

SOFTWARE DEVELOPMENTS AND DETECTOR MODEL

CLIC Workshop 2018

Marko Petrič

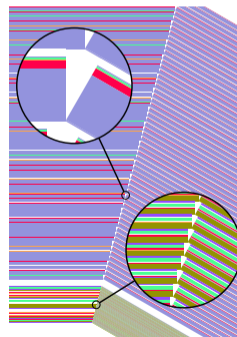
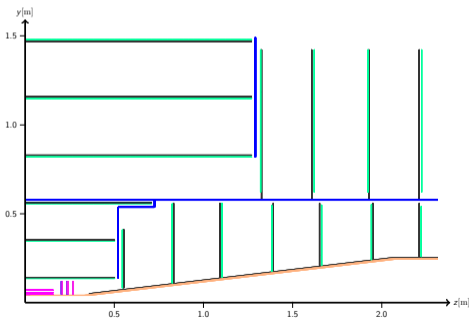


On behalf of the **CLICdp** collaboration

Geneva, 23 January 2018

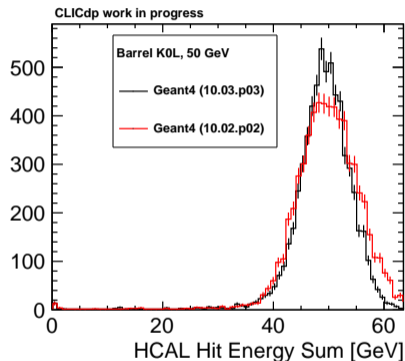
Detector Model

- ▶ Geometry of final detector model implemented: CLIC_o3_v014
 - ▶ 6 new models since last year (minor changes)
 - ▶ Birks' law, unified readout, shift segmentation, overlaps
- ▶ Final production detector to be named **CLICdet**
- ▶ From now on only bug fixes, if necessary
- ▶ Documented in detail in **CLICdp-Note-2017-001**



Simulation Parameters

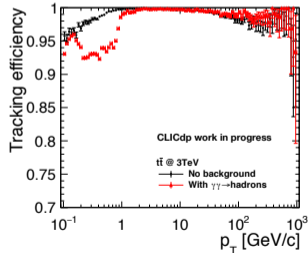
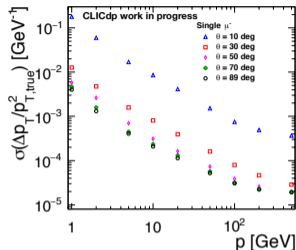
- ▶ Geant4 version 10.2.2, frozen at least for now, large changes in physics list (FTFP_BERT) afterwards
- ▶ Evaluating Geant 10.3.3 and 10.4.0
 - ▶ difference in shower development
- ▶ DetailedShowerMode, all individual calorimeter contributions (timing)
- ▶ Changed magnetic field stepper
HelixSimpleRunge → G4ClassicalRK4
 - ▶ factor 2 improvement for single muons
 - ▶ 25% improvement for single pions



Simulation Performance

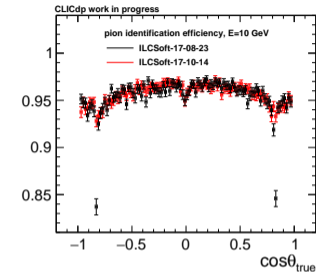
- ▶ Startup time slow, due to many volumes in tracker ~2min
- ▶ **Simulation time for 3 TeV ttbar event: ~3 min/event**
- ▶ Output file size: 14 MB/event with detailed shower mode
- ▶ Memory: 1.4 GB, well below 2GB/core for grid sites

Tracking Developments

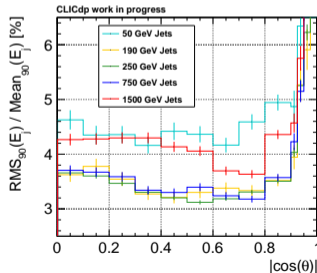


- ▶ Using ConformalTracking track finding
- ▶ Performs well down to 10° in CLIC case
- ▶ Successfully tackles displaced tracks
- ▶ Technical rewrite:
 - ▶ Improved memory management
 - ▶ Usage of fast math etc. → 30% faster
- ▶ More than 99% efficiency for above 1 GeV
- ▶ Using DDKalTest track finding
- ▶ Achieving resolution of $\sim 2 \times 10^{-5} \text{GeV}^{-1}$ at high energy in central barrel
- ▶ More info → talk by E. Leogrande (Tue.)

Calorimetry Performance and Validation

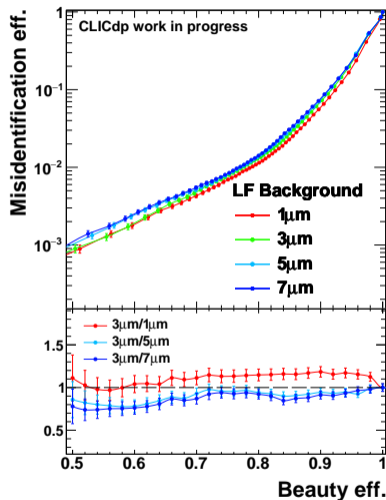


- ▶ Modification in PandoraPFA to address long standing issues of inefficiency of charged particle ID in Calo transition region
 - ▶ Only minor effect of gap remaining
- ▶ Adopted software compensation as default in Pandora settings
- ▶ Developed CLIC specific weights
- ▶ Extending reweighing procedure to higher energies and densities
- ▶ Improved JER for higher centre-of-mass energies
- ▶ More info → talk by M. Weber (Thur.)



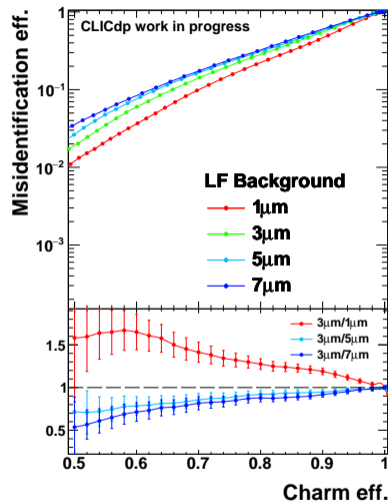
Flavour Tagging Developments

- ▶ Using LCFIPlus
- ▶ Studying impact of vertex resolution only on flavour tagging
- ▶ Larger impact of single point resolution on c tagging efficiency compared to b tagging efficiency
- ▶ Strides with Conformal tracking and bkg. overlay underway
- ▶ More info → [talk by I. Garcia Garcia \(Tue.\)](#)



Flavour Tagging Developments

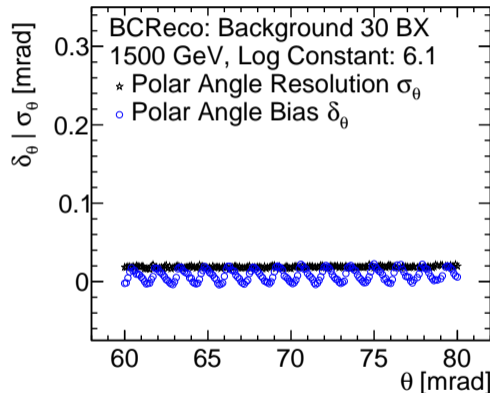
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Forward Region

- ▶ Detailed look at performance
- ▶ Good reconstruction efficiencies, energy resolution as expected
- ▶ Extended BeamCal reco for LumiCal reco
- ▶ Achieving expected polar angle resolution
- ▶ More info → [talk by A. Sailer \(Tue.\)](#)

LumiCal



Final Reconstruction Workflow

Reconstruction workflow

1. Overlay
 2. Digitisation
 3. Track Pattern recognition (TruthTracking, ConformalTracking)
 4. Track Fit (Refit for better track parameter estimate)
 5. Particle Flow Reconstruction (PandoraPFA)
 6. Forward calorimeter reconstruction (LumiCal/BeamCal)
 7. PFO selection
- ▶ Implemented in one unified steering file for the reconstruction that can be configured on the fly: avoid duplicating parameter settings in different files that will diverge as much as possible
`CLICPerformance/examples/clicReconstruction.xml`
 - ▶ `Marlin --Config.Tracking=Conformal --global.LCIOIn...`

Reconstruction run-time Performance

- ▶ Reconstruction chain finalized
- ▶ Improvements since last year:
 - ▶ Improvements in reconstruction time
 - ▶ Improvements in memory management
- ▶ Automated check memory leaks via valgrind
- ▶ Tracking run-time/hot-spot checks with “Intel VTune Amplifier”
- ▶ Reconstruction time for 3 TeV ttbar event: ~15-20 min/event
- ▶ Reconstruction takes ~ 5 times longer than simulation

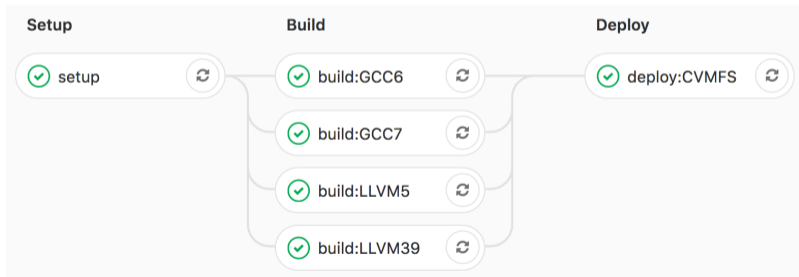
Monitoring Code Quality 1/2

- ▶ Run on merge re-build of iLCSoft with gcc and clang
- ▶ Run simulation and reconstruction tests with new build
- ▶ If all tests pass, re-deploy to CVMFS directly
- ▶ Individual nightlies to monitor number of compiler warnings
 - ▶ Once package without warnings, easy to disallow new ones (-Werror in CI build)
 - ▶ Since last year fixed ~ 2000 warnings
 - ▶ many packages with 0 warnings

S	W	Name ↓	Last Success	Last Failure	Last Duration	# Compiler Warnings
●	☀	aidaTT	6 hr 47 min - #253	N/A	56 sec	0
●	☀	CED	23 hr - #250	N/A	24 sec	116
●	☀	CEDViewer	15 hr - #250	N/A	50 sec	192
●	☀	ClicPerformance	9 hr 33 min - #280	N/A	51 min	0
●	☀	Clupatra	12 hr - #249	N/A	45 sec	77
●	☀	ConformalTracking	19 hr - #247	N/A	43 sec	0
●	☀	DDKaTest	11 hr - #255	N/A	37 sec	2
●	☀	DDMarinPandora	18 hr - #245	N/A	1 min 5 sec	0
●	☀	FCalClusterer	14 hr - #247	N/A	4 min 33 sec	17
●	☀	ForwardTracking	19 hr - #254	N/A	1 min 18 sec	230
●	☀	ILCUI	20 hr - #245	N/A	41 sec	0
●	☀	KalDet	13 hr - #252	N/A	2 min 7 sec	262
●	☀	KalTest	10 hr - #247	N/A	1 min 12 sec	115
●	☀	KITrack	11 hr - #249	N/A	58 sec	96
●	☀	KITrackMarlin	23 hr - #249	N/A	46 sec	192
●	☀	LCFIPlus	13 hr - #250	N/A	2 min 35 sec	6
●	☀	LCFIVertex	20 hr - #249	N/A	4 min 6 sec	4
●	☀	logoo	4 hr 17 min - #257	N/A	6 min 15 sec	0
●	☀	LCIO	56 min - #247	N/A	5 min 27 sec	10
●	☀	Marlin	4 hr 5 min - #252	N/A	1 min 37 sec	0
●	☀	MarlinDD4hep	1 hr 33 min - #250	N/A	17 sec	0
●	☀	MarlinFastJet	23 hr - #247	N/A	31 sec	0
●	☀	MarlinKinfit	16 hr - #246	N/A	1 min 8 sec	226

Monitoring Code Quality 2/2

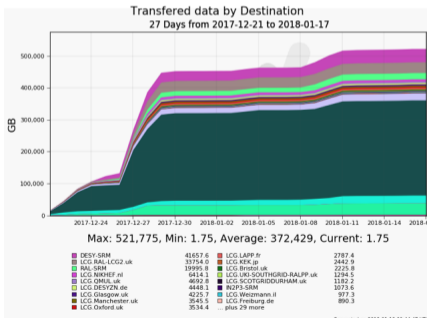
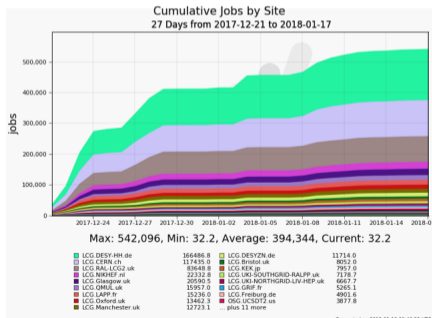
- ▶ Compile iLCSoft with several compilers: GCC 6.2, 7.2 LLVM/Clang 3.9, 5.0
- ▶ Test if simulation and reconstruction work
- ▶ Deploy immediately to CVMFS via gitlab for usage in CI
- ▶ Rebuild iLCSoft if PR merged on GitHub to ConformalTracking, DD4hep, DDMarlinPandora, lcgeo, LCIO, Marlin, MarlinReco...



- ▶ Use same procedure for tags

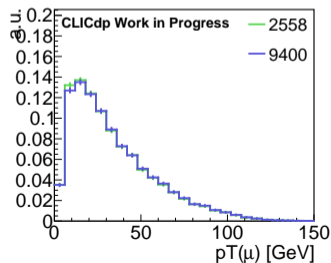
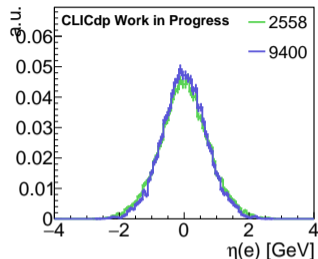
Pilot Production

- ▶ Compare previous production with new detector and new reconstruction
 1. 350 GeV: $ee \rightarrow HZ, Z \rightarrow qq$
 2. 1.4 TeV: $ee \rightarrow qq\bar{q}l\nu(WW)$
 3. 3 TeV: $ee \rightarrow HH\nu$
- ▶ Generated samples over the end-of-year closure
 - ▶ Test also performance of iLCDIRAC (see talk H. Zafar)



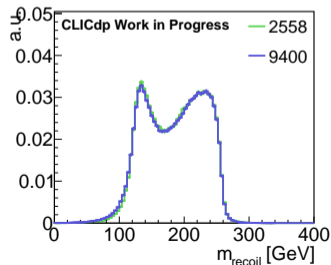
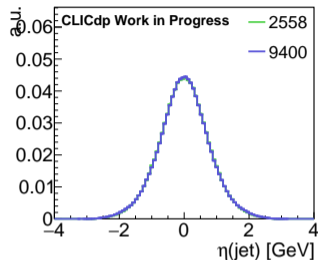
ee \rightarrow HZ, Z \rightarrow qq Comparison

- ▶ Comparison of **ProdID=2558(OLD)** and **ProdID=9400(NEW)**
- ▶ e: slightly more narrow in η
- ▶ μ : slightly harder p_T spectrum
- ▶ jets: no significant change in distributions
- ▶ Truth selection for $H \rightarrow \mu\mu$
 - ▶ Decreased resolution for factor 1.5



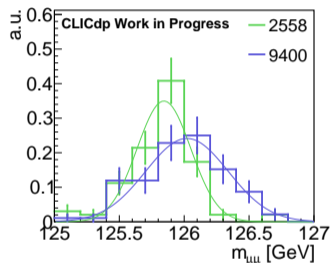
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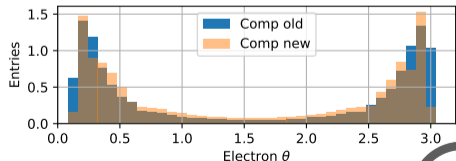
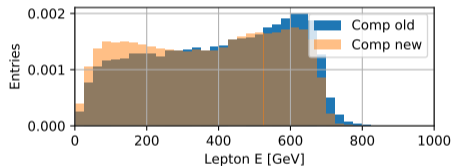
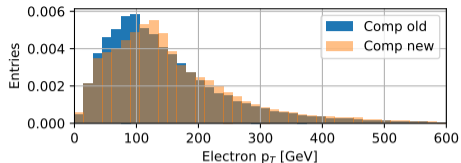
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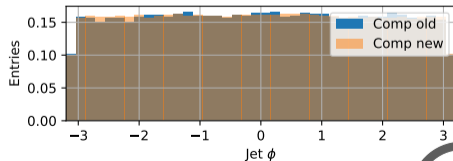
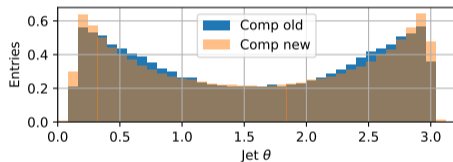
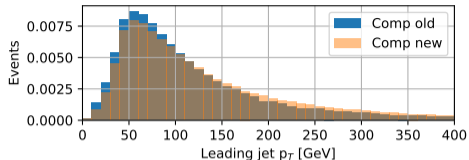
ee \rightarrow qq ν (WW) Comparison

- ▶ Comparison of **ProdID=3249(OLD)** and **ProdID=9402(NEW)**
- ▶ lepton type: new has more muons and less electrons
- ▶ lepton energy spectrum: new is softer
- ▶ lepton θ : new is less forward
- ▶ jet energy spectrum: new is harder
- ▶ jet θ : new is more forward



ee \rightarrow qq ν (WW) Comparison

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Production Plans

- ▶ All elements for large scale production in place
- ▶ Increase pilot production sample to the scale of 10^6
- ▶ Generate new samples with WHIZARD 2.6.3.
- ▶ Include new beam-spectra and background (see talk D. Arominski)
- ▶ Start with BSM studies

Summary

- ▶ **Detector model finalised and validated**
- ▶ Note on detector performance being finalised
- ▶ Reconstruction chain finalised and validated
- ▶ Tested simulation and reconstruction chain in pilot production
- ▶ **Large scale production to commence in coming weeks**