Calice Oversight Committee – Questions on documents submitted Sept 2006

1. *Section 4.3 fig 3 (p 8)*
   How does the resolution deltaE/E compare to expectation – slope and intercept? Are there problems in these data due to multiple events and loss of energy by bremsstrahlung?

The data shown here were not finally calibrated and, at the time the report was written, we did not have a Monte Carlo with the correct geometry. Given that, the results were encouragingly close to expectations, although we are not yet ready to give any quantitative numbers publicly. Progress has being made since this time and is ongoing. The talks at the recent EFCA/ILC meeting in Valencia were mainly to demonstrate the quality of the data; the ECAL summary (given by a UK member) is available at
http://www.hep.ph.imperial.ac.uk/calice/others/061106valencia/magnan.ppt

The data indeed contain multiple events and there is some bremsstrahlung from the air and trigger scintillators in front of the calorimeters. The former will certainly complicate the analysis, but we shall also be able to take advantage of the double events to study two-particle resolution. The latter demands careful attention to simulation of the beam line, and this we have been doing in the UK. In terms of resolution studies, the effects of bremsstrahlung may be mitigated by focussing on the upper side of the asymmetric response curve.

2. *Section 5.1 para 2 (p 8)*
   'incorporate all features expected of the ILC ASIC'. Is there a list of requirements in functionality. Are there issues of variability of gain, cross-talk and the like?

The ASICs which will be tested over the period of the grant are expected to have the ILC functionality but will not necessarily satisfy the requirements for the ILC. The functions needed include

- Switches for power pulsing
- Internal ADC
- Threshold suppression
- Buffering during bunch trains
- Internal calibration
- Number of channels per ASIC

These functions can clearly all be implemented without the ASIC performing to the level required for ILC operations. The purpose of the UK tests is to check how the ASICs perform. The issues are

- Noise performance
- Pedestal stability against time, temperature and power pulsing
- Gain uniformity and stability against the same factors
- Cross-talk
- Rate of full buffers during bunch trains
- Power consumption

Some of these have reasonably well-defined criteria; for example, the noise level needs to be below ~0.2MIP so as to give a negligible contribution to the resolution of EM showers. However, most do not have definite requirements; for example, pedestal stability is less of an issue if it can be tracked accurately. This could be achieved by reading out some rate of channels below threshold or having the ASIC perform a pedestal correction using a low-pass filter or similar. These would push up the DAQ or ASIC complexity. Similarly, a high power consumption to reduce noise could be accommodated with a higher specification cooling system which is likely to require more space between tungsten layers and hence increase the effective

Molière radius. The idea of the UK tests is to see how well the ASIC performs for each of these items and so allow the optimisation of these parameters to be made.

3. If extra versions are needed how is it funded and how does it affect the time lines?

The UK has committed to testing two rounds of ASIC chips during the period of this grant. It is highly unlikely the second of these will be the "final" ASIC which will be used in an ILC detector being built for physics at earliest in 2016. The short-term issue for the French groups is to provide as much of a proof-of-principle of the ASIC as possible in time for the TDRs in 2009. Their longer-term goal is to produce an ASIC which satisfies all the ILC requirements in time for the detector construction. This is not a UK project and hence funding for the current and future production of ASICs is external to the UK and is already factored into longer-term planning in France. The UK work is to help with the validation of the ASIC, influence its design, and ensure the DAQ work is compatible with it, as far as can be foreseen. If we wish to continue testing ASICs beyond the next two versions, we will bid for funds in the next grant following the current period.

4. Section 5.4 task 2.4 – how high are the radiation levels? Why is simulation appropriate?
The combination of literature search and staff loss makes it sound like the experiment is short of expertise. How will you know your answer is correct?

We do not know the radiation levels, hence this task. Using simulation, we aim to estimate the amount of the radiation on the electronics outside the ECAL. Choosing a wide array of physics processes and a detailed analysis of the particle flux, the simulation will allow us to estimate this. There is no other avenue open to us.

The loss of the RA was unfortunate and affected Task 2.4 the most. However, we have re-hired quickly and have someone who has experience in physics analysis and simulation as well as networking so is well-suited to work on the DAQ workpackage. She has also performed a very similar task on radiation dose for parts of the calorimeter for CDF just recently. In combination with the fact that the previous RA left his code well documented and ready to use, we are confident this task will be back on schedule quickly.

We do not know if simulation is correct but in the absence of a real detector, it is difficult to do anything else.

5. Section 6 page 11 para 2. what is the event rate of the cosmics run? What are the objectives?

See answer to Q9 below.

6. Section 8.4 task 5.4 line 6 – 'the analysis is not truly generic for technical reasons'. This sounds like the coherent simulation structure is lacking. How fast will it all come together?
What is the risk of present work being lost when new structures are introduced? How will you ensure that UK are central players as the project ends?

The original intention had been for one of the UK group to implement a physics analysis that could be applied equally well to any of the evolving conceptual designs for a complete, general purpose detector. While the analysis of the reconstructed events can be close to generic and applied to simulations of different "whole detector" geometries, the *reconstruction* of simulated events — the starting point for the physics analysis — is not. For example, there are intrinsic differences in reconstruction algorithms required by a large TPC (LDC) and a silicon based tracker with a very small number of precisely measured space points (SiD). Each of the whole-detector concepts has to a large extent been developed in separate regions (*SiD* in N.America, *LDC* in Europe, *GLD* in Asia, plus much smaller fourth concept, ex. N.America). Each region has its own coherent simulation and analysis framework, and two of these can simulate the geometries of the other detector concepts in detail, but no framework provides a uniformly high quality of reconstruction of the simulated events for multiple detector concepts. (The output format used for simulated data is harmonised to allow interoperability and the geometry information necessary to reconstruct and analyse them can be exchanged to some extent.) To allow a completely fair comparison between the performance of different detector concepts, which is the main aim of the study, there are pragmatic options such as using Monte Carlo truth information about generated tracks with some smearing to emulate finite efficiency and resolution. This is not a major problem to our work.

The possibility of present work being lost, i.e. the physics analysis/code not being re-usable in the future, is significant and almost expected. It is for this reason that we set out to perform relatively simple, robust studies rather than investing a large amount of time fine tuning algorithms at such an early stage. Longer term, the concepts developed and the conclusions drawn from the studies are much more important than the analysis software itself.

To ensure that members of the UK community are central players, we have to ensure that the studies carried out enhance our credibility, and ideally influence detector design decisions.

7. *Risk proforma – in every case inherent risk and residual risk are the same, implying that controls and mitigating factors are useless.*

We developed the risk register in 2006 and the inherent risk assessments included the controls and mitigating factors in place at the time such that the inherent and residual risks were the same then by construction. In fact, one risk item (WP1.2a) has changed since then; the likelihood of AHCAL failure has been reduced due to most modules now having being constructed. This was the only item that we considered to have changed materially by the time the OsC document was prepared.

Why are there no risks in WP4? What happens if no suitable rad-hard glue is found in the literature search?

Suitable glues have been found for use at the LHC. We are investigating their long-term suitability both for structural and electrical purposes. The attachment of wafers may require precision glue dots of 100 µm thickness. It is not currently clear what the long-term behaviour of such small samples is, hence the tests. However, this should not be counted as a risk of failure to the overall project in the sense that if glue is unsuitable, other methods of connection to the wafers will be found. As such, the glue studies in WP4 will run until around Easter 2007, after which we hope to be in a position to make a decision as to the long-term suitability of conductive glue for CALICE.

Note, as discussed at the last OsC meeting, the aim of the UK WP4 work is to evaluate the suitability of conductive glue, not to find a general solution. The success or failure of the workpackage should be judged on whether we are able to determine if using glue is viable or not. Hence, the failure of glue as a solution is not a risk for the UK work. Indeed, if we show it is not viable (and hence prevent it being used and so avoid a failing calorimeter later) then we will have been successful.

8. Gantt charts:
WP1 ID19. What has to happen for a test beam run to be considered a success? What are the 2006 objectives?

This is an easy question to ask, but there is no simple answer. Broadly speaking, we set ourselves the objective of 10^4 good quality events at each of a series of energies, from 1 to 6 GeV at DESY and from 6 to 50 GeV at CERN, at angles from 0 to 45°, and at several positions on the calorimeter front face. This was in order to achieve 1% precision on the quantities of interest. In practice, in order to study position dependence, we exploited the beam width and tracking so we therefore set out to record 10^5 events at each energy/angle combination. In all configurations taken during the runs, we got at least twice this number of events. The usable number will depend on the exact cuts we end up using to select good events for analysis and this is not yet settled, but it is clear it will be above 10^5.

However, not all the sensitive layers of the AHCAL were installed at CERN. The showers were fully contained and sampled, though not with the eventual sampling frequency. This means that valid and illuminating comparisons between data and MC can be made, but the ultimate performance of the system will not be achieved until next year's data taking. Furthermore, the rotating stage for the HCAL was not available, so the hadron data were only recorded at normal incidence so far. So we consider that we have achieved the goals for the present year, but we still need data next year.

WP2 ID67. present simulation results. What are the criteria of success?

This milestone refers to a presentation of results on the radiation environment. The only criterion for success is that we have some results which we are prepared to make public; see Q4 for information on progress on this. How the findings will impact on the electronics will be dealt with in milestone ID70.

WP4. The Gantt chart looks very confused in the period May-Sept 07. Can you spread out the start dates to put less pressure on the timeline.

We agree and a modified version will be presented at the next OsC meeting.

WP4, ID8. Why is this split in 2 with 20 month gap? The reason for this is not clear.

This was a technical error that we did not spot and it has been updated.

WP5 ID34 30/9/06 has happened. Does this mean there is now a single coherent simulation for the whole detector?

Complete, coherent detector simulations for each of the four whole-detector concepts have existed for some time; see the answer to Q6 above. This item is referring to the implementation of an example physics analysis within our preferred framework. The code is available on the web as specified in footnote 16 of the OsC document or directly at

http://www.pp.rhul.ac.uk/~calice/giannell/
This will be used as a starting point to allow others to develop further physics analyses in different channels.

7. Financial charts.
Explain the (non) treatment of VAT

This was a typographical mistake on our part, i.e. the charts should say "including VAT" as VAT is included in all costs in the tables. We understand we cannot reclaim any VAT on this project as none of the equipment will be exported permanently to another country. Hence, we have always included VAT in all cases.

8. Section 2.2
The OsC would like to know if the EUDET Module 0 pre-supposed any of the ILC layout options and the objectives of the various test beam and cosmic studies (other than to collect huge data samples) as well as the simulation effort.
When will it be possible to start to be able to compare MC with collected data (I note from WP1 Gantt chart that this should be quite advanced for the DESY data). Similar question for analysis of the CERN data wrt Monte Carlo. It is assumed the purpose of these runs is to validate the MC models for later use in a final ILC calorimeter proposal.

The structure of the EUDET module follows the current main CALICE-proposed design for an ECAL and HCAL.

The EUDET project is an infrastructure project. This means the work is focused more on technical aspects of the various equipment being built. Specifically, under this EU-funded scheme, a structure which can hold various designs of a calorimeter is more important than the performance of the calorimeter itself. Therefore under the EU grant there is no such milestone as "Simulation validation".

The Module 0 will therefore answer a number of questions on temperature, ASIC characteristics, design of 1.5 m board, etc. The collection of data will happen towards the end of the EU grant and also after the PPARC grant. Real exploitation of this module from the UK side would need to come via a new PPARC grant following the current one.

The work of comparing the MC with the DESY data is indeed quite well advanced. Many comparisons have been made but no quantitative results have been made public yet. The CERN data are less studied in this respect as the critical modelling of the beam line is still being finalised. The main aim is indeed validation of the simulation to enable the detailed design of the calorimeter to proceed.

9. WP3 section, as written, is not clear. The OsC would want to know why source tests cannot be used to establish basic parameters like minimum ionising particle Signal/Noise and comparison with specifications. Why go to cosmics? Maybe it should be clearer what criteria would be used to decide if MAPS are a promising approach in a way that the WP3 Gantt chart does not seem to address. There is a danger that EID just keeps churning out more devices without a clear idea as to what the key specifications are and a measurement programme to clearly find if they are being met or not.

The main physics driver for a high-granularity calorimeter is jet energy resolution through particle flow techniques. This requires tracking individual particles through the calorimeter explicitly. Hence, the calorimeter sensitive layers have to be sensitive to charged hadrons which leave MIP deposits. We consider it essential that we test the sensor response to these directly, rather than extrapolate from higher energy deposits.

The sensor tests are documented in the "Sensor Testing Specification" from the PDR, available at footnote 2 in the OsC document or directly at http://www.hep.ph.ic.ac.uk/calice/maps/pdr/TestingSpecification_v1.0.doc There will be tests with a laser system to measure the charge diffusion and collection to compare with the detailed sensor-level simulations currently being done. However, the absolute size of the charge produced by the laser will be relatively uncertain and so this will not give an accurate efficiency measurement for MIPs. The main aim of the source tests is to measure the response of the sensor to physics energy deposits similar to MIPs with high statistics. They will measure efficiency and crosstalk (due to charge diffusion between pixels) vs. threshold. However, sources will provide slow, highly ionising particles (alphas) or electrons (betas), neither of which directly gives MIP-level deposits. Therefore, as stated above, we felt it was essential to see cosmics also, where the MIP efficiency can be directly measured. With four sensors, we would also be able to make some crude tracking estimate and so potentially check for angular dependences also. The document at the above URL gives an estimate of around 0.01Hz for the rate, requiring two months to acquire a sample with reasonable statistics. This is one of the main reasons for the long period of tests specified in the WP3 Gantt chart, ID12 and ID21. By cross-checking the high statistics source sample against the low statistics cosmics sample, we hope to make an accurate estimate of the sensor response to MIP signals.

Furthermore, there is a new possibility which has arisen since the OsC document was submitted. The better definition of the WP1 beam test program means we know we are now scheduled to be running at FNAL during the sensor testing period. Hence, it would be possible to parasitically take some data with MAPS in the CALICE beam line with muon or pion beams during this period. This would of course give a much higher rate of real MIP deposits than cosmics, potentially up to 100's of Hz, and so could be much more efficient. This option is under investigation.

The criteria for determining the viability of MAPS for calorimetry are complex, as discussed in the last paragraph of Sec 6 of the OsC document. (These criteria should not be expected to be determined from the Gantt chart, as this gives information on schedules and milestones.) It is likely the MAPS option will be cheaper but how that will be balanced against for example the likely higher power consumption of MAPS is not clear at this stage. Our best guess at reasonable requirements, which are what we are currently working towards, are given at
http://www.hep.ph.ic.ac.uk/calice/maps/MapsRequirements.txt

The current grant funds two rounds of sensor testing within the grant period and so there is no possibility of RAL/EID producing further sensors for no reason. Any future funding consideration will clearly look closely at the performance of the sensors produced during this grant to evaluate the viability of this approach given the wider ILC situation, in particular the likely funding levels, at that time.

10. *On WP5, it was not clear what would be the key criteria from simulation that might be expected to establish the superiority of one technology with respect to others. This*

would be true both for MAPS vs silicon pads but also silicon pads compared with other, cheaper options.

The quantitative, technical performance can only be established by comparing the results of several physics studies. For the calorimeter, these need to be analyses which depend heavily on reconstructing hadronic jets with good energy resolution, For example, the "bottom lines" might include the predicted resolution on the ZHH coupling, the efficiency for separating WW from ZZ events at a given significance and the mass resolution in top pair events. The UK is studying the first two of these.

11. There seems to be a lot of worthwhile activity, but from the report, not a clear link to easily identifiable goals. Maybe those links are obvious to the collaboration but some of them are difficult to fully identify in the document.

As discussed in Sec 3 of the OsC document, the overall objective of all UK work is to position the UK so that it can participate in the ILC detector collaborations. We intend to achieve this through contributing strongly to the TDRs, gaining a reputation for competence and by establishing a significant presence in the ILC community.

WP1 The main goal in the past few months has been to operate the ECAL, AHCAL, TCMT and DAQ successfully in a test beam, and to record data suitable for analysis. This has been achieved, as reported. The overall goal for this workpackage is to understand the degree of agreement of the simulation to real data, so as to be able to trust the simulation sufficiently to design the ILC detectors and hence contribute to the TDRs. This directly relates to the primary goals above.

WP2 The UK is leading the way on DAQ in the ILC. We are the only group thinking beyond just providing a DAQ for current systems and trying to exploit new technology. We are clearly the only people within CALICE doing this and so have a well-defined role. Within the ILC as a whole, there is also little activity, hence the first sentence. Therefore, the fact that we are pursuing these areas of activity in DAQ establishes our leading role. For example, this meant that we were unquestionably the group who would provide the DAQ for the EUDET project. Our top-level goals over the next three years are to provide the DAQ for the upcoming EUDET prototypes and to write the DAQ section in at least one of the detector TDRs. For the first goal, we are already signed up to do this. For the second, we cannot see any other group who could compete. This will then put us in place to build the DAQ for the calorimeter (or even other detectors if the UK can provide the funding) should the final project be realised.

WP3 There is a clear overall goal for WP3 which is to evaluate the viability of MAPS for calorimetry at the ILC. The production and testing of two rounds of sensors is directly targeted at this goal. If MAPS prove viable, then this would establish us with a very significant presence in the ILC calorimetry groups.

WP4 The goal of WP4 is to contribute significantly to the development and design of the assembly system for the ECAL. We are working with the French mechanical engineers to this end, with the ultimate aim of assembling a large part of the ECAL in the UK.

WP5 The overall goals include development of an improved particle flow algorithm, contributions to development of global detector design, simulation studies which facilitate development within other WPs e.g. optimisation of MAPS sensor geometry, and development of a robust physics analysis within our preferred software framework that can be used as a quantitative benchmark for detector design decisions. All of these will allow us to contribute to physics and detector design studies for the TDRs.

12. Section 4(WP1) talks a lot about millions of events collected but the OsC would like to understand how this translates into precision on measurements etc. if 20M events are expected is 10M enough?

The facile answer is that the measurements would be less accurate by a factor of √2, or else that we would have to measure fewer energies or angles. The aim is to distinguish between various hadronic shower simulations, which can have differences at the level of 10% in some variables. Our aim is for 1% precision on the distributions. Some details can be found at
http://www.hep.ph.imperial.ac.uk/calice/others/040901durham/ward.pdf
The actual numbers of events needed also depend on the data quality and the cuts we need to apply in the analysis; see our reply to Q8.

Additional questions communicated on 9 November

1. List of crucial performance measurements and key graphs/plots that the Collaboration plan to produce to monitor the success of the beam tests;

The key analysis plots would include the following:

- Energy response for electrons (ECAL) and for pions (ECAL+HCAL+TCMT)
- Energy response vs beam energy (linearity test)
- Energy, angular, positional resolution vs energy
- Longitudinal shower profile
- Transverse shower profile
- Dependence of the above on position and angle of incidence
- "Deep structure" of hadronic showers (i.e. substructure within showers)
- All the above compared with various Monte Carlo models.

Work on the above, especially for electrons, is already under way, and has been shown within the collaboration, and the first results are encouraging. We can not yet show these quantitative results publicly (beyond the highly preliminary and confidential plots included in the OsC report), because CALICE is now implementing strict approval procedures on presentation of results.

2. The formal sign-off procedures to ensure that the chips produced meet their specs;

The formal sign-off procedures were given in the OsC document, Sec 6, paragraph 4, where it specifies that all reviews will be run using the ISO9001 system and the WP leader, not the RAL/EID group leader, is responsible for the final sign-off.

3. The mechanism by which the Collaboration plan to undertake the management of monitoring the progress and resources in, and between, the different work packages.

The principal mechanism is a two-monthly meeting of the five WP Managers with the Project Manager, either face-to-face or via a phone conference. The agenda for these meetings includes

- Financial issues, for example at the last meeting we discussed the requirement of additional funding for MAPs.
- Staffing issues, such as those mentioned in Q4.
- Update the risk register.

- Progress on each WP.

For the last of these each WP Manager reports progress against the Gantt chart for the WP and progress bars are updated after the meeting.