UNIVERSITY OF CAMBRIDGE

Calibration

23rd February 2016
Steven Green

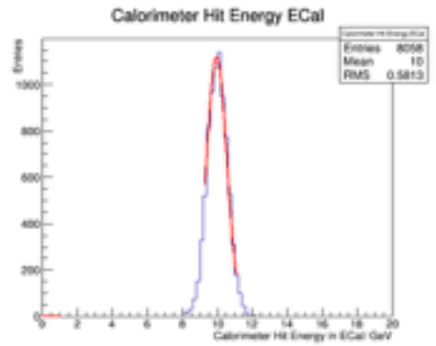
Overview of Calibration Procedure

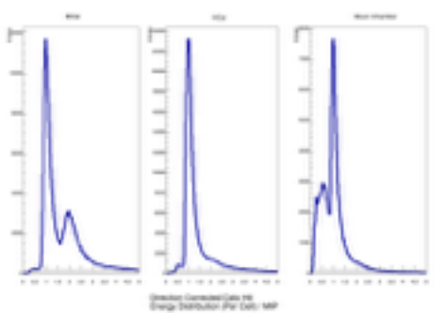
Simulation Output
Energy Deposited in Active Material of Calorimeters

Calorimeter Energy
Energy Deposited in the Total Calorimeter Volume

Reconstructed Particle Energy
Energy of Particle(s) Depositing Energy in Calorimeters

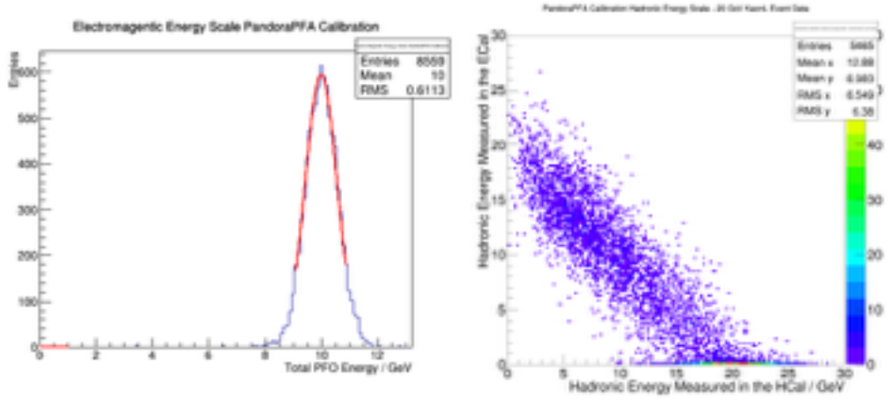
Digitisation
Set by looking at contained kaonL and ɣ events throughout the calorimeters.





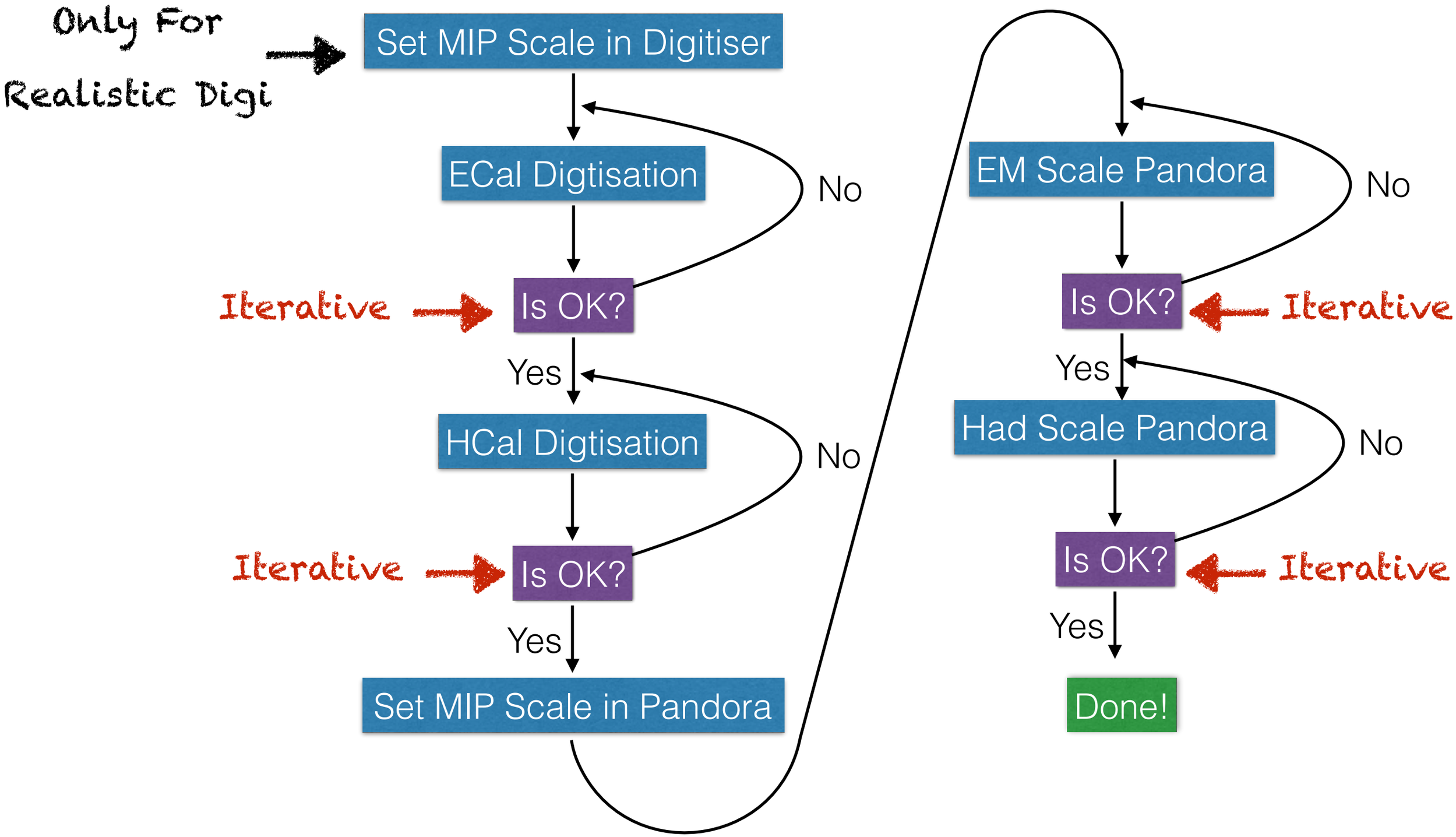
Minimum Ionising Particle (MIP) Detector Response
Determine the response of each part of the detector to a MIP, μ^- events. MIP scale used in PandoraPFA.

Electromagnetic and Hadronic Scale Setting
Electromagnetic/Hadronic scale set using PFO energy of contained ɣ and kaonL events.



The PandoraAnalysis toolkit has several scripts designed for setting the digitisation and calibration constants. The user has to provide samples of kaonL, ɣ and μ^-.
These scripts make automation of this procedure possible.

Logic of Calibration Procedure



Calibration Processors

```
<execute>
    ...
    <!-- ========== the post tracking patrec   ================= -->
    <processor name="MyKinkFinder"/>
    <processor name="MyV0Finder"/>
    <!-- ========== calorimeter digitization ======= -->
    <processor name="MyILDCaloDigi"/>
    <!-- ========== PFA ======= -->
    <processor name="MyMarlinPandora"/>
    <processor name="MyPfoAnalysis"/>
    ...
</execute>
```

- Post Tracking Patter Rec
- Digitisation
- PFA

Marlin steering file snippet. Processors needed for calibration.

Digitisation

Factors affecting calibration:

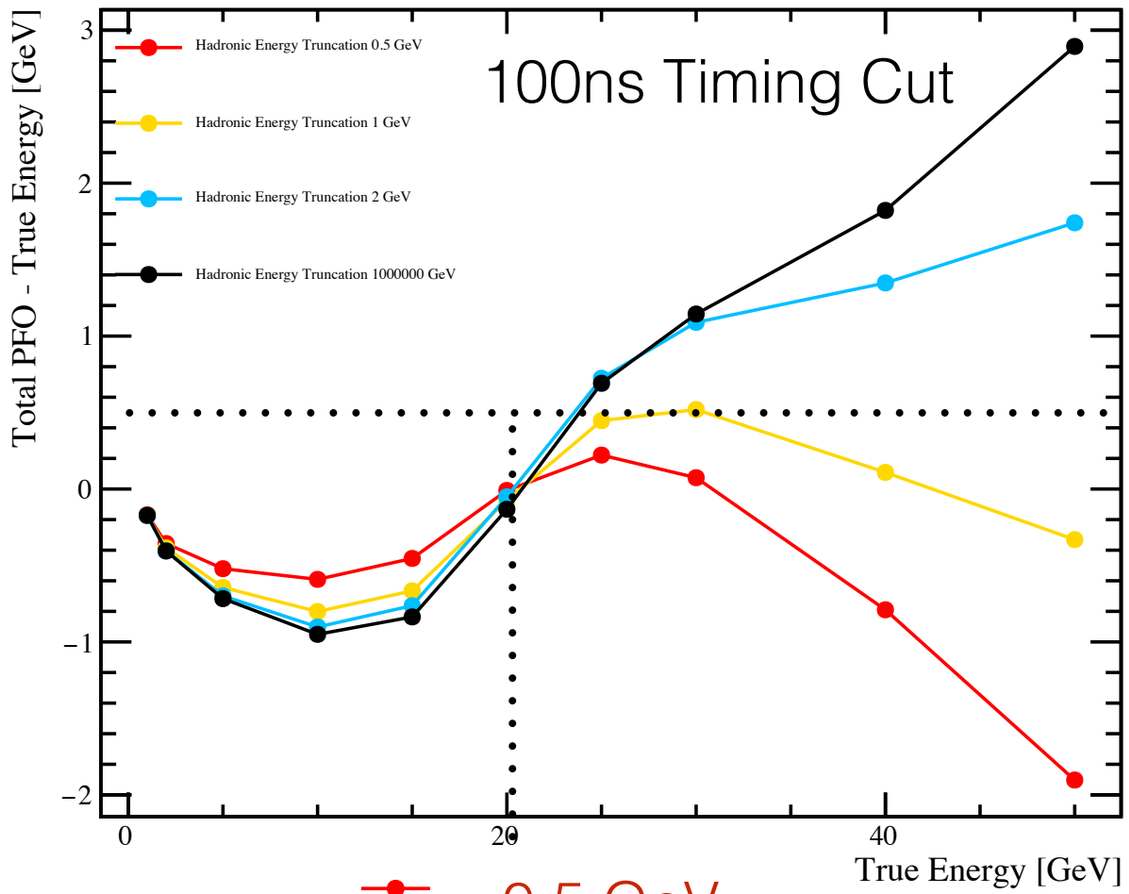
- Choice of digitiser ILDCaloDigi/ NewLDCCaloDigi/DDCaloDigi
- Timing Cuts.
- Digitisation options, such as realistic digitisation for ECal (Si/Sw) or HCal.
- Settings in the realistic options.
- ECal Gap Correction.

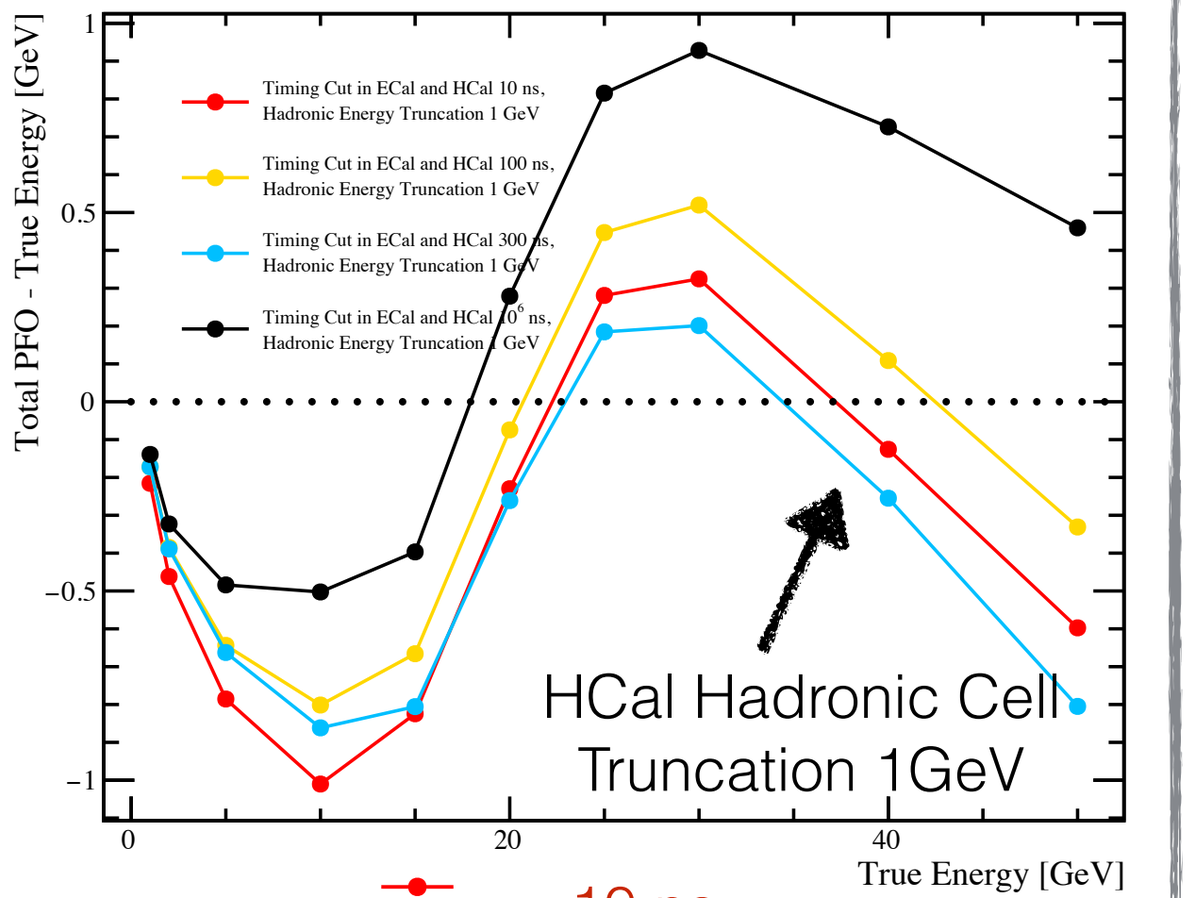
PFA

Factors affecting calibration:

- Hadronic energy truncation.
- Software compensation (needs development).
- Photon likelihood data.

Linearity





* Calibration ensures correct reconstructed energy for a single energy point, but cannot guarantee perfect reconstruction at all energies.

Automation

```
class Calibration:
    'Common base class for all calibration process'
```

* I have attempted to decouple the calibration logic from the Cambridge batch farm as was requested from Frank in LCWS15.

* Current status:
  - All logic is implemented in a python class.
  - There are functions in the python class which process a list of Marlin steering files.
  - Could be replaced by ILCDirac implementation? → Difficulty comes from having to iterate.

* Ideal case: Replace Cambridge batch farm production with ILCDirac.

* Less than ideal case (but might work quickly): Remove batch production. Run all files as 1 job on the grid. Will required at least 2 x 50,000 10 GeV muon events, 2 x 50,000 10 GeV photon events, 2 x 50,000 10 GeV Kaon0L events to run. Ballpark figure ~100 hours (conservative estimate) of processing time.

Details to follow…

Automation

https://github.com/StevenGreen1/OptimisationStudies/blob/master/Calibration/MyCalibration/CalibrateLogic.py

```
#!/usr/bin/python

import os, sys, getopt, re, subprocess, math, dircache, logging, time, random, string

class Calibration:
    'Common base class for all calibration process'

### ------------------------------------------------------------------------------------------
### Start of constructor
### ------------------------------------------------------------------------------------------

    def __init__(self, detModelNumber, recoVariant, slcioFormat, slcioPath, gearFile, pandoraSettings,

        'Detector Model Number'
        self._DetectorModelNumber = detModelNumber

        'Reconstruction Variant Number'
        self._ReconstructionVariant = recoVariant
```

* Decoupled calibration logic somewhat from Cambridge batch farm.
* Script makes python list of Marlin xml files, which need running then analysing.

https://github.com/StevenGreen1/OptimisationStudies/blob/master/Calibration/MyCalibration/CalibrateMuon.py

```
Calibration(detectorModel, recoStage, slcioFormat, slcioPath,
gearFile, pandoraSettings, outputPath, timingCut,
hadronicEnergyTrunc, 'Si', True)
```

Automation

```
### ------------------------------------------------------------------------------------------------------
### Start of calibration process function
### ------------------------------------------------------------------------------------------------------

    def calibrationProcess(self):
        self.logger.info('Checking that calibration text document, root folder and marlin folder exists and if not make them')

        # Set MIP scale in digitisers
        self.prepareSteeringFiles('Muon',self._MuonEnergyCalibration)
        self.runCondorJobs()
        self.checkCondorJobs()

        executable = os.path.join(self._PandoraAnalysisPath,'SimCaloHitEnergyDistribution')
        runExecutable = subprocess.Popen([executable, '-a', self._MuonRootFiles, '-b', str(self._MuonEnergyCalibration), '-c', self._
        runExecutable.wait()
        self.setMIPScaleDigitser()

        # ECal Digitsation
        ecalDigitsationOk = False
        while not ecalDigitsationOk:
            self.prepareSteeringFiles('Photon',self._PhotonEnergyCalibration)
            self.runCondorJobs()
            self.checkCondorJobs()

            executable = os.path.join(self._PandoraAnalysisPath,'ECalDigitisation_ContainedEvents')
            runExecutable = subprocess.Popen([executable, '-a', self._PhotonRootFiles, '-b', str(self._PhotonEnergyCalibration), '-c'
            runExecutable.wait()
            ecalDigitsationOk = self.setCalibrECal()
```

Iterative

Digitisation

```
<processor name="MyILDCaloDigi" type="ILDCaloDigi">
    <!--ILD digitizer...-->
    <!--Calibration coefficients for ECAL-->
    <parameter name="CalibrECAL" type="FloatVec">42.9631192209 85.9262384418</parameter>
    <!--Calibration coefficients for HCAL barrel, endcap, other-->
    <parameter name="CalibrHCALBarrel" type="FloatVec">49.3344654494</parameter>
    <parameter name="CalibrHCALEndcap" type="FloatVec">55.3271575116</parameter>
    <parameter name="CalibrHCALOther" type="FloatVec">31.1454028868</parameter>
    <!--Gap Correction-->
    <parameter name="ECALGapCorrection" type="int"> 1 </parameter>
    <!--Gap Correction Fudge Factor-->
    <parameter name="ECALGapCorrectionFactor" type="float">1</parameter>
    <parameter name="ECALModuleGapCorrectionFactor" type="int"> 0.0 </parameter>
    <!-- Timing -->
    <parameter name="UseEcalTiming" type="int">1</parameter>
    <parameter name="UseHcalTiming" type="int">1</parameter>
    <parameter name="ECALBarrelTimeWindowMax" type="float">100.0</parameter>
    <parameter name="HCALBarrelTimeWindowMax" type="float">100.0</parameter>
    <parameter name="ECALEndcapTimeWindowMax" type="float">100.0</parameter>
    <parameter name="HCALEndcapTimeWindowMax" type="float">100.0</parameter>
    <parameter name="ECALTimeWindowMin" type="float"> -1.0 </parameter>
    <parameter name="HCALTimeWindowMin" type="float"> -1.0 </parameter>
    <parameter name="ECALCorrectTimesForPropagation" type="int">1</parameter>
    <parameter name="HCALCorrectTimesForPropagation" type="int">1</parameter>
    <parameter name="ECALDeltaTimeHitResolution" type="float"> 20.0 </parameter>
    <parameter name="HCALDeltaTimeHitResolution" type="float"> 20.0 </parameter>
```

Digitisation Constants

ECal Gap Correction

Timing - Choice?

Marlin steering file snippet. ILDCaloDigi.

Digitisation

```
<!-- Realistic ECal -->
<parameter name="ECAL_apply_realistic_digi" type="int">1</parameter>
<parameter name="CalibECALMIP" type="float">0.0001475</parameter>
<parameter name="ECAL_maxDynamicRange_MIP" type="float">2500</parameter>
<parameter name="ECAL_elec_noise_mips" type="float">0.07</parameter>
<parameter name="ECAL_deadCellRate" type="float">0</parameter>
<parameter name="ECAL_miscalibration_uncorrel" type="float">0</parameter>
<parameter name="ECAL_miscalibration_uncorrel_memorise" type="bool">false</parameter>
<parameter name="ECAL_miscalibration_correl" type="float">0</parameter>
<parameter name="energyPerEHpair" type="float">3.6</parameter>
<parameter name="ECAL_PPD_PE_per_MIP" type="float">7</parameter>
<parameter name="ECAL_PPD_N_Pixels" type="int">10000</parameter>
<parameter name="ECAL_PPD_N_Pixels_uncertainty" type="float">0.05</parameter>
<parameter name="ECAL_pixel_spread" type="float">0.05</parameter>
<!-- Realistic HCal -->
<parameter name="HCAL_apply_realistic_digi" type="int">1</parameter>
<parameter name="HCALThresholdUnit" type="string">MIP</parameter>
<parameter name="CalibHCALMIP" type="float">0.0004925</parameter>
<parameter name="HCAL_maxDynamicRange_MIP" type="float">99999999</parameter>
<parameter name="HCAL_elec_noise_mips" type="float">0.06</parameter>
<parameter name="HCAL_deadCellRate" type="float">0</parameter>
<parameter name="HCAL_PPD_N_Pixels" type="int">2000</parameter>
<parameter name="HCAL_PPD_PE_per_MIP" type="float">15</parameter>
<parameter name="HCAL_pixel_spread" type="float">0.05</parameter>
<parameter name="HCAL_PPD_N_Pixels_uncertainty" type="float">0</parameter>
<parameter name="HCAL_miscalibration_uncorrel" type="float">0</parameter>
<parameter name="HCAL_miscalibration_correl" type="float">0</parameter>
<!-- Histograms-->
<parameter name="Histograms" type="int"> 0 </parameter>
</processor>
```

Realistic ECal

Realistic HCal

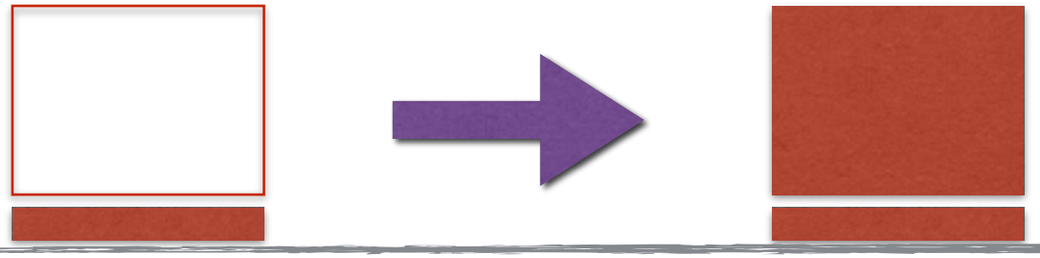
Marlin steering file snippet. ILDCaloDigi.

Digitisation

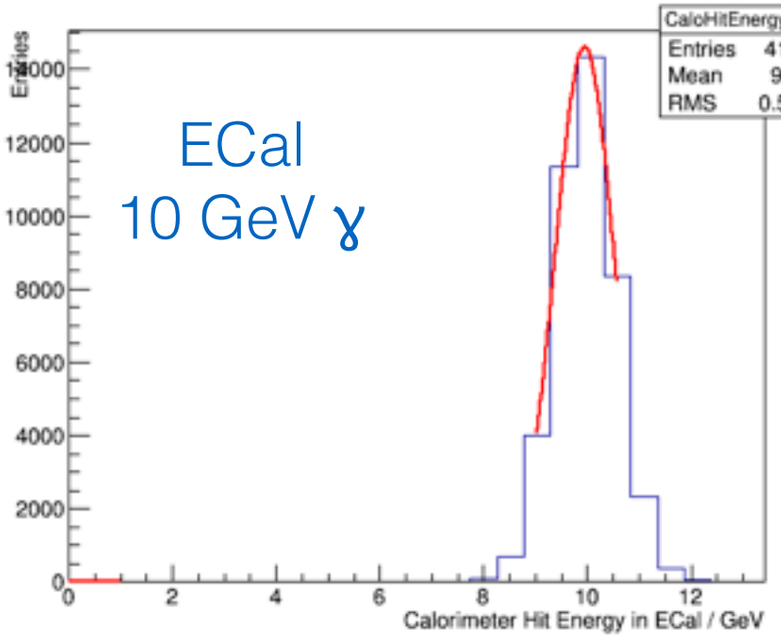
```
<!--Calibration coefficients for ECAL-->
<parameter name="CalibrECAL" type="FloatVec">42.9631192209 85.9262384418</parameter>
<!--Calibration coefficients for HCAL barrel, endcap, other-->
<parameter name="CalibrHCALBarrel" type="FloatVec">49.3344654494</parameter>
<parameter name="CalibrHCALEndcap" type="FloatVec">55.3271575116</parameter>
<parameter name="CalibrHCALOther" type="FloatVec">31.1454028868</parameter>
```

Digitisation Constants

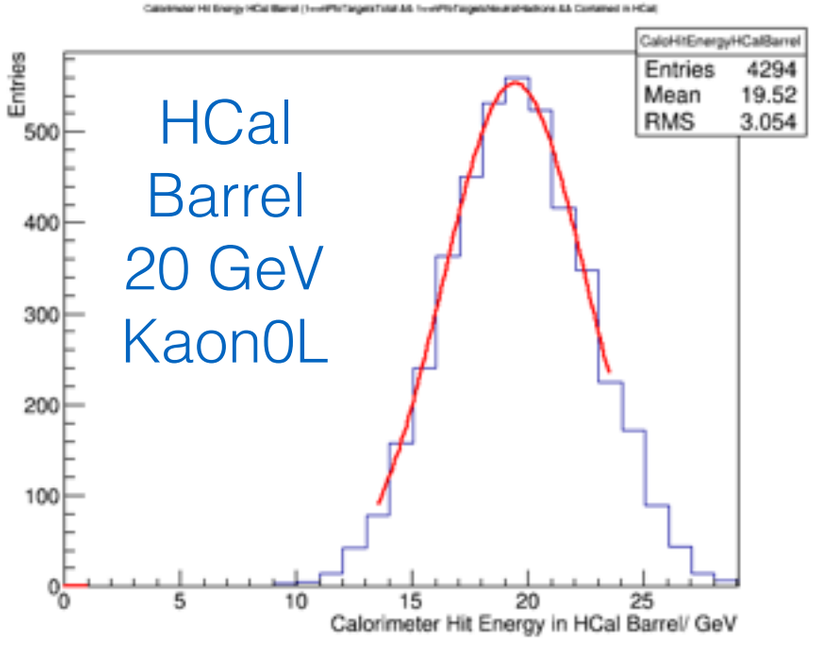
Active Material Energy



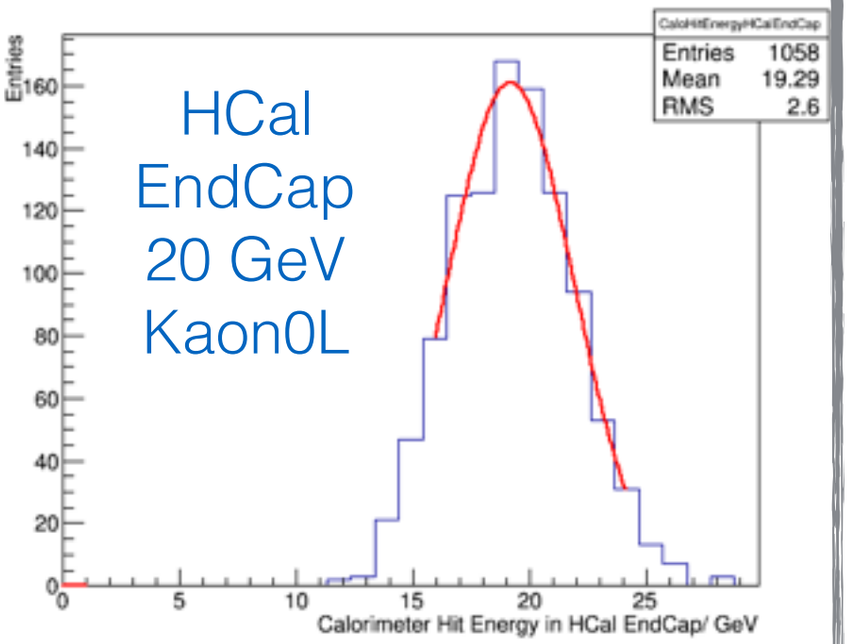
Absorber + Active Material Energy



ECal
10 GeV ɣ



HCal
Barrel
20 GeV
Kaon0L



HCal
EndCap
20 GeV
Kaon0L

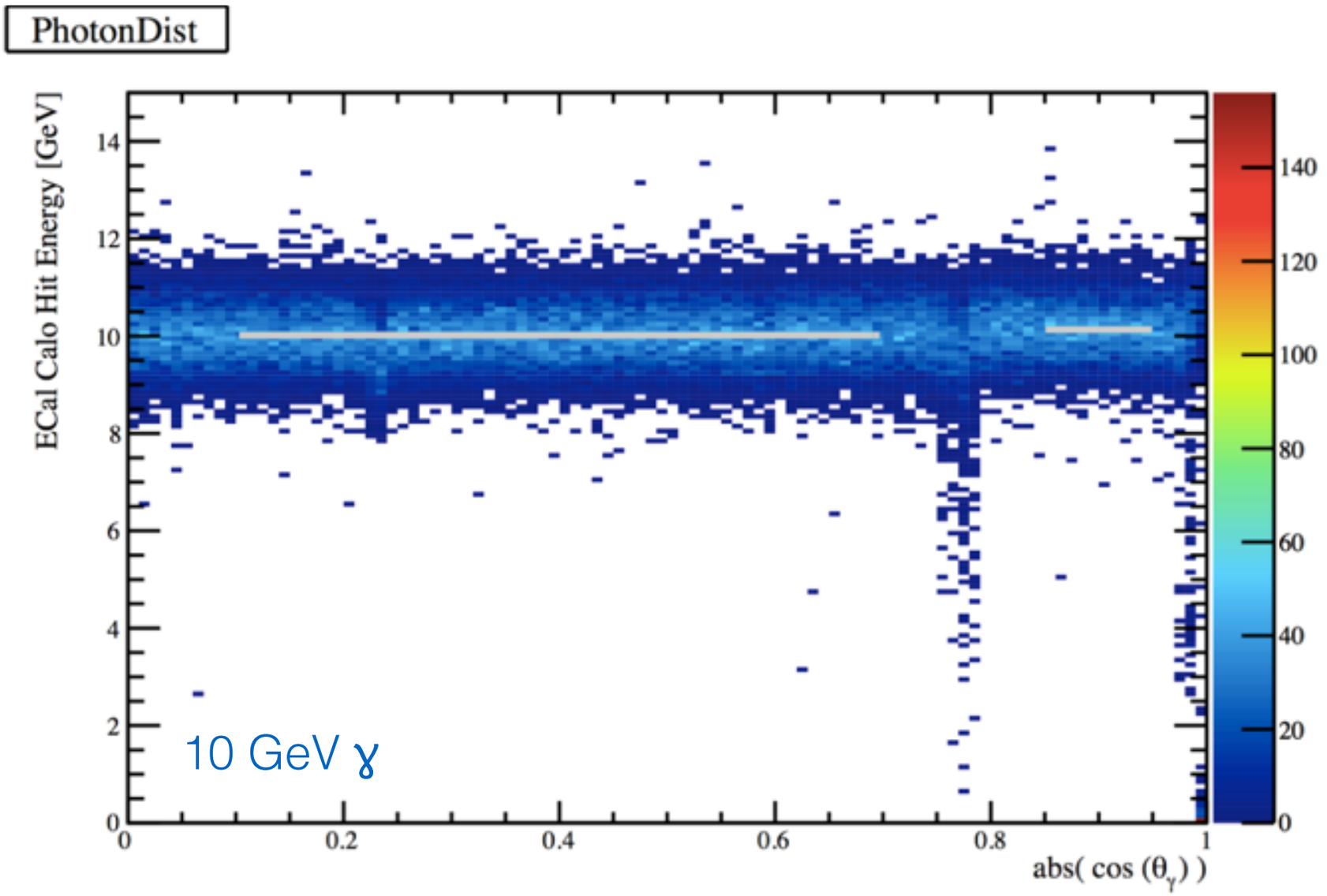
- Centre distributions of total calo hit energies (active + absorber) for events contained in various parts of the detector.
- Number of parameters is digitiser dependant (ILDCaloDid 1 ECal, 3 HCal, NewLDCCaloDigi (1 ECal, 1 HCal)

Digitisation

```
<!--Gap Correction-->
<parameter name="ECALGapCorrection" type="int"> 1 </parameter>
<!--Gap Correction Fudge Factor-->
<parameter name="ECALGapCorrectionFactor" type="float">1</parameter>
<parameter name="ECALModuleGapCorrectionFactor" type="int"> 0.0 </parameter>
```

ECal Gap Correction

* Currently only applied for Sc ECal option.
* ECal Calo Hit Energy as function of cos(θ_γ).
* Fit Barrel and EndCap with flat line.
* Gap correction is ratio of the two.

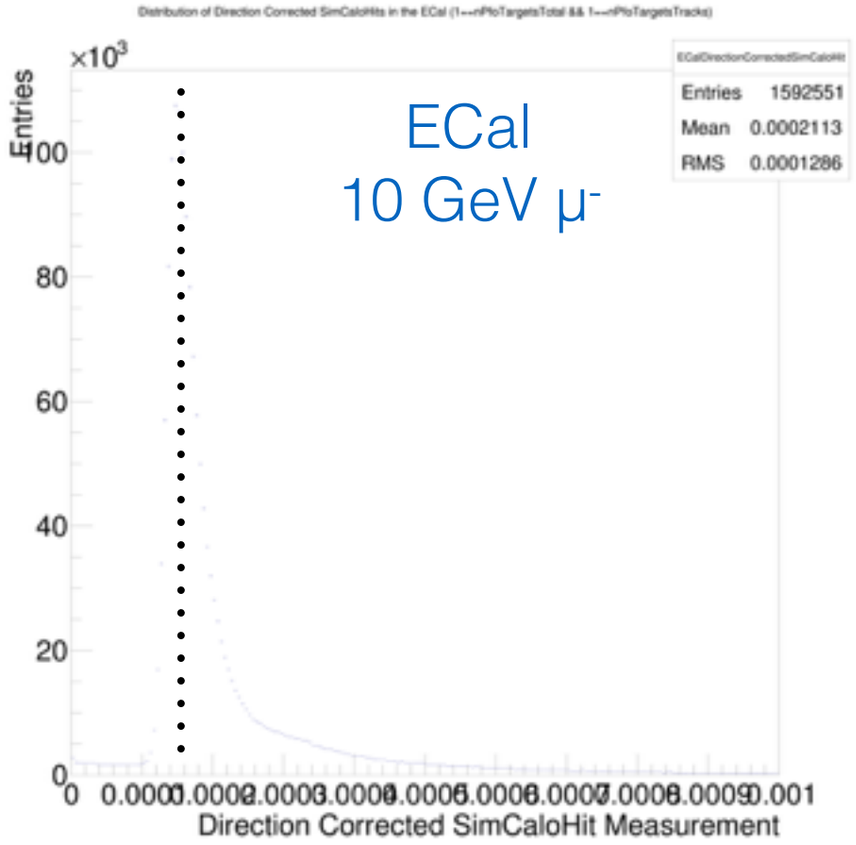


Digitisation

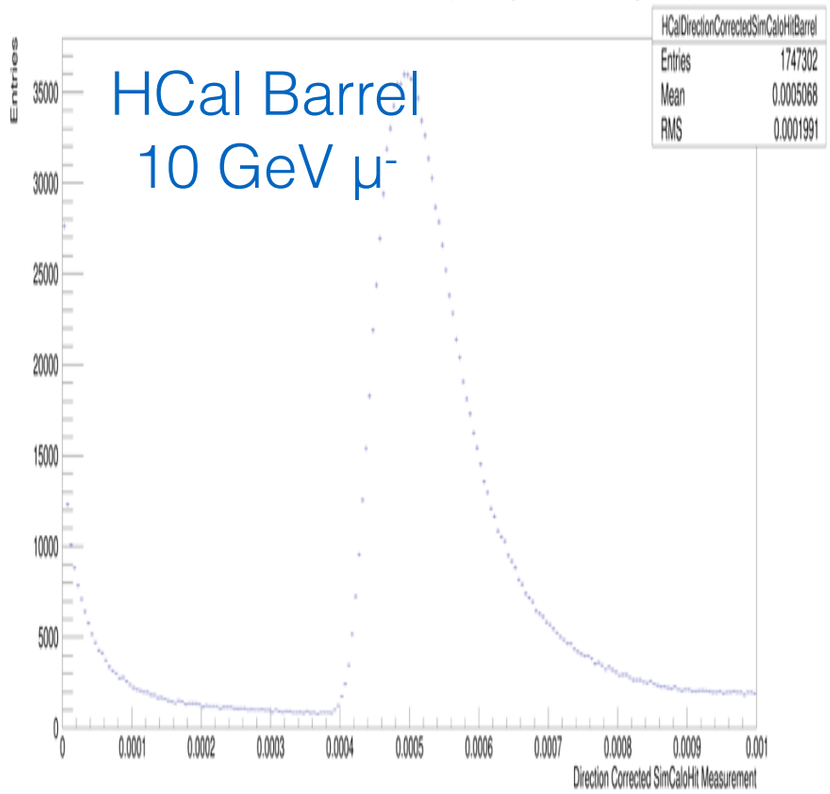
```
<!-- Realistic ECal -->
<parameter name="CalibECALMIP" type="float">0.0001475</parameter>
<!-- Realistic HCal -->
<parameter name="CalibHCALMIP" type="float">0.0004925</parameter>
```

Realistic ECal

Realistic HCal



ECal
10 GeV μ^-



HCal Barrel
10 GeV μ^-

- MIP Scale in Digitisers has to be set.
- Look at direction corrected SimCaloHit MIP peak for ECal and HCal.

Pandora

```
<processor name="MyMarlinPandora" type="PandoraPFANewProcessor">
    <parameter name="PandoraSettingsXmlFile" type="String">PandoraSettingsDefault.xml</parameter>
    <!-- Collection names -->
    <parameter name="TrackCollections" type="StringVec">MarlinTrkTracks</parameter>
    <parameter name="ECalCaloHitCollections" type="StringVec">ECALBarrel ECALEndcap ECALOther</parameter>
    <parameter name="HCalCaloHitCollections" type="StringVec">HCALBarrel HCALEndcap HCALOther</parameter>
    <parameter name="LCalCaloHitCollections" type="StringVec">LCAL</parameter>
    <parameter name="LHCalCaloHitCollections" type="StringVec">LHCAL</parameter>
    <parameter name="MuonCaloHitCollections" type="StringVec">MUON</parameter>
    <parameter name="MCParticleCollections" type="StringVec">MCParticle</parameter>
    <parameter name="RelCaloHitCollections" type="StringVec">RelationCaloHit RelationMuonHit</parameter>
    <parameter name="RelTrackCollections" type="StringVec">MarlinTrkTracksMCTruthLink</parameter>
    <parameter name="KinkVertexCollections" type="StringVec">KinkVertices</parameter>
    <parameter name="ProngVertexCollections" type="StringVec">ProngVertices</parameter>
    <parameter name="SplitVertexCollections" type="StringVec">SplitVertices</parameter>
    <parameter name="V0VertexCollections" type="StringVec">V0Vertices</parameter>
    <parameter name="ClusterCollectionName" type="String">PandoraClusters</parameter>
    <parameter name="PFOCollectionName" type="String">PandoraPFOs</parameter>
    <parameter name="StartVertexCollectionName" type="String">StartVertices</parameter>
    <!-- Calibration constants -->
    <parameter name="ECalToMipCalibration" type="float">153.846</parameter>
    <parameter name="HCalToMipCalibration" type="float">38.0228</parameter>
    <parameter name="ECalMipThreshold" type="float">0.5</parameter>
    <parameter name="HCalMipThreshold" type="float">0.3</parameter>
    <parameter name="ECalToEMGeVCalibration" type="float">1.00356141304</parameter>
    <parameter name="HCalToEMGeVCalibration" type="float">1.12083052744</parameter>
    <parameter name="ECalToHadGeVCalibrationBarrel" type="float">1.14127910463</parameter>
    <parameter name="ECalToHadGeVCalibrationEndCap" type="float">1.14127910463</parameter>
    <parameter name="HCalToHadGeVCalibration" type="float">1.12083052744</parameter>
    <parameter name="MuonToMipCalibration" type="float">10.3093</parameter>
    <parameter name="DigitalMuonHits" type="int">0</parameter>
    <parameter name="MaxHCalHitHadronicEnergy" type="float">1.0</parameter>
    <parameter name="AbsorberRadLengthECal" type="float">0.2854</parameter>
    <parameter name="AbsorberIntLengthECal" type="float">0.0101</parameter>
    <parameter name="AbsorberRadLengthHCal" type="float">0.0569</parameter>
    <parameter name="AbsorberIntLengthHCal" type="float">0.0060</parameter>
    <parameter name="AbsorberRadLengthOther" type="float">0.0569</parameter>
    <parameter name="AbsorberIntLengthOther" type="float">0.0060</parameter>
</processor>
```

Collection Names

Calibration Constants

Additional Geometry Information

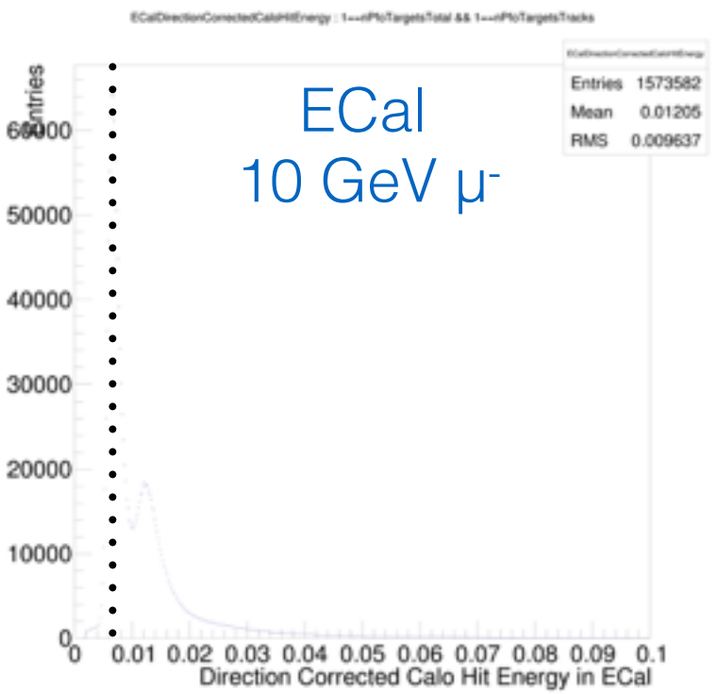
Marlin steering file snippet. MarlinPandora.

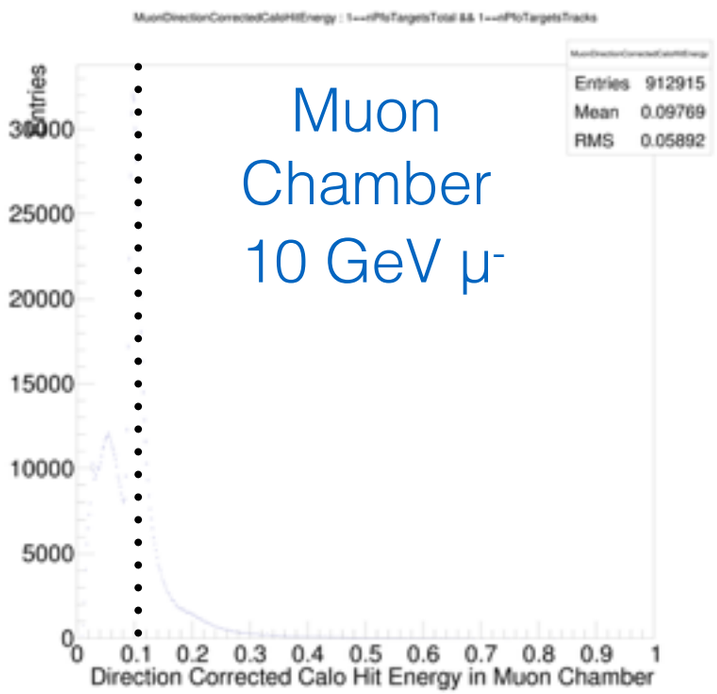
Pandora

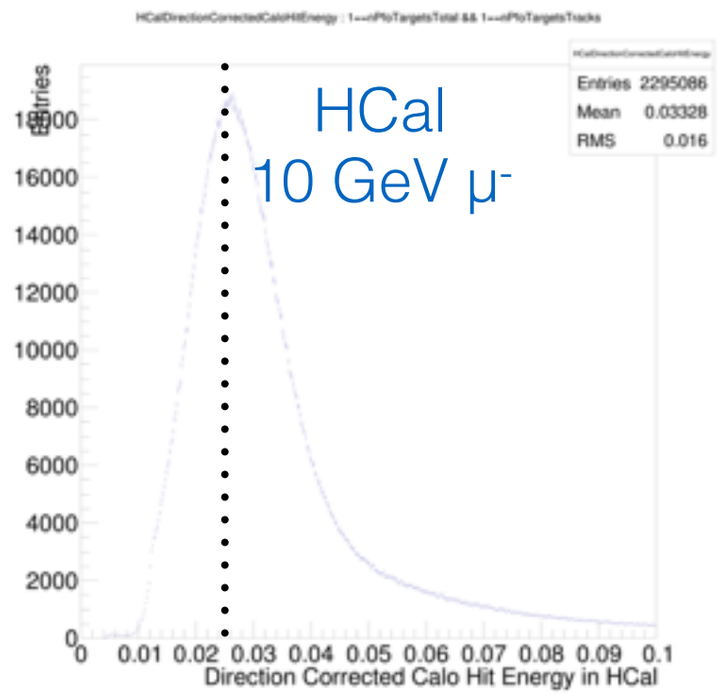
```
<!-- Calibration constants -->
<parameter name="ECalToMipCalibration" type="float">153.846</parameter>
<parameter name="HCalToMipCalibration" type="float">38.0228</parameter>
<parameter name="ECalMipThreshold" type="float">0.5</parameter>
<parameter name="HCalMipThreshold" type="float">0.3</parameter>
<parameter name="ECalToEMGeVCalibration" type="float">1.00356141304</parameter>
<parameter name="HCalToEMGeVCalibration" type="float">1.12083052744</parameter>
<parameter name="ECalToHadGeVCalibrationBarrel" type="float">1.14127910463</parameter>
<parameter name="ECalToHadGeVCalibrationEndCap" type="float">1.14127910463</parameter>
<parameter name="HCalToHadGeVCalibration" type="float">1.12083052744</parameter>
<parameter name="MuonToMipCalibration" type="float">10.3093</parameter>
```

Calibration Constants

* MIP Scale in Pandora has to be set.
* Used for applying MIP cuts, which must also be specified.
* Look at direction corrected CaloHit MIP (Absorber + Active) peak for ECal and HCal.







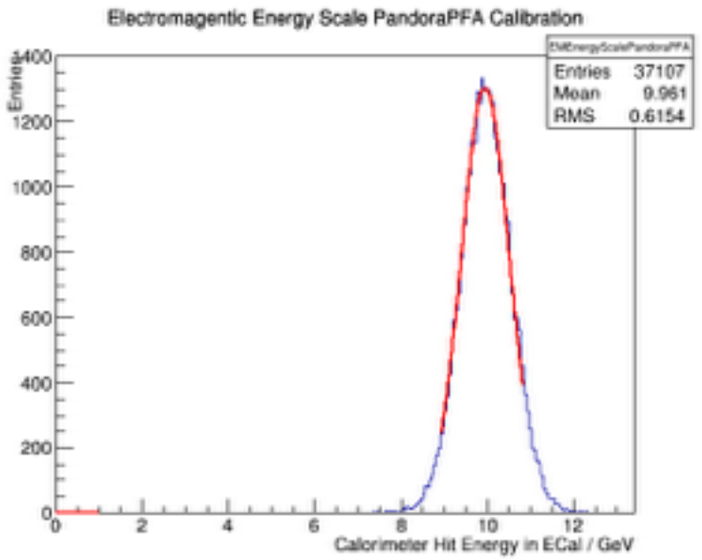
Pandora

```
<!-- Calibration constants -->
<parameter name="ECalToMipCalibration" type="float">153.846</parameter>
<parameter name="HCalToMipCalibration" type="float">38.0228</parameter>
<parameter name="ECalMipThreshold" type="float">0.5</parameter>
<parameter name="HCalMipThreshold" type="float">0.3</parameter>
<parameter name="ECalToEMGeVCalibration" type="float">1.00356141304</parameter>
<parameter name="HCalToEMGeVCalibration" type="float">1.12083052744</parameter>
<parameter name="ECalToHadGeVCalibrationBarrel" type="float">1.14127910463</parameter>
<parameter name="ECalToHadGeVCalibrationEndCap" type="float">1.14127910463</parameter>
<parameter name="HCalToHadGeVCalibration" type="float">1.12083052744</parameter>
<parameter name="MuonToMipCalibration" type="float">10.3093</parameter>
```

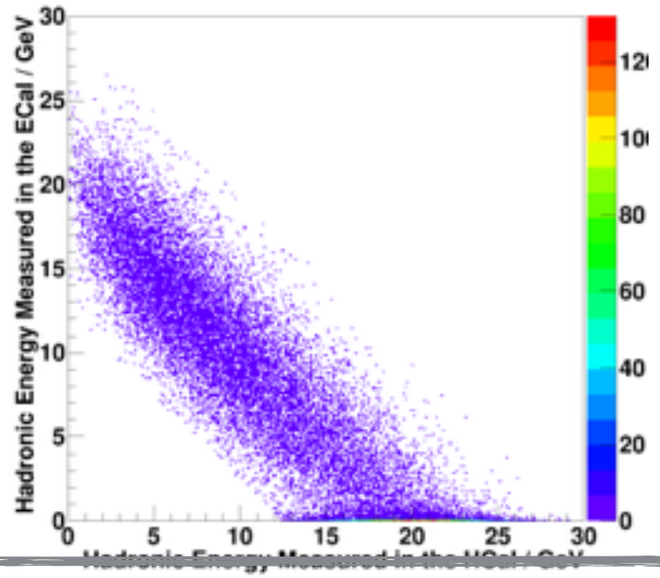
Calibration Constants

* Set the electromagnetic and hadronic energy scale in Pandora.
* Look at distributions of PFO energies, apply fits and readjust constants until fits have the appropriate distribution,
* Simple Gaussian fit for electromagnetic showers as all energy for photons confined there.
* 2D straight line fit for hadronic as energy hadronic showers have energy split between ECal and HCal

ECal
10 GeV ɣ



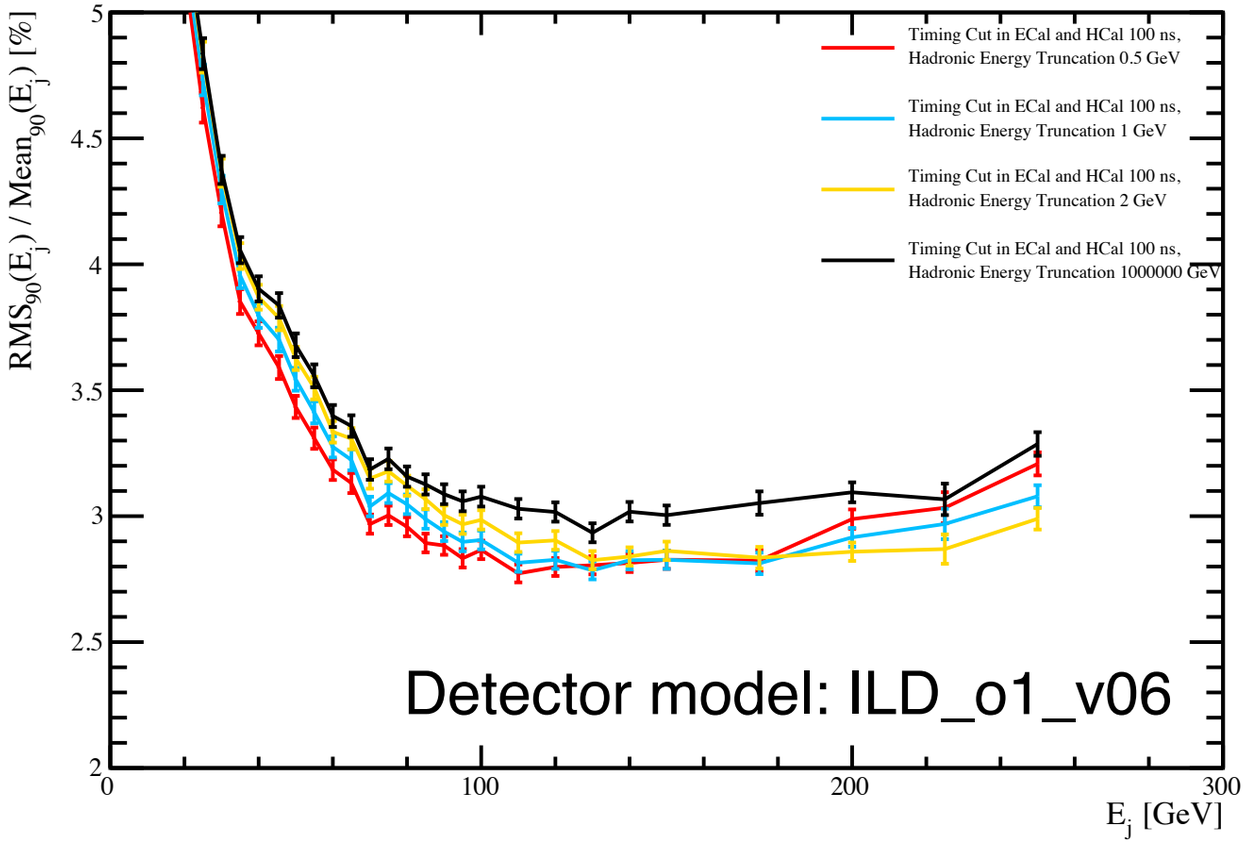
HCal
20 GeV
Kaon0L



Pandora

```
<parameter name="MaxHCalHitHadronicEnergy" type="float">1.0</parameter>
```

→ Primitive software compensation



- Truncation of hadronic energy measured in the HCal.
- Primitive software compensation, but big effect.

0.5 GeV
1 GeV
2 GeV
Semi-Infinite

- Must be considered for detector optimisation.

HCal Timing Cuts : 100 ns
ECal Timing Cuts : 100 ns
HCal Hadronic Cell Truncation : Various
Software : ilcsoft_v01-17-07, including PandoraPFA v02-00-00
Digitiser : ILDCaloDigi, realistic ECal and HCal digitisation options enabled
Calibration : PandoraAnalysis toolkit v01-00-00

PFO Analysis - Calibration Processor

```
<processor name="MyPfoAnalysisDefault" type="PfoAnalysis">
    <!--PfoAnalysis analyses output of PandoraPFANew, Modified for calibration-->
    <!--Names of input pfo collection-->
    <parameter name="PfoCollection" type="string" lcioInType="ReconstructedParticle">PandoraPFOsDefault</parameter>
    <!--Names of mc particle collection-->
    <parameter name="MCParticleCollection" type="string" lcioInType="MCParticle">MCParticle </parameter>
    <!--Set the debug print level-->
    <parameter name="Printing" type="int"> 0 </parameter>
    <!--Output root file name-->
    <parameter name="RootFile" type="string">MyPfoAnalysis_Default.root</parameter>
</processor>
```

Default setup for jet energy resolution studies

Marlin steering file snippet. PandoraAnalysis. Default setup.

* Simply reads in PFOs produced by Pandora and the MC particle collection.
* Writes a root file containing of various parameters.
* AnalysePerformance binary can be run on these root files to produce the jet energy resolution.

PFO Analysis - Calibration Processor

```
<processor name="MyPfoAnalysis" type="PfoAnalysis">
    <!--Names of input pfo collection-->
    <parameter name="PfoCollection" type="string" lcioInType="ReconstructedParticle">PandoraPFOs </parameter>
    <!--Names of mc particle collection-->
    <parameter name="MCParticleCollection" type="string" lcioInType="MCParticle">MCParticle </parameter>
    <!--Collect Calibration Details-->
    <parameter name="CollectCalibrationDetails" type="int">1</parameter>
    <!--Detector Geometry Missing From Gear-->
    <parameter name="HCalRingOuterSymmetryOrder" type="int">8</parameter>
    <parameter name="HCalRingOuterPhi0" type="int">0</parameter>
    <!--Name of the ECAL collection used to form clusters-->
    <parameter name="ECalCollections" type="StringVec" lcioInType="CalorimeterHit">ECALBarrel ECALEndcap ECALOther</parameter>
    <!--Name of the HCAL collection used to form clusters-->
    <parameter name="HCalCollections" type="StringVec" lcioInType="CalorimeterHit">HCALBarrel HCALEndcap HCALOther </parameter>
    <!--Name of the MUON collection used to form clusters-->
    <parameter name="MuonCollections" type="StringVec" lcioInType="CalorimeterHit">MUON </parameter>
    <!--Name of the BCAL collection used to form clusters-->
    <parameter name="BCalCollections" type="StringVec" lcioInType="CalorimeterHit">BCAL</parameter>
    <!--Name of the LHCAL collection used to form clusters-->
    <parameter name="LHCalCollections" type="StringVec" lcioInType="CalorimeterHit">LHCAL </parameter>
    <!--Name of the LCAL collection used to form clusters-->
    <parameter name="LCalCollections" type="StringVec" lcioInType="CalorimeterHit">LCAL </parameter>
    <!--ECal Collection SimCaloHit Names-->
    <parameter name="ECalCollectionsSimCaloHit" type="StringVec">EcalBarrelSiliconCollection EcalEndcapSiliconCollection
        EcalEndcapRingCollection </parameter>
    <!--HCal Barrel Collection SimCaloHit Names-->
    <parameter name="HCalBarrelCollectionsSimCaloHit" type="StringVec"> HcalBarrelRegCollection </parameter>
    <!--HCal Endcap Collection SimCaloHit Names-->
    <parameter name="HCalEndCapCollectionsSimCaloHit" type="StringVec"> HcalEndCapsCollection </parameter>
    <!--HCal Other/Ring Collection SimCaloHit Names-->
    <parameter name="HCalOtherCollectionsSimCaloHit" type="StringVec"> HcalEndCapRingsCollection</parameter>
    <!--Set the debug print level-->
    <parameter name="Printing" type="int"> 0 </parameter>
    <!--Output root file name-->
    <parameter name="RootFile" type="string"> PFOAnalysisCalibration.root </parameter>
</processor>
```

Setup For Calibration

Marlin steering file snippet. PandoraAnalysis. Calibration setup.

PFO Analysis - Calibration Processor Extra Info

```
<!--Collect Calibration Details-->
<parameter name="CollectCalibrationDetails" type="int">1</parameter>
<!--Detector Geometry Missing From Gear-->
<parameter name="HCalRingOuterSymmetryOrder" type="int">8</parameter>
<parameter name="HCalRingOuterPhi0" type="int">0</parameter>
```

Setup Calibration and Extra Geometry Information

```
<!--Name of the ECAL collection used to form clusters-->
<parameter name="ECalCollections" type="StringVec" lcioInType="CalorimeterHit">ECALBarrel ECALEndcap ECALOther</parameter>
<!--Name of the HCAL collection used to form clusters-->
<parameter name="HCalCollections" type="StringVec" lcioInType="CalorimeterHit">HCALBarrel HCALEndcap HCALOther </parameter>
<!--Name of the MUON collection used to form clusters-->
<parameter name="MuonCollections" type="StringVec" lcioInType="CalorimeterHit">MUON </parameter>
<!--Name of the BCAL collection used to form clusters-->
<parameter name="BCalCollections" type="StringVec" lcioInType="CalorimeterHit">BCAL</parameter>
<!--Name of the LHCAL collection used to form clusters-->
<parameter name="LHCalCollections" type="StringVec" lcioInType="CalorimeterHit">LHCAL </parameter>
<!--Name of the LCAL collection used to form clusters-->
<parameter name="LCalCollections" type="StringVec" lcioInType="CalorimeterHit">LCAL </parameter>
```

Calorimeter Hits Collections

```
<!--ECal Collection SimCaloHit Names-->
<parameter name="ECalCollectionsSimCaloHit" type="StringVec">EcalBarrelSiliconCollection EcalEndcapSiliconCollection
    EcalEndcapRingCollection </parameter>
<!--HCal Barrel Collection SimCaloHit Names-->
<parameter name="HCalBarrelCollectionsSimCaloHit" type="StringVec"> HcalBarrelRegCollection </parameter>
<!--HCal Endcap Collection SimCaloHit Names-->
<parameter name="HCalEndCapCollectionsSimCaloHit" type="StringVec"> HcalEndCapsCollection </parameter>
<!--HCal Other/Ring Collection SimCaloHit Names-->
<parameter name="HCalOtherCollectionsSimCaloHit" type="StringVec"> HcalEndCapRingsCollection</parameter>
```

Sim Calo Hit Collections

Photon Likelihood Data

* If you are running with PandoraSettingsDefault.xml then photon likelihood data is used in the reconstruction.

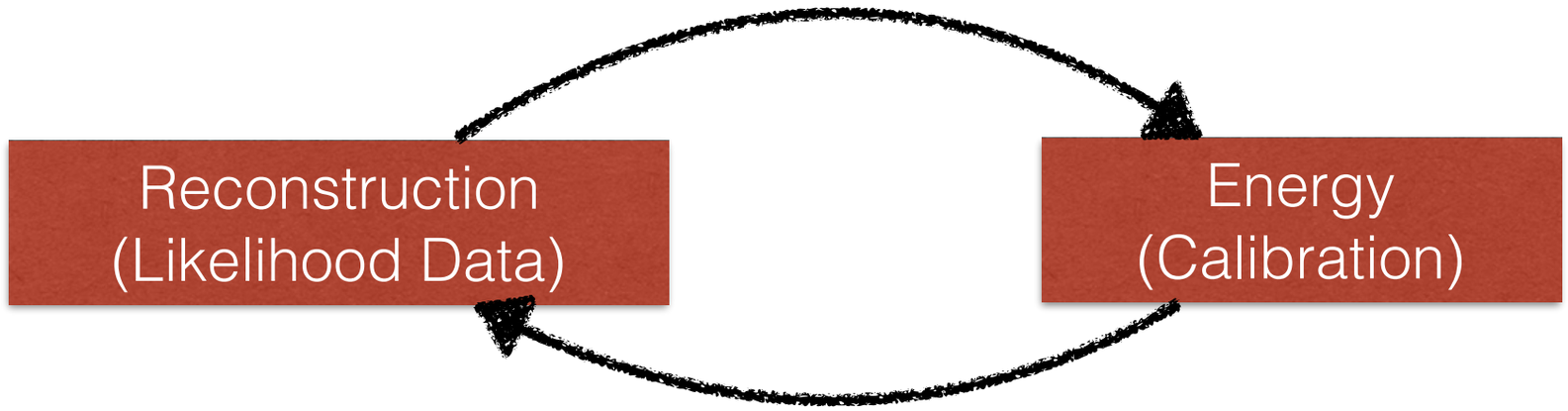
Pandora Settings Snippet

```
<pandora>
    <!-- GLOBAL SETTINGS -->
    <IsMonitoringEnabled>true</IsMonitoringEnabled>
    <ShouldDisplayAlgorithmInfo>false</ShouldDisplayAlgorithmInfo>
    <ShouldCollapseMCParticlesToPfoTarget>true</ShouldCollapseMCParticlesToPfoTarget>

    <!-- PLUGIN SETTINGS -->
    <HadronicEnergyCorrectionPlugins>CleanClusters ScaleHotHadrons</HadronicEnergyCorrectionPlugins>
    <EmShowerPlugin>LCEmShowerId</EmShowerPlugin>
    <PhotonPlugin>LCPhotonId</PhotonPlugin>
    <ElectronPlugin>LCElectronId</ElectronPlugin>
    <MuonPlugin>LCMuonId</MuonPlugin>

    <!-- ALGORITHM SETTINGS -->
    ...
    <!-- Standalone photon clustering -->
    <algorithm type = "PhotonReconstruction">
        <algorithm type = "ConeClustering" description = "PhotonClusterFormation">
            <ClusterSeedStrategy>0</ClusterSeedStrategy>
            <ShouldUseTrackSeed>false</ShouldUseTrackSeed>
            <ShouldUseOnlyECalHits>true</ShouldUseOnlyECalHits>
            <ConeApproachMaxSeparation>250.</ConeApproachMaxSeparation>
        </algorithm>
        <ClusterListName>PhotonClusters</ClusterListName>
        <ReplaceCurrentClusterList>false</ReplaceCurrentClusterList>
        <ShouldMakePdfHistograms>false</ShouldMakePdfHistograms>
        <HistogramFile>PandoraLikelihoodData9EBin.xml</HistogramFile>
    </algorithm>
    ...
</pandora>
```

Photon Likelihood Data

Photon Likelihood Data

* This data is trained on 500 GeV Z→uds events.
* Likelihood data used in reconstruction of photons only, therefore, only varies with changes to the ECal.
* Changing ECal requires retraining likelihood data.



Change ECal Method

1) Calibrate with PandoraSettingsMuon.xml
(No likelihood data)

2) Train Photon Likelihood data

3) Calibrate with PandoraSettingsDefault.xml
(With new likelihood data)