4th generation fermions at CDF

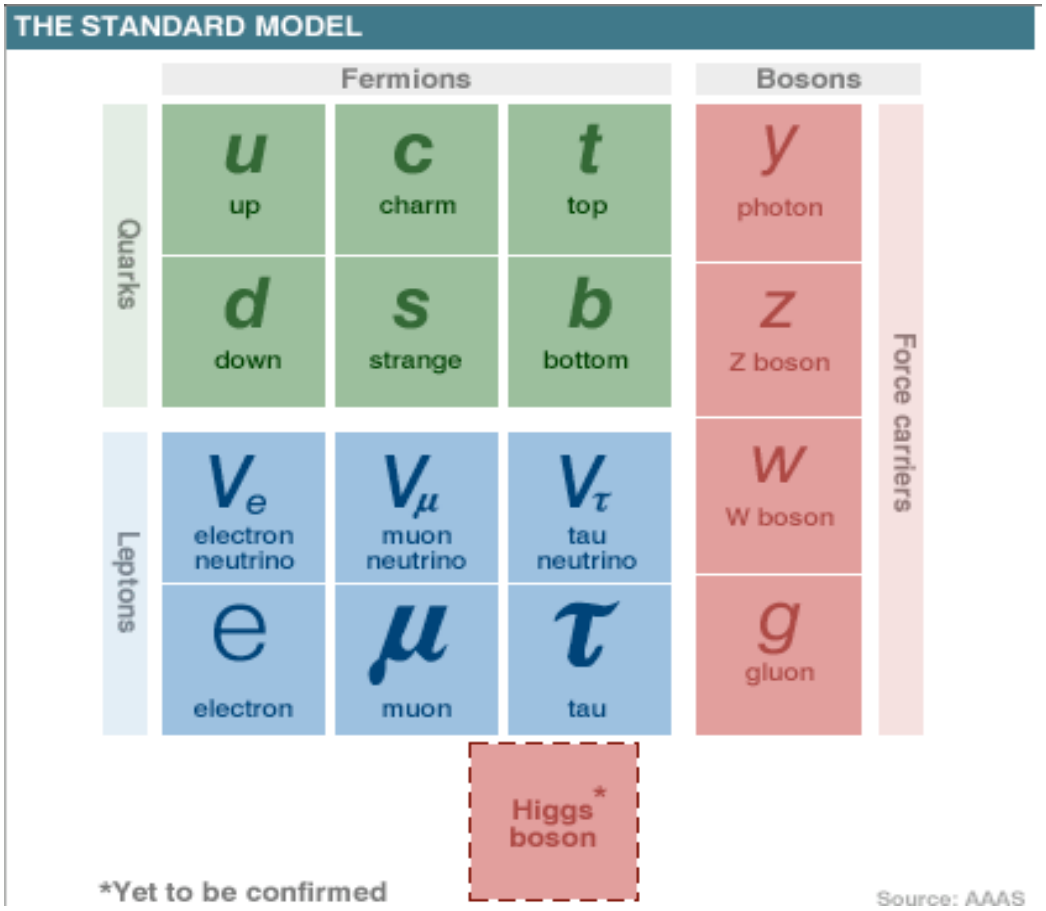
Direct searches for b′,t′ and neutrinos

Daniel Whiteson, UC Irvine

4th gen workshop

Jan 14, 2010

b′,t′, leptons



4th generation

Natural extension.

Indirect limits

LEP $Z \to \nu\nu$

No problem

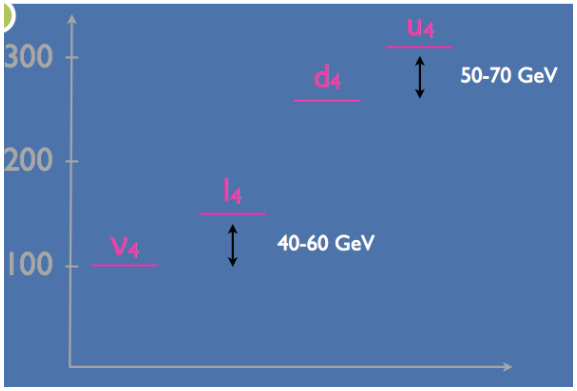
if $m_{\nu 4} > m_Z/2$

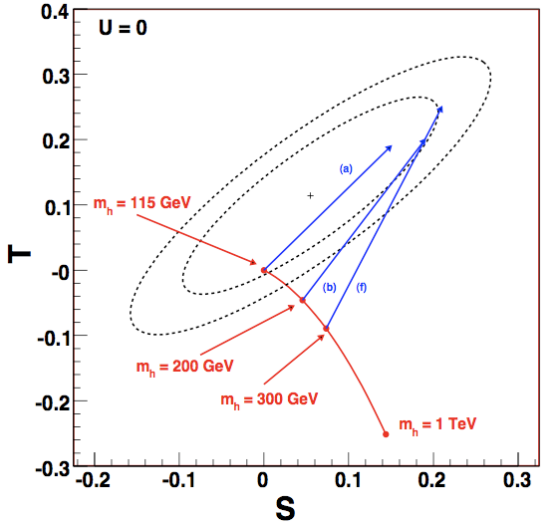
Mixing measurements

$$|V_{ud_4}| \lesssim 0.04$$
$$|V_{u_4 d}| \lesssim 0.08$$
$$|V_{cd_4}| \lesssim 0.17$$

Kribs, Plehn, Spannowsky, Tait
arXiv/0706.3718

Electroweak precision

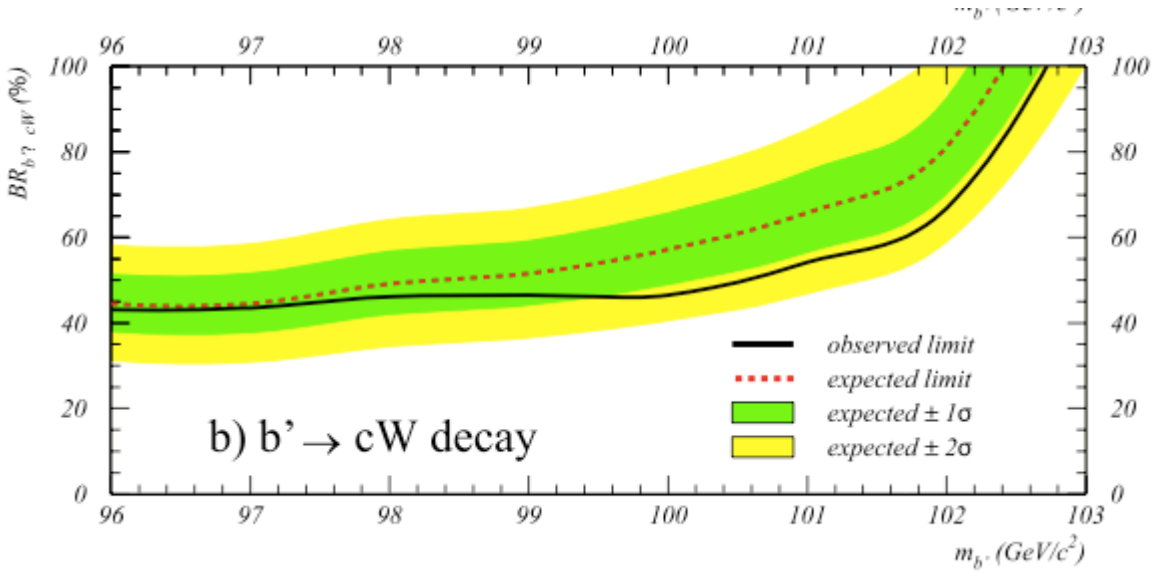




LEP Limits

LEP

$m_{b'} >\sim 100$ GeV



Overview

CDF

1) b′ → Wt
2) t′ → Wq
3) N → Wl

Indirect searches discussed by E. Nagy.

b′

CDF

1) b′ → Wt

2) t′ → Wq

3) N → Wl

Signal & Selection

Selection

2 like-signed leptons

pt>20 GeV

at least one isolated

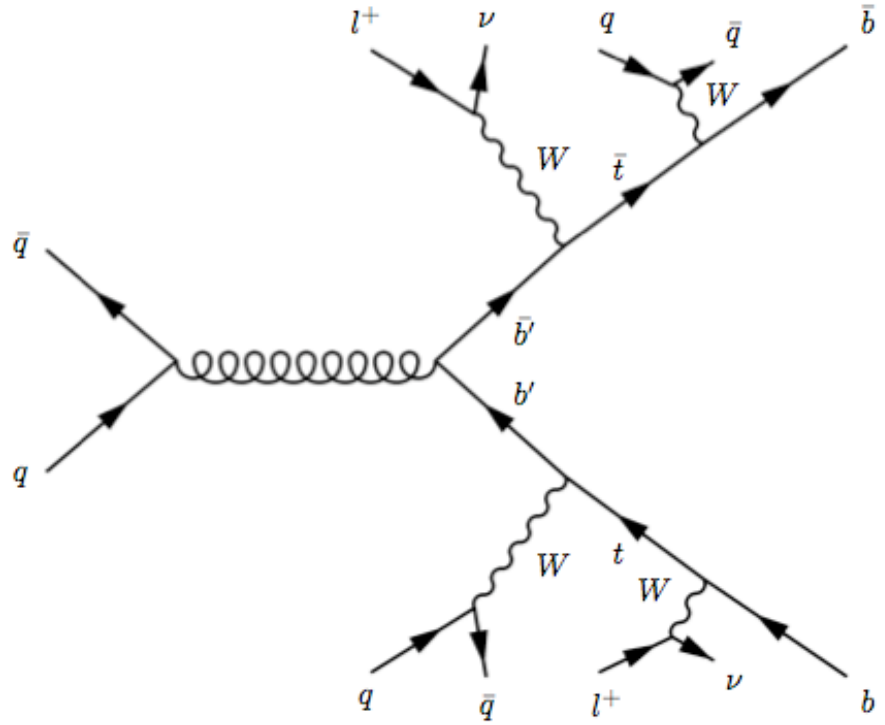
2 jets

pt>20 GeV

>=1 btags

Missing transverse energy

>20 GeV

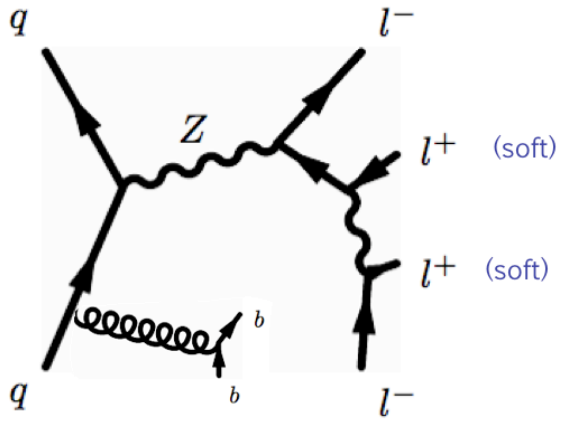


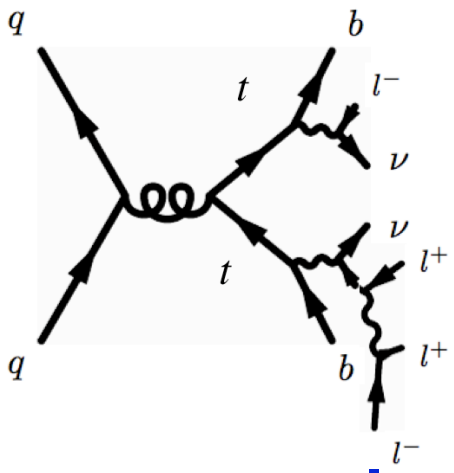
Sample

2.7/fb

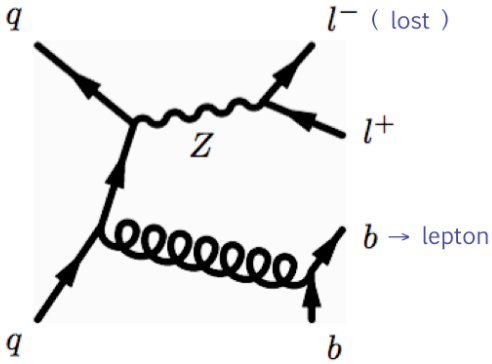
Backgrounds

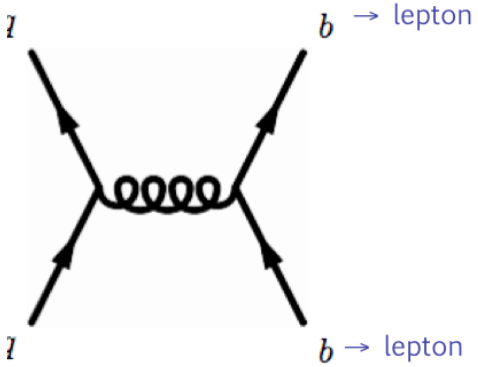
Same charge leptons from $e^+ \rightarrow e^+\Upsilon \rightarrow e^+ e^+ e^-$

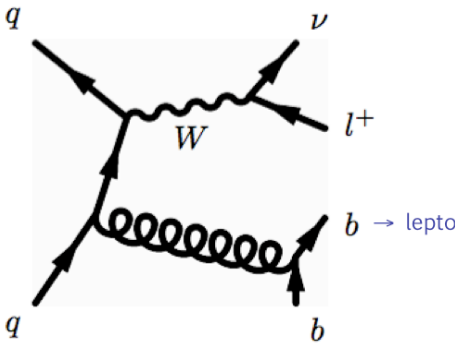


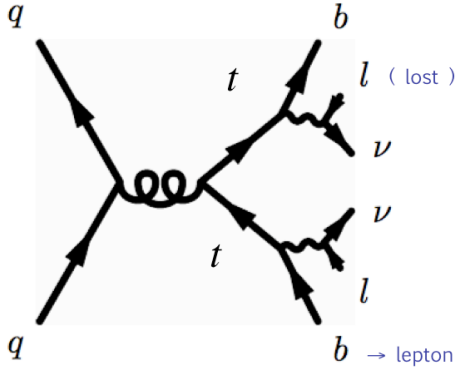


Same charge lepton from jet → lepton









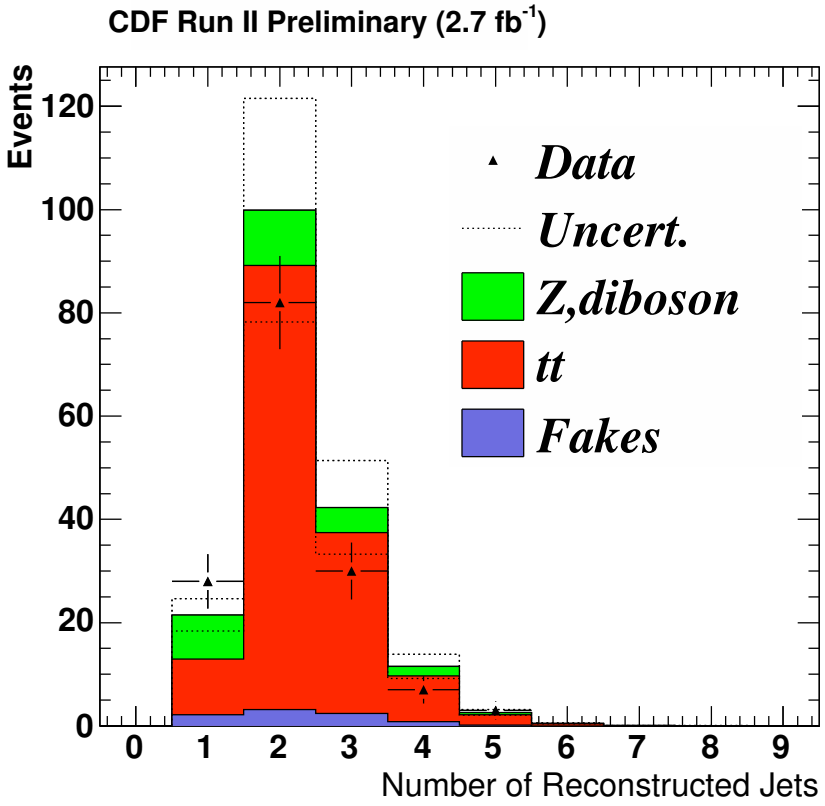
Cross-checks

Cross-check

2 opposite-signed leptons

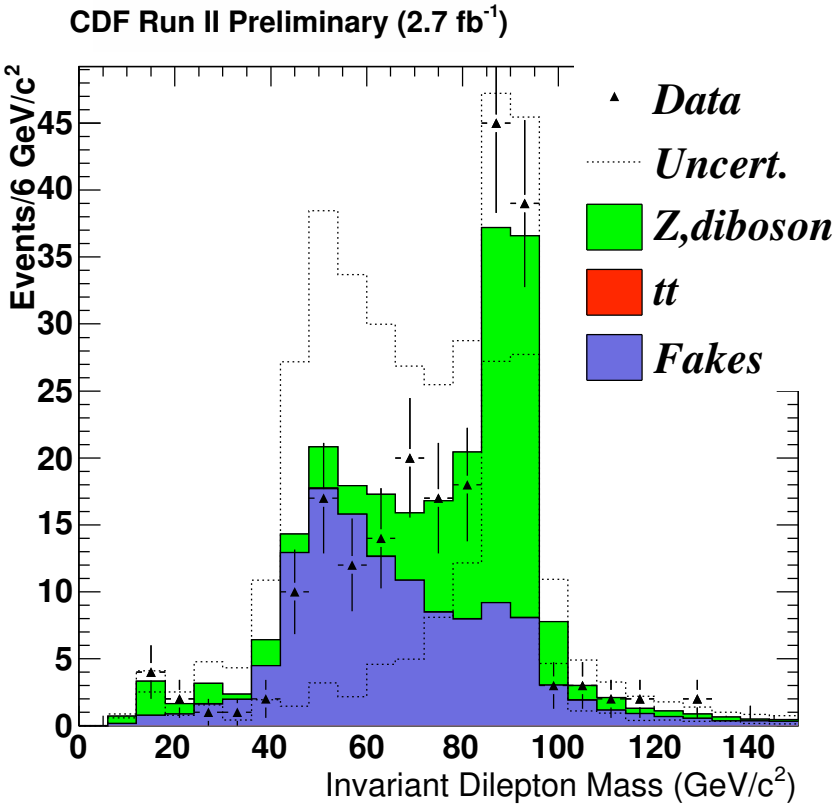
>=1 jet *>=1 btags*

Missing transverse energy



Cross-check

2 like-signed leptons



Final selection (2.7/fb)

Final selection

2 like-signed leptons

2 jets *>=1 btags*

Missing transverse energy

Source	*ee*	*μμ*	*eμ*	*ll*
Z	0.01 ± 0.01	0	0.02 ± 0.02	0.03 ± 0.03
top dilep	0.06 ± 0.04	0	0.09 ± 0.03	0.15 ± 0.05
Fakes	0.6 ± 0.6	0.3 ± 0.3	0.5 ± 0.5	1.4 ± 1.4
Total	0.7 ± 0.6	0.3 ± 0.3	0.6 ± 0.5	1.6 ± 1.4
Data	0	1	1	2

Final selection (2.7/fb)

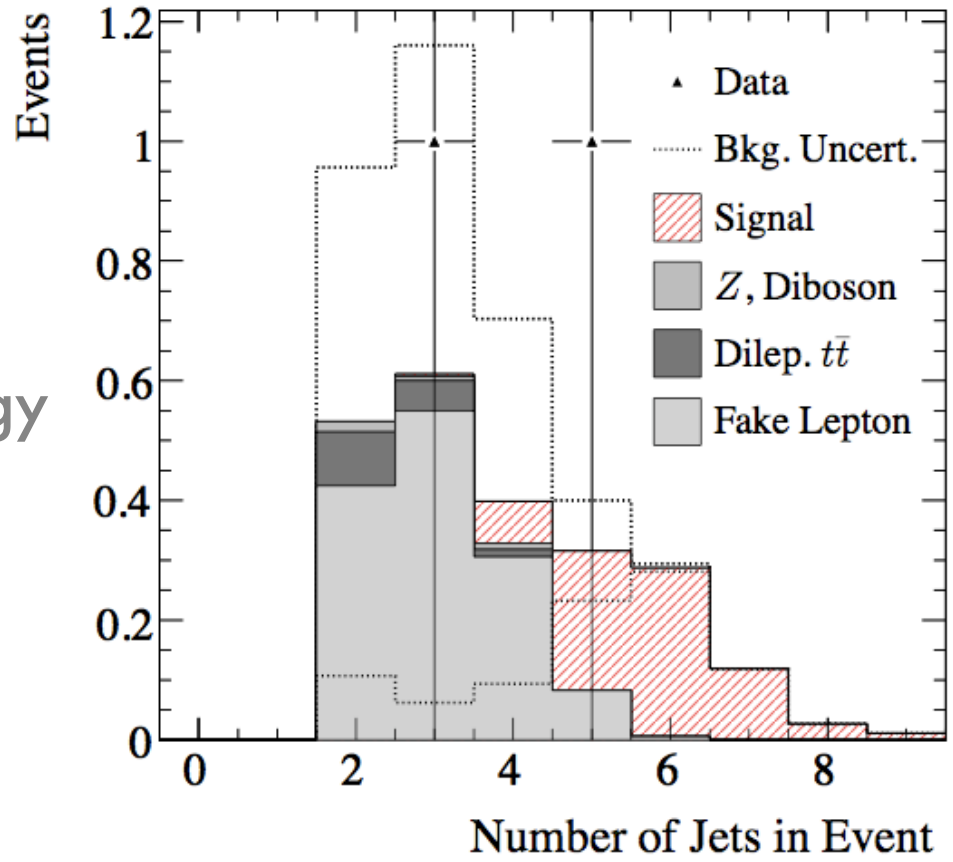
arxiv:0912.1057

Final selection

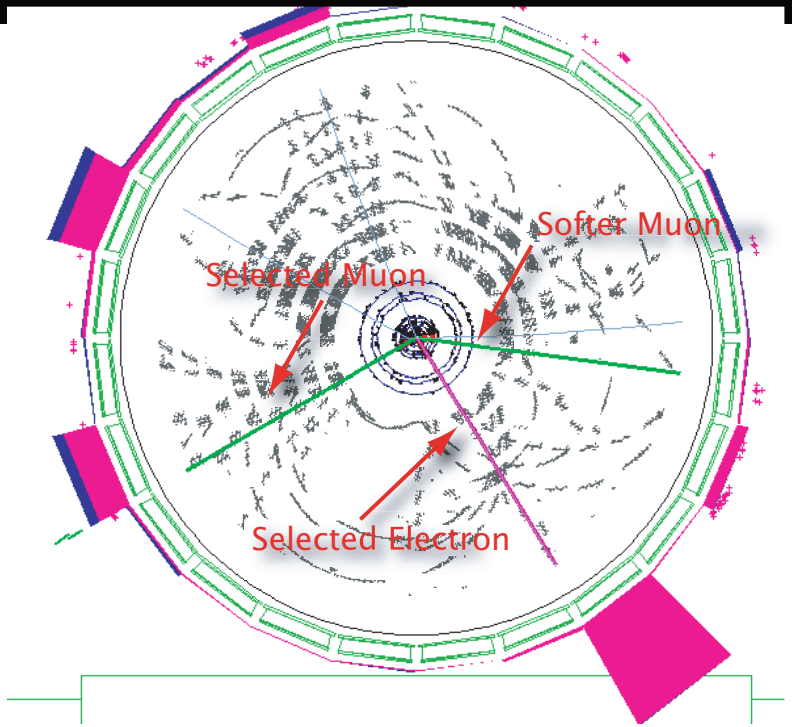
2 like-signed leptons

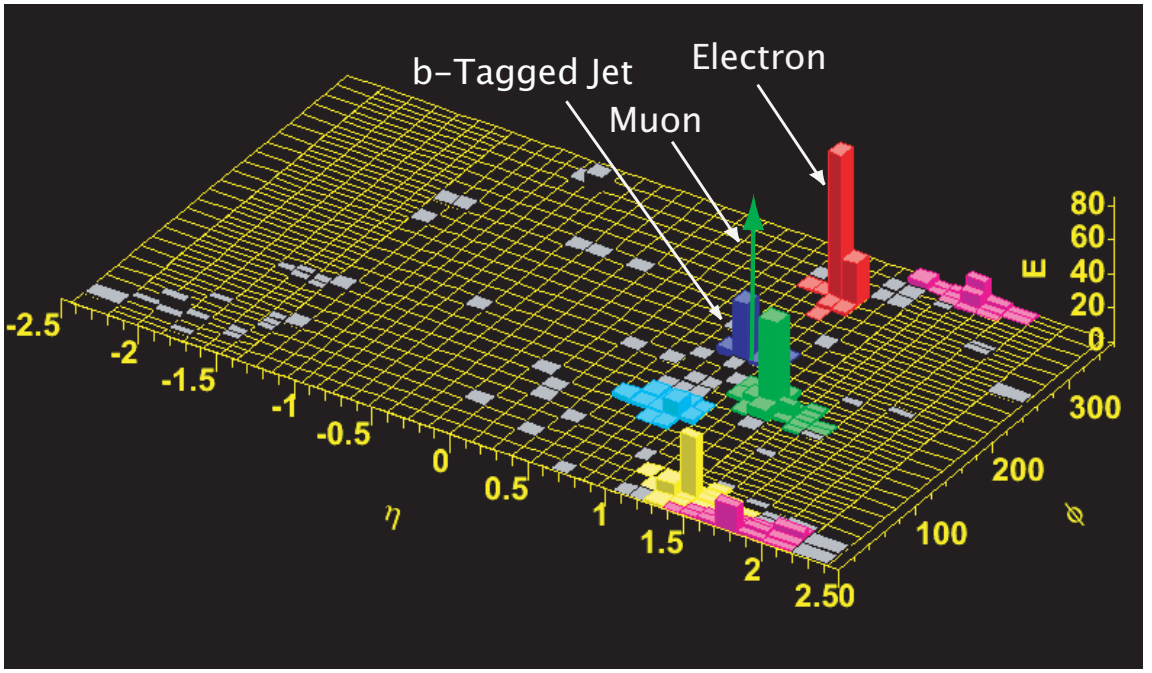
2 jets *>=1 btags*

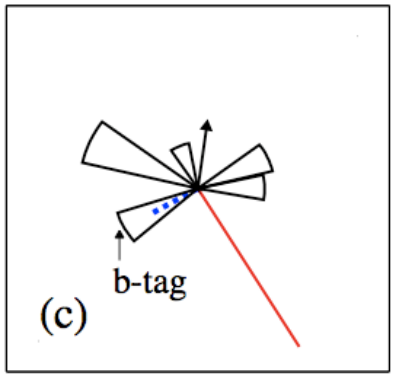
Missing transverse energy



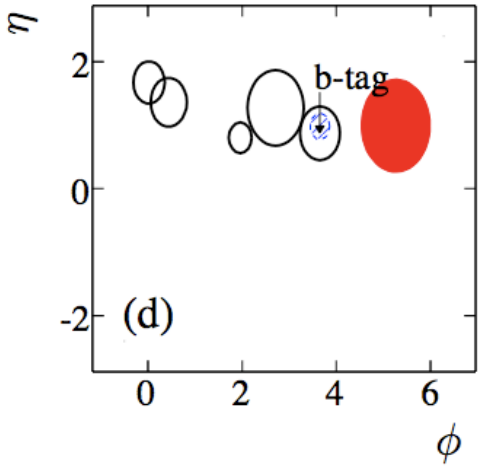
5-jet $e^+\mu^+$ event







r-ϕ Projection



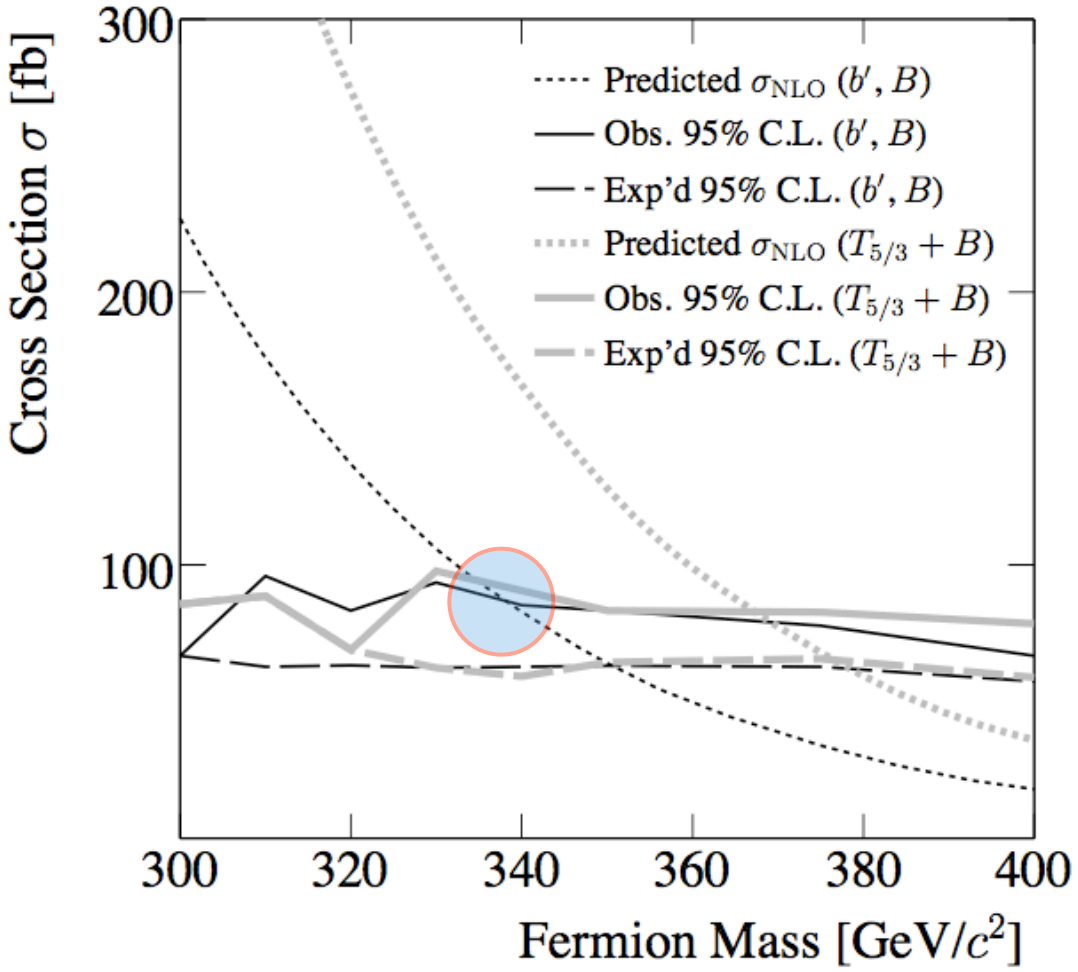
Jet
Electron
Muon

Limits

arxiv:0912.1057

Limit

$m_{b'} > 338$ GeV



Limits

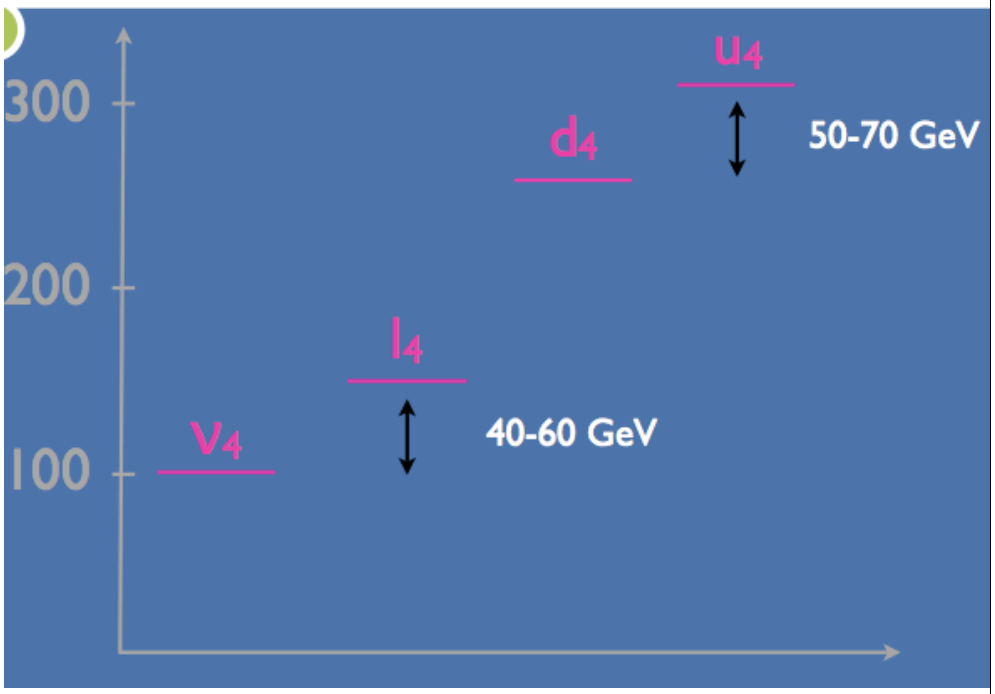
Limit

$m_{b'} > 338$ GeV

Impact

Shift the spectrum higher

Same splitting



From Tim Tait

Outline

CDF

1) b′ → Wt

2) t′ → Wq

3) N → Wl

Signal & Selection

Selection

1 lepton

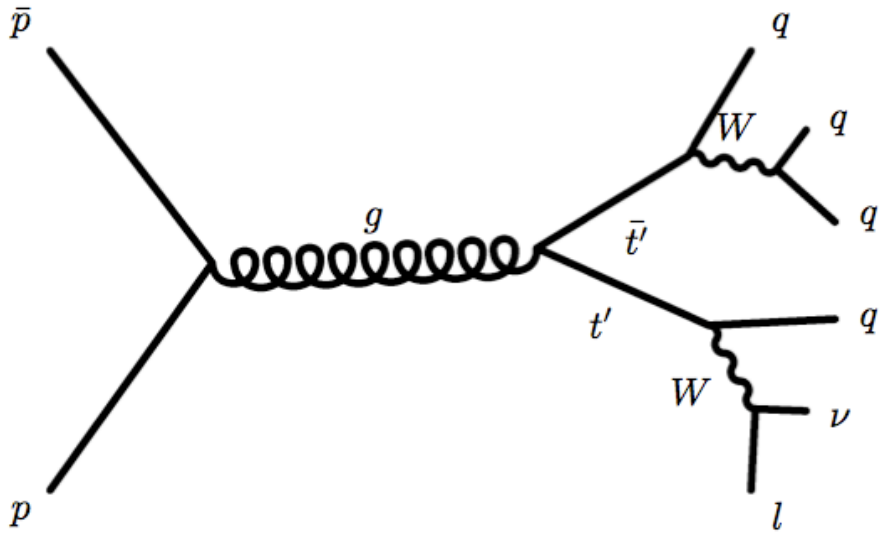
pt>20 GeV

4 jets

pt>20 GeV

Missing transverse energy

>20 GeV

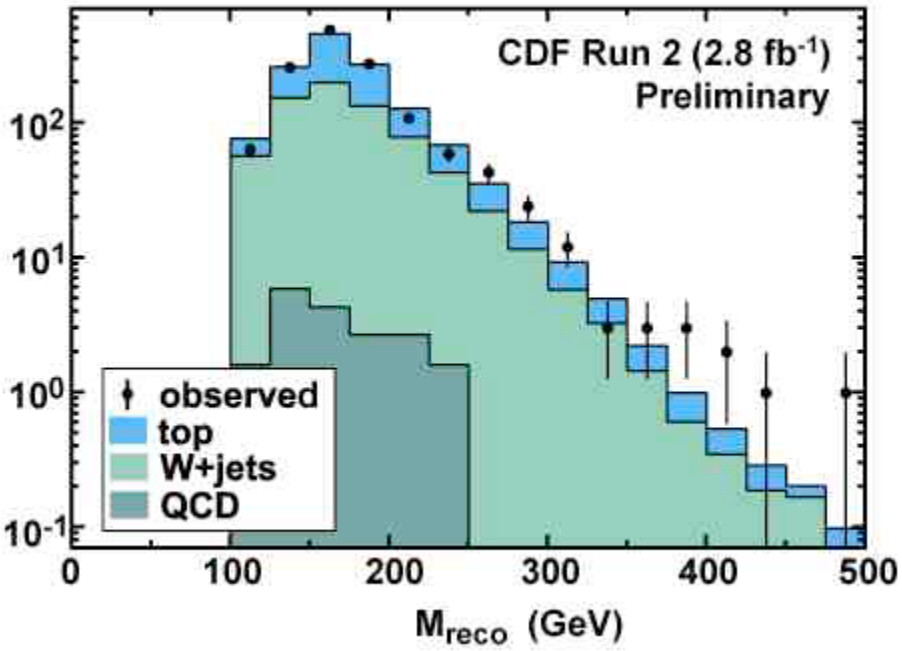


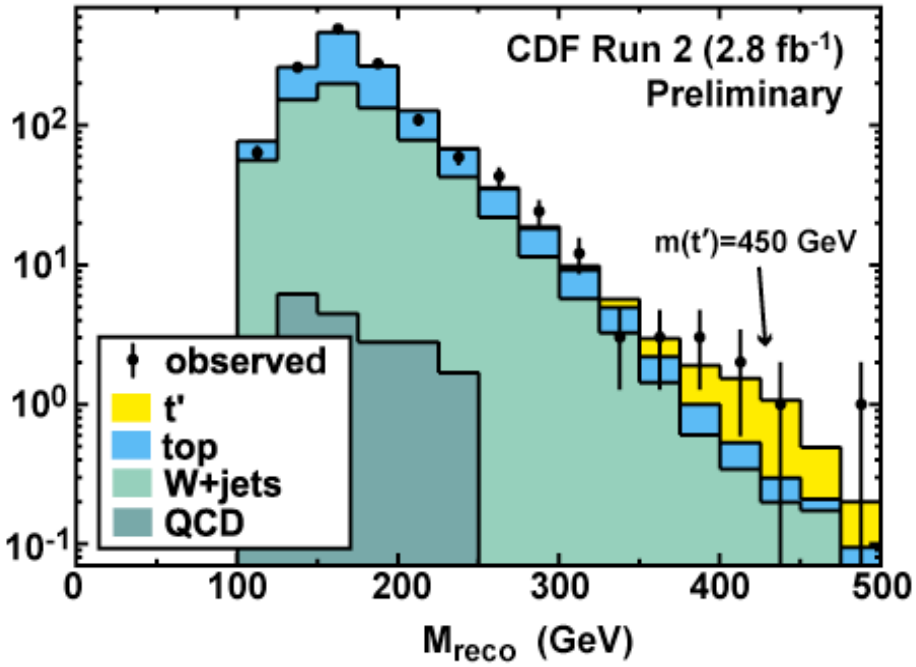
Sample

2.8/fb

Mass fit

Fit mass of each event

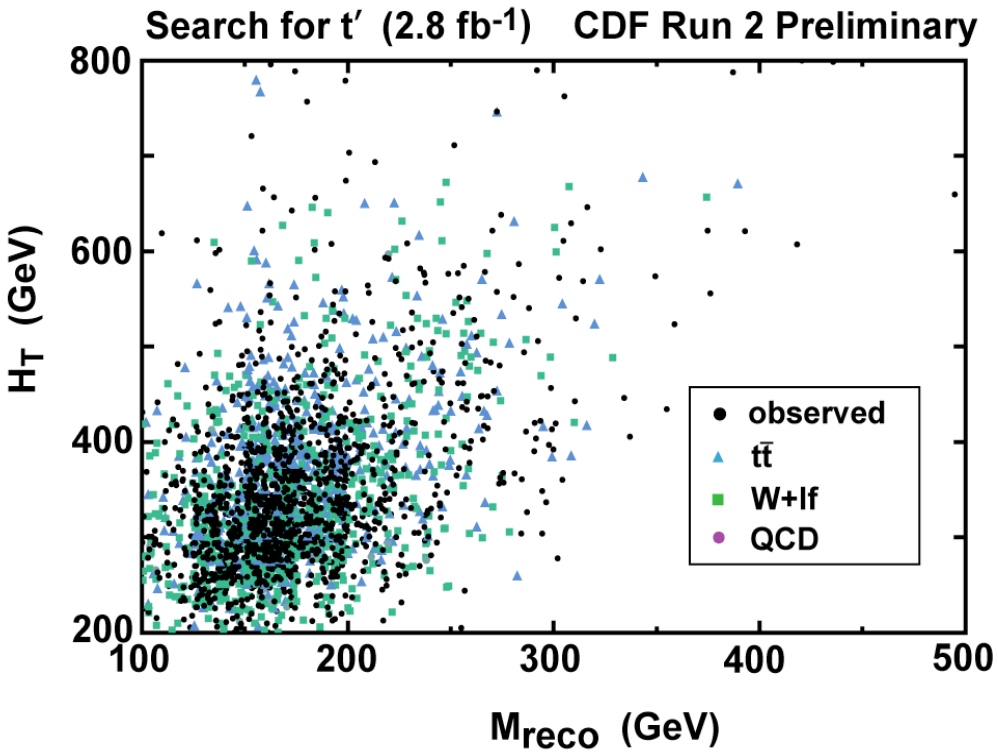




Room on tail for signal events

Events

Total scalar energy



Fitted mass

t′

Limit

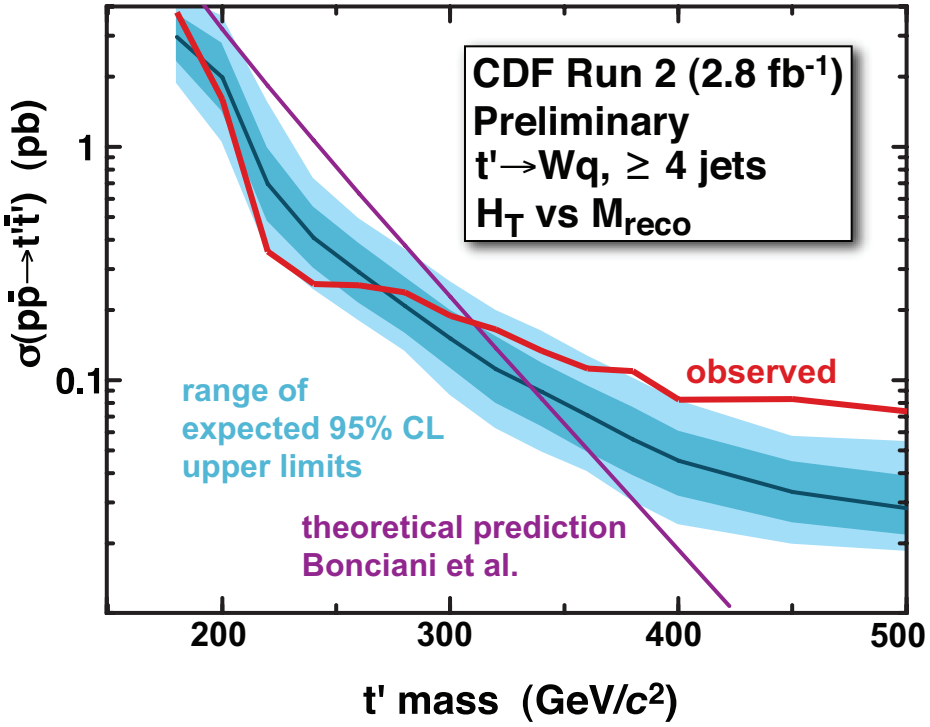
$m_{t'} > 311$ GeV

Plans

WqWq→l+jets with 5/fb

Study WbWb→l+jets mode

New mode WqWq→ dilepton



Overview

CDF

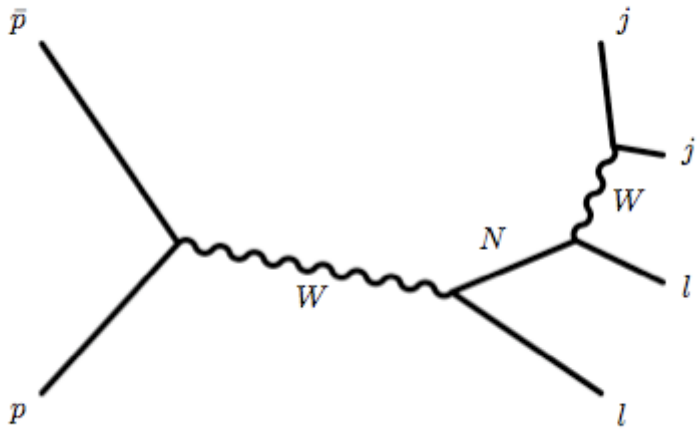
1) b′ → Wt

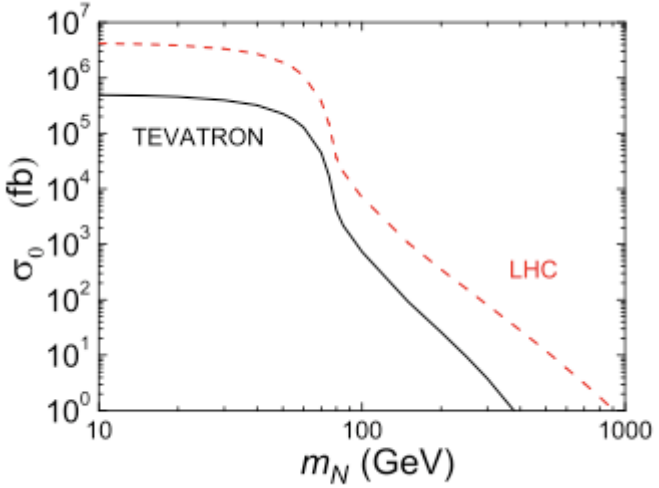
2) t′ → Wq

3) N → Wl

Majorana neutrinos

Production via W has been studied





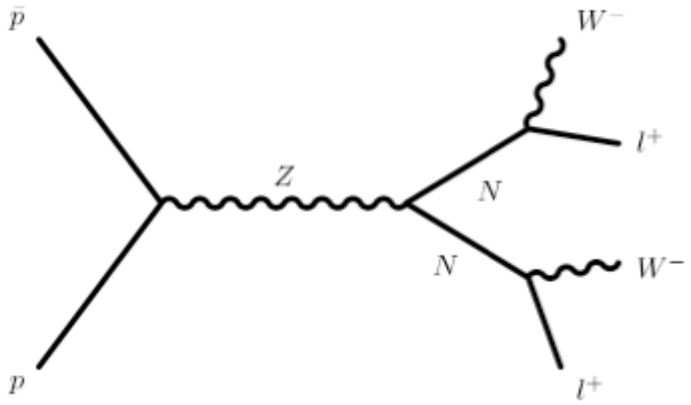
hep-ph/0604064

LEP limits at 90 GeV

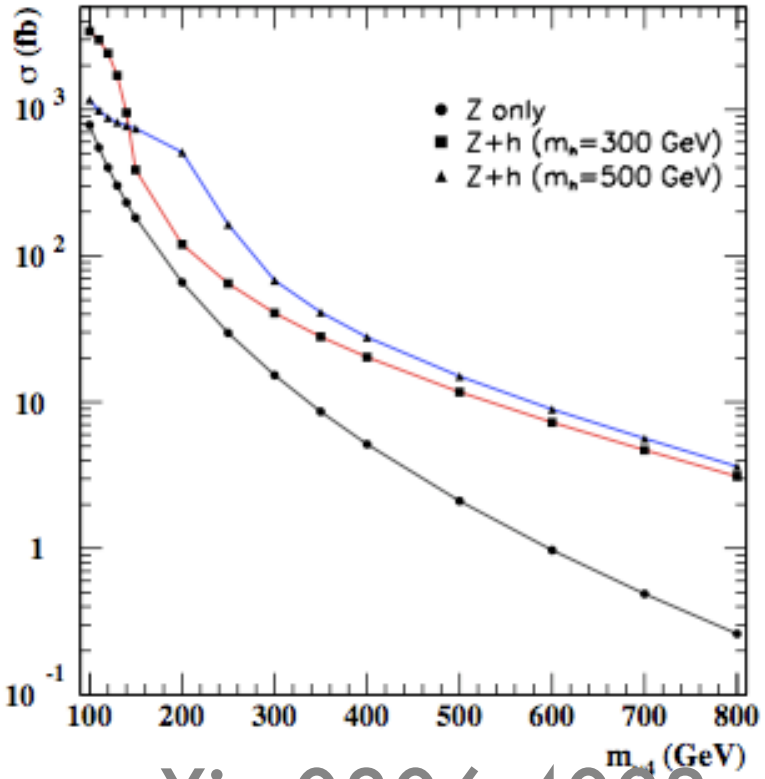
Majorana neutrinos

Production via Z

avoids *WIN* vertex in production mechanism

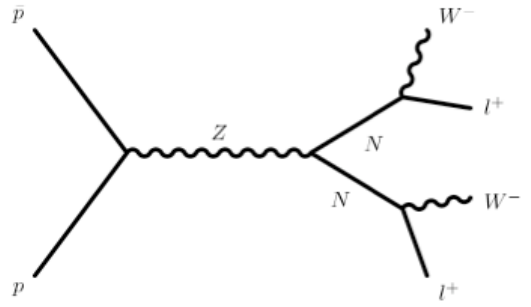


One mass point studied for LHC



arXiv:0806.4003

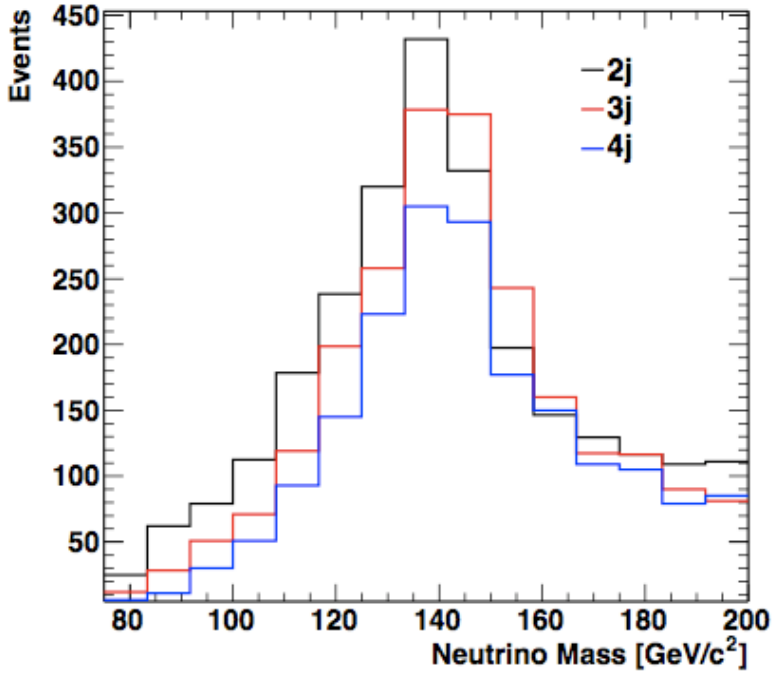
Reconstruction



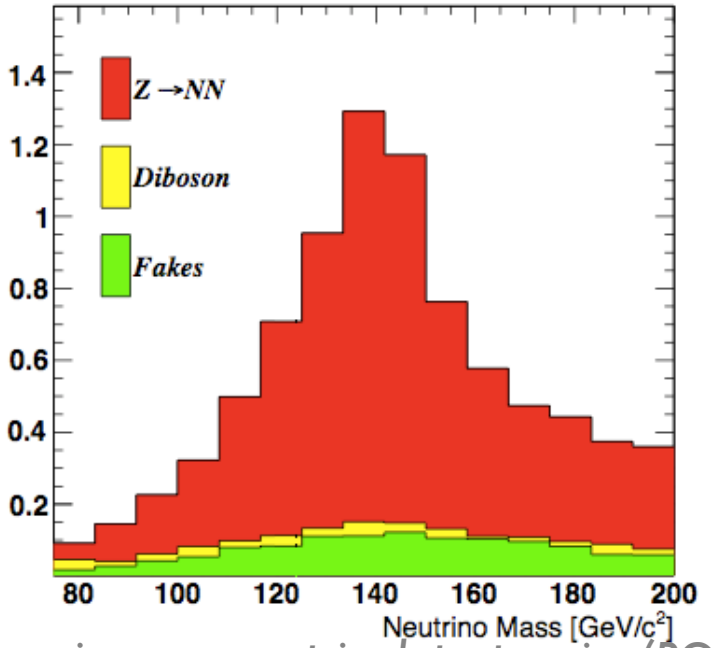
arXiv:1001.1229

Reconstruct N mass as M_{ljj}

Mass reconstruction



Signal and backgrounds

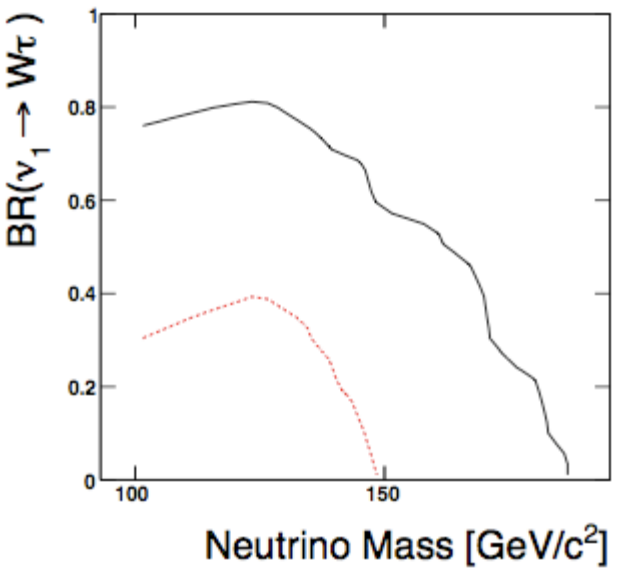


Study using parametric detector sim (PGS)
Not official CDF results

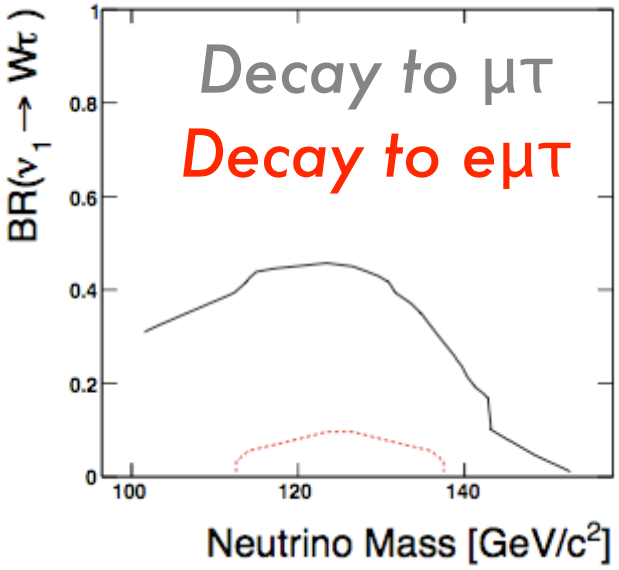
Power

arXiv:1001.1229

95% Exclusion



3σ evidence



Study using parametric detector sim (PGS)
Not official CDF results

Conclusions

CDF has strong 4th gen efforts

World's strongest limits in direct quark searches

Great sensitivity to leptons

backups

CDF b′->bZ

$m_{b'} > 268$ GeV

If BR(b′→bZ=100%)

Unlikely for $m_{b'} > m_W + m_{top} = 255$