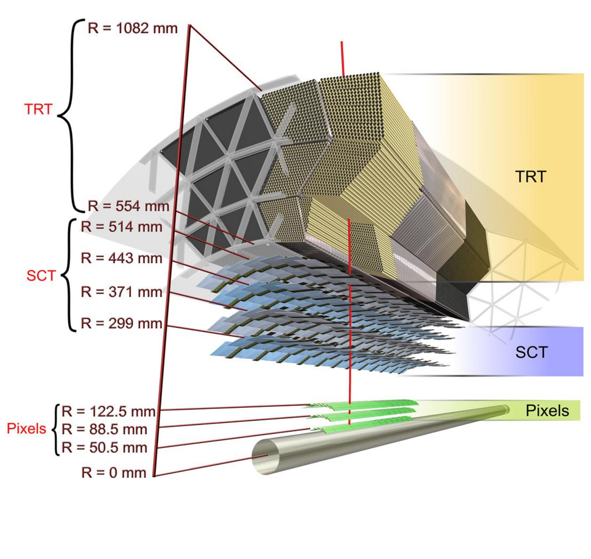
LHCC Poster Session –CERN, 28 February 2018

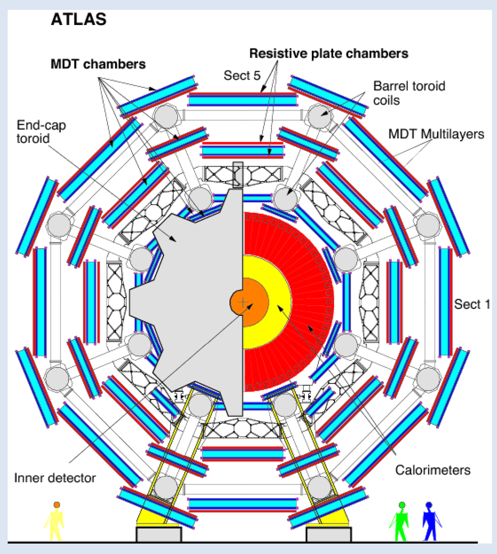
Muon Reconstruction Performance at ATLAS in Run-II

Muons are abundant in the ATLAS detector and are essential ingredients of the most interesting physics results and analyses produced by the ATLAS experiment. The Muon Combined Performance group is tasked with producing the most accurate muon data for physics analyses. This includes muon isolation, identification, reconstruction, and analysis of efficiency, as well as muon momentum scale and resolution. The group's goal is to create a number of "working points" tailored to different types of physics analyses that will isolate, identify, and reconstruct muons in the region of interest to the analyses. The working points are continuously updated and improved before being tested and implemented on different analyses.

Inner Detector (ID) and Muon Spectrometer (MS)



Inner Detector (ID): main tracking detector with acceptance $|\eta|< 2.5$ operating in a 2T solenoidal field.



Muon Spectrometer (MS): Muon tracking detector providing independent muon momentum measurements with acceptance $|\eta| < 2.7$ using air core 0.5T toroidal magnets

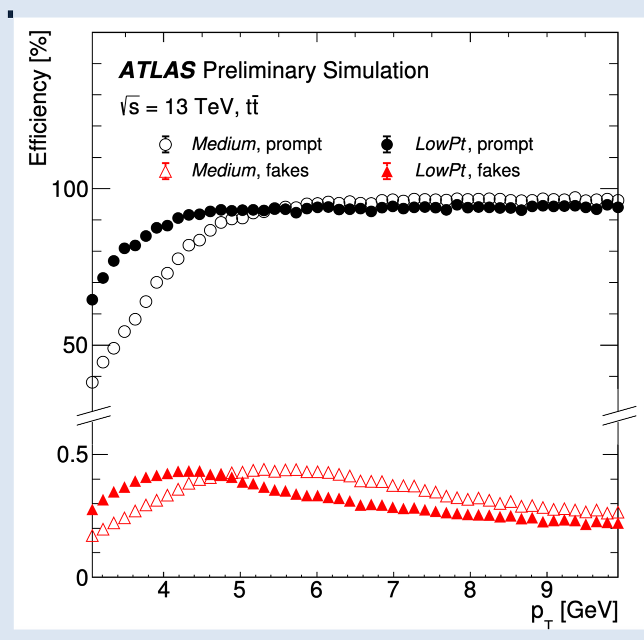
Muon Reconstruction and Identification

Muons are identified by combining information from the ID and MS detectors. Depending on their purity and/or transverse momentum resolution, muons are assigned to one of five categories:

- **Loose** - maximizes efficiency, optimized for $H\rightarrow 4l$
- **Medium** - default selection that minimizes systematic uncertainties
- **Tight** - minimizes the rate of secondary muons originating from π and K decays instead of the primary vertex.
- **High p_T** - optimizes resolution for $p_T > 100$ GeV
- **Low p_T –** maximizes efficiency for 3 GeV < p_T < 10GeV

The low p_T working point is a newly optimized identification category with maximal efficiency as low as ~3 GeV p_T.

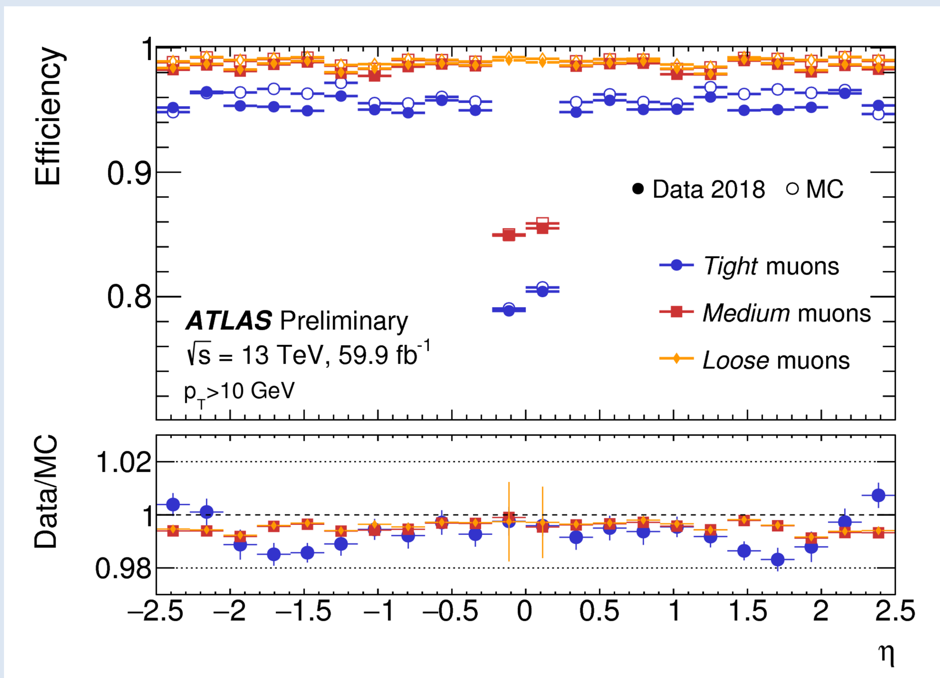
Expected efficiency as a function of p_T for Low p_T and Medium muons is shown (right) [1].

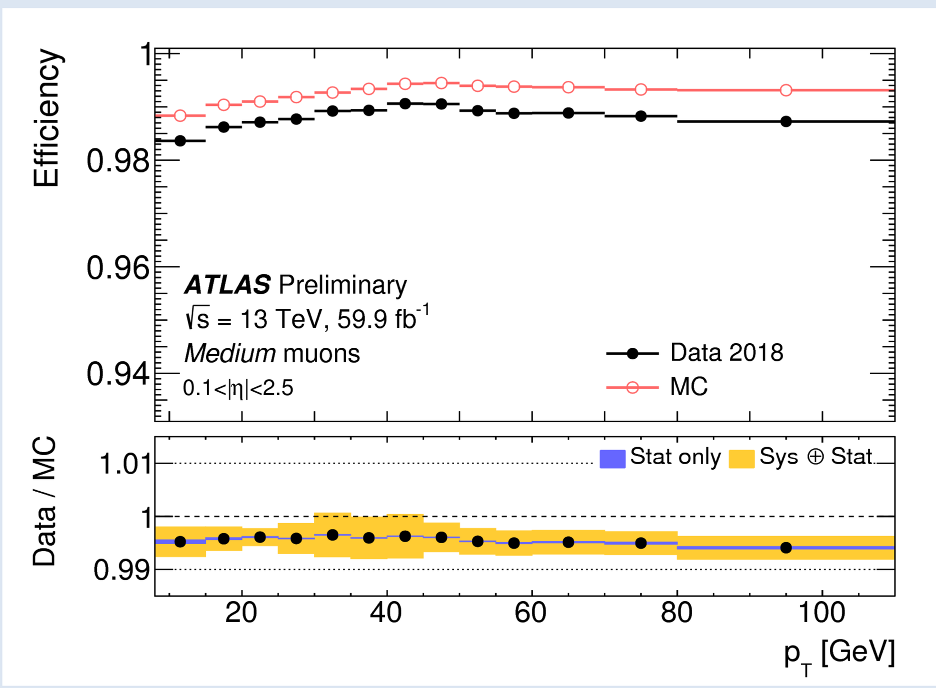


Muon Reconstruction Efficiency

The reconstruction efficiency is measured using the Tag and Probe (T&P) method applied to Z and $J/\psi\rightarrow\mu\mu$ events. The tag is a combined muon track which triggers the event. The probe is a track reconstructed in the ID. The fraction of signal probes reconstructed as muons by successfully combining with an MS track measures the muon identification efficiency.

- Z decays provide a sample of probes with p_T > 10 GeV
- J/ψ decays provide a sample of probes with 2.5 GeV < p_T < 15 GeV





Muon efficiencies are extracted separately for MC and data using the T&P method for the uniform detector regions (above left) and as a function of probe p_T (above right) [2]. Efficiencies for the full 2018 dataset are shown.

Reference: "Muon reconstruction performance of the ATLAS detector in proton–proton collision data at √s=13 TeV" Eur. Phys. J. C 76 (2016) 292

Plots: [1] ATLAS Collaboration, "Low-p_T Muon Selection: Preliminary Public Plots", https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PLOTS/MUON-2018-005 (2018)
[2] ATLAS Collaboration, " Muon reconstruction and identification efficiency with 59.9 fb⁻¹ of data collected in the full 2018 with the ATLAS detector. ", https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PLOTS/MUON-2018-007 (2018)
[3] ATLAS Collaboration, "Momentum calibration validation with the Upsilon→μμ channel based on 3.2 fb⁻¹ (2015) and 33.3 fb⁻¹ (2016)", https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PLOTS/MUON-2018-008 (2018)
[4] ATLAS Collaboration, "ATLAS Muon Combined Performance with 2017 and 2016 dataset .", https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PLOTS/MUON-2017-002 (2017)
[5] ATLAS Collaboration, "Muon performance plots with first 2018 data: efficiency, scale and resolution.", https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PLOTS/MUON-2018-001 (2018)

Muon Momentum Scale and Resolution Corrections

Data-to-simulation agreement is improved by applying the following momentum corrections to the MC, separately for ID and MS tracks:

$$p_T = \frac{\Delta s_0 + (1+\Delta s_1)\cdot p_T}{G(1,\sqrt{(\Delta r_0/p_T)^2+\Delta r_1^2+(\Delta r_2\cdot p_T)^2})}$$

Δs_0 Offset of average energy loss in calorimeter & other materials

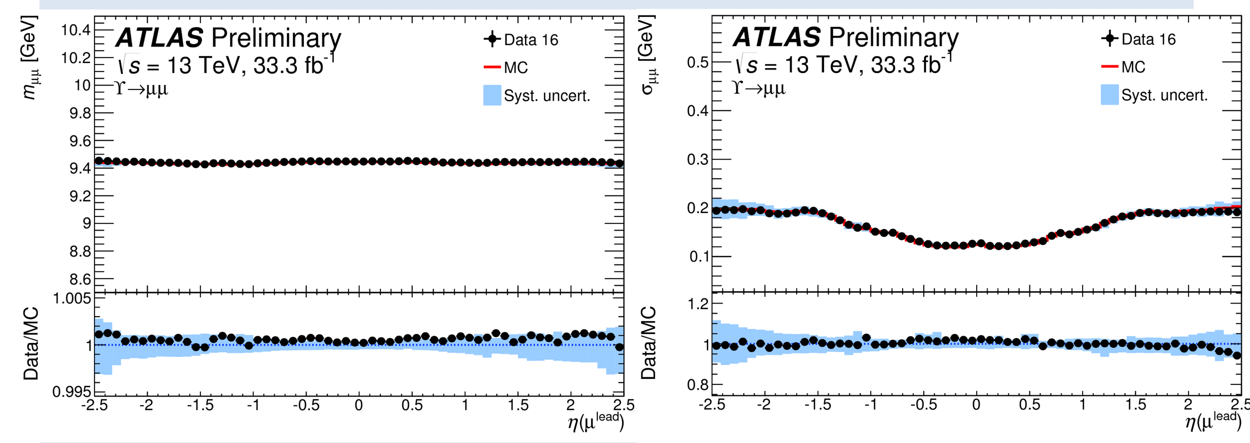
Δs_1 Scale of magnetic field integral & global radial distortions of the detector

Δr_0 Energy loss fluctuations in the material

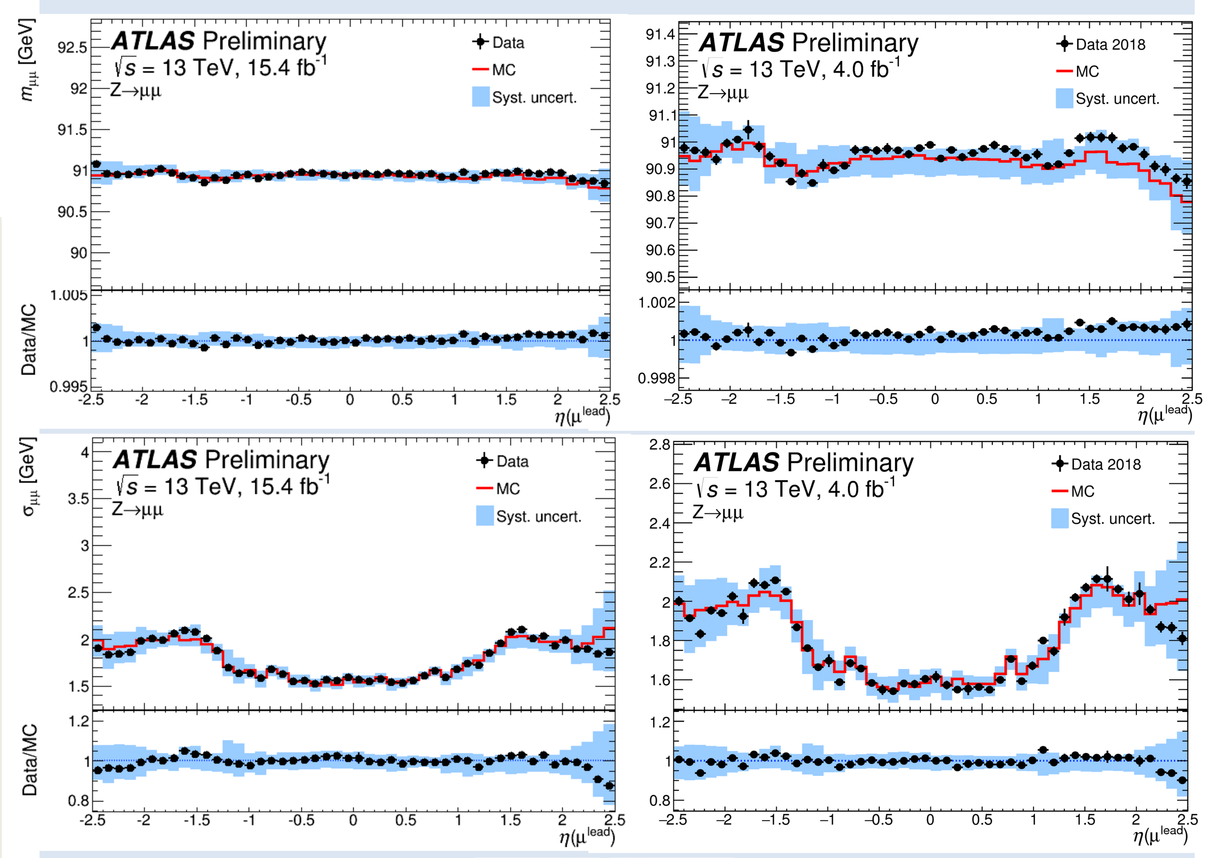
Δr_1 Multiple scattering, local radial distortions, & local distortion of magnetic field

Δr_2: Intrinsic resolution and misalignments

Δs and Δr are extracted by fitting Z and J/ψ invariant mass peaks. This parametrization is validated by comparing the position and resolution of Z and J/ψ -invariant mass distributions observed in Run-II data.



Z and J/ψ resonances are used as standard candles due to their excellent purity and high statistics. New standard candle, $\Upsilon\rightarrow\mu\mu$, was tested with 2016 data and has shown very good agreement between data and corrected MC (above)[3]. Muon momentum resolution and scale on data collected in 2017 (left) are compared to the first 4.0fb⁻¹ in 2018 (right) [4,5].



Laura Bergsten (Brandeis University) on behalf of the ATLAS Collaboration