Pandora for key4hep

Wenxing Fang (IHEP)

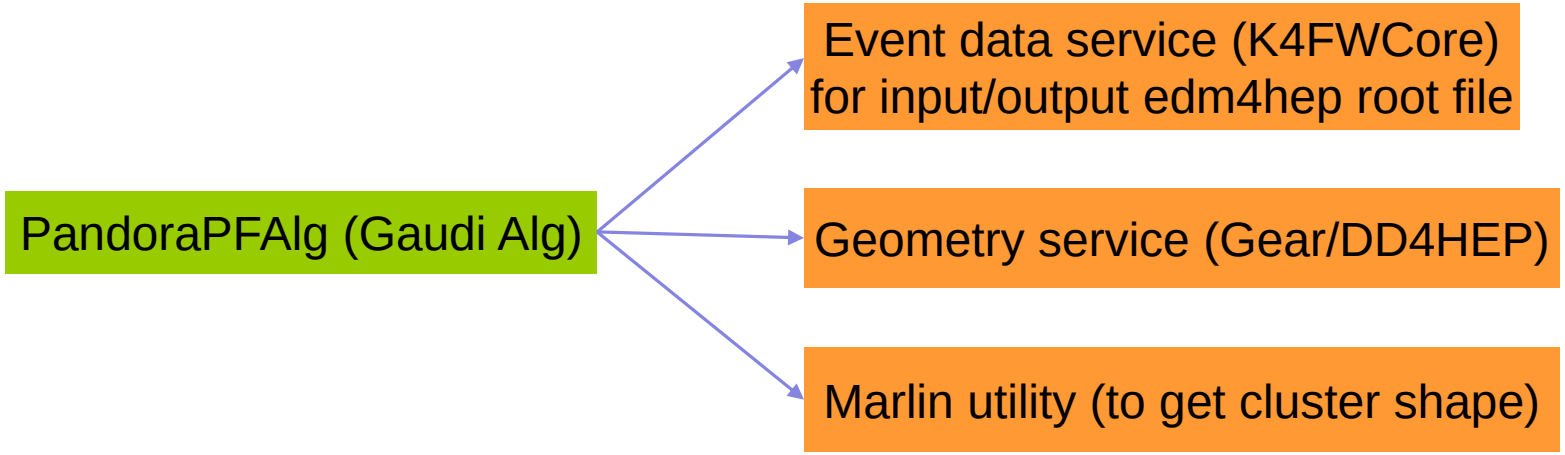
2020-07-14

Pandora for key4hep

- Originate from MarlinPandora https://github.com/PandoraPFA/MarlinPandora
- Migrate it to Gaudi framework, using edm4hep as event data model
- It is now used in CEPC experiment (https://github.com/cepc/CEPCSW)
- The package is now put in git https://github.com/wenxingfang/CEPCSW_Pandora

Pandora

- The pandora repository includes:
  - Pandora: pandora client (wrapped in PandoraPFAlg)
  - Utility: Marlin utility
  - Service: provide geometry service
  - Examples: option file example (see next slide)



- The input data for pandora:
  - edm4hep::CalorimeterHit
  - edm4hep::Track
  - edm4hep::MCParticle
  - edm4hep::MCRecoCaloAssociation
  - edm4hep::MCRecoTrackerAssociation
- The output data for pandora:
  - edm4hep::ReconstructedParticle
  - edm4hep::Cluster
  - edm4hep::MCRecoParticleAssociation

Pandora option file example

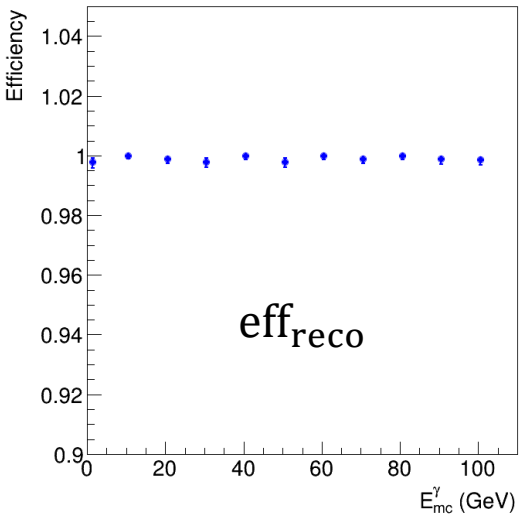
- edm4hep root data is input using K4FWCore
- The detector geometry information is read using GearSvc (or DD4HEP)
- The PandoraPFAlg performs pandora reconstruction
- Finally the output of edm4hep root file is saved

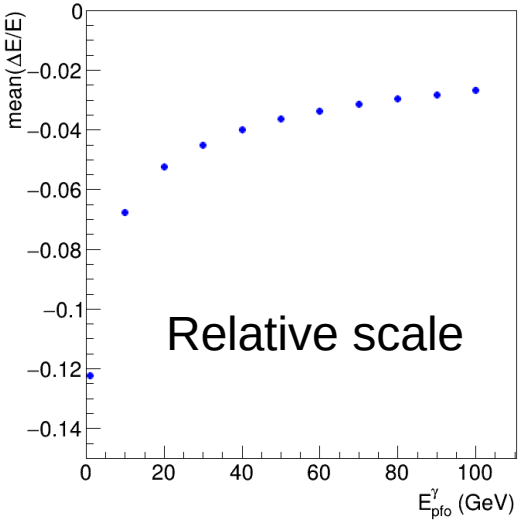
```
##############################################################################
from Configurables import K4DataSvc
dsvc = K4DataSvc("EventDataSvc", input="you_input.root")
##############################################################################
from Configurables import PodioInput ## set the input collection data
podioinput = PodioInput("PodioReader", collections=[
    "MCParticle",
    "ECALBarrel"
    ])
##############################################################################
from Configurables import GearSvc
gearSvc  = GearSvc("GearSvc")
gearSvc.GearXMLFile = "../Pandora/FullDetGear.xml"
##############################################################################

pandoralg = PandoraPFAlg("PandoraPFAlg")
## KEEP same with lcioinput name for the ReadXXX ###########
pandoralg.ReadMCParticle                       = "MCParticle"
pandoralg.ReadECALBarrel                       = "ECALBarrel"
pandoralg.ReadECALEndcap                       = "ECALEndcap"
pandoralg.ReadECALOther                        = "ECALOther"
pandoralg.ReadHCALBarrel                       = "HCALBarrel"
pandoralg.ReadHCALEndcap                       = "HCALEndcap"
pandoralg.ReadHCALOther                        = "HCALOther"
pandoralg.WriteClusterCollection               = "PandoraClusters"
pandoralg.WriteReconstructedParticleCollection = "PandoraPFOs"
pandoralg.WriteVertexCollection                = "PandoraPFANewStartVertices"
                    ⋮
pandoralg.PandoraSettingsDefault_xml = "../Pandora/PandoraSettingsDefault.xml"

# write PODIO file
from Configurables import PodioOutput
write = PodioOutput("write")
write.filename = "test.root"
write.outputCommands = ["keep *"]

# ApplicationMgr
from Configurables import ApplicationMgr
ApplicationMgr(
        TopAlg = [podioinput,pandoralg,write],
        EvtSel = 'NONE',
        EvtMax = 10,
        ExtSvc = [dsvc, gearSvc],
        OutputLevel=INFO
```

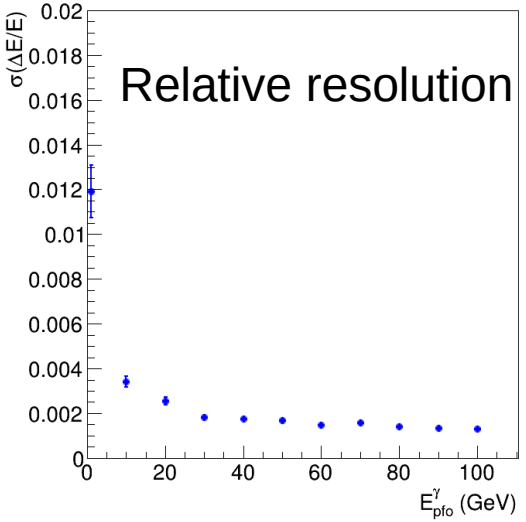
Test pandora for Matrix ECAL

- Matrix ECAL: 60*60*60 cm^3 BGO scintillator, cell size is 1*1*1 cm^3
- Getting the needed geometry information for pandora using DD4HEP (saved in dd4hep::rec::LayeredCalorimeterData)
- Using single γ events for test:
  - Energy: 1, 10, 20, … , 100 GeV. $\theta = 90^{\circ}, \phi = 0^{\circ}$
- No energy calibration is performed here

```
<detectors>
  <detector id="1" name="CaloDetector" type="EcalMatrix" readout="CaloHitsCollection"
    <position x="0"  y="0"  z="1835*mm+30*cm"/>
    <dimensions dx="30*cm"  dy="30*cm"  dz="30*cm"/>
  </detector>
</detectors>

<readouts>
  <readout name="CaloHitsCollection">
    <segmentation type="CartesianGridXYZ"
                  grid_size_x="1*cm"
                  grid_size_y="1*cm"
                  grid_size_z="1*cm"/>
    <id>system:8,x:32:-6,y:-6,z:-6</id>
  </readout>
</readouts>
```



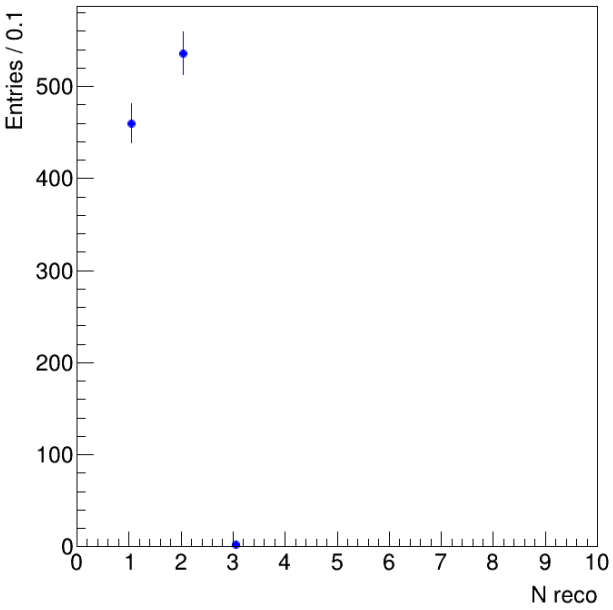


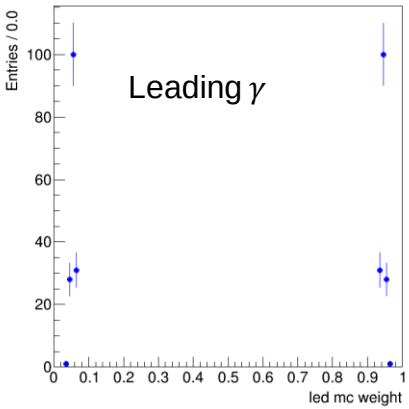


Test pandora for Matrix ECAL

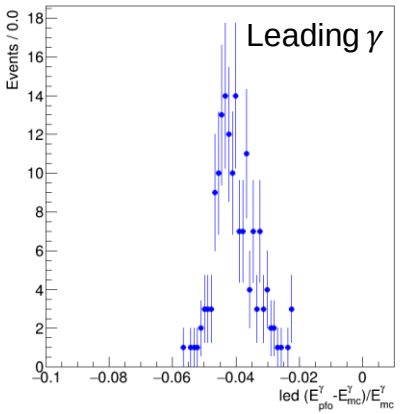
- Test MCRecoParticleAssociation class
- $\gamma 1$ (E=10GeV, θ=90°, ϕ=0°) , $\gamma 2$ (E=10GeV, θ=90°, ϕ=1°), distance ~ 3 cm in Matrix Ecal surface. More in backup.
- The weight of relation (between reco and MC particle) is given according to the energy contribution of the MC particle in the reconstructed gamma

```
<detectors>
  <detector id="1" name="CaloDetector" type="EcalMatrix" readout="CaloHitsCollection"
    <position x="0"  y="0"  z="1835*mm+30*cm"/>
    <dimensions dx="30*cm"  dy="30*cm"  dz="30*cm"/>
  </detector>
</detectors>

<readouts>
  <readout name="CaloHitsCollection">
    <segmentation type="CartesianGridXYZ"
                  grid_size_x="1*cm"
                  grid_size_y="1*cm"
                  grid_size_z="1*cm"/>
```

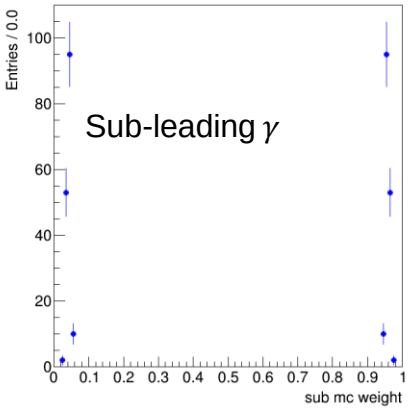


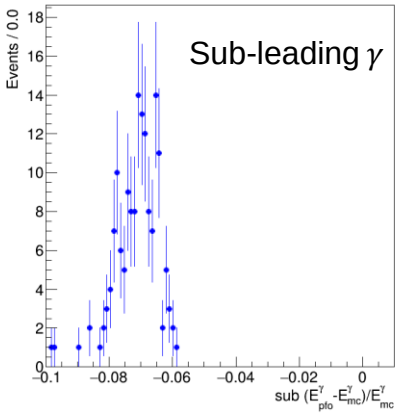


MC relation weight



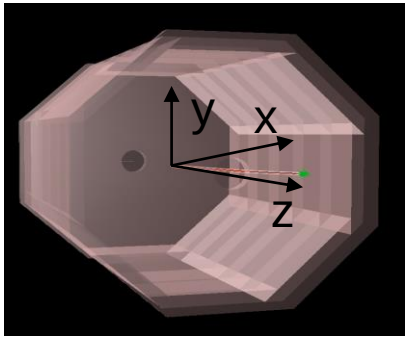
Relative scale

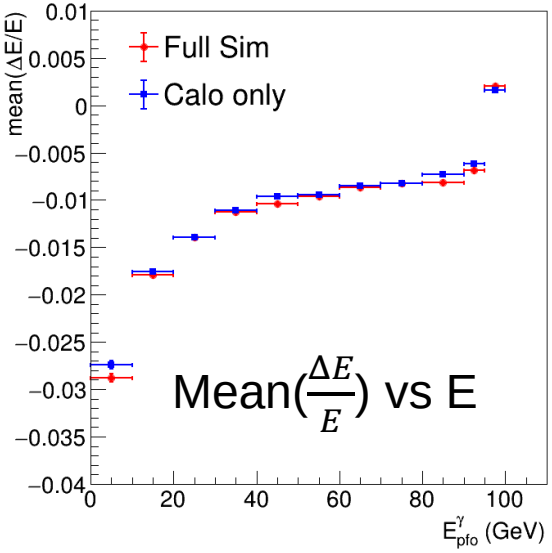


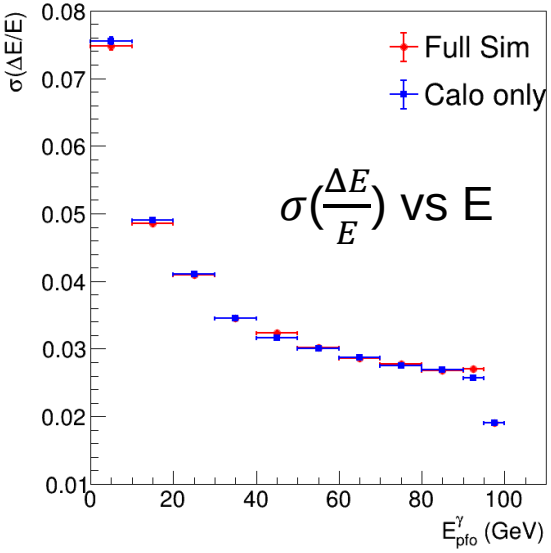


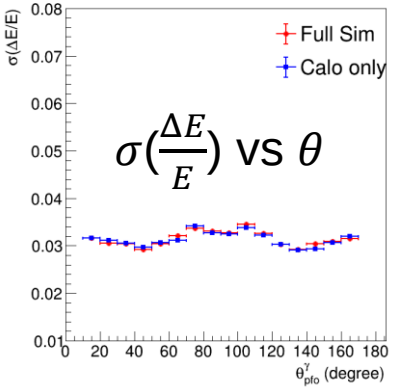
Test pandora for CEPC detector

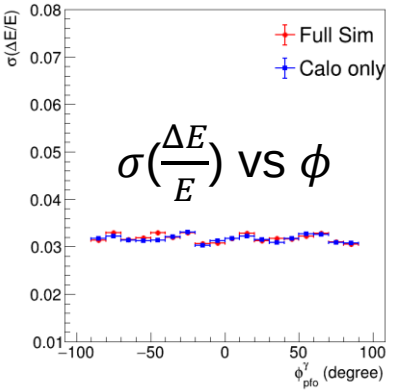
- CEPC ECAL: PFA oriented electromagnetic calorimeter. Silicon-tungsten sandwich structure (30 layers)
- The geometry information is read using gear service
- Single γ (1-100 GeV) events are used in test











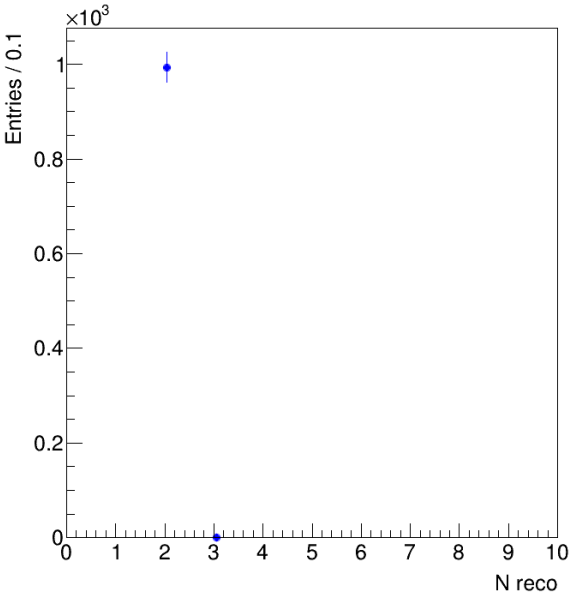
Thanks !

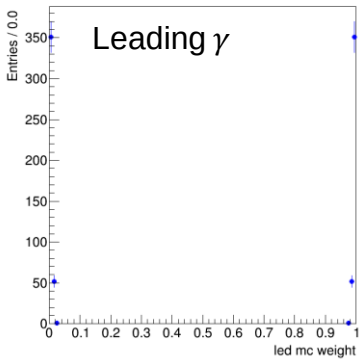
backup

Test pandora for Matrix ECAL

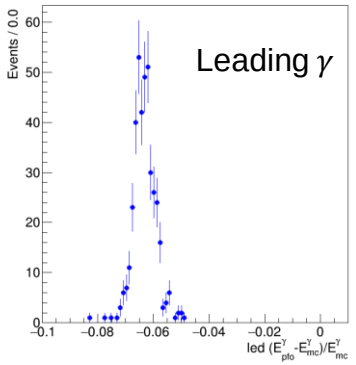
- Test MCRecoParticleAssociation class
- $\gamma 1$ (E=10GeV, θ=90°, ϕ=0°) , $\gamma 2$ (E=10GeV, θ=90°, ϕ=3°), distance ~ 3 cm in Matrix Ecal surface. More in backup.
- The weight of relation (between reco and MC particle) is given according to the energy contribution of the MC particle in the reconstructed gamma

```
<detectors>
  <detector id="1" name="CaloDetector" type="EcalMatrix" readout="CaloHitsCollection"
    <position x="0"  y="0"  z="1835*mm+30*cm"/>
    <dimensions dx="30*cm"  dy="30*cm"  dz="30*cm"/>
  </detector>
</detectors>

<readouts>
  <readout name="CaloHitsCollection">
    <segmentation type="CartesianGridXYZ"
                  grid_size_x="1*cm"
                  grid_size_y="1*cm"
                  grid_size_z="1*cm"/>
    <id>system:8,x:32:-6,y:-6,z:-6</id>
  </readout>
</readouts>
```

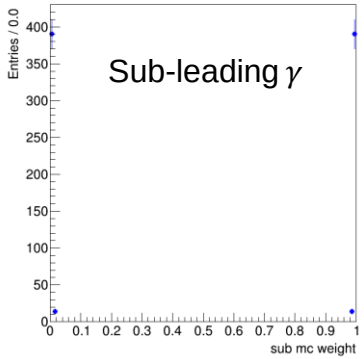


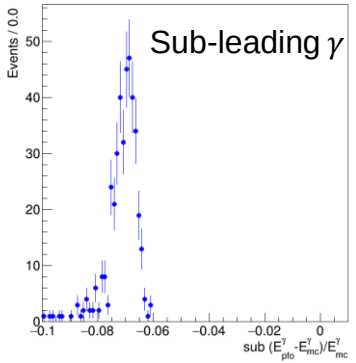


MC relation weight



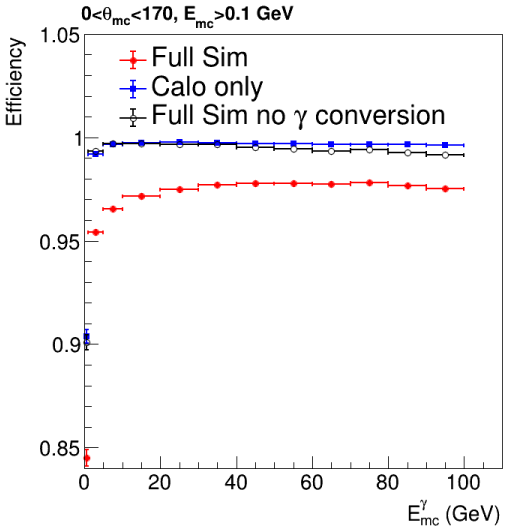
Relative scale

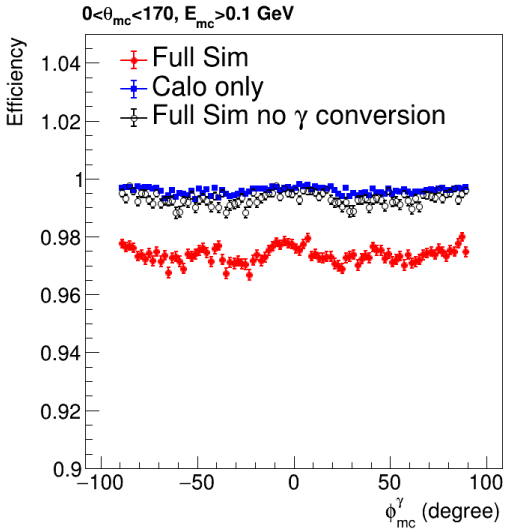


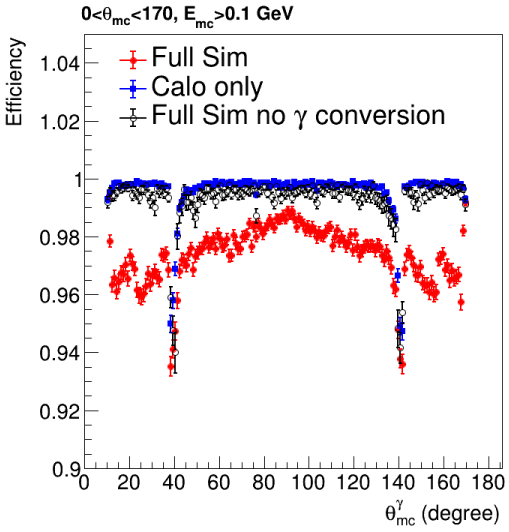


Test pandora for CEPC detector

- Below are γ reconstruction efficiencies as function of E_{mc} , θ_{mc}, and ϕ_{mc}







- The tracker detector before the ECAL makes the reconstruction efficiency lower. Should be improved after including reconstructed vertex information
- In high energy region, few photons are reconstructed as neutrons which are produced before calorimeter

Pandora for key4hep

- The user can set the wanted collections for pandora reconstruction
- Finally some detector material and calibration related parameters needs to be set correspondingly

- Some Notices
  - Please specify your own cell id decode in CaloHitCreator.cpp in order to get correct layer and stave number of hits
  - A function to get clustershape of a cluster is still from Marlin (it dependents GSL 1.14)
  - Currently vertices information is not used

```
pandoralg.TrackCollections      =  ["Tracks"]
pandoralg.ECalCaloHitCollections=  ["ECALBarrel", "ECALEndcap", "ECALOther"]
pandoralg.HCalCaloHitCollections=  ["HCALBarrel", "HCALEndcap", "HCALOther"]
pandoralg.LCalCaloHitCollections=  ["LCAL"]
pandoralg.LHCalCaloHitCollections= ["LHCAL"]
pandoralg.MuonCaloHitCollections=  ["MUON"]
pandoralg.MCParticleCollections =  ["MCParticle"]
pandoralg.RelCaloHitCollections =  ["RecoCaloAssociation_ECALBarrel"]
pandoralg.RelTrackCollections   =  ["RecoTrackerAssociation"]
pandoralg.KinkVertexCollections =  ["KinkVertices"]
pandoralg.ProngVertexCollections=  ["ProngVertices"]
pandoralg.SplitVertexCollections=  ["SplitVertices"]
pandoralg.V0VertexCollections   =  ["V0Vertices"]
pandoralg.ECalToMipCalibration  = 160.0
pandoralg.HCalToMipCalibration  = 34.8
pandoralg.ECalMipThreshold      = 0.5
pandoralg.HCalMipThreshold      = 0.3
pandoralg.ECalToEMGeVCalibration= 0.9 #for G2CD Digi, 1.007 for NewLDCaloDigi
pandoralg.HCalToEMGeVCalibration= 1.007
pandoralg.ECalToHadGeVCalibrationBarrel= 1.12 #very small effect
pandoralg.ECalToHadGeVCalibrationEndCap= 1.12
pandoralg.HCalToHadGeVCalibration= 1.07
pandoralg.MuonToMipCalibration= 10.0
pandoralg.DigitalMuonHits= 0
pandoralg.MaxHCalHitHadronicEnergy   = 1.0
pandoralg.UseOldTrackStateCalculation= 0
pandoralg.AbsorberRadLengthECal= 0.2854 #= 1/3.504 mm
pandoralg.AbsorberIntLengthECal= 0.0101 #= 1/99.46 mm
pandoralg.AbsorberRadLengthHCal= 0.0569
pandoralg.AbsorberIntLengthHCal= 0.006
pandoralg.AbsorberRadLengthOther= 0.0569
pandoralg.AbsorberIntLengthOther= 0.006
```