ILD and SiD Detector Concepts for CLIC

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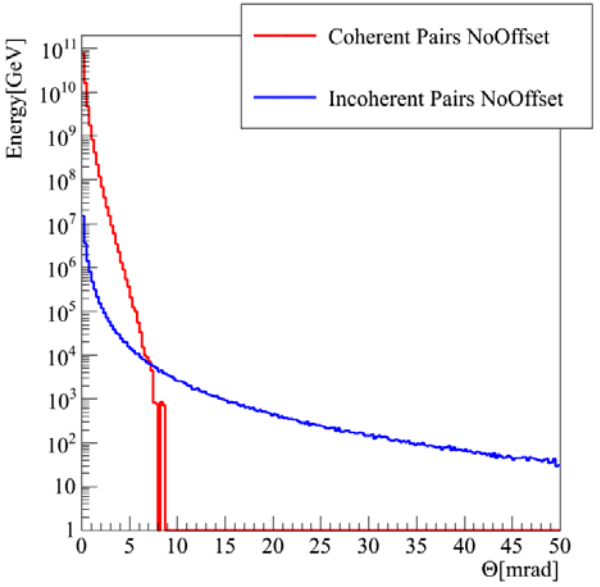
Outline

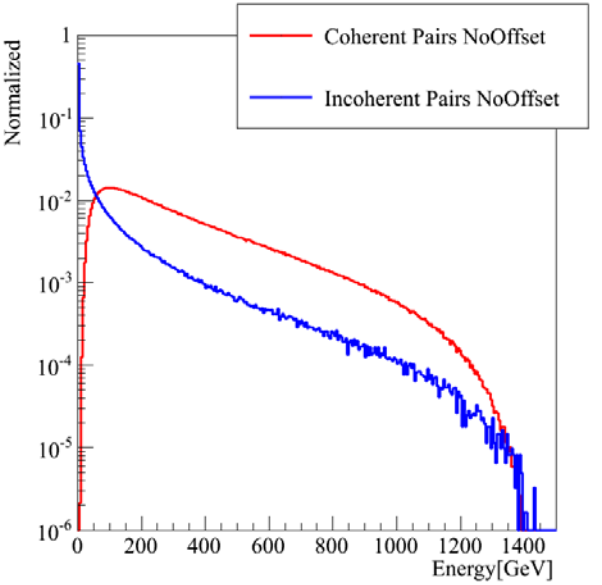
- Required changes
  - Vertex detectors and forward region
  - Calorimeters
  - MDI
- Status of detector models
  - CLIC_ILD
  - CLIC_SiD

Detector models presented are not yet fully finalized for the CDR

Vertex Detector & Forward Region

- Crossing angle: 20mrad (14 mrad @ ILC)
- Beam-beam interactions produce photons and e^+e^- pairs
  - coherent pairs with high energies and low angles, can be confined by magnetic field and leave the through the beam pipe
  - incoherent pairs with high angles and low energies per particle (~300k per BX)



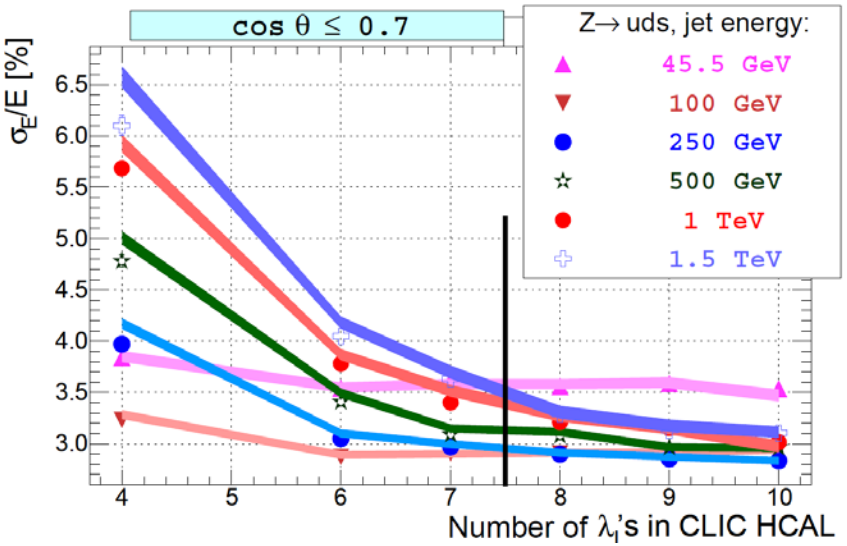


André Sailer

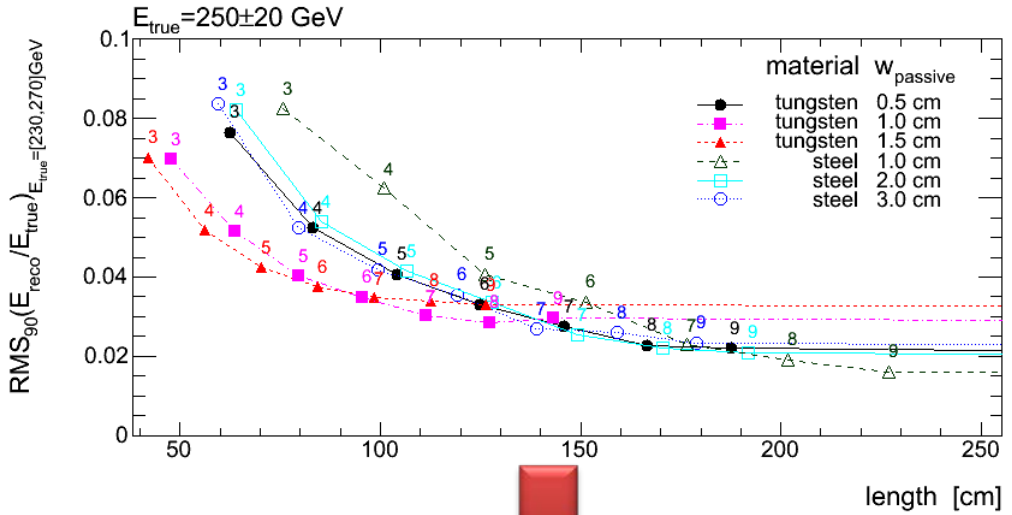
• Move beam pipe and first vertex layer to ~30 mm to reduce direct hits from pair background
• Increase outgoing beam pipe radius to 10 mrad (r_{min} BeamCal)
• Allow space for intra-train-feedback-system and kickers between BeamCal and QD0

- Need good jet energy resolution up to TeV jets
  - increase HCal depth to contain energetic showers
  - keep coil size reasonable (cost & feasibility)

→ tungsten HCal



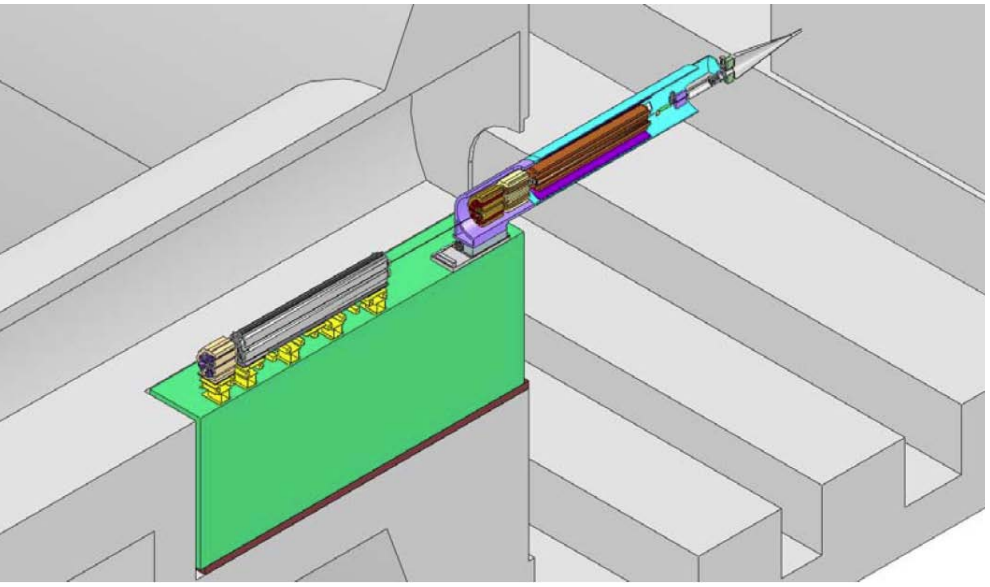
HCal depth studies with Pandora PFA
(see talk by Angela Lucaci-Timoce)



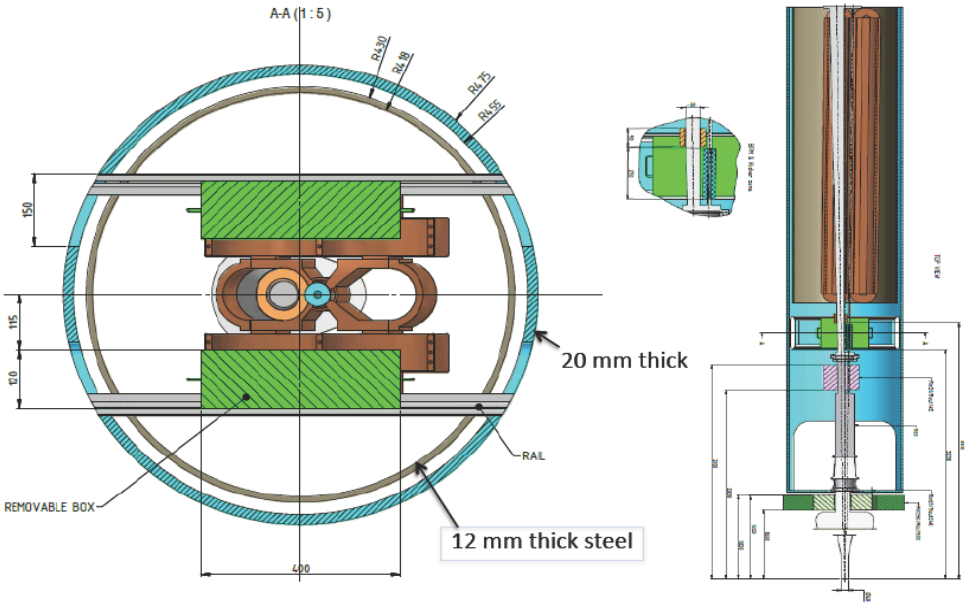
Optimization of sampling fractions in steel or tungsten HCal
(see talk by Peter Speckmayer)

~7.5 λ_i in HCal, barrel: 75*1cm W, endcap: 60*2cm steel

- QD0 has to be stabilized with nm precision at CLIC
- Has to be as close as possible to IP to gain maximum luminosity
- Support QD0 from tunnel with a stable support tube



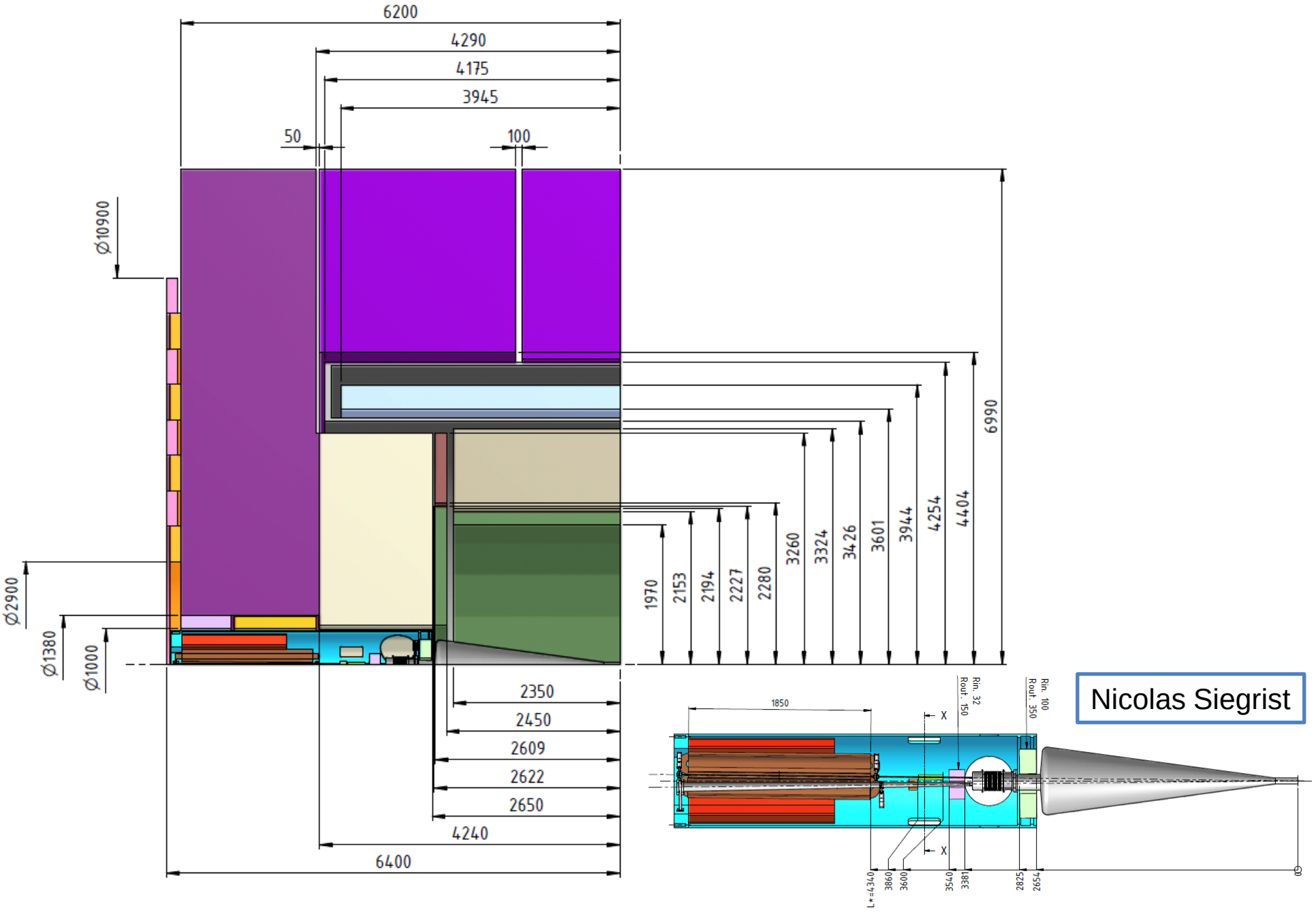
Cross-section support tube, dimensions



Hubert Gerwig

Significant cut into acceptance of HCal and Muon system:
- r_{min} HCal: ~50cm (support tube)
- r_{min} Muon System: ~70cm (support tube + anti solenoid)

CLIC_ILD Numbers



Nicolas Siegrist

CLIC_ILD in Mokka

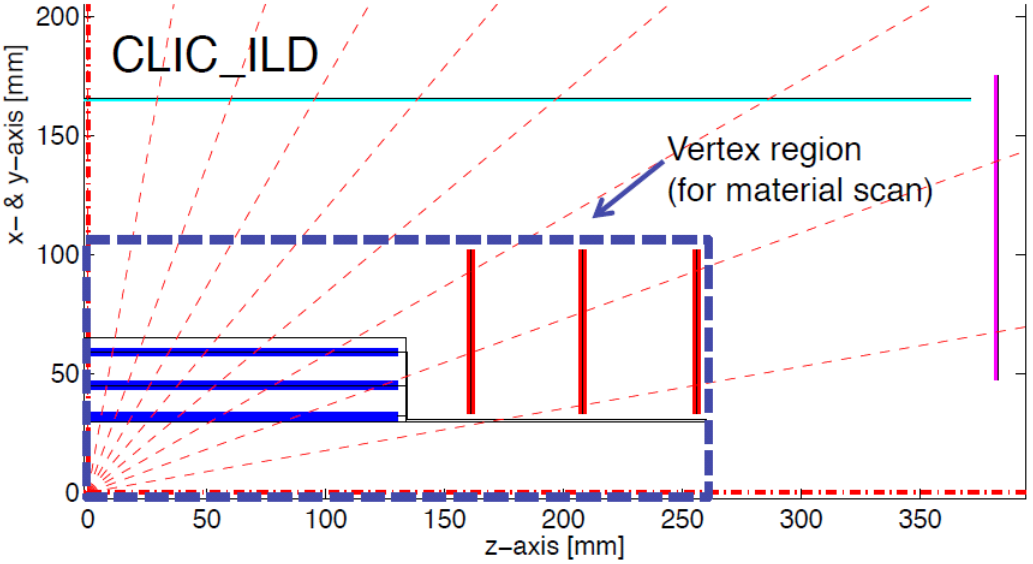
available with next Mokka release as CLIC_ILD_CDR

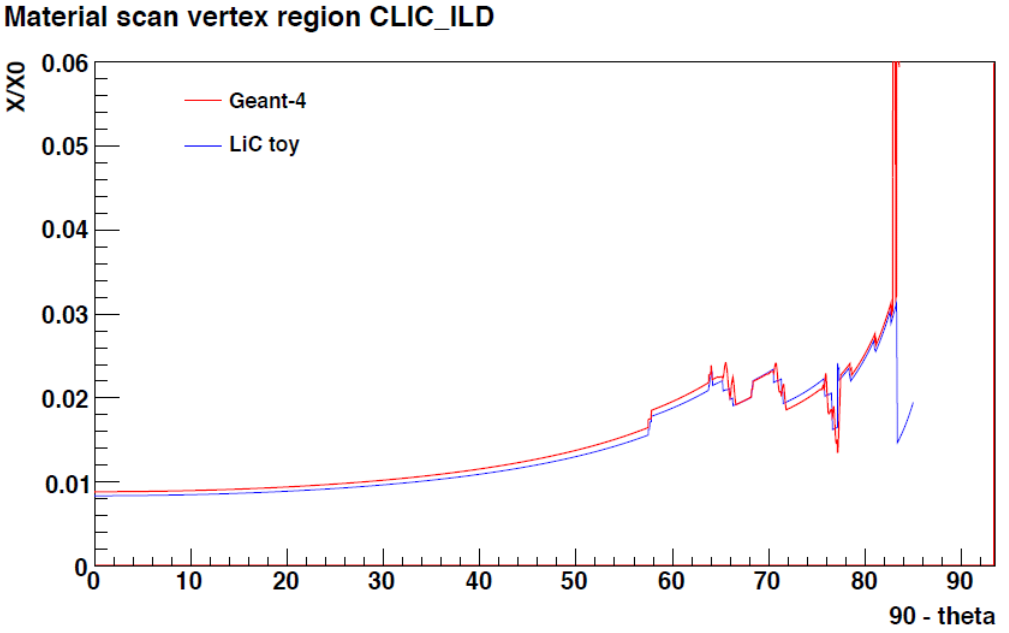
André Sailer

CLIC_ILD Vertex Detector

- 0.6 mm Be beam pipe with r_{max} = 30 mm
- 3 double pixel layers in barrel z_{max} = 100 mm
- 3 double pixel disks in endcap
- 20*20 µm² pixels with analog readout (σ = 2.8µm)
- 2*50 µm Si + 134µm Carbon support per double layer (0.18% X_0)

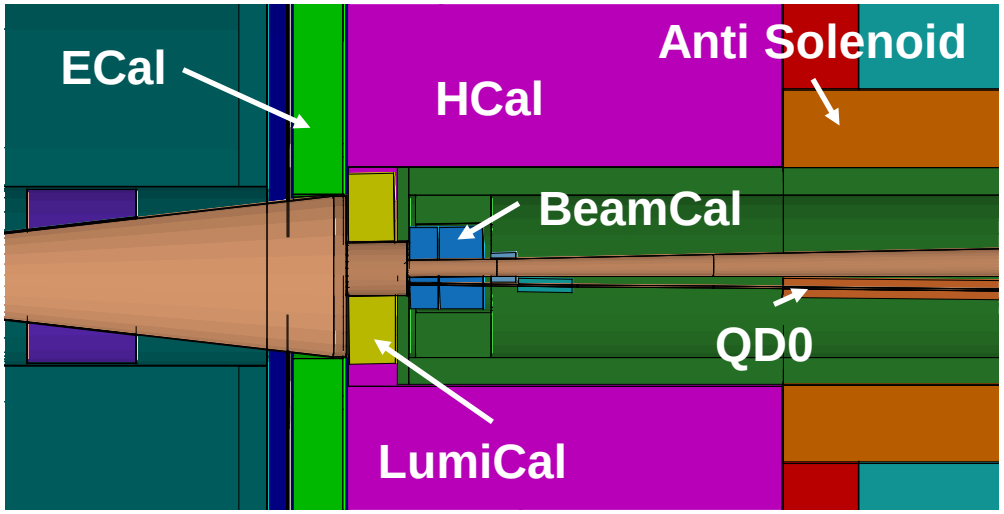
Talk on optimization study for CLIC vertex and forward tracking region by Dominik Dannheim

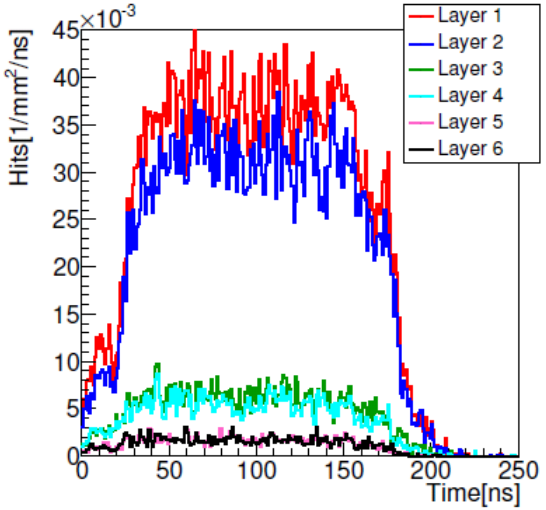




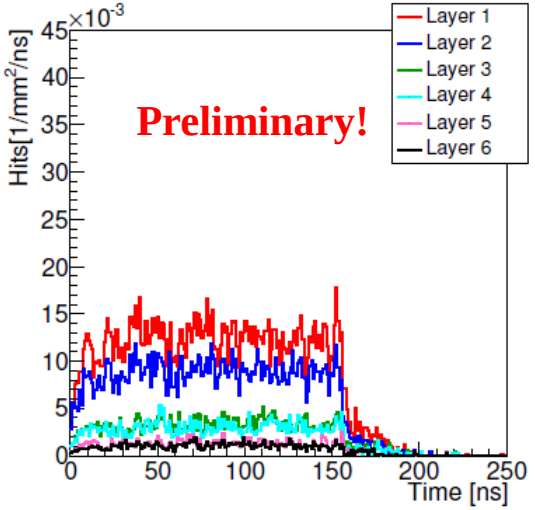
CLIC_ILD Forward Region

- Moved LumiCal behind ECal and increased radius to avoid gap, increased to 40 layers
- Removed LHCal
- Moved BeamCal as close as possible to the IP to allow for kickers and intra-train-feedback-system, increased to 40 layers
- Pair background levels in Vertex Barrel





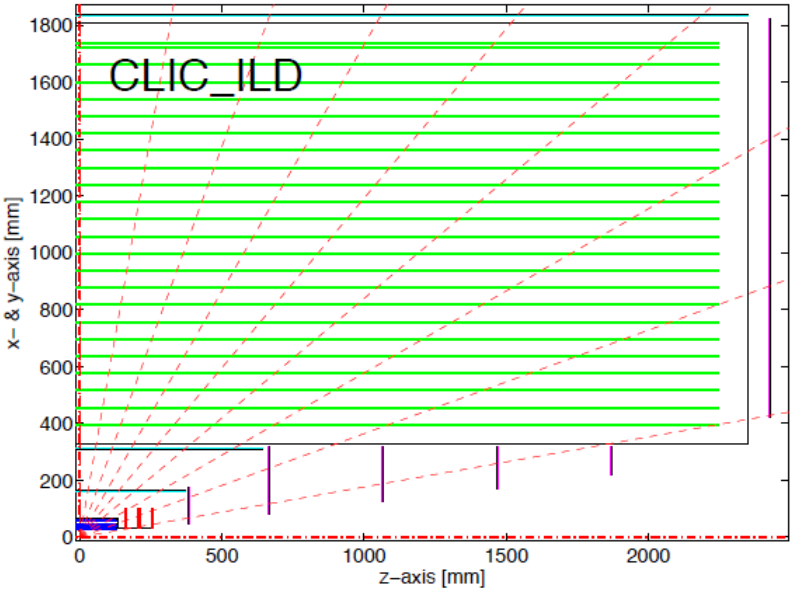
introduce more material into conical beam pipe

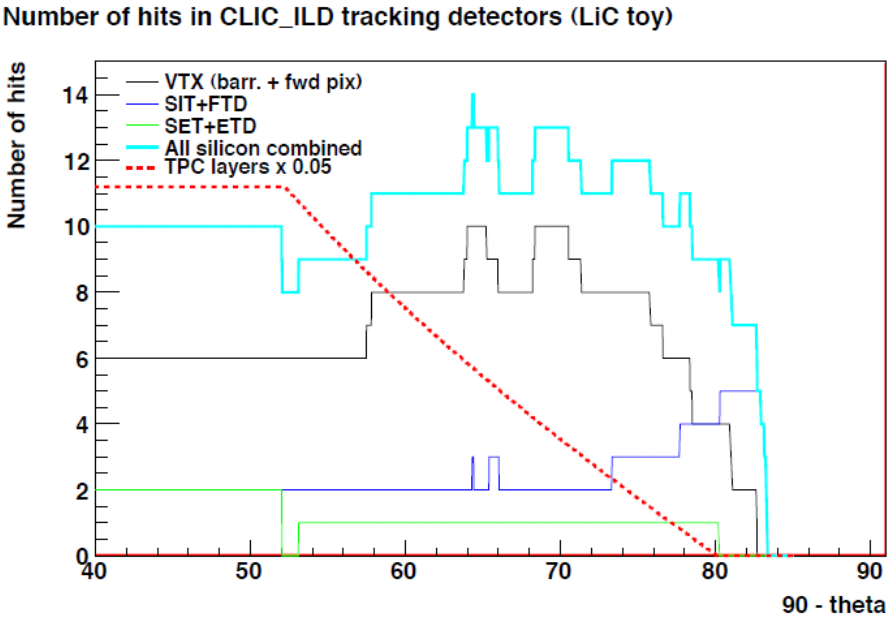


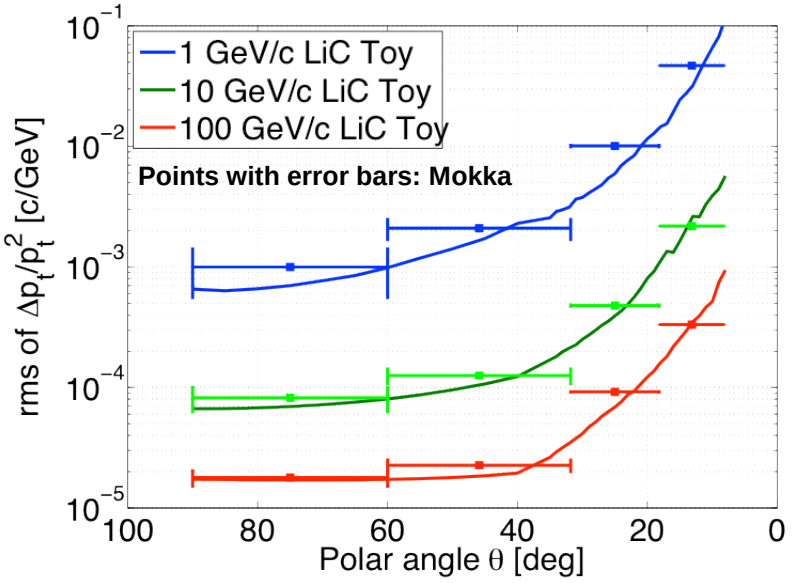
see talk on beam-beam-background @ CLIC by André Sailer

CLIC_ILD Tracker

- 4T solenoid field
- TPC as main tracking device
  - changed cathode: removed air gap and use 100 µm Mylar + 10 µm copper on each side
- Si strip layers inside and outside of the TPC (2 layers SIT & SET, $\sigma_{r\text{-}\varphi}$ = 7µm, σ_z = 50µm)
- Si strip layers behind TPC endcap (ETD, $\sigma_{x,y,z}$ = 7µm)
- 5 forward tracking disks (FTD, Si stereo strips, $\sigma_{r\text{-}\varphi}$ = 7µm, σ_r = 50µm)



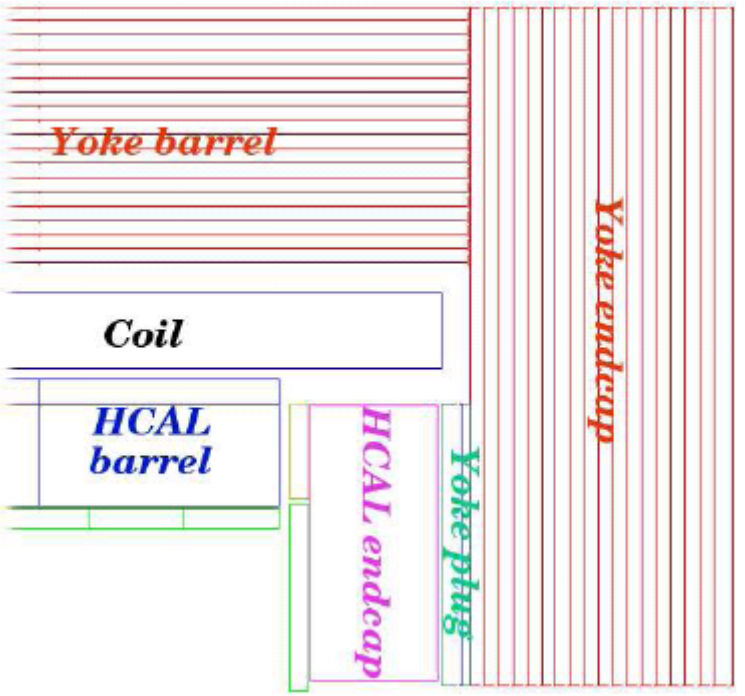




Dominik Dannheim

CLIC_ILD Calorimeters

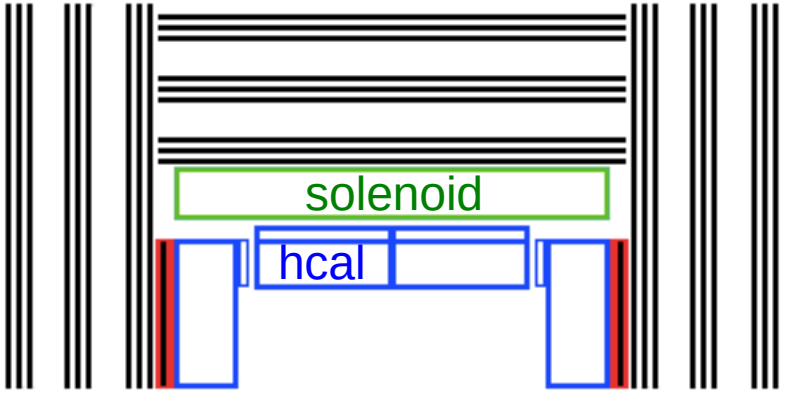
- ECal (8 sides)
  - Absorbers:
    - 20*2.1 mm tungsten absorber layers
    - 10*4.2 mm tungsten absorber layers
  - Active:
    - 3.15 mm gap size (0.3 mm Si + Air, Copper Capton), 5*5 mm² readout
- HCal (8 sides inside, 16 sides outside)
  - Barrel: 75*10mm tungsten
  - Endcap: 60*20mm steel
  - Active: 6.5 mm gap size (5 mm polystyrene + 1.5 mm air), 3*3 cm² cell size

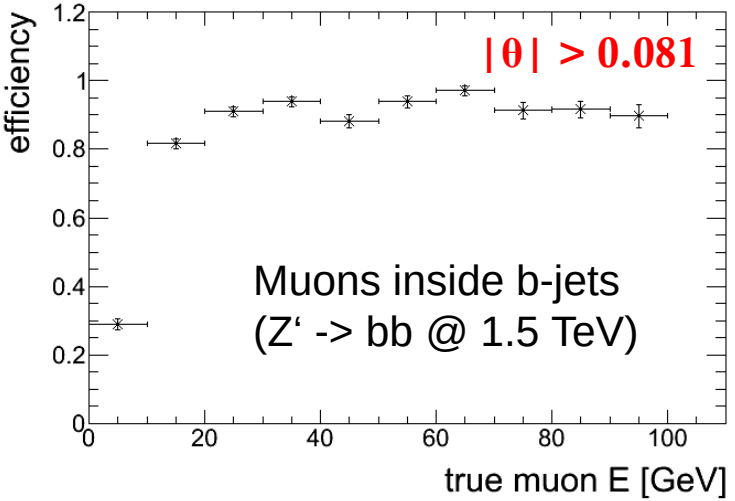


• Analog readout for the HCal was chosen as a baseline for mass production
• Alternative technologies will be investigated in dedicated studies and presented in the CDR

CLIC_ILD Muon System & Yoke

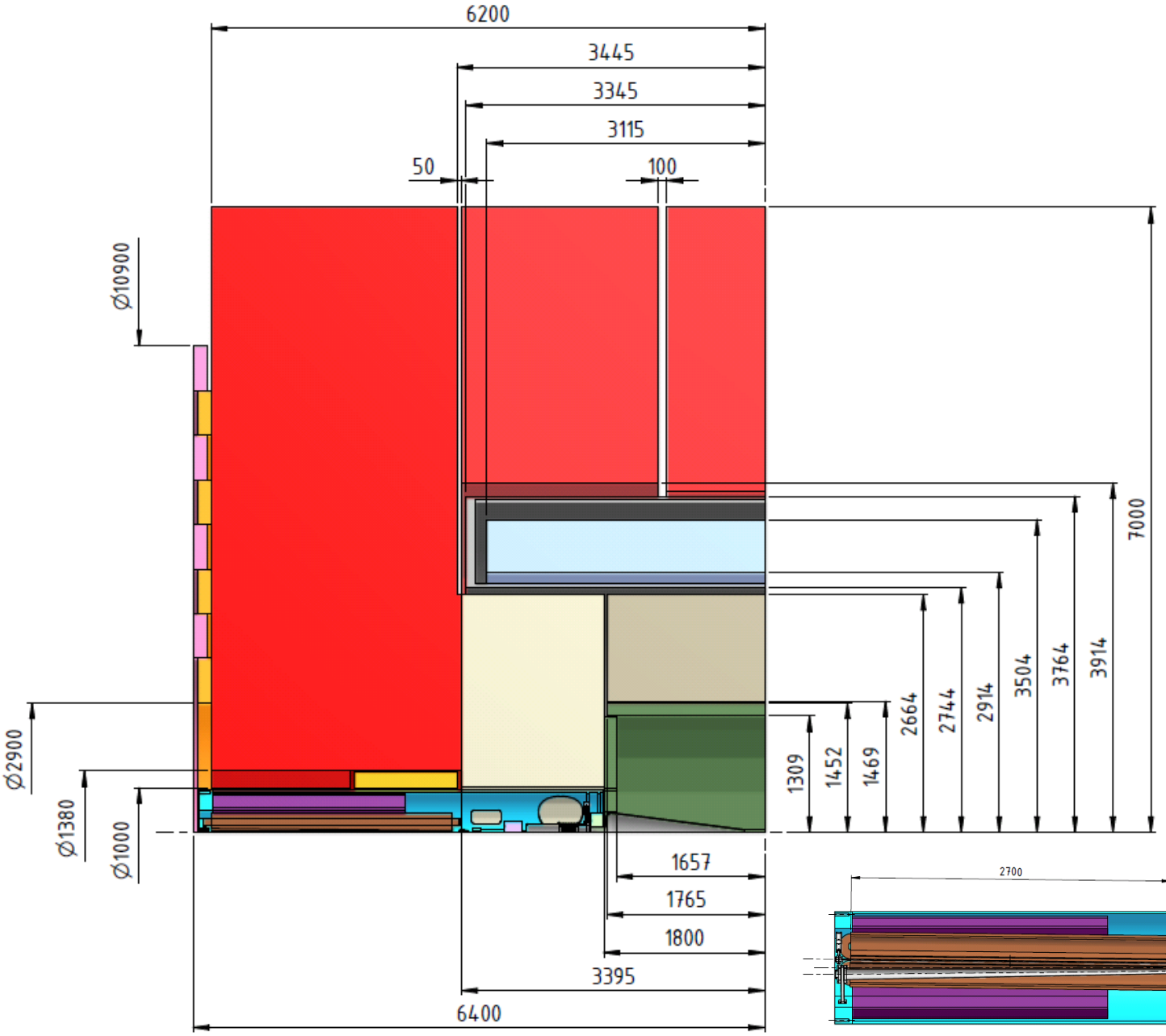
- Yoke (8 sides)
  - Absorber: 15*10 cm steel
  - Active: 4cm gap size (RPC 3*3 cm²)
  - Barrel: 20 cm steel layer after first active layer to take stresses
- Yoke Plug (12 sides)
  - Introduced in order to align start of yoke in the endcap with end of the conductor
  - Instrumented with first muon chamber: 15 cm steel + 4 cm RPC + 9 cm steel
- Choose active layers during digitization
  - First 3 layers are used as a tail catcher
  - Simulations indicate that two additional sets of 3 layers provide good Muon ID



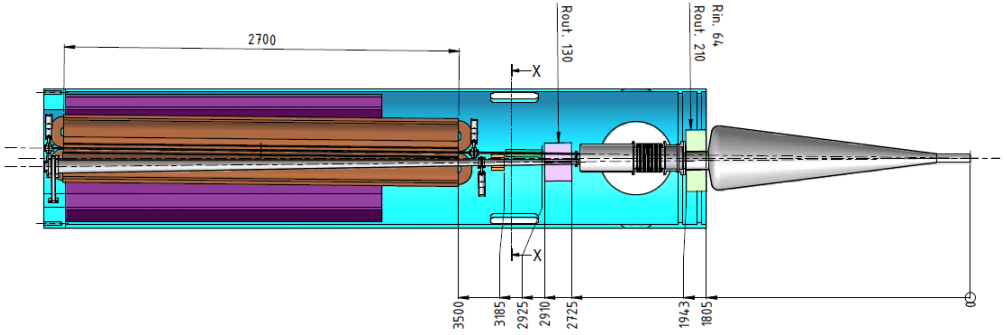


talk on Muon ID using PandoraPFA
by Erik van der Kraaij

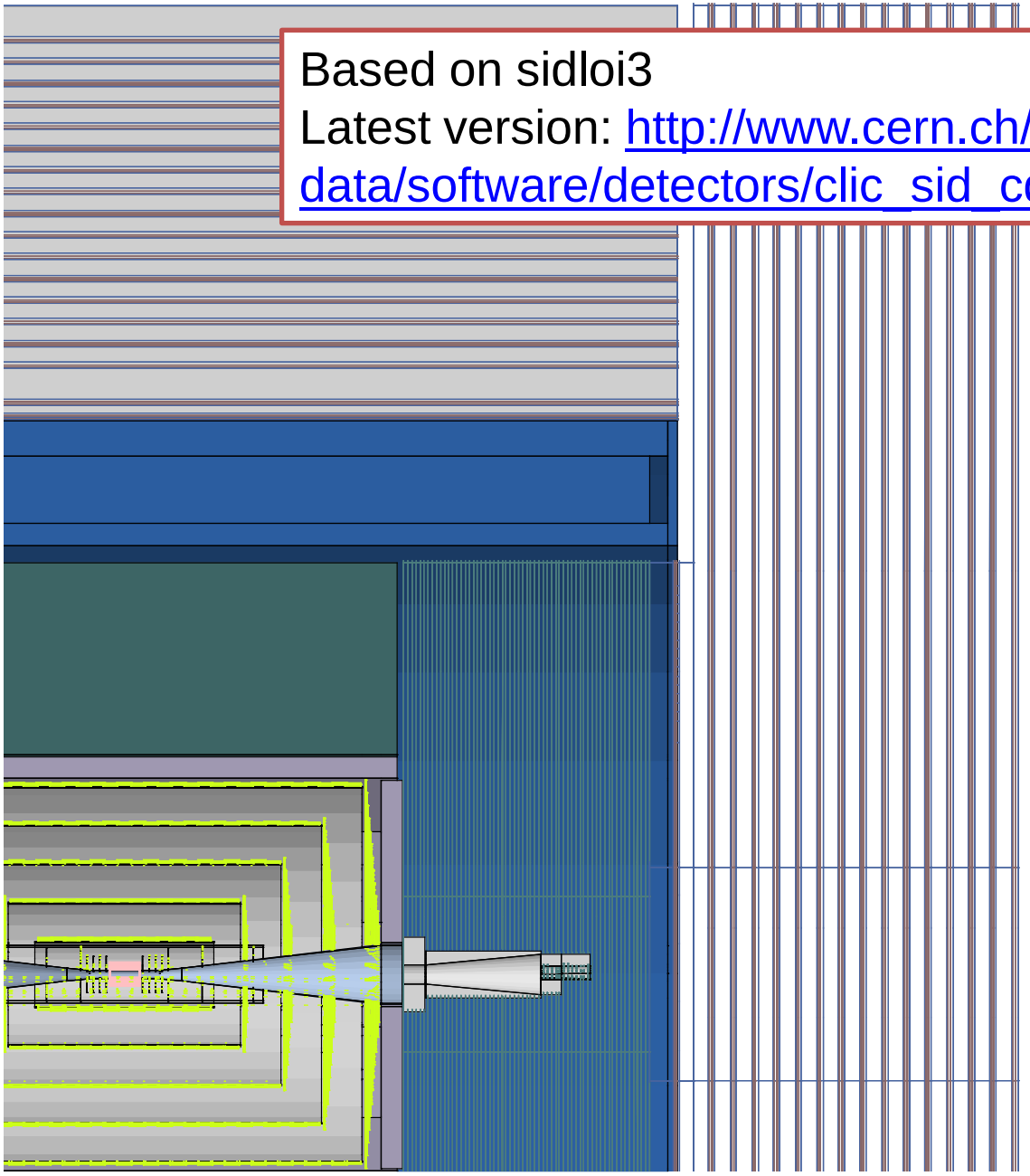
CLIC_SiD Numbers



Nicolas Siegrist

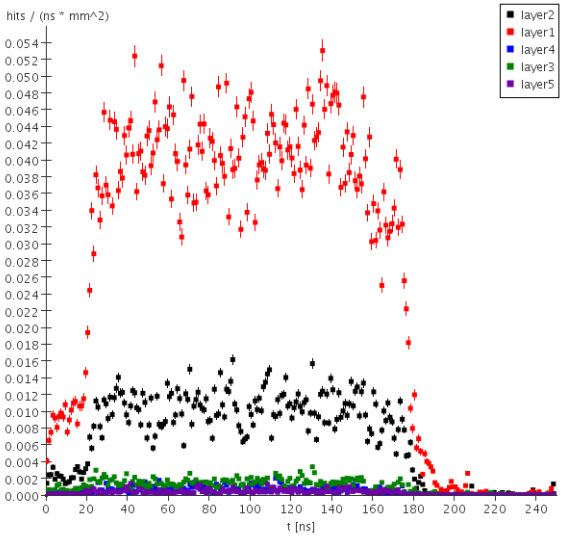


CLIC_SiD in SLIC

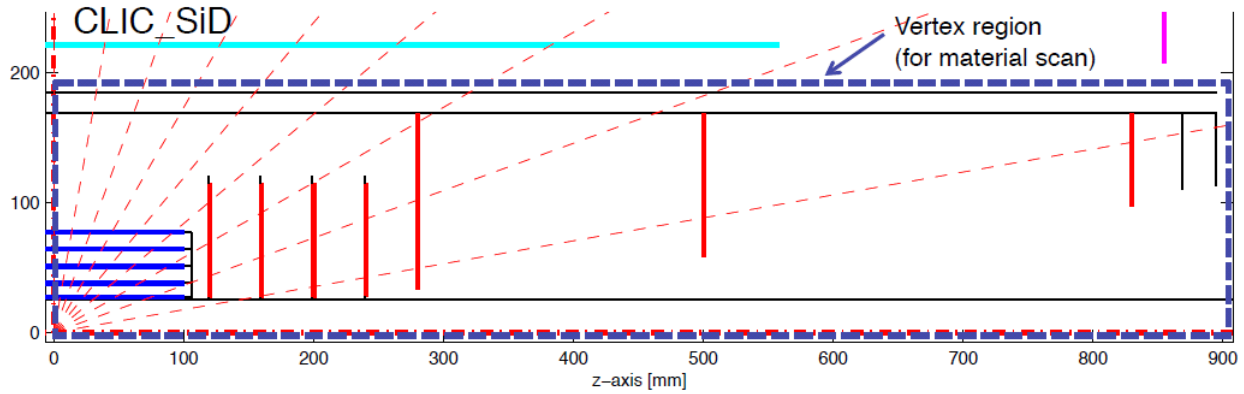


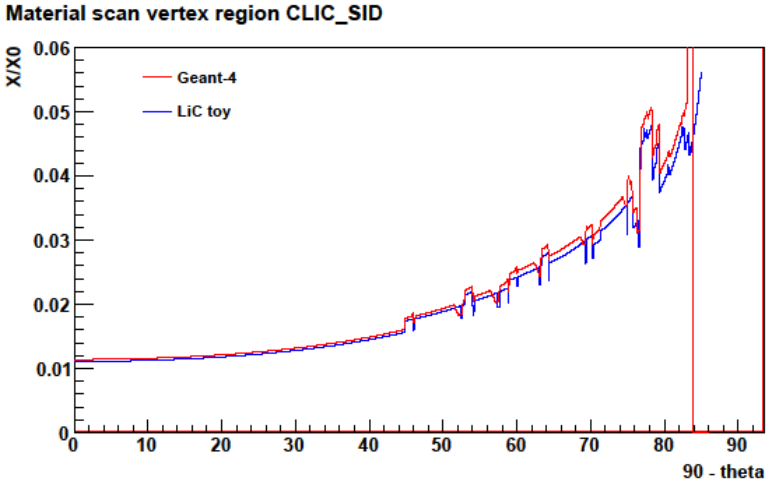
Based on sidloi3
Latest version: http://www.cern.ch/lcd-data/software/detectors/clic_sid_cdr_a.zip

CLIC_SiD Vertex Detector



- 0.5 mm Be beam pipe with r_{max} = 25 mm
- removed titanium coating inside beam pipe
- 5 pixel layers in barrel (z_{max} = 100 mm)
- 7 pixel disks in endcap and forward
- 20*20 µm² pixels with digital readout
- 50 µm Si + 130µm Carbon support per double layer (0.12% X_0)
- first pair background simulations in agreement with results from detailed studies in CLIC_ILD

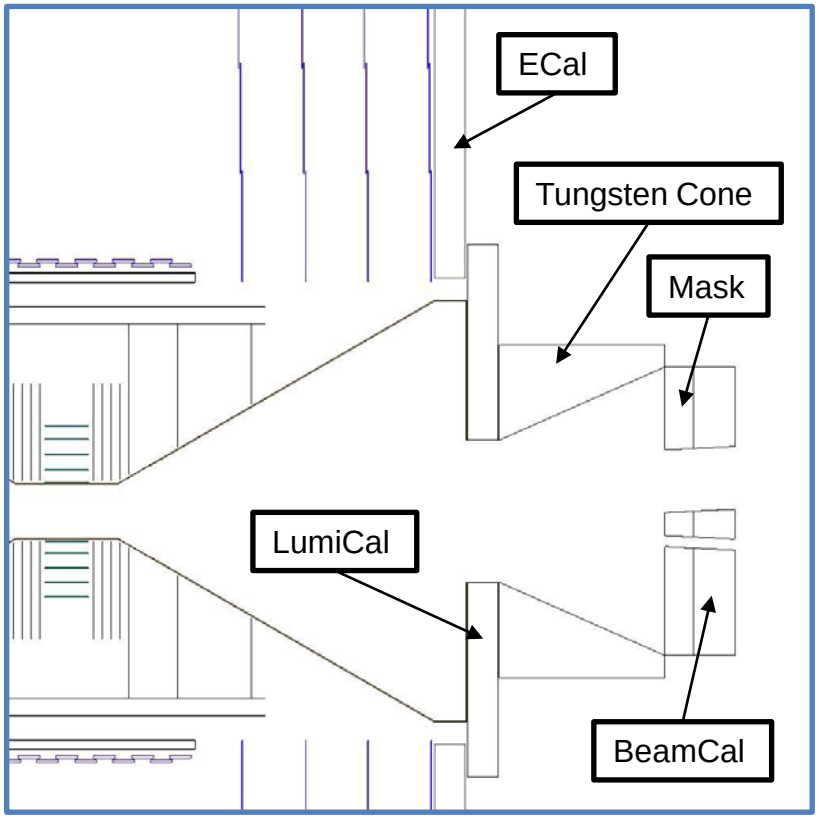




Dominik Dannheim

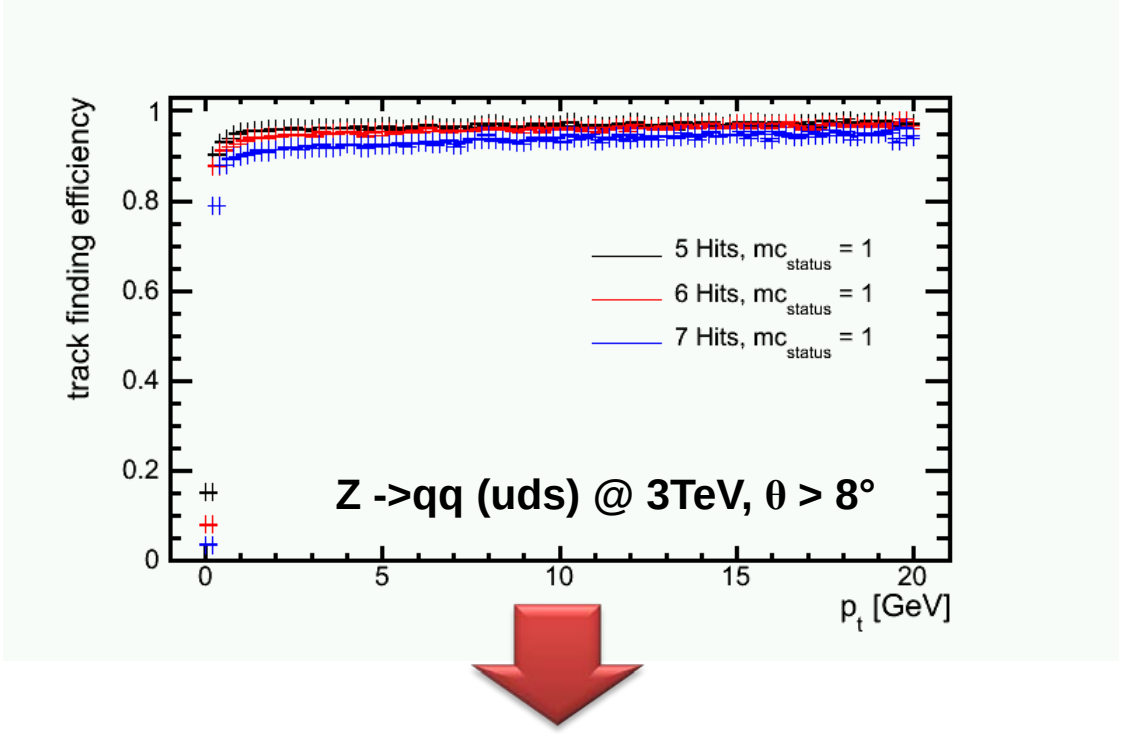
CLIC_SiD Forward Region

- “almost” pointing beam pipe to avoid passing material in a shallow angle
- LumiCal:
  - implemented like ECal
  - 20*2.7 mm + 10*5.4 mm layers tungsten
  - 1 mm gap size (0.3 mm Si + Air, Copper Capton), 3.5*3.5 mm² readout
  - moved LumiCal behind ECal to avoid gap
- BeamCal:
  - 50*2.7 mm tungsten + 1mm gap size
  - increase outgoing beam pipe opening to 10 mrad
  - ~50 cm space for kicker and intra-train-feedback between BeamCal and QD0 (L*=3.5 m)

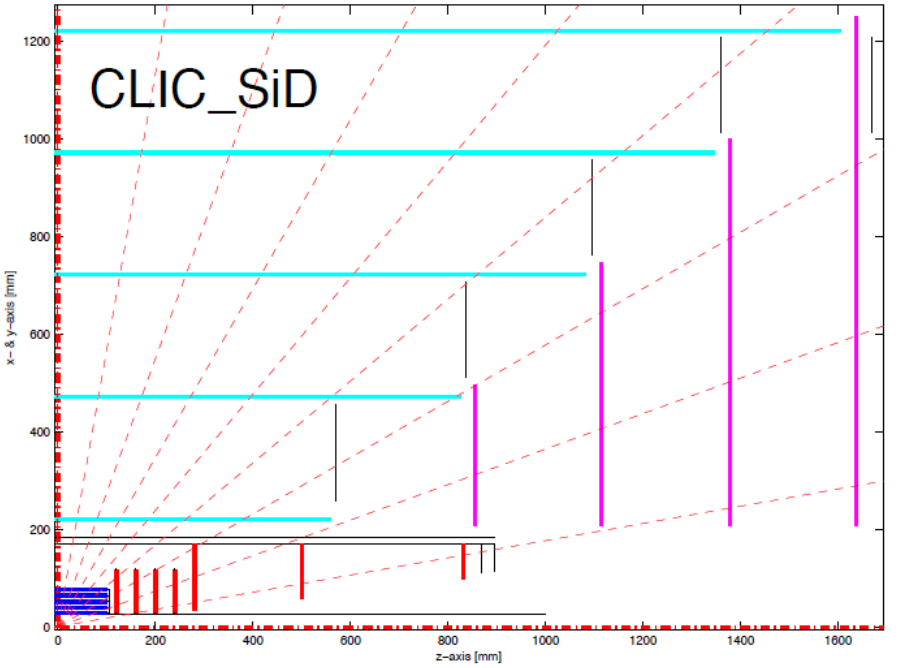


CLIC_SiD Tracker

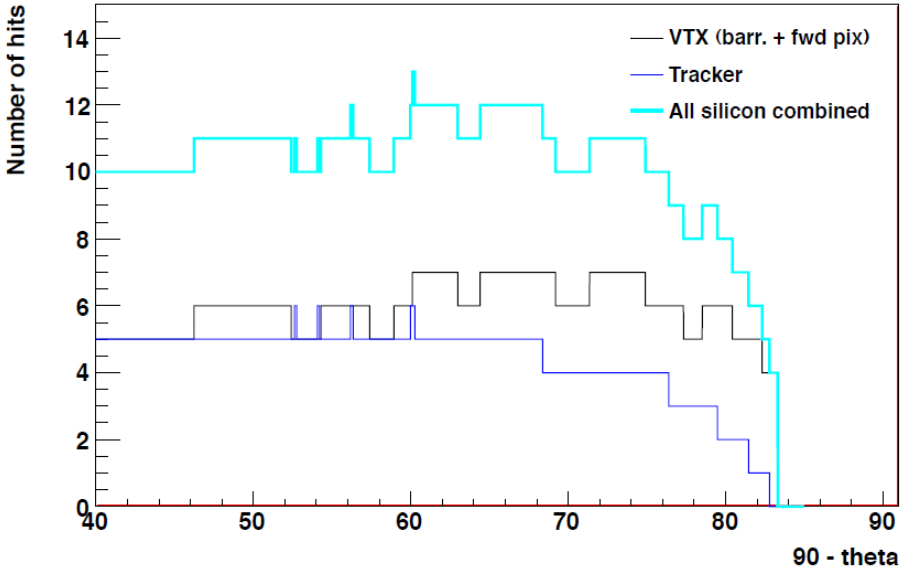
- 5T solenoid field
- 5 barrel strip layers (10cm * 25µm with 50µm digital readout)
- 4 endcap stereo strip layers (10cm * 25µm with 50µm digital readout)



talk on SiD tracking performance @ CLIC by Blai Pié i Valls



Number of hits in CLIC_SiD tracking detectors (LiC toy)



CLIC_SiD Calorimeters

- ECal (12 sides)
  - Absorbers:
    - 20*2.5 mm tungsten absorber layers
    - 10*5.0 mm tungsten absorber layers
  - Active:
    - 1.25 mm gap size (0.3 mm Si + Air, Copper Capton), 3.5*3.5 mm² readout
- HCal (12 sides)
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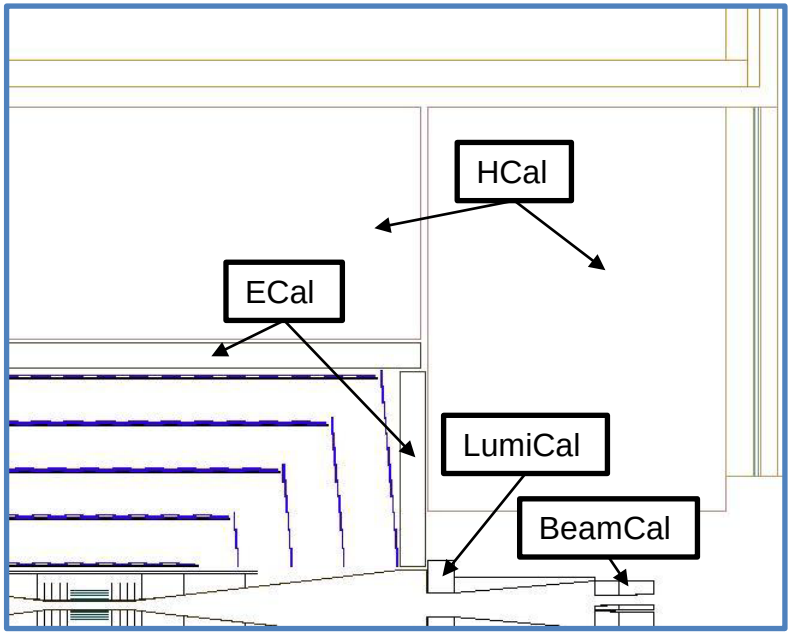

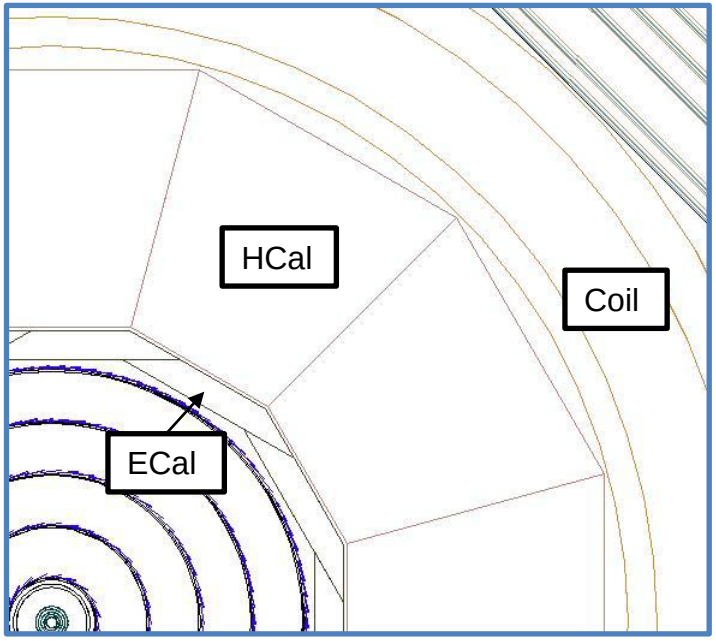

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CLIC_SiD Muon System & Yoke

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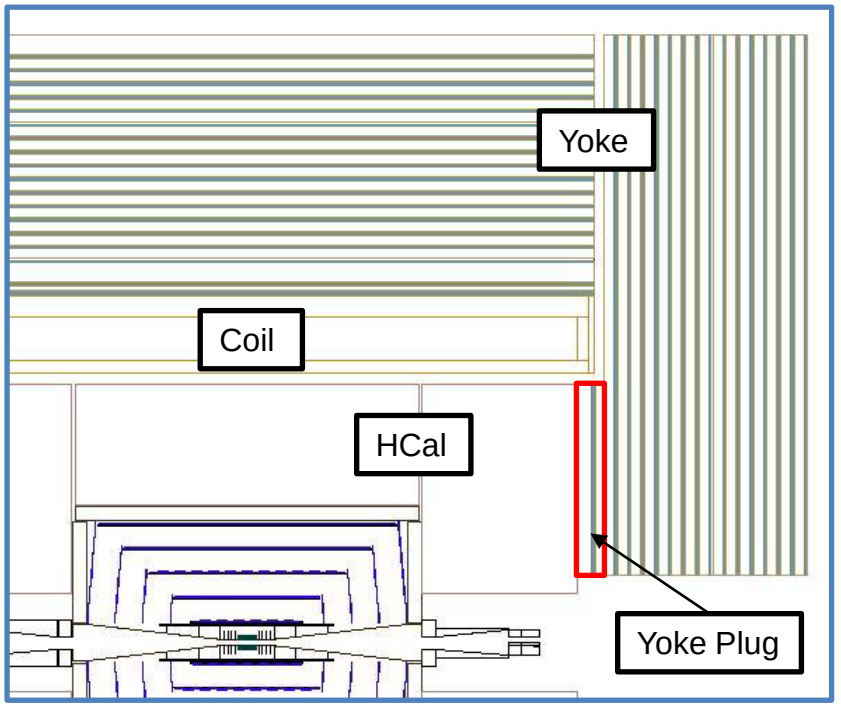
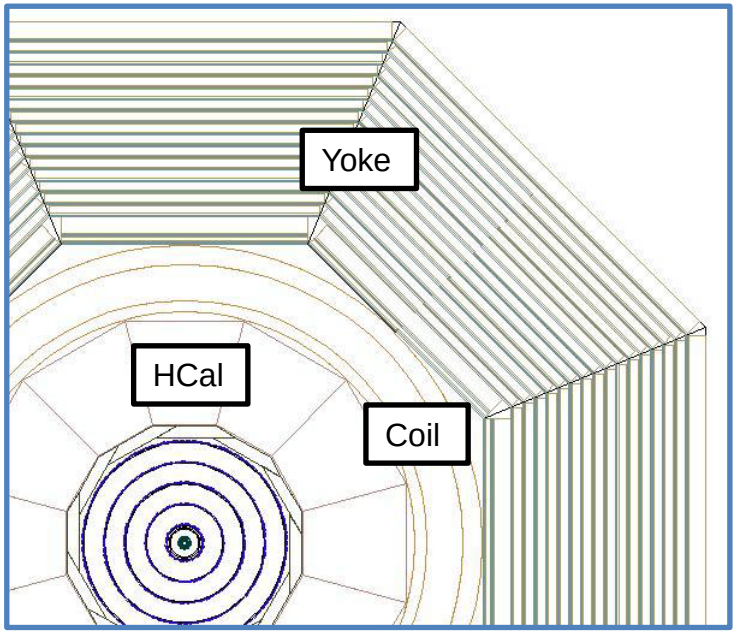
  - Active: 4cm gap size (RPC 3*3 cm²)
  - Barrel: 20 cm steel layer after first active layer to take stresses
- Yoke Plug (12 sides)
  - Introduced in order to align start of yoke in the endcap with end of the conductor
  - instrumented with first muon chamber: 15 cm steel + 4 cm RPC + 9 cm steel
- Number of actually used layers defined during digitization
  - 3 sets of 3 active layers (see above)





Conclusions

- The two detector models CLIC_ILD and CLIC_SiD for the CDR simulations are almost finalized but might still change a bit
- Thorough testing of all subdetectors is ongoing

- Reference for detector parameters: https://twiki.cern.ch/twiki/bin/view/CLIC/ClicCDRNumbers

- Detector models for full simulation (currently latest version)
  - CLIC_ILD_CDR available in next Mokka release (or trunk)
  - CLIC_SiD: http://www.cern.ch/lcd-data/software/detectors/clic_sid_cdr_a.zip