Performance of a Gridpix detector based on the TimePix3 chip

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Abstract

Abstract goes here

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1. Introduction

In the context of a Time Projection Chamber for a future linear collider a gaseous pixel detector is developed based on the TimePix3 chip. The Gridpix single chip detector discussed here, allows for a detection of single electrons with a granularity of 256×256 pixels of size $55\,\mu m \times 55\,\mu m$. By counting the number of single electrons, the number of clusters can be estimated allowing for a rather precise measurement of dE/dx.

Since the invention of the device [1, 2], a series of developments have taken place that culiminated in GridPix detectors using the Timepix1 chip [3]. In this paper the results using a TimePix3 chip will be described. In the design of the detector special attention has been given to minimize the distortions in the pixel and drift plane in order to meet the tracking precision needed for a TPC at a linear collider. The device can also be applied for medical imaging, proton radiotherapy and used in other particle physics experiments [4]. Here testbeam results taken at the ELSA facility in Bonn will be presented. The results using this device in a laser setup were presented at TIPP17 [5].

2. Description of the Gridpix device

A Gridpix is a gaseous pixel detector [3]. It consists of a Timepix3 chip with a $8\,\mu m$ thick Silicon-Rich Nitride protective layer, and $50\,\mu m$ high SU8 pillars

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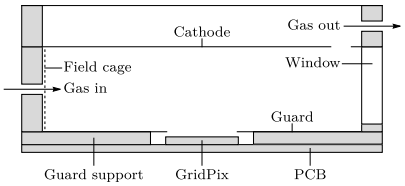

Figure 1: Timepix3 Gridpix no laser

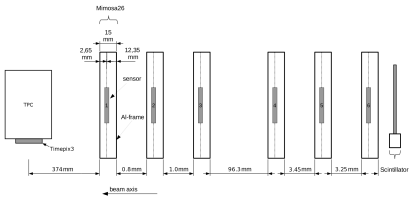

Figure 2: Setup with telescope. (Image to be modified)

that support the 1 µm thick Al grid with 35 µm holes aligned to the pixels. The growing of the protection layer of Timepix chip has been further optimized at the Fraunhofer Institute for Reliability and Microintegration (IZM) in Berlin, making the device more spark proof. An ionizing particle will liberate electrons in the TPC drift volume that will drift towards the grid and enter the avalanche region. The avalanche yields an electronic signal on the pixel. The Timepix3 chip consists of 256×256 pixels of size $55\,\mu m \times 55\,\mu m$. It has low noise ($\approx 70$ e-) and allows per pixel for a precise measurement of the arrival time using a TDC (clock frequency 560 MHz) as well as the time over threshold.

For the read-out the SPDR sofware is used [6]. In figure 1 a cross-section of the Gridpix detector ($14.1\,mm \times 14.1\,mm$) located in a small drift volume is shown. The box has length of 69 mm, a width (not shown) of 42 mm and a height of 17 mm. The beam enters the drift volume through the window from the right side. The electric drift field is defined by a series of parallel strips in the cage and is about 280 V/cm. On the guard plane - located 1 mm above the grid - a voltage is applied that matches the grid voltage.

3. Testbeam description

1. Description of the beam, detectors and setup beam - Telescope - Grid pix, figure 2
2. Trigger and readout
3. Data taking conditions We use a premixture consisting of 95 % Ar, 3 % CF_4, and 2 % iC_4H_{10} which we call *T2K TPC gas*. HV T p Gas mixture etc.
4. Method of Track reconstruction (figure 3?) Alignment planes

Table 1: run parameters

Length	60 minutes
Triggers	4 733 381
V_{grid}	350 V
E_{drift}	280 V/cm
Rotation	17 degree
	0 degree
Threshold	800e

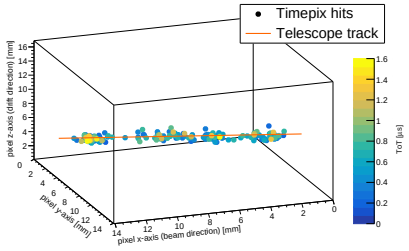

Figure 3: Track display

4. Testbeam results

1. Table with selections 2
2. nr of hits on a track (figure 4) efficiency of the detector
3. ToT correction, Timewalk correction figure 5
4. hit resolution in pixel plane, figure 6
5. in drift plane, figure 7
6. deformations in the pixel (figure 8) and drift plane (figure 9)
7. results for dEdx: combine e.g. 25 events

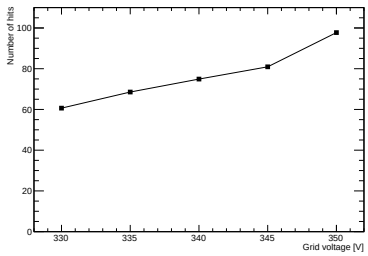

Figure 4: Number of hits. Image to be updated to include both hits in detector and hits in track

Table 2: Selection

Telescope
At least 4 planes hit
Reject extreme outliers ($> 700\ \mu m$)
Telescope fit goes through tpc
Timepix3
Hit ToT $> 0.15\ \mu s$
At least 30 hits
Exactly one cluster
Cut hit outliers ($> 3\sigma_{drift}$, $> 2\sigma_{plane}$)
Fit goes through front and back (pixel row)
Matching
Fits closer than 1 mm in both x and y at center of tpc
A unique time match
Delta rejection
At least 75% of total number of tpc hits in fit

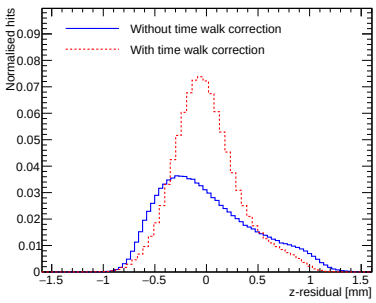

Figure 5: Timewalk correction

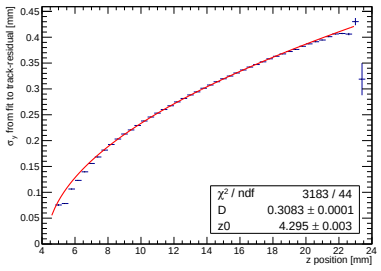

Figure 6: hit resolution in pixel plane

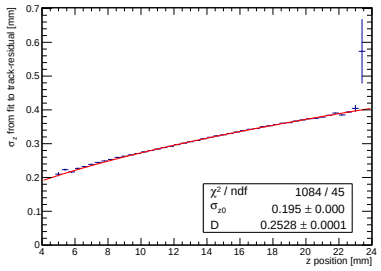

Figure 7: Hit resolution in drift direction

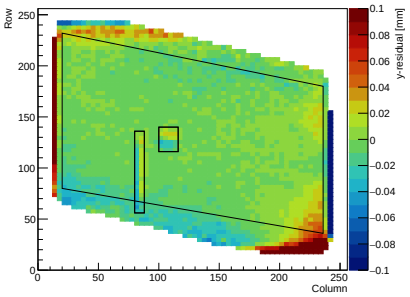

Figure 8: Caption

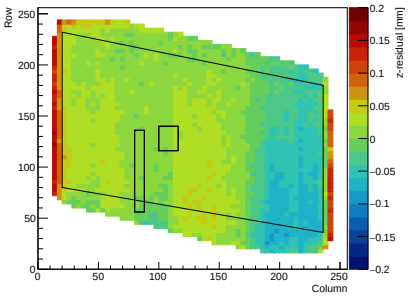

Figure 9: Caption

5. Conclusions and Outlook

next step construction of larger size detectors

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