Update on LCIO implementation in LuCaS

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LuCaS LCIO

- void LCRootOut::InitLCIO()
  - Creates LCIO file for output and saves RunHeader with run information.
- void LCRootOut::ProcessEventLCIO(const G4Event* event, LCHitsCollection *coll, ..)
  - Creates data container for event as IMPL::LCEventImpl;
  - Creates and save the collection of primary particles IMPL::LCCollectionVec(EVENT::LCIO::MCPARTICLE);
  - Creates LCIO collection for hits as IMPL::LCCollectionVec(EVENT::LCIO::SIMCALORIMETERHIT);
  - Use LCIO cell encoding utilitues:
    - UTIL::CellIDEncoder<IMPL::SimCalorimeterHitImpl> cellid("I:7,J:6,K:6,L:1" ,calVec) ;

      // rCell 0-64, phiCell 0-48, layer 0-40, side 0-1
  - Loops on the hits in LuCaS collection and creates and fills IMPL::SimCalorimeterHitImpl;
  - Saves LCIO event data container with two collection of primary particle and LumiCal hits in the file.
- void LCRootOut::End()
  - One line was adde to close LCIO file.

Run LumiCalClustererClass with DEBUG streamer

```
[ DEBUG "LumiCalReco"]  Run LumiCalClustererClass::buildClusters()
[ DEBUG "LumiCalReco"]  Total positive detector arm energy =  2819.77
[ DEBUG "LumiCalReco"]
[ DEBUG "LumiCalReco"] Hits in layer   0     3
[ DEBUG "LumiCalReco"] Hits in layer   1     8
[ DEBUG "LumiCalReco"] Hits in layer   2     8
[ DEBUG "LumiCalReco"] Hits in layer   3    20
[ DEBUG "LumiCalReco"] Hits in layer   4    20
[ DEBUG "LumiCalReco"] Hits in layer   5    25
[ DEBUG "LumiCalReco"] Hits in layer   6    33
[ DEBUG "LumiCalReco"] Hits in layer   7    35
[ DEBUG "LumiCalReco"] Hits in layer   8    48
[ DEBUG "LumiCalReco"] Hits in layer   9    58
[ DEBUG "LumiCalReco"] Hits in layer  10    57
[ DEBUG "LumiCalReco"] Hits in layer  11    56
[ DEBUG "LumiCalReco"] Hits in layer  12    61
[ DEBUG "LumiCalReco"] Hits in layer  13    62
[ DEBUG "LumiCalReco"] Hits in layer  14    64
[ DEBUG "LumiCalReco"] Hits in layer  15    65
[ DEBUG "LumiCalReco"] Hits in layer  16    64
[ DEBUG "LumiCalReco"] Hits in layer  17    46
[ DEBUG "LumiCalReco"] Hits in layer  18    45
[ DEBUG "LumiCalReco"] Hits in layer  19    49
[ DEBUG "LumiCalReco"] Hits in layer  20    46
[ DEBUG "LumiCalReco"] Hits in layer  21    41
[ DEBUG "LumiCalReco"] Hits in layer  22    36
[ DEBUG "LumiCalReco"] Hits in layer  23    20
[ DEBUG "LumiCalReco"] Hits in layer  24    32
[ DEBUG "LumiCalReco"] Hits in layer  25    18
[ DEBUG "LumiCalReco"] Hits in layer  26    15
[ DEBUG "LumiCalReco"] Hits in layer  27    12
[ DEBUG "LumiCalReco"] Hits in layer  28    17
[ DEBUG "LumiCalReco"] Hits in layer  29    13
[ DEBUG "LumiCalReco"] Shower peak layers:
[ DEBUG "LumiCalReco"]   min # of hits, min energy/hit([signal],[GeV]) : 32          (0.0698951 , 5.62635)
[ DEBUG "LumiCalReco"]   layers chosen : 6 , 7 , 8 , 9 , 10 , 11 , 12 , 13 , 14 , 15 , 16 , 17 , 18 , 19 , 20 , 21 , 22 , 24 ,
```

Run LumiCalClustererClass with DEBUG streamer

[DEBUG "LumiCalReco"] **run initialClusterBuild and initialLowEngyClusterBuild:**
[DEBUG "LumiCalReco"] layer 6
[DEBUG "LumiCalReco"] cluster Id, pos(x,y), engy: 1 (-246.425 , 16.1515) 139.188
[DEBUG "LumiCalReco"] cluster Id, pos(x,y), engy: 3 (-178.314 , -42.7264) 1.58357
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] layer 7
[DEBUG "LumiCalReco"] cluster Id, pos(x,y), engy: 1 (-246.654 , 16.1665) 214.523
[DEBUG "LumiCalReco"] cluster Id, pos(x,y), engy: 2 (-272.855 , 10.4083) 2.02465
[DEBUG "LumiCalReco"] cluster Id, pos(x,y), engy: 4 (-285.035 , 18.6822) 1.47952
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] layer 8
[DEBUG "LumiCalReco"] cluster Id, pos(x,y), engy: 1 (-247.316 , 16.2099) 228.781
[DEBUG "LumiCalReco"] cluster Id, pos(x,y), engy: 2 (-273.788 , 17.945) 1.8509
[DEBUG "LumiCalReco"] cluster Id, pos(x,y), engy: 3 (-202.12 , -2.25963) 1.93644
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] layer 9
[DEBUG "LumiCalReco"] cluster Id, pos(x,y), engy: 1 (-248.16 , 16.2652) 274.388
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] layer 10
[DEBUG "LumiCalReco"] cluster Id, pos(x,y), engy: 1 (-248.488 , 16.2868) 263.597
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] layer 11
[DEBUG "LumiCalReco"] cluster Id, pos(x,y), engy: 1 (-248.458 , 16.2848) 247.49
[DEBUG "LumiCalReco"]
.....
[DEBUG "LumiCalReco"] -> Assume that there are 6 global clusters
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] **Fit lines through the averaged CM**
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] Fit Param should be this size: 0
[DEBUG "LumiCalReco"] Extrapolate virtual cluster CMs
[DEBUG "LumiCalReco"]

***** Break *** segmentation violation**
LumiCalClusterer_buildClusters.cpp:433: if (fitParamX[clusterNow].empty()) continue; //APS

Run LumiCalClustererClass with DEBUG streamer

After investigating the code in details, some changes were made and the reconstruction procedure run till the end.

```
[ DEBUG "LumiCalReco"]   -> Assume that there are 3 global clusters in 6 layers
[ DEBUG "LumiCalReco"]
[ DEBUG "LumiCalReco"] Considering only above preselected layers, the biggest energy: 252.709 is in layer: 12
[ DEBUG "LumiCalReco"]
[ DEBUG "LumiCalReco"] Fit lines through the averaged CM
[ DEBUG "LumiCalReco"]
[ DEBUG "LumiCalReco"] Fit Param should be this size: 3
[ DEBUG "LumiCalReco"] clusterId 0
[ DEBUG "LumiCalReco"]  layer , avPos(x,y) : 7   (-247.158 , 16.1301)
[ DEBUG "LumiCalReco"]  layer , avPos(x,y) : 8   (-247.528 , 16.2239)
[ DEBUG "LumiCalReco"]  layer , avPos(x,y) : 12          (-249.122 , 16.3283)
[ DEBUG "LumiCalReco"]  layer , avPos(x,y) : 14          (-251.485 , 16.4951)
[ DEBUG "LumiCalReco"]  layer , avPos(x,y) : 17          (-252.249 , 17.2892)
[ DEBUG "LumiCalReco"]  layer , avPos(x,y) : 24          (-262.291 , 18.0363)
[ DEBUG "LumiCalReco"]   -> xFitPar 0,1:  -239.921 (+-) 16.7854         ,       -0.853706 (+-) 1.13813
[ DEBUG "LumiCalReco"]   -> yFitPar 0,1:  15.1721 (+-) 4.32295  ,       0.114918 (+-) 0.295436
[ DEBUG "LumiCalReco"]
[ DEBUG "LumiCalReco"] clusterId 1
[ DEBUG "LumiCalReco"]  layer , avPos(x,y) : 8   (-202.12 , -2.25963)
[ DEBUG "LumiCalReco"]  layer , avPos(x,y) : 12          (-217.883 , -9.24487)
[ DEBUG "LumiCalReco"]  layer , avPos(x,y) : 14          (-214.097 , 11.0044)
[ DEBUG "LumiCalReco"]  layer , avPos(x,y) : 17          (-221.372 , -22.8061)
[ DEBUG "LumiCalReco"]  layer , avPos(x,y) : 24          (-230.75 , 15.7456)
[ DEBUG "LumiCalReco"]   -> xFitPar 0,1:  -192.168 (+-) 19.4549         ,       -1.66318 (+-) 1.23428
[ DEBUG "LumiCalReco"]   -> yFitPar 0,1:  -9.30328 (+-) 2.94657         ,       0.708941 (+-) 0.241165
[ DEBUG "LumiCalReco"]
[ DEBUG "LumiCalReco"]  decrease the global cluster number by 1
[ DEBUG "LumiCalReco"]
[ DEBUG "LumiCalReco"] Extrapolate virtual cluster CMs
[ DEBUG "LumiCalReco"]
[ DEBUG "LumiCalReco"]  build cluster around a virtual CM in layer 0
[ DEBUG "LumiCalReco"]  build cluster around a virtual CM in layer 1
.....................................................................
```

Run LumiCalClustererClass with DEBUG streamer

.....
[DEBUG "LumiCalReco"] build cluster around a virtual CM in layer 28
[DEBUG "LumiCalReco"] build cluster around a virtual CM in layer 29
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] **Build superClusters**
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] - superClusters:
[DEBUG "LumiCalReco"] Id 0 energy 2744.46 pos(x,y) = (-248.481 , 16.2863) pos(theta,phi) = (0.0919346 , 3.07614)
[DEBUG "LumiCalReco"] Id 1 energy 75.3116 pos(x,y) = (-217.38 , 5.23786) pos(theta,phi) = (0.0801161 , 3.1175)
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] **RUN engyInMoliereCorrections() ...**
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] Clusters:
[DEBUG "LumiCalReco"] Id 0 energy 2819.77 pos(x,y) = (-248.481 , 16.2863) pos(theta,phi) = (0.0919346 , 3.07614)
[DEBUG "LumiCalReco"]
[DEBUG "LumiCalReco"] **Run LumiCalClustererClass::clusterMerger()**
[MESSAGE3 "LumiCalReco"] Clusters:
[MESSAGE3 "LumiCalReco"] Id 0 Energy 2819.77 Method -1 Weight 80.1039 pos(x,y,z) = (-248.481 , 16.2863 , 0) pos(theta,phi) = (0.0919346 , 3.07614)
[DEBUG4 "LumiCalReco"] **Final clusters:**
[DEBUG4 "LumiCalReco"] Arm: 1 Id: 0 Energy 2819.77 Method -1 Weight 80.1039 pos(x,y,z) = (-248.481 , 16.2863 , 0) **pos(theta,phi) = (0.0919346 , 3.07614)**

Generated: 0.0664529, 0.17147

Generated and reconstructed θ and φ are not in agreement!

Conclusions

- LCIO output has been added to LuCaS.
- LumiCal cluster reconstructing processor can read and apply reconstruction procedure to the LuCaS simulated data.
- Reconstructed polar and azimuthal angles are not in agreement with generated ones:
  - Check coordinates definitions in LuCaS and in reconstructing processor;
  - Check output from each stage of reconstruction.