Top-mass effects in differential Higgs production through gluon fusion at order α_s^4

BERGISCHE
UNIVERSITÄT
WUPPERTAL

Tobias Neumann

Bergische Universität Wuppertal

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Overview

Introduction

- Higgs production through gluon fusion in effective theory
- LO considerations for Higgs+Jet production

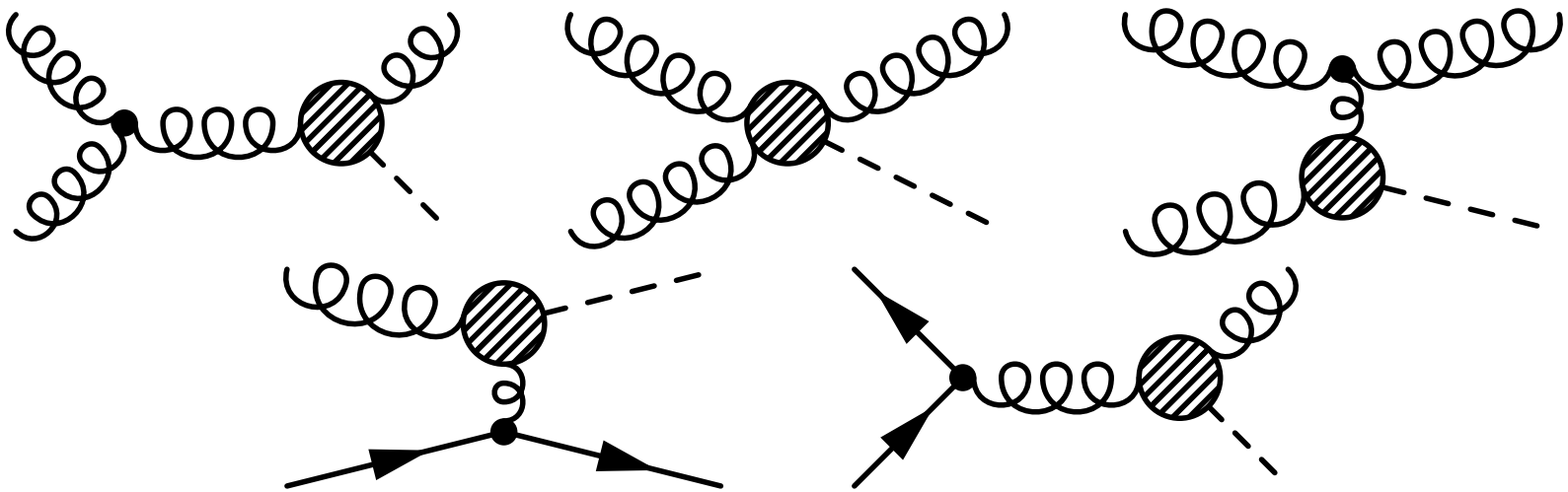
Top-mass effects at next-to-leading order

- Inclusive cross section σ
- Differential cross section $\mathrm{d}\sigma/\mathrm{d}p_T$

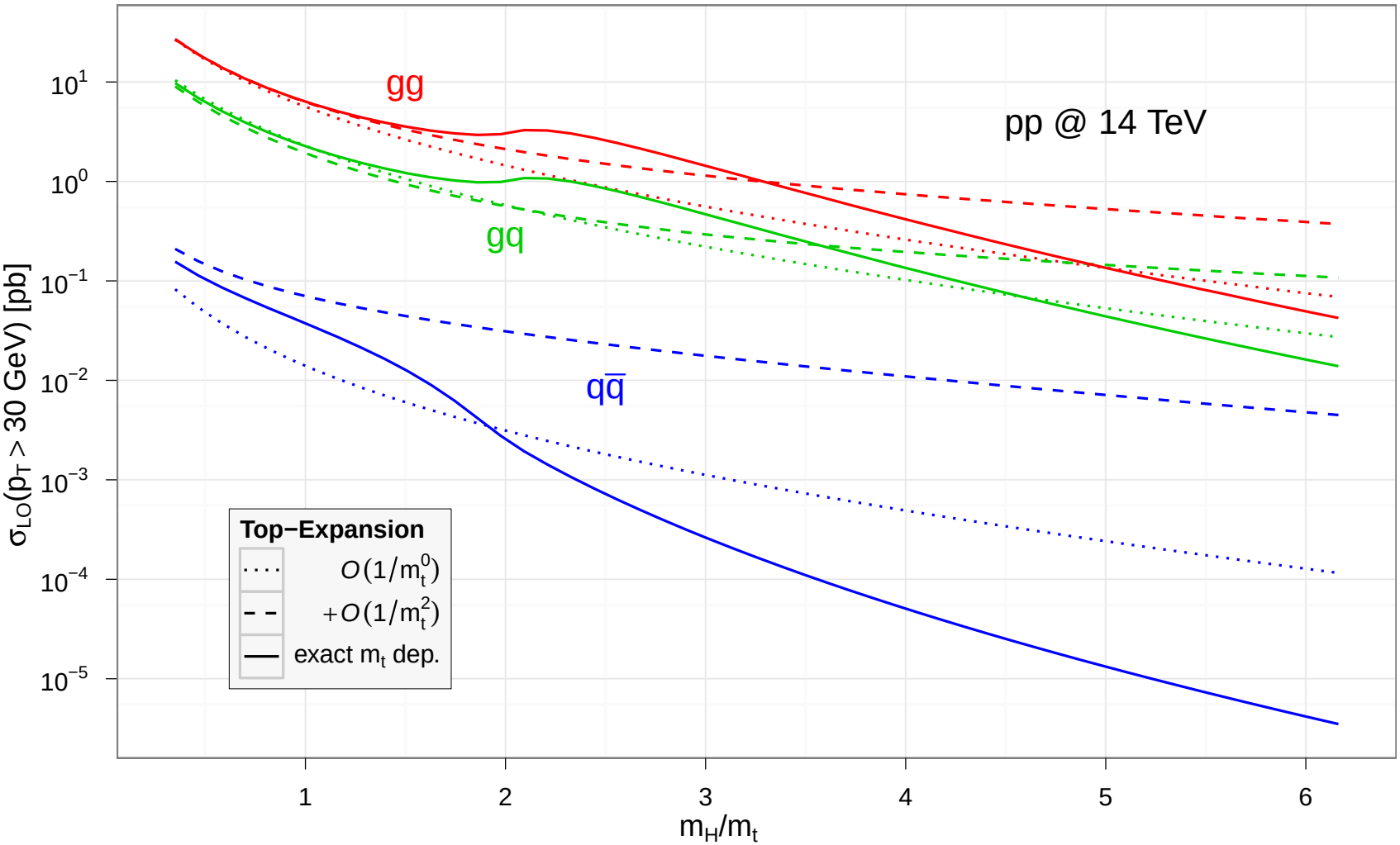
Lessons from inclusive Higgs production

1. NLO increases LO by $\simeq 50 - 100\%$, NNLO again by $\simeq 20\%$
2. Asymptotic expansion in Λ/m_t, $\Lambda \in \{m_H, \sqrt{\hat{s}}, p_T, \ldots\}$ with leading order: $m_t = \infty$, $\mathcal{O}(1/m_t^0)$ reduces loops by one
3. Error for inclusive total Higgs production cross section due to $m_t = \infty$ at NNLO: $\simeq 1\%$

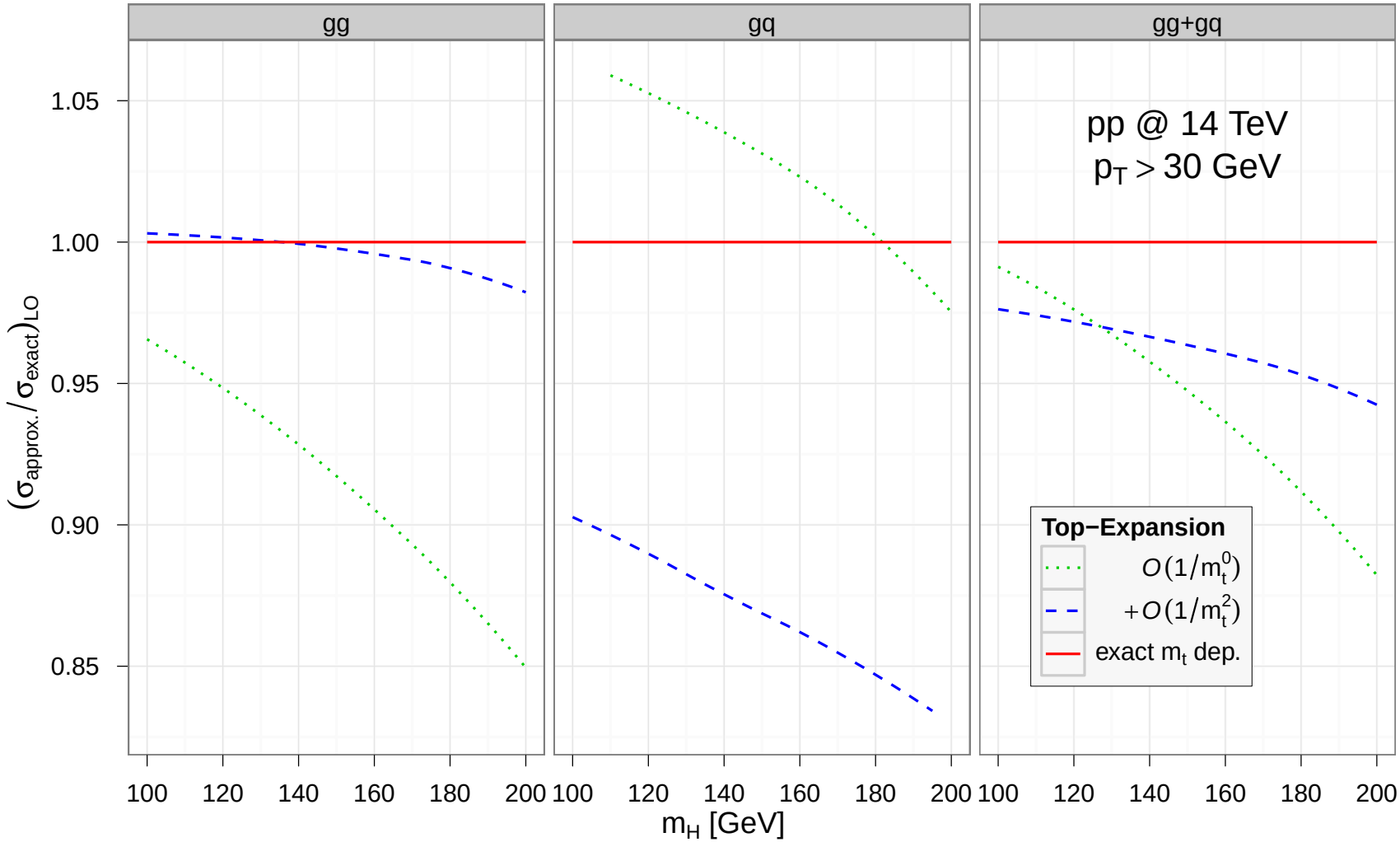
Error for non-inclusive/differential Higgs production uncertain before:



LO considerations for Higgs+Jet production through gluon fusion



LO considerations for Higgs+Jet production through gluon fusion



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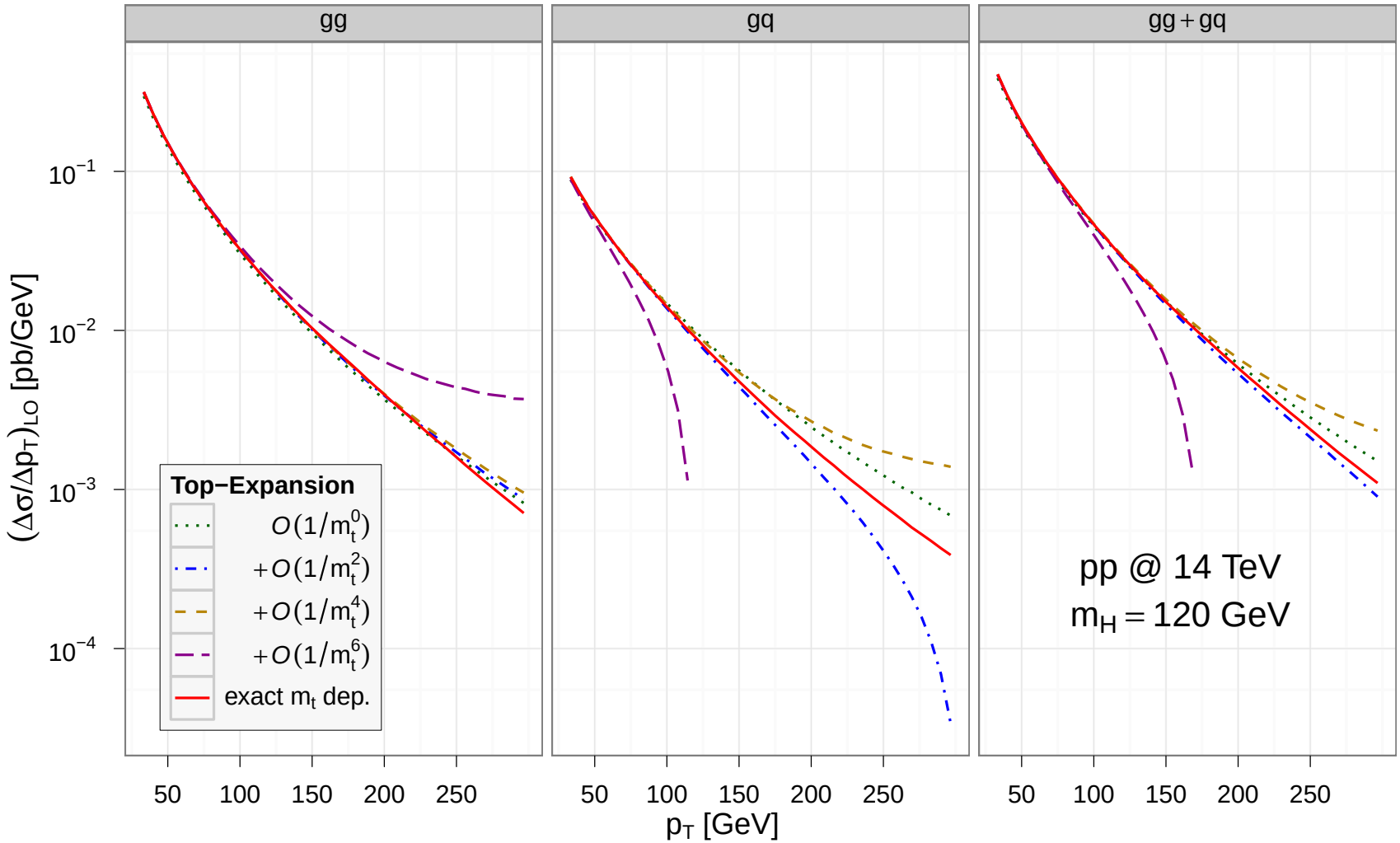
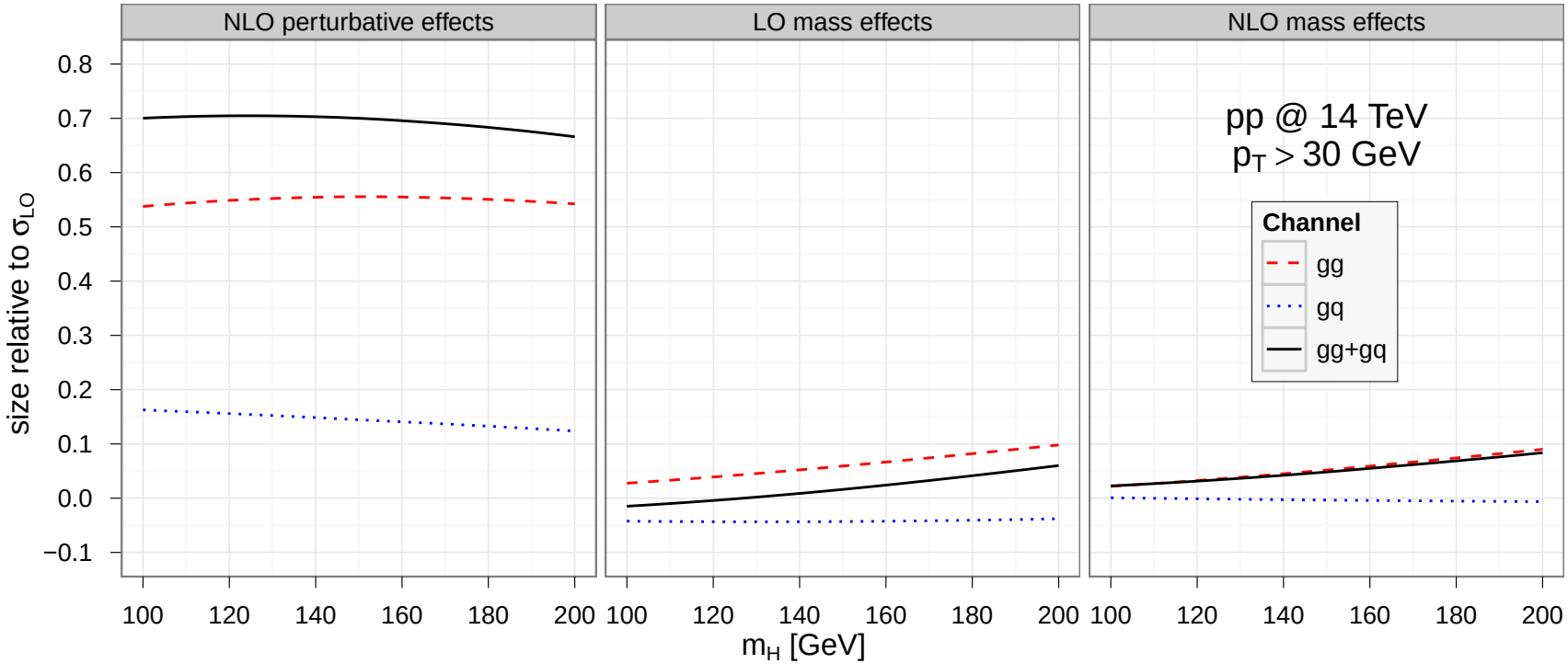


Inclusive cross section σ

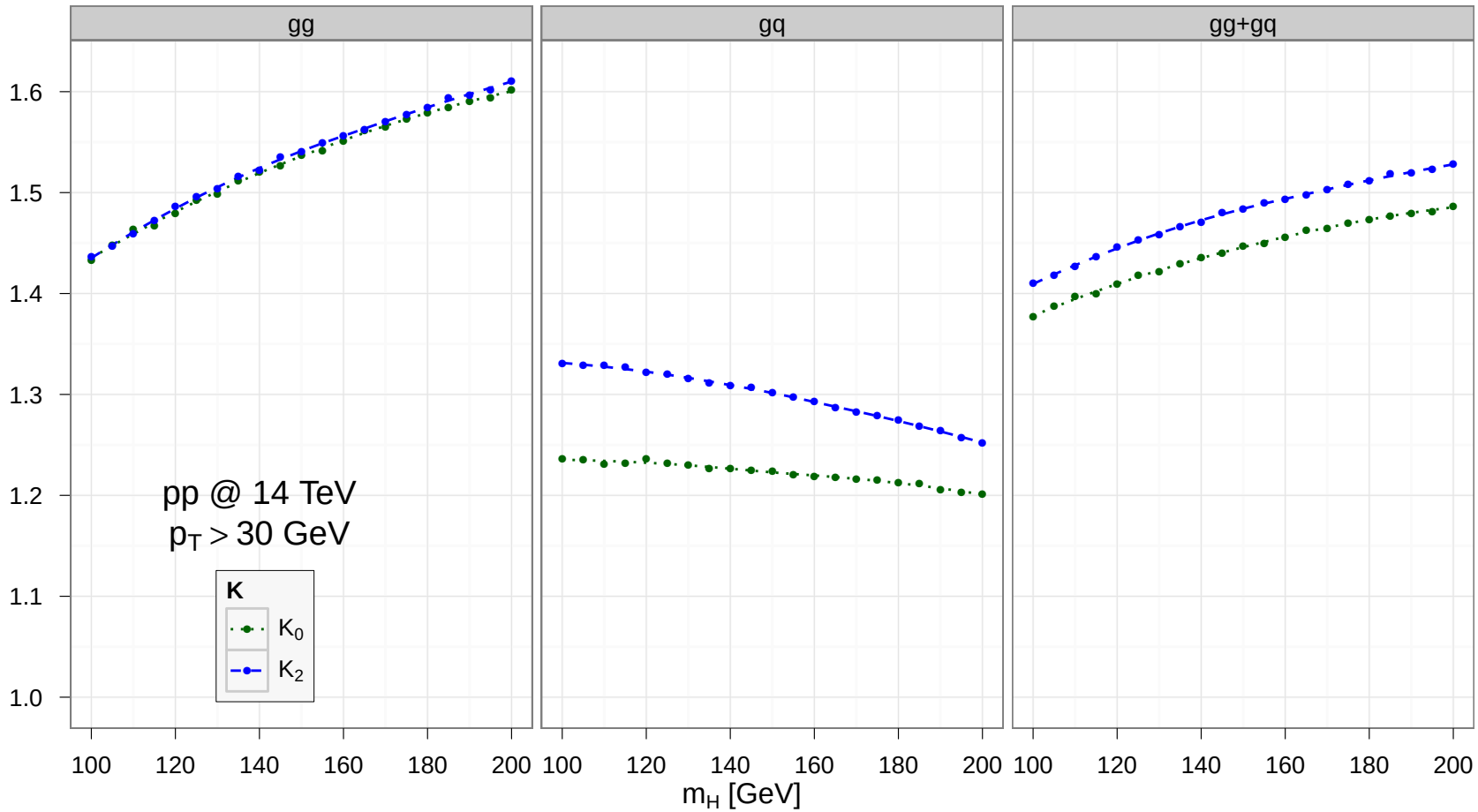


$$\text{perturbative effects} = \sigma\mathcal{O}(\alpha_s^4 \cdot 1/m_t^0) \,/\, \sigma_{\text{LO}}^{m_t\text{exact}}$$

$$\text{LO mass effects} \quad = \sigma\mathcal{O}(\alpha_s^3 \cdot 1/m_t^2) \,/\, \sigma_{\text{LO}}^{m_t\text{exact}}$$

$$\text{NLO mass effects} \quad = \sigma\mathcal{O}(\alpha_s^4 \cdot 1/m_t^2) \,/\, \sigma_{\text{LO}}^{m_t\text{exact}}$$

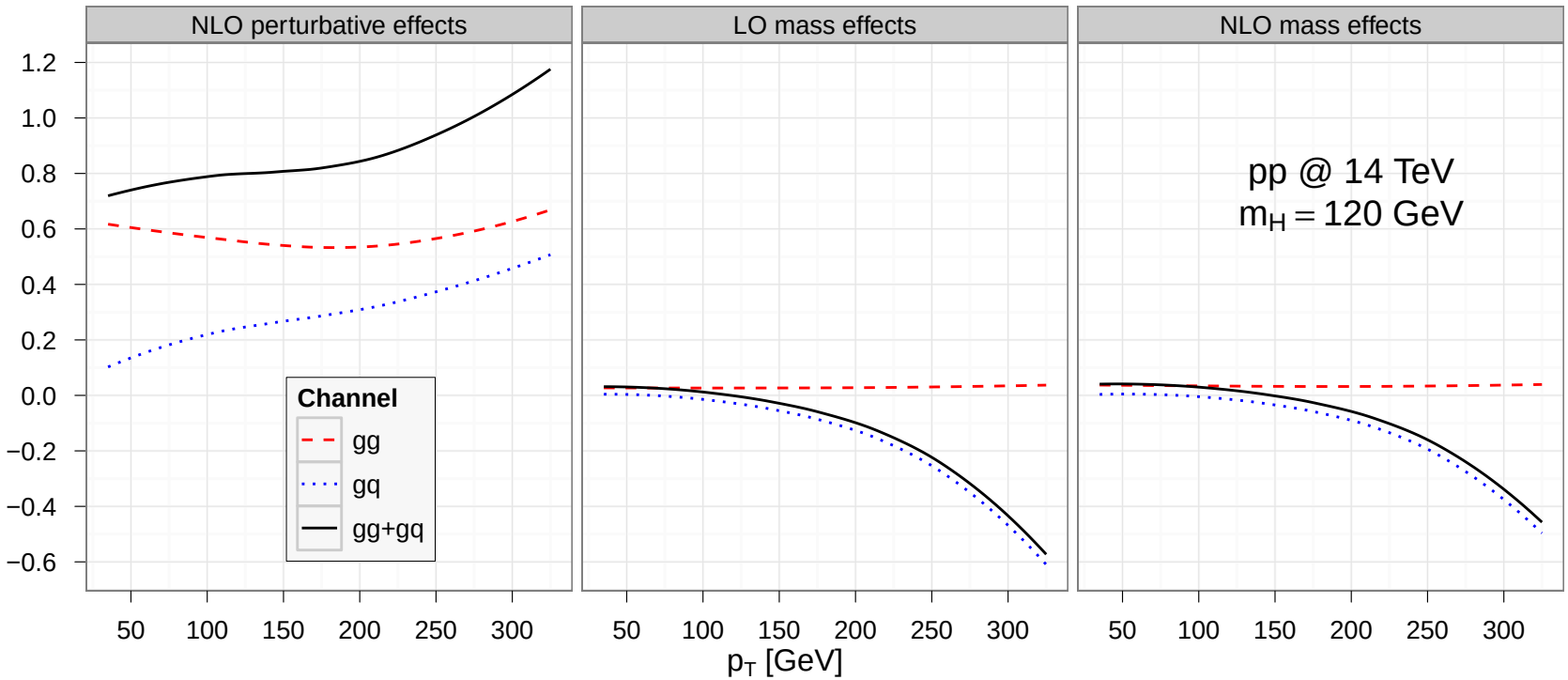
Inclusive cross section σ



K_0 : numerator and denominator $1/m_t^0 = m_t \to \infty$

K_2 : with additional $1/m_t^2$ contributions each

Differential cross section $d\sigma/dp_T$



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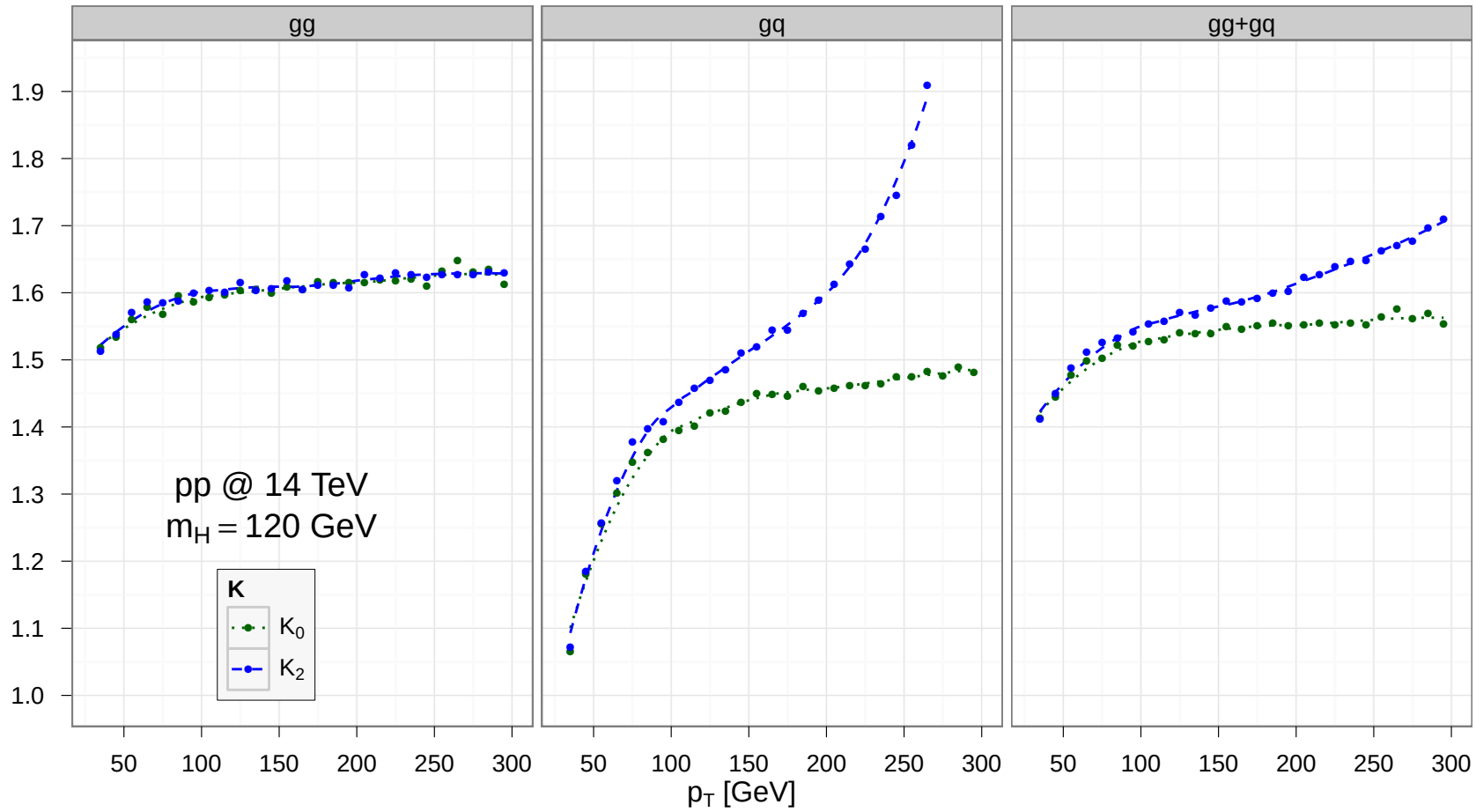

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Summary & Conclusion

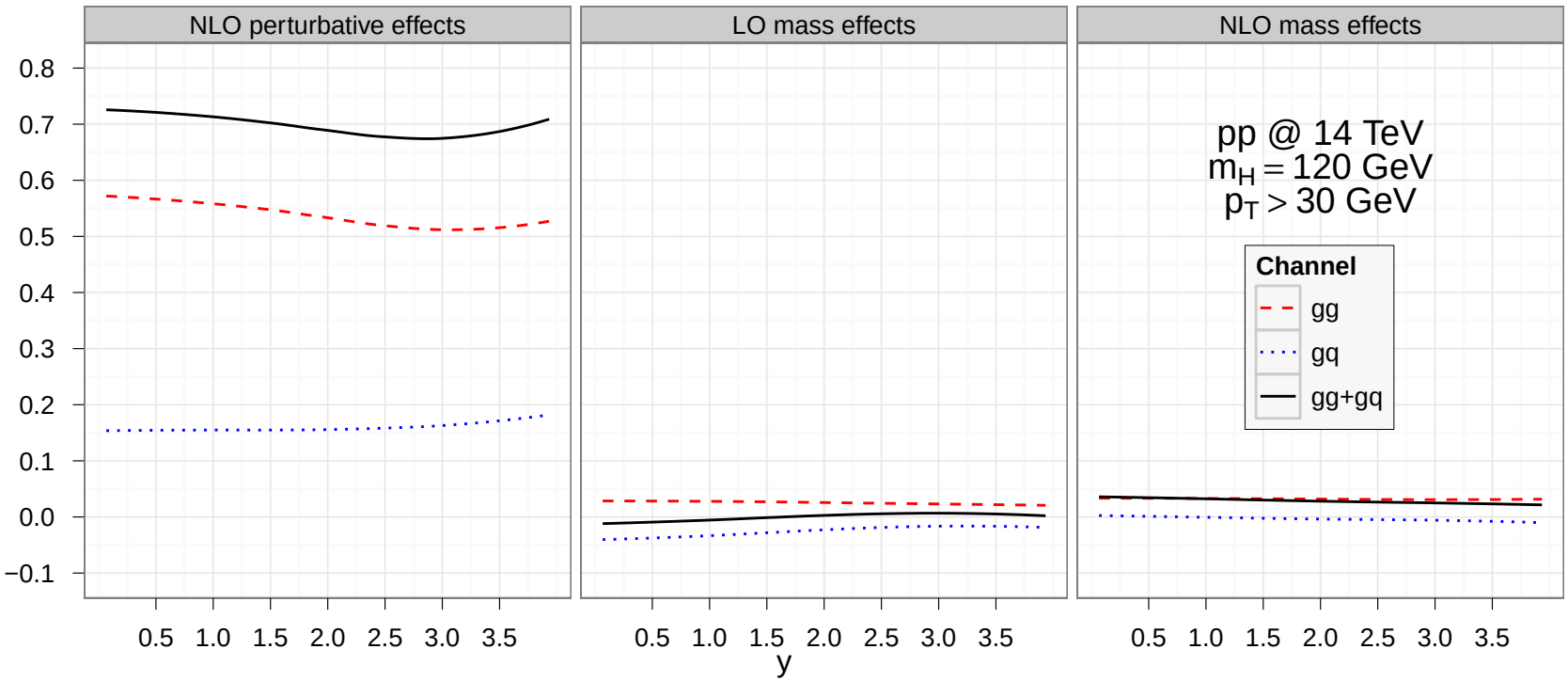
- K-factor for gluon fusion large $\rightarrow$ NLO, NNLO calculations necessary
- LO: 1 loop; N^{n}LO: no efficient multi-loop evaluation
- Effective theory $m_t \rightarrow \infty$ reduces loops by one
  - Total inclusive cross section: error $\simeq 1\%$
  - As yet: Unknown behaviour for non-inclusive processes
- Differential cross section (H+jet):
  - $1/m_t^2$-contributions for gg-channel just a few percent
  - K-factor provides excellent approximation up to $p_T \simeq 150\,\text{GeV}$

Conclusion: Errors in $gg + gq$ for $m_t \rightarrow \infty$ are small compared to uncertainties in PDF, m_b, α_s, α, ...

Thank you for your attention!

Top-mass effects in differential Higgs production through gluon fusion at $\mathcal{O}(\alpha_s^4)$
Harlander, Neumann, Ozeren, Wiesemann: JHEP 08 (2012) 139; arXiv: 1206.0157

Differential cross section dσ/dy



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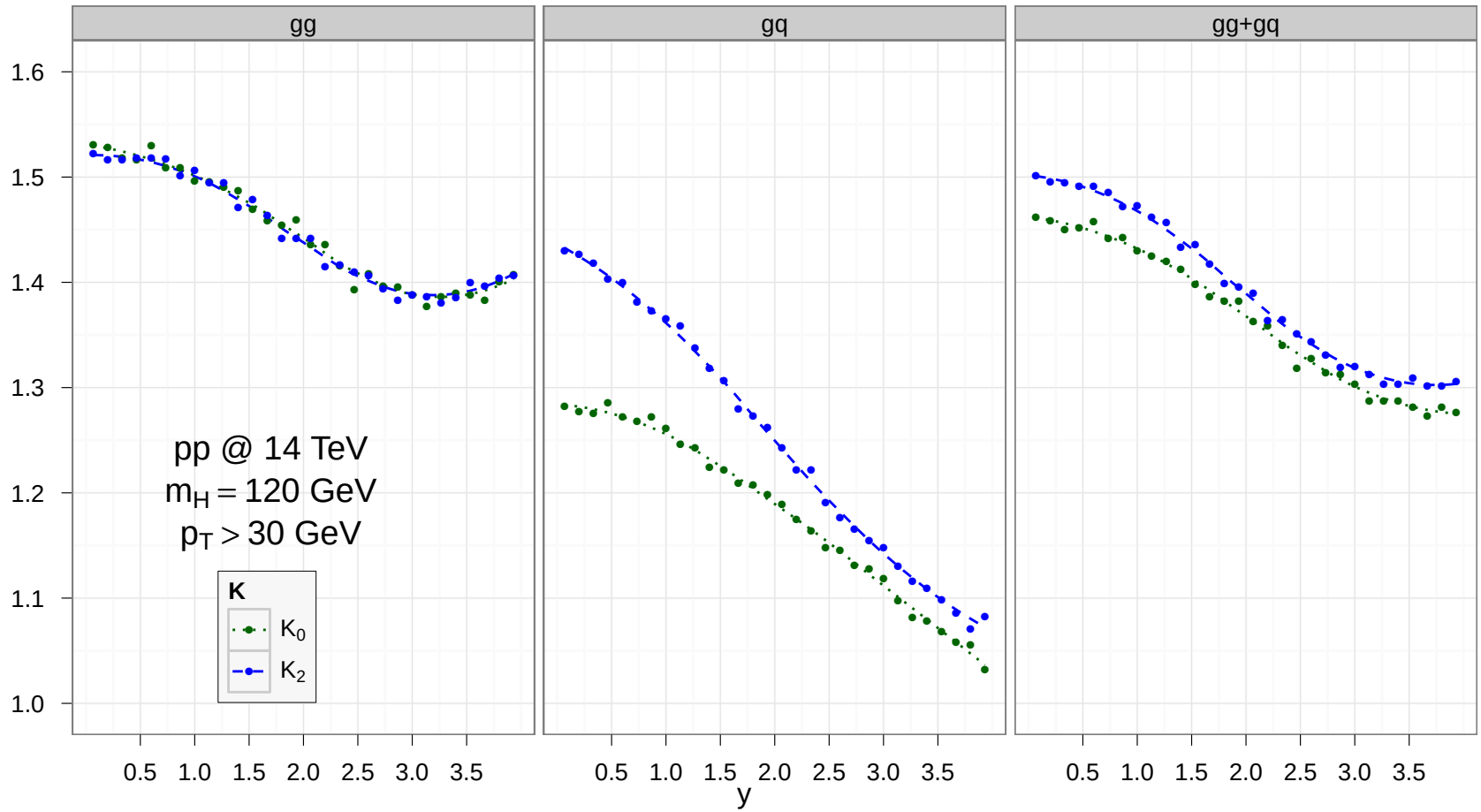

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$1/m_t^2$-terms as given by dimension 7 Higgs-Gluon operators

$$\mathcal{L}_{\text{eff}} = \frac{C_1}{m_t} H \cdot F^a_{\mu\nu} F^{a\,\mu\nu} + \frac{C_2}{m_t^3} H \cdot D_\alpha F^a_{\mu\nu} D^\alpha F^{a\,\mu\nu} + \frac{C_3}{m_t^3} H \cdot F^{a\,\mu}_{\nu} F^{b\,\nu}_{\sigma} F^{c\,\sigma}_{\mu} f^{abc} + \frac{C_5}{m_t^3} H \cdot F^a_{\alpha\nu} D^\nu D^\beta F^{a\,\alpha}_{\beta}$$