EW corrections to the ggF cross section and related uncertainties

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Total cross section in hadron collisions

- Fold PDFs with partonic cross section

$$\sigma(h_1 h_2 \to H) = \sum_{i,j} \int_0^1 dx_1 dx_2\, f_{i,h_1}(x_1,\mu_F^2) f_{j,h_2}(x_2,\mu_F^2) \times \int_0^1 dz\, \delta\left(z - \frac{M_H^2}{s x_1 x_2}\right) z\, \sigma_{\rm LO}\, \underbrace{G_{ij}^{\rm QCD}(z,\mu_R^2,\mu_F^2)}_{\rm pQCD}$$

$$G_{ij}^{\rm QCD} = \underbrace{G_{ij}^{\rm QCD,(0)}}_{\delta_{ig}\delta_{jg}\delta(1-z)} + a_s\, G_{ij}^{\rm QCD,(1)} + a_s^2\, G_{ij}^{\rm QCD,(2)} + \ldots \qquad a_s = \frac{\alpha_s}{\pi}$$

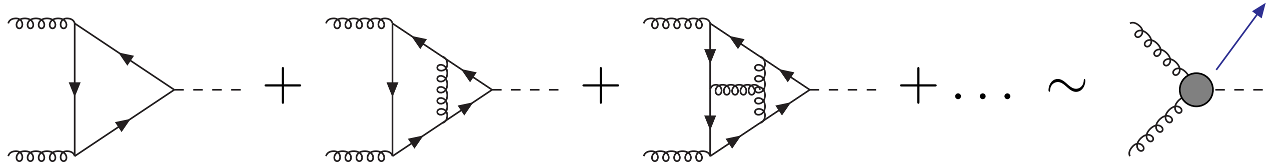
- Two factorization options for QCD/ EW:

$\delta_{\rm EW} \sim 5\%$

  - Partial factorization (PF): $G_{ij}^{\rm QCD} \to G_{ij}^{\rm QCD} + \delta_{\rm EW}\, G_{ij}^{\rm QCD,(0)}$
  - Complete factorization (CF): $G_{ij}^{\rm QCD} \to (1+\delta_{\rm EW}) G_{ij}^{\rm QCD}$

- Correct result: $G_{ij}^{\rm QCD} \to G_{ij}^{\rm QCD} + \delta_{\rm EW} G_{ij}^{\rm QCD,(0)} + a_s G_{ij}^{\rm QCD+EW,(1)} + a_s^2 G_{ij}^{\rm QCD+EW,(2)}$

QCD effective theory:

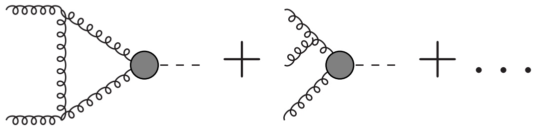


$\sim a_s\sqrt{G_F}$

$$(1 + a_s \underbrace{C_{1q}} + a_s^2 \underbrace{C_{2q}} + \ldots)$$

Wilson coefficients

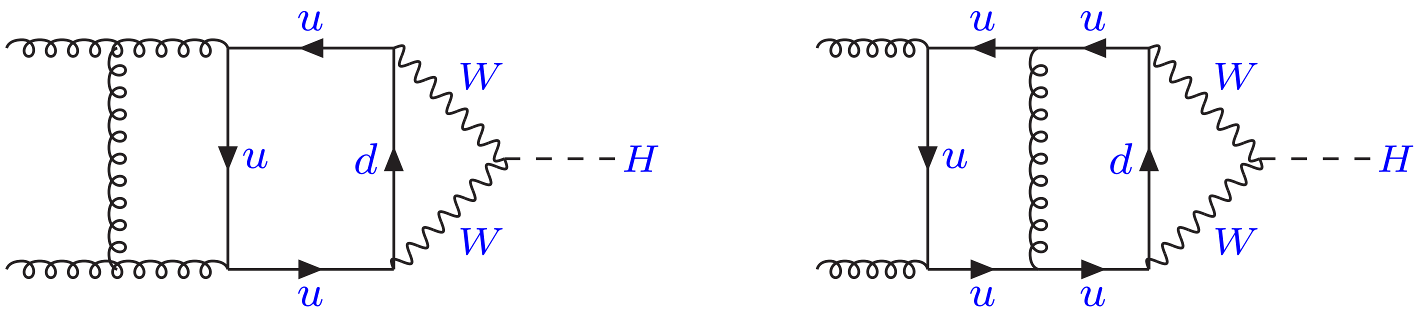
$$\Rightarrow \quad G_{ij}^{\mathrm{QCD},(1)} \sim a_s\, G_{ij}^{\mathrm{QCD},(0)} C_{1q} + F_{ij}^{\mathrm{QCD},(1)}$$



Equivalent to expanding in $\dfrac{M_H}{2\,M_t} \ll 1$

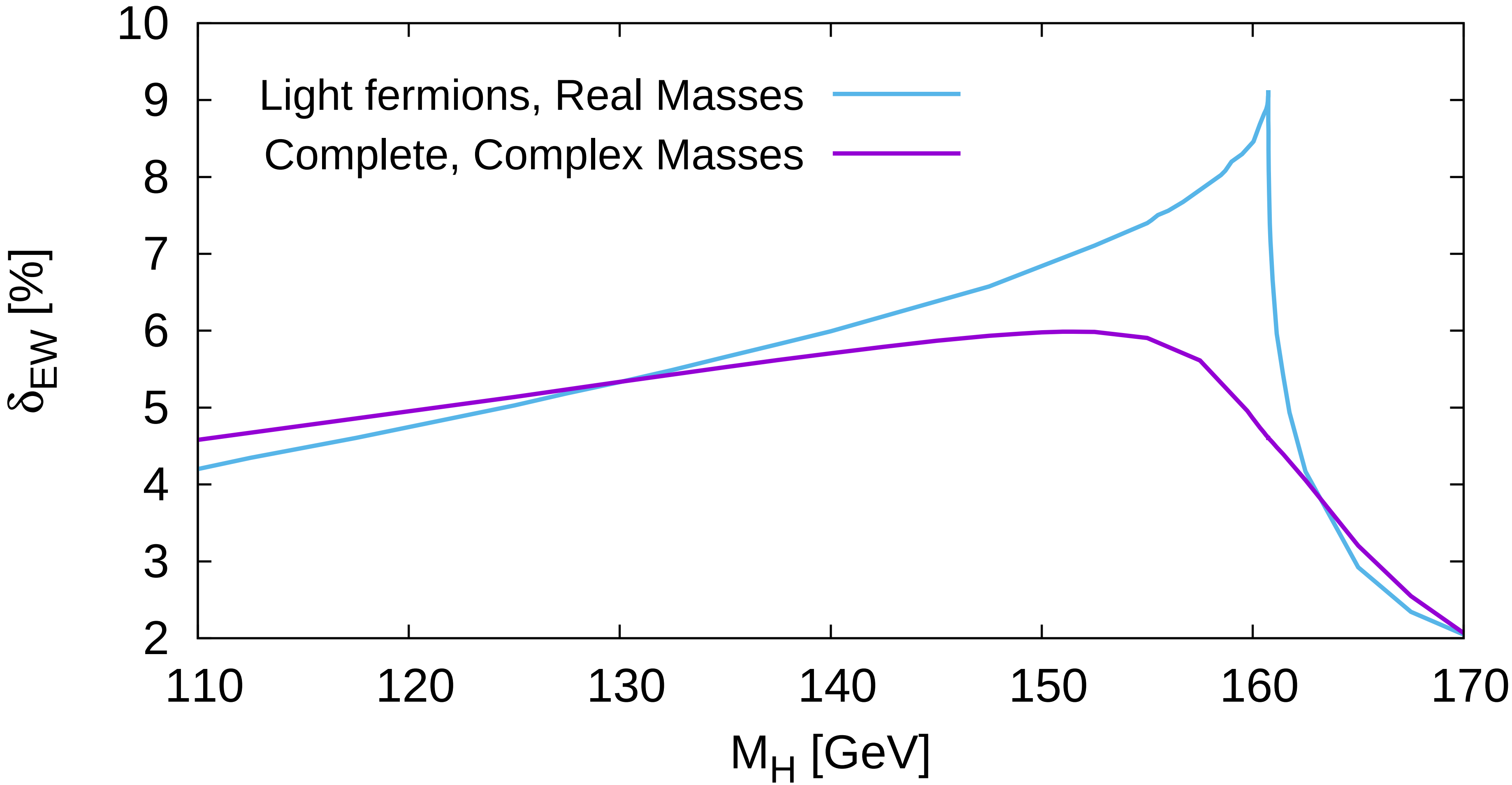
Result valid up to $M_H \sim 2$ TeV because of factorization of σ_{LO}

`Anastasiou-Boughezal-Petriello '08 [0811.3458]:`



Contribution of light fermions EW corrections to the Wilson coefficient

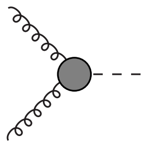
Equivalent to expanding in $\dfrac{M_H}{M_W} \ll 1$



At $M_H = 125$ GeV $\rightsquigarrow$ $\delta_{EW}^{(lf)} = 5.03\% \sim \delta_{EW} = 5.14\%$

Light fermion contribution $\Rightarrow$ good approximation for $M_H = 125$ GeV

Evaluation of $G_{ij}^{\mathrm{QCD+EW},(1)}$ in the effective theory:



$$\left[1+\lambda_{\mathrm{EW}}\,(1+a_s C_{1w}+a_s^2 C_{2w}+\ldots)+a_s C_{1q}+a_s^2 C_{2q}+\ldots\right] \qquad \delta_{\mathrm{EW}}\Big|_{M_H=0} \rightarrow \lambda_{\mathrm{EW}}$$

CF hypothesis: $C_{1w} \sim C_{1q}$ Result: $C_{1w} = \frac{7}{6} \neq C_{1q} = \frac{11}{4}$

$\Rightarrow$ **No CF** for Wilson coefficients

However, at hadronic level

$$\sigma_{\mathrm{EFF}} = \sigma_{\mathrm{CF}} + \mathrm{PDFs} \otimes \sigma_{\mathrm{LO}} \left[\delta_{\mathrm{EW}}\, a_s\, G_{ij}^{\mathrm{QCD},(0)} \left(C_{1w} - C_{1q}\right) + \ldots \right] \sim \sigma_{\mathrm{CF}}$$

$\delta_{\mathrm{EW}} \sim 0.05$, $a_s \sim 0.04$, $(C_{1w} - C_{1q}) \sim -1.6$

$\Rightarrow$ **Ok CF** at hadronic level

Open question:

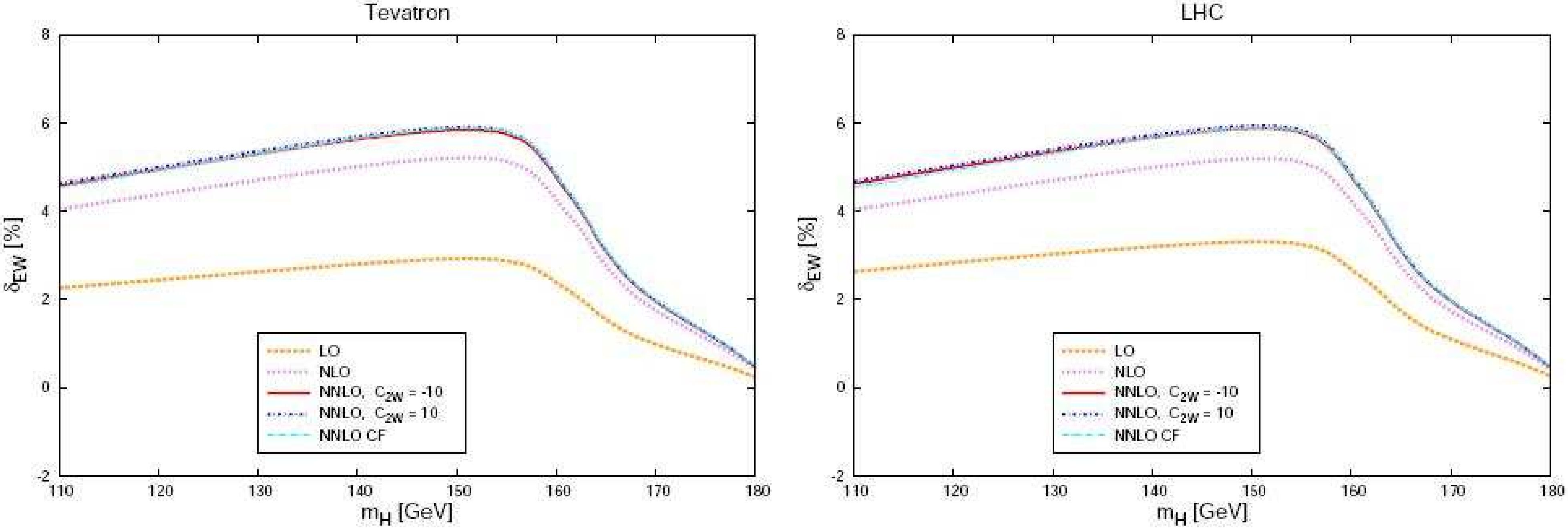
Can QCD corrections heavily modify the behaviour at the M_W-cut?

```
 mh    =   125.000000000000
 mt    =   170.900000000000
 mw    =   80.3707518628511
 mz    =   91.1534550673752
 Wwidth=   2.09300000000000
 Zwidth=   2.49520000000000
 alpha =  7.297352994426403E-003
 Gf    =  1.166369999999999E-005
 alphas(   91.1534550673752      ) =  0.118000000000000

 The one-loop part of the amplitude:
Re A1 =  0.669279078558985E+02  +/- 0.000E+00   err=  0.00%
Im A1 =  0.871314341651154E+00  +/- 0.000E+00   err=  0.00%
 The two-loop part of the amplitude:
Re A2 =  0.168234764498589E+01  +/- 0.330E-02   err=  0.20%
Im A2 =  0.225705568483504E+00  +/- 0.308E-02   err=  1.37%

The 1-loop decay width:
G1   =  0.214363034782947E-03  +/- 0.000E+00   err=  0.00%
The 2-loop part of the decay width:
G2   =  0.107937577107577E-04  +/- 0.211E-07   err=  0.20%

Delta =  5.04% +/-   0.01%
```


Tevatron
LHC
δ_{EW} [%]
m_H [GeV]
LO
NLO
NNLO, C_{2W} = -10
NNLO, C_{2W} = 10
NNLO CF