New Physics Searches at the Tevatron in 2015

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It is hard to compete with the LHC!

(and even harder with LHC+ILC...)

Still, the Tevatron has smaller backgrounds and more $\bar{q}$ per collision.

$\rightarrow$ there are some examples of physics beyond the standard model where the Tevatron would be useful after the LHC.

Warning: **It is hard to say at this point how likely these scenarios are.**

Light Stop in the MSSM

Demina, Lykken, Matchev, Nomerotski, hep-ph/9910275

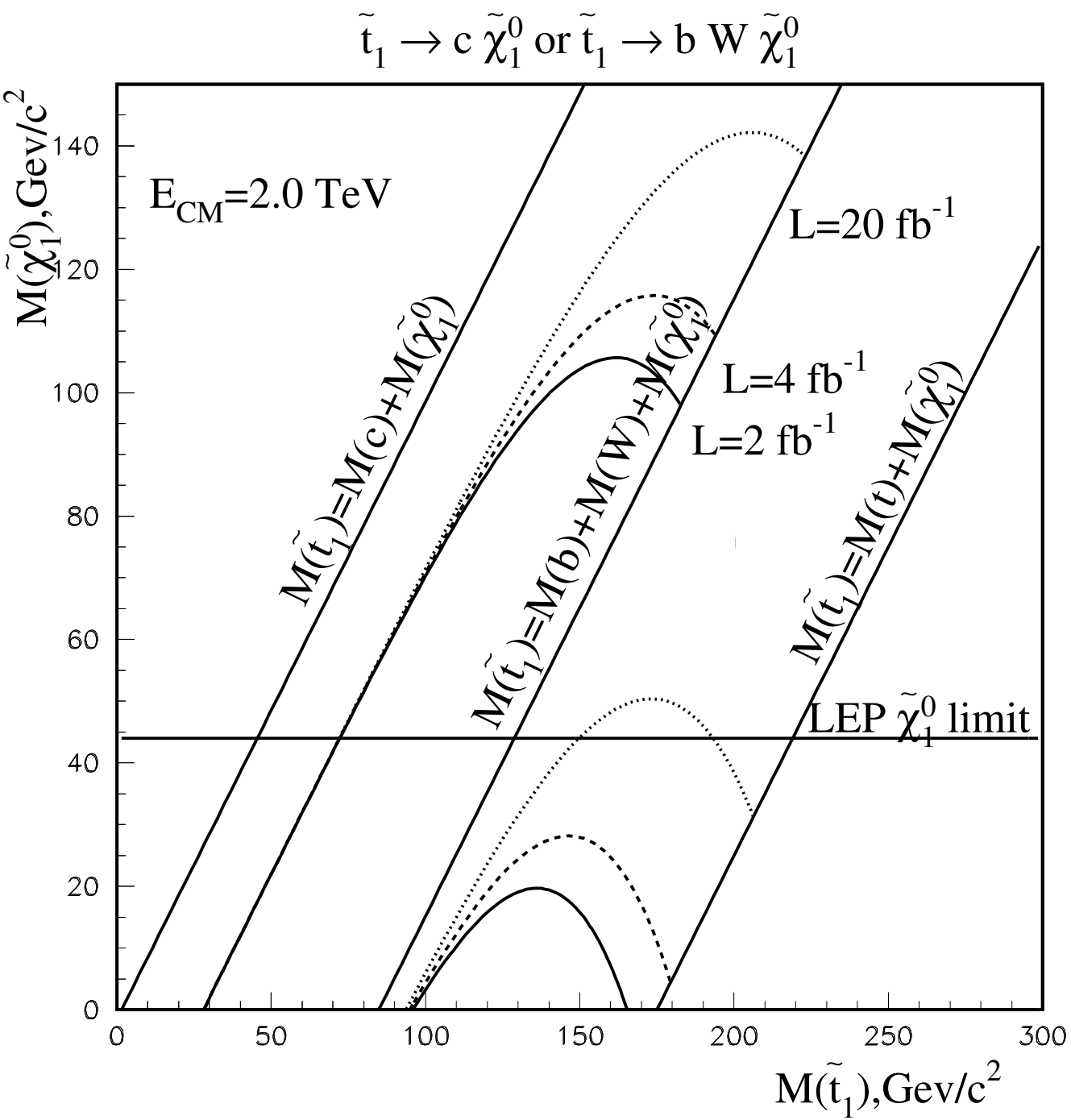
Typically: $\tilde{t} \to t\chi_1^0$

For $m_{\tilde{t}} < m_t + m_\chi$**:**

$\tilde{t} \to c\chi_1^0$ **is the dominant decay mode**

Stop searches in Run II: $\tilde{t}\tilde{t}^\star \to c\bar{c}\not{E}_T$

Challenging at the LHC because of large backgrounds.


$\tilde{t}_1 \to c\,\tilde{\chi}_1^0$ or $\tilde{t}_1 \to b\,W\,\tilde{\chi}_1^0$
E_{CM}=2.0 TeV
L=20 fb^{-1}
L=4 fb^{-1}
L=2 fb^{-1}
$M(\tilde{t}_1)=M(c)+M(\tilde{\chi}_1^0)$
$M(\tilde{t}_1)=M(b)+M(W)+M(\tilde{\chi}_1^0)$
$M(\tilde{t}_1)=M(t)+M(\tilde{\chi}_1^0)$
LEP $\tilde{\chi}_1^0$ limit
$M(\tilde{\chi}_1^0)$,Gev/c^2
$M(\tilde{t}_1)$,Gev/c^2
0
20
40
60
80
100
120
140
0
50
100
150
200
250
300

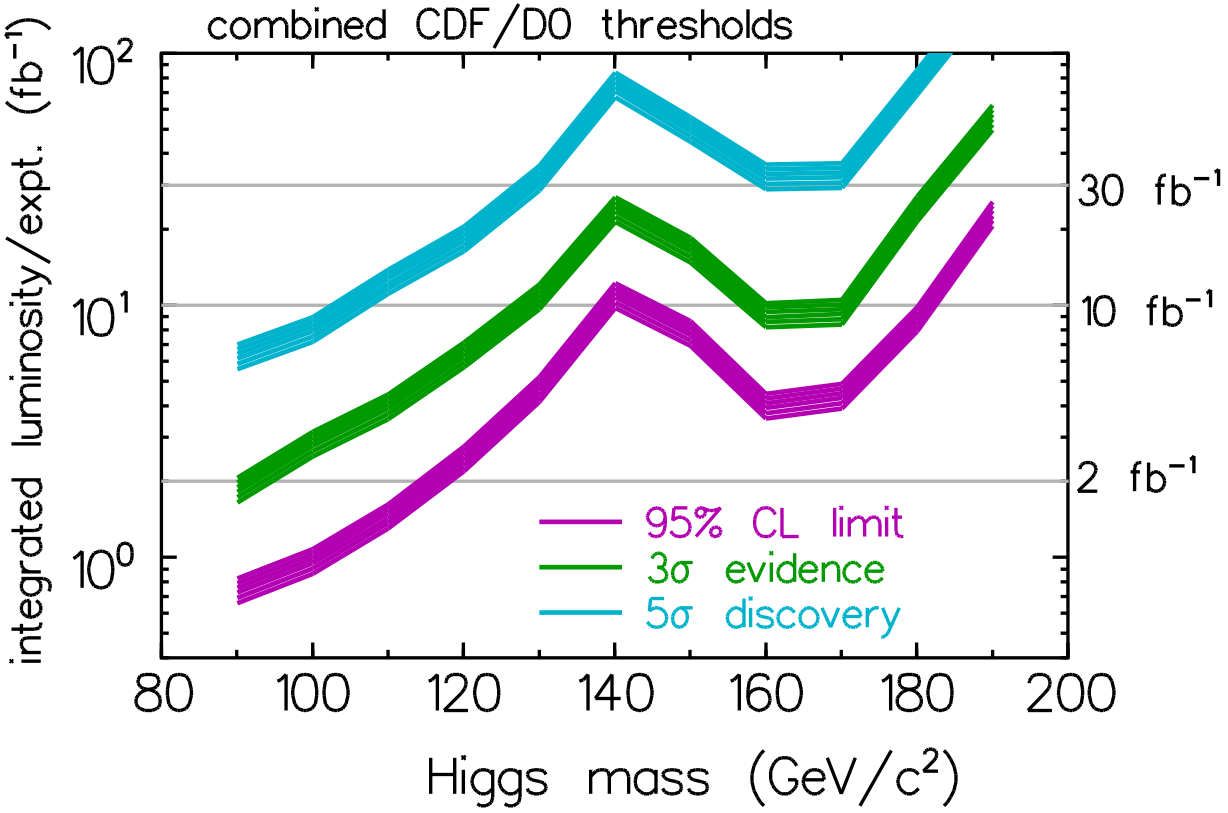
Higgs bosons

For 115 GeV $< M_h <$ 130 GeV:

the Tevatron may measure the $h\bar{b}b$ coupling

Associated production ($q\bar{q} \to W^* \to hW$) with $h \to \bar{b}b$

At the LHC: huge $\bar{b}b$ background.


combined CDF/D0 thresholds
integrated luminosity/expt. (fb^{-1})
10^2
10^1
10^0
30 fb^{-1}
10 fb^{-1}
2 fb^{-1}
95% CL limit
3σ evidence
5σ discovery
80
100
120
140
160
180
200
Higgs mass (GeV/c^2)

Z' bosons

M. Carena, A. Daleo, B. Dobrescu, T. Tait: hep-ph/0408098

New $U(1)_z$ gauge symmetry

Assume:

- **generation-independent charges**
- **quark masses from standard model Yukawa couplings**
- **no gauge anomalies**

Fermion gauge charges:

	$SU(3)$	$SU(2)$	$U(1)_Y$	$U(1)_{B-xL}$	$U(1)_{q+xu}$	$U(1)_{10+x\bar{5}}$	$U(1)_{d-xu}$
q_L	3	2	$1/3$	$1/3$	$1/3$	$1/3$	0
u_R	3	1	$4/3$	$1/3$	$x/3$	$-1/3$	$-x/3$
d_R	3	1	$-2/3$	$1/3$	$(2-x)/3$	$-x/3$	$1/3$
l_L	1	2	-1	$-x$	-1	$x/3$	$(-1+x)/3$
e_R	1	1	-2	$-x$	$-(2+x)/3$	$-1/3$	$x/3$
ν_R	1	1	0	-1	$(-4+x)/3$	$(-2+x)/3$	$-x/3$
ν'_R				·	·	$-1-x/3$	·
ψ^l_L	1	2	-1	-1	·	$-(1+x)/3$	$-2x/5$
ψ^l_R				$-x$	·	$2/3$	$(-1+x/5)/3$
ψ^e_L	1	1	-2	-1	·	·	·
ψ^e_R				$-x$	·	·	·
ψ^d_L	3	1	$-2/3$	·	·	$-2/3$	$(1-4x/5)/3$
ψ^d_R				·	·	$(1+x)/3$	$x/15$

In general: Z' **mixes with** Z

$$\Rightarrow \textbf{LEP I requires } M_{Z'} \gtrsim 2\ \mathrm{TeV}$$

Special case: $SU(3)_C \times SU(2)_W \times U(1)_Y \times U(1)_{B-L}$

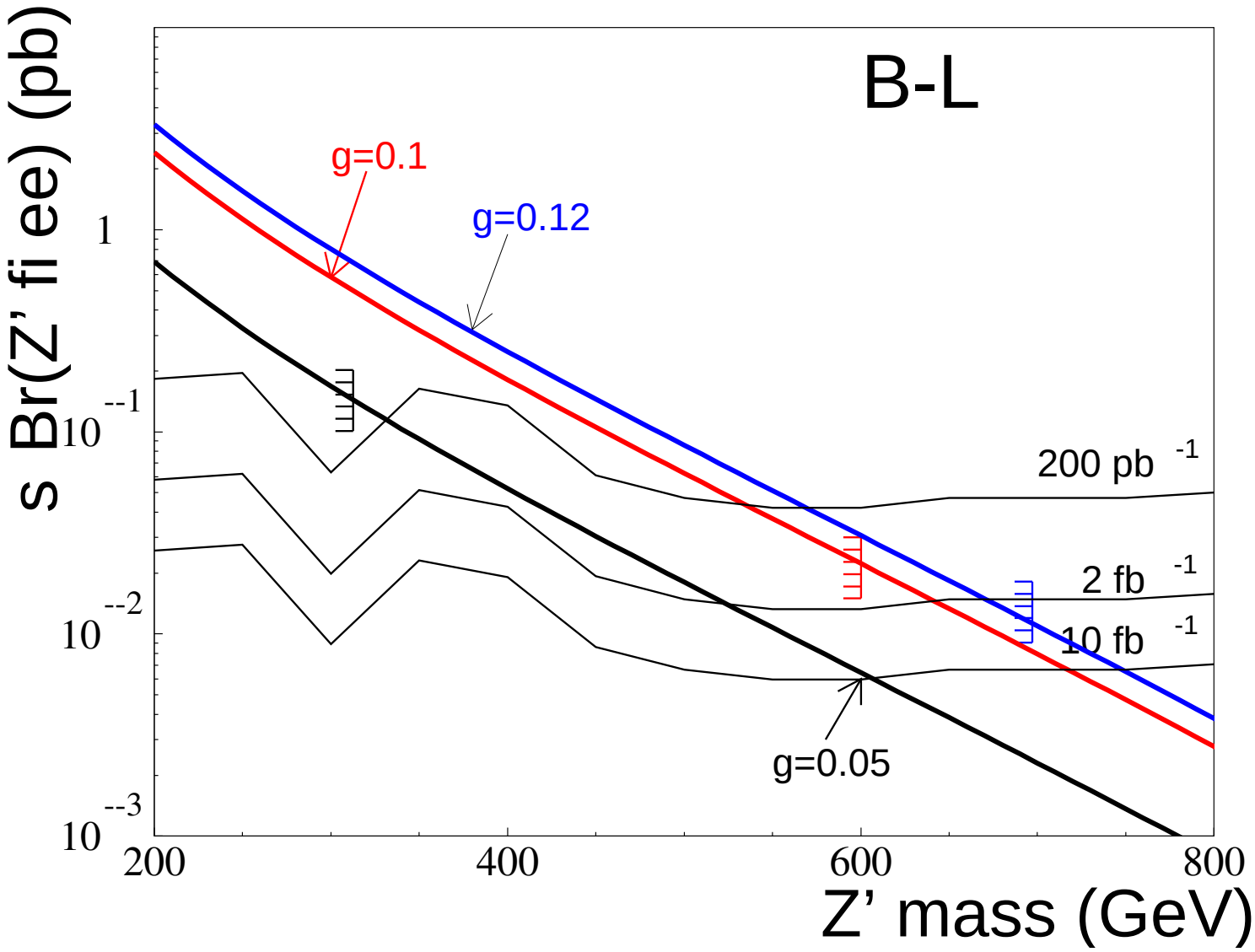
$$z_q = z_u = z_d = -\frac{z_l}{3} = -\frac{z_e}{3} = -\frac{z_\nu}{3} \quad \Longrightarrow \quad z_H = 0$$

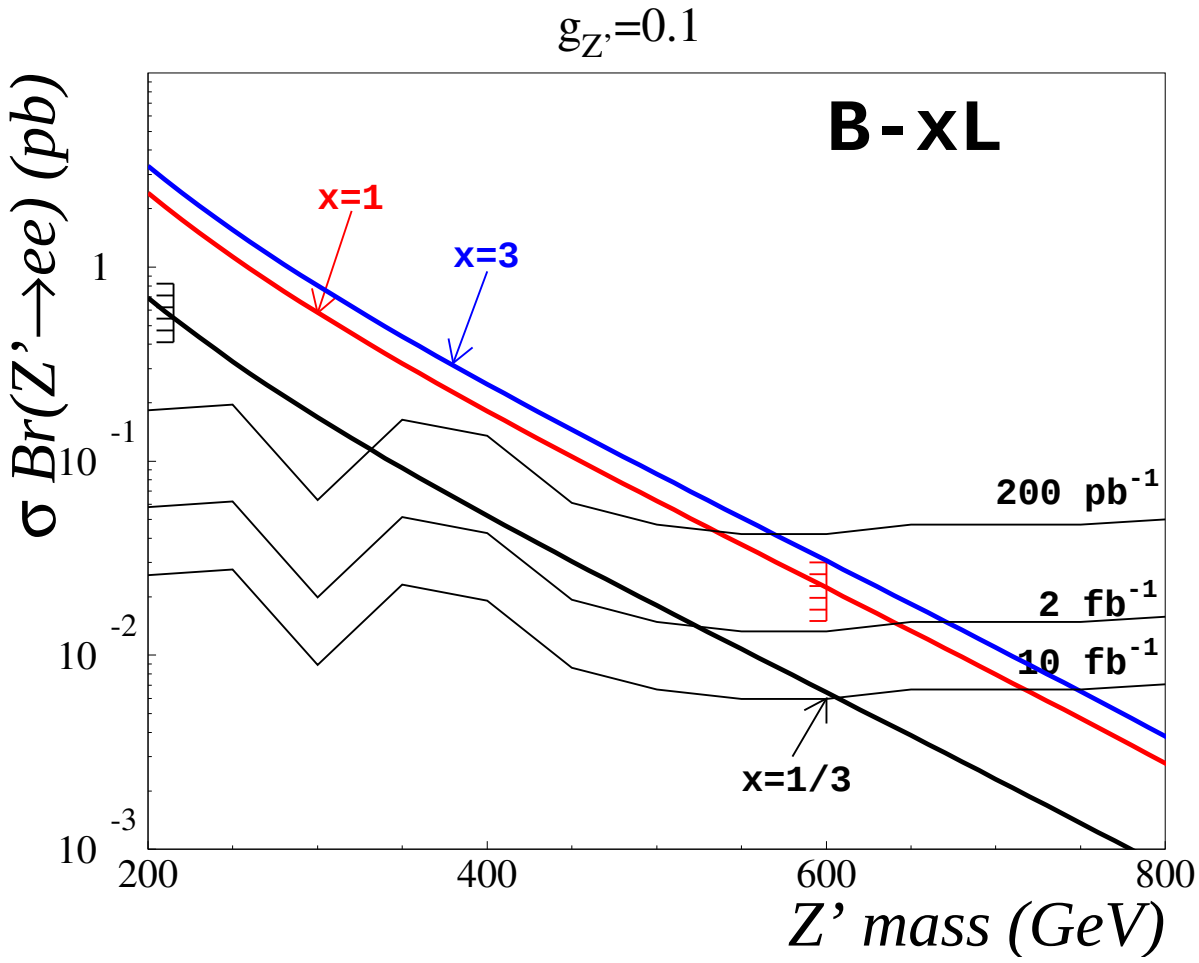
No Z_{B-L}**-**Z **mixing at tree level!**

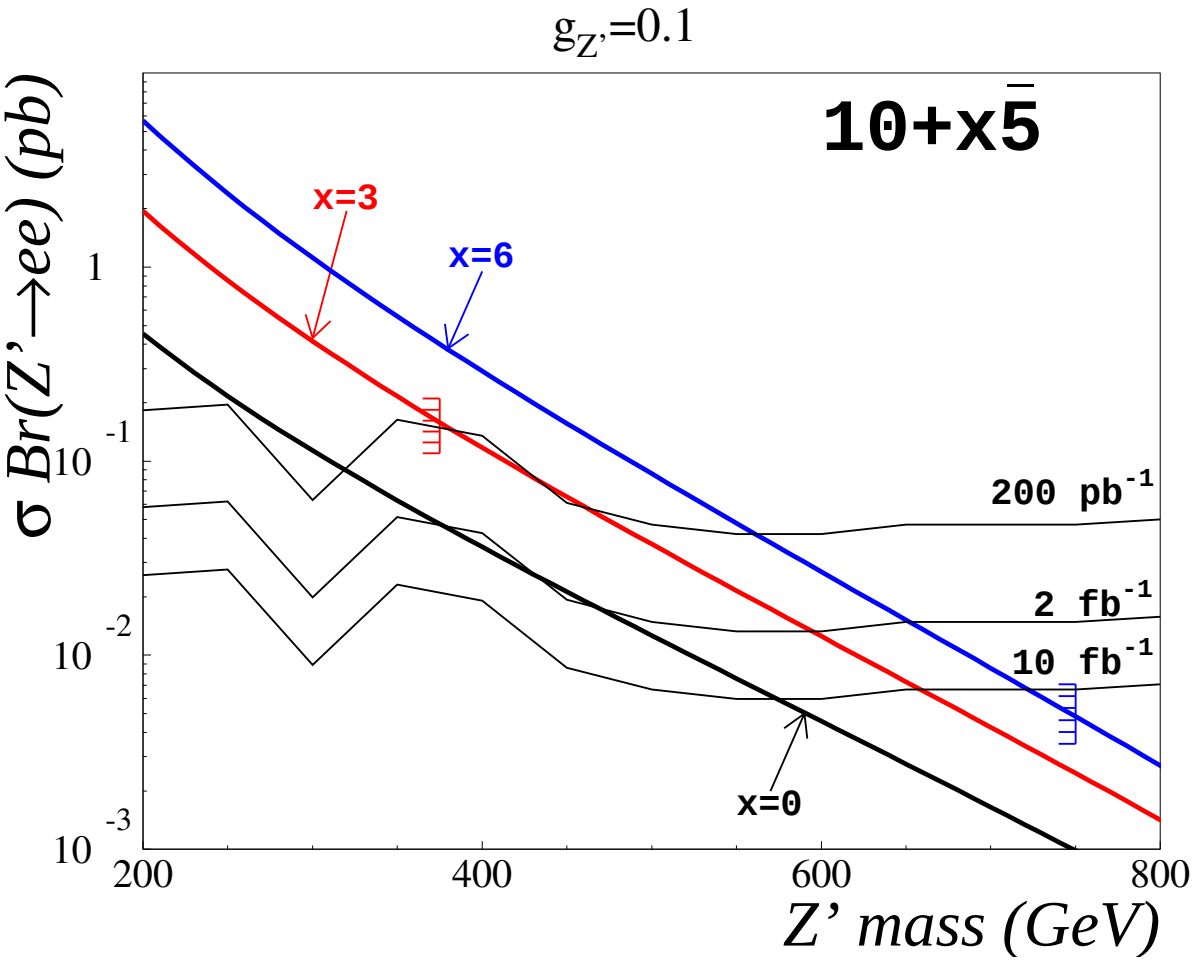
Best bounds on $z_l g_z$ *come from limits on direct production at the Tevatron and at LEP II*

$$\sigma^{Z'} = \frac{\pi}{48\,s}\, W_{Z'}\left(\frac{M^2_{Z'}}{s}, M^2_{Z'}\right)\ \mathrm{Br}(Z' \to l^+ l^-)\,,$$

Z' searches at the Tevatron:




$g_{Z'}$=0.1
B-xL
x=1
x=3
x=1/3
200 pb^{-1}
2 fb^{-1}
10 fb^{-1}
σ Br(Z'→ee) (pb)
Z' mass (GeV)
1
10^{-1}
10^{-2}
10^{-3}
200
400
600
800

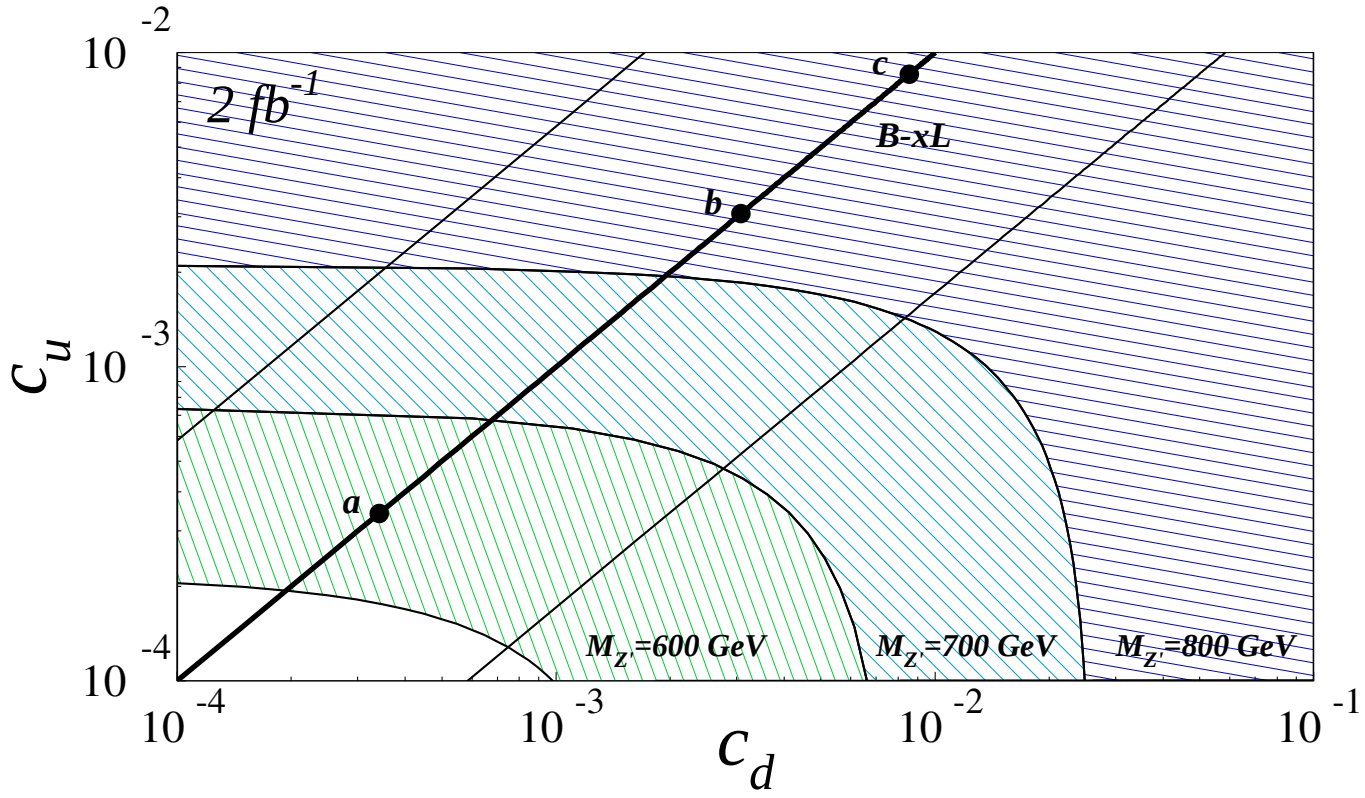

$g_{Z'}$=0.1
10+x$\bar{5}$
x=3
x=6
x=0
200 pb^{-1}
2 fb^{-1}
10 fb^{-1}
σ Br(Z'→ee) (pb)
1
10^{-1}
10^{-2}
10^{-3}
200
400
600
800
Z' mass (GeV)

A user-friendly parametrization:

$$\sigma^{Z'} = \frac{\pi}{48\,s}\left[c_u\,w_u\left(\frac{M^2_{Z'}}{s}, M^2_{Z'}\right) + c_d\,w_d\left(\frac{M^2_{Z'}}{s}, M^2_{Z'}\right)\right]$$

$$\begin{aligned} w_{u(d)} = \sum_q \int_0^1 dx_1\,dx_2\,dz\,\{ & f_{q/P}(x_1, M^2_{Z'})\,f_{\bar{q}/\bar{P}}(x_2, M^2_{Z'})\,\Delta_{qq}(z, M^2_{Z'}) \\ & + f_{g/P}(x_1, M^2_{Z'})\,(f_{q/\bar{P}}(x_2, M^2_{Z'}) + f_{\bar{q}/\bar{P}}(x_2, M^2_{Z'}))\,\Delta_{gq}(z, M^2_{Z'}) \\ & + (x_1 \leftrightarrow x_2, P \leftrightarrow \bar{P})\}\,\delta\left(\frac{M^2_{Z'}}{s} - x\,x_1\,x_2\right) \end{aligned}$$

$$c_{u,d} = g_z^2\,(z_q^2 + z_{u,d}^2)\,\mathrm{Br}(Z' \to l^+ l^-)$$


10^{-2}
10^{-3}
10^{-4}
c_u
$2\ fb^{-1}$
c
B-xL
b
a
$M_{Z'}$=600 GeV
$M_{Z'}$=700 GeV
$M_{Z'}$=800 GeV
10^{-4}
10^{-3}
10^{-2}
10^{-1}
c_d

Leptophobic Z', *e.g.*, $U(1)_B$

- No significant bound from LEP or ILC
- LHC has large dijet background
- The Tevatron with high luminosity has probably the best chance of discovering a leptophobic Z'.

Conclusion

After the ATLAS and CMS will start presenting physics results it will be easier to guess what a high luminosity Tevatron will be able to do in 2015!

Bogdan Dobrescu (Fermilab)