ATLAS Alignment Integration in software infrastructure

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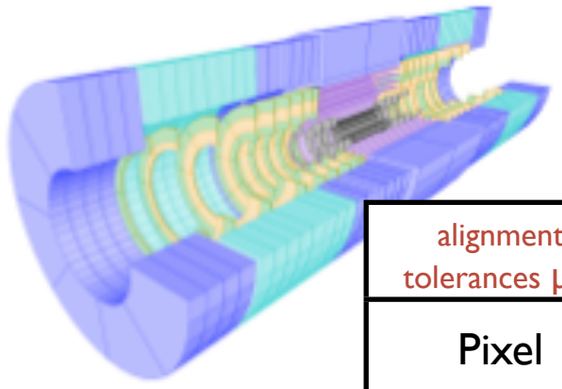
Outlines

- Overview of Alignment tasks for ID and MS
- Muon Alignment
  - Optical Alignment corrections data flow
  - Track based alignment data flow
  - Monitoring
- ID Alignment
  - ID Alignment Data Flow : data sample, software chain
  - Full Dress Reharsal 2008 exercise report
  - Monitoring
- Summary

Overview of Alignment in ATLAS

ID internal Alignment

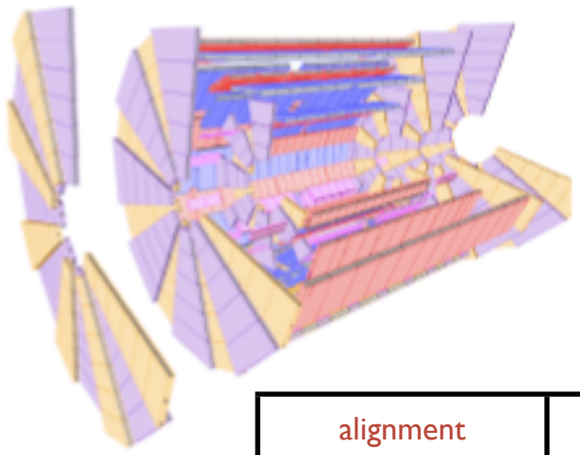
- mostly track based, plus FSI in SCT
- 7 mechanically independent sub-detectors
- ~ 6000 modules x 6 DoF ⇒ ~36000 DoFs



alignment tolerances μm	Azimuthal	Radial(Brl/EC)	Axial(Brl/EC)
Pixel	7	10/20	20/100
SCT	12	100/50	50/200
TRT	30	-	-

Muon internal Alignment

- based on optical sensors, plus muon tracks for overlapping regions
- 3 large subsystems (Barrel + 2 Endcaps)
- ~1200 MDT precision chambers each described by 6 positional parameters giving ~7000 DoFs
- adding 11 chamber internal deformation parameters gives a total of ~21000 DoFs

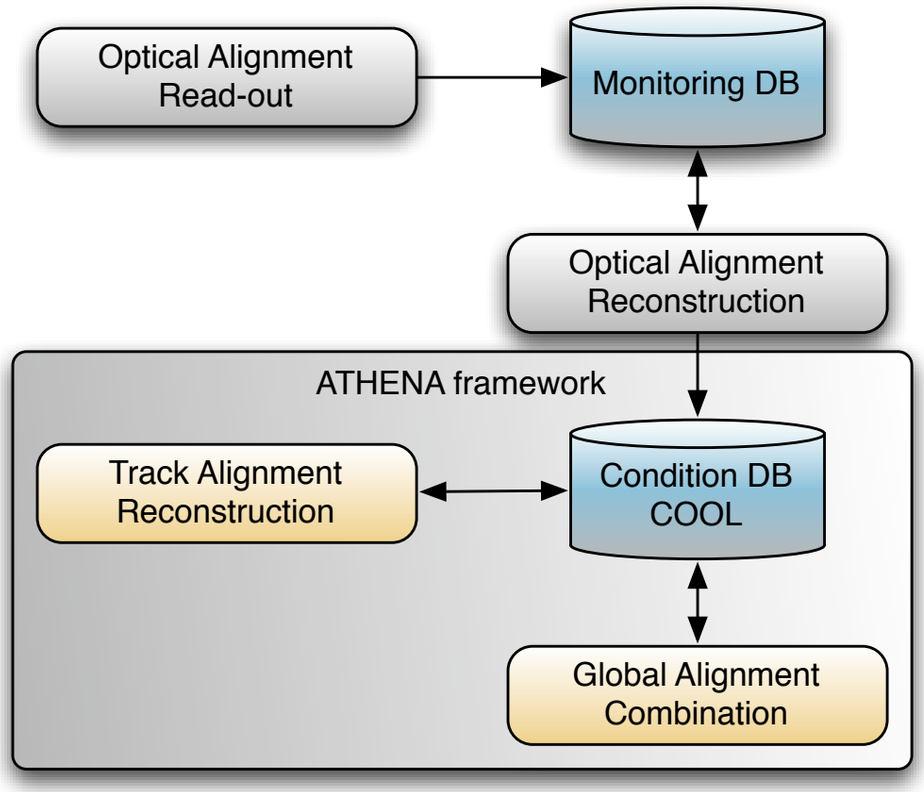


alignment tolerances μm	30 in R-z plane

MS-ID Alignment

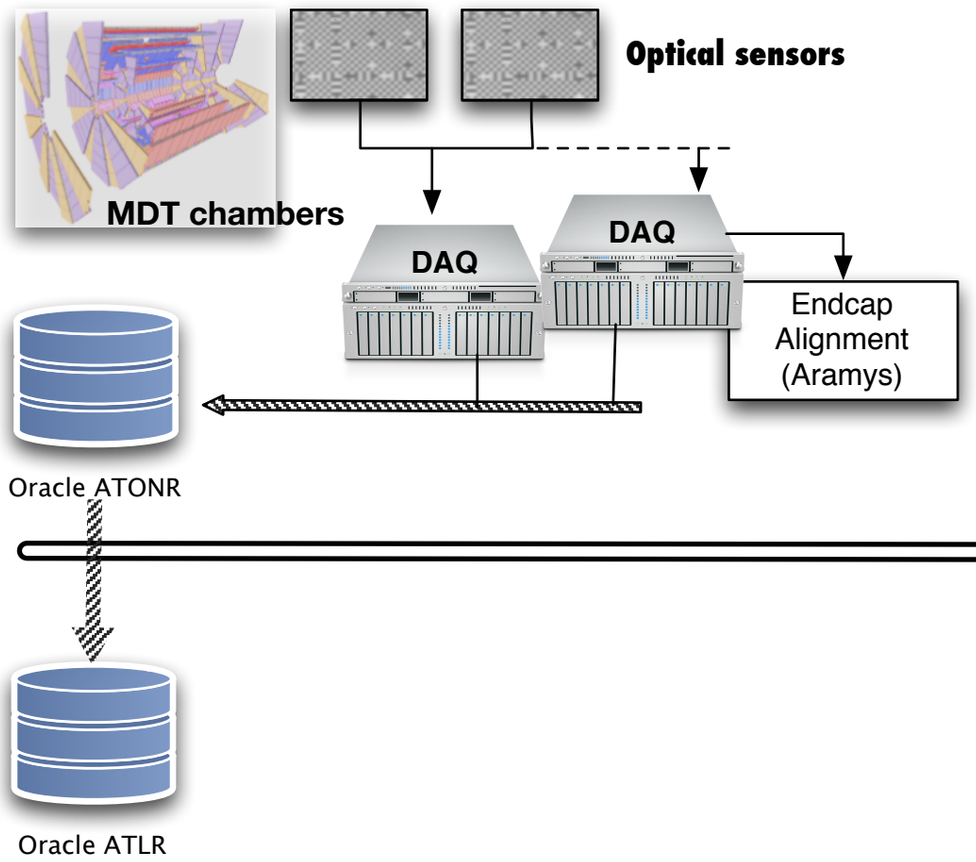
- Muon Spectrometer should be aligned respect to ID at the level of few 100 microns

Overview of Muon Alignment



- Optical alignment system using sensor read-out values to provide geometry correction in a private monitoring DataBase (Oracle) and in the Condition DB
- Track Alignment processes running on physics data set and writing correction in Condition DB
- MS-ID alignment: information from different corrections set should be merged in one final set available inside the Condition DB to reconstruction

Muon Optical Alignment Data Flow/1



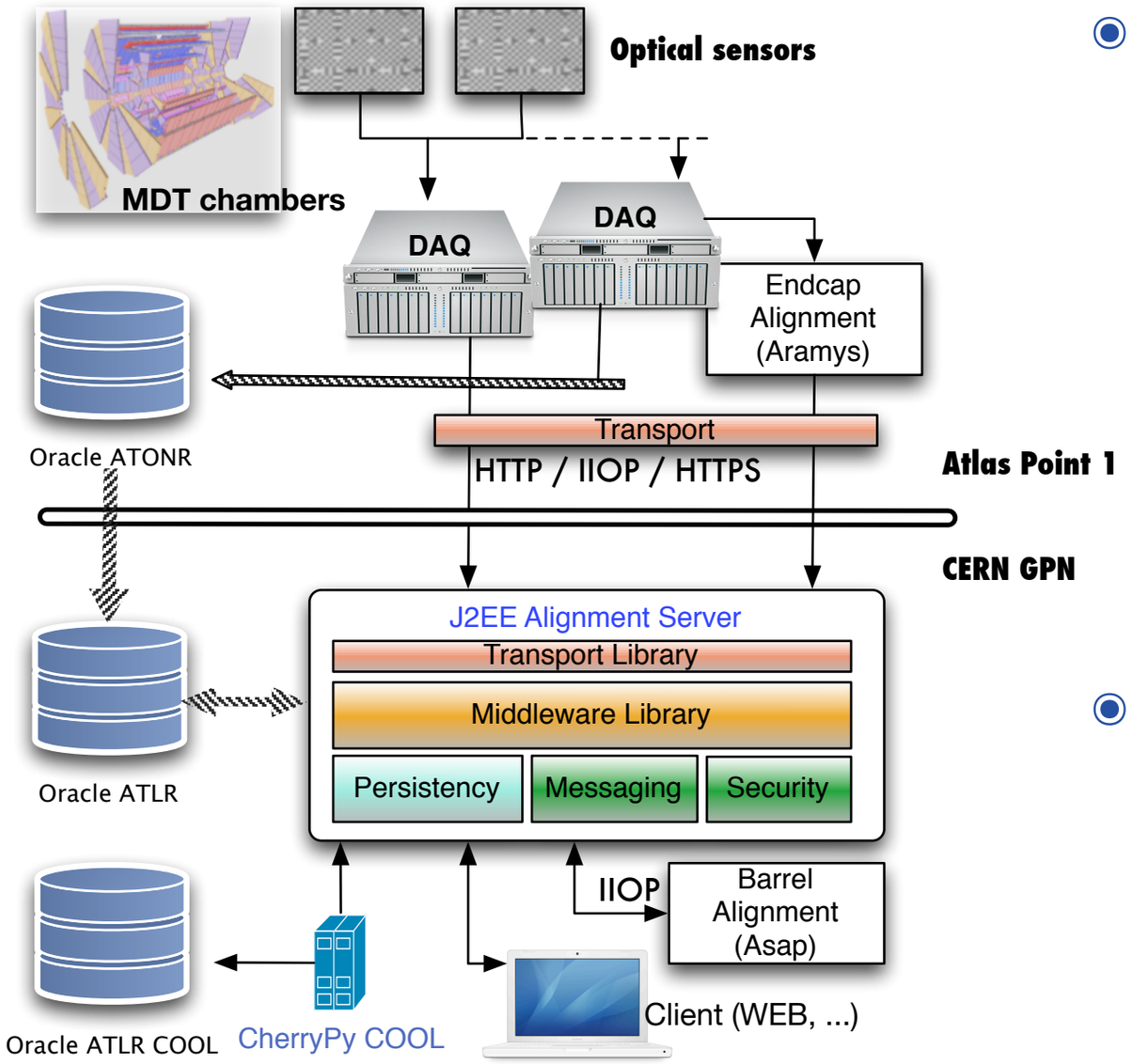
ATLAS Point 1

- Optical RO system : 8 PCs (Barrel) + 2 PCs (Endcaps)
  - Analyze images from optical sensors.
  - Store analysis results in Oracle online (ATONR) with rate :
    - Barrel : ~6000 optical-lines every ~15 minutes (~10GB / year)
    - EndCap: ~6000 optical-lines every ~45 minutes (~10GB / year)
- Endcap Alignment (1 PCs)
  - Conversion from optical sensors measurements into chamber position and deformation parameters (via a fit).
  - Resulting corrections stored in Oracle offline (ATLR) outside point 1 via the Alignment Monitoring Server (next slide).
  - In future this process will run outside point 1 as for Barrel

Oracle DB

- The online cluster ATONR is used to store images analysis results , as well as other DCS values (like magnetic field sensor values, temperatures...) : uses standard Oracle tables
- The ATONR data are streamed continuously to the Oracle offline cluster ATLR for usage by monitoring processes

Muon Optical Alignment Data Flow/2



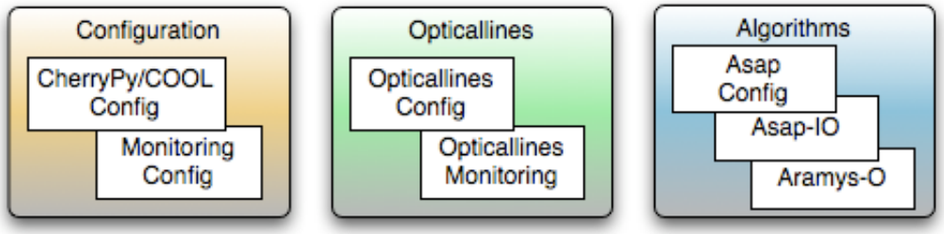
ATLAS CERN GPN

- Barrel Alignment (1 PC, in future *voatlas*)
  - Conversion from optical sensors measurements taken from ATLR into chamber position and deformation parameters (via a fit) : results stored to Oracle (ATLR).
  - All input/output with the DB is performed via a Java application deployed in a J2EE Application Server
  - The Java server controls the Barrel Alignment algorithm library via CORBA.
  - The same server is used by the EndCap alignment program to store corrections in the monitoring DB.

Migration to Condition DB:

- Alignment corrections are migrated to Condition DB (COOL) in ATLR for usage by track reconstruction programs (via a COOL-aware CherryPy server, using HTTP methods)
- Estimated data volume in COOL (Brl+EC) : ~2 GBy / year

Muon Optical Alignment today status



Monitoring DB contains normal relational tables

IOV is coded in a 63 bits integer which can be interpreted either as a timestamp or run number

IOV {timestamp, RUN/Lumi} **Tag : unique String**

IOVStart 1	*IOVEnd 1*	*Channel i*	*Tag A*	*Payload 1*
IOVStart 2	*IOVEnd 2*	*Channel i*	*Tag A*	*Payload 2*

CLOB

Different set of corrections are tagged depending either on the algorithm type or on the processing passes

Optical RO system :

- Fairly stable for the last 2 years.
- The image analysis algorithms for EC and Barrel have been extensively tested and debugged. Actual performances are very satisfactory.

Optical Alignment Reconstruction performances :

- Aramys (EC) and Asap (Barrel) have been smoothly running for months.
- Reconstruction rate : ~1/ hour
- Output data stored in several monitoring tables in Oracle (ATLR)

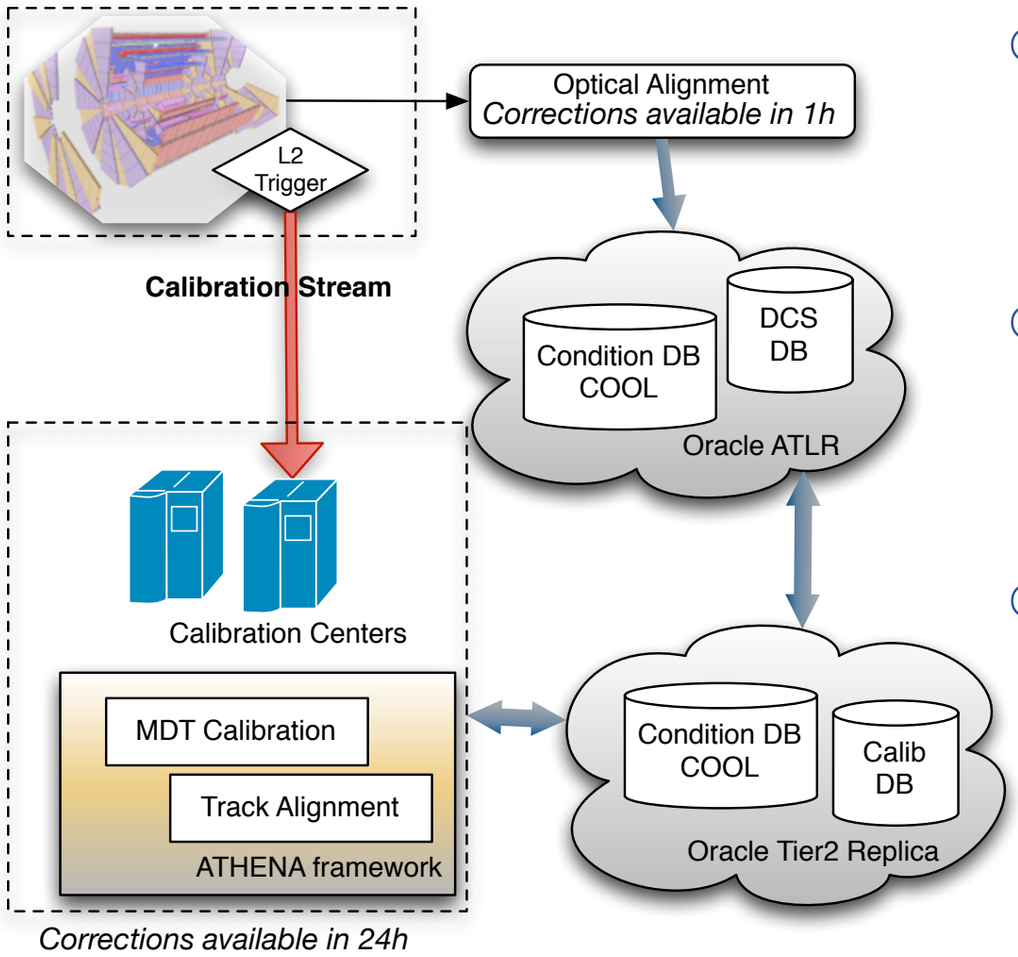
Alignment DataBase

- Optical alignment is a stand-alone system with a large monitoring and configuration DB in a dedicated schema (ATLR cluster).
  Central J2EE application deployed to interact with this DB either via WEB or command line client.
  Tested and validated.

Condition DataBase (COOL)

- simple CLOB migrated from Monitoring DB to COOL, containing chamber corrections parameters needed by track reconstruction programs.
  Tested and validated.

Track based Muon Alignment

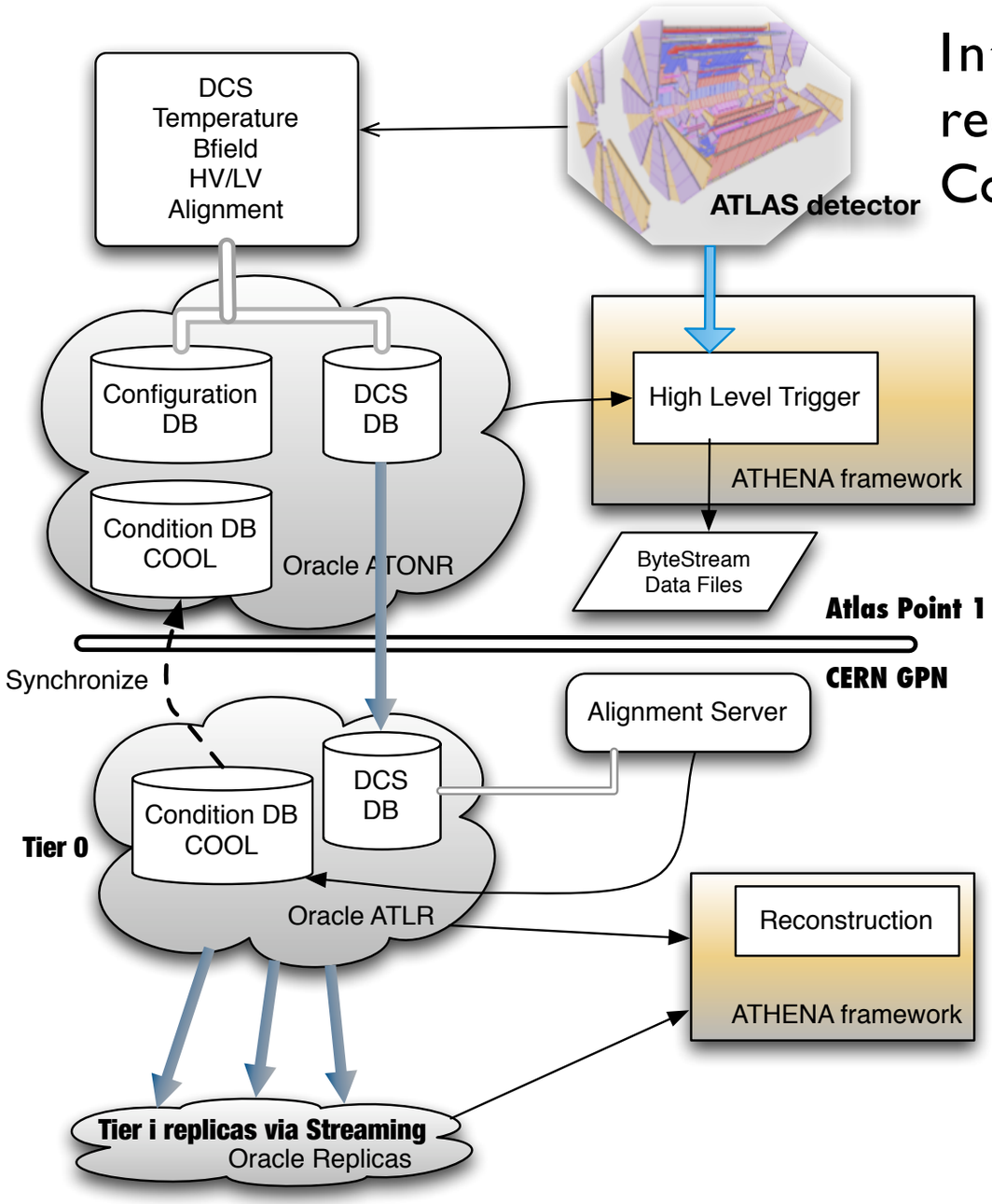


- The Track based alignment is performed in calibration centers using a selected sample of events used for the calibration of the muon detector (*calibration stream*) produced by L2 Trigger in ATLAS
- Muon tracks flagged directly by TDAQ system (μFast) : the stream contains tracks and associated hits in MS. (Muons with p_T > 6 GeV, rate: 100 Hz , event size: 2KB, total estimated data volume: 15 GB/day)
- Out of the 3 RT-calibration centers one performs additionally track based alignment (Munich):
  - Data are migrated from Tier-0 to the calibration Tier. Computer farm performs event reconstruction using the Atlas framework (Athena).
  - Optical alignment corrections have to be ready before this processing step.
  - Output of combined alignment: within 24 hours (after data taking). Corrections stored again in ATLR Condition DataBase (COOL).

Combination of different corrections

- Combination of set of corrections is under study for the moment
- Several options are foreseen
  - combination during alignment reconstruction : use the information from optical sensors AND tracks together in the same global fit (either in stand-alone alignment programs or in Athena)
  - combination after the alignment reconstruction : use the set of parameters + errors coming from different methods and combine them in a new set (need full error matrix)
- We do not have a clear data flow for this step yet

Muon Alignment and Reconstruction



Interface between Alignment corrections and reconstruction algorithms in Athena is done via Condition DB (using specific Athena IOV services).

Alignment for HLT

- The Alignment corrections for HLT will be synchronized from the offline COOL DB using a special TAG.
- The corrections required for HLT are at the mm level and should not vary too frequently (once / year)

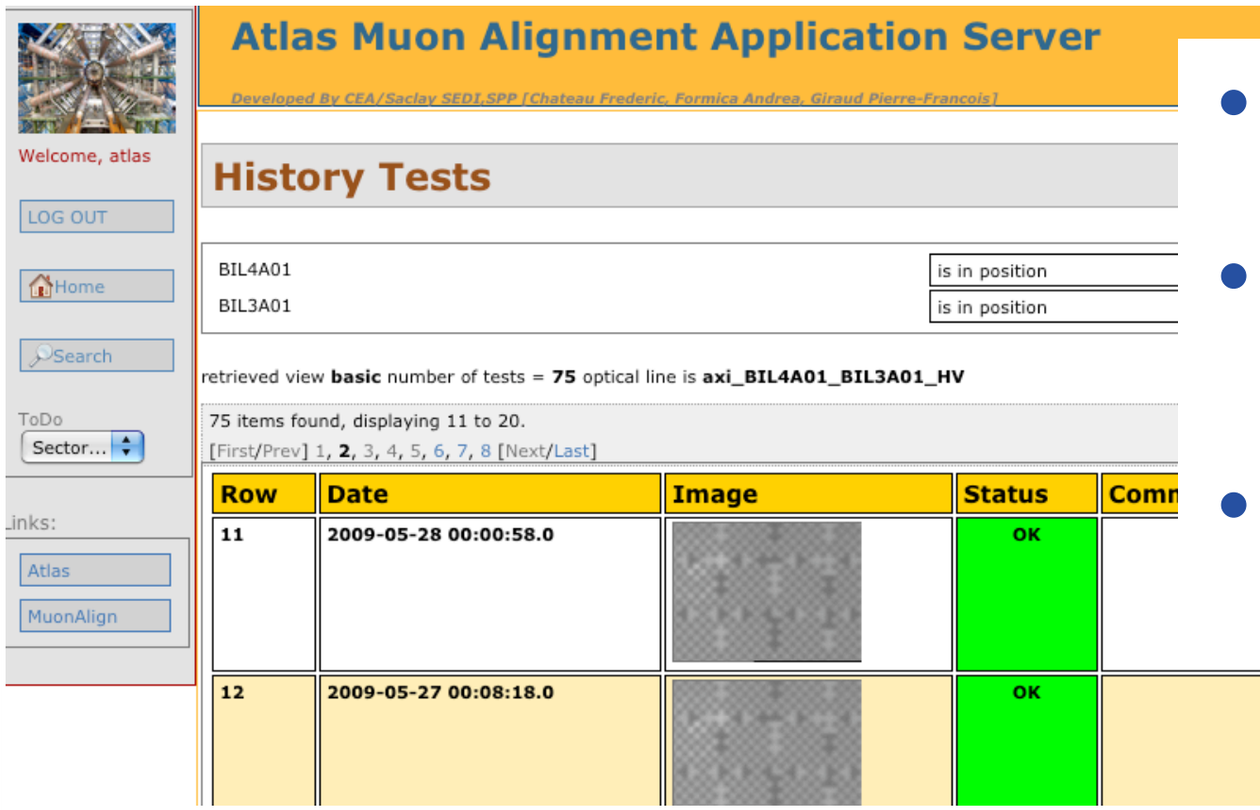
Alignment for First Reconstruction

- They should be ready in 24 hours from the data taking, and contain a first set of corrections combining optical alignment with tracks alignment.

Alignment for Data Reprocessing

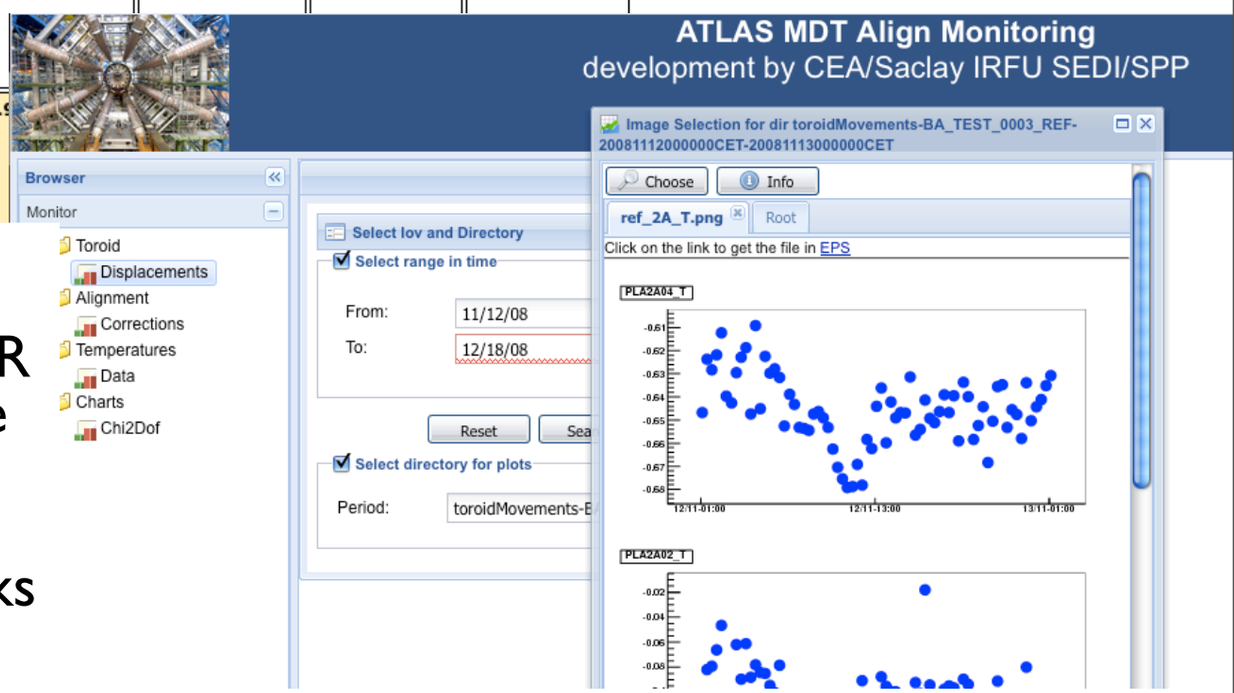
- This set of corrections reflects the best knowledge of the system. Should be ready within 2-3 months after the first data processing.

Muon Alignment monitoring



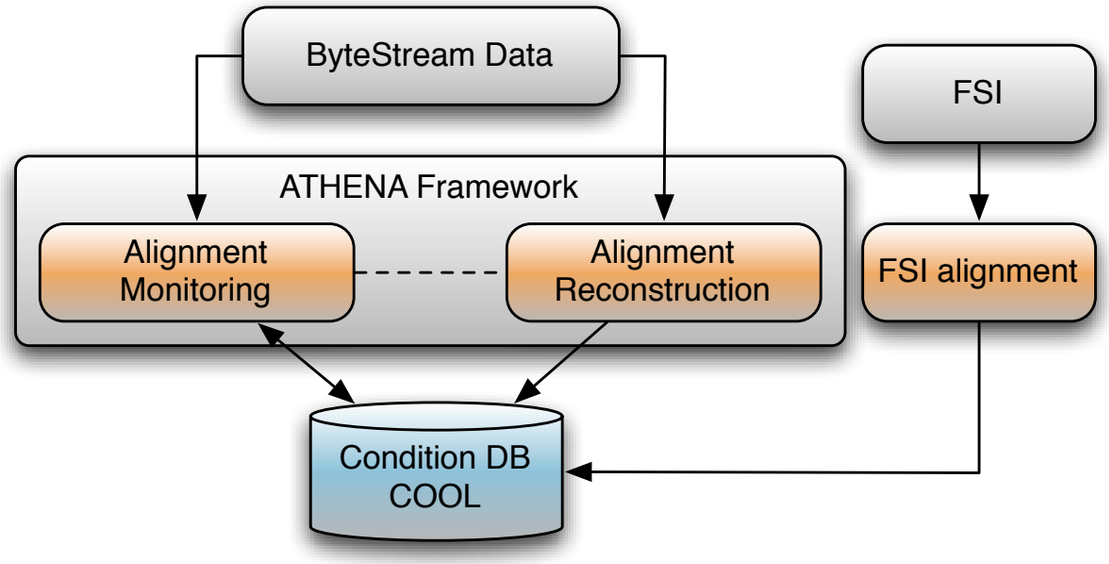
Google Web Toolkit

- Web application for access to Alignment DataBase (JSP & GWT based)
- Image analysis monitoring: averages computed every 6 hours to spot potential problems in online data processing
- DAQ monitoring: number of errors / DAQ-PC



- The Optical Alignment Monitoring makes large usage of ad hoc Oracle queries stored in the ATLR cluster under appropriate PL/SQL packages inside the monitoring DB schema.
- Alignment Data Quality checks using high p_T tracks to catch millimeter (and lower) errors in the alignment corrections. Under development.

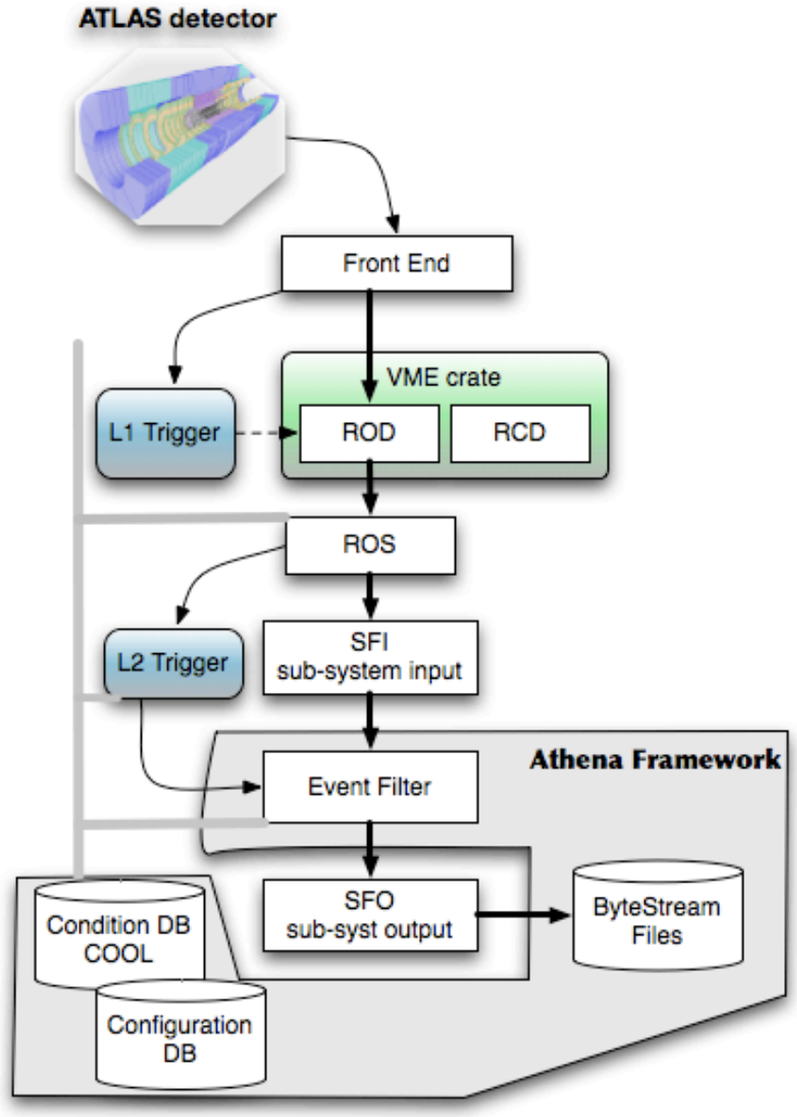
Overview of ID Alignment



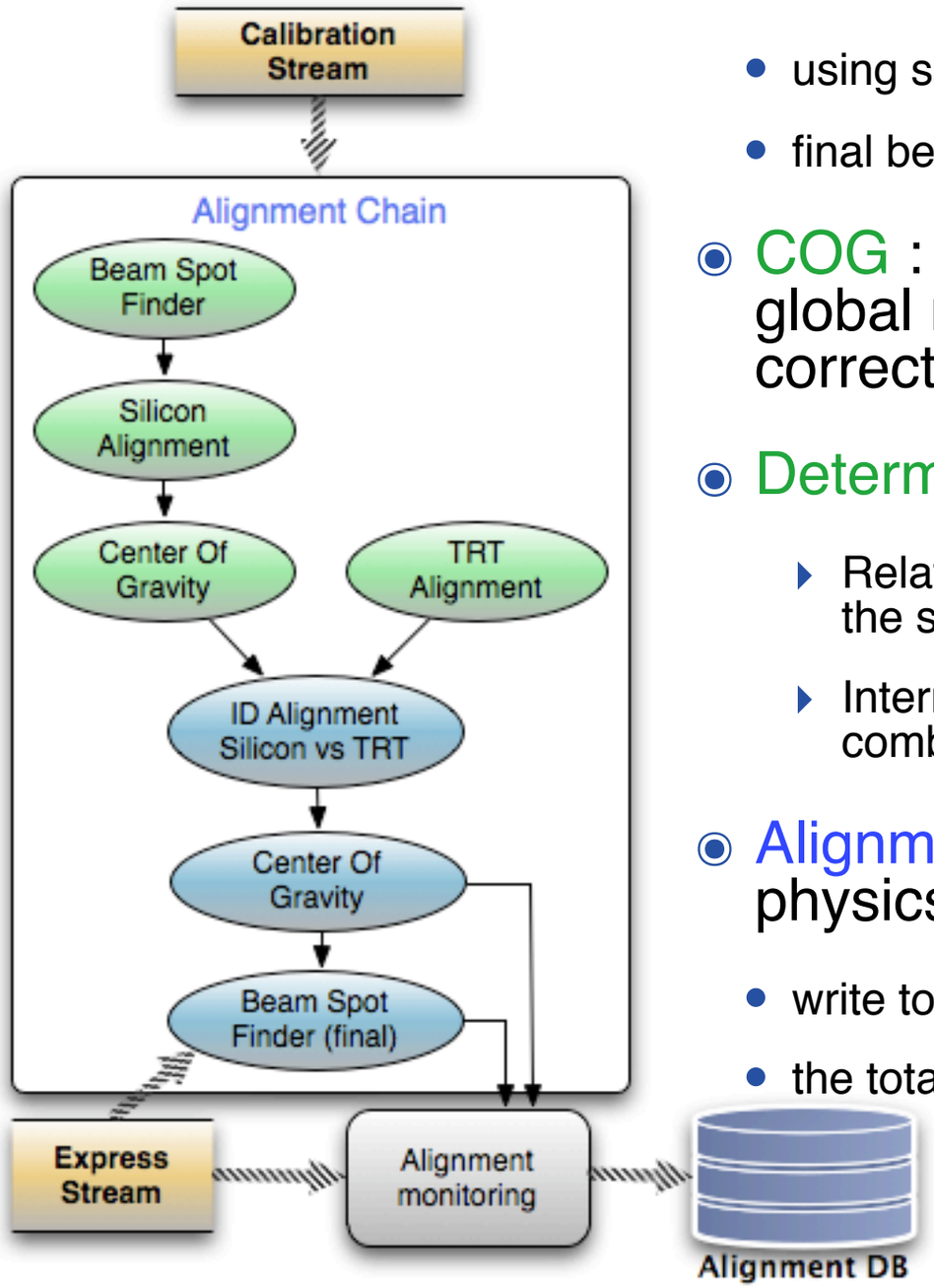
- ID Alignment input: several data streams selected via L2 trigger algorithms
- Alignment Reconstruction and Monitoring (for validation) run on the bytestream data and register corrections into the Condition DB
- Frequency Scanning Interferometry: stand alone hardware system to monitor SCT movements

ID Alignment Data Sample

- ID Alignment uses the bytestream data produced by the Event Filter and containing track with associated ID hits.
  - calibration stream : p_T>9GeV, high ratio of isolated tracks, uniform detector illumination (best track sample for alignment)
  - express stream : sub-set of physics data (~5%) used for data quality, alignment validation
  - primary stream : physics data reconstruction (beginning 24 hours from data taking)
- Data volume required for alignment :
  - Pixel/SCT: 100-1000 hits per module
  - TRT: 100 tracks per module
  - Calibration stream : rate 50 Hz, size 10 Kb/event; integrated over 6 hours fill, ~30GB of data
- Bytestream data are stored in Tier-0 : ~80 CPUs @ CAF are assigned to run alignment algorithms for Pixel, SCT , TRT.
  - final goal is to have computation and validation of alignment constants in 24h



ID Alignment Processing Chain

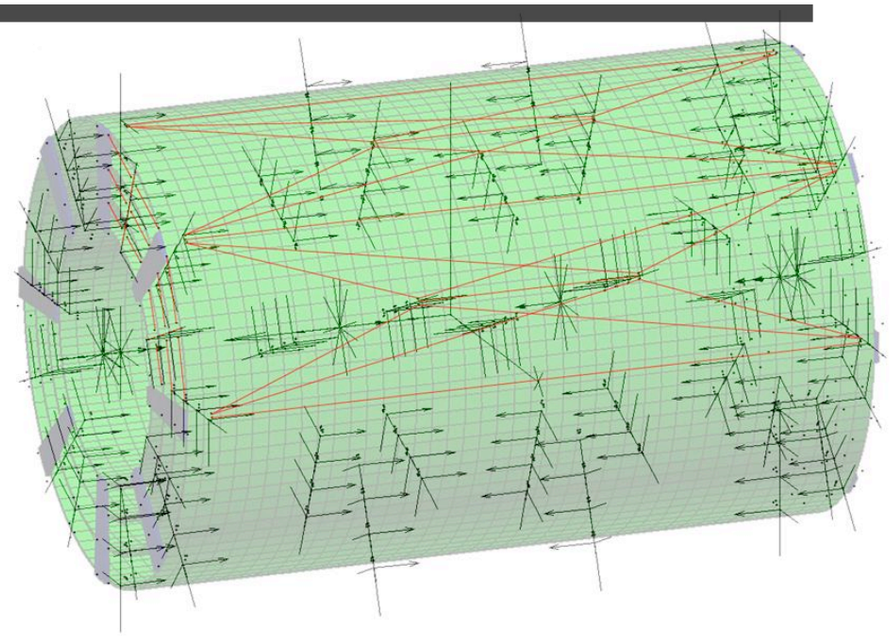


- Beam Spot : several types of algorithms
  - using single tracks to find the axis of the beam (minimize the impact parameters)
  - final beam spot can use vertices because it uses physics events
- COG : find center of gravity of the whole system to eliminate global movements in positions (Pixel/SCT, whole ID for final corrections)
- Determination of alignment parameters is an iterative process:
  - Relative alignment : align silicon detectors, and then the TRT with respect to the silicon using combined tracks.
  - Internal alignment: align the Si and TRT detectors modules, using both combined or TRT only tracks.
- Alignment validation : study alignment output parameters using physics data
  - write to Condition DB the corrections and the beam spot information
  - the total amount is around ~150KB per IOV

FSI system in SCT

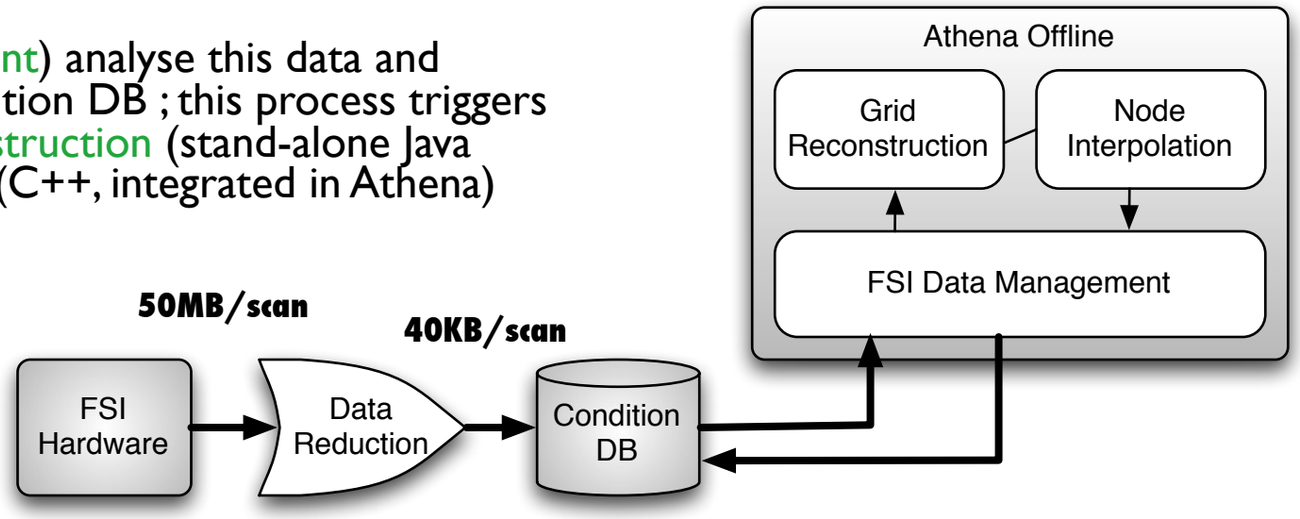
Frequency Scanning Interferometry :

- it is a separate laser based alignment system for SCT detector
- it consists in 842 simultaneous micron precise distance measurements between grid nodes attached to SCT
- repeated grid measurements will monitor shape changes of SCT at the level of ~1μm on short time scale
- A complete cycle will take ~1 hour (acquisition + analysis)



Software Chain :

- a read-out system send to an online process the data from FSI ; data are analysed and only reduced set of parameters is registered to Condition DB (~40 KB / scan)
- An offline process (FSI data Management) analyse this data and record the output back into the Condition DB ; this process triggers two other processes , the Grid Reconstruction (stand-alone Java program) and the Node Interpolation (C++, integrated in Athena)



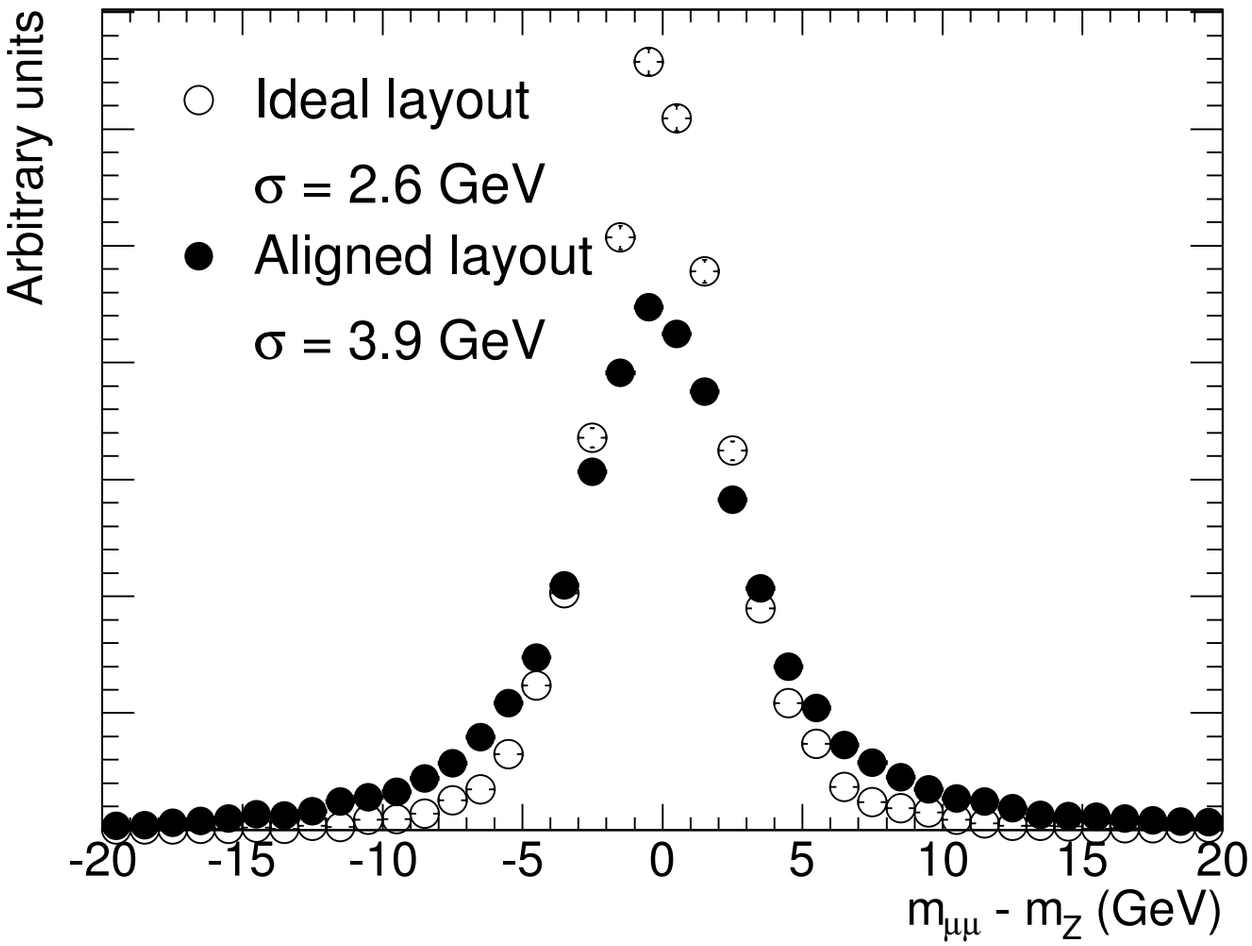
FDR exercise in 2008

- The 2008 ATLAS Full Dress Rehearsal's main purpose was an evaluation of different data streaming techniques for physics analysis and calibration
- The calibration and alignment was run like in real data taking with a 24 hours loop
- The simulation used a misaligned detector
  - Shifts of O(1mm) for Level 1 and O(100 microns) for layer and module level
- The input data for the alignment was a simulated calibration stream
  - Pt > 9 GeV, same misalignment as physics samples, sample size worth of several hours of data taking (1 M tracks = 6 hours @ 50Hz)
- The ID alignment participated actively in the FDR exercise
  - Running the alignment and beam spot jobs at the CAF
  - Producing alignment and beam spot constants
  - Validating the alignment and beam spot constants using the monitoring program
  - Output constants were used for the official reconstruction

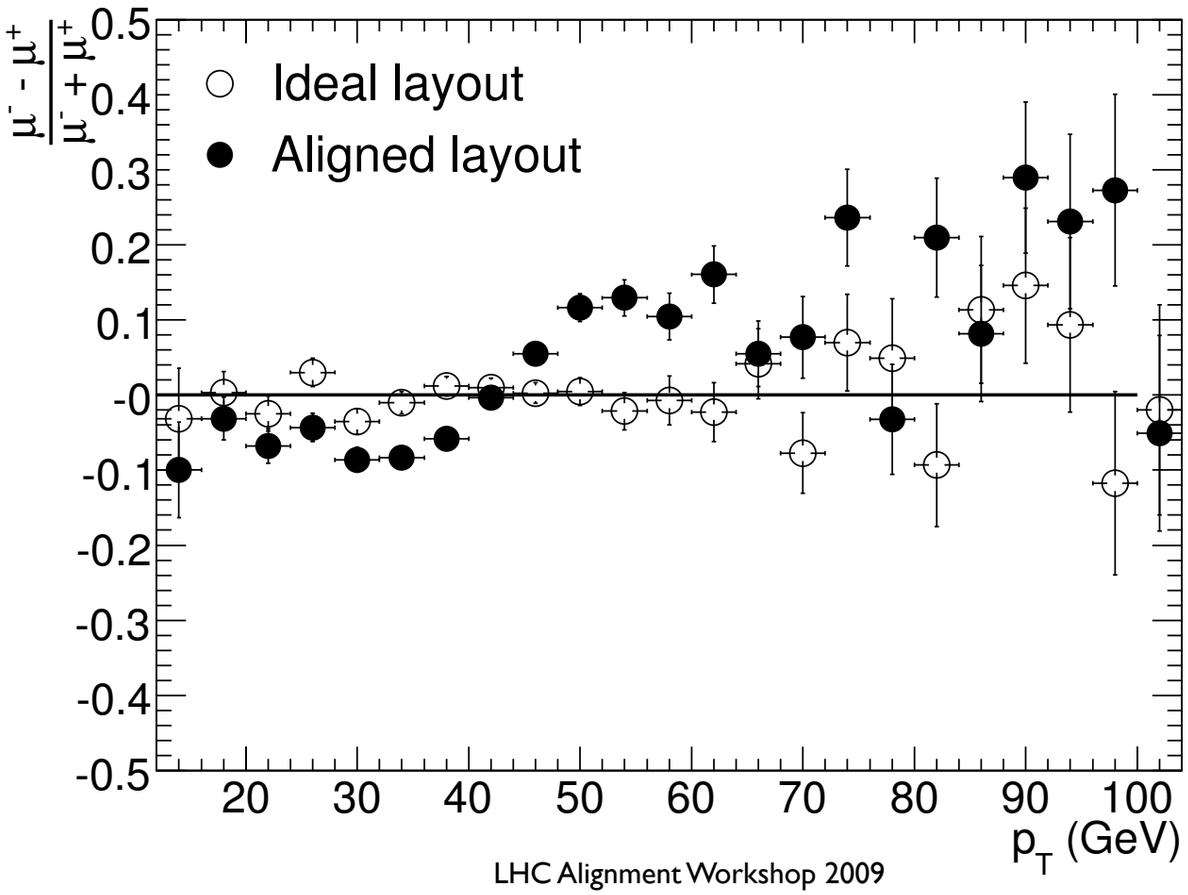
ID Alignment Monitoring

- Integrated in Data Quality Monitoring Framework (running inside Athena)
  - analysis of monitoring data (mainly stored as histograms)
  - processing and filling distributed to many CPU nodes
- Track selection on express stream physics data
  - configurable cuts on physical quantities (p_T...), number of hits / track etc...
- Monitor general track quantities: χ^2, residuals at each detector surface, efficiencies
- Monitor track parameters comparing with / without align.
- Beam Spot Monitoring: check that parameters uploaded in COOL DB are correctly providing beam spot position for usage in ID tracking.
- Physics based monitoring: physics channel can be used to prove validity of alignment parameters (e.g. $K^0_S \rightarrow \pi^+\pi^-$ invariant mass, mass peak versus p_T, η, φ)
- Monitoring processes are controlled via a set of python scripts.

Physics Validation in ID Monitoring



- Example plots to monitor alignment quality using selected $Z \rightarrow \mu^+\mu^-$
- Data sample similar to FDR 2008
- Plots taken from Atlas Detector Paper (JINST 3 2008 S08003)



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Summary

Muon Alignment

- Optical Alignment software chain is well advanced and has been tested extensively (cosmic data and simulated data) : chamber corrections produced are used by reconstruction algorithms via the geometry model
- Track Alignment software chain is still in a development phase, data flow is partially tested but well designed
- Combined (MS-ID, ...) Alignment is also under development, with less clear ideas about implementation in the software chain
- Monitoring exists already but is not finalised

ID Alignment

- Software chain well defined and tested during simulation exercises (FDR in 2008), from stream data selection to correction production inside ConditionDB
- Monitoring well advanced and tested, plays major role in the chain
- Alignment of ID in 24 hours with 10μm accuracy has been proven