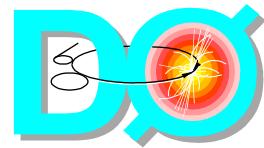




New TeVatron searches in BSM physics



Michel Jaffré



on behalf of the CDF and D0 collaborations



Rencontres de Moriond EW

Motivations

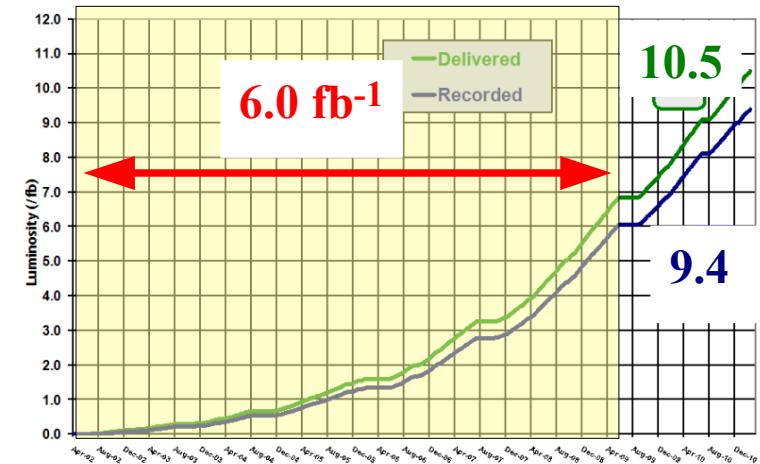
In BSM models, new physics will manifest in similar event topology

- Take a given final state and try to constrain several models at once

Tevatron assets in BSM physics searches : large accumulated datasets and well understood detectors and reconstructed objects

- Search in more complex final state

Delivered/Recorded
luminosity

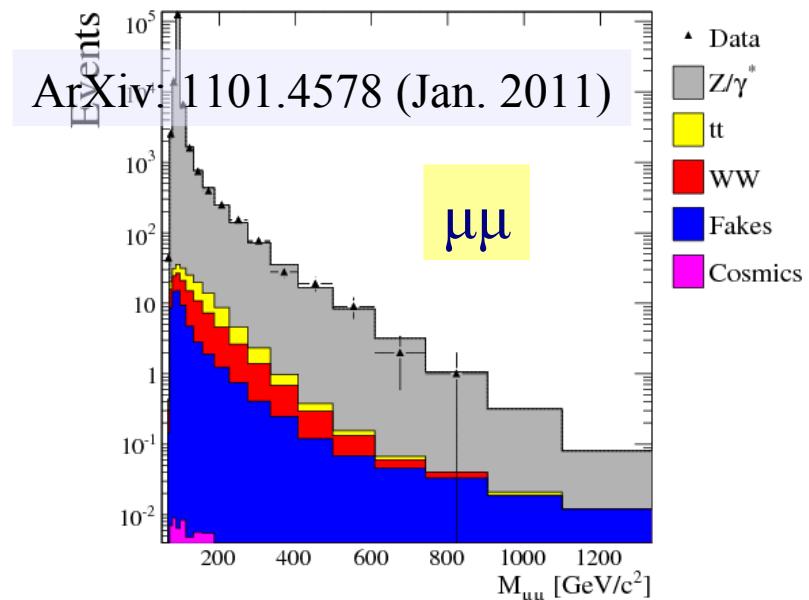
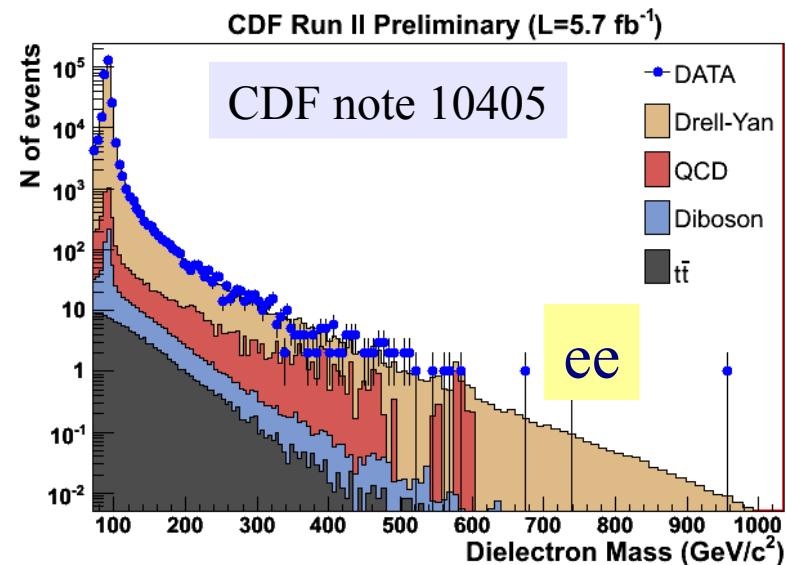
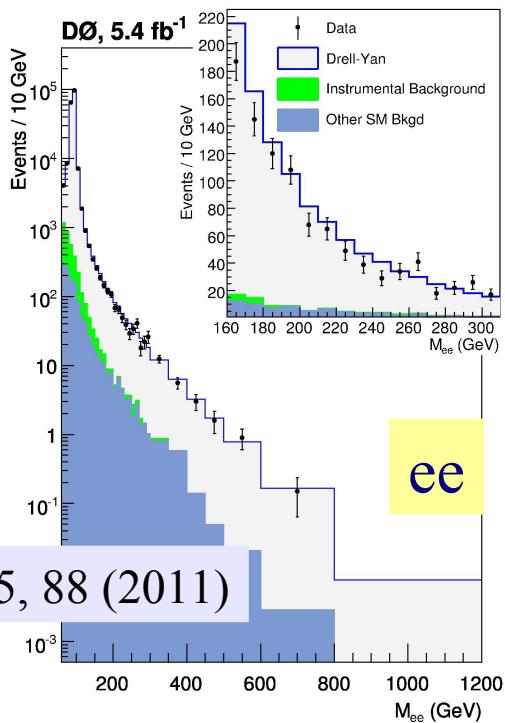
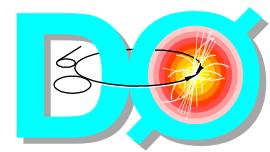


Outline

- Dilepton/diphoton resonances
- Diboson resonances
- More complex signatures

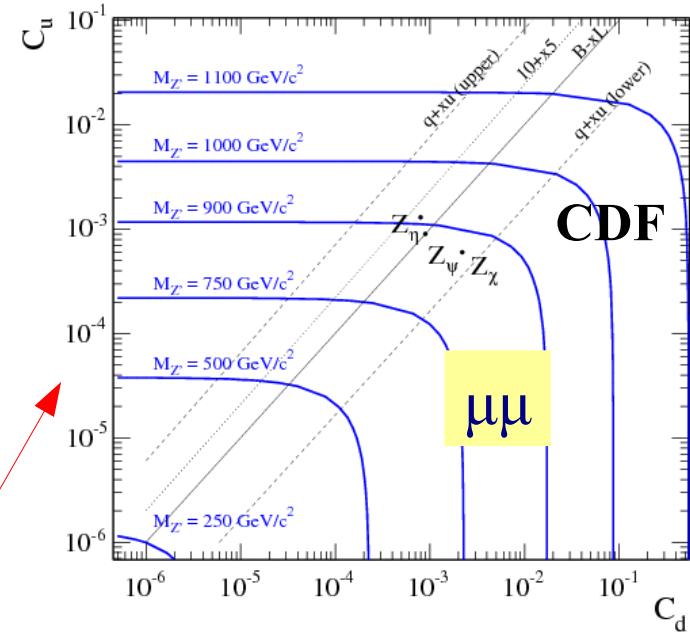
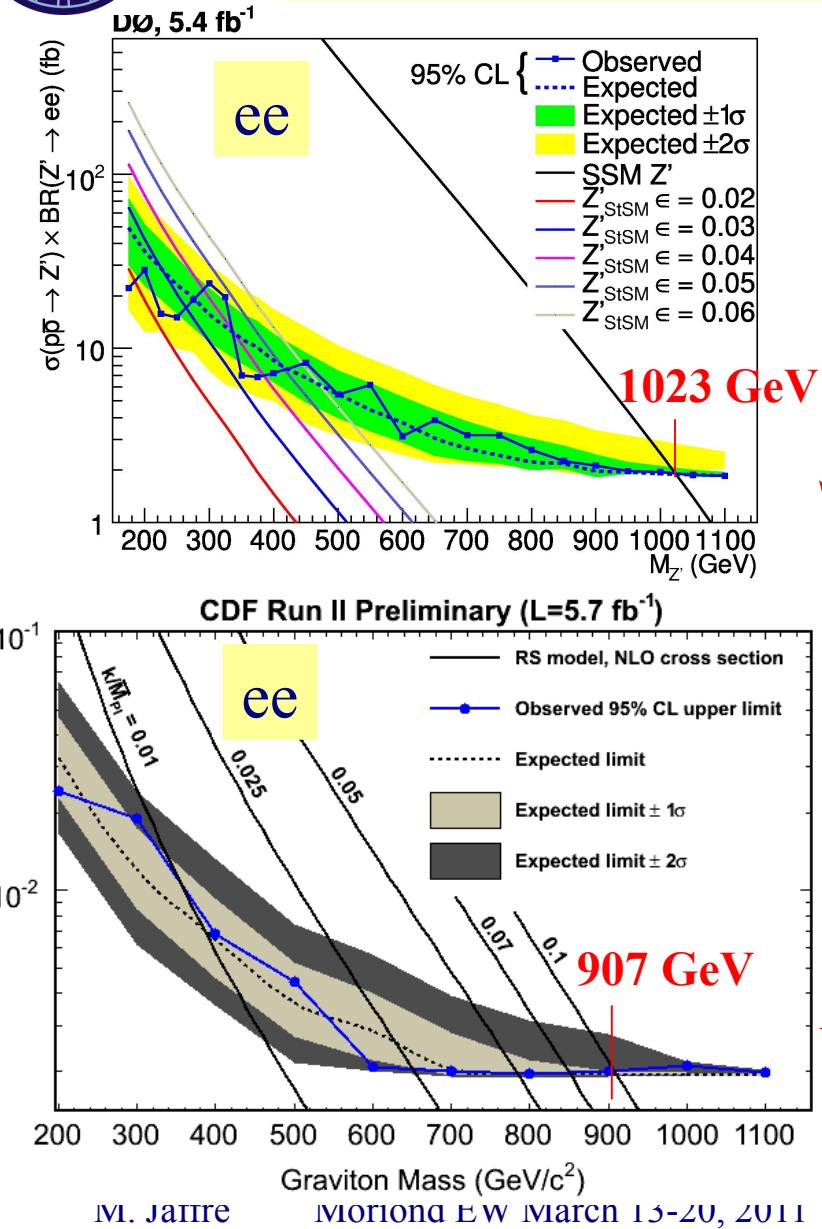


ee/ $\mu\mu$ mass spectra



- Large datasets CDF(D0) : 5.7 (5.4) fb^{-1}
- Well understood electron/muon objects
- $\mu\mu$ practice new ME likelihood method
- Good agreement with SM predictions

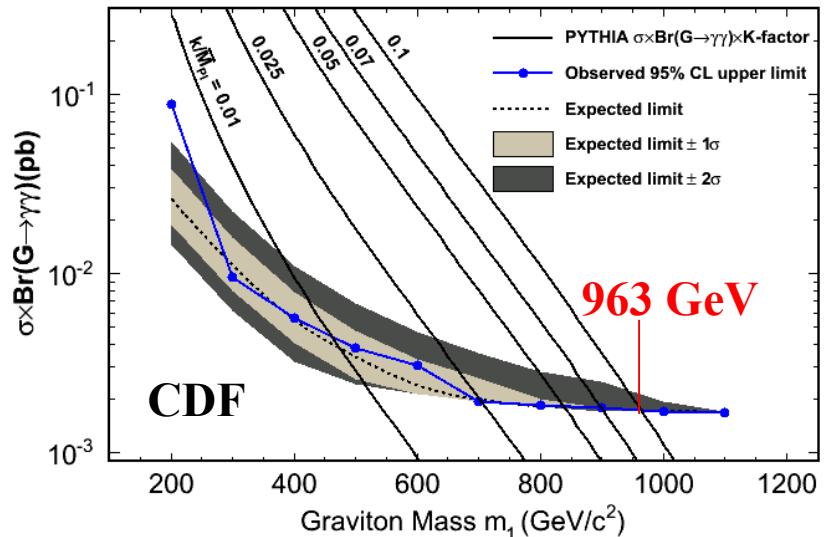
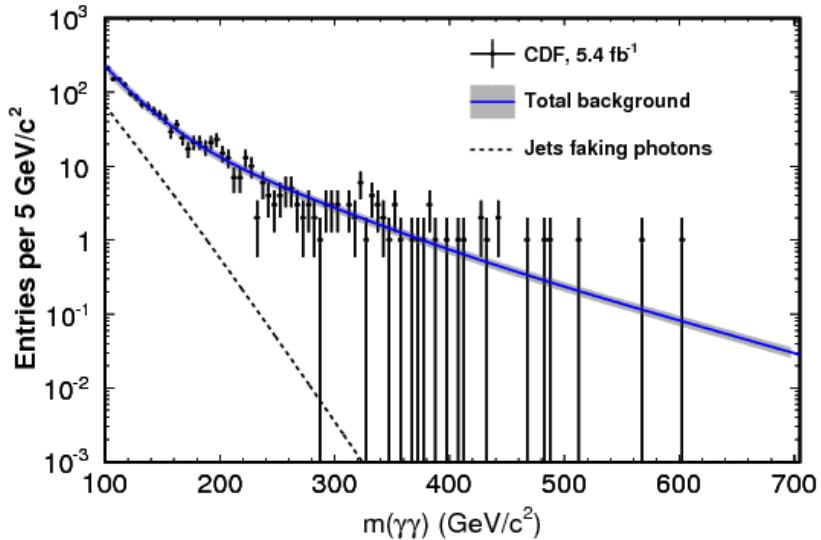
ee/ $\mu\mu$ resonance search



- Mass limits for various Z' models, constraints on couplings
 - ✓ SSM , string E6, Stuekelberg extension models
- Mass limits for RS graviton for $k/\bar{M}_{Pl} = [0.01, 0.1]$ using mass dependent K factor

Diphoton mass distribution

PRD 83, 011102 (2011)

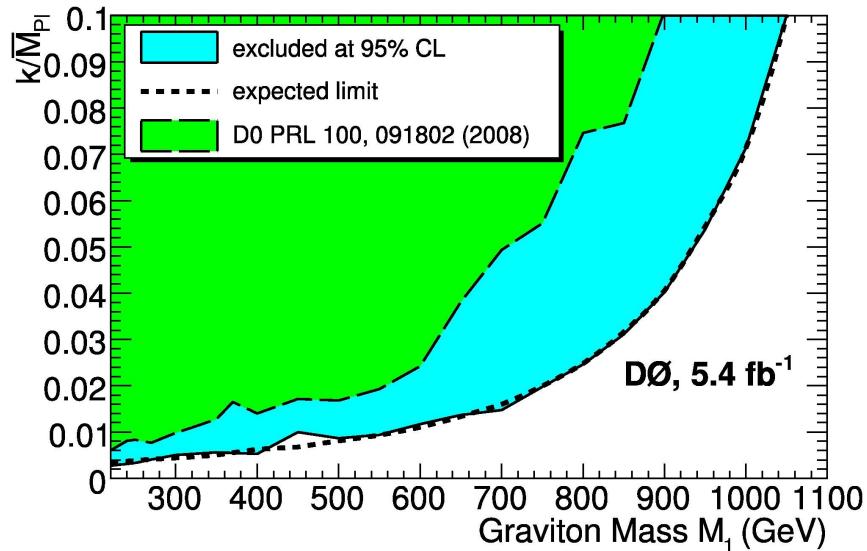
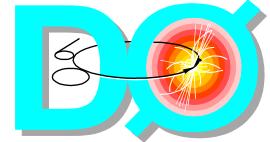


No significant deviation from expectation

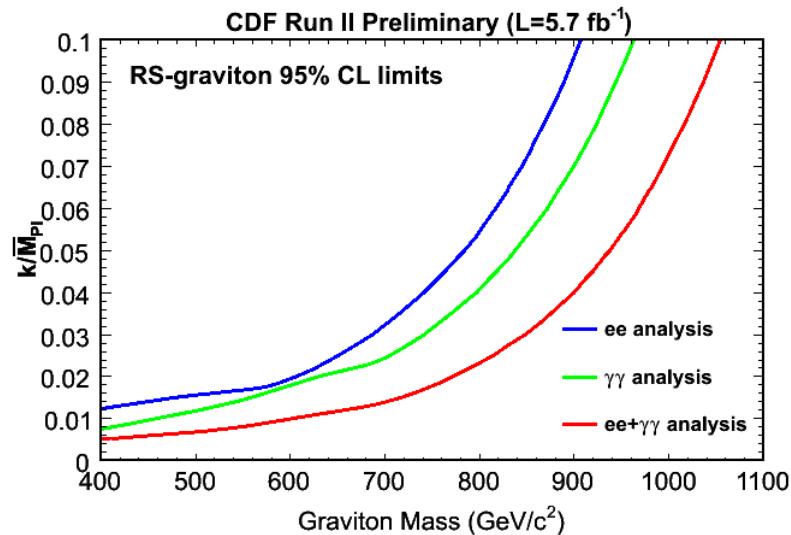
RS graviton $M_G > 963$ GeV for $k/\bar{M}_{Pl} = 0.1$ using a mass dependent K factor for the signal cross section



Combined dielectron/diphoton resonance search



PRL 104, 241802 (2010)

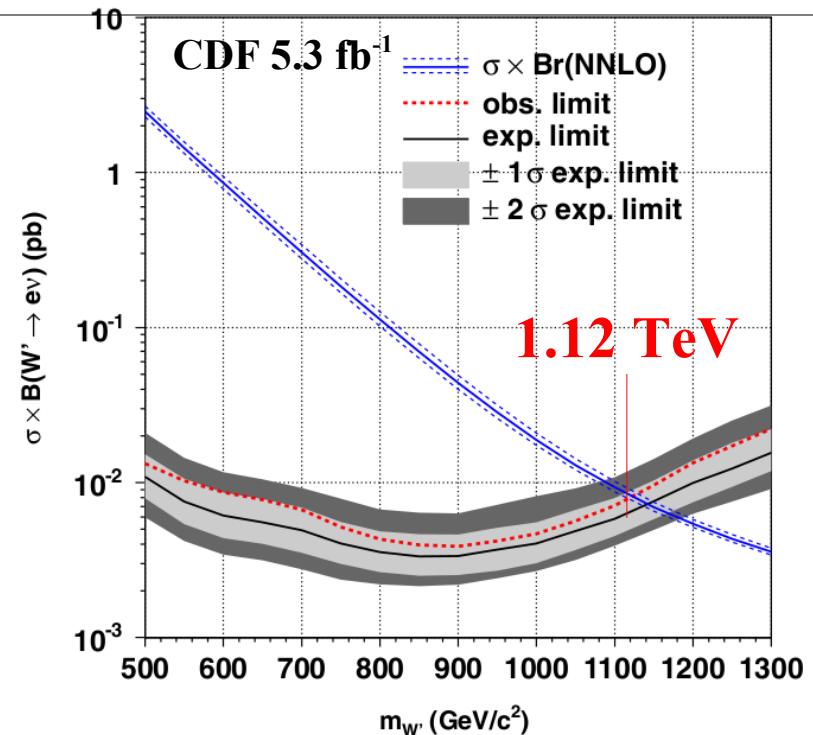
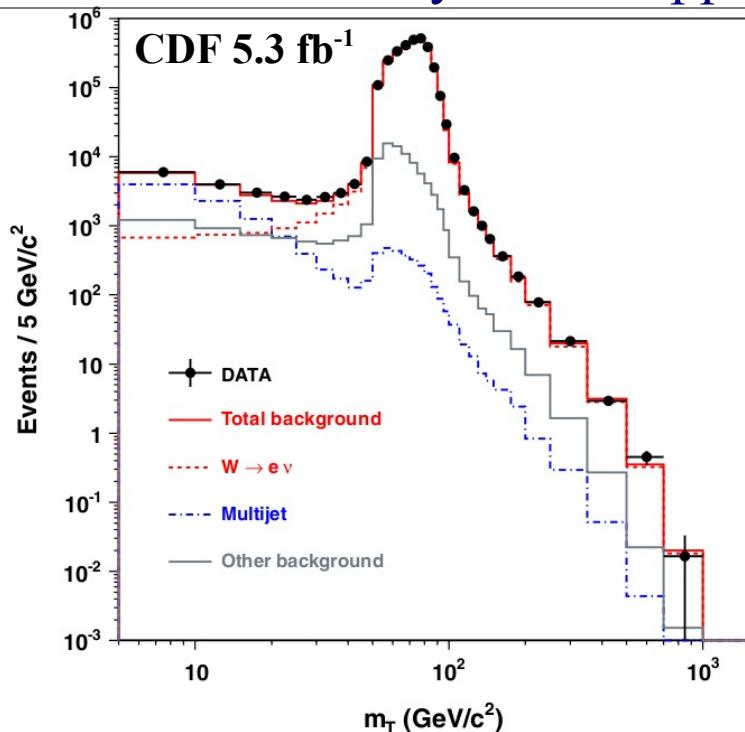


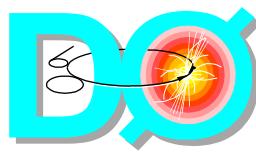
CDF public note 10405

Improved limits on RS graviton mass by combining ee and $\gamma\gamma$ analysis

- ✓ DØ : 560-1050 GeV for $0.01 \leq k/M_{Pl} \leq 0.1$ (fixed k-factor)
- ✓ CDF: 604-1055 GeV (mass dependent k-factor)

- Simple final state : hight pT electron and high mET
- Reaching Tevatron phase space limits : PDF at large x
- Xsection limit interpreted within the left-right symmetric model
- $W' \rightarrow WZ$ decay mode suppressed

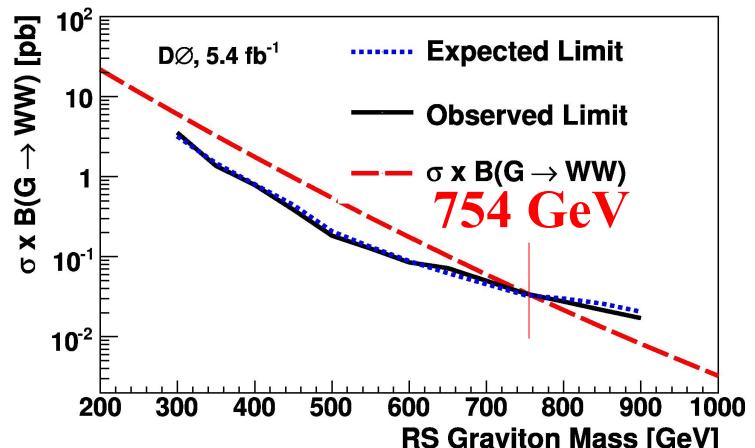
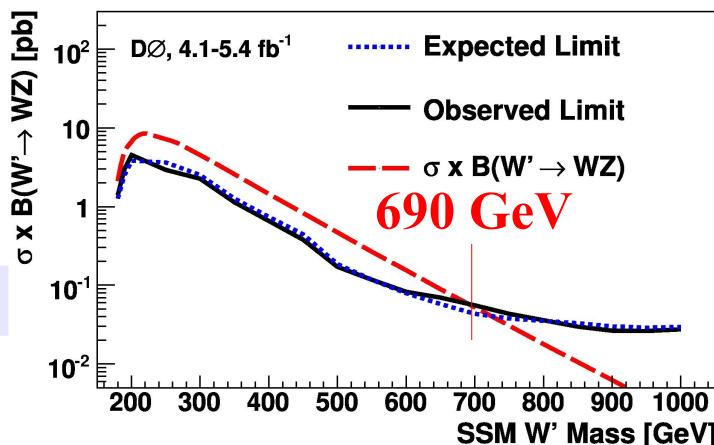
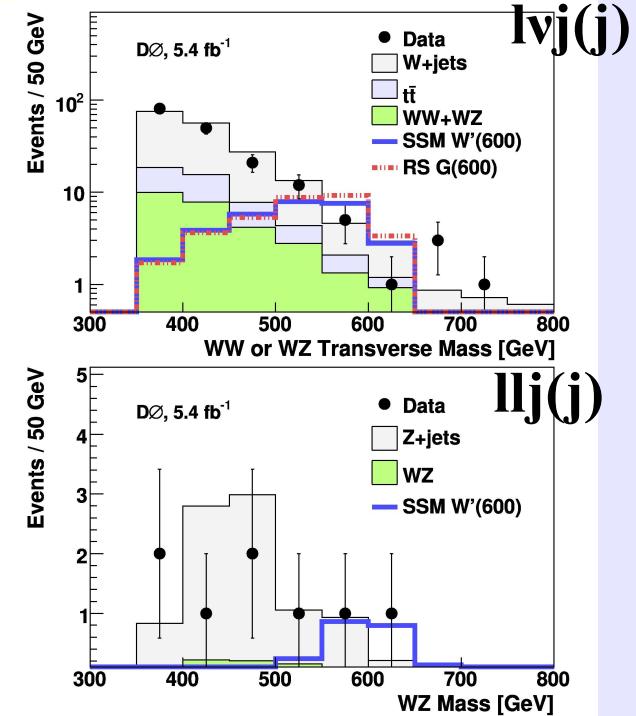




Di boson resonances : WW/WZ

ArXiv : 1011.6278

- Resonance decaying to on shell vector bosons
- $W' \rightarrow WZ \rightarrow lll' + mET$ 4.1 fb^{-1} PRL 104, 061801 (2010)
- $W'/Z'/G^* \rightarrow WZ/WW \rightarrow e/\mu + mET + 1(+1)\text{jets}$
- $W' \rightarrow WZ \rightarrow ee/\mu\mu + 1(+1) \text{jets}$
- Kinematic cuts use the fact that bosons from decay are highly boosted, 2 jets from decay may even merge
 \Rightarrow Jet mass > 60 (70) GeV comes from $W(Z)$ decay

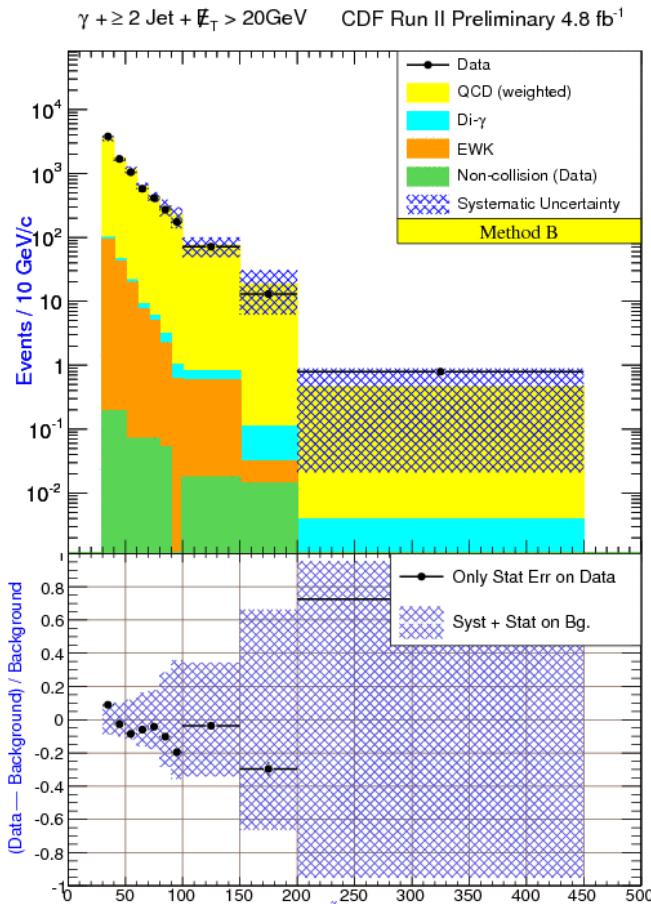


PRL 104, 241801 (2010)

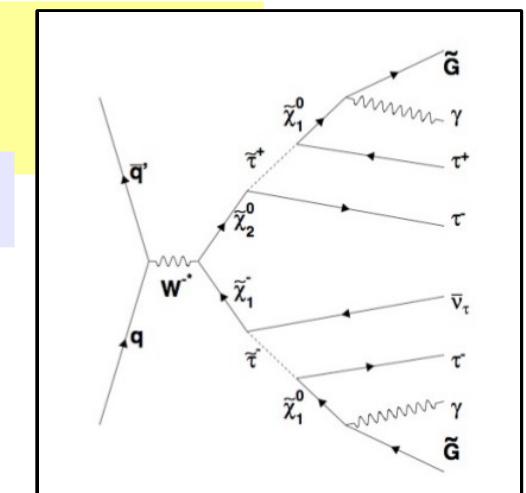


$\gamma + \text{jets} (+ \text{ mET})$

CDF public note 10355



E_T^{γ}



- Method independent and signature based analysis on **4.8 fb-1**
 - Searching for excess of events in lot of distributions
 - Photon $E_T > 30 \text{ GeV}$
 - Jet $E_T > 15 \text{ GeV}$
 - Importance to model QCD background from data
- All plots compatible with expectations.**



$\gamma + \text{lepton} + \text{mET} + \text{b-jet}$

follow-up of PRD 80, 011102 (2009)
with 6fb^{-1}

$E_T^{\text{lepton}} > 20\text{ GeV}, E_T^\gamma > 10\text{ GeV}$

$\text{mET} > 20\text{ GeV}, E_T^{\text{jet}} > 15\text{ GeV}$

85 events vs 99.1 ± 9.3 expected

Isolate the $t\bar{t}\gamma$ contribution by

≥ 3 jets and $H_T > 200\text{ GeV}$

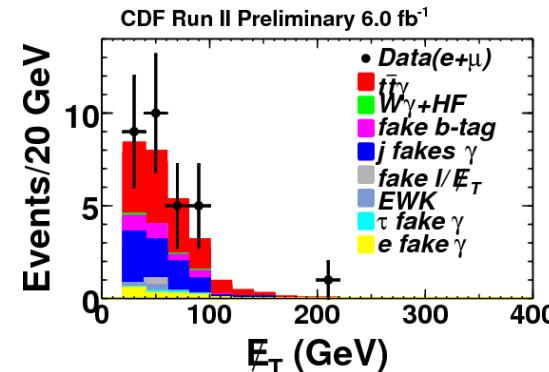
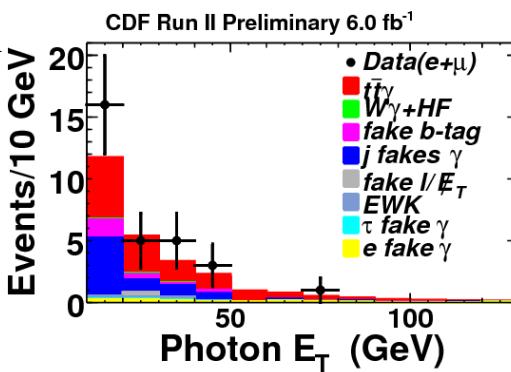
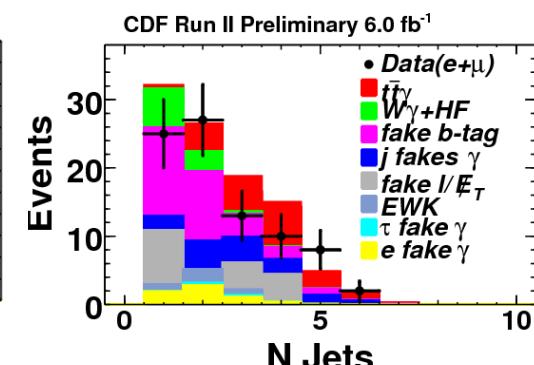
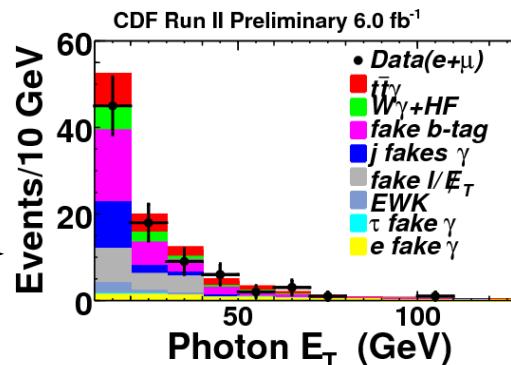
30 events vs 26.9 ± 3.4 expected

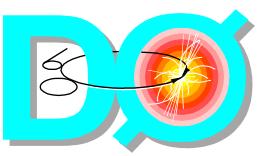
Searching for a deviation to SM
leads to a SM Xsection
measurement

$$\sigma(t\bar{t}\gamma) = 0.18 \pm 0.07 \pm 0.04 \text{ pb}$$

$$\sigma(t\bar{t}\gamma)/\sigma(t\bar{t}) = 0.024 \pm 0.009 \pm 0.001$$

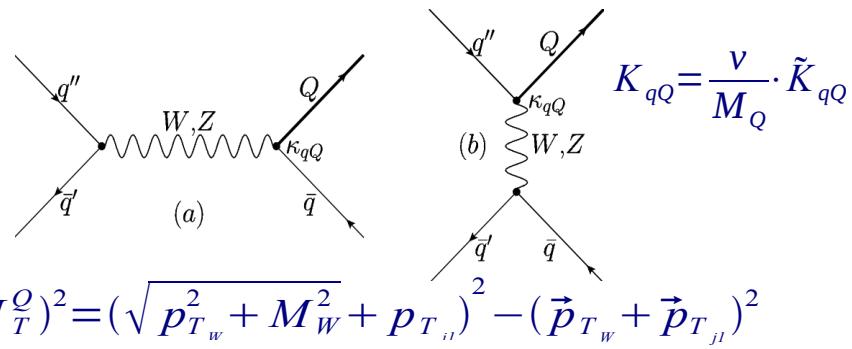
CDF public note 10270



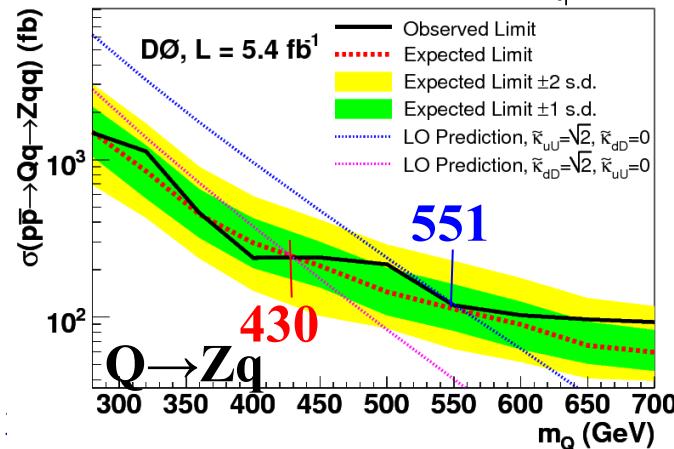
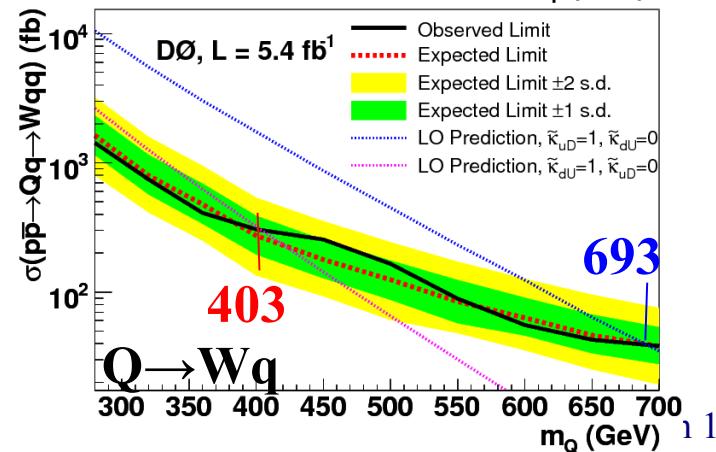
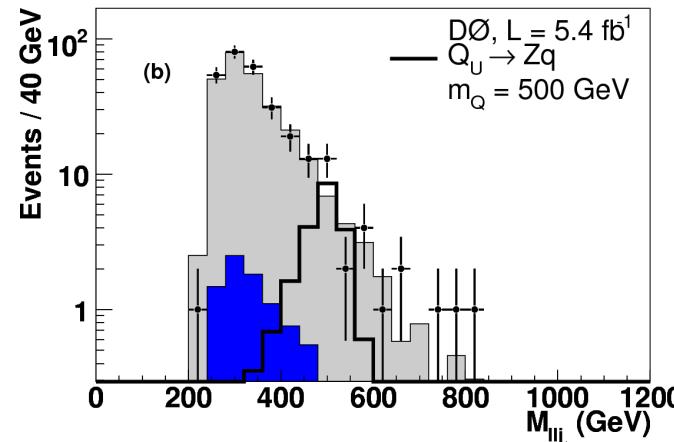
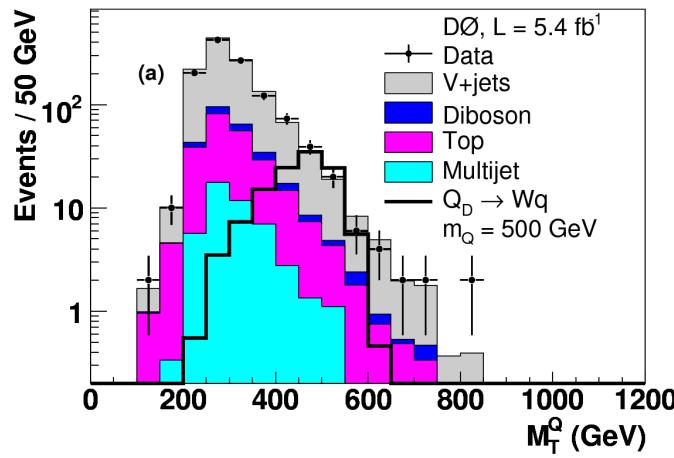


Single vector-like quarks

PRL 106, 081801 (2011)



Q_L and Q_R same transformation under $SU(3) \times SU(2) \times U(1)$



2 scenarios:

no coupling to d quark
 $\tilde{K}_{uD} = 1, \tilde{K}_{uU} = \sqrt{2}, \tilde{K}_{dQ} = 0$

no coupling to u quark
 $\tilde{K}_{dU} = 1, \tilde{K}_{dD} = \sqrt{2}, \tilde{K}_{uQ} = 0$



3-jet resonance

CDF public note 10256

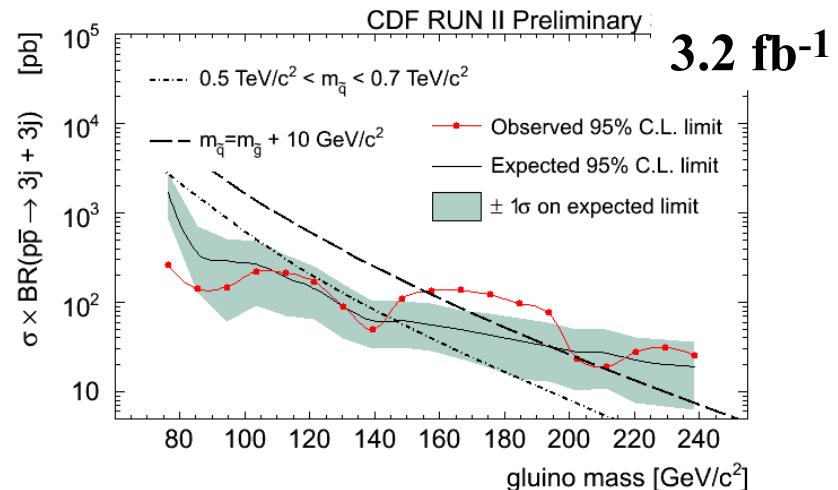
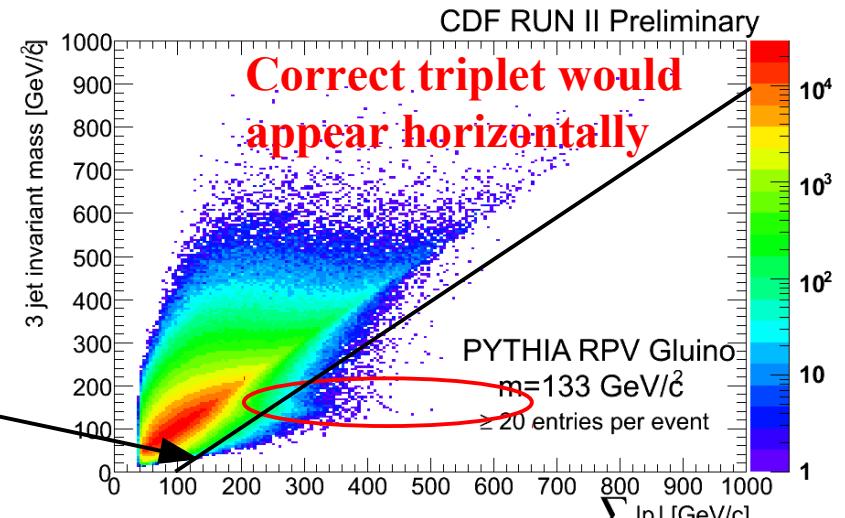
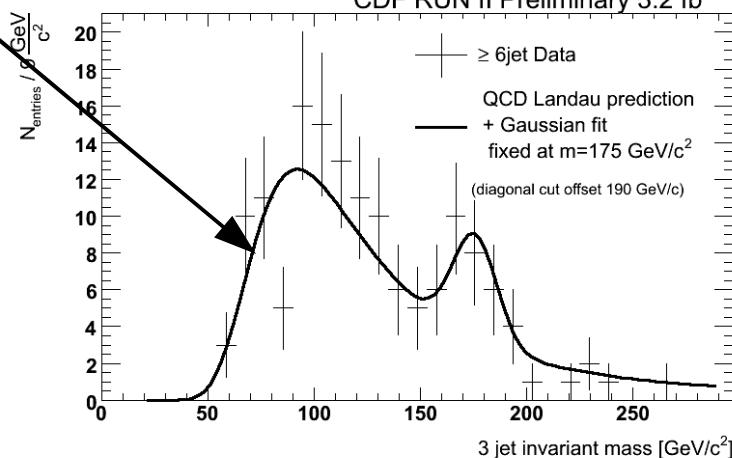
Model indep. search $q\bar{q} \rightarrow Q\bar{Q} \rightarrow 3j+3j$

≥ 6 jets($p_T > 13$ GeV), $m_{ET} < 50$ GeV,

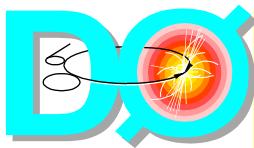
$$\sum_{\text{6 jets}} p_T \geq 250 \text{ GeV}$$

- Diagonal cut adjusted for each mass to isolate object decaying into 3 jets

Landau shape from 5-jet events



Largest excess seen around the top mass



New fermions “Quirks”

PRL 105, 211803 (2010)

A new unbroken $SU(N)$ gauge group
(scale $\Lambda \ll M_Q = 0.1 - 1 \text{ TeV}$)

If new fermions Q are charged they can
be pair produced.

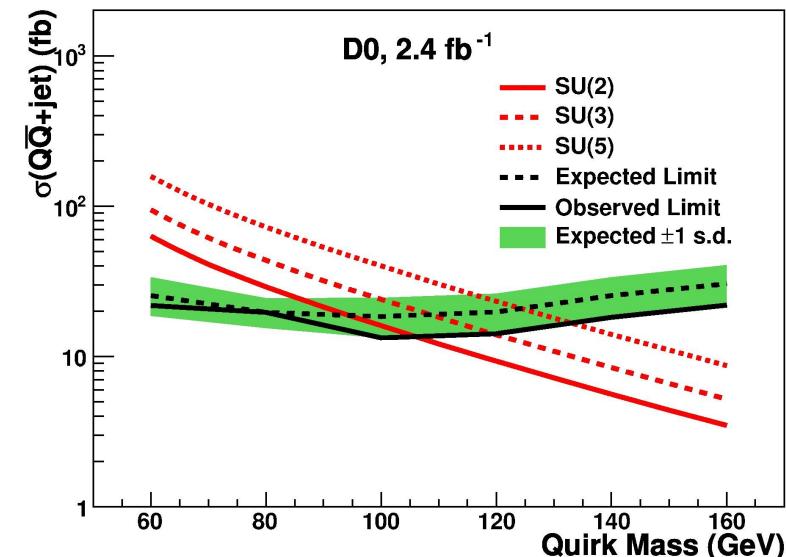
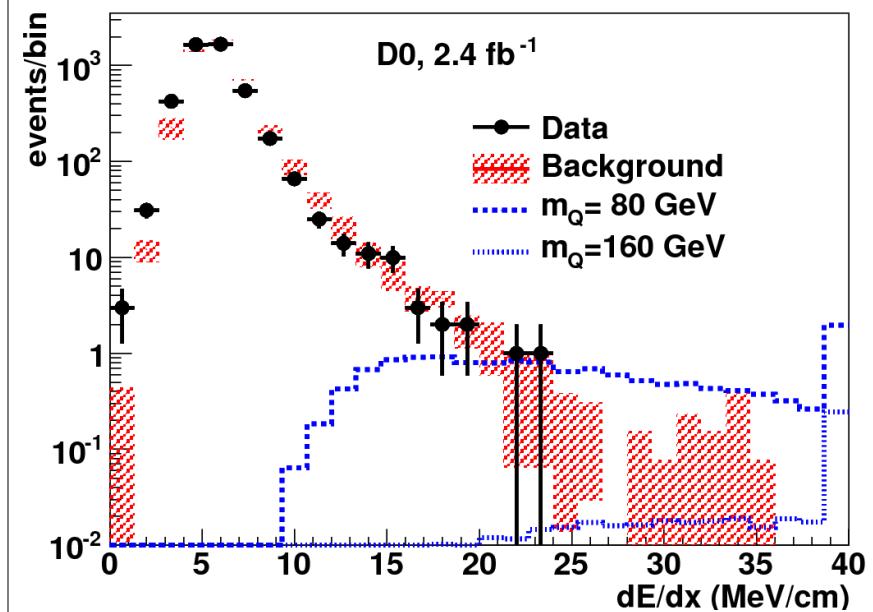
But no hadronization will occur;

QQ pair will stay connected as with a
rubber band ($L \sim M_Q / \Lambda^2 \approx 1 - 100 \mu\text{m}$)

And be reconstructed as a highly
ionizing straight track

dE/dx distribution as expected

95%CL $M_Q > 107 \text{ GeV}$ for $SU(2)$



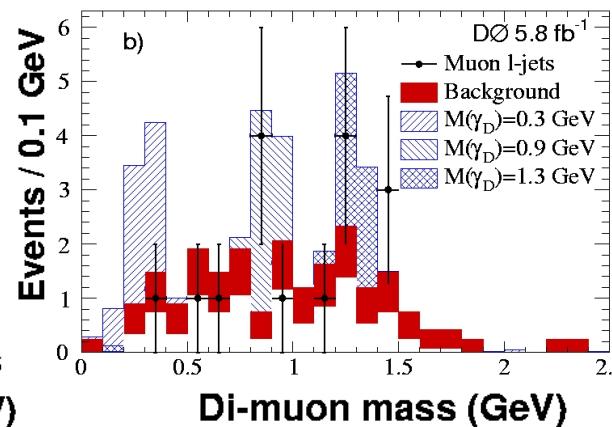
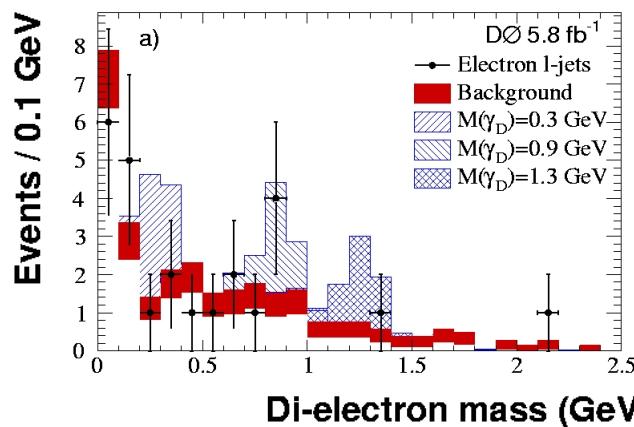
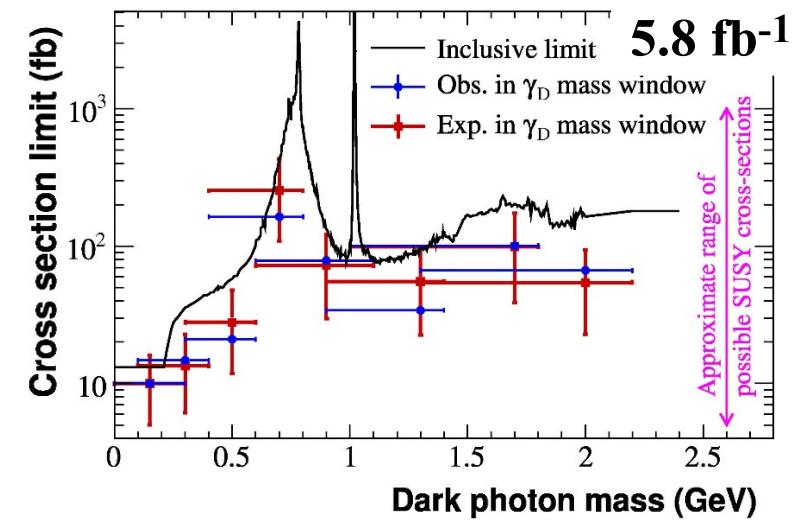
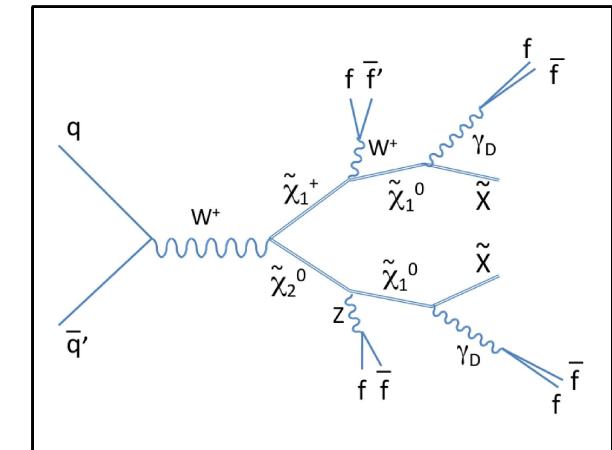
Exotic SUSY model : \exists hidden sector weakly coupled to SM particles

Dark photon γ_D is light \rightarrow collimated lepton pair

Darkino $\tilde{\chi}$ escapes detection \rightarrow mET

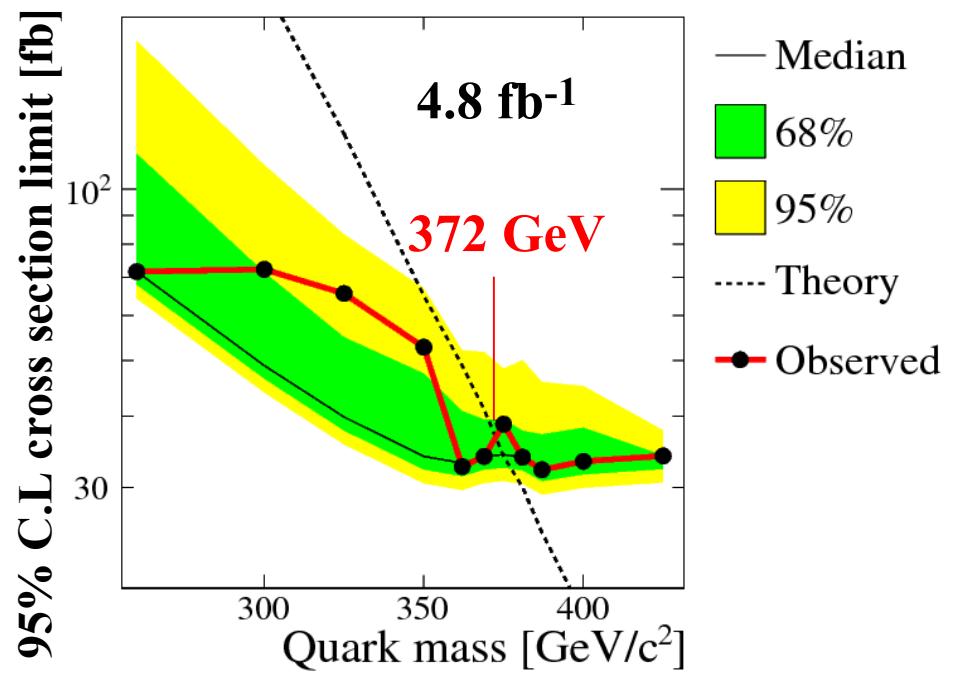
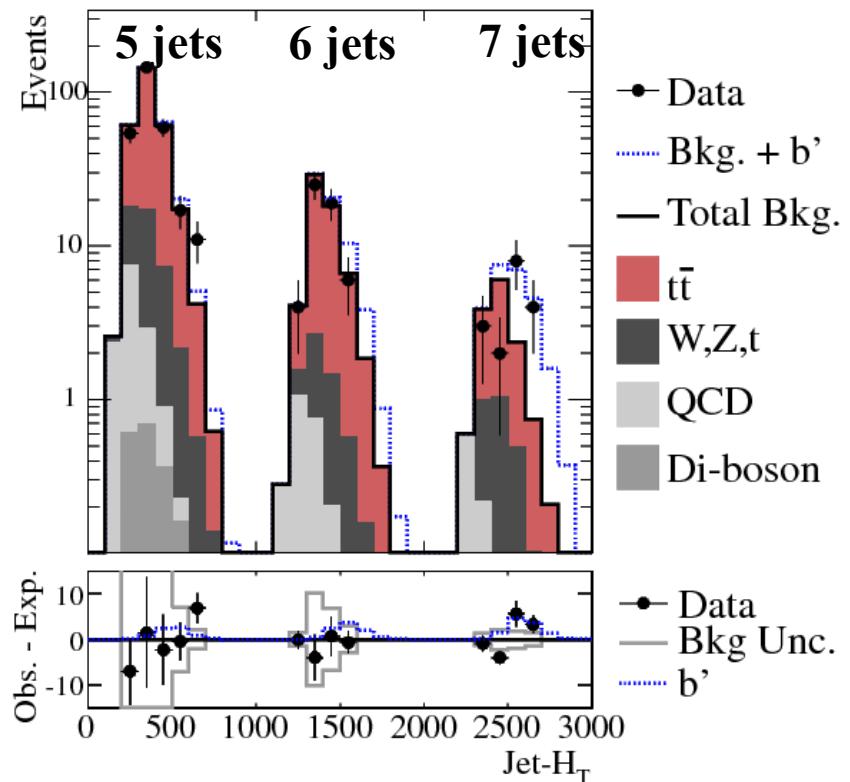
Ask for a track of opposite charge close to lepton candidate

Change the isolation criteria in lepton definition



Search for a 4th generation down type quark

- Current limits push $M_{b'} > M_{top} + M_W$
- $q\bar{q} \rightarrow b'b' \rightarrow t\bar{t}WW \rightarrow b\bar{b}WWWW \rightarrow l + mET + \geq 5 \text{ jets } (\geq 1 \text{ b-jet})$
- 2D-analysis performed : N_{jets} and $H_T = \sum_{\text{jets, lepton, mET}} E_T$



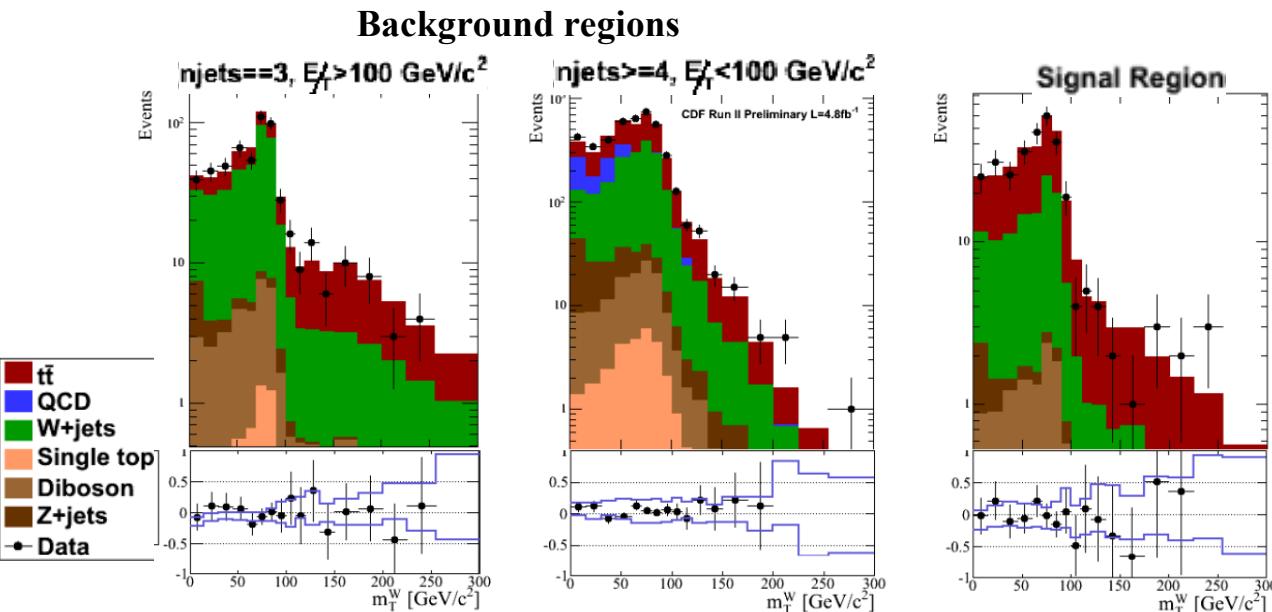
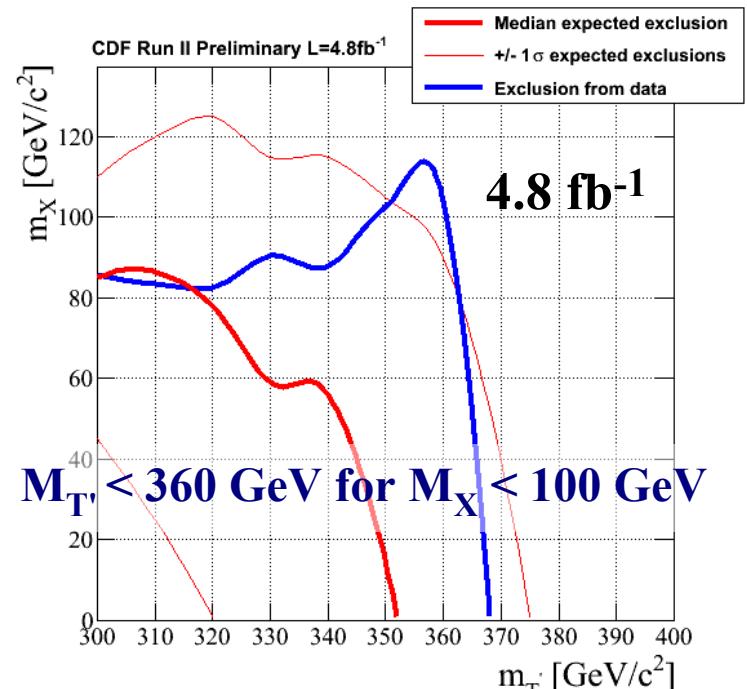
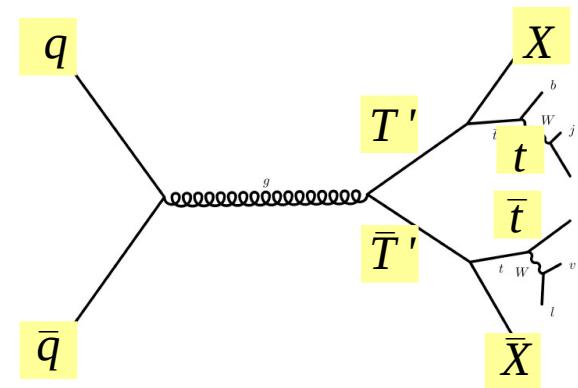
Exotic $T' \rightarrow t X$ ($300 < M_{T'} < 600$ GeV); $T' \not\rightarrow Wb$

Signal : $1 + \geq 4$ jets + mET $> [100-160]$ GeV

Background : ttbar and W + jets under control

95% C.L. cross section limits for $(M_{T'}, M_X)$ points

Limits for $M < 300$ GeV valid for $\tilde{s} \rightarrow t \chi_1^0$



Summary and Outlook

- ✓ No excess of events over SM expectations in $\rightarrow 6 \text{ fb}^{-1}$
- ✓ **Hints in B sector (dimuon charge asymmetry) and Top sector (FB Asymmetry)**
- ✓ Performances of the Tevatron has brought limits on BSM physics beyond one could have expected.
Search for BSM physics is now in the ballpark of LHC
- ✓ Given the large datasets, searches at the Tevatron will concentrate on more complex final states;
Exercise more advanced techniques of use also at LHC

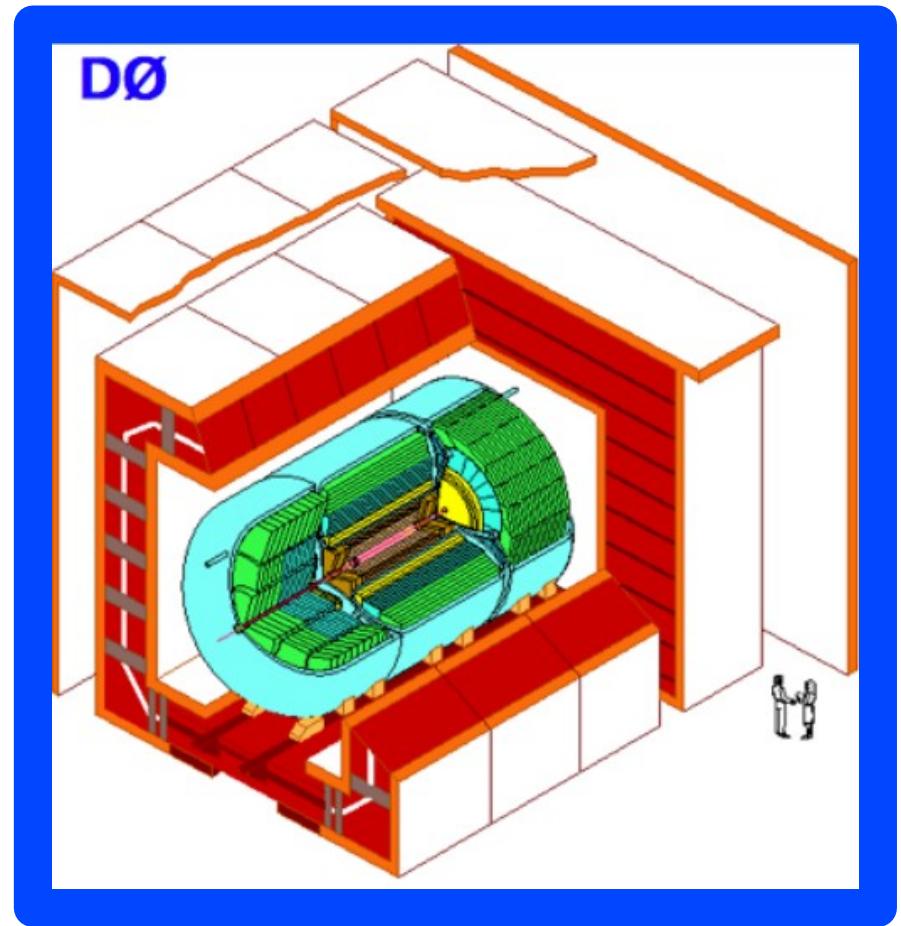
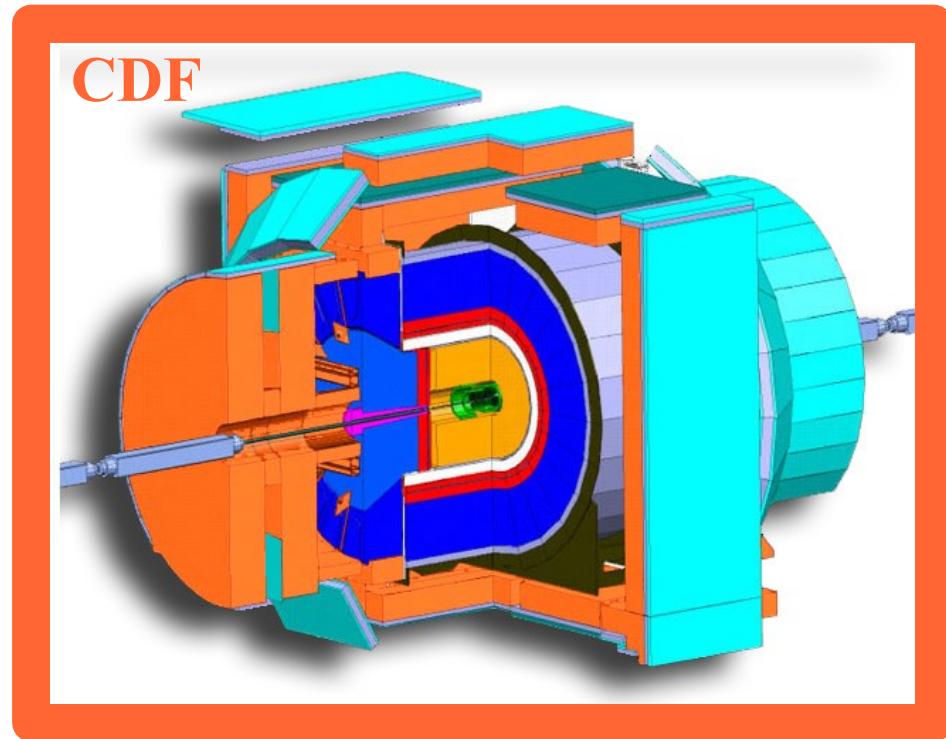
All CDF and D0 results are available on :

<http://www-cdf.fnal.gov/physics/exotic/exotic.html>

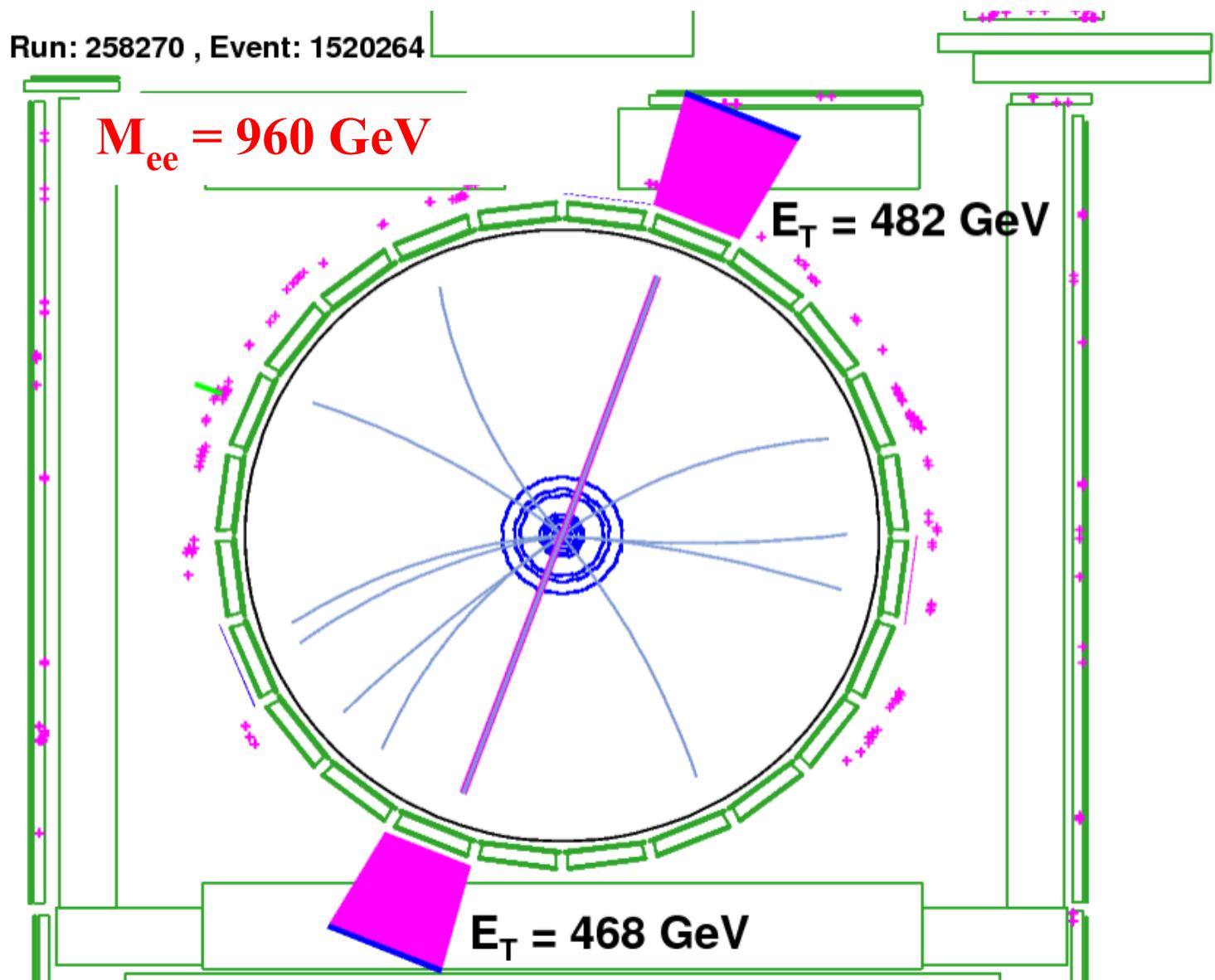
<http://www-d0.fnal.gov/Run2Physics/WWW/results/np.htm>

Backup

CDF & D0 detectors



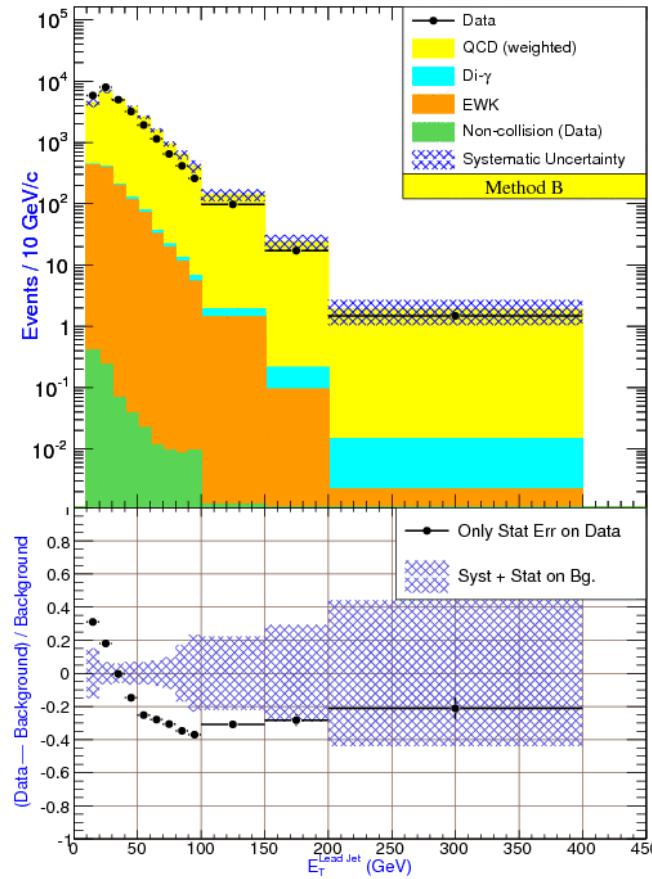
Dielectron highest mass event





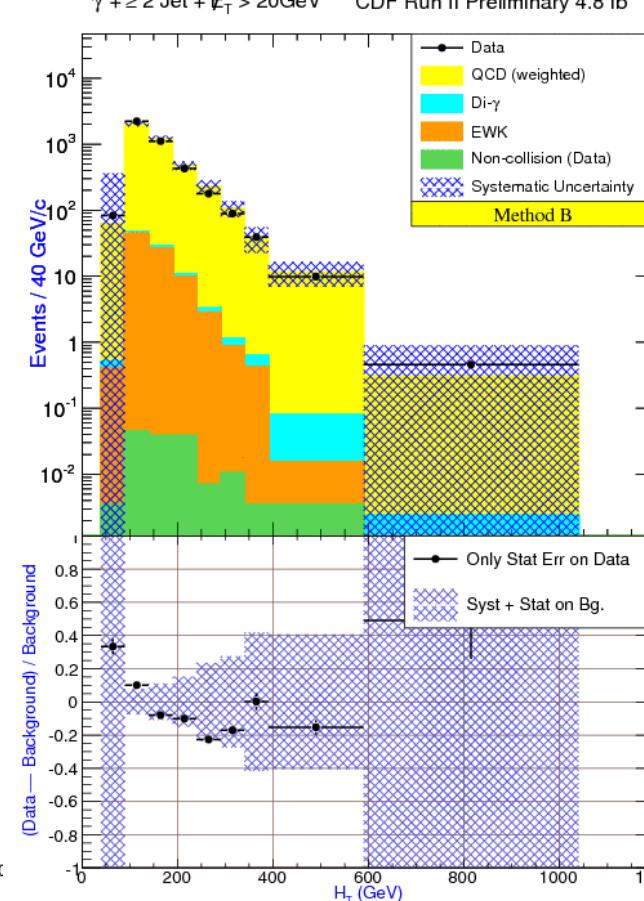
$\gamma + \text{mET} + \text{jets}$

$\gamma + \geq 2 \text{ Jet} + \cancel{E}_T > 20\text{GeV}$ CDF Run II Preliminary 4.8 fb^{-1}



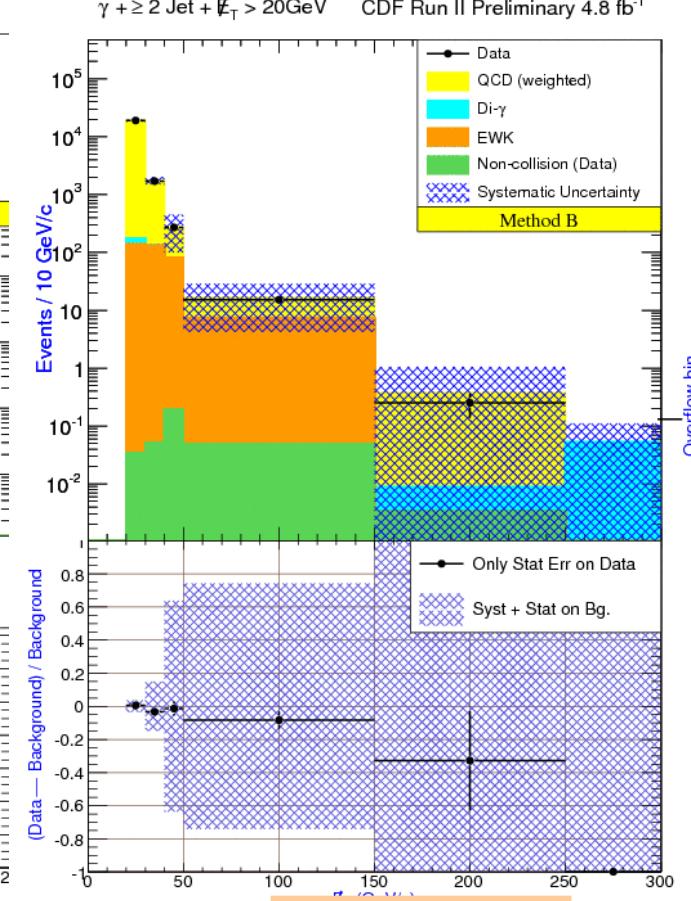
Leading jet E_T

$\gamma + \geq 2 \text{ Jet} + \cancel{E}_T > 20\text{GeV}$ CDF Run II Preliminary 4.8 fb^{-1}



H_T

$\gamma + \geq 2 \text{ Jet} + \cancel{E}_T > 20\text{GeV}$ CDF Run II Preliminary 4.8 fb^{-1}



Missing E_T