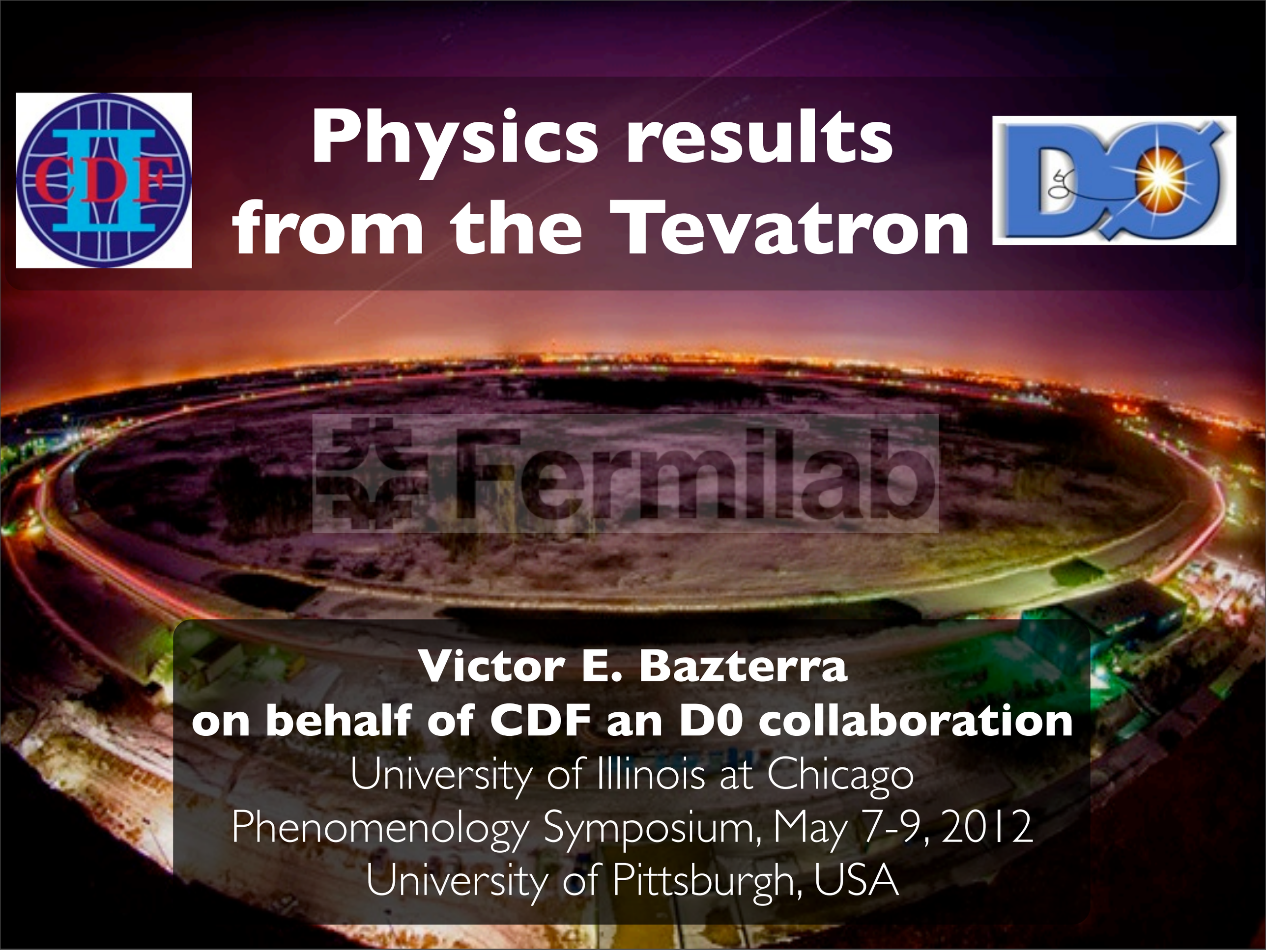
Physics results from the Tevatron



Victor E. Bazterra
on behalf of CDF an D0 collaboration
University of Illinois at Chicago
Phenomenology Symposium, May 7-9, 2012
University of Pittsburgh, USA

Outline

- I will present some of the resent physics result from the Tevatron.
- There are 46 new results from the Tevatron and these are excluding all the results related to Higgs searches and new results were not included in the winter conference.
- In today's presentation is a small sample where I will cover:
  - New W boson mass Tevatron combination.
  - Measurement W helicity using top pair events.
  - Constrains to anomalous coupling in Wtb vertex.
  - Search for Lorentz invariance violation and forward-backward asymmetry in the top pair production.
  - Exotic searches of heavy particles produce in association with tops and pair production of Kaluza-Klein quarks.

The Tevatron collider 1983-2011

Chicago

Booster

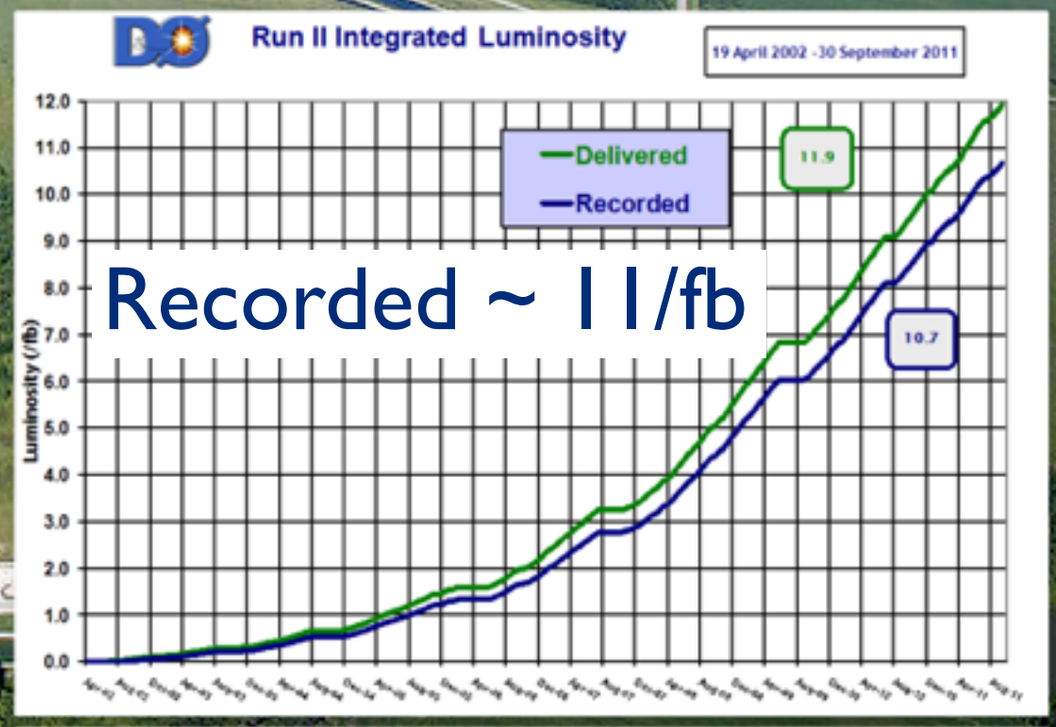
CDF

DØ

Tevatron

Anti-proton source

Main Injector



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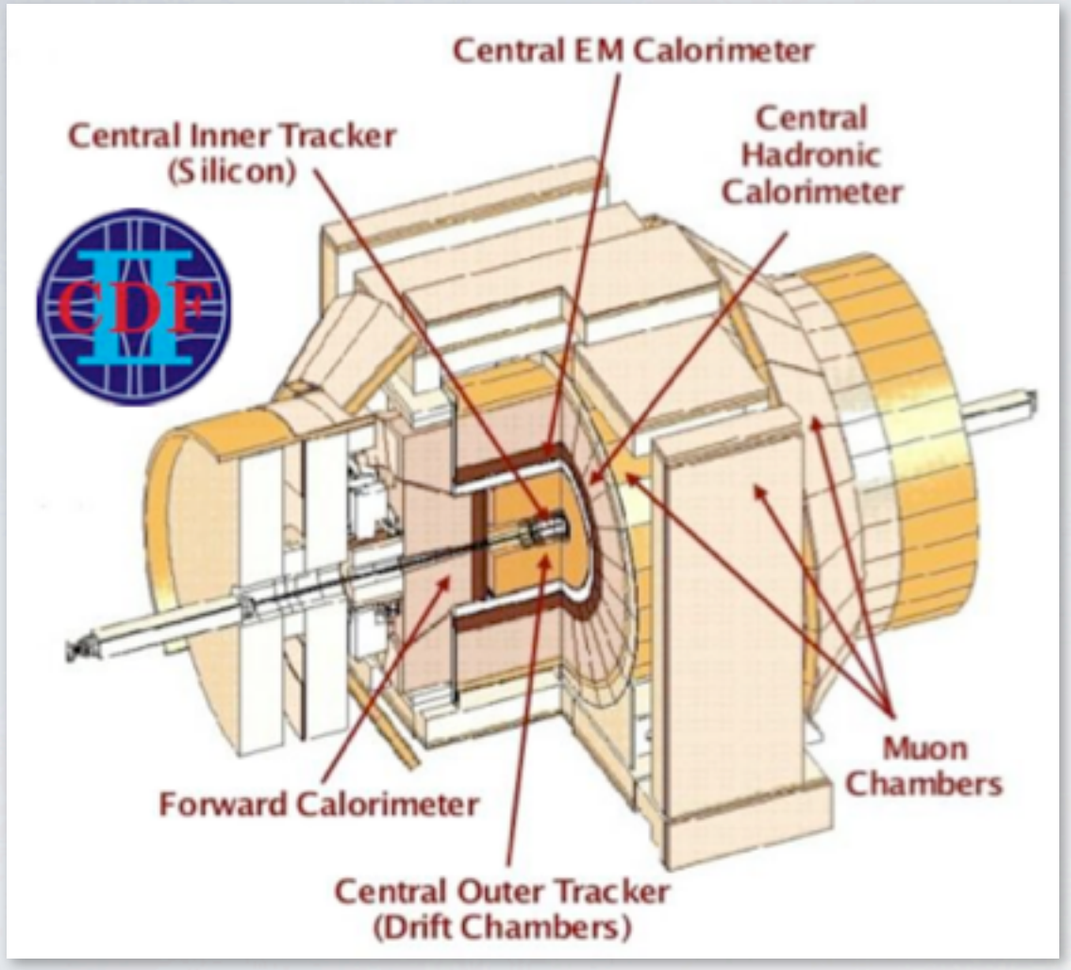
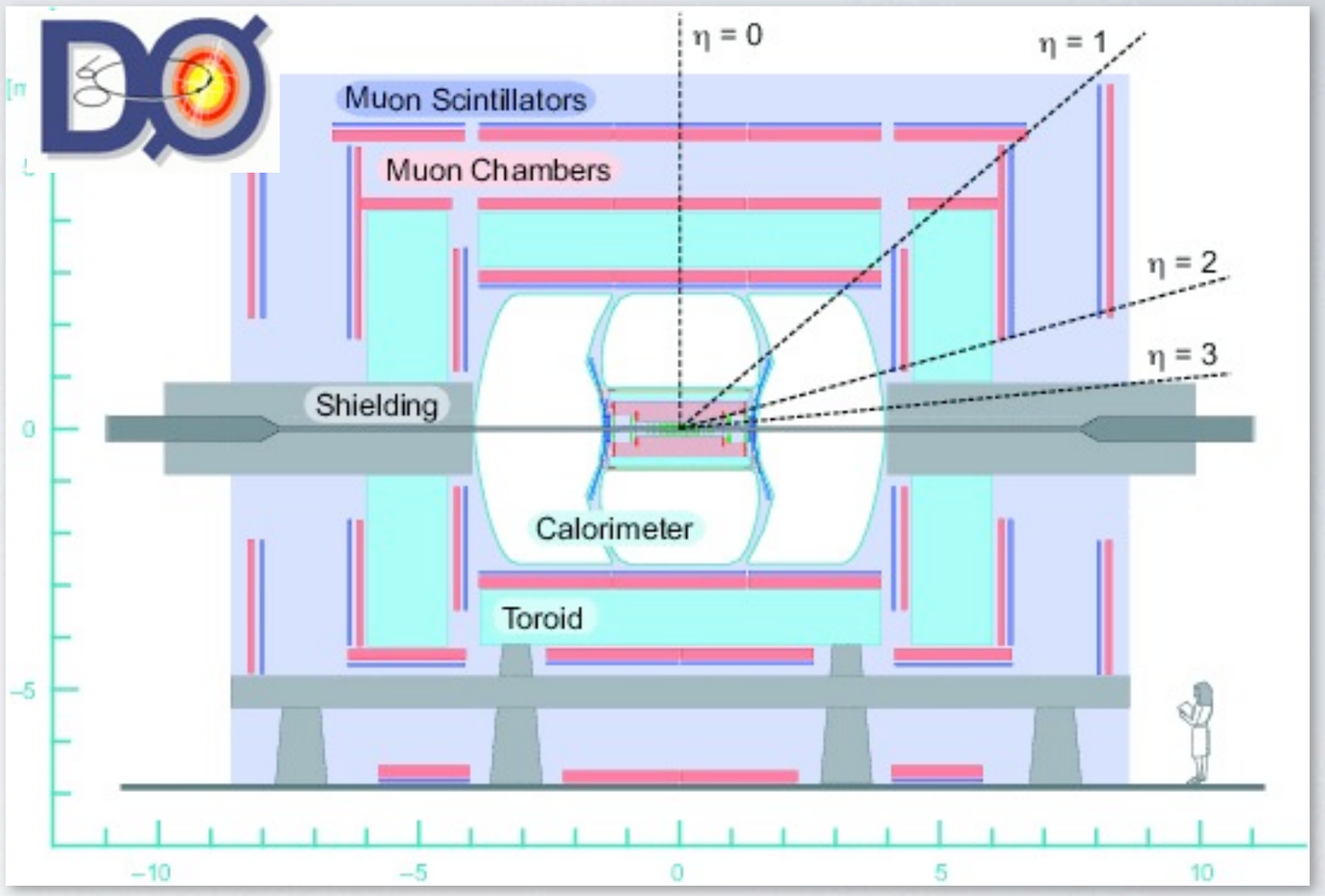
The CDF and D0 detectors



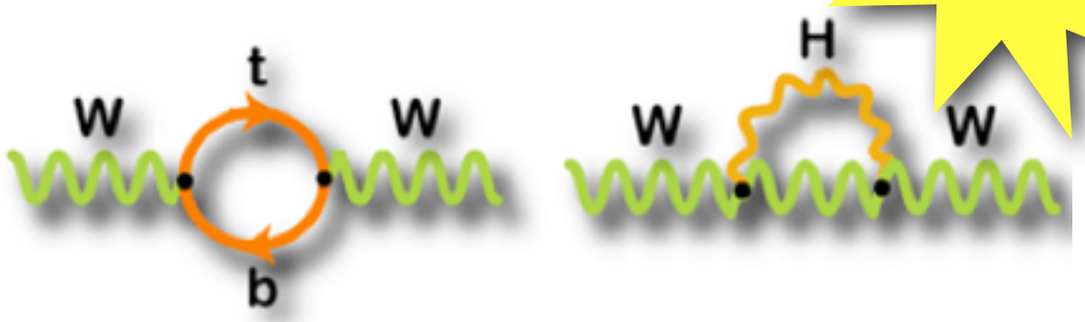


- **Tracking**
  - Momentum measurement of charged particles.
  - Vertex and b-jet identification
- **Calorimeter**
  - Energy measurement of jets, electrons and neutrinos.
- **Muon system**
  - Momentum measurement of muons
- **Three level trigger system.**

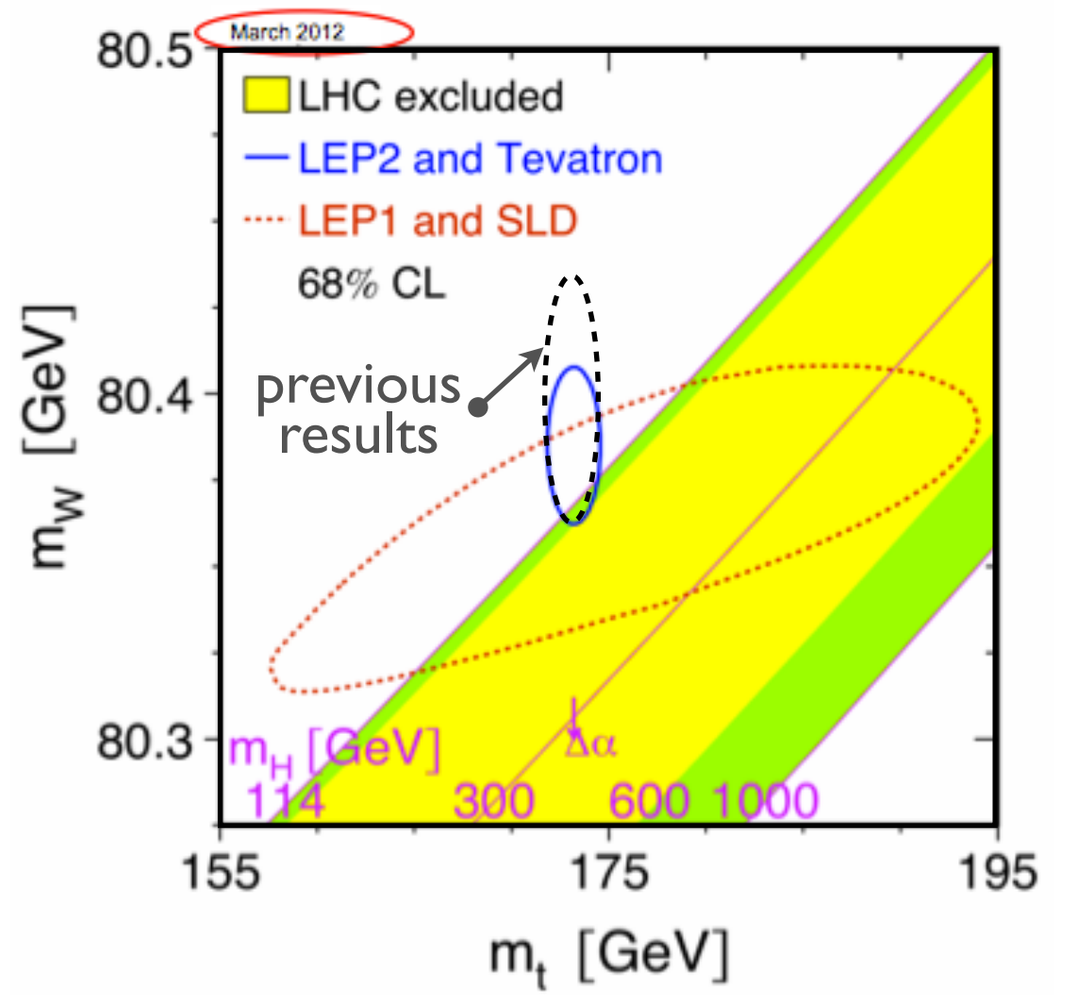
W boson mass

- Radiative corrections to m_W include those due to top and Higgs.
- Measuring m_W and m_t places constraints on the m_H.
- Current error top mass $\sigma(m_t)=0.54\%$.
- Same constrain to m_H implies an $\sigma(m_W)\sim 0.001\%$.
- Even if Higgs is observed at LHC or Tevatron precise electroweak measurements test the SM consistency.
- It could also constrain new physics at higher energy scales.

New



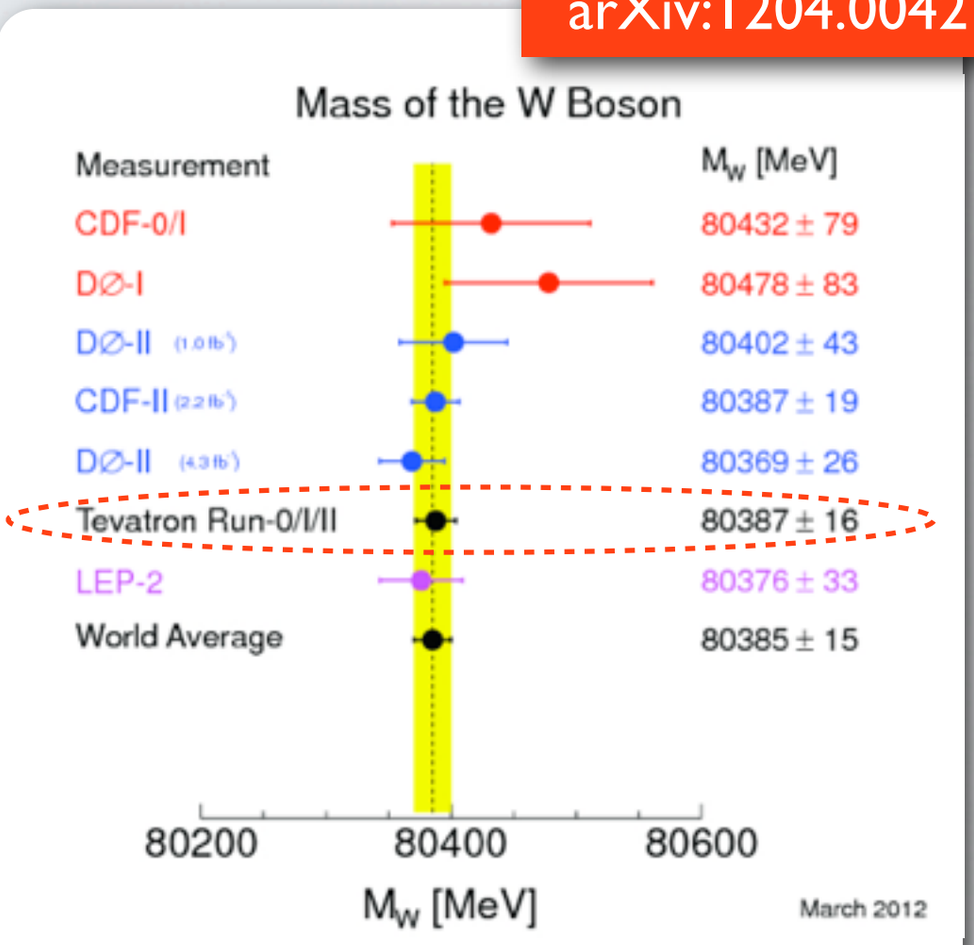
$$\Delta m_W \propto m_t^2 \qquad \Delta m_W \propto \log m_H$$



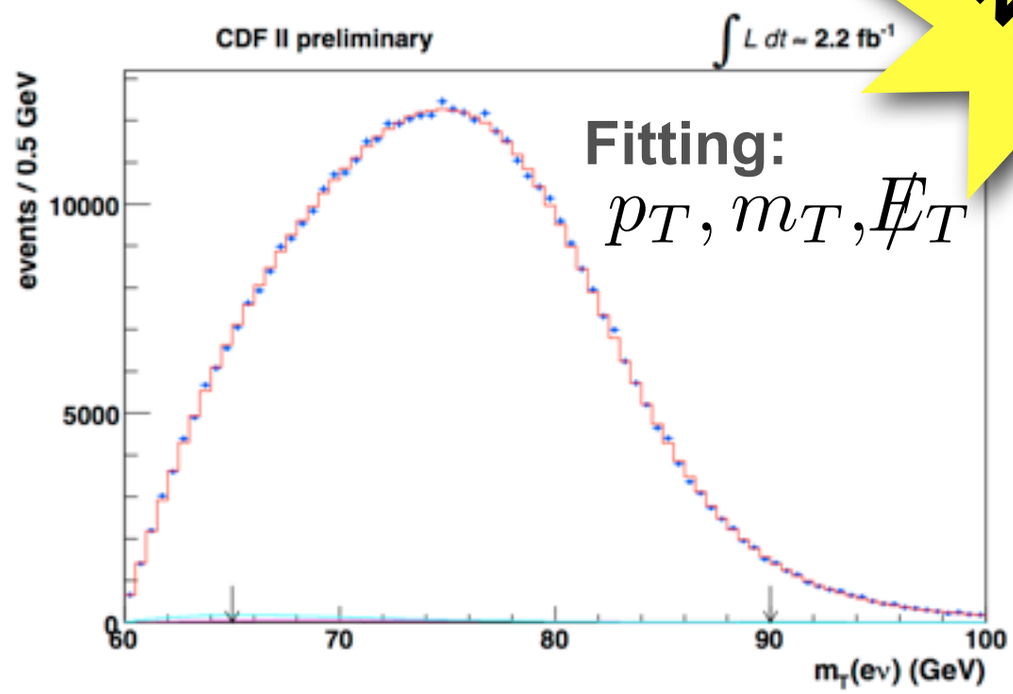
W boson mass

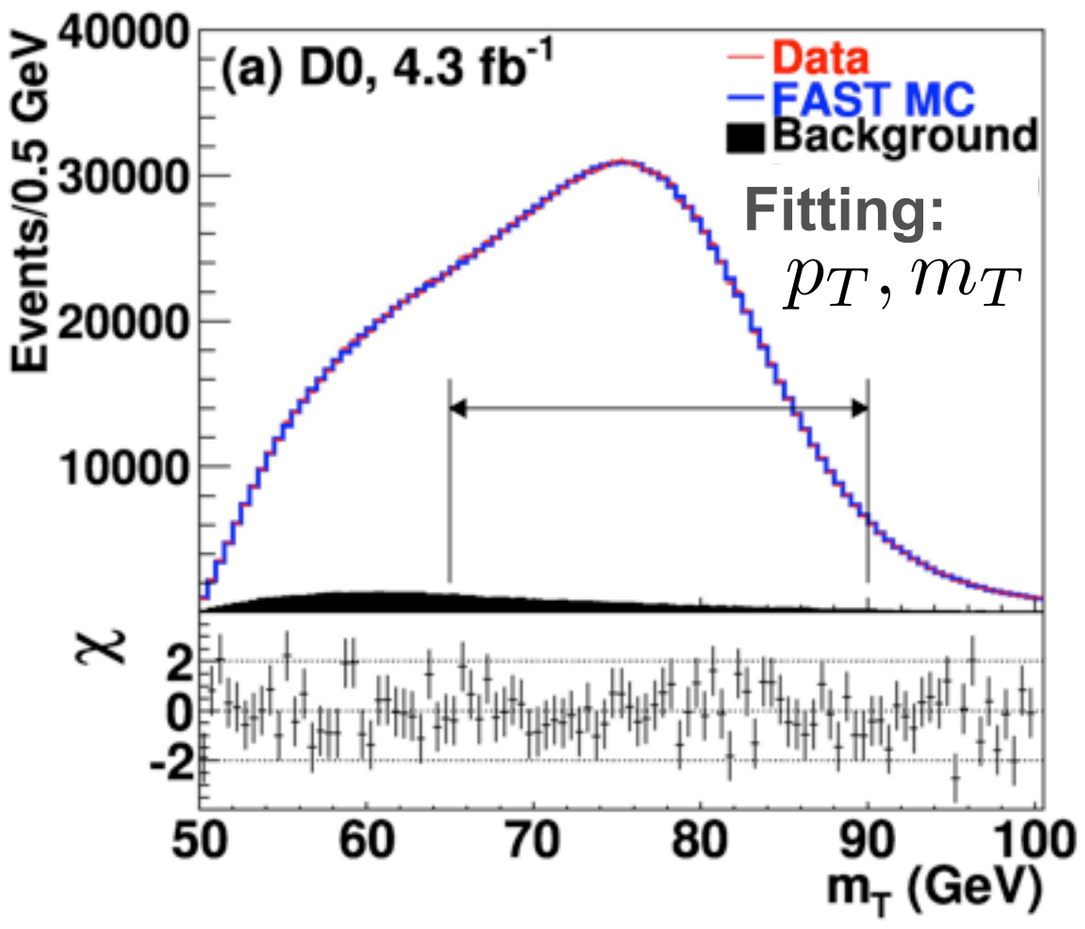
- CDF: Phys. Rev. Lett. 108, 151803 (2012)
- D0: Phys. Rev. Lett. 108, 151804 (2012)
- Main issues are:
  - Absolute electron and muon energy scales and resolution.
  - Recoil model.

arXiv:1204.0042

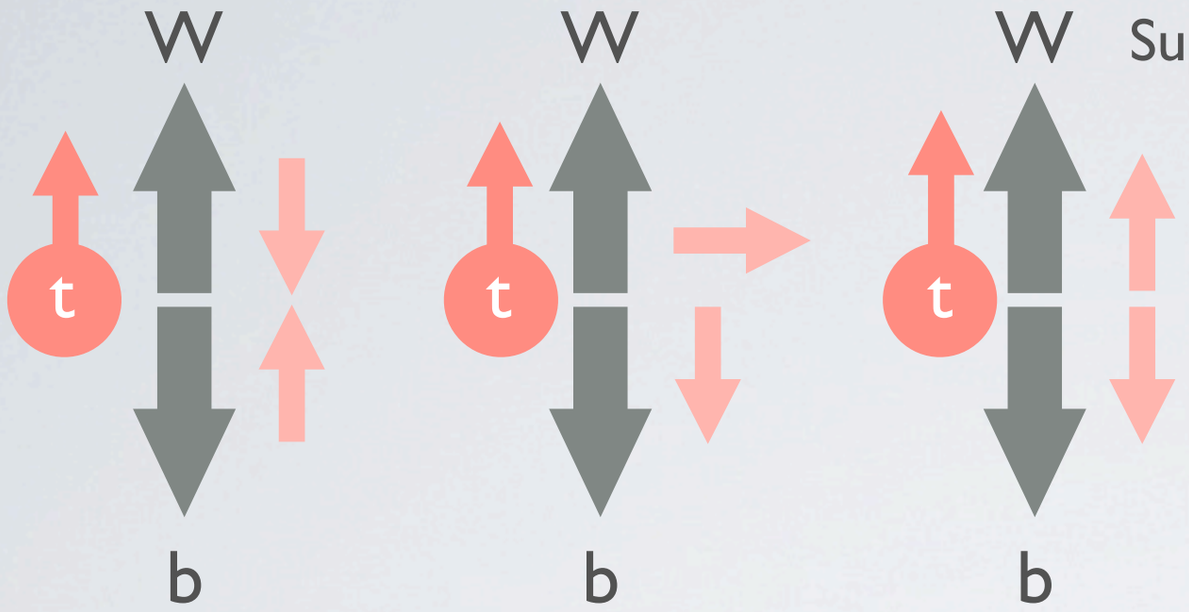


New





W Boson Helicity Fractions

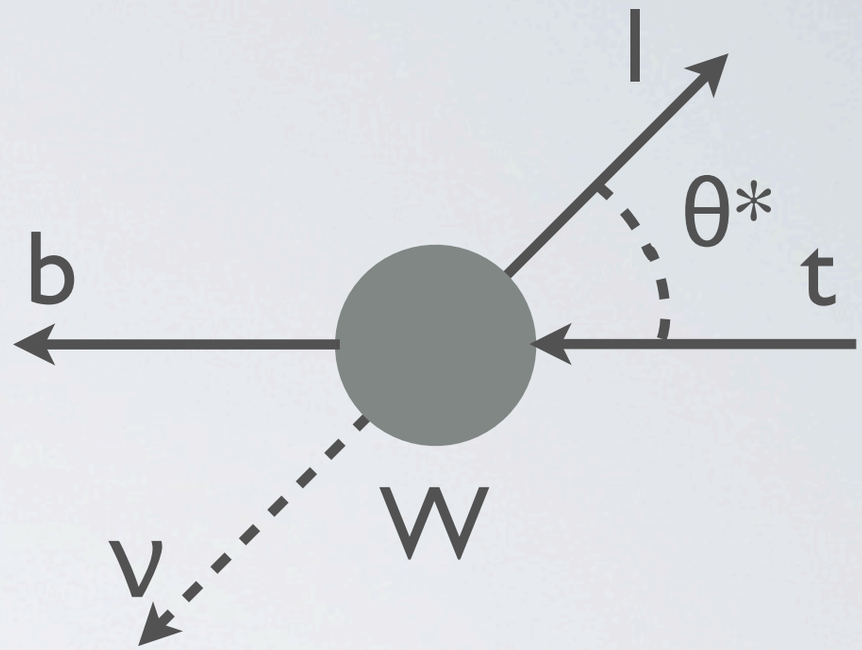


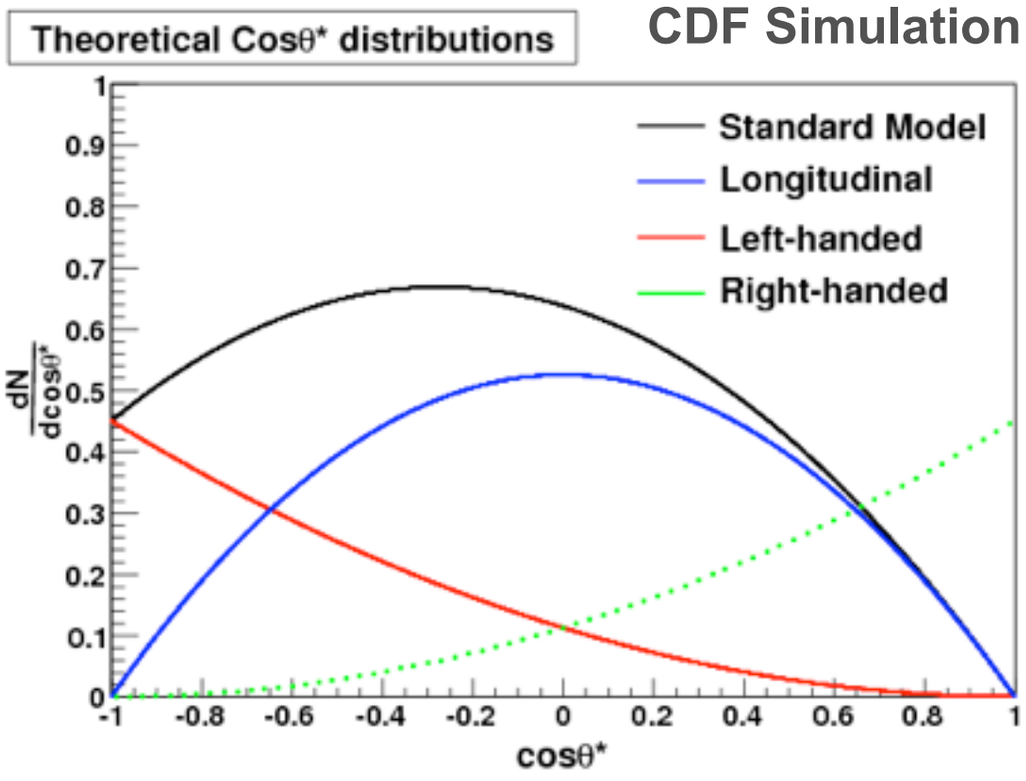
W_- left-handed fraction F_-

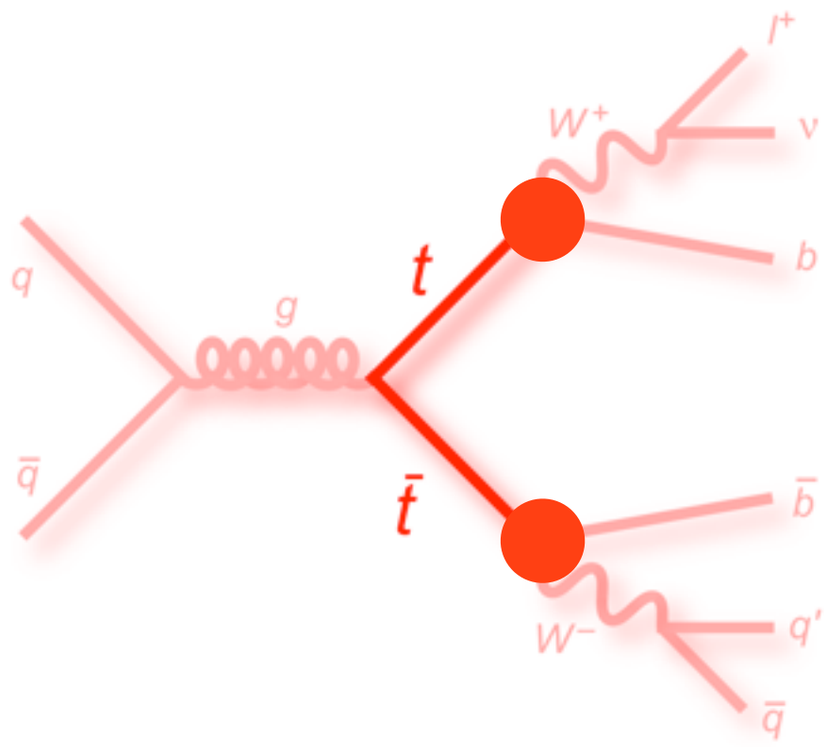
W_- longitudinal fraction F_0

Suppressed by V-A

W_+ right-handed fraction F_+







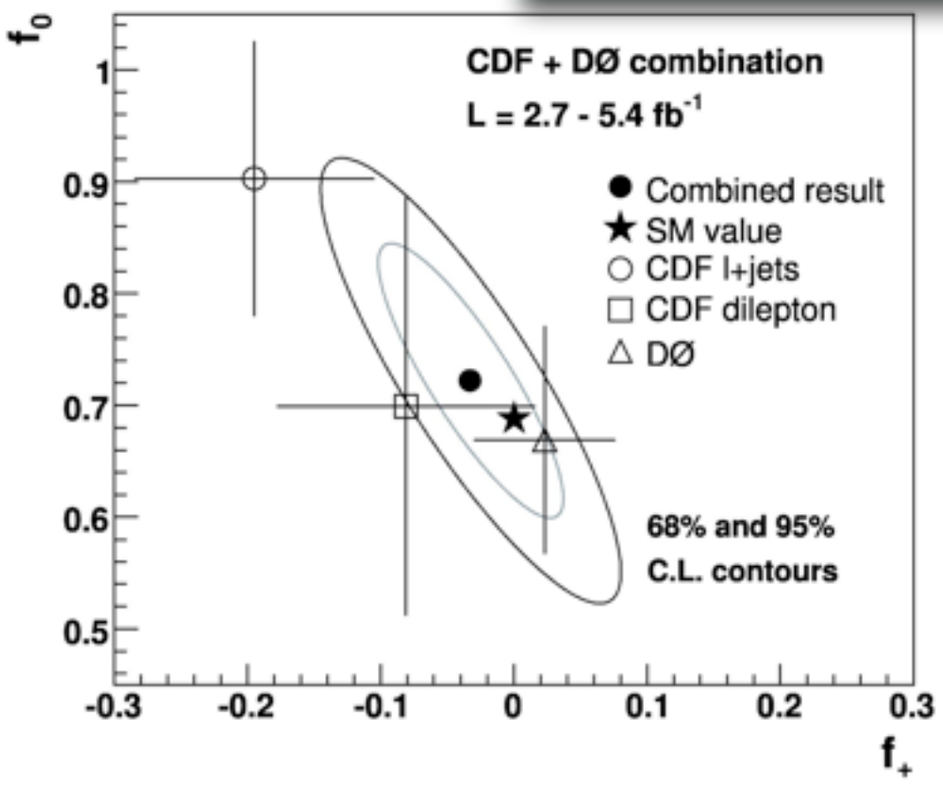
W Boson Helicity Fractions

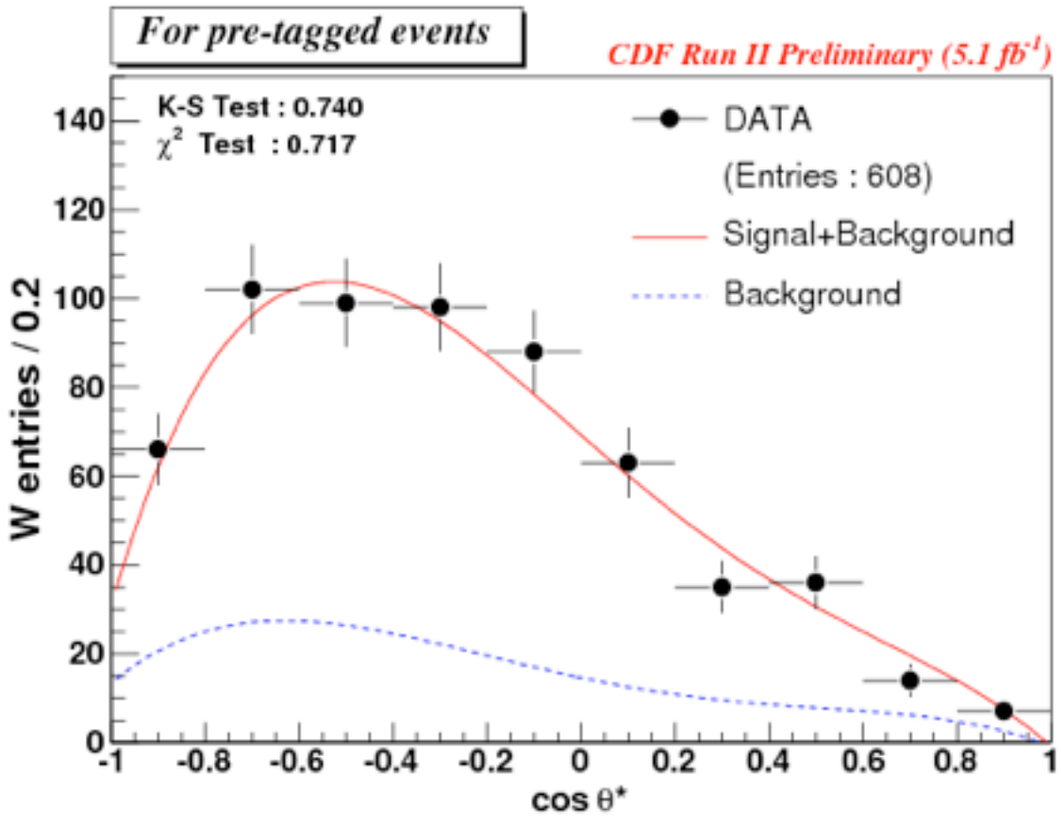
Combination inputs:

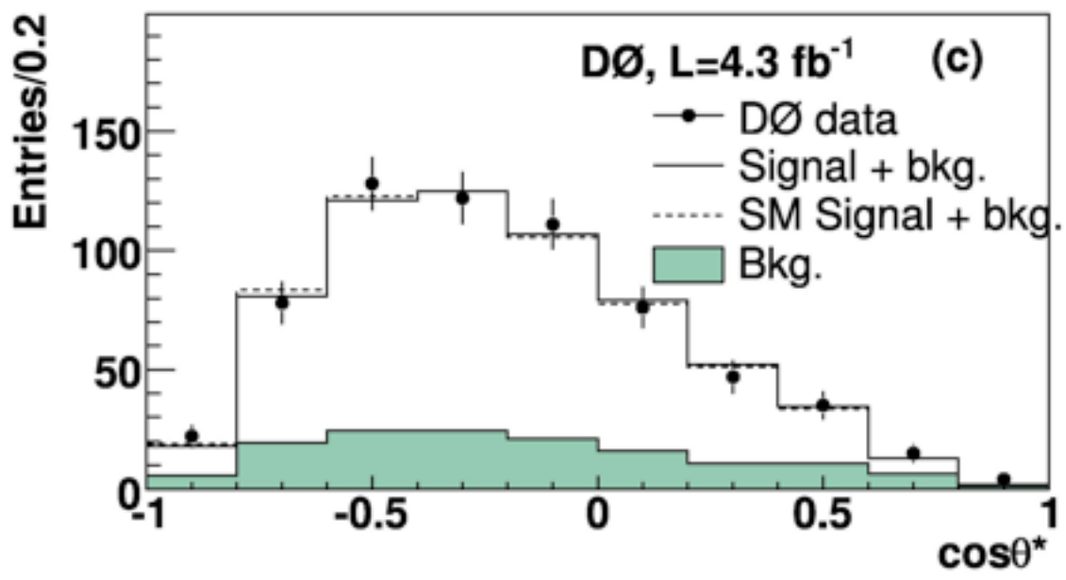
- Phys. Rev. Lett. 105, 042002 (2010)
- Conf. Note 10543
- Phys. Rev. D 83, 032009 (2011)

$$f_0 = 0.682 \pm 0.057$$
$$[\pm\ 0.035\ (\text{stat.}) \pm 0.046\ (\text{syst.})],$$
$$f_+ = -0.015 \pm 0.035$$
$$[\pm\ 0.018\ (\text{stat.}) \pm 0.031\ (\text{syst.})]$$

arXiv:1202.5272







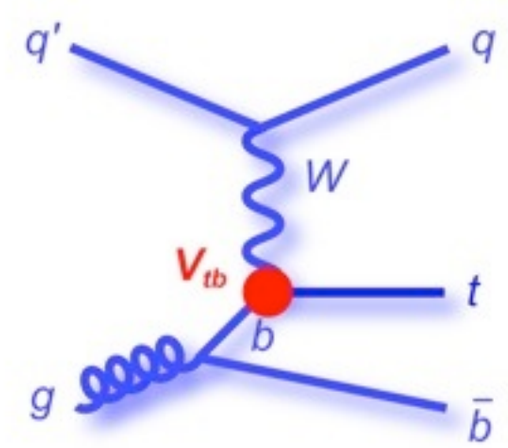
Search anomalous Wtb couplings

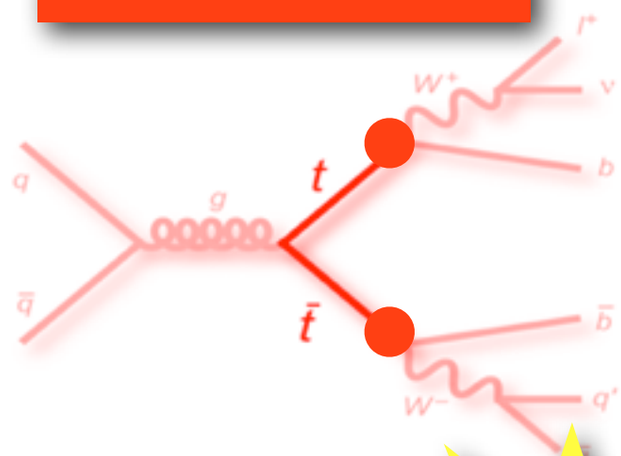
Extract constraints on couplings of Wtb vertex by combining information from single top and W helicity analyses.

SM: $f_V^L = 1$ $f_V^R = f_T^L = f_T^R = 0$

$$\mathcal{L} = \frac{g}{\sqrt{2}}\bar{b}\gamma^\mu V_{tb}(f_V^L P_L + f_V^R P_R)tW_\mu^- - \frac{g}{\sqrt{2}}\bar{b}\frac{i\sigma^{\mu\nu}q_\nu V_{tb}}{M_W}(f_T^L P_L + f_T^R P_R)tW_\mu^- + h.c.$$

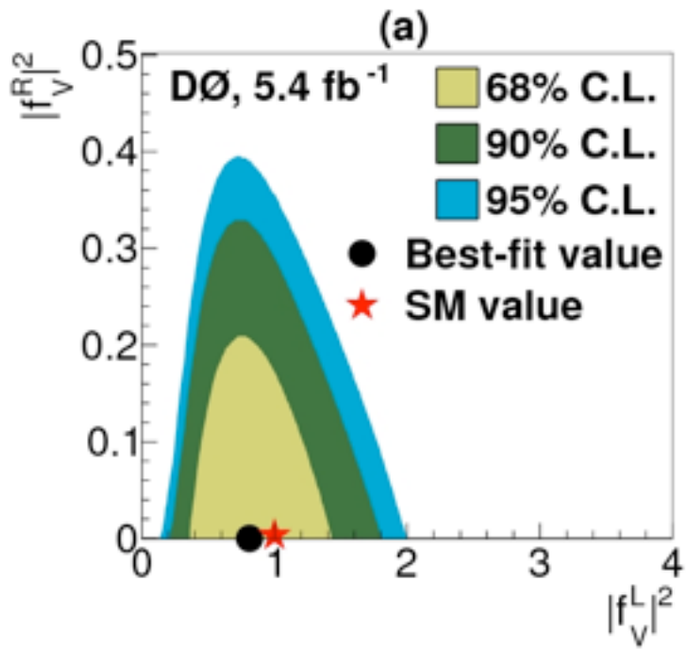
Scenario	only W helicity	only single top	combination
$\lvert f_V^R\rvert^2$	0.62	0.89	0.30
$\lvert f_T^L\rvert^2$	0.14	0.07	0.05
$\lvert f_T^R\rvert^2$	0.18	0.18	0.12

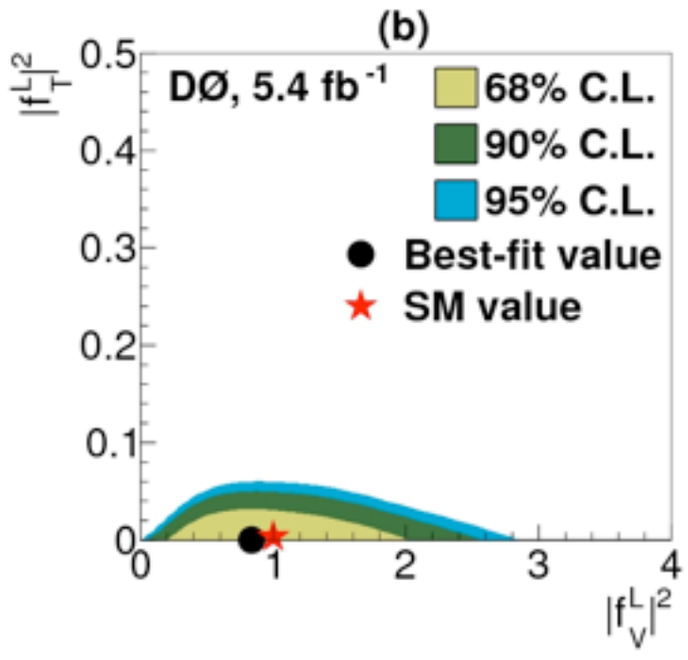


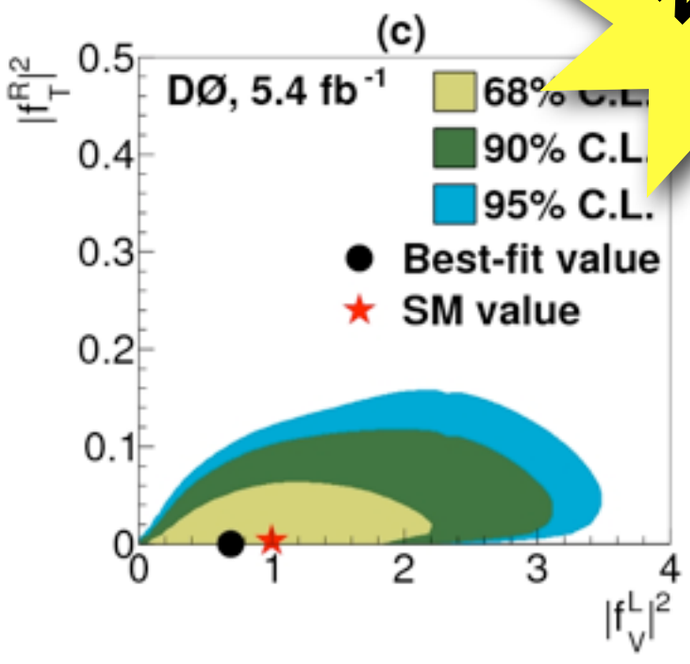


arXiv:1204.2332

New



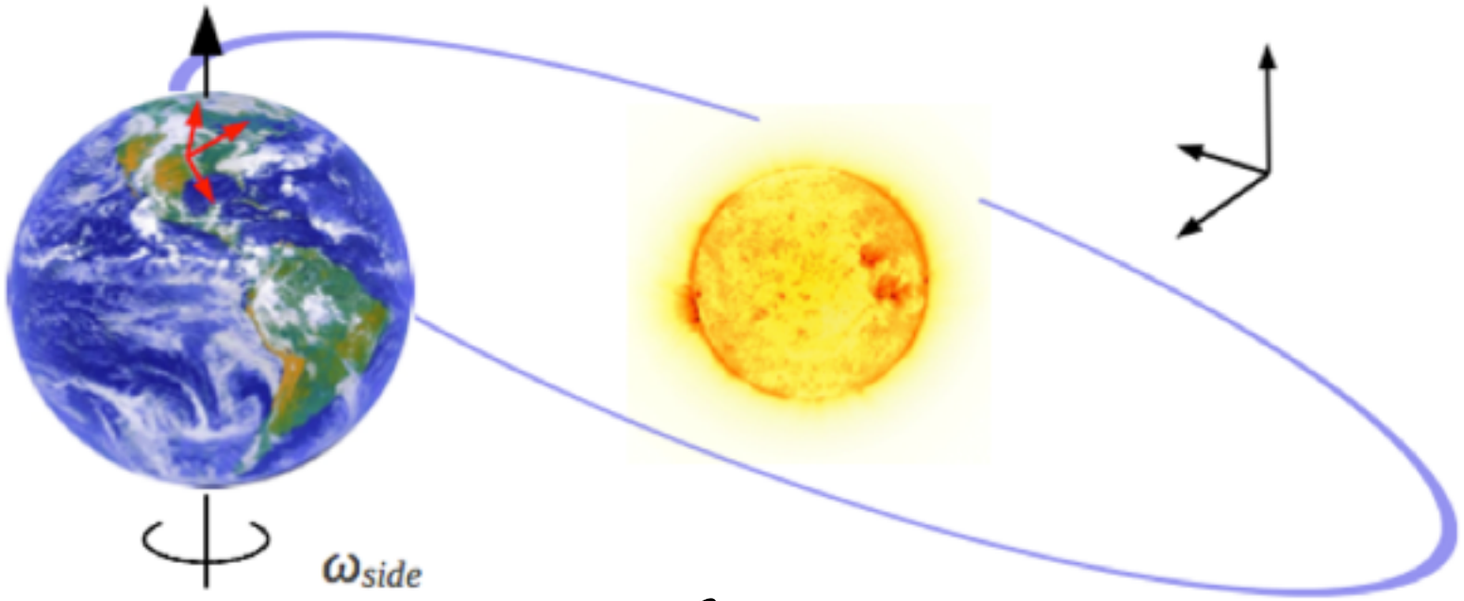




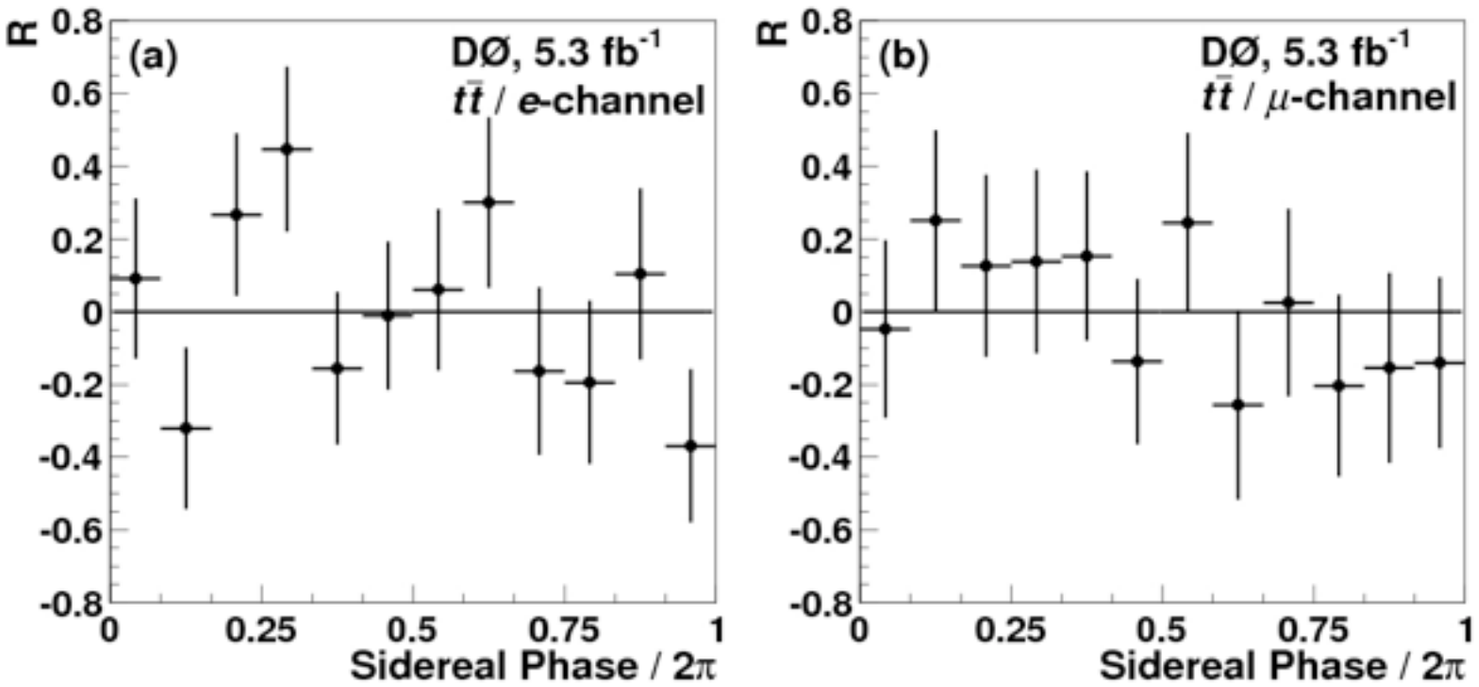
Search for Lorentz Invariance Violation (LIV)

Consequences of LIV:

- Pair top production and decay change with the sidereal time.
- Therefore time dependent event rate.



$$N_i \approx N_{\rm tot} \frac{\mathcal{L}_i}{\mathcal{L}_{\rm int}} \left[1 + f_{\rm S} f_{\rm SME}(\phi_i, \{c_{\mu\nu}\})\right]$$



$\mathcal{L}_i$: luminosity over sidereal phase ϕ_i

$f_{\rm S}$: mean signal fraction

$f_{\rm SME}$: signal fraction depend on ϕ_i

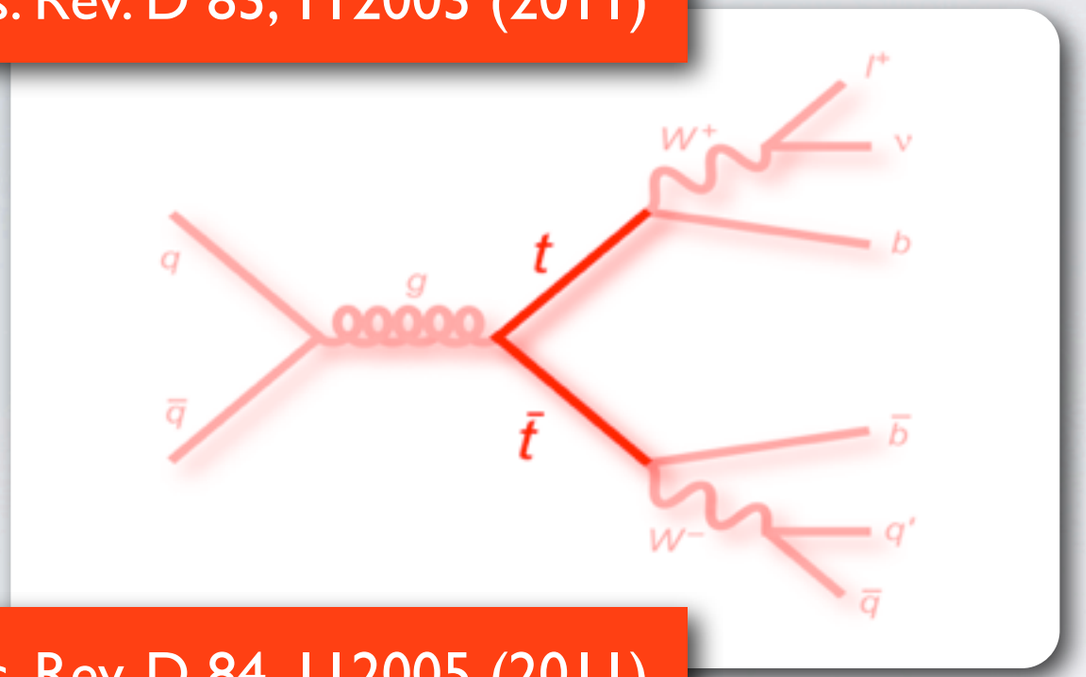
$$R_i = \frac{1}{f_{\rm S}} \left(\frac{N_i/N_{\rm tot}}{\mathcal{L}_i/\mathcal{L}_{\rm int}} - 1 \right)$$

$c_{\mu\nu} \approx 0$ (consistent SM)

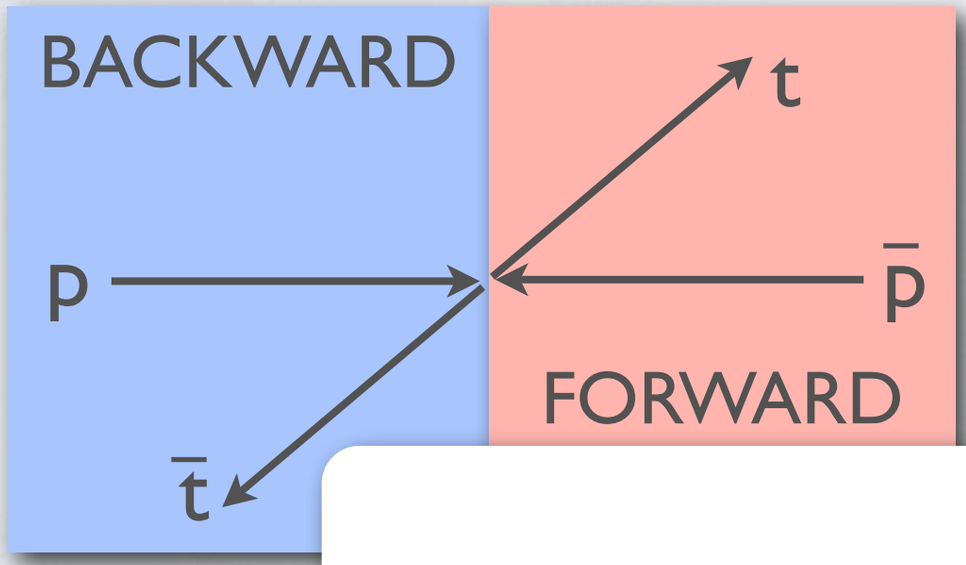
arXiv:1203.6106

Forward Backward Asymmetry

Phys. Rev. D 83, 112003 (2011)

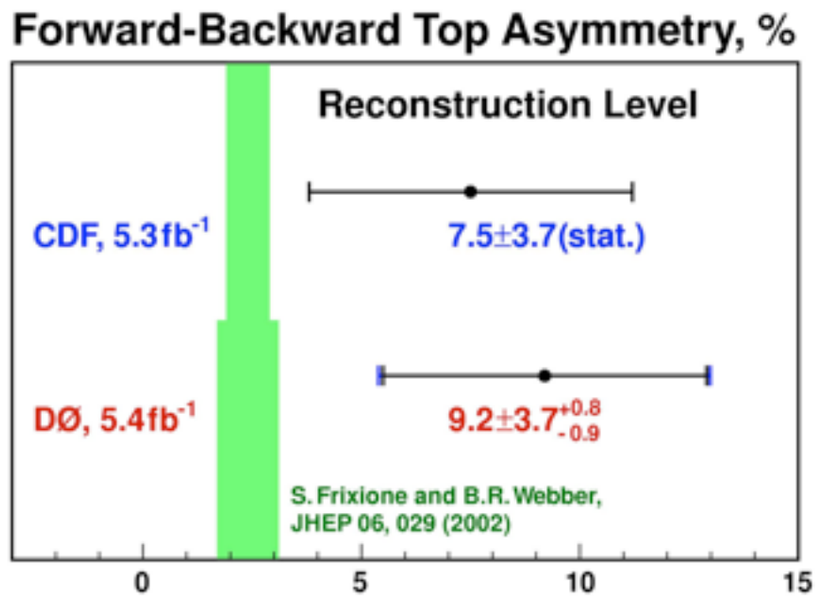


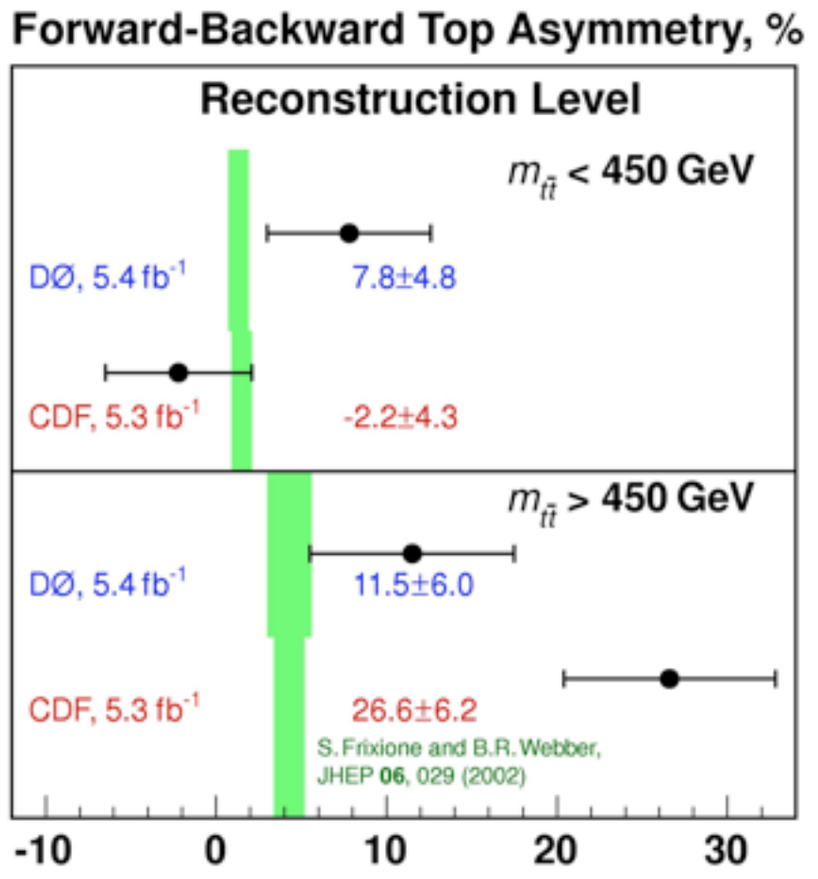
Phys. Rev. D 84, 112005 (2011)



$$\Delta y = y_t - y_{\bar{t}}$$

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

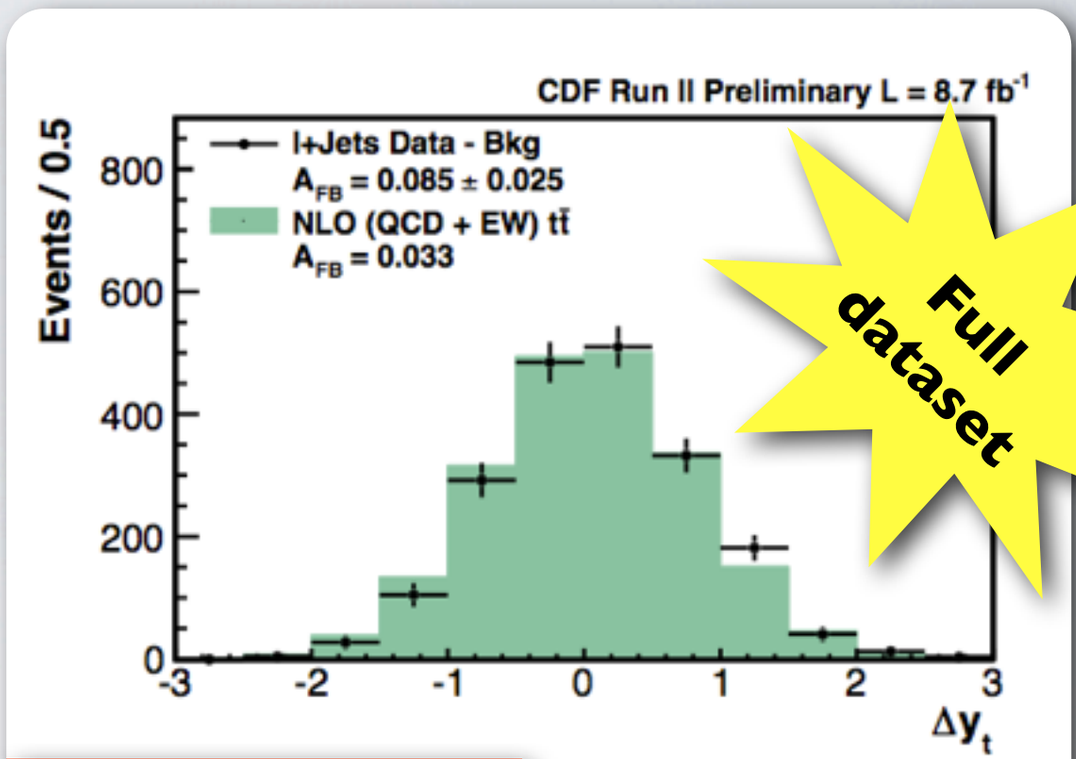




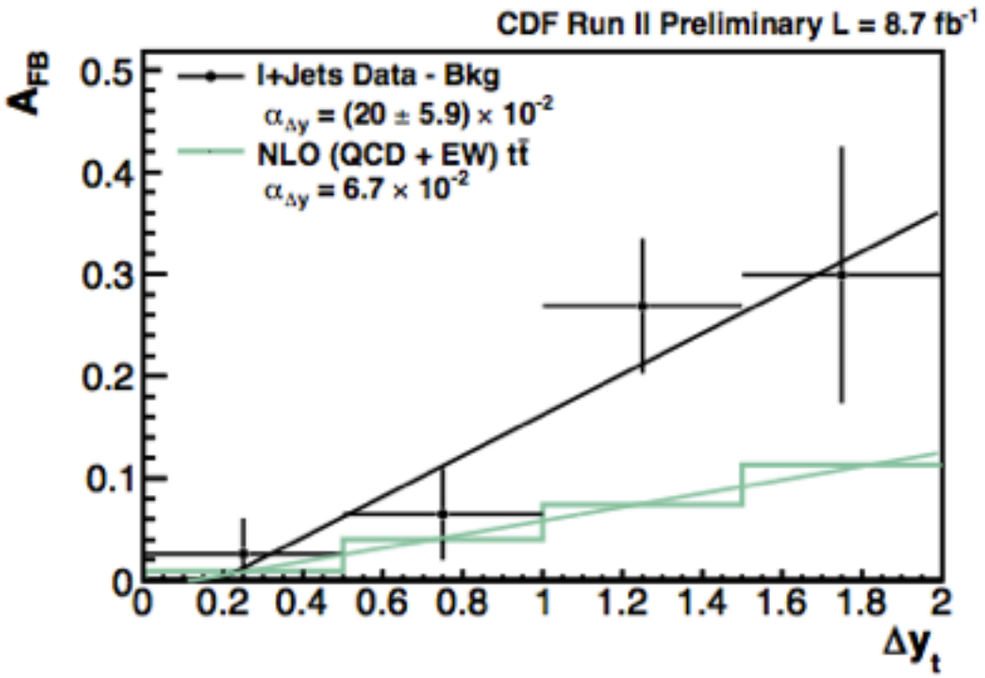
Forward Backward Asymmetry

Forward-Backwards Asymmetry:

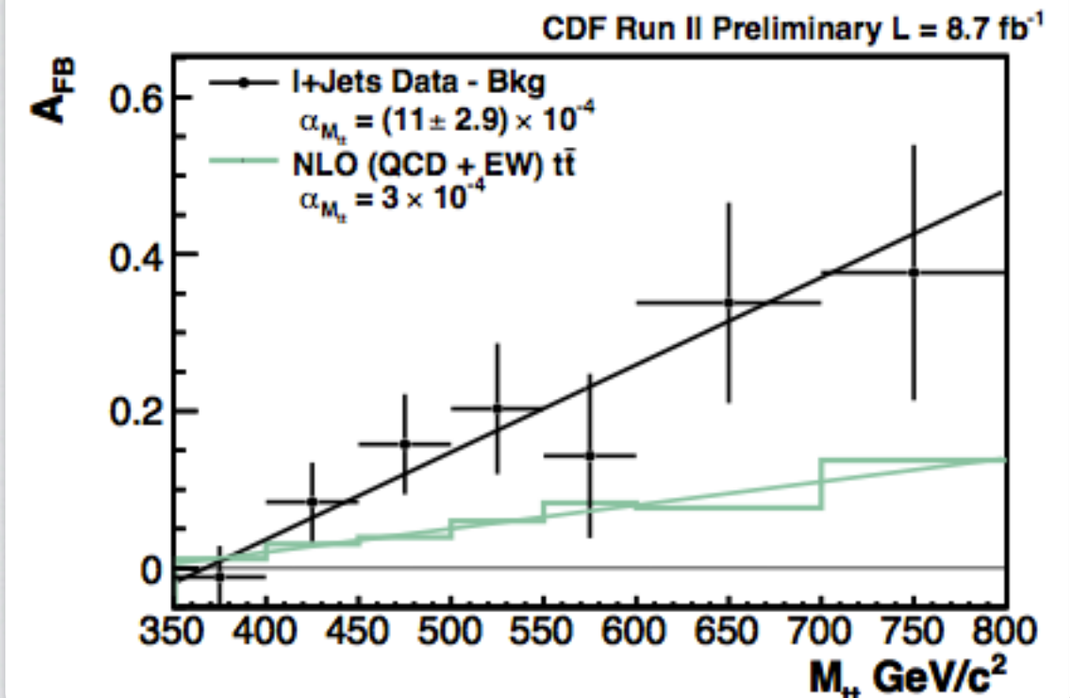
- An asymmetry is observed in both reconstructed and parton level Δy distributions.
- The is a proximate linear dependence in $M_{t\bar{t}}$ and $|\Delta y|$.



CDF Note 10807



CDF Note 10807



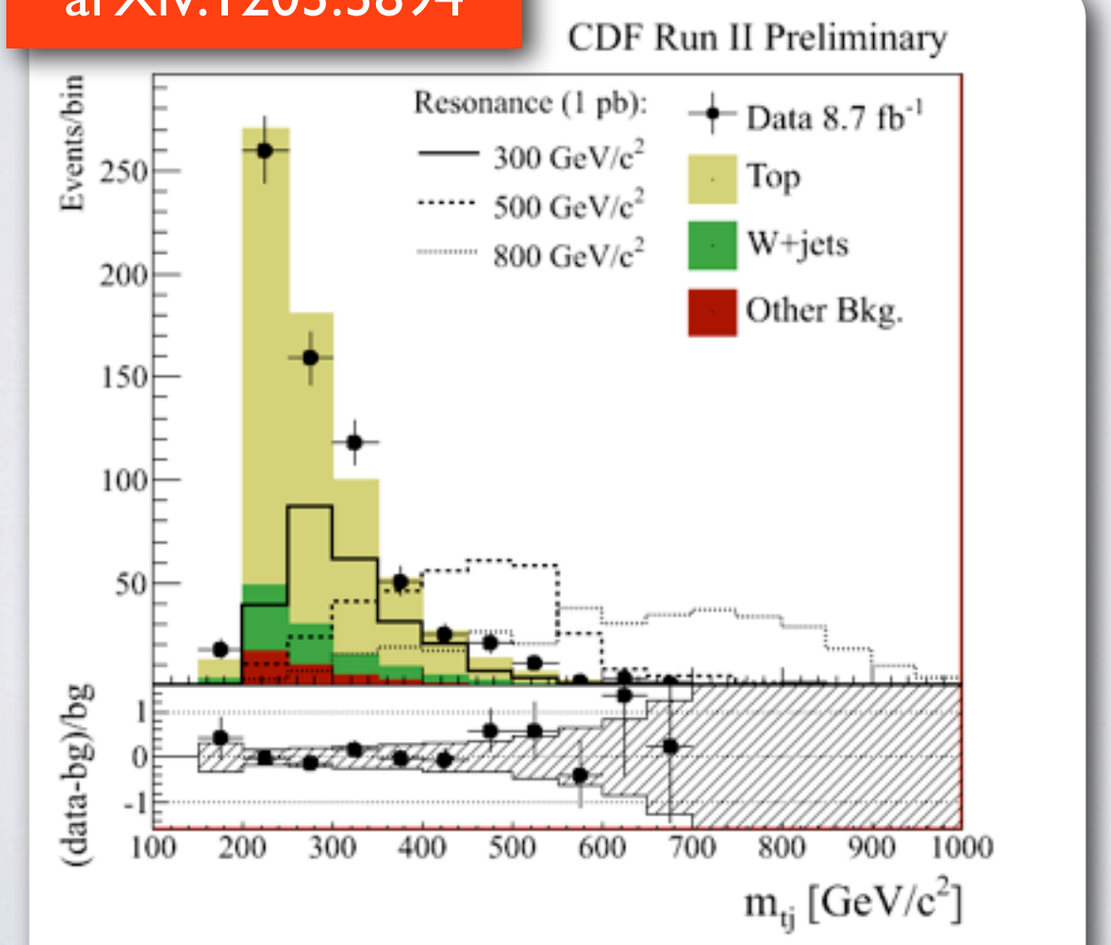
Search for top+jet resonances

- Search for new heavy particle M, produced in association with top.
- Result in resonances in the top+jet system in top pair production.
- Look at events with five or more jets with at least one b-tagged jet.

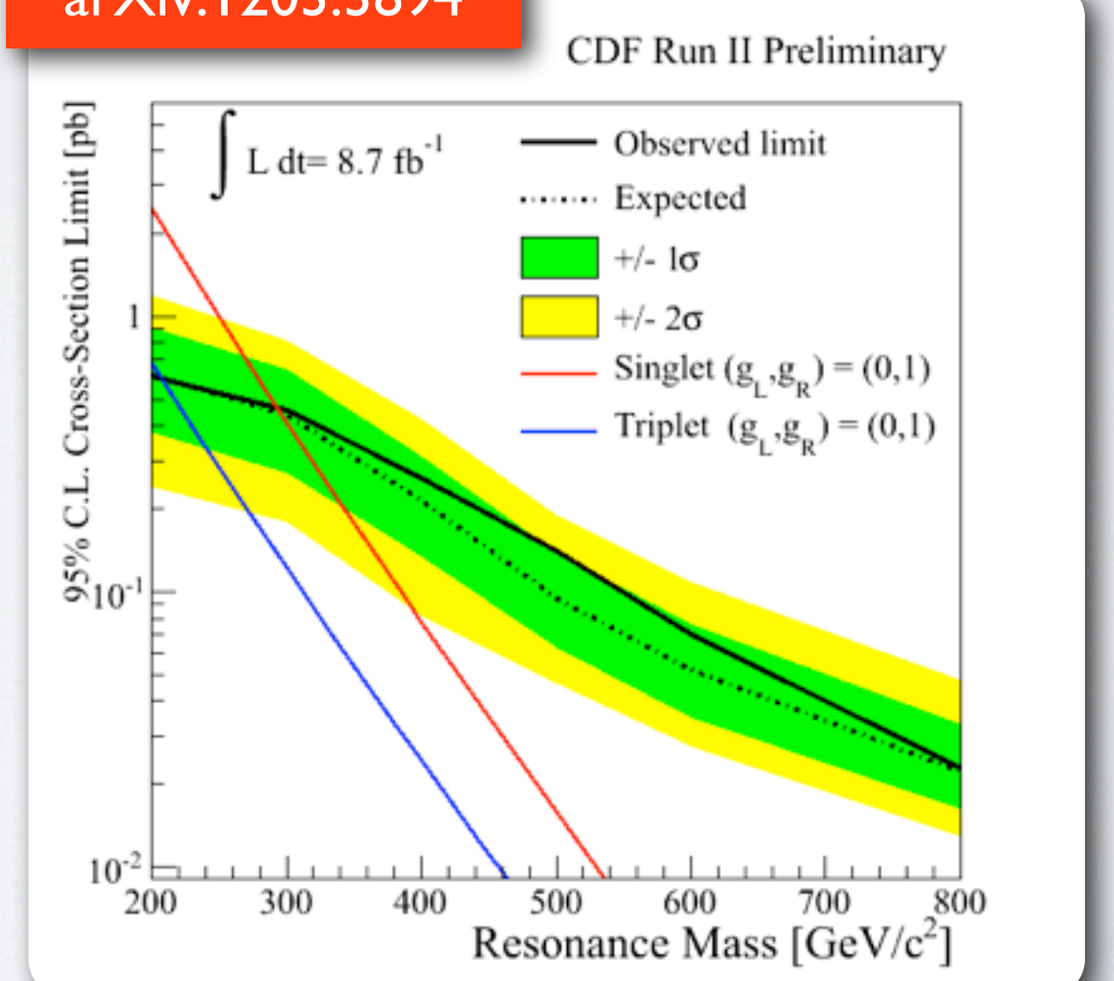
- Reconstruct first the $t\bar{t}$.
- Paired the remaining jets to the $t/\bar{t}$ and that m_{tj} as the one with highest invariant mass.

$$p\bar{p} \rightarrow M\bar{t} \rightarrow \bigwedge (tj)\bar{t}$$

arXiv:1203.3894



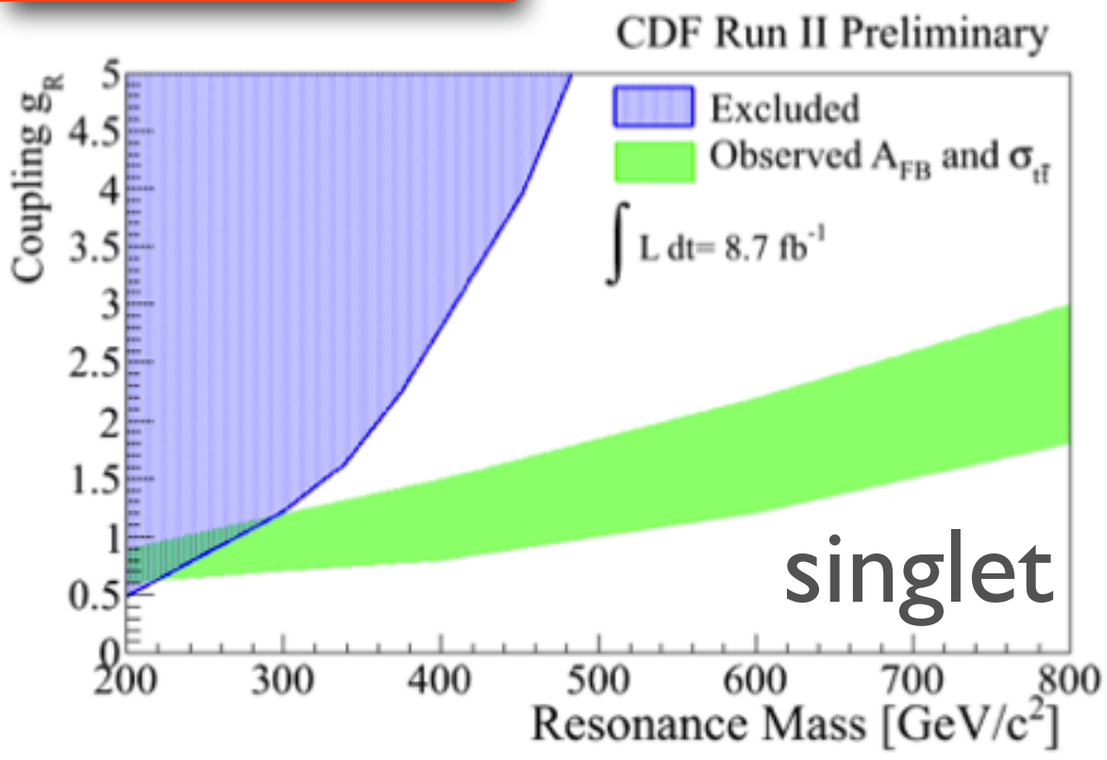
arXiv:1203.3894



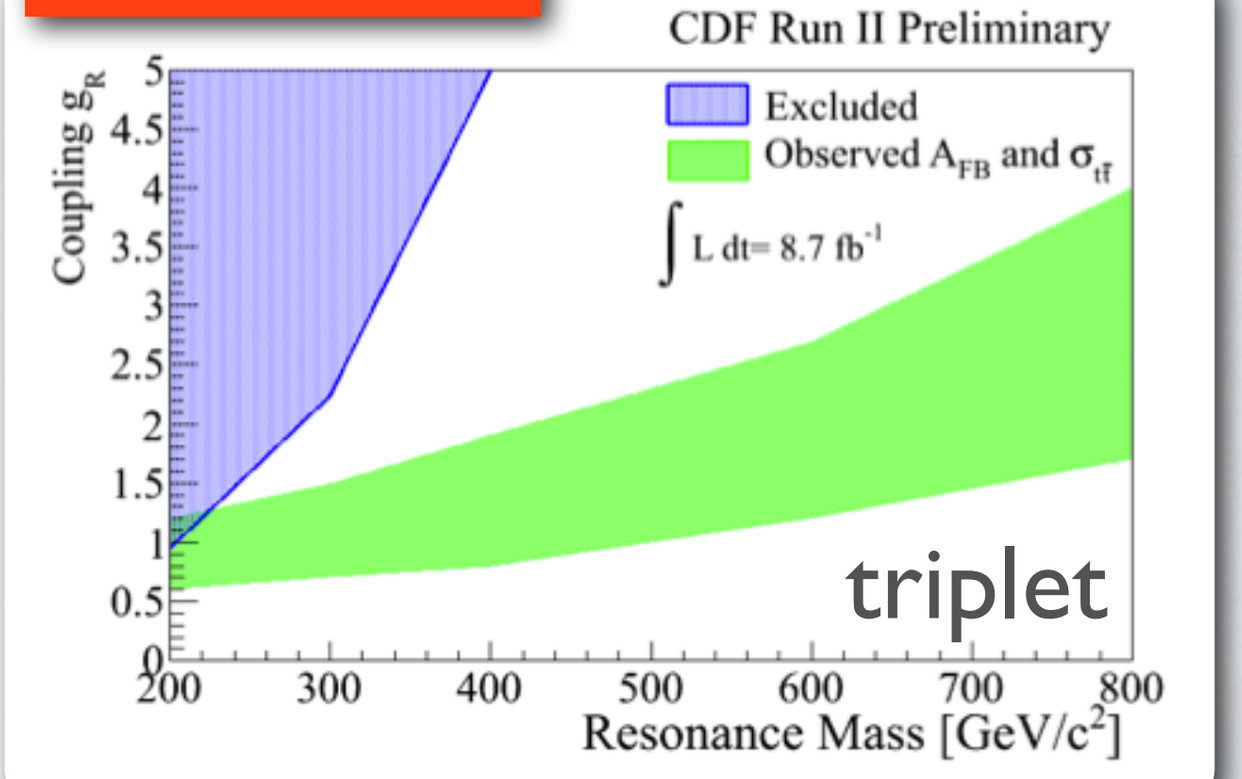
Search for top+jet resonances

- Search for new heavy particle M, produced in association with top:
  - Search interesting in context of tt forward-backward asymmetry Afb
  - Many models predict heavy particle that could enhance Afb (**arXiv1102.0018**):
    - For example M being part of new singlet or colored triplet

arXiv:1203.3894



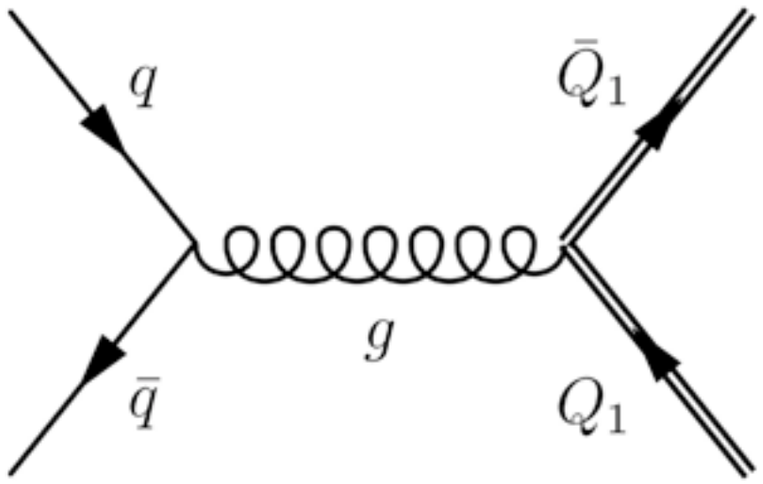
arXiv:1203.3894



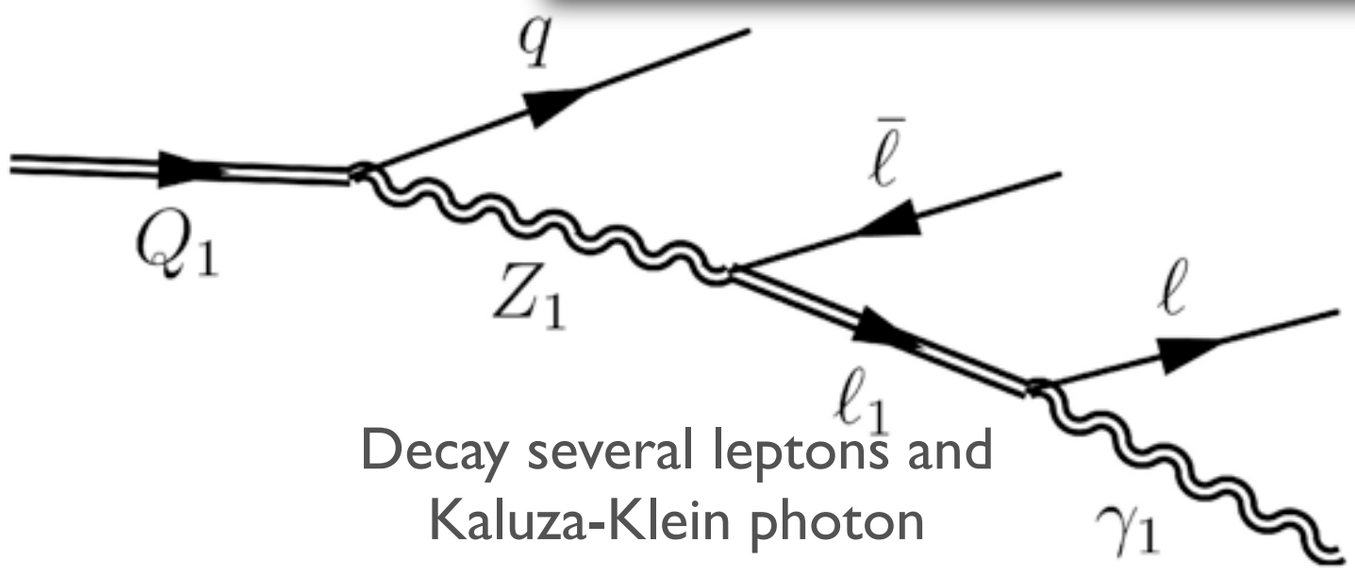
For more information look at Ian-Woo Kim's presentation

Minimal Universal Extra Dimensions

Phys Rev Lett 108 131802 (2012)

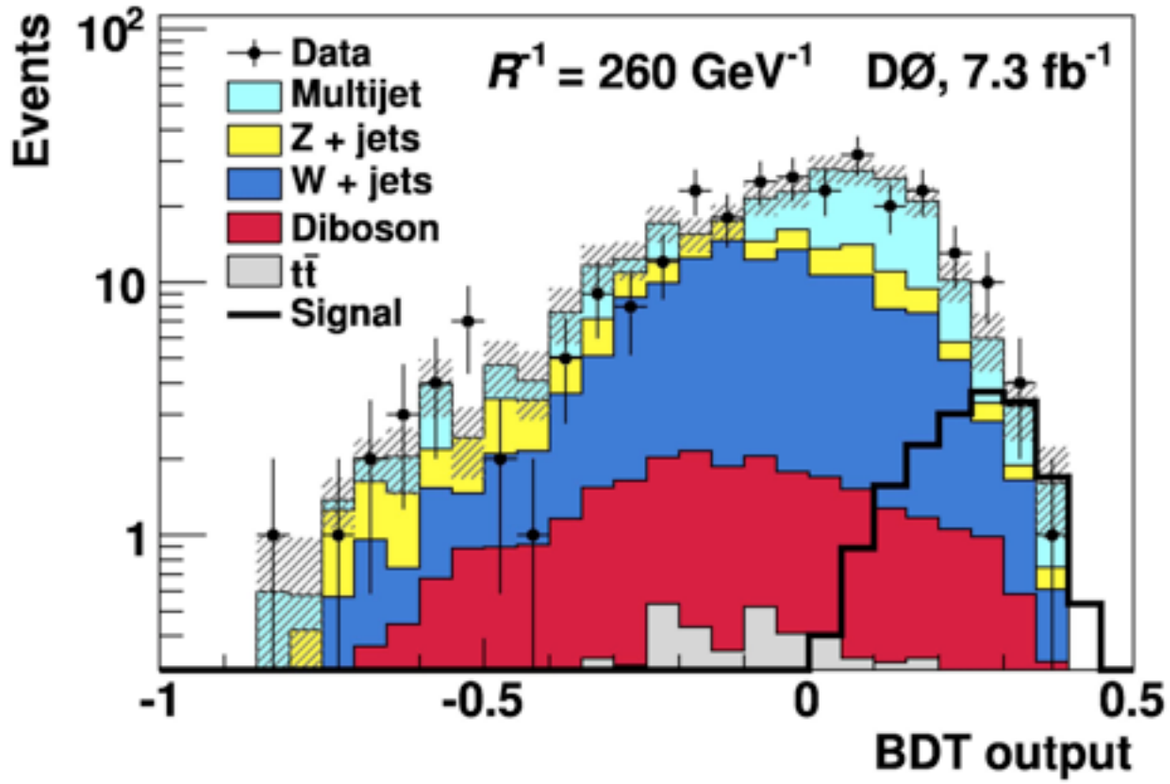


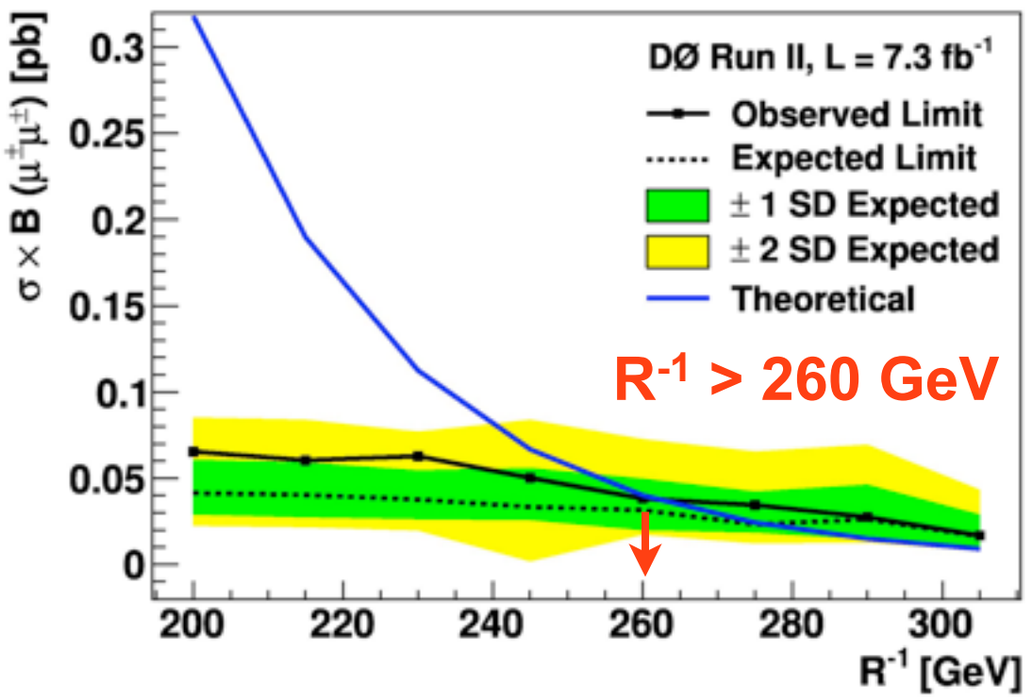
Pair production of
Kaluza-Klein quark



Decay several leptons and
Kaluza-Klein photon

- Search for 2 muons with the same charge.





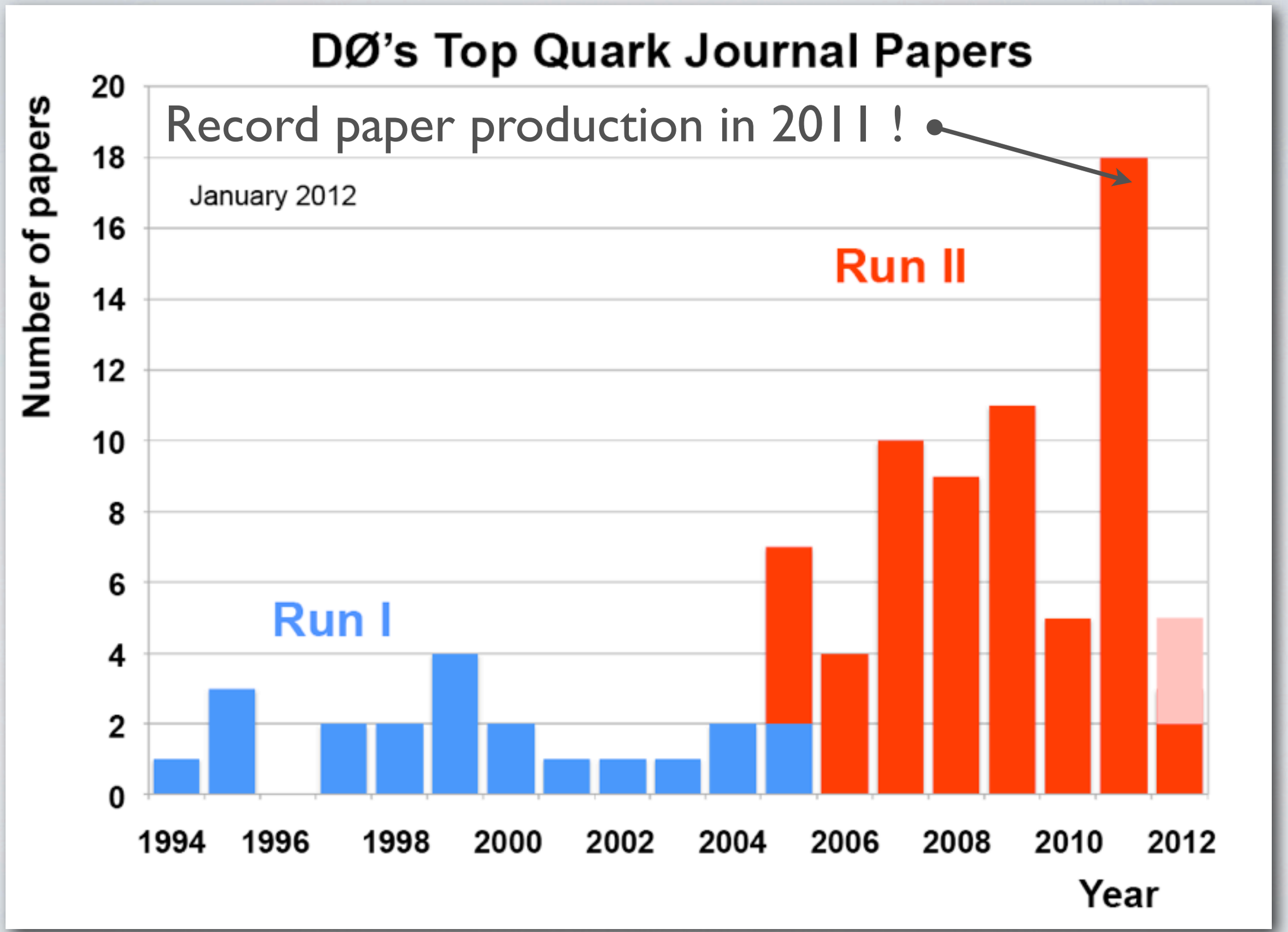
- first direct lower limit on compactification scale in this channel !

Summary

- A very active physics program is pursued at the Tevatron in all the fronts of collider physics.
- Today I show only a small sample of the most resent results from the Tevatron.
- These examples have in common a nice interplay between phenomenological models and experimental searches.
- Many more results are coming exploiting the full dataset of both CDF and D0 collaboration.
- Please take a look to the most recent results at:
  - CDF: http://www-cdf.fnal.gov/physics/W12CDFResults.html
  - D0: http://www-d0.fnal.gov/Run2Physics/D0Winter2012.html

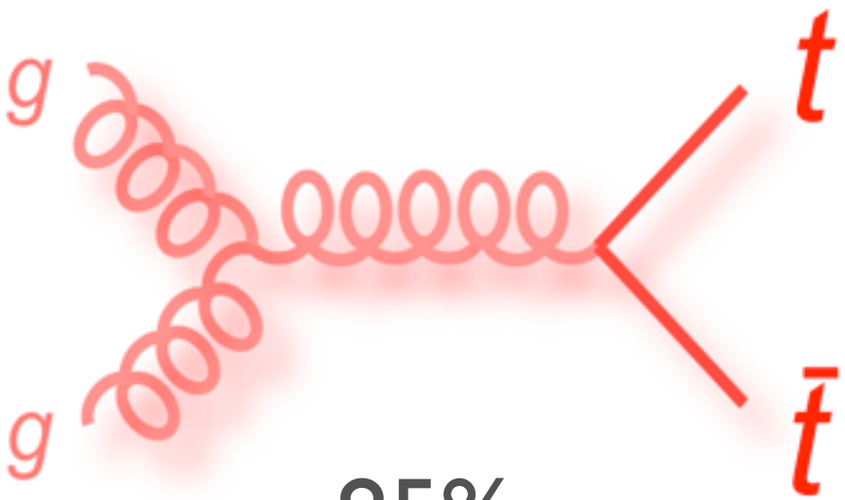
Backup slides

Example of production from D0 top group

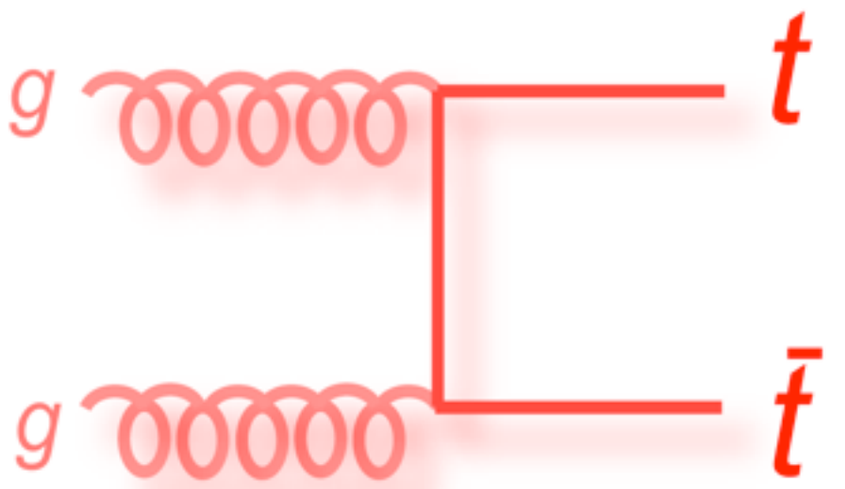


SM top pair production and decays

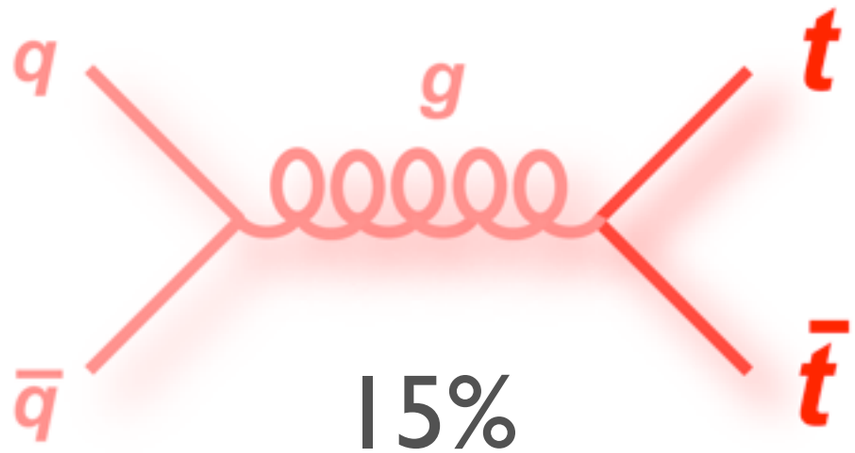
Gluon fusion ($gg \to t\bar{t}$)



85%



$q\bar{q}$ annihilation ($qq \to t\bar{t}$)



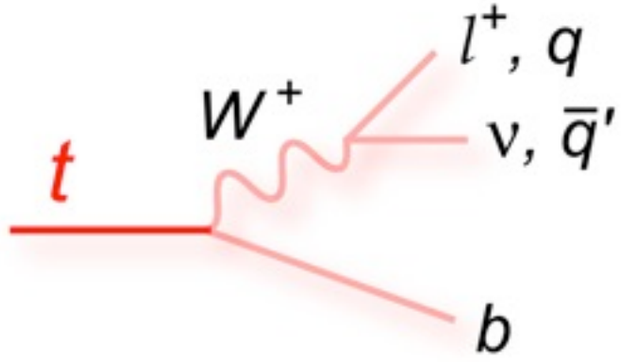
15%

Top decay

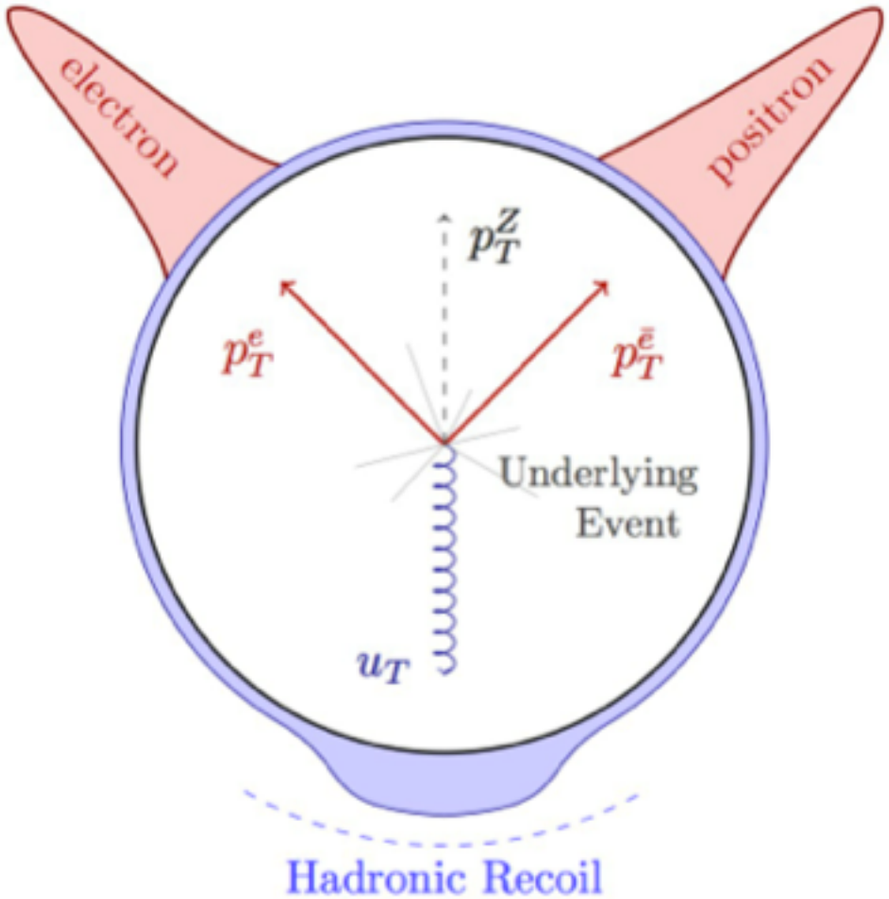
Top Pair Decay Channels

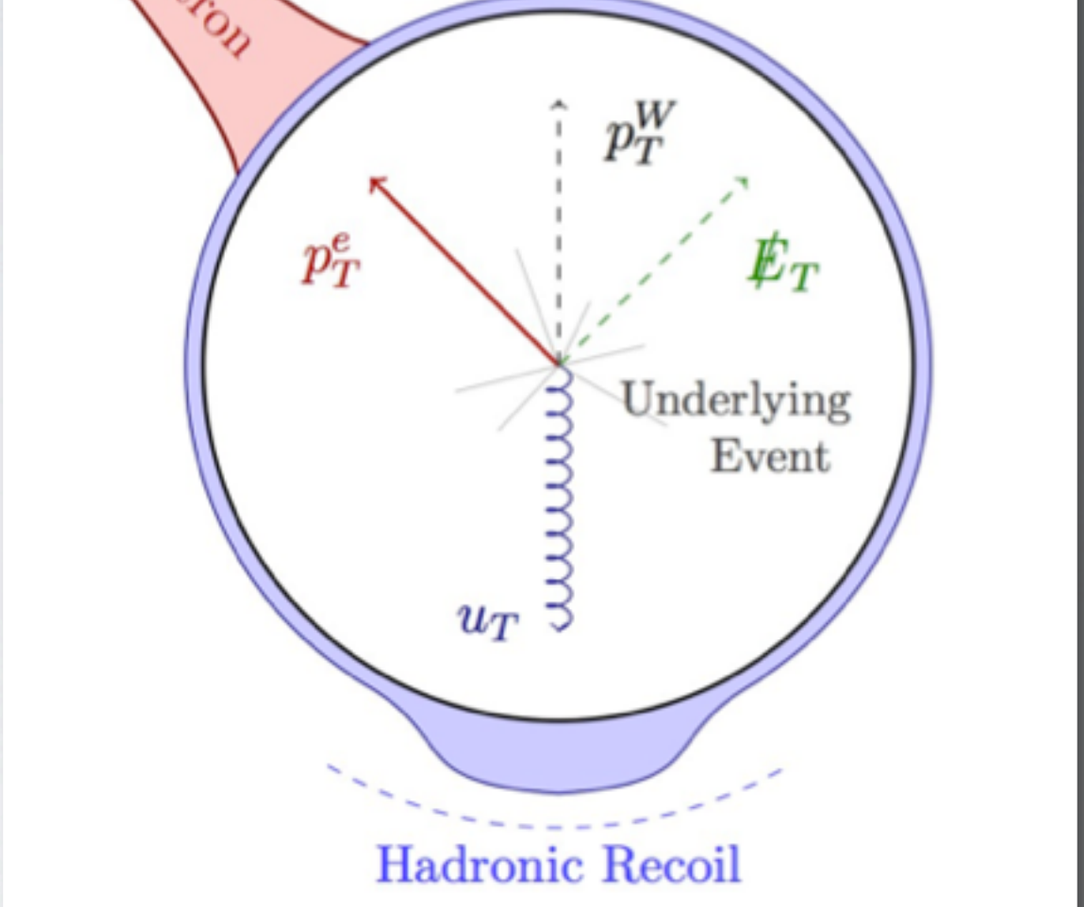
W decay	e^+	μ^+	τ^+	$u\bar{d}$	$c\bar{s}$
e^-		$e\mu$	$e\tau$	electron+jets	
μ^-	$e\mu$		$\mu\tau$	muon+jets	
τ^-	$e\tau$	$\mu\tau$		tau+jets	
$\bar{u}d$	electron+jets	muon+jets	tau+jets	all-hadronic	
$\bar{c}s$					

dileptons



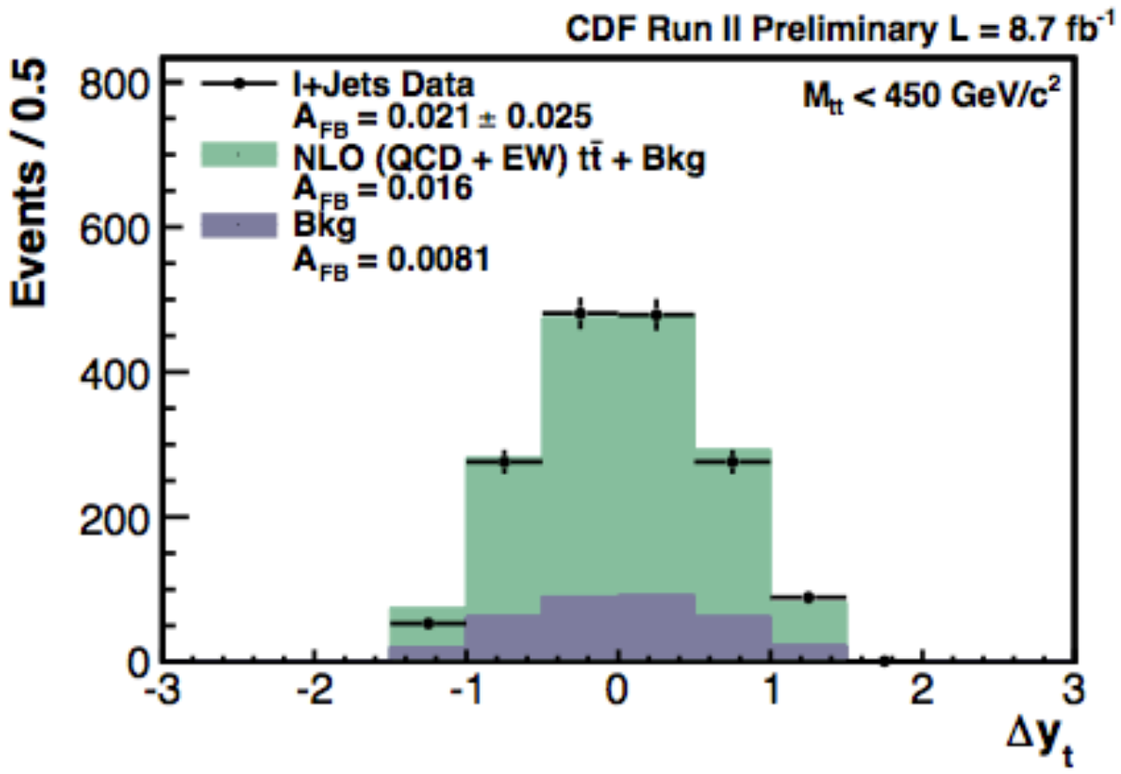
Electron absolute energy scale and recoil model

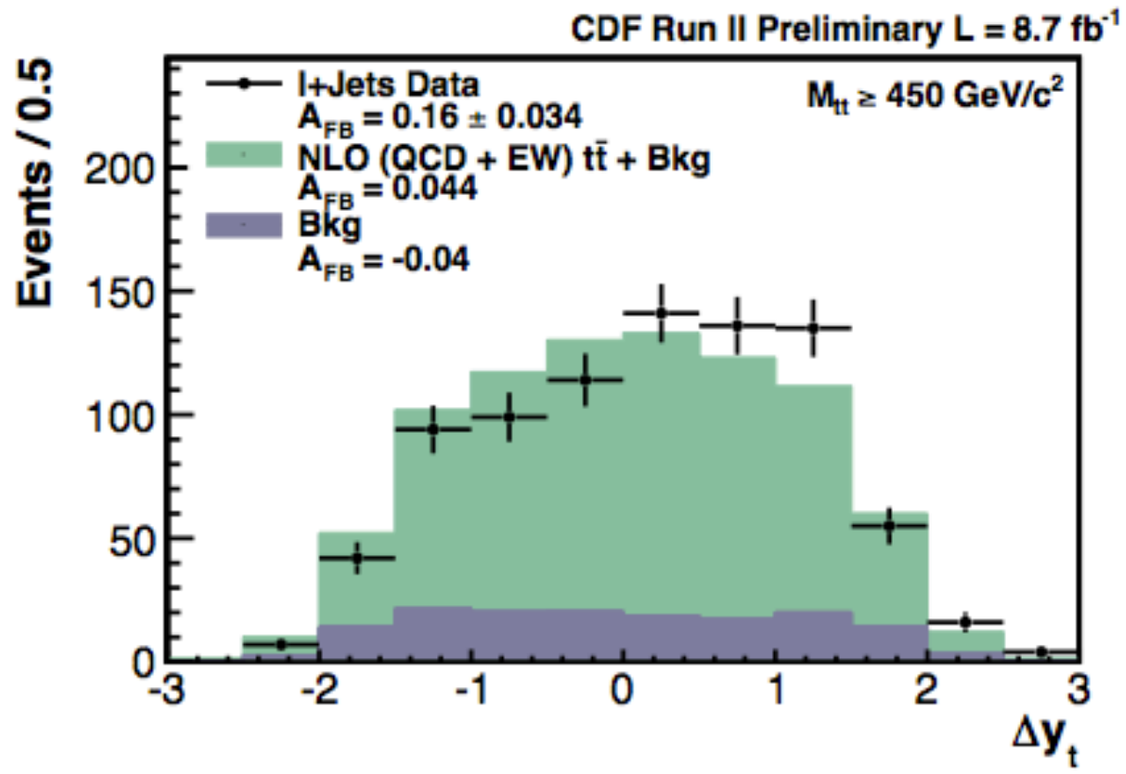


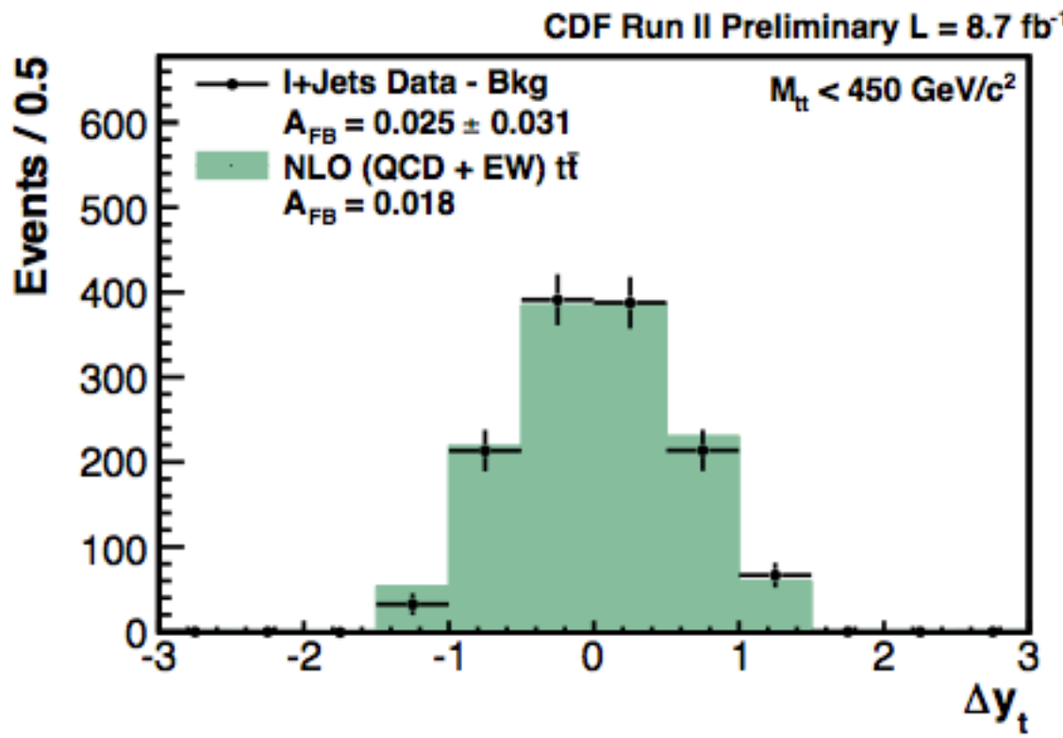


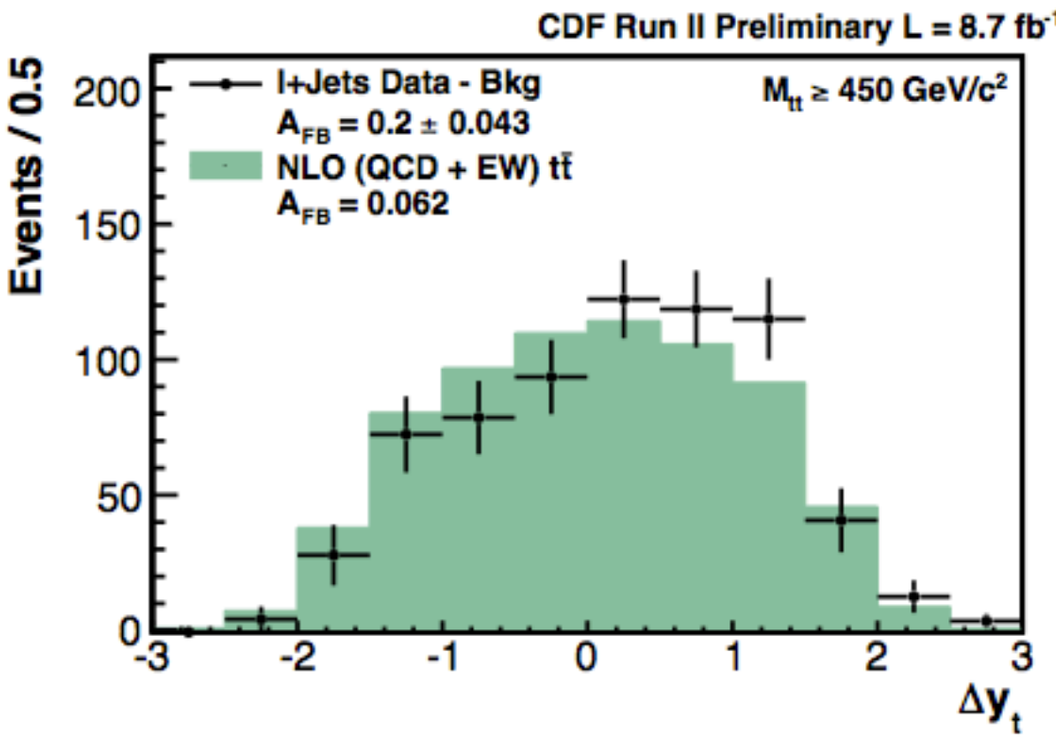
We are effectively measuring mw/mz.

Forward Backward Asymmetry









Forward Backward Asymmetry

Forward-Backwards Asymmetry:

- An asymmetry is observed in both reconstructed and parton level Δy distributions.
- The is a proximate linear dependence in $M_{t\bar{t}}$ and $|\Delta y|$.