LCD Common Software

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SiD Meeting
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Common LCD Software

- General agreement among LC concept working groups that most efficient way forward is to move to more common software tools
- Already have an unprecendently strong base of collaborative software used by CLIC, ILD and SID:
    - LCIO - common EDM and persistency
    - PandoraPFA, LCFIVertex/LCFIPlus
    - Geant4 (slic, Mokka)
- Informal series of Linear Collider Software Meetings held at CERN with software experts from CLIC, ILD and SiD in 2009, 2012 & 2013
    - – Continue to identify areas for collaborative development.

LCD Software Meetings

- At 2012 meeting, reached a consensus to work towards:
  - a common simulation application based on the geometry description developed in AIDA WP2
  - a common C++ tracking package in the context of AIDA WP2
- At 2013 meeting discussion focused on the details of how these goals can be achieved
  - interface between geometry description and simulation
  - interface to reconstruction (tracking)
  - decided to develop prototypes to investigate options
  - agreement to use DD4hep as geometry tool

Full Detector Response Simulation

- Use Geant4 toolkit to describe interaction of particles with matter and fields.
- Program framework provides access to:
  - Event Generator particle input
  - Detector Geometry description input
  - Detector Hits output
- slic used primarily by SiD
- Mokka used primarily by ILD
  - support at LLR has been reduced
  - main developers and maintainers moved on to other tasks

Geometry Definition

- Goal is to free the end user from having to write any C++ code or be expert in Geant4 to define the detector.
- All of the detector properties should be definable at runtime with an easy-to-use format.
- Selected xml, and extended the existing GDML format for pure geometry description.

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>`	

lcdd Features

- **Regions**: production cuts
- **Physics limi**ts: track length, step length, etc.
- **Visualization**: color, level of detail, wireframe/solid
- **Sensitive detectors**
  - calorimeter, optical calorimeter, tracker
  - segmentation
- **ID**s
  - volume identifiers (physical volume id)
- **Magnetic field**s
  - dipole, solenoid, field map
- utilities
  - information on Geant4 stores
  - GDML load/dump

“Compact” Description

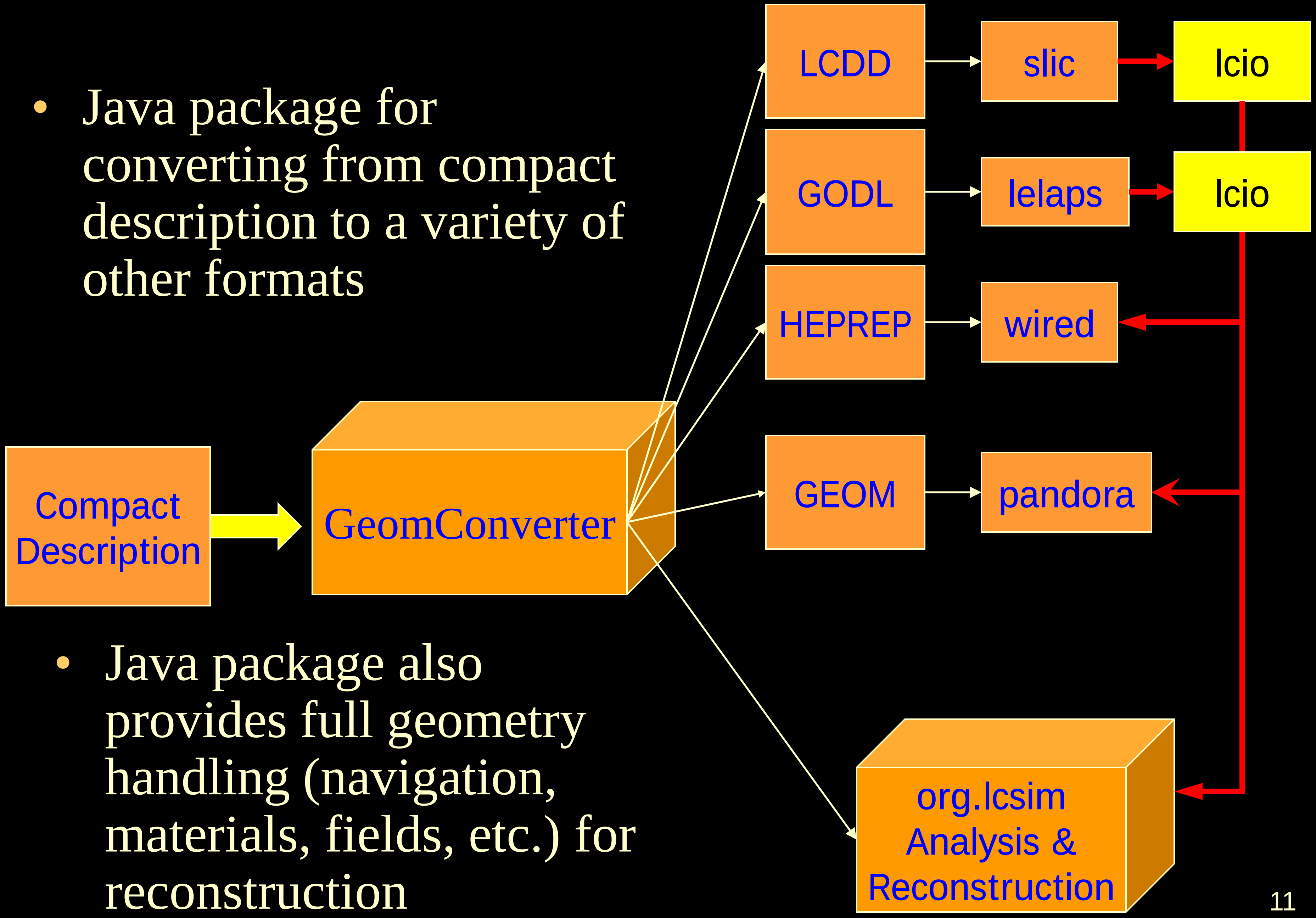
- The lcdd file is very descriptive, but therefore also very verbose.
- Can be written by hand, but prone to human error.
  - Also, just specific to the simulation and not easily accessible to reconstruction and visualization.
- Developed a “compact” detector description which encapsulates the basic properties of a detector and which is further processed by code to produce the input specific to different clients.

Compact Detector Description

- A number of generally useful detector types (at least for HEP collider detectors) have been developed, such as:
  - Sampling calorimeters
  - TPCs
  - Silicon trackers (microstrip as well as pixel)
  - Generic geometrical support structures
- Can also incorporate GDML snippets
  - Allows inclusion of more complicated volumes derived for instance from engineering (CAD) drawings.

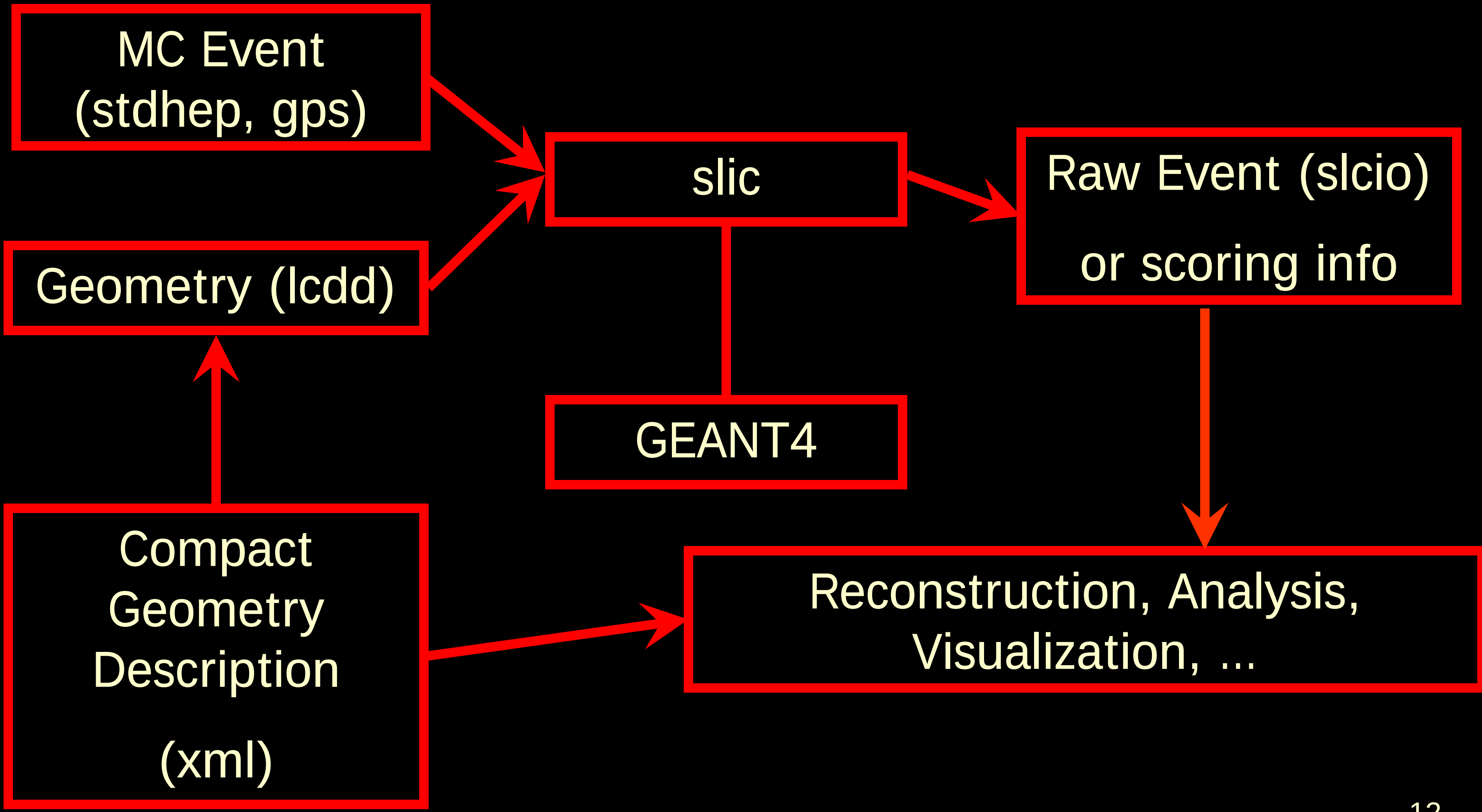
GeomConverter

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



- Java package also provides full geometry handling (navigation, materials, fields, etc.) for reconstruction

Detector Full Simulation



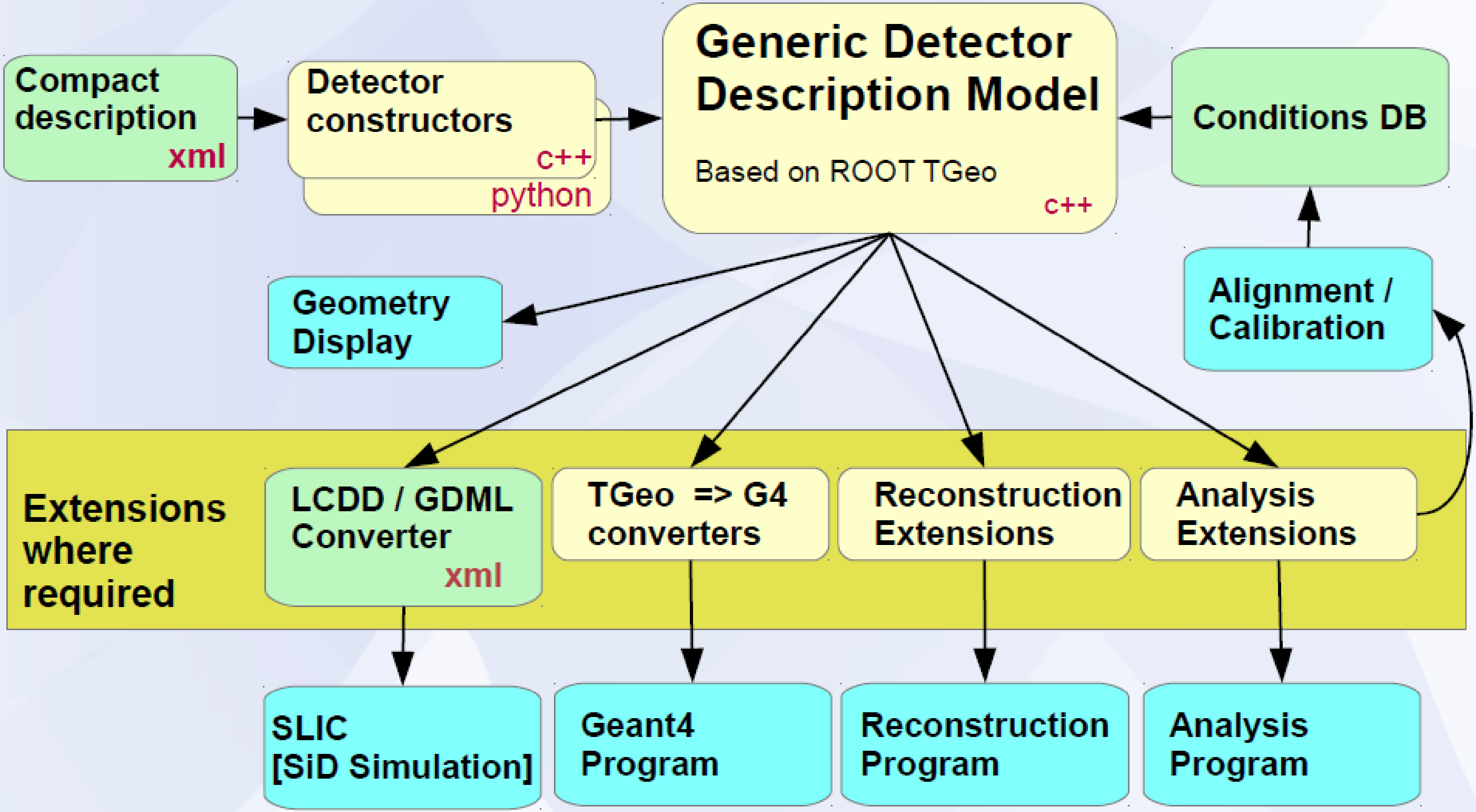
DD4hep

- AIDA deliverable to provide Detector Description for HEP experiments supporting the full experimental life cycle:
  - – Detector concept development & optimization
  - – Detector construction and operation
  - – Simulation, reconstruction, analysis
  - – Support for:
    - Geometry
    - Readout
    - Alignment
    - Calibration

DD4hep and slic

- Instead of reinventing another Geant4 program, will use slic as the simulation program.
- Instead of reinventing a geometry manipulation & navigation program, will use root’s TGeo class.
- Will remain decoupled from slic code base by producing lcdd file.
- Virtual segmentation classes (used e.g. for calorimeter readout) will be shared between simulation and C++ reconstruction.

DD4hep Overview



Compact description xml

Detector constructors c++ python

Generic Detector Description Model

Based on ROOT TGeo c++

Conditions DB

Geometry Display

Alignment / Calibration

Extensions where required

LCDD / GDML Converter xml

TGeo => G4 converters

Reconstruction Extensions

Analysis Extensions

SLIC [SiD Simulation]

Geant4 Program

Reconstruction Program

Analysis Program

“Virtual Segmentation”

- Unrealistic to include all pixels in LC detectors as physical or logical elements in Geant4
- Unrealistic to store every step of every particle (especially secondaries in calorimeter showers)
- Use “virtual segmentation” to aggregate energy depositions in calorimeters.
  - Fixed number of different types
  - position to cell ID (used in simulation)
  - cell ID to position (used in reconstruction)
  - list of neighboring cell IDs (reconstruction)

Virtual Segmentation

- Working to provide package which provides implementations of basic types of segmentation.
- Want minimal coupling between simulation (Geant4) and reconstruction (root) environments.
- Refactoring of Geomconverter / lcdd packages.
- Ongoing work by Christian Grefe to explore calorimeter reconstruction and Frank Gaede to investigate track reconstruction using new API.

DD4hep Status & Plans

- Have developed simple prototypes:
  - ILD: VXD, SIT, TPC, AHcal
  - Calice test beam
  - CLICSiD
- Being used to study technical issues:
  - cellIDs, detector segmentations
  - sensitive detectors
  - interface to reconstruction
- Working meeting planned for December @ CERN

ILCSoft

- System to build and release software packages
- slic, XercesC, HepPDT, GDML, LCDD are now included
  - SimDist no longer being used
- DD4hep also included
- Number of additional packages added in latest release, e.g.
  - added python bindings to LCIO (C.Grefe)
  - partial reading of LCIO files

Summary

- LCD sim/reco working groups continue to work towards increased software commonality.
- Midterm goal: all concept working groups use SLIC for full detector response simulation via lcdd
- Provide common source of geometry for simulation and (C++/root) reconstruction via DD4hep (Tgeo)