Higgs Boson Properties

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OUTLINE

1. *Present: facts and perspectives*
2. **H** *meets QFT*
3. *Inward Journey*

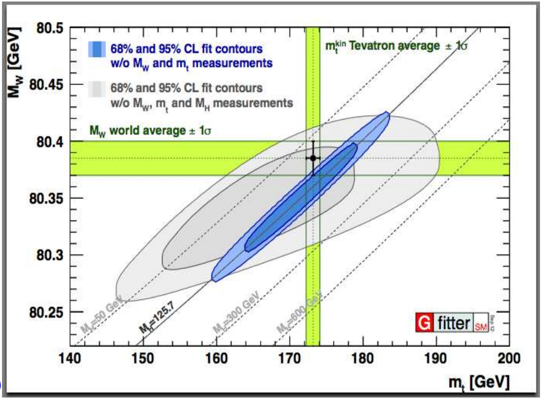
Present: facts and perspectives

MSM *triumph of thinking simple*

- ➽ LHC(**125**) looks very much like the (light) SM Higgs boson The exp. discovery is fundamental but *wasn't already clear* 20 *years ago?*
- **NO LHC signal of New Physics.** But … (*debatable*) aren't precision Lep data, precision flavour data, etc. pointing in that direction? e.g. consistency with **EW precision data** ↬ no conspiracy between heavy Higgs and N P effects

There is nothing either good or bad but thinking makes it so

(William Shakespeare)



68% and 95% CL fit contours
w/o M_W and m_t measurements
68% and 95% CL fit contours
w/o M_W, m_t and M_H measurements
M_W world average ± 1σ
m_t^{kin} Tevatron average ± 1σ
M_H=50 GeV
M_H=125.7
M_H=300 GeV
M_H=600 GeV
G fitter SM
Sep 12
80.5
80.45
80.4
80.35
80.3
80.25
140
150
160
170
180
190
200
M_W [GeV]
m_t [GeV]

Intermezzo As a theorist I am somewhat ambivalent subdued about the affair.

- **THE SM** *has now got a degree of validity that has extended way beyond what we had before the discovery of a Higgs-like particle*
- *However,* *the one aspect that dominates here* *is that a Higgs could close the last door of the SM that could lead us to a deeper theory*

To love SM is to not always agree with SM. It is usually right, but not always right

Is SM(**125**) the FINAL THEORY ? Maybe no

Problems

- hierarchy problem
- dark matter
- ν-mass, BAU
- inflation
- cosmological constant
- gauge coupling unification
- strong CP

Additionally, there is *no scientific reason to justify the belief that all the big problems have solutions*, let alone ones we humans can find.

What about Hierarchy? nature choosing fine-tuning? *nothing new*

- CNO - cycle (stars convert hydrogen to helium)
- if gravity stronger or weaker by **1** part in **10^{40}**, then life-sustaining stars like the sun could not exist

If we nudge one of the constants just a few percent in one direction, stars burn out within a million years of their formation, and there is no time for evolution. If we nudge it a few percent in the other direction, then no elements heavier than helium form. No carbon, no life. Not even any chemistry. No complexity at all (D. D. Deutsch)

- size of sun-moon from earth . . . , many more in the **10^{3-4}** ballpark (neutron/proton mass ratio, initial explosion of big bang, etc.)

It is worth remembering how well *classical Ptolemaic epicycles* could predict astronomical positions *despite being based on false (but highly-tuned) Roman science*

The PTOLEMAIC approach : *forget some of the problems (hierarchy, gauge coupling unification, strong CP). Extend SM*

- Introduce real scalar DM ✓

$$\mathscr{L}_{\mathrm{S}} \quad = \quad -m_{\mathrm{S}}^2\, S^2 - g_{\mathrm{S}}\, \|\Phi^2\|\, S^2 - \lambda_{\mathrm{S}}^2\, S^4$$

- Introduce two ν_{R} and leptogenesis ✓

$$\mathscr{L}_{\nu\mathrm{R}} \quad = \quad -\mathrm{M}\,\overline{\mathrm{N}}^{\mathrm{c}}\,\mathrm{N} + y_\nu\,\mathrm{L}\,\widetilde{\smile}\,\overline{\mathrm{N}}$$

- Introduce real scalar inflaton ✓

$$\mathscr{L} \quad = \quad -m^2\,\phi^2 - \mu\,\phi^3 - \kappa\,\phi^4$$

- Forget about cosmological constant, call it **MBSM** (Minimal Beyond Standard Model)

The optimistic scenario (OS) :

is the usual picture sold pre-LHC: detection of non-SM Higgs.

Some of us are optimist, but gave no argument for the optimistic scenario beyond the one that it's a good idea in life for a scientist to be an optimist

✎ A concrete (forget gravity) **OS** wish list:

- Systematizing THU in the sense of MHO and MHOU : accuracy over precision. THU in differential form (jets, p_T, η, etc.)
- Beyond **NWA**
- Decays: weird (vector meson) and rare (Dalitz)
- Anything that would use the Higgs as a probe for **BSM**

✎

- Marrying EW precision data with Higgs
- General **EWSB** aspects (dibosons, $\mathbf{VV}$-scattering) and **EW** fits (M_t, M_W, α_s, etc.)
- Predictions/generators to constrain the (finally agreed upon) **EFT** coupling space, esp. using Higgs plus other data (like EW data as mentioned above).

PRECISION?

next step

ILC plans to provide the next significant step in the precision study of Higgs boson properties. LHC precision measurements in the **5–10%** range sould be brought down to the level of **1%**.

But this means that the $\boldsymbol{\kappa}$*-language must be updated with the inclusion of* **NLO EW**. *This means*

- ✂ No precision for precision's sake!
- ✌ Precision for a discovery search

Vacuum stability vision

Definition

Trivially: in the absence of NP the LHC-boson makes the universe metastable at $\Lambda \approx 10^{10-12}$ *GeV*

Various speculations on the meaning of that result are popping out

Precision striking back : **But ... small deviations from SM couplings is a guess based on absence of NP so far with more data the properties of the LHC-boson could get even closer to the SM predictions which is very challenging (more than rushing now to too quick conclusions): deviations may be of the order of the present SM uncertainties**

An induced approach: The *put money where mouth is* approach

- No matter how challenging it may be to see BSM
- Precision Higgs Physics looks now like a must! ✓

❝ Science can only be understood backwards; but it must be lived forwards ❞ (paraphrasing Soren Kierkegaard)

- QUINTESSENTIAL PRECISION: we find ourselves in a *just-so* situation, the vacuum is at the verge or being stable or metastable. A sub-percent change of ~ 1 ***GeV*** in either M_{t} or M_{H} is all it takes to tip the scales

The *Missing Guiding Principle* scenario

- Have we lost our motivation (e.g. no guiding principle from naturalness)?
- Maybe yes, maybe no if motivation remains *derive* **EWSB** and/or *compute parameters in a deeper theory*

After all, naturalness is a vague concept and the

SM is a renormalizable theory

❝ *If one ignores the hierarchy problem it is completely fine and predictive* ❞ (G. Altarelli)

Only when you try to predict **EW** observables from a deeper theory you face naturalness It is plausible to assume that Nature has a way, still hidden to us, to realize *a deeper form of naturalness at a more fundamental level*

Feynmanian versus Wilsonian visions, i.e. Λ cutoff versus scale of NP

$$\mathscr{L}_{\rm ESM} = \mathscr{L}_{\rm SM} + \sum_{n>4} \sum_{i=1}^{N_n} \frac{a_i^n}{\Lambda^{n-4}} \mathscr{O}_i^{(d=n)} + \sum_{i=1,2,4} b_i \Lambda^i \mathscr{O}'_i$$

- SM *not embedded* means $b_{1,2} = 0$, *it's renormalization*!
- SM *embedded* (Wilsonian scenario), b_2 not suppressed by any symmetry
  - $M_{\rm H}$ should be $\mathscr{O}(\Lambda)$ and it is light, thus $\delta M_{\rm H}^2 \sim \Lambda^2$
  - $M_{\rm H} \approx 125$ *GeV* which means $\Lambda \approx 1$ *TeV* (which doesn't seem to be the case) or FINE TUNING (**not a theorem!**)

QFT: infinities, renormalization, predictions. Status OK (but Landau poles are there and, possibly, instability is present), many things remain unexplained. **SM** is **QFT**, as it is **QED** (not embedded into **SM**)

QFT with embedding: requires a cutoff scale for the embedding, the physics of that scale is unknown. Keywords are triviality and vacuum stability

Lindner CLASSIFICATION:

- $M_{\rm H} = 125–126$ *GeV* → instability → new physics
- $M_{\rm H} = 126–157$ *GeV* SM … non-minimal Susy perfect
- $M_{\rm H} > 157$ *GeV* real BSM required

Now we know where we stand ✓

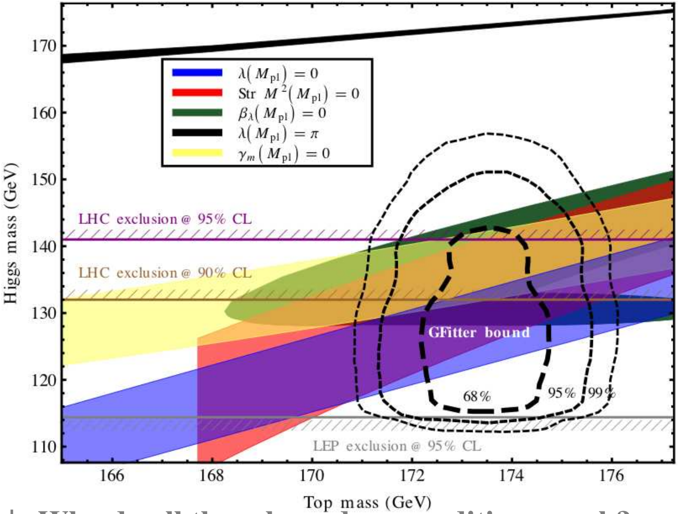
Why all of a sudden questions like *a special value of* $\boldsymbol{\lambda}$ *at* $\boldsymbol{M_{\mathrm{plank}}}$*?* are becoming a popular tune?

$$V = \frac{1}{4}\,\lambda(\mu)\,\mathrm{H}^4, \qquad \lambda_0 = \frac{1}{4}\frac{M_{\mathrm{H}}^2}{v^2}$$

Conceivable special scenarios

- Vacuum stability, $\boldsymbol{\lambda\left(M_{\mathrm{plank}}\right) = 0}$
- vanishing of $\boldsymbol{\beta}$ -function, $\boldsymbol{\beta_\lambda\left(M_{\mathrm{plank}}\right) = 0}$
- the *Veltman* condition (cancellation of quadratic divergencies)

From M. Lindner talk at SCALARS 2013



m_H

!

exc

•! **Why do all these boundary conditions work?**

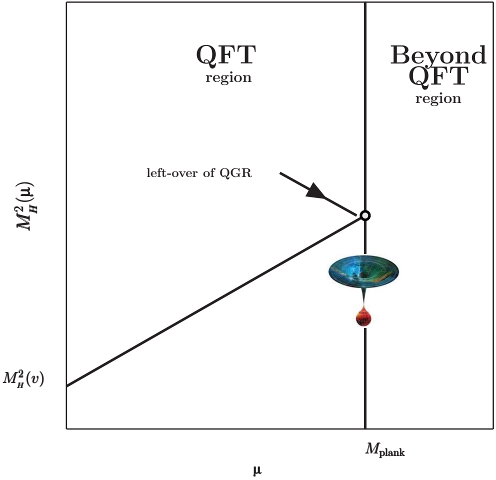
- suppression factors compared to random choice = O(1

The most interesting question: *is the Higgs potential at* $\boldsymbol{M}_{\mathbf{plank}}$ *flat? Why?*

- $\boldsymbol{V}$ flat means no Higgs self-interaction
- Is the **SM** *directly embedded* into gravity …?

In this case

- We do not have a renormalizable **QFT** of gravity
- we need to move beyond QFT ! *It means new non-QFT Plank-scale concepts* !


QFT
region
Beyond
QFT
region
left-over of QGR
$M_H^2(\mu)$
$M_H^2(v)$
M_{plank}
μ

The *Set your preferences* scenario

1. New **QFT**
2. Beyond **QFT**

The second scenario is relatively new and avoids hierarchy problem by shifting it to the unknown region, the first is the traditional one where one plays with

- more representations, new groups, inclusion of **XXXSSM**
- and … runs into hierarchy problem
- or set NP-scale above $\boldsymbol{M_{\mathrm{plank}}}$ …

H *meets* $\mathscr{QFT}$

HIGGS boson production and decay: the analytic structure

$$A(s) \;=\; \frac{f(s)}{s-s_{\mathrm{H}}} + N(s),$$

where $\boldsymbol{N(s)}$ denotes the part of the amplitude which is non-Higgs-resonant. Strictly speaking, signal ($\mathbf{S}$) and background ($\mathbf{B}$) should be defined as follows:

$$A(s) \;=\; S(s) + B(s) \qquad S(s) = \frac{f(s_{\mathrm{H}})}{s-s_{\mathrm{H}}}$$

$$B(s) \;=\; \frac{f(s) - f(s_{\mathrm{H}})}{s-s_{\mathrm{H}}} + N(s)$$

Definition

The Higgs complex pole (describing an unstable particle) is conventionally parametrized as

$$s_{\mathrm{H}} \;=\; \mu_{\mathrm{H}}^2 - i\,\mu_{\mathrm{H}}\,\gamma_{\mathrm{H}}$$

The familiar concept of on-shell production$\otimes$branching ratio can be generalized to

$$\sigma_{ij\to \mathrm{H}\to \mathrm{F}}(s) \;=\; \frac{1}{\pi}\,\sigma_{ij\to \mathrm{H}}(s)\,\frac{s^2}{\Big|s-s_{\mathrm{H}}\Big|^2}\,\frac{\Gamma_{\mathrm{H}\to \mathrm{F}}(s)}{\sqrt{s}}$$

☛ It is also convenient to rewrite the result as

$$\sigma_{ij\to \mathrm{H}\to \mathrm{F}}(s) \;=\; \frac{1}{\pi}\,\sigma_{ij\to \mathrm{H}}\,\frac{s^2}{\Big|s-s_{\mathrm{H}}\Big|^2}\,\frac{\Gamma^{\mathrm{tot}}_{\mathrm{H}}}{\sqrt{s}}\,\mathrm{BR}\left(\mathrm{H}\to \mathrm{F}\right)$$

☛ where we have introduced a sum over all final states,

$$\Gamma^{\mathrm{tot}}_{\mathrm{H}} \;=\; \sum_{\mathrm{f}\in \mathrm{F}} \Gamma_{\mathrm{H}\to \mathrm{f}}$$

We define an **off-shell production cross-section** (for all channels) as follows:

$$\sigma^{\text{prop}}_{ij\to\text{all}} = \frac{1}{\pi}\,\sigma_{ij\to\mathrm{H}}\,\frac{s^2}{\left|s - s_{\mathrm{H}}\right|^2}\,\frac{\Gamma^{\text{tot}}_{\mathrm{H}}}{\sqrt{s}}$$

☞ When the cross-section $ij \to \mathrm{H}$ refers to an off-shell Higgs boson the choice of the QCD scales should be made according to the virtuality and not to a fixed value. Therefore, for the PDFs and $\sigma_{ij\to\mathrm{H+X}}$ one should select $\mu_F^2 = \mu_R^2 = zs/4$ (zs being the invariant mass of the detectable final state).

Let us consider the case of a *light Higgs boson; here, the common belief was that*

- ☛ the product of **on-shell production cross-section** (say in gluon-gluon fusion) and **branching ratios** reproduces the correct result to great accuracy. The expectation is based on the well-known result ($\Gamma_{\mathrm{H}} \ll M_{\mathrm{H}}$)

$$\Delta_{\mathrm{H}} = \frac{1}{\left(s - M_{\mathrm{H}}^2\right)^2 + \Gamma_{\mathrm{H}}^2 M_{\mathrm{H}}^2} = \frac{\pi}{M_{\mathrm{H}} \Gamma_{\mathrm{H}}} \delta\left(s - M_{\mathrm{H}}^2\right) + \mathrm{PV}\left[\frac{1}{\left(s - M_{\mathrm{H}}^2\right)^2}\right]$$

where **PV** denotes the principal value (understood as a distribution). Furthermore s is the Higgs virtuality and M_{H} and Γ_{H} should be understood as $M_{\mathrm{H}} = \mu_{\mathrm{H}}$ and $\Gamma_{\mathrm{H}} = \gamma_{\mathrm{H}}$ and not as the corresponding on-shell values. In more simple terms,

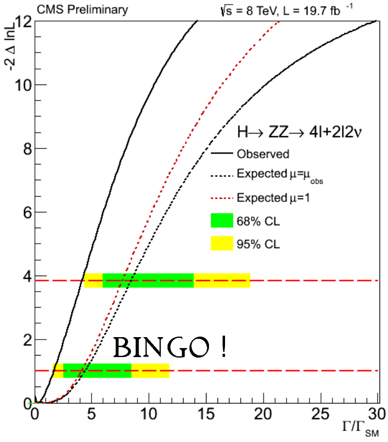
- ☞ the first term puts you on-shell and the second one gives you the off-shell tail
- ☞ Δ_{H} is the Higgs propagator, there is no space for anything else in QFT (e.g. Breit-Wigner distributions).

Inward Journey

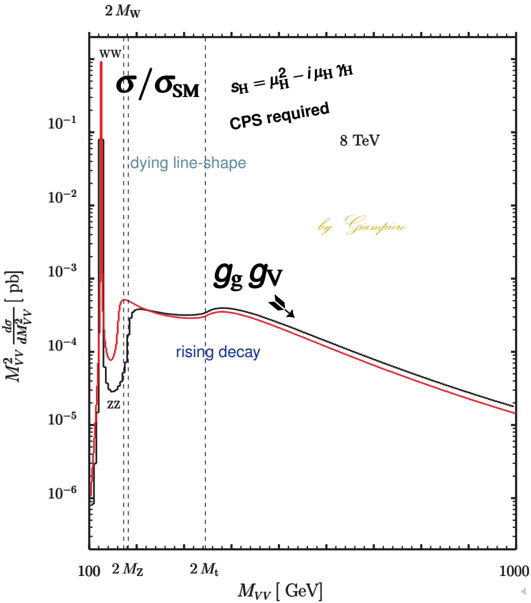
$d\sigma^{\text{off}} = \mu\, r\, d\sigma^{\text{peak}}$ $\quad r = \frac{\Gamma_H}{\Gamma_H^{SM}}$ ↬ assume $\mu = 1$ ⇝ measure r

Combined limit

~ peak, exp resolution / SM width **2–3 *GeV*/4 *MeV***



- Combined observed (expected) values
  - $r = \Gamma/\Gamma_{SM} < 4.2$ (8.5) @ 95% CL
    (p-value = 0.02)
  - $r = \Gamma/\Gamma_{SM} = 0.3^{+1.5}_{-0.3}$
- equivalent to:
  - $\Gamma < 17.4$ (35.3) MeV @ 95% CL
  - $\Gamma = (1.4^{+6.1}_{-1.4})$ MeV

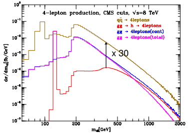


The big picture @ 8TeV

- Peak at Z mass due to singly resonant diagrams.
- Interference is an important effect.
- Destructive at large mass, as expected.
- With the standard model width, s_H, challenging to see enhancement/deficit due to Higgs channel.

$p_{T,\mu} > 5$ GeV, $|\eta_\mu| < 2.4$,
$p_{T,e} > 7$ GeV, $|\eta_e| < 2.5$,
$m_{ll} > 4$ GeV, $m_{4\ell} > 100$ GeV.

CMS cuts
CMS PAS HIG-13-002



dynamic
QCD
scales

A short History of beyond ZWA (don't try fixing something that is already broken in the first place)

① There is an enhanced Higgs tail **Kauer - Passarino (arXiv:1206.4803)**: away from the narrow peak the propagator and the off-shell H width behave like

$$\Delta_{\mathrm{H}} \approx \frac{1}{\left(M^2_{\mathrm{VV}} - \mu^2_{\mathrm{H}}\right)^2}, \qquad \frac{\Gamma_{\mathrm{H}\to\mathrm{VV}}\left(M_{\mathrm{VV}}\right)}{M_{\mathrm{VV}}} \sim G_{\mathrm{F}}\, M^2_{\mathrm{VV}}$$

② Introduce the notion of ∞-**degenerate** solutions for the Higgs couplings to SM particles **Dixon - Li (arXiv:1305.3854), Caola - Melnikov(arXiv:1307.4935)**

③ Observe that the enhanced tail is obviously γ_{H}-independent and that this could be exploited to constrain the Higgs width model-independently

④ Use a matrix element method (MEM) to construct a kinematic discriminant to sharpen the constraint **Campbell, Ellis and Williams (arXiv:1311.3589)**

① On-shell ∞-**degeneracy**: allow for a scaling of the Higgs couplings and of the total Higgs width defined by

$$\sigma_{i\to\mathrm{H}\to f} \quad = \quad (\sigma\cdot\mathrm{BR}) = \frac{\sigma_i^{\mathrm{prod}}\,\Gamma_f}{\gamma_{\mathrm{H}}} \quad \sigma_{i\to\mathrm{H}\to f} \propto \frac{g_i^2\,g_f^2}{\gamma_{\mathrm{H}}} \quad g_{i,f} = \xi\, g_{i,f}^{\mathrm{SM}}, \;\; \gamma_{\mathrm{H}} = \xi^4\,\gamma_{\mathrm{H}}^{\mathrm{SM}}$$

Remark *Looking for ξ -dependent effects in the highly off-shell region is an approach that raises sharp questions on the nature of the underlying extension of the SM; furthermore it does not take into account variations in the SM background*

- The signal strength in $4l$, relative to the expectation for the SM Higgs boson, is measured to be

$$0.91^{+0.30}_{-0.24}\ \text{CMS} \qquad 1.43^{+0.40}_{-0.35}\ \text{ATLAS}$$

② Use κ-language, allowing for a consistent HEFT interpretation, Passarino:2012cb Neglecting loop-induced vertices, we have

$$\frac{\Gamma_{gg}}{\Gamma_{gg}^{SM}(\mu_H)} = \frac{\kappa_t^2 \cdot \Gamma_{gg}^{tt}(\mu_H) + \kappa_b^2 \cdot \Gamma_{gg}^{bb}(\mu_H) + \kappa_t \kappa_b \cdot \Gamma_{gg}^{tb}(\mu_H)}{\Gamma_{gg}^{tt}(\mu_H) + \Gamma_{gg}^{bb}(\mu_H) + \Gamma_{gg}^{tb}(\mu_H)}$$

$$\sigma_{i \to H \to f} = \frac{\kappa_i^2 \kappa_f^2}{\kappa_H^2}\, \sigma_{i \to H \to f}^{SM}$$

Remark *The measure of off-shell effects can be interpreted as a constraint on γ_H only when we scale couplings and total width to keep σ_{peak} untouched, although its value is known with* 15$-$20% *accuracy.*

THE GENERALIZATION IS AN ∞^2-**degeneracy**, $\kappa_i \kappa_f = \kappa_H$.

③ On the whole, we have a constraint in the multidimensional κ-space, since $\kappa_g^2 = \kappa_g^2(\kappa_t, \kappa_b)$ and $\kappa_H^2 = \kappa_H^2(\kappa_j, \forall j)$.

- Only on the assumption of degeneracy we can prove that off-shell effects measure κ_H; a combination of on-shell effects (measuring $\kappa_i \kappa_f / \kappa_H$) and off-shell effects (measuring $\kappa_i \kappa_f$) gives information on κ_H without prejudices.

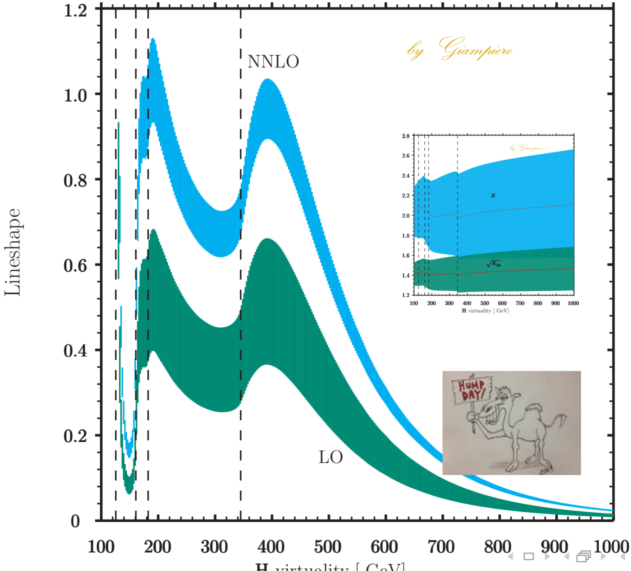
- Denoting by $\mathbf{S}$ the signal and by $\mathbf{I}$ the interference and assuming that $\mathbf{I}_{\text{peak}}$ is negligible we have

$$\frac{S_{\text{off}}}{S_{\text{peak}}}\,\kappa_H^2 + \frac{I_{\text{off}}}{S_{\text{peak}}}\,\frac{\kappa_H}{x_{if}}, \qquad\qquad x_{if} = \frac{\kappa_i \kappa_f}{\kappa_H}$$

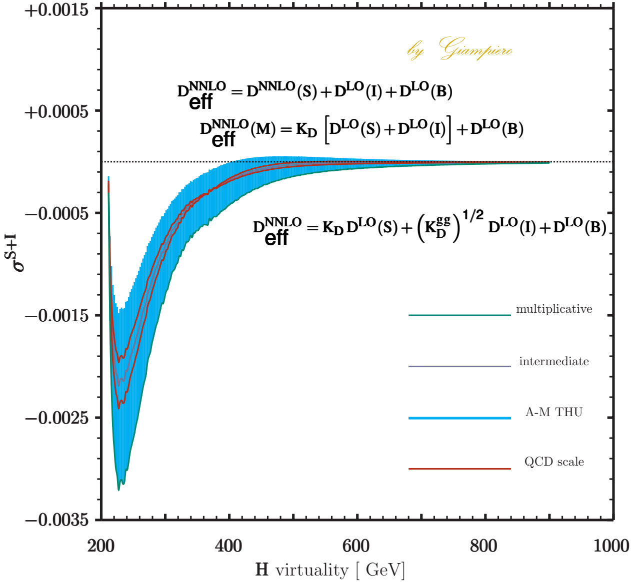
for the normalized $\mathbf{S}+\mathbf{I}$ off-shell cross section.

- The background, e.g. $\mathrm{gg} \to 4\mathrm{l}$, is also changed by the inclusion of $d = 6$ operators and one cannot claim that New Physics is modifying only the signal

The higher-order correction in gluon-gluon fusion have shown a huge $\mathbf{K}$-factor $\mathbf{K} = \sigma^{\mathrm{NNLO}}_{\mathrm{prod}} / \sigma^{\mathrm{LO}}_{\mathrm{prod}}$, $\sigma_{\mathrm{prod}} = \sigma_{\mathrm{gg} \to \mathrm{H}}$.



① The *zero-knowledge* scenario



The *soft-knowledge* scenario: in a nutshell, one can ✎

$$\sigma \;=\; \sigma^{\text{LO}} + \sigma^{\text{LO}}\,\frac{\alpha_{\text{S}}}{2\pi}\,[\text{universal} + \text{process dependent} + \text{reg}]$$

- ☛ where *universal* (the " $+$ " distribution) gives the bulk of the result
- ☛ while *process dependent* (the $\boldsymbol{\delta}$ function) is known up to two loops for the signal but not for the background
- ☛ and *reg* is the regular part.

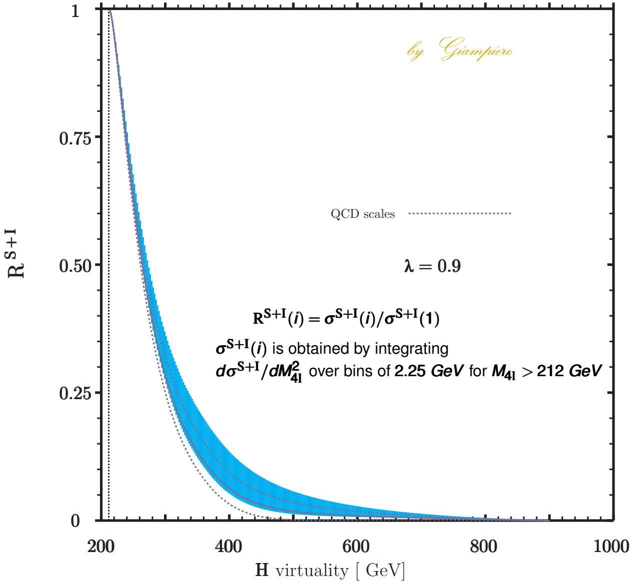
A possible strategy (Bonvini et al. arXiv:1304.3053) would be to use for background the same *process dependent* coefficients and allow for their variation within some ad hoc factor.

✴ The total systematic error is dominated by $\boxed{\text{theoretical}}$ uncertainties, therefore one should never accept theoretical predictions that cannot provide uncertainty in a systematic way (i.e. providing an algorithm).

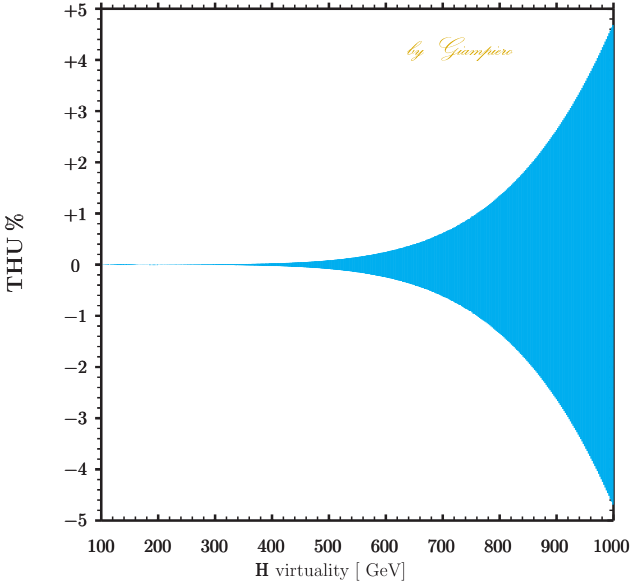
$$\begin{aligned} \mathrm{D}_{-}\left(\lambda, M_{4l}\right) &= \lambda \mathrm{D}_{\mathrm{M}}\left(M_{4l}\right) + (1-\lambda)\,\mathrm{D}_{\mathrm{I}}\left(M_{4l}\right) \\ \mathrm{D}_{+}\left(\lambda, M_{4l}\right) &= \lambda \mathrm{D}_{\mathrm{I}}\left(M_{4l}\right) + (1-\lambda)\,\mathrm{D}_{\mathrm{A}}\left(M_{4l}\right) \end{aligned}$$

☞ $\mathbf{0 \leq \lambda \leq 1}$, has a flat distribution

☞ We will have $\mathbf{D_{-} < D_{I} < D_{+}}$ and a value for $\boldsymbol{\lambda}$ close to one (e.g. **0.9**) gives less weight to the additive option, highly disfavored by the eikonal approximation.



by Giampiero
QCD scales
$\lambda = 0.9$
$R^{S+I}(i) = \sigma^{S+I}(i)/\sigma^{S+I}(1)$
$\sigma^{S+I}(i)$ is obtained by integrating
$d\sigma^{S+I}/dM^2_{4l}$ over bins of 2.25 GeV for $M_{4l} > 212$ GeV
R^{S+I}
1
0.75
0.50
0.25
0
200
400
600
800
1000
H virtuality [GeV]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+5
+4
+3
+2
+1
0
−1
−2
−3
−4
−5
THU %
100
200
300
400
500
600
700
800
900
1000
H virtuality [GeV]

THU summary

① PDF $+ \alpha_s$; these have a Gaussian distribution;

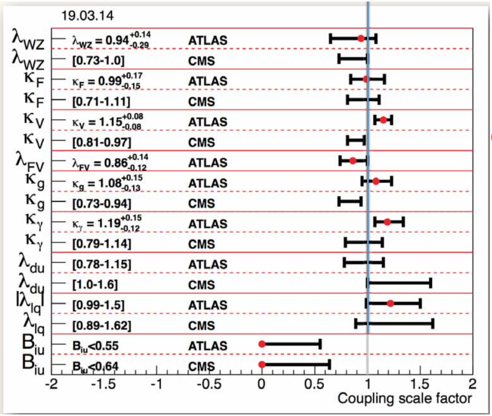
② ✓ μ_R, μ_F (renormalization and factorization QCD scales) variations; they are the standard substitute for missing higher order uncertainty (MHOU); MHOU are better treated in a Bayesian context with a flat prior;

③ uncertainty on γ_H due to missing higher orders, negligible for a light Higgs;

④ ✓ uncertainty for $\Gamma_{H \to F}(M_f)$ due to missing higher orders (mostly EW), especially for high values of the Higgs virtuality M_f (i.e. the invariant mass in $pp \to H \to f + X$);

⑤ ✓ uncertainty due to missing higher orders (mostly QCD) for the background

FUTURE (Moriod EW **2014**)



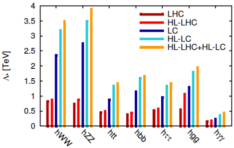


FIG. 2: Effective new physics scales Λ_* extracted from the Higgs coupling measurements collected in Table I. T for the loop-induced couplings to gluons and photons contain only the contribution of the contact terms, as t of the loop terms are already disentangled at the level of the input values Δ. (The ordering of the columns fr right corresponds to the legend from up to down.)

34

$$\mathscr{L} = \mathscr{L}_4 + \sum_{n>4} \sum_{i=1}^{N_n} \frac{a_i^n}{\Lambda^{n-4}} \mathcal{O}_i^{(d=n)}$$

TH has to improve with NLO κ-language

CONCLUSIONS

- The successful search for the on-shell Higgs-like boson has put little emphasis on the potential of the off-shell events
- The associated THU is (almost) dominating the total systematic error and *precision Higgs physics* requires control of both systematics, not only the experimental one
- Very often THU is nothing more than educated guesswork but a workable falsehood is more useful than a complex incomprehensible truth. In other words, *closeness to the whole truth is in part a matter of degree of informativeness of a proposition*

What can be said at all can be said clearly and whereof one cannot speak thereof one must be silent **Ludwig Wittgenstein**

Thanks for your attention