Summary
EUDET JRA1 Brainstorming meeting
DESY 3/4 November 2005

Present:
Massimo Caccia (INFN, Milano) via VRVS
Gilles Claus (CNRS-LEPSI, Strasbourg)
David Cussans (University of Bristol)
Mattieu Deveaux (CNRS-LEPSI, Strasbourg)
Wojtek Dulinski (CNRS-LEPSI, Strasbourg)
Peter Fischer (Uni Mannheim)
Ingrid-Maria Gregor (DESY)
Daniel Haas (Université de Genève) via VRVS
Tobias Haas (DESY)
Marc Winter (CNRS-IRES, Strasbourg)
Christine Hue (CNRS-IRES, Strasbourg)
Uli Kötz (DESY)
Tatsyana Klimkovitch (DESY)
Hans Krüger (Uni Bonn)
Pierre Lutz (CEA DAPNIA) via Teleconference
Hans-Günther Moser (MPI München)
Martin Pohl (Université de Genève) via VRVS
Yolanda Sztuk (Uni Hamburg)

Agenda and Material presented
The agenda and the material presented can be found here:
http://indico.cern.ch

General Summary:
A first brainstorming meeting was held at DESY on 3/4 November in order to clarify the specific goals of the project and to agree on some basics if possible. The workshop was very well attended with representatives from almost all partners involved. Three partners were connected via video/teleconference. After an introduction where all partners present introduced themselves one session on general architecture and on one on DAQ were held. The workshop closed with a discussion on open questions and further steps.

Introductory Remarks and Charge:
Tobias Haas welcomed the participants and reminded everyone on the overall scope and the timeframe of the project. The total budget of the project is € 3.8 Mio with a € 1.4 Mio EU contribution. The greatest part of the money goes to paying people. There are 501 person months planned. The project will start in January 2006 and run for 4 years. However, the test beam infrastructure should be available already after three years and being operational and available to users during the final year. The goal of the project is three-fold:

- Build a very high precision, fast beam telescope,
- Provide a general purpose test beam infrastructure for ILC detector R&D (not limited to pixel research!),
- Improve and validate various pixel technologies along the way.

The plan is to follow an iterative approach in the project by building first a demonstrator using technology that is currently in hand and then use that telescope to characterize the next general pixel chip to be used in the final telescope.

As an introduction to the workshop a list of questions with respect to the three topics, hardware/general, DAQ and analysis, were sent to the participants so that these could be used as a basis of discussion. These questions are attached as an appendix.

Hardware session

There was one presentation by Wojtek Dulinski during this session followed by an extended discussion.

Wojtek Dulinski gave an overview over recent CMOS maps sensors developed by the Strasbourg group. These are MIMOSA 8, 9 and 11 and the MIMO*. These chips were developed in order to test different aspects of the sensor design, such as “self-bias” pixel (avoiding dead time during pixel reset), different oxide thickness, the binary readout and different CMOS processes. Departing from the original idea, Wojtek proposed to use a variant of the recently developed MÏMO* chip already for the demonstrator telescope.

not the well established MIMOSA 5 chip for the telescope processor but the recently developed MÏMO* chip. Wojtek’s arguments are the following:

- MIMOSA 5 has a poor S/N at room temperature and therefore needs to be operated at a temperature of less then 0 degrees.
- MIMOSA 5 has 4 matrices of 256 x 256 pixels of 17 micron pitch. The minimum frame rate is 12 ms.
- MIMOS 5 is larger (20 x 20 mm) than it needs to be for the telescope
- MIMOSA 5 needs to be reset periodically. This generates dead time.

The advantages of MIMOSA 5 are:

- It reaches very good precision (1 – 2 microns) with its small pixel size,
- It is in hand and has been tested by different groups.

In contrast MIMO* has these properties

- It can be operated with good S/N at room temperature,
- Its operation is flexible with all reference voltage generated internally. These are programmable via a JTAG interface.
- The freedom to arrange pixel arrays should allow a frame readout time of 1.6 ms.

The disadvantage of using the MIMO* are

- The precision should be slightly worse than MIMOSA 5 due to the 30 micron pixel pitch,
- Only a small device with 128 x 64 pixels (MIMO* 2) exists currently and this has not been tested extensively.

Wojtek then went on and discussed specific layouts for a future telescope. He proposes a very compact design (20x20x20cm) with four standard planes and possibly 1 or two additional high precision planes (10 x 10 micron) pixels with one placed very close

(5mm) to the DUT. This would allow high precision tracking with resolution better than 2 microns event in a “low” energy beam such as the DESY 6 GeV test beam.

Following this presentation Wojtek’s proposal was discussed in detail. The points raised were the following:

- Who are the future users of the telescope and what would they like to measure?
- What beam environments need to be covered (energy and rate?)
- How should the demonstrator telescope look like and what is expected of it?

From this question these follow directly:

- What surface area needs to be covered?
- Can there be a long and a short side?
- What longitudinal size for the DUT needs to be foreseen?
- What temperature is required for the telescope and for the DUT?
- Should the telescope operate in a magnetic field?

DAQ Session

There were three presentations during this session.

- Martin Pohl discussed ideas for the DAQ as previously discussed between him and Massimo,
- Gilles Claus presented the current Strasbourg test beam DAQ system,
- Hans Krüger showed a wish list for a future test beam DAQ system

Martin discussed a beam telescope with a two-arm geometry, at least two planes per arm and up to 4 2x2cm MIMOSA 5 sensors per plane. The telescope should usable at DESY and at CERN and provide sustained RO speed of greater than 10 Hz. In order to achieve that with the MIMOSA 5 architecture, digitization and data reduction on the front end is necessary. Various open design issues were also discussed. These were:

- Choice of interface between front end and D/R board: analog or digital
- Choice of noise suppression: CDS or Ped/CN
- Data reduction: sparsification or clustering
- D/R processor: FPGA+DSP or CPU

Martin pointed out that the most difficult part of the enterprise was the telescope demonstrator. In the final telescope the task would be easier since some of the DAQ would already be integrated into the sensor chip.

Gilles Claus discussed the current Strasbourg testbeam DAQ system and the future plans. The system is VME based and consists essentially of a VME sequencer and ADC board that is read out by a power PC running LynxOS inside the VME crate. The data are then transferred via Ethernet to a PC and stored on disk. The system works well but has a number of disadvantages:

- It does not handle digital output from MAPS chips
- On board sparsification cannot be done
- The board can only go to 20MHz
- Output bandwidth is maximally 4 MB/s

For these reasons a new board is being developed. This will read out the data via USB-2 instead of the VME bus. It will also provide on board CDS and sparsification and should operate at frequencies up to 100 MHz.

Hans Krüger showed the state of the Bonn DEPFET test beam DAQ system. This consists of two components, the hybrid with the DEPFET and the R/O board based on a FPGA architecture which transfers the data over a USB-2 connection to the control and archiving PC. Hans also presented a wish list for the test beam and the telescope:

- highest possible beam energy (> 6 GeV),
- moderate to high flux (adjustable),
- variable bunch structures,
- telescope resolution better than 2 µm,
- telescope plane minimum area 1 x 2 cm^2,
- low material in the telescope planes,
- minimum (adjustable) distance between telescope planes,
- high event rate (~ O(kHz)),
- positioning system for DUT (x, y, theta), < 1 µm x-y resolution,
- cooling,
- different trigger scintillator sizes to adapt to DUT active area,
- simple, configurable trigger interface to connect to DUT (Trigger, Busy, BOR),
- event by event r/o or buffered r/o.

Closeout
In the closing session an attempt was made to pull together the open ends and come to some conclusion on open issues:

- Telescope layout and configuration:
    - A transverse size of ca 2 cm will be provided at least in one direction. The second direction can be smaller.
    - The longitudinal layout will be configurable and should provide at least two configurations: a very compact one (ca. 20cm) and a two-arm one with space for a larger DUT in the middle. The mounting will be such that at least one plane can be brought very close to the DUT in the compact configuration
    - Precision positioning for a pixel DUT will be built
- Telescope chip
    - A CMOS Maps will be used for the telescope.
    - The telescope chip will have a discriminator and ADC on board
    - Frame R/O time will be of the order of 1 ms
- Cooling
    - The temperature of the DUT must be able to be kept constant. What temperatures are needed is still open
- DAQ
    - Telescope and DUT DAQ will be kept separate. The interface is via trigger, busy and event number.

    - The telescope F/E will do digitization and sparsification for the demonstrator.
    - R/O should be over a standard interface such as USB-2
    - Martin Pohl will organize a DAQ WS for the interested parties to hammer out the details early December
- Demonstrator
    - The demonstrator should be a fully usable system
    - It will use the MIMO* 3 chip with the MIMOSA 5 as a fall back solution
- Organizational
    - Regular video/teleconference meetings are foreseen on a monthly basis. Next one at the beginning of December following the planned DAQ WS,
    - Task leaders still need to be nominated.

Appendix – Questions for the brainstorming meeting

General/HW

- What will the telescope be used for? What do we want to measure? Do we want to set up a complete tracking system?
- Could pixel technologies other than MAPS (DEPFET, CCD) be used as reference detectors?
- For which beam line should this telescope be developed (DESYII, ...)? Which rates do we want to read out and what energies do we want to measure?
- Do we want to operate the telescope in a magnetic field?
- What should be the geometrical size of the telescope? Here we should think about how many pixels we would like to choose as active area and how many layers are we envisaging. What should be the maximum length (this question is connected to the question of which beam lines we want to use)?
- Furthermore we should think about if the detectors are movable, if the DUT is rotatable and with what precision all this should be done.
- Do we want to cool the detectors and how do we want to build the cooling?
- What kind of alignment do we want to foresee, an external system such laser or a self-alignment procedure?

DAQ

- How do we want to trigger?
- How should the DUT be integrated in the DAQ? All in one DAQ, or rather two system to be flexible for different DUTs? What do we want to include in the slow control?

Analysis

- Do we need a formal analysis system? What data format should be used?