ILD and SiD Detector Concepts for CLIC

International Workshop on Linear Colliders, Geneva October 21, 2010

Christian Grefe CERN, Bonn University











- 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





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





CLIC_ILD Numbers















- 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 μ m² pixels with analog readout (σ = 2.8 μ m)
- 2*50 µm Si + 134µm Carbon support per double layer (0.18% X₀)

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



Material scan vertex region CLIC_ILD







- 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-feedbacksystem, increased to 40 layers
- Pair background levels in Vertex Barrel





see talk on beam-beambackground @ 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, $\sigma_{r-\phi} = 7\mu m$, $\sigma_z = 50\mu m$)
- Si strip layers behind TPC endcap (ETD, $\sigma_{x,y,z} = 7\mu m$)
- 5 forward tracking disks (FTD, Si stereo strips, $\sigma_{r-\phi} = 7\mu m$, $\sigma_r = 50\mu m$)







Page 10





- 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

Yoke barrel			
Coil HCAL barrel	HCAI	Yek	Yoke endcup
	L endcap	te plug	



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





CLIC_SiD Numbers













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 μ m Si + 130 μ m Carbon support per double layer (0.12% X₀)
- first pair background simulations in agreement with results from detailed studies in CLIC_ILD



Page 15





- "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-trainfeedback between BeamCal and QD0 (L*=3.5 m)







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





Number of hits in CLIC_SiD tracking detectors (LiC toy)







- 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)
 - 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_SiD 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
- Number of actually used layers defined during digitization
 - 3 sets of 3 active layers (see above)







- 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: <u>https://twiki.cern.ch/twiki/bin/view/CLIC/ClicCDRNumbers</u>
- Detector models for full simulation (currently latest version)
 - CLIC_ILD_CDR available in next Mokka release (or trunk)
 - CLIC_SiD: <u>http://www.cern.ch/lcd-data/software/detectors/clic_sid_cdr_a.zip</u>