W/Z boson production cross sections with the CMS detector

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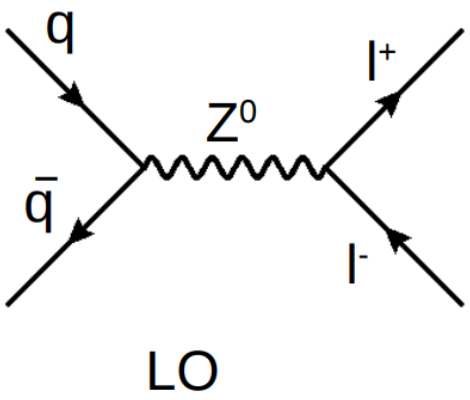
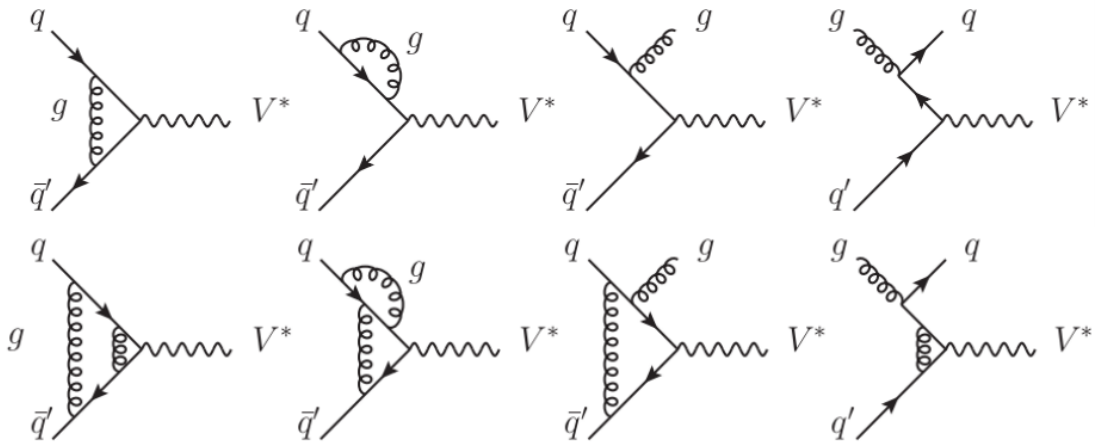
JINR, Dubna

July 6, 2018

Motivation



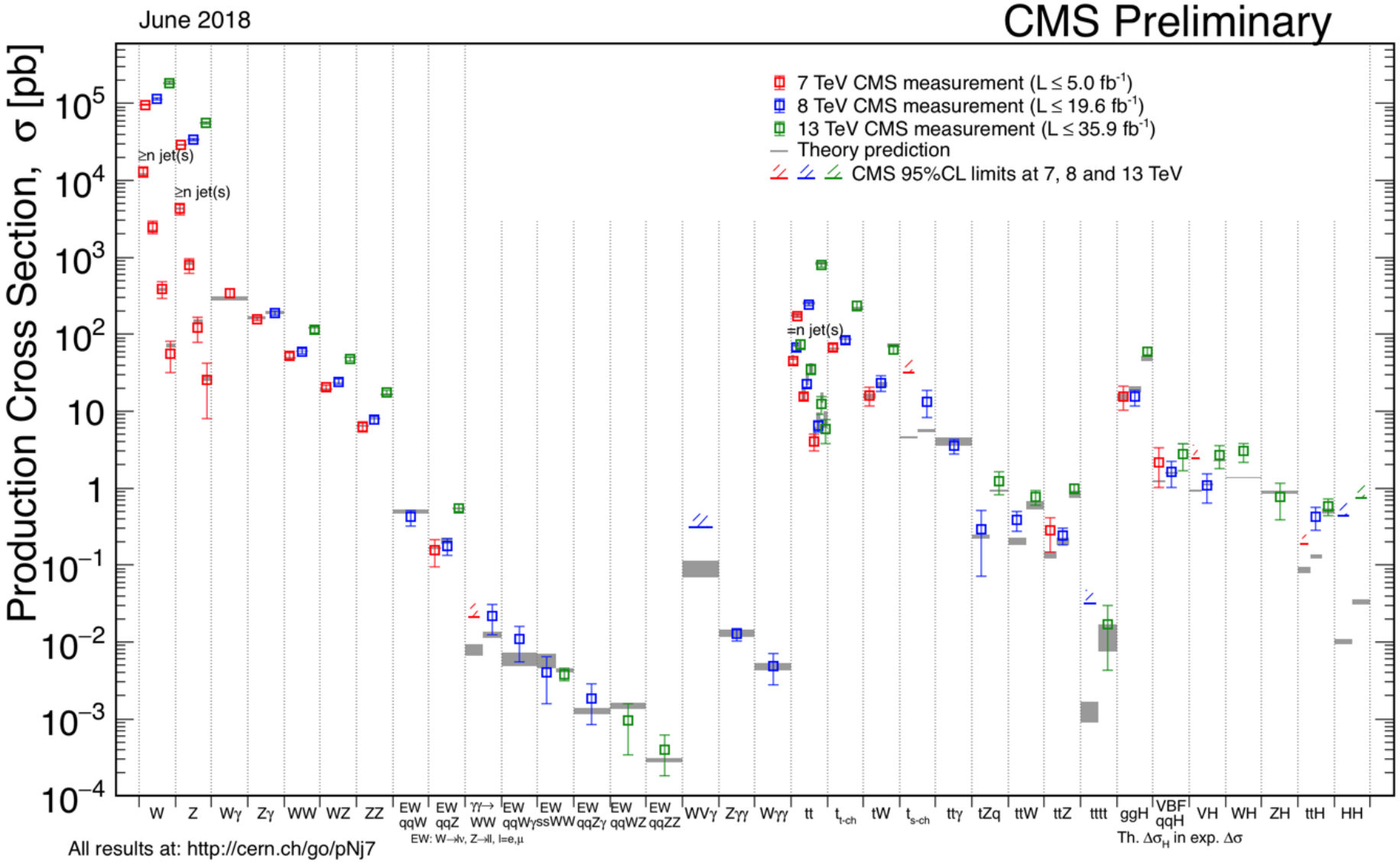


$p_T(\ell\ell) \sim 0$

$p_T(\ell\ell) \gg 0$

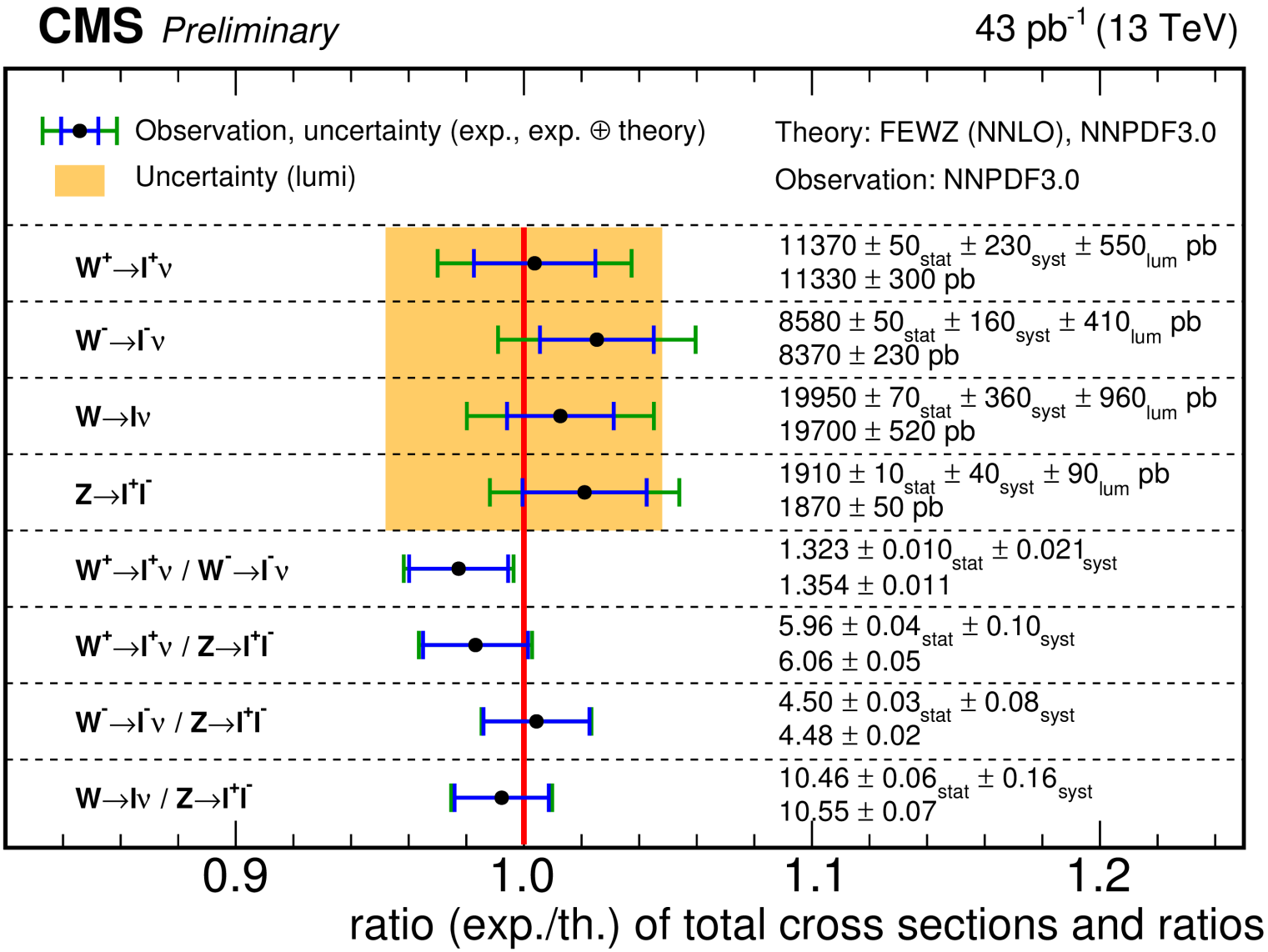
- Testing Standard model (SM)
- Constraining parton distribution functions (PDFs)
- Extracting parameters
- Background evaluation
- Testing different Monte Carlo models
- Testing production mechanism dynamics
- Precise measurements with a hadron collider!

Results Overview



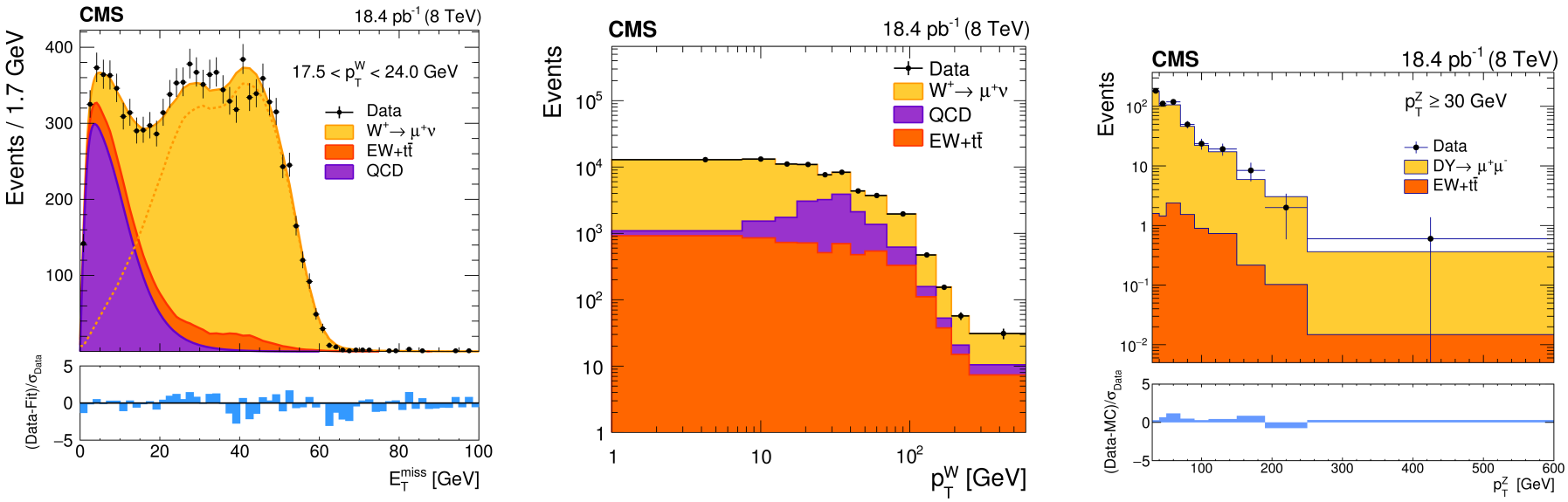
CMS have a large W and Z cross section measurement program

Inclusive W/Z production cross sections at 13 *TeV*



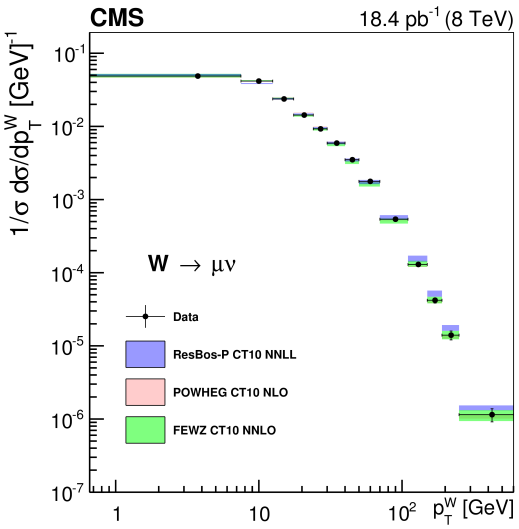
CMS-PAS-SMP-15-004

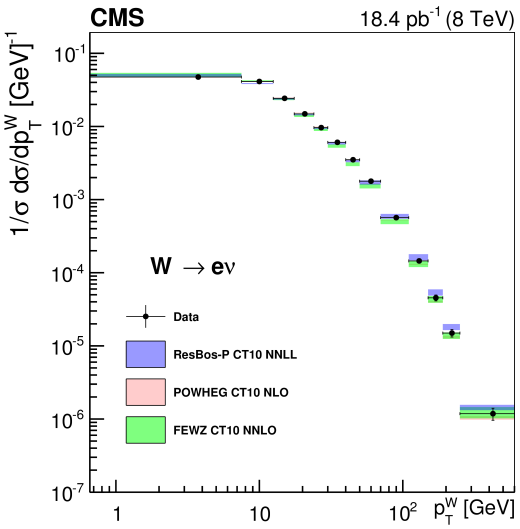
W/Z p_T spectra measurement at 8 TeV

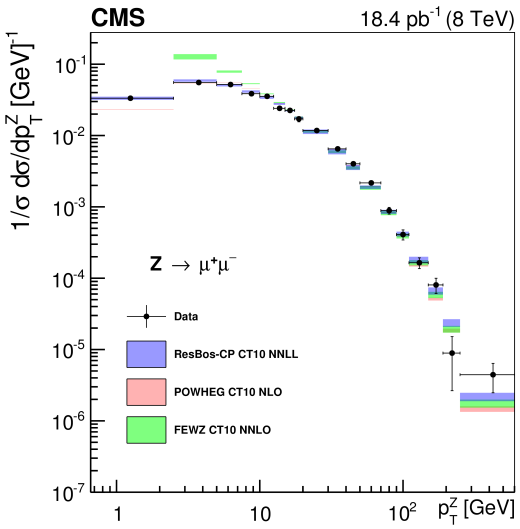


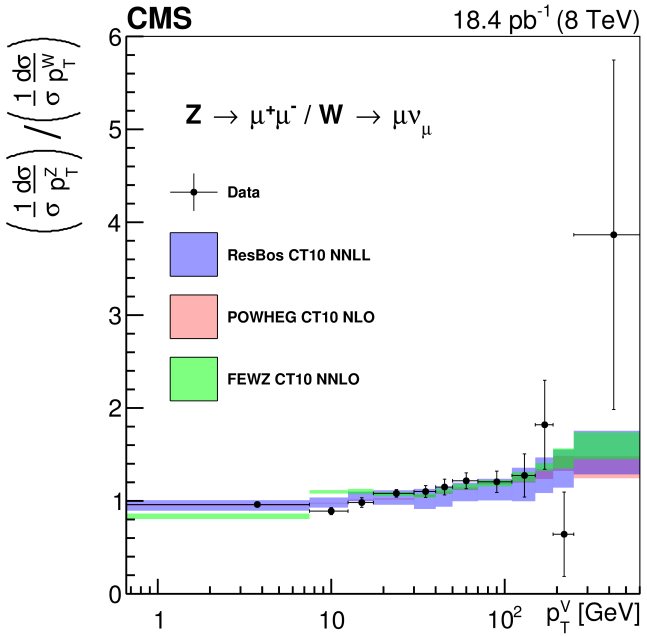
- Measured at 8 TeV using 18.4 pb^{-1} of special low-luminosity data
- W production studied in e and μ decay modes, Z production studied in dimuon mode
- Compared NNLO in QCD predictions
- J. High Energ. Phys. (2017) 2017: 96

W/Z p_T spectra measurement at 8 *TeV* II



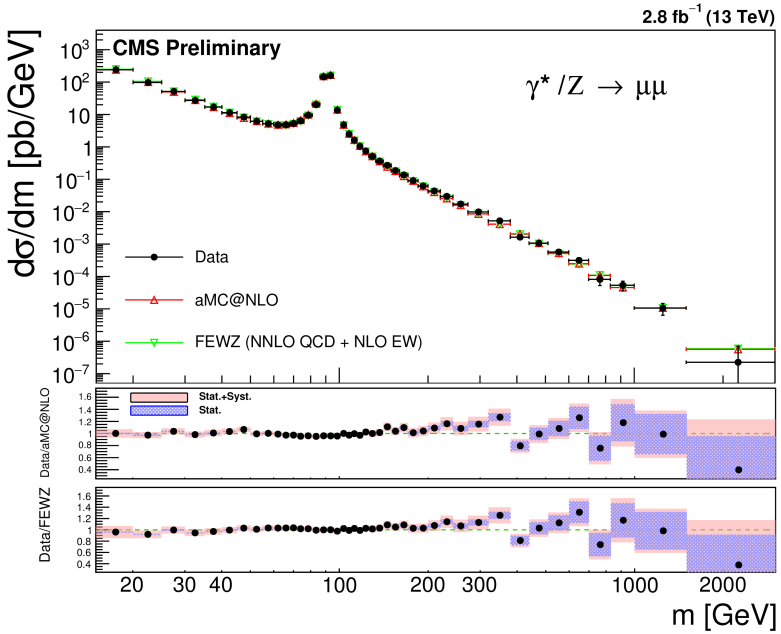


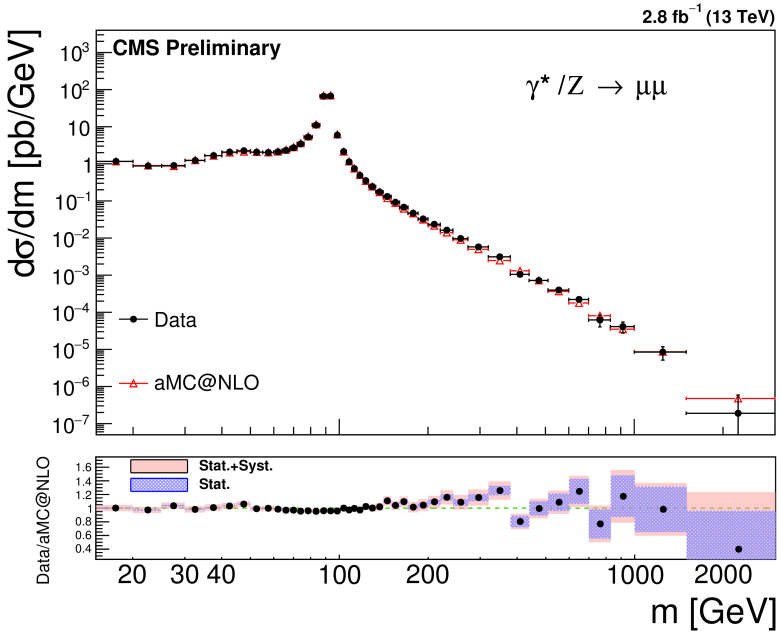




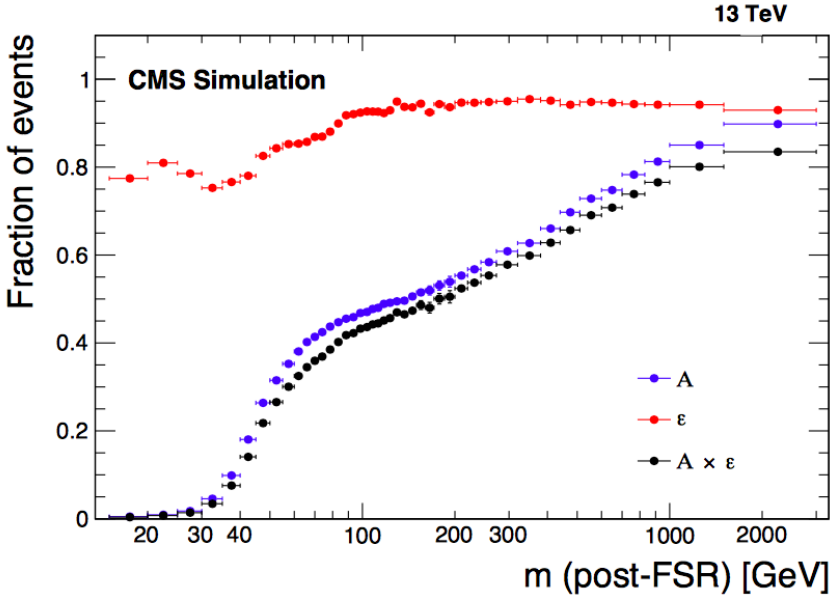
- Measured and theoreticaly predicted values are in good agreement within statistical and systematical uncertainties
- J. High Energ. Phys. (2017) 2017: 96

Drell-Yan differential cross section at 13 TeV



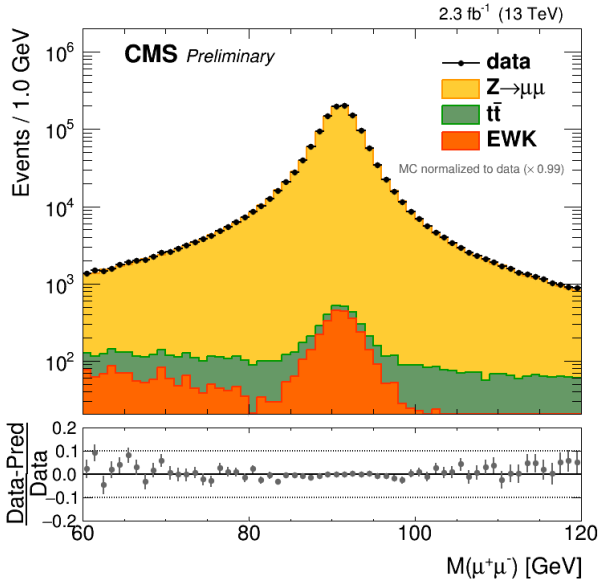


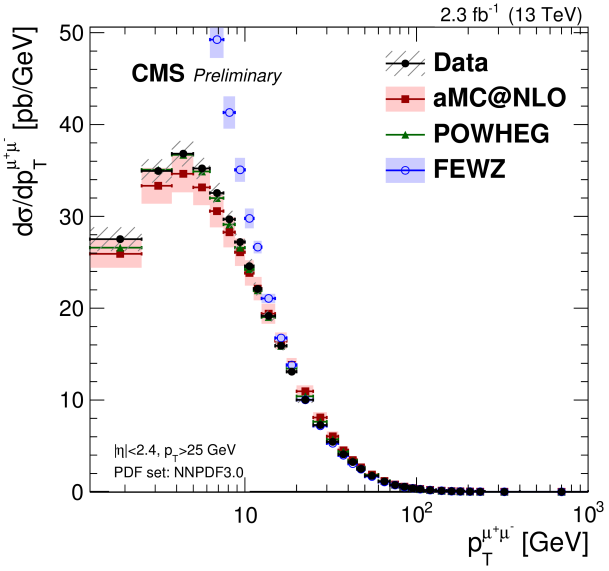
- Measured at 7, 8 and 13 TeV
- At 13 TeV measured in the invariant mass range from 15 to 3000 GeV using 2.8 fb^{-1} of 2015 data
- In good agreement with SM

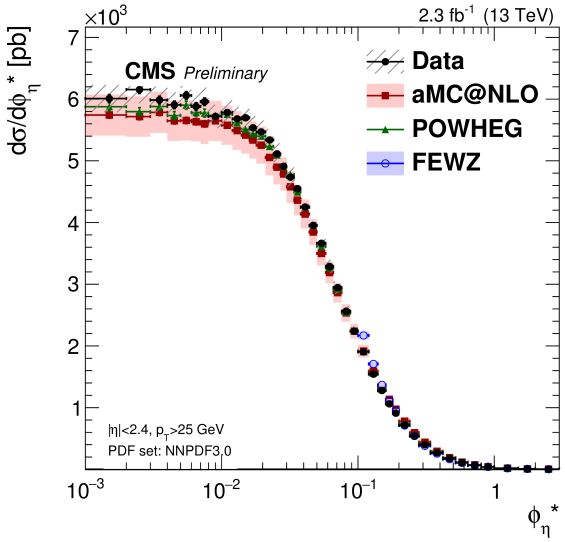


CMS-PAS-SMP-16-009

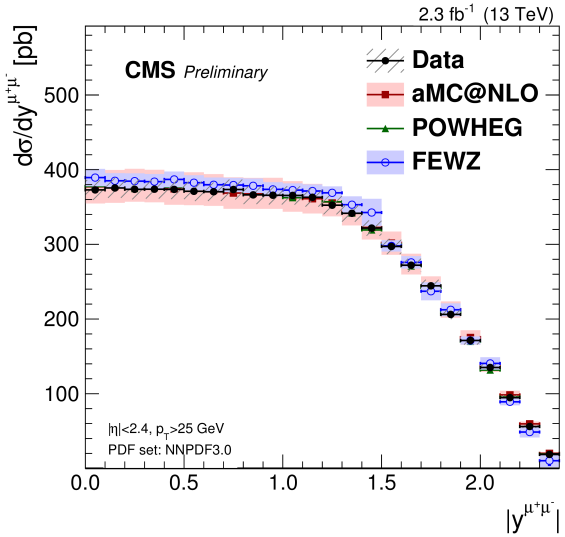
Z production cross section at 13 TeV



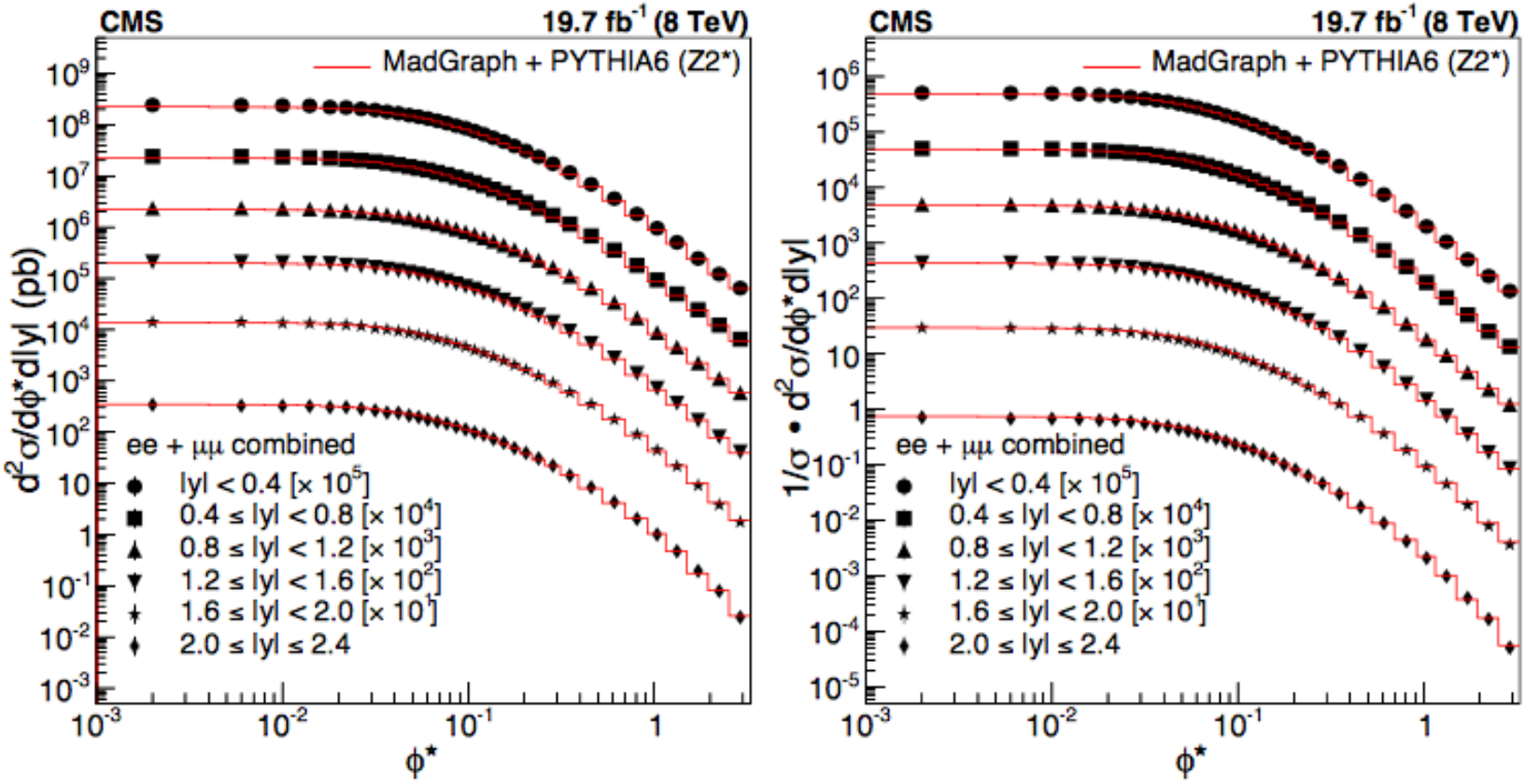




- At 13 TeV $p_T^{\mu\mu}$, $\phi_\eta^s tar$, $Y_{\mu\mu}$, p_T^μ are measured using 2.3 fb^{-1}
- $\sigma(pp \to ZX) \times B(Z \to \mu^+\mu^-) = 1870 \pm 2(stat) \pm 35(syst) \pm 51(lumi)\ pb$ for $M_{\mu\mu}$ from 60 to 120 GeV
- CMS-PAS-SMP-15-011

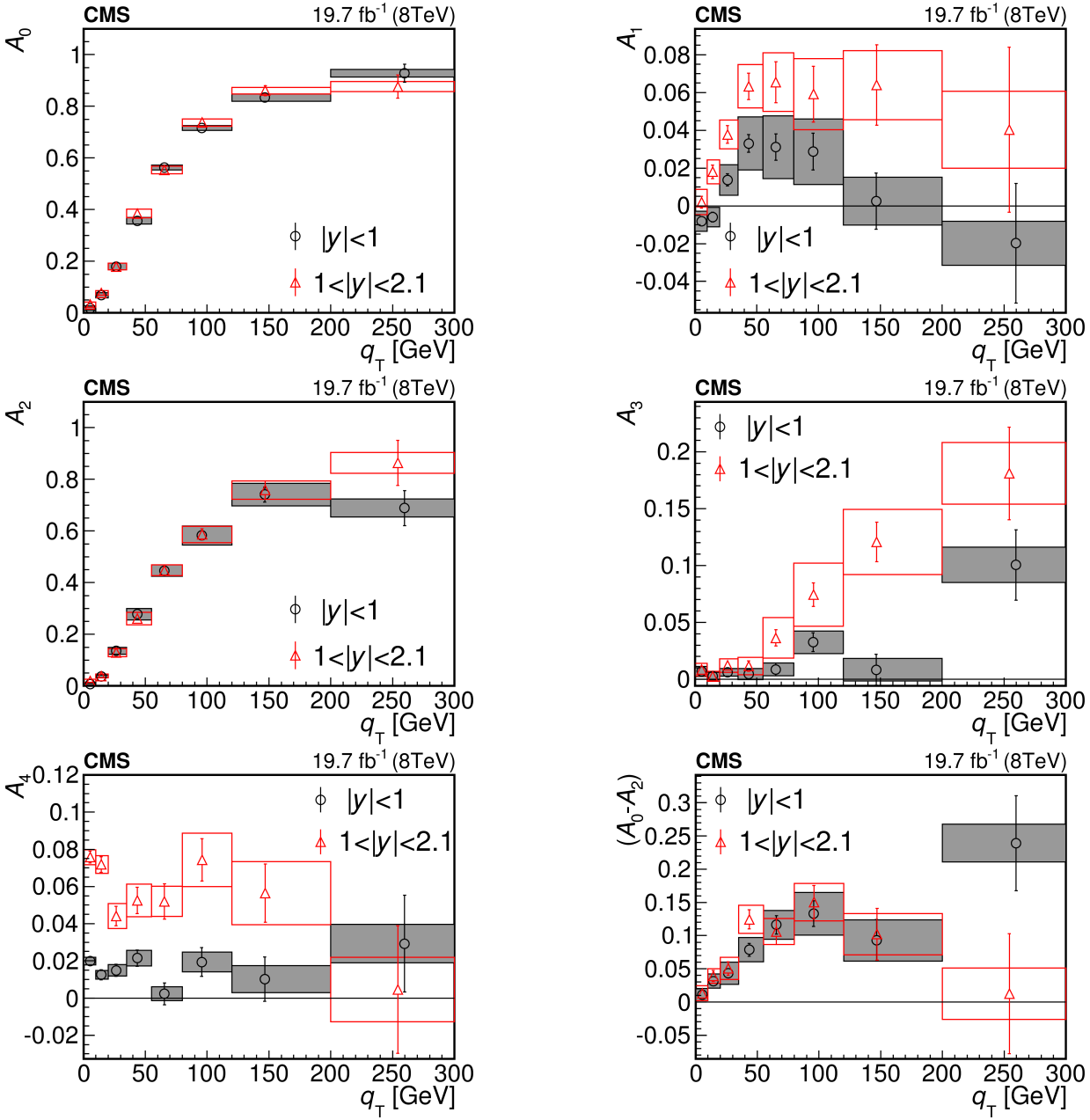


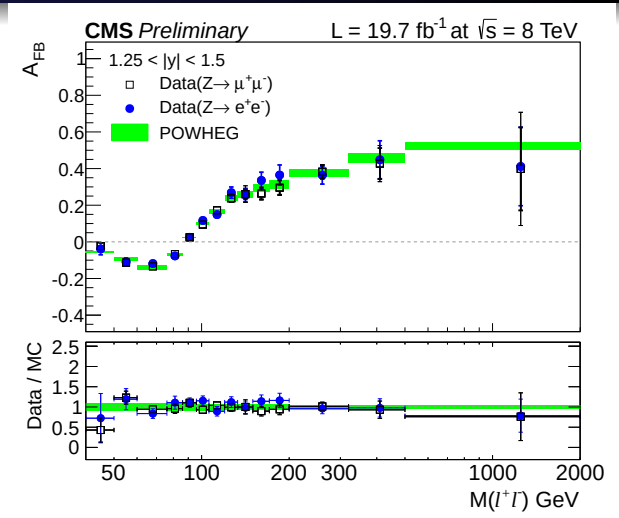
Differential in $\phi^\star$ and Rapidity Z cross section



- 19.7 fb^{-1} of 8 TeV data
- $\phi^\star = tan((\pi - \Delta\phi)/2)sin(\theta^\star_\eta)$, $cos(\theta^\star_\eta) = tanh((\eta^- - \eta^+)/2)$, $\phi^\star \sim q_T/m_{ll}$
- Connected to p_T but more precise
- J. High Energ. Phys. (2018) 2018: 172

A_{FB} and angular coefficients at 8 TeV

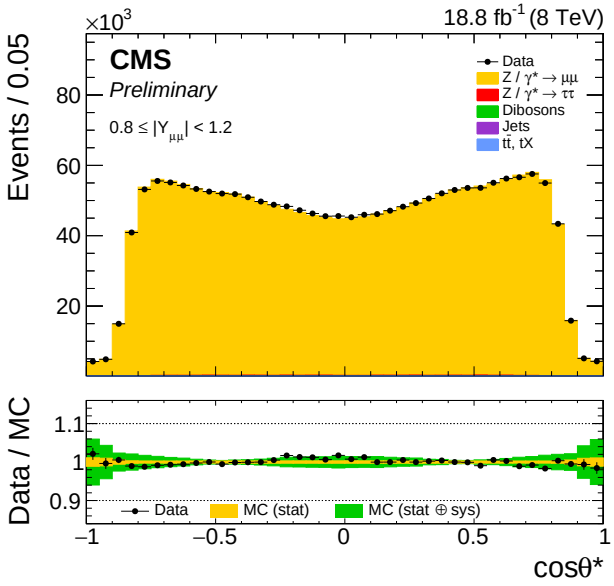


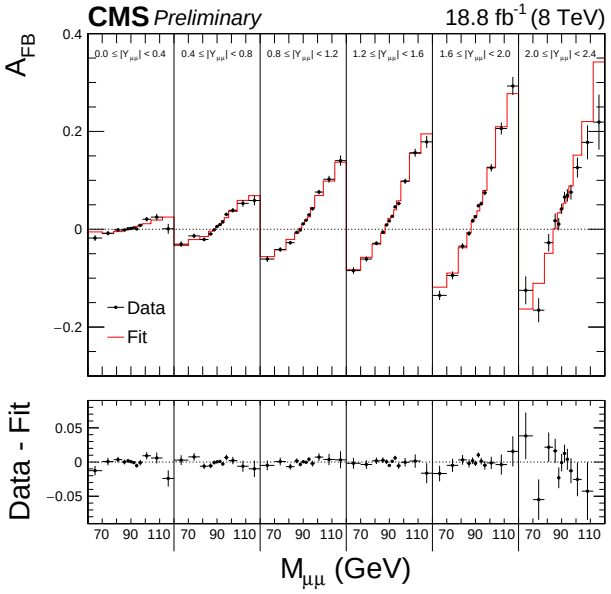


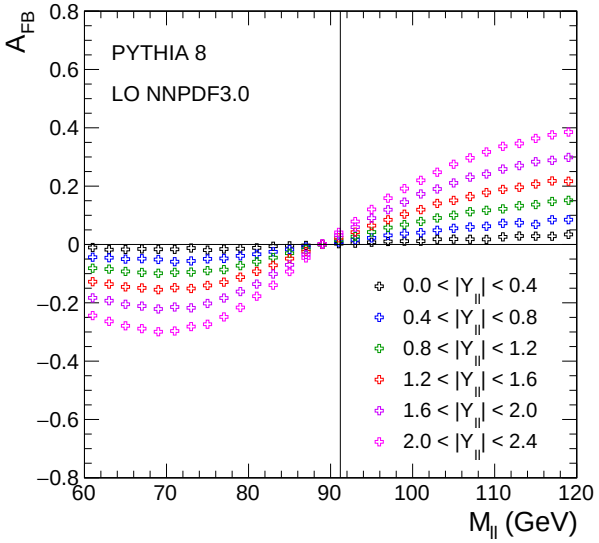
- $\frac{d^2\sigma}{dcos\theta^\star d\phi^\star} \propto (1+cos^2\theta^\star) + A_0\frac{1}{2}(1-3cos^2\theta^\star) + A_1 sin(2\theta^\star)cos\phi^\star + A_2\frac{1}{2}sin^2\theta^\star cos(2\phi^\star) + A_3 sin\theta^\star cos\phi^\star + A_4 cos\theta^\star + A_5 sin^2\theta^\star sin(2\phi^\star) + A_6 sin(2\theta^\star)sin\phi^\star + A_7 sin\theta^\star sin\phi^\star$
- Lam-Tung relation violated
- Strong $|y|$ and q_T dependence

Phys. Lett. B Vol. 750, 12/11/2015, pp. 154-175, Eur. Phys. J. C (2016) 76: 325

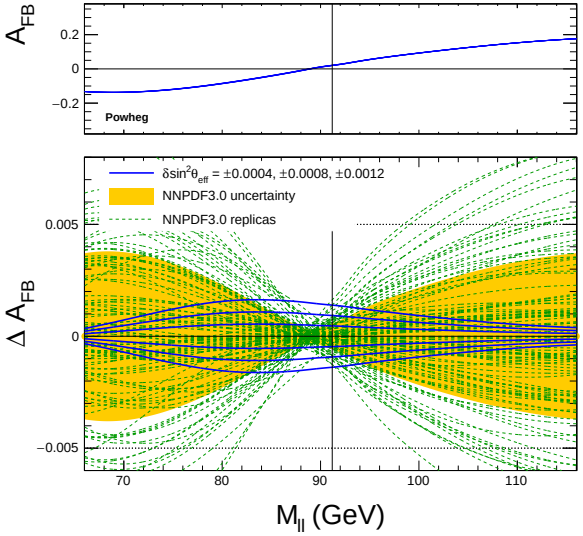
Weak mixing angle using A_{FB} at 8 TeV





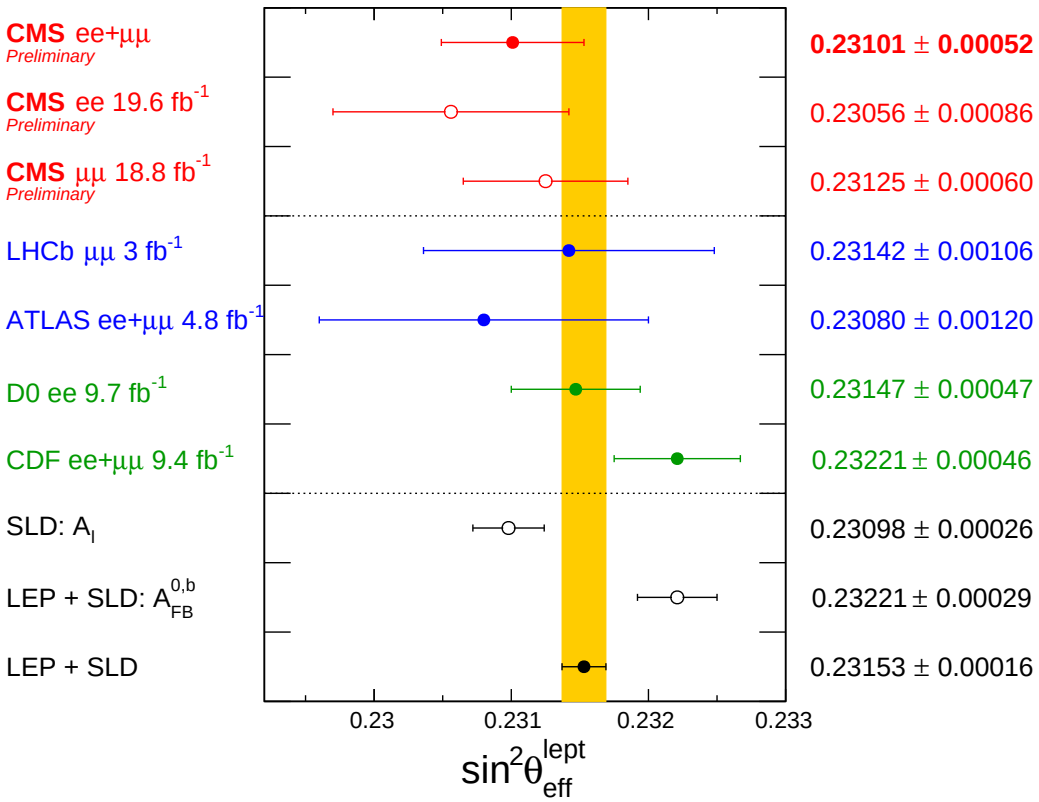


- $\sim 19\ fb^{-1}$ of 8 TeV data used
- The statistical and systematic uncertainties are significantly reduced
- Fit of experimental A_{FB} with theory
- CMS-PAS-SMP-16-007



Weak mixing angle using A_{FB} at 8 TeV (II)

- One of the most precise measurements
- PDF are constrained in-situ
- $sin^2\theta^{lept}_{eff} = 0.23101 \pm 0.00036(stat) \pm 0.00018(syst) \pm 0.00016(theory) \pm 0.00030(pdf)$
- CMS-PAS-SMP-16-007
- Can reach better precision then LEP+SPD after LHC and CMS upgrade CMS-PAS-FTR-17-001



L_{int}	$\delta_{stat}[10^{-5}]$		$\delta^{nominal}_{nnpdf3.0}[10^{-5}]$		$\delta^{constrained}_{nnpdf3.0}[10^{-5}]$	
(fb^{-1})	$\lvert\eta\rvert < 2.4$	$\lvert\eta\rvert < 2.8$	$\lvert\eta\rvert < 2.4$	$\lvert\eta\rvert < 2.8$	$\lvert\eta\rvert < 2.4$	$\lvert\eta\rvert < 2.8$
10	76	51	75	57	39	29
100	24	16	75	57	27	20
500	11	7	75	57	20	16
1000	8	5	75	57	18	14
3000	4	3	75	57	15	12
19	43		49		27	
19 (from [1])	44		54		32	

Conclusion

Many W/Z cross section measurements were done by CMS

- High precision measurements
- Some channels are analyzed at 13 TeV
- SM predictions tested
- PDFs constrained
- High precision weak mixing angle measurements available

More 13 TeV data to analyze ($\sim 100\ fb^{-1}$)