Introduction

GridPix detectors are micro Time Projection Chambers (μTPCs) with a pixel chip as readout anode. It measures the 3D positions of single electrons from ionization by ionizing particles (fig.1). The readout of a GridPix detector is a TimePix chip [11] controlled with Pixelman [2] software. The chip was developed at CERN and is based on the Medipix2 [3] design. The TimePix chip has 256x256 square pixels with a pitch of 55 μm. Each individual element of the pixel matrix is connected to a preamplifier, discriminator and digital counter integrated on the readout-chip.

Since the base TimePix chip is not able to measure charges of single electrons, a grid has been placed on 50 μm pitch (fig.1, left). The grid is a layer of 1 μm thick aluminum with holes etched in it. Between the grid and the chip the electric field (6000 V/cm) is large enough to create avalanches, to generate enough charge to be measured by the chip. A Si3N4 protection layer is placed over the pixels to avoid damage from possible discharges. The individual drift electrons from the ionizations are focused into the grid-holes and their avalanches are measured by the readout pads of the chip.

The electron drift time is measured by an internal counter, that can be started by an external trigger to obtain an absolute time measurement.

Gossip (Gas On Slimmed Silicon Pixels)

Gossip [4] is a GridPix type detector with a 1 mm gas layer, that is recently approved as candidate inner tracker for the upgrade of CERN’s ATLAS experiment. The drift gap size is minimized to have a drift time below 25 μs, corresponding to the LHC bunch crossing frequency, to separate events and to have a detection efficiency for Minimum Ionizing Particles (MIPs) of ~99%. The detection medium of GridPix detectors is gas, which has a negligible mass and is radiation hard, rather then silicon detectors.

The position resolution in the chip plane is dominated by both the pitch and drift electrons suffering from diffusion. Diffusion is strongly affected by the electric field and the type of gas. The diffusion of CO2/DME (50:50) is found to be ~30 μm/μm cm at E=6000 V/cm (fig. 2). The ionization rate for MIPs is about 4 ionizations/mm resulting in ~100 μm/mm.

Novel Applications

- Polarized X-ray detection: GridPix detectors are considered to be used in measuring polarized X-rays for astrophysical purposes. A gas molecule in GridPix emits a photoelectron in a preferred direction depending on the direction of polarization of the incident photon according to figure 3 (left). From the 3D track of a photoelectron the direction of polarization can be reconstructed.

- Electron Emission Foils (EEF): Studies are done to improve the yield of GridPix detectors with electron emission foils. Inside a material an interaction of MIPs results in electron emission. The -Electron Emission Foils (EEF): Studies are done to improve the yield of GridPix detectors with electron emission foils. Inside a material an interaction of MIPs results in electron emission. The EEFs might also find their application in novel ideas like an electron multiplier.

Simulations

In order to study the performance of Gossip with a 1 mm gas layer in ATLAS, several simulations for 100 GeV muons are done in Garfield [6]. To simplify the calculations the electric field in Gossip is assumed to be homogeneous. Figure 4 shows the position resolution from simulations, in addition figure 5 shows both the track and electron efficiency, as function of the angle of the muon track and the pitch.

In the testbeam period of August 2010, four GridPix detectors have been tested in a 150 GeV muon beam (Fig. 6, left). The measurement was triggered by two scintillators connected to photomultiplier tubes. The four GridPix detectors are read out simultaneously by one readout device (Muros), that sends the data to a DAQ PC. The simultaneous read out gives the opportunity to correlate the measurements without discrepancy (Fig. 6, right).

The analysis of the testbeam data is work in progress, the eventual goal is the comparison of the results with simulations and establish whether the detector behaviour is as expected. Both the spectrum of the number of electrons per event as well as the time spectrum can be understood with the results of the simulations. Figure 7 (left) shows the measurement for different grid voltages in the testbeam, the tails at lower voltages are explained in fig.2 (right). Figure 7 (right) shows the comparison of the number of electrons per event from the testbeam with the simulated spectrum.

Conclusions

The raw testbeam data agrees with the expectations. Both the spectrum of the number of drift electrons and the time spectrum show agreement with the simulated data. All chips survived over a period of 2 weeks in the beam with large electric fields, obviously the protection layer did the right job. Further steps for the analysis will be related to the understanding of the data and the correlation of the tracks in the four detectors e.g. resolution and efficiency. In addition, gas parameters like ion and electron drift velocities, diffusion and ionization loss need to be determined. In conclusion, the data is expected to give large amounts of information for further development of the detector.

References