# Simulation Studies regarding Beam-Beam Background in a CLIC Detector

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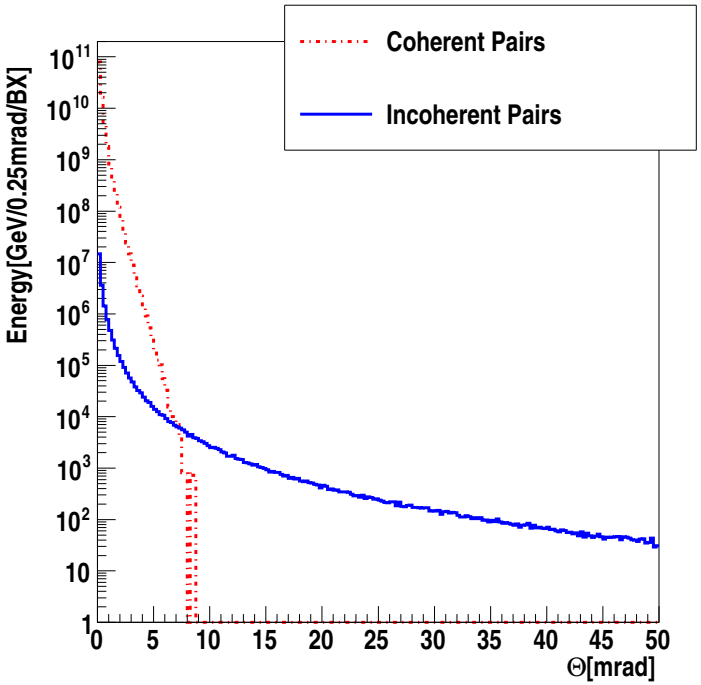
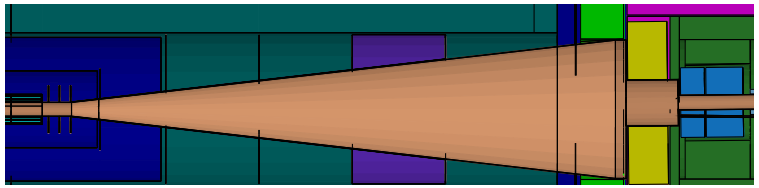
# Contents

# Beam-Beam Background

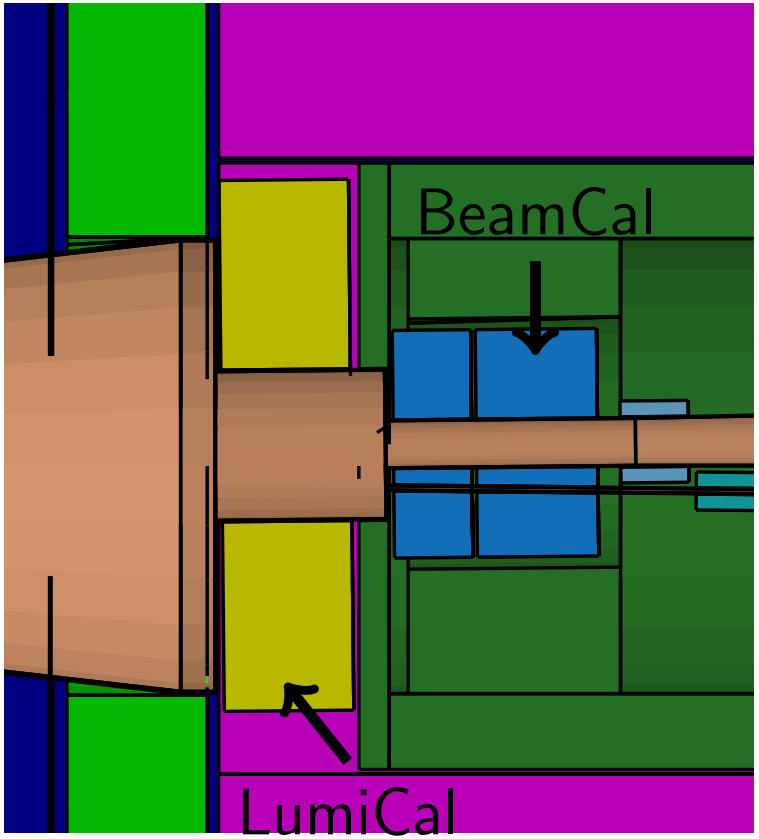
- Beam-beam background simulated with GuineaPig
- Nominal $\sqrt{s} = 3$ TeV CLIC
- $3 \cdot 10^5$ incoherent particles/BX
- $6 \cdot 10^8$ coherent particles/BX
  - Minimal inner acceptance for BeamCal 10 mrad
- Only incoherent particles simulated in full Geant4 (Mokka & Slic) simulations



# CLIC_ILD: Simulation Model

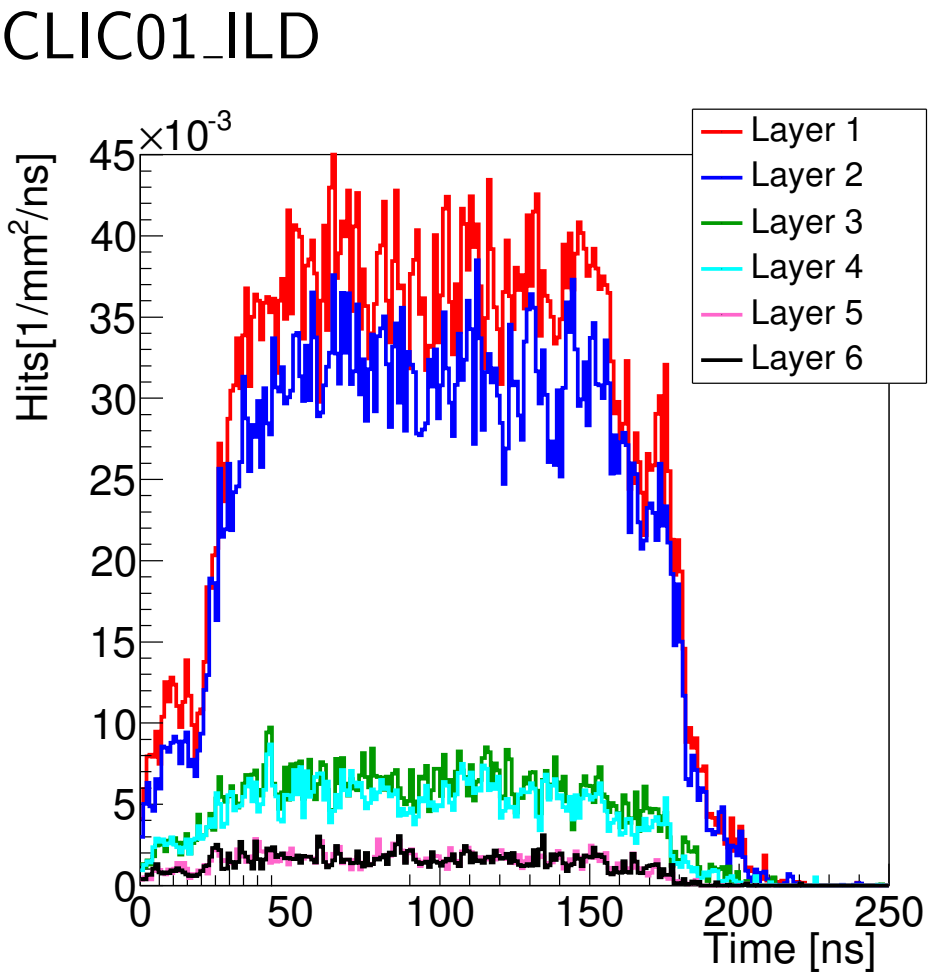


- GEANT4 9.3p1, MOKKA-07-05, `rangeCut` 5 $\mu$m, QGSP_BERT_HP
- Current CLIC_ILD detector model
  - 3 double layer vertex detector
    - ★ $Z = \pm 130$ mm
    - ★ $R = 31,\ 44,\ 58$ mm
  - 4 T magnetic field (no AntiDID)
  - Forward region as seen on right
  - "pointing" conical beam pipe (tracks in forward tracking pass only cylindrical beam pipe region)



# CLIC_ILD: Background Rate

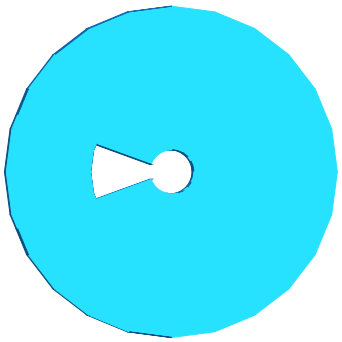
- Presented at LCWS10, Beijing
- Hit rate: 0.04 Hits/mm$^2$/ns when back-scatters hit VXD
- Back-scatters originate in BeamCal and beam-tube inside BeamCal
- Mostly low energy electrons and photons



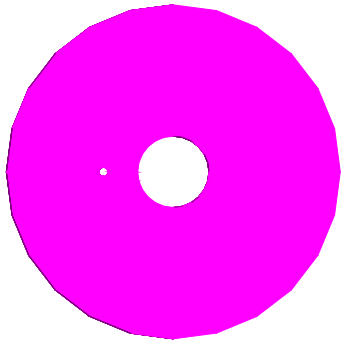
# CLIC_ILD: Geometry Changes I

- Added tungsten/graphite absorber between beam-pipes in BeamCal

Old

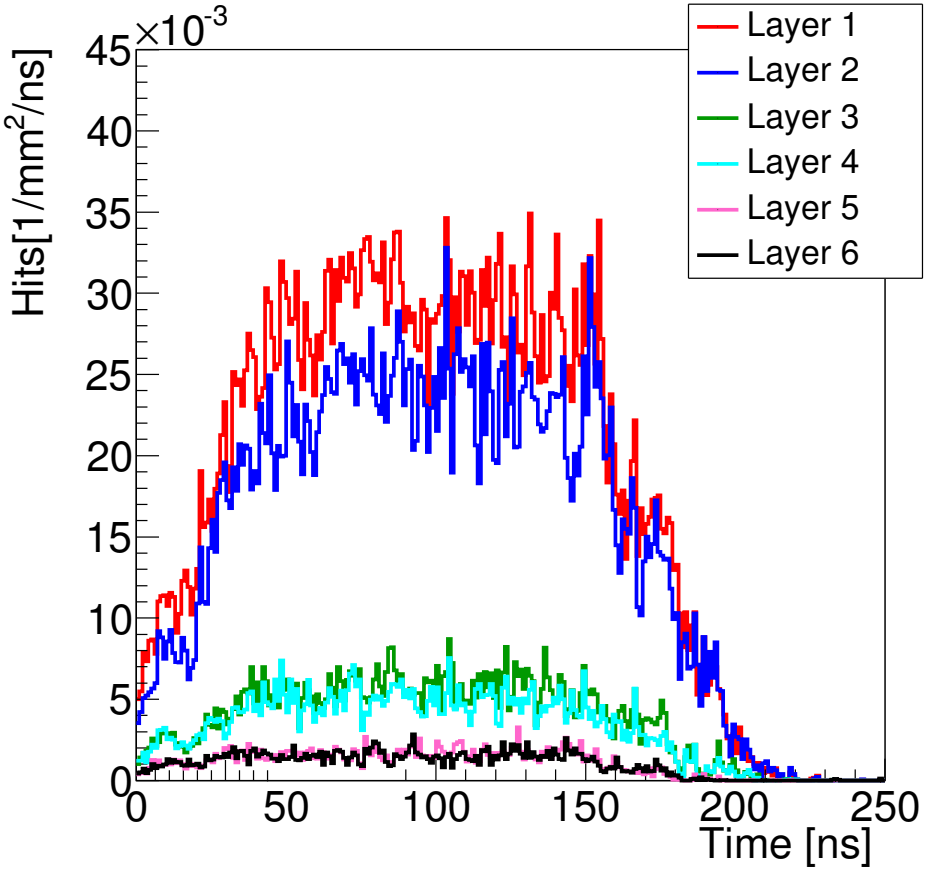


New



- Reduce back-ground from 0.04 to 0.03 Hits/mm$^2$/ns

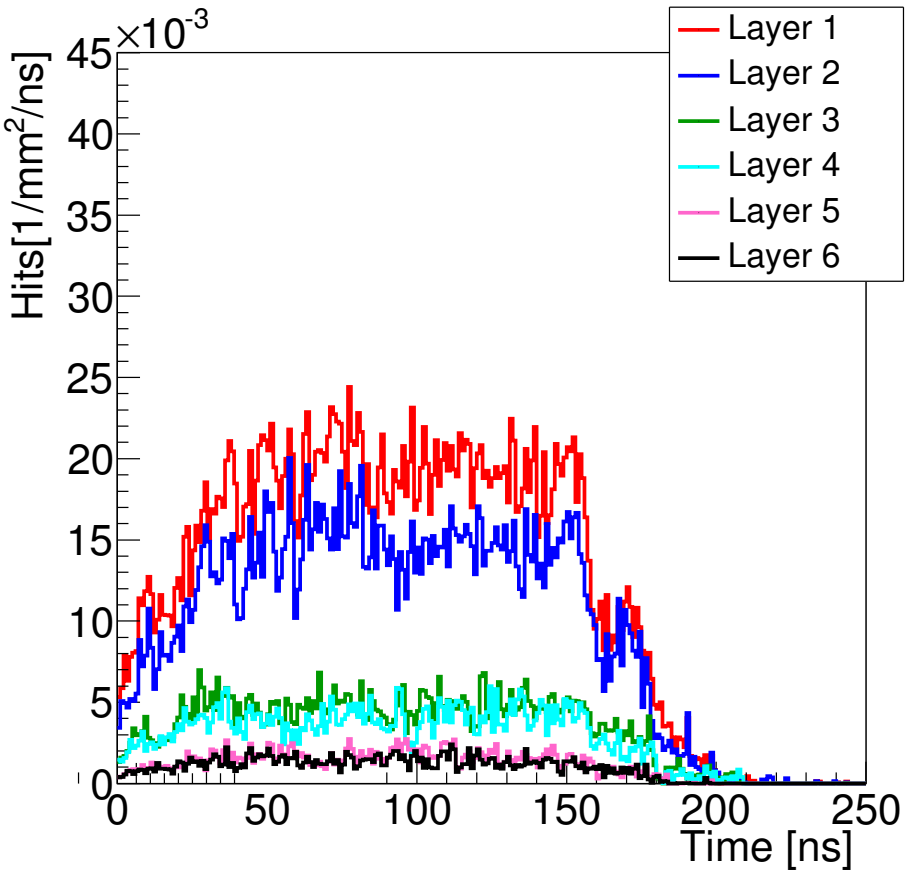
CLIC01_ILD: New BeamCal



# CLIC_ILD: Geometry Changes II

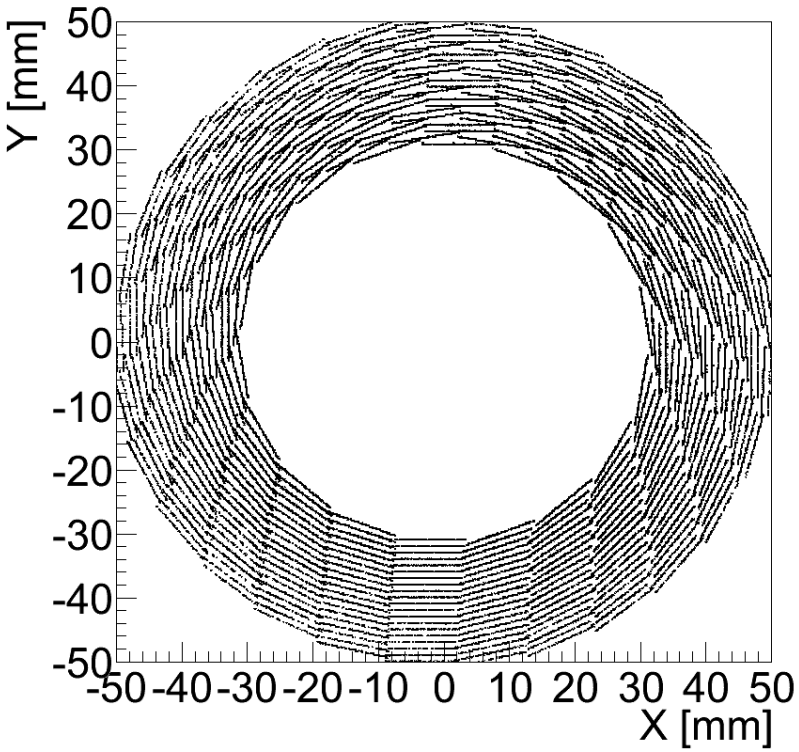
- Later changed the conical beam-pipe from beryllium to iron
- Increased thickness of the conical beam-pipe (1.2 mm in $R$)
- Reduce background from 0.03 to 0.02 Hits/mm$^2$/ns
- Using this model in following slides

Current CLIC_ILD



# CLIC_ILD: Vertex Radius vs. Background I

- Hit density in vertex detector impacts pattern recognition, tracking, need fast time stamping, maybe requires multi-hit capability
- Increase radius to reduce occupancy, which allows to soften technological requirements
- Simulated in current CLIC_ILD, moving whole vertex detector outward
- Length of VXD not changed




Hits on the first layer for the different inner radii. Overlaid for all the different geometries.

# CLIC_ILD: Vertex Radius vs. Background I

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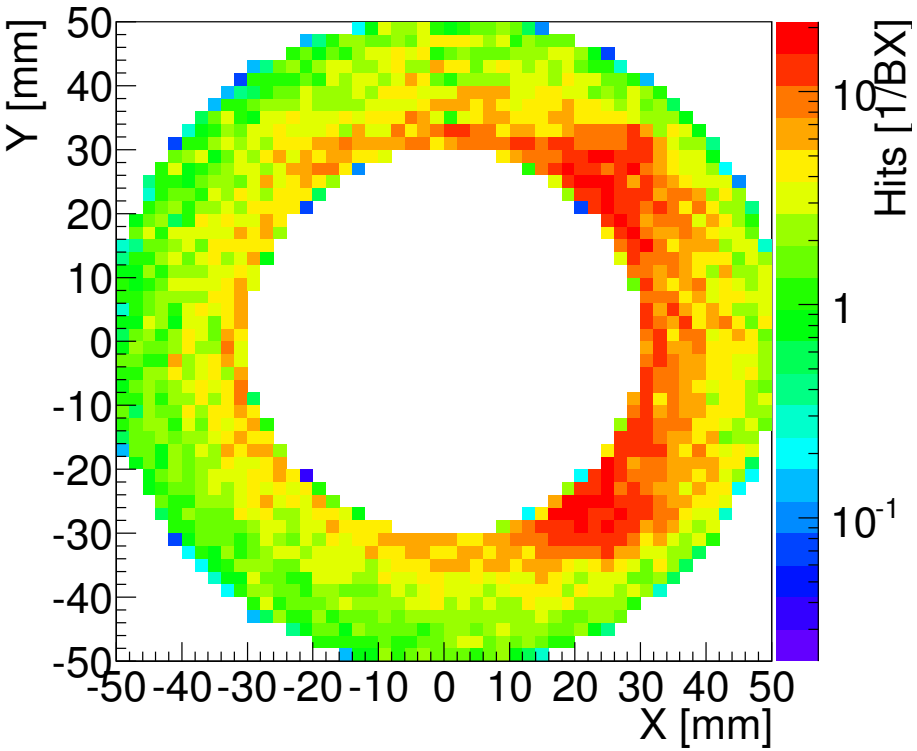
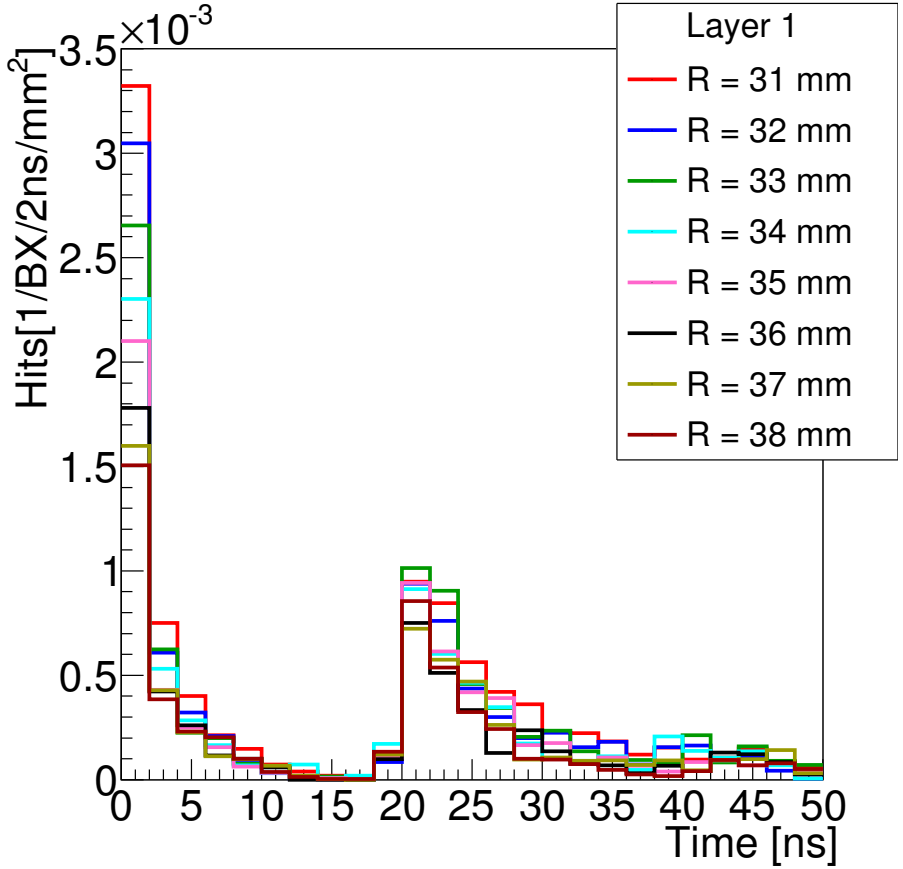



Re-binned histogram, hot spots are corresponding to hole for outgoing beam pipe in BeamCal

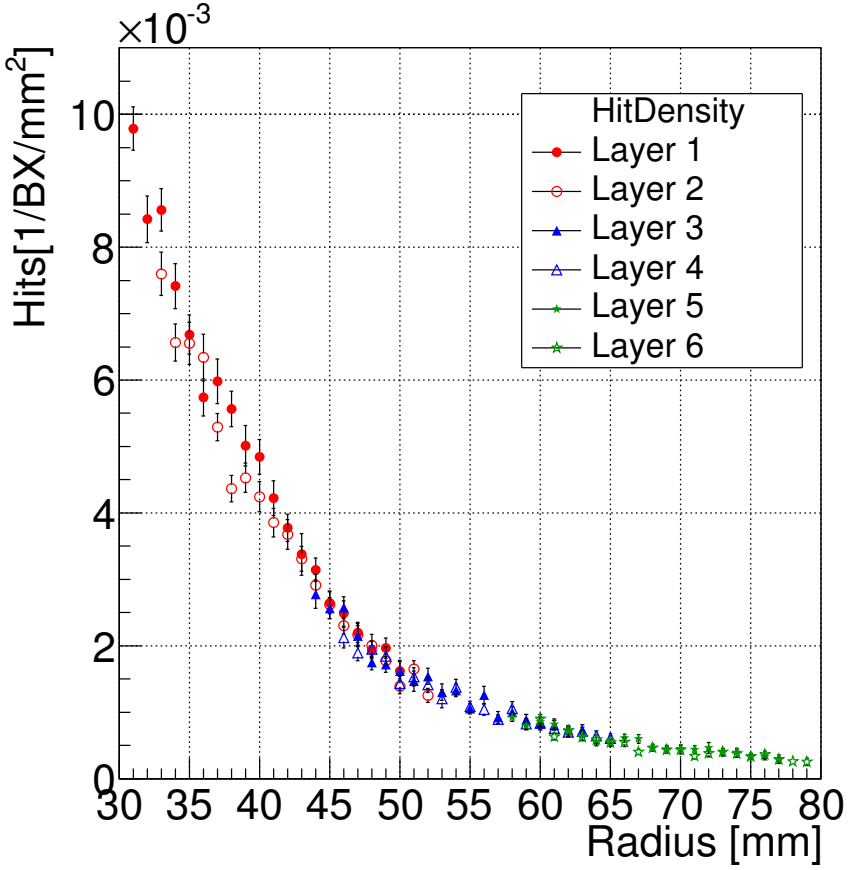
# CLIC_ILD: Vertex Radius vs. Background II

- Direct hits ($t < 10$ ns) are reduced with increased radius
- Hits from back-scatters are not falling as fast
- Still significant contribution from back-scattering hits



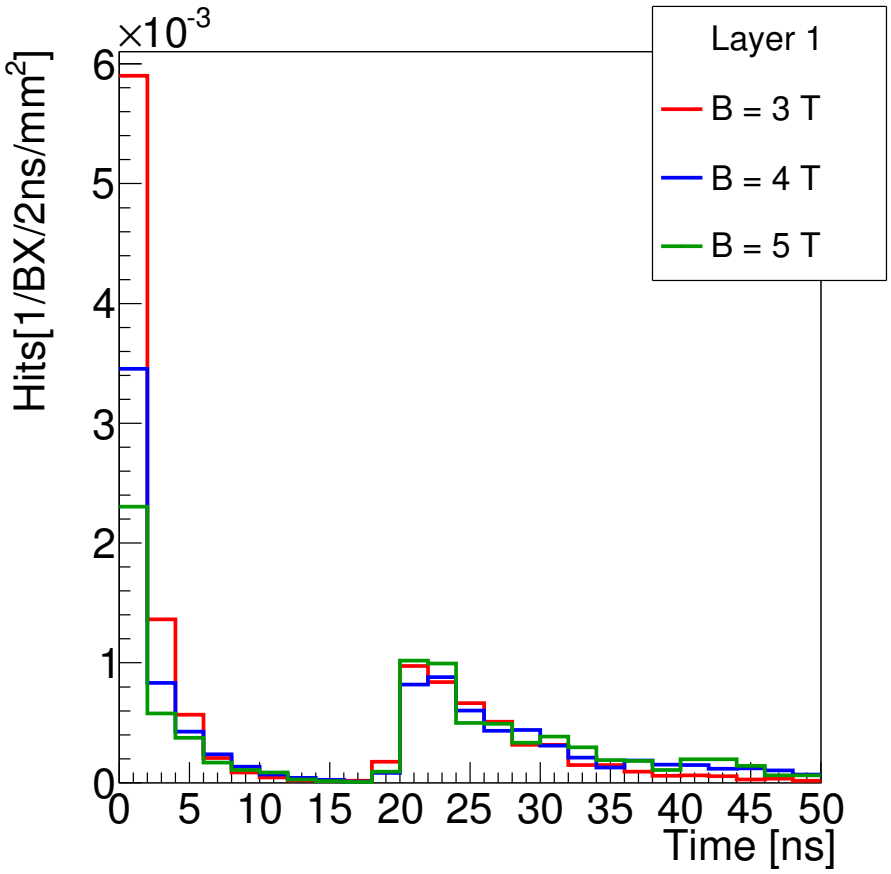
# CLIC_ILD: Vertex Radius vs. Background III

- Integrated all hits for each bunch crossing
- Hit rate falls with increasing radius



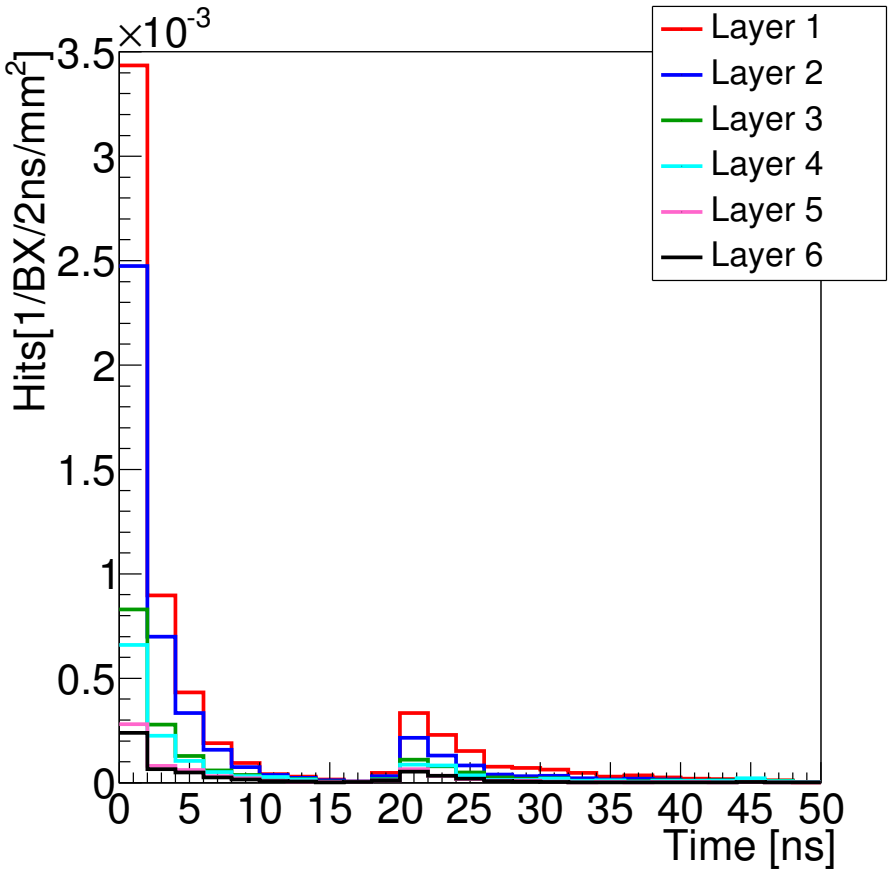
# CLIC_ILD: Magnetic Field vs. Background

- Now looking at default vertex radii: $R = 31$ mm etc.
- Vary B-field = 3, 4, 5 T
- Direct hits ($t < 10$ ns) are reduced with increased B-field
- Hits from back-scatters are not reduced by B-field



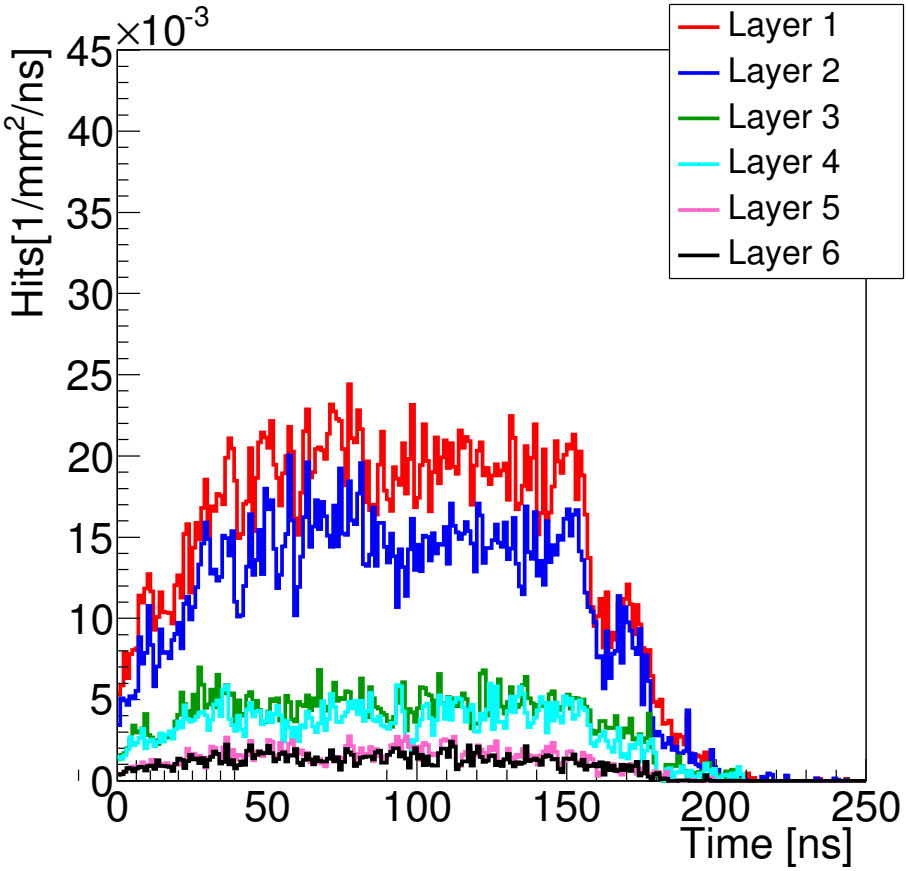
# CLIC_ILD: Beam pipe vs. Background I

- Back-scattering particles have to pass through conical part of beam pipe
- Increase depth to absorb these particles
- Changed conical beam pipe material to tungsten
- Most back-scatters removed
- Have to try with more realistic beam pipe material

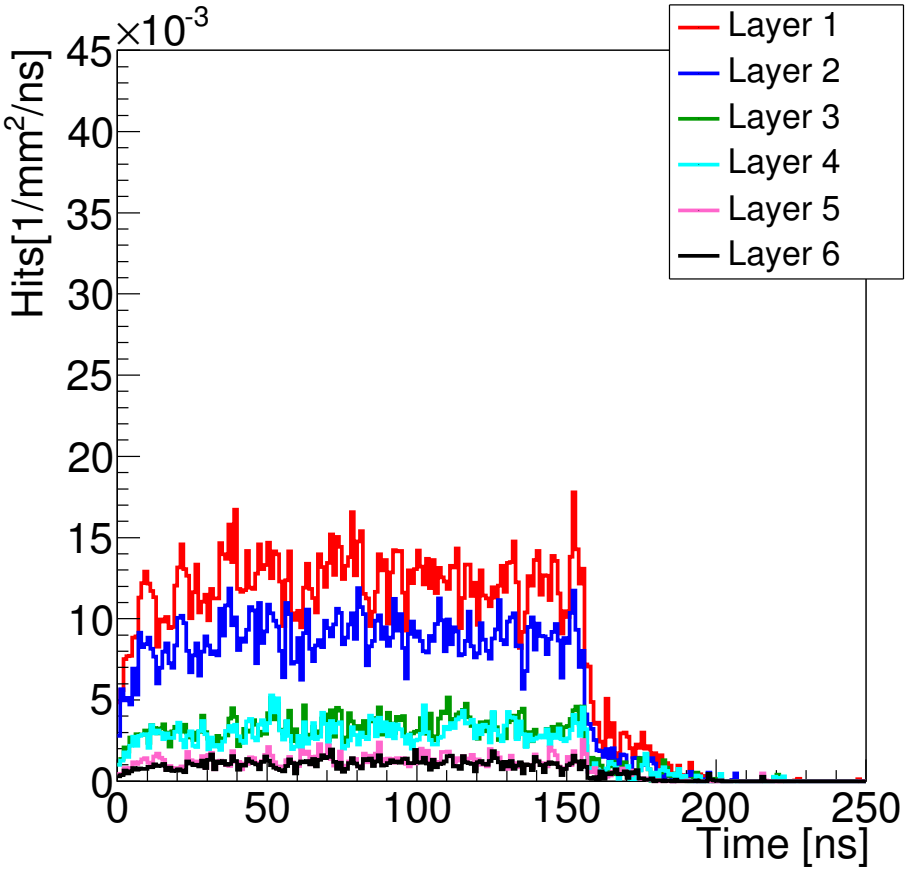


# CLIC_ILD: Beam pipe vs. Background II

CLIC_ILD




with "Tungsten Tube"



# CLIC_ILD: Background Hit Density Summary

| Model | Hits/mm$^2$/ns |
|---|---|
| Beijing | 0.04 |
| New BeamCal | 0.03 |
| Iron beam pipe | 0.02 |
| "Tungsten beam pipe" | 0.01 |

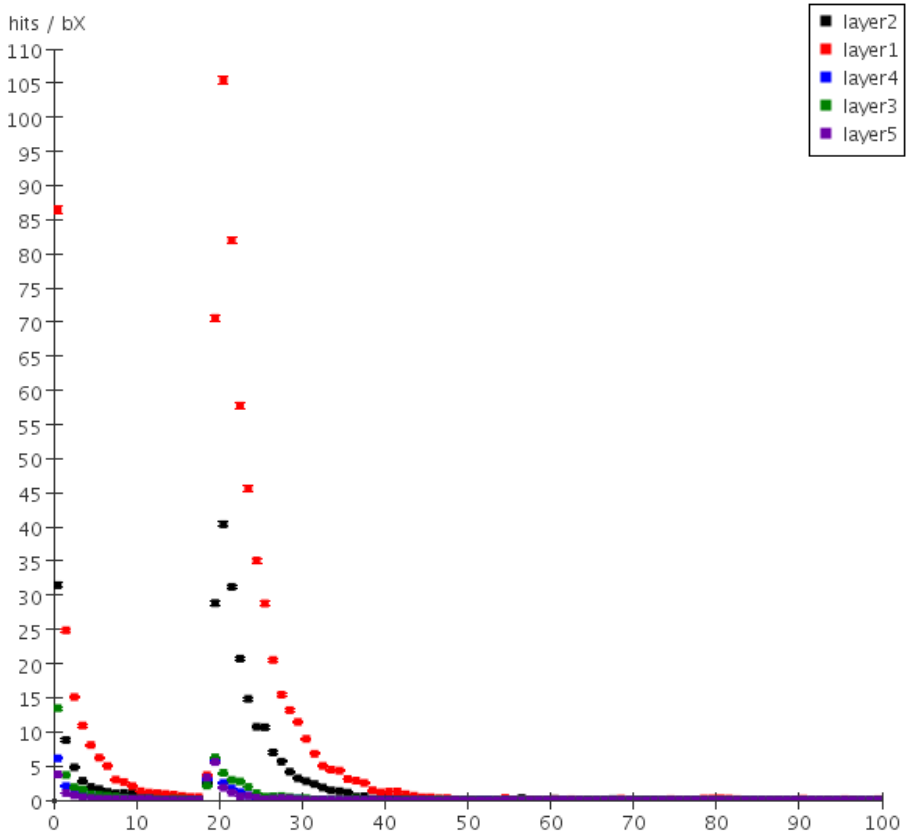
Iron beam pipe is in the current detector model. More work required.

# CLIC_SiD Simulation Model

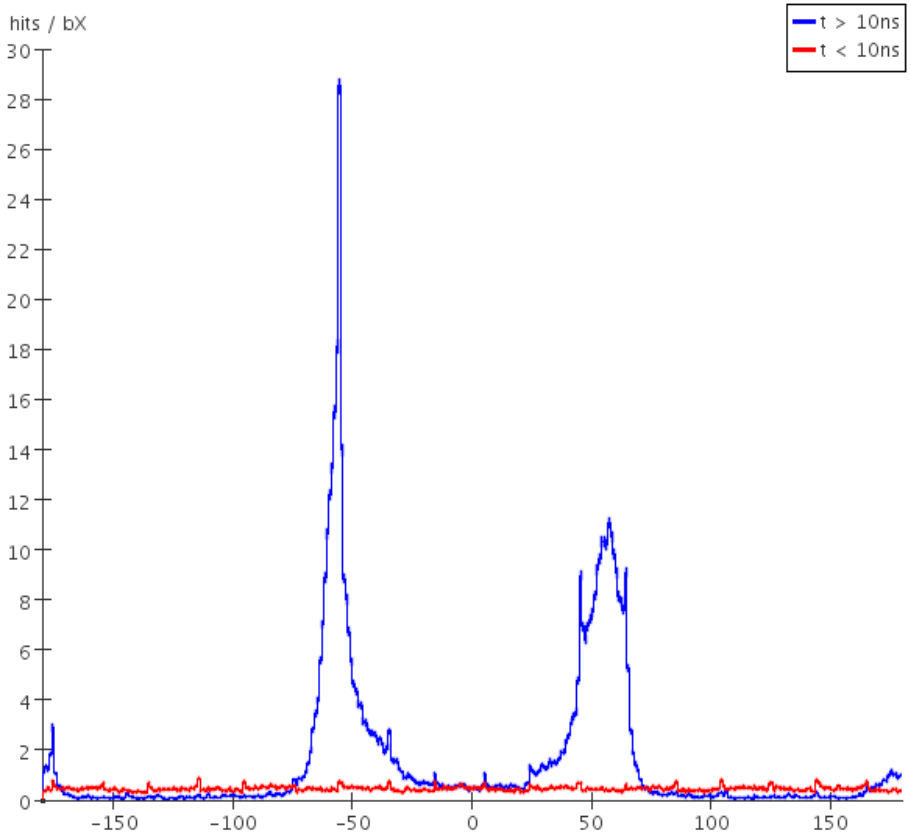
- GEANT4 9.3p1, SLICv2r8p4, `rangeCut` 1 mm, QGSP_BERT
- Current CLIC_SiD detector model
  - 5 single layer vertex detector
    - ⋆ $Z = \pm 100$ mm
    - ⋆ $R = 27,\ 38,\ 51,\ 64,\ 77$ mm
  - 5 T magnetic field (no AntiDID)
  - Almost "pointing" conical beam pipe

# CLIC_SiD: Background during one BX (C.Grefe)

- First simulations for CLIC_SiD show same features as CLIC_ILD background simulations



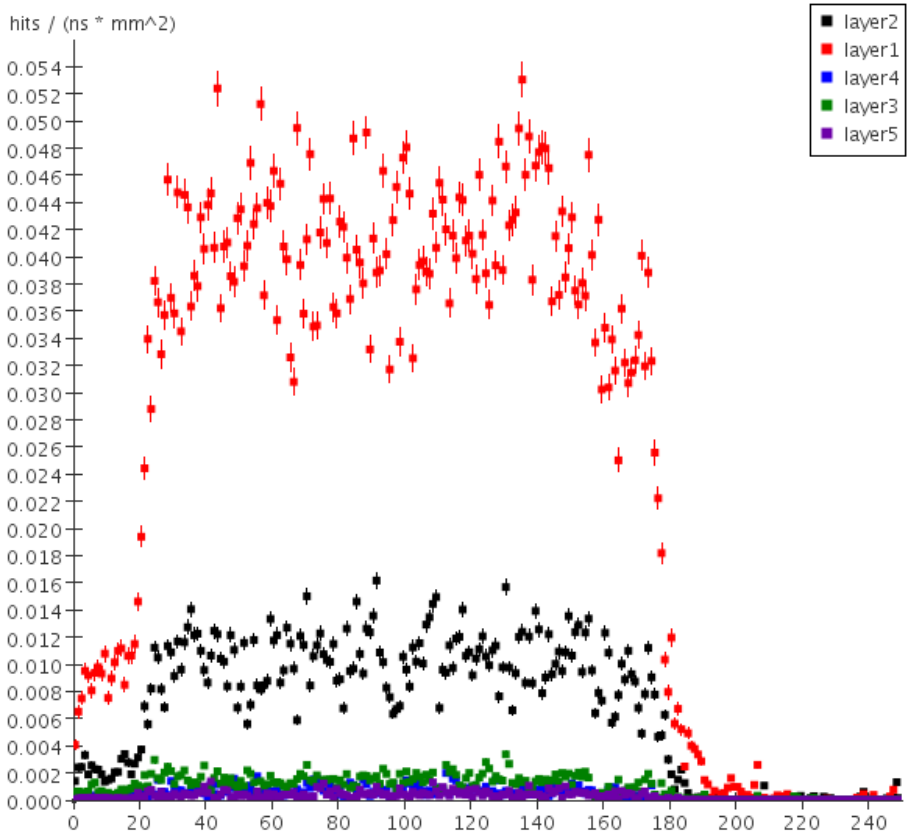

Hits vs. Time[ns] after BX




Hits in the VXD vs. Azimuthal Angle[deg]

# CLIC_SiD: Background for one Train (C.Grefe)

- Rise in hit density once back-scatters come back from BeamCal
- Similar to first results for CLIC_ILD
  - Work in progress
  - Optimize forward region, materials




Hits[1/mm$^2$/ns] vs Time[ns] during a bunch train

# Summary

- Incoherent Pairs can have a negative impact on the detector
  - Direct hits depend on B-field and VXD Radius
- Proper forward region design can reduce back-scatters into the detector
- Further reduction of back-scatters through beam-pipe design possible
- Hit density in CLIC_ILD reduced to 0.02 Hits/mm$^2$/ns (from 0.04)
  - Further reduction possible
- Hit density in CLIC_SiD currently at 0.04 Hits/mm$^2$/ns
  - Further reduction possible

Backup Slides

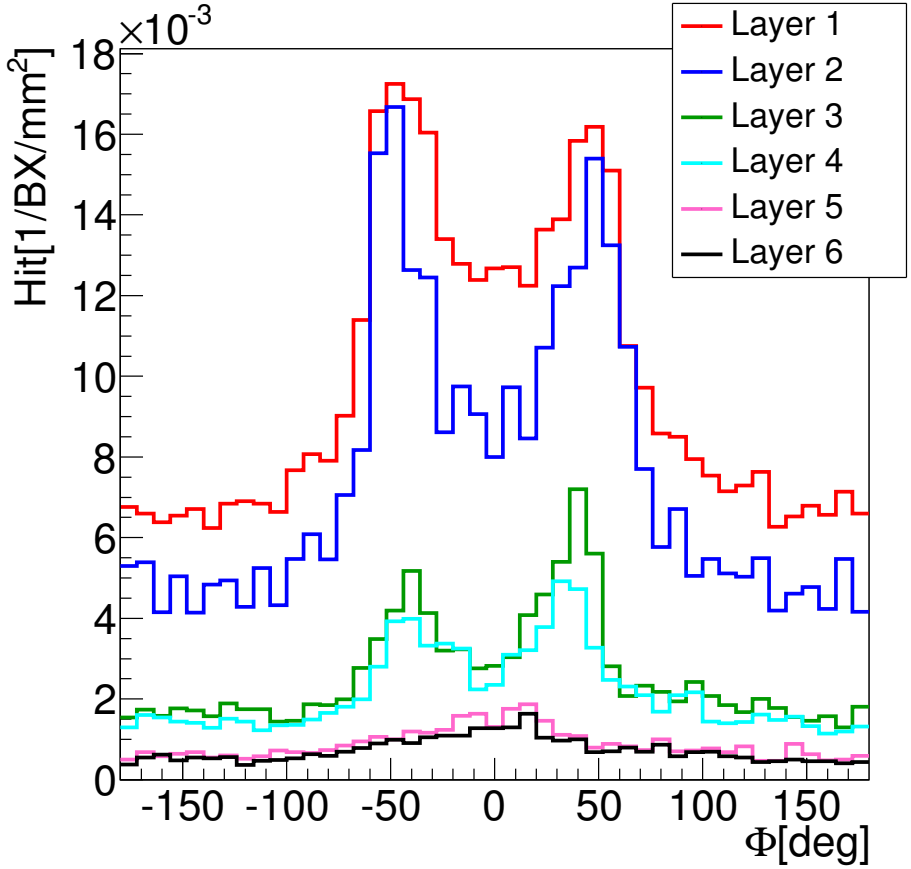
# Forward Regions and VXDs

| | CLIC_SiD | CLIC_ILD |
|---|---|---|
| VXD Layout | 5 Single | 3 Double |
| Innermost VXD Radius | 27 mm | 31 mm |
| B-Field | 5 T | 4 T |
| LumiCal $Z_{\text{Start}}$ | 1.8 m | 2.5 m |
| LumiCal $R_{\text{Inner}}$ | 64 mm | 100 mm |
| BeamCal $Z_{\text{Start}}$ | 2.8 m | 2.9 m |
| BeamCal $R_{\text{Inner}}$ | 28 mm | 32 mm |

Coverage of very forward calorimeters very similar by design

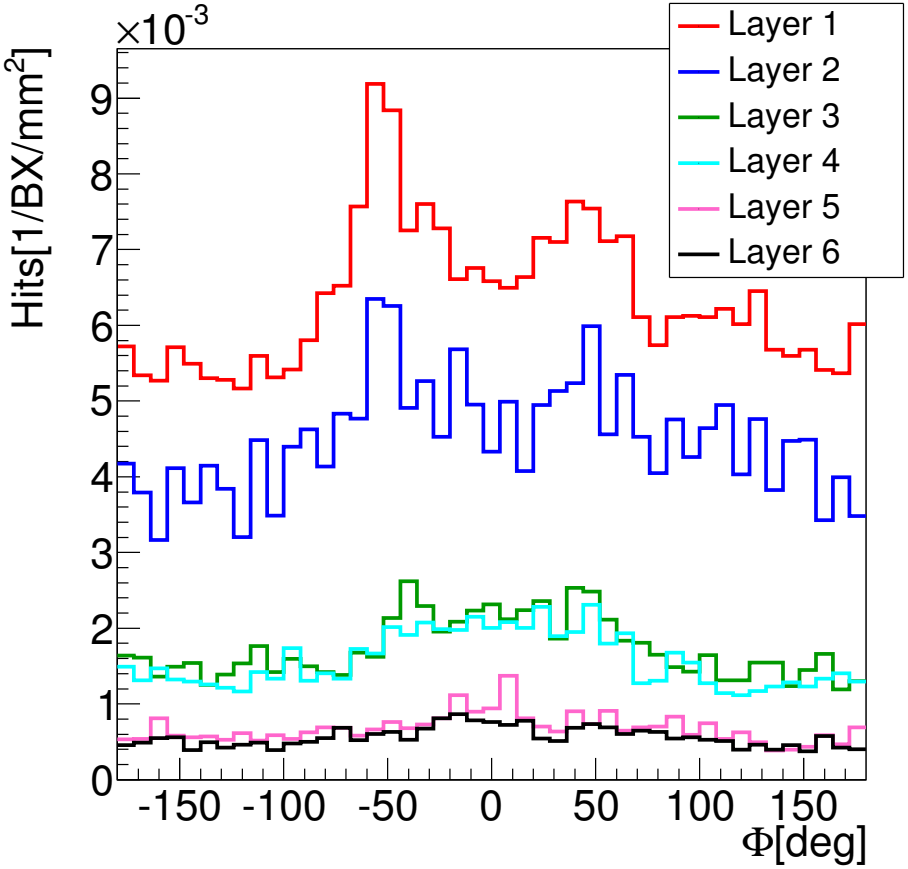
# CLIC_ILD: Azimuthal Distribution of Background

- Current CLIC_ILD baseline model
- For first layer hot spots only factor 2 above average



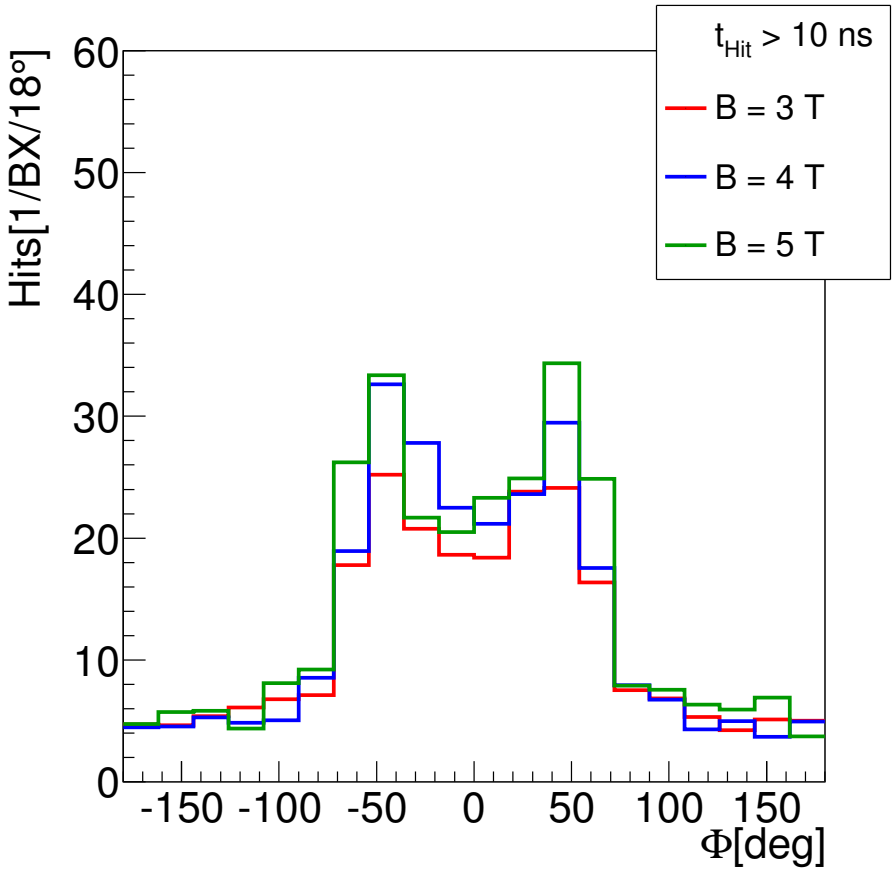
# CLIC_ILD: Azimuthal Distribution of Background

- "Tungsten beam pipe"
- For first layer hot spots only factor 1.5 above average



# CLIC_ILD: Magnetic Field vs. Background II

- Right: Only hits from back-scatters ($t > 10$ ns)
- Hits from back-scatters on VXD not homogeneously distributed



# CLIC_ILD: Magnetic Field vs. Background III