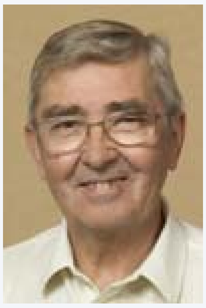
international linear collider

Director's Corner

24 June 2010



Ewan Paterson

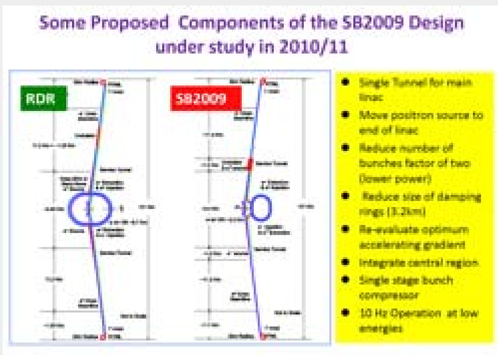
Flexibility in the ILC design

Today's issue features a Director's Corner by Ewan Paterson, member of the Global Design Effort Executive Committee.

In a new large accelerator complex which will take years to get approved and constructed, one must maintain some degree of flexibility in its design as many things can change before a construction start. The accelerator physics and technology that constrains the performance will advance and the knowledge of the physics which determines its future physics programmes will be better known and continually evolving. At the same time a complete baseline design and associated cost estimate is needed to support the many technical and cost reviews that will be required to obtain the necessary global support and funding.

There is an obvious conflict here, and there are two opposing solutions or paths that we, the accelerator and physics communities, can follow. We could design a machine that can cover every possible contingency but it would probably be a compromise in being not ideal for any particular scenario and would be very (too) expensive to support. Or, we could try to design one which is less costly but has flexibility, defined as having several well understood upgrade paths, to optimise the physics programme as it develops. I believe we are following the latter path. However there are differences of opinion on which scenarios of accelerator performance and or physics programmes should be assumed for the baseline design. This baseline is needed in engineering and costing a design for a *Technical Design Report* (TDR) and the TDR is a necessary step in gaining project approval. This dilemma can be greatly aided by a better understanding of the possible flexibility in the design and the upgrade options.

Many accelerators have optional upgrade plans which are studied before and during construction but not planned for actual implementation until experience has been obtained with operation. The Large Hadron Collider (LHC) is a good example. Energy and or luminosity upgrades are the most common choices and upgrading the ILC energy to one teraelectronvolt (TeV), has always been a future option although a well-developed upgrade path was not part of the *Reference Design Report* (RDR). The TDR will consider this option in more detail, and studies of other areas of flexibility in design are a natural component of the ongoing cost containment efforts which have been discussed in past Directors Corners.



Schematics of the ILC with the *Reference Design Report* layout on the left and one "SB2009" version, which is under study, on the right.

Let us look at a few components of the *Strawman Baseline 2009* proposal, which are under study for inclusion in a possible new baseline. The 'Central Region' of the ILC now contains all sources, injectors, damping rings and beam delivery with final focus systems. This leaves the linear accelerators (linacs) (including the positron and electron return lines) extending outwards for many kilometres uninterrupted, and the design length could easily be changed to accommodate any new physics, new base design energy, new accelerator gradient, or cost re-optimisation. This also could be an important component in planning energy upgrade scenarios.

The damping rings now have race track design with the about one-kilometre injection and extraction straight sections parallel to the linac beam delivery system and off to one side. Two ring circumferences are being considered, 6.4 and 3.2 kilometres, but both have the same interchangeable injection/extraction straight sections and detail-engineering designs of the central region can proceed without a final decision on the circumference at this time.

Why in the RDR was the positron source at the 150-gigaelectronvolt (GeV) point in a 250-GeV linac and not at the end, in the central region? There are several physics and engineering reasons for producing the positrons via photons from the electron beam passing through a helical undulator, (including polarised positrons and beam power on target). Unfortunately the yield of positrons from the total positron system is strongly dependent on the electron beam energy. If one desires and the physics requires operation at high beam current (high luminosity) over a large range of beam energies, say 100 to 500 GeV per beam, then one has a difficult optimisation problem. In the RDR design the choice was made to accelerate the electron beam to 150-200 GeV, (the lowest energy that would give adequate positron yield), pass through the positron production system and then be accelerated or decelerated to the energy required at the collision point. Today we are studying an interesting alternative with the positron source at the end of the linac.

If one has built the linacs to operate at say 250 GeV, and five-hertz repetition rate, then roughly speaking, one has enough radiofrequency and cryogenic capacity to operate at 125 GeV and 10 Hz. Therefore the operating scenario under study for lower energy running would be to run the electron injectors, damping rings and linac at 10 Hz, where an interleaved 5 Hz produces positrons at the end of the linac with an electron energy through the undulator similar to that envisaged in the RDR. The alternate 5 Hz of electrons would be used for collisions with 5 Hz positrons (positron linac still operates at 5 Hz) and at an energy which could be lower (or higher) than the positron production beam, again using the whole linac without the need for deceleration. The large energy bandwidth of a linac makes this possible and ongoing studies look like this is both attractive and straightforward. We would maintain the RDR performance while maintaining the flexibility of an uninterrupted electron linac with all sources in the central region.

There are many other examples of on-going studies that are related to site dependent choices or optimisation but using these few examples, I hope that I have shown that although we are working on a "*baseline*" for the TDR, we are maintaining "*flexibility"* to quickly adapt to pleasant surprises that will push us into a fast start in seeking approval for rapid construction of the ILC.

-- Ewan Paterson