Application for transnational access to the CERN testbeam for high granularity shower studies

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1 Scientific background

The SPiDeR (Silicon Pixel Detector R&D) collaboration [1] is investigating monolithic CMOS pixel sensors for future collider detectors, 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 studying the feasibility of a digital electromagnetic calorimeter (DECAL). The DECAL would be a new approach to electromagnetic calorimetry where the initial electron or photon energy is estimated by counting particles rather than from the deposited energy. This work is being undertaken in association with the CALICE collaboration [2] and we include members of both the ILD and SiD collaborations.

2 Electromagnetic shower density

The DECAL concept uses a silicon-tungsten sampling calorimeter, where the silicon detector pixels are such that the probability of more than one shower particle passing through any pixel is small. This means that the number of pixel hits gives a direct estimate of the number of particles, which is itself proportional to the total shower energy. This removes the Landau contribution to the energy resolution which occurs in more standard sampling calorimeters with analogue readout, and so should give better resolution.

Simulations indicate that the major uncertainty in the predicted performance of a DECAL is in the particle densities in the core of the showers. The detector pixel size must be small compared with the average distance between particles in order to correctly count the particles in the core. However, there are no systematic measurements of electromagnetic showers with highly granular ($\sim 50\,\mu$m) detectors so the predictions from shower simulations must be verified experimentally to be confident of the predicted performance of a DECAL.

The aim of this beam test is to perform measurements of the core densities in electromagnetic showers from around 10 to 100 GeV. This dramatically extends the range of measurements from those done by us at DESY in March 2010, which only covered 1 to 5 GeV. First results from the DESY data were shown at the ICHEP conference this summer [3].

3 Beam test programme

The programme will consist of measuring the core density in electromagnetic showers across the range of electron beam energies between 10 and 100 GeV and with a range of thicknesses of tungsten converter between 1 and 10 radiation lengths. We foresee around 40 different energy/converter combinations and will require at least 100k events per combination for a significant measurement. In addition, runs with an out-of-time trigger to record backgrounds, noise

and event pileup effects will be needed. It is foreseen that a total of around 6M events will be needed to be taken within the one week.

The actual measurements will be taken using the EUDET telescope directly. Tungsten converter plates will be installed between the two arms of the telescope. The front three planes will then define the incoming electron track, giving a well-defined projected position and direction for the centre of the shower in the tungsten. The back three telescope planes will record the shower emerging from the chosen thickness of the converter. The pattern and density of the hits measured will give unprecedented information on the showers. The pixel size of the EUDET telescope sensors, $\sim 18\,\mu$m, is more than sufficient for the granularity assumed for a DECAL and so should easily be able to separate the particles in the core.

To obtain 6M events in one week requires an averaged event rate of at least 10Hz. With a spill duty cycle of 17 sec per minute, this implies a required in-spill rate of 35Hz, which should be easily achievable. If a higher rate is possible, then more combinations and/or more data per combination can be taken.

Except for the modifications for out-of-time triggers, which are currently under discussion, the measurement only depends on the EUDET telescope. This has been running for several months at CERN this year and so no major technical issues are foreseen.

4 Financial request

CERN has granted us one week of beam time from Monday 20 to Monday 27 September. We request travel support for five people to come to CERN for this run, some of whom will arrive on September 19. (One other person will be involved but will be funded from other sources.)

For each of the five people, we will need a flight from the UK (approx 200 euros) as well as accomodation (80 euros/night) and subsistance (40 euros/day) for the duration of their stays. These visits will vary between five and eight days and total around 30 days for all five people. We will also need a rental car (200 euros) for the whole period to get to and from the beam test area. Hence, we estimate the total cost to be around 4800 euros.

Note, there are no equipment transport costs; the tungsten sheets we will use are small and can be carried out in hand luggage by one of the visitors.

References

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

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

[3] P. D. Dauncey, on behalf of the SPiDeR Collaboration, "Performance of CMOS sensors for a digital electromagnetic calorimeter", ICHEP2010 International Conference on High Energy Physics, Paris, July 22-28 2010, and proceedings thereof.