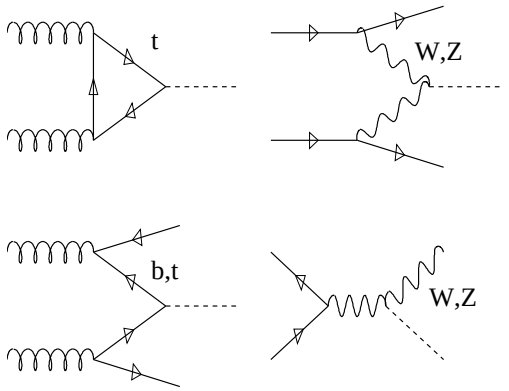
Tesing the Higgs–Top Lagrangian

Tilman Plehn

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

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

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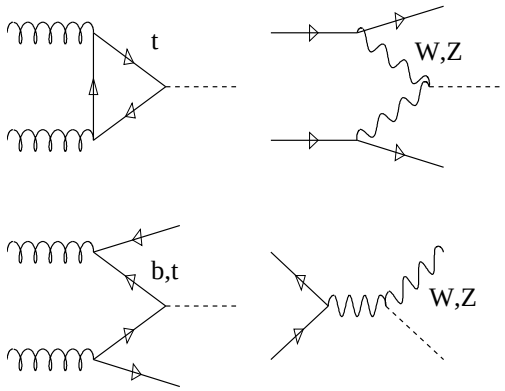

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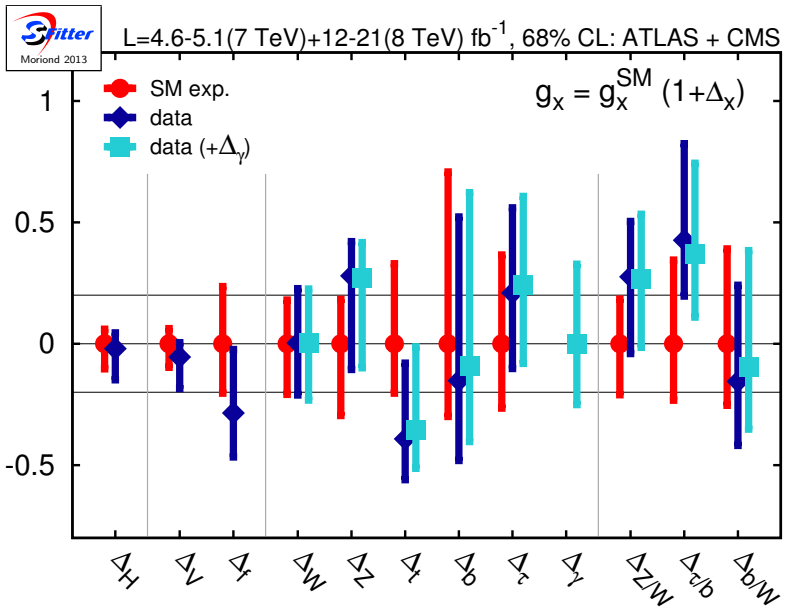
After Run 1 [Lopez-Val, TP, Rauch]

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



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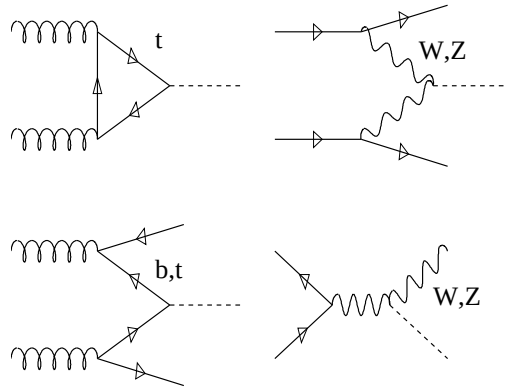

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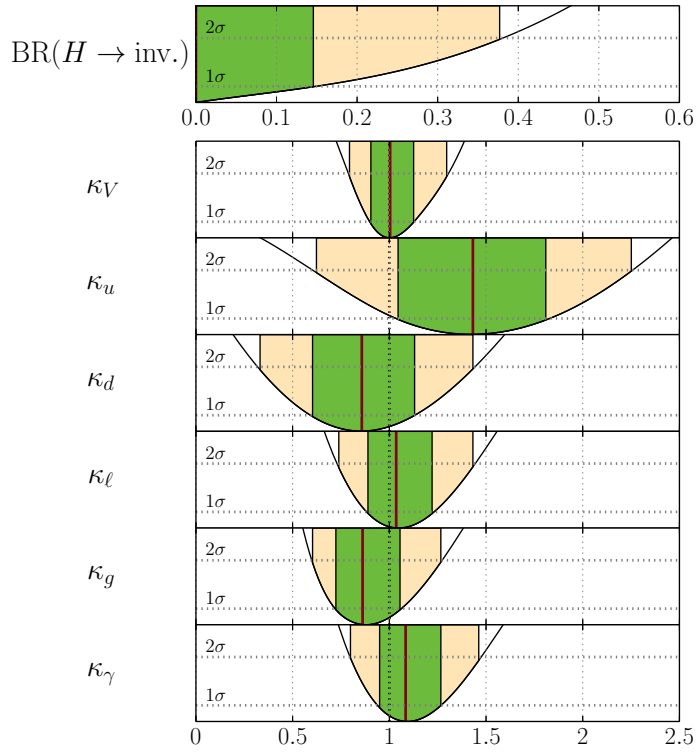
After Run 1 [Lopez-Val, TP, Rauch]

- 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

$\Rightarrow$ effective theory next SFitter step...



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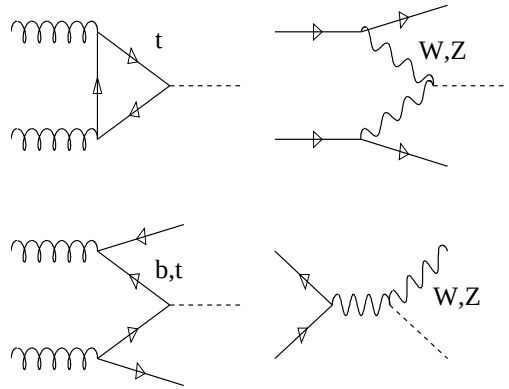

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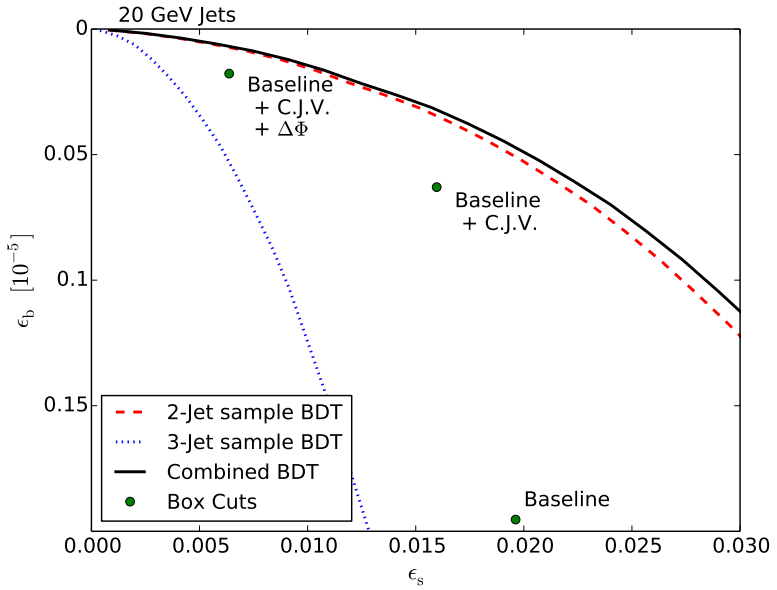
LHC challenges: invivible decays [Bernaciak, TP, Schichtel, Tattersall]

- 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

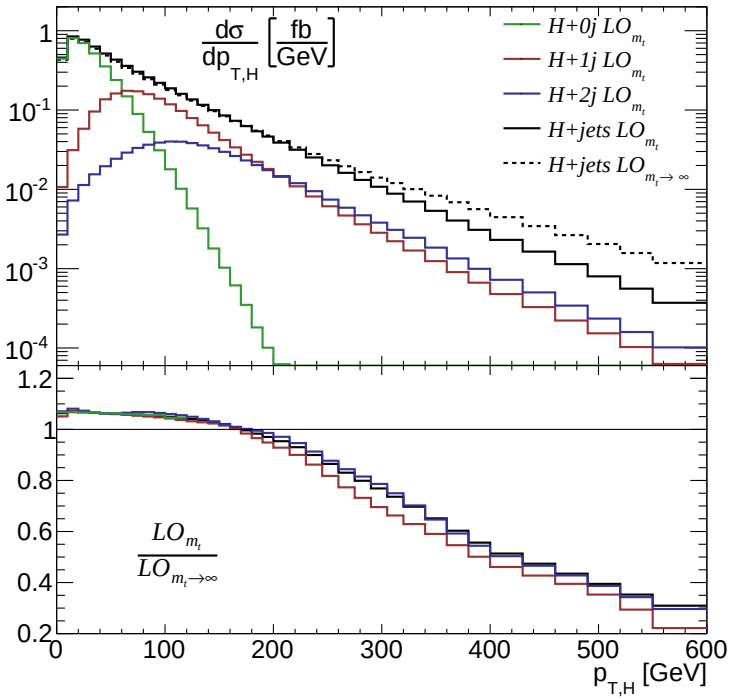
Top–Higgs–gluon Lagrangian [Ellis, Hinchliffe, Soldate, v d Bij; Baur & Glover]

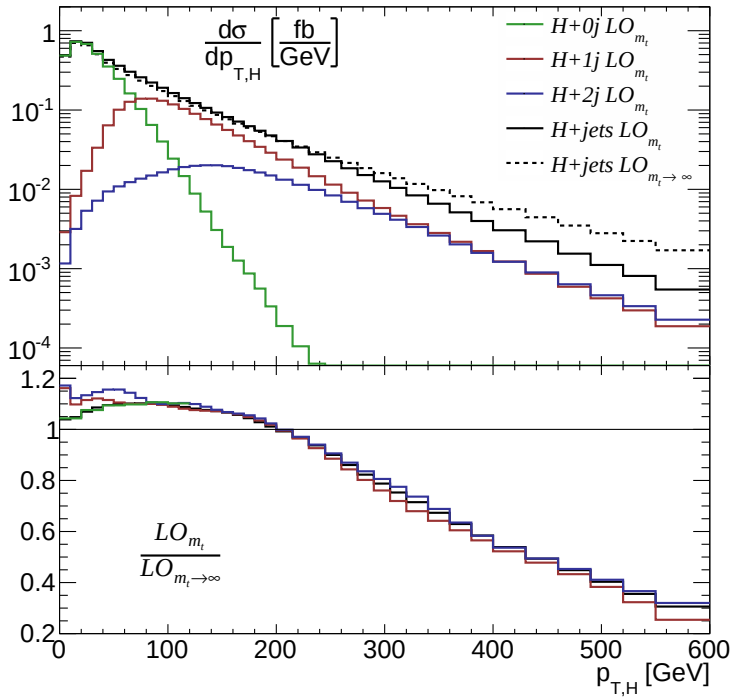
– test *ggH* vertex structure [to keep production rate]

$$\mathcal{L} = \mathcal{L}_{\text{SM}} + (\Delta_t + \Delta_g)\ g_{ggH} \frac{H}{v}\ G_{\mu\nu} G^{\mu\nu} - \Delta_t\ \frac{m_t}{v} H\ (\bar{t}_R t_L + \text{h.c.})$$

– 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]

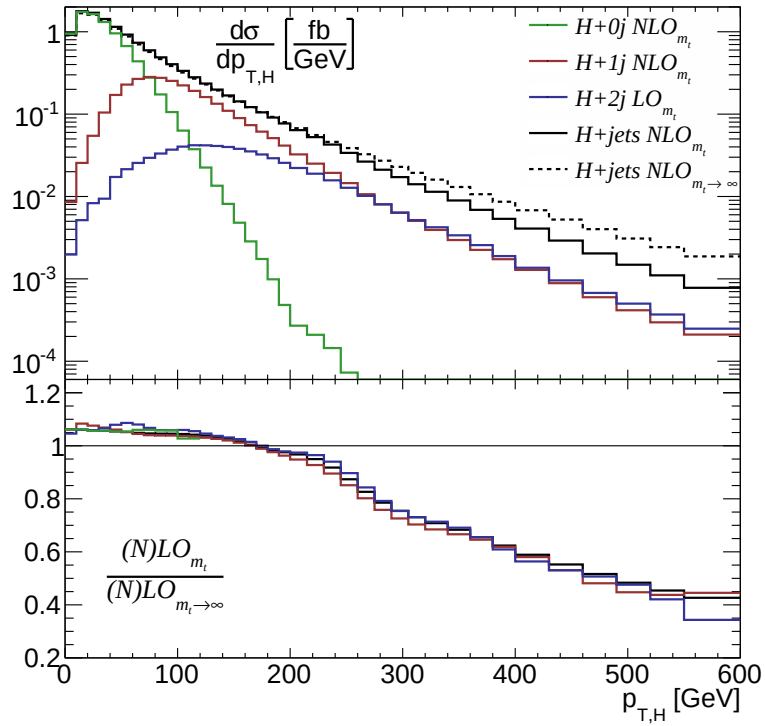
– simulation: SHERPA

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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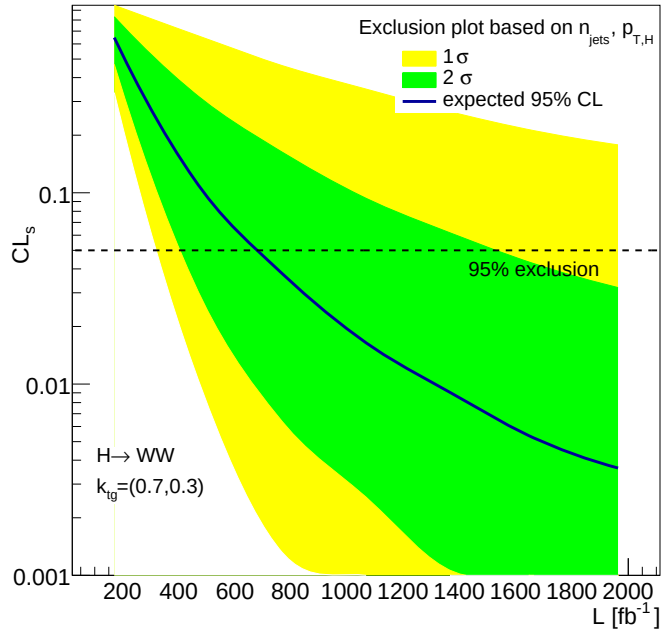
$H \to WW$ analysis

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 $H \to ZZ$

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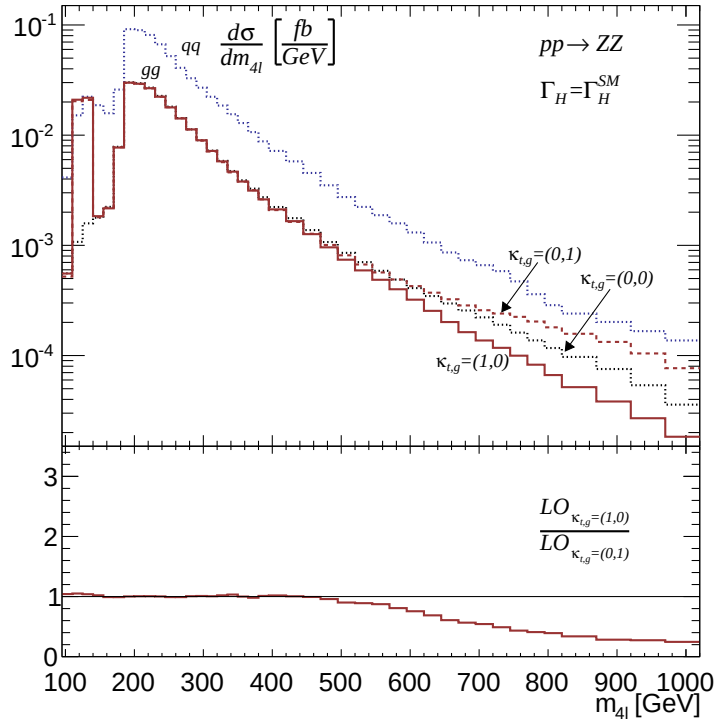

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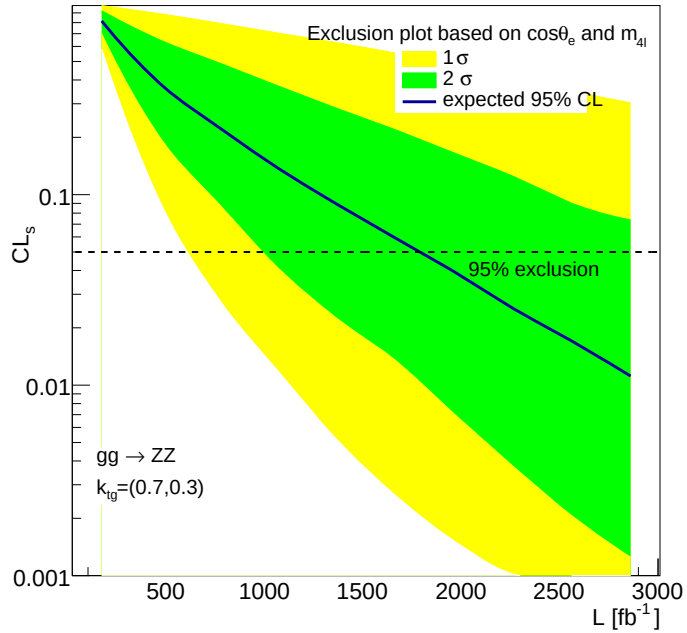

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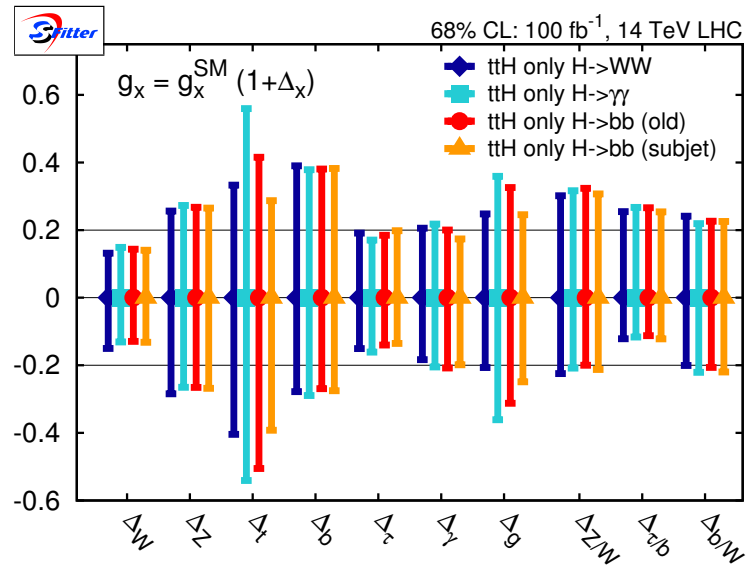

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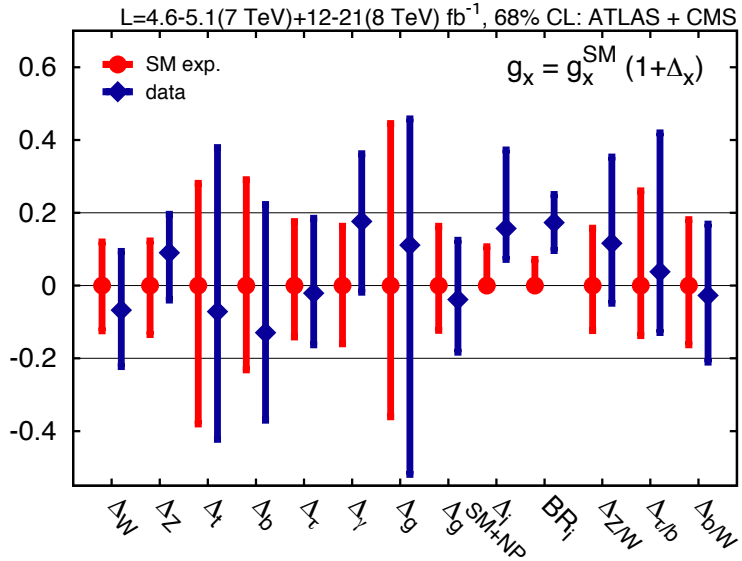

Bottom line?

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