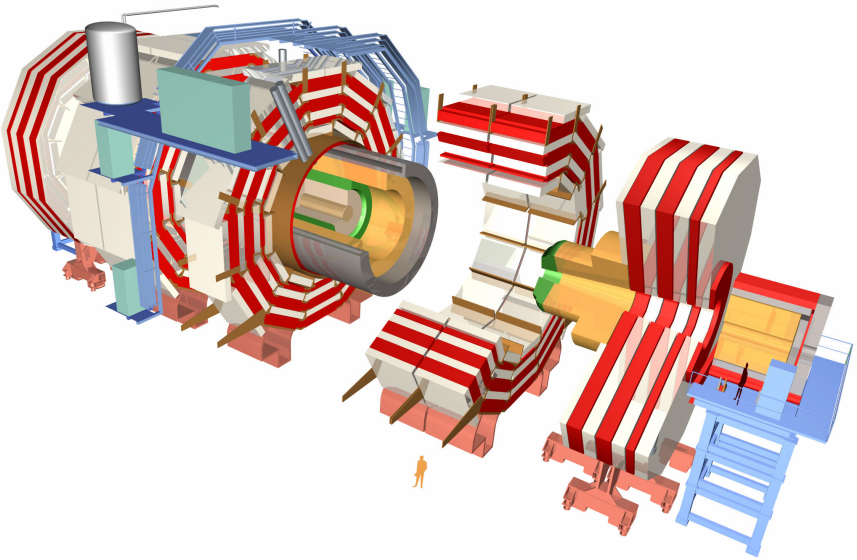
EWK Physics Results from CMS

Ilya Kravchenko
University of Nebraska-Lincoln
on behalf of CMS Collaboration

Outline

Recent EWK results

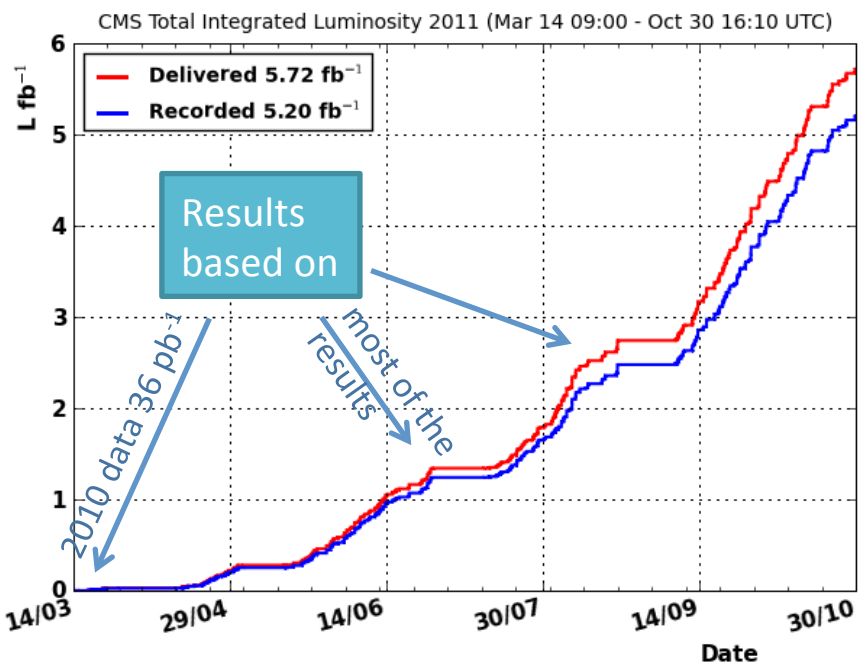
- W and Z production physics
- Z/W + light and heavy quarks (really, pQCD)
- Diboson production and anomalous TGC(backup)

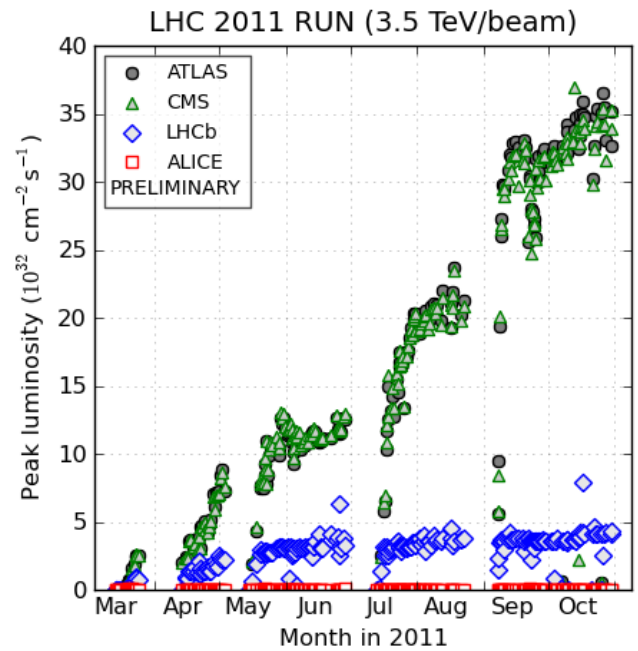


CMS 2011 dataset

pp collisions at 7 TeV

- 5.7 fb^{-1} delivered, ~4.7 fb^{-1} is the golden "dataset"
- Instantaneous luminosity reached $3.5*10^{33}$
- Pile-up: serious factor in second half of 2011 data





multiple interactions

15

10

5

Z and W physics

All analyses in this report are based on W and Z

- precision SM measurements
- backgrounds to Higgs, BSM searches, top physics,…
- tools for detector calibration, lepton reco, etc.

W reconstruction

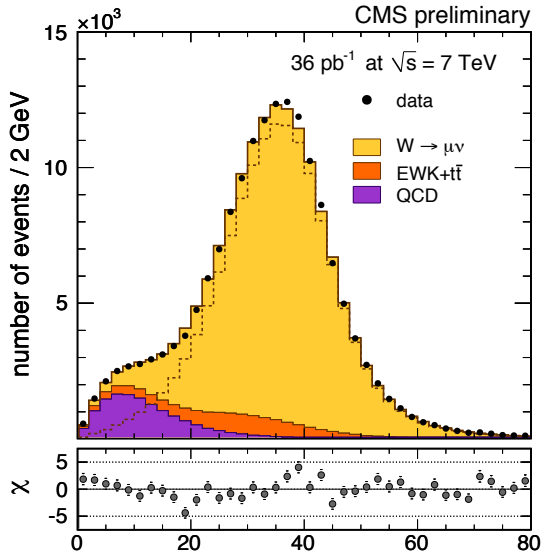
- high-P_T lepton (>20-25 GeV)
- isolated from hadronic activity
- missing E_T in the event

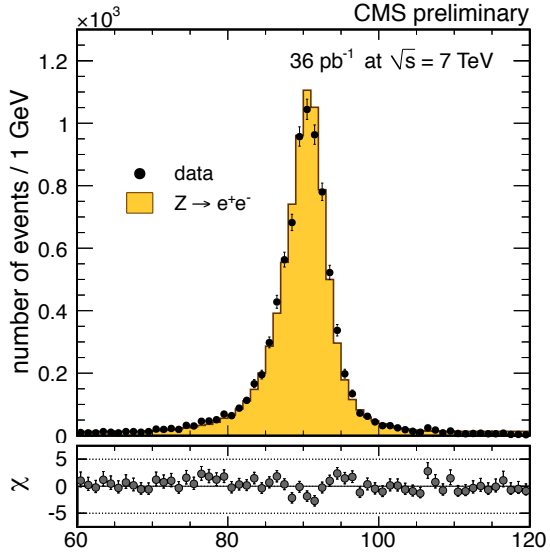
Z reconstruction

- two high-P_T leptons
- isolated from hadronic activity
- mass consistent with m_Z

Backgrounds: measured with data-based methods.
Efficiencies and resolutions: derived from data as well.
Pile-up: event by event subtr. of pile-up energy in lepton isolation.

Inclusive x-sections: W and Z





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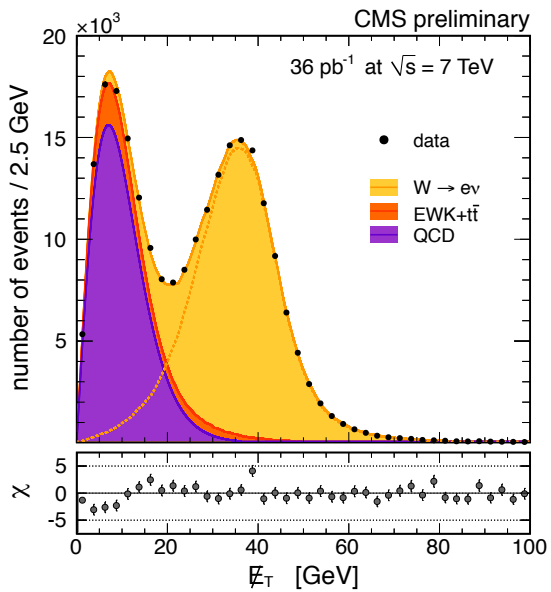
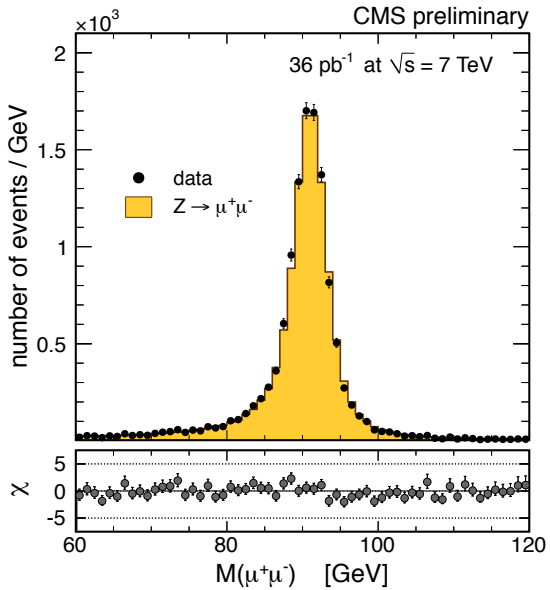
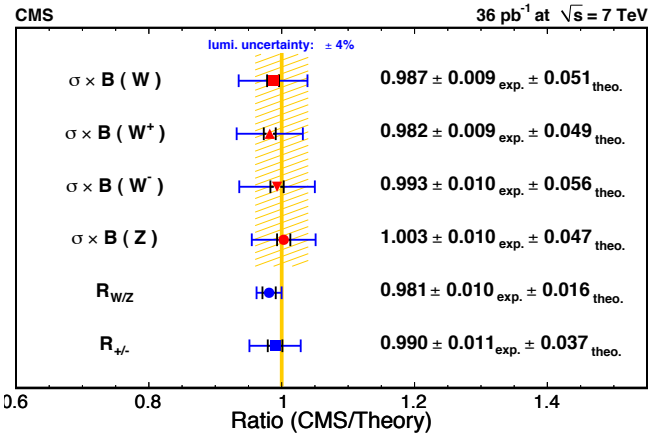
Dataset L=36pb^{-1}

Systematics-limited (σ_{lumi}=4%)

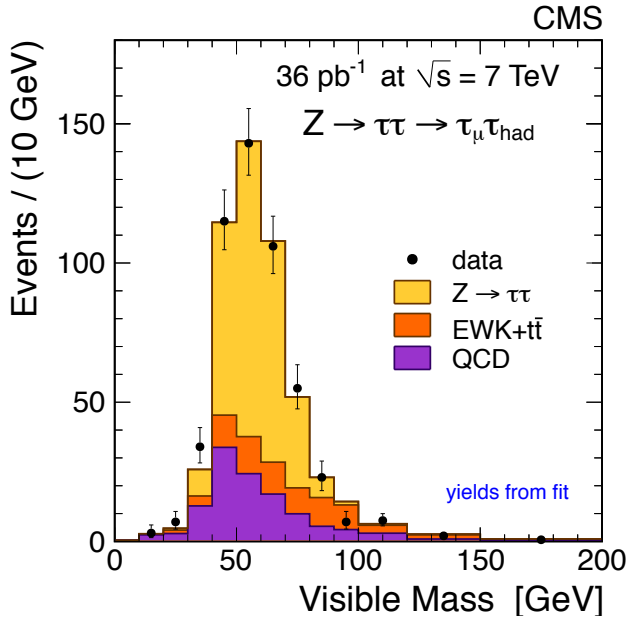
Agree with NNLO QCD predictions







Inclusive x-sections: W/Z→τ(τ)



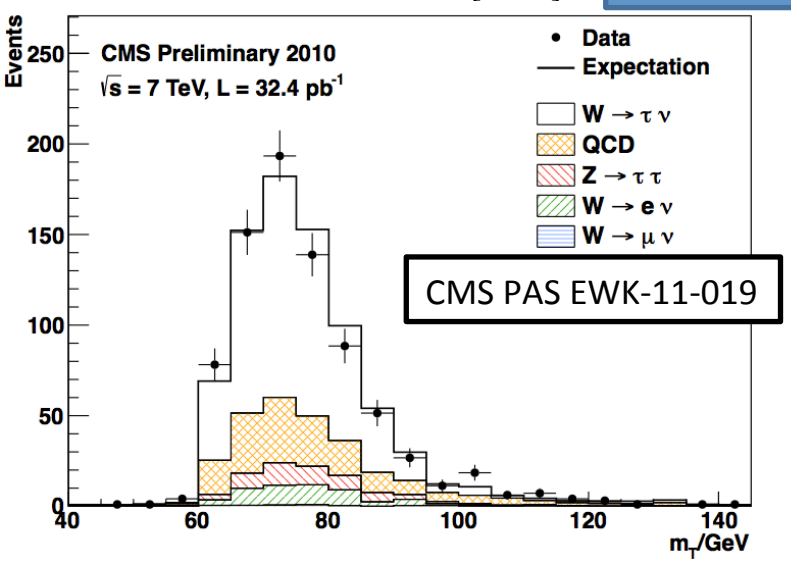
Z→ττ:

- e, μ, hadronic channels of τ
- 2010 dataset, JHEP 08 (2011) 117

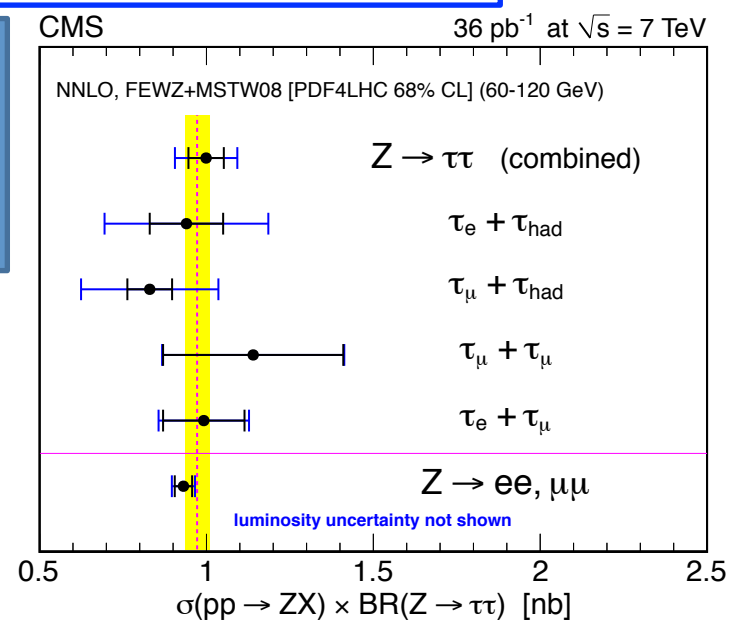
W→τν:

- hadronic channel, 2010 dataset

Both statistics limited, to be updated on 2011 data



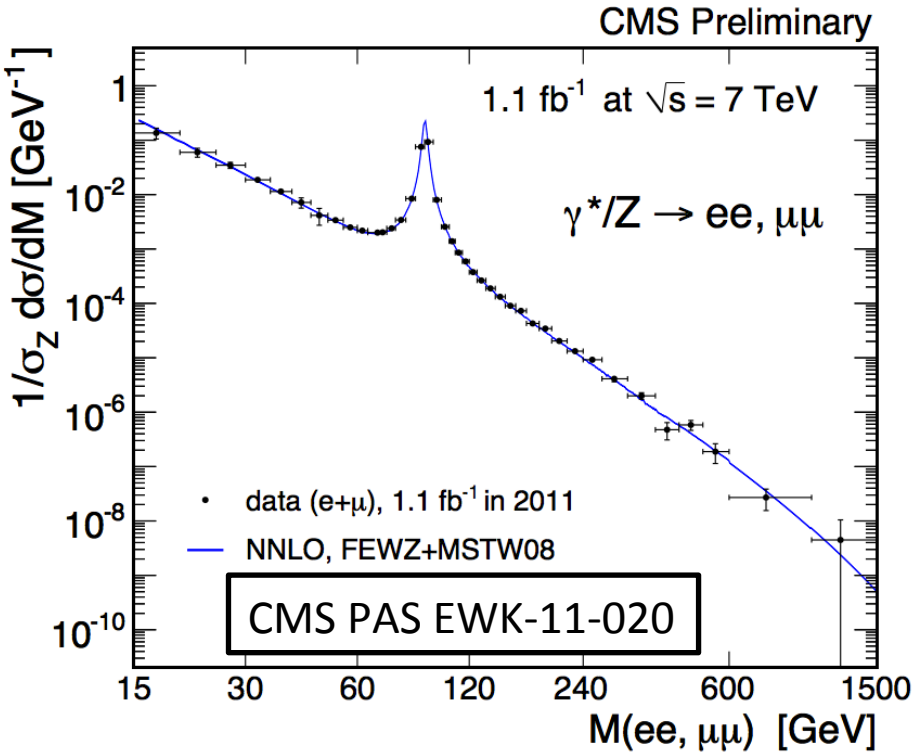
CMS PAS EWK-11-019

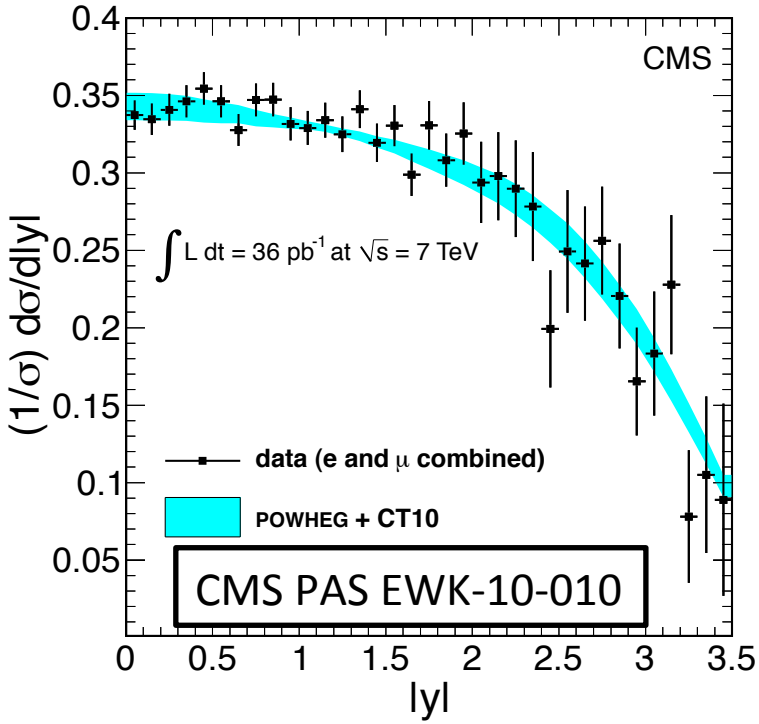


Channel	$\sigma(pp \to WX) \times \mathcal{B}$ (nb)	NNLO (nb)
$W \to \tau\nu$	$8.96 \pm 0.51(\text{stat.})^{+2.32}_{-2.26}(\text{syst.}) \pm 0.36(\text{lumi.})$	10.44 ± 0.52
$W^+ \to \tau^+\nu$	$5.26 \pm 0.39(\text{stat.})^{+1.36}_{-1.29}(\text{syst.}) \pm 0.21(\text{lumi.})$	6.15 ± 0.29
$W^- \to \tau^-\nu$	$3.40 \pm 0.33(\text{stat.})^{+0.92}_{-0.93}(\text{syst.}) \pm 0.14(\text{lumi.})$	4.29 ± 0.23

Z differential xsec: dσ/dm, dσ/dy

- Constraints on PDFs from both dσ/dm and dσ/dy
- High-mass tail: sensitive to BSM
- Z→ee/μμ combined shown
- dσ/dm, dσ/dy, $d^2\sigma/(dmdy)$ on full 4.7 fb^{-1} is in progress

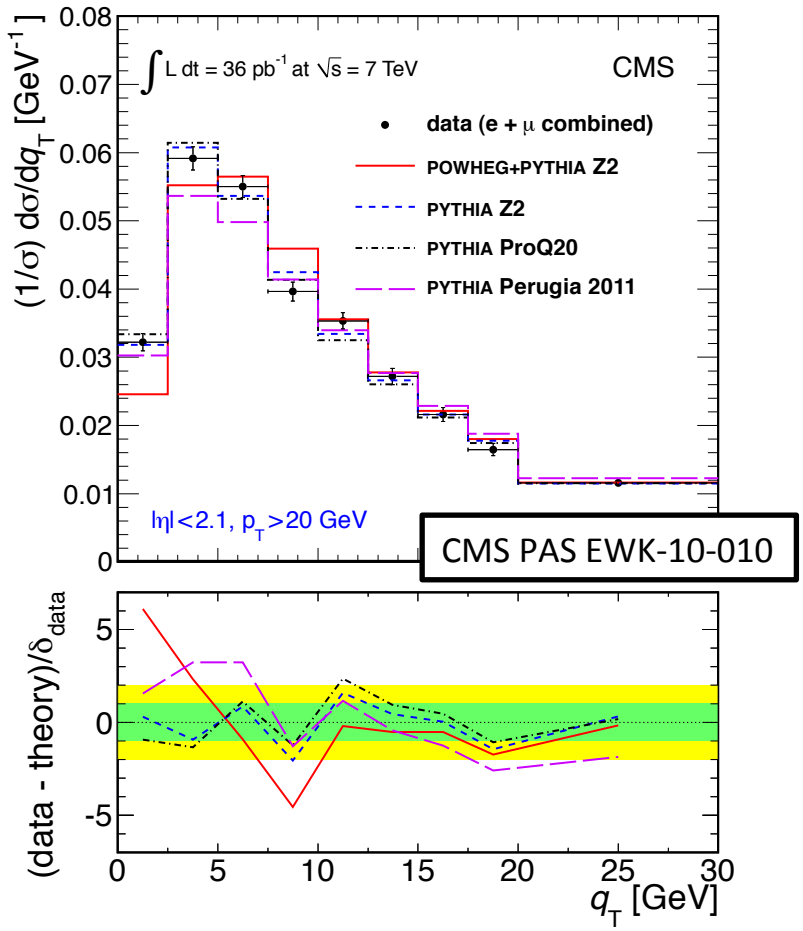


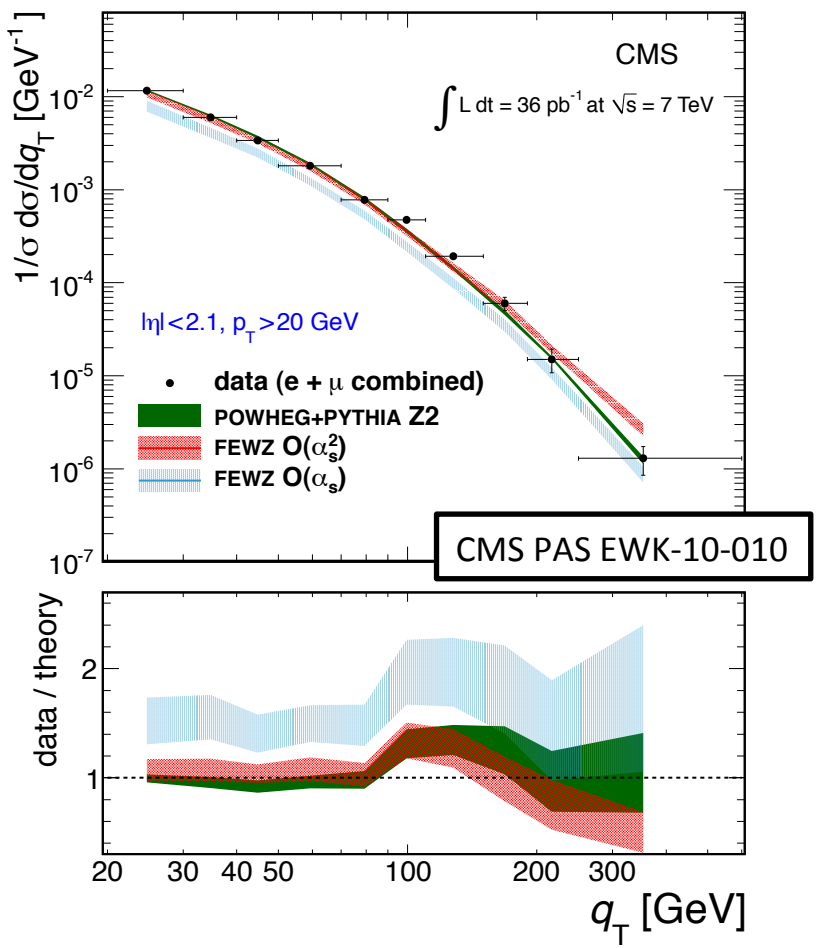


Z differential xsec: $d\sigma/dp_T$

High-P_T: single hard gluon, perturbative, reasonable agreement with theory

Low-P_T: soft gluons, non-perturbative effects, tunes Z2, ProQ20 work well





W charge asymmetry

Inclusive W+/W- asymmetry at LHC: ~1.4

Differential asymmetry dA/dy is very sensitive to PDFs

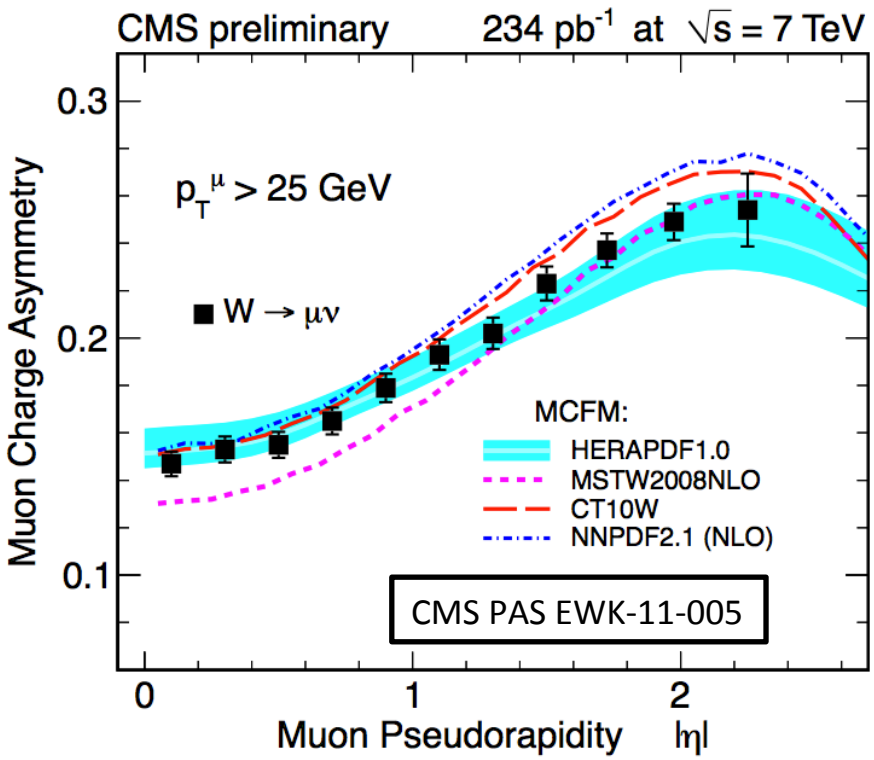
$$A = \frac{[d\sigma(W^+)/dy]-[d\sigma(W^-)/dy]}{[d\sigma(W^+)/dy]+[d\sigma(W^-)/dy]} \Rightarrow \frac{dN_{\ell+}/d\eta - dN_{\ell-}/d\eta}{dN_{\ell+}/d\eta + dN_{\ell-}/d\eta}$$

Many systematic uncertainties cancel

This measurement:

- larger dataset, higher PT threshold.
- W→μν channel

(Previous CMS results: e+μ on 36pb^{-1})



Good agreement with HERAPDF
More flat than MSTW (χ^2=5.3), CT10 (χ^2=2.1), NNPDF (χ^2=4.1)
Provides significant constraints to the PDF global fits

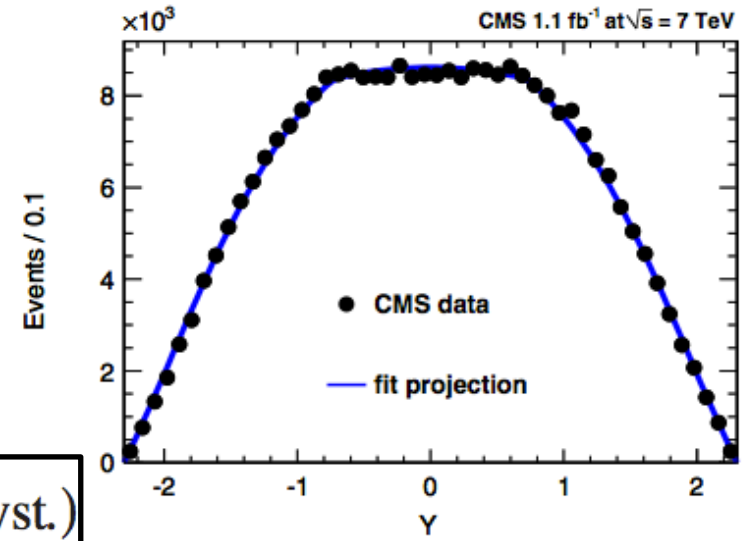
Weak mixing angle

Effective weak mixing angle θ_{eff} measured in $u\bar{u}, d\bar{d} \rightarrow Z/\gamma^* \rightarrow \mu\mu$

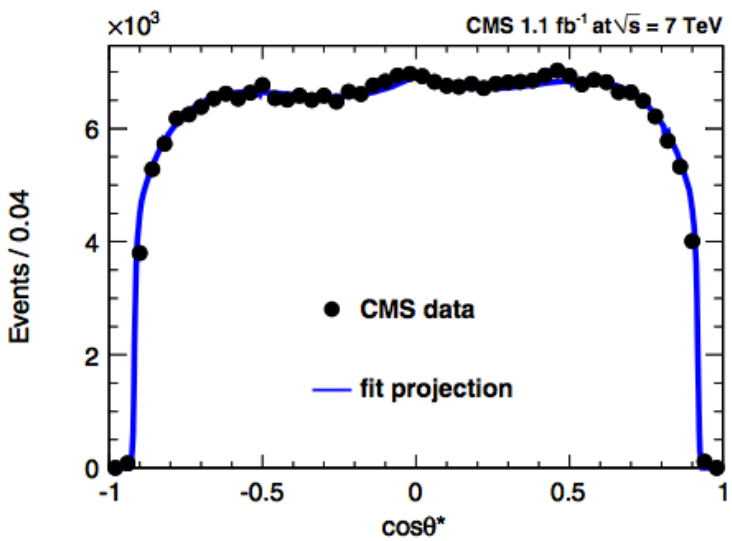
Symmetric pp: quark direction not known

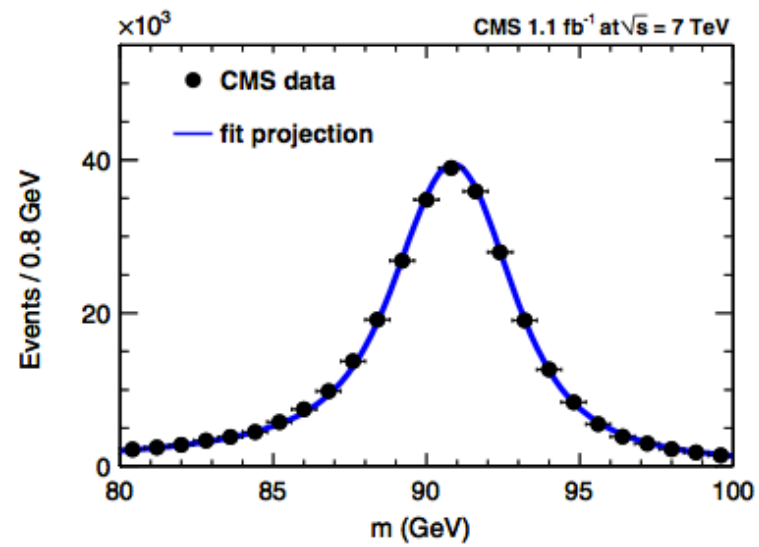
Multivariate analysis of μμ mass, rapidity, decay angle

PRD 84, 112002 (2011)



$$\sin^2\theta_{eff} = 0.2287 \pm 0.0020\,(\text{stat.}) \pm 0.0025\,(\text{syst.})$$





V+jets: x-sec(n jets) ratios

Test of perturbative QCD

Cross section ratios measured:

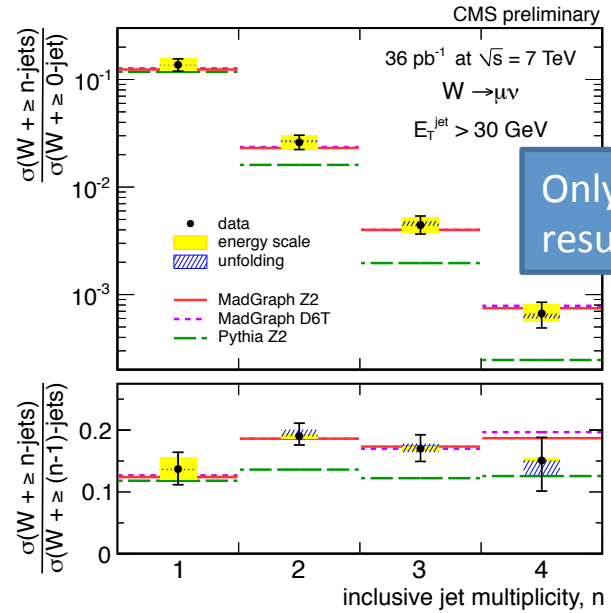
- Z+(n-jets), W+(n-jets)
- Z→ee and μμ, W->eν and μν

Jet reconstruction:

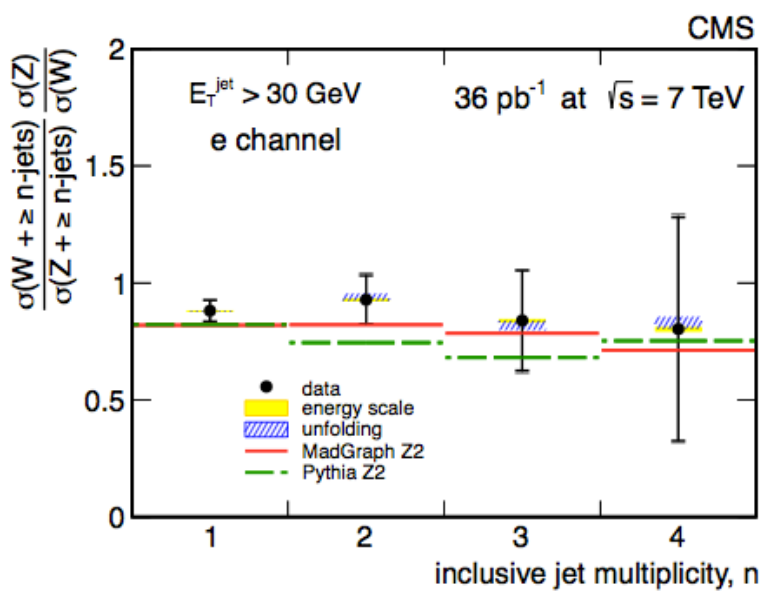
- anti-kt, cone 0.5
- event-by-event correction for pile-up

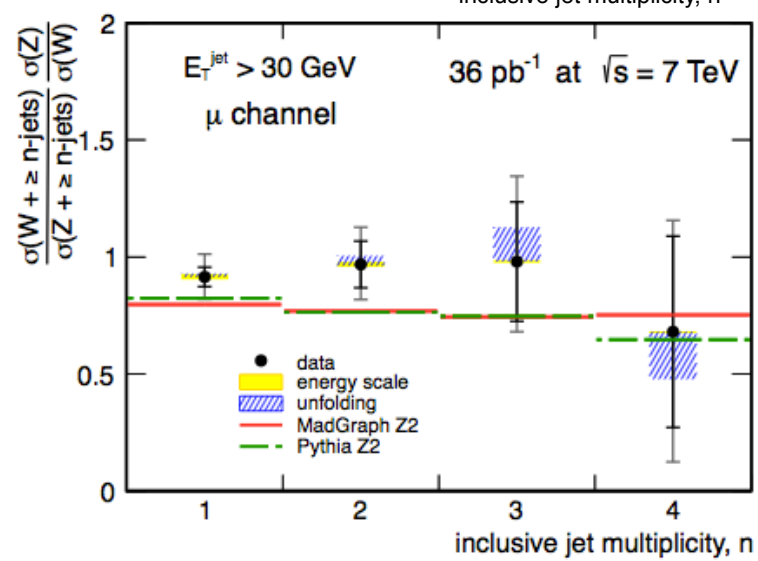
CMS PAS EWK-10-012

Good agreement with Madgraph generator



Only fraction of results shown





W+charm production

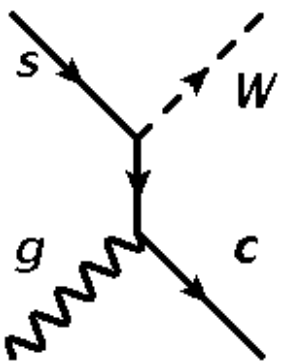
W+c production sensitive to strange content of proton PDF

- relative s vs sbar in proton PDF: $R^{\pm}_c = \sigma(W^+cbar)/\sigma(W^-c)$
- toward reduction of PDF uncertainties for, e.g., W mass: $R_c = \sigma(Wc)/\sigma(Wjets)$

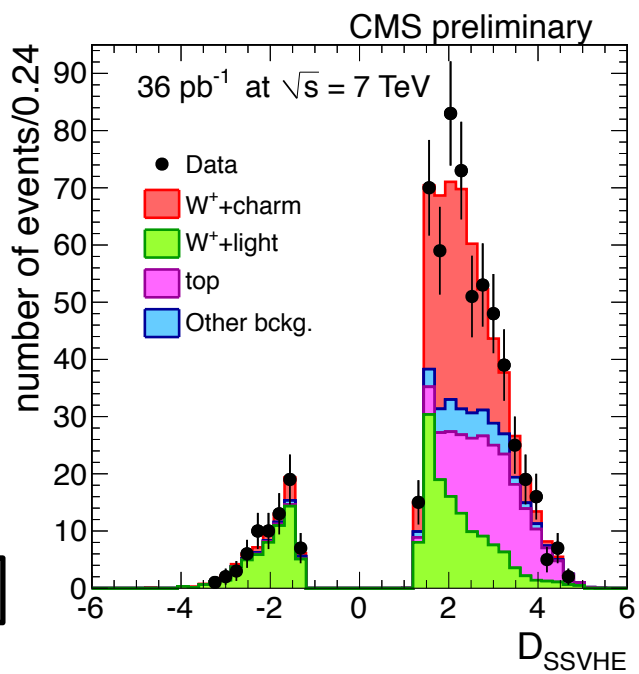
Charm jet identification: tagged by secondary vertex

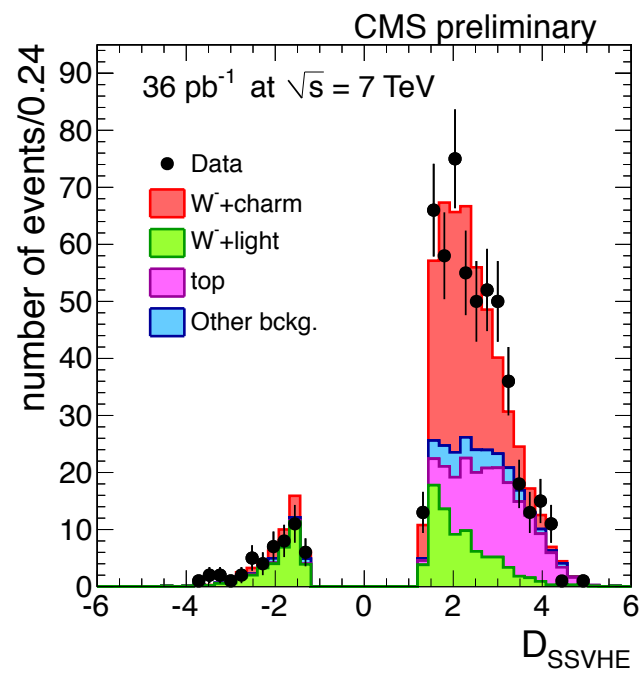
$$R_c^{\pm} = 0.92 \pm 0.19\ (stat.) \pm 0.04\ (syst.)$$
$$R_c = 0.143 \pm 0.015\ (stat.) \pm 0.024\ (syst.)$$

in agreement with NLO predictions



CMS PAS EWK-11-013

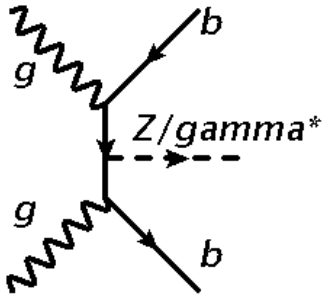




Z+b(b) production rate

Motivation:

- b quark component of proton PDFs
- benchmark, main background for ZH, H→bb

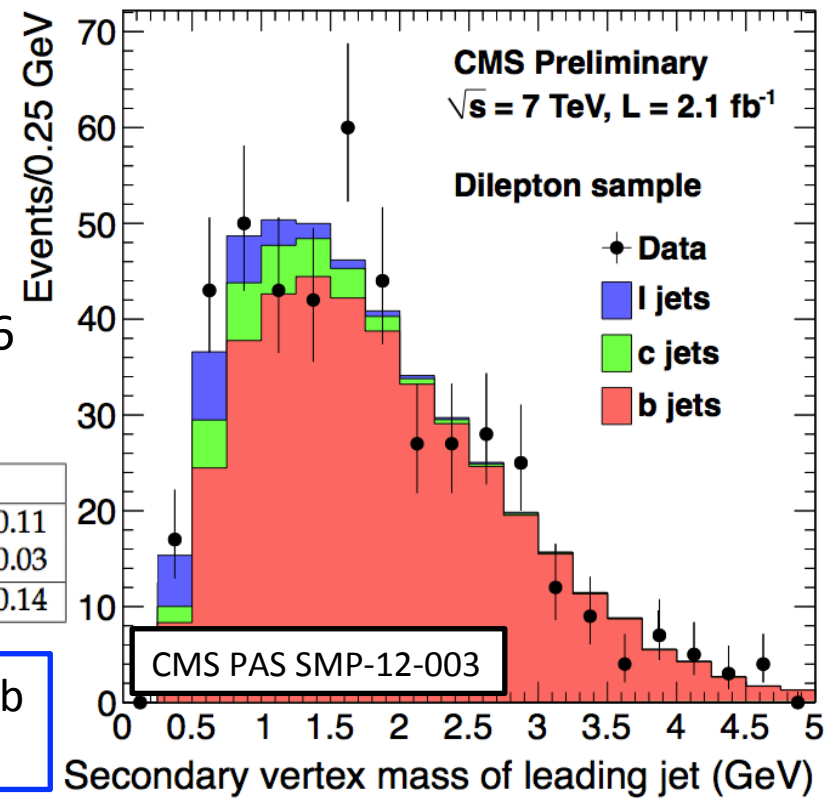


many other diagrams possible

Analysis:

- Z→ee and μμ
- b-jet ID: secondary vertex tagging
- measured in acceptance
  - leptons: P_T> 20 GeV, |η|<2.5, 76<M_{ll}<106
  - jets: P_T> 25 GeV, |η|<2.1, ΔR(j,l)>0.5

Multiplicity bin	ee	$\mu\mu$
σ_{hadron}(Z+1b,Z→ $\ell\ell$)(pb)	$3.25 \pm 0.08 \pm 0.29 \pm 0.06$	$3.47 \pm 0.06 \pm 0.27 \pm 0.11$
σ_{hadron}(Z+2b,Z→ $\ell\ell$)(pb)	$0.39 \pm 0.04 \pm 0.07 \pm 0.02$	$0.36 \pm 0.03 \pm 0.07 \pm 0.03$
σ_{hadron}(Z+b,Z→ $\ell\ell$)(pb)	$3.64 \pm 0.09 \pm 0.35 \pm 0.08$	$3.83 \pm 0.07 \pm 0.31 \pm 0.14$



Combined σ(Z+2b)=0.37±0.02^{stat}±0.07^{syst}±0.02^{theory} pb
Madgraph expectation: 0.33±0.01 pb

Dibosons measurements

Motivation:

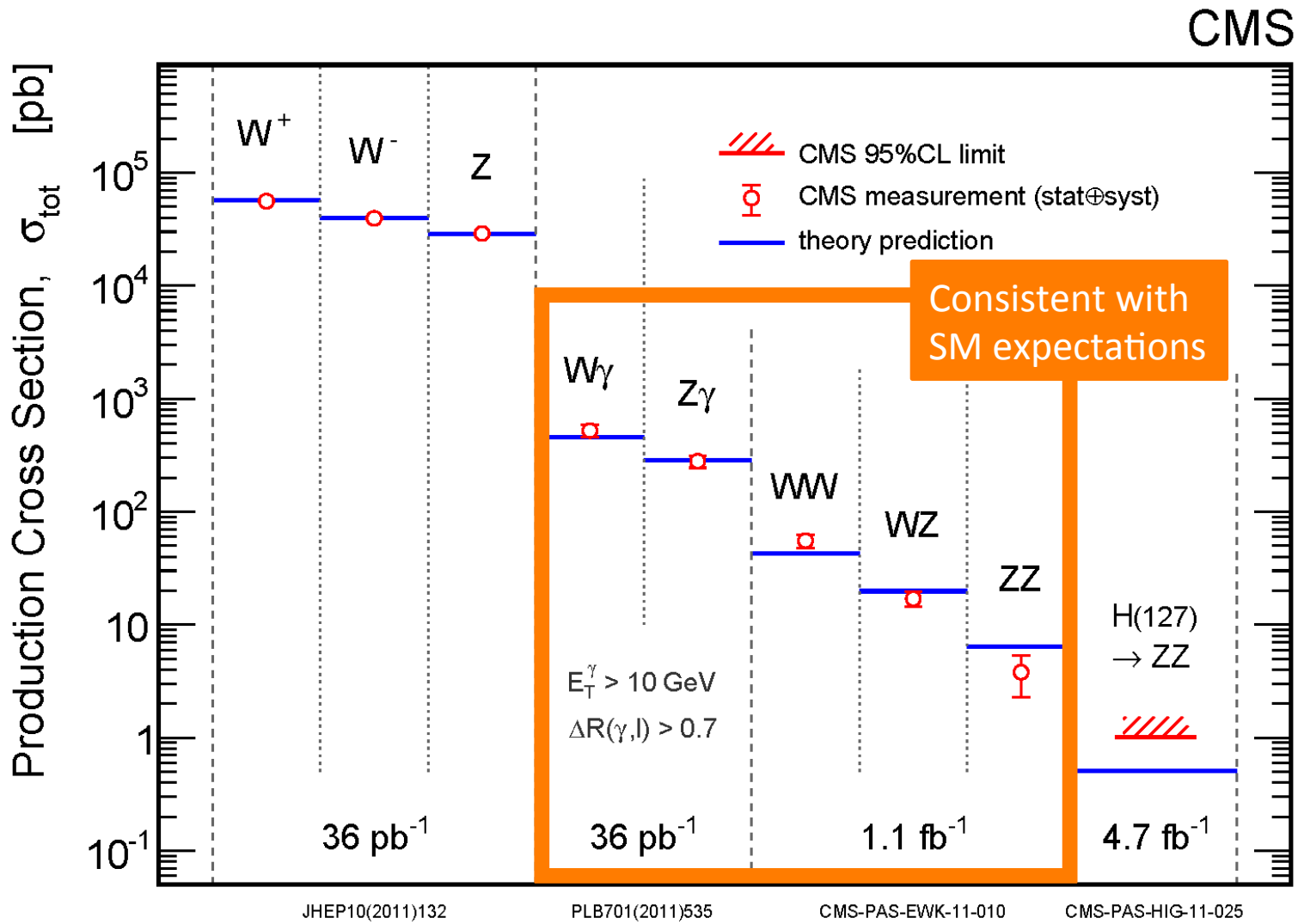
- sensitive to new physics
- WW and ZZ are primary background to Higgs search
- measure production x-section, limits on anomalous TGC

Results from CMS:

- WW, WZ, ZZ on 2011 data, 1.1 fb^{-1}
- Wγ and Zγ on 2010 data, 36 pb^{-1}
- all above on full 7 TeV dataset: coming soon

All analyses: lepton signatures only

Diboson production rate results



Conclusions

Detailed studies of W and Z production are in progress in CMS with the large dataset of 5 fb^{-1}:

- ratios, asymmetries, differential cross sections
- V+jets, V+heavy quarks
- dibosons

All results agree with SM predictions

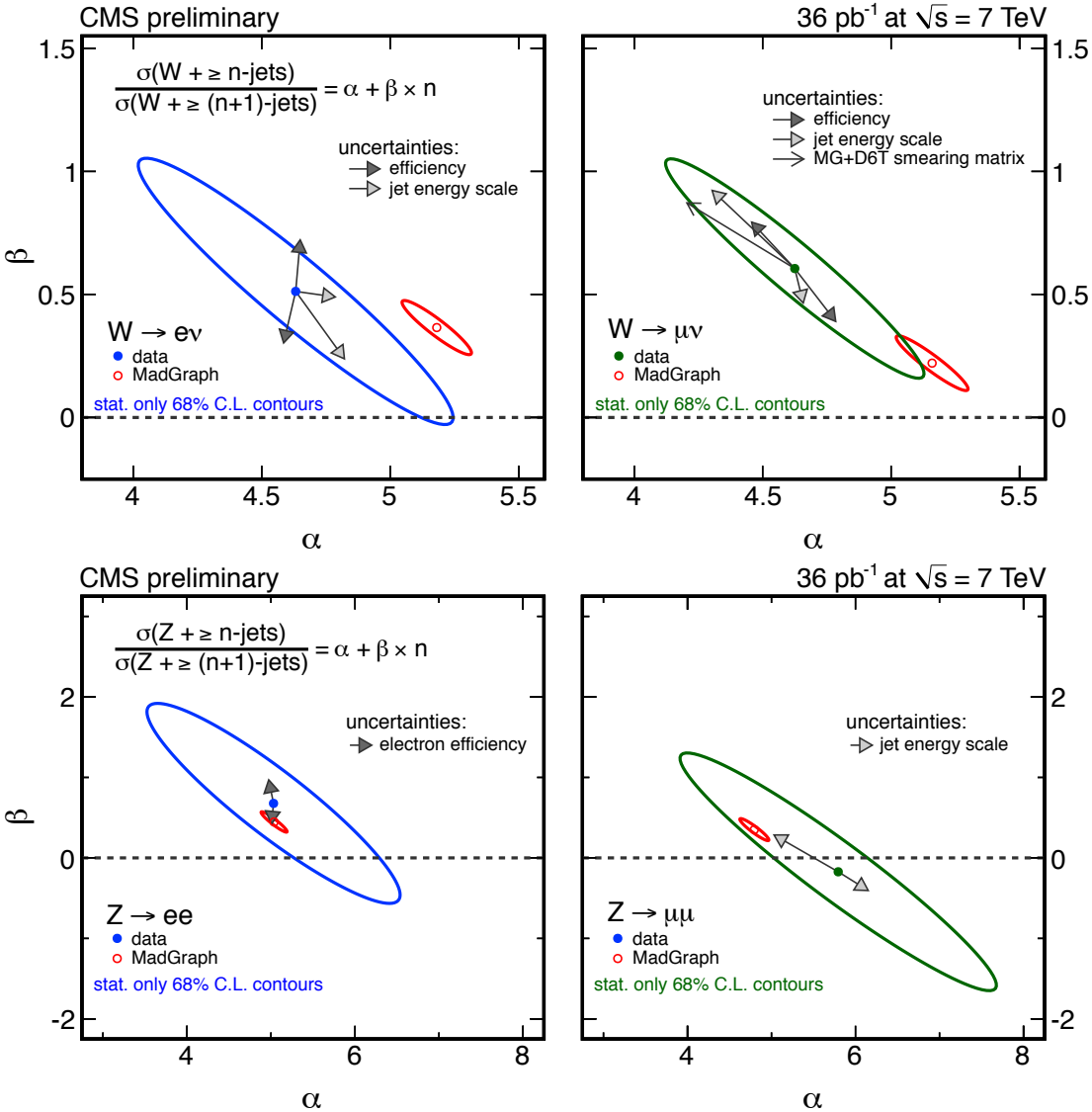
Many measurements in pipeline on full 7 TeV dataset

- several measurements presented will have updates at Moriond EWK, stay tuned

Preparing to repeat the full suite on 8 TeV data of 2012

BACKUP SLIDES

V+jets: Berends-Giele scaling



Test Berends-Giele scaling:

$$\frac{\sigma(V+\geq njets)}{\sigma(V+\geq(n-1)jets)} = \alpha + \beta \times n$$

Fit results for each W, Z channel shown.

Scaling hypothesis works well up to the tested 4-jet case.

Agreement with expectations (Madgraph – ME plus Pythia – PS) within 1-2 sigma.

CMS PAS EWK-10-012

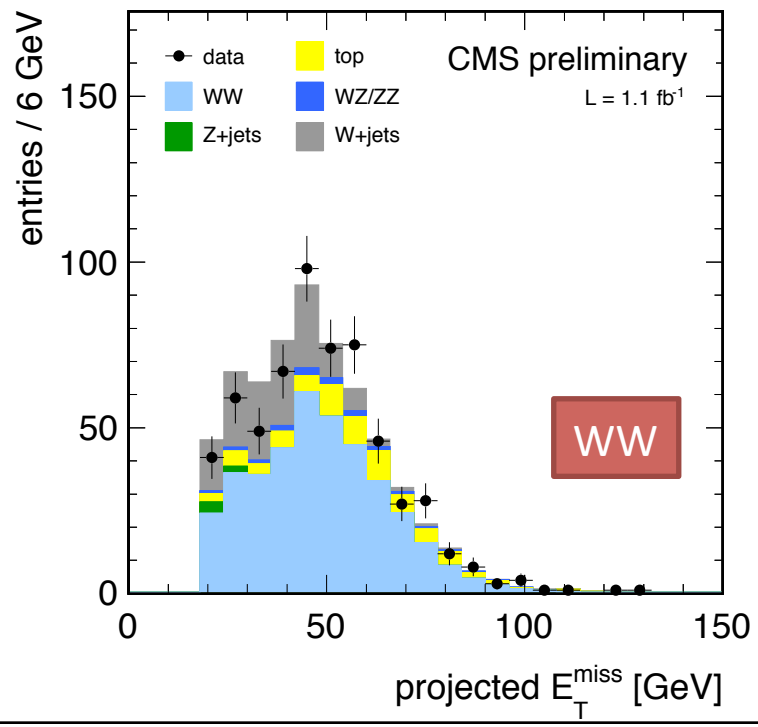
WW, WZ, and ZZ production

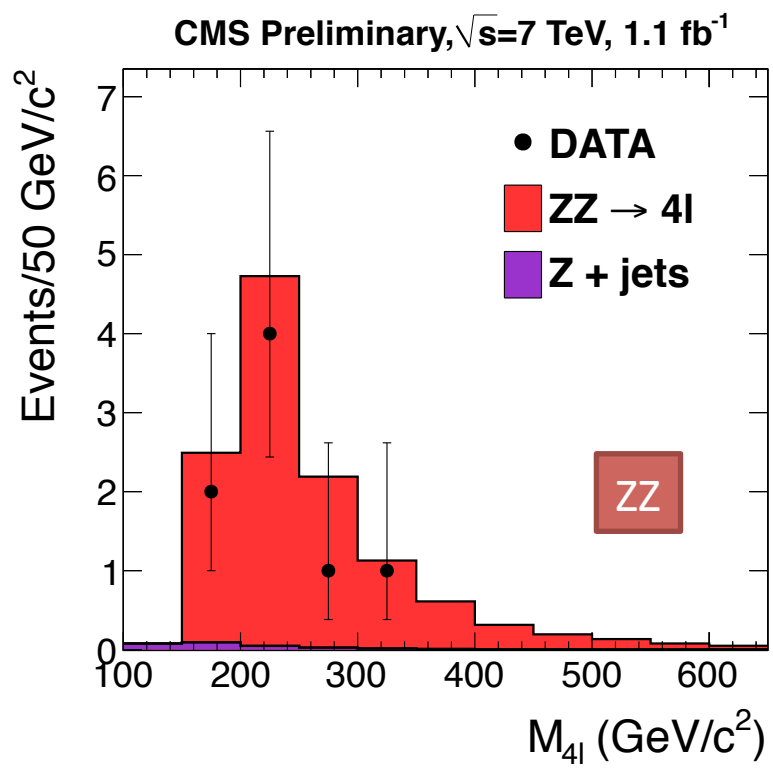
WW production
- high background: 40%
- require MET
- veto low MET, extra leptons, extra jets

WZ production
- moderate backgr: 10%
- require MET
- Z mass window cut

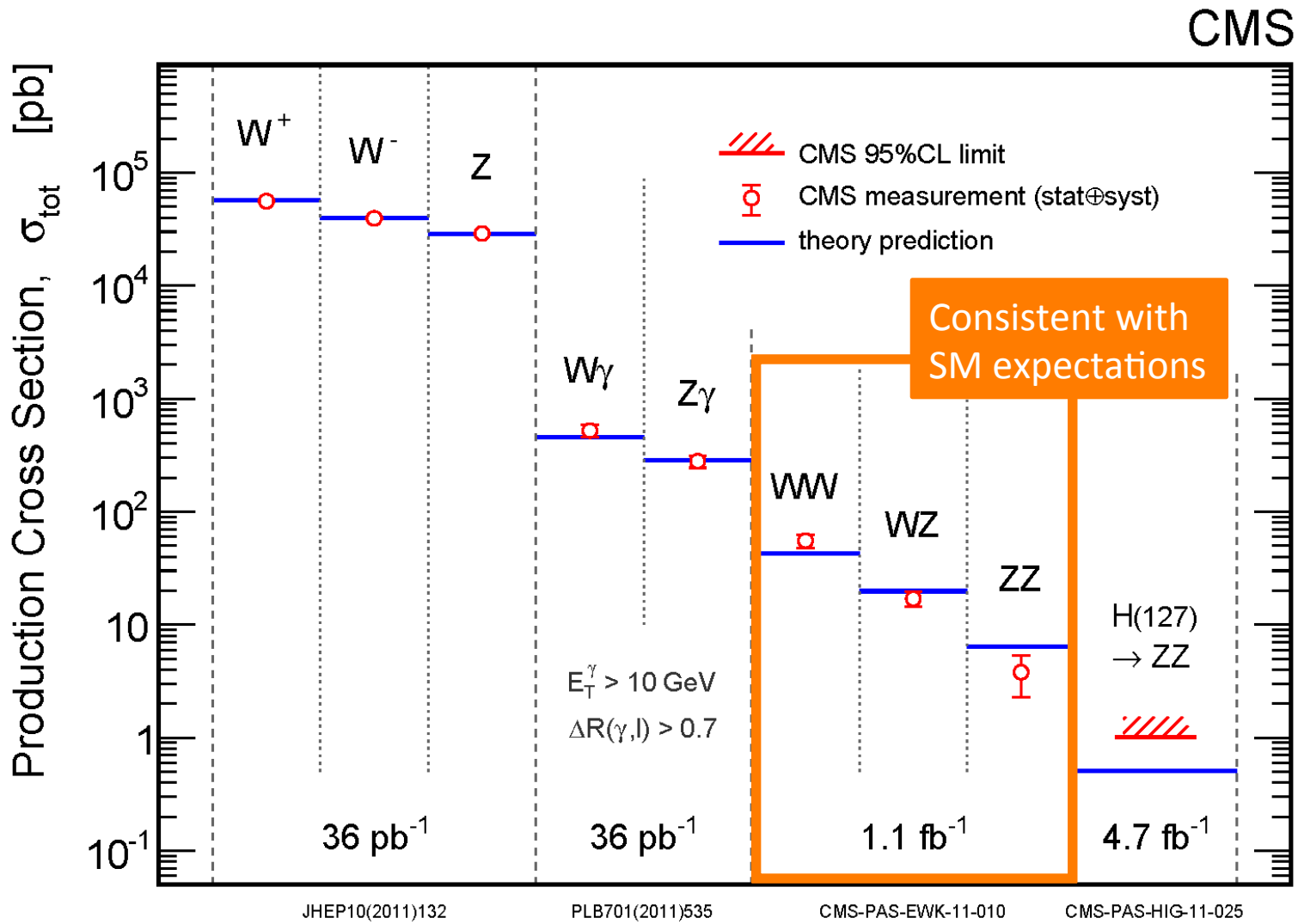
ZZ production
- negligible background
- relaxed ID, p_T cuts
- one Z may decay to ττ

All electron, muon channels included in WW/WZ/ZZ.





WW/WZ/ZZ production rate

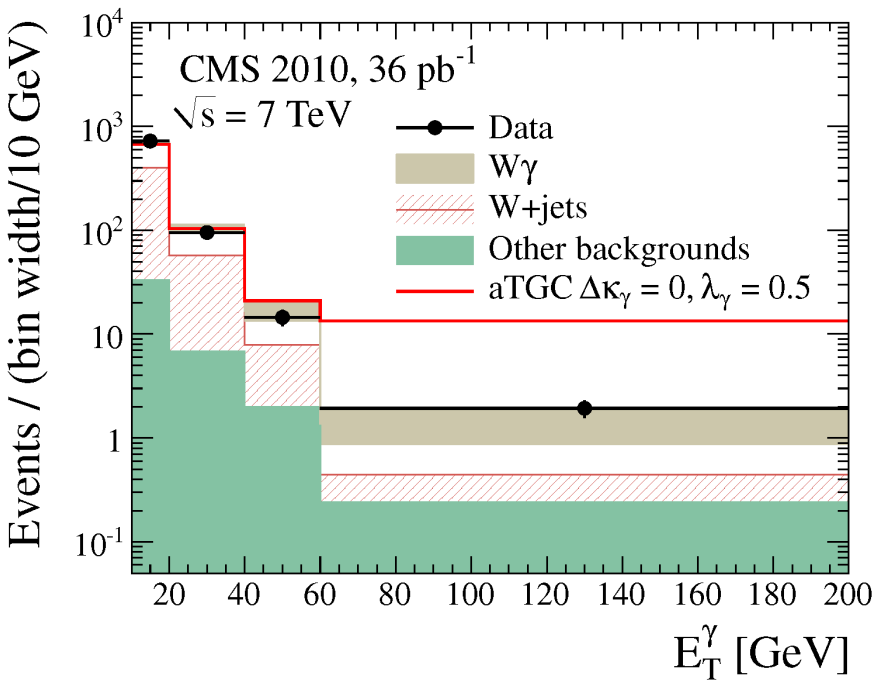


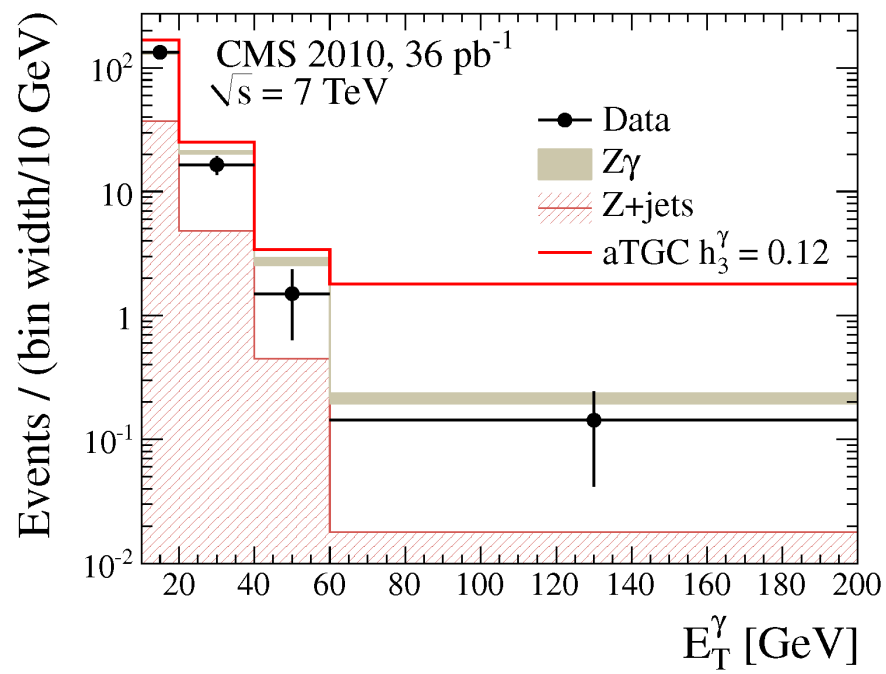
Wγ and Zγ production

Wγ production
- isolated lepton
- Isolated photon
- require MET
- ΔR separation lepton-photon

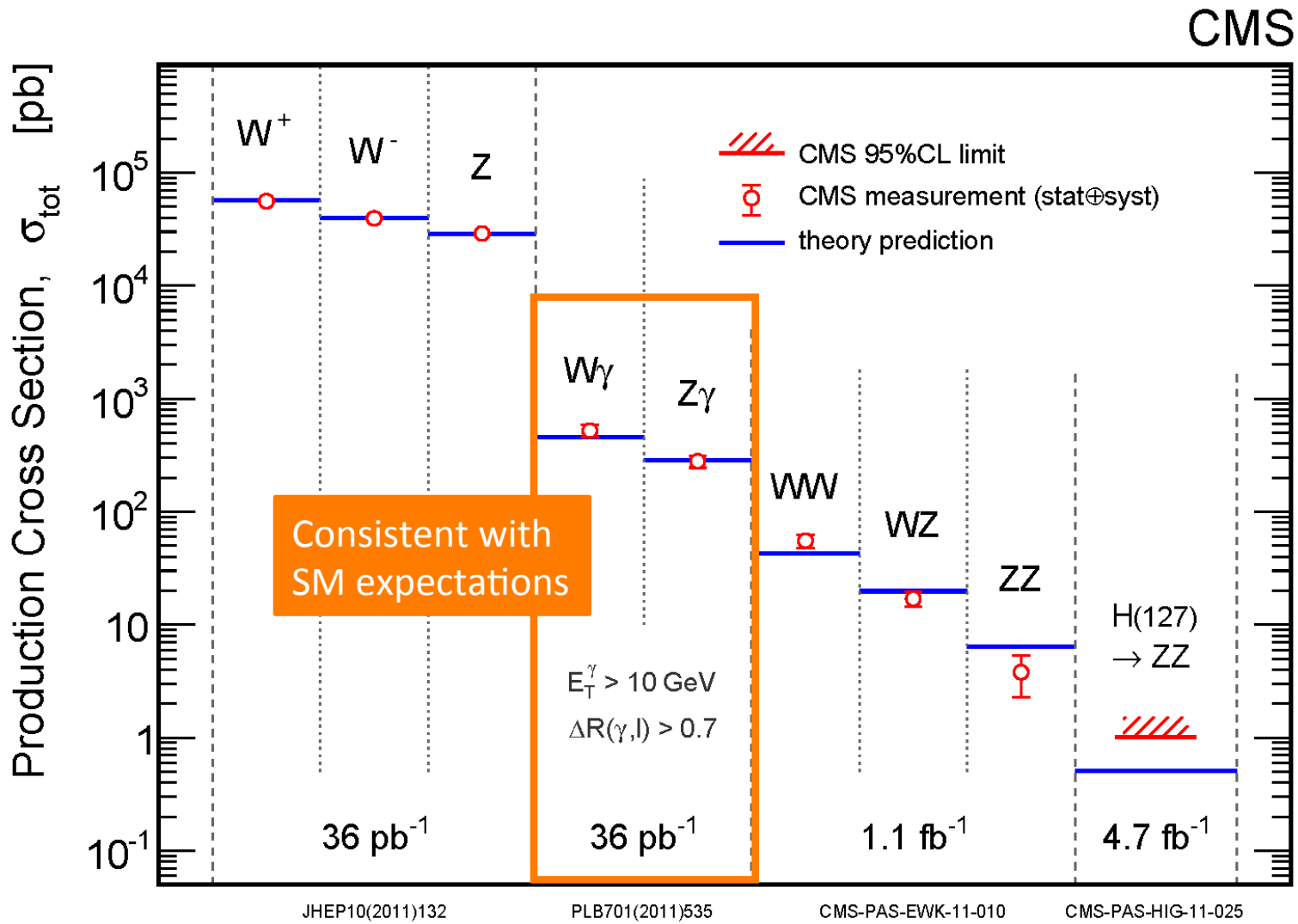
Zγ production
- two isolated lepton
- dilepton mass >50 GeV
- Isolated photon
- ΔR separation lepton-photon

Data driven background measurements used for both channels.





WW/WZ/ZZ production rate

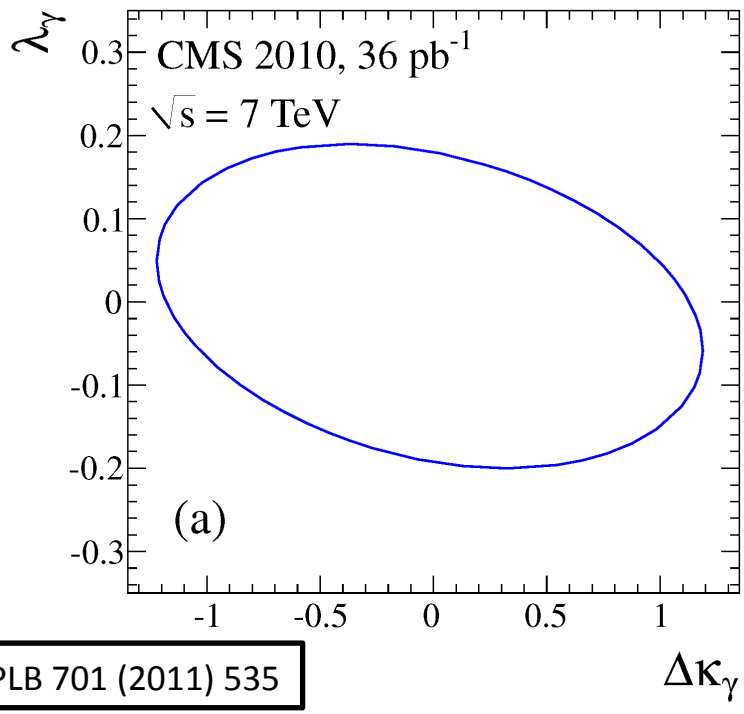


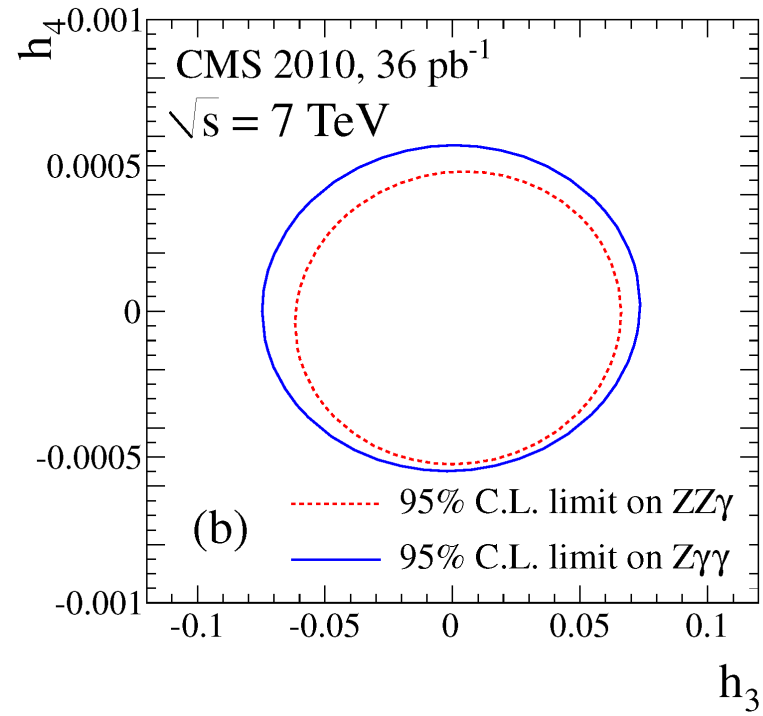
Consistent with SM expectations

Anomalous TGC limits

Set limits on:

- WWγ: $\Delta g^Z_1 = g^Z_1 - 1$ and $\Delta\kappa_Z = \kappa_Z - 1$
- ZZγ/Zγγ: h_3 and h_4 (high sensitivity to h_4)
- no evidence for anomalous WWγ/ZZγ/Zγγ couplings





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