Pair background simulation for Vertex detector at ILC

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Tools

- Generator: CAIN
- Simulator: JUPITER
  - GEANT4 based full simulator
- Parameters
  - $E_{\text{CM}} = 500$ GeV, $N_e = 2.0 \times 10^{10}/\text{BX}$
  - $\gamma \varepsilon_x = 10 \ \mu m, \ \gamma \varepsilon_y = 0.03 \ \mu m$
  - $\sigma_x = 553 \ \text{nm}, \ \sigma_y = 5 \ \text{nm}, \ \sigma_z = 0.3 \ \text{mm}$
  - $L = 3.4 \times 10^{34}/\text{cm}^2\text{s}$
  - Crossing angle = 7 mrad
Detector Configuration

- B=3, 4, 5 T
- Large bore super-conducting Q-magnet, l*=3.5m
- No beam-calorimeter
- Radius of the innermost layer of VTX (R1) as a parameter
  - Be beam pipe radius is 0.4 cm smaller than R1
  - 4 layers of 300 μm thick Si
  - Distance between adjacent layers is 1.2 cm
  - VTX angular coverage : |cosθ|<0.9
Detector Configuration
Background hit uniformity

- $B=3T$, $R1=1.2\text{cm}$
Number of fired pixels per track hit

- Pixel size: $25 \times 25 \mu m^2$
- Active layer: $30 \mu m$
- Diffusion not included

$\Rightarrow$ Number of fired pixels per track hit $= 3.7$
**Hit rate vs. B**

- **Fit function:** \( f(x) = p0 \cdot \exp(-p1(x - p2))/x + p3 \)
- **When 1/20 train is accumulated, 0.5% pixel occupancy at**
  - \( R = 1.92 \; \text{cm} \) @3T
  - \( R = 1.69 \; \text{cm} \) @4T
  - \( R = 1.55 \; \text{cm} \) @5T

**Occupancy = 0.5%**
Comparison with other studies

- With B=4T, R=15mm
  - Our study: \(~2.5 \text{ hits/cm}^2/\text{BX}\)
  - By K. Buesser: \(~3.5 \text{ hits/cm}^2/\text{BX}\)
    - CAIN ⇔ Guinea Pig?
    - Geometry? (Thickness of sensitive layer)
    - Back scattering? (very few b.s. in our geom.)
    - Statistics?
Summary

- Pair background at ILC has been studied using CAIN and JUPITER
- B-dependence of hit rate at fixed R is large, but B-dependence of R at fixed hit rate is not so large: ~20% difference between 3T and 5T
- Pixel occupancy of ~0.5% can be achieved with R=1.92cm@3T, 1.69cm@4T, and 1.55cm@5T
- Some discrepancy between K.Buesser’s result
- Future plan
  - Different geometry (longer l*, beam-CAL, different X-angle)
  - Simulation for Fine Pixel CCD Vertex Detector
Fine Pixel CCD

- Standard CCD

- Fine Pixel CCD