Higgs Physics in Warped Extra Dimensions

Florian Goertz

Summer School "Physics at TeV Colliders"
Cargese, 27.07.2010

S. Casagrande, FG, U. Haisch, M. Neubert, T. Pfoh, arXiv:1005.4315[hep-ph]

Outline

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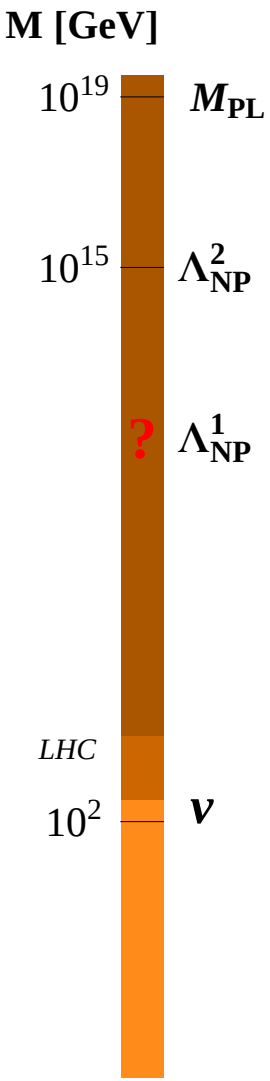
Gauge Hierarchy Problem and Flavor Puzzle



- Higgs mass recieves quadratically divergent corrections

$\Rightarrow$ expect $m_h^2 \sim \max[\Lambda^i_{NP}]^2$

- Gauge bosons: gauge symmetry
- Fermions: $SU(2)_L$

} small masses natural

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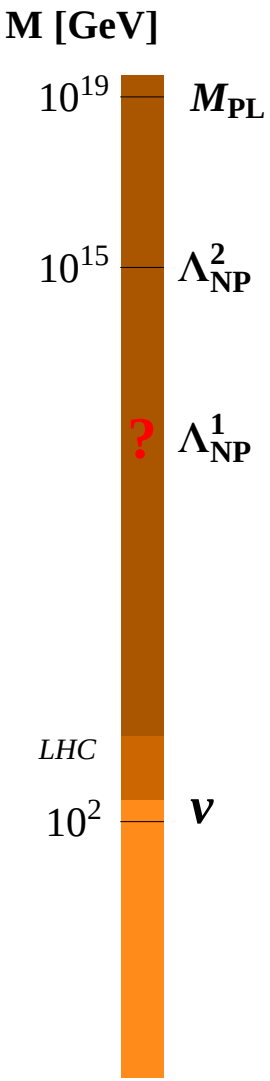

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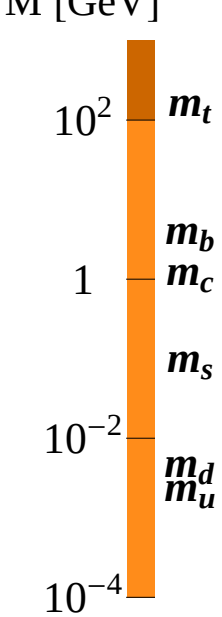

$m_u/m_t \sim 10^{-5}$

$$\mathbf{V}_{CKM} \sim \begin{pmatrix} 1 & \lambda & \lambda^3 \\ -\lambda & 1 & \lambda^2 \\ -\lambda^3 & -\lambda^2 & 1 \end{pmatrix}$$

$\lambda \sim 0.2$

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The Randall-Sundrum (RS) Model hep-ph/9905221

- Solution to the gauge hierarchy problem in 5D spacetime

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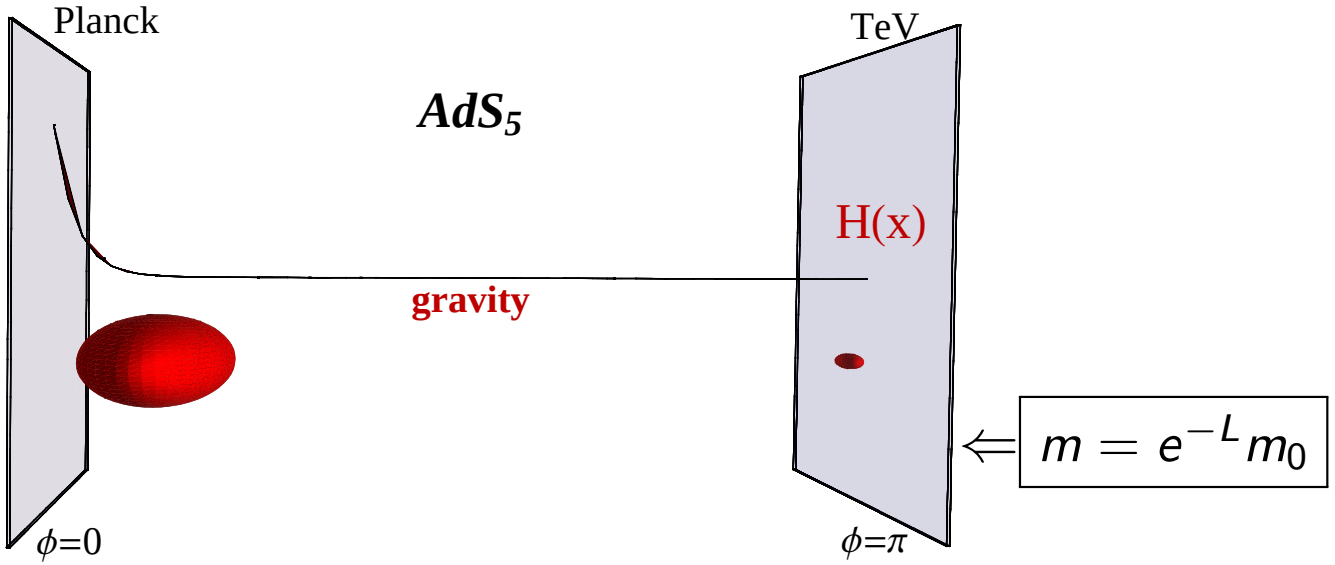

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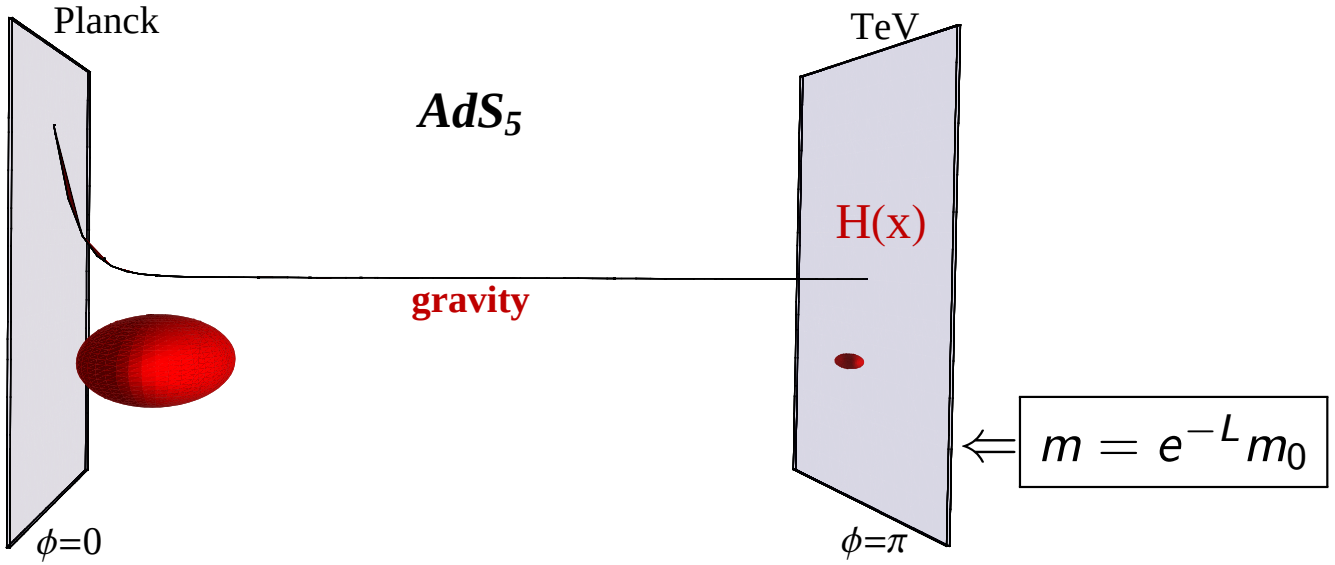

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many observables enhanced by L

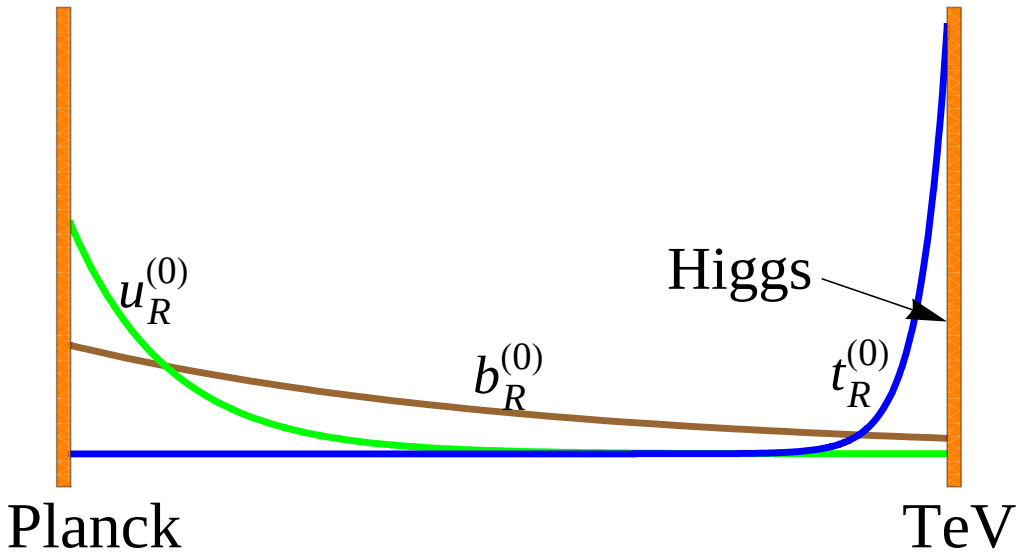
- All fundamental parameters of $\mathcal{O}(M_{PL})$

The Standard Model in AdS_5

Just the Higgs boson has to be localized at (close to) the TeV brane in order to solve the hierarchy problem $\Rightarrow$ *Bulk-SM*

Davoudiasl, Hewett, Rizzo, hep-ph/9911262,

Grossman, Neubert, hep-ph/9912408



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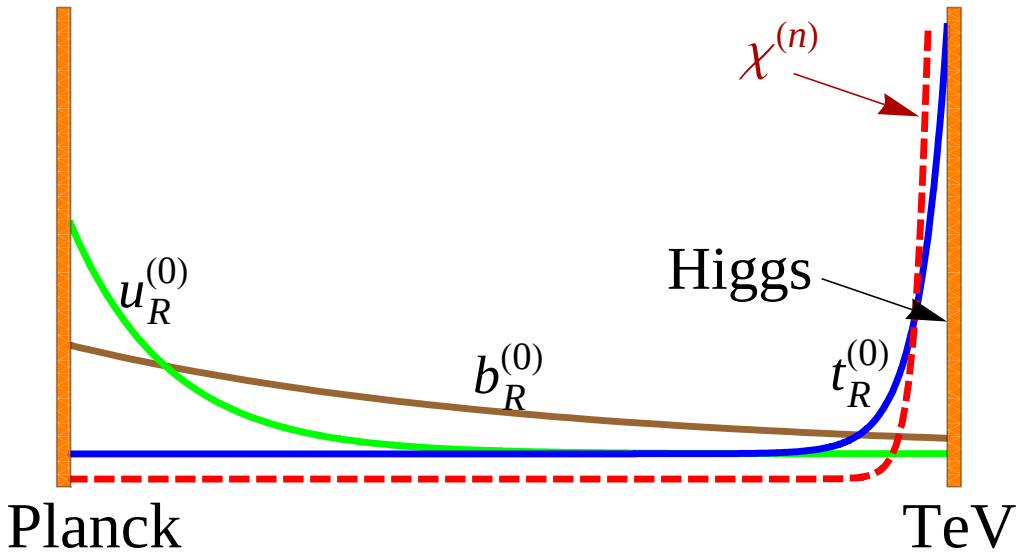

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$M_{\mathrm{KK}} = k e^{-L} \sim TeV$

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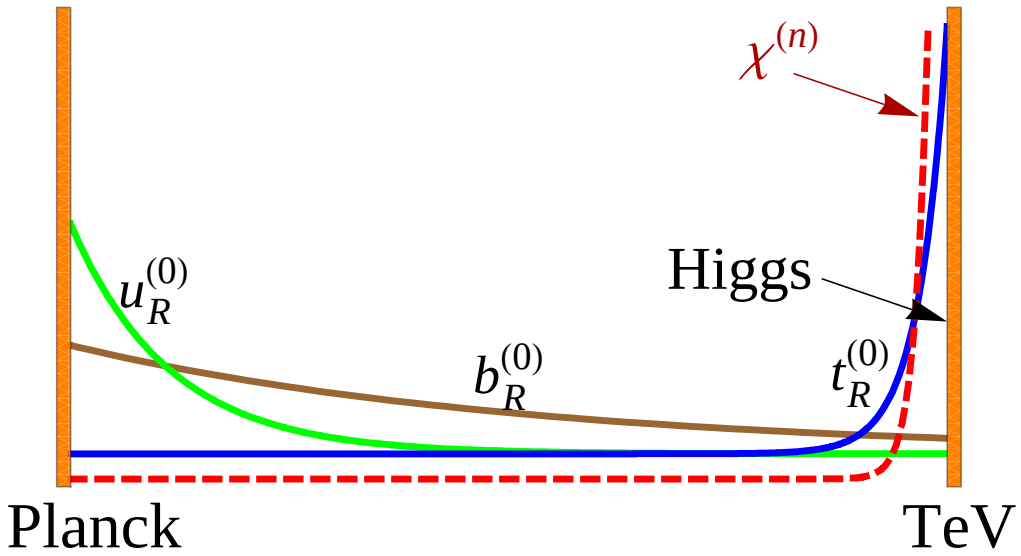

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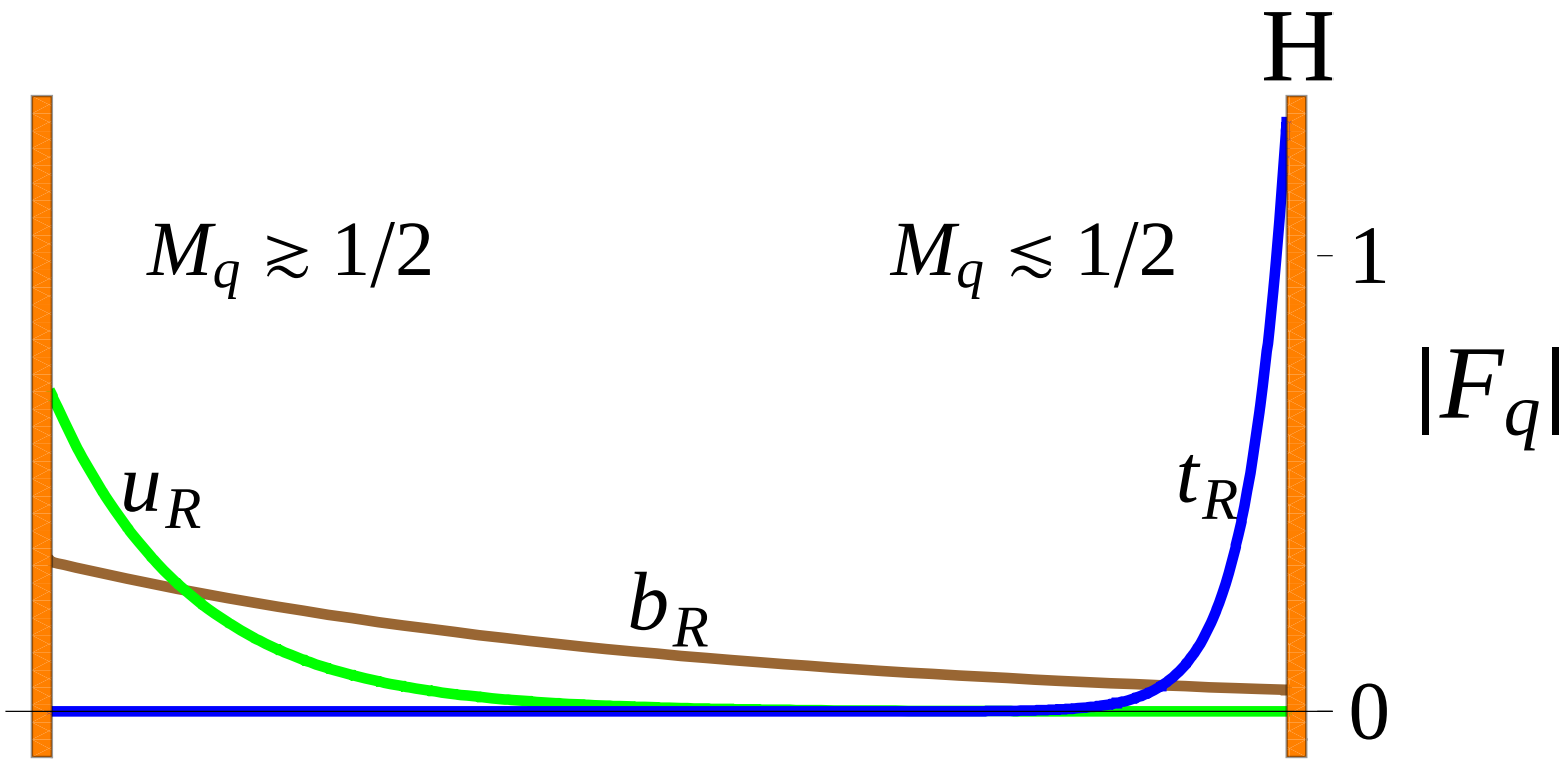
Non-trivial overlaps + doublet-singlet mixing

$\Rightarrow$ fields with same QN under unbroken symmetry have different couplings to gauge bosons of broken symmetry $\Rightarrow$ tree FCNCs

RS as a Solution to the Flavor Puzzle

- RS offers an explanation for the fermion mass hierarchies and small CKM mixing angles Huber, hep-ph/0303183; Huber, Shafi, hep-ph/0010195



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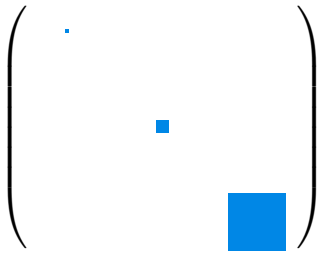
$$m_{q_i} = \mathcal{O}(1) \times \frac{v}{\sqrt{2}} |F_{Q_i} F_{q_i}|$$



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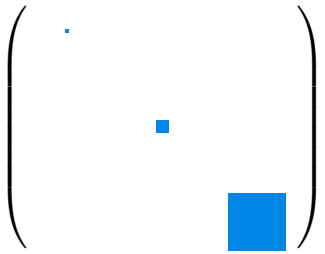

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Custodial protection

Implement custodial protection by extending the SM gauge group[1]

$$SU(3)_c \times SU(2)_L \times SU(2)_R \times U(1)_X \times P_{LR}$$

- $SU(2)_R \times U(1)_X \xrightarrow{\text{UV}} U(1)_Y$
- P_{LR} : interchange $SU(2)_L \leftrightarrow SU(2)_R$
- T parameter protected [2]
- $b_L \in (2,2)_{2/3} \rightarrow Zb_L\bar{b}_L$ protected

[1] Agashe, Delgado, May, Sundrum, hep-ph/0308036,
Agashe, Contino, Da Rold, Pomarol, hep-ph/0605341

[2] alternative option: heavy higgs, Casagrande, FG, Haisch, Neubert, Pfoh, 0807.4937[hep-ph]

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Rare decays $t \longrightarrow cZ^0$ and $t \longrightarrow ch$

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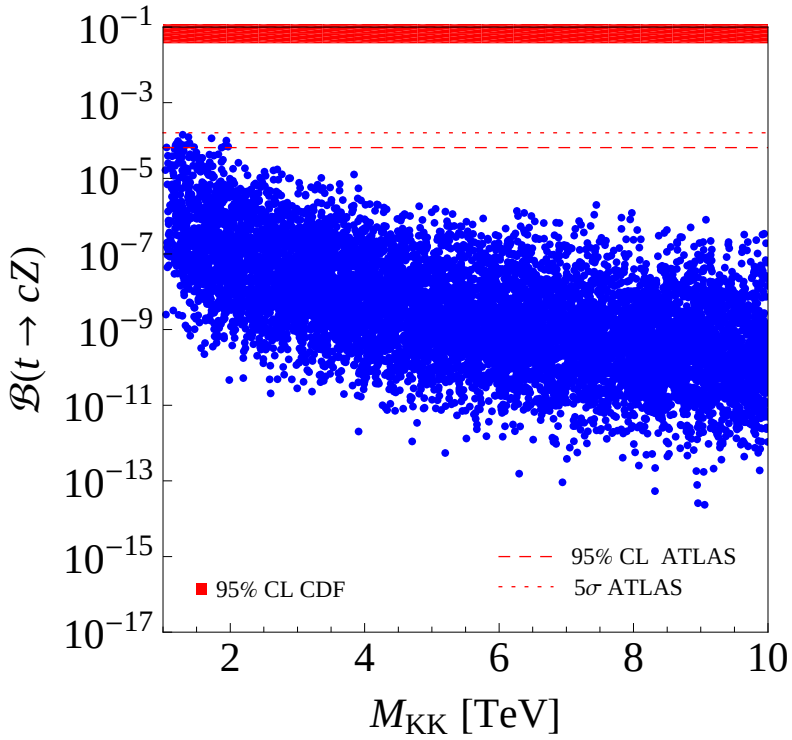
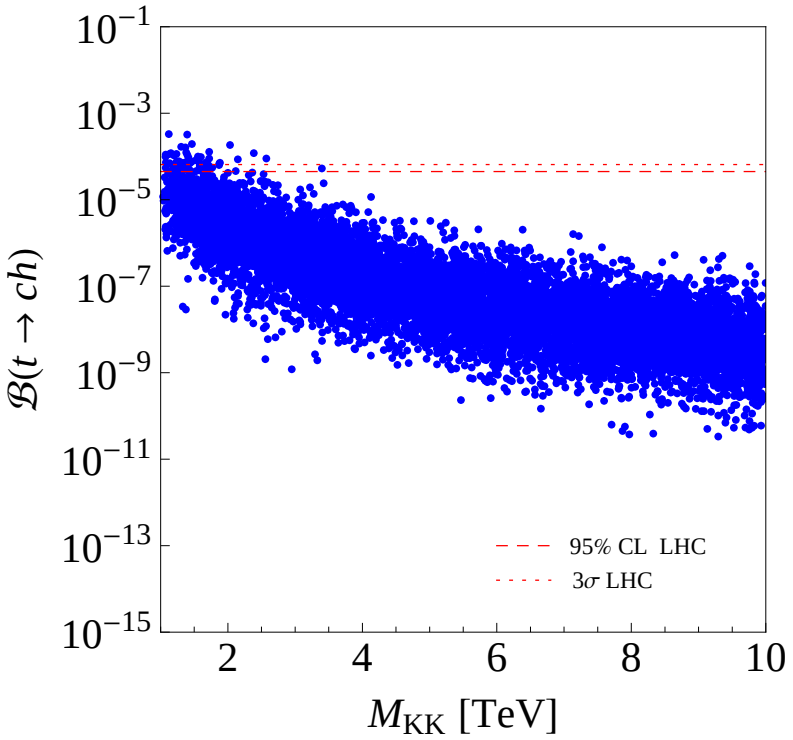
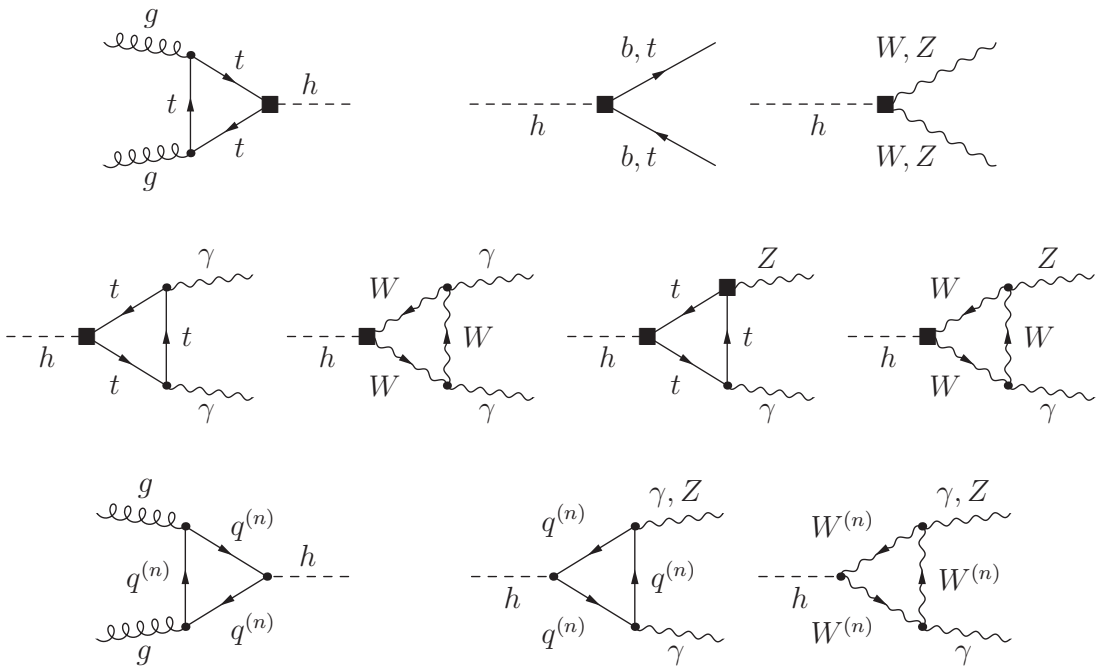




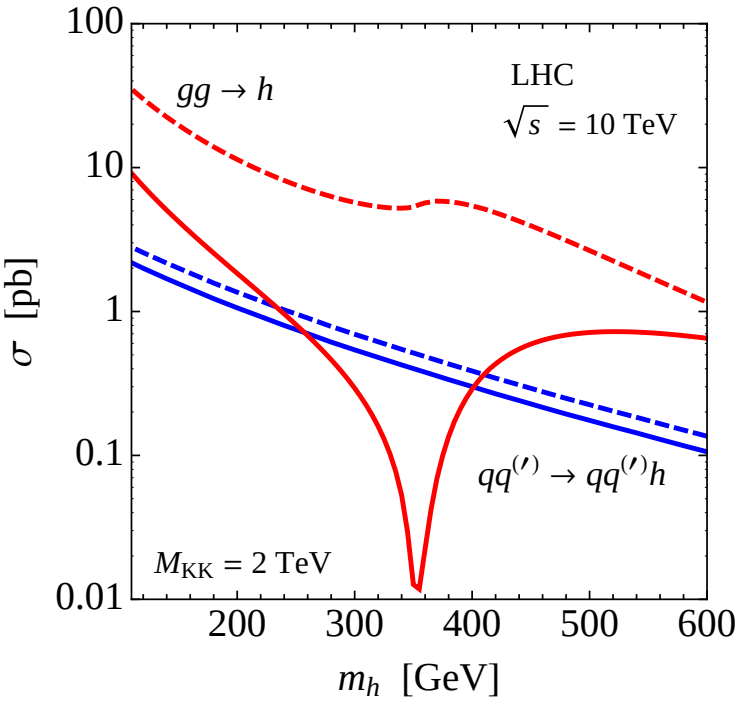
Higgs production and decay

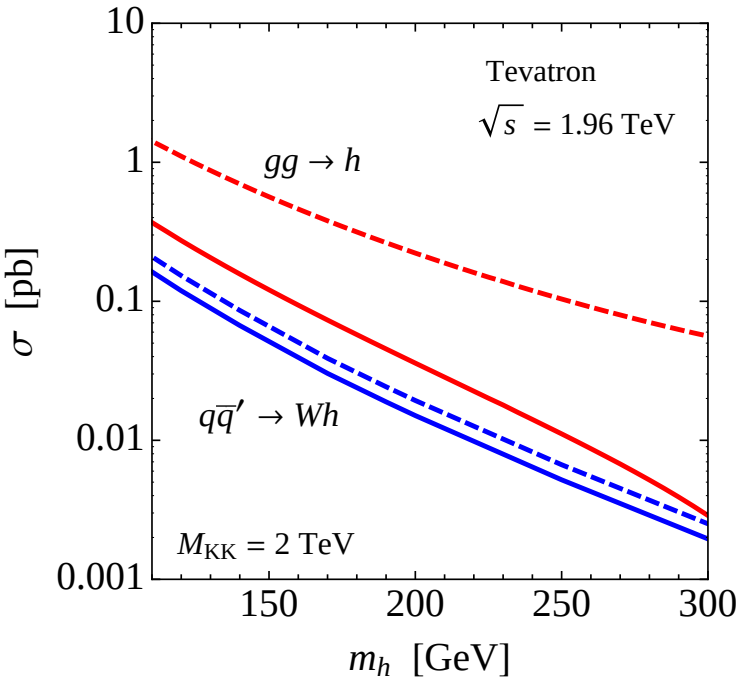
First complete one-loop calculation in RS



- Higgs couplings to heavy quarks and massive gauge bosons recieve sizable negative corrections up to -50% ($M_{\mathrm{KK}} = 2\mathrm{TeV}$)

Higgs production





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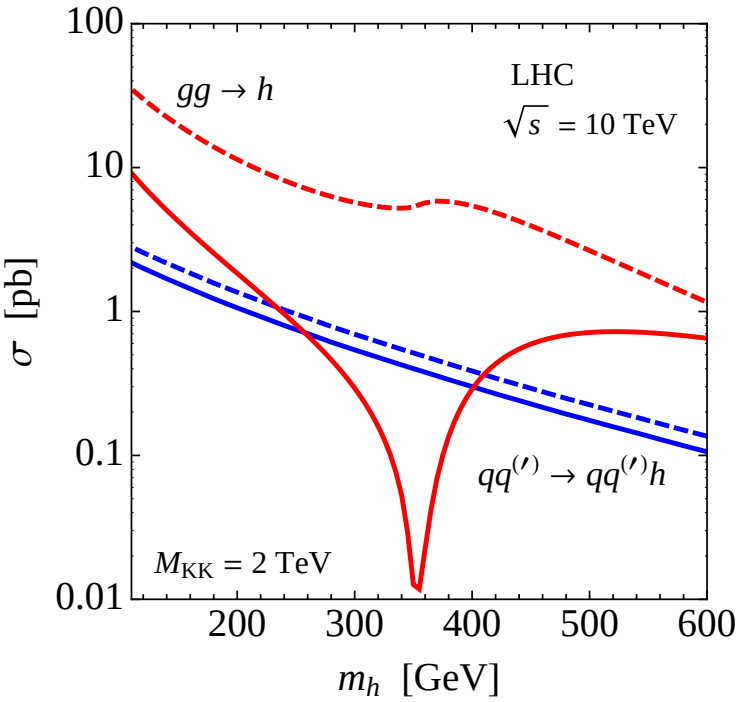
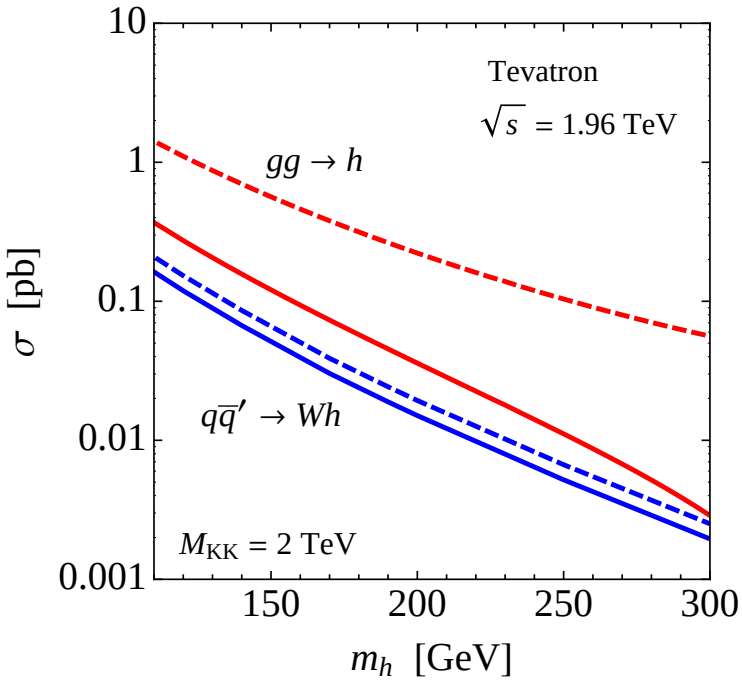
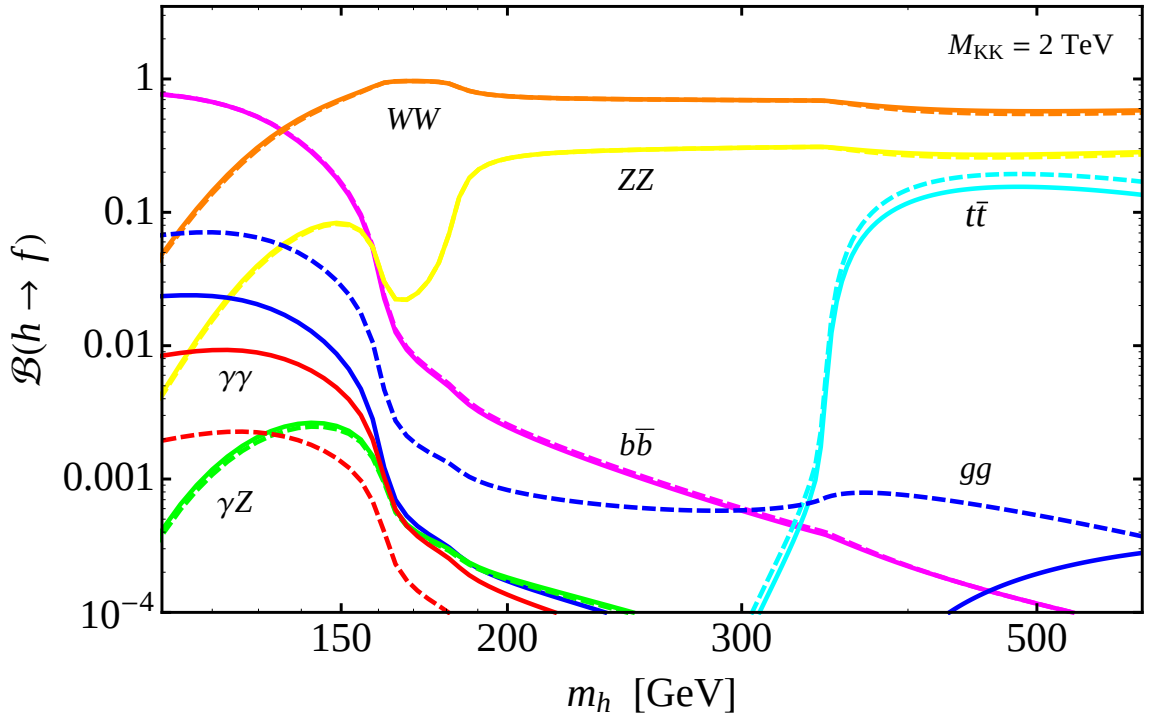




Higgs mass bounds could be altered

Higgs decay



- above WW threshold: Higgs discovery via golden channel
  $gg \to h \to Z^{(*)}Z^{(*)} \to l^+l^-l^+l^-$ more difficult
- below WW threshold: slightly better potential to discover the Higgs via
  $gg \to h \to Z^{(*)}Z^{(*)} \to l^+l^-l^+l^-$ for $M_{\mathrm{KK}} = 2$ TeV

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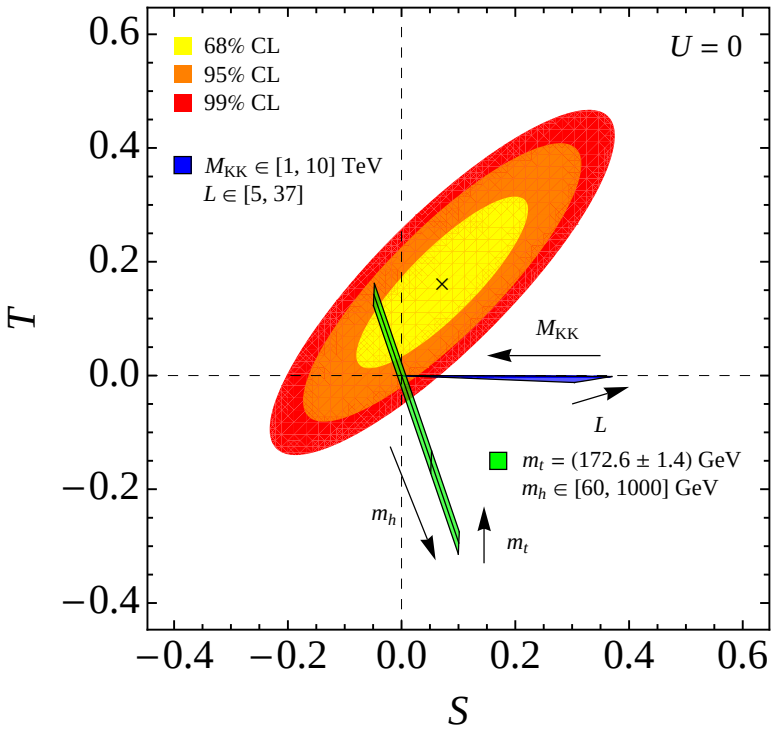
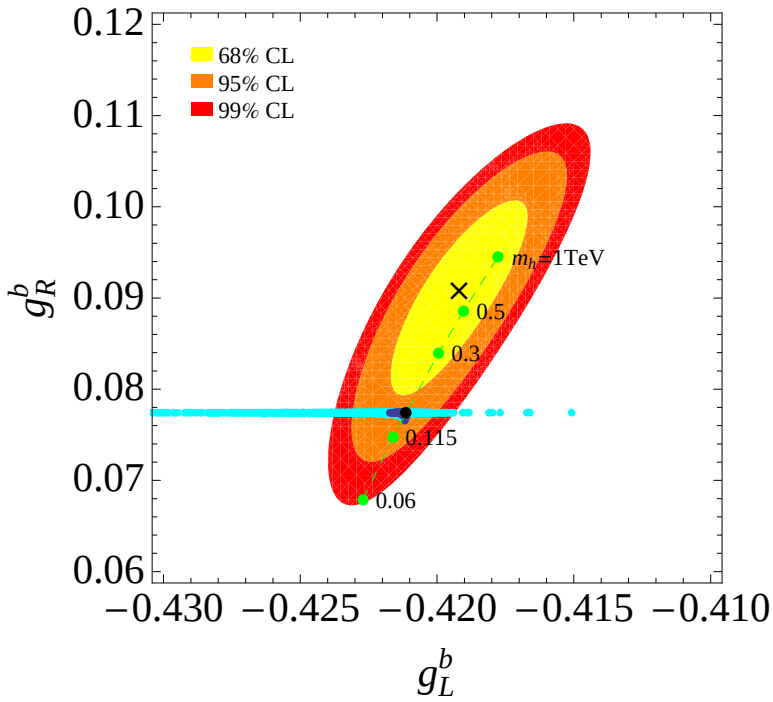
Thank you for your attention!

Backup: Electroweak Precision (custodial model)





$$T = \frac{\pi v^2}{2\cos^2\theta_W M_{\rm KK}^2}\left(\not{L} - \frac{1}{2L}\right)$$

blue: P_{LR} protection also for fermion mixing

$$\Rightarrow M_{\rm KK} > 2.4\,\text{TeV}\ (99\%\,\text{CL}) \quad (m_h = 150\,\text{GeV})$$