DESIGNING THE TESLA INTERACTION REGION WITH *L** = 5 M

O.Napoly, J.Payet, CEA/DAPNIA/SACM Saclay

Abstract

We study the main implications of increasing the last drift length l^* from 3 to 5 meters, in the TESLA interaction region: namely, the design of a new final focus system with a better chromatic correction, the extraction of the beam after the collision through the opposite doublet, and the new collimation requirements.

1 INTRODUCTION

Increasing the distance l^* between the final doublet (FD) and the interaction point (IP) to $l^* = 5$ m would be beneficial for the TESLA Interaction Region (IR) design. From the accelerator point of view, the superconducting final quadrupoles would move out of the large field (4 T) region of the detector solenoid, thus reducing the need for an optical correction of the solenoid effect on the beam, and also re-introducing the standard NbTi superconducting cable technology as a possible solution in parallel with the more ambitious Nb3Sn technology. From the detector point of view, the forward acceptance would increase at low angles, the TPC (Time Projection Chamber) and calorimeter background created in the quadrupole cold mass would reduce, and it would offer the possibility of a lighter mask with a simpler support system.

In counterpart, it raises three problems mainly:

- The correction of the chromaticity created by the last doublet, proportional to l^*
- The extraction of the spent beam
- The extraction of the synchrotron radiation generated in the last doublet.

We successively discuss these three points.

2 THE FINAL FOCUS SYSTEM

By adopting the central idea of the NLC final focus system [1,2,3] – non-zero dispersion in the final doublet to correct its chromaticity locally by inserting one sextupole between the quadrupoles – the performance of the chromatic correction can be greatly improved. However the NLC layout as such is not compatible with the TESLA head-on collision scheme and the position of the beam dump. Indeed, a magnet free drift space of about 240 m is necessary to let the beamstrahlung cone be intercepted at the position of the beam dump. A preliminary design of such a final focus system with $l^* = 5$ m is shown in Figure 1.

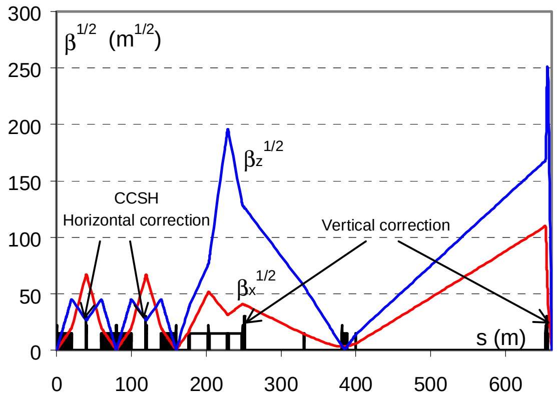

Figure 1: Optics of TESLA Final Focus with $l^* = 5$ m.

The vertical chromatic correction is based on the new NLC scheme. The transfer matrix M_V between the two vertical sextupoles is:

$$M_V = \begin{vmatrix} F & 0 & 0 & 0 \\ F_{21} & 1/F & 0 & 0 \\ 0 & 0 & F & 0 \\ 0 & 0 & F_{43} & 1/F \end{vmatrix}$$

where the nonzero terms are arbitrary. Then the second order aberrations produced by the two vertical sextupoles are cancelled [2].

Upstream in the line, the horizontal chromatic correction is obtained with the previous horizontal chromatic correction system (CCSH) [4], which is a second order achromat. The angular dispersion at the IP is about 3 mrad, and then the dispersion in the FD is about 3.5 cm (Figure 2).

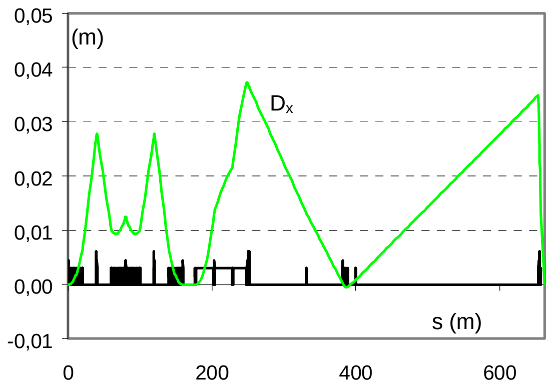

Figure 2: Dispersion function of the new Final Focus.

This system offers about 0.3 % chromatic bandwidth as shown by tracking studies in Figure 3. This performance is disappointing with respect to the NLC final focus system and more work is needed to understand the aberration content and to derive a better system. Its total length should also be reduced by 50 m in order to match the previous beam line.

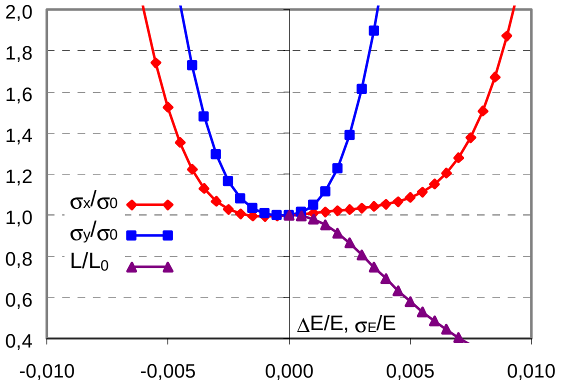

Figure 3: IP bandwidth of the new Final Focus. Normalized beam sizes versus energy offset $\Delta E/E$ and normalized luminosity versus rms energy spread σ_E/E.

3 THE SPENT BEAM EXTRACTION

The acceptance of the opposite final doublet to particles originating from the IP at a given angle can be easily calculated as a function of their energy. Figure 4 plots the maximum angle θ_{max} with respect to the axis for a particle to hit the doublet aperture, as a function of its energy and of the angle Φ of its plane of emission ($\Phi = 0°$ corresponding to the x-plane). The aperture diameter of the doublet is 48 mm and a 4 T solenoid field is applied over the first 4.5 m.

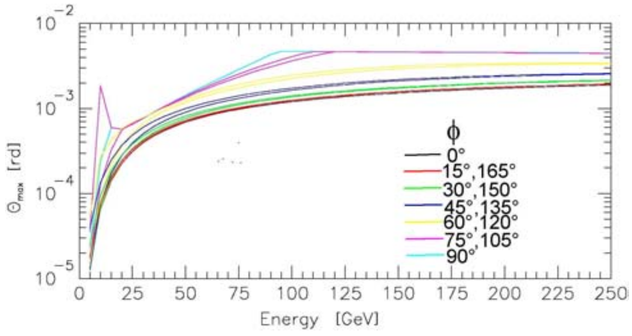

Figure 4: Angular acceptance of the final doublet as a function of energy and angle Φ.

Due to the doublet polarity, the tightest acceptance is in the x-plane. These acceptances are compared in Figure 5 in the cases where $l^* = 3,4,5$ m. The difference between the three curves is small and the $l^* = 5$ m case is actually more favourable to extract the low energy particles like the $e+e-$ pairs and the $e\pm$ bremsstrahlung. Tracking simulations must be done to confirm this analysis.

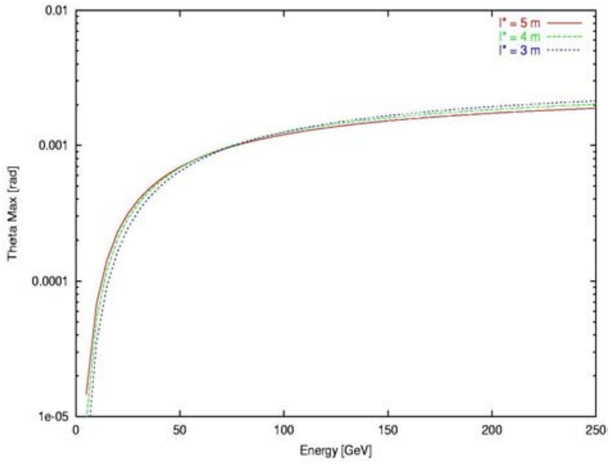

Figure 5: Angular acceptance in the x-plane of the final doublet as a function of particle energy.

4 THE COLLIMATION REQUIREMENTS

The extraction of the synchrotron radiation from the doublet regions for an incoming beam with a $7.8\ \sigma_x \times 42\ \sigma_y$ transverse extension is shown in Figure 6.

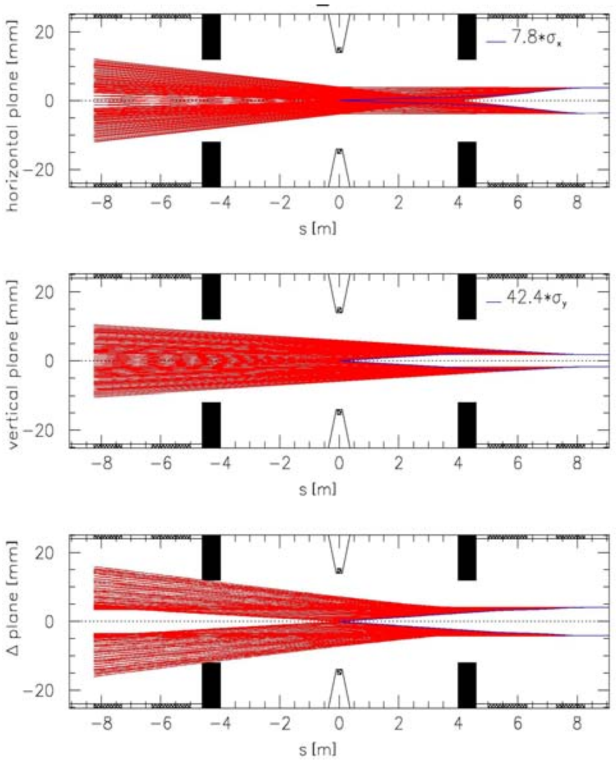

Figure 6: Extraction of the synchrotron radiation emitted by the final doublet through the opposite inner mask (black) and doublet apertures (hatched).

The collimation requirements are set by the location and by the aperture of the inner mask. A diameter of 24 mm at most is required to properly mask the vertex detector of 14 mm radius. Moving the mask 2 meters away from the IP, along with the doublet, is more favourable for the detector point-of-view because it increases the low-angle coverage and minimizes the weight of the mask. But, as shown in Table 1, the collimation requirements are indeed much tighter than if the mask is kept at a 2 m distance from the IP. These tight collimation requirements should be met by an improved collimation optics using tail folding by non-linear elements (octupoles) [5].

Table 1: Beam collimation requirements for synchrotron radiation extraction.

	*l** [m]	Mask distance from IP [m]	Number of σ_x N_x	Number of σ_y N_y
TDR design	3	2	13	81
New design	5	2	10	48
“	5	4	7.8	42

5 CONCLUSIONS

In order to simplify the IR design of TESLA, the optics of a final focus system with $l^* = 5$ m has been studied. A first approach, combining a NLC like chromatic correction system for the vertical plane and a traditional achromat correction system for the horizontal plane, has been presented. The optics must still be optimised to reduce the beam line length and to improve its chromatic aperture. The spent beam extraction seems more favourable for low energy particles. More tracking must be made to confirm this analysis.

6 REFERENCES

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