MUON IDENTIFICATION AND PERFORMANCE IN THE ATLAS EXPERIMENT

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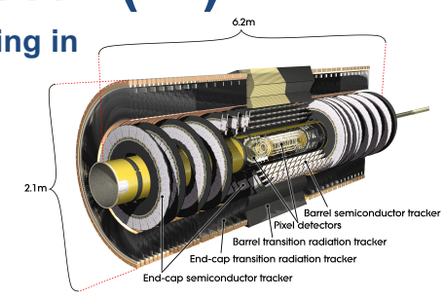
Inner Detector (ID)

- ID with acceptance $|\eta| < 2.5$ operating in a $2\ T$ solenoidal field
- 3 layers of pixel sensors
- 4 layers of silicon strips
- 72 straw layers of transition radiation tracker

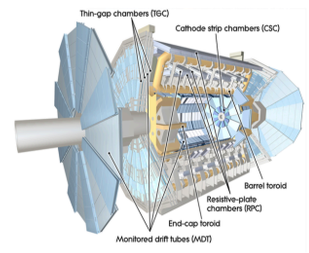


Muon Spectrometer (MS)

Muon tracking detector providing independent muon momentum measurements with acceptance $|\eta| < 2.7$ using air core $0.6\ T$ Toroidal magnets:

<u>Precision Chambers</u>
- 3 layers of Monitored Drift Tube chambers ($|\eta| < 2.7$)
- Innermost layer replaced by Cathode Strip Chambers ($|\eta| > 2.0$)

<u>Trigger Chambers</u>
- 3 layers of Resisted Plate Chambers ($|\eta| < 1.05$)
- 3 layers of Thin Gap Chambers ($1.05 < |\eta| < 2.4$)



Reconstruction

Muon reconstruction is first performed independently in the ID and MS and then the information are combined to form the muon tracks, for physics analyses.
Four muon types are defined depending on which and how subdetectors are used in the reconstruction:
<u>Combined:</u> muon tracks are reconstructed in the MS and are associated to ID tracks;
<u>Segment-tagged:</u> ID track is extrapolated to the MS;
<u>Calo-tagged:</u> ID tracks associated with an energy deposit in the calorimeter;
<u>Stand-alone:</u> muon tracks are reconstructed only in the MS

Muon Identification

Four muon identification selections are provided to address specific needs of different physics analysis:
- Loose - maximizes reconstruction efficiency
- Medium – minimizes systematic uncertainties
- Tight – maximizes the purity of muons at the cost of $3-4\%$ loss in efficiency
- High-p_T – maximizes momentum resolution for $p_T > 100\ GeV$

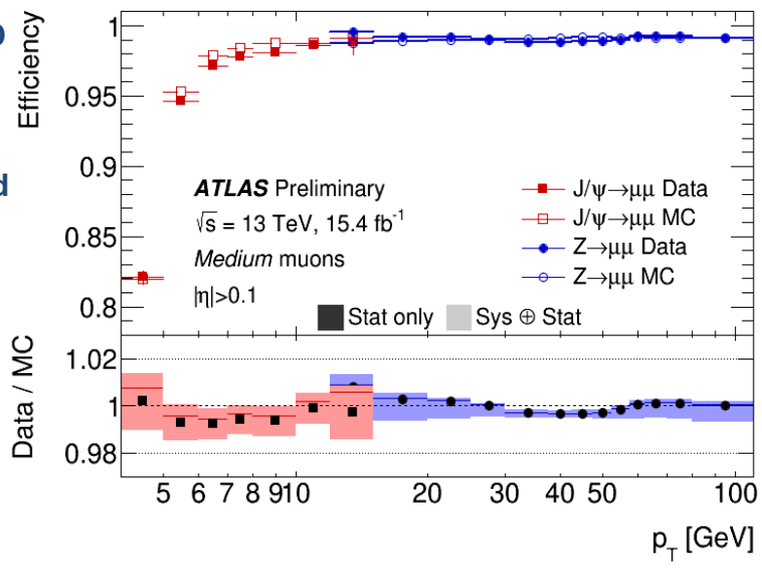
(NEW: Low-pT – optimized for muon identification below 5 GeV)

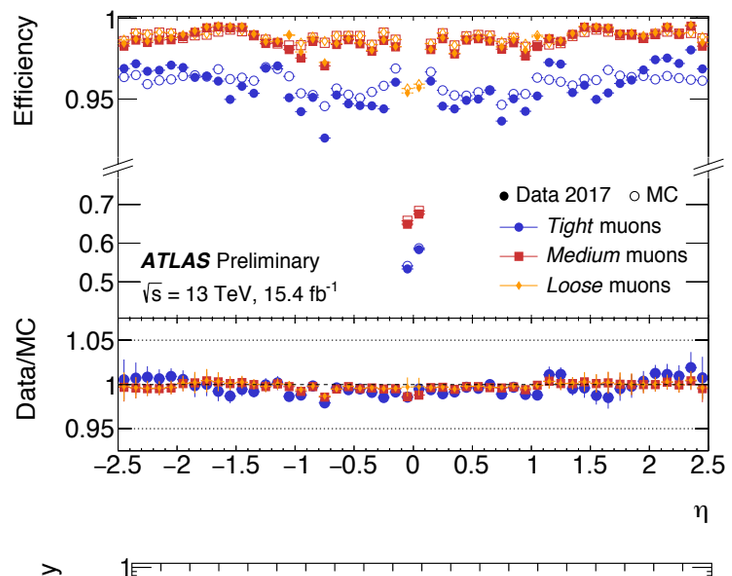
Reconstruction Efficiency

Muon reconstruction is performed independently in the ID and MS detectors: we measure efficiencies both for ID track and for MS track, using different methodology and then we combine the two.

Reconstruction efficiency is measured using the Tag and Probe method applied to the $Z \to \mu\mu$ and $J/\Psi_{\mu\mu}$ events
- $Z_{\mu\mu} \to \mu\mu$ decays provide a sample of probes with $p_T > 15\ GeV$
- $J/\Psi_{\mu\mu} \to \mu\mu$ decays provide a sample of probes with $2.5\ \text{GeV} < p_T < 20\ GeV$

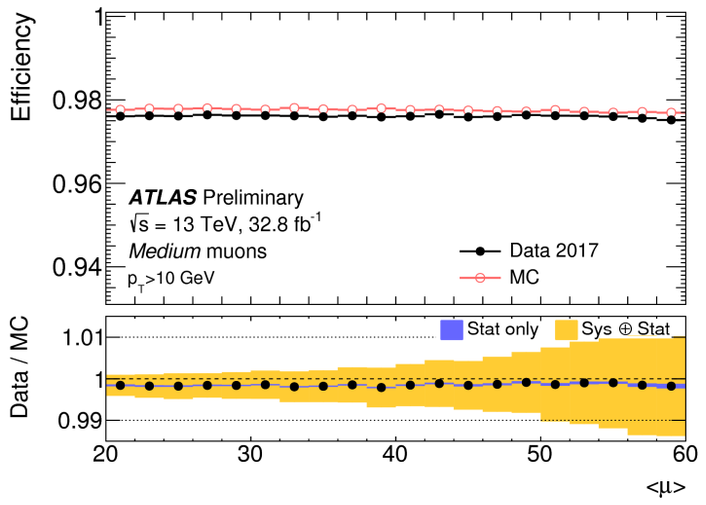
Muon efficiencies are extracted separately from simulation and data as a function of probe p_T, and as a function of η.





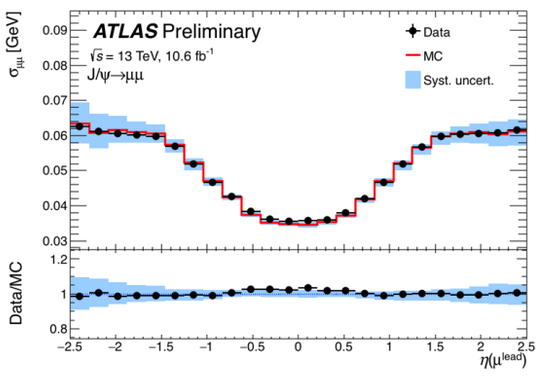
The ratio between data and simulation efficiencies provides scale factors: they are close to unity. Efficiency is reduced in the MS crack region, i.e. $|\eta| < 0.1$, on account of gaps between muon chambers for ID and calorimeter services. Muon efficiencies are extracted separately from simulation and data as a function of probe p_T, and as a function of η.

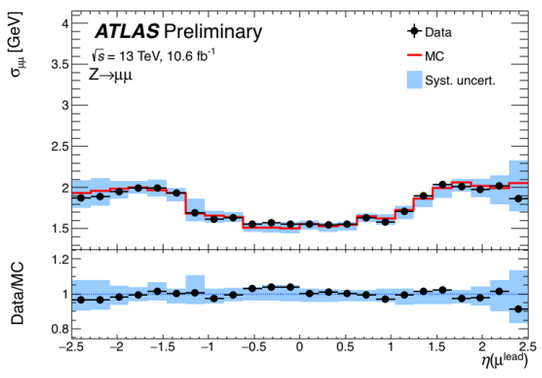
Effect of pile-up (PU) on reconstruction efficiency has been study at PU up to 60: Muon reconstruction efficiencies for the Medium identification algorithm, measured in Z → μμ events as a function of the PU for muons with p_T > 10 GeV, comparing detector simulation with observation in collision data. The bottom panel shows the efficiency scale factor. Blue band shows the statistical error; orange band the quadratic sum of statistical and systematic uncertainty.

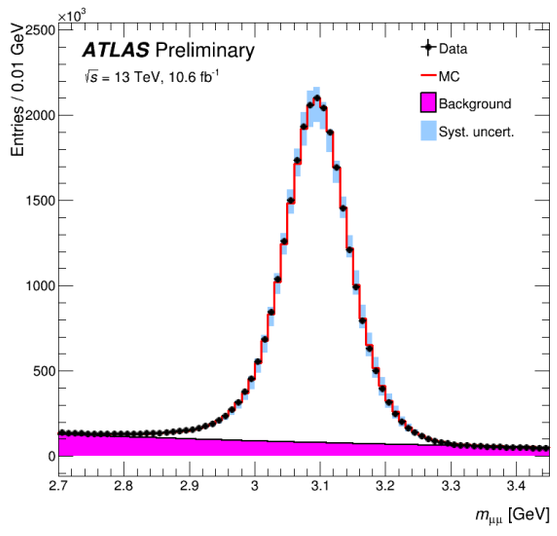


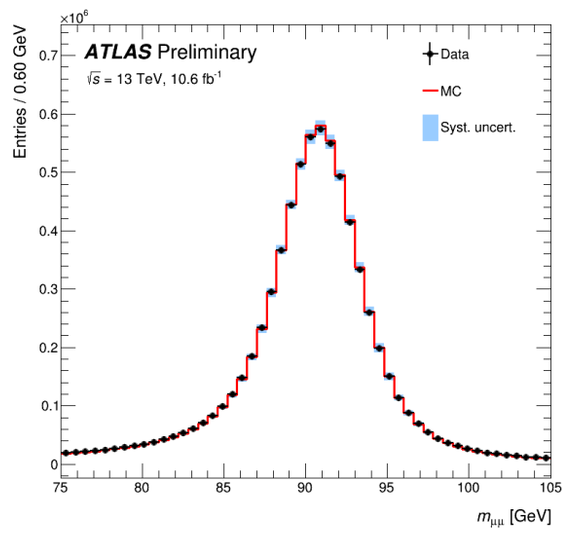
Momentum Scale and Resolution

The data-driven calibration of the simulated muon momenum resolution and scale is obtained using a simultaneous template fit of $Z_{\mu\mu} \to \mu\mu$ and $J/\Psi_{\mu\mu} \to \mu\mu$ events.
The momentum scale is known to per-mill level and the resolution to a few per-cent, in order to obtain such level of agreement between data and simulation a set of corrections is applied: p_T and η distributions of the Z and $J/\Psi_{\mu\mu}$ resonances in simulation are reweighted to the distributions observed in data.









Dimuon invariant mass distribution (combined muons) with the muon momentum corrections applied (up).
Transverse momentum (p_T) resolution as a function of pseudorapidity (η), Muons are reconstructed combining Inner Detector and Muon Spectrometer tracks (left)

ATLAS Collaboration, Muon reconstruction performance of the ATLAS detector in proton-proton collision data at $\sqrt{s} = 13\ TeV$, EPJC (2016) 76:292 DOI 10.1140/epjc/s10052-016-4120-c
Public page: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/MuonPublicResults