DD4hep Status

HEP detector description supporting the full experiment life cycle

- **Motivation and Goals**

  => Introduction / Reminders

- **Concepts and Design**

- **Going to the 'real world'**

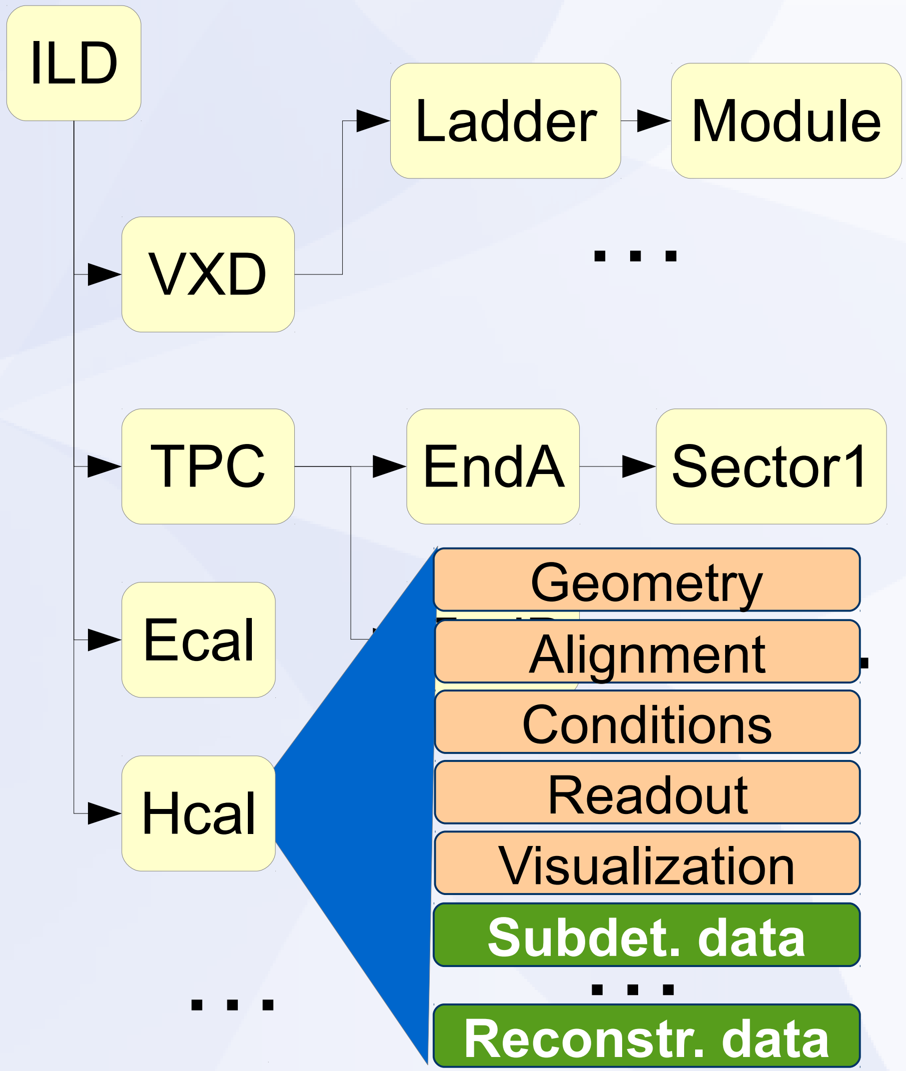
- **Summary**

Motivation and Goal

- Develop a detector description
  - For the full experiment life cycle
    - detector concept development, optimization
    - detector construction and operation
    - "Anticipate the unforeseen"
  - Consistent description, with single source, which supports
    - simulation, reconstruction, analysis
  - Full description, including
    - Geometry, readout, alignment, calibration etc.

What is Detector Description ?

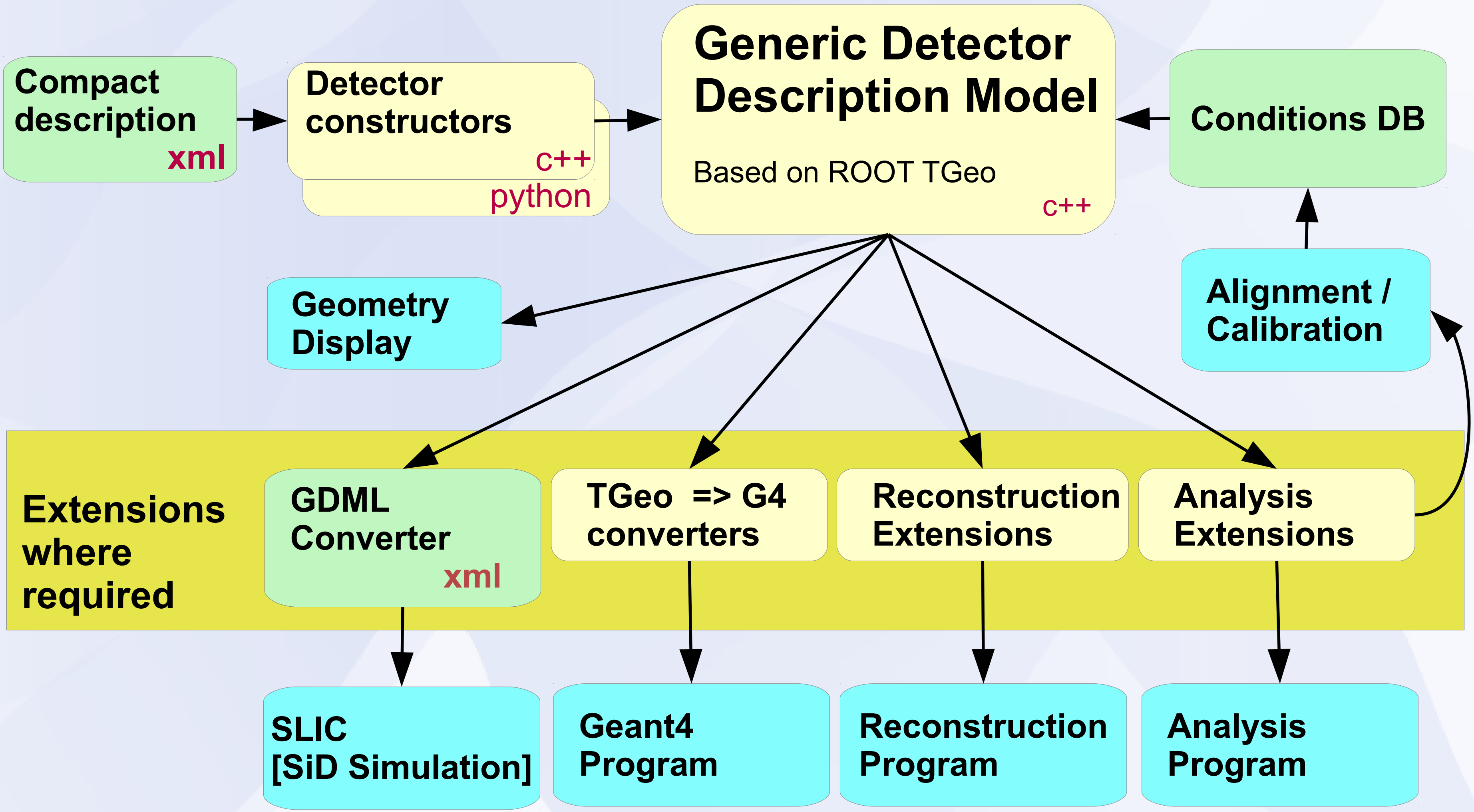
- **Description of a tree-like hierarchy of “detector elements”**
  - **Subdetectors or parts of subdetectors**
- **Detector Element describes**
  - **Geometry**
  - **Environmental conditons**
  - **Properties required to process event data**
  - **Optionally: experiment, sub-detector or activity specific data**



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

  => Reminder
- Going to the 'real world'
- Summary

DD4Hep - The Big Picture



- Motivation and Goals
- Concepts and Design
- **Status of Ongoing Work**
  - **Simulation**
  - **Reconstruction**
- Future work – next steps
- Summary

Simulation: Generic Geant 4 Gateway

(Markus Frank)

- Simulation =
  Geometry + Detector response + Physics
- Attempt for formalization of Geant4
  - Ideally: configuration without user code
  - Extensive usage of plugins
- DDG4
  - Bootstrap Geant4 from DD4hep in memory geometry
  - Configure using XML, python or Cint (ROOT 5)
  - Configure Geant4 actions, physics-list, processes, particle constructors, sensitive actions, I/O etc using module palette

Simulation: DDG4

(Markus Frank)

- Concept
  - Walk through the geometry starting from “world”
  - Convert the geometry from ROOT to Geant4
  - Instantiate sensitive detectors from palette [similar to palette of detector constructors]
  - Instantiate physics list, -constructors and -processes
  - Start simulating
- Processing chain is implemented
  - Validation in progress – time consuming process
- Palette of sensitive detectors
  - Is limited to some existing examples
  - Hope: palette gets populated by 'donations' of clients

Geant 4 Gateway using slic (1)

(Norman Graf, Jeremy Mccormick)

- CERN/LCD follow suggestion to benefit from the 'slic' simulation framework (SiD)
  - Convert DD4hep geometry to LCDD notation (xml)
  - GDML: materials, solids, limit sets, regions
    logical-, placed volumes / physical volumes

    + Fields

    + Sensitive detector information
- Collaboration with SiD/SLAC (N.Graf, J.McCormick)
  - Introduce new segmentations, identification of deficiencies
- F.G. successfully simulated ILD example det.

Detector Segmentations

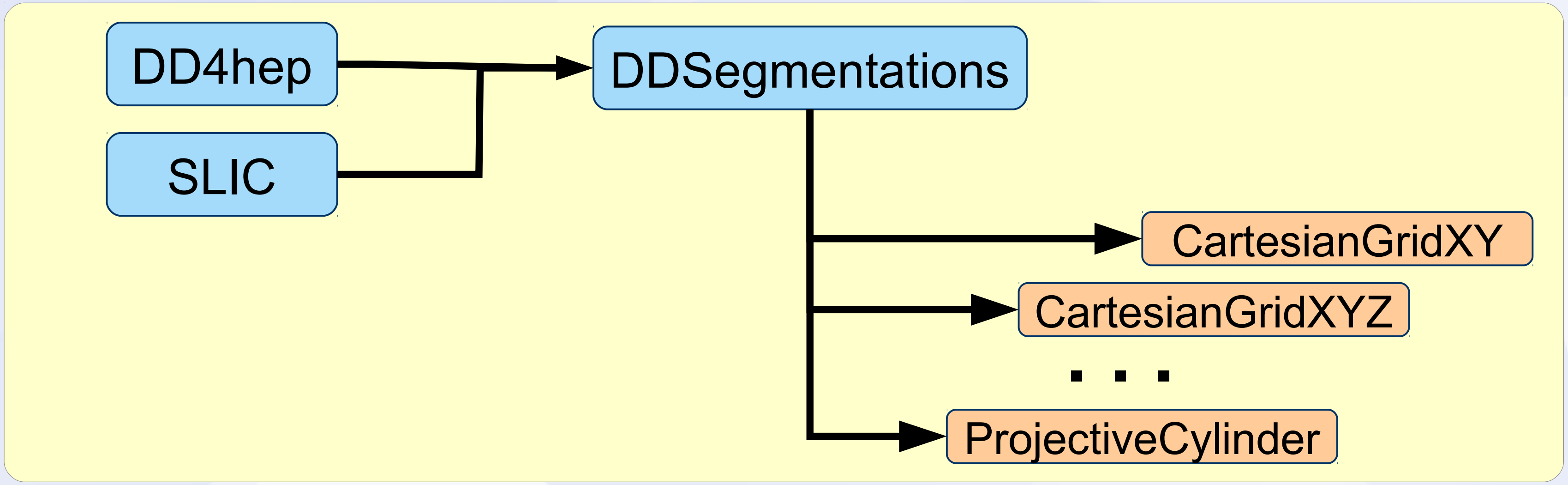
(Christian Grefe)

- Are the description of the sensitive detector regions
- Define encoding of the location of energy depositions (hits) in a simulation program
  - Encoding depends on the sensitive area(s)
    and detector technology
    Si Tracker: Side / Layer / Wafer / x-y local coordinates
  - Bi-directional
    volume ID in hit < == > full resolution of
    - detector/component
    - local coordinate
  - But there are also less obvious segmentations
    mostly projective segmentations (e.g. calo towers)

Detector Segmentations

(Christian Grefe)

- **Essential components to implement**
  - **Simulation programs**
  - **Digitization / Reconstruction applications**
  - **Bridge between the two worlds**
- **Shared, independent package**



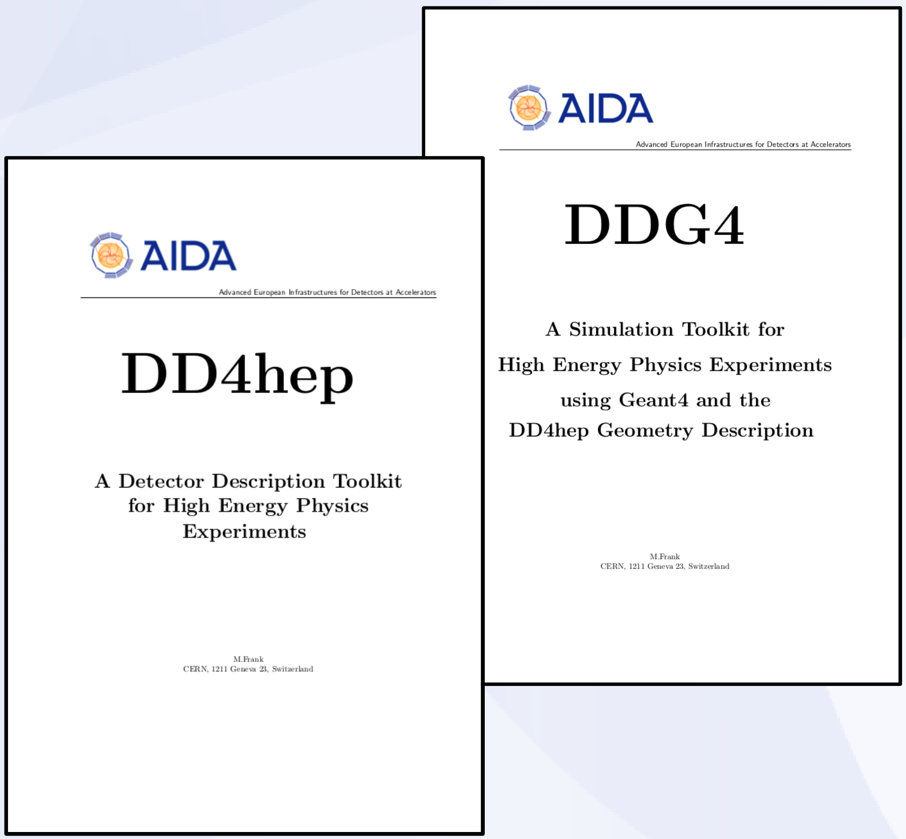
Reconstruction Interfaces

(Christian Grefe, Astrid Munich)

- Set of utilities to easy for users the retrieval of specialized geometrical questions
  - Work connected to segmentations
  - Transparently chain reoccurring call sequences
  - Precompute and cache information difficult or expensive to obtain but regularly needed
    [Implemented using extension mechanism]
- Astrid mimicked the GEAR-TPC model as in Marlin
  - Work done ~ year ago
  - Need to restart support for tracking detectors
- Christian was working on CALO interfaces
  - Layered detectors consisting of segmented active modules

Documentation

- http://aidasoft.web.cern.ch/DD4hep
- https://svnsrv.desy.de/basic/aidasoft/DD4hep/trunk
- In the svn doc area
  - DD4hepManual.pdf
    core API: 37 pages
  - DDG4Manual.pdf
    simulation: 25 pages
  - First issues
- Doxygen documentation



- Motivation and Goals
- Concepts and Design
- Implementation
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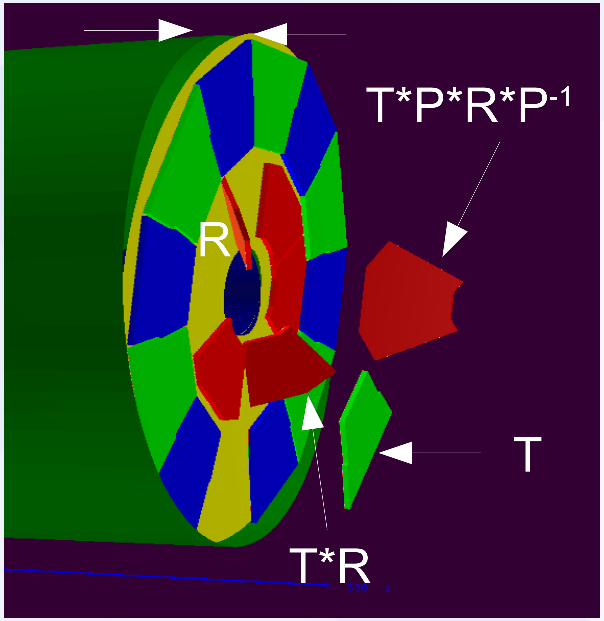
Alignment and Detector Conditions

(Markus Frank)

- **Less an issue during the experiment design phase**
  - **Less important for the communities designing detectors**
  - **Selling argument for existing (e.g. LHC) experiments**
- **Important topic to interpret event data from existing ('real') detectors**
  - **Necessity to deal with imperfections**
    - **Geometry => (Mis)Alignment**
  - **Anomalous conditions**
    - **Pressures, temperatures**
      => Gains, refractive indices
      => Contractions, expansions



Other Upcoming Work [2014]

- Validate the two simulation paths
  - Verify the translation mechanisms
  - Help new clients to use the infrastructure
- Extend, validate and support work on reconstruction interfaces
  - Currently concrete only for calorimetry
  - Tracking support starting (=> see talk of F.Gaede)
- Must come to gears with Mokka replacement
  - ILD simulation program: support will disappear
  - Test of concept done. Bulk driver translations missing
  - Item was on the list already last year
- Support for new clients

DD4hep Clients

- **Linear Collider Detector community (ILD+SiD)**
  - **Work group established several months ago**
    - **M.Frank[1], F.Gaede[2], C.Graefe[1], N.Graf[3], J. McCormick[3], N.Nikiforou[1], C.Rosemann[2], A.Sailer[1]**

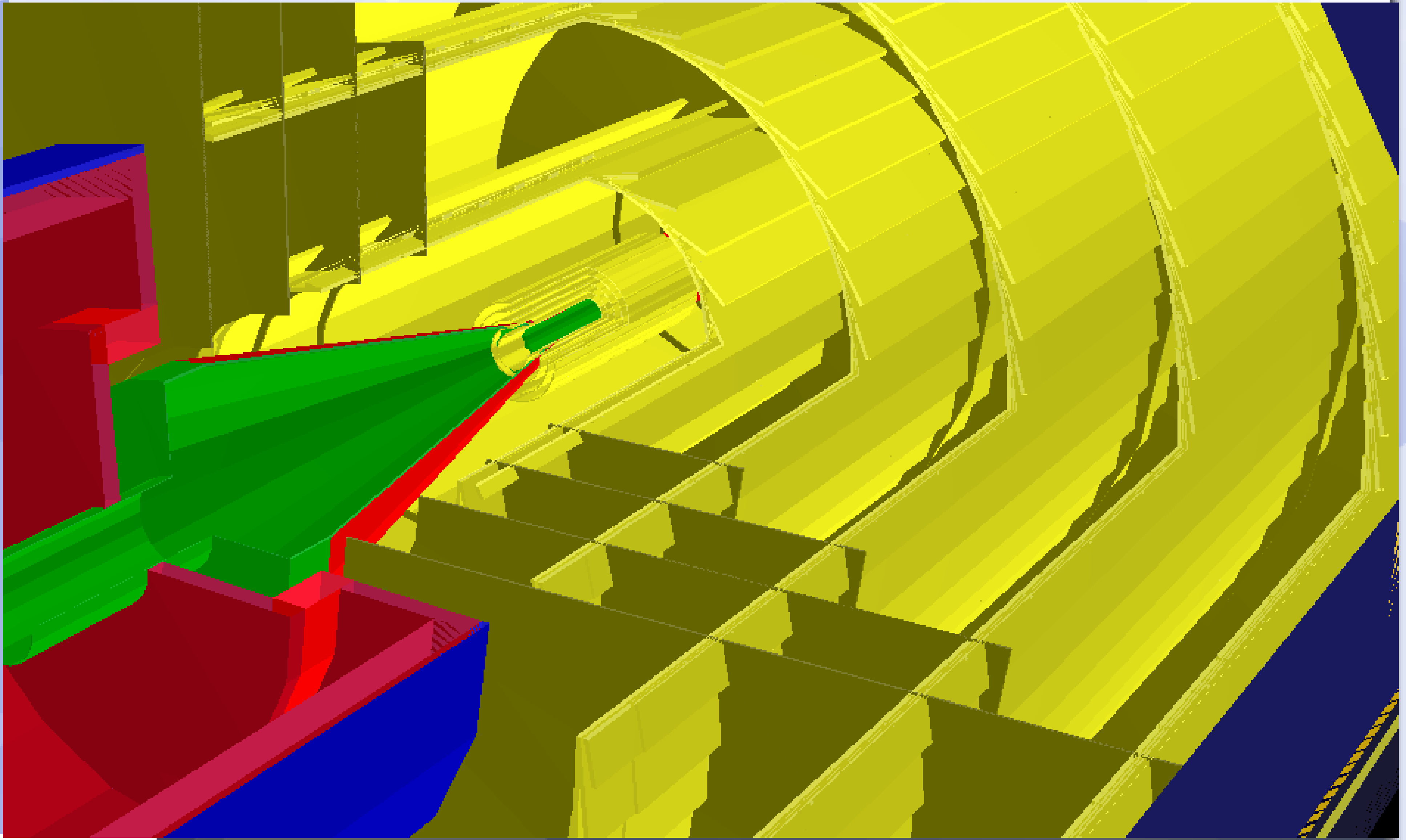
- **Clients evaluating DD4hep**
  - **LheC contact: P. Kotzka[2]**
  - **FHC contact: C. Helsens[1]**
  - **LHCb contact: M. Clemencic[1]**

[1] CERN [2] Desy [3] SLAC

Summary

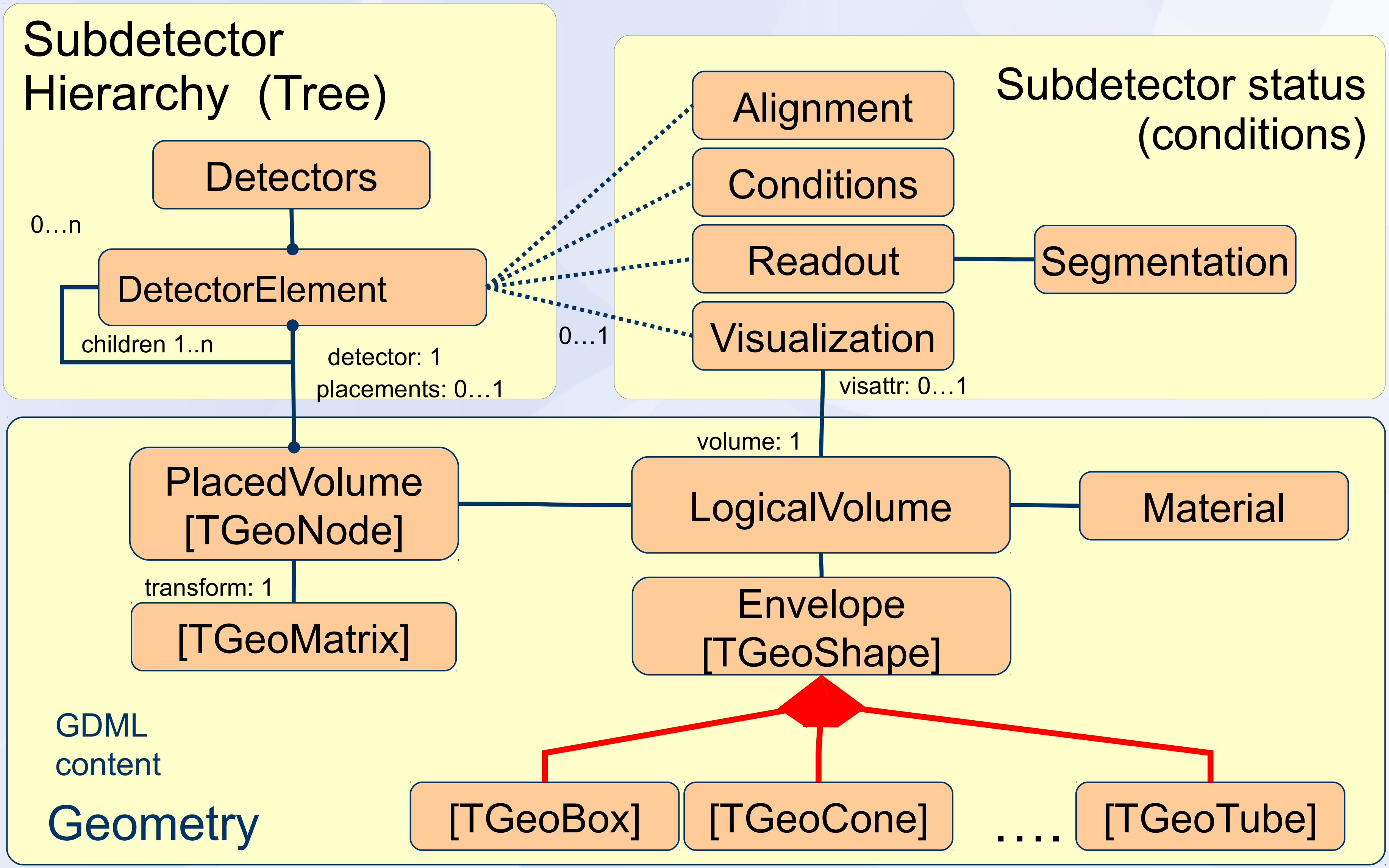
- **The DD4hep core was consolidated**
- **On the track for simulation framework**
  - **2 pathes for ILD, generic framework else**
- **Support and developments event data processing beyond simulation ongoing**
- **We see interest from the HEP community**
  - **Clients want to leverage development effort to common infrastructure projects (LheC, FHC, LHCb)**

Questions and Answers



Backup slides

Implementation: Geometry



DDG4 Configuration Example (Incomplete)

Geant4 event action setup

Geant4 generator action setup

Sensitive detector setup

```
<sequences>
  <sequence name="Geant4EventActionSequence/EventAction">
    <properties Control="true"/>
    <action name="Geant4Output2ROOT/RootOutput">
      <properties Control="true" Output="simple.root"/>
    </action>
  </sequence>
  <sequence name="Geant4GeneratorActionSequence/GeneratorAction">
    <action name="Geant4ParticleGun/Gun">
      <properties .... />
    </action>
  </sequence>
  <sequence sd="SiVertexBarrel" type="Geant4SensDetActionSequence">
    <properties Control="true"/>
    <filter name="GeantinoRejector"/>
    <filter name="EnergyDepositMinimumCut"/>
    <action name="Geant4SimpleTrackerAction/SiVertexBarrelHandler">
      <properties Control="true"/>
    </action>
  </sequence>
  ....
</sequences>
```

Instance type from palette

Instance name for reference

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

Non Transparent Design Decisions

- Things which look of small importance
  => but have significant impact on users
- Units: TGeo: GeV/cm/sec [CKM] Geant4: MeV/mm/ns
  - Consequently apply units
    TGeoBBox(10*tgeo::mm, 10*tgeo::mm, 10*tgeo::mm)
    G4Box(10*CLHEP::mm, 10*CLHEP::mm, 10*CLHEP::mm)
  - To get raw number always divide (both TGeo, Geant4):
    g4Box->GetXHlafLength()/CLHEP::mm
- Transformations
  - CLHEP is a dead end (support ?)
  - Use ROOT::Math vectors & matrices to build geometries
    very similar (but not identical!)
    started from same code bases, then deviated
  - Used by most LHC experiments

Porting Mokka Drivers

(Frank Gaede, Andre Sailer, Shaojun Lu)

- Aim is to investigate the translation of Mokka drivers 'with minimal effort' (Model: ILD_o1_v05)
  - Create compact xml file from Mokka database
    - Serves as input to DD4hep driver
  - Translate G4 in driver calls to DD4hep calls
    - G4Shape, G4LogicalVolume, ... => Shape, Volume, …
    - Created 'detector constructor' (~driver)
    - Leave as much unchanged as possible
  - Experience: VXD, SIT, TPC, SET, beamcal and HCAL barrel
    - Tracker driver simple, calorimeters much more complicated
    - Parameters change in Mokka at run-time,...
    - Automation without brain is difficult, and will be hard to maintain
    - Will need some policy how to avoid parameter anarchy

Porting existing Mokka Drivers