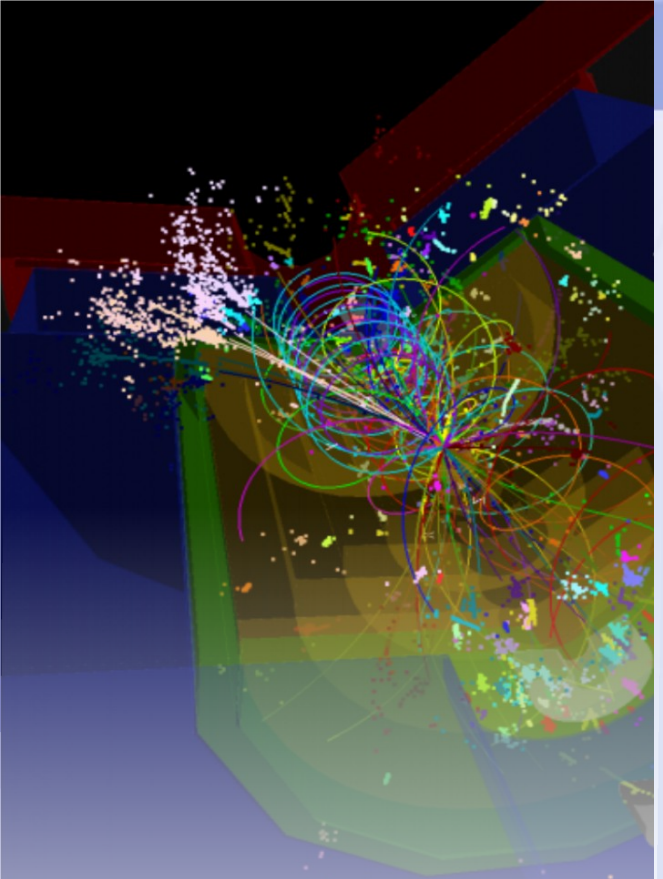


DD4hep Status

HEP detector description supporting the full experiment life cycle

M.Frank, F.Gaede, N.Nikiforou, A.Sailer

- **Motivation and Goals**

  => Introduction / Reminders

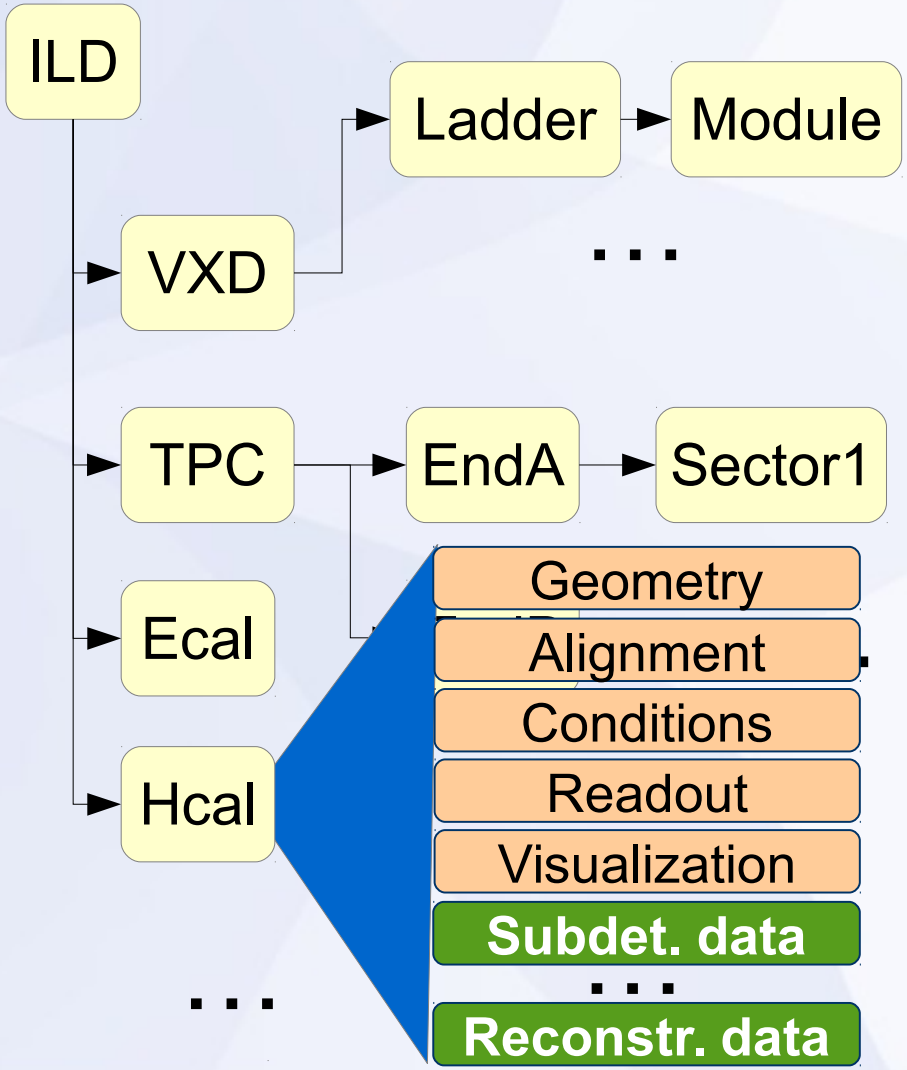
- **Concepts and Design**
- **Going to the 'real world'**
- **Summary**

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, single source of information, which supports**
    - **simulation, reconstruction, analysis**
  - **Full description, including**
    - **Geometry, readout, alignment, calibration etc.**

What is Detector Description ?

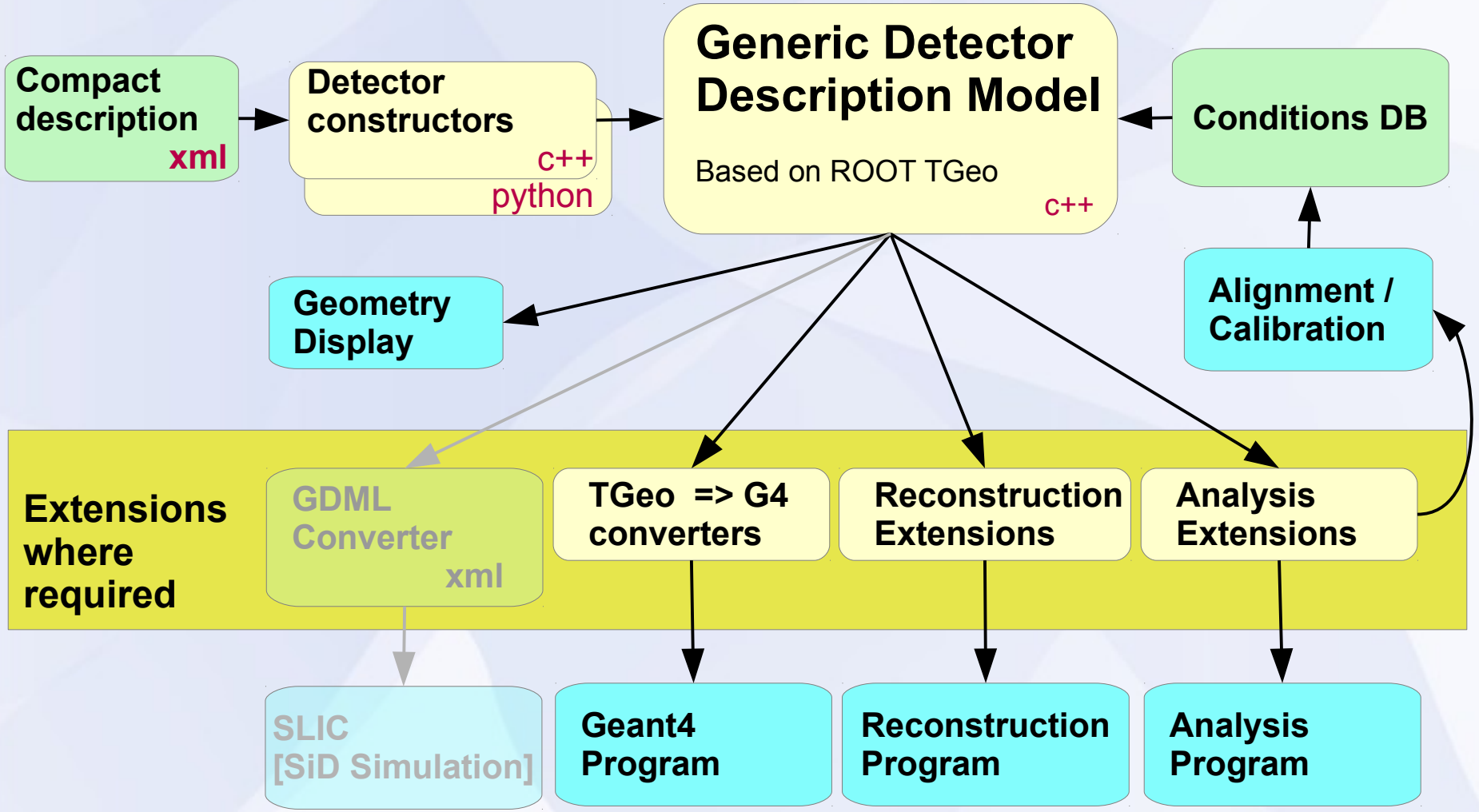
- **Description of a tree-like hierarchy of 'detector elements'**
  - **Subdetectors or parts of subdetectors**
- **Detector Element describes**
  - **Geometry**
  - **Environmental conditons**
  - **Properties required to process event data**
  - **Optionally: experiment, sub-detector or activity specific 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**
  - **Need to reshuffle work-list on demand of stake-holders:**
    - **Support for simulation**
    - **Support for reconstruction**
    - **Standard detector palette: DDDetectors**
  - **Alignment: DDAlign**
- Future work – next steps
- Summary

Simulation: Generic Geant 4 Gateway

- **Simulation =**
  Geometry + Detector response + Physics
- **Attempt for formalization of Geant4**
  - **Ideally: configuration without extra (C++) user code**
- **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

- Concept
  - Walk through the geometry and convert on the fly from ROOT to Geant4
  - Instantiate sensitive detectors from palette [similar to palette of detector constructors]
  - Instantiate physics list, -constructors and -processes
  - Start simulating
- Palette of sensitive detectors
  - Basic concepts present
- Processing chain is implemented
  - Validation in progress – time consuming process

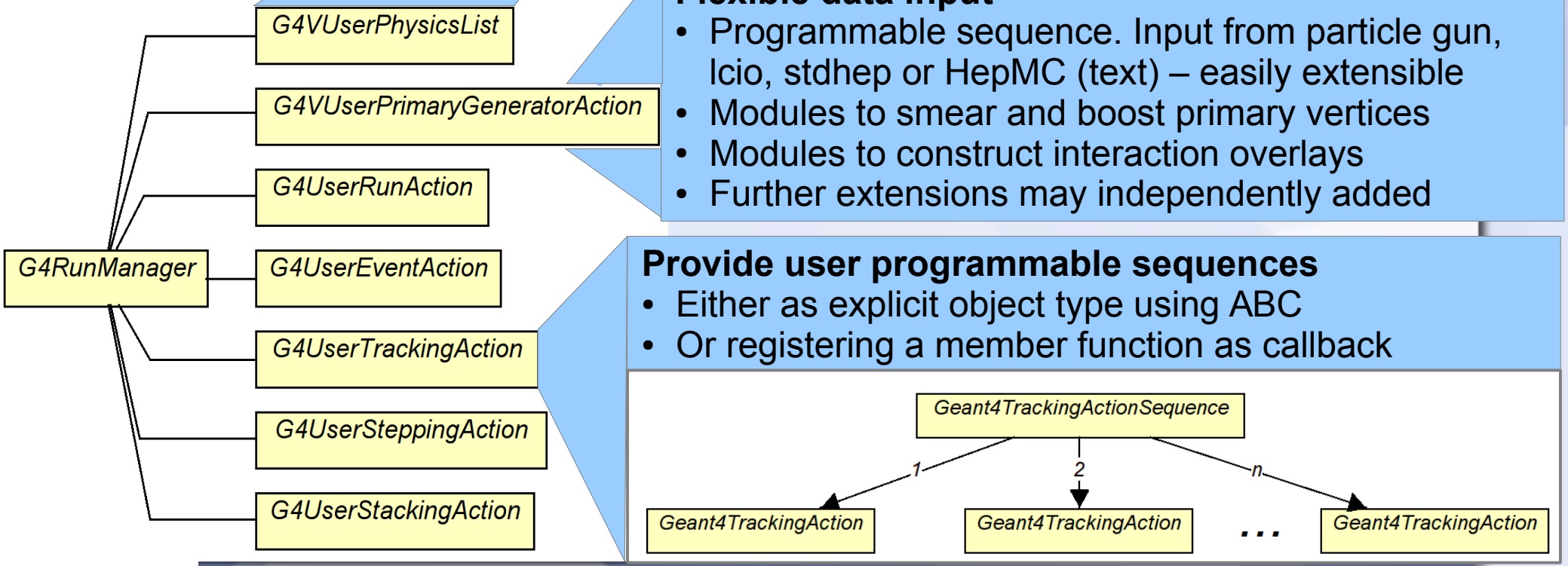
DDG4 Design Illustration

Flexible configuration

Flexible definition of the physics list
- Define particles, processes, physics constructors or use/extend predefined physics lists

Flexible data input
- Programmable sequence. Input from particle gun, lcio, stdhep or HepMC (text) – easily extensible
- Modules to smear and boost primary vertices
- Modules to construct interaction overlays
- Further extensions may independently added

Provide user programmable sequences
- Either as explicit object type using ABC
- Or registering a member function as callback



Standard Detector Palette (DDDetectors)

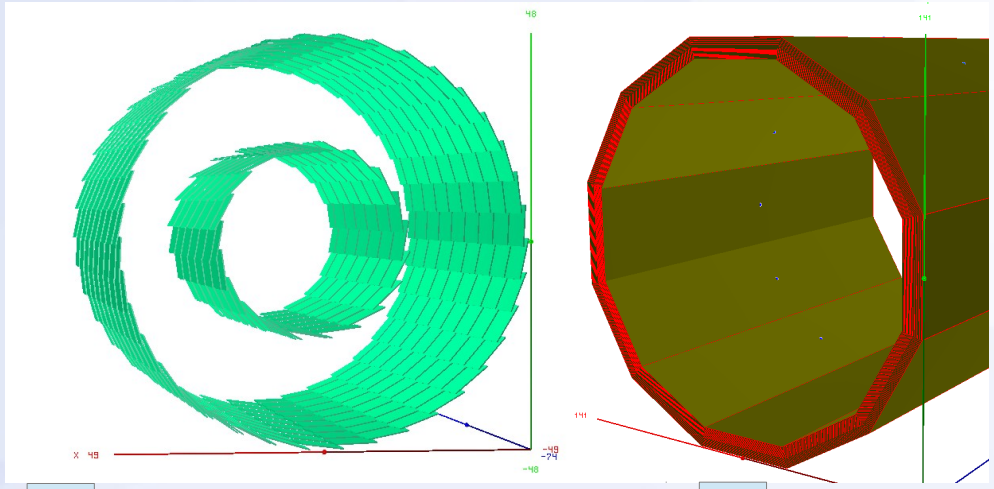
- Mostly arose from the SiD model
  - Layer based detectors
  - Tracker barrel & endcap
  - Several calorimeter constructs
- Partially with measurement surfaces

  (see also talk by F. Gaede)
- Plugin mechanism to enhance detector elements
  - Neat mechanism to attach user defined optional data

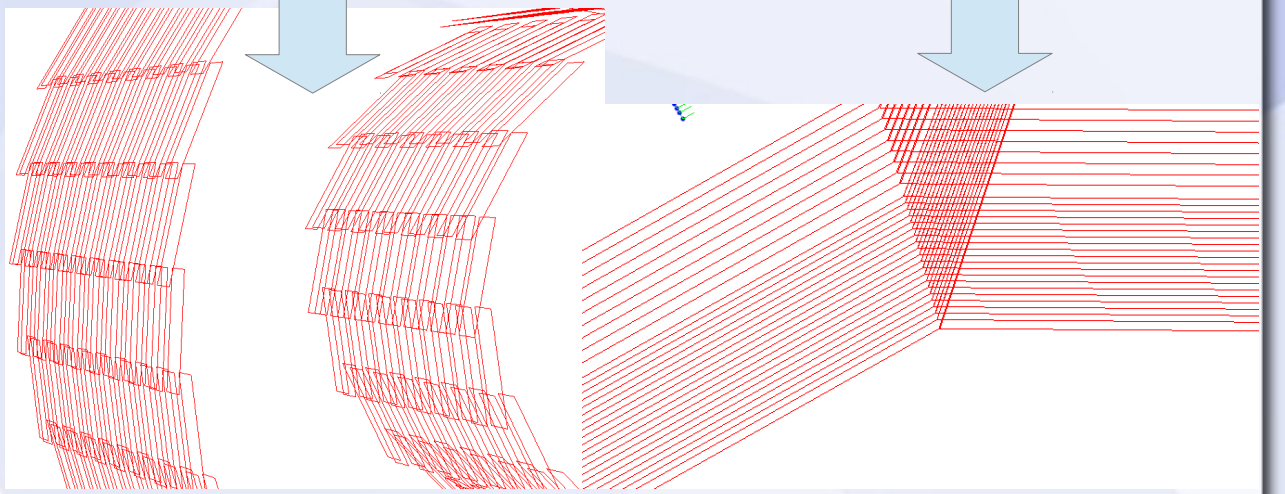
    => Proof that 'anticipate the unforeseen' works
  - NOT intrusive to detector constructors
  - Flexible definition of the measurement surface

Extension Plugins for DDDetectors

- **Example**
  - **Tracking surfaces**
  - **Apply plug-ins based on detector patterns**

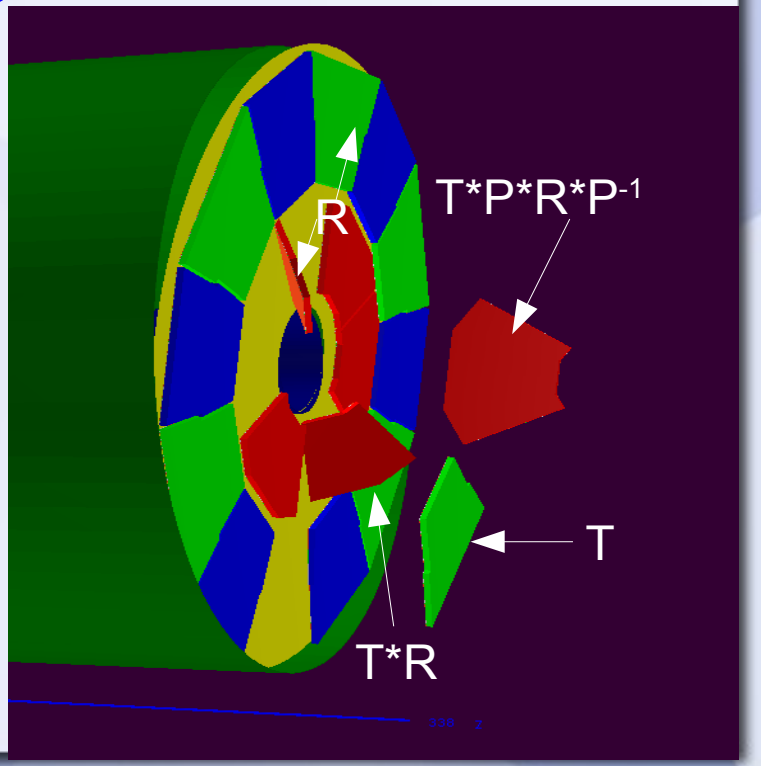


- **Same plug-in, different detectors, common Pattern:**
  'layered modules' build of one or several 'slices'



Alignment and Detector Conditions

- **Fundamental functionality to interpret event data from existing ('real') detectors**
  - **Selling argument for existing (e.g. LHC) experiments**
  - **Necessity to handle imperfections**
    - **Geometry => (Mis)Alignment**
  - **Anomalous conditions**
    - **Pressures, temperatures**
      => Gains, refractive indices
      => Contractions, expansions



Alignment and Detector Conditions (2)

- **Functionality to handle the displacement of volumes is implemented**
- **Input / Output from xml is provided**

But:

To fully use this functionality it must be combined with validity interval related data

Alignment and Detector Conditions (3)

- **Validity interval related information is** not handled **by the alignment support package**
  - **Should not be handled for good reasons:**

    This is typically called the conditions database
  - **Scope is much broader than only alignment**
    - **Environmental conditions etc.**
- **Will extend the DD4hep toolkit to provide such functionality**
  - **'DDCond' – last extension of the DD4hep toolkit**
  - **Then apply alignment operations using data therein...**

Alignment and Detector Conditions (3)

- **Validity interval related information is** not handled **by the alignment support package**
  - **...and should also not be handle**
  - **This is typically called the conditions database**

- **Will extend the DD4hep toolkit to provide such functionality**
  - **'DDCond' – last extension of the DD4hep toolkit**
  - **Then apply alignment operations using data therein...**

Documentation

- http://aidasoft.web.cern.ch/DD4hep
- https://svnsrv.desy.de/basic/aidasoft/DD4hep/trunk
- In the svn doc area
  - DD4hep manual
    core API: 39 pages
  - DDG4 manual
    simulation: 40 pages
  - DDAlign manual
    alignment support
    15 pages
  - DDRec manual (F.Gaede)
  - First issues, to be completed
- Doxygen documentation

Toolkit Clients

Known client designs

- SiD: geometry conversion to DD4hep: M. Frank
  original design: J. McCormick
- ILD: F. Gaede et al., ported complete Mokka model ILD_o1_v05
- CLICdp: starting new design after CDR
- FCC-eh: P. Kostka et al.
- FCC-hh: starting
- LHCb: investigations by technical student

DD4hep	DDG4
X	X
X	X
(X)	
X	X
X	
X	

DD4hep core rather stable
DDG4 simulation under validation

Toolkit Clients (2)

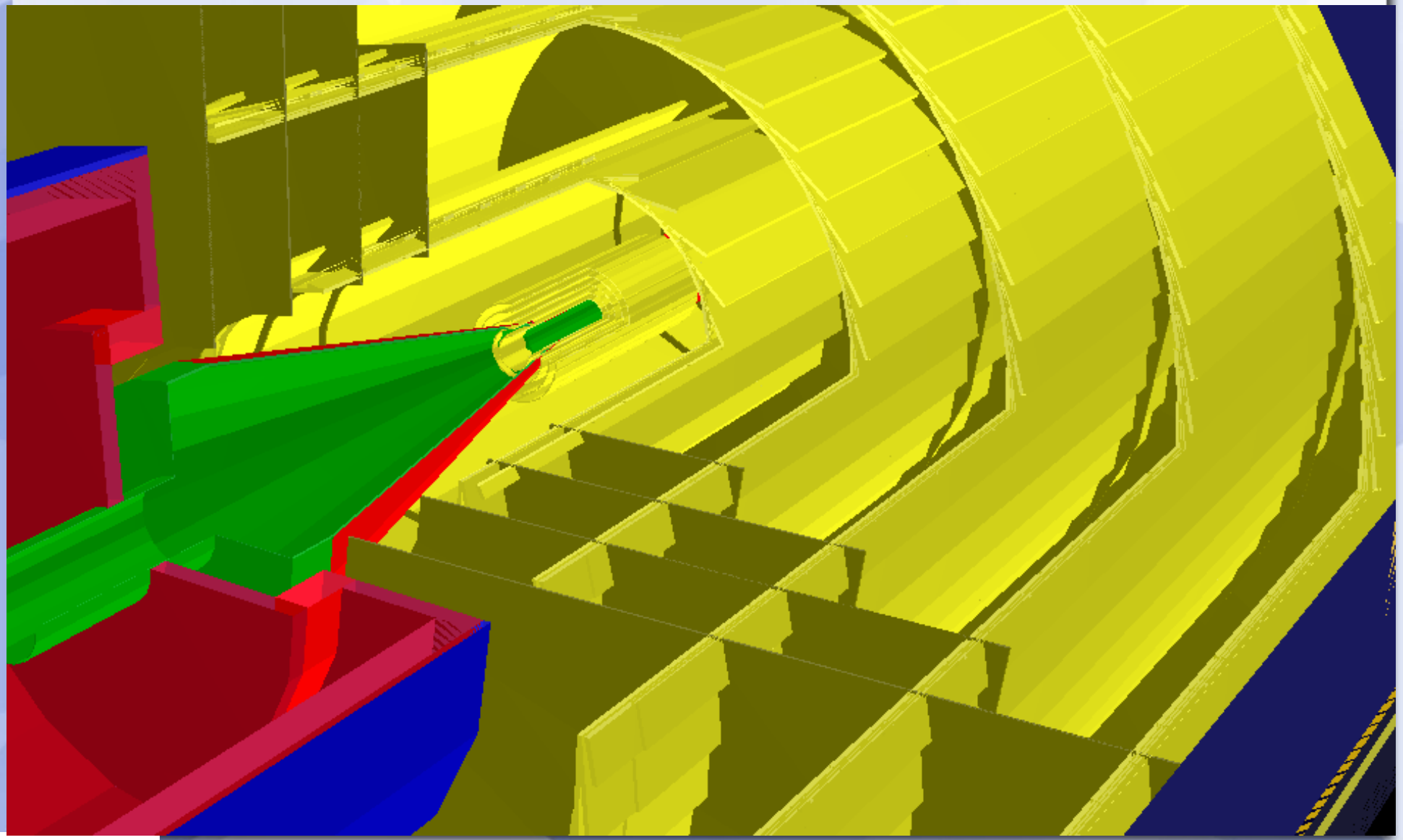
- Design and implementation of simulation framework DDG4 finished
  - Validation ongoing: ILD, FCC-eh, CLICdp starting
- Possible new requirement (FCC)
  - Support for fast simulation
  - Parametrized simulation
  - Heterogenous simulation
    - Full, fast and parametrized simulation in parallel depending on subdetector or subdetector region

Summary and Outlook

- The DD4hep toolkit (+extensions) start to become accepted: Client validation has started
- Basic DD4hep API essentially stable
- Simulation kit DDG4 being validated
- Reconstruction extensions start to appear: DDRec
- Detector palette DDDetectors established
  - Hope of user contributions
- Alignment support implemented
  - Requires conditions support for full functionality

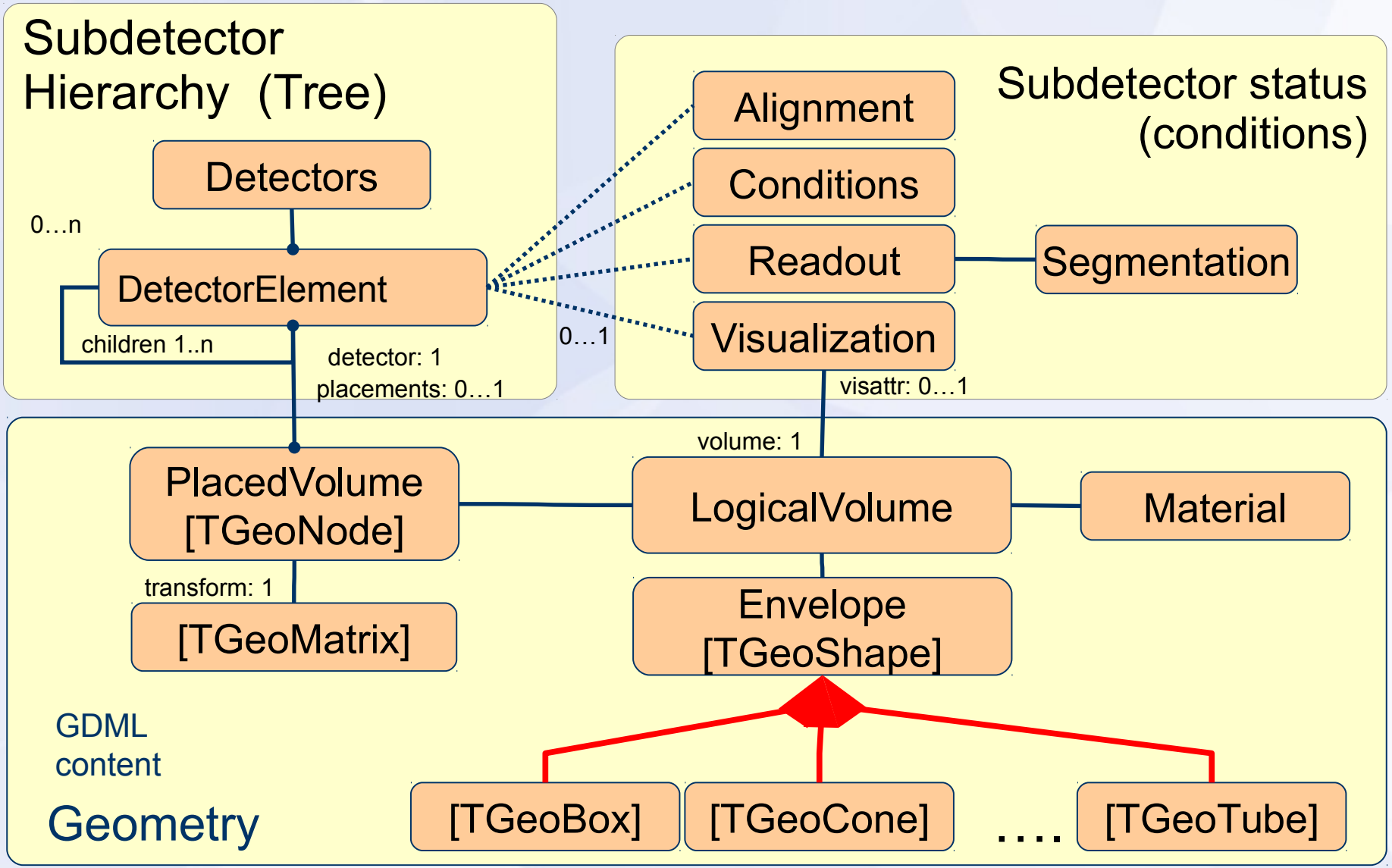
  => DDCond: extension to be developed
- Validate, verify, enhance and document

Questions and Answers



Backup slides

Implementation: Geometry



DDG4 Configuration Example (Incomplete)

```
<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>
```

Geant4 event action setup

Geant4 generator action setup

Sensitive detector setup

Instance type from palette

Instance name for reference

Complete Mokka model ILD_o1_v05 ported

(F.Gaede, L.Shaojun)

- **VXD, FTD, SIT, TPC, SET, beam pipe**
- **Ecal, Hcal, Yoke, Beamcal, Lcal, LHcal**
- services
- two generic SensitiveDetectors