Boosted Higgs in gluon fusion

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FCC Higgs/EWSB group discussion

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References:

Harlander and Neumann 1308.2225
Banfi, Martin and Sanz, 1308.4771
Azatov and Paul, 1309.5273
Grojean, ES, Schlaffer and Weiler 1312.3317
Schlaffer, Spannowsky, Takeuchi, Weiler and Wymant, 1405.4295
Buschmann, Englert, Goncalves, Plehn and Spannowsky, 1405.7651
See also Englert, McCullough and Spannowsky, 1310.4828

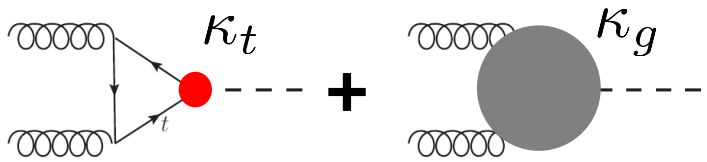
Higgs production in gluon fusion

$$\mathcal{L} = -\kappa_t \frac{m_t}{v} h t\bar{t} + \kappa_g \frac{\alpha_s}{12\pi v} h\, G^A_{\mu\nu} G^{A\,\mu\nu}$$

loops of top partners? stops? ...?

Inclusive production:

$$\mathcal{M}(gg \to h) \;=$$



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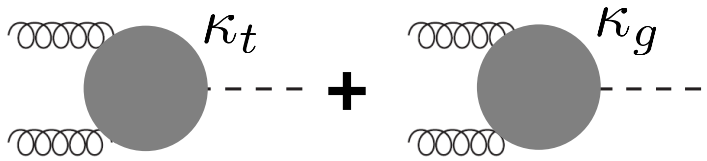
$\mathcal{M}(gg \to h) \;=$ 

$(\hat{s} = m_h^2)$

$$\mu_{\text{inclusive}} = \frac{\sigma(pp\to h)}{\sigma(pp\to h)_{\text{SM}}} \simeq (\kappa_t + \kappa_g)^2$$

degeneracy between 'long-distance' and 'short-distance' contributions

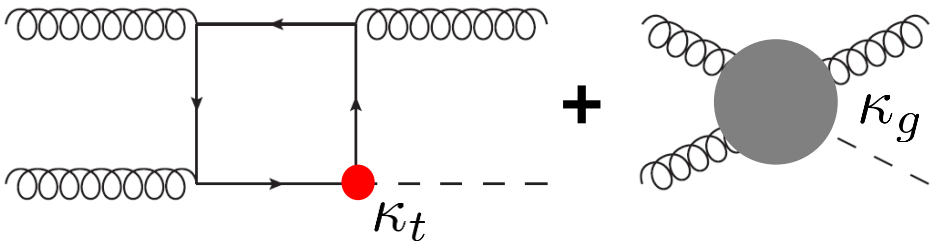
$$\mathcal{M}_{m_t} \simeq \mathcal{M}_\infty \left(1 + \frac{7}{30}\frac{m_h^2}{4m_t^2}\right)$$

How to break the degeneracy and pin down κ_g ?

Boosted Higgs

Higgs recoiling against a hard jet

$$\mathcal{M}(gg \to gh) \sim$$



for $p_T \gg m_t$, **resolve the top loop**

same degeneracy as inclusive rate

$$\frac{\sigma_{p_T^{\min}}(\kappa_t,\kappa_g)}{\sigma^{\rm SM}_{p_T^{\min}}} = (\kappa_t+\kappa_g)^2 + \delta\,\kappa_t\kappa_g + \epsilon\,\kappa_g^2$$

different combination of couplings

$p_T^{\min}$ [GeV]	$\sigma^{\rm SM}_{p_T^{\min}}$ [fb]	δ	ϵ
100	2180	0.0031	0.031
150	837	0.070	0.13
200	351	0.20	0.30
250	157	0.39	0.56
300	74.9	0.61	0.89
350	37.7	0.85	1.3
400	19.9	1.1	1.7
450	10.9	1.4	2.3
500	6.24	1.7	2.9
550	3.68	2.0	3.6
600	2.22	2.3	4.4
650	1.38	2.6	5.2
700	0.871	3.0	6.2

Combining inclusive and boosted measurements breaks the degeneracy

Breaking the degeneracy: 14 vs 100 TeV

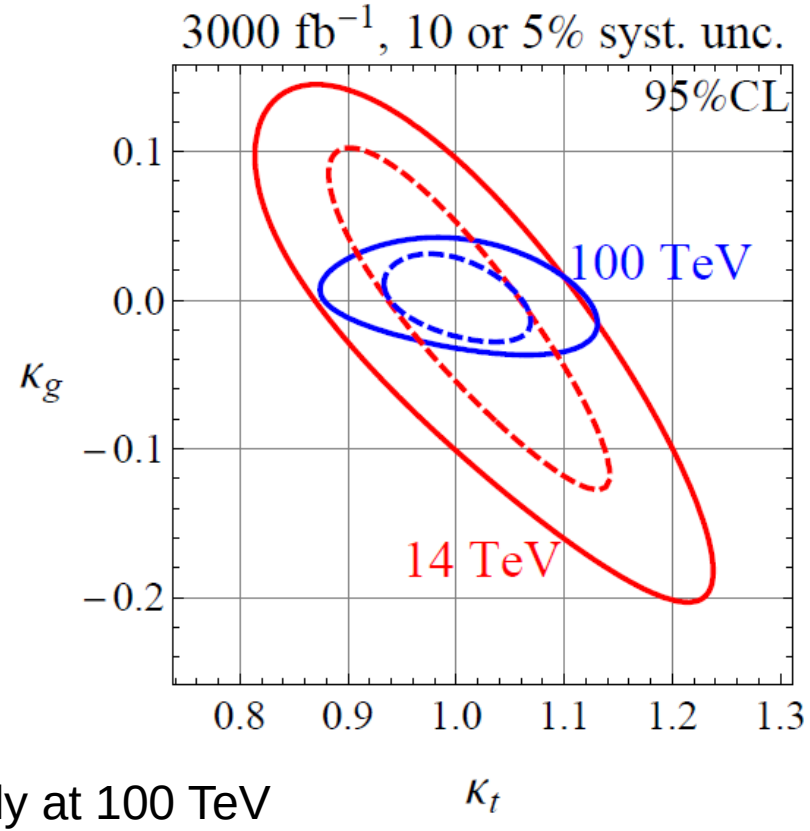
- Rough estimate: combine boosted and inclusive measurements using simple χ^2 (no backgrounds)

Grojean, ES, Schlaffer and Weiler

- For boosted regime consider $h \to \tau\tau$, and take ratio of cross sections to reduce theory uncertainty:

$$\mathcal{R}_{14} = \frac{\sigma(p_T > 650\,\text{GeV})}{\sigma(p_T > 150\,\text{GeV})}$$

$$\mathcal{R}_{100} = \frac{\sigma(p_T > 2000\,\text{GeV})}{\sigma(p_T > 500\,\text{GeV})}$$



- Discrimination power on κ_g improves strongly at 100 TeV

$$\sigma(p_T > 650\ \text{GeV}, 14\,\text{TeV}) \quad \approx \quad \sigma(p_T > 2000\ \text{GeV}, 100\,\text{TeV})$$