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W and Z Studies at CMS

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On Behalf of CMS

- Inclusive W and Z boson cross section at $\sqrt{s}$ = 8 TeV (NEW)
- Measurement of the charge asymmetry in inclusive W at $\sqrt{s}$ = 7 TeV:
  - using electron decay
  - using muon decay
- Drell-Yan at $\sqrt{s}$ = 7 TeV
  - Differential and double-differential cross section
  - Forward-backward asymmetry
  - Measurement of the weak mixing angle

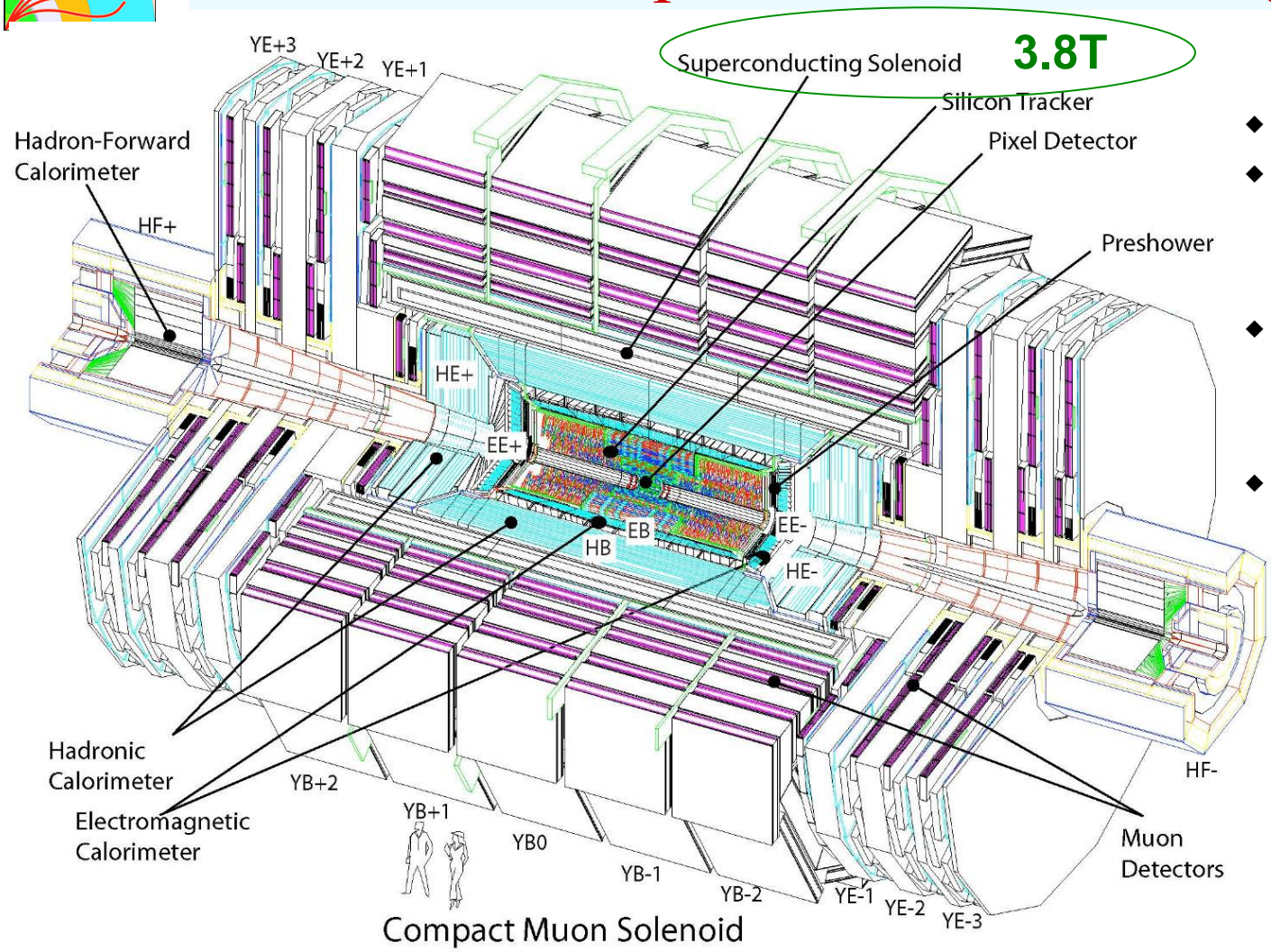
W/Z studies

The main LHC goal: explore physics at the TeV energy scale via pp collision

Benefits of W and Z studies:

- ✚ Test for the Standard Model (sensitive to new physics)
- ✚ Precision measurements at TeV scale
- ✚ Unique test and contribution to the proton PDF
- ✚ Better understanding of background for Higgs and new physics search analyses

The Compact Muon Solenoid (CMS)



- The strongest magnet
- Tracking system:
  - silicon pixel
  - strip tracker
- ECAL:
  ~76000 lead tungstate crystal
- Muon system:
  - DT
  - CSC
  - RPC

L1 level up to 100 kHz ➔ High Level Trigger to record ~ 300 Hz

W and Z boson cross section at $\sqrt{s}$ = 8 TeV

CMS-PAS-12-011

Precise measurement is any important test
for Standard Model and contribution PDFs:

- We repeat analysis in similar way like it was done for 2010 data with low pile-up with $\mathcal{L}$ = 36 pb^{-1} (J. High Energy Phys. 10 (2011) 132)

- CMS requested special LHC conditions during luminosity ramp up period to achieve low pile-up events (~5) for good MET resolution at W:
  - ➔ LHC separate beams in transverse plane to reduce effective overlap
  - ➔ separation was periodically adjust to keep instantaneous $\mathcal{L}_{inst}$ ~ 3E32 – 6E32 cm^{-2}s^{-1}
  - ➔ Integrated $\mathcal{L}$ = 18.8 pb^{-1}
  - ➔ Special HLT menu with low thresholds: 22 GeV for e and 15 GeV for μ
  - ➔ minimal ID/Iso requirement to suppress background

W and Z boson cross section at $\sqrt{s}$ = 8 TeV

CMS-PAS-12-011

Event Selection:

e-channel:

E_T > 25 GeV and |η|< 2.5, exclude 1.4442 < |η| < 1.566 (barrel/forward transition)

W ➔ eν: Reject events with 2nd e with E_T > 20 GeV

μ-channel:

p_T > 25 GeV and |η| < 2.1

W ➔ μν: Reject events with 2nd μ with p_T > 10 GeV

Z→ll: 60 GeV < M_{ll} < 120 GeV

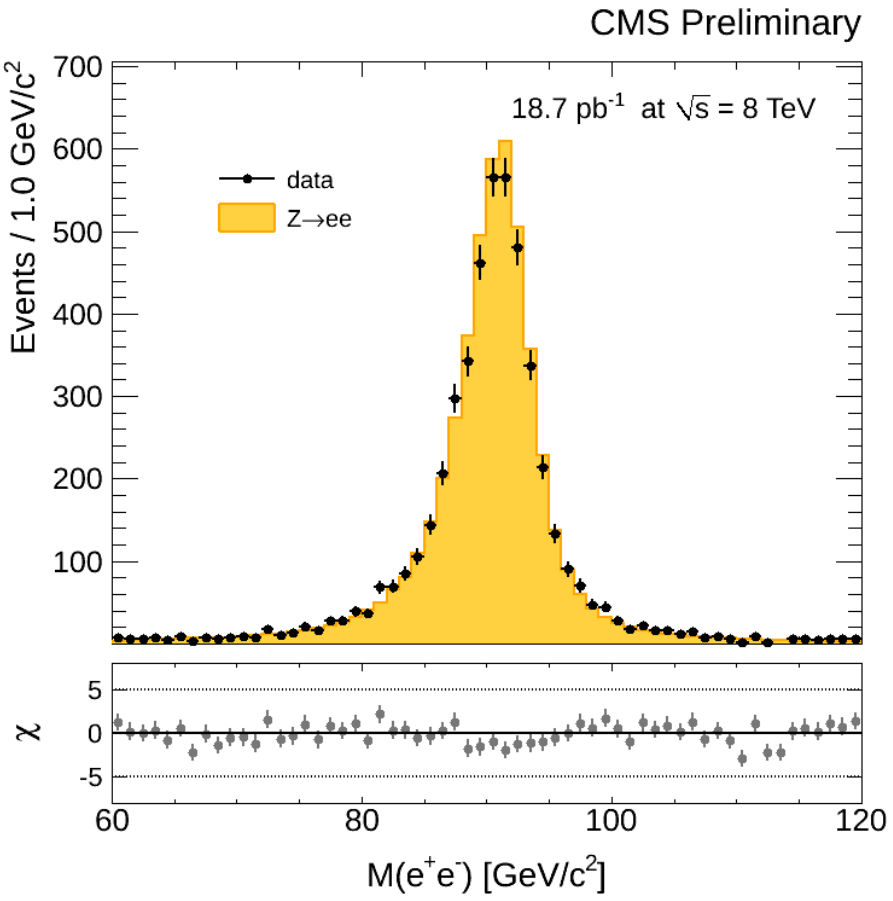
The dominant source of systematic uncertainty:

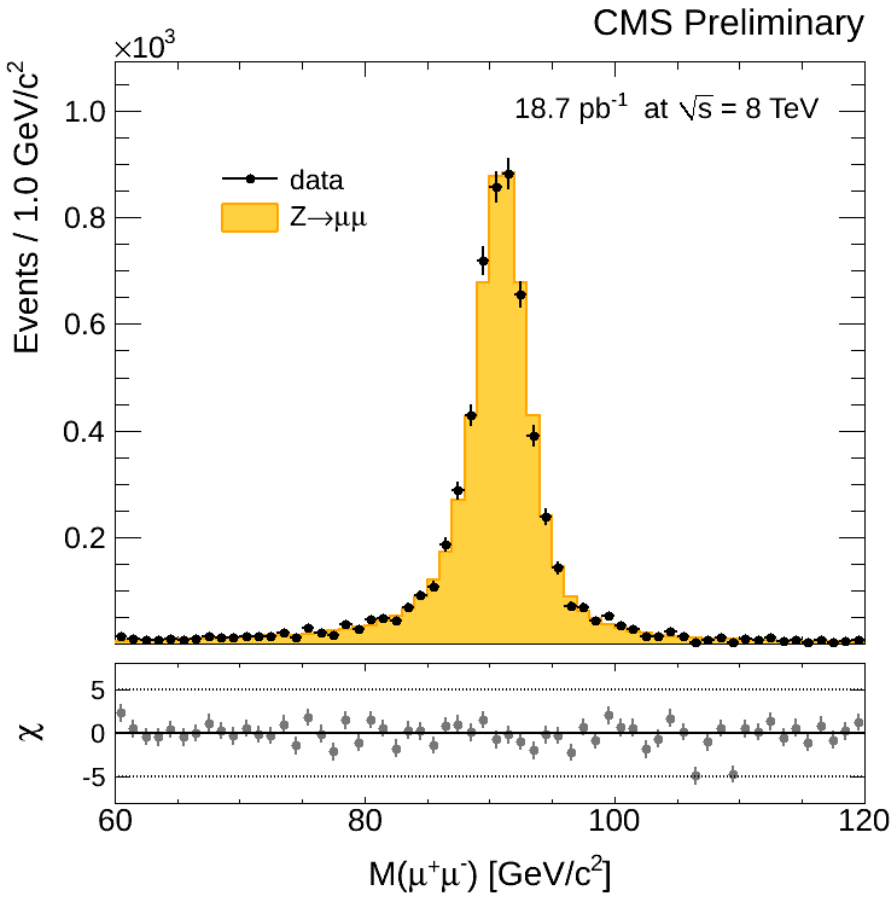
- Experimental:
  - Luminosity (4.4%) for absolute cross sections
  - Lepton efficiency (1-3%)
  - Theoretical uncertainty in acceptance (2-3%)
- Theoretical:
  - PDFs
  - Higher order QCD corrections
  - Higher order electroweak corrections

W and Z boson cross section at $\sqrt{s}$ = 8 TeV

CMS-PAS-12-011

Z Signal Extraction: cut and count

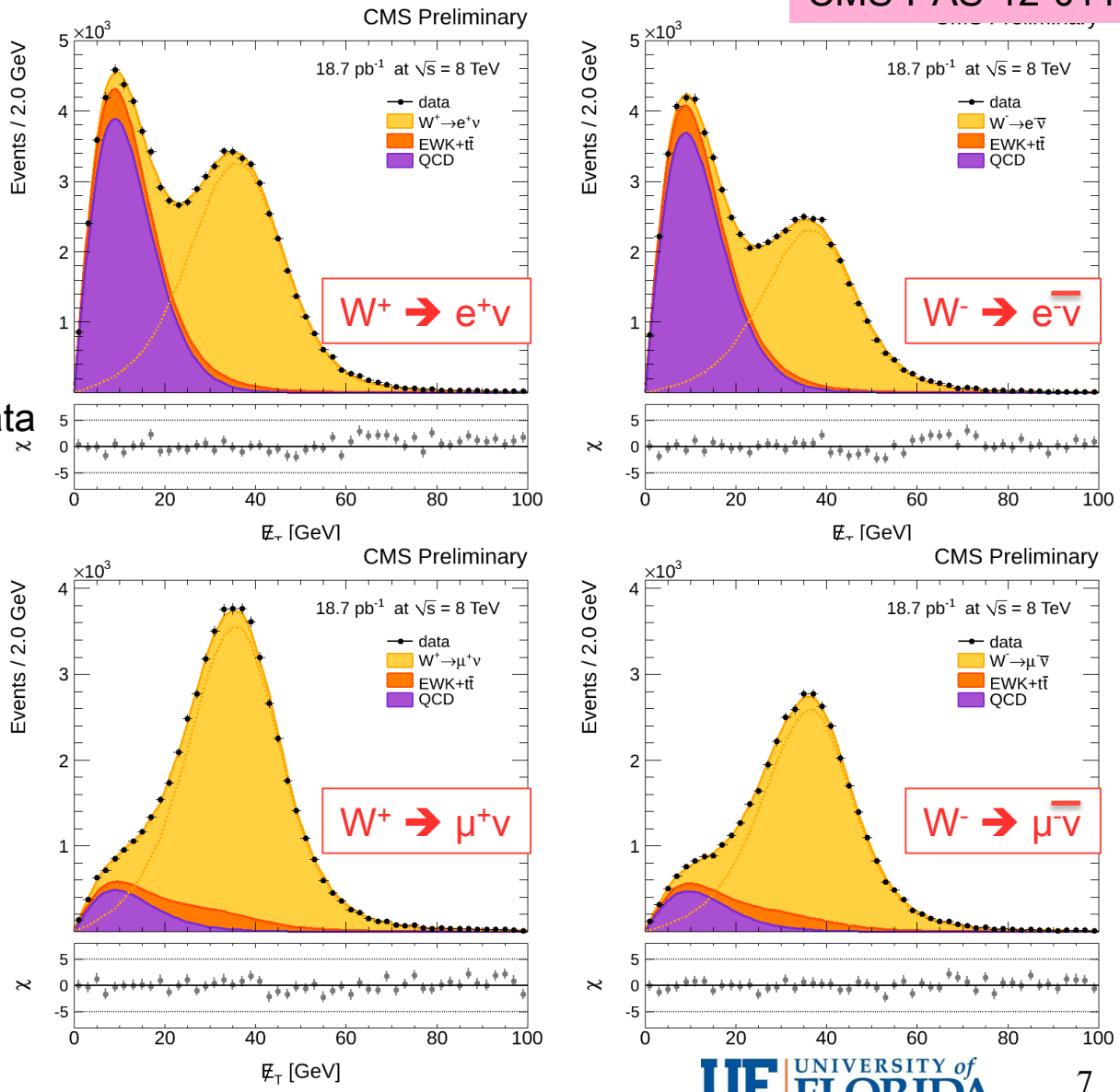




W and Z boson cross section at √s = 8 TeV

CMS-PAS-12-011

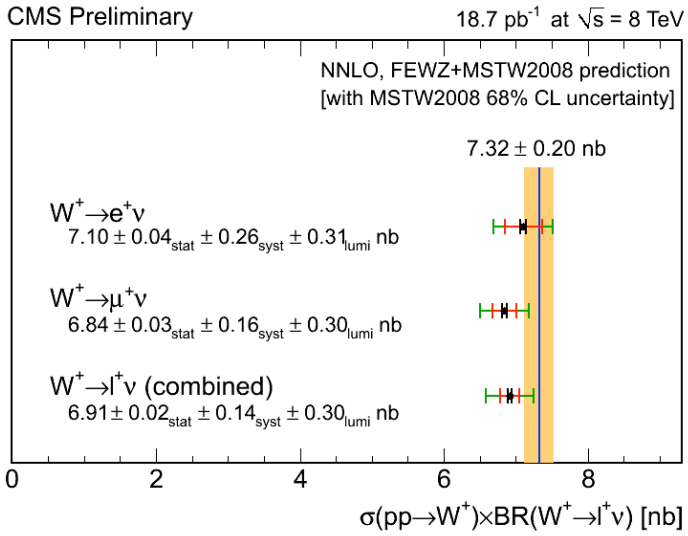
W extraction: fit MET distribution
- W: MC with recoil corrected to data
- QCD model: analytic function
- Other background: from MC with xsec fixed to W from theory

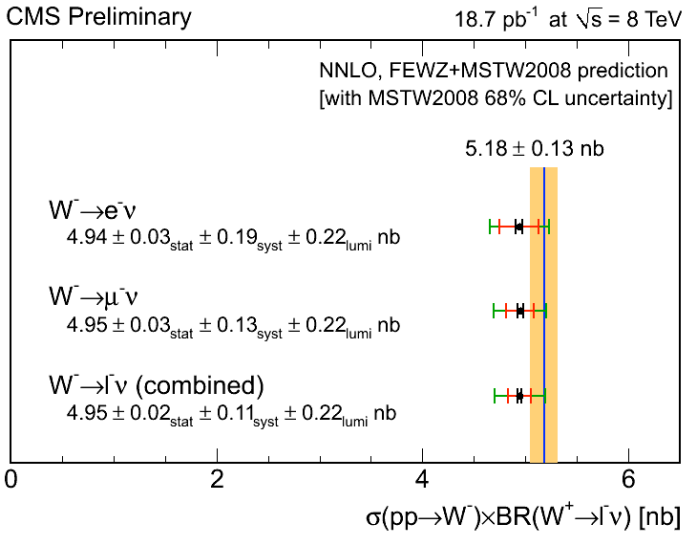


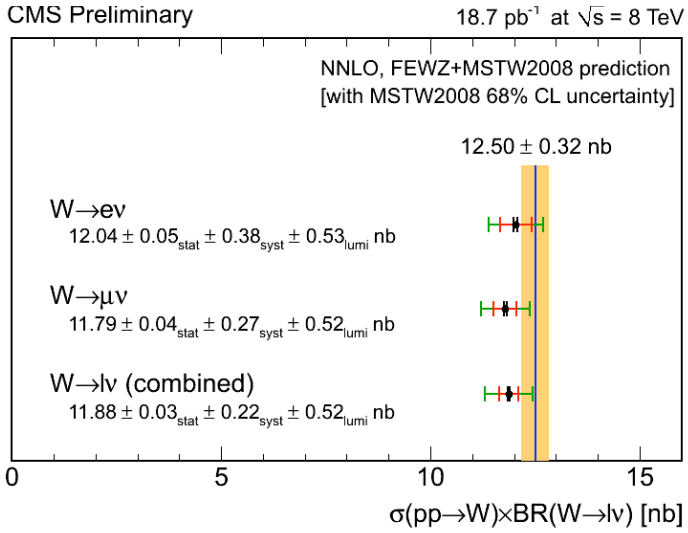
W and Z boson cross section at $\sqrt{s}$ = 8 TeV

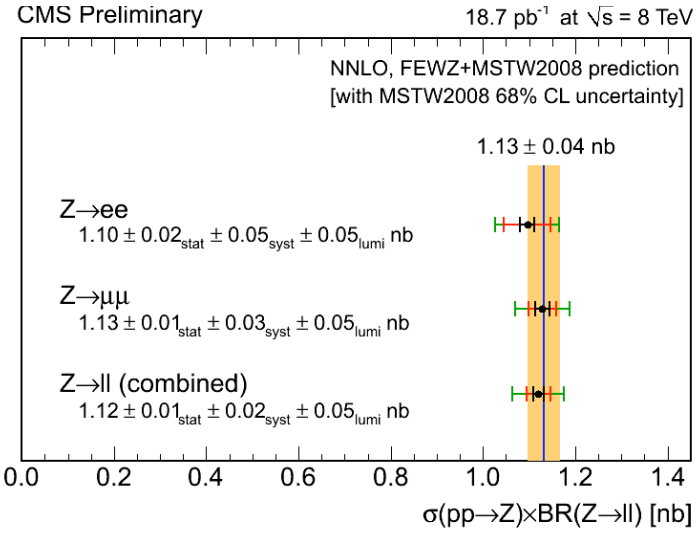
W, Z cross-section

CMS-PAS-12-011







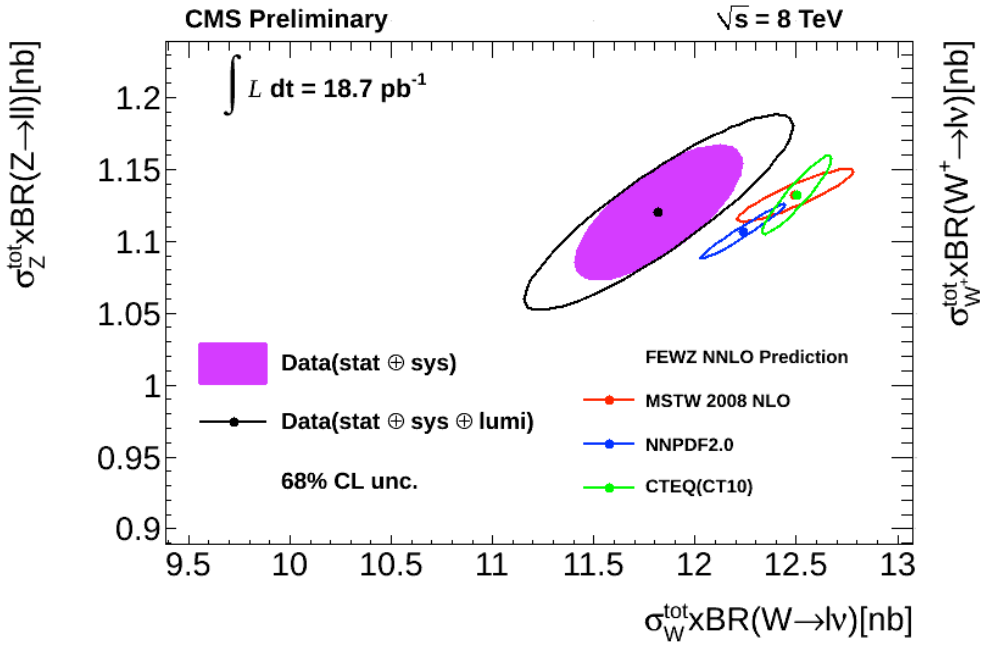


- Good agreement with theoretical NNLO prediction

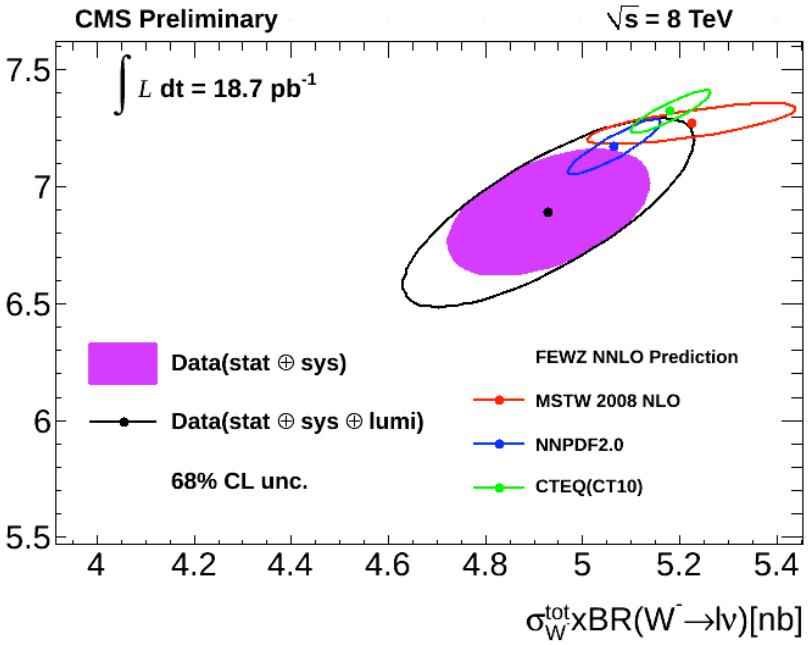
W and Z boson cross section at $\sqrt{s}$ = 8 TeV

CMS-PAS-12-011

Z vs W cross section



W+ vs W- cross section



- Good agreement with theoretical NNLO prediction

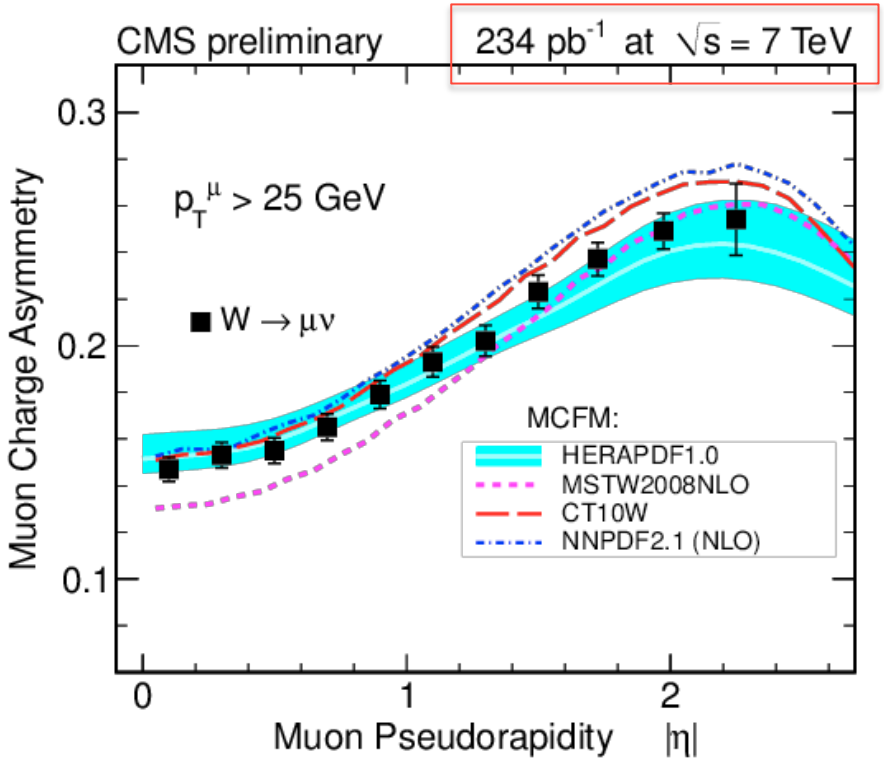
Charge asymmetry in inclusive W➔μυ (7 TeV)

CMS-PAS-EWK-11-005

Proton: 2u and 1d ➔ W^+ (uđ) is easier to produce then W^- (dū)
Asymmetry A(η) is observed:

$$A(\eta) = \frac{d\sigma/d\eta(W^+) - d\sigma/d\eta(W^-)}{d\sigma/d\eta(W^+) + d\sigma/d\eta(W^-)}$$

Precise measurement will provide significant contribution to PDFs

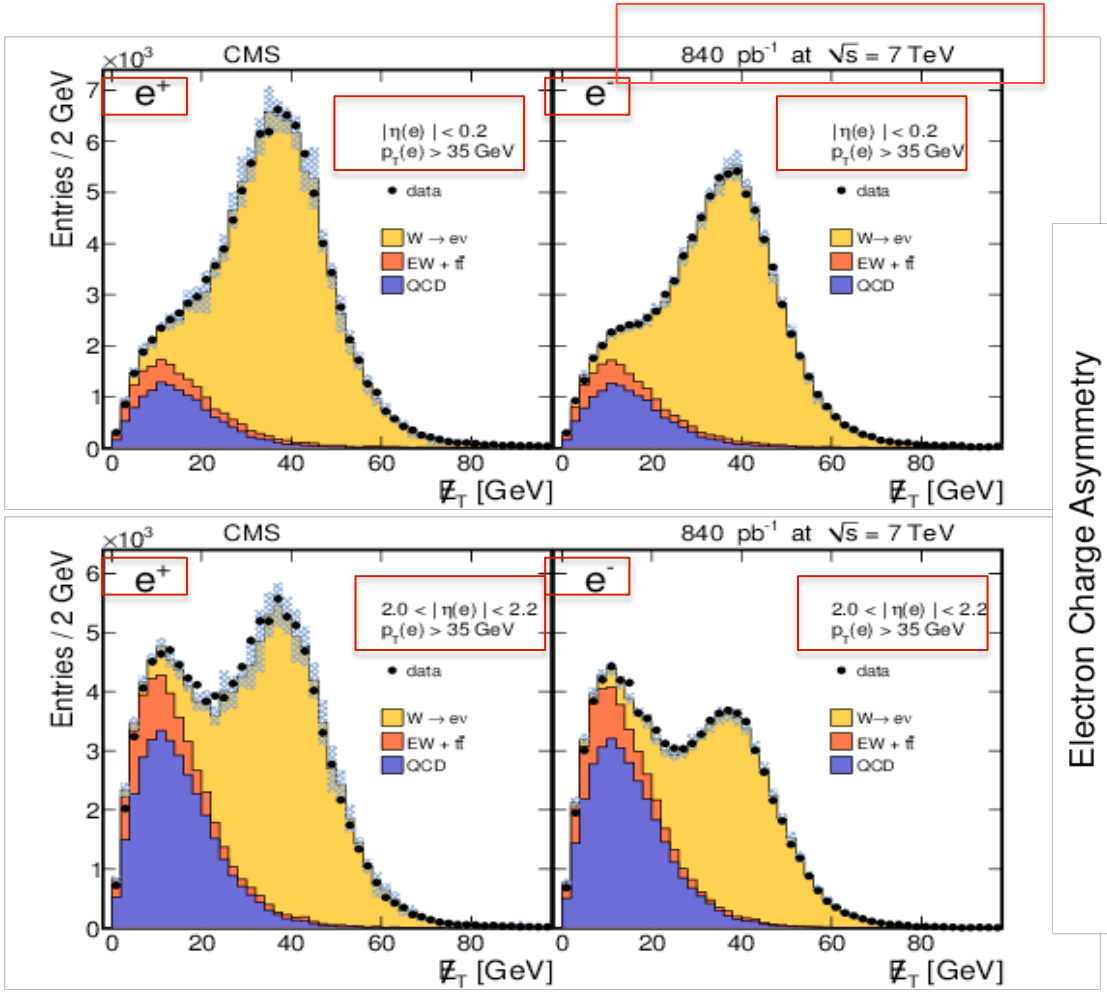


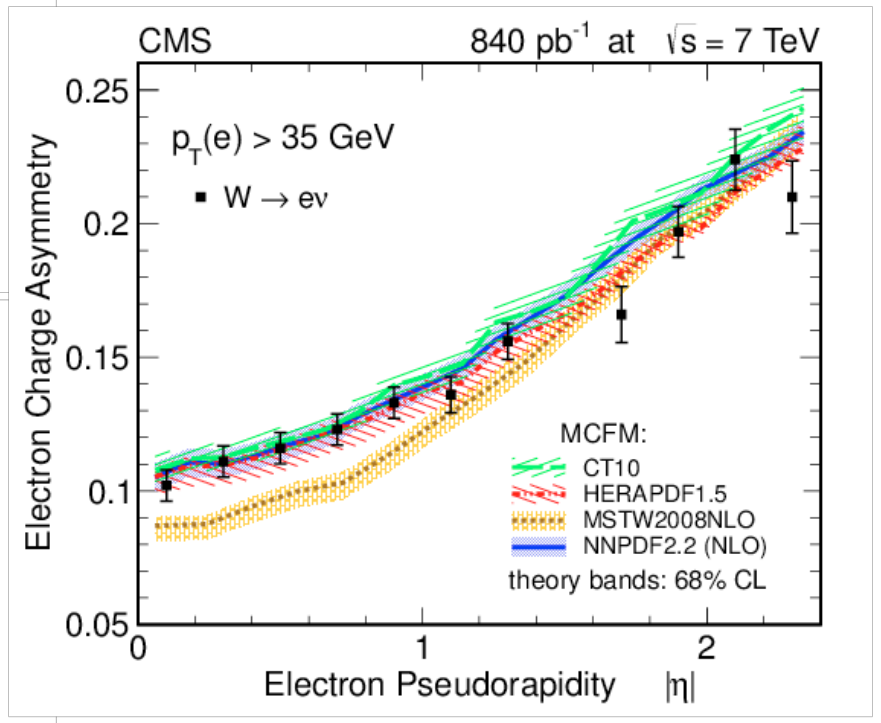
Muon charge asymmetry for p_T > 25 GeV

✓ Data has flatter variation of the asymmetry in η then predicted by MSTW2008NLO, CT10W and NNPDF2.1 (NLO)
✓ will provide significant contribution to PDFs

Charge asymmetry in inclusive W➔eυ (7 TeV)

arXiv:1206.2598
CERN-PH-EP-2012-151

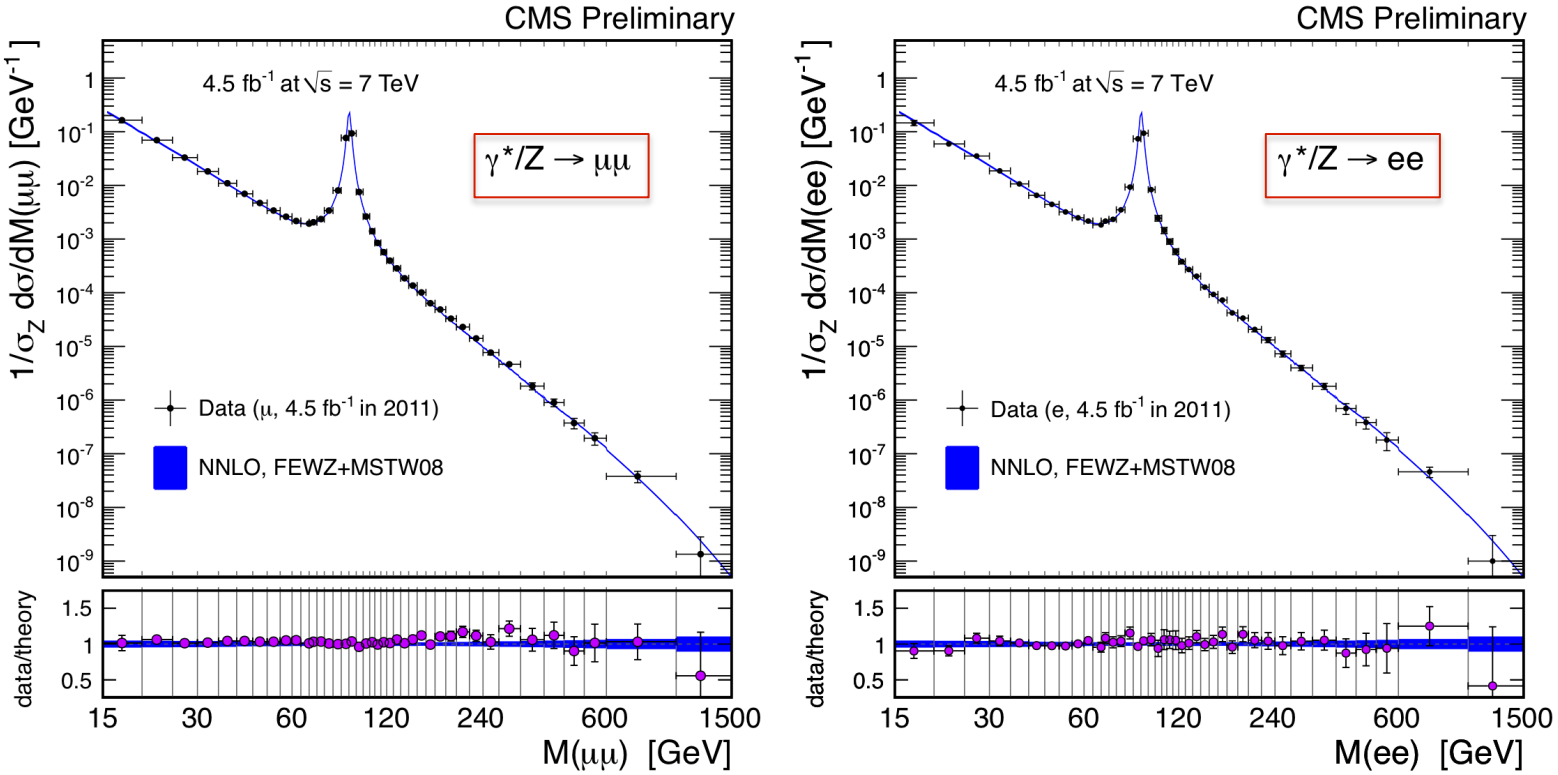




✓ Good agreement with NLO prediction except MSTW
✓ Background contribution increase with η
✓ will provide significant contribution to PDFs

Drell-Yan: dσ/dM (7 TeV)

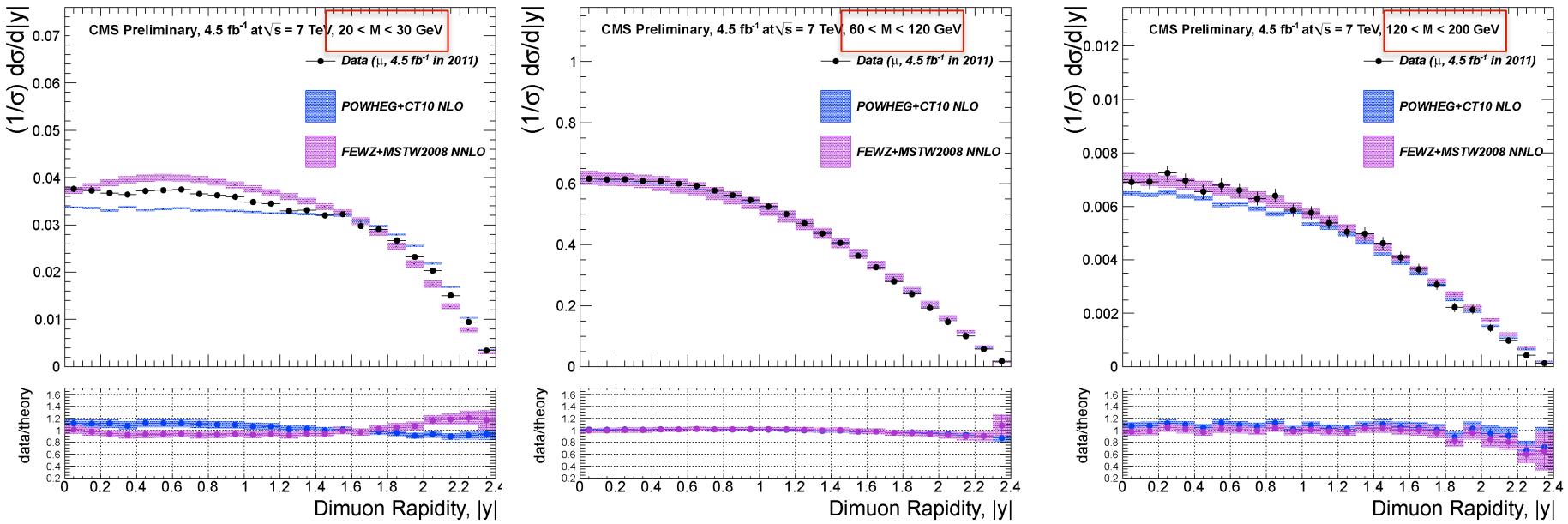
CMS-PAS-EWK-11-007



- ✓ dσ/dM is calculated in the full phase space
- ✓ normalized to the cross section in the Z peak region (60 < M <120 GeV) to reduce systematic uncertainties
- ✓ good agreement with NNLO theoretical prediction, computed with FEWZ using MSTW2008 PDFs
- ✓ NNLO correction is required to describe low dilepton invariant masses

Drell-Yan: dσ/dMdY (7 TeV)

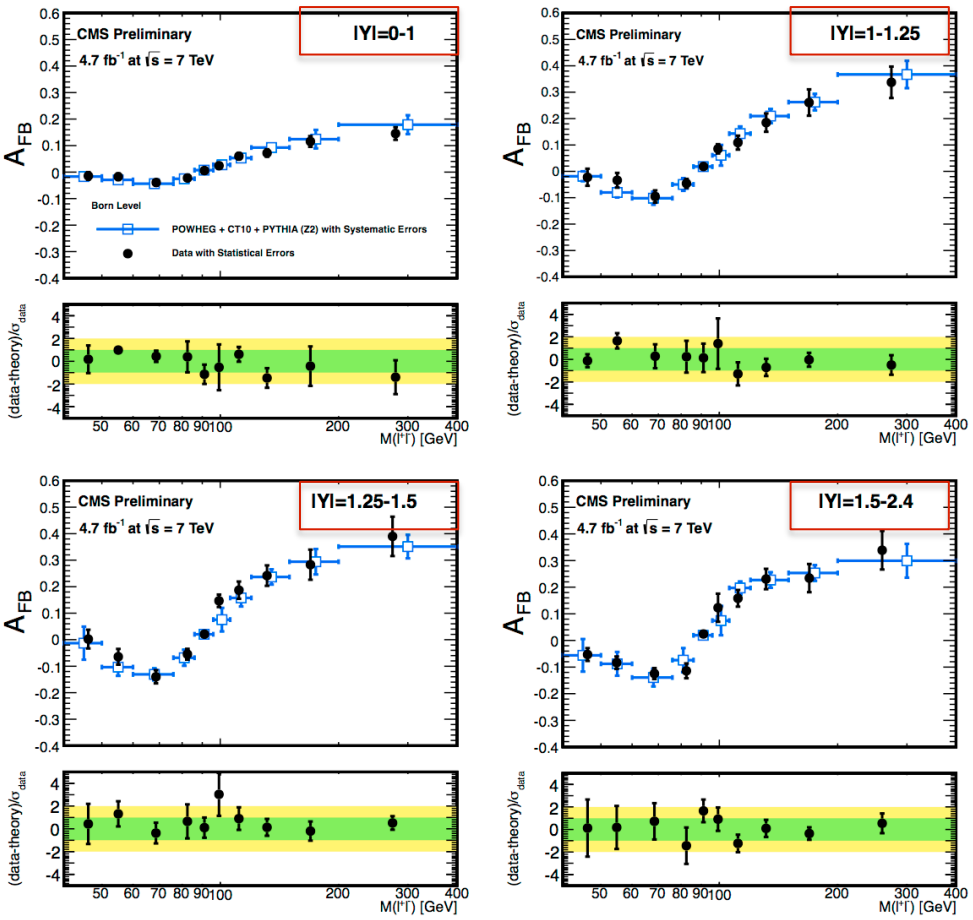
CMS-PAS-EWK-11-007



- ✓ dσ/dMdY is measured for muons only within detector acceptance and normalized to the Z peak region with |Y| < 2.4 to reduce systematic
- ✓ 6 bins at M from 20 to 1500 GeV
- ✓ very important measurement for test and contribution to PDFs

Drell-Yan: forward-backward asymmetry (7 TeV)

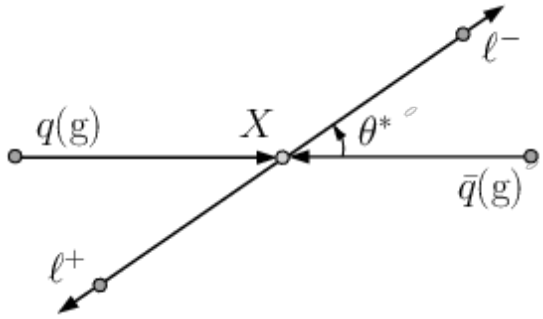
CMS-PAS-EWK-11-004



Interference γ* and Z boson

➔ forward-backward asymmetry A_{FB}

$$A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B}$$



✓ unfolded, combined (ee and μμ) and Born level A_{FB} is measured with acceptance cuts:
p_T > 20 GeV, |η| < 2.4, M(ll) > 40 GeV

✓ test of Standard Model:
A_{FB} is in agreement with Standard Model prediction within uncertainties

Drell-Yan: weak mixing angle (7 TeV)

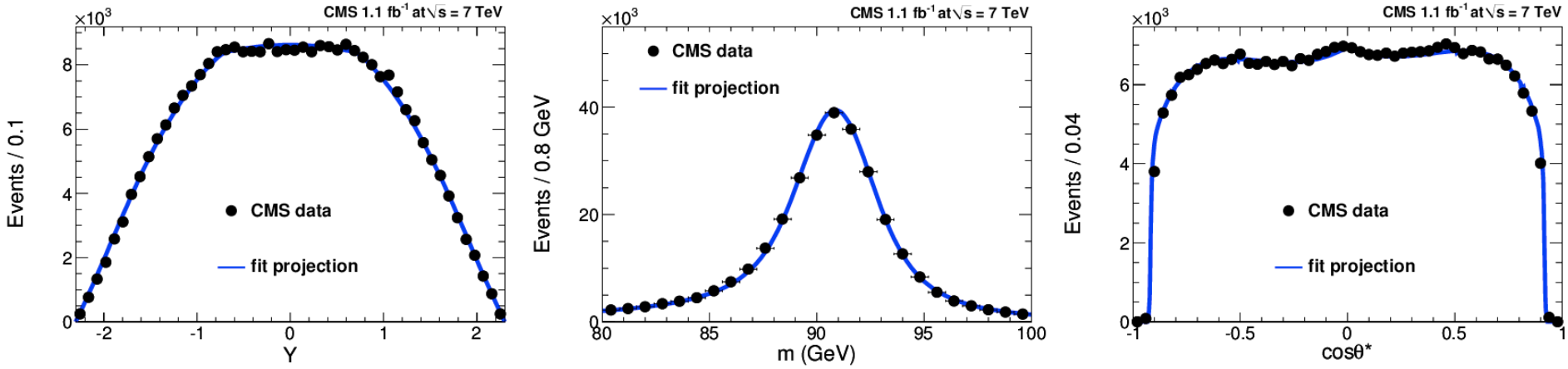
Phys. Rev. D 84 (2011) 112002

✓ $\sin^2\theta_w$ is measured at $\sqrt{s}$ = 7 TeV with 1% precision like at all hadronic experiments: CDF and D0 (Tevatron), H1 (HERA)

✓ dominant processes: $u\bar{u}$ and $d\bar{d}$ ➔ γ^*/Z ➔ $\mu\mu$

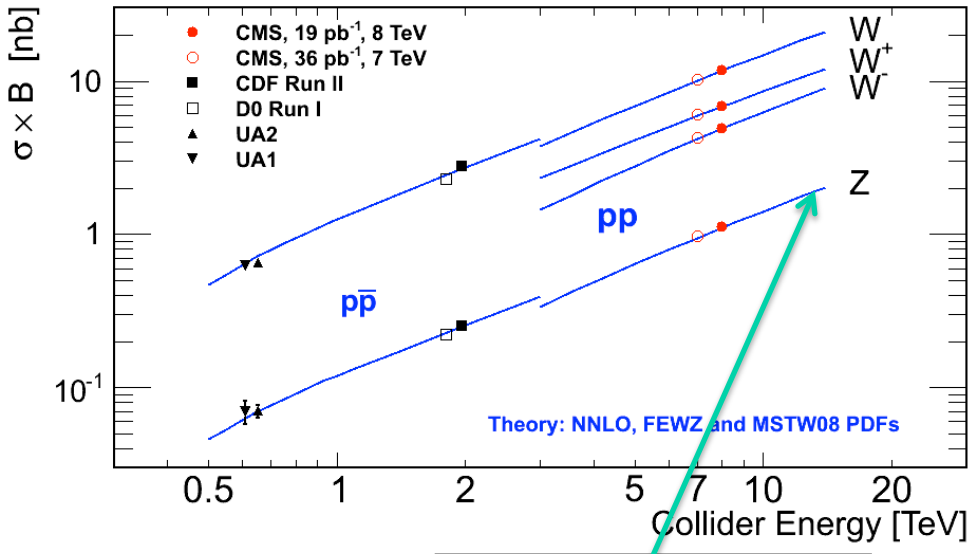
✓ use unbinned extended maximum-likelihood, simultaneous fit data of di-muon rapidity, di-muon invariant mass and di-muon decay angle

$\sin^2\theta_w = 0.2287 \pm 0.0020(\text{stat.}) \pm 0.0025(\text{syst.})$
as expected in Standard Model



Conclusion

- First results at √s = 8 TeV are presented: W and Z inclusive cross section
- W, Z and Drell-Yan are studied very detailed at √s = 7 TeV:
  - ✓ Precise test of Standard Model
  - ✓ Sensitive to New Physics
  - ✓ Significant contribution to PDFs
- Looking forward for more 8 TeV results … and 14 TeV

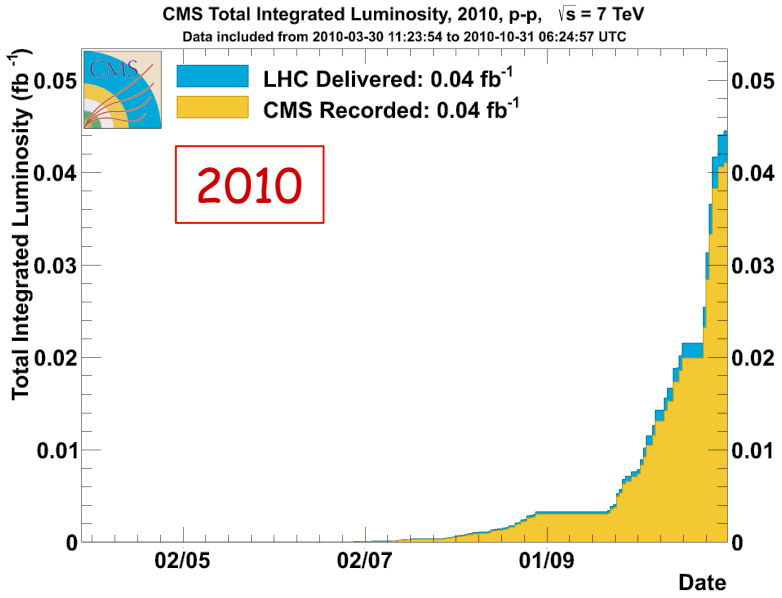


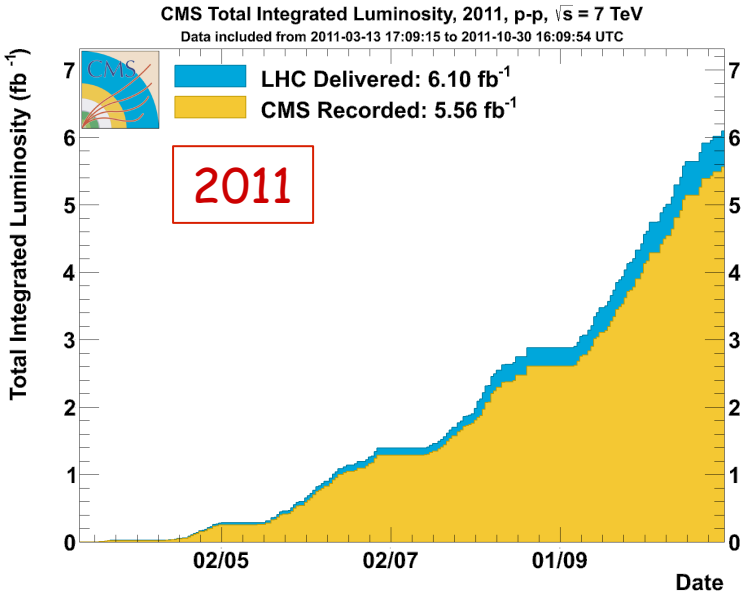
What about 14 GeV?

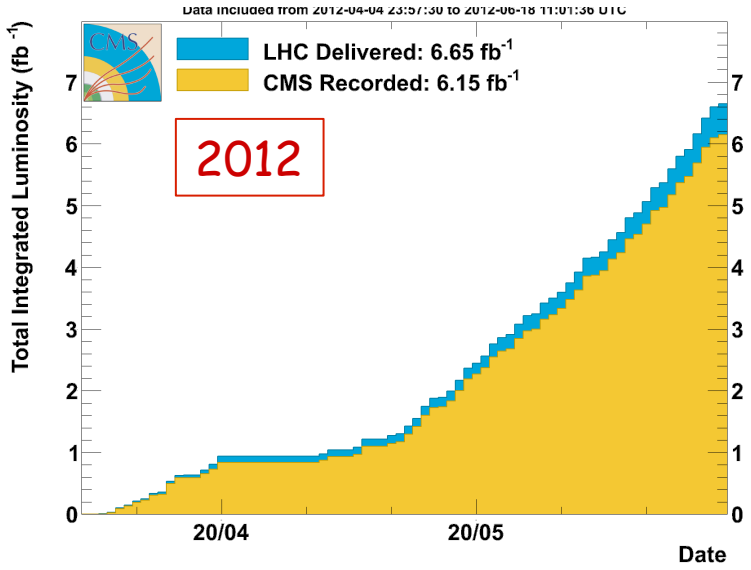
The most recent public results always could be found at
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSMP

BACK UP

LHC Luminosity







✓ Good start up from 2010 to 2012

✓ In 2012 before ICHEP2012 CMS recored more data then in 2010&2011

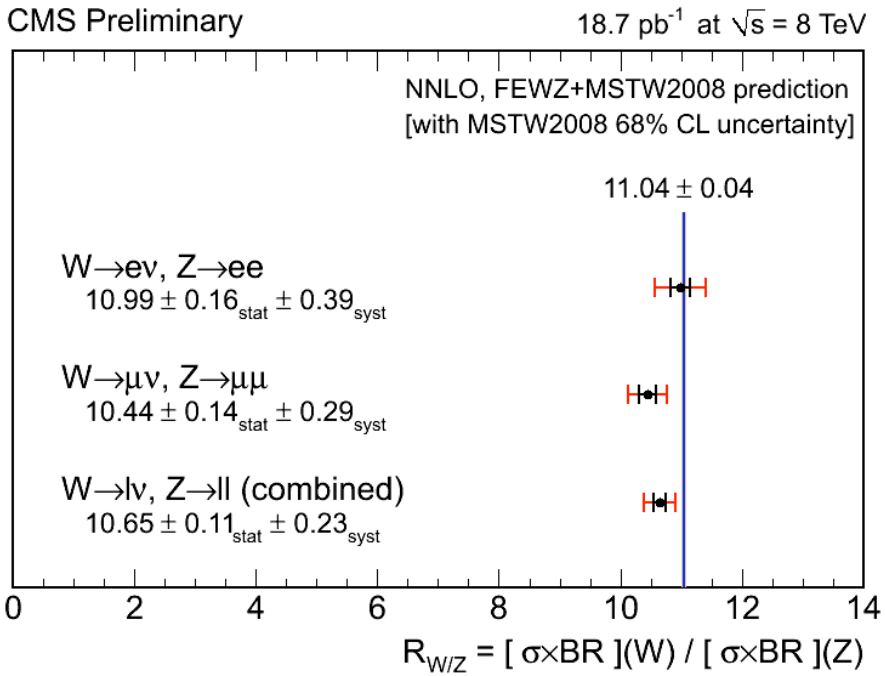
➔ Much more data coming soon

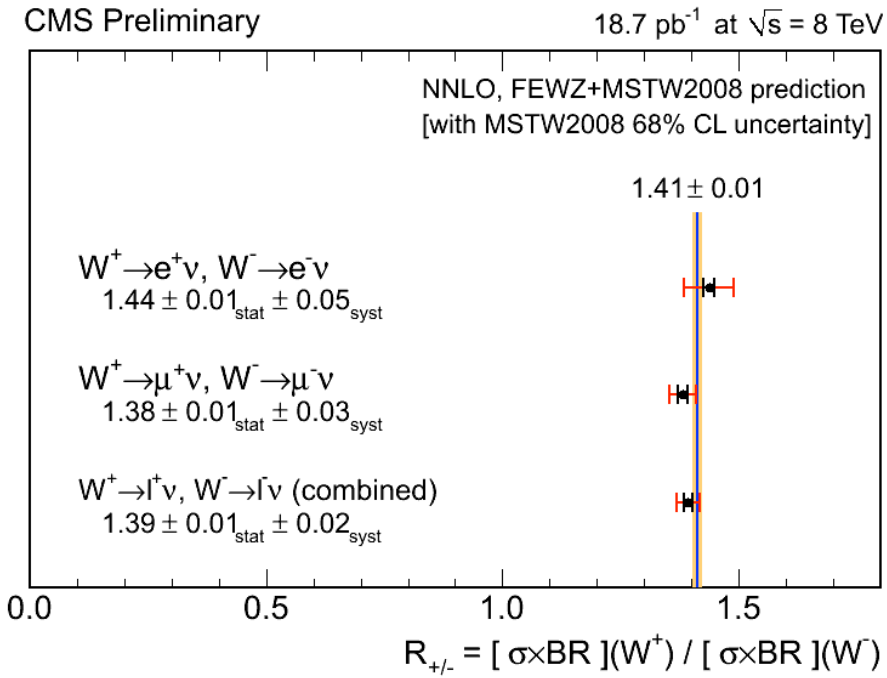
➔ Very exiting time

W and Z boson cross section at $\sqrt{s}$ = 8 TeV

CMS-PAS-12-011

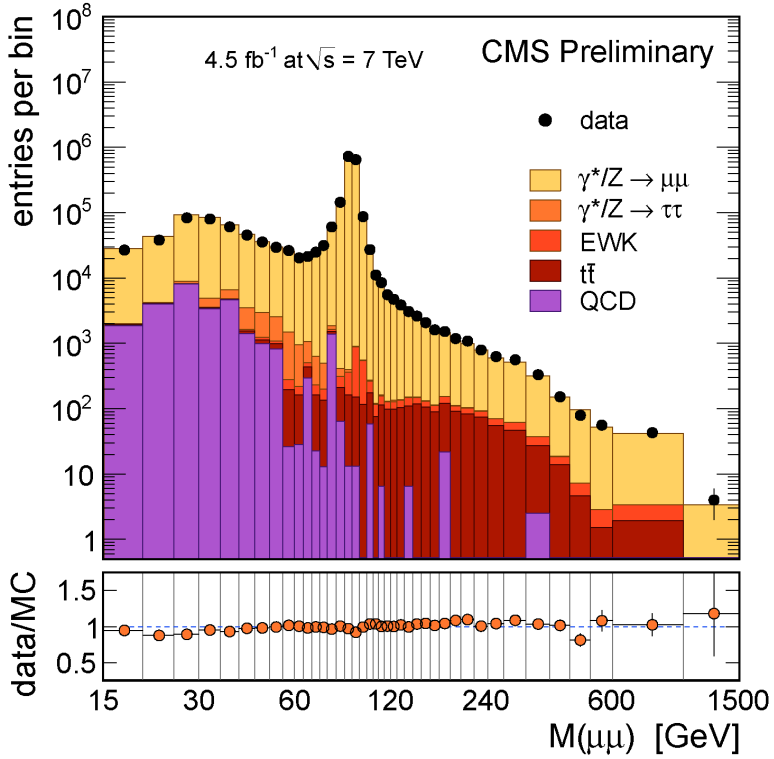
W/Z ratio

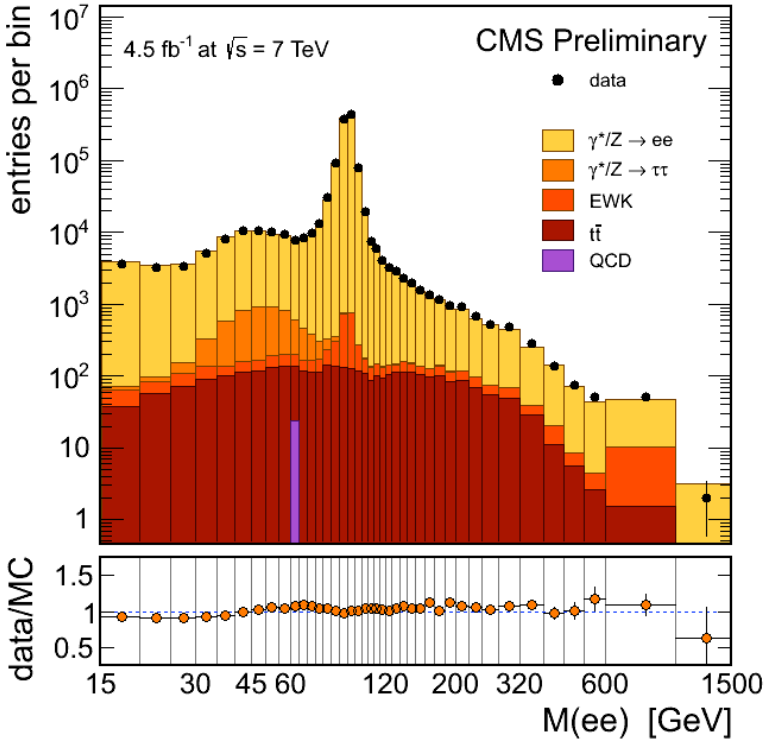




Drell-Yan: dσ/dM

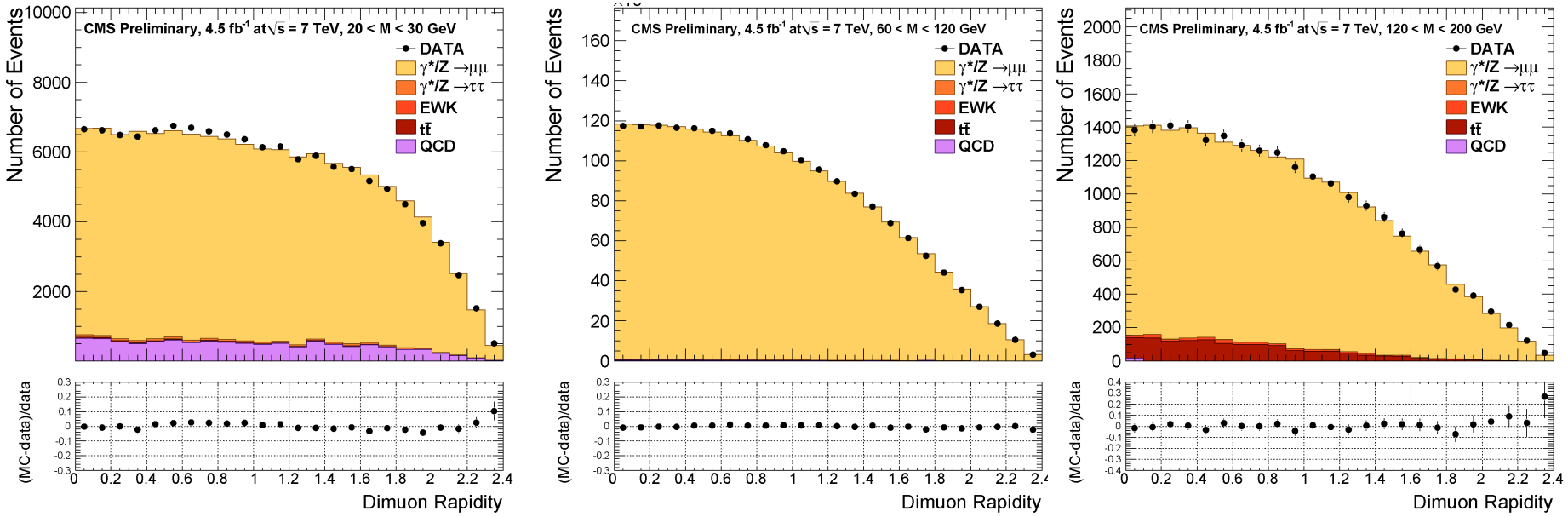
CMS-PAS-EWK-11-007





Drell-Yan: dσ/dMdY

CMS-PAS-EWK-11-007



✓ at low M dominates QCD BG
✓ at high M dominates ttbar BG