Searches for Same Sign Dilepton Events and WZ Resonances at the Tevatron

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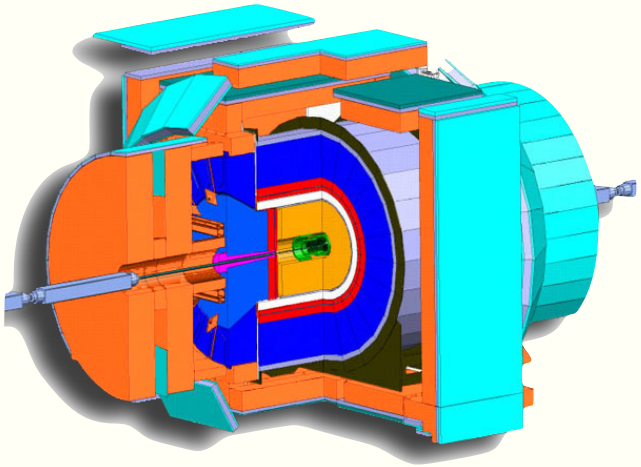
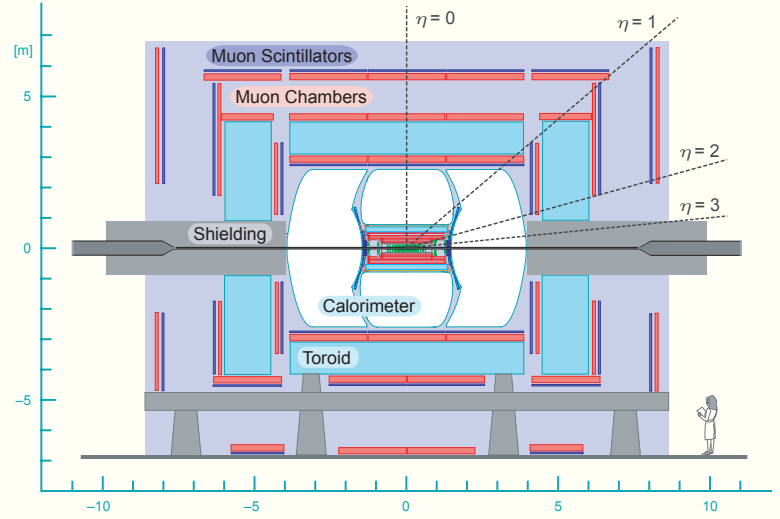
Representing the CDF and DØ Collaborations





35th International Conference on High Energy Physics
Paris, July 2010

There are MANY models that describe possible New Physics

Six models covered here...

Low scale technicolor
Extra dimensions
Extended gauge models
Heavy 4th generation quarks
Maximal flavor violation
mSUGRA

+ model independent

The signatures are the tools to investigate these models of New Physics

Signatures:
Dileptons (same sign covered here),
Trileptons,
Jets,
Missing Energy,
Photons
and combinations of the above

Mechanism
Direct decays,
via resonances (covered here)

Five analyses are presented here

Same sign dilepton analyses and
WZ resonance analyses
from CDF and DØ

Starting with the $\ell^{\pm}\ell^{\pm}$ analyses...

Same sign dileptons are a great signature for New Physics

… because $\ell^{\pm}\ell^{\pm}$ events are uncommon in SM processes thus backgrounds are low

4 types of background sources of $\ell^{\pm}\ell^{\pm}$ include...

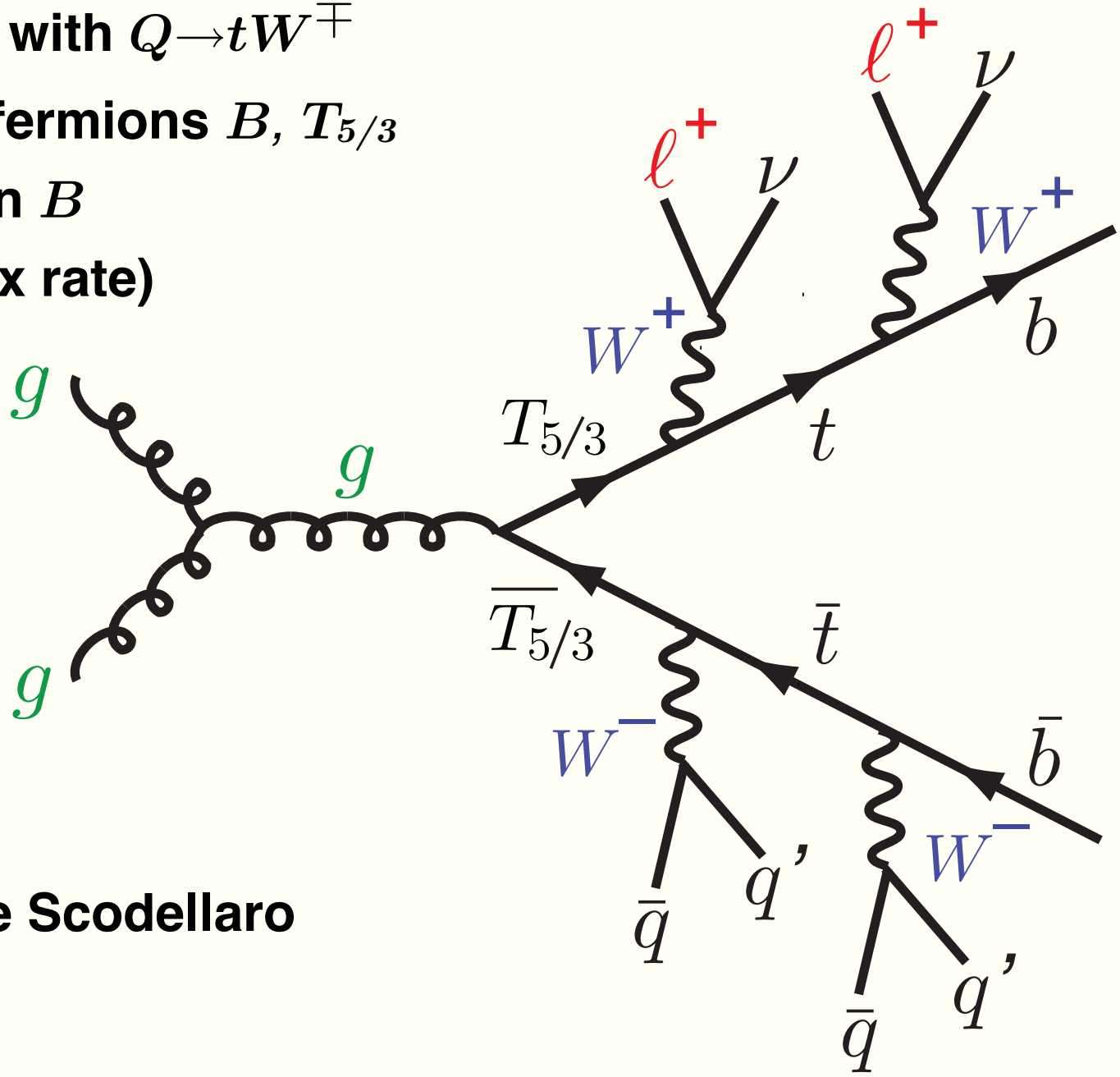
- **On & off shell dibosons: WZ, ZZ**
- **Drell-Yan with radiated γ that converts asymmetrically, $Z\gamma$, $W\gamma$ (γ converts)**
- **$W+j$, $Z+j$ where jet is misidentified as lepton, Semileptonic $t\bar{t}$ where jet is misidentified as lepton**
- **Opposite sign dilepton events but one charge is misidentified**
- **$B\overline{B}$ oscillations (but leptons are not isolated)**

1) CDF searched for 4th generation fermions with $\ell^{\pm}\ell^{\pm}$

Examine models with $Q \to tW^{\mp}$

Q = Composite fermions B, $T_{5/3}$

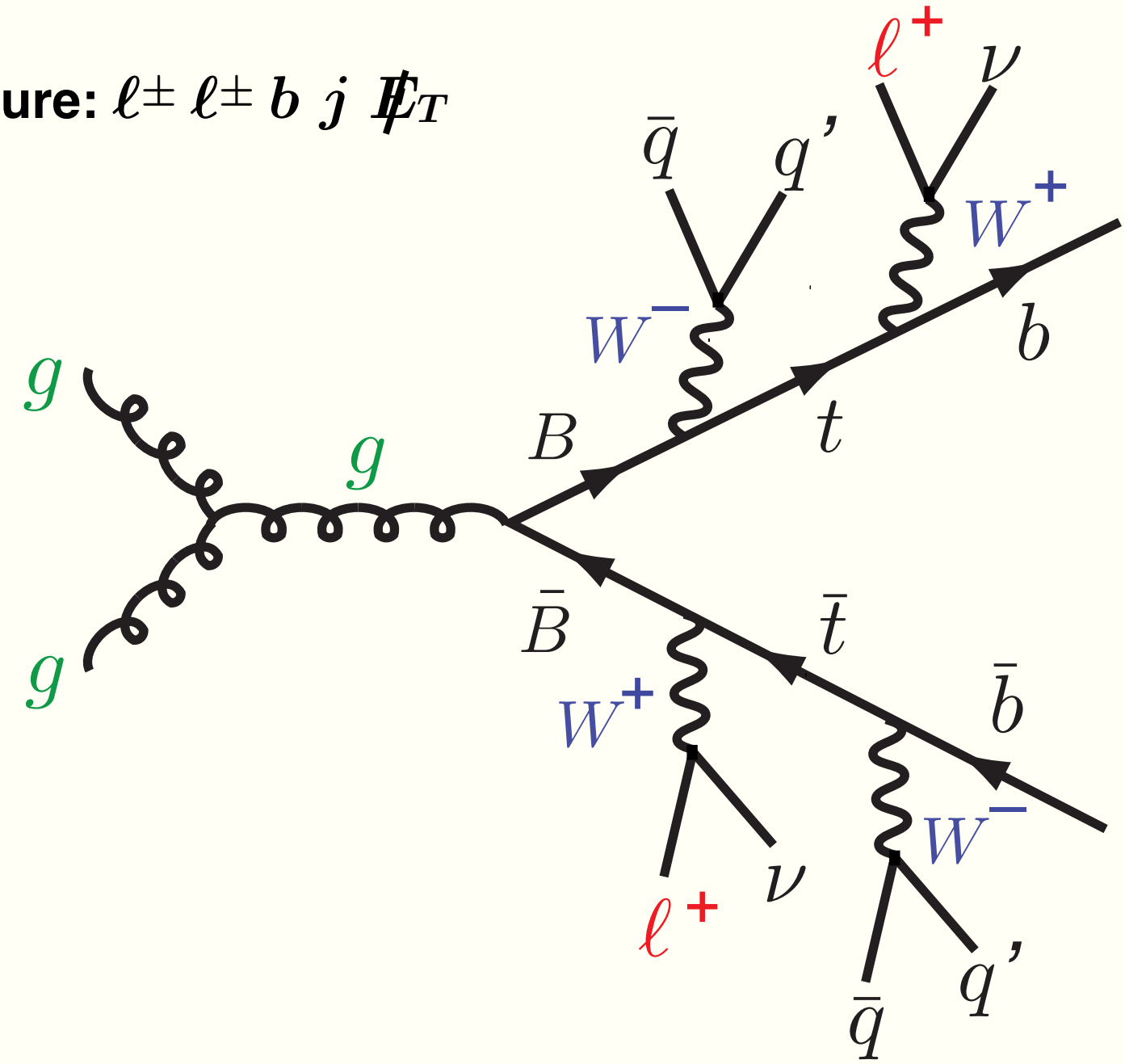
If $T_{5/3}$ exists, then B must exist too (2x rate)



For b' result, see Scodellaro talk tomorrow

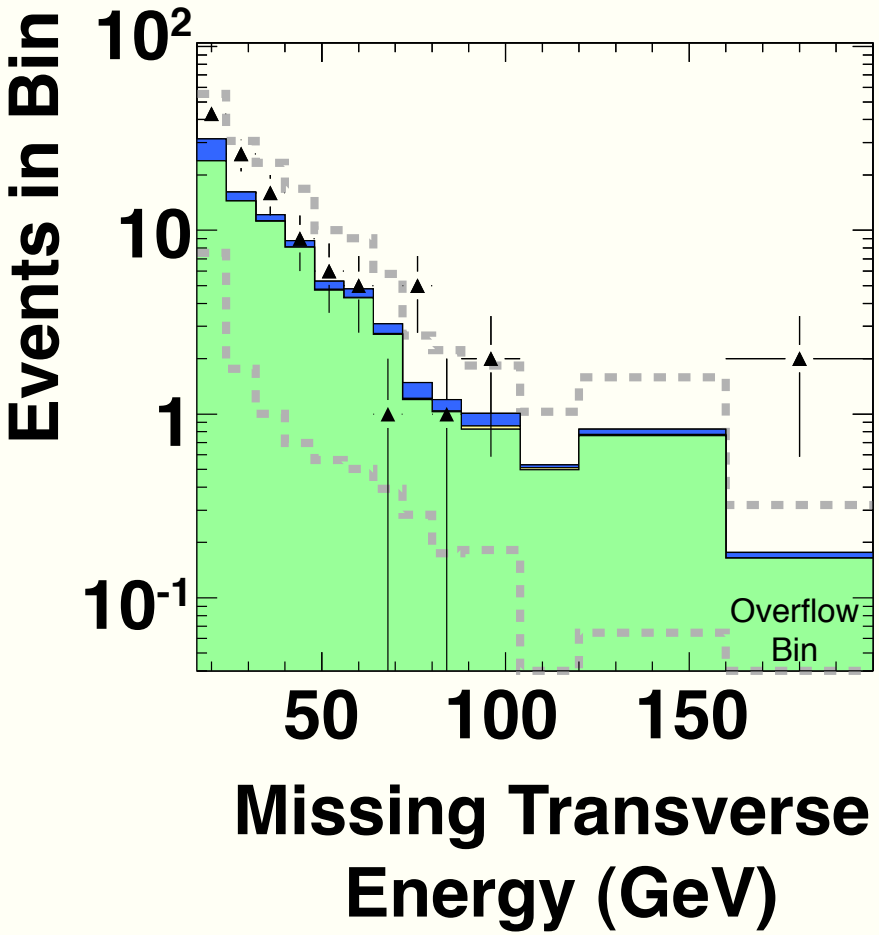
... bottom-like composite fermion

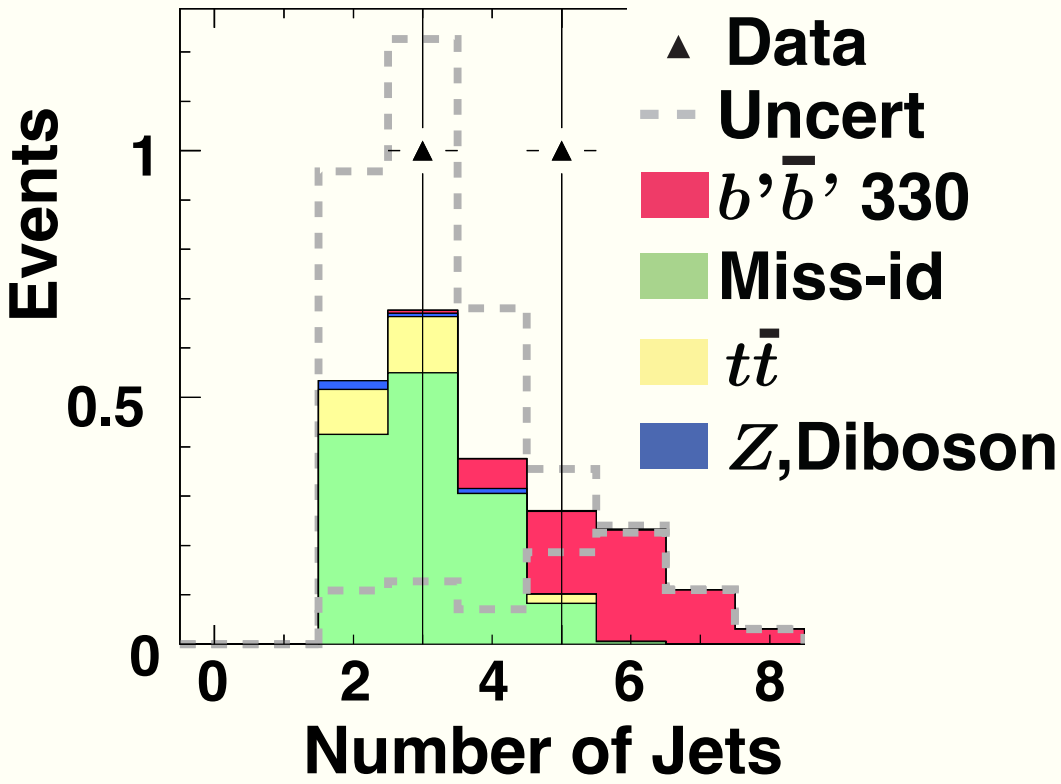
Require signature: $\ell^{\pm}\,\ell^{\pm}\,b\,j\,\not{E}_T$



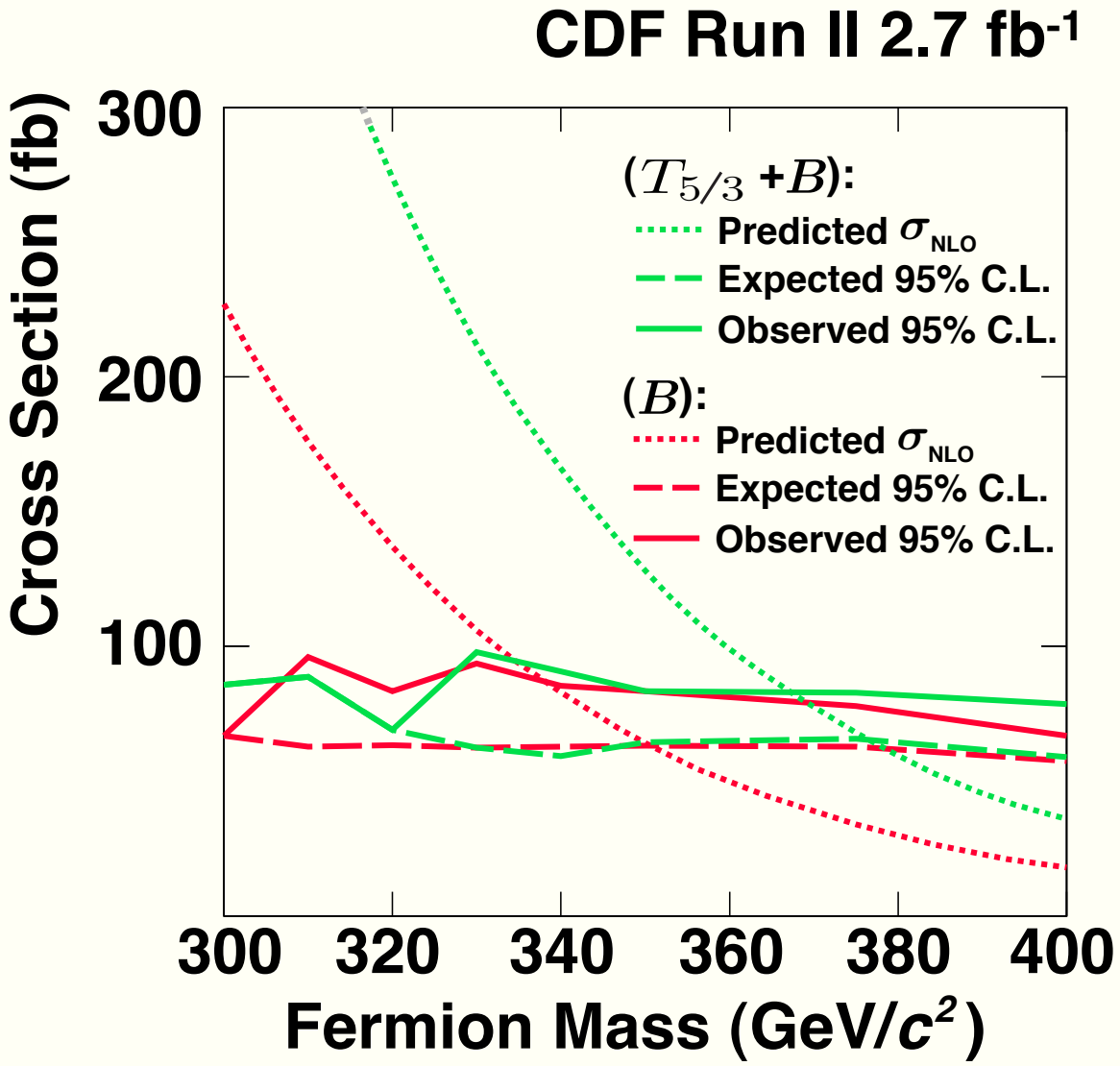
No heavy 4th generation fermion signal was observed

In 2.7 fb^{-1} at CDF, expect 1.6 ± 1.4 events background
2 events were observed





Limits were set on heavy fermion masses by CDF



PRL 104, 091801 (2010)

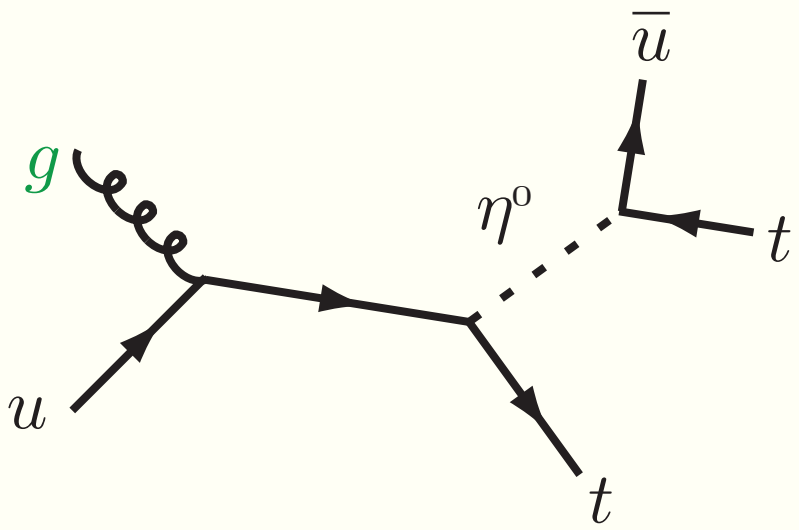
$m_B > 338\ \mathrm{GeV}/c^2 \quad m_{T5/3} > 365\ \mathrm{GeV}/c^2\ @95\%\ \mathrm{C.L.}$

2) CDF searched for maximal flavor violating scalars using $\ell^{\pm}\ell^{\pm}$

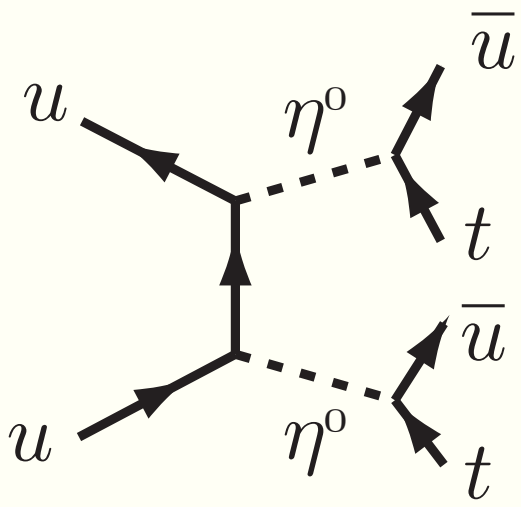
The SM favors minimal flavor violation (MFV) in the quark sector. Does New Physics follow this rule too?

Maybe not! Investigate MAXIMAL Flavor Violation (MxFV)…

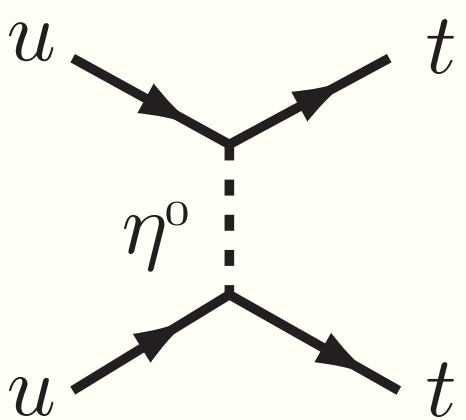
New scalar field $\Phi_{FV} = (\eta^0,\ \eta^+)$ that couples to quarks with coupling ξ_{ij}. MxFV$_1$ has coupling matrix terms $\xi_{31},\ \xi_{13} \sim 1$



$ug \to t\eta^0 \to tt\bar{u}$



$u\bar{u} \to \eta^0\eta^0 \to tt\bar{u}\bar{u}$

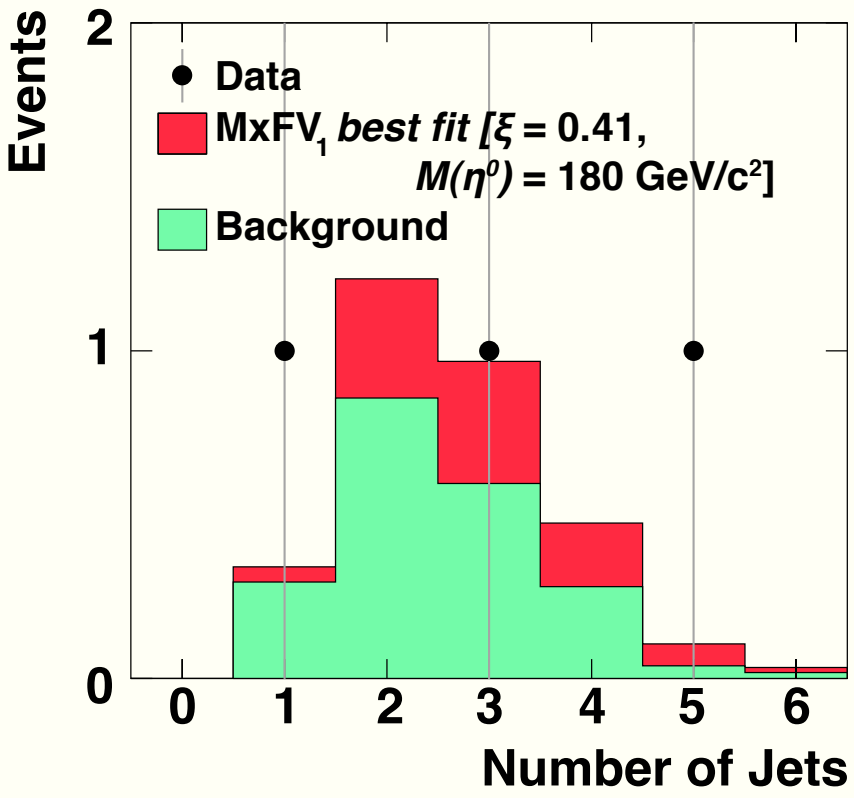


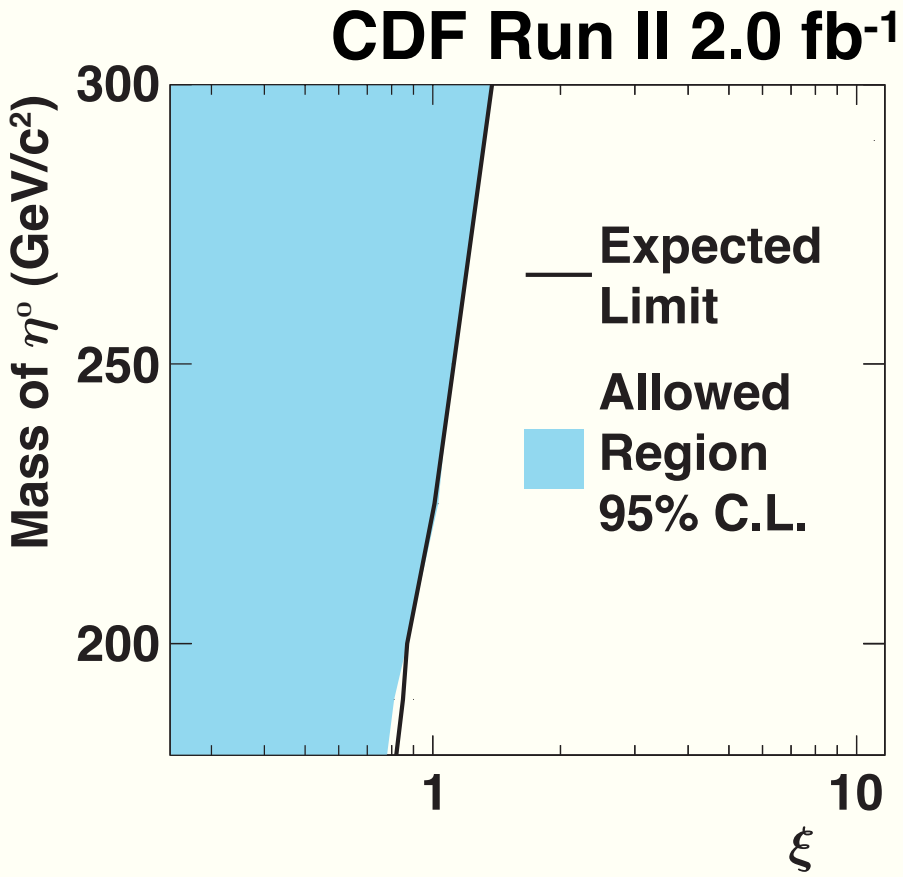
$uu \to tt$

Use two same sign tops to search for MxFV

Require signature (two same-sign tops!): $\ell^{\pm}\,\ell^{\pm}\,b\,\not\!\!E_T$

In 2.0 fb^{-1} at CDF, expect 2.1 ± 1.8 events background
3 events were observed





PRL 102, 041801 (2009)

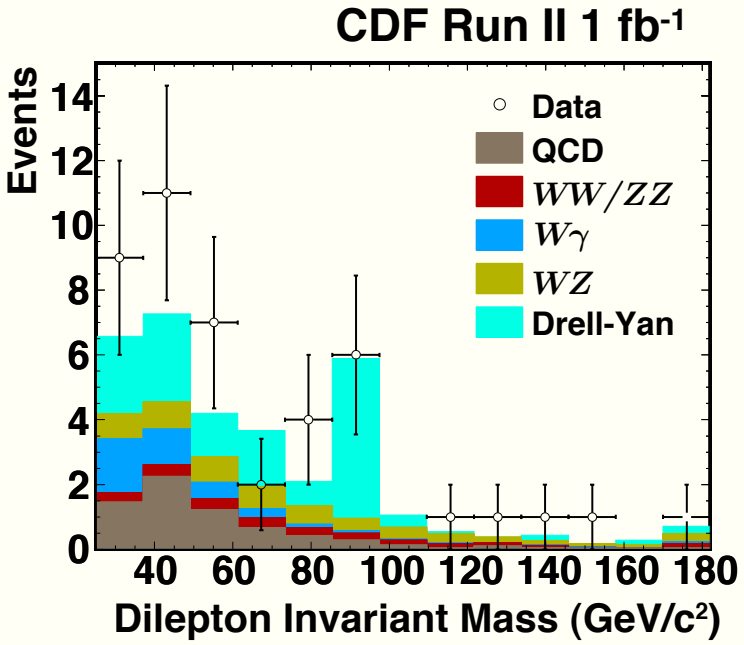
3) CDF searched for generic New Physics using $\ell^{\pm}\ell^{\pm}$

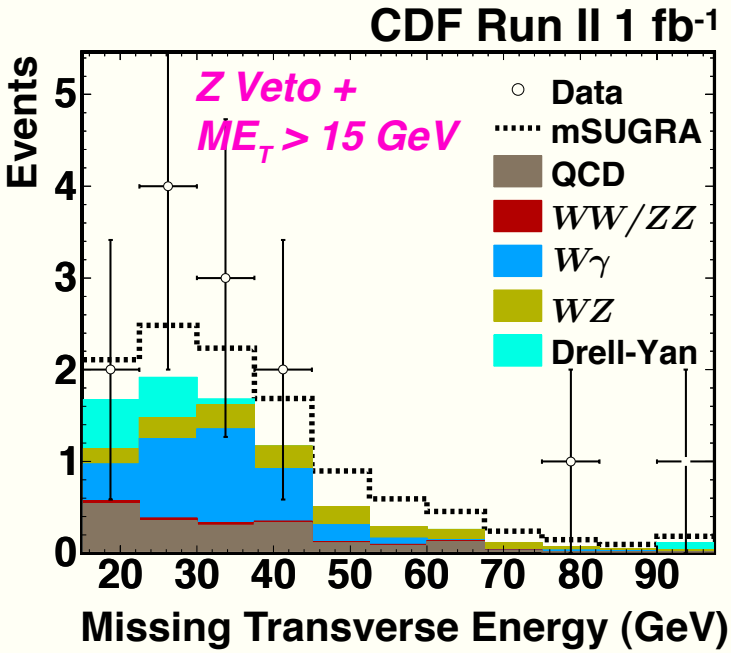
PRL 98, 221803 (2007)

With a model, optimize the analysis for maximal discovery reach

… BUT, what if no one has a model for the New Physics that might actually be present? Experiments could miss it!

Use same sign dilepton events $E_{T1} > 20\ \mathrm{GeV};\ E_{T2} > 10\ \mathrm{GeV}$





expect 34 ± 4 events, 44 observed

expect 8 ± 1 events, 13 observed

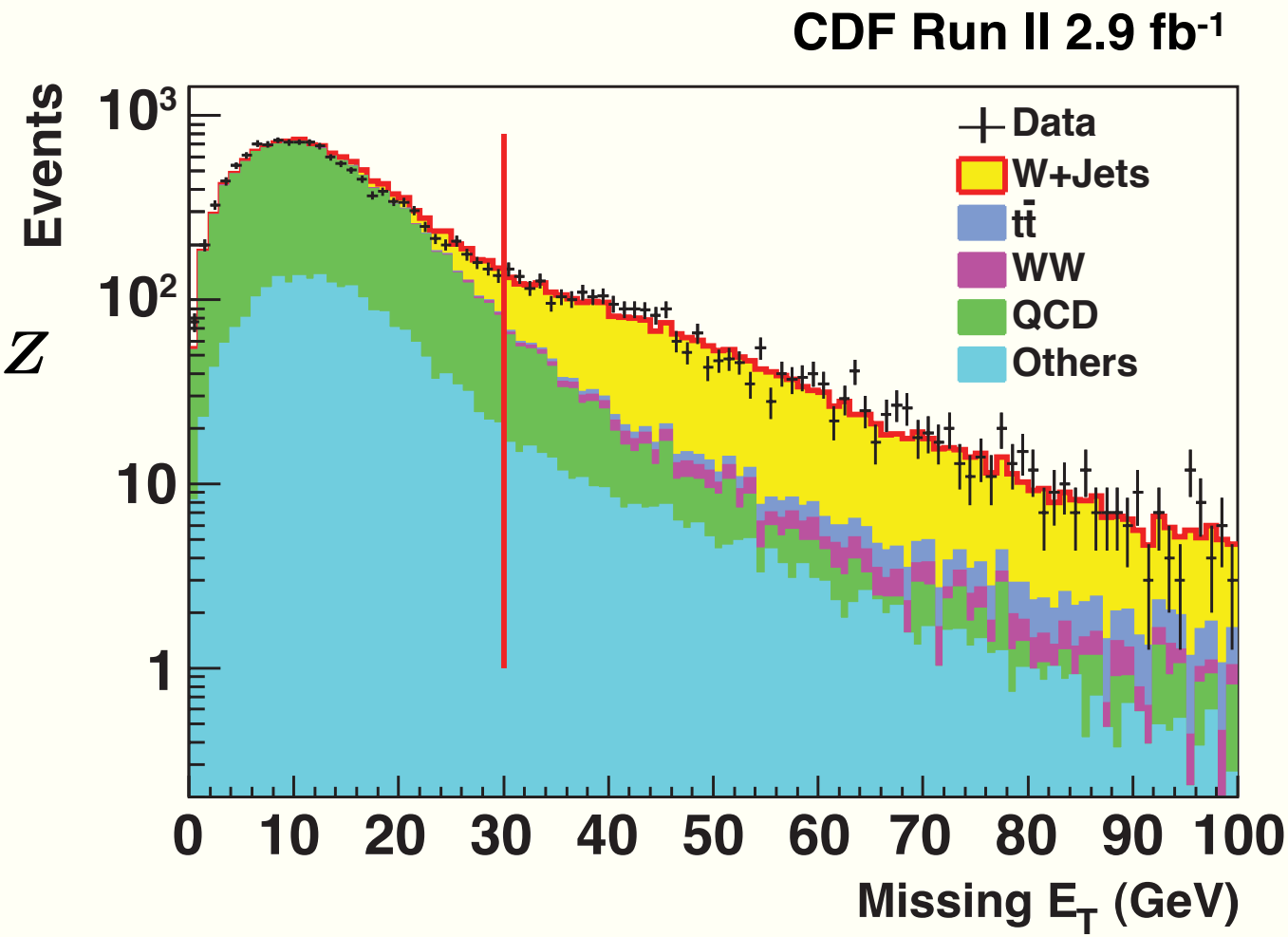
Investigate more BSM models using
WW/WZ Resonances...

4) CDF searched for W', Z', and G^* decaying to dibosons (WW and WZ resonances)

For extended gauge, set limits on mass and gauge coupling strength. $g\cos\theta_w \rightarrow \xi\, g\cos\theta_w \quad \xi = C(M_W/M_V)^2$

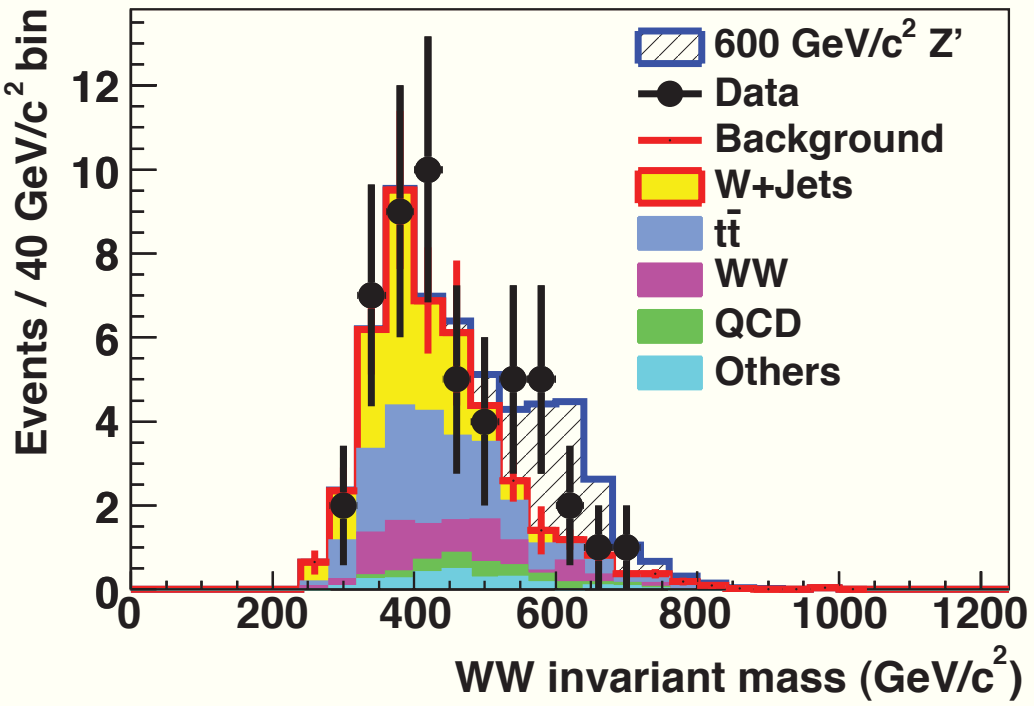
Require signature: $e\nu jj$

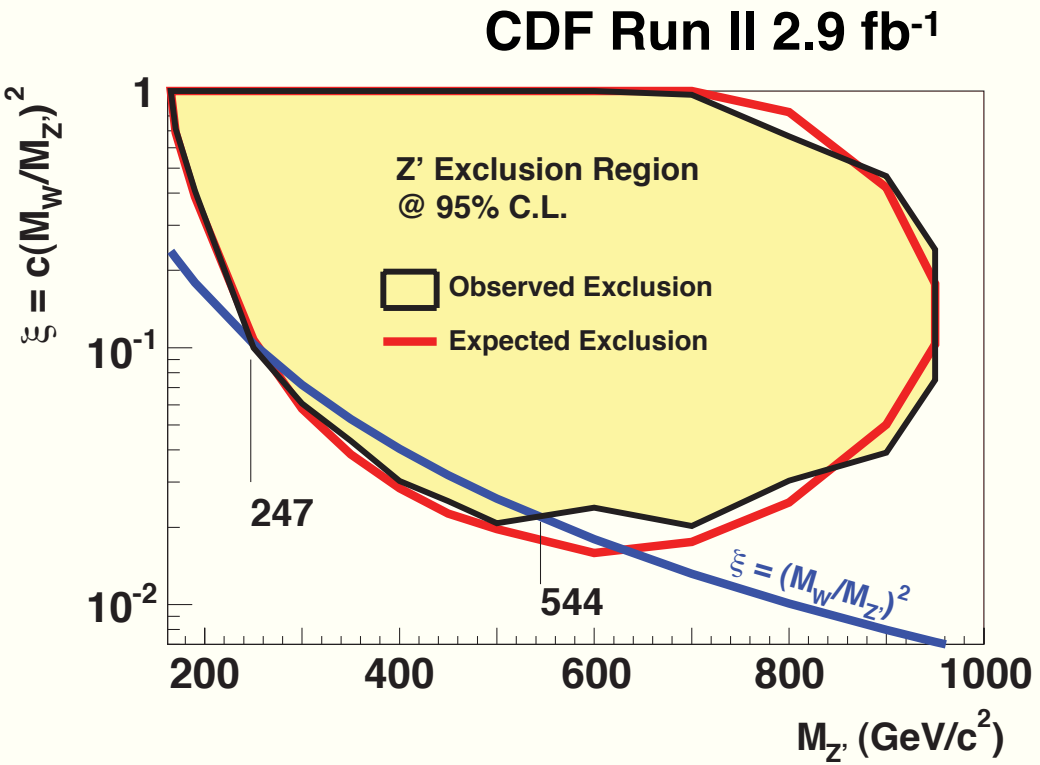
Reconstruct W and Z to form WW or WZ



Limits were set on extended gauge models...

In 2.9 fb^{-1}, for $Z' \rightarrow WW$ expect 43 ± 6 events bkg; 51 observed
at CDF for $W' \rightarrow WZ$ expect 41 ± 7 events bkg; 38 observed

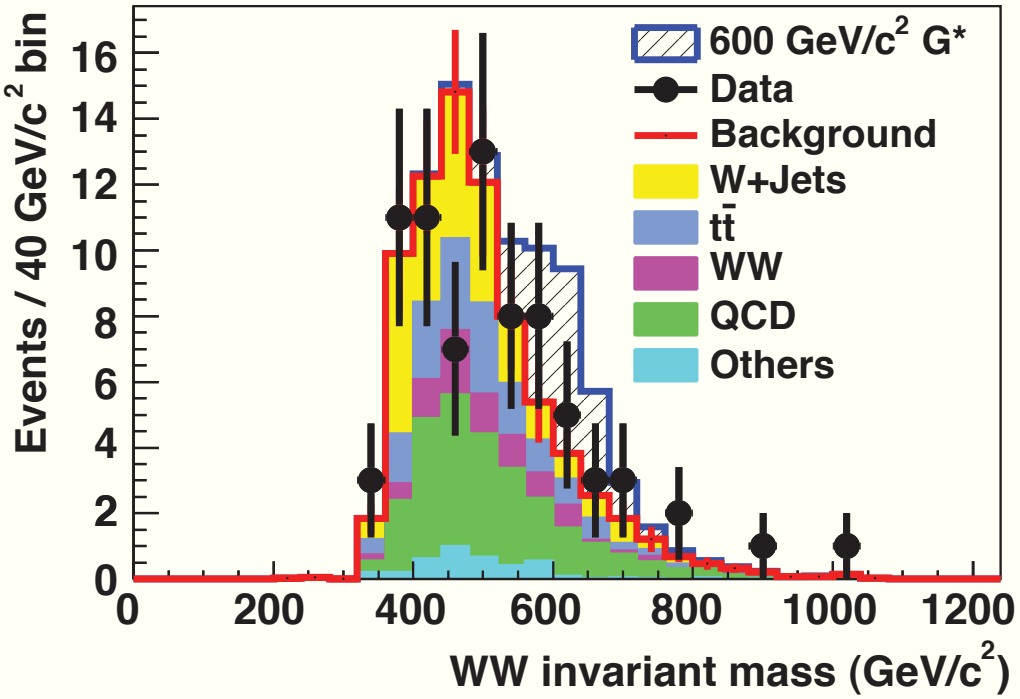


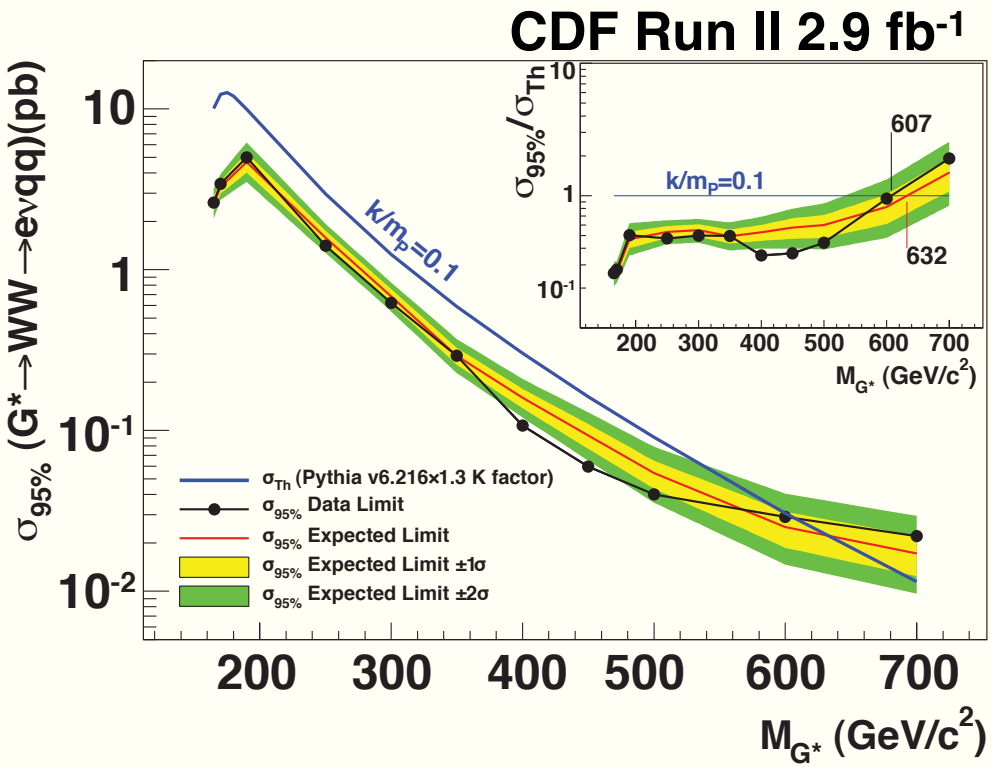


Excluded regions @ 95% C.L: Z' mass 247 – 544 GeV/c²
W' mass 285 – 516 GeV/c²

… and on the Randall-Sundrum graviton

In 2.9 fb^{-1}, expect 41 ± 7 events background; 38 observed





Excluded region @ 95% C.L: G^* mass < 607 GeV/c^2

PRL 104, 241801 (2010)

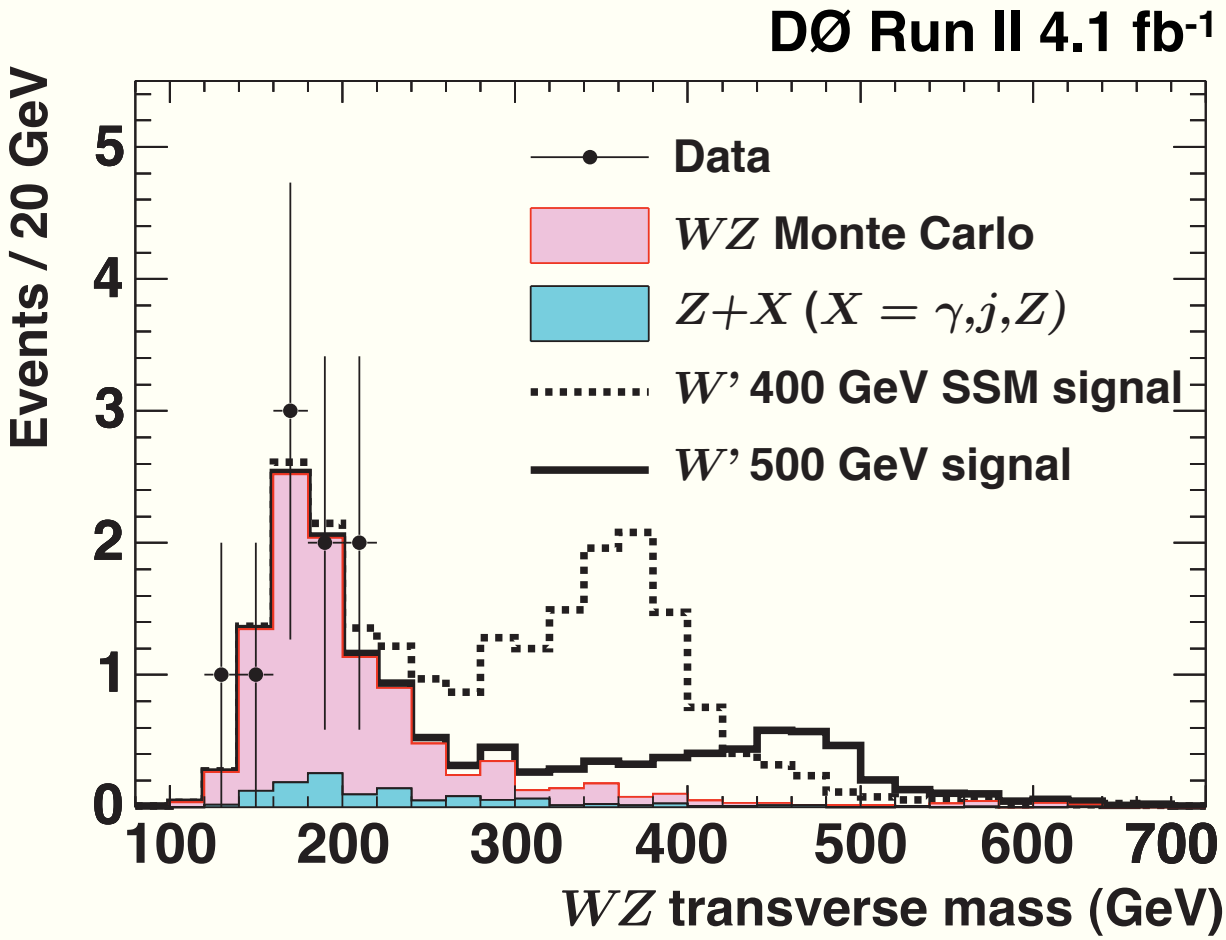
5) DØ investigated models with W' via WZ resonance

See Grenier talk tomorrow about technicolor models and this analysis

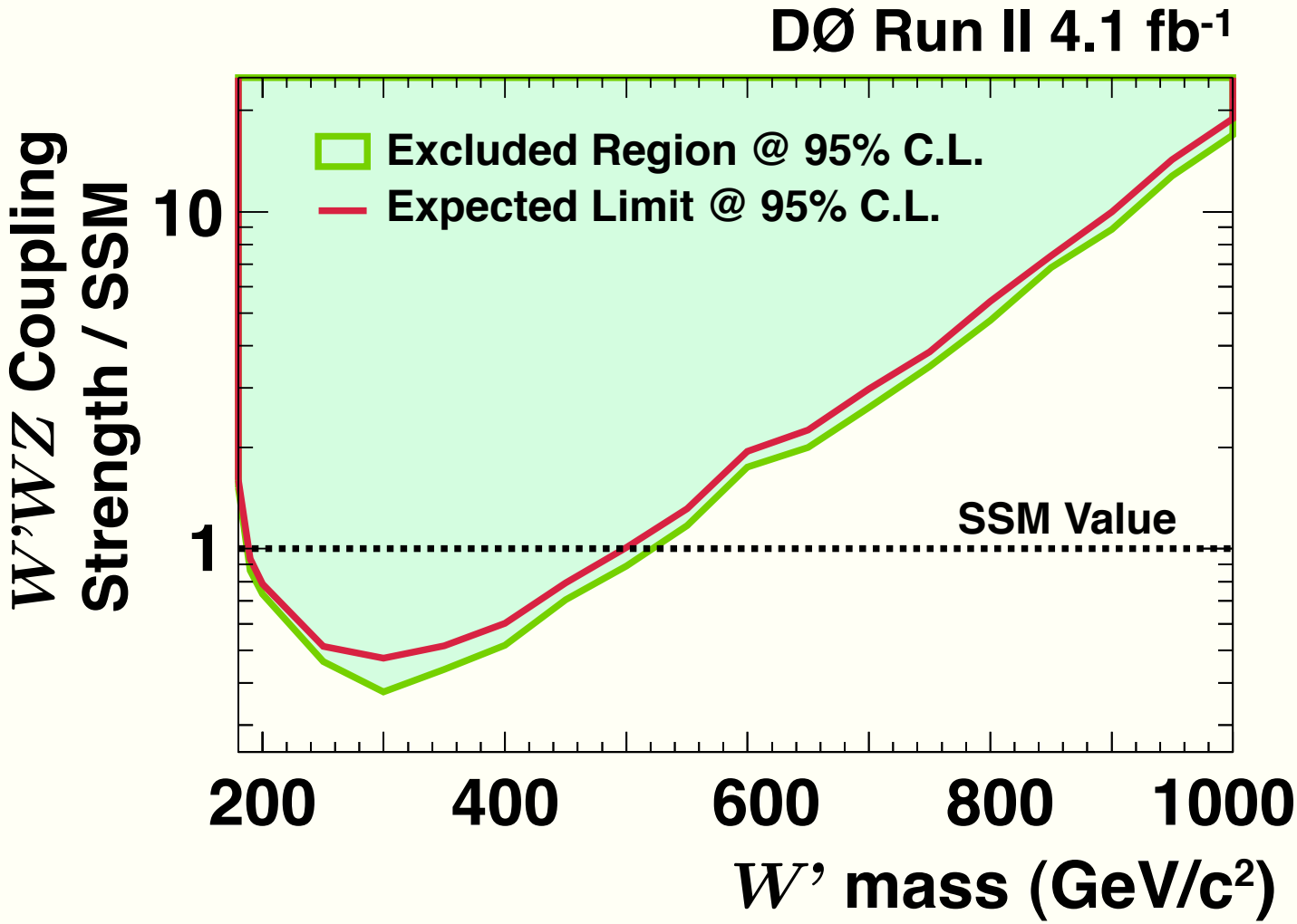
Here, compare to sequential standard model W'

Require signature: $\ell\nu\ell\ell$ (fully leptonic)

In 4.1 fb^{-1} at DØ, expect 10.2 ± 1.6 events bkg; 9 observed



… and limits were set on models with a W'



Excluded region @ 95% C.L: W' **mass 188 – 520 GeV/c²**
for SM coupling strength (SSM)

PRL 104, 061801 (2010)

We have examined lots of models!

Five analyses from CDF and DØ involving same-sign dileptons and WZ resonances were presented.

No new physics observed yet.

But lots more to do…
Both CDF and DØ have recorded ~ 8 fb^{-1}.
Tevatron and detectors are running extremely well!

… and LHC experiments will join with searches too.

What's down the road for Beyond the Standard Model Physics?

Hopefully not…

… but instead lots of exciting New Physics to untangle

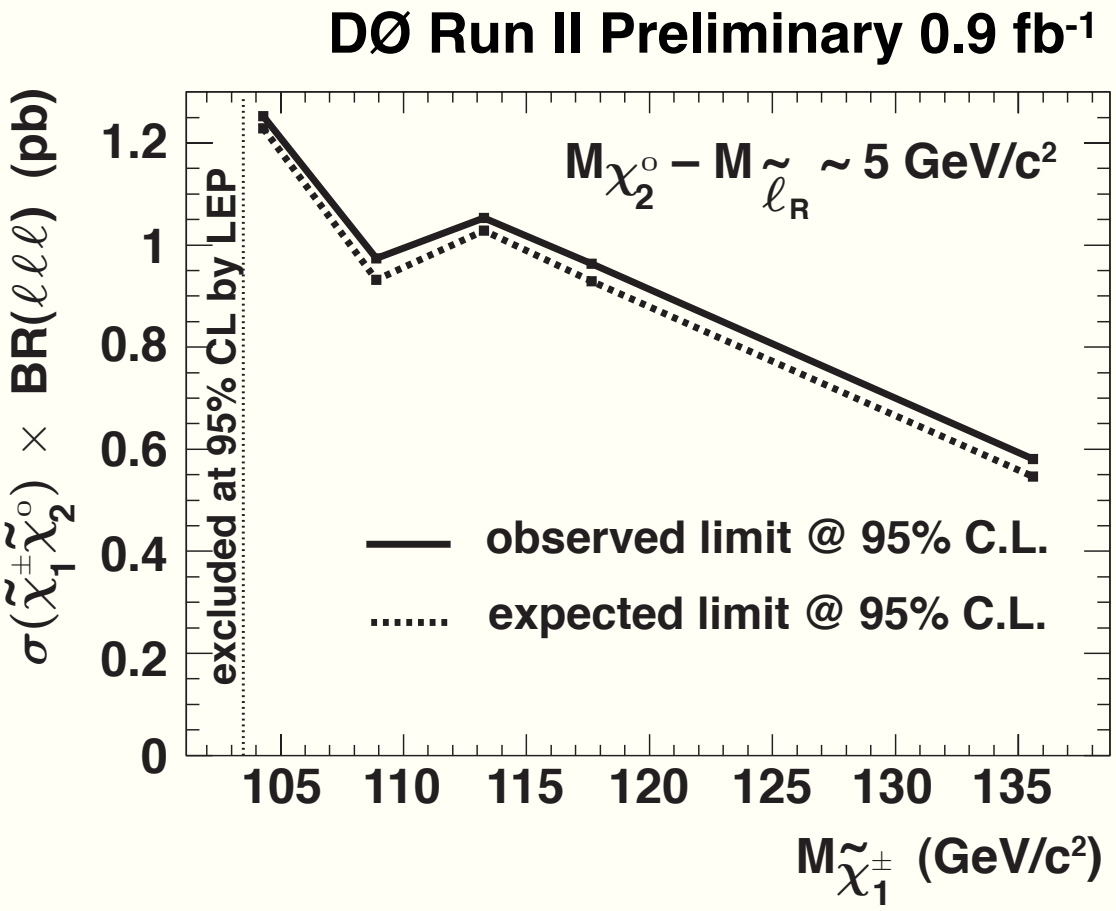
BACKUP SLIDES BEYOND THIS POINT

DØ searched for associated chargino/neutralino production with same sign $\mu\mu$

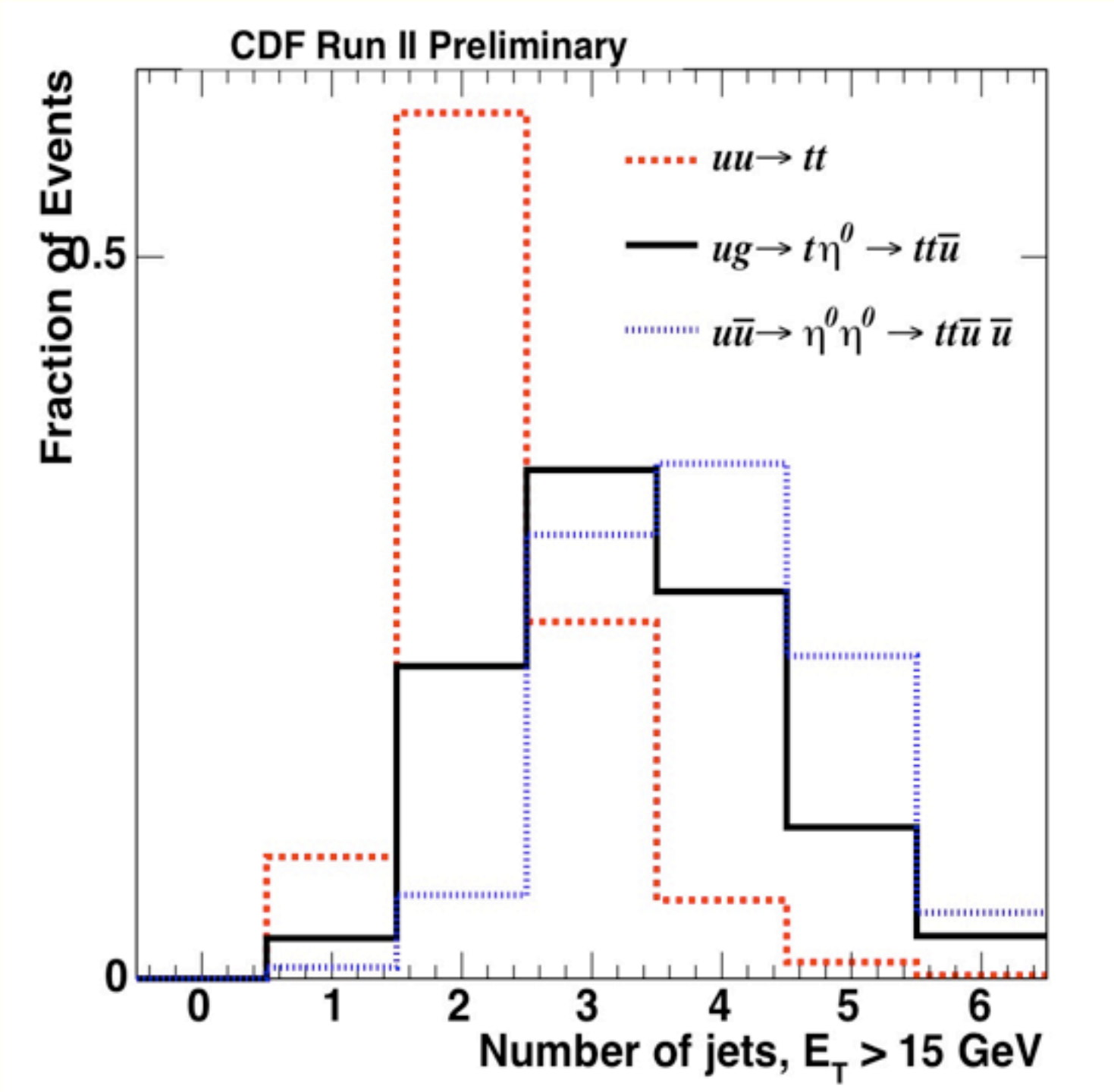
Some mSUGRA models yield trileptons with a very soft 3rd lepton.

Instead, require same sign dimuons to recover some acceptance while restricting backgrounds

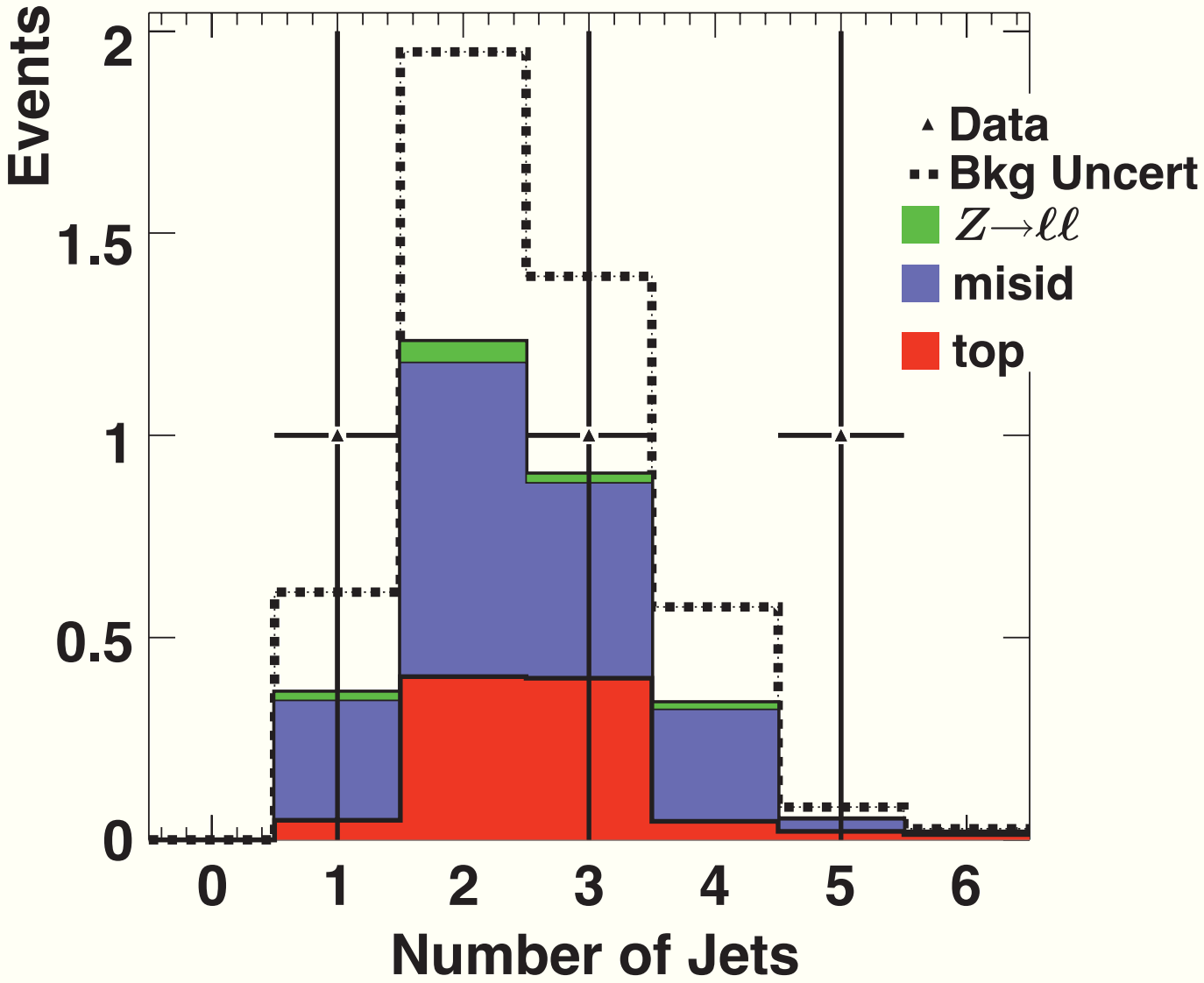
In 0.9 fb^{-1}, expect 1.1 ± 0.4 events background
1 event was observed



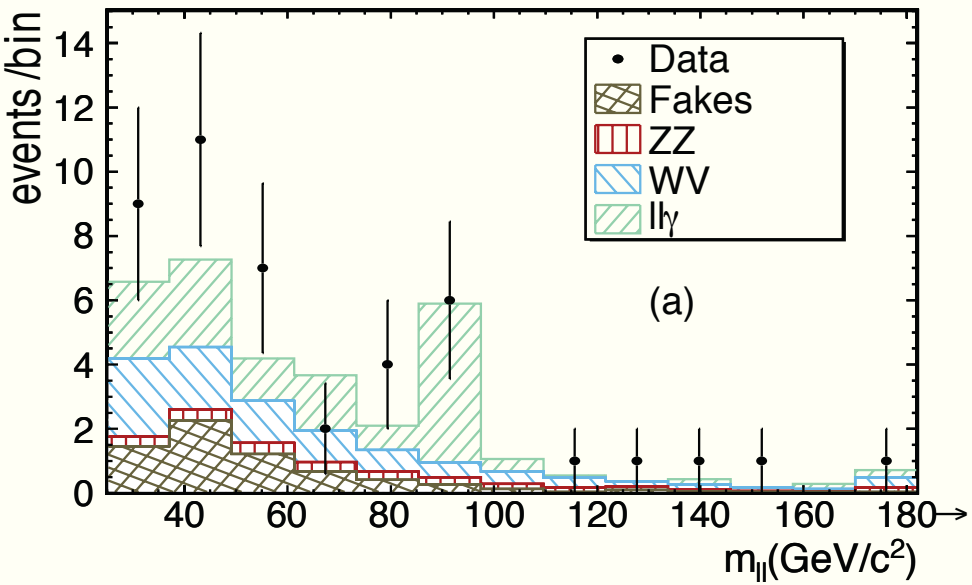
$MxFV_1$

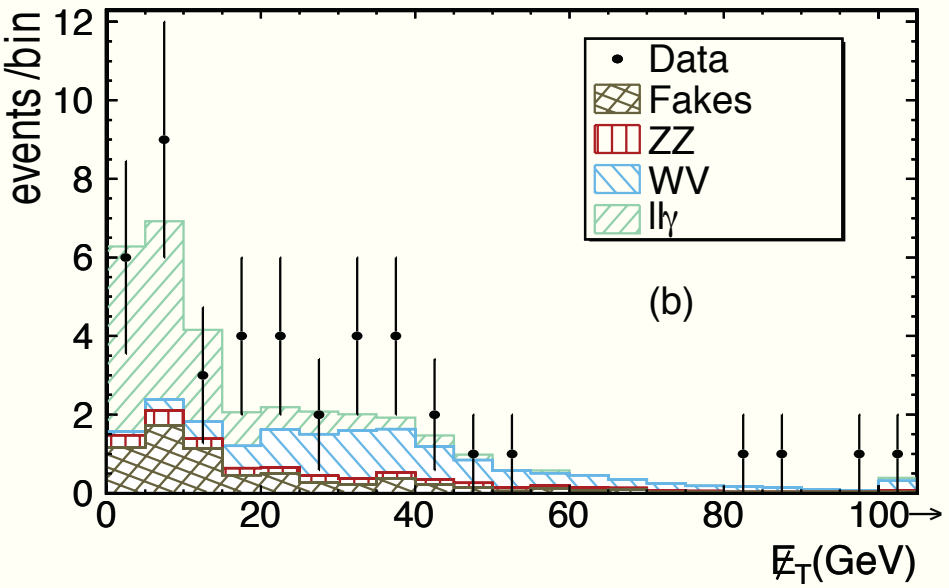

CDF Run II Preliminary
Fraction of Events
0.5
0
$uu \rightarrow tt$
$ug \rightarrow t\eta^0 \rightarrow tt\bar{u}$
$u\bar{u} \rightarrow \eta^0\eta^0 \rightarrow tt\bar{u}\,\bar{u}$
0
1
2
3
4
5
6
Number of jets, $E_T > 15$ GeV

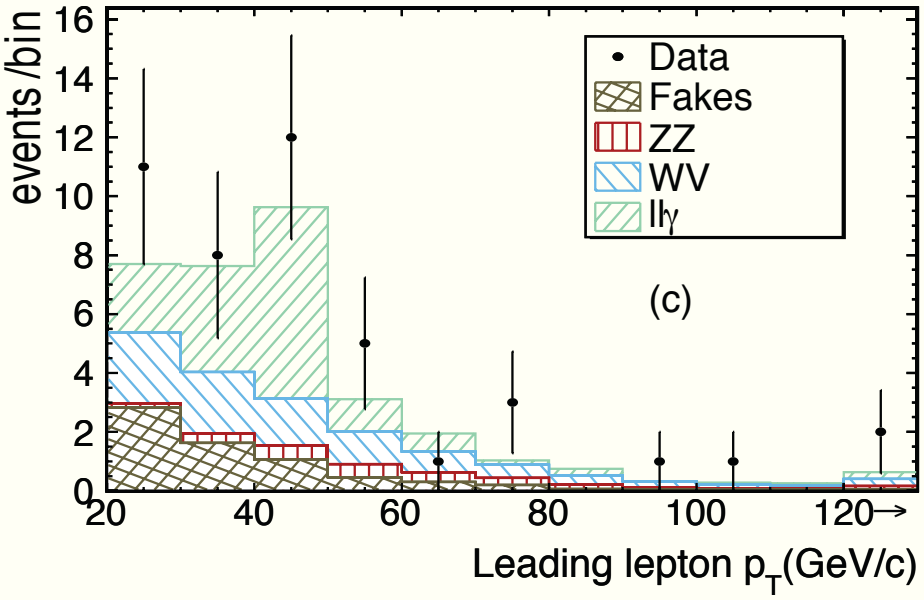
MxFV1

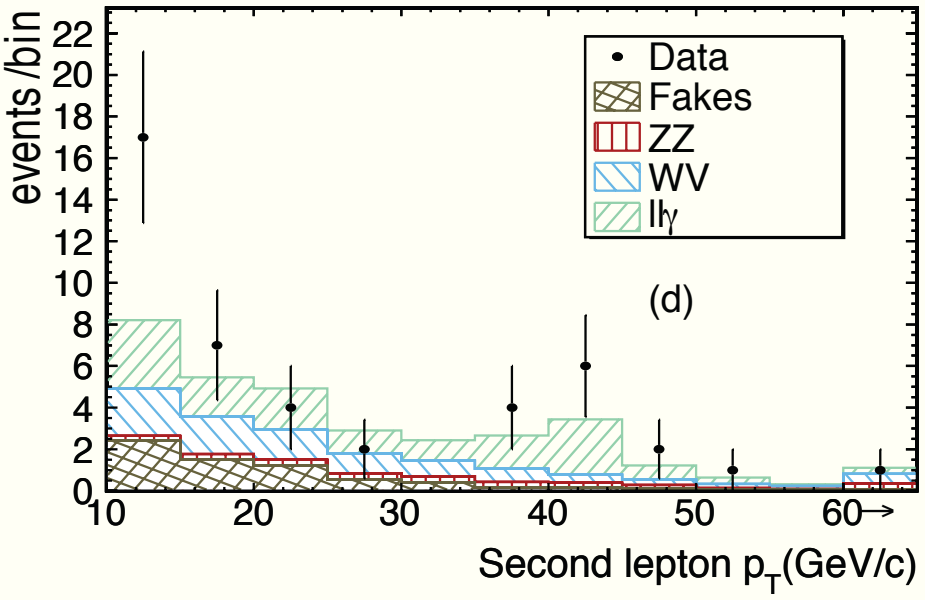

Events
2
1.5
1
0.5
0
0
1
2
3
4
5
6
Number of Jets
Data
Bkg Uncert
$Z \to \ell\ell$
misid
top

CDF Model Independent Search

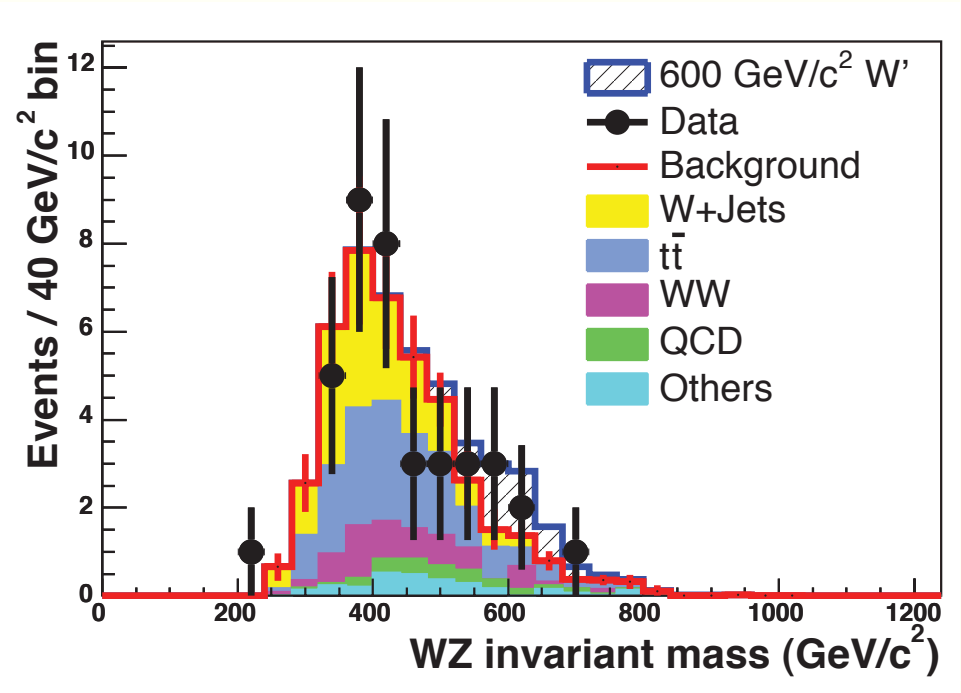


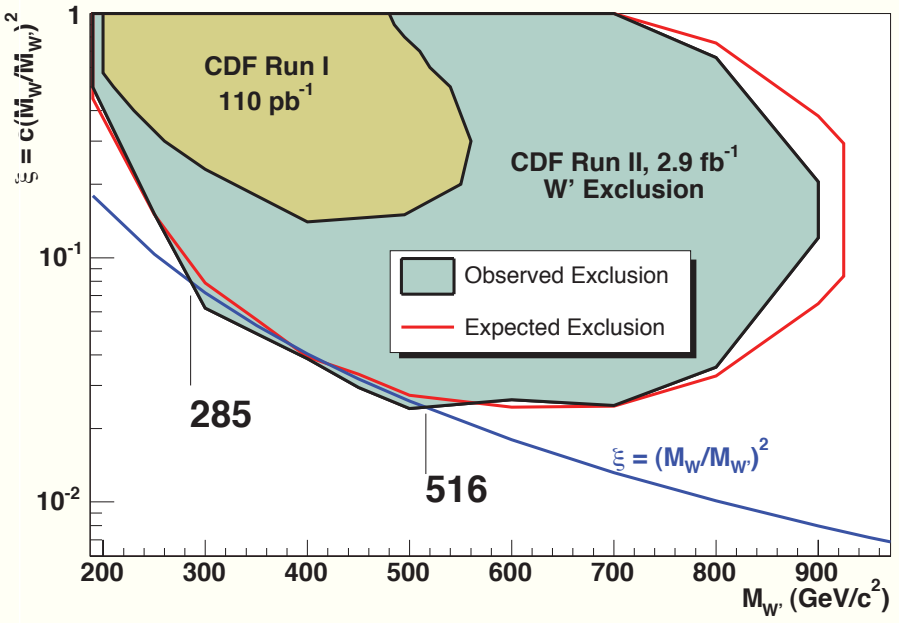




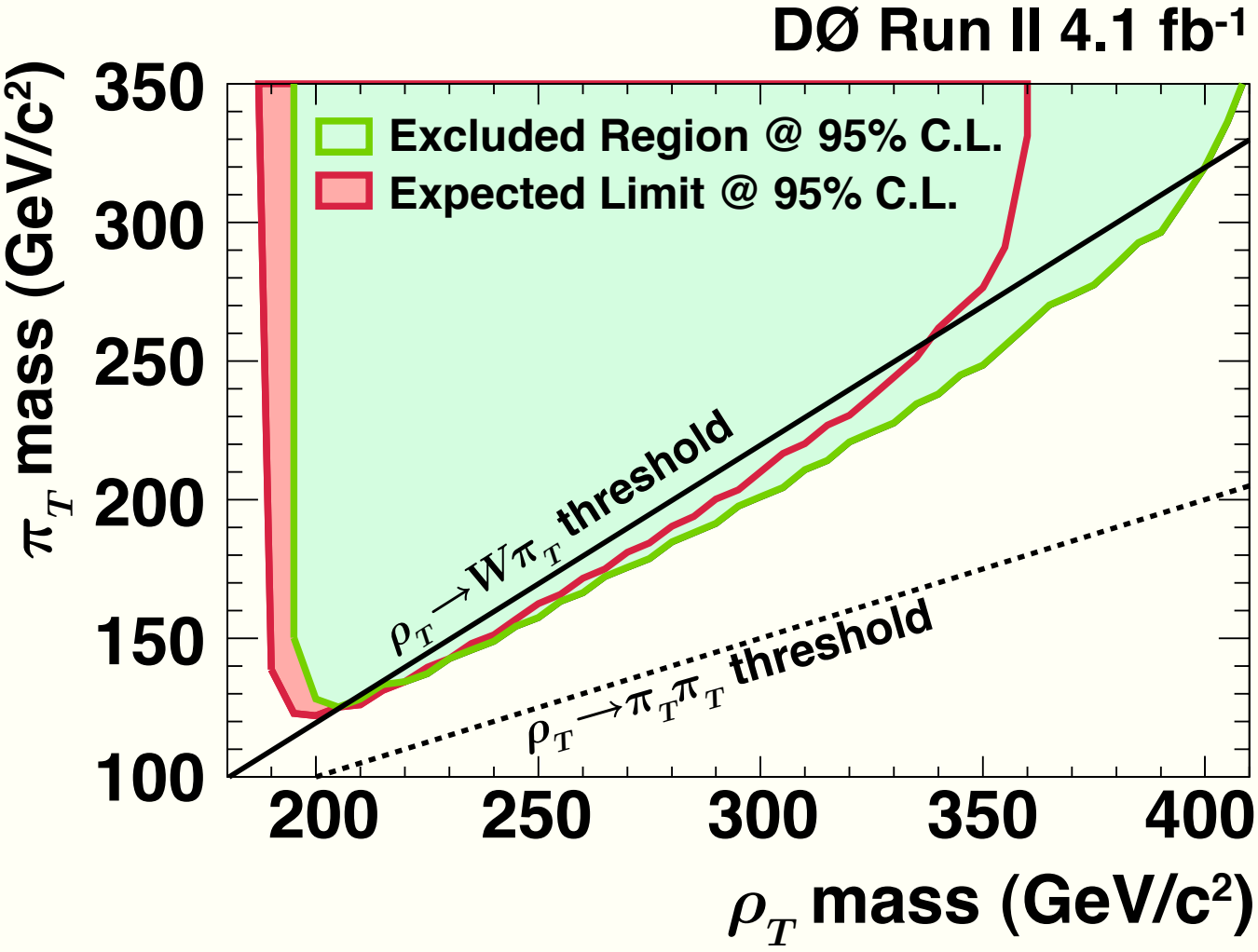


CDF W' Limit


600 GeV/c^2 W'
Data
Background
W+Jets
$t\bar{t}$
WW
QCD
Others
Events / 40 GeV/c^2 bin
WZ invariant mass (GeV/c^2)


CDF Run I
110 pb^{-1}
CDF Run II, 2.9 fb^{-1}
W' Exclusion
Observed Exclusion
Expected Exclusion
285
516
$\xi = (M_W/M_{W'})^2$
$\xi = c'(M_W/M_{W'})^2$
$M_{W'}$ (GeV/c^2)

Limits were set on LSTC...



Excluded region @ 95% C.L: ρ_T **mass 208 – 408 GeV/c²**

for $M(\ \rho_T\ ) < M(\ \pi_T) + M\ (W)$