SiD Tracker Occupancies

Motive:

• Do occupancies in SiD Trackers compromise pattern recognition?

Topics:

• What is impact of “new” 2-photon backgrounds?

• Can SiD tracking handle Warm RF? (Integrating 192 bunch crossings/300ns)

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Update on Backgrounds

New estimates of $\gamma \gamma \rightarrow$ hadrons yield 56 events/NLC train (192 bunches).

(T. Barklow SLAC ALCPG 1/04)

**Occupancies/Train**
- 8600 $e^+e^-$ pairs
- 35k $\gamma$'s (~MeV)
- 154 $\mu^+\mu^-$ pairs
- 56 had events
Baseline SiD Detector/Tracker
Understand Photon Interactions in Si with Geant 3 Simulation

- Beam pipe, Mask, VXD and detector materials are in the simulation.
- 300 \( \mu \text{m} \) Si with 50 \( \mu \text{m} \) strip width in 5T field for photon interactions.
Occupancy from Photon Conversions

**Barrel Occupancy**

- **Layer 1** 0.42%
  
  \( r = 20 \text{ cm}; 50 \mu \text{m}; \Delta z = 25 \text{cm} \)

  \[ \text{Occ} \sim 1/r \]

**Forward Occupancy**

- **Layer 1** 0.09%
  
  \( z = 25 \text{ cm}; 50 \mu \text{m}; \Delta r = 16 \text{ cm} \)
- **Layer 5** 0.10%
  
  \( z = 168 \text{ cm}; 50 \mu \text{m}; \Delta r = 105 \text{ cm} \)

  \[ \text{Occ} \sim \text{constant} \]

**Photon Conversion Occupancy Low** ~ .1-.4%
Charged Particle Occupancies/Train

- Pairs and $\gamma\gamma \rightarrow$ hads dominate. Most are $< 1\%$.
- Worst Case: Pairs forward occupancy $\sim 3\%$ in Layer 1 at smallest radii.
Forward $e^+e^-$ Hit Distribution

- Most hits in the forward detectors are at small radii
- Segmenting radially would guarantee low occupancy for most of the detector
Hit Occupancies/Train are Low

- **Pattern recognition in SiD trackers should be OK.** (see talk by S. Wagner)

- **Adding timing capability to Si channels is possible.** This allows track hits to be associated with particular bunch crossings within the train. Noise hits won’t obscure timing information.
Track Occupancies per Train
\( \gamma\gamma \rightarrow ee, \mu\mu, \text{hadrons} \)

**Barrel**
\( |\cos \Theta| < 0.80 \)
48 tracks/train
\( \sim N_{\text{physics}} \)

**Fwd+Bwd**
\( 0.80 < |\cos \Theta| < 0.995 \)
390 tracks/train
\( 10 \times N_{\text{physics}} \)

Barrel’s not bad; Forward’s not good.
Lowering Hit and Track Occupancies

• **Shorter Microstrips.** Could revert to 10cm (in z) microstrip detectors. Reduction factor X 3 in Layer 1 hit occupancies.

• **Si Drift Detectors.** Intrinsically 3-d, effective pixels ~ 250 X 2500 µms but 500 µm thick. Reduction factor X 6 in Layer 1 hit occupancies.

• **Track occupancies can be substantially reduced by timing.**
  \[ \sigma_{\text{track}} \sim 1 \text{ ns} \Rightarrow \text{Reduction factor } 192/4 = 48 \times \text{fewer background tracks.} \]
Timing Reduces Track Occupancies

- **How well can Si timing be done?**
  - BaBar SVT: 20ns/strip (operating)
  - Atlas Tracker: 8ns/strip (prototype?)
  - SiD Cal: 5ns/pixel (design)

- **Now:** \(\sigma_t \sim \frac{t_{rise}}{(S/N)} \text{ ns} = 50 \text{ ns} / 10 = 5\text{ ns}\)
  - **Future:** \(\sigma_t \sim 2.5 \text{ ns (?)}\)

  Pulsed Power permits more power to amp, better bandwidth, headroom. **R&D Required.**

- **Track Timing:** \(\sigma_t / \sqrt{N}\)
  - 1.1 - 2.2 ns (N=5 tracker layers)
  - 0.45 - 0.9 ns (N=30 Ecal layers)

- **Identify track time within 2 – 4 NLC bunch crossings, to reduce physics backgrounds significantly** (~ 1 – 2 Tesla crossings)
SiD Occupancy Conclusions

• Warm hit occupancies/ train are typically $\leq 1\%$ and manageable.

• Track Occupancies are high in the forward direction.

• Timing the microstrips or Si ECAL pixels can yield $\sim 1$ns track resolution, and $X$ 50 – $X$100 reductions in track backgrounds. This would simplify forward tracking significantly, and remove almost all physics backgrounds.