PHENOMENOLOGY FOR WARPED EXTRA DIMENSION AT LHC

Shi Ang Li
In collaboration with Chong Sheng Li, Hai Tao Li, Jun Gao, Xing Wang
Peking University
Sun Yat-sen University
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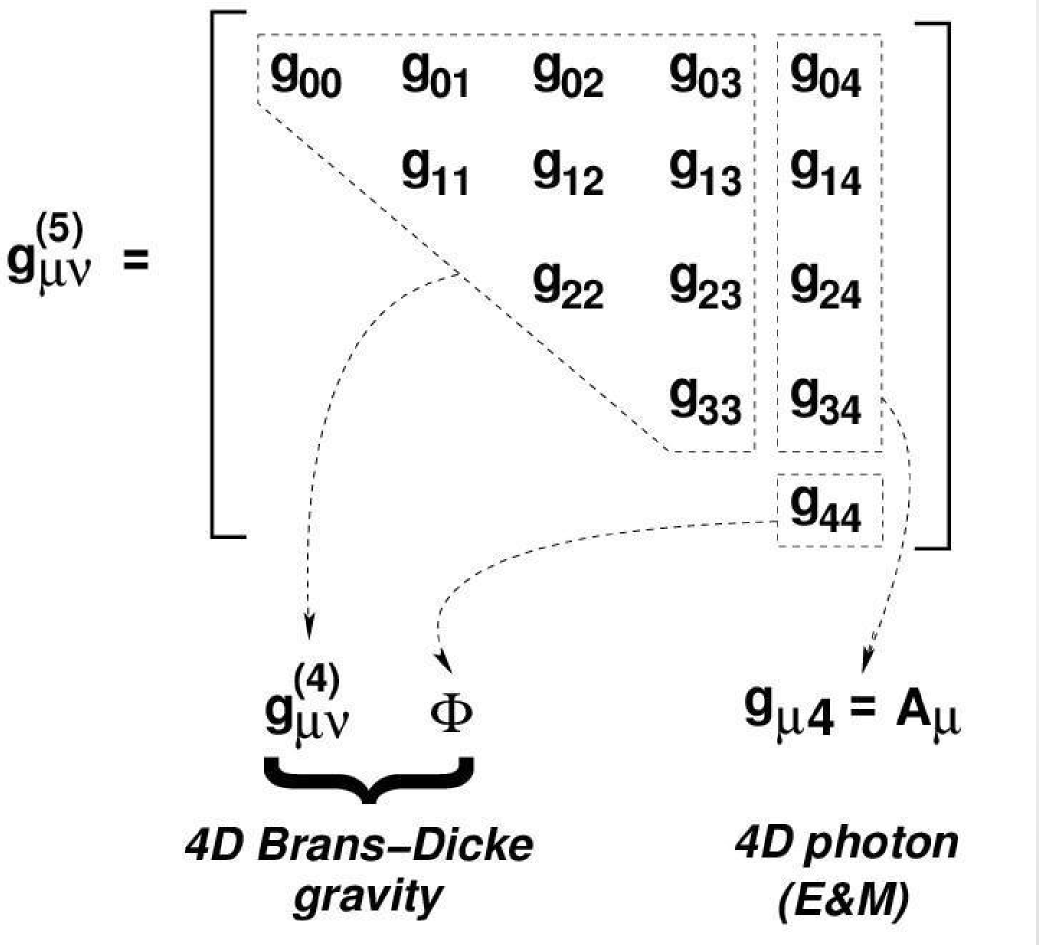
Kaluza-Klein idea

- The fundamental field is the five-dimensional metric $g_{\mu\nu}^{(5)}$
- Decomposed into representations of the four-dimensional Lorentz group.
- Yields three different representations ,spin-2,spin1,spin0
- $g_{gauge}^2 = \frac{2\kappa_5}{R^2}$



C. Csaki et al.: From fields to strings [hep-ph/0404096]

Extra dimension

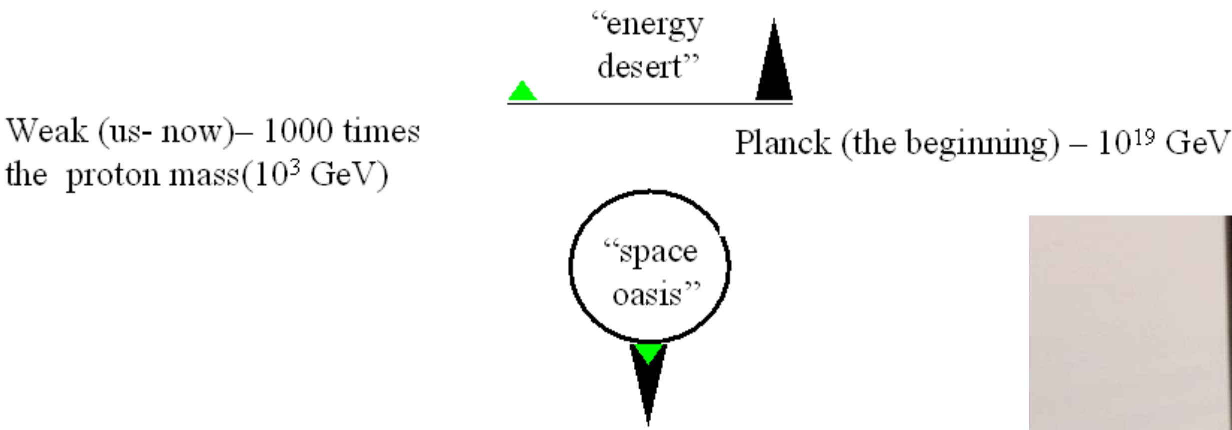


Figure 2. The “hierarchy of scales” (energy desert) problem (up) and (down) the new view of the scales in the compactified extra dimensions world

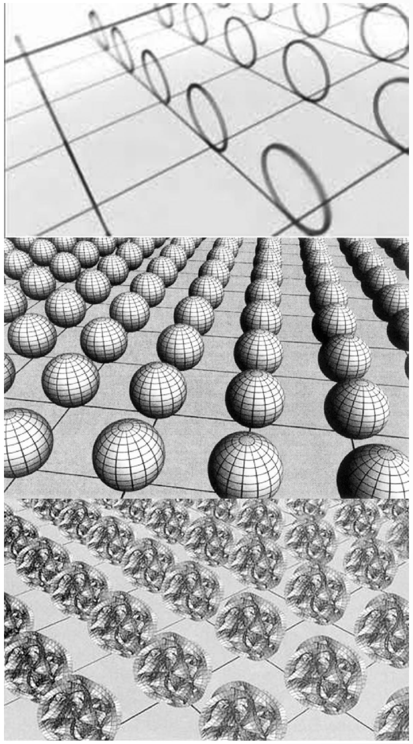
Extra dimension solution

$$S_4 = -M_{Pl}^2 \int d^4x \sqrt{g^{(4)}} R^{(4)}$$

$$S_{4+n} = -M_*^{n+2} \int d^{4+n}x \sqrt{g^{(4+n)}} R^{(4+n)}$$

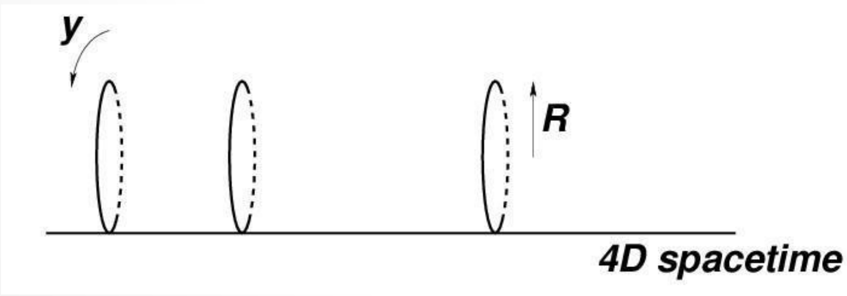
$$= -M_*^{n+2} \int d\Omega_{(n)} r^n \int d^4x \sqrt{g^{(4)}} R^{(4)}$$

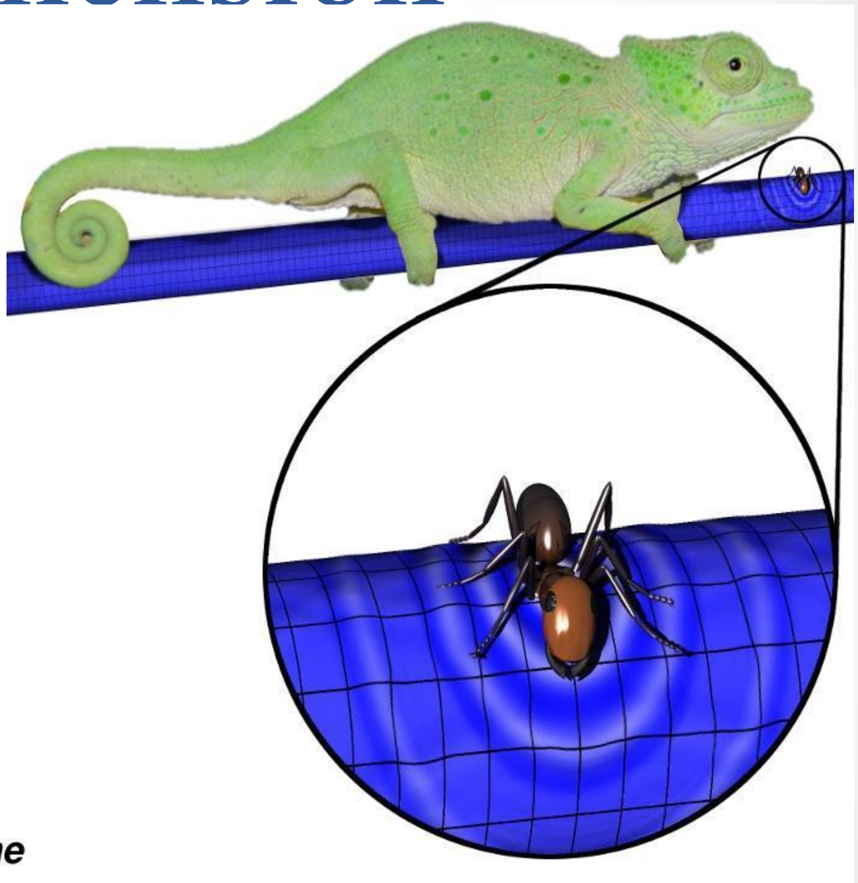
$$M_{Pl}^2 = M_*^{n+2} V_{(n)} = M_*^{n+2} (2\pi r)^n$$



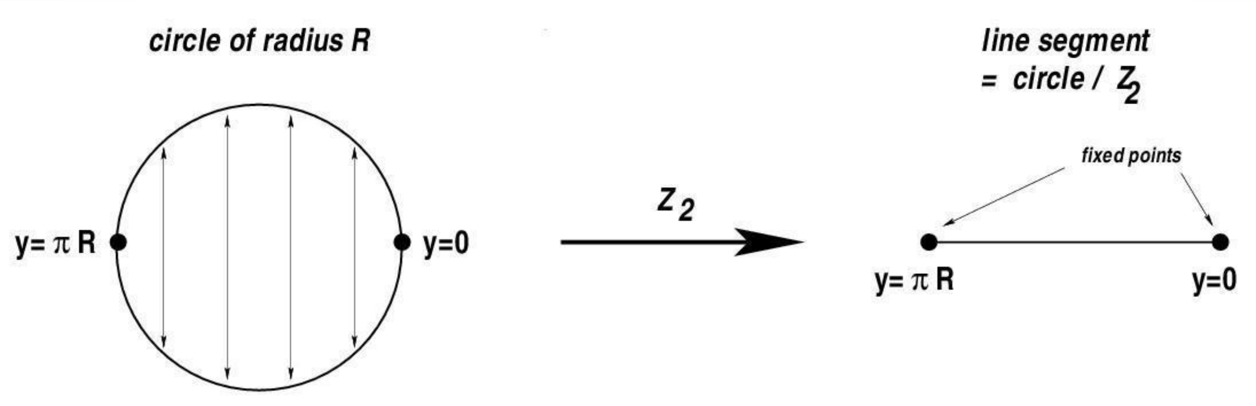
Extradimension

- Have not observed the extra dimension, so they must be compactified to a small length scale
- Compactify δ extra spacetime dimensions $M_4 \times K$





Randall-sundrum model

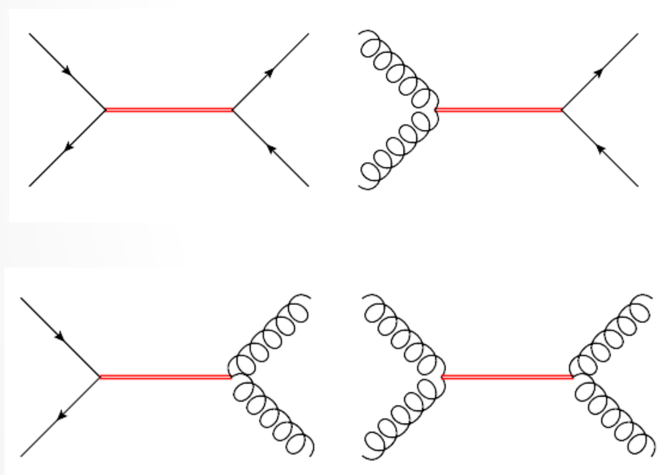


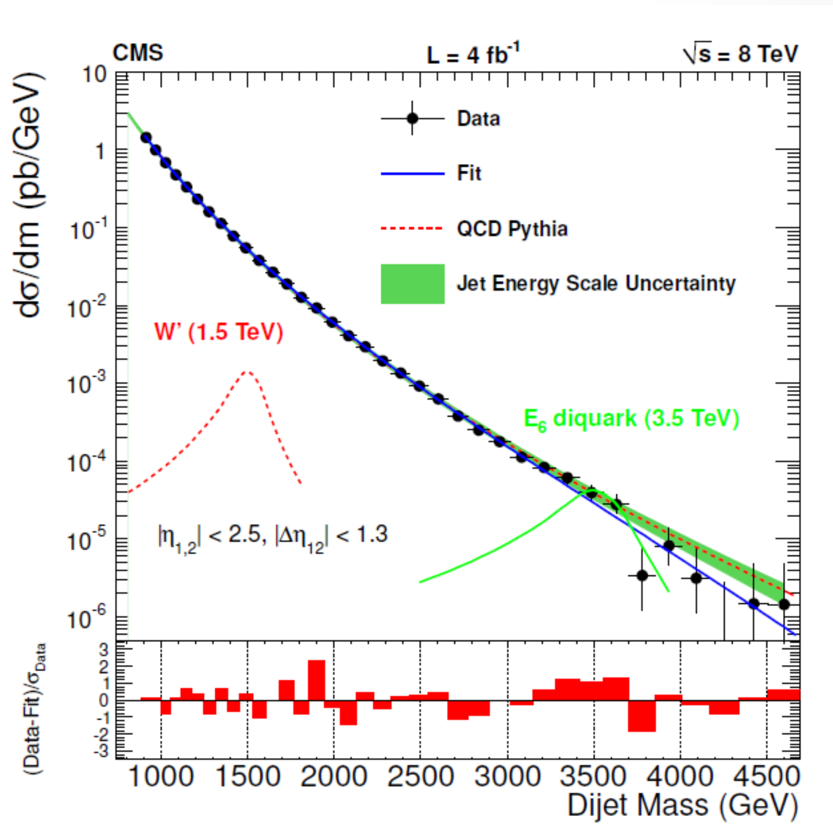
$$\bar{M}_P^2 = \frac{M_*^3}{k}(1 - e^{-2kr_c\pi})$$

$$\mathcal{L} = -\frac{1}{\bar{M}_P} T^{\alpha\beta}(x) h^{(0)}_{\alpha\beta}(x) - \frac{1}{\Lambda_\pi} T^{\alpha\beta}(x) \sum_{n=1}^{\infty} h^{(n)}_{\alpha\beta}(x)$$

Process

$$p + p \rightarrow G \rightarrow jet + jet$$





CMS Collaboration .CMS-PAS-EXO-12-016

NLO QCD

- We use two cut off phase space slicing method.

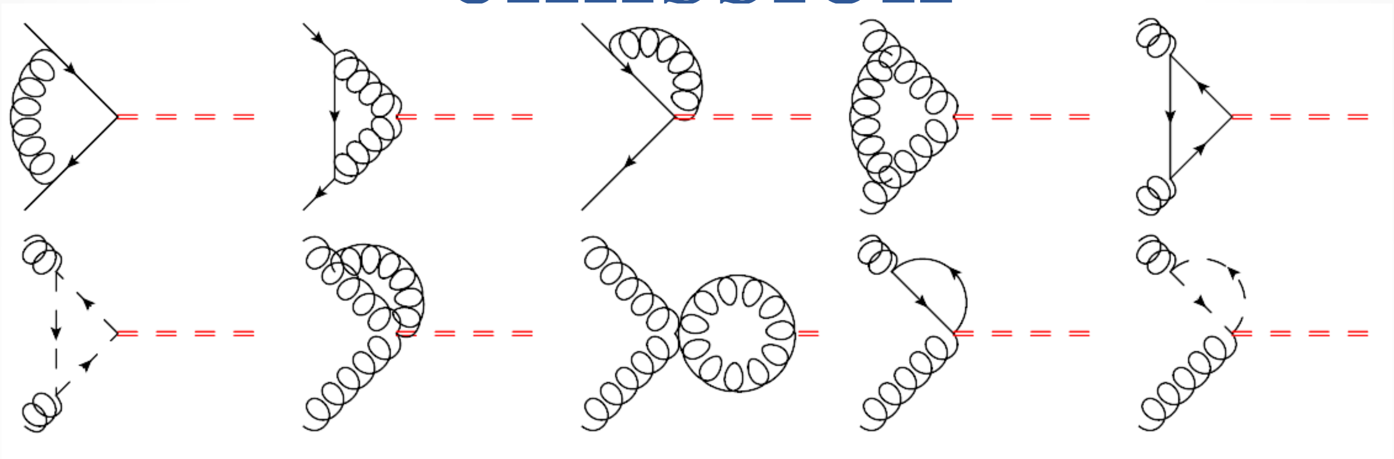
$$\sigma_{total} = \sigma_{2-body} + \sigma_{3-body}$$

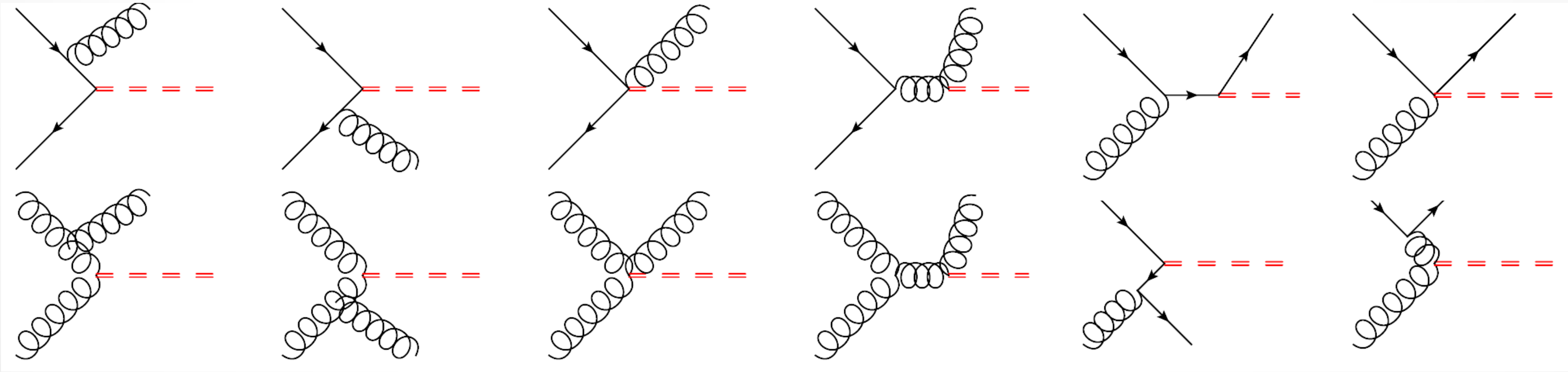
virtual real

$$\sigma = \frac{1}{2\Phi}\int \overline{\sum}|M_3|^2 d\Gamma_3 = \frac{1}{2\Phi}\int_{\mathrm{S}} \overline{\sum}|M_3|^2 d\Gamma_3 + \frac{1}{2\Phi}\int_{\mathrm{H}} \overline{\sum}|M_3|^2 d\Gamma_3$$

$$\frac{1}{2\Phi}\int_{\mathrm{H}} \overline{\sum}|M_3|^2 d\Gamma_3 = \frac{1}{2\Phi}\int_{\mathrm{HC}} \overline{\sum}|M_3|^2 d\Gamma_3 + \frac{1}{2\Phi}\int_{\mathrm{H\overline{C}}} \overline{\sum}|M_3|^2 d\Gamma_3$$

Virtual corrections and Real emission



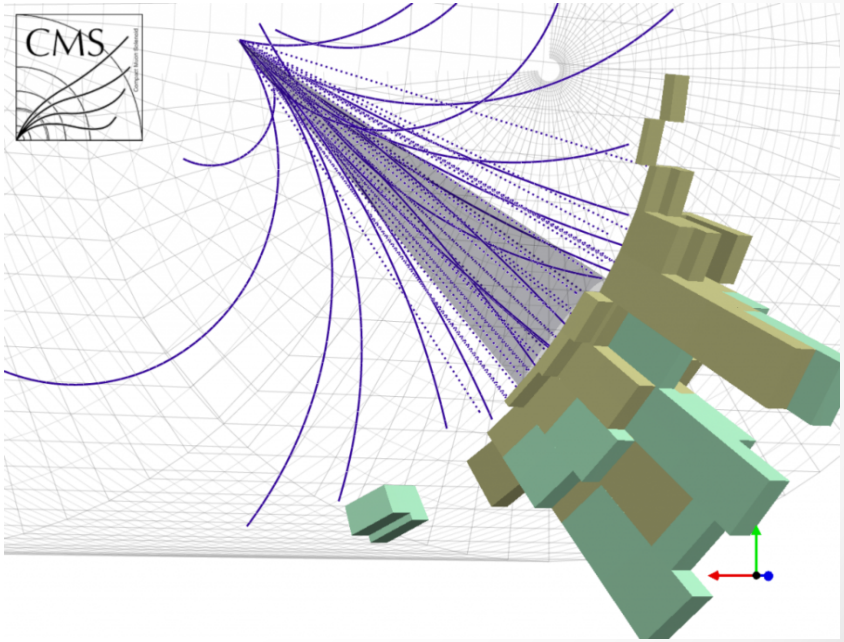


Cut and Jet algorithm

- We focus on two jets final state processes.
- Anti-kt jet algorithm was applied, R=0.5 for jet combinition.
- We select jets with $p_T > 30GeV, \eta < 2.5$
- To improving the result, we formed wide jet around each leading jet.

  $\Delta R = \sqrt{\Delta\eta^2 + \Delta\varphi^2} < 1.1$
- Two cut-off parameter choice

  $\delta_s = 1 \times 10^{-2}, \delta_c = \delta_s/50$



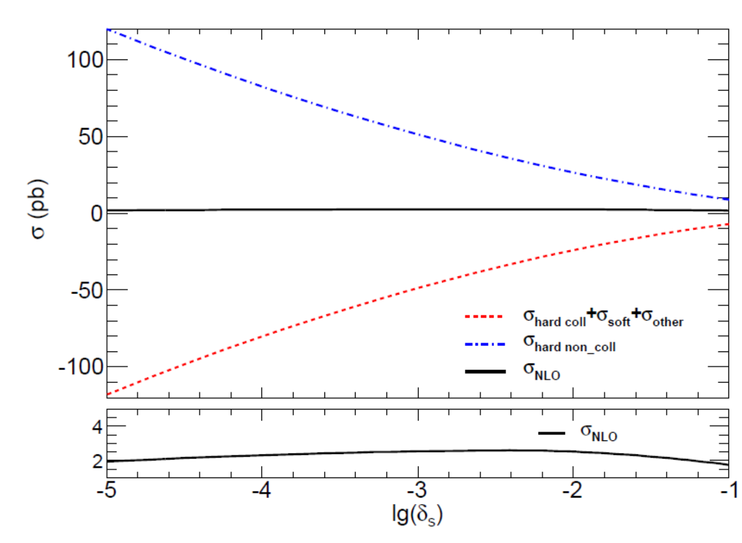
NLO WIDTH

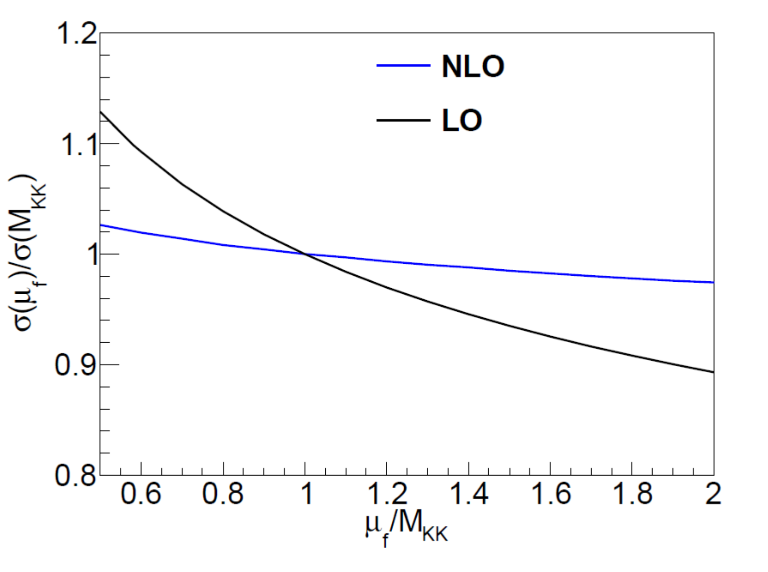
$$\sigma_{NLO} = (\sigma_0 + \sigma_1)\frac{1}{\Gamma_0 + \Gamma_1} = \sigma_0(\frac{1}{\Gamma_0} - \frac{\Gamma_1}{\Gamma_0^2}) + \sigma_1\frac{1}{\Gamma_0}$$

$$\frac{1}{(s^2 - m_{KK}^2)^2 + \Gamma_{NLO}^2 m_{kk}^2} = \frac{1}{(s^2 - m_{KK}^2)^2 + (\Gamma_0 + \Gamma_1)^2 m_{kk}^2}$$

$$\sigma_{NLO} = \sigma_{LO}\frac{(s^2 - m_{KK}^2)^2 + \Gamma_0^2 m_{kk}^2 - 2m_{kk}^2\Gamma_0\Gamma_1}{[(s^2 - m_{KK}^2)^2 + \Gamma_0^2 m_{kk}^2]^2} + \sigma_{NLO}\frac{1}{(s^2 - m_{KK}^2)^2 + \Gamma_0^2 m_{kk}^2}$$

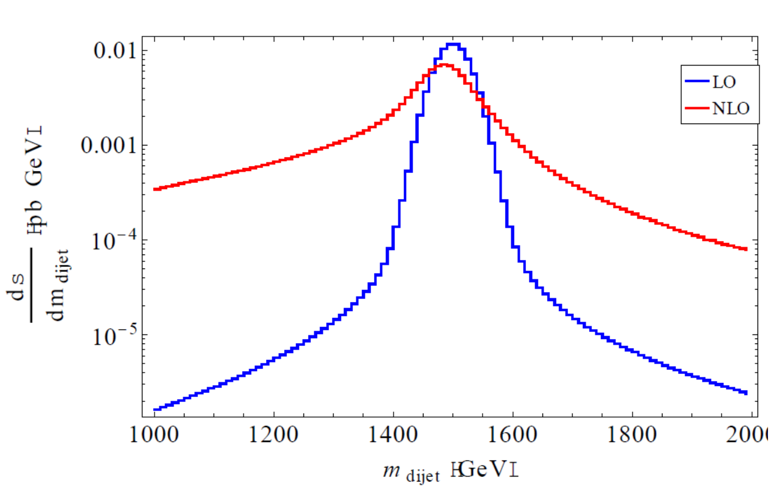
Total cross section

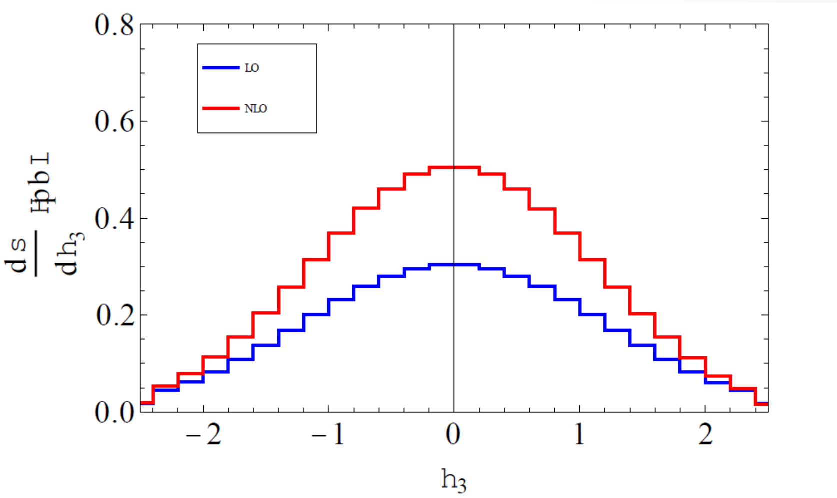




LO (pb)	NLO (pb)	K Factor
0.6044	0.9139	1.51

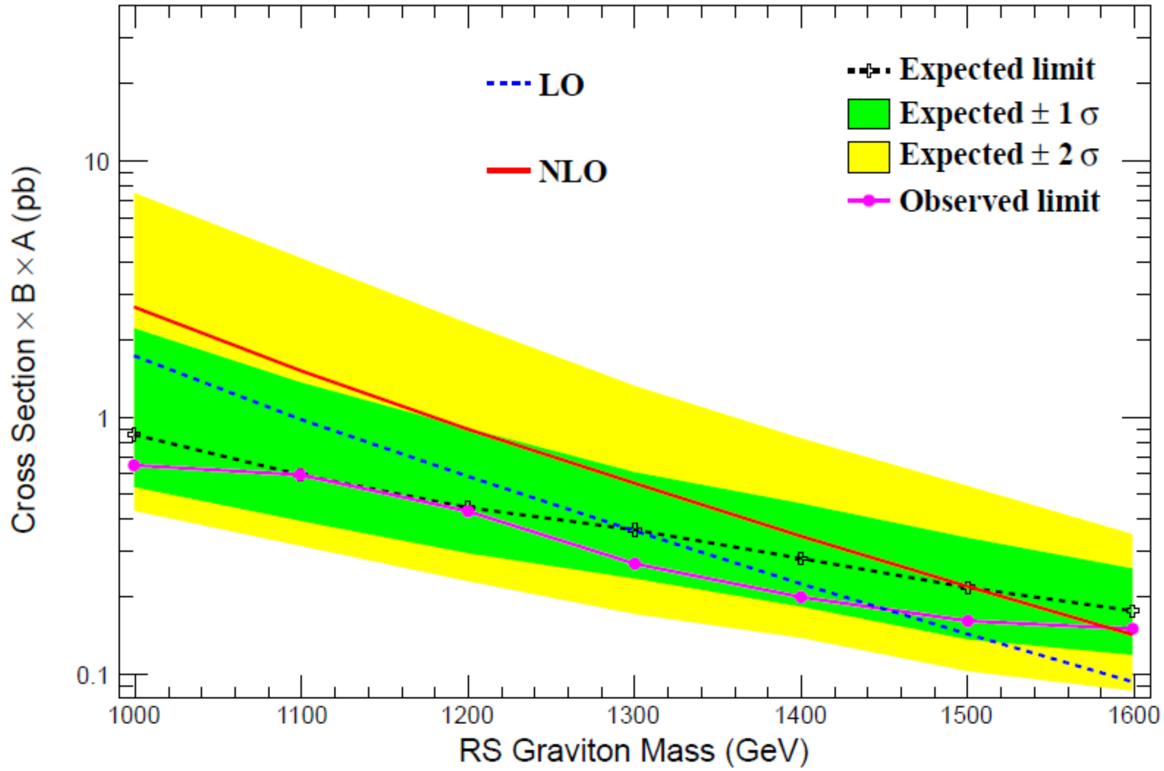
Differential cross section





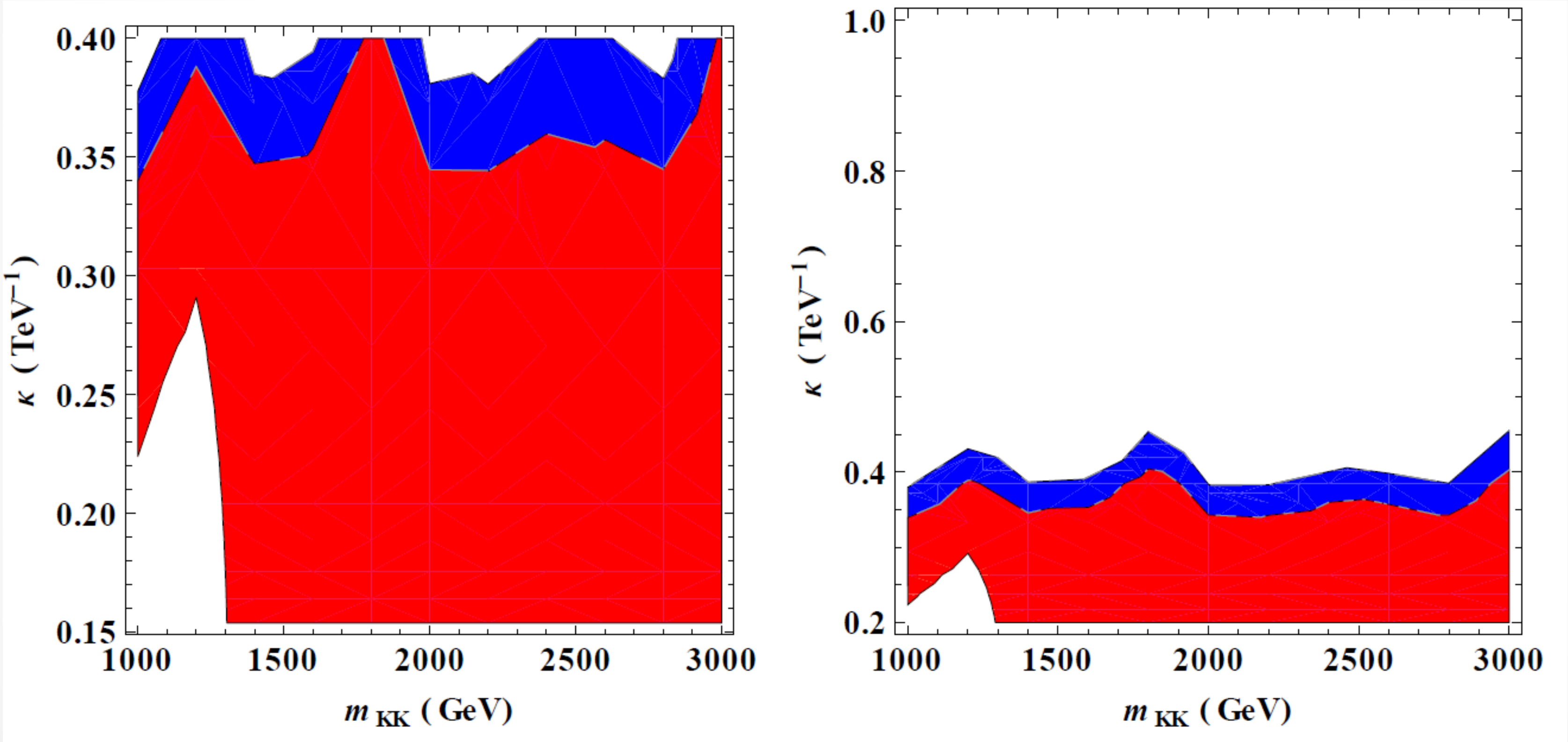
At the NLO the heavy resonance can decay into a quark pair plus a hard gluon, so the NLO corrections increase the distributions in the lower invariant mass value region, and the changes of the distributions are more significant as the resonance mass increases.

Signal analysis



RS Graviton	Observed Excluded Mass Range(TeV)
LO	1.45
NLO	1.58

Parameter space



Conclusion

- RS extra dimension model still can play a important role in solving Standard Model problem, such as hierarchy problem.
- Dijet process is a useful way to search for the new physics particles.
- NLO QCD corrections for the dijet production via KK graviton can significantly enhance the LO total cross section and change the shape of the differential distribution of the LO.
- Constraint on the extra dimension model become more and more stringent.
- Future study will give us more information.

Thanks!