IDENTIFYING NEW PHYSICS CONTRIBUTIONS IN THE HIGGS SECTOR

at linear e+ e- colliders

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- Summary

Decay modes of Higgs

- The Higgs boson in the Standard Model has the following decay modes

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H &\rightarrow \gamma\gamma,\ gg \\
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- We are interested in the loop induced decay modes: $H \longrightarrow \gamma\gamma$

$$\Gamma(H \rightarrow \gamma\gamma) = \frac{G_\mu \alpha^2}{128\sqrt{2}} \left(\frac{M_H}{\pi}\right)^3 |I_\gamma|^2$$

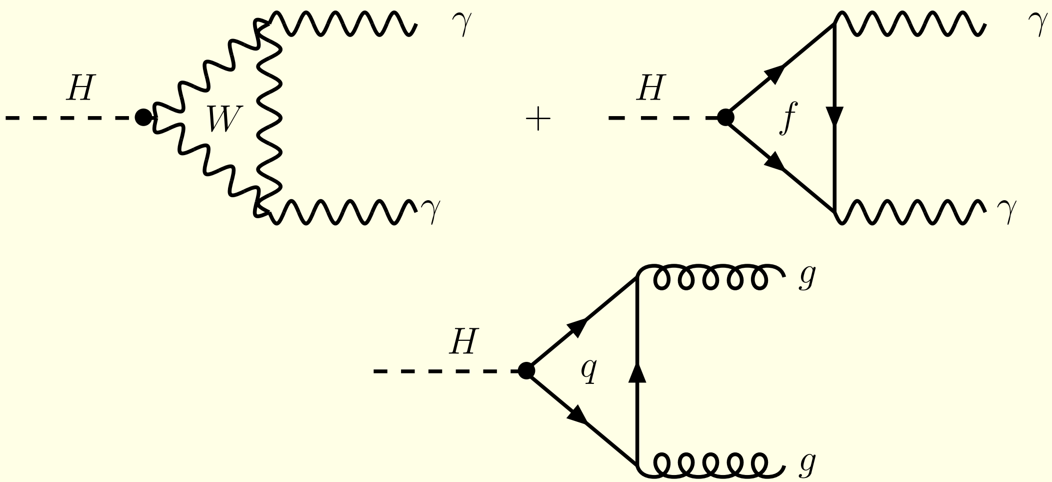
$$\text{where} \quad I_\gamma = I_W + \sum_f N_c\, Q_f^2\, I_f$$

Decay modes of Higgs..

- $H \to g\ g$

$$\Gamma(H \to gg) = \frac{G_\mu \alpha_s^2}{36\sqrt{2}} \left(\frac{M_H}{\pi}\right)^3 \left|\frac{3}{4} I_g\right|^2$$

$$\text{where} \quad I_g = \sum_q I_q$$



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  - Possible probe of new particles which are too heavy to be produced directly
- New particles contributing to the loops..
  - Modification of the form factors..
- Probe for the scale of new physics scenarios..
- These decays are interesting $\longrightarrow$ strength sensitive to scales far beyond the Higgs boson mass

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- However contributions may well be masked. Large uncertainties...
- Linear colliders will be the ideal place to determine the effects more effectively
- We look at some new physics scenarios....

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New Physics Scenarios

- Many beyond standard model physics scenarios predict particles that can modify the partial width of the Higgs decay to these massless gauge bosons..
  - Universal extra dimensions (UED), Little Higgs, etc..
- Case of UED is discussed. Sensitivity of other scenarios can be tested similarly.
- A way of distinguishing radions from Higgs bosons too...

New Physics Scenarios..

- In the minimal form of UED, all SM particles propagate in a single extra dimension, which is compactified on an S_1/Z_2 orbifold.
  - Should not disturb experimental constraints... $\rightarrow$ This puts a limit on the maximum size (R) of the extra dimension.
  - Usual Kaluza Klein (KK) mechanism $\rightarrow$ KK excitations of all SM particles.
  - The masses of the first (n=1) excitations $\sim R^{-1}$ GeV.
- The momentum along the extra dimension is conserved $\rightarrow$ Conservation of KK number which forces the KK particles to be pair produced.
- Our interest is how to identify the effects of the KK tower on the partial width of $H \rightarrow gg$ at linear e^+e^- colliders in a simple way.

Channel of Interest

- We consider the dominant channel of Higgs production at a $\sqrt{s} = 500$ GeV linear e^+e^- collider.

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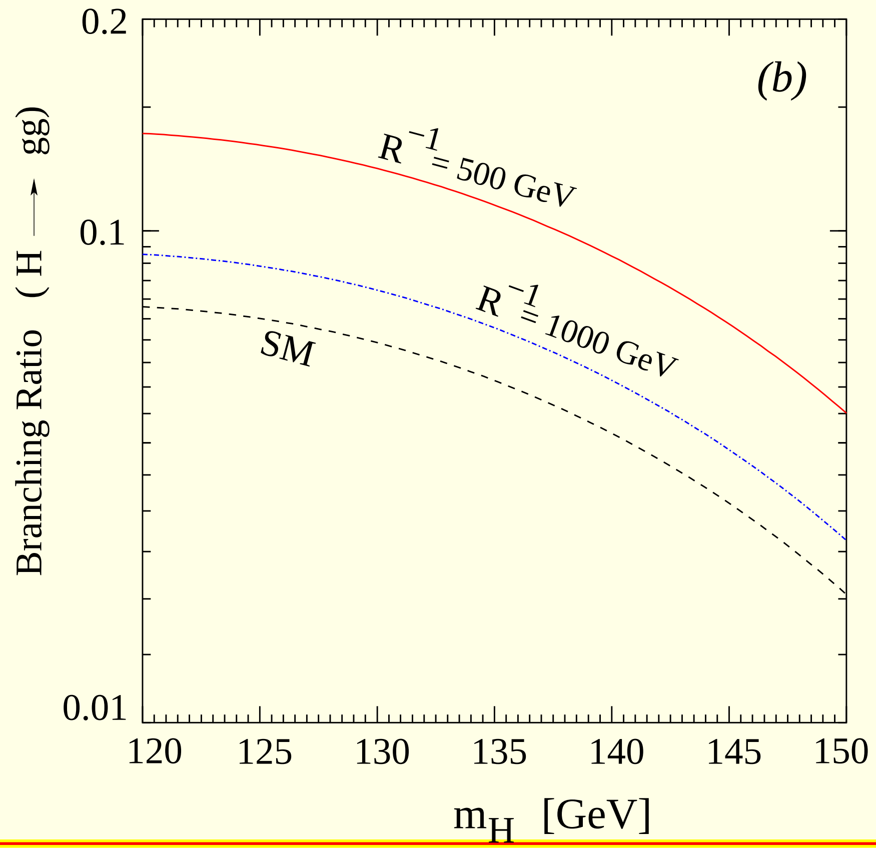
- The modification due to the additional contribution of KK excitations of the quarks in the loops will cause an enhancement in the overall branching ratio of $H \rightarrow jj$.
- The change in the 2-gluon decay mode will have a small effect on the branching ratio for the $b\bar{b}$ mode as the branching ratios differ by more than an order of magnitude in the intermediate mass range of the Higgs boson.

Channel of Interest..

- $H \to g\ g$

$$\Gamma(H \to gg) = \frac{G_\mu \alpha_s^2}{36\sqrt{2}} \left(\frac{M_H}{\pi}\right)^3 \left| \frac{3}{4} I_g + \sum_n \tilde{I}_q^{(n)} \right|^2$$

[F. Petriello, JHEP 0205:003,2002]



Some Results

- Cuts imposed for our analysis:
  - Final state leptons and jets should have $p_T^{(\ell,j)}$ > 10 GeV
  - Final state leptons should have $|\eta^{(\ell)}|$ < 3.0
  - Final state jets should have $|\eta^{(\ell)}|$ < 2.5
  - Final state jets should be well separated ΔR_{jj} > 0.4
- We have removed the non-Higgs part of the Standard Model contributions..
  - Such as $e^+e^- \to ZZ, ZZ^*$,etc. which lead to large SM four fermion background by rejecting events which correspond to 2-jet invariant mass of Z boson.
  - The continuum background ($\gamma^*\gamma^*, Z^*Z^*$) too can be easily neglected as it lies below $10^{-3}\ fb$ and would hardly affect the rates for the signal in consideration.

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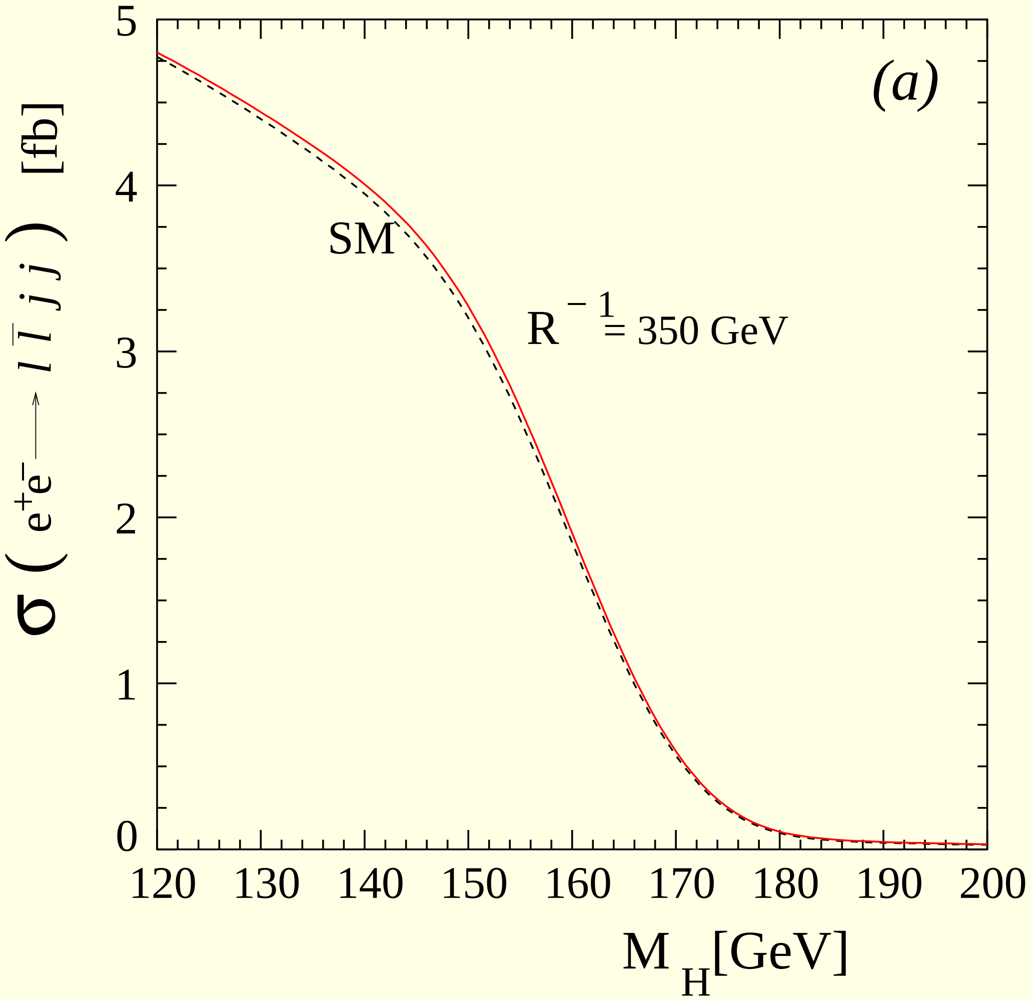

The cross-section for the process $e^+e^- \to \ell^+\ell^- + \ two\ jets$.

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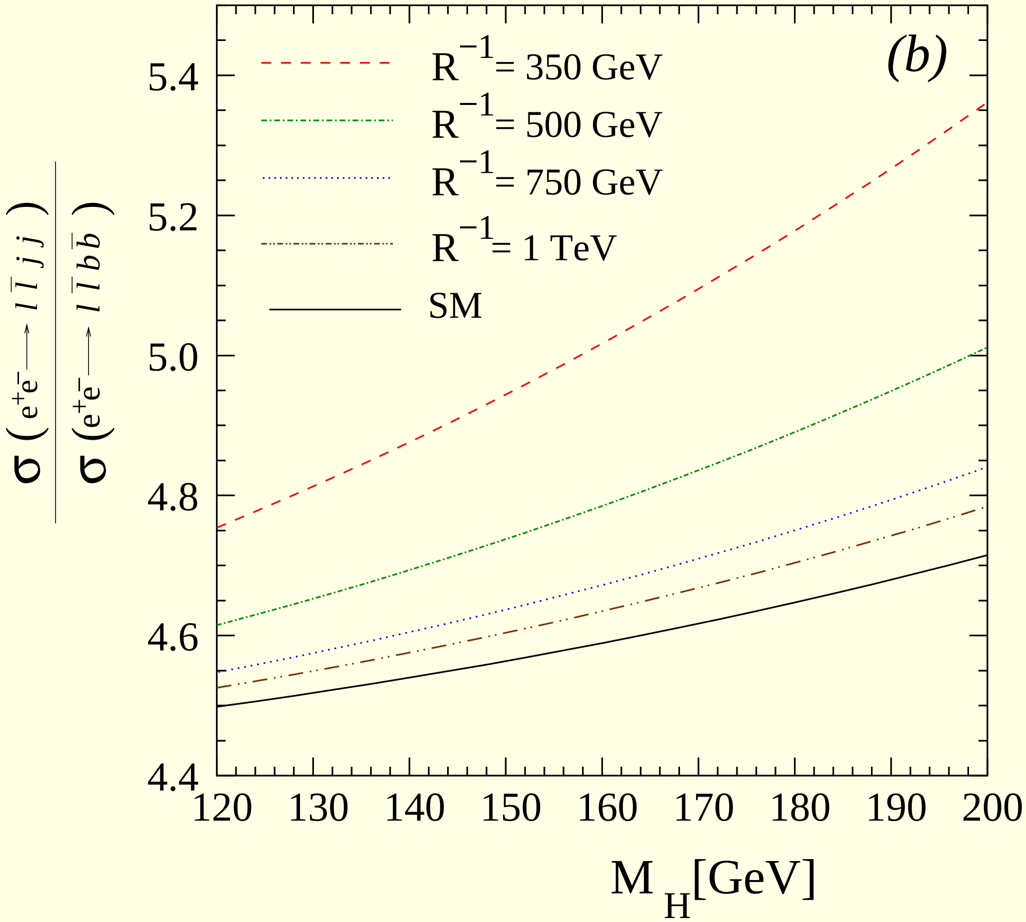
[A. Datta, SKR; hep-ph/0509277]



The ratio of cross-section between two final states $\frac{e^+e^- \to \ell^+\ell^- + \, two \; jets}{e^+e^- \to \ell^+\ell^- + b\bar{b}}$ *for different values of the compactification radius.*

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  - *need for higher luminosity...*

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- The robustness of the method is in the fact that although the $H \to gg$ branching ratio is more than an order smaller than that of $H \to b\bar{b}$ in the intermediate mass range for the Higgs boson, we are still able to identify the difference due to UED contribution.

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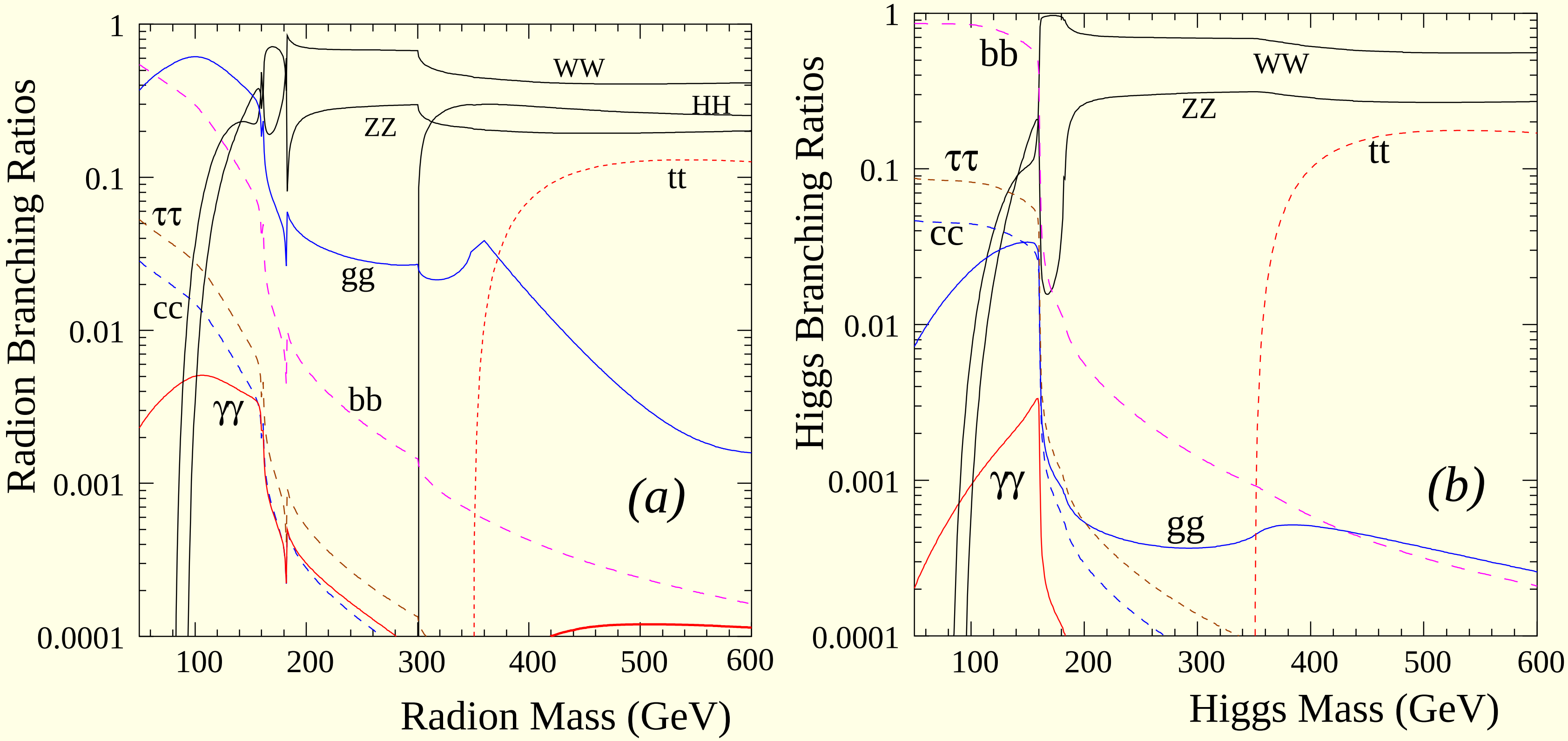
- The ratio of cross-sections would also help cancel out uncertainties like different efficiency factors and systematics associated with particle identifications.
- The effects of the KK excitations in the UED scenario can be evident through the decay mode of the Higgs, driven by loops.
- In fact any new physics contribution to the above decay mode can be identified by this method.

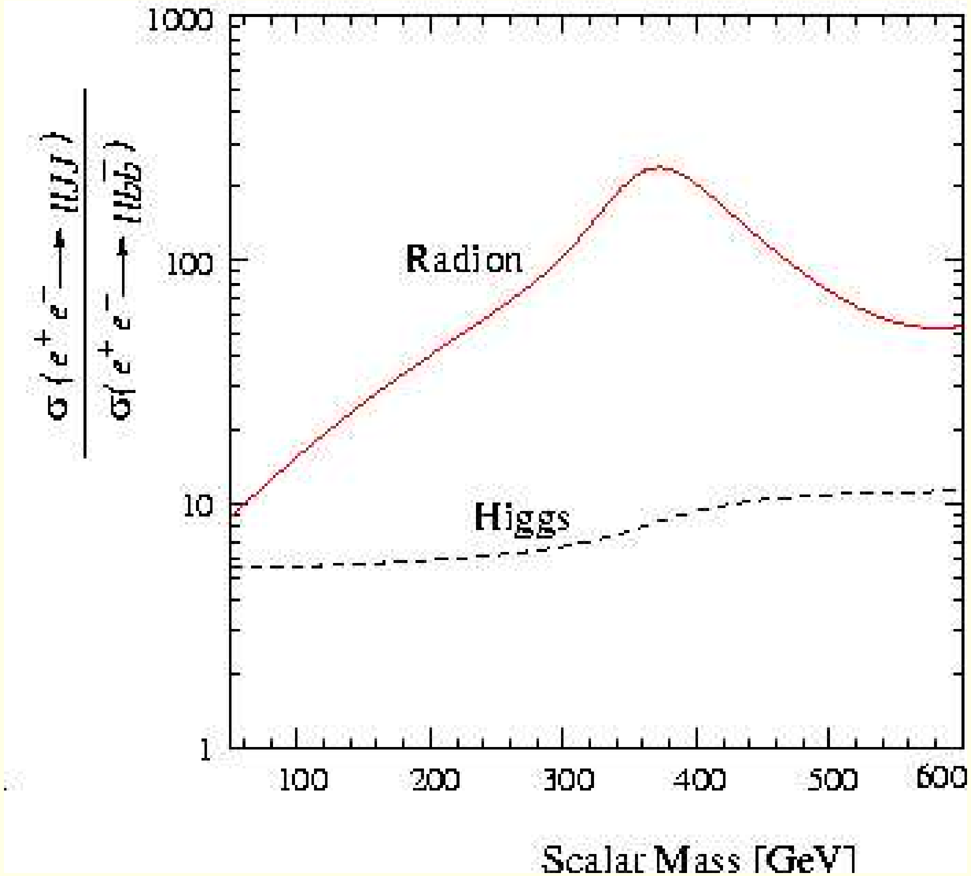
Radion Vs. Higgs



The branching ratios of Radion and Higgs boson. There is a large enhancement in the $\Phi \longrightarrow gg$ due to the trace anomaly which can be instrumental in distinguishing radions from Higgs boson

Radion Vs. Higgs..

[P. Das, SKR, S. Raychaudhuri; Phys.Lett.B618, 2005]



The ratio of cross-section between two final states $\frac{e^+e^- \to \ell^+\ell^- + two\ jets}{e^+e^- \to \ell^+\ell^- + b\bar{b}}$ *for the case of radion and Higgs.*