The PixelGEM Tracking System for the COMPASS Experiment ◇

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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].

For the hadron spectroscopy program, which was started in 2008, hadron beams of $2.5 \cdot 10^6$ particles per second were used. The study of mesons and baryons in the light quark sector requires precise tracking of charged particles scattered by very small angles with respect to the incident beam. Detectors with a high resolution in space and time are necessary to disentangle pile-up and multi-track events inside the primary beam. During previous years, scintillating fibre detectors were used for tracking of the beam. Due to their high material budget of $1.0-1.5\,\%$ interaction length (λ_I) they caused a large number of secondary interactions in a first pilot run in 2004 and were to be replaced by thinner detectors.

GEM detectors with a two-dimensional strip read-out have been used in COMPASS since its start-up [2]. These gaseous detectors have proven to be able to cope with the high particle fluxes in the beam centre, but the strip read-out makes it impossible to separate individual hits close to the beam due to a too high occupancy. For the hadron run in 2008 GEM detectors with a novel kind of read-out and a thickness of only $0.2\,\%\,\lambda_I$ were developed.

2. The PixelGEM Detector

The read-out structure has been realised on a polyimide printed circuit foil of only $100\,\mu m$ total thickness with three conductive layers. The inner $32 \times 32\,\mathrm{mm}^2$ are covered with pixels of $1 \times 1\,\mathrm{mm}^2$, the rest of the active area of $100 \times 100\,\mathrm{mm}^2$ is covered with a two-dimensional strip read-out. A total of 2048 channels per detector is read out with the analogue APV25-S1 ASIC. Three signal amplitudes saved per event and channel are used to improve the spatial and temporal resolution of the detector.

A first prototype of this detector has been successfully tested in muon beams with fluxes of up to $1.2 \cdot 10^5\,\mu/\left(\mathrm{mm}^2\mathrm{s}\right)$ [3].

3. Performance in 2008

Five detectors, built and tested at TUM, were set up in the spectrometer. A detailed analysis has been performed for reduced beam fluxes of $3.5 \cdot 10^3\,\pi^-/\left(\mathrm{mm}^2\mathrm{s}\right)$ [4]. Spatial resolutions in the order of $90\,\mu$m and temporal resolutions of 8.5 ns were obtained at these low intensities (Fig. 1). Efficiencies, corrected for background due to picking up uncorrelated combinations of hits and tracks or due to noise, above 99 % are reached.

A higher background probability degrades the performance when using higher beam fluxes of $2.4 \cdot 10^4\,\pi^-/\left(\mathrm{mm}^2\mathrm{s}\right)$ as they are used for physics data taking. This part of the analysis is still ongoing, but first results indicate that an efficient replacement for the old beam tracking system was built. Spatial resolutions around $135\,\mu$m, temporal resolutions below 10 ns and efficiencies above 97 % are reached.

The observed performance within the spectrometer is in good agreement with results obtained for the tests of the prototype. The five detectors were a very important part for a successful beam time in 2008. Their good performance and small material budget was crucial for the quality of the data taken.

References

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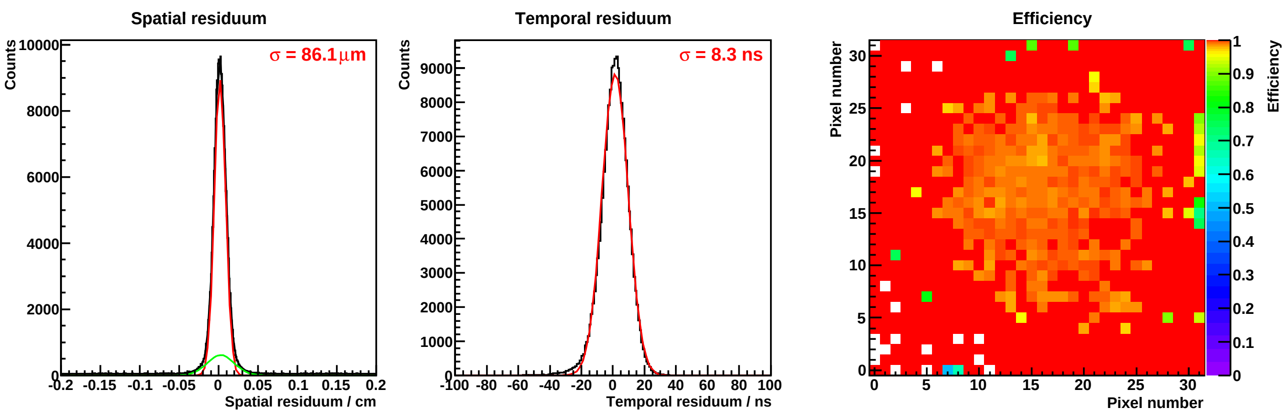

Fig. 1: Spatial residuum in one projection, temporal residuum and efficiency of one of the pixel detectors at intensities of $3.5 \cdot 10^3\,\pi^-/\left(\mathrm{mm}^2\mathrm{s}\right)$.

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