Status and future plans of dead material corrections in Athena

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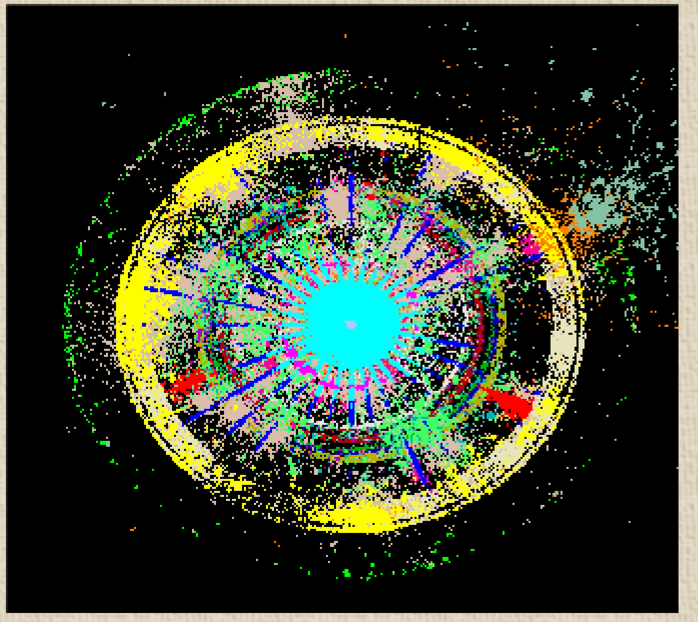

- ☼ Short reminder of DM hits features, part I
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Short reminder of DM hits features, part I.

Dead material calibration hits (type LArCalibrationHit) have separate fields for each of (em, nonem, invisible and escaped) energies and special DM identifier. They are stored in two separate containers "LArCalibrationHitDeadMaterial" and "TileCalibrationDMHitCnt".

DM identifier contains following components: *detector=10/ subdet / type / sampling / region / etaBin / phiBin*

A latest description of DM identifiers can be found at:
www.nevis.columbia.edu/~lelchuk/DeadMaterials/Version_1.10_draft.txt

There are ~72000 unique DM hits ("channels") in 53 DM areas, where "area" means same *subdet / type / sampling / region* but different *etaBin* and *phiBin*.

It is convenient to use following code number for labeling of each DM area:
abs(*subdet*)*1000+*type**100+*sampling**10+*region* (…*area 4120 – "DM between barrel and TileExt"…*)

To get real *eta*, *phi*, *distance* (*r* or *z*) for dead material hit one can use class GeoCaloCalibHit from the package DetectorDescription/GeoModel/GeoAdaptors. (These coordinates are not directly taken from g4step, they are calculated inside GeoCaloCalibHit from identifier fields using huge set of case/if statements just reproducing file Version_1.10.txt).

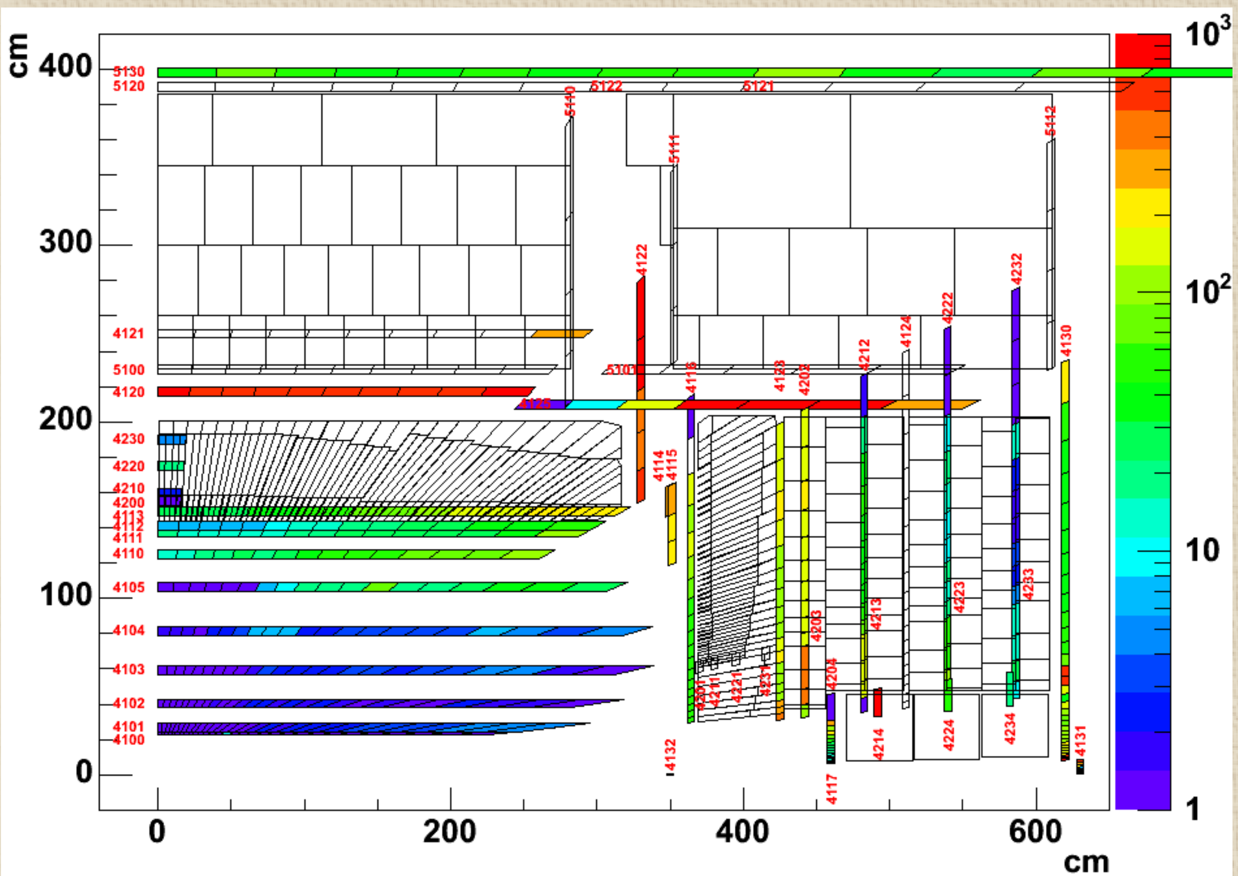
To have DM hits in CBNT one can use CBNT_CalibrationInfoDM algorithm, in this case he will get list of DM hits in the tree CalibHit/CalibrationInfoDM with all attendant information: identifier sub-fields, five energies, real *eta*, *phi, deta, dphi* and *distance*.

See also: W. Seligman *"Status of Calibration Hits in LArG4"*, ATLAS LAr week, http://agenda.cern.ch/fullAgenda.php?ida=a04335, Jan 26, 2004
http://agenda.cern.ch/fullAgenda.php?ida=a043912, Sep 8, 2004

Simple procedure for DM energy correction:

Developing of simple procedure for DM energy correction was started from single-pions PostRome data (based on 10.3.0):

20k pi+ and 20k pi-, energy 1, 3, 5, 10, 20, 50,100, 200, 500,1000 GeV with flat |eta|<5. and |phi|<pi.



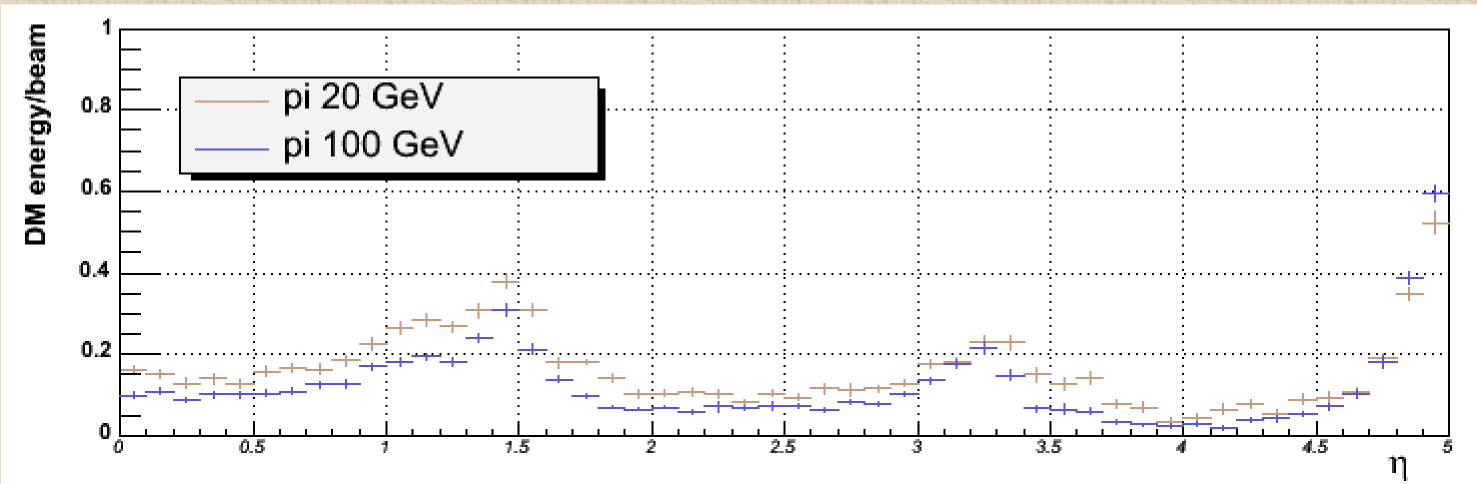
•picture shows average energy in DM hits, 500 GeV pi-, 10000 events. Each hit is presented as colored boxes on RZ plane (the more energy, the more red is the colour). Energy from hits with same *eta* and *distance* but different *phi* are gathered into one box.

Some problems with DM hits, mainly at eta>2.0, were found:

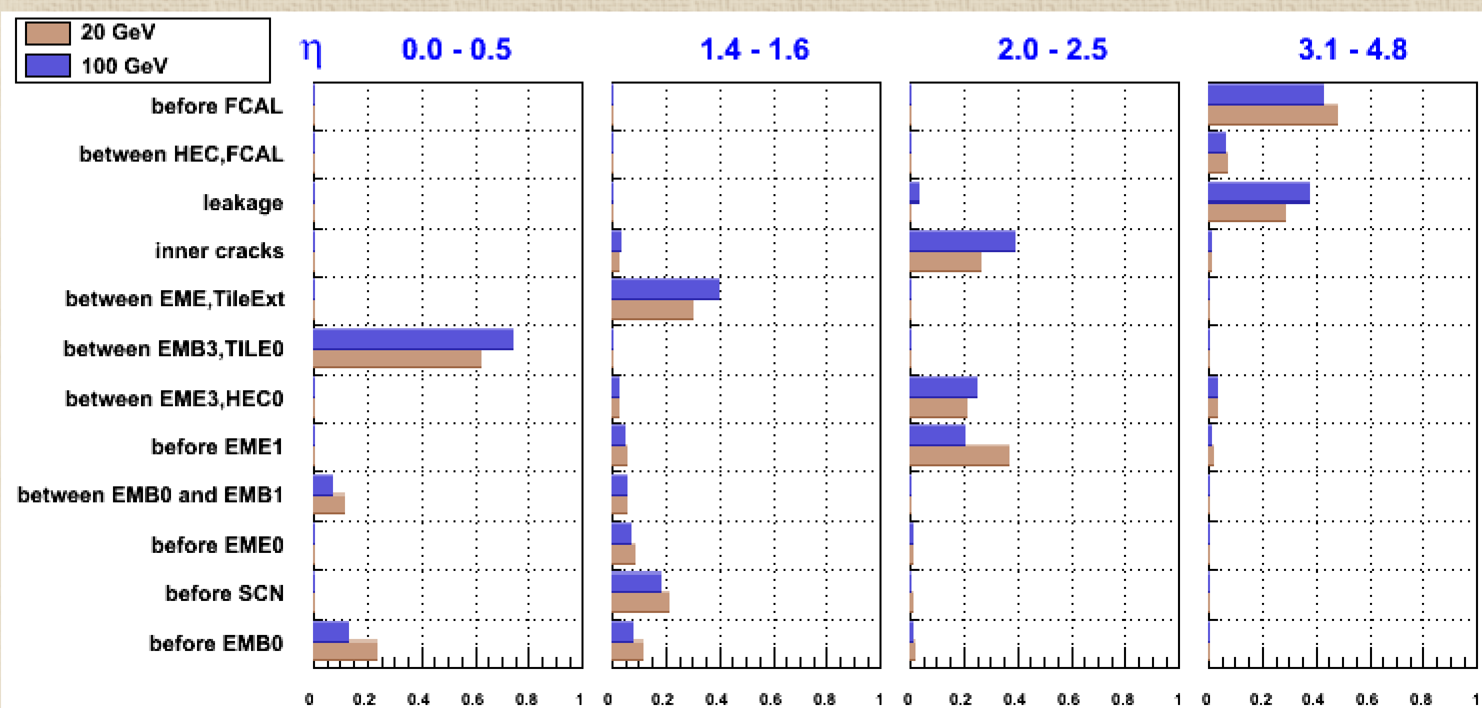
- HEC azimutal cracks
- between inner and outer EMEC wheels.
- between HEC and FCAL.
- between HEC wheels
- before FCAL

• later, in the period 11.0.0-11.4.0 situation becomes even worse: some parts of barrel cryostat went to the Default Calculator. There was no possibility to disentangle material before strips and before scintillator. Similar problem with endcap cryostat…

DM energy in different zones for 20 and 100 GeV pi-.



Ratio of total DM energy to the beam energy as a function of particle eta.



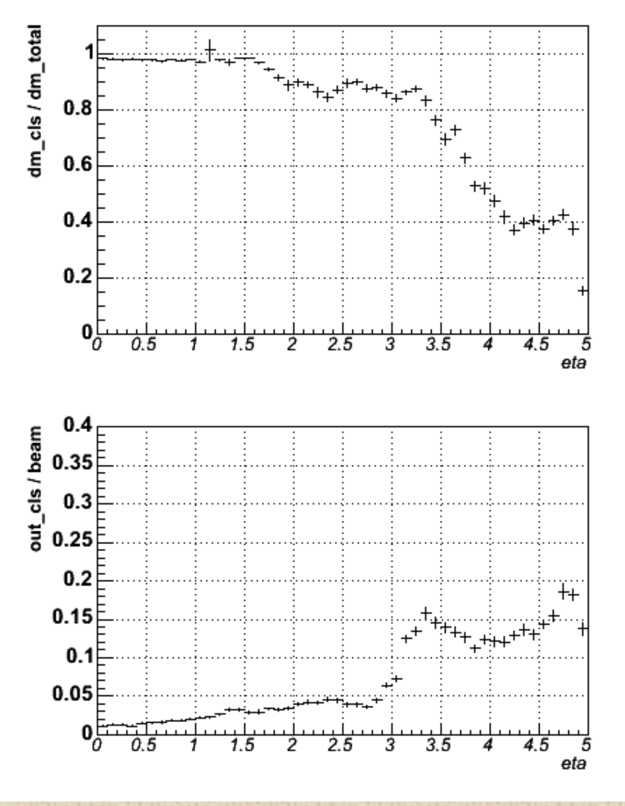
Ratio of DM energy released in particular zone to full DM energy accumulated in container. Four different eta areas are shown.

Question of assignment of DM energy to cluster, out-of-cluster energy…

To create cluster local procedure for DM energy correction we have to determine the way to give to each cluster his own DM energy. Simple approach was tried

(simple approach is to assign energy of given DM hit to the cluster, if hit is located not far from cluster cells:
abs(phi_cell – phi_hit) < (dphi_cell + dphi_hit)/2. && abs(eta_cell – eta_hit) < (deta_cell + deta_hit)/2.)

and show results that significant part of DM energy (especially for eta>2.5) remains unassigned.



Top plot shows ratio of DM energy assigned to clusters to the total DM energy in container as a function of particle eta.

Bottom plot shows out-of-cluster (topo) energy as function of eta. It was obtained in “direct” way, i.e. using hits in active and inactive containers:

out_cls = AI_total – AI_cls, where

AI_Total – sum of energy in all active and inactive hits in containers.
AI_cls – sum over all active and inactive hits for which corresponding ID can be found among topo cluster ordinary cells.

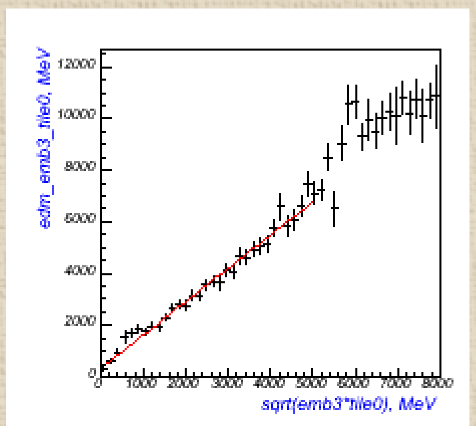
For simple procedure of DM energy correction presented below this question was temporary postponed. To get DM calibration coefficients all DM energy in container was used and summation over all energies in single-pion-clusters was performed.

Simple procedure for DM energy correction:

Single pions from PostromeData is used.

DM energy in zone is approximated from reconstructed energy in appropriate calorimeter sampling. If more than one cluster is found, summation over all clusters energies in samplings is performed.

For recovering energy, for example, between barrel presampler and strips, dependence of this DM energy on sqrt(emb0*emb1) was obtained in the form of 15 profile histograms (one per interval deta=0.1 in eta region 0.0-1.5). There are thresholds for histogram filling: DM energy > 50 MeV, emb0 > 1.*noise, emb1 > 1.*noise.



Histograms were fitted with parabola.

On reconstruction stage the DM energy is reconstructed separately for each cluster. Appropriate set of fitting coefficients is selected according to the cluster momentum *m1_eta* and cluster energy.

4 energy intervals for cluster energy are used with boundaries at
0, 30, 60, 300, 1000 GeV.

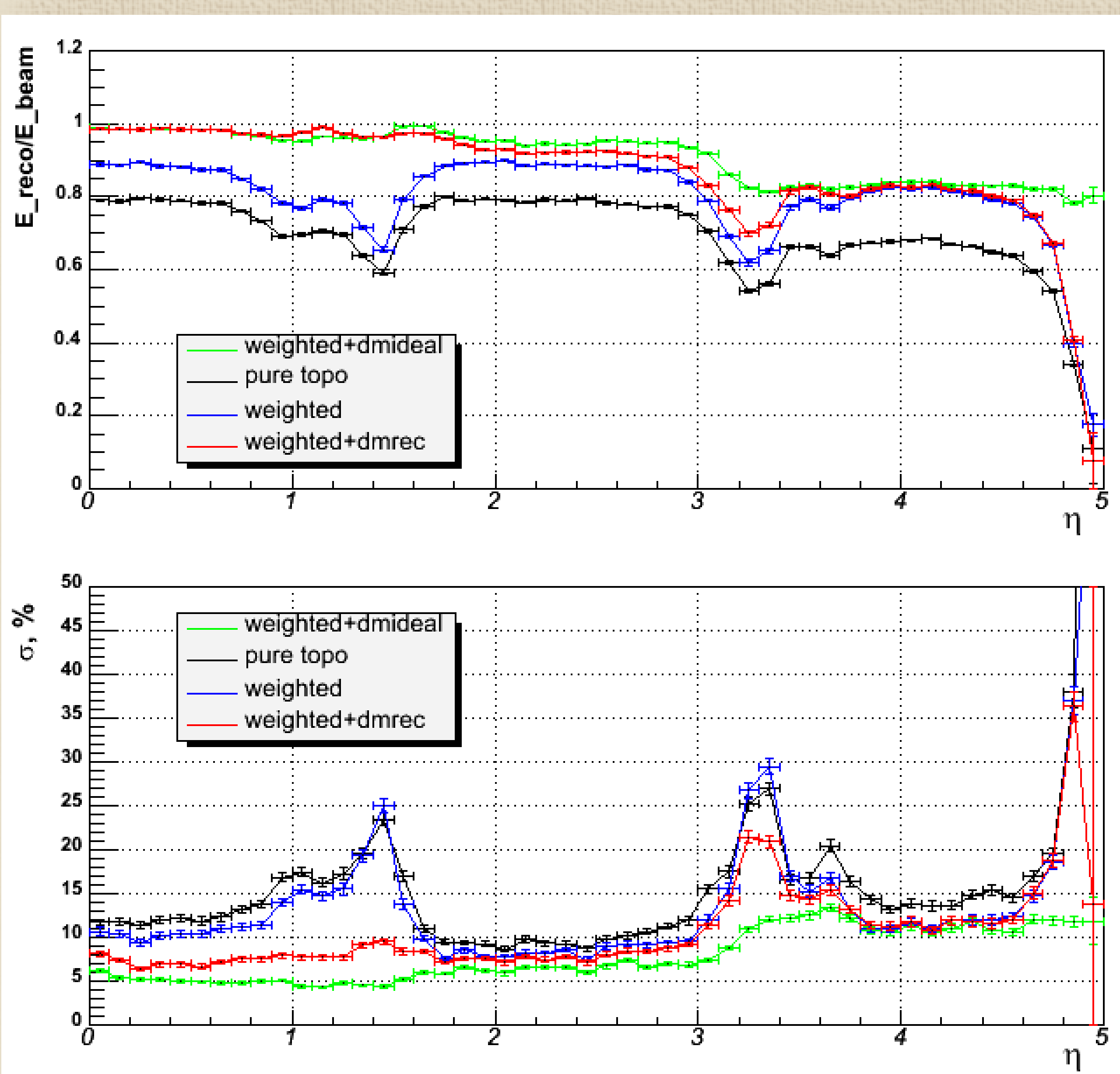
Currently the DM energy is corrected in 10 DM zones. See table on the next page for DM zones definition.

Simple algorithm for DM correction

	DM energy label	description	Eta region	nbins	Recovered with
0	EMB0	before barrel presampler	0.0-1.5	15	EMB0
1	SCN	before scintillator	1.0-1.6	6	TileGap3
2	EME0	before endcap presampler	1.5-1.8	3	EME0
3	EMB1	between barrel presampler and strip	0.0-1.5	15	sqrt(EMB0*EMB1)
4	EME1	before endcap active accordion (or between presampler and strips)	1.5-3.1	16	EME1 or sqrt(EME0*EME1)
5	EME3_HEC0	between Emec and Hec	1.5-3.0	15	sqrt(EME3*HEC0)
6	EMB3_TILE0	between Barrel and Tile	0.0-1.0	10	sqrt(emb3*TileBar0)
7	EME_EXT	between scintillator and Extended Tile or between Emec and Extended Tile	1.2-1.7	5	sqrt(TileExt0*TileGap3) for eta<1.4, sqrt(TileExt0*(EME+HEC)) for eta>1.4 with cut on cell_rho>180 for EME+HEC.
8	GAP1	energy in crack between Tile and Extended Tile	0.9-1.0	1	TileGap1
9	FCAL0	energy before Fcal	3.1-5.0	3	sqrt(FCAL0*EME3) for eta<3.7, otherwise ?

- No correction for DM energy in HEC azimuthal crack, between EMEC inner and outer wheel, between HEC wheels, between HEC and FCAL, between two barrel halves (bad DM hits).
- No correction for energy leakage.
- No correction for energy before FCAL for eta>3.7 (no good ideas).

Reconstructed energy and resolution for 100 GeV pion.



Top plot shows mean reconstructed energy for 100 GeV pions for 4 cases:

Topo: sum of energy in topo clusters

Weighted: after applying of weights using Sven procedure

Weighted+dm_ideal: same as "weighted"+DM total energy from calibration hits

Weighted+dm_rec: same as "weighted" + reconstructed DM energy.

Bottom plot shows energy resolution for same cases.

There are 50 points on each graph, each point represents results of fitting of energy spectra obtained in deta=0.1 interval.

Athena algorithm

Simple DM correction procedure is implemented in Athena since 11.5.0. It is the part of *Calorimeter/CaloClusterCorrection* package and inherits from *CaloClusterCorrectionTool.*

CaloClusterCorrection/CaloTopoLocalCalibDM.h
src/CaloTopoLocalCalibDM.cxx
share/*CaloTopoLocalCalibDM_jobOptions.py*
share/H1CaloClusterLocalCalibDM_v1.txt

Procedure requires the cluster to be classified as hadronic.

To use it following string has to be added in jobOption after Sven's weighting:
include(CaloClusterCorrection/CaloTopoLocalCalib_jobOptions.py)   # Sven's weighting
include(CaloClusterCorrection/CaloTopoLocalCalibDM_jobOptions.py)   # DM correction
(To use it before or without cell weighting some additional python coding is required to call classification.)

The procedure has one parameter which the user may want to change: WeightModeDM=0/1/2 to define the way of adding DM energy to the cluster.
0 – setting cluster energy to the new value without changing cell weights, i.e. using cluster->setE() method.
1 – weights of all cluster cells will be changed proportionally to treat DM energy,
i.e. cluster->reweightCell(cell,weight) method.
2 – same as 1, but only weights of cells involved into DM calculations will be changed (default).

Short reminder of DM hits features, part II.

(Very amateur description how g4step becomes dead material hit)

Simulation/G4Atlas/G4AtlasApps/python/atlas_calo.py contains assignment of Sensitive Detector name to Logical Volume name.

Sensitive Detector creates LArG4Hit's and fills LArHitContainer. Sensitive Detector has pointer to the CalibrationCalculator to calculate LArG4Identifier from g4step.

CalibrationCalculator takes coordinates and volume name of g4step and defines identifier fields using lots of 'if' statement. Everything is hard coded. Following calculators have dealing with DM identifiers:

LArCalorimeter/LArG4/LArG4HEC/Geometry.cc
LArCalorimeter/LArG4/LArG4EC/EmecSupportCalibrationCalculator.cc,
CryostatCalibrationMixedCalculator, CryostatCalibrationLArCalculator, CryostatCalibrationCalculator.cc
LArCalorimeter/LArG4/LArG4Barrel/CryostatCalibrationCalculator, CryostatCalibrationLArCalculator,
CryostatCalibrationMixedCalculator.cc, LArBarrelPresamplerGeometry.cc, LArBarrelGeometry.cc
LArCalorimeter/LArG4/ LArG4Code/DefaultCalculator.cc
TileCalorimeter/TileG4/TileGeoG4Calib/TileGeoG4CalibSD2.cc

At the end of event LArG4HitManagement makes CaloCalibrationHitsContainer's with collection of CaloCalibrationHit from collections of LArG4Hit.

Bad dead material hits arise from one of two reasons:

- atlas_calo.py.
- calculators.

DM hit validation: formal way.

There are three ways of dead material hits validation:

Formal – checking of DM identifier for valid fields.

Natural – when user finds something strange during his attempt to correct DM energy.

Ultimate – more on this later…

Formal way:

Checking of DM identifier can be done with help of LArG4HitManagement in DEBUG mode. IdDictCalorimeter.xml should correspond to Version_1.10_draft.txt.

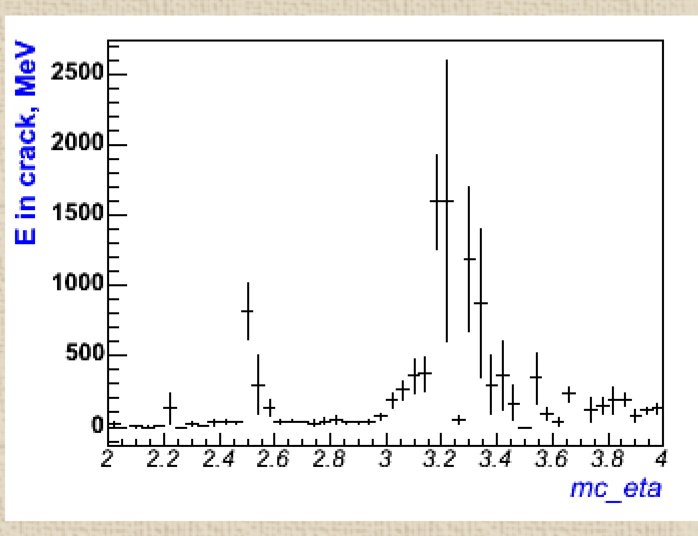
CaloCalibHitRec package can be also used to check contents of CalibrationHitContainer:
- Algorithm CalibHitIDCheck.
- Algorithm CalibrationInfoDM.

Formal way is rather simple and effective, but it can't do too much – after some time identifiers are good, but still no luck…

Natural way of DM hit validation: 11.4.0 working example.

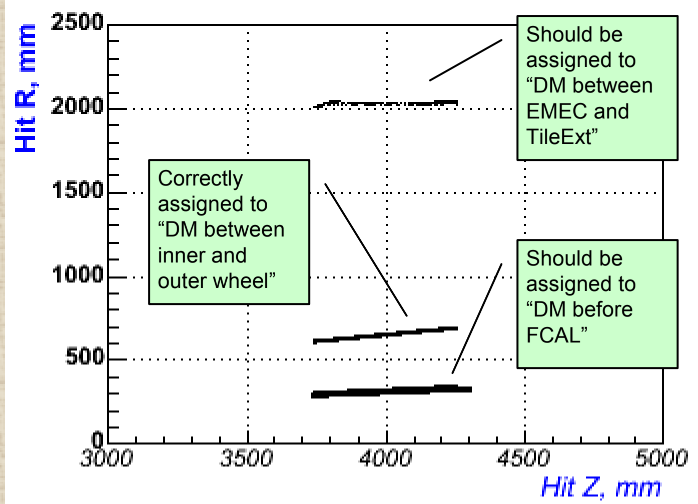
Hypothetic researcher wishing to correct energy, say, between inner and outer wheel most presumably will pass through three stages:

Study correlation between DM energy in crack and calorimeter cells energy near crack eta=2.5. For this purpose he will look for DM identifiers with subdet=4, type=2 and region=1.
As a result he will find no correlation.



When he will plot dependence of DM energy in crack eta=2.5 on particle eta. He will find lots of DM energy in wrong place =>

After that, he will find place in Athena, where such DM hits are producing from g4step, to put printout for x,y,z and volumeName of g4steps. In such a manner he will find which g4steps are wrongly considered as “DM between inner and outer wheel” =>



This is a natural way of DM hits validation, but general approach is required.

DM hit validation: ultimate solution.

Fair and square way to validate DM hits is to check for consistency coordinate of g4step and calculated values of DM identifier. The only place where both data meet together - ::Process method of calculators.

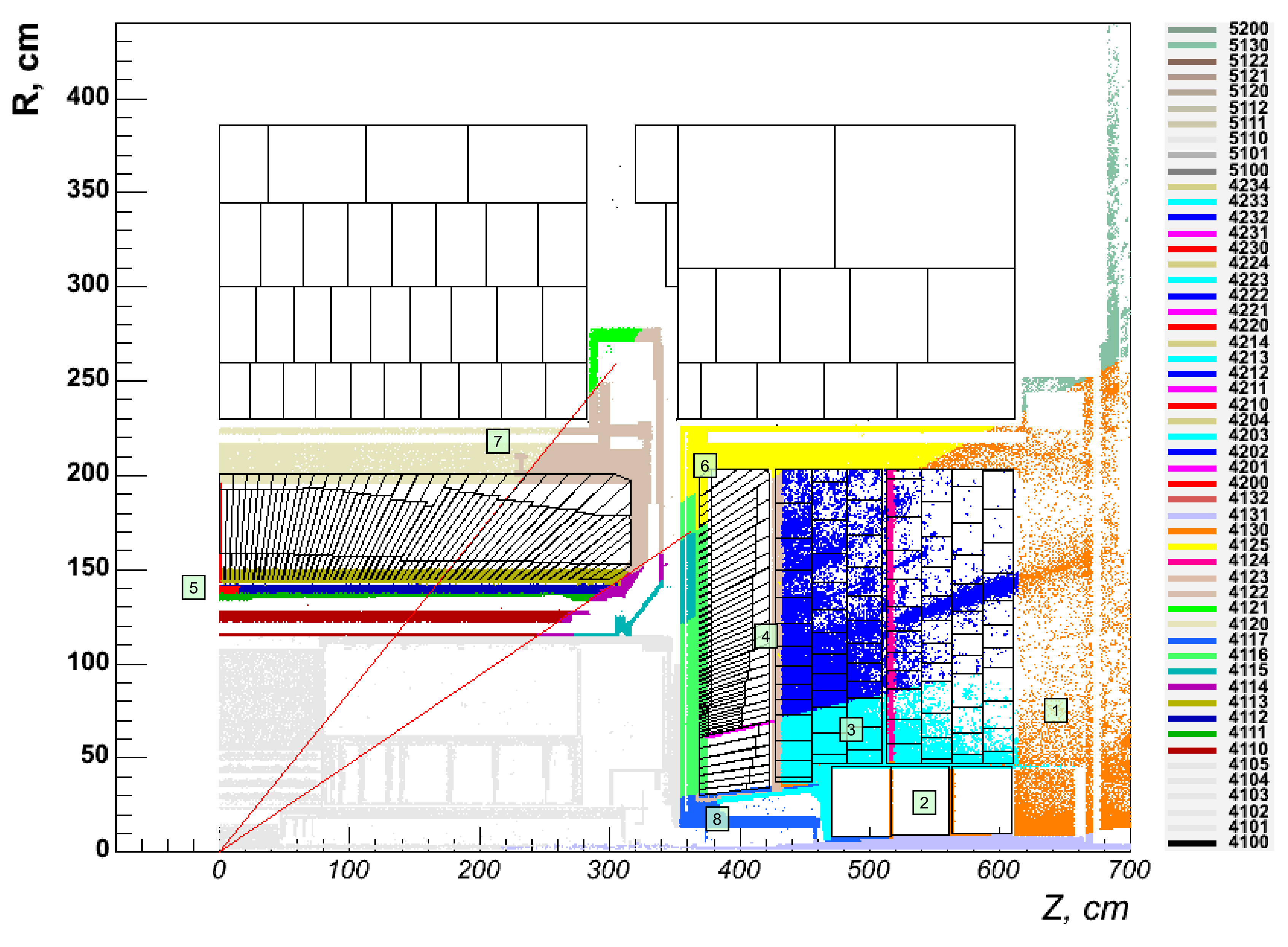
To check DM hits in 11.4.0 special simulation was done. All calculators dealing with DM identifiers were modified to print g4step coordinates, identifier fields etc.

LArG4EC-EMECSupportCalibrationCalculator > area=4123 xyz=1456.0651,786.5759,-4307.416 E=0.6142 id=[10.-4.1.2.3.1.5] volumeName=LArMgr::LAr::EMEC::BackSupportMother copyNumber:16969

500 events of 100 GeV single pions were simulated and ~500Mb log file was produced. File was analyzed in the standalone program.

Picture on next pages shows R-Z scattered histogram, where each point is one DM hit with energy > 100 kev, color of the plot represents number of DM area, point coordinates are taken from g4step.

DM hit validation: ultimate solution.



DM hit validation: ultimate solution.

List of new problems found in 11.4.0 (see previous page).

1. 4130 – “leakage outside HEC and FCAL”.
   Also collect energy between HEC and FCAL, before FCAL, before TileExt.

2. 4204,4214,4224,4234 – “energy between HEC and FCAL”.
   Absent.

3. 4203,4213,4223,4233 – “azimuthal crack between HEC modules 2.5<eta<3.3”.
   Also collect energy from FcalNose, beetween HEC and FCAL, behind HEC and FCAL.

4. 4123 – “between EMEC and HEC”.
   Also collect energy near inner wheel at eta~3.2, between inner and outer wheel.

5. 4200 – “between two barrel halves”.
   Area corresponding to sampling=0 seems to be too large.

6. 4125 – “in front of extended Tile “.
   Also collect energy before emec strips.

7. 4122 – “in front of scintillator and behind active layer of accordion”.
   Also collect energy before Tile.

8. 4117 – “material in front of FCAL”
   Collect leakage outside FCAL.

9. 4201, 4211, 4221, 4231 – “between inner and outer EMEC wheel”.
   Also collect energy at eta~3.2 and eta~1.4. (not shown on previous picture).

DM hit validation: status of 11.5.0.

+ Pavol corrected well-known bug with wrong energy in HEC azimuthal crack.

+ Number of wrong DM identifiers in calibration containers is close to zero (occasional phiBin=32 for DM in azimuthal HEC crack).

- But LArG4HitManagement still intercepting several hits per event with negative values of etaBin (DEBUG mode should be switched ON to know about it).

+ No volumes in Default Calculator (except inner detector service and calorimeter envelope, i.e. as it should be).

+ IdDictCalorimeter.xml correspond to DM hit description Version_1.9.txt.

-- Still wrong DM energy between HEC and FCAL, before FCAL, between inner and outer wheel. Plus several others, not very principal but annoying discrepancies between DM area number and real g4step coordinates (see previous page).

● Conclusion: from the point of view of DM hits 11.5.0 seems to be not very ready for large simulation, but during scheduled two weeks period before release 12, situation will change…

Conclusion:

First iteration on the way towards the ideal DM correction procedure seems to be settled.

DM hits are OK in general. Only small effort is required to have all DM hits as they were designed couple of years ago.

Procedure for DM energy correction works rather well on single pion data at eta < 2.5, mean energy and resolution are restored significantly. From the other hand, resolution is worse than in ideal case (DM energy just taken from container), what encourages for more sophisticated procedure.

Before release 12

Need to correct every 11.4.0-discovered bug. (Probably it will be reasonable to switch all warning messages to the level WARNING instead of DEBUG in all calculators and hit management. It might save us against growth of new dm hits problems in the future…)

Next short-term steps

Validation of DM correction procedure using physically meaningful data is required (di-jets etc.).

New single-pions data is required to develop missing algorithm parts concerning HEC and FCAL cracks.

Inserting missing algorithm parts for HEC and FCAL into Athena using same simple approach.

Next developing might consider correct assignment of DM energy to the cluster. It ought to be linked with out-of-cluster correction. Also going to follow Pierre-Antoine's proposal and try his code for assigning DM energy to the cluster using the cone around cluster momentum.

What next

Thanks.

Many thanks to
Alexei, Pavol and Sven
for help and useful discussion.

Backup:

List of 52 DM areas (from Version_1.9.txt)

4100 hits from default calculators # 0 < |eta| < 5 deta = 0.1 dphi = pi/32 #

4101 1st radial layer of Inner Detector # 0 < |eta| < 5 deta = 0.1 dphi = pi/32 #

4102 2st radial layer of Inner Detector # 0 < |eta| < 5 deta = 0.1 dphi = pi/32 #

4103 3rd radial layer of Inner Detector # 0 < |eta| < 5 deta = 0.1 dphi = pi/32 #

4104 4th radial layer of Inner Detector # 0 < |eta| < 5 deta = 0.1 dphi = pi/32 #

4105 5th radial layer of Inner Detector # 0 < |eta| < 5 deta = 0.1 dphi = pi/32 #

4110 barrel warm wall and solenoid in front of the barrel presampler, # 0 < |eta| < 1.5, deta 0.1, dphi=pi/32 #

4111 barrel cryostat cold wall in front of the barrel presampler, # 0 < |eta| < 1.5, deta 0.1, dphi=pi/32 #

4112 all materials in front of the barrel presampler at radius # larger than cold wall outer radius, # 0 < |eta| < 1.5, deta 0.1, dphi=pi/32 #

4113 all materials from the active layer of the barrel # presampler to the active layer of accordion, # 0 < |eta| < 1.5, deta 0.1, dphi=pi/32 #

4114 LAr materials in front of the scintillator and # behind the active layer of accordion for # 1.5 < |eta| < 1.6, deta 0.1, dphi=pi/32 # (not including materials of Inne

4115 LAr materials in front of the endcap presampler # 1.5 < |eta| < 1.8, deta 0.1, dphi=pi/32 # (for 1.5<|eta|<1.6: materials behind the scintillator) # (not including m

4116 LAr materials in front of the active layer of the spanish fan # (for 1.5<|eta|<1.8: materials behind the active layer of the endcap presampler) # 1.3 < |eta| < 3.2

4117 LAr materials in front of FCal # 3.2 < |eta| < 5.0, deta 0.1, dphi=pi/32 # (not including materials of Inner Detector and its services) #

4120 all materials behind the active layer of accordion # in front the Tile barrel for |eta| < 1.0 # deta 0.1, dphi pi/32 #

4121 all materials in the crack between barrel and # extended barrel for |eta| < 1.0 # deta 0.1, dphi pi/32 #

4122 all materials in front of the scintillator and # behind the active layer of accordion # for 1.0 < |eta| < 1.5 # deta 0.1, dphi pi/32 #

4123 all materials behind the active layer of EMEC and in front of HEC including # a front copper plate of HEC-1, i.e. this is the crack between active layers # of EME

4124 crack between HEC wheels: ~4 cm of dead LAr + front copper plate of HEC-2 # (such a plate is out of the regular HEC structure). # 1.5 < |eta| < 3.3 # deta 0.1, dphi

4125 all materials in front of Tile extended barrel # and behind the scintillator for 1.0 < |eta| < 1.5 # or behind EMEC-HEC for 1.5 < |eta| < 1.7 # deta 0.1, dphi pi/32

4130 Leakage outside HEC and FCal calorimeters # 1.7<|eta|<5.0, deta=0.1, dphi=pi/32 #

4131 Leakage outside HEC and FCal calorimeters # 5.0<|eta|<8.0, deta=0.2, dphi=pi/32 #

4132 Leakage outside HEC and FCal calorimeters # |eta|>8.0, no eta-phi subdivision # distance=3500 means attached to inner detector cavity #

4200 dead materials between two halves of EMB, # sampling depths are the same as in nearest EMB part, # 0 < |eta| < 0.1 # only one cell in eta # dphi=pi/32 #

4201 dead materials between inner and outer EMEC wheels, # sampling depths are the same as in nearest outer # EMEC wheel part, only one cell in eta # 2.45 < |eta| < 2.55 #

4202 azimuthal cracks between HEC modules (wedges), # i.e. dead materials between HEC modules including 2mm # wide edges of copper plates. # four sampling depths are the

4203 azimuthal cracks between HEC modules (wedges), # i.e. dead materials between HEC modules including 2mm # wide edges of copper plates. # four sampling depths are the

4204 dead materials between HEC and FCal, # sampling depths are the same as in HEC, # 3.0 < |eta| < 3.4 # only one cell in eta # dphi = pi/32 #

4210 dead materials between two halves of EMB, # sampling depths are the same as in nearest EMB part, # 0 < |eta| < 0.1 # only one cell in eta # dphi = pi/32 #

4211 dead materials between inner and outer EMEC wheels, # sampling depths are the same as in nearest outer # EMEC wheel part, only one cell in eta # 2.45 < |eta| < 2.55 #

4212 azimuthal cracks between HEC modules (wedges), # i.e. dead materials between HEC modules including 2mm # wide edges of copper plates. # four sampling depths are the

4213 azimuthal cracks between HEC modules (wedges), # i.e. dead materials between HEC modules including 2mm # wide edges of copper plates. # four sampling depths are the

4214 dead materials between HEC and FCal, # sampling depths are the same as in HEC, # 3.0 < |eta| < 3.4 # only one cell in eta # dphi = pi/32 #

4220 dead materials between two halves of EMB, # sampling depths are the same as in nearest EMB part, # 0 < |eta| < 0.1 # only one cell in eta # dphi = pi/32 #

4221 dead materials between inner and outer EMEC wheels, # sampling depths are the same as in nearest outer # EMEC wheel part, only one cell in eta # 2.45 < |eta| < 2.55 #

4222 azimuthal cracks between HEC modules (wedges), # i.e. dead materials between HEC modules including 2mm # wide edges of copper plates. # four sampling depths are the

4223 azimuthal cracks between HEC modules (wedges), # i.e. dead materials between HEC modules including 2mm # wide edges of copper plates. # four sampling depths are the

4224 dead materials between HEC and FCal, # sampling depths are the same as in HEC, # 3.0 < |eta| < 3.4 # only one cell in eta # dphi = pi/32 #

4230 dead materials between two halves of EMB, # sampling depths are the same as in nearest EMB part, # 0 < |eta| < 0.1 # only one cell in eta # dphi = pi/32 #

4231 dead materials between inner and outer EMEC wheels, # sampling depths are the same as in nearest outer # EMEC wheel part, only one cell in eta # 2.45 < |eta| < 2.55 #

4232 azimuthal cracks between HEC modules (wedges), # i.e. dead materials between HEC modules including 2mm # wide edges of copper plates. # four sampling depths are the

4233 azimuthal cracks between HEC modules (wedges), # i.e. dead materials between HEC modules including 2mm # wide edges of copper plates. # four sampling depths are the

4234 dead materials between HEC and FCal, # sampling depths are the same as in HEC, # 3.0 < |eta| < 3.4 # only one cell in eta # dphi = pi/32 #

5100 Dead material around sensitive material in Tile calorimeter. Barrel. # Front plate of the module (fixed R, different Z, iron between LAr and Tile). # 0.0 < |eta| <

5101 Dead material around sensitive material in Tile calorimeter. Ext. Barrel. # Front plate of the module (fixed R, different Z, iron between LAr and Tile). # 1.1 < |et

5110 Dead material around sensitive material in Tile calorimeter. # End plate of barrel (fixed Z, different R). # 0.7 < |eta| < 1.1 # deta=0.1 (roughly), dphi = 0.1 # exact

5111 Dead material around sensitive material in Tile calorimeter. # End plate of ext barrel at smaller Z (fixed Z, different R). # 0.9 < |eta| < 1.2 # deta=0.1 (roughly),

5112 Dead material around sensitive material in Tile calorimeter. # End plate of ext barrel at higher Z (fixed Z, different R). # 1.3 < |eta| < 1.7 # deta=0.1 (roughly), d

5120 Dead material around sensitive material in Tile calorimeter. # So-called "girder" - iron at higher R. Barrel. # 0 < |eta| < 0.7 # deta=0.1 (roughly), dphi = 0.1 # exact

5121 Dead material around sensitive material in Tile calorimeter. # So-called "girder" - iron at higher R. Ext. Barrel. # 0.9 < |eta| < 1.3 # deta=0.1 (roughly), dphi = 0.

5122 Dead material around sensitive material in Tile calorimeter. # So-called "girder"- iron at higher R. Gap region between barrel and ext. barrel. # 0.7 < |eta| < 0.9 #

5130 Leakage outside Tile calorimeters. # 0.0 < |eta| < 1.7 # deta=0.1, dphi=pi/32 #

Backup: field of honour