Probing the nature of the Higgs-gluon coupling

based on arXiv:1308.2225 **with R. Harlander**

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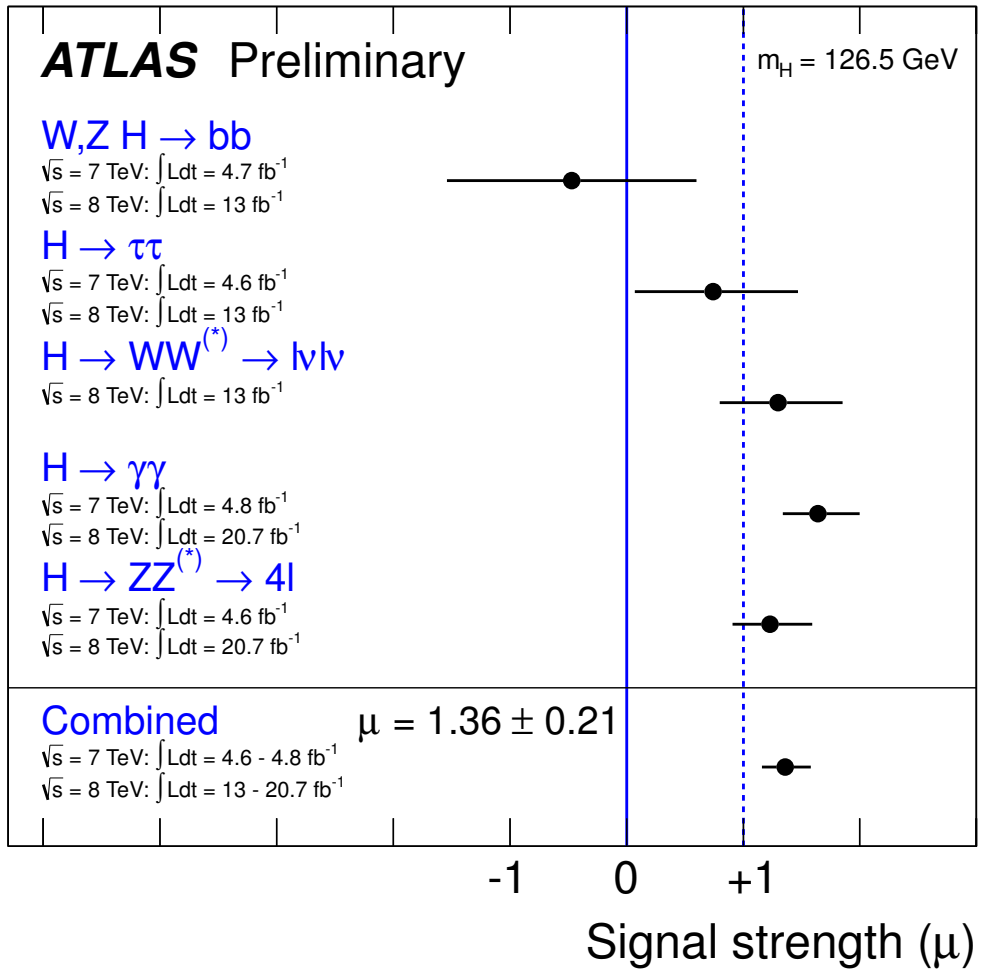
Higgs Hunting, July 21, 2014

Run1 Aftermath: SM-like Higgs boson!

Total / semi-inclusive cross-sections match SM predictions well

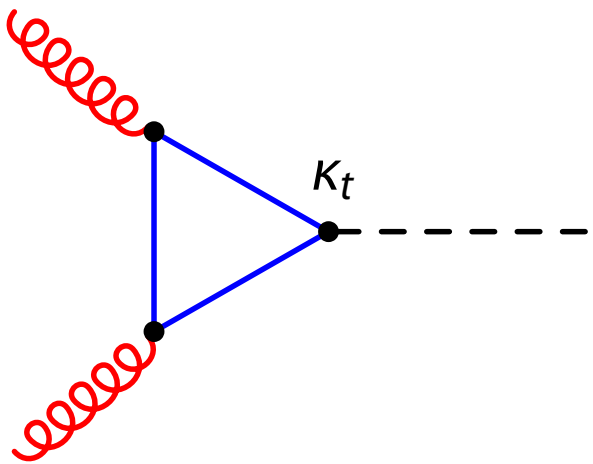


Run1 Aftermath: *The* SM Higgs boson?

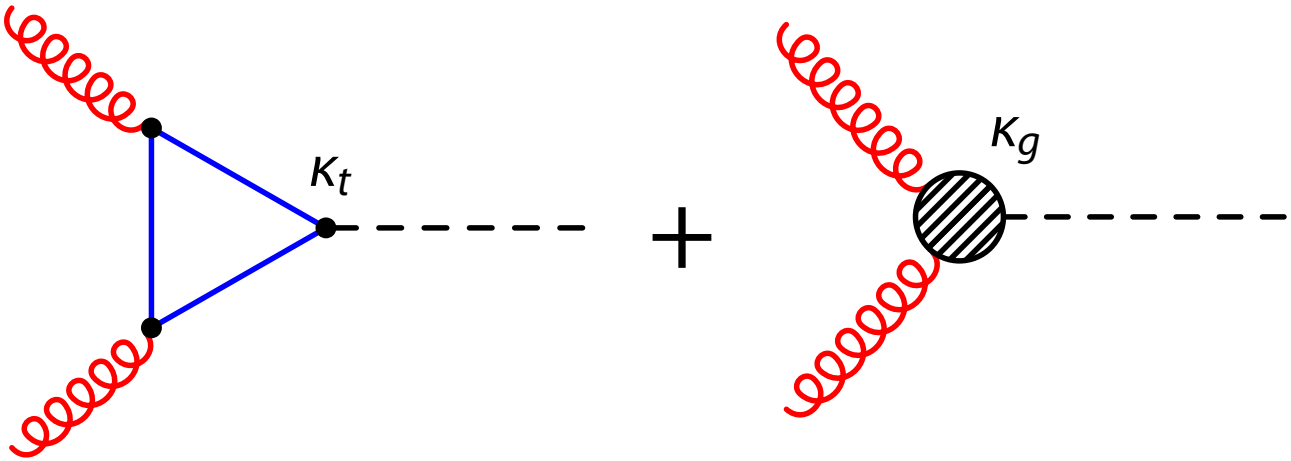
Couplings of H to other particles? Top-Higgs, Gluon-Higgs, . . .

$$\mathcal{L} \sim \kappa_t \frac{m_t}{v} \bar{t} t H, \quad \left(-1.3 \leq \kappa_t \leq 8.1, \quad \text{ATLAS-CONF-2014-043}\right)$$

Determine $t\bar{t}H$ indirectly via gluon fusion:



Probe new physics by effective theory



$$\mathcal{L} \sim \kappa_t \frac{m_t}{v} \bar{t}tH + \kappa_g \frac{\alpha_s}{12\pi} \frac{h}{v} G^a_{\mu\nu} G^{\mu\nu,a}$$

- Inclusive case: low energy dependence on $\simeq (\kappa_g + \kappa_t)^2$
- Many models: $\kappa_g + \kappa_t = \text{const.}$
- Lift degeneracy by looking at high p_T Higgs

Grojean, Schlaffer, Weiler; Banfi, Martin, Sanz; Azatov, Paul; (2013)

Schlaffer, Spannowsky et al.; Campanario, Kubocz; Buschmann, Englert, Goncalves, Plehn, Spannowsky; (2014)

Dimension-7 Higgs-gluon operators

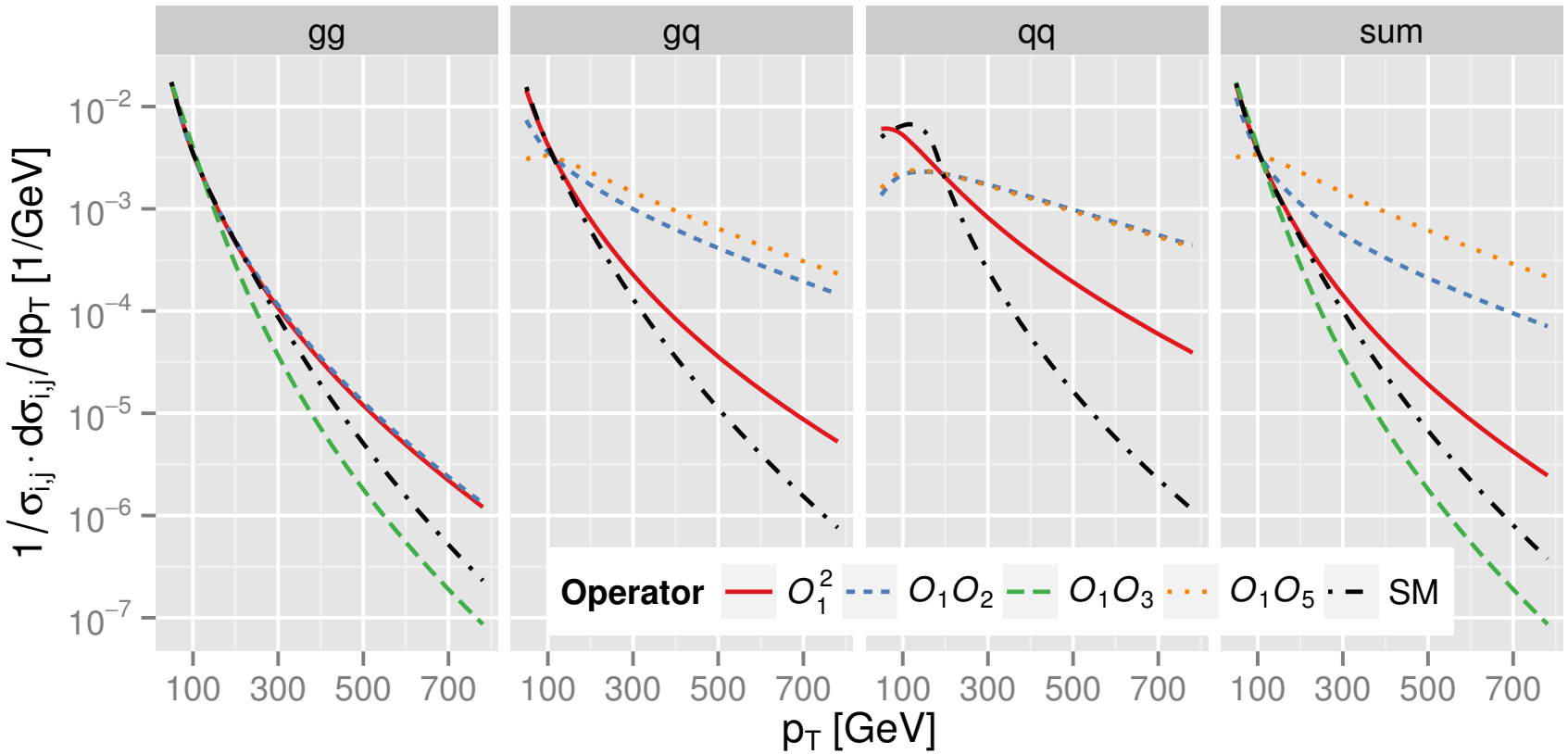
Structure of Higgs-gluon vertex can be parametrized by dim.-7 operators: (Gracey 2002; Neill 2009; Germer 2007)

$$\mathcal{L}_{eff} = \frac{C_1}{\Lambda} H F^a_{\mu\nu} F^{a\,\mu\nu} + \frac{C_2}{\Lambda^3} H D_\alpha F^a_{\mu\nu} D^\alpha F^{a\,\mu\nu} + \frac{C_3}{\Lambda^3} H F^{a\,\mu}_{\nu} F^{b\,\nu}_{\sigma} F^{c\,\sigma}_{\mu} f^{abc}$$
$$+ \frac{C_4}{\Lambda^3} H D^\alpha F^a_{\alpha\nu} D_\beta F^{a\,\beta\nu} + \frac{C_5}{\Lambda^3} H F^a_{\alpha\nu} D^\nu D^\beta F^{a\,\alpha}_{\beta}$$
$$\equiv \frac{C_1}{\Lambda} \mathcal{O}_1 + \frac{C_2}{\Lambda^3} \mathcal{O}_2 + \frac{C_3}{\Lambda^3} \mathcal{O}_3 + \frac{C_4}{\Lambda^3} \mathcal{O}_4 + \frac{C_5}{\Lambda^3} \mathcal{O}_5$$

Becomes relevant when:

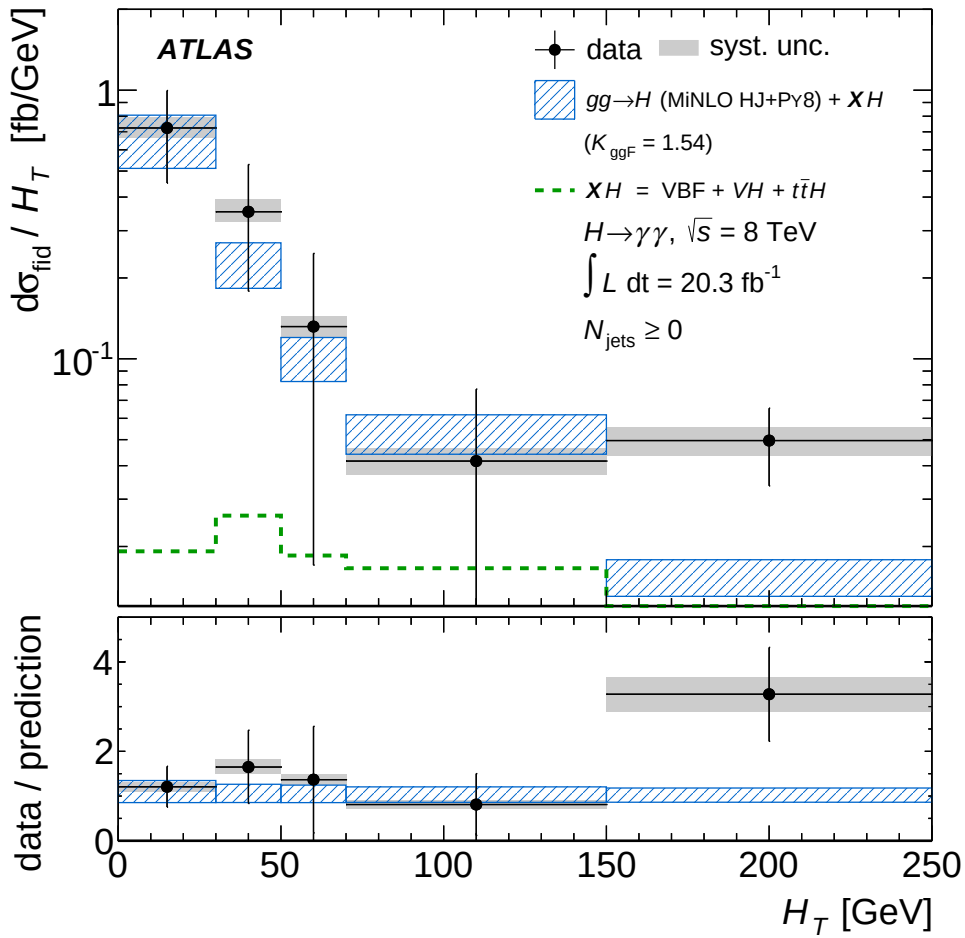
- we reach high precision regime (3000 fb^{-1}) until 2030
- one assumes models where κ_t and/or $\kappa_g \sim C_1$ are small

Higgs+Jet p_T-distribution



$$\sigma \sim \mathcal{O}_1^2 + \mathcal{O}_1\mathcal{O}_2 + \cdots + \mathcal{O}_1\mathcal{O}_5$$

Run2+: Detailed Higgs couplings



arXiv:1407.4222

Theory problem:

- H + jet p_T spectrum only known at *LO*.
- NLO: only effective theory (mass effects 2-3% below 150 GeV)

(Harlander, Neumann, Ozeren, Wiesemann 2012)

Conclusions

- Experimentally the Higgs boson is SM-like (σ)
- Detailed kinematics / couplings undetermined
- Parametrisation/Quantification of SM deviations for important Higgs-gluon coupling by dim.-5 and -7 operators at high p_T

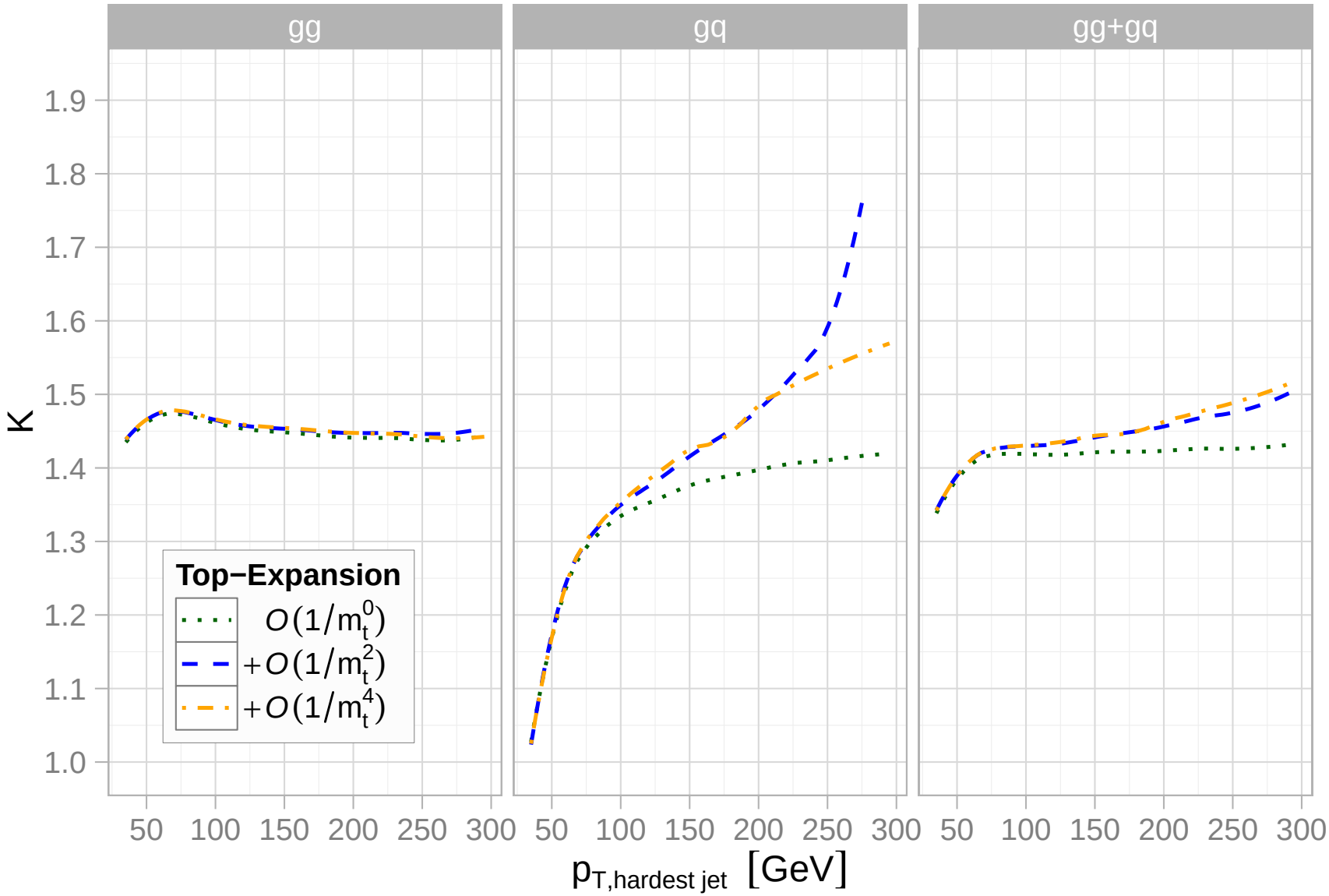
$$\mathcal{L}_{eff} = \frac{C_1}{\Lambda} H F^a_{\mu\nu} F^{a\,\mu\nu} + \frac{C_2}{\Lambda^3} H D_\alpha F^a_{\mu\nu} D^\alpha F^{a\,\mu\nu} + \frac{C_3}{\Lambda^3} H F^{a\,\mu}_{\nu} F^{b\,\nu}_{\sigma} F^{c\,\sigma}_{\mu} f^{abc} + \dots$$

- $H +$ jet p_T spectrum with finite m_t only known at LO

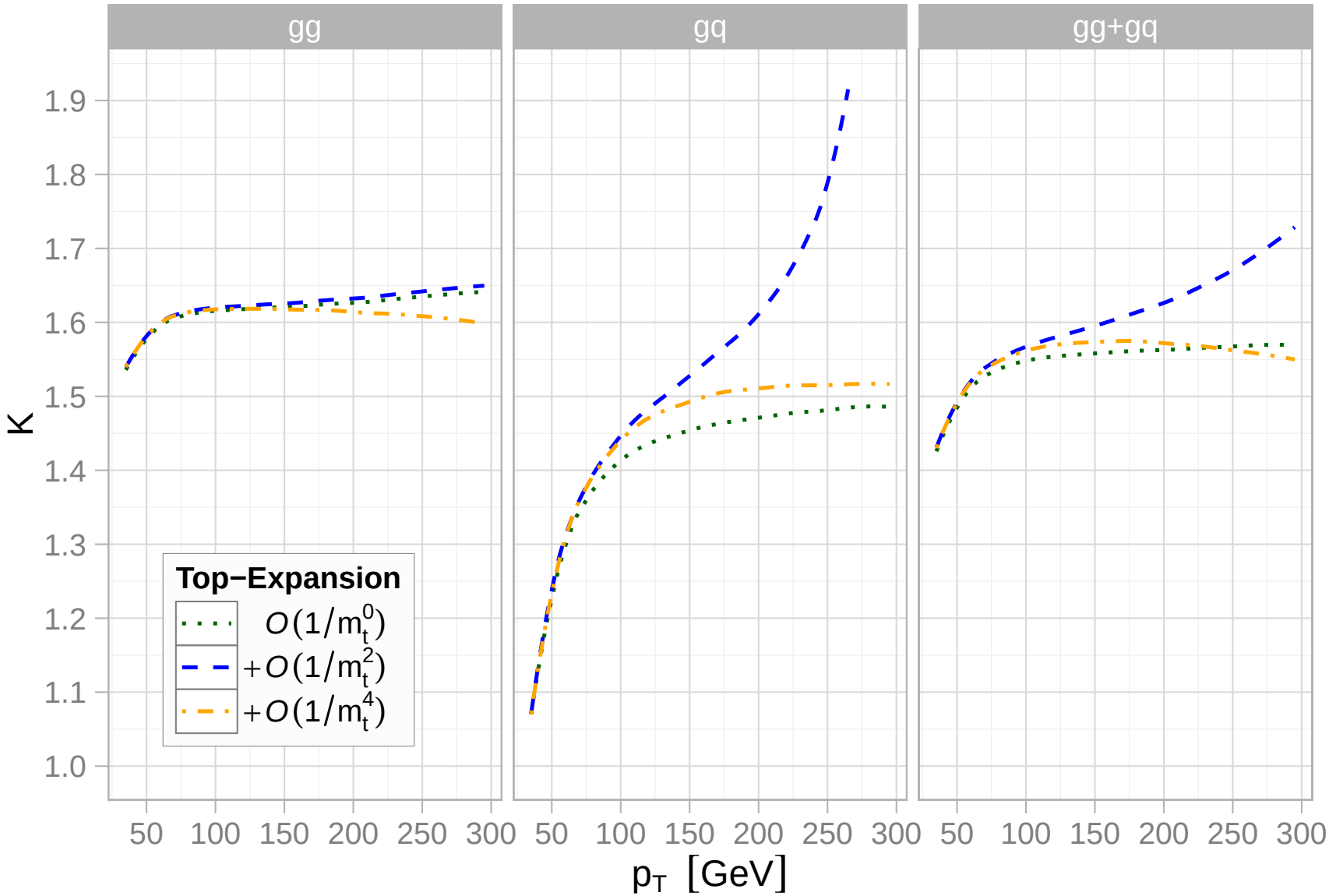
Run2+ will allow us to probe the nature of the Higgs-gluon coupling

Appendix

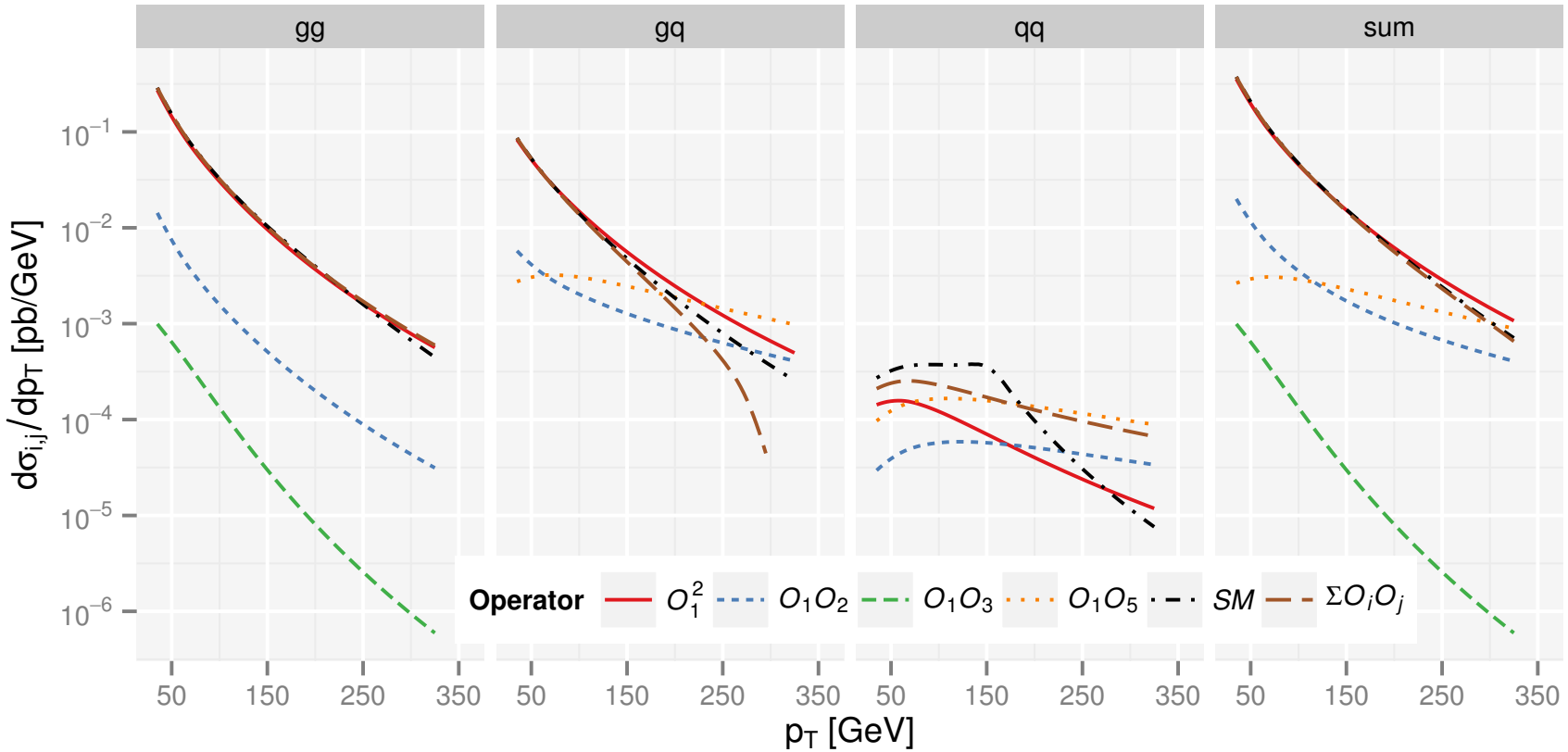
H + jet: hardest jet p_T



H + jet: Higgs p_T

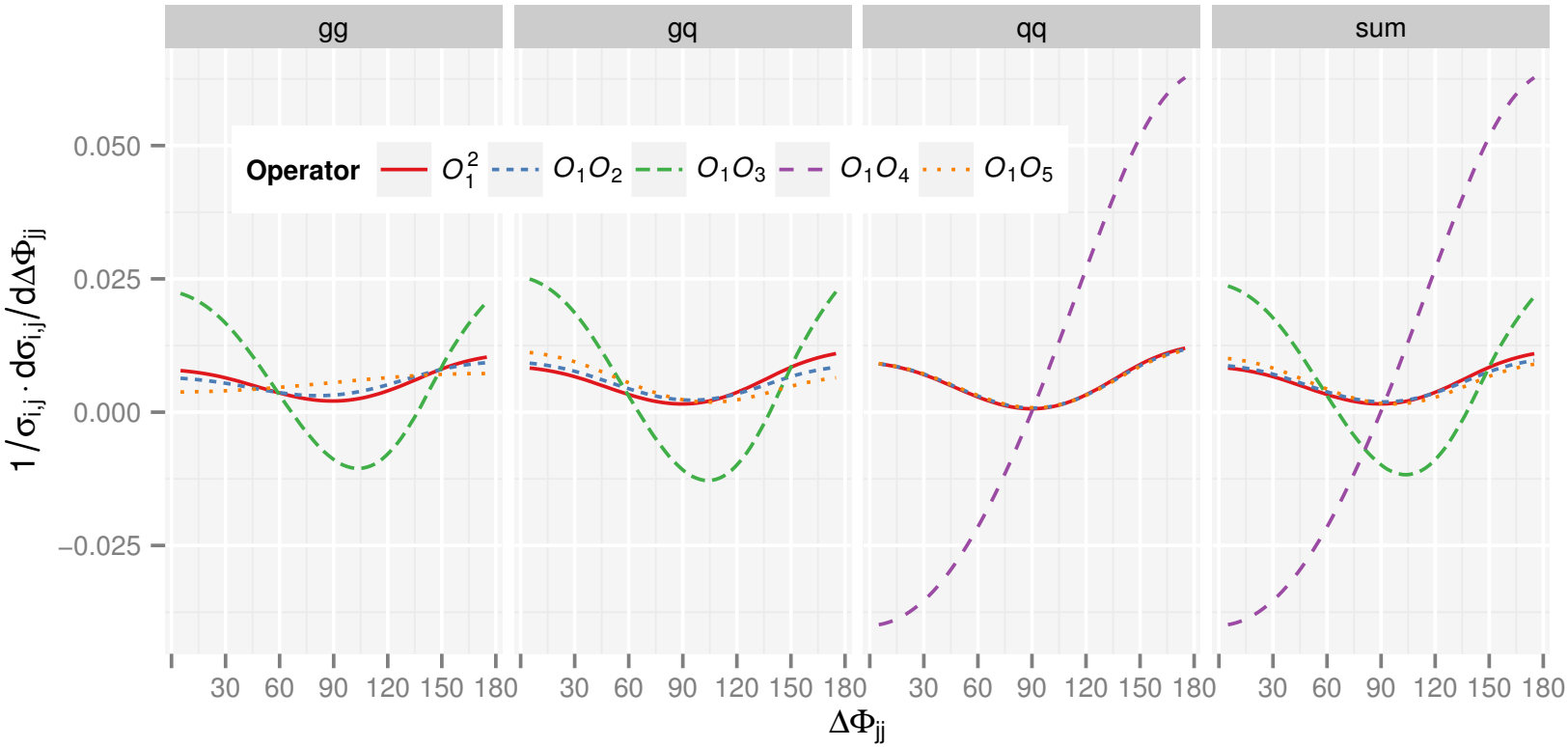


SM matched p_T-distribution



gq, $\mathcal{O}_1\mathcal{O}_5$ and qq, $\mathcal{O}_1\mathcal{O}_2$ have been multiplied with -1.

$\Delta\Phi_{jj}$-distribution



$\Delta\eta_{jj}$-distribution