Performance of the ATLAS Muon Spectrometer at $\sqrt{s} = 13$ TeV

Johannes Junggeburth, on behalf of the ATLAS Collaboration

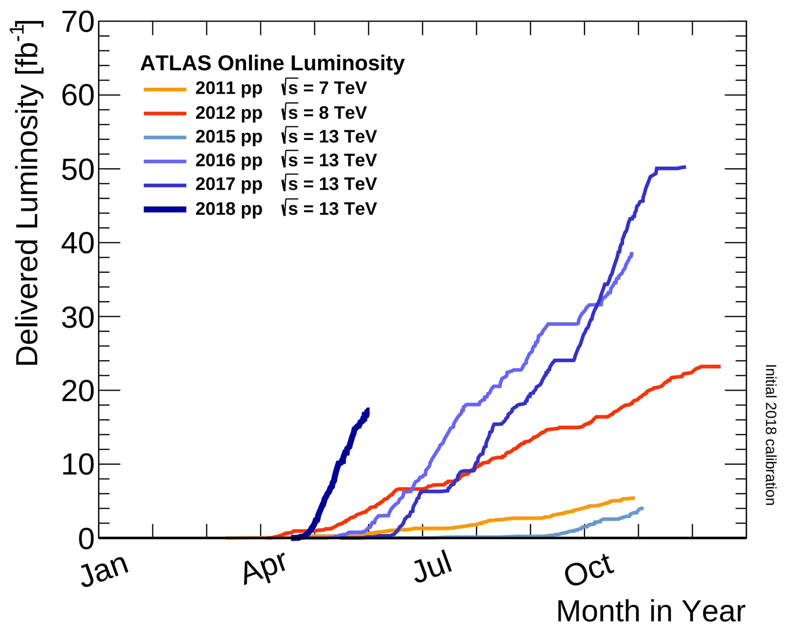
ATLAS EXPERIMENT

Max-Planck-Institut für Physik

ABSTRACT

Muon reconstruction and identification play a fundamental role in many analyses of central importance in the LHC run-2 Physics programme. The algorithms and the criteria used in ATLAS for the reconstruction and identification of muons with transverse momentum from a few GeV to the TeV scale will be presented. Their performance is measured in data based on the decays of Z and J/Ψ to pair of muons, that provide a large statistics calibration sample. Reconstruction and identification efficiencies are evaluated, as well as momentum scales and resolutions, and the results are used to derive precise MC simulation corrections.

LHC RUN-II DATA

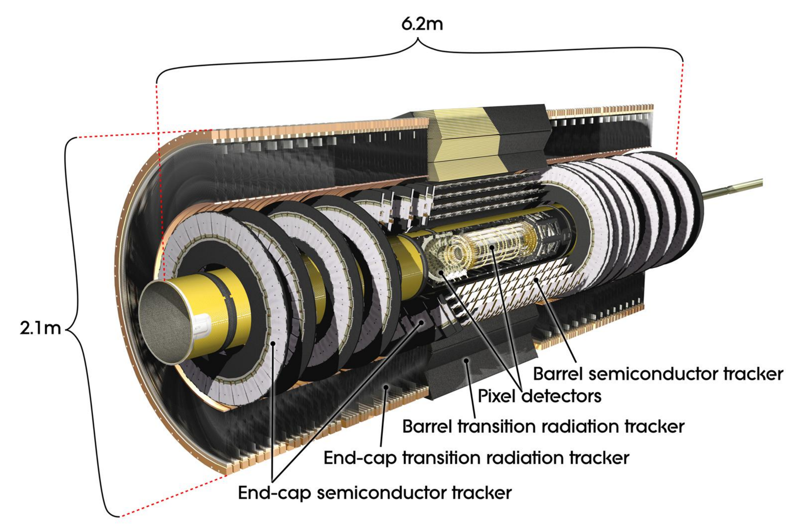


The ATLAS dataset taken at $\sqrt{s} = 13$ TeV comprises an integrated luminosity of ≈ 100 fb^{-1}, of which 90 fb^{-1} are suitable for physics analyses.

MUON RECONSTRUCTION AND SELECTION

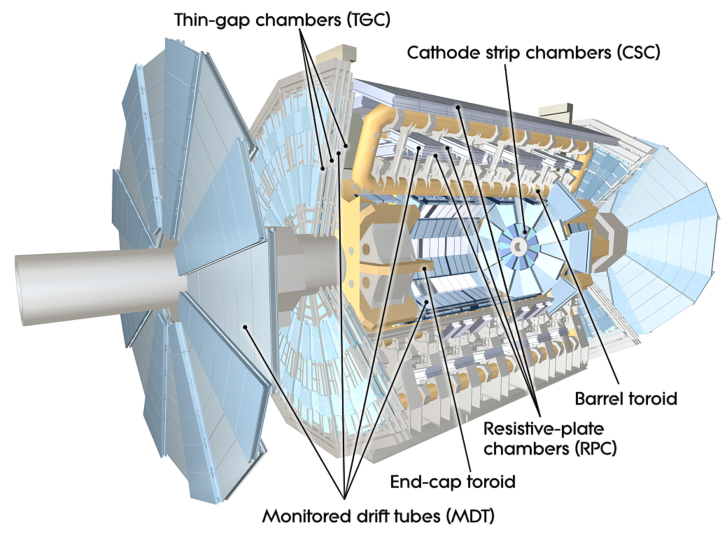
INNER DETECTOR - ID

The Inner Detector's task is to track charged particles and determine their charge and momentum within $|\eta| < 2.5$ using a 2 T solenoid magnetic field, as well as to identify vertices.



MUON SPECTROMETER - MS

The Muon Spectrometer is designed for muon detection in the range $|\eta| < 2.7$. Three large air core toroidal magnets with a mean magnetic field of 0.5 T allow for a precise measurement of muon momenta up to the TeV range.

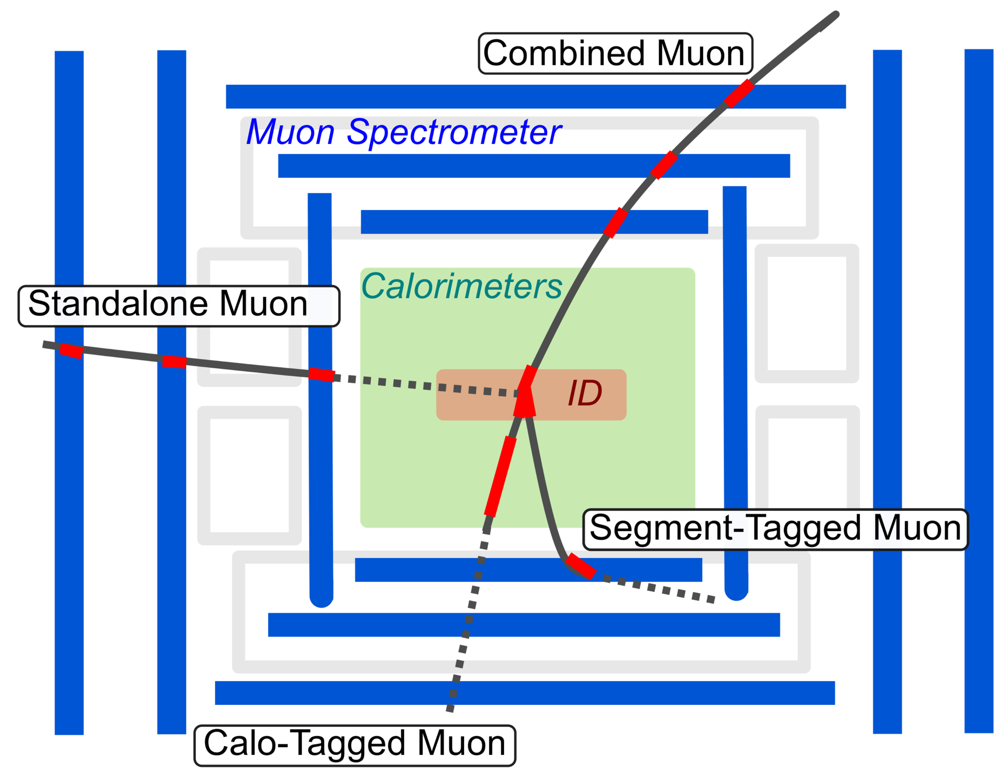


MUON SELECTION

Combining tracks of the ID and MS, the ATLAS software provides four complementary types of reconstructed muons: Combined, Segment-tagged, Stand-alone and Calorimeter-tagged muons.

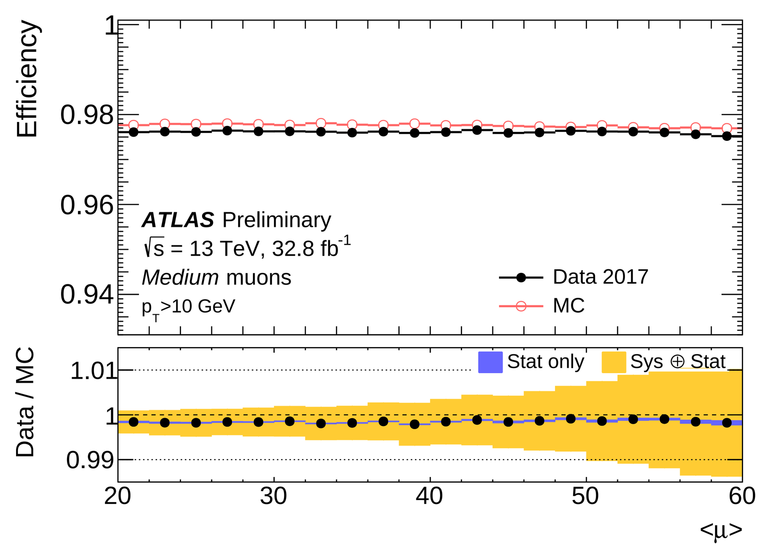
Depending on the kinematics and desired purity, these form five categories of muons:

- **Loose** - maximized efficiency
- **Medium** - compromise between efficiency and purity, low systematic uncertainties
- **Tight** - strong rejection of misidentifications
- **High p_T** - maximized momentum resolution for $p_T > 100$ GeV
- **Low p_T** - optimized to maintain high purity for $p_T \lesssim 5$ GeV



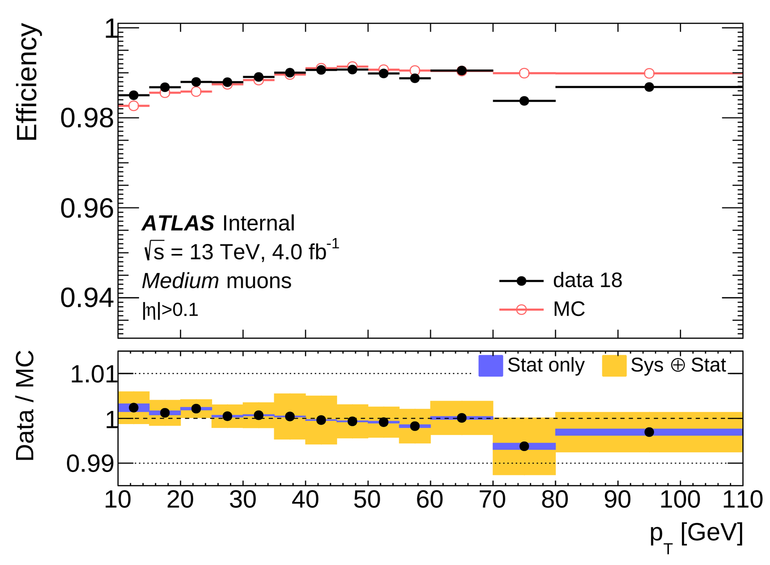
MUON RECONSTRUCTION EFFICIENCY

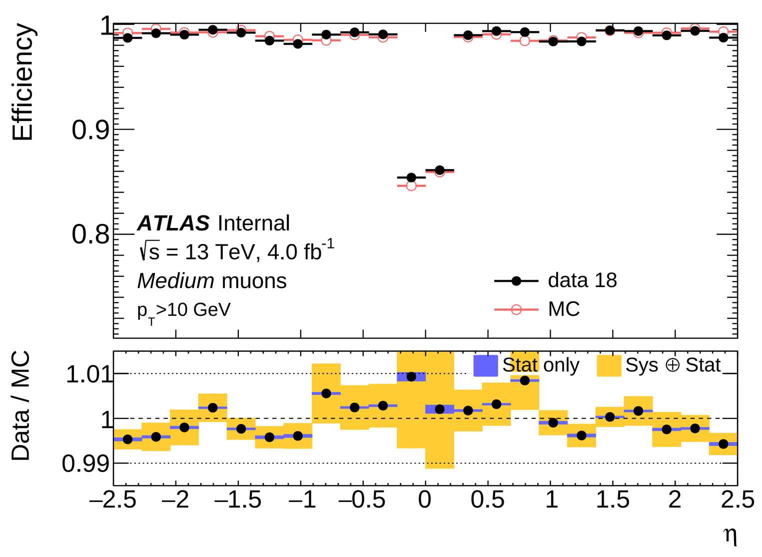
The **reconstruction efficiency** is measured using a **tag-and-probe method** based on $Z \rightarrow \mu^+\mu^-$ and $J/\psi \rightarrow \mu^+\mu^-$ events described in Eur.Phys.J.C (2016) 76:29.2. The measurement is carried out in both data and simulation, and a **scale factor** is derived as the ratio between the two results. These scale factors are applied to the simulation in order to correct for a possible mismodeling of the muon reconstruction efficiency.



Left: Measured reconstruction efficiency as a function of the pile-up $\langle\mu\rangle$ for muons with $p_T > 10$ GeV in 2017 data.

Below: Muon reconstruction efficiency as a function of the pseudorapidity (left) and of the transverse momentum (right) in early 2018 data.



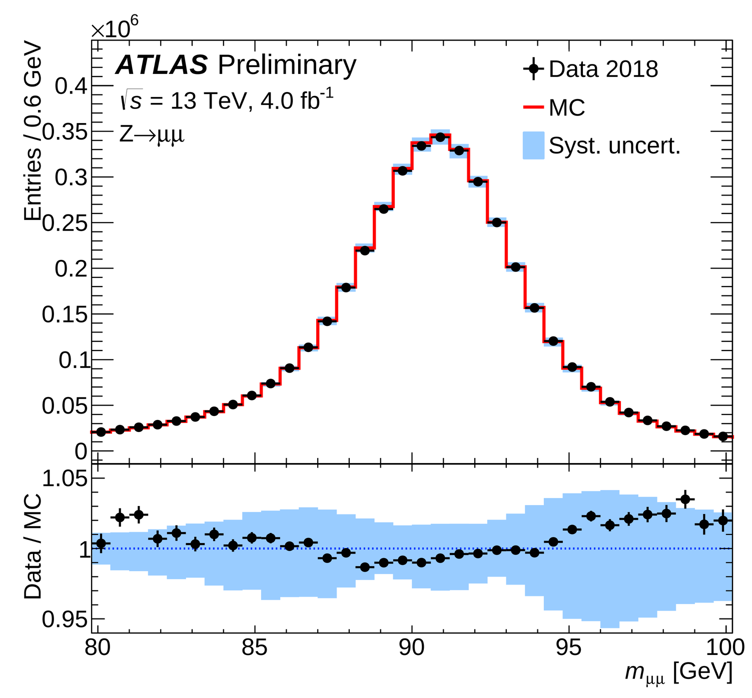


The measured muon reconstruction efficiency exceeds 98% and is robust against high pile-up. Excellent agreement between reconstructed efficiencies in data and simulation is observed.

MUON-2017-005 MUON-2018-001

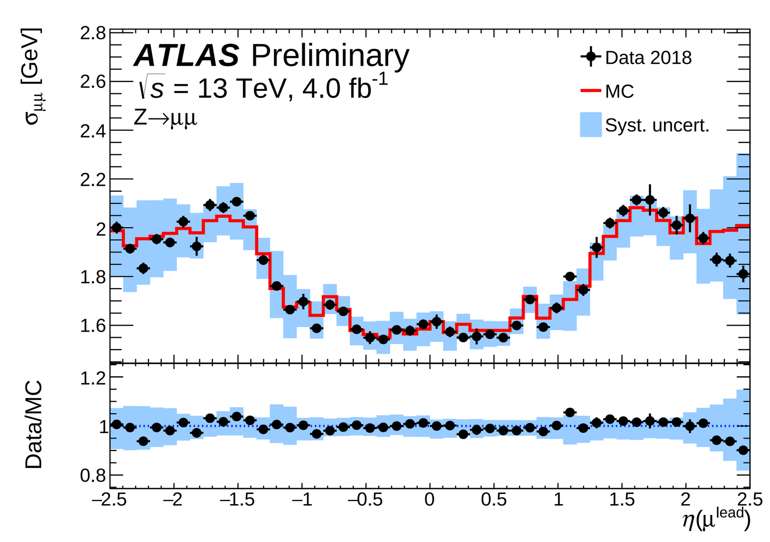
MUON MOMENTUM SCALE AND RESOLUTION

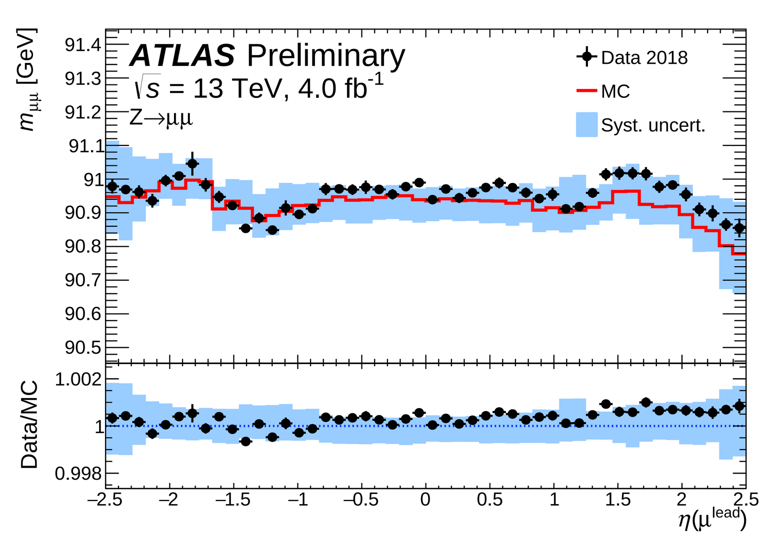
Corrections to the simulated muon momentum **scale and resolution** are extracted separately for ID and MS tracks using a template-based likelihood fit as described in Eur.Phys.J.C (2016) 76:29.2. The bulk of the corrections is derived from $Z \rightarrow \mu^+\mu^-$ and $J/\psi \rightarrow \mu^+\mu^-$ decays in 33.3 fb^{-1} of pp data collected at $\sqrt{s} = 13$ TeV in 2016.



Left: Dimuon invariant mass distribution of $Z \rightarrow \mu^+\mu^-$ candidate events reconstructed with CB muons out of 4.0 fb^{-1} of proton-proton collision data collected in 2018.

Below: Fitted resonance mass parameter for $Z \rightarrow \mu^+\mu^-$ decays (left) and mass resolution (right) as a function of the leading muon pseudorapidity shown for 4 fb^{-1} of early 2018 data.





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