IP BPM POSITION ERROR AT CLIC DUE TO SECONDARY EMISSION FROM BEAM-BEAM BACKGROUNDS

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Abstract

Beam-beam background impacts on the IP BPM are studied for the CLIC machine. The large number of coherent pairs (1.8×10^8 charges per BPM strip per bunch crossing) for the CLIC-G default parameter set, potentially leads to a large secondary emission in the BPM strips. Detailed GuineaPig++ and Geant studies reveal, however, that the coherent pairs travel down the extraction line without significant secondary showering. Geant studies of the CLIC incoherent pairs show a flux of secondary emission two orders of magnitude less than that expected for the ILC 1 TeV high luminosity scheme. Since previous studies showed that FONT IP BPM signal distortion for the ILC was of no concern, then it can also be neglected at CLIC

INTRODUCTION

Beam based feedback systems for the alignment of CLIC beams faces many challenges. The short bunch spacing defined in the CLIC-G parameter set requires a feedback system that can operate on the fastest time scales possible. The FONT3 project demonstrated such a system with a latency of 54 ns [1]. FONT4 is a digital version that makes use of FPGA programming for smart processing of the beam [2]

One element of the FONT system is a stripline BPM which records beam position and provides input to the FONT processor and kicker system which bring the beams into alignment. A restriction on the operation of such a feedback system is the effect of beam backgrounds on the FONT BPM striplines. The T-488 experiment at SLAC ESA has shown that a significant flux of background particles impinging on the striplines results in a distorted voltage signal and a misreading of the beam position. Simulations developed to explain these experimental results showed good agreement with the data [3].

The default CLIC operating parameters specify, via the Upsilon parameter, high bunch fields and consequently a large flux of background particles. The simulations developed in the course of the SLAC ESA experiment can be employed with the CLIC default parameter set to determine the impact on BPM readings for a potential FONT application to the CLIC machine.

CAIN AND GEANT SIMULATIONS

The published CLIC-G parameter set [4] defines a 3 TeV centre of mass collision between bunches each containing 3.72×10^9 electrons and positrons. Simulations indicate that this parameter set will produce a high flux of coherent pairs, numerically 3 orders of magnitude in excess of the incoherent pairs. Guineapig++ [5] was chosen to simulate the bunch collision since it contains an option to record the energy-momenta of the coherent as well as the incoherent pairs.

Previous simulations for ILC parameters have shown that it is the pairs of a certain transverse velocity v_t that cause the secondary showering incident on the FONT BPM striplines. For instance, simulation of the high luminosity, 1 TeV scheme for the ILC revealed up to 10^5 impacts per stripline per bunch crossing. For CLIC there are many more coherent pairs. However these are produced with relatively high energy and small transverse velocity. Consequently they travel down the extraction line without causing secondary showering. The incoherent pairs, in contrast, do have a large enough v_t sufficient to impact the edge of the beam calorimeter and therefore require further investigation (see fig 1).

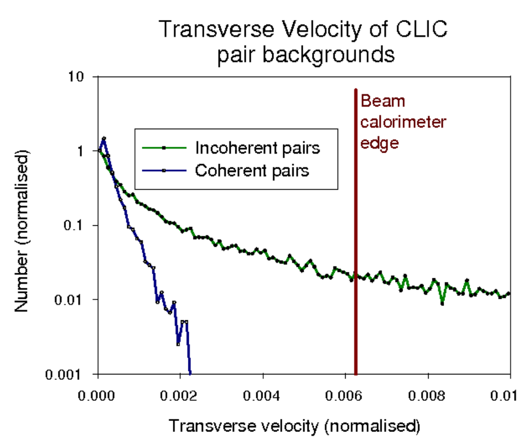

Figure 1: Transverse velocity of CLIC background pairs.

The pairs were used as an input to a geant simulation of the CLIC interaction region containing a stripline BPM placed in the extraction line between the calorimeter mask and the first extraction line quadrupole. The striplines are modelled to be steel conic sections, 15.2cm in length, subtending 44 degrees at the bpm axis and having a 1mm width. The particle hits on each stripline were recorded and are presented in table 1.

Table 1: Comparison of Geant simulation results for CLIC-G and the ILC 1TeV high luminosity schemes.

	CLIC-G	ILC baseline
beam charge	$0.4 \times 10^{1}0$	$2 \times 10^{1}0$
beam charge subtended by each strip	4.7×10^{8}	2.3×10^{9}
incoherent pairs	366214	694603
coherent pairs	1.32×10^{8}	818
avg hits (per strip)	17818	647830
avg residual charge (per strip)	+1666	+115232

SIMULATION OF BPM SIGNALS

In order to estimate errors in BPM readings due to the impact of secondary showering upon BPM striplines, it is necessary to reconstruct the raw voltage signals in the strips. The time dependency of hits and secondary emission is determined with the aid of Geant's time of flight (TOFG) parameter. The electrical weight of each hit is determined by the method of image charge. A single charge e moving effectively from infinity to the strip surface contributes an image charge of e. Emitted charges e moving from the surface to effective infinity, contribute -e.

Similarily, the BPM signal from the spent beam is obtained by calculating the charge density between the striplines at the upstream end of the BPM. The plane transverse to the spen beam motion can be divided up into a grid. Each component of charge density thus obtained contributes an image current to the BPM strips depending on the angle subtended transversely to the strip edges. Each component of the BPM stripline current travels down the strip and reflects back from its shorted downstream end.

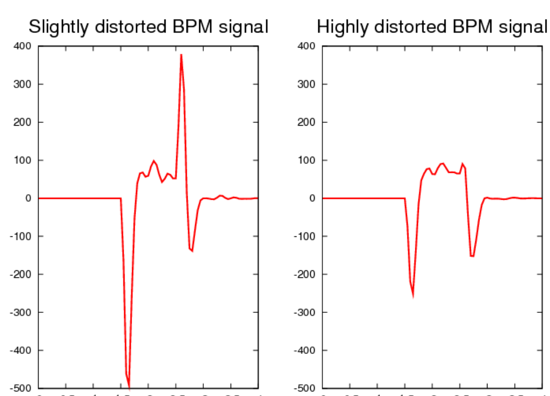

Figure 2: Slightly and highly distorted BPM signals due to secondary emission.

The two image current contributions are added together and a voltage signal can be obtained. Since the bulk of the secondary showering is still travelling at close to the speed of light, the reflected current from the secondary emission tends to 'pile up' diminishing the overall reflected peak (see figure 2). The extent of distortion in the BPM signal can thus be approximated to first order simply by comparing the net charge from secondary emission with the charge resulting from the spent beam. Table 1 reveals that the exported distortion is in ratio $1 : 1.74 \times 10^{5}$ for the ILC, 1 TeV high luminosity scheme and $1 : 2.4 \times 10^{6}$ for the CLIC-G. At this level, signal distortion from secondary emission can be ignored.

There is, however, concern about the signal due to the coherent pairs travelling down the extraction line. These constitute a flux approaching 10% of the spent beam charge. The coherent pairs at the upstream end of the BPM strips have a split x-profile of FWHM $\approx 0.2cm$ (figure 3). Any variation in the symmetry of the coherent pair beam at the FONT IP beam may give a significant false reading to the primary spent beam position. A future, detailed study of this issue is warranted.

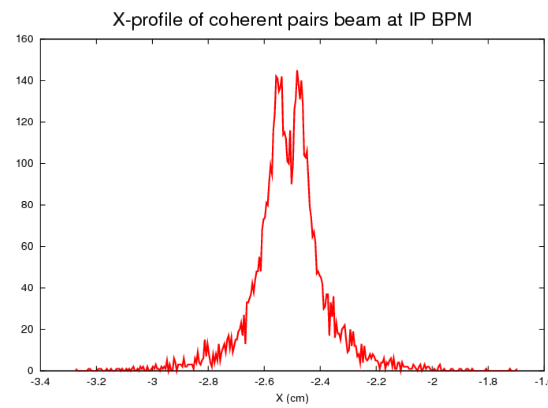

Figure 3: X-profile of the coherent pairs beam at the upstream end of the IP BPM.

CONCLUSION

The CLIC beam-beam interaction produces a background environment that may affect the operation of FONT feedback system for beam alignment. One crucial element of that feedback system is a stripline BPM placed near the interaction point in the extraction line.

The operation of this feedback BPM in an intense background environment was tested at the T-488 experiment at SLAC EndStation A. For a rate of secondary emission much greater than that expected for the ILC 1 TeV high luminosity scheme, no distortion of BPM signals was seen. Simulations of the BPM signals have been developed and confirm the null result obtained by experiment.

The CLIC machine operating at the default CLIC-G parameter set was simulated using Guineapig++, Geant and the BPM signal simulation. The rate of secondary emission is expected to be at least an order of magnitude less than the ILC worst case scenario and can therefore be disregarded at CLIC. However the large flux of coherent pairs expected at CLIC deserves a further detailed study.

REFERENCES

[1] FONT3: P.N. Burrows *et al.*, Proceedings PAC05.

[2] FONT4: R. Apsimon *et al.*, Design and Performance of a prototype digital feedback system for the ILC IP, these proceedings.

[3] A.F. Hartin *et al.*, Simulation of ILC feedback BPM signals in an intense background environment, PAC07 Proceedings.

[4] See http://clic-meeting.web.cern.ch/clic-meeting/clictable2007.html

[5] LAL Guineapig++ project: https://trac.lal.in2p3.fr/GuineaPig