ALCPG Software Status:
Simulation & Reconstruction

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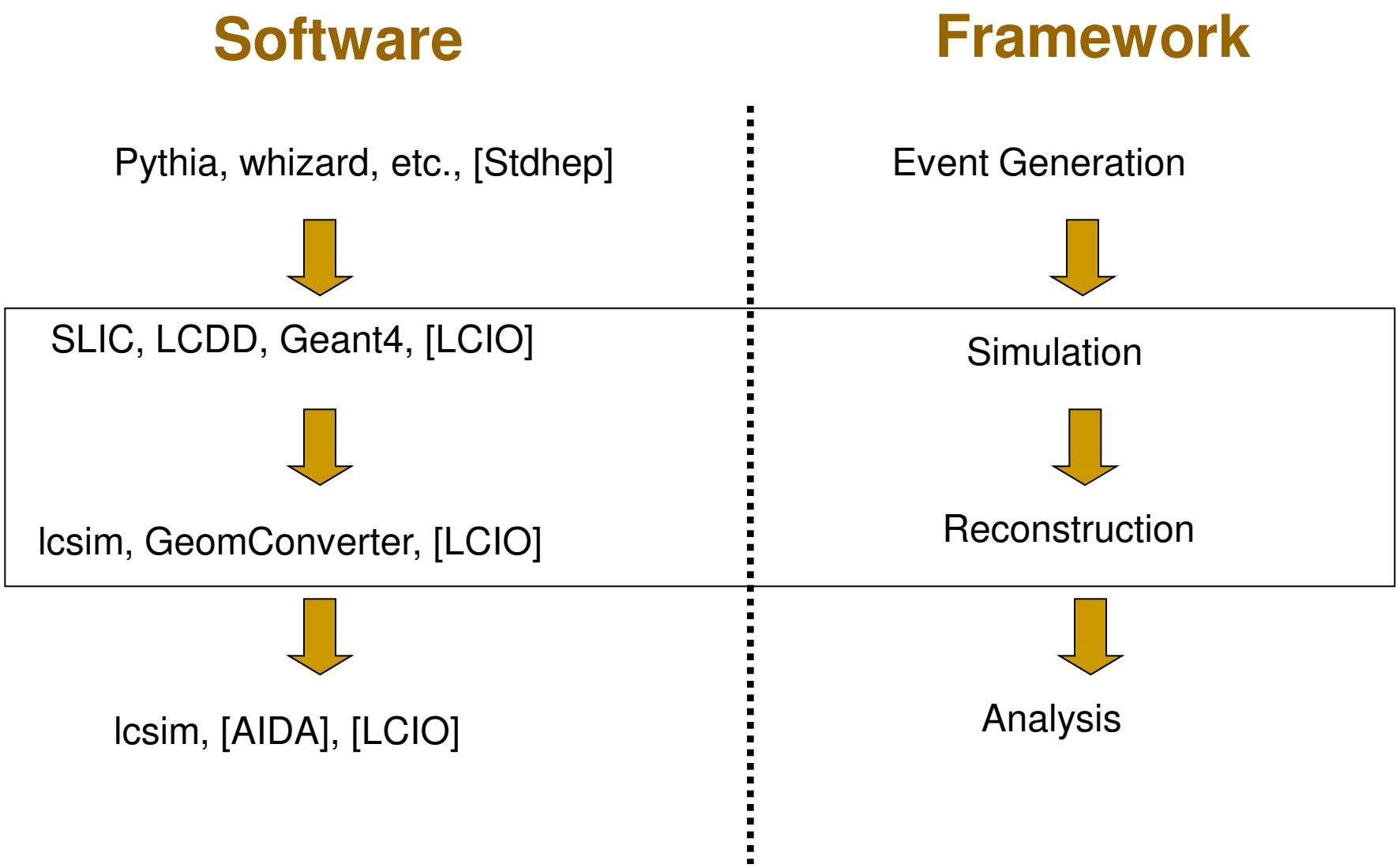
(for the sim/reco team)
LCWS 2010, Beijing
March 27, 2010

The LOI Physics Benchmarks Process

- The Letter of Intent (LOI) process required a number of physics analyses to be conducted with full-detector simulation, *ab initio* event reconstruction, and analysis.
- Although still far from "real", the physics benchmarking requirements presented us with a large-scale, end-to-end exercise which stressed most aspects of the software systems.
  - Event Generation
  - Detector Simulation
  - Event Reconstruction
  - Physics Analysis
- Let's do it again!
- But let's fix (and improve) a few things before doing so…

Framework Diagram



Work Plan for 2012

1. Demonstrate proof of principle on critical components.
2. Define a feasible baseline design.
3. Complete basic mechanical integration of the baseline design…
4. Develop a realistic simulation model of the baseline design, including the identified faults and limitations.
5. Develop a push-pull mechanism, …
6. Develop a realistic concept of integration with the accelerator …
7. Simulate and analyze updated benchmark reactions with the realistic detector model.

   Include the impact of detector dead zones and updated background conditions.
8. Simulate and study some reactions at 1 TeV, including realistic higher energy backgrounds, demonstrating the detector performance.

   For 7 and 8, Specific physics channels will be investigated and defined by the Physics Common Task Group and supported by the Software Common Task Group.
9. Develop an improved cost estimate.

slic - Features

- grid ready
  - can be setup to require no external connections
  - minimal dependencies on dynamic libraries
  - Condor and LSF scripts available
- SimDist build kit
  - GNU autoconf
  - binary distributions available for Linux, OSX, & Cygwin
- autonaming of output files
- logging system for easy debugging
- simple and familiar command line interface
- Working to include into automated pipeline toolkit.
- Working on data cataloging / accessing
  - Looking forward to collaboration with ILD & CLIC.

slic – New Features

- Optical Physics (e.g. for dual-readout crystals)
  - can be used with any physics list supported by slic
- HEPPDT for use with long-lived SUSY
  - supports extended SM and SUSY particle set using input data table
  - simple transport (charged will bend in field)
  - simple dEdx to create hits in detector
- additional segmentors for planar geometries
  - CartesianGridXY, CartesianGridXZ
- geant4 9.3
  - All physics lists available except LCPhys
  - Default is QGSP_BERT
- Windows, Mac OSX & Linux executables

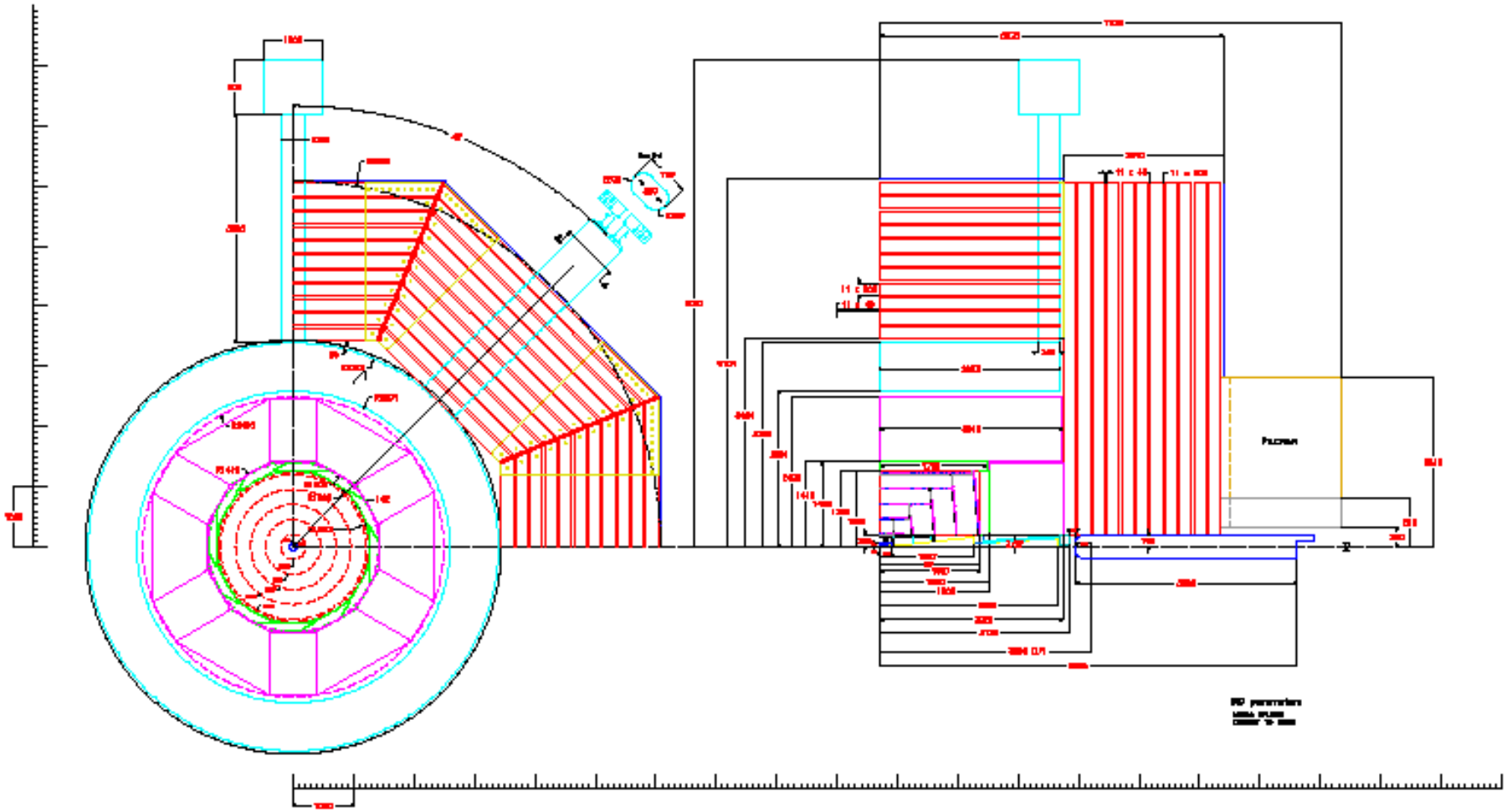
Detector Design

- Develop a realistic simulation model of the baseline design, including the identified faults and limitations.
- LOI studies were conducted with the sid02 geometry, using simplified geometries.

Beyond sid02

- The detector model sid02 was a necessary compromise between the desire to include all the details of the engineering designs and the need to complete the large-scale physics benchmarking simulations in a timely fashion.
- Since then have developed a detector model which includes more realistic detectors.
  - Benefits from engineering work done for the LOI.
  - Allows much more realistic subdetector performance studies to be undertaken.

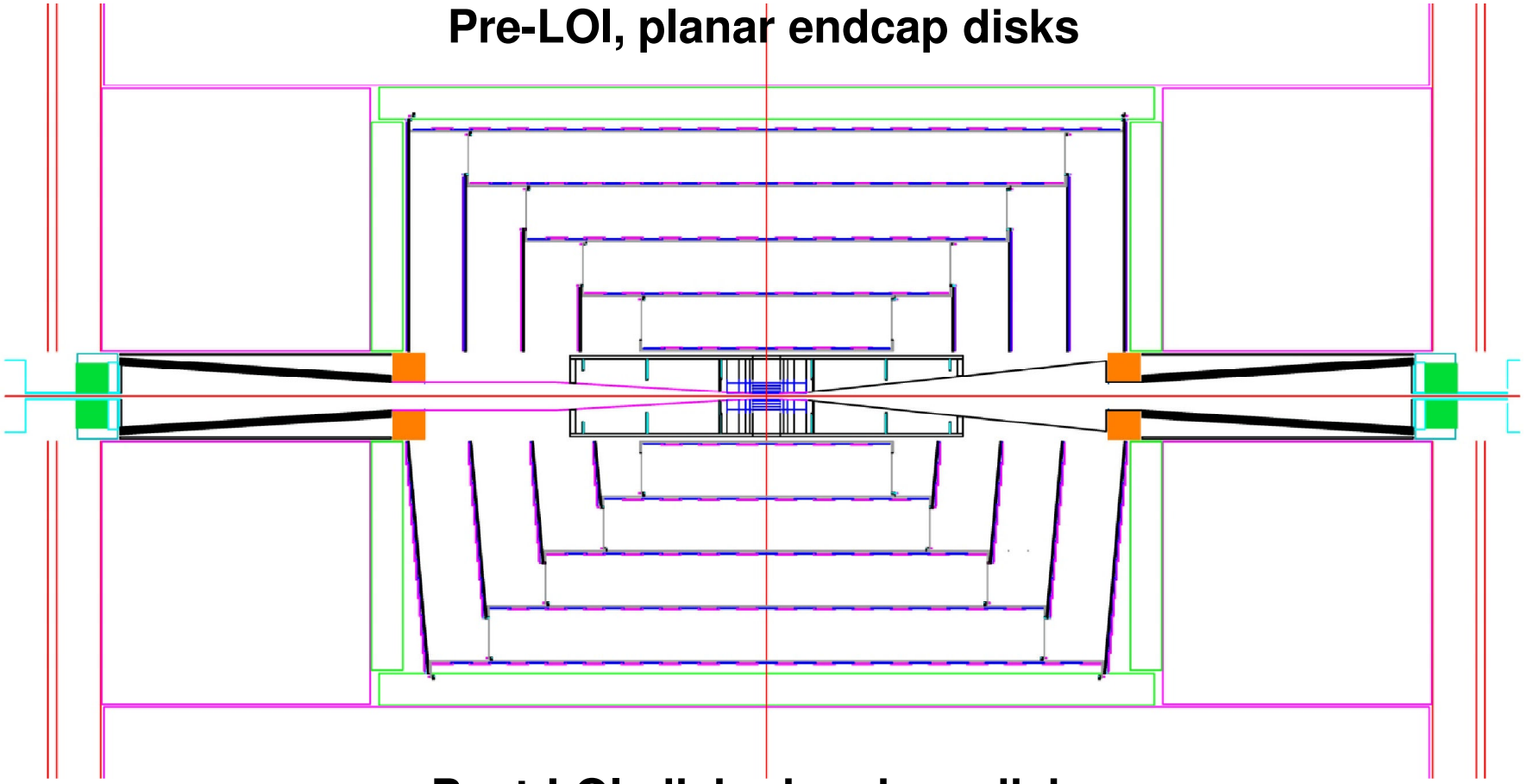
Detector Modeling



sidloi

- This model attempts to incorporate the detector as described in the LOI in as much detail as possible.
- Trackers composed of silicon wafers with support structures and readout.
- More realistic modular calorimeters, but much more detail needs to be incorporated.
- Still a work in progress, as many of the details remain to be resolved.

Pre-LOI, planar endcap disks

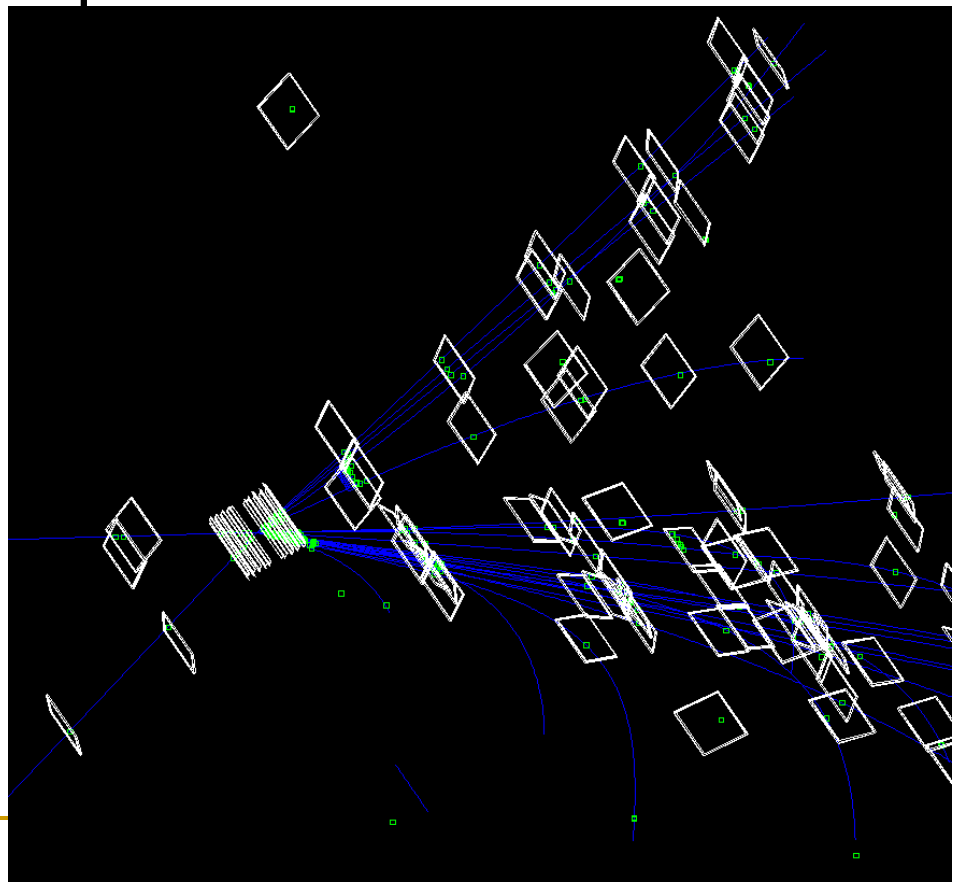


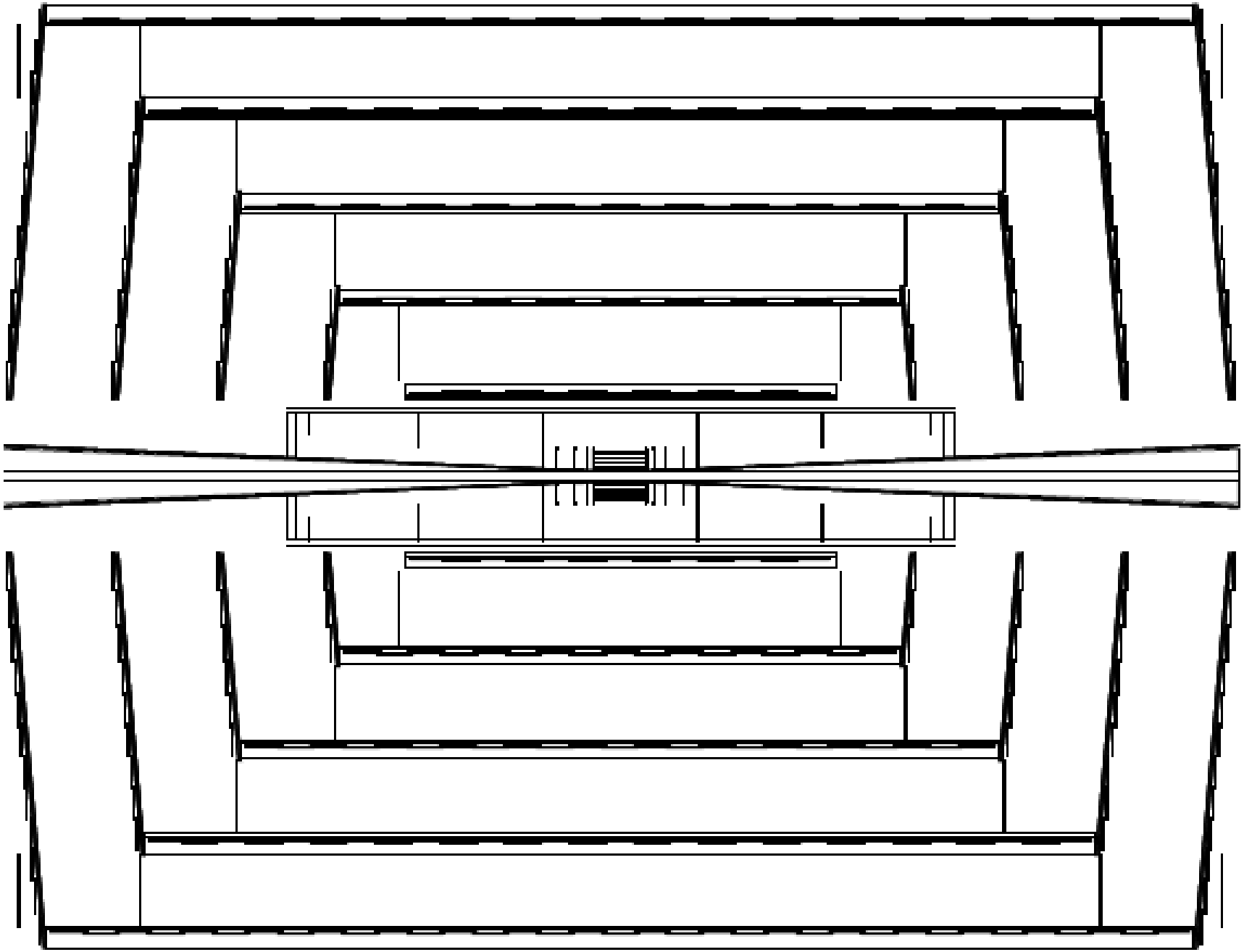
Post-LOI, dished endcap disks

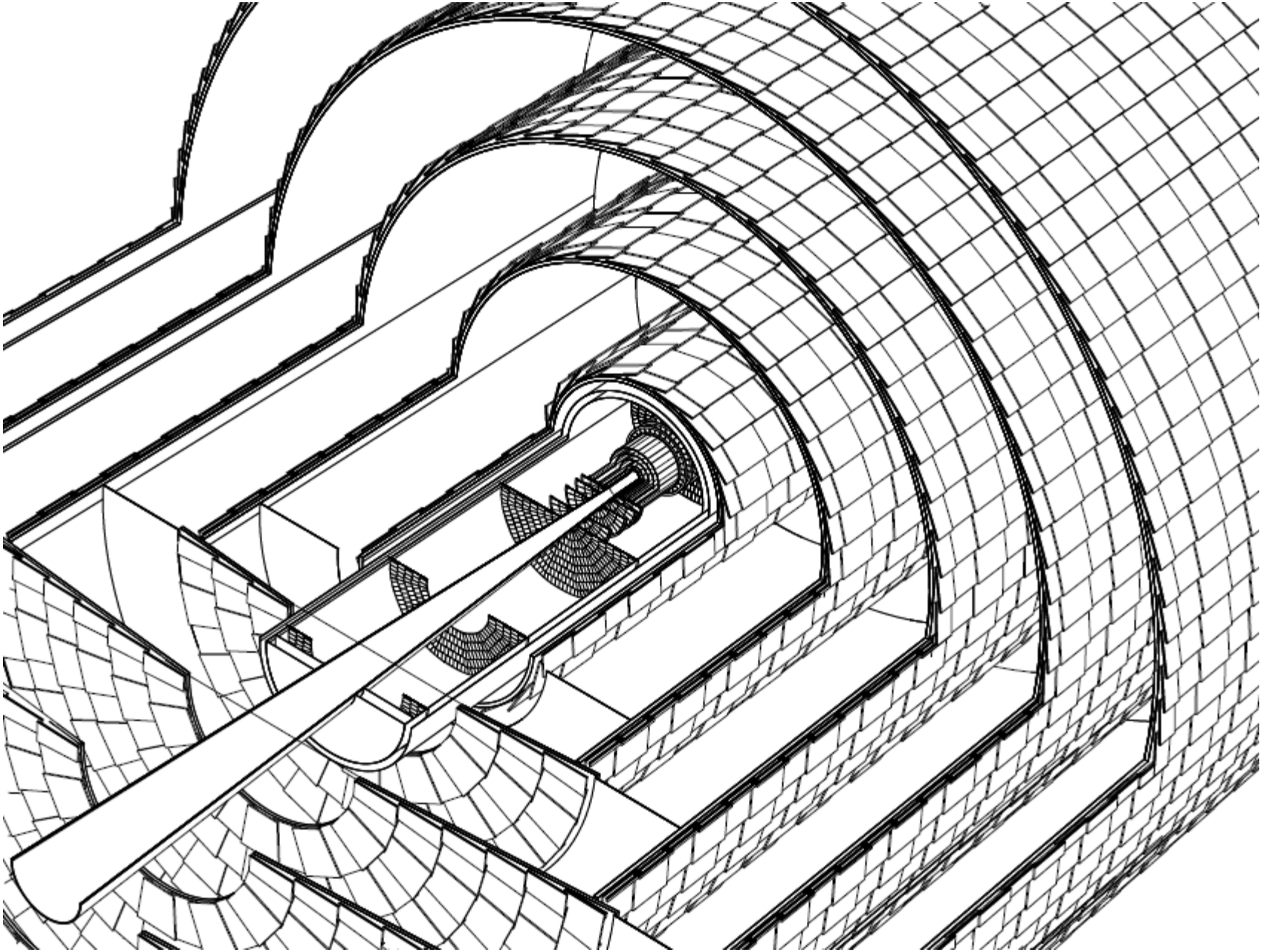
GeomConverter – Planar Trackers

- Si trackers and vertex detectors
- planar modules
- size/layout/material parameters specifiable
- segmented into pixels/strips
  - full digitization
  - full clustering

sidloi2

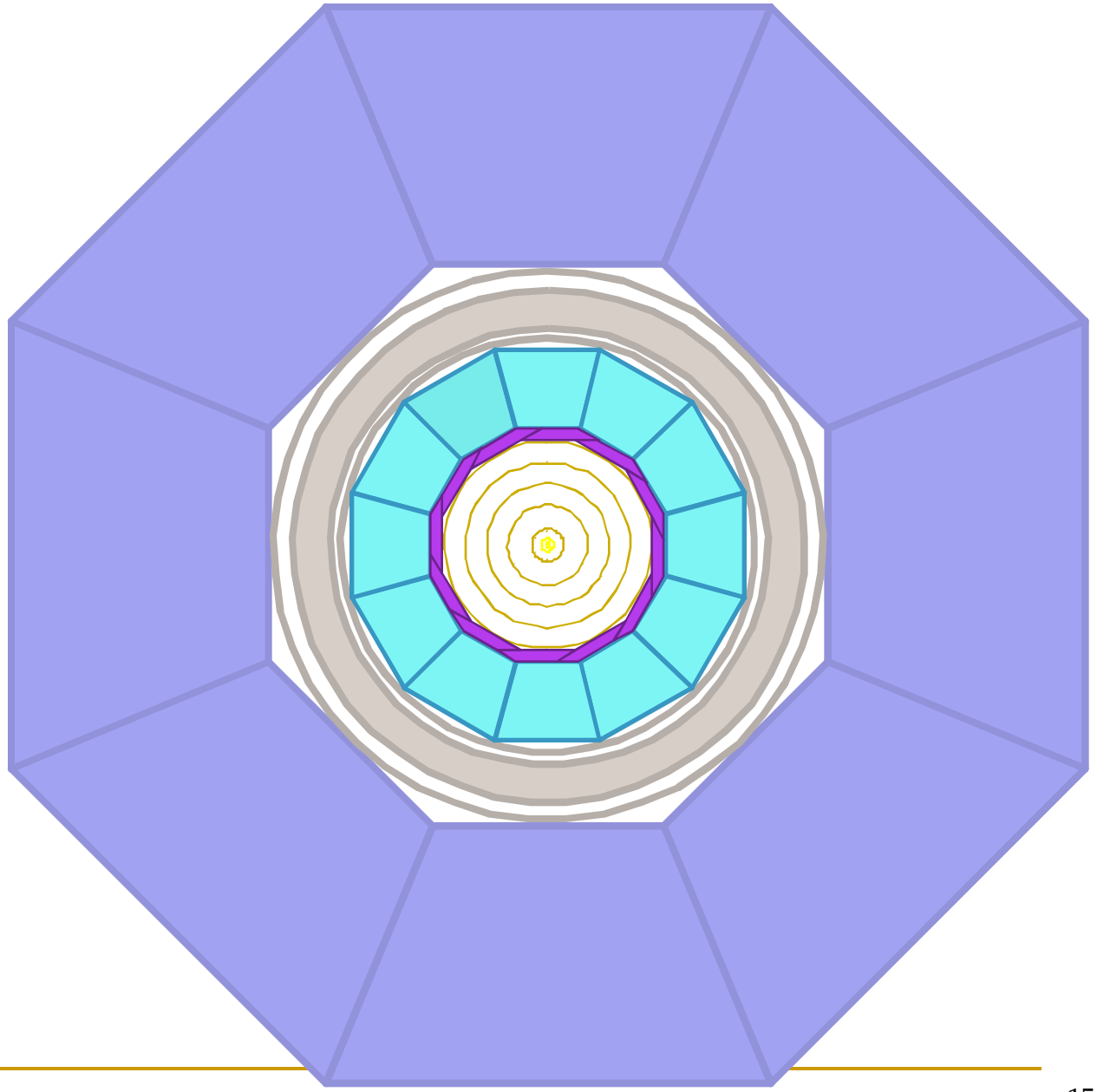






sidloi

- Dodecagonal, overlapping stave EMCal
- Dodecagonal, wedge HCal
- Cylindrical Solenoid with substructure
- Octagonal, wedge Muon



lcsim Reconstruction

- Fully support an xml-driven reconstruction
  - As much as possible is now run-time configurable using an xml format.
- Tracking reconstruction now features planar silicon wafers, full hit digitization, clustering to form hits (with hit-size dependent uncertainties) and ab initio track-finding.
- Calorimeter code has been modified to support polygonal modules (e.g. neighboring)
- PFA code is being improved and also adapted to the new geometries.

lcsim – XML Interface

- input format to lcsim for batch jobs
- creates drivers with input parameters
- automatically accepts single arguments based on setter functions (Java Beans)
  - Java primitive types
  - 1D arrays of primitive types
  - custom XML element
  - global expression evaluation
- easy to add external libraries
  - URL to jar file
- input files
  - remote (ftp, http) or local files
- control arguments
  - number of events, logging, data caching, etc.
- JobControlManager

lcsim – XML Example

```
<inputFiles>
    <file>/path/to/myfile.slcio</file>
</inputFiles>
<execute>
    <driver name="MyDriver"/>
</execute>
<drivers>
    <driver name="MyDriver"
        type="org.lcsim.ADriver"/>
        <paramX>1.2</paramX>
        <paramXX>1.2 2.3 3.4</paramXX>
    </driver>
</drivers>
```

list of input LCIO files

Driver execution order

Driver definitions

unique name of Driver

Java type of Driver

single parameter

array parameter

Tracking

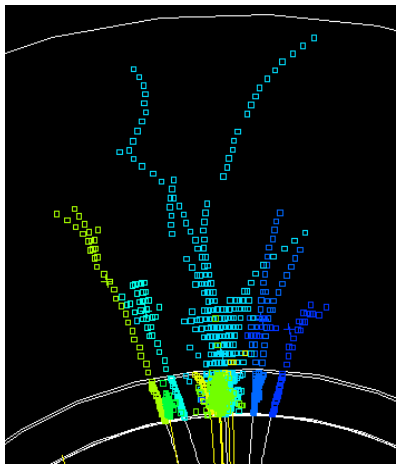
- Digitization improves from the virtual segmentation used in the LOI to full digitization of SimTrackerHits into ADC counts in pixels and strips, using detailed drift, diffusion, readout, …
- Full clustering of neighboring hits, giving cluster-dependent measurement position and uncertainties.
- Tracking seems to work well, currently characterizing performance.
- Will implement full fitting, accounting for multiple scattering and energy loss.

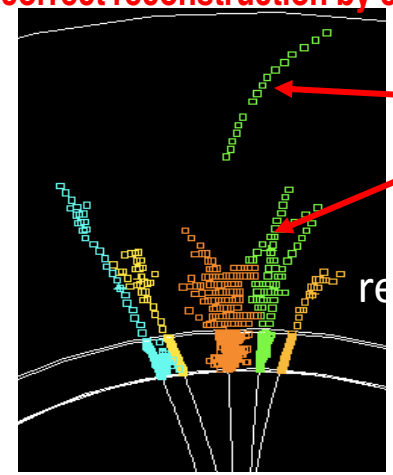
Calorimeter Clustering & PFA

- Code has been developed to provide full functionality for modular calorimeters
  - Return list of neighboring cells within module
  - Given position, return ID
  - Given ID, return position
- Testing that clustering code works with new geometries, modifying or augmenting as necessary.
- Developing cross-module clustering.
- Modifying existing PFA code to make it work with new geometries, modify or replace as necessary.

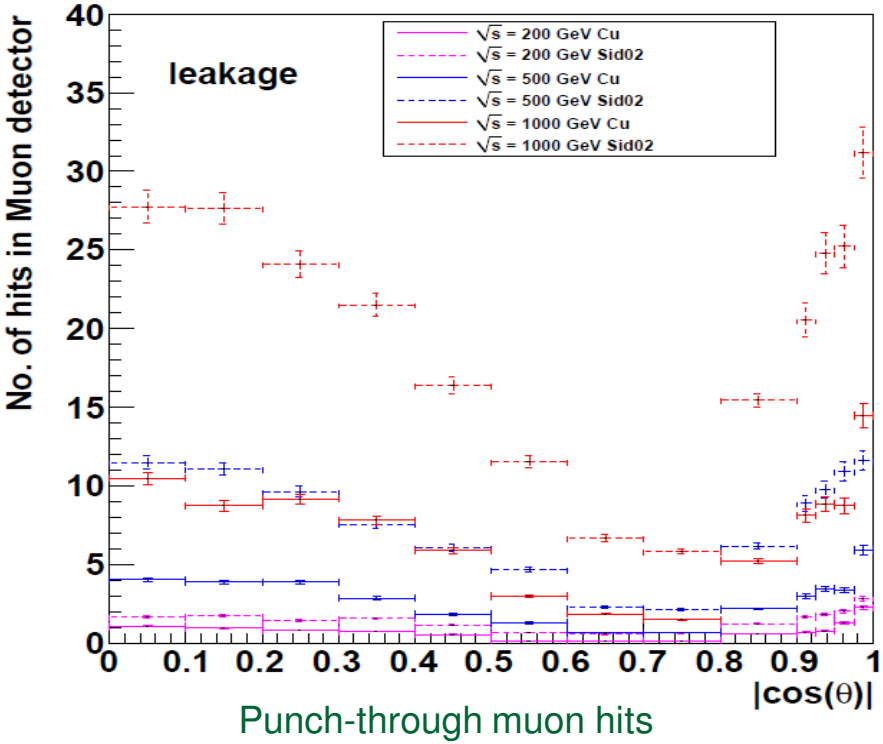
PFA Development

- Ongoing development of SiD (Iowa/SLAC/MIT) PFA
- Focus on reduction of wrongly assigned hits (confusion) and leakage.

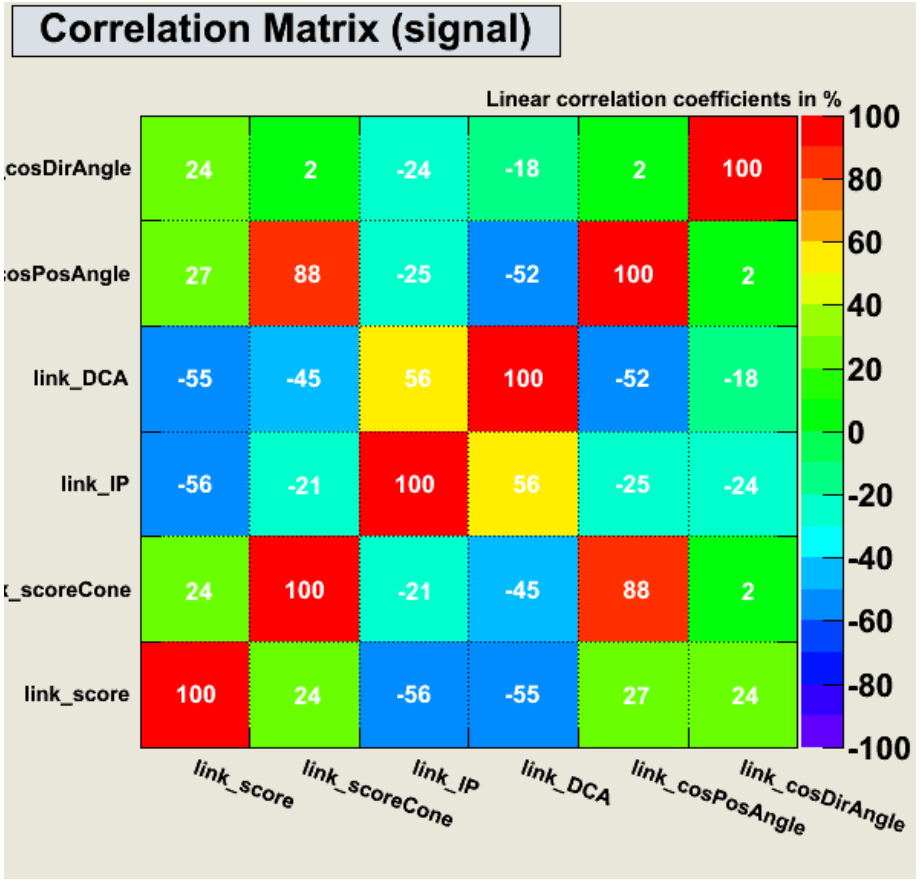




PFA Development



Punch-through muon hits

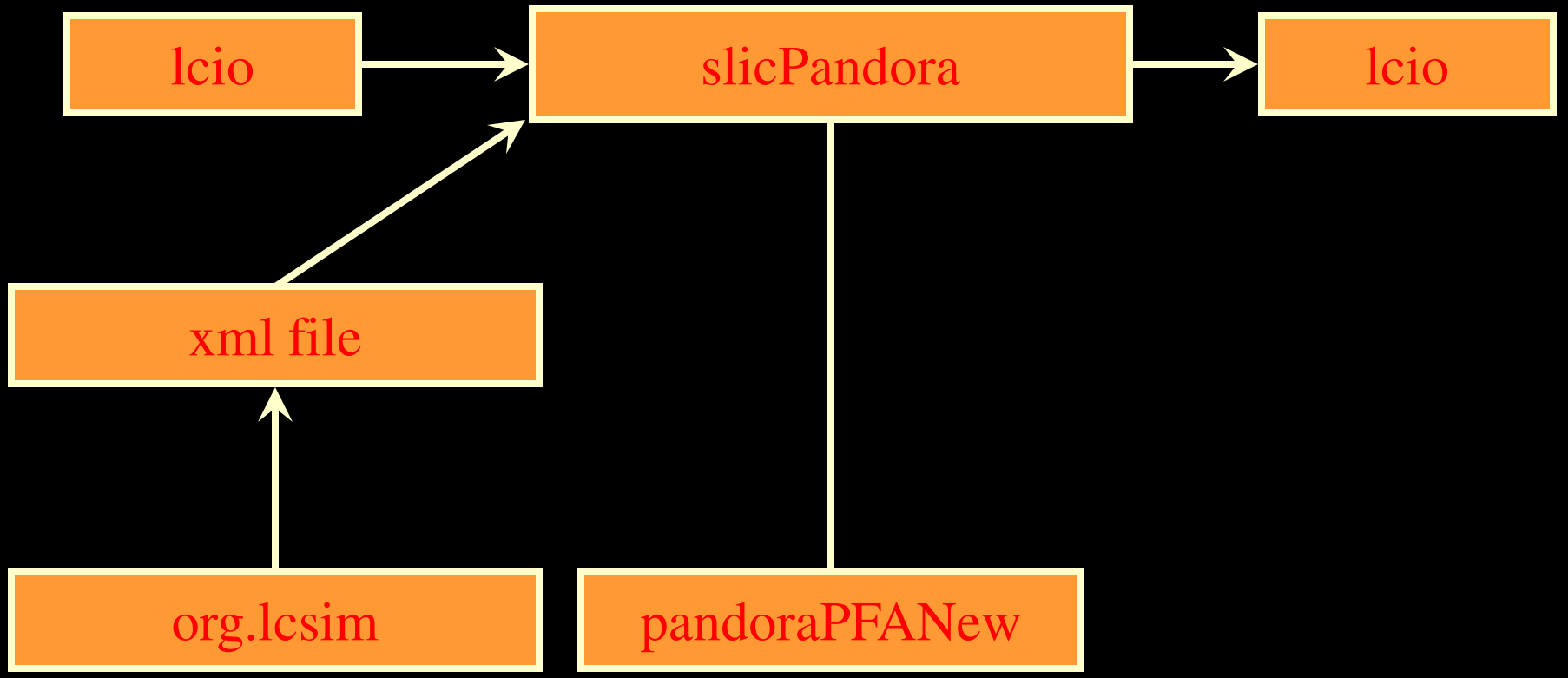


Code is also being adapted to the new, planar, polygonal calorimeter geometries. Neutral showers being found, work ongoing to handle charged track/shower extrapolation.

slic + PandoraPFANew

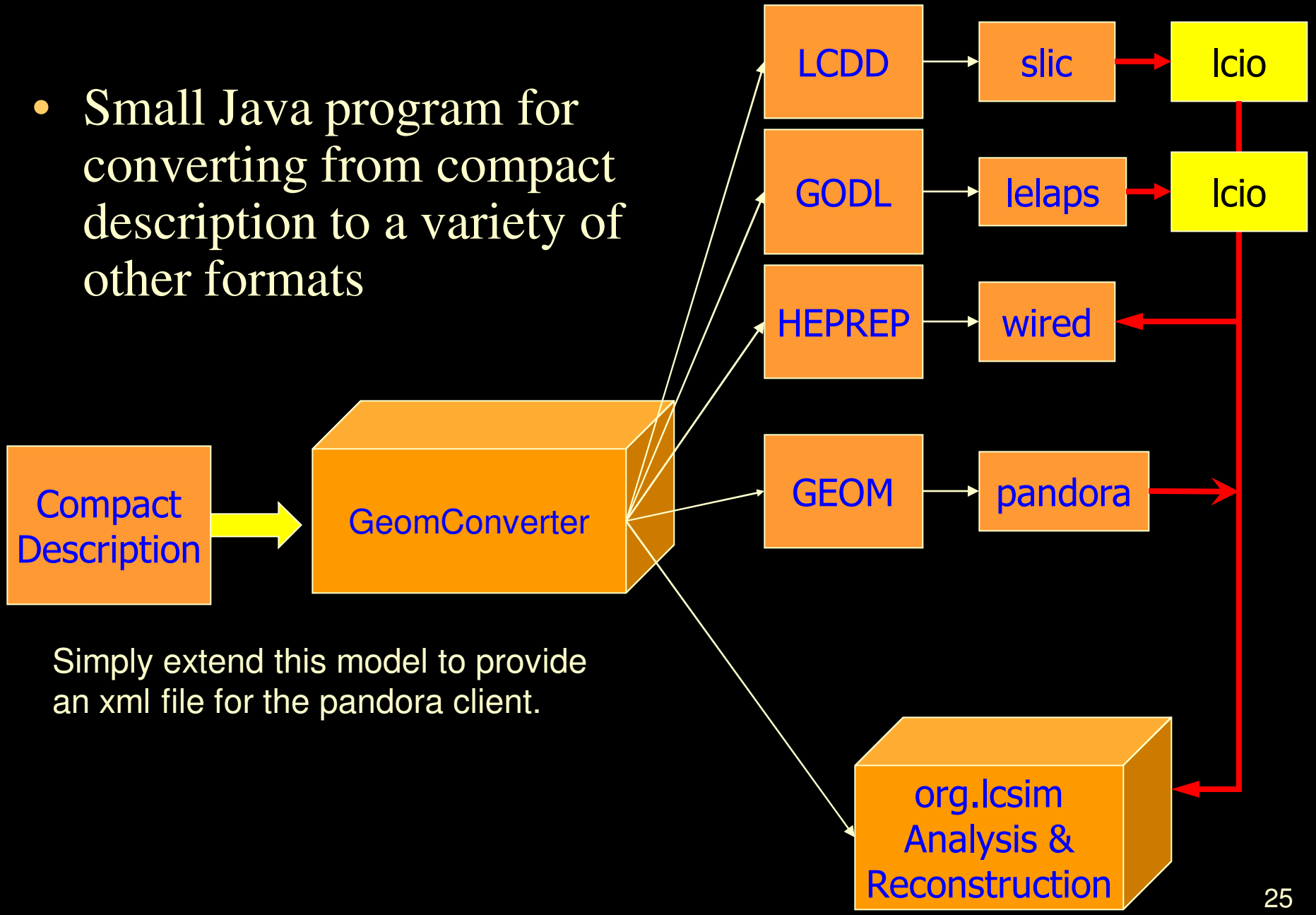
- PandoraPFA being rewritten to make it modular and framework independent
  - See John Marshall's talk
- An effort is underway to provide a binding between the slic LCIO output and the compact.xml geometry description and this new package.

Architecture



GeomConverter

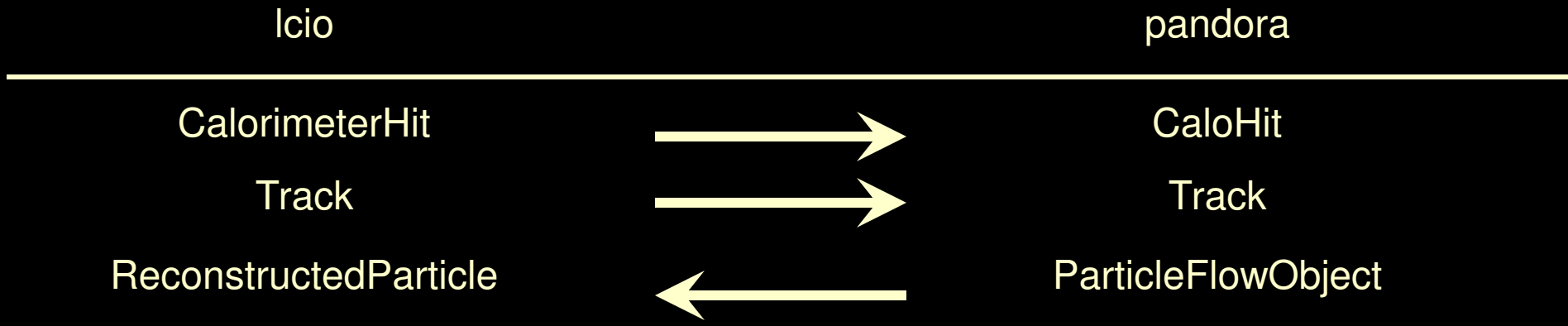
- Small Java program for converting from compact description to a variety of other formats



Simply extend this model to provide an xml file for the pandora client.

Architecture

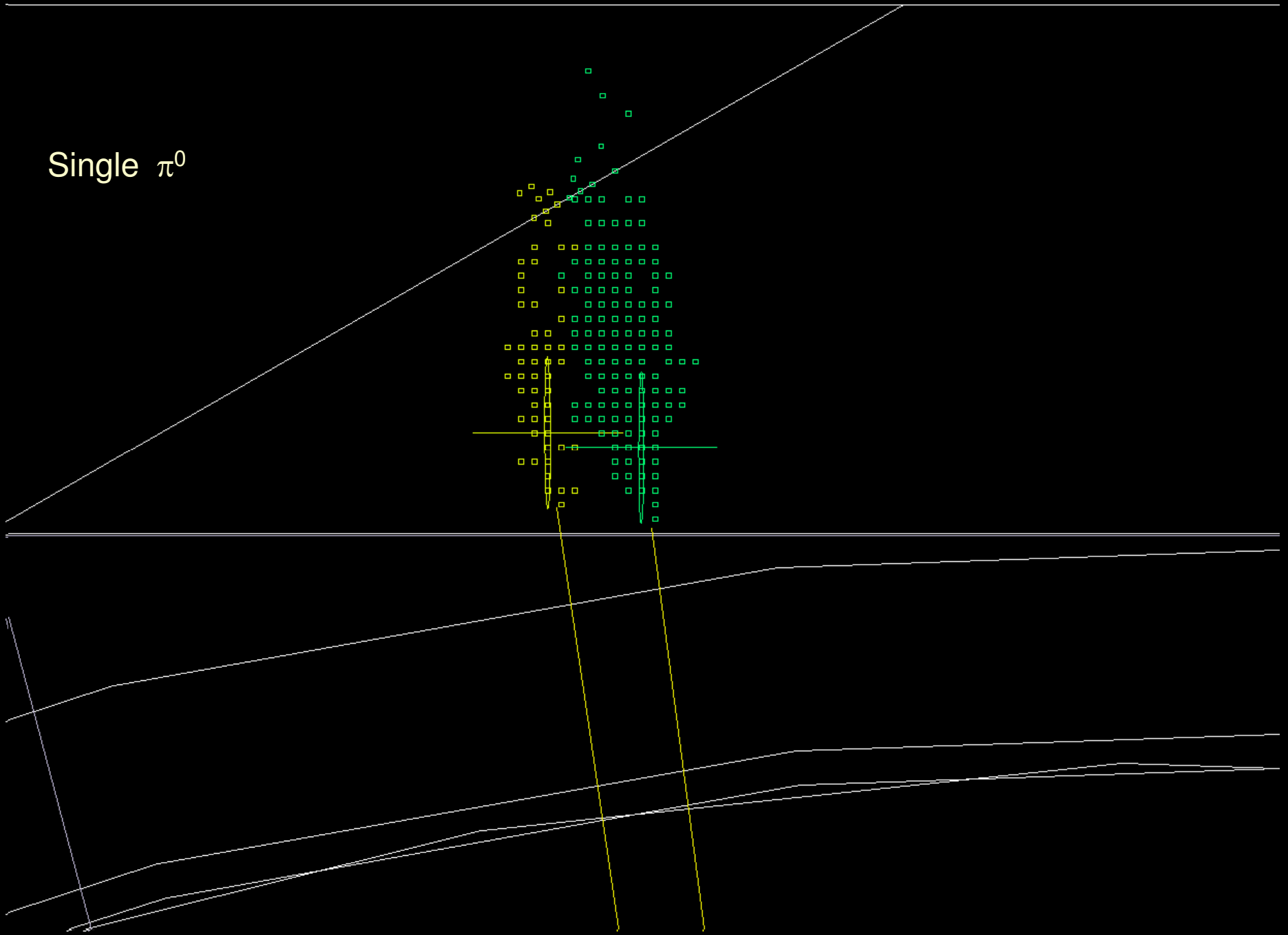
- Package provides access to events processed with slic (not necessarily SiD).
- Access to the detector geometry is via xml.
  - Parse compact.xml natively to produce the information required by pandora.
  - Use existing tinyxml parser bundled with pandora.
- Access to the event is through lcio.



Development & Testing

- Adopted a systematic approach to development and testing:
  - Single γ (single neutral particle, just ECal)
  - $\pi^0 \rightarrow \gamma\gamma$ (2 neutral particles, just ECal)
  - μ (single MIP trace, multiple calorimeters, track match)
  - $\psi \rightarrow \mu\mu$ (multiple track-MIP associations)
  - single π (shower clustering, track-cluster association)
  - $\rho^{\pm} \rightarrow \pi^{\pm}\gamma$, $\pi^{\pm}\pi^0$ (nearby charged & neutral particles)
  - single quarks, single vector bosons, …
  - $t\bar{t}$

Single π^0



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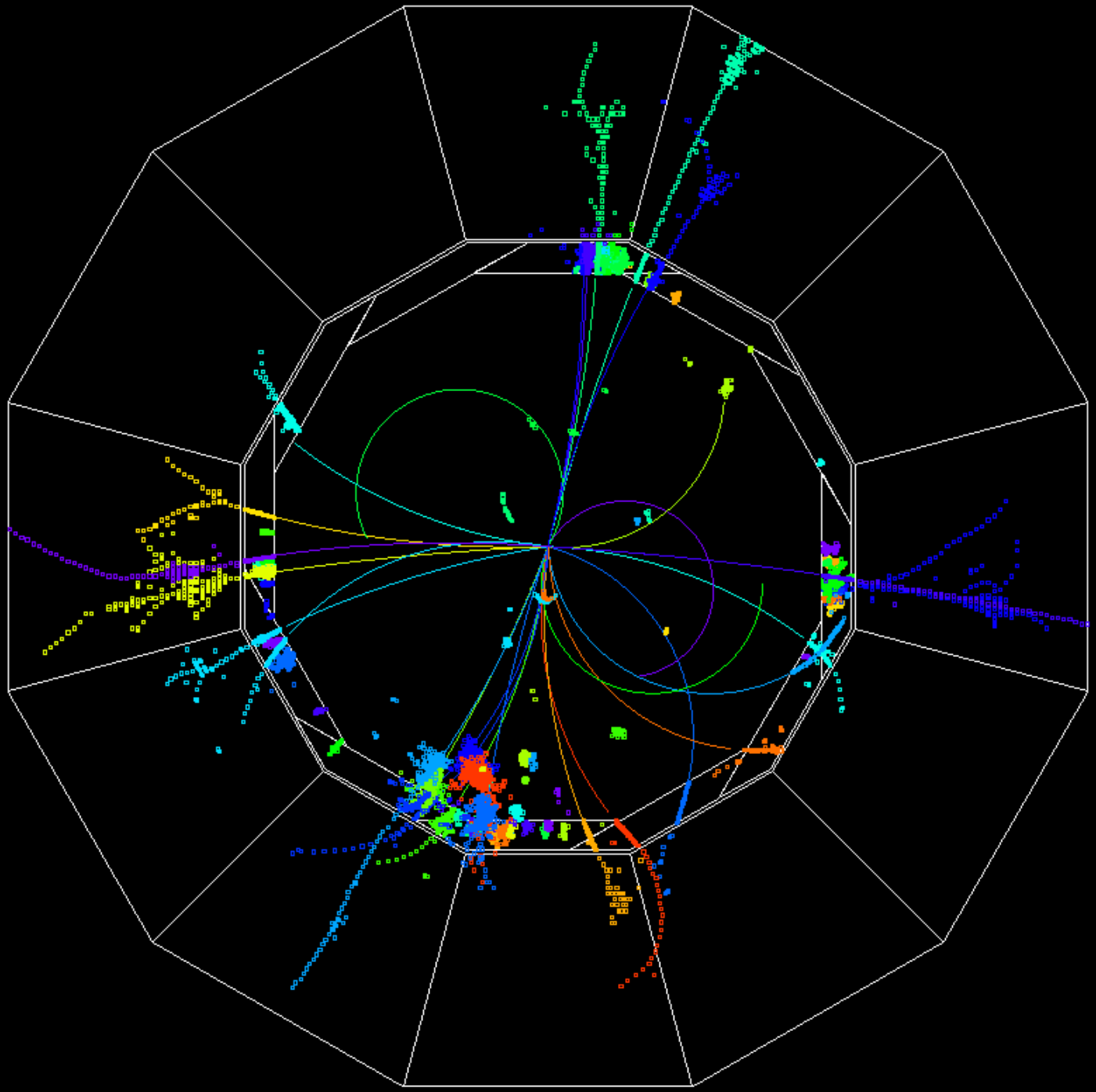

Status

- Connection between slic output and pandora library was established during recent visit to Cambridge (albeit by hardcoding geometry) and first simple events processed.
- Have now developed and implemented an xml format for the geometrical information needed by pandoraPFANew.
- Developed C++ front end to read lcio files + geometry.xml + pandoraPFA.xml and process events.
- QA ongoing, expect to release package soon.

Detector Optimization

- MIT group engaged in systematic study of detector variants based on simplified SiD geometry (sid02) using slic + SiD PFA.
  - extending studies done for the LOI by Marcel Stanitzki using Mokka + Marlinreco (SiD-ish)
  - primarily studying HCal depth and layout.
- Expect that once the reconstruction framework fully supports the detailed geometry we will engage in a similar exercise, studying:
  - Tracker layouts
  - Detector aspect ratios
  - HCal absorber materials, layout, readout technologies.

LCIO2.0

- Access to a common event data model and a common persistence format played a large part in the successful use of cross-concept software packages, e.g. LCFIVertex, now pandoraPFA.
- Number of improvements to the EDM, especially related to Si hits (1D & 2D) are needed, as are inclusion of additional track states along the particle trajectory.
- Discussions initiated on LCIO2.0 in response to user experiences to-date. Requires manpower to implement
- Collaborating within aegis of the Software CTG.

Physics Benchmarking

- Simulate and analyze updated benchmark reactions with the realistic detector model.
  - Include the impact of detector dead zones and updated background conditions
- Physics Common Working Group has first draft proposal.
- New machine configuration, SB2009 means starting ~from scratch.
  - Running GuineaPig to calculate e+, e-, γ spectra
  - Generating SM Backgrounds
  - Generating Signal

Summary

- Much was done for the LOI, but much more will need to be done for this exercise.
- Reconstruction being adapted for complex geometries.
- Workflow being streamlined & automated.
- Expect a round of detector optimization studies before major event production.
- Many areas in which new groups or individuals can contribute, or where closer collaboration with ILD & CLIC would save effort.