The ILC DEPFET Prototype: Report of the Test Beam at CERN 2008

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The DEPFET Collaboration pursues the developm ent of a high resolution pixel vertex detector for future colliders (like ILC), based on the integration of am plifying transistors into a fully depleted bulk. In August 2008, six DEPFET prototypes were tested in a pion beam at SPS com plex at CERN, collecting m ore than 20 m illion of events. In this contribution, the prototype system, the experim ental setup, the analysis software and prelim inary results are presented.

1 Introduction

DEPFET (DEpleted P-channelField E ect Transistor) based detectors are currently developed for X-ray astronom y [1], biom edical autoradiography [2] as well as for vertex detectors in future e^+e^- colliders. The latter application requires excellent vertex reconstruction and e cient heavy quark avour tagging using low momentum tracks. These requirements im pose unprecedented constraints on the detector: H igh granularity, fast read-out, low material budget and low power consumption. Measurements on realistic DEPFET prototypes have demonstrated that the concept is one of the principal candidates [3, 4] to meet these challenging requirements.

2 DEPFET principle and operation

In the DEPFET active pixel detectors [5], each pixel consists of a p-channel Field E ect Transistor integrated in a fully depleted bulk. Free charge carriers created in the substrate by ionizing particles drift towards a deep in plant underneath the transistor channel. The charge trapped in the internal gate modulates the transistor current. Thus, the amplication of the signal is achieved in the sensor. A fler read-out the accumulated signal is removed from the internal gate by applying a positive voltage on a clear contact. A matrix of DEPFET pixels is read out using the rolling shutter concept [6].

3 The ILC prototype system

The ILC DEPFET prototype system consists of two mayor parts: The hybrid and the r/o boards. The hybrid board hosts the DEPFET matrix (128x64 pixels, from the most recent production PXD5), two steering chips (the so-called C lear/G ate Switchers that address the rows for read-out and clear) and the readout chip (CUrrent R eadOut, with on-chip pedestal substraction). The readout board takes care of the con guration of all the chips, the digitization and storage of the analog data as well as the communication with the PC (wich runs the DAQ program) via an USB board. This prototype system is analog to the one used in past Test B eams [7] [8].

On behalf of the DEPFET collaboration.

4 TestBeam atCERN

In August 2008 beam test measurements were carried out at the SPS complex at CERN, using 120 GeV/c pions. All the modules in the beam test have been fully characterized using laser and radioactive sources and the electrical settings optimized for the best performance. The setup is shown in the Figure 1. 5 DEPFET planes (matrices with 128x64 pixels of size 32x24 m² and 450 m thick) were used as telescope, to reconstruct the tracks and pre- Figure 1: The set-up of the DEPFET teledict the impact position in the Device Under scope in the CERN SPS H6B area Test (DUT). In the middle of the telescope,



the DUT (128x64 pixels, size 24x24 m², 450 m thick and working fully depleted) was placed in a rotating m otorstage. The synchronization of all the system wasm ade by a TLU (Trigger Logit Unit) [9].

5 Prelim inary results

The data from the 2008 test beam were analyzed using the software fram ework developed by EUDET [10]. The DEPFET raw data were converted from a proprietary form at to the standard Linear Collider I/O (LC IO) form at, pedestal and common mode corrections were applied, the signal on adjacent pixels was clustered. The position of clusters was determ ined using the center-of-gravity method with an -correction. The alignment of the telescope modules was determined using the Millipede algorithm [11]. Finally, the position of the particle on the DUT is predicted using a track t to the telescope hits.

The result obtained for the signal collected in a 3x3 cluster for norm al beam incidence is shown in Figure 2. The most probable deposited charge of a M IP is s 1700 ADC units. Combining this value with an average noise of s 12.5 ADC units, the signalover noise ratio (SNR) is 135 for a DUT of 450 m (g $_{\rm q}$ 360pA/e).

A typical residual distribution (the difference between predicted position and the DUT measurement) is shown in Figure 3. The width of this distribution is a measure of the intrinsic DUT resolution, but also receives sizeable contributions due to multiple scattering and the resolution of the telescope. The width of the residual distribution was measured to be 1.94 in the y-



Figure 2: Signal collected by a 3x3 cluster for normal incidence of 120 GeV/c pions on a DEPFET DUT in nom inal conditions. 7 and 3 cuts for seed and neighbours.

direction and 2.84 mm in X. The di erence between the results in both coordinates is due to the rectangular pixels in the telescope.

6 Conclusions

A telescope m ade up of six DEPFET planes from the PXD5 sensor production was operated successfuly in the SPS beam line in August 2008. On the 450 m thick device under test with $24x24 \text{ m}^2$ pixels the most probable signal was found to be 17000 ADC units, compared to a pixel noise of 12.5 ADC counts. The intrinsic resolution of this device was found to be better than 1.94 m. The analysis is in progress and nal results will be presented in a future.



7 Bibliography

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