Testing the Higgs–Top Lagrangian

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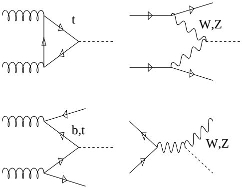
Universität Heidelberg

Madgraph Meeting, KIPMU, March 2015

Couplings from LHC rates



Standard Model operators [SFitter: Klute, Lafaye, TP, Rauch, Zerwas]

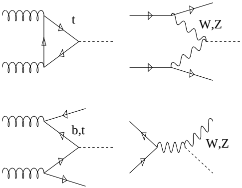
– most inclusive information: signal strengths

– assume: narrow CP-even scalar
Standard Model operators

– couplings from production & decay rates

$$\begin{array}{l} gg \to H \\ qq \to qqH \\ gg \to t\bar{t}H \\ qq' \to VH \end{array} \quad \longleftrightarrow \quad g_{HXX} = g_{HXX}^{\text{SM}} \; (1+\Delta_X) \quad \longleftrightarrow \quad \begin{array}{l} H \to ZZ \\ H \to WW \\ H \to b\bar{b} \\ H \to \tau^+\tau^- \\ H \to \gamma\gamma \end{array}$$

Couplings from LHC rates



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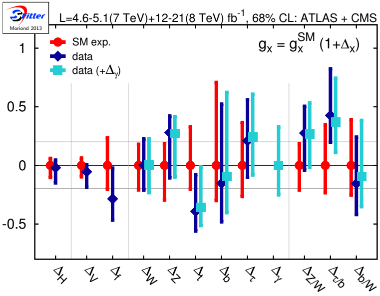
After Run 1 [Lopez-Val, TP, Rauch]

- SFitter: focus on theory uncertainties
  6D, SM-like [secondary solutions possible]
  ratios and correlations fully included



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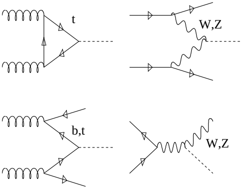

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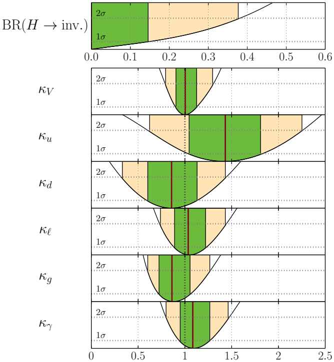
- SFitter: focus on theory uncertainties
  6D, SM-like [secondary solutions possible]
  ratios and correlations fully included
- HiggsSignals: focus on public tool
  7D including invisible decay
- ATLAS and CMS similar

⇒ effective theory next SFitter step...



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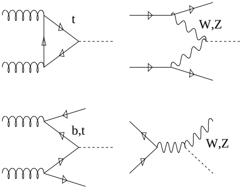

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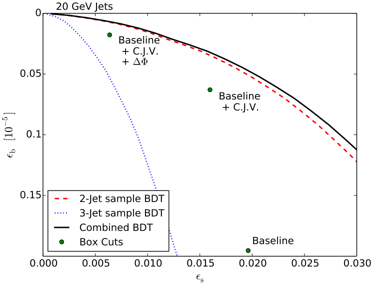
LHC challenges: invivible decays [Bernaciak, TP, Schichtel, Tattersall]

- WBF best channel at LHC [Eboli & Zeppenfeld]
- baseline cuts: jet veto plus $\Delta\phi_{jj}$
  multivariate: 2-jet, 3-jet sample
- reach $\text{BR}_{\text{inv}} \sim 7\%$ for 3000 fb^{-1}
- further improvement to 3%
  from QCD jets to 10 GeV...

$\Rightarrow$ QCD the limiting factor



Couplings from LHC distributions 1

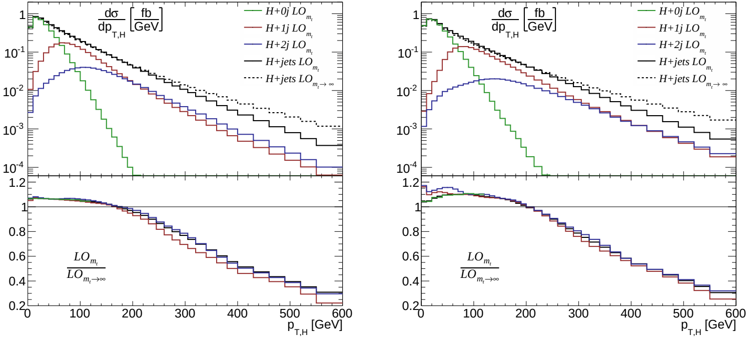
Top–Higgs–gluon Lagrangian [Ellis, Hinchliffe, Soldate, v d Bij; Baur & Glover]

– test ggH vertex structure [to keep production rate]

$$\mathcal{L} = \mathcal{L}_{\text{SM}} + \left(\Delta_t g_{ggH} + \Delta_g \frac{\alpha_s}{12\pi} \right) \frac{H}{v} \, G_{\mu\nu} G^{\mu\nu}$$

– high-p_T logarithms from 1,2 jets [Banfi etal; Azatov etal; Grojean etal; Buschmann etal]

$$|\mathcal{M}_{Hj(j)}|^2 \sim \frac{m_t^4}{p_T^4} \, \log^4 \frac{p_T^2}{m_t^2}$$



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Measuring $\Delta_{t,g}$ from $p_{T,H}$ distributions [Buschmann, Goncalves, Kuttimalai, Schönherr, Krauss, TP]

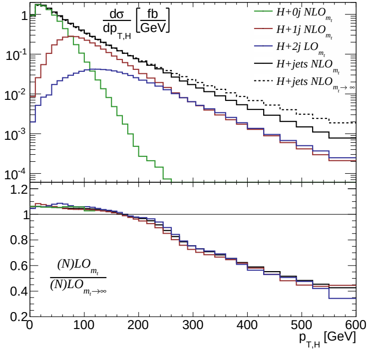
– simulation: SHERPA

sensitive region $p_{T,H} > 250$ GeV

systematic/theory errors potentially bad

NLO vs top mass orthogonal

jet count vs top mass orthogonal



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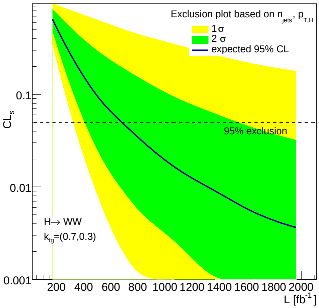
2D likelihood study of $n_{\text{jets}}, p_{T,H}$

$\Rightarrow$ $\Delta_t = -0.3$ to 95% CL with 700 fb^{-1}



Couplings from LHC distributions 2

Not-model-independent width measurements [Kauer & Passarino; Caola & Melnikov; Ellis & Williams]

– peak cross section vs off-shell interference in $H \to ZZ$

$$\sigma_\text{peak} \sim \frac{g_g^2 g_Z^2}{(s-m^2)^2 + m^2\Gamma^2} = \frac{g_g^2 g_Z^2}{m^2\Gamma^2} \qquad \sigma_\text{off}(g_g g_Z) \sim \sigma_{cont} - \frac{A_\text{int}\, g_g g_Z}{s-m^2} + \frac{A_H\, g_g^2 g_Z^2}{(s-m^2)^2}$$

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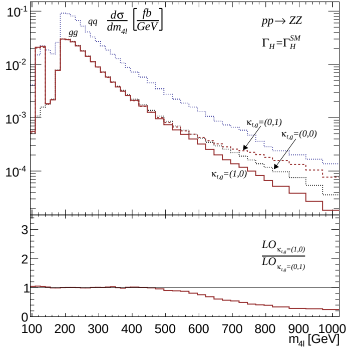

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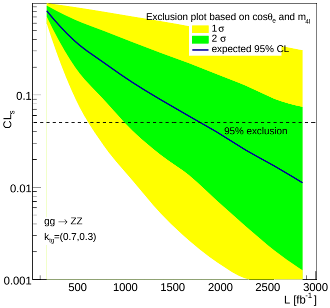

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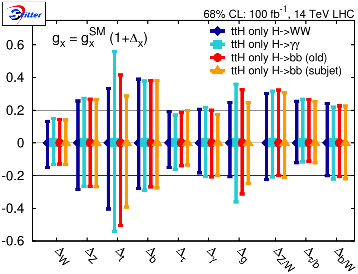

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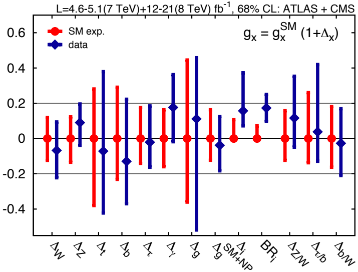

Bottom line?

Higgs property tests

– coupling strengths worked/work great

– distributions new observables

– impact for given hypothesis unclear

Much of this work was funded by the BMBF Theorie-Verbund which is ideal for relevant LHC work

Bundesministerium
für Bildung
und Forschung