DD4hep Status

The attempt towards a HEP detector description supporting the full experiment life cycle

- **Motivation and Goals**

  => Introduction

- **Concepts and Design**
- **Going to the 'real world'**
- **Summary**

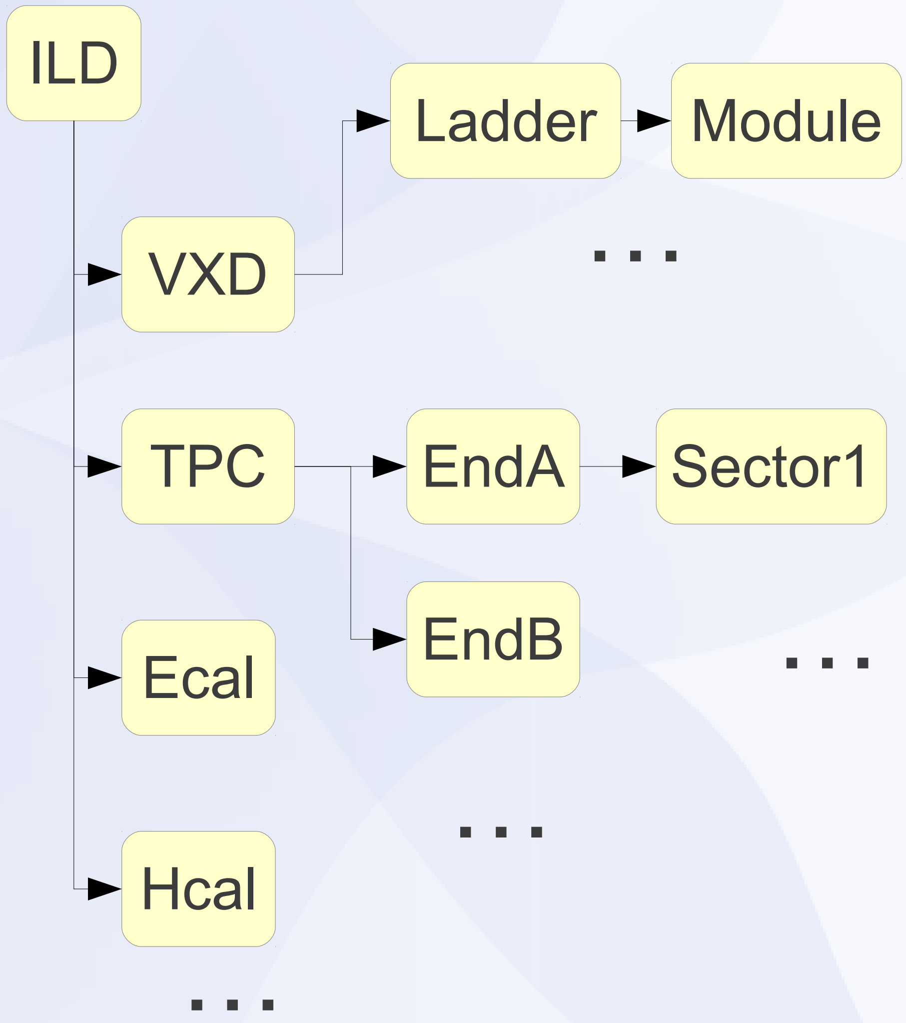
Motivation and Goal

- **Develop a detector description**
  - **For the full experiment life cycle**
    - **detector concept development, optimization**
    - **detector construction and operation**
    - **Easy transition from one phase to the next**
    - **“Anticipate the unforeseen”**
  - **Consistent description, with single source, which supports**
    - **simulation, reconstruction, analysis**
  - **Full description, including**
    - **Geometry, readout, alignment, calibration etc.**

  + standard commercials apply: simple usage etc.

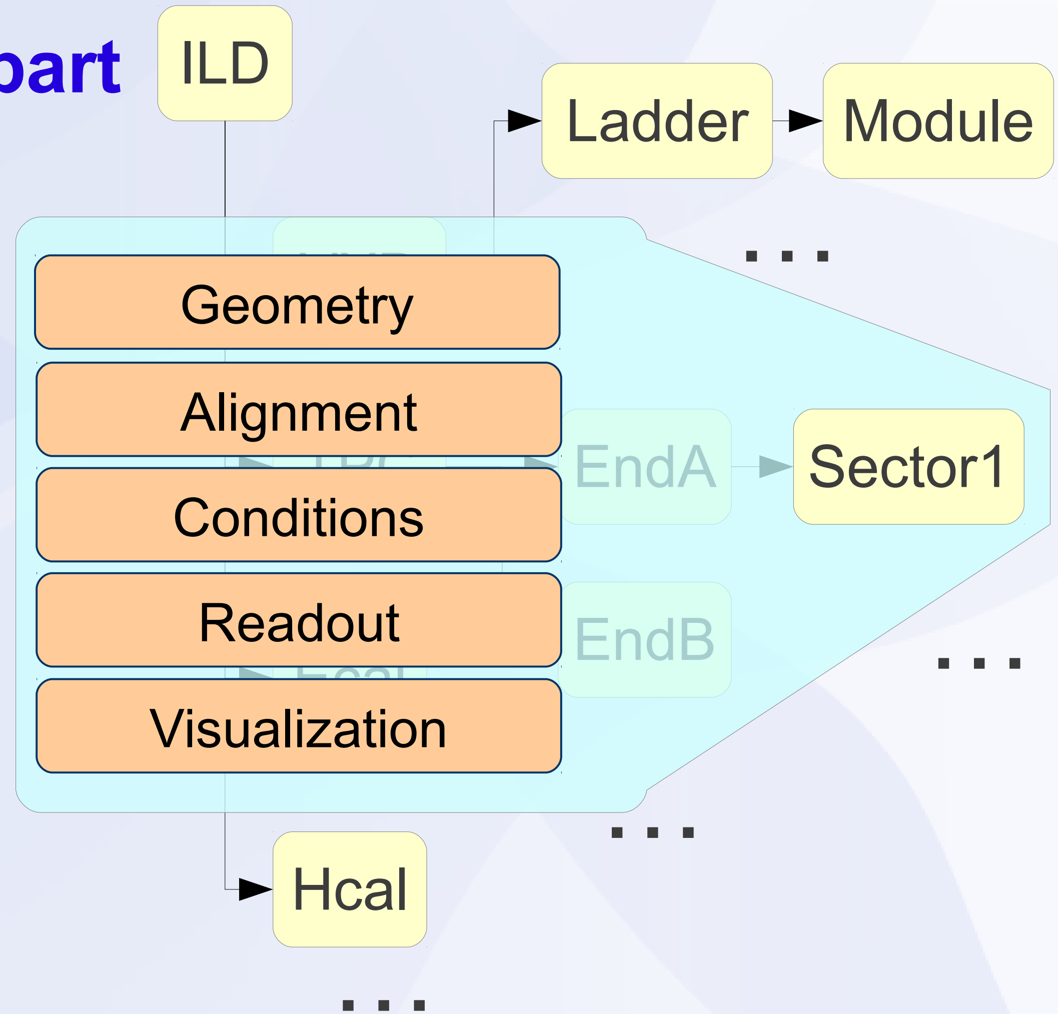
What is Detector Description ?

- **Description of a tree-like hierarchy of "detector elements"**
  - **Subdetectors or parts of subdetectors**
  - **Example:**
    - Experiment
    - TPC
    - Endcap A/B
    - Sector
    ...



What is a Detector Element ?

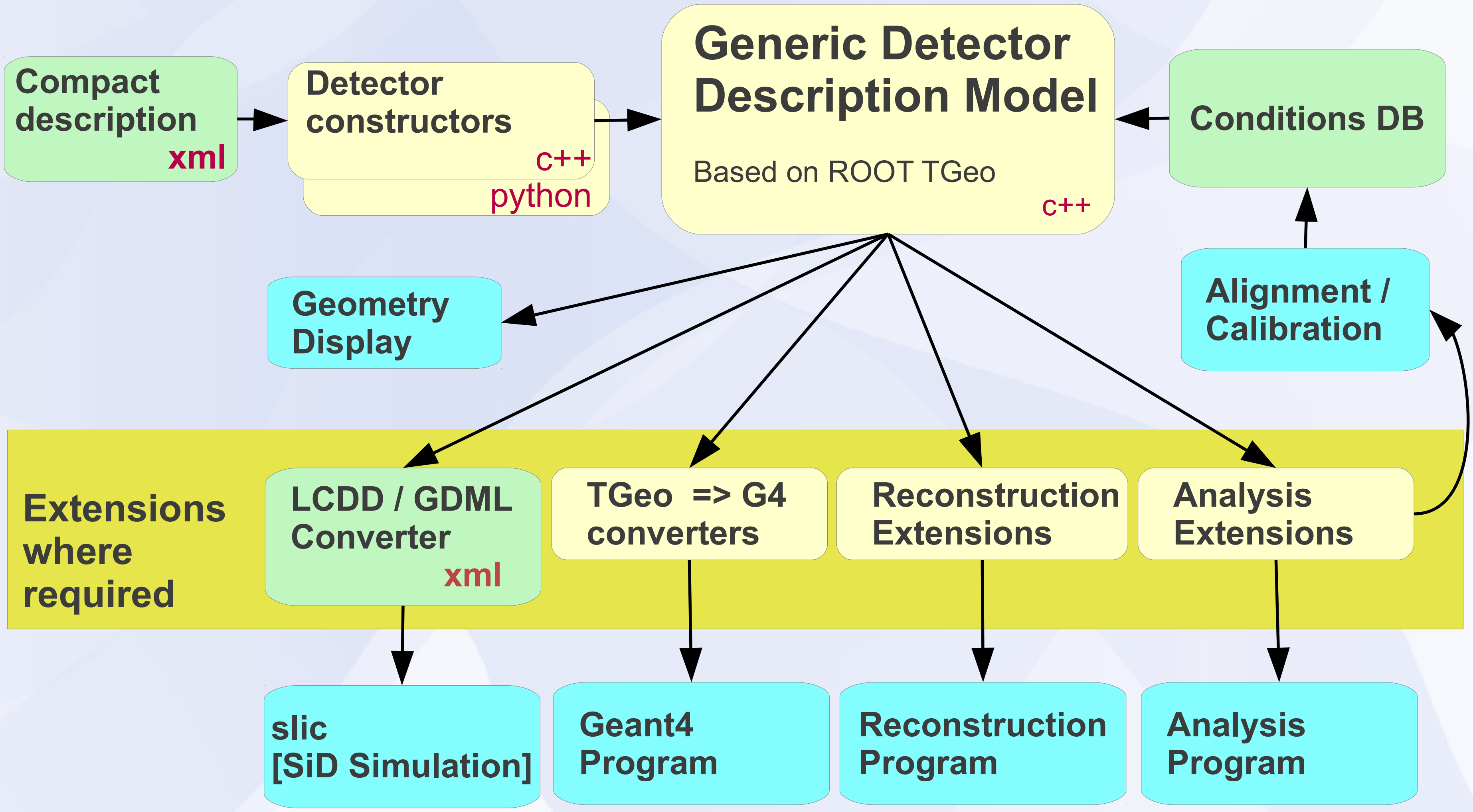
- **Subdetector or the part of a subdetector including the description of its state**
  - **Geometry**
  - **Environmental conditons**
  - **Properties required to process event data**



- Motivation and Goals
- **Concepts and Design**

  => Focus on recent developments
- Going to the 'real world'
- Summary

Reminder: DD4Hep - The Big Picture

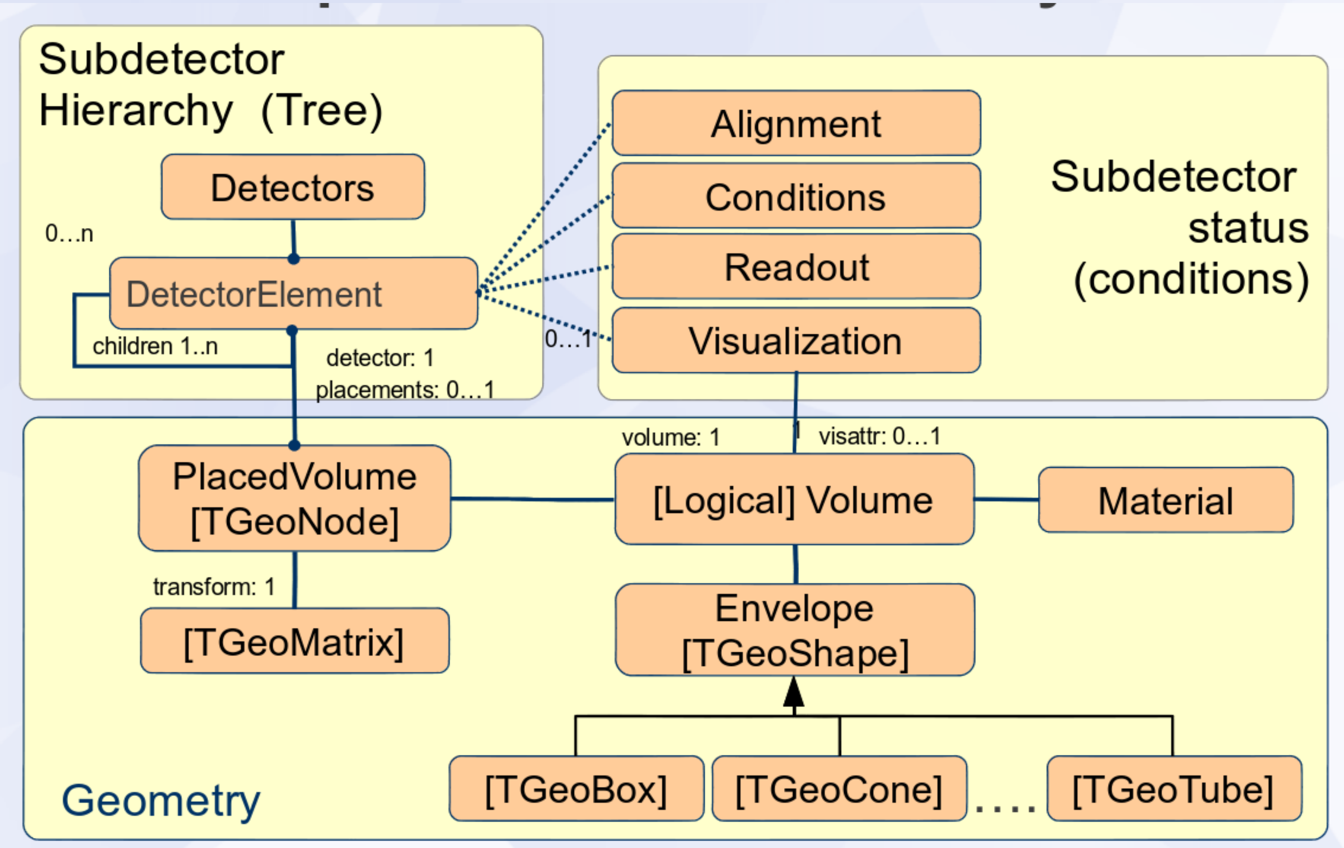


Implementation: Design Choices

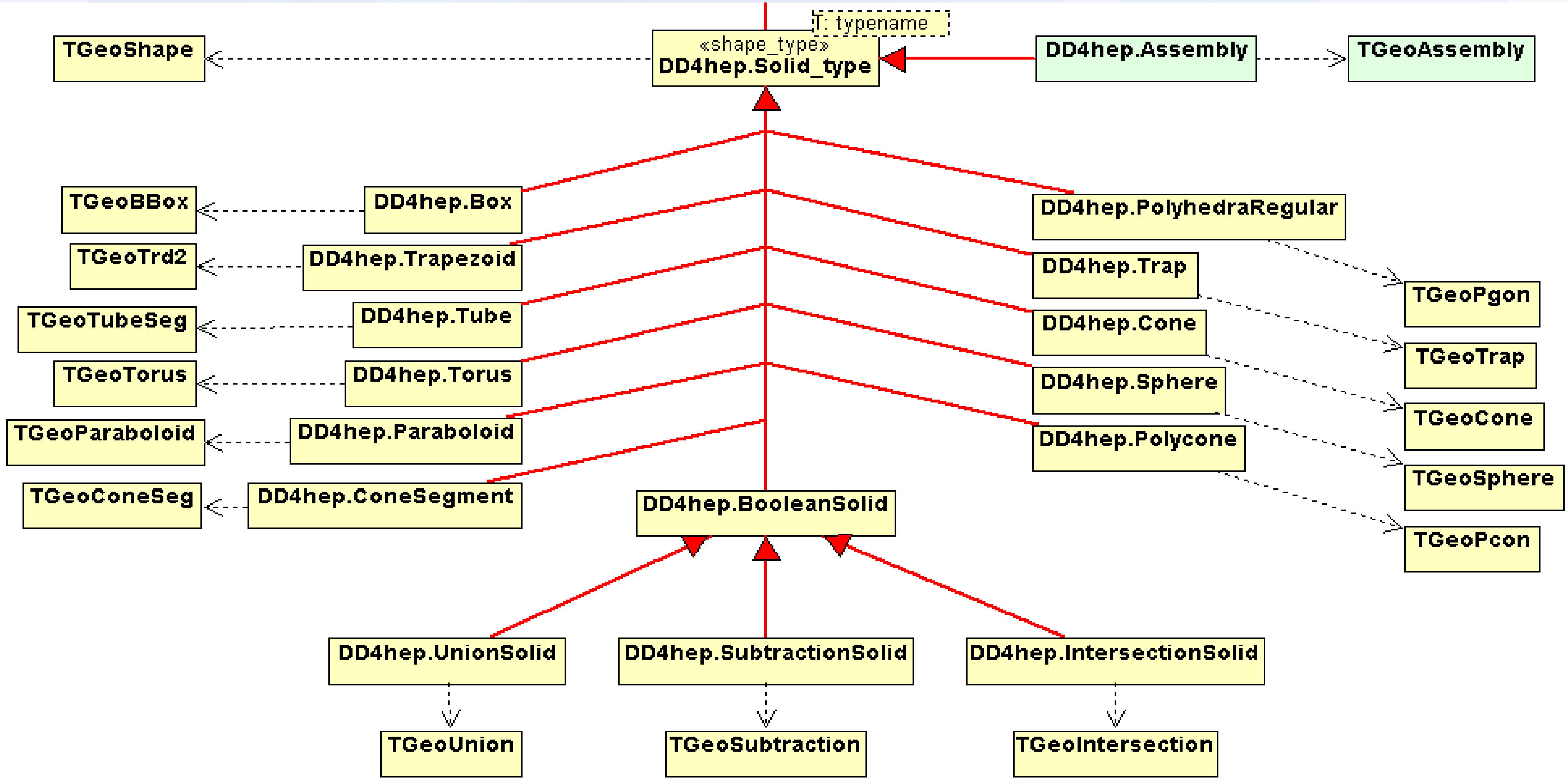
- **Detectors are described by a compact notation**
  - **Inspired by SiD compact description [Jeremy McCormick]**
  - **Flexible and extensible**
- **Separation of ‘data’ and ‘behavior’**
  - **Classes consist of a single ‘reference’ to the data object**
  - **Same ‘data’ can be associated to different ‘behaviors’**
- **Implementation based on TGeo (ROOT)**
  - **TGeo classes directly accessible (no hiding)**
  - **TGeo has support for alignment**

Follow-up: Geometry Implementation

- **Based on ROOT TGeo**
- **No insufficiencies found: model seems correct**

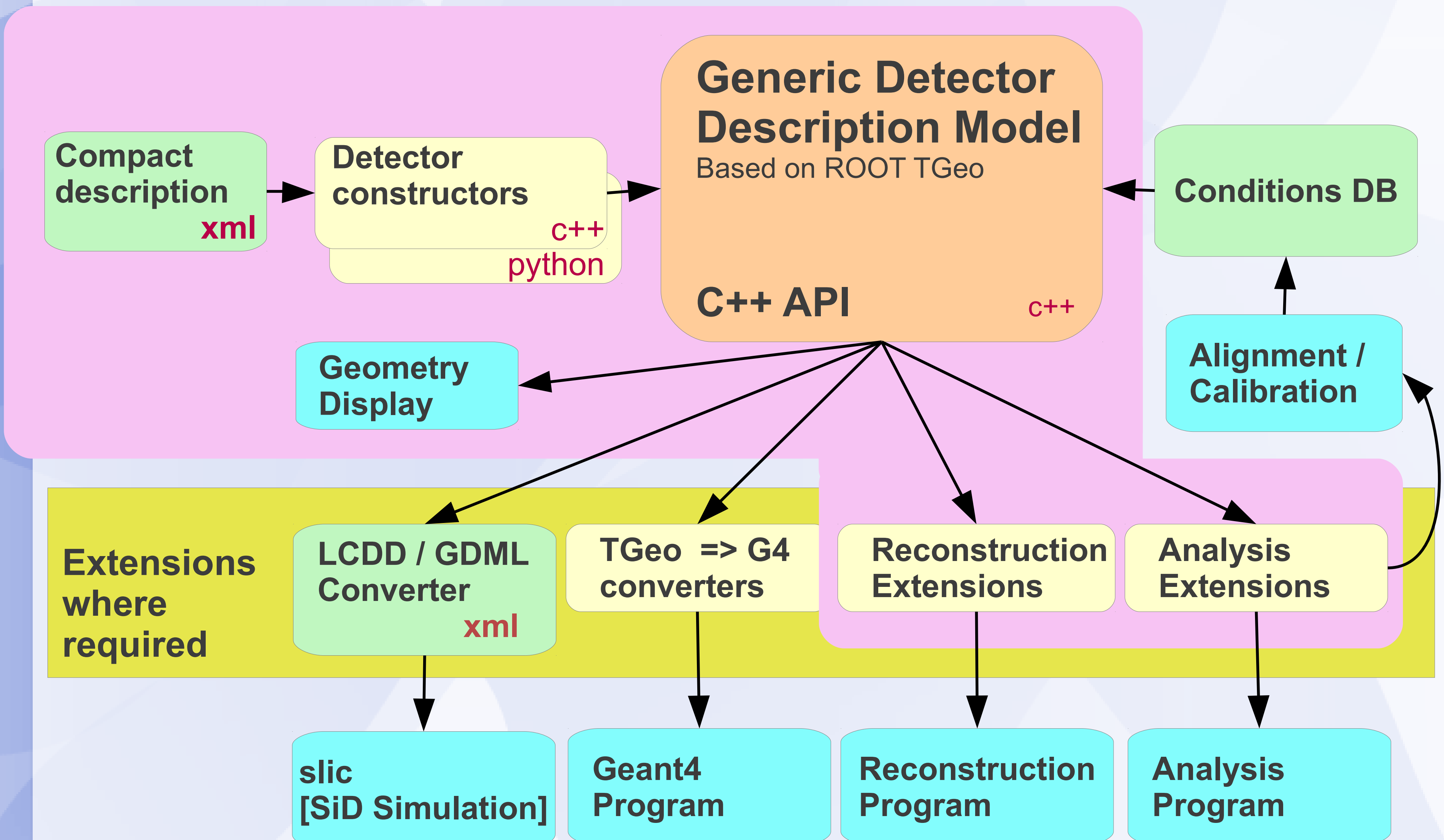


Shapes and Solids: Enhanced Palette



- TGeo shapes used internally. Palette ~complete
- Commitment of TGeo to use USolids

Dealing with the 'Unforeseeable'



Client Extensions

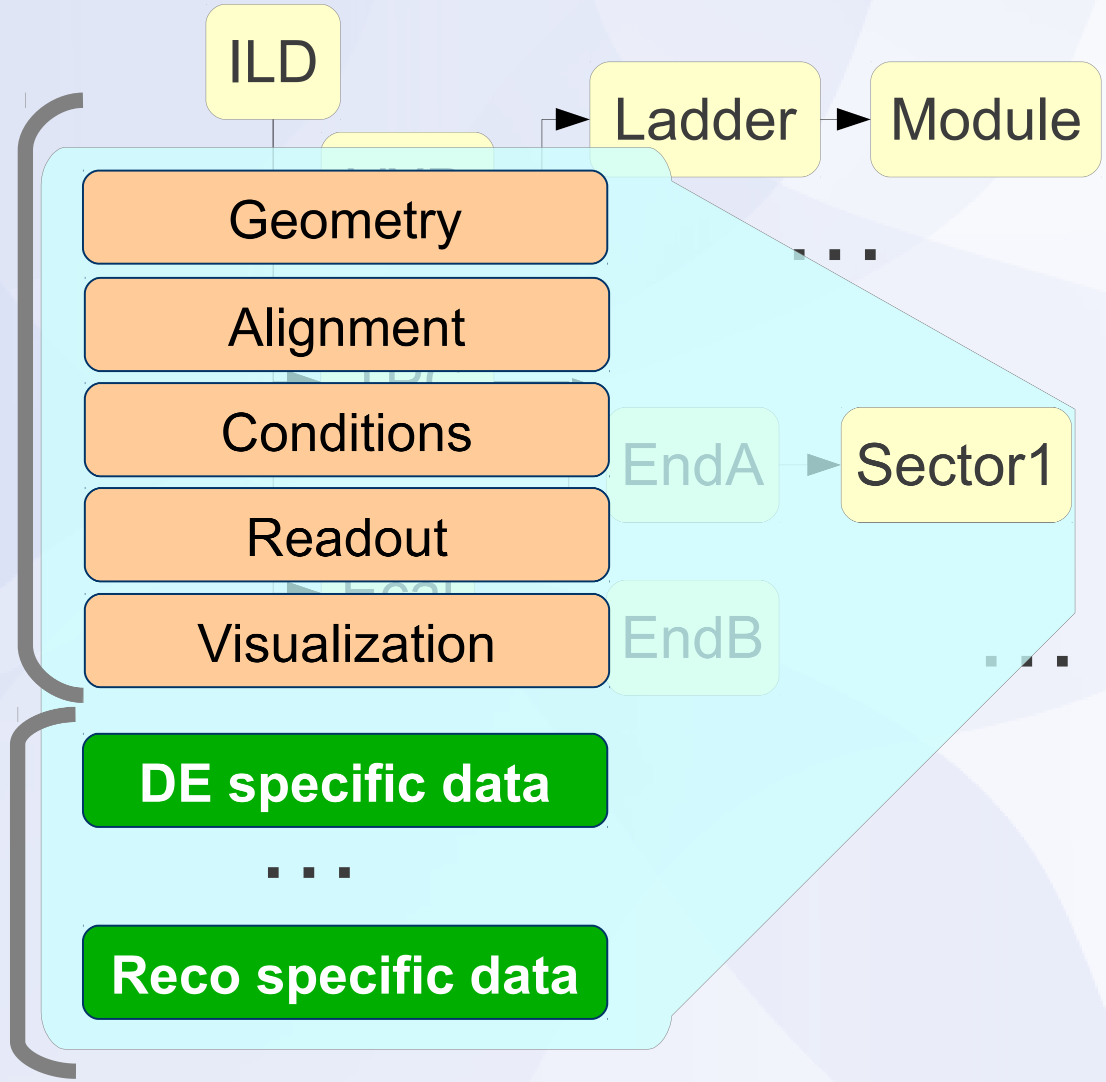
- **Provide flexible functionality to solve reconstruction and analysis problems**
- **Approach to deal with the “unforeseeable”**
- **Motivated by the fact that**
  Different use cases require different functionality
  - **Example: Optimization of coordinate transformations**
    local TPC hit to experiment coordinates
    => specialized data required
    (cache of precomputed results)
  - **Need to extend the detector element's data**

Implementation: Client Extensions

- **Functionality achieved by 'views'**
  - **Corollary of the design choice to separate ‘data’ from ‘behavior’**
  - **Possibility of many views based on the same data**
    - **All views share the same data __OR__**
    - **Same ‘data’ can be associated to different ‘behaviors’**
    - **All views are consistent**
  - **Public data describing a detector**
    - **User objects may be attached to data**
  - **Views are 'handles' to the data**
    - **Creating views is efficient and fast**
    - **Typically only a pointer needs to be copied**

Client Extensions

- **Default DetElement properties and data**
- **Added subdetector specific data**



Example: TPC (A.Muennich)

- Customize a DetElement object to support TPC specific questions and cached data
  - Data cache: save CPU using precomputed results
  - Facilitate TPC specific interface to clients
- Which is the mechanism behind ?
- How to implement such extensions ?

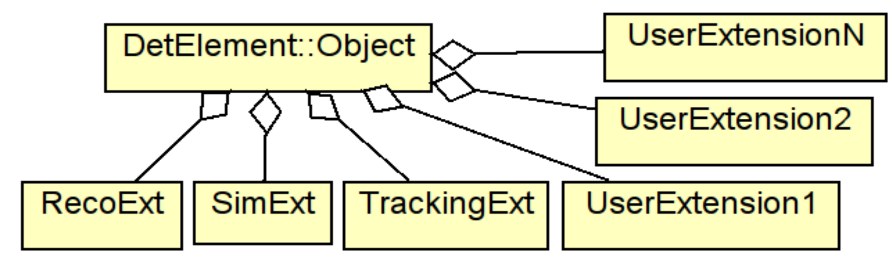
TPC – Detector Constructor

```
DetElement  module(part_det,m_nam,mdcount);
PadLayout*  pl = new RectangularPadRowLayout(module);
module.addExtension<PadLayout>(pl);
```

Detector element to extend

Extension object

Public type of the extension object
(May be ABC or interface like here)



- **Any number of extensions**
  - **Must differ by public type**
- **Adding an extension is possible anywhere**
  - **Extensions are not confined to detector constructor**
  - **Could also be somewhere in the reconstruction code**

TPC Module View

```
TPCModule(const Geometry::DetElement& e)
: Geometry::DetElement(e), padLayout(0)
{
  getExtension();
}

void TPCModule::getExtension() {
  padLayout = isValid() ? extension<PadLayout>() : 0;
}
```

DD4hep/DDExamples/ILDExDet/src/TPCModule.cpp

- **The PadLayout is retrieved from the detector element if present**
  - **Lookup relatively cheap, but not for free**
    Hence: extension pointer is cached
  - **Map lookup by type_info**

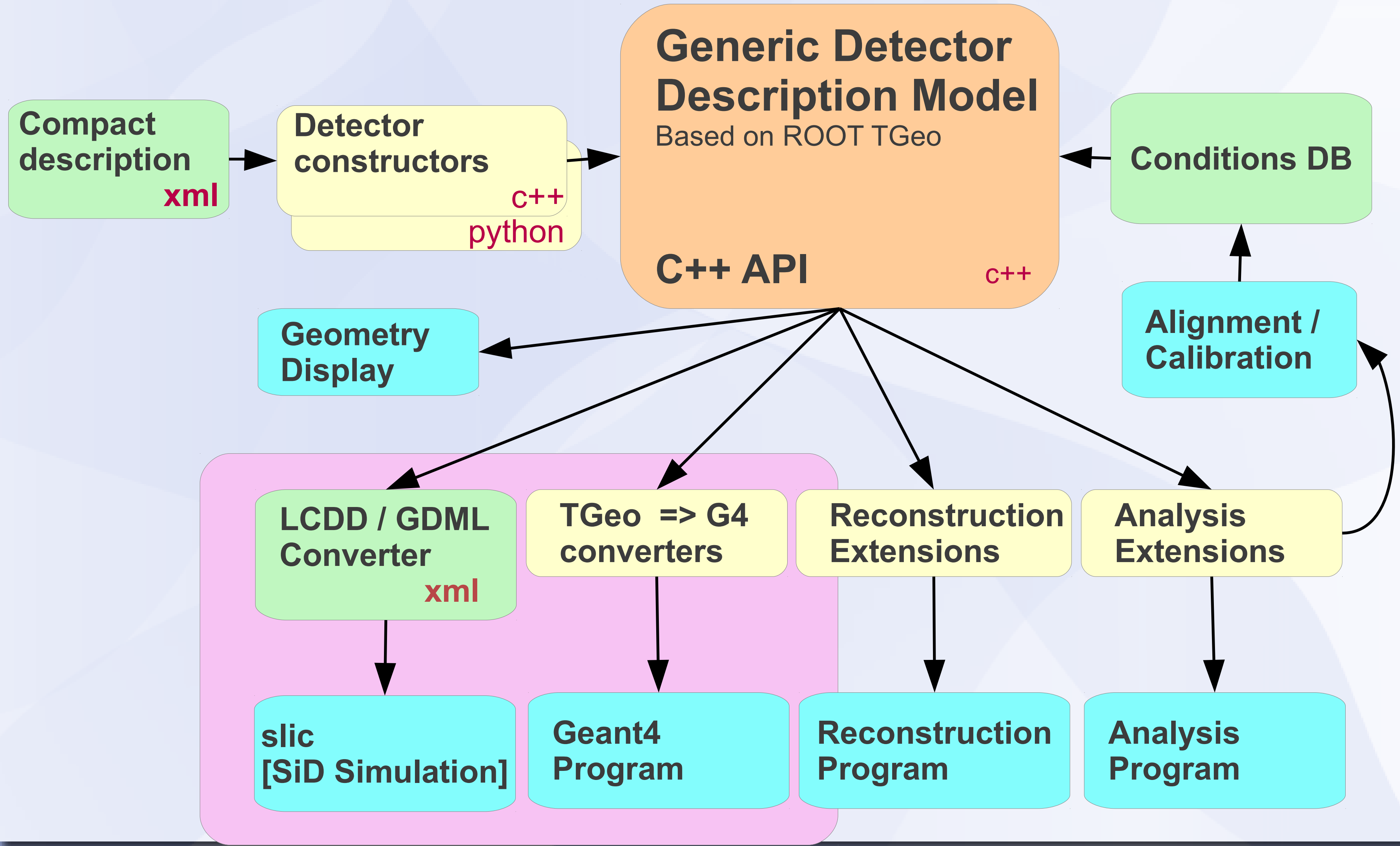
- Motivation and Goals
- Concepts and Design
- **Going to the 'real world'**

  => Out of 'lab conditions' towards clients
- Summary

End of Playing: Getting Mature

- Identified first 'massive' client
  - Linear Collider Detector community (ILD)
- Simulation framework (Mokka) at end of life
  - Replacement required for future detector studies
- Small study group established to verify feasibility
  - M.Frank, C.Graefe, A.Sailer, J.Strubbe (CERN/LCD)
- Additional complication: 2 frameworks
  - ILD: Mokka + Marlin
  - SiD: slic + java based reconstruction/analysis

DD4Hep - The Big Picture



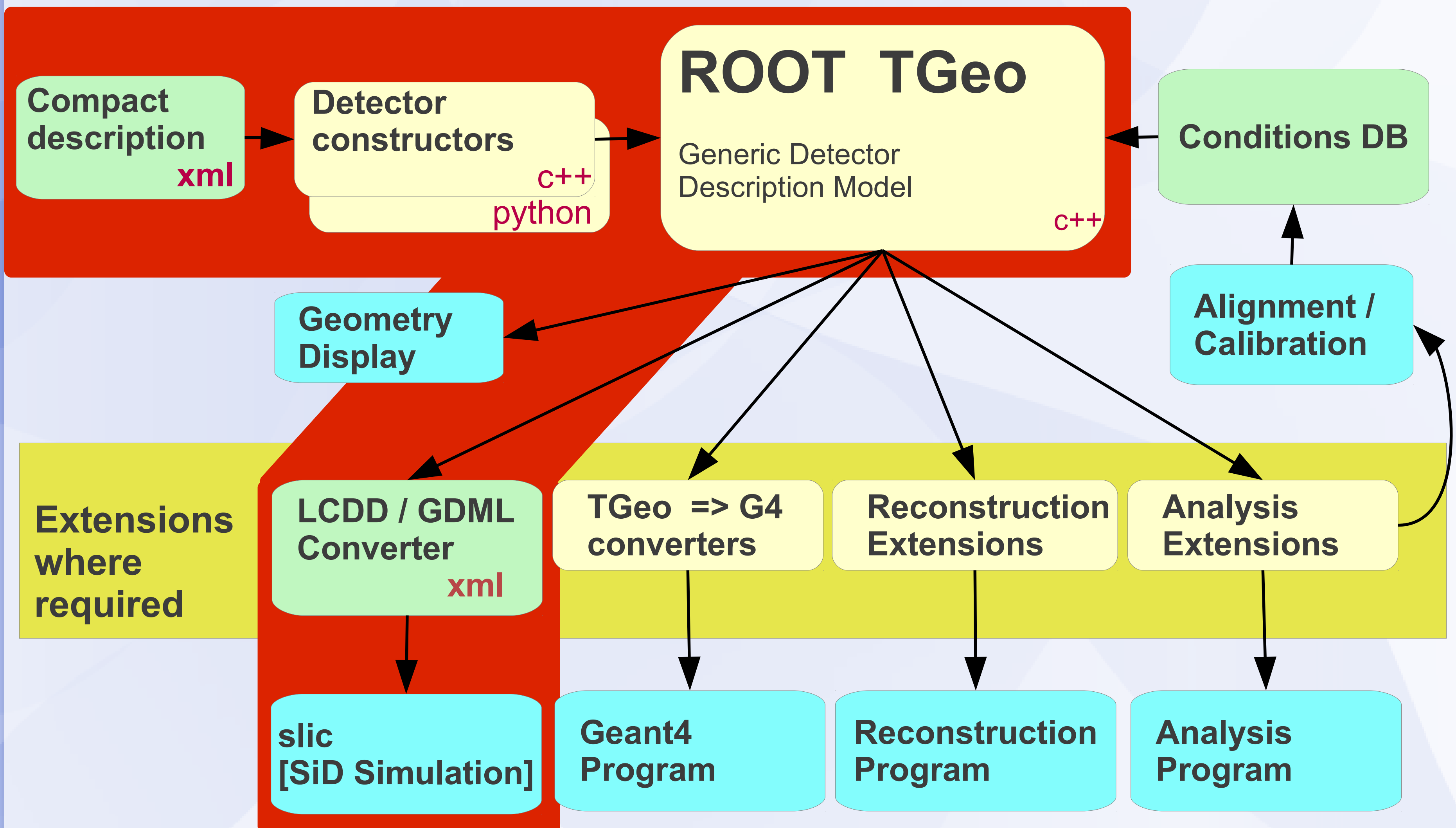
Geant 4 Gateway

- **Idea:**
  - walk through the geometry starting from "world"
  - convert the geometry from ROOT to Geant4
  - all runs by magic
- **Geometry is automatically converted to Geant4**
  - Materials, Solids, Limit sets, Regions
  - Logical volumes, Placed volumes / physical volumes
  - Fields
  - Sensitive detectors

In Memory Translation to Geant 4

- This processing chain was implemented
- Unfortunately the approach was a little bit naïve
  - Requires additional development of sensitive detectors
  - Couples detector 'construction' to reconstruction, MC truth and Hit production
- For ILD it was decided to benefit from 'slic' developments as simulation framework
  - Convert DD4hep geometry to LCDD notation (xml)

Next Step: Translate one Mokka model and feed simulation



Using the SiD Simulation with DD4hep

- The SiD simulation application 'slic' solves these issues with bravura
  - Collaboration with slic developers started at LCD software workshop in February (N.Graf et al.)
- Goal: Allow to flexibly attach Geant4 sensitive detectors to slic (plugin like mechanism)
- Requires a detector description in 'lcdd' format (XML) with some 'gdml' section

Slic and DD4hep: Status

- Sensitive detector work is ongoing
- Geometry converter was build and is part of the repository
  - Technique to generate such a file is similar to 'in-memory' conversion
  - Slic 'understands' the generated lcdd file (proof of concept)
- Formally the slic engine and the Geant4 event simulation is functional
  - If only existing sensitive detectors are required

Summary

- The DD4hep core was consolidated
- A extensible way to support flexibility is in place
- A functional path to event simulation is present
- Start to face 'real-world-conditions'
  - LCD as major client
  - Start to establish a common toolkit for simulation and reconstruction for linear collider detector studies

Questions and Answers