Occupancies from Beam-Related Backgrounds in SiD for the DBD

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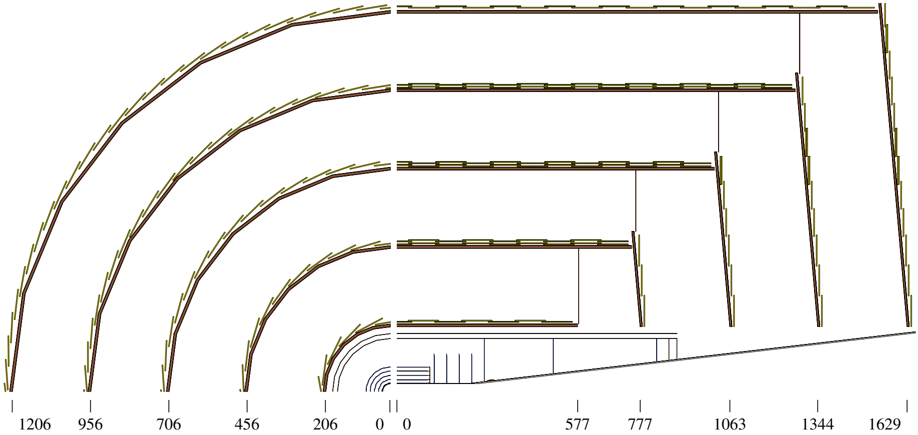
Outline

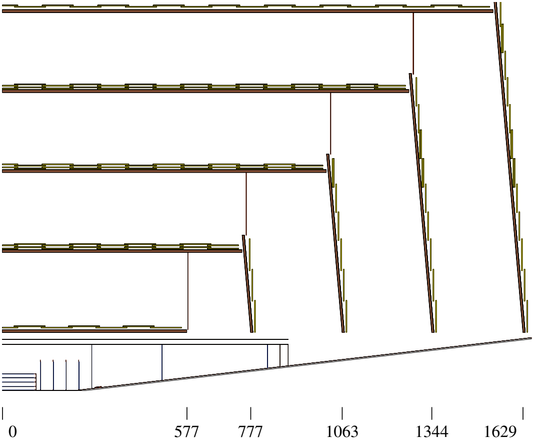
Tracker Layout



(a) *xy* (b) *zx*

Tracker Layout

- All-silicon tracker
- Pixelized vertex detector
  - 5 barrel layers + 7 disk layers
  - 20 µm pitch
- Main tracking detector
  - 5 barrel layers + 4 disk layers (stereo strips)
  - 25 µm strip pitch
  - 50 µm read-out pitch
  - 100 mm strip length



(b) *zx*

Background Samples

- Incoherent pair samples generated by GuineaPig
- $\gamma\gamma \rightarrow$ hadrons generated by WHIZARD (photon spectrum from GuineaPig)
- Hadronization of $\gamma\gamma \rightarrow$ hadrons in PYTHIA
- Use ILC DBD beam configurations @ 1 TeV for highest occupancies

Simulation & Digitization

- Full detector simulation using SLIC (GEANT4)
  - Incoherent pairs: single particle per simulated event
  - $\gamma\gamma \rightarrow$ hadrons: one interaction per event
- Merge events to represent 1 BX in `org.lcsim`
  - Merging $\sim$ 400k simulated pair particles impossible using LCIO merge
  - Dedicated driver in `org.lcsim` creating deep copies of merged objects to allow efficient garbage collection
- Run standard tracker hit digitization in `org.lcsim` (SiSim)
- Nearest neighbor clustering to form TrackerHits
- Apply MIP cuts for calorimeter hits: $\sim$ 0.5 MIP in active material
- Calorimeter cell sizes: ECal $3.5 \times 3.5\,\mathrm{mm}^2$, HCal $10 \times 10\,\mathrm{mm}^2$

1 Introduction

2 Hit Time Structure

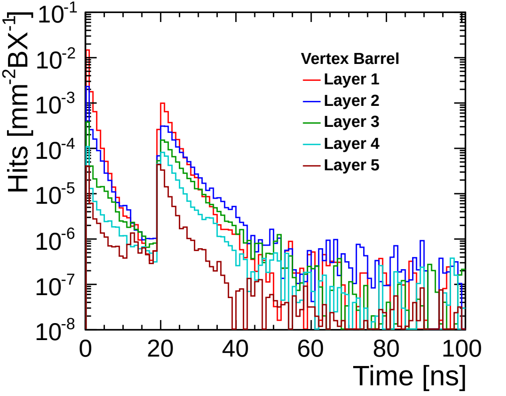
3 Hit Rates and Occupancies

4 Conclusion

Hit Time Structure (Incoherent Pairs)

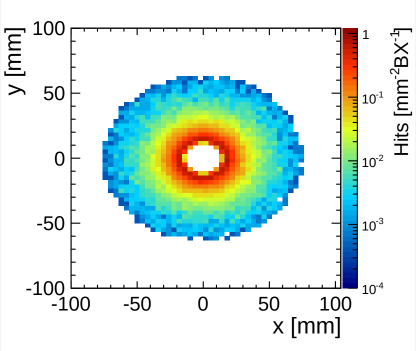
- Back-scattered particles create indirect hits
- Time delay given by time of flight from the IP to the BeamCal
- Conical beam pipe can be used to shield inner detector (CLIC studies)
- Careful design of forward region is important to minimize backscatters (still to be done)

sidloi3

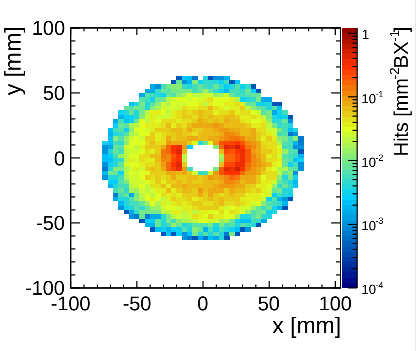


Direct and Indirect Hits (sidloi3 Vertex Disk)

Direct Hits ($t < 15\,\mathrm{ns}$)

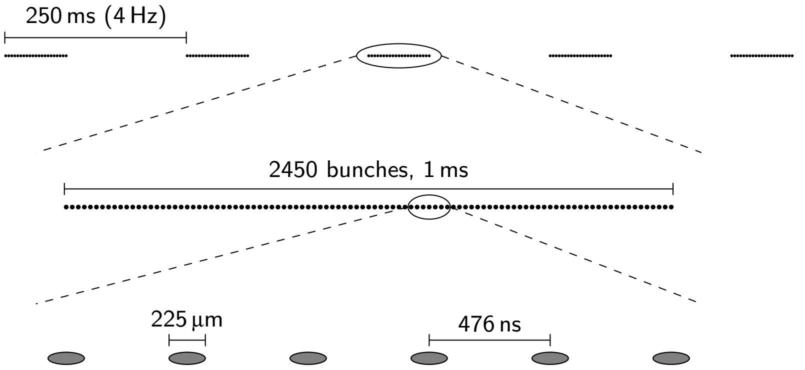


Indirect Hits ($t > 15\,\mathrm{ns}$)



- Back-scattered particles not symmetric in ϕ
- Hot spots projection of openings in BeamCal

Beam Structure for ILC DBD @ 1 TeV



Occupancy Estimation

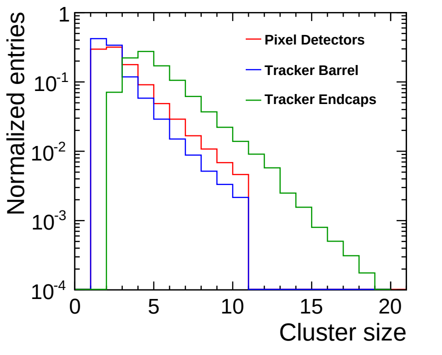
- Start from hit rates
- Take into account segmentation
- Take into account average cluster size (for tracking detectors)
- Assume reading out full train (2450 BX)
- Add safety factors
  - Incoherent pairs: 5 (large uncertainty in amount of back scatters)
  - $\gamma\gamma \rightarrow$ hadrons: 2
- Note: digitized of single BX $\Rightarrow$ underestimate ghost hits in stereo strips

Tracker Cluster Sizes

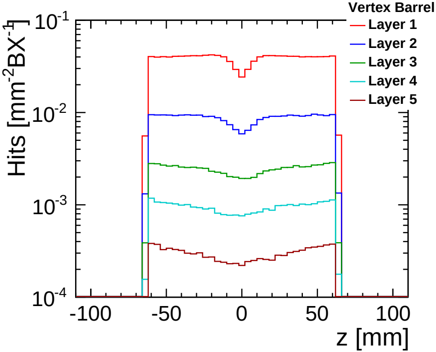
Mean values

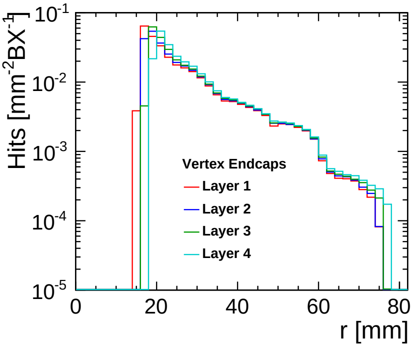
- Pixel detectors: 3.0
- Strip detectors: 2.6
- Stereo strip: 5.2 (two strips hit)

sidloi3



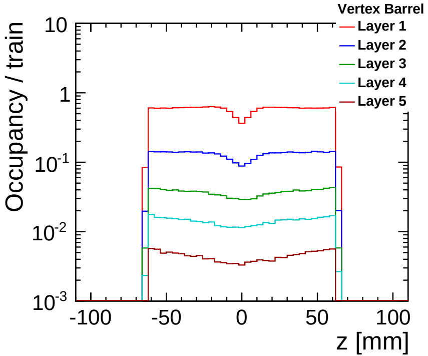
Vertex Detector (sidloi3, Incoherent Pairs)

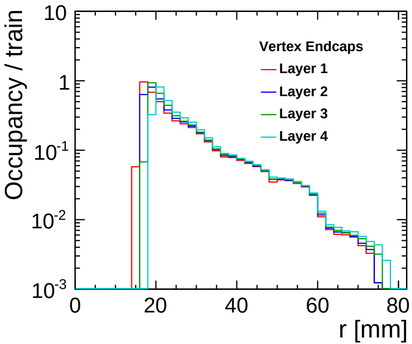




- Up to 0.06 $\mathrm{Hits/mm^2/BX}$

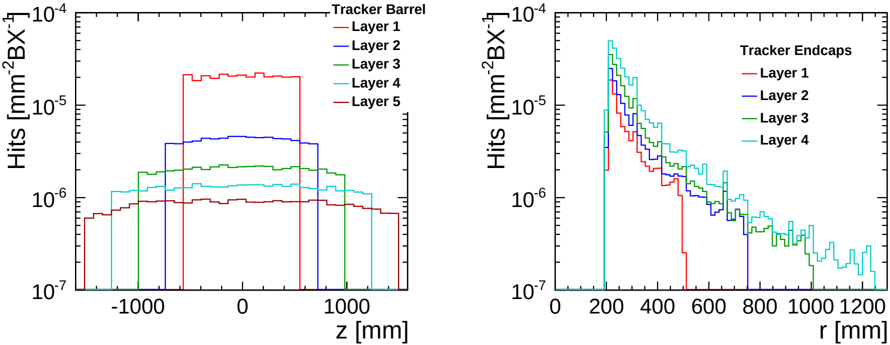
Vertex Detector (sidloi3, Incoherent Pairs)





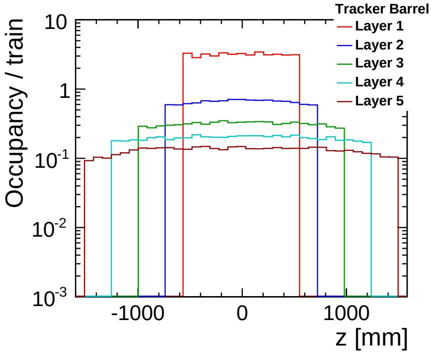
- Occupancies reach up to 100% over full train

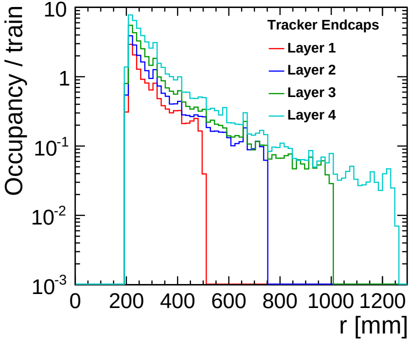
Main Tracker (sidloi3, Incoherent Pairs)



- Up to $5 \times 10^5\,\mathrm{Hits/mm^2/BX}$

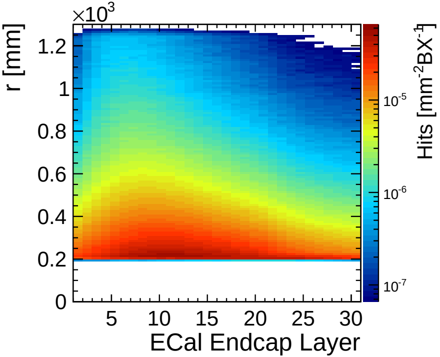
Main Tracker (sidloi3, Incoherent Pairs)

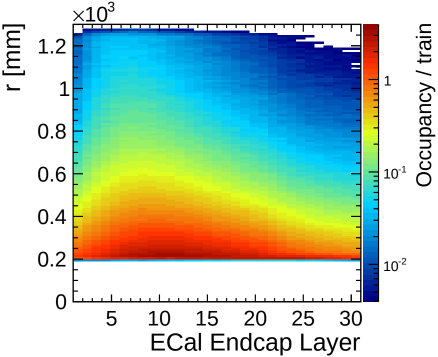




- Occupancies reach up to 300% in strip detectors
- Occupancies reach up to 900% in stereo strip detectors

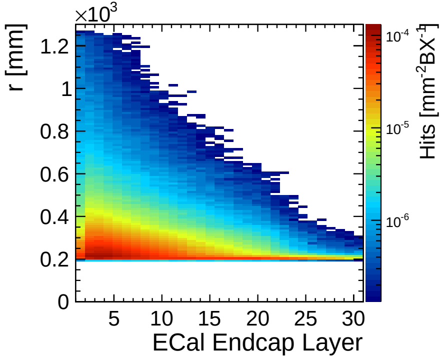
ECal Endcaps (sidloi3, $\gamma\gamma \rightarrow$ hadrons)

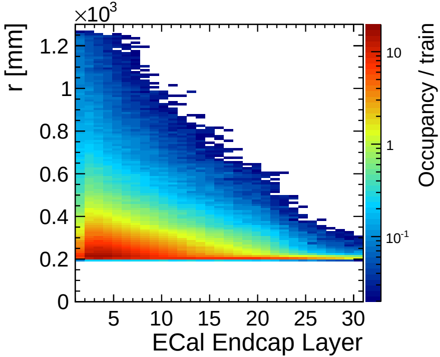




- Highest occupancy around ECal layer 9 (mean shower maximum)
- Up to $5 \times 10^5 \, \mathrm{Hits/mm^2/BX}$
- Occupancy reaches 300% at low radii

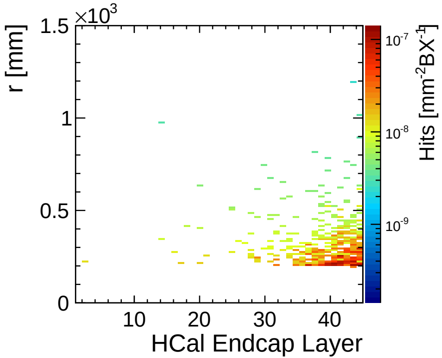
ECal Endcaps (sidloi3, Incoherent Pairs)

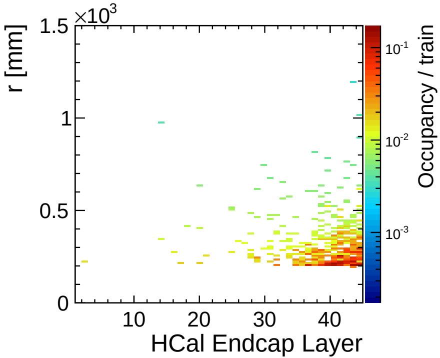




- Highest occupancy around ECal layer 2 (mean shower maximum)
- Up to $1 \times 10^4\,\mathrm{Hits/mm^2/BX}$
- Occupancy exceeds 1000% at low radii

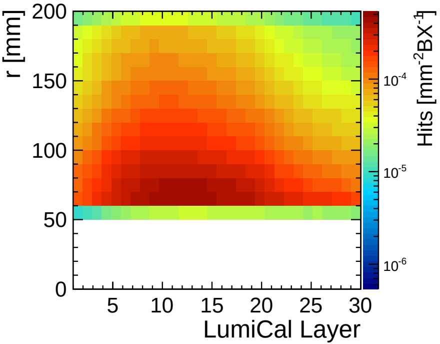
HCal Endcaps (sidloi3, Incoherent Pairs)

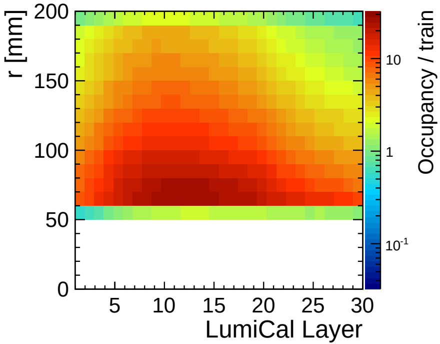




- Backscatters from downstream of the forward calorimeters leads to activity in the last HCal layers

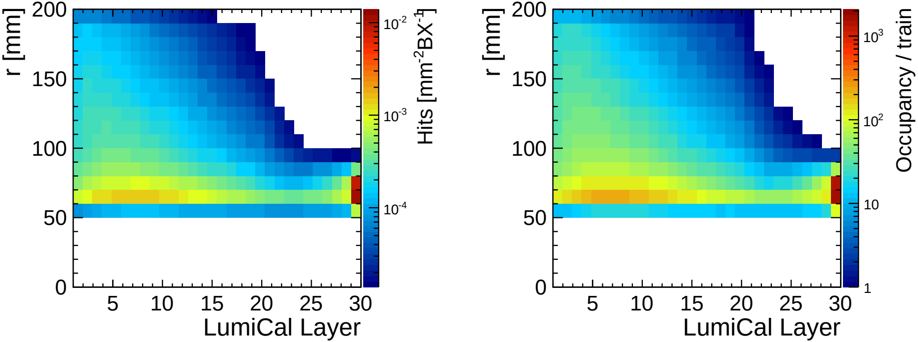
LumiCal (sidloi3, $\gamma\gamma \rightarrow$ hadrons)





- Occupancy exceeds 100% throughout all LumiCal

LumiCal (sidloi3, Incoherent Pairs)



- Occupancy from incoherent pairs ∼ 10 times larger

Conclusion and Outlook

- Occupancies in central detectors are challenging at ILC
- Innermost barrel strip layer most critical
  - Multi-hit capability
  - Shorter strips
- Stereo strip detectors at low radii also problematic
- Innermost ECal layers need multi-hit capability
- Optimization studies of forward region and beam pipe required to reduce amount of back scattered particles