Statement of Interest: Calorimetry for a Future Linear Collider

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a) A brief description of the project, its scientific goals, and the context in which it is proposed, including other related national or international current or planned projects;

A future linear collider is widely seen as one of the most important future projects for high energy physics [1]-[4] and the next step beyond the LHC. The physics potential of such a collider is well documented [5] and is complementary to the LHC. It includes precision measurements of any Higgs and SUSY particles observed at the LHC as well as having a significant discovery potential of its own.

Research into the development of linear colliders with the required energies and luminosities is taking place around the world [5]-[7]. However, any future linear collider is likely to be a globally funded and operated machine, with European, US and Asian participation. There is UK interest in participating in the collider design and development [8]. The timescale and location of such a machine are very uncertain, although the earliest schedule at present is for the TESLA machine, for which a start date of 2012 has been mentioned.

A detector for a future linear collider would require significant R&D to achieve the performance needed to match the physics possibilities and there are many groups already working in this area [9]. The UK is already heavily involved in R&D for a vertex detector [10] and an effort on the machine-detector interface is starting [11]. This statement of interest concerns the R&D necessary to design and build the high-performance calorimetry for such a detector. Due to the long timescales involved, this is at a preliminary stage and so firm quantitative answers cannot be given in the following.

b) Details of the collaboration proposing the project, showing, in the case of projects involving international collaborators, where the UK group(s) are leading the project, UK strengths and the extent to which the UK contribution is essential to the success of the project. Possible opportunities for UK industry, and the role of the international partners should also be described;

The UK groups involved are currently bidding for funding for a precursor project, the CALICE collaboration [12], which is aimed at a beam test using the most promising technologies. The CALICE effort involves around 120 people, mainly from Europe but also including US and Korean groups, and covers both electromagnetic (ECAL) and hadronic (HCAL) calorimeters. The UK proposal builds on our experience from LEP and BaBar and concerns the ECAL, where a silicon-tungsten sampling device is being considered. A major goal of CALICE is to validate the simulation program, so as to allow accurate evaluation and optimisation of this technology.

Within CALICE, the UK groups propose to provide the readout electronics and data acquisition system [13]. CALICE grew out of the TESLA TDR studies and has been in existence for about one year. Hence, if the UK proposal is successful and we join the collaboration, we will be coming in a little late. However, there are no other groups bidding for the UK items and we are already seen as an essential part of the program. We also propose to become heavily involved in the simulation and beam test data analysis studies within CALICE, so as to be able to contribute to the longer term decisions.

The CALICE project is a three-year effort and should result in establishing whether the silicon-tungsten option is feasible, performant and cost-effective. If this is the case, we will be in a very strong position to play a leading role in the calorimeter for a linear collider detector when a full collaboration is formed, presumably following approval of the collider itself. Note, it is also likely that the location and timescale of the collider will be much better defined on the same timescale. Hence it will be around three years before we would be in a position to follow up this SoI with a detailed, costed proposal for an ECAL.

c) The timescale of the project, including the international selection process where appropriate, date when a firm funding commitment by PPARC is required, duration of the project;

As stated above, the timescale for a linear collider is uncertain. However, taking the most optimistic start date of 2012, then it is estimated that construction of the calorimeters would take around five years so that this may need to start around 2007. Prototyping would take around two years, which means it would need to start in 2005. Hence, the earliest date for a definite commitment for UK involvement would be at this time, although the dates will become firmer over the next two years.

Whenever the start date, it is likely that a linear collider physics program would take at least a decade and possibly substantially longer. This depends to a large extent on what is discovered both at the LHC and the linear collider itself.

d) An estimate of the PPARC resources likely to be needed for the capital construction phase, and where possible, for the exploitation phase: staff effort (including the cost of RAL staff), equipment, travel. In addition to an estimate of the total cost, an approximate spend profile would be helpful. An indication should be given of resources which *may be available in the proposing institutes, the relation to other projects depending on the same resources, and the resources needed soon to establish the feasibility of the project;*

The ECAL specified in the TESLA TDR [5] was effectively designed without any cost constraint and consequently was projected to be very expensive, 133Meuros. A major aim of the CALICE studies is to perform a cost optimisation of the ECAL so as to bring this down to a more realistic level. It is likely a reduction by at least a factor of two will be possible, without significant degradation of the physics performance. Even then, the cost would be high enough that is is clear this would not be a detector the UK would attempt to fund by itself, but it would collaborate with groups from other countries. An assumed total cost of around 70Meuros, or around £40M, is not unreasonable, although we emphasise the actual cost is effectively unknown at this time.

The UK is currently around 20% of the CALICE collaboration and to maintain a significant presence, it is likely that proportion would need to be maintained. This would imply a UK share of the capital cost of around £8M. However, we would not want to simply write a cheque for our fraction, but would take on some part of the calorimeter to design and build. Examples would be the electronics, the end-caps or the mechanical support structure. The first of these is seen as particularly interesting by us. Our role in CALICE is in the electronics so there could be a direct progression from our current precursor studies. The TDR costed the electronics at 10Meuros or around £6M, so that this again indicates the same sort of level at which we might hope to contribute. Prototype work would be expected to cost around 10%; in round terms, approximately £1M in addition to the above. On the earliest schedule, the £1M would be needed in 2005 and 2006, while the £6M would be needed between 2007 and 2012, probably with most spend towards the end of that period.

A project of this size would need substantial staff effort both from the Universities and CLRC although it is effectively meaningless to estimate numbers at this time, given the other uncertainties. Similarly, travel costs will strongly depend on the location of the collider as well as which other countries we would be collaborating with on the ECAL.

e) A statement showing what resources have already been provided for the project (from whatever source), and for what purpose;

We have bid to PPARC, through PPRP, for funding for the precursor project. This is currently being considered and we expect a decision in early July. The resources requested are around £100k for capital costs; including staff and travel, the total cost to PPARC is estimated to be around £500k.

f) A description of any new technology that needs to be developed before the project can be considered to be technically secure.

Silicon-tungsten calorimeters have been used in previous experiments [14, 15], although on a much smaller scale as forward luminosity monitors. The main issues to be solved before this technology could be considered to be secure are the cost and the system problems of building and operating a much larger device. These are being tackled by the precursor CALICE project, which we hope will establish the feasibility of the silicon-tungsten approach.

Our proposal for CALICE is only for the next three years, following which we have no definite commitment to silicon-tungsten. If it turns out that our judgement of this being the optimal technology was correct, then we are well placed to continue. However, it this technology proves not to be appropriate, then we would be able to redirect our efforts at that time.

References

[1] HEPAP Subpanel Report (January 2002), `http://bohr.pha.jhu.edu/~bagger/report.pdf`

[2] See `http://snowmass2001.org/`

[3] See `http://ccwww.kek.jp/acfa/document/2ndLC.html`

[4] G. A. Blair et al., *A Leading UK Involvement in the Future Linear Collider*, (September 2001), `http://www.hep.ph.rhul.ac.uk/~blair/lc_Report/eeReport_final.doc`

[5] *TESLA Technical Design Report*, DESY 2001-011, ECFA 2001-209, TESLA Report 2001-23 (2001).

[6] For information on US studies, see `http://www-project.slac.stanford.edu/nlc/home.html`

[7] For information on Japanese studies, see `http://www-jlc.kek.jp/`

[8] See `http://www.astec.ac.uk/ap/collider/`

[9] *Linear Collider Detector R&D*, (June 2002), J. Brau et al., `http://blueox.uoregon.edu/~jimbrau/LC/LCrandd.ps`

[10] For the most recent information, see *Status Report and Proposed Future Programme*, (April 2002), S. F. Biagi et al., `http://hep.ph.liv.ac.uk/~green/lcfi/notes/PprpPropApr02.pdf`

[11] See `http://www.astec.ac.uk/lc-abd/`

[12] See `http://polywww.in2p3.fr/tesla/calice.html`

[13] C. M. Hawkes et al., *Specification of the readout electronics for the CALICE beam test*, `http://www.hep.ph.ic.ac.uk/~dauncey/lc/specification.ps`

[14] D. Bederede et al., Nucl. Intr. Meth. A365 (1995) 117.

[15] G. Abbiendi et al., Eur. Phys. J. C14 (2000) 373.