CALICE - Replies to Referees' Comments

January 28, 2005

The four referees' reports forwarded to us requested further information and clarification. We answer most of these points below. The technical clarifications related to Workpackage 3 will be dealt with in the open presentation and subsequent closed session.

1 Referee 1

The referee made several comments in the report asking for more information.

1. **Section "The Proposal" 3b:** The elements of Workpackage 4 were defined and agreed as part of a coherent R&D programme within CALICE, specifically including the French and Korean groups who are involved in this area. The UK has taken on several key elements of this work and we will continue to liaise with the other groups in future to ensure that close co-operation continues.

   The glue studies are one-off and self-contained and need to be done soon, since if the glue is unsuitable we need to know as soon as possible to sort out alternatives. Apart from that, there are not a great many interdependencies.

   The thermal simulation and modelling is much more interconnected with other developments. The first stage is to establish and validate a thermal simulation of the detector, on the timescale shown which is under our own control. The design optimisation can then be done on the basis of this model and results from other studies. The timing of such design changes cannot be predicted at this point; we want to be in a position to respond and contribute to the decision process as and when they do.

2. **Section "The Proposal" 3c:** The referee asks about the CALICE central management structure. CALICE has a well-defined management organisation and a brief overview on this is given in Section 8 of the proposal. We attach the document "Internal rules and structure of the CALICE Collaboration" which gives more detail on this organisation.

3. **Section "The Proposal" 3e:** Links to both the CALICE collaboration and the ILC community in the UK are well-developed. The proposal (and the internal document mentioned above) show that UK members are heavily involved in the central CALICE management and so can both influence the direction of the collaboration and also keep in close touch with developments outside of the UK. UK members have attended every CALICE ECAL meeting as well as the general collaboration meetings since we joined the collaboration two years ago. The talks given at these (and other) meetings are listed at [1]. We have no doubt that the UK is closely connected to the rest of the collaboration.

   The UK community involved in the ILC [2] meets regularly and CALICE plays an active role in these meetings. The community is organised into a Steering Group and a Collaboration Council. The Steering Group is chaired by Prof. B.Foster (Oxford) and has representatives from all aspects of the UK ILC programme; LC-ABD, LCFI, CALICE and theory. The CALICE UK Spokesperson (currently P.D.Dauncey) sits on this committee. The Collaboration Council is chaired by Prof. D.J.Miller (UCL) and its members represent every institute in the UK involved in ILC activities, with one member per institute per activity. CALICE currently has five members but if the proposal is approved, two new groups (RAL and RHUL) will join, giving two more representatives. The UK community hold regular meetings, the last of which was at Imperial College on 21 December 2004 [3]. CALICE is always well represented at these meetings through attendence and presentations.

There were also five explicit questions in Section 9 of this referee's report.

1. *Could CALICE-UK elaborate on the extent to which the proposed work areas have been presented and discussed within the wider CALICE collaboration?*

   We consider it essential to work within the framework of CALICE. The collaboration is by far the biggest involved in ILC calorimetry and it would be a very negative step to try and work independently after all the progress we have made in the last two years. Therefore, we have made a big effort to present our ideas for the proposal to our collaborators at several meetings, most notably at the last general collaboration meeting on 8 December 2004, where M.Wing gave a talk specifically covering the proposal plans [4]. This generated a lot of interest and useful suggestions. We have attached a letter from Dr J.-C.Brient, the CALICE Spokesperson, stating his view of the UK proposal. Note, the UK is not the only group within CALICE working on longer term issues; within the ECAL, the French and Korean groups are considering mechanical structures for a real ILC detector and the VFE ASIC has a well-defined development programme over at least the next three years.

   Beyond CALICE, we have also kept the worldwide ILC community informed about our activities in the DAQ and simulation areas through many talks at EFCA and LCWS workshops, which are listed in Annex E of the proposal and available at [1]. (The MAPS and mechanical/thermal work were at too preliminary a stage to be presented at the last such workshop, ECFA04 in September 2004 at Durham.)

2. *What is the high-level timeline across the work packages and what are the dependencies between work packages in project management terms?*

   Section 1.4 outlines the overall schedule which we are working to. The basic goal for the next three years is to position ourselves so as to be able to make a big impact at the time of the TDR in 2009. We believe this is when many far-reaching decisions will be made on technologies for the detectors. This schedule clearly drives all the workpackages.

   Within this overall time frame, the workpackages are to a large extent independent. Each has to achieve its aims by 2008 in order to be able to write the relevant parts of the TDR within the following year. There are of course some interdependencies, mainly between the data analysis and simulation Workpackages 1 and 5 and the hardware Workpackages 2, 3 and 4; data and simulation results will drive the choices in the hardware, while results on data rates and sensor resolutions will change the detector simulation. With regards to project management, we have tried to keep this interdependence simple by having the people with the expertise bridging the workpackages. Specifically, the University RAs are all involved in both data/simulation work as well as hardware tasks.

3. *The applicants identify that delay to the TDR beyond 2009 would have an impact on all the work described. If there was a delay, how would the overall UK timeline be modified and which components would require higher priority development?*

   We assume a delay in the TDR would result from a delay in the overall schedule for the ILC. Hence, the issue is that either more could be achieved by the time of the TDR, or that the same amount of work could be done but at a slower pace. If we knew today that the TDR would be later, we would do the former, particularly for the MAPS work where there is a lot of work to do done. However, all indications are that the TDR will need to be written in 2009 and so we must work to this deadline. The statement in Annex C3 was therefore supposed to indicate the latter option; a delay in the TDR which arose during the period of the proposal would mean many of our deliverables could in principle be delayed correspondingly, as they aim directly for the TDR. The relevance to Annex C is that many of the risks relate to schedule and so they would have less of a detrimental impact if the TDR was delayed.

4. *Could WP4 elaborate on the external timeline and constraints and hence describe when the pre-prototype is required?*

   The assembly procedure prototyping has its timing driven by the TDR. When a detector design is proposed, we need to establish that the specification - in terms of tolerances, accuracy, and efficiency for making good connections - is something which is achievable. With this large number of silicon wafers, a highly automated manufacturing system is vital to the successful build. When in the future we are asking for the millions of pounds required to buy the silicon and assemble it, we have to be able to prove that we can build the detector, and specify the budget in time and equipment for doing so. This can only be done convincingly by having developed a pre-prototype system that can actually do the job, and that is the goal of this activity.

   Because of the nature of this work, the request is at a level we consider rather modest. We are not asking for any major items of equipment, only for minor equipment, materials and software licenses.

5. *Could CALICE-UK elaborate upon the likely proposed work area for future developments at Edinburgh?*

   This is strongly dependent on the person who will be hired as the new lecturer, as they will define the programme to a large extent. Hence, a definitive statement is not yet possible and so we do not rely in any way on their effort for the tasks in this proposal.

   However, the interests of the group are generally in computing, networking and DAQ, so it seems likely that they would want to enlarge the scope of Workpackages 2 and 5, bringing more influence to the UK.

2 Referee 2

There were several comments from this referee in various sections. There were also some statements which perhaps indicate the proposal was worded ambiguously and so we feel should be clarified.

1. **Section "Resources" c:** The referee states *For some reason they have excluded 46% overheads which adds £800k.* Annex A (page 38) states we have costed staff for the "exact total costs". These do indeed include the 46% overhead as well as NI and pension contributions and the actual cost for each individual named member of staff was used, to get as accurate a figure as possible.

Regarding the points in the section "Comments for the applicant":

1. With regard to the comments on the necessity for test beams, we can only agree. The test beam data will be used to check and tune the level of simulation agreement. However,

these data have only just started to be collected this month, so we have no signficant results comparing data and simulation yet. This is the major aim of Workpackage 1 over the next two years.

To correct one misunderstanding; the simulation, shown in figures 5 and 7 of the proposal and also discussed in Task 5.1 of Workpackage 5, is of a full ILC detector, not the test beam detector, as the idea here is to study the application of the method to the physics output of an ILC detector. This simulation does include a magnetic field. It is clear that the test beam studies would benefit from being immersed in a high magnetic field, similar in strength to those proposed for an ILC detector, i.e. around 4-5 T. However, given the $1 \times 1 \times 1\,\mathrm{m}^3$ size of the HCALs, plus the associated electronics and mechanical support, there is no magnet available of this size for the test beam at FNAL which can accomodate the equipment. With regard to the angle of incidence, the referee is correct to say this will need to be correctly modelled and so we plan to take data with the test beam at other angles than perpendicular, as stated in Sections 2.1.2 and 3.2 of the proposal.

For the photon-pion separation plots, these were intended to be illustrative of the ability of the current clustering algorithms (developed in the UK) to separate closely-spaced showers in the calorimeters. As stated above, these studies were done with the full detector simulation so in principle the tracking detectors could be used to find the starting point of the pion cluster. However, this information was purposefully not used; as the referee correctly indicates, there is no a priori way to know the identity of the clusters beforehand and so the algorithm used only the calorimeter information to attempt to recognise if there were one or two incoming particles. Figure 5 shows the separation is clean for particles separated by only a few cm at the front face of the ECAL, clearly because of the high granularity of the ECAL $1 \times 1\,\mathrm{cm}^2$ readout pads. Figure 7 shows even this excellent separability can be improved with the finer granularity of MAPS.

2. The question of radiation levels for the MAPS detectors is raised. The levels expected in the calorimeter are orders of magnitude below those experienced by the LHC. The exact levels will depend on the ILC accelerator configuration, particularly the final focus near the detector, but the TESLA study [5] found the rates for electron and neutron background were each around $10^3 - 10^4$ per beam crossing for the whole ECAL. Given around 10^4 beam crossings per second, this translates into at most 10^{16} of each per year hitting the ECAL. Even under the very pessimistic assumption that these are all absorbed in the first layer of the ECAL, which has an area of order $50\,\mathrm{m}^2$, these figures correspond to around $10^{10}/\mathrm{cm}^2/\mathrm{year}$. Referee 4 states radiation effects have been seen in MAPS at the level of 10^{12} hadrons/cm^2 although sensors have also been shown to work at levels up to 10^{14} protons/cm^2 [6]. In either case, these numbers are well beyond anything expected at the ILC.

   We note that MAPS are also being considered for the vertex detector in the ILC, which will have radiation levels around an order of magnitude higher than the above values.

   One possible area where the backgrounds may be higher is the innermost part of the calorimeter endcaps, where there may be radiation from low angle Bhabha scattering and beamstrahlung hitting the focusing magnets and scattering into the endcap. This will require careful shielding but it is not thought that there will be levels orders of magnitude higher than the above estimates. Note, as stated in Section 6.1 of the proposal, the endcap design (including the shielding) is a major outstanding issue.

   It would be straightforward to extend Workpackage 3 to include radiation hardness studies of MAPS but we did not consider it a high enough priority at this time to ask for the extra resources which would be needed.

3. The comments on WP5 relate to a possible lack of leadership for the UK in Task 5.1. We do not believe there is such a lack. One measure of the UK's standing is that several CALICE members are convenors of international ILC working groups (outside of CALICE), as mentioned in Section 2.3 of the proposal.

   Within CALICE collaboration meetings, the UK groups have presented many talks in this area; these are collected at proposal reference [31]. In addition, talks outside the collaboration, as listed in Annex E, include several (mainly by C.G.Ainsley and G.Mavromanolakis) on the issue of Energy Flow algorithms.

   The ratio of new to existing staff is high here as we think this work is mainly appropriate for RAs; it requires detailed, concentrated software and physics effort. Hence, this is an area where we foresee the new RAs would play a strong role. In contrast, Workpackages 2, 3 and 4, which involve hardware, have more of a mix of physicist, engineering and technician effort. While the latter two are generally available through the rolling grants, due to ring-fencing at the institutes involved, none of the groups have more than a small fraction of RA effort available from this source. In addition, to become a major player in the long term, we need to build up the size and expertise in the groups; this can only come through new posts.

3 Referee 3

We reply to the comments other than those concerning technical aspects of Workpackage 3 below.

1. **Section "The Proposal" e:** The question of the level of integration of the UK groups within CALICE is covered in the answers to Referee 1 above.

2. **Section "The Proposal" f, WP1:** The referee states we should be aiming to run the simulation on the Grid. This is indeed the aim; GridPP2 is funding a "Portal" post (filled by G.Moont) at Imperial to provide a generic Grid submission structure for smaller experiments and CALICE is one of the test cases for this. The aim is to do simulation, data storage, data access and the first pass reconstruction (conversion to LCIO format) on the Grid. The last of these is being used as a test case now real data are available and the first release of a Grid conversion job is expected in March this year.

3. **Section "The Proposal" f, WP4:** The UK work programme outlined in this workpackage was defined in close collaboration with the Ecole Polytechnique team responsible for manufacturing the test beam ECAL carbon fibre structure. The items listed are things which they jointly considered to be essential but which the Ecole Polytechnique group had no effort available to look into. The groups developing the diode pad wafers themselves (Prague and Moscow) are more interested in the electrical rather than mechanical aspects and neither group has invested any R&D effort in the areas covered in this workpackage.

4. **Section "The Proposal" f, WP5:** The referee gives two very interesting areas for future work, both of which are important. We hope to be able to answer these (and many other) questions within the period of the proposal.

5. **Section "The Proposal" g:** A correction to one statement here; the current MAPS seedcorn-funded project finishes in May 2005 and so there will be no "existing project" after that time. We would like to take advantage of the work done within that project over the last two years by now applying the technology which has been developed.

6. **Section "The Applicants" c:** The fraction of P.D.Dauncey's time on CALICE (40% although due to rounding to staff months, this is not obvious from the tables given) is set against teaching (30%) and leading the ongoing BaBar group at Imperial (30%). The latter includes two students and RAs and could not easily be dropped immediately. Hence, the possibility of removing the teaching element through a PPARC fellowship would be very desirable. Note, the fellowship case stated exlicitly that all the extra time would be dedicated to CALICE, not BaBar.

   Although the referee considers 40% is not high, this is the larger of P.D.Dauncey's two research areas. Note that this division has been constant throughout the period of the prevous grant and so his ability to be effective at this level can be judged from the last two years. During this time, he was CALICE UK Spokesperson and lead both the electronics and DAQ efforts, including personally writing almost the entire suite of board test software as well as the final DAQ software itself. He feels that continuing his effort at this level would be sufficient to cover the tasks in the proposal although would of course welcome the fellowship.

4 Referee 4

Again, we reply only to comments not concerning technical aspects of Workpackage 3.

1. **Section "The Proposal" 3b:** We think it is both unfeasible and undesirable for the UK to attempt to build the whole of the ECAL for an ILC detector by itself. However, the CALICE collaboration as a whole *does* have that goal; we (the collaboration) want to be responsible for all aspects of the design, construction, commissioning and operation of the ECAL (and hopefully also HCAL) of an ILC detector. We (the UK) are collaborating within CALICE specifically so that we can benefit from mutual experience and expertise as well as share the (large) cost of the final ECAL between the countries involved.

   The long term goals of the UK groups strongly depend on the outcome of the TDR, which is why we are emphasising its importance. The ECAL be a very challenging project whichever technology is chosen for the TDR. We have defined a programme so that the UK will be able to have a leading role whatever that outcome; however we will only be successful in this if we have a strong team and adequate resources over the whole programme.

   Take one scenario; the MAPS concept can be shown to be viable and is accepted within the detector collaboration at the TDR stage. The UK would be seen to be clearly leading this field (as there are no other proposals for MAPS in calorimetry at this time) and so would push this as a very high priority. This would put the UK at the very heart of the ECAL. It is very likely we would also continue to work on aspects of the DAQ, given the lead we will have established in this area. Given a guess for the input from the UK of £10-15M in the ECAL, then we could feasibly be providing around one third of the ECAL wafer costs.

   The alternative outcome would be that MAPS (due to technical problems or underfunding) are not proven by the time of the TDR, in which case the DAQ work would become the highest priority in the UK, again because of clear UK leadership in this area. While not then as novel, we would aim to build the complete DAQ system from front end to PC farm; this is likely to match the above UK financial input. Note, the UK effort in Workpackage 4 would mean the UK would also contribute to some of the on-detector mechanical work, most likely in either scenario.

   Either way, the UK would have a large part of the ECAL and hence have influence in the detector.

2. **Section "The Proposal" 3c:** Comments on the overall schedule and workpackage interdependencies have been given in the reply to Referee 1 above.

3. **Section "The Proposal" 3f, WP2:** The comments here show the case for support was possibly ambiguous. In section 4.3, we state ideally the data for the whole ECAL (in fact the whole detector) would be sent to a single PC. This is supposed to mean each bunch train goes to one PC, but each train goes to a different PC in a large farm (which would indeed have fast networking, as discussed in Section 4.2). This would allow optimal reconstruction as all data for the train (which contains multiple events) are available to analyse. This is certainly not done in experiments at present but the aim is to take advantage of the expected improvements in data networking during the intervening years, when it may be possible to achieve this. Splitting the data between several PCs requires special care at the boundaries where the neighbouring data are not available. One of the parts of Task 2.5 is specifically to study how detrimental this is in terms of reconstruction and data suppression.

   For the rest of the detector; the UK concepts for the calorimetry DAQ are significantly more advanced than any other detector subsystem that we are aware of. The generally agreed overall goal for the ILC detector is to have a "triggerless" DAQ system so all data from all bunch trains are read out and analysed offline. Effectively, the trigger is then purely a software selection of events from the bunch trains. There is also a desire to have a "backplaneless" system, meaning as few custom components as possible are used, with most of the DAQ system being built from standard commercial units. This has obvious benefits in terms of cost as well as ability to upgrade in the future. The TESLA TDR DAQ designs, while being triggerless, were traditional crate-based systems. The UK conceptual design, as presented at ECFA04 at Durham in September 2004 [7], was the first detailed study for the ECAL (and possibly any detector subsystem as far as we are aware) which was able to fulfill these criteria.

4. **Section "The Proposal" 3f, WP3:** The main aim of Workpackage 3 is to prove the viability (or otherwise) of the MAPS concept. The risks we specified in Annex C3 are those which could prevent us from knowing if this is a viable option within three years. The possibility that MAPS is not a suitable technology is not a risk to this programme; it is a perfectly acceptable (albeit unwanted) outcome in terms of achieving our stated aims for the next three years.

References

[1] `http://www.hep.ph.imperial.ac.uk/calice/`.

[2] `http://hepunx.rl.ac.uk/lcuk/`.

[3] `http://hepunx.rl.ac.uk/lcuk/lcukmtg1204.html`.

[4] `http://www.hep.ph.ic.ac.uk/calice/calice/041207desy/wing.pdf`.

[5] "TESLA: The superconducting Electron-Positron Linear Collider with an integrated X-Ray Laser Laboratory," Technical Design Report, DESY 2001-011, March 2001.

[6] P.Allport et al., "Design and characterization of active pixel sensors in 0.25 CMOS," presented at IEEE-NSS04, Rome, October 2004 and submitted to IEEE Trans. Nucl. Sci.

[7] `http://www.hep.ph.ic.ac.uk/calice/others/040901durham/dauncey040901.pdf`.