NEW BEAM PROFILE MONITOR BASED ON GEM DETECTOR FOR THE AD TRANSFER AND EXPERIMENTAL LINES

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Abstract

Many multi-wire proportional chambers, (MWPC's), are installed on the CERN Antiproton Decelerator (AD) transfer and experimental lines. They are used for the steering and profile measurement of the low energy antiproton beam that is extracted at the energy of 5.3 MeV from the AD machine. At this very low energy the standard MWPC's are not only destructive for the beam but also perturb strongly the 2D profile measurement. These chambers are also based on technology that is outdated and in recent years have shown to be fragile and expensive to repair. For these reasons a new profile monitor, based on a Gas Electron Multiplier (GEM) detector is under development as a possible replacement of the MWPC's. This new profile monitor will enable high precision, true 2D profile measurements of the low energy antiproton beam. In this paper, we present the modification of the standard GEM detector required by our specific application and the first results of the profile monitor with antiproton beams.

INTRODUCTION

On the extraction lines of CERN's antiproton decelerator (AD), beam profile measurements are made using MWPC chambers. The technology of these chambers is such that, at the energy of concern (5.3 MeV), the antiprotons are anihilated in the first H-plane so that measurements made in the downstream V-plane are drastically perturbated. The use of GEM based detector is aimed to avoid such a drawback.

The relatively simple construction of the GEM chambers also make them a good candidate for HEP extraction lines.

After having recalled the GEM principle and detector arrangement, we present the first test measurements made in the laboratory. In a second step, preliminary results obtained on the AD and SPS transfer lines are given and commented.

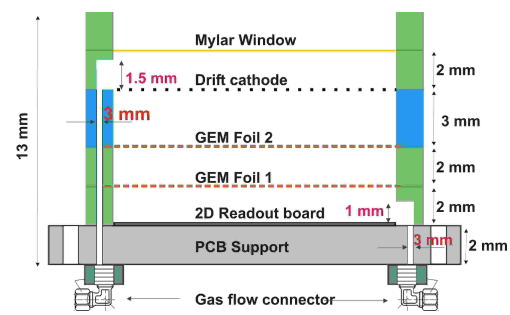
GEM BASED PROFILE MONITOR

GEM detector

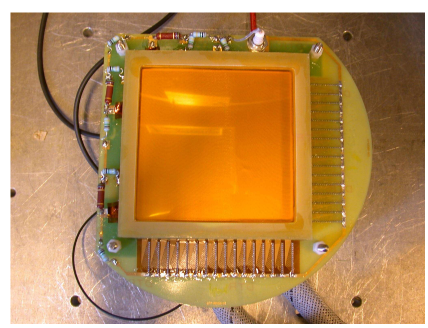
A micro pattern gaseous detector operating as a gas electron multiplier (GEM) has been introduced in 1996 by Sauli (CERN) [1]. A GEM consists of a double sided thin metal-clad polymer foil, perforated with a high density of chemically etched holes (typically ten thousand per square centimeter). On application of a potential difference between the two sides, the foil acts as a charge multiplier for electrons produced by ionization in the gas. A patterned charge-collection anode permits the detection and localisation of the primary ionization [2, 3]. The GEM chamber is an assembly of a window foil, a drift cathode, 1,2 or 3 GEM foils and a readout plane on a substrate with a set of resistance network to apply the specific high voltages to the differents stages of the chamber.

GEM Profile monitor

Although GEM detectors have been developped for HEP experiments like for COMPASS at CERN [4], we here propose to use them for beam profile measurements as previously done for MWPC's. Some modifications of a standard GEM detector has been done for this purpose :



(a) double GEM chamber drawing



(b) triple GEM chamber photo

Figure 1: The GEM Profile monitor.

- ⋄ A reduction of matter seen by the beam using a 50 μm micro-mesh nickel layer with more than 80% transparency for the particle as drift cathode.
- ⋄ The GEM chamber should be compatible with the existing electronics for the old MWPCs. Different adapters have been developped to ensure a flexible use of the chamber for the CERN AD, PS and SPS beam lines.
- ⋄ The chambers have to also fit into the specific mechanical installations (support and dimensions etc...) available for the MWPC's on the AD, PS and SPS beam lines.

Fig. 1(a) shows a drawing of a double GEM detector. Below (Fig. 1(b)) is an image of the triple GEM chamber with its circular shape to fit with AD mechanical conditions. The GEM foils as well as the nickel micro-mesh drift cathode and the 20 μm Mylar window have a active area of $100\mathrm{mm} \times 100\mathrm{mm}$. They are glued on respectively 2 mm, 3mm and 2mm thick $124\mathrm{mm} \times 124\mathrm{mm}$ frames and then glued together (Fig. 1(a)) to the readout board that consists of 2D cartesian pick-up strips ([3]) with a pitch of 400 μm. This gives 256 strips per plane on a 2 mm thick semicircular subtrate. The width of the upper electrode strips is 80 μm and 340 μm the lower plane. The 256 strips on each plane, are later regrouped four by four into 64 channels by the means of an adapter board. All the elements of the chamber have been made at CERN and the GEM foils are standard at the CERN store.

TEST & MEASUREMENT

Description of the chamber

So far, two GEM chambers have been built. One is a double GEM chamber installed in a vacuum tank on the AD/DEM beam line and the second is a triple GEM for the SPS North Area M2 beam line in air. Construction and preliminary tests have been done with the collaboration of Fabio Sauli and Leszek Ropelewski from CERN/PH/TA1/GDD section. The validation tests for GEM chamber are described in [5].

Gain uniformity

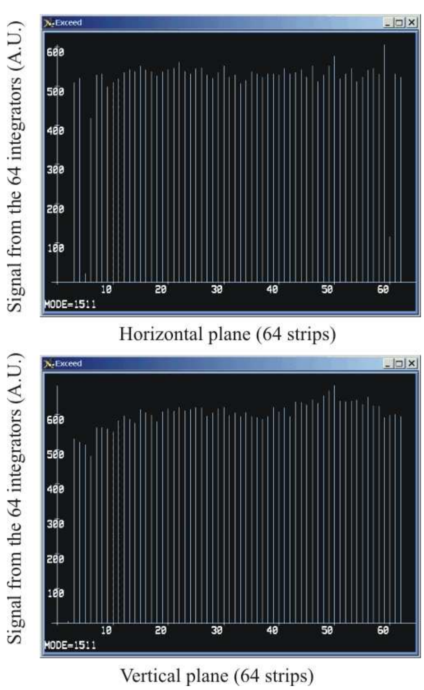


Figure 2: Gain uniformity of the triple GEM monitor with a 70/30 $\mathrm{ArCO_2}$ gas mixture. Irradiated by $90^{\mathrm{S}}\mathrm{r}$.

Gain uniformity tests have been performed in our section CERN/AB/BDI/EA. The GEM chamber, under a 70/30 Argon-CO2 mixture gas flow, was irradiate by a ^{90} Sr source. The charges received by the 64 channels on each plane were collected by 64 integrators of the existing test bench for the MWPCs

Fig. 2 shows a good gain uniformity for both horizontal and vertical planes for the triple GEM chamber with a high voltage of 386 V on each GEM foil, a drift field of 2280 V/cm and a transfer and induction field of about 3420 V/cm. An equal sharing of the charges between the superimposed readout planes can be observed.

Double GEM chamber on AD/DEM beam line

In Fig. 3, we show the horizontal and vertical profiles from the AD/DEM low energy antiproton beam with the double GEM prototype. The AD beam has an energy of about 5.3 MeV, the extraction time is about 200 ns for the 10^7 particles which leads to a high instantaneous intensity current such that the gaseous detector works in ionisation mode only. The H & V profiles from the GEM chamber

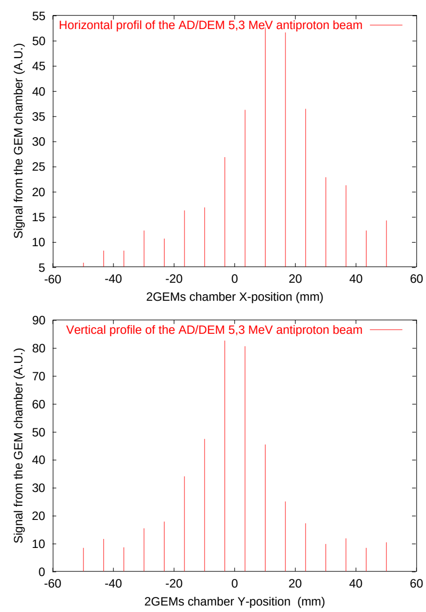


Figure 3: Profiles from a double GEM monitor on the AD beam line.

are quite good. Nethertheless, in the AD beam conditions it would be more appropriate to use a single GEM chamber as we do not need electron multiplication.

Triple GEM chamber on SPS North Area M2 beam line

Fig. 4 shows the H & V profiles from the triple GEM chamber on the SPS North Area M2 line. The beam is a secondary hadron beam (65% of protons, 32% of pions and 3 % of kaons) with an intensity of about 5 10^5 particles per 2.5s spill and an energy of 190 GeV. For this we,

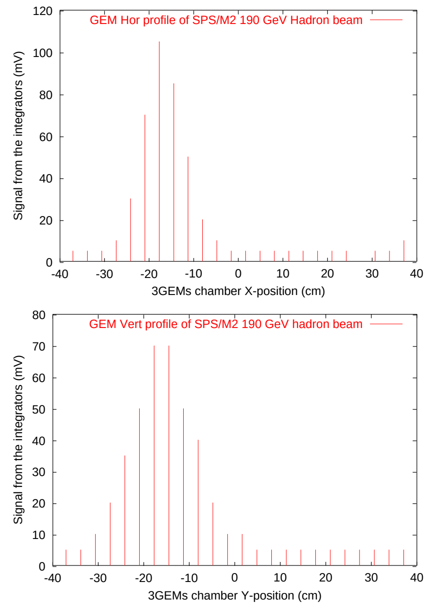


Figure 4: Profiles from a triple GEM monitor on the SPS/M2 beam line.

once again, used the existing analog electronics used for the MWPCs with 32 integrators for each plane. The measured profiles are quite consistent with the ones obtained from the two FISCs (filament scintillators [6]) placed just in front of the triple GEM chamber (Fig. 5). We also notice a shift of the center compared with the profiles from the FISC due a misalignment of the GEM chamber's active area compare to its fixation points.

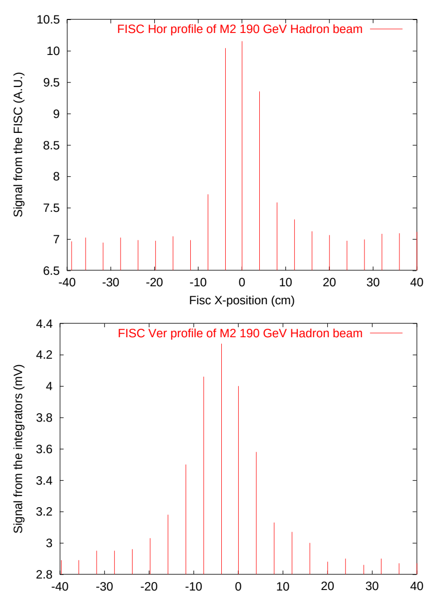


Figure 5: Profile from two FISC on the SPS/M2 beam line

DISCUSSION & PERSPECTIVES

The first results from the AD/DEM suggest that a single GEM chamber is more adapted to these instantaneous intense beam where only ionization mode is needed to avoid saturation. Thus an appropriate choice of the voltage for the different stage of the GEM chamber will enable to optimize the signal shape by reducing the charges scattering. A single GEM prototype, under construction, is going to be installed in the AD/DEM line for more advanced tests and performance comparison with the standard MWPCs.

For the high energy, the first results are also promising for triple GEM chamber. A chamber with a larger drift region should be built to enable higher gain when one wants to work at low intensity beams. For high energy beams the drift cathode could be made of plain aluminium as the matter is less perturbating for the profile.

CONCLUSION

We have designed and constructed a new beam profile monitor based on GEM detector technology as an alternative to MWPCs used on the CERN AD, PS and SPS experimental and transfer beam lines. This new chamber allows a more precise beam profile measurement at low energy than a conventional MWPC. The first results obtained from tests on two different beam conditions (AD low energy and high intensity antiproton beam, and SPS at higher energy hadron beam) are quite promising. More precise measurements are foreseen for the coming months in order to compare profiles from GEM chambers with conventional MWPCs ones.

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