FB asymmetry in $t\bar{t}$ production at CDF

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on behalf of
the CDF Collaboration

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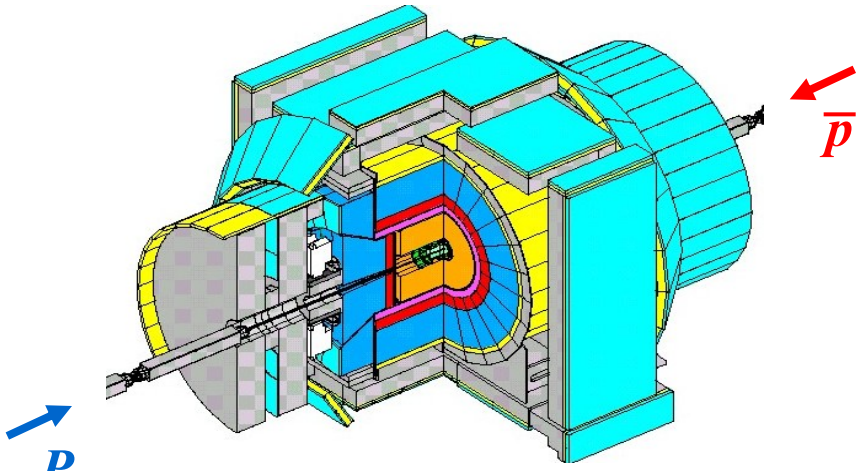
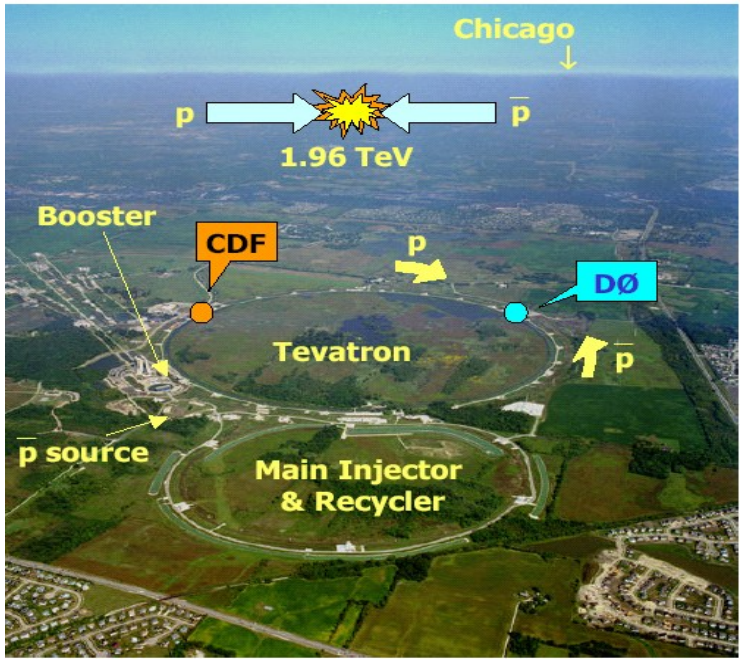
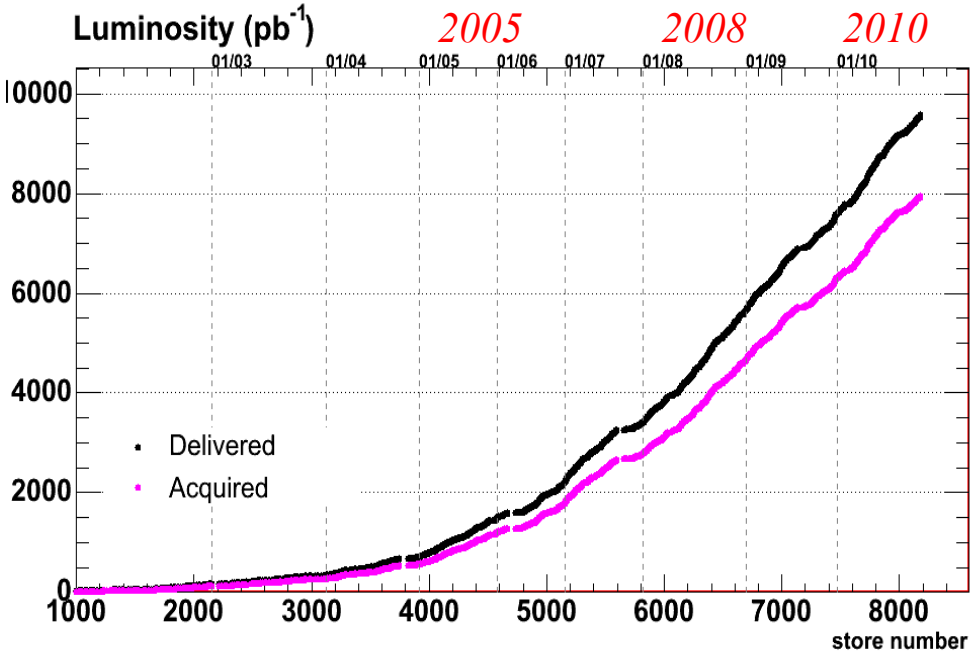


CDF II Detector

CDF Experiment and Data

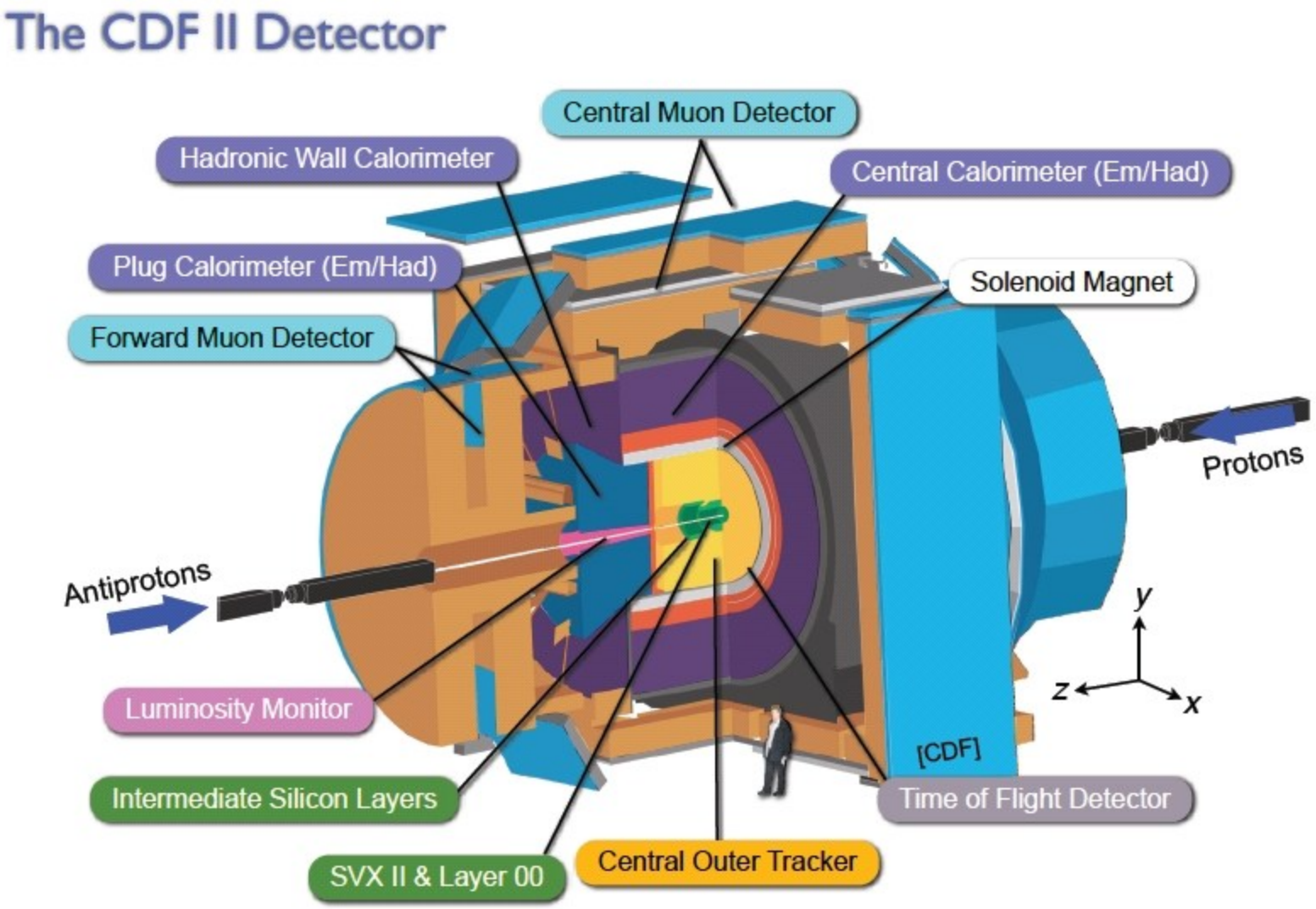




- *Run I (1992~1996): ~110 pb^{-1}, 1.8 TeV*
- *Run II(2001~2010): ~7.0 fb^{-1}, 1.96 TeV*
  - *1 km Radius Ring*
  - *36 x 36 bunches, 396 ns spacing*
  - *280 Billion protons/bunch*
  - *80 Billion anti-p/bunch*
  - *2 million collisions/sec*

	Run II
Delivered	*9.6 fb^{-1}*
Recorded	*8.0 fb^{-1} (83%)*
Produced	*7.0 fb^{-1} (76%)*
Analyzed	*5 fb^{-1}*

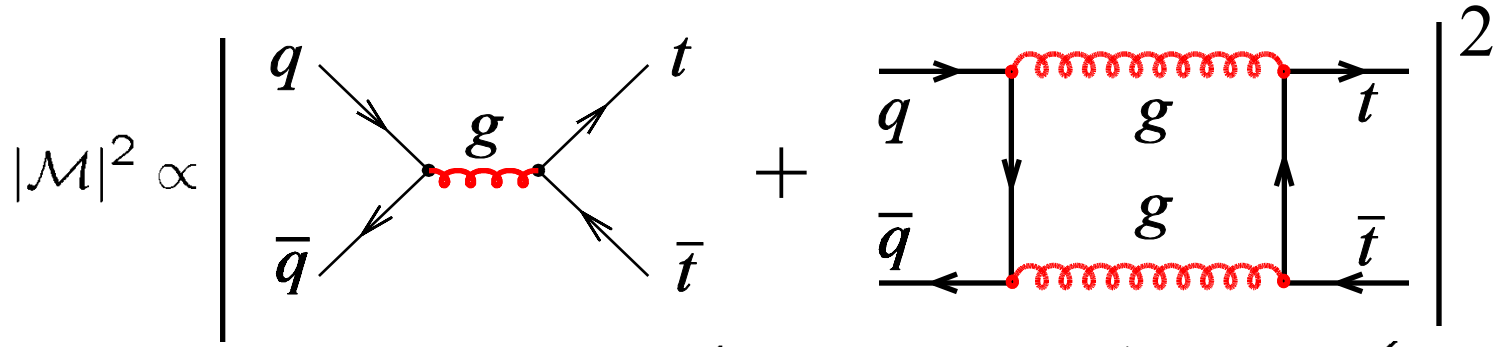
CDF Detector



$t\bar{t}$ Forward Backward Asymmetry

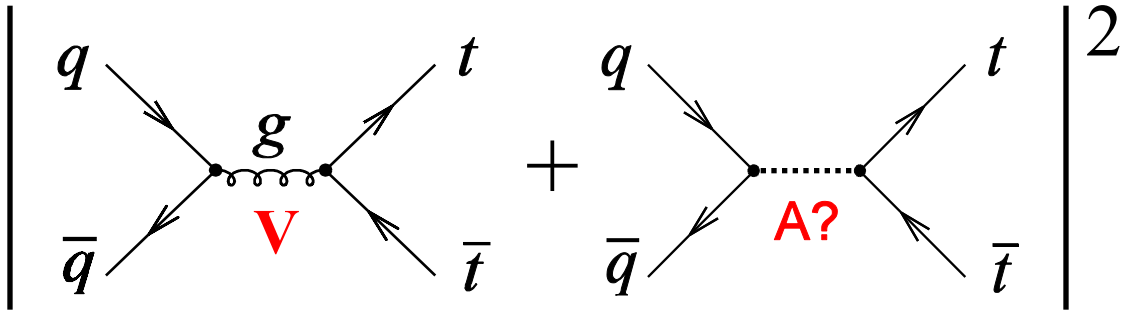
LO only: No forward-backward asymmetry

NLO prediction: Interference between LO and NLO



$$A_{fb} = 0.06 \pm 0.01 \text{ (NLO)}$$

Also presence of new physics could make asymmetry



From Yuji's slide

Theoretical interest

- exotic gluons
  - massive chiral color
  - RS gluon
  - color sextets, anti-triplets
- IVB´
  - Z´
  - FV W´Z´ t-channel
- FV scalars
- effective Lagrangians

- nice theoretical review by Cao et al. PRD 81,014016, arXiv:1003.3461

- model building must contend with
  - total σ in good agreement with SM
  - $d\sigma/dM_{tt}$ in good agreement with SM

From Dan's slide

Prior measurements

- CDF, 1.9 fb^{-1} , inclusive, corrected to "parton-level"
  - tt rest frame $A^{t\bar{t}} = 0.24 \pm 0.14$
  - NLO QCD $A^{t\bar{t}} = 0.06 \pm 0.01$

PRL 101, 202001 (2008)

  - lab (pp) frame $A^{p\bar{p}} = 0.17 \pm 0.08$
  - NLO QCD $A^{p\bar{p}} = 0.04 \pm 0.01$

- D0, inclusive, background subtracted "data-level"
  - tt rest frame $A^{t\bar{t}} = 0.12 \pm 0.08$ 0.9 fb^{-1} PRL 100, 142002 (2008)

    $A^{t\bar{t}} = 0.08 \pm 0.04$ 4.3 fb^{-1} ICHEP 2010

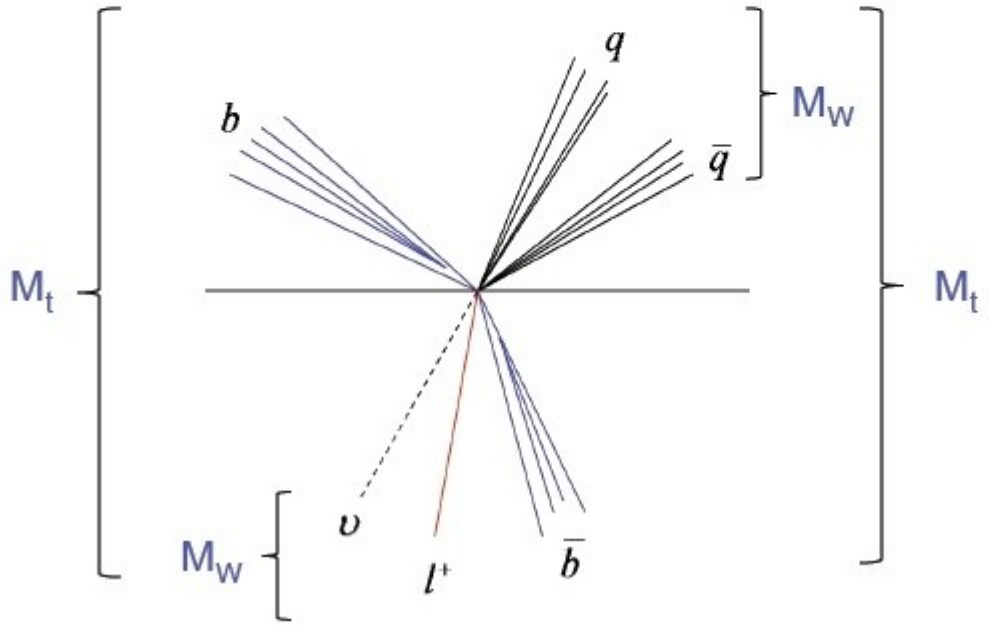
From Dan's slide

Reconstruction of Top L+jets

$$l^+ + \not\!\!E_T + 4j + \geq 1\, btag \rightarrow (l^+ \upsilon b)(q\bar{q}\bar{b}) \rightarrow (W^+ b)(W^- \bar{b}) \rightarrow t\bar{t}$$

- Jet-parton assignment, $p_z(\nu)$ via minimum of simple χ^2
  - Constraints: M_W = 80.4 GeV/c2, Mt = 175 GeV/c^2, btag = b
  - Float jet p_t within errors

$$\chi^2 = \sum_{lep,\,jets} \frac{(p_t^{i,\,meas} - p_t^{i,\,fit})^2}{\sigma_i^2} + \sum_{j=x,y} \frac{(p_j^{UE,\,meas} - p_j^{UE,\,fit})^2}{\sigma_j^2} + \frac{(M_{jj} - M_W)^2}{\Gamma_W^2} + \frac{(M_{l\nu} - M_W)^2}{\Gamma_W^2} + \frac{(M_{bjj} - M_{top})^2}{\Gamma_t^2} + \frac{(M_{bl\nu} - M_{top})^2}{\Gamma_t^2}$$



From Dan's slide

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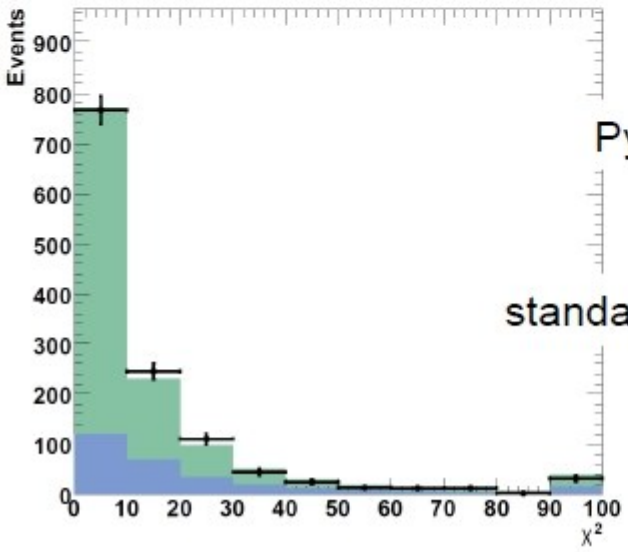
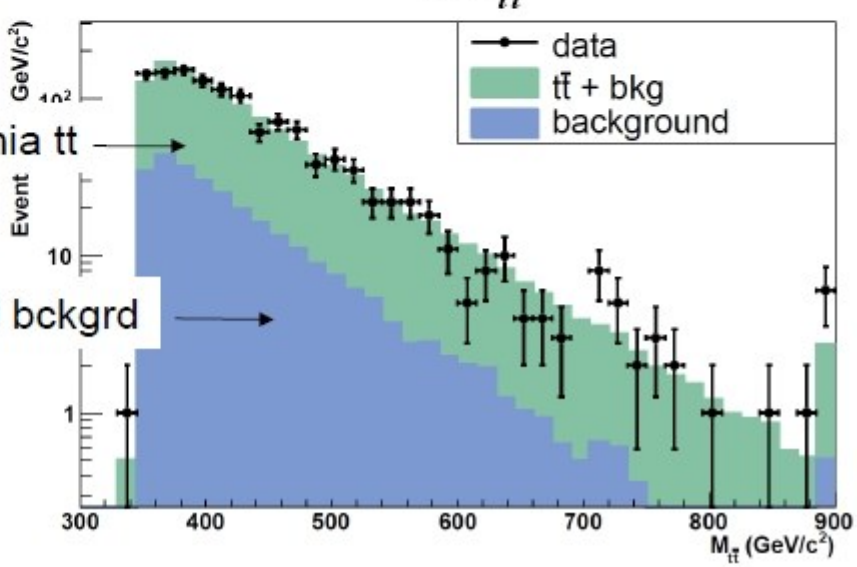
χ^2



$M_{t\bar{t}}$



From Dan's slide

Reconstruction of Top Dilepton

- *Dilepton channel*
  - *Two neutrino missing (6 unknown variables)*
  - *6 constraints (M_W:2, M_t:2, MET:2)*
  - *b-bbar ambiguity*

➔ *Several (max 4) solutions x 2 comb.(b-bbar) with no redundant constraint.*

Basic idea

One solution: $(\vec{p}_\nu, \vec{p}_{\bar{\nu}}) \Rightarrow p_z^{t\bar{t}}$, $p_T^{t\bar{t}}$, and $M_{t\bar{t}}$

Choose most likely solution from reconstructed $p_z^{t\bar{t}}$, $p_T^{t\bar{t}}$, and $M_{t\bar{t}}$

➔ These three variables are mostly distributed by initial parton distribution function.

From Yuji's slide

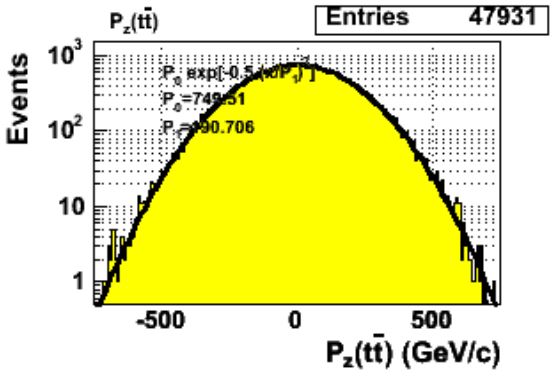
Reconstruction of Top Dilepton

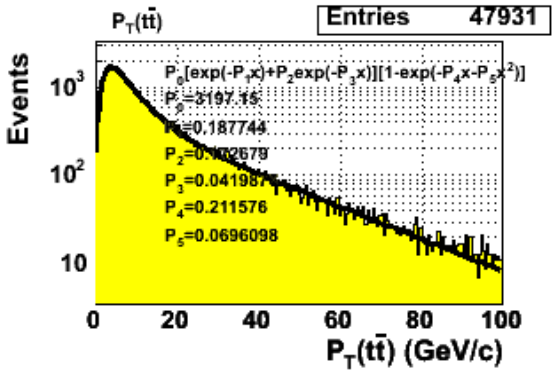
$$\mathcal{L}(\vec{p}_\nu, \vec{p}_{\bar{\nu}}, E_b^{\text{guess}}, E_{\bar{b}}^{\text{guess}}) = P(p_z^{t\bar{t}})P(p_T^{t\bar{t}})P(M_{t\bar{t}})\times$$

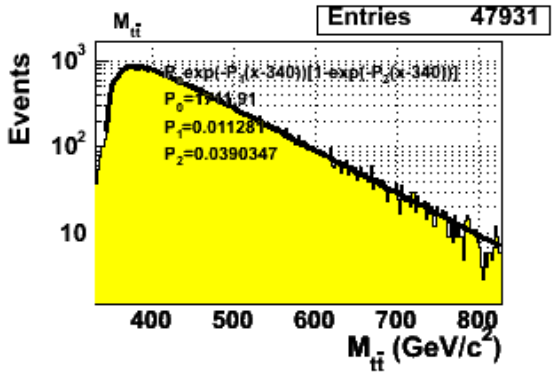
$$\frac{1}{\sigma_{\text{jet1}}}\exp\left[-\frac{1}{2}\left\{\frac{E_{\text{jet1}}^{\text{meas}} - E_{\text{jet1}}^{\text{guess}}}{\sigma_{\text{jet1}}}\right\}^2\right] \times \frac{1}{\sigma_{\text{jet2}}}\exp\left[-\frac{1}{2}\left\{\frac{E_{\text{jet2}}^{\text{meas}} - E_{\text{jet2}}^{\text{guess}}}{\sigma_{\text{jet2}}}\right\}^2\right] \times$$

$$\frac{1}{\sigma_x^{\text{MET}}}\exp\left[-\frac{1}{2}\left\{\frac{\not{E}_x^{\text{meas}} - \not{E}_x^{\text{guess}}}{\sigma_x^{\text{MET}}}\right\}^2\right] \times \frac{1}{\sigma_y^{\text{MET}}}\exp\left[-\frac{1}{2}\left\{\frac{\not{E}_y^{\text{meas}} - \not{E}_y^{\text{guess}}}{\sigma_y^{\text{MET}}}\right\}^2\right]$$

$P(p_z^{t\bar{t}})$, $P(p_T^{t\bar{t}})$, and $P(M_{t\bar{t}})$ are obtained from DIL candidates in PYTHIA MC





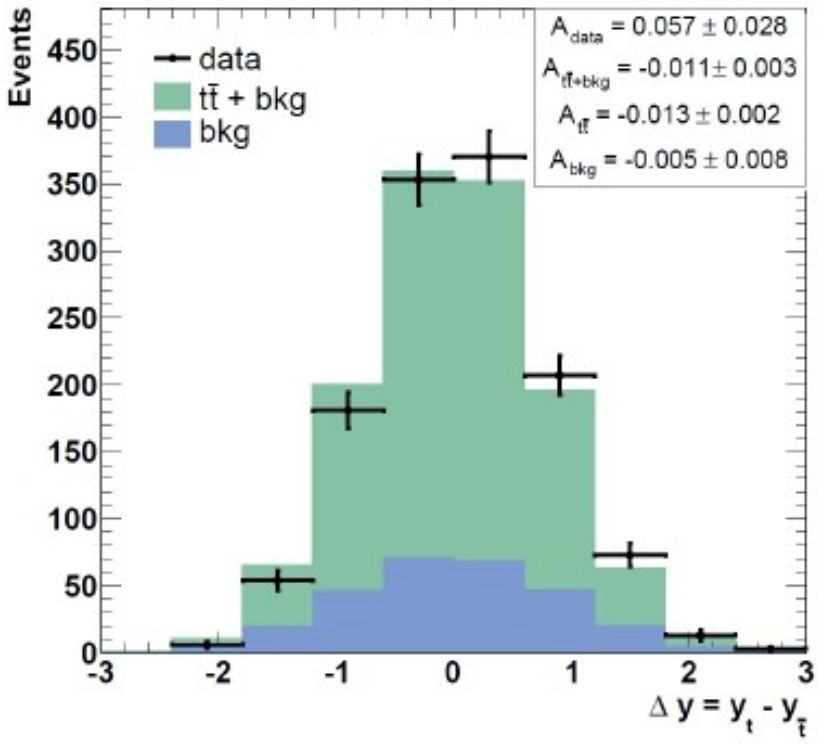


We take one representative $(\vec{p}_\nu, \vec{p}_{\bar{\nu}}, E_b^{\text{guess}}, E_{\bar{b}}^{\text{guess}})$ which gives maximum likelihood in an event.

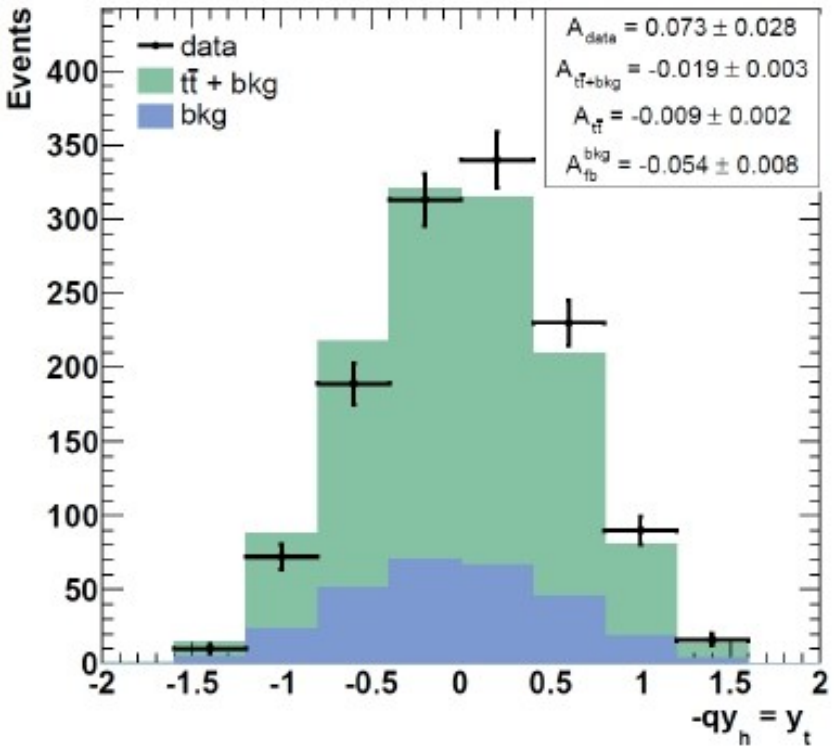
From Yuji's slide

Asymmetry of Top L+jets

tt frame



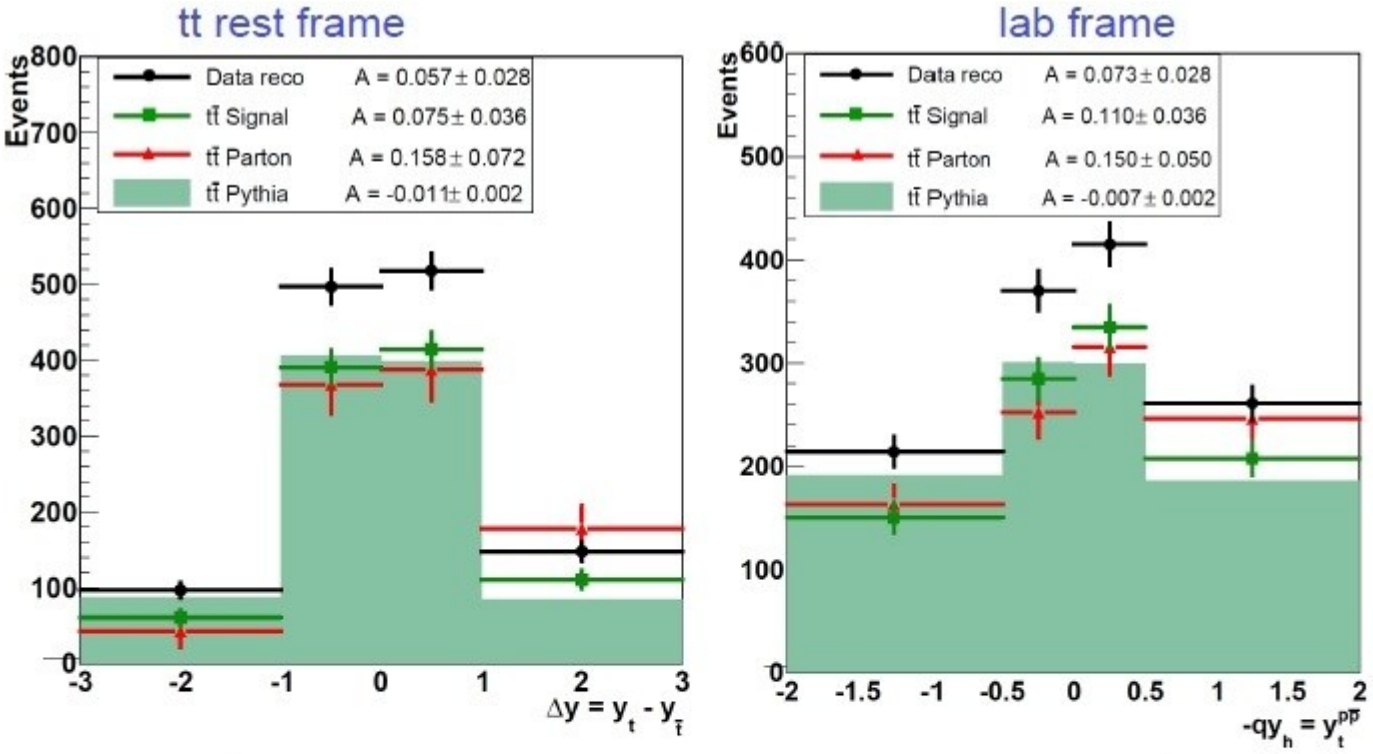
lab frame



- Combined Δy:
  $A_{FB} = 0.057 \pm 0.028$
- Compare to mc@nlo
  $A_{FB} = 0.024$

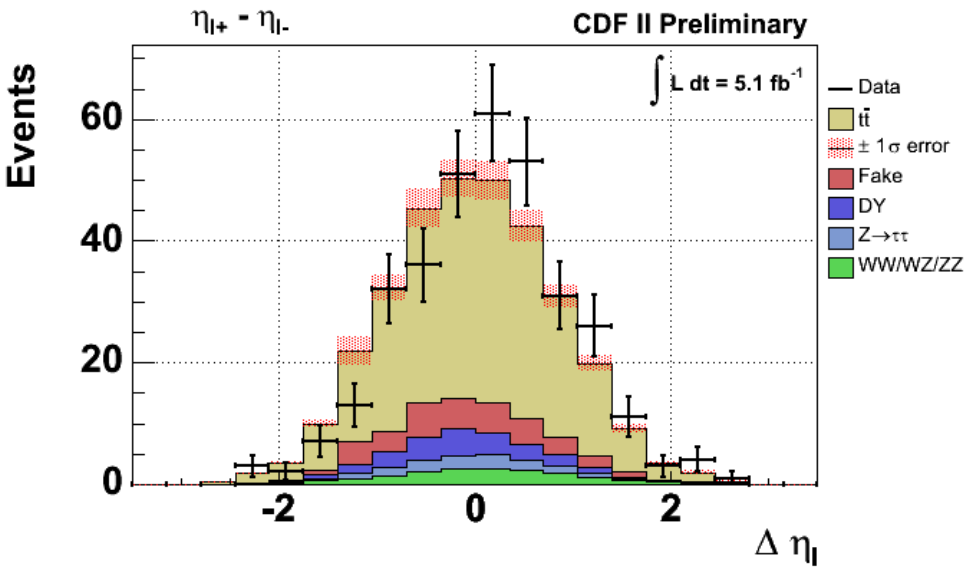
- Combined $-q^*y_h$:
  $A_{FB} = 0.073 \pm 0.028$
- Compare to mc@nlo
  $A_{FB} = 0.001$

Asymmetry of Top L+jets

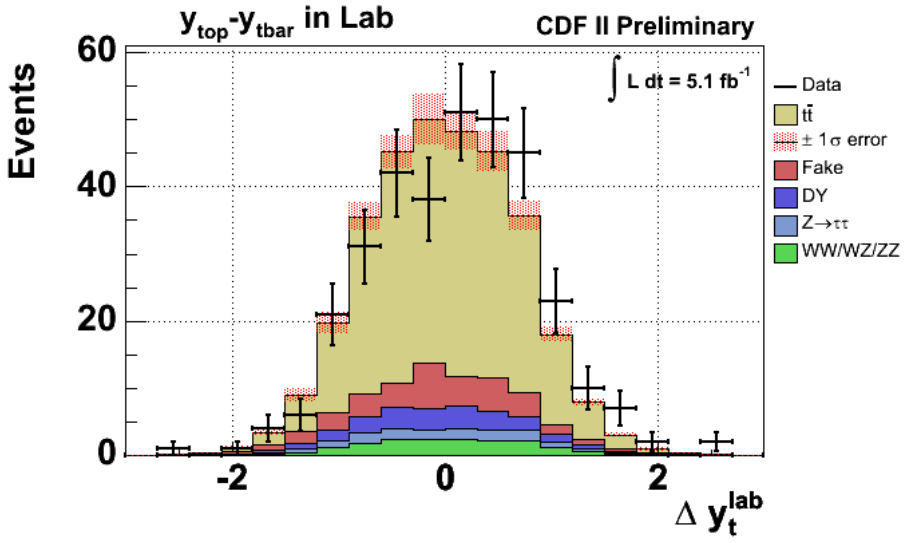


sample	level	$A^{t\bar{t}}$	$A^{p\bar{p}}$
data	data	0.057 ± 0.028	0.073 ± 0.028
MC@NLO	$t\bar{t}$+bkg	0.017 ± 0.004	0.001 ± 0.003
data	signal	0.075 ± 0.037	0.110 ± 0.039
MC@NLO	$t\bar{t}$	0.024 ± 0.005	0.018 ± 0.005
data	parton	0.158 ± 0.074	0.150 ± 0.055
MCFM	parton	0.058 ± 0.009	0.038 ± 0.006

Asymmetry of Top Dilepton

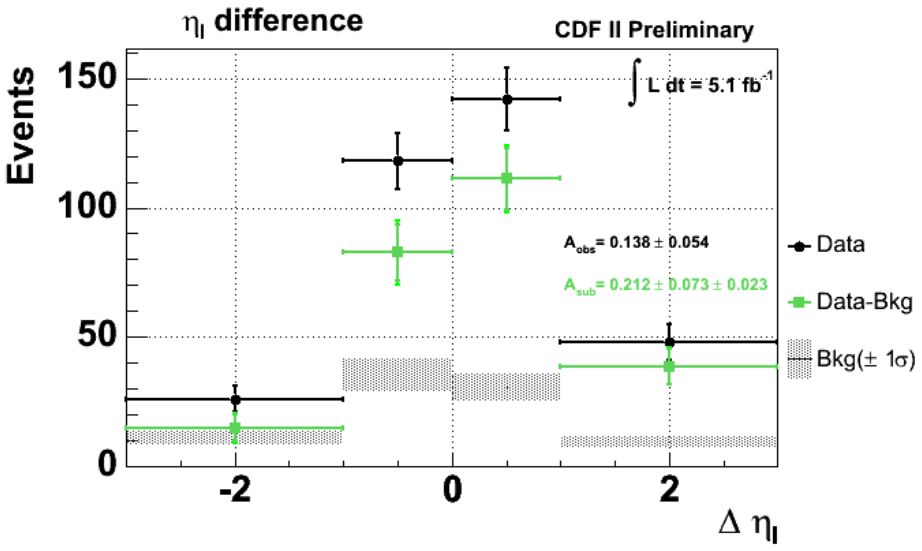


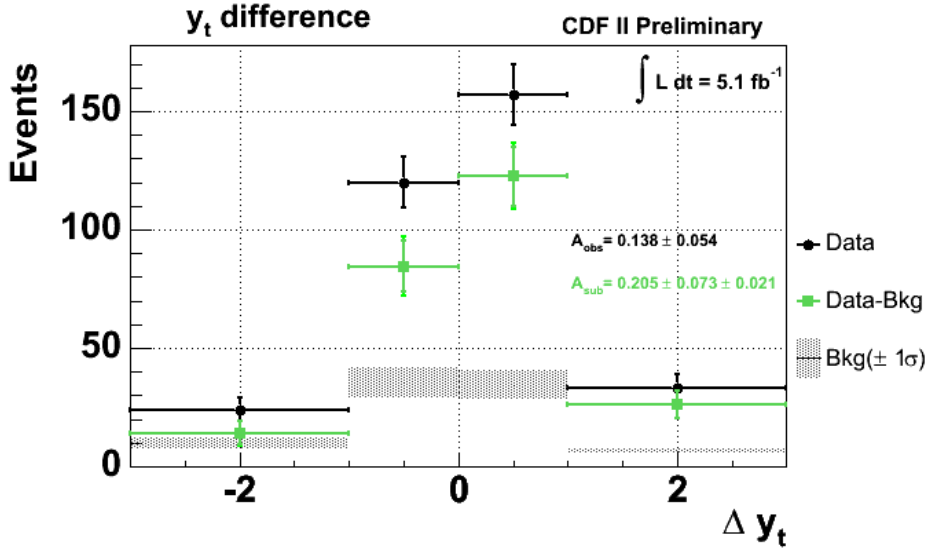
- $A_{\text{obs}} = 0.138 \pm 0.054(\text{stat.})$
- Pred: $A_{\text{obs}} = -0.022 \pm 0.022$



- $A_{\text{obs}} = 0.138 \pm 0.054(\text{stat.})$
- Pred: $A_{\text{obs}} = -0.015 \pm 0.023$

Asymmetry of Top Dilepton





$\Delta\eta_l$

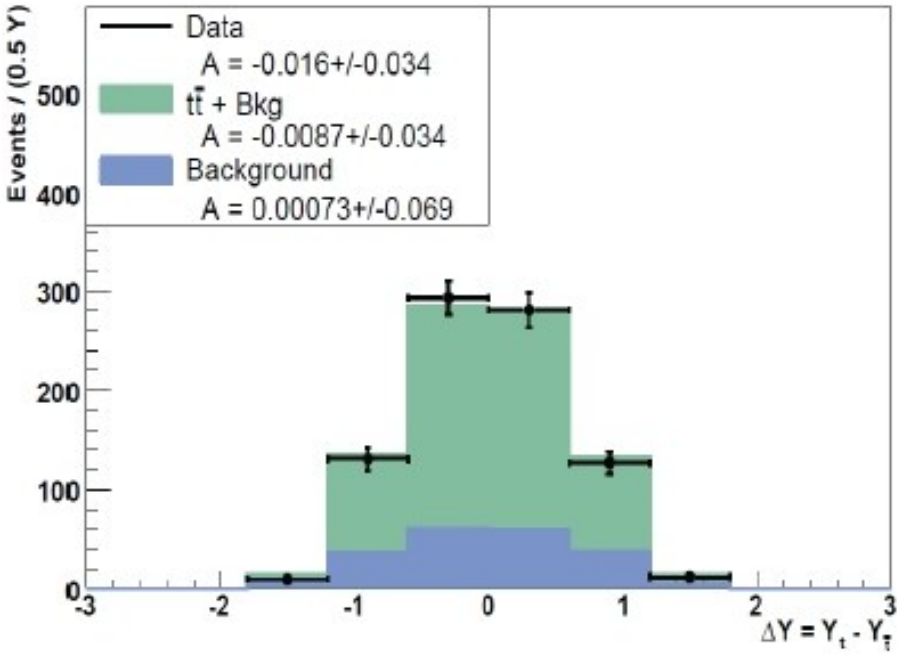
$$A_{sub} = 0.212 \pm 0.073(\text{stat.}) \pm 0.023(\text{bkg.shape.})$$

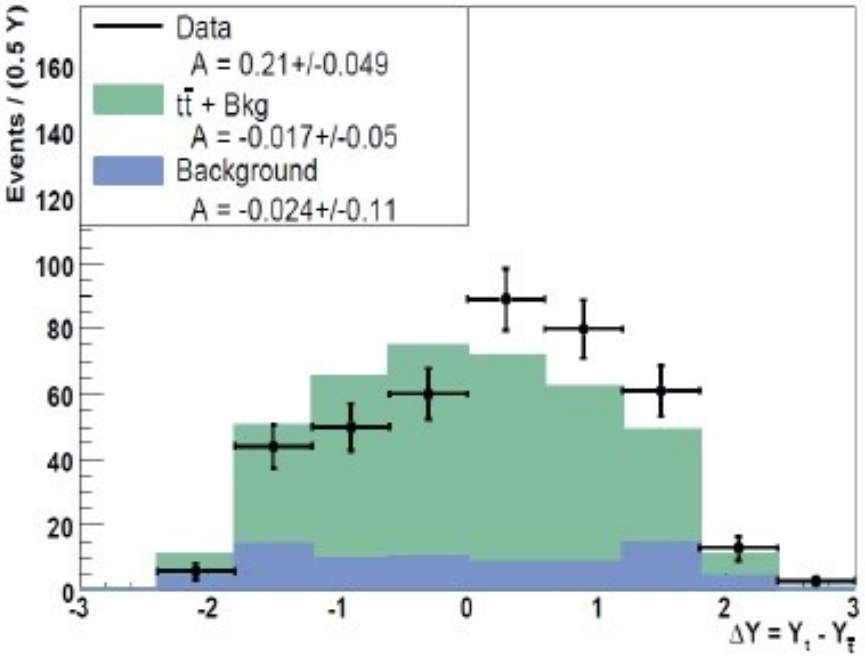
Δy_t

$$A_{sub} = 0.205 \pm 0.073(\text{stat.}) \pm 0.021(\text{bkg.shape.})$$

$$A_{true} = 0.417 \pm 0.148(\text{stat.}) \pm 0.053(\text{bkg.shape})$$

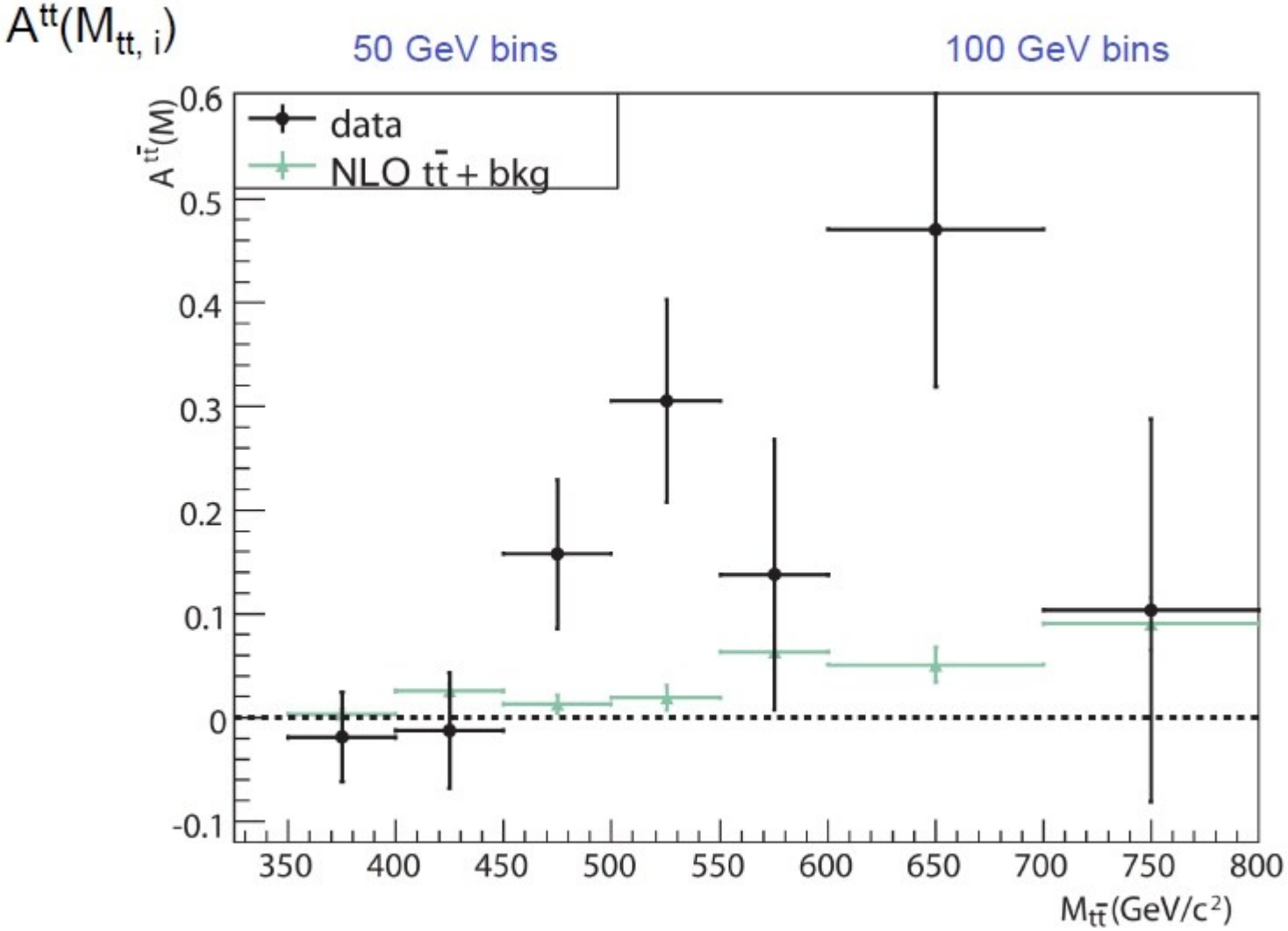
Asymmetry in high/low Mtt (LJ)





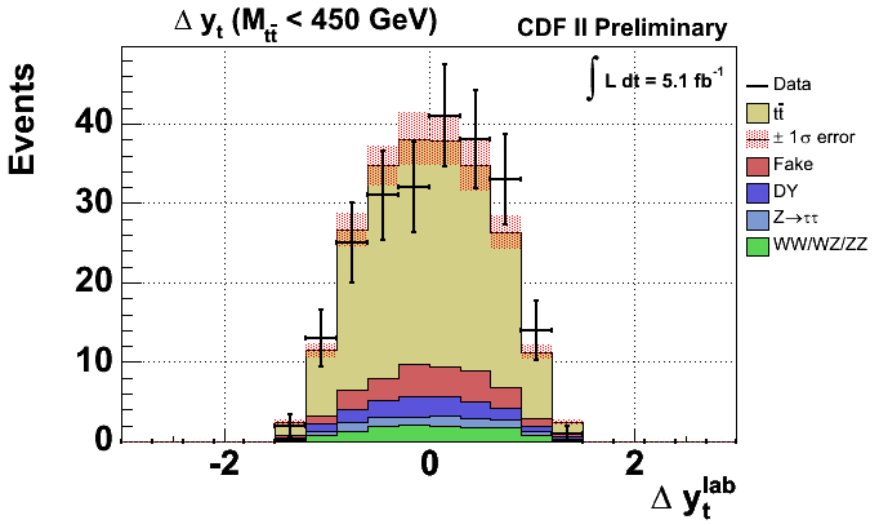
selection	all M	$M < 450$ GeV/c^2	$M \geq 450$ GeV/c^2
reco data	0.057±0.028	-0.016±0.034	0.212±0.049
MC@NLO	0.017±0.004	0.012±0.006	0.030±0.007

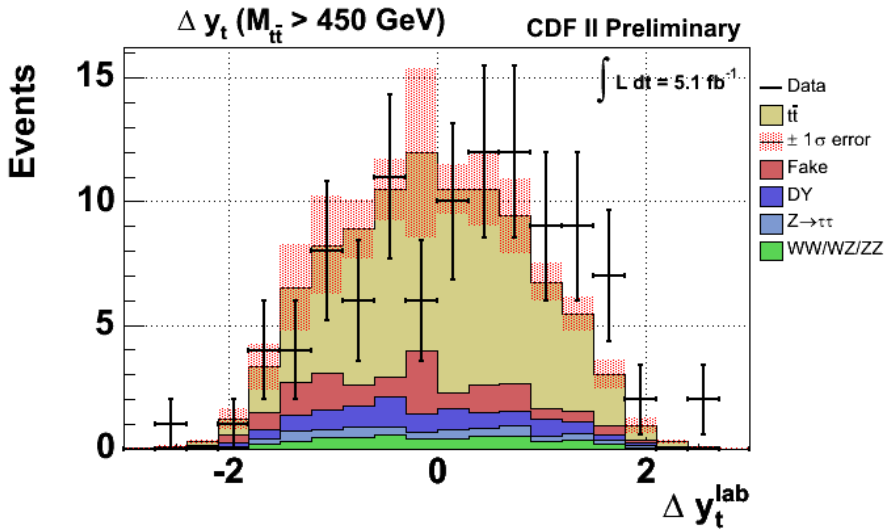
Asymmetry in high/low Mtt (LJ)



- How to quantify? Two bins: high and low

Asymmetry in high/low Mtt (DIL)





Aobs = 0.104 +- 0.066(stat.)

Asub = 0.134 +- 0.088(stat.)

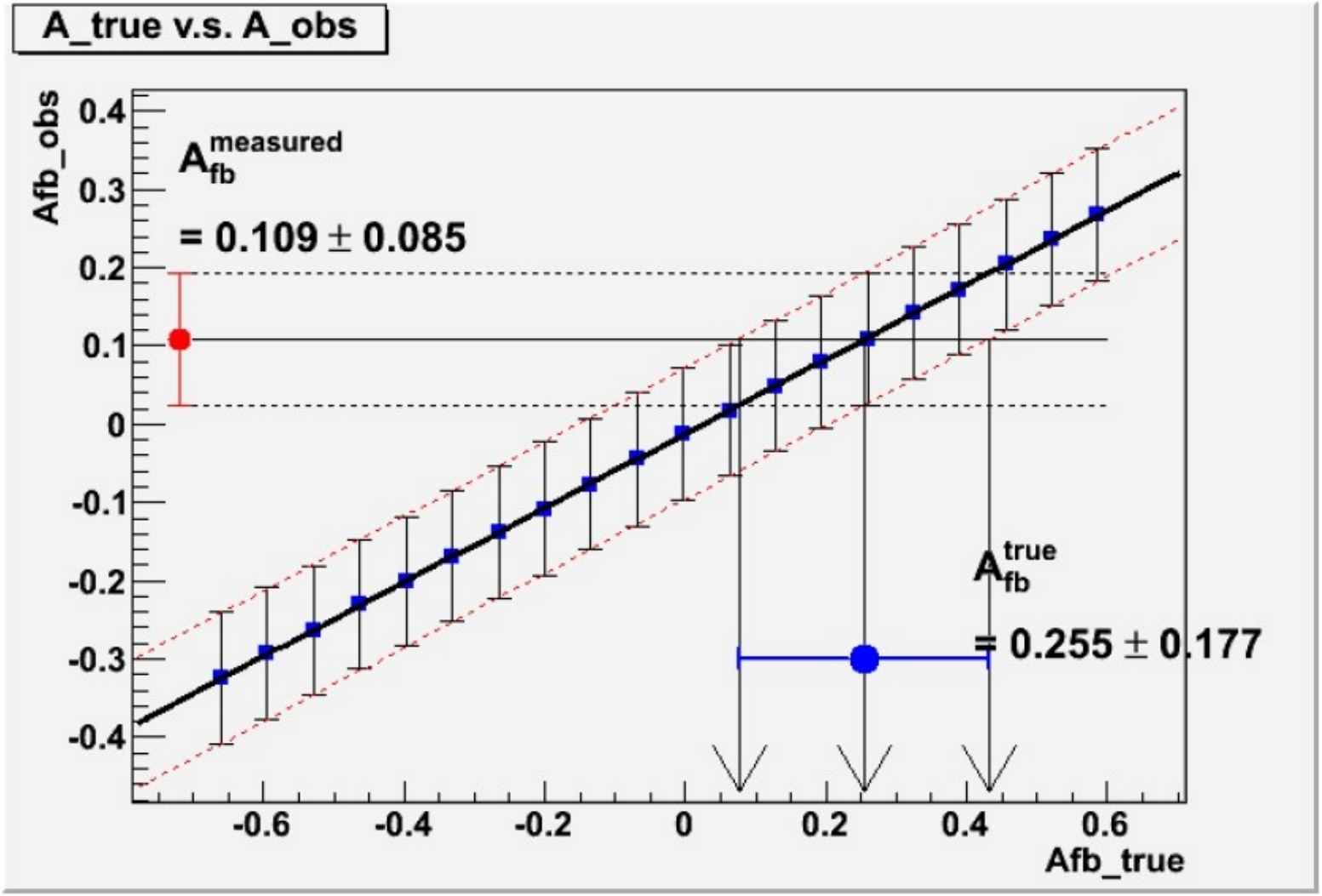
Aobs = 0.212 +- 0.096(stat.)

Asub = 0.368 +- 0.137 (stat.)

- *In high Mtt region, asymmetry looks larger.*
- *This is just rough estimation with only stat. error by hand. No bkg shape systematics is imcorporated.*

Preliminary result of b-tagged Dilepton

nominal A_true = 0.255 ± 0.177(stat)



Summary

- Measured asymmetry in lab and tt frames in 2 sigma excess over SM for both of L+jets and Dilepton channel.

  L+jets channel For $M_{tt} > 450$ GeV/c^2

  $$A^{tt}_{reco} = 0.210 \pm 0.049,\ A^{tt}_{parton} = 0.475 \pm 0.112$$

  Dilepton channel

  $$A_{obs} = 0.138 \pm 0.054_{stat.}$$

  $$A_{sub} = 0.205 \pm 0.073_{stat.} \pm 0.021_{bkg\ shape.}$$

  $$A_{true} = 0.417 \pm 0.148_{stat.} \pm 0.053_{syst..}$$

- Att has a dependence on Δy, Mtt, especially L+jets channel.

Backup Slide

Systematic uncertainty (DIL)

Source of uncertainty	δA_{true}
Bkg shape	0.043
Detector effect	0.010
Signal MC stat.	0.010
Signal MC model	0.018
ISR/FSR	0.015
JES	0.008
Color reconnection	0.011
PDF	0.004
Syst. total	0.053
Stat.	0.148
Total uncertainty	0.157

← Reduced due to S/B improvemen

← New

μ^- efficiency as a function o f η from Z+1jet sample sh ows different asymmetry fr om the prediction (ΔA=0.0 10)

$$A_{\text{true}} = 0.417 \pm 0.148(\text{stat.}) \pm 0.053(\text{syst.})$$

Systematic uncertainty (LJ)

Source	$M < 450$ GeV/c^2	$M \geq 450$ GeV/c^2
background size	0.017	0.032
background shape	0.003	0.003
JES	0.005	0.012
ISR/FSR	0.012	0.008
color reconnection	0.009	0.004
PDF	0.018	0.004
physics model	0.035	0.035
total	0.047	0.049