Updates on the FCal Reconstruction Software

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Content

FCalClusterer

FCalClusterer is a collection Marlin Processors for reconstruction and analysis for the forward calorimeters

- Repository on github http://github.com/FCalSW/FCalClusterer.git
- Continuous integration: every pull request is compiled
- Code review
- Issue tracker

LumiCalClusterer

- The LumiCalClusterer was developed by Iftach Sadeh.
- For reconstruction/separation of Bhabha electrons and photons
- See his Master Thesis for all the details

LumiCalClusterer and DD4hep

In last few months

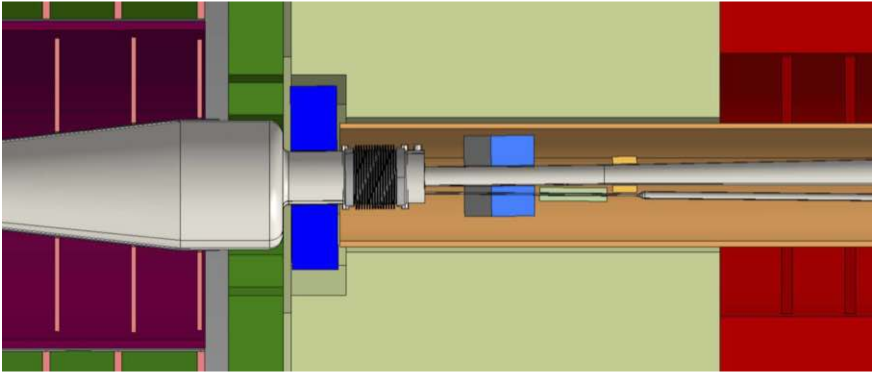
- Implemented the option to obtain geometry information from DD4hep
- Some cleanup of functions and small/medium bugfixes
  - Cell neighbour calculation, affecting initial clustering of hits, small impact on final results
  - Changed internal coordinate systems used in reconstruction to be more natural
    - Work in the centre-of-mass frame, i.e., positions only rotated towards $+/-$ Z axis, not all hits rotated to positive side
    - Easier comparison with expected position, `MCParticle` momentum, reconstructed objects
  - Checked DD4hep and Mokka that reconstructed objects are in the right place

LumiCal Reconstruction Performance

Preliminary look at LumiCal performance to test reconstruction algorithm

- Simulated 2k–20k events per polar angle and energy in CLIC LumiCal
- CLIC detector model
  - LumiCal 40 layers, 39 mrad to 134 mrad geometric acceptance, 48 azimuthal, 64 radial segments, no Anti-DID
  - Parts of LumiCal covered by ECal endcap ($\approx$ 100 mrad), depending on azimuthal angle
- Lorentz boost for crossing angle, theta in the LumiCal system
- Step of 0.1 mrad in $\theta^{\star}$, flat in ϕ, from 42.0 mrad to 129.9 mrad
- Energies[GeV]: 10 20 30 50 100 150 200 250 300 400 500 750 1000 1250 1500

CLICdet Forward Region



Tuning Knobs

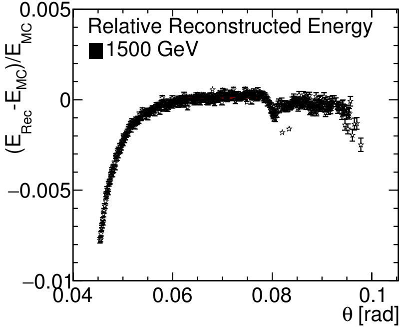
There are a few tuning knobs in the LumiCal reconstruction software

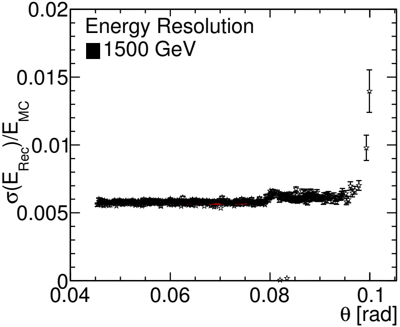
- Energy calibration factor
- Logarithmic weighting constant for energy weighting: $w = C + log(E/E_{\text{total}})$
  Goal is to have best resolution in polar angle reconstruction
- Expected shower size, controlling two particle separation, cluster merging

Not a lot of tuning has been done for the results presented in the next two slides besides energy calibration.

Energy Calibration

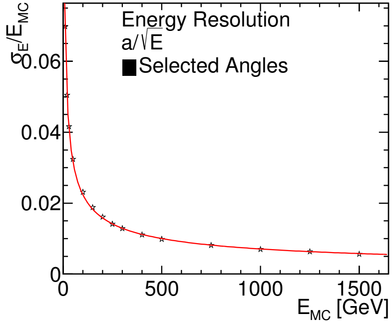
- Obtain fiducial volume based on constant reconstructed energy
- Change calibration factor until correct energy is reconstructed
- Bias in energy reconstruction, while resolution is constant in larger range
- Used 62 mrad $< \theta <$ 77 mrad to estimate energy resolution



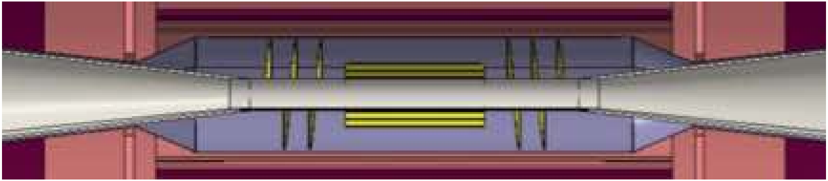


Energy Resolution

- Based on the standard deviations of the selected angular range for the different energies
- $\sigma E/E = a/\sqrt{E[\mathrm{GeV}]}$
- $a = 0.22$, constant term negligible
- As expected from the design from 2009



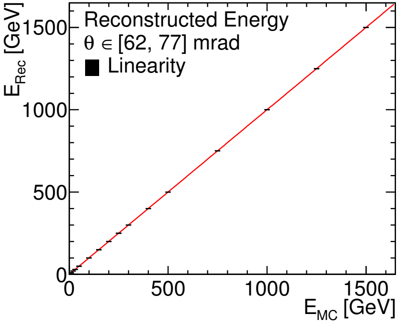
CLICdet Vertex Region

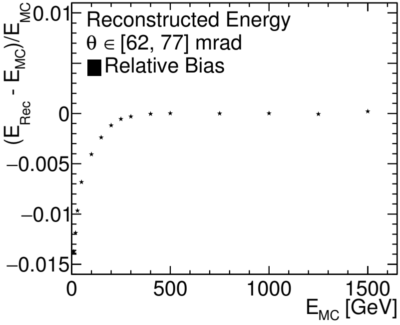


- Last part of cylindrical beampipe cuts into LumiCal acceptance at R=29.4 mm, Z=337 mm, corresponds to 79 mrad including Lorentz Boost

Energy Linearity

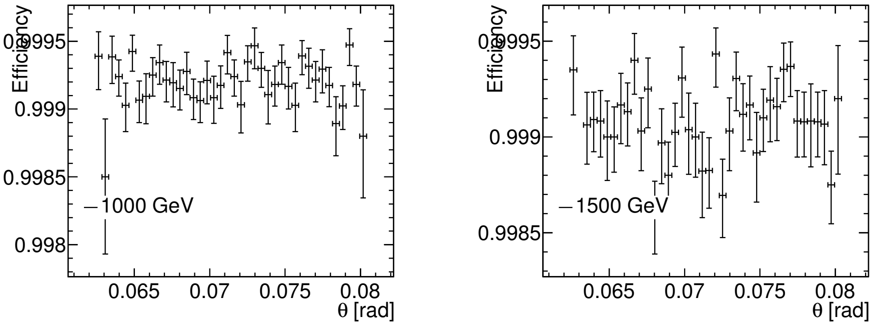
- Reconstructed energy is linear
- Very small bias at higher energies, larger at lower energies





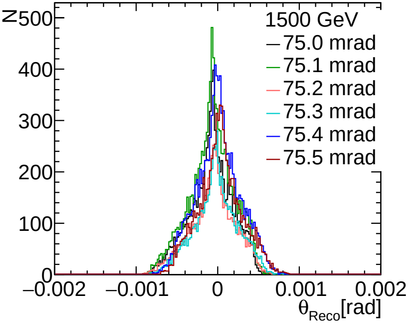
Efficiencies

- Efficiency to find cluster within 10% of expected energy in LumiCal
- Efficiency above 99.8% in fiducial volume



Theta Resolution

- No tuning of logarithmic weighting (4) to minimise angular resolution
- For 1.5 TeV electrons find bias dependent on polar and resolution of 20 mrad. Resolution 10 times worse than previously estimated.
  - Using RMS of distribution
  - Bad weighting constant, bug, too much material before LumiCal?



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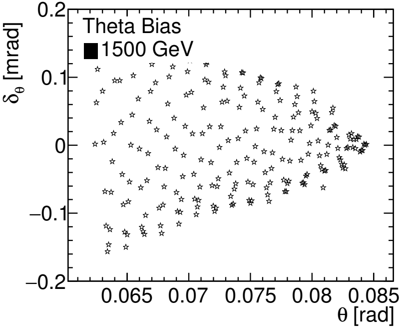
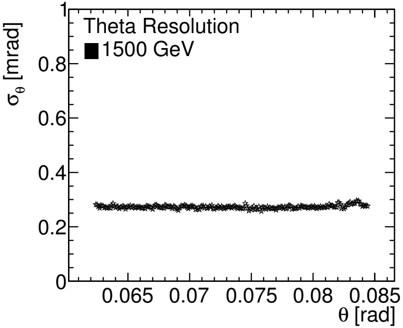
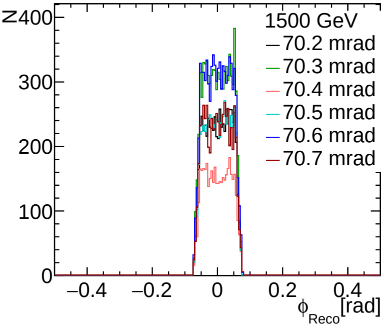




Phi Resolution

- Distribution of reconstructed azimuthal angle uniform
- Resolution $2.1^{\circ} = 30$ mrad as expected for 48 segments. $360/(48 * \sqrt{12})$
  - Only one azimuthal segment per shower?



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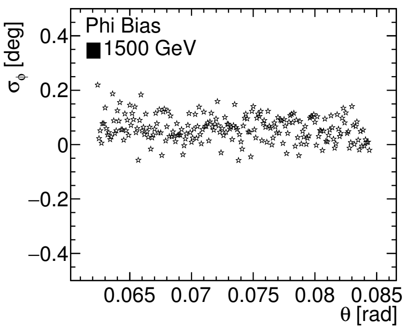
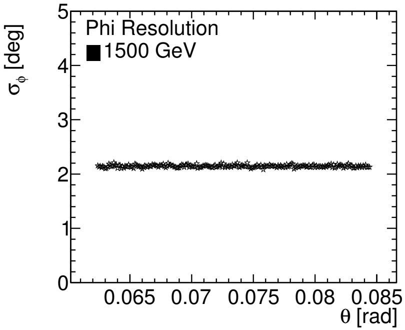


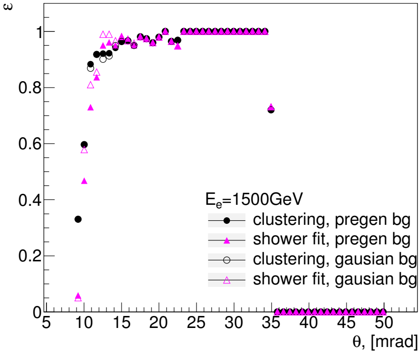


Open Issues

- Theta resolution
- Tune logarithmic weighting constant, expected shower size
- Two particle separation, actual Bhabha events
- . . .

BeamCal Reconstruction Update

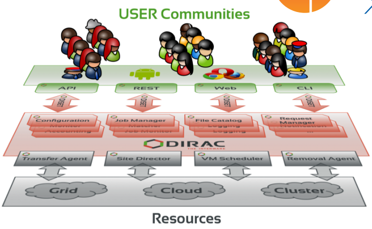
- CLICdp-Note-2016-005 on BeamCal reconstruction was finished in October
- BeamCal reconstruction used by Moritz Habermehl (ILD/Desy)
- Fixed bug in suppression of printout of Root errors for integration



iLCDirac in a Nutshell

iLCDirac is based on the DIRAC interware originally developed for LHCb

- Dirac (Distributed Infrastructure with Remote Agent Control): High level interface between users and distributed resources
- iLCDirac: Additional functionality to provide simple interface for the users to the LC Software (Whizard, Marlin, Mokka, org.lcsim, SLIC, ROOT, ddsim)
- Central system for large scale productions
- https://ilcdirac.cern.ch
- http://lcd-data.web.cern.ch/lcd-data/doc/ilcdiracdoc/
- ilcdirac-support@cern.ch



diracgrid.org

```
from DIRAC.Core.Base import Script
Script.parseCommandLine()
import UserJob
import Marlin
import DiracILC
d = DiracILC()
j = UserJob()
j.setOutputSandbox("recEvents.slcio")
m = Marlin()
m.setVersion("ILCSoft-01-17-09")
m.setSteeringFile("Steering.xml")
m.setInputFile("SimEvents.slcio")
j.append(m)
j.submit(d)
```

Summary

- LumiCal and BeamCal reconstruction working with DD4hep geometry
- First close look at LumiCal reconstruction performance since moving code shows decent results.
- Tuning of reconstruction and further performance checks necessary