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CMS Muon Results

Contacts

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Plots and Results

Muon reconstruction and identification performance during run 2

Twiki: PhysicsResultsMUODP2020040

CDS: https://cds.cern.ch/record/2727091?ln=en

This DPS note is focusing on:

- low pT efficiency using Jpsi
- comparison between the Ultra Legacy 2017 and End Of Year 2017 looking at scale and resolution plots
- trigger efficiency for the full run 2

Muon reconstruction performance during Run II

- DPS with approved plots: CMS DP-2019/022

Muon identification and isolation efficiencies with 2017 and 2018 data

- DPS with approved plots: CMS DP-2018/042

Muon HLT Performance with 2018 Data

- DPS with approved plots: CMS DP-2018/034

Muon HLT Performance with 2016 data.

- DPS with approved plots: CMS DP-2017/056

Muon Identification and Isolation efficiency on full 2016 dataset

- DPS with plots approved on 27 March 2017: CMS DP-2017/007

Show plots  Hide plots

- Loose ID efficiencies vs . Error bars in the plot include only statistical uncertainty.
- Medium ID efficiencies vs $\eta$. Error bars in the plot include only statistical uncertainty.

- High-pT ID efficiencies vs $\eta$. Error bars in the plot include only statistical uncertainty.
• Tight ID efficiencies vs $\eta$. Error bars in the plot include only statistical uncertainty.

• Tight Isolation efficiencies vs $\eta$, with respect to Tight ID. Error bars in the plot include only statistical uncertainty.
- Tight Isolation efficiencies vs pT, with respect to Tight ID. Error bars in the plot include only statistical uncertainty.

- Tight Isolation efficiencies vs vtx, with respect to Tight ID. Error bars in the plot include only statistical uncertainty.
• Loose Tracker Isolation efficiencies vs $\eta$, with respect to High-pT ID. Error bars in the plot include only statistical uncertainty.

• Loose Tracker Isolation efficiencies vs $p_T$, with respect to High-pT ID. Error bars in the plot include only statistical uncertainty.
Loose Tracker Isolation efficiencies vs vtx, with respect to High-pT ID. Error bars in the plot include only statistical uncertainty.

Performance of muon reconstruction including Alignment Position Errors for 2016 Collision Data

- DPS with plots approved on 02 November 2016: CMS DP-2016/067

- RMS width of residuals of the local-x position, given by the position of the muon segment with respect to the extrapolated tracker track, as a function of the muon station, for DT chambers in the barrel region (left) and CSCs in the endcap regions (right). Data (with asymptotic alignment) is compared with MC expectations.
RMS width of residuals of the local-x position for the track-to-segment match in the first muon station as a function of the muon pseudorapidity, with a requirement on momentum $p > 90 \text{ GeV/c}$. Data (with asymptotic alignment) is compared with MC expectations.
RMS width of residuals of the local-x position for the track-to-segment match in the first muon station as a function of the muon momentum in different angular regions: BARREL $|\eta| < 0.9$, and ENDCAP $1.2 < |\eta| < 2.4$. Data (with asymptotic alignment) is compared with MC expectations.
MC muon generation flat in p, eta, phi. Selected range: 20 GeV < P < 500 GeV. Left: Number of muon hits in Global muon tracks selected with Tight quality cuts except for the quality cuts in the global track. Right: Normalized chi2 of the global muon track (tracker+muon hits) selected with Tight quality cuts except for the quality cuts in the global track.
• Gaussian width of the reconstructed q/p w.r.t. the MC truth, for a dedicated high-pT algorithm (picky muon reconstructor), including tracker and muon hits, for the various misalignment scenarios with and without APE. The ideal scenario is also shown. The performance of the tracker-only fit is shown for comparison.
- Number of muon hits in Global muon tracks selected with Tight quality cuts except for the quality cuts in the global track.

- RMS of the pull between the reconstructed segment in the first muon station and the extrapolated tracker track. The most sensitive coordinate is considered (local-X position, corresponding to the bending coordinate in the transverse plane).
Impact of the muon Alignment Position Errors (APE) on the 2016 Startup HLT efficiency of the Mu20 trigger path.

Performance of muon reconstruction including Alignment Position Errors for 2016 Collision Data
Muon ID efficiencies and heavy flavour results in 2016 early data

- DPS with plots approved on 9 June 2016: CMS DP-2016/027

Muon ID efficiencies in 2015 RunB data

- DPS with plots approved on 12 August 2015: ppt pdf

Muon Isolation Performance with the Pile Up Per Interaction (PUPPI) method on 13 TeV Montecarlo

- Collection of several PUPPI performance plots incl. muon isolation, approved on 5 August 2015: CMS DP-2015/034

Collection of heavy flavor distributions with dimuons in 2015 RunB data

- DPS with plots approved on 20 July 2015: CMS DP-2015/018

Muon Reconstruction and Identification Improvements for Run-2 and First Results in 2015 RunB data

- DPS with plots approved on 20 and 21 July 2015: ppt pdf
Double muon trigger efficiencies in 2012 data

- DPS with plots: pdf

Muon ID performance: low-pT muon efficiencies

- DPS with plots approved on 18 June 2014: pptx pdf

Muon Identification performance: hadron mis-Id measurements and RPC Muon selections

- DPS with approved performance plots: pptx pdf
  - pion and proton mis-ID probabilities, approved on 16 April 2014 (pion results supersede those contained in the previous note CMS DP-2013/024)
  - RPC Muon ID results and other pion and kaon mis-ID probabilities, approved on 19 February 2014

New Pion and Kaon misID results and momentum calibration plots

- DPS with plots approved on 18 September 2013: pptx pdf

Single Muon efficiencies (Identification, Isolation and Trigger) in 2012 data

- DPS with approved performance plots: ppt pdf
  - Identification and Isolation efficiencies in 2012 RunABCD data (approved on 27 February 2013)
  - Trigger Efficiencies in 2012 RunD data (approved on 13 March 2013)

Muon ID and Isolation efficiencies in 2012 RunAB data (52X)

- DPS approved on 10th October 2012: ppt pdf

Muon isolation efficiency in 2011 data (@ L~1.1 fb-1)

Show plots  Hide plots

- Isolation efficiency vs $p_T$ in the barrel (left), in the endcap (middle), and vs. the number of vertices in the event (right) for Particle-Flow muons with Tight Muon quality requirements. The isolation variable is calculated using the Particle-Flow algorithm; the isolation cone is 0.4 and the isolation cut is 0.15. The isolation algorithm uses only charged hadron tracks associated to the $Z \rightarrow \mu\mu$ primary vertex (PfNoPileUp); no PU correction is applied to the neutral component. The measurement is done by applying the Tag&Probe method to $Z \rightarrow \mu\mu$ events.
Muon trigger efficiency in 2011 data (@ L~1.1 fb-1)

- HLT efficiency of single muon trigger not requiring isolation (HLT_Mu30/L1_Mu12, left) and the combined Level-1*HLT efficiency (L1_Mu12*HLT_Mu30, right) vs. for Tight Muon selection with p_T > 35 GeV obtained by applying the Tag&Probe method to Z $\rightarrow$ $\mu\mu$ events. Overall (l_1 < 2.1) Level-1*HLT efficiency: 93.3% in data, 94.2% in MC; scale factor (data/MC)=0.991. Barrel (l_1 < 0.9) Level-1*HLT efficiency: 95.0% in data, 96.8% in MC; scale factor=0.982. Endcap (0.9 < l_1 < 2.1) Level-1*HLT efficiency: 89.9% in data, 89.0% in MC; scale factor=1.01
Muon trigger efficiency in 2011 data (@ L~1.1 fb⁻¹)
Muon identification efficiency in 2010 data

The measurement is made by applying the tag-and-probe technique to muons from $J/\psi \rightarrow \mu\mu$ in the range of $p_T < 20$ GeV and from $Z \rightarrow \mu\mu$ in the range of $p_T > 20$ GeV.

- Soft muon selection, $|\eta| < 1.2$ (left) and $1.2 < |\eta| < 2.4$ (right). Efficiency in data is slightly higher than in simulation due to more conservative uncertainty estimates used.

- Particle-flow muon selection, $|\eta| < 1.2$ (left) and $1.2 < |\eta| < 2.4$ (right).

- Tight muon selection, $|\eta| < 1.2$ (left) and $1.2 < |\eta| < 2.4$ (right). In the endcaps, efficiency is slightly lower in data than in simulation because the latter does not take into account a few chambers that were not operational in 2010.
Z $\mu\mu$ invariant mass in 2010 data

Show plots  Hide plots

Invariant mass distribution of Z $\mu\mu$ candidates for $L_{\text{int}} = 35 \text{ pb}^{-1}$. The number of candidates observed in data is 11697; MC predictions (no data-driven corrections) are 11968 signal events and 52 background events.
Transverse mass distribution, $M_T$, of $W \rightarrow \mu\bar{\nu}$ candidates for $L_{int} = 35$ pb$^{-1}$. In the region $M_T > 50$ GeV, the number of candidates observed in data is 144718, whereas the number of expected events is 144995.
Y(nS) $\mu\mu$ invariant mass in 2010 data

Invariant mass distribution of dimuons in the vicinity of the Y(nS) resonances, for an integrated luminosity of 40 pb$^{-1}$ at 7 TeV

- Invariant mass distribution integrated over the full rapidity range:

- Invariant mass distribution for dimuons with both muons in the region of $|\eta| < 1$:
Values correspond to $L_{\text{int}} = 40 \text{ pb}^{-1}$

<table>
<thead>
<tr>
<th></th>
<th>Full rapidity range</th>
<th>$\text{abs}(\eta(\text{muons})) &lt; 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal events $Y(1S)$</td>
<td>$94161 \pm 564$</td>
<td>$23390 \pm 194$</td>
</tr>
<tr>
<td>Signal events $Y(2S)$</td>
<td>$28715 \pm 366$</td>
<td>$7298 \pm 133$</td>
</tr>
<tr>
<td>Signal events $Y(3S)$</td>
<td>$15109 \pm 330$</td>
<td>$3999 \pm 113$</td>
</tr>
</tbody>
</table>

**J/Ψ → µµ and ψ(2S) → µµ invariant mass in 2010 data**

Show plots  Hide plots

* J/Ψ invariant mass distributions for $|y(J/Ψ and ψ(2S))| < 0.5:

**J/Ψ → µµ invariant mass in 2010 data**

Show plots  Hide plots

Invariant mass distribution of dimuons in the vicinity of the $J/Ψ$ resonance, for an integrated luminosity of 40 pb$^{-1}$ at 7 TeV

* $J/Ψ$ invariant mass distribution integrated over the full rapidity range ($|y(J/Ψ)| < 2.4$):
• $J/\psi$ invariant mass distributions for $|y(J/\psi)| < 1.4$ (left) and for $1.4 < |y(J/\psi)| < 2.4$ (right):

• $J/\psi$ invariant mass distributions for $|y(J/\psi)| < 0.7$ (left) and $|Y(J/\psi)| < 0.5$ (right):
Values correspond to $L_{\text{int}} = 40$ pb$^{-1}$

<table>
<thead>
<tr>
<th></th>
<th>Full rapidity range</th>
<th>$\text{abs}(y(J/\psi)) &lt; 0.5$</th>
<th>$\text{abs}(y(J/\psi)) &lt; 0.7$</th>
<th>$\text{abs}(y(J/\psi)) &lt; 1.4$</th>
<th>$1.4 &lt; \text{abs}(y(J/\psi)) &lt; 2.4$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal events</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Events</td>
<td>$(2267.2 \pm 1.9) \times 10^{3}$</td>
<td>$(120.5 \pm 0.8) \times 10^{3}$</td>
<td>$(172.3 \pm 0.5) \times 10^{3}$</td>
<td>$(571.3 \pm 1.2) \times 10^{3}$</td>
<td>$(1726.8 \pm 4.2) \times 10^{3}$</td>
</tr>
<tr>
<td><strong>Sigma (MeV/c$^2$)</strong></td>
<td>$44.5 \pm 0.2$ (stat.)</td>
<td>$19.9 \pm 0.6$ (stat.)</td>
<td>$21.2 \pm 0.4$ (stat.)</td>
<td>$31.4 \pm 0.2$ (stat.)</td>
<td>$49.9 \pm 0.7$ (stat.)</td>
</tr>
<tr>
<td><strong>$M_0$ (GeV/c$^2$)</strong></td>
<td>$3.0967 \pm 0.0001$ (stat.)</td>
<td>$3.0978 \pm 0.0001$ (stat.)</td>
<td>$3.0975 \pm 0.0001$ (stat.)</td>
<td>$3.0968 \pm 0.0001$ (stat.)</td>
<td>$3.0961 \pm 0.0001$ (stat.)</td>
</tr>
<tr>
<td><strong>$\chi^2$/ndof</strong></td>
<td>$5.6$</td>
<td>$44$</td>
<td>$39$</td>
<td>$18$</td>
<td>$4.3$</td>
</tr>
</tbody>
</table>

Invariant-mass spectra of opposite-sign muon pairs using 2010 and 2011 data

Show plots ▶ Hide plots ✗

2011 data collected by early July, corresponding to an integrated luminosity of 1.1 fb$^{-1}$, superposition of various dimuon trigger paths:
Major results

Papers and PASes

- **CMS MUO-10-002**: Performance of muon identification in pp collisions at \( \sqrt{s} = 7 \text{ TeV} \)
- **2012 JINST 7 P10002** (based on CMS MUO-10-004): "Performance of CMS muon reconstruction in pp collision events at \( \sqrt{s} = 7 \text{ TeV} \)".
PhysicsResultsMUO < CMSPublic < TWiki

CMS Notes


Performance Notes (collections of plots)

• CMS DP-2010/001: Dimuons in 2009 collision data (pages 31-35).
• CMS DP-2010/005: Dimuons in CMS at 900 and 2360 GeV.
• CMS DP-2010/016: First two months of data taking at 7 TeV: J/ψ, W, Z, μ μ mass plots and displays of Z, μ μ candidates.
• CMS DP-2010/020: Muons in minimum-bias events at 7 TeV: data-MC comparisons for a few basic kinematic distributions. Updated with more statistics on 19/07/2010: pdf, ppt.
• CMS DP-2010/039: Comparisons of the Fast Simulation with the first LHC data.
• CMS DP-2012/025: Muon ID and Isolation Efficiencies in 2012 RunAB.
• CMS DP-2013/009: Single Muon efficiencies in 2012 Data.
• CMS DP-2013/024: New Pion and Kaon misID results and momentum calibration plots.
• CMS DP-2014/038: Double Muon Trigger efficiency in 2012 data.
• CMS DP-2015/015: Muon Reconstruction and Identification Improvements for Run-2 and First Results with 2015 Run Data.

Publications

• Papers
• Physics Analysis Summaries with collision data
• Physics Analysis Summaries from MC studies

This topic: CMSPublic > PhysicsResultsMUO
Topic revision: r89 - 2020-08-20 - DevinTaylor

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