EUDET-JRA1 kick-off meeting, Hamburg (DESY), 3-4 November 2005

0. Disclaimer
In this report, I shall try to summarize the “spirit” of the first discussion, as seen by me myself. Any conclusion and any specification for the device we are going to built as stated below is to be considered as the basis for the final discussion, before the final agreement and approval by all Collaboration members. Therefore, I invite everybody for critical comments and clarifications.

1. Introduction
As it was clearly stated in our Coordinator introductory remarks, the goal of the Collaboration is to build a “Very High Precision Beam Telescope”. This mean for me that we have to exploit the limits of existing pixel (monolithic pixel?) technology, but remaining pragmatic and proposing solutions reachable in 3 years with a good confidence level. At that stage it seems obvious that the CMOS MAPS is the only existing monolithic pixel technology which is mature enough and ready to be used for this application.

2. General detector specification
a. Telescope layout
Two options has been proposed and discussed. The first is rather compact structure (~20x20x20 cm^3) with four reference planes and a space for tested device (DUT) in the middle; the second is two-arm spectrometer having three reference planes in each arm. It has been agreed that the first version is the must for internal tracking precision of few microns; the second option is of interest for testing bulky, medium resolution devices. Discussions with other EUDET members from outside JRA-1 should clarify the real needs for the latter solution.

b. Spatial resolution
The general feeling is that the reference device should provide tracking precision in the range of 2-4µm. To overcome spatial resolution degradation due to multiple scattering (critical for medium energy test beams), a special care should be taken for the set-up layout. The distance between reference planes and DUT should be minimized, as well as an overall material budget. The MAPS reference planes can be thinned down to about 100 µm, using very standard industrial procedure. The tracking station (unit made out of two reference planes) can be quite compact, with a dimension along the beam line not exceeding 15 mm. The distance between inner reference plane and DUT could be as small as 5 mm, at least on one DUT side.

c. Active area
Rather divergent opinion has been expressed, varying from 5x5mm^2 up to (a minimum) 20x20mm^2. To remind everybody: the maximum size of monolithic CMOS device, without applying for special techniques (stitching), rather excluded because of budget consideration, is about 20x20 mm^2. The argument for having large area is to have a device useful also for the realistic detector ladder scan. However, it turned out that in any case the ladder stepping along one direction will be necessary, because of their length of order of tens centimeters. Therefore, the reference sensitive area of 20x10 mm^2 is going also to do the same job. The general feeling was that this is a good compromise. Larger area, if really needed, may be achieved by assembling of a mosaic of several individual detector pieces. If the I/O pads of 20x10 mm^2 device are placed along one long side only (as it is planned), assembling of larger

area mosaic is going to be relatively easy, with very limited dead (or double thickness) area along single device periphery. It is eventually possible to assemble a monolithic 20x20 mm^2 sensor from two back-to-back halves, on a single reticle without any dead area in the middle and without any supplementary design constrain.

d. Readout speed

Data taking rate of 10-20 Hz was mentioned by some of us as satisfactory for at list the “demonstrator” phase. In my view, this is not enough. With the hardware in our hands (or almost in our hands), we should be able to reach the frame readout rate (in CONTINOUS sensitivity mode) of 500 Hz for the first stage (demonstrator) and something between 5 and 10 kHz for the final telescope. I believe that this should be our goal, in order to exploit fully the beam conditions at least at DESY (typical particle rate of up to few kHz)

e. Cooling

Except CCD, all other detector types seem not to require any cooling below room temperature. However, temperature stabilization (with the precision of ~1°C) is strongly recommended. For the CCD’s cooling, it was not clear which should be the lower limit: either around minus 80°C (still considered as relatively easy) or liquid nitrogen temperature range. To be investigated by CCD developers. Two options for the implementation seem possible: cooling of entire telescope or cooling of DUT module only. Cooling of entire telescope seems to be an overshot; on the other hand, high spatial resolution measurements would need at least two reference planes as close as possible to tested device and inside the thermal insulation. Shall we build a special, add-on module for the CCD testing? This may be the pragmatic solution. To be discussed. Heat sinking from reference MAPS can be solved without any active system. Metal frames of moderate thickness (~1cm) around active tracking area should be efficient enough.

3. The demonstrator

Originally, it was planned to build the first stage telescope (“the demonstrator”) based on existing (since several years) Mimosa5 devices. Mimosa5 is one million pixel array; with 17 µm readout pitch (17x17 mm^2 sensitive area). It has four parallel analog output channels; the minimum frame readout time is 12 ms. The spatial resolution of minimum ionizing particles was measured to be 2µm. To achieve satisfactory tracking performances, Mimosa5 must be run at low temperature, around 0°C. In addition, it has to be periodically reset which creates non negligible amount of dead time. Because of this disadvantages, Strasbourg team is proposing to use a new generation device, based on the prototype developed for STAR microvertex upgrade. The device (MimoStar3) is going to be submitted for production in June 2006 and available for test three months later. The smaller version of it (MimoStar2) is available now and it has been tested (including beam tests) with very positive results. It provides S/N ratio of factor two better than Mimosa5, it is operated at room temperature and has no dead time due to the use of so called self-biasing pixel scheme. All internal reference voltages and currents are generated internally and may be programmed using JTAG interface, thus minimizing the number of external electronics components needed in the system. The readout pitch is of 30µm, providing spatial resolution of 3µm. The CMOS process used for MimoStar fabrication (AMS-035 OPTO) is the same as the one planned for the final device. MimoStrar3 array size is 256x512 pixels and an active area of 15x7.5 mm^2. The frame readout time is 1.6 ms, for two analog output channels and 40 MHz clock frequency.

After longer discussion, it has been agreed that MimoStar3 represents a better choice for the demonstrator, Mimosa5 remaining as a back-up solution in case of unforeseen delivery delay of MimoStar3. In the mean time, the Strasbourg team will be able to deliver to Collaboration a small number of existing MimoStar2 chips, needed for the development and evaluation of the DAQ system. Except for the array size (128x128 pixels), the architecture of MimoStar2 is identical to MimoStar3. It was stressed several times that the production schedule of MimoStar3 is compatible with the demonstrator schedule and the risk of failure is very small.

4. The final detector

For the final reference detector we propose the detector having digital readout. This consists of pixel architecture allowing for in-pixel (analog) CDS processing, column-parallel readout followed by analog-to-digital conversion using low precision (3-4 bits) ADC integrated at the end of each column. Some simple, telescope specific sparsification/data reduction scheme shall be implemented. This is the extension of our successful Mimosa8 binary readout device architecture. The goal will be 20 to 25µm readout pitch, for the column length of 512 pixels. The estimated frame readout time is 100 to 200 µs (continuous mode). According to our study, the spatial resolution should be 2 to 3µm, depending on the chosen pitch and the measured S/N ratio. Thousand columns for the final version should provide an active area of 10x20 mm^2.

5. Very High Precision Tracking add-on module

A very high spatial resolution module is proposed in addition to the standard reference planes. Such a module may be useful for some specific detector tests requiring submicron precision. In connection with specific geometric layout, it can also be used to overcome the limitation of medium energy beams (5 GeV electrons for example) for high precision tracking study. The proposed device consist of an array of 512x512 pixels, with a pitch of 10 µm (so the active area of 5x5 mm^2), readout through four parallel outputs. The readout scheme is the one proposed for the demonstrator stage, thus not requiring specific development effort. The device may be a part of AMS-035 OPTO engineering run foreseen in mid-2006.

6. Trigger system

The triggers system should be simple and based on external scintillator for time resolution, plus internal sub-area trigger. The latter one is possible in principle, because of planned fast sparsification readout scheme (either on-chip or using external FPGA on the DAQ boards). The time resolution of internal trigger is limited of course to the frame readout time.

7. DAQ (seen from the detector side)

The main discussion was how to provide a data acquisition open enough to be able to acquire different users. The consensus is that the solution should allow for a co-existence of two independent DAQs (one for telescope readout and the second for specific DUT). The synchronization shall be baser on fast handshake protocol using trigger/busy signal (“two LEMO cables plus an event counter”). The row data should be on-line merged to a common file. The proposition was to use (or at least to start with) existing hardware platforms. Several groups presented their present DAQ solutions. The specific workshop to discuss in details all DAQ aspects is to be organized shortly.

8. Conclusions

The goal seems to be well defined, realistic and within a reach, taking into account the Collaboration lifetime. All remaining details (not very controversial) should be clarified soon.

Wojtek Dulinski