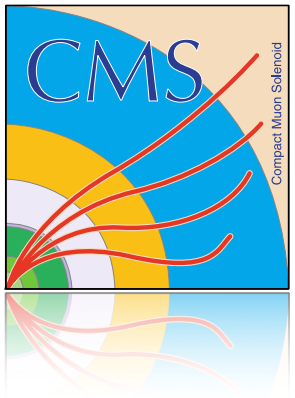

Measurement of W and W/Z transverse momentum spectra at 8 TeV

mW topical meeting

June 22, 2017

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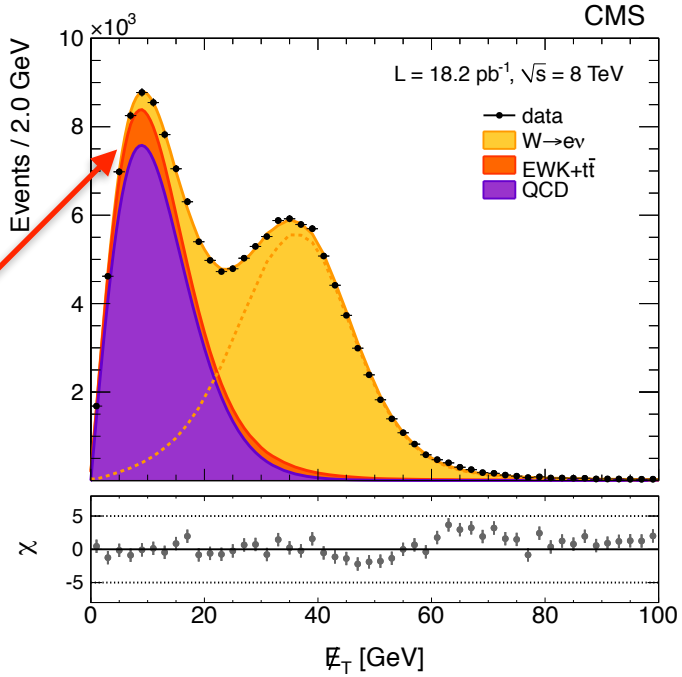
On behalf of CMS Collaboration

Introduction

- Measurements of the transverse momentum (pT) distributions of W and Z bosons at the LHC
- W pT must be reconstructed using the hadronic recoil in leptonic decays
  - The modeling of hadronic recoil->W mass
- Experimental challenges with large instantaneous luminosities:
  - Single lepton trigger thresholds
  - Resolution degradation of recoil (pileup)
    - Signal and background separation
    - Binning of unfolded W pT
- Making use of a low-pileup data sample
  - Collected ~18 pb^{-1} of integrated luminosity at 8 TeV



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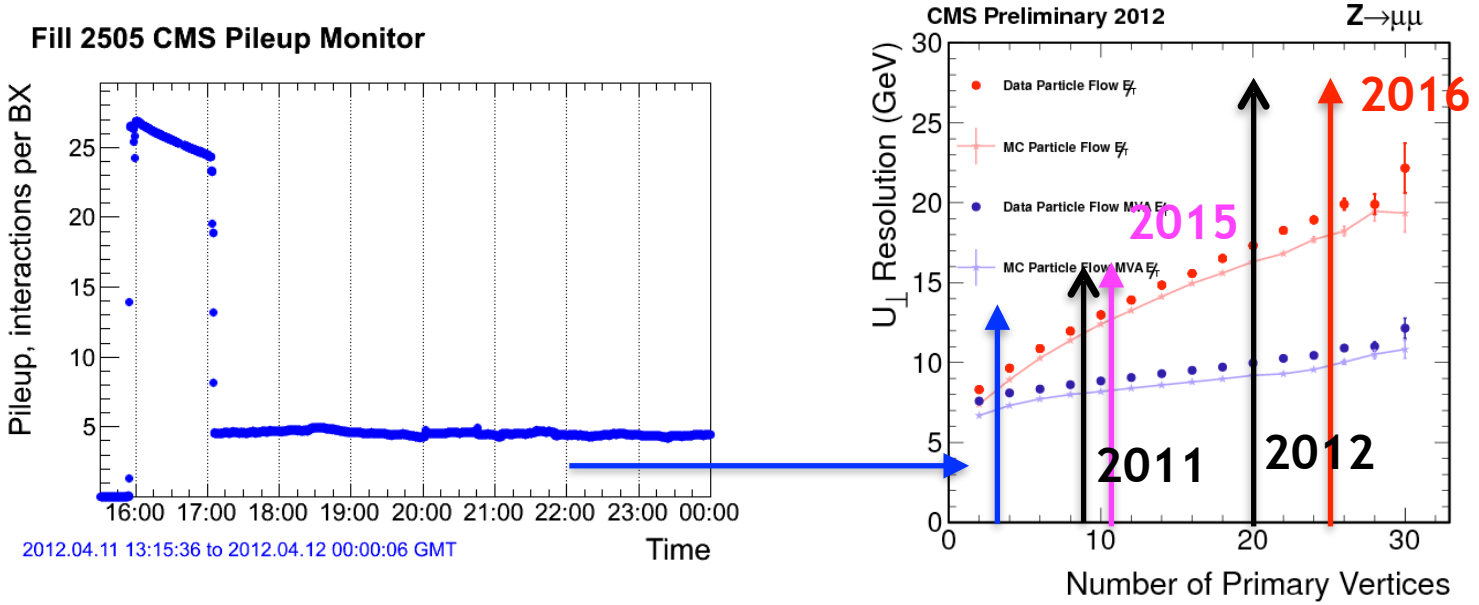
Low pileup run

- Special run with low pileup
  - Using luminosity leveling technique
  - Conditions: inst. Luminosity of ~3e32 $cm^{-2}\,s^{-1}$, $<N_{PU}>$ ~ 5
- Dedicated trigger setup with low pT thresholds
  - Muons:15 GeV with no isolation requirements
  - Electrons: 22 GeV with loose calorimetric isolation requirements



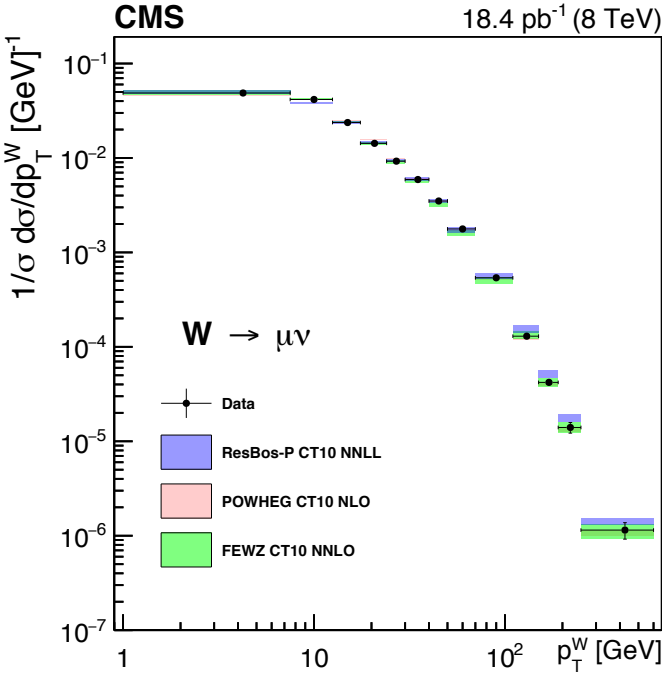
Recoil resolution as function of number of primary vertices

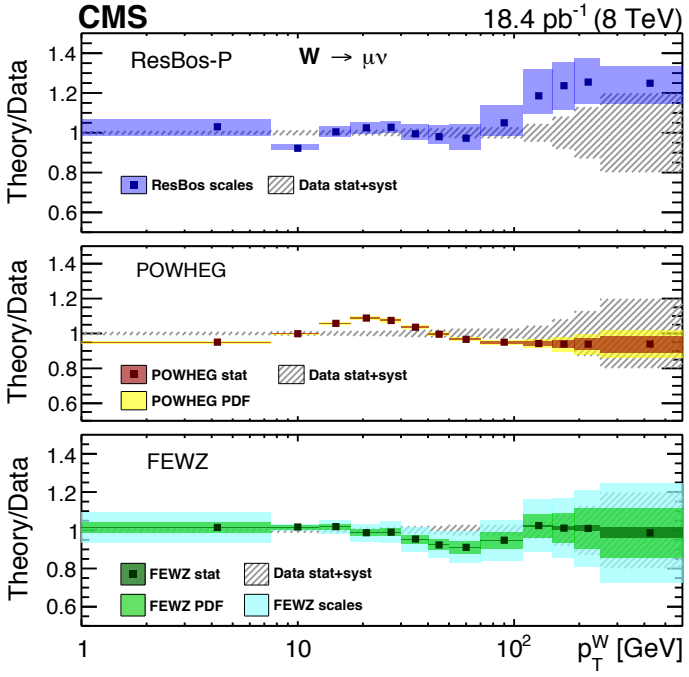
Measurement of W pT

- Fiducial region: JHEP02(2017)096
  - Muons with pT>20 GeV and |eta|<2.1 (Born level)
  - Electrons with pT>25 GeV and |eta|<2.5 (Born level)
- Missing energy distribution is used to evaluate the signal yield
  - Transverse mass is used in muon channel for large W pT bins
  - W signal shape is computed by calibrating the recoil in simulation to data using Z events
- Detector resolution and FSR effects are corrected with unfolding
  - The W pT bin widths are chosen to limit the migration of events between neighboring bins (stability of unfolding)
    - 0-7.5 GeV, 7.5-12.5 GeV, 12.5-17.5 GeV, …
    - Possible to improve the recoil resolution with sophisticated techniques

W pT measurement

- Normalized transverse momentum distribution in muon final state
- Powheg with Pythia overestimates the yields by up to 12% near 25 GeV
- Resbos-P systematically overestimates the data above 100 GeV
- FEWZ fixed order predictions show deviations of ~10% near 60 GeV





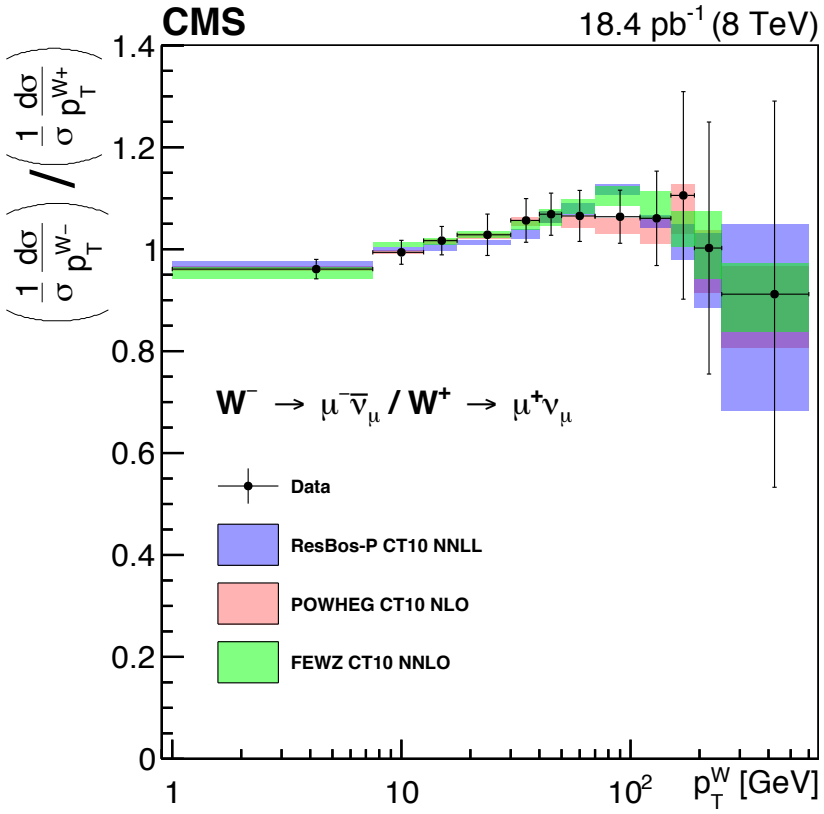
Experimental uncertainties

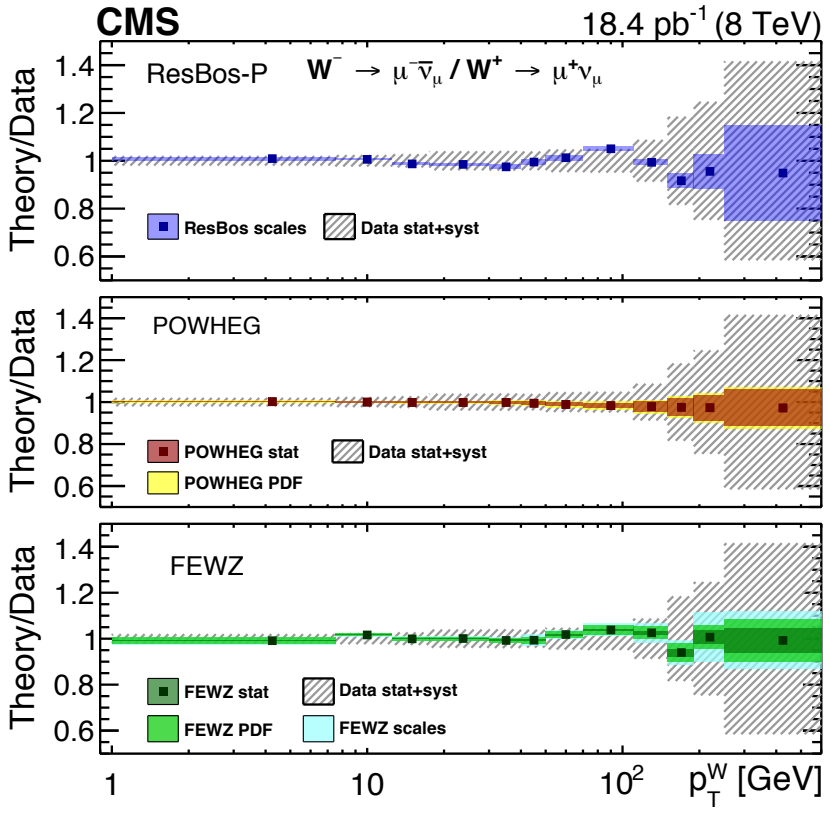
- Systematic uncertainties are largely reduced in normalized distributions
  - Luminosity uncertainties cancel out
  - Lepton reconstruction/identification uncertainties are reduced
- Leading systematic uncertainties: QCD background estimation, and uncertainties related to unfolding
  - Can be constrained with more integrated luminosity

Bin (GeV)	Lept. recon.	Mom. res.	$E_{\mathrm{T}}^{\mathrm{miss}}$ res.	QCD bkgr.	QCD shape	EW	SVD unfld.	FSR	Unfld. bias	Total syst.	Stat.	$(1/\sigma)(\mathrm{d}\sigma/\mathrm{d}p_{\mathrm{T}})$ (GeV^{-1})
0–7.5	0.31	0.21	0.22	0.51	0.20	0.05	0.08	0.05	0.75	1.03	0.60	$(4.74 \pm 0.06) \times 10^{-2}$
7.5–12.5	0.26	0.09	0.10	0.64	0.26	0.04	0.08	0.05	1.43	1.62	0.74	$(4.12 \pm 0.07) \times 10^{-2}$
12.5–17.5	0.17	0.24	0.10	0.48	0.37	0.02	0.08	0.04	1.11	1.31	0.89	$(2.42 \pm 0.04) \times 10^{-2}$
17.5–24	0.16	0.30	0.27	0.66	0.43	0.04	0.09	0.00	0.36	0.98	0.95	$(1.49 \pm 0.02) \times 10^{-2}$
24–30	0.37	0.26	0.35	0.80	0.51	0.05	0.10	0.06	0.58	1.25	1.28	$(9.64 \pm 0.17) \times 10^{-3}$

W^-/W^+ ratio measurement

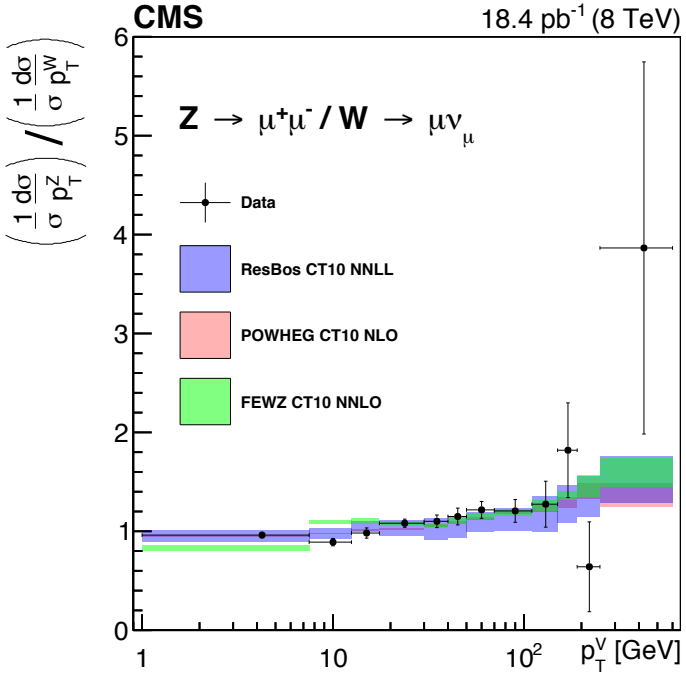
- Predictions describe the data reasonably well within experimental uncertainties
  - Compared to ResBos, Powheg, and FEWZ predictions

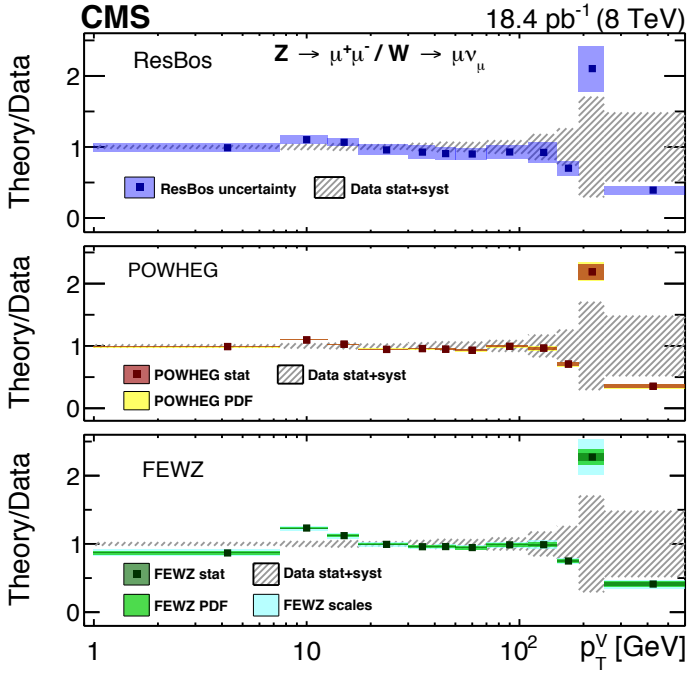




Z/W ratio measurement

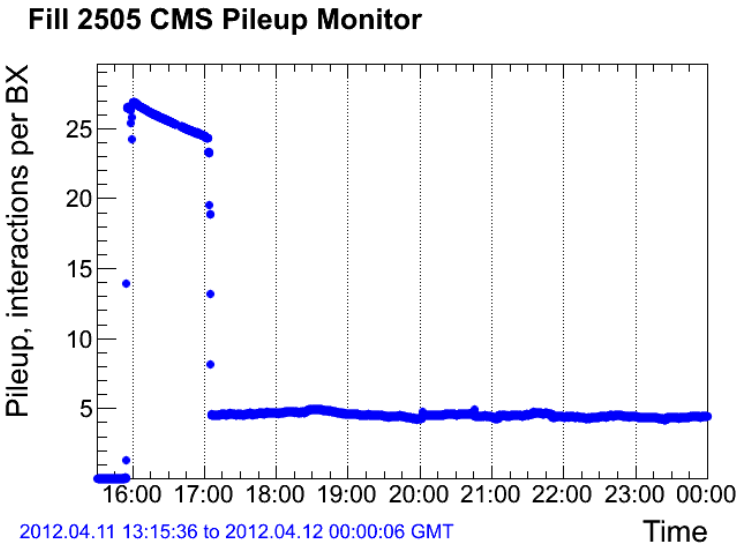
- Z/W differential cross section ratio in muon final state ($60<m_Z<120$ GeV)
  - Fiducial requirements on leptons for Z are the same as for the W
- Powheg shows goos agreement but overestimates by ~10% near 10 GeV
  - Similar behavior shown by ResBos





Low pileup run at 13 TeV?

- We can think about taking a low pileup run at 13 TeV
  - Special runs during the luminosity ramp up (~1 PU events)
  - Both ATLAS and CMS can benefit
- Useful to have a data sample with integ. lumi of ~100pb^{-1}
  - Aim for very precise 'low' W pT measurements
  - Doesn't come for free->loss of luminosity at high intensity



Summary

- Measurement of W pT and corresponding ratios (W^-/W^+ and W/Z) at 8 TeV using the low pileup data sample (JHEP02(2017)096)
  - Uncertainties can be reduced with larger data sample
  - Results compared to ResBos, Powheg, and FEWZ predictions
    - Reasonable description of data with some deviations
- Low pileup run at 13 TeV will help to make precise measurements
  - Doesn't come for free

ADDITIONAL MATERIAL

Z pT measurment

- Normalized Z pT distribution
- Results are shown with finer binning compared to Z/W ratio measurement