Outline

- $SU(2)_{brane} \times U(1)_{bulk}$ model, Z boson localization.
- Processes with particle escape from brane. Cross-section computation.
- Comparison with ADD prediction.

$SU(2)_{brane} \times U(1)_{bulk}$

- (4+1+n) space time

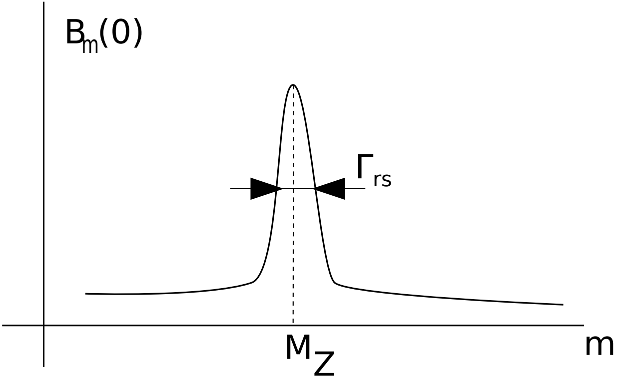
Action. $SU(2)$ and Higgs fields on the brane, $U(1)$ in bulk.

$$S = \int d^x dz \Pi_i \frac{d\theta_i}{2\pi R_i} \sqrt{|g|} \left(\left(-\frac{1}{4} F^a_{\mu\nu} F^a_{\mu\nu} + \right. \right. \\ \left. + (D\phi)^\dagger D\phi - \frac{\lambda}{4} \left(\phi^\dagger \phi - \frac{v^2}{2} \right)^2 \right) \delta(z) \\ \left. - \frac{1}{4} B_{\bar{\mu}\bar{\nu}} B_{\bar{\gamma}\bar{\delta}} g^{\bar{\mu}\bar{\gamma}} g^{\bar{\nu}\bar{\delta}} \right) \quad (1)$$

Effective action

$$S_{eff} = \int d^4 x dm \left(-\frac{1}{4} B_{\mu\nu} B_{\mu\nu} + \frac{m^2}{2} B_\mu B_\mu \right) + \\ + \int d^4 x dm B_m(0) \bar{\psi} \gamma^\mu \psi B_\mu \quad (2)$$

Z boson invisible width



Width of particle escape from the brane

$$\Gamma_{rs} = \frac{\pi(M_Z^2 - M_W^2)}{\Gamma(\frac{n}{2})\Gamma(\frac{n}{2}+1)M_Z}\left(\frac{m_z}{k}\right)^n \tag{3}$$

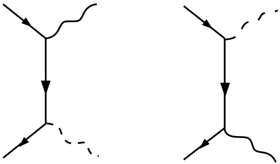
Limits for k

Limits for k from Z invisible width

$\Gamma_{invis} = 0.4990 \pm 0.0003$ GeV (PDG)

- $n = 1,\ k > 1.2 \cdot 10^4$ TeV
- $n = 2,\ k > 40$ TeV
- $n = 3,\ k > 5$ TeV
- $n = 4,\ k > 1.6$ TeV

Collider processes $e^+e^- - \to \gamma + B_{bulk}$



In the rest frame of fermions the differential cross-section

$$\frac{d\sigma}{dx\,dy} = \left(1 + \frac{(\sin^2\theta_w - 0.5)^2 + \sin^4\theta_w}{2\sin^2\theta_w\cos^2\theta_w}\right)\frac{4\pi\alpha^2}{n\Gamma^2(\frac{n}{2})}\cdot \cdot\frac{1}{s}\left(\frac{\sqrt{s}}{2k}\right)^n\cdot f(x,y) \quad (4)$$

$$f(x,y) = \frac{(1-x)^{\frac{n}{2}-1}}{x}\cdot\frac{(2-x)^2 + x^2y^2}{1-y^2} \quad (5)$$

here $x = 2E/\sqrt{s}$, $y = \cos\theta$

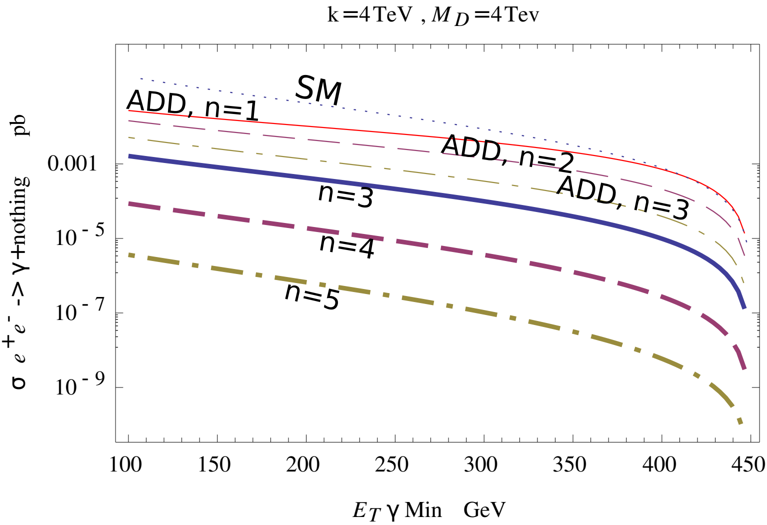
The Add prediction

the ADD cross section to graviton and photon computed by G.F. Giudice, R. Rattazzi and J.D. Wells (hep-ph/9811291)

$$\frac{d^2\sigma}{dx_\gamma d\cos\theta}(e^+e^- \to \gamma G) = \frac{\alpha}{64}\cdot\frac{2\pi^{n/2}}{\Gamma(n/2)}\cdot\left(\frac{\sqrt{s}}{M_D}\right)^{n+2}\frac{1}{s}f(x_\gamma,\cos\theta) \tag{6}$$

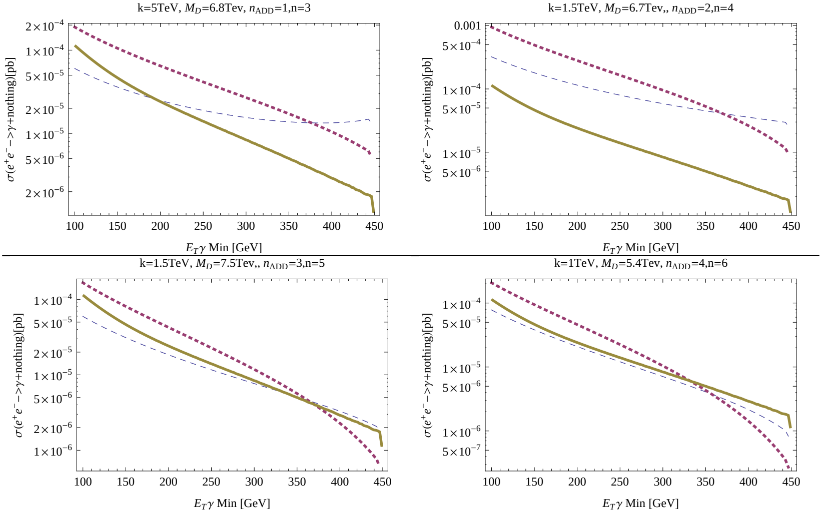
$$f(x,y) = \frac{2(1-x)^{\frac{n}{2}-1}}{x(1-y^2)}\cdot \left[(2-x)^2(1-x+x^2) - 3y^2x^2(1-x) - y^4x^4\right]. \tag{7}$$

Comparison with ADD prediction



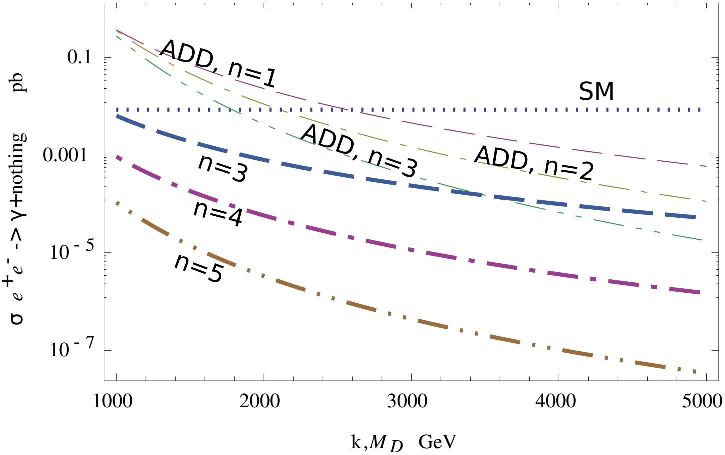
$\sqrt{s} = 1\,TeV$, $E_\gamma^T > 100\,GeV$, $E_\gamma < 450\,GeV$, integrated over angle between photon and fermion momentum.

Comparison with ADD prediction



$E_\gamma^T > 100\ GeV$, $E_\gamma < 450\ GeV$, integrated over angle between photon and fermion momentum $84^\circ \leqslant \theta \leqslant 90^\circ$

Comparison with ADD prediction



$\sqrt{s} = 1\,TeV$, $300\,GeV < E_\gamma < 450\,GeV$, integrated over angle between photon and fermion momentum
$E_\gamma^T < 300\,GeV$.

- It is possible to distinguish this model and ADD.
- $n = 3$, $k > 5 TeV$ is interesting for future colliders.

Thank for your attention!

$SU(2)_{brane} \times U(1)_{bulk}$

Metric

$$ds^2 = e^{-2k|z|}\left(dt^2 - d\vec{x}^2 - \sum_i d\theta_i^2\right) - dz^2 \tag{8}$$

Action

$$S = \int d^x dz \Pi_i \frac{d\theta_i}{2\pi R_i}\sqrt{|g|}\left(\left(-\frac{1}{4}F^a_{\mu\nu}F^a_{\mu\nu} + \right.\right.$$
$$\left. + (D\phi)^\dagger D\phi - \frac{\lambda}{4}\left(\phi^\dagger\phi - \frac{v^2}{2}\right)^2\right)\delta(z)$$
$$\left. -\frac{1}{4}B_{\bar{\mu}\bar{\nu}}B_{\bar{\gamma}\bar{\delta}}g^{\bar{\mu}\bar{\gamma}}g^{\bar{\nu}\bar{\delta}}\right) \tag{9}$$

Interaction with fermions

$$S_{int} = \int d^4x dz \delta(z)\bar{\psi}\gamma^\mu\psi A_\mu \tag{10}$$

Classical equations of motion after symmetry breaking, unitary gauge

$$\frac{1}{a^2}\partial_\mu\partial_\mu B_\nu - \partial_z^2 B_\nu + (n+2)ksign(z)\partial_z B_\nu =$$
$$= \frac{2v^2 g'}{8}\sqrt{\frac{2}{kn}}\left(g'\sqrt{\frac{2}{kn}}B_\nu - gA_\nu^3\right)\delta(z) \quad (11)$$

$$\partial_\mu F_{\mu\nu} + \frac{2gv^2}{8}\left(gA_\nu^3 - g'\sqrt{\frac{2}{kn}}B_\nu(x,0)\right) = 0 \quad (12)$$

Particle set after symmetry breaking, unitary gauge

- A_μ — localized zero mode, photon.
- $W_\mu^\pm$ — resides on the brane.
- B_μ^m — continuous spectrum of massive modes.

Particle localization

Integration out compact extra dimension

$$\int dz \Pi_i \frac{d\theta_i}{2\pi R_i} \sqrt{|g|} \longrightarrow \int e^{-2kn|z|} dz \quad (13)$$

Effective action for B_μ

$$S_{eff} = \int d^4x dm \left(-\frac{1}{4} B_{\mu\nu} B_{\mu\nu} + \frac{m^2}{2} B_\mu B_\mu \right) + \\ + \int d^4x dm B_m(0) \bar{\psi} \gamma^\mu \psi B_\mu \quad (14)$$