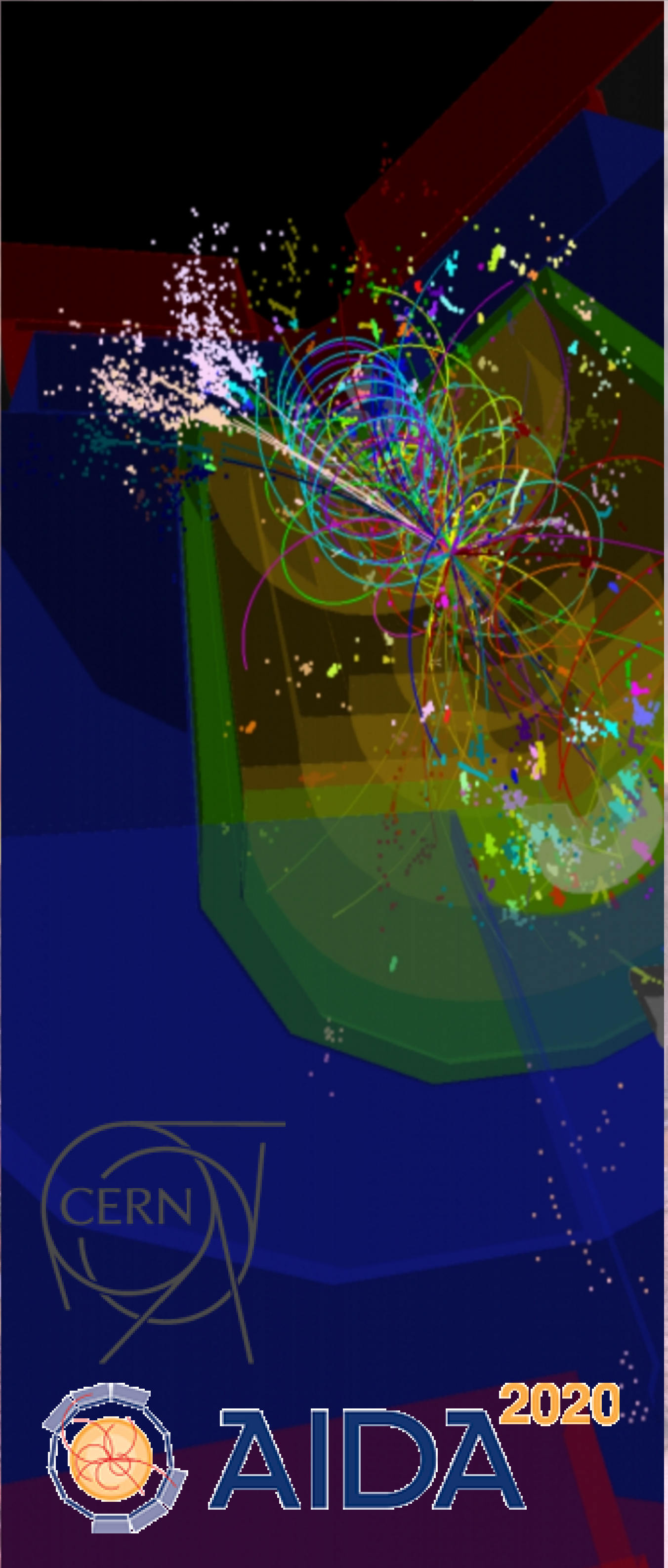


DD4hep Status

HEP detector description supporting the full experiment life cycle

M.Frank, F.Gaede, M.Petric, A.Sailer

- **Motivation and Goals**

  => Introduction / Reminders

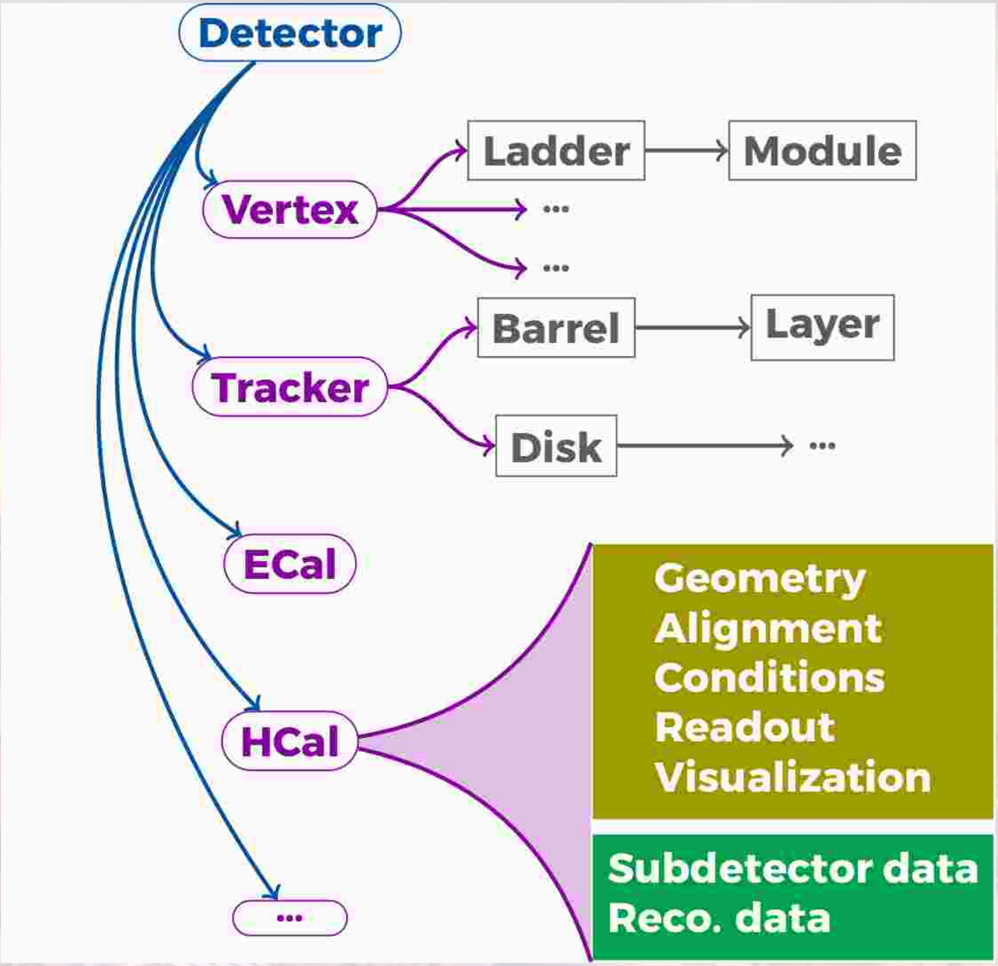
- **Simulation**
- **Conditions and Alignment**
- **Conditions use case study**
- **Miscellaneous**
- **Summary**

Motivation and Goal

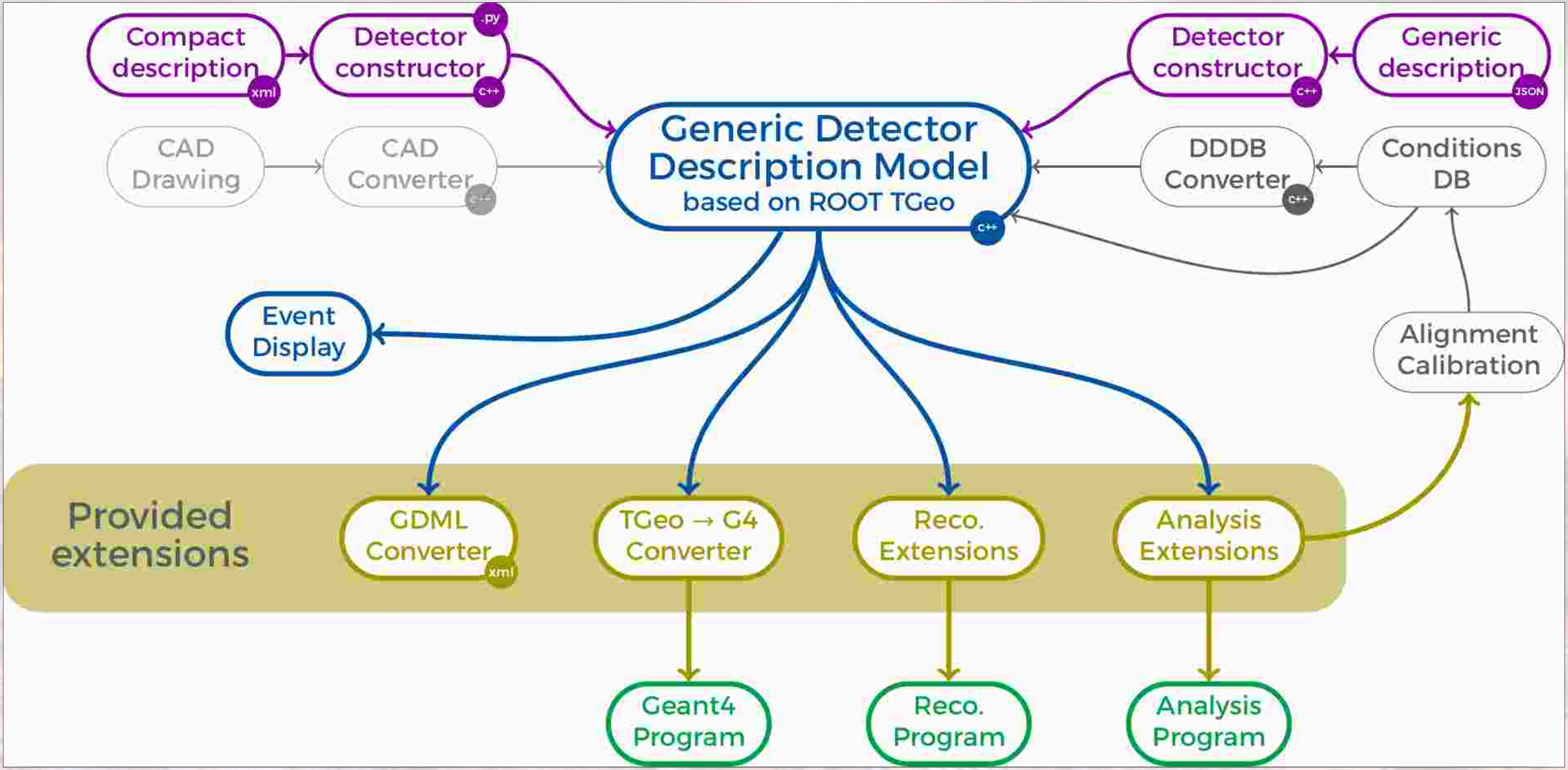
- **Develop a detector description**
  - **For the full experiment life cycle**
    - **detector concept development, optimization**
    - **detector construction and operation**
    - **“Anticipate the unforeseen”**
  - **Consistent description, with single source, which supports**
    - **simulation, 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

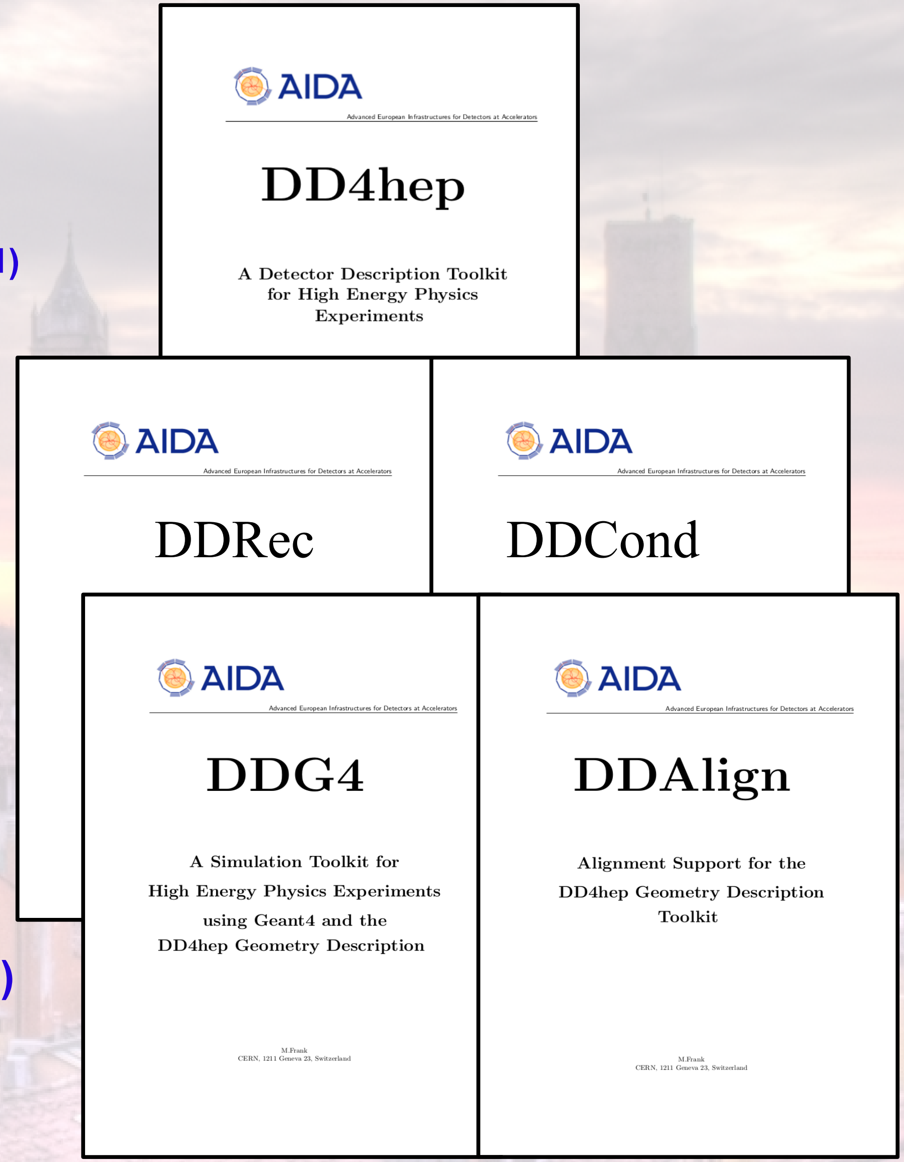


DD4Hep - The Big Picture



Saga in 5 Episodes: Sub-packages

- **DD4hep – basics/core** (1)
- **DDG4 – Simulation using Geant4** (1)
- **DDRec – Reconstruction supp.** (2)
- **DDCond – Detector conditions** (1,3)
- **DDAlign – Alignment support** (1,3)


AIDA
Advanced European Infrastructures for Detectors at Accelerators
DD4hep
A Detector Description Toolkit for High Energy Physics Experiments

AIDA
Advanced European Infrastructures for Detectors at Accelerators
DDRec

AIDA
Advanced European Infrastructures for Detectors at Accelerators
DDCond

AIDA
Advanced European Infrastructures for Detectors at Accelerators
DDG4
A Simulation Toolkit for High Energy Physics Experiments using Geant4 and the DD4hep Geometry Description
M.Frank
CERN, 1211 Geneva 23, Switzerland

AIDA
Advanced European Infrastructures for Detectors at Accelerators
DDAlign
Alignment Support for the DD4hep Geometry Description Toolkit
M.Frank
CERN, 1211 Geneva 23, Switzerland

(1) Bug-fixes and maintenance
(2) See presentation of F. Gaede (WP3, Task 3.6)
(3) Work since start of AIDA^{2020}

- Motivation and Goals

  => Introduction / Reminders

- **Simulation**
- Conditions and Alignment
- Conditions use case study
- Miscellaneous
- Summary

Simulation: DDG4

- **Simulation = Geometry +**
  Detector response + Physics
- **Mature status**
  - **Eventual bug fixes, smaller improvements**
  - **Phase of constant re-validation**
- **CLICdp implementation was presented at CHEP 2017 (M. Petric)**
- **Deliverable 3.6**
  Submitted in time March 2018

GEANT4 BASED SIMULATION TOOLKIT DDG4

Grant Agreement No: 654168

AIDA-2020

Advanced European Infrastructures for Detectors at Accelerators
Horizon 2020 Research Infrastructures project AIDA-2020

[redacted]

GEANT4 BASED SIMULATION TOOLKIT DDG4

DELIVERABLE: D 3.6

Document identifier:	AIDA2020-D3.6
Due date of deliverable:	End of Month 35 (March 2018)
Justification for delay:	[if delays occurred]
Report release date:	28/02/2018
Work package:	WP3: Advanced Software
Lead beneficiary:	1 - CERN
Document status:	Draft

Abstract:

Simulation of particles interacting with the detector in high energy physics experiments is of crucial importance during the whole life-time of an experiment, from the planning phase to the physics analyses. DD4hep offers a single source of geometry information and the DDG4 toolkit based on DD4hep provides users with the ability to simulate their detector response in the Geant4 framework. DDG4 offers its users access to all Geant4 entry points via a flexible plug-in system, it comes with a comprehensive set of plug-ins that address common simulation requirements. This report details the design principles, implementation, and existing plug-ins for DDG4 and describes configuration possibilities for DDG4 based applications.

DDG4 in Production

- Fully deployed for CLICdp in DIRAC
  - For every detector study (now ~14) centrally generated:

    ≈ 200k Z^{o} —> qq (uds)

    ≈ 20k Signal events (Z^{o} —> tt, Z^{o} —> H+x, etc.)

    + private productions by team members
  - Used as input for ~ 20 physics analyses and detector studies
- Eagerly awaiting ILC mass production
  - Should have started beginning of the year
  - Client confirmation that concept works at large scale

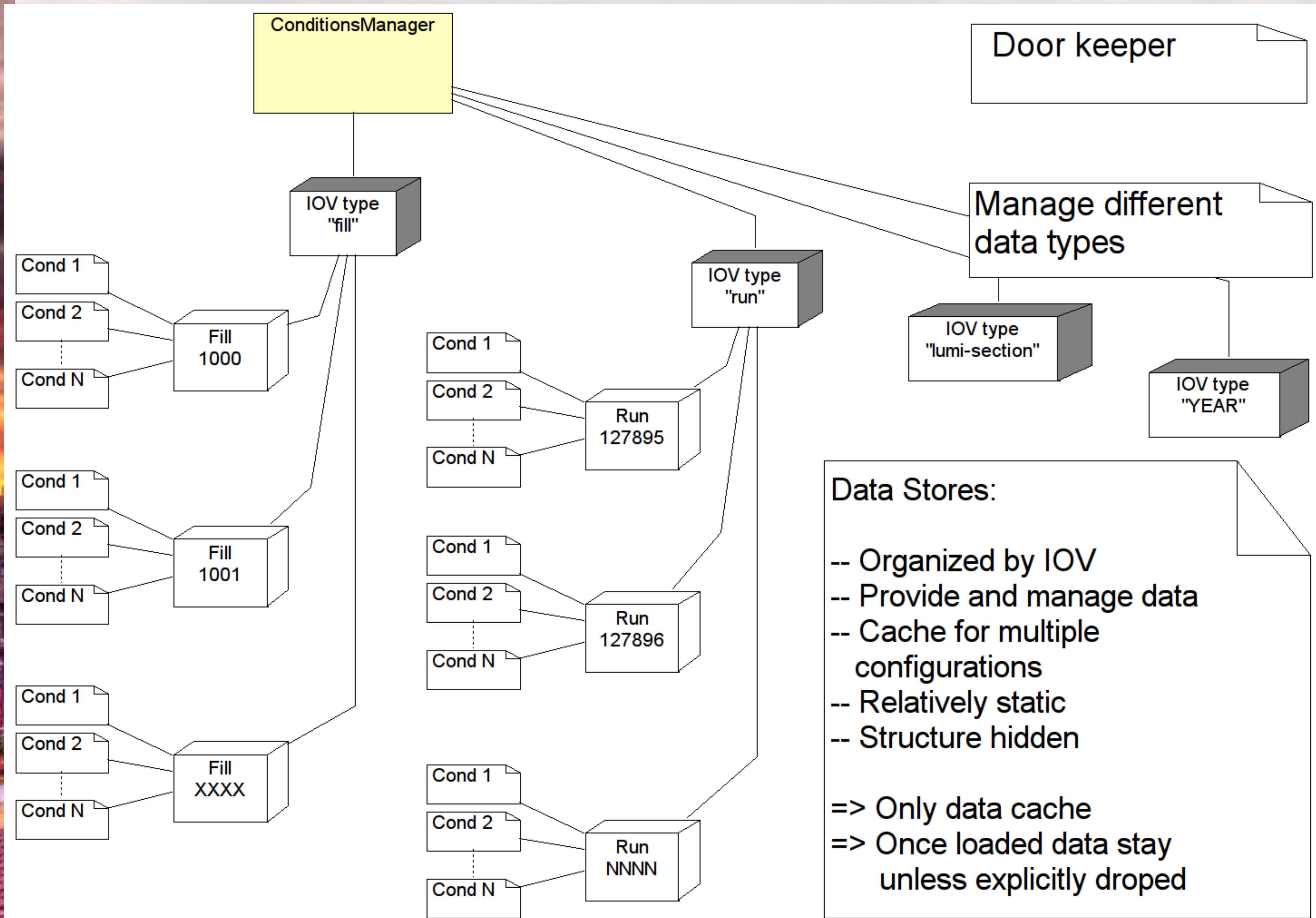
- Motivation and Goals
- Simulation
- **Conditions and Alignments**

  => DDCond, DDAlign
- Conditions use Case Study
- Miscellaneous
- Summary

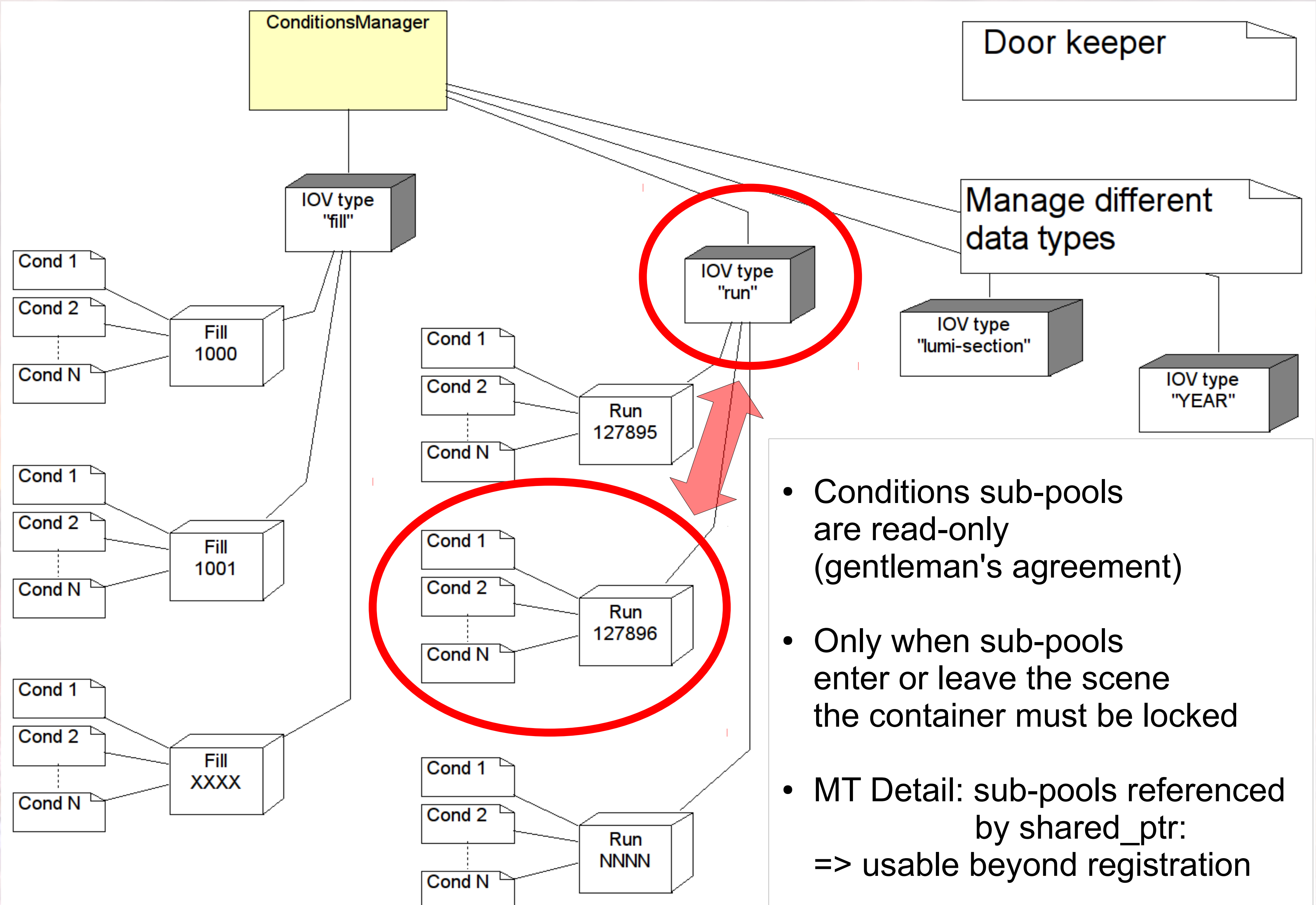
DDCond: Conditions Data

- Time dependent data necessary to process the detector response [of particle collisions]
  - slowly changing: every run O(1h), lumi section O(10min) ...
  - multiple conditions change in batches: require discipline
  - conditions may be the result of computation(s)
- DDCond deals with the management of these data
  - Efficient and fast, if used according to design ideas
  - Manage resources
  - Supports multi threading by design
    Well define locking points
  - Cache where necessary but no more
- But all this got presented already last time ...

DDCond: The Data Cache

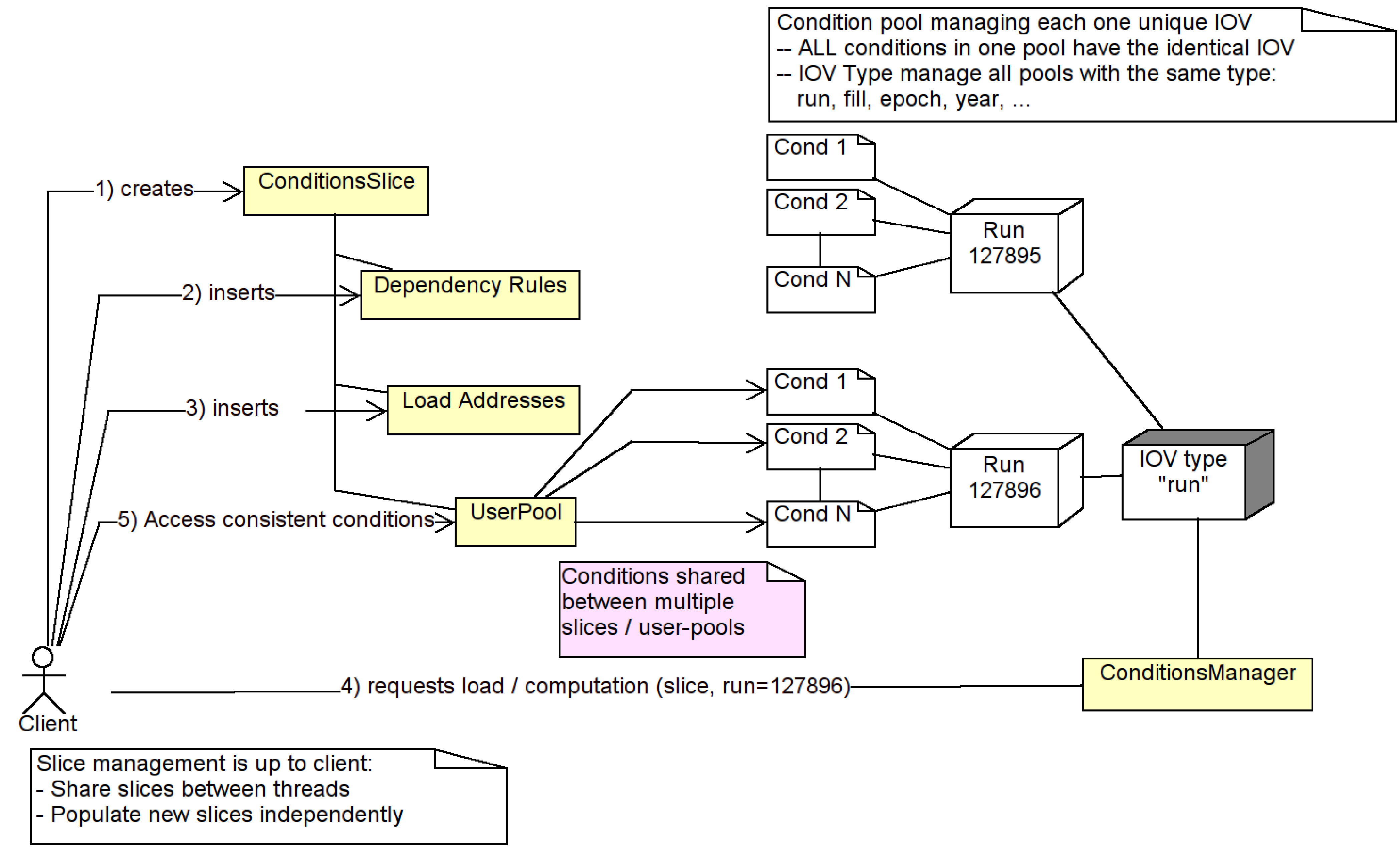


DDCond: The Data Cache



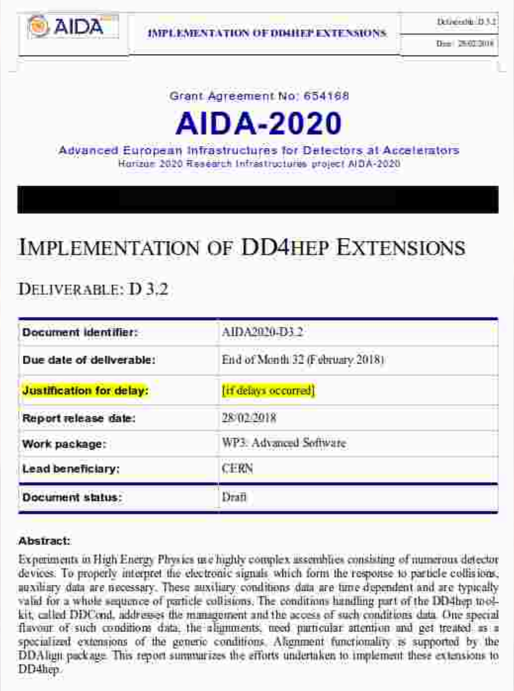
- Conditions sub-pools are read-only (gentleman's agreement)
- Only when sub-pools enter or leave the scene the container must be locked
- MT Detail: sub-pools referenced by shared_ptr:
  => usable beyond registration

DDCond: IOV Data Projection



DDCond: Status

- Described functionality is implemented
  - Tested with LHCb conditions data
- Accomplished implementation deliverable D3.2, Submitted February 2018
  - Includes alignment support to handle geometry imperferctions
- Local Alignments are derived conditions
  - Convert Δ parameters (translation, rotation, pivot-point) to transformations to world or reference point



AIDA | IMPLEMENTATION OF DD4HEP EXTENSIONS | Deliverable: D3.2 / Date: 28/02/2018

Grant Agreement No: 654168

AIDA-2020

Advanced European Infrastructures for Detectors at Accelerators

Horizon 2020 Research Infrastructures project AIDA-2020

IMPLEMENTATION OF DD4HEP EXTENSIONS

DELIVERABLE: D 3.2

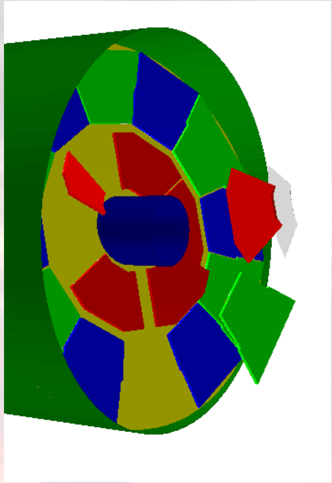
Document identifier:	AIDA2020-D3.2
Due date of deliverable:	End of Month 32 (February 2018)
Justification for delay:	[if delays occurred]
Report release date:	28/02/2018
Work package:	WP3: Advanced Software
Lead beneficiary:	CERN
Document status:	Draft

Abstract:

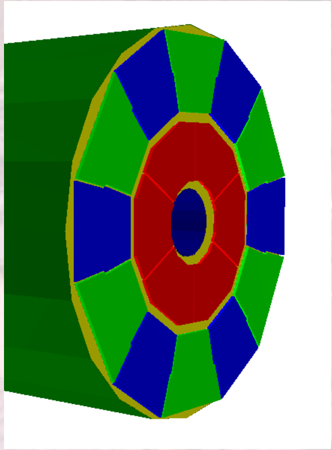
Experiments in High Energy Physics are highly complex assemblies consisting of numerous detector devices. To properly interpret the electronic signals which form the response to particle collisions, auxiliary data are necessary. These auxiliary conditions data are time dependent and are typically valid for a whole sequence of particle collisions. The conditions handling part of the DD4hep tool-kit, called DDCond, addresses the management and the access of such conditions data. One special flavour of such conditions data, the alignments, need particular attention and get treated as a specialized extensions of the generic conditions. Alignment functionality is supported by the DDAlign package. This report summarizes the efforts undertaken to implement these extensions to DD4hep.

DDAlign: Global and Local Alignments

- **Global alignment corrections**
  - Physically alters geometry with intrinsic support by ROOT
  - Transition between geometries by construction not multi-threaded
  - Possibility to simulate misaligned geometries

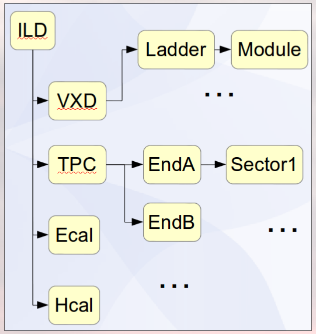


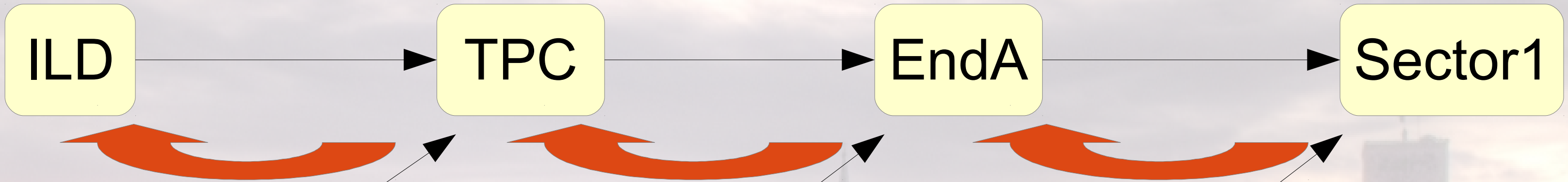
- **Local alignment corrections**
  - Geometry stays intact (either ideal or globally aligned)
  - Multi-threading supported, multiple versions
  - Local alignment corrections are conditions
  - Provide matrices from ideal geometry to world e.g. to adjust hit positions



- **Both supported and implemented**

Local Alignment: Apply Δ - Parameters





$$Tr^{World}_{Sec\,1} = Tr^{World}_{EndA} \times \left(Tr^{Parent(EndA)}_{Sec\,1} + \Delta_{Sec\,1} \right)$$

$$Tr^{World}_{EndA} = Tr^{World}_{TPC} \times \left(Tr^{Parent(TPC)}_{EndA} + \Delta_{EndA} \right)$$

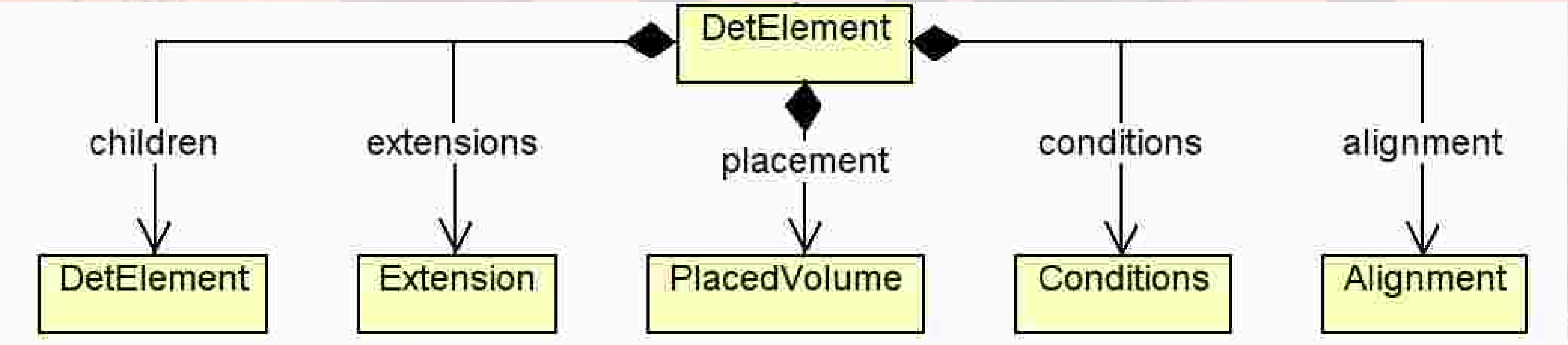
$$Tr^{World}_{TPC} = Tr^{World}_{ILD} \times \left(Tr^{Parent(ILD)}_{TPC} + \Delta_{TPC} \right)$$

- Trickle-up the hierarchy and compute the matrices the most effective way with re-use of intermediate results
- Math verified (and corrected) by C. Burr

- Motivation and Goals
- Simulation
- Conditions and Alignments
- **Conditions Use Case Study**
  - **VELO (upgrade) detector elements**
- Miscellaneous
- Summary

Get Fingers Dirty: LHCb Velo Detector

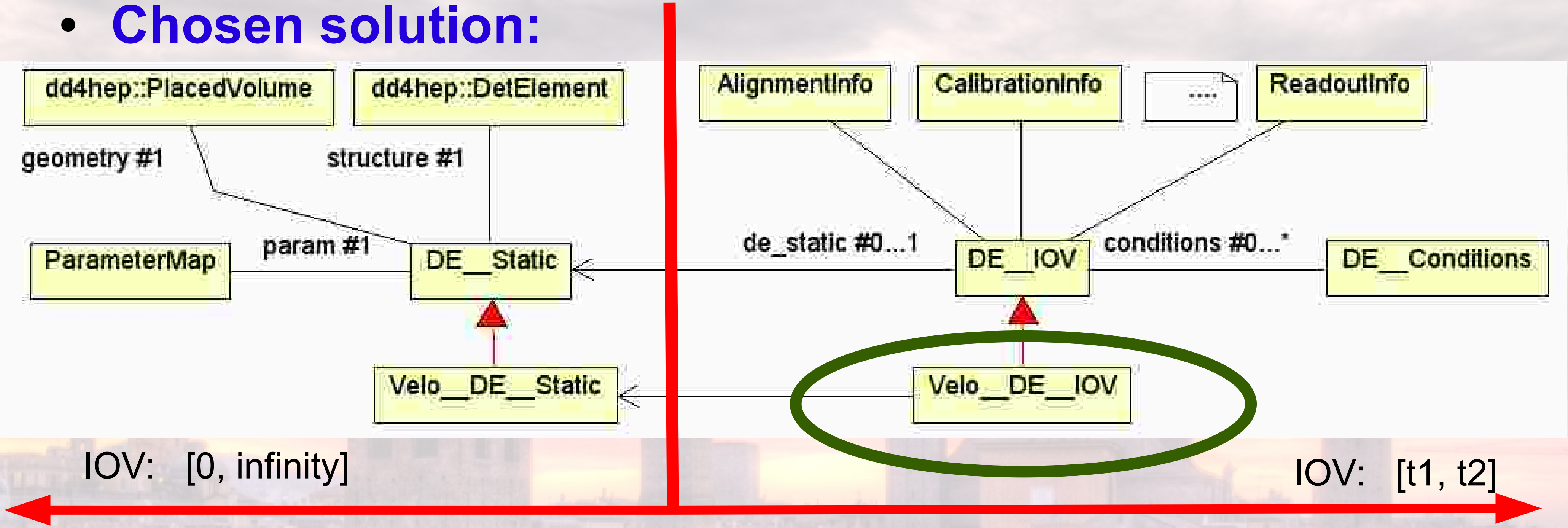
- **People want to see "Detector elements"**
  - **Fully functional description of parts of the detector**
    - **Long term valid stuff (structure)**
    - **Short lived quantities (temperature, alignment, …)**
- **A "natural" aggregation would be similar to:**



- **Intuitive, but not good: violates multi-threading.**
  (DetElements exist only in one instance)

Real World Use Case: LHCb Velo Detector

- **Chosen solution:**



- **Use IOV dependent projection for event processing**
  - **This is our new "detector element"**
  - **Keeps reference to the not changing properties**
- **Dress with facade to provide required functionality(ies)**

Real World Use Case: LHCb Velo Detector

- Structures are build using the derived conditions callback mechanism
  - Static part: once only
  - IOV dependent part: when not in pools
    Also fills link to static information
- Since conditions in existing pools still can be shared while preparing new IOV depending conditions
  - No locking strategy necessary
- Alignment computation incorporated
  - Reminder: alignments must be computed 'en block'
    for an efficient computation
- Common activity with WP3 Task 3.3 (C.Burr et al.)

- Motivation and Goals
- Simulation
- Conditions and Alignment
- Conditions use case study
- **Miscellaneous**

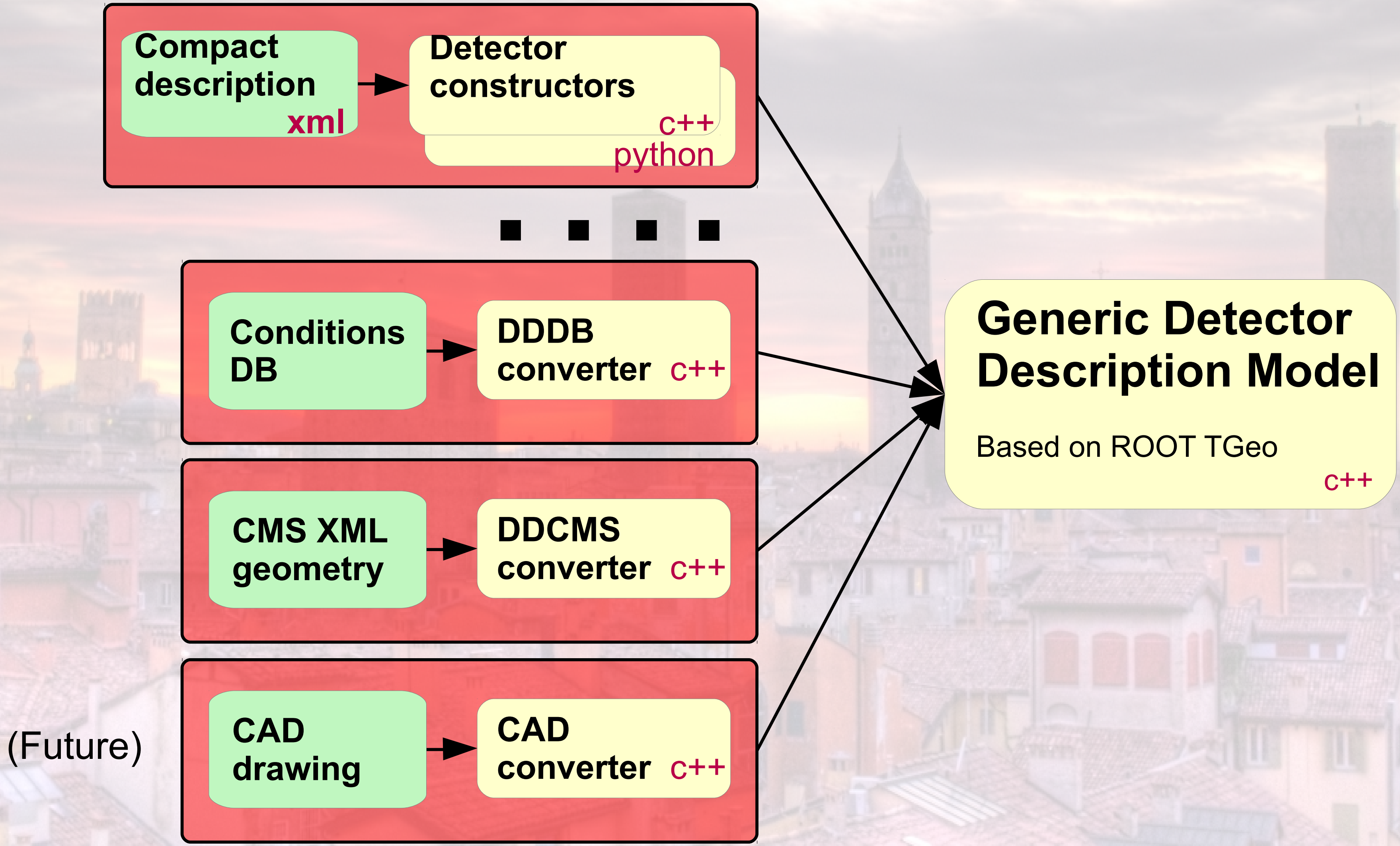
  stake holders, docummentation
- Summary

Toolkit Users

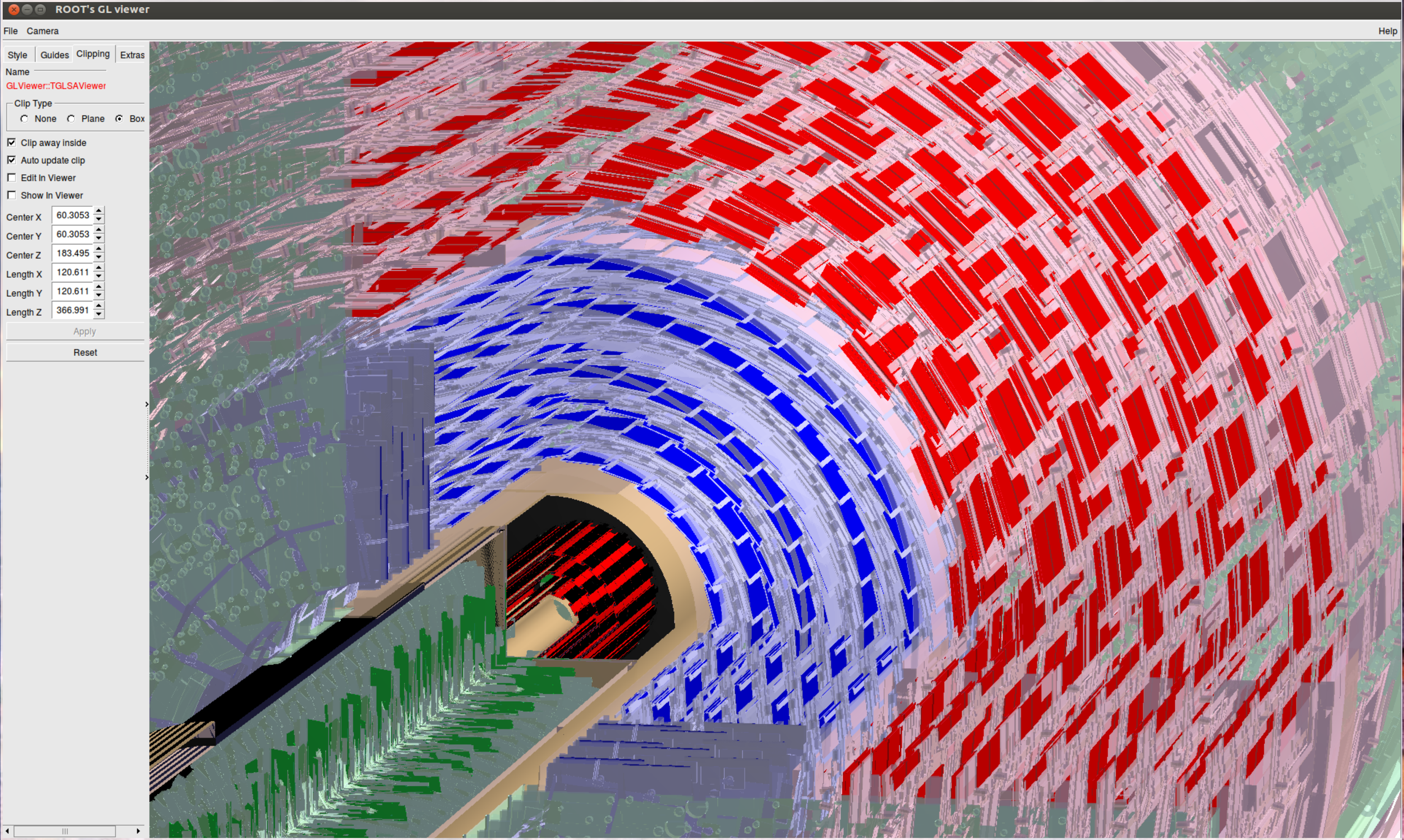
Increasing interest in the HEP community

ILC	F. Gaede et al.
CLICdp	A. Sailer et al.
SiD	W. Armstrong
FCC-eh	P. Kostka et al.
FCC-hh	A. Salzburger et al.
FCC-ee	O. Viazlo (CLD design), N. Alipour, G. Voutsinas
CMS	Evaluation for upgrade started (202x) (I.Osborne et al.)
LHCb	Evaluation for upgrade started (2019) (B.Couturier et al.)
CALICE	Calorimeter R&D, started
EIC	Evaluation considered/started

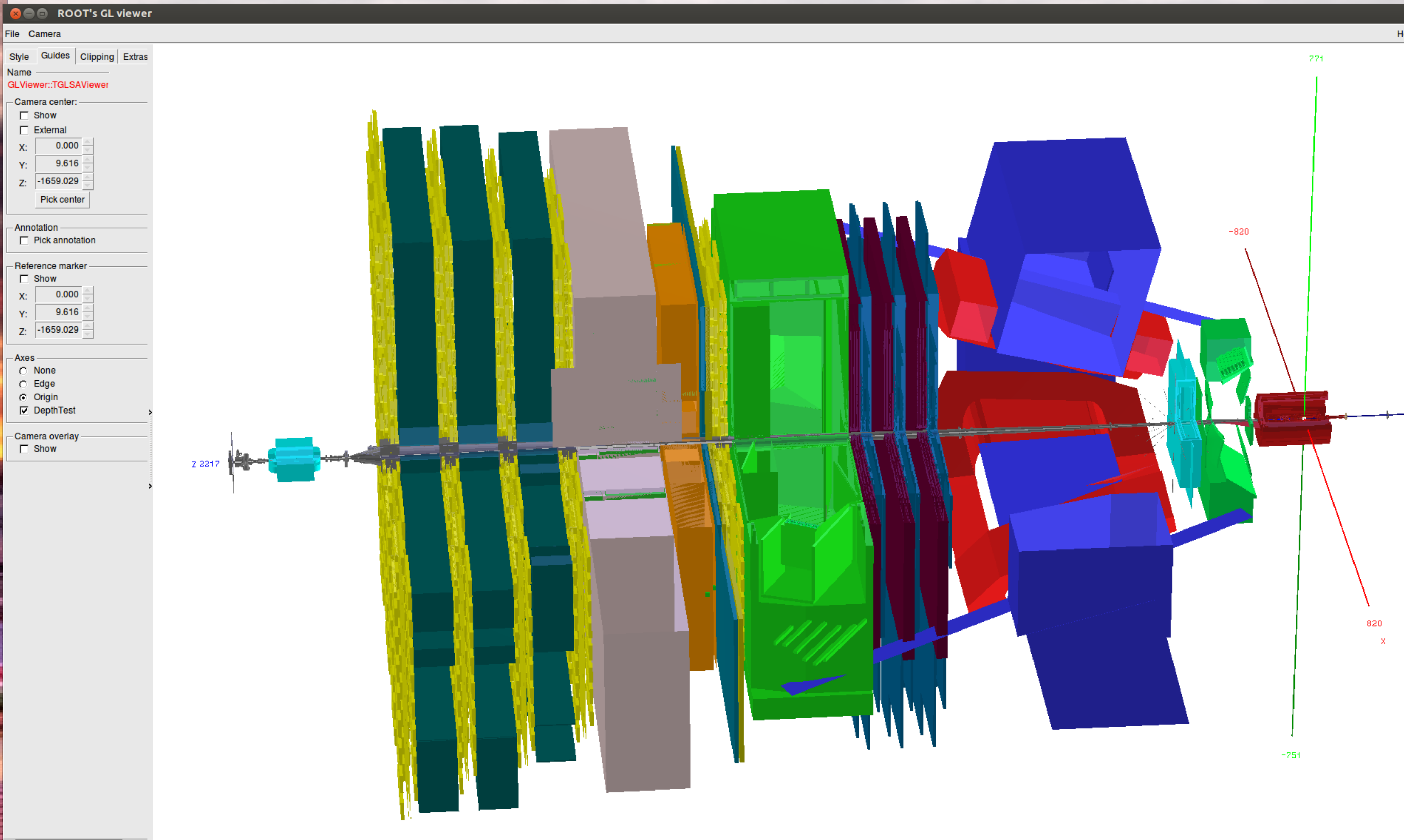
Multiple Input Sources (Update)



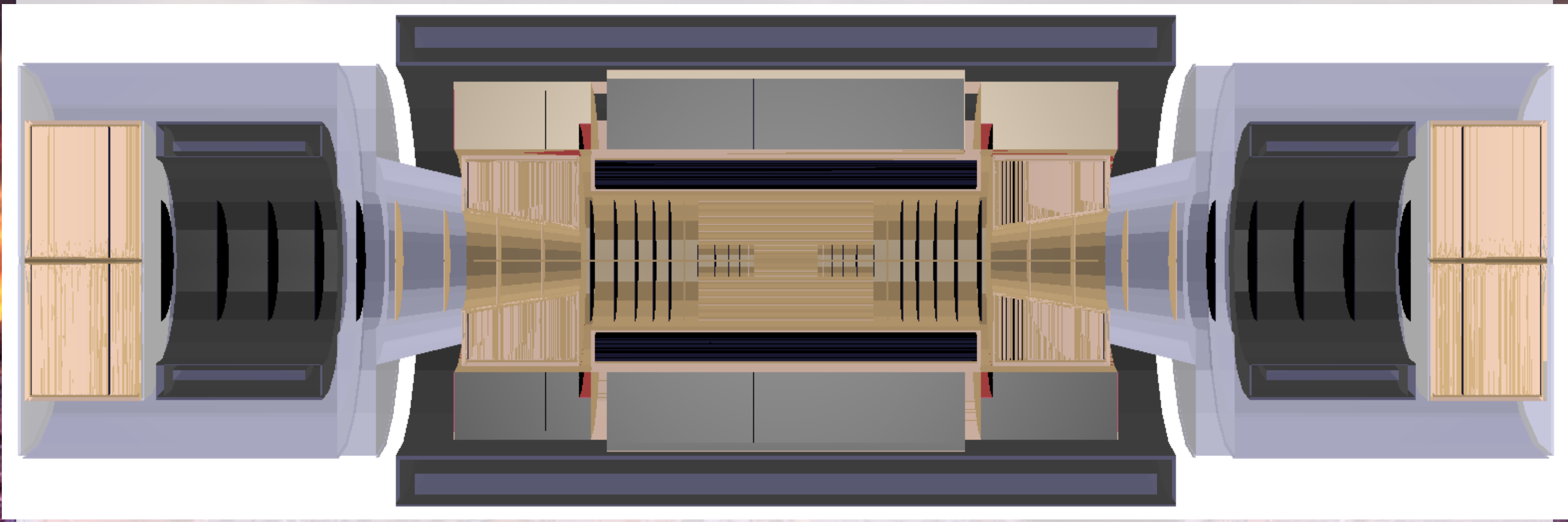
PR-Plot: CMS Trackers



PR Plot: LHCb Detector of RunI and RunII



PR Plot: FCC Design Study



Miscellaneous

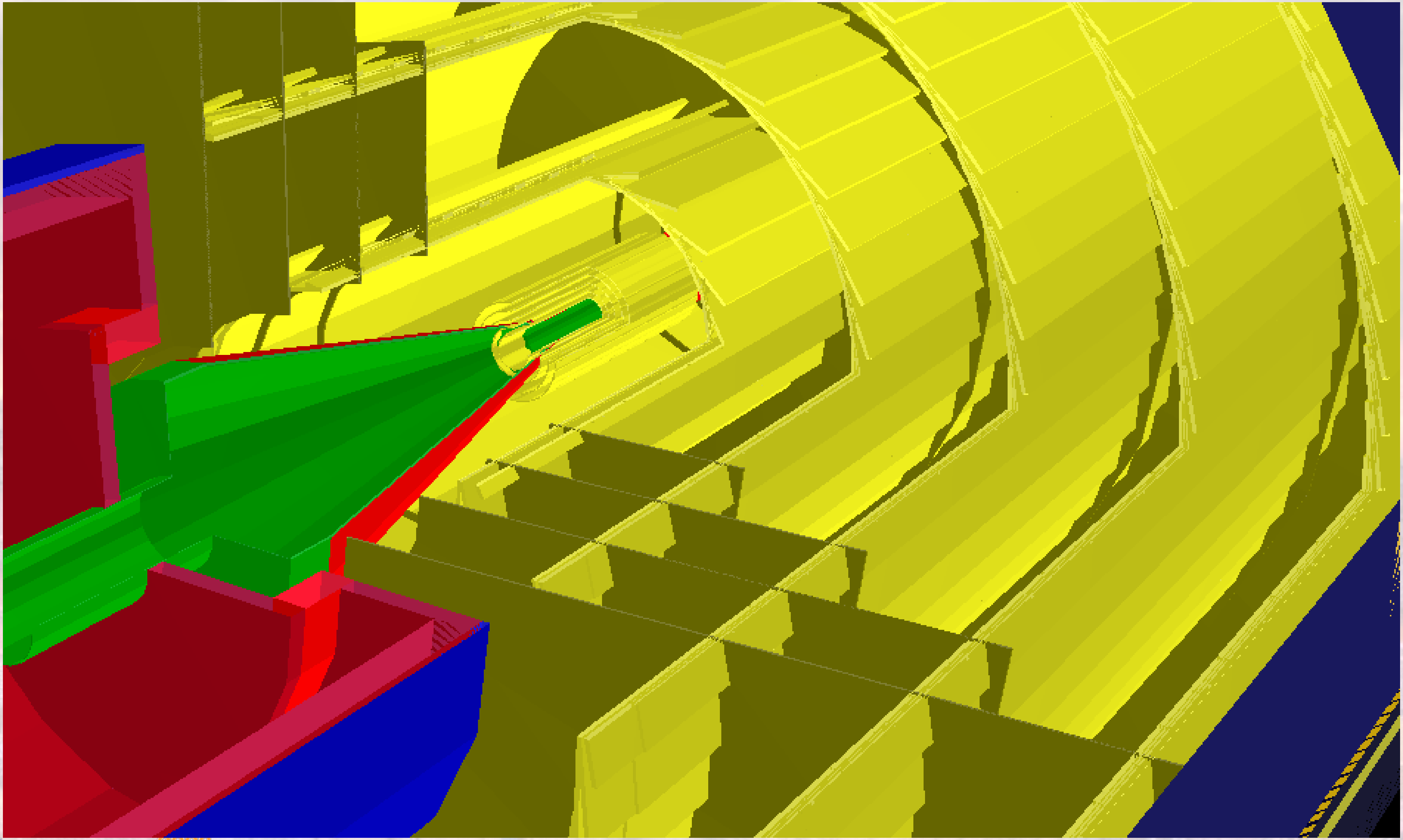
- New comprehensive web-site
  - `http://dd4hep.cern.ch`
  - Doxygen updates bound to git mergers: doc up to date
- User Manuals improved but not perfect
  - DDCond manual was updated
  - DDAlign user manual still to be largely rewritten
- Things are not entirely stable and in the past for sure were not
  - It is difficult to document a moving target
  - Concrete deployment examples only arise
    Documentation with concrete running use cases is simpler

- Motivation and Goals
- Simulation
- Conditions support
- Alignment Support
- Miscellaneous
- **Summary**

Summary

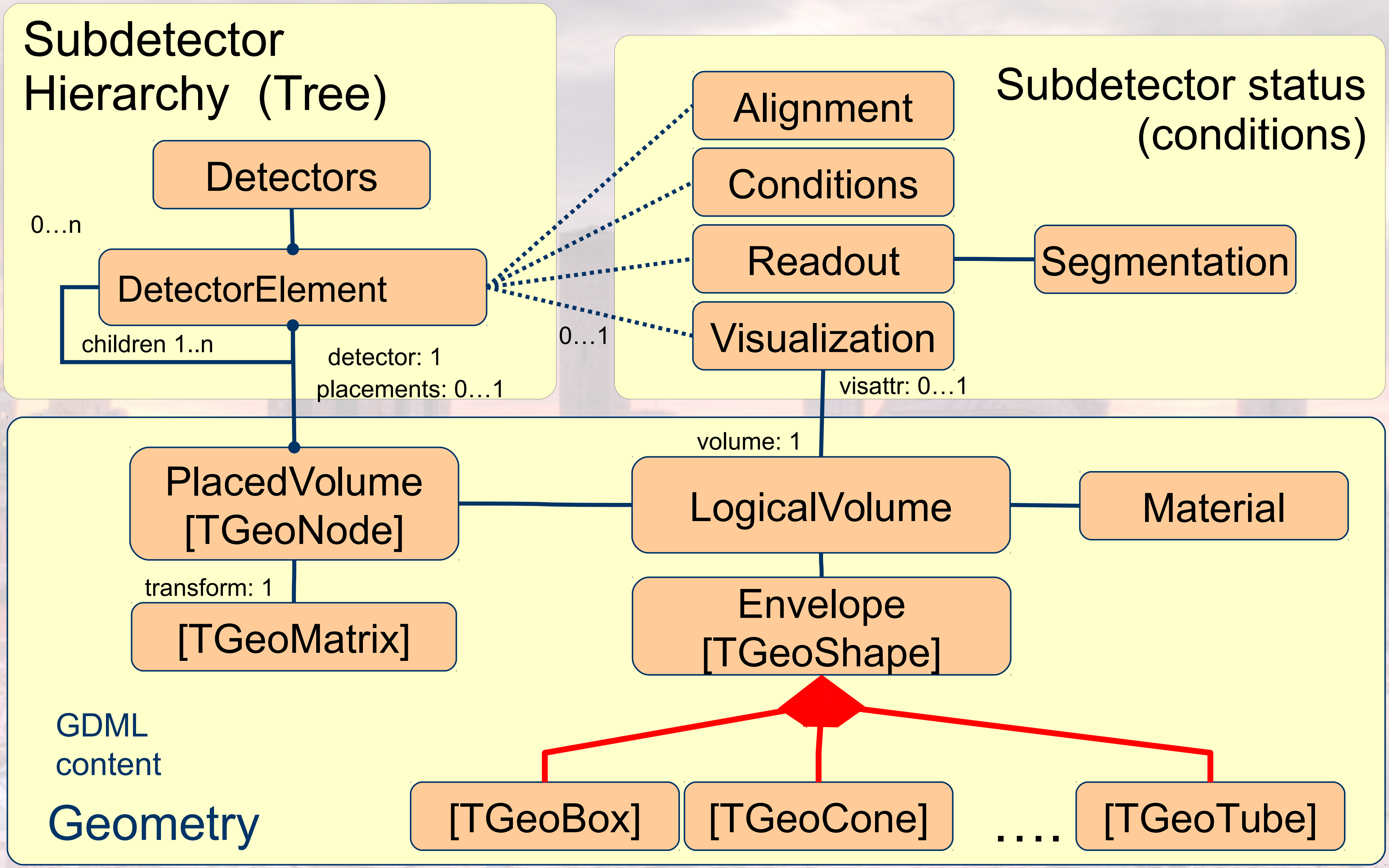
- The DD4hep core the sub-packages are at a quite mature state
  - Increasing interest from the community
- Support for alignment handling
  In collaboration with WP3 / Task 3.3, C.Burr et al.
- It is now time to think about guidelines for concrete deployment strategies based on the toolkit
  - Example: LHCb VELO
- Documentation is better, but still needs improvement
  - There is hope. Documentation target getting more stable

Questions and Answers



Backup

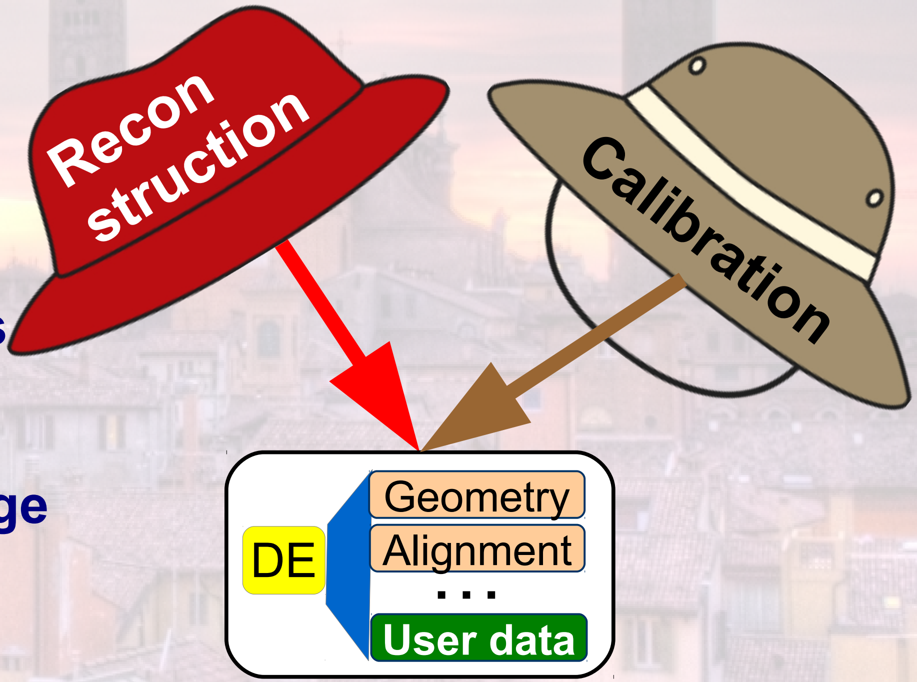
Implementation: Geometry



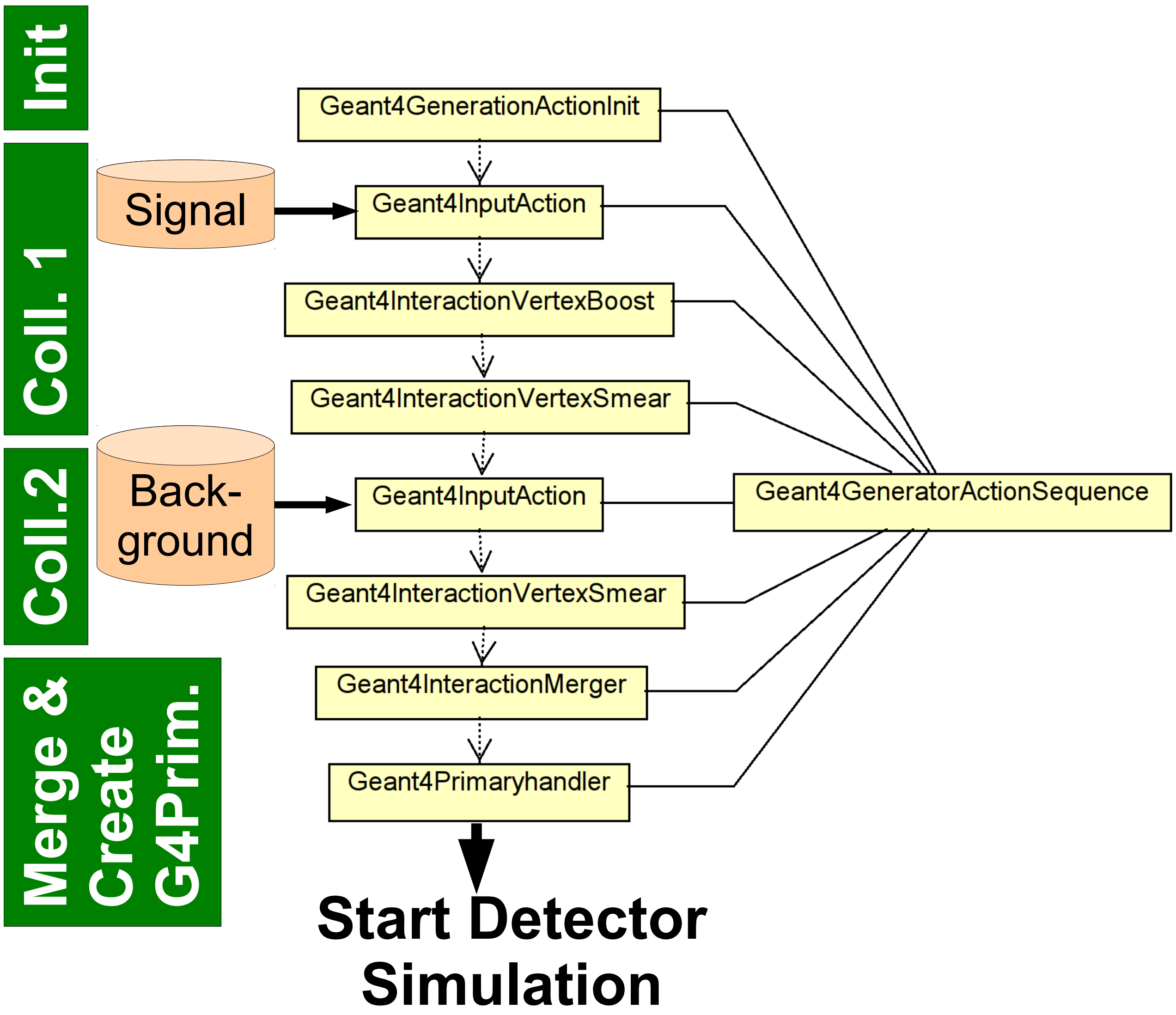
Views & Extensions: Users Customize Functionality

DD4hep is based on handles to data

- Clients only use the handles
- Possibility of many views based on the same DE data
  - Associate different behavior to the same data
  - Views consistent by construction
  - User data according to needs
- Be prudent: blessing or curse
  - User data: common knowledge
  - No one fits it all solution
  - Freedom is also to not do everything what somehow looks possible



Example of a DDG4 Action Sequence: Event Overlay with Features



- Combine simple and reusable modules
  - Input module
  - Any data format
- Primary vertex smearing
- Primary vertex boost
- Common: initialization, final merge