The First Measurement of the Forward-Backward Charge Asymmetry in Top Pair Production at DØ

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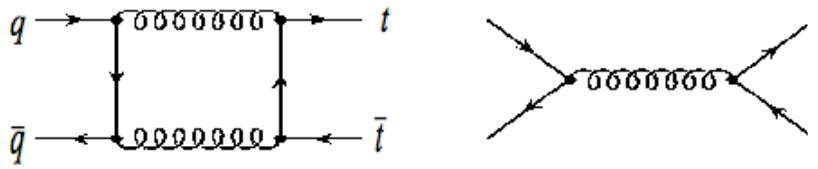
SM Asymmetry

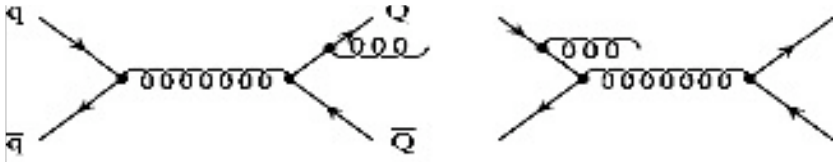
- In the Standard model, top production is symmetric at α_s^2
- At α_s^3 or higher, interference terms can give rise to asymmetric production
- A calculation for t-tbar+jet gives:
  - -(7-8)% @ LO (~α_s^3)
  - -(0-2)% @ NLO (~α_s^4)
  - hep-ph/0703120
- Total asymmetry predicted to be about 5%
  - Kuhn *et al.* (LO), Bowen *et al.* @ α_s^3

Box/Tree Interference



"4 Jets", Positive contribution

ISR/FSR Interference



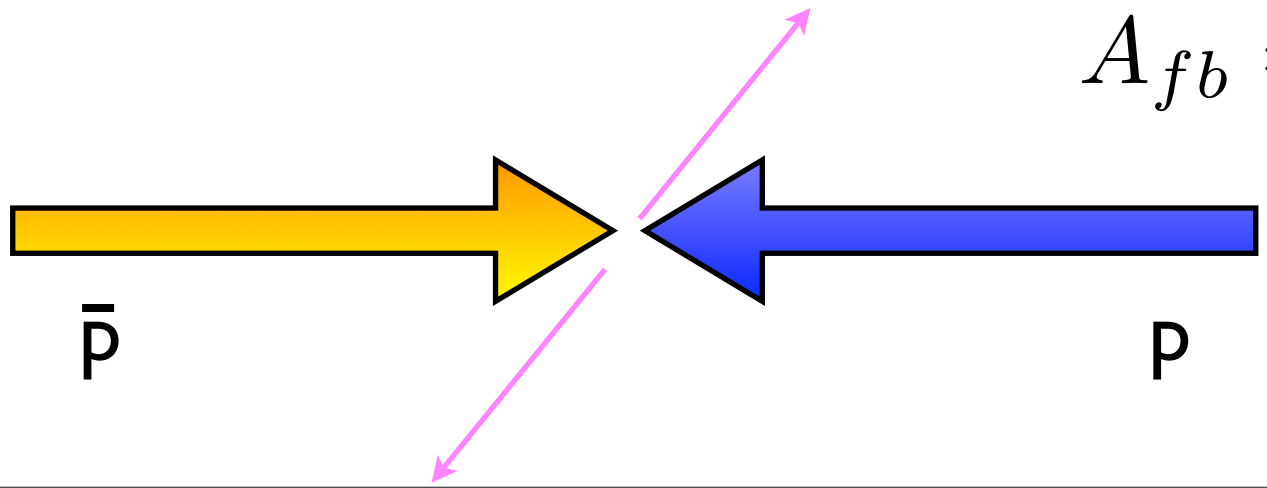
"≥5 Jets", Negative contribution

Measurements split between 4 and ≥ 5 Jets

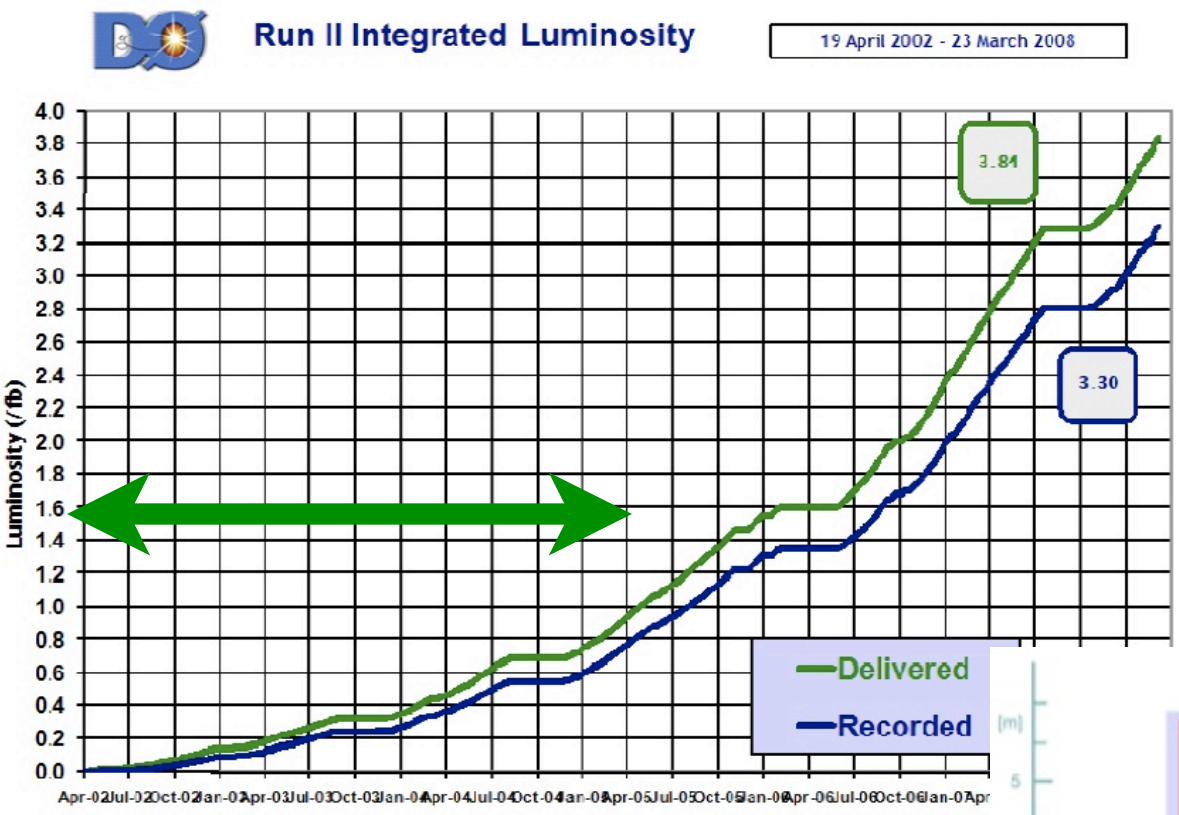
Forward-Backward Asymmetry

- At the Tevatron, the charge asymmetry in top pair production is visible as a forward-backward asymmetry.
  - Is it the top or the anti-top that is preferentially produced in the direction of the incoming proton?
  - Sensitive to new physics.
- Difficult to measure at LHC

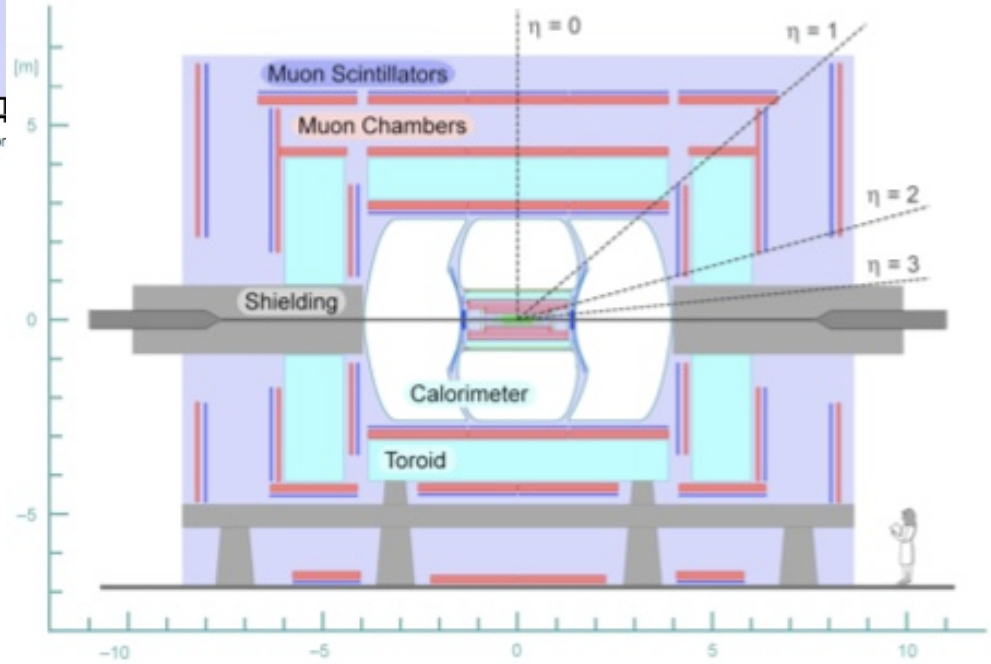
$$A_{fb} = \frac{N_f - N_b}{N_f + N_b}$$



The DØ Detector



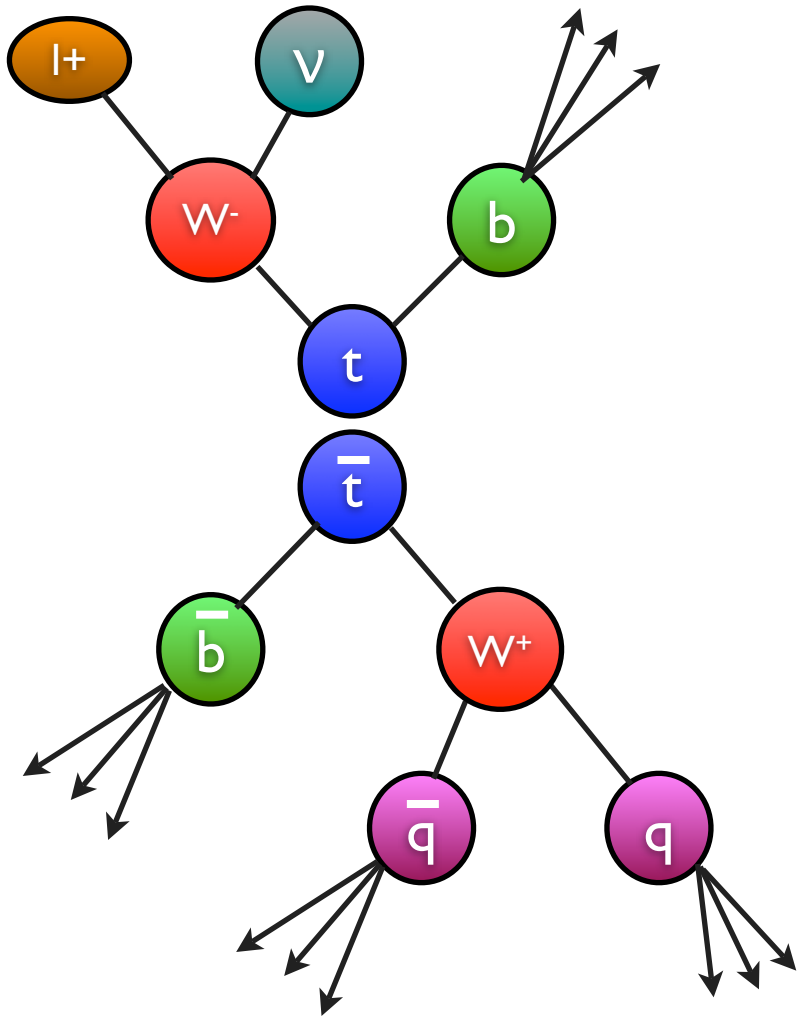
Data taken between 2002-2005 (0.9 fb^{-1})



lepton + jet analysis uses every major component at DØ

Final State Selection

- Select Events with at least 4 jets in lepton+jets channel, with a loose b-tag.
- Use kinematic fitter to reconstruct Δy, according to top pair hypothesis, resolutions, b-tags, and the constraints:
  - M(W)=80.4 GeV
  - M(t) = 170 GeV
- 2 times stronger than using lepton rapidity



- Define:

$$N_f = N_{y_t > y_{\bar{t}}}$$
$$N_b = N_{y_{\bar{t}} > y_t}$$

  - Combine Information from both top quarks
  - Invariant to boosts along the beam axis

$$A_{fb} = \frac{N_f - N_b}{N_f + N_b}$$

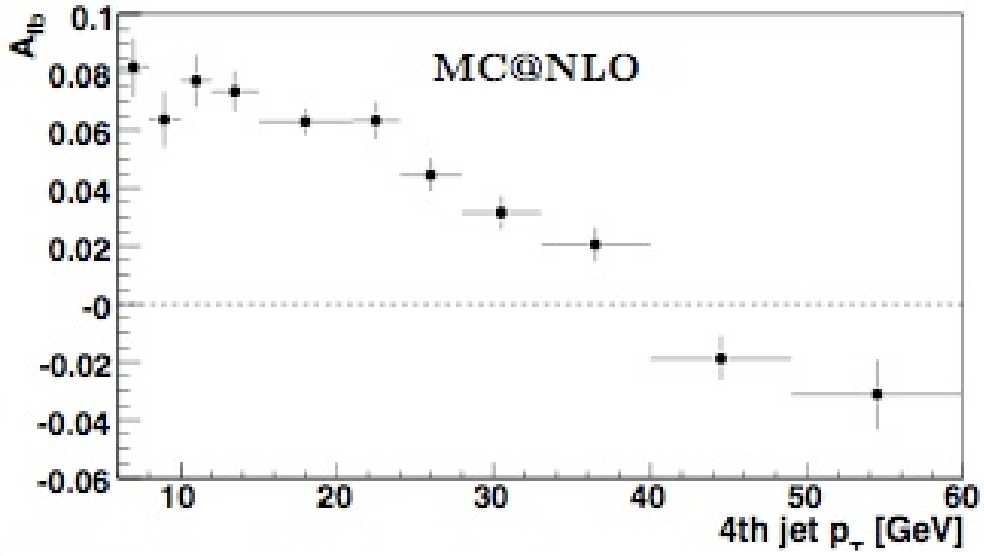
Analysis

- Select Events and estimate signal and background contribution
- Reconstruct event kinematics, label as forward or backward
- Compute Asymmetry
  - Sample composition and asymmetry extracted simultaneously through maximum likelihood fit
    - Choose variables to not bias A_{fb}

Acceptance

- We know that the asymmetry changes over phase space, but not the details of how it changes.
- For this reason, we do not apply acceptance corrections back to the particle level.

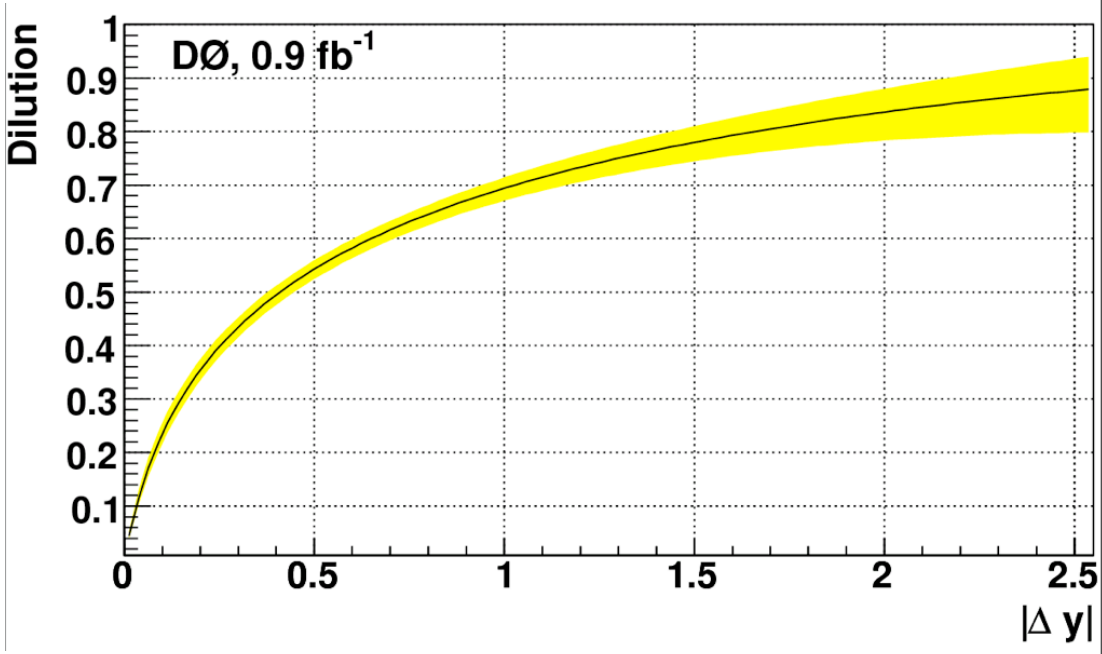
What regions of phase space are probed?



- Acceptance effects approximated through simple parton level cuts
  - Does not change asymmetry be more than 2%
  - Analysis designed to allow this approximation to work

Reconstruction and Dilution

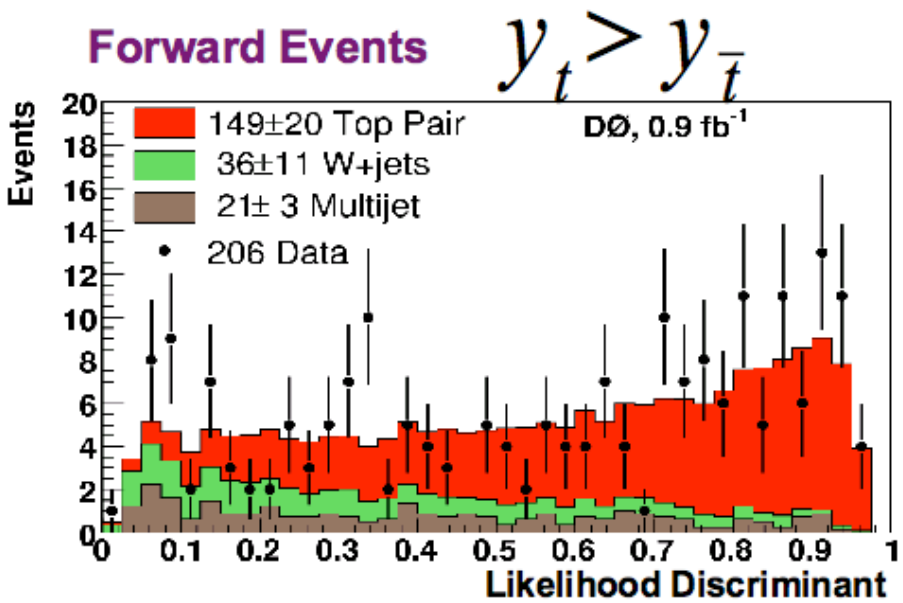
- *Mis*reconstruction of Δy dilutes the observed asymmetry
  - D=2p-1
- At small Δy, much harder to get right the sign of Δy.
- A dilution correction is very model dependent.
  - May kill sensitivity to new physics
  - Therefore, we provide a parameterization rather than a correction.

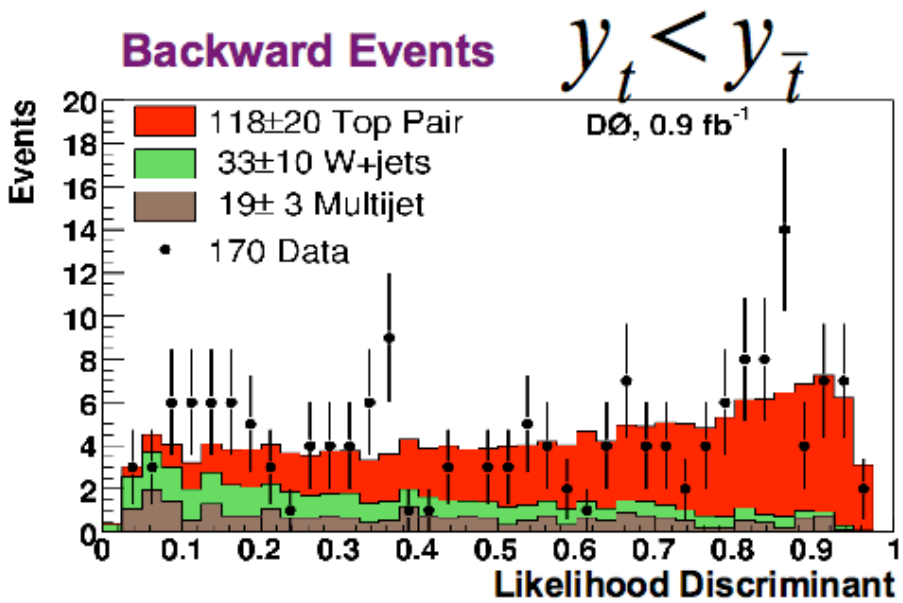


With acceptance and dilution parameterizations, any model can be compared to this analysis

Asymmetry

Sample composition and asymmetry fit simultaneously





MC@NLO Predictions

$$A_{fb}^{pred} = (0.8 \pm 0.2(stat) \pm 1(acc))\%$$

Measured Asymmetries

$$A_{fb} = (12 \pm 8(stat) \pm 1(syst))\%$$

As a function of number of Jets:

$$A_{fb,4}^{pred} = (2.3 \pm 0.2(stat) \pm 1(acc) \pm 0.1(dilu))\%$$

$$A_{fb,4} = (19 \pm 9(stat) \pm 2(syst))\%$$

$$A_{fb,\geq 5}^{pred} = (-4.9 \pm 0.4(stat) \pm 1(acc) \pm 0.2(dilu))\%$$

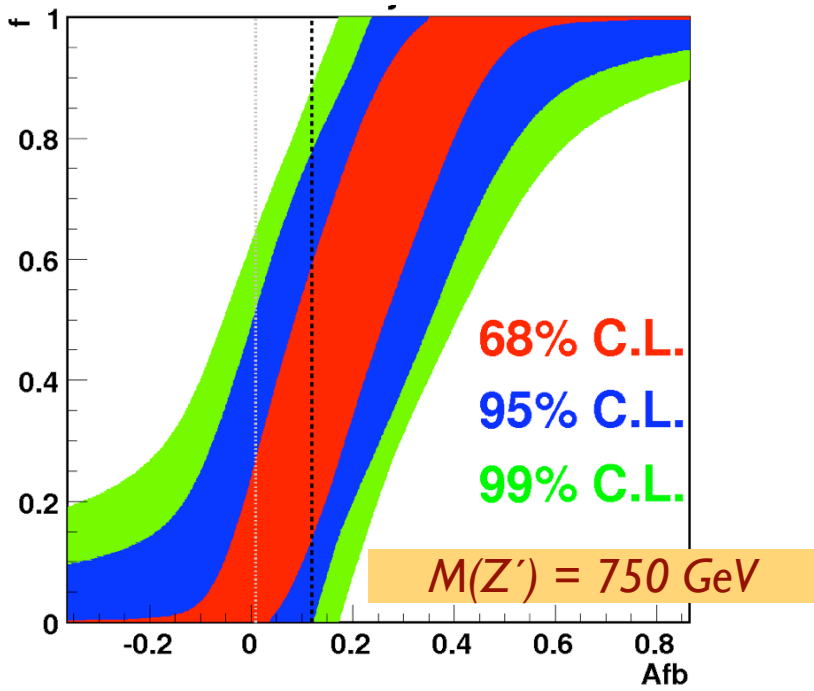
$$A_{fb,\geq 5} = (-16 \pm 16(stat) \pm 3(syst))\%$$

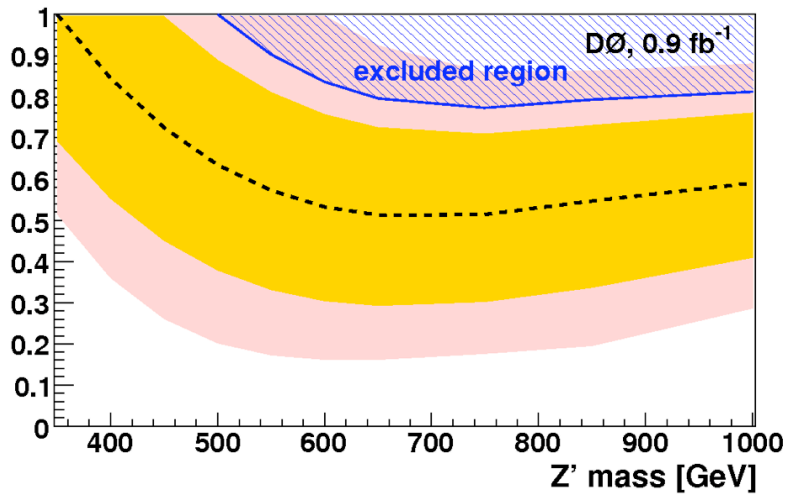
Beyond the SM

- Resonant production?
  - Can probe for wide resonances
  - Z´ resonances
    - Asymmetry varies by model
      - asymmetries typically positive
        - leptophobic Z´ (hep-ph/0408098)
        - top color and top flavor models (hep-ph/9602390)
- Interference with axigluon production? (arXiv:0709.1652)
  - asymmetries typically negative

Beyond the SM: Z´

- Production through Z´ is asymmetric in most models
  - If Z like couplings assumed, A_{fb} ~13-35%
  - Unique probe for wide resonance
- Can put limits on the fraction of top pairs produced via Z´ (f).
  - Compliments searches for narrow resonances
- High measured asymmetry means that our data is compatible with a large Z´ fraction





Summary

- Top pair production asymmetry measured at DØ
- Z´ t-tbar production costrained
- Results can be compared any model, including new physics that is calculated to particle level.
- Published in Phys. Rev. Lett. **100** 142002 (2008)
  - arXiv:0712.0851