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JRA1 - The DEPFET sensor as the first fully integrated DUT in the EUDET pixel telescope: The PS test beam 2008

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Abstract

The DEPFET prototype system for the ILC is the first device under test using the EUDET JRA1 pixel telescope. This memo summarizes the experiences gathered during the 2008 CERN PS test beam period. In this presentation the current status of the integration of DEPFET into the EUDET Telescope frame work will be presented.

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1 Introduction

The International Linear Collider (ILC) is a proposed linear particle accelerator with a collision energy of 500 GeV. In the scope of these efforts a number of ILC detector R&D projects have been started. Among these projects is an EU initiative to support detector R&D for a future International Linear Collider (EUDET). The DEPFET collaboration has a significant presence in this program. Also within the EUDET program a high resolution pixel telescope using monolithic active pixel sensors will be provided as test beam infrastructure. DEPFET sensors were the first *D*evice *U*nder *T*est (DUT) for this telescope system, commissioning the user interfaces of this infrastructure.
The first part of this document presents the current status of integrating the DEPFET data acquisition (DAQ) in the EUDET telescope DAQ.
The second part describes the experiences gathered during the common test beam campaign at the PS (the Proton Synchroton) facility at CERN in the summer 2008.

2 DEPFET Principle and Operation

The *DEP*leted *F*ield *E*ffect *T*ransistor (DEPFET) principle of operation is shown in Figure 1: A planar p-channel MOSFET structure is embedded in a fully depleted, high resistive bulk. A deep n-implant below the transistor p-channel forms a potential minimum for electrons. Collected electrons change the potential of the internal gate of the transistor and thus modulate the transistor current according to the collected charge. As this is a non destructive read out the charge has to be removed by the clear contact (not shown in the picture) [1]. DEPFET sensors offer a unique possibility for a high spatial resolution and low noise pixel vertex detector as the innermost component of the tracking system in an ILC detector.

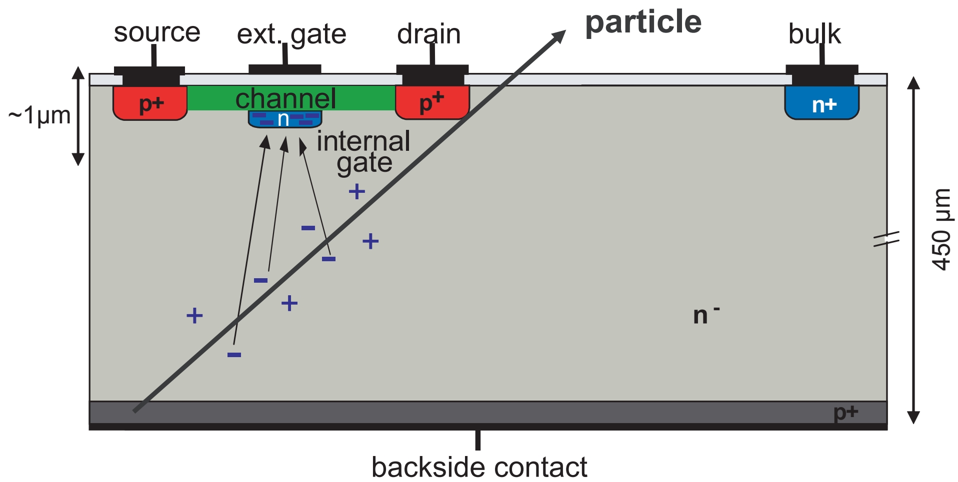

Figure 1: DEPFET Principle and Operation

A prototype system comprising of a 64 $\times$ 128 (32 $\times$ 24 μm^2 pitch, 450 μm thickness) DEPFET pixel matrix and a current based readout system has been built and operated successfully in the laboratory and in various beam tests [2].

3 EUDET Telescope

The EUDET telescope provides up to six reference planes subdivided into two arms to allocate the DUT in between these two arms. Mechanical actuation helps to move the DUT, in this case DEPFET sensors, through the usable area of the telescope. The main components of the EUDET telescope system are shown schematically on the Figure 2. The reference plane sensors are based on Monolithic Active Pixel Sensors (MAPS) with 256 $\times$ 256 pixels and a pitch of 30μm (MimoTel)[3]. This results in an active area of 7.7 $\times$ 7.7 mm^2.The sensor is divided into 4 sub-arrays of 64 $\times$ 256 each read out in parallel.

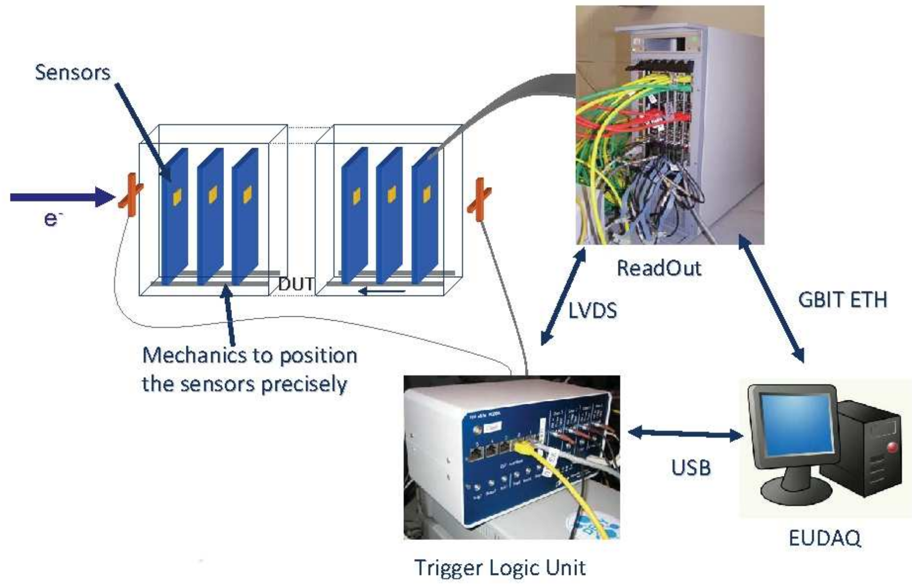

Figure 2: Components of the EUDET Telescope

The MAPS sensors are read out by general purpose acquisition boards (EUDRB). A MVME6100 Power PC computer collects the data from the different EUDRBs inside the VME64x crate and sends it via Ethernet to the main DAQ PC.
A dedicated Trigger Logic Unit (TLU), with a built-in scintillator signal discriminator and coincidence unit, synchronizes the read out with a system wide coincidence trigger signal. Furthermore each trigger carries a trigger number and time stamp.

4 DAQ Integration

There are several methods of integration of a device under test (DUT) into the EUDET telescope DAQ. The simplest one is by having two separated and independent DAQ systems for the telescope and the DUT. The only connection is a trigger-busy handshake protocol via a trigger logic unit (TLU) assuring that no new event is triggered while one of the participating devices is still busy with e.g. read out of the sensor. This can be expanded by receiving an individual trigger number from the TLU for each event. Using this procedure the data will be written to file in two separate data streams. A more sophisticated method is the integration of the DUT DAQ into the EUDET telescope DAQ framework. A key issue here is the modularity of the telescope DAQ which will be explained in more detail later. Here the DUT DAQ is steered by the telescope DAQ and the data is received and merged to one data stream and into one file.
The first part of this chapter will cover the DEPFET DAQ. The second part will describe the integration of the DEPFET DAQ and the EUDET telescope DAQ on a trigger level. In the third part of this chapter the integration of DEPFET DAQ into the EUDET telescope DAQ framework will be given, which was the status of the integration at the CERN test beam in 2008.

4.1 The DEPFET DAQ

To improve functionality during the test beam measurements and facilitate the integration with other detectors a new version of the DAQ software was developed. It is based on Linux OS and uses network distributed client/server architecture. The network distributed system allows sharing of resources and tasks, remote control and monitoring, and running monitoring programs on the remote computers without affecting resources of DAQ computers.
This new version of DEPFET DAQ was successfully tested in the laboratory. A schematic view of the data acquisition is shown in Figure 3.
The DAQ components are: a LINUX based USB driver for the DEPFET DAQ board, a USB readout client transferring data to an event builder via network, an event builder assembling complete events and storing them in a shared memory buffer, an event server sending complete event to consumers (file writer, DQM, upper level DAQ, histogram server) and a Data Quality Monitoring (DQM) package based on ROOT.

4.2 Integration on trigger level

The DEPFET DAQ integration during the CERN test beam season in 2007 happened only on a trigger level. The event synchronization was ensured by the trigger-busy handshake of the EUDET TLU including the transmission of event numbers for each trigger, while having two separated data acquisitions for the DEPFET DUT and the EUDET telescope. This implies that no common online monitoring was available.

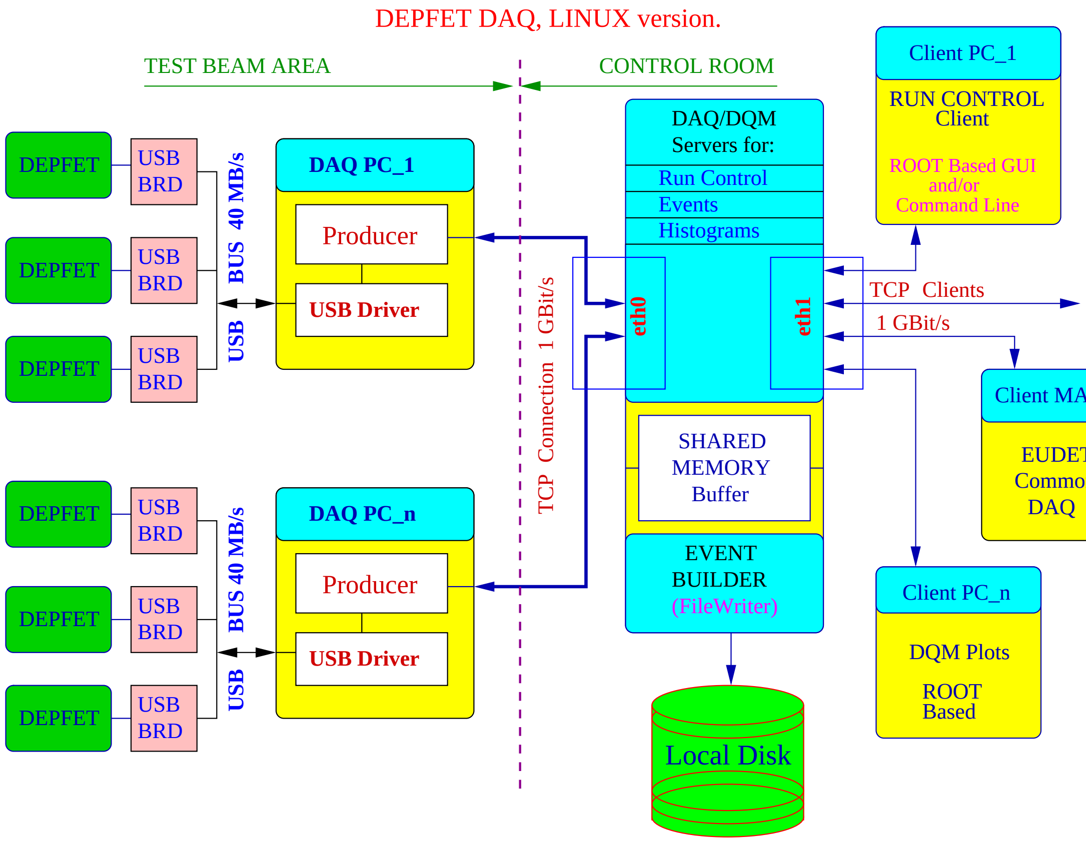

Figure 3: DEPFET Linux based data acquisition system

4.3 Integration on the DAQ level

The second level of integration was achieved during the CERN test beam season in 2008 and was accomplished by having the DEPFET system steered by the EUDET DAQ software. Here the high modularity of both the EUDET telescope and the DEPFET Data Acquisition software played a crucial role.

DEPFET and EUDET telescope Run Controls were synchronized with each other via TCP/IP and all controls such as configuration, start, and stop were done from the main EUDET Run Control window (see Figure 4). DEPFET data was sent to the EUDET PC via TCP/IP where it was received by the *DEPFET producer* software task. *DEPFET producer* is a one of several *Data Producer* tasks. These tasks are running on the EUDET DAQ and provide a software interface for any piece of hardware in the system that is producing data. At the end of each event, all Data Producers make their respective data available to the *DataCollector* task via shared memory. The collected data is then written as one data stream into a file. Furthermore the *DataCollector* passes requested data on to all online monitoring task in the DAQ.

In addition the EUDET Data Quality Monitor (DQM), a tool that provides an online quality assessment of the data currently taken, was modified in order to process data

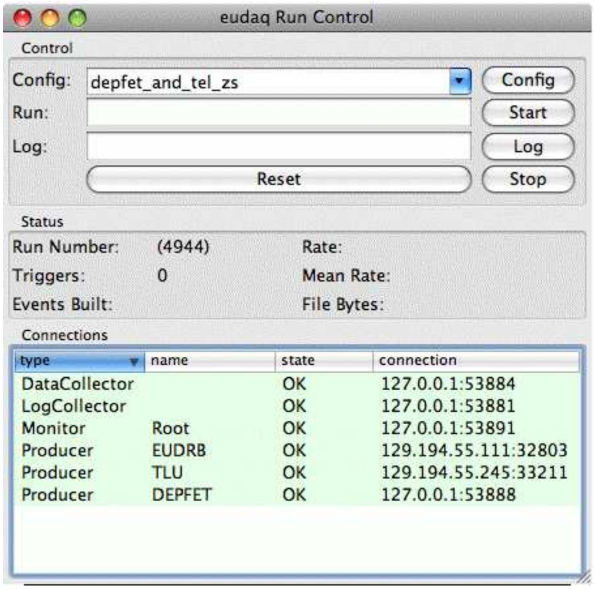

Figure 4: EUDAQ Run-control with DEPFET Producer

from the DEPFET DUT, thus allow for instance correlation plots between MAPS and DEPFET sensors hit positions.

5 The 2008 CERN PS Test Beam Campaign

To test the full functionality of the integrated system a test beam at CERN PS facility was carried out in the second half of July 2008. The setup is shown schematically in Figure 5. The device under test was placed in between two arms of EUDET telescope. The setup is triggered by a coincidence signal of two scintillators in front of and behind the setup. The Trigger Logic Unit (TLU) synchronized the read out of all telescope planes and DUTs. The position of DEPFET DUT has been adjusted using a remote controlled motor stage.
During the CERN PS test beam period the DEPFET Linux based DAQ software has been tested. The initialization and configuration of the system was carried out from the main EUDET run control window running on the EUDET DAQ PC, while a *Data Collector Processor* running on the same PC merged both the EDUET telescope and the DEPFET DUT data streams into a common file. In addition DEPFET only data was stored on the local disk of the DEPFET DAQ computer as a backup.
Due to instabilities of the PS test beam and limited time a test of the DEPFET on-line alignment had to been postponed until the CERN SPS test beam period which is described in the according EUDET memo.

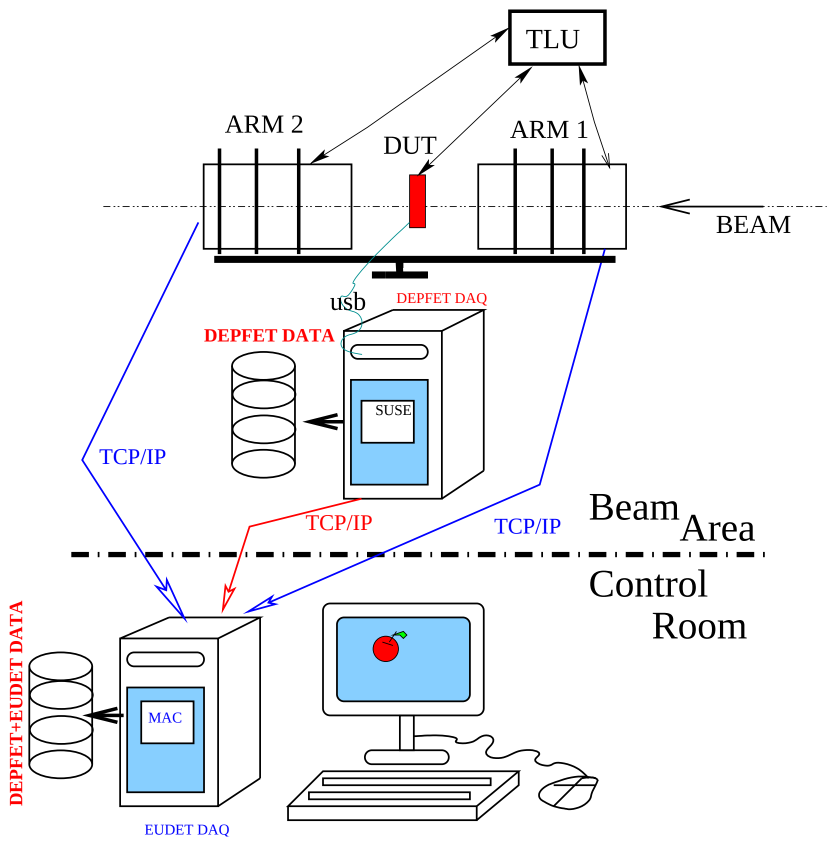

Figure 5: Test beam setup, schematic view

6 Conclusion

In July 2008 the DEPFET prototype system for the ILC has been successfully operated as a DUT with the EUDET pixel telescope at the CERN PS test beam facility. Apart from a common online data monitoring all major steps towards a common DAQ were achieved: the read out was synchronized with a common TLU, the data of both the telescope and the DUT was merged into one file during data taking, and the system including the DEPFET DUT was steered by the EUDET DAQ software. Yet a common online DQM (data quality monitoring) allowing for quick alignment was not accomplished until the follow up test beam at the SPS two weeks later (more information in the respective EUDET memo).

Acknowledgment

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References

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