

Simulation of Beam-Beam Background at CLIC

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FCal Collaboration Meeting

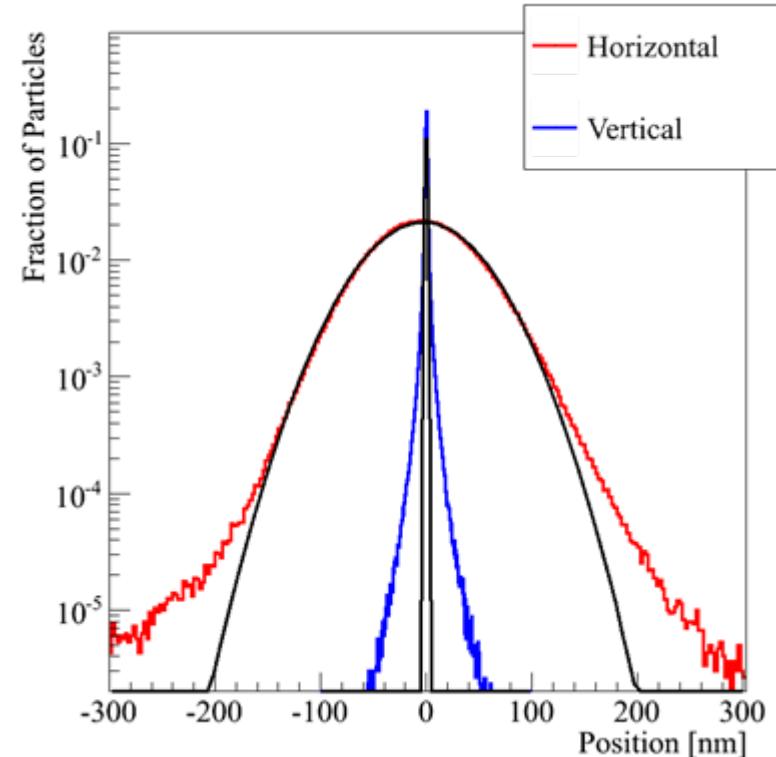
Krakow: April 12, 2010

Content

- Beam-Beam Simulation with GuineaPig
- CLIC_ILD Detector and Forward Region
- Background Simulation in the Detector with Mokka
- Background rate in the Vertex Detector
- Non Perfect Beam Collisions and Background

Beam-Beam Simulation with GuineaPig

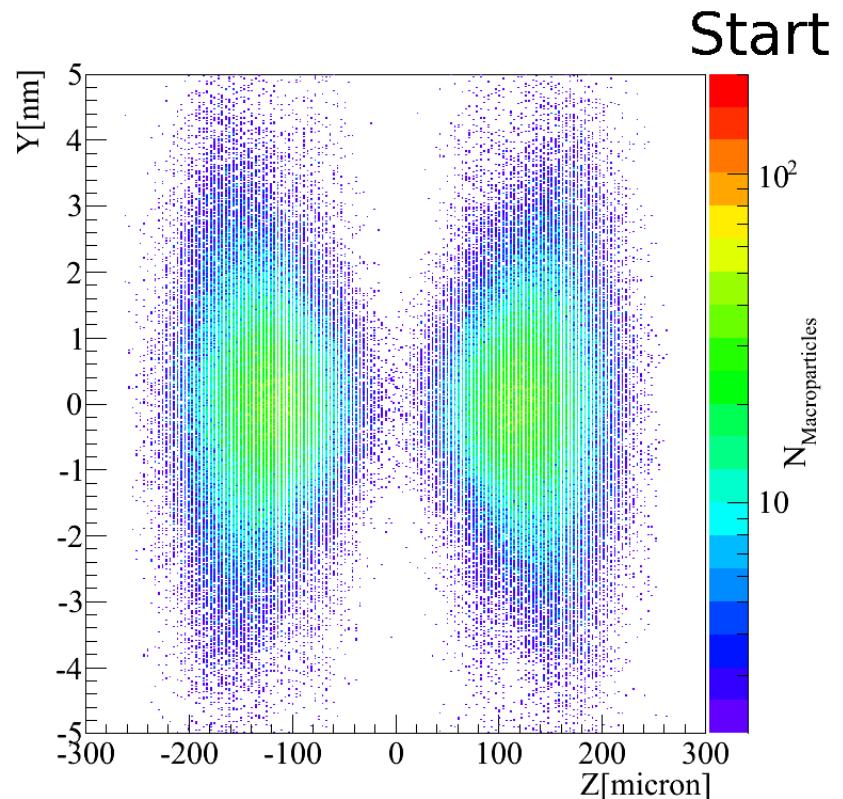
- Using C version of GuineaPig
<http://isscvs.cern.ch/cgi-bin/viewcvs-all.cgi/gp/?root=placet>
- Input particle distributions
 - Non Gaussian tails
 - Simulation of Accelerator and BDS
 - 312 file pairs (1 bunch train) provided by B. Dalena
- Nominal CLIC Beam parameters:
 - Horizontal size: 45 nm
 - Vertical size: 1nm
 - Bunch separation 0.5 ns (312 per Train)



Beamprofiles for CLIC.
Black lines are Gaussian fits

CLIC Beam Crossing

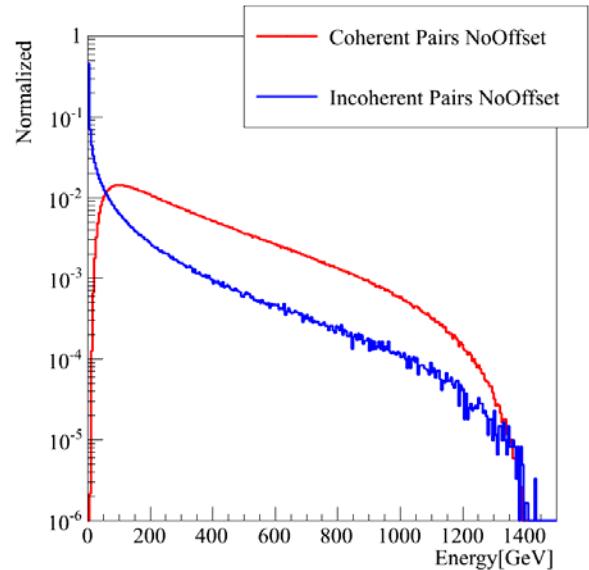
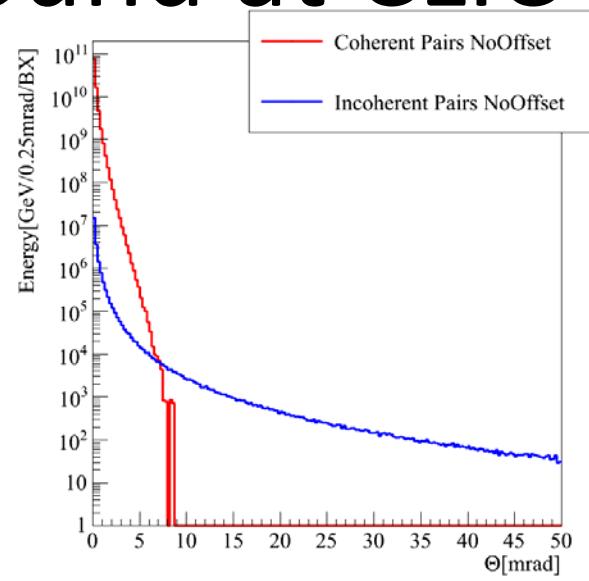
- “Sideways” view of CLIC bunch crossing
- No Offset
- Focusing, Pinch, Deflection



Animation of Bunch crossing
simulated with GuineaPig.
NB: Axis scales differ by factor 1000

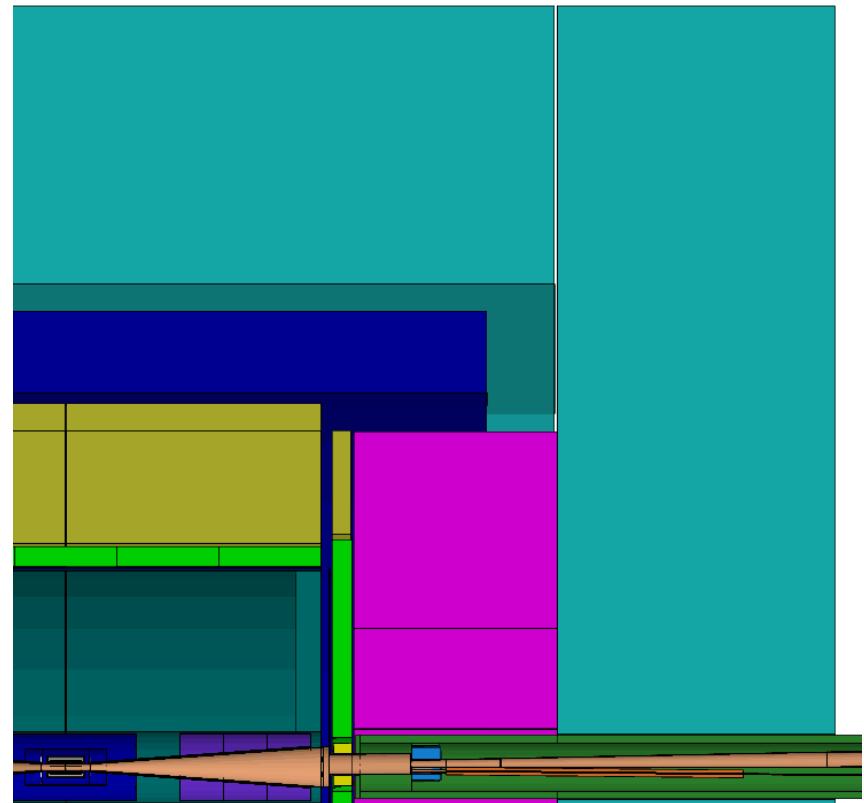
Beam-Beam-Background at CLIC

- Incoherent Pairs:
 - 310k / BX with $E > 5\text{MeV}$
 - Peaking at low energy
- Coherent Pairs:
 - $O(10^8)$ particles, but smaller production angle → Make outgoing beam pipe large enough
 - Peaking at higher energy
 - (Coherent Pairs simulated as Macroparticles)



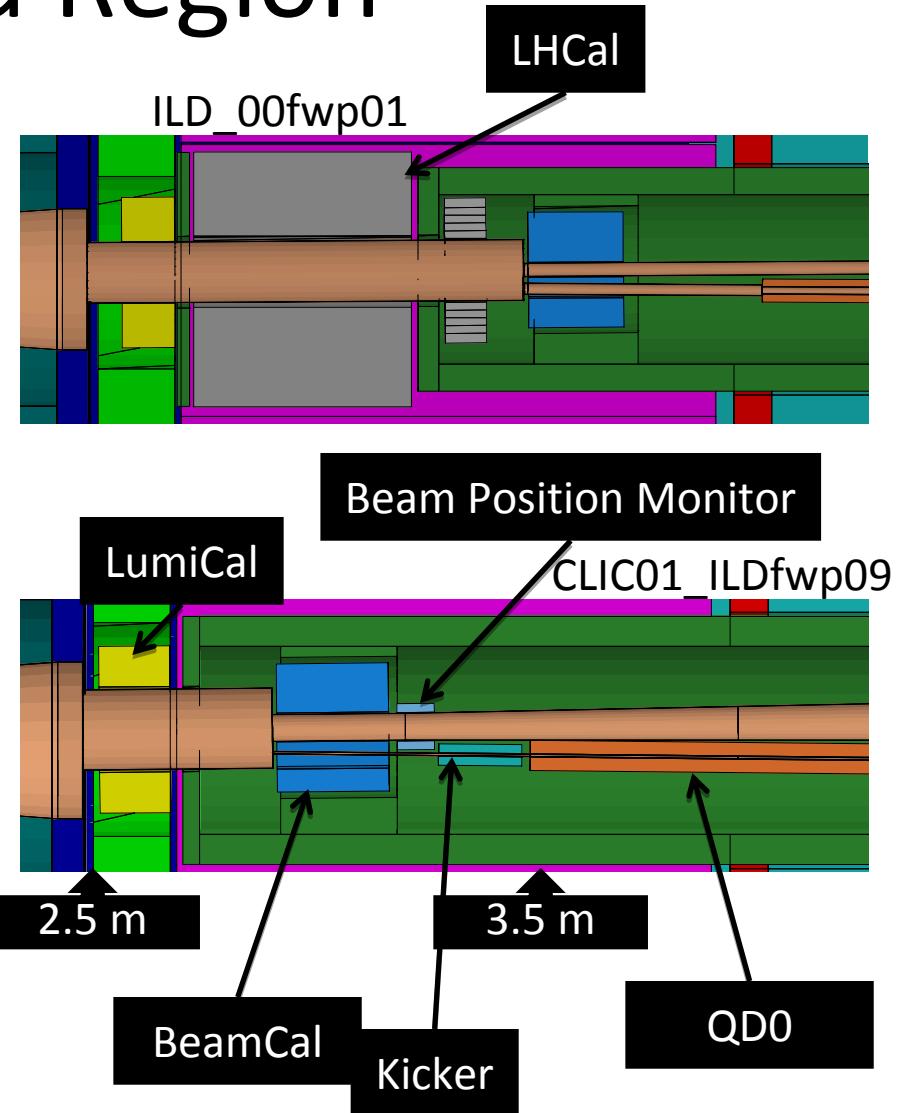
CLIC01_ILD Detector Model

- Based on ILD00
- But
 - 20 mrad crossing angle
 - 4 Tesla solenoid field
 - No AntiDID, (A-DID causes ~20 % lumi loss)
 - Tungsten HCal barrel
 - Iron endcap → Longer detector
 - Vertex detector double layers at 31, 46 and 61mm all 25cm long



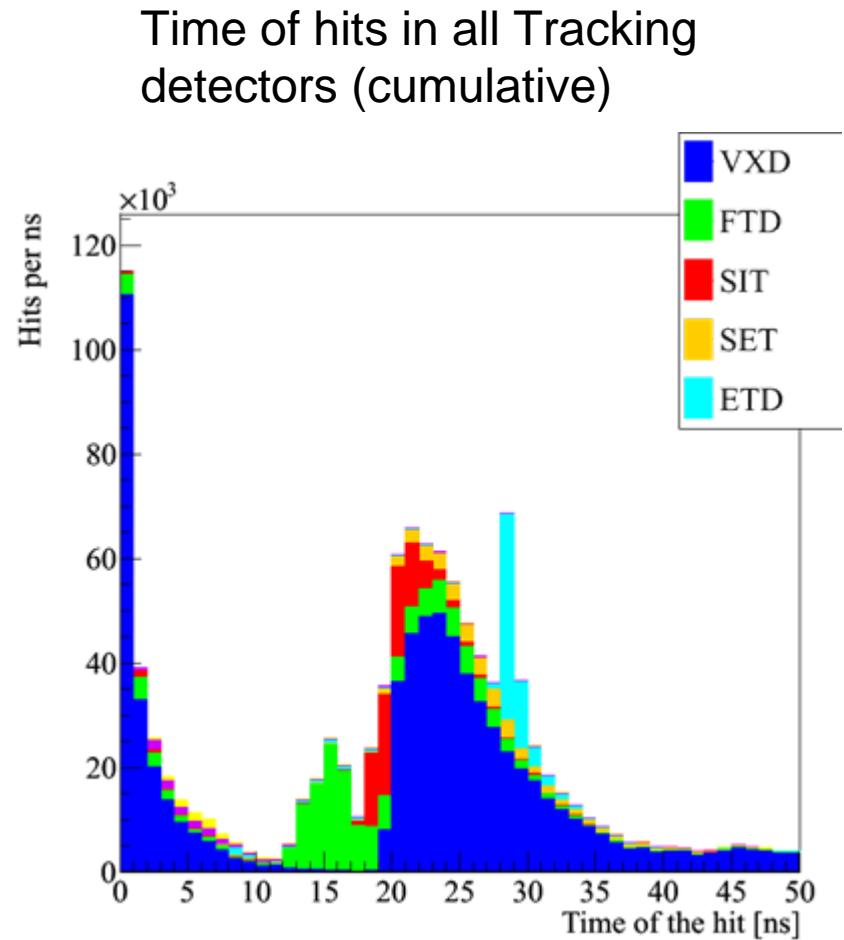
Forward Region

- Based on ILD00(fwp01)
- But
 - Moved QD0 to 3.5 m
 - (Will be moved back again)
 - Moved BeamCal to 2.8m
 - Increased inner radius
 - 40 Layers
 - Had to drop LHCAL
 - LumiCal
 - Inner radius: 10 cm
 - 40 Layers
 - Intra train feedback components: BPM & Kicker
 - Changes to the vacuum tubes



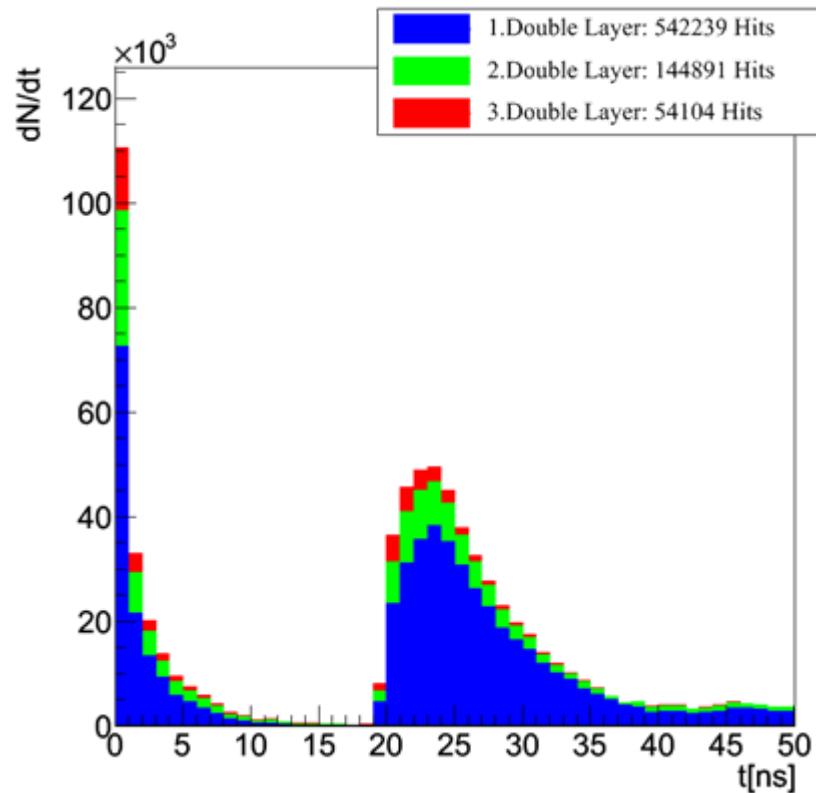
Background Hits from Incoherent Pairs

- Simulation
 - RangeCut 0.005 mm
 - Physics List: QGSP_BERT_HP
 - Counting Monte Carlo SimTrackerHits (no Digitization)
- Incoherent pairs produce hits in all tracking detectors
- Main back-scattering surface for pairs is BeamCal
- E.g. hits in the Endcap Tracking Disk (ETD) at $T \sim 28\text{ns}$



Hits in the Vertex Detector (VXD)

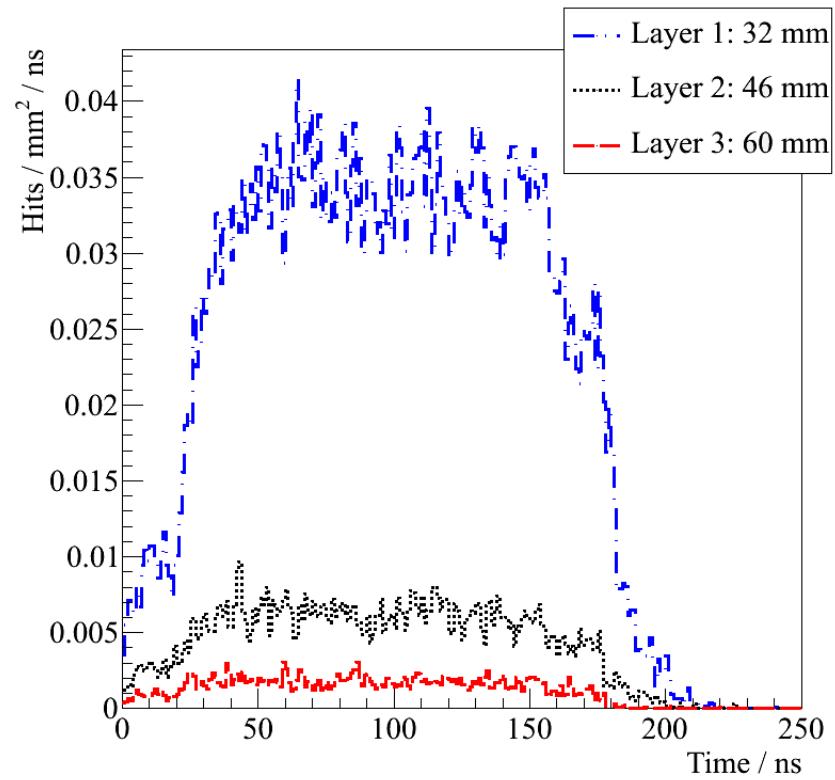
- Now focusing only on Hits in the Vertex Detector
- Because of 0.5 ns BX spacing background of several BX will overlap
- Clear separation between direct and back-scattered Hits
- 2/3 coming from back-scatters → somewhat reducible with forward region design



Hits for 312 BX counted without taking bunch arrival time into consideration (cumulative)

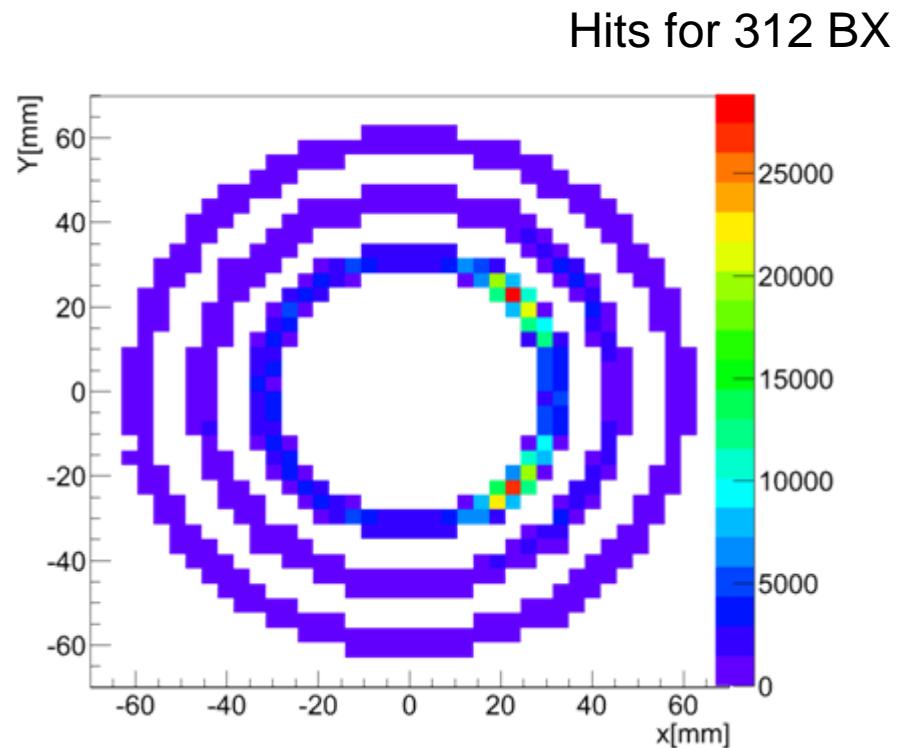
Hit Density in VXD

- Overlapping hits
- A few clean ns, before hits from back-scatters set in
- Need fast readout to limit integration time
- For a full bunch train:
 - 1st: 5.4/mm²
 - 2nd: 1.0/mm²
 - 3rd: 0.3/mm²
- ILC_RDR (ILD):
 $\sim 6/\text{mm}^2/312\text{BX}$
 - See Talk by K. Wichmann



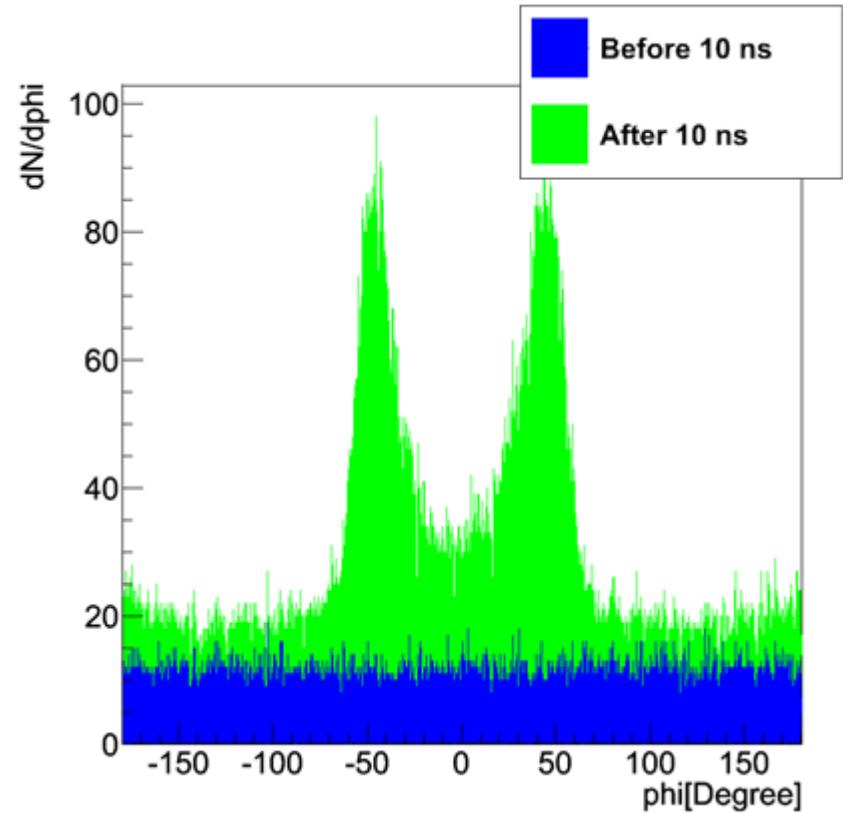
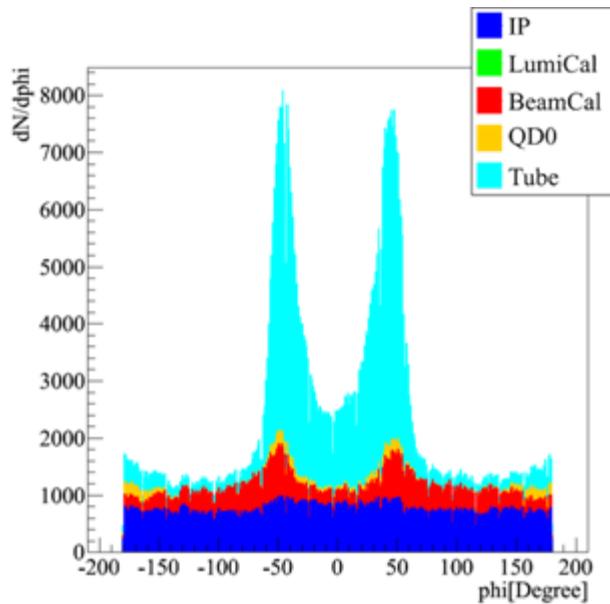
XY Distribution in VXD

- Inhomogeneous distribution of hits in phi for the first layer of the VXD
- Reminder: Not using AntiDID
- Highest hit rate limits detector lifetime



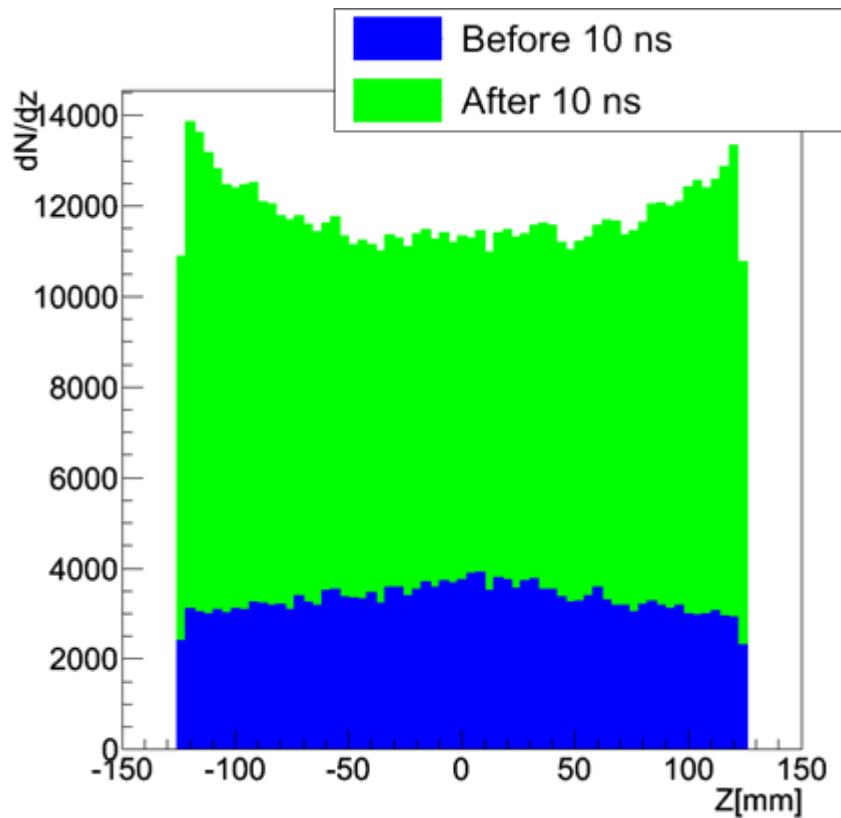
Phi Distribution in 1st layer of VXD

- Clearly due to back-scattered particles
- With origin from BeamCal and vacuum tube inside/behind BeamCal



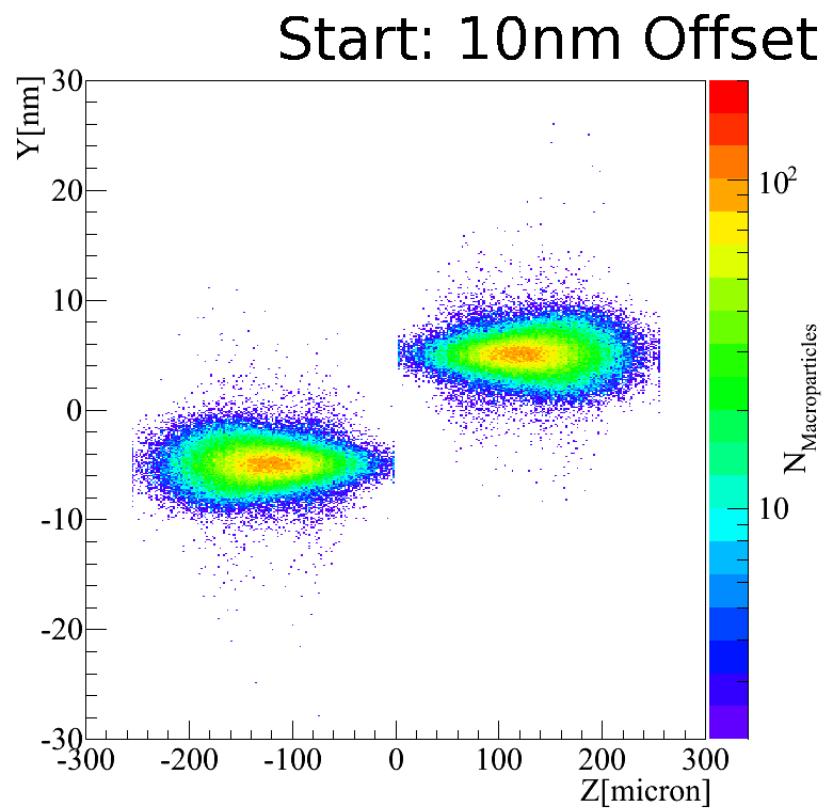
Along the Length of the VXD

- Distribution of direct hits flat/slightly higher in the center, not touching $\text{Sqrt}(z)$ envelope of pairs
- Increased at the edge of the vertex detector for back-scattering particles
 - Low energy back-scatters absorbed



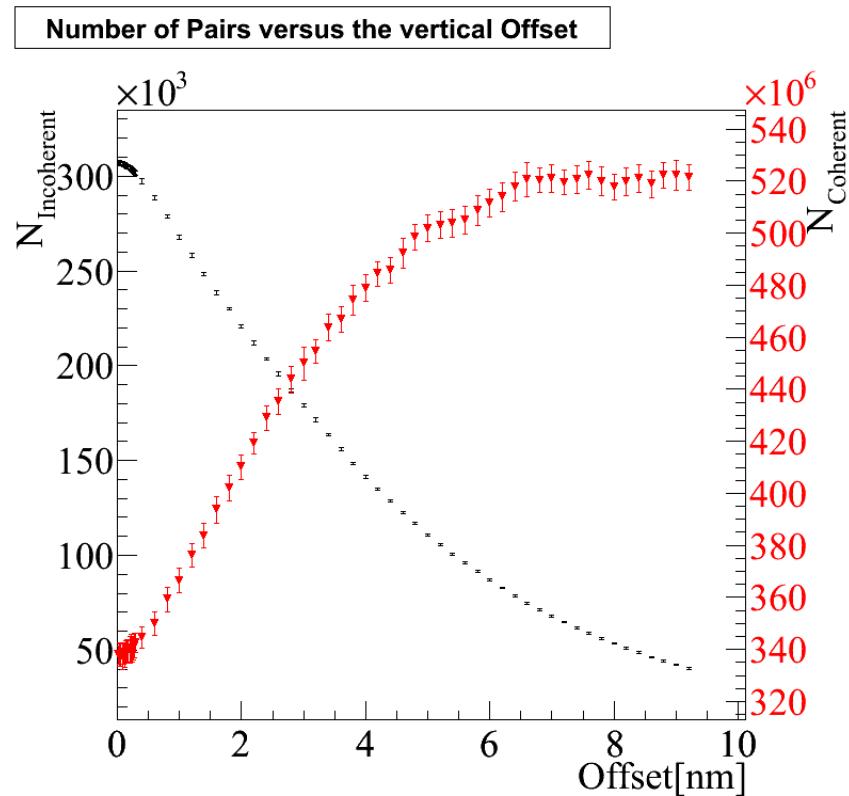
Non Perfect Beam Collisions

- Animation on the right with 10nm offset (NB: scales differ)
- Due to jitter in accelerator, BDS, QD0 not all collision happen perfectly head on
- How does the pair background change due to offsets?

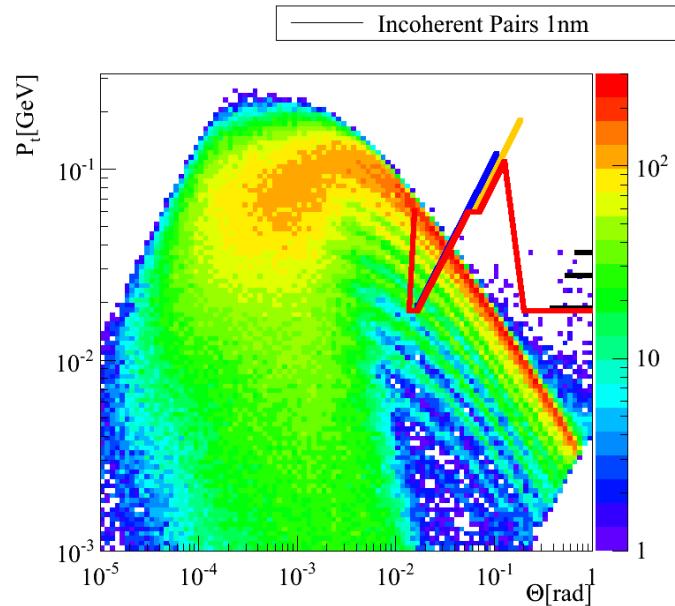
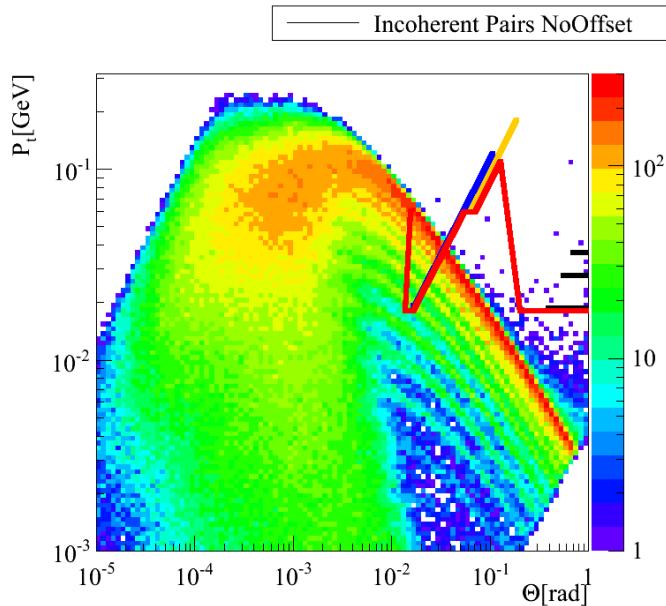


Non Perfect Beam Collisions

- Number of incoherent pairs decreases
 - Photons see less real particles
 - For small offsets $< 1\text{nm}$ only slight decrease
- Number of Coherent Pairs increases
 - Field still very strong
- Luminosity much smaller for offsets, but are (coherent) pairs a problem for the mask?



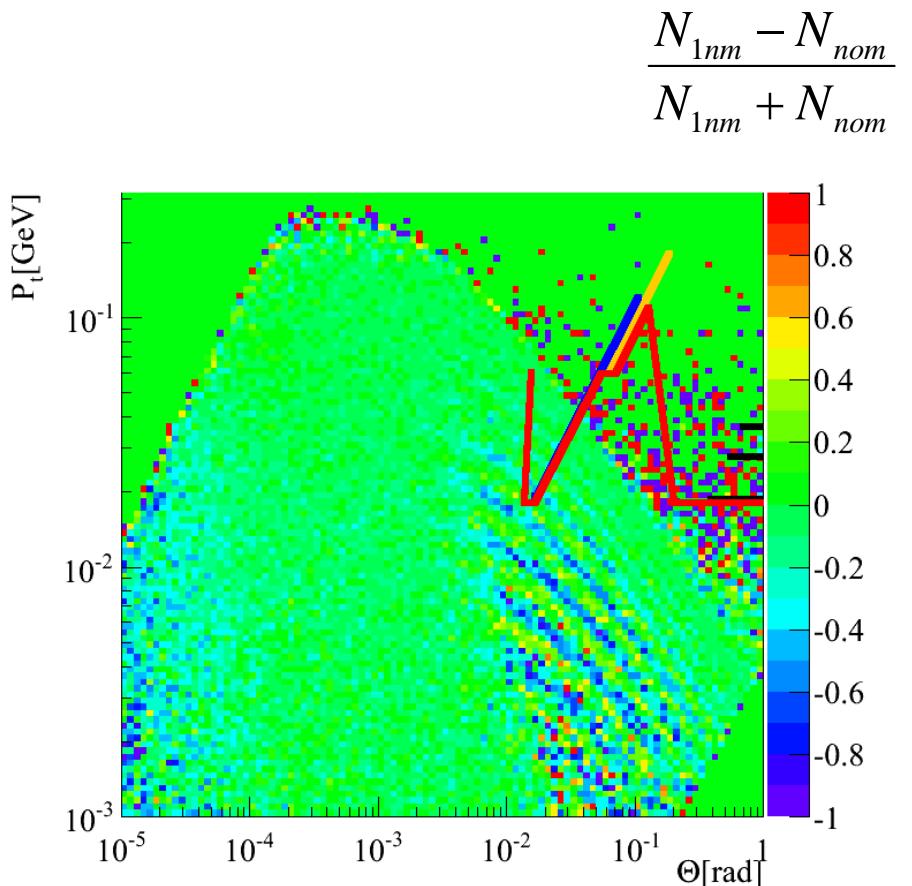
Background rate from incoherent Pairs



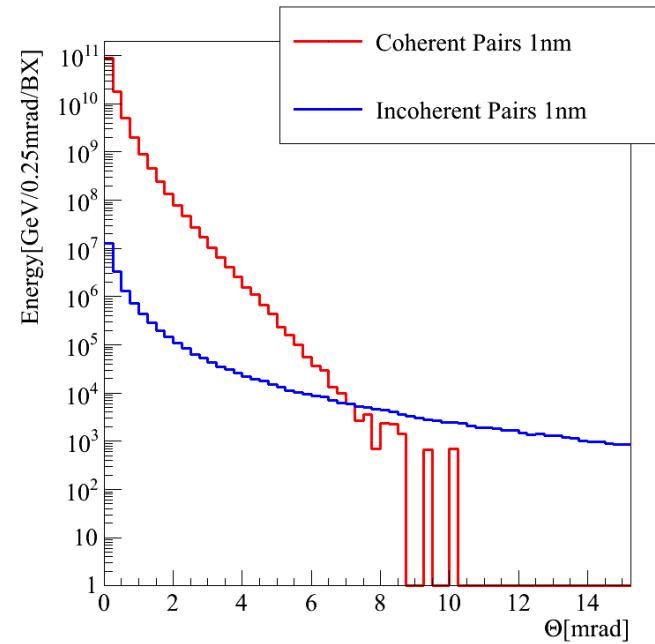
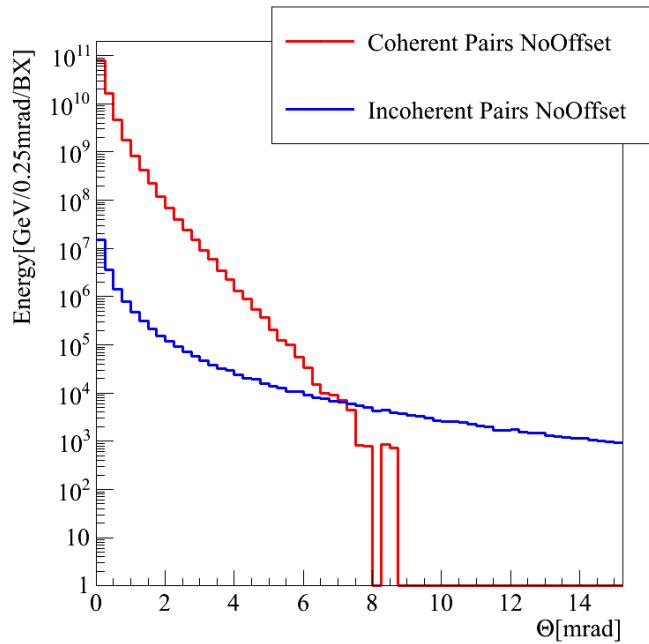
- Plotting P_t vs. Theta angle of incoherent Pairs
 - Not taking crossing angle or detailed field into account
- Lines representing position of Detector Elements
 - **Vertex, LumiCal, BeamCal, Beam pipe**

Background Rate

- No increase or decrease in background rate can be expected from these figures
- Mostly no change for 1nm offset
- Larger fluctuations only at the edge of the distribution
- No large change in the energy deposit in BeamCal
- →No need for a full simulation for a large number of offsets



Coherent Pairs and Offset



- From 0 to 1 nm offset, very small change in maximum angle for coherent pairs
- Need higher statistics and look at larger offset to confirm

Summary & Outlook

- Simulated a full bunchtrain of background in the CLIC_ILD detector
- Average hit density in 1st double layer of VXD is 5.4/mm² per bunch train but large inhomogeneity in Phi
 - How does this affect pattern recognition, and what are the requirements for time stamping?
- Non Perfect Beam collisions
 - Number of pairs only slightly reduced for small offsets
 - No change in background rate, BeamCal energy deposit expected
 - No need to do full simulations
 - Coherent pairs should still not be an issue
- Updating Forward Region with QD0 position
- Simulate with Intra Train Feedback parts

Backup

Coherent Pairs and Offset II

