Mask Design and Background Studies for TESLA

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Abstract.
A detailed design of the low angle region of the TESLA detector has been developed. Fast and radiation hard sampling calorimeters provide instrumentation down to $\theta =$ 4.6 mrad for physics and luminosity monitoring. Beam induced background sources, especially beamstrahlung pairs, hadronic background, neutrons, synchrotron radiation, beam gas induced background and muons have been studied. All background rates in the detector are at tolerable levels.

INTRODUCTION

The low angle region of the TESLA detector has been designed with respect to two main tasks, background reduction and instrumentation in the very forward region. The main background source are e^+e^- pairs produced in beam-beam interaction which are focused in the forward direction. The mask, a system of shielding around the first quadrupole doublet, protects the detector from backscattered and secondary particles produced from the impinging pairs as well as from other beam induced background sources. All background sources are described in detail in references [1–3]. Fast and radiation hard calorimeters are foreseen in the forward region to provide as much hermeticity as possible for the TESLA detector. Additionally one calorimeter acts as a monitor for the pair background for luminosity stabilization issues.

MASK DESIGN

The design of the TESLA mask is shown in Fig. 1. The tungsten shield absorbs secondaries produced by the impinging pairs. The graphite absorbers act as a shield for neutrons which have been produced upstream in the beam delivery system and which are coming from the beam dump. Additionally the graphite provides a low Z absorber for backscattered particles. The inner mask which defines the smallest aperture for the beam pipe is also part of the collimation system.

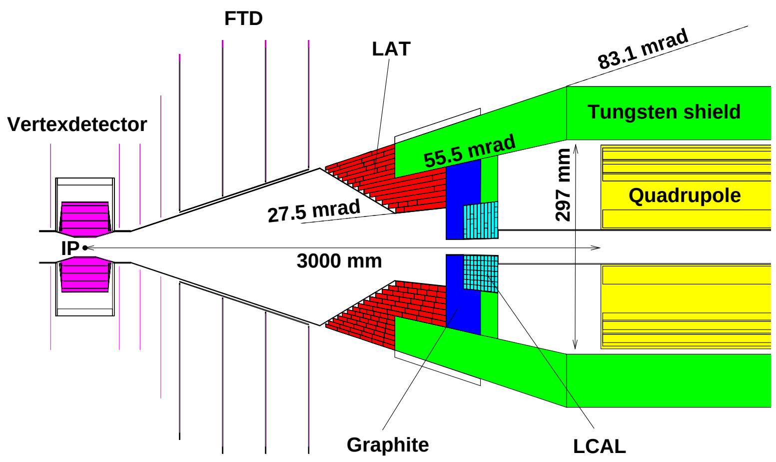

FIGURE 1. Layout of the TESLA mask region.

The instrumentation consists of two calorimeters. The low angle tagger (LAT) covers the range from 27.5 mrad $\leq \theta \leq$ 83.1 mrad. The lower angular limit is outside the area of the high pairstrahlung background so that the background load on this calorimeter is low. A second calorimeter, the luminosity calorimeter LCAL, is mounted directly around the beam pipe and covers the angular range of 4.6 mrad $\leq \theta \leq$ 27.5 mrad. The LCAL serves mainly as a pair monitor and receives per bunch crossing (BX) pairs with a total energy of 21 (35.5) TeV for a $\sqrt{s} = 500$ (800) GeV TESLA machine. Both calorimeters will be tungsten sampling calorimeters. Readout of the LAT will be done with SI detectors, for the LCAL radiation hard diamond detectors are studied.

BACKGROUND STUDIES

Beam-beam background

Pairs: The beam beam interaction results in the production of e^+e^- pairs which are focused in the forward direction. These pairs have been simulated with GUINEA PIG [2]. Tracking has been done with the GEANT3 based full detector simulation BRAHMS201 [4]. The cut-offs in GEANT have been set to 10 keV for electrons, photons, hadrons and muons. Fig. 2 shows the numbers of charged hits in the layers of the vertex detector (CCD option) per BX. The maximum number of charged hits for $\sqrt{s}$ = 800 GeV and a 3 T magnetic coil field is $\approx$ 650. This corresponds to hit densities on the innermost detector layer of less than $0.07 mm^{-2}/BX$, which is acceptable. Table 1 summarizes the numbers of charged hits in the forward tracking disks (FTD), the silicon intermediate tracker (SIT) and in the TPC.

Hadronic Background: The hadronic background resulting from the reaction $e^+e^- \longrightarrow e^+e^-\gamma\gamma \longrightarrow hadrons$ has been studied in detail [5] using GUINEA PIG for the production of the photons and HERWIG 5.9 with multiparton interaction for the

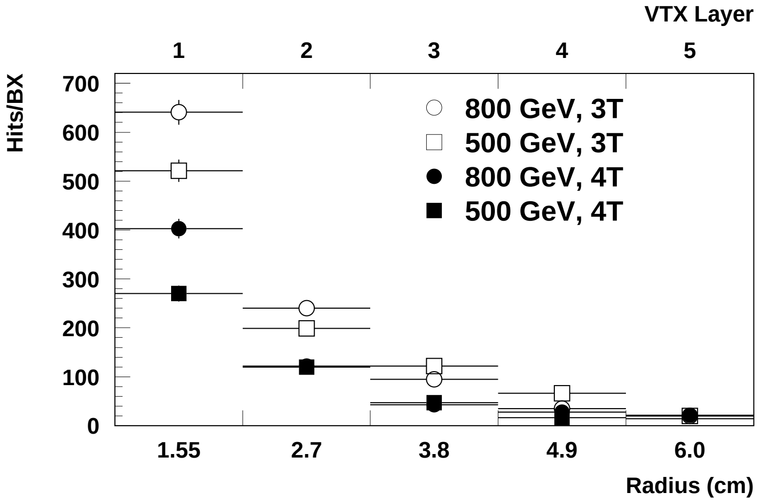

FIGURE 2. Charged pair hits in the CCD vertex detector layers. Open (closed) symbols denote a detector coil field of 3T (4T), square (circles) represent a $\sqrt{s} = 500$ (800) GeV TESLA machine.

TABLE 1. Charged pair hits per BX (TPC: Number of tracks).

Detector	500 GeV, 3 T	500 GeV, 4 T	800 GeV, 3T	800 GeV, 4 T
FTD	230	160	252	187
SIT	30	32	16	18
TPC	7	5	7	8

$\gamma\gamma$ reaction. The total number of direct, single resolved and double resolved events is $2.05 \cdot 10^{-2}$ per BX with an averaged (charged) multiplicity of 34.4 (17.4) and a total energy of 2.07 GeV. This leads to a charged hit density of $< 3.4 \cdot 10^{-5} mm^{-2}$ on the inner vertex detector layer. The total number of charged tracks in the TPC is < 0.7 per BX.

Neutrons: Neutrons are produced by photons hitting beam line elements upstream of the detector. Photons resulting from beamstrahlung, pairstrahlung and radiative Bhabhas have been taken into account. Simulation and tracking has been performed with FLUKA98 [3]. More than $2.5 \cdot 10^{10}$ neutrons are produced per BX which leads to the neutron fluxes presented in Table 2. The numbers of neutrons in the detector are acceptable. Due to the recent changes in the beam line, beam dump, mask and detector design these numbers are being updated now.

Other Background Sources

Synchrotron Radiation: The collimation system has been designed so that no direct synchrotron radiation hits detector parts. The first collimator is hit by $\approx 6.5 \cdot 10^{11}$ photons per BX. Calculations show [3] that the number of photons which scatter from there into the vertex detector is ≈ 60 per cm^2. No photons

TABLE 2. Neutron fluxes in the subdetectors.

VTX n [1 MeV n] (cm^{-2}/year)	TPC n/BX [E_{tot} (GeV)]	ECAL-B n/BX [E_{tot} (GeV)]	ECAL-EC n/BX [E_{tot} (GeV)]
$< 3.8 \cdot 10^8$	5600	4100	7500
$[0.5 \cdot 10^8]$	[13.7]	[10.4]	[30.7]

reach the TPC and the ECAL.

Beam-Gas Background: Assuming a rest gas pressure of $5 \cdot 10^{-9}$ mbar (CO) approx. $3 \cdot 10^{-3}$ $e^{\pm}$ leave the beam pipe near the vertex detector per BX [3].

Muons: Simulations show [6] that each $\approx 7 \cdot 10^4$ electrons/positrons which are lost in the beam delivery system produce one muon. With an assumed loss of 10^4 particles this results in a permanent rate of 0.3 muons per BX in the TESLA detector. As the TPC samples 150 BX and covers about 1/4 of the detector area this results in 11 muon tracks which are sampled in the TPC for each readout.

CONCLUSION AND OUTLOOK

Detailed background studies have been performed for most of the background sources. The studied backgrounds are all on a tolerable level. However the recent changes in the beam delivery system and detector design are not included in all studies (e.g. for the neutron background). Recalculations of these backgrounds have just been started.

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