Measurement of the W-Boson Mass with the ATLAS Detector at the LHC

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Overview

- Finding the W-mass at the muon channel
- We don't know the Z-component of ν_μ
- $m_T = \sqrt{2 p_T \not{E}_T \left(1 - \cos\left(\phi_{MET} - \phi_\mu\right)\right)}$. The shape depends on m
- Do MC templates for different M_W
- Compare m_T for different W-mass in MC with data. χ^2-fit
- p_T is better because of high uncertainty on $\not{E}_T$-scale
- Look at Z-events for comparison and calibration

Transverse Mass og W

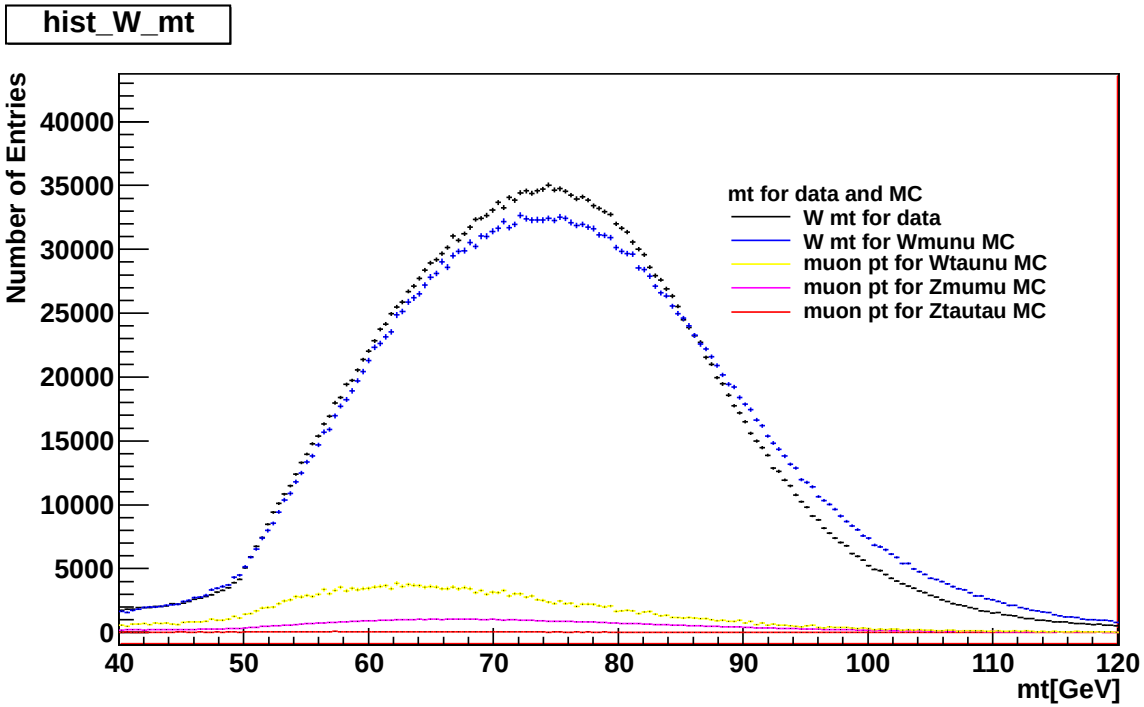


Figure: Transverse Mass of W

- MC is not consistent with data because of the E_T^{Miss}
- p_T-destribution of the muon is better

Template Fit

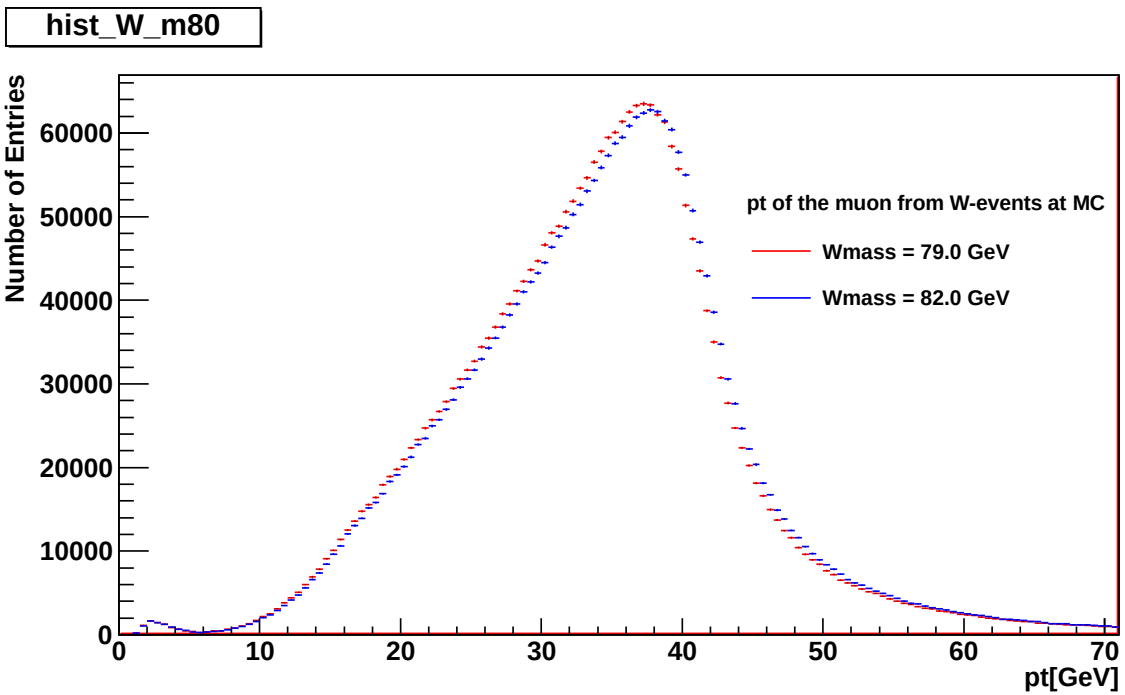


Figure: Muon p_T destribution for different templates

- Generate MC-events with different W-mass
- Compare data with each MC-sample
- Make a χ^2-test to find the W-mass

Muon Selection

- Combined (detected as a muon in inner detector and muon detector)
- mimimum 1 hit in the Pixel detector and 6 hits in the SCT detector
- At least 1 hit in the TRT
- pseudorapidity $|\eta| < 2.4$
- Isolation criteria - p_T of a cone of size 0.2 divided by muon $p_T < 0.1$

W and Z Events in the muon channel

$W \rightarrow \mu\nu$

- $p_T > 25\text{GeV}$
- $\not{E}_T > 25\text{GeV}$
- $m_T > 40\text{GeV}$

$Z \rightarrow \mu\mu$

- Each muon should have $p_T > 25\text{GeV}$
- Two combined muons with opposite charge
- $66 < M_{\mu\mu} < 116$

Transverse Momentum

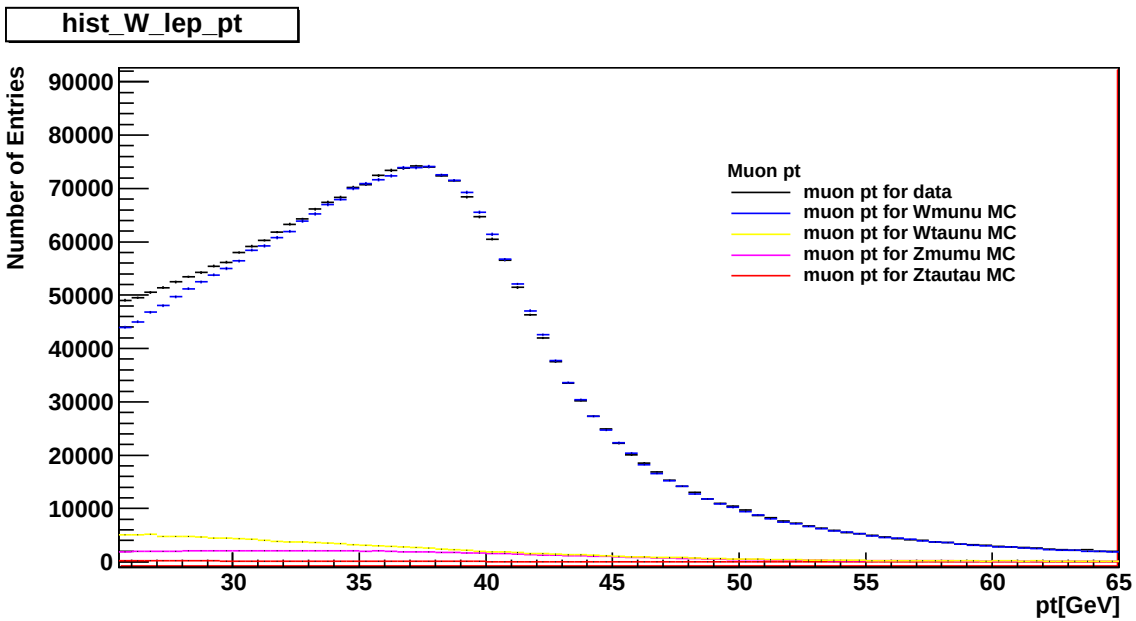


Figure: Transverse Momentum of muons for $W \to \mu\nu$ in GeV. MC histograms is added

- Scaling p_T insteed of changing m_W
- Smearing
- More background (QCD)
- Data peaks at low p_T because of QCD

χ^2-test for $p_T^{Scaling}$ for muons in $W \to \mu\nu$ - channel

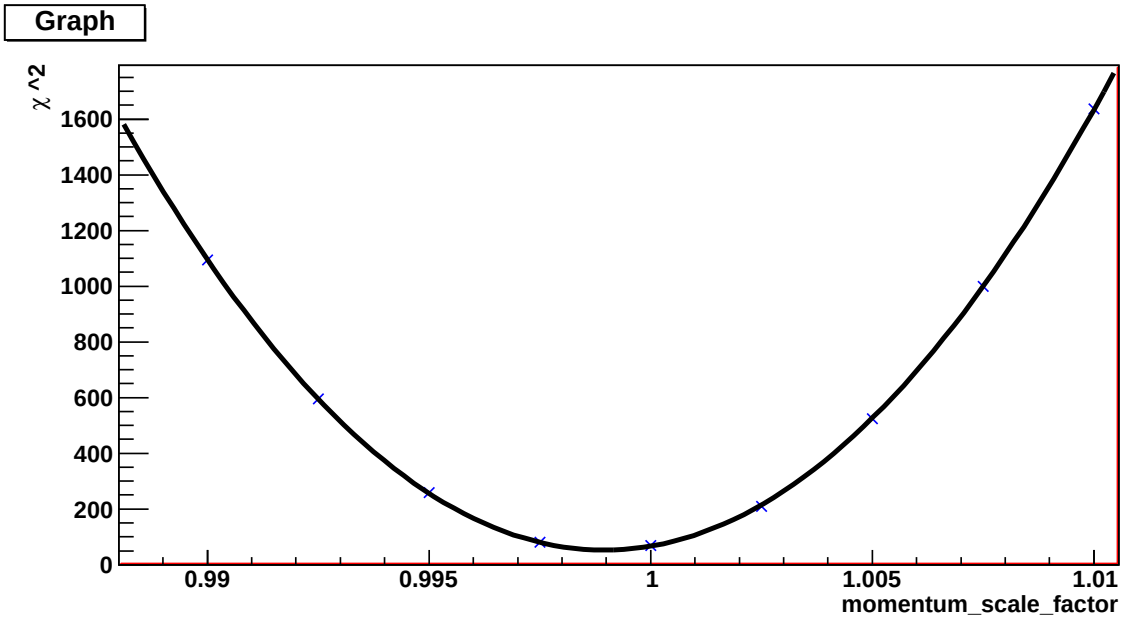


Figure: χ^2-test for $p_T^{Scaling}$ for muons in $W \to \mu\nu$

- High χ^2 because of smearing
- Fit with a parabola
- Minimum for $TS_W = 0.9990$
- Uncertainty of 0.0003
- $M_W^{DATA} = M_W^{TRUTH} \cdot TS_W$

M_{inv} for $Z \to \mu\mu$

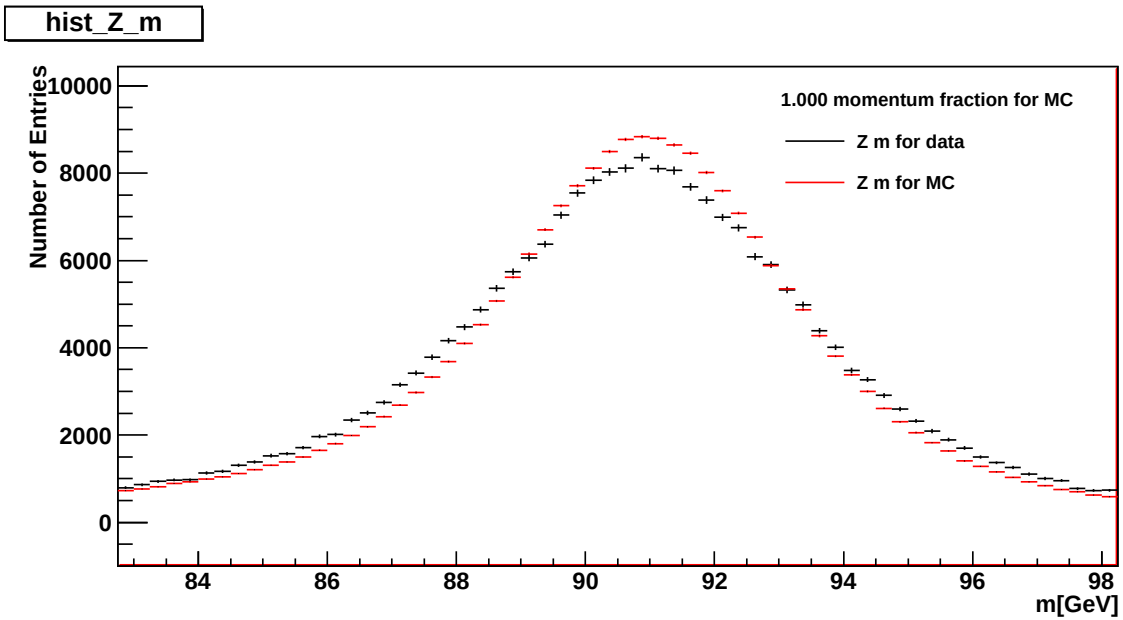
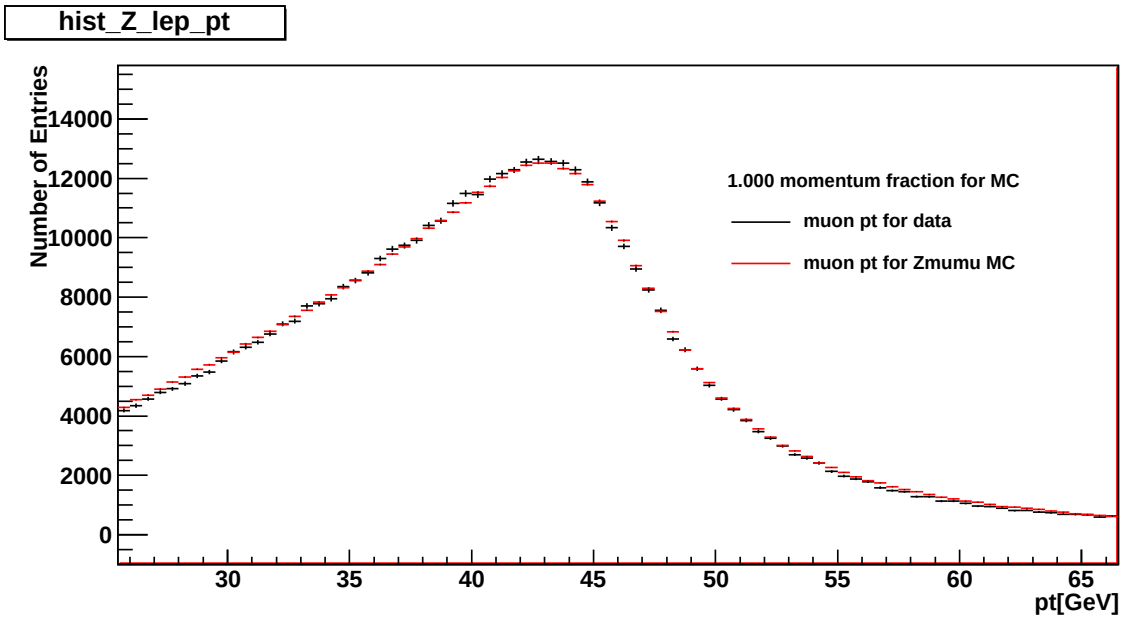


Figure: M_{inv} for $Z \to \mu\mu$ in GeV

- Energy/momentum scale and resolution
- Z-events for calibration
- no background on MC

Transverse Momentum



- Smearing
- Scalled the fit range to $\frac{M_Z}{M_W}$.

Figure: Transverse Momentum of muons for $Z \to \mu\mu$ in GeV

χ^2-test for p_T for muons in $Z \to \mu\mu$ - channel

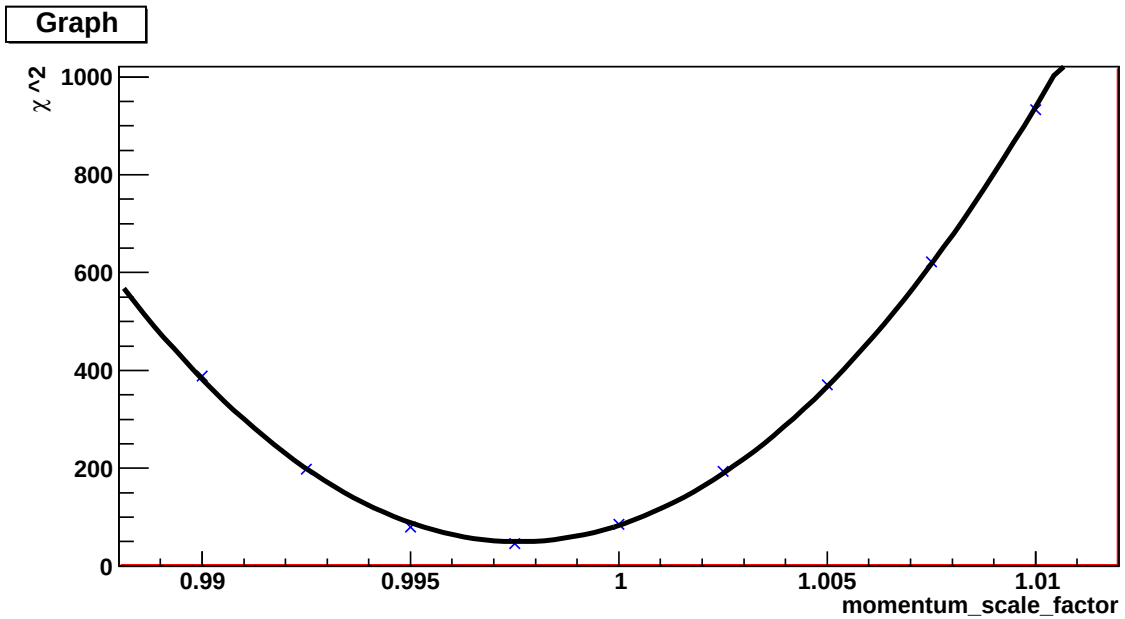


Figure: χ^2-test for $p_T^{Scaling}$ for muons in $Z \to \mu\mu$

- High χ^2 because of background and smearing
- Fit with a parabola
- Minimum for $TS_Z = 0.9976$
- Uncertainty of 0.0004

W-mass

W-mass

- $M_W^{truth} = 80.399 \pm 0.023$ GeV (pdg)
- $TS_Z = \frac{M_Z^{DATA}}{M_Z^{MC}}|_M = 0.9976 \pm 0.0004$
- $TS_W = \frac{M_W^{DATA}}{M_W^{MC}}|_{PT} = 0.9990 \pm 0.0003$
- $M_W^{DATA} = M_W^{TRUTH} \cdot \frac{TS_W}{TS_Z} = 80.510 \pm 0.032$ GeV

End

Comparing variables. m_T and p_T

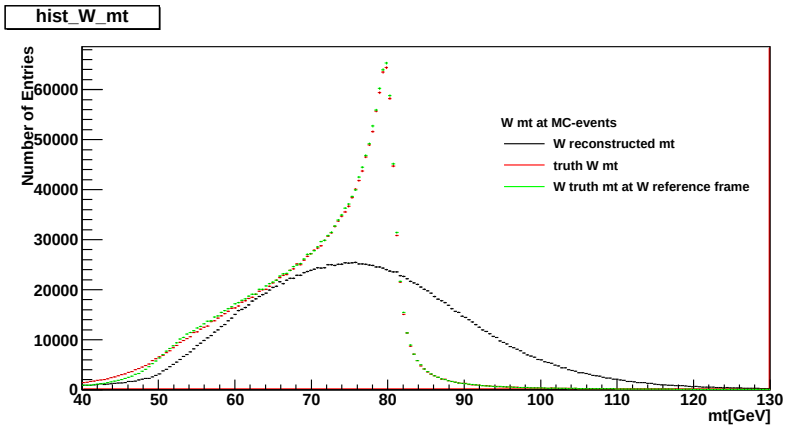


Figure: M_T in MC

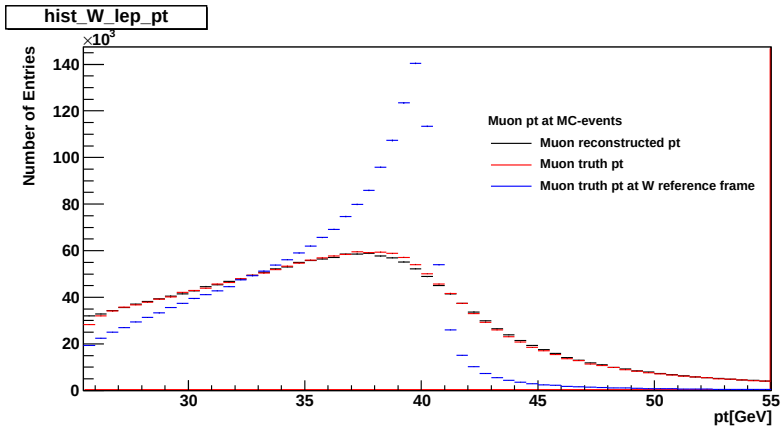


Figure: Muon p_T in $W \to \mu\nu$-events