



$t\bar{t}$ FB asymmetry in the dilepton channel at CDF

Top physics: from charge asymmetry to the boosted regime, CERN

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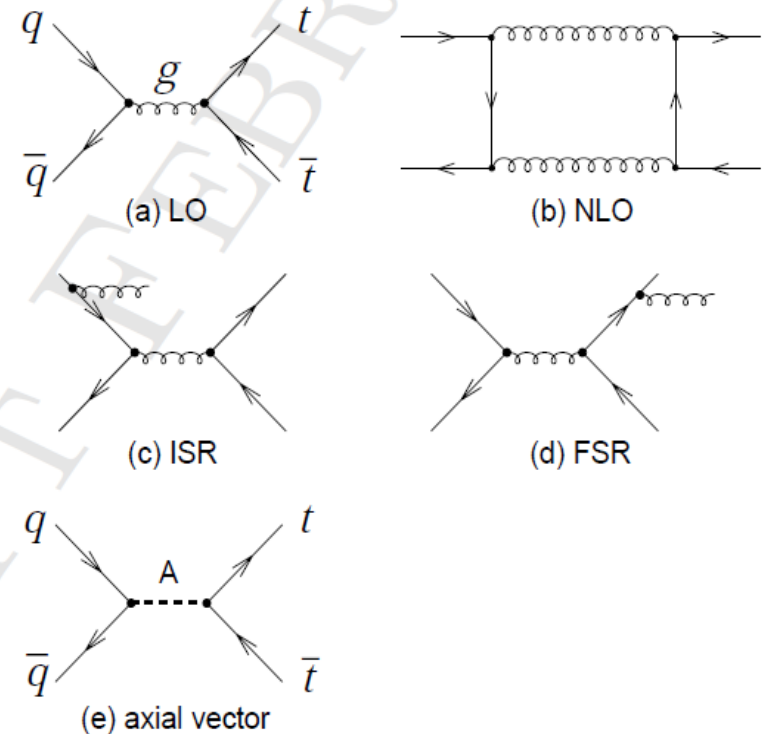
- Currently, large forward-backward asymmetry in $t\bar{t}$ production has been measured at lepton+jet channel and dilepton channel

- In Standard Model

At LO QCD, top production is symmetric.

At NLO, slight asymmetry is predicted as ~ 0.05

- Afb is measured using dilepton samples of CDF data





Part I :

- btagged dilepton samples



Event selection



➤ Signal Selection

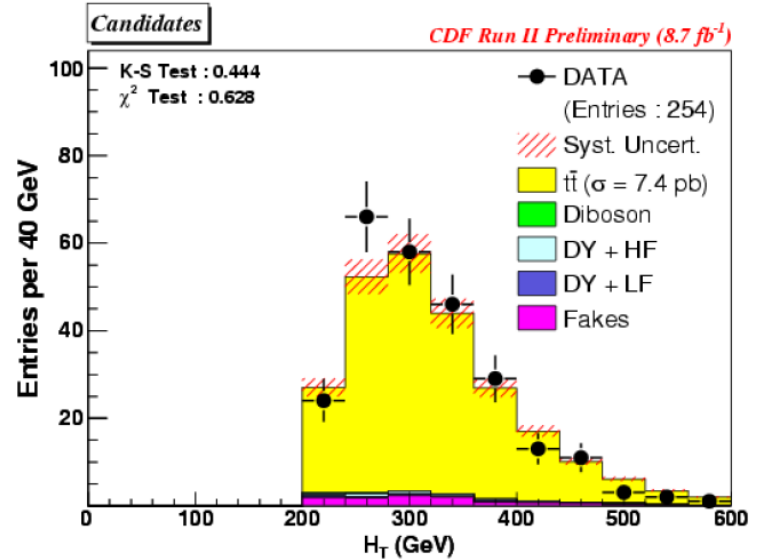
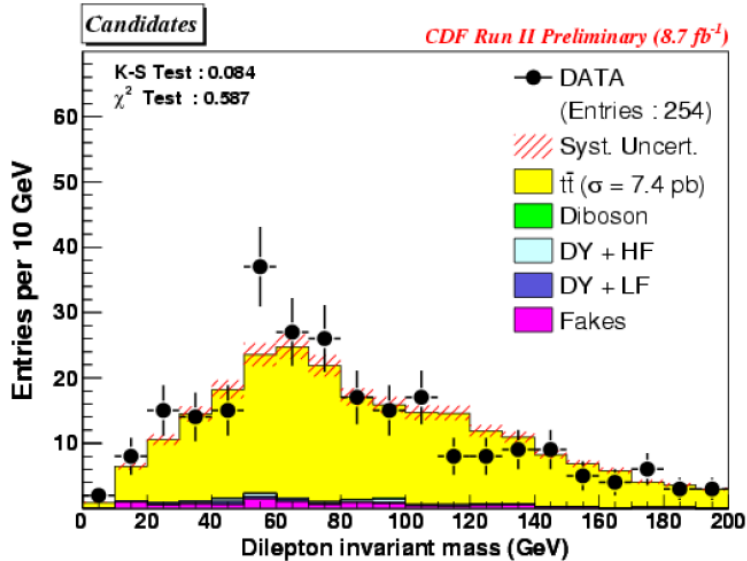
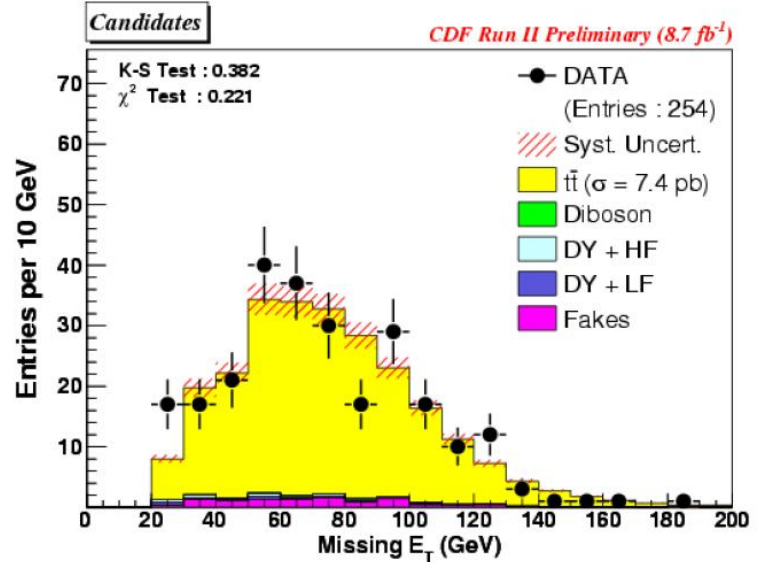
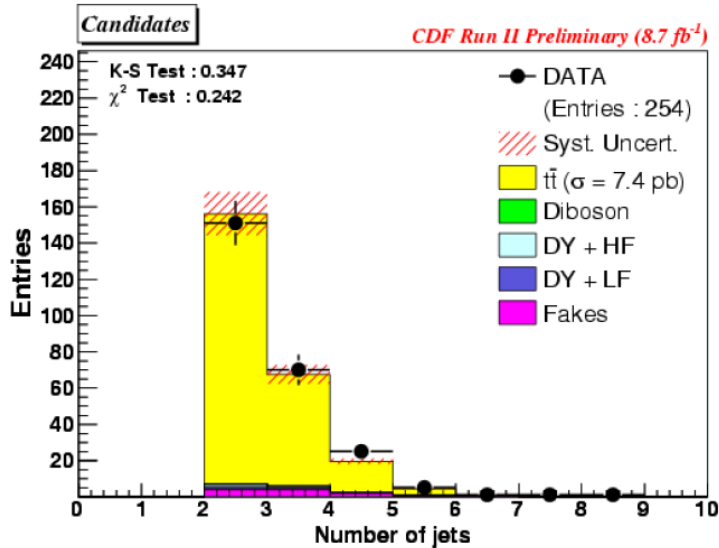
- 2 leptons
at least one tight lepton in CEM/PHX/CMX/CMUP with $E_T > 20 \text{ GeV}$
- At least 2 tight jets with $E_T > 15 \text{ GeV}$
- MET > 25 GeV
- At least one jet with b-tag passed

➤ Background rejection

- MET > 50 GeV
if minimum angle between MET and any lepton or jet is less than 20°
- Z-veto
MET significance > 4 for event with same lepton flavour with
 $76 < M_{ll} < 106 \text{ GeV}$
- HT > 200 GeV , for opposite charged leptons
- $M_{ll} > 5 \text{ GeV}$, for COT radius cut > 140 cm



b-tagged dilepton events





Background expectation



Int. Luminosity = 8.7 fb^{-1}

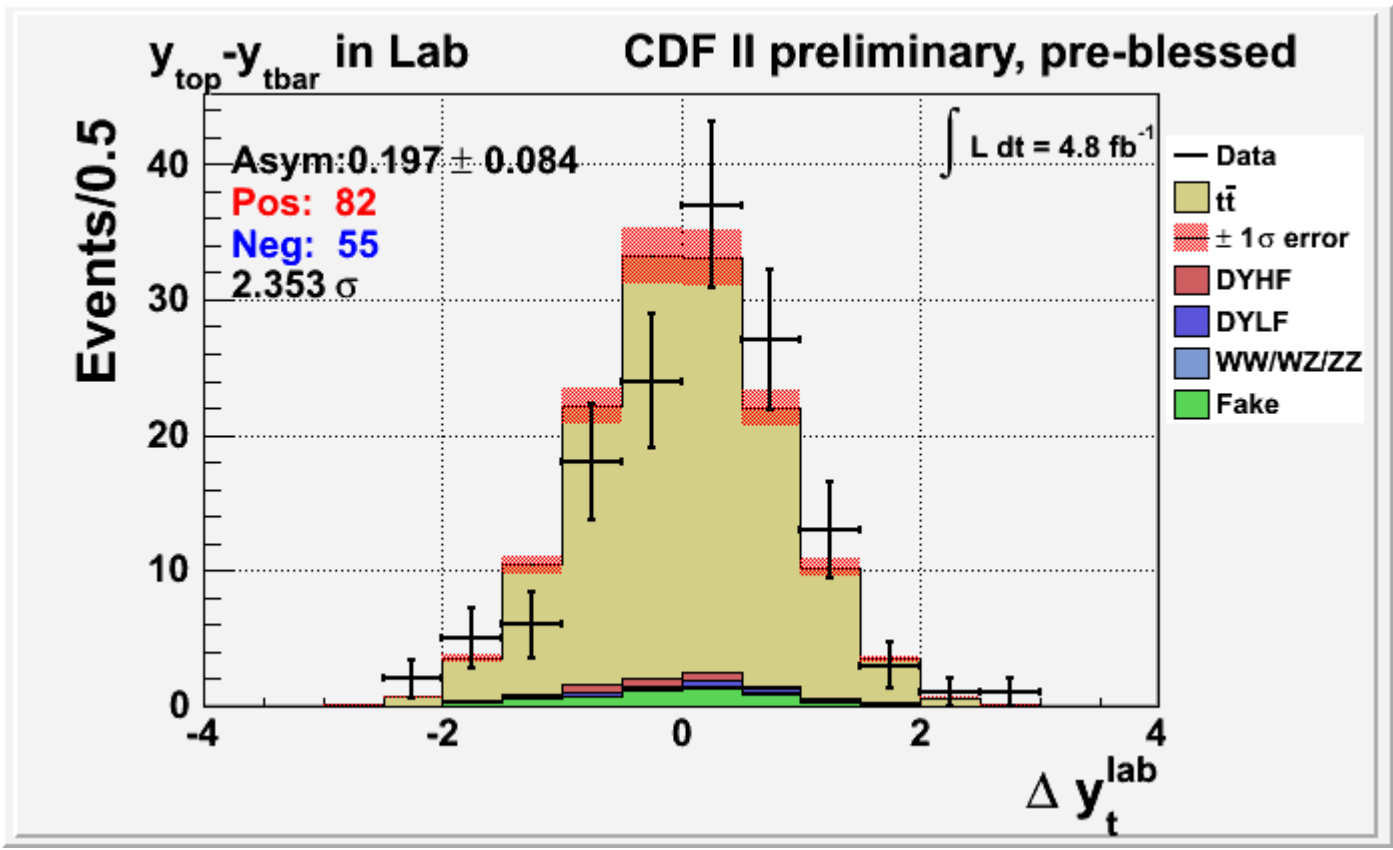
DY_HF	2.88 ± 0.34
DY_LF	2.61 ± 0.27
WW	0.59 ± 0.16
WZ	0.13 ± 0.03
ZZ	0.97 ± 0.26
Fake	10.76 ± 3.06
Total background	17.94 ± 3.20
ttbar ($\sigma=7.4\text{pb}$)	231.89 ± 16.04
Total SM expectation	249.84 ± 19.08
Data	254

- After DIL event selection, likelihood fitting is applied to reconstruct the direction of t and $tbar$ and Δy_t

$$\mathcal{L}(\vec{p}_\nu, \vec{p}_{\bar{\nu}}, E_b, E_{\bar{b}}) = P(p_z^{t\bar{t}}) P(p_T^{t\bar{t}}) \times \frac{1}{\sigma_{\text{jet1}}} \exp\left[-\frac{1}{2} \left\{ \frac{E_{\text{jet1}}^{\text{meas}} - E_{\text{jet1}}^{\text{guess}}}{\sigma_{\text{jet1}}} \right\}^2\right] \times \frac{1}{\sigma_{\text{jet2}}} \exp\left[-\frac{1}{2} \left\{ \frac{E_{\text{jet2}}^{\text{meas}} - E_{\text{jet2}}^{\text{guess}}}{\sigma_{\text{jet2}}} \right\}^2\right] \times \frac{1}{\sigma_x^{\text{MET}}} \exp\left[-\frac{1}{2} \left\{ \frac{E_x^{\text{meas}} - E_x^{\text{guess}}}{\sigma_x^{\text{MET}}} \right\}^2\right] \times \frac{1}{\sigma_y^{\text{MET}}} \exp\left[-\frac{1}{2} \left\{ \frac{E_y^{\text{meas}} - E_y^{\text{guess}}}{\sigma_y^{\text{MET}}} \right\}^2\right],$$

- Resolution functions of JES, MET and probability functions of P_T , P_Z are estimated from MC samples

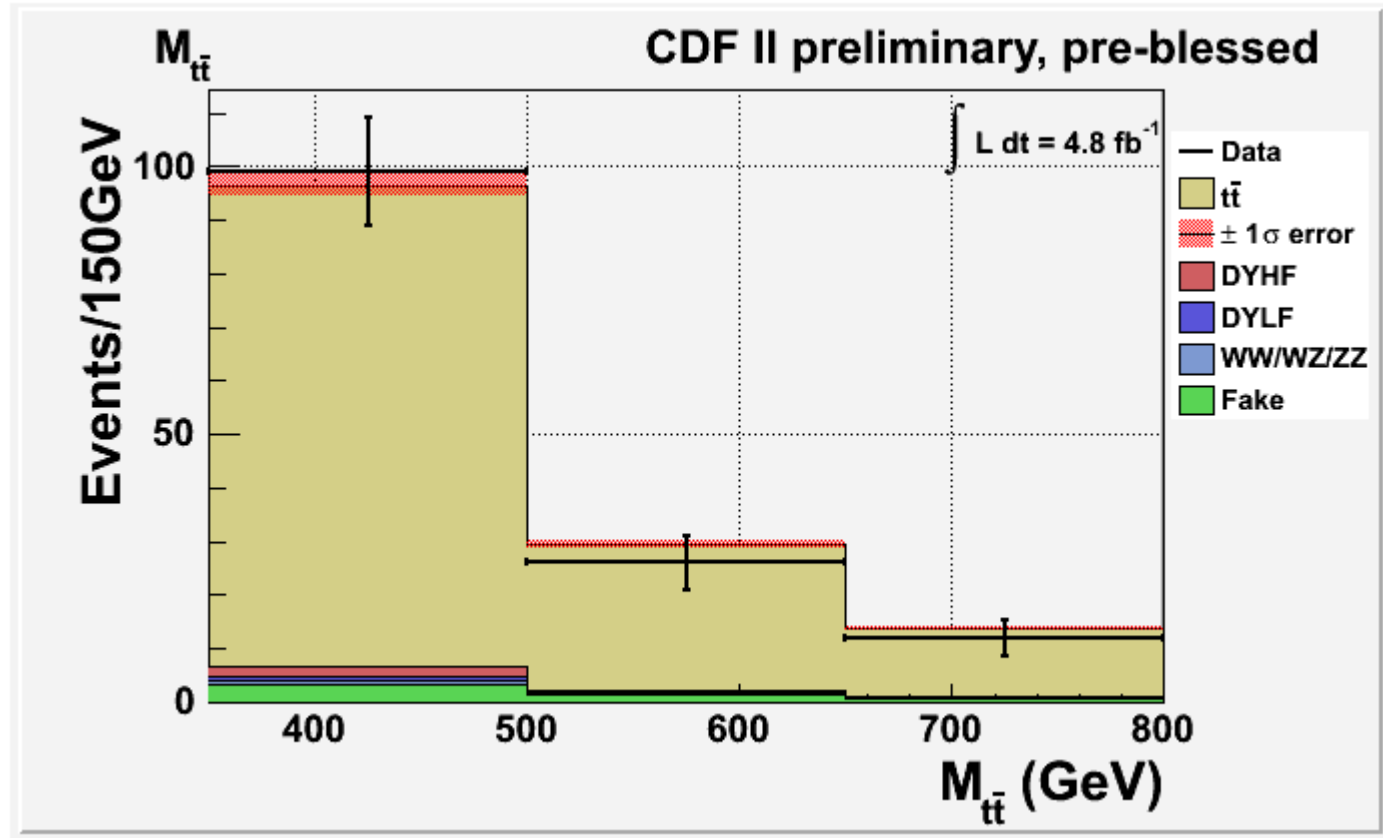
$\Delta y_t = y_{top} - y_{tbar}$ in lab frame, int. luminosity = 4.8 fb^{-1}



- Raw asymmetry = $0.20 \pm 0.08(\text{stat.})$, (2.35σ away from 0)
- After background is subtracted in Δy_t
 Observed $A_{fb} = 0.21 \pm 0.08(\text{stat.})$, (2.52σ away from 0)

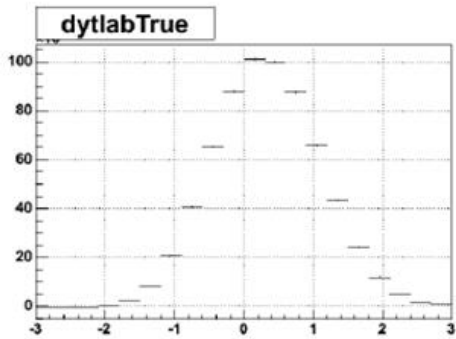


$M_{t\bar{t}}$ distribution



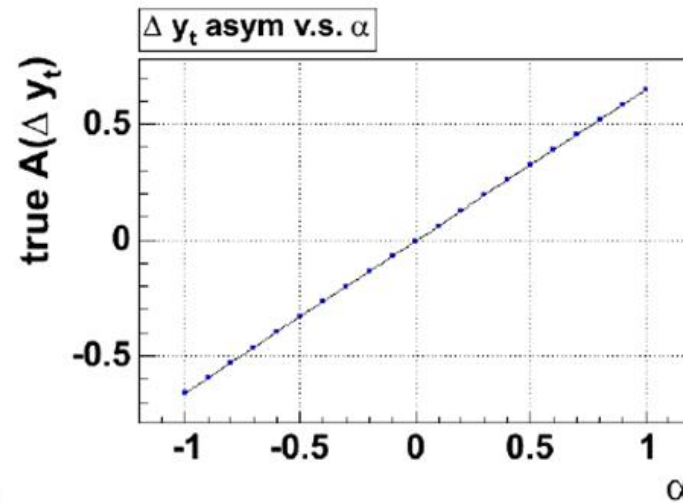
$A(\Delta y_t^{\text{true}})$ vs α

- All dilepton events in pythia with event-by-event weight of $(1 + \alpha \Delta y_t^{\text{true}})$



Example

True Δy_t^{true} distribution @ $\alpha=0.5$
 Asym = 0.324 ± 0.001



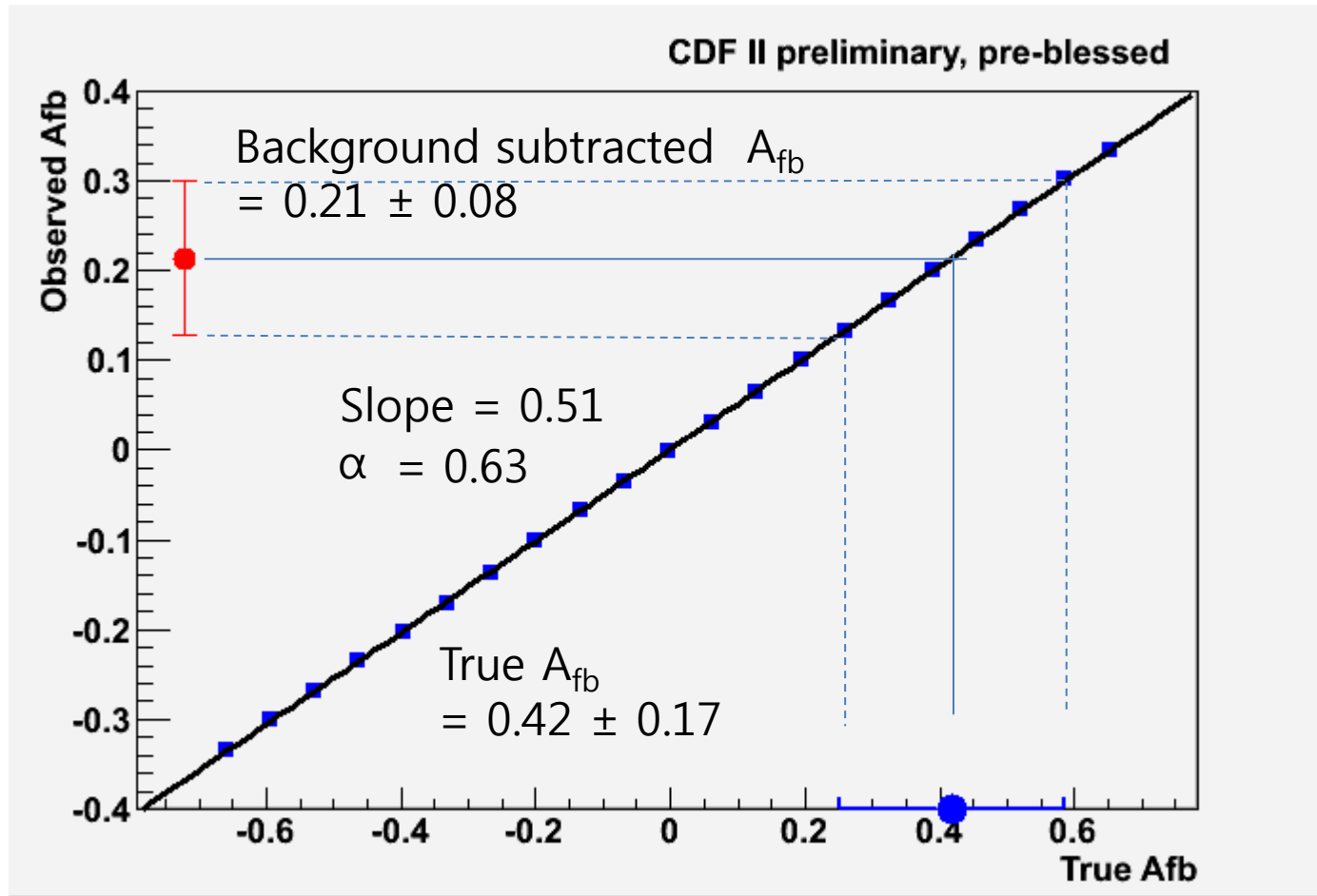
- Weighted true samples are simulated & reconstructed for CDF detector
- Observed Asymmetry is measured as a function of α from reconstructed samples
- The linear function between true Afb and observed Afb is extracted.



True A_{fb} by $1 + \alpha \Delta y$ method



Int. Luminosity = 4.8 fb^{-1}



True $A_{fb} = 0.42 \pm 0.17$ (stat)



Systematics



(1) Background shape

(2) MC generator

(3) ISR/FSR

(4) Color reconnection

(5) Jet energy scale

(6) PDF

(All systematics are evaluated for 8.7 fb^{-1} samples)



Systematics : Background shape

	Expected background (8.7fb^{-1})		
	Total error	Negative side of Delta Y	Positive side of Delta Y
Sum	17.94 ± 3.20	8.92 ± 2.26	9.02 ± 2.27

- The errors of background in negative and positive side for are varied by ± 1 sigma

➔ largest deviations from nominal true $A_{fb} = 0.045$

The systematic uncertainty by background shape is taken as **0.045**



Systematics : MC generator



- herwig and pythia are compared :
pythia is used as nominal generator.

$$\rightarrow \text{true } A_{\text{fb}}^{\text{herwig}} - \text{true } A_{\text{fb}}^{\text{pythia}} = \mathbf{-0.017}$$



Systematics : ISR/FSR



➤ less ISR/FSR :

$$\text{Less true } A_{fb} - \text{nominal } A_{fb} = -0.017$$

➤ more ISR/FSR :

$$\text{More true } A_{fb} - \text{nominal } A_{fb} = -0.023$$

The systematic uncertainty by ISR/FSR is taken as **0.023**



➤ Apro, ACRpro

$$\text{true } A_{\text{fb}}^{(\text{ARCpro})} - \text{true } A_{\text{fb}}^{(\text{Apro})} = 0.022$$

The systematic uncertainty by color reconnection is taken as **0.022**



Systematics : Jet energy scale



➤ JES -1σ

$$\text{true } A_{\text{fb}} - \text{nominal } A_{\text{fb}} = -0.007$$

➤ JES $+1\sigma$

$$\text{true } A_{\text{fb}} - \text{nominal } A_{\text{fb}} = -0.011$$

The systematic uncertainty by JES is taken as **0.011**



Systematics : PDF uncertainty



- CTEQ6M, MRST72, MRST75, CTEQ5L

The systematic uncertainty by PDF is taken as **0.004**



Systematics



Int. Luminosity = 8.7 fb^{-1}

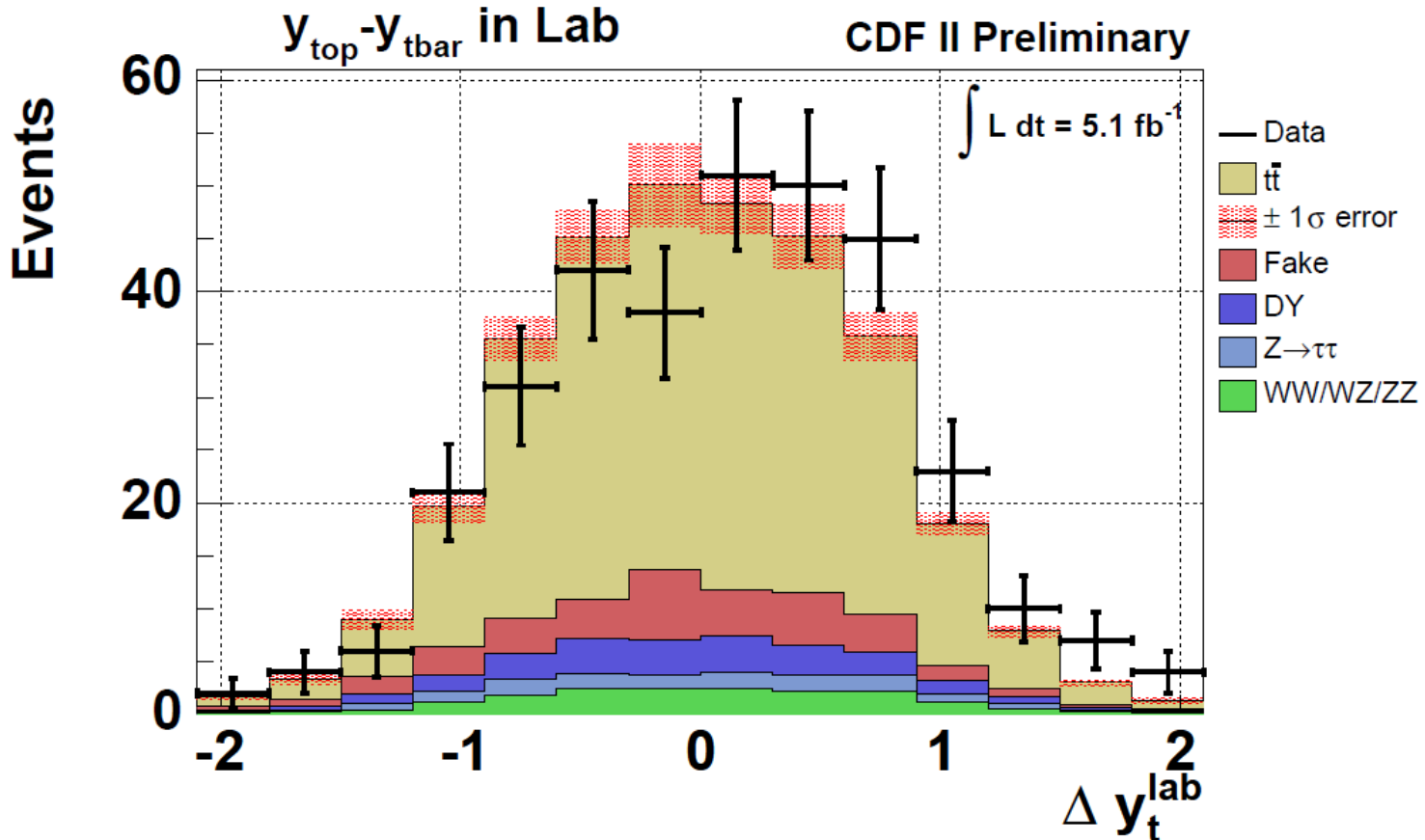
Sources	Systematics uncertainty
Background shape	0.045
ISR/FSR	0.023
signal MC genetator	0.017
Color reconnection	0.022
Jet energy scale	0.011
PDF	0.004
total	0.059



Part II :

- pretag dilepton samples
- same event selection without b tagging is applied
- Likelihood fitting is done to reconstruct t and $t\bar{t}$

$$\Delta y_t = y_{top} - y_{tbar} \quad (\text{pretag})$$



- Raw asymmetry from data : $A_{fb} = 0.14 \pm 0.05$
- Background subtracted asymmetry : $A_{fb} = 0.21 \pm 0.07(\text{stat.})$
- True asymmetry : $A_{fb} = 0.42 \pm 0.15(\text{stat.}) \pm 0.05(\text{syst.})$



Summary



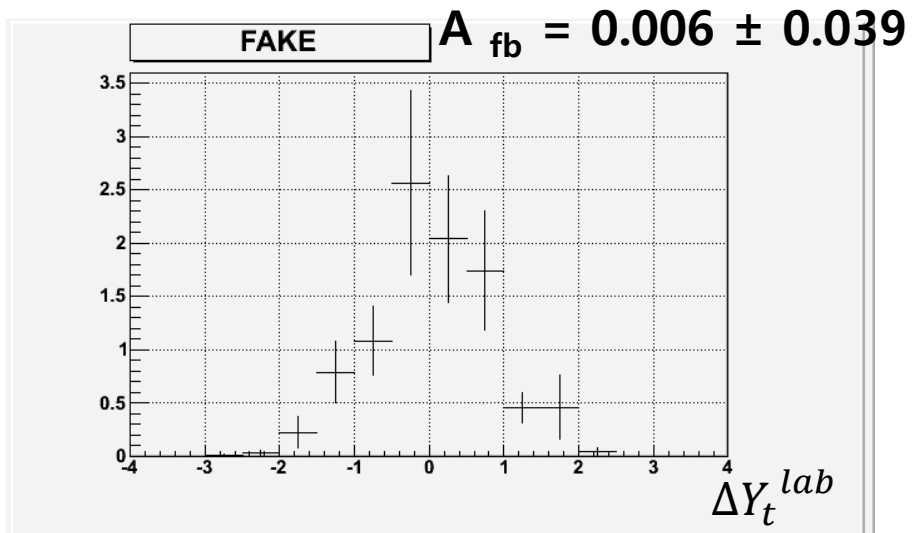
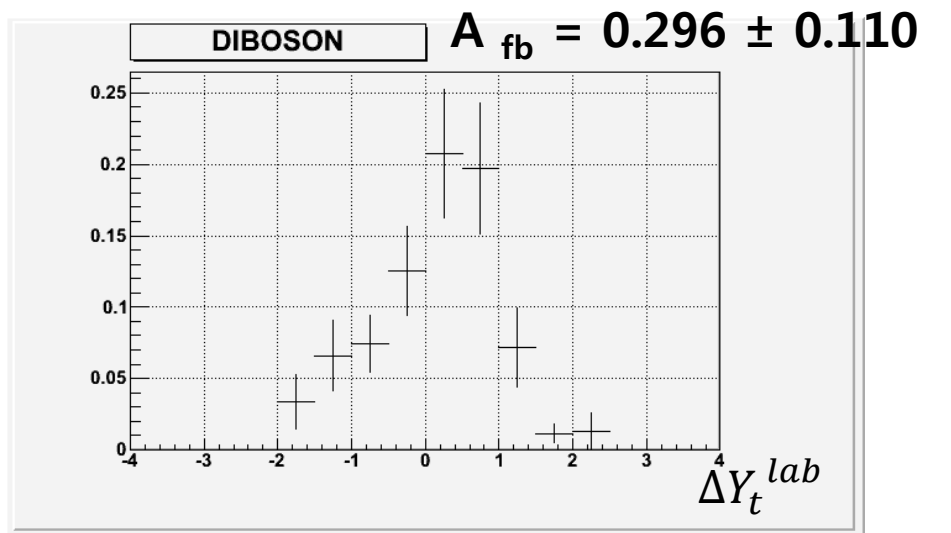
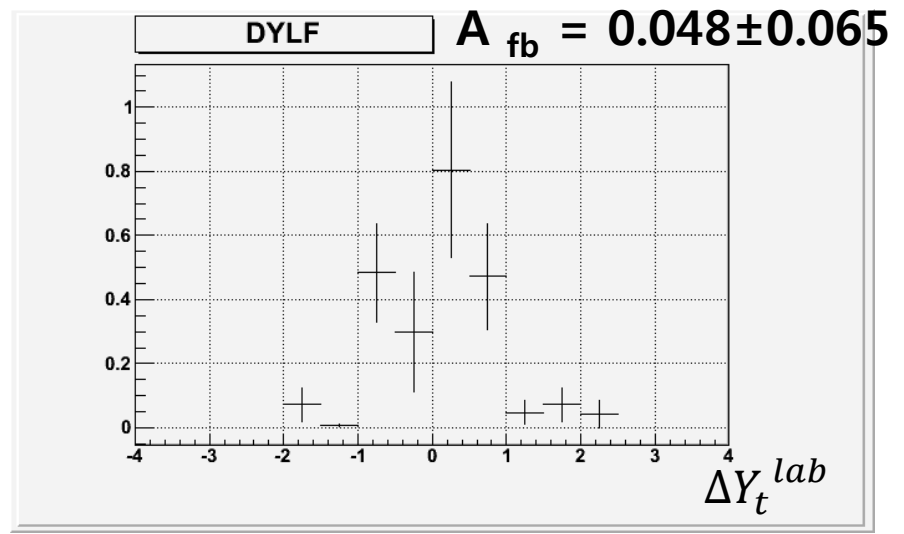
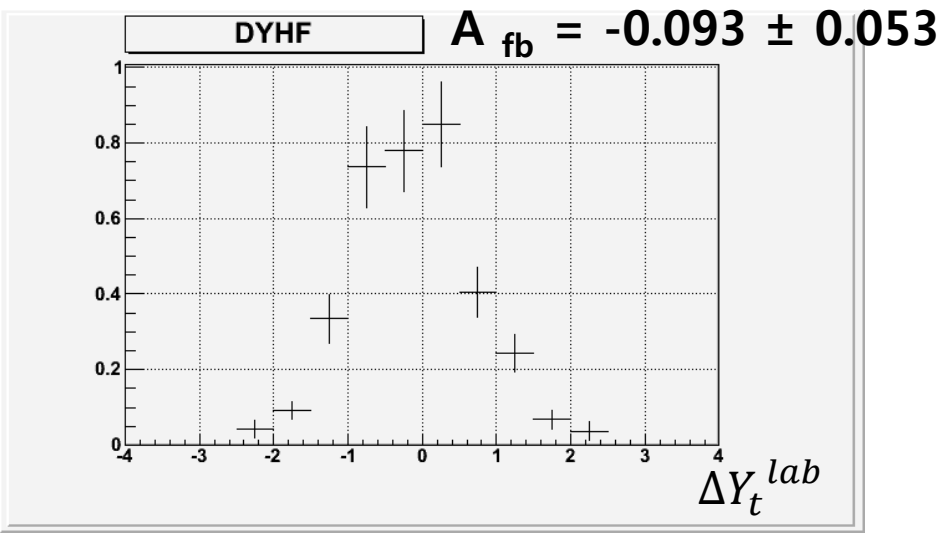
- Top Afb measurement is done using dilepton samples with CDF data.
- FB Asymmetry observed in Δy distribution
[**pretag sample , int. L = 5.1 fb⁻¹**]
true $A_{fb} = 0.42 \pm 0.15(\text{stat.}) \pm 0.05(\text{syst.})$
- [**btag sample , int. L = 4.8 fb⁻¹**]
true $A_{fb} = 0.42 \pm 0.17(\text{stat.}) \pm 0.04(\text{syst.})$
- [**btag sample , int. L = 8.7 fb⁻¹ , CDF full data**]
true $A_{fb} = \text{[redacted]} \pm 0.13(\text{stat.}) \pm 0.06(\text{syst.})$
- New results from full CDF data will be updated soon.

Backup



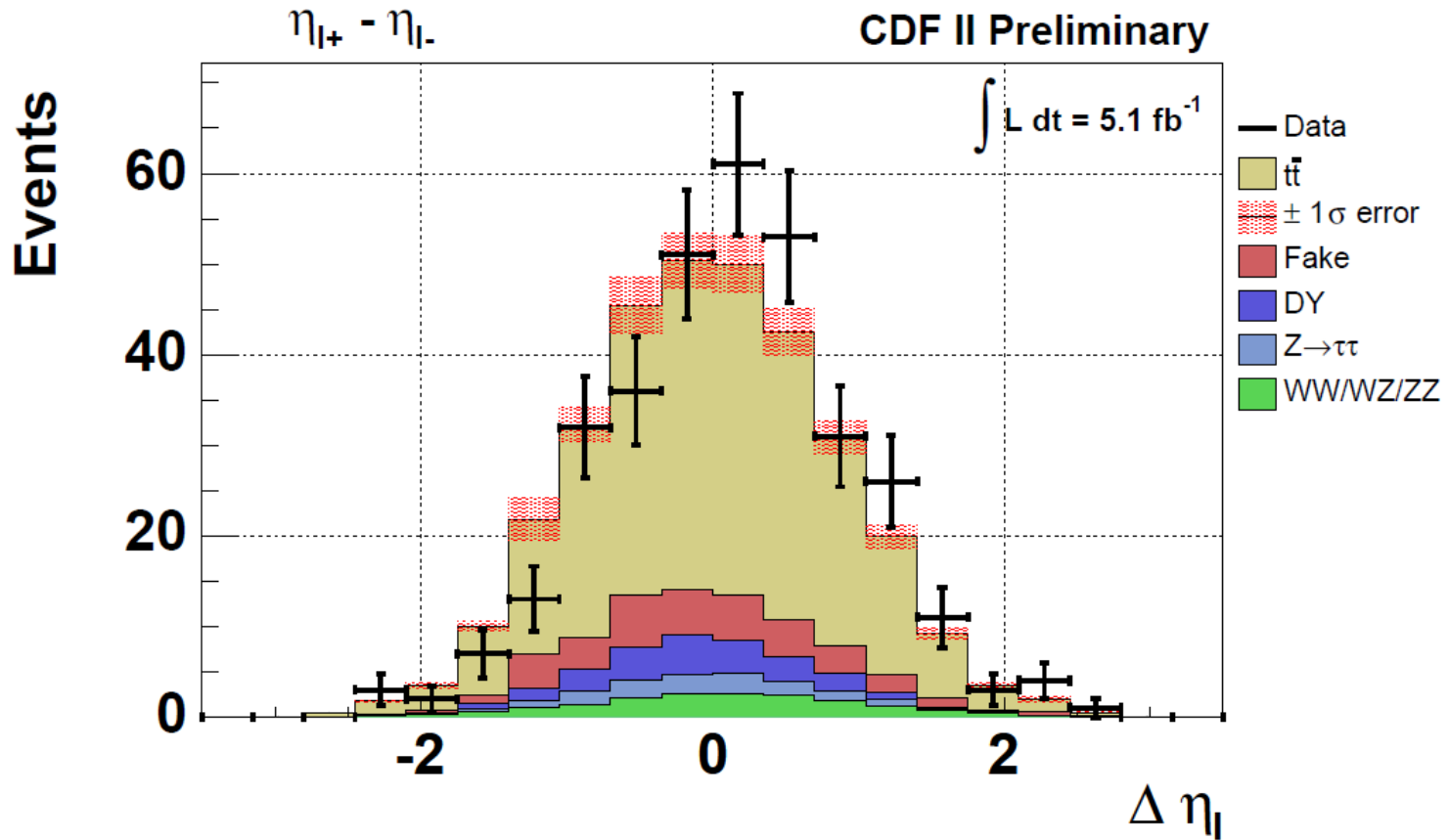
Δy_t distribution of backgrounds

Int. luminosity = 8.7 fb^{-1}



$$\Delta\eta_l = \eta_{l+} - \eta_{l-} \quad (\text{pretag})$$

$\Delta\eta_l = \eta_{l+} - \eta_{l-}$ in lab frame



$\Delta\eta_l = \eta_{l+} - \eta_{l-}$ in lab frame

