

# Simulation and Reconstruction: ALCPG Framework & Toolkit

A 3D perspective rendering of a particle detector, likely a calorimeter or tracker, showing a central cylindrical core with a yellow interior and a purple exterior, surrounded by a larger, translucent blue structure. The entire assembly is set against a dark background with a blue, geometric, low-poly pattern.

**Norman Graf**  
**(for the ALCPG Simulation & Reconstruction Team)**

**ILC Software and Tools Workshop**  
**May 2, 2007**

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# Introduction

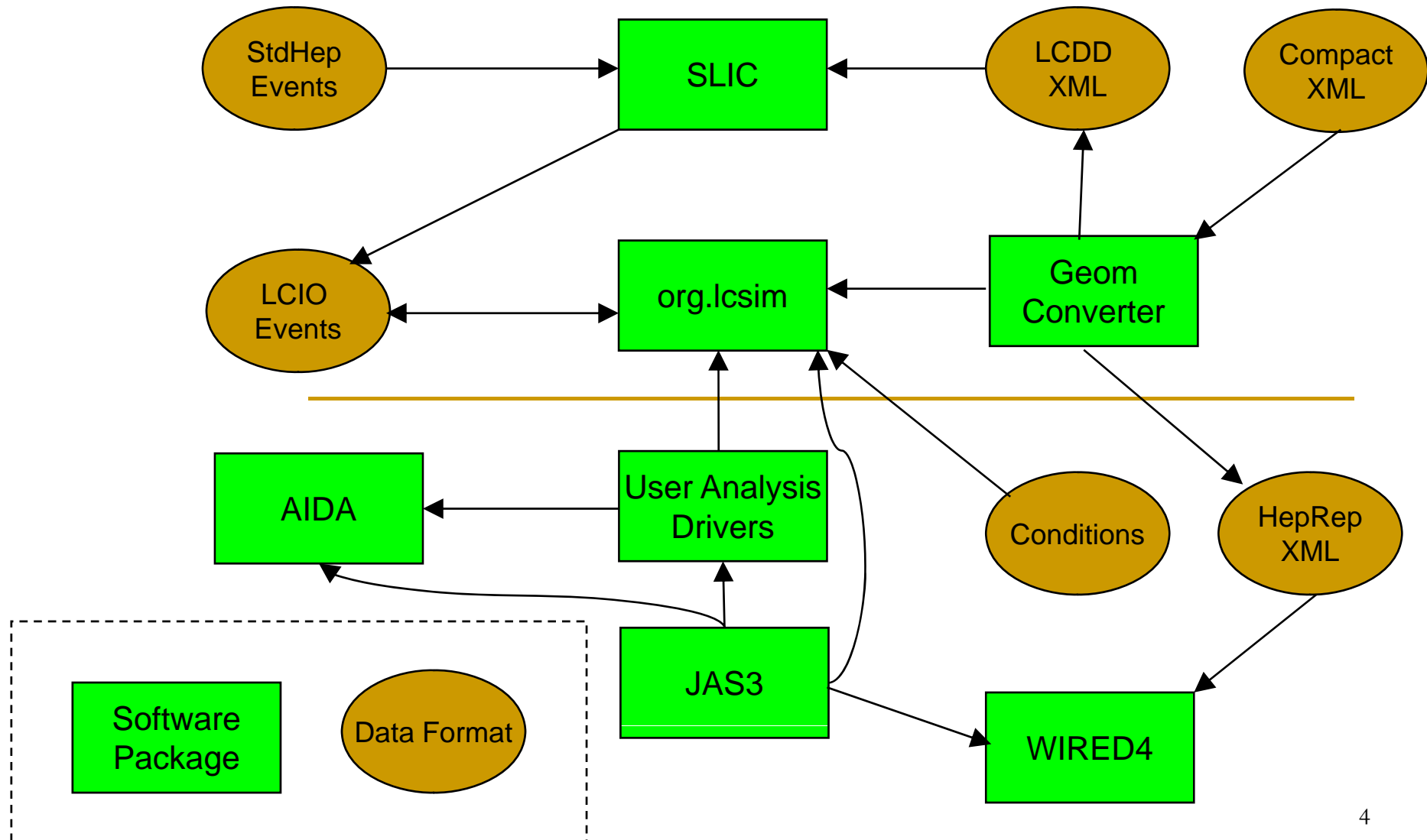
- This talk not meant to be an in-depth summary of all existing functionality.
  - Not enough time.
  - Been done many times in the past.
- Simply an update on some recent, added functionality.
- Improvements to “easy” detector simulations (i.e. via compact.xml).
  - Si wafers, TPC simulation with cuts by region
  - lélaps for fast MC hits generation.
  - polyhedral Calorimeters
- Reconstruction:
  - trf toolkit (see tracking talk)
  - Individual particle reconstruction template (see Jet Energy Resolution talk)
- lcio tools split/merge/concatenate etc.
- Event samples, both signal and backgrounds.

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# Goals

- Enable full studies of ILC physics to optimize detector design and eventual physics output
  - Use realistic detector geometries
  - Full simulation (in combination with fast parameterized MCs)
  - Full reconstruction
    - Simulate benchmark physics processes on different full detector designs.
    - Encourage development of realistic analysis algorithms
    - See how these algorithms work with full detector simulations
- Facilitate contribution from physicists in different locations with various amounts of time available (normally not much!)
  - Software should be easy to install, learn, use
    - Goal is to allow software to be installed from CD or web with no external dependencies
    - Support via web based forums, tutorials, meetings.

# Overview: “SiD/ALCPG” Framework



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# Improved Detector Simulations

- Need to clarify exactly what is required for the CDR and what is deferred to the TDR.
- However, generally agreed that the detector design should have some semblance to a detector which can be built.
  - e.g. no floating cylindrical calorimeters.
- Is the simulation infrastructure capable of modeling realistic detector geometries?
- Yes! The full simulation package slic reads in geometries in lcdd, which is a low-level format that targets Geant4 primitives.

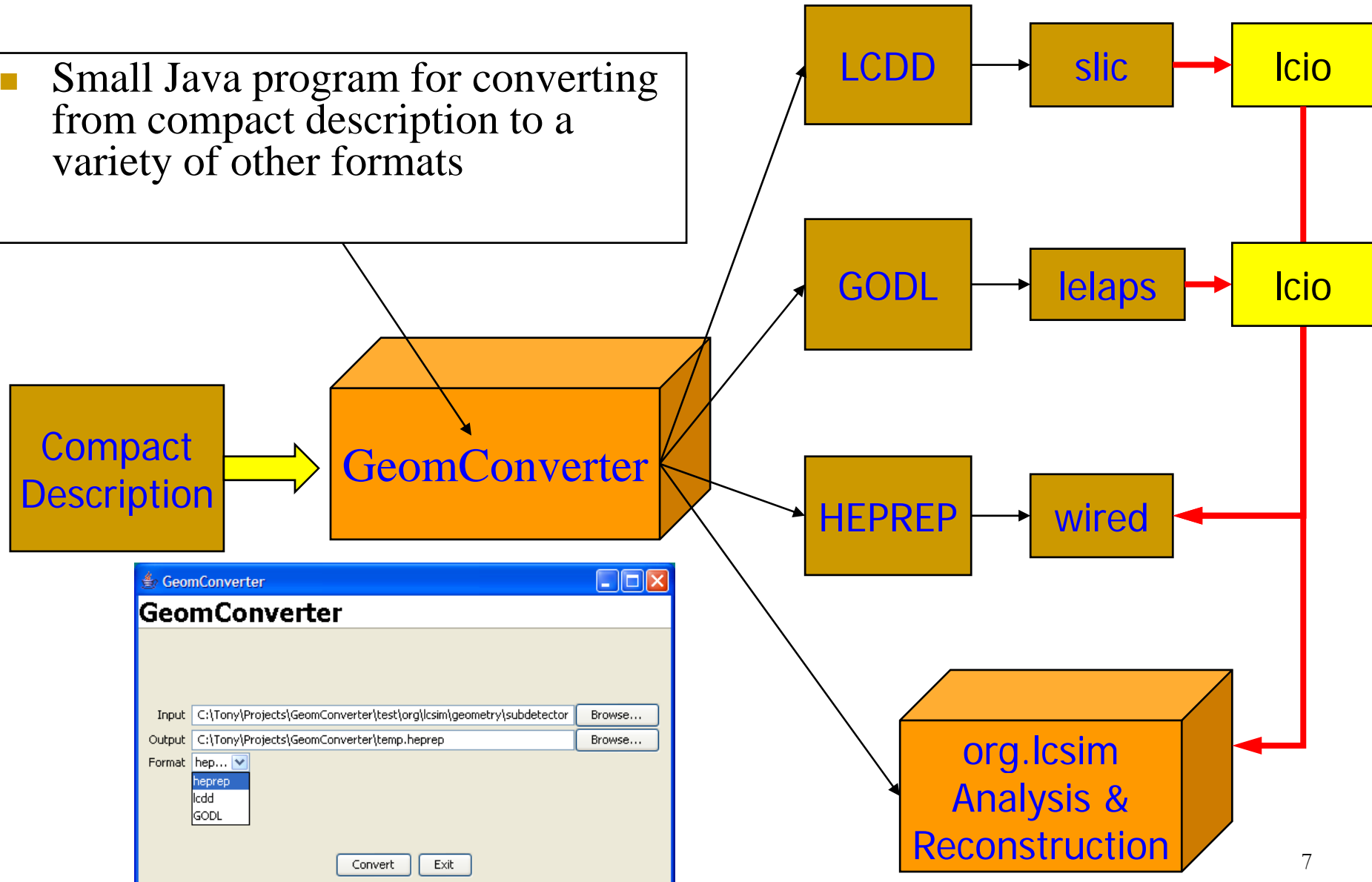
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# Improved Detector Simulations

- The full simulation package slic reads in geometries in lcdd, which is a low-level format that targets Geant4 primitives.
  - Detectors of arbitrarily complex shape and readout can be simulated using only xml file as input.
- However, it would be extremely tedious to generate these files.
- Would also not provide a connection to the reconstruction, nor to the event display.
- Prefer (but not required) to define geometries using a “compact” description.
- Small Java program for converting from compact description to a variety of other formats.
  - GeomConverter.

# GeomConverter

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



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# Silicon Tracking Detectors

- For the purposes of quickly scanning the parameter space of number of tracking layers and their radial and z positioning, etc. have been simulating the trackers as cylindrical shells or planar disks.
- Are now moving beyond this to be able to realistically simulate buildable subdetectors.
- Have always been able to simulate arbitrarily complex shapes in slic using lcdd, but this is a very verbose format.
- Introduced Geometry and Detector Element trees to handle arbitrary hierarchies of detector elements.
- Have now introduced tilings of planar detectors (simulating silicon wafers) into the compact xml description.

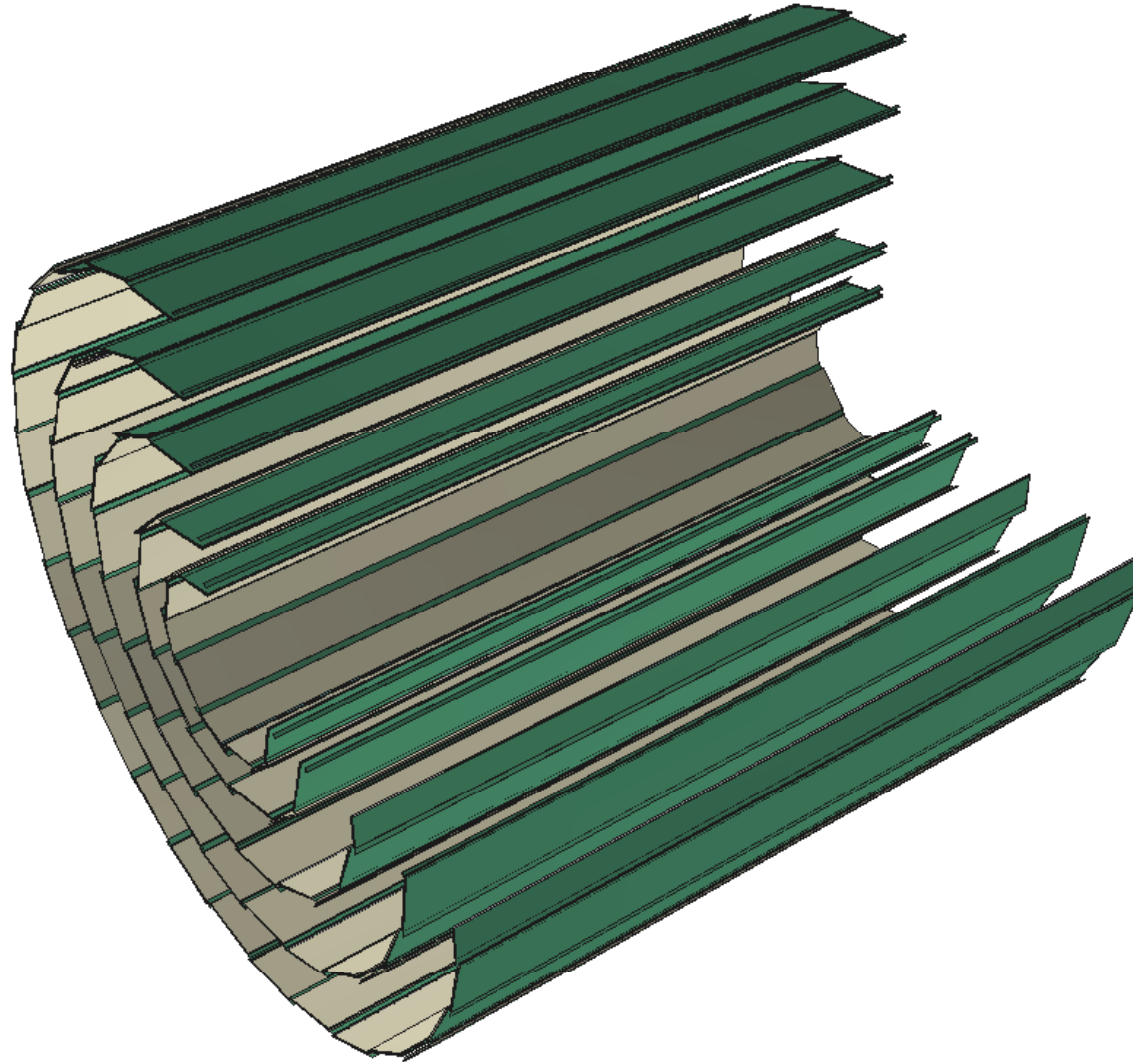


# Detailed Geometry in org.lcsim

- Geometry tree
  - hierarchy of PhysicalVolumes and LogicalVolumes
    - LogicalVolume
      - shapes – parameters, isInside
      - materials - A, Z, density, radiation length, interaction length, etc.
    - PhysicalVolume
      - transformation - translation + rotation
- DetectorElement tree –
  - hierarchy of DetectorElements with uplinks
    - What DetectorElement is point inside?
    - What position of a DetectorElement?
    - What is the global to local coordinate transformation for the DetectorElement?
- Existing Detector, Subdetector become DetectorElements

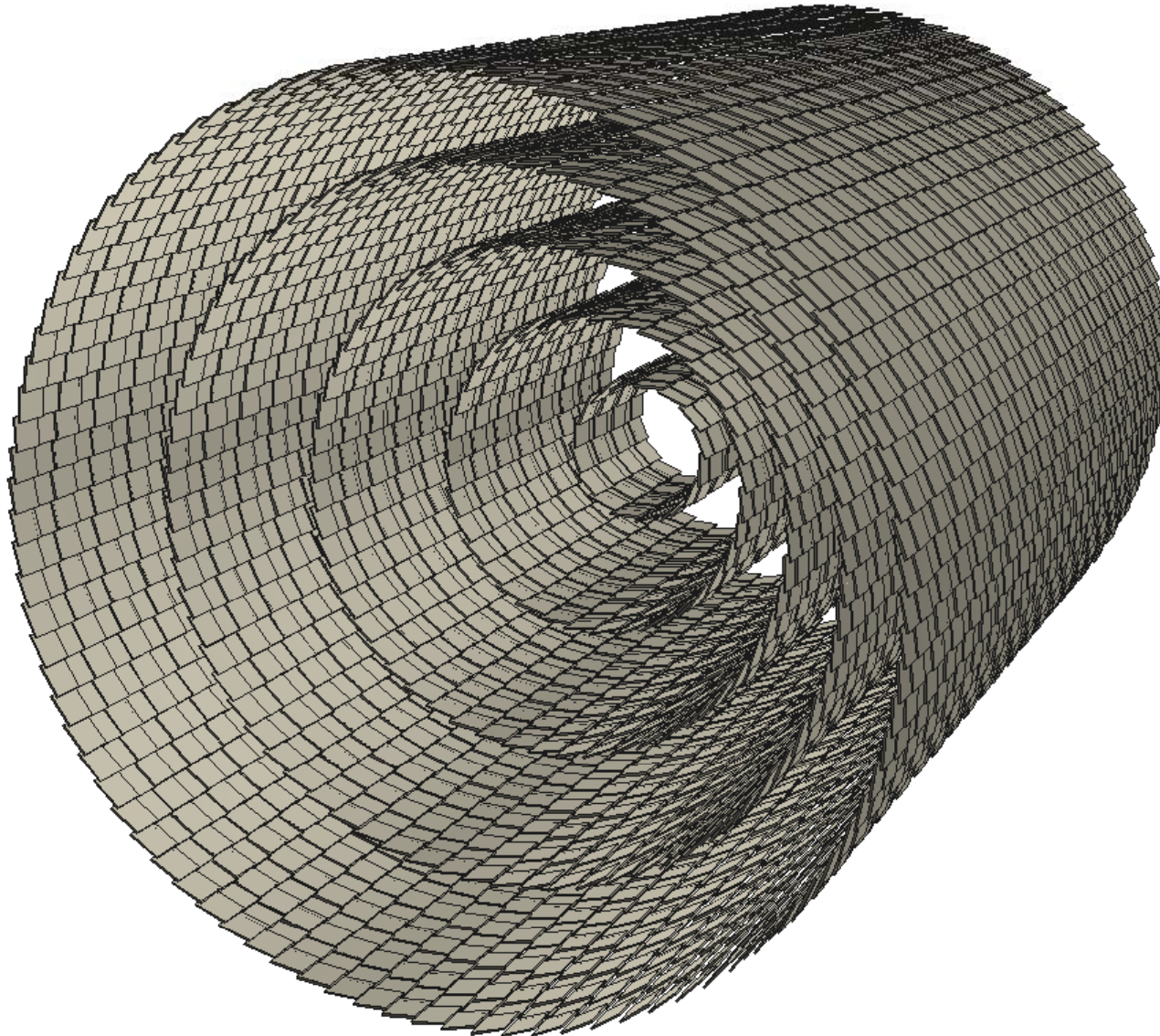
```
// Get child DetectorElements of the Detector.
IDetectorElementContainer detElems = detector.getChildren();
// Loop over the child DEs.
for ( IDetectorElement de : detElems )
{
    // Print the name.
    System.out.println( de.getName() );
    // Print the position.
    if ( de.hasGeometryInfo() )
    {
        System.out.println( de.getGeometry().getPosition() );
    }
    // Print the names of the children.
    for ( IDetectorElement child : de.getChildren() )
    {
        System.out.println( " " + child.getName() );
    }
}
```

# The Barrel Vertex Detector



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# The Barrel Outer Tracker

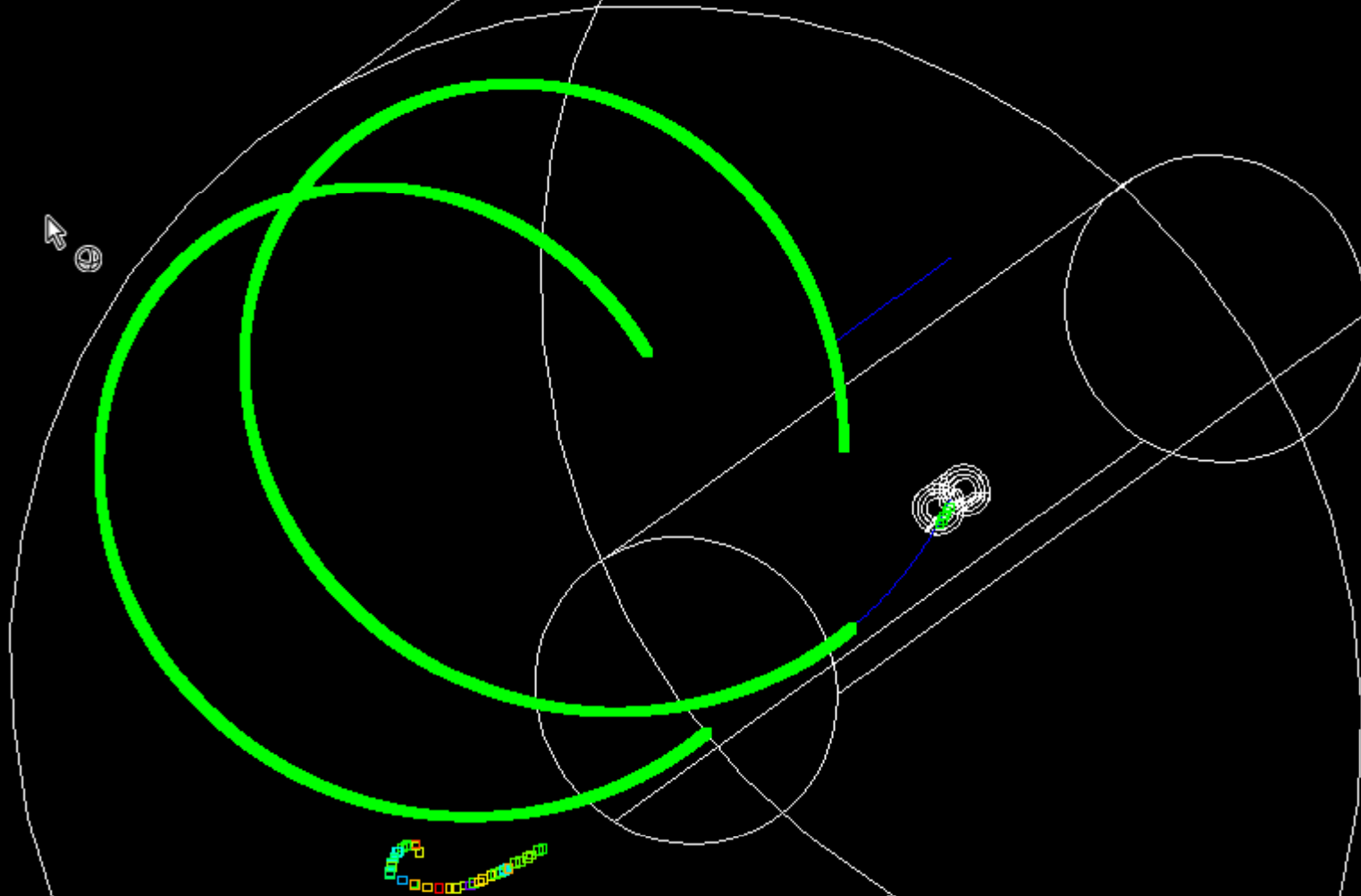


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## TPC Simulations

- Most simulations to-date have created single hit at intersection with pad row “cylinder”.
- Not too bad an approximation for stiff tracks, but causes problems for loopers.
- Can improve simulations with a combination of range cuts and maximum step size cuts.
- These are configurable by region (themselves configurable) in the compact description.
  - Can define them differently for silicon and TPC.
  - Can change them at runtime to study settings.

Note uniform deposition of hits along track length as a result of tuning maximum step size in region.



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# Big Picture Decisions

- There is still a need for people to investigate larger issues, such as the number and layout of tracker and vertex barrel and disk layers.
- This is most easily done with the simplified geometries.
- For example, changing from the 5-layer cylindrical barrel geometry to an 8-layer geometry took less than 15 minutes.
- The work lies in the analysis and comparisons.
- Tight connection between geometry/sim/reco also advantageous in TB analyses.

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# lelaps

- Fast detector response package.
- Handles decays in flight, multiple scattering and energy loss in trackers.
- Parameterizes particle showers in calorimeters.
- Produces lcio data at the hit level.
- Uses runtime geometry (compact.xml → godl).
- An excellent tool for designing tracking detectors!

<http://lelaps.freehep.org/index.html>

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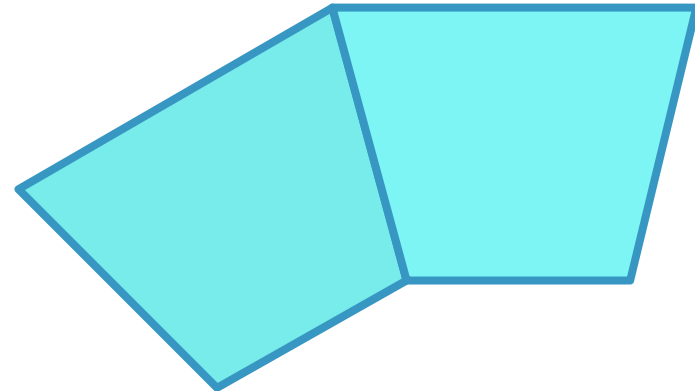
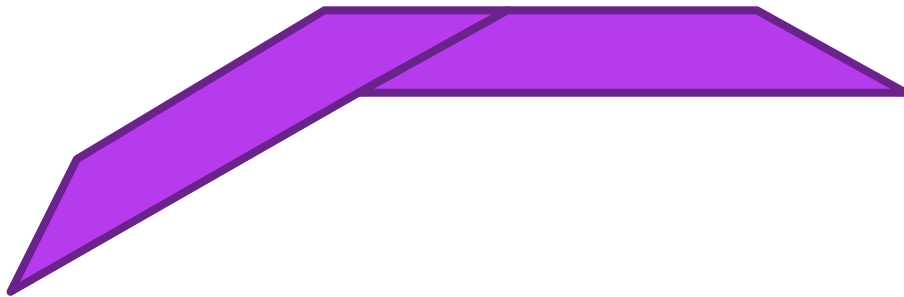
# Calorimeter Improved Simulations

- Having settled on a concept with the requisite performance, will have to design a detector which can be built.
- Engineering will have to be done to come up with the plans, but the existing simulation package can already handle arbitrarily complex shapes.
- Can then study effects of support material, dead regions due to stay-clears, readout, power supplies, etc.
- However, hard work is in analyzing this, not simulating it.



# Improved Calorimeter Simulations II

- Have two types of polygonal barrel geometries defined in the compact description:
- Overlapping staves:      Wedge staves:



- Can define ~arbitrary layerings within these envelopes to simulate sampling calorimeters.

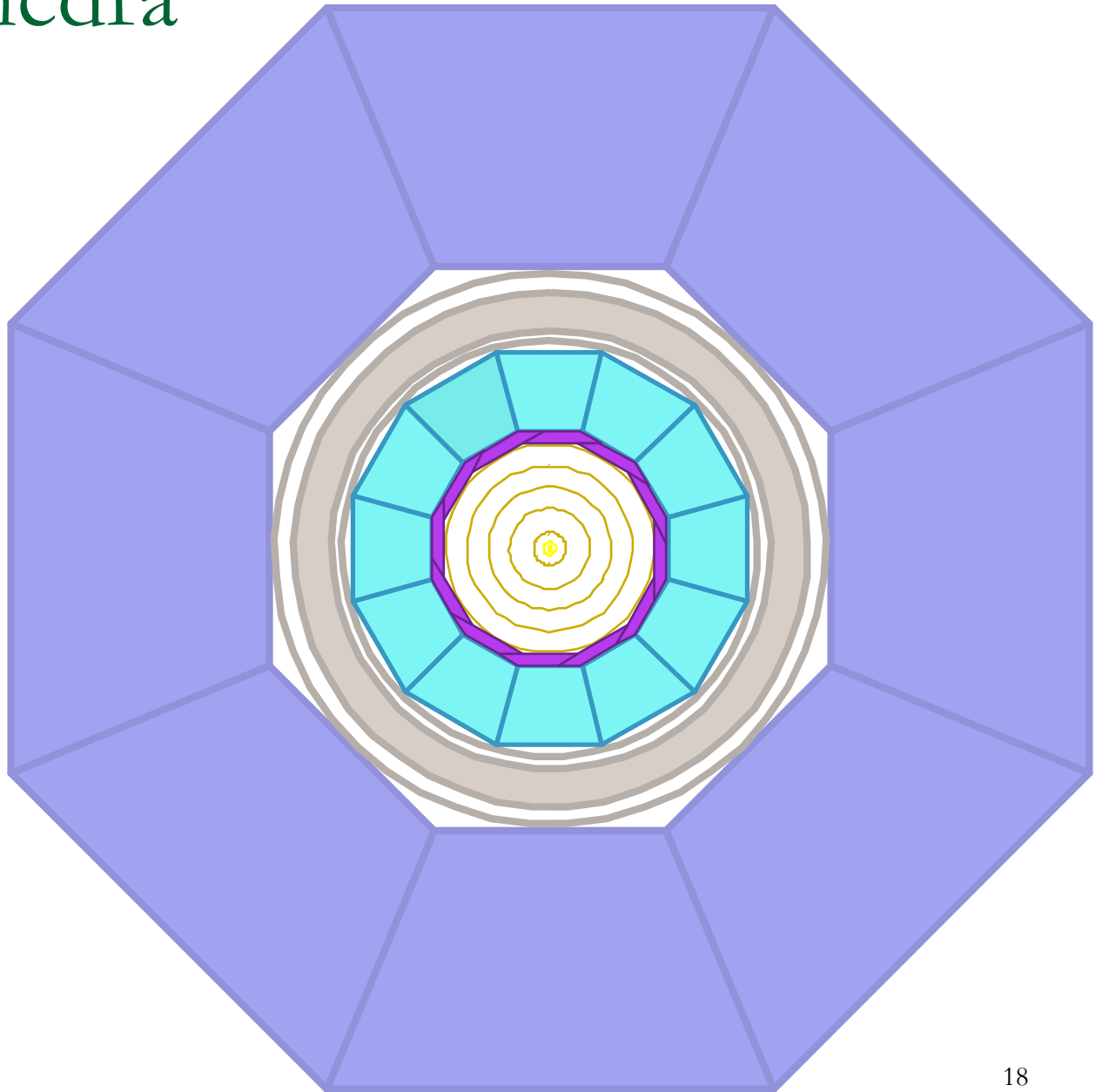
# sid01\_polyhedra

Dodecagonal,  
overlapping  
stave EMCAL

Dodecagonal,  
wedge HCal

Cylindrical  
Solenoid with  
substructure

Octagonal,  
wedge Muon

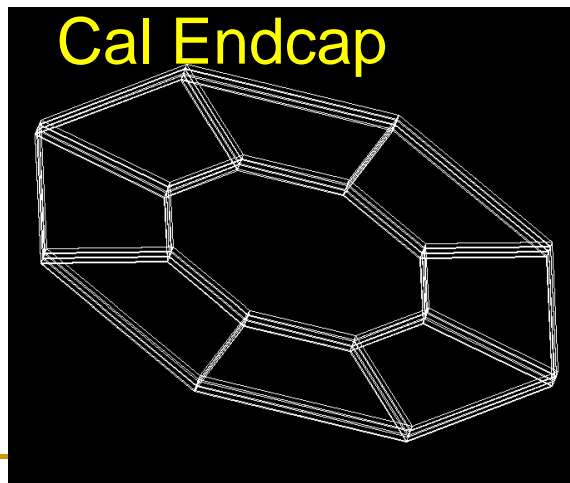
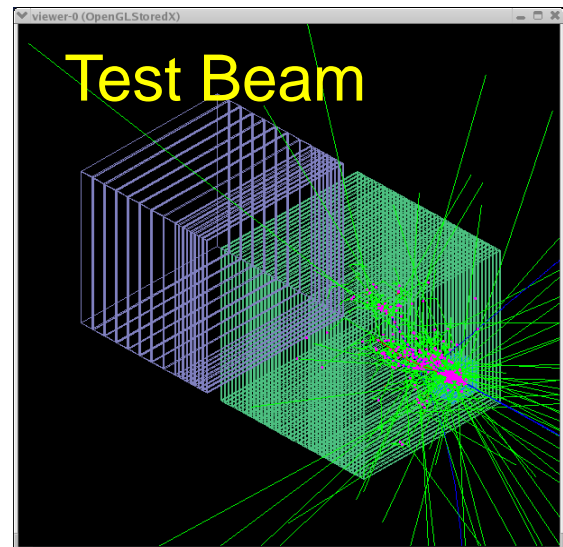
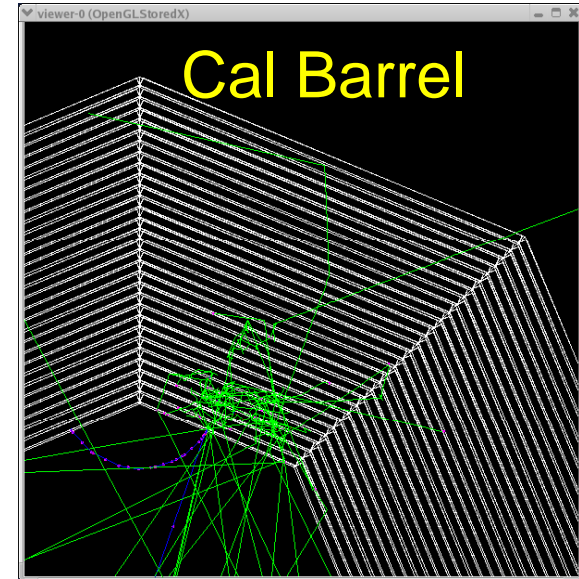
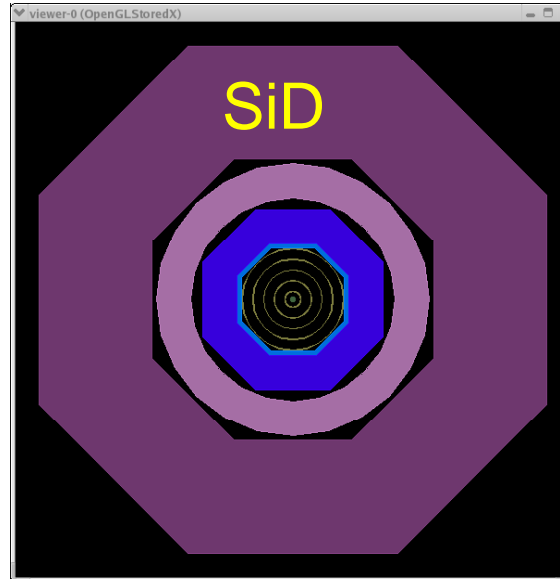
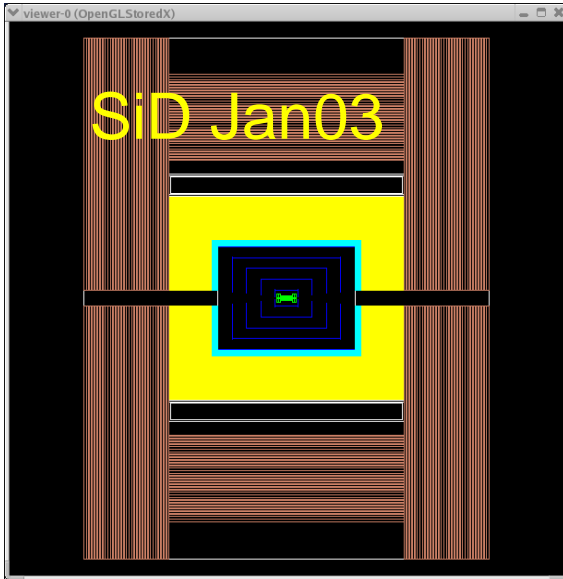


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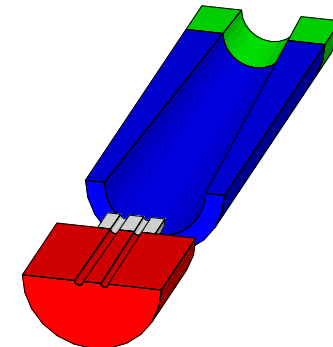
# Detector Variants

- Runtime XML format allows variations in detector geometries to be easily set up and studied:
  - ❑ Stainless Steel vs. Tungsten HCal sampling material
  - ❑ RPC vs. GEM vs. Scintillator readout
  - ❑ Layering (radii, number, composition)
  - ❑ Readout segmentation (size, projective vs. nonprojective)
  - ❑ Tracking detector technologies & topologies
    - TPC, Silicon microstrip, SIT, SET
    - “Wedding Cake” Nested Tracker vs. Barrel + Cap
  - ❑ Field strength
  - ❑ Far forward MDI variants (0, 2, 14, 20 mr )

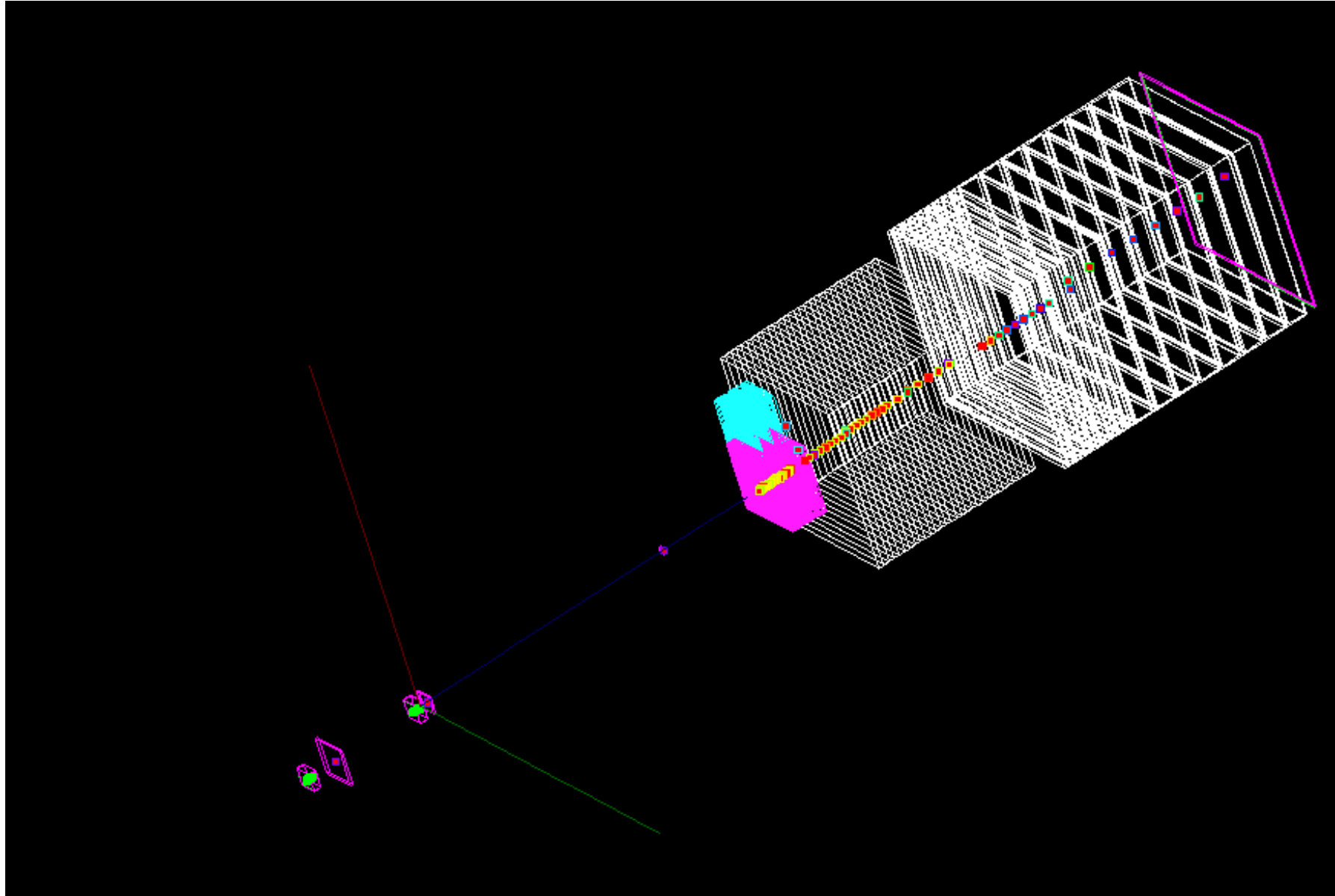
# Example Geometries



MDI-BDS



# Example of Test Beam Analysis

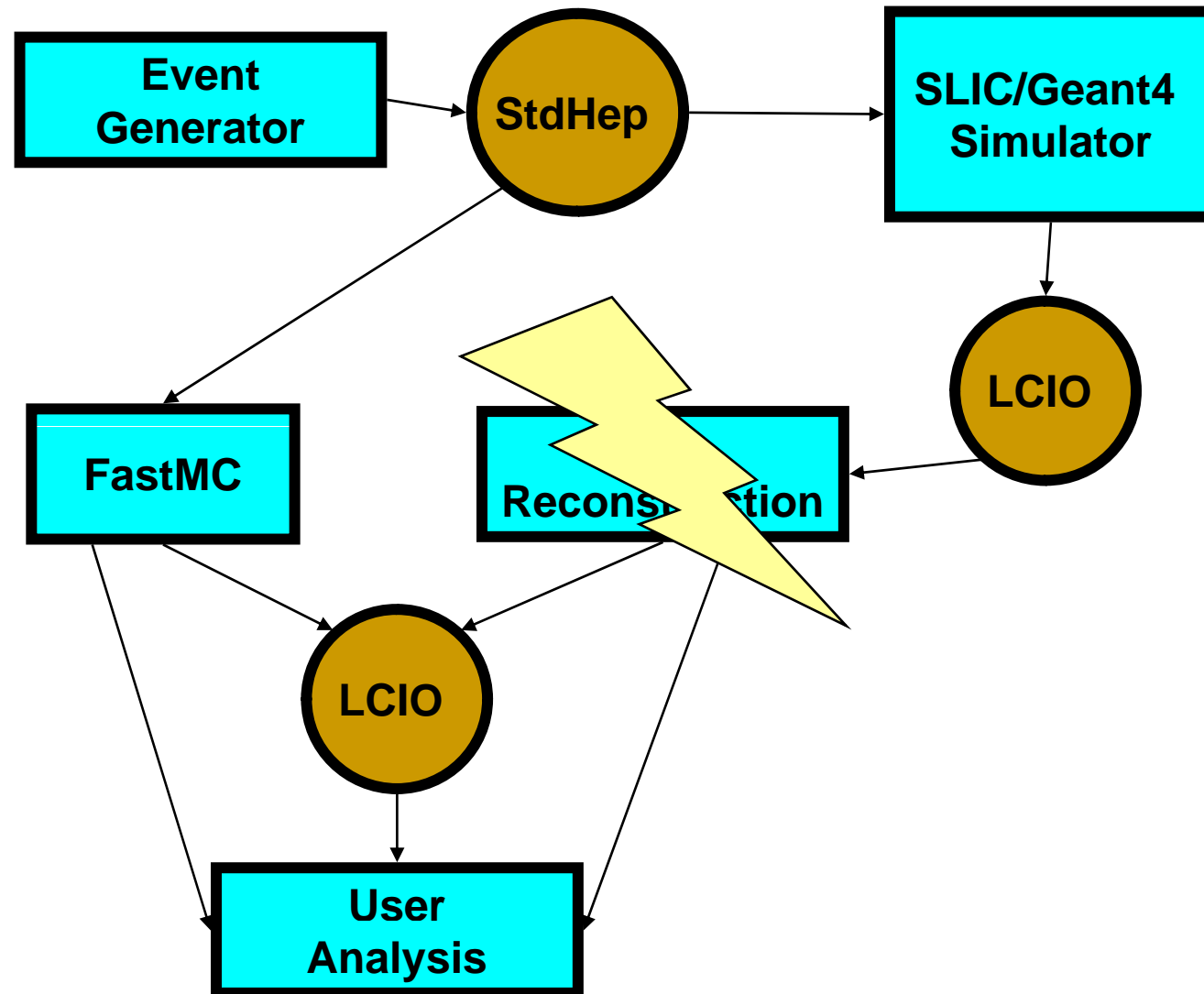


## slic

- Number of internal optimizations and refactorings.
  - Should not be noticed by end users.
- Upgrades to recent version of Geant4 has essentially eliminated problem of event aborts when particle tracking became stuck.
- slic from scratch:

```
cvs -d :pserver:anonymous@cvs.freehep.org:/cvs/lcd co SimDist
cd SimDist
./configure
make
```
- Binaries also available for Windows, Mac, Linuxes

# How to run full reconstruction?



# org.lcsim Reconstruction Packages

## Contrib

Package	Author	State	Docs/Talks	Description
<a href="#">org.lcsim.contrib.CalAna</a>	?	?	?	
<a href="#">org.lcsim.contrib.CarstenHensel</a>	Carsten Hensel	?		HMatrix cluster analysis
<a href="#">org.lcsim.contrib.Cassell.recon.Cheat</a>	Ron Cassell	?		Cheat Recon driver
<a href="#">org.lcsim.contrib.EricBenevides.EMClusterID</a>	Eric Benevides	?		HMatrices analysis of single particle events
<a href="#">org.lcsim.contrib.JanStrube.tracking</a>	Jan Strube	complete JUnit tests Javadoc	<a href="#">A New Track Interface</a>	Alternate implementation of Track, FastMCTrack, Swimmer. Awaiting incorporation into main body of code
<a href="#">org.lcsim.contrib.JanStrube.vtxFinder</a>	Jan Strube	incomplete		Vertex filter, using the Kalman approach by Grab, Luchsinger. Add the VtxFinderDriver from the sandbox to get an idea of the current status
<a href="#">org.lcsim.contrib.JanStrube.zvtop</a>	Jan Strube	incomplete		ZVTop implementation, taking advantage of the new Track interface, alpha quality
<a href="#">org.lcsim.contrib.KFFiter</a>	Fred Blanc	?		Kalman Filter Fitter
<a href="#">org.lcsim.contrib.LeiXia</a>	Lei Xia	?		PFA analysis
<a href="#">org.lcsim.contrib.NickSinev.tracking.wmfinder</a>	Nick Sinev	?		SLD Weight matrix filter
<a href="#">org.lcsim.contrib.NickSinev.ztracking</a>	Mike Ronan+Nick Sinev	?		Track cheater?
<a href="#">org.lcsim.contrib.onoprienko.mcTrackFinder</a>	D. Onoprienko	complete		Configurable cheater track finder and related utilities.
<a href="#">org.lcsim.contrib.onoprienko.test</a>	D. Onoprienko	functional, under development		Track finder performance testing suite
<a href="#">org.lcsim.contrib.SODTracker</a>	Fred Blanc	?		Silicon Outer Detector (SOD) Tracker
<a href="#">org.lcsim.contrib.SiStripSim</a>	Tim Nelson	?		Silicon Strip Simulation (moving soon to org.lcsim.detector)
<a href="#">org.lcsim.contrib.SteveMagill</a>	Steve Magill	?		PFA Analysis example
<a href="#">org.lcsim.contrib.niu</a>	Vishnu and Guilherme	?		NIU PFA code
<a href="#">org.lcsim.contrib.proulx</a>	?	?		?
<a href="#">org.lcsim.contrib.seedtracker</a>	Richard Partridge	?		Tracking algorithm based on forming track seeds from all 3-hit combinations
<a href="#">org.lcsim.contrib.subdetector.tracker.aalicon</a>	Tim Nelson	?		Experimental geometry package (Developed further in Geomconverter as org.lcsim.detector by Jeremy)
<a href="#">org.lcsim.contrib.tracking</a>	Tim Nelson	?		Outer-tracker-only track finding
<a href="#">org.lcsim.contrib.uiowa</a>	Mat Charles	unstable		Template-style PFA implementation (NonTrivialPFA)

## Production

Package	Author	State	Docs/Talks	Description
<a href="#">org.lcsim.digisim</a>	Guilherme Lima	?		Calorimetry digitization simulator
<a href="#">org.lcsim.mc.CCD5im</a>	Nick Sinev	?		CCD digitization
<a href="#">org.lcsim.mc.fast</a>	Many	?		Fast MC package, including tracking, calorimetry
<a href="#">org.lcsim.recon.cat</a>	D. Onoprienko E. von Toerne	functional, under development		Calorimeter Assisted Track Finder
<a href="#">org.lcsim.recon.cheater</a>	Mike Ronan	?	<a href="#">confluence</a>	Recon cheater
<a href="#">org.lcsim.recon.cluster.analysis</a>	Ron Cassell	?		Generic cluster performance analysis
<a href="#">org.lcsim.recon.cluster.cheat</a>	Ron Cassell	?		Cluster cheater
<a href="#">org.lcsim.recon.cluster.clumpfinder</a>	Mat Charles	?		finds dense clumps within clusters
<a href="#">org.lcsim.recon.cluster.directedtree</a>	G.Lima, J.McCormick, Vishnu	?		Directed tree cluster finder
<a href="#">org.lcsim.recon.cluster.fixedcone</a>	Norman Graf	?		Cluster finder
<a href="#">org.lcsim.recon.cluster.mipfinder</a>	Wolfgang Mader, Mat Charles	stable		MIP finding
<a href="#">org.lcsim.recon.cluster.mst</a>	Mat Charles	stable		Minimal spanning tree cluster finder
<a href="#">org.lcsim.recon.cluster.nn</a>	Norman Graf	?		Nearest neighbor cluster finder
<a href="#">org.lcsim.recon.cluster.structural</a>	Mat Charles	stable		Specialized clusterer for hadronic showers
<a href="#">org.lcsim.recon.emid.hmatrix</a>	Norm Graf	?		HMatrix package
<a href="#">org.lcsim.recon.ganging</a>	Ron Cassell	?		Allows virtual ganging of calorimeter hits
<a href="#">org.lcsim.recon.muon</a>	C. Milstene	?		Muon finding
<a href="#">org.lcsim.recon.particle</a>	Ron Cassell	?		Perfect PFA
<a href="#">org.lcsim.recon.pfa.cheat</a>	Mat Charles	functional		Cheating tools for PFA
<a href="#">org.lcsim.recon.pfa.identifier</a>	Mat Charles	functional		Turn more primitive objects (clusters, tracks, etc) into ReconstructedParticles
<a href="#">org.lcsim.recon.pfa.output</a>	Mat Charles	?		Modules to produce standard plots for PFAs
<a href="#">org.lcsim.recon.pfa.structural</a>	Mat Charles	?	incomplete	Iowa PFA implementation (when stable) and associated tools
<a href="#">org.lcsim.recon.tracking.cheat</a>	Ron Cassell	?		Track Cheater
<a href="#">org.lcsim.recon.tracking.tff</a>	?	?		?
<a href="#">org.lcsim.recon.tracking.trf</a>	Norm Graf	?		TRF track finder + fitter
<a href="#">org.lcsim.recon.vertexing.biloir</a>	Norman Graf, (Jan Strube)	incomplete		vertex fitting based on Biloir's method. Needs testing
<a href="#">org.lcsim.recon.vertexing.zvtop4</a>	Jan Strube	incomplete		Vertex finding/fitting, awaiting completion of a vertex fitter
<a href="#">org.lcsim.recon.ztracking</a>	M. Ronan	?		Track cheater

- Conclusions
  - ❑ Many people are working on reconstruction code
  - ❑ Effort to persuade people to commit code to “contrib” area has been successful
  - ❑ But it is not easy for new users to understand how to use or contribute
- Working to extend tutorials to also cover reconstruction packages
  - ❑ Encourage developers to contribute documentation
  - ❑ Start by updating: <http://confluence.slac.stanford.edu/x/f3c>
  - ❑ Need more realistic analysis examples (help from benchmarking and physics groups?)
  - ❑ Extend PFA template idea to full reconstruction



# Reconstruction

- Many of the core reconstruction algorithms (track finding, fitting, calorimeter clustering, etc.) are in place.
- Have defined interfaces for a number of tasks, with many different plug-&-play implementations (e.g. calorimeter clustering).
- Standardized algorithm comparison tools.
- Standard calorimeter calibration procedures.
- Concentrating on implementing a template for individual particle reconstruction:
  - Decouples interdependencies of different tasks.
  - Allows comparisons between different algorithms or implementations.
  - Easily swap in MC “cheater” to study effects of particular analysis task, independent of other tasks.

# LCIO Utilities

- A number of LCIO file-handling tasks have been assembled and are available as command-line options.

> lcio -h

usage: LcioCommandLineTool

Commands:

compare

concat

validate

siodump

print

stdhep

split

random

count

merge

-h Print lcio command-line tool usage.

-v Set the verbosity.

## LCIO split / concat

- *split* simply splits input file into smaller parts

> lcio split

usage: split

- i The input LCIO file.
- n The number of events to split.

- Similarly, *concat* concatenates many lcio files into one single file.

> lcio concat -h

usage: concat

- f List of input files, 1 per line.
- i Add an input file.
- o Set the name of the output file.

# LCIO stdhep & merge

- *stdhep* converts MC files in stdhep format into LCIO format.
- *merge* combines events, merging MC particle and detector hit lists, including time offsets:  
> `lcio merge -i file1.slcio -i file2.slcio -o merged.slcio`

can also specify a file with a list of files to merge:

> `lcio merge -f mergefiles.txt -o merged.slcio`

The file `mergefiles.txt` should have the following format:

`[file_name],[n_reads_per_event],[start_time],[delta_time]`

So this would pileup 5 backgrounds onto some events:

`events.slcio,1,0,0`

`backgrounds1.slcio,5,0,1`

# “Signal” and Diagnostic Samples

- Have generated canonical data samples and have processed them through full detector simulations.
- simple single particles:  $\gamma$ ,  $\mu$ ,  $e$ ,  $\pi^{+/-}$ ,  $n$ , ...
- composite single particles:  $\pi^0$ ,  $\rho$ ,  $K_S^0$ ,  $\tau$ ,  $\psi$ ,  $Z$ , ...
- Z Pole events: comparison to SLD/LEP
- WW, ZZ, tt, qq, tau pairs, mu pairs,  $Z\gamma$ , Zh:
- Web accessible:

<http://www.lcsim.org/datasets/ftp.html>

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# Backgrounds

- Cain (to be done) & GuineaPig pairs and photons.
  - Add crossing angle, converted to stdhep
- Muons and other backgrounds from upstream collimators & converted to stdhep.
- $\gamma\gamma \rightarrow$  hadrons generated as part of the “2ab<sup>-1</sup> SM sample.”
- All events then capable of being processed through full detector simulation.
- Additive at the detector hit level, with time offsets, using LCIO utilities.

# Resources for getting started

## ■ <http://lcsim.org/> Web Site

### □ Tutorials

- Software installation
- Using tools
- Simple Analysis Examples
- Developers Guide

### □ Datasets

### □ Documentation

## ■ Confluence Wiki

- More tutorials
- More documentation
- Frequently asked Questions
- You are encouraged to comment on, add to, or correct existing documentation
  - <https://jira.slac.stanford.edu/signup>

The screenshot displays the lcsim.org website. At the top, there's a navigation menu with links: Introduction, Getting Started, Datasets, Detectors, Wiki, and Feedback. Below this, a sidebar on the left shows a diagram of an e+e- collider. The main content area lists links for each section: 'org.lcsim Tutorial' for Getting Started, 'ILC Datasets' for Datasets, 'Detectors' for Detectors, 'ILC Confluence Wiki' for Wiki, and 'LinearCollider.org Forum' for Feedback. Below the navigation menu, there's a Confluence Wiki interface for the 'ILC Wiki' space. It includes a search bar, a 'Contributing to the ILC Wiki' message, and sections for 'Links' and 'News'. The 'Links' section lists various resources like 'org.lcsim Tutorials', 'org.lcsim Wiki', 'org.lcsim Frequently Asked Questions', 'org.lcsim homepage', 'GeomConverter homepage', 'LCIO', and 'Marlin'. The 'News' section shows a table of recent updates with columns for Title, Author, and Date Posted.

**Introduction**

This site is designed to provide physicists the tools needed to investigate the physics potential of a linear e<sup>+</sup>e<sup>-</sup> collider. Many of the tools necessary to generate Monte Carlo events, simulate the response of typical detectors, and conduct the ensuing analysis of the "data" can be found at this site or others linked from here.

**Getting Started**

- [org.lcsim Tutorial](#) - instructions on setting up and using the Java reconstruction framework

**Datasets**

- [ILC Datasets](#) - instructions for accessing datasets via anonymous FTP

**Detectors**

- [Detectors](#) - list of available compact format detector descriptions

**Wiki**

- [ILC Confluence Wiki](#) - collaborative documentation site

**Feedback**

- [LinearCollider.org Forum](#) - get feedback from the experts

Dashboard > Linear Collider > Home

Welcome Tony Johnson | History | Preferences | Administration | Log Out

**Home**

View Edit Attachments (0) Info Browse Space Add Page Add News

Added by Tony Johnson, last edited by Jeremy McCormick on Apr 02, 2007 (view change)

Labels: (None) EDIT

**ILC Wiki**

This is the [International Linear Collider](#) space on SLAC's [Confluence Wiki](#). Much of the content is related to [Detector Simulation](#) and the [Reconstruction and Analysis](#) of simulated physics events. We welcome your comments and suggestions. You can add a comment by using the textbox at the bottom of each page. Here is the [Full Content Index](#) for this space.

Search

Contributing to the ILC Wiki

If you are affiliated with the ILC and would like an account on this Wiki you can [sign up here](#).

**Links**

This includes top-level Confluence pages and some important external sites.

**Reconstruction and Analysis**

- [org.lcsim Tutorials](#)
- [org.lcsim Wiki](#)
- [org.lcsim Frequently Asked Questions](#)
- [org.lcsim homepage](#)
- [GeomConverter homepage](#)
- [LCIO](#)
- [Marlin](#)

**Detector Simulation**

- [SLIC FAQ](#)
- [SLIC Wiki](#)
- [MOCKA](#)
- [ILC Detector Simulation FAQ](#)
- [ILC Detector Simulation Picture Gallery](#)

**News**

Title	Author	Date Posted
<b>Recently Updated</b>		
<a href="#">org.lcsim Package overview</a>	by Tony Johnson	(16 hours ago)
<a href="#">HEP Framework Links</a>	by Jeremy McCormick	(18 hours ago)
<a href="#">Java Links</a>	by Jeremy McCormick	(19 hours ago)
<a href="#">Re: org.lcsim Package overview</a>	by Jeremy McCormick	(20 hours ago)
<a href="#">How do I turn on histograms in Drivers (e.g. FastMC2)</a>	by Tony Johnson	(03 Apr)
<a href="#">org.lcsim</a>	by Tony Johnson	(03 Apr)
<a href="#">How can I write out an LCIO file from org.lcsim?</a>	by Tony Johnson	(03 Apr)
<a href="#">Contributing to ILC Software Projects</a>	by Jeremy McCormick	(02 Apr)

# Resources for getting started

## ■ Discussion Forums

❑ <http://forum.linearcollider.org/>

■ SLIC, org.lcsim

❑ Not recommended

■ Spray E-mail to developers

❑ Banging head against wall

❑ Uninstall and reinstall software 3 times

❑ Recommended

■ Post questions on the forum

❑ You will get faster answers

❑ You will get more accurate answers

❑ Others will benefit from seeing answers to your questions

■ Discuss what you would like to do

❑ get feedback on best practices

The screenshot displays the Linear Collider Forum website. At the top, there is a navigation bar with links for Members, Search, Help, Control Panel, Logout, Home, and Admin Control Panel. Below this, a welcome message for user 'tonyj' is shown, along with links for Today's Messages, Unread Messages, Unanswered Messages, Show Polls, and Message Navigator. The main content area is divided into several forum sections, each with a table of messages. The sections include:

- Software Tools - Developers and users discussion forum**: Topics like Fast Simulations, LCIO, org.lcsim, and Marlin et al.
- Analysis and Reconstruction - Linear Collider Reconstruction and Analysis**: Topics like Analysis Tools, Reconstruction, Results, Tracking & Vertexing, Individual Particle Reconstruction, and EUEDET Telescope.
- Simulation - Detector Response Simulation**: Topics like Full Simulations, Mokka, LCDG4, Common Simulation Framework, and slc.

Below the forum sections, there is a list of replies to a post titled 'Cheater example'. The replies are from users like bjasper, tonyj, and others, dated from March 2007. At the bottom, there are links to frequently asked questions and a section for SimTrackerHit getLayer method.



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# ALCPG Simulation Summary

- ALCPG Sim/Reco team supports an ambitious detector simulation effort.
- Goal is flexibility and interoperability, not technology or concept limited.
- Provides full data samples for ILC physics studies.
  - Stdhep and LCIO files available on the web.
- Provides a complete and flexible detector simulation package capable of simulating arbitrarily complex detectors with runtime detector description.
- Reconstruction & analysis framework exists, core functionality available, individual particle reconstruction template developed, various analysis algorithms implemented.
- Need to iterate and apply to various detector designs.

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# Additional Information

- lcsim.org - <http://www.lcsim.org>
- ILC Forum - <http://forum.linearcollider.org>
  
- Wiki - <http://confluence.slac.stanford.edu/display/ilc/Home>
- org.lcsim - <http://www.lcsim.org/software/lcsim>
- Software Index - <http://www.lcsim.org/software>
- Detectors - <http://www.lcsim.org/detectors>
  
- LCIO - <http://lcio.desy.de>
- SLIC - <http://www.lcsim.org/software/slic>
- LCDD - <http://www.lcsim.org/software/lcdd>
- JAS3 - <http://jas.freehep.org/jas3>
- AIDA - <http://aida.freehep.org>
- WIRED - <http://wired.freehep.org>