Application to test TPAC sensors in the DESY testbeam through EUDET transnational access

P.D. Dauncey[1] (Coordinator), M. Stanitzki[2], J.J. Velthuis[3], N.K. Watson[4], J.A. Wilson[4]

[1] Imperial College London,
[2] Rutherford Appleton Laboratory,
[3] University of Bristol,
[4] University of Birmingham

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1 Scientific background

The SPiDeR (Silicon Pixel Detector R&D) collaboration [1] is investigating monolithic CMOS pixel sensors for future colliders, in particular high energy lepton colliders (ILC and CLIC). The collaboration is studying both fundamental technologies for future detector sensors and also novel applications of CMOS sensors. These could be applied both to tracking and calorimetry. In particular, the collaboration is currently doing preliminary tests towards a digital electromagnetic calorimeter (DECAL). The DECAL would be a new approach to EM calorimetry where the initial electron or photon energy is estimated by counting particles rather than from the deposited energy. This work is being undertaken as part of the CALICE collaboration [2].

Further information about the SPiDeR collaboration and its aims can be found in a recent DESY PRC submission [3]. The DECAL technique and status is summarised in the CALICE submission to the same meeting [4].

2 The TPAC sensor

The sensor which the collaboration would like to test in beam in 2010 is the TPAC (Tera-Pixel Active Calorimeter) sensor [5]. This is a study sensor for the DECAL application. This has a uniform array of $50 \times 50\,\mu\mathrm{m}^2$ pixels with a readout architecture compatible with an ILC beam timing structure. It incorporates a per-pixel trimming, threshold data suppression and on-sensor data storage, with readout following data acquisition.

While this $1 \times 1\,\mathrm{cm}^2$ sensor is too small to contain a full EM shower, it can be used to study the shower core densities which dominate the EM resolution and which determine the pixel size requirement for a realistic DECAL. Such measurements of high energy EM shower densities at the sub-millimetre level have not previously been performed. These measurements would help to constrain significantly the sensor design for the large-scale DECAL. The aim would be to do the first measurements of the shower densities with the electron beam at DESY in March 2010.

3 Beam test programme

TPAC sensors were tested in a 120 GeV pion beam at CERN in August 2009. These tests were to measure the sensor response to minimum ionising particles. These basic measurements confirmed the sensors operated well and with high efficiency. However, the sensors were not operated in a way which allowed the measurements of electromagnetic shower properties, hence the current proposal.

At the DESY test beam, the TPAC response to electron showers will be measured with varying amounts of tungsten converter material added in front of the sensors to get measurements of the shower density as a function of material depth. The DESY beam energy can be varied between 1 and 6 GeV range, so the beam energy will also be scanned over this range.

The EUDET telescope is needed to provide an accurate shower centre; this is essential as the core density falls rapidly on the scale of 1 mm so that the centre needs to be known significantly more accurately than this. The telescope can provide an impact point on the TPAC sensors of better than 100 μm which is ideal for these measurements.

The DAQ system is the same as used at CERN. It has been tested and found to run at around 50 Hz. With an estimate of around 1M events being needed to accurately measure the shower core for each combination of converter thickness and energy point, then around five hours will be needed per combination. With five beam energies and a similar number of tungsten thicknesses, then at least six days will be needed to acquire the total dataset when running smoothly.

4 DESY beam request

The collaboration estimates that 1.5 weeks in the DESY test beam would give sufficient statistics for the complete set of TPAC shower density studies. These measurement require an external tracking telescope and so we ask to have the EUDET telescope available. Hence, we request beam time from Thursday 25 March to Friday 2 April 2010 (inclusive) to complete the programme outlined above. We also request travel support for six people to come to DESY during this period.
Furthermore, we ask to rent a van. This is by far the cheapest and safest way to transport our equipment to and from DESY. We will use this van to transport not only to transport the TPAC equipment, but also the LowMass and FORTIS equipment. In the LowMass application, we asked for half of teh rental money. Here we ask for the other half. This comes to 800 Euros.

So the total estimated cost for this beam test are 5300 Euro including the rental of the van. This is calculated based on staying in the DESY hostel and a per diem of 25 Euros.

References

[1] `https://www.spider.ac.uk`.

[2] `https://twiki.cern.ch/twiki/bin/view/CALICE/WebHome`.

[3] The SPiDeR Collaboration, "DESY PRC Report", Oct 2009, `http://www.hep.ph.imperial.ac.uk/calice/official/091105prc/spider.pdf`

[4] The CALICE Collaboration, "Report to the DESY PRC", Oct 2009, `https://twiki.cern.ch/twiki/pub/CALICE/CaliceCollaboration/CALICE_PRC09.pdf`.

[5] J. A. Ballin *et al.*, "Monolithic Active Pixel Sensors (MAPS) in a quadruple well technology for nearly 100% fill factor and full CMOS pixels,", Sensors **8** (2008) 5336.