Measurement of the Forward-Backward Charge Asymmetry in $p\bar{p} \to Z/\gamma^* \to ee$ at DØ

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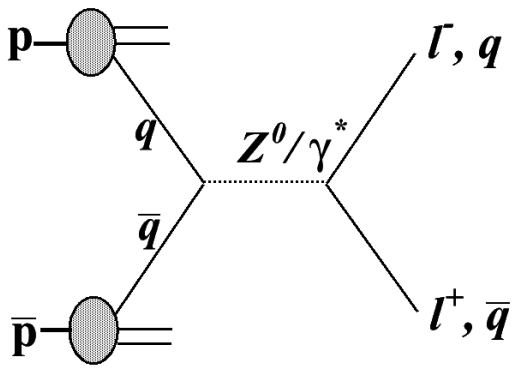
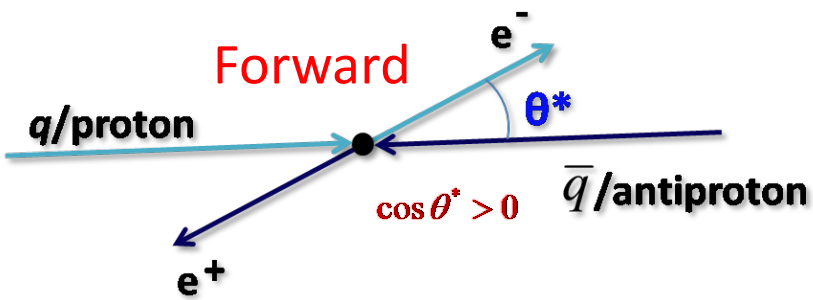
Lake Louise Winter Institute 2010

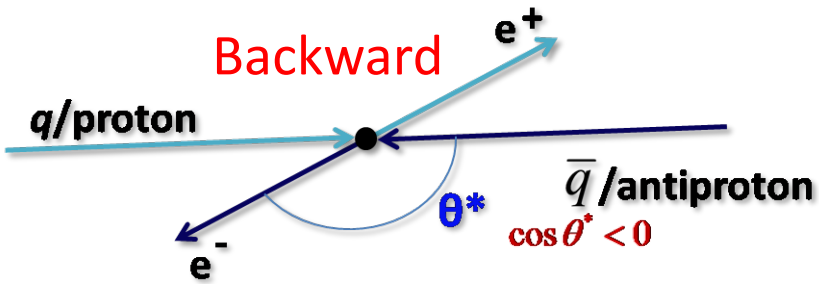
Introduction



- Vector and axial-vector couplings of Z boson to fermion: $g_V^f = I_3^f - 2Q_f \sin^2\theta_W$ and $g_A^f = I_3^f$

  The presence of both vector and axial vector couplings gives rise to non-zero A_{FB}.

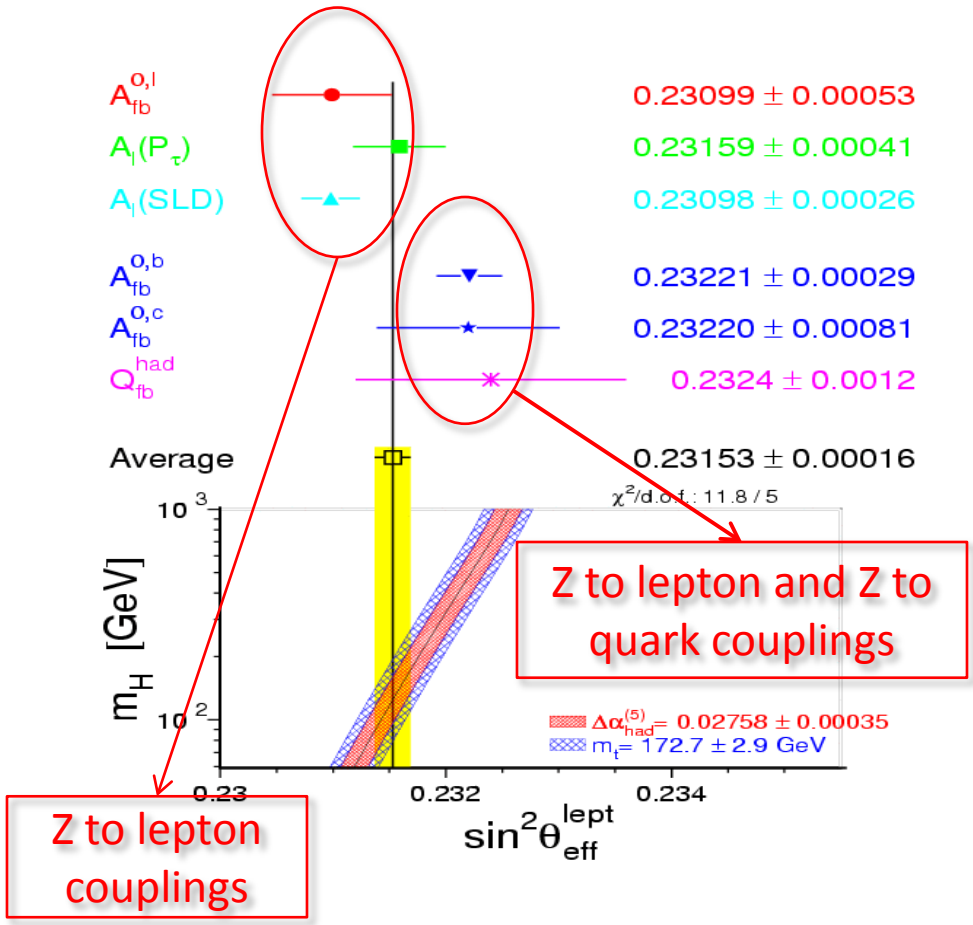


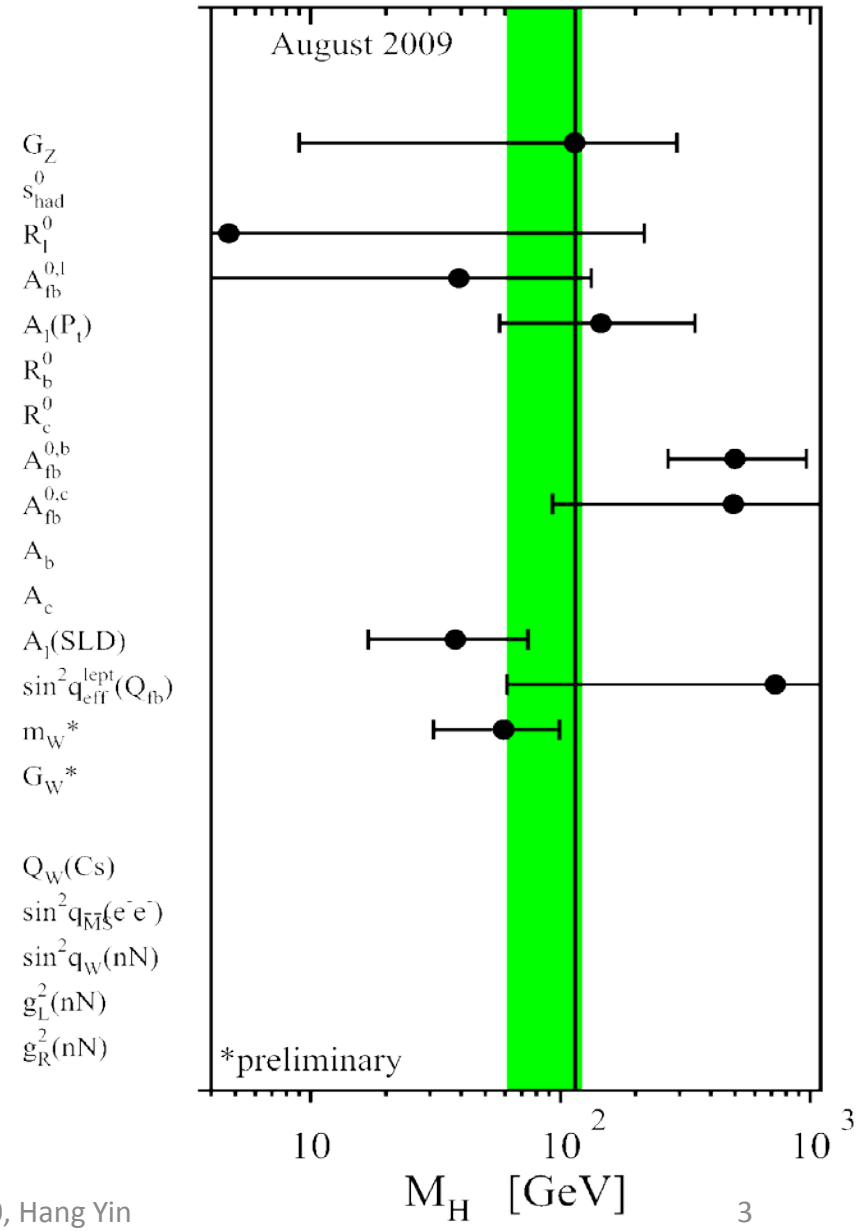


- The differential cross section: $\frac{d\sigma}{d\cos\theta^*} = A(1+\cos^2\theta^*) + B\cos\theta^*$
- Forward-backward asymmetry : $A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B}$
  - σ_F : the cross section for events with $\cos\theta^* > 0$
  - σ_B : the cross section for events with $\cos\theta^* < 0$

$\sin^2\theta_W$

- A_{FB} is sensitive to $\sin^2\theta_W$
- Given α, G_f, and M_Z, we can use $\sin^2\theta_W$ to constraint higgs mass



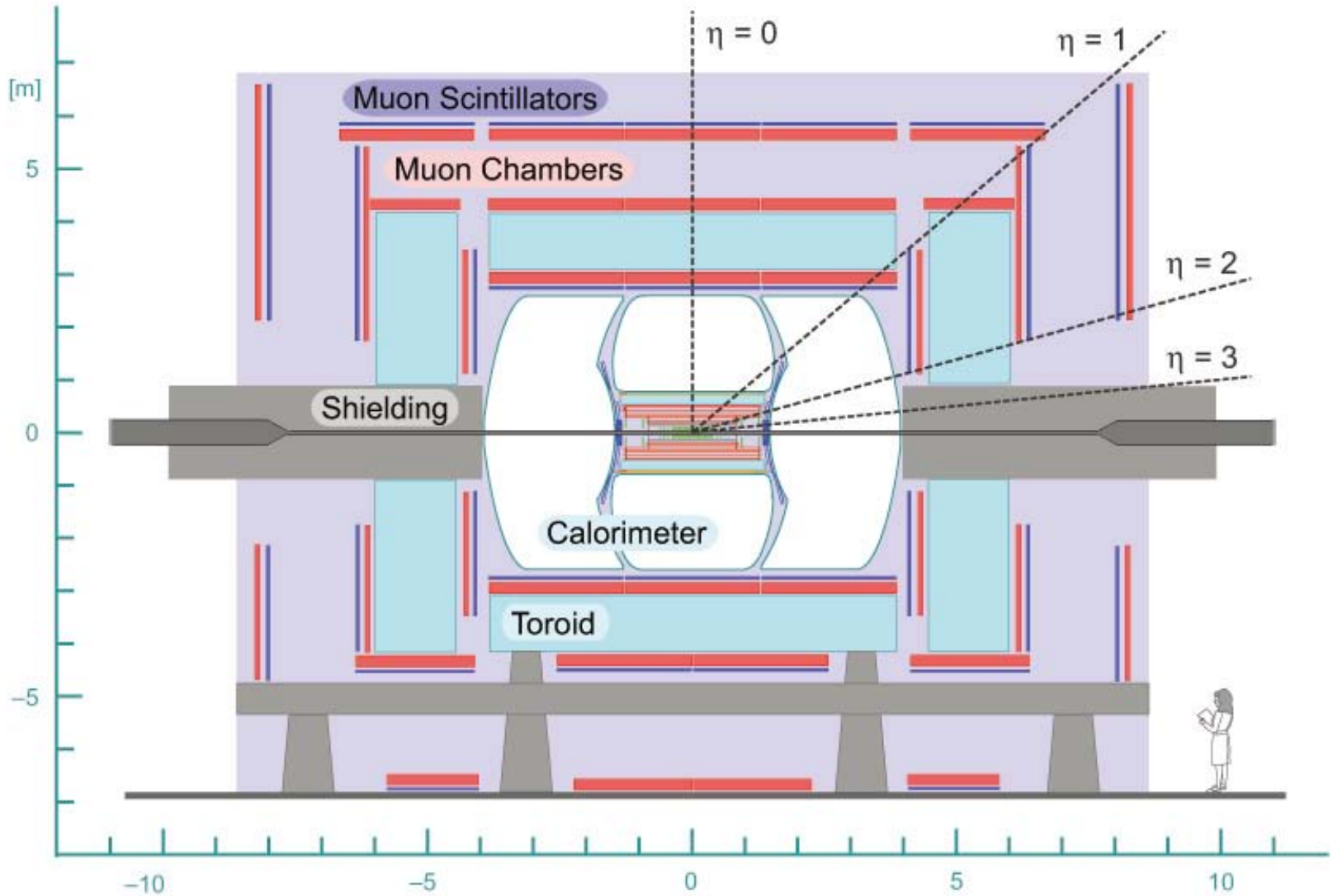


Motivation

- Test of Standard Model
  - Forward-backward asymmetry
  - Weak mixing angle
  - Differential cross section in high mass region
  - Z to light quark couplings

- Sensitive to beyond SM physics

DØ detector


η = 0
η = 1
η = 2
η = 3
[m]
5
0
−5
Muon Scintillators
Muon Chambers
Shielding
Calorimeter
Toroid
−10
−5
0
5
10

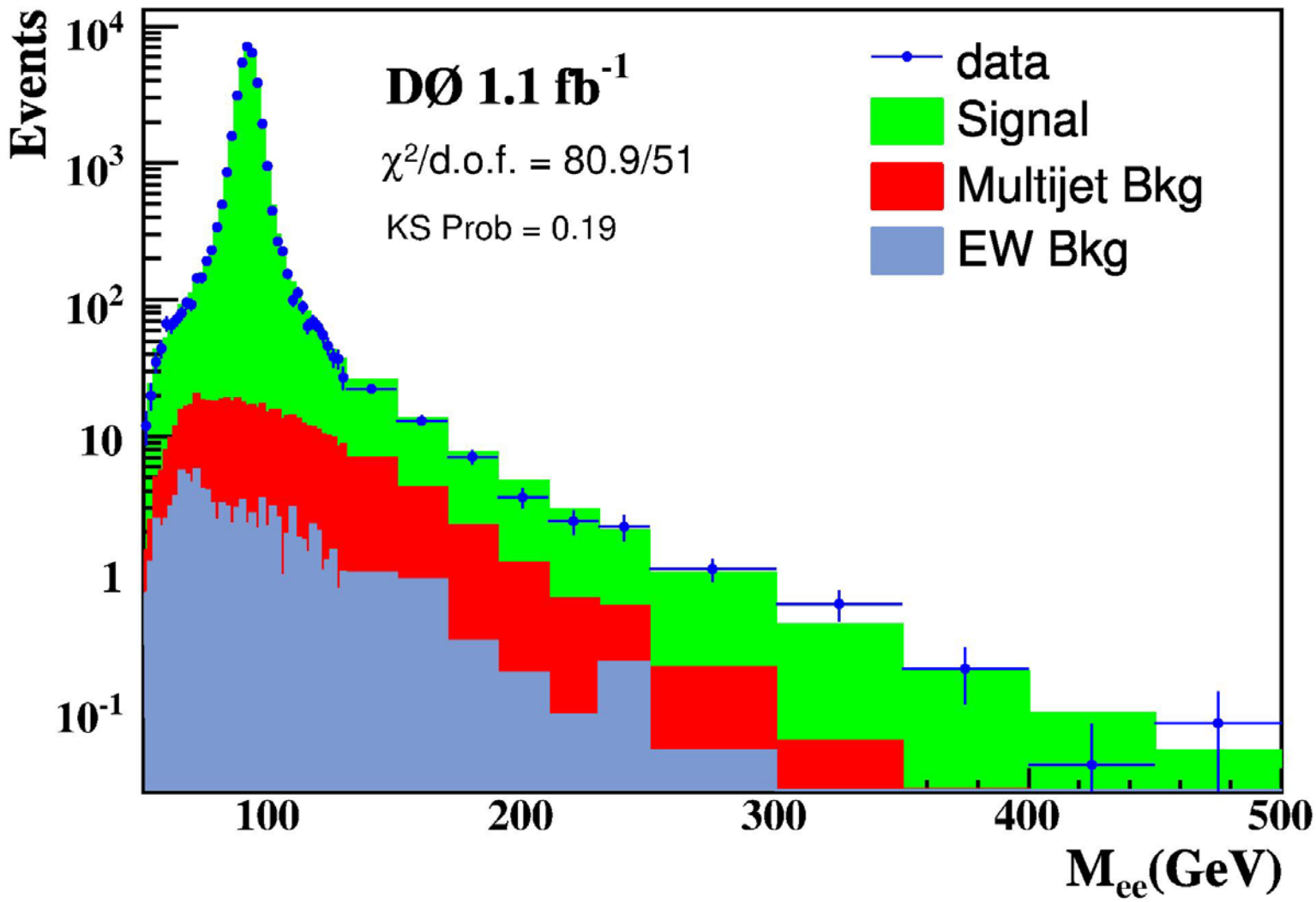
Event selections

- D∅ data: L = 1.1 fb^{-1}
- Two isolated electrons requirements:
  - pT > 25 GeV
  - Shower shape consistent with that of a electron
- At least one electron in central calorimeter
  - Two electrons in central calorimeter(CC), require two opposite charge
  - Only one electron in CC, require CC electron must have a track match(use the charge of CC electron to determine forward/backward event)

MC signals and backgrounds

- Signal: Pythia samples:
  - ***Z/γ*->ee*** samples: Mass region(40-1000GeV) passed through Geant simulation of D∅ detector
  - Generator level: Z-pT rapidity and Z Mass reweighting
  - Reconstructed level: Tuned to data by applying EM smearing, efficiencies scaling
- SM backgrounds***: Z->ττ, W+X, WW, WZ, ttbar***
- QCD background: measured from real data

Data and MC comparison



Weak mixing angle measurement

- Extraction of $\sin^2\theta_W^{eff}$

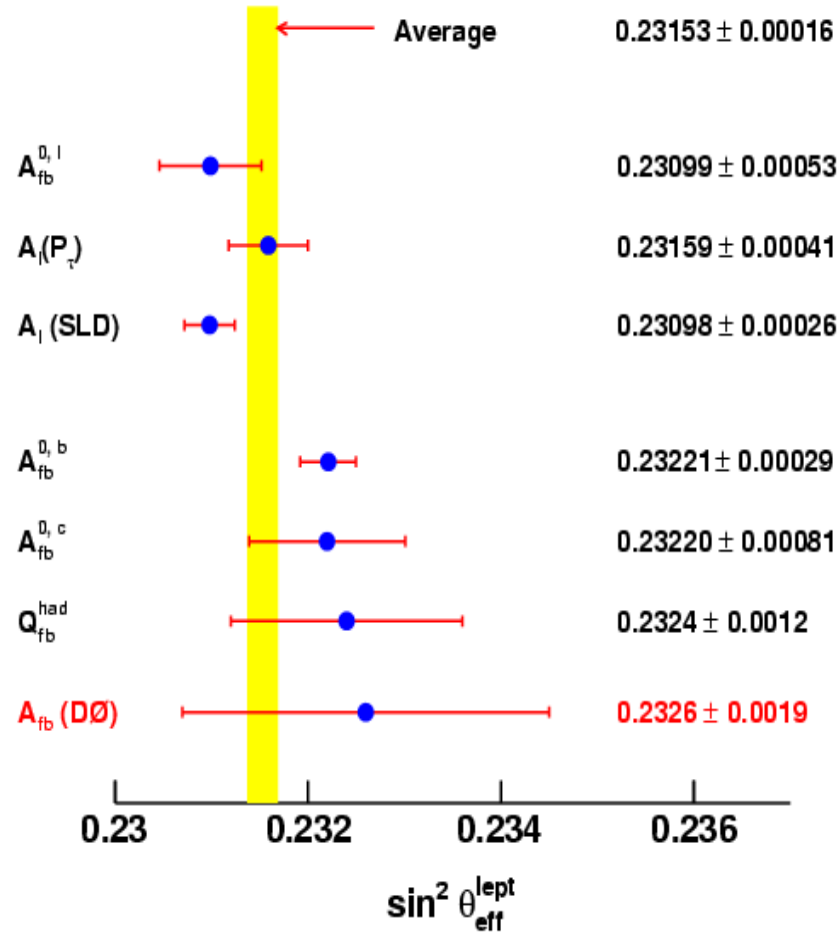
  Compare data raw AFB with predicted raw AFB from Geant MC samples with different $\sin^2\theta_W^{eff}$ input to extract the best value .

- Measured values:

  $$\sin^2\theta_W^{eff} = 0.2326 \pm 0.0018(Stat.) \pm 0.0006(Syst.)$$

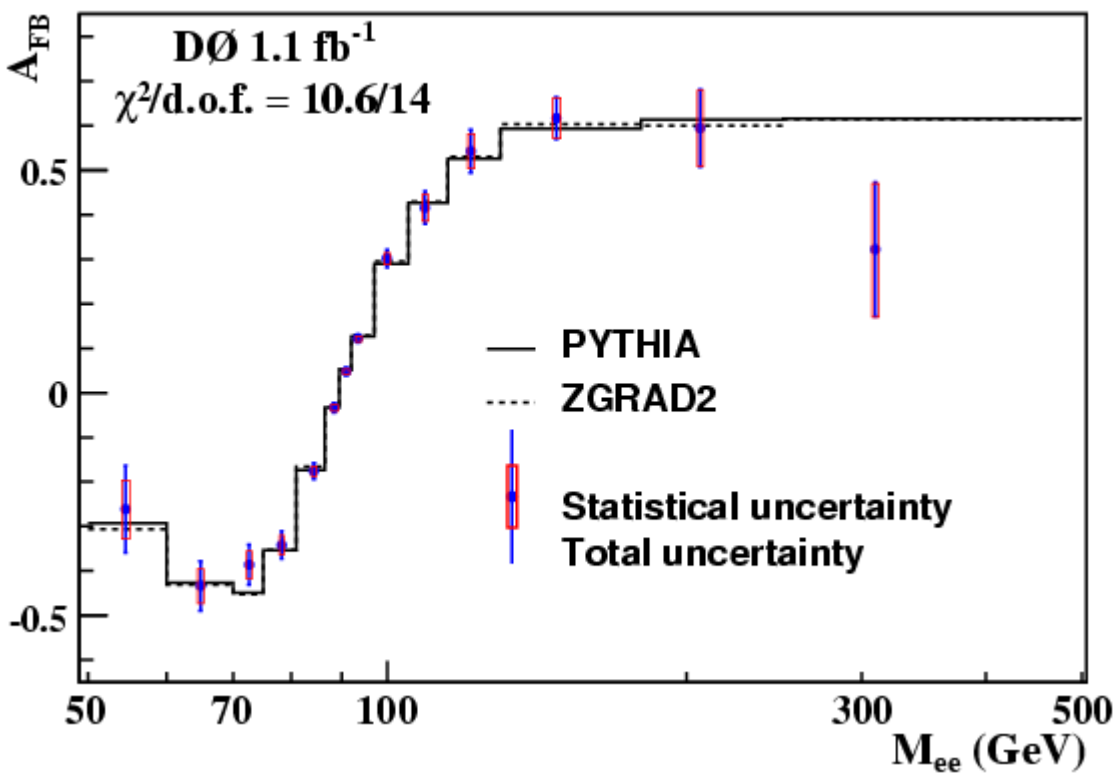
- High order correction calculated from ZGrad2: 0.0005

Phys. Rev. Lett. **101**, 191801 (2008), 1.1 fb-1



Unfolded AFB measurement

Phys. Rev. Lett. **101**, 191801 (2008), 1.1 fb-1



- Unfolding:
  - Correction due to detector resolution, Acceptance * efficiency and charge mis-ID
- Source of systematic uncertainties:
  - QCD background subtraction, charge mis-ID rate,
  - difference between F/B efficiencies, energy scale/smear,
  - PDF, QCD correction, unfolding method, mc sample input AFB

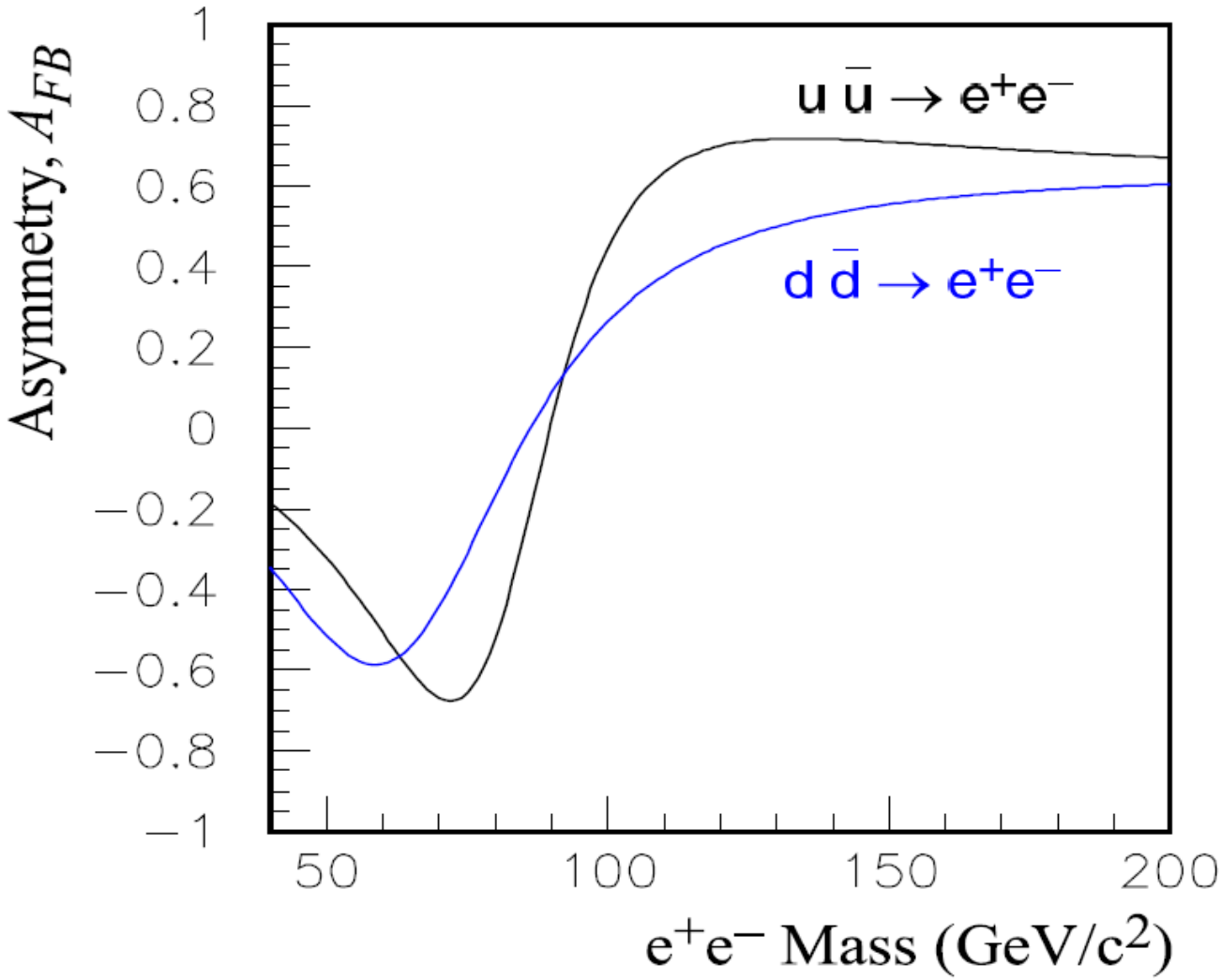
Summary

- Measured A_{FB} with 1.1 fb^{-1} DØ data, has been published in Phys. Rev. Let. 101,191801(2008)
- Unfolded data A_{FB} agrees with PYTHIA prediction
  - Use 10 times more data than previous results(CDF Phys. Rev. D 71, 052002 (2005))
- Measured $\sin^2\theta_W^{eff} = 0.2326 \pm 0.0018(Stat.) \pm 0.0006(Syst.)$
  - Just using electron channel, the precision is comparable with the uncertainty of LEP(HAD) and NuTeV
  - Results agrees with Global EW fit

- For weak mixing angle, with 8-10 fb-1 combine both electron and muon channel with CDF, the expected precision will be comparable with WA
- Also can measure Z to light quark couplings and differential cross section

BACKUP

u/d AFB


Asymmetry, A_{FB}
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
50
100
150
200
e^+e^- Mass (GeV/c^2)
$u\,\bar{u} \to e^+e^-$
$d\,\bar{d} \to e^+e^-$