NEW BASELINE DESIGN OF THE ILC RTML SYSTEM*

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Abstract

The new ILC baseline was proposed in 2009 (Strawman baseline - SB2009) to minimize cost of the machine and accommodate many changes made in the design of the accelerator systems. The biggest changes are made in the central area, where BDS, RTML, DR, electron and positron sources are sharing the tunnels. A new layout of the compact Damping Ring (DR) and re-location of the electron and positron sources to the main tunnel requires a new lattice design for all beamlines in this area. Some changes were also introduced in return line and bunch compressor to accommodate latest changes in design. The lattice design was coordinated between accelerator systems and Convention Facility and Siting (CFS) group to eliminate conflicts between beamlines and satisfy construction requirements. In this paper we present a new design of the RTML electron and positron lattices in the central area and other modifications made in the RTML line to accommodate changes to the beamline layouts.

INTRODUCTION

As the ILC collaboration is approaching the Technical Design Report (TDR) publication, some changes to the Reference Design Report (RDR) configuration have been implemented in the new design of the RTML system. For reader's convenience we report in Fig. 1 the different beamlines in which the RTML is divided with their names, namely: Electron/Positron Ring To Linac (ERTL/PRTL), Electron/Positron Long Transfer Line or Return line (ELTL/PLTL), Electron/Positron Turnaround (ETURN/PTURN), Electron/Positron Spin Rotator (ESPIN/PSPIN), First and second stages of the Electron/Positron Bunch Compressor (EBC1/PBC1 and EBC2/PBC2) and their respective Dump Lines. In the following sections we will discuss the new design of these beamlines and report optics results for the critical parts.

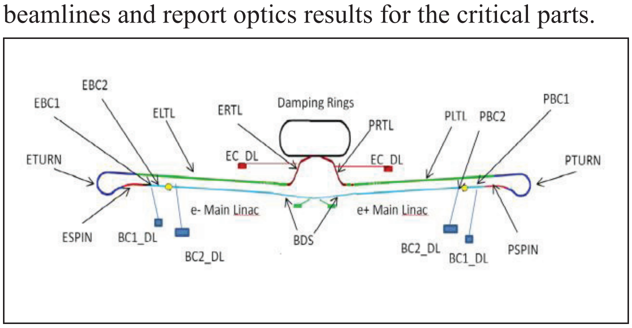

Figure 1: Layout of RTML beamlines.

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NEW CENTRAL AREA DESIGN

The modifications carried out to the central area [1] were necessary after a new design of the damping rings was developed. New designed damping rings are now 3.2 km of circumference, compared to the old 6 km long design, and are pushed horizontally outside of the interaction region. The separation between the rings and the main tunnel needs then to be large enough to provide space for the big Detector Hall. The ERTL/PRTL geometry is largely determined by the requirements of other areas, like the positron/electron injection lines that share the same tunnel with them. Fig. 2 shows plots of MAD-8 survey data for both ERTL and PRTL lines using the global Cartesian coordinate system {X, Y, Z} with origin at interaction point. In order to specify a geometry, the ERTL and PRTL lines have been divided onto four logical sub-lines: horizontally straight section B, horizontal arc C, straight section D, and horizontal arc E. Along with solid-lines of beamline survey, these plots show circles for the given coordinates of the connection points between the sections. The nominal values of the coordinate displacements {X, Y, Z} and angles {Θ,Φ,Ψ} for the connection points are written in plates. Following extraction from the damping rings, the beams are brought parallel to the long axis of Main Linac Tunnels.

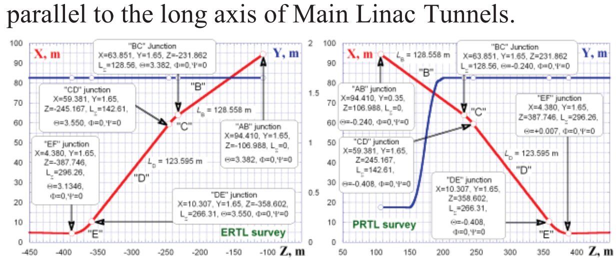

Figure 2: Layout of ERTL and PRTL beamlines.

Section B of PRTL consists of entrance matcher, regular FODO cells, and a vertical dog-leg ensuring merging of two bunches extracted from two positron DR's separated vertically by 2.6 m. The entrance matcher adapts the incoming beams to the regular FODO cells of section B. In a first phase only electron ring and one positron ring (lowest) will be needed. The electron ring will be placed at the same height of the ELTL, namely 1.65 m of elevation respect to the interaction point, while the positron ring will be placed below the electron one, at an elevation of 0.35 m. Thus the PRTL line needs to accommodate a vertical dog-leg (shown in fig. 2, section B) to bring the beam to the height of the PLTL line in the Main Tunnel. In the upgrade phase, a second positron ring will be placed on the top of electron ring with 1.3 m of vertical separation and a second extraction line with a symmetrical dog-leg will be used. To merge the beams,

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two magnets of the vertical dog-leg already in use will be replaced with a merger composed of two septum, fast kicker and specially designed quadrupole magnets to provide focusing of two positron beams in the area where they have small vertical separation.

In Section D the extraction system for the DR dump line is located. The design of these dump lines is now identical to the dump lines used after the first stage of the bunch compressor [2], since in the new design the Twiss functions of the beams are similar in both locations. The radius of curvature of sections E is constrained by the geometry of the spin rotator in the positron/electron injection beamlines (share the same tunnels) which are needed to change the direction of the spin from longitudinal to vertical before the beams enter their damping rings to avoid dilution of the polarization.

The Twiss functions of the ETRL and PRTL calculated using MAD-8 code are shown in Fig. 3. The boundaries of sections B, C, D and E are shown by blue colour.

The skew quadrupole correction, beam diagnostics and collimation sections that were originally placed along GETAWAY beamline in old (RDR) RTML design are now located at the beginning of the ELTL/PLTL lines.

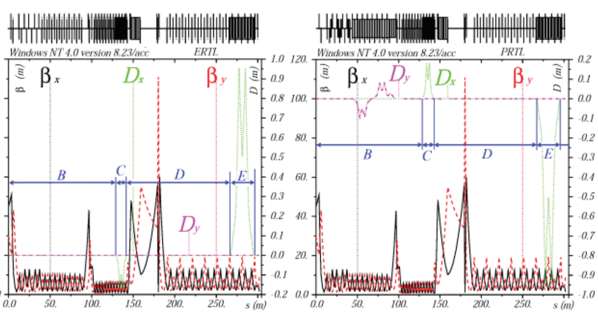

Figure 3: New optics of ERTL and PRTL beamlines.

NEW DESIGN OF RETURN LINES (ELTL/PLTL)

The ELTL and PLTL lines are follow to the earth curvature in the ML tunnel and have straight line geometry in other locations except of areas near connection of Main linac and BDS where the beam geometry is carefully adjusted using horizontal doglegs. In the first section of this line we have the skew quadrupole system for coupling correction, beam diagnostics section with few laser wire stations and magnet chicane for emittance measurements, and the collimation section needed to get rid of the beam halo. The lattices for these sections were borrowed from RDR design and re-matched in new line. Since the first part of the ELTL and PLTL share the BDS tunnel, a horizontal dog-leg needed to be inserted at the juncture between the BDS and Main Linac [3] to follow the geometry of the tunnel in this area. At that point on the electron side it is situated the positron source, and the electron beam performs a dog-leg after passing through the undulator, to avoid the positron target. The ELTL needed then to follow the same path in the opposite direction (see Fig. 4).

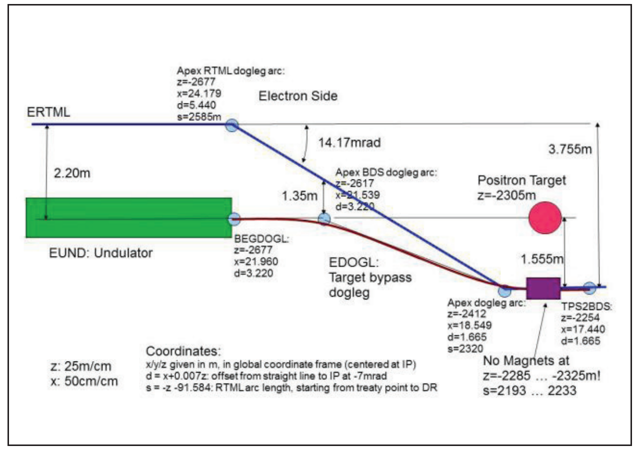

Figure 4: Layout of ELTL dog-leg.

It should be noted that because of the radiation produced at the positron target, the beamlines passing next to it need to be magnet-free to come through the radiation shielding wall. The result of the optical study for this section is reported in Fig. 5.

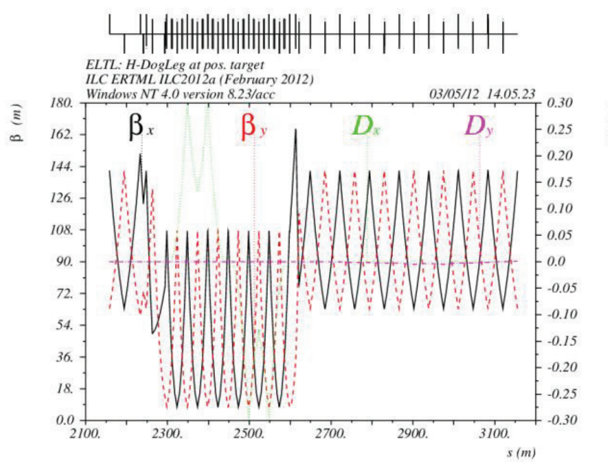

Figure 5: Optics result for ELTL dog-leg.

The PLTL line also includes a dog-leg at the conjunction between Main Linac and BDS system for symmetry of the project, but without the complication of the positron target and radiation.

For reasons related to Helium level in the Cryogenic system, the Main Linac needs to follow the curvature of the Earth, and so does the part of the Return Line system that shares the Main Tunnel with it. To accomplish this task, vertical correctors were added to each quadrupole of the FODO system in the ELTL/PLTL located in the Main Tunnel. Each of these correctors gives to the beam the vertical kick necessary for the beam to be bent down, following the curvature of the Earth (and of the beamline). Clearly these correctors generate a small dispersion that is propagated periodically along the FODO system cells. To match this vertical dispersion with the straight lines other 4 vertical correctors were used before and after the curved lines. In Fig. 6 it is presented the optics results for the vertical position and dispersion in the ELTL section, obtained with MAD-8.

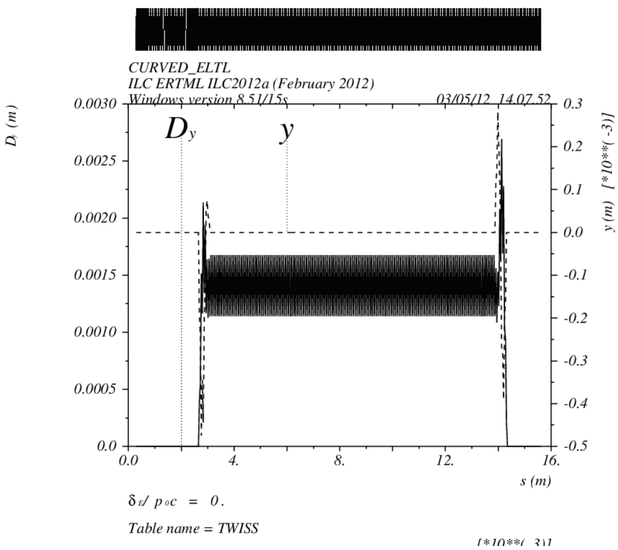

Figure 6: Optics of the curved ELTL FODO system.

The PLTL line has identical optics.

ILC BUNCH COMPRESSOR (BC1/BC2)

Given its flexibility in obtaining the required final bunch lengths for different operation modes [4] and its easier tunability, it has been decided to adopt the 2-stage Bunch Compressor design for ILC TDR [5], with minor modifications, for example number of SRF cryomodules in the BC2 beamline [6]. In BC1, the RF system is now composed of 3 cryomodules, containing 8 cavities and a quadrupole each, for a total voltage of 465 MV. The nominal RF phase is -115 deg, with a gradient of 18.7 MV/m. After the RF acceleration a 6-cell wiggler with nominal R_{56} = -372 mm will provide the required compression. After this stage a diagnostic section with a dump line for intra-train extraction or beam abort is foreseen. The BC2 RF system is now composed of 16 RF units, each consisting of 3 cryomodules with only the central cryomodule containing a quadupole for focusing while the others are 9-cavity cryomodules (same structure is used in the Main Linac). In the previous design there were only 15 RF units used. This choice was adopted to reduce the average gradient needed in the cavities, which is now 27.1 MV/m at a RF phase varying between -27.2 and -24 deg. according to the operation mode, giving a total voltage of 11 GV, and reduce the risk of cavity breakdown. After BC2 RF system a second wiggler with a nominal R_{56} = -55 mm will provide the magnetic compression to reach a bunch length of 0.3 mm. Also after the BC2 a diagnostic section and abort/extraction system to a dump line is foreseen. In Fig. 7 MAD-8 results for the optics of the Bunch Compressor are reported. Due to the non-periodicity of the RF system in both the stages, it was not possible to design a FODO lattice. A solution presenting almost periodic regularity was then adopted to avoid possible emittance dilution.

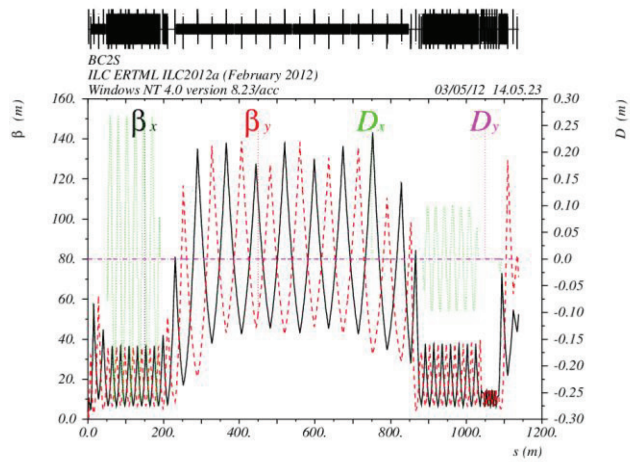

Figure 7: Optics result for the Bunch Compressor.

Due to the changes to the RF system a new set of simulations of the Bunch Compressor performance for different operation modes have been carried out showing positive results [5].

CONCLUSIONS

In this paper we presented the latest changes introduced in the design of the RTML of ILC. The central region design has been modified to fit the new beamlines location. Horizontal dog-legs have been added to the return lines to reflect the geometry of the tunnel shared with Main Linac, BDS and Positron Source. Vertical curvature of the ELTL/PLTL has been designed to follow the curvature of the Earth. The new configuration of the Bunch Compressor RF system has been implemented and simulations of its performance have been carried out.

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