slic
A Geant4-based detector simulation package

Jeremy McCormick, Norman Graf, Ron Cassell, Tony Johnson
SLAC
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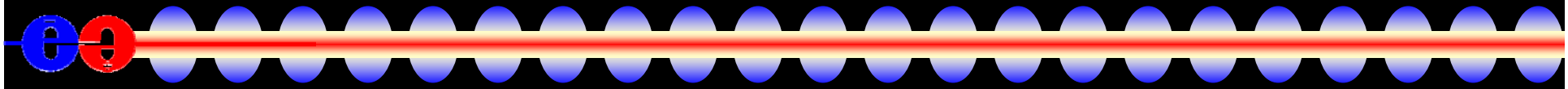
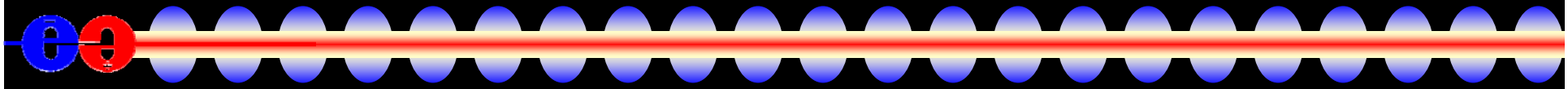
Mission Statement



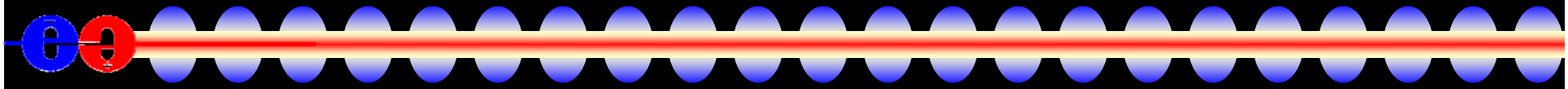
- Provide full simulation capabilities for Linear Collider physics program:
  - Physics simulations & detector designs.
- Need flexibility for:
  - New detector geometries/technologies.
- The system should be flexible, powerful, yet simple to install and maintain.
- Limited resources demand efficient solutions, focused effort.

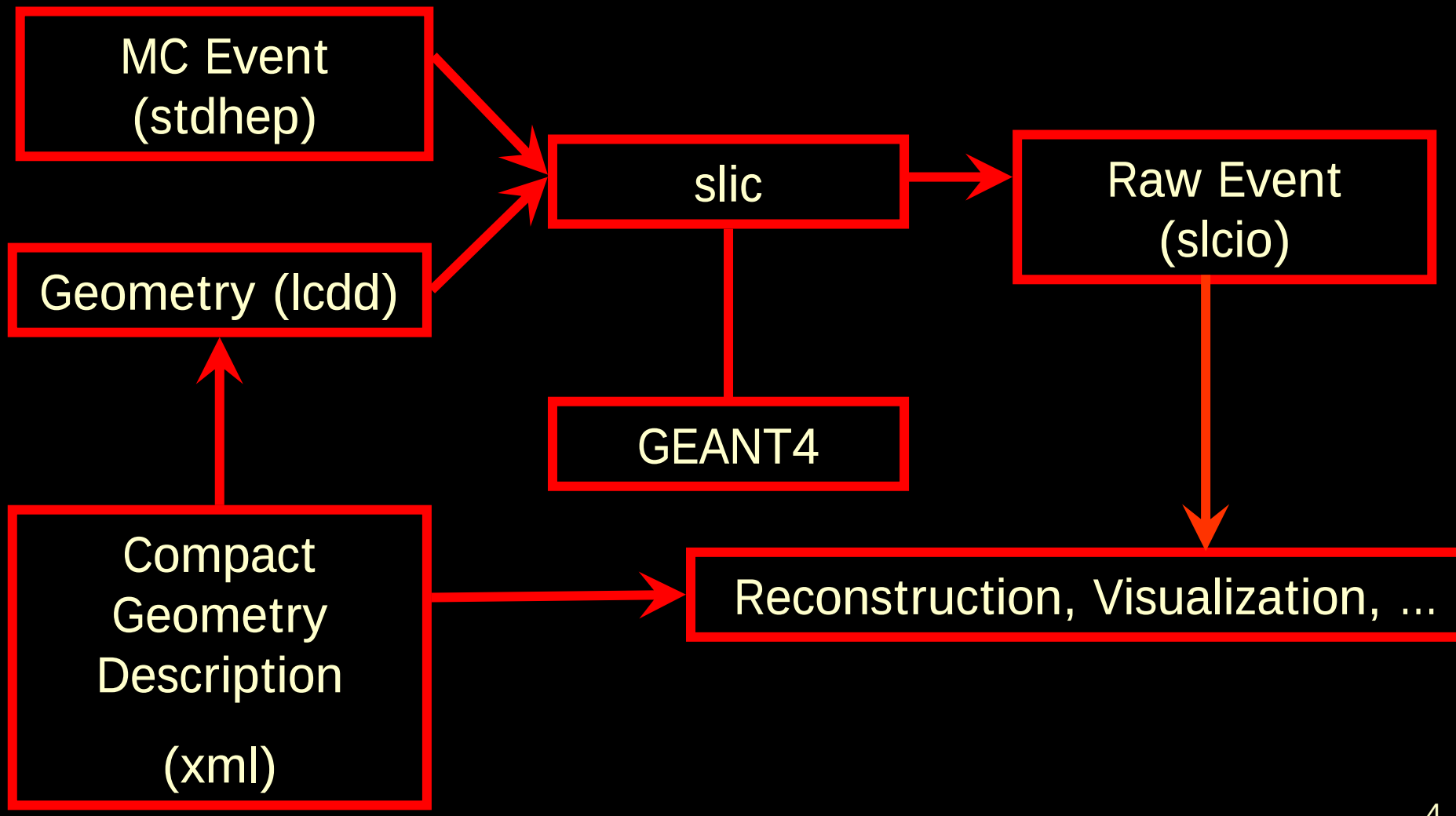
Full Detector Response Simulation



- Use Geant4 toolkit to describe interaction of particles with matter.
- Thin layer of LC-specific C++ provides access to:
  - Event Generator input (binary stdhep format)
  - Detector Geometry description (XML)
  - Detector Hits (LCIO)
- Geometries fully described at run-time!
  - In principle, as fully detailed as desired.
  - In practice, will explore detector variations with simplified approximations.

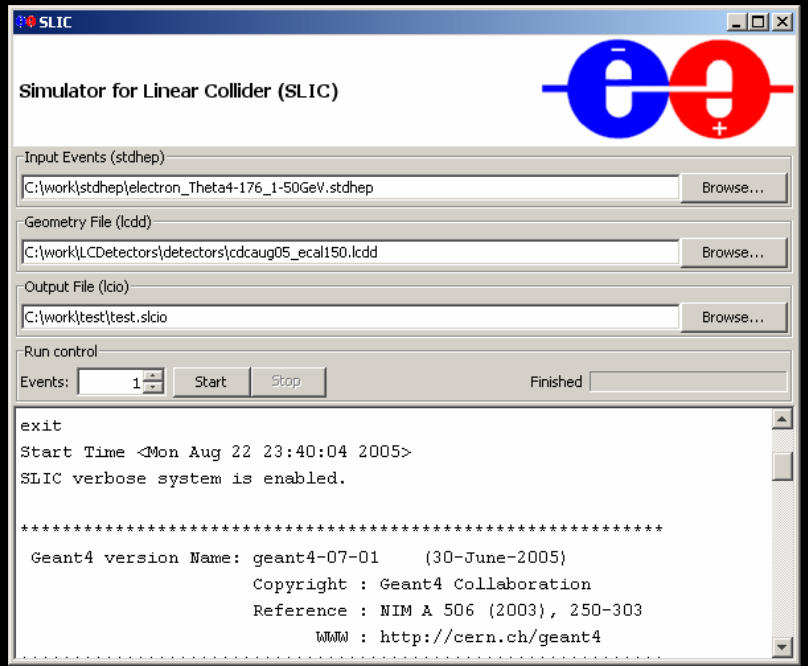
LC Detector Full Simulation



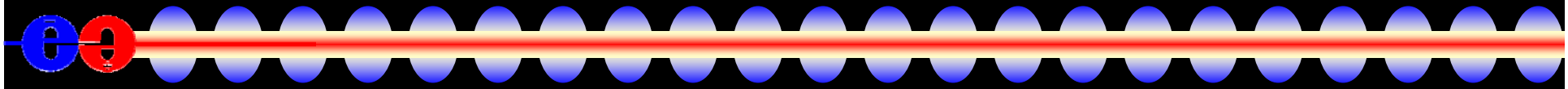


slic: The Executable

- Build static executable on Linux, Windows, Mac.
- Commandline or G4 macro control.
- Only dependence is local detector description file.
  - Trivial Grid usage (no database call-backs, etc.)
- Java GUI developed
  - Cross-platform
  - Auto-update of exe



Why XML?



- Simplicity: Rigid set of rules
- Extensibility: easily add custom features, data types
- Interoperability: OS, languages, applications
- Self-describing data, validate against schema
- Hierarchical structure $\leftrightarrow$ OOP, detector/subdetector
- Open W3 standard, lingua franca for B2B
- Many tools for validating, parsing, translating
- Automatic code-generation for data-binding
- Plain text: easily edited, cvs versioning

LCDD and GDML

- Adopted GDML as base geometry definition, then extended it to incorporate missing detector elements.

LCDD

- detector info
- identifiers
- sensitive detectors
- regions
- physics limits & cuts
- visualization
- magnetic fields

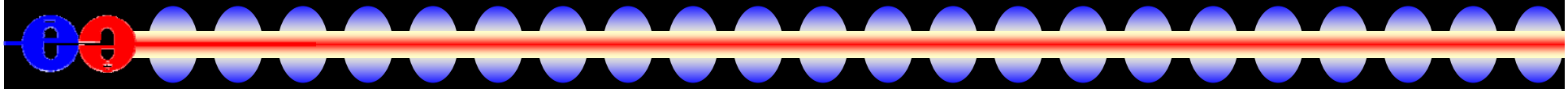
GDML

- expressions (CLHEP)
- materials
- solids
- volume definitions
- geometry hierarchy

LCDD Structure

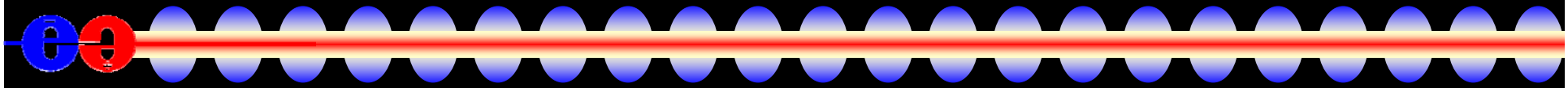
`<lcdd>`	LCDD Root Element
`<header>`	Information about the Detector
`<iddict>`	Identifier Specifications
`<sensitive_detectors>`	Detector Readouts
`<limits>`	Physics Limits
`<regions>`	Regions (sets of volumes)
`<display>`	Visualization Attributes
`<gdml>`	GDML Root Element
`<define>`	Constants, Positions, Rotations
`<materials>`	Material Definitions
`<solids>`	Solid Definitions
`<structure>`	Volume Hierarchy
`</gdml>`	
`<fields>`	Magnetic Field
`</lcdd>`	

Generic Hits Problem Statement



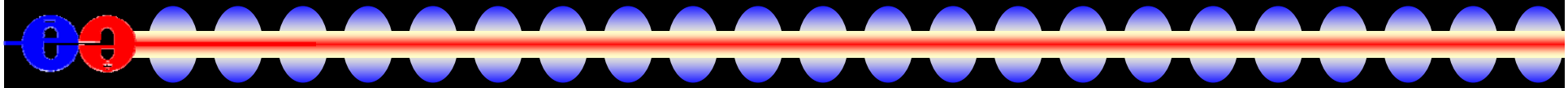
- We wish to define a generic output hit format for full simulations of the response of detector elements to physics events.
- Want to preserve the “true” Monte Carlo track information for later comparisons.
- Want to defer digitization as much as possible to allow various resolutions, etc. to be efficiently studied.

Types of Hits



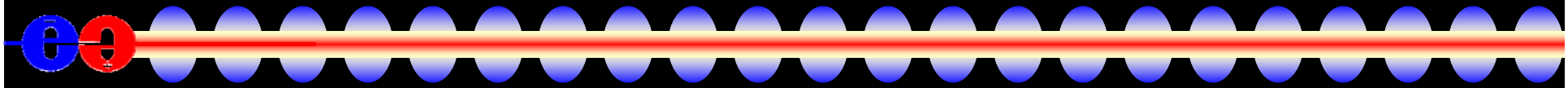
- "Tracker" Hits
  - Position sensitive.
  - Particle unperturbed by measurement.
  - Save "ideal" hit information.
- "Calorimeter" Hits
  - Energy sensitive.
  - Enormous number of particles in shower precludes saving of each "ideal" hit.
  - Quantization necessary at simulation level.

LCIO



- Persistency framework for LC simulations.
- Currently uses SIO: Simple Input Output
  - on the fly data compression
  - some OO capabilities, e.g. pointers
  - C++ and Java implementation available
- Changes in IO engine designed for.
- Extensible event data model
  - Generic Tracker and Calorimeter Hits.
  - Monte Carlo particle heirarchy.

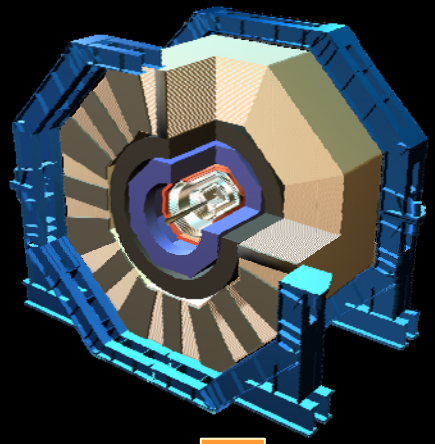
Detector Variants



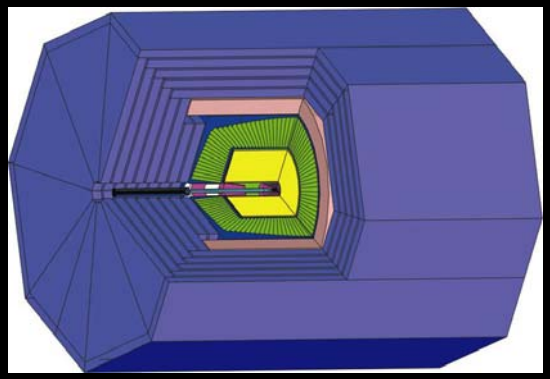
- Runtime XML format allows variations in detector geometries to be easily set up and studied:
  - Stainless Steel vs. Tungsten HCal sampling material
  - RPC vs. GEM vs. Scintillator readout
  - Layering (radii, number, composition)
  - Readout segmentation (size, projective vs. nonprojective)
  - Tracking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

ILC Full Detector Concepts

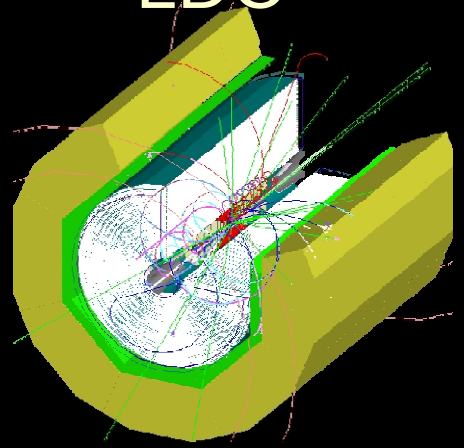
SiD

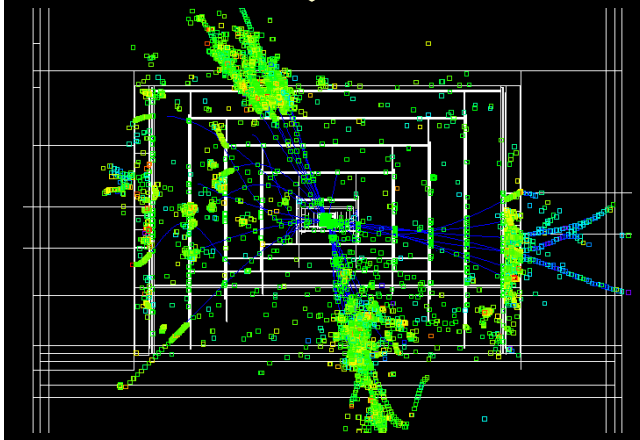


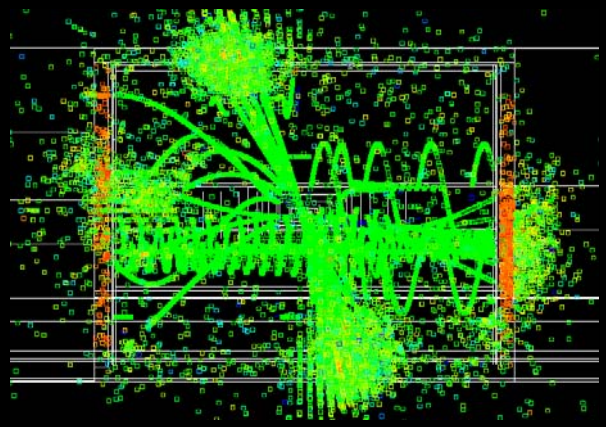
GLD

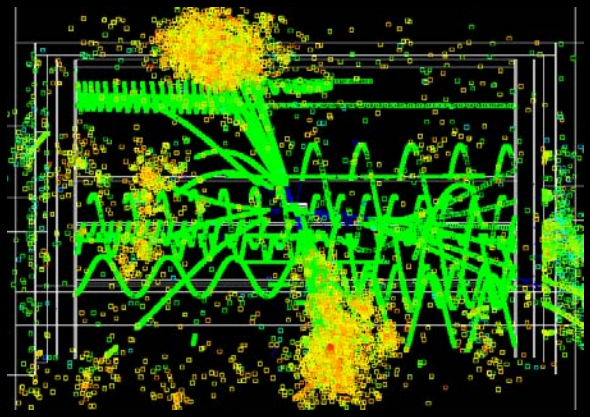


LDC

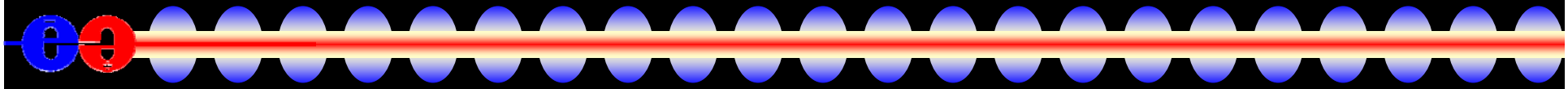






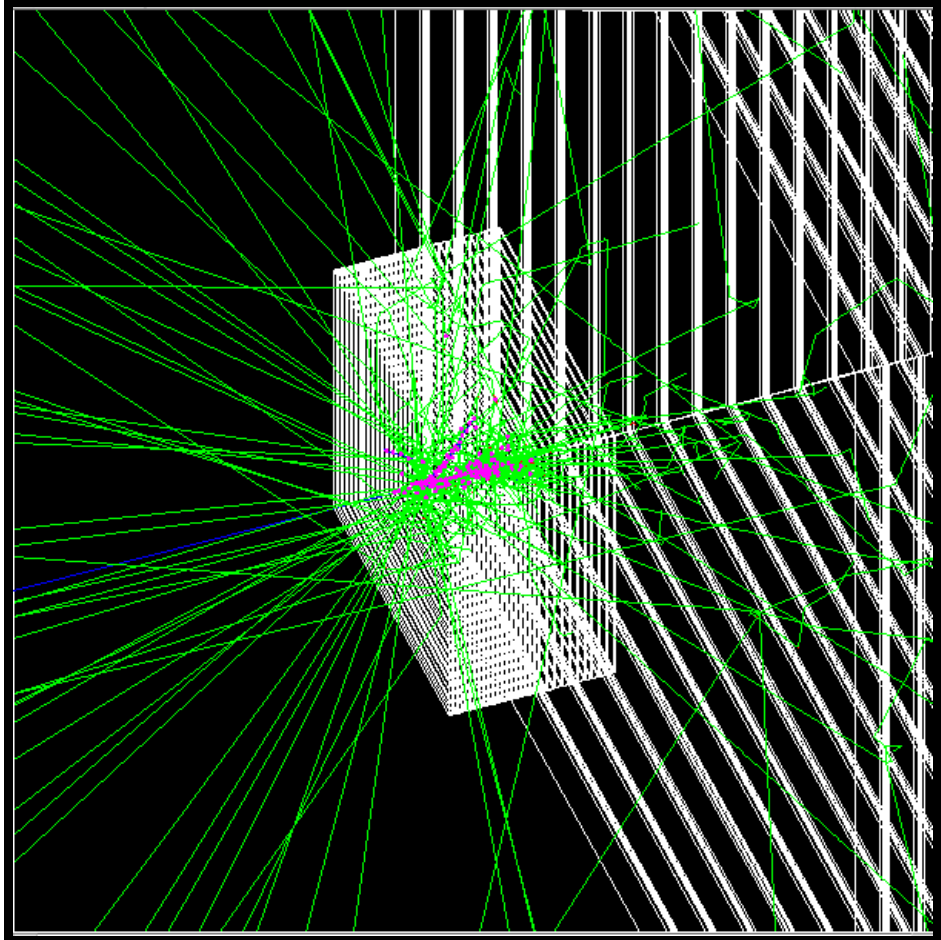


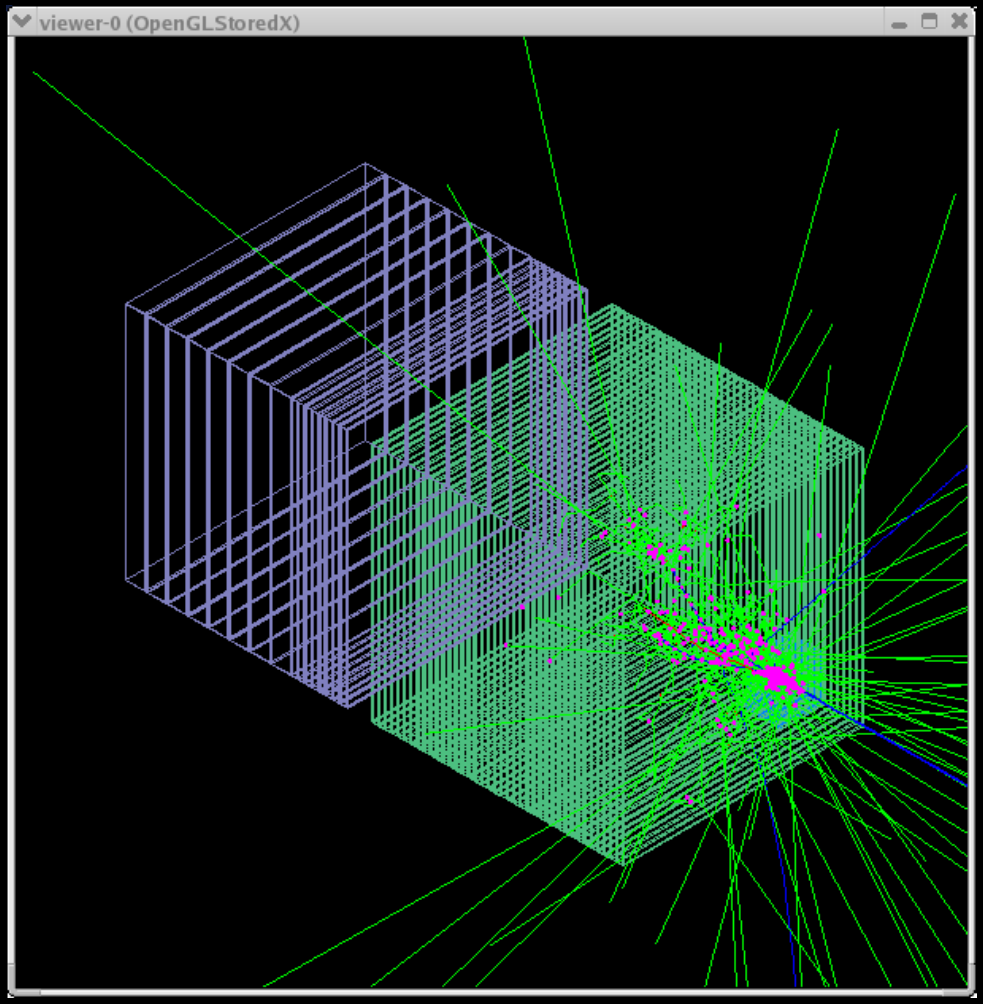
Geant4 Calorimeter Studies



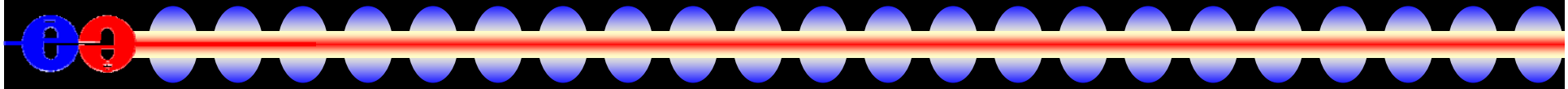
- Still investing a lot of time understanding Geant4!
- slic is very useful for investigating details of shower simulations.
  - simple setups can be analyzed same as complex.
- Strong EM calorimeter resolution dependence on range cuts for thin active material.
- Energy non-conservation in hadron showers.
  - Bugs found in GEISHA and patches provided for G4 several years ago.
  - n and n treated with different models.

Test Beams





Summary

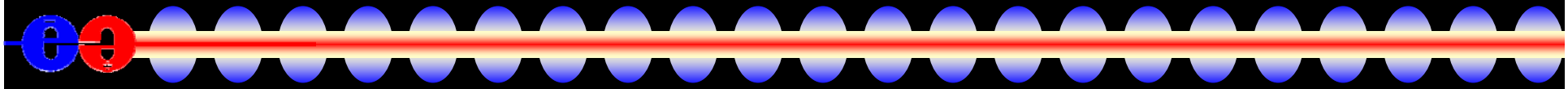


- Provides a complete and flexible detector simulation package capable of simulating arbitrarily complex detectors with runtime detector description.
- Being used by ILC detector community for simultaneous and iterative evolution of different detector concepts and their variations.
- Could be used by other communities (astro, medical) for rapid prototyping or simulation.

Additional Information

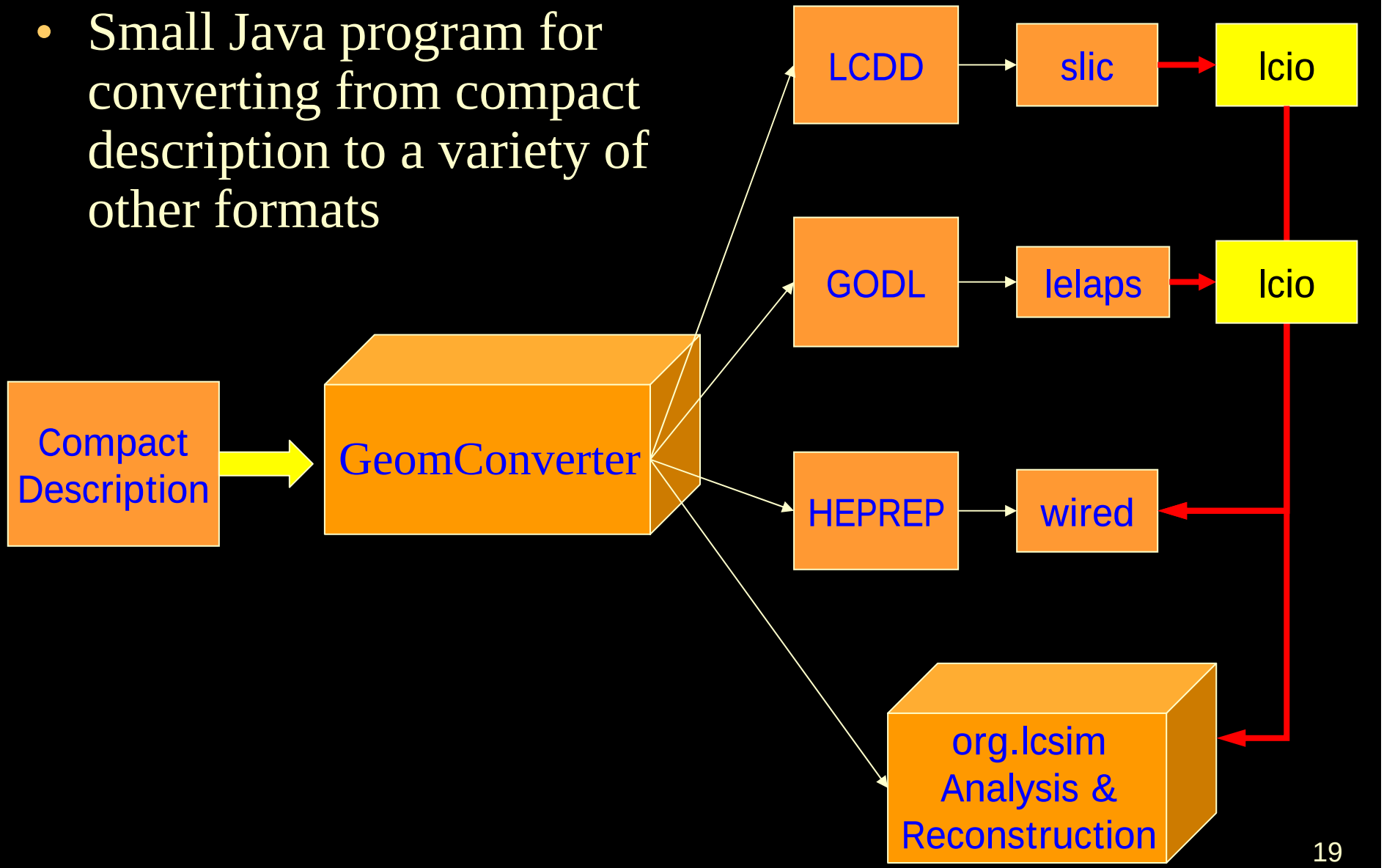
- ILC Detector Simulation http://www.lcsim.org
- ILC Forum http://forum.linearcollider.org
- SLIC http://www.lcsim.org/software/slic
- LCDD http://www.lcsim.org/software/lcdd
- Wiki http://confluence.slac.stanford.edu/display/ilc/
- LCIO http://lcio.desy.de
- GDML http://gdml.web.cern.ch/GDML/
- JAS3 http://jas.freehep.org/jas3
- WIRED4 http://wired.freehep.org
- AIDA http://aida.freehep.org

Backup Slides

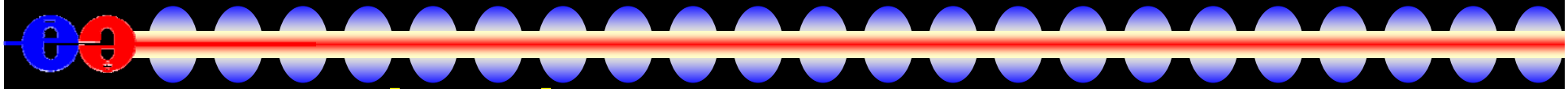


GeomConverter

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



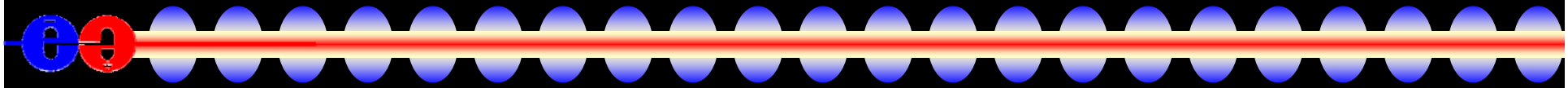
Tracker Hit



- **MC Track Number**
- Encoded **detector ID** (detector dependent)
- Global **hit position at entrance** to sensitive volume
- Global **hit position at exit** of sensitive volume
- **Track momentum** at entrance to sensitive volume
- **Energy deposited** by track in sensitive volume
- **Time** of track's crossing

- Hit number
- Local hit position at entrance to sensitive volume
- Local hit position at exit of sensitive volume
- Step size used by simulator in sensitive volume

Calorimeter Hit



- Encoded detector ID (detector dependent)
- MC ID
- energy
- time of deposition
- for each energy contribution