First Test of the PixelGEM Detector in High-Intensity Beams ◇

B. Ketzer, A. Austregesilo, F. Haas, I. Konorov, M. Krämer, A.B. Mann, T. Nagel, and S. Paul

1. Introduction

COMPASS (**CO**mmon **M**uon and **P**roton **A**pparatus for **S**tructure and **S**pectroscopy) is a two-stage magnetic spectrometer, built for the investigation of the gluon and quark structure of nucleons and the spectroscopy of hadrons using high-intensity muon and hadron beams from CERN's Super Proton Synchrotron (SPS) [1]. The first phase of data taking between 2002 and 2006 was mostly dedicated to studying the spin structure of the nucleon by scattering a polarized beam of 160 GeV/c μ^+ from a polarized deuterium target. After an upgrade of the spectrometer in 2005, the spin program has been completed in 2007 by taking data with a polarized proton target.

From 2008 onward, experiments with a hadron beam of $2 \cdot 10^7$ particles/s are foreseen to perform spectroscopy of mesons and baryons in the light quark sector. These experiments require the tracking of charged particles scattered by very small angles with respect to the incident beam, calling for fast detectors with good resolution in space and time in order to disentangle pile-up and multi-track events inside the primary beam. Further demands of the high hadron flux density are radiation hardness and minimal material in order to avoid secondary interactions. This task will be performed by a set of triple-GEM [2,3] beam trackers with a hybrid readout structure, consisting of pixels in the central region and strips in two orthogonal projections in the periphery ("PixelGEM").

2. The PixelGEM Detector

The readout structure has been realised on a polyimide printed circuit foil of only 100 μm total thickness with three conductive layers. The pixel size has been chosen to be 1×1 mm^2, which constitutes a compromise between the spatial resolution achievable and the number of readout channels. A 2-D strip readout structure with a pitch of 400 μm surrounds the pixel area. In total an active area of 10×10 cm^2 is covered using 2048 readout channels. Analogue readout by the APV25 ASIC has been chosen in order to profit from amplitude measurements which help to improve the spatial resolution by clustering neighbouring hit strips or pixels. The total amount of material of the detector exposed to the beam corresponds to only 0.4% of a radiation length X_0 or 0.1% of an interaction length λ_I.

3. Results from Beam Test

A prototype detector was built and installed in the COMPASS spectrometer in 2006 in order to prove the stability of the detector and to assess its performance in high-intensity muon and hadron beams. To this end the detector was placed upstream of the target in the immediate vicinity of a beam telescope, made up of 12 planes of silicon microstrip detectors and two planes of scintillating fibers, providing precise reference tracks.

The detector was characterized using a high-intensity 160 GeV/c muon beam with a local flux density of up to $1.2 \cdot 10^5$ μ/mm^2/s, as well as with a 190 GeV/c pion beam with a local flux density about 5 times lower than with the muon beam. Fig. 1 shows beam profiles measured in the pixel region of the detector prototype for these two cases.

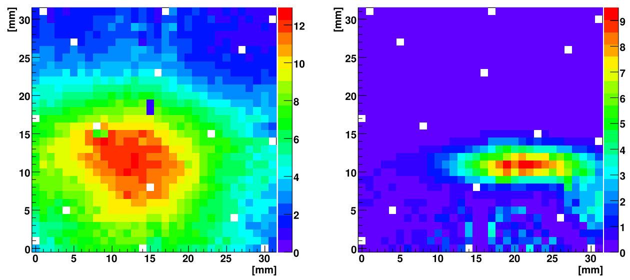

Fig. 1: Beam profiles as measured by the PixelGEM detector in the high-intensity muon bem (left) and in the pion beam (right).

Figure 2 shows the distribution of spatial residuals along one coordinate of the pixel region, obtained with the low- and high-intensity muon beam, respectively, for each hit pixel (histogram) and for adjacent hits combined to clusters (histogram).

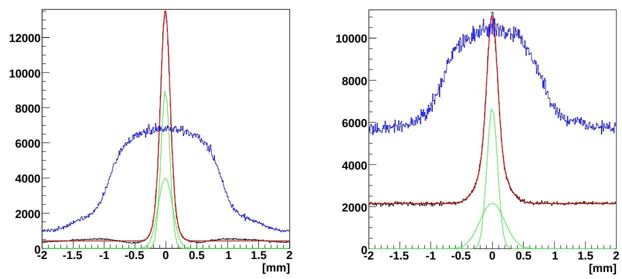

Fig. 2: Distribution of residuals along one coordinate of the pixel region for each hit pixel (histogram) and for clusters (histogram).

The beneficial effect of the clustering is clearly seen. In the low intensity beam a spatial resolution of 90 μm is achieved for the pixel region. At full intensity the resolution is lowered to a value of 135 μm mostly due to pile-up of out-of time tracks. No electrical instabilities or discharges were observed during these tests, making this type of detector a promising candidate for a low-mass, radiation-hard beam tracker in high-rate hadron beams.

References

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