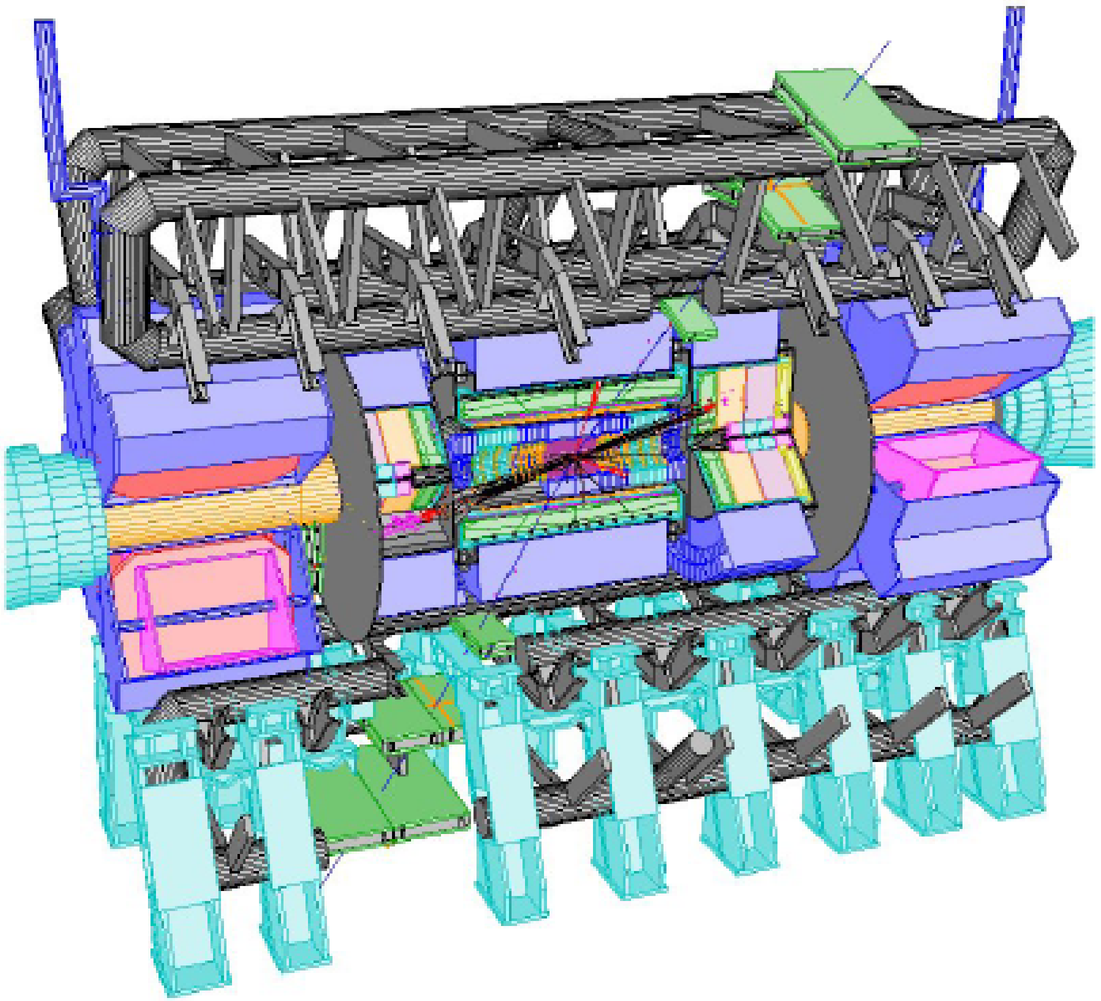
Muon Performance status

Outline

- Muon performance key points
  - Calibration
  - Alignment
  - Reconstruction
    - Standalone
    - Combined
  - Detector description
  - Data quality

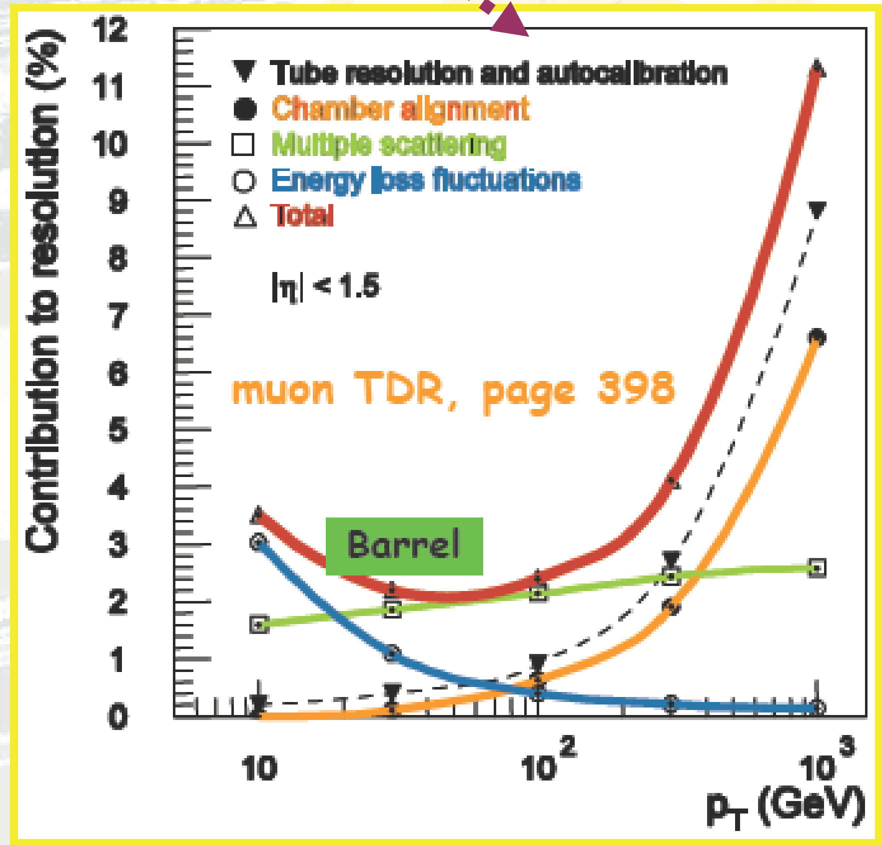
- Artemis deliverables status

- Artemis work plan in the muon domain



Key points of muon performance

The following key points affect the muon identification, the reconstruction efficiency and momentum resolution

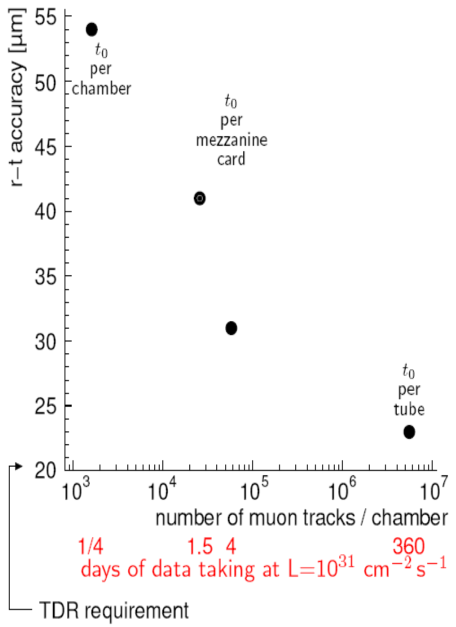


- Calibration
  - T0, R-T relation
- Alignment
  - (chambers positions, deformations)
- Trigger efficiency
- Material description
- Magnetic field
- Energy loss in the calorimeters
- γ/n cavern background

- Reconstruction optimization
  - Inclusion of all possible effects
    - (wire sag, treatment of dead noisy channels e.t.c)

MDT R-T Calibration and calibration stream

r-t accuracy after time synchronization and autocalibration



Assumptions:

- $L=10^{31}$ cm^{-2} s^{-1}
- Calibration stream at a rate of 100 Hz, i.e. 0.25 Hz/chamber.

Conclusions:

- Reasonable r-t accuracy already after 1 days of data taking.
- 30 μm r-t accuracy close to TDR requirement after 1 week of data taking!
- TDR requirement of 20 μm unreachable due to missing statistics for a tube-by-tube synchronization.

- Dedicated stream of MS data containing low momentum single muons at a rate of 2 kHz, (5 Hz/ muon chamber) extracted at L2 level.
- 4 calibration centres Michigan, Munich, Rome, Naples process this stream with a latency of 24 h
- The calibration framework and the calibration algorithms are ready and being tested in the cosmic runs since last year and recently in the FDR2 exercise (CSC chamber technology to be included)
  - ➢ Streaming of Events and the Data Base replication from Tier0 to calibration centres successful.
- Calibration stream to be used for detailed monitoring of the MS
  - ➢ To be used also for identifying dead and noisy channels.

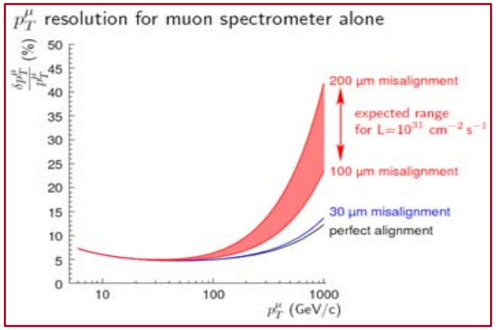
Alignment in one slide

MS alignment: Final goal to obtain a 30 μm level on sagitta measurement
MS/ID alignment: Final precision ~100-200 μm precision

1. Optical Alignment: dedicated optical lines installed in the muon chambers controlling the movements and positions of the chambers.
   - The response of the optical system to trace the departure from a reference geometry was validated during the Combined Test Beam activities in 2004
   - Recent tests on FDR2 exercise were performed
   - Tests with the cosmics also started

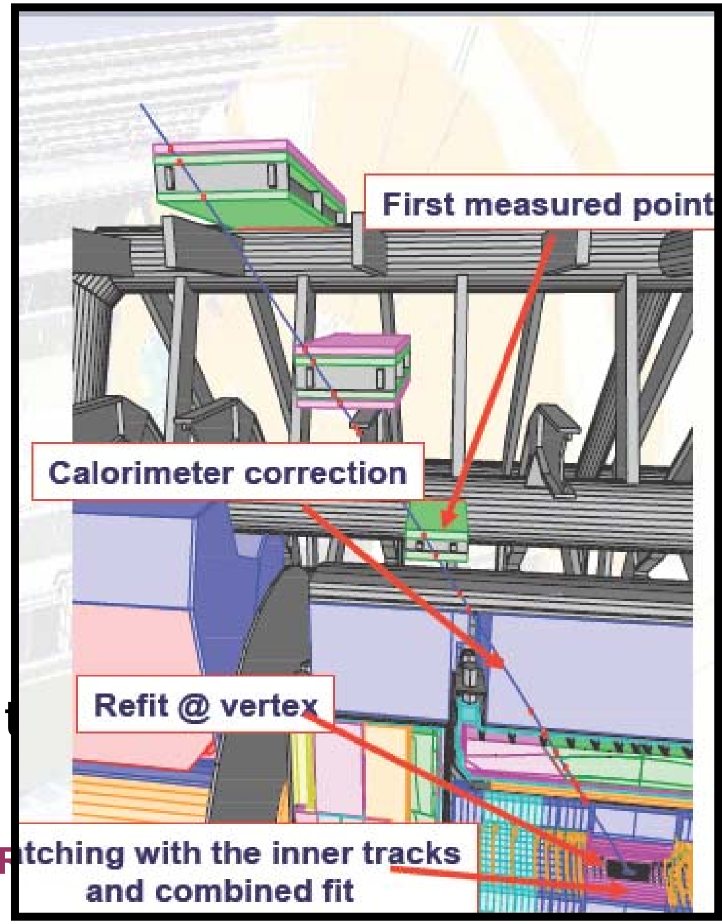
2. Alignment with tracks: pointing straight tracks of a run with B=0 in the toroids in the beginning of pp collisions. Need ~few days at $L=10^{31}$ for ~1000 tracks per chamber tower (600 towers in ATLAS) to obtain a precision of ~100μm on sagitta measurement.
   - Then use optical system to observe movements of the MS chambers with Bfield#0

3. MS/ID alignment: relative alignment of the MS sectors w.r.t. ID. For muon tagging (matching ID and MS tracks), 1mm is enough.
   - work ongoing



Muon Reconstruction algorithms in one slide

- Stand-alone reconstruction in the Muon Spectrometer
  - Muons are reconstructed in the Muon Spectrometer (MS) and are backtracked in the Inner Detector (ID) taking into account material effects and their energy loss in the calorimeters.
    - Name of algorithms: **Moore** (**MuidStandAlone**) / **Muonboy**
- Combined algorithms
  - Combining Muon Spectrometer tracks with ID tracks either by fitting all MS and ID hits, or by statistical combination of the two uncorrelated measurements (MS and ID)
    - Name of algorithms: **MuID** / **Staco**
- Tagging algorithms
  - Tag ID tracks with MS segments
    - Name of algorithms (**MuTag**, **Mugirl**)
  - Tag ID track with calorimeter measurement
    - Name of algorithms: (**Calotag** , **CaloLR**)



Different containers of muons in the AOD

3 containers of muons exist in the Analysis Object Data (AOD)

"StacoMuonCollection": (Staco/MuTag/Muonboy) no overlaps

- **1st step: Staco tracks: All possible combinations of Muonboy MS tracks with the ID (mainly for high P_T tracks~ P_T> 6 GeV)**
- **2nd step: MuTag tracks: ID tracks not combined in Staco matched to a Muonboy segment in the MS (mainly for low P_T tracks)**
- **3rd step: Muonboy only tracks in the region of $2.5<\eta<2.7$ outside the ID acceptance**

"MuidMuonCollection": (Moore/MuId/Mugirl) overlap between Moore/MuId and Mugirl tracks

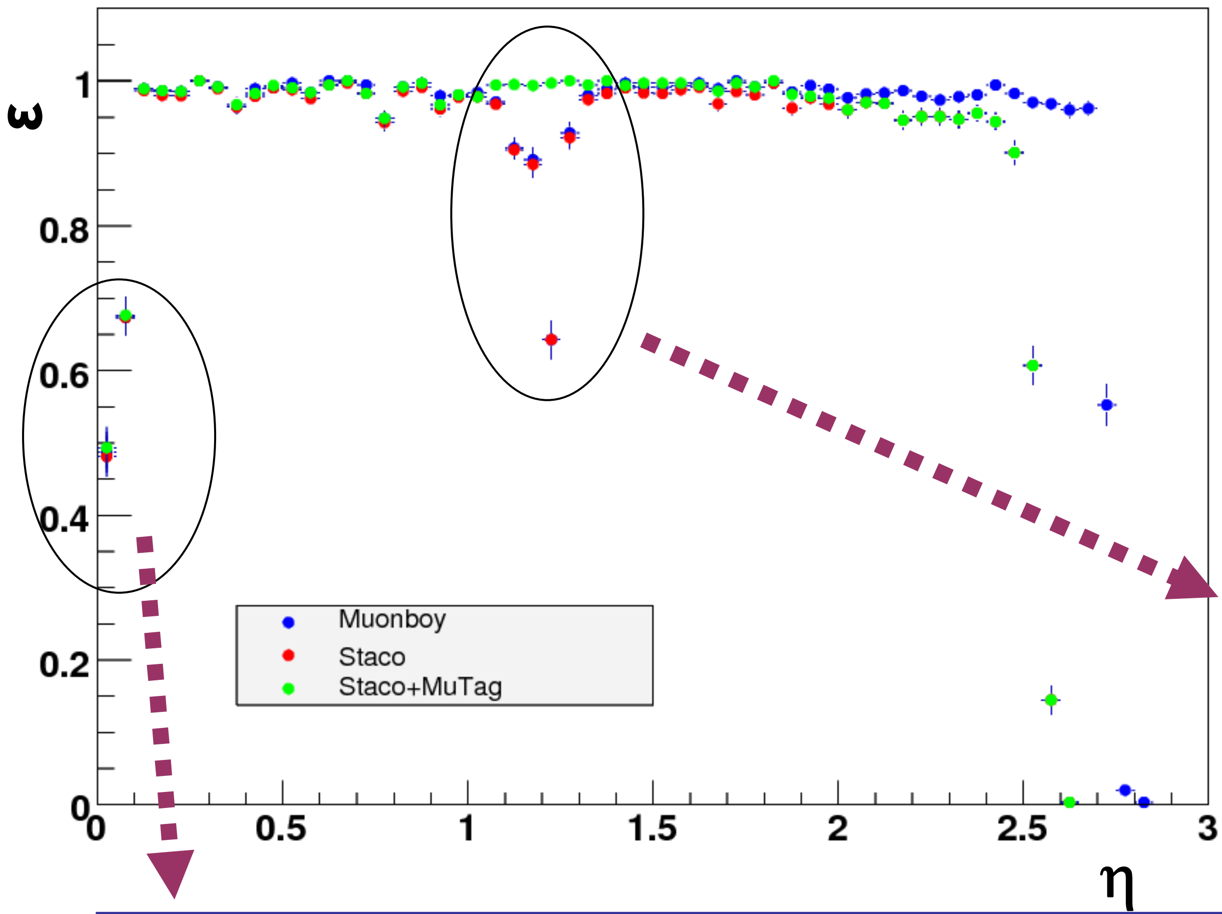
- **Similar performance with "StacoMuonCollection"**

"CaloMuonCollection": (CaloTag/CaloLR) overlap between the two algorithms

- **Mainly to recover efficiency at η~0**

Performances

Efficiency versus η for single μ of p_T=100 GeV

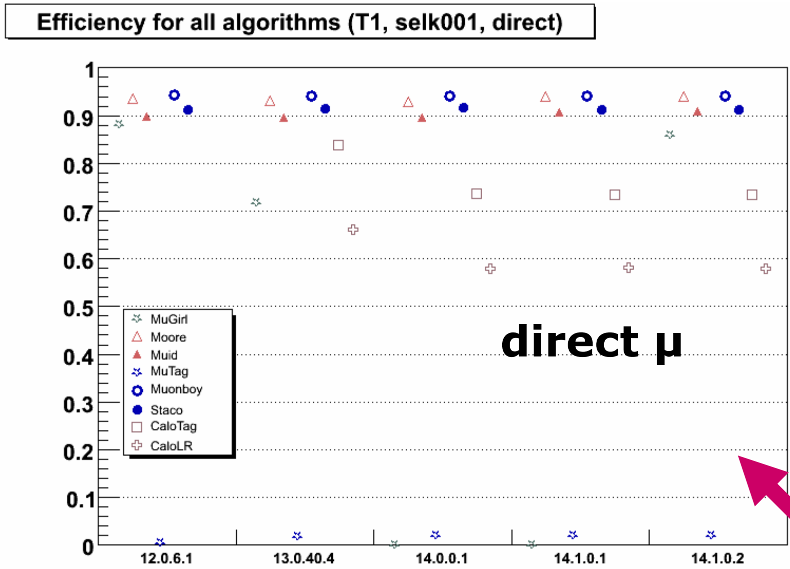


Missing muon chambers to be installed after the first shut down
Drop of eff. recuperated by MuTag extrapolation to the medium stations

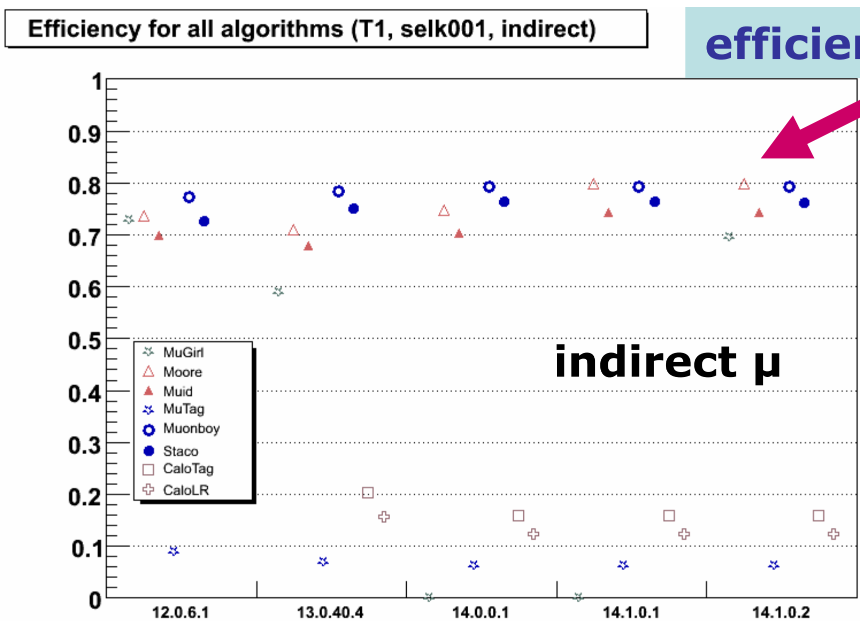
missing muon chambers / access to services
Could we complete this region with a Calorimeter algorithm?
Fake rates and increase of background need to be thoroughly investigated

Performances

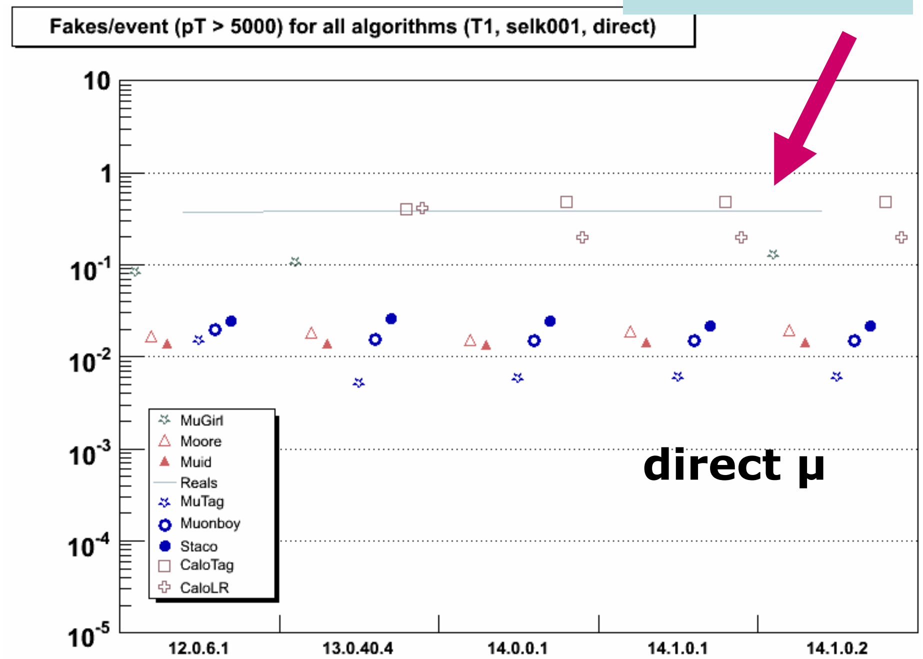
Checking performances of all
μ-reconstruction algorithms in
different software releases with a
ttbar sample in
direct μ from W decays
and
indirect μ from τ, b,c,π,K decays



efficiency



Fake rates



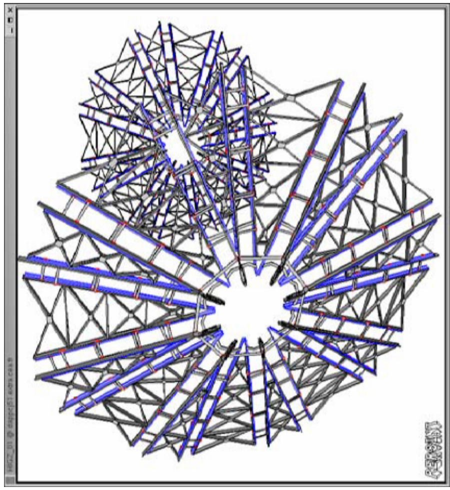
Missing parts in the reconstruction chain

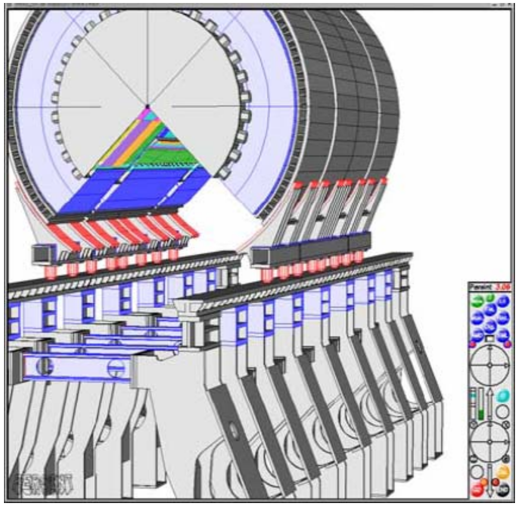
- Stand-alone reconstruction in the Muon Spectrometer
  - Handling of dead and noisy channels (work just started)
  - Tests of chamber deformations
    - Construction or alignment
  - Robustness tests against missing hits in different technologies
    - Work just started need to be fully validated
- Combined reconstruction
  - Improvement of energy loss treatment by using the measurement in the calorimeters
    - (e.g catastrophic energy losses of muons in the calorimeters)
      - Tools exist, validation needs to be done

Missing from both chains (standalone and combined) is the proper validation of fake rates in the presence of pile-up and cavern background, due to missing correctly simulated samples

Simulation / Detector Description

- Dead matter inside our geometry description GeoModel is underestimated (e.g ~5-10 % in between coils)
  - Recent work to include most of the dead matter done,
    - Needs thorough validation
    - Heavy task, lack of person-power





- Correcting geometry with the cosmic analysis
  - E.g Mounting of trigger chambers RPC at the Cavern different from the designs recently corrected
- Simulation: A lot of work ahead to be done
  - E.g Optimization of G4 parameters
  - Validation of new ingredients
- Fast simulation: ATLFAST 1:
  - Parameterization of μ-efficiency and resolution ok
    - Need to be updated with new fully simulated samples

Offline Data quality and monitoring

- Calibration centres
  - Profit from large statistics (~2KHz), only muon information
    - Data from all technologies (MDT, CSC, RPC,TGC)
  - Detailed studies of chamber performances
    - E.g Flag dead/noisy channels
- At Tier-0 (first processing of the data)
  - Express stream ~10 % of total data processed with ~1-2 delay by accessing the calibration and alignment constants coming from the calibration centres
    - Muon Spectrometer standalone track/segment performances
    - ID/MS track reconstruction comparison and combination
    - Reconstruction of resonances (J/Ψ,Y,Z)

See Nectarios and Electra's talks

➢ Infrastructure tested successfully during the cosmic runs and the FDR2 exercise

➢ Work on going to define the Data Quality flags out of the monitoring online and offline results

Comments Conclusions

- Lots of progress was done in the muon reconstruction domain
  - Unfortunately with very few people only
  - Painful work most of the time due to instabilities of the software chain caused by consecutive changes in the chain; this has to stop sometime !!! Hopefully with the arrival of the data

But

- A lot of areas are still uncovered
  - Especially many areas need thorough validation
    - (lack of person-power)
- Commissioning with cosmics proved to be a very useful test-bench for the MS
  - Unfortunately again with a very few people involved
- Also the recent FDR exercise has been proved quite useful to test dedicated parts of the software chain
  - FDR samples should be also used to test the efficiency and robustness of the various analysis programs as well.

Artemis deliverables in the muon domain

Artemis deliverables already ready or in good shape

- ✓ Parameterization of efficiencies in the fast simulation (done)
- ✓ Treatment of alignment corrections from the database (almost done, currently under test)
- ✓ Involvement in the commissioning effort
  - ✓ Especially Data Quality Monitoring effort (in very good shape, continuously tested on cosmics, Tier-0 processing which mimics the "express stream")
- ✓ Tool for muon identification in the calorimeters
  - ✓ Tool done , need some more extensive validation

Artemis work plan in the muon domain I

A restrictive (non exhaustive) list of items that can be shared among Artemis partners

- **Reconstruction:**
  - Validation of dead and noisy channel handling on the reconstruction by using cosmic data
  - Validation of energy loss correction (for muons with catastrophic energy losses),
  - improvement of reconstruction efficiency in $\eta \sim 0$ region by using calorimeter information
- **Alignment :**
  - Straight track alignment
    - **Getting reference geometry from straight tracks**
      - Initially from cosmics, later from B=0 runs on pp collisions
  - Test of chamber deformations

Artemis work plan in the muon domain II

- Trigger efficiency: the first and most important ingredient to optimize final statistics and check detector performance (we don't have the expertise of muon trigger inside Artemis) but we have started having trigger aware offline analyses

  See Tulay's talk

  - Need to continue and provide quick feedback on trigger using for example multiple trigger events Z->$\tau\tau$->eμ..., WW->eμ or pure dimuon samples Z->$\mu\mu$, from single muon trigger
- Analysis side: Study loose muon identification possibilities in multi-muon channels (e.g H→4l)
  - Playing with the either only ID track or only an MS track + isolation + calorimeter information
    - Use cases:
      - η=0 crack region (no MS ID)
      - for 2.5<η<2.7 (beyond ID acceptance)