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INTERACTION REGION LAYOUT AND e+e- PAIR BACKGROUNDS IN e-e- COLLISIONS

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The production of soft e+e- pairs through the interactions of beamstrahlung photons is the major expected background at the next generation of high energy e+e- and e-e- colliders. This process has been simulated and the resulting distributions of particles in the very forward 5-25 mrad pair luminosity monitor are shown.

Keywords: pairs; linear collider; background; luminosity monitor

1.0 Simulation Results

It is expected that the same detector will be used to study both e+e- and e-e interactions at the next generation linear collider. The main detector background in both cases is expected to be the copious low energy e+e- pairs produced through the interactions of the beamstrahlung photons produced when the bunches are accelerated toward or away from each other during the beam-beam interaction. This process has been studied[1] extensively and several simulation programs have been written. When the GUINEA PIG program[2] is used to simulate a single e+e- bunch crossing at the nominal NLC 500 GeV IP parameters (N_e=$0.75\cdot10^{10}$, σ_x=243 nm, σ_y=3.0 nm, σ_z=110 μm) 49000 particles of mean energy 4.1 GeV are produced for a total energy of 199 TeV. When e-e- bunch interactions are simulated using the same IP parameters, 14370 particles of the same mean energy are produced for a total energy of 59 TeV. Similar results[3] have already been presented. As there are 192 bunches in the 120 Hz NLC bunch train the pairs are the main source of backgrounds and radiation damage.

Figure 1 shows the current concept of the forward masking, calorimetry and tracking for the proposed silicon-based detector, SiD. The detectors solenoid field has a value of 5 Tesla. The nearest quadrupole magnet (QD0) of the final doublet ends at 3.51 m. Between 3.15-3.50 m there is a calorimeter element labeled “Pair-Lumon” that will measure the energy of the e+e- pairs as a real-time measure of machine luminosity and identify high energy electrons from two-photon events. Lost electrons are a major background in searched for supersymmetric particles such as the stau. As there is a 20 mrad crossing angle between incoming and outgoing beams in the NLC design, the Pair-

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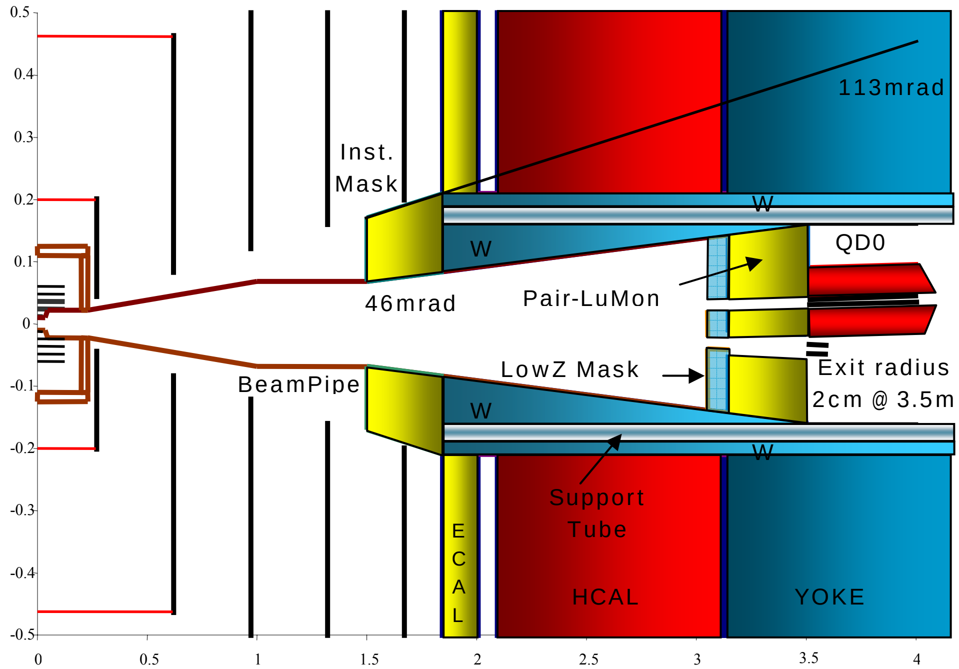
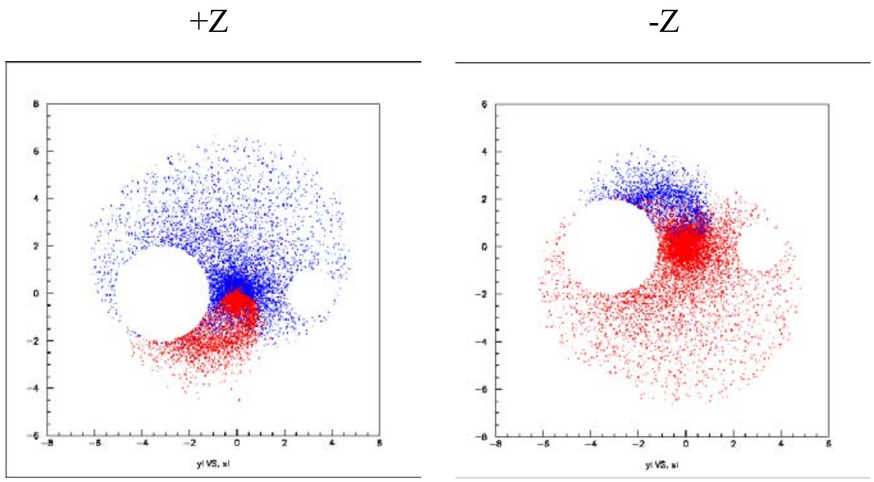


Fig. 1. A detail of the forward region of the SiD detector showing masking, calorimetry and tracking.

Lumon has two holes at x=±3.15cm. The incoming beam enters through a 1 cm radius hole while the exit beam is permitted to leave through a hole whose size is chosen to a) maximize the number of pair particles that can exit while b) providing as much solid angle coverage for electron identification as is useful. The hole must be small enough so that it doesn't interfere with QD0 and allow enough space so that a beam position monitor can be shadowed behind the Pair-Lumon. The radial value of the exit aperture used for these studies was 2.0 cm, a number which will probably be revised downward when the design is next iterated.

In the e+e- case, 11.8k particles (24%) carrying 170 TeV of energy (85%) leave the immediate IP region through the two apertures. The number versus energy fractional difference results from the fact that higher energy particles tend to follow the beam direction through the exit aperture while low energy pairs spiral in the 5 Tesla field until they hit the Pair-Lumon near x=y=0. The hit distribution for the e+e- case is shown in Figure 2. There are 18,600 particles per side which carry 14.5 TeV of energy per bunch crossing.

Figure 3 shows the pair distribution at z=+3.15m for the case of e-e- bunch interactions; the left side shows all the pairs while the right side removes those which leave through the apertures. 3000 particles (21%) leave carrying 50 TeV (85%) of the energy. 5700 particles with 4.3 TeV of energy hit a Pair-Lumon on either side of the IP.



Blue = e+, Red = e-

Fig. 2. Distribution of e+e- pairs produced in e+e- collisions at the front face of the Pair-Lumon at z=3.15 m.

After the particles are tracked to the Pair-Lumon in GEANT3 they are allowed to shower. For this purpose the detector is simulated as 50 layers of W (2.0mm) and Si (0.3mm). To estimate the maximum radiation dose, the energy deposited in each 5mm x 5mm section of Si is calculated for each layer and the result converted to Rads. For e+e- produced pairs, the maximum dose is $\sim 70 \cdot 10^6$ rads per year (10^7 seconds), peaking on the edges of the exit aperture and in the geometric center (x=y=0) of the device. This distribution is shown in Figure 4. Similar calculations for the first quadrupole in the extraction line and

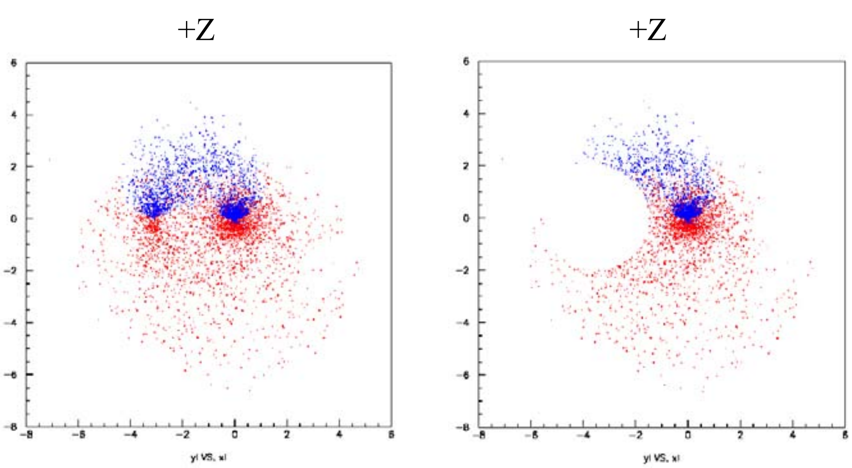


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Fig. 3. Distribution of e+e- pairs produced in e-e- collisions at the front face of the Pair-Lumon at z=3.15 m. In the plot on the right particles that exit through the incoming and outgoing beam apertures are removed.

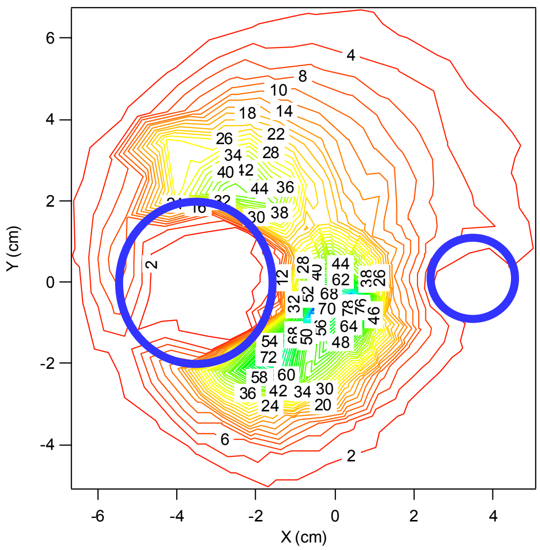

Fig. 4. Radiation dose per year in the Pair-Lumon from pairs arising from e+e- interactions. The peak yearly dose is 70 Mrad.

for the Be mask immediately in front of the Pair-Lumon yield doses of 100 and 30 Mrad/yr, respectively.

References

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