Alignment Strategy for ATLAS: Detector Description and Database Issues

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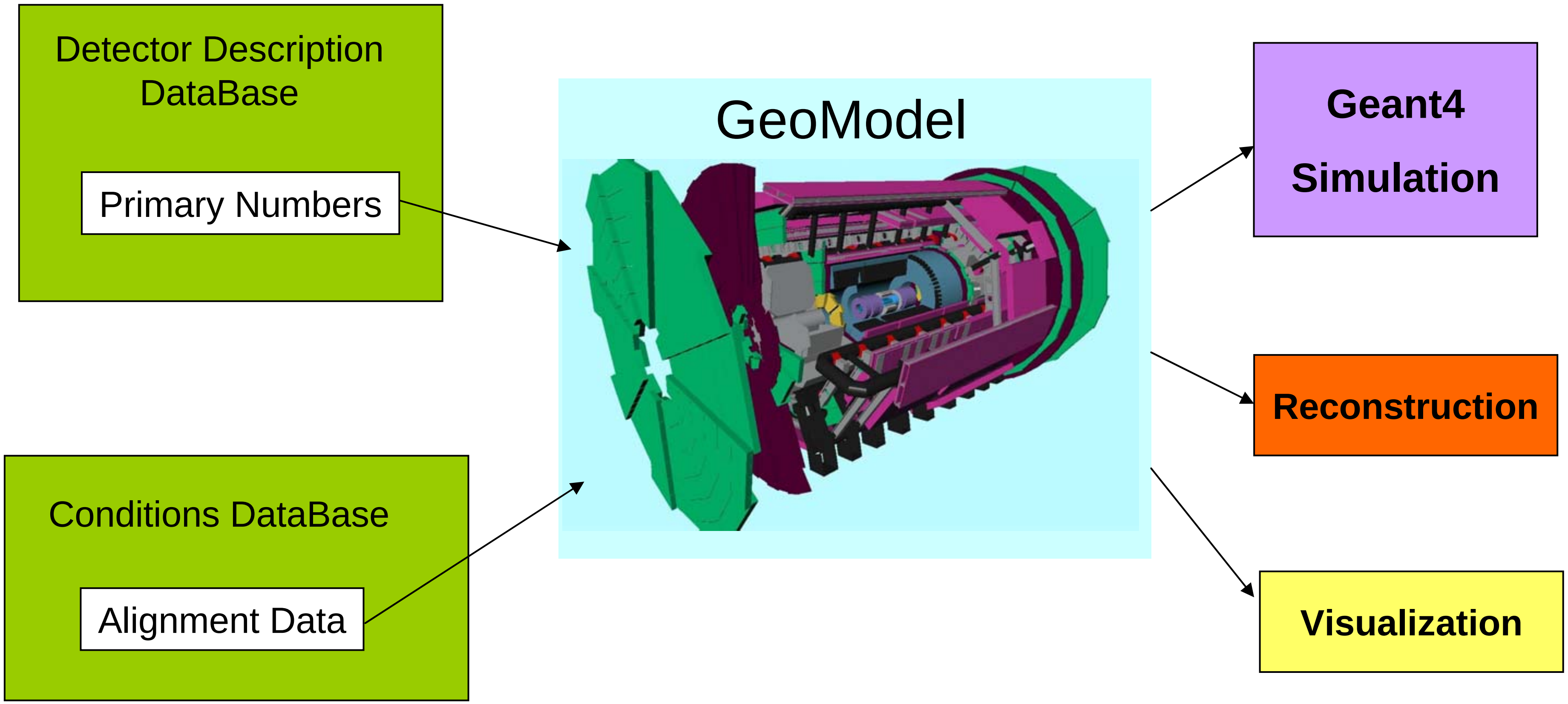
Outline

- Motivation
- GeoModel Detector Description
  - Raw Geometry
  - Readout geometry
- Databases
  - Primary Numbers
  - Conditions Database
    - Alignment constants
- Misalignments in Simulation and Reconstruction.
- Testing the alignment cycle.

Motivation

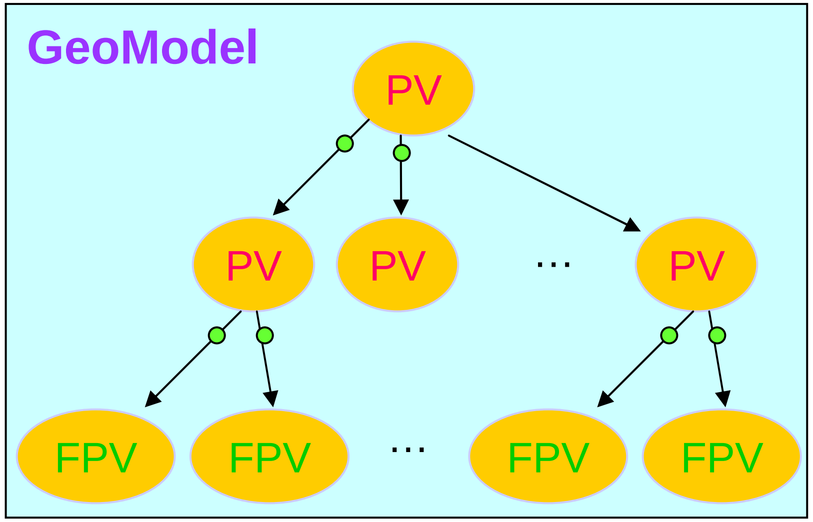
- Detector Description and Database are essential infrastructure for doing alignment and using the results.
- Integral to preparations for our Computing Systems Commissioning
  - Simulate a mis-aligned, mis-calibrated detector
    - Also distorted material and asymmetric B field
  - Run alignment algorithms → produce alignment sets
    - Study reconstruction performance and physics channels with residual misalignment
  - "Dress Rehearsal" for data taking – Test of our computing model.
    - Provide calibration and alignment within 24h.

Detector Description Overview



Detector Description- Raw Geometry

- GeoModel
  - GeoModel Kernel
    - toolkit of geometry primitives: shapes, materials, etc
    - Physical Volumes (PV) have attached nodes – connects other physical volumes via transform
  - Special "Alignable" nodes.
    - Default transform + Delta transform.
    - Can be at several levels
  - Full Physical Volume (FPV)
    - Calculates and caches local to global transform.
    - When alignable node higher up in hierarchy is modified
      - cache is invalidated.
      - Transform recalculated on next access.



Alignable node

PV = physical volume

FPV = full physical volume (transform cached)

Alignable nodes at several levels

For example we have 3 levels in the silicon detectors.

Level 1: Subsystem (Whole Pixel, Barrel SCT and Endcap for SCT)

- Global reference frame

Level 2: Layers/Discs

- Global reference frame

Level 3: Modules

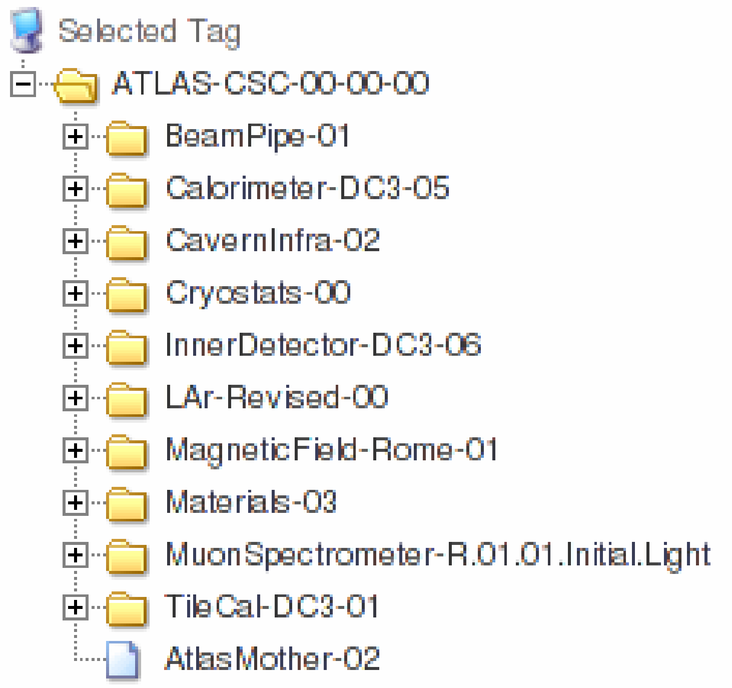
- Local reference frame

Detector Description – Readout Geometry

- Readout Geometry
  - Detector Manager
    - Access to detector elements (sensitive elements)
    - Manages transfer of alignment constants from Conditions Database to GeoModel alignable nodes.
    - Alignments updated via callback (or explicit call in geometry initialization)
  - Detector Elements
    - Points to GeoModel Full Physical Volume
    - Quantities derived from transform cached for fast access.
  - Reconstruction only accesses geometry information via detector elements in readout geometry.
    - Always gets aligned positions.
    - Most clients do not need to worry about alignment infrastructure.

Detector Description Database

- Contains Primary Numbers
- Uses Hierarchal Versioning System
  - Each table has tag, build up tags in folder structure.
- Geometry configuration specified by an overall tag (eg ATLAS-CSC-00-00-00)
- Either Ideal geometry or
- For some sub detectors limited misalignment scenarios also in Detector Description database



Conditions Database

- Alignment constants written to LCG POOL Root file using same persistency technology as event data.
- LCG COOL database records IOV (Interval Of Validity) and reference to POOL file.
  - IOV: run/event range or time
- Clients register callbacks on conditions object
- IOV services takes care of loading new data if IOV changes (checked at start of each event) and triggering callbacks.

Alignment Constants

- As currently implemented for Inner Detector. Other subsystems very similar.
- Two categories
  - Rigid body transforms (rotation + translation)
    - Delta transform (differences from ideal geometry)
    - Use CLHEP HepTransform3D
    - Applied directly in Detector Description at several levels in hierarchy.
    - Alignment data in AlignableTransform collection: (Container of **Identifier** and **HepTransform3D** pairs)
      - Common ATLAS **Identifier** uniquely identifies detector element or higher level structure (eg a silicon layer)
  - Fine corrections. Eg module distortion, wire sag
    - Arbitrary length array of floats
    - Interpretation is detector specific.
    - Not dealt with at Detector Description level. Applied at Reconstruction level when track is known. Also plans to use at digitization level.

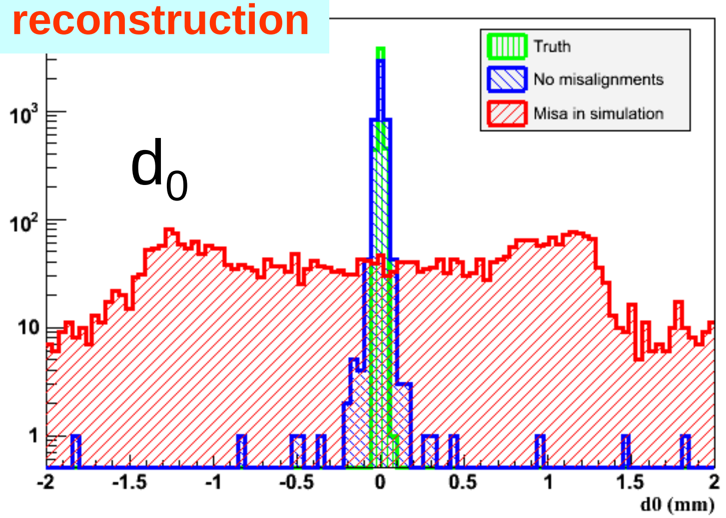
Survey data

- Can be stored and fed into geometry using the same infrastructure
  - Acts as a first alignment set.
- Survey Constraint Tool to constrain track-based alignment
  - Constants stored in second instance of AlignableTransform collection.
- Different levels of hierarchy helps as the survey numbers follow the same hierarchy to some extent.
- Similarly for input from hardware based alignment.

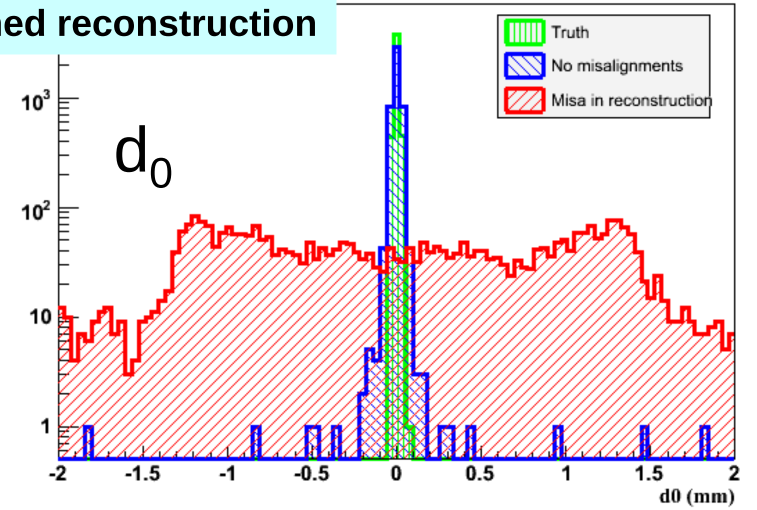
Misalignments in Simulation and/or Reconstruction

- Can apply misalignments at both reconstruction and simulation levels.
  - GeoModel Detetctor Description is common source for both Geant4 simulation and reconstruction
    - → Same infrastructure for misalignments in both.
    - Simulation: Alignments loaded at initialization. GeoModel → G4
    - Reconstruction: Alignments loaded before event if IOV changes.

Misaligned simulation, Nominal reconstruction



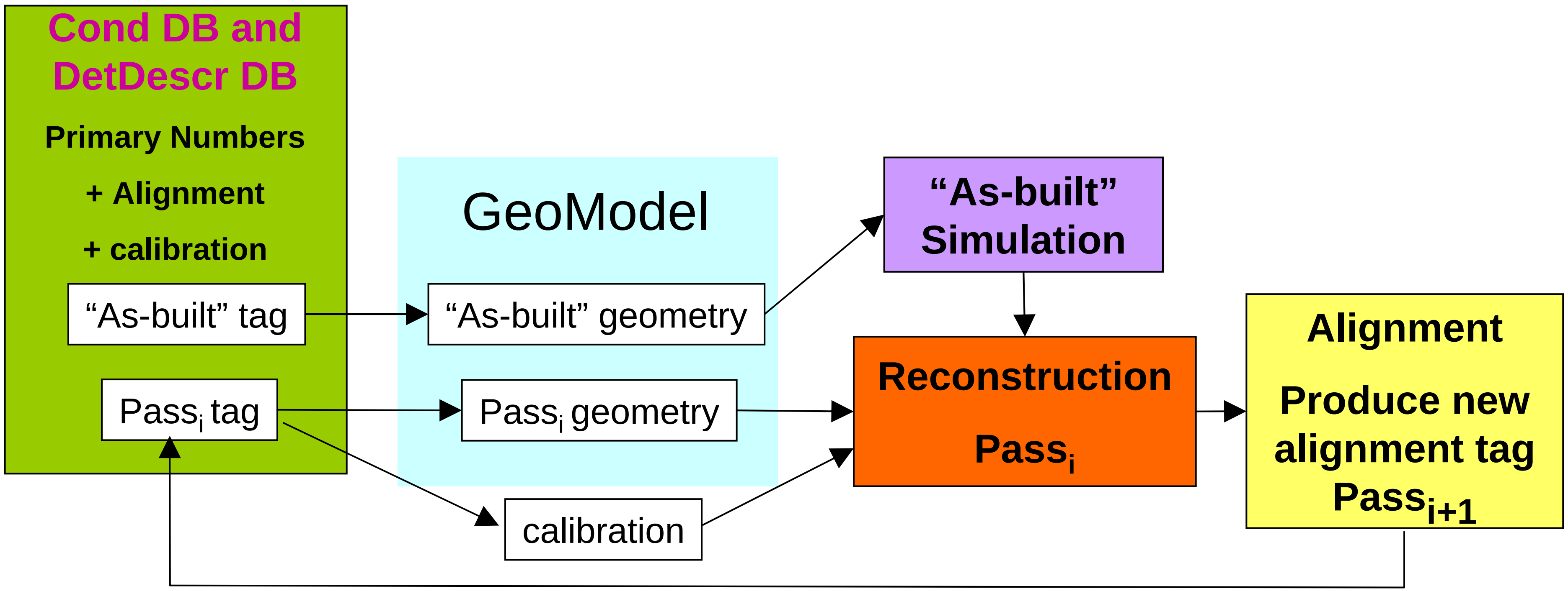
Nominal simulation, Misaligned reconstruction



Misalignment in Simulation

- Motivation
  - Misaligning only at reconstruction level not exactly the same as physically moving detectors.
    - Overlaps change.
  - Can do a blind misalignment challenge
  - Validate our reconstruction works in a non symmetric detector.
  - More realistic exercise of computing model.
- Extra challenges for misalignment in simulation geometry
  - Need enough clearance to avoid geometry clashes. Mostly a matter of resizing/reshaping some envelopes. Some services had to be artificially thinned or moved.
  - Facilitated by alignable nodes at several levels - allows larger movements of big structures (eg subsystem) and smaller movements of lower structure (eg modules).

Testing the alignment cycle (in our Computer System Commissioning)



- Pass0 – nominal geometry or different from "as built" by uncertainty in survey.
- Pass1 – First pass alignment
- Then iterate

Alignment in the Computing Model

- Provide alignment for Tier-0 first pass processing
  - Delivery of alignment constants required within 24h
  - dedicated calibration stream from Event Filter under study
  - track selection, size and content also under study
  - development of monitoring of stream and data quality at Event Filter and Tier-0.

Summary

- Detector Description and Databases are an integral part of the alignment infrastructure.
  - Has been and is being used in Combined Test Beam and Cosmics commissioning.
- Same infrastructure used in both reconstruction and simulation.
- The alignment infrastructure and ability to misalign in simulation are important aspects for preparing to do our data taking rehearsal.