Les Rencontres de Physique de la Vallée d'Aoste 2017

Top, EWK and Recent Results from CDF and Combinations from the Tevatron

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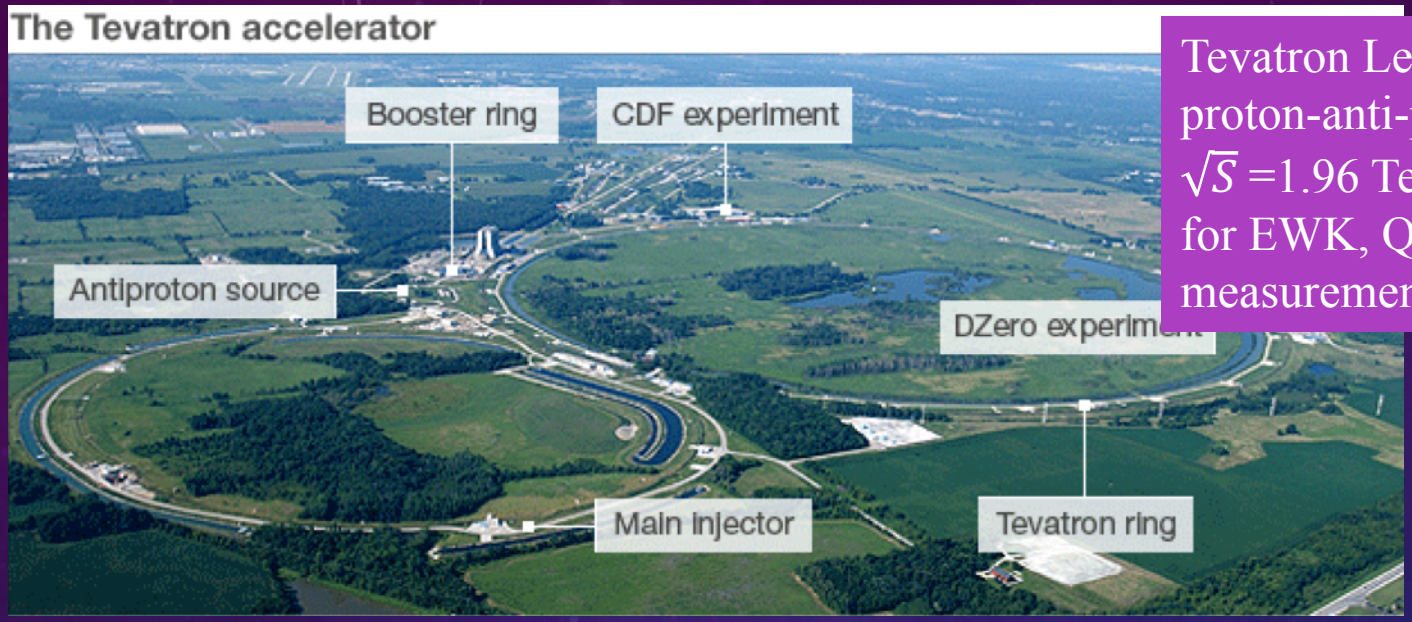
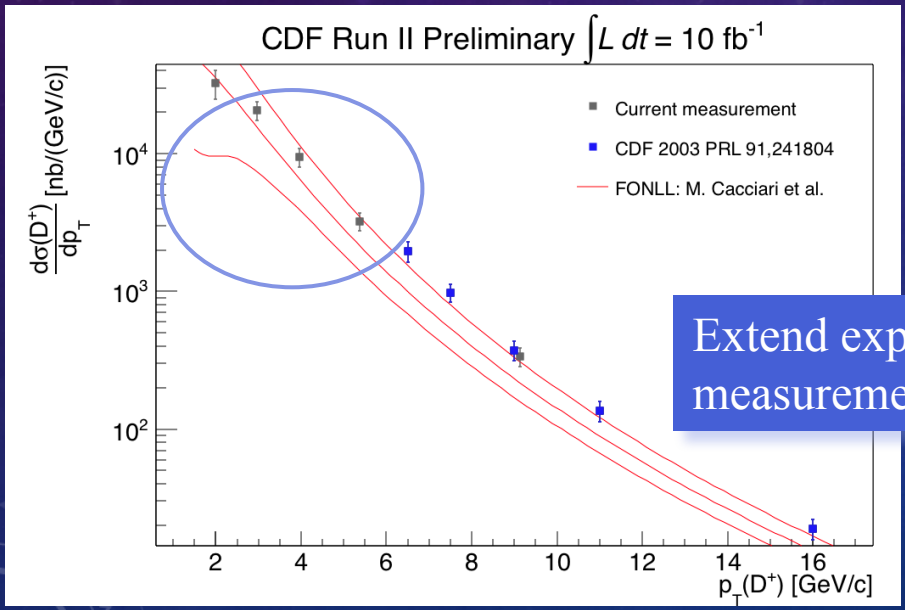
On behalf of CDF & D0 Collaborations



Tevatron Legacy: proton-anti-proton data at $\sqrt{S}$ =1.96 TeV still interesting for EWK, QCD, Top measurements



Low momentum D^+ meson production cross section, CDF Public page

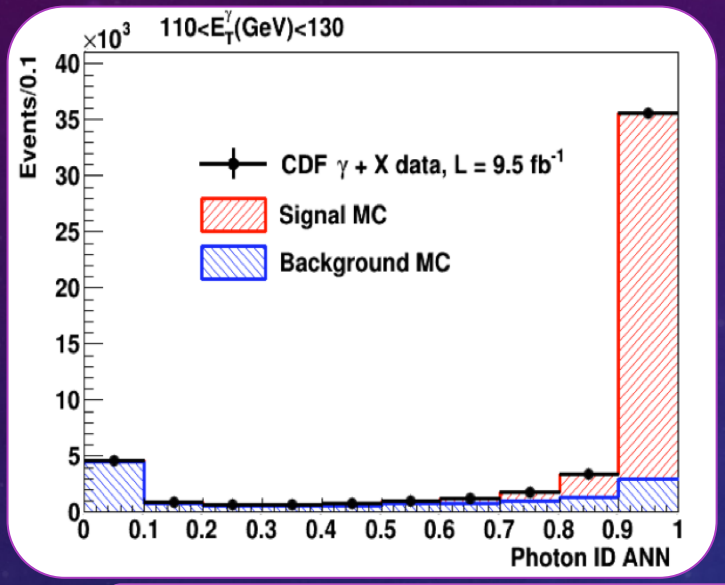
$$D^+ \rightarrow K^-\pi^+\pi^+$$

Extend experimental $p\bar{p}$ measurement down to 1.5 GeV/c^2

Inclusive Prompt Photon Cross Section

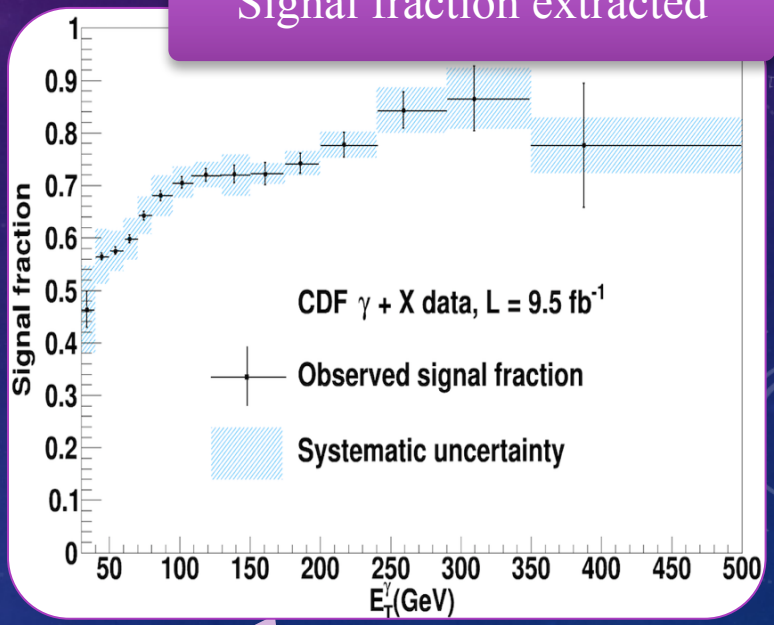
arXiv:1703.00599 (Sub. Phys. Rev. D-RC)

- QCD tests via Parton Distribution Function (PDF) probe
- Environment where New Physics can manifest itself

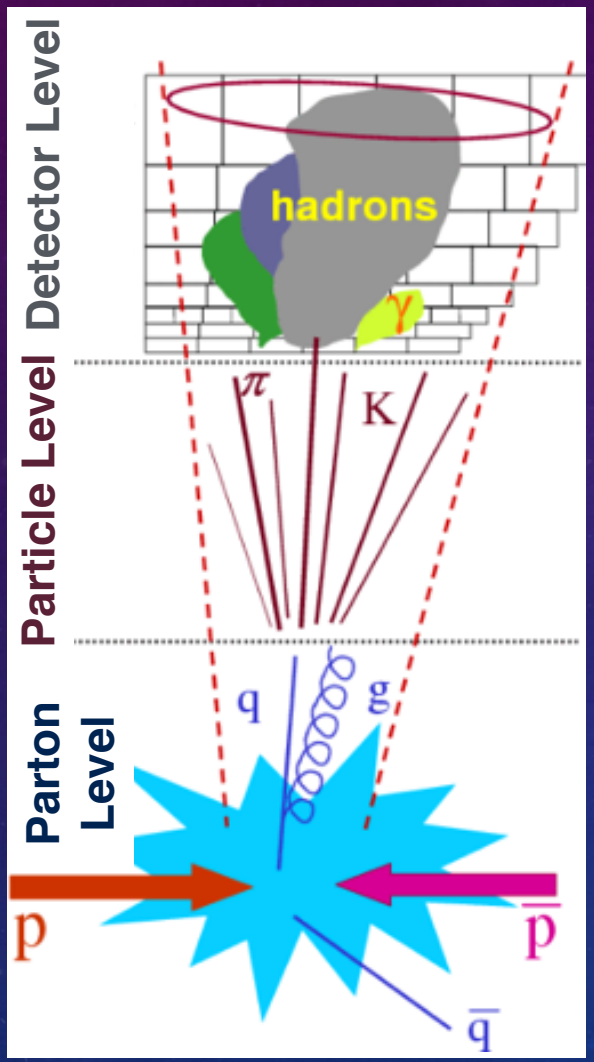


Signal separated by the QCD background with Artificial Neural Network by fitting data in E_T bin

Signal fraction extracted



Experimental measurement → parton level information



CDF detector simulation

Particle Level

PYTHIA LO generator + hadronization

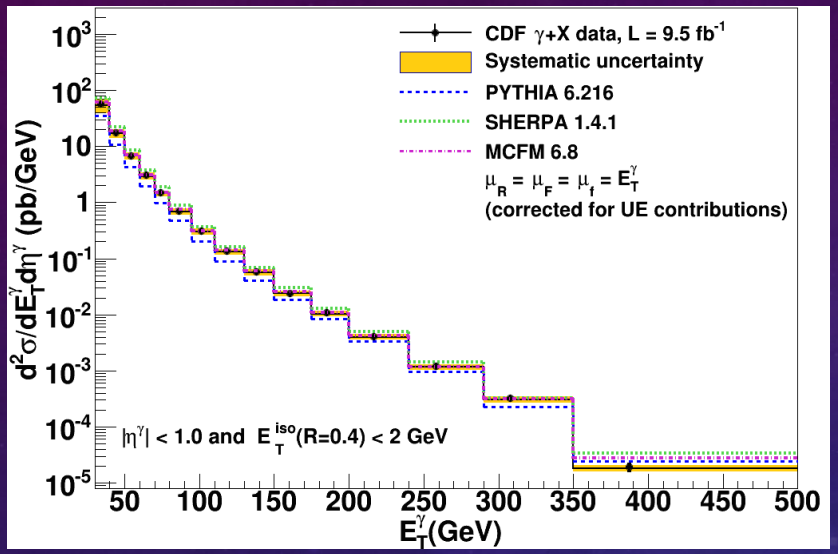
SHERPA Matrix Element generator + Parton Shower

Predictions at particle level can be compared directly to data measurement.

PYTHIA is used to unfold the measurement to be compared to theory

MCFM Fixed-order NLO calculation

Comparison with theoretical predictions

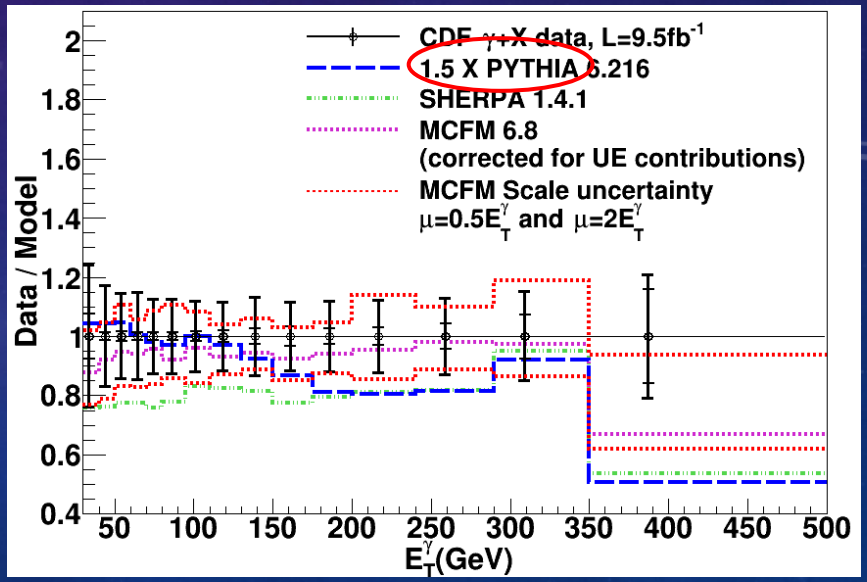


E_T Differential Cross Section compared to

- PYTHIA
- SHERPA
- MCFM

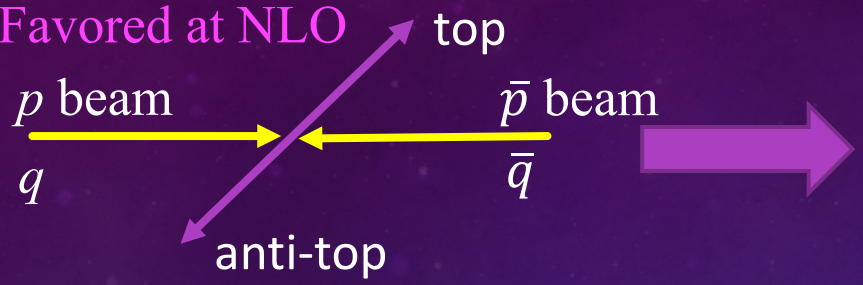
• Total uncertainty dominated by the uncertainty on ANN template

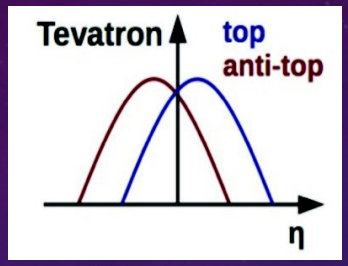
Data points centered to 1
Lines: Data/Model ratio



Measurement of $t\bar{t}$ Asymmetries

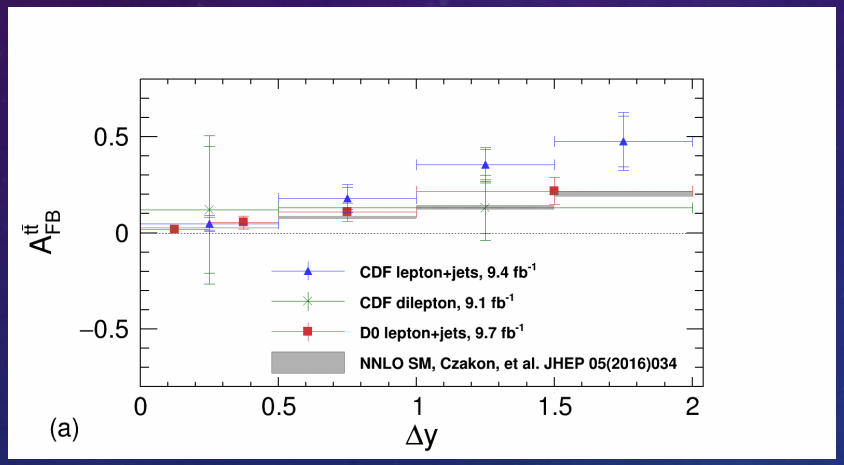
Favored at NLO



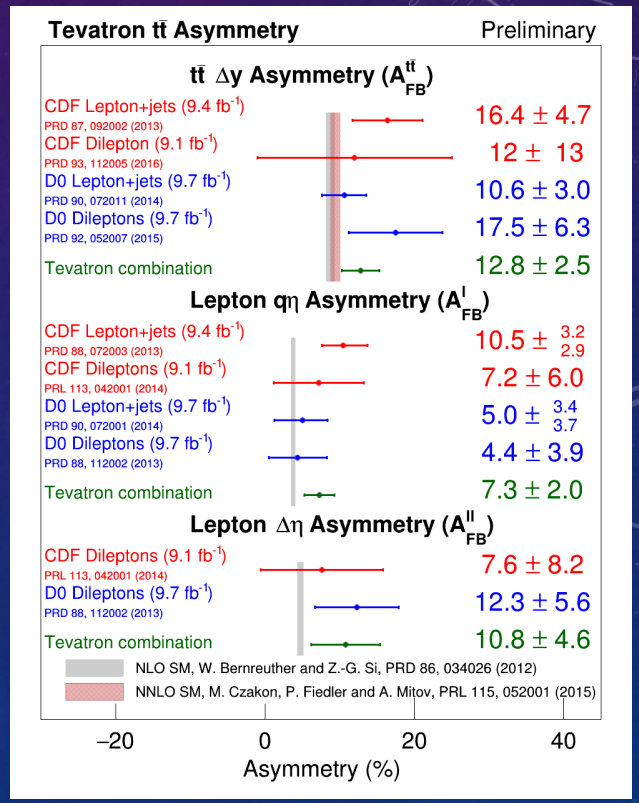


SM predictions at NLO, A_{fb}~10%

See Boris Tuchming talk this morning



Aim to combine A_{fb} as function of Δy, $m_{t\bar{t}}$



Electroweak Mixing Angle from $p\bar{p} \rightarrow Z/\gamma^{*}+X \rightarrow \ell^{+}\ell^{-} + X$

- At Born level:
  - Proceeds through $q\bar{q} \rightarrow \gamma^{*} \rightarrow \ell^{+}\ell^{-}$ and $q\bar{q} \rightarrow Z^{0} \rightarrow \ell^{+}\ell^{-}$
  - The interaction vertex of a fermion with Z boson contains axial (A) and vector (V) current components, which depends on $\sin^2\theta_w$
- Radiative corrections:
  - Born-level couplings → effective couplings $\sin^2\theta_{eff}^{lep}$

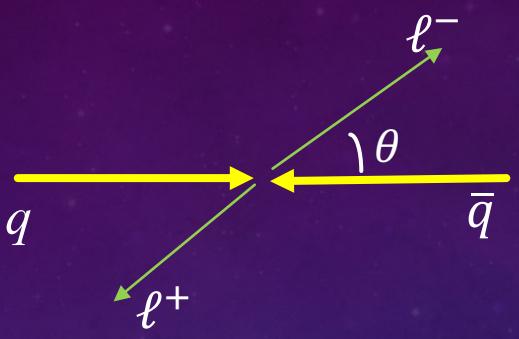
Tension between the two most precise measurements, differ by 3.2 standard deviations

	LEP-1	SLD
$\sin^2\theta_{eff}^{lep}$	0.23221 ± 0.00029	0.23098 ± 0.00026

Interesting measurement possible with the Tevatron data

Electroweak Mixing Angle and the Forward-Backward Asymmetry

Collins-Soper frame:
the center of mass frame
of dileptons



Forward, f: $cos\theta \geq 0$
Backward, b: $cos\theta < 0$

$f(\sin^2\theta_w)$

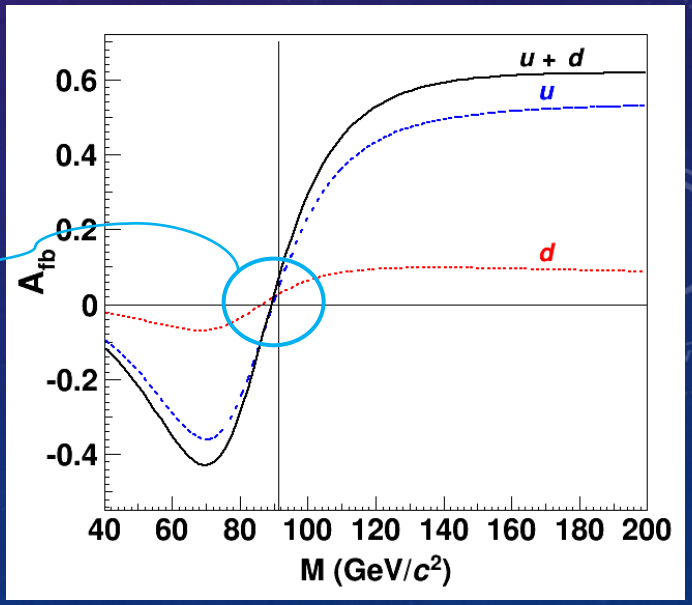
Angular distribution: $\frac{d\sigma}{dcos\theta} \propto 1 + cos^2\theta + A_4 cos\theta$

Forward-backward cross section asymmetry

$A_{fb} = \frac{\sigma_f(M) - \sigma_b(M)}{\sigma_f(M) + \sigma_b(M)} = f(A_4)$

Related to $\sin^2\theta_w$

outside dominated by
$\gamma^* - Z$ interference



Leptonic Electroweak Mixing Angle, $\sin^2 \theta_{eff}^{lep}$

CDF Public Page

Measure raw asymmetry and subtract background form QCD di-jets, W+jets, $\gamma^*/Z \rightarrow \tau\tau$

Remove effects of detector resolution and QED Final State Radiation (FSR) with simulation to get asymmetry in mass bins $A_{fb} = \frac{N_f - Nb}{N_f + Nb}$

Fit A_{fb} to templates generated with NLO simulation (POWHEG-BOX) + ZFITTER, with different values of $\sin^2 \theta_{eff}^{lep}$

Asymmetry Measurements

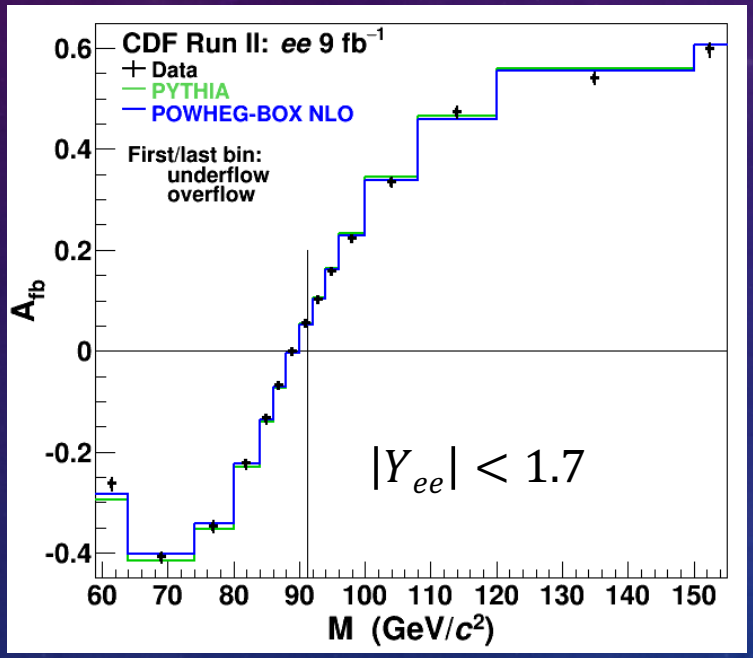
$Z \rightarrow ee$

$E_T > 20\ (25/15)\ GeV$

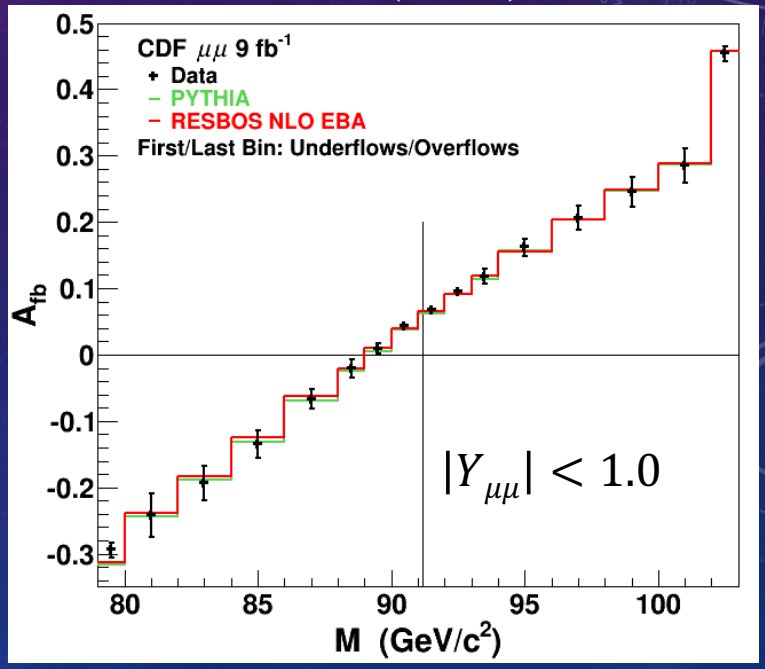
$Z \rightarrow \mu\mu$

$P_T > 20\ GeV$

PRD 93, 112016(2016)



PRD 89, 072005(2014)

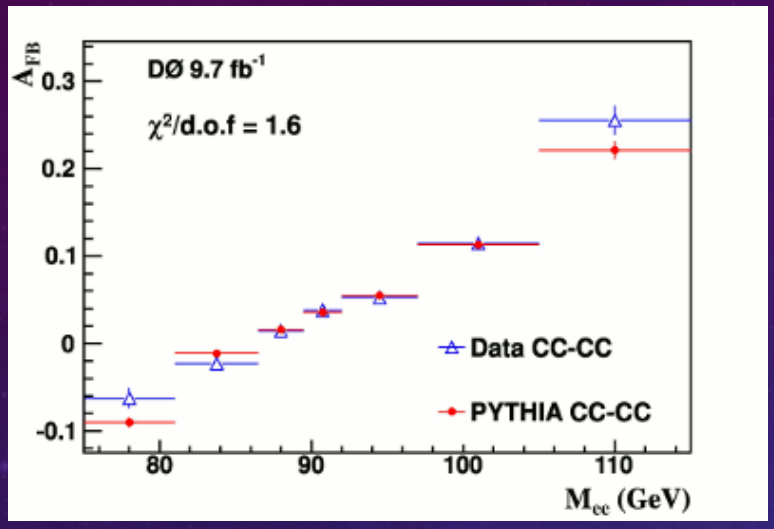


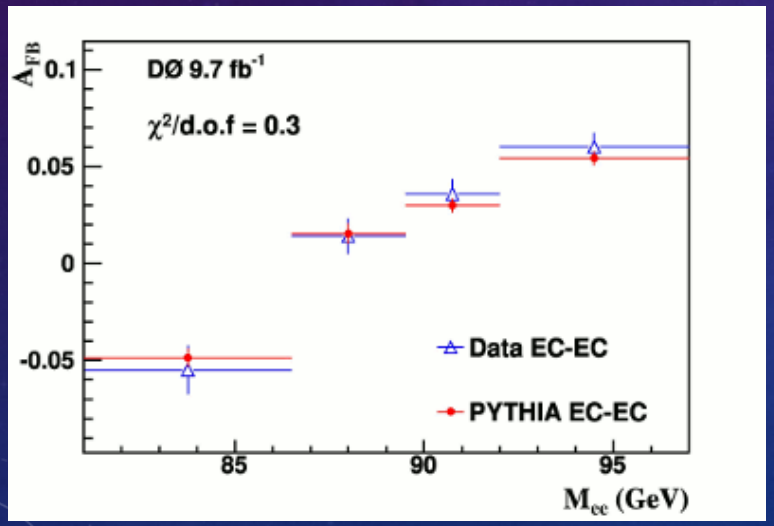
$0.23248 \pm 0.00049(stat) \pm 0.00019(sys)$

$0.2315 \pm 0.0009(stat) \pm 0.0004(sys)$

Asymmetry Measurements

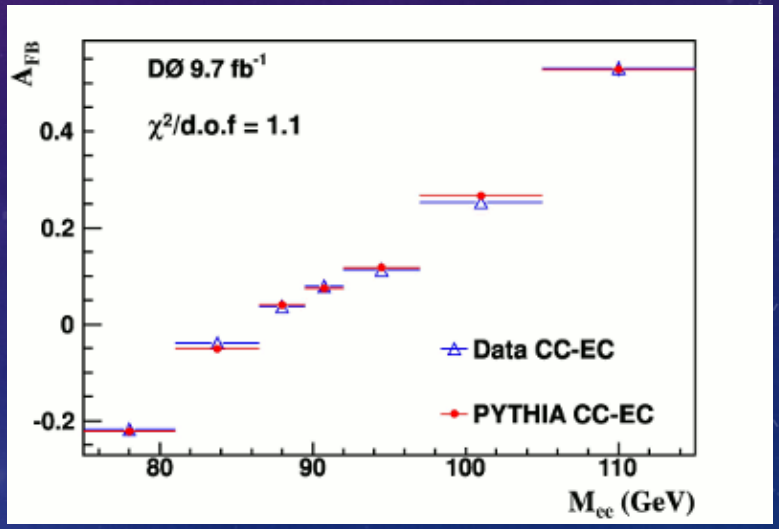
PRL 115, 041801(2015)





$Z \rightarrow ee$

$E_T > 20\ (25/15)\ GeV$



$0.23147 \pm 0.00043(stat) \pm 0.00019(sys)$

Combination of $\sin^2\theta_{eff}^{lep}$ Measurements

D0 used $Z/\gamma^* \rightarrow e^+ e^-$

$0.23137 \pm 0.00043(stat) \pm 0.00019(sys)$

CDF combination

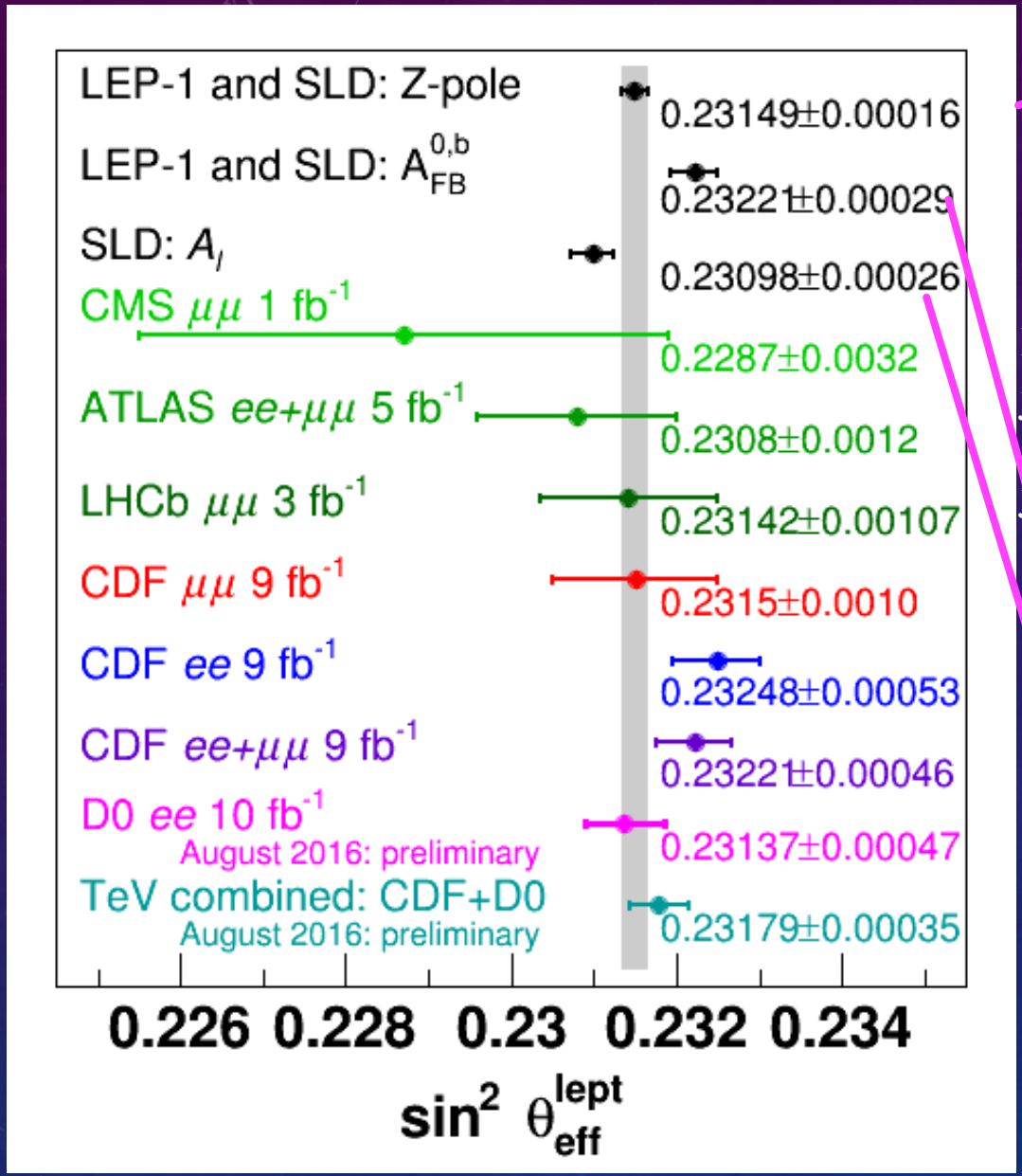
$0.23221 \pm 0.00043(stat) \pm 0.00018(sys)$

Use Best Linear Unbiased Estimate (BLUE) method to

Source	CDF Inputs	D0 Inputs
Statistics	± 0.00043	± 0.00043
NNPDF PDF	± 0.00016	± 0.00017
Uncorrelated	± 0.00007	± 0.00008
Correction		± 0.00005

Result:

$\mathbf{\sin^2\theta_{eff}^{lep} = 0.23179 \pm 0.00030(stat) \pm 0.00017(sys)}$



combination of six Z-pole measurements

Phys. Rev. D84 112002, 2011

J. High En. Phys. 09 (2015) 049

J. High En. Phys. 11 (2015) 190

Corresponding to this measurement

LR polarization asymmetry of Z

Inference of W boson Mass

In the SM $\sin^2\theta_w \equiv 1 - \frac{M^2{}_w}{M^2{}_z}$ from which the W mass is inferred

Assuming:

- $M_Z = 91.1875 \pm 0.0021\ GeV/c^2$ LEP-1+SLD

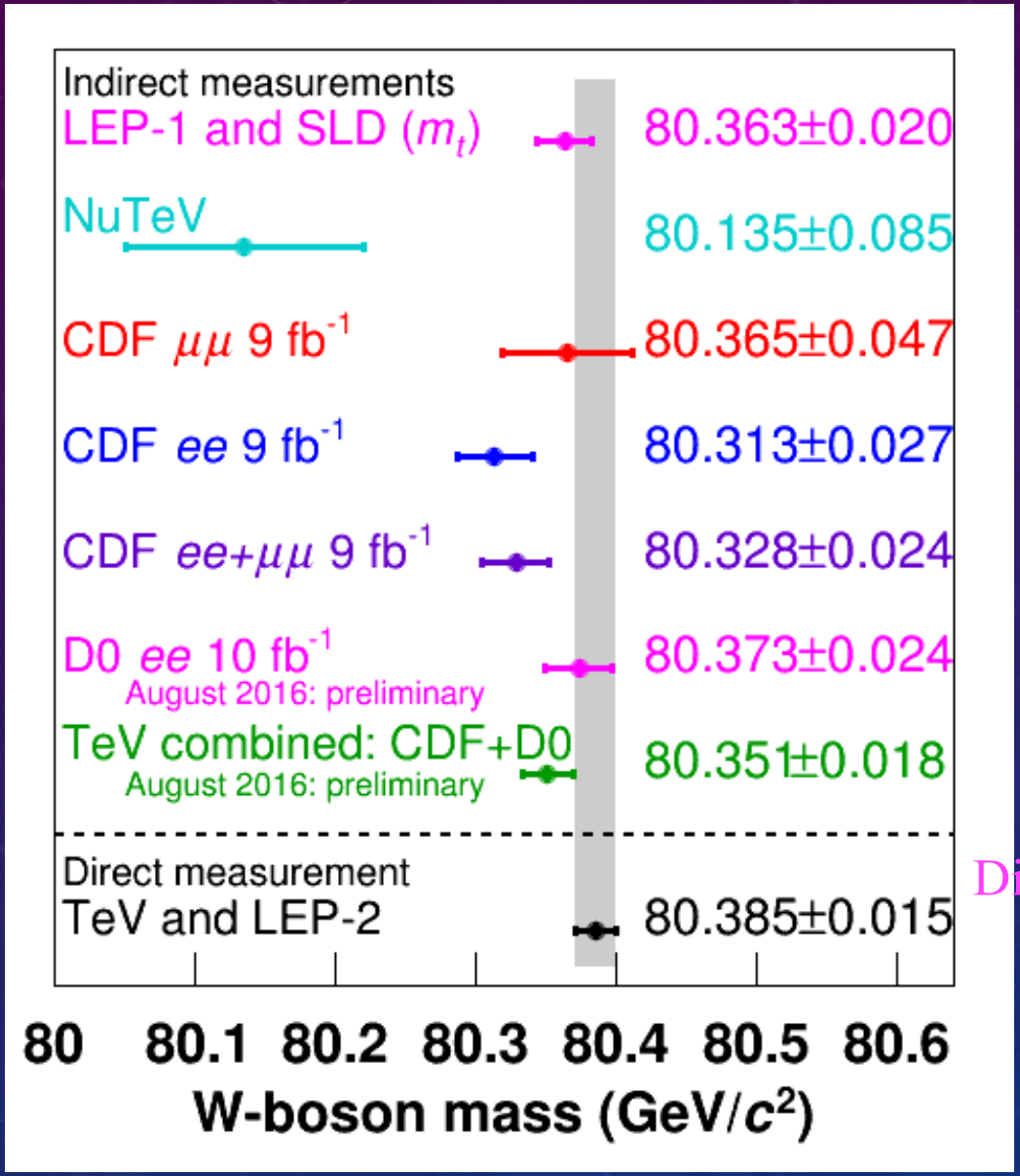
and obtaining $\sin^2\theta_w$

- $\sin^2\theta_{eff}{}^{lep} = Re[k_l(M^2{}_z, \sin^2\theta_w)]\sin^2\theta_w$

≈ 1.037 from ZFITTER
It depends on SM parameters, most sensitive to
Top Mass: 173.2±0.9 GeV/c²
Higgs Mass: 125

Results

	$\sin^2\theta_w$	Mw
CDF	$0.22400 \pm 0.00041 \pm 0.00019$	$80.328 \pm 0.021 \pm 0.010\ GeV/c^2$
D0	$0.22313 \pm 0.00041 \pm 0.00020$	$80.373 \pm 0.021 \pm 0.010\ GeV/c^2$
CDF+D0	$0.22356 \pm 0.00029 \pm 0.00019$	$80.351 \pm 0.015 \pm 0.010\ GeV/c^2$



Direct measurement

Conclusion

CDF and D0 collaboration are still producing interesting results some of them competitive to the LHC measurements

For CDF further results are still expected on :

- $Z \rightarrow b\bar{b}$ cross section measurement and b-jet energy scale determination
- Limit on Higgs in the MSSM framework
- W mass, direct measurement with significant sample increase (current measurement is with 2.2 fb^{-1})
- Top polarization
- Tetraquarks

... and Tevatron combinations