The CLICdp Optimization Process

André Sailer (CERN-EP-LCD)
On Behalf of the CLICdp Collaboration

ILD Software and Optimisation Workshop
DESY, Hamburg
February 22-26 2016

Table of Contents

1 Introduction: The CLIC CDR and Beyond

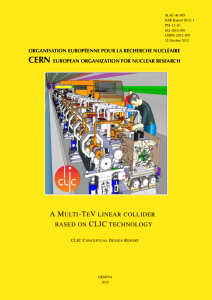
2 Sub-detector Optimisation Studies
- Vertex Detector
- Tracking
- ECal
- HCal
- Forward Region
- Magnetic Field and the Yoke

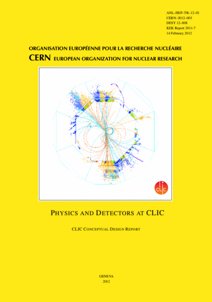
3 Summary

Studies for the CDR

- Validated ILC detector models adapted for CLIC background and energy conditions
  - Deeper HCal
  - Larger inner radius of the vertex detector
  - Changes in the very forward region
- Re-arrangement of the silicon tracker layers

Successful physics studies with both detector models and software chains





Conclusions from the CDR Studies

Some conclusions from the CDR:

- HCal endcap coverage important for physics processes at small polar angles (e.g., HHH coupling)
  - Move the QD0 outside the detector, 3.5m to 6m $L^{\star}$
- Prefer longer tracker over short detector
- Too large occupancies for a TPC to work with CLIC timing structure
  - Full Silicon tracker
- Only one detector model and one software chain

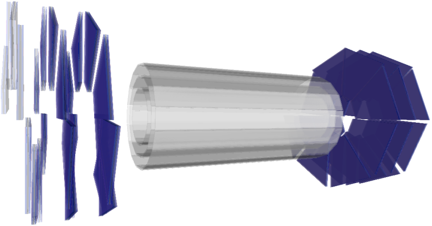
To conclude on the layout of the new CLIC detector model made several studies focusing on the issues identified

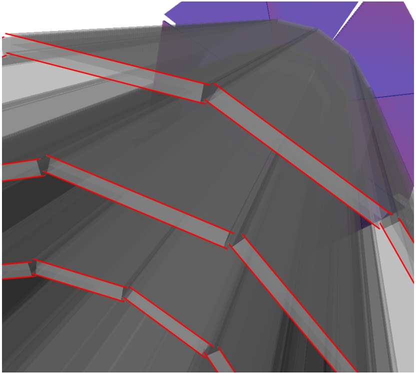
- Studies using fast simulation tools (e.g., LicToy), the CDR detector models and software, and with DBD software chain

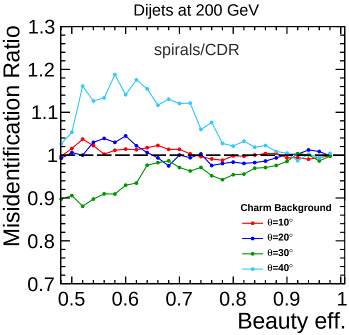
Vertex Detector Studies

Studied flavour tagging, occupancy, and resolutions to decide on

- Material budget
- Layer positions
- Spiral geometry
- Single vs. double layer







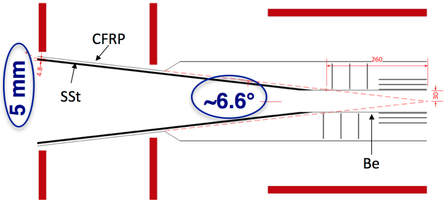
Air Cooling of the Vertex Detector

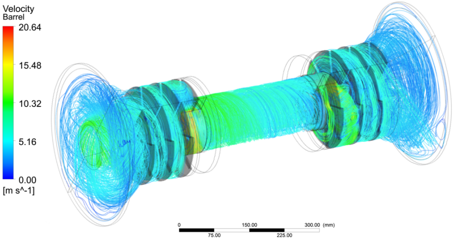
Rationale:

- Need a way to get cool air into and hot air out of the vertex detector region
- Use double walled beam-pipe as air-duct
- Need spiral vertex endcaps to get air to vertex barrel

Studies

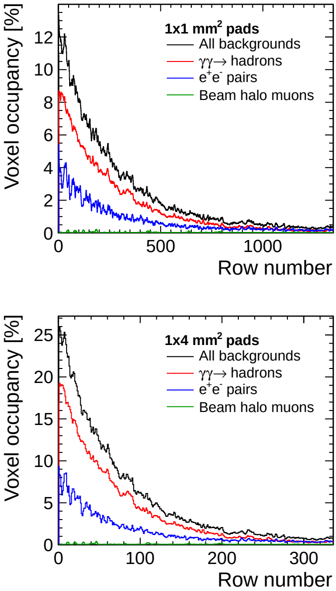
- Simulations and full scale mock-up of vertex region





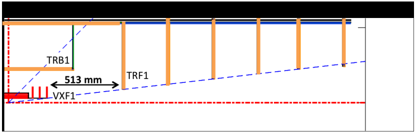
TPC at CLIC?

- Dedicated study of the TPC at CLIC
- Simulation of beam and machine induced backgrounds
  - Incoherent electron–position pairs
  - $\gamma\gamma \rightarrow$ hadron events
  - Muons from the beam line
- The TPC integrates over a full 156 ns bunch train
- Occupancy deemed too large $\rightarrow$ use all silicon tracker

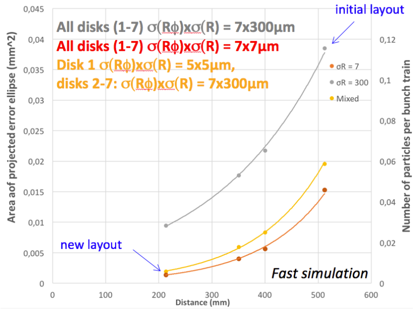


Silicon Tracker

The new detector model uses an all-silicon tracker

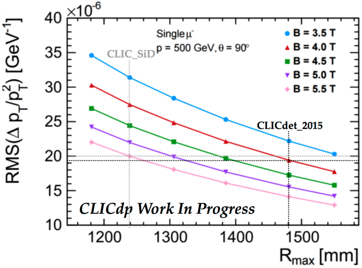


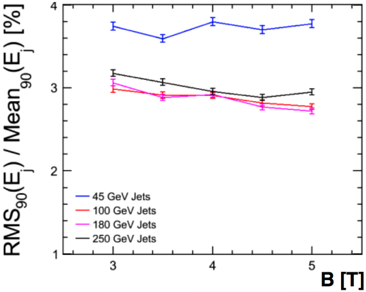
- Fast simulation studies of geometry layout and material (support, cabling, cooling)
  - Using p_T and d_0 to gauge performance
- Material budget between 1.6% and 2.2% of X_0 per layer
- Additional pixelated disk



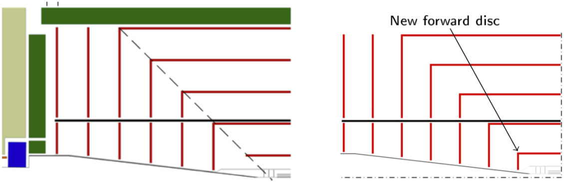
Silicon Tracker: Radius and B-Field

- Momentum resolution dependent on B and R_{max}
- Also impacts particle flow performance
- Converged on 4 T and $R_{max} = 1.5$ m
- Tracker half-length 2.3 m

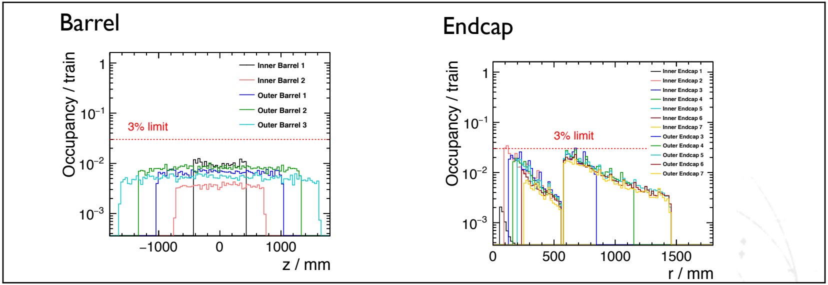




Occupancies in the Tracker Layout



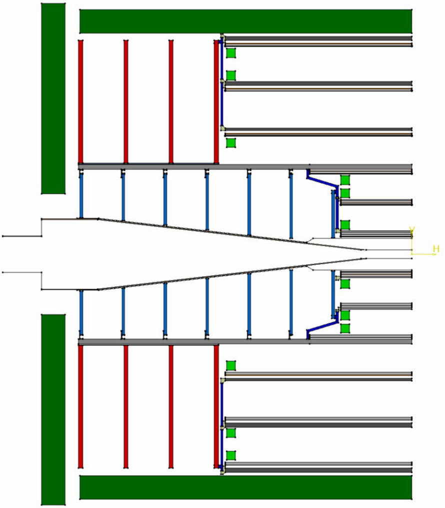
Study hit rate and occupancy from beam-induced backgrounds in the new silicon tracker layout



- Assuming 1 mm long strips, occupancy in the new forward disk (see figure top left) close to 10% in the inner parts
- Pixels in the first forward disk, also benefits tracking

New Tracker Layout

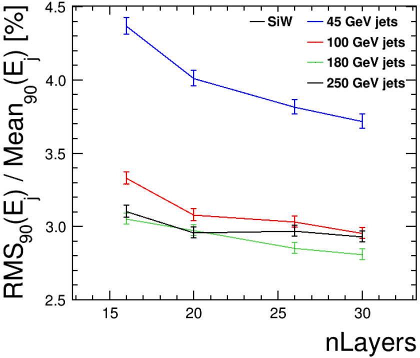
- New engineering design
- Inner and Outer Tracker
  - Support tube for extraction with beam-pipe assembly
- 3 short and 3 long barrel layers
- 7 inner and 4 outer endcaps
- At least 8 hits for $\theta > 8^\circ$



ECal

- Extensive ECal studies together with ILD
- Studying: Layers, depth, granularity,. . .

Final decision will be taken soon



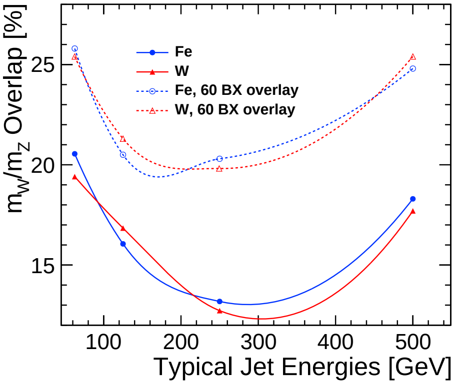
HCal: Iron vs. Tungsten

In CDR Studies used tungsten as the absorber in the HCal barrel. This decision was re-evaluated. And due to:

- Reduced outer radius of the HCal (compared to CLIC_ILD)
- 4 Tesla Field
- More complicated engineering of a tungsten calorimeter
- No benefit in terms of energy resolution compared to steel

$\rightarrow$ No longer use tungsten in HCal barrel

HCal depth of 7.5 λ_I will be kept



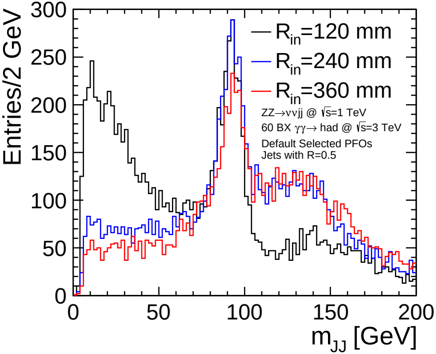
$\mathrm{WW} \rightarrow \nu\ell jj$ and $\mathrm{ZZ} \rightarrow \nu\nu jj$ events

HCal Endcap Coverage

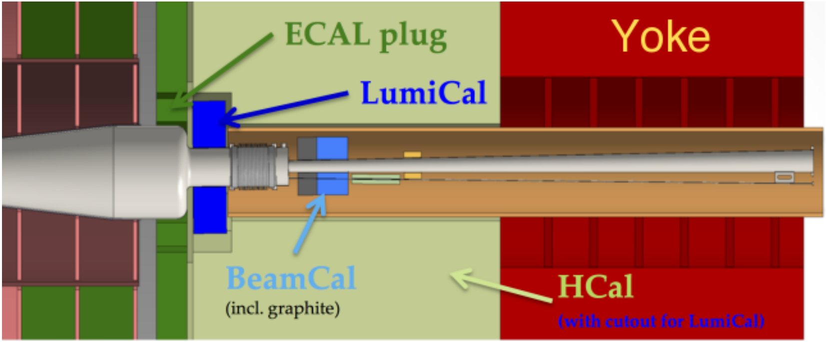
Increased hadronic calorimeter coverage needed

- Studied the jet energy resolution with $\gamma\gamma \rightarrow$ hadron background and different inner radii of the HCal endcap
- At 12 cm background rate spoils energy resolution and it is not feasible

$\rightarrow$ Can increase the HCal endcap inner radius to 25 cm

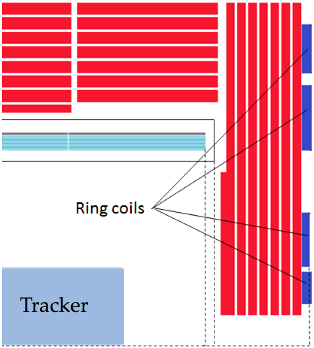


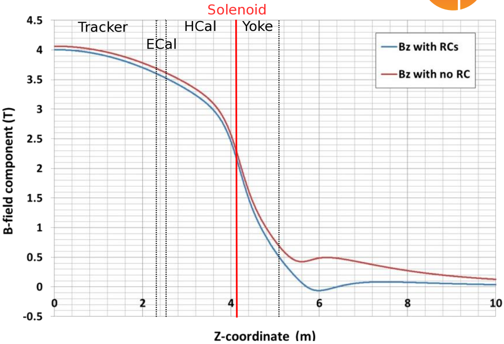
Forward Region



- HCal endcap coverage extended
- QD0 $L^{\star} = 6$ m, outside the detector
  - Less stringent requirements on stability, less rigid support
  - Anti-solenoid no longer needed
  - Decreased support tube radius to 25 cm

Magnetic Field and the Yoke

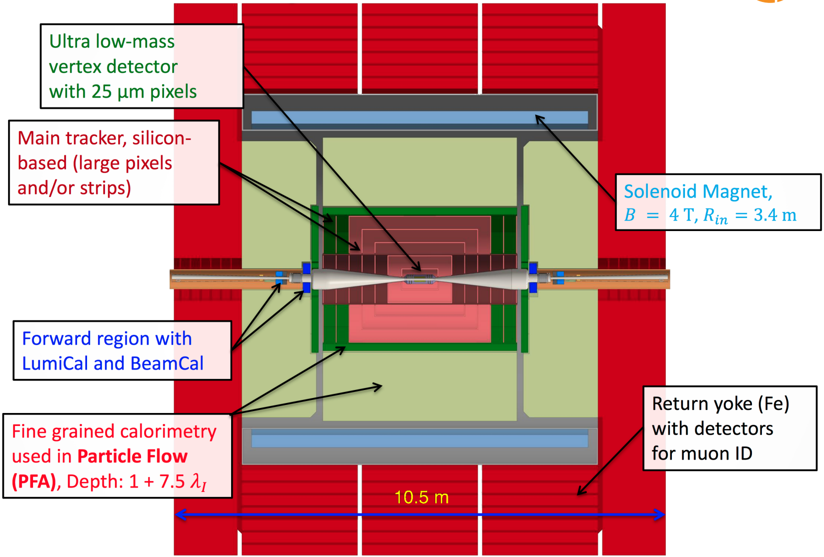




- Thinner endcaps
- Use end coils to compensate for reduced thickness
- No need for an anti-solenoid (according to beam simulations)
- Do not fill with iron, better field quality on beam

- B_z component with and without endcoils as a function of z
- Muon System with 6 equidistant layers

Summary



The new detector model, except that the tracker layout will be different