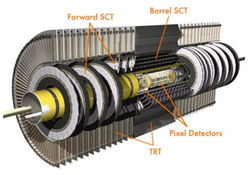
EPS Conference on High Energy Physics 2015 • Vienna, Austria

Muon Reconstruction Performance in ATLAS at Run-II

Inner Detector (ID)



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

Muon Reconstruction

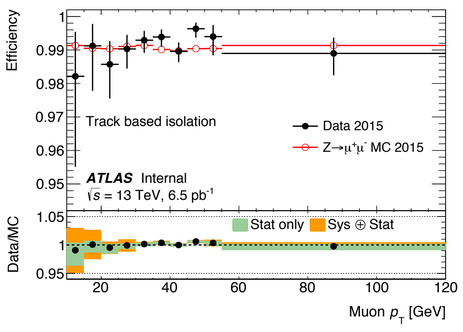
Muons are identified by combining information from the ID and MS detectors. About 96% of muons are reconstructed by fitting hits from ID and MS tracks. The remainder are formed by tagging ID tracks with muon signatures in the calorimeter or the MS.

Muon Selection for Analysis

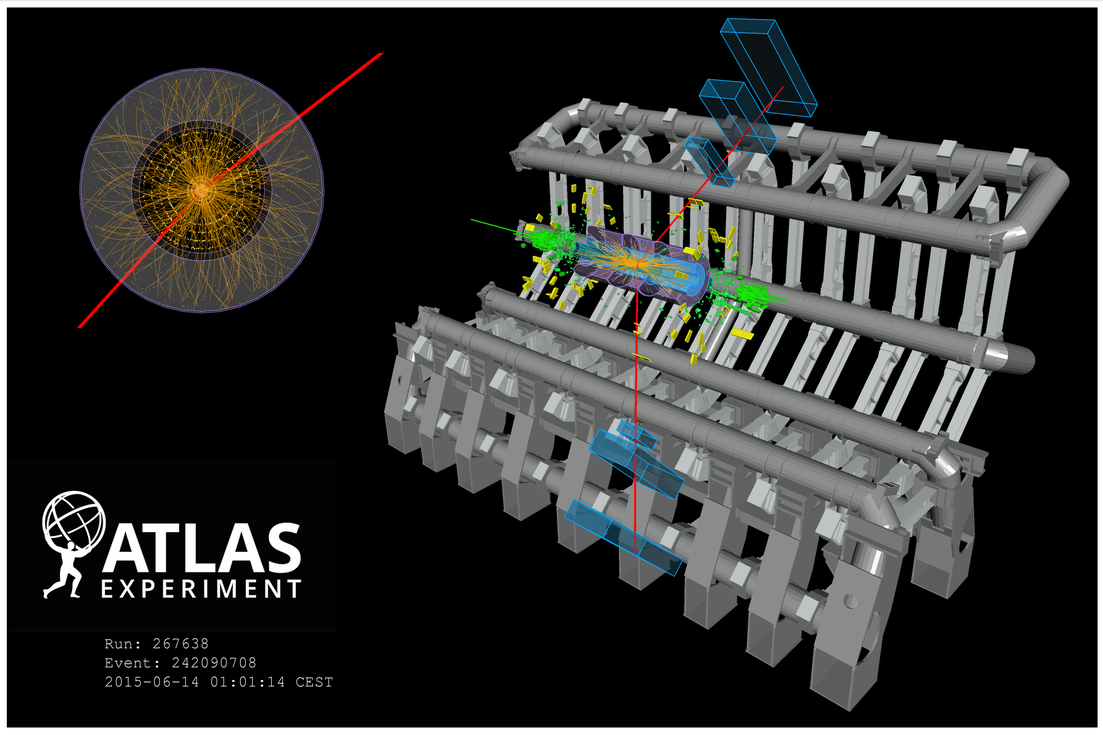
Depending on their purity and/or p_T resolution, muons are assigned to one of four categories:

- **Loose** - maximizes efficiency, optimized for H→4l
- **Medium** - default selection that minimizes systematic uncertainties
- **Tight** - minimizes the rate of fake muons, those originating from π and K decays instead of the primary vertex.
- **High p_T** - maximizes resolution for $p_T > 100$ GeV, optimized for Z'→μμ

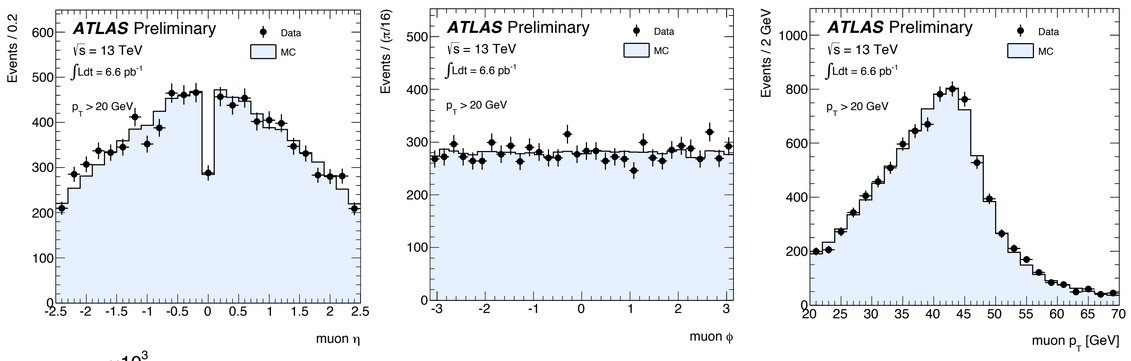
Isolation

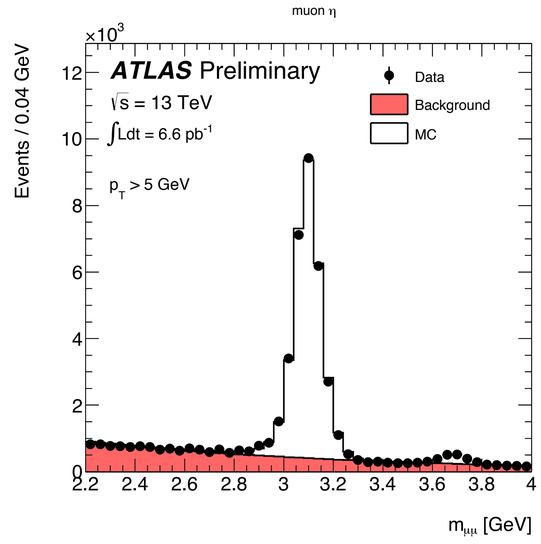


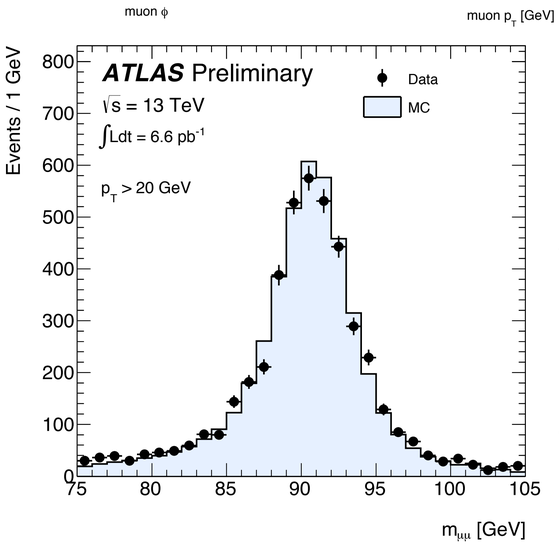
Muon isolation is both track-based (left) and calorimeter-based (not shown). The plots show efficiency as a function of p_T. The data and MC are in good agreement.



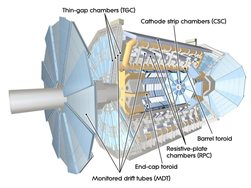
Above $Z \rightarrow \mu^+\mu^-$ event recorded at $\sqrt{s} = 13$ TeV. Red lines show the paths of two muons through the detector.







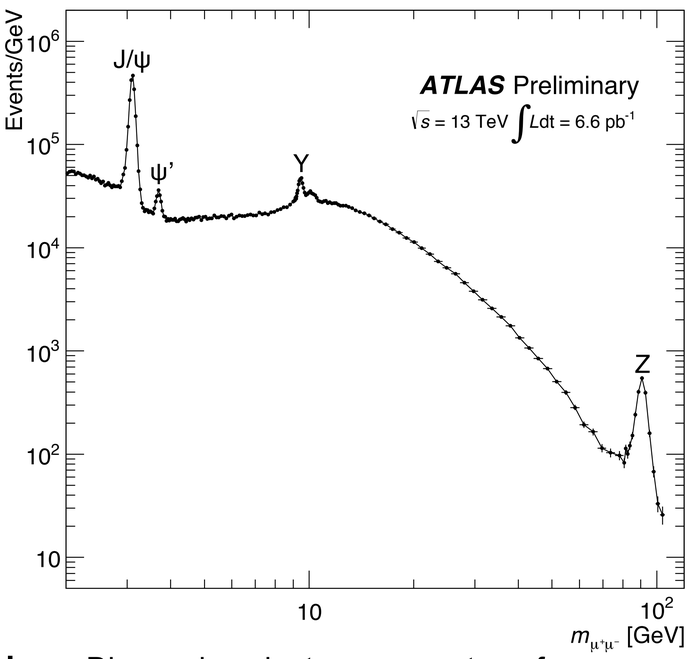
Muon Spectrometer (MS)



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

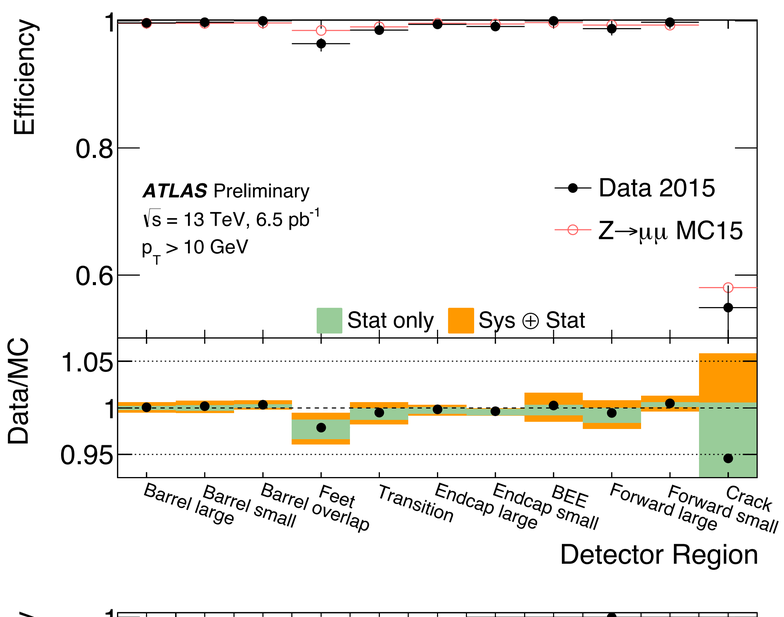
- Precision chambers
  - 3 layers of monitored drift tube chambers ($|\eta| < 2.7$)
  - Innermost layer replaced by cathode strip chambers ($|\eta| > 2.0$)
- Trigger chambers
  - 3 layers of resistive plate chambers ($|\eta| < 1.05$)
  - 3 layers of thin gap chambers ($1.05 < |\eta| < 2.4$)

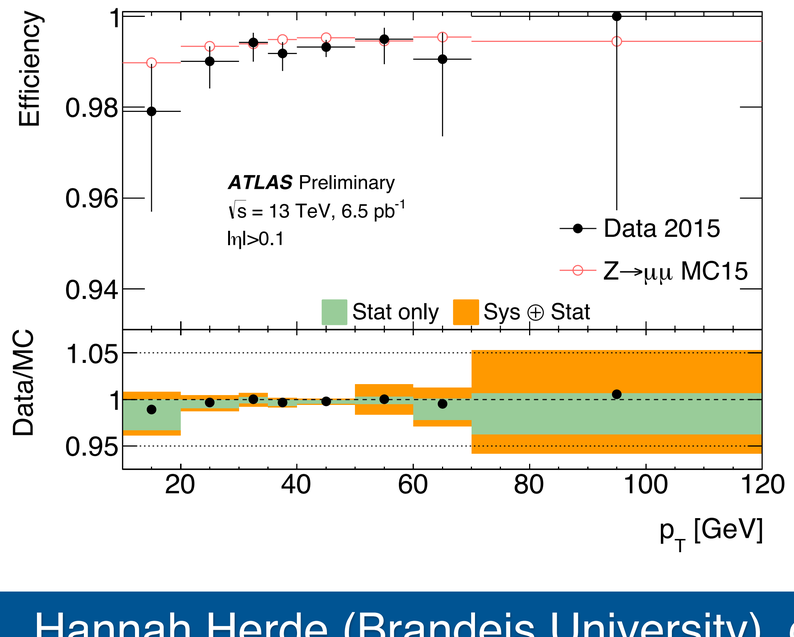
Run-II Data First Look



Above Dimuon invariant mass spectrum for oppositely charged, combined track pairs with $p_T > 4$ GeV, $|\eta| < 2.5$ in data.
Left (Top Row) Kinematic distributions of oppositely-charged, combined muon track pairs in Z→μμ events. Sum of background and signal Monte Carlo (MC) is normalized to by the number of events observed in data. **(Bottom Row)** Dimuon invariant mass distributions for $J/\psi \rightarrow \mu^+\mu^-$ and $Z \rightarrow \mu^+\mu^-$

Reconstruction Efficiency



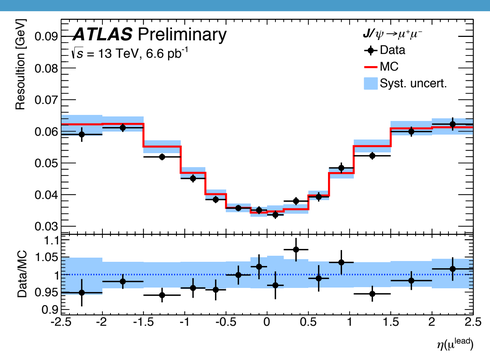


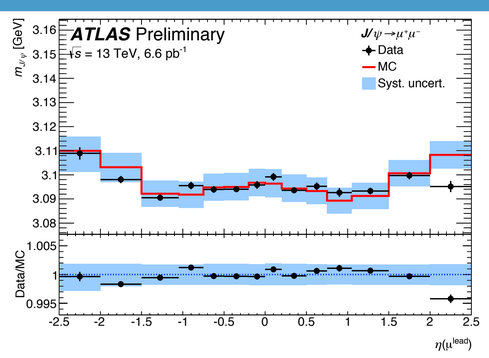
The reconstruction efficiency is measured using the Tag and Probe (T&P) method applied to Z and J/ψ→μμ events. The *tag* is a combined muon track which triggers the event. The *probe* is a track reconstructed in the ID. The fraction of signal probes reconstructed as muons by successfully combining with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

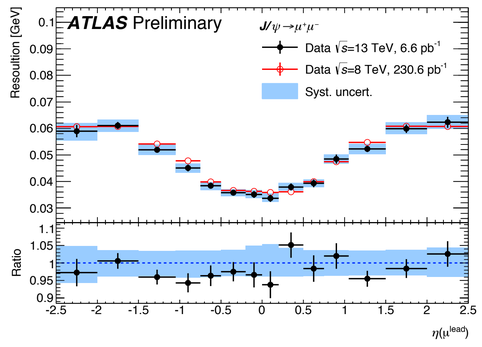
- Z decays provide a sample of probes with $p_T > 10$ GeV
- J/ψ decays provide a sample of probes with $2.5\text{ GeV} < p_T < 15\text{ GeV}$

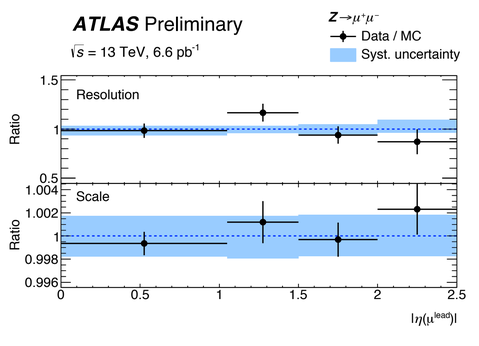
Muon efficiencies are extracted separately for MC and data using the T&P method for the uniform detector regions (top) and as a function of probe p_T (bottom). The ratio between data and MC efficiencies provides scale factors for the experiment. The scale factors are close to unity as a result of already good initial agreement observed in data and MC. Efficiency is reduced in the MS crack region, $|\eta| < 0.1$, on account of gaps between muon cambers for ID and calorimeter services.

Momentum Scales & Resolution









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

$$p_T \rightarrow \frac{\Delta s_0 + (1 + \Delta s_1) \cdot p_T}{G(1, \sqrt{(\Delta p_0/p_T)^2 + \Delta p_1^2 + (\Delta p_2 \cdot p_T)^2})}$$

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
Δp_0 Energy loss fluctuations in the material (MS only)
Δp_1 Multiple scattering, local radial distortions, & local distortion of magnetic field
Δp_2 Intrinsic resolution and misalignments

The parameters, Δs and Δp, are extracted by fitting the Z and J/ψ invariant mass peaks using Run I (8 TeV) data and MC. The validity of the parameterization is tested by comparing the position and resolution of Z and J/ψ peaks observed in Run II (13 TeV) data and MC. The plots show the agreement between data and MC for the mean is within 0.1% in the barrel region ($|\eta| < 1.05$) and 0.2% in the end caps ($1.05 < |\eta| < 2.5$), where the alignment is still preliminary. The full alignment with collision data is underway. The resolution measured in data agrees with MC to within 3%.

Hannah Herde (Brandeis University), on behalf of the ATLAS Collaboration