Muon Reconstruction Performance in ATLAS at Run-II.

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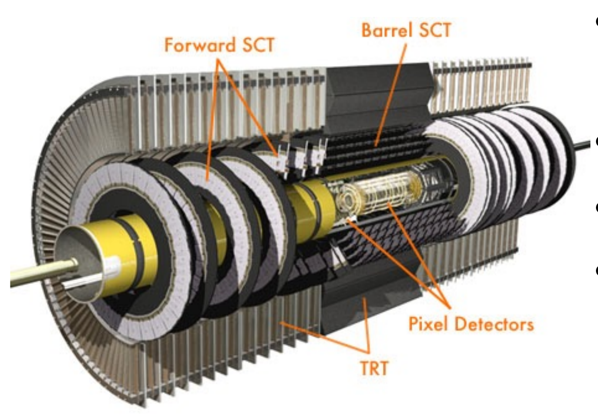
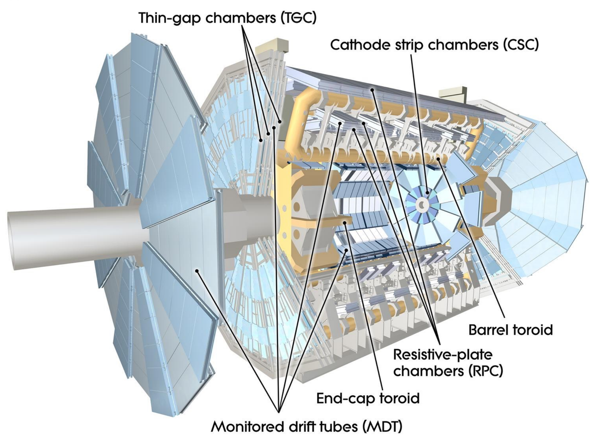
Inner Detector (ID) & Muon Spectrometer (MS)



- ID with acceptance $|\eta|<2.5$ operating in a 2T solenoidal field.
- 3 layers of pixel sensors (50 cm < r < 12 cm)
- 4 layers of silicon strips (30 cm < r < 51 cm)
- 72 straw layers of transition radiation tracker modules (55 cm < r < 108 cm)

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

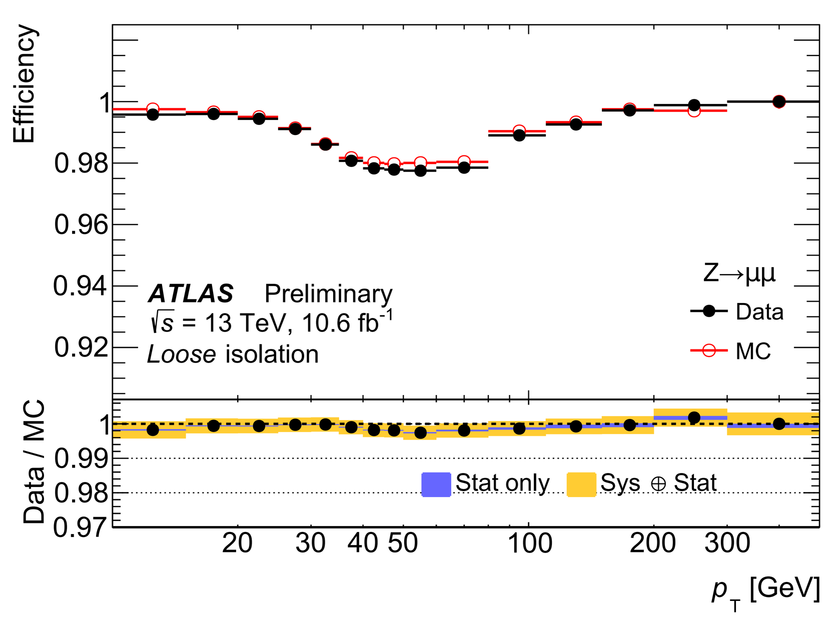


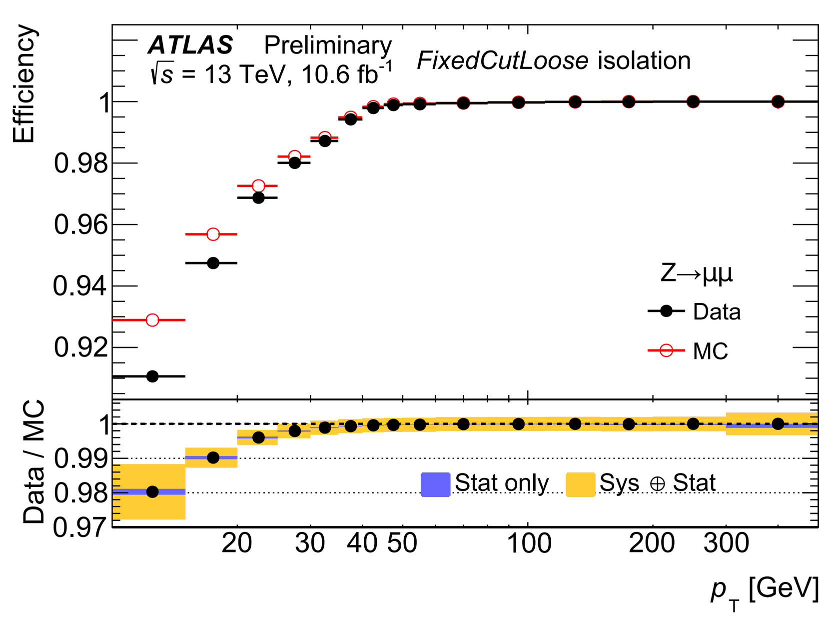
- Precision chambers
  - 3 layers of Monitored Drift Tube chambers ($|\eta|$ < 2.7)
  - Innermost layer replaced by Cathode Strip Chambers ($|\eta|$ > 2.0)
- Trigger chambers
  - 3 layers of Resistive Plate Chambers ($|\eta|$ < 1.05)
  - 3 layers of Thin Gap Chambers (1.05 < $|\eta|$ < 2.4)

Isolation

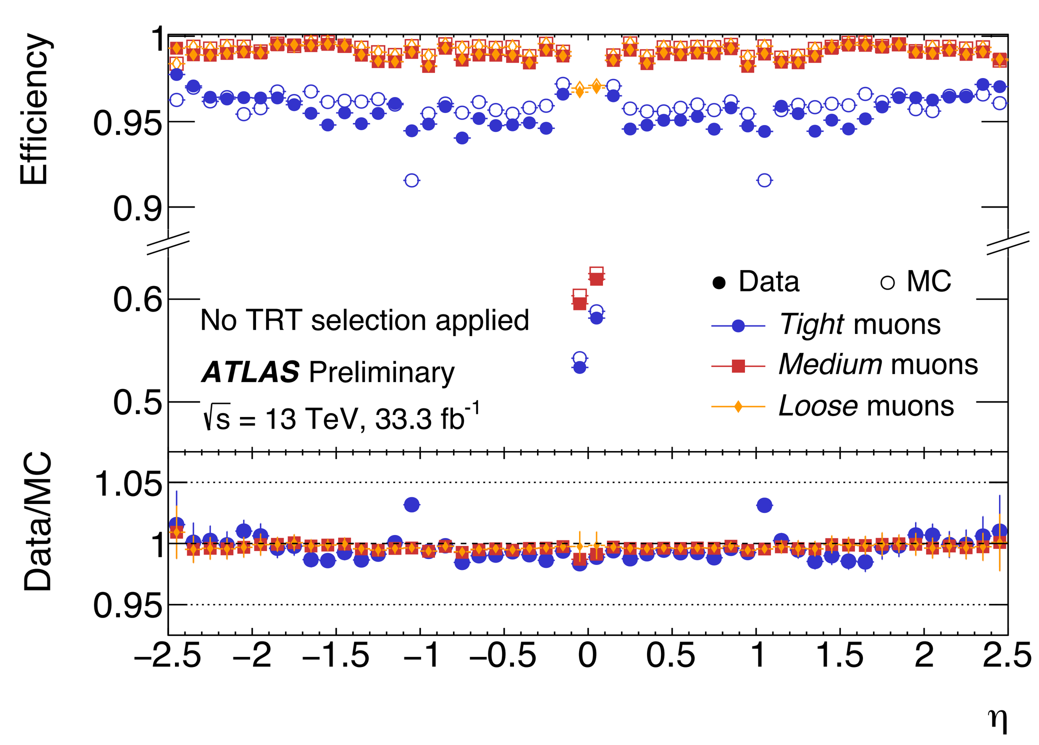
Muon isolation is both track-based and calorimeter-based. It is measured as the sum of the momenta (energy) of tracks (energy deposits) within cones of varied sizes.
The efficiency is measured with the Tag&Probe method from $Z\rightarrow\mu^+\mu^-$ events.
Selections build targeting specific efficiency regimes.

- The *loose* selection (left) targets an uniform efficiency across a wide momentum range. The measured efficiency is above 95% in the range 10 GeV < p_T < 300 GeV.
- The *FixedCutLoose* targets constant 85% (70%) background rejection in track (calorimeter) isolation.





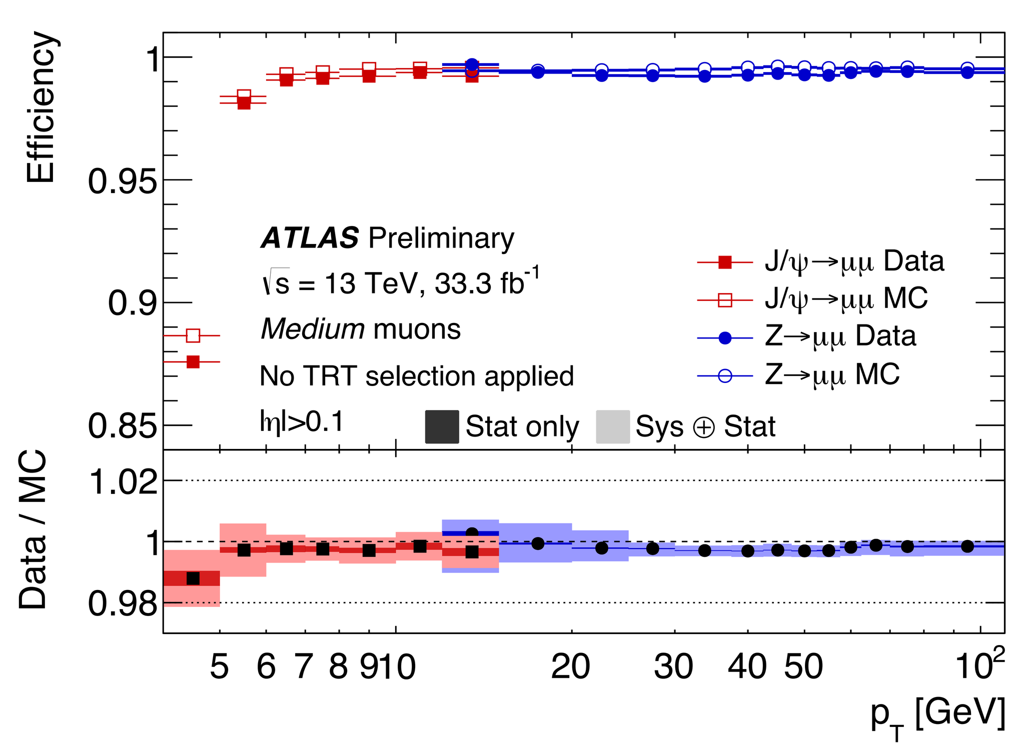
Reconstruction efficiency



The reconstruction efficiency is measured using the Tag and Probe method applied to the $Z\rightarrow\mu^+\mu^-$ and $J/\psi\rightarrow\mu^+\mu^-$ events.

- $Z\rightarrow\mu^+\mu^-$ decays provide a sample of probes with p_T > 15 GeV
- $J/\psi\rightarrow\mu^+\mu^-$ decays provide a sample of probes with 2.5 GeV < p_T < 20 GeV

Muon efficiencies are extracted separately from simulation and data for the uniform detector regions (top) and as a function of probe p_T (bottom).



The ratio between data and simulation efficiencies provides scale factors. They are close to unity as a result of an already good initial agreement observed in data and simulations. Efficiency is reduced in the MS crack region, $|\eta|$ < 0.1, on account of gaps between muon chambers for ID and calorimeter services.

Muon reconstruction

Muons are identified by combining information from the ID and MS detectors. About 96% of muons are reconstructed by fitting hits from ID and MS tracks. The remainder are formed by tagging ID tracks with muon signatures in the calorimeter or the MS.

Momentum scale and resolution

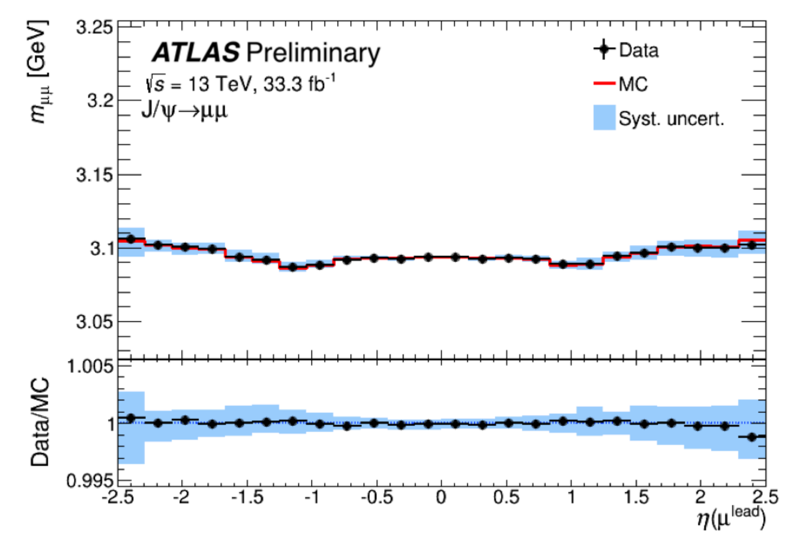
Data-to-simulation agreement is improved by applying the following momentum corrections to the MC, separately for ID and MS tracks:

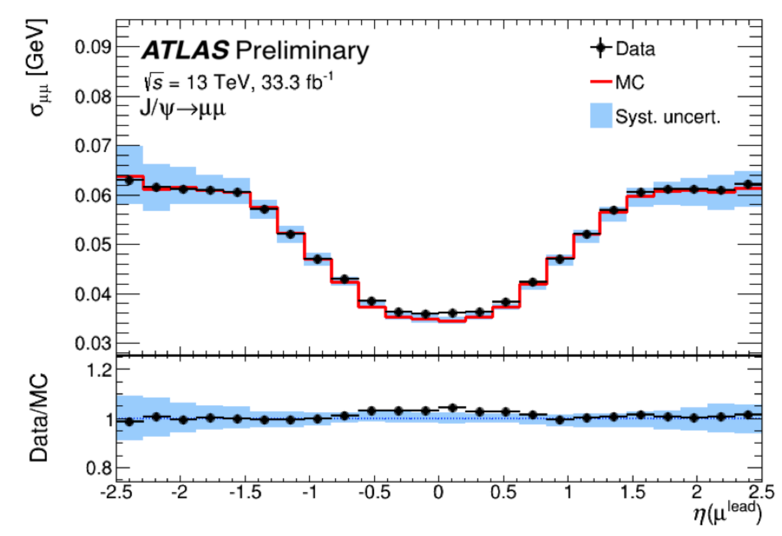
$$p_T \rightarrow \frac{\Delta s_0 + (1+\Delta s_1)\bullet p_T}{G(1, \sqrt{(\Delta r_0/p_T)^2 + \Delta r_1^2 + (\Delta r_2 \bullet p_T)^2})}$$

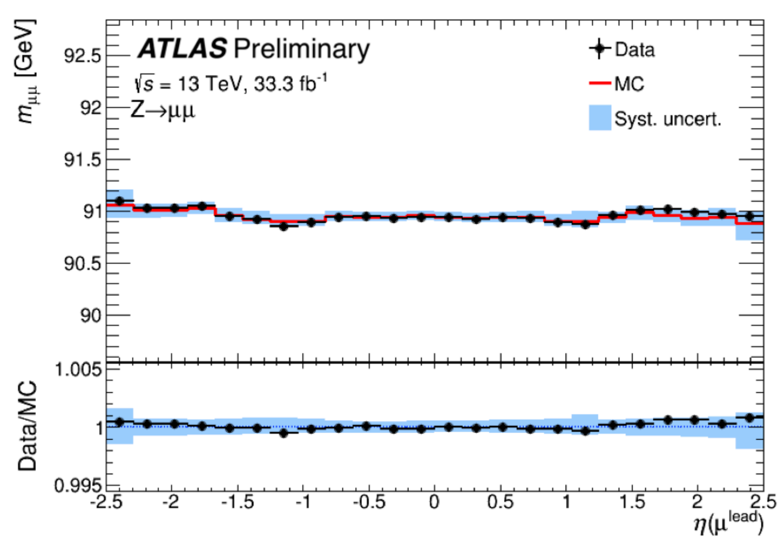
Δs_0 Offset of average energy loss in calorimeter & other materials (MS only)
Δs_1 Scale of magnetic field integral & global radial distortions of the detector
Δr_0 Energy loss fluctuations in the material (MS only)
Δr_1 Multiple scattering, local radial distortions, & local distortion of magnetic field
Δr_2 Intrinsic resolution and misalignments

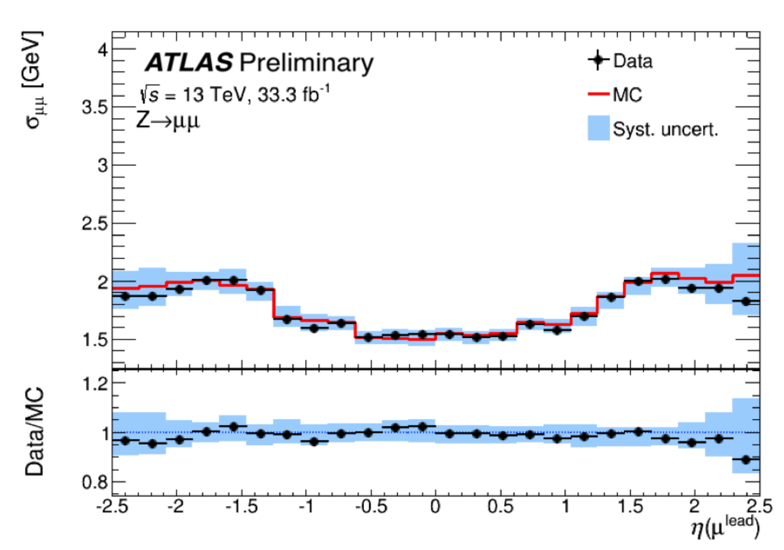
Δs and Δr, are extracted by fitting the Z and J/ψ invariant mass peaks.
This parametrisation is validated by comparing the position and resolution of Z and J/ψ invariant mass distribution observed in Run II (13 TeV) data.

The agreement between data and simulation for the mean is within 0.1% in the barrel region ($|\eta|$<1.05) and 0.2% in the end caps (1.0<$|\eta|$<2.5), where the alignment is still preliminary.
The resolution measured in data agrees with MC to within 10%.









Data taken in 2016 of prompt reconstruction were characterised by significant local misalignments in the inner detector. These misalignments manifest as charge-dependent biases in the momentum reconstruction. These local sagitta biases are of the order of 1 TeV^{-1}. In order to parametrise this effect, we define the quantity δ_s which biases the reconstructed momentum p_T^{rec} with respect to its true value p_T

$$p_T^{rec}(\mu) \rightarrow \frac{p_T(\mu)}{1+q(\mu)\delta_s p_T(\mu)} \quad (1)$$

These biases are studied and corrected in data by comparing the local inhomogeneities of the charge dependent dimuon mass the mass of well-known neutral resonances.
A correction on each momentum is derived by an iterative procedure where the momentum at each iteration is transformed as according to eq. (1).
The residual bias is reduced after correction to the per mille level at the Z pole mass from the percent level. This correction leads to an improvement of the resolution of dimuon states ranging from 1% in the central region to 5% in the forward region for muons with p_T~45 GeV