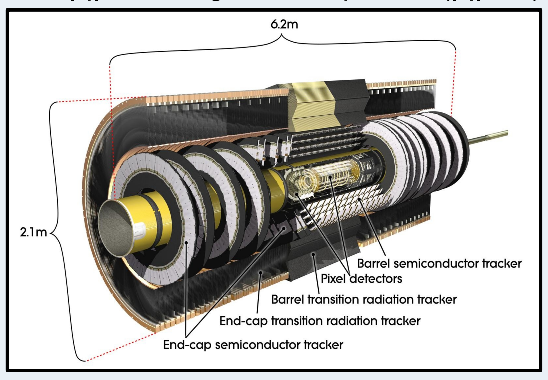
# LHCC Poster Session - CERN, 23 March 2011

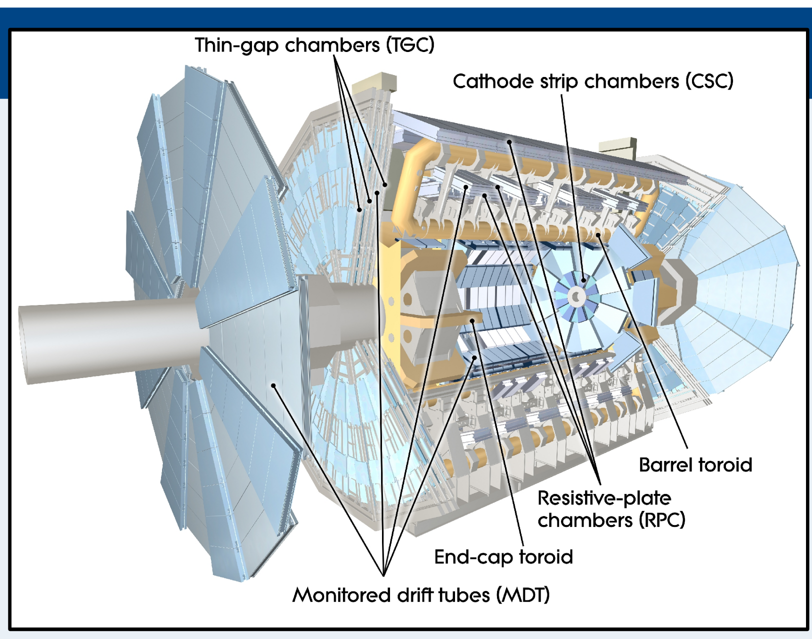
# Performance of the Muon Identification with the Atlas Detector in 2010 LHC pp Collision Data


Measurements of the muon reconstruction efficiency and misidentification rate as well as the muon momentum resolution have been carried out with collision data at $\sqrt{s}$ = 7 TeV recorded by the ATLAS experiment in 2010. The muon efficiency is determined with dimuon decays of J/ψ mesons and Z bosons. The momentum resolution is extracted from the width of the dimuon mass distribution in $Z \rightarrow \mu\mu$ decays and the comparison of the independent measurements of muons from $Z \rightarrow \mu\mu$ and $W \rightarrow \mu\nu_\mu$ decays provided by the ATLAS tracking systems, the inner detector and the muon spectrometer.


## Atlas Inner Detector

- Inside solenoid (2T)
- Pixels, SemiConductor Tracker, Transition Tradiation Tracker
- Cover |η| ≤ 2.5 region, except TRT (|η| ≤ 2)



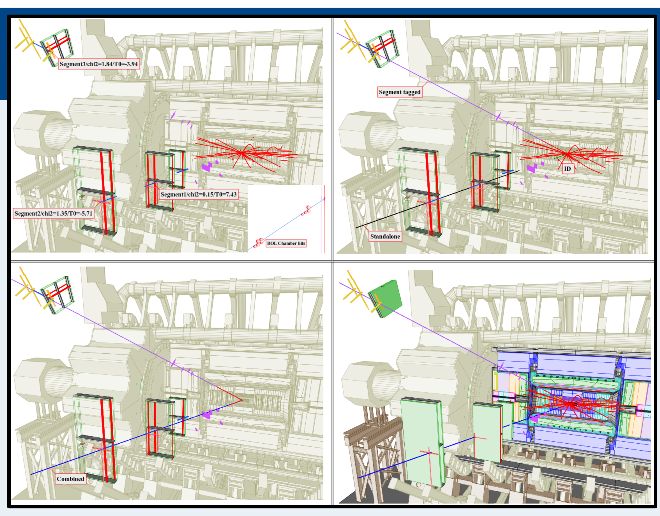

## Atlas Muon Spectrometer

- Use a toroidal field (about 0.5T)
- **Precision chambers**
  - Monitored Drift Tubes in barrel and endcaps
    3 layers for |η|<2.0, 2 layers for 2.0 < |η| < 2.7,
    resolution of 35 μm per chamber
  - Cathode Strip Chambers :
    1 layer (inner) for 2.0 < |η| < 2.7,
    resolution in precise coordinate of 40 μm per station
- **Trigger chambers**
  - Resistive Plate Chambers in barrel (|η| < 1.05),
    1.5 ns of time resolution
  - Thin Gap Chambers in endcaps (1.05 < |η| < 2.7)

## Muon Reconstruction Principles

**Standalone**
The track is entirely reconstructed in the MS, from trigger chambers hits and segments reconstructed in the precision chambers. The track is then extrapolated to IP and the momentum is corrected for the energy loss due to the material crossed before reaching the MS.

**Combined**
The combined muon track results of the combination of MS and ID measurements by a statistical combination or a refit of the entire track. Energy losses in the calorimeter are taken into account using parametrisation and possibly calorimeter measurements



**Segment Tagged**
These muon tracks are based on the ID measurement. The muon is identified if at least one segment in MS matches with the ID track.

**Calorimeter tagged**
Starting from an ID track it is identified as a muon if the calorimeter deposit is compatible with a minimum ionizing particle.

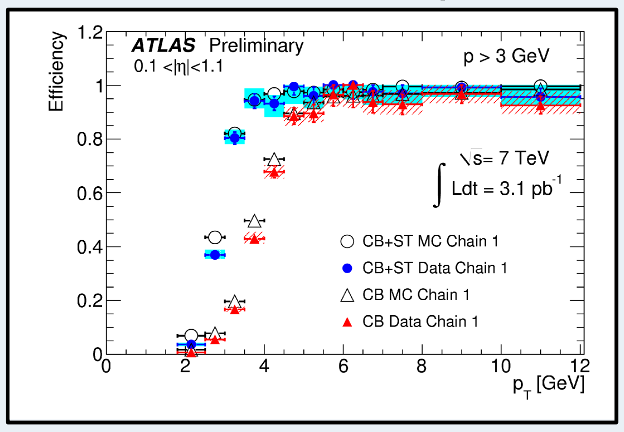
## Efficiencies

**Using tag and probe method with muons from**
- J/ψ mesons for low $p_T$ muons
- Z bosons for medium $p_T$ muons
- Using high quality muon as the tag track
- Using high quality ID track in the corresponding mass window as probe
- Matching probe with a reconstructed muon

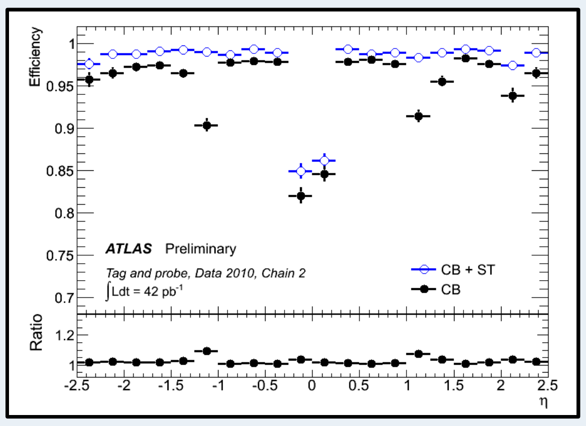
**Main results**
- Efficiency increase when adding the tagged muons
- Excellent agreement with MC: the ratio of data/MC efficiencies are presented in the table

| | Combined | Combined + segment tagged |
|---|---|---|
| J/ψ | 0.980 ± 0.013 | 1.009 ± 0.007 |
| Z | 0.9918 ± 0.0020 | 1.0006 ± 0.0015 |

**J/ψ mesons**




**Z bosons**

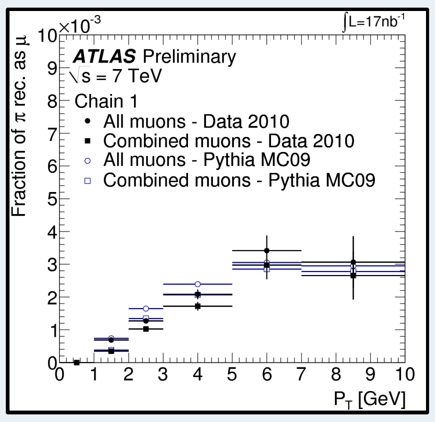



## Fake Rate

**What is a fake muon ?**
- Real muon coming from long-living mesons (π,K) or baryons decaying in the detector,
- Misidentified hadrons (punch-through),
- Reconstruction ghosts.

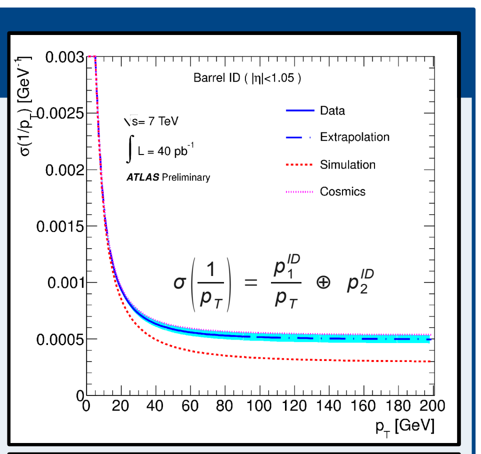
**Estimation of misidentification of pions as muons**
- Using $K^0_S \rightarrow \pi^+\pi^-$ reconstructed in ID
- Look for muon matching with the highest $p_T$ pion track

The fake rate coming from π is of the order of 0.1%.

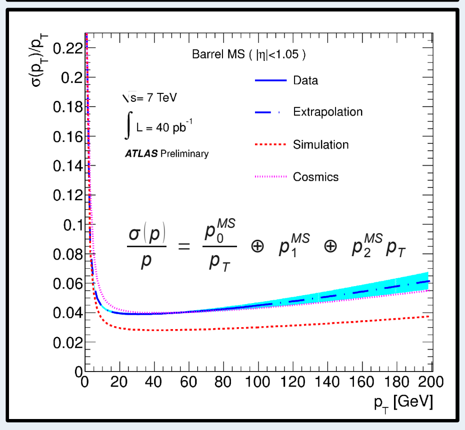



## Momentum Resolution

**Combined fit results to get the correction to MC resolution from**
- MC distributions, obtained with smeared reconstructed momenta, are used for a simultaneous fit to the data distributions.
- The distributions
  - Dimuons from Z bosons decay
    - Invariant mass reconstructed independently for MS and ID
    - Sensitive to $\sigma_{mult.\,scat.} \oplus \sigma_{intrinsic}$ in each case
  - Single muons W and Z bosons decay
    - $(q/p_T^{ID} - q/p_T^{MS})$ for different values of $p_T$
    - Sensitive to $\sigma_{ID} \oplus \sigma_{MS}$.
- Use constraints on MS alignment from straight tracks measurements
- Results: resolution parameters and smearing function




$$\sigma\left(\frac{1}{p_T}\right) = \frac{p_1^{ID}}{p_T} \oplus p_2^{ID}$$

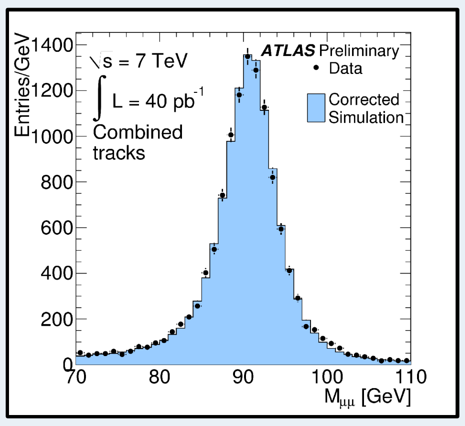



$$\frac{\sigma(p)}{p} = \frac{p_0^{MS}}{p_T} \oplus p_1^{MS} \oplus p_2^{MS} p_T$$

**Main contributions and results for barrel**

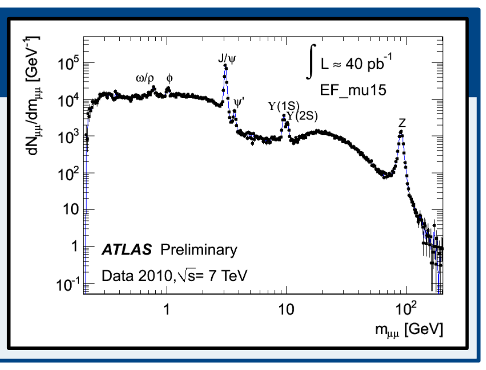
| | $p_0$ (TeV) Energy losses in calorimeters | $p_1$ (%) Multiple scattering | $p_2$ (TeV$^{-1}$) Intrinsic resolution |
|---|---|---|---|
| ID | | 1.60 ± 0.32 | 0.49 ± 0.04 |
| MS | 0.23 ± 0.01 | 3.75 ± 0.10 | 0.24 ± 0.04 |

**Observed effects**
- Missing material in barrel and endcaps: too small multiple scattering contribution in simulation
- ID misalignment → under improvement
- MS misalignment → small effect for W/Z decays, but improvements in CSC, BEE, BIS7/8 and EE regions




## Dimuon Spectrum

**Invariant mass between opposite sign combined muons coming from a common vertex**
- One muon of at least 15 GeV
- All expected resonances are observed





Eve Le Ménédeu, for the ATLAS Collaboration


ATLAS EXPERIMENT