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Understanding the ageing process in RPC materials from an ion conductivity approach

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Resistive Plate Chambers operating at high particle fluxes require the use of materials with a specific set of properties. At present it is believed that the dominant effect, for the case of sustained and homogeneous irradiation, is caused by the product of the plate thickness (d) times its resistivity (r) times the average charge per gap (q), as expected from the dynamic ohmic drop in a simple (stationary) DC model of the device as a whole. The first variable is much dominated by mechanics requirements and it is in fact changing little in typical designs, the latter is roughly fixed once the working mode is decided, so in practice one is left with only one parameter free for optimisation, the plate resistivity, that should fullfill the approximate phenomenological relation (F·r)<1-5 for timing RPCs, in order not to deteriorate the detector performances (F is the particle flux given in kHz/cm2 and r the resistivity in TWcm). Coping with particle fluxes as high as 20 kHz/cm2, as intended in the future CBM experiment at FAIR, will therefore require to work with materials having resistivities in the range r=0.05-0.25 TWcm or lower. It is, however, difficult to find 'well-behaved' materials in this range. For such purpose ceramic/metal composites have been essayed. Several electric measurements have been done on this system such as I/V curves, impedance spectroscopy and ageing, and we have found evidences of ion conductivity at high values of the electric field. In this sense, the RPC plates under high irradiation have been compared with the electrical response of a classic solid electrolyte in order to understand the ageing phenomena. Thus, simple estimations can be made for determining the maximum RPC working time before instabilities related to electrochemical breakdown appear. Several solutions will be proposed in order to span the RPC lifetime.

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