Status of ILC Global Timing

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Some History of Timing "Headache" (1)

- http://www.linearcollider.org/wiki/lib/exe/fetch.php?cache&media=bcd:timingrecommendations-revapril17.pdf
- This was the first "complete" report on the Global Timing Issues of the ILC that because the E- produce the E+ and collide with those from the previous machine cycle, the DR circumference, Harmonic number, Length of linacs and other transport lines, are all coupled. In simplified form →
- ***To maintain the maximum flexibility in bunch patterns in operation of the ILC, the difference in path-length, ΔL, between target and IR for the E+ and E-, should be an integer number of the damping ring circumferences.***
- At the time of the RDR in 2006, ΔL was -2.6 km!
- To complete the RDR a task force proposed (a change request) a 1.2 km extension of the E+ linac including a path-length changing trombone.
- This was obviously expensive and not very practical in adjustability, so let us return to this later.

Some History of Timing "Headache" (2)

- The proposed solution to allow the RDR process to move forward, is to extend the e+ linac with an insert, of 1.2 Km. This is (2.6/2 –X) Km .the factor of two comes from the double transit of the e+ and the X is the length in the insert for a trombone in the beam transport which would allow say up to ~ 200m of path length adjustment for other requirements such as an IP at a different longitudinal position, or a small change in the damping ring circumference corresponding to a different harmonic number.
- Above is a quote from the change request which we did not incorporate in the RDR, which said the following, leaving the subject open the future and there have been many changes which have affected the global timing!

2.1.5 Bunch Spacing and Path Length Considerations

In order to extract the bunches in the damping ring one by one and inject into the main linac there are certain constraints to satisfy among the DR circumference, number of bunches, RF frequencies and bunch distances in the DR and main linac. The present beam parameters do not meet all of the constraints needed to best facilitate injection and extraction from the damping rings [12]. The parameters will continue to be optimized during the next design phase to better satisfy the constraints, and it is expected that the damping ring circumference and linac bunch spacing will change by small amounts.

In addition, there is another constraint due to the fact that the positrons are generated by electrons on the previous pulse. For flexible operation, it is highly desireable that the sum of certain beamline lengths such as the main linac and the transport lines be a multiple of the DR circumference. Because of this constraint, the exact location of the injector complex and the layout of the transport lines is a subject that can be fixed only after the final component lengths and the site are decided.

The RDR to Now

- There have been many changes in the ILC design since the RDR and throughout this evolution we have tried to always keep track of **ΔL.**
- As of May 2014 (AWLC 14, Benno List) the 'FINAL TDR' lattice and layout gives ΔL = minus 294 meters
- The TDR says almost the same as the RDR

less flexible.. Because of this constraint, the exact location of the injector complex and the layout of the transport lines is a subject that can be fixed only after the final component lengths and the site details are decided.

- **BUT NOW WE HAVE THE FINAL COMPONENT LENGTHS (System lengths) AND SITE DETAILS AVAILABLE**
- **WE HAVE TO START FINALIZING THE GLOBAL TIMING SYSTEMS BOTH PASSIVE AND ACTIVE, and they are, *the final machine layout and path-length adjustment systems.***

There are 3 different scales to this E+/- path difference problem and all require study and proposed solutions

Possible scales

$\Delta L \approx$ 100-200 m

Needs final site and design layout and is required in a few months. Need to check present lattice designs for completeness and propose the lattice and layout change to correct path length, $\Delta L \approx 0$. This must be compatible with any staging or upgrade scenarios!

$\Delta L \approx$ 1 m

Needs study of Survey and Alignment above and below ground and used during design, construction, installation and commissioning. Will need best estimate of the absolute accuracy of path lengths after installation and some adjustment method during commissioning with two beams? How many sigma? 3 or 5?

$\Delta L \approx$ 1 mm

Need study and estimate of variations in path-lengths during operation, both magnitude and timescale, hours,days,years.

Need some fine path length adjustment system?

CHARGE TO
GLOBAL TIMING WORKING GROUP

- As you know there has been much discussion over the global timing (path length) constraint imposed by the use of the undulator-based positron source. In order to consolidate a design solution to this problem, we'd like to ask you (including Kaoru) to form a small working group, with Ewan acting as chair. Your charge is essentially to look at all aspects of the problem (including tolerances) and propose a practical solution which can then be integrated into the baseline design.

- The key aspects as I see them are :-
- Proposing a realistic scheme which maintains the overall IP collision timing constraint
- Explore any possible constraints on the allowed bunch patterns in the damping ring (flexibility)
- Understanding the tolerances for the required path length adjustment(s):
  - static - a 'one time' correction concept for an survey (installation) error for the path length
  - dynamic - dealing with 'drifts' (both 'slow' long term as well as any relatively fast corrections required)

Status of Global Timing Working Group

- Formed and had first few e-mail exchanges
- Reviewing past documentation
- First priority survey and alignment accuracy
- 2nd Variations and time scales
- 3rd Correction systems and operating scenarios
- 4th Propose final system with passive and active correction at LCWS 2014?

Need some guidance. Questions on next slide.

Some Guidance Questions from GT WG

- **For the overall fixed correction of ΔL should one consider:-**

a) Shortening the BDS by 100 to 200 meters? Do both sides? **(Y&No)**

b) Changing the length of the Linac(s) by ≈1.5 km, as in RDR **(Y?)**

c) Redesign central region, with new DR size and position **{NO}**

This is more complex than it sounds, and affects almost every system.

Note that b) would not use any trombone as in RDR proposal (use wiggler and or DR dynamic frequency shifts) and in phase one of graded construction and operation, would be extension of tunnel and transport only! Needs costing.

- **Can the systems leaders review the path-lengths in Benno's presentation at AWLC 14 (next slide) and based on the TDR, before 8/31, and propose any corrections or omissions?**
- **Vertical shafts for cryo? How many and how big? Share with survey and alignment? Large impact on error in ΔL.**
- **How conservative should we be, 1,3,5 sigma on estimated error.**

- **(Y)** is my opinion only!

Calculation for the TDR baseline (Asian site)

Undulator Photon Transport UPT (BEGEDOGL -> PTARGET)	372.0		
Positron to DR injection PTARGET -> MPDRINJ	2232.4		
INJ straight	89.3		
Photons/positrons to z=0		**2693.7**	
Electron dogleg EDOGL (BEGDOGL -> TPS2BDS)	-423.6		
Electron BDS to IP	-2253.5		
Electrons to z=0, i.e. IP		**-2677.1**	
Difference Positrons-Electrons to z=0:			**16.6**
Positrons to DR extraction	107.9		
Positron RTML (DKS version)	15993.0		
ML length (DKS)	11071.7		
Positron BDS to IP	2252.6		
Positron Path			**29425.2**
Total Sum			29441.8
9 / 10*DR circumference	3238.7	29148.1	32386.8
Mismatch (m)		**-293.6**	**2945.0**