Z'_{B-L} phenomenology at LHC and ILC

Elaine Cristina Ferreira Silva Fortes – Institute of Theoretical Physics- IFT/Unesp

In Collaboration with: Vicente Pleitez (IFT), J. C. Montero (IFT), Y. do A. Coutinho (UFRJ)

Introduction

- In this work we study the phenomenology of two models with $SU(2)_L \otimes U(1)_1 \otimes U(1)_2$ gauge symmetry for the colliders LHC and ILC. We will explore reactions like:
- ✓ $p + p \rightarrow \mu^+ \mu^- + X$
- ✓ $e^+ + e^- \rightarrow f\,\bar{f}$

- In order to perform these studies we will consider important observables for LHC as: total cross sections, number of events, forward-backward asymmetry, rapidity and transverse momentum distribution related to the final states. For ILC we will consider some asymmetry distributions.

The Models

- B-L Secluded: $SU(2)_L \otimes U(1)_Y \otimes U(1)_Z$
- B-L Flipped: $SU(2)_L \otimes U(1)_{Y'} \otimes U(1)_{B-L}$

Charge Operator	
B-L Secluded	B-L Flipped
$Q/e=I_3+Y/2$	$Q/e=I_3+1/2[Y'+(B-L)]$

- These models have two massive neutral vector bosons that will be denoted as Z_1 and Z_2 and their weak neutral currents will be parameterized as:

$$L^{NC} = -\frac{g}{2c_w}\sum \bar{\psi}_i \gamma_\mu \left[\left(g_V^i - g_A^i \gamma_5 \right) Z_1^\mu + \left(f_V^i - f_A^i \gamma_5 \right) Z_2^\mu \right] \psi_i$$

B-L Secluded Model

- In this model the masses of the neutral gauge bosons arise from the following terms in the covariant derivatives $z_\varphi = 2$

$$g^2 \frac{v^2}{8}\left(W_3^\mu - t_W B_Y^\mu - z_H t_Z B_Z^\mu\right)^2 + \frac{u^2}{8}\left(z_\varphi g_Z B_Z^\mu\right)^2 \qquad t_Z = \frac{g_Z}{g} \qquad t_W = \frac{g_Y}{g}$$

- In the basis W_3, B_Y and B_Z the mass square matrix for the three electrically neutral gauge bosons is:

$$M^2_{neutral} = \frac{g^2 u^2}{4}\begin{pmatrix} \bar{v}^2 & -t_W \bar{v}^2 & -2t_Z z_H \bar{v}^2 \\ -t_W \bar{v}^2 & t_W^2 \bar{v}^2 & 2t_W t_Z z_H \bar{v}^2 \\ -2t_Z z_H \bar{v}^2 & 2t_W t_Z z_H \bar{v}^2 & 4t_Z^2 (1 + z_H^2 \bar{v}^2) \end{pmatrix} \qquad g_Z > 0$$

B-L Flipped Model

- The masses of the neutral gauge bosons arise from the following terms in the covariant derivatives:

$$\frac{v^2}{8}\left(gW_3^\mu - g'B_{Y'}^\mu - g_{B-L}B_{B-L}^\mu\right)^2 + \frac{u^2}{8}\left(g'Y_\phi^{'}B_{Y'}^\mu - g_{B-L}Y_\phi^{'}B_{B-L}^\mu\right)^2$$

$$Y_\phi^{'} = -2$$

- The mass square matrix for the three electrically neutral gauge bosons in the basis $W_3, B_{Y'}, B_{B\text{-}L}$ is:

$$M_{neutral}^2 = g^2u^2\begin{pmatrix} \bar{v}^2/4 & t'\bar{v}^2/4 & 0 \\ t'\bar{v}^2/4 & t'^2(1+\bar{v}^2/4) & -t't_{B-L} \\ 0 & -t't_{B-L} & t_{B-L}^2 \end{pmatrix}$$

$$t' = \frac{g'}{g}$$

$$t_{B-L} = \frac{g_{B-L}}{g}$$

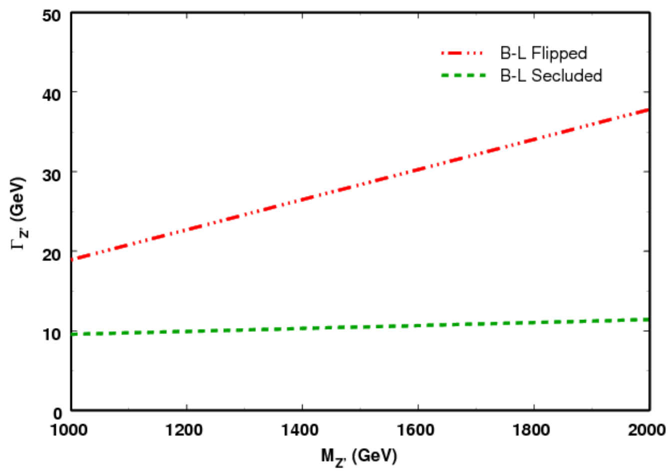
Imputs Chosen for Both Models

2 scenarios: First: $M_{Z'}$=1000 GeV; Second $M_{Z'}$=1500 GeV

B-L Flipped	B-L Secluded

B-L Flipped

- g'= 0.44
- g_{B-L}=0.6132
- u =1324.4 / 1987
- $\Gamma_{Z'}$= 26.37 GeV/ 38.87 GeV



B-L Secluded

- g_Z=0.2
- z_q= 1/3
- u = 5000 / 7500
- z_H=0 $\longrightarrow$ f_A's vanish
- The vectorial couplings of Z' to fermions will be given by:

$$f_V^{\nu} = f_V^{l} = -3 f_V^{u} = -3 f_V^{d} = t_Z c_W$$

- $\Gamma_{Z'}$= 9.55 GeV/ 10.48 GeV

Neutral Coupling Constants $f_{V,A}$ and Decay Widths for Both Models

$M_{Z'}$=1000 /1500 GeV	B-L Flipped		B-L Secluded	
	f_V	f_A	f_V	f_A
neutrinos	0.8412 / 0.8420	-0.1739 / -0.1732	0.2690 / 0.2690	0 / 0
leptons	0.4977 / 0.4977	0.1739 / -0.1732	0.2690 / 0.2690	0 / 0
u-quarks	-0.0510 / -0.0511	-0.1739 / -0.1732	-0.0897 / -0.0897	0 / 0
d-quarks	-0.3949/-0.3955	0.1739 / -0.1732	-0.0897 / -0.0897	0 / 0

$M_{Z'}$=1000 /1500 GeV	B-L Flipped	B-L Secluded
$Z' \to \sum_i \bar{\nu}_i \nu_i$	36% / 36%	23.5% / 23.6%
$Z' \to \sum_i \bar{l}_i l_i$	18.6% / 18.6%	45.1% / 45.5%
$Z' \to \sum_i \bar{q}_i q_i$	42.4% / 42.6%	31.4% / 30.9%
$Z' \to W^+W^-$	3% / 2.8%	0%/ 0%

Observables of Z' at Colliders

LHC

- ✓ Total cross sections;
- ✓ Forward-backward Asymmetry;
- ✓ Rapidity Distributions;
- ✓ Transverse moment Distributions;
- ✓ Lepton angular Distribution.

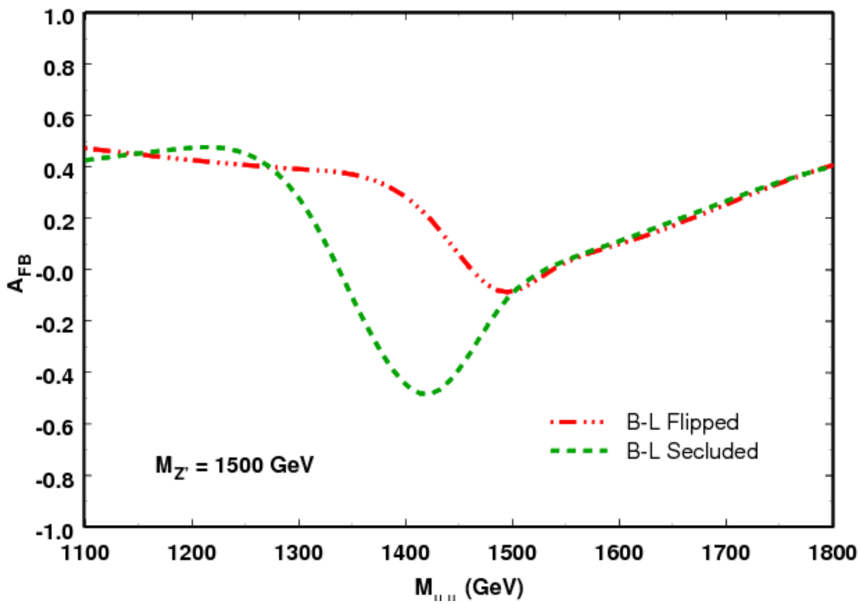
ILC

- ✓ Forward-backward Asymmetry;
- ✓ Left-right Asymmetry;
- ✓ Polarization Asymmetry;
- ✓ Mixed Asymmetries.

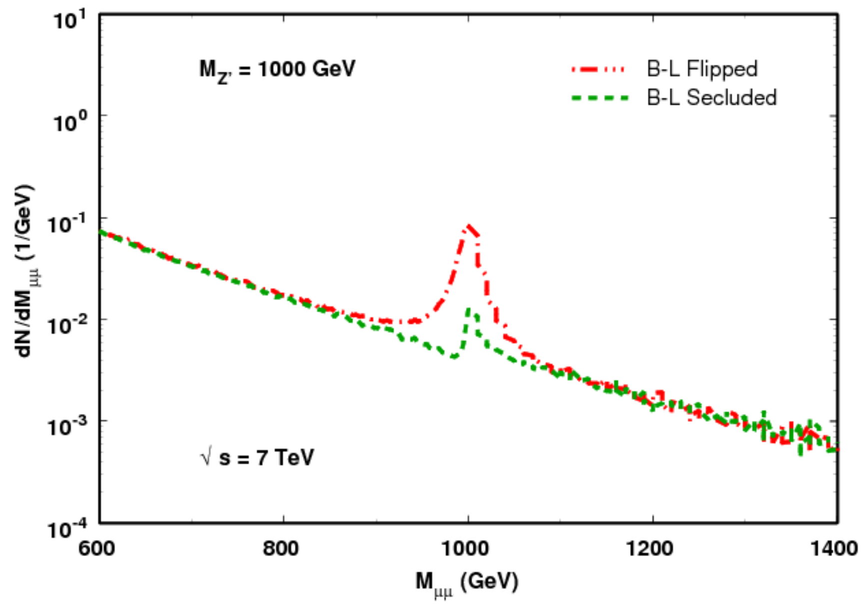
Drell-Yan Channel: $p + p \rightarrow \mu^+ + \mu^- + X$

$e^+ + e^- \rightarrow \mu^+ + \mu^-$

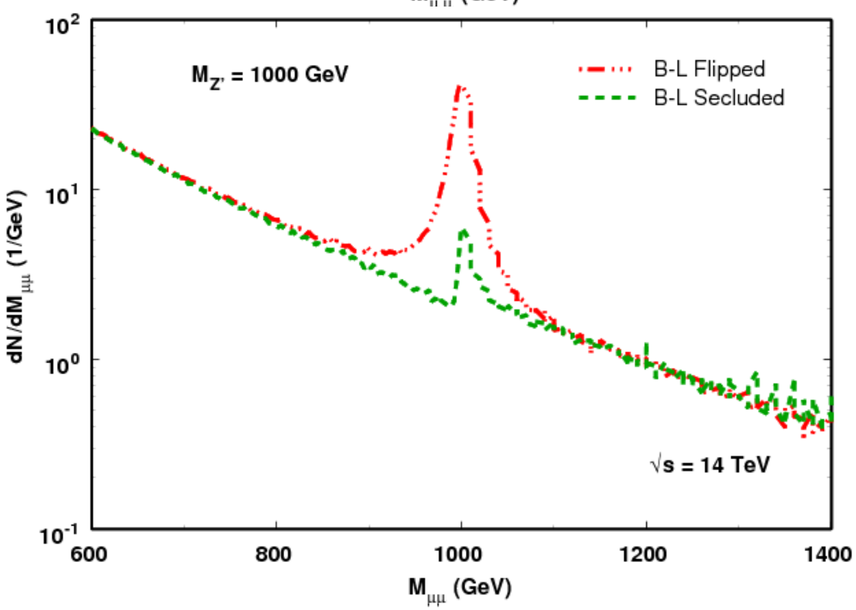
Results - LHC



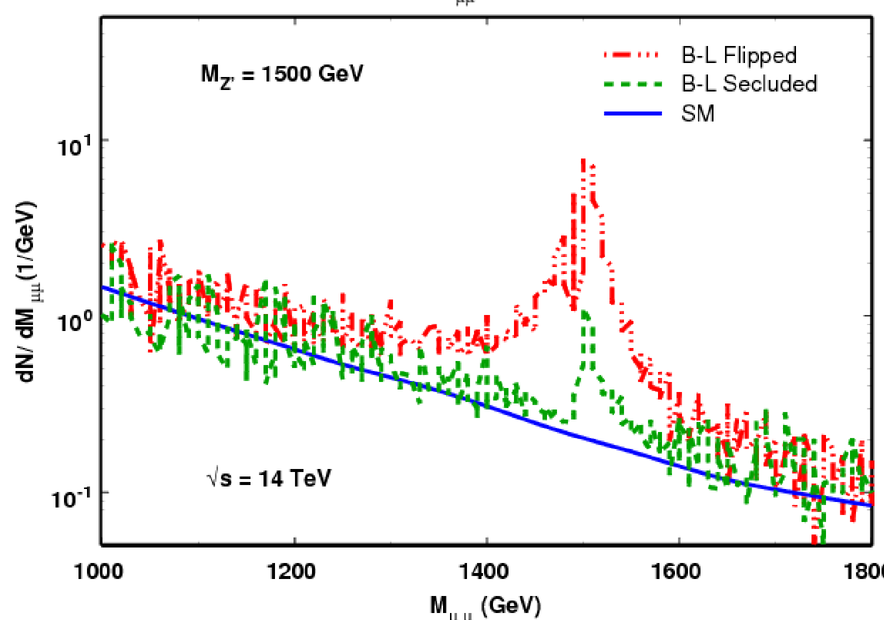
A_{FB}
$M_{\mu\mu}$ (GeV)
B-L Flipped
B-L Secluded
$M_{Z'}$ = 1500 GeV



$dN/dM_{\mu\mu}$ (1/GeV)
$M_{\mu\mu}$ (GeV)
$M_{Z'}$ = 1000 GeV
B-L Flipped
B-L Secluded
$\sqrt{s}$ = 7 TeV

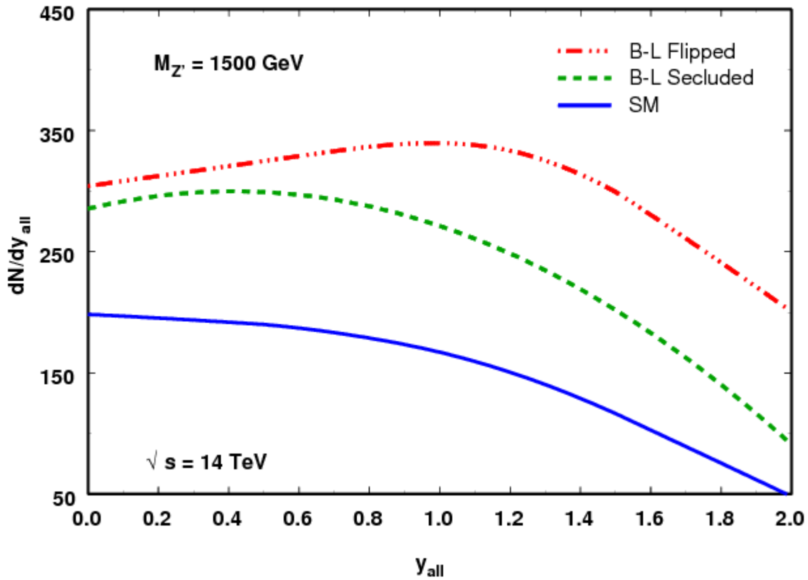


$dN/dM_{\mu\mu}$ (1/GeV)
$M_{\mu\mu}$ (GeV)
$M_{Z'}$ = 1000 GeV
B-L Flipped
B-L Secluded
$\sqrt{s}$ = 14 TeV

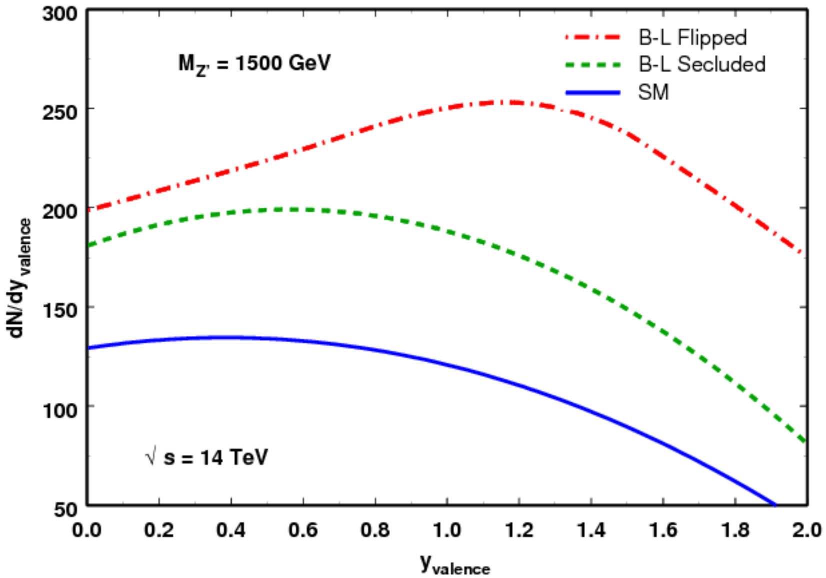


$dN/dM_{\mu\mu}$ (1/GeV)
$M_{\mu\mu}$ (GeV)
$M_{Z'}$ = 1500 GeV
B-L Flipped
B-L Secluded
SM
$\sqrt{s}$ = 14 TeV

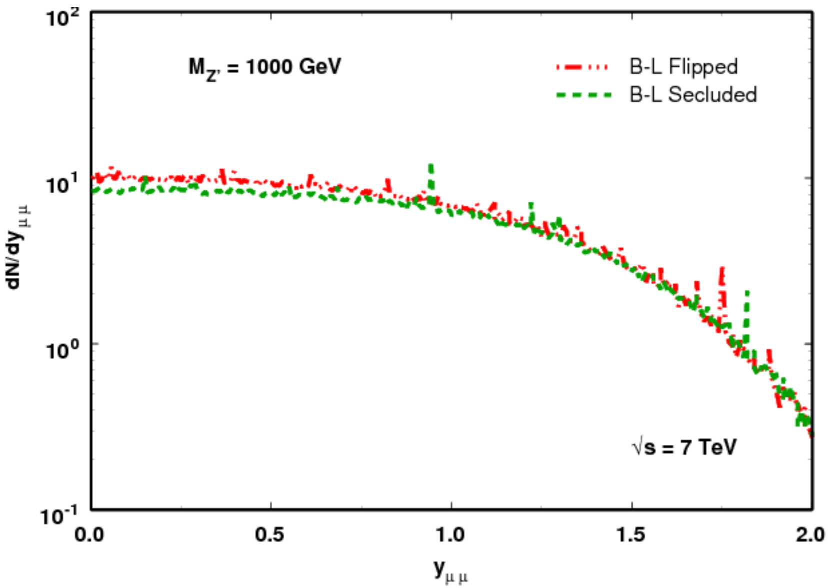
Results - LHC



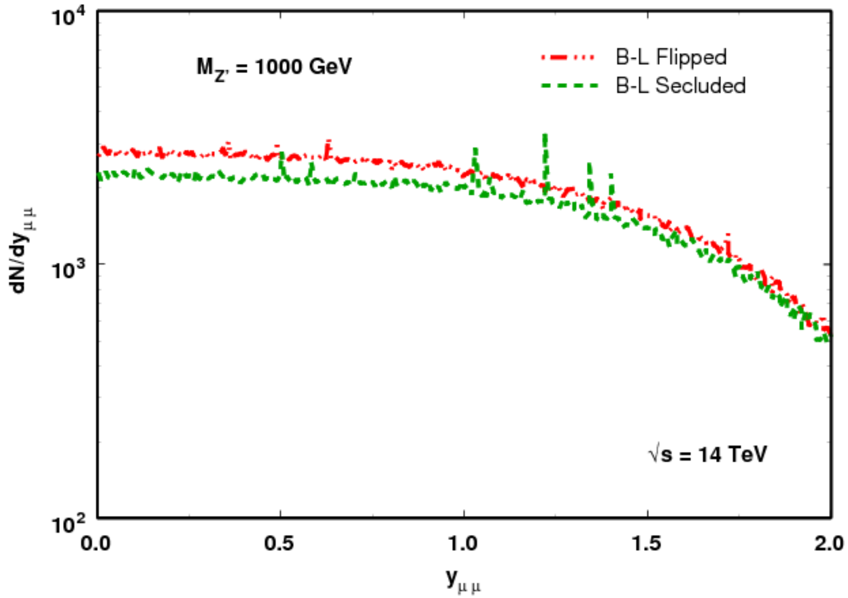
$M_{Z'}$ = 1500 GeV
B-L Flipped
B-L Secluded
SM
√ s = 14 TeV
dN/dy_{all}
y_{all}



$M_{Z'}$ = 1500 GeV
B-L Flipped
B-L Secluded
SM
√ s = 14 TeV
$dN/dy_{valence}$
$y_{valence}$

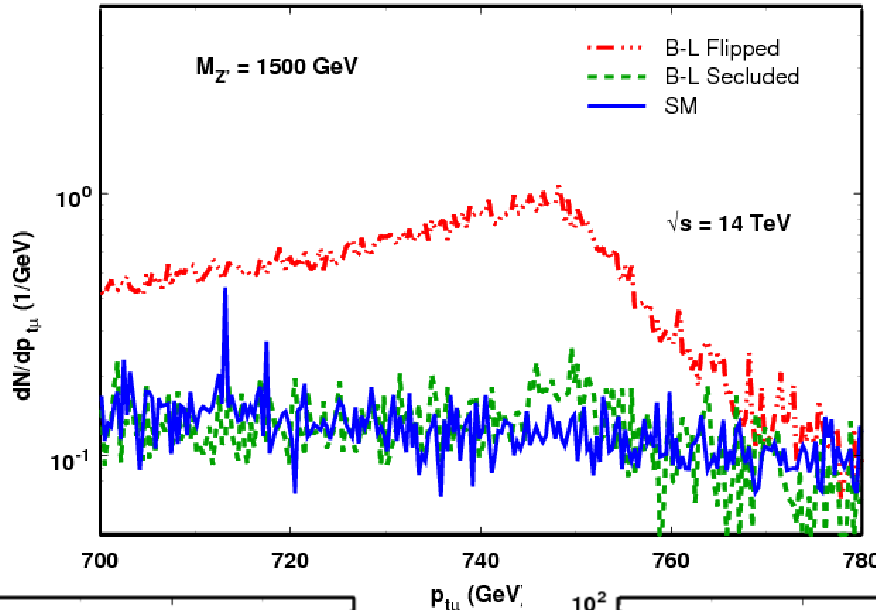


$M_{Z'}$ = 1000 GeV
B-L Flipped
B-L Secluded
√s = 7 TeV
$dN/dy_{\mu\mu}$
$y_{\mu\mu}$

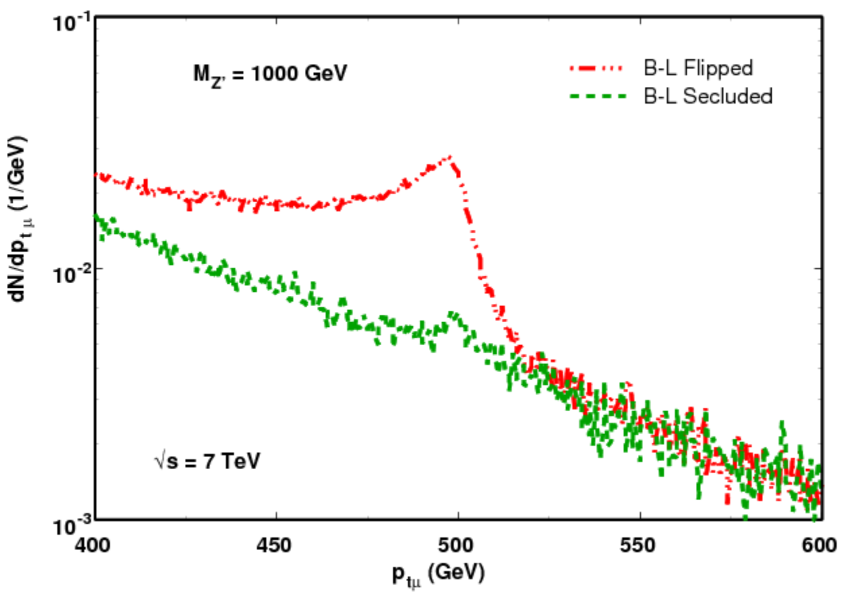


$M_{Z'}$ = 1000 GeV
B-L Flipped
B-L Secluded
√s = 14 TeV
$dN/dy_{\mu\mu}$
$y_{\mu\mu}$

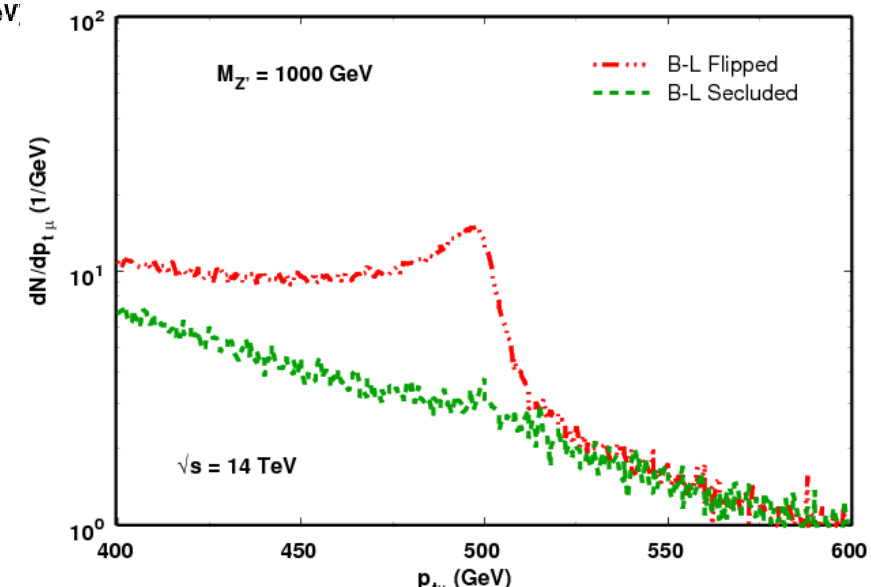
Results - LHC



$M_{Z'}$ = 1500 GeV
B-L Flipped
B-L Secluded
SM
$\sqrt{s}$ = 14 TeV
10^0
10^{-1}
dN/dp$_{t\mu}$ (1/GeV)
700
720
740
760
780
p$_{t\mu}$ (GeV)

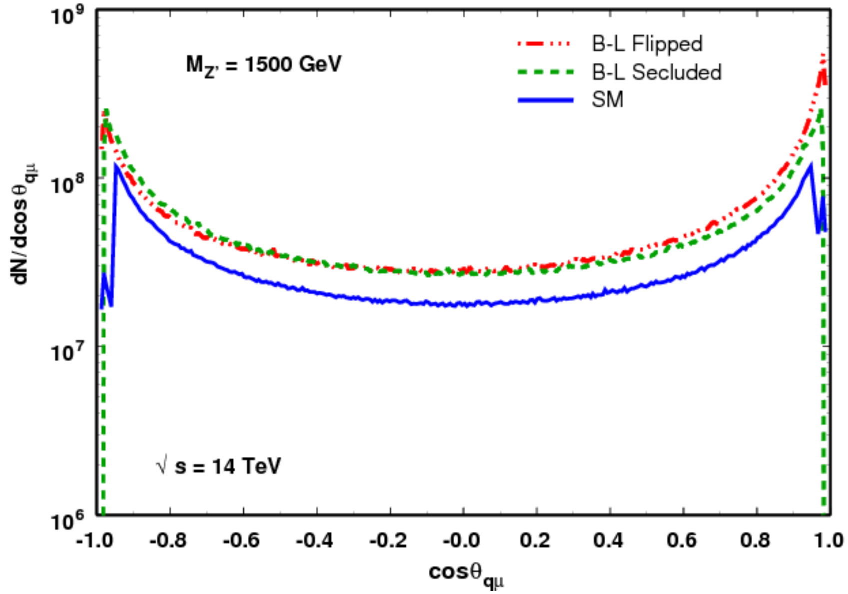


$M_{Z'}$ = 1000 GeV
B-L Flipped
B-L Secluded
$\sqrt{s}$ = 7 TeV
10^{-1}
10^{-2}
10^{-3}
dN/dp$_{t\mu}$ (1/GeV)
400
450
500
550
600
p$_{t\mu}$ (GeV)

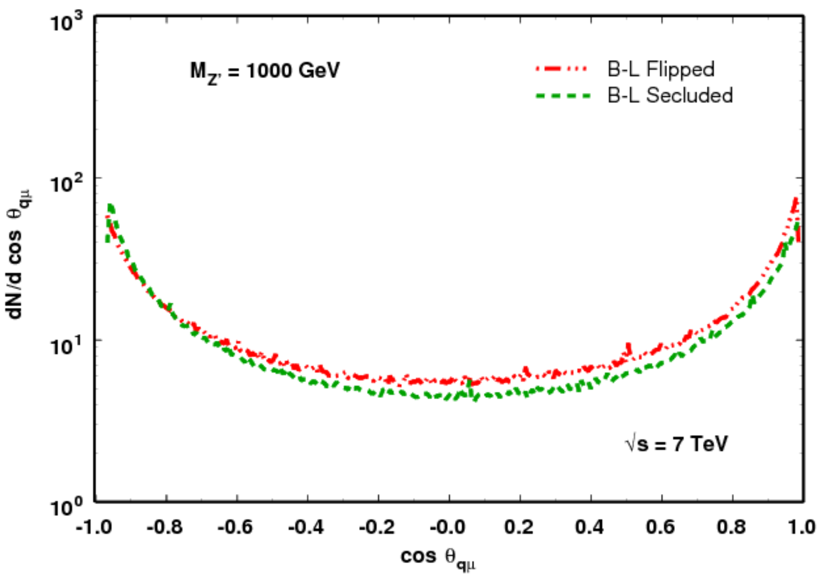


$M_{Z'}$ = 1000 GeV
B-L Flipped
B-L Secluded
$\sqrt{s}$ = 14 TeV
10^2
10^1
10^0
dN/dp$_{t\mu}$ (1/GeV)
400
450
500
550
600
p$_{t\mu}$ (GeV)

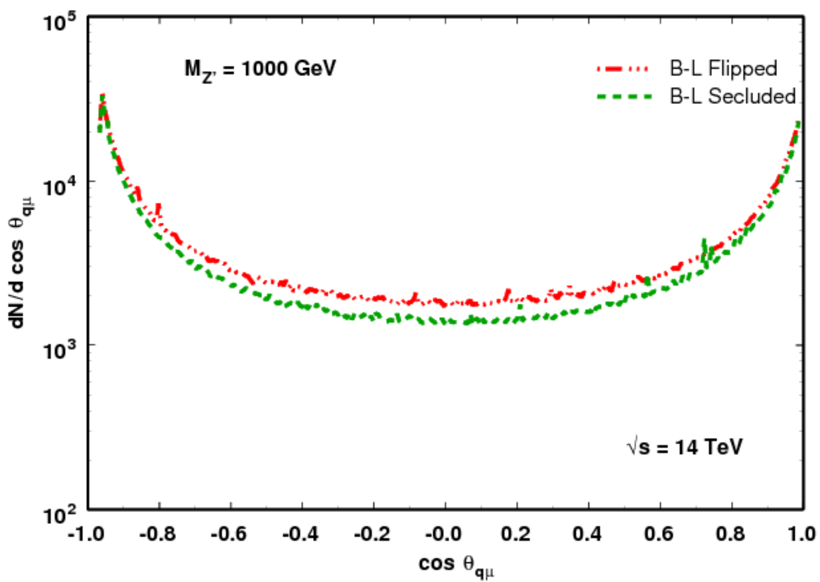
Results - LHC



$M_{Z'}$ = 1500 GeV
B-L Flipped
B-L Secluded
SM
√ s = 14 TeV
dN/dcos$\theta_{q\mu}$
cos$\theta_{q\mu}$

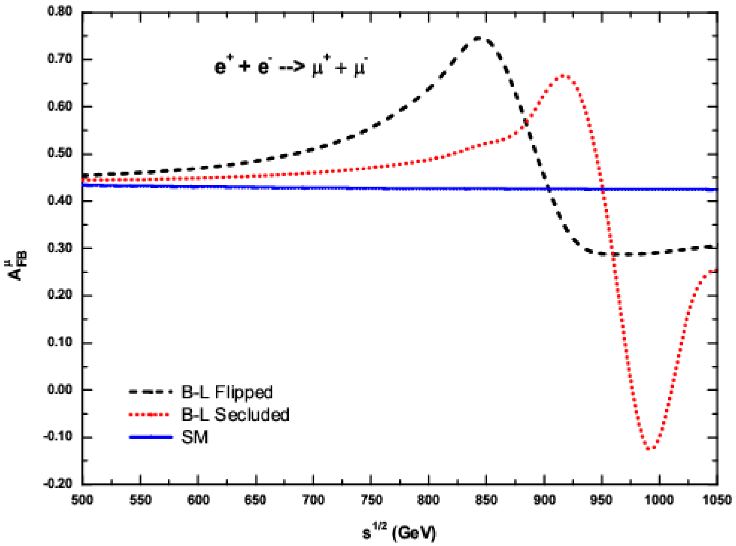


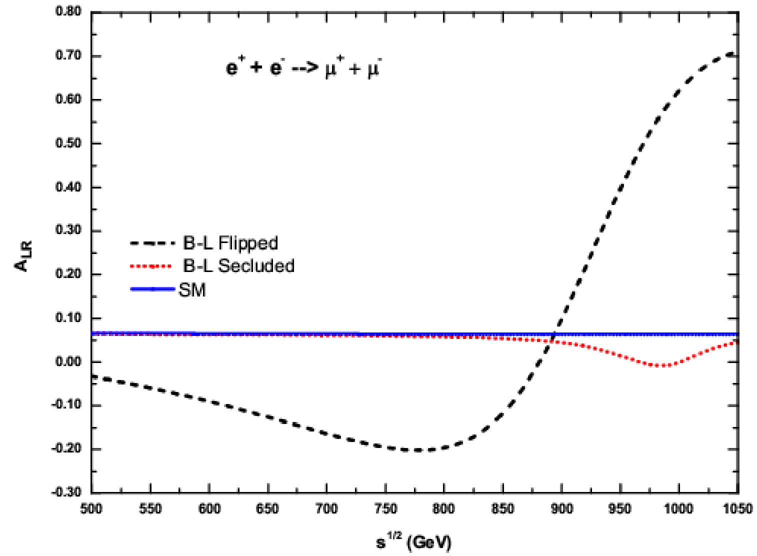
$M_{Z'}$ = 1000 GeV
B-L Flipped
B-L Secluded
√s = 7 TeV
dN/d cos $\theta_{q\mu}$
cos $\theta_{q\mu}$

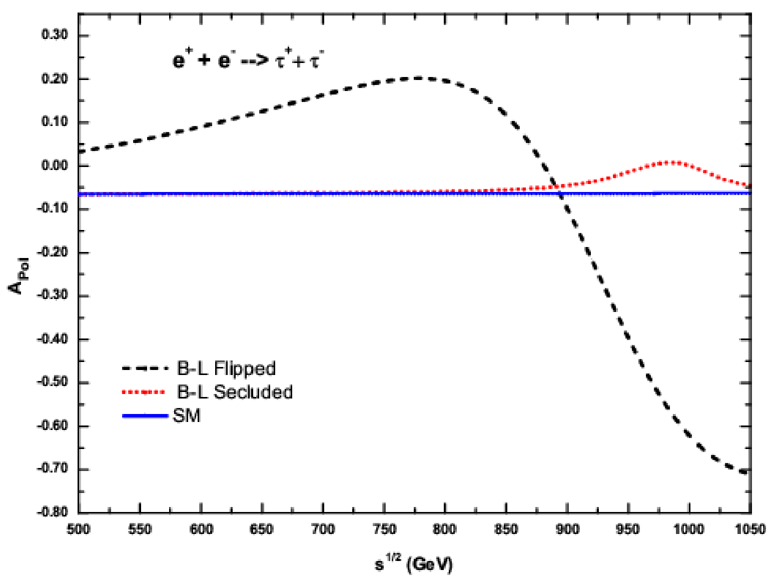


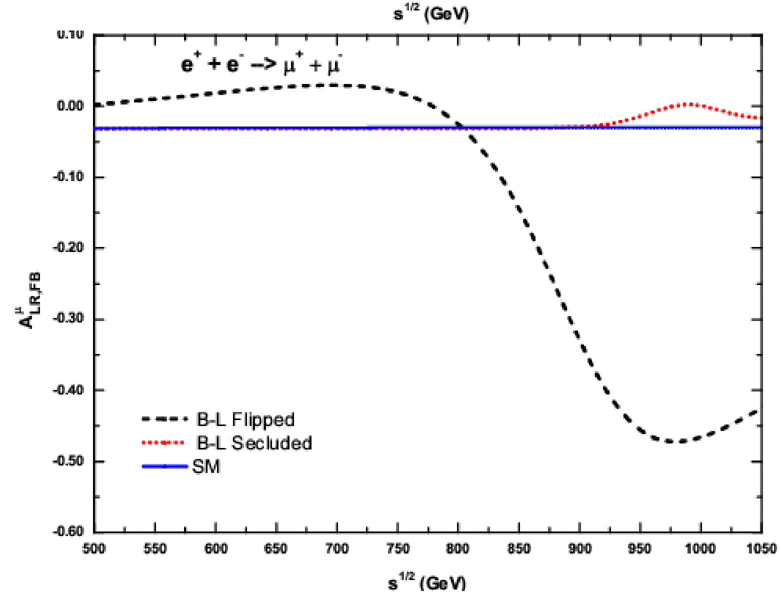
$M_{Z'}$ = 1000 GeV
B-L Flipped
B-L Secluded
√s = 14 TeV
dN/d cos $\theta_{q\mu}$
cos $\theta_{q\mu}$

Results – ILC (M_{Z_2}=1000 GeV)









Conclusions

- The B-L Secluded Model is leptofilic, its cross section near the Z_2-peak, is larger for leptons if compared to quarks;
- In both models, Z_2 decays preferentially to leptons compared to the SM;
- The Z_2 widths are very different in each model and are larger in the flipped model;
- According to the chosen parameters, the Flipped model has better chances to be disentangled from the background of the standard model, due to the nature of Z_2 couplings to fermions;

References

- J. C. Montero and V. Pleitez, Phys. Lett. **B765, 64 (2009); arXiv:0706.0473;**
- T. Appelquist, B. A. Dobrescu, and A. R. Hopper, Phys. Rev. D **68, 035012 (2003);**
- L. Basso, A. Belyaev, S. Moretti, and G. M. Pruna, Phys. Rev. D **80, 055030 (2009); and** JHEP **10, 006 (2009);**
- M. Carena, A. Daleo, B. A. Dobrescu, and T.M.P. Tait, Phys. Rev. D **70, 093009 (2004);**
- G. Cacciapaglia, C. Csaki, G. Mrandella, and A. Strumia, Phys. Rev. D **74, 033011 (2006);**
- J. Erler, P. Langacker, S. Munir, and E. Rojas, JHEP **08, 017 (2009); arXiv:0906.2435;**
- M. Dittmar, Anne-Sylvie Nicollerat, A. Djouadi, Phys. Lett. B **583**, **111 (2004).**
- LEP and SLD Collaborations, Phys. Rept. **467, 257 (2006).**