

## **CALICE: Proposal to the PP Consultation Committee**

The following is a detailed breakdown of a proposed plan for funding CALICE at a significantly reduced level in FY08/09. Because of the current financial situation at STFC, we understand that we have to reduce CALICE spending in the next FY to a minimum and complete the remaining work within the year. However, there are various factors (specifically; work close to being published, R&D which is generic and has applications well beyond the ILC, and UK responsibilities upholding the UK reputation as a reliable partner) which mean we believe there is a good case for not shutting down this work immediately.

The current CALICE grant consists of five workpackages and, for each, we have planned a programme of work. We outline the cases for these below and give the cost of each workpackage in FY08/09. The total cost of all five workpackages in FY08/09 is £629k.

**WP1: Beam Tests.** The CALICE collaboration has been testing “physics prototypes” of both electromagnetic (ECAL) and hadronic (HCAL) calorimeters in beams at DESY and CERN over the last two years and this will continue at FNAL throughout 2008 and into 2009. These are prototypes to measure electromagnetic and hadronic showers in detail and to compare them with simulation. A large dataset has already been taken with a silicon wafer ECAL and scintillating tile HCAL and is currently being analysed. This work is quite generic and so the long term outcome will be an improvement in simulation models and tools not only for linear colliders but also for many other experiments.

CALICE-UK is responsible for the data acquisition and real-time monitoring of the beam test systems, and leads several aspects of the data analysis. Given the investment of effort and equipment in this area, we should reap some benefit from the results. We plan to continue with these analyses until they are published, which will be within FY08/09. This requires RA, support physicist and academic effort, which would be needed throughout most of the FY. This includes effort from an RA who is now funded through EUDET (see below). We also have three graduate students writing theses on these data, and we need to support them until they finish their work.

Not getting the FNAL data would represent a significant loss of important results and of influence within the community. These data will significantly extend the low energy range of the hadron beam data, which is a region likely to be crucial for jet reconstruction based on “particle flow” techniques. In addition, two new calorimeters (a scintillating tile ECAL and a binary readout HCAL) will be ready this year and so for the first time we will be able to compare very different calorimeter designs directly in the same beam line.

We need to provide the minimal effort needed to uphold the UK responsibilities for the FNAL runs in FY08/09. We plan to provide very little shift or run coordination effort, despite making a very significant contribution in these areas in the past; unfortunately this will place a heavy burden on our collaborators. However, we cannot reduce the UK effort completely to zero; it is effectively impossible for the DAQ responsibility to be passed onto a non-UK group as the expertise only exists within the UK. The DAQ is

common to all the calorimeters being tested; unless this is continued until the finish of the beam test programme, the UK will be seen to be destroying the central part of the overall CALICE collaboration programme. This task requires academic and technical effort. The UK responsibility for the real-time monitoring will require some RA effort to maintain but, in this case, the expertise is more easily transferable and this responsibility will be handed over to non-UK collaborators during the first run period in 2008. We also proposed to have some RA effort allocated to a first analysis of the FNAL data.

The total cost to STFC in FY08/09 of the revised WP1 programme is £124k.

**WP2: Long Term DAQ.** The UK groups in CALICE are in a world-leading position with regard to studies into practical applications of DAQ for future colliders. The concept in this workpackage is to use cutting-edge technologies as a basis for DAQ systems rather than the traditional bespoke solutions previously used in HEP. This concept needs to be tested and used in anger, specifically on large prototype detectors in a test beam, to be able to validate the approach. This approach is expected to be applicable to any future experiment and so the whole workpackage is highly generic, as was noted by the PPRP at the time the original bid was approved. The completion and demonstration of this concept is therefore beneficial to the UK groups in DAQ systems throughout HEP and not just linear colliders; indeed, work is being pursued by some of our groups on the use of our DAQ systems for LHC upgrade projects. It is therefore vital to demonstrate this approach in order to maintain our lead position and the potential to build DAQ systems for any future collider detectors.

The plan is to use the EUDET collaboration large-scale “technical prototype” beam test programme for the DAQ system validation. The UK already has major deliverables and significant international partnerships within EUDET. Funding from the EU relies on the current matching funding from STFC, both legally and scientifically. Any withdrawal from delivering the DAQ system for the planned would be very damaging for the UK’s reputation as a reliable partner. Hence, we propose to complete the design of the EUDET DAQ system as planned but will negotiate with our international partners for them to pay for some of the physical equipment required to read out their detectors from EUDET central funding. In addition, we will drop all testing of the readout ASICs designed outside the UK and will no longer take responsibility for aspects of the software and firmware. This means we make the best use of STFC funds to promote UK DAQ expertise and also can fulfil the UK responsibilities in the DAQ design. This requires academic, engineering, technical and RA effort but a low level of requisitions funds.

Because this work is highly generic, we plan to submit a proposal within 2008 for future funding to cover FY09/10 and beyond. This would aim to pick up the programme and develop it in a broader sense than the original linear collider application. Hence, it is important that the expertise which has been built up is not allowed to disperse. In particular, this requires that rolling grant staff are retained throughout FY08/09.

The total cost to STFC in FY08/09 of the revised WP2 programme is £173k.

**WP3: MAPS Sensors.** The UK is developing a novel and unique approach to electromagnetic calorimetry, where silicon active pixel detectors (incorporating the pixel readout into the sensors) are used to produce a binary readout calorimeter of very high granularity. This has the potential to give very significant improvements in spatial and energy resolution at lower cost. In addition, as part of this work, a CMOS device processing step has been developed which has wider applications to many areas of sensor development, not only within particle physics but also to other areas of STFC science. To abandon this work at this point would be a major loss to UK leadership and would waste the resources already spent on the project. Hence, the aim here would be to complete a descope version of the current workpackage, again with the aim of a future generic R&D proposal coming online in FY09/10 to develop the project further at that time.

The first sensor was produced in the second half of 2007 and is currently under test, originally with a second design planned for early in 2008. The only way to continue the project at a reduced cost is to slow down, to reduce the effort needed, and also to produce a cheaper second sensor, specifically one much smaller than originally planned and with no “ILC-like” features. The fabrication of this smaller sensor would then be later in 2008. The level of effort needed for the external readout electronics design will be heavily reduced as the second sensor will now be consistent with the first in terms of readout, so the existing readout and DAQ system can be reused. The work needed here requires academic, RAL/TD and engineering design effort.

The tests on the first sensor need to continue during the design of the second so as to feed into the latter all knowledge gained from the former. In addition, the second sensor itself will need to be tested following its fabrication. This work will require academic, RAL/TD, RAL/PPD and RA effort.

The total cost to STFC in FY08/09 of the revised WP3 programme is £252k.

**WP4: Mechanical and Thermal Studies.** The effort in this workpackage will now be concentrated solely on the construction of the electromagnetic calorimeter “technical prototype” for the EUDET project. This part of the programme must continue as part of the reduced CALICE-UK work or else the UK will fail to deliver on its responsibilities. In addition, the WP2 programme described above makes no sense if there is no calorimeter with which to validate the DAQ system.

Even within the EUDET area, the scope of the work will have to be substantially reduced due to the constraints on funding. We will now no longer be able to lead the design for the ECAL module end and services integration, so this work will be carried out by our French collaborators. The work on assembling the ECAL slab active sensor units (ASU) will also necessarily be scaled back to the level of demonstrating a working solution to fixing the sensors to the PCBs. Assembly of the ASUs for the EUDET prototype will still be possible in Manchester, but the process will not be “production ready”. It will meet our commitments to EUDET and no more.

All the thermal studies will be stopped by the start of FY08/09. In addition, a planned contribution to a linear collider detector endcap design will not now be started.

The effort needed for this workpackage is academic, engineering and technical. Funding for consumables, notably conducting glue and for adapting the glue robot, will be needed but this cost has been reduced to the bare minimum.

The total cost to STFC in FY08/09 of the revised WP4 programme is £28k.

**WP5: Physics Studies.** The UK groups within CALICE have been performing studies of the physics potential of particle flow algorithm (PFA) techniques to improve jet energy resolution. The concept of a PFA approach can be applied to any future collider detector and so this work is generic in its application. The development and optimisation of algorithms can only be performed in the context of detailed detector simulation models and within CALICE-UK, these studies have so far been applied to detector concepts developed for the ILC.

Despite the large future potential of this approach, we propose to continue these studies throughout FY08/09 at a reduced level, such that a proposal for generic R&D into detector designs optimised for PFA can be submitted in 2008. The bare minimum effort needed to achieve this is academic, support staff and RAL/PPD. There will also be a University-funded RA working in this area. This work will necessarily continue to be based on existing ILC detector models as there are no alternatives available at present which have the required level of detail. This pragmatic approach also keeps the effort required within the UK to a minimum, as it avoids any need to develop and maintain new detector simulation models.

All other current studies within this workpackage, in particular those which are related to developing physics analyses to benchmark the performance of the evolving ILC detector designs, and to assess the stability of the PFA algorithms, e.g. to uncertainties in hadronic shower models, will be stopped by the start of FY08/09.

The total cost to STFC in FY08/09 of the revised WP5 programme is £51k.

**Summary:** As noted above, the total cost of all five workpackages in FY08/09 is £629k. A similar programme was discussed with the CALICE OsC in January, which they strongly supported. The difference is in WP1; an additional £65k has been included here for part of an RA and some travel. This resulted from a reconsideration of the effort which would be available for beam test analysis in the programme discussed with the OsC. That had the number of RAs reduced from roughly 5 to 2FTEs, which would not have been sufficient to allow analysis work of the FNAL data given the other aspects of the programme. Hence, with the extra £65k, we can support another 0.75FTE of an RA, which would allow us to contribute to the FNAL data-taking and be able to maintain the UK lead in the analysis of these data for the next year.