Higgs couplings parameterizations (in and beyond the standard model)

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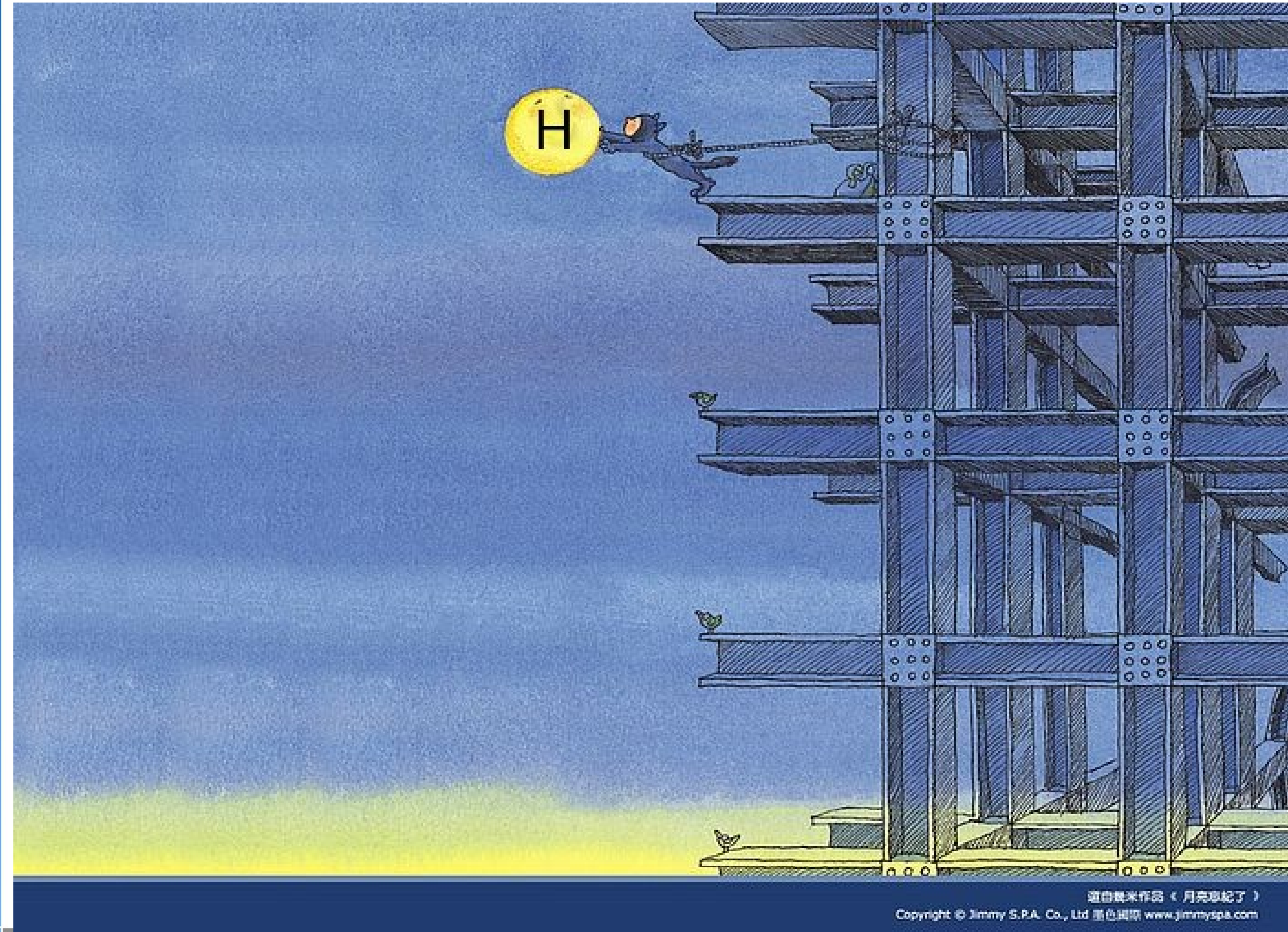
Catching a SM Higgs?

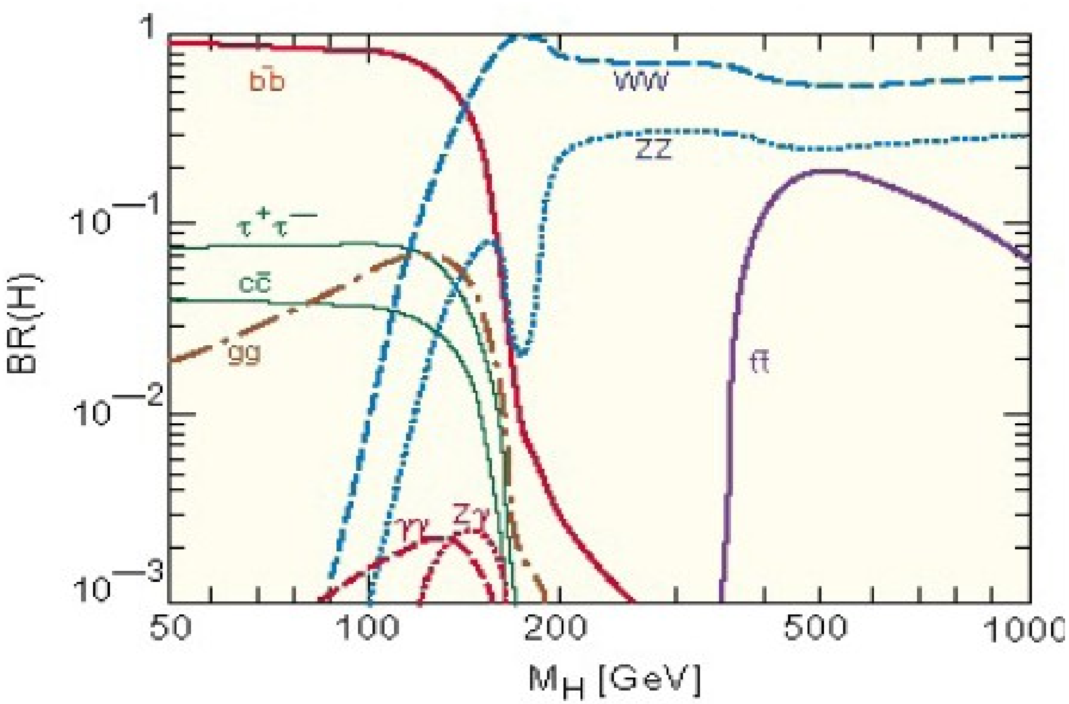


Outline

- Observables and parameterization
- Use for data analysis and model survey
- Conclusions

Light Higgs at LHC

- Higgs boson is light (m_H ~ 126 GeV) and consistent with SM expectations
  - Mainly production from gluon fusion in SM
  - Decay channel through two photons small but “clear” signature in the EM calorimeter.
  - Decay to W and Z bosons



Data vs models? Not so simple

Input : cross-sections

$$\hat{\mu}_i = \frac{\sigma_{pp\to h\to X_i}}{\sigma^{\rm SM}_{pp\to h\to X_i}}$$

In Gaussian approximation :

$$\chi_i^2 = \left(\frac{\mu_i\,|_{\rm model} - \hat{\mu}_i}{\sigma_i}\right)^2$$

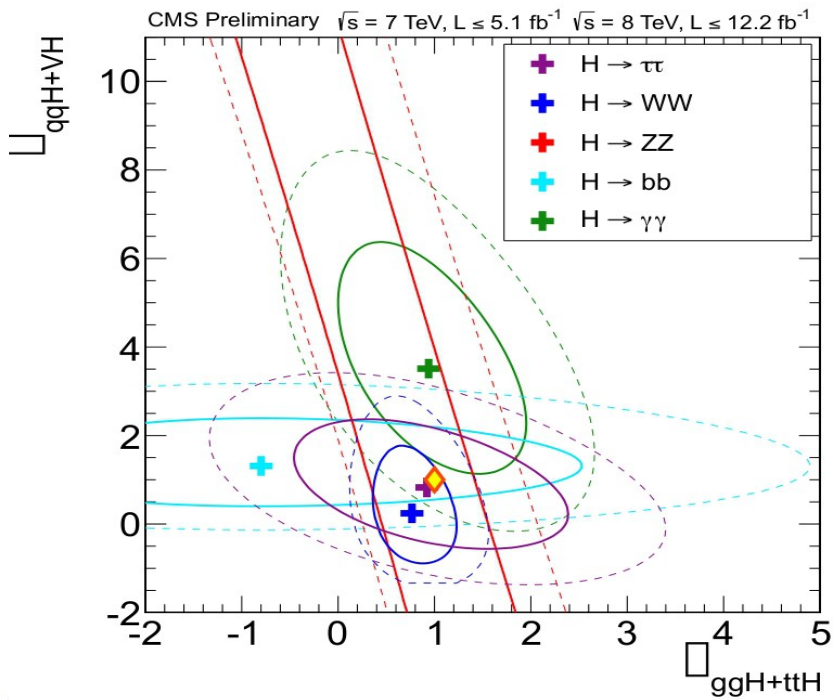
and if uncorrelated

$$\chi^2 = \sum_i \chi_i^2$$

quite a few caveats however (correlations, sub-channels, statistics dominate?...)

Improved χ^2 method

- Instead of sub-channels, use χ^2 as a function of the production modes



$$(\hat{\mu}_{WW}, \sigma_{WW})$$

$$\downarrow$$

$$(\hat{\mu}^{0j}_{WW}, \sigma^{0j}_{WW}), (\hat{\mu}^{1j}_{WW}, \sigma^{1j}_{WW}) ... + \epsilon^{ggh}_{0j}, \epsilon_{0j}$$

- 2D Gaussian approximation

$$\chi^2 = \begin{pmatrix} \mu_{\mathrm{ggh,tth}} \\ \mu_{\mathrm{VBF,VH}} \end{pmatrix}^T V^{-1} \begin{pmatrix} \mu_{\mathrm{ggh,tth}} \\ \mu_{\mathrm{VBF,VH}} \end{pmatrix}$$

Data re-use in BSM (arXiv:1307.5865)

- For models with the same tensor structure as SM
  - Likelihood rescaling possible (selections and acceptances independent of model parameters)
  - Replace global signal strengths by specific ones (production X and decay Y) also separating sub-channels (ex. in γγ untagged (ggF), 2-jets (VBF),lepton-tagged (VH)
  - Better: give full-likelyhoods (at present ggF+ttH and VBF+VH, in future separately?)
- For different tensor structure
  - H → n with n>2 can probe the tensor structure (ex. H → VV* → 4f)
  - Change in selection efficiencies → fiducial cross-sections (simple fiducial model criteria can be implemented in MC for any model)
  - Analyses @different CM energies allow tests of anomalous couplings

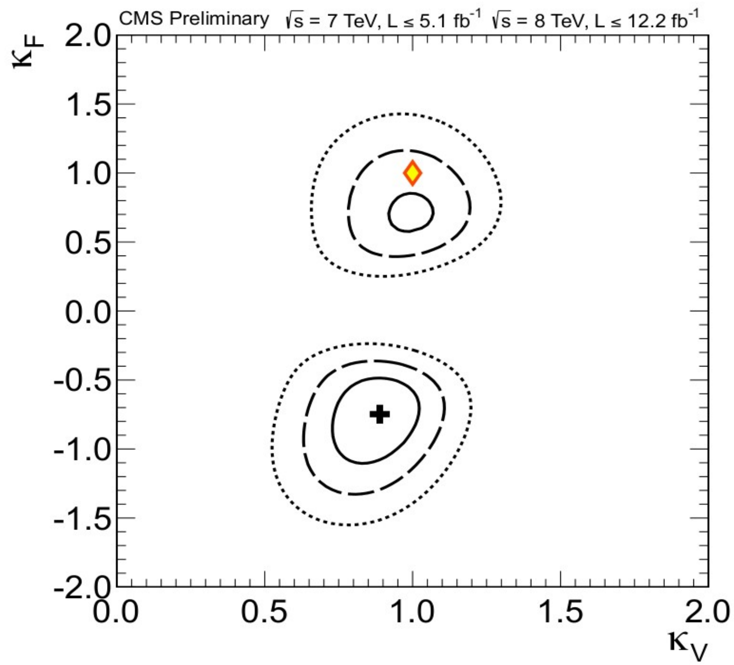
Exploring BSM in Higgs physics

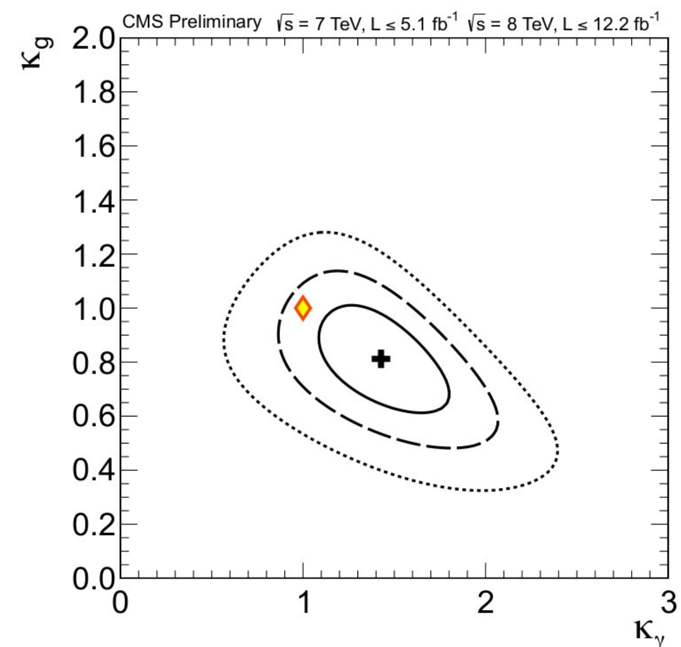
BSM parameterisations

- Specific model detailed fits
  - Possible but no general indications
  - Quite time consuming
- Effective parameterisations
  - Specialised for classes of models, use few parameters
  - Can avoid correlations
- Model independent
  - Effective Lagrangian approach (operator based, assuming no light new particles in the spectrum)
  - General but many more parameters
  - Extra “hidden” assumptions to reduce them (no FV, no CPV Higgs couplings, custodial symmetry, no large cancellations in EWPT)
- All of them are useful for different purposes

Simple parameters (exp. motivated)

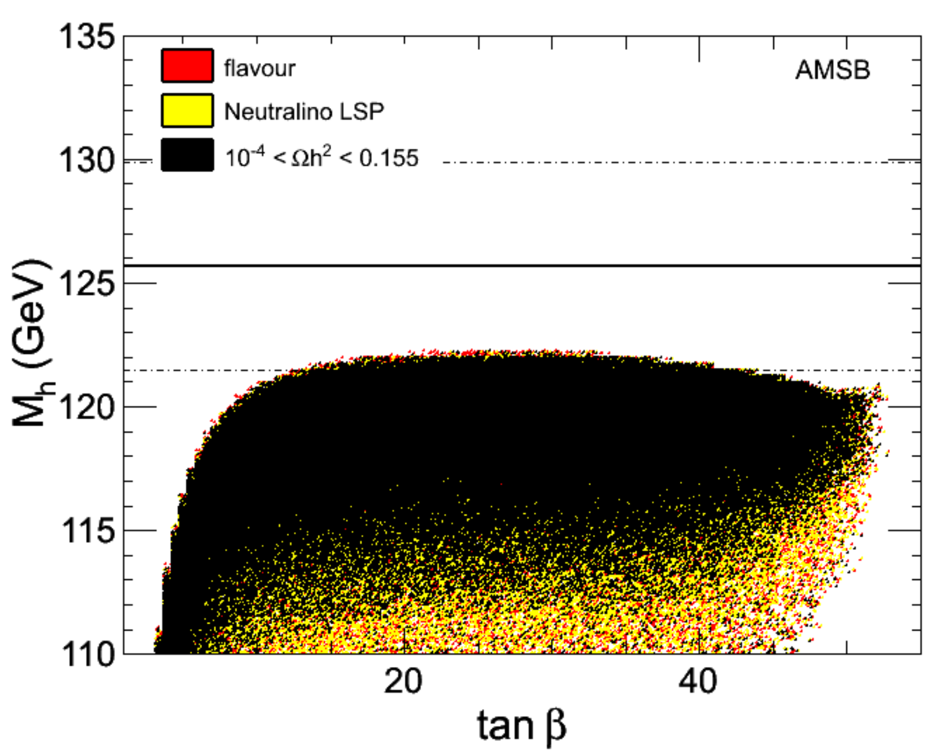
Take parameters as independent prefactors of cross-sections in the different channels

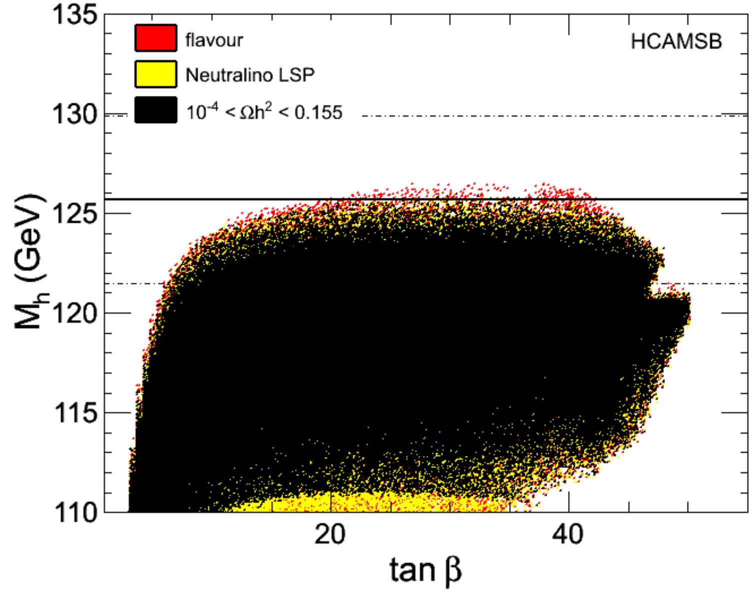


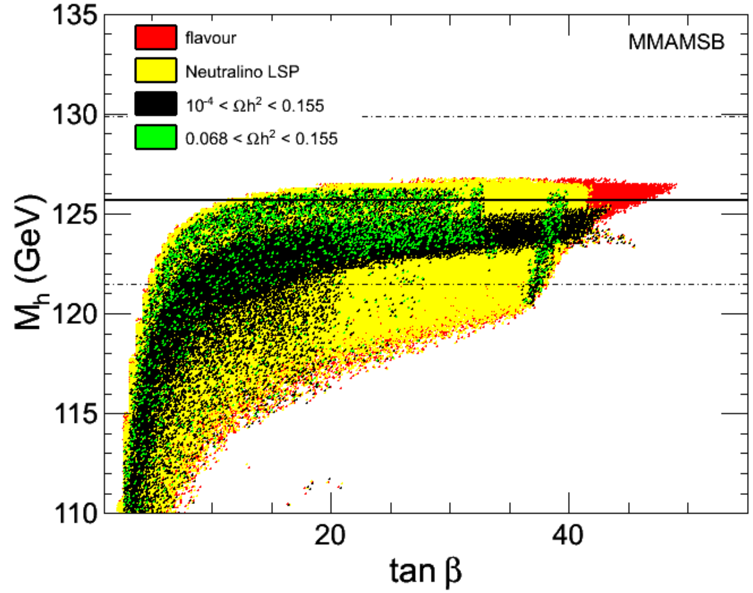


simple 2D contours with limited possibility to test my FTV (Favourite Theory Model)

A specific model example (theory motivated)







Scan of parameters space for AMSB models, from arXiv:1304.0381

Effective Lagrangian for light Higgs doublet

- Effective chiral EW Lagrangian : at low scale one can use a derivative expansion to describe the eaten Goldstones of the breaking SU(2)xU(1) → U(1)em

$$\Sigma = e^{i\sigma_a \pi^a / v} \qquad v = 246\,\mathrm{GeV}$$

$$\begin{aligned} \mathcal{L} \;=\; & \frac{1}{2}(\partial_\mu h)^2 - V(h) + \frac{v^2}{4}\mathrm{Tr}\left(D_\mu \Sigma^\dagger D^\mu \Sigma\right)\left[1 + 2a\,\frac{h}{v} + b\,\frac{h^2}{v^2} + \dots\right] \\ - \; & m_i\, \bar{\psi}_{Li}\, \Sigma \left(1 + c\,\frac{h}{v} + \dots\right)\psi_{Ri} + \mathrm{h.c.} \end{aligned}$$

$$V(h) = \frac{1}{2} m_h^2 h^2 + d_3\,\frac{1}{6}\left(\frac{3m_h^2}{v}\right) h^3 + d_4\,\frac{1}{24}\left(\frac{3m_h^2}{v^2}\right) h^4 + \dots$$

see hep-ph/0703164 and overview in 1303.3876

Effective Lagrangian for light Higgs doublet

- Taking $a=b=c=d_3=d_4=1$ and zero higher order terms one recovers the SM Higgs Lagrangian with

$$U = \left(1 + \frac{h}{v}\right)\Sigma$$

  the scalar h is a “linear” multiplet (to be contrasted to the non-linear sigma model realization)

- Total of 28 operators involving the Higgs field
- Relaxing SM constraints (but still custodial, CP+, flavor conserving)
  - 4 O(p2) coefficients: Cv, Ct, Cb, Ctau
  - 2 O(p4) coefficients (contributing to the same order as p2 to gg → h and h → gamma gamma) : Cγ, Cg
  - Note : Cγ, Cg not uncorrelated to tree level coefficients! (see 1210.8120 and later slides)

Effective Lagrangian for light Higgs doublet : dim 6

$$\mathcal{L} = \mathcal{L}_{SM} + \sum_i c_i \mathcal{O}_i$$

- For a choice of basis for Higgs physics see for example 1303.3876
  - 28 CP+ operators with h
  - 5 bosonic operators
  - 22 4-fermion op.
  - -2 fermion op. (oblique corr.)
  - = 53 independent

$$\begin{aligned}
\Delta\mathcal{L}_{SILH} = {} & \frac{\bar{c}_H}{2v^2}\partial^\mu\left(H^\dagger H\right)\partial_\mu\left(H^\dagger H\right) + \frac{\bar{c}_T}{2v^2}\left(H^\dagger \overleftrightarrow{D^\mu} H\right)\left(H^\dagger \overleftrightarrow{D}_\mu H\right) - \frac{\bar{c}_6\,\lambda}{v^2}\left(H^\dagger H\right)^3 \\
& + \left(\frac{\bar{c}_u}{v^2} y_u H^\dagger H\, \bar{q}_L H^c u_R + \frac{\bar{c}_d}{v^2} y_d H^\dagger H\, \bar{q}_L H d_R + \frac{\bar{c}_l}{v^2} y_l H^\dagger H\, \bar{L}_L H l_R + h.c.\right) \\
& + \frac{i\bar{c}_W\, g}{2m_W^2}\left(H^\dagger \sigma^i \overleftrightarrow{D^\mu} H\right)\left(D^\nu W_{\mu\nu}\right)^i + \frac{i\bar{c}_B\, g'}{2m_W^2}\left(H^\dagger \overleftrightarrow{D^\mu} H\right)\left(\partial^\nu B_{\mu\nu}\right) \qquad (2.2) \\
& + \frac{i\bar{c}_{HW}\, g}{m_W^2}\left(D^\mu H\right)^\dagger \sigma^i \left(D^\nu H\right) W^i_{\mu\nu} + \frac{i\bar{c}_{HB}\, g'}{m_W^2}\left(D^\mu H\right)^\dagger\left(D^\nu H\right) B_{\mu\nu} \\
& + \frac{\bar{c}_\gamma\, g'^2}{m_W^2} H^\dagger H B_{\mu\nu} B^{\mu\nu} + \frac{\bar{c}_g\, g_S^2}{m_W^2} H^\dagger H G^a_{\mu\nu} G^{a\mu\nu} ,
\end{aligned}$$

$$\begin{aligned}
\Delta\mathcal{L}_{F_1} = {} & \frac{i\bar{c}_{Hq}}{v^2}\left(\bar{q}_L \gamma^\mu q_L\right)\left(H^\dagger \overleftrightarrow{D}_\mu H\right) + \frac{i\bar{c}'_{Hq}}{v^2}\left(\bar{q}_L \gamma^\mu \sigma^i q_L\right)\left(H^\dagger \sigma^i \overleftrightarrow{D}_\mu H\right) \\
& + \frac{i\bar{c}_{Hu}}{v^2}\left(\bar{u}_R \gamma^\mu u_R\right)\left(H^\dagger \overleftrightarrow{D}_\mu H\right) + \frac{i\bar{c}_{Hd}}{v^2}\left(\bar{d}_R \gamma^\mu d_R\right)\left(H^\dagger \overleftrightarrow{D}_\mu H\right) \\
& + \left(\frac{i\bar{c}_{Hud}}{v^2}\left(\bar{u}_R \gamma^\mu d_R\right)\left(H^{c\,\dagger} \overleftrightarrow{D}_\mu H\right) + h.c.\right) \qquad (2.3) \\
& + \frac{i\bar{c}_{HL}}{v^2}\left(\bar{L}_L \gamma^\mu L_L\right)\left(H^\dagger \overleftrightarrow{D}_\mu H\right) + \frac{i\bar{c}'_{HL}}{v^2}\left(\bar{L}_L \gamma^\mu \sigma^i L_L\right)\left(H^\dagger \sigma^i \overleftrightarrow{D}_\mu H\right) \\
& + \frac{i\bar{c}_{Hl}}{v^2}\left(\bar{l}_R \gamma^\mu l_R\right)\left(H^\dagger \overleftrightarrow{D}_\mu H\right) ,
\end{aligned}$$

$$\begin{aligned}
\Delta\mathcal{L}_{F_2} = {} & \frac{\bar{c}_{uB}\, g'}{m_W^2} y_u\, \bar{q}_L H^c \sigma^{\mu\nu} u_R\, B_{\mu\nu} + \frac{\bar{c}_{uW}\, g}{m_W^2} y_u\, \bar{q}_L \sigma^i H^c \sigma^{\mu\nu} u_R\, W^i_{\mu\nu} + \frac{\bar{c}_{uG}\, g_S}{m_W^2} y_u\, \bar{q}_L H^c \sigma^{\mu\nu} \lambda^a u_R\, G^a_{\mu\nu} \\
& + \frac{\bar{c}_{dB}\, g'}{m_W^2} y_d\, \bar{q}_L H \sigma^{\mu\nu} d_R\, B_{\mu\nu} + \frac{\bar{c}_{dW}\, g}{m_W^2} y_d\, \bar{q}_L \sigma^i H \sigma^{\mu\nu} d_R\, W^i_{\mu\nu} + \frac{\bar{c}_{dG}\, g_S}{m_W^2} y_d\, \bar{q}_L H \sigma^{\mu\nu} \lambda^a d_R\, G^a_{\mu\nu} \\
& + \frac{\bar{c}_{lB}\, g'}{m_W^2} y_l\, \bar{L}_L H \sigma^{\mu\nu} l_R\, B_{\mu\nu} + \frac{\bar{c}_{lW}\, g}{m_W^2} y_l\, \bar{L}_L \sigma^i H \sigma^{\mu\nu} l_R\, W^i_{\mu\nu} + h.c.
\end{aligned}$$

(2.4)

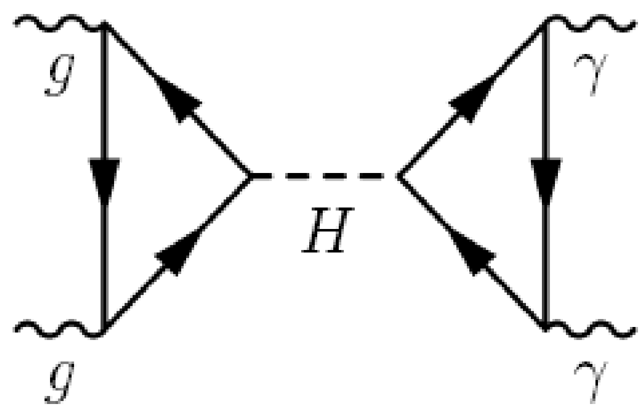
Higgs Chiral Lagrangian power counting

- Many parameters, but easy naïve power counting:
  - Extra derivatives ~ p/m
  - Extra Higgs field ~ h/f
- Anomalous dimensions may change counting
- Note: operator dims different if h is not a doublet :

  ex: a h singlet starts with dim 5 operators not dim 6
- Other remarks
  - Easy to add radiative corrections in a systematic way
  - Useful, but impossible to fit too many parameters with present data (at most 7 parameter fits attempted now)
  - Implicitly assumes no extra light particles in the spectrum

BSM in loops

- At tree level → No coupling between Higgs and massless gauge bosons.
- Decay in two gammas → Loop contributions.



- Small couplings depending on the properties of the virtual particles running into the loop.

$$\mathcal{L}_{\gamma\gamma} = -\left(\sqrt{2}G_F\right)^{\frac{1}{2}} \frac{\alpha}{2\pi} \, I_{\gamma\gamma} \, F_{\mu\nu}F^{\mu\nu} H$$

$$\mathcal{L}_{gg} = -\left(\sqrt{2}G_F\right)^{\frac{1}{2}} \frac{\alpha_s(m_H^2)}{4\pi} \, I_{gg} \, G^a_{\mu\nu}G_a^{\mu\nu} H$$

Influence of virtual particles in the decay widths

- Effective Lagrangians ➡ Decay widths

$$\Gamma_{\gamma\gamma} \propto \left|I_{\gamma\gamma}\right|^2 = \left|A_W(\tau_W) + \sum_{fermions} N_c Q_f^2 A_F(\tau_f) + \sum_{NP} N_c Q_{NP}^2 A_{NP}(\tau_{NP})\right|^2$$

$$\Gamma_{gg} \propto \left|I_{gg}\right|^2 = \left|\frac{3}{4}\sum_{fermions} A_F(\tau_f) + \sum_{NP} C_c(r_{NP}) A_{NP}(\tau_{NP})\right|^2 \quad where \quad \tau_x = \frac{m_H^2}{4\mathrm{m}_x^2}$$

- SM: Main contribution from top and W.

- New physics: New charged or colored particles interacting with the Higgs
  ➡ Modification of effective vertices.

- **A** depends on the spin, the masses and the coupling of the virtual particles running into the loop.

Amplitudes and Couplings to the Higgs

- For SM, masses proportional to the Higgs VEV

$$y^{SM}_{h\bar{f}f} = \frac{m_f}{v_{SM}} \quad for \quad fermions$$

$$y^{SM}_{hWW} = 2\frac{m_W^2}{v_{SM}} \quad for \quad bosons$$

- Definition of A_w, A_F and A_S are well-known functions of τ
- For New Physics
  - Mass of NP not necessarily proportional to Higgs VEV
  - Small correction from EW breaking

$$y^{NP}_{h\bar{f}f} = \frac{\partial m_f(v)}{\partial v} \quad and \quad y^{NP}_{hWW} = \frac{\partial m_W^2(v)}{\partial v}$$

- Definition of A_{NP} :

$$A_{NP} = \frac{v_{SM}}{m_{NP}} \frac{\partial m_{NP}}{\partial v} A_{F,S,W}$$

  - Spin and mass taken into account in $A_{F,W,S}$
  - Coupling effects contained in the pre-factor

Model-independent parameterization

- Normalization of new contributions to the top's one.
  - Solutions to naturalness problem, NP closely related to top physics
- If SM-like Higgs sector and tree level structure assumed

  Only 2 parameters in this case (see arXiv:0901.0927)

$$\Gamma_{\gamma\gamma}=\frac{G_F \alpha^2 m_H^3}{128\sqrt{2}\pi^3}\left|A_W(\tau_W)+3\left(\frac{2}{3}\right)^2 A_F(\tau_{top})[1+\kappa_{\gamma\gamma}]+\ldots\right|^2$$

$$\Gamma_{gg}=\frac{G_F \alpha_s^2 m_H^3}{36\sqrt{2}\pi^3}\left|\frac{3}{4}A_F(\tau_{top})[1+\kappa_{gg}]+\ldots\right|^2 \quad where \quad \tau_x=\frac{m_H^2}{4m_x^2}$$

$$\kappa_{\gamma\gamma}=\sum_{NP}\frac{3}{4}N_c Q_{NP}^2 \frac{v}{m_{NP}}\frac{\partial m_{NP}}{\partial v}\frac{A_{F,S,W}(\tau_{NP})}{A_F(\tau_{top})}$$

$$\kappa_{gg}=\sum_{NP}\frac{4}{3}C_c(r_{NP})\frac{v}{m_{NP}}\frac{\partial m_{NP}}{\partial v}\frac{A_{F,S,W}(\tau_{NP})}{A_F(\tau_{top})}$$

Approximations and Corrections

- Light Higgs, so: $m_H{}^2 << m_{NP}{}^2$ or $\tau_{NP} << 1$
- So the **A** ratios only depend on the spin of NP

$$\frac{A_{NP}}{A_{top}} = \begin{Bmatrix} 1 & for\ \ fermions \\ -21/4 & for\ \ vectors \\ 1/4 & for\ scalars \end{Bmatrix}$$

- Most of time, at tree level, masses of top and W are not proportional to the Higgs VEV ➡ New kappas

$$\kappa_{\gamma\gamma}(top) = \kappa_{gg}(top) = \left(\frac{v_{SM}}{m_t} \frac{\partial m_t}{\partial v} - 1 \right)$$

$$\kappa_{\gamma\gamma}(W) = \frac{3}{4} \left(\frac{v_{SM}}{m_W} \frac{\partial m_W}{\partial v} - 1 \right) \frac{A_W(\tau_W)}{A_F(\tau_{top})} \quad and \quad \kappa_{gg}(W) = 0$$

Modifications of LHC Observables

- Branching ratio for H ► γγ normalized to SM value:

$$\overline{BR}(H\to\gamma\gamma)=\frac{\Gamma^{NP}_{\gamma\gamma}}{\Gamma^{SM}_{\gamma\gamma}}\frac{\Gamma^{SM}_{tot}}{\Gamma^{NP}_{gg}+\Gamma^{NP}_{\gamma\gamma}+\Gamma^{SM}_{others}}$$

Influence of new physics

$$\overline{BR}(H\to\gamma\gamma)\simeq\left(1+\frac{\kappa_{\gamma\gamma}}{\frac{9}{16}A_W(\tau_W)+1}\right)^2\frac{\Gamma^{SM}_{tot}}{(1+\kappa_{gg})^2\Gamma^{SM}_{gg}+(\Gamma^{SM}_{tot}-\Gamma^{SM}_{gg})}$$

- Inclusive cross section for H ► γγ normalized to SM value:

$$\overline{\sigma}(H\to\gamma\gamma)=\frac{\sigma^{NP}_{gg}+\sigma^{SM}_{VBF}+\sigma^{SM}_{VH,tH}}{\sigma^{SM}_{gg}+\sigma^{SM}_{VBF}+\sigma^{SM}_{VH,tH}}\overline{BR}(H\to\gamma\gamma)$$

Influence of new physics

$$\overline{\sigma}(H\to\gamma\gamma)\simeq\frac{(1+\kappa^2_{gg})\sigma^{SM}_{gg}+\sigma^{SM}_{VBF}+\sigma^{SM}_{VH,tH}}{\sigma^{SM}_{gg}+\sigma^{SM}_{VBF}+\sigma^{SM}_{VH,tH}}\overline{BR}(H\to\gamma\gamma)$$

Generalizations

- The previous parameterization implicitly assumes a SM-like Higgs sector and tree level structure
- Easy to take into account a more general situation

  - Multiple Higgs $\phi_i = \frac{1}{\sqrt{2}}(v_i + c_i h + \ldots)$

$$\frac{v}{m}\frac{\partial m_f(v)}{\partial v} \rightarrow \frac{v}{m}\sum_i \frac{\partial m}{\partial v_i} c_i$$

  - Mixing with scalars with no vev

$$\frac{v}{m}\frac{\partial m_f(v)}{\partial v} \rightarrow \frac{v}{m}\left(\sum_i \frac{\partial m}{\partial v_i} c_i + \sum_j g_j s_j\right)$$

Generalization with tree-level couplings

- Modification of the tree level couplings can be explicitly introduced (see arXiv:1210.8120)

$$\sigma_{Wh} = \kappa_W^2 \sigma_{Wh}^{SM}\,, \quad \sigma_{Zh} = \kappa_Z^2 \sigma_{Zh}^{SM}\,, \quad \sigma_{t\bar{t}h} = \kappa_t^2 \sigma_{t\bar{t}h}^{SM}\,.$$

- And loop couplings are redefined as

$$\Gamma_{\gamma\gamma} = \frac{G_F \alpha^2 m_H^3}{128\sqrt{2}\pi^3} \left| \kappa_W\, A_W(\tau_W) + C_t^\gamma\, 3\left(\frac{2}{3}\right)^2 A_t(\tau_t)\, [\kappa_t + \kappa_{\gamma\gamma}] + \ldots \right|^2 ,$$

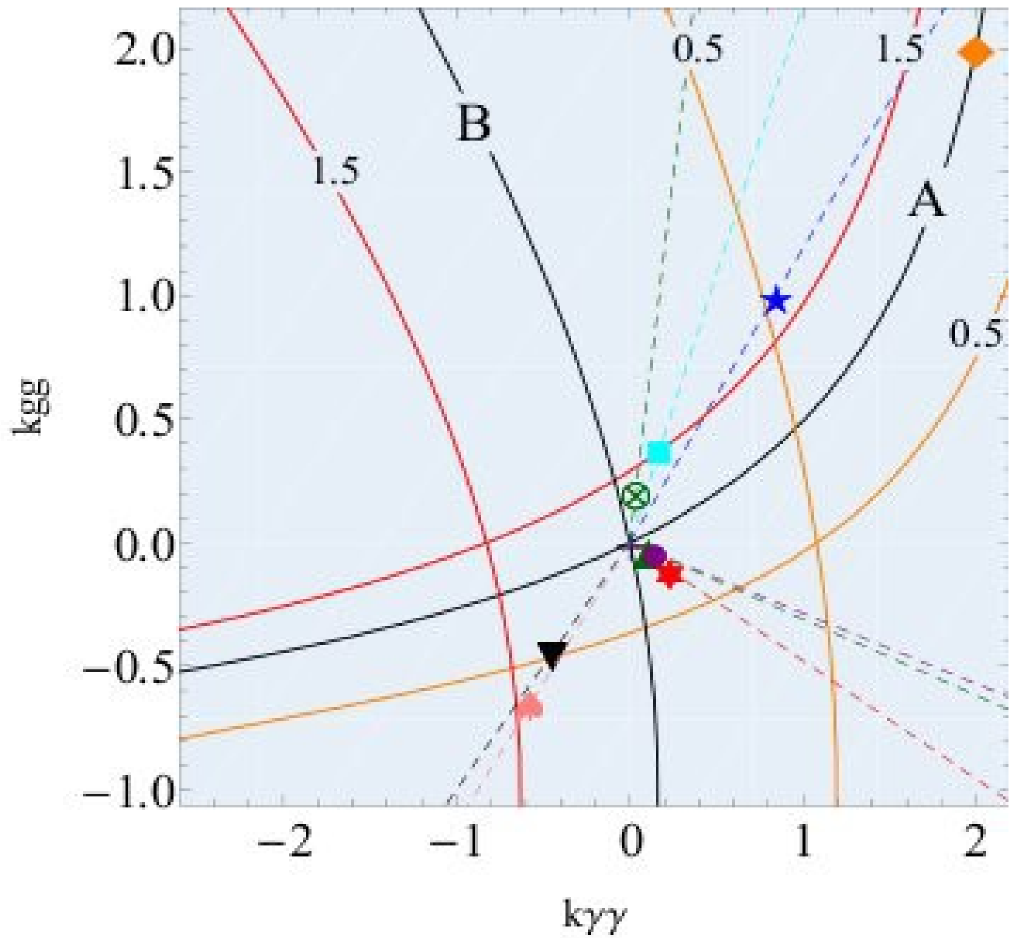
$$\Gamma_{gg} = \frac{G_F \alpha_s^2 m_H^3}{16\sqrt{2}\pi^3} \left| C_t^g \frac{1}{2} A_t(\tau_t)\, [\kappa_t + \kappa_{gg}] + \ldots \right|^2 ,$$

- Correlations due to tree level couplings in the loops explicitly taken into account

Survey of models

- 4th generation of fermion (♦)
- SUSY in the MSSM golden region (♣)
- Little Higgs models
  - Simplest Little Higgs model (▲) (W' at 2 TeV)
  - Littlest Higgs model with (f= 500 GeV) and without T-parity (f=5 TeV) (✶)
- 5D models for flat and warped space (W$^{(1)}$ at 2 TeV)
  - Universal Extra Dimension (★)
  - Minimal Composite Higgs (●)
  - Brane Higgs with flavor (▼ and ♠)
- Survey of known new physics scenarios
  ➡ Impact of new physics on Higgs searches

Plane ($\kappa_{\gamma\gamma}$-κ_{gg}) and models



- iso-lines pp → h → γγ constant (A)
- iso-lines VBF to γγ constant (B)
- Straight lines 1/M dependence of the models

Fit method

- Build chi-square for each channel :

$$\chi^2(\kappa) = \sum_i \frac{(\mu_i(\kappa) - \hat{\mu}_i)^2}{\sigma_i^2}$$

$$\mu_i(\kappa) = \frac{(\sum_a \mu_a(\kappa)\sigma_a^{\mathrm{SM}}\epsilon_a^i) \times \mathrm{Br}_i}{(\sum_a \sigma_a^{\mathrm{SM}}\epsilon_a^i) \times \mathrm{Br}_i^{\mathrm{SM}}}$$

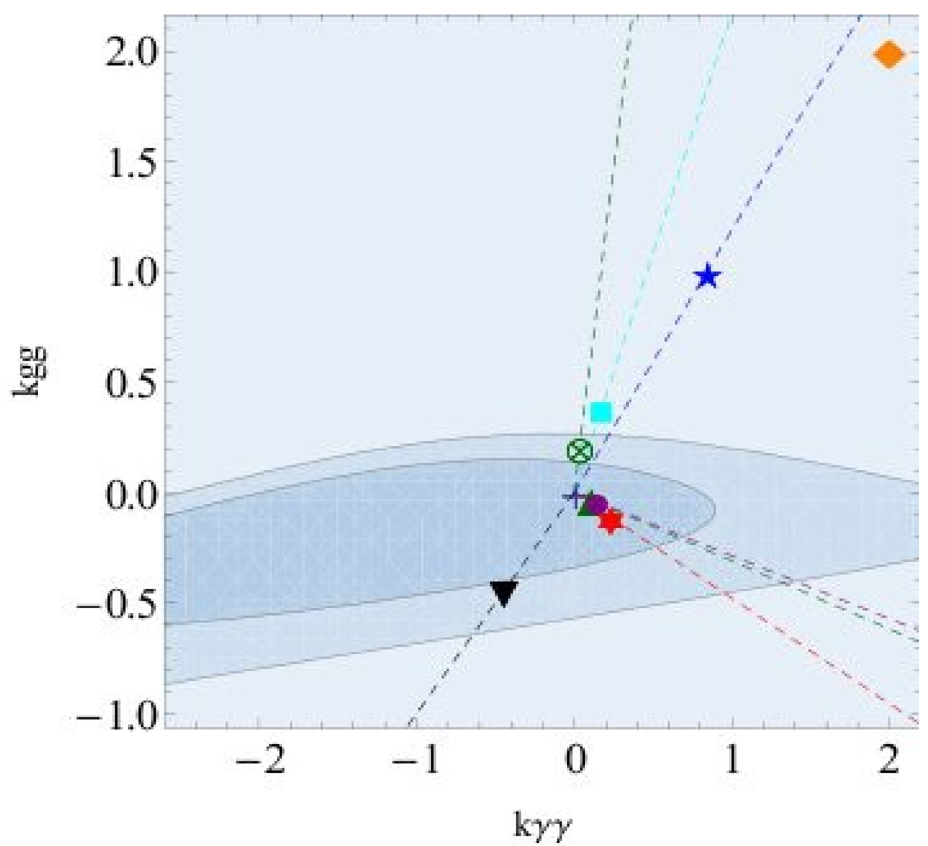
where $\hat{\mu}_i$ is the best fit signal strength (ratio obs/expected$_{\mathrm{SM}}$)

- Fit per production mode

$$\chi^2(\mu_{\mathrm{VBF}}, \mu_{\mathrm{VH}}, \mu_{\mathrm{ggH}}, \mu_{\mathrm{ttH}})$$

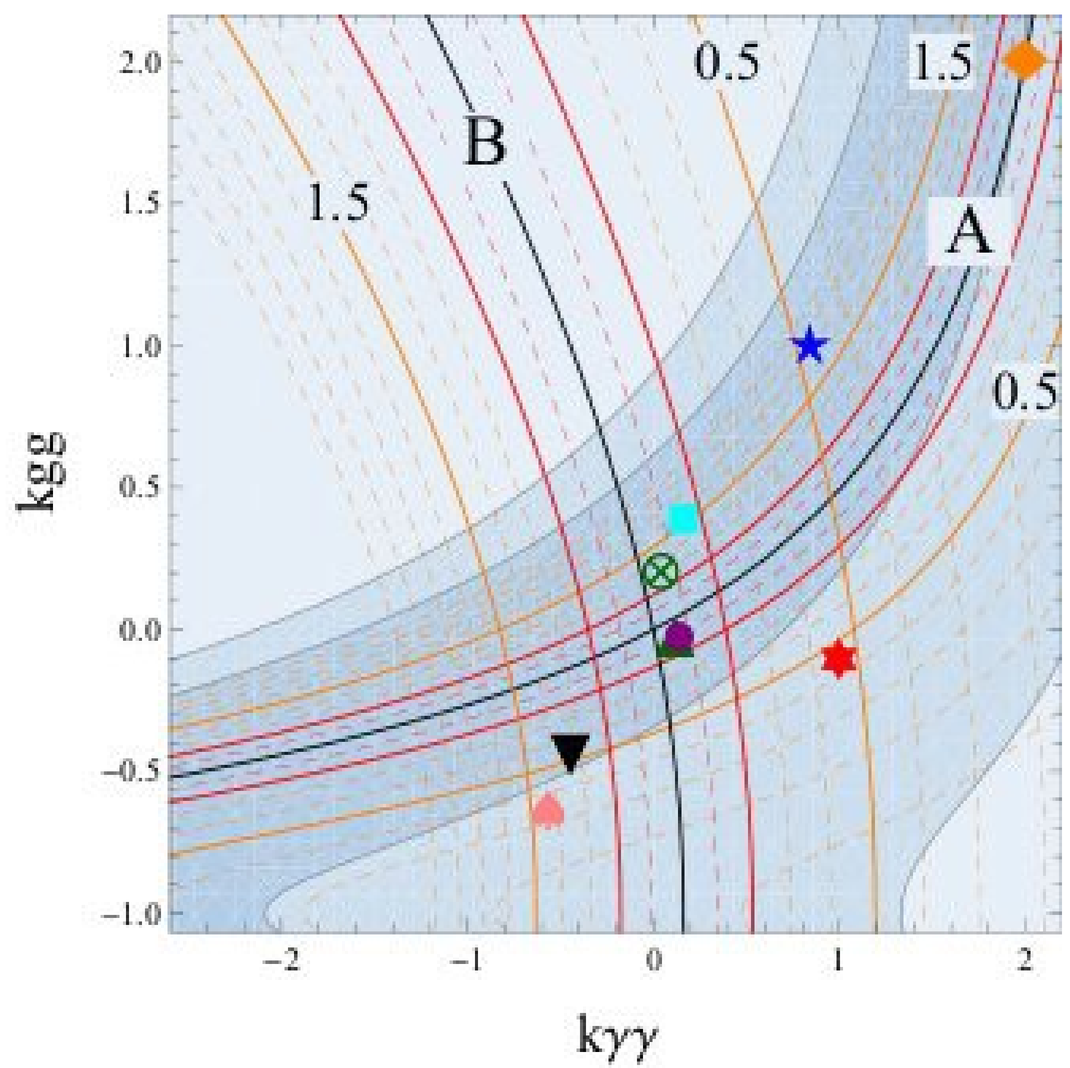
- Fit on a chosen set of parameters

Exclusion of models



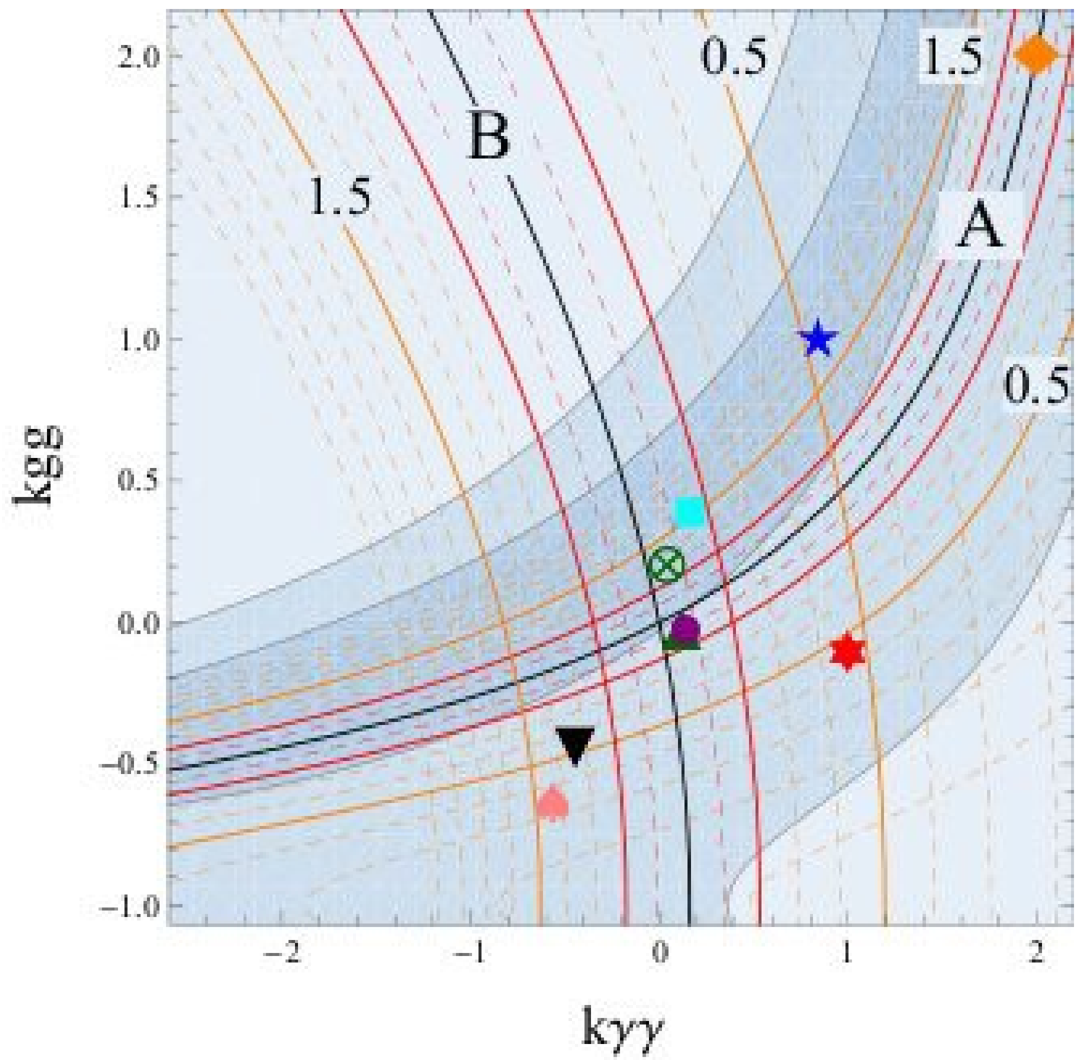
- Excluded at 95% CL :
- 4th generation
- 6D UED

The 2 parameter fit (γγ data only) CMS



- 4[th] generation (♦)
- SUSY in the MSSM golden region (♣)
- Simplest Little Higgs model (▲)
- Littlest Higgs (✶)
- 6UED (★)
- Minimal Composite Higgs (●)
- Brane Higgs with flavor, flat space (▼), warped space(♠)
- 5UED (⊗)

The 2 parameter fit (γγ data only) ATLAS



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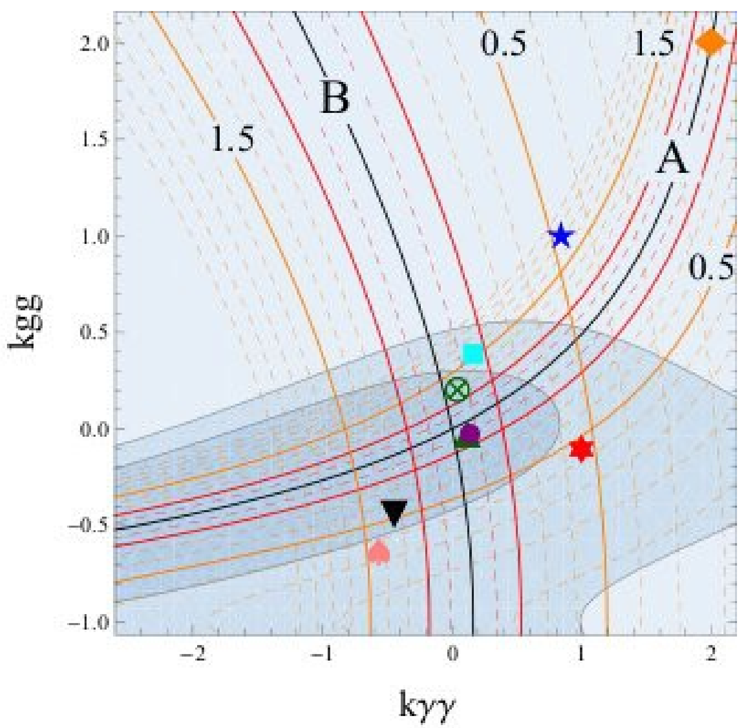
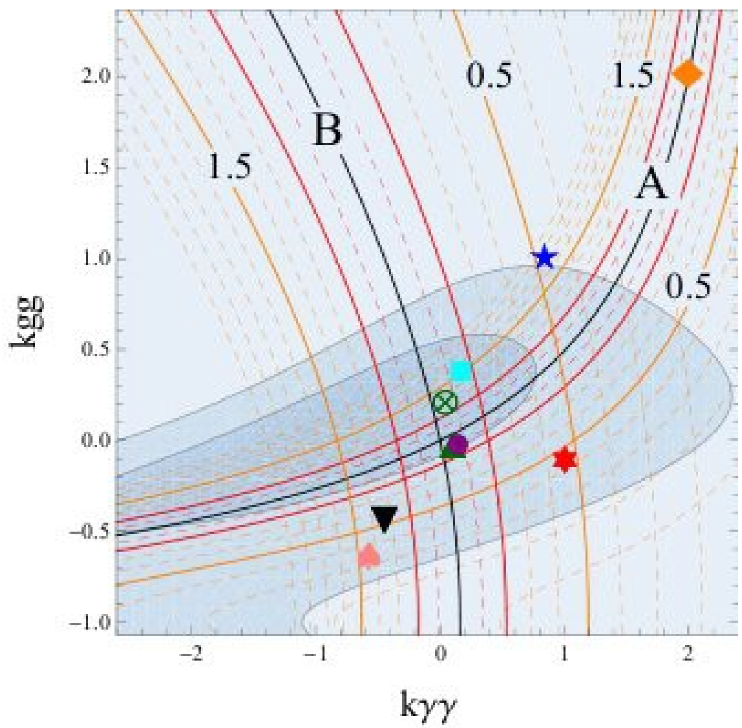
2 parameter fit ($\gamma\gamma$ and ZZ data)

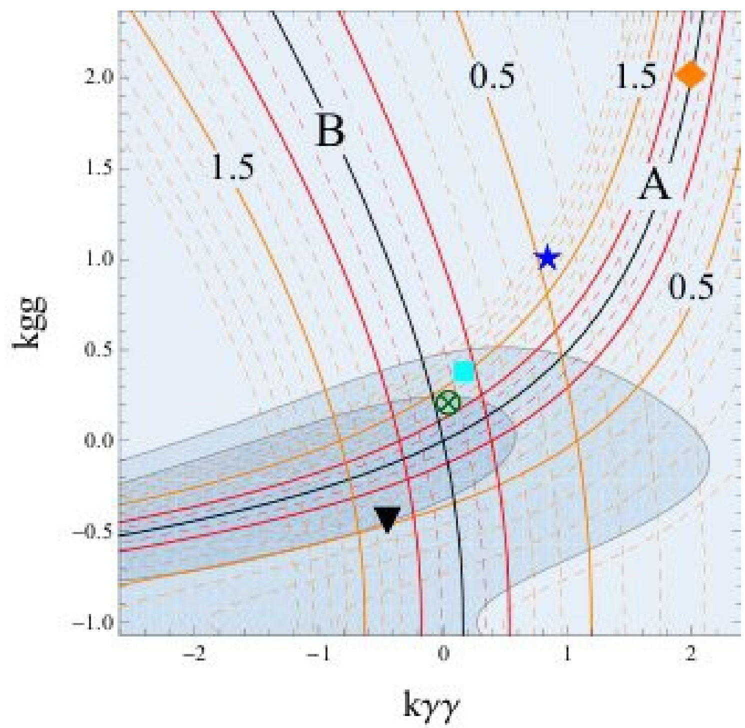




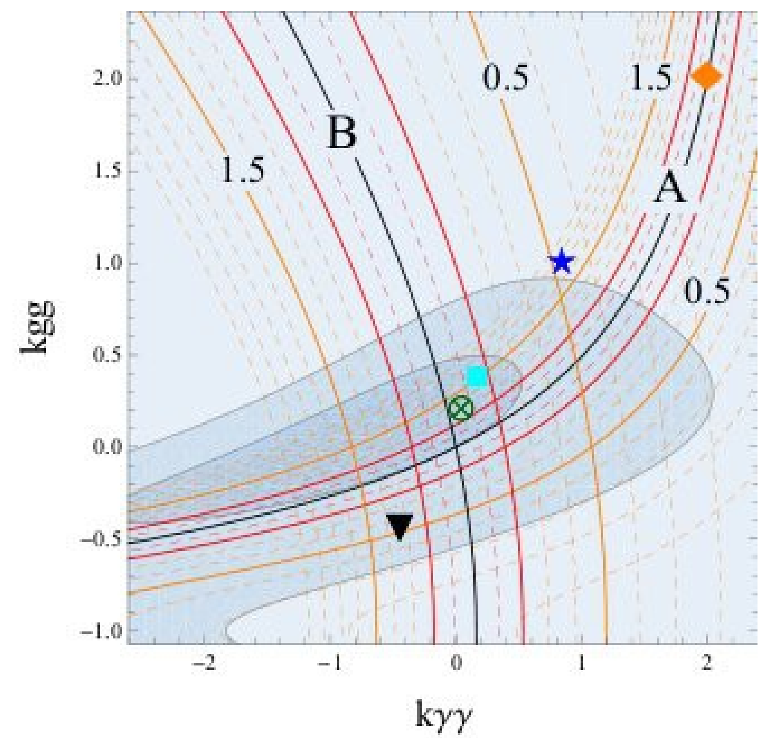
CMS and ATLAS data from inclusive γγ and ZZ to leptons channels

3 parameter fit ($\kappa_{\gamma\gamma}, \kappa_{gg}, \kappa_v$) slice κ_v=1

- CMS



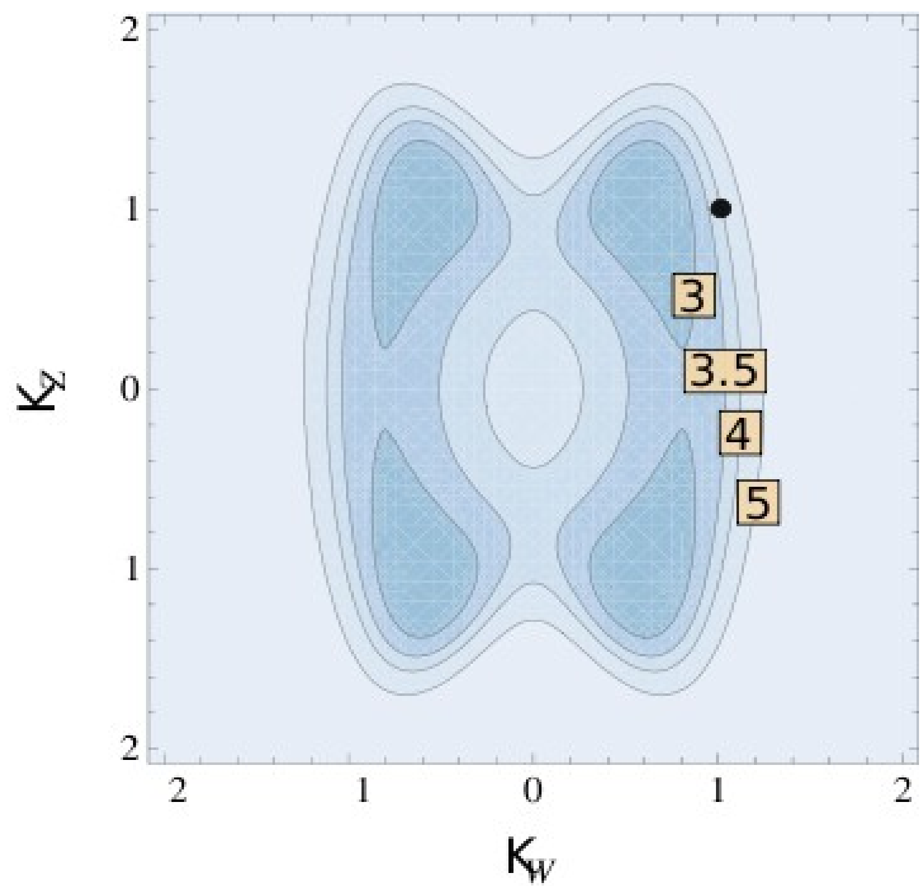
- ATLAS



Both γγ and ZZ channels included κ_v=1 slice to show a 2d plot

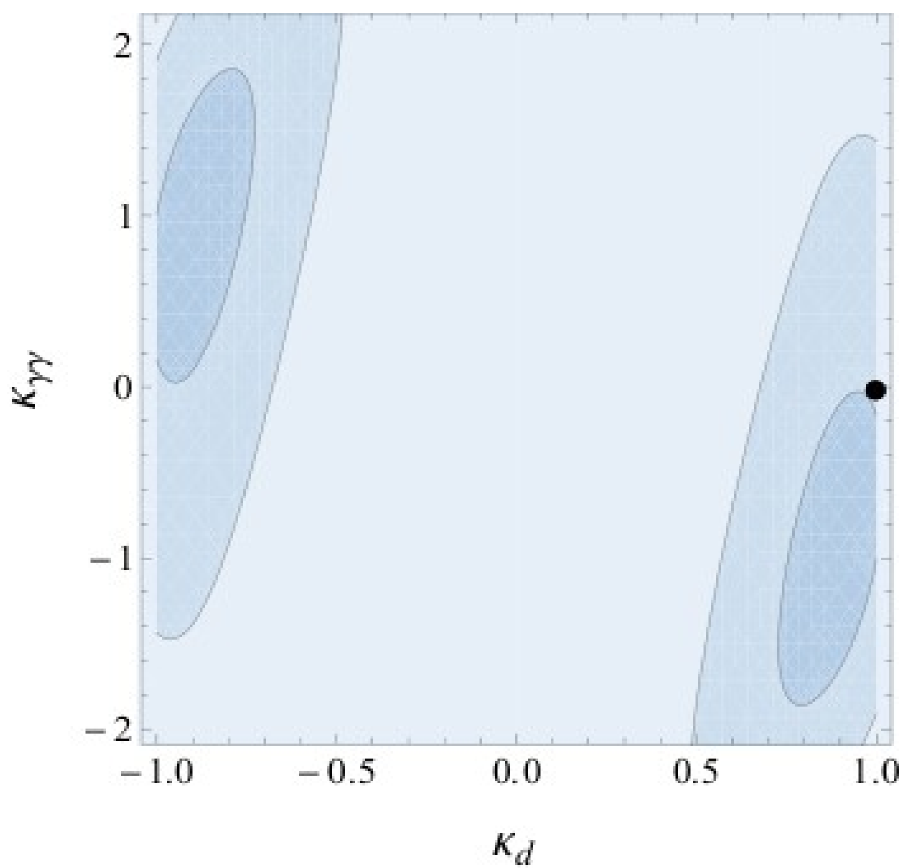
Fermiophobic model

- Study the $k_W\, k_Z$ plane with no couplings to fermions (μ_{ggh}=0, μ_f=0)

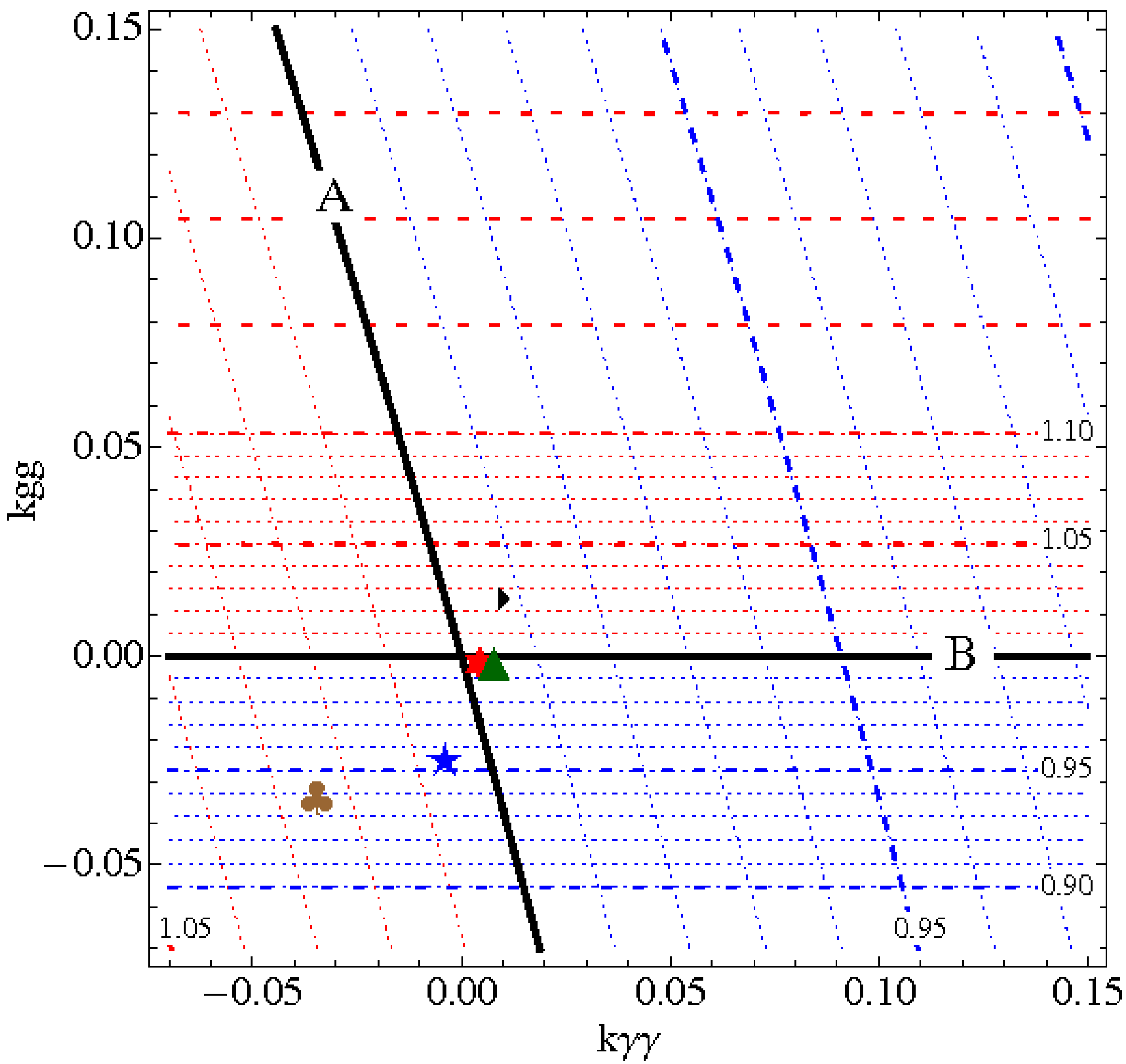


Simple dilaton model impostor

- Study the $k_{\gamma\gamma}$ k_{gg} k_d space and take a slice for k_{gg}=0
- k_d =v/f is is a common scale factor for all massive states couplings, f scale breaking scale inv.



The $\kappa_{\gamma\gamma}$-κ_{gg} for a Linear Collider



- SUSY in the MSSM golden region (♣)
- Simplest Little Higgs model (▲)
- Littlest Higgs (✶)
- Universal Extra Dimension (★)
- Minimal Composite Higgs (●)

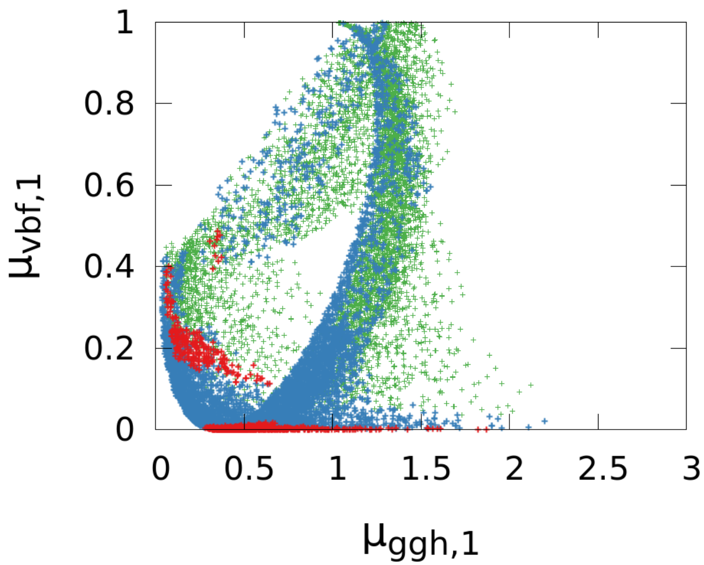
A lighter Higgs? (SM + singlet or doublet)

- Data can be used also to test and constrain the presence of an extra lighter Higgs boson S (NMSSM, 2HDM, extra singlet scalar...)
- New k's can be introduced, but a combination of H, S has a non-zero vev, in the mass basis SM Higgs properties are shared by H,S via a rotation.
- More constraining: effective Lagrangian

$$\begin{array}{ll} \text{singlet} & \frac{1}{\Lambda} S F_{\mu\nu} F^{\mu\nu},\ \frac{1}{\Lambda} S H \psi_L \psi_R,\ \frac{1}{\Lambda} \partial_\mu S \bar{\psi} \sigma^\mu \psi \\ \text{doublet} & \frac{1}{\Lambda^2} |S|^2 F_{\mu\nu} F^{\mu\nu},\ \frac{1}{\Lambda^2} |S|^2 (H/S) \psi_L \psi_R,\ \frac{1}{\Lambda^2} (S^\dagger D^\mu S + \text{h.c.}) \bar{\psi} \sigma_\mu \psi. \end{array}$$

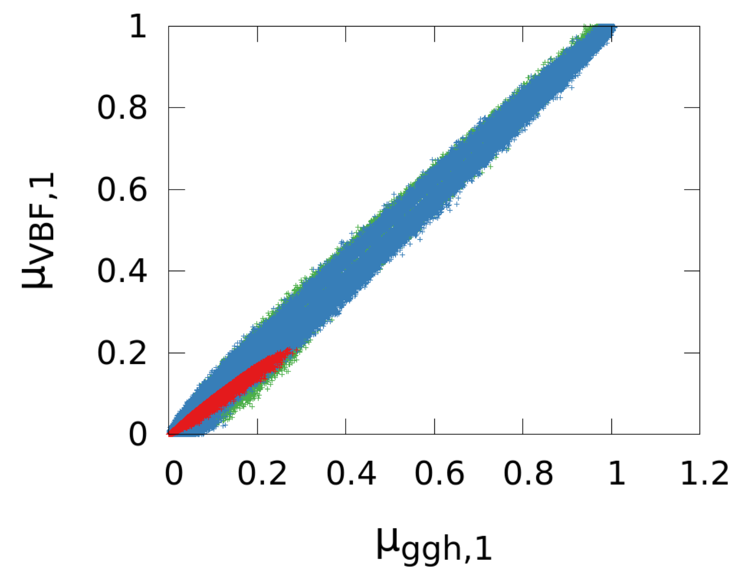
so that k's will scale as v/Λ and (v/Λ)^2

2HDM and NMSSM examples



2HDM (left), green passes flavour tests & EWPT, blue also LEP light Higgs constraints, red LHC constraints on the heavier 126 GeV H

NMSSM (right) same colour code



Results from LHC

- Inclusive cross section is typically reduced in BSM models. Enhancement leads to unexpected new physics. Present data still compatible with some enhancement.
- For LHC:
  - Pointing a quadrant in the κ's parameter space
    General behaviors of this new physics
  - Some models have signature visible at LHC.
- For ILC
  - Sizable effects for all kind of scenarios and below the direct production threshold of NP.
- $\kappa_{\gamma\gamma}$-κ_{gg} parameters + tree level couplings:
  - Useful tool for the study of EW symmetry breaking.
  - Complementary to the direct detection of new particles

Conclusions

- Higgs physics does depend on new physics (if present)
- Parameterizations
  - Allows a survey of new physics with minimal assumptions
  - largely model independent
  - Generalization possible with few extra parameters
  - Can give hints about the kind of expected or unexpected new physics behavior
  - To reject some models of new physics beyond SM.
- How to do better? Data analysis provided with full likelihoods, fiducial cross-sections, standardized form-factors for tensor structures with separated likelihoods.