps sigma for minimum ionizing particles.

In practice, the counting rate capability of RPCs is strongly conditioned by the availability of suitable resistive materials for the electrodes. For many applications of tRPCs, e.g., time-of-flight measurements in heavy-ion high-energy physics, the extension of the counting rate capabilities achievable with glass electrodes, around 2 kHz/cm2, to much higher values is of fundamental importance. To address this issue we developed 9 cm2 single-gap tRPCs with electrodes made from metal and from a commercially available ceramic material with a measured resistivity of 109 Ω•cm and free of charge-depletion effects.

Time resolution tests were performed irradiating with simultaneous 511 keV photons from the annihilation of positrons emitted by 22Na. The time resolution remains essentially unchanged, at around 90 ps σ, up to 20 kHz/cm2 without any visible rate-induced efficiency loss. Previous experience with timing RPCs, tested both in particle beams and with annihilation photons, has shown that, while single-gap counters may reach a time resolution close to 50 ps σ in particle beams, similar counters irradiated with 511 keV simultaneous photons reach only about 90 ps σ. Such behaviour may be attributed to the different characteristics of the primary charge distributions resulting from each irradiation method.

The present result establishes the practical feasibility of accurate timing measurements with RPCs at rates up to 20 kHz/cm2, while keeping a time resolution below 100 ps σ.

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