Generic Technologies

Introduction

Specific areas in which the UK can make a large contribution to the LC have been presented in earlier sections of this document. However, the UK also has significant industrial expertise in several technologies of importance to accelerators in general and the LC in particular; these are discussed in this section and mention is made of some of the companies involved together with the possible wider impact of developments made for the LC. It is worthy of note that many of these technologies have already benefited strongly from developments made initially for particle physics and are now used in a broad range of medical, industrial and military applications. For example, electromagnetic power at radio frequencies is used for radio and television broadcasting, radar, telecommunications and electronic counter-measures as well as for powering particle accelerators for scientific, industrial and medical purposes. Superconducting magnets are used in magnetic resonance imaging devices in hospitals throughout the world and find application in the mineral extraction industry, where they make possible highly efficient separation on the basis of magnetic properties. They are also used to control convection currents in the growth of the large diameter silicon crystals crucial to the electronics industry.

High Power Radio-Frequency Engineering

The LC requires a large amount of radio-frequency power in order to accelerate the electron and positron beams: at 500 GeV centre-of-mass energy, the TESLA design requires about 600 klystrons, each capable of delivering a peak power of about 10 MW, with the attendant high voltage power supplies and modulators. This number approximately doubles at an energy of 800 GeV. The development of these devices presents considerable scientific and technical challenges, as improvements in the efficiency, reliability, spectral output and power of RF systems are required, in conjunction with cost reductions. These can only be achieved through advances in science and engineering in areas such as:

- Surface physics, particularly primary and secondary emission, DC and RF breakdown mechanisms.
- Materials science, study of ceramics and permanent magnets.
- Computer simulation, “right-first-time” design through advanced electromagnetic modelling.
- High frequency and high voltage power conversion.
- Control and monitoring systems.
- Vacuum and superconductor technology and manufacturing techniques.

Above and beyond the immediate benefits for the LC, advances in RF power engineering will have impact in the areas mentioned in the introduction to this document. Many other fields will also benefit, however. Considering only the accelerator developments facilitated by improved RF systems, some of these are:

- Engineering, physical and biological sciences. Free electron laser based "fourth generation" light sources will allow investigations of surfaces, of novel materials, time resolved studies of protein folding mechanisms and a wealth of other topics as documented in the CASIM proposal[1].

- Medicine. Compact sources of synchrotron radiation will make possible new and powerful imaging techniques, proton and heavy ion accelerators will improve the efficacy of radiotherapy.

- Nuclear waste management. Accelerator driven transmutation of nuclear waste allows conversion of extremely long-lived radioactive isotopes to those with manageable lifetimes.

- Power generation. The possibility of generating electricity using sub-critical fission maintained by accelerators is being actively investigated in Europe. In addition to the inherent safety offered by sub-critical operation, this technique produces waste with half-lives orders of magnitude smaller than conventional fission power plants.

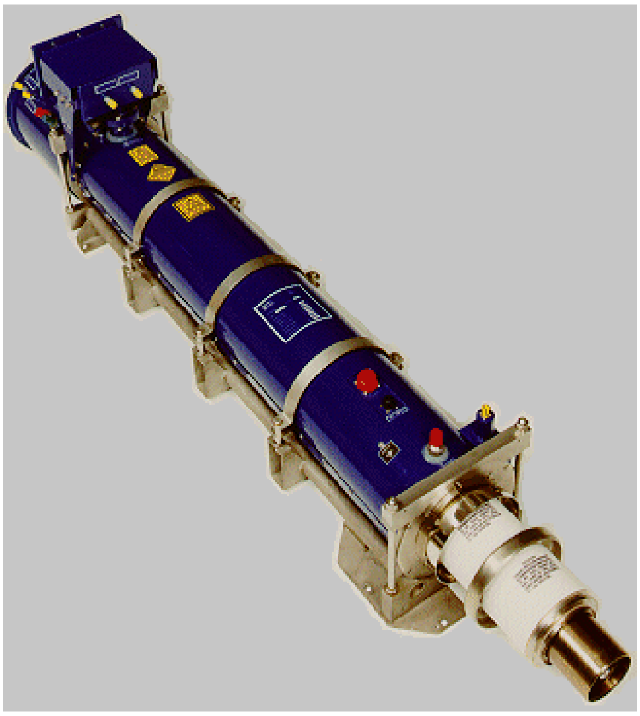

Figure 1: TMD technologies L-band Travelling Wave Tube.

The UK is fortunate in having significant expertise in the field of RF power engineering. Marconi Applied Technologies is one of only three companies worldwide awarded a contract to work on RF power issues for the NLC project. A second UK company, TMD technologies, one of whose products allied to developments necessary for TESLA is illustrated in figure 1, is recognised as a European centre of excellence for cathode and electron gun technology and designs and produces high power klystrons, as do Marconi. However, uncertainties in the scheduling and funding of the LC make it difficult for these companies to justify the development of klystrons *etc.* for

[1] See http://hep.ph.liv.ac.uk/~green.casim

the LC on a purely commercial basis, so funding at the £ 1M level is needed in the next two years to perform the necessary R&D. (Note that Marconi and TMD's competitors in the USA are known to receive DoD and DoE funding to support such basic R&D. Similarly, their French rivals are supported through DRET.) These companies have therefore formed a Faraday partnership with the Universities of Lancaster, Strathclyde and Oxford and with the CCLRC Daresbury and Rutherford Laboratories and are seeking funding through that route. This endeavour should be supported and alternatives sought if the Faraday initiative is not successful.

Superconducting and Magnet Technology

The LC will require a large number of magnets, some superconducting, for the steering and focussing of the beams. In addition, if the LC is of the TESLA type, a large amount of superconducting infrastructure will be necessary to keep the superconducting cavities at their operating temperature of about 2 K; the installation will be of a similar size to that needed for the LHC. Again, this presents challenges and opportunities for some of the UK's most technologically advanced companies, including Oxford Instruments and Tesla Engineering.

Oxford Instruments is an internationally renowned company with acknowledged expertise in many aspects of superconductor technology, from the production of superconducting wire and cable to the design and construction of the complete cryogenic systems and superconducting magnets used in MRI systems. They also have experience of working for high-energy physics experiments and accelerators, for example they produced the Cleo II magnet used on the Cornell storage ring and have designed and tested the large aperture low-β insertions for the LHC. It is interesting to note that the Rutherford wire used in the latter was originally developed for high energy physics at the Laboratory of the same name, has found widespread industrial application and is now being used by industry for particle physics applications. Oxford Instruments have invested considerable effort in increasing the efficiency of the cryogenic systems for their magnets, which means they are both ideally placed to provide systems for TESLA, where the large scale will make efficient operation mandatory, and able to exploit developments made for the LC in a broader context.

Normal and superconducting magnets are also the area in which Tesla Engineering specialises. This UK company has also designed and supplied magnets for accelerators, for example the sextupole illustrated in figure 2.

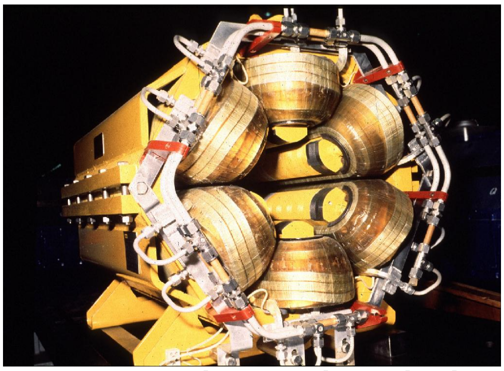
Figure 2: Sextupole magnet designed and constructed by Tesla Engineering.

Again, the uncertainties with respect to the timing of the LC make it difficult for these companies to undertake the design work necessary to compete on the world stage for LC contracts, unless support is provided. Discussions as to how this may be achieved have been initiated.

Further UK Participation

Other areas in which UK expertise would benefit the LC project include:

- The design and construction of the undulator magnet, which uses the spent electron beam to produce intense synchrotron radiation and hence, via interaction with a target, the required 4×10^{13} positrons per pulse for subsequent acceleration. Experience in the design and operation of the Daresbury SRS and Diamond will be useful here.
- Design of the laser system for a $\gamma\gamma$ interaction region. Here, laser light, directed against the incoming particle beams, must be introduced into the beam pipe and brought into collision with those beams. The resulting collisions transfer the majority of the beam particle's energy to laser photons, allowing high-energy photon-photon collisions to be studied.

- Development of "GRID-like" fail-safe and secure control and monitoring middleware to enable the realisation of the proposed remote accelerator control rooms for TESLA.

Summary

In addition to the possibility that the UK take responsibility for the beam delivery system or the damping rings, the construction of the LC presents significant opportunities for UK industry. These require some early funding in order to allow UK companies to do the R&D necessary to profit from the LC. The spin-offs from this investment are considerable.