A novel approach to H coupling measurements

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Based on arXiv:1401.0080

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CP3 - Université Catholique de Louvain

MINIWORSHOP ON SCALAR SEARCH & STUDY

S3Be meeting - ULB Brussels - **January 23th 2014**

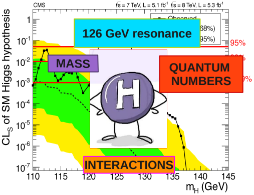
Outline

Outline

The context

One evidence

One program



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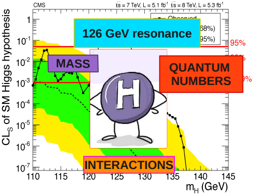

Two prominent caveats

- Theoretical uncertainties
  - Poorly defined: scale/scheme dependence, kinematic cuts, parton shower . . .
  - Not probabilistic $\Rightarrow$ Not suitable for statistical treatment
- New Physics effects
  - Overlayed with theory uncertainties
  - Similar low–energy impact from manifold UV origin

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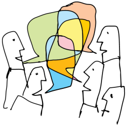

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(K. & S.)

(T. & D.)

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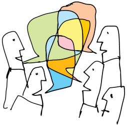

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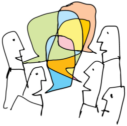

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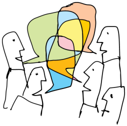

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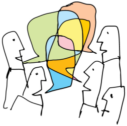

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- recouple them at any point later ?
- Pin down & assess robustness of new physics signatures ?

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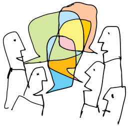

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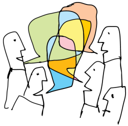

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Laying out the strategy

♠ **Stage 0:** ♣ **statistical model**

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♠ Stage 0: ♣ statistical model

CMS-NOTE-2011-005

- Data sets $D_c = \{x_1 \ldots x_{n_c}\}$ per disjoint category c
- PDF $f(\vec{x_c}|H(\mu,\alpha))$ – signal strength μ – nuisance param. α
- Expected signal: $s_{cpd}(\vec{\alpha}) = L(\vec{\alpha})\ \sigma_p^{\textsf{SM}}(\vec{\alpha})\ \textsf{BR}_d^{\textsf{SM}}(\vec{\alpha})\ \epsilon_{cpd}(\vec{\alpha})$
- Expected number of events: $\nu_c(\vec{\mu},\vec{\alpha}) = \sum_{p,d} \mu_{pd}\, s_{cpd}(\vec{\alpha}) + b_c(\vec{\alpha})$
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$$\lambda(\vec{\mu}) = \frac{L(\vec{\mu},\hat{\hat{\alpha}})}{L(\hat{\vec{\mu}},\hat{\vec{\alpha}})}$$

Cowan, Cranmer, Gross, Vitells ['11]

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We trade a **shift** in α by a **shift** in μ^{eff}

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♣ Expected signal dependence w.r.t **uncertainties**

⋆ on **total rates**

$$s_{cpd}(\vec{\alpha}) = s_{cpd}(\vec{\alpha}_0)\left[1 + \sum_i \eta_{pi}(\alpha_i - \alpha_{0,i})\right]$$

⋆ on **background**

$$b_c(\vec{\alpha}) = b_c(\vec{\alpha}_0)\left[1 + \sum_i \phi_{ci}(\alpha_i - \alpha_{0,i})\right] \quad (\forall p, d)$$

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$$V_{ij}^{-1} \equiv \partial_i \partial_j \, L_{\text{full}}(\vec{\mu}, \vec{\alpha}) \to V_{\text{main}}^{-1} + V_{\text{constr.}}^{-1}$$

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♠ Computational tools available at http://github.com/svenkreiss/decouple

♠ Analytical toy example available at arXiv:1401.0080

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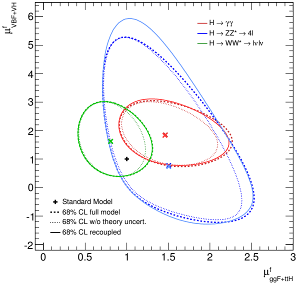
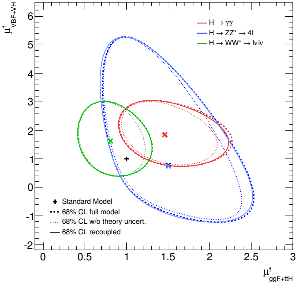
♣ Reconstruction based on the **local equivalence** $V_{\textsf{full}}^{-1} - V_{\textsf{eff}}^{-1}$ around $(\hat{\mu},\hat{\alpha})$.





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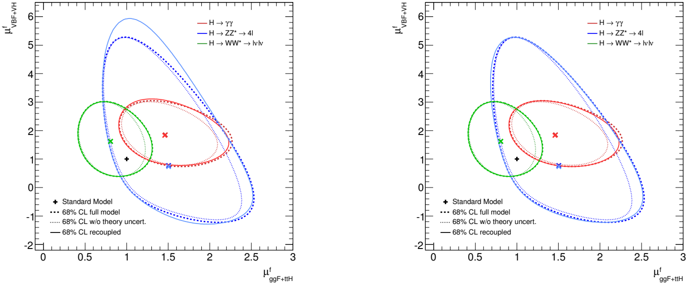
♣ Reconstruction based on the **local equivalence** $V_{\mathsf{full}}^{-1} - V_{\mathsf{eff}}^{-1}$ around $(\hat{\mu},\hat{\alpha})$.



♣ To be dealt with care: **non–linearities** in μ, α & **category–weighted** effects

Outline

Theory uncertainties VS new physics effects

GEOMETRY

Theory uncertainties VS new physics effects

UNCERTAINTIES

⇕

RECONSTRUCTING

GEOMETRY

Theory uncertainties VS new physics effects

UNCERTAINTIES

⇕

RECONSTRUCTING

GEOMETRY

NEW PHYSICS

⇕

DISENTANGLING

Theory uncertainties VS new physics effects

UNCERTAINTIES

⇕

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NEW PHYSICS

⇕

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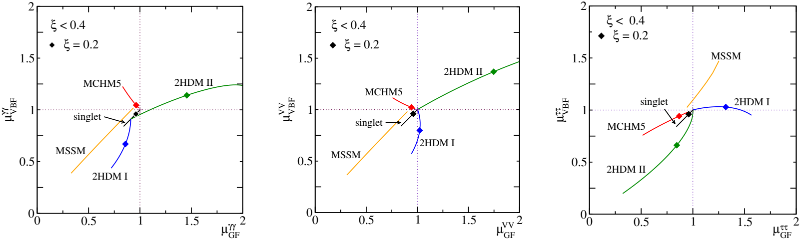
♠ BSM patterns yield characteristic signal strength correlations



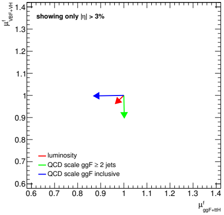
Theory uncertainties VS new physics effects

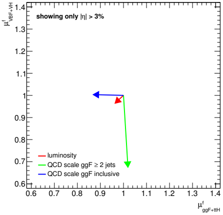
UNCERTAINTIES ⇕ RECONSTRUCTING

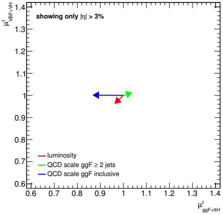
GEOMETRY

NEW PHYSICS ⇕ DISENTANGLING

♣ New physics effects **neatly depart** from theory uncertainties







Theory uncertainties VS new physics effects

Deviations from the SM

Theory uncertainties VS new physics effects

Deviations from the SM

SIZE

How large?

Theory uncertainties VS new physics effects

Deviations from the SM

SIZE

How large?

DIRECTION

How orthogonal?

Theory uncertainties VS new physics effects

Deviations from the SM

SIZE

SIGNAL STRENGHT CORRELATIONS

DIRECTION

How large?

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Robustness heuristic for new physics effects

$$R_i(\mu) = \frac{|\mu - 1|^2 |\partial_{\alpha_i}\, \mu^{\textbf{fix}}|}{(\mu - 1)\,(\partial_{\alpha_i}\, \mu^{\textbf{fix}})}$$

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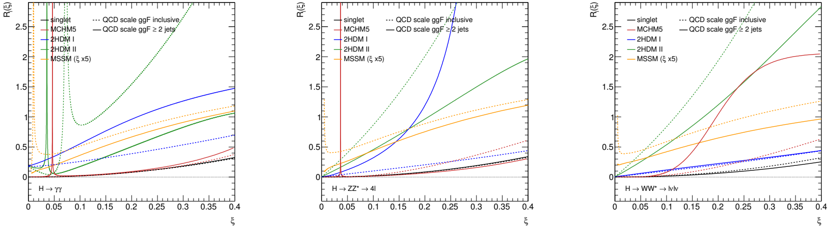

$\xi \to 0$: model–independent SM–like limit

Outline

A novel approach to Higgs coupling measurements

A strategy based on

- One Purpose : **decoupling(recoupling)** uncertainties from(to) **best–fit estimates**
- Three key elements $L^{\textsf{eff}}$ – $\mu^{\textsf{eff}}(\mu, \alpha)$ – reconstruction technique

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Allows to

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  - Reinsert **a priori correlations** in the systematics
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  - Combine likelihoods consistently
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- Software & worked examples available at http://github.com/svenkreiss/decouple
- way broader applications foreseen !