

Warped Gauge Bosons at the LHC

(Work in Progress)

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with

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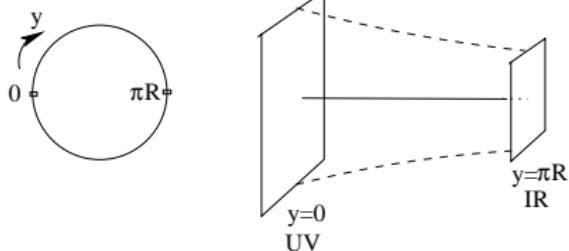
BNL Forum 2007

Motivation

- SM Hierarchy Problem: $M_{Pl} \leftrightarrow M_{EW}$
- New dynamics?
 - Extra dimensions (Warped, Flat)
 - Supersymmetry
 - Strong dynamics
 - Little Higgs
- AdS/CFT correspondence

Warped Model

Randall-Sundrum :
Higgs on the IR brane
 Z_2 Orbifold



Precision Electroweak Constraints (S & T)
Bulk $SU(2)_R \leftrightarrow$ Custodial Symmetry

- T parameter
- $Z b\bar{b}$ coupling

Bulk Gauge Bosons : $SU(2)_L \times SU(2)_R \times U(1)_X$
Bulk Fermions \rightarrow mass hierarchy naturally explained
FCNC's under control

[Agashe, Contino, Da Rold, Pomarol]

Custodial Symmetry protects :

- T parameter
- $Zb\bar{b}$

Allows Z' to be ~ 2 TeV

Fermion Reps

- $Q_L = \begin{pmatrix} t_L & \zeta_L \\ b_L & T_L \end{pmatrix} \rightarrow (2, 2)$
- $t_R, b_R \rightarrow (1, 1)$

$Zb_L b_L$ does not get corrected

Gauge Sector

Focus on Neutral Sector : $SU(2)_L \times SU(2)_R \times U(1)_X$

- Three neutral gauge bosons
 - $(W_L^3, W_R^3, X) \leftrightarrow (A, \tilde{Z}, \tilde{Z}x)$

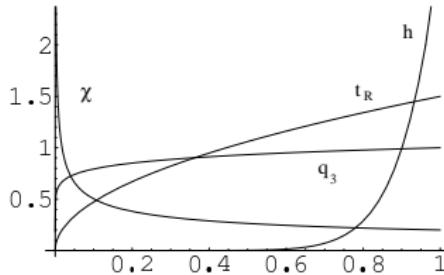
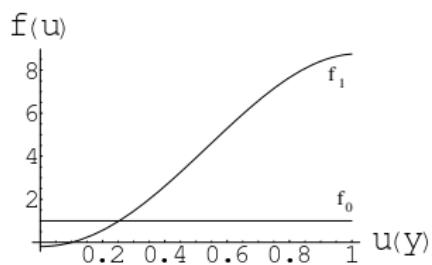
Symmetry Breaking :

- $SU(2)_R \times U(1)_X \rightarrow U(1)_Y$: $(W_L^3, W_R^3, X) \rightarrow (W_L^3, B, Z_X)$
 - Z_X (- , +)
 - W_L^3, B (+ , +)
- $SU(2)_L \times U(1)_Y \rightarrow U(1)_{EM}$: $(B, W_L^3, Z_X) \rightarrow (A, Z, Z_X)$
 - By Higgs on IR
 - EWSB mixes $(Z, Z_X) \rightarrow (\tilde{Z}, \tilde{Z}_X)$

Wave functions

Zero Mode is SM ($A, Z, 0$) and ψ

1st Kaluza-Klein (KK) Mode (A_1, Z_1, Z_{X1}) \rightarrow Z' and ψ_1

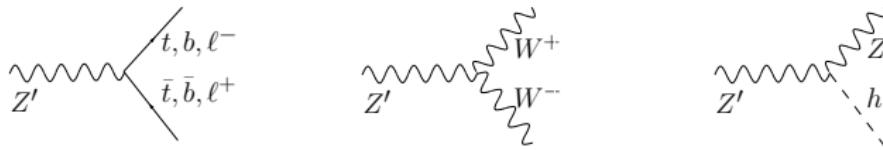


Overlap integrals to get couplings

Compared to SM

- Z' couplings to t_R, h enhanced
- Z' couplings to χ suppressed

Z' decays



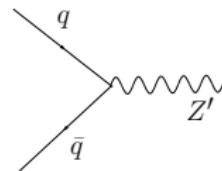
Total Width ($M_{Z_1} = 2 \text{ TeV}$) :

- $\Gamma(A_1) \approx 75 \text{ GeV}$
- $\Gamma(Z_1) \approx 265 \text{ GeV}$
- $\Gamma(Z_{X1}) \approx 105 \text{ GeV}$

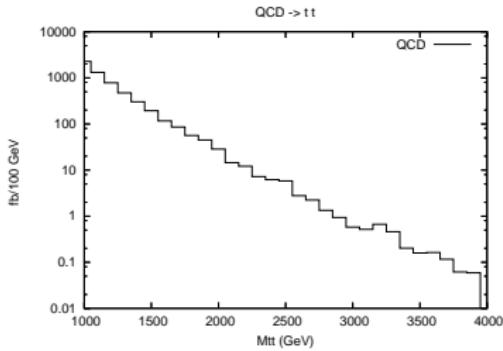
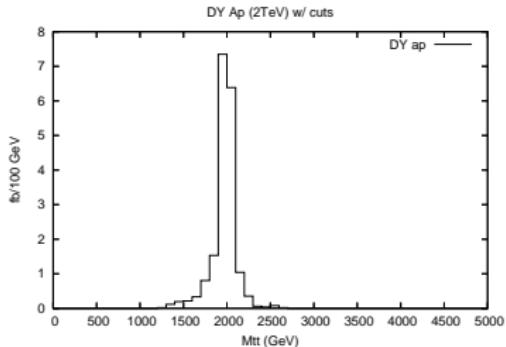
Z' production at the LHC

Drell-Yan ($M_{Z'} = 2 \text{ TeV}$) :

- $\sigma(pp \rightarrow Z' \rightarrow t\bar{t}) \approx 8 \text{ fb}$
- $\sigma(pp \rightarrow Z' \rightarrow W^+W^-) \approx 12 \text{ fb}$
- $\sigma(pp \rightarrow Z' \rightarrow \ell^+\ell^-) \approx 0.1 \text{ fb}$



$$pp \rightarrow Z' \rightarrow t\bar{t}$$



$Z' \rightarrow t\bar{t}$; $t \rightarrow Wb$; $W \rightarrow (qq') \text{ or } (\ell\nu)$

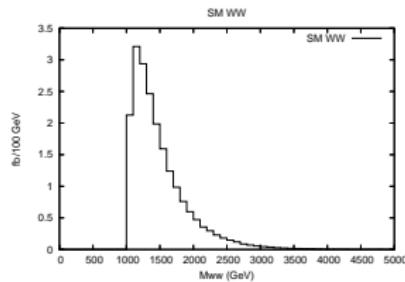
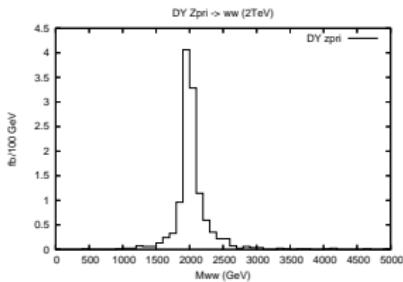
Signature for semi-leptonic mode : $b\bar{b}qq'\ell E_m$

Due to t boost, expect $\Delta R_{qq} \approx 0.32$

For $t\bar{t}$ mode, background : QCD + KK Gluon

Forward-backward asymmetry as a discriminant?

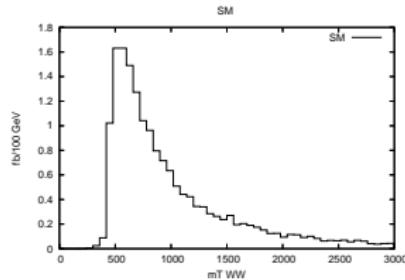
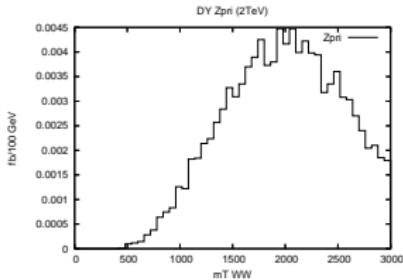
$$pp \rightarrow Z' \rightarrow W^+W^-$$



Decay W^+W^-

Semi-leptonic : $qq'\ell\nu$: Expect $\Delta R_{qq} \approx 0.16$ Very Challenging!

Fully leptonic : $\ell^+\ell^-\nu\nu$



Conclusions

- Warped model with $SU(2)_L \times SU(2)_R \times U(1)_X$
- A_1, Z_1, Z_{X1} neutral Gauge Bosons (Z')
- LHC : $p p \rightarrow Z' \rightarrow (\bar{t}t, W^+W^-, \ell^+\ell^-)$
- S/\sqrt{B} : Work in progress
- Thanks to colleagues at BNL : Bill Kilgore, Frank Paige
- Thanks to CalcHEP , MadGraph developers