



# Measurement of Inclusive Vector Boson Production Cross Sections at $\sqrt{s} = 7$ TeV with CMS

Jessica Leonard

University of Wisconsin – Madison

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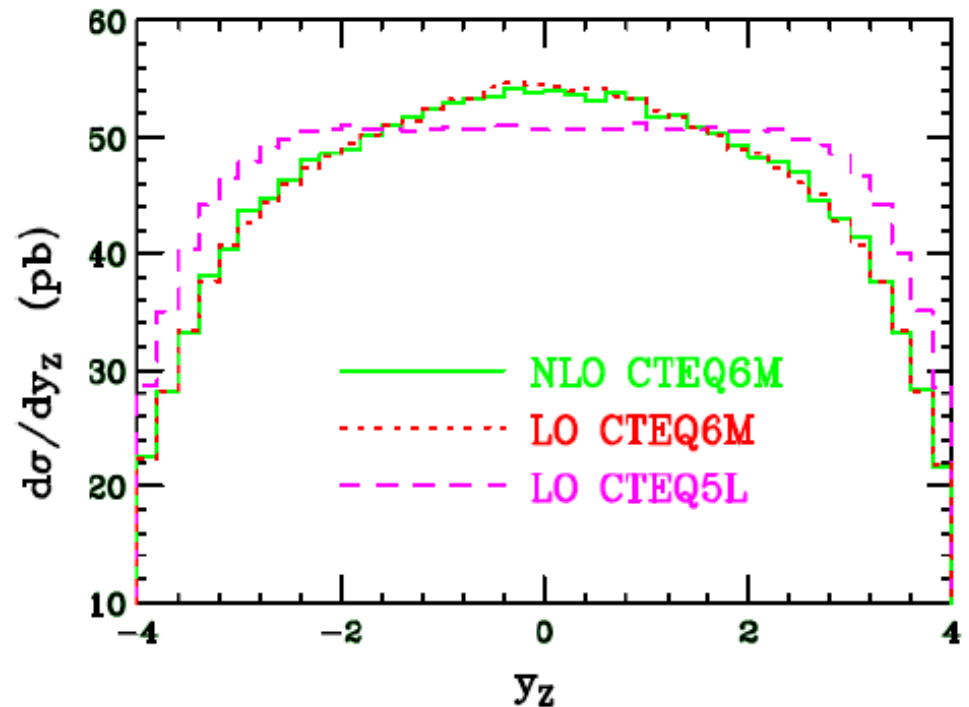
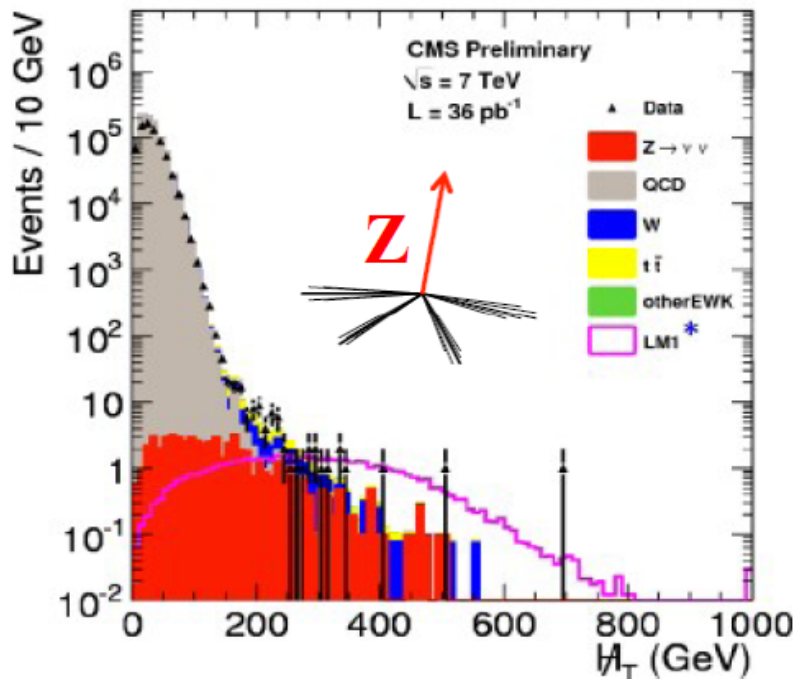
# Motivation



Test of higher-order QCD calculations

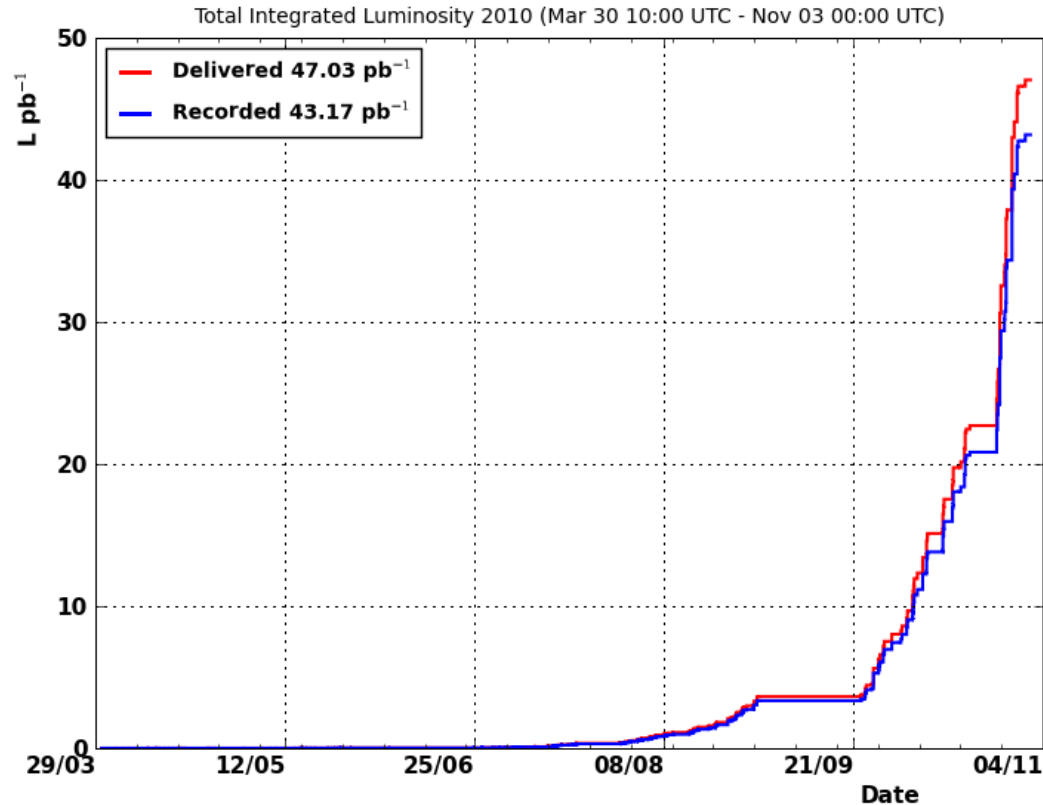
Signature of new physics / Background to searches

Measurement of PDFs, calibration of detector response

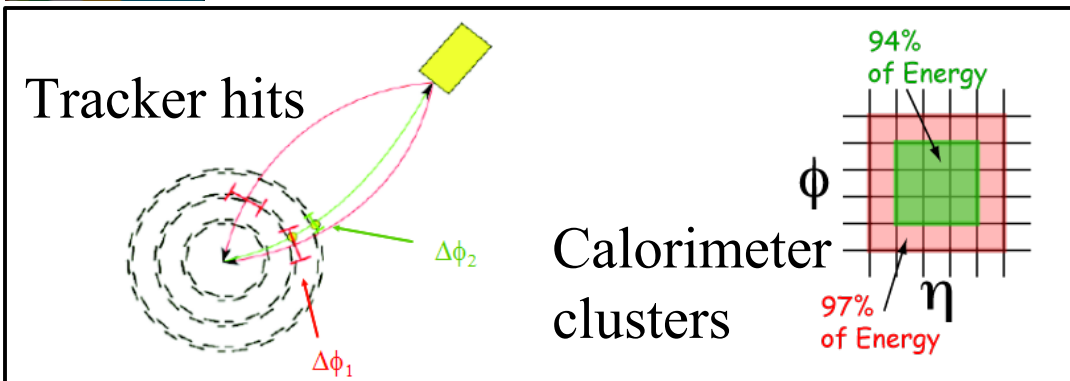




# Luminosity

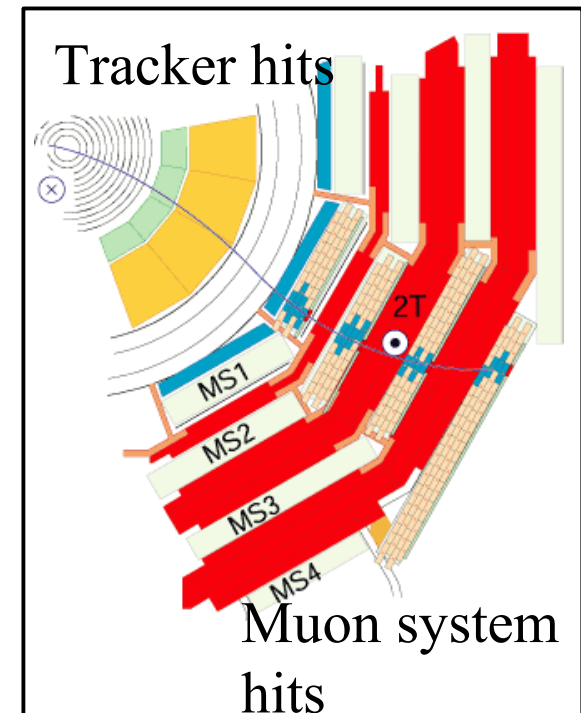
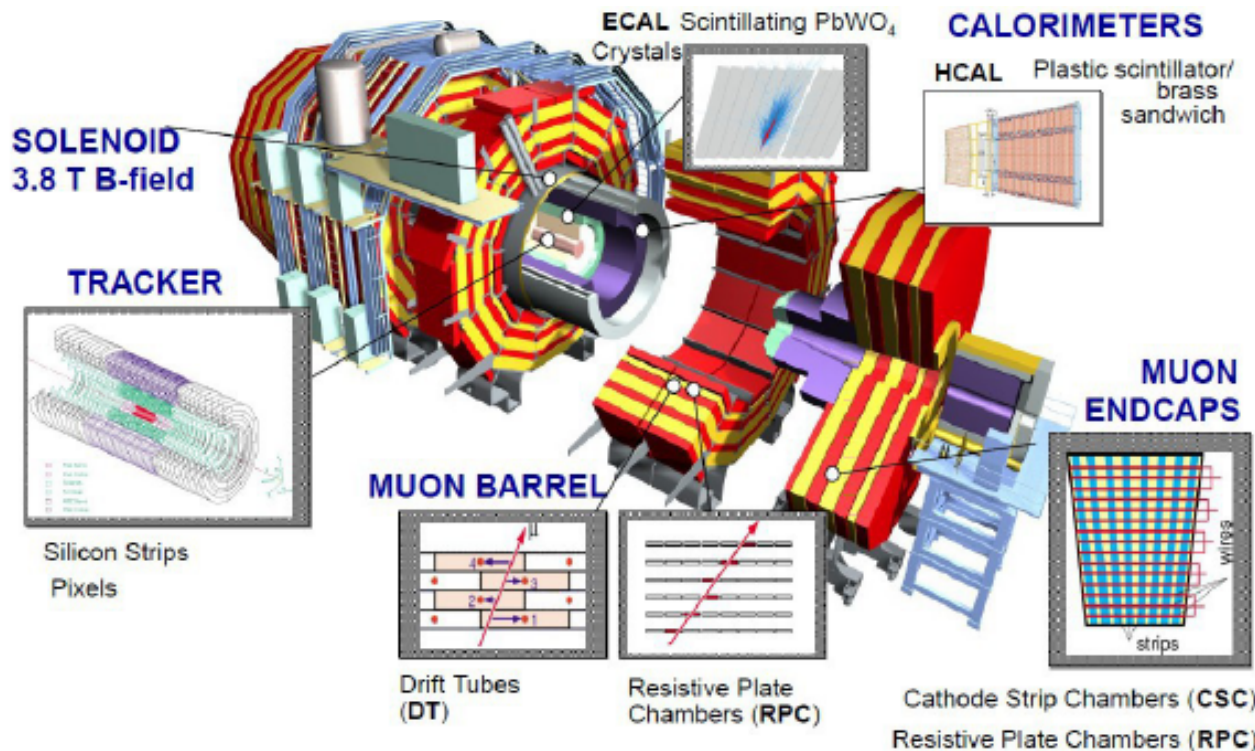


2010 running:  $\sim 36 \text{ pb}^{-1}$  integrated luminosity of certified data

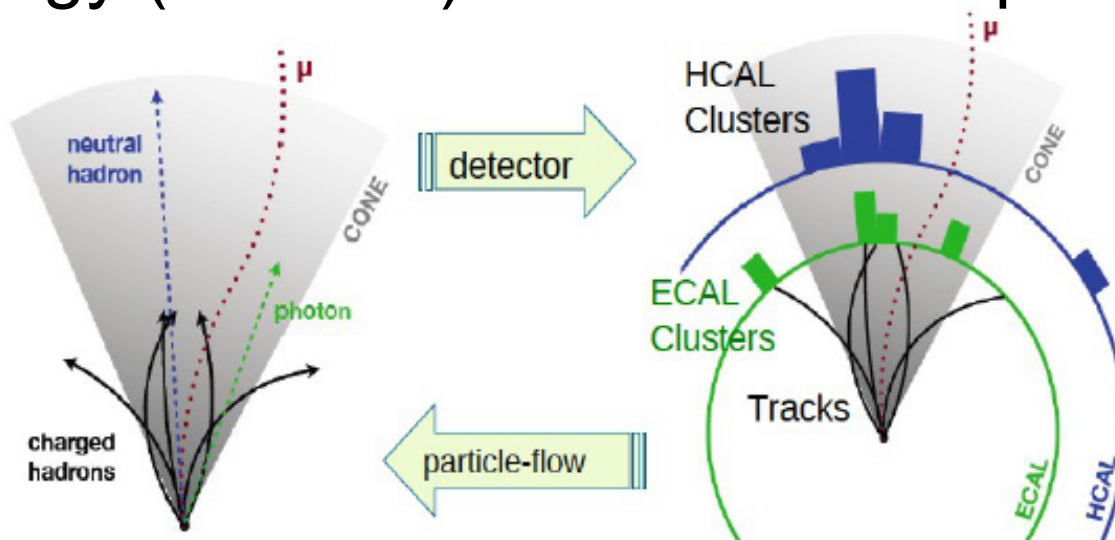


Electron reconstruction

Muon reconstruction



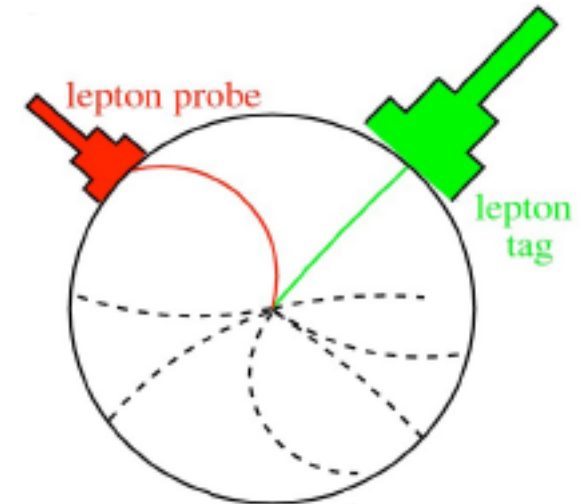
## Missing energy (neutrino) reconstruction: particle flow algorithm



- Reconstructed elements: tracker tracks, muon system tracks, calorimeter clusters
- Elements linked together into “blocks”
- Iteration: as particle objects identified, removed from block
- Missing energy calculated from full particle collection

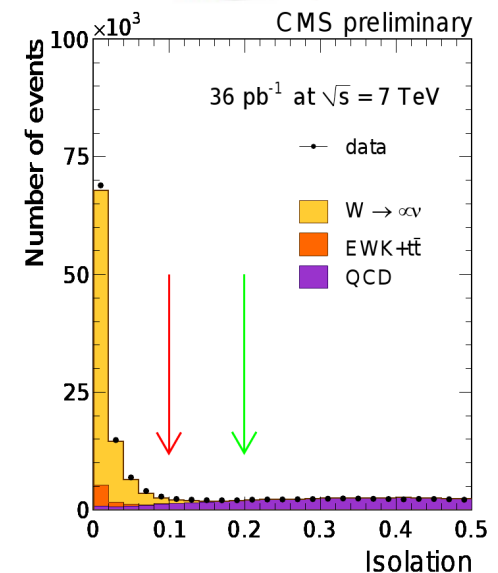
## Lepton Selection Efficiency: Tag and Probe method

- Reconstruction, isolation, trigger steps
- Select sample of probable Z events using mass window 60-120 GeV
- Identify well-reconstructed lepton object as “Tag”
- Partner object is “Probe”
- Efficiency = (probes passing given selection)/(total probes)



## Data-driven Background Estimation: Template

- Relative Isolation: Ratio of energy, momentum in cone around lepton to lepton momentum
- Invert isolation cut to select QCD-rich sample
- Take shape of this sample as QCD background





# W → eν Event Selection



## Require

- Isolated electron,  $E_T > 25$  GeV, ECAL fiducial
- Zero additional good electrons

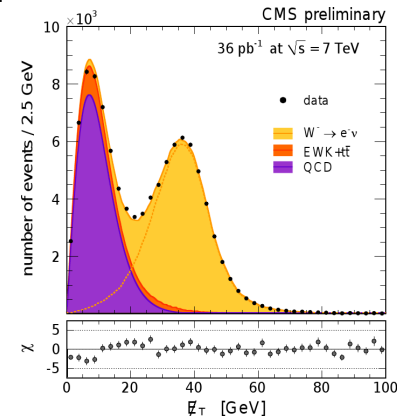
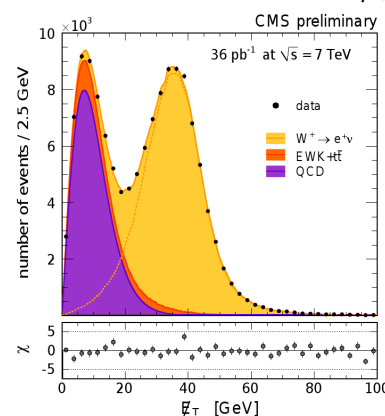
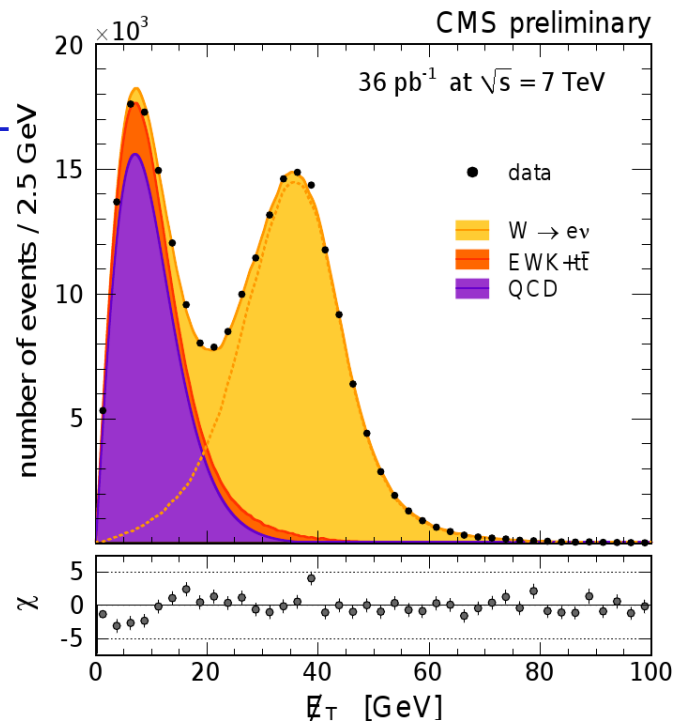
## Acceptance

- W: 0.4933 ± 0.0003
- W+: 0.5017 ± 0.0004
- W-: 0.4808 ± 0.0004

Simultaneous fit to  $W^+$  and  $W^- E_T^{\text{miss}}$  distributions

Fraction of events within acceptance passing full selection

- W: ( 73.5 ± 0.9 )%
- W+: ( 73.7 ± 1.0 )%
- W-: ( 73.2 ± 1.0 )%





# W → μν Event Selection



## Require

- Muon  $p_T > 25$  GeV,  $|\eta| < 2.1$
- Reject events with two good muons,  $p_T > 20$  and 10 GeV

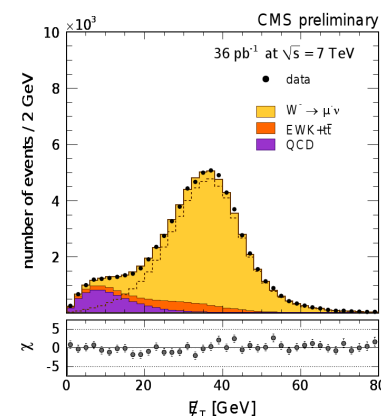
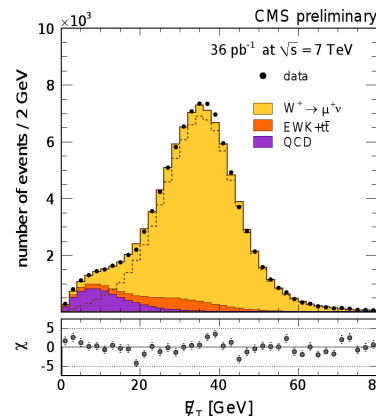
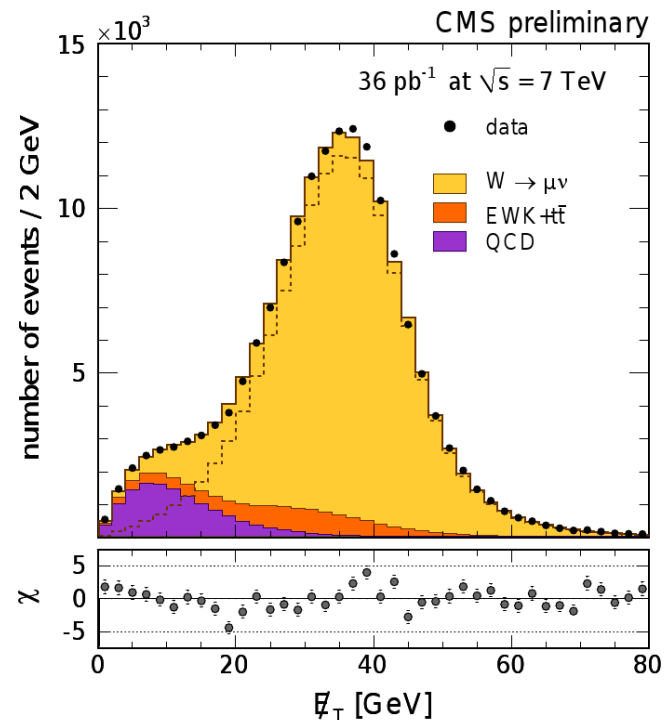
## Acceptance

- W: 0.4638 ± 0.0003
- W+: 0.4570 ± 0.0004
- W-: 0.4706 ± 0.0004

QCD  $E_T^{\text{miss}}$  distribution obtained by inverting isolation cut

Fraction of events within acceptance passing full selection

- W: (83.0 ± 0.3)%
- W+: (83.5 ± 0.4)%
- W-: (82.5 ± 0.4)%







# Z $\rightarrow$ ee Event Selection



## Require

- Two good electrons: isolated,  $E_T > 25$  GeV, ECAL fiducial
- Invariant mass between 60 and 120 GeV

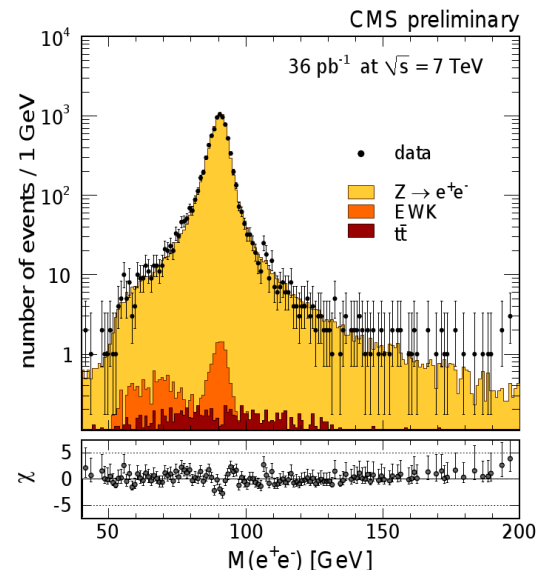
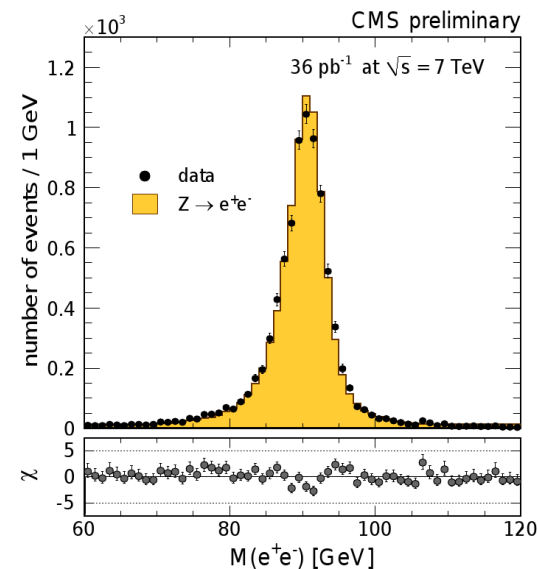
## Acceptance

- $0.3876 \pm 0.0005$

QCD background estimated by inverting isolation cut

Fraction of events within acceptance passing full selection

- $(60.9 \pm 1.1)\%$





# Z $\rightarrow$ $\mu\mu$ Event Selection



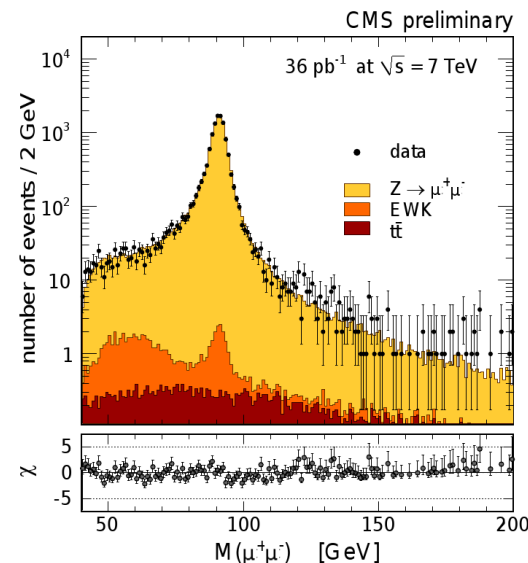
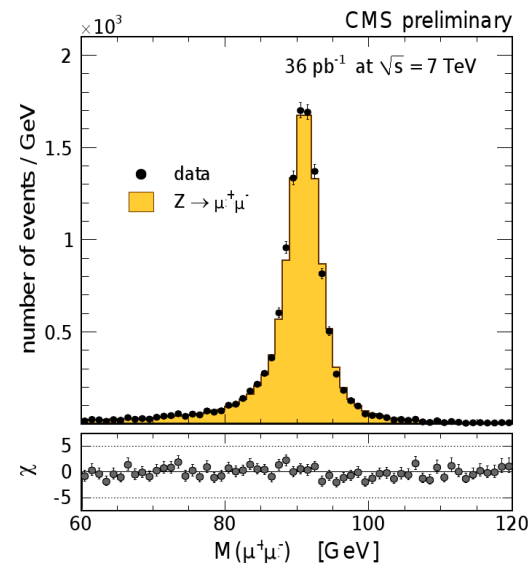
## Require

- Two good muons,  $p_T > 20$  GeV,  $|\eta| < 2.1$
- Invariant mass between 60 and 120 GeV

## Acceptance

- $0.3977 \pm 0.0017$

Simultaneous fit to events with muons passing or failing one of two reconstruction methods, trigger, or isolation





# Systematic Uncertainties



Source	$W \rightarrow e\nu$	$W \rightarrow \mu\nu$	$Z \rightarrow e^+e^-$	$Z \rightarrow \mu^+\mu^-$
Lepton reconstruction & identification	1.3	0.9	1.8	n/a
Trigger pre-firing	n/a	0.5	n/a	0.5
Momentum scale & resolution	0.5	0.22	0.12	0.35
$E_T$ scale & resolution	0.3	0.2	n/a	n/a
Background subtraction / modeling	0.35	0.4	0.14	0.28
Total experimental	1.5	1.1	1.8	0.7
PDF uncertainty for acceptance	0.6	0.7	0.9	1.2
Other theoretical uncertainties	0.7	0.8	1.4	1.6
Total theoretical	0.9	1.1	1.7	2.0
Total	1.7	1.6	2.5	2.1

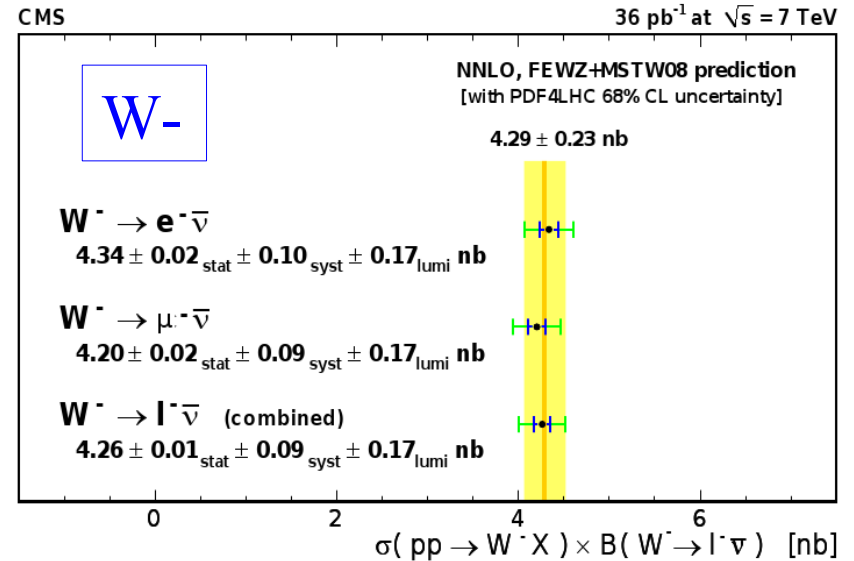
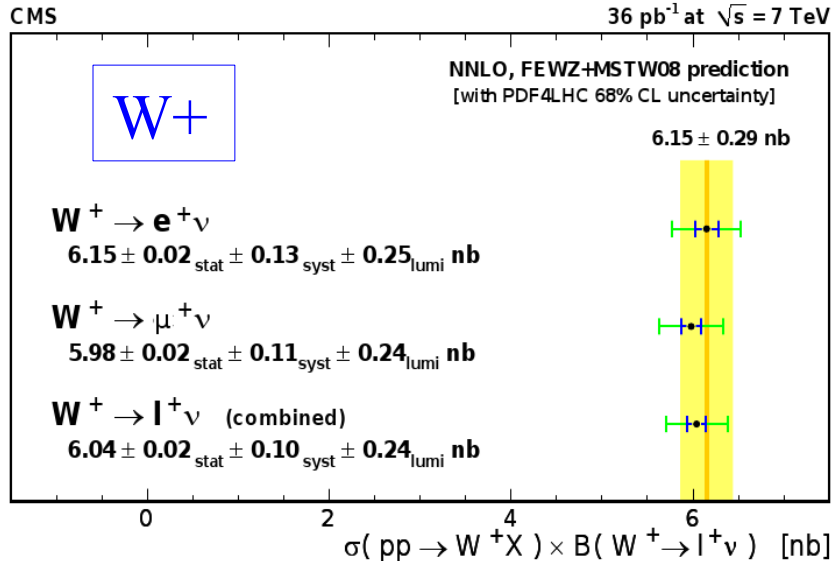
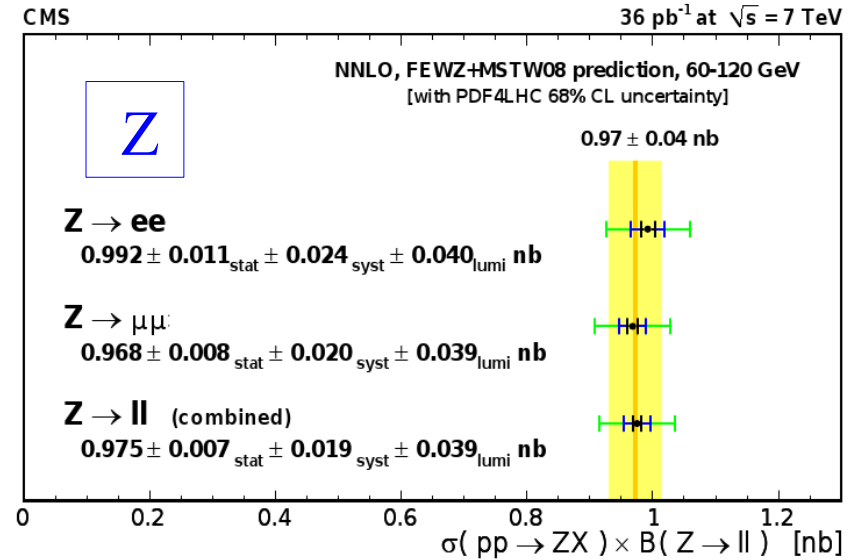
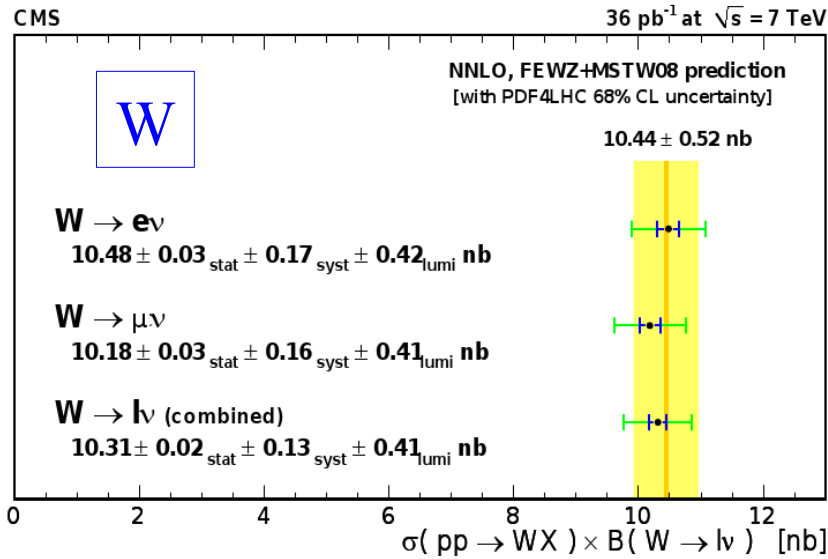
Lumi uncertainty 4%

Theoretical uncertainty

- PDF's: MSTW08, CT10, NNPDF2.0
- Other: renormalization scale; calculated ISR/FSR corrections, NNLO and >NNLO corrections

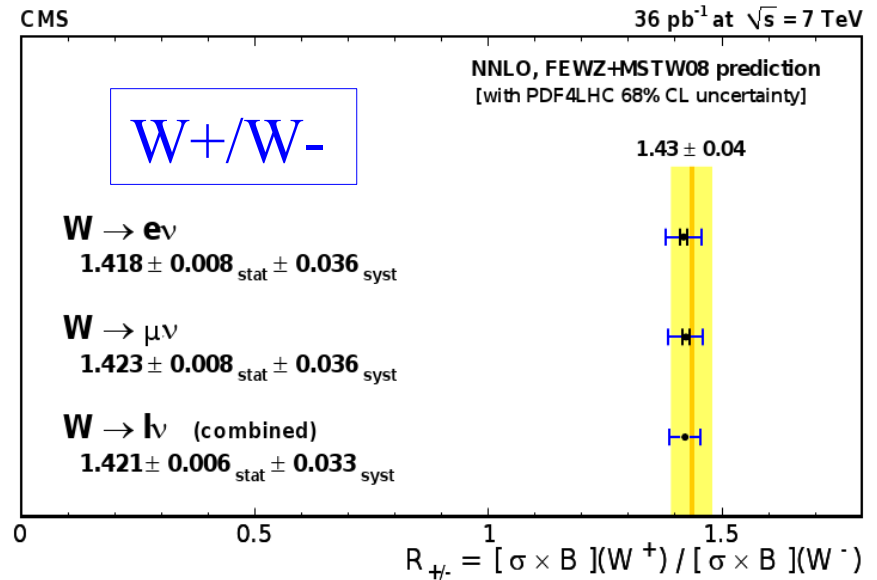
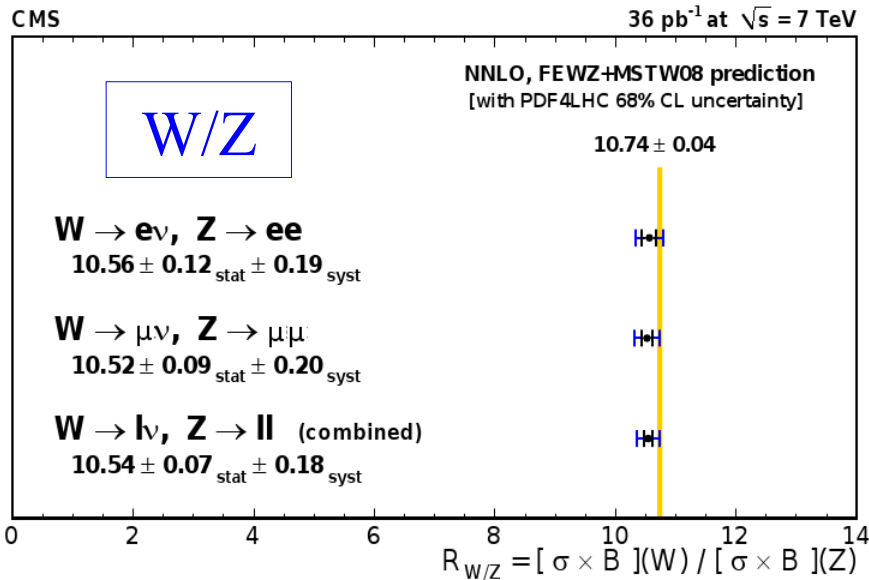


# Cross Sections





# Cross Section Ratios

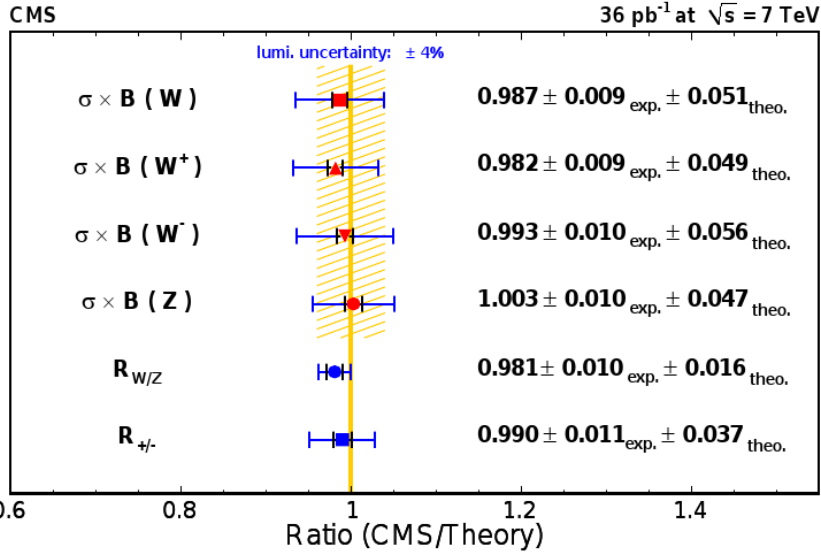


Cross sections and ratios: Overall good agreement with theory

Good consistency between electron, muon measurements

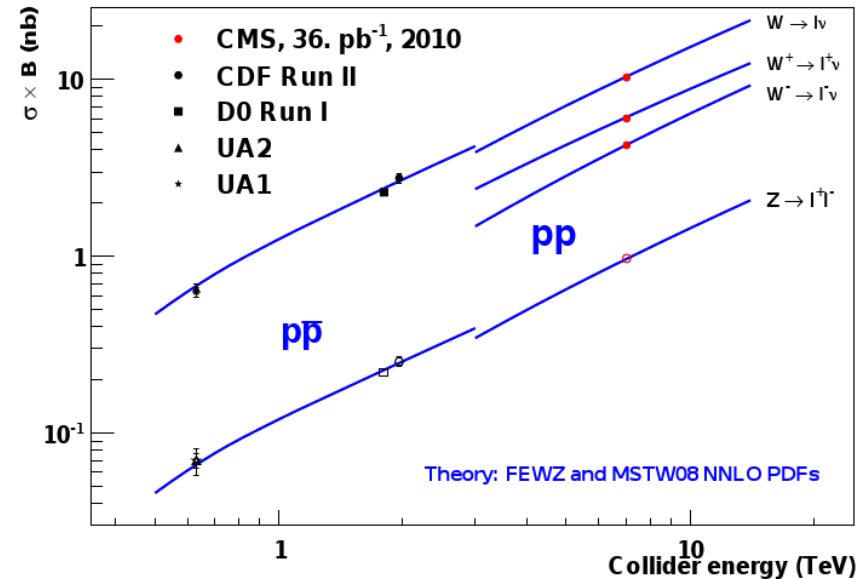


# Comparison With Theory/ Previous Results



Combined results agree well with theory

Results confirm increase of cross section with increasing energy, consistent with theory and previous results





# Conclusions



Inclusive cross sections of  $W$  and  $Z$  measured with  $36 \text{ pb}^{-1}$  of 7 TeV data

Results agree with NNLO calculations

Results consistent with previous measurements from SPS and Tevatron