Search for Leptoquarks and Technicolor at the Tevatron

Gérald Grenier
Université Lyon 1, IPN Lyon, IN2P3

ICHEP 2010, Paris, July 22nd-28th 2010

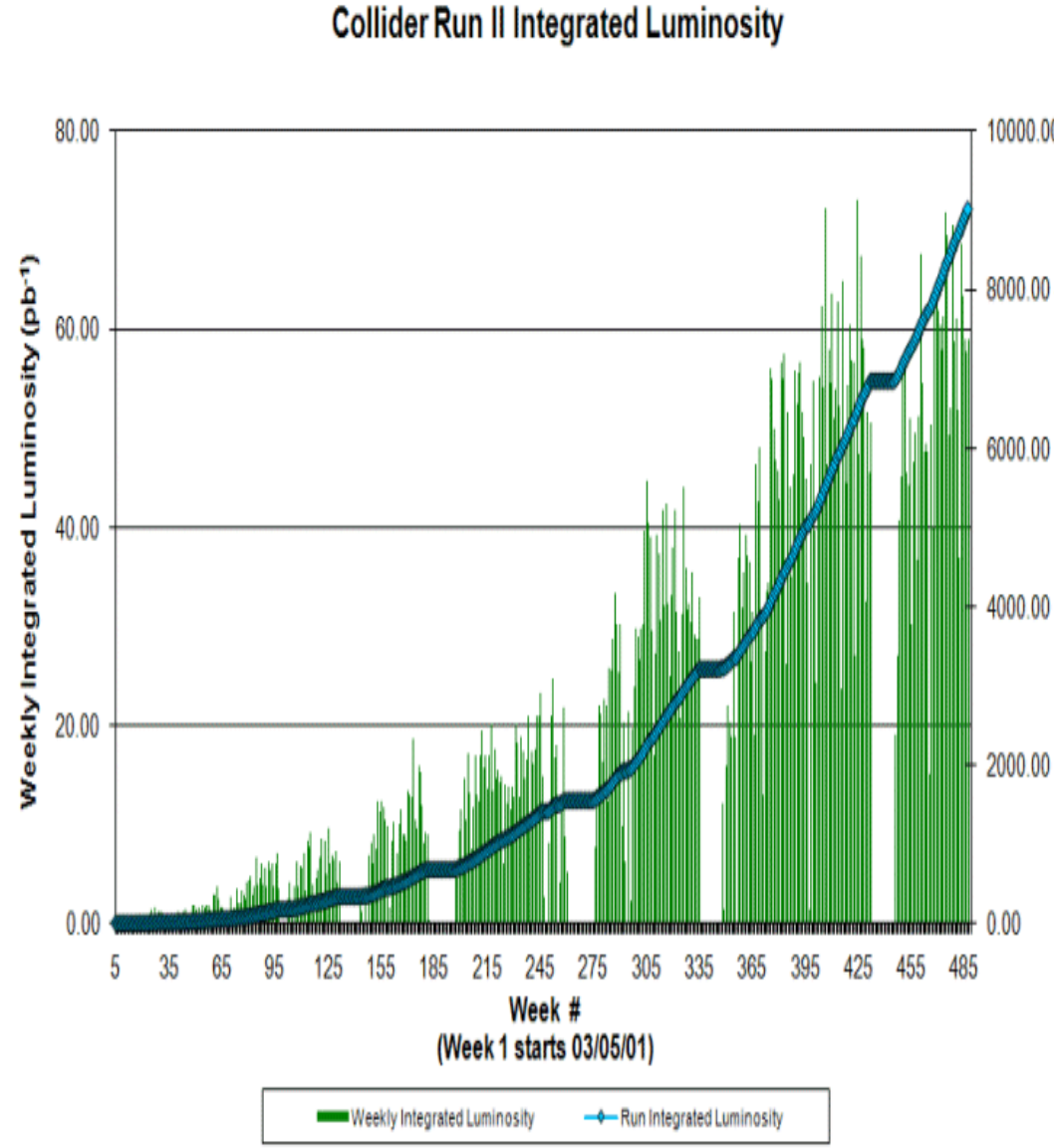
On behalf of the CDF and DØ collaborations

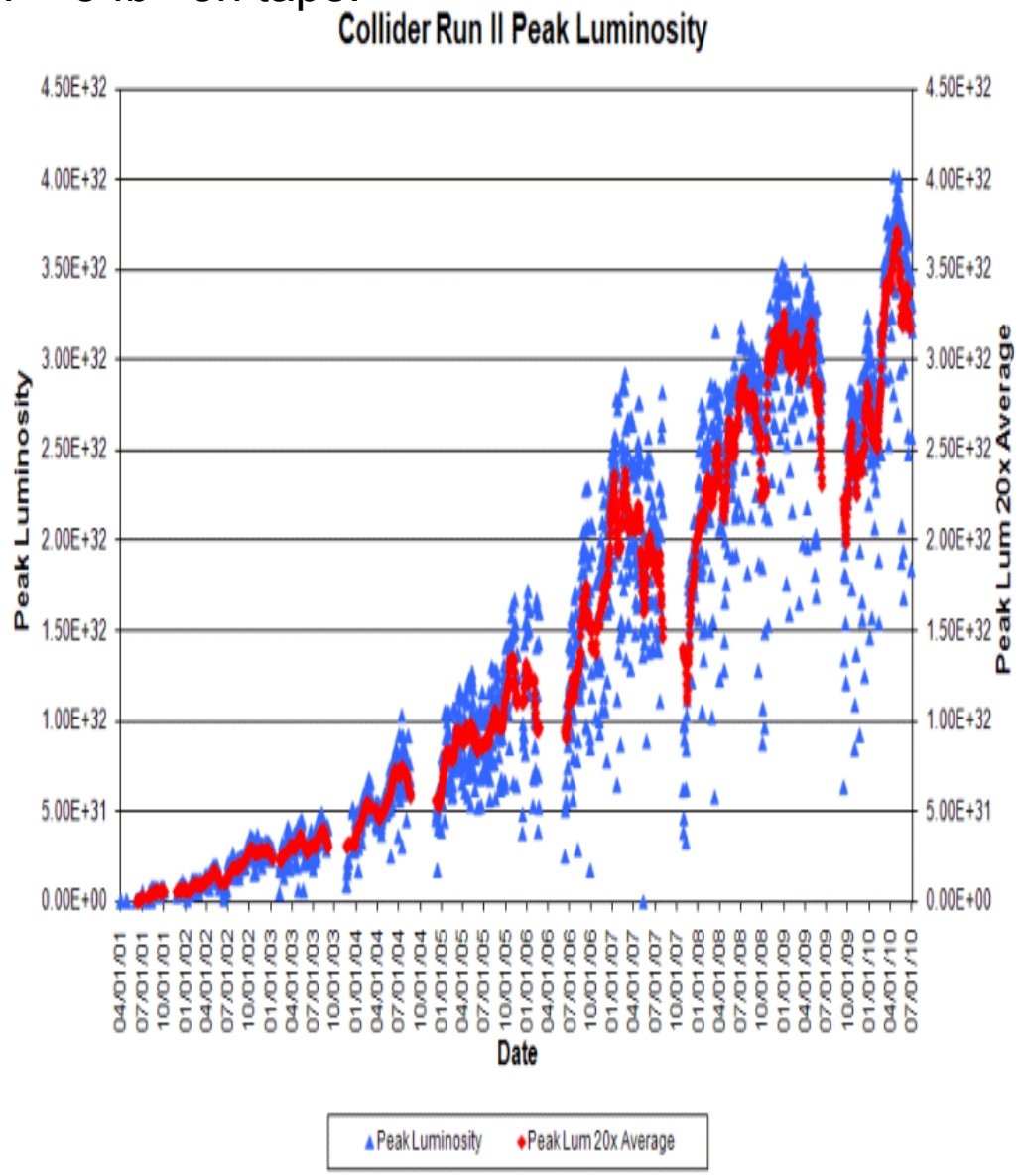
Tevatron luminosity

Run II (2001-ongoing) $\sqrt{s} = 1.96$ TeV

Current peak luminosity ~3.5 x 10^{32} $cm^{-2}s^{-1}$

Both experiments have now ~ 8 fb^{-1} on tape.

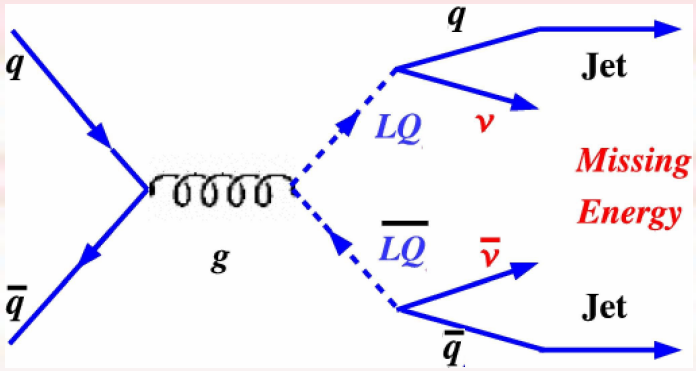




Leptoquarks

New interactions (scalar or vector) with quark-lepton-leptoquark vertices.
All predicted leptoquarks (LQ) are color triplets.

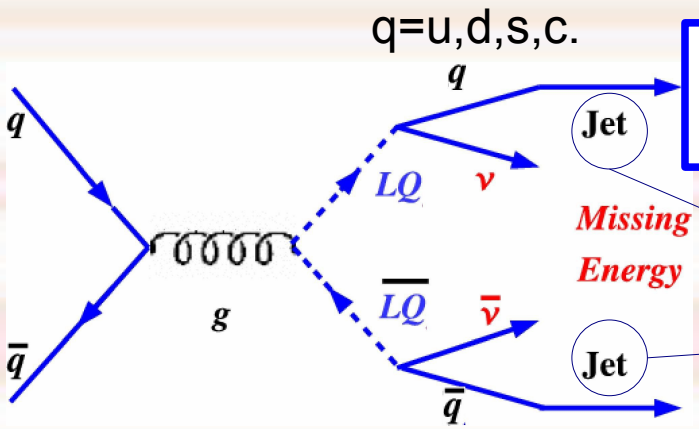
TeVatron studies assume **leptoquark pair production through gluon s-channel.**



followed by decay in quark+lepton

Scalar LQ production depends only on LQ mass.
Vector LQ production depend on LQ masses and anomalous couplings κ_G and λ_G.
Vector LQ production > scalar LQ production.

LQ → qν



D0 : Pt>35GeV, |η| < 0.8
CDF : Pt>30GeV, |η| < 1

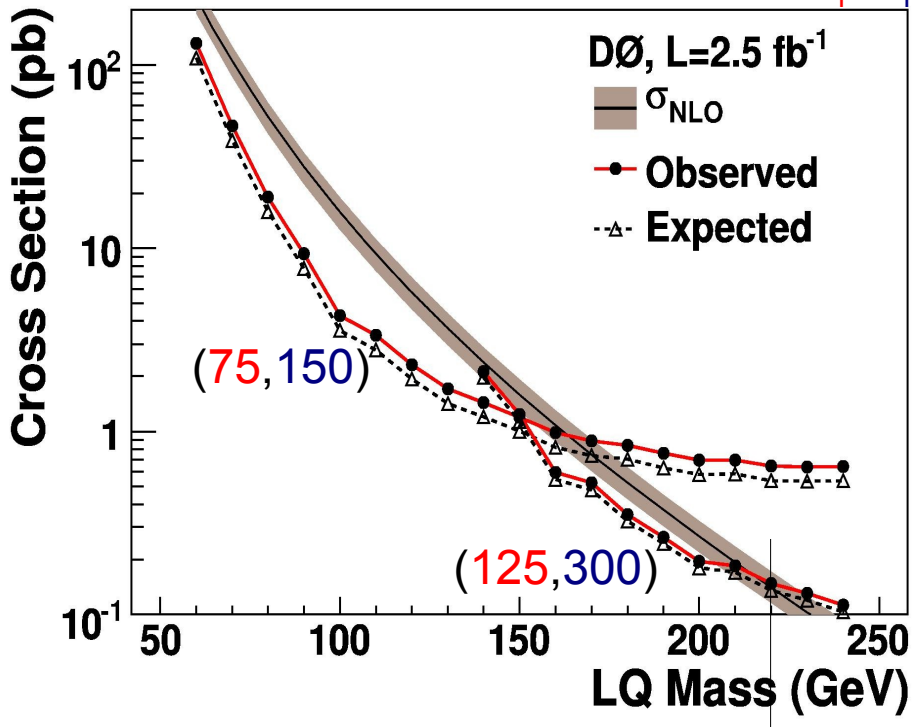
Veto on additional jets, electrons and muon

Scalar sum = H_T

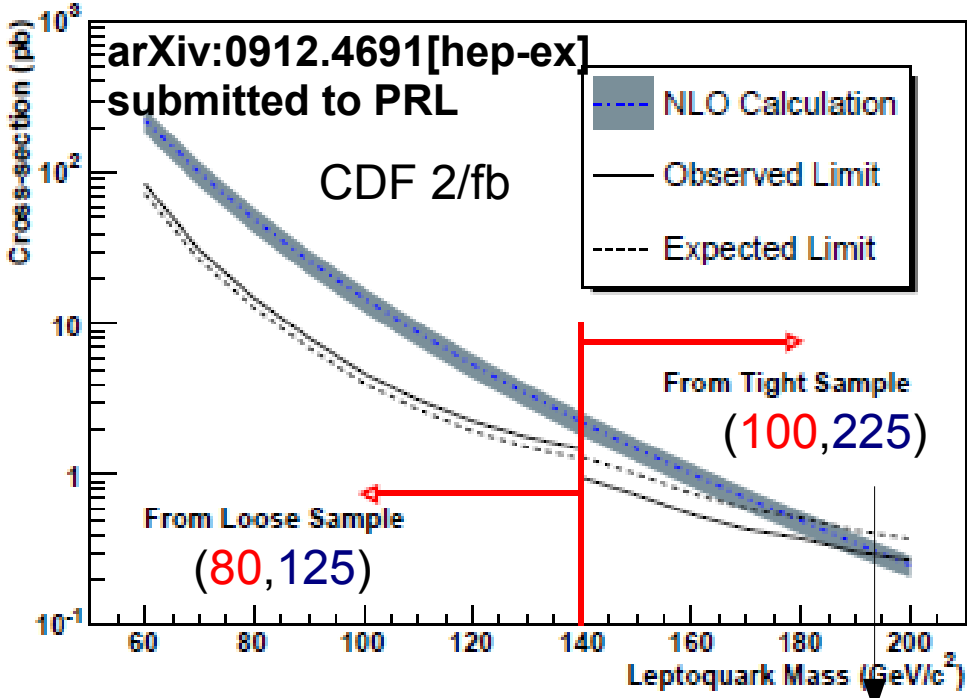
Main backgrounds
W+jets,Z+jets

PLB 668, 357 (2008)

$(ME_T, H_T) > (X, Y)$ GeV



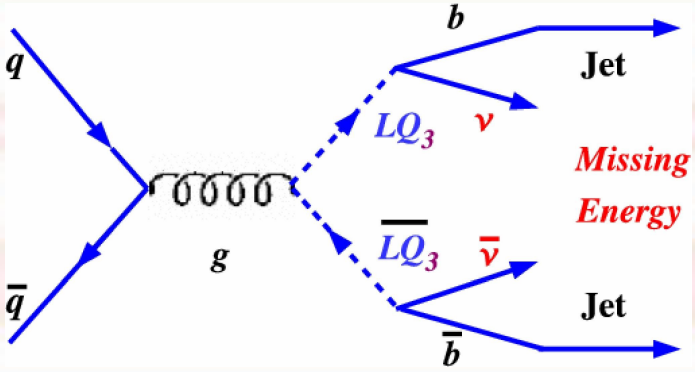
M_{LQ} > 214 GeV



M_{LQ} > 187 GeV

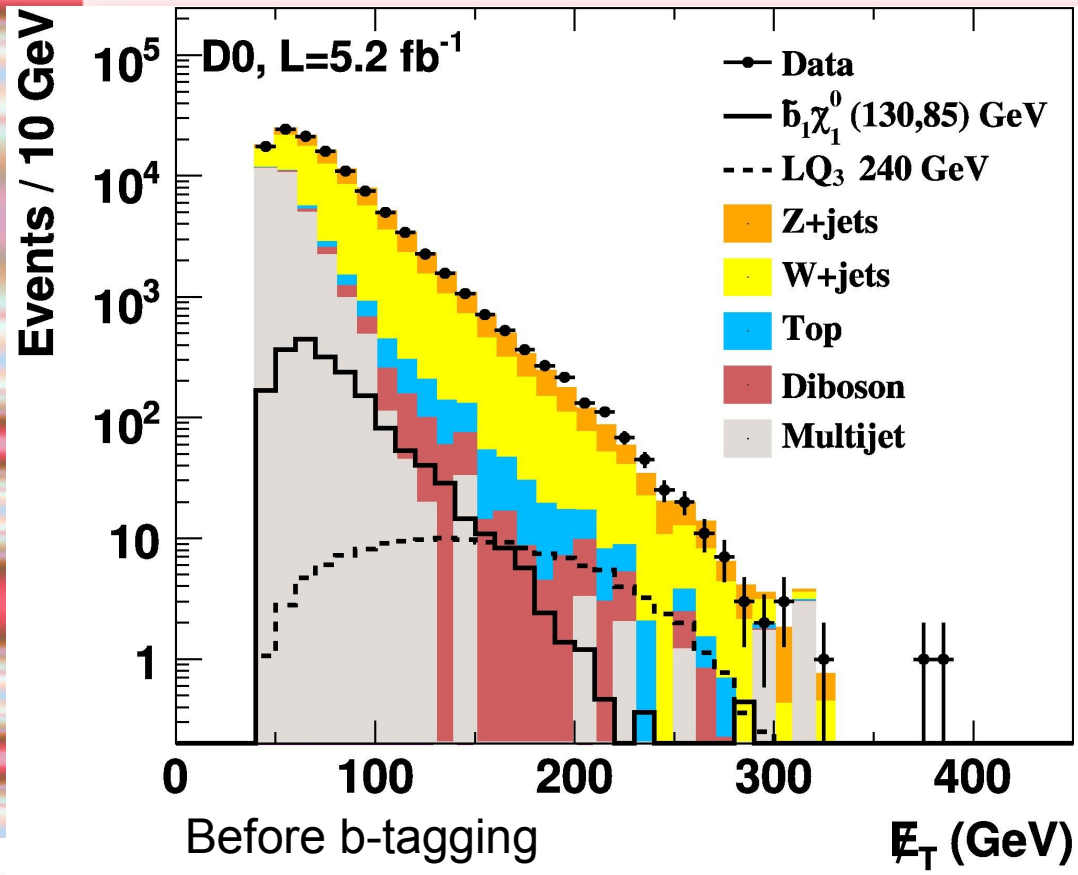
LQ → bν

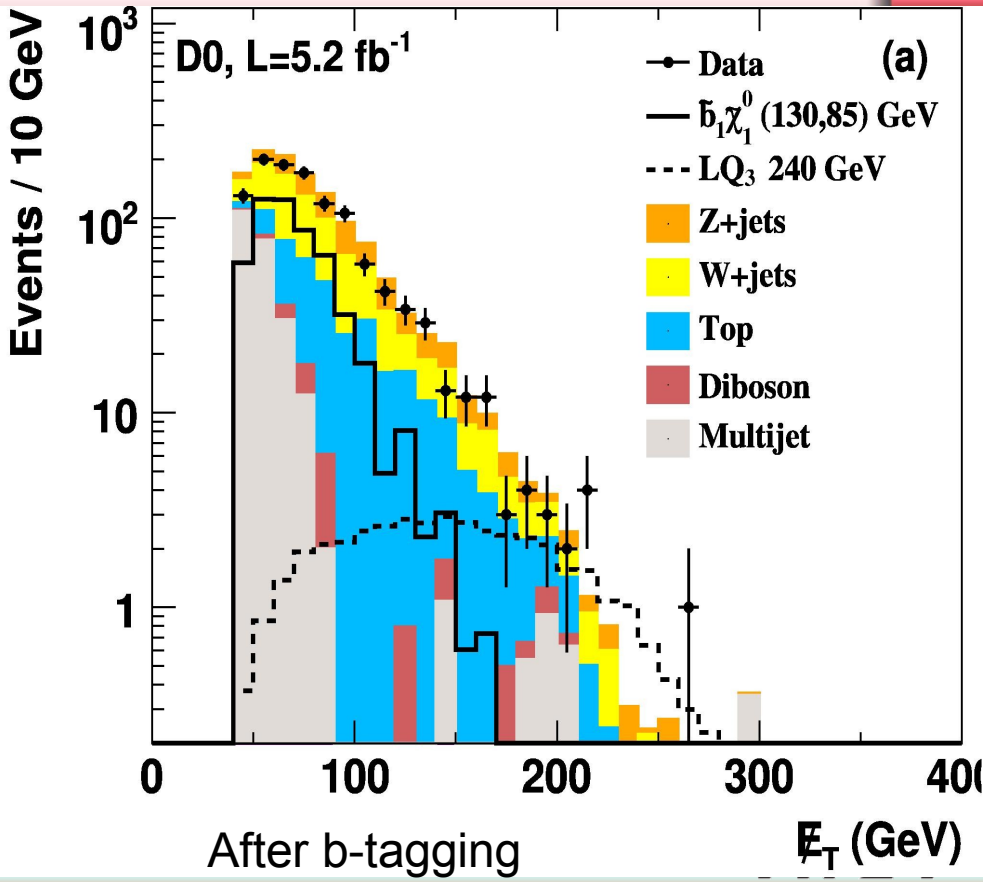
2b + Missing Transverse Energy (MET) signature.



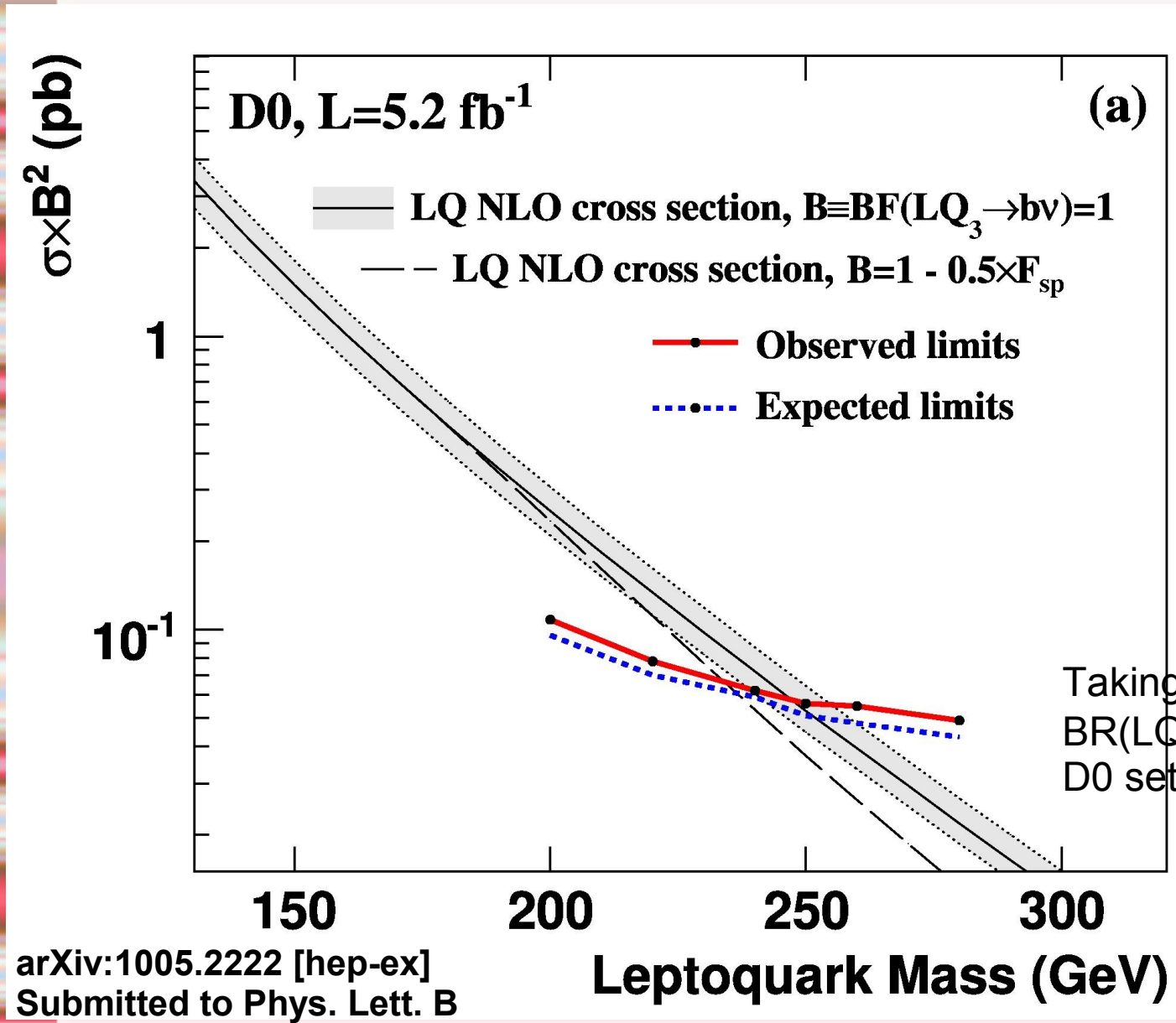
- 2 or 3 jets, Pt>20 GeV, |η|<2.5.
- Veto on isolated leptons.
- 2 jets tagged as b-jets
- Δφ(MET, any jet)>0.6 rad
- MET > 40 GeV
- H_T > 60 GeV
- (sum of 2 leading jets Pt)/H_T >0.75 (top background)

Main backgrounds
- Z+bb̄
- W+bb̄
- top





LQ → bν



95% CL lower scalar LQ mass limit for BR (LQ → bν) = 1:

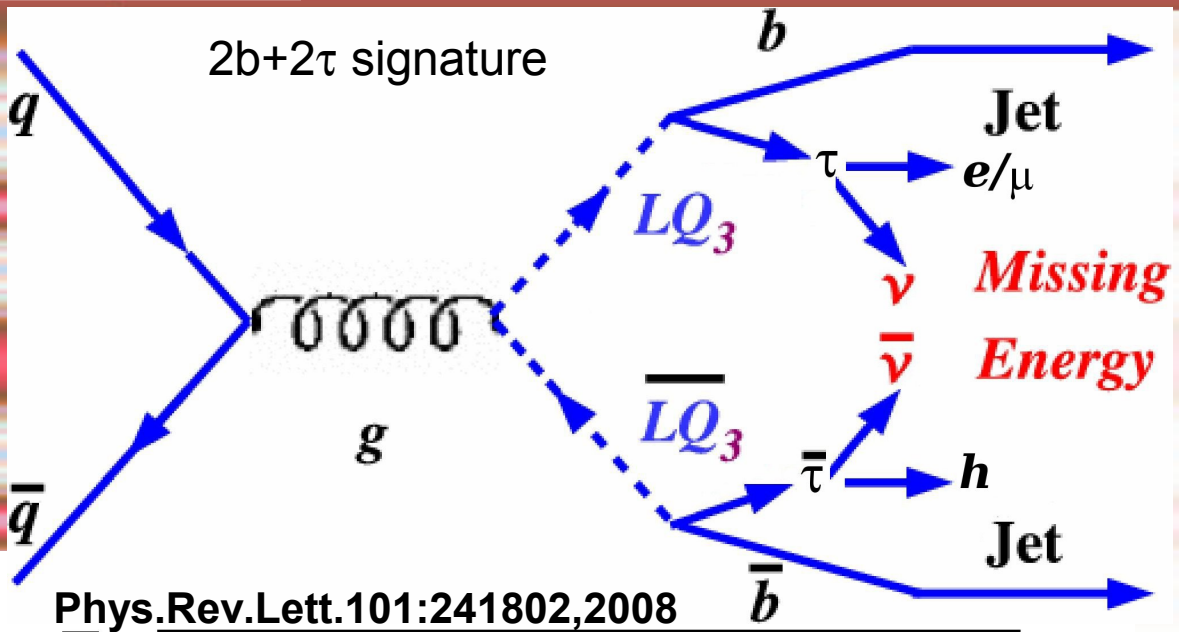
M_{LQ} > 247 GeV

Taking into account BR(LQ → tτ) = 0.5*phase space D0 sets a limit at 234 GeV

arXiv:1005.2222 [hep-ex]
Submitted to Phys. Lett. B

(same analysis also interpreted in sbottom pair production)

LQ → bτ

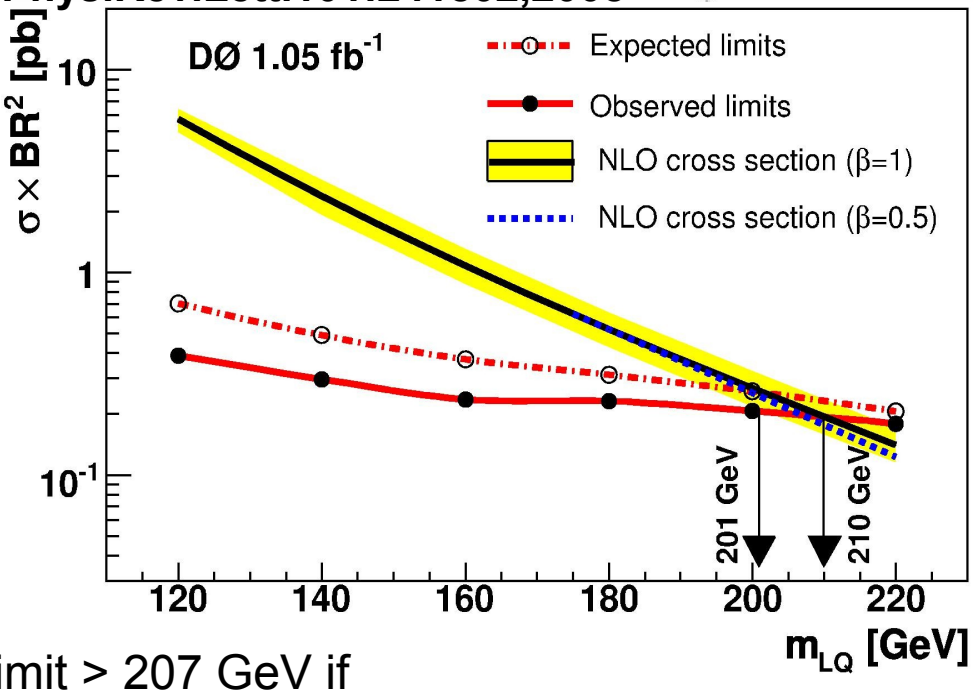


D0 : only muon case.

CDF no use of b-tag
CDF result valid for LQ → qτ

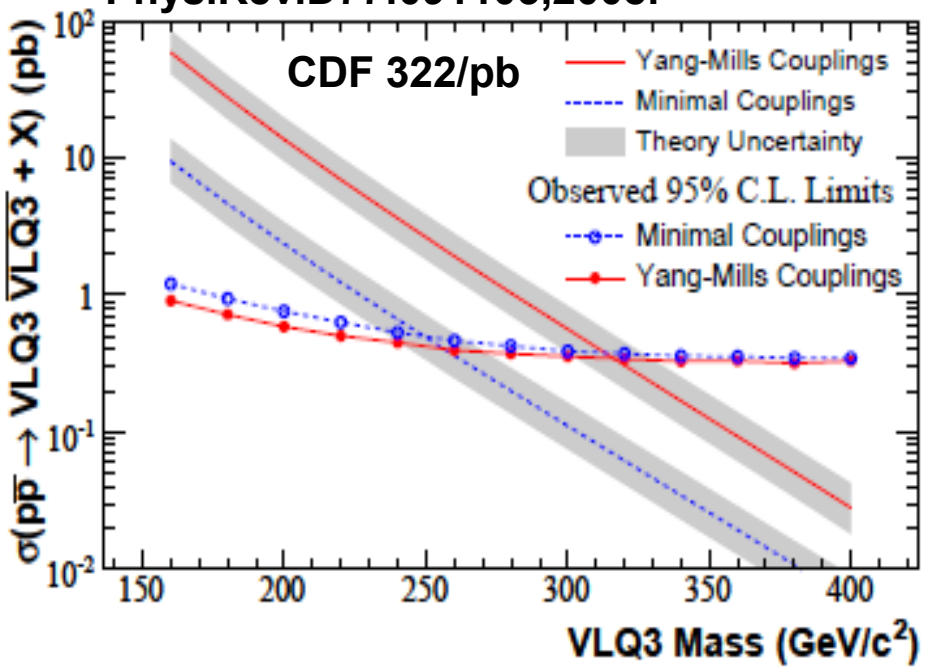
CDF :
only vector LQ lower mass limits :
>251 GeV (κ_G=1 and λ_G=0)
>317 GeV (κ_G=0 and λ_G=0)

Phys.Rev.Lett.101:241802,2008



Limit > 207 GeV if
BR(LQ → tν$_\tau$) = 0.5*Phase Space

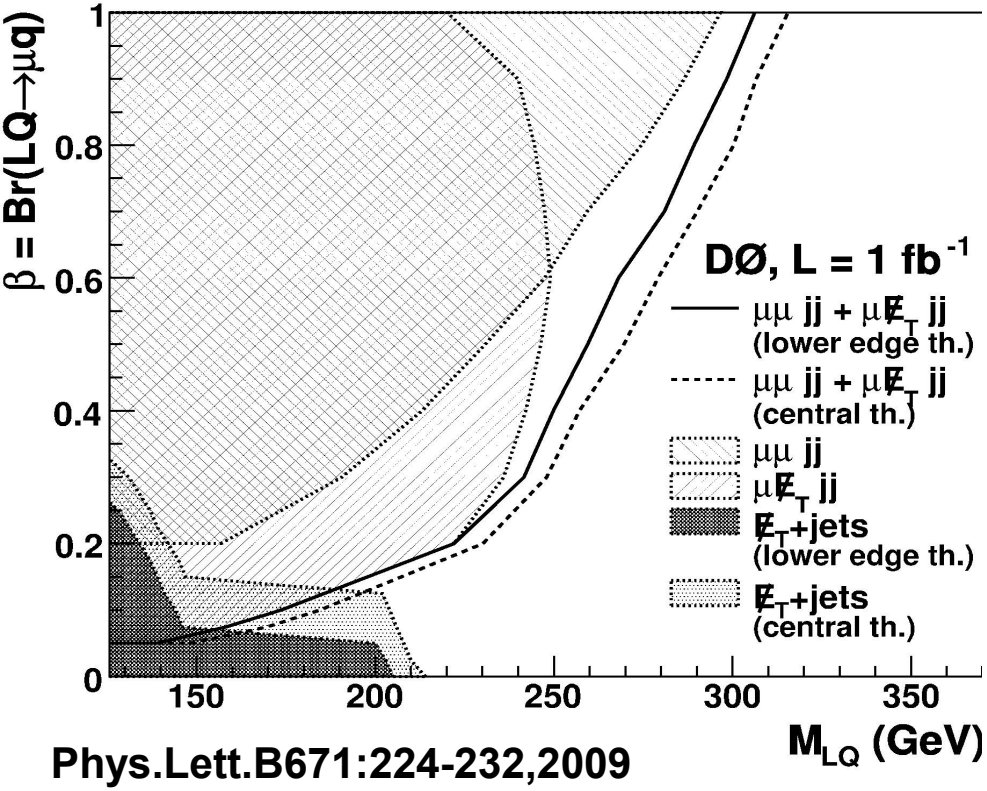
Phys.Rev.D77:091105,2008.



LQ → qμ or qe with LQ → qν

μ+MET+2jets and 2μ+2jets signatures

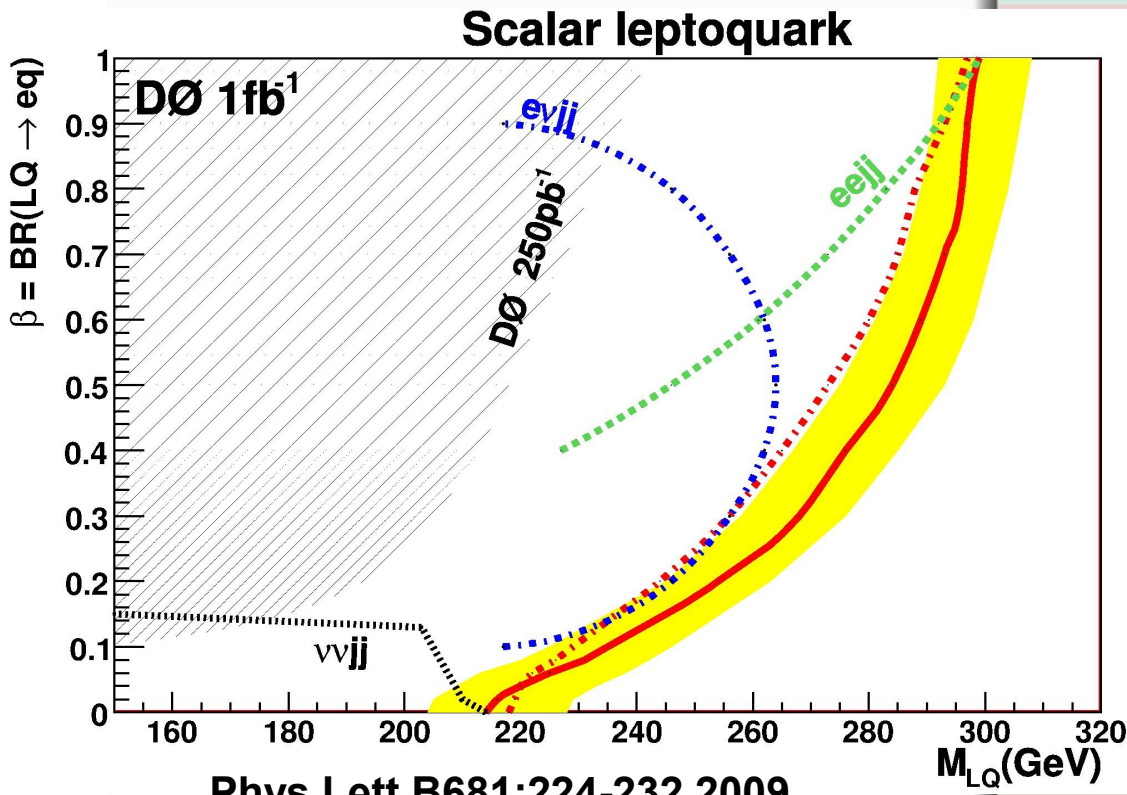
Mass limit for BR(LQ → μq)=1 : 316 GeV



Phys.Lett.B671:224-232,2009

e+MET+2jets and 2e+2jets signatures

for BR(LQ → eq)=1 : 299 GeV



Phys.Lett.B681:224-232,2009

Technicolor

From C. Amsler et al. (Particle Data Group), Physics Letters B667, 1 (2008) and 2009 partial update for the 2010 edition

Process	Excluded mass range	Decay channels
$p\bar{p} \to \rho_T \to W\pi_T$	$170 < m_{\rho_T} < 215$ GeV and $80 < m_{\pi_T} < 115$ GeV for $M_V = 500$ GeV	$\rho_T \to W\pi_T$ $\pi_T^0 \to b\bar{b}$ $\pi_T^\pm \to b\bar{c}$
$p\bar{p} \to \omega_T \to \gamma\pi_T$	$140 < m_{\omega_T} < 290$ GeV for $m_{\pi_T} \approx m_{\omega_T}/3$ and $M_T = 100$ GeV	$\omega_T \to \gamma\pi_T$ $\pi_T^0 \to b\bar{b}$ $\pi_T^\pm \to b\bar{c}$
$p\bar{p} \to \omega_T/\rho_T$	$m_{\omega_T} = m_{\rho_T} < 203$ GeV for $m_{\omega_T} < m_{\pi_T} + m_W$ or $M_T > 200$ GeV	$\omega_T/\rho_T \to \ell^+\ell^-$
	$m_{\omega_T} = m_{\rho_T} < 280$ GeV for $m_{\omega_T} < m_{\pi_T} + m_W$ or $M_T > 500$ GeV	$\omega_T/\rho_T \to \ell^+\ell^-$
$e^+e^- \to \omega_T/\rho_T$	$90 < m_{\rho_T} < 206.7$ GeV $m_{\pi_T} < 79.8$ GeV	$\rho_T \to WW$, $W\pi_T$, $\pi_T\pi_T$, $\gamma\pi_T$, hadrons
$p\bar{p} \to \rho_{T8}$	$260 < m_{\rho_{T8}} < 480$ GeV	$\rho_{T8} \to q\bar{q}$, gg
$p\bar{p} \to \rho_{T8} \to \pi_{LQ}\pi_{LQ}$	$m_{\rho_{T8}} < 510$ GeV	$\pi_{LQ} \to c\nu$
	$m_{\rho_{T8}} < 600$ GeV	$\pi_{LQ} \to b\nu$
	$m_{\rho_{T8}} < 465$ GeV	$\pi_{LQ} \to \tau q$
$p\bar{p} \to g_t$	$0.3 < m_{g_t} < 0.6$ TeV for $0.3m_{g_t} < \Gamma < 0.7m_{g_t}$	$g_t \to b\bar{b}$
$p\bar{p} \to Z'$	$m_{Z'} < 480$ GeV for $\Gamma = 0.012m_{Z'}$	$Z' \to t\bar{t}$
	$m_{Z'} < 780$ GeV for $\Gamma = 0.04m_{Z'}$	

New signal $\rho_T \to WZ$ by DØ

DØ update by CDF

CDF

DØ

CDF Analysis updated but no technicolor interpretation

CDF update by CDF

CDF

CDF

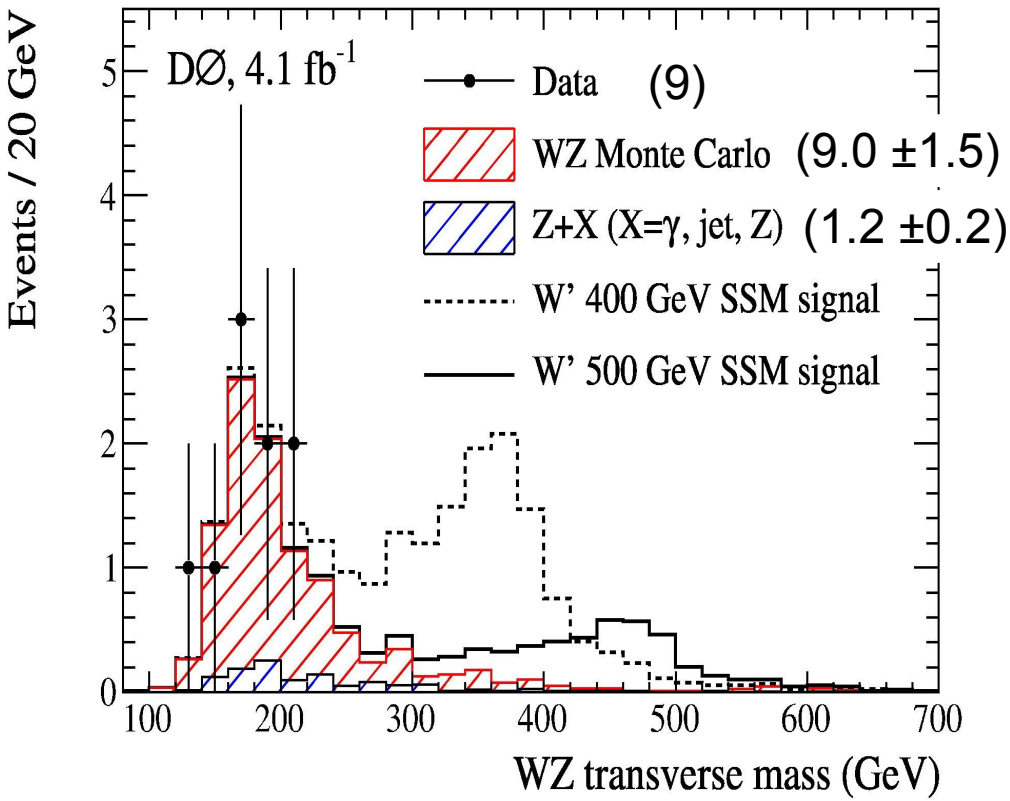
CDF update by CDF DØ

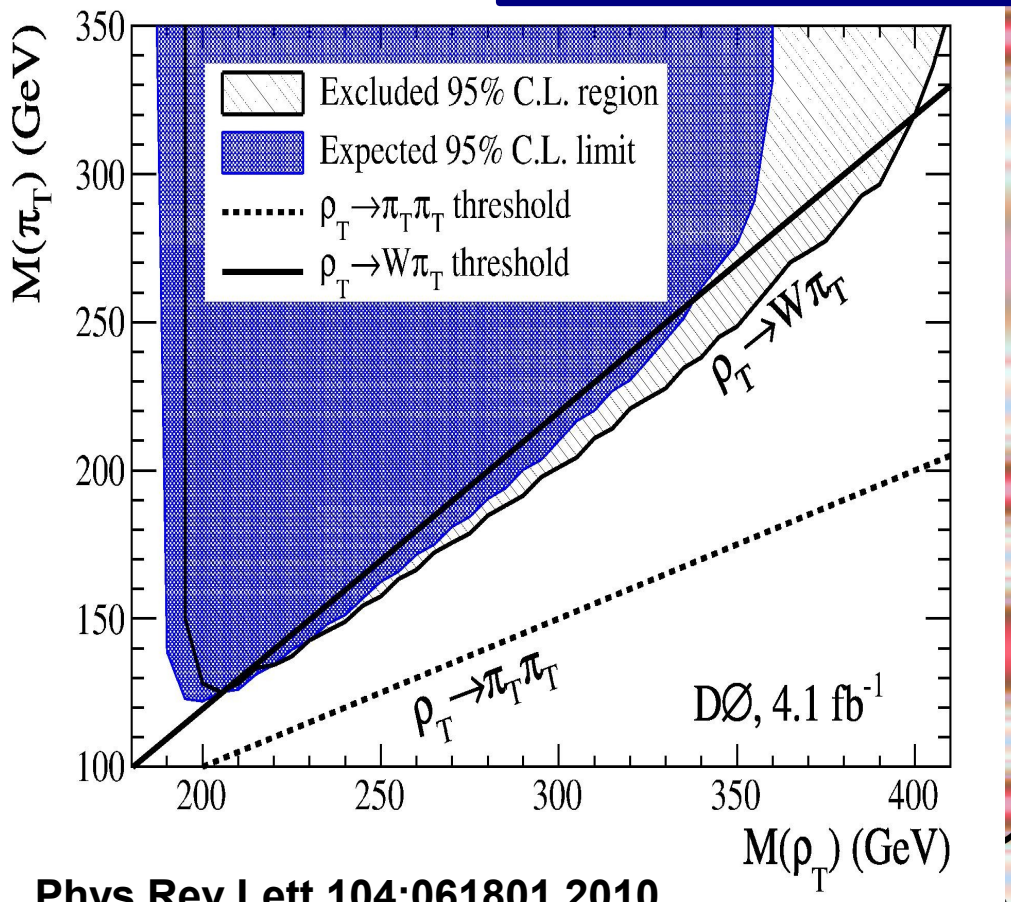
$\rho_T \rightarrow WZ$

Look for WZ production with W and Z decaying to electron or muon.

Select events with MET> 30 GeV and >=3 electron/muon with Pt>20 GeV.
Electron $|\eta|<1.1$ or $1.5<|\eta|<2.5$ and muon $|\eta|<2$
First select Z with opposite charge electron or muon pairs.
$80 < M_{ee} < 102$ GeV and $70 < M_{\mu\mu} < 110$ GeV
Then select highest Pt remaining lepton + MET to form W candidate.
Discriminate signal with WZ transverse mass.

95% CL exclusion
$208<M(\rho_T)<408$ GeV
for $M(\rho_T) < M(\pi_T) + M(W)$





Phys.Rev.Lett.104:061801,2010

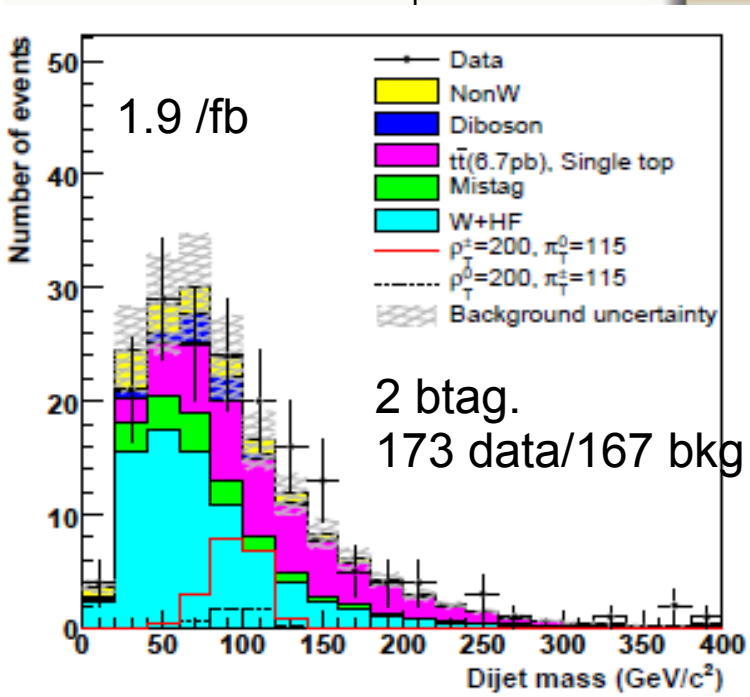
$\rho_T \rightarrow W\pi_T$

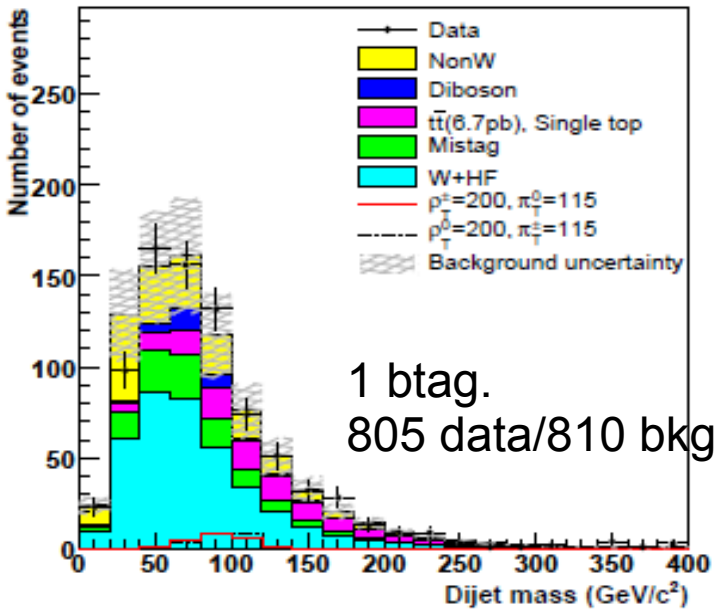
Select events with MET> 20 GeV
exactly 1 electron/muon with Pt>20 GeV.
Electron $|\eta|<1.1$ and muon $|\eta|<1.0$
Reject events where lepton+track mass $76 < M_{ll} < 106$ GeV

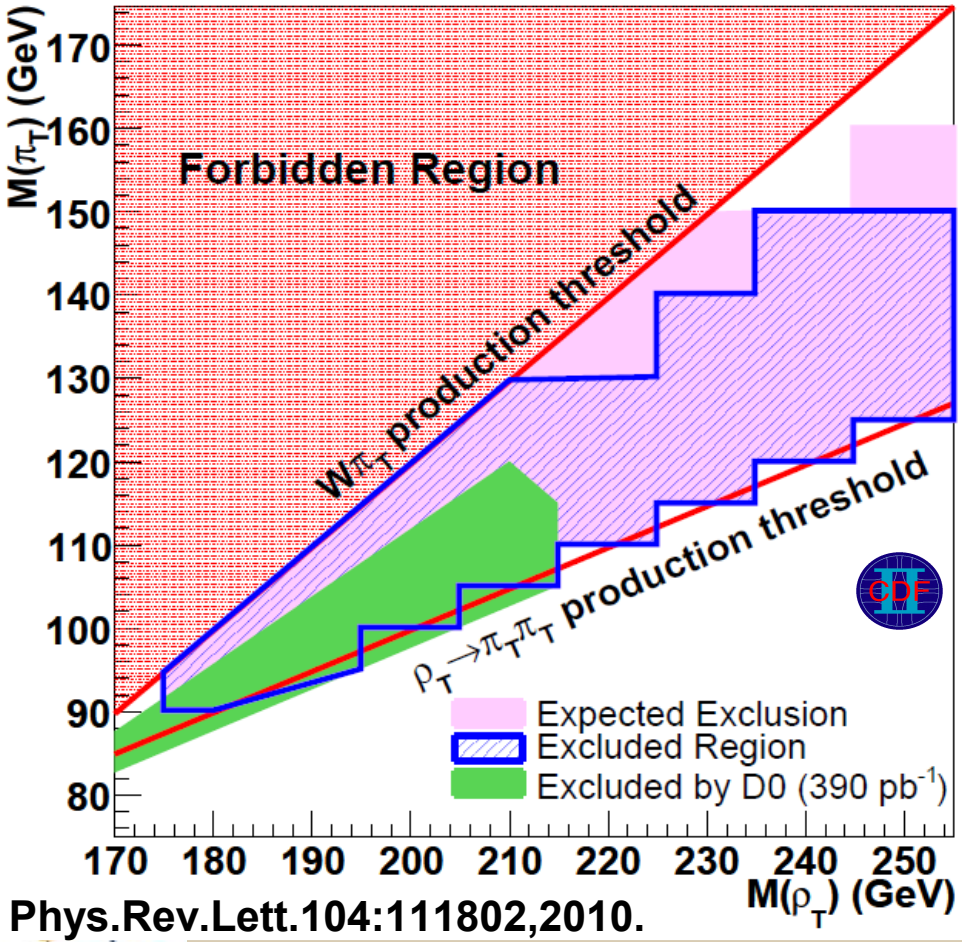
>=2 jets, Pt>20 GeV, $|\eta|<2.0$ with 1 or 2 b-tag.
Constrain lepton+MET to form W mass (ν P_z).

Discriminating variables : dijet mass and $M(\rho_T)$-$M(\pi_T)$-$M(W)$.

$W \rightarrow (\mu/e)\nu$ and $\pi_T \rightarrow b\bar{b}/b\bar{c}/b\bar{u}$





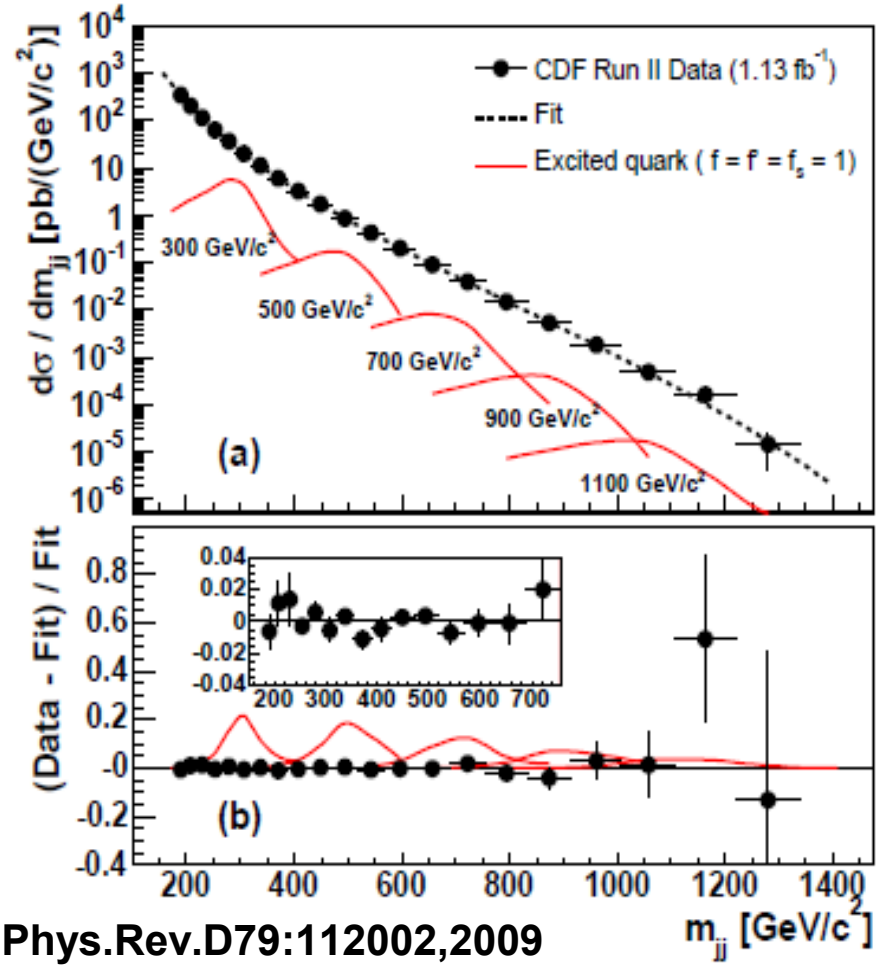


Phys.Rev.Lett.104:111802,2010.

Resonances

CDF-detector level fit of the di-jet mass distribution.

$$\frac{d\sigma}{dm} = p_0(1-x)^{p1} / x^{p2+p3\log(x)}, \quad x = m/\sqrt{s}$$



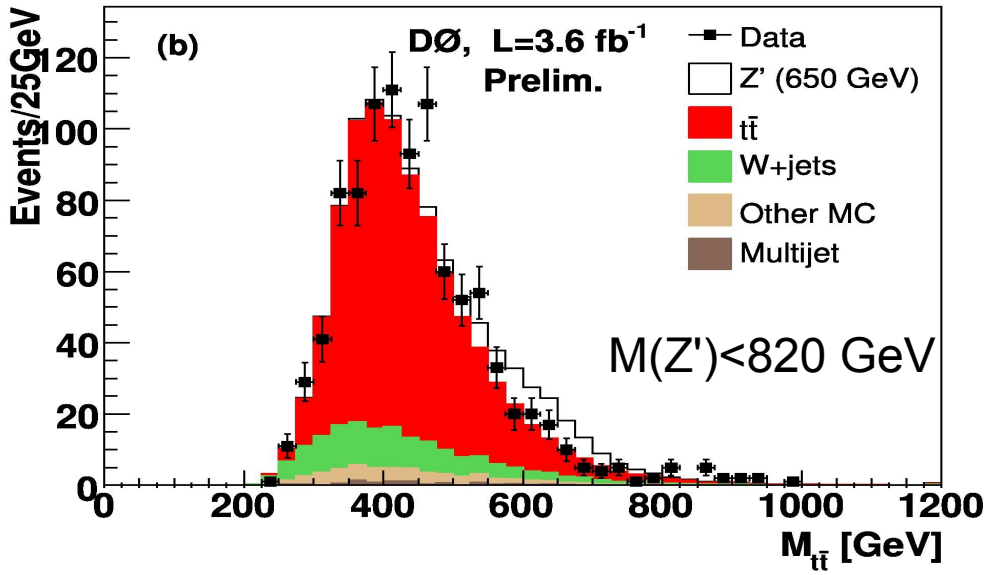
Phys.Rev.D79:112002,2009

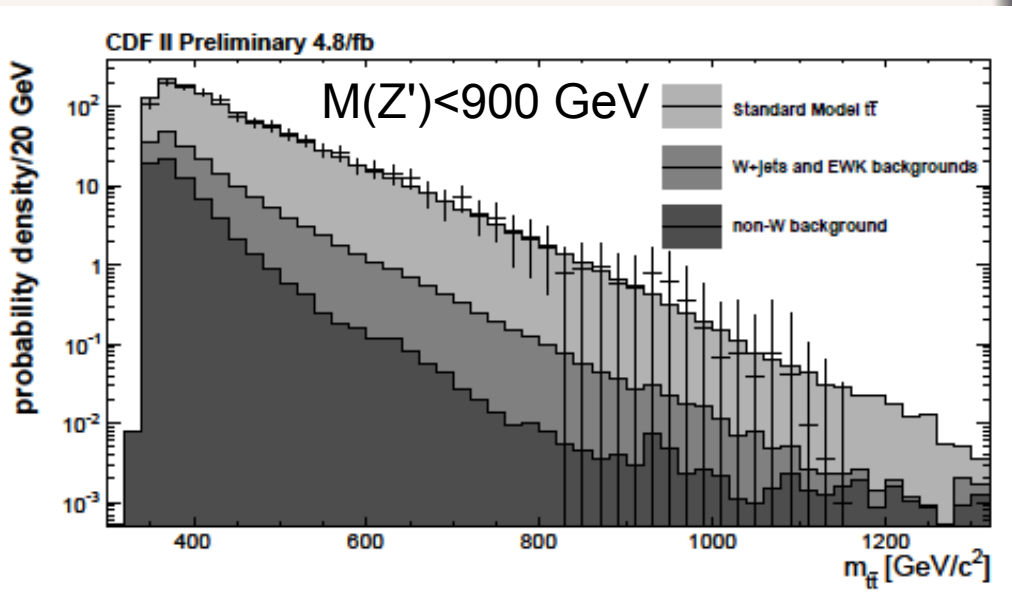
color-octet ρ_{T8} 95% CL mass exclusion

260 < m < 1100 GeV

$t\bar{t}$ resonance searched in semi-leptonic mode

See Nathan Goldschmidt's talk yesterday.





Summary of results

95% CL lower mass limits for scalar leptoquarks in lepton+quarks with BR=100%

LQ → e+q with q=u,d,s,c,b : M_{LQ} > 299 GeV D0 with 1/fb

LQ → μ+q with q=u,d,s,c,b : M_{LQ} > 316 GeV D0 with 1/fb

LQ → τ+q with q=u,d,s,c : no scalar mass limits,
Vector M_{LQ} > 251 GeV CDF with 322/pb

LQ → τ+b : M_{LQ} > 210 GeV D0 with 1.05/fb

LQ → ν+q with q=u,d,s,c : M_{LQ} > 214 GeV D0 with 2.5/fb

LQ → ν+b : M_{LQ} > 247 GeV D0 with 5.2/fb

No direct searches for LQ → t+ν, t+e, t+μ and t+τ.

Technicolor updated 95% CL exclusion domains

208<$M(\rho_T)$<408 GeV for $M(\rho_T) < M(\pi_T) + M(W)$ (D0 $\rho_T \rightarrow$ WZ trilepton with 4.1/fb)

180<$M(\rho_T)$<250 GeV and 95<$M(\pi_T)$<145 GeV (CDF $\rho_T \rightarrow W\pi_T$ with 1.9/fb)

260< $m_{\rho T8}$ < 1100 GeV (CDF dijet resonance with 1.13/fb)

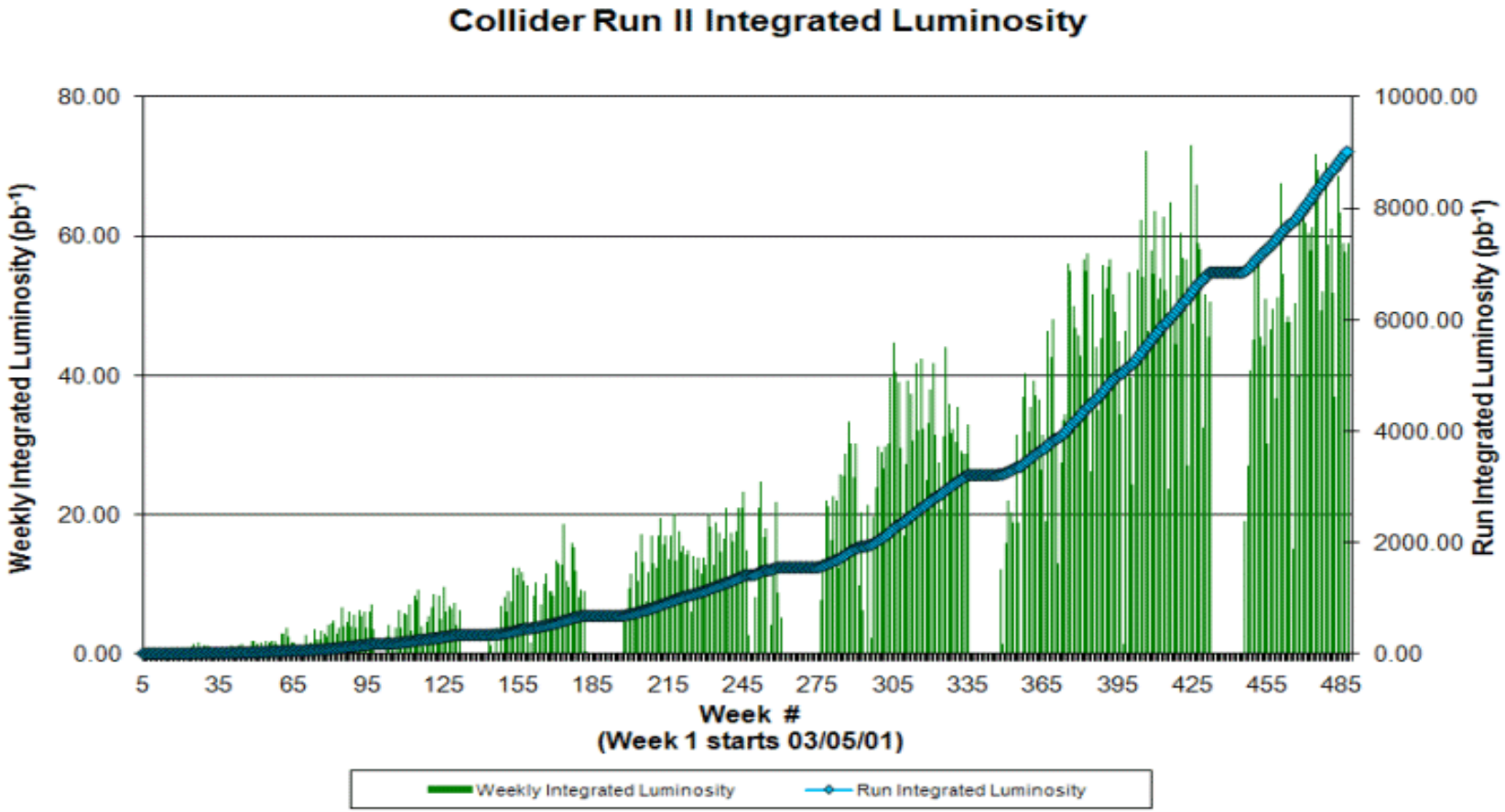
m(Z')<900 GeV (CDF $t\bar{t}$ resonance with 4.8/fb)

Conclusion

No sign of leptoquarks nor technicolor at the TeVatron so far.

Signals have been searched for in a wide range of final states

95% CL exclusion domains have been extended but there is still room for further searches.



Backup

Technicolor

From particle data group review.

Process	Excluded mass range	Decay channels
$p\bar{p} \to \rho_T \to W\pi_T$	$170 < m_{\rho_T} < 215$ GeV and $80 < m_{\pi_T} < 115$ GeV for $M_V = 500$ GeV	$\rho_T \to W\pi_T$ $\pi_T^0 \to b\bar{b}$ $\pi_T^\pm \to b\bar{c}$
$p\bar{p} \to \omega_T \to \gamma\pi_T$	$140 < m_{\omega_T} < 290$ GeV for $m_{\pi_T} \approx m_{\omega_T}/3$ and $M_T = 100$ GeV	$\omega_T \to \gamma\pi_T$ $\pi_T^0 \to b\bar{b}$ $\pi_T^\pm \to b\bar{c}$
$p\bar{p} \to \omega_T/\rho_T$	$m_{\omega_T} = m_{\rho_T} < 203$ GeV for $m_{\omega_T} < m_{\pi_T} + m_W$ or $M_T > 200$ GeV	$\omega_T/\rho_T \to \ell^+\ell^-$
	$m_{\omega_T} = m_{\rho_T} < 280$ GeV for $m_{\omega_T} < m_{\pi_T} + m_W$ or $M_T > 500$ GeV	$\omega_T/\rho_T \to \ell^+\ell^-$
$e^+e^- \to \omega_T/\rho_T$	$90 < m_{\rho_T} < 206.7$ GeV $m_{\pi_T} < 79.8$ GeV	$\rho_T \to WW$, $W\pi_T$, $\pi_T\pi_T$, $\gamma\pi_T$, hadrons
$p\bar{p} \to \rho_{T8}$	$260 < m_{\rho_{T8}} < 480$ GeV	$\rho_{T8} \to q\bar{q}$, gg
$p\bar{p} \to \rho_{T8}$ $\to \pi_{LQ}\pi_{LQ}$	$m_{\rho_{T8}} < 510$ GeV	$\pi_{LQ} \to c\nu$
	$m_{\rho_{T8}} < 600$ GeV	$\pi_{LQ} \to b\nu$
	$m_{\rho_{T8}} < 465$ GeV	$\pi_{LQ} \to \tau q$
$p\bar{p} \to g_t$	$0.3 < m_{g_t} < 0.6$ TeV for $0.3m_{g_t} < \Gamma < 0.7m_{g_t}$	$g_t \to b\bar{b}$
$p\bar{p} \to Z'$	$m_{Z'} < 480$ GeV for $\Gamma = 0.012m_{Z'}$	$Z' \to t\bar{t}$
	$m_{Z'} < 780$ GeV for $\Gamma = 0.04m_{Z'}$	

$180 < m_{\rho T} < 250$ GeV
and $95 < m_{\pi T} < 145$ GeV
(CDF with 1.9 /fb)

New
$208 < M(\rho_T) < 408$ GeV
for $M(\rho_T) < M(\pi_T) + M(W)$
(D0 with 4.1 /fb)

$260 < m_{\rho T8} < 1100$ GeV (CDF with 1.13 /fb)

m(Z')<720 GeV (CDF with 0.955 /fb)
<820 GeV (D0 with 3.6 /fb)