Searches for Resonances Decaying to Top

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on behalf on the

and

Collaborations

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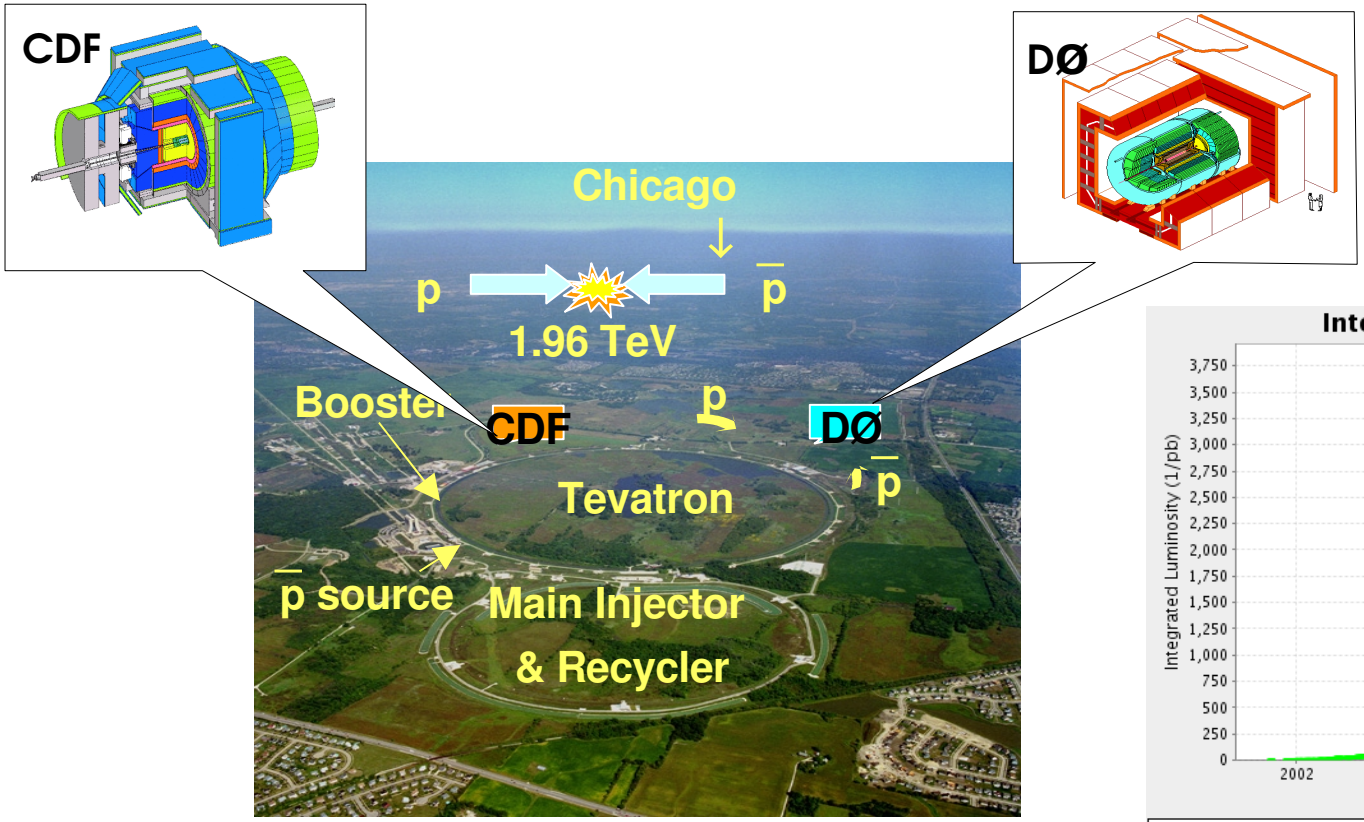
- Tevatron at Fermilab
- Top Quark Production in SM and beyond
- Search for narrow width resonances
- Search for massive Gluon
- Measurement of $d\sigma/dM_{t\bar{t}}$
- Results and Summary

The Tevatron at Fermilab



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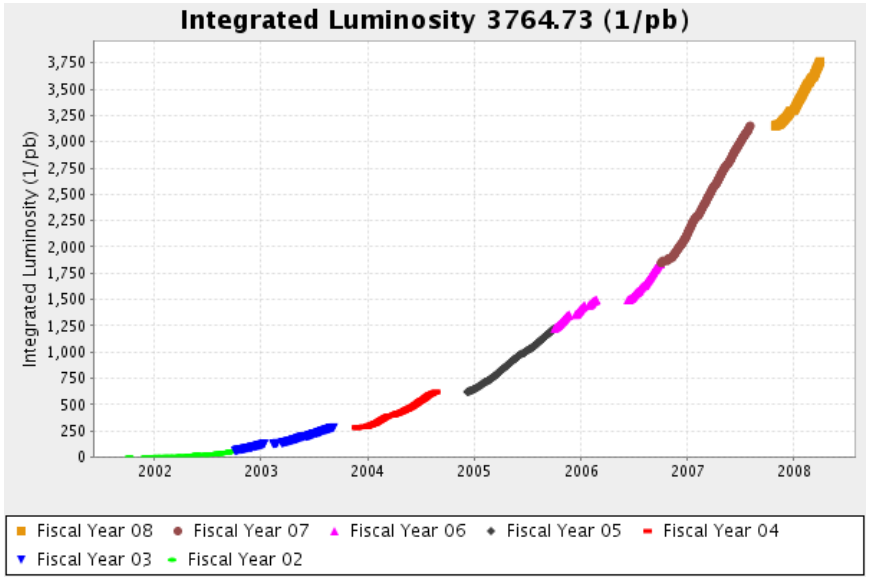


1995	2001	2006	2008
Prediction of and search for top quark	Observation of top-pair production	Begin of Run II	Evidence of single top production

$\Delta\sigma(t\bar{t})\sim 11\%$

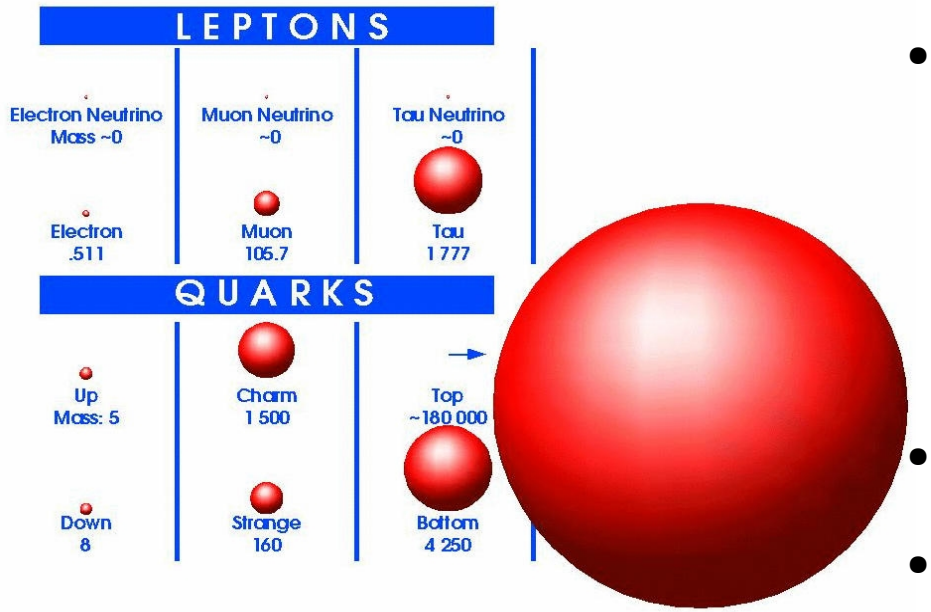
$\Delta m_t = 0.8\%$

differential X-sections

test of production mechanism

searches for BSM

Top Quark

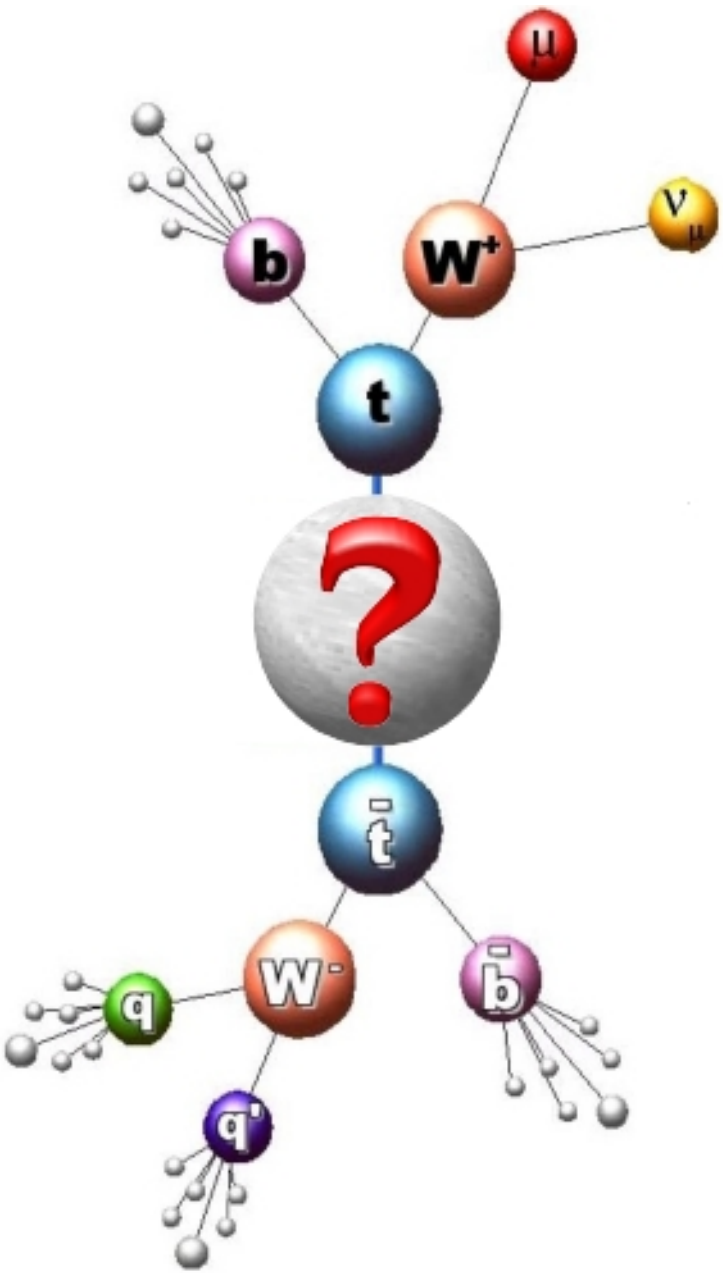


- Top quark is heaviest known elementary particle:
  172.6 ± 0.8 (stat.) ± 1.1 (syst.) GeV
  hep-ex/0703034, March 2008
- Short lifetime ~ $5 \cdot 10^{-25}$s < Λ^{-1}_{QCD}
- Decays before it hadronizes
- Only quark w/o observed resonances

- Why is top so heavy?
- Special role in electroweak symmetry breaking?
- Is it connected to new physics?

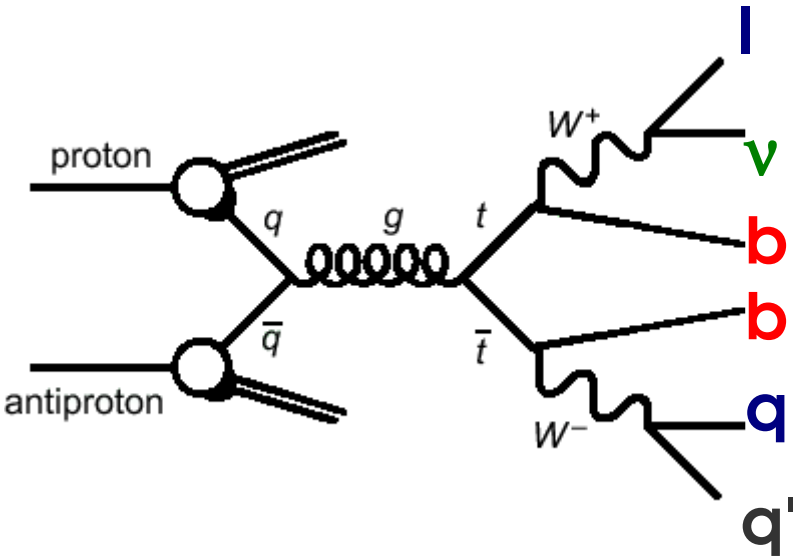
ttbar Resonances

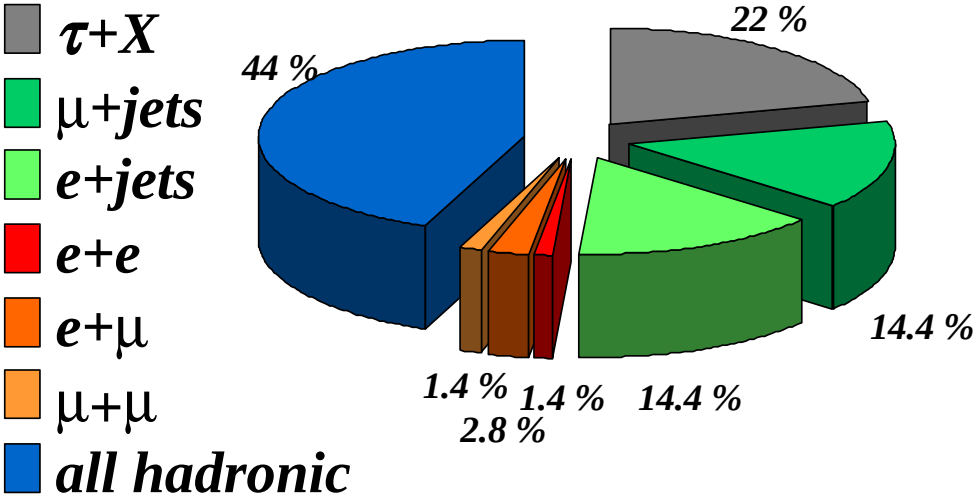
- No resonance production in SM
- Some Beyond SM Models suggest:
  - Kaluza Klein states of gluon or Z
    JHEP 09 (2007) 074, Phys. Rev. D61 (2000) 055005
  - new strong gauge force coupling to 3rd generation
    - topcolor assisted technicolor predicts leptophobic Z'
      Phys. Rev. D49 (1994) 4454
- Heavy higgs → ttbar
- Searches: generic search for resonances in M_{tt} distribution
- Width small compared to detector resolution



Decay of Top Pairs

- Top decays to W-Boson and b-quark (~100% in SM)
- Top-Antitop Signature detemined by W decay modes
- lepton + jets channel
  - 4 jets, high p_T e or μ, 1ν
  - BR ~ 30%





Reconstruction of Mtt

DØ:

- take ν solution with smallest p_z
- calculate Mtt from all objects
- analyse 3 jets and ≥4 jets events

CDF:

- Dynamical Likelihood Method
- Does not include production matrix element
- takes all jet-lepton assignments and both ν solutions into account

W mass constraint

2 ν solutions

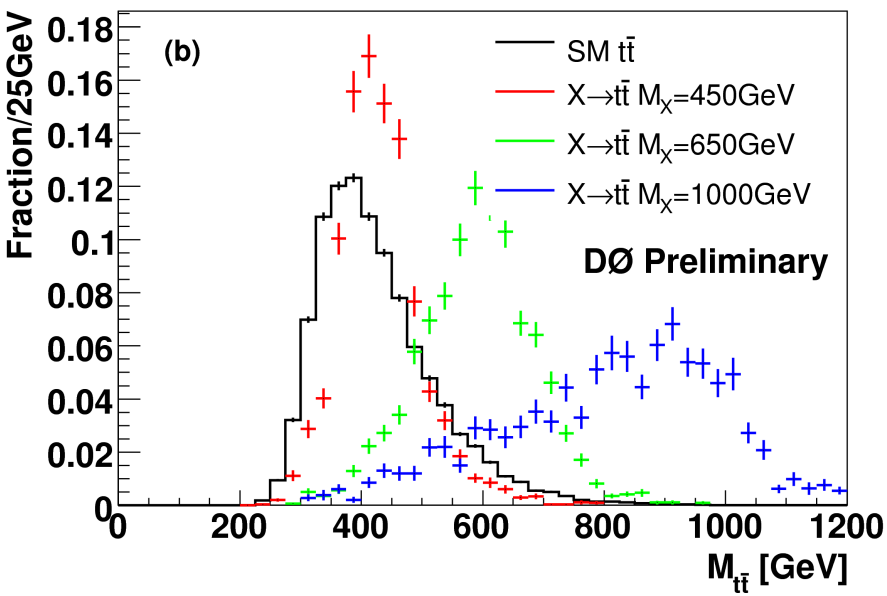
top mass constraint

b-tagging

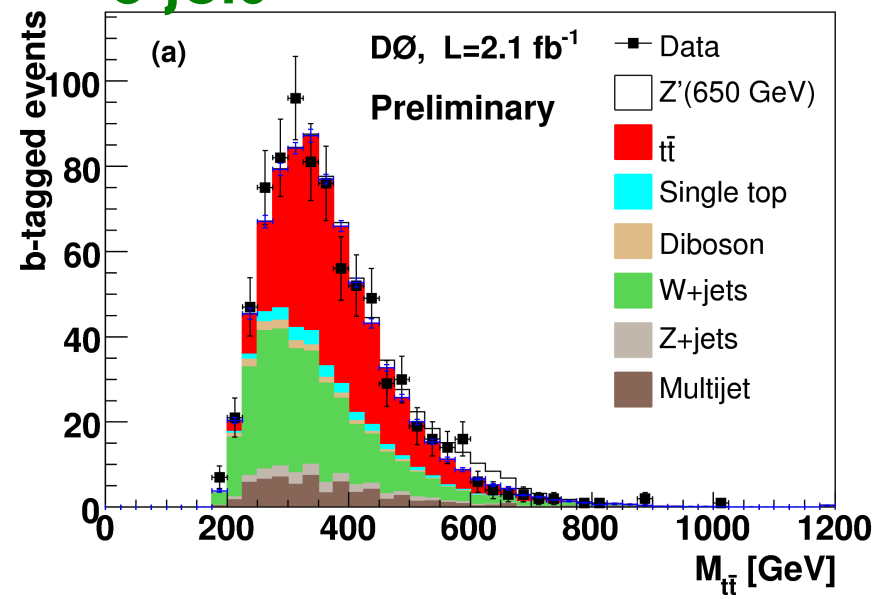
Search for narrow resonance (DØ)

$M_{t\bar{t}}$ distribution for SM ttbar and different narrow resonance samples:

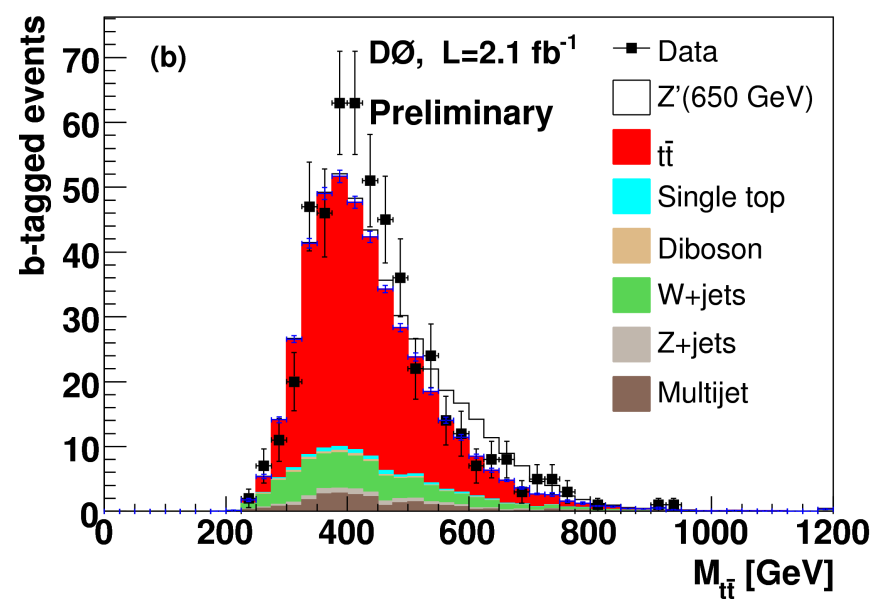
Γ=0.012 M_x



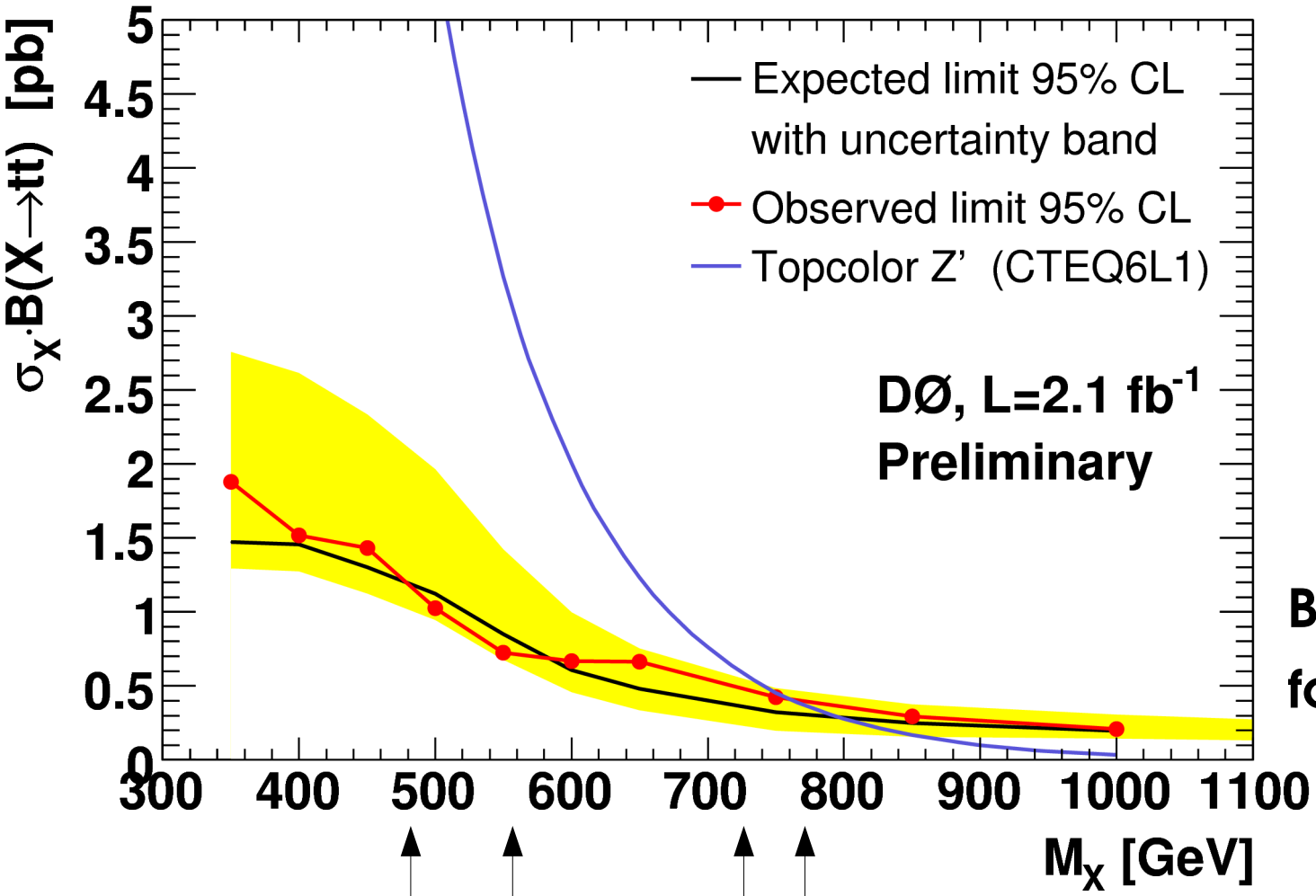
3 jets



≥ 4 jets



Limits on σ_X BR(X→tt) and Mass of Z'



Bayesian approach for limit calculation

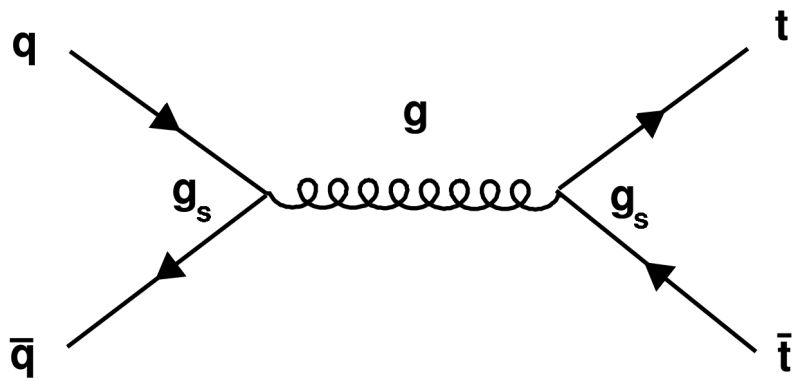
CDF Run I | DØ Run I | CDF Run II | DØ Run II

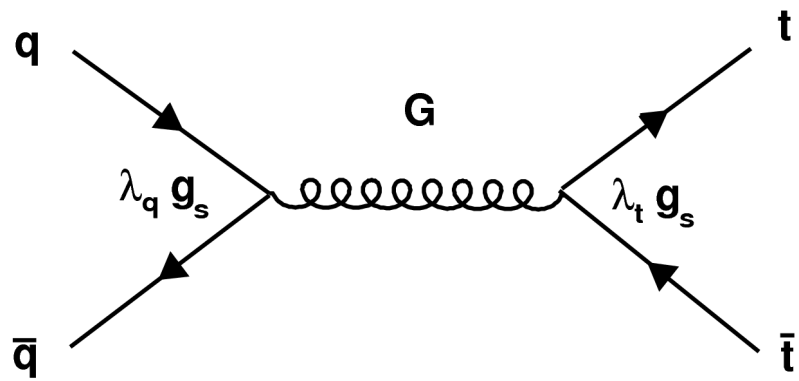
$\Gamma_{Z'} = 0.012\ M_{Z'}$

$M_{Z'}$>760 GeV @95% C.L.

Search for Massive Gluon (CDF)

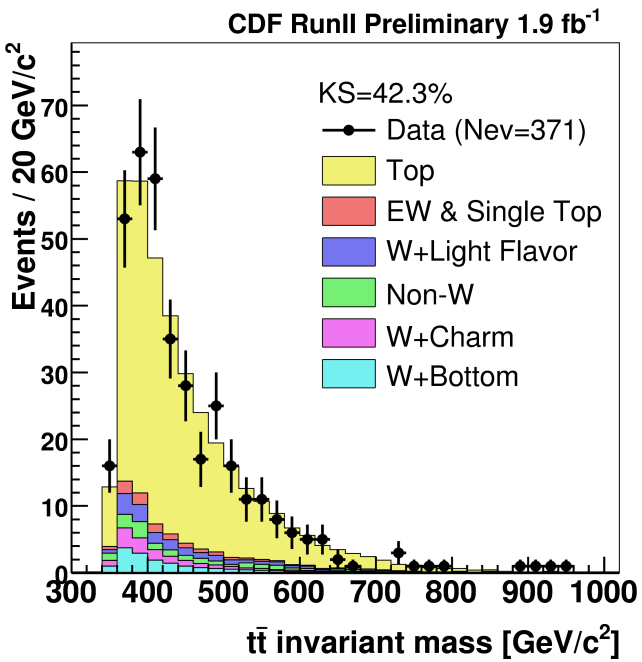
- Massive Gluon (G): new color-octet particle decaying to top quark pair
- Interference of: qqbar→G→ttbar and qqbar→g→ttbar
- SM decay: lepton + jets channel

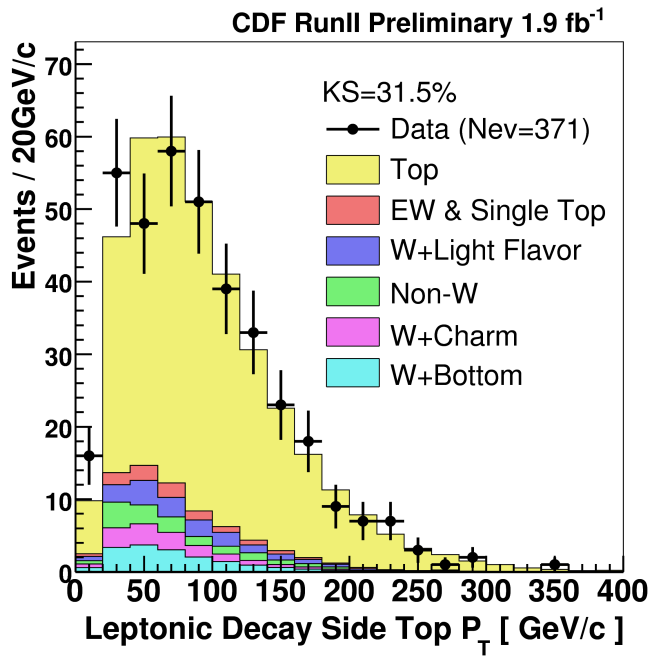


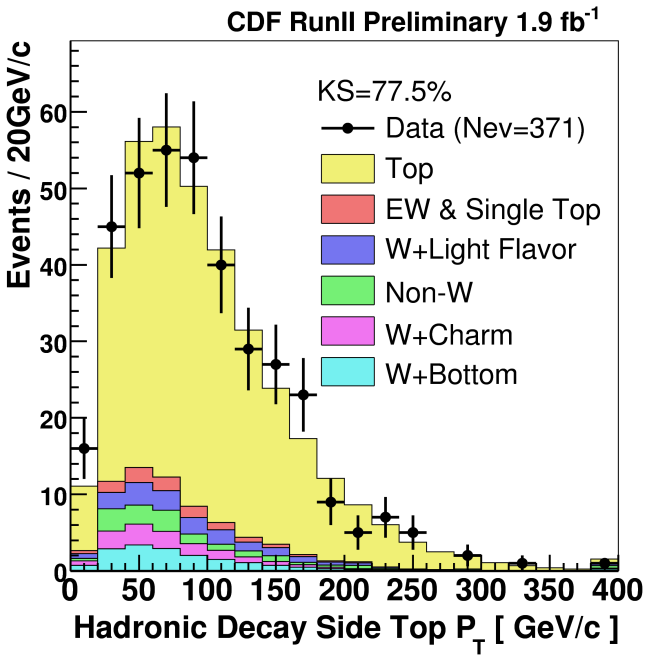


- 3 parameters: λ, M, Γ

Search for Massive Gluon (CDF)

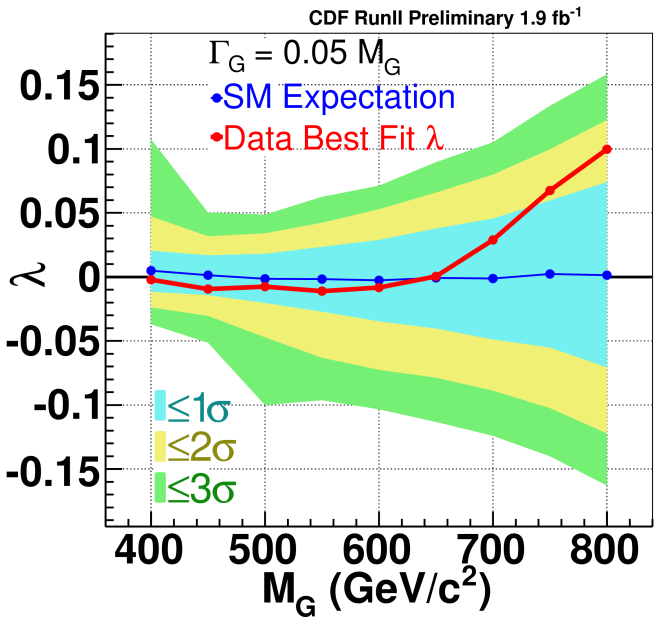


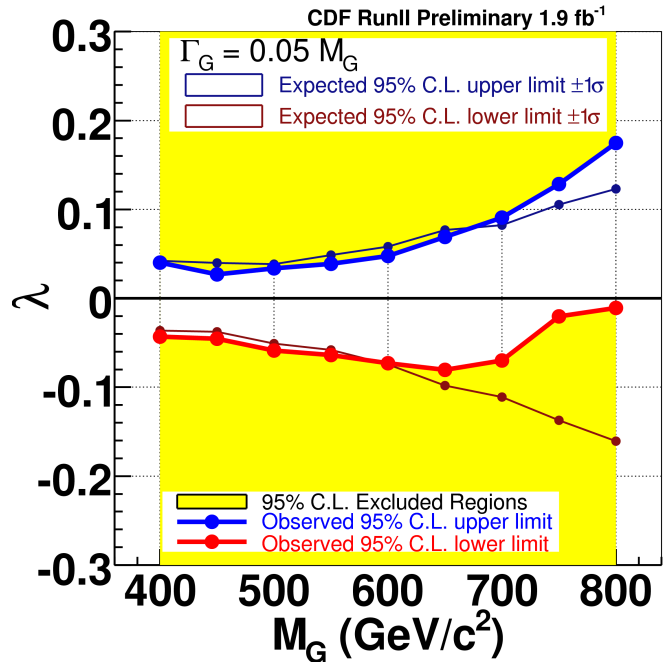


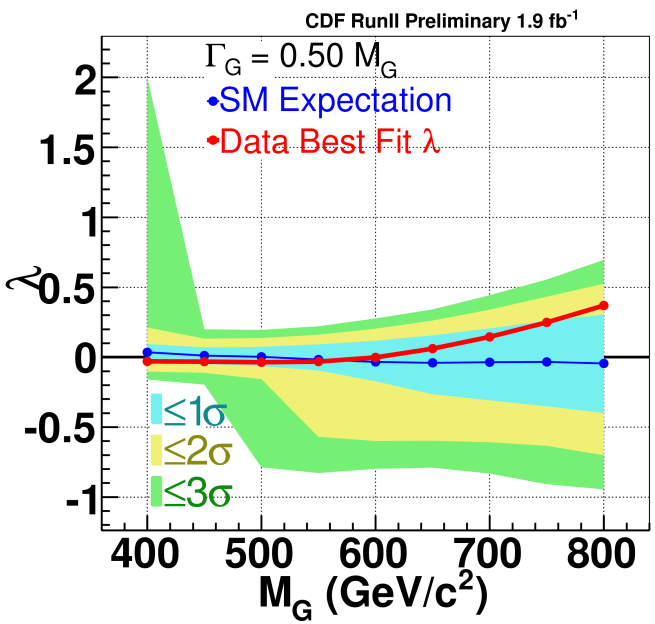


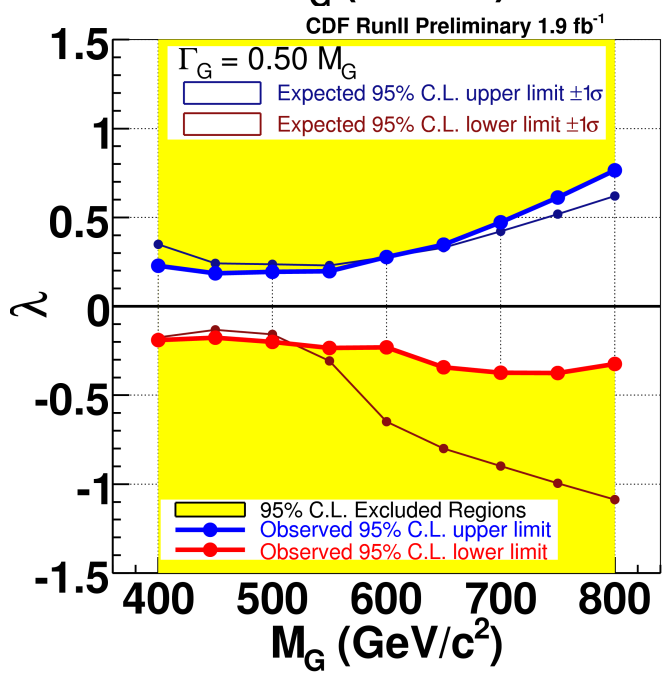
- Unbinned maximum likelihood fit to extract coupling λ for different M_G and Γ

Best Fitted Couplings and Limits





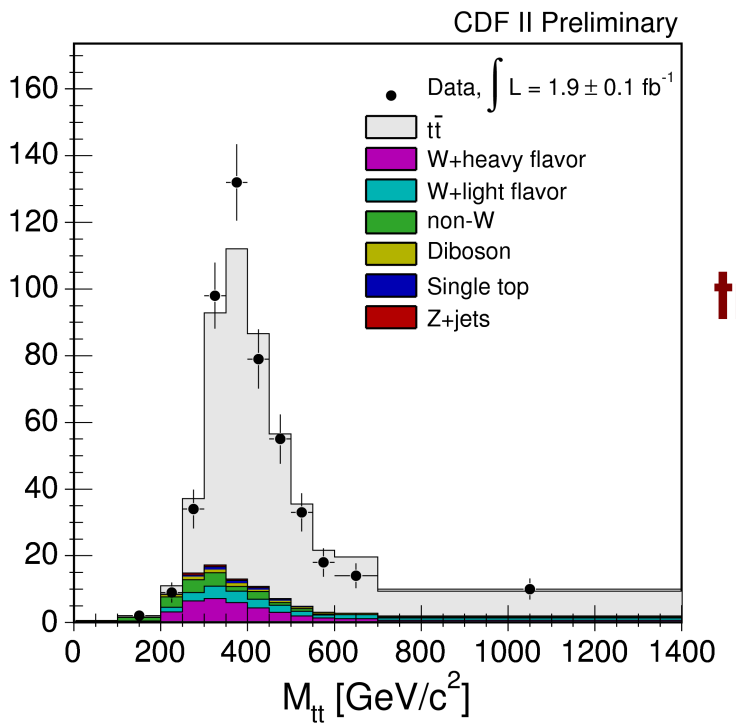




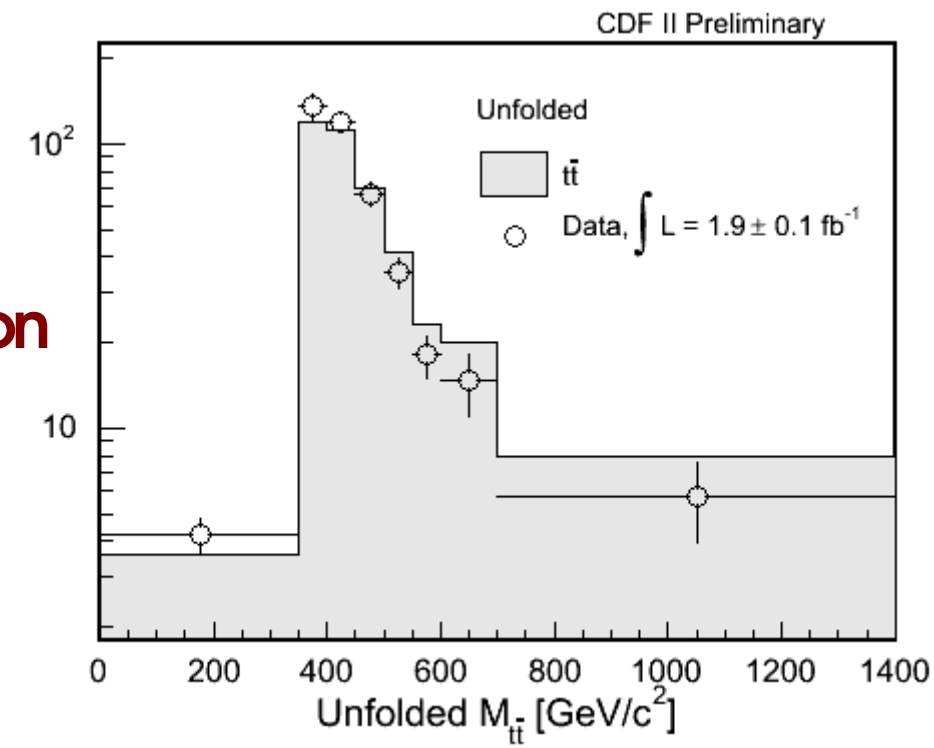
- Fitted coupling strength consisten with SM (within 1.7σ)
- Γ/M_G points: 0.05, 0.1, 0.2, 0.3, 0.4, 0.5

Differential Cross Section $d\sigma/dM_{t\bar{t}}$ (CDF)

Differential cross section: $$\frac{d\sigma^i}{dM_{t\bar{t}}} = \frac{N_i - N_i^{bkg}}{\mathscr{A}_i \int \mathscr{L} \Delta^i_{M_{t\bar{t}}}}$$



Unfolding via linear transformation



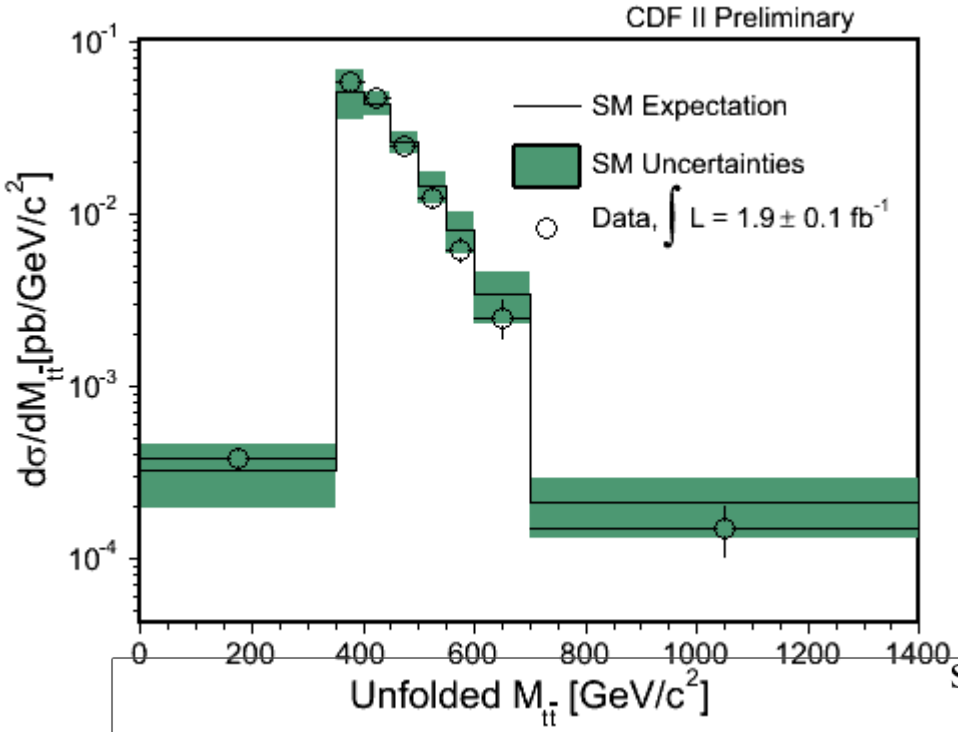
Measured distribution

"true" Distribution w/o detector effects

Differential Cross Section $d\sigma/dM_{t\bar{t}}$ (CDF)

484 candidate events (1.9 fb^{-1})

expected background 85.7± 22.0



- **No discrepancy from SM**
- **p-value for consistency with SM: 0.45**

Summary of systematic uncertainties for $d\sigma/dM_{t\bar{t}}$ measurement
CDF II Preliminary, $\int \mathscr{L} = 1.9 \pm 0.1\ fb^{-1}$

$M_{t\bar{t}}$ $[GeV/c^2]$	0-350	350-400	400-450	450-500	500-550	550-600	600-700	700-1400
MC Generator [%]	13.6	10.0	2.8	4.9	10.9	15.7	19.6	22.1
Inital State Radiation [%]	8.7	5.8	1.2	4.5	6.7	6.9	6.4	6.1
Final State Radiation [%]	4.6	3.1	0.7	2.1	2.9	3.0	3.7	4.7
Jet Energy Scale [%]	16.0	11.0	2.1	7.9	12.9	15.8	17.9	19.3
Background Shape [%]	30.2	24.6	14.1	7.8	6.8	9.0	12.1	14.3
Background Normalization [%]	9.4	7.7	4.6	2.9	3.0	4.0	5.3	6.1
Acceptance [%]	4.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2
MC PDF Set [%]	7.9	6.3	3.0	1.6	6.9	12.6	17.5	20.6
Total [%]	40.2	31.4	16.1	14.1	21.4	28.7	35.5	40.0

Summary

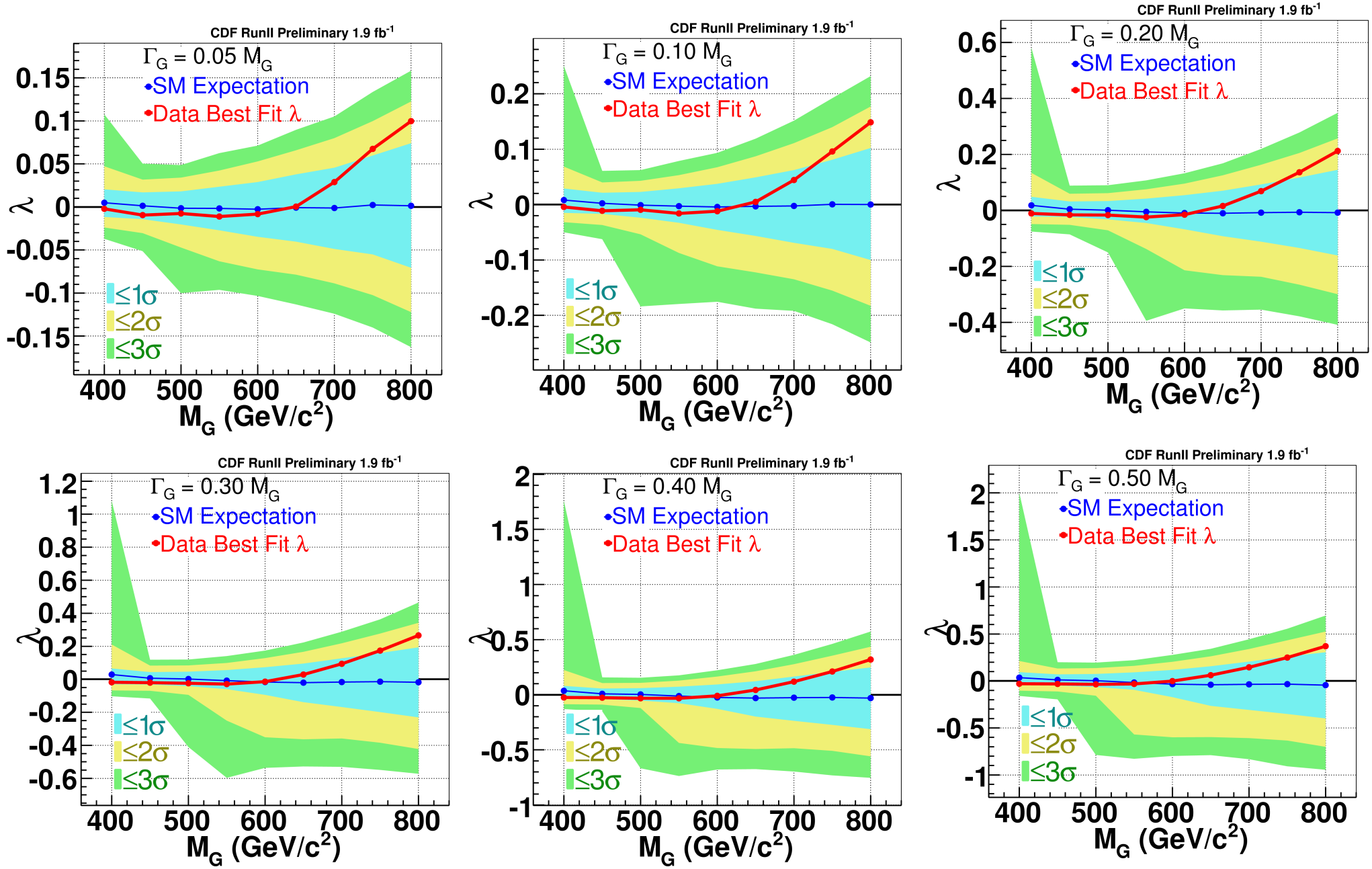
- Searches for Resonant ttbar production
- No discrepency from Standard Model

- Limits on the production cross section of narrow resonance
- Mass limit on leptophobic Z': $M_{Z'}$ > 760 GeV (Γ=0.012 $M_{Z'}$)
- Limits on coupling of massive gluon at various M_G, Γ
- Differential cross section $d\sigma/dM_{t\bar{t}}$

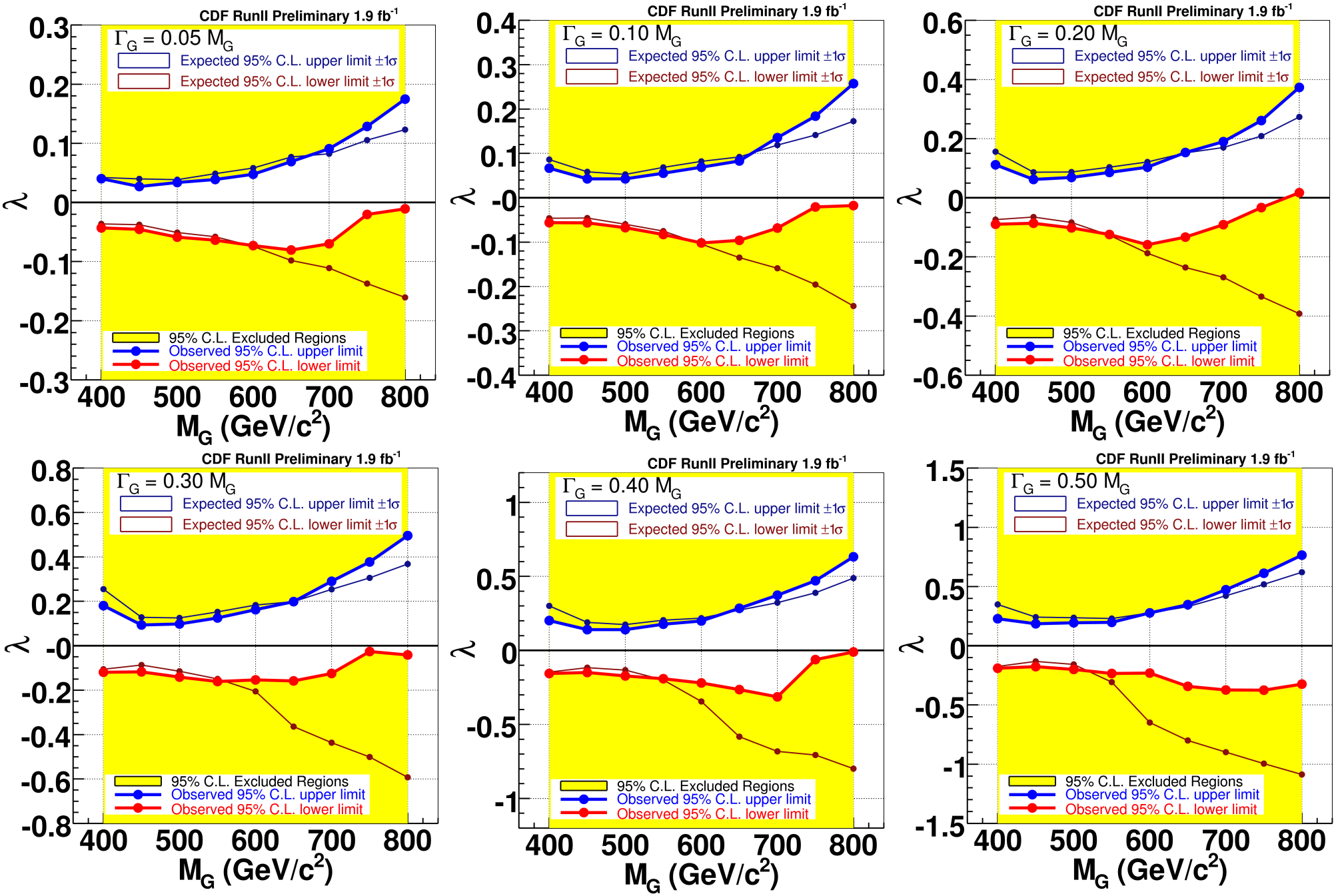
- Tevatron has started to perform precision tests of top quark production
- Expect more interesting results from CDF and DØ with more data (6-7 fb^{-1})

backup slides

Best Fitted Strength of Coupling



Limits on Massiv Gluon Coupling



Differential Cross Section

	$W \to \ell\nu + \geq 4$ jets data with ≥ 1 secondary vertex tags CDF II Preliminary, $\int \mathscr{L} = 1.9 \pm 0.1\ fb^{-1}$			
$M_{t\bar{t}}$ $[GeV/c^2]$	$d\sigma/dM_{t\bar{t}}$ $[pb/GeV/c^2]$			
≤ 350	0.0013 ±	0.0002 (stat.) ±	0.00051 (syst.) ±	7.7e-05 (lumi.)
350-400	0.059 ±	0.0064 (stat.) ±	0.018 (syst.) ±	0.0035 (lumi.)
400-450	0.044 ±	0.0032 (stat.) ±	0.007 (syst.) ±	0.0026 (lumi.)
450-500	0.025 ±	0.0024 (stat.) ±	0.0035 (syst.) ±	0.0015 (lumi.)
500-550	0.013 ±	0.0015 (stat.) ±	0.0028 (syst.) ±	0.00078 (lumi.)
550-600	0.0067 ±	0.0011 (stat.) ±	0.0019 (syst.) ±	0.0004 (lumi.)
600-700	0.0027 ±	0.00062 (stat.) ±	0.00096 (syst.) ±	0.00016 (lumi.)
700-1400	0.00016 ±	4.6e-05 (stat.) ±	6.4e-05 (syst.) ±	9.7e-06 (lumi.)
	Assumes $M_{top} = 170\ GeV/c^2$			