ラディオン質量に対するヒッグス探索実験からの制限

arXiv:1305.4431 [hep-ph]

Yoshiko Ohno (Ochanomizu Univ.)

in collaboration with

Gi-Chol Cho (Ochanomizu Univ.) and Daisuke Nomura (Tohoku Univ.)

お茶の水女子大学 Ochanomizu University

Abstract

* We study production and decay of the radion in Randall-Sundrum (RS) model at the LHC taking account of the recent SM Higgs search by the ATLAS and CMS experiments.

  - We investigate the constraints on free parameters of radion (Λ_Φ, m_Φ) from the result of SM Higgs search and the direct search of 1st KK graviton at the LHC.

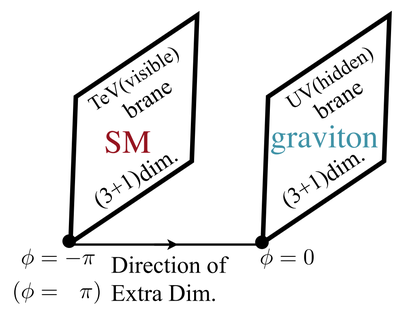
1. Radion in RS model

Randall-Sundrum model solves the gauge hierarchy problem

Randall-Sundrum metric is

$$ds^2 = e^{-2kr_c\phi}\eta_{\mu\nu}dx^\mu dx^\nu + r_c^2 d\phi^2$$

To solve the hierarchy problem
the parameter kr_c should be 10 ~ 12



Randall, Sundrum, (1999)

Radion Φ is metric fluctuation and it couples to the trace of SM energy-momentum tensor.

Interaction of radion to SM fields :

$$\mathcal{L}_{\rm int} = \frac{\phi}{\Lambda_\phi} T^\mu_\mu({\rm SM})$$

for fermion, W, Z, SM Higgs

$$T^\mu_\mu({\rm SM}) = \sum_f m_f \bar{f} f - 2m_W^2 W^+_\mu W^{-\mu} - m_Z^2 Z_\mu Z^\mu + (2m_H^2 H^2 - \partial_\mu H \partial^\mu H) + \ldots$$

for gluon, photon

$$T^\mu_\mu({\rm SM})^{\rm anom} = \sum_a \frac{\beta_a(g_a)}{2g_a} F^a_{\mu\nu} F^{a\mu\nu}$$

$$\beta_{\rm QCD}/2g_s = -(\alpha_s/8\pi) b_{\rm QCD} \quad (b_{\rm QCD} = 7)$$

free parameters:
Λ_Φ, m_Φ

C. Csáki et al. PR**D62**, 045015 (2000)

Radion Φ：Metric fluctuation G_{55} , Scalar particle (spin=0)

i) Production & decay are very similar to Higgs

ii) Radion mass is O(TeV) and it is lighter than 1st KK graviton

iii) Strength of coupling to the SM fields is proportional to $1/\Lambda_\Phi$ (O(1TeV))

2. Constraints on Λ_Φ and m_Φ

Experimental bound from LHC

Radion interaction to SM fields is very similar to SM Higgs.

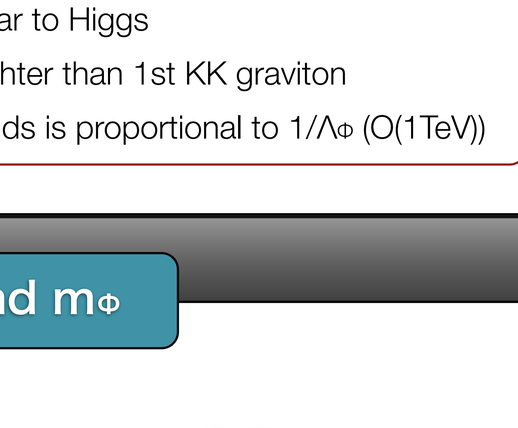
We know the ratio of σ/σ_{SM} from SM Higgs search.

It might be an indirect constraint on an extra (SM Higgs like) scalar.
In other words, we calculated ...

$$\left[\int \mathcal{L}_{7\rm TeV} dt \cdot \sigma(pp \to \phi X; 7{\rm TeV}) + \int \mathcal{L}_{8\rm TeV} dt \cdot \sigma(pp \to \phi X; 8{\rm TeV})\right] {\rm Br}(\phi \to ZZ)$$

$$\leq$$

$$f(m_h)\left[\int \mathcal{L}_{7\rm TeV} dt \cdot \sigma(pp \to hX; 7{\rm TeV}) + \int \mathcal{L}_{8\rm TeV} dt \cdot \sigma(pp \to hX; 8{\rm TeV})\right] \times {\rm Br}(h \to ZZ)\Big|_{m_h = m_\phi}$$

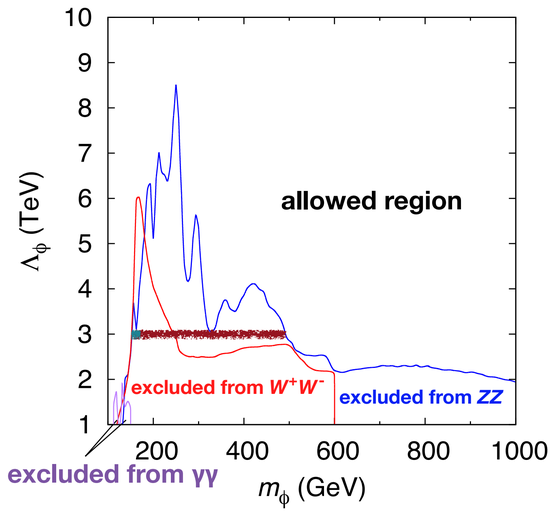


CMS PAS HIG-13-002

→ We study allowed region of Λ_Φ and m_Φ.

3. Results

Using h→ZZ / h→W^+W^- / h→γγ decay modes :



We obtained a large excluded region

- **Λ_Φ < 2TeV is excluded** at $m_W \leq m_\phi \leq 1000{\rm GeV}$.
- **Λ_Φ = 8TeV , m_Φ ~ 260 GeV is excluded** from h→ZZ mode.

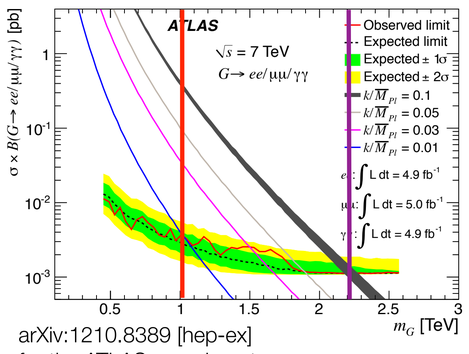
The result of previous study:

Λ_Φ = 3TeV , 163 < m_Φ < 180 GeV.

V. Barger and M. Ishida, PL**B709**, 185 (2012)

J. F. Gunion et al. PL**B585**, 295 (2004) etc...

4. Λ_Φ from 1st KK graviton search



arXiv:1210.8389 [hep-ex]
for the ATLAS experiments

1st KK Graviton mass is

$$m_{G_1} = x_1 \frac{k}{M_{pl}} \Lambda_G \quad (x_1 = 3.83)$$

k/M_{pl} : free parameter

Relation between Λ_G and Λ_Φ is

$$\Lambda_\phi = \sqrt{6}\Lambda_G$$

Thus the relation between Λ_Φ and m_{G1} is

$$\therefore \quad \Lambda_\phi = \frac{\sqrt{6}}{x_1}\frac{M_{pl}}{k} m_{G_1}$$

k/M_{pl}=	0.1	0.01
m_{G1}	2.23TeV	1.03TeV

→

k/M_{pl}=	0.1	0.01
Λ_Φ	14.3TeV	65.8TeV

5. Conclusion and Future Works

We studied production and decay of the radion in Randall-Sundrum (RS) model at the LHC taking account of the recent SM Higgs search .

→ We obtained severe bounds **@ high mass region.**

Future Works ...

We will suggest that

γ-γ collider ***(as an option of ILC)***
might be able to give the severe constraints on Λ_Φ and m_Φ
@ large low mass region.