Studies of the CLIC HCAL depth with Pandora PFA

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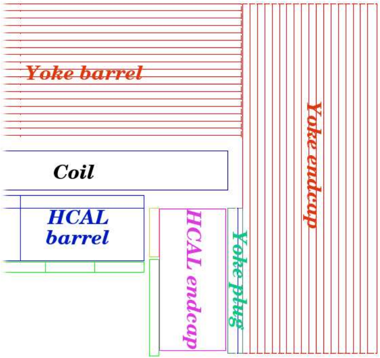
Introduction

- Purpose: determine optimal **HCAL depth for CLIC**, based on physics performance (i.e. **jet energy resolutions**, obtained with PandoraPFA algorithm, developed by *Mark Thomson*)
- Started with Mokka model CLIC01_ILD
- HCAL: tungsten absorber for both barrel and endcaps (for CDR studies, steel will be used in the endcaps)
- Muon yoke: modifications introduced after discussions with Alain Herve and Hubert Gerwig (see next slide)

Introduction - continued



Yoke barrel

- Needed: one thick absorber at small radius and another at large radius, to absorb compression forces of the endcap
- Simulated: 19 sensitive layers (4 cm sensitive part + 10 cm iron absorber)
- Some of the layers will be disabled during reconstruction to get a thicker passive layer

Yoke plug:

- For a good magnetic field shape, align the z-position of the solenoid coil to the endcap nose
- Instrumented (1 sensitive layer)

Data samples and tools

- **Data samples**: $Z \Rightarrow uds$ events, at $\sqrt{s} = 91.5,\ 200,\ 500,\ 1000,\ 2000$ and 3000 GeV
- Simulation and reconstruction jobs submitted to **grid** via DIRAC (Distributed Infrastructure with Remote Agent Control) - interface for grid jobs submission, initially developed for LHCb
- DIRAC developed for ILC and maintained by *S. Poss* and *P. Majewski*
- **Rough** approximation of time needed to process **100 events**:

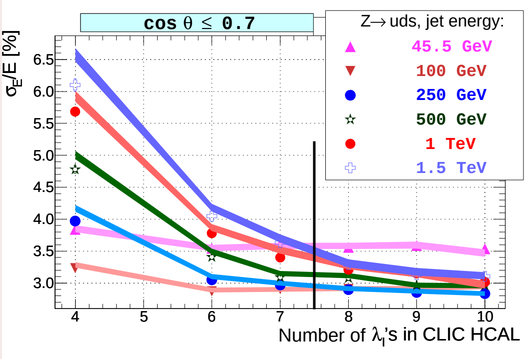
$\sqrt{s}$	Simulation (Mokka)	Reconstruction (Marlin)
500 GeV	6 h	0.7 h
1 TeV	16 h	1.1 h
2 TeV	32 h	3.3 h

(Expect simulation to be approx. 2 times faster with higher range cut)

Jet energy resolution

- **Markers**: with Tail Catcher; **bands**: WITHOUT Tail Catcher

HCAL barrel

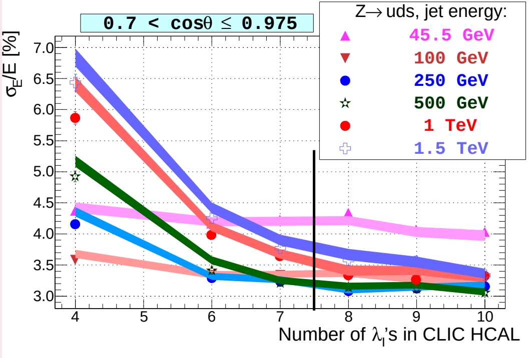


- $E_{jet} = 45.5$ GeV: resolution approx. constant, dominated by calorimeter resolution
- $E_{jet} \geq 100$ GeV: dominated by leakage (in small HCAL) and by confusion

Jet energy resolution

- **Markers**: with Tail Catcher; **bands**: WITHOUT Tail Catcher

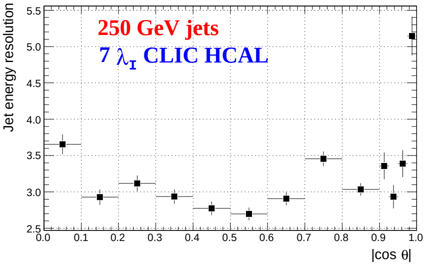
HCAL endcaps

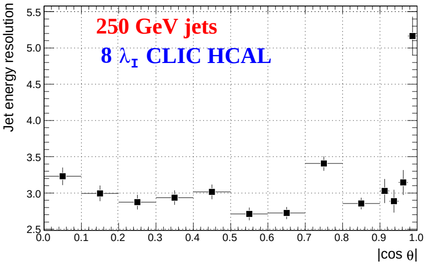


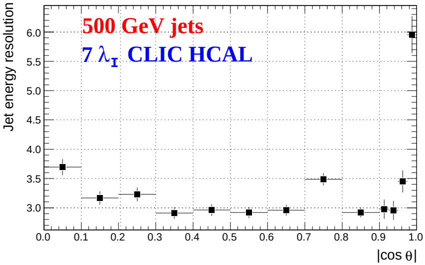
- A little bit worse resolution than in the barrel (probably effect of gaps)

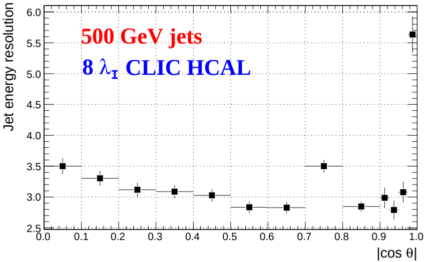
- Tail catcher effect: large for high energies and small HCAL, but less significant for HCAL $> 6\ \lambda_I$
- Final decision on HCAL depth: 7.5 λ_I ($+1\ \lambda_I$ ECAL)

Resolution vs $|\cos\theta|$

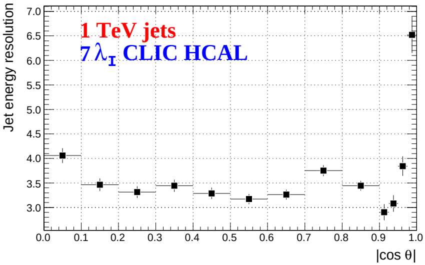


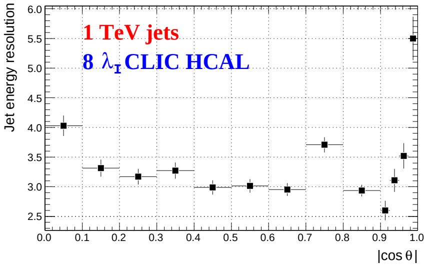


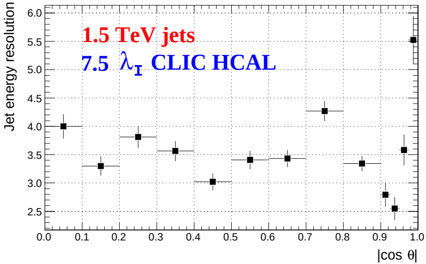




Resolution vs $|\cos\theta|$ - continued







- Worsening of the resolution at $\cos\theta \approx 0$ due to TPC central membrane
- Also worsening for $0.7 < |\cos\theta| < 0.8$ (gap between barrel and endcaps)
- Large fluctuations in the barrel for high energy jets

Conclusions

- Monte Carlo studies of CLIC HCAL to determine optimal calorimeter depth
- Simulations done with Mokka model CLIC01_ILD model
- Reconstruction done with PandoraPFA
- Profited from ILC DIRAC developments (time consuming simulation of high energy showers)
- Final decision: 7.5 λ_I CLIC HCAL based on balance between cost (HCAL as small as possible), reasonable shower containment and good energy resolution of high energy jets
- Important step towards finalisation of geometry to be used for CLIC CDR studies