Muon/ID combined studies using cosmic data

María Moreno Llácer (IFIC-Valencia)
on behalf of the Muon Combined Performance group
ATLAS week, February 19th 2009

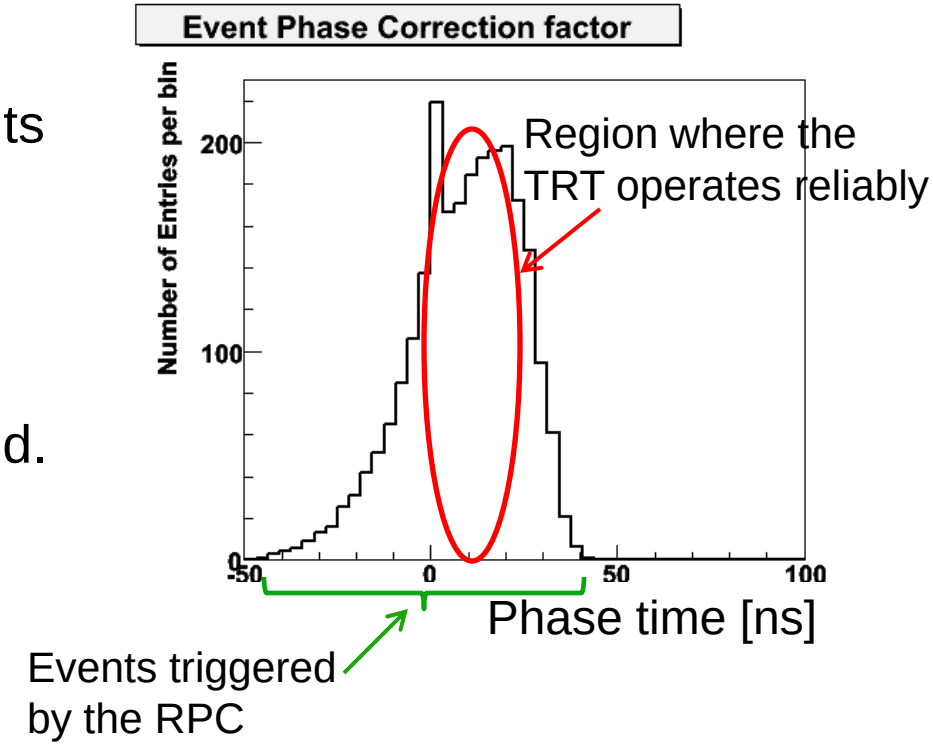
Contents

- Introduction
- Data analyzed
- Event selection
- Correlation Inner Detector & Muon tracks
- Performance of the Combined tracking
- Measurement of the $N\mu^+/N\mu^-$ ratio
- Conclusions

Introduction

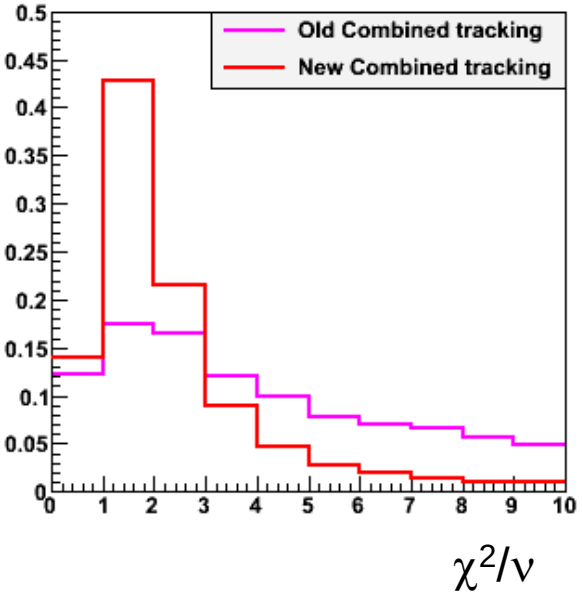
- Cosmic data are very useful for studying the performance of the combined muon reconstruction algorithms with real data.

- Of course, this requires:
  - the reconstruction in the differents sub-systems (including alignment and calibrations) to be in good shape (see previous talks).
  - detectors to be well synchronized.



- Different combined muon reconstruction algorithms have been running over cosmic data @ Tier0 and Tier1, but this work will focus on the Global χ^2 combined tracking (T. Cornelissen et al., CHEP'07, Journal of Physics: Conference Series 119 (2008) 032013).

- The quality of the combined tracks was expected to be much better in the re-processing release since calorimeter material effects were included.



• **Old Combined tracking**
(release<14.5.0.5, ATLAS Production, calorimeter material effects NOT taken into account)
• **New Combined tracking**
(release: 14.5.0.5, ATLAS Production, calorimeter material effects TAKEN INTO ACCOUNT)

Data analyzed

Data Type	Real Data	Simulation
Run Number/ Simulation files	**91890** **Stream: IDCosmic** **DPD: IDCOMM** (only 18k events analyzed)	/castor/cern.ch/grid/atlas/atlasgroupdisk/proj-simcos/rel14/ATLAS-GEO-03-00-00/dig/***TRTBarrel*** (only 10k events analyzed)
Magnet configuration	Toroid On Solenoid On	Toroid On Solenoid On
Detector configuration	All sub-detectors except CSC (some non readout parts)	All sub-detectors

- DATA:
  - The output (DPDs) of the re-processing at Tier1´s has been used.
  - Combined global chi2 tracking was re-run (since it was off by mistake).
- SIMULATION:
  - Latest simulation done with release 14 used:
    - TRT Xe based gas mixture instead of Ar based.
    - Detector description updated.
  - processed with the same release used for data re-processing @ Tier1´s.

Event selection

→ In order to compare data and MC, one should take into account the detector and trigger configuration and the data stream used.

→ **Detector configuration:**

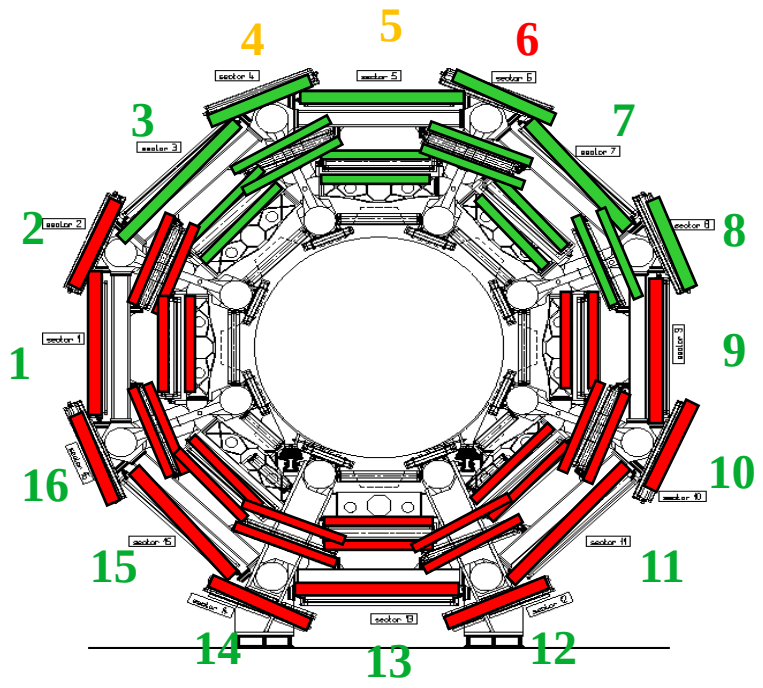
- Masking RPC sector 6 and CSC chambers that were not readout (for MC).

→**Trigger configuration and data stream:**

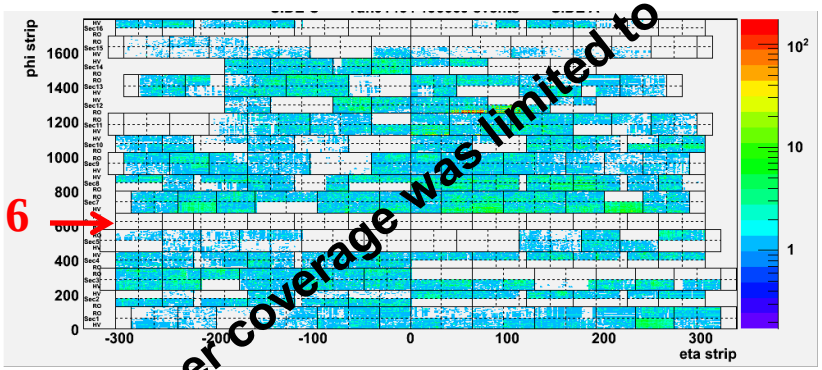
Select events (for data and MC) with:

- ID tracks.
- Combined tracks that pass through the 3 RPC chambers (Most of the events in the IDCosmic stream have been triggered by RPC; during ATLAS combined data taking TRT FastOr trigger was not in).

After trigger and stream emulation:
- **DATA: 4.8k events** (initially 18k)
- **SIMULATION: 6k events** (initially 10k)



RPC chambers are distributed in 16 ϕ sectors
-1-3, 7-16 were read-out,
-sector 4 & 5 read-out at lower value,
-sector 6 not read-out.

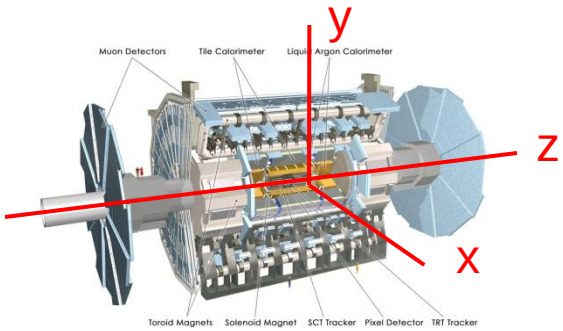


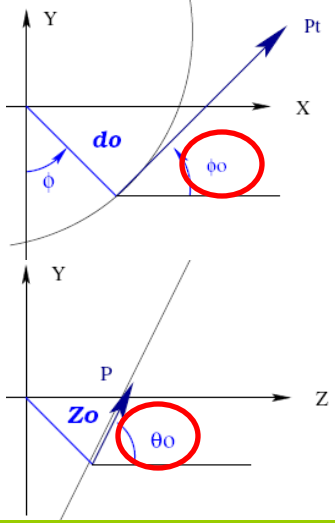
See talk from F. Pastore on Monday afternoon.

Correlations between Inner Detector & Muon Spectrometer tracks

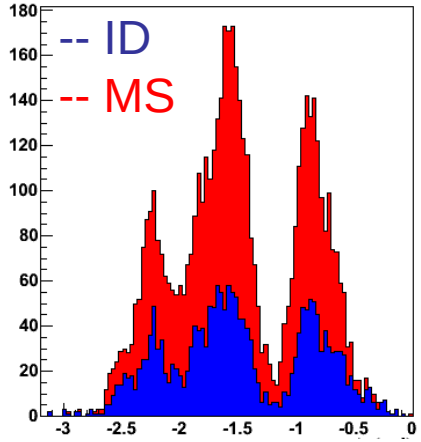
Correlation ID and MS tracks

Tracks are characterized by 5 parameters: (d_0, z_0, ϕ, θ, q/p)

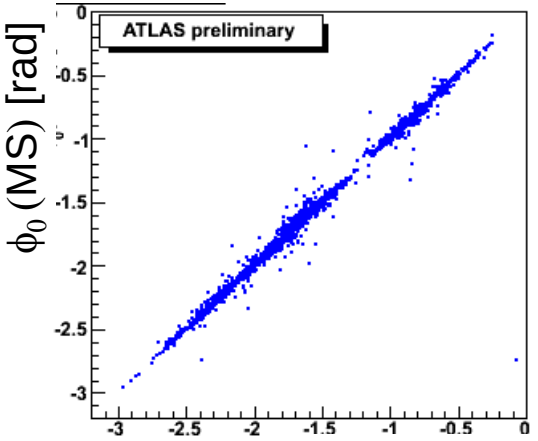




ϕ_0



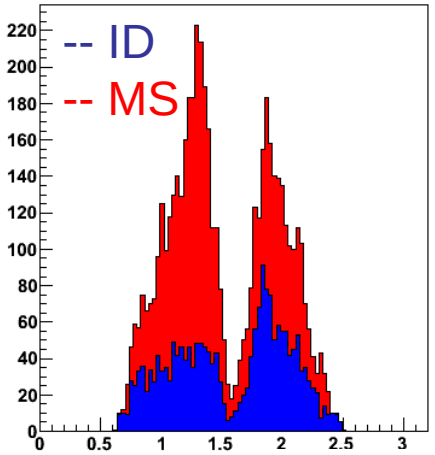
ϕ_0 [rad]



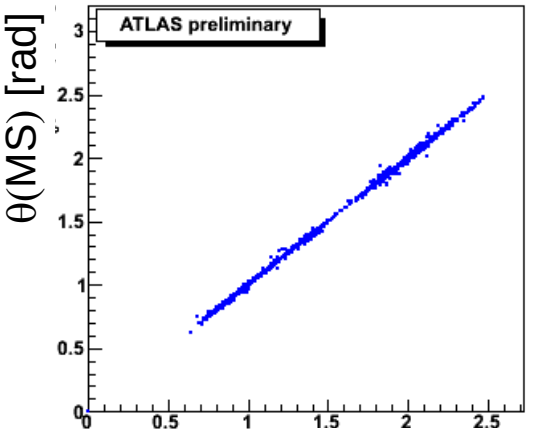
ϕ_0 (MS) [rad]

ϕ_0 (ID) [rad]

θ_0



θ_0 [rad]

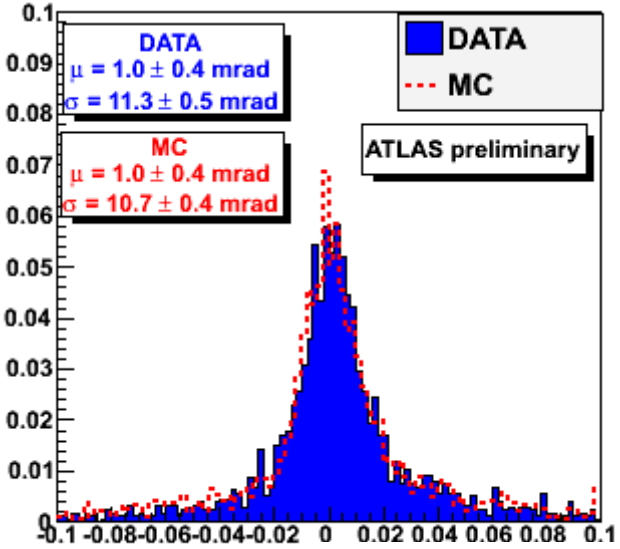


θ_0(MS) [rad]

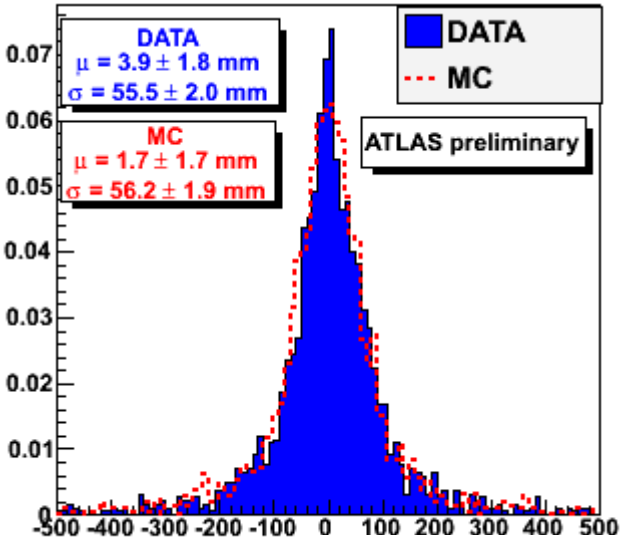
θ_0 (ID) [rad]

- ID and Muon tracks show the same acceptance since only events with an ID track are selected.
- Note: Muon tracks are separated in top and bottom tracks.
- Good correlation between the parameters measured in both sub-detectors.

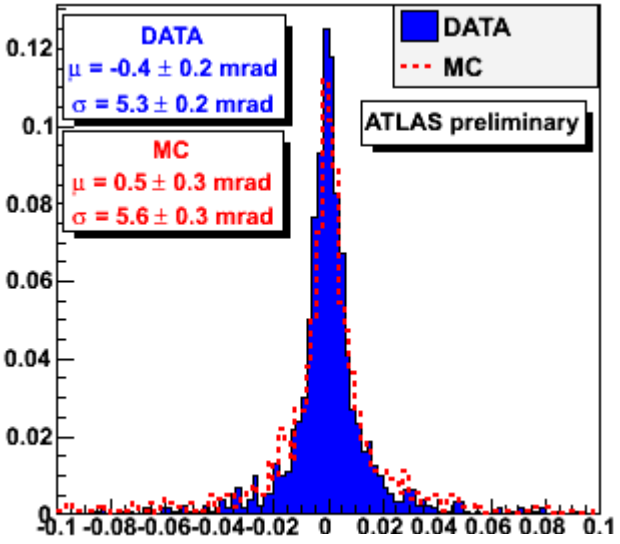
Correlation ID and MS tracks



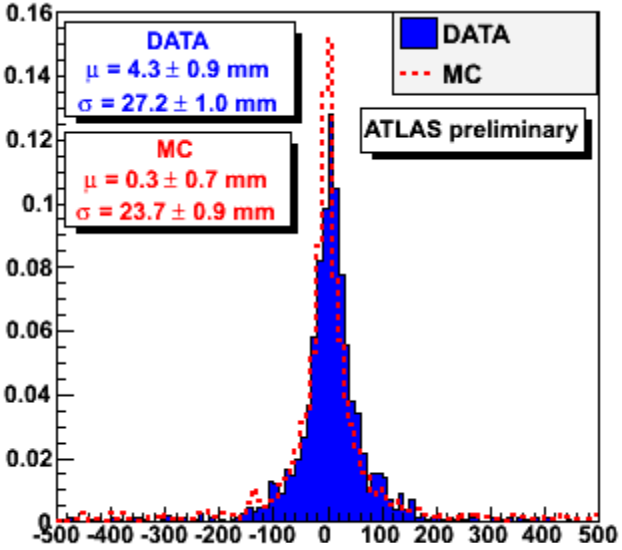
ϕ_0 (MS-ID) [rad]



d_0(MS-ID) [mm]

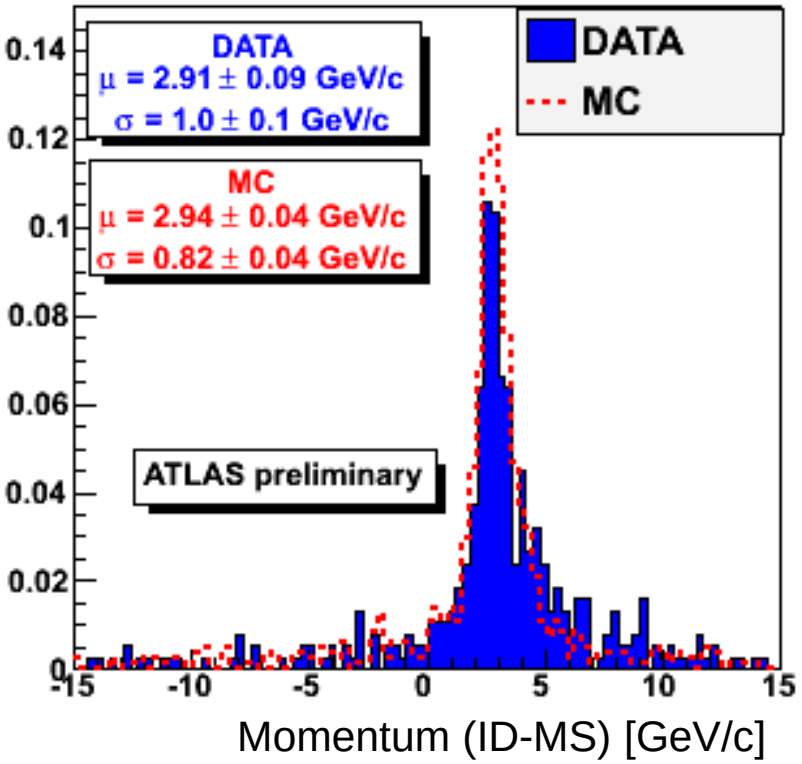


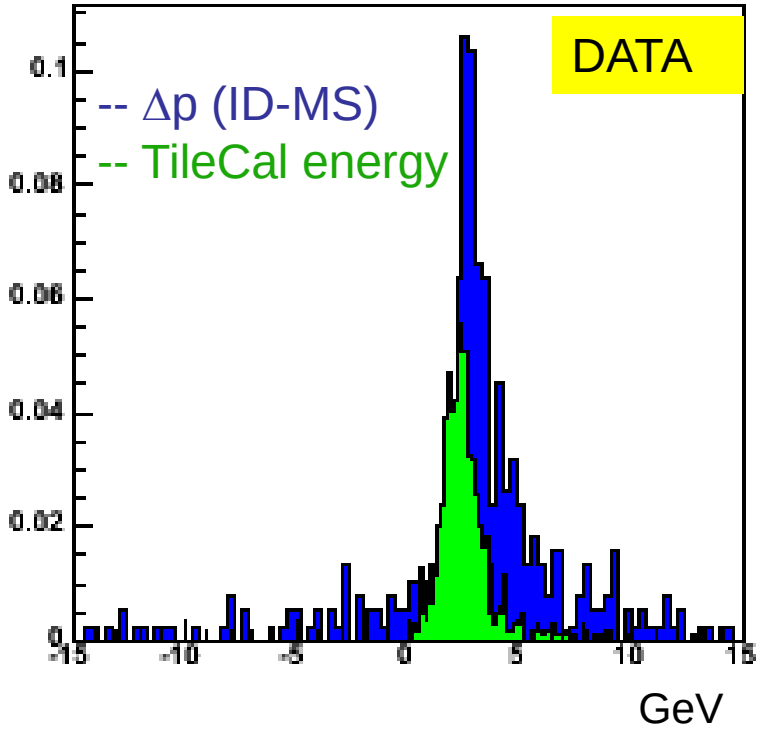
θ_0 (MS-ID) [rad]



z_0(MS-ID) [mm]

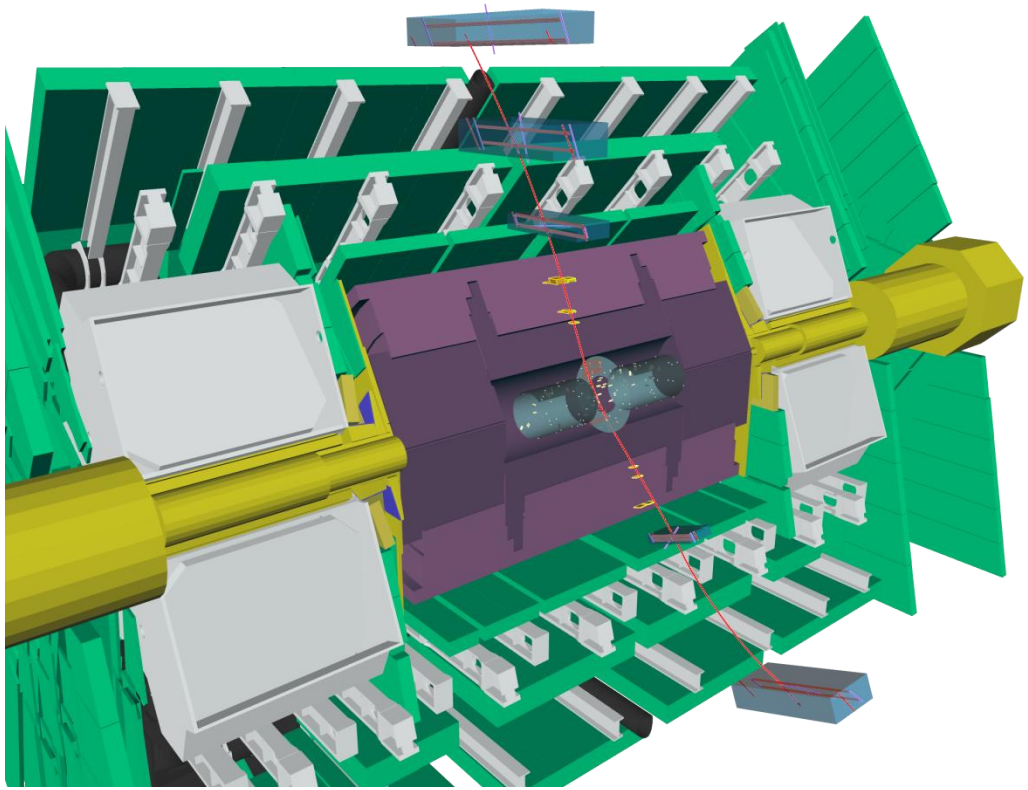
Correlation ID and MS tracks



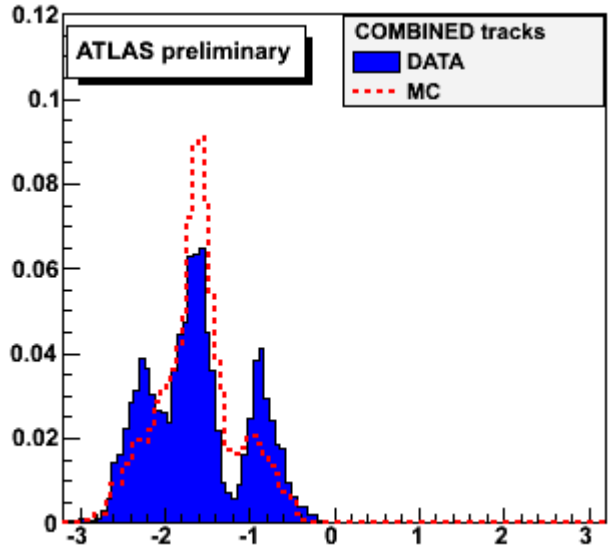


- The data/MC agreement for all track parameter differences is fairly good.
- Improvements with respect to the first processing observed.
- However, the measured deposited energy in the Tile calorimeter is smaller than the ID-MS momentum difference (under investigation).

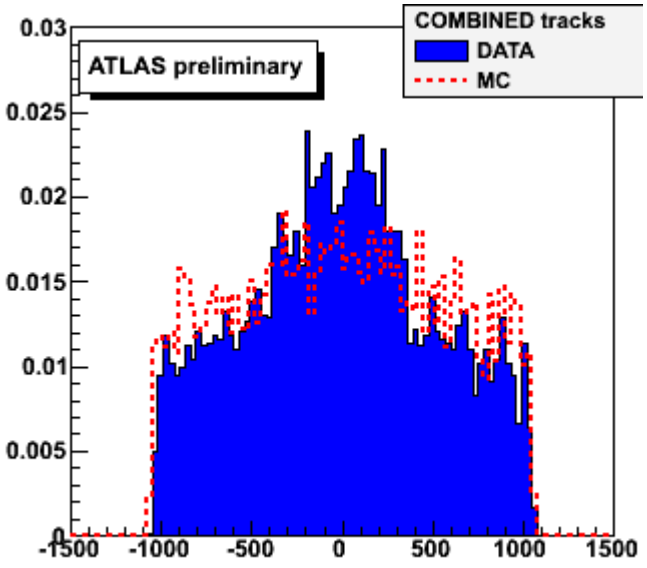
Performance of the COMBINED TRACKING (Inner Detector + Muon Spectrometer)



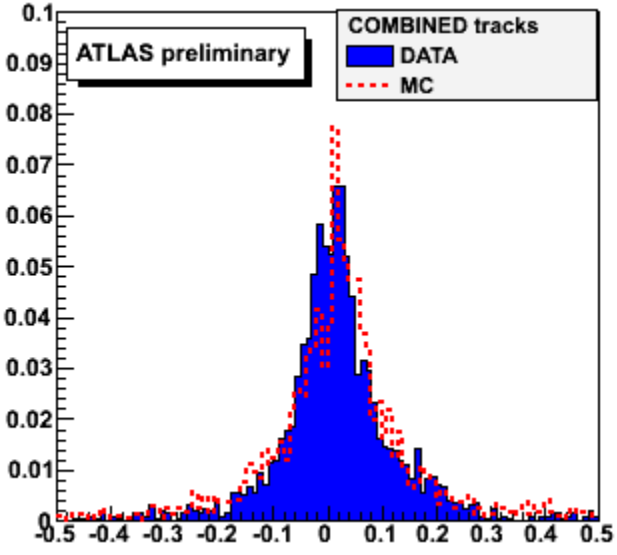
Combined Track parameters



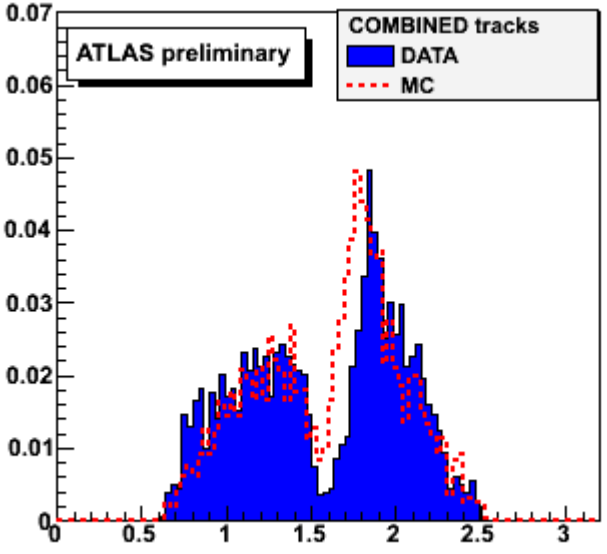
ϕ_0 [rad]



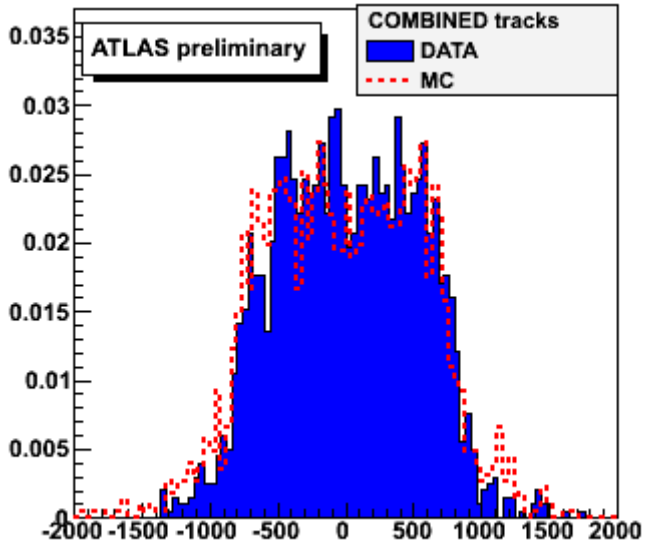
d_0 [mm]



q/p [c/GeV]



θ_0 [rad]



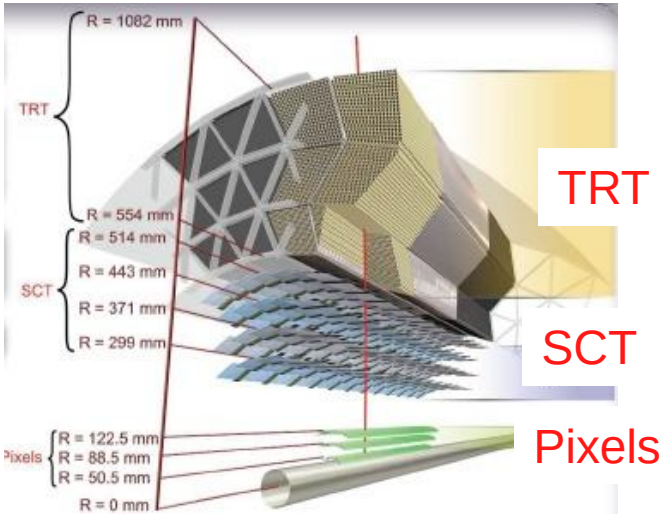
z_0 [mm]

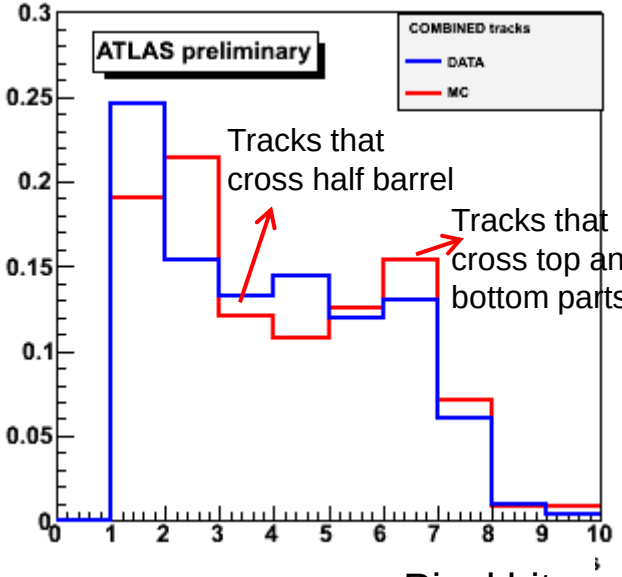
- Relatively good agreement data/MC.
- Discrepancies observed specially in ϕ and θ distributions (due to discrepancies in the readout and trigger conditions).

Hits associated to combined tracks

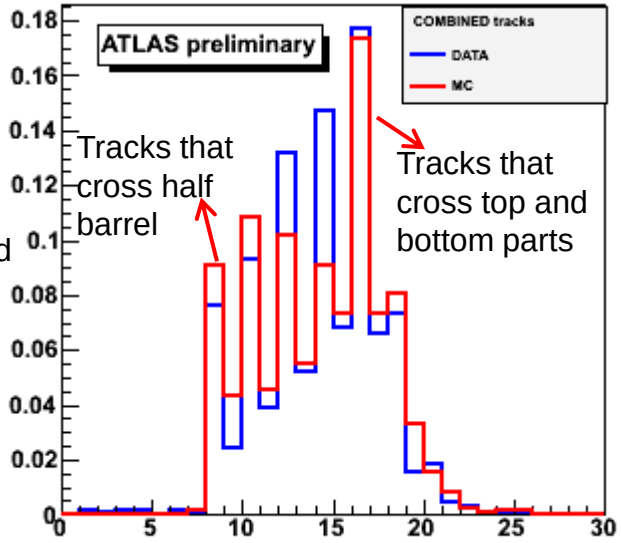
Hits in the ID

Most of the tracks come through the **barrel** and cross the whole detector. In each half (top or bottom) there are:
Pixels→ 3 barrel layers, each one provides 2 measurements.
SCT→ 4 layers, each one provides 2 measurements.
TRT→ 36 straw planes.

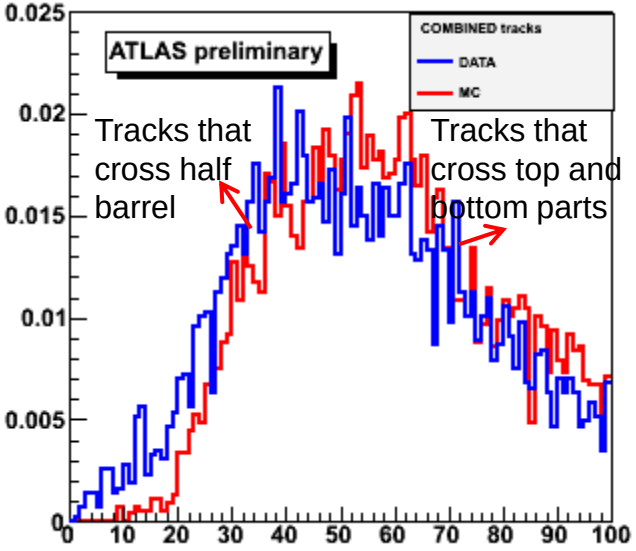




Pixel hits



SCT hits

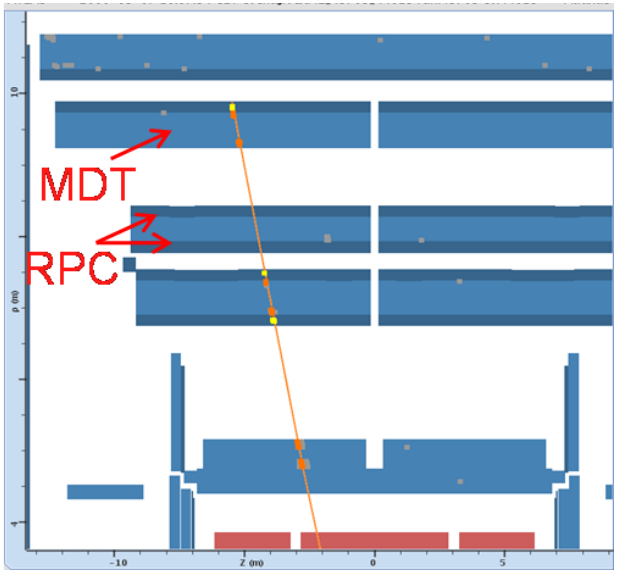


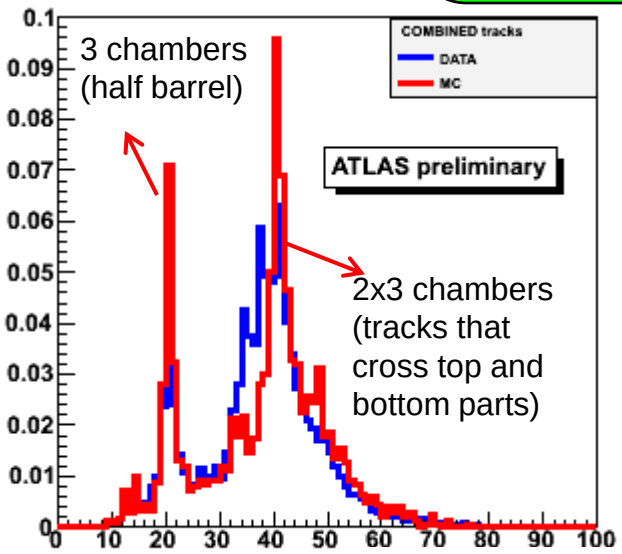
TRT hits

Hits associated to combined tracks

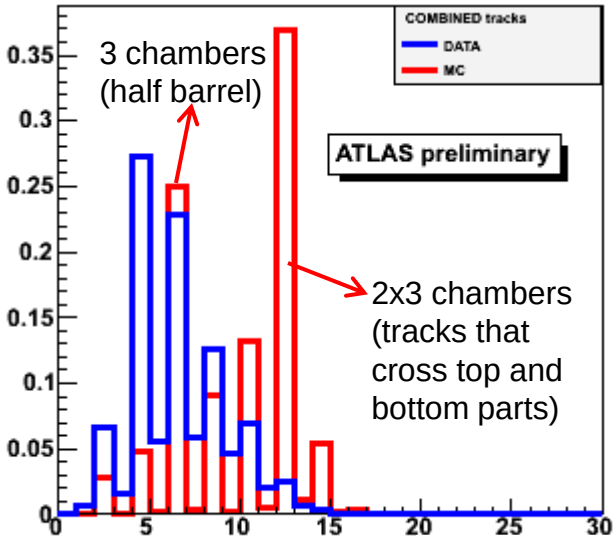
Hits in the MS

In one hemisphere:
•**MDT**s: There are 3 MDT chambers: the first one provides 8 hits and the other two 6 hits.
• **RPC**s: There are 3 RPC chambers, each one provides 2 hits (1 ϕ and 1 η).





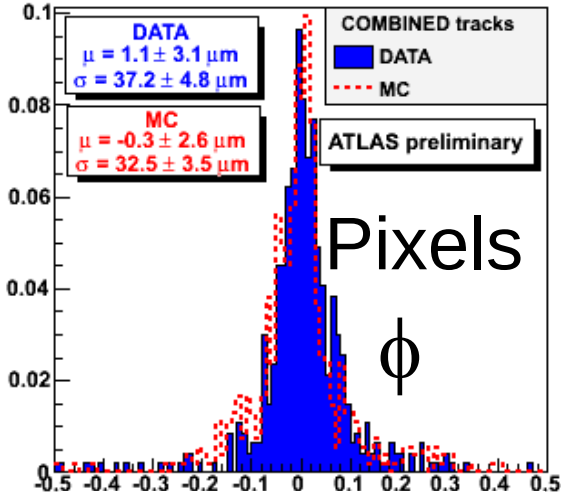
MDT hits



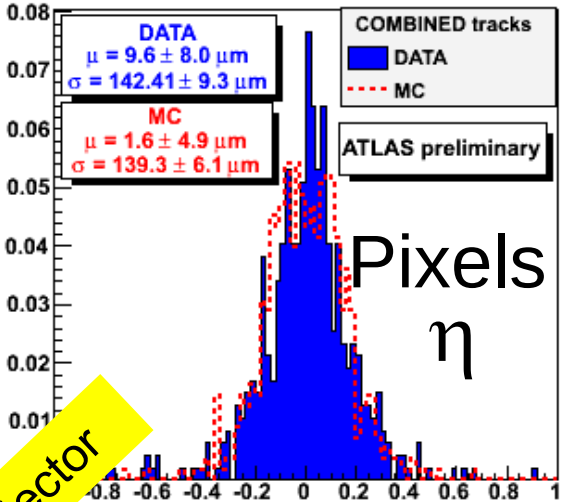
RPC hits

• The agreement data/MC is fairly good (except for RPC). Slightly more associated hits in simulation than in data.
• For RPC, there are less hits associated for data due to the non readout elements or the ones operating at lower voltages.

Residuals in the ID and MS

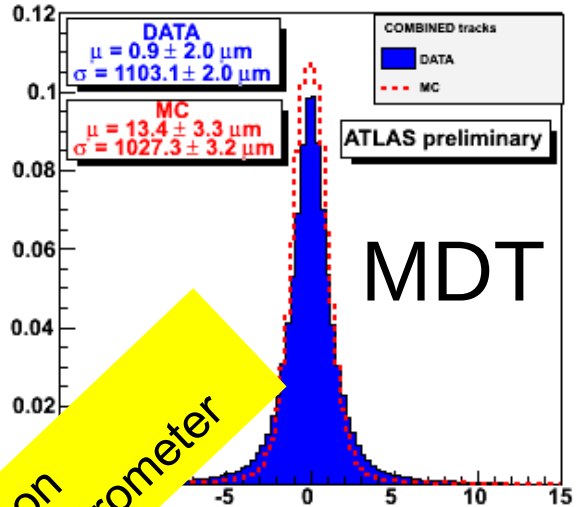


Pixels ϕ residuals [mm]



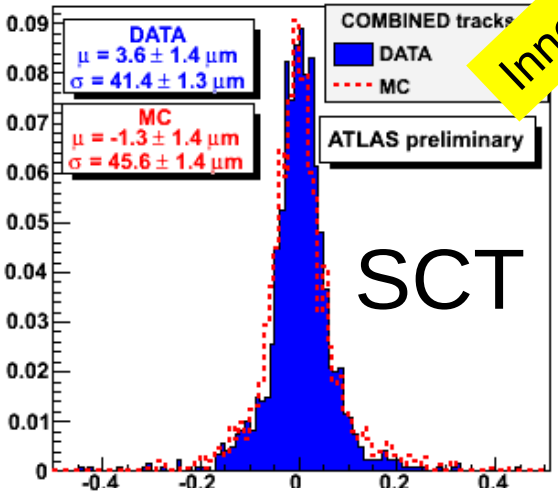
Pixels η residuals [mm]

Inner Detector

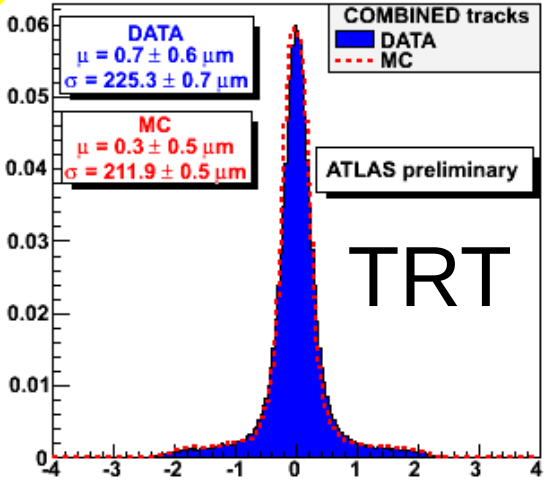


MDT residuals [mm]

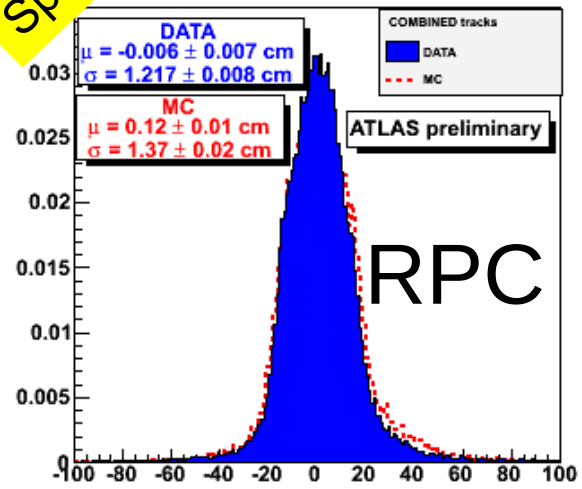
Muon Spectrometer



SCT residuals [mm]



TRT residuals [mm]



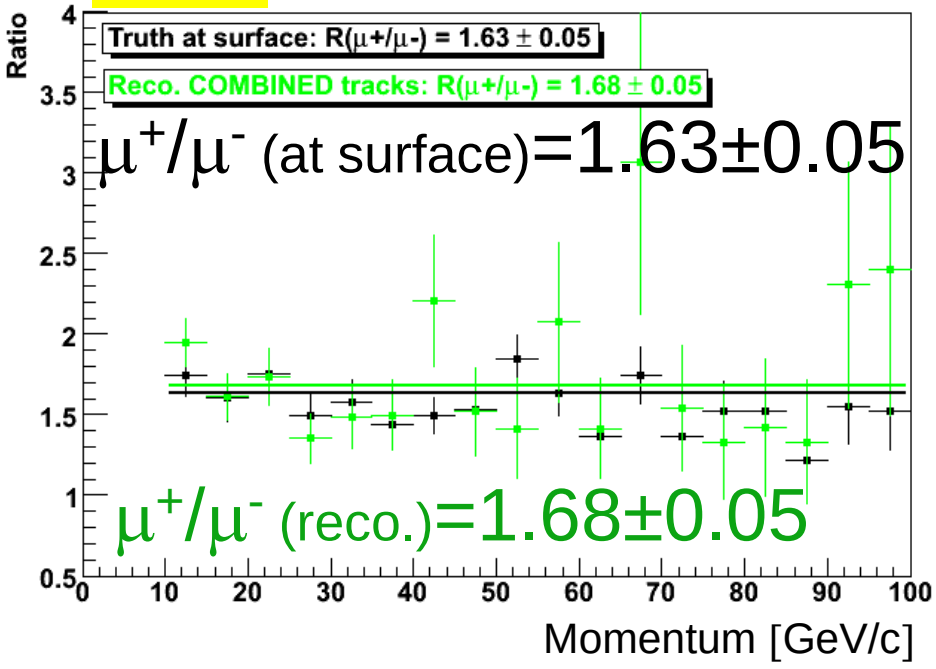
RPC residuals [mm]

- The data/MC agreement is fairly good for all sub-detectors.
- Big improvements with respect to the first processing due to the fact that now calorimeter material effects are taken into account and for data also due to the updated alignment and calibration constants.

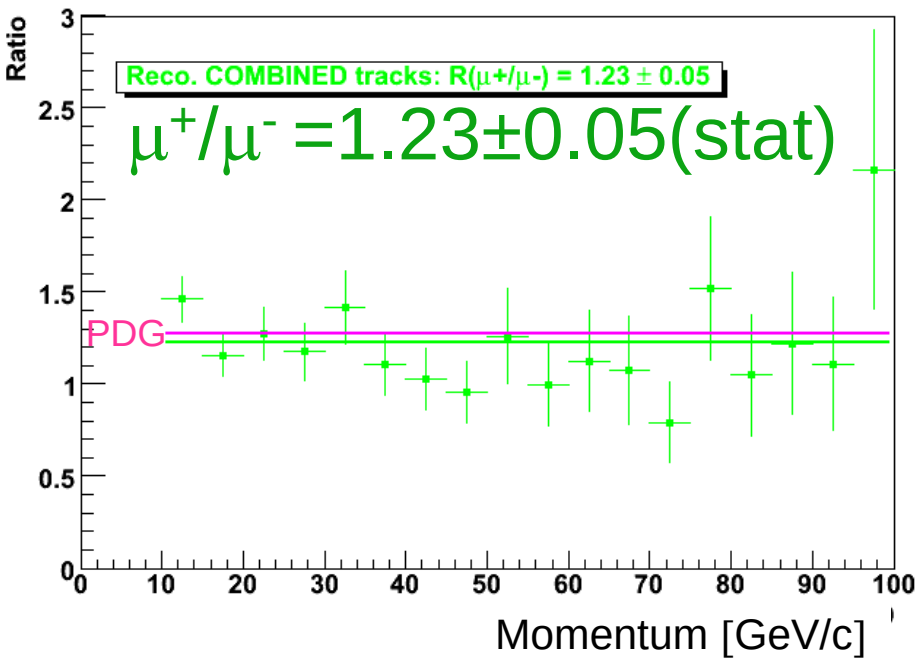
RATIO $N\mu^+/N\mu^-$

Measurement of the ratio μ+/μ- using combined tracks

MC



DATA



- The value of the ratio in the generator is different from the PDG value (1.27 @sea level for momentum from 10 to 100 GeV).
- Correction factor (R (at surface)/ R (at reconstruction)) ~1.
- The measured value for μ^+/μ^- ratio is compatible with the PDG value.
- Only statistical uncertainties considered.

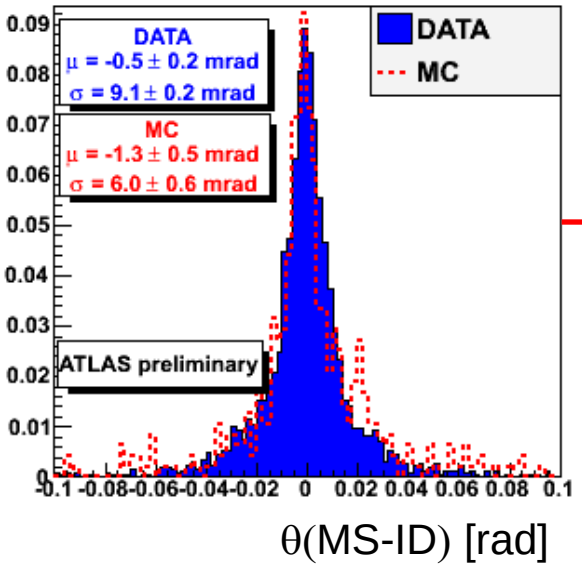
Conclusions

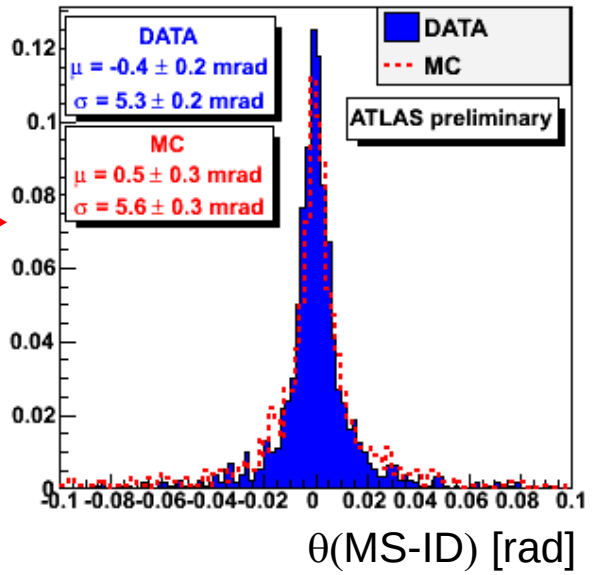
- The performance of the combined tracking with cosmic data has been studied using the output (DPDs) of the re-processing @ Tier1´s
(and re-running the combined reconstruction).

- The results obtained have been compared with simulated cosmic data and the agreement is reasonable (given the different readout and trigger conditions).

- Significant improvements observed in ID and Muon track parameters differences:

Before

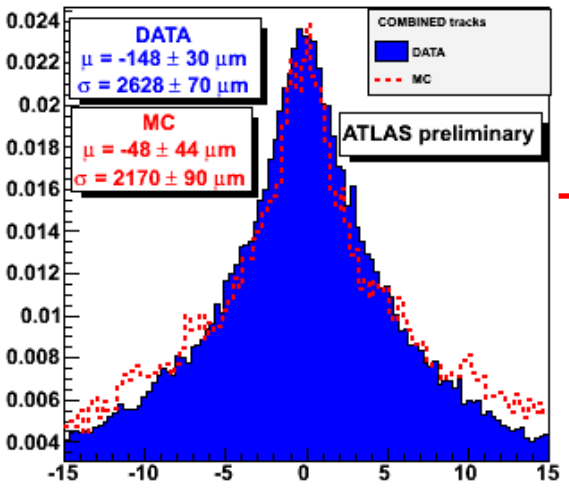




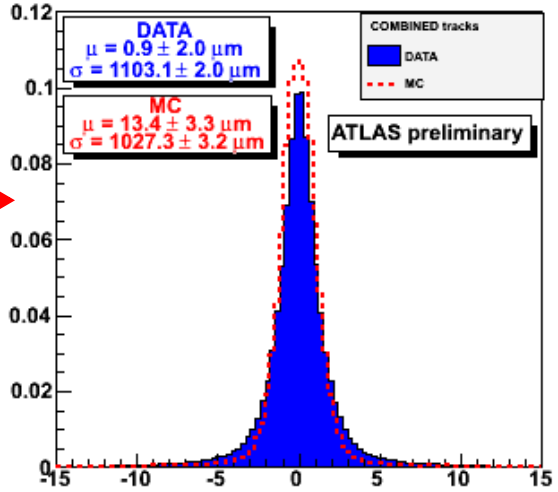
After

- Very significant improvements observed in the track quality due to the fact that now calorimeter material effects are taken into account and for data also due to the alignment and calibration constants provided:

Before



MDT residuals [mm]



MDT residuals [mm]

After

- A first very preliminary measurement of the μ^+/μ^- ratio in the 10 - 100 GeV momentum range has been done:

μ^+/μ^- (Combined) =1.23±0.05(stat)

Compatible with PDG value: 1.27 @ sea level.
Only statistics uncertainties considered.

BACK-UP

Reconstruction Software

→Cosmic data,
- Release: 14.5.0.5
- Detector Description tag: ATLAS-GEO-03-00-00
- ConditionsTag: COMCOND-REPC-001-03
- Input: DPDs from the re-processing

•**data08_cosmag.00091890.physics_IDCosmic.merge.DPD_IDCOMM.o4_r602_p16_tid034730/**
DPD_IDCOMM.034730._00002.pool.root.1
DPD_IDCOMM.034730._00004.pool.root.2
DPD_IDCOMM.034730._00006.pool.root.3
DPD_IDCOMM.034730._00019.pool.root.1
DPD_IDCOMM.034730._00026.pool.root.1
DPD_IDCOMM.034730._00031.pool.root.2
DPD_IDCOMM.034730._00032.pool.root.1

data08_cosmag.00091890.physics_IDCosmic.merge.DPD_IDCOMM.o4_r602_p16_tid034731/

DPD_IDCOMM.034731._00033.pool.root.1
DPD_IDCOMM.034731._00034.pool.root.1
DPD_IDCOMM.034731._00035.pool.root.1

- re-run combined tracking
- create CBNT and TrkValidation ntuples

→Cosmic simulation,
- Release: 14.5.0.5
- Simulation input:
/castor/cern.ch/grid/atlas/atlasgroupdisk/proj-simcos/rel14/ATLAS-GEO-03-00-00/dig/*TRTBarrel*

- Simulation conditions:
  - masking RPC sector 6 and CSC chambers
  - fix in TRT calibrations (a t0 shift of 8 ns was applied in 14.5.0.5)
- DetDescription = ATLAS-GEO-03-00-00

- The same software release was used for both data and MC reconstruction.