Status of background simulation studies

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Tracker discussion, 12. 2. 2015

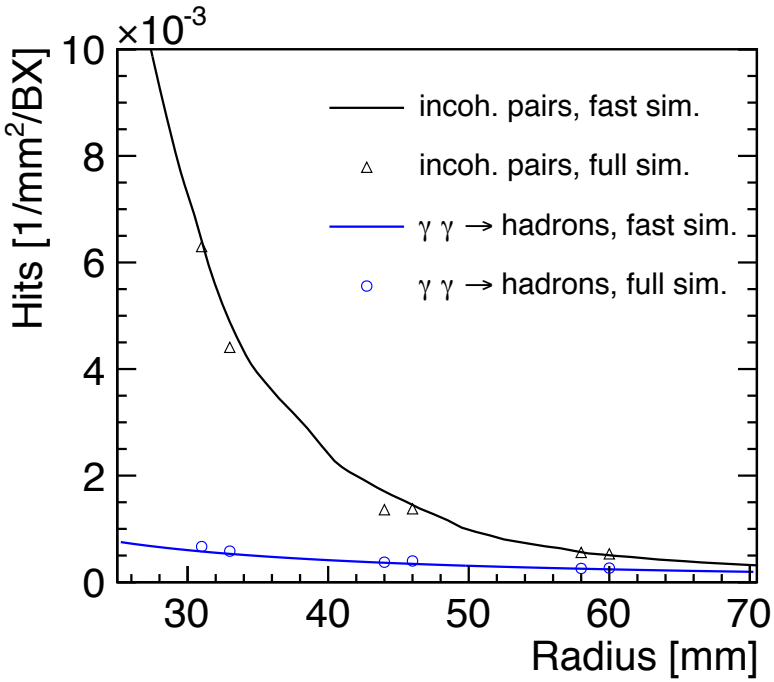
Introduction

- As starting point, reproduce occupancy studies performed for the CDR using the CLIC_ILD_CDR detector model
- After that, modify detector model by replacing the TPC with an all-silicon tracker
- Disclaimer: So far, we considered only hits from incoherent pairs

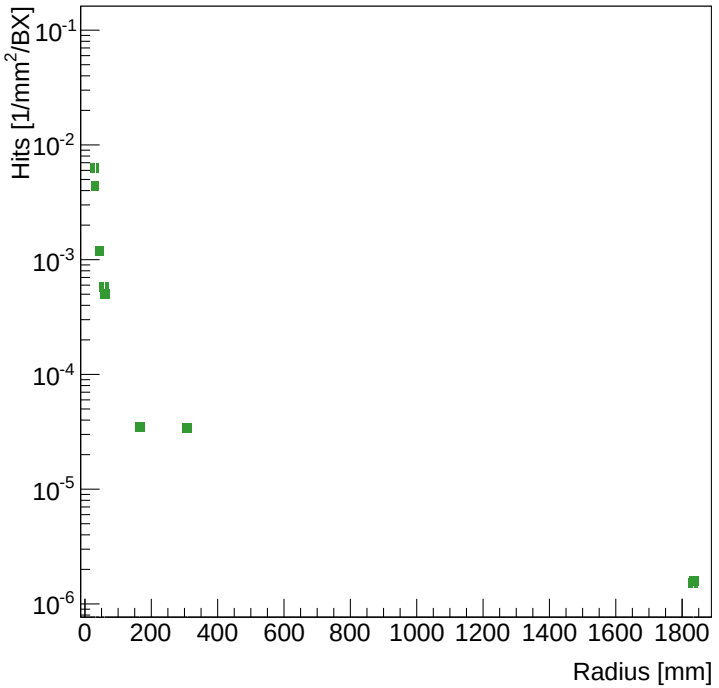
Validaiton using CLIC_ILD_CDR model

- Radial dependence of hit density from incoherent pairs in vertex barrel layers

- CDR



- our work (Magdalena)



- Good agreement

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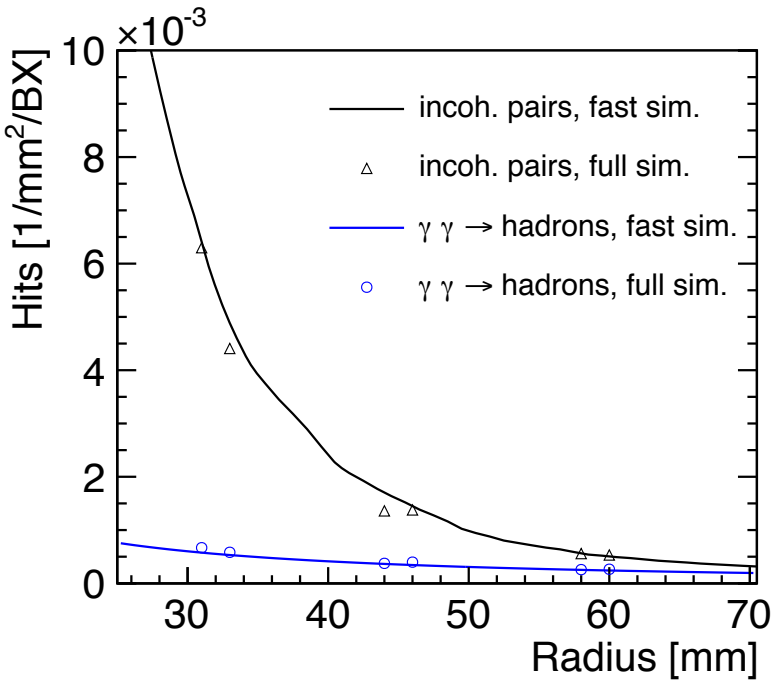
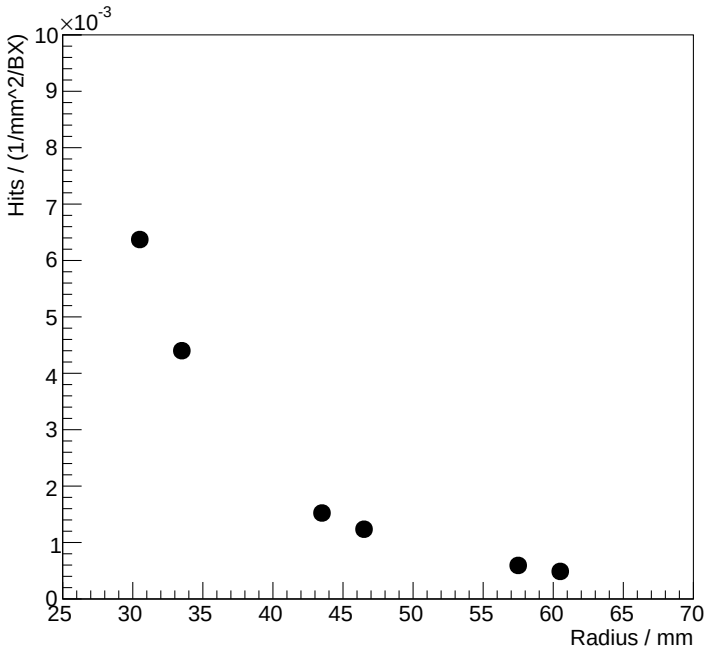


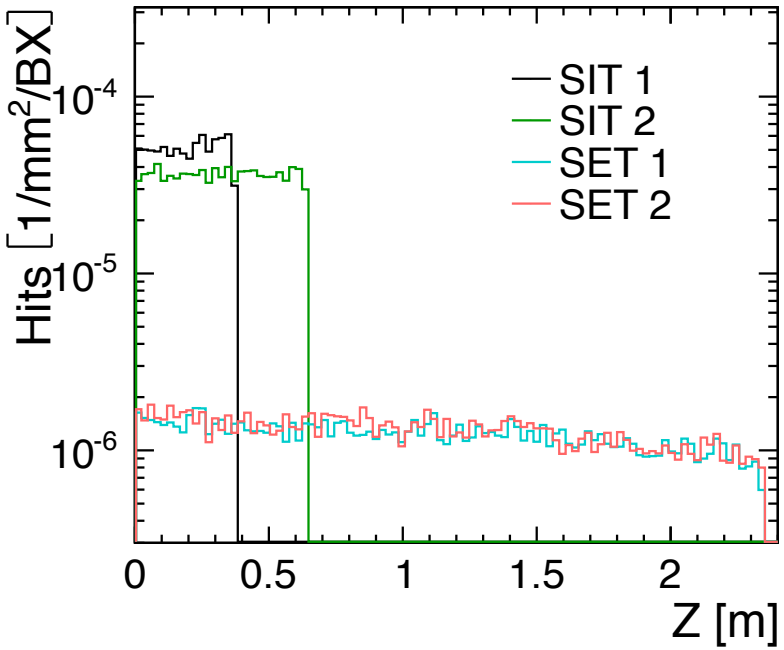
- our work (Andreas)



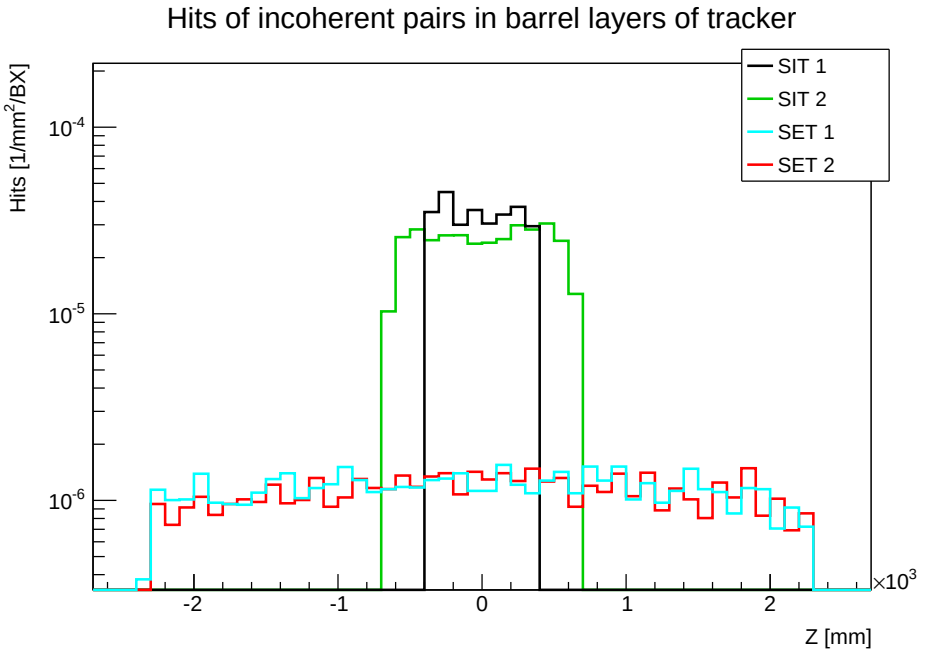
- Good agreement

Validaiton using CLIC_ILD_CDR model

- z-dependence of the hit density in the outer tracker layers
  - CDR



  - our work (Magdalena)

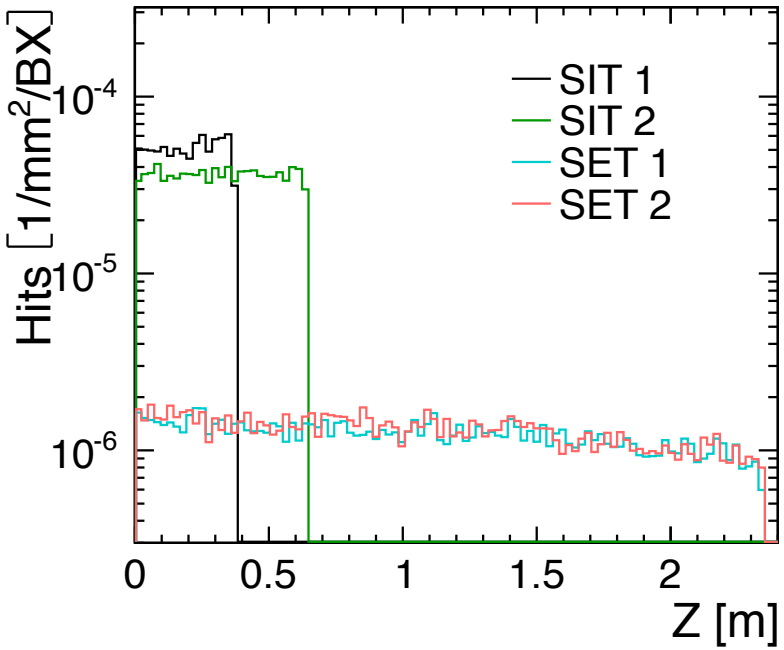


  - Good agreement

Validaiton using CLIC_ILD_CDR model

- z-dependence of the hit density in the outer tracker layers

- CDR



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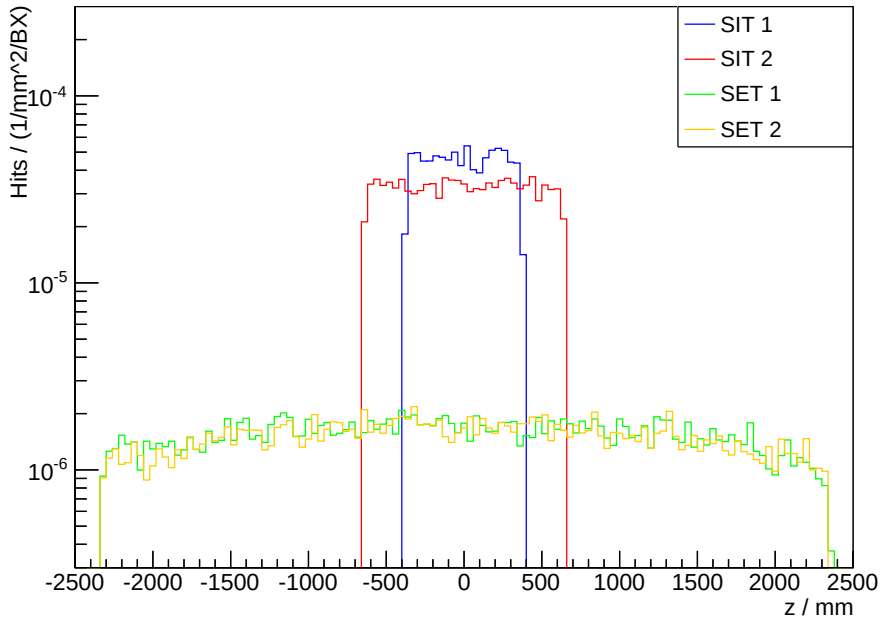
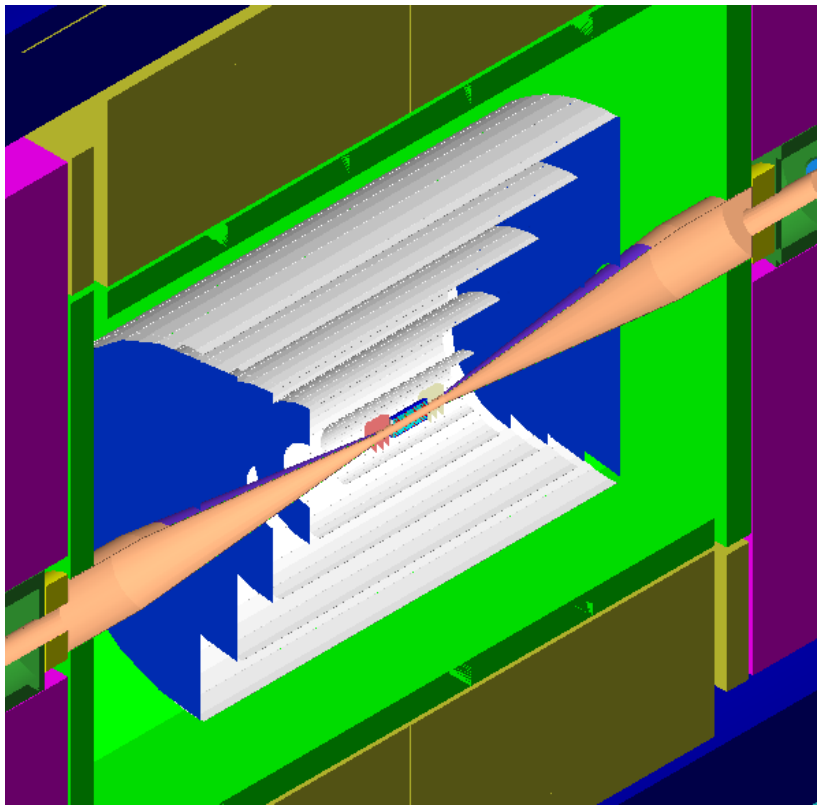


- Good agreement

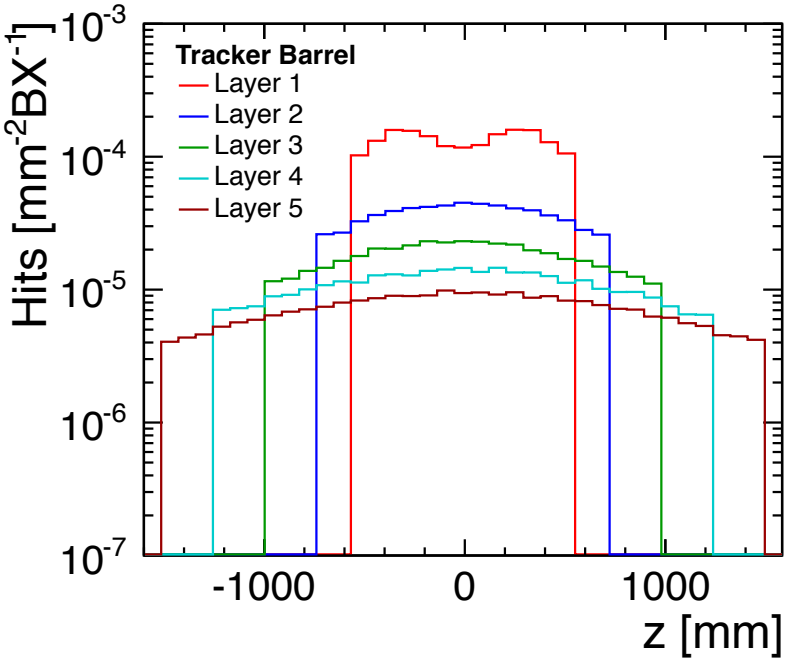
CLIC_SiD-Tracker

- Replace TPC and surrounding silicon tracking layers with an all silicon tracker
- Keep everything else (4 T field, VXD layout,...)
- Material description esp. in the endcaps probably not yet correct
- Rerun the same simulation and analysis and check on hit densities

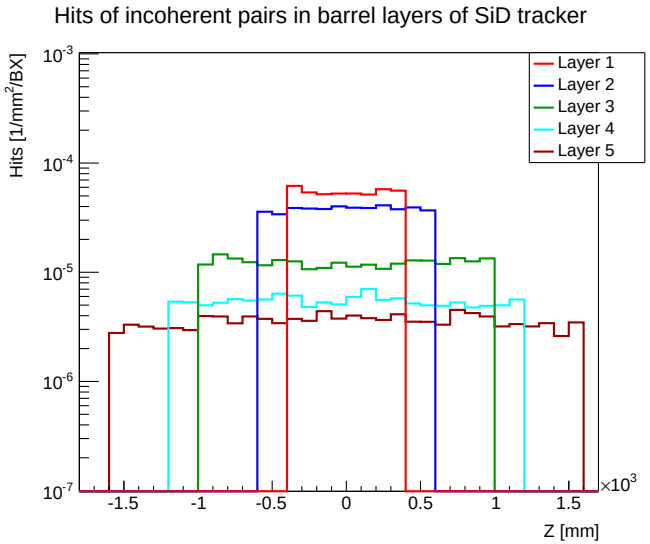


CLIC_SiD Barrel layers - z dependence

- Thesis Christian



- Magdalena



CLIC_SiD Barrel layers - z dependence

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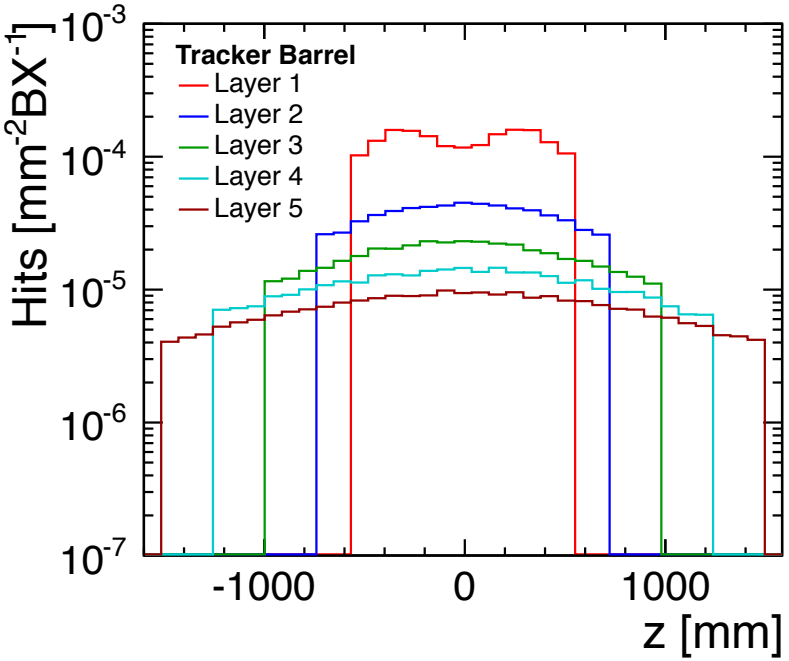
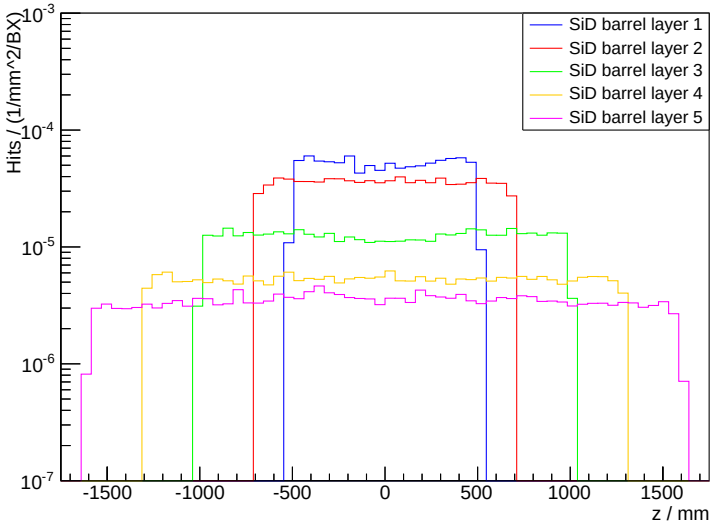
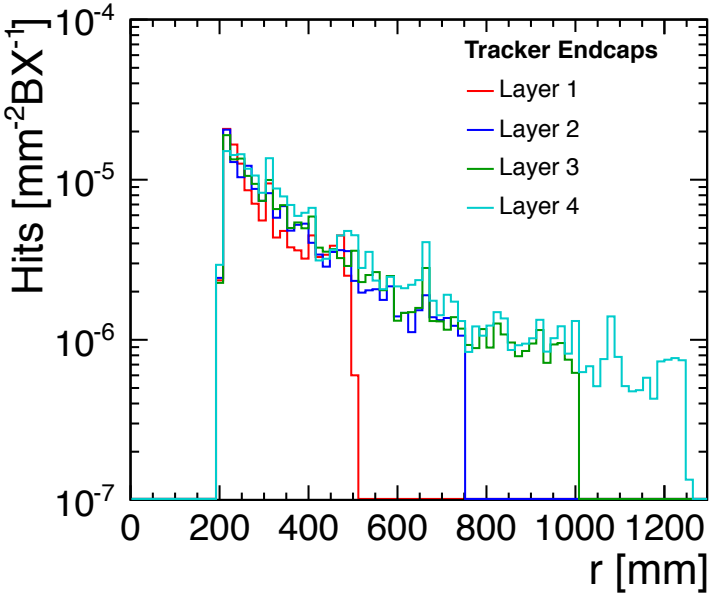


- Andreas

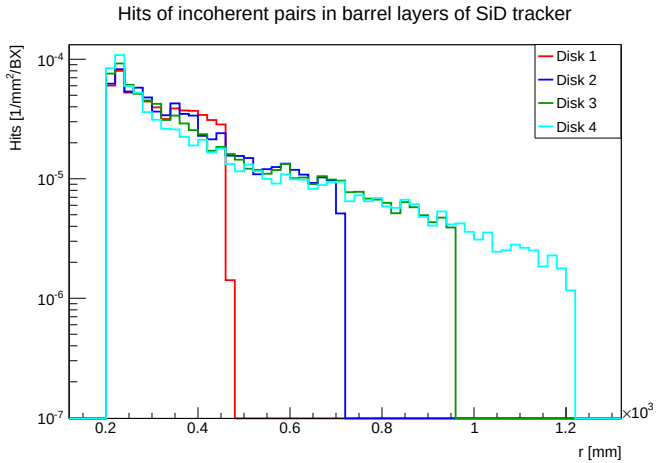


CLIC_SiD Endcap discs

- Thesis Christian



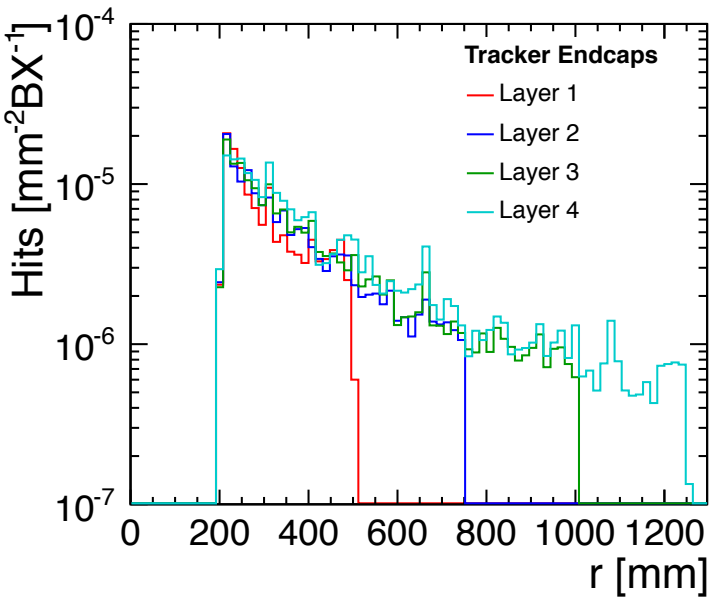
- Magdalena



- Normalization is under investigation

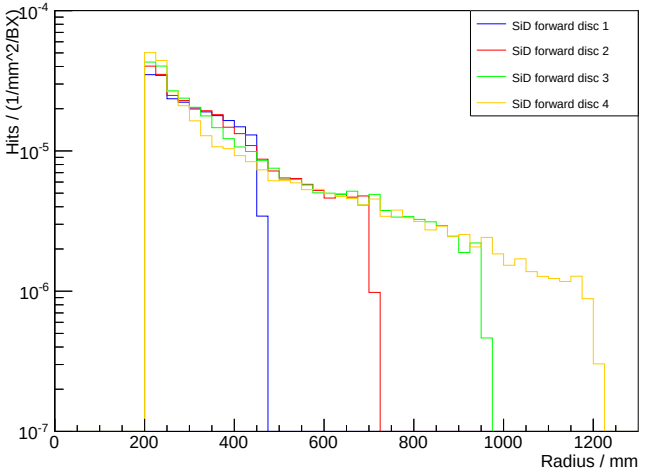
CLIC_SiD Endcap discs

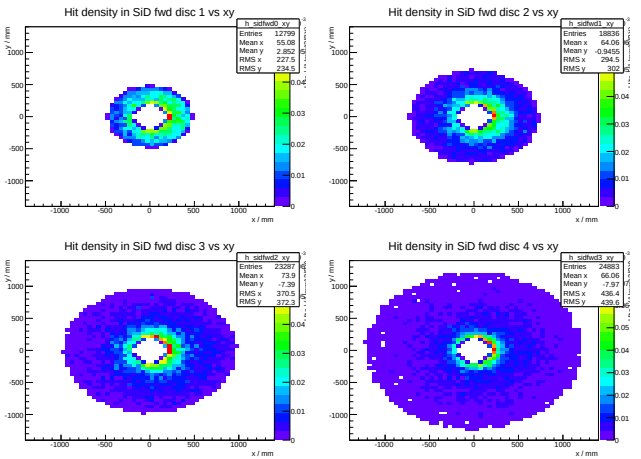
- Thesis Christian



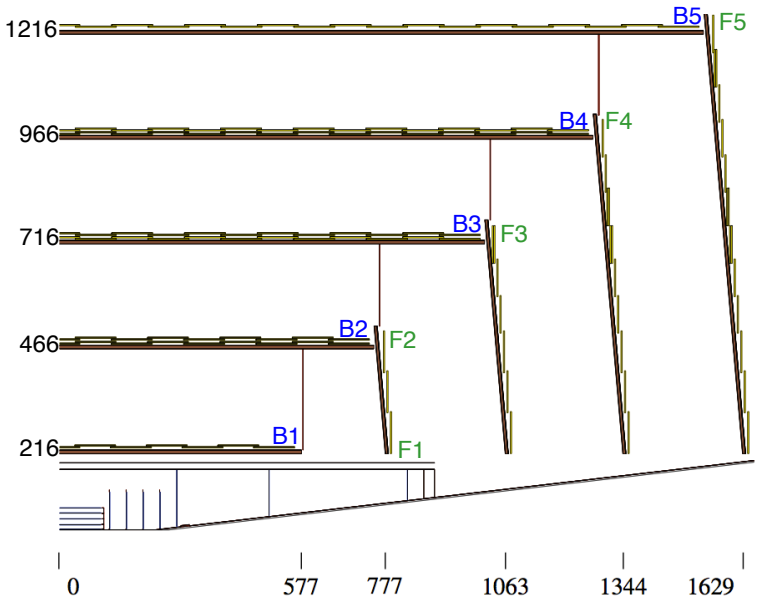
- Too low statistics at large radii

- Andreas





Hit density (incoh. pairs) in CLIC_SiD Tracker



- Max. occupancy per train: 3 %
- Strip pitch: 50 µm
- Cluster size: 3 strips
- Safety factor: 5

Place	Hits/ mm^2/BX	max strip length / mm
B1	5.9e-05	2.2
F1	3.5e-05	3.7
B2	3.7e-05	3.5
F2	1.5e-05	8.6
B3	1.3e-05	10
F3	4.7e-06	27
B4	5.8e-06	22
F4	1.9e-06	68
B5	3.3e-06	39
F5	1.3e-06	100

- In addition, hits from $\gamma\gamma \rightarrow$ hadrons

Hit density (incoh. pairs) in CLIC_SiD Tracker

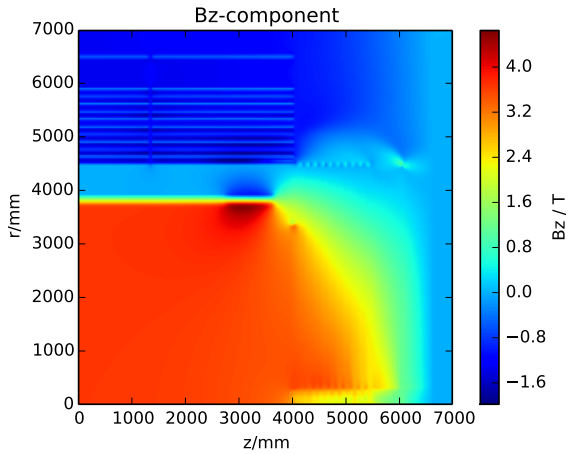
Place	pairs [hits/ mm^2/bx]	gghad [hits/ mm^2/bx]	max stripl. [mm]
B1	8.2E-5	2.3E-5	1.4
F1	2.0E-5	5.0E-5	3.2
B2	2.6E-5	5.0E-6	4.6
F2	4.0E-6	9.0E-6	16.9
B3	1.3E-5	1.9E-6	9.4
F3	1.3E-6	2.6E-6	54.8
B4	7.7E-6	1.1E-6	15.8
F4	1.0E-6	1.0E-6	91.6
B5	4.8E-6	7.6E-7	25.0
F5	8.0E-7	6.0E-7	123

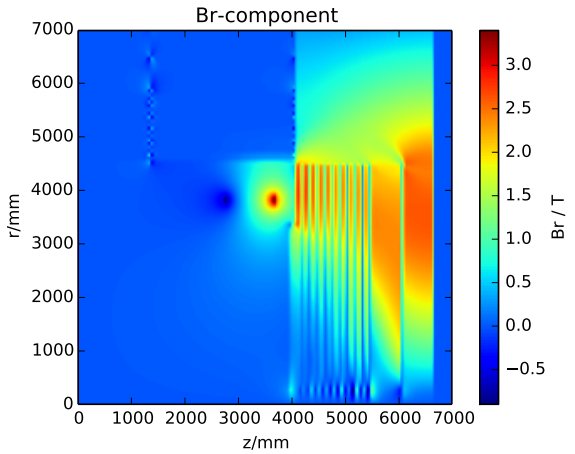
from: D. Dannheim et al., Silicon Tracking Optimization, http://indico.cern.ch/event/309925/contribution/2/material/slides/

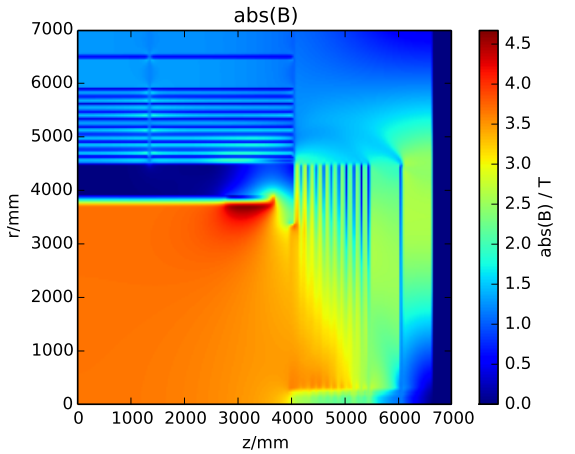
Place	Hits/ mm^2/BX	max strip length / mm
B1	5.9e-05	2.2
F1	3.5e-05	3.7
B2	3.7e-05	3.5
F2	1.5e-05	8.6
B3	1.3e-05	10
F3	4.7e-06	27
B4	5.8e-06	22
F4	1.9e-06	68
B5	3.3e-06	39
F5	1.3e-06	100

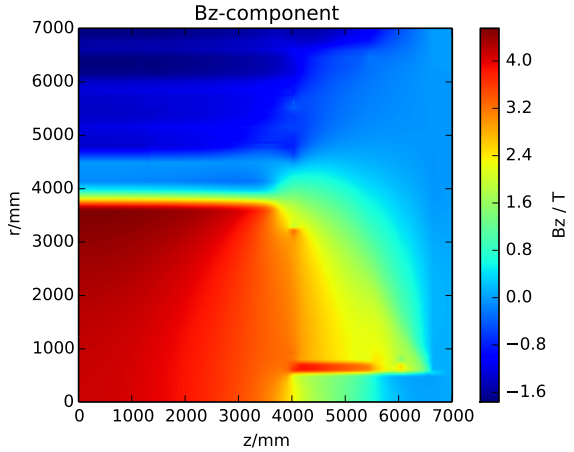
- In addition, hits from $\gamma\gamma \rightarrow$ hadrons
- Much smaller differences between B and F of the same layer. $B \approx 2.5 \times F$

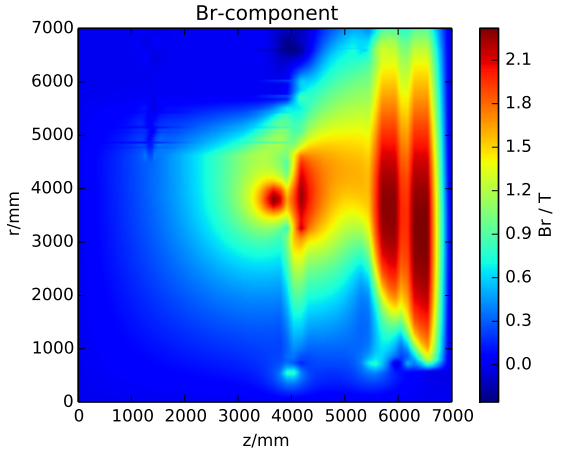
Field maps (old vs. new)

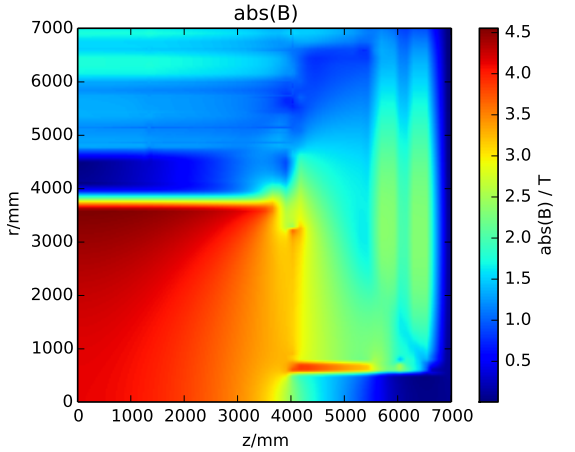










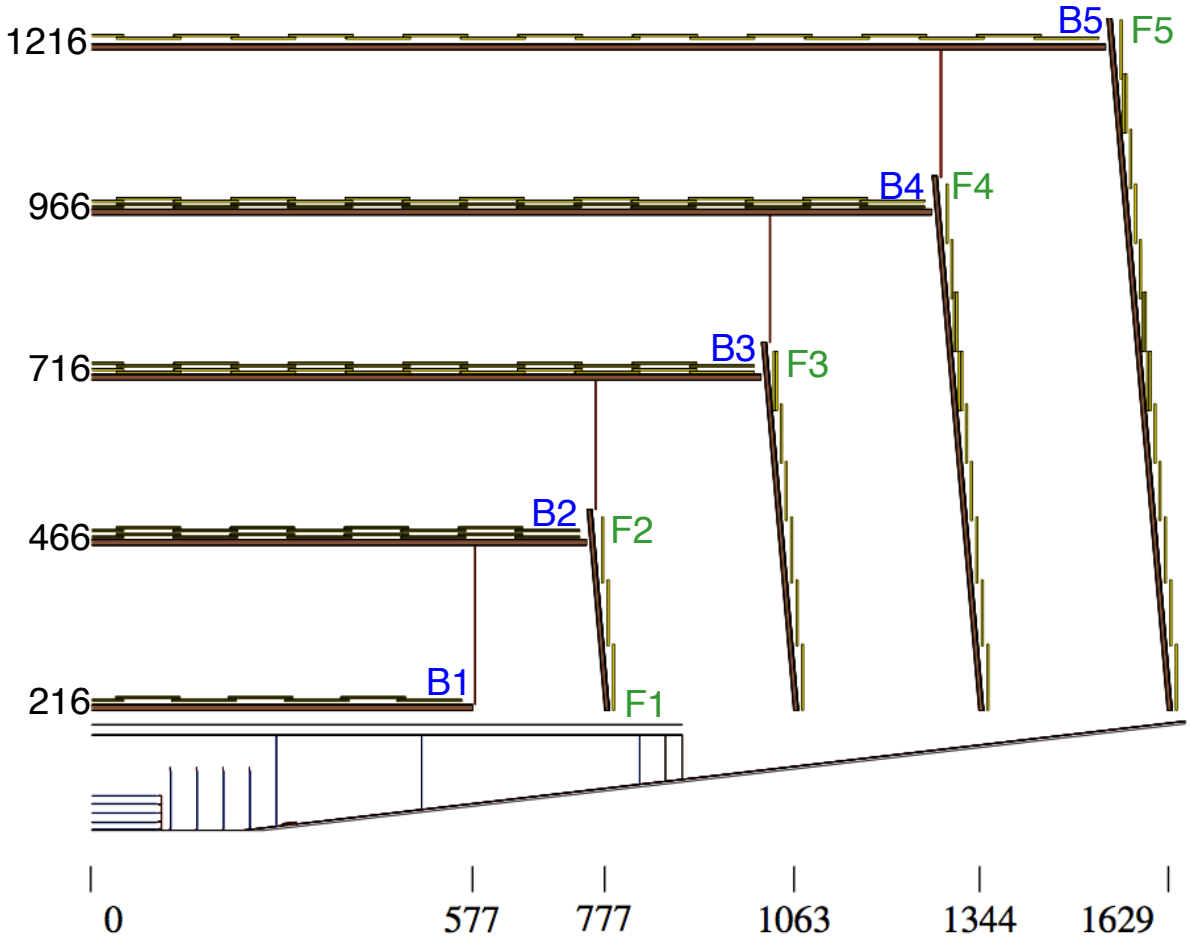


Summary & next steps

- Summary
  - Implemented a SiD-like tracker in mokka simulation framework, starting from CLIC_ILD_CDR model
  - Background hit densities within $\approx$ factor 2 to previous studies
  - Uncertainties may still be large, so far we considered less than two bunch trains
- Next steps
  - Update plots with higher statistics
  - Use new magnetic field map
  - Implement more realistic endcap discs (support material, segmentation,...)
  - Investigate $\gamma\gamma \rightarrow$ hadron background
  - Technical detail: currently, all our changes are hardcoded into the geometry drivers. Transfer them to database and use official mokka version.

Backup

Hit rates CLIC_SiD w/o digitization

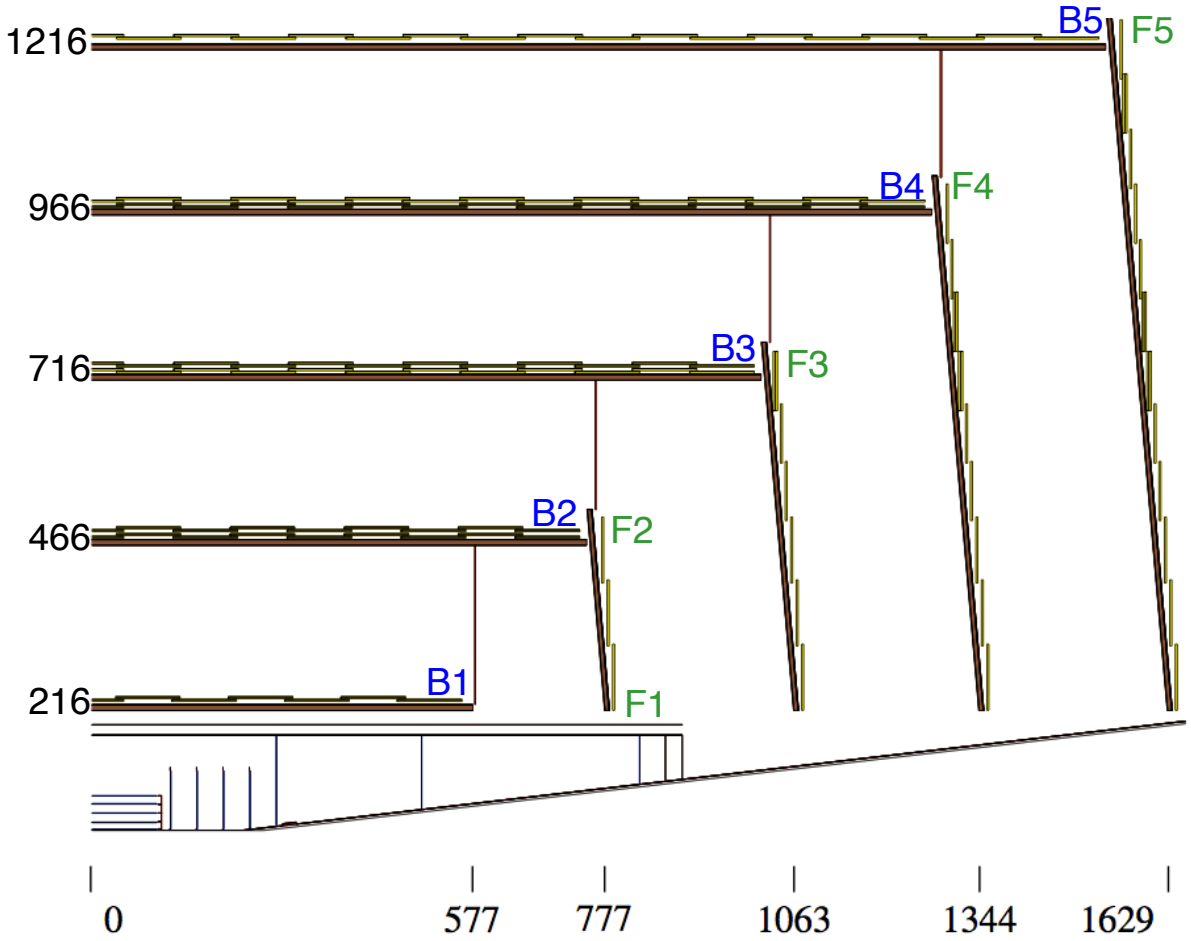


Place	pairs [hits/ mm²/bx]	gghad [hits/ mm²/bx]	max stripl. [mm]
B1	1.6E-4	2.7E-5	0.8
F1	1.1E-4	8.0E-5	0.9
B2	4.1E-5	6.6E-6	3.0
F2	3.3E-5	1.2E-5	3.4
B3	1.9E-5	2.7E-6	6.3
F3	1.5E-5	5.0E-6	7.5
B4	1.1E-5	1.6E-6	10.8
F4	8.0E-6	2.0E-6	14.6
B5	6.8E-6	1.0E-6	17.7
F5	5.0E-6	1.1E-6	23.6

- Raw particle hit rates from Geant4 with energy threshold of 1/5 MIP
- includes geometry correction factor for barrel layers to account for overlap (~0.6-0.7)
- Max. strip length for 3% train occupancy, 50 um strip pitch, including:
  - safety factor of 5 (2) for incoh. pairs (gghad)
  - cluster size 3

Pair forward disk (F) hit rates ~2x smaller than for barrel (B) layers
→ effect of curlers (note: large contribution from backscatters)
For gg→hadrons not observed, not understood

Hit rates CLIC_SiD after clustering



Place	pairs [hits/ mm²/bx]	gghad [hits/ mm²/bx]	max stripl. [mm]
B1	8.2E-5	2.3E-5	1.4
F1	2.0E-5	5.0E-5	3.2
B2	2.6E-5	5.0E-6	4.6
F2	4.0E-6	9.0E-6	16.9
B3	1.3E-5	1.9E-6	9.4
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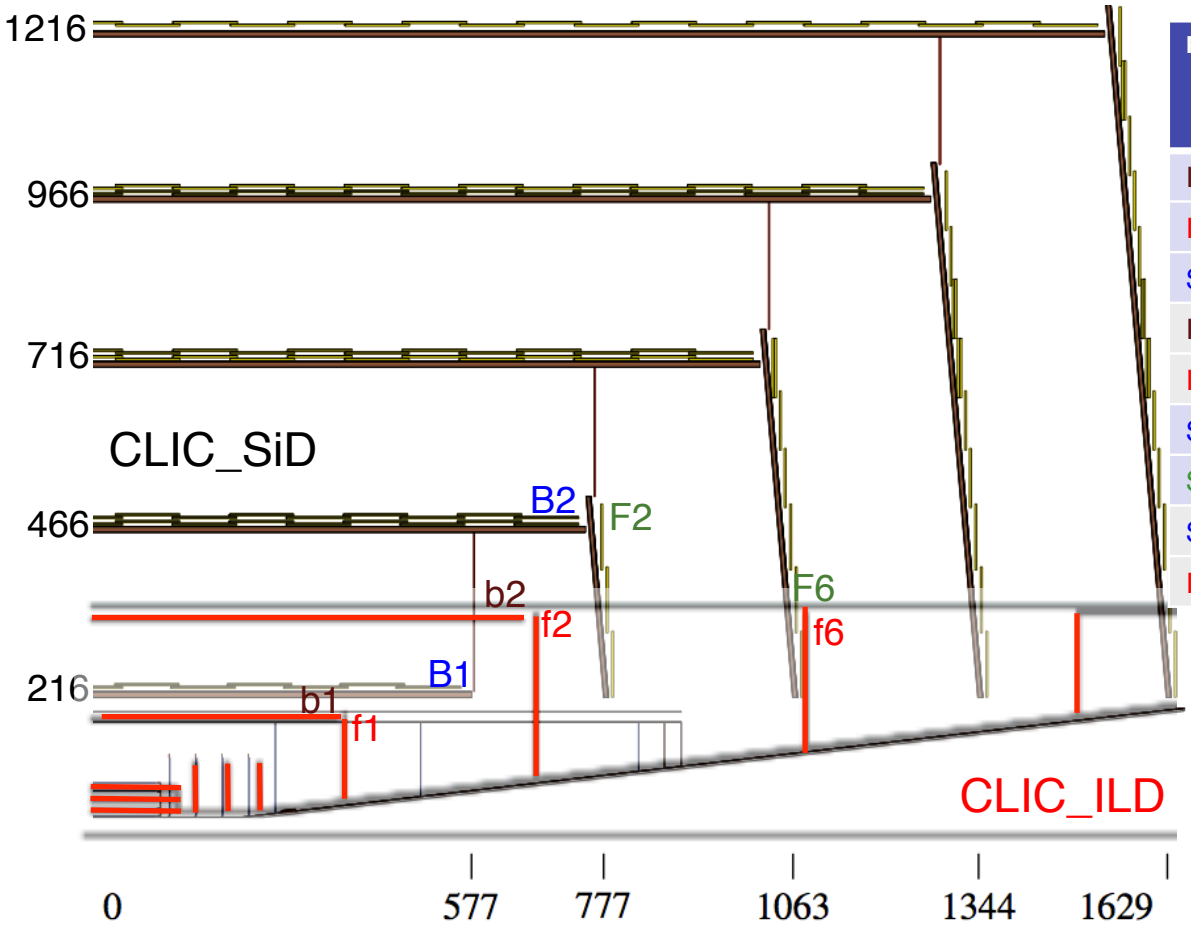
B5	4.8E-6	7.6E-7	25.0
F5	8.0E-7	6.0E-7	123

- Hit rates after digitization per bx and reco (1 cluster = 1 hit)
- includes geometry correction factor for barrel layers to account for overlap (~0.6-0.7)
- Max. strip length for 3% train occupancy, 50 um strip pitch, including:
  - safety factor of 5 (2) for incoh. pairs (gghad)
  - cluster size 3

up to 2-5 times lower hit rates than w/o digitization
pair forward hit rates ~5-10x smaller than for barrel layers
→ not understood

Hit rates CLIC_SiD vs. CLIC_ILD



Place	pairs [hits/ mm²/bx]	gghad [hits/ mm²/ bx]	max stripl. [mm]
ILD-b1	6.0E-5	8.5E-5	1.4
ILD-f1	4.5E-5	4.1E-5	2.1
SiD-B1	1.6E-4	2.7E-5	0.8
ILD-b2	4.0E-5	3.2E-5	2.4
ILD-f2	2.1E-5	1.5E-5	4.8
SiD-B2	4.1E-5	6.6E-6	3.0
SiD-F2	3.3E-5	1.2E-5	3.4
SiD-F6	4.0E-5	2.5E-5	2.6
ILD-f6	2.0E-5	1.7E-5	4.8

- Raw particle hit rates from Geant4 with energy threshold of 1/5 MIP
- includes geometry correction factor for SiD barrel layers, to account for overlap (~0.6-0.7)
- Max. strip length for 3% train occupancy, 50 um strip pitch, including:
  - safety factor of 5 (2) for incoh. pairs (gghad)
  - cluster size 3

Larger pair rates in barrel than in forward disks (both SiD and ILD), for ILD also true for gg→had.
Difference between SiD and ILD ~factor 2, for similar regions (note: B_{SiD}=5 T vs. B_{ILD}=4 T)

Summary: background rates

- rather large differences (factor of >~2) in hit-rate estimates between CLIC_SiD and CLIC_ILD
  - SiD has higher rates from incoherent pairs (possibly due to more back scatters)
  - Different rates for gg→hadrons observed, without clear trend ILD vs. SiD
- two different methods for estimating tracker hit rates for CLIC_SiD do not agree
- further full-simulation and optimization studies needed,
  to reduce hit rates and improve uncertainty on hit-rate estimates
  → optimization of forward region
  → influence of realistic B-field
- current level of understanding not sufficient for making technology choice

- Preliminary conclusions:
  - innermost barrel and forward tracking layers probably not suited for micro-strip technology (wire bonding)
    (for 3% max. occupancy, 50 µm r/o pitch: 0.8-2 mm length)
    → ~3 m^2 additional area for CLIC_SiD to be equipped with pixel technology (bump bonding),
    not necessarily the same technology as in vertex detector
  - for outer layers strips of 3-30 mm and 50 µm readout pitch could be envisaged,
    ~74 m^2 total area
  - note: for the CLIC_ILD design the maximum strip length at the inside of the forward layers would be significantly smaller (see backup slide 21)