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Draft

Comments on the Baseline Configuration Design

I. Introduction

Unfortunately, I find myself here in California rather than in Frascati taking part in the meeting to set the BCD. I am sending these comments along based on the material now on the web. Barry was particularly interested in my comments on the white papers. To go into two of them, the energy upgrade and the interaction region layout, I think it important to set the scientific context.

I will assume a start of ILC construction in the year 2012. This seems to me to be the earliest date possible in the United States for money to begin flowing to a new and very large scientific construction project. Even starting this soon assumes that all the technical milestones are met, all the reviews are positive, and all these reviews are scheduled at the earliest possible moment. A new administration will take office in the beginning of the year 2009 and they will need some time to think about things too. A start in the year 2012 means that the money request has to go to our Congress early in the year 2011.

Colleagues in Japan and Europe also believe that 2012 is around the earliest time possible in their regions. Japan has other construction projects on the books and the completion of payments for LHC in Europe doesn't occur until 2010. An additional problem, which will take some time, is to get the governments that are going to be involved to agree on a construction & operating model.

If 2012 is the start then the completion date will be around 2018. LHC will have begun taking data in the year 2008. Three or so years will elapse from the start of LHC physics to the beginning of ILC construction. Personally, I believe that if the LHC finds nothing new the ILC will not be approved. Based on what we know now about the physics, the most likely "something" is a relatively low-mass Higgs (100 GeV-250 GeV) and new particles that are strongly coupled (super-symmetry for example) with masses of around 1 TeV. The weak and electromagnetically coupled decay products of these new particles will need lots of integrated luminocity to be seen at LHC and we'll probably not see such things before the start of work on the ILC.

II Energy Upgrade Scenario

By the time the ILC itself begins to operate, the LHC will have been doing physics for 10 years. What this science scenario means to the ILC project is that while there is likely to be considerable enthusiasm for starting a 500 GeV project around the end of this decade, as the construction project goes on there will be more and more pressures to start operations at an energy higher than 500 GeV - to upgrade sooner rather than later. In turn this means to me that we should be prepared for an adiabatic upgrade, increasing the maximum energy is steps as the physics demands.

This would favor constructing full-length tunnels in the ILC first phase. In the terminology of the white paper this means choosing either Option 1 or Option 2 (I'm not sure that I understand option 4 well enough to say whether it is a serious candidate). The choice between Option 1 and Option 2 is really related to superconducting cavity issues and not to the upgrade scenario and so I leave that to later.

I am told that the ILC group is using a cost of $15-20 million/meter for twin-bore empty tunnels. I will use $25 million/meter to account for additional roads, power lines, water pipes, etc., required to go with the extra length. This will add about $500 million to the cost estimate for an additional 19 Km of tunnel. This is about 7% of the $7 billion (today's dollars) cost of the full project. This is an unfortunate number; it is neither dramatically larger nor negligibly smaller than the baseline cost estimate.

An upgrade starting from the low-cost option (Option 3) requires that it all be done in one shot. The new tunnel goes backwards from the injector end. While I do not believe that the damping rings need to be moved, a 5-10 GeV post damping ring linac booster will probably be needed to make the damping ring output beams less vulnerable to emittance growth effects. Turnarounds, where these backward going beams meet the new sections of linac, can be designed to have little emittance growth and I expect that they have radii of about 100-200 meters. The transport lines would, of course, be in the main tunnel and the focusing and steering magnets in the "old" front end would also have to be redone. The cost increase of Option 3 is more than just the additional tunnel.

The potential scientific advantages of partial energy upgrades make me think that Option 3, the short tunnel, is the least desirable choice. Go with options 1 or 2.

III. Interaction Point Configuration

The choice that really has to be made now in setting the baseline configuration design is whether there is to be one beam delivery system or two beam delivery systems. The specific crossing angles are something that can be determined during the next year or so. Altering those is not going to significantly affect the cost estimates until one gets into the real engineering design phase.

I would list the options as follows:

a. Two Beam delivery systems each feeding a separate detector
b. One Beam delivery system feeding two detectors (the push-pull option)
c. One Beam delivery system feeding only one detector.

While the choice of crossing angle has little effect on costs, one or two beam delivery systems have a large effect. Also, in Option 2 the size of the size of the experimental hall is strongly affected by the choice of one or two detectors.

I would suggest that the baseline configuration include provision for two detectors. The physics is likely to be sufficiently broad so as to benefit from two detection facilities optimized somewhat differently. This is, after all, the case at LHC with the ATLAS and CMS detectors.

The choice between one- and two-beam delivery systems depends on your view of the reality of the push-pull system for objects that weigh over 1,000 tons each. To be useful in a push-pull configuration the hall has to be large enough for each detector to be worked on while the other detector is on the beam line. This means “garages” on each side of the interaction region and the necessary shield walls to protect people working on the out detector from radiation that occurs behind the shield walls, including the necessary shielding to protect them from muons. Thus, the push-pull hall will be thus considerably larger than the hall for one detector. Personally, I am not sure that the push-pull system can be implemented in a practical fashion. If I recall correctly, the minimum roundtrip of the CDF detector at Fermilab, from on the beam line to off the beam line and back on again requires three months.

One-beam delivery system means, at best, one detector in for a year and then replaced by another detector for a year. Alternatively, it means one detector for many years to be replaced eventually by a new one with improved and possibly different characteristics. I would recommend the two-beam delivery system for the base line configuration since I think it would have a more productive physics program.

IV. Other Items

a) Tunnel alignment

I agree with the recommendation that the laser straight option be abandoned. The multi-segmented curve configuration has advantages for cryogenic system and utilities. There should be no problem with the few achromatic bends required.

b) Positron source

This is a complicated technical trade off. I cannot contribute to this one without being a lot more informed. The recommendation in the white paper is not unreasonable.

c) Number of tunnels

To me this is simple. Two tunnels is the proper choice if the machine is deep enough so that one tunnel and a surface service gallery are impractical. The advantages are clear and are identified in the white paper. My only disagreement with the white paper is that even in the case of the Marx modulator, two tunnels are the preferred solution.

d) Accelerator gradient

The current favorite option is to start with an accelerating gradient of 31.5 MV/m. While the experience with the current, hand-made cavities makes this seem reasonable, there is still much to learn. Two issues which concern me are mass production and accident recovery.

Somehow, the ILC group is going to have to see if the requirements for high gradient lend themselves to mass production techniques. The only way to do that is to have industry propose how to build these cavities and then award one or more contracts for some number (10-100) of prototypes.

For years I have urged DESY, without success, to let a cold structure up to air and see what it takes to recover its full performance. Such accidents will be rare but they will happen unless extensive and expensive precautions are taken. If recovery is a matter of few weeks it is one thing, but recovery that requires disassembly and retreatment of the effected sections is quite another.

At SLAC, vacuum accidents have occurred because the beam gets away and burns a hole through the accelerator or when somewhere opens a wrong valve, or hit a vacuum manifold with a forklift. SLAC has isolation systems every 100 meters of accelerator.

Without finding out how difficult recovery is in the superconducting system, no convincing estimate of the cost of accident prevention can be made.