LHCC Poster Session - CERN, 21 March 2012

ATLAS Muon Performance in the Presence of Pile-up

Muons are a key ingredient for many physics analyses in ATLAS. A measurement of the performance of the muon reconstruction and identification on LHC collisions recorded in 2011 is presented, with a particular focus on the effects of pile-up and a comparison with Monte-Carlo simulations.

Muon Reconstruction in ATLAS

Muon Spectrometer (MS) tracks:
- Entirely reconstructed in the MS
- Extrapolated to the primary vertex
- Corrected for the energy loss in the material

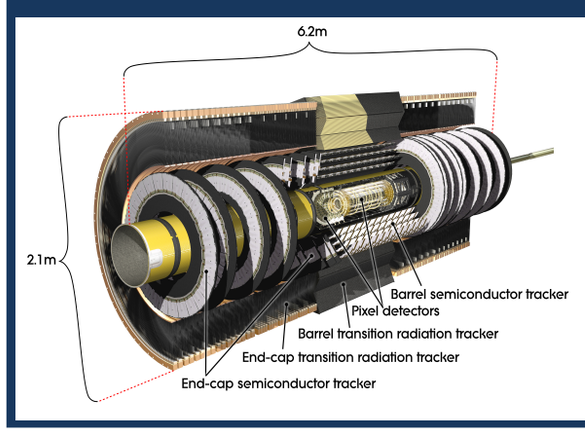
Calorimeter Muon tracks:
- ID tracks
- Identified as muons if calorimeter measurement is compatible with minimum ionizing particle

Combined (CB) tracks:
- Combination of MS and ID tracks
- Result of a statistical combination or of a full refit
- Best momentum measurement

Segment Tagged (ST) tracks:
- Inner detector tracks
- Identified as muons using partial MS information
- Allow for efficiency recovery in regions with low MS acceptance

The Inner Detector

The Inner Detector (ID) measures tracks up to |η|<2.5 in a solenoidal field of 2T

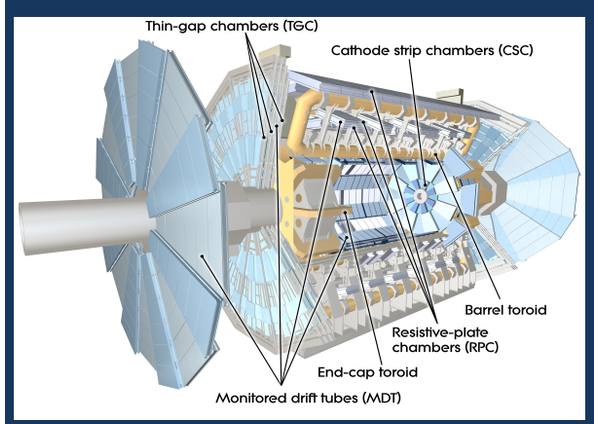


Three detectors exploited:

- Silicon pixel detector ensures a precise vertex reconstruction
- Silicon strip detector (SCT) provides an accurate momentum measurement
- Transition Radiation Tracker (TRT) plays a key role for pattern recognition and for particle identification

The Muon Spectrometer

The Muon Spectrometer (MS) measures muons up to |η|<2.7 in an air-core toroid which provides a mean field of 0.5 T



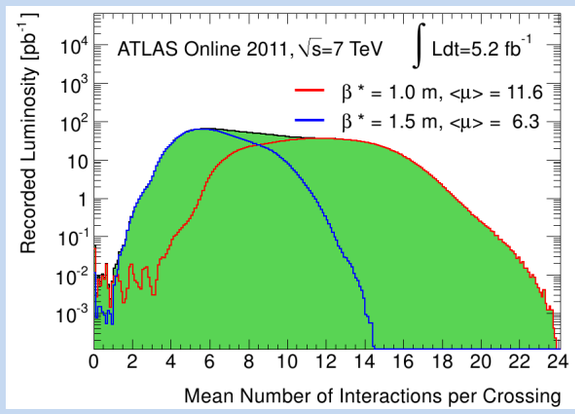
Four detectors exploited:

- Monitored Drift Tubes (MDT) chambers and Cathode Strip Chambers (CSC) are used for the position measurement in the bending plane.
- Resistive Plate Chambers (RPC) and Thin Gap Chambers (TGC) provide the muon trigger and the position measurement in the non-bending plane.

Pile-up in 2011

LHC performance in 2011 was in line with the most optimistic expectations, with a delivered luminosity two orders of magnitude higher than in 2010.

The increase of the instantaneous luminosity led to an higher average number of particle interactions per beam crossing. In a single event, the hard scattering most physics analyses are interested in took place together with up to 25 inelastic collisions, which represent the so-called "pile-up". The growing impact of pile-up during the 2011 data taking represented a challenge for the ATLAS detector and its subsystems, and a training ground for the even higher levels expected in 2012.



Performance measurement

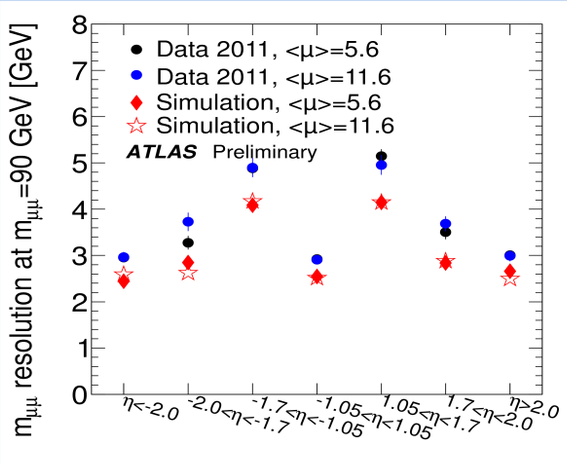
J/Ψ and Z boson dimuon decays are processes with well known cross sections and energies, especially useful for the muon performance measurement.

Muon momentum resolution:
Measured with a fit to the Z invariant mass peak, and used to derive a smearing correction for the Monte-Carlo simulations.

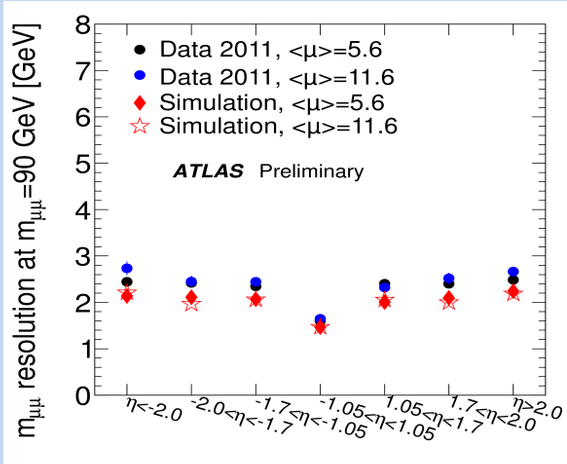
Muon efficiency reconstruction:
Measured using a Tag-and-Probe method on Z and J/Ψ events.
The efficiency of combined muons is defined as $\varepsilon = \varepsilon_{ID}\varepsilon_{MS}\varepsilon_{comb}$
Data/Monte-Carlo efficiency scale factors are defined to correct the simulations and are applied in physics analyses.

Muon Momentum Resolution

The resolution on the dimuon invariant mass at the Z peak was studied in pile-up conditions corresponding to the early and the late 2011 data taking periods in the different η regions of the ATLAS detector.



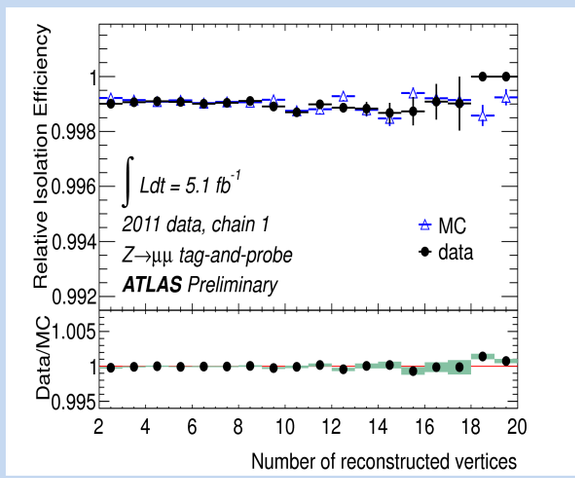
MS dimuon mass resolution
- Disagreement to simulations due to residual MS misalignment
- No significant pile-up effect



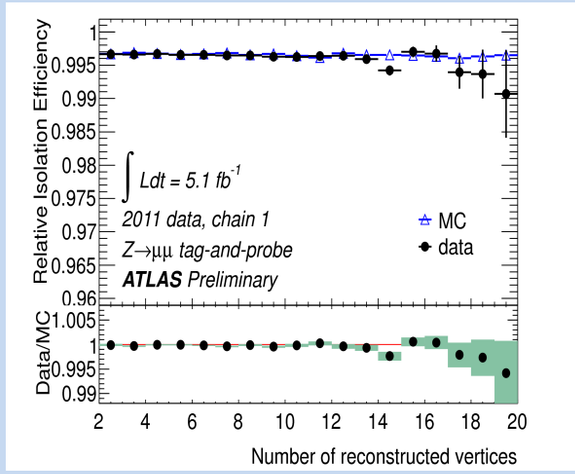
Combined mass resolution
- Good agreement with simulations
- No significant pile-up effect

Muon Isolation Efficiency

Muon isolation is a fundamental requirement in many analyses to suppress backgrounds. Both track-based and calorimetric isolation are used, with the latter expected to suffer more because of pile-up; the measurement shows that the performance is in agreement with simulation.



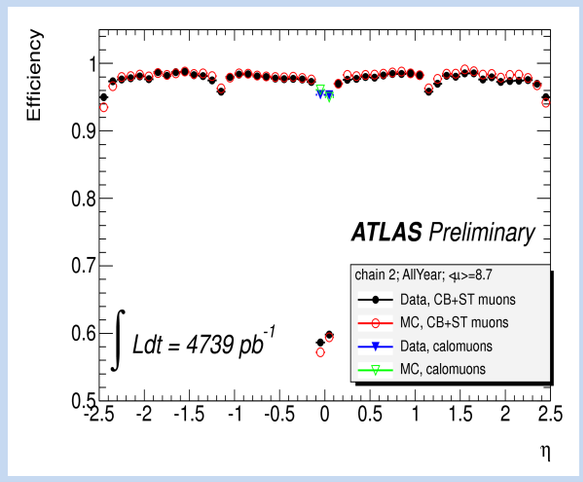
Calorimetric isolation

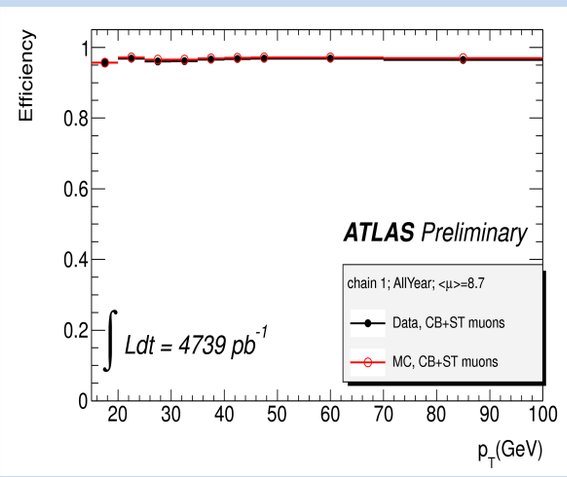


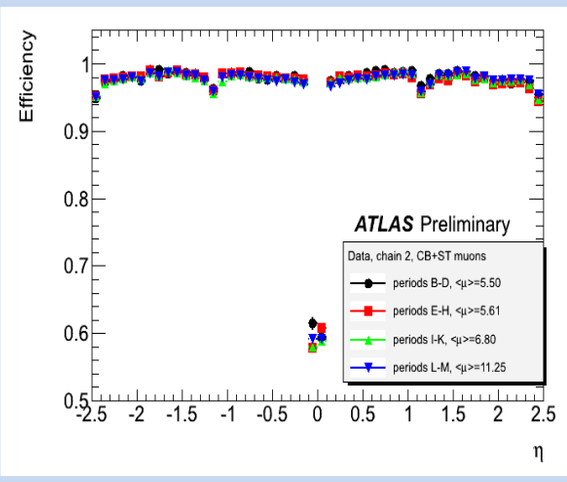
ID isolation

Muon Reconstruction Efficiency

The muon reconstruction efficiency is studied as a function of muon η and p_T, and in data taking periods with different pile-up conditions. The performance is in very good agreement with simulation, and show a negligible pile-up dependency.







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ATLAS EXPERIMENT