Progress on simulation and first prototype results on a beam monitor based on MPGD detectors for hadron therapy

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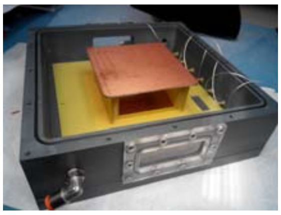
INTRODUCTION

Remarkable scientific and technological progress during the last years has led to the construction of accelerator based facilities dedicated to hadron therapy. This kind of technology requires precise and continuous control of position, intensity and shape of the ions or protons used to irradiate cancers. Patient safety, accelerator operation and dose delivery should be optimized by real time monitoring of beam intensity and beam profile before and during the treatment, by using **non-destructive, high spatial resolution detectors**. For this purpose, the authors have studied and developed an innovative beam monitor based on Micro Pattern Gaseous Detectors (MPDGs) called TPC-GEM (TPG) detector, characterized by high spatial resolution and rate capability.

THE TPC-GEM DETECTOR PROTOTYPE

A GEM based beam monitor has very good spatial and time resolution but a suitable beam monitor should also perturb as little as possible the beam characteristics. A TPC-GEM (TPG) detector, due to the low amount of material (the radiation length is of the order of fractions of the percent) in the active volume, is "not invasive", therefore the beam characteristics are preserved, so minimizing the uncertainties on beam position, intensity and stability. The TPG (Fig. 1) prototype consists of a drift volumes of 40 × 100 × 100 mm^3 with a uniform electric field produced by a field cage (100 µm diameter wires with a pitch of 2 mm) having the shape of a cuboid, and two transparent sides orthogonal with respect to the beam direction, to reduce the beam degradation as much as possible. The sides parallel with the beam are printed circuits boards on which the wires are soldered. The detector is completed by three GEM foils, such that the two transfer gaps are 1.6 mm wide and the induction gap is 2.1 mm wide. The read-out electrode is divided into pads, there are two available geometries: 60 × 2 pads of 5 × 1 mm^2 and 30 × 4 pads of 3×3 mm^2. The detector is filled with a gas mixture of Ar and CO_2 (the percentages used are 70%-30%, 80%-20% and 90%-10%).

Fig. 1 TPG prototype. The beam crosses the detector through two mylar windows.



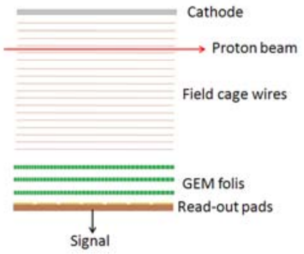


Fig. 2 TPG prototype schema.

STUDIES AND EXPERIMENTAL TEST IN PROGRESS

Simulations of the beam monitor prototype based on Garfield++ Monte Carlo simulation code and ANSYS software were carried out to optimize the geometrical set up and to predict the behavior of the detector. In the following some results about the field cage electric field simulation (Fig. 3), the potential profile in the drift region (Fig. 4) and the charge amplification inside the chamber (Fig. 5).

Fig. 3 Field cage electric field computed with ANSYS

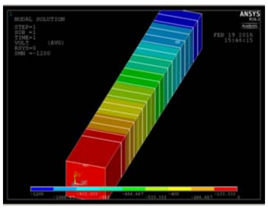


Fig. 4 Electric potential in the y-z plane

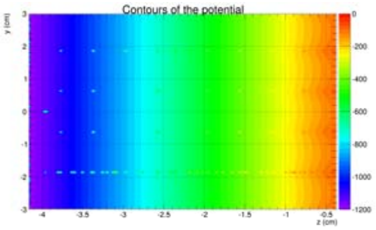
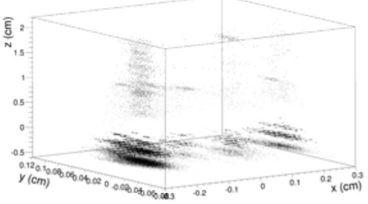


Fig. 5 Charge amplification inside the TPG simulated with Garfield++.



A beam monitor characterization using X-rays is being finalized, here we show preliminary experimental results :

Fig. 6 Rate obtained for Ar/CO_2 (70:30) gas mixture as a function of transfer field.

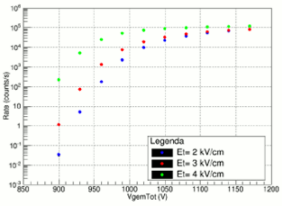


Fig. 7 Read out cluster size.

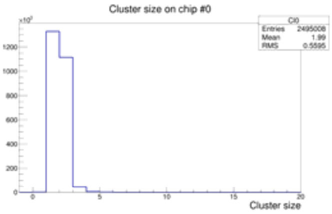
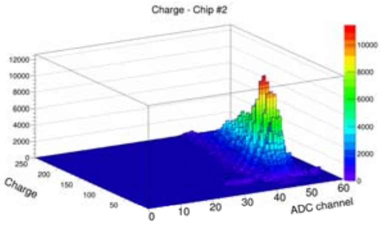


Fig. 8 Read out charge distribution.



A performance test using a therapeutic proton beam is foreseen in the near future.

CONCLUSIONS

The TPG chamber presented is an example of technology transfer from high energy physics to medicine, in particular to cancer therapy. Such a detector can, from the medical point of view, improve the accuracy and quality of the treatment by **increasing patient safety and so minimizing any associated risk. Moreover, since the spread of hadron therapy is still limited by the high cost of the technologies required, the TPG detector can fulfill the present research and technology challenge to reduce the costs and increase the availability of particle treatment.**