The Radions

Upsetting or Enriching the Higgs Program at the LHC/LC ?

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Some Useful References

G Giudice, R Rattazzi and J Wells, *Nucl. Phys.* **B 595** (2001), 250 and hep-ph/0002178

J Hewett and T Rizzo, *Radion Mixing Effects on the Properties of the SM Higgs Boson*, SLAC-PUB-9072 and hep-ph/0112343

J Hewett and T Rizzo, *Shifts in the Properties of the Higgs Boson from Radion Mixing*, SLAC-PUB-9132 and hep-ph/0202155

D Dominici *et al.*, *Higgs Boson Interactions within the Randal Sundrum Model*, hep-ph/0206197

D Dominici *et al.*, *The Scalar Sector of the Randall-Sundrum Model*, hep-ph/0206192

Radions Phenomenology

✧ Radions ϕ arise in Randall Sundrum models with a 5-dim AdS space (curvature r), which aim at solving the hierarchy problem, as quantum excitations of the brane separation;

Three Fundamental Parameters :

$$\boxed{m_r \qquad \xi \qquad v/\Lambda}$$

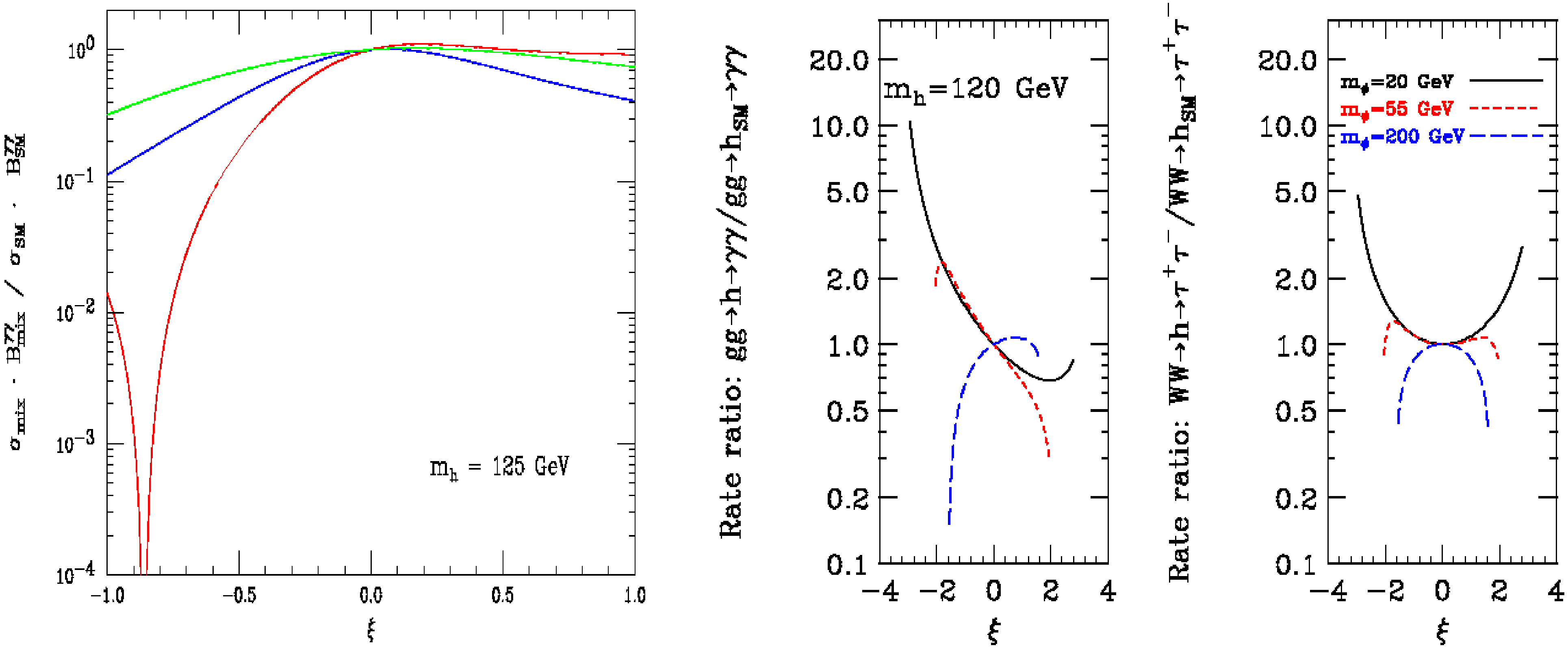
✧ Radion Couplings to Gauge Bosons and Fermions similar to SM H^0;

✧ ϕ Mixing to H ξ cause shift in g_{HVV} and g_{Hff} couplings

$$\boxed{\frac{g'_{HVV}}{g^{SM}_{HVV}} = \frac{g'_{Hff}}{g^{SM}_{Hff}} = f_1(\xi, v/\Lambda, m_\phi) + \frac{v}{\Lambda} f_2(\xi, v/\Lambda, m_\phi)}$$

The Higgs Observability at LHC

✧ May the modified effective couplings to Gluons, Photons and Gauge Bosons affect the H observability at LHC ?

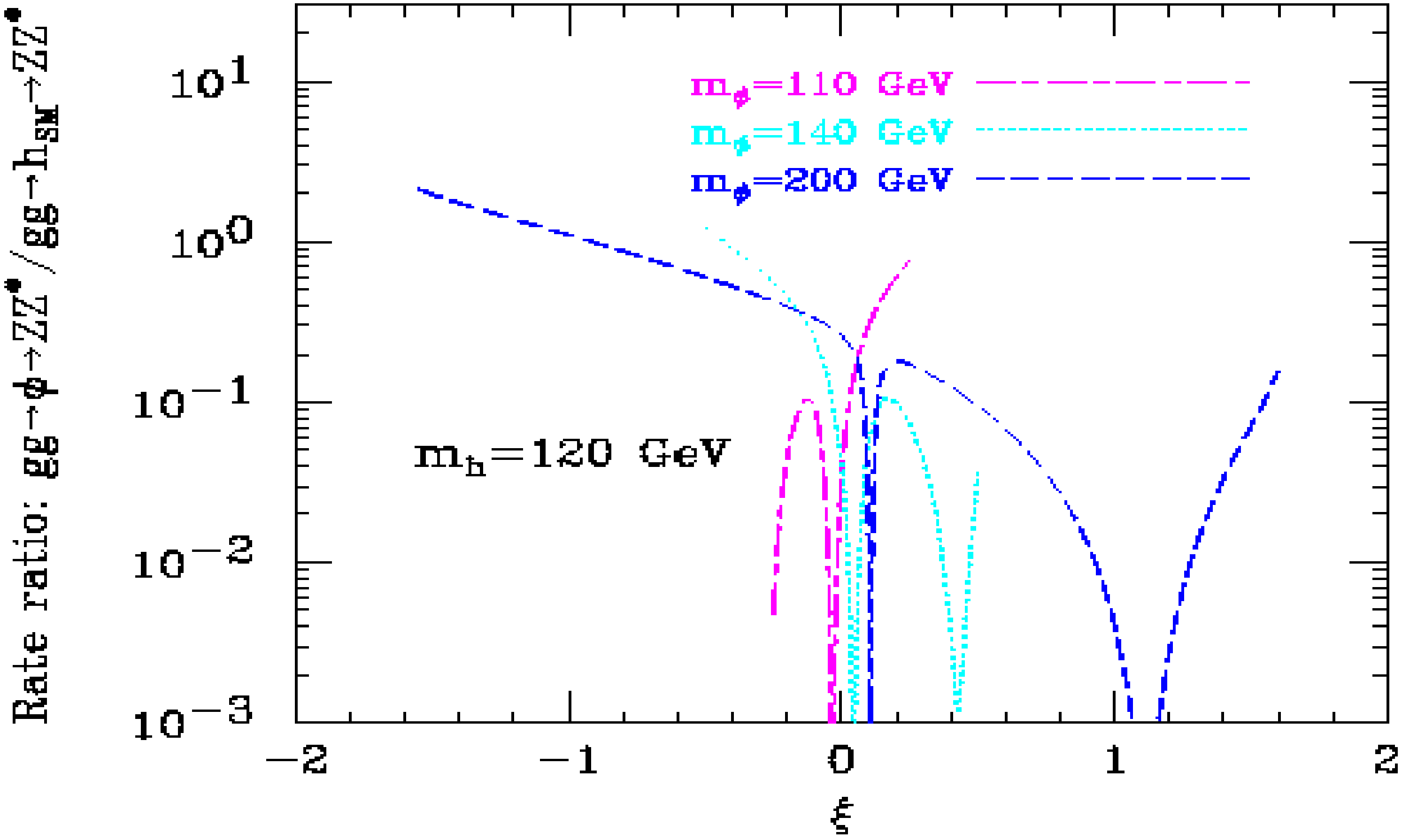


$gg \to H \to \gamma\gamma$ 5σ with ATLAS+CMS 30 fb^{-1}

$M_H = 120$ GeV $\sigma' \times g' > 0.85$

✧ Detection of the Radion at the LHC should cover the regions where $gg \to H \to \gamma\gamma$ is significantly suppressed:

$\phi \to ZZ$



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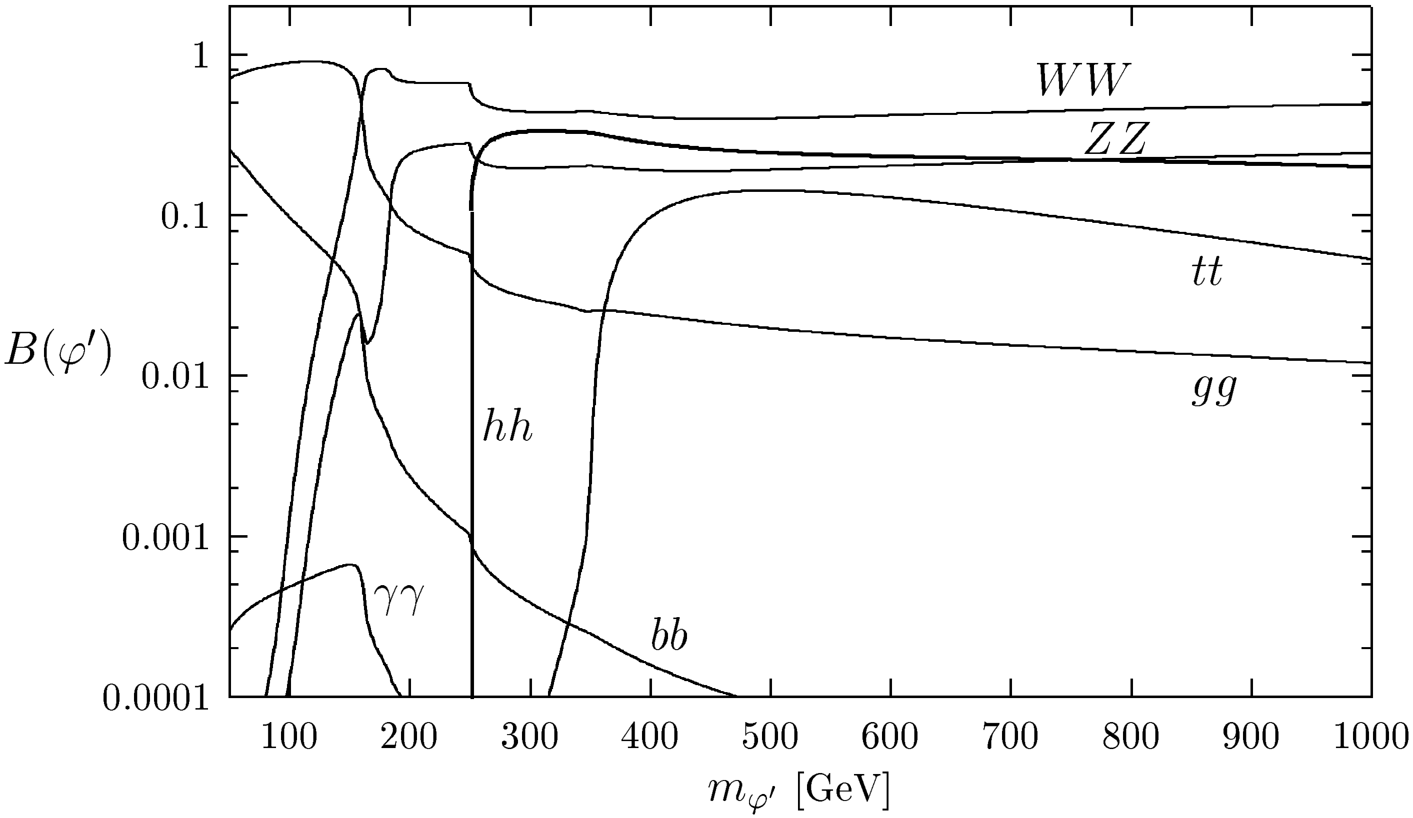
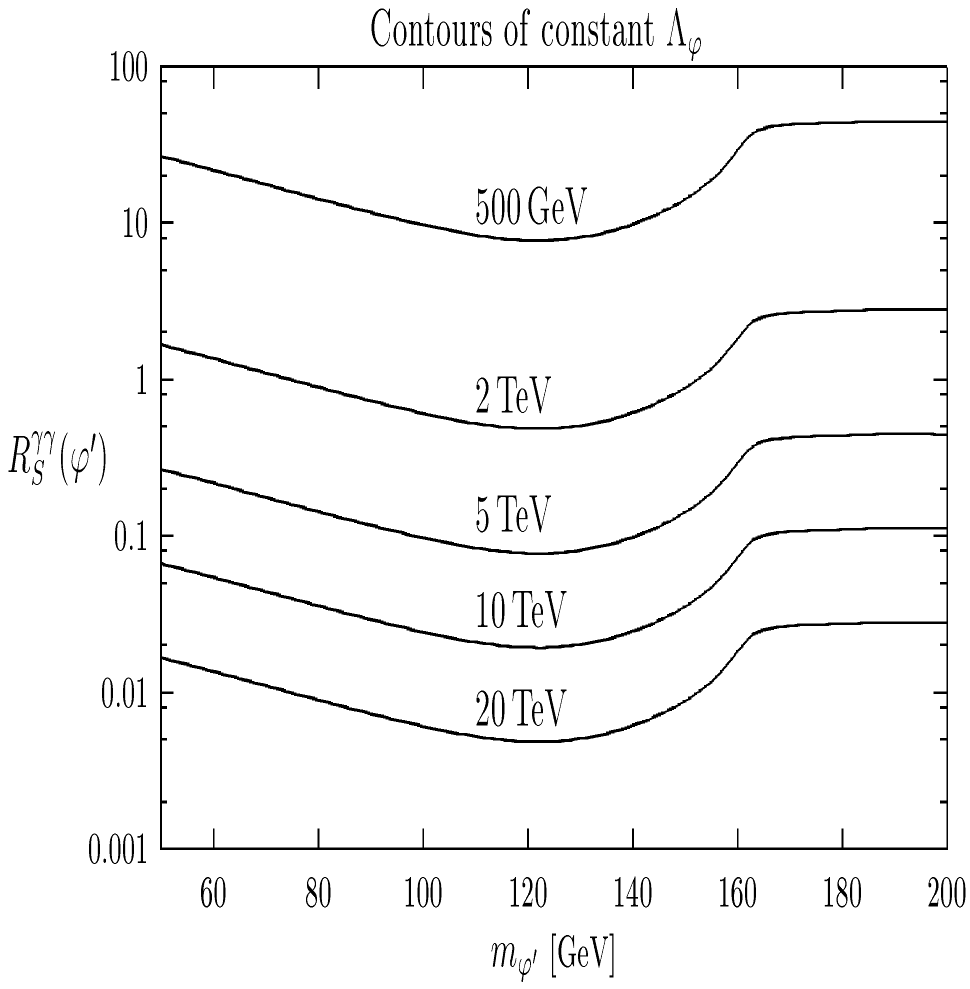
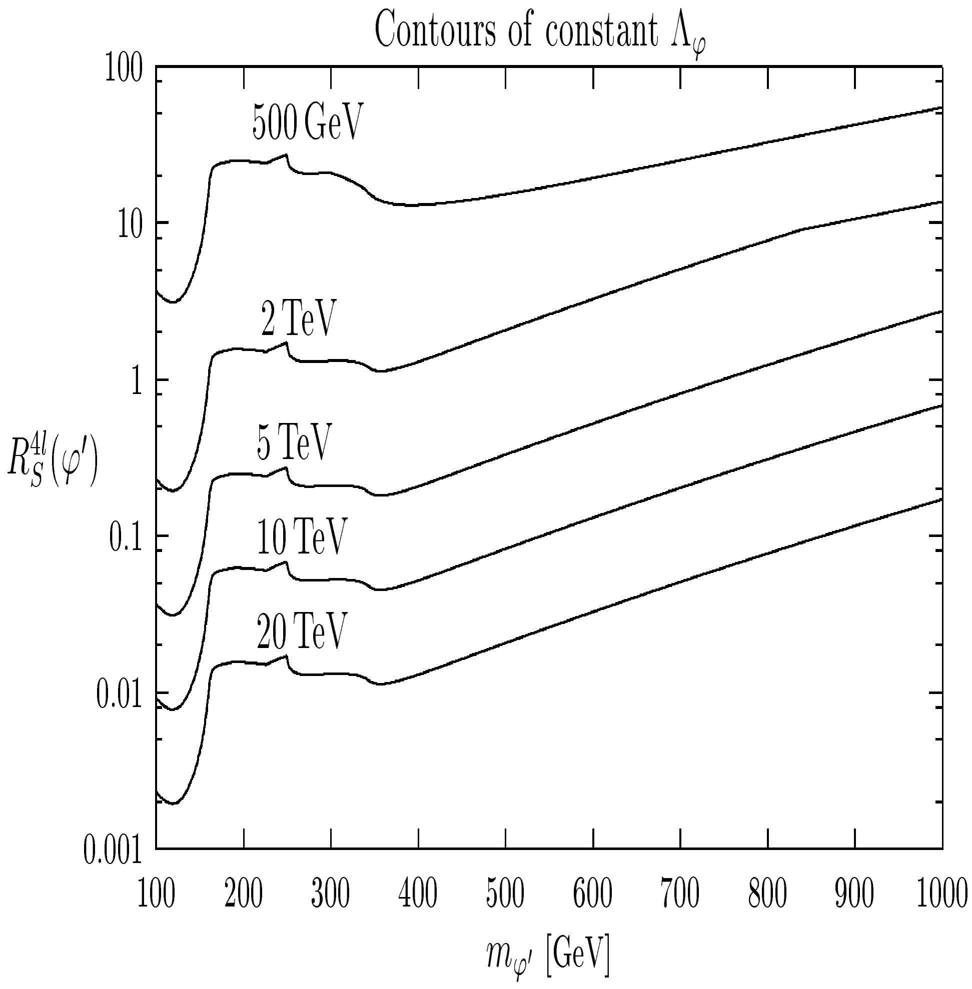
Typical Radion Branching Fractions





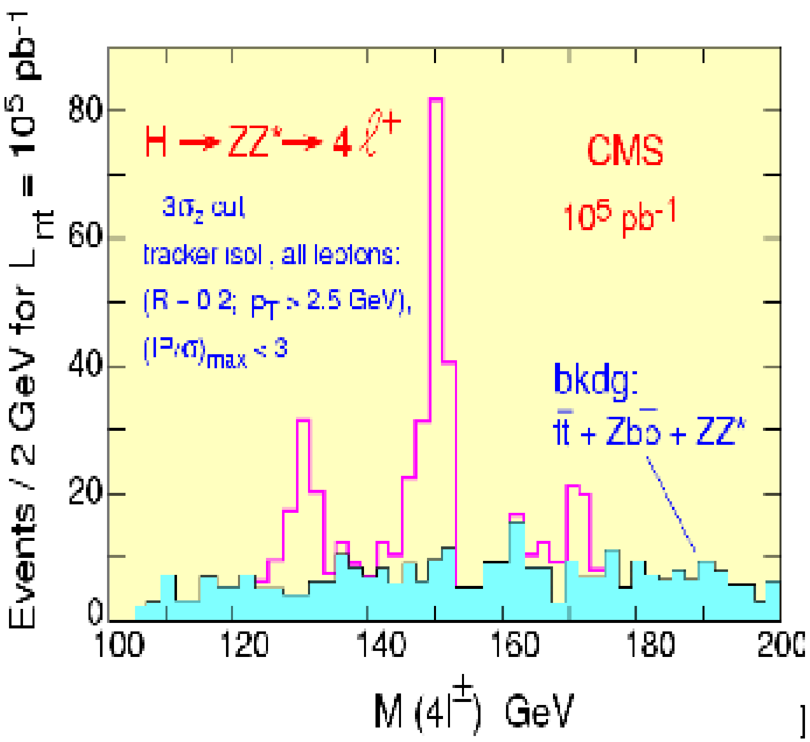


G Giudice *et al.*

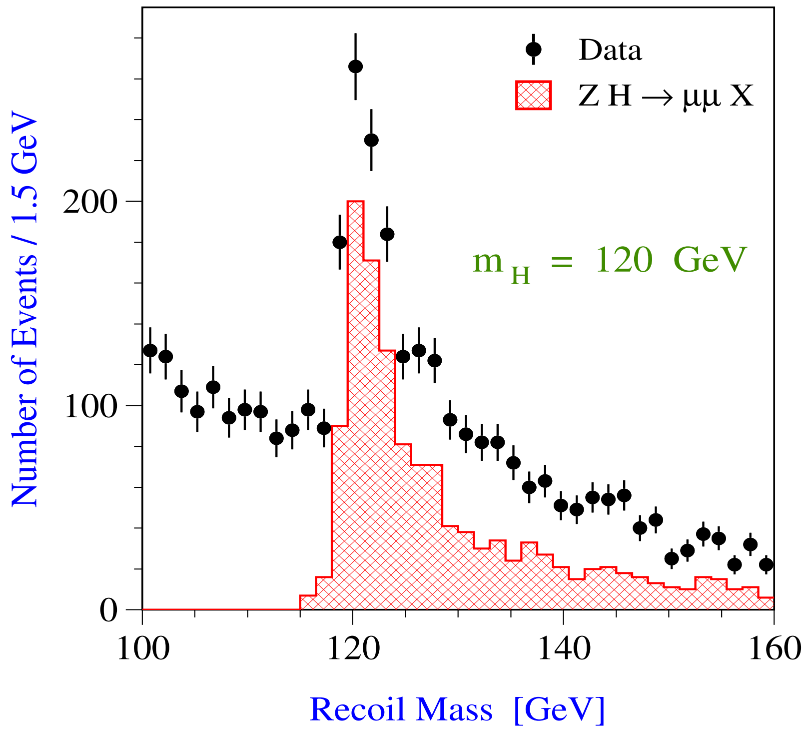
Telling if there is a Radion

✧ Direct observation of Radions appears possible at LHC and LC as long as gauge couplings are sizeable, but needs quantitative estimates vs M_ϕ, ξ and v/Λ

CMS



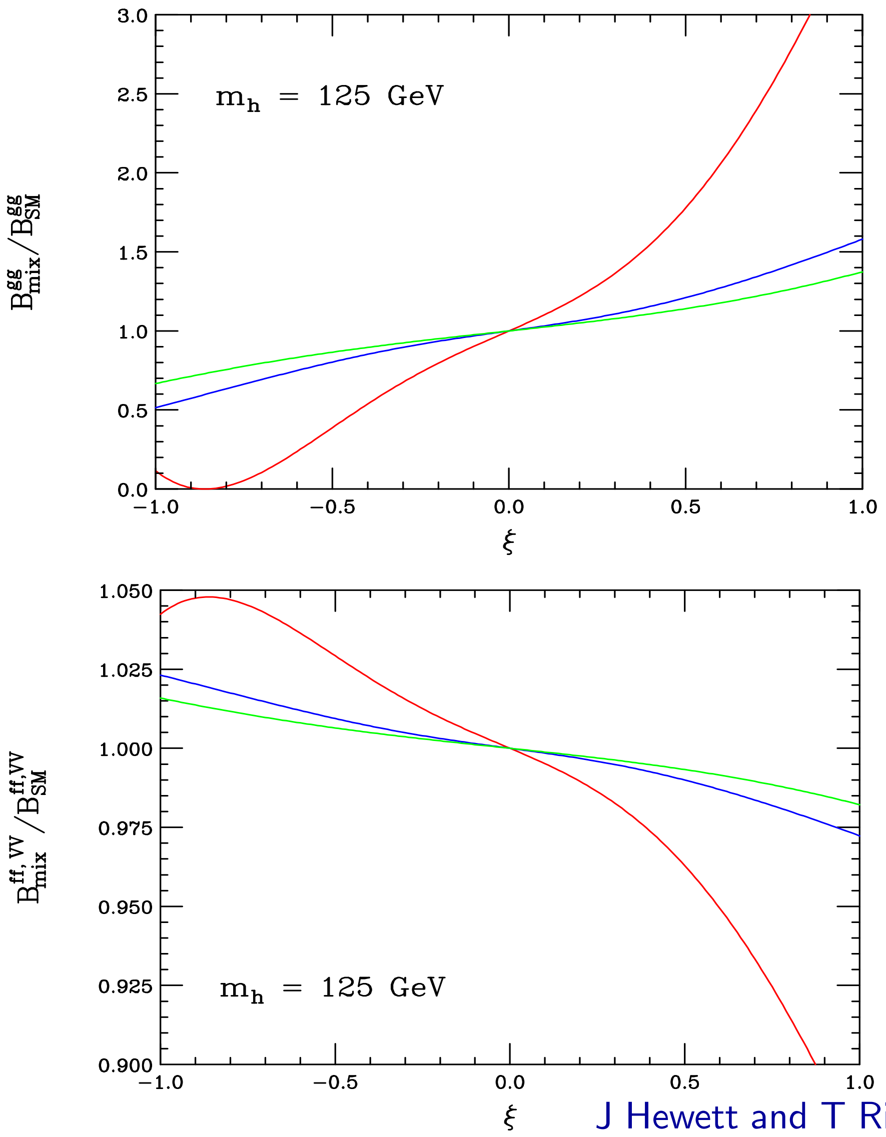
TESLA



Light Higgs Profile at LC

	M_H (GeV)	$\delta(X)/X$ LC-500-LC-3000 0.5ab^{-1}-5ab^{-1}
M_H	120-180	(3-5) $\times 10^{-4}$
Γ_{tot}	120-140	0.04-0.06
g_{HWW}	120-160	0.01-0.03
g_{HZZ}	120-160	0.01-0.02
g_{Htt}	120-140	0.02-0.06
g_{Hbb}	120-160	0.01-0.03
g_{Hcc}	120-140	0.03-0.10
$g_{H\tau\tau}$	120-140	0.03-0.05
$g_{H\mu\mu}$	120-140	0.15 - 0.04-0.06
CP test	120	0.03
g_{HHH}	120	0.20 - 0.07

$M_\phi/v/\Lambda$=300/0.2, 500/0.2, 300/0.1



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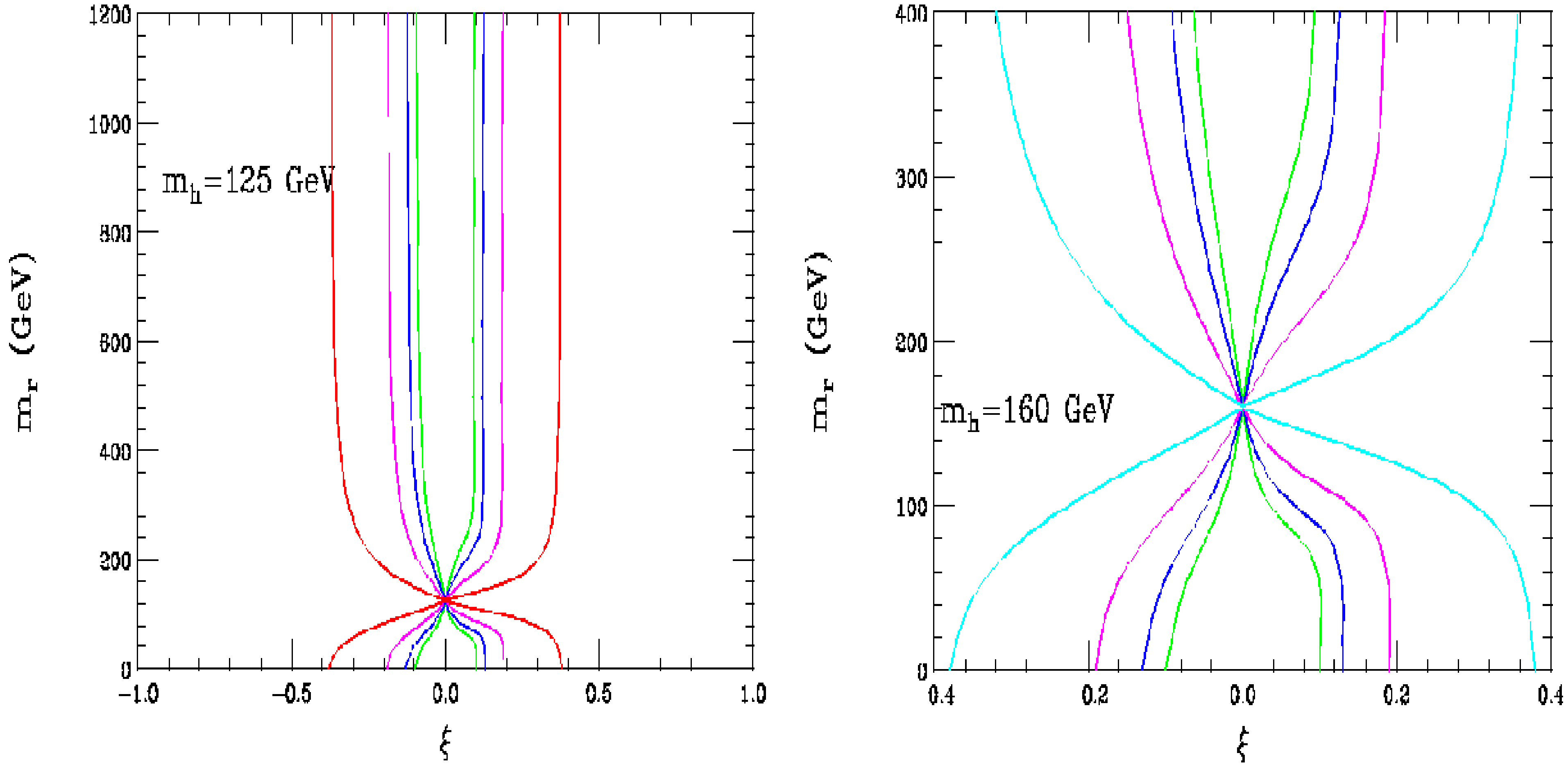
Indirect Exclusion Curves from LHC+LC data on Higgs couplings

$v/\Lambda =$ 0.20, 0.15, 0.10, 0.05



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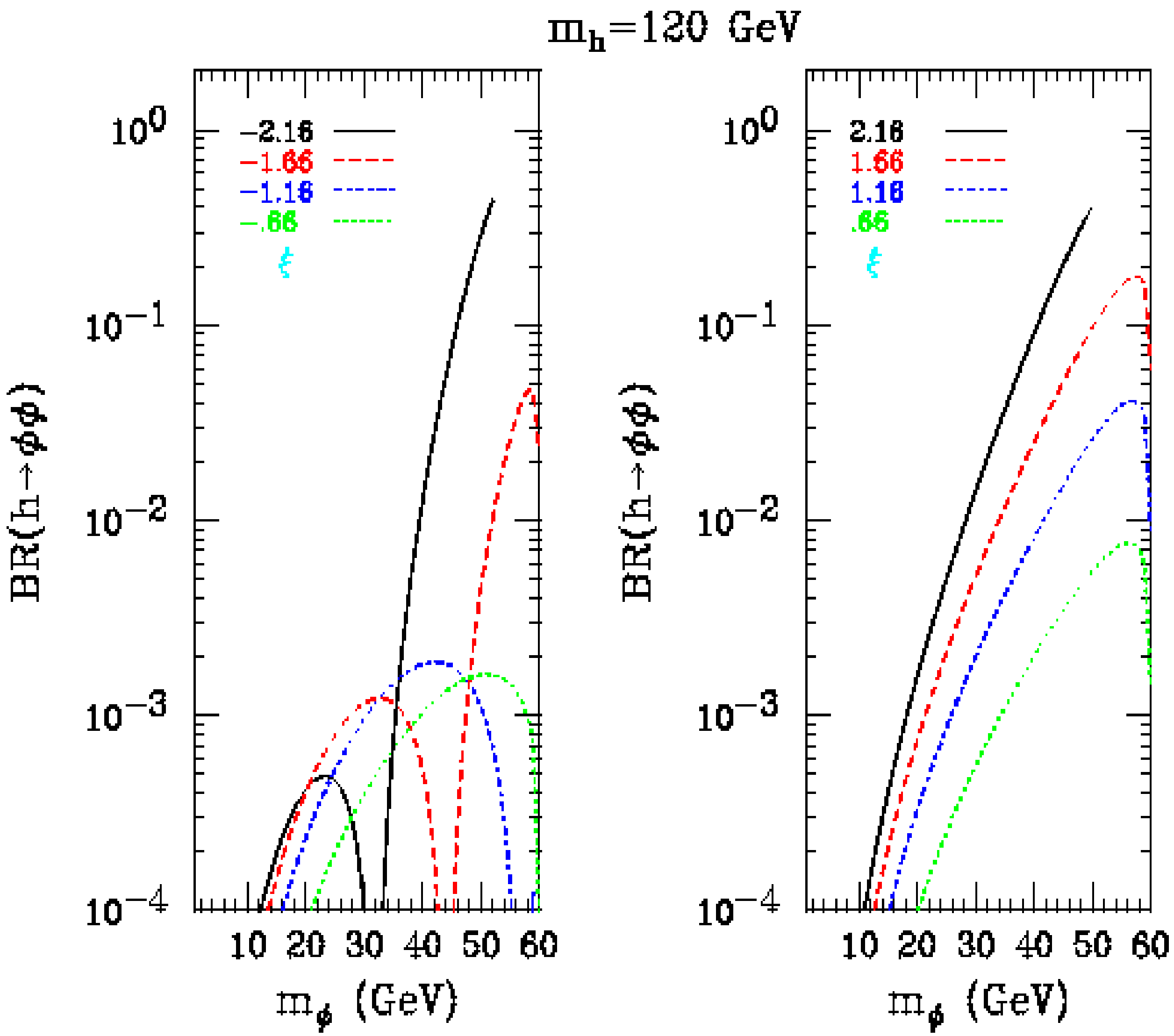
New Signatures

✧ Radion Decays $\phi \rightarrow HH$ represent a new interesting signature;

✧ Study may profit of techniques developed for measurement of triple Higgs vertex $H^* \rightarrow HH$;

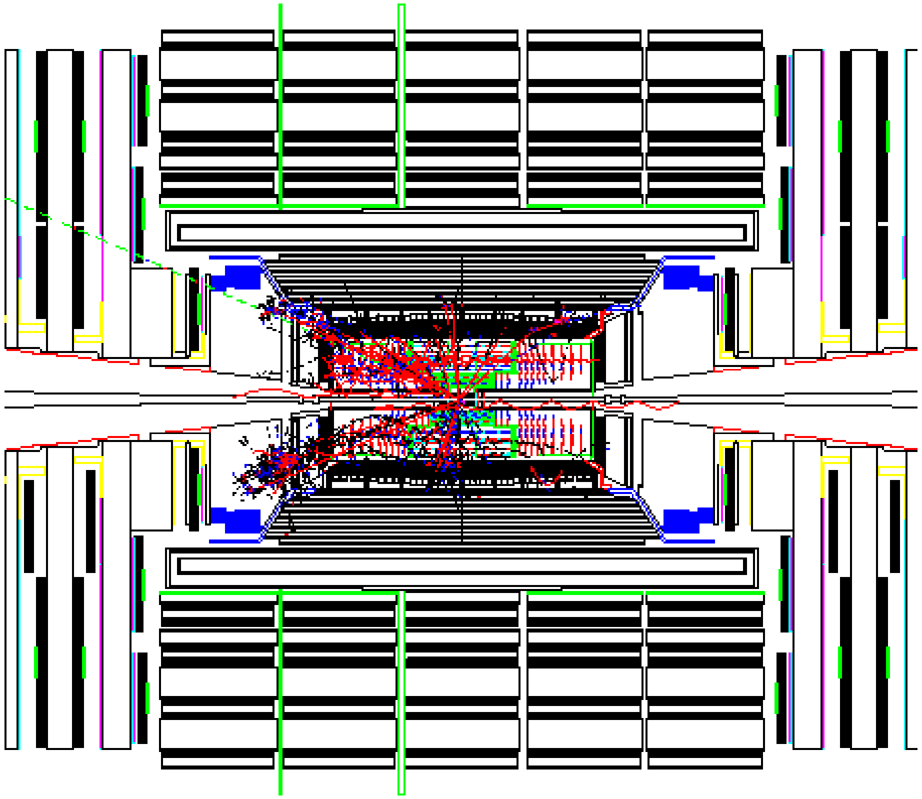
✧ Should be relatively straightforward at LC;

✧ Interesting to probe the LHC sensitivity to the 4-b final state.



✧ Matrix elements for radion decays are not yet implemented but a reasonable strategy for an exploratory study is to use $gg \to H \to HH$ and rescale production cross - section by $\sigma(gg \to \phi) \times \mathrm{BR}(\phi \to HH)$:

$$\phi^0(250) \to H^0(120)H^0(120) \to b\bar{b}b\bar{b}$$



A Plan for Future Activities

- ✧ Use present data on LHC and LC sensitivities to draw H and ϕ observation contours as function of v/Λ, M_H, M_ϕ, ξ
- ✧ Study complementarity of ϕ to H observation at LHC
- ✧ Define sensitivities to ϕ from precise data on g_{HVV} and g_{Hff}
- ✧ Consider new signatures such as $\phi \rightarrow HH \rightarrow b\bar{b}b\bar{b}$
- ✧ Need to generate interest and coherence within ATLAS, CMS, ECFA/DESY LC communities for studies beyond re-interpretation of existent results.