

# **CALICE-UK Final Report to the STFC Oversight Committee**

**May 2009**

## **Introduction**

In this final report to the Oversight Committee we concentrate primarily on the overall achievements of the project and some of its important legacies. Although the project has ended, many of the R&D issues we have been addressing are continuing, some in the UK, others elsewhere. The international CALICE project continues and is providing important input to the development of the detector concepts for the International Linear Collider project.

While UK involvement in CALICE began in 2002, the present project was funded for three years to 31 March 2009. Following the STFC financial crisis and publication of the Delivery Plan in 2007, funding was reduced and grants withdrawn. This particularly affected the last year of the programme, which was funded at around 50% of the level originally announced. Furthermore, it had a disproportionate impact on PDRA support since, not unnaturally, the PDRAs sought alternative employment and left as soon as possible.

Nevertheless, many of the original aims and objectives were achieved and we list these for each workpackage in this document. We end with a short section on the financial status.

## **WP1: Beam test programme**

The purpose of this programme was to carry out tests on a number of prototype calorimeters in electron and pion beams at DESY, CERN and FNAL and to make comparisons with, and hence improve, Monte Carlo shower simulations. The UK made key contributions in online software for data-taking, in provision of run coordinators, and in the analysis of the data.

Key achievements:

- collection of electron and pion data as planned in 2006 and 2007 with a DAQ system working efficiently;
- conference presentations and refereed journal papers on the electron data, including a CALICE-UK member being primary author of the first CALICE paper;
- contribution to analysis of the pion data to the level of internal collaboration reports.

Work lost as a result of cuts:

- contribution to collection of electron and pion data at FNAL in 2008;
- contribution to the analysis of the pion data to journal publication level.

Legacy:

The dataset obtained comprises the only detailed sample using high-granularity calorimeter detectors and as such will continue to be exploited for several years to come. Only a small amount of (non-STFC-funded) effort continues for this within the UK through an academic and graduate student at Cambridge, concentrating on pion interactions in the electromagnetic calorimeter.

### **WP2: A modular data acquisition system**

The principal aim of this workpackage was the demonstration of a triggerless DAQ system based as much as possible on commercially available items. The generic aspects of this workpackage continued to receive STFC support after the financial cuts. It had also been enhanced in 2006 by additional EU funding through the EUDET collaboration to allow the UK to provide a DAQ technical prototype for the readout of electromagnetic and hadronic calorimeter prototype modules. The EU funding ends in December 2009.

Key achievements:

- a realistic ILC-like DAQ system design, with a specific hardware implementation;
- delivery of the working EUDET system to allow the calorimeters to be tested.

Work lost as a result of cuts:

- stress testing and gain of experience of the DAQ system in a real data-taking environment;
- UK leadership in future DAQ developments.

Legacy:

The UK DAQ design is much more advanced than any other DAQ system proposed for the ILC. As such, it will provide a basis for future developments for the ILC detector concepts. While the UK will stay involved in this work until the end of 2009, beyond this, the UK leadership will be lost.

### **WP3: Maps studies**

This workpackage was concerned with providing a proof-of-principle for the novel technique of a digital electromagnetic calorimeter (DECAL). The original project involved the production of a small test sensor followed by a large version suitable for a real DECAL. The latter was cut in 2007 and so this project was not able to deliver on its main aim. However, many studies of the performance of the test sensor were done.

Key achievements:

- design, fabrication and characterisation of the test sensor;
- study of expected performance of a full-size, ILC-like DECAL based on the test sensor performance.

Work lost as a result of cuts:

- production of the large sensor;
- proof-of-principle of DECAL.

Legacy:

The fundamental idea of a DECAL looks viable based on the studies done so far. The work to produce a working DECAL stack is approved to continue within the SPIDER collaboration, although the funding status is currently uncertain. Assuming funding is forthcoming, this will allow three of the CALICE groups (Birmingham, Imperial, RAL) to continue in this area.

#### **WP4: Mechanical and thermal studies**

Aspects of the mechanical structure and assembly of a realistic ILC calorimeter were studied in this workpackage. In addition, some modelling of the heat load and cooling requirements were also done.

Key achievements:

- industrialisation of gluing techniques for ECAL silicon sensors;
- assembly of a mechanical structure for the EUDET technical prototype.

Work lost as a result of cuts:

- development of a scalable robotic assembly system.

Legacy:

The gluing and mechanical structure will be used for the EUDET calorimeter prototype studies over the next few years. However, there will be no UK effort involved in this and so no benefit to the UK.

#### **WP5: Physics and simulation**

The principal aims of this workpackage were to take part in the global effort to optimise the detector concepts for a linear collider experiment based on studies of a number of key physics channels and to develop event reconstruction algorithms. In the latter we concentrated particularly on particle flow algorithms and the reconstruction and identification of particles in the calorimeters. This workpackage also provided simulations of the performance of the MAPS detectors under development in WP3.

Key achievements:

- production of the leading, state-of-the-art program for particle flow studies;
- contribution of several physics studies to the ILC detector concept LoIs.

Work lost as a result of cuts:

- completion of simulation comparisons with real data and hence studies of shower simulation uncertainties on particle flow resolutions.

Legacy:

The UK is leading the world in the area of particle flow. This should continue with a new grant to support these studies further, allowing groups at Cambridge and RAL to

continue. The contributions to the LoI studies will be used to optimise the detector designs but are unlikely to be developed further within the UK.

## Finances

We reported at the September 2008 Oversight Committee meeting as follows. “During [the first two years of the project] there was an underspend of approximately £230k against the expected expenditure and this is one element of the savings made with the reduction in scope of the project. The allocation to completion shows the amount approved following the community consultation and subsequent PPAN recommendation. This is around £220k less than the original planned spend in 2008/9 and is a second element of the savings. These therefore total £552.5k [...]. In addition the FEC costing method adds £93k, which is included in the allocation to completion. Thus in total there is a saving of around £645k in the cost of the science being bought compared with the original proposal.”

The financial position for the final year of the project is not yet clear since full university costs have not yet been reported but there is an indication of an underspend of about £8k on PDRA salary costs. The position regarding those elements recorded in the Rutherford Laboratory FRS system is shown in the table; there is an overspend of about £13k.

	Allocation	Spend
Travel	£49.0k	£50.2k
Requisitions	£85.0k	£92.8k
EI Staff	£73.4k	£77.4k
Total	£207.4k	£220.4k

## Reports and publications

A large number of talks have been given by UK people during the project, with the main ones being listed in the individual institute final reports submitted via JeS, and on the CALICE Twiki (<https://twiki.cern.ch/twiki/bin/view/CALICE/CaliceConferenceTalks>) and Calice UK web pages (<http://www.hep.ph.ic.ac.uk/calice/>). Fewer presentations were given in the last 12 months owing to the reduction in scope of the project and the departure of staff and students.