A_{fb}/A_c and A *vs* M_{tt} in tt Pair Production

The CDF-II Collaboration
including
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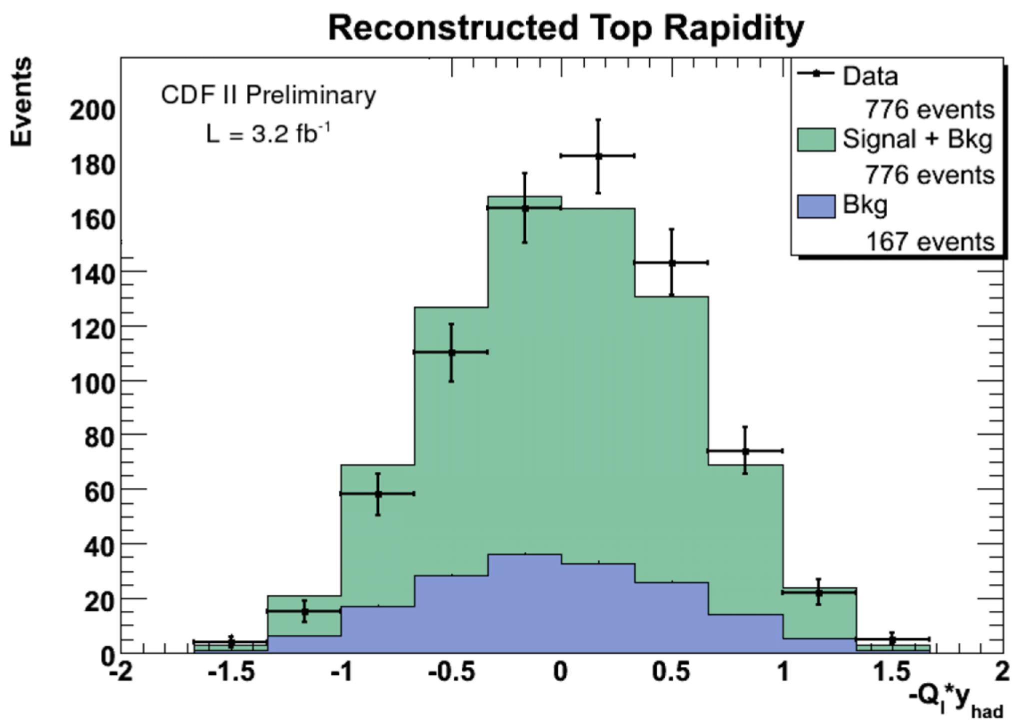
Universitat Karlsruhe: J. Wagner, T.Chwalek, W. Wagner



Single Particle Asymmetries

- Forward-backward asymmetry A_{FB}
  - chiral color (axigluons)
  - Z'

$$A_{FB} = \frac{N_t(y>0) - N_t(y<0)}{N_t(y>0) + N_t(y<0)}$$

- Charge asymmetry A_C
  - Net top current
  - 5 ±1.5% from NLO QCD

$$A_c = \frac{N_t(y>0) - N_{\bar{t}}(y>0)}{N_t(y>0) + N_{\bar{t}}(y>0)}$$

- If CP is good $A_C = A_{FB}$

Two Particle Asymmetry

- Rapidity difference
  - equivalent to tt rest frame

$$\Delta Y = Y_t - Y_{\bar{t}}$$

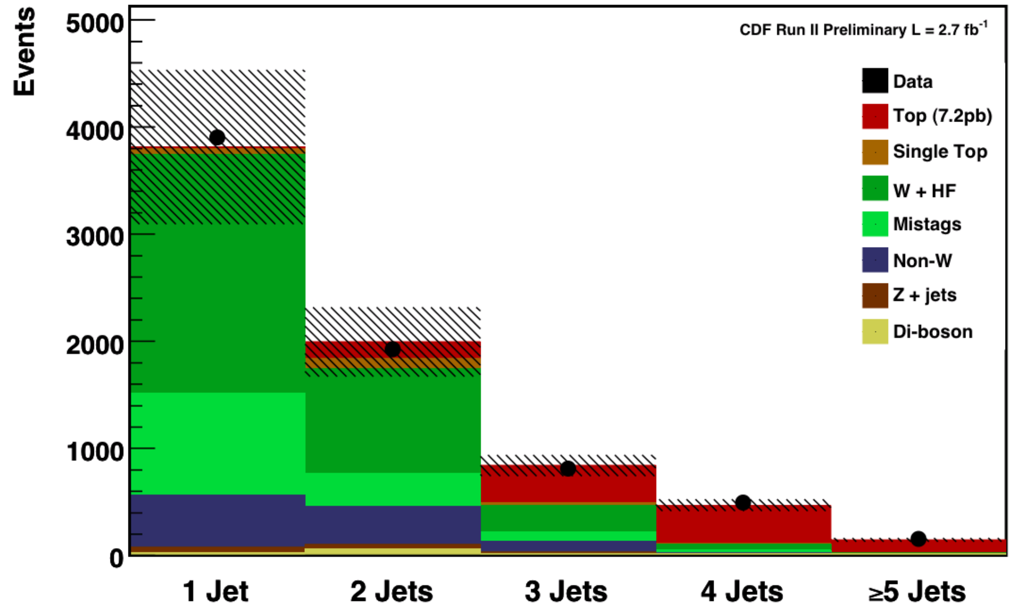
$$A_{\Delta Y} = \frac{N(\Delta Y>0) - N(\Delta Y<0)}{N(\Delta Y>0) + N(\Delta Y<0)}$$

Data Sample

- $L = 3.2\ fb^{-1}$
- e/μ E_t / p_t > 20 GeV/c, |n|<1.0
- MET > 20 GeV
- 4 jets Et > 20 GeV/c, |n|<2.0
- >= 1 btag
- 776 events

- Backgrounds
  - W+jets w/h.f. or "mis"tag
  - +QCD + small EWK
  - 167.5 ± 41.8 events

- 608 tt events. S:N ~4:1
- for σ_{eff} ~ 7.2 pb



Process	
W+HF Jets	86.56 ± 27.40
Mistags (W+LF)	27.43 ± 7.70
Non-W (QCD)	33.44 ± 28.06
Single Top	7.82 ± 0.50
WW/WZ/ZZ	7.57 ± 0.74
Z+Jets	4.78 ± 0.59
Top	569.08 ± 78.81
Total Prediction	736.64 ± 89.22

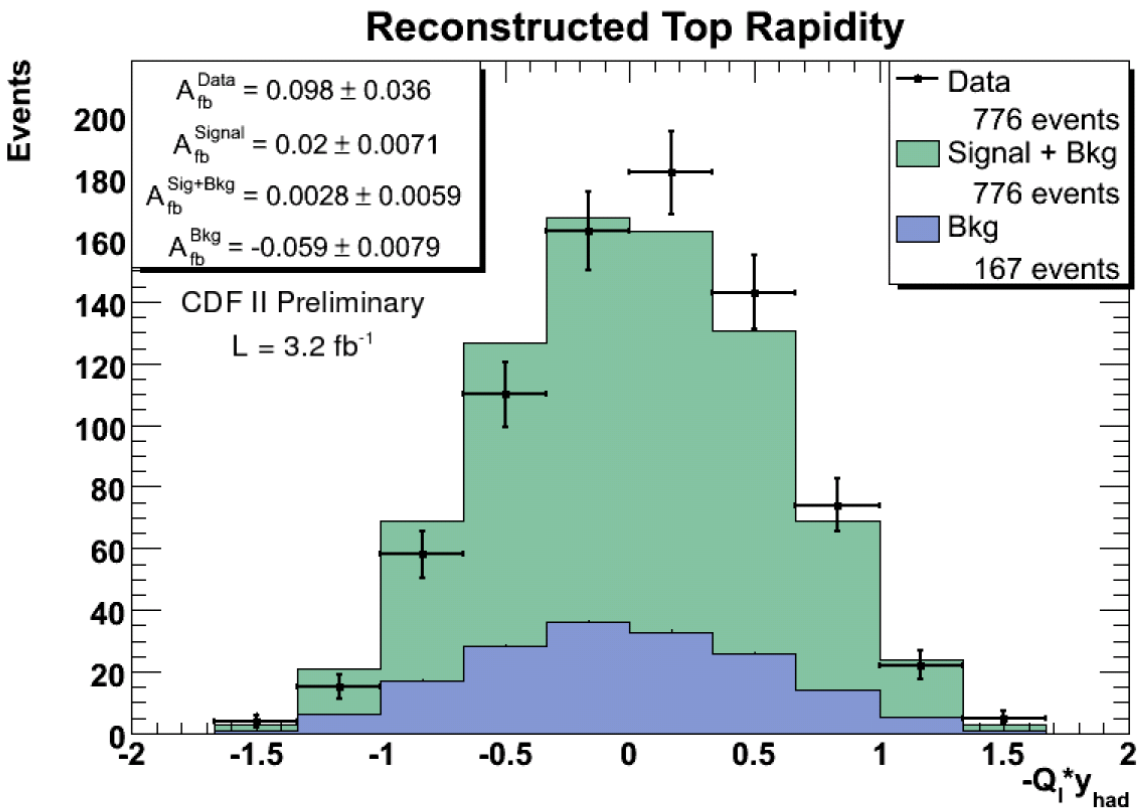
Top Reconstruction

- Jet-parton assignment via χ^2
  - Constraints: $M_W = 80.4$ GeV/c^2 (n.b. p_z ν!), $M_t = 175$ GeV/c^2, btag = b
  - Float jet p_t within errors

Rapidity Variables

- each event has a leptonic and hadronic top decay
  - Q_l + : t_{lep} + $tbar_{had}$
  - Q_l - : $tbar_{lep}$ + t_{had}
- this analysis: hadronic top in the lab frame
  - Y of t_{had}
  - charge of lepton from t_{lep}
  - use $-Q_l$*$Y(t_{had})$

The Top Rapidity Distribution (-Q*Y)



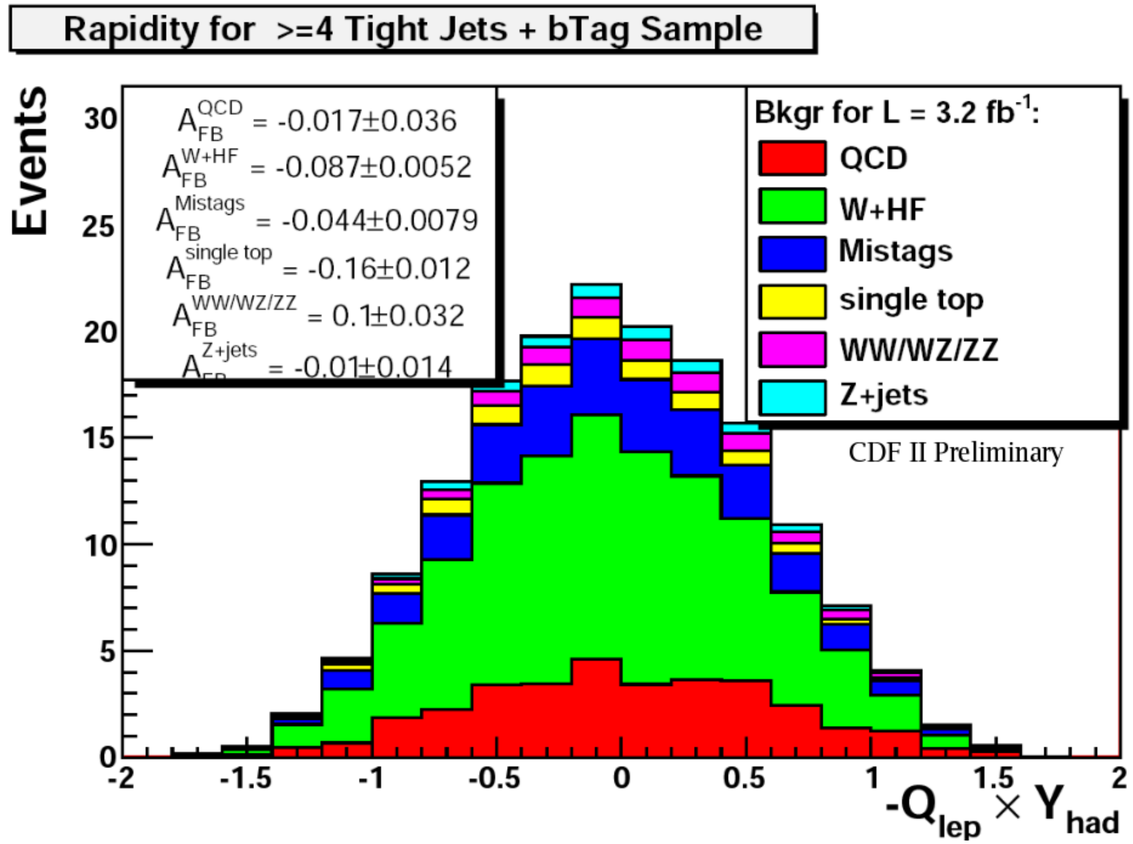
- combined -Q*Y

  A_{FB} = +9.8 ± 3.6 %
- MC@NLO

  A_{FB} = +1.9 ± 0.7 %

Subtract (somewhat asymmetric) Backgrounds

backgrounds reconstructed as top



Process	>=4 jets
W+HF Jets	-0.087±0.0052
Mistags (W+LF)	-0.044±0.0079
Non-W (QCD)	-0.017±0.036
Single Top	-0.16±0.012
WW/WZ/ZZ	0.1±0.032
Z+Jets	-0.01±0.014
Total Prediction	-0.059±0.0079

Unfold to the parton-level

- dN/dY : histogram
  - parton level bins j w/ contents Pj
  - data: in bins i w/ contents D_i
- then
  - $D_i = M_{ij} \times \varepsilon_j \times P_j$
- where
  - the ε_j are the acceptances for each bin
  - the M_{ij} are the bin-to-bin migration ratios
  - both measured with symmetric Pythia
- the inverse propagates data to parton level
  - $P_j = x\ \varepsilon_j^{-1} \times M_{ji}^{-1} \times D_i$
- result is optimized when nbins =4

bin	Y
1	-2.0 to -0.4
2	-0.4 to 0.0
3	0.0 to 0.4
4	0.4 to 2.0

Measurements

-Q*Y (pp frame) with 3.2 fb^{-1}

A_{FB} = 0.19 ± 0.07 ± 0.02

ΔY (tt frame) with 1.9 fb^{-1}

A_{FB} = 0.24 ± 0.13 ± 0.04

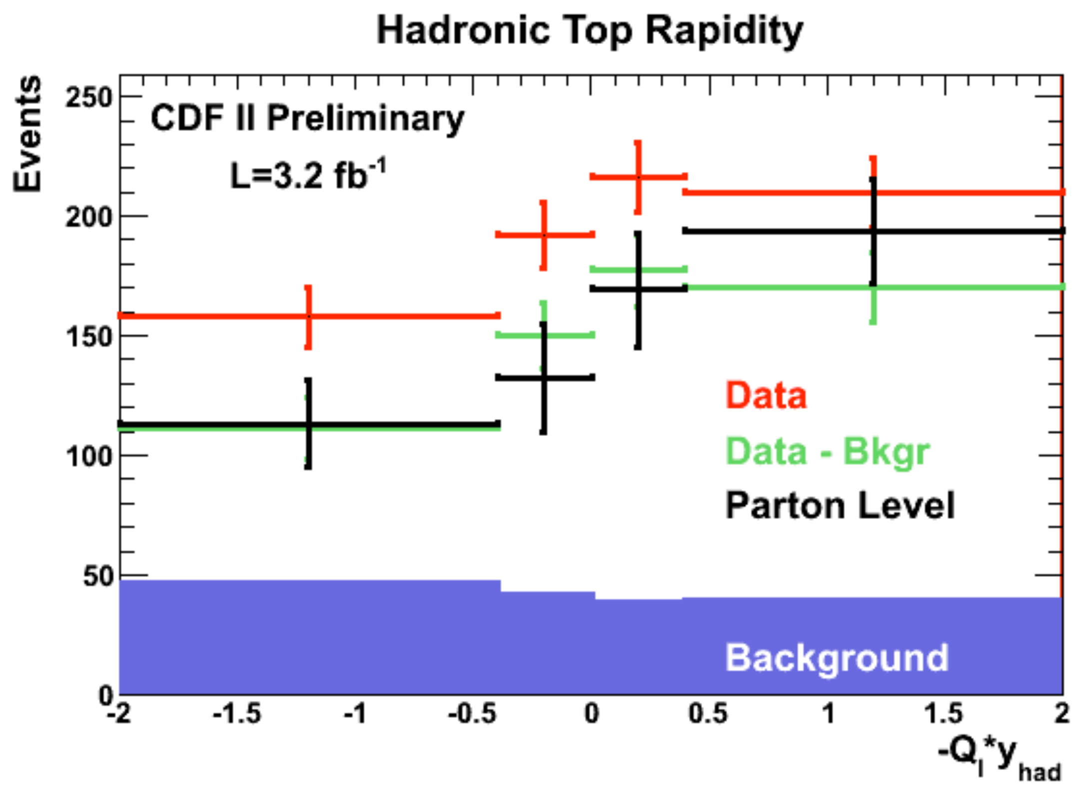
D0 has measured

ΔY (uncorrected) with 0.9 fb^{-1}

A_{FB} = 0.12 ± 0.08 ± 0.01

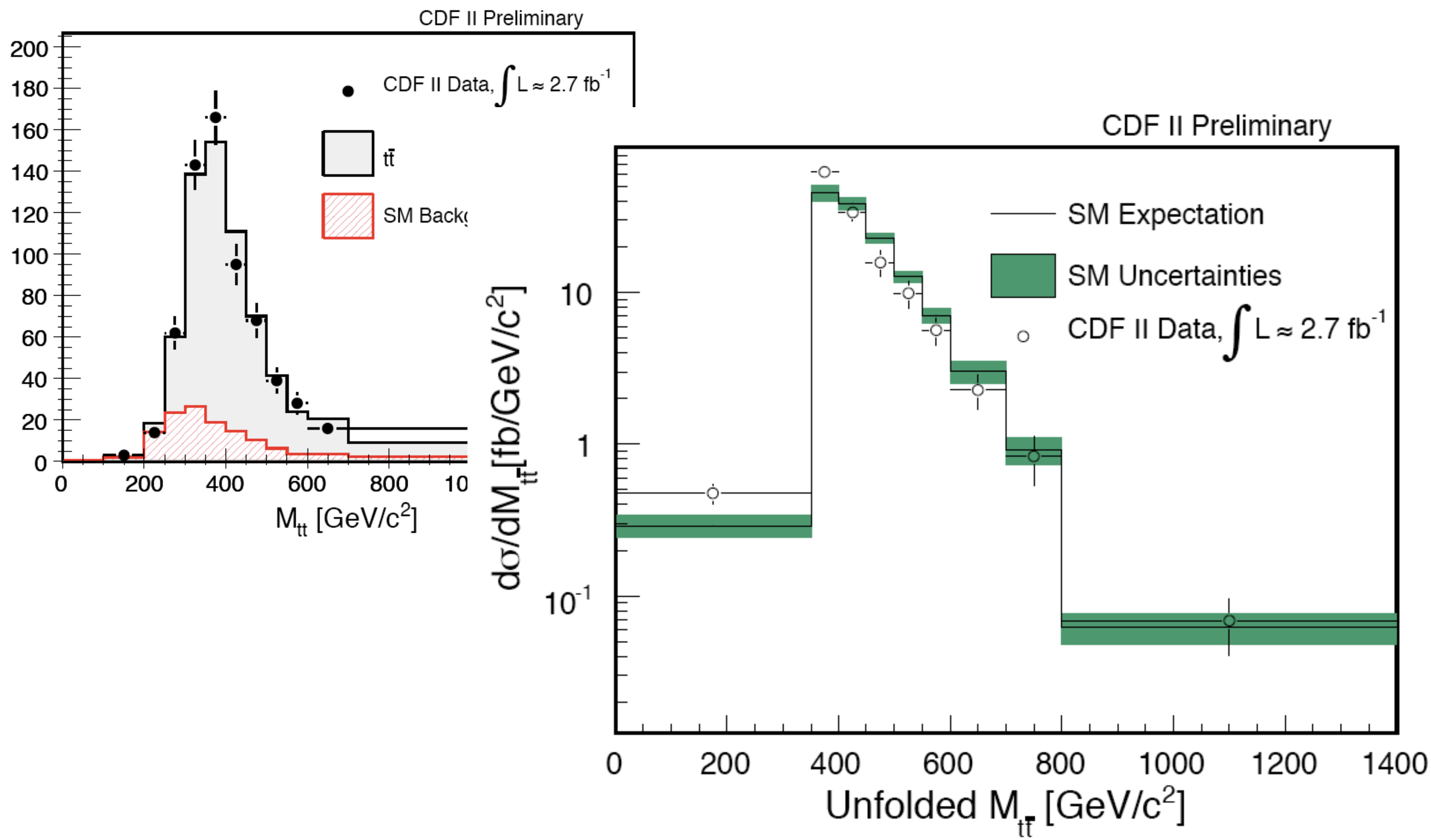
compare CDF ΔY uncorrected

A_{FB} = 0.11 ± 0.04



The M_{tt} distribution Bridgeman, Liss (CDF)

- A proper unfold to parton level
  - "no evidence of departure from SM"

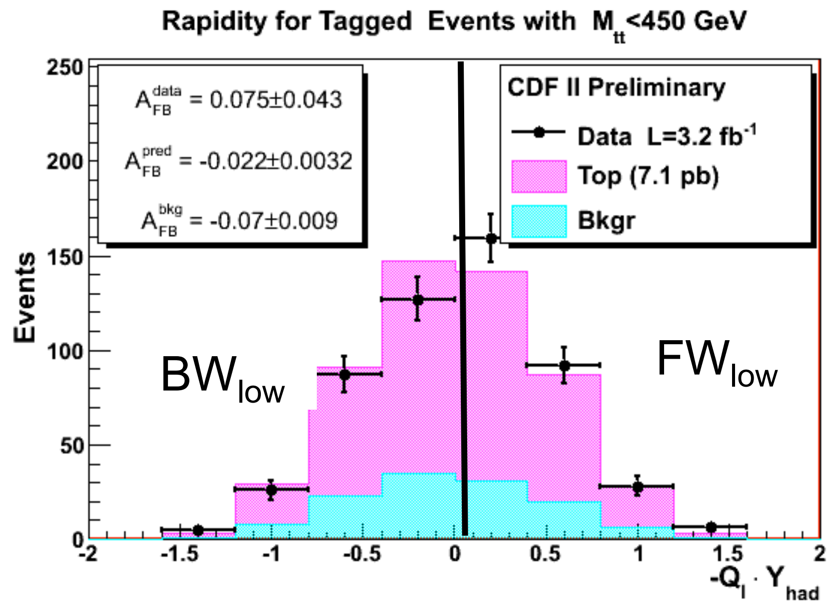


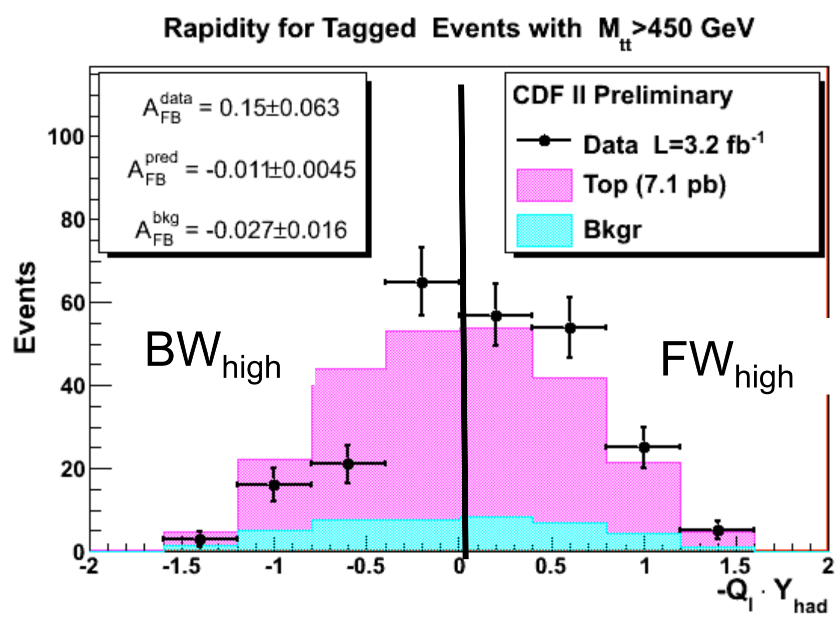
Mass Dependence of the Asymmetry M. Tecchio, T. Schwarz

- unfold in M_{tt} *and* A_{fb}

for some mass cut

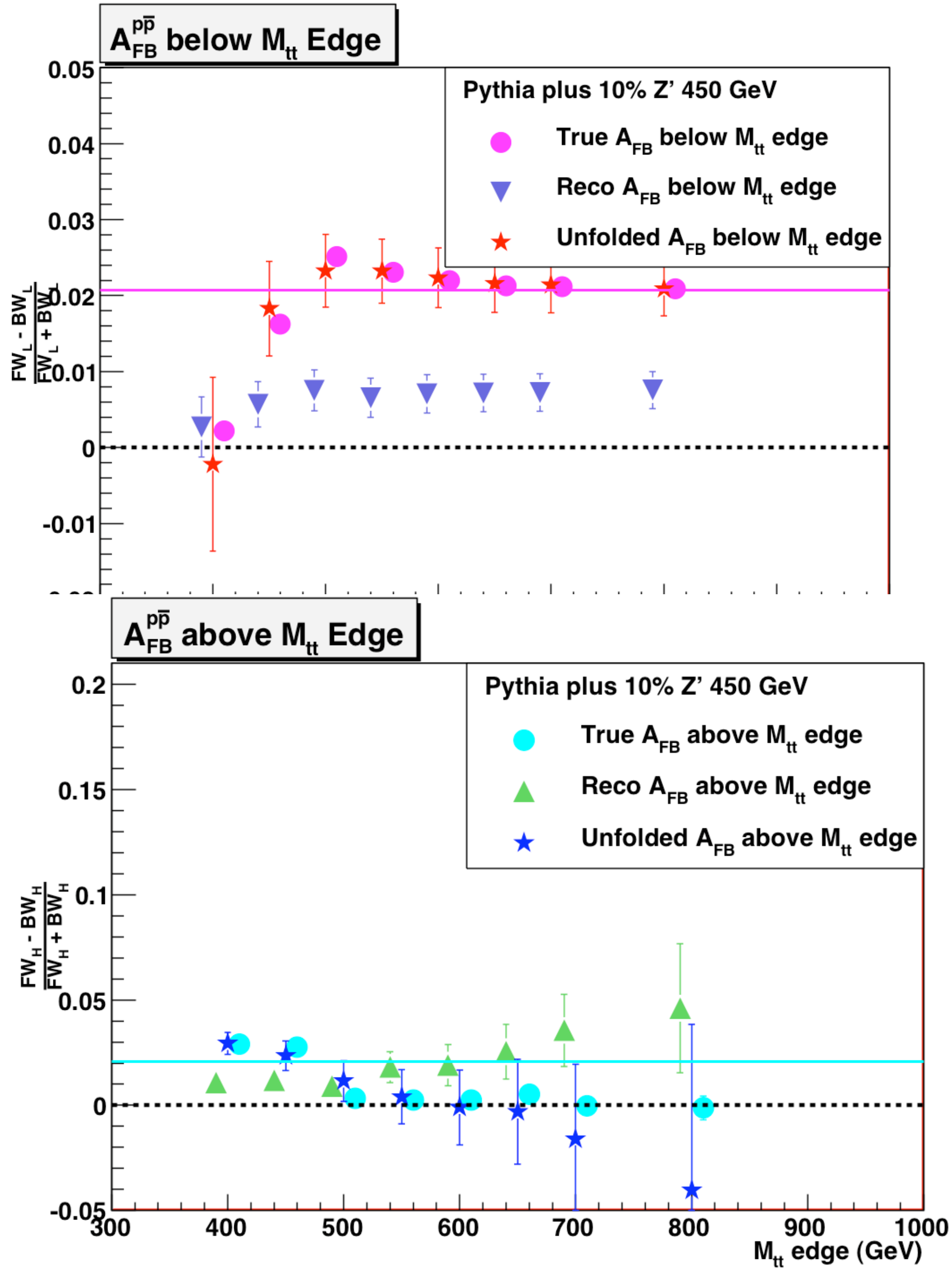
- reconstructed data divided into 4 exclusive bins
  - low mass FW
  - low mass BW
  - high mass FW
  - high mass BW
- backgrounds subtracted
- selection bias, reco slews corrected simultaneously in mass and Y with 2x2 unfold
- parton level A_{fb} for 2 mass bins "high and low"
- can study as function of cut





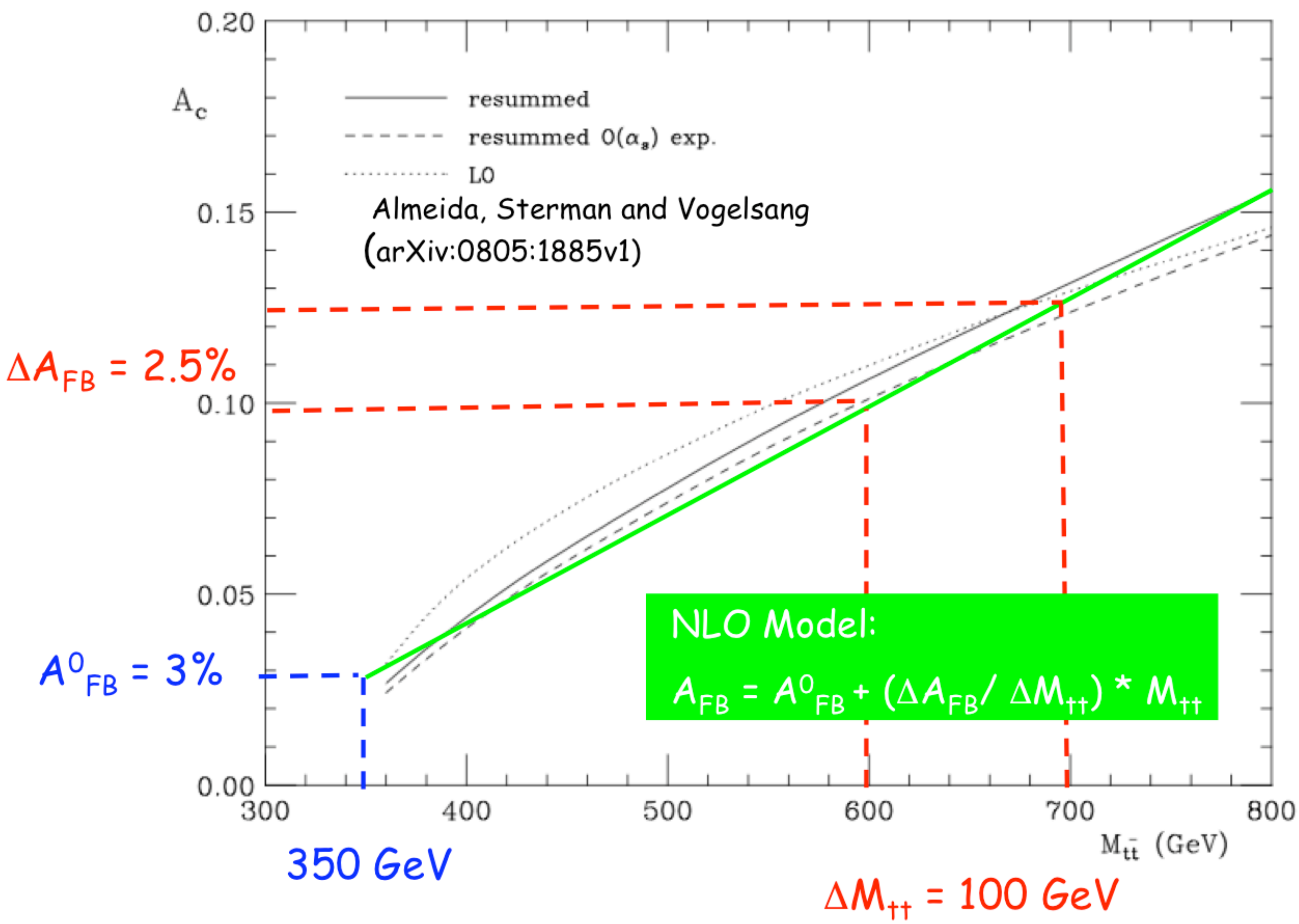
A_{fb} vs M unfold performance check

- add 10% contribution (0.7pb) of sequential Z' at 450 GeV
  - expected integral Afb ~ 2%
- In Afb low mass cut scan
  - sharp rise to 450
  - overshoot
  - settles back to integral
  - unfold works nicely
- In Afb high mass cut scan
  - starts above integral
  - asymptotes to Pythia symmetry as Z' contribution fades

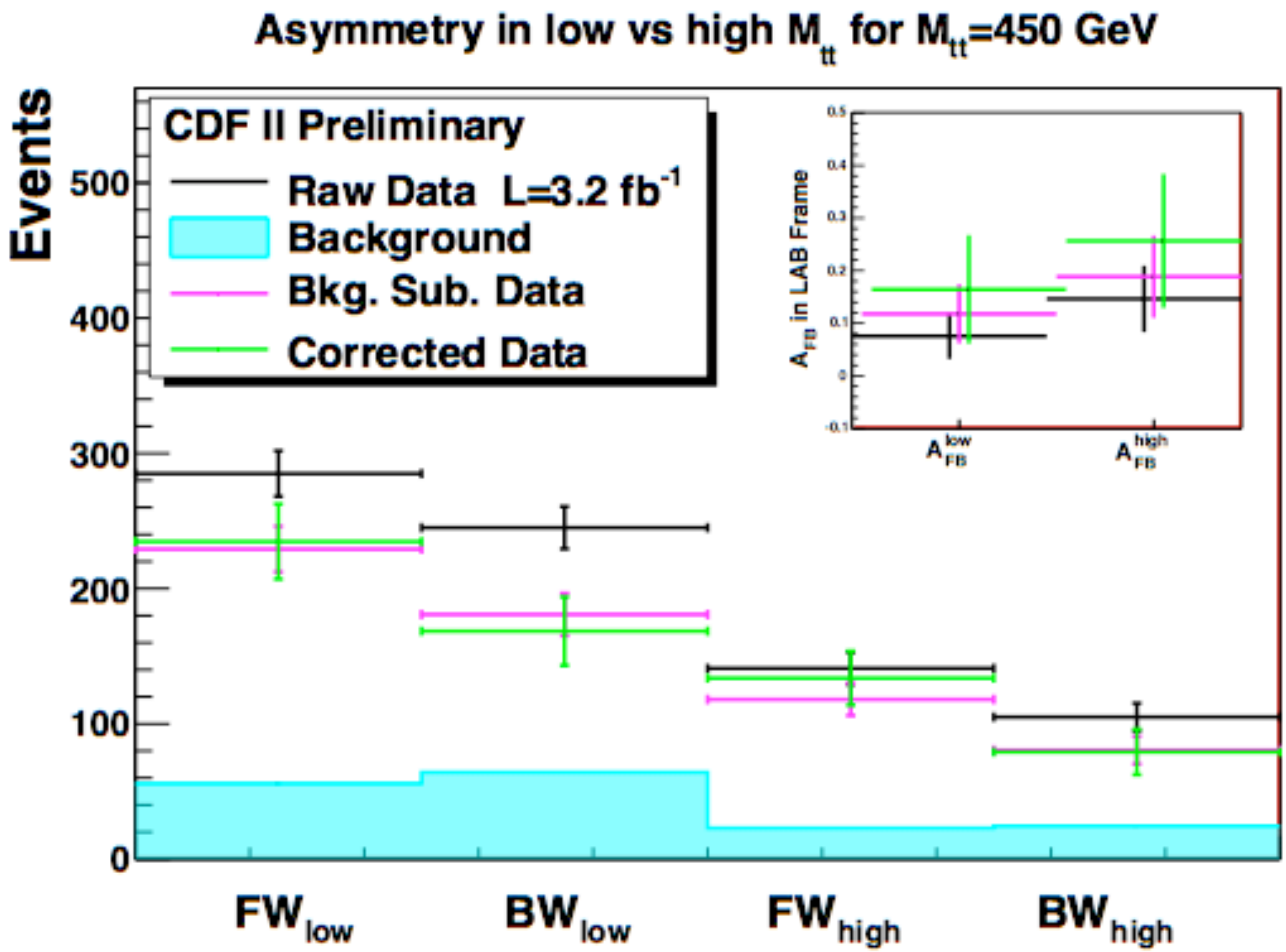


What do we expect?

- in qq frame the NLO effect has a linear mass dependence
  - Almeida, Sterman, Vogelsang

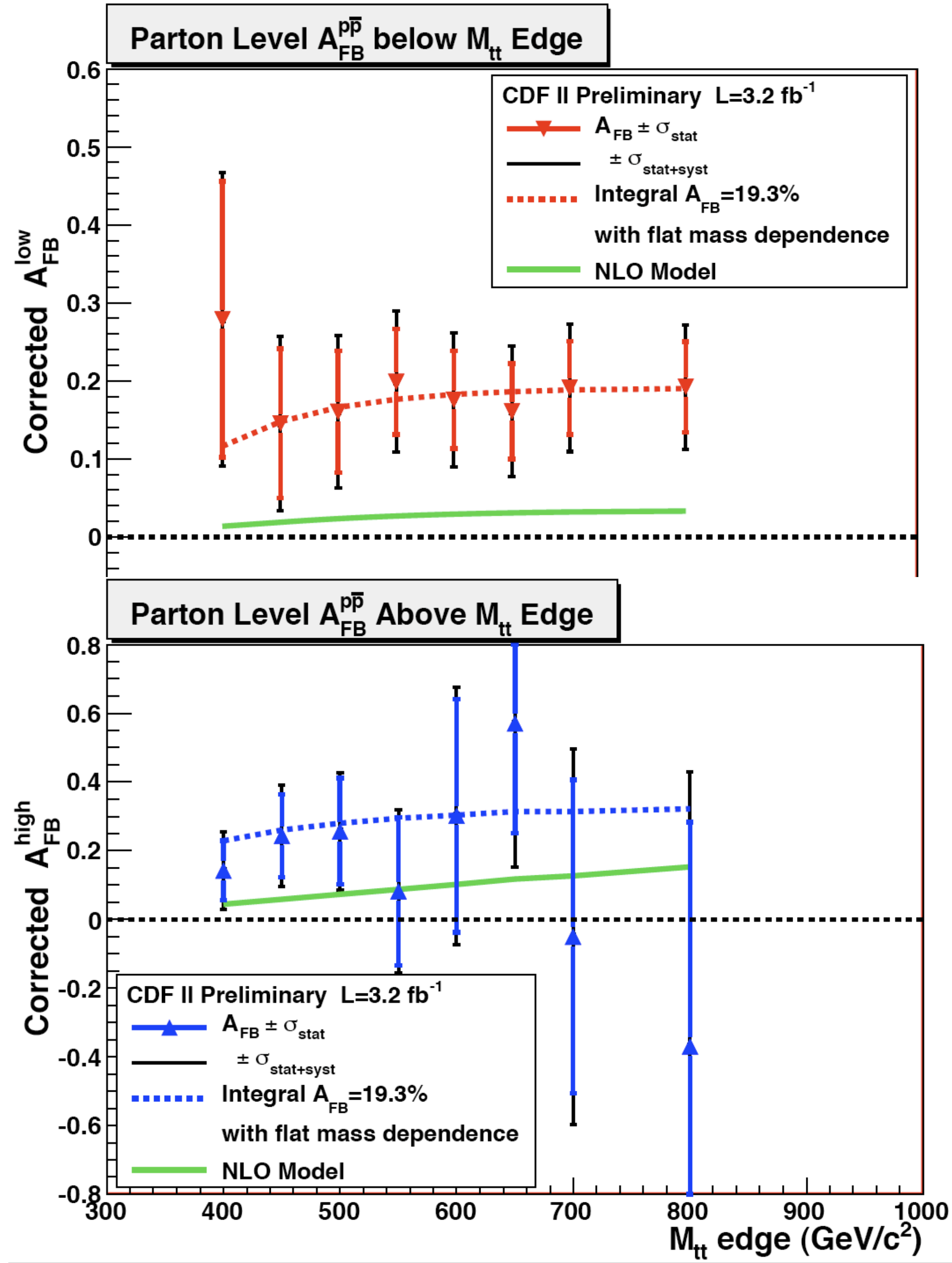


Data Measurement with Mass Cut at 450 GeV



Now Scan the Cut

- points: data
- dashed: Pythia reweighted with flat Acosθ asymmetry
  - A = 19%
  - no mass dependence
- green: "NLO model", Pythia reweighted with A_{FB} linearly dependent on M_{tt} as per fit to NLL calculation
- awaiting more data!



Now what?

- A_{FB} in pp frame

  $A_{FB} = 0.19 \pm 0.07 \pm 0.02$

- Procedure for study of mass dependence
- It's all 2σ

- more studies with more data
  - ΔY variable
  - understand systematics
  - A_{FB} vs M_{tt}
  - A_{FB} vs Y
  - asymmetries of decay products

- more data!!

Bonus Question

- Highest Q^2 prior test of C in strong interactions ?

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Test of charge-conjugation invariance in $\bar{p}p$ interactions

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Using $\bar{p}p$ interactions at $\sqrt{s} = 5.44$ GeV we have tested for evidence of C noninvariance through a comparison of the transverse-momentum distributions of particle and antiparticle produced at 90° in the center of mass. We found an average charge asymmetry for pions with $p_\perp$ between 0.5 and 2.7 GeV/c of $\Delta = (N_+ - N_-)/(N_+ + N_-) = 0.006 \pm 0.009$. This corresponds to a limit on the magnitude of the C-violating (relative to C-conserving) amplitude of $\text{Re}\,\alpha \leq 0.0045$.

- What's the rub ?
  - jets: don't know the charge
  - proton collisions: don't know the initial state

- $q\bar{q} \rightarrow t\bar{t}$ at the Tevatron is ideal