

Study of the ATLAS muon identification efficiency in the presence of high pile-up

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The muon reconstruction and isolation efficiency of the ATLAS detector [1] at the Large Hadron Collider have been measured using the data collected in 2011. An unbiased sample of muons is selected, using tag-and-probe on the J/ψ and Z resonances, to measure these efficiencies. The tag-and-probe method selects events with one well reconstructed muon, the tag, and one loose opposite charge muon, the probe, that form an invariant mass near the mass of the resonance. The specific selections on the probes are tuned to provide a high purity sample of muons that will not bias the efficiency being measured. In both reconstruction efficiency measurements, a combined (CB) muon¹ is chosen as tag. For the muon reconstruction efficiency, measured at low transverse momentum (p_T) using the J/ψ sample [2] and at high p_T using the Z sample [3], a calo-tagged² inner detector track was used as probe. For the isolation efficiency, a CB muon was used as probe.

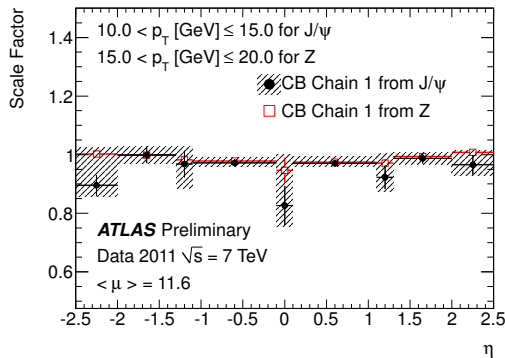


Figure 1: Combined muon data/MC efficiency scale factor comparison between the J/ψ and Z measurements for p_T range of $10 \text{ GeV} < p_T \leq 15 \text{ GeV}$ for the J/ψ measurement and $15 \text{ GeV} < p_T \leq 20 \text{ GeV}$ for the Z measurement [4].

¹A combined muon is the statistical combination of an inner detector track with a track in the muon spectrometer.

²Calo-tagging selects inner detector tracks whose energy deposition in the calorimeter is consistent with that of a minimum ionizing particle.

Figure 1 shows the scale factors, calculated by dividing the efficiency in data by the efficiency in Monte Carlo, comparing the Z and J/ψ measurements versus the pseudo-rapidity³, η . The results show good agreement between the J/ψ and Z measurements. The track and calorimetric isolation⁴ efficiency versus the number of reconstructed vertices per event is seen in Figure 2. The pile-up⁵ corrected calorimeter isolation efficiency displays a small dip in efficiency at high pile-up. The track isolation efficiency, on the other hand, remains constant at even the highest levels of pile-up.

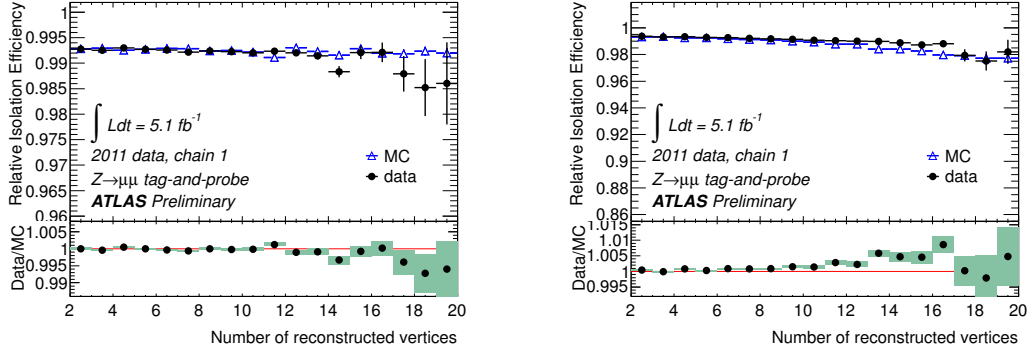


Figure 2: Track isolation (left) and pile-up corrected calorimeter isolation (right) efficiencies versus the number of reconstructed vertices [5].

References

- [1] ATLAS Collaboration, JINST **3** S08003 (2008).
- [2] ATLAS Collaboration, ATLAS-CONF-2012-125.
- [3] ATLAS Collaboration, ATLAS-CONF-2011-063.
- [4] ATLAS Collaboration, ATL-COM-MUON-2012-013, https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/MUON/PublicPlots/2011/May_2012/.
- [5] ATLAS Collaboration, ATL-COM-PHYS-2011-1640, <https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/MUON/PublicPlots/2011/Dec/>.

³Where $\eta = -\ln \left[\tan \left(\frac{\theta}{2} \right) \right]$ and θ is the polar angle of the particle from the beam line.

⁴Relative isolation is when the sum of the track momentum or calorimeter energy deposition around the given particle in a specific cone does not exceed a certain threshold. For this analysis, track isolation is defined by $\sum p_T (\Delta R < 0.3) / p_T < 0.15$ and calorimeter isolation is defined by $\sum E_T (\Delta R < 0.3) / p_T < 0.14$

⁵The term pile-up refers to multiple interactions per bunch crossing. Accordingly, high pile-up events are those with many reconstructed vertices.