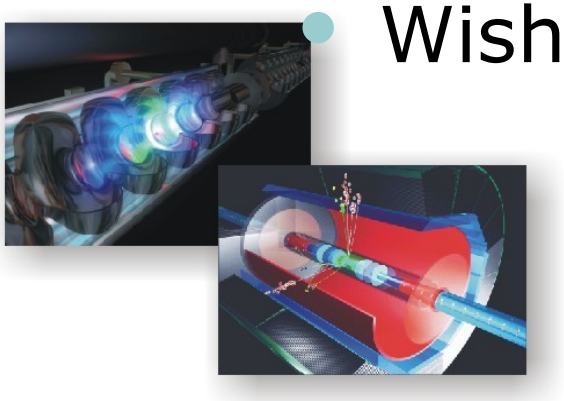
Calorimetry in slic How-to

Hans Wenzel
Fermilab

- Motivation for dual readout Calorimeter
- What are our requirements
- Why did we choose SLIC
- What did we have to add/change
- Wish-list



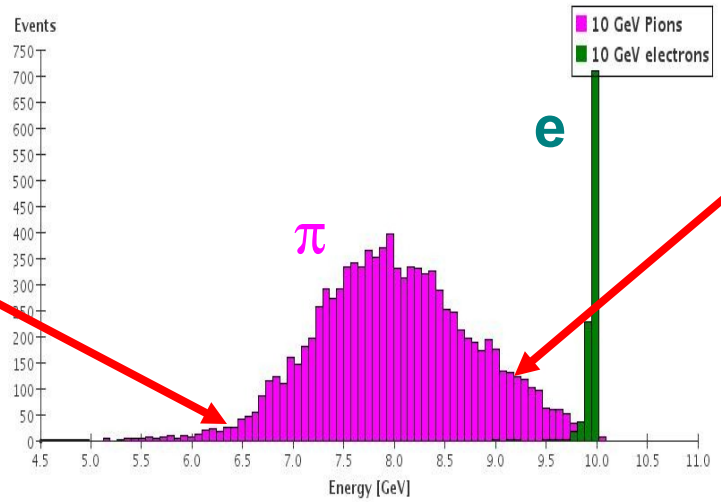
Motivation: Total absorption Calorimeters

G. Mavromanolakis, A. Para, N. Saoulidou, H. Wenzel, Shin-Shan Yu, Fermilab
Tianchi Zhao, University of Washington

- For e^+,e^- and γ's the total energy of the incoming particle is converted into detectable kinetic energy of electrons.
  → Excellent energy resolution for electrons/photons
- Hadrons break nuclei and liberate nucleons/nuclear fragments. Even if the kinetic energy of the resulting nucleons is measured, the significant fraction of energy is lost to overcome the binding energy. Fluctuations of the number of broken nuclei dominate fluctuations of the observed energy.
  → Relatively poor energy resolution for hadrons

Large number of broken nuclei:

- Large number of slow neutrons
- Small fraction of energy in a form of π^0's

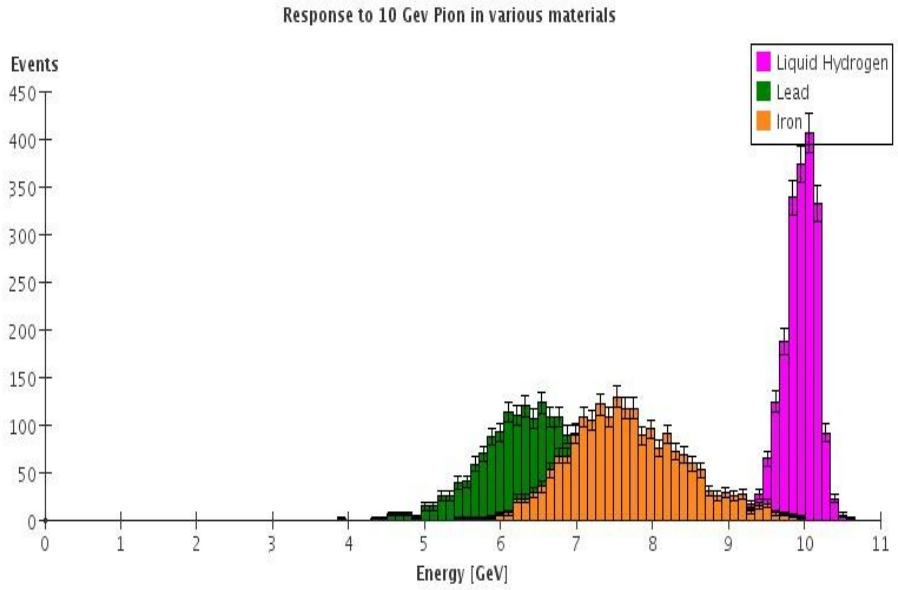


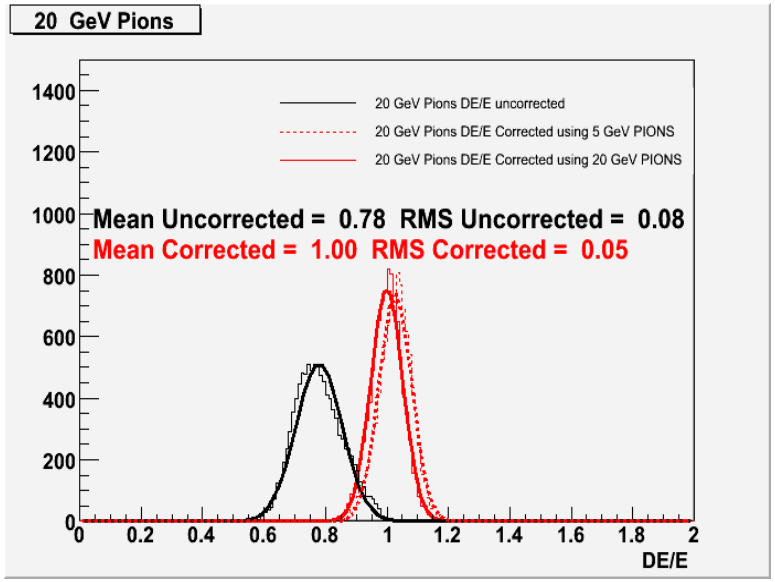
Very few broken nuclei:

- Small number of slow neutrons
- Large fraction of energy in a form of π0's

Cherenkov-assisted hadron calorimetry:

- $E_{em}/E_{tot} \sim E_{Cherenkov}/E_{ionization}$
- 'EM' shower => Relativistic electrons => Lots of Cherenkov light
- Hadronic shower => Most particles below the Cherenkov threshold
- Use this fact to correct hadron response





Requirements

- Replaces stand alone Geant4 application (no Sensitive Detectors/no transverse segmentation).
- Need to be able to change configuration quickly: geometry, materials, various material properties (e.g. optical properties), segmentation, physics models without recompiling.
- Visualization, Persistence, GRID

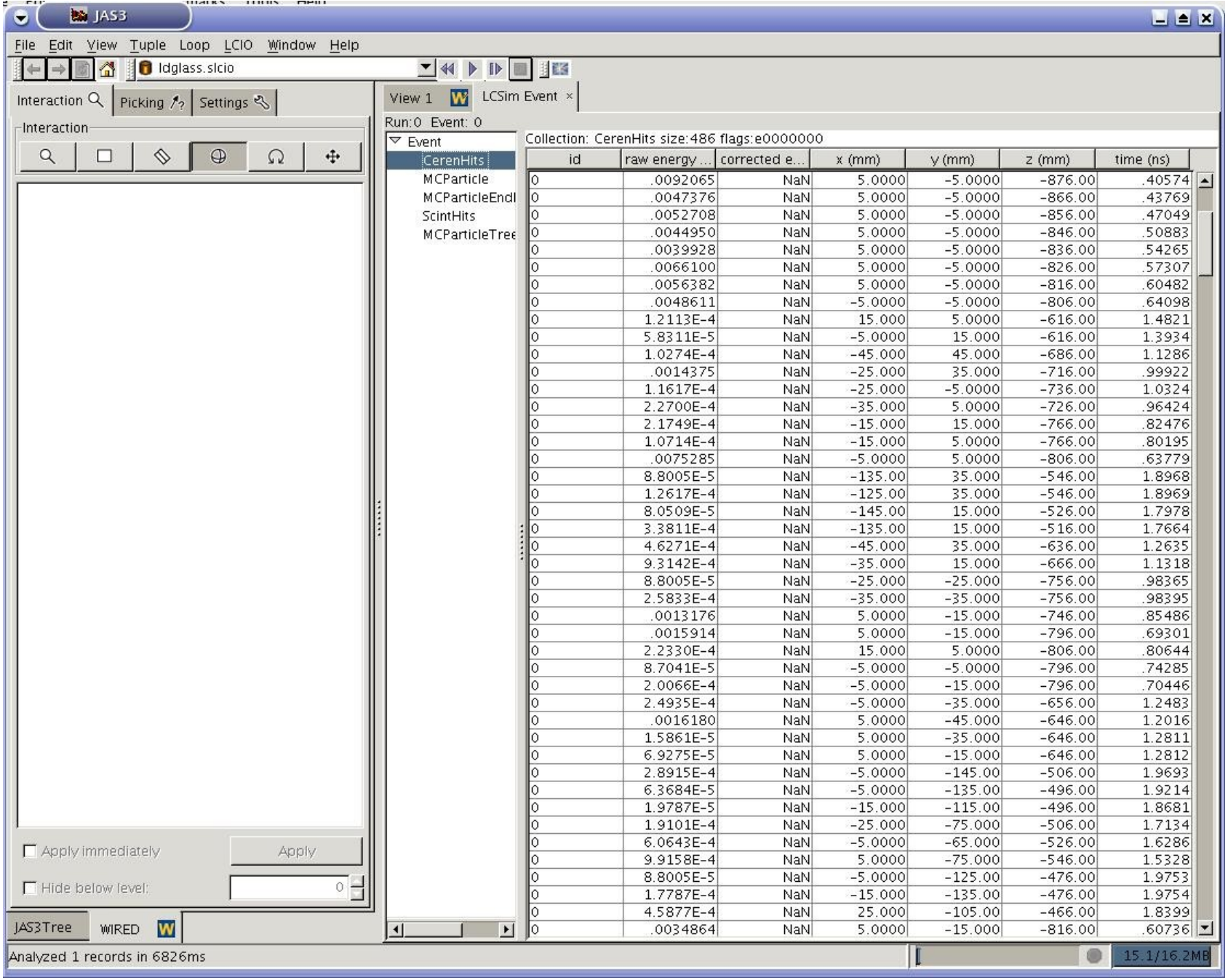
Why did we chose SLIC

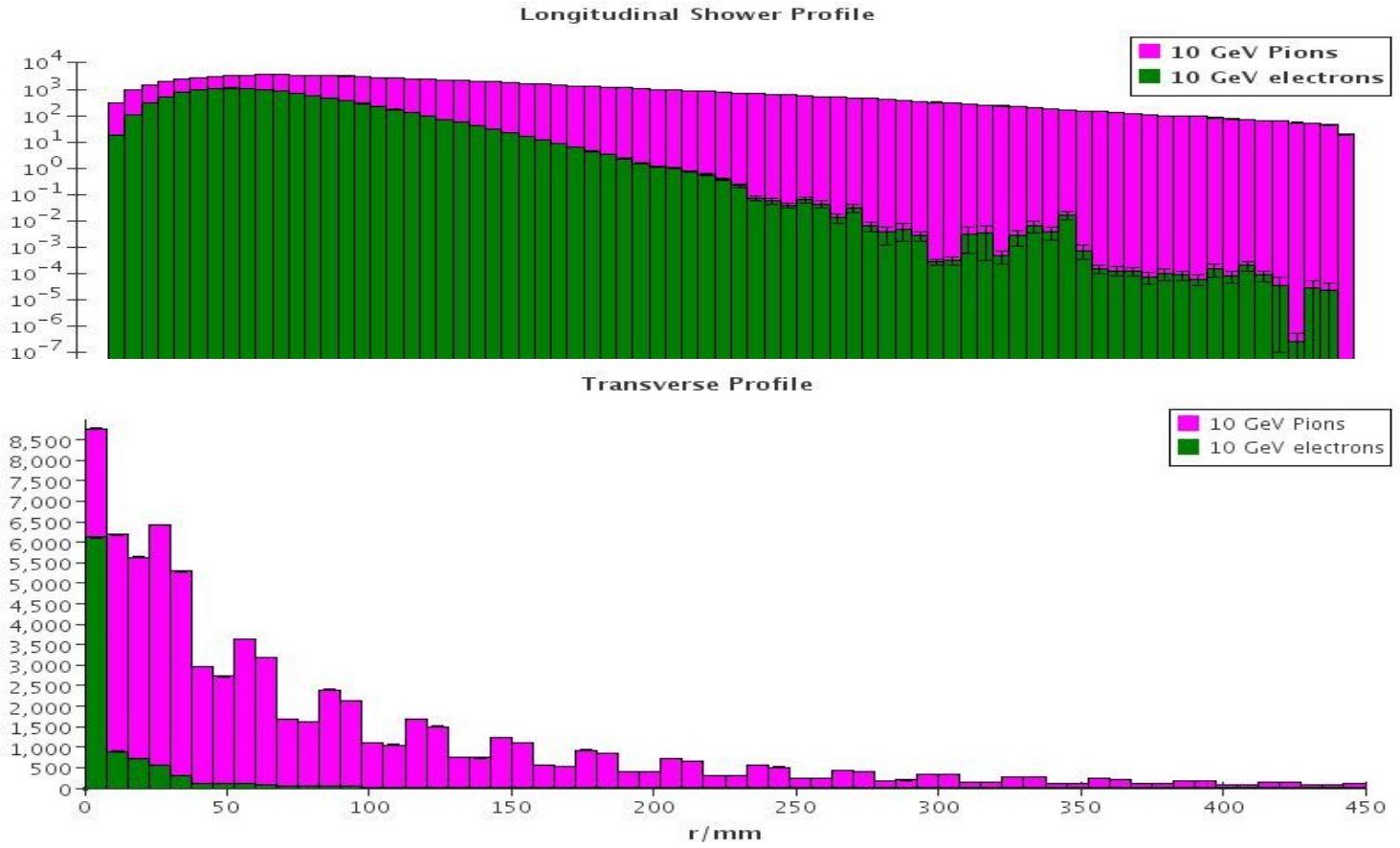
Geant 4 based: **S**imulator for the **Li**near **C**ollider

- Name sounds cool!
- to become familiar with the SID/ALCPG framework easy to integrate this Calorimeter into SID later on
- Available Utilities: event display, event browser, Visualization of geometry (integrated in JAS3)
- xml geometry/sensitive detector description: (compact, gdml, lcdd), human readable/editable!
- LCIO output
- lcsim.org framework (integrated in JAS3) to analyse the data

Why did we chose SLIC (cont.)

- Maintenance: use the existing infrastructure: CVS repositories, distributions (SimDist), keep up with changes
- very easy to use command line interface/macros
- statically linked --> easy on run on the GRID when it becomes necessary scripts been developed
- Confluence is a nice way for users to exchange information--> Need to make this a habit!


JAS3
File Edit View Tuple Loop LCIO Window Help
ldglass.slcio
Interaction
Picking
Settings
Interaction
Apply immediately
Apply
Hide below level:
0
JAS3Tree
WIRED
View 1
LCSim Event
Run:0 Event: 0
Event
CerenHits
MCParticle
MCParticleEndl
ScintHits
MCParticleTree
Collection: CerenHits size:486 flags:e0000000
id | raw energy ... | corrected e... | x (mm) | y (mm) | z (mm) | time (ns)
0 .0092065 NaN 5.0000 -5.0000 -876.00 .40574
0 .0047376 NaN 5.0000 -5.0000 -866.00 .43769
0 .0052708 NaN 5.0000 -5.0000 -856.00 .47049
0 .0044950 NaN 5.0000 -5.0000 -846.00 .50883
0 .0039928 NaN 5.0000 -5.0000 -836.00 .54265
0 .0066100 NaN 5.0000 -5.0000 -826.00 .57307
0 .0056382 NaN 5.0000 -5.0000 -816.00 .60482
0 .0048611 NaN -5.0000 -5.0000 -806.00 .64098
0 1.2113E-4 NaN 15.000 5.0000 -616.00 1.4821
0 5.8311E-5 NaN -5.0000 15.000 -616.00 1.3934
0 1.0274E-4 NaN -45.000 45.000 -686.00 1.1286
0 .0014375 NaN -25.000 35.000 -716.00 .99922
0 1.1617E-4 NaN -25.000 -5.0000 -736.00 1.0324
0 2.2700E-4 NaN -35.000 5.0000 -726.00 .96424
0 2.1749E-4 NaN -15.000 15.000 -766.00 .82476
0 1.0714E-4 NaN -15.000 5.0000 -766.00 .80195
0 .0075285 NaN -5.0000 5.0000 -806.00 .63779
0 8.8005E-5 NaN -135.00 35.000 -546.00 1.8968
0 1.2617E-4 NaN -125.00 35.000 -546.00 1.8969
0 8.0509E-5 NaN -145.00 15.000 -526.00 1.7978
0 3.3811E-4 NaN -135.00 15.000 -516.00 1.7664
0 4.6271E-4 NaN -45.000 35.000 -636.00 1.2635
0 9.3142E-4 NaN -35.000 15.000 -666.00 1.1318
0 8.8005E-5 NaN -25.000 -25.000 -756.00 .98365
0 2.5833E-4 NaN -35.000 -35.000 -756.00 .98395
0 .0013176 NaN 5.0000 -15.000 -746.00 .85486
0 .0015914 NaN 5.0000 -15.000 -796.00 .69301
0 2.2330E-4 NaN 15.000 5.0000 -806.00 .80644
0 8.7041E-5 NaN -5.0000 -5.0000 -796.00 .74285
0 2.0066E-4 NaN -5.0000 -15.000 -796.00 .70446
0 2.4935E-4 NaN -5.0000 -35.000 -656.00 1.2483
0 .0016180 NaN 5.0000 -45.000 -646.00 1.2016
0 1.5861E-5 NaN 5.0000 -35.000 -646.00 1.2811
0 6.9275E-5 NaN 5.0000 -15.000 -646.00 1.2812
0 2.8915E-4 NaN -5.0000 -145.00 -506.00 1.9693
0 6.3684E-5 NaN -5.0000 -135.00 -496.00 1.9214
0 1.9787E-5 NaN -15.000 -115.00 -496.00 1.8681
0 1.9101E-4 NaN -25.000 -75.000 -506.00 1.7134
0 6.0643E-4 NaN -5.0000 -65.000 -526.00 1.6286
0 9.9158E-4 NaN 5.0000 -75.000 -546.00 1.5328
0 8.8005E-5 NaN -5.0000 -125.00 -476.00 1.9753
0 1.7787E-4 NaN -15.000 -135.00 -476.00 1.9754
0 4.5877E-4 NaN 25.000 -105.00 -466.00 1.8399
0 .0034864 NaN 5.0000 -15.000 -816.00 .60736
Analyzed 1 records in 6826ms
15.1/16.2MB

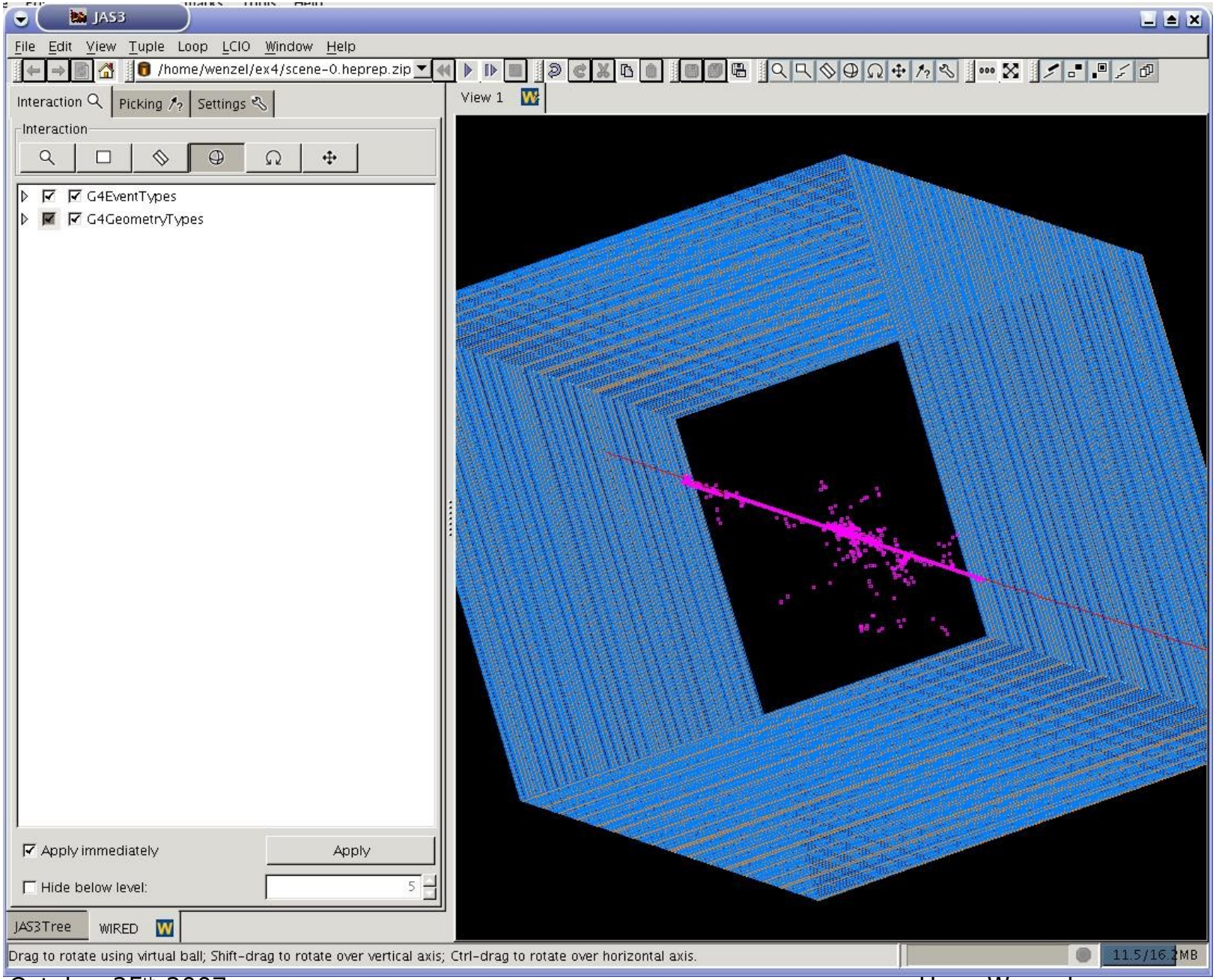

Longitudinal Shower Profile
10 GeV Pions
10 GeV electrons
Transverse Profile
10 GeV Pions
10 GeV electrons
r/mm

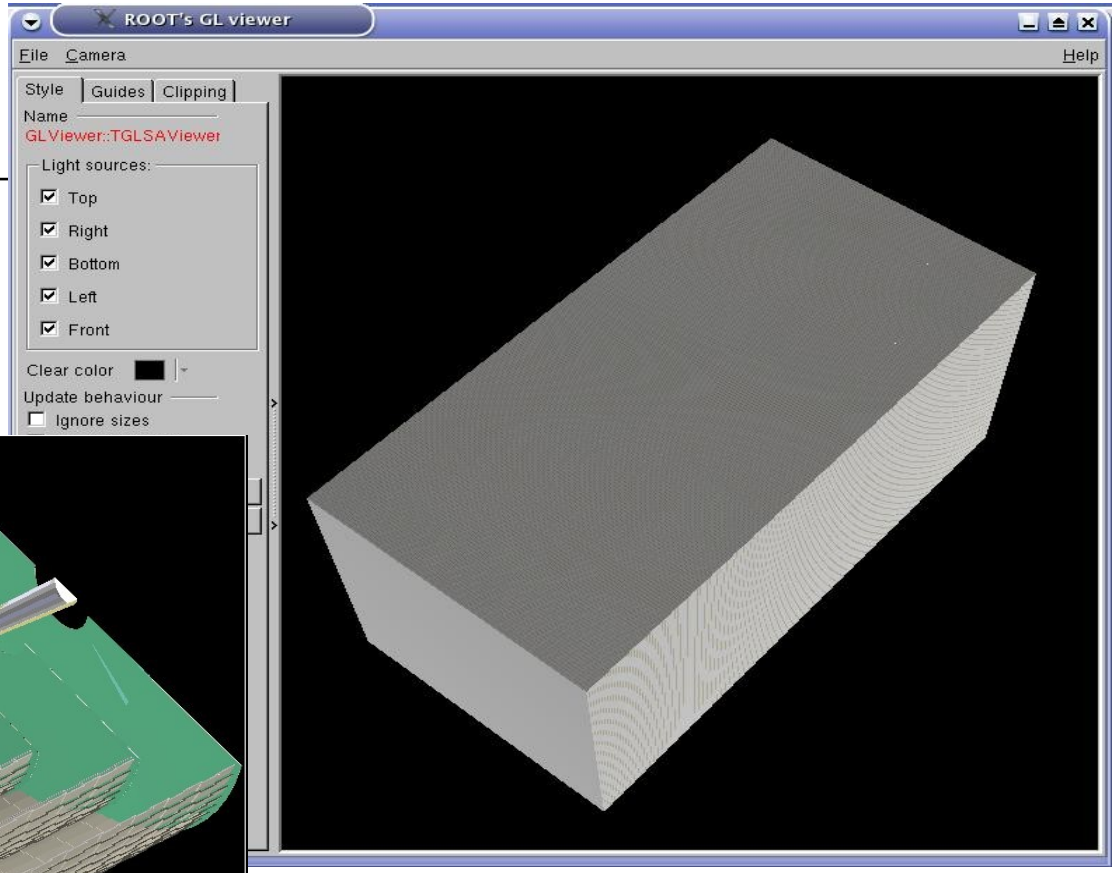
LCIO

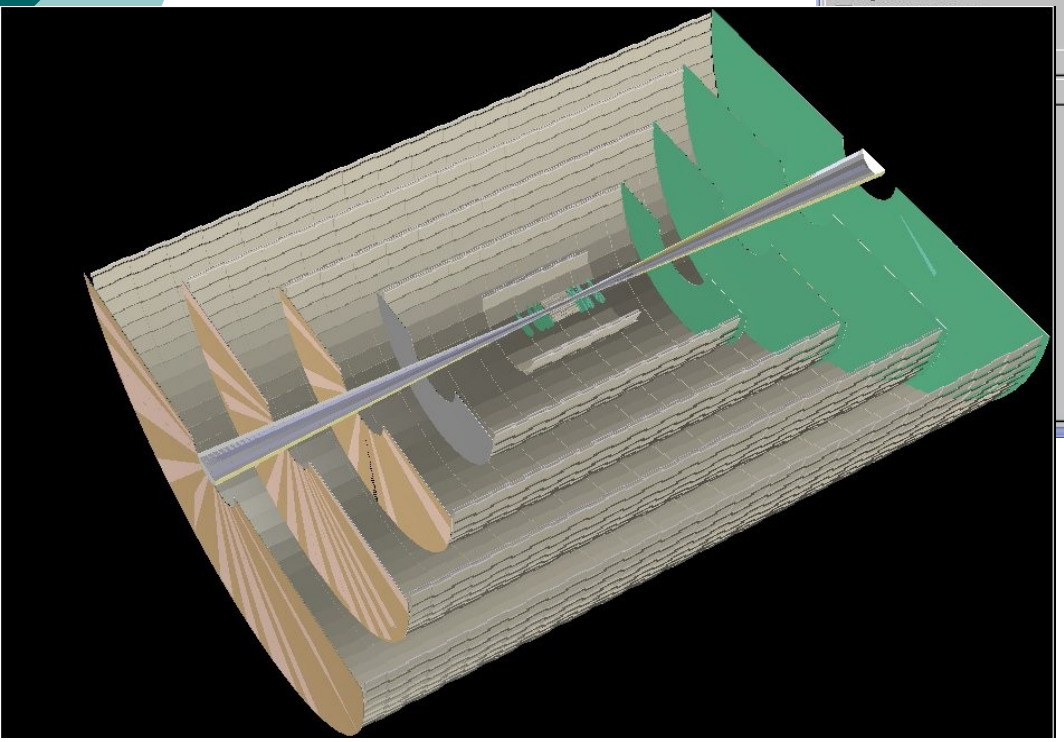
- Persistence framework for linear collider studies
  http://lcio.desy.de/
- Can be browsed/analysed within jas.
- Lcsim.org analysis frame work (JAVA based)
  http://confluence.slac.stanford.edu/display/ilc/lcsim+Tutorial
- One of the draw backs of this framework can't define your own objects and make them persistent. Have to deal with our own objects while they are in memory.
- Here we were lucky that objects exists that fit.

LCDD

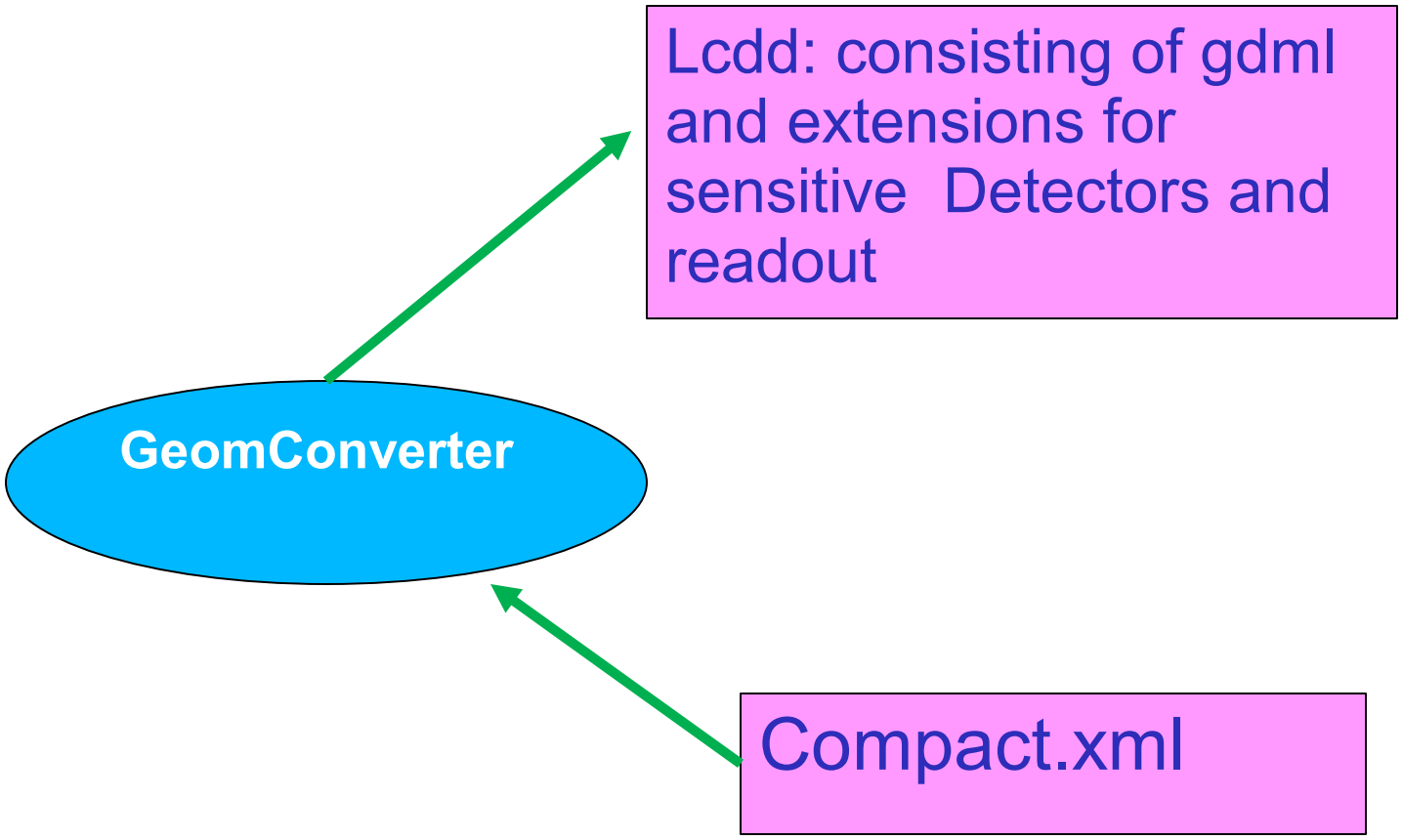
- Linear Collider detector description xml based: an example ecal.lcdd is attached to the agenda representing a calorimeter of 200 layers of lead glass and scintillator. http://lcsim.org/software/lcdd/
- Can be visualized with root (geometry) or Wired/JAS (full event display) http://jas.freehep.org/jas3/ http://confluence.slac.stanford.edu/display/ilc/lcsim+Getting+Started
- Easy to implement read out segmentation (sensitive detectors) example has 1 cm readout cells for both scintillator and lead glass.
- No recompiling necessary when geometry changes.
- Easy to integrate 'our' calorimeter with existing detector concepts e.g. What happens when we replace the SID calorimeter with a dual readout calorimeter.


JAS3
File Edit View Tuple Loop LCIO Window Help
/home/wenzel/ex4/scene-0.heprep.zip
Interaction
Picking
Settings
Interaction
G4EventTypes
G4GeometryTypes
Apply immediately
Apply
Hide below level:
5
JAS3Tree
WIRED
View 1
Drag to rotate using virtual ball; Shift-drag to rotate over vertical axis; Ctrl-drag to rotate over horizontal axis.
11.5/16.2MB


ROOT's GL viewer
File Camera
Help
Style
Guides
Clipping
Name
GLViewer::TGLSAViewer
Light sources:
Top
Right
Bottom
Left
Front
Clear color
Update behaviour
Ignore sizes



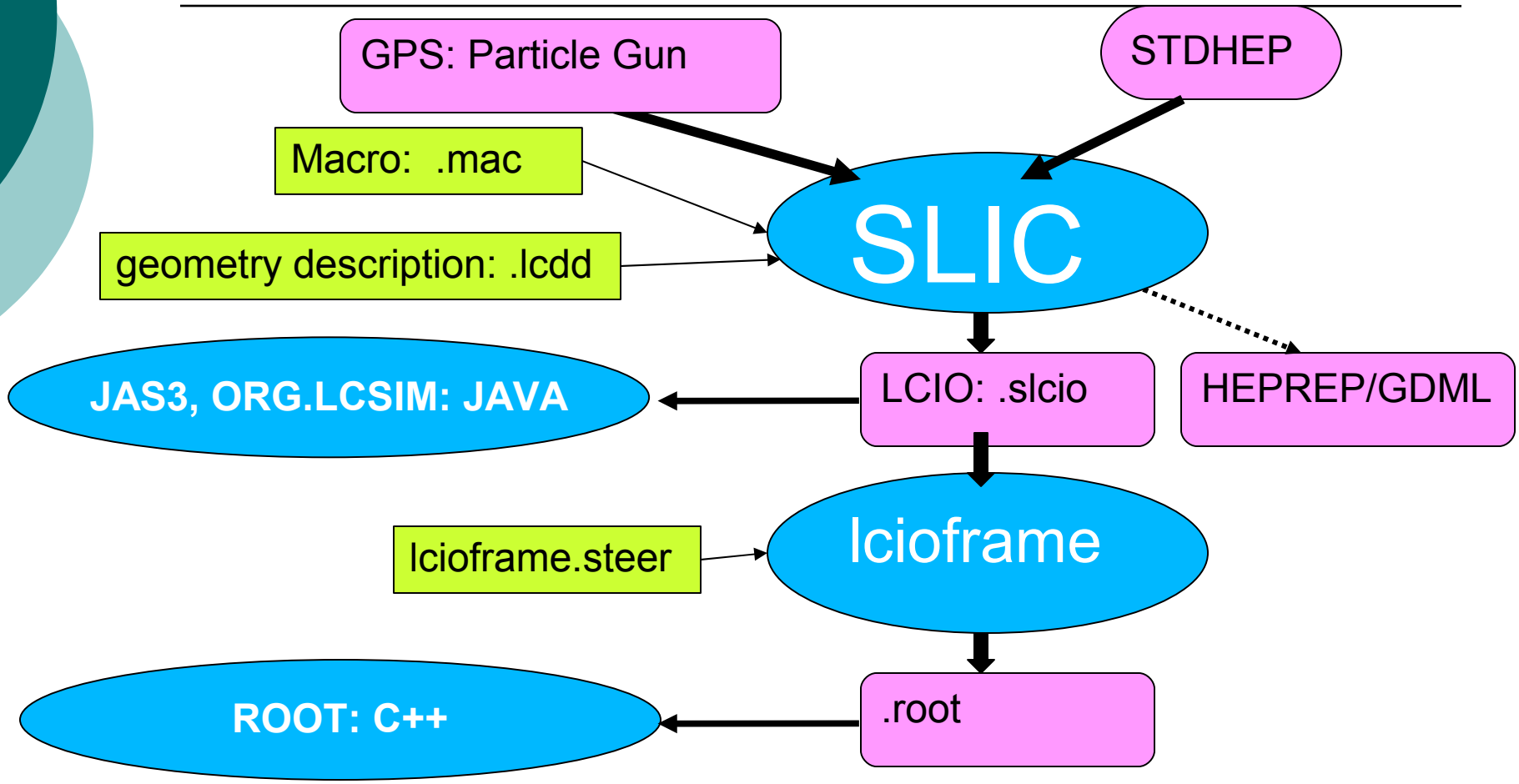
Geometry description



What did we have to add/change

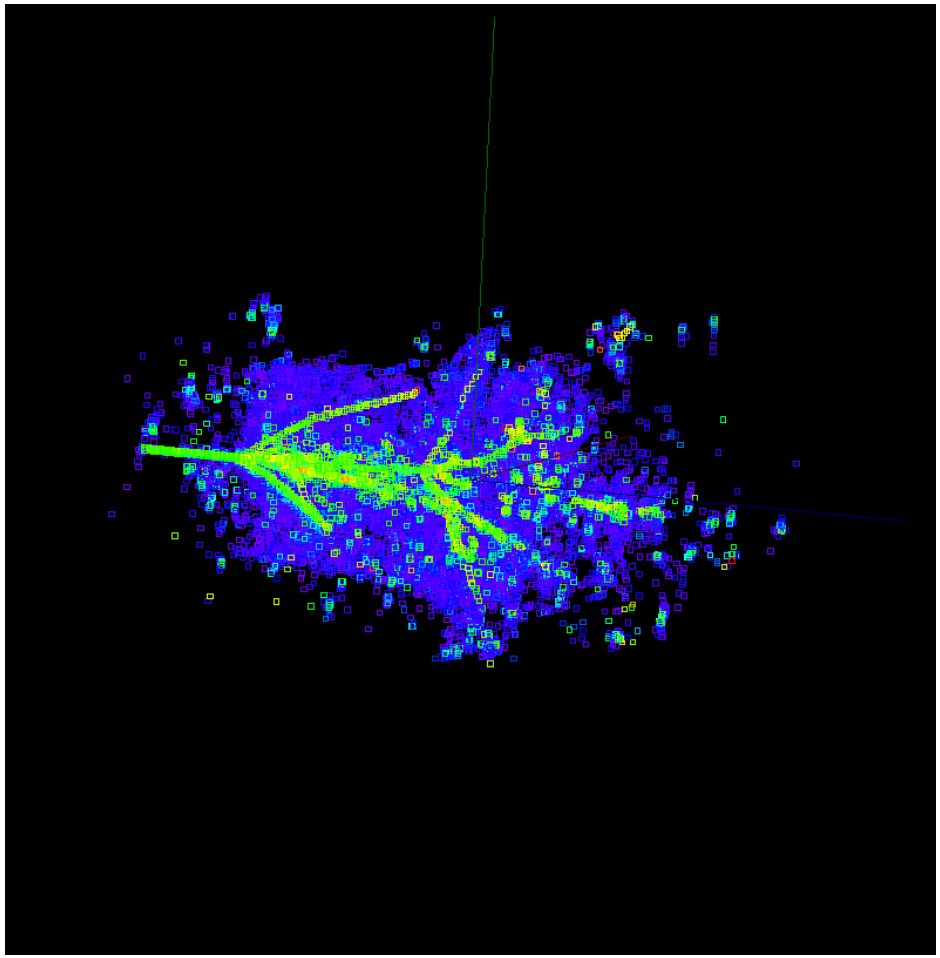
- Adding optical physics processes.
- Go from StackingAction--> SteppingAction.
- Adding optical material properties (refraction index/absorption) → new version of gdml/fix bug in gdml. (thanks to Witold Pokorski)
- Create LCDD detector description.
- Create new detector (SD) sensitive to Cerenkov light. (photons need special treatment)
- LCIO to Root converter (ROOT is the 'de Facto' standard for analysis and that's what physicists want)
- Thanks to slic maintainer all but the LCIO to root converter is now part of SLIC/SIMDIST!!

Data flow

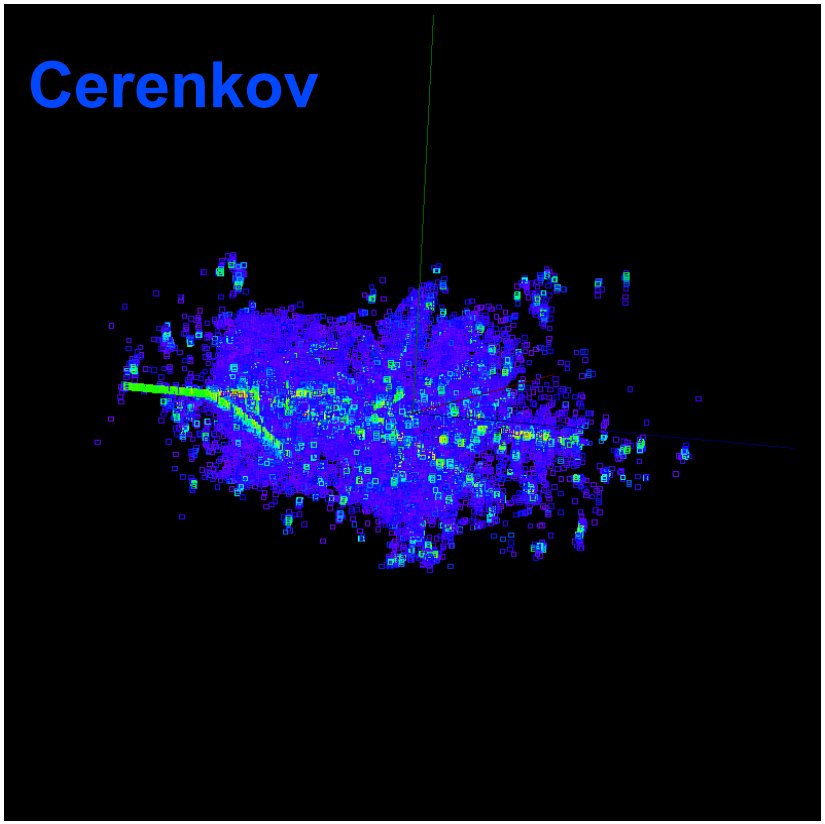

GPS: Particle Gun
STDHEP
Macro: .mac
SLIC
geometry description: .lcdd
JAS3, ORG.LCSIM: JAVA
LCIO: .slcio
HEPREP/GDML
lcioframe.steer
lcioframe
ROOT: C++
.root

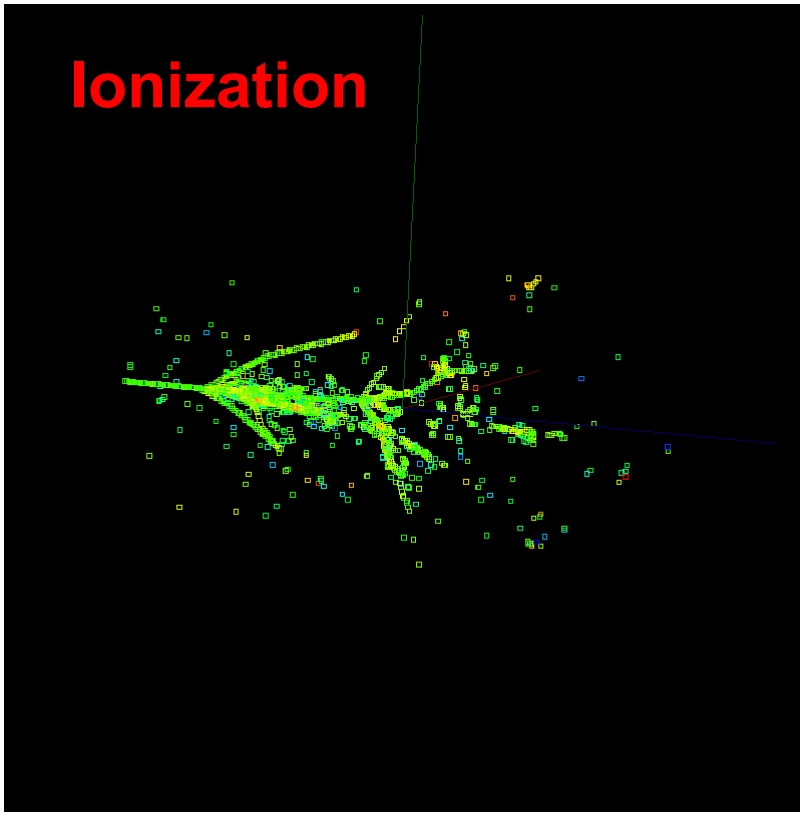
20 GeV Pion Cerenkov and Scintillator

Alternating layers of lead glass and scintilator
read out segmentation 1 cm^2



20 GeV Pion in Scintillator

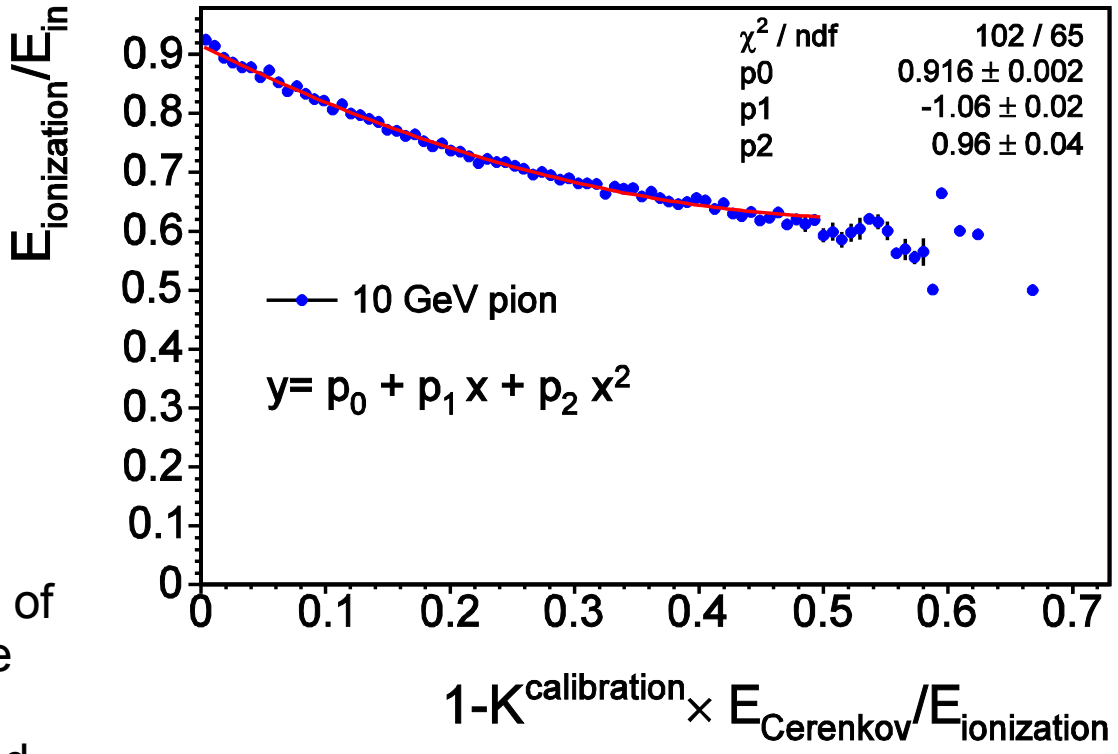




Wish list

- Releases
- Visualisation of segmentation
- multiple sensitive detectors per Volume (e.g. Cerenkov, Ionization, neutrons)
- Easy flexible way to define readout geometry
- LCIO to ROOT converter or Root shared libraries to access LCIO files

Correction function:



Correlation between the total observed ionization energy and the electromagnetic component of the shower, as measured by the Cherenkov component. The calibration factor K is determined by the requirement that $K \times E_{Cherenkov} = E_{ionization}$ for electrons.