Simulation of Beam-Beam Background at CLIC

André Sailer (CERN-PH-LCD, HU Berlin)

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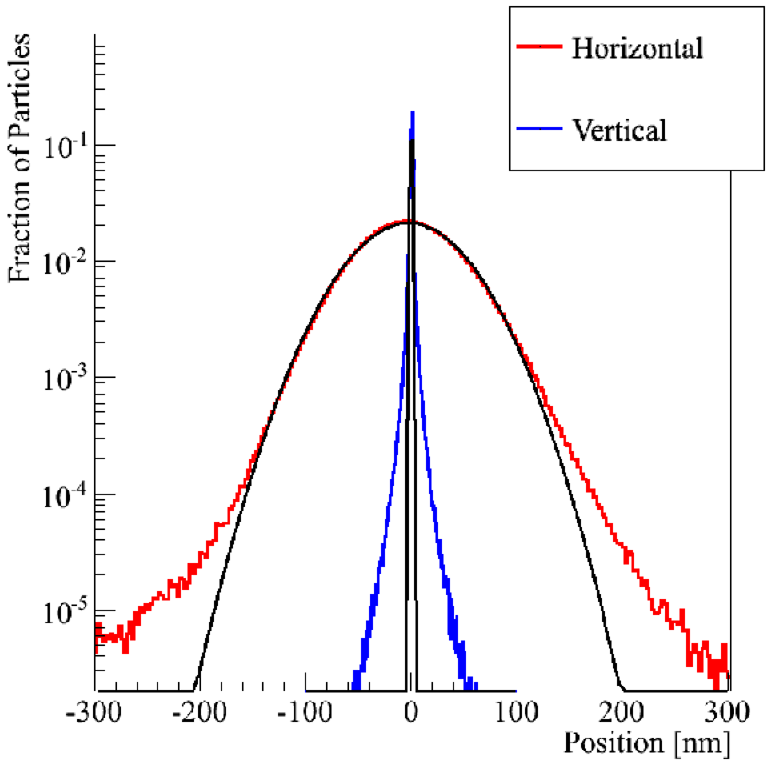
Content

- 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

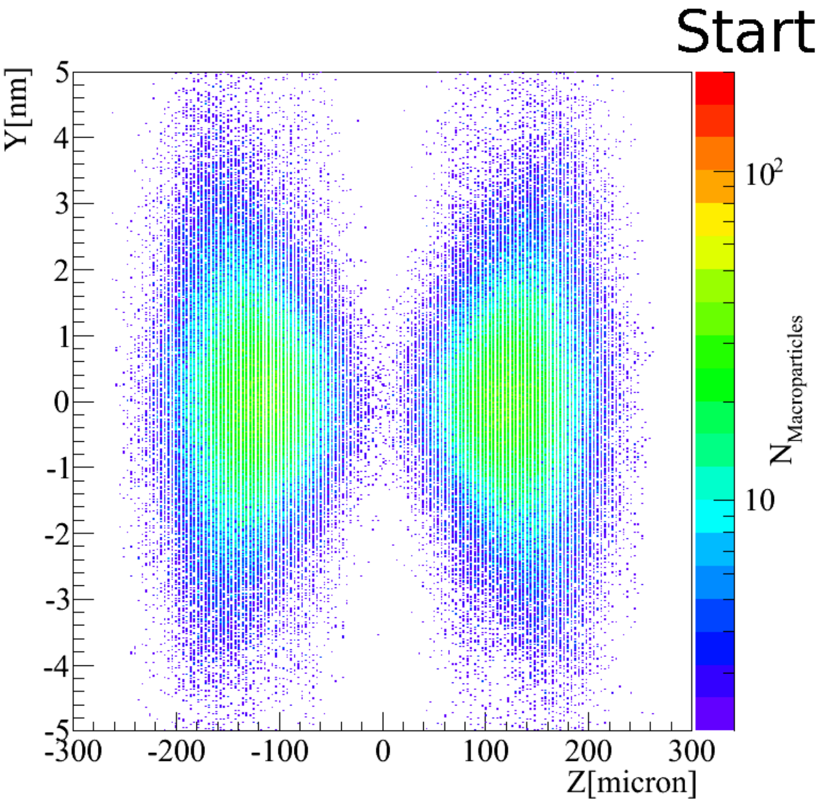
- Using C version of GuineaPig
  - http://isscvs.cern.ch/cgi-bin/viewcvs-all.cgi/gp/?root=placet
- Input particle distributions
  - Non Gaussian tails
  - Simulation of Accelerator and BDS
  - 312 file pairs (1 bunch train) provided by B. Dalena
- Nominal CLIC Beam parameters:
  - Horizontal size: 45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



Beamprofiles for CLIC.
Black lines are Gaussian fits

CLIC Beam Crossing

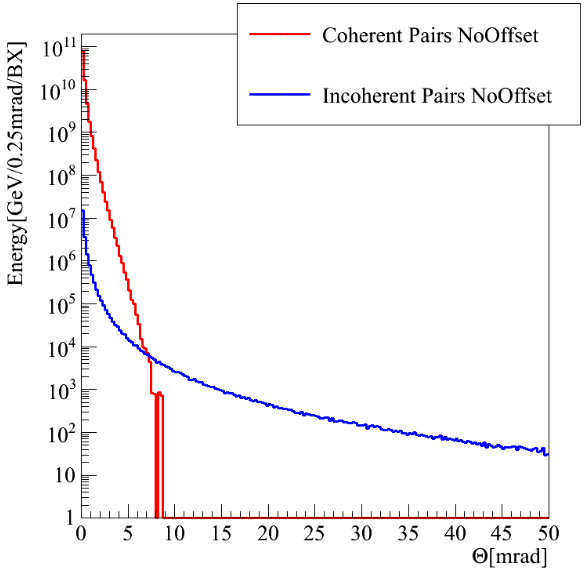
- “Sideways” view of CLIC bunch crossing
- No Offset
- Focusing, Pinch, Deflection

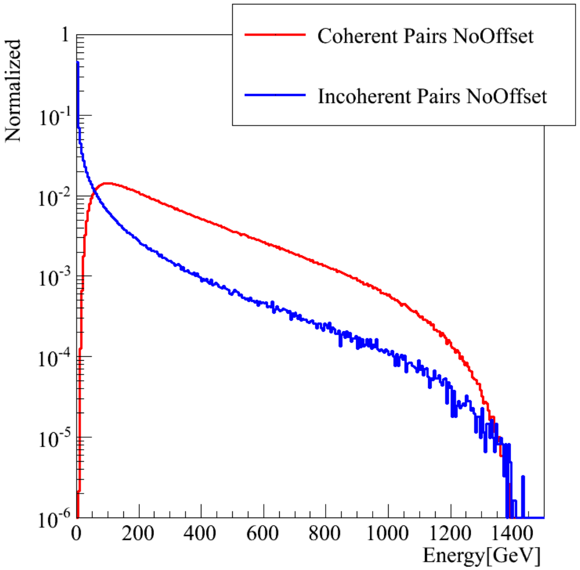


Animation of Bunch crossing simulated with GuineaPig.
NB: Axis scales differ by factor 1000

Beam-Beam-Background at CLIC

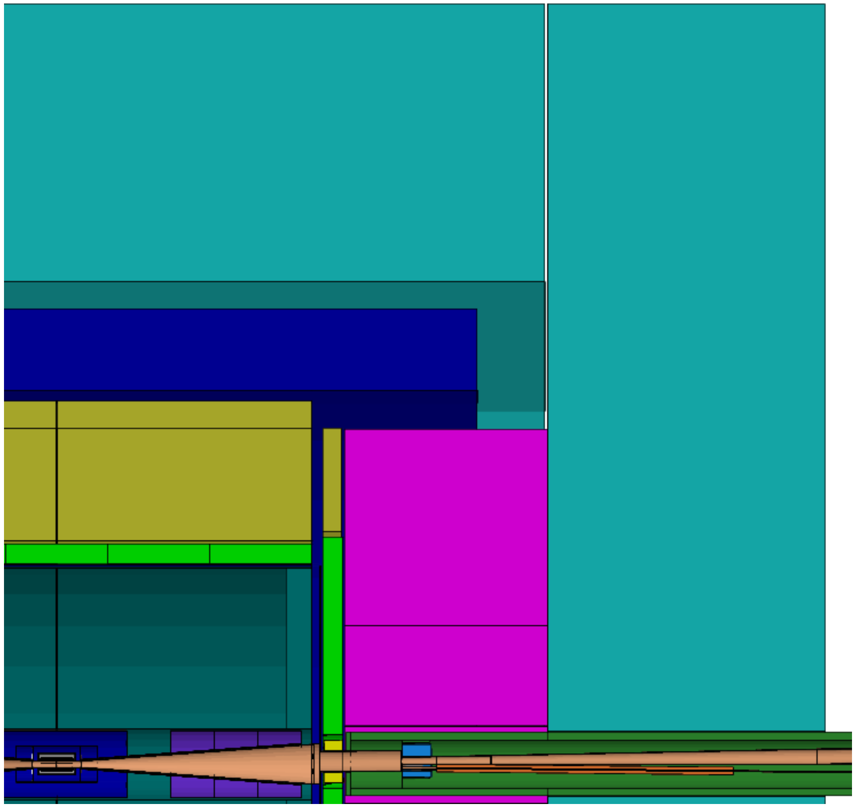
- Incoherent Pairs:
  - 310k / BX with E > 5MeV
  - Peaking at low energy
- Coherent Pairs:
  - O(10^8) particles, but smaller production angle →Make outgoing beam pipe large enough
  - Peaking at higher energy
  - (Coherent Pairs simulated as Macroparticles)





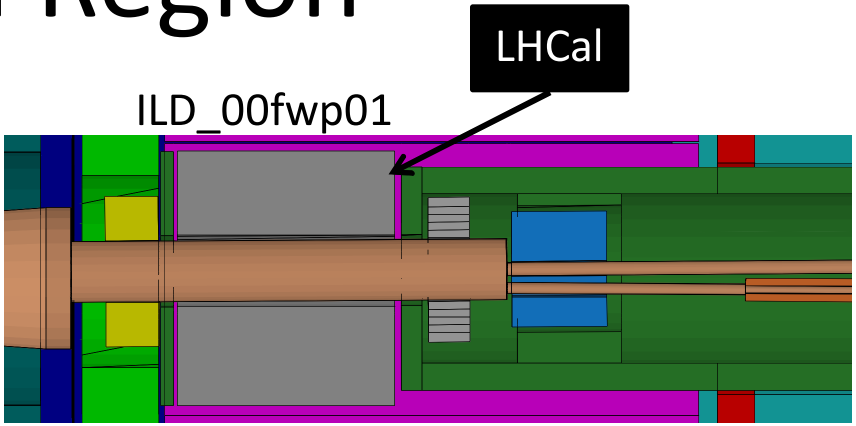
CLIC01_ILD Detector Model

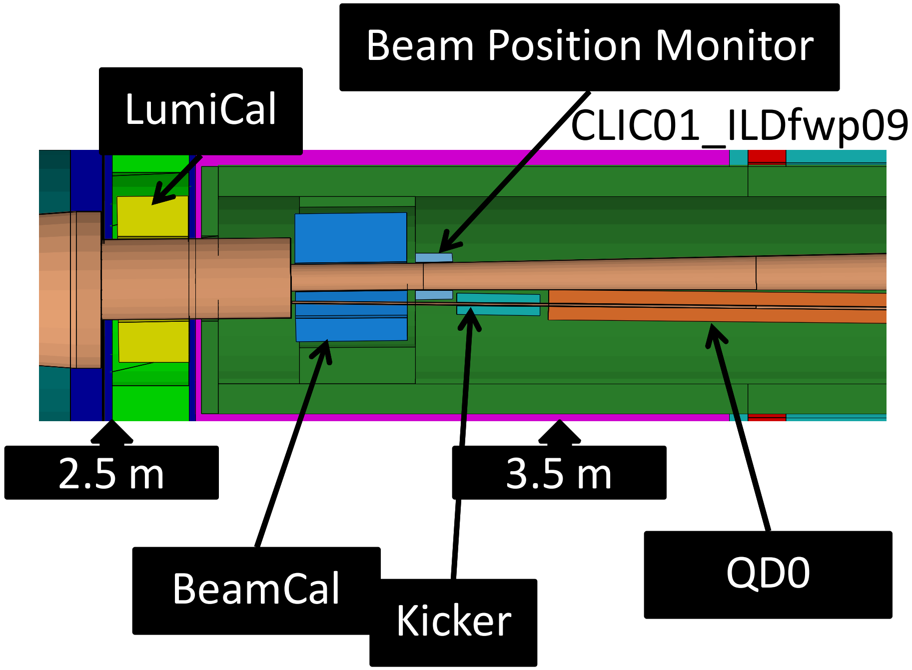
- Based on ILD00
- But
  - 20 mrad crossing angle
  - 4 Tesla solenoid field
  - No AntiDID, (A-DID causes ~20 % lumi loss)
  - Tungsten HCal barrel
  - Iron endcap →Longer detector
  - Vertex detector double layers at 31, 46 and 61mm all 25cm long



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

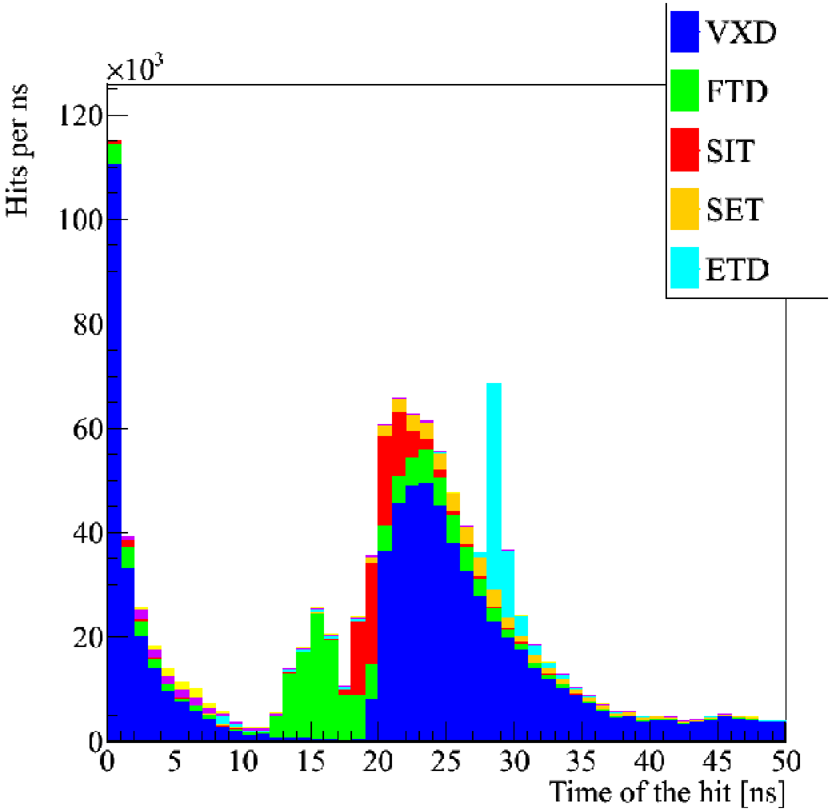




Background Hits from Incoherent Pairs

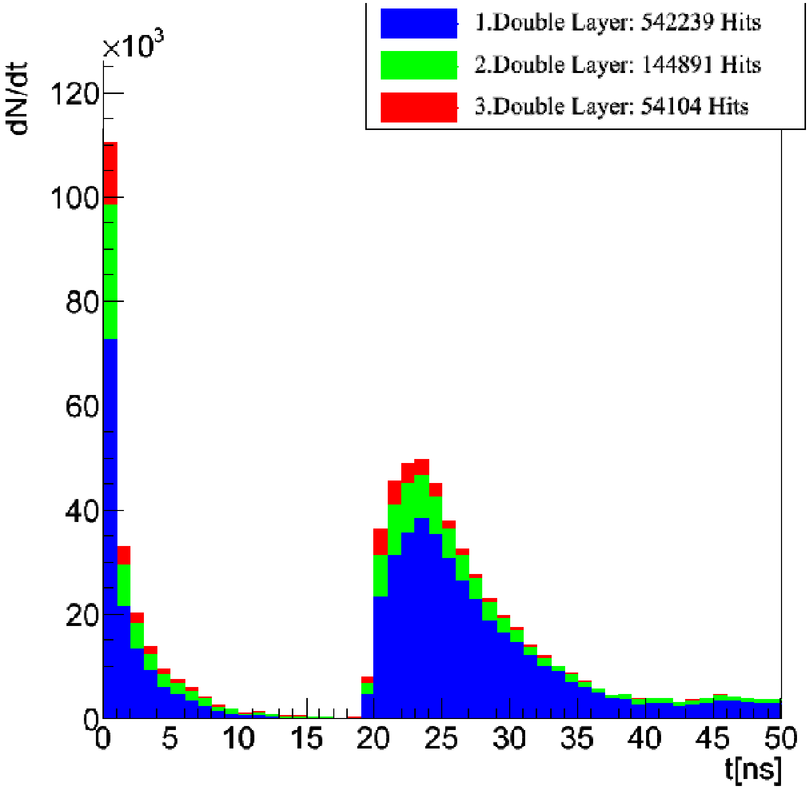
- Simulation
  - RangeCut 0.005 mm
  - Physics List: QGSP_BERT_HP
  - Counting Monte Carlo SimTrackerHits (no Digitization)
- Incoherent pairs produce hits in all tracking detectors
- Main back-scattering surface for pairs is BeamCal
- E.g. hits in the Endcap Tracking Disk (ETD) at T~28ns

Time of hits in all Tracking detectors (cumulative)



Hits in the Vertex Detector (VXD)

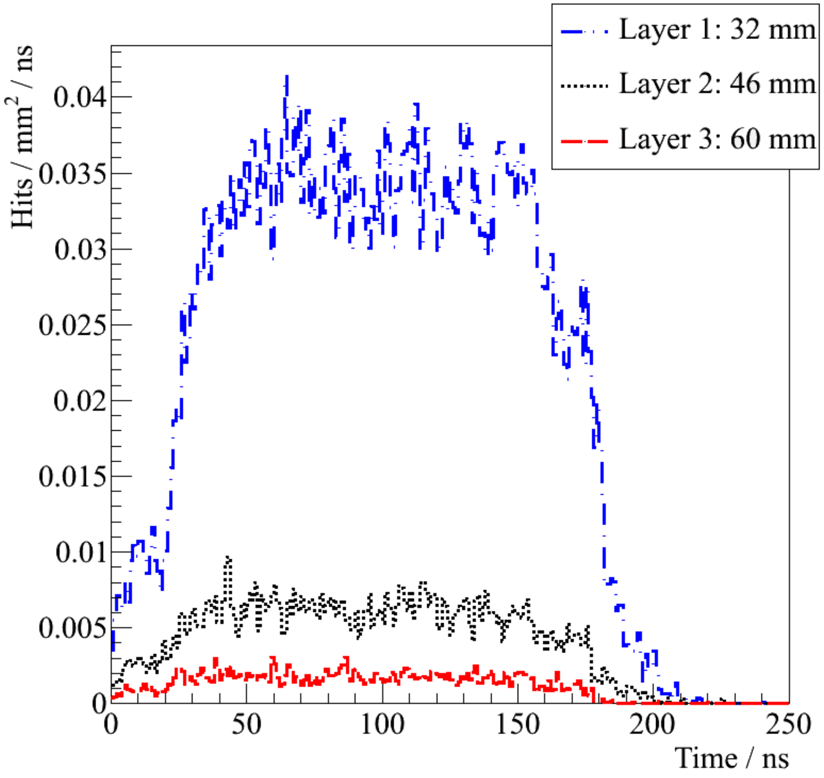
- Now focusing only on Hits in the Vertex Detector
- Because of 0.5 ns BX spacing background of several BX will overlap
- Clear separation between direct and back-scattered Hits
- 2/3 coming from back-scatters → somewhat reducible with forward region design



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

Hit Density in VXD

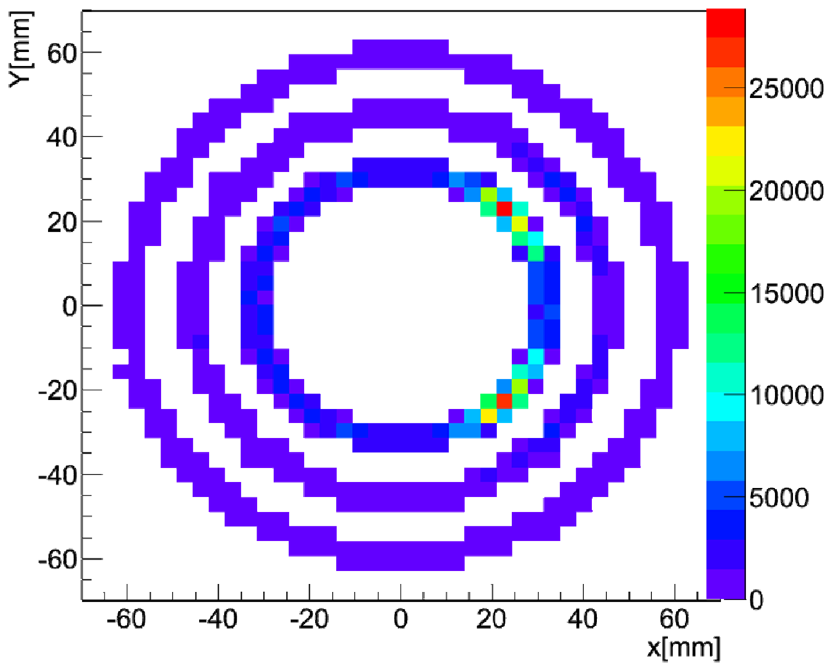
- Overlapping hits
- A few clean ns, before hits from back-scatters set in
- Need fast readout to limit integration time
- For a full bunch train:
  - 1st: $5.4/mm^2$
  - 2nd: $1.0/mm^2$
  - 3rd: $0.3/mm^2$
- ILC_RDR (ILD): $\sim 6/mm^2/312BX$
  - See Talk by K. Wichmann



XY Distribution in VXD

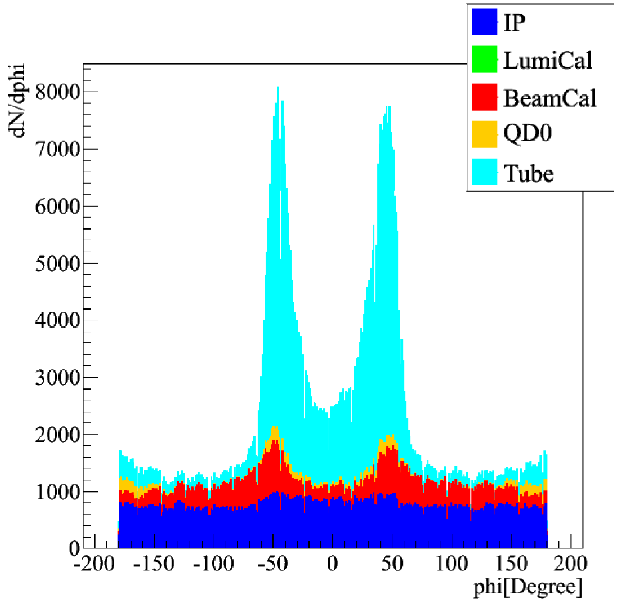
- Inhomogeneous distribution of hits in phi for the first layer of the VXD
- Reminder: Not using AntiDID
- Highest hit rate limits detector lifetime

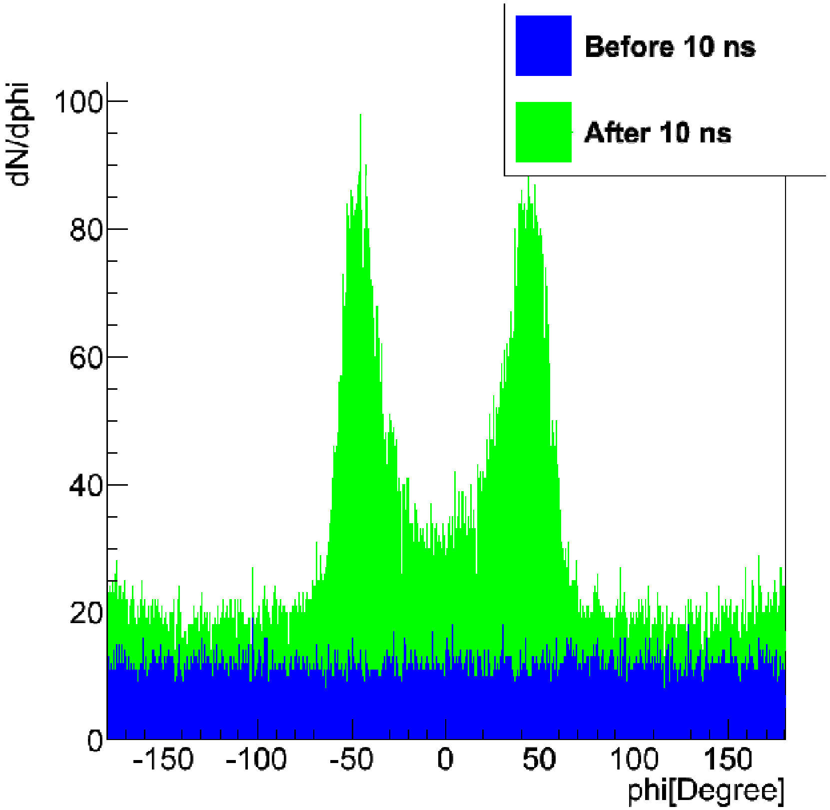
Hits for 312 BX



Phi Distribution in 1st layer of VXD

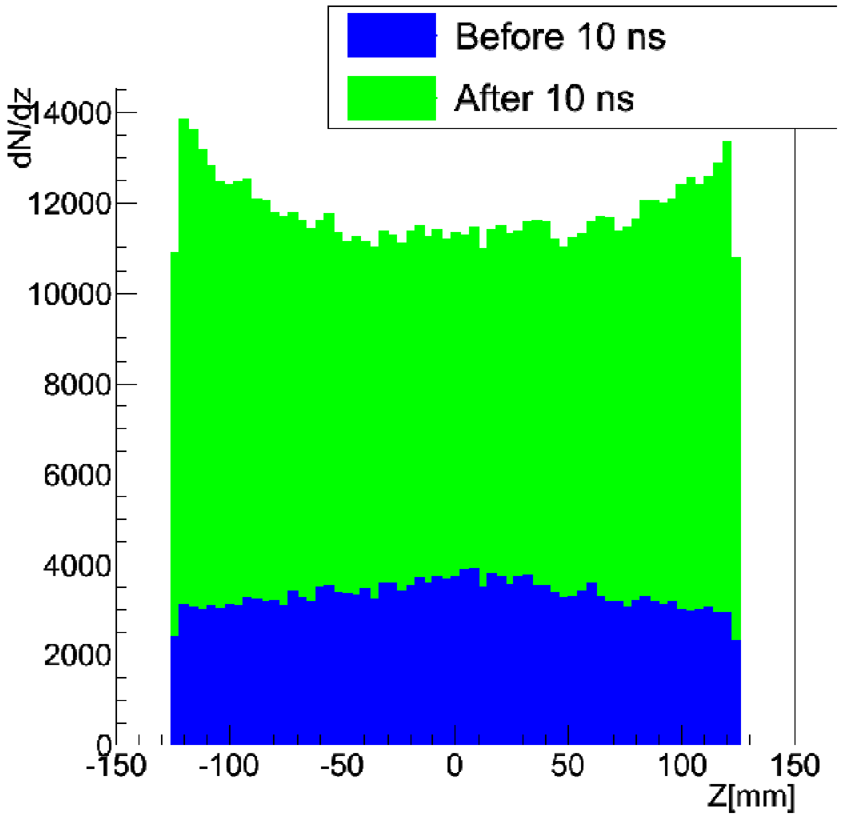
- Clearly due to back-scattered particles
- With origin from BeamCal and vacuum tube inside/behind BeamCal





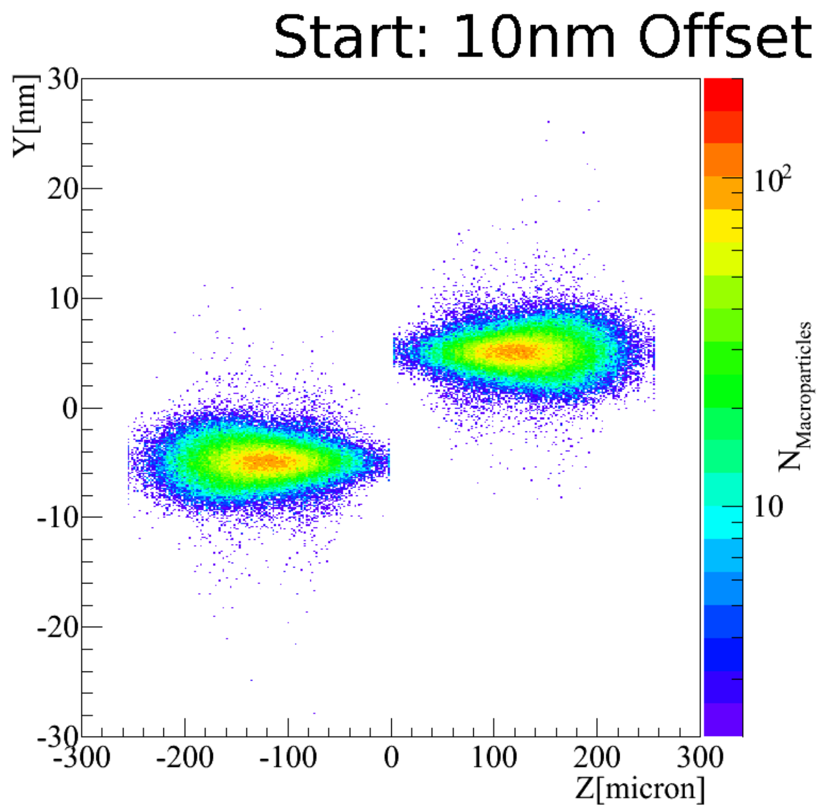
Along the length of the VXD

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



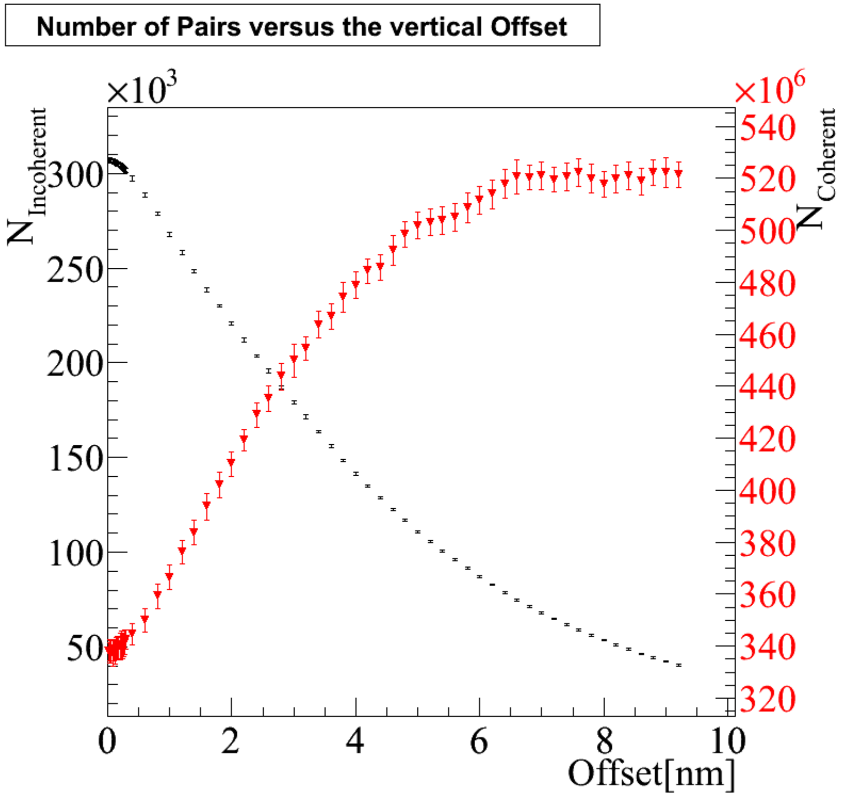
Non perfect beam collisions

- Animation on the right with 10nm offset (NB: scales differ)
- Due to jitter in accelerator, BDS, QD0 not all collision happen perfectly head on (though should be much smaller than 10nm)

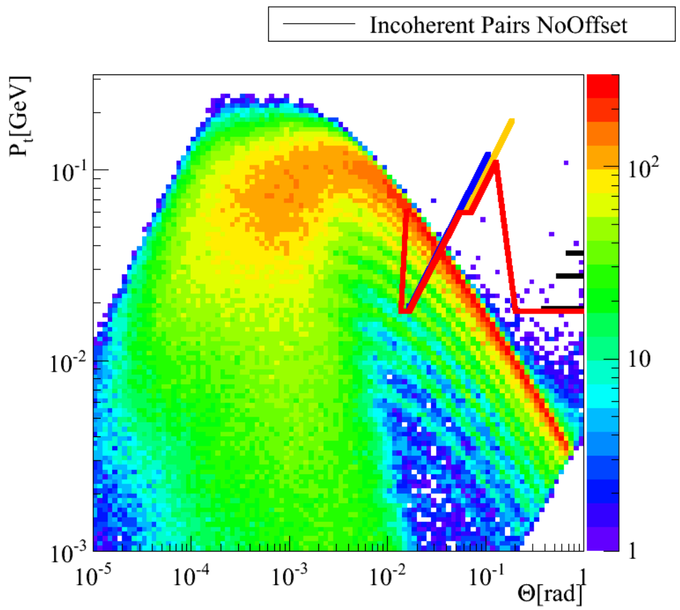


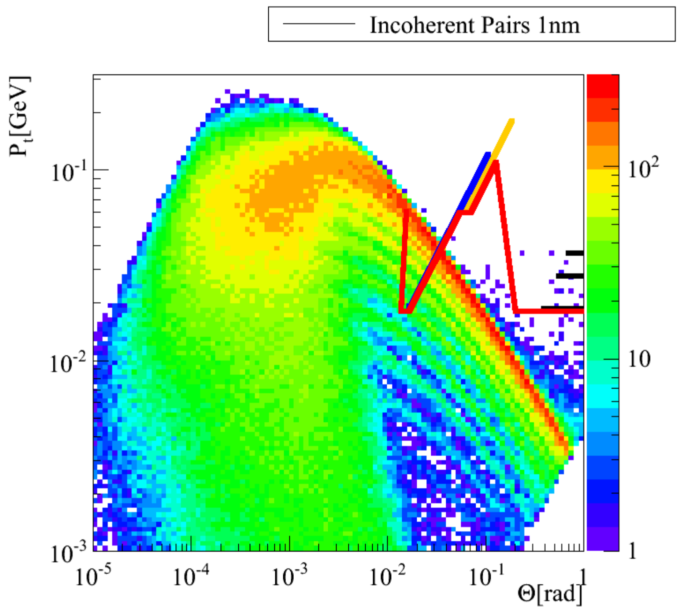
Non Perfect Beam Collisions

- Number of incoherent pairs decreases
  - Photons see less real particles
  - For small offsets < 1nm 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





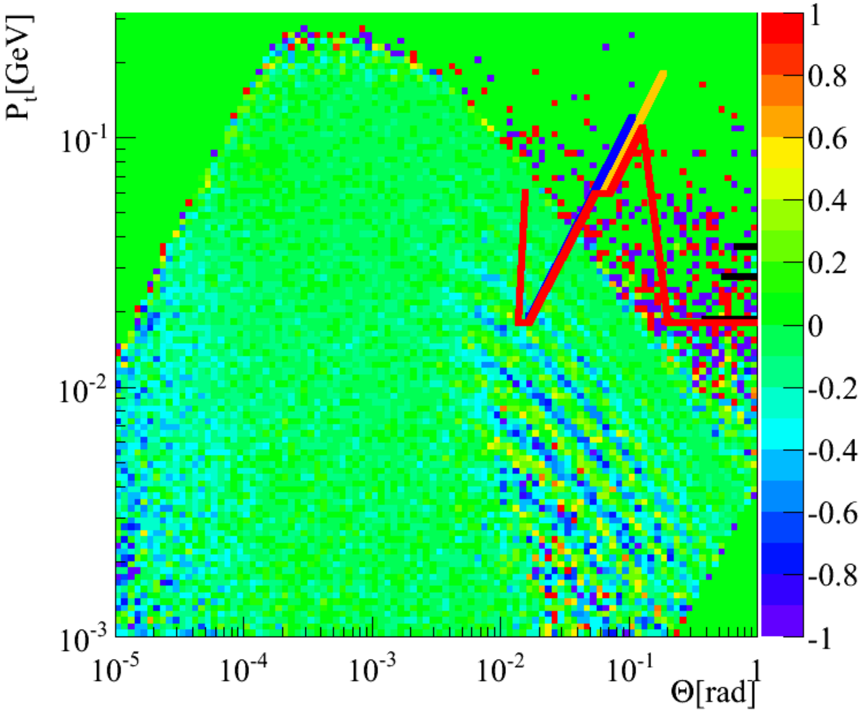
- Plotting Pt vs. Theta angle of incoherent Pairs
  - Not taking crossing angle or detailed field into account
- Lines representing position of Detector Elements
  - Vertex, LumiCal, BeamCal, Beam pipe

Thanks to Mikael Berggren (Desy)

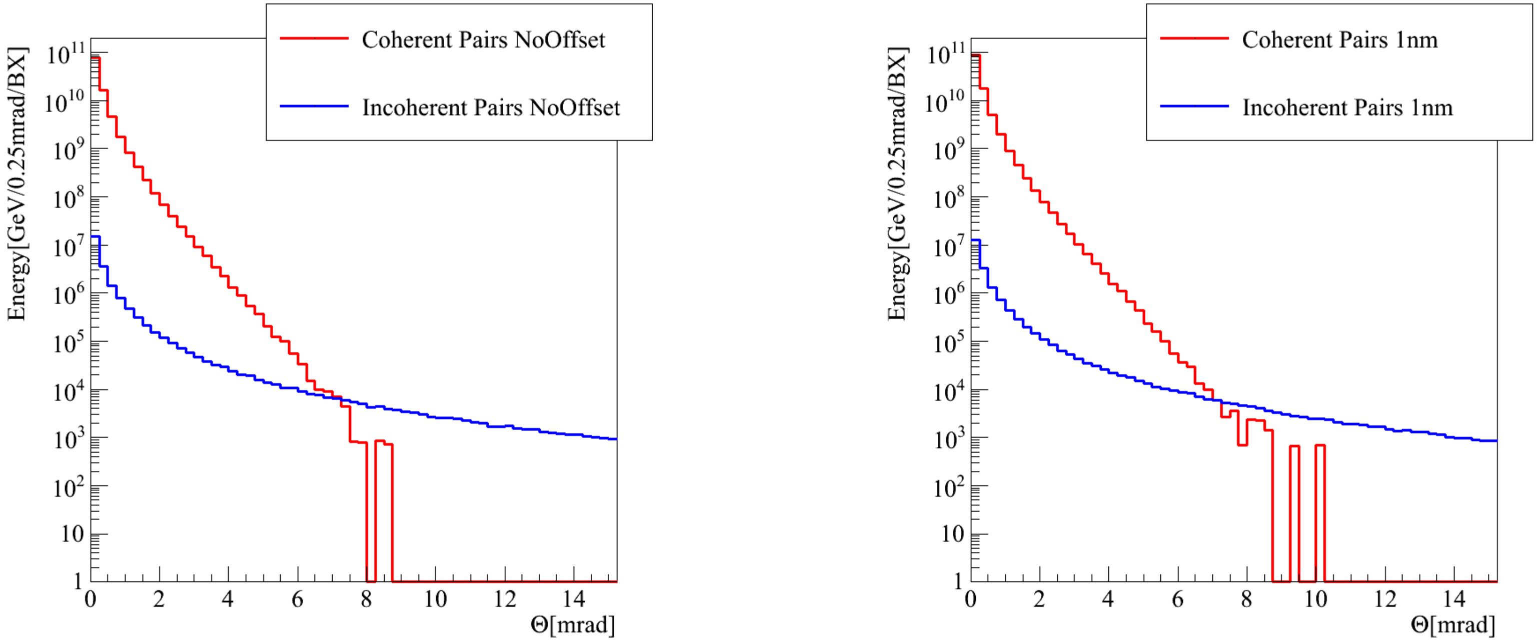
Background Rate

- No increase or decrease in background rate can be expected from these figures
- Mostly no change for 1nm offset
- Larger fluctuations at the edge of the distribution

$$\frac{N_{1nm} - N_{nom}}{N_{1nm} + N_{nom}}$$



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/mm^2 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 expected
  - 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