SB2009 BDS UPDATES

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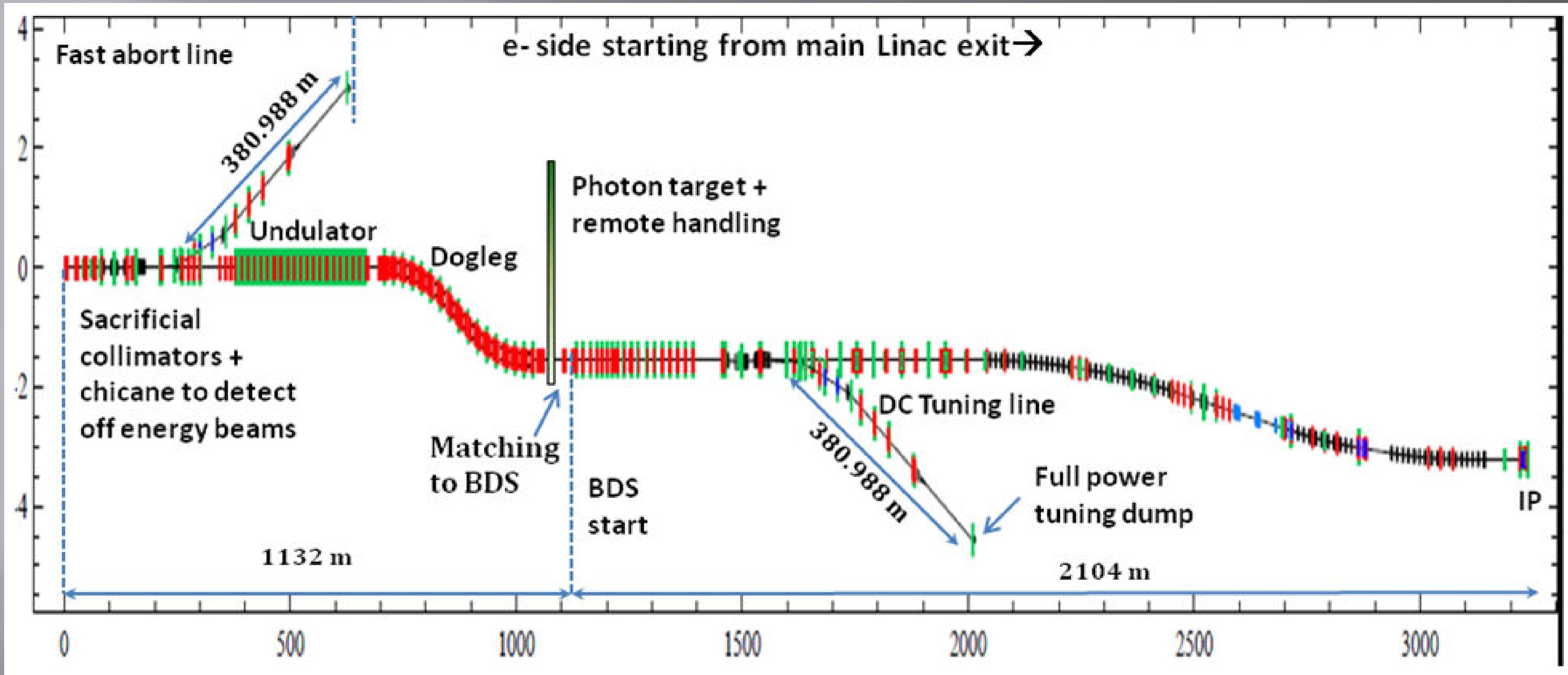
Main changes related to BDS

- Changes in the subsystem integration of the central region: As of the RDR, the BDS, the electron source and the damping rings are clustered in the central region of the ILC accelerator complex. The proposed changes in the baseline envisage relocation of the positron source system to the downstream end of the electron main linac, so that they also join this central region. This impacts the subsystem layout in ways that affect the implementation of electron side BDS.

- Changes in the baseline parameter set: Proposed adoption of the low power beam parameter set (same machine pulse repetition rate and the same bunch intensity, but a reduced number of bunches per pulse) leads to a desire to push the beam-beam parameter, so that the same luminosity as in RDR can be achieved. As a solution the so-called *travelling focus scheme* is being considered.

Max energy

- In terms of beam energy handling, similar to the RDR design, the BDS design remains compatible with 1 TeV CM upgrade which is expected to be accomplished by installing additional dipoles and replacing the final doublet



- The central integration includes the sources in the same tunnel as the BDS. Relocation of the positron production system to the downstream end of the electron linac means placing it just before the beginning of the electron BDS. These changes need suitable design modifications to the layout of this area. Figure above shows the proposed new layout of the electron BDS

Features in the new e- BDS:

- Sacrificial collimator now located at the linac end rather than in the BDS upstream end
  - The RDR has sacrificial collimators in the beginning of e- and e+ BDS to protect the BDS from any beam with error to enter from the large aperture of the main linac (r=70mm) into small aperture (r=10mm) of the BDS. In the new layout, the small aperture undulator (~8mm full) is located immediately after the linac and thus it needs to be protected against any error beam entering the undulator. This is done by moving the sacrificial collimator section and an energy chicane to detect the off energy beam in front of the undulator which reduced the electron BDS length to 2104m from 2226m as shown in Figure 4.7.1. Any beam entering this section with errors will be detected and sent to the fast abort line just before entering the undulator. The fast abort line is presently the same length as the RDR abort line, which was designed as a fast abort + tuning line (the positron BDS side still has this combined functionality), however the fast abort beam dump needs to be able to take only the number of bunches between abort signal and stopping the beam at the extraction of the damping ring and does not need to be a full power beam dump. The exact rating for this dump remains to be determined
- Matching line after the fast abort detection energy chicane into the undulator and design requirements for positron target location
  - The matching line to the undulator needs to allow sufficient transverse separation for the abort line and then matches into the undulator FODO cells. The photons generated in the undulator will pass through a drift length of 400m up to the positron target (~1070m point in Figure 4.7.1). To implement the positron target and the remote handling of the components in this area, a transverse offset of 1.5m is required between the electron beamline and the photon target. The remote handing area needs a drift space of approximately 40m in length. No BDS component are placed in this space. This is achieved by using a matching section after the undulator to match into a dogleg, a dogleg itself giving a transverse offset of 1.5m and a 40m long drift at the end

Features in the new e- BDS:

- Dogleg lattice to create the required separation between the photon target and the electron beamline
  - The dogleg lattice has been designed to be a TME (Theoretical Minimum Emittance) lattice. This keeps the emittance growth due to synchrotron radiation at 1 TeV CM to be within few percent. The dogleg provides an offset of 1.5m in 400m as required and the emittance growth at 1 TeV CM is ~3.8%. The dipoles in the dogleg are presently not decimated but can be decimated similar to the rest of the BDS so that only few dipoles are installed at 250 GeV. The beam dynamics and tuning effects on the BDS due to the presence of the dogleg need to be assessed
- Matching section into the BDS diagnostics section
  - The 40m long drift is followed by a matching section into the skew and coupling correction section, chicane for detection of the laser wire photons and a slow tune-up (DC tuning) line leading to a full power beam dump. Since the fast abort functionality is being taken care of by the fast abort line before the undulator, the energy acceptance of the DC tuning line is much reduced and thus the DC tuning line can be shortened using only DC magnets. This optimisation will be done during the TDP2 phase.
- Polarimeter chicane, collimation, energy spectrometer and final focus
  - The polarimeter chicane will be located just after the take-off section for the tuning line, which is not shown in the layout. This will need some additional length but will be accommodated by slightly reducing the final focus length allowing some emittance growth at 1TeV CM. The polarimeter chicane will be followed by the betatron and energy collimation, energy spectrometer and final focus sections similar to the RDR.
- Post collision extraction line and main dump
  - Similar as in RDR

Reduced beam-power parameters

- The proposed reduction in the beam power (number of bunches per pulse) requires us to squeeze the beam-beam parameters to compensate the nominal factor-of-two reduction in luminosity. SB2009 explores two possibilities
  - Pushing the beam-beam parameters into a high-disruption regime close to the single-beam kink-instability limits, at the expense of higher beamstrahlung and tighter collision tolerances. The proposed parameters could in principle recover the nominal RDR luminosity to within 25% (1.5×10^{34} $cm^{-2}s^{-1}$).
  - Making use of the so-called Travelling Focus effect [BDS1], which can recover the remaining 25% luminosity without a further increase in the beamstrahlung. This approach comes at the cost of a very high disruption parameter, and the need for additional hardware

RDR parameter plane ranges compared to SB2009

		RDR			SB2009	
		min	nominal	max	no TF	with TF
Bunch population	x 10^{10}	1	2	2	2	2
Number of bunches		1260	2625	5340	1312	1312
Linac bunch interval	ns	180	369	500	530	530
RM bunch length	mm	200	300	500	300	300
Normalized horizontal emittance at IP	mm-mr	10	10	12	10	10
Normalized vertical emittance at IP	mm-mr	0.02	0.04	0.08	0.035	0.035
Horizontal beta function at IP	mm	10	20	20	11	11
Vertical beta function at IP	mm	0.2	0.4	0.6	0.48	0.2
RMS horizontal beam size at IP	nm	474	640	640	470	470
RMS vertical beam size at IP	nm	3.5	5.7	9.9	5.8	3.8
Vertical disruption parameter		14	19.4	26.1	25	38
Fractional RMS energy loss to beamstrahlung	%	1.7	2.4	5.5	4	3.6
Luminosity	x $10^{34} cm^{-2} s^{-1}$		2		1.5	2

Travelling Focus Scheme

- The travelling focus[BDS1] is a technique in which the focussing of opposing bunches is longitudinally controlled so as to defeat the hourglass effect and to restore the luminosity. The matched focusing condition is provided by a dynamic shift of the focal point to coincide with the head of the opposing bunch. The longer bunch helps to reduce the beamstrahlung effect and improvement of background conditions is expected. Similar to the nominal 500GeV CM case, the 250GeV CM parameters would also benefit from application of travelling focus – the work on development of a corresponding parameter set is ongoing

The travelling focus can be created in two ways

- Method 1 is to have small (uncompensated) chromaticity and coherent E-z energy shift dE/dz along the bunch. The required energy shift in this case is a fraction of a percent.
- Method 2 is to use a transverse deflecting cavity giving a z-x correlation in one of the Final Focus sextupoles and thus a z-correlated focusing. The needed strength of the travelling focus transverse cavity was estimated to be about 20% of the nominal crab cavity

R&D and Design Work to Pursue in TDP2

- The more demanding beam-beam parameters associated with SB2009 force us to be in a regime of higher disruption. Although there appears to be no fundamental show stoppers, a comprehensive study involving simulations is still required in an attempt to quantify the performance. Specifically:
  - The higher disruption results in a higher sensitivity to any beam-beam offset. Thus, operation of the intra-train feedback and intra-train luminosity optimisation becomes more important and more challenging than in the case of RDR. Early estimates suggest that in order to contain the luminosity loss within 5%, a bunch-to-bunch jitter in the train needs to be less than 0.2nm at the IP (~5% of a nominal beam sigma).
  - The parameter sets also have twice as small vertical betatron functions at the IP, which imply either tighter collimation, with gaps 40% closer to the beam core. This has implications for wakefields (emittance preservation) and fast feedback systems.
  - Enhanced beam-halo loss in the tighter collimation could potentially increase the number of generated muons and hence the muon shielding requirements[BDS2]. (This is difficult to quantify as it depends on the specifics of the models of beam halo used.)