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Heavy-ion test of detectors with conventional & resistive MicroMegas used in TPC configuration

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Within the international FAIR project, the R3B collaboration (Reaction studies with Radioactive Relativistic beams) will be in charge of the physics program with secondary beams of energy between 200 & 1500 MeV per nucleon. Central to the R3B set-up will be a large-aperture superconducting magnet under construction at CEA-Saclay. A European collaboration has formed to work on the design of a large time-projection chamber (TPC) to be installed behind this magnet to cover the full phase-space of the charged fragments produced in the target, from protons to beam heavy ions. The goal of this detector is to provide particle identification from energy-loss measurements & tracking for each individual fragment, event by event.Within this work, we have performed tests of detector prototypes with the heavy-ions beams of GSI (Darmstadt, Germany) from 12C to 179Au & from 250 to 1000 MeV per nucleon. These prototypes were equipped with MicroMegas, with two amplification technologies, either conventional or resistive MicroMegas & two construction concepts, bulk-MicroMegas or micro-meshes screwed on the PCB. The resistive MicroMegas exhibit a major interesting feature for our application: a large transversal & in-time spread of the heavy-ion signals, making possible the linear amplification & collection of huge signals.
During the presentation, we will report on our heavy-ion test results & the position resolutions already achieved & present the following steps of the study of the TPC.

Summary (Additional text describing your work. Can be pasted here or give an URL to a PDF document):

Our collaboration is focused on the conceptual design of a time projection chamber (TPC) to be installed on the R3B set-up (Reaction studies with Relativistic Radioactive beams) of the future international FAIR facility (Facility for Antiproton & Ion Research). Such a detector will cover the entire phase-space sampled by charged fragments produced in the target in front of the R3B-GLAD large-aperture dipole magnet by primary or secondary beams This magnet is under construction at the CEA-Saclay. On an event-by-event basis, it will provide physicists with the tracking information of each fragment (positions & angles) as well as charge identification.

This charge identification has to be done on a range of fragments from protons (Z=1) to uraniums (Z=92) by integration of the energy loss on the track lengths inside the active volume of the detector. For such almost-minimum ionising particles, the range in fragment charges produces a dynamics of the primary signals to be collected by the detector of almost 1:10,000. Taking into account the transport properties of the magnet & the multiple scattering from the target point to the detector, the position reconstruction in this TPC has to be performed with a resolution of 200 micrometers (RMS). Moreover, because of the large dimensions of the volume to be covered by this TPC behind the large-aperture magnet (a width of approx. 8 meters, a length between one & two meters & a height of 1.8 meters), it is essential to reduce as much as possible the number of channels to reduce its price, all the more as the track density is rather low. It is therefore of great importance to be able to work with charge collection pads as wide as possible, & as long as possible.

Within this design study, we have performed heavy-ion tests of small detector prototypes equipped with MicroMegas signal amplification, either "classical" or resistive MicroMegas. We have used the relativistic heavy ion beams of GSI (Darmstadt, Germany): 12C, 58Ni & 197Au at energies of 1 GeV per nucleon for the first two & at 250 MeV per nucleon for the gold beam.

Our set-up was made of two pairs of scintillators (paddles of 10 cm width & height active areas or "fingers", 10 cm long & 1 cm wide) to provide the DACQ trigger. In between these two pairs were installed 3 or 6 detector prototypes, depending on the test. These prototypes were read-out using flash-ADCs, which provided us with the full time-dependence information of the signals of the tracks going through the detectors.

The prototypes consisted of plastic boxes, with thin entrance & exit windows equipped with a PCB & a cathode plane, in order to produce the drift field. The PCBs were either only segmented charge collections on which an independent micromesh was screwed or bulk MicroMegas. For bulk MicroMegas, we tested "classical" MicroMegas or resistive MicroMegas. The PCBs were produced at CERN. The MicroMegas were used, thus, in TPC mode

The charge collecting surface was roughly 5 x 5 cm2. The pads were either 835 micrometer wide or 5 mm wide, separated respectively by 65 micrometers or 150 micrometers. They were 5 cm long. The preamplification was provided by a discrete electronics developed for the Kaon spectrometer of the NA48C experiment (Kabes) and adapted to our specificities. The detector gas was either P10 (90 % argon, 10 % methane) or different "magic" gas mixtures.

Our first test was to measure the position resolution, in heavy-ion beams, of detector prototypes (trackers) with classical MicroMegas equipped with 835 micrometer-width pads, to be used as a reference. These trackers exhibit position resolution in-between 80 & 120 micrometers (RMS). In a second test, we measured 5 mm-wide pads equipped with resistive MicroMegas along with 835 micrometer-wide trackers, three classical & one resistive. We could determine from this test a position resolution of 200 micrometers for the 5 mm-wide pads.

During our presentation, we will show our results for the first time. We will have the opporrtunity to present our project & discuss the next steps of the design study towards a complete definition of the detector.

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