New Particle and Interaction Search Results from CDF:

BSM Higgs, Top and SUSY

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New Particle and Interaction Searches at CDF

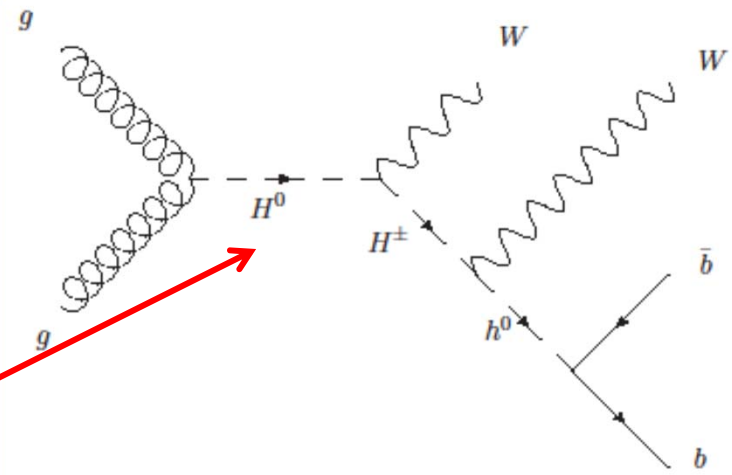
Two of the important questions we are still following up on:

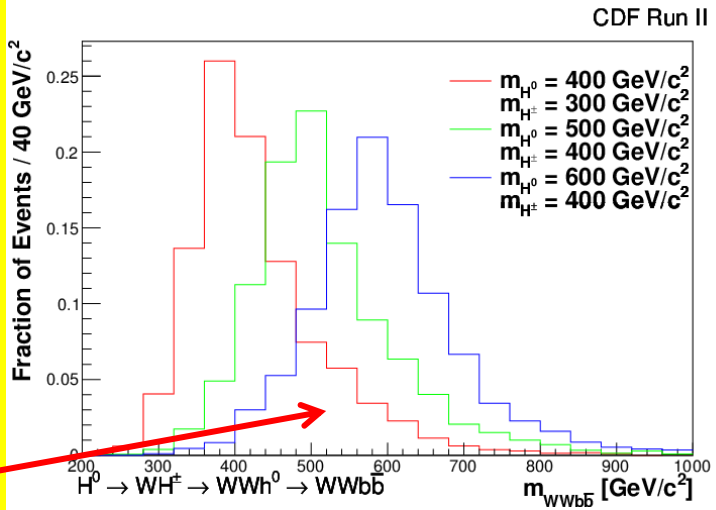
1. ***Is the Boson observed in $\gamma\gamma$, ZZ and $\bar{b}b$ channels the Higgs? A Higgs? A couple of Higgses?***
2. ***Is the forward-backward asymmetry of $\bar{t}t$ at the Tevatron an indication of new physics?***

- **While the higher energies at the LHC make many searches there more sensitive, there are a number of searches which are still very competitive at the Tevatron**
- **Show a number of those searches as well as why they are important and/or interesting**

2-Higgs Doublet Models

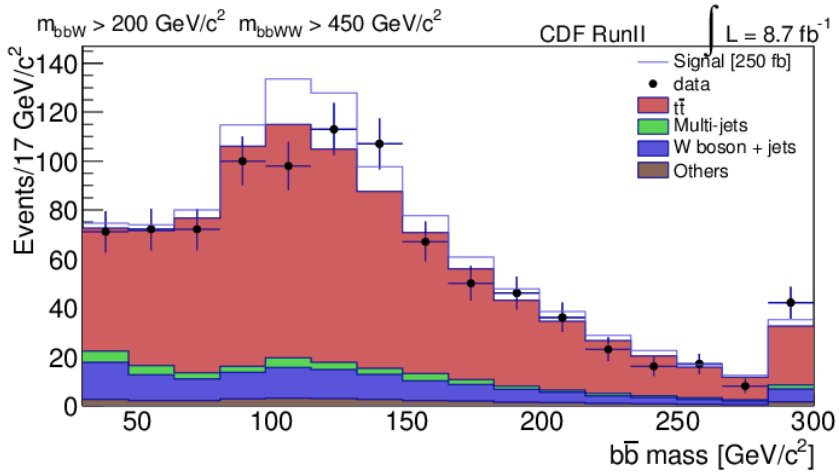
- In many extensions to the SM, there are a number of additional Higgs bosons
  - For example, Minimal SUSY has a 2-Higgs Doublet
- Produce a heavy Higgs in collisions
  - Final state particles are the same as $\bar{t}t$ (two W's and two b's), but the kinematics would be very different.
- Reconstruct the lepton+jets final state using this hypothesis and search for bumps in the $\bar{b}b$ invariant mass, in the $W\bar{b}b$ invariant mass and in the full system mass

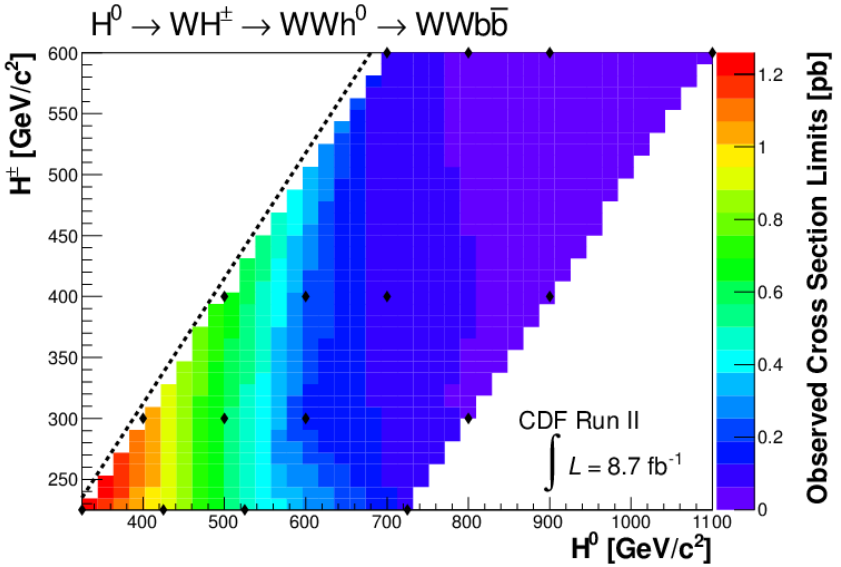




2-Higgs Doublet Results

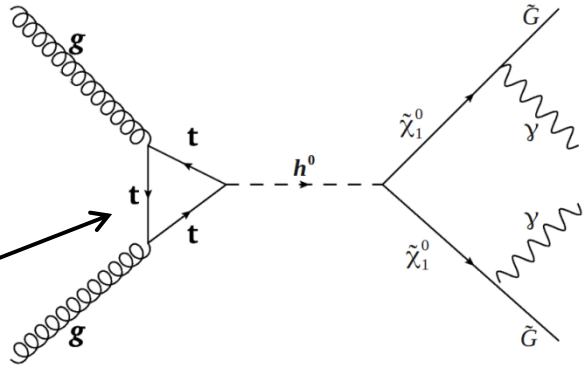
- No evidence of new physics → set limits
- Not sensitive to expected production levels at the Tevatron, but these are the first limits of their kind
- Results (arXiv 1212.3837) accepted for publication in PRL



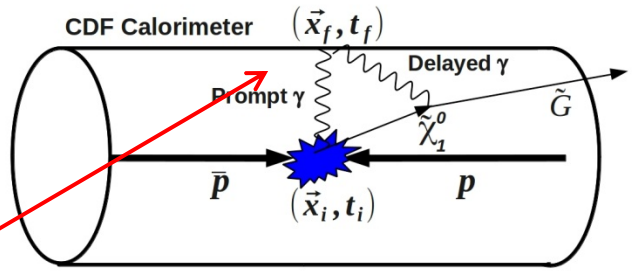


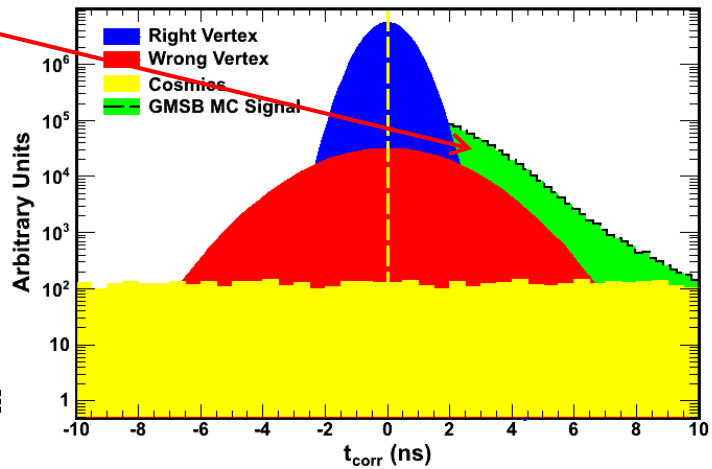
Delayed Photon from Higgs and Supersymmetry

- New search for Gauge Mediated SUSY in single Higgs which decays to a pair of lightest neutralinos
- Focus on neutralinos with a nanosecond lifetime which decay in flight and produce photons that arrive at the detector later-than-expected
- Search exclusive photon+Met final state where the photon is *delayed*

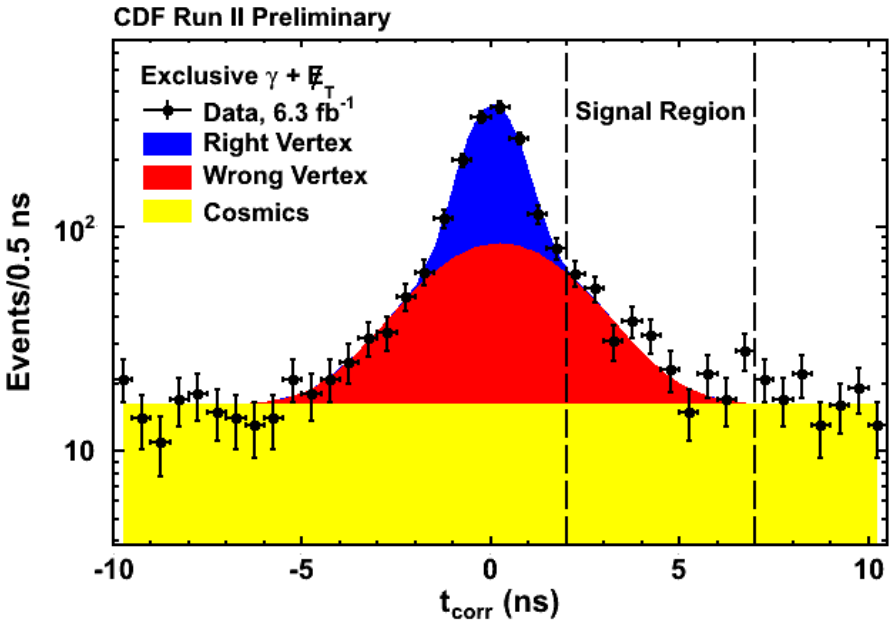


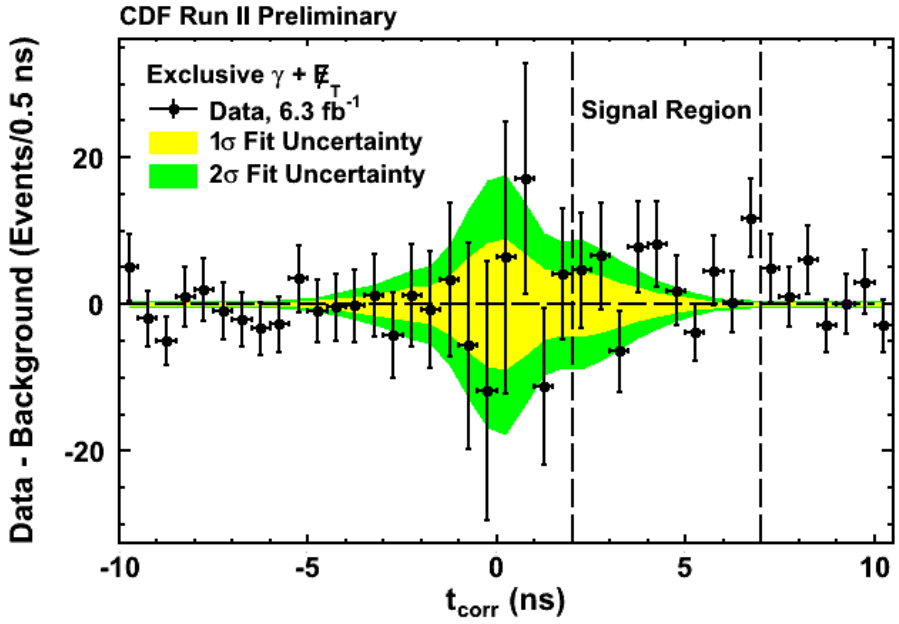
J. Mason and D.T. PLB 702,377 (2011)
And D.T. and Z. Hong in arXiv/1210.1884





Delayed Photons in the Exclusive γ+Met Final State





Result using 6.3fb^{-1} of data is done with a simple counting experiment

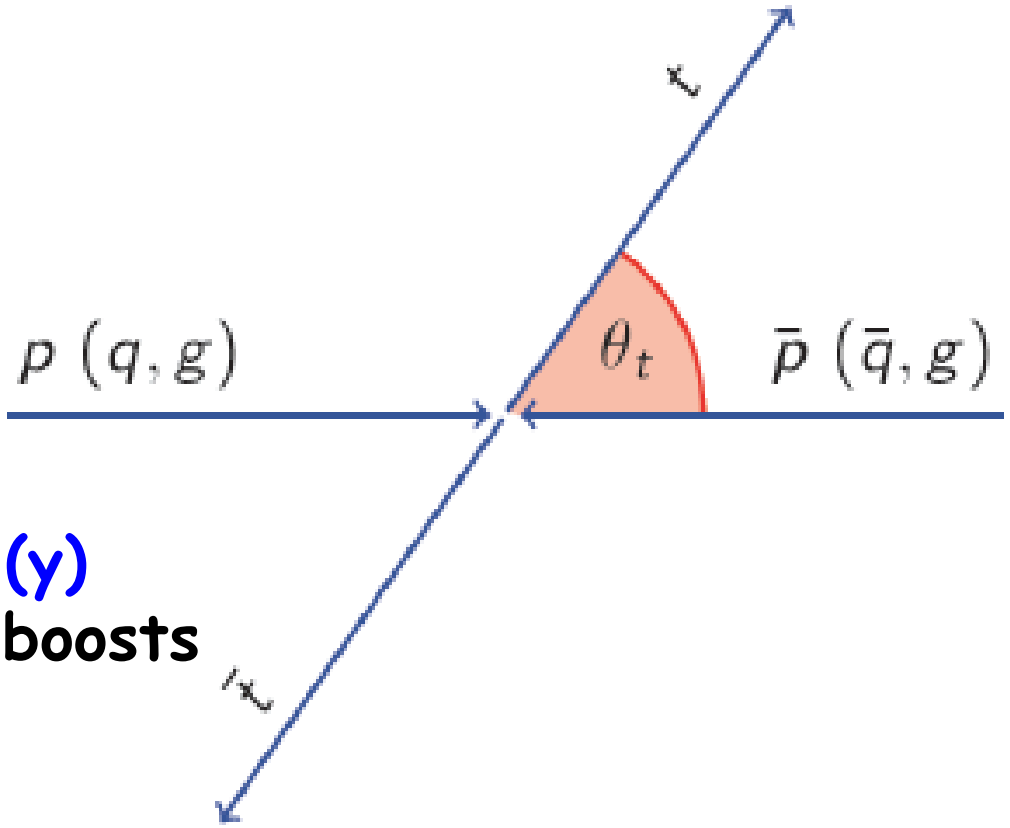
Observe 322 events on a background of 286±24

Results in CDF Public Note 10788

Updates expected for summer with full dataset and fitting to improve sensitivity

What are A_{FB} and ΔY?

In proton-antiproton collisions can measure the forward-backward asymmetry (A_{FB}) in the production angle

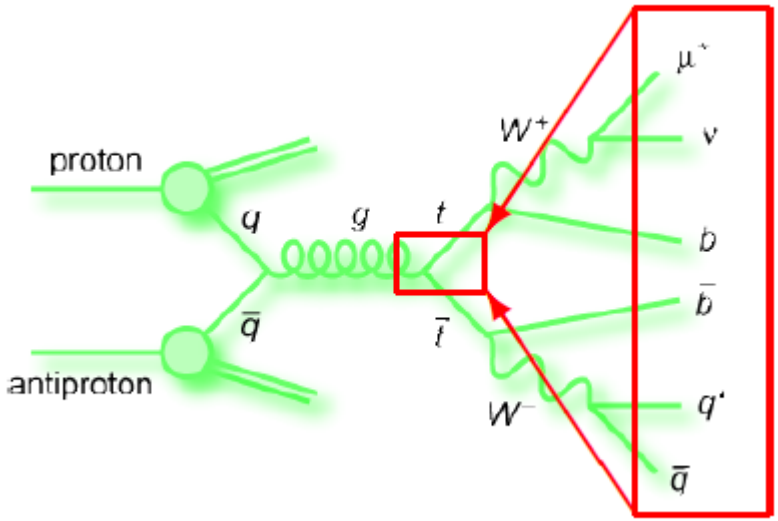


Transform from Θ_t to *rapidity* (y)

Invariant under longitudinal boosts

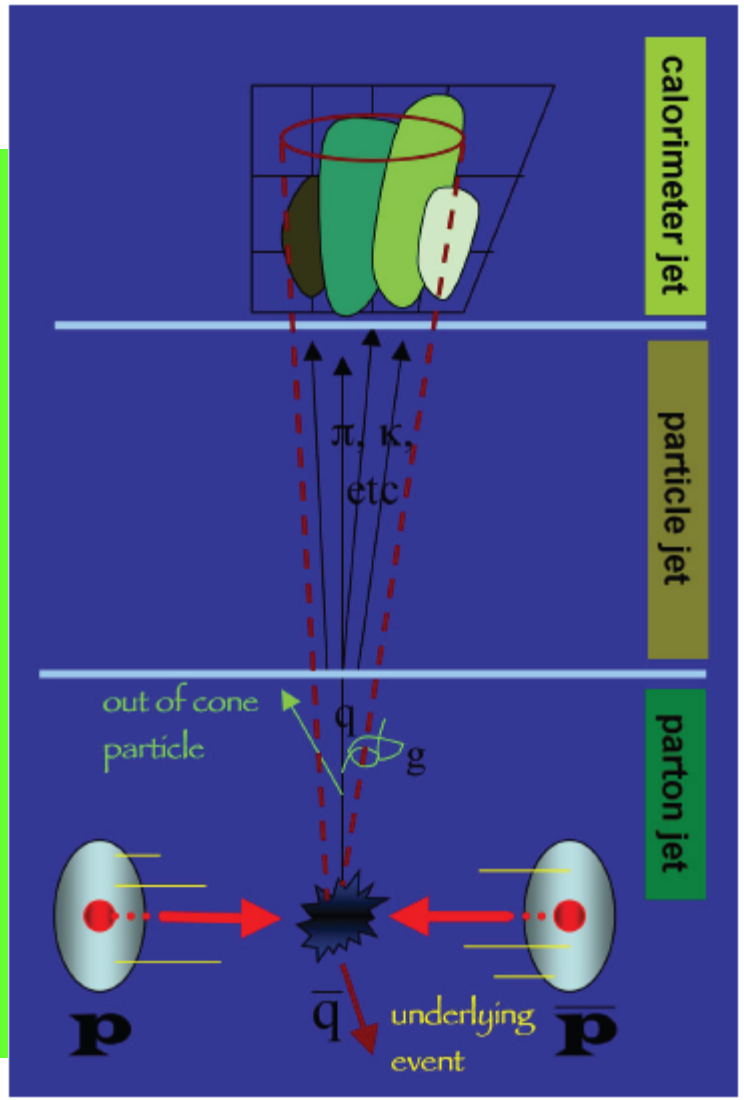
$$\text{Measure } \Delta y = y_t - y_{\bar{t}}, \text{ where } y = \frac{1}{2} ln\left(\frac{E+p_z}{E-p_z}\right)$$

$$A_{FB} \equiv \frac{N(\Delta y > 0) - N(\Delta y < 0)}{N(\Delta y > 0) + N(\Delta y < 0)}$$



Goal: Work back to parton level to understand production

- Used measured objects and take into account a number of effects which wash out the asymmetry
  - Detector resolution
  - Smearing from incorrect reconstruction
  - Finite geometry etc.
- Use NLO simulations to unfold back to the parton level

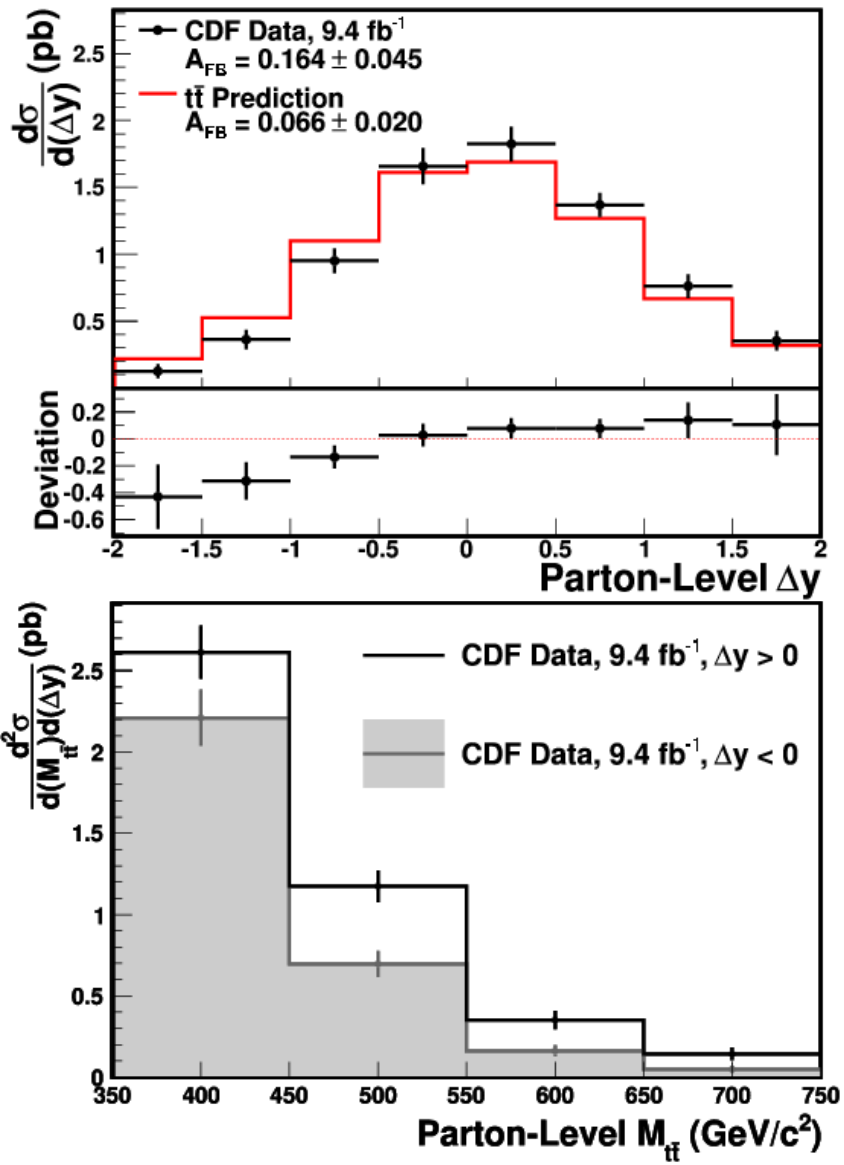


CDF and DØ have observed-larger-than-SM values of A_{FB} for awhile

Three main types of activities:

1) Convince ourselves that we understand both the predictions as well as the measurement systematics
2) Gather facts about the asymmetry and look for other clues
3) Follow up with searches for new particles

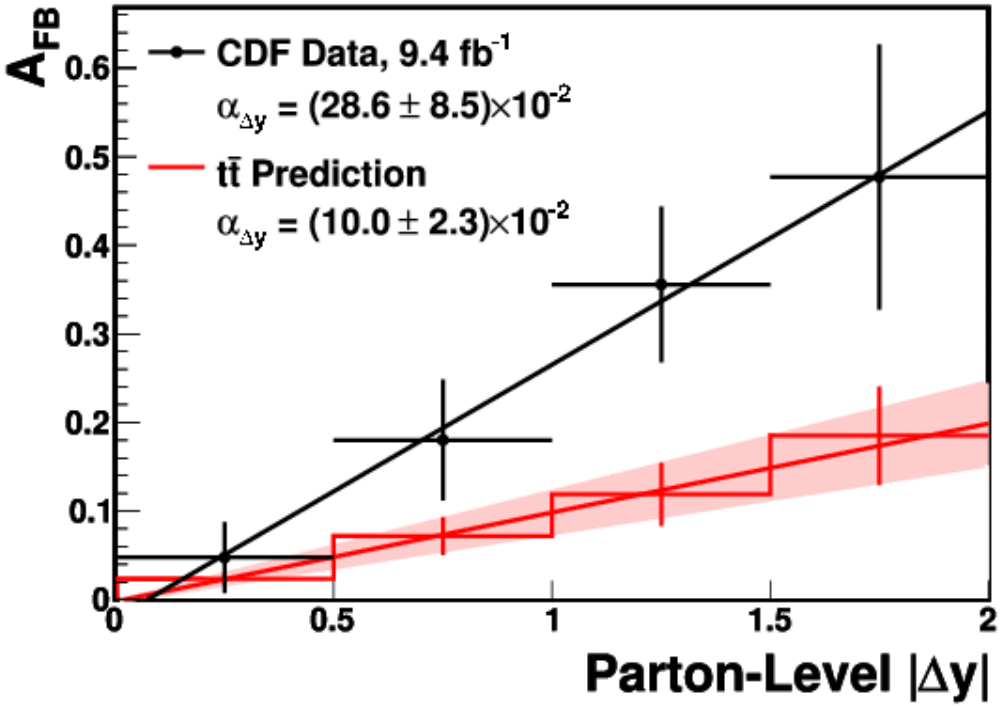
Most recent CDF Results with Full dataset

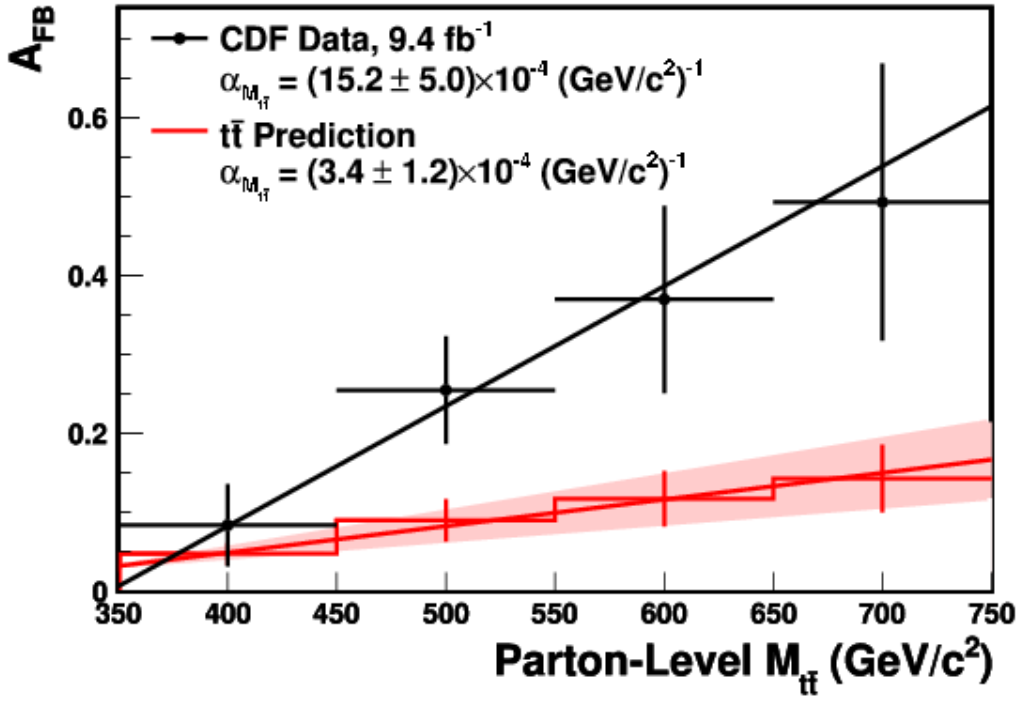


Important Clues and Facts from A_{FB} Measurements

Consider the asymmetry as a function of a number of important parameters

Differential values of Asymmetry appear linear





Slopes are 3σ from zero and inconsistent with SM predicted slopes

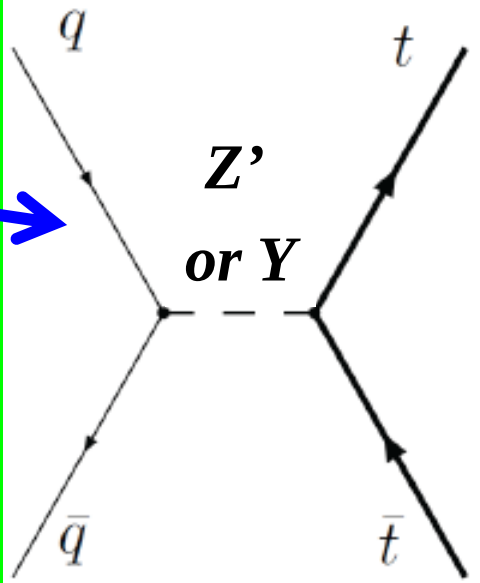
Many more checks have been done on both the data and SM predictions at NLO.

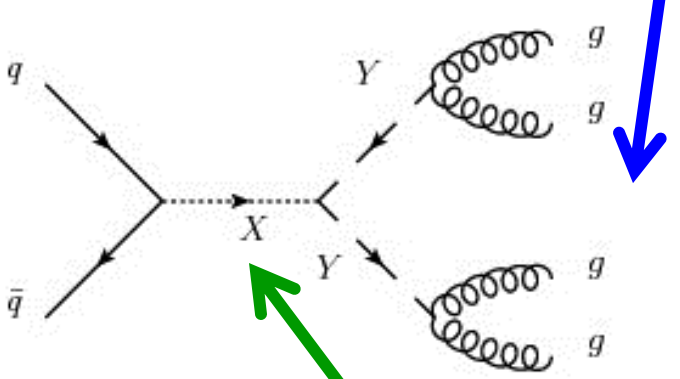
Results in both Lepton+Jets and Dilepton Final states, as well as CDF and DØ are consistent

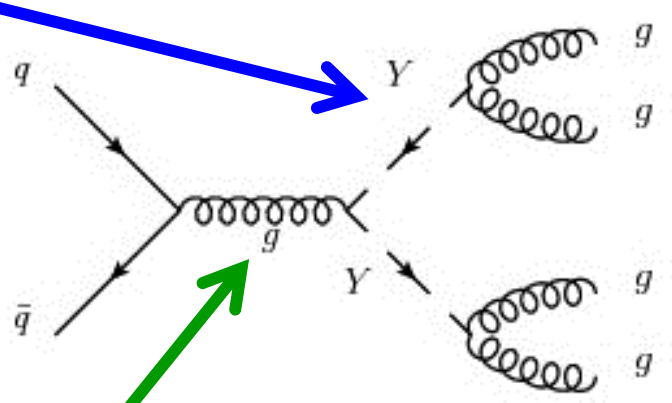
Many of the details are in arXiv 1211.1003, submitted to PRD. More results in a few weeks

Follow up with Searches for new particles in the $\bar{t}t$ and 4-jet Final State

If the A_{FB} result is due to a Z' or light axi-gluon mixing with SM production, then we should be able to see new particle production and decay in the $\bar{t}t$ or 4-jet final state



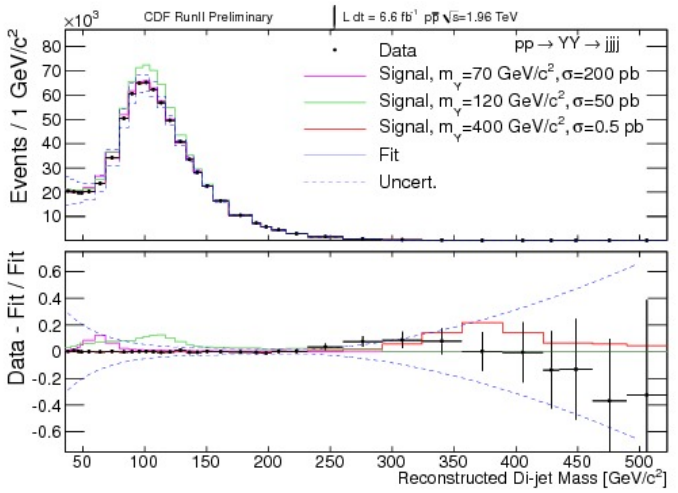


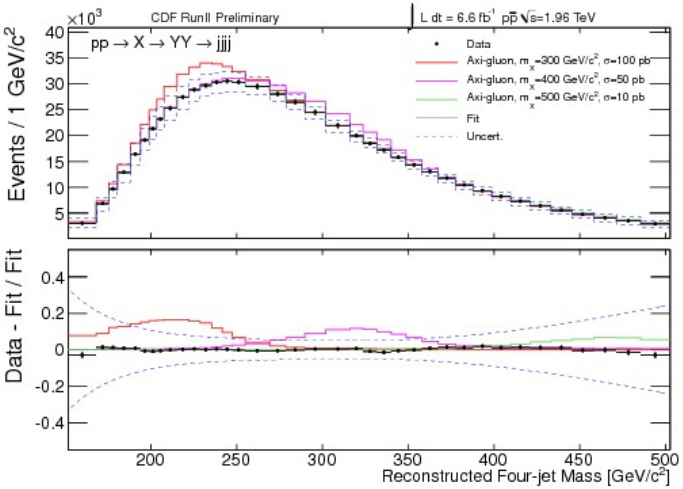


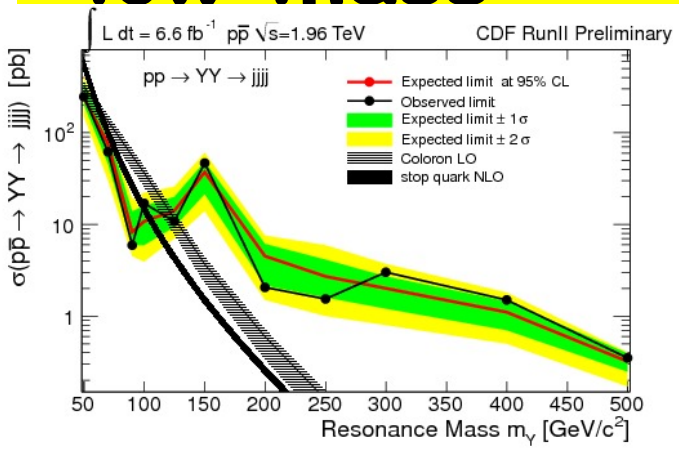
- LHC has ruled out large-mass axi-gluons and Z's, but Tevatron has better sensitivity at low mass
- Consider both resonant and non-resonant production

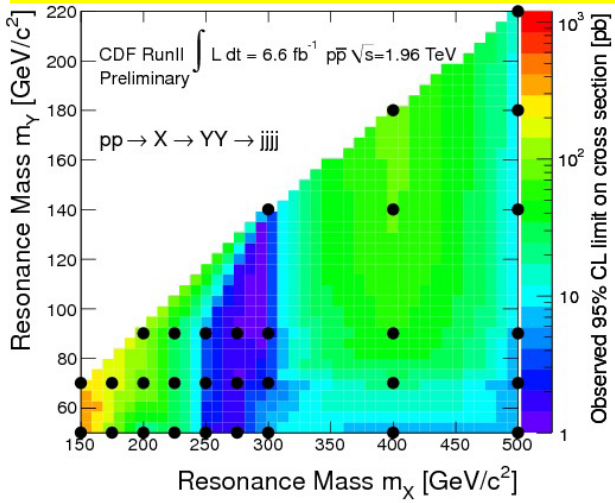
Bump Hunting in 4-Jet Events

- Consider the mass of dijet pairs and the 4-body mass
- No evidence for new physics in either
- Important new limits at low mass







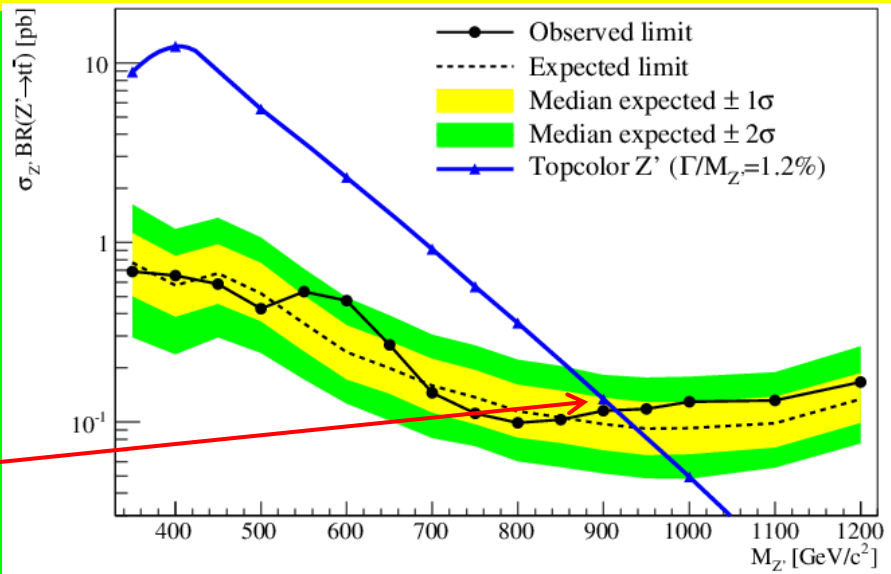


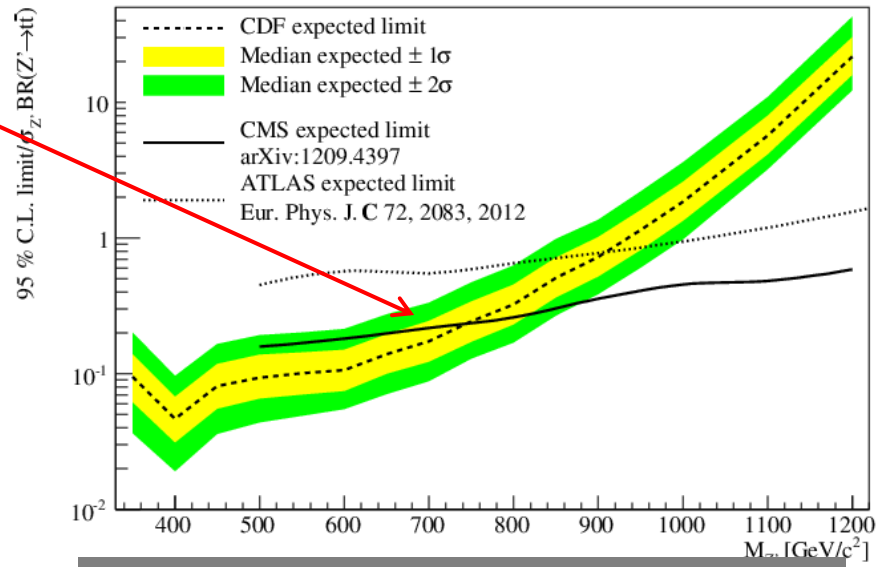
More detail in CDF Public Note 10946

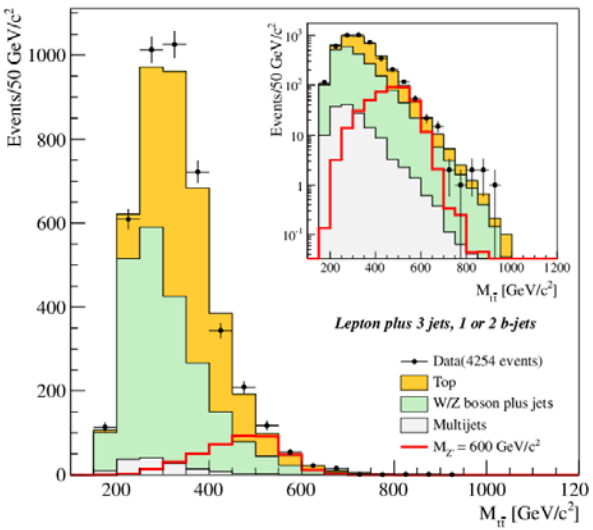
Nearing submission to PRL

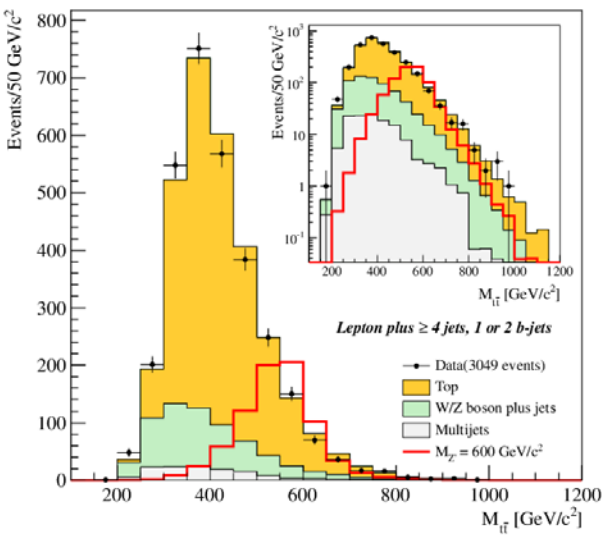
Z' → $\bar{t}t$ Limits

- Reconstruct the t and $\bar{t}$ in lepton+jets events and form the system invariant mass
- No evidence for new physics
- Exclude to almost a TeV, but provide the most sensitive limits below about 750 GeV









arXiv 1211.5363,
Accepted for publication in PRL

Summary and Conclusions

- The observation of X(125) and the anomalous Forward-Backward asymmetry in $\bar{t}t$ production at the Tevatron continue to intrigue
- New studies have shed important facts in our quest for understanding
- Direct searches for other particles and interactions that might be produced in some of the New Physics models have not panned out
- More results are being blessed and will be shown in a few weeks