Update on the Beam-Related Backgrounds in the LDC Detector

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In this talk [1] recent simulation results for beam-related backgrounds in the LDC detector are presented, using Guinea-Pig as a particle generator and Mokka as a full detector simulation. Different beam parameter sets and designs of the forward region are compared with respect to the background hits on the vertex detector.

1   Backgrounds at the ILC

Electron-positron pairs are a main source of background at the ILC. The very strongly-focussed bunches of the ILC interact though their high spatial charge densities and can emit photons, the so-called "beamstrahlung" [2]. These can in turn scatter and create electron-positron pairs – typically in amounts in the order of 10^5 per bunch crossing and with energies in the GeV range. Other sources of background are either supposed to be negligible (such as the beam dump or synchrotron radiation from the final focus) or have to be studied in further detail (e.g. the beam halo or losses in the extraction line).

The pairs can hit the forward calorimeters (mostly the BeamCal, which is in fact designed to observe the spatial distribution of the pairs) and the magnets of the beam delivery system and/or the extraction line, where they are over-focussed and deflected into the magnet material. In these processes, large amounts of photons and charged particles are created, and also neutrons can be released by photonuclear reactions.

Some of these particles (either directly from the IP or backscattered from the forward region) can reach the inner parts of the detector, most notably causing hits from charged particles on the inner silicon trackers, but also gradually damaging the silicon bulk and sometimes reaching the main gaseous tracker or the calorimeters.

2   Simulation Tools

2.1   Guinea-Pig – Particle Generator

Guinea-Pig [3] is used to simulate the beam-beam interaction. Given a set of beam parameters (energy, bunch sizes, emittances, bunch charge, etc.), Guinea-Pig writes out the electron-positron pairs which are created in one bunch crossing. Simulated data exists for the TESLA and various ILC beam parameter sets [4].

2.2   Mokka – Full Detector Simulation

The Geant4-based application Mokka [5] is used for a full simulation of the detector. The default detector geometry corresponds to the shortened "LDC version 2" [6], with an increased distance between LumiCal ($z = 2270\ldots2470$ mm, $r = 100\ldots350$ mm) and Beam-Cal ($z = 3550\ldots3750$ mm, $r = 20\ldots165$ mm), thus resulting in a better shielding against
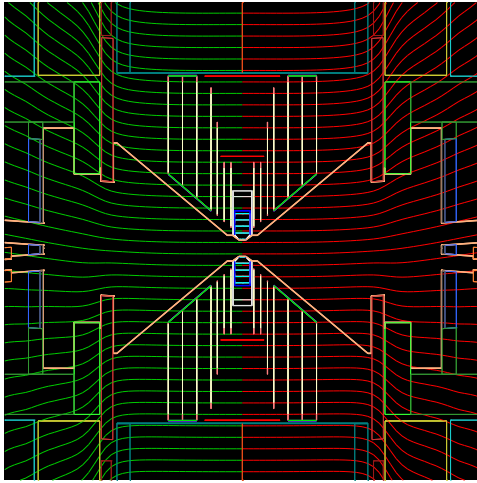
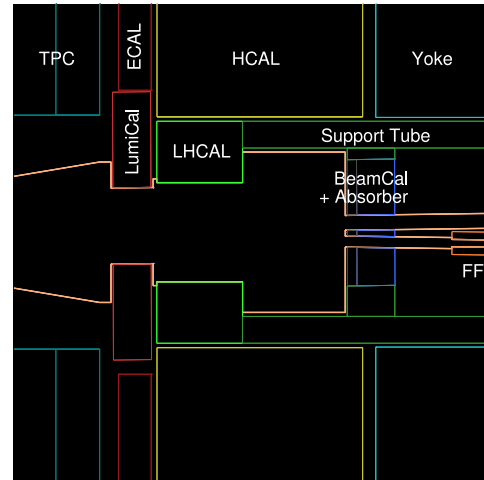Figure 1: Overall detector geometry and anti-DID field (compressed view 1:10)

Figure 2: Design of the forward region (compressed view 1:2)

backscattering from the BeamCal. The geometry is implemented with a crossing angle of 14 mrad and an anti-DID field [7] which bends the magnetic field lines from the IP towards the holes for the outgoing beams (Figures 1 and 2).

3   Hits on the Vertex Detector

The number of hits per layer generally decreases with the layer number, even though the innermost layer is only half as long as the rest and the outer layers have steadily increasing radii. The error bars of the following plots indicate the fluctuation (i.e., the standard deviation) per bunch crossing, not the statistical error of all 100 simulated bunch crossings.

3.1   Beam Parameter Sets

In the comparison of various beam parameter sets (Figure 3), the number of hits on the vertex detector clearly correlates with the number of primary electron-positron pairs. The nominal ILC parameters (at $\sqrt{s} = 500\,\text{GeV}$) produce the least backgrounds, whereas the "low power" option with its even stronger-focussed beams gives more than twice the amount of background hits per bunch crossing. The old TESLA parameters are shown just for illustrational purposes – the original TESLA detector [8] had a completely different forward design than the LDC.

3.2   Influence of the Low-Z Absorber

About one third of the vertex detector hits are caused by backscatterers, most of which originate from the BeamCal. In the current design, the BeamCal is covered by a graphite absorber with a thickness of 50 mm which is intended to reduce backscattering.

Figure 4 shows that the graphite absorber in fact serves its purpose well: With a thickness of only 20 mm, the number of hits on the critical first layer increases by a factor of almost two,
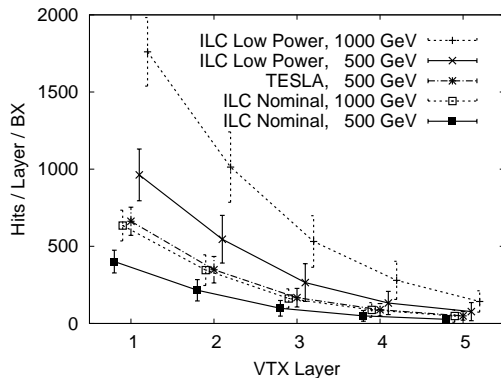
Figure 3: Number of hits on the vertex detector for various beam parameter sets
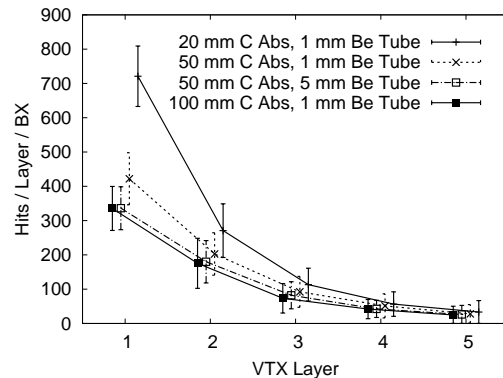
Figure 4: Number of hits on the vertex detector in relation to the thickness of the low-Z absorber

whereas the minimal profit from an increased thickness of 100 mm would hardly be justified in comparison with the degraded resolution of the BeamCal itself – this is in agreement with previous dedicated studies of the absorber thickness [9]. However, a cladding of the inner surface of the BeamCal with 5 mm of beryllium would be an advantageous option.

4   Summary and Outlook

Backgrounds from backscattering particles have an important impact on the vertex detector, but they can be suppressed by appropriate means: The forward region has to be designed carefully in order to avoid "hot spots", and the anti-DID helps in the reduction of backgrounds by preventing backscattered particles from hitting the vertex detector. For the low-Z graphite absorber in front of the BeamCal, a thickness of 50 mm looks reasonable, but additional absorber material inside the BeamCal could reduce backscattering further.

To study the impact of backgrounds on the whole reconstruction chain (including vertex detector, main tracker, and possibly the calorimeters), a large-scale production of background events is foreseen.

References

[1] Slides:
http://ilcagenda.linearcollider.org/contributionDisplay.py?confId=1296&contribId=176

[2] K. Yokoya, KEK Report 85-9 (1985).

[3] D. Schulte, DESY Report TESLA 97-08 (1997).

[4] ILC@SLAC Beam Parameters Web Site,
http://www-project.slac.stanford.edu/ilc/acceldev/beamparameters.html

[5] Mokka Web Site, http://mokka.in2p3.fr

[6] Large Detector Concept Web Site, http://www.ilcldc.org

[7] B. Parker and A. Seryi, Phys. Rev. ST Accel. Beams **8**, 041001 (2005).

[8] T. Behnke *et al.*, DESY-2001-011, Part IV (2001).

[9] S. Niehage, Private communication