THE CLIC BDS TOWARDS THE CONCEPTUAL DESIGN REPORT

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Abstract

The CLIC Conceptual Design Report must be ready by 2010. This paper aims at addressing all the critical points of the CLIC BDS to be later implemented in the CDR. This includes risk evaluation and possible solutions to a number of selected points. The smooth and practical transition between the 500 GeV CLIC and the design energy of 3 TeV is also studied.

COLLIMATION SYSTEM

The CLIC collimation system was fully revised in [1, 2]. Since then the efficiency of this system has been slightly optimized by a precise adjustment of the phase advance between the collimators and the Final Doublet (FD) [3]. The tapering angle of the collimators is being optimized to reduce the luminosity loss for off-axis beams due to collimator wakefields [4]. Reducing this angle significantly increases the luminosity performance when taking into account the natural beam jitter of 0.2σ. However this implies the use of longer collimators increasing the energy deposition of the beam in the event of an impact [5]. The later reference also addresses the effect of impact shock waves in the collimators.

Various alternatives are being investigated for the CLIC collimation system. The use of dielectric materials could provide very resistant collimators [6, 7]. Swapping the energy and the betatron collimation system could reduce the muon background in the detector [8].

BDS LAYOUTS

The Beam Delivery Systems (BDS) for the 3 TeV and the 500 GeV CM energy extend over almost 3 km and 2 km, respectively. Figure 1 shows the BDS original layouts at both energies placed inside the 4.5 m diameter tunnel. The original layout for the 500 GeV BDS deviates too much from the 3 TeV layout requiring modifications in the tunnel. A modification of the 500 GeV BDS is needed to bring its footprint closer to that of the 3 TeV BDS. The easiest modification has been identified by allowing for a slightly different angle at the Interaction Point (IP) and a reduction of the bending angle in the dipoles of the collimation section [9], see Fig. 2. The 0.7 mrad rotation around the IP reduces the deviations between both BDS while the reduction of the bending angle aligns the BDS entry to the main linac. The rotation around the IP implies a reduced crossing angle, from 20 mrad to 18.6 mrad. This does not pose any major problem for the detector, the Machine Detector Interface (MDI) or the post-collision line.

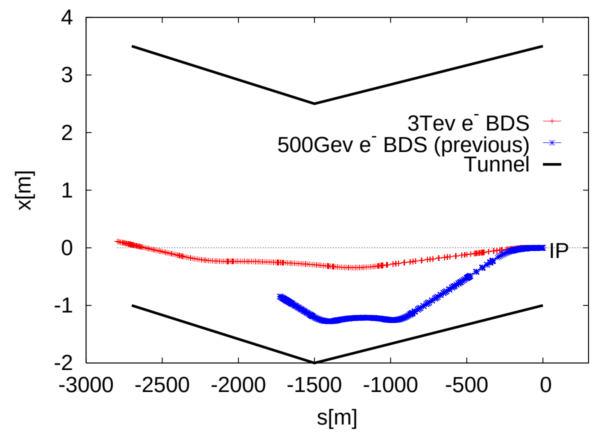

Figure 1: 3 TeV BDS & 500 GeV original BDS both inside a 4.5m diameter tunnel. The 500 GeV BDS is too close to the tunnel's walls restricting placement of other instruments.

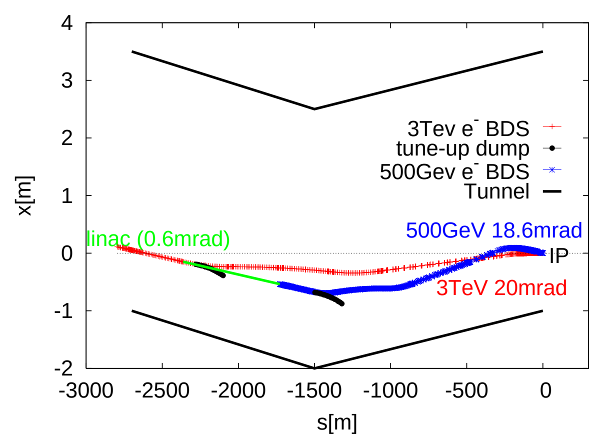

Figure 2: 3 TeV BDS & 500 GeV BDS. The modified 500 GeV BDS fits better in the tunnel, both BDS are now aligned with the LINAC.

BDS APERTURES

The CLIC BDS beam pipe aperture are assumed to be round. They have to be large enough to accommodate the beam with $10\sigma_x$ and $55\sigma_y$. Figure 3 shows the current aper-

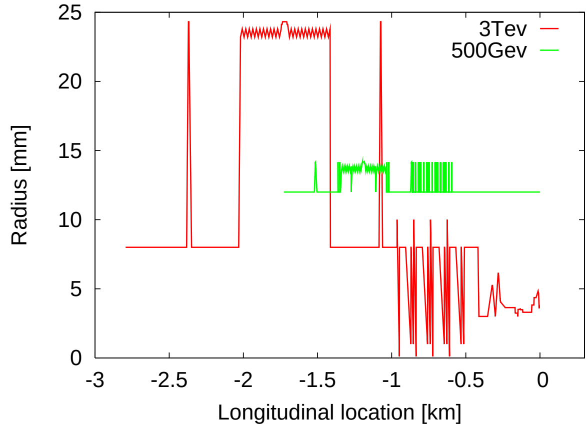

Figure 3: 3 TeV BDS & 500 GeV BDS apertures.

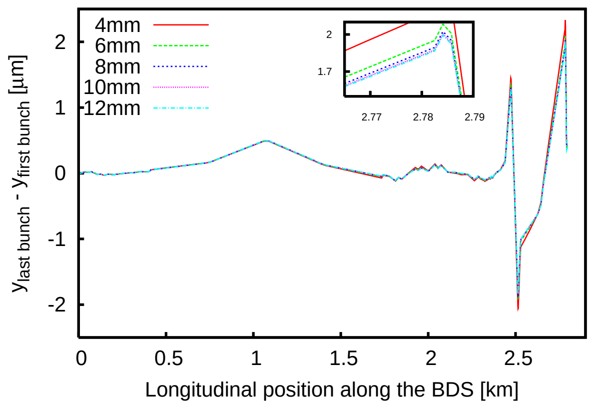

Figure 4: Effect of resistive wall in the excursion of the last bunch with respect to the first bunch of a CLIC nominal train for different beam pipe radius at 1 TeV.

tures for 3 TeV and 500 GeV lattices. The curve for the 3 TeV case also contains the collimator apertures.

The multi-bunch effect of the beam pipe resistive wall wakefield has been checked by computing the excursion of the last bunch of the train [10]. It was verified that the resistive wall wakefield is negligible at 3 TeV and 500 GeV. However the CLIC experiments have requested to use the 3 TeV BDS to collide beams at 1 TeV. From simulations at 1 TeV a reference beam pipe aperture of 10 mm would be required to make the resistive wall negligible, see Fig. 4.

Lastly, it has to be verified that the quadrupoles in the BDS have a peak magnetic field lower than 1.5 T with the current aperture in order to be feasible with normal conducting technology. Few quadrupoles do not respect this constraint at the moment but there is enough space to lengthen these quadrupoles.

FFS WITH L*=6M

In [11] it was proposed to use a longer L* to ease the QD0 stabilization challenge by supporting the FD on the tunnel. The initial lattice featured a L*=8m with about 30% lower luminosity than the current design and tighter pre-

Table 1: Total and Peak luminosities for different L* lattices. The target peak luminosity is 2 $10^{34} cm^{-2} s^{-1}$ plus a 20% margin to cope with the BDS dynamic and static imperfections, 10% and 10%, relatively.

L* $[m]$	Total luminosity $[10^{34} cm^{-2} s^{-1}]$	Peak luminosity $[10^{34} cm^{-2} s^{-1}]$
3.5	6.9	2.5
4.3	6.4	2.4
6	5.0	2.1
8	4.0	1.7

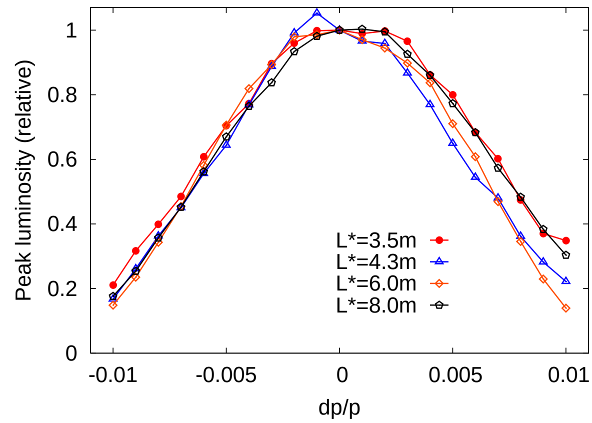

Figure 5: Relative luminosity versus relative momentum deviation for different FFS designs. Similar energy bandwidths are observed for all cases.

alignment tolerances to guarantee a successful tuning [2]. In the meantime the CLIC experiments have proposed to reduce the length of the detector to 6 m [12]. Consequently a new FFS has been designed with an L*=6m by scaling the old CLIC FFS with L*=4.3 m [13]. This lattice currently features IP rms beam sizes of $\sigma_x = 60.8$ nm and $\sigma_y = 1.9$ nm. Table 1 shows the total and energy peak luminosities for the different available FFS systems. Luminosity clearly decreases as L* increases. The L*=6 m case has a 16% lower peak luminosity than the nominal one (L*=3.5 m). Figure 5 displays the luminosity versus relative energy offset for all the FFS designs, showing a similar energy bandwidth in all the cases.

Tuning the FFS

Tuning the FFS under realistic conditions to bring it to its design performance remains a major challenge. Simulations show that assuming 10 μm pre-alignment for the nominal CLIC FFS there is a 80% probability of reaching 80% of the luminosity [2]. The requirement on this figure of merit is a probability of 90% for reaching 90% of the luminosity. A large effort has been launched to improve the tuning algorithms [15] with emphasis on new beam-based alignment techniques.

A first tuning study of the L*=6 m case showed that if only the transverse position of the quadrupoles in the FF

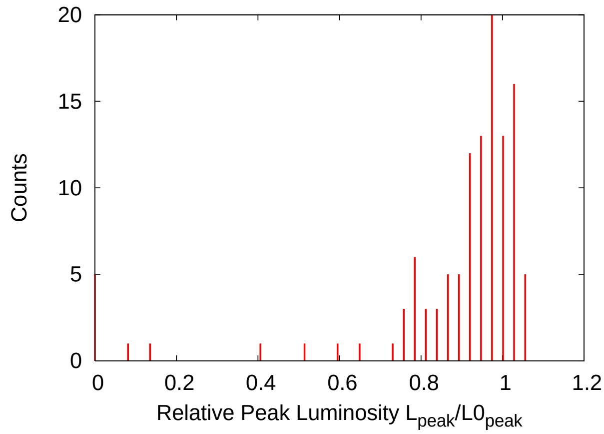

Figure 6: L*=6m tuning histogram,pre-alignment 8 μm quadrupoles and sextupoles as correctors. About 80% of the seeds reach 80% of L_0.

were used as correctors a pre-alignment of 4 μm would be required. This prealignment tolerance is increased to 8 μm if the transverse positions of sextupoles is also used, preserving the same number of iterations needed. Figure **??** shows the luminosity probability after tuning the L*=6 m case with 8 μm pre-alignment. It is planed to apply the same lattice optimizations used for the new FFS to the nominal one since it has been observed that a slight reduction in luminosity can increase the tuning performance.

SOLENOID EFFECTS

The effects of different solenoid designs, proposed for ILC and for CLIC, on the beam phase space at the IP has been studied [16]. Compensating solenoids, by means of bucking coils or antisolenoids, is required together with tuning knobs in order to fully cancel the distortions. Detector Integrated Dipoles are not envisaged at CLIC because they increase the luminosity loss due to incoherent synchrotron radiation and at the same time tighten the tolerances of the main solenoid field stability.

ATF2 ULTRA-LOW β

It has been proposed to use ATF2 to test CLIC-like chromaticities by further reducing the IP β^* [17]. To avoid the emittance blow-up by multipoles in the FD few solutions have been studied: (i) to replace the normal-conducting focusing quadrupole of the final doublet (QF1FF) by a superconducting one, (ii) to reduce the emittance by the insertion of super-conducting wigglers in the ATF damping ring, and (iii) to decrease the beta function at QF1FF in order to minimize the impact of its multipoles to the IP beam size [18]. Thanks to new measurements of Ground Motion (GM) it has been possible to improve the GM model. However the new model still overestimates the relative motion at short distances. This model predicts a beam jitter of 12.1 nm at the IP [19]. This number should be compared to the expected beam size after tuning between 25 and 30 nm [18]. Further improvements of the GM model in the short distances to better reproduce the measurements could reduce the jitter.

CONCLUSIONS AND OUTLOOK

The CLIC BDS is ready for the Conceptual Design Report (CDR) in the end of 2010. Its collimation system fully meets the specifications and the current efforts are being put in addressing the technical issues and investigating alternative designs or materials that could improve the performance or the robustness of the system. The FFS is still challenged by the need of tight pre-alignment tolerances in the order of 10 μm and the lack of beam-based tuning algorithms that could guarantee 90% of the luminosity with a 90% probability. The current performance is not far from these values but a large effort is being put in this subject to finally meet all FFS requirements.

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