High efficiency Transition Radiation Detectors for high rate environments

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The Transition Radiation Detector considered to be implemented in the CBM experiment at the future FAIR facility at GSI Darmstadt will be used for particle tracking and identification of high energy electrons and positrons for J/Ψ meson reconstruction [1]. The specific challenge for such a detector in the CBM experiment is the high granularity and a good performance in a high counting rate environment.

Based on the experience of the TRD for ALICE [2] and of the TRT for ATLAS [2], various prototypes of fast Multiwire Proportional Chambers (MWPC) [4] -[7] were designed, built and tested. Up to intensities of 100 kHz/cm^2, no major deterioration of the performance has been observed. However, this performance of the prototypes was reached decreasing drastically the conversion efficiency of the transition radiation in a single layer of such a MWPC based TRD. In order to circumvent this aspect, we designed and built a few prototypes of TRD based on double sided pad read-out electrode. The main idea is to increase by a factor of ∼2 the conversion efficiency obtaining the same performance and number of read-out channels of the protypes mentioned above. This can be reached by symmetrizing the counter structure relative to the readout electrode using a double sided pad-plane electrode. A sketch of the counter structure and a photo of the prototype is shown in Fig.1. The anode-cathode gap and the anode wire pitch

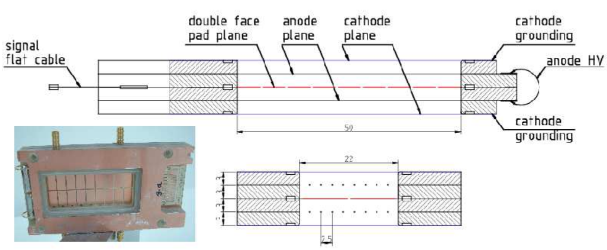

Figure 1: Exploded view of the counter structure

were kept the same as in the former, one sided, prototype built by us [5], i.e. 3 mm and 2.5 mm, respectively. The pad size is 5x10 mm^2. Three versions of such prototypes were built. The first one, used to test the functionality of such a structure, has the intermediate read-out electrode made out of a PCB with two rows of 9 pads on either side. The prototype was tested using ^{55}Fe source. Custom built charge-sensitive preamplifier/shapers were used to process the detector signals which were digitized by an AD811 peak sens ADC. In Fig.2 we show the energy spectra of ^{55}Fe source taking the signal from the anode wires (Fig.2a)) or from the pads (Fig.2b)), respectively. These results indicate that the counter can be operated as designed. In order to test the performance of such a structure even for low energy X rays, a second prototype was built in which the middle electrode was made out of mylar foil of 3 μm thickness, aluminized on both sides. The energy resolution for an ^{55}Fe source is shown in Fig.2c). The observed 12.5% resolution is mainly due to the high capacity of the intermediate electrode, the pad size being equal to the counter surface ∼22 x 50 mm^2. For such an intermediate electrode the measured transmission is 98.5%. All these measure-

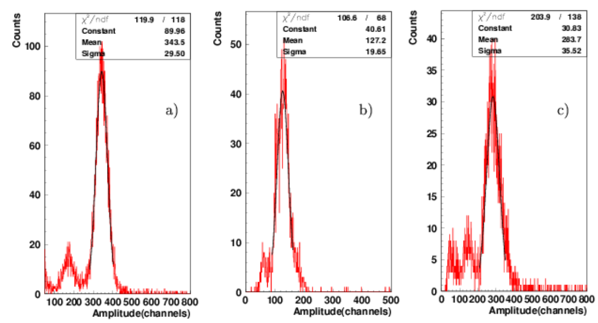

Figure 2: Energy spectra of ^{55}Fe source

ments were performed at 1700 V anode voltage using an Ar/CO$_2$(70%/30%) gas mixture. The third prototype, ready to be tested, combines the features of the previous two, i.e. the double sided pad read-out electrode is obtained by etching the pad structure on a double sided copperized kapton foil of 25 μm. Based on detailed measurements done with the ALICE-TRD configuration [2], these prototypes would have a TR conversion efficiency of more than 80% relative to the ALICE-TRD counters which have a drift zone of 30 mm, for Xe/CO$_2$(70%/30%) gas mixture. In-beam tests will be done in the near future at GSI-Darmstadt. In conclusion, this type of TRD is recomended as a candidate for the TRD subdetector at small polar angles, where the counting rate could exceed 100 kHz/cm^2, with particle densities of about 0.05/cm^2. High efficiency is important in order to reduce the number of electronic channels and the overall material budget.

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References

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