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A pixelated Telescope for the E.U Detector R&D

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Abstract

A beam telescope with up to six sensor planes based on monolithic active pixel sensors is currently constructed and evaluated within the EUDET collaboration. The telescope is lightweight, moveable and can be operated in magnetic fields of up to 1.2 T. It provides a convenient test environment for a wide variety of pixelated sensor technologies and can be used as a realistic test bed for tracking studies for a vertex detector at a future linear collider.

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1 Introduction to EUDET

EUDET [2] is a project supported by the European Union in the 6th Framework Programme [3] structuring the European Research Area. The project comprises 31 European partner institutes from twelve different countries working in the field of High Energy Physics. In addition, over twenty associated institutes will contribute to and exploit the EUDET research infrastructure which the aim to support the detector R&D in Europe for the next large particle project, the International Linear Collider. The EUDET collaboration will provide test beam infrastructure, including a 1 Tesla solenoid magnet and a high resolution beam telescope as well as infrastructure for tracking detectors and calorimeters.

2 Requirements of the pixel telescope

The pixel telescope consists of a mechanical support structure, the sensor planes and a dedicated readout chain. It has to be used for a wide range of R&D activities and different devices under test (DUT), ranging in size from a few millimeters up to one meter. Its resolution should be high (<4 μm) even at low energies of a few GeV/c, like at DESY. This can be achieved providing sensors with individual plane resolutions of 2-3 μm or better and careful optimization of the telescope geometry. The lateral dimensions of the sensors should support the readout of high precision pixel devices without mechanical movement of the DUT. A minimum size of 20 mm is adequate for this. For larger structures, scanning of the DUT using mechanical actuators will be provided. The readout speed of the telescope should take advantage of testbeam environments and achieve around 1 kHz.

2.1 Pixel sensor

As mentioned before, the sensors for the telescope have to provide single point resolutions of 2 to 3 μm with a minimum of material and a reasonable size. R&D towards an ILC vertex detector is actively pursued on a number of different sensor technologies such as CCD [4], DEPFET [5] and CMOS [6] sensors. The EUDET collaboration will use sensors derived from the MIMOSA-5 [7] chip by CNRS/IRES Strasbourg.
The initial MIMOTEL sensor shown in Figure 1 will provide 256 x 256 pixels with a 30 μm pitch and an active area of 7.6 x 7.6 mm^2. A thinned down version of the MIMOTEL will be available as well in a next step. Also a high resolution tracker sensor (HRT) with 512 x 512 pixels, 10 μm pitch on an active area of 5 x 5 mm^2 with a single point resolution of about 1 μm is available. By the end of 2008, the 'final' sensor for the EUDET pixel telescope should be available. It will be based on the MIMOSA-22+ technology, providing integrated zero suppression, column parallel readout, 1088 columns of 576 pixels on 20.0 x 10.5 mm^2, a readout time of around 100 μs and a thinned sensor.

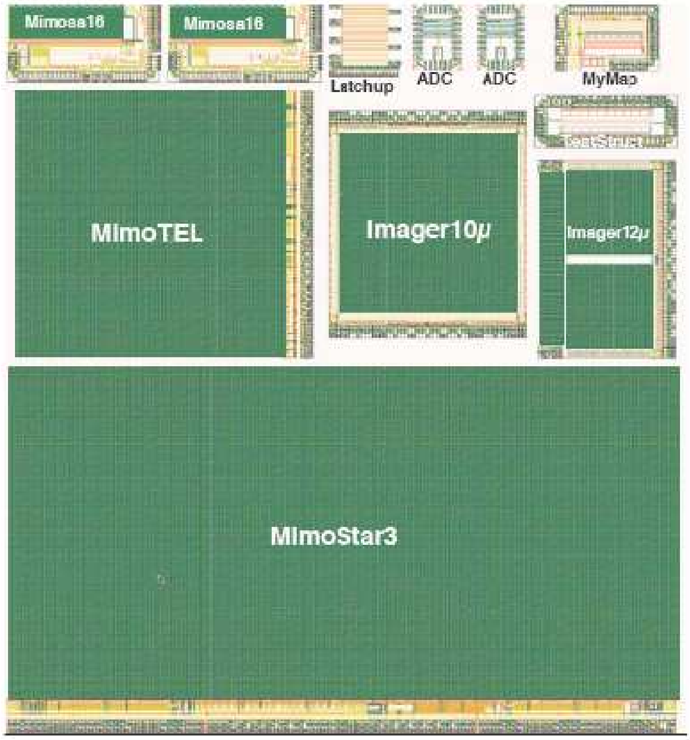

Figure 1: The MIMOTEL sensor (left) and the HRT imager sensor (center).

2.2 Mechanics

Depending on the application of the beam telescope, different setups of the sensor planes need to be foreseen and the mechanical support structure has to provide a flexible solution. The mechanics will allow the usage of the telescope in different scenarios: A compact setup, with the telescope planes very close to the DUT, allowing the characterisation of a high precision device. The compact scenario can also be used inside a magnetic field. In addition, the telescope can be split up in a 2-arm geometry, with up to 3 sensors in front and up to 3 sensors behind larger structures. Lightweight DUTs can also be put on a moving table, allowing scanning of the device with high precision within the pixel telescope. The mechanics also provides cooling to the pixel sensors.

2.3 Data acquisition

The data of the pixel sensors is acquired via a dedicated readout board, the EUDET data reduction board (EUDRB) [8], situated in a VME64x crate.
Data acquired on the EUDRBs will be collected by an MVME6100 CPU on the VME and send to the central data acquisition system. The synchronization with the DUT is done via a dedicated trigger logic unit (TLU), designed by the University of Bristol for EUDET. The unit allows a simple trigger/busy/reset communication with the DUT, but also a more advanced mode, tagging events via a distributed event number. In such

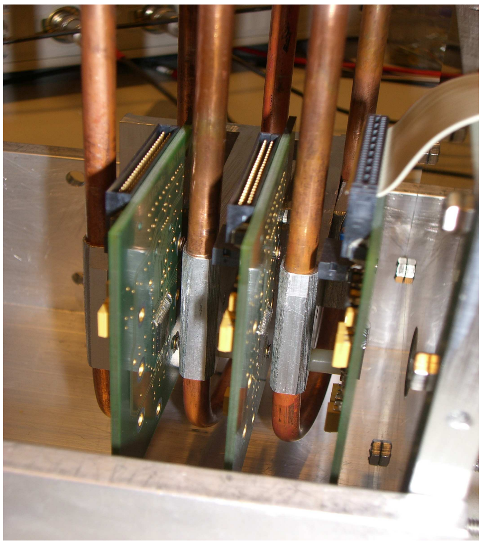

Figure 2: The demonstrator at the DESY testbeam.

a way, users of the pixel telescope can choose their level of integration in the global DAQ scheme. They can run either completely independent, synchronizing only via a standard trigger/busy logic or they can use the provided event number for enhanced data synchronization. Even a full integration in the EUDET DAQ is possible. Sample producer tasks to do this are provided. Data taken is stored locally, but then converted to lcio format on the GRID for easy analysis and compatibility within the ILC software framework.

2.4 'Demonstrator' telescope

In the summer 2007, the 'demonstrator' telescope will be evaluated in different testbeams at DESY and CERN. The demonstrator will run with 3 to 6 planes and serve as a proof of concept. A first test has been performed already at DESY just after the end of the LCWS, using a 3 plane telescope as shown in Figure 2 and the full system has been proven to work.

3 Performance evaluation

Preliminary results of the demonstrator are shown in Figure 3 and show noise distributions on the sensors as well as the cluster profile for sensors with different epitaxial layers. The noise per plane is around 4 ADC counts and the most probably value for 3x3 signal clusters around 140 ADC counts. Further studies of the telescope are still ongoing to measure the resolution of the telescope as expected from simulations.

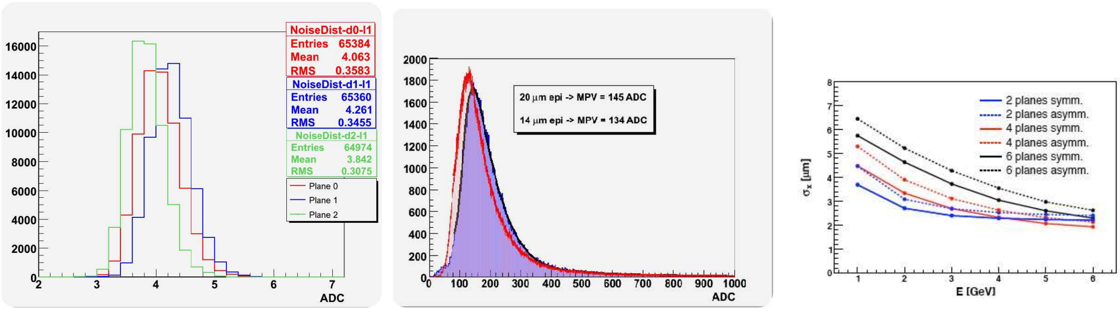

Figure 3: Noise (left) and cluster (middle) profile measurements of the demonstrator telescope. Right: Expected resolutions for different telescope geometries.

4 Summary

A first version of the EUDET pixel telescope is currently being evaluated and has been proven to work. First users of the telescope are expected by the end of this summer. The final version of the telescope with increased performance will be available in 2009. Interested parties are welcome to contact the EUDET collaboration for the exploitation of the device.

Acknowledgement

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References

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