Global Higgs Fits

and invisible Higgs decays

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Based on work with

G. Belanger, B. Dumont, U. Ellwanger and J.F. Gunion

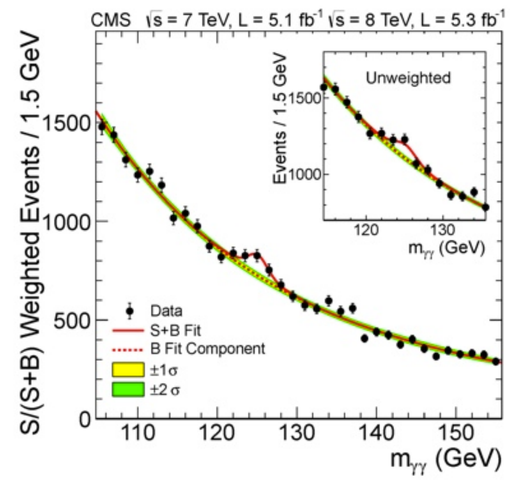
arXiv:1212.5244, 1302.5694, 1306.2941, 1307.5865

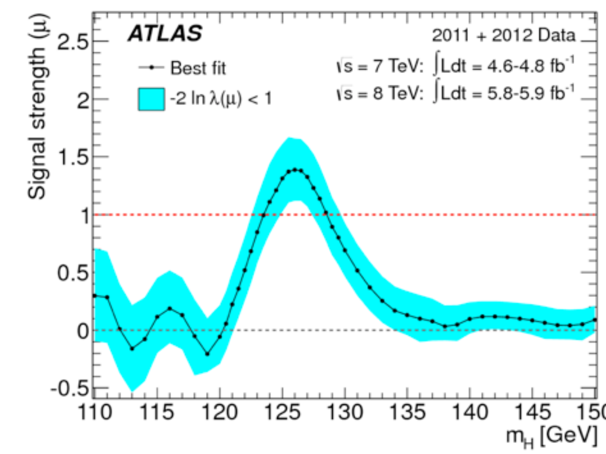
New Perspectives in Dark Matter

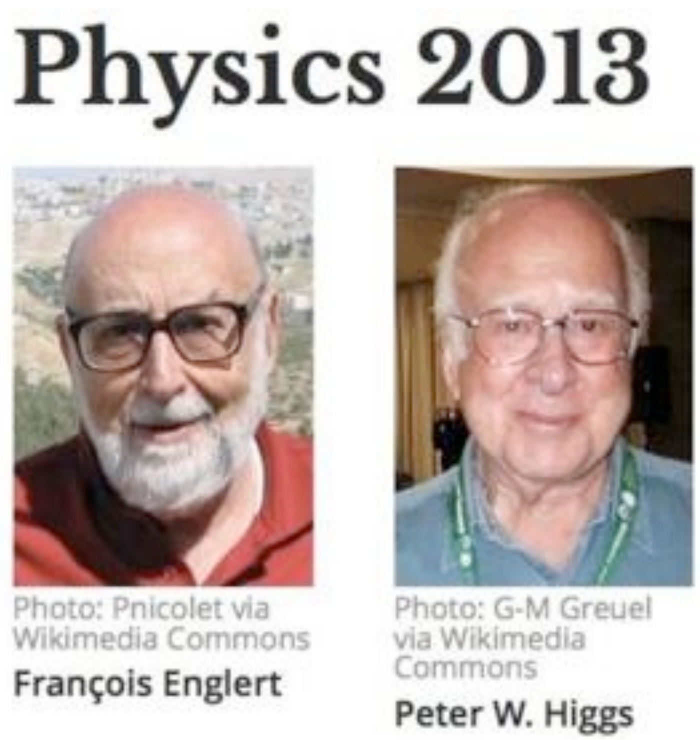
IPN Lyon, 22-25 Oct 2013

introduction

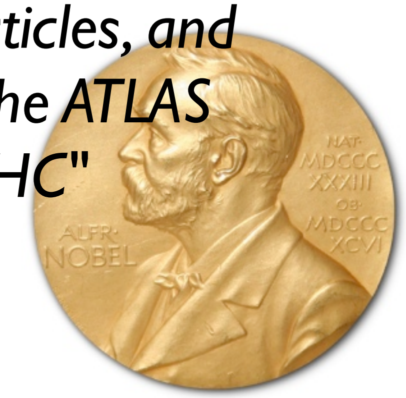
- The 2012 Higgs discovery at ~125 GeV is a tremendous first success of the LHC physics program.
- The data collected at $\sqrt{s}$ = 7 and 8 TeV already provide quite a comprehensive picture of the production and decay properties of the 125 GeV Higgs boson.





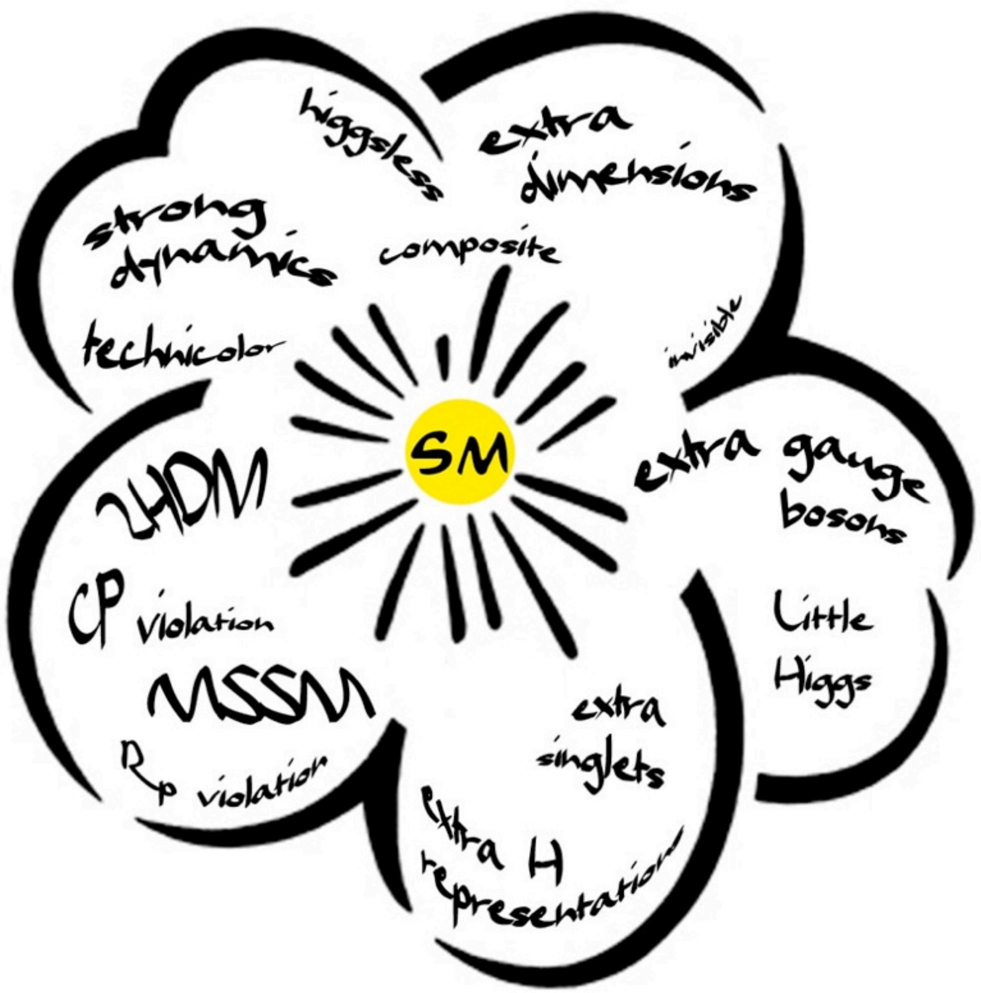


- Consequently, the Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs "*for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed [...] by the ATLAS and CMS experiments at the CERN LHC*"

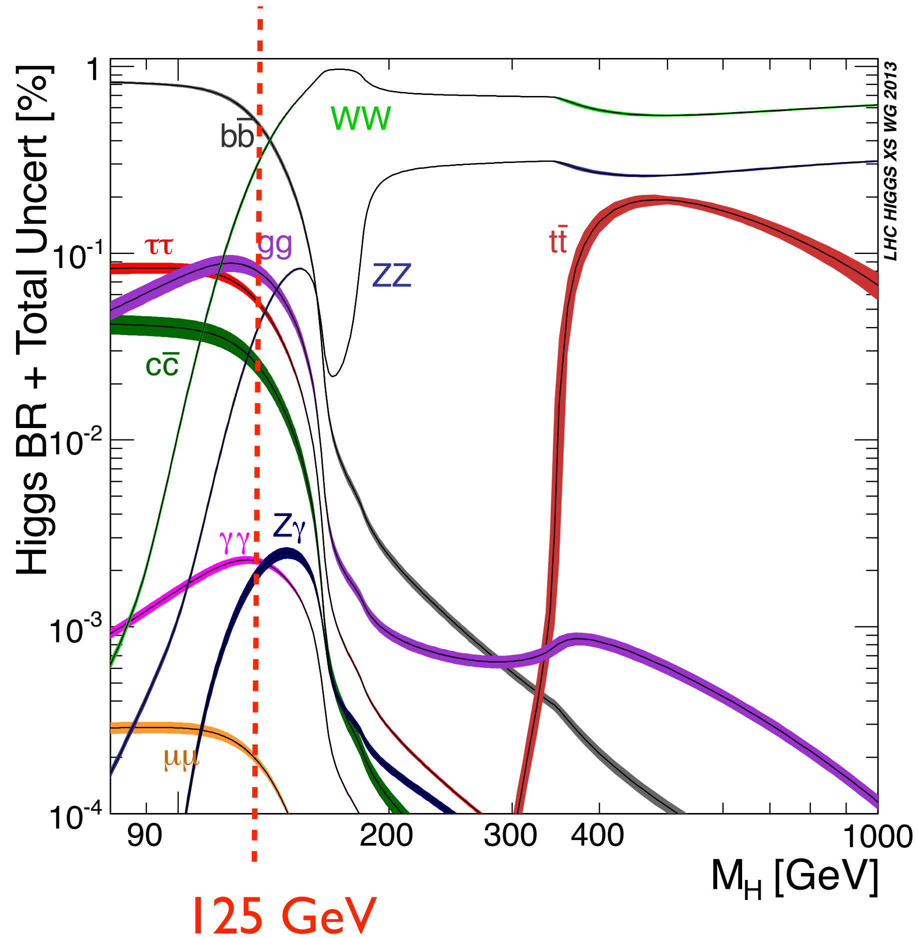


the Higgs as guide to BSM ?

- However, while the Higgs discovery completes our picture of the SM, it still leaves many fundamental questions open (naturalness, hierarchy problem) → new physics beyond the SM at the TeV scale ?
- With the absence, so far, of any sign of new physics the Higgs results become our main guide for where to look for new physics beyond the SM
- This new physics might also provide the dark matter of the Universe
- Exciting potential interplay between LHC and DM searches
- In BSM theories, the Higgs production cross sections, decay branching ratios, kinematic distributions, and even the number of Higgs particles may differ from SM predictions → dedicated interpretation of experimental results



125 GeV is quite lucky

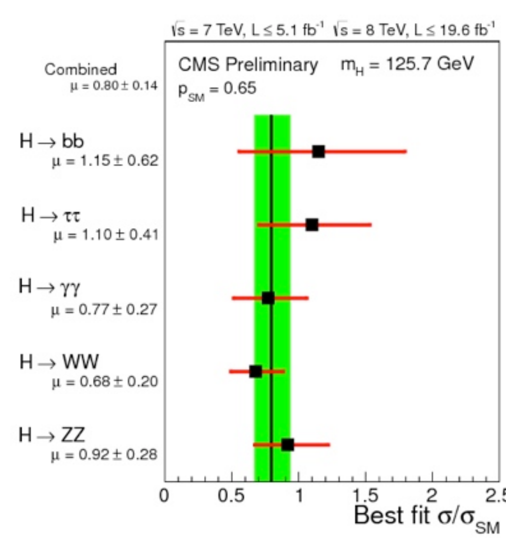


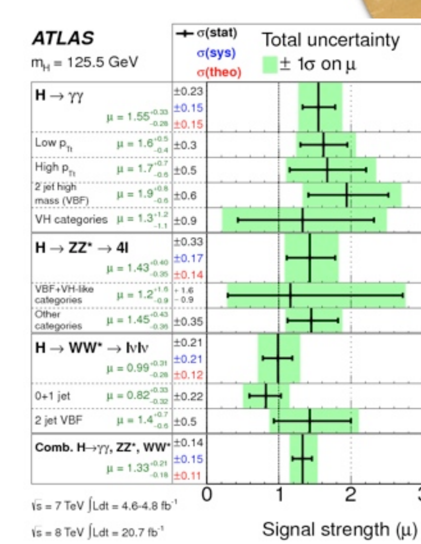
- The fact that the Higgs mass is about 125 GeV is quite lucky, as it allows to observe the Higgs signal in a variety of channels:

$$H \to \gamma\gamma,\, ZZ^*,\, WW^*,\, \tau\tau,\, b\bar{b}$$

- Gives a comprehensive picture already from the first phase of LHC running.

- It is a Higgs !





this talk

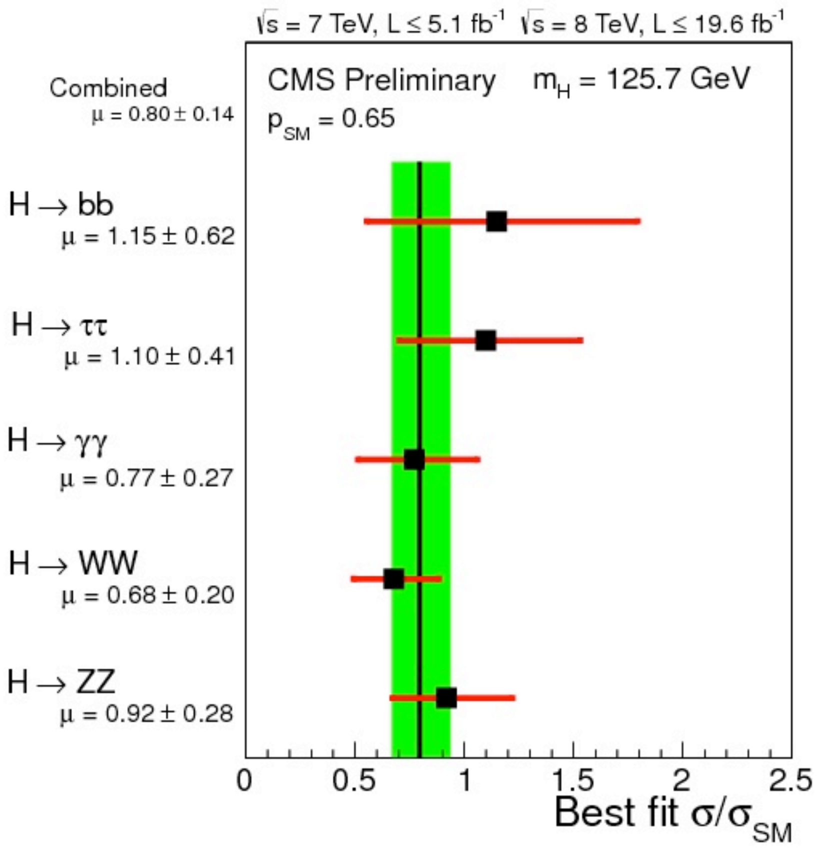
- Motivation
- Higgs signal strengths
  - what the experiments publish
  - how we use the experimental results
- Global coupling fits
- Constraining invisible Higgs decays
- Interplay with dark matter searches

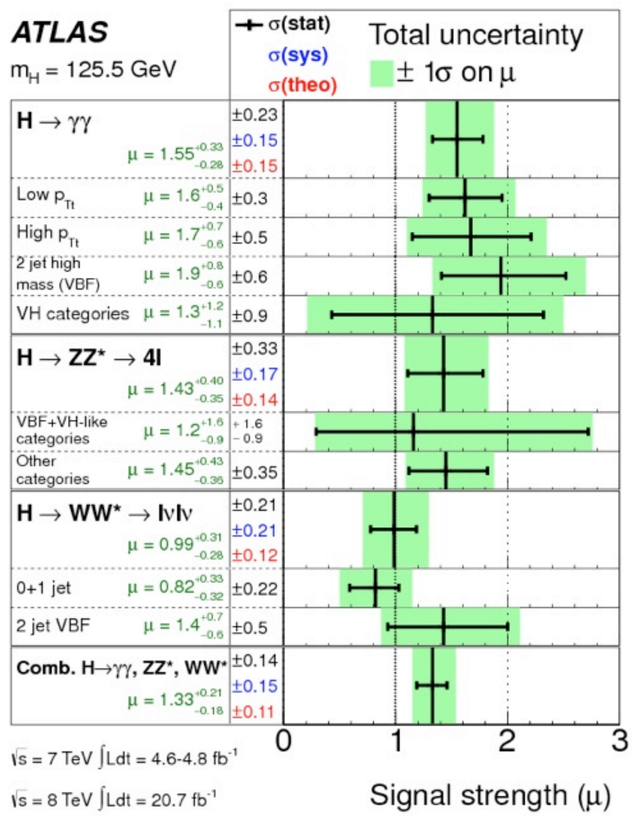
from PhD comics

signal strengths:

using the experimental results

signal strengths





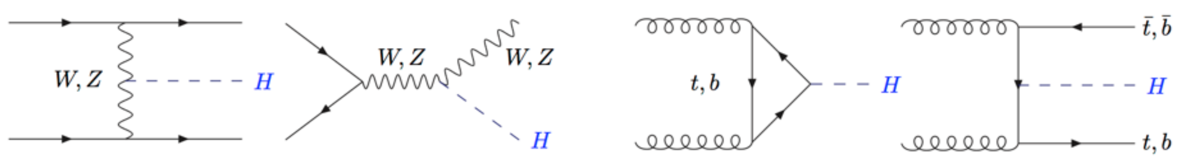
- A very convenient way to quantify the agreement with (or deviations from) SM expectations is presenting results in terms of signal strengths relative to SM $\mu=\sigma/\sigma_{SM}$
- Can be used to constrain models that lead to the same kinematical distributions as the SM → SM tensor structure
- Combined μ's per decay mode are however not are not sufficient to this end
- BSM contributions affect production as well as decay rates → detailed breakdown in terms of production×decay modes needed to test SM and BSM.

signal strengths in "theory space"

decay mode ($\gamma\gamma$, WW, ZZ, bb, $\tau\tau$, ...)

$$\mu(X,Y) \equiv \frac{\sigma(X)\,\mathrm{BR}(H \to Y)}{\sigma(X_{\mathrm{SM}})\,\mathrm{BR}(H_{\mathrm{SM}} \to Y)}$$

fundamental production mode such as gg fusion (ggF), VBF, etc.



(note that μ(Y) is not sufficient because BSM contributions may affect different production modes differently!)

- In experimental practice, the data related to a single decay mode H→Y are divided into different categories (or "sub-channels") I, in order to improve sensitivity or discrimination among the production mechanisms X.

  Example: for $\gamma\gamma$, these include "untagged", 2-jet tagged, and lepton tagged categories, designed to be most sensitive to ggF, VBF, and VH, respectively.

using sub-channel information

- The likelihood in terms of μ(X,Y) can be approximately recomputed combining the χ^2 of all categories $\boldsymbol{I}$ using an efficiency-weighted sum:

$$\mu_I(Y) = \sum_X \mu(X,Y)\, T(I,X)\, \sigma(X_{\rm SM})\, {\rm BR}(H_{\rm SM} \to Y)$$

selection efficiencies for each production mode, normalized to one.

- It is critical that for each of the categories $\boldsymbol{I}$ the selection efficiencies (and uncertainties thereon) be provided for all production modes. Unfortunately this is not yet done in a systematic way :-(

- NB important correlations may be missed in this approach, e.g., from migration of events between categories.

using sub-channel information

- The likelihood in terms of μ(X,Y) can be approximately recomputed combining the χ^2 of all categories I using an efficiency-weighted sum:

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selection efficiencies for each production mode, normalized to one.

crucial !

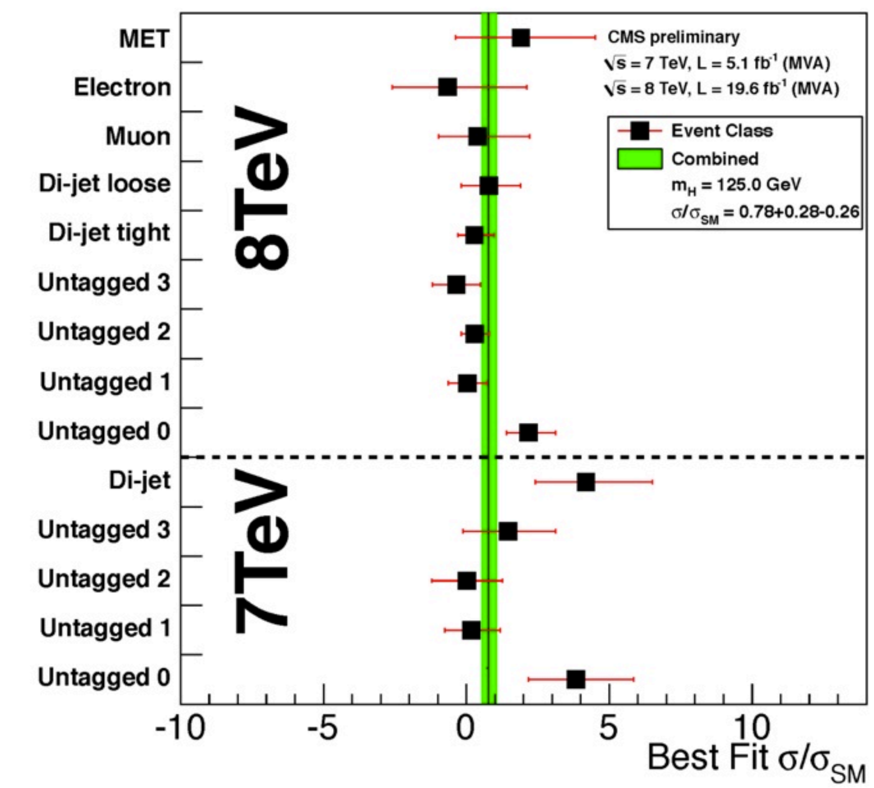
- It is critical that for each of the categories I the selection efficiencies (and uncertainties thereon) be provided for all production modes. Unfortunately this is not yet done in a systematic way :-(

- NB important correlations may be missed in this approach, e.g., from migration of events between categories.

T(I,X) .... a good example

Expected signal and estimated background

Event classes		SM Higgs boson expected signal (m_H=125 GeV) Total	ggH	VBF	VH	ttH	σ_{eff} (GeV)	FWHM/2.35 (GeV)
7 TeV 5.1 fb^{-1}	Untagged 0	3.2	61.4%	16.8%	18.7%	3.1%	1.21	1.14
	Untagged 1	16.3	87.6%	6.2%	5.6%	0.5%	1.26	1.08
	Untagged 2	21.5	91.3%	4.4%	3.9%	0.3%	1.59	1.32
	Untagged 3	32.8	91.3%	4.4%	4.1%	0.2%	2.47	2.07
	Dijet tag	2.9	26.8%	72.5%	0.6%	–	1.73	1.37
8 TeV 19.6 fb^{-1}	Untagged 0	17.0	72.9%	11.6%	12.9%	2.6%	1.36	1.27
	Untagged 1	37.8	83.5%	8.4%	7.1%	1.0%	1.50	1.39
	Untagged 2	150.2	91.6%	4.5%	3.6%	0.4%	1.77	1.54
	Untagged 3	159.9	92.5%	3.9%	3.3%	0.3%	2.61	2.14
	Dijet tight	9.2	20.7%	78.9%	0.3%	0.1%	1.79	1.50
	Dijet loose	11.5	47.0%	50.9%	1.7%	0.5%	1.87	1.60
	Muon tag	1.4	0.0%	0.2%	79.0%	20.8%	1.85	1.52
	Electron tag	0.9	1.1%	0.4%	78.7%	19.8%	1.88	1.54
	E_T^{miss} tag	1.7	22.0%	2.6%	63.7%	11.7%	1.79	1.64

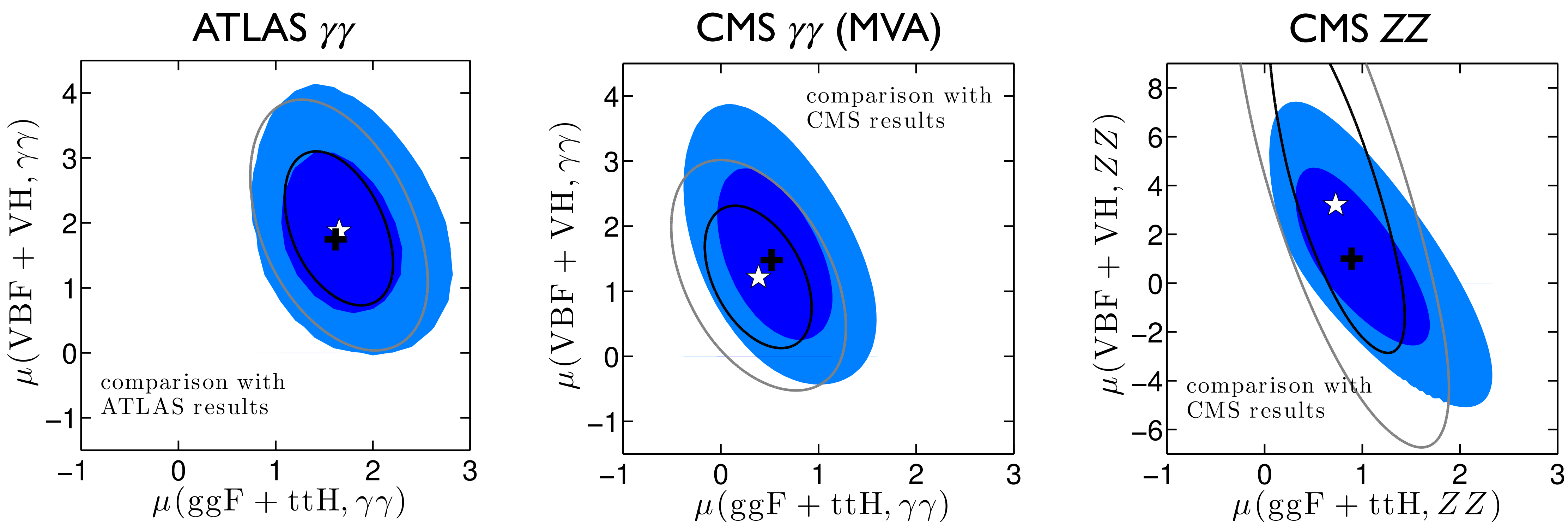


from CMS-PAS-HIG-13-001 (H→$\gamma\gamma$, mass-fit MVA analysis)

but unfortunately not yet available for all channels from both ATLAS and CMS
(also not for CMS H→$\gamma\gamma$ CiC analysis)

using sub-channel information

- Reconstruction of 68 and 95% CL contours from sub-channel info (black/grey) and comparison to official ATLAS/CMS results (blue)



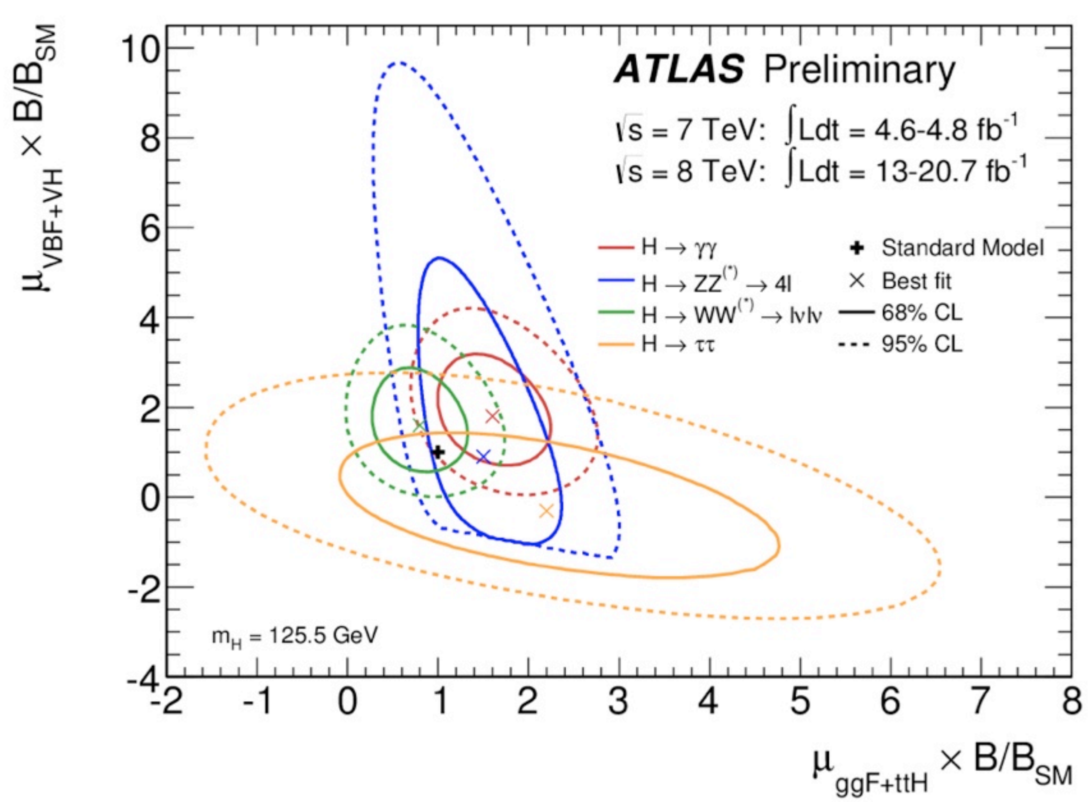
arXiv:1307.5865

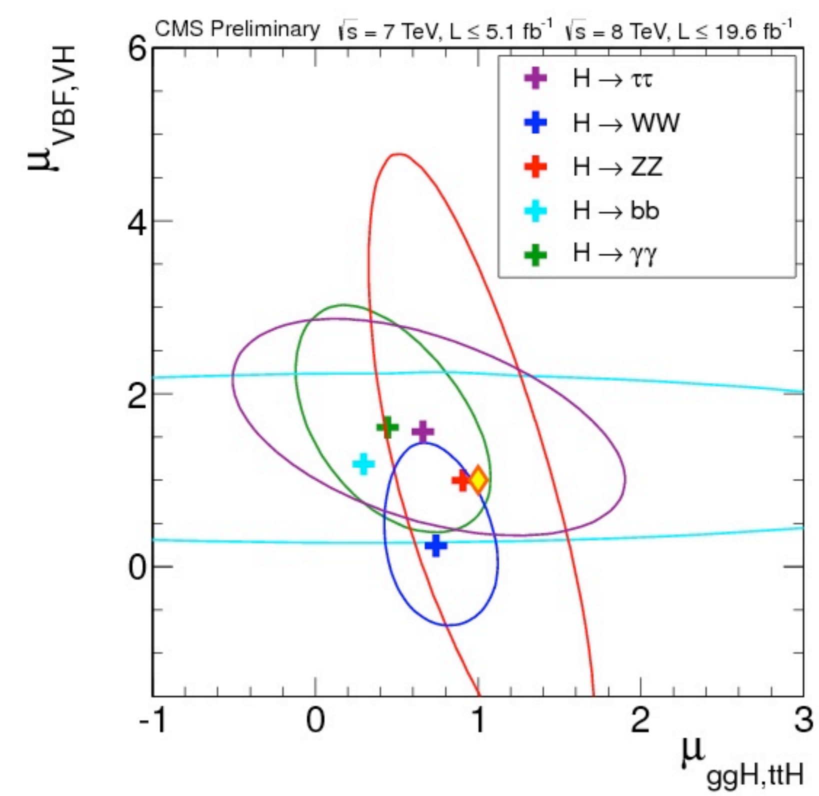
- NB important correlations may be missed in this approach. In particular, some systematic uncertainties lead to migration of events between categories, and these uncertainties can dominate over the statistical ones.

μ(ggF+ttH) vs μ(VBF+VH) plots

- It has become standard that for each decay mode the experiments present 68% and 95% CL contours in the μ(ggF+ttH) versus μ(VBF+VH) plane:

VH=WH+ZH





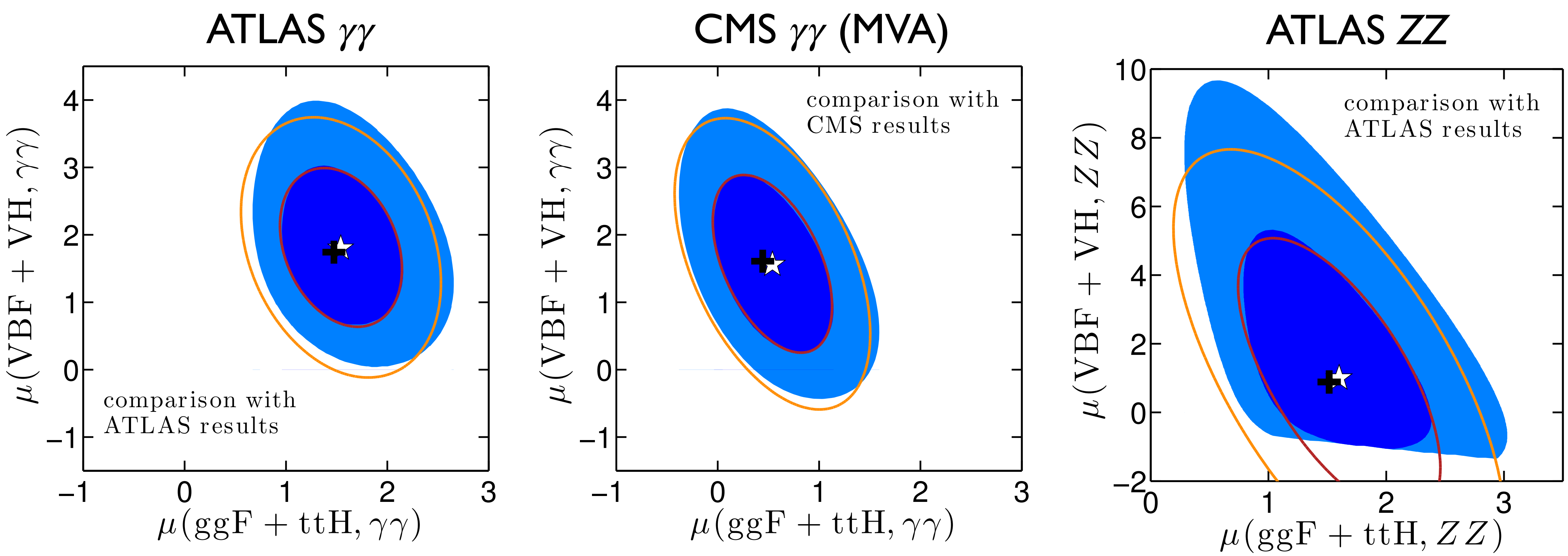
- This is a boon for interpretation studies because the fundamental production modes are already "unfolded" from the experimental categories.

- Could be extended to other μ(X,Y) vs μ(X',Y') combinations, e.g. WH, ZH for H→bb

μ(ggF+ttH) vs. μ(VBF+VH): limitations

- μ(VBF+VH) assumes custodial symmetry.
- If only 68% and 95% CL contours are given, one first needs to reconstruct the likelihood. Simplest solution is fitting a 2D Gaussian:

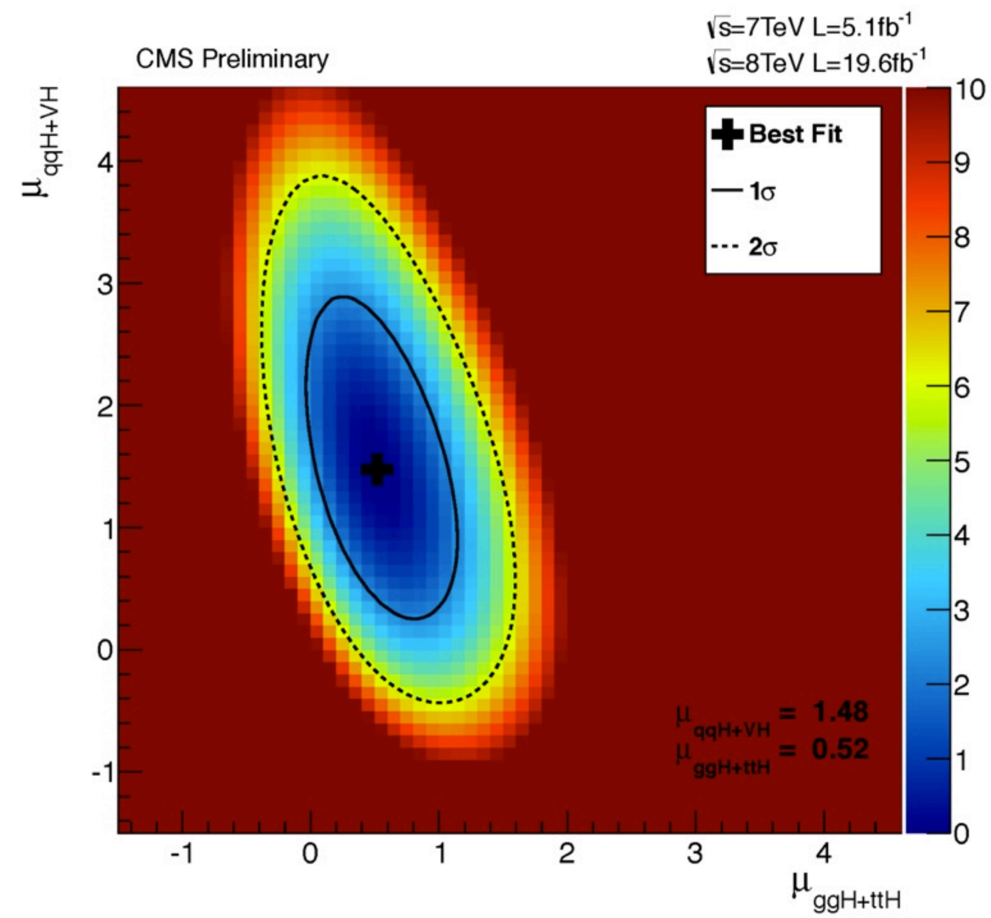
arXiv:1307.5865



Gaussian fits (red/orange contours) to signal strengths in the μ(ggF+ttH) vs μ(VBF+VH) plane and comparison to official ATLAS and CMS results (in blue).

In each case, we approximately reconstruct the likelihood by fitting a bivariate normal distribution to the 68% CL contour given by the collaboration

- It would be of great advantage to have the full likelihood information in the μ(ggF+ttH) vs μ(VBF+VH) plane ... or other relevant planes

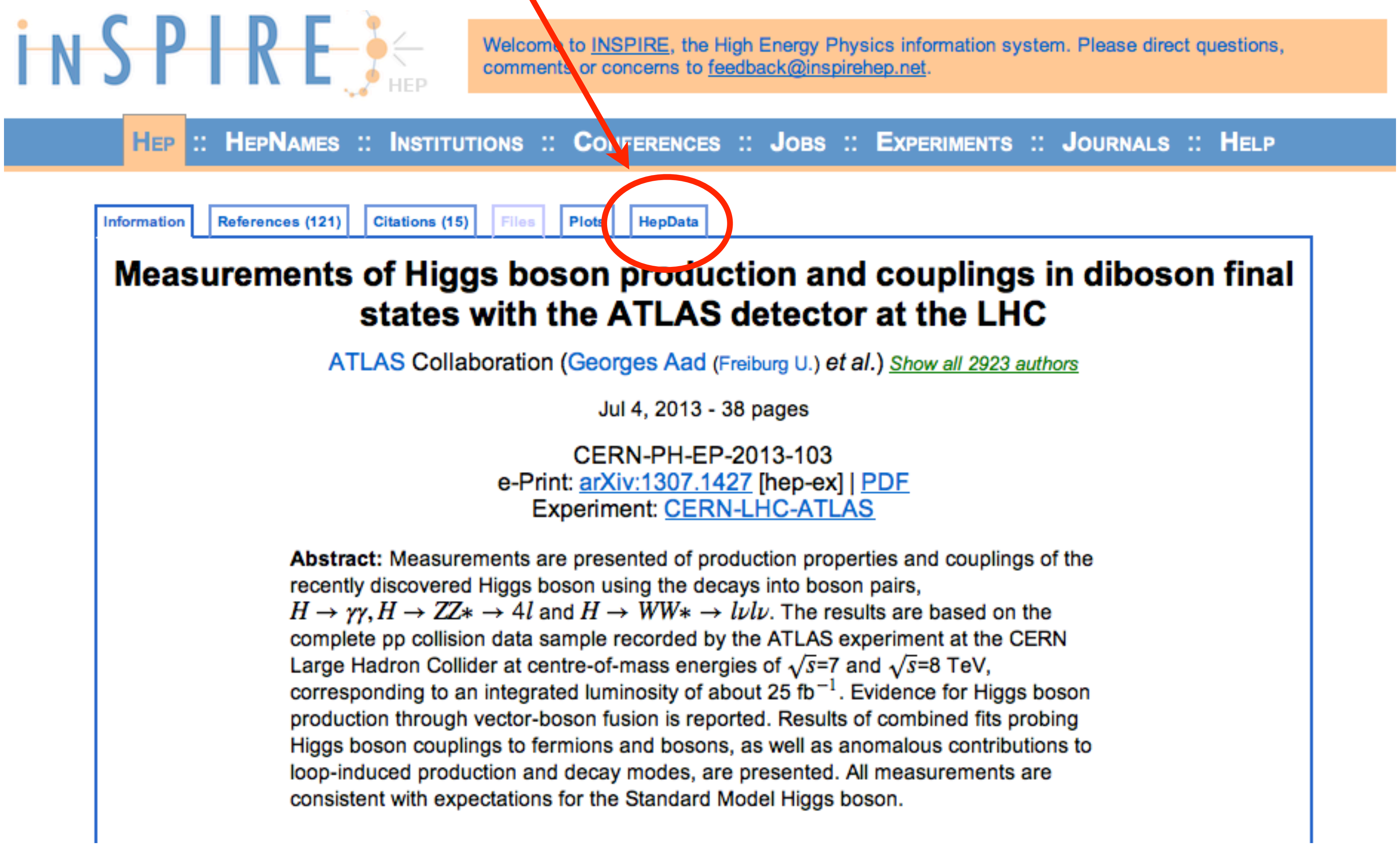


from CMS-PAS-HIG-13-001 ($H \to \gamma\gamma$)

- Preferably this information should be directly available in numerical form (via INSPIRE → DOI → searchable and citable)

a big step forward

[....] the ATLAS collaboration has taken an important step forward by making the likelihood function for three key measurements about the Higgs available to the world digitally. [K. Cranmer, QuantumDiaries, 12-Sep-2013]



Measurements of Higgs boson production and couplings in diboson final states with the ATLAS detector at the LHC

ATLAS Collaboration (Georges Aad (Freiburg U.) *et al.*) *Show all 2923 authors*

Jul 4, 2013 - 38 pages

CERN-PH-EP-2013-103
e-Print: arXiv:1307.1427 [hep-ex] | PDF
Experiment: CERN-LHC-ATLAS

Abstract: Measurements are presented of production properties and couplings of the recently discovered Higgs boson using the decays into boson pairs, $H \to \gamma\gamma, H \to ZZ* \to 4l$ and $H \to WW* \to l\nu l\nu$. The results are based on the complete pp collision data sample recorded by the ATLAS experiment at the CERN Large Hadron Collider at centre-of-mass energies of $\sqrt{s}$=7 and $\sqrt{s}$=8 TeV, corresponding to an integrated luminosity of about 25 fb^{-1}. Evidence for Higgs boson production through vector-boson fusion is reported. Results of combined fits probing Higgs boson couplings to fermions and bosons, as well as anomalous contributions to loop-induced production and decay modes, are presented. All measurements are consistent with expectations for the Standard Model Higgs boson.

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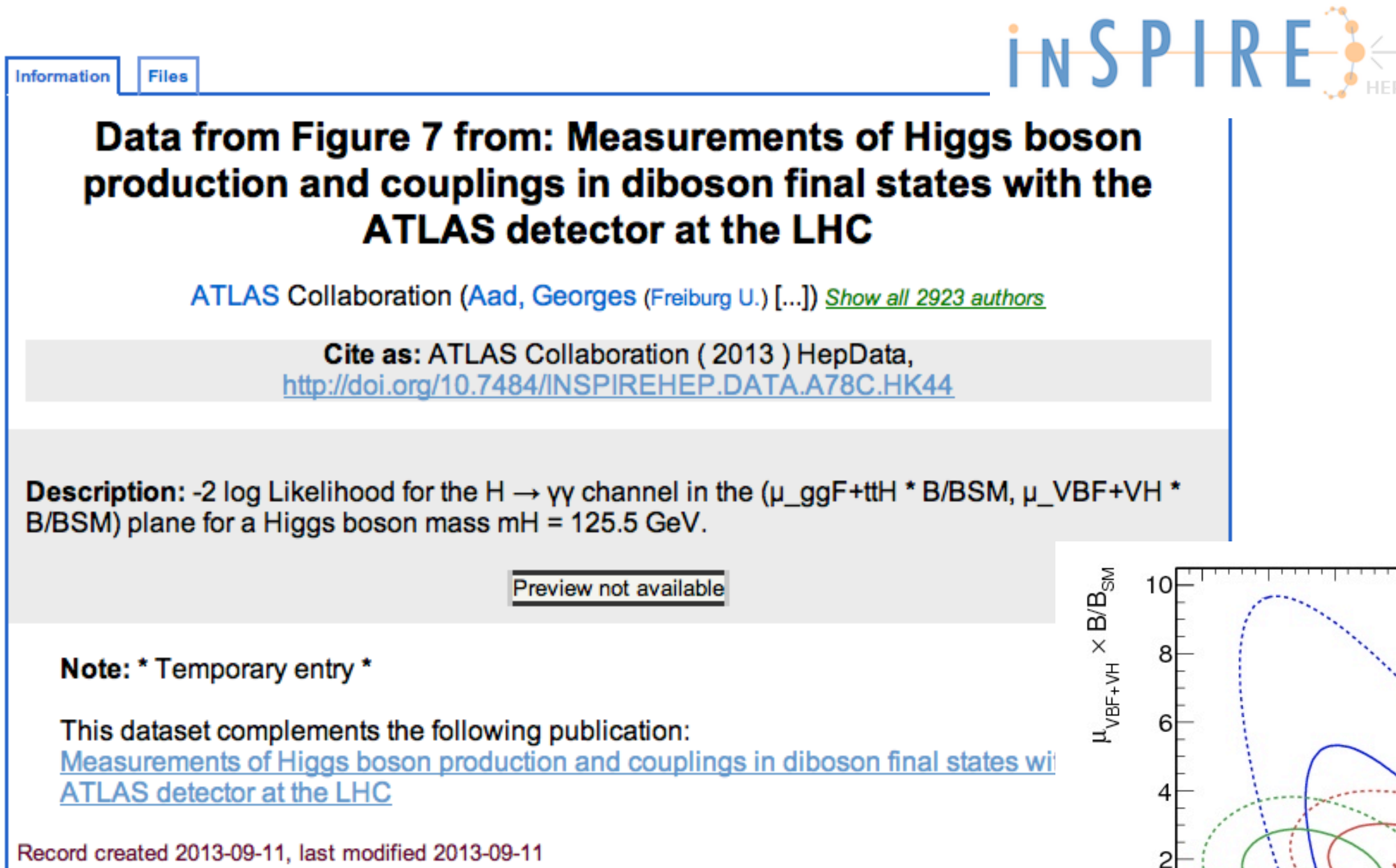
Information Files

Data from Figure 7 from: Measurements of Higgs boson production and couplings in diboson final states with the ATLAS detector at the LHC

ATLAS Collaboration (Aad, Georges (Freiburg U.) [...]) Show all 2923 authors

Cite as: ATLAS Collaboration (2013) HepData, http://doi.org/10.7484/INSPIREHEP.DATA.A78C.HK44

Description: -2 log Likelihood for the H → γγ channel in the (μ_ggF+ttH * B/BSM, μ_VBF+VH * B/BSM) plane for a Higgs boson mass mH = 125.5 GeV.

Preview not available

Note: * Temporary entry *

This dataset complements the following publication:
Measurements of Higgs boson production and couplings in diboson final states wi
ATLAS detector at the LHC

Record created 2013-09-11, last modified 2013-09-11

Figure 7

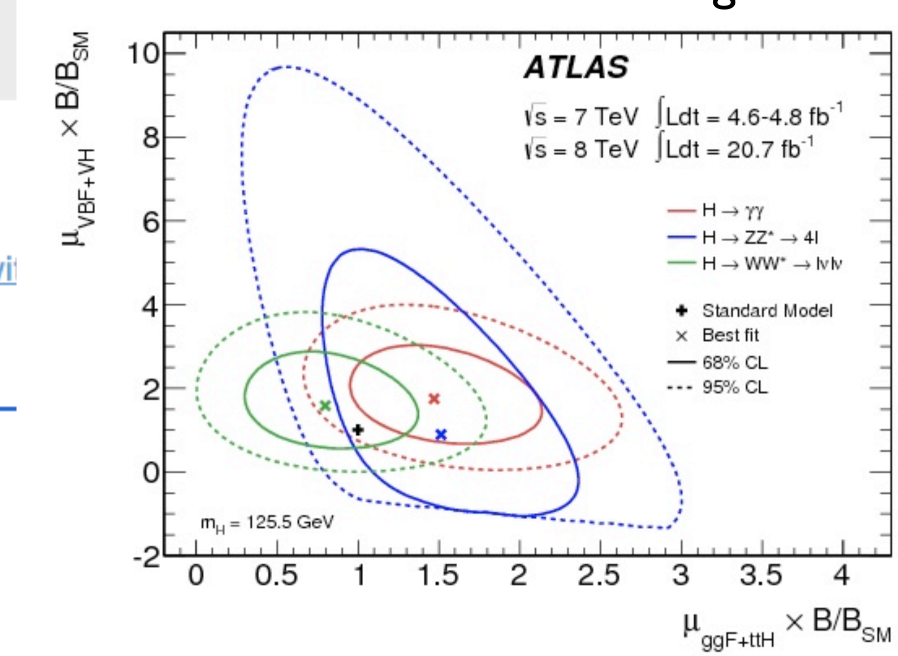

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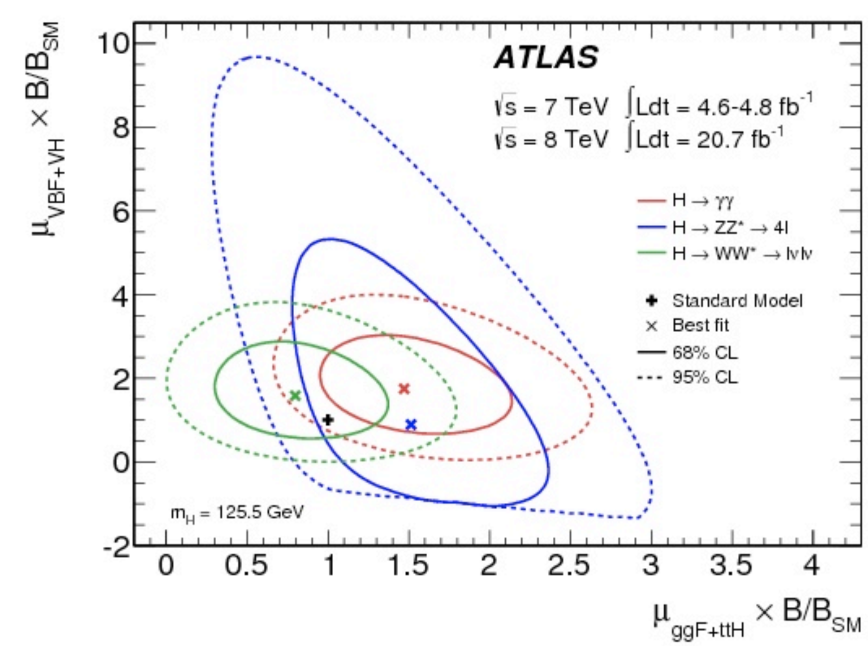
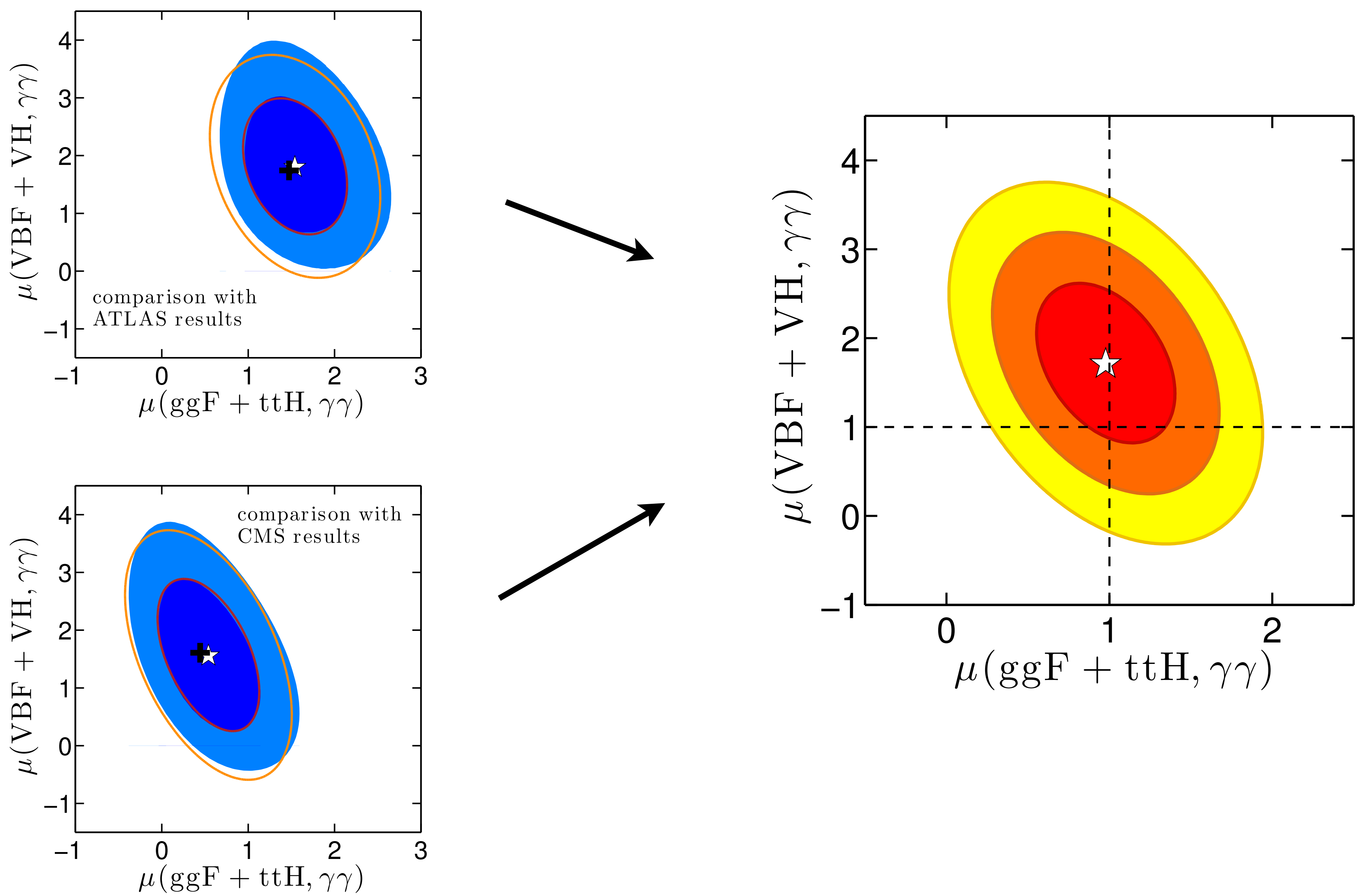
Figure 7



combined signal strengths

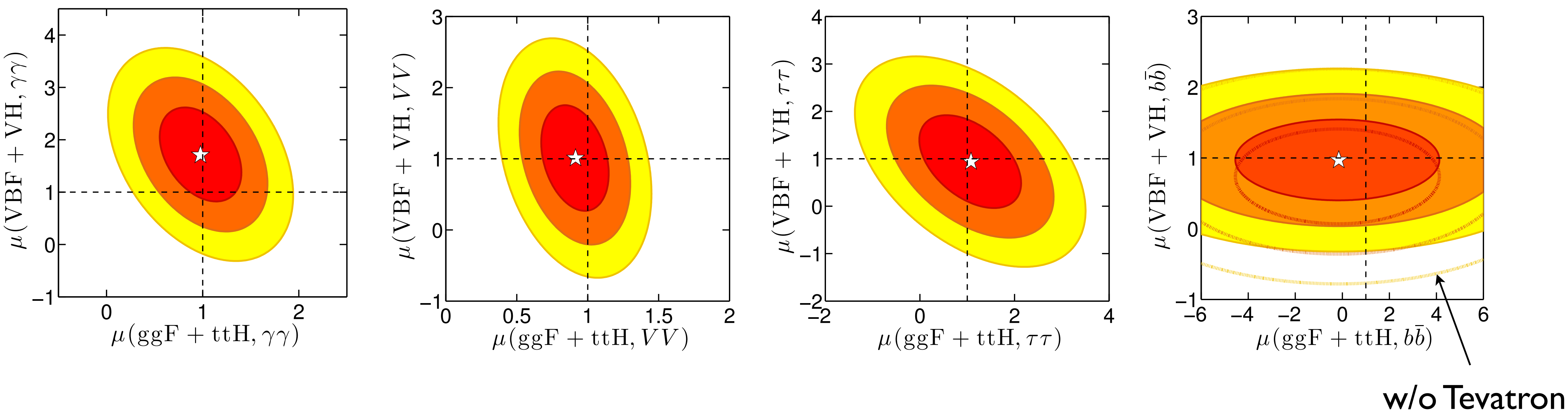
Combining ATLAS, CMS and Tevatron results

Fitting 2D Gaussians to the 68% CL contours from the experiments, we construct a combined likelihood in the (ggF+ttH,VBF+VH) plane for each final state:

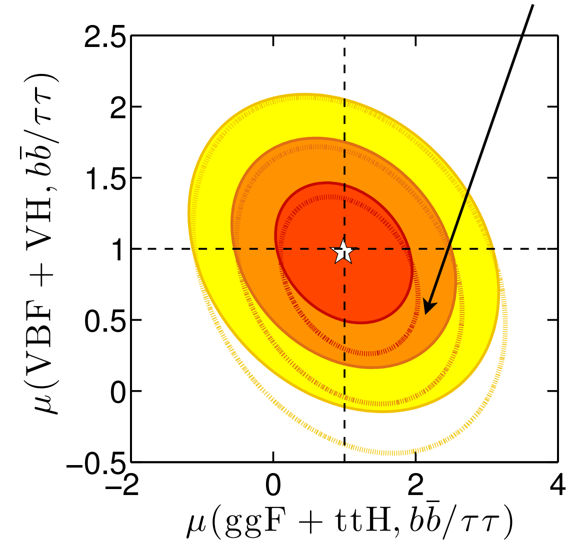


arXiv:1306.2941

Combined μ's



	$\hat{\mu}(\mathrm{ggF} + \mathrm{ttH})$	$\hat{\mu}(\mathrm{VBF} + \mathrm{VH})$	ρ
$\gamma\gamma$	0.98 ± 0.28	1.72 ± 0.59	-0.38
VV	0.91 ± 0.16	1.01 ± 0.49	-0.30
$b\bar{b}/\tau\tau$	0.98 ± 0.63	0.97 ± 0.32	-0.25
$\tau\tau$	1.07 ± 0.71	0.94 ± 0.65	-0.47
$b\bar{b}$	-0.23 ± 2.86	0.97 ± 0.38	0



Agrees frustratingly well with SM :-(
but, there's still room for sizable deviations ...

global fits

arXiv:1306.2941

Coupling Fits

- Need to specify the Lagrangian

$$\mathcal{L} = g\left[C_V\left(M_W W_\mu W^\mu + \frac{M_Z}{\cos\theta_W} Z_\mu Z^\mu\right) - C_U \frac{m_t}{2M_W}\bar{t}t - C_D \frac{m_b}{2M_W}\bar{b}b - C_D \frac{m_\tau}{2M_W}\bar{\tau}\tau\right] H\,.$$

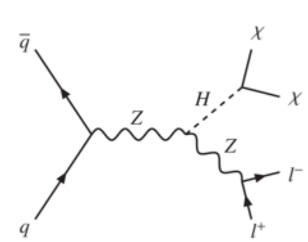
C's scale couplings relative to SM ones; $C_U=C_D=C_V=1$ is SM.

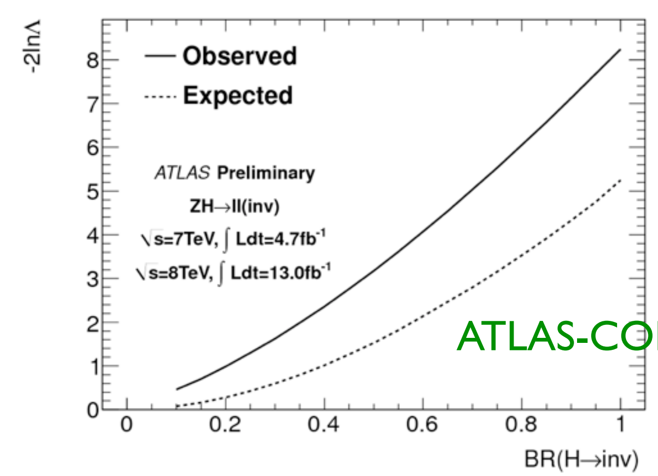
- Couplings to gluons and photons: we compute $\overline{C}_g$ and $\overline{C}_\gamma$ from C_U, C_D, C_V; we also allow additional loop contributions ΔC_g and ΔC_γ from new particles → $C_g = \overline{C}_g + \Delta C_g$ and $C_\gamma = \overline{C}_\gamma + \Delta C_\gamma$

- Calculation of σ×BR following the recommendations of the LHC Higgs Cross Section Working Group, arXiv:1209.0040

- Fit includes ATLAS, CMS and Tevatron results from Moriond and LHCP 2013.

- NB when relevant we also include searches for invisible decays. In particular ATLAS ZH→ll+MET gives B(inv)<0.65 at 95% CL.



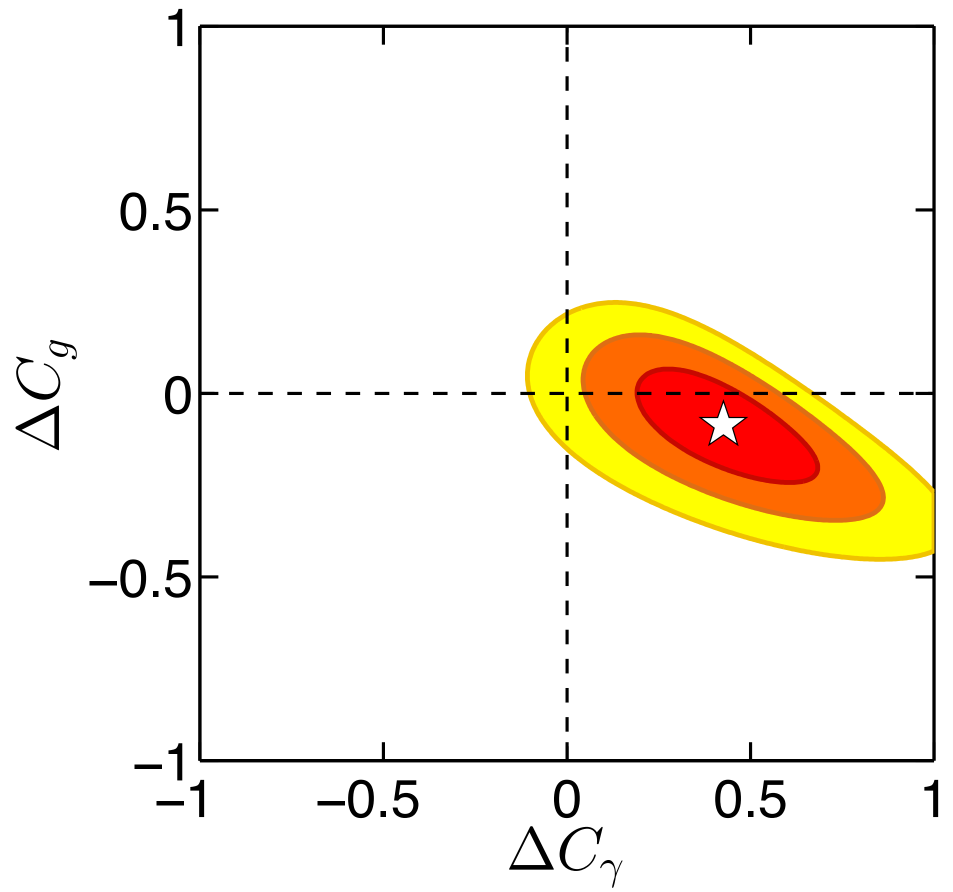


ATLAS-CONF-2013-011

$\Delta C_g, \Delta C_\gamma$ Fit

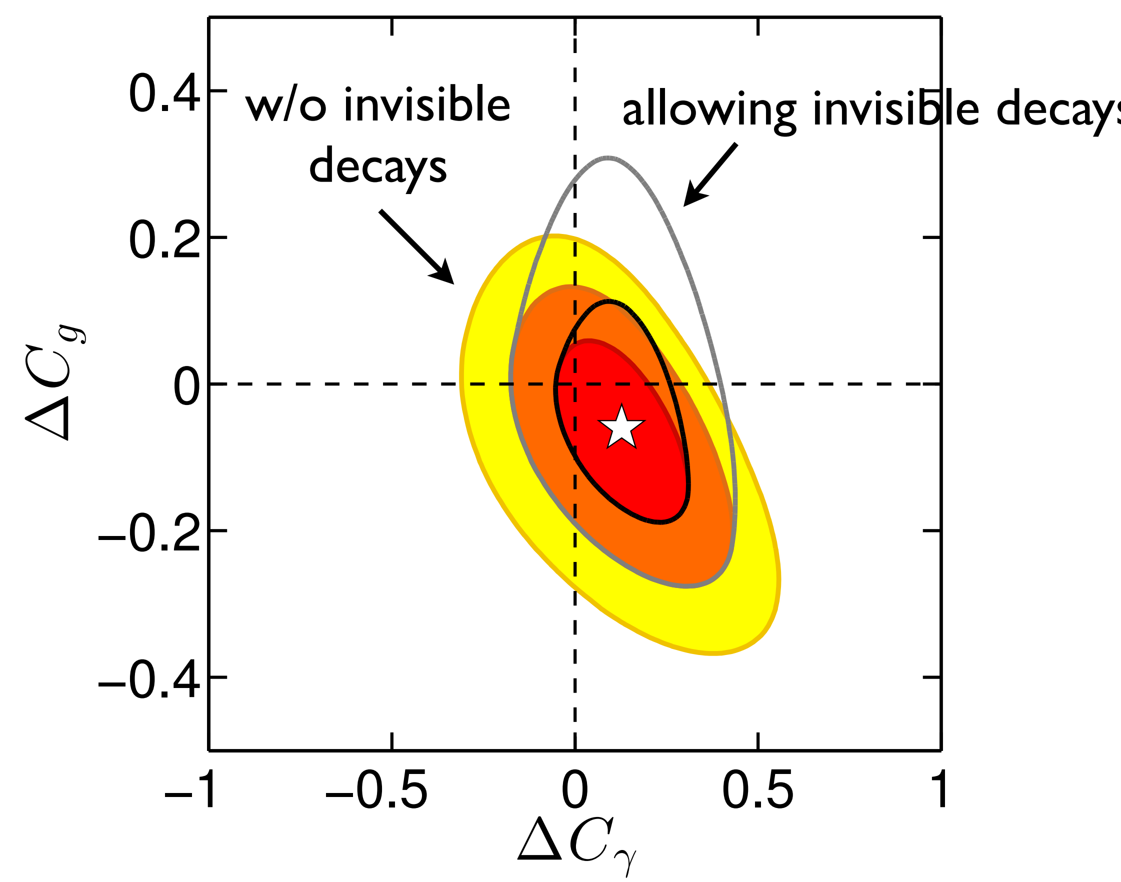
$C_U=C_D=C_V=1$

end of 2012 (with γγ excess)



SM was more than 2σ away from best fit

NOW

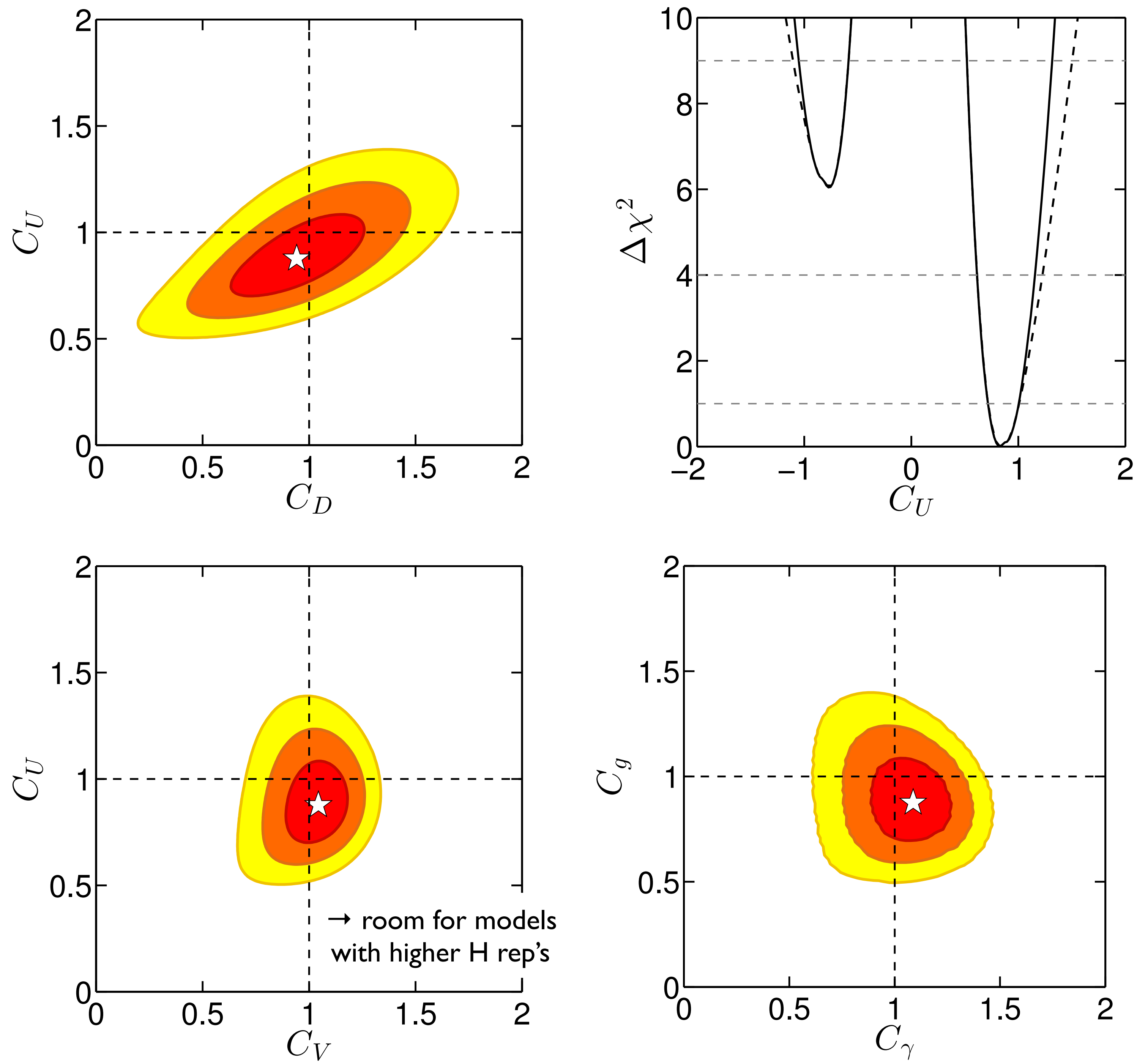


Best fit now $\Delta C_g = -0.06$, $\Delta C_\gamma = 0.13$

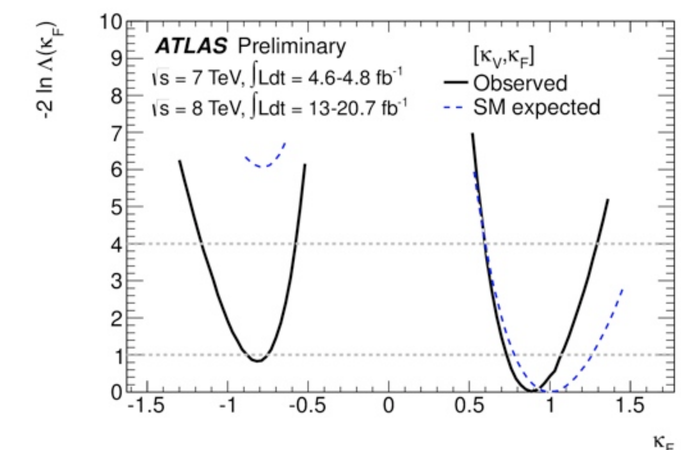
$\chi^2_{min}/\text{dof} = 0.84$ (SM: 0.82)

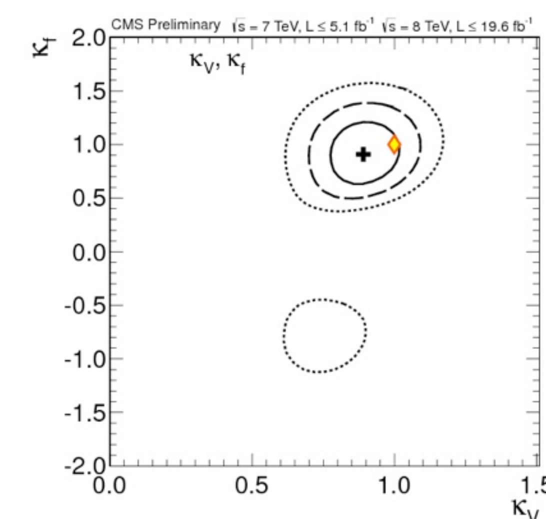
plots show 68%, 95% and 99.7% CL contours

C_U, C_D, C_V Fit ($\Delta C_g = \Delta C_\gamma = 0$)



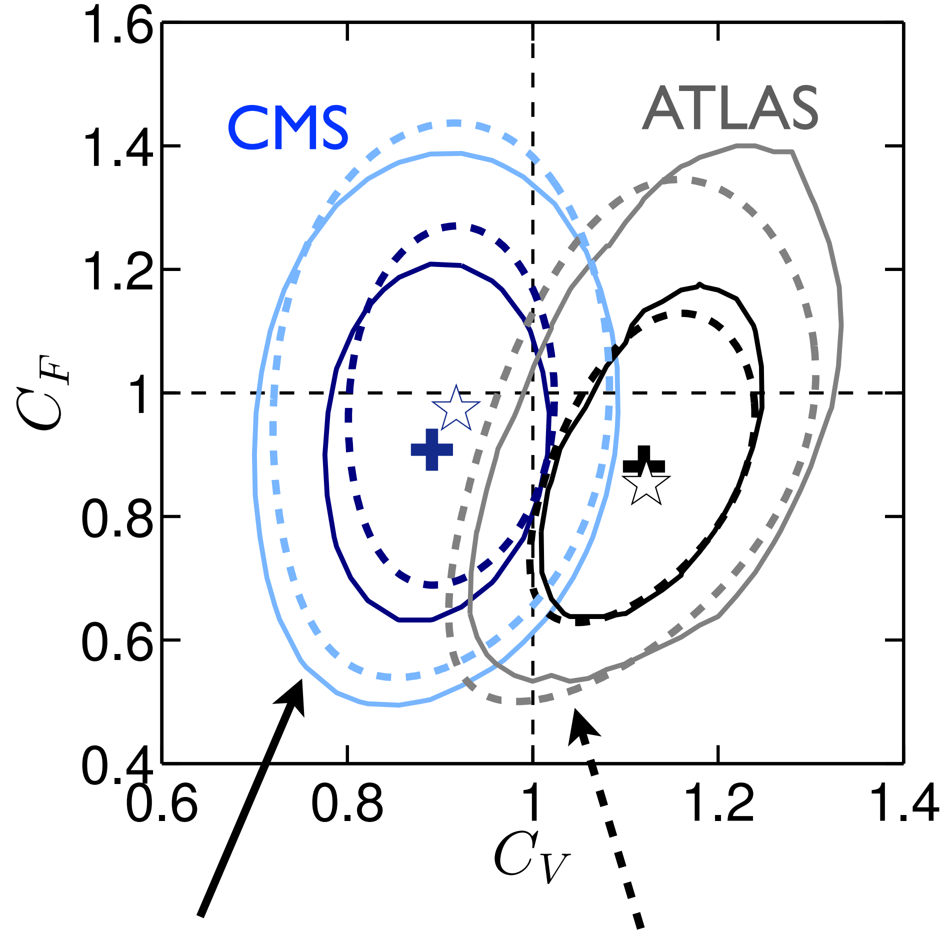
C_U<1 disfavored by our fit
(sign ambiguity in C_D remains)





Comparison with ATLAS and CMS coupling fits

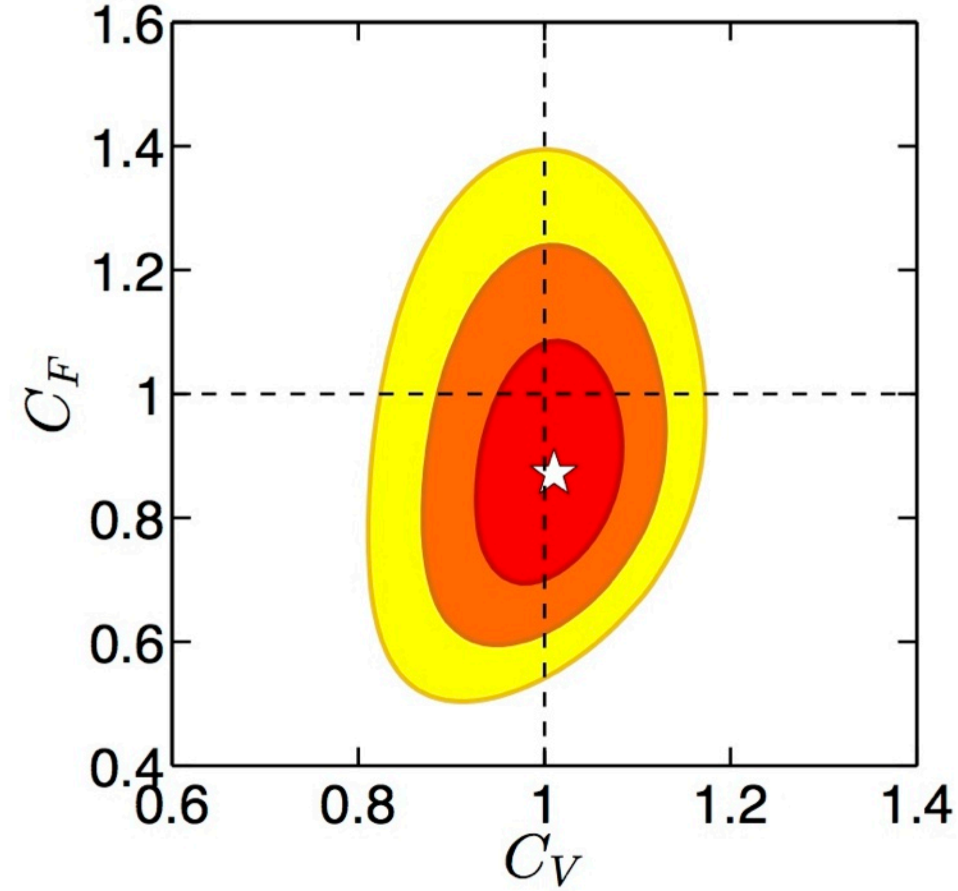
ATLAS/CMS individually



solid contours: official results

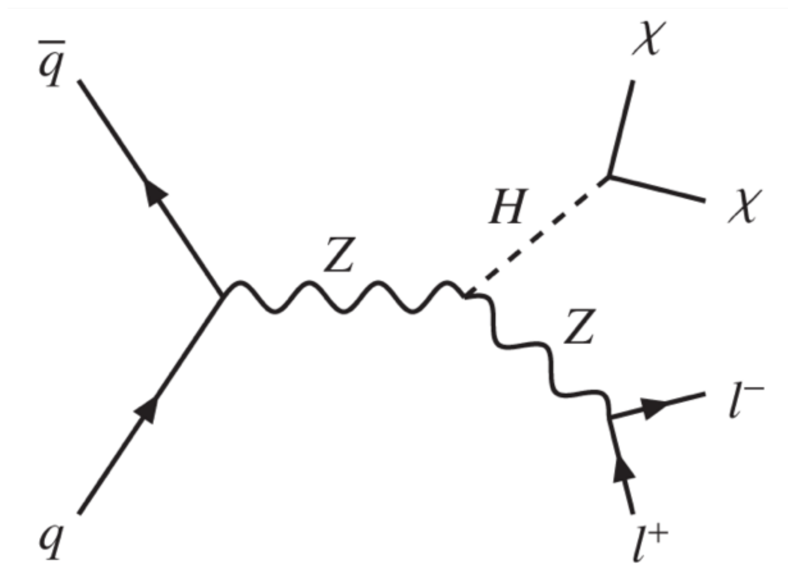
dashed: our fit

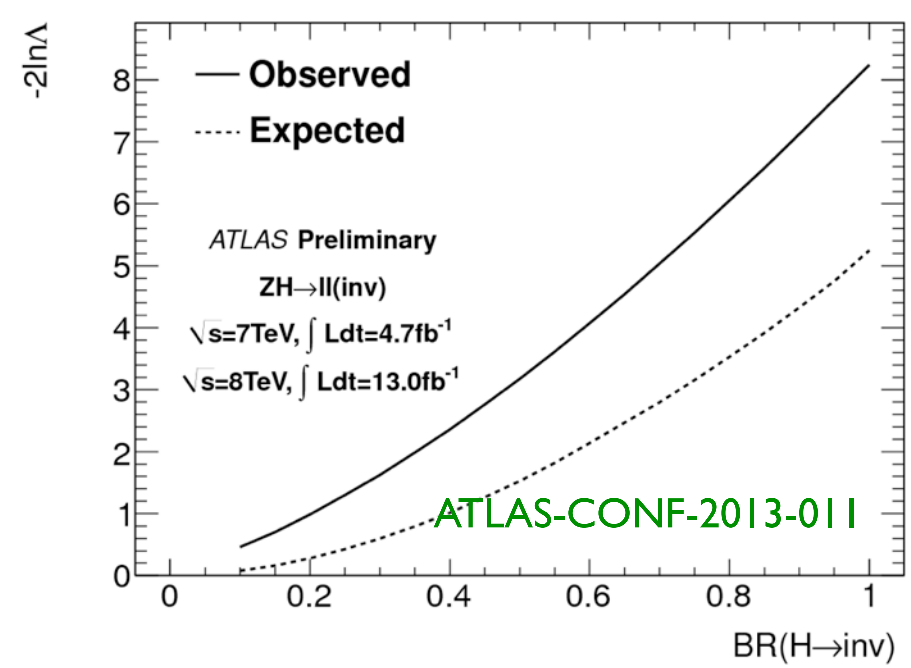
combined fit



applicable, e.g., to 2HDM type-I or Georgi-Machacek triplet Higgs model

constraining invisible decays





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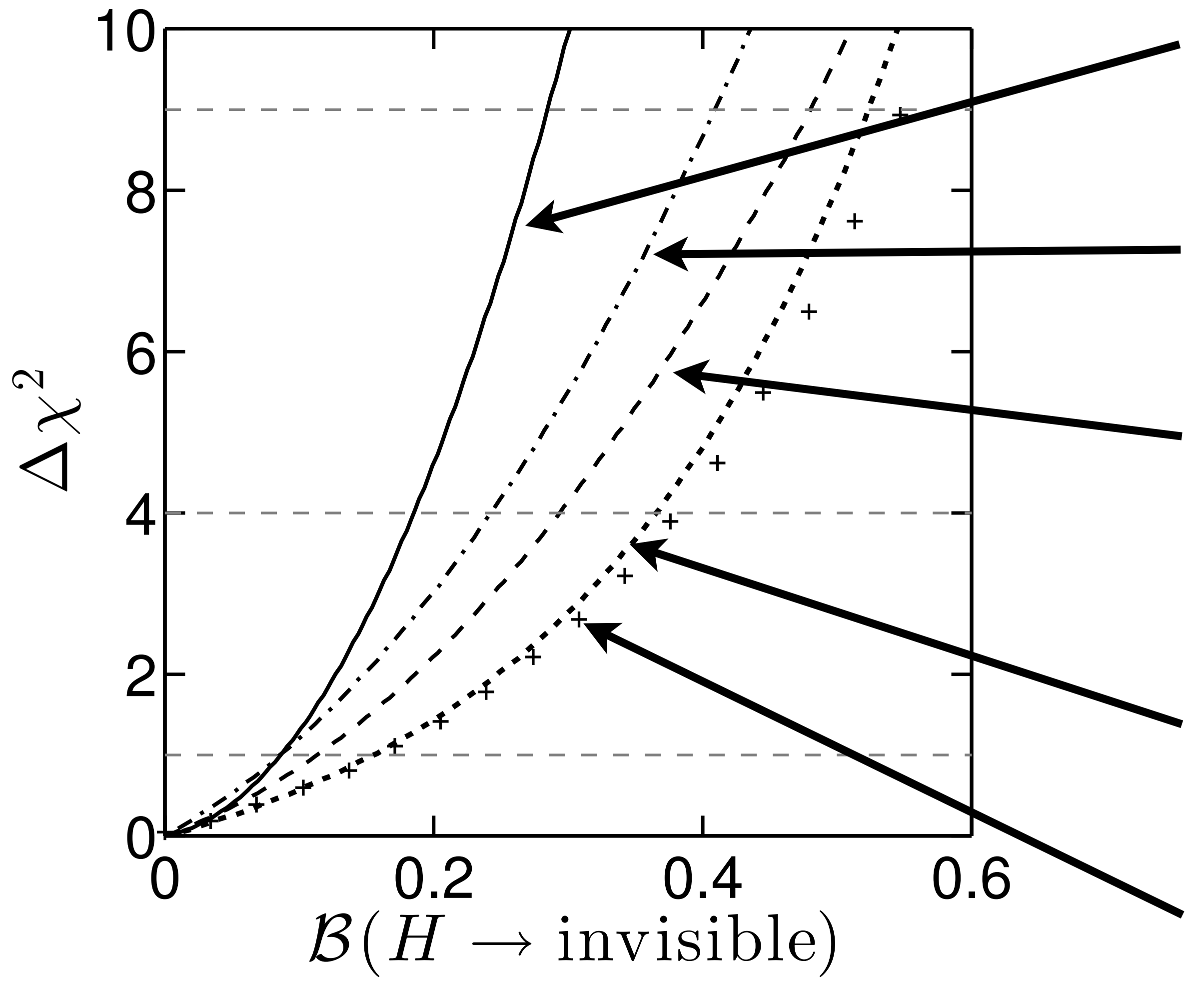
invisible decays



SM+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.19$ at 95% CL

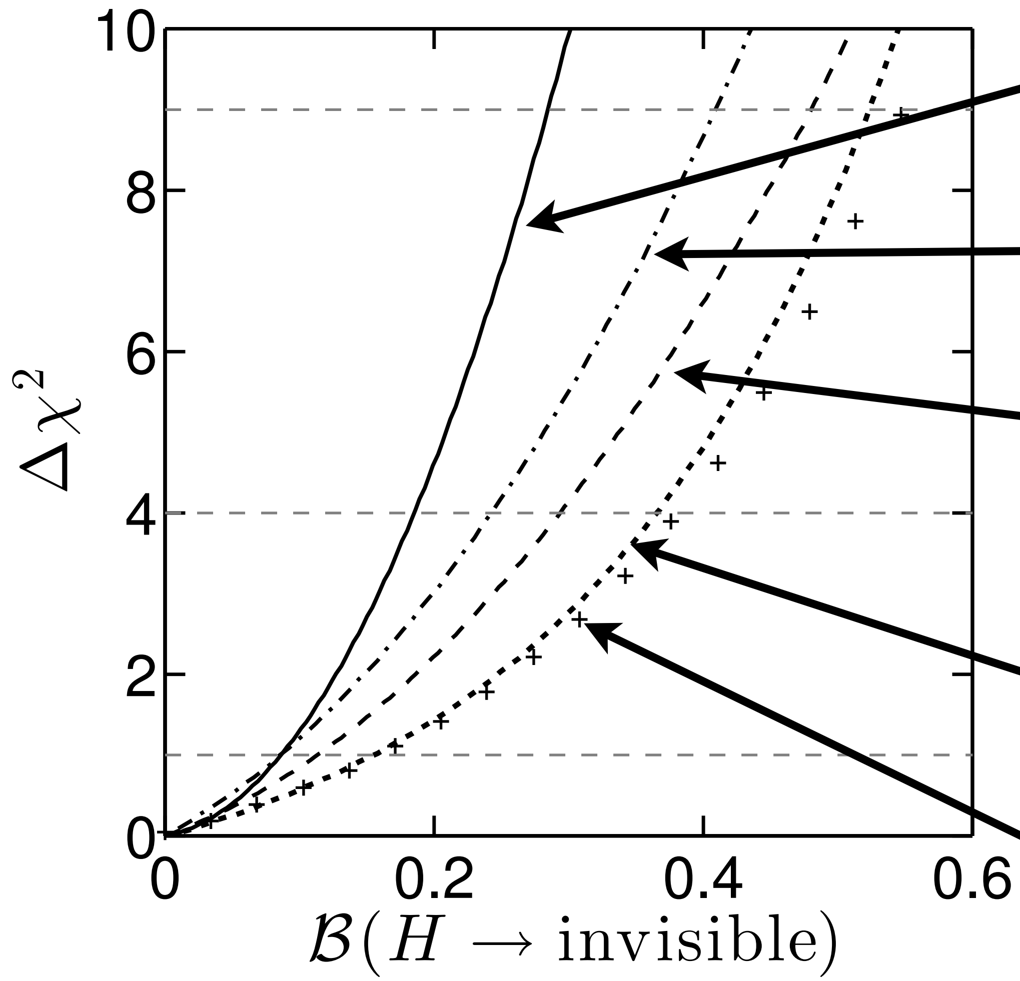
$C_U + C_D + (C_V \leq 1)$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.24$ at 95% CL

SM+$\Delta C_g + \Delta C_\gamma$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.29$ at 95% CL

$C_U + C_D + C_V$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.36$ at 95% CL

$C_U + C_D + C_V + \Delta C_g + \Delta C_\gamma$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.38$ at 95% CL

invisible decays



SM+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.19$ at 95% CL

$C_U + C_D + (C_V \leq 1)$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.24$ at 95% CL

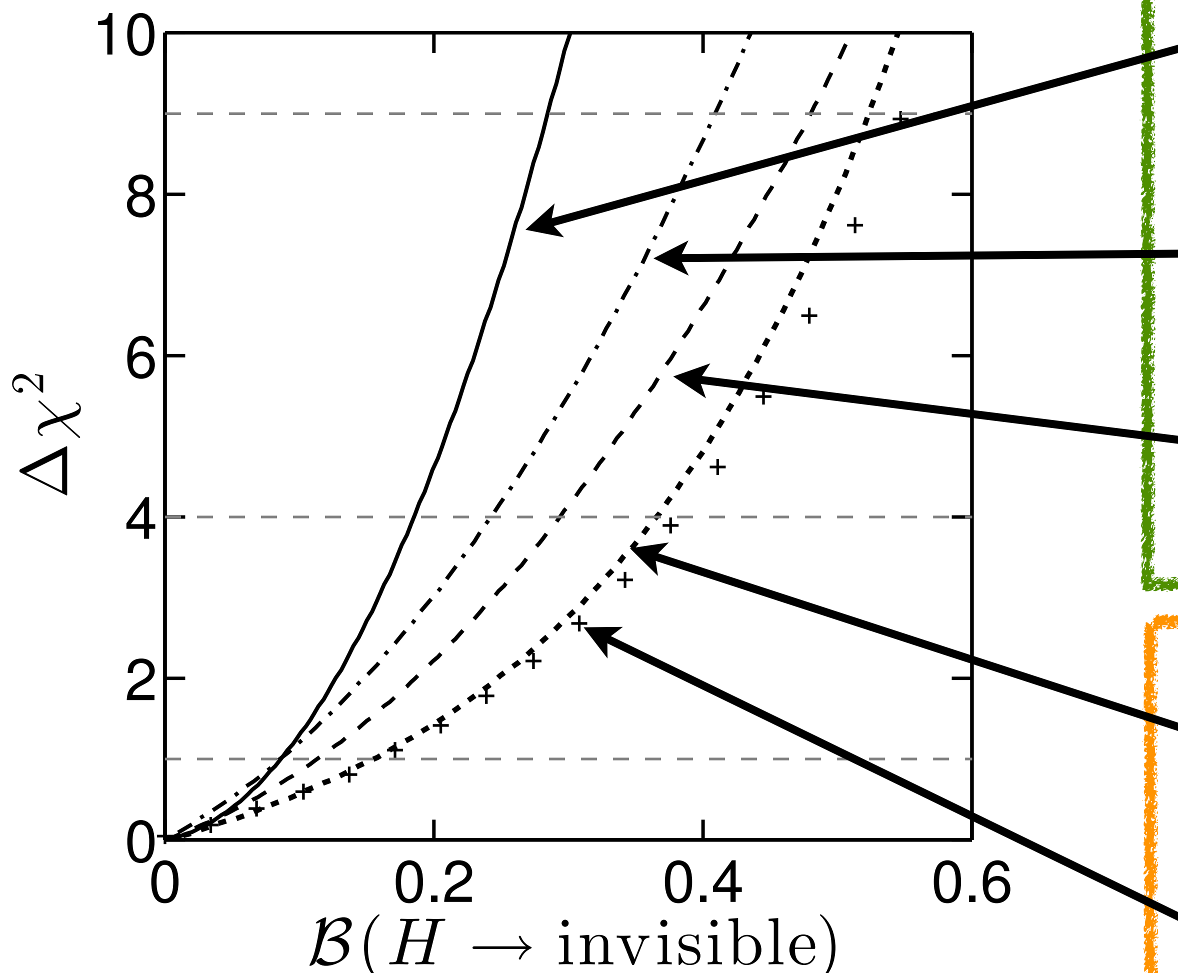
SM+$\Delta C_g + \Delta C_\gamma$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.29$ at 95% CL

mainly from global μ fit

$C_U + C_D + C_V$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.36$ at 95% CL

$C_U + C_D + C_V + \Delta C_g + \Delta C_\gamma$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.38$ at 95% CL

invisible decays



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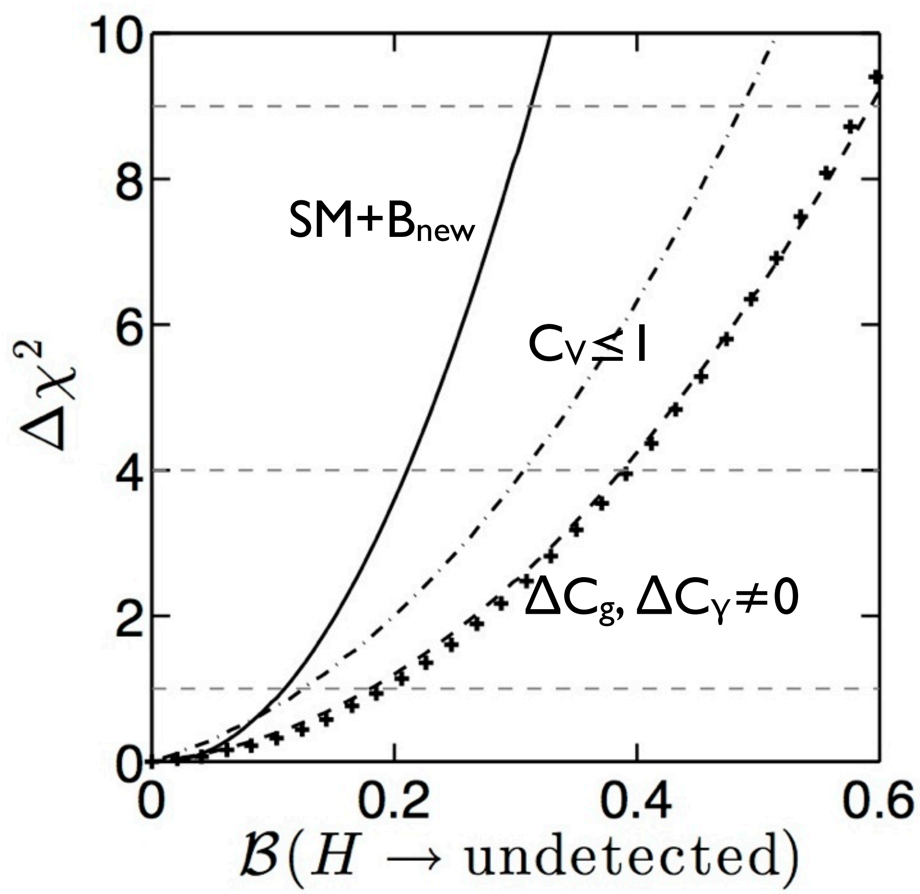
$C_U + C_D + C_V + \Delta C_g + \Delta C_\gamma$+invisible
$\mathcal{B}(H \to \text{inv.}) < 0.38$ at 95% CL

constrained by searches for invisible H

unseen decays



- In principle all the Higgs production*decay rates can be kept fixed by scaling up the C's while adding a new, unseen decay mode with branching ratio B_{new}.

- For $C \equiv C_U = C_D = C_V$: $C^2 = 1/(1-B_{new})$

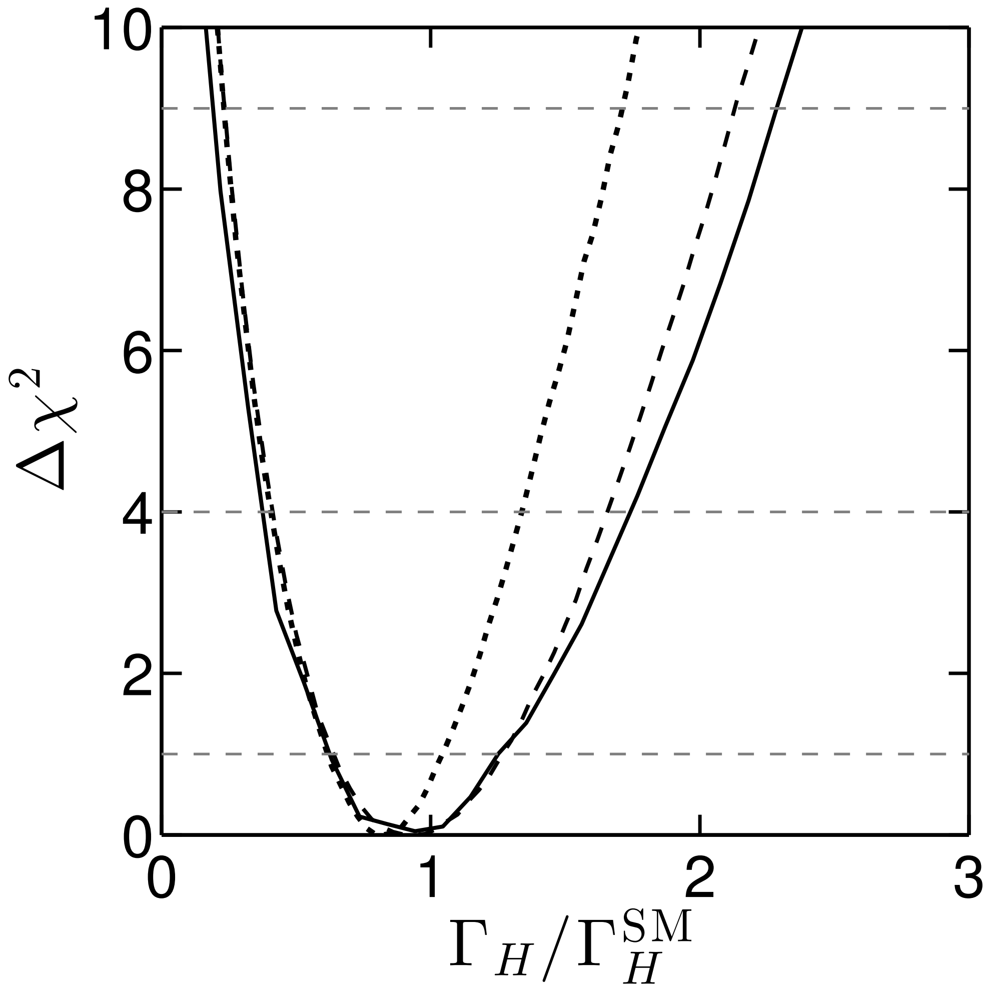
D. Zeppenfeld et al, hep-ph/0002036
A. Djouadi et al, hep-ph/0002258
M. Duhrssen et al, hep-ph/0406323

- This gives a flat direction in C_U, C_D, C_V. For $C_V \leq 1$ however, we can still get a strong constraint on B_{new} similar to the case of invisible decays. At 95% CL:

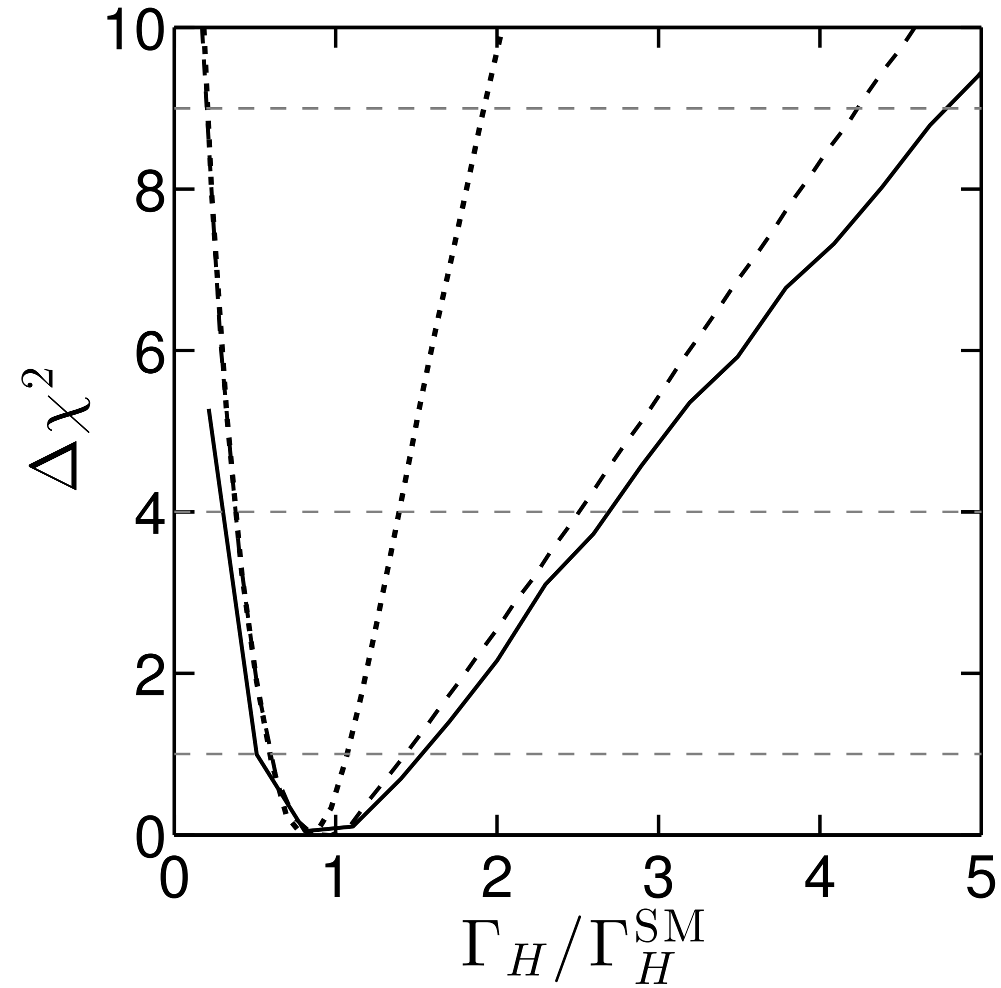
i) $\mathcal{B}_{\rm new} < 0.21$ for a SM Higgs with allowance for unseen decays;
ii) $\mathcal{B}_{\rm new} < 0.31$ for C_U, C_D free, $C_V \leq 1$ and $\Delta C_\gamma = \Delta C_g = 0$; and
iii) $\mathcal{B}_{\rm new} < 0.39$ for $C_U = C_D = C_V = 1$ but $\Delta C_\gamma, \Delta C_g \neq 0$ allowed for.

total width

no invisible/unseen decays



including invisible decays



dotted: C_U, C_D, $C_V \leq 1$
dashed: C_U, C_D, C_V
solid: C_U, C_D, C_V, ΔC_g, ΔC_γ

limits from monojet searches

monojet searches

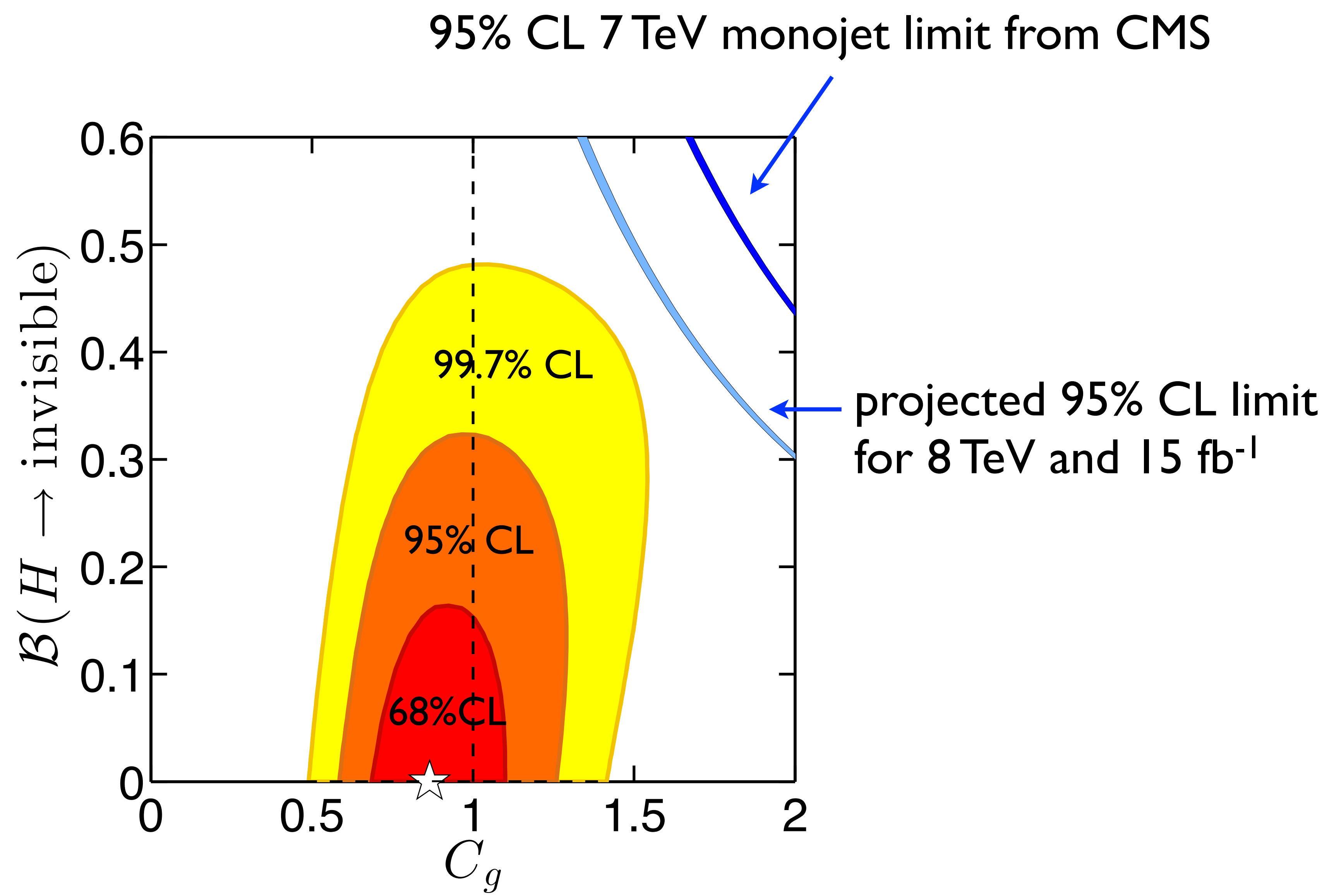
- Truly invisible Higgs decays can also be probed at the LHC in monojet searches in the ggF mode where a gluon is radiated from the initial state, or in VBF when one of the jets is missed.
- The sensitivity can be phrased in terms of limits on

$$R_{\rm inv}(X) = \frac{\sigma(X \to H)\mathcal{B}(H \to {\rm invisible})}{\sigma_{\rm SM}(X \to H)}$$

- Re-interpretation of the CMS monojet analysis at 7 TeV and 4.7 fb^{-1}, assuming relative contributions from ggF and VBF to be the same as in the SM gives $\overline{R_{\rm inv}} = 2/3\, R_{\rm inv}({\rm ggF}) + 1/3\, R_{\rm inv}({\rm VBF}) < 1.3$ at 95% CL.
- The projection for 15 fb^{-1} at 8 TeV gives $\overline{R_{\rm inv}} < 0.9$
- Assuming only one production channel: $R_{inv}(ggF) < 1.9$ or $R_{inv}(VBF) < 4.3$.

[Djouadi, Falkowski, Mambrini, Quevillon, arXiv:1205.3169]

monojet limits vs. global fit results

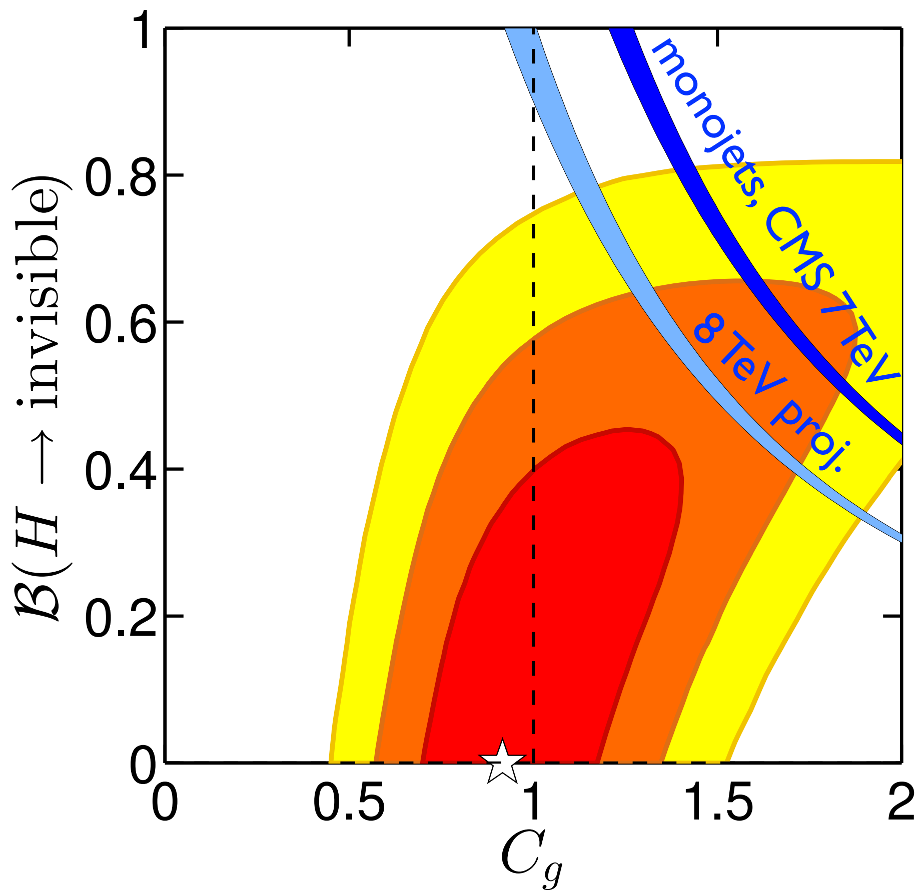


fit of C_U, C_D, $C_V \leq 1$

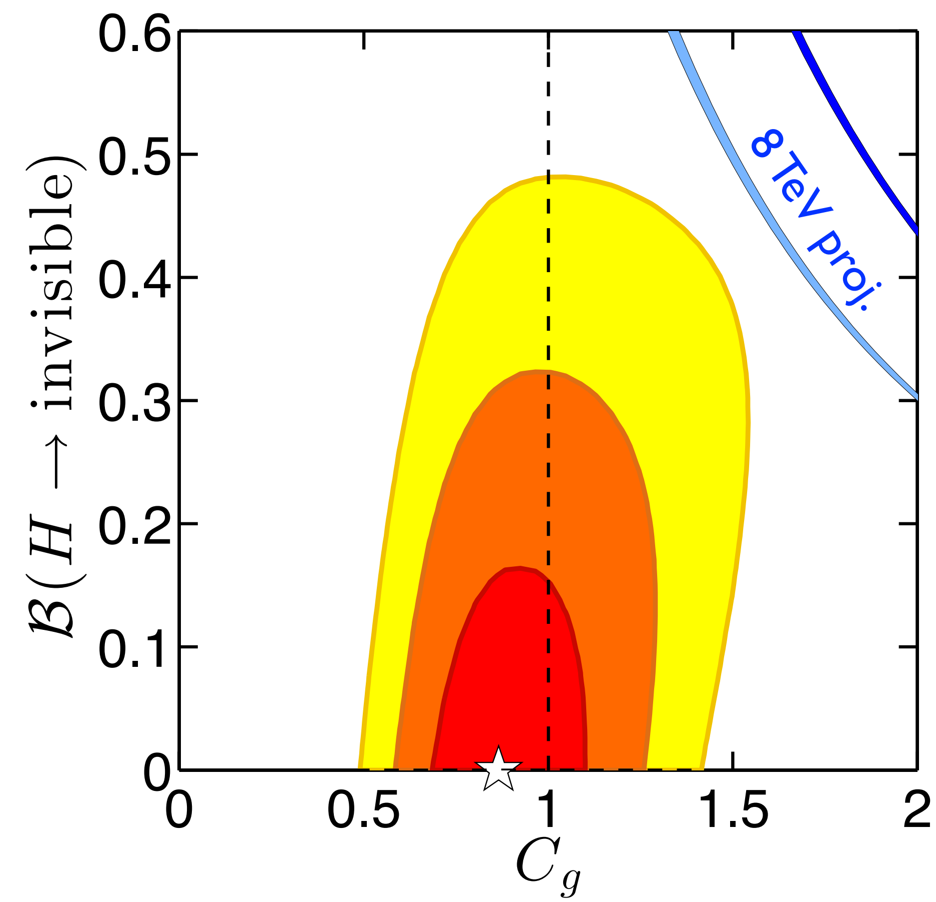
evolution of precision

(slide 1 of 2)

end of 2012



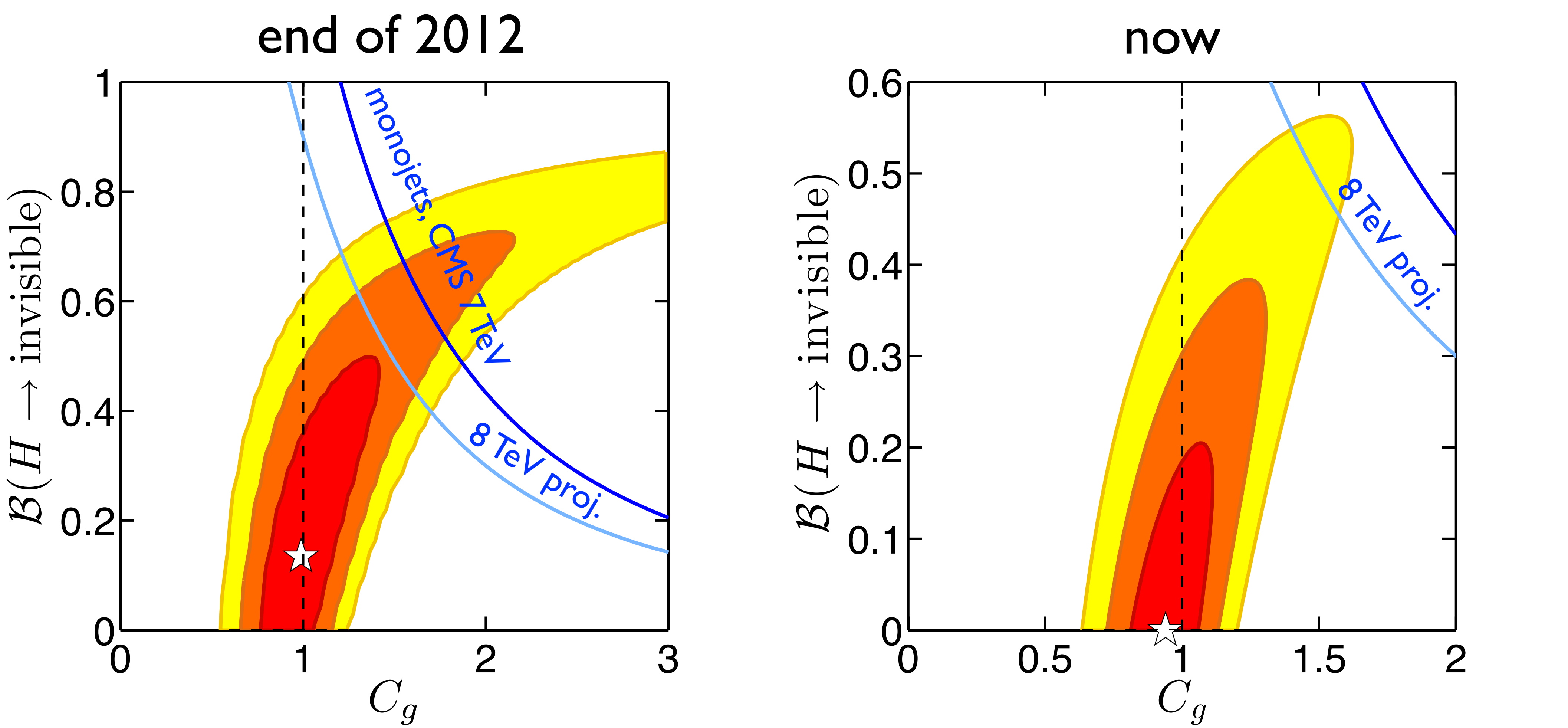
now



fit of C_U, C_D, $C_V \leq 1$

evolution of precision

(slide 2 of 2)



fit of ΔC_g and ΔC_γ; $C_U=C_D=C_V=1$

interplay with dark matter

Kanemura, Matsumoto, Nabeshima, Okada,
arXiv:1005.5651

Higgs portal

- Real scalar, vector or majorana fermion dark matter

$$\Delta\mathcal{L}_S = -\frac{1}{2}m_S^2 S^2 - \frac{1}{4}\lambda_S S^4 - \frac{1}{4}\lambda_{hSS} H^\dagger H S^2 ,$$
$$\Delta\mathcal{L}_V = \frac{1}{2}m_V^2 V_\mu V^\mu + \frac{1}{4}\lambda_V (V_\mu V^\mu)^2 + \frac{1}{4}\lambda_{hVV} H^\dagger H V_\mu V^\mu ,$$
$$\Delta\mathcal{L}_f = -\frac{1}{2}m_f \bar{\chi}\chi - \frac{1}{4}\frac{\lambda_{hff}}{\Lambda} H^\dagger H \bar{\chi}\chi .$$

- annihilation cross section into light fermions

$$\langle\sigma^S_{\rm ferm} v_r\rangle = \frac{\lambda_{hSS}^2 m_{\rm ferm}^2}{16\pi}\frac{1}{(4M_S^2 - m_h^2)^2} ,$$
$$\langle\sigma^V_{\rm ferm} v_r\rangle = \frac{\lambda_{hVV}^2 m_{\rm ferm}^2}{48\pi}\frac{1}{(4M_V^2 - m_h^2)^2} ,$$
$$\langle\sigma^f_{\rm ferm} v_r\rangle = \frac{\lambda_{hff}^2 m_{\rm ferm}^2}{32\pi}\frac{M_f^2}{\Lambda^2}\frac{v_r^2}{(4M_f^2 - m_h^2)^2} ,$$

- spin-independent DM-nucleon scattering cross section

$$\sigma^{SI}_{S-N} = \frac{\lambda_{hSS}^2}{16\pi m_h^4}\frac{m_N^4 f_N^2}{(M_S + m_N)^2} ,$$
$$\sigma^{SI}_{V-N} = \frac{\lambda_{hVV}^2}{16\pi m_h^4}\frac{m_N^4 f_N^2}{(M_V + m_N)^2} ,$$
$$\sigma^{SI}_{f-N} = \frac{\lambda_{hff}^2}{4\pi\Lambda^2 m_h^4}\frac{m_N^4 M_f^2 f_N^2}{(M_f + m_N)^2} ,$$

- Higgs decay width into DM particles

$$\Gamma^{\rm inv}_{h\to SS} = \frac{\lambda_{hSS}^2 v^2 \beta_S}{64\pi m_h} ,$$
$$\Gamma^{\rm inv}_{h\to VV} = \frac{\lambda_{hVV}^2 v^2 m_h^3 \beta_V}{256\pi M_V^4}\left(1 - 4\frac{M_V^2}{m_h^2} + 12\frac{M_V^4}{m_h^4}\right)$$
$$\Gamma^{\rm inv}_{h\to\chi\chi} = \frac{\lambda_{hff}^2 v^2 m_h \beta_f^3}{32\pi\Lambda^2} ,$$

all depend on the same coupling: λ_{hSS}, λ_{hVV} or $\lambda_{h\chi\chi}$

Kanemura, Matsumoto, Nabeshima, Okada, arXiv:1005.5651

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$$\Gamma^{\rm inv}_{h\to\chi\chi} = \frac{\lambda_{hff}^2 v^2 m_h \beta_f^3}{32\pi\Lambda^2} ,$$

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Kanemura, Matsumoto, Nabeshima, Okada,
arXiv:1005.5651

Higgs portal

- Real scalar, vector or majorana fermion dark matter

$$\Delta\mathcal{L}_S = -\frac{1}{2}m_S^2 S^2 - \frac{1}{4}\lambda_{\ldots}$$

$$\Delta\mathcal{L}_V = \frac{1}{2}m_V^2 V_\mu V^\mu + \frac{1}{4}\ldots$$

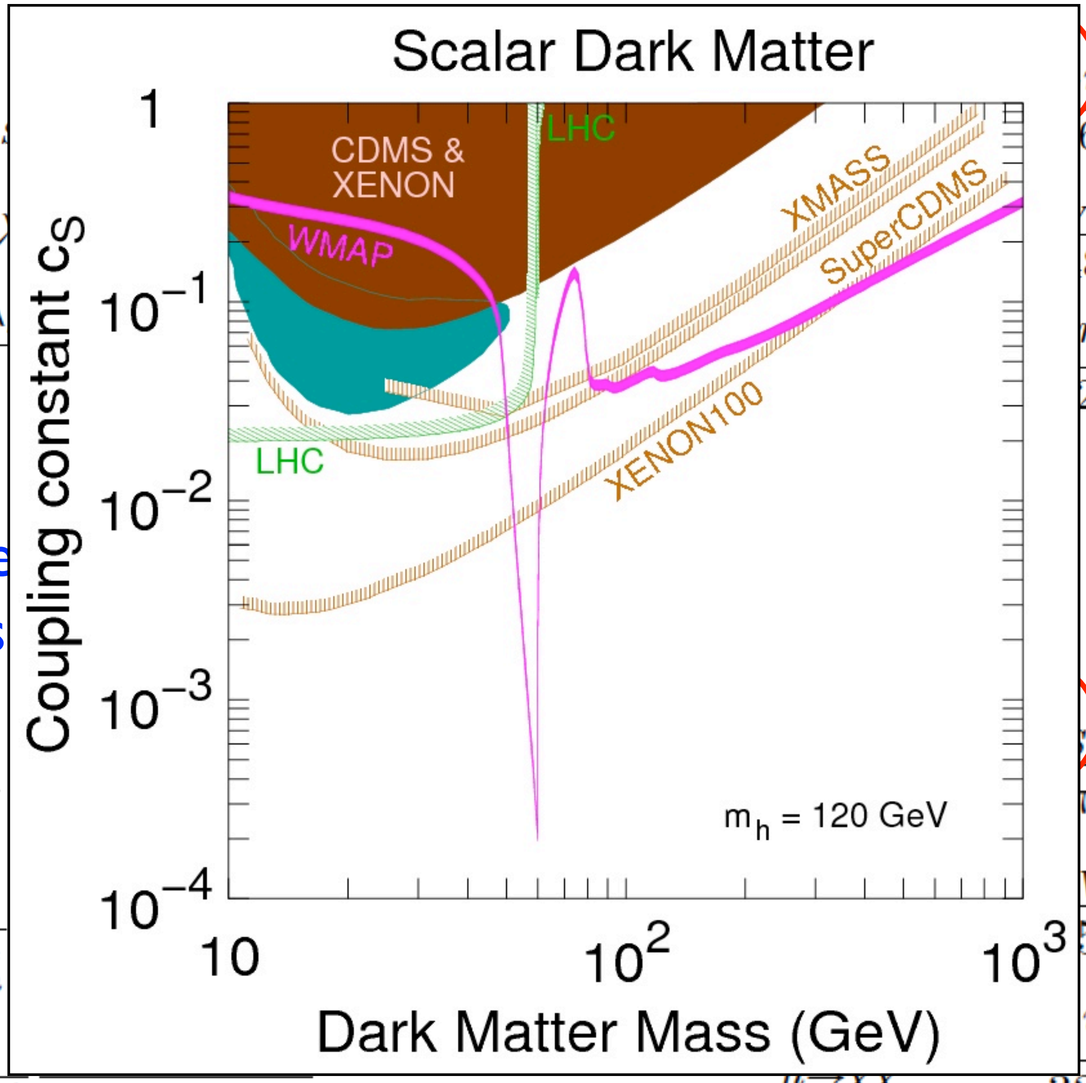
$$\Delta\mathcal{L}_f = -\frac{1}{2}m_f\bar{\chi}\chi - \frac{1}{4}\frac{\lambda}{\ldots}$$

- annihilation cross section into light fermions

$$\ldots \frac{m_{\rm ferm}^2}{\ldots 6\pi}\frac{1}{(4M_S^2 - m_h^2)^2},$$

$$\ldots \frac{m_{\rm ferm}^2}{\ldots 8\pi}\frac{1}{(4M_V^2 - m_h^2)^2},$$

$$\ldots \frac{m_{\rm ferm}^2}{\ldots 2\pi}\frac{M_f^2}{\Lambda^2}\frac{v_r^2}{(4M_f^2 - m_h^2)^2},$$



- spin-independent scattering cross section

$$\sigma^{SI}_{S-N} = \frac{\lambda_{hSS}^2}{16\pi m_h^4}\ldots$$

$$\sigma^{SI}_{V-N} = \frac{\lambda_{hVV}^2}{16\pi m_h^4}\ldots$$

$$\sigma^{SI}_{f-N} = \frac{\lambda_{hff}^2}{4\pi\Lambda^2 m_h^4}\ldots(M_f + m_N)^2,$$

- width into DM particles

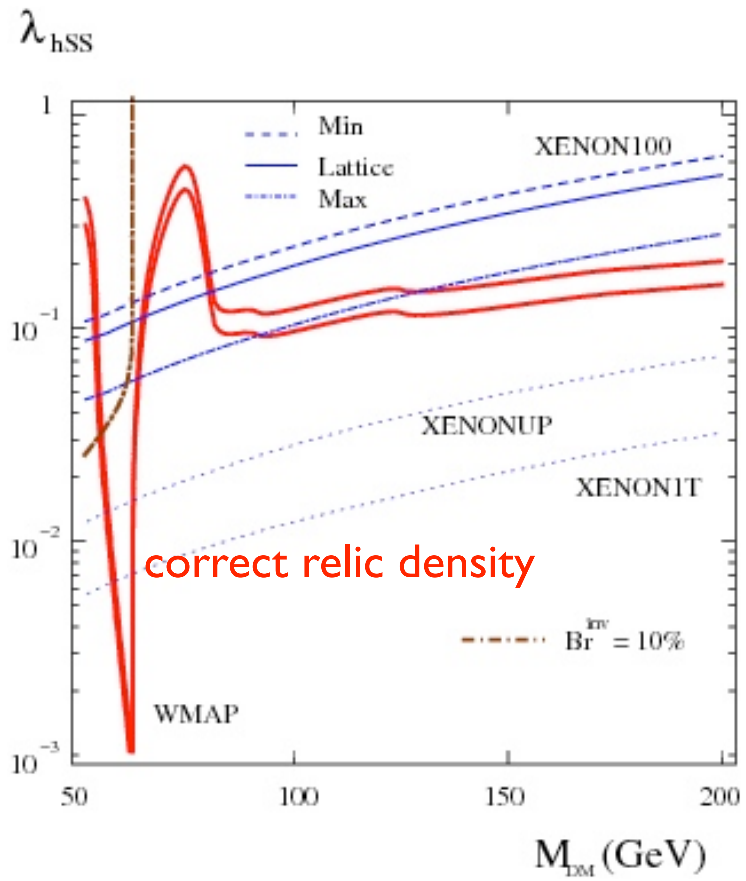
$$\ldots \frac{\ldots v^2\beta_S}{\ldots m_h},$$

$$\ldots \frac{\ldots_V v^2 m_h^3\beta_V}{\ldots 56\pi M_V^4}\left(1 - 4\frac{M_V^2}{m_h^2} + 12\frac{M_V^4}{m_h^4}\right)$$

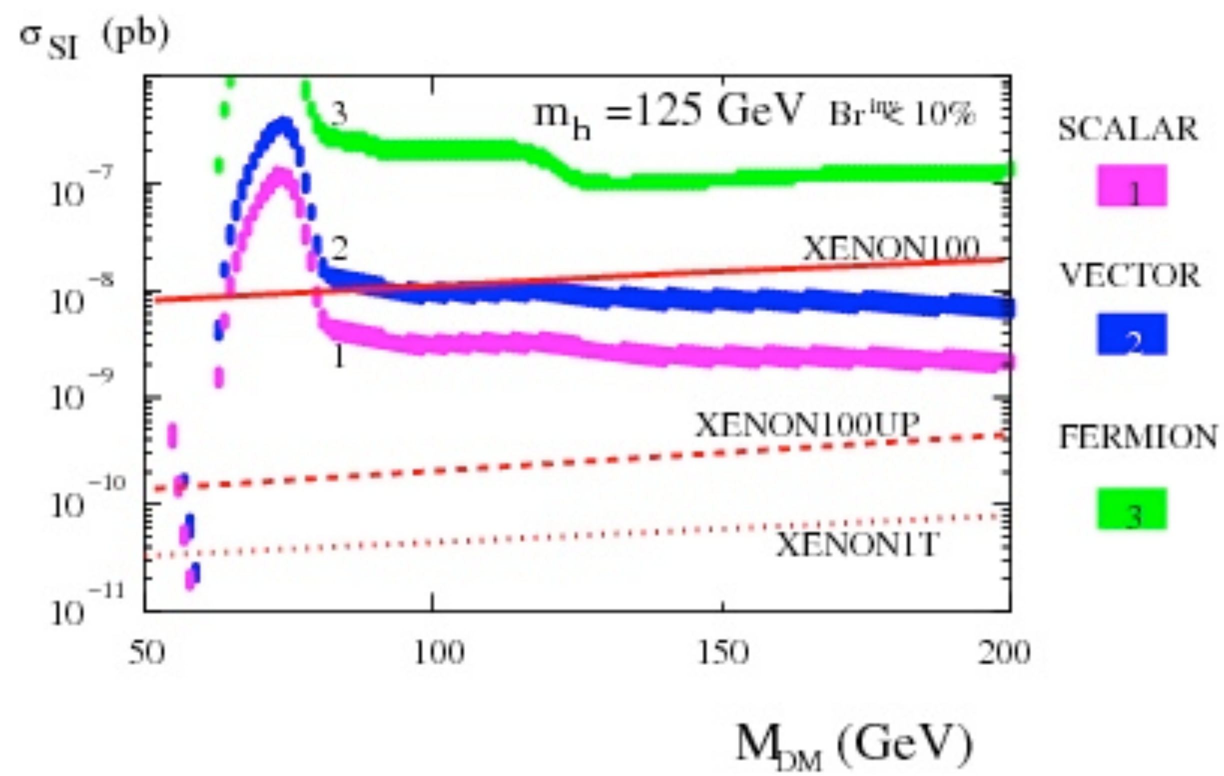
$$\Gamma_{h\to\chi\chi} \ldots \frac{\ldots v^2 m_h\beta_f^3}{32\pi\Lambda^2},$$

all depend on the same coupling: λ_{hSS}, λ_{hVV} or $\lambda_{h\chi\chi}$

Higgs portal dark matter



Djouadi, Lebedev, Mambrini, Quevillon
arXiv:1112.3299

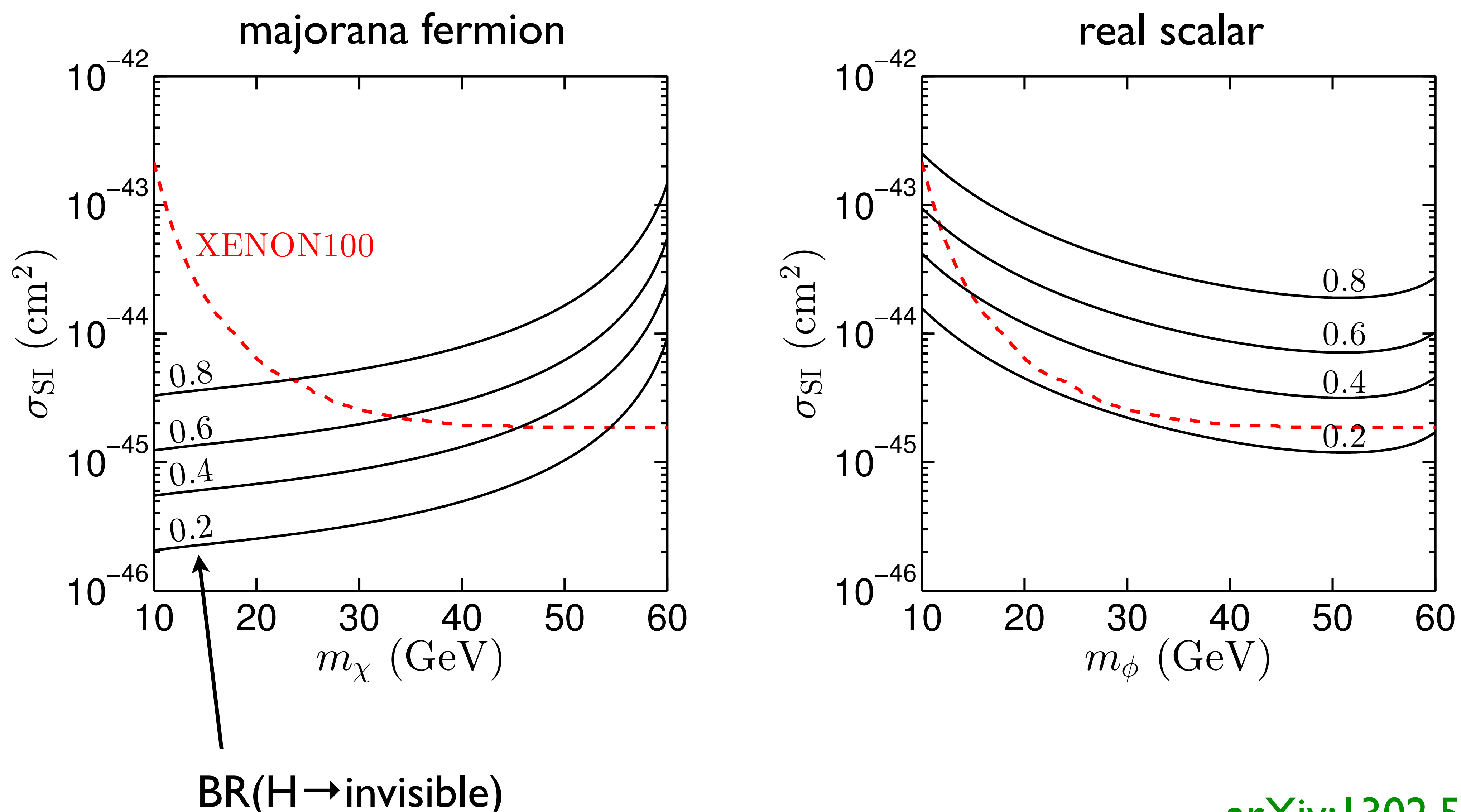


- If DM is light enough to contribute to invisible Higgs decays, i.e. $m_{DM}<m_H/2$, it can only be a thermal relic if there are additional light particles present with masses below a few 100 GeV !

Greljo, Julio, Kamenik, Smith, Zupan
arXiv:13093561

BR_{inv} versus σ^{SI}

without Ωh^2 requirement



arXiv:1302.5694

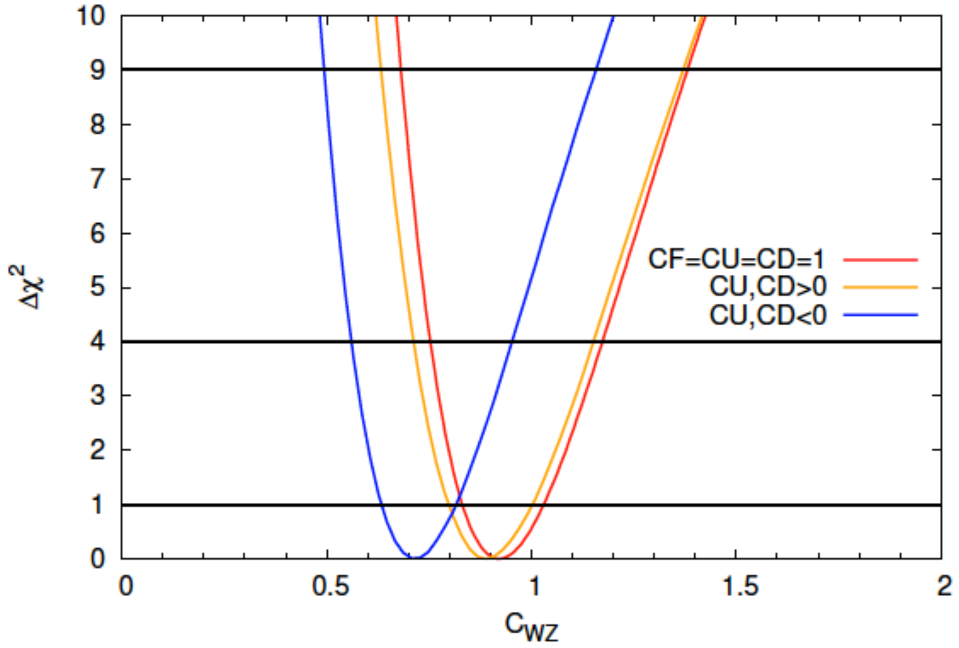
conclusions

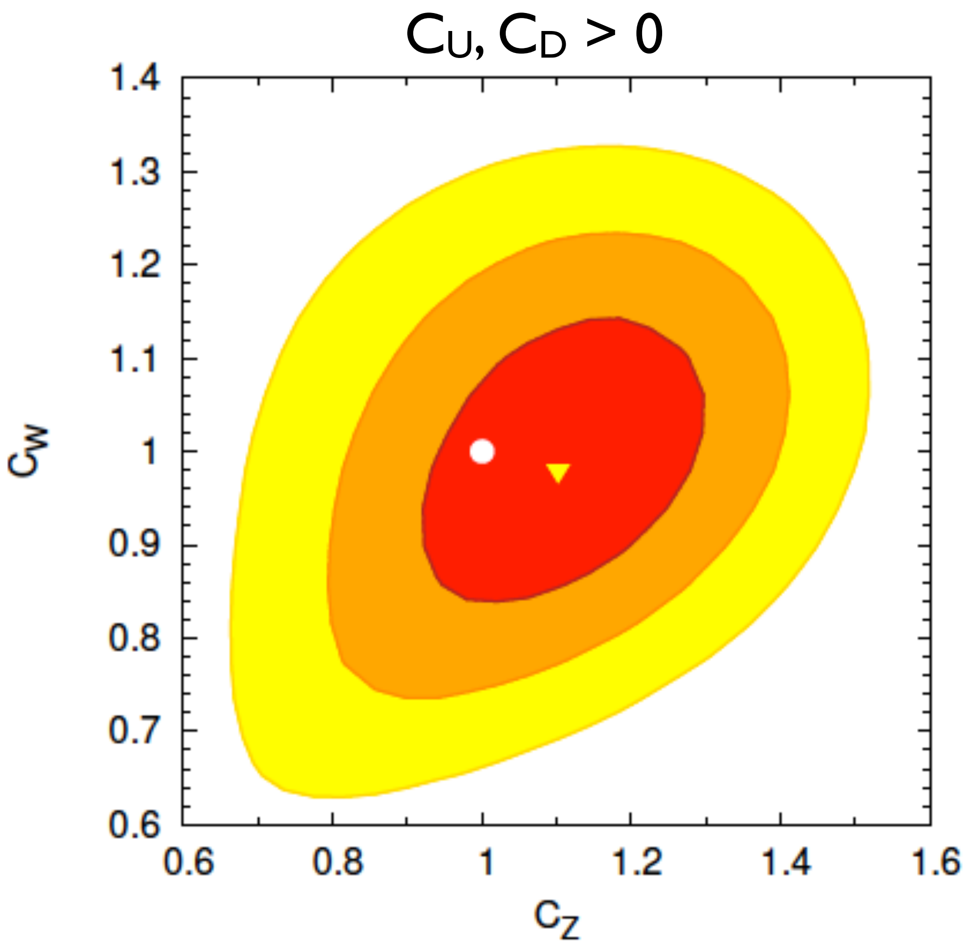
- The current LHC results already give a very coherent picture of the 125 GeV Higgs boson
- At the moment everything looks very SM-like, but there is still room for new physics contributions, including invisible Higgs decays into dark matter
- Interesting potential interplay with dark matter searches
- Both Higgs and DM promise an exciting way ahead .... hopefully to new unmapped territory

backup

testing custodial symmetry

Fit to ATLAS and CMS results as in arXiv:1306.2941 but taking C_W and C_Z as independent parameters. $C_{WZ} = C_W / C_Z$





Best fit: C_Z=1.1, C_W=0.98

[internship Jeremy Bernon]

On the presentation of the LHC Higgs results

F. Boudjema, G. Cacciapaglia, K. Cranmer, G. Dissertori, A. Deandrea, G. Drieu la Rochelle, B. Dumont, U. Ellwanger, A. Falkowski, J. Galloway, R.M. Godbole, J.F. Gunion, A. Korytov, S. Kraml, H.B. Prosper, V. Sanz, S. Sekmen

Abstract:

We put forth conclusions and suggestions regarding the presentation of the LHC Higgs results that may help to maximize their impact and their utility to the whole High Energy Physics community.

Conclusions and suggestions from the workshops
"Likelihoods for the LHC Searches", 21-23 Jan 2013 at CERN,
"Implications of the 125 GeV Higgs Boson", 18-22 March 2013 at LPSC Grenoble,
and from the 2013 Les Houches "Physics at TeV Colliders" workshop.

signal strengths beyond 2D

- Eventually, we want to test ggF, ttH, VBF, ZH and WH separately, which means that we need a more detailed break down of the channels beyond 2D plots.
- The optimum would of course be to have the full statistical model available → RooFit workspaces ?
- What we would like to advocate (as a compromise) is that for each final state Y the experiments give the signal strength likelihood in the 6D form

$$\mathcal{L}(m_H, \mu_{\rm ggF}, \mu_{\rm ttH}, \mu_{\rm VBF}, \mu_{\rm ZH}, \mu_{\rm WH})$$

- This way, a significant step could be taken towards a more precise fit in the context of a given BSM theory.
- The likelihood could be communicated either as a standalone computer library or as a large grid data file.
- Open point: final state correlations → covariance matrix ?