Invisible Higgs in the ADD model at LHC and LC

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Based on

Battaglia, DD, Gunion, Wells hep-ph/0402062

Battaglia, DD, Gunion, in preparation

In large extra dimension models the presence of an interaction between the Higgs H and the Ricci scalar curvature of the induced 4-dimensional metric g_{ind},

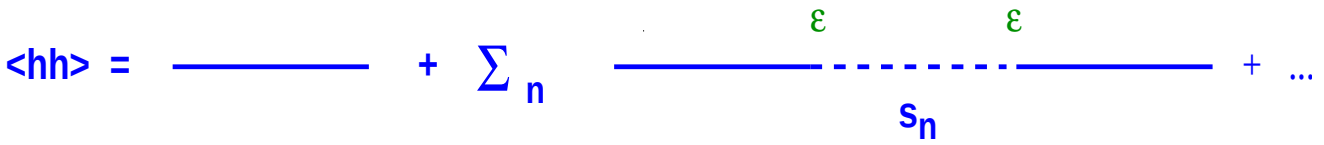
$$S = -\xi \int d^4x \sqrt{g_{ind}} R(g_{ind}) H^\dagger H$$

generates, after the shift $H = (\frac{v+h}{\sqrt{2}}, 0)$, a mixing term (Giudice, Rattazzi and Wells) $(H^{\vec{n}} = \frac{1}{\sqrt{2}}(s_{\vec{n}} + i a_{\vec{n}}))$

$$\mathcal{L}_{mix} = \epsilon h \sum_{\vec{n}>0} s_{\vec{n}} \qquad \epsilon = -\frac{2\sqrt{2}}{\overline{M}_P} \xi v m_h^2 \sqrt{\frac{3(\delta-1)}{\delta+2}}\,.$$

This mixing generates an oscillation of the Higgs itself into the closest KK graviscalar levels which are invisible since they are weakly interacting and mainly reside in the extra dimensions.

The mixing invisible width $\Gamma_{h \to graviscalar}$ calculated by extracting the imaginary part of the mixing contribution to the Higgs self energy (Giudice et al, Wells)

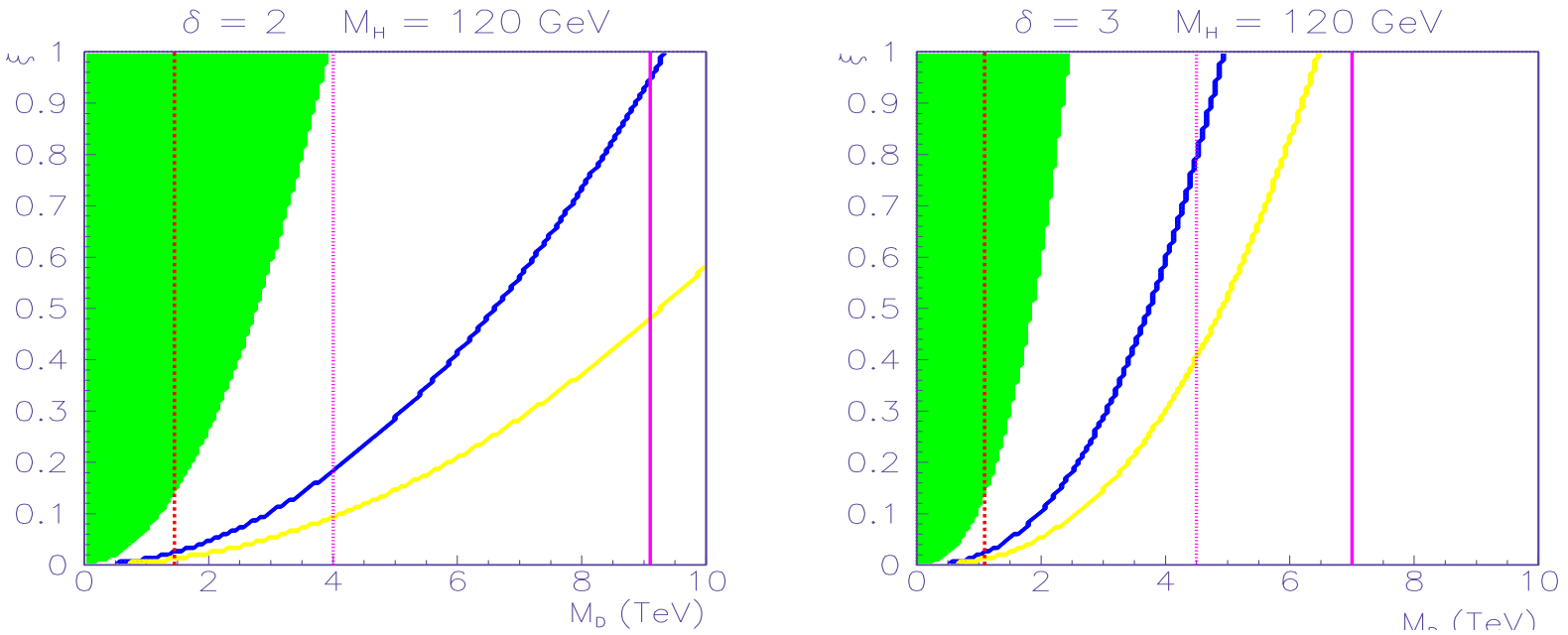


$$\Gamma_{h_{eff}\to graviscalar} \sim (16\,MeV)20^{2-\delta}\xi^2 S_{\delta-1}\frac{3(\delta-1)}{\delta+2} \times \left(\frac{m_h}{150\,GeV}\right)^{1+\delta}\left(\frac{3\,TeV}{M_D}\right)^{2+\delta}$$

S_δ denotes the surface of a unit radius sphere in δ dimensions, M_D the effective Planck scale.

- For a light Higgs boson the invisible width causes a significant suppression of the LHC rates in the standard visible channels
- There are regions where the invisible Higgs could be the first measured effect from extra dimensions

The green regions: the Higgs standard signal at the LHC $< 5\ \sigma$ for 100 fb^{-1}. The regions above the blue line are the parts where the LHC invisible Higgs signal in the WW-fusion channel $> 5\ \sigma$. The purple line at the largest M_D value shows the upper limit on M_D which can be probed at the $5\ \sigma$ by the analysis of jets/γ with missing energy at the LHC. The red dashed line at the lowest M_D value is the 95% CL lower limit from Tevatron and LEP/LEP2 limits. The regions above the yellow line are the parts of the parameter space where the LC invisible Higgs signal will exceed $5\ \sigma$ assuming $\sqrt{s} = 350$ GeV and $L = 500$ fb^{-1}.



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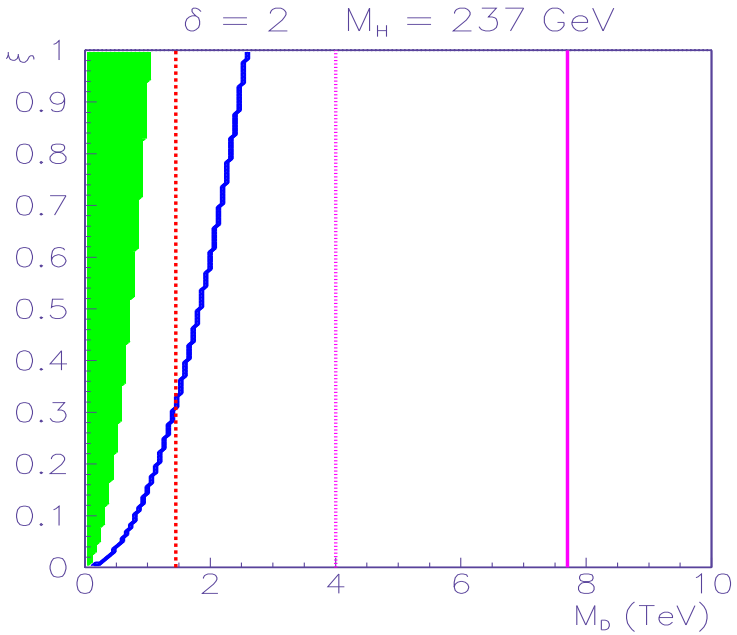
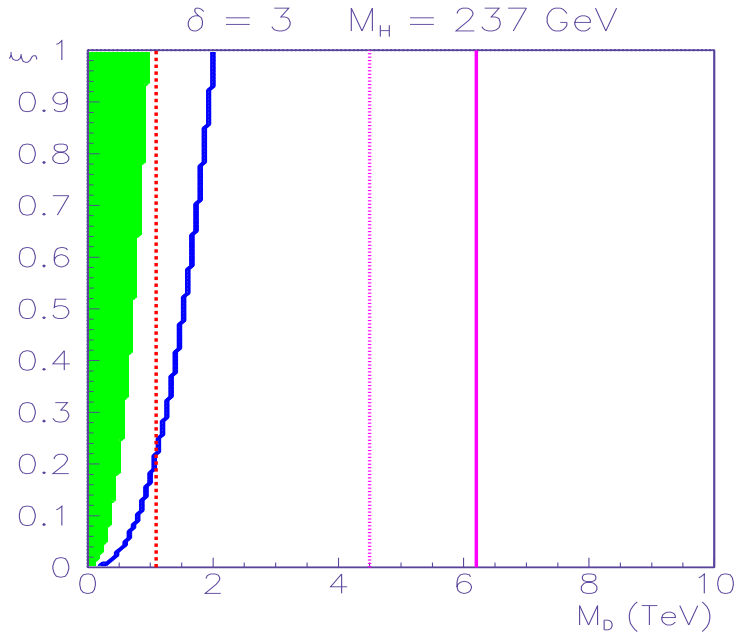
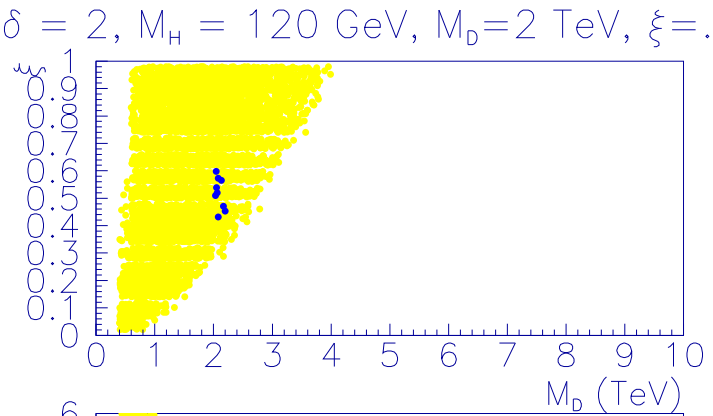


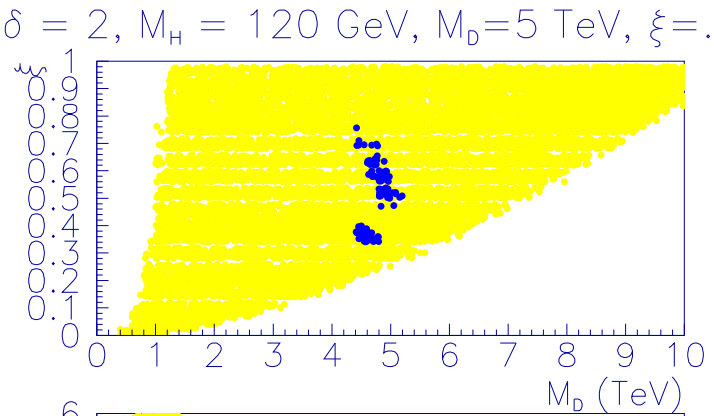


Determining ADD parameters from LHC and LC data

- For LHC we employed the visible and invisible Higgs signal assuming SM production rate for 30 fb^{-1} and 100 fb^{-1}.
- For LC we have used measurements of the visible (WW^*, $b\bar{b}$) and the invisible branching ratio at $\sqrt{s} = 350$ GeV.
- For LC we have also used the measurements of $\gamma + \not{E}_T$ signal at two different energies: the ratio of the two cross sections gives a strong constraint on δ. We have considered measurements performed at $\sqrt{s} = 500$ GeV and $\sqrt{s} = 1000$ GeV of either 500 fb^{-1} and 1000 fb^{-1}, respectively, or 1000 fb^{-1} and 2000 fb^{-1}, respectively.

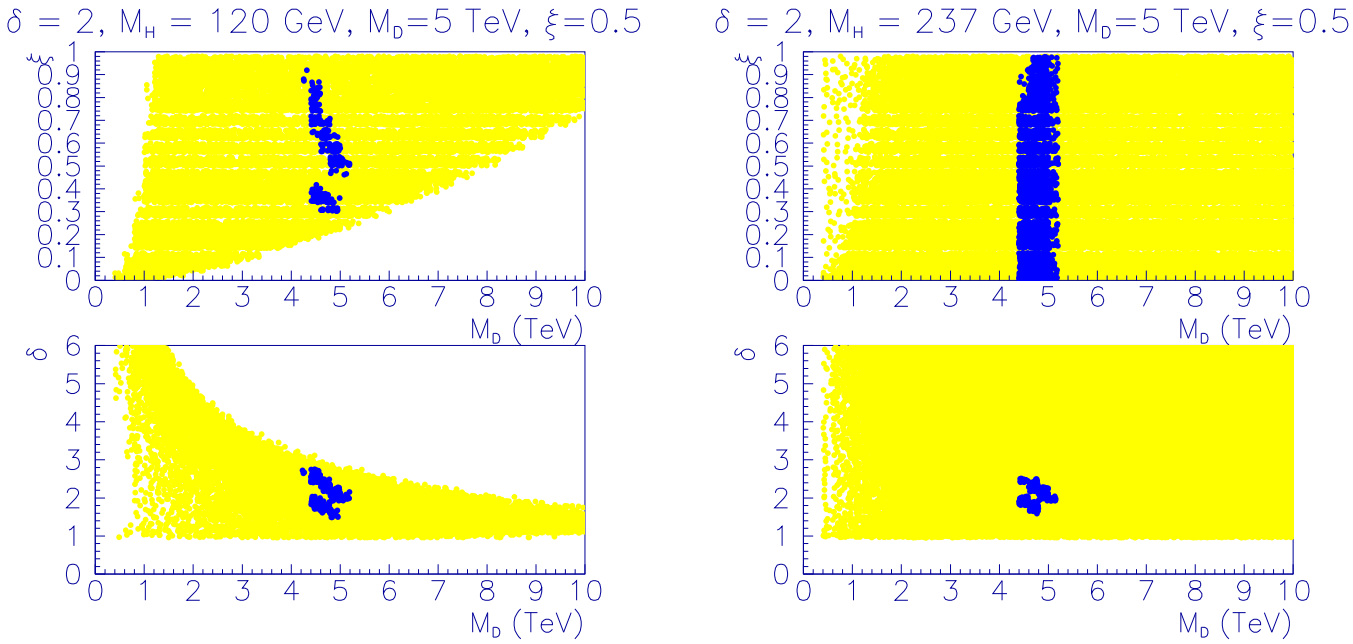
Determining ADD parameters from LHC and LC data





The larger (yellow) regions are the 95% CL regions using only $\Delta\chi^2(LHC)$. The smaller (blue) regions or points are the 95% CL regions using $\Delta\chi^2(LHC + LC)$.

Determining ADD parameters from LHC and LC data



The larger (yellow) regions are the 95% CL regions using only $\Delta\chi^2(LHC)$. The smaller (blue) regions or points are the 95% CL regions using $\Delta\chi^2(LHC + LC)$.
Left: $m_H = 120$ GeV, lower integrated luminosities, $L = 30$ fb^{-1} at the LHC and $L = 500$ fb^{-1} and $L = 1000$ fb^{-1} at $\sqrt{s} = 500$ GeV and $\sqrt{s} = 1000$ GeV at the LC.
Right: $m_H = 237$ GeV, higher integrated luminosities.