FLORIDA STATE UNIVERSITY
COLLEGE OF ARTS & SCIENCES

Higgs Production via Gluon Fusion in the SMEFT at NLO

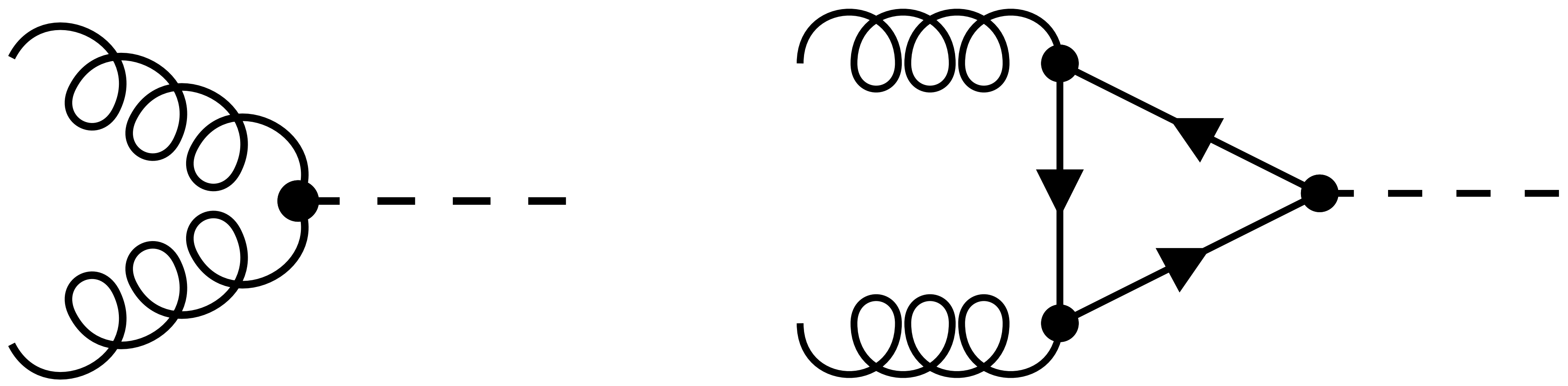
Based on: LB,L.Reina, *arXiv (2026)*

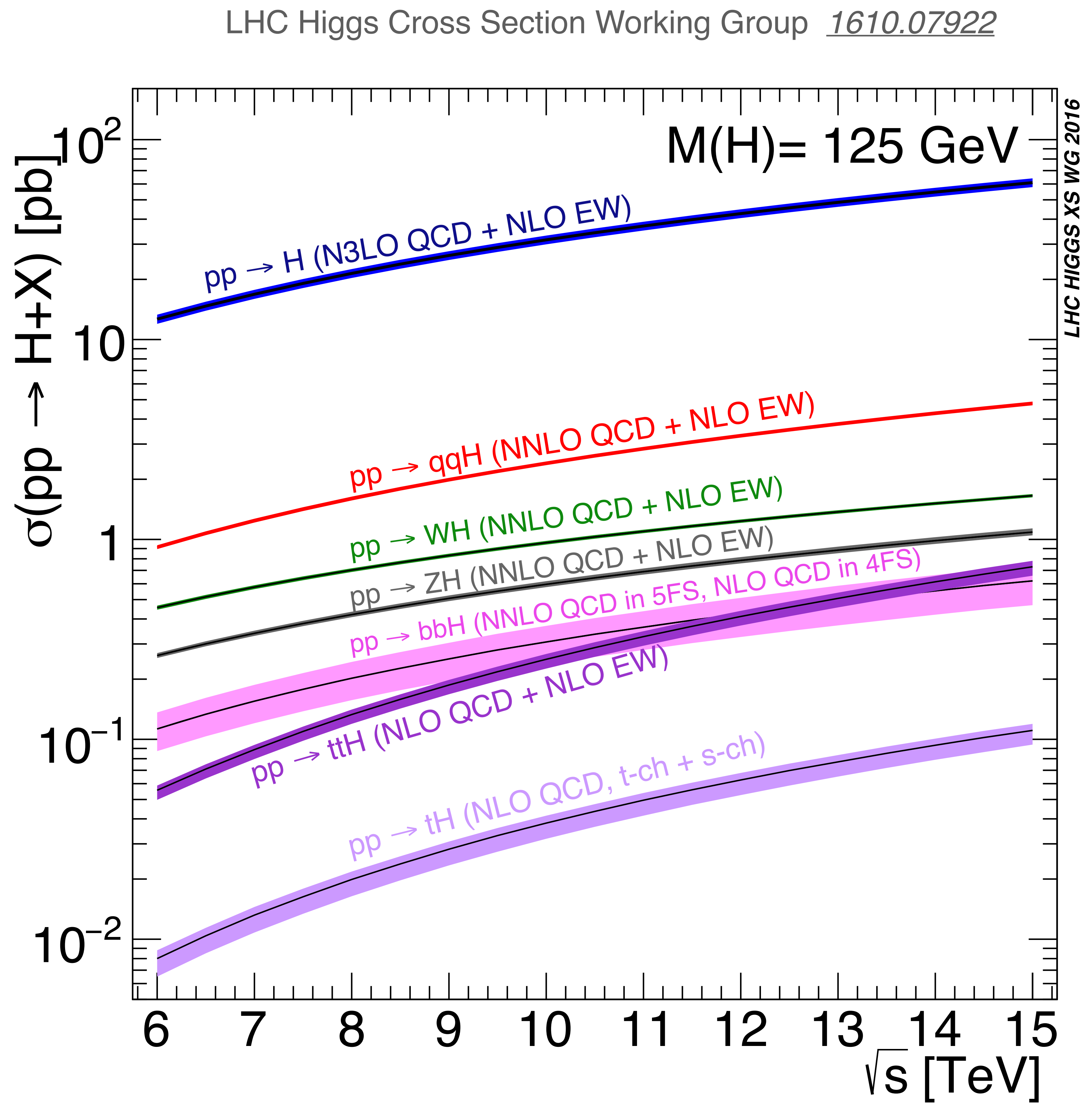
Luigi Bellafronte

Brookhaven, NY, USA *27th May 2026*

Motivation

gg->H

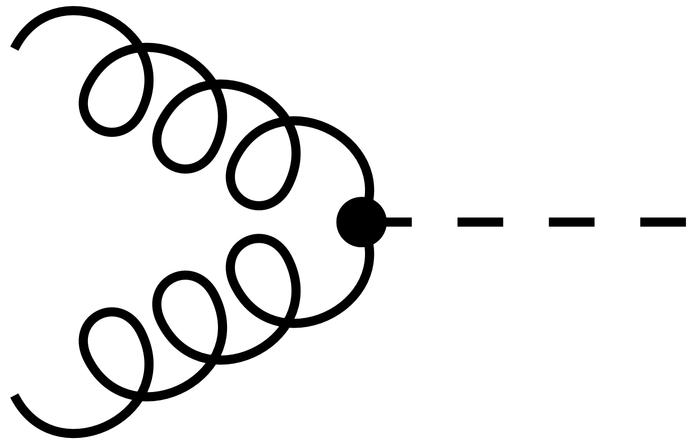
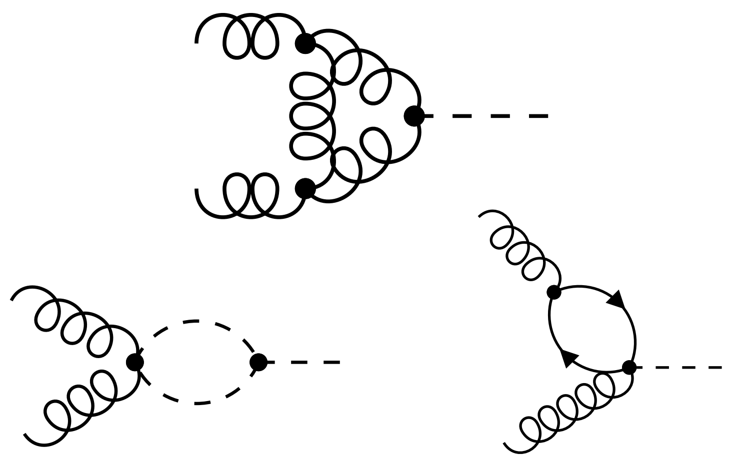
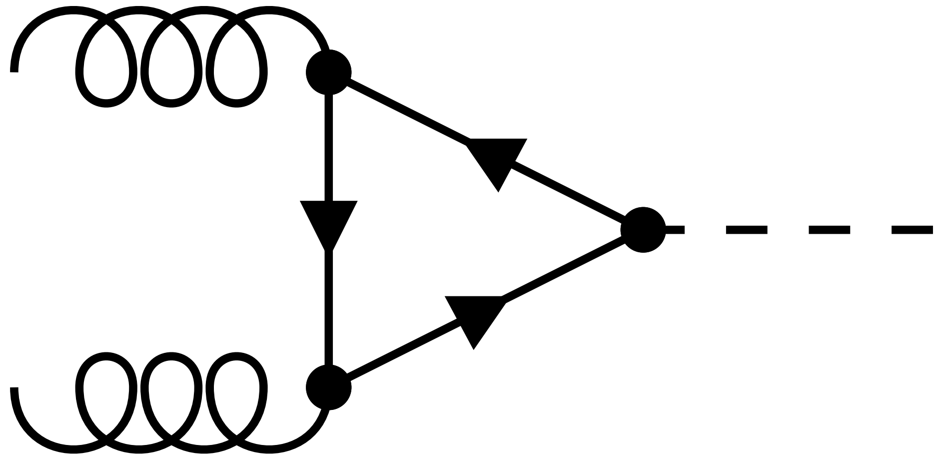
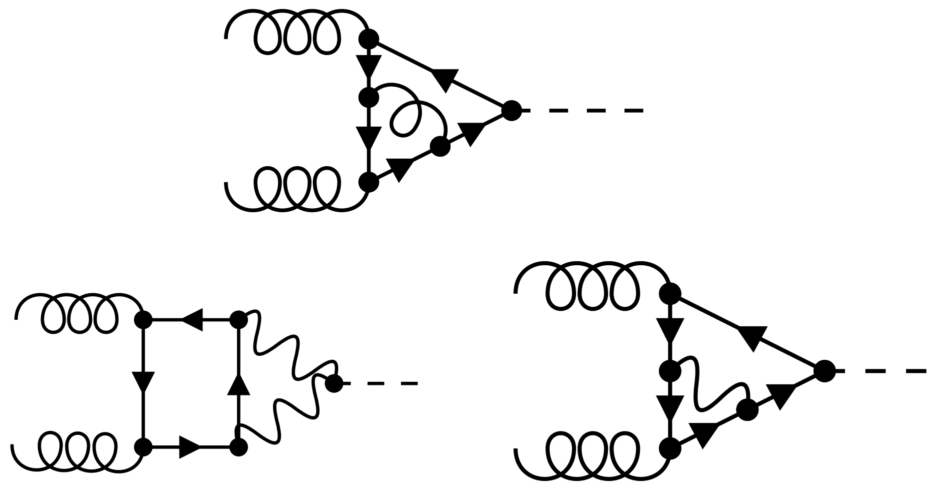




- **Despite being a loop-induced process in the SM, it is highly enhanced by the gluon density in the proton and it provides the most important Higgs-production channel at the LHC.**
- **At HL LHC, further improvement on the uncertainties are expected, therefore more precise calculations are required.**
- **This process can be an highly sensitive probe for new physics.**
- **Our calculation is performed without assumptions on NP, e.g we do not assume it is loop generated.**

Definitions

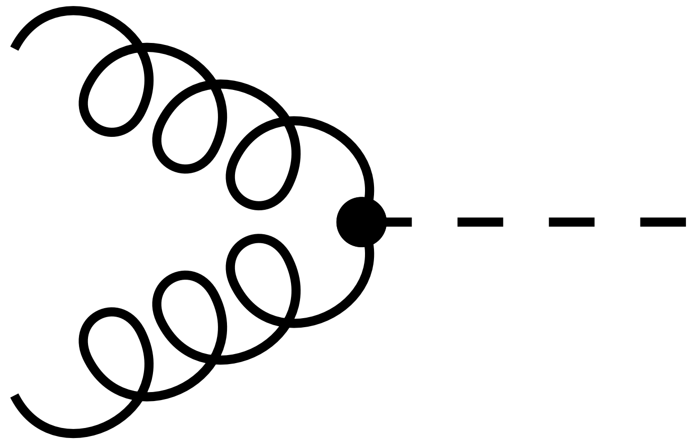
gg->H

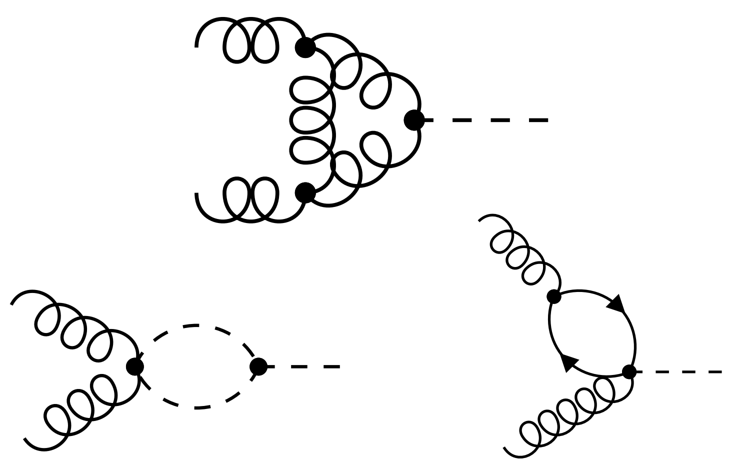





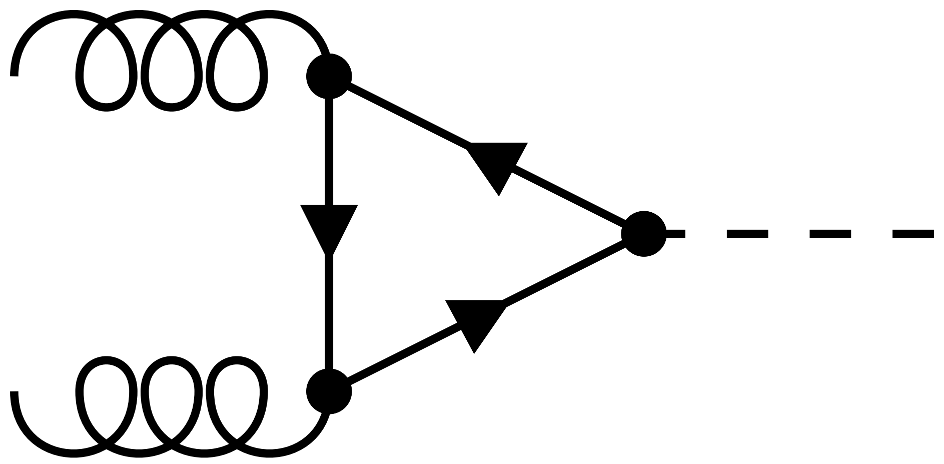
$$A^{\mu\nu} = i\delta_{ab}\left(g^{\mu\nu} - \frac{k_1^{\nu}k_2^{\mu}}{k_1 \cdot k_2}\right)\left[\alpha_{SM}\,F_{SM}^{1l} + \alpha_{SM}^2\,F_{SM}^{2l} + \frac{1}{\Lambda^2}\left(F_{EFT}^{0} + \alpha_{SM}\,F_{EFT}^{1l}\right)\right]$$

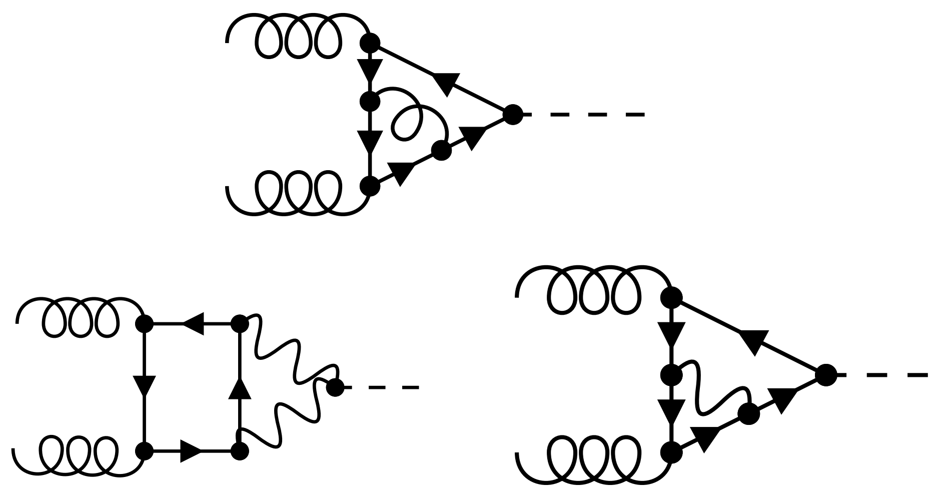
Definitions

gg->H









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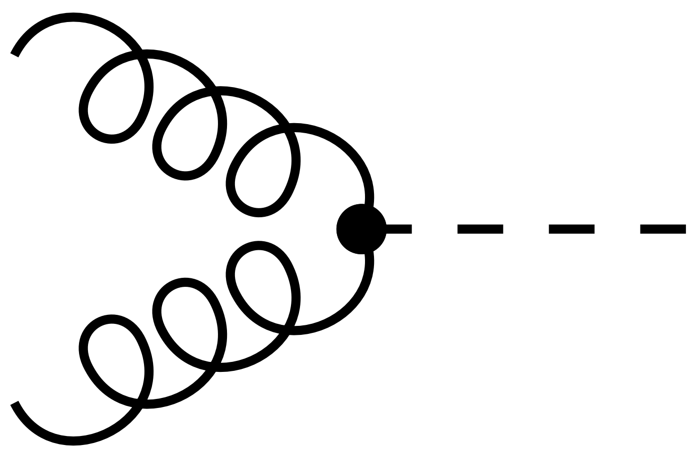

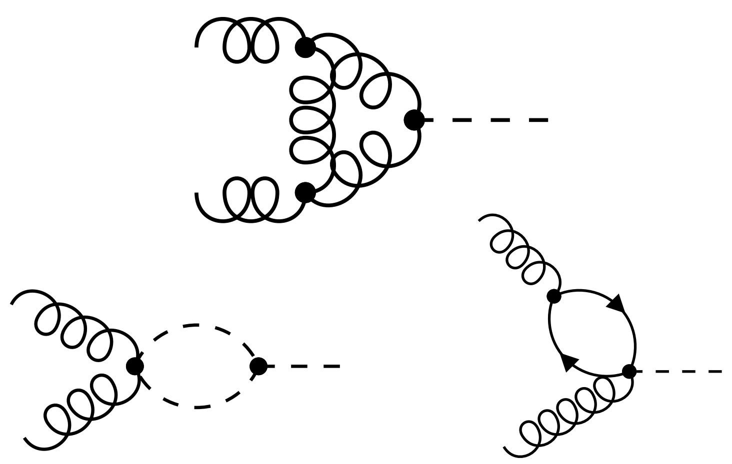

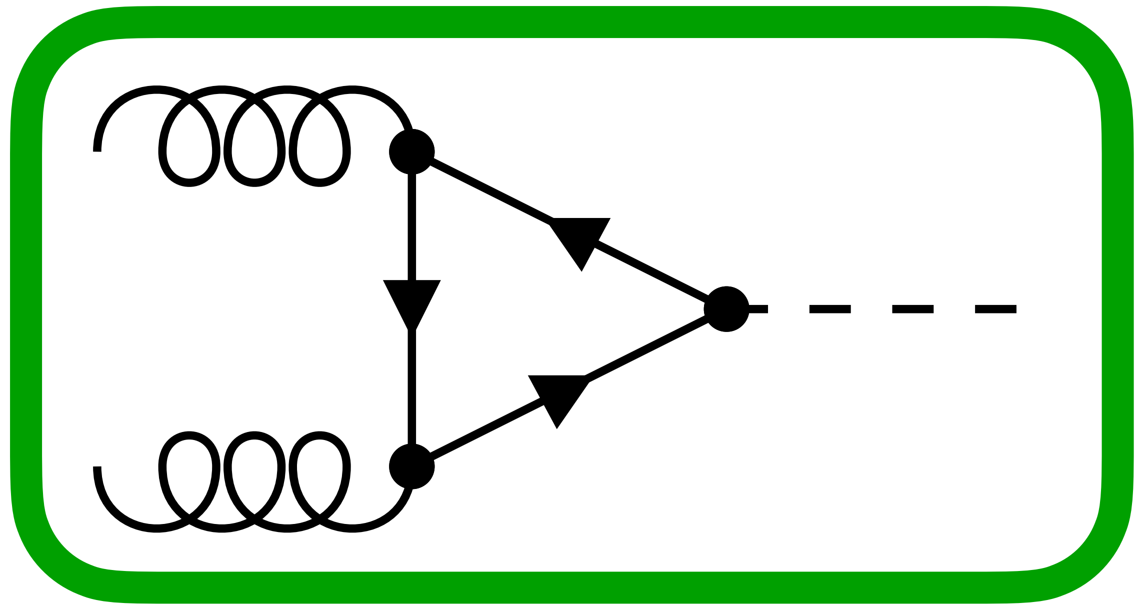

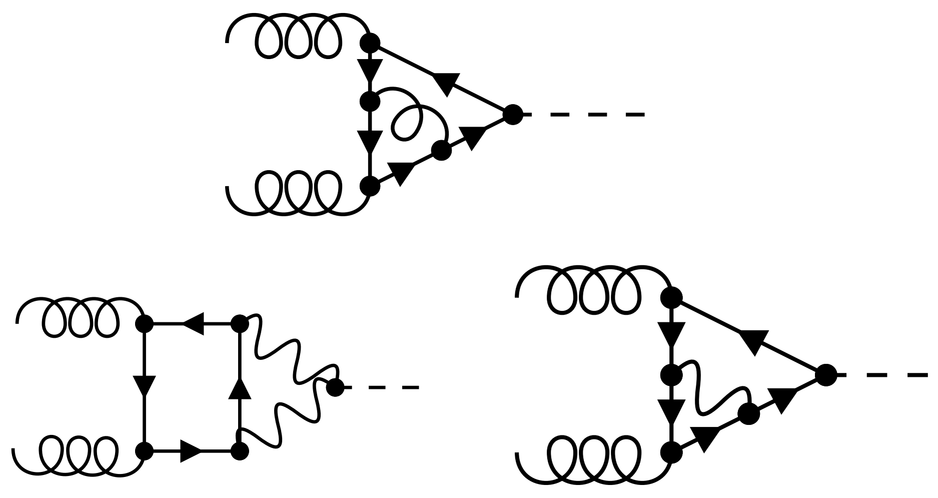

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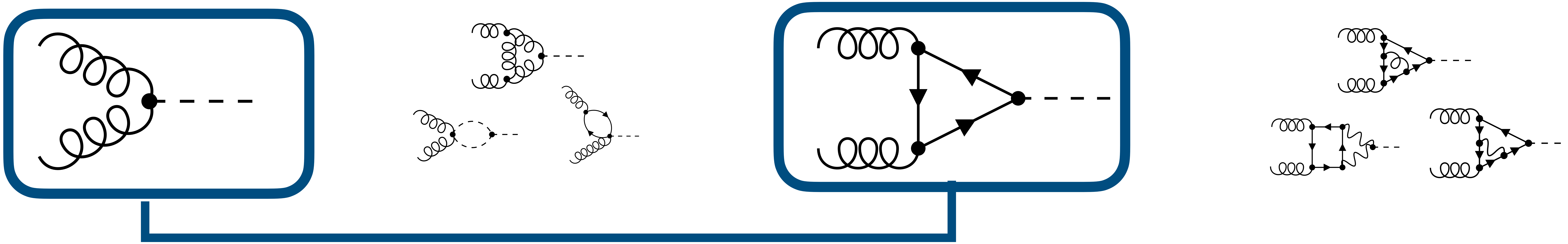

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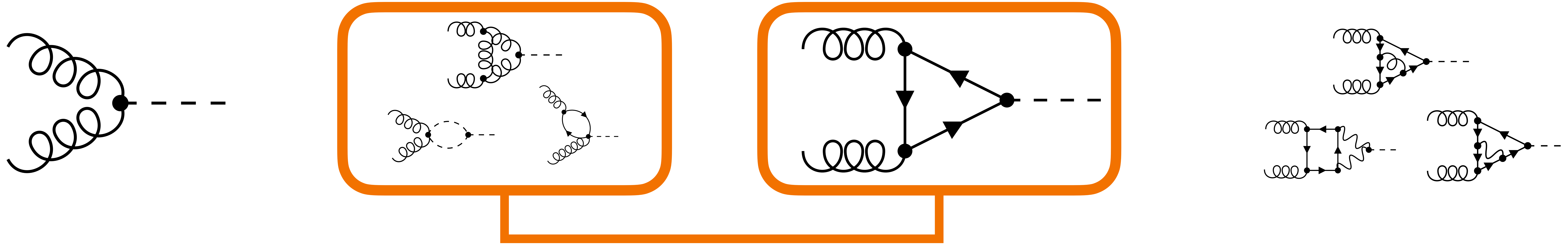

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gg->H

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gg->H

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gg->H

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$$F_{loop} = \sum_k c_k j_k[\nu_1, \nu_2, \nu_3, \ldots]$$

$$j[\nu_1, \nu_2, \nu_3, \ldots] \sim \int \frac{d^D q}{(2\pi)^D} \frac{(q \cdot k_i)^{-\nu_3} \ldots}{(q^2 - m^2)^{\nu_1}((q - k_j)^2 - m^2)^{\nu_2} \ldots}$$

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Feynarts & FeynCalc

gg->H

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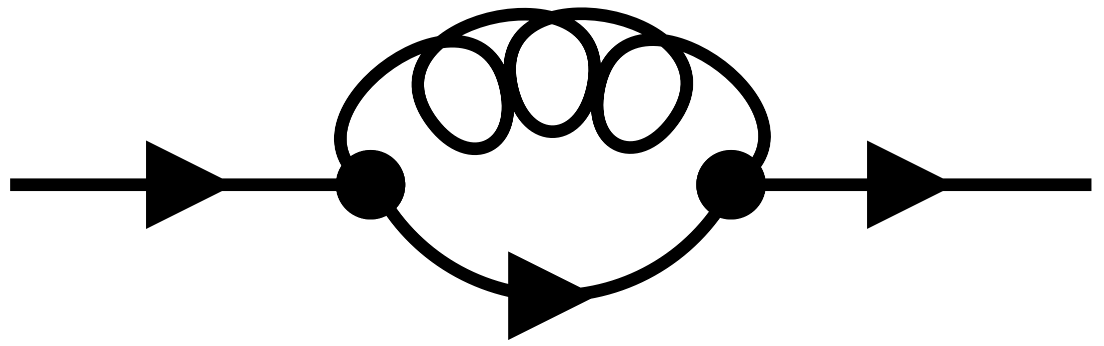
One loop

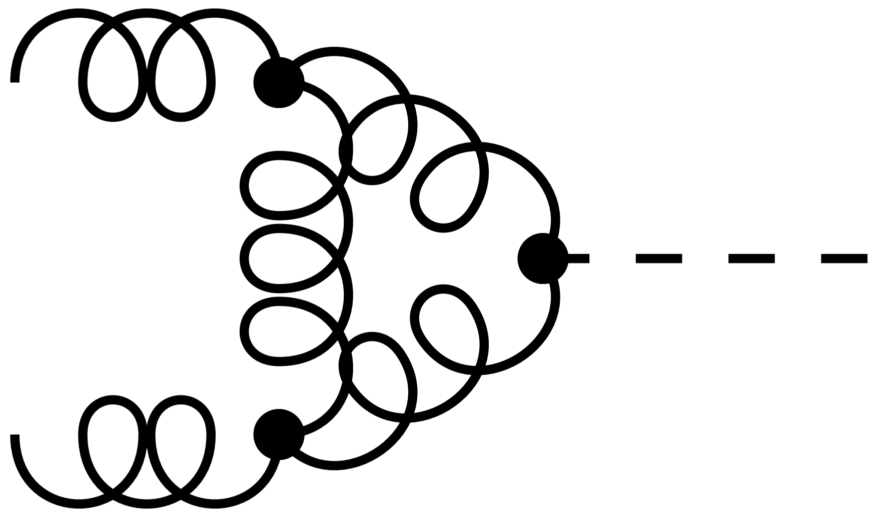
The calculation, including the renormalisation, is straightforward.

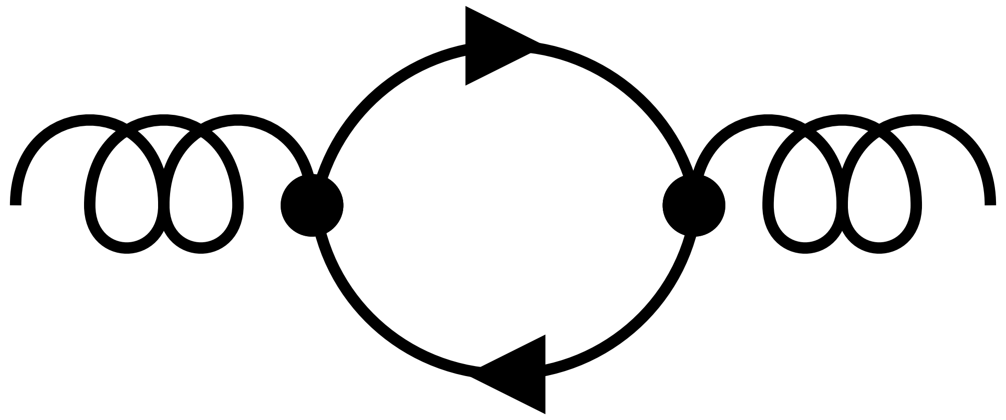
Using Passarino-Veltman reduction, we can reduce the loop integrals in terms of known analytical functions, the so-called PaVe basis (bubble, triangle, etc).

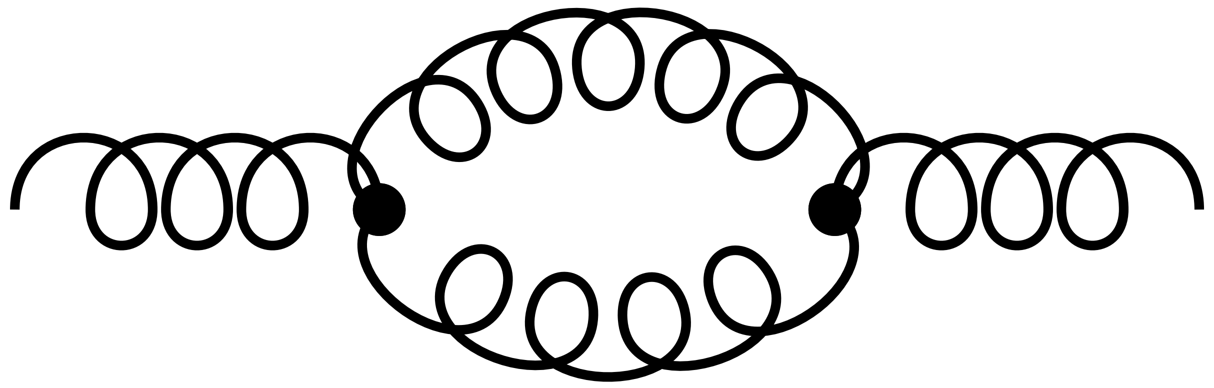
Method

gg->H









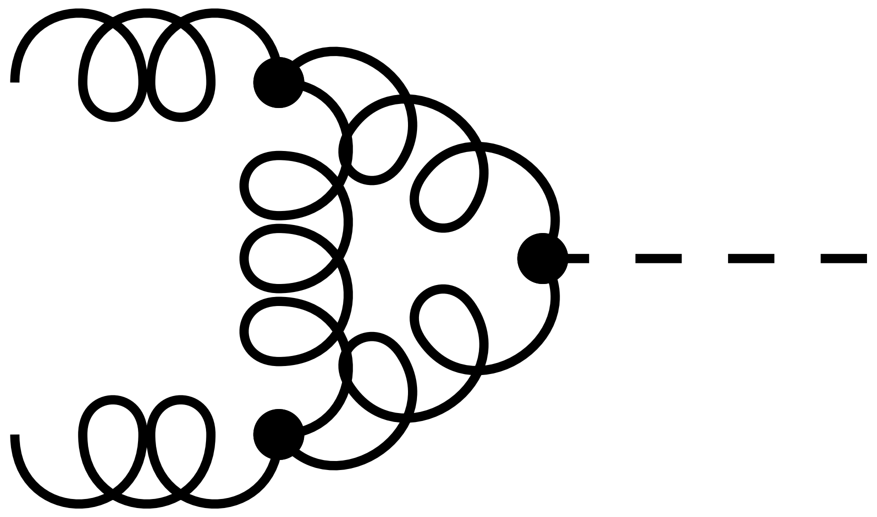
$$\alpha_s^b \Longrightarrow Z_{\alpha_s}\alpha_s$$

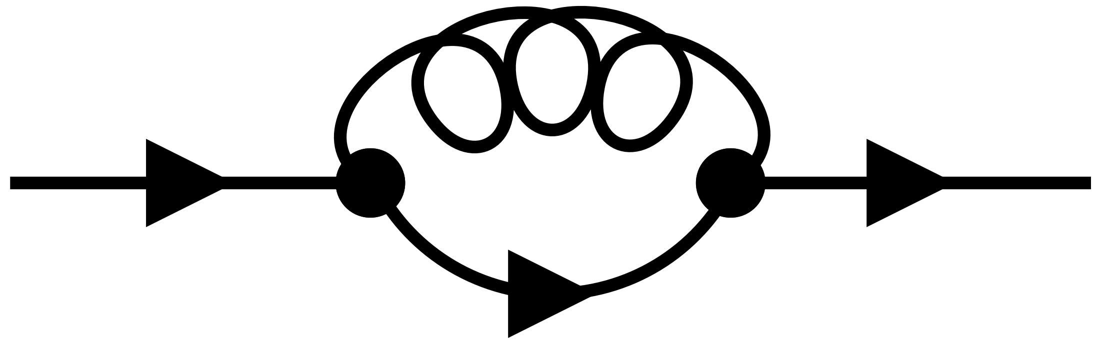
$$g_A^b \Longrightarrow Z_{g_A} g_A$$

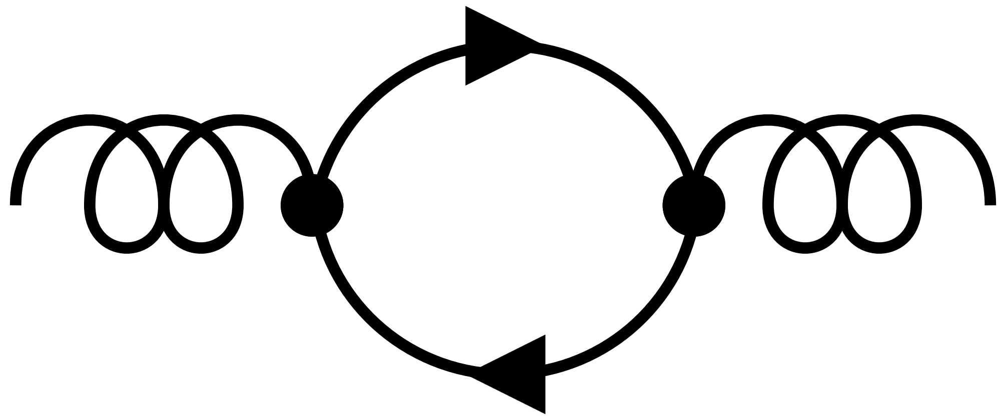
$$m_t^b \Longrightarrow Z_{m_t} m_t$$

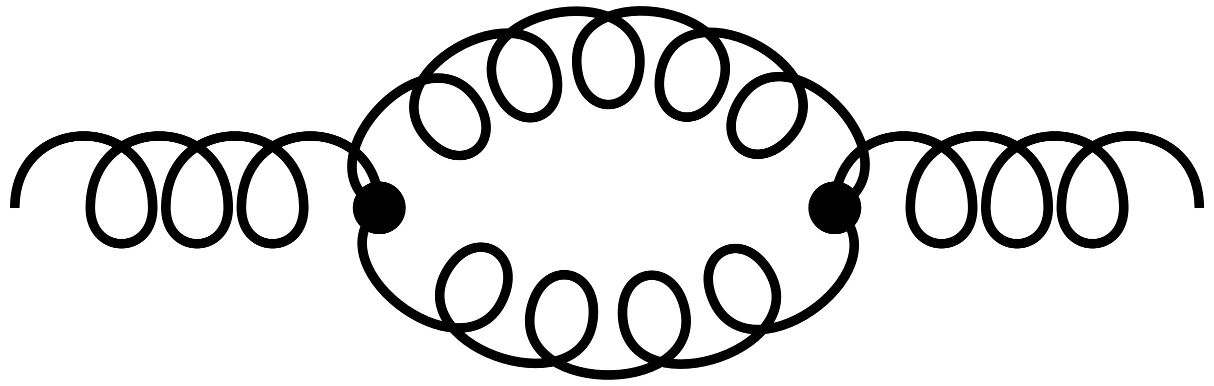
$$C_{\phi G}^b \Longrightarrow Z_{C_{\phi G}} C_{\phi G}$$

gg->H









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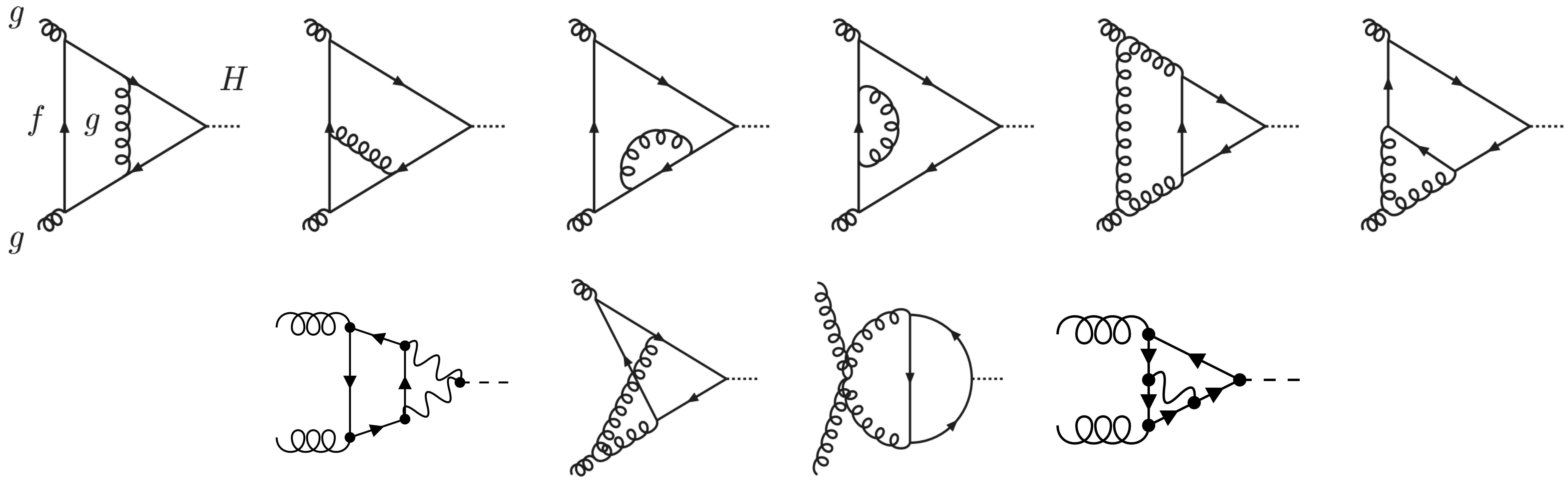
$$C_{\phi G}^b \Longrightarrow Z_{C_{\phi G}} C_{\phi G}$$

E. Jenkins *et al* 1308.2627 E. Jenkins *et al* 1310.4838
R.Alonso *et al* 1312.2014

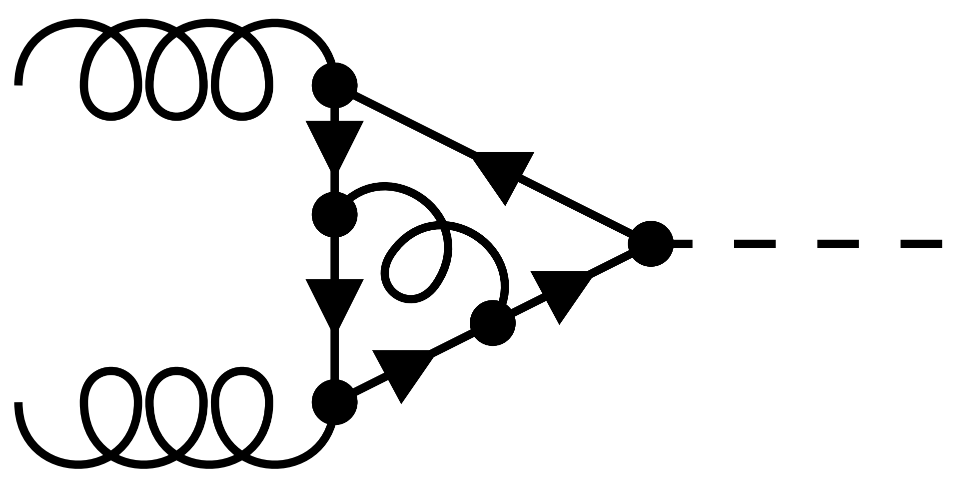
gg->H

At two loop the situation is more complicated. We have more Feynman diagrams and more complicated Feynman integral to deal.



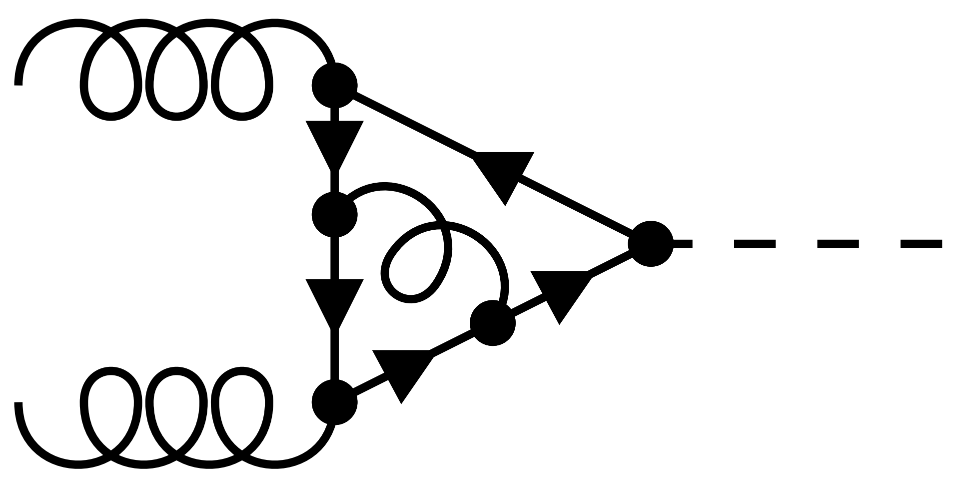
The first step is to reduce the number of integrals one need to compute ($O(1000)$) in order to evaluate them numerically.

Integration-By-Parts (IBP) equations is a powerful technique used to simplify and reduce the number of integrals needed to compute multi-loop Feynman diagrams.



81

Integration-By-Parts (IBP) equations is a powerful technique used to simplify and reduce the number of integrals needed to compute multi-loop Feynman diagrams.



81

IBP →

FIRE
(1901.07808)
LiteRed
(1310.1145)

Method

gg->H

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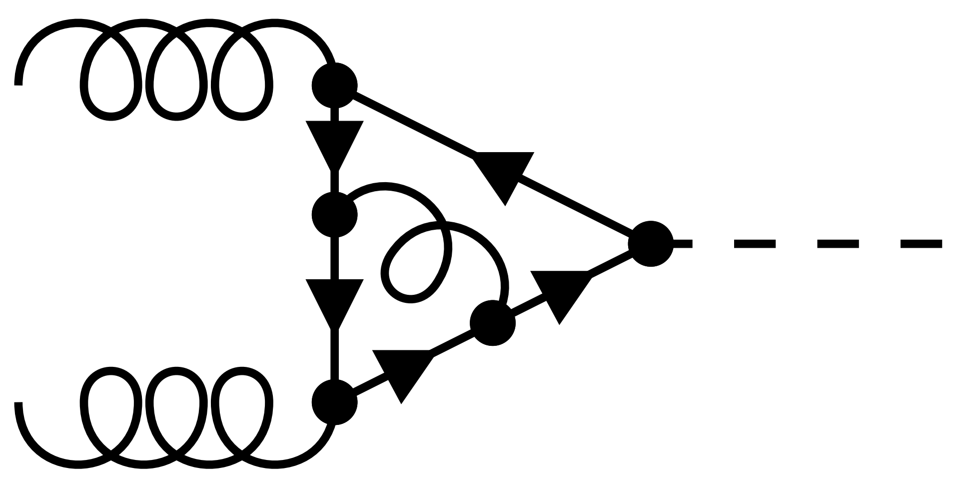

81 → **IBP** → 7

FIRE
(1901.07808)
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gg->H

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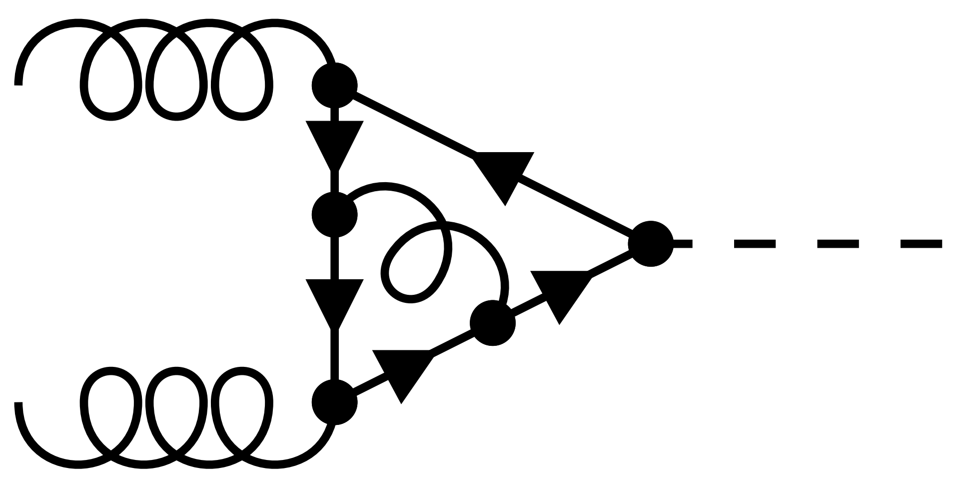
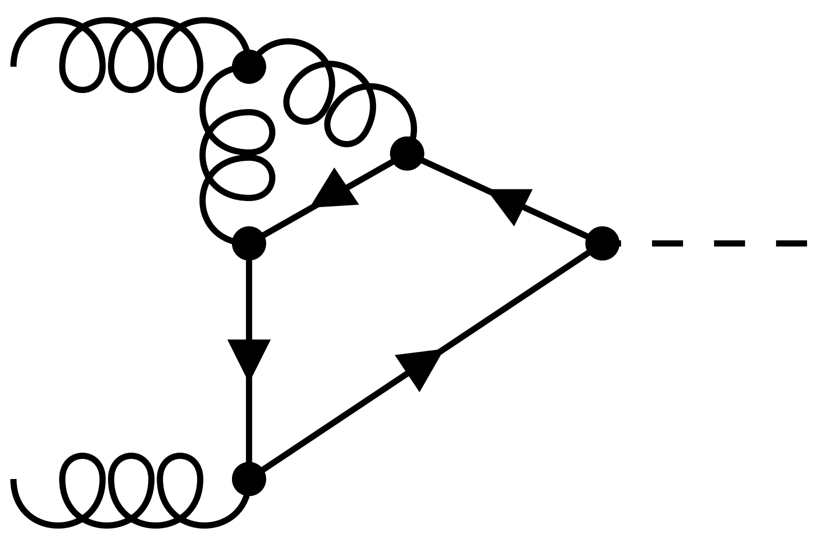


81 → **IBP** → 7



68 → 4

FIRE

(1901.07808)

LiteRed

(1310.1145)

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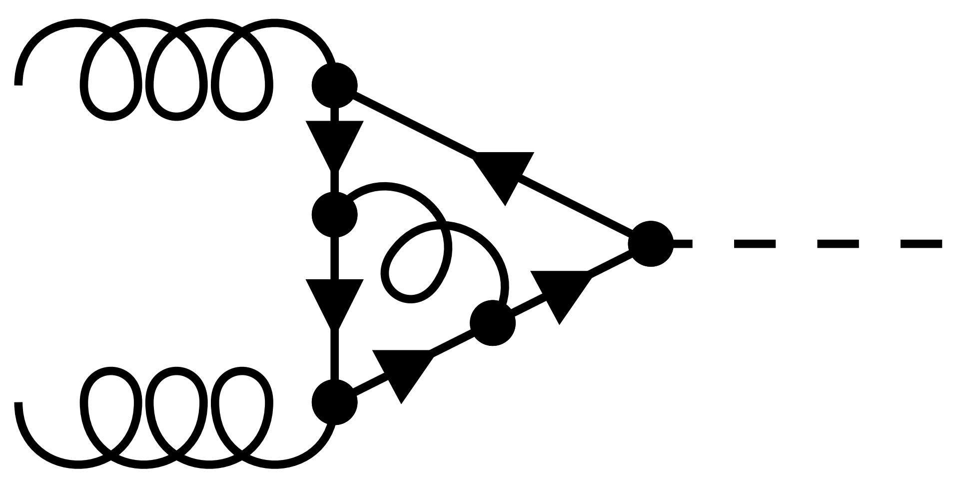

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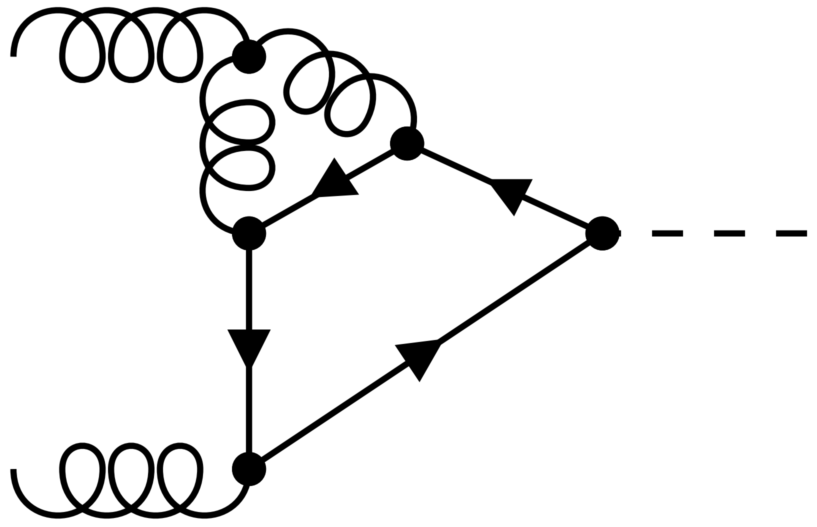

4

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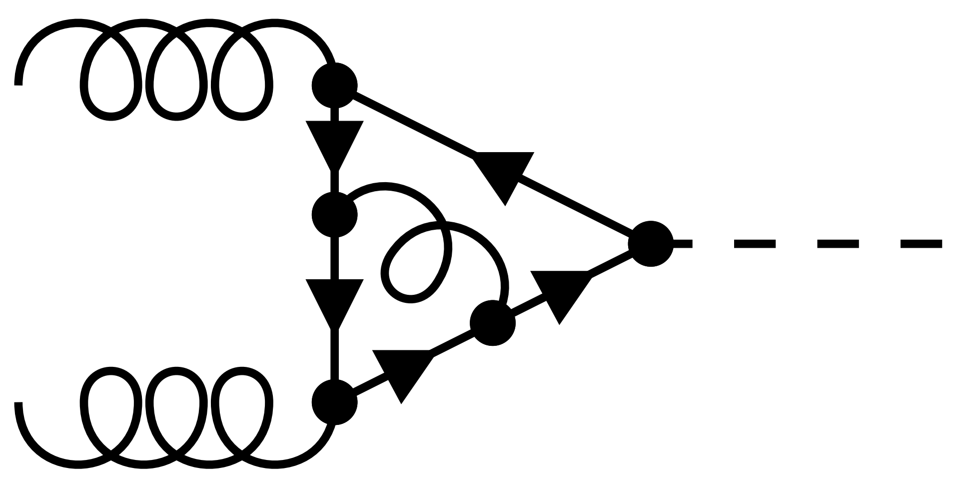

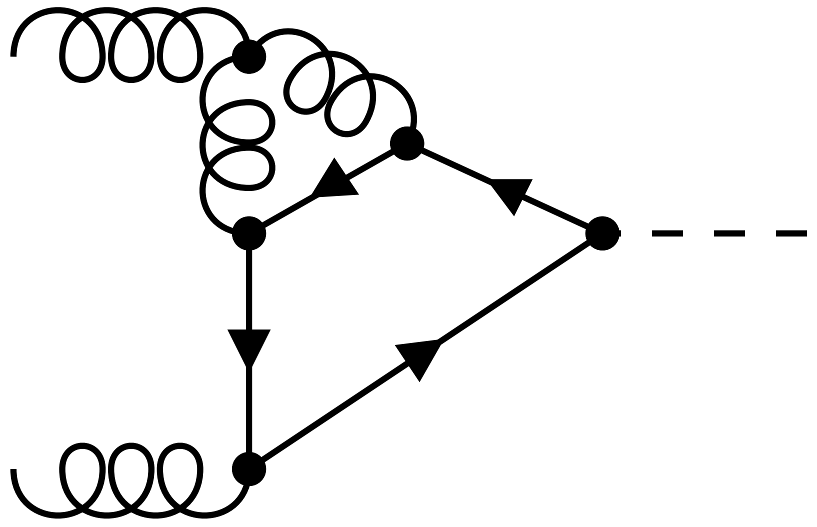

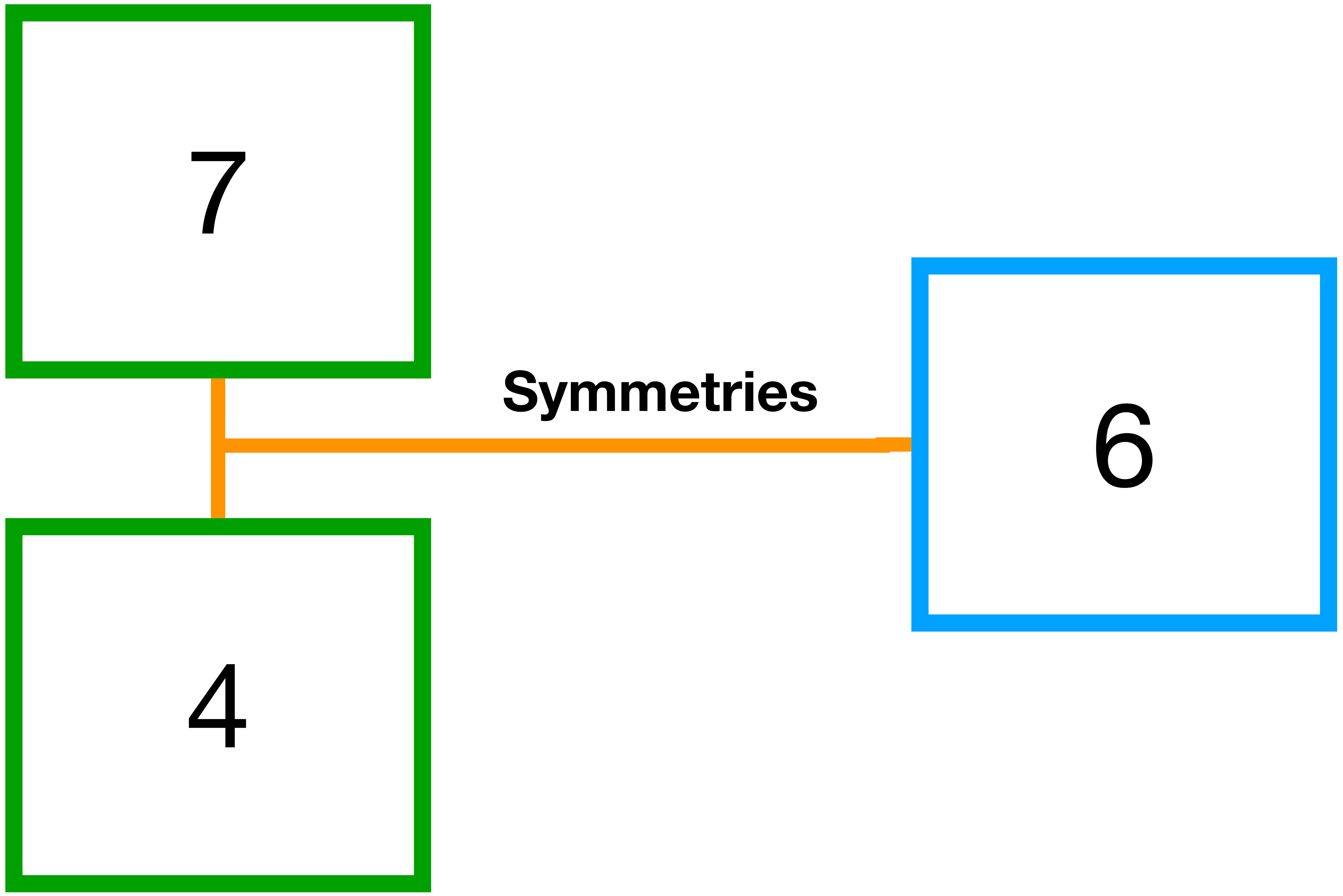

gg->H

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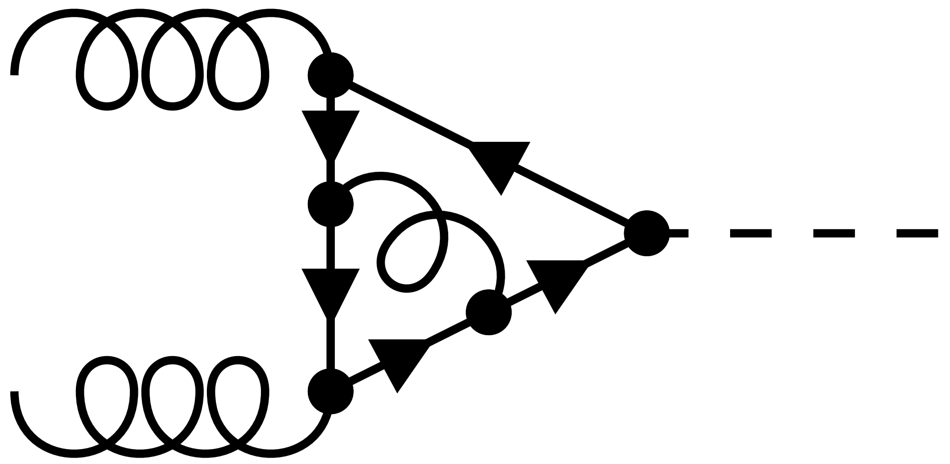
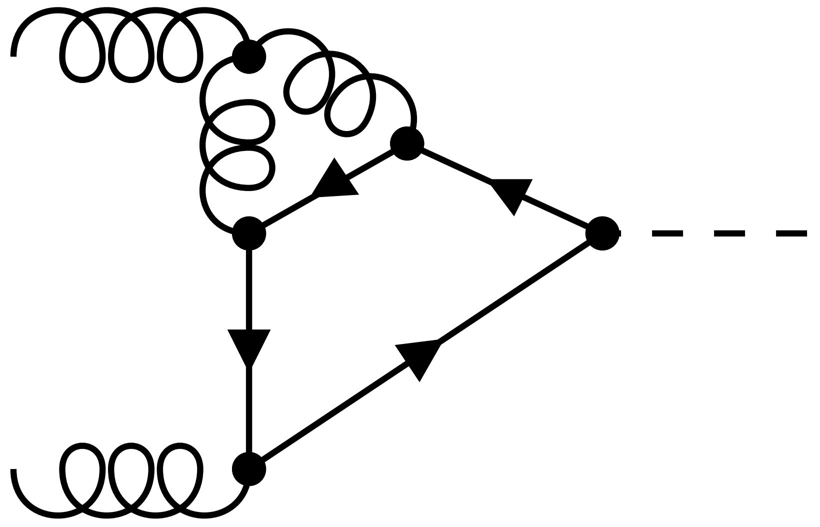
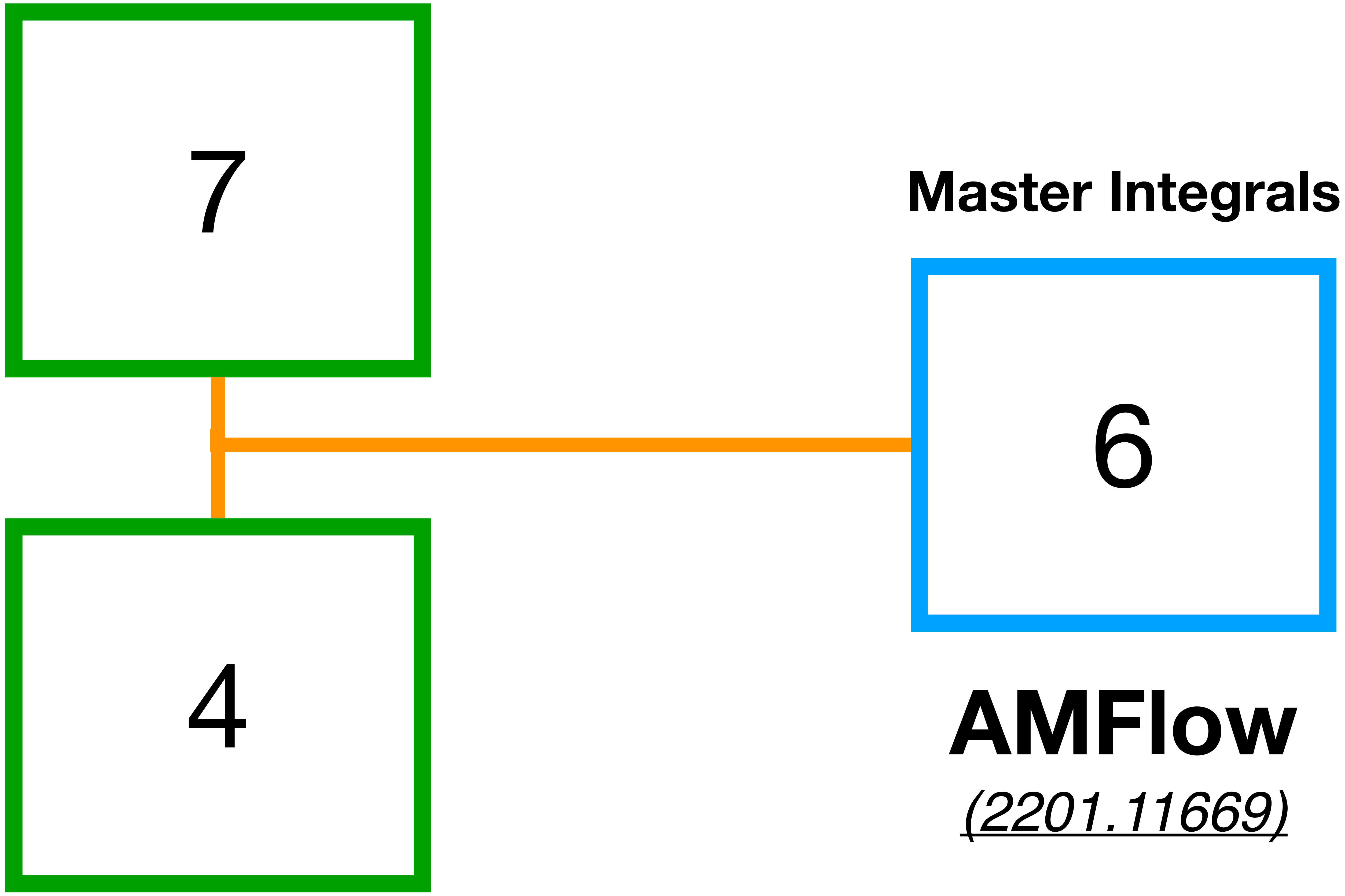
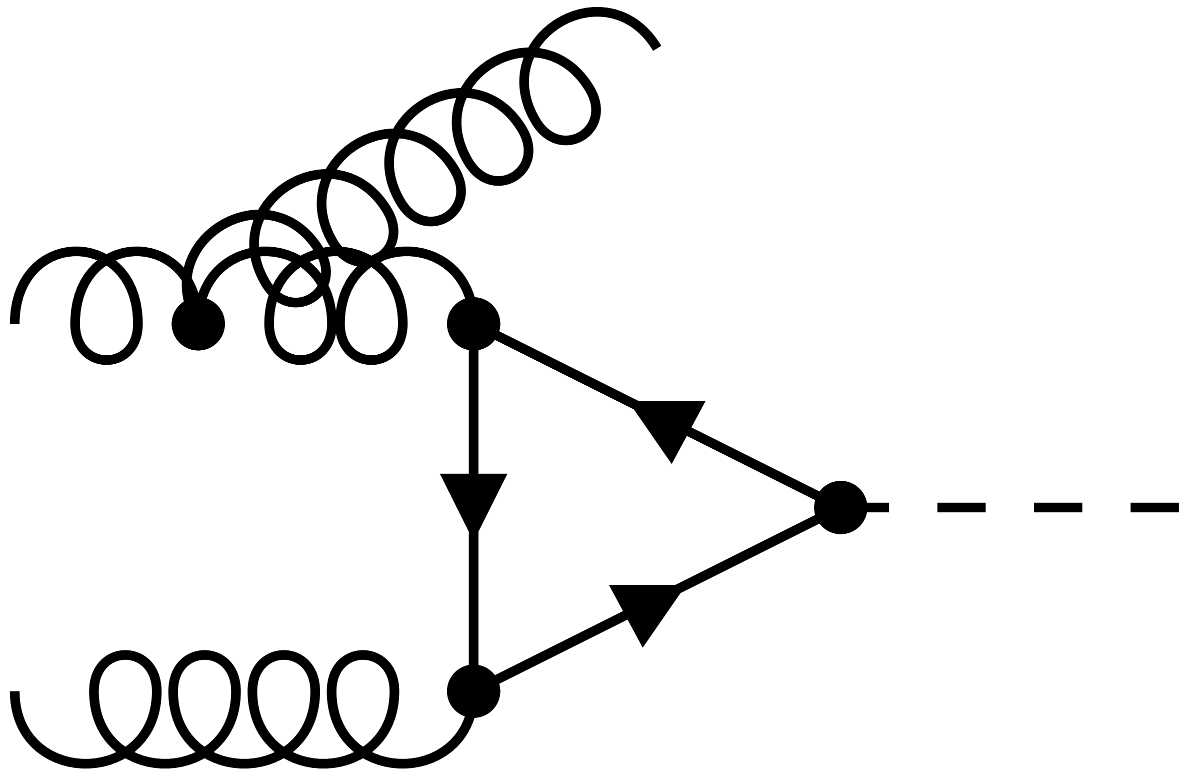


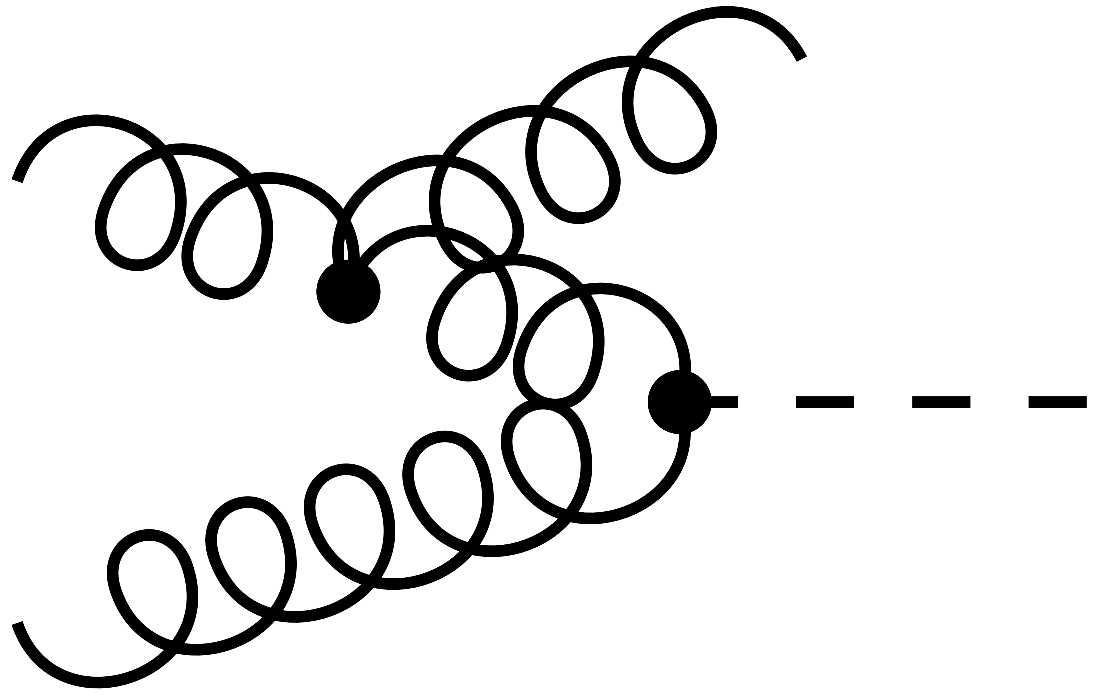




Real corrections

gg->Hg



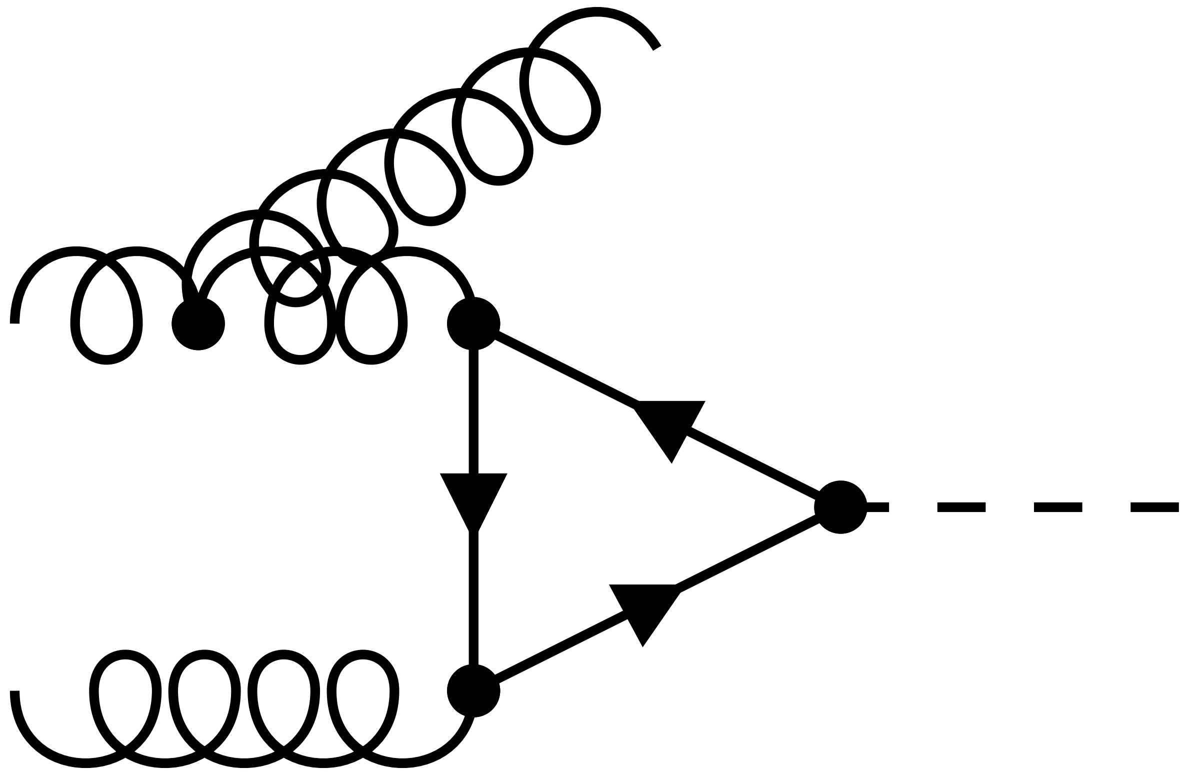


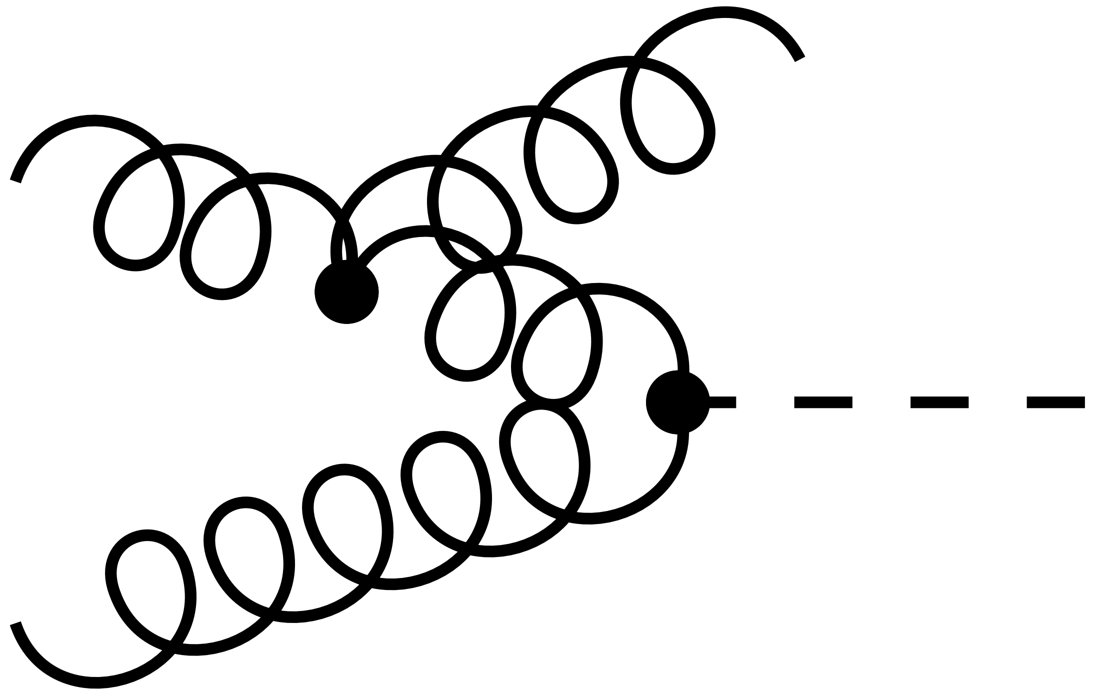
$$\sigma_{soft+coll} = \sigma_0 \frac{\alpha_s}{2\pi}\left[\frac{\Gamma[1-\epsilon]}{\Gamma[2-\epsilon]}\left(\frac{4\pi\mu^2}{s}\right)^{\epsilon}\right]\left(\frac{C_A}{\epsilon^2}+\frac{\beta_0}{2\epsilon}+c_0\right)$$

Harris, B. W. and Owens, J. F. *et al* *0102128*

Real corrections

gg->Hg





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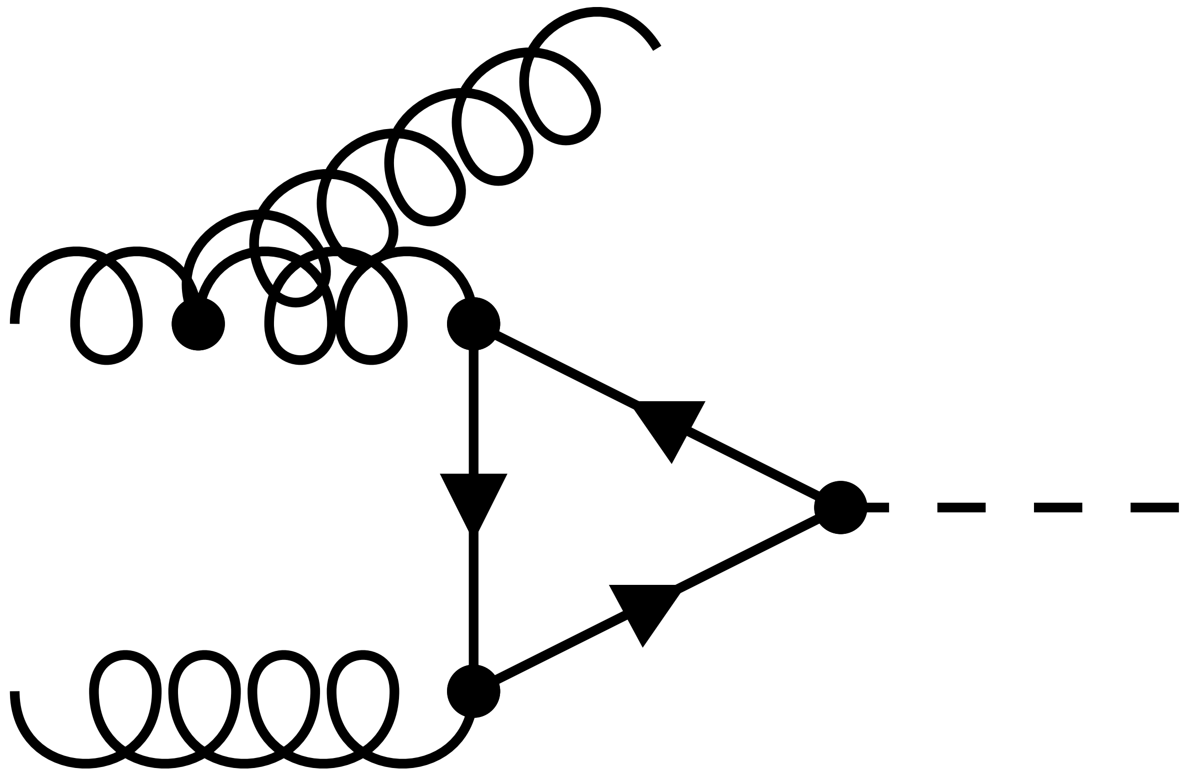
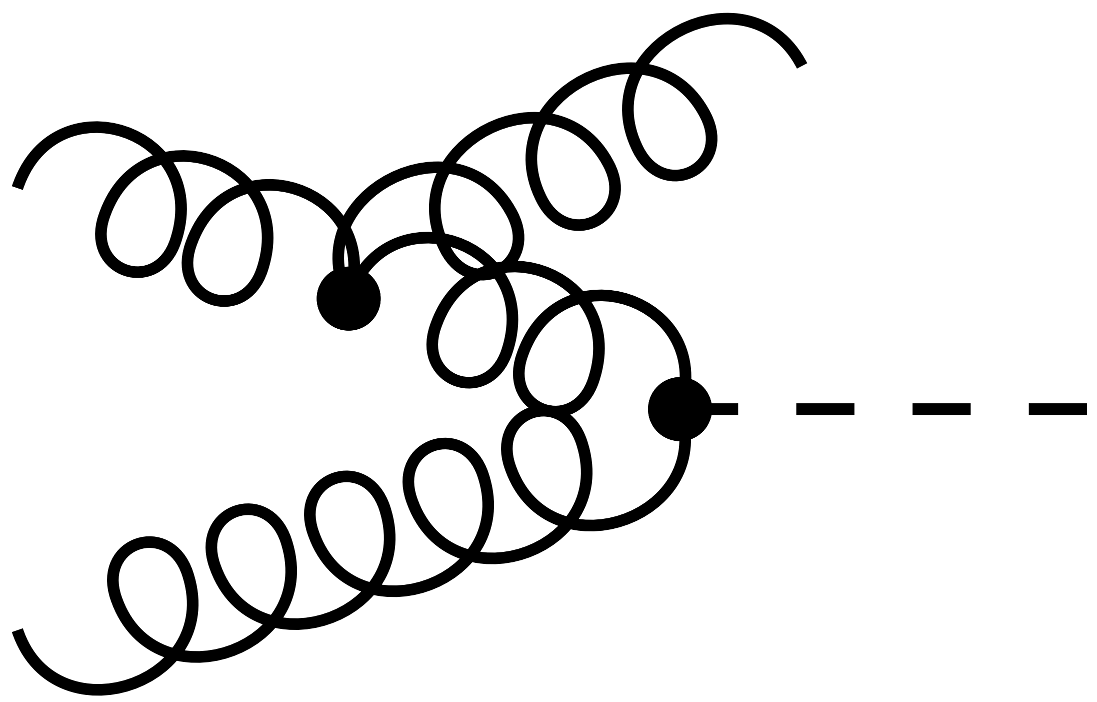
Catani term

Harris, B. W. and Owens, J. F. *et al* *0102128*

Real corrections

gg->Hg





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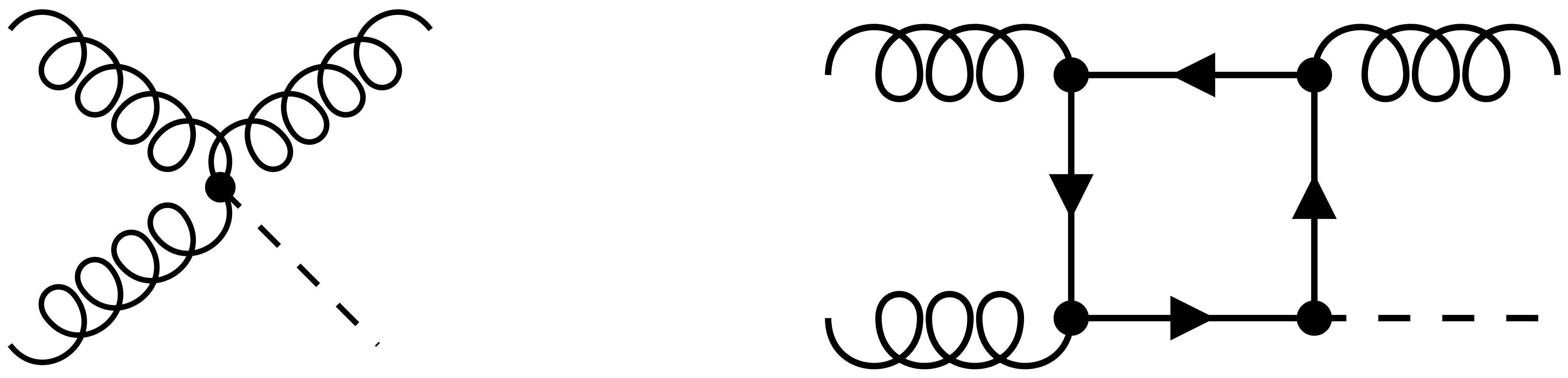
Finite+cutoff terms

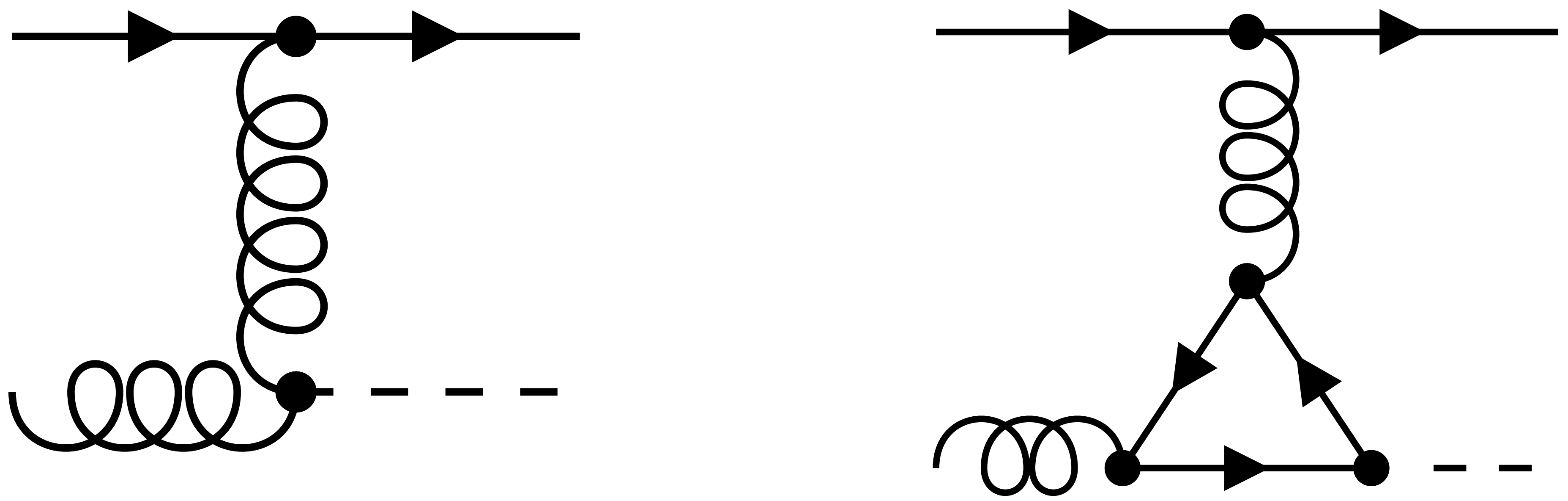
Harris, B. W. and Owens, J. F. *et al* 0102128

Real corrections

gg->Hg

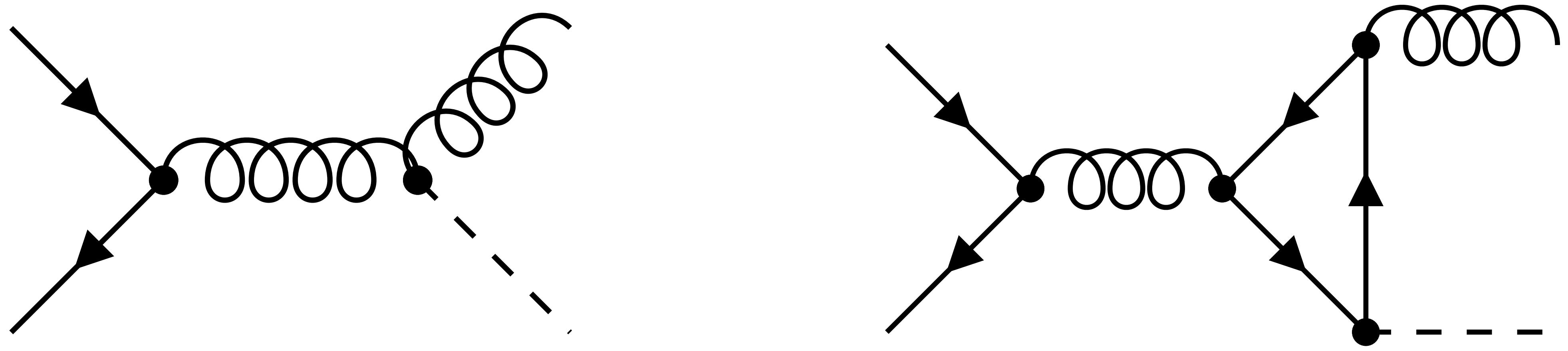


qg -> qH



$$\sigma_{real}^{2\to2} = \frac{1}{2s}\int |A_i|^2 d\Gamma_2$$

q$\bar{\text{q}}$ -> gH



Real corrections

$$\sigma_{real}^{2\to2} = \frac{1}{2s}\int |A|^2 d\Gamma_2$$

Results

$$\mu_{ggh} \equiv \frac{\sigma_{SMEFT}}{\sigma_{SM}}$$

$$\mu_{ggh}^{exp} = 1.03 \pm 0.04$$

$$|\mu_{ggh} - \mu_{ggh}^{exp}| < 2\delta_{\mu}$$

Wilson Coefficient	95% CL ranges
$C_{\phi G}$	$\{-0.0017, 0.0037\}$
$C_{uG}[3,3]$	$\{-0.1191, 0.0541\}$
$C_{u\phi}[3,3]$	$\{-0.8979, 0.4081\}$
C_{ll}	$\{-0.8248, 1.8145\}$
$C_{\phi\Box}$	$\{-0.4124, 0.9072\}$
$C_{\phi D}$	$\{-3.6289, 1.6495\}$
$C_{\phi l}^{(3)}$	$\{-0.9072, 0.4124\}$

Numerical bounds for the dimension-six Wilson coefficients at $\mathcal{O}(\frac{1}{\Lambda^2})$

Results

Deutschmann *et al 1708.00460*

$$-0.0025 < C_{\phi G} < 0.0043$$

$$-0.12 < C_{uG}[3,3] < 0.21$$

De Blas *et al 2507.06191*

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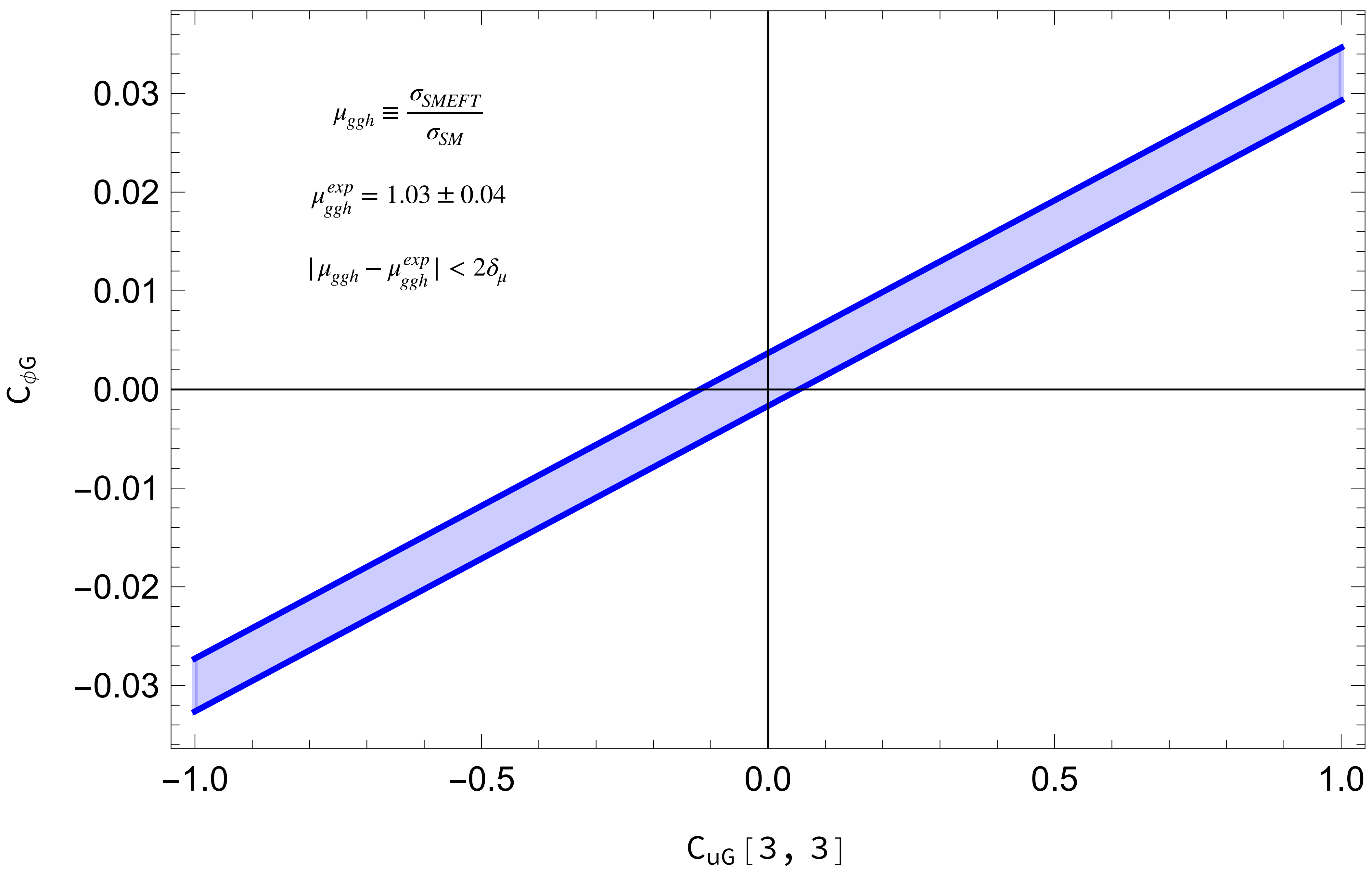
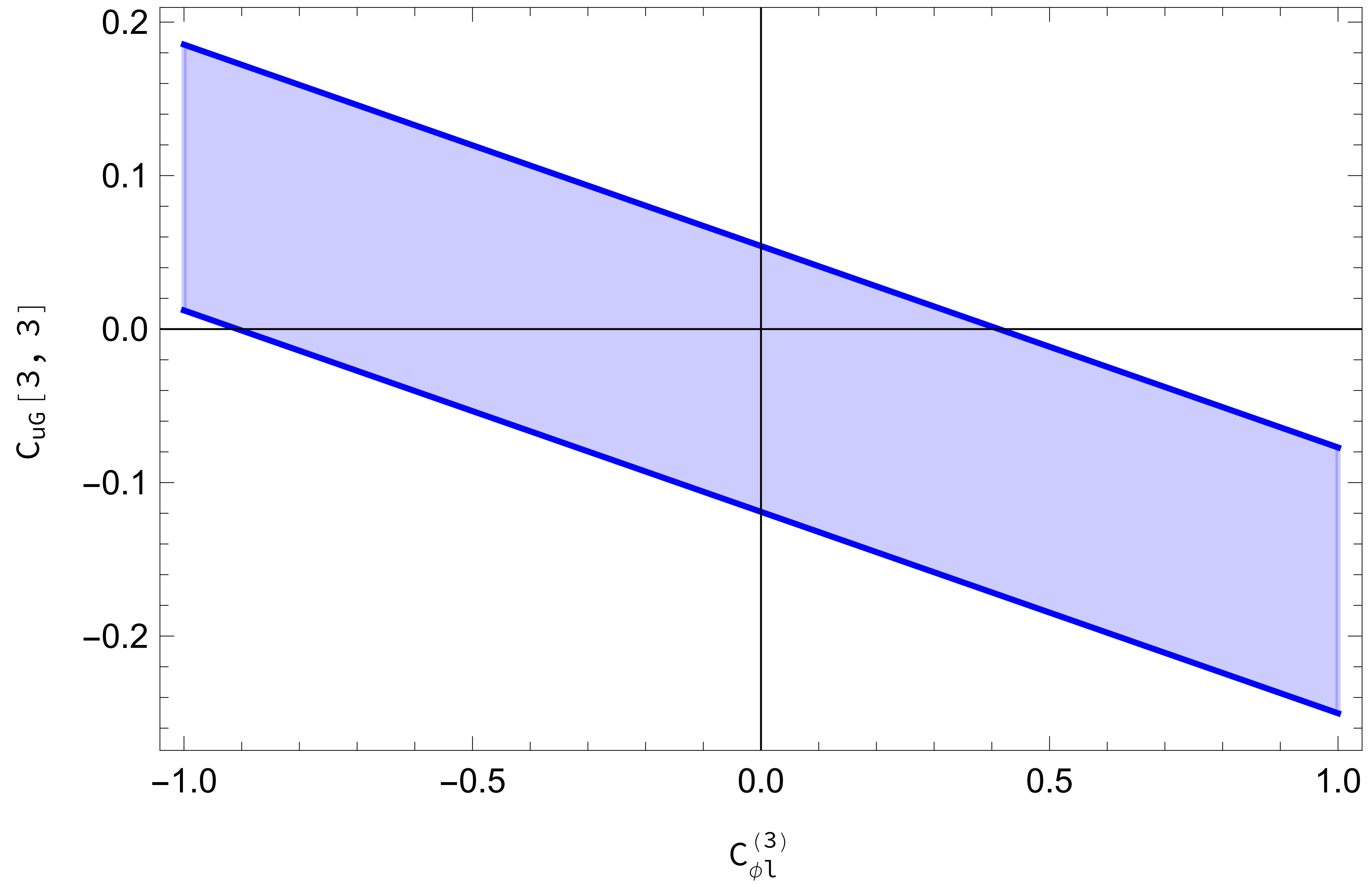
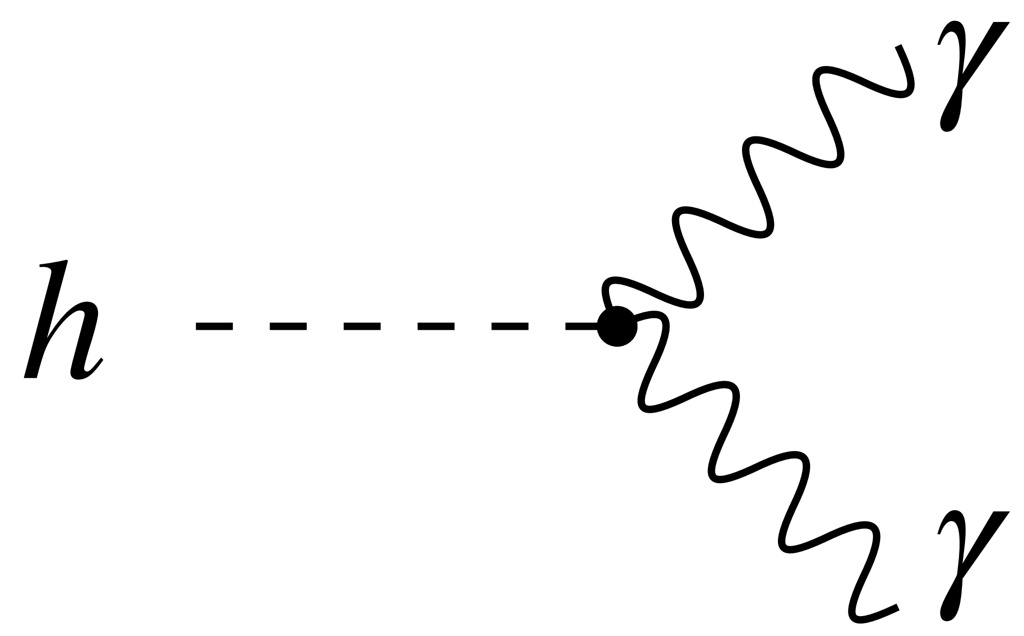
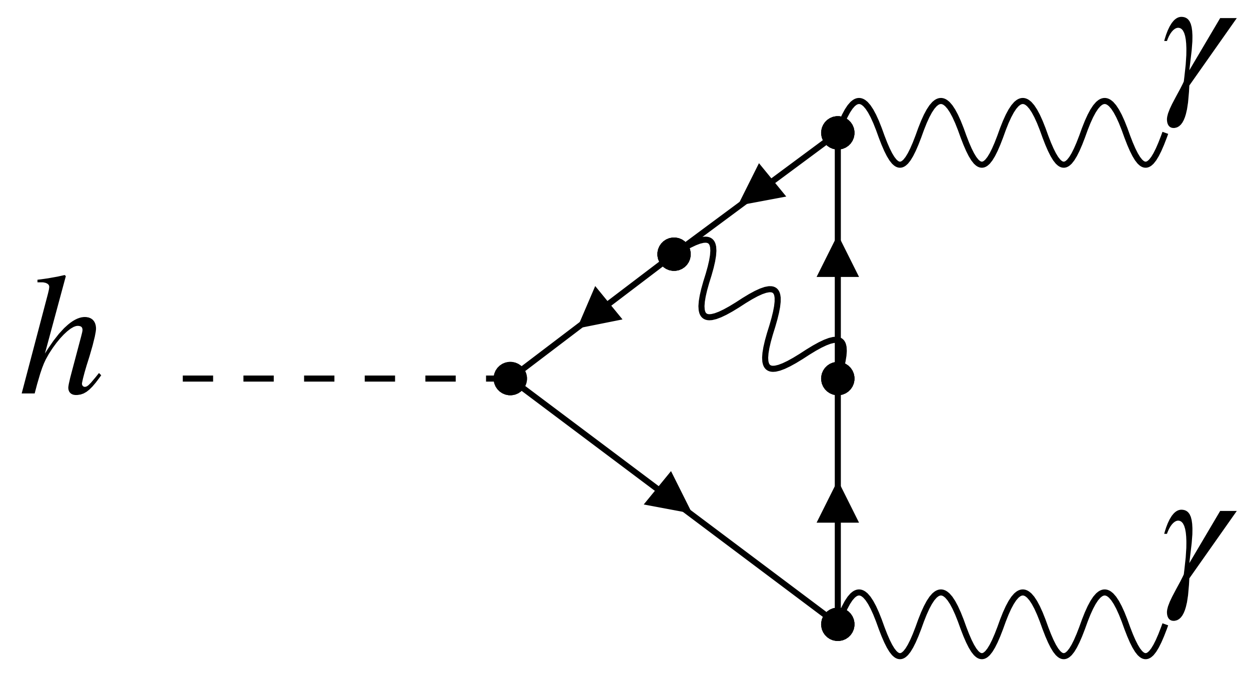




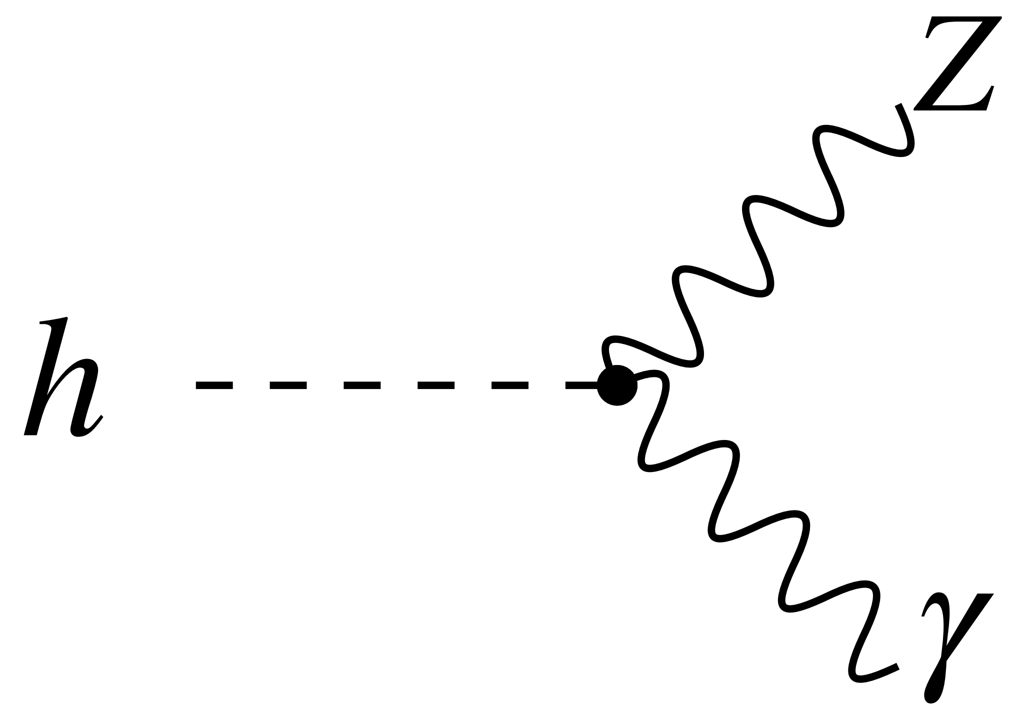
The two parameters show a strong correlation and we see how strongly constrained is $C_{\phi G}$ when we set bounds on the other coefficient.

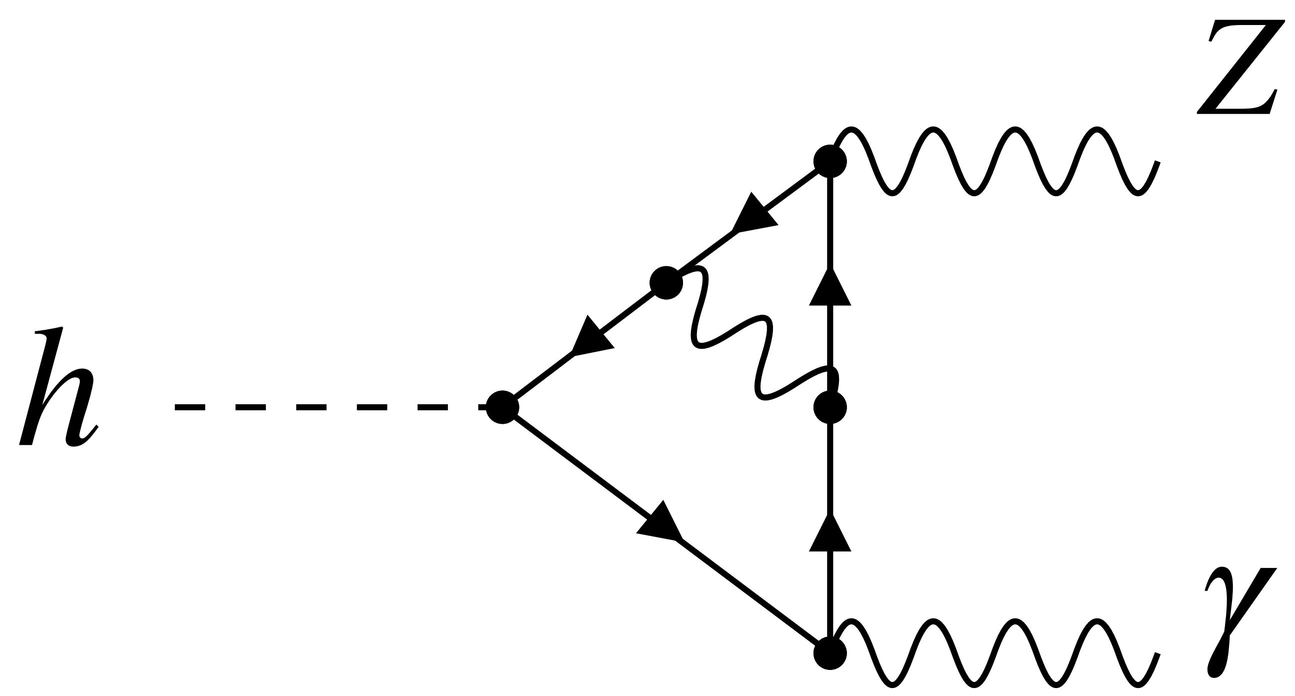
Future projects





$C_{\phi B}, C_{\phi W}, C_{\phi WB}$





With the tools and the code developed for this project, one can study similar processes like $h \to \gamma\gamma$ and $h \to Z\gamma$

Conclusions

- **Gluon Gluon Fusion:** ***We computed $\sigma_{SMEFT}(gg \to h)$ at $O(\alpha_{SM}^2, \Lambda^{-2})$ including two loops corrections using Mathematica packages. With the results we have shown the correlation of some SMEFT coefficients focusing our attention on $C_{\phi G}$ and some naive bounds. This operator plays a crucial role giving large contributions to the cross section and showing a strong correlation with the other coefficients.***

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- ***Gluon Gluon Fusion*: We computed $\sigma_{SMEFT}(gg \to h)$ at $O(\alpha_{SM}^2, \Lambda^{-2})$ including two loops corrections using Mathematica packages. With the results we have shown the correlation of some SMEFT coefficients focusing our attention on $C_{\phi G}$ and some naive bounds. This operator plays a crucial role giving large contributions to the cross section and showing a strong correlation with the other coefficients.**
- ***Future projects*: The calculations performed for this process can be adapted to other similar processes involving Higgs physics, in particular $h \to \gamma\gamma$ and $h \to Z\gamma$. Furthermore we can now consistently study the impact of SMEFT double insertion on $gg \to h$ including all the contributions in a general framework.**

Thank you very much!

Grazie mille!