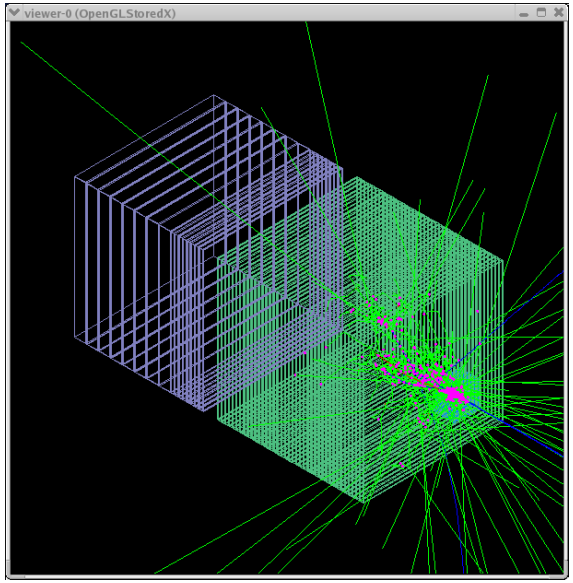
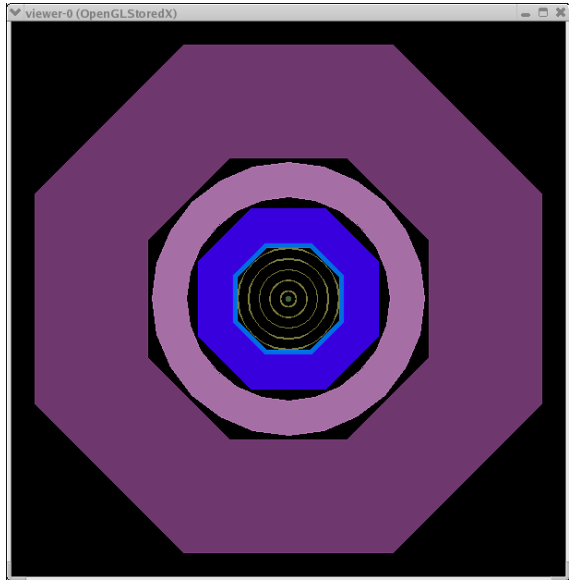
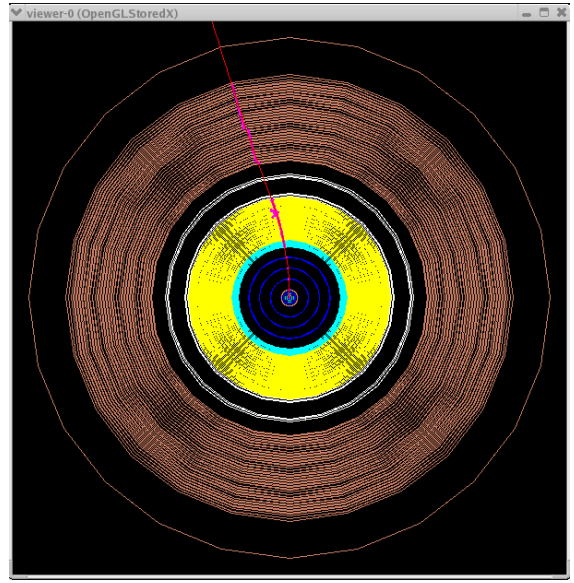
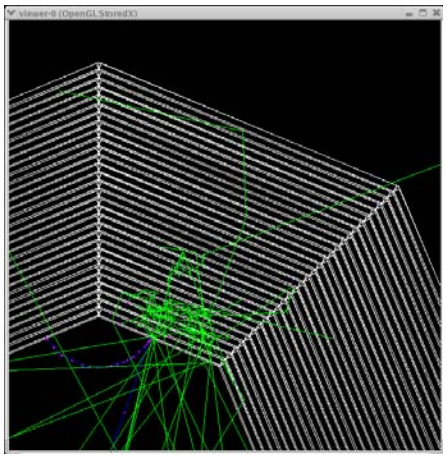
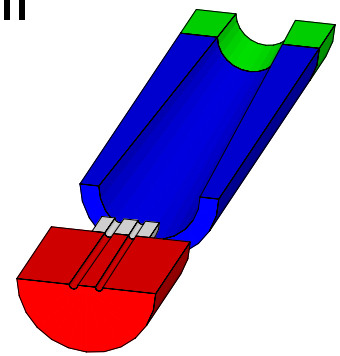




Detector Simulation with SLIC and LCDD



Jeremy McCormick, Ron Cassell

for SLAC Simulations Group



Overview

1. Simulation Requirements
2. LCDD XML Format for Detector Description
3. GDML for Geometry
4. Compact XML Format
5. LCDD Visualizations
6. SLIC Simulations Package
7. Diagnostic Histograms
8. Plans
9. Resources

Simulation Requirements

- any geometry that can be represented in Geant4
    - any testbeam or full detector
- any Geant4 physics list
- any readout type
- user friendly interface to geometry input
    - avoid add-on C++ code or inflexible/incomplete data formats
- customizable LCIO output
- correct implementation of LCIO MCParticle tree and status codes
- minimize package (inter)dependencies
- complete and consistent commandline and macro interface

LCDD

What is it?

- extension of GDML
- C++ geometry package for Geant4
- low-level XML format for detector description

What does it provide?

- embedded GDML element for geometry: constants, materials, solids, volumes
- detector description elements for the simulation
    - sensitive detectors
    - readout types (volume segmentation)
    - ID dictionary
    - regions
    - fields
    - visualization

LCDD volume Element

- Red elements extend the GDML volume type.
- Any number of **physvolid** elements are allowed on the **physvol** child tag.
- **sdref** is a named sensitive detector from the **sensitive_detectors** section.
- **regionref** points to a named region within **regions**.
- **vis_attributesref** is a named vis_attributes element from display.

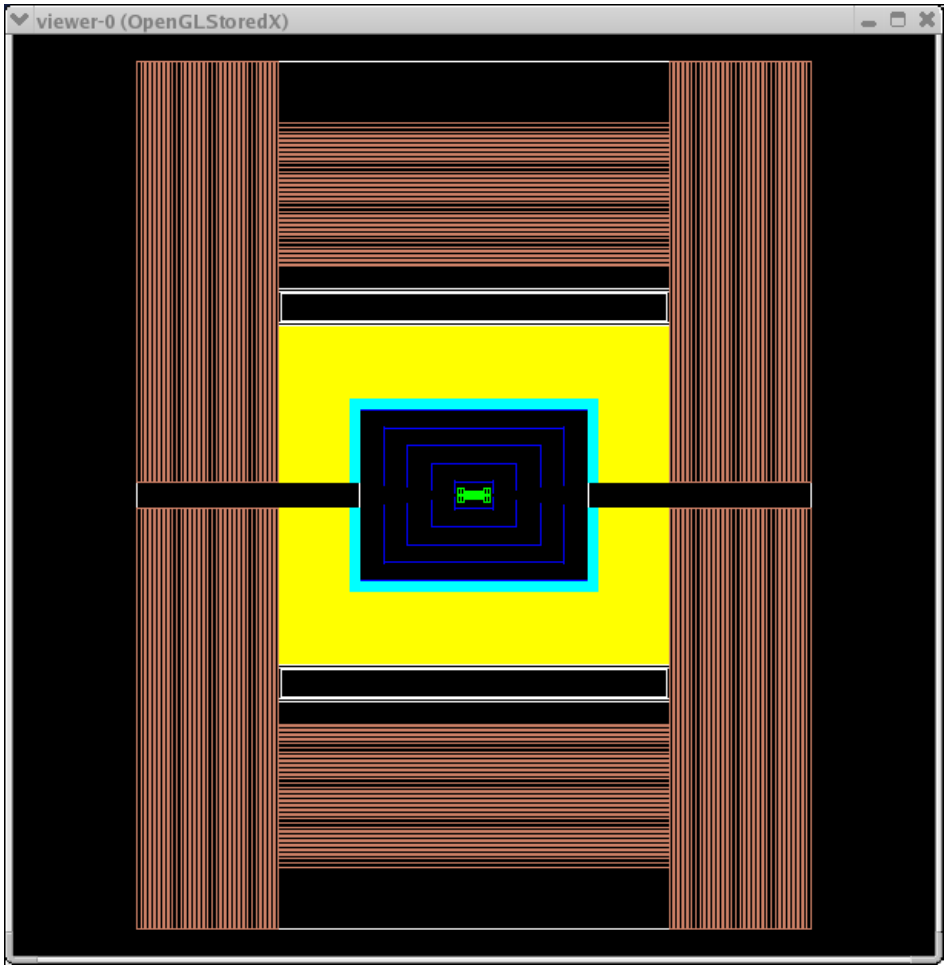
Example

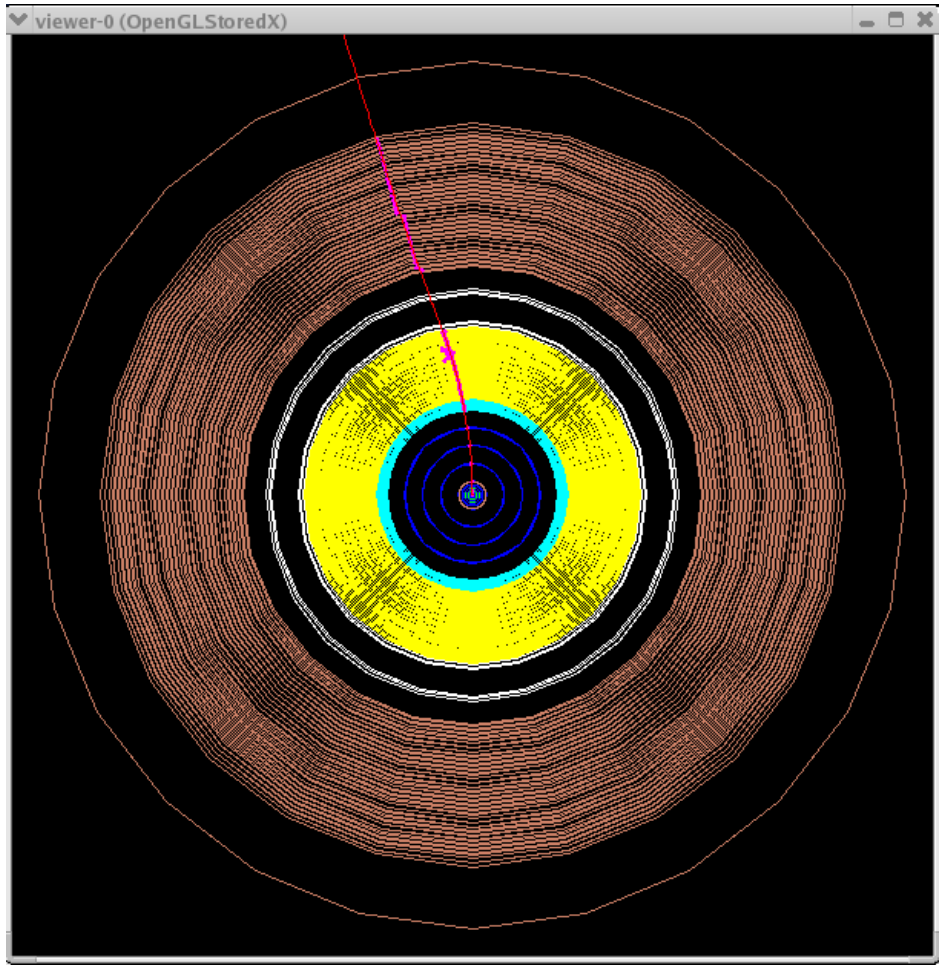
```
<volume name="ecal_barr">
  <materialref ref="Air" />
  <solidref ref="ecal_barr_tube" />

  <physvol>
    <volumeref ref="ecal_barr_lay0" />
    <positionref ref="identity_pos" />
    <rotationref ref="identity_rot" />
    <physvolid name=“layer” value=“0”
  </physvol>

  <sdref ref=“EcalSD” />
  <regionref ref="EcalRegion" />
  <vis_attributesref ref="EcalVis"/>
</volume>
```

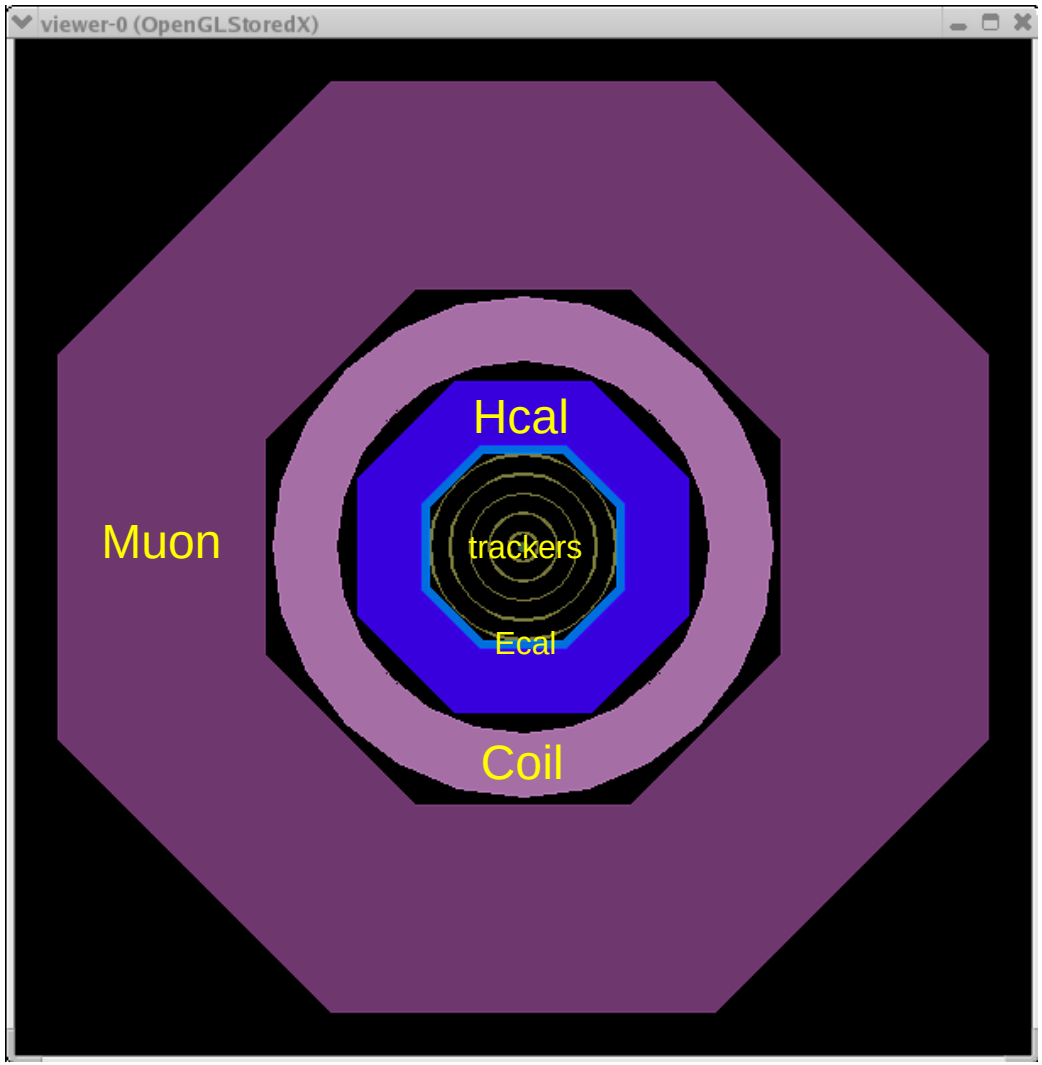
SDJan03 Reprise





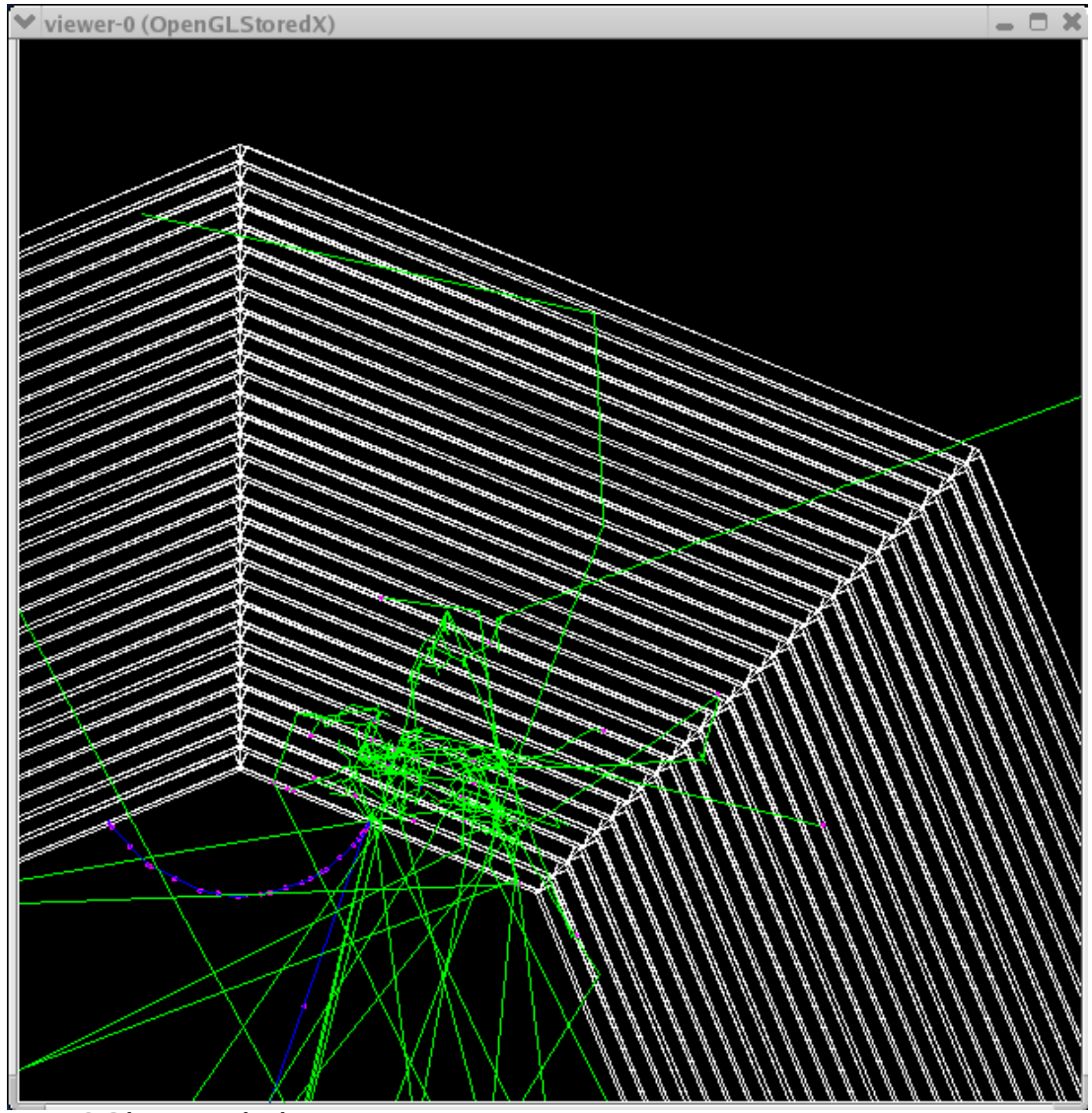
SiDFeb05 Detector Envelopes

- polyhedra (octagons) for calorimeters
- envelopes only (for now)
- modelling realistic detector designs with “corners”
    - need to add trapezoid-shaped readout modules with box layers



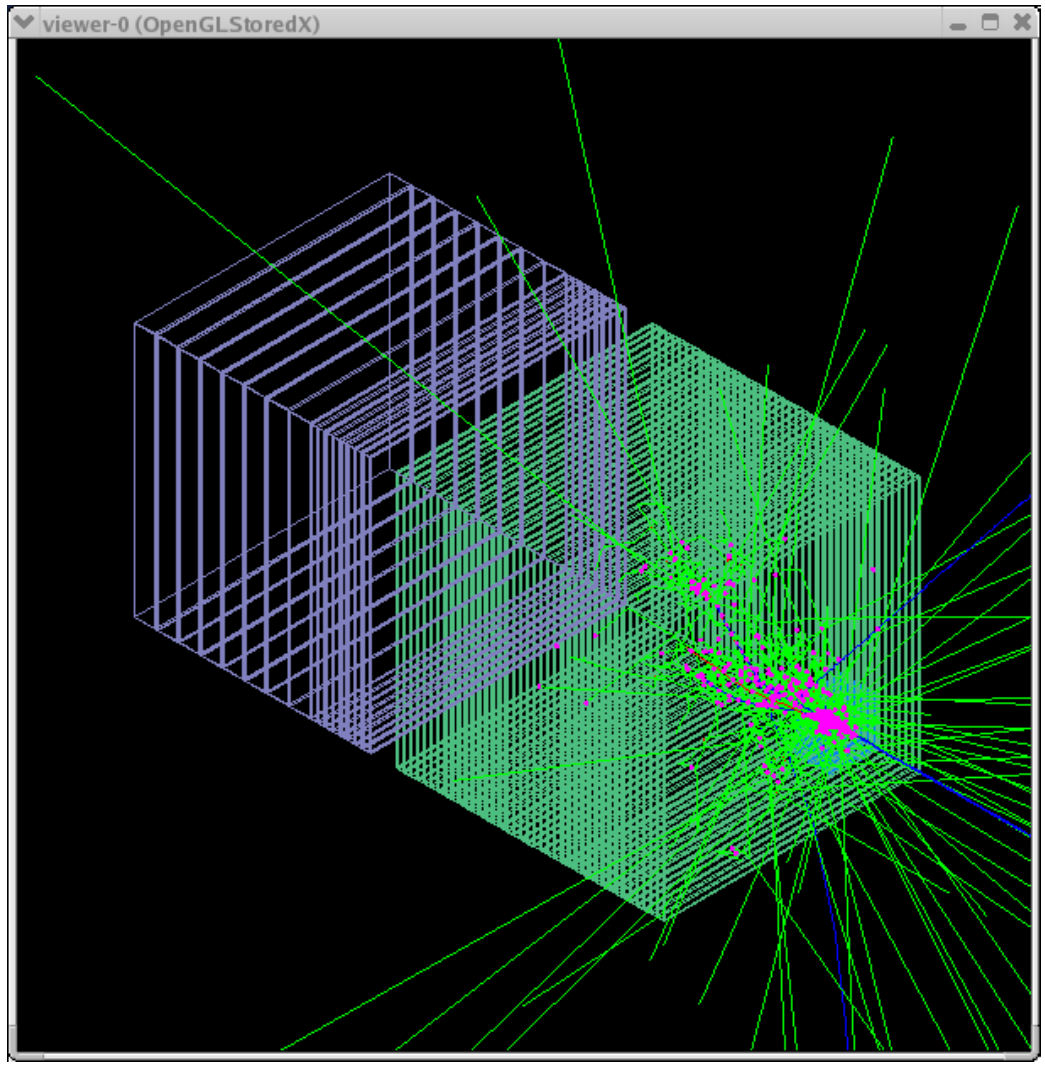
Octagonal Calorimeter Barrel

- 2 GeV pion
- storing calorimeter-type hits in a region where secondaries are created
- magnetic field
- Geant4 range cut settable by region, especially useful for tweaking secondary / shower physics.
- Range cut is 10 mm here vs. Geant4's 1 mm default.



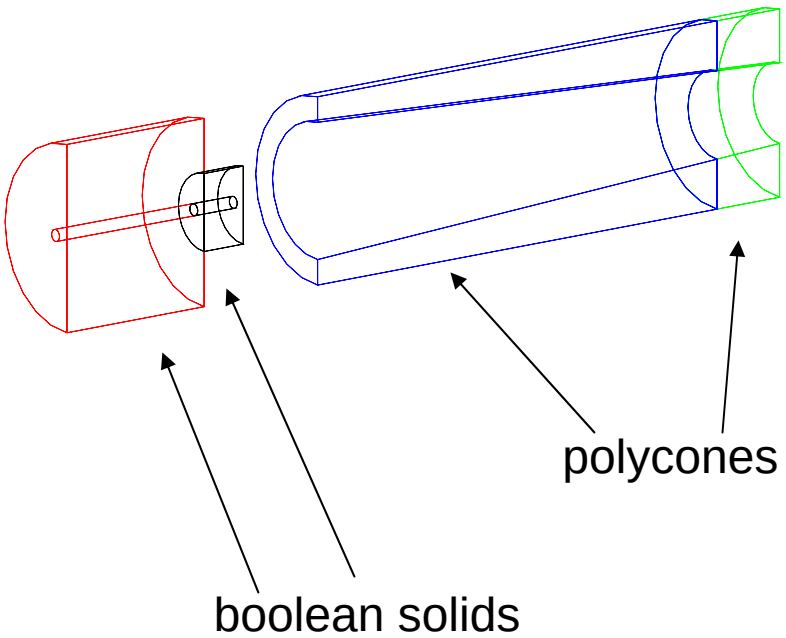
Testbeam

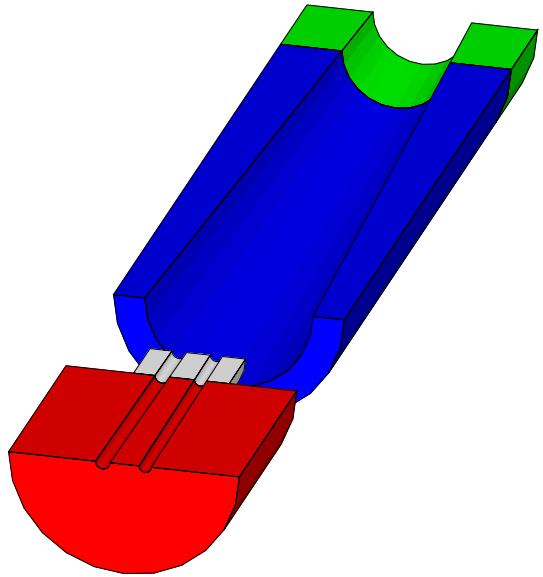
- 2 GeV pion
- geometry similar to Mokka's TB03 model
- store_secondaries is ON for viewing detailed shower structure.



MDI - BDS

Machine Detector Interface and Beam Delivery System





Visualized with dawn and dawncut.

SLIC

What is it?

- C++ simulator authored by Jeremy McCormick and Ron Cassell
- simulator command and control, “hub” package
    - **Geant4**
    - **LCDD** for the geometry description
    - **LCIO** for IO

What does it provide?

- macro/commandline interface
- binding to LCDD geometry package
- physics list selection
- StdHep interface (from Willy Langeveld)
    - implementation of LCIO status flags
    - options for LCIO output formatting: include positions/PDG IDs, overwrite/append
    - MCParticle tree handling from input MCParticles, primaries, trajectories
    - flexible logging/debugging facilities (soon!)

SLIC Command Interface

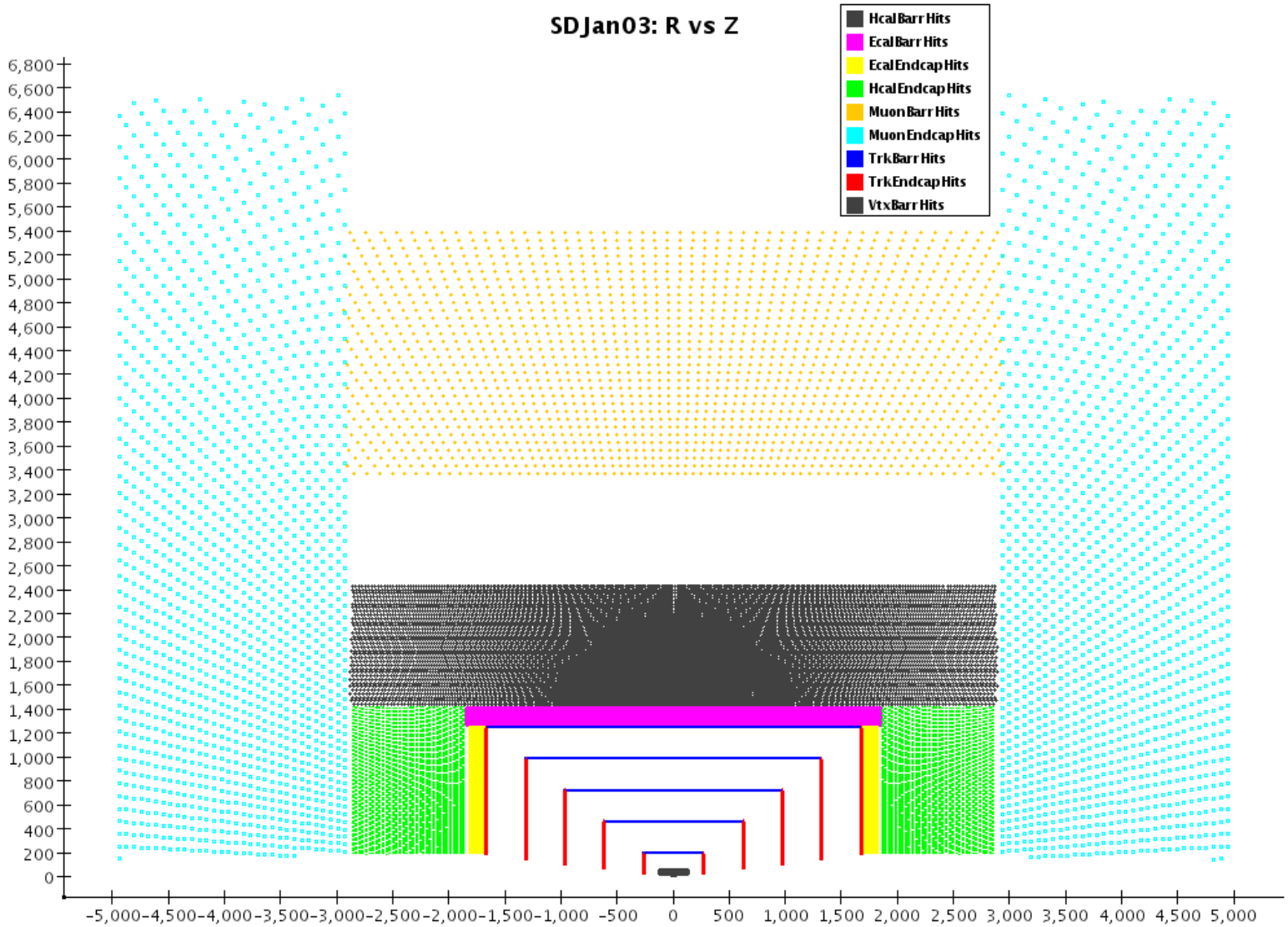
Macro

```
/lcdd/setURI ./examples/sdjan03/SDJan03.lcdd
/physics/select LHEP
/stdhep/setFile stdhep_inputfile
/lcio/path lcio_files
/lcio/filename output_file
/control/execute user_settings.mac
/stdhep/skipEvents 100
/run/initialize
/run/beamOn
/control/interactive
```

Same with Command Line

```
slic -g ./examples/sdjan03/SDJan03.lcdd
     -l LHEP
     -i stdhep_inputfile
     -p lcio_files
     -o output_file
     -m user_settings.mac
     -s 100
     -z
     -r 1
     -n
```

R vs. Z [histo]


SDJan03: R vs Z
HcalBarrHits
EcalBarrHits
EcalEndcapHits
HcalEndcapHits
MuonBarrHits
MuonEndcapHits
TrkBarrHits
TrkEndcapHits
VtxBarrHits
6,800
6,600
6,400
6,200
6,000
5,800
5,600
5,400
5,200
5,000
4,800
4,600
4,400
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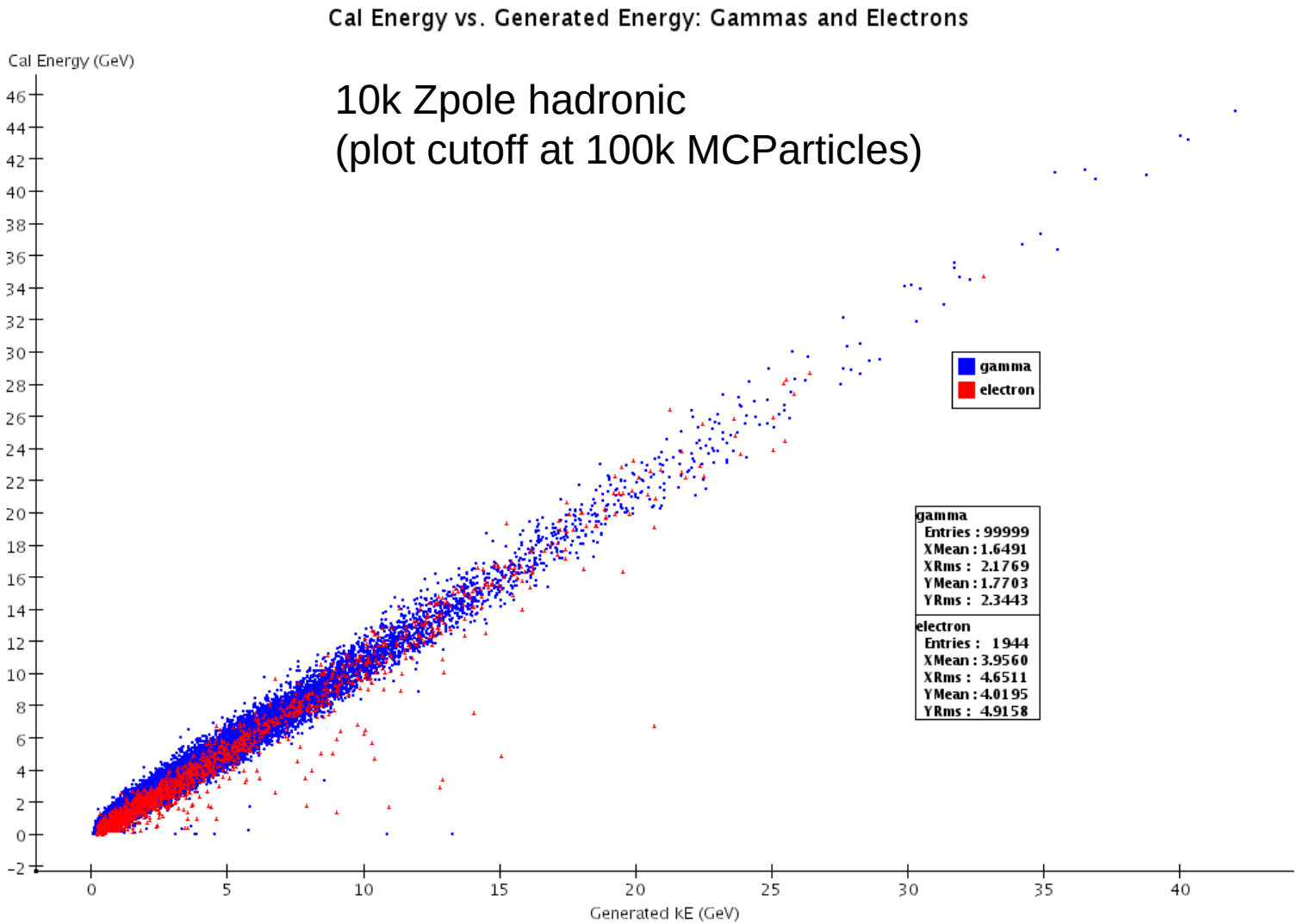
1,200
1,000
800
600
400
200
0
-5,000 -4,500 -4,000 -3,500 -3,000 -2,500 -2,000 -1,500 -1,000 -500 0 500 1,000 1,500 2,000 2,500 3,000 3,500 4,000 4,500 5,000

MCParticles: EM Energy [histo]



10k Zpole hadronic
(plot cutoff at 100k MCParticles)

Compact Description

- **GeomConverter** in SLAC CVS
- converted to LCDD for simulation
- easily change detector params
- used as primary geometry input to lcsim.org reconstruction package
- high level interface to geometry
  - layers, slices
  - specialized detector types
  - dimensions: inner, outer radii
  - readouts, IDs

Example

```
<detector id="2"
          name="EMBarrel"
          type="CylindricalCalorimeter"
          readout="EcalBarrHits">
  <dimensions inner_r = "127.0*cm"
              outer_z = "179.25*cm" />
    <layer repeat="30">
      <slice material = "Tungsten"
          width = "0.25*cm" />
      <slice material = "G10"
          width = "0.068*cm" />
      <slice material = "Silicon"
          width = "0.032*cm"
          sensitive = "yes" />
      <slice material = "Air"
          width = "0.025*cm" />
  </layer>
</detector>
```

Plans

- event samples
  - comparison and mutual certification of LCIO output with Mokka and LCDG4
- detector comparisons
  - SiD, LDC, GLD, …
- debugging, bullet-proofing, certification, etc.
- more flexible logging, debugging facilities
- contributions to GDML project where needed
- compact description
  - support more detector types and readouts
- user requests
  - What do you need to simulate?

Resources

- SLIC Homepage

http://www.lcsim.org/software/slic

- LCDD Homepage

http://www.lcsim.org/software/lcdd

- GDML Homepage

http://gdml.web.cern.ch/GDML/

- LinearCollider.org forum

http://forum.linearcollider.org/

- ILC Confluence Wiki

http://confluence.slac.stanford.edu/display/ilc/Home

- LCSim05 Simulations Presentation (expands on this overview talk)

http://www.slac.stanford.edu/~jeremym/presentations/03172005_JMcCormick_Simulations.ppt