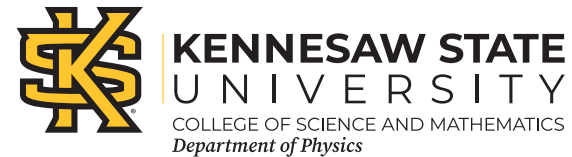


Resummation for tqH production¹

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¹M. Forslund and N. Kidonakis, arXiv:2103.01228 [Preprint]

Soft-gluon corrections: $2 \rightarrow 2$

- Corrections from emission of soft gluons, incomplete cancellations of IR divergences
- For $2 \rightarrow 2$ top processes, often dominate full QCD corrections- excellent approximations¹
 - single-top (s and t -channel, tW), $t\bar{t}$, tH^- , $t\gamma$, tZ , tZ'
- Define a threshold variable $s_4 = s + t + u - p_{top}^2 - p_2^2$ representing the extra energy of the emitted soft gluon
- $s_4 \rightarrow 0$ approaching partonic threshold

¹N. Kidonakis, Int. J. Mod. Phys. A (2018) [arXiv:1806.03336] for a review

Soft-gluon resummation: $2 \rightarrow 2$

- Corrections involve logarithmic plus distributions

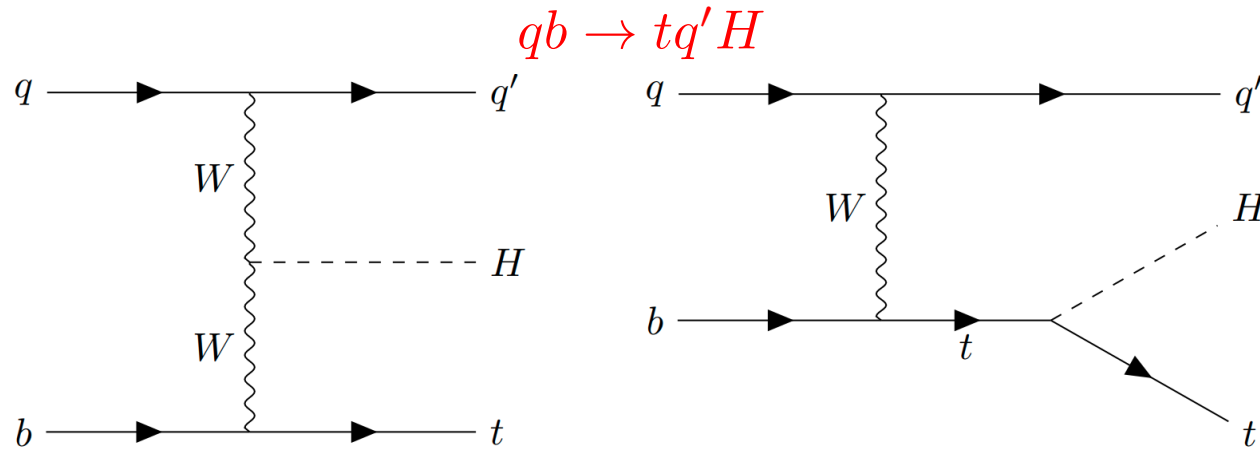
$$\int_0^{s_{4max}} ds_4 \left[\frac{\ln^k(s_4/m_t^2)}{s_4} \right]_+ f(s_4), \quad k \leq 2n - 1$$
$$= \int_0^{s_{4max}} ds_4 \frac{\ln^k(s_4/m_t^2)}{s_4} [f(s_4) - f(0)] + \frac{1}{k+1} \ln^{k+1} \left(\frac{s_{4max}}{m_t^2} \right) f(0)$$

- Resum these corrections to specific accuracy
 - At NLL, need one-loop soft anomalous dimensions
 - At NNLL, need two-loop soft anomalous dimensions

Soft-gluon resummation: $2 \rightarrow 3$

- Our formalism was recently extended to $2 \rightarrow n$ processes¹
- Define a generalised threshold variable $s_4 = s + t + u - p_{top}^2 - p_{2\dots n}^2$ with the same physical meaning
- General form of the corrections remains the same, with the modified s_4 and generalised kinematics
- tqH production is the first application to processes beyond $2 \rightarrow 2$ in 1PI kinematics

¹M. Forslund and N. Kidonakis, Phys. Rev. D (2020) [arXiv:2003.09021]



- Direct probe of the Higgs' coupling to bosons and the top Yukawa
- Small cross section (~ 100 fb at 14 TeV)
- Interference sensitive to new physics- robust theoretical predictions necessary
- massless final state q'
- soft corrections very similar to t -channel single top

tqH soft corrections

- NLO soft corrections take the form

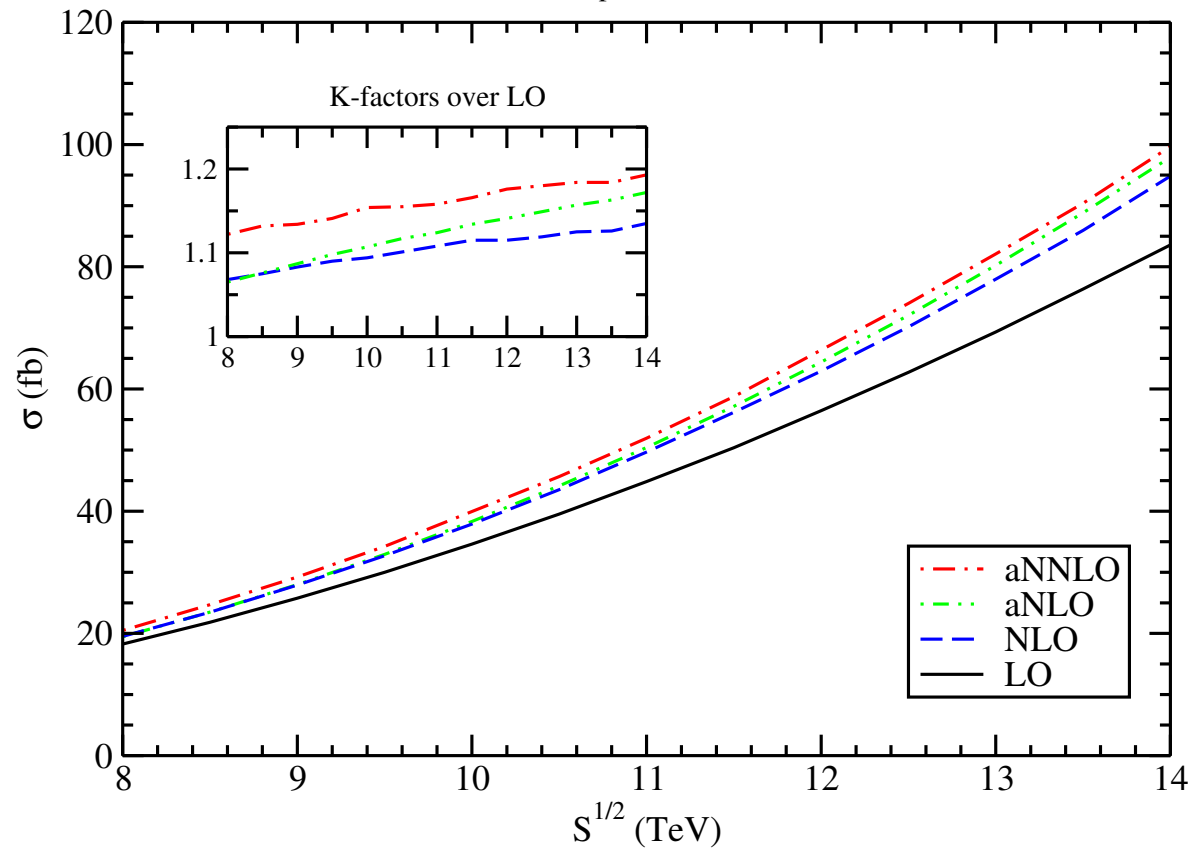
$$\frac{d^2\hat{\sigma}^{(1)}}{dtdu} = F_{LO} \frac{\alpha_s(\mu_R)}{\pi} \left\{ 3C_F \left[\frac{\ln(s_4/m_t^2)}{s_4} \right]_+ + c_2 \left[\frac{1}{s_4} \right]_+ + c_1 \delta(s_4) \right\}$$

- c_2 and c_1 are more complicated and involve kinematic variables and the renormalization and factorization scale
- The NNLO-NLL soft corrections are much more complicated
- Complete NLO corrections from MadGraph5_aMC@NLO
- aNLO = LO + soft NLO
- aNNLO = Exact NLO + soft NNLO

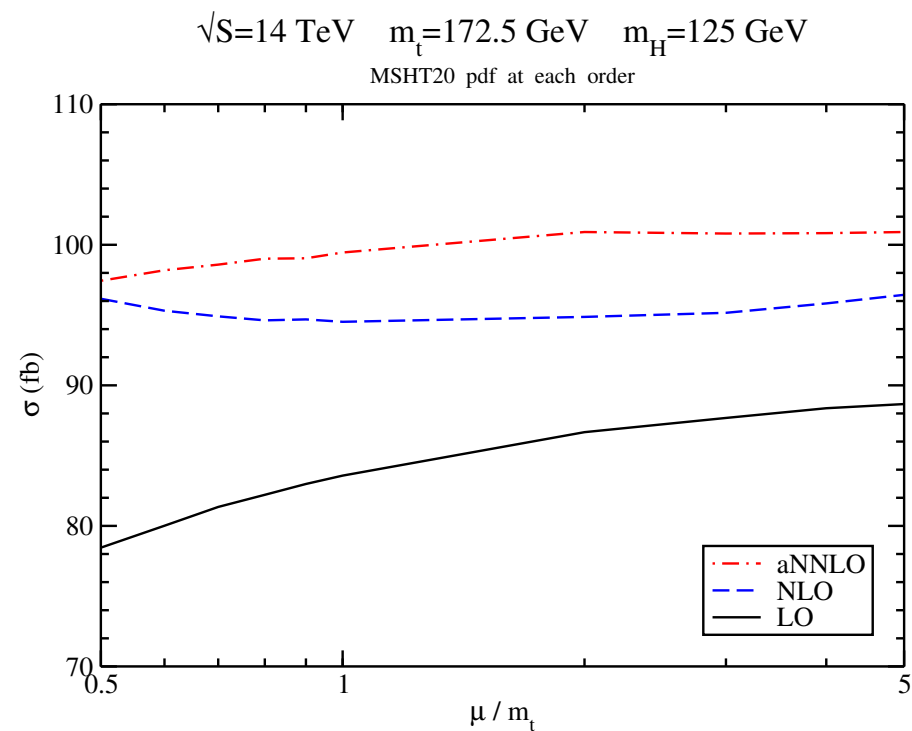
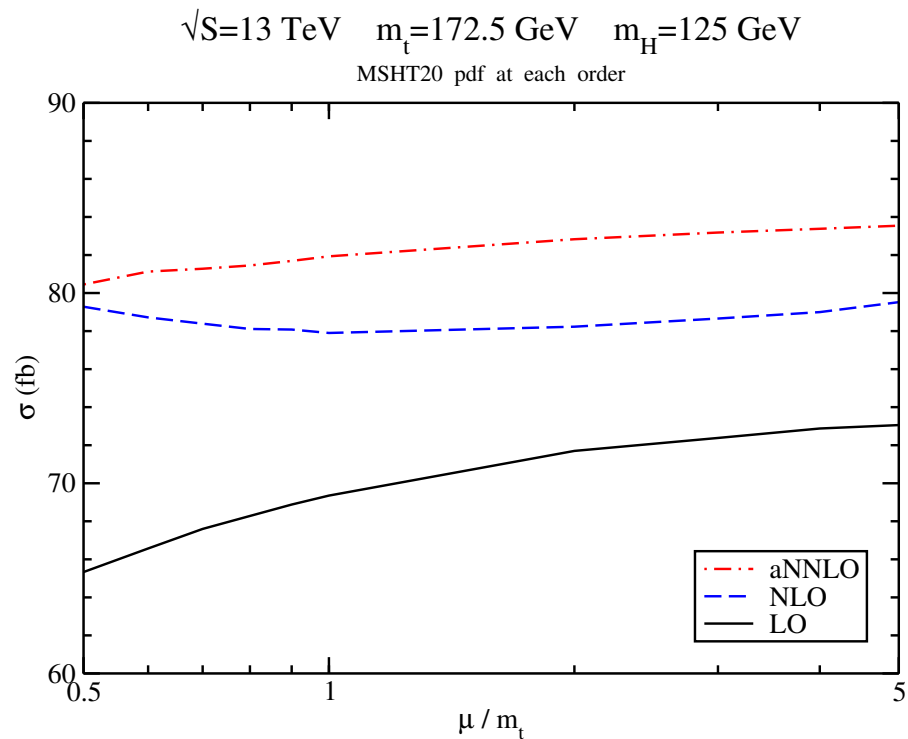
Total cross section

Energy variation $\mu=m_t=172.5$ GeV $m_H=125$ GeV

MSHT20 pdf at each order

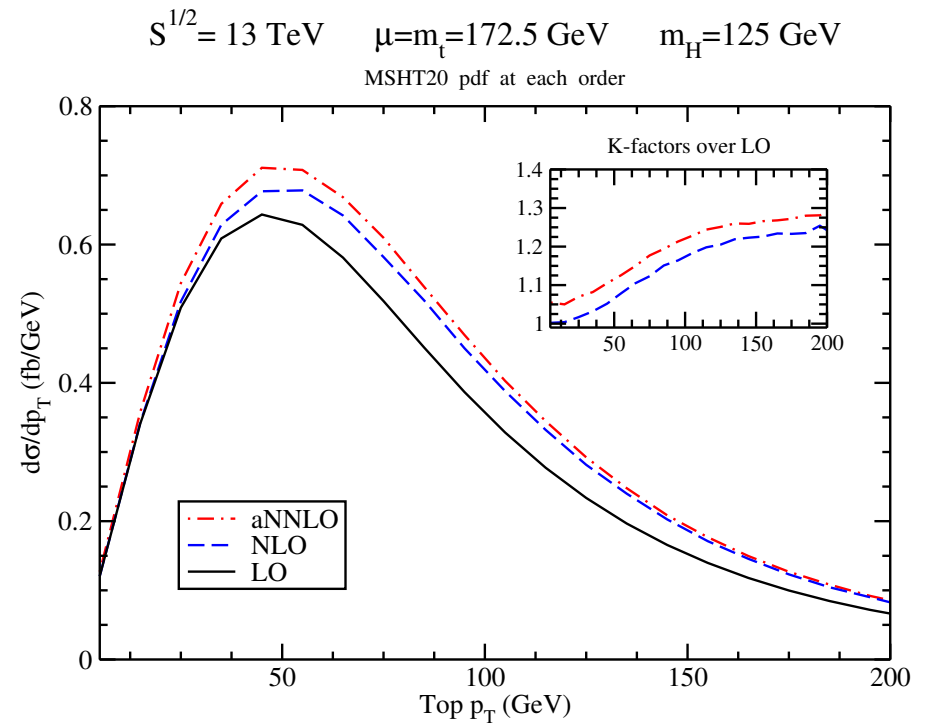
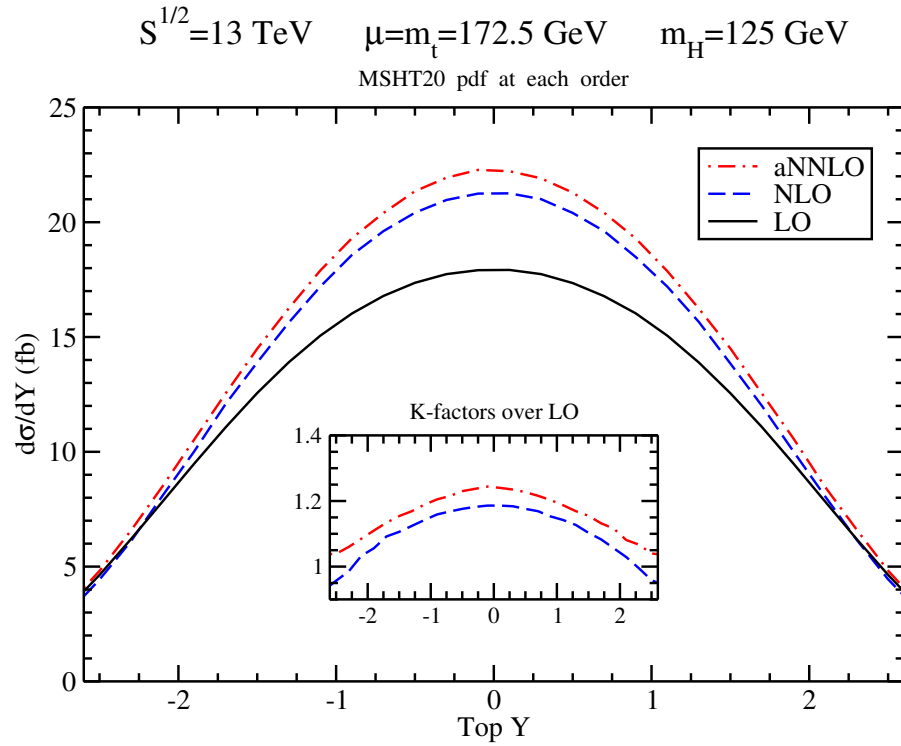


Scale dependence



- Scale variation of $<4\%$ over whole range

Differential distributions



Conclusion

- The updated formalism has allowed the first calculation of soft-gluon corrections in 1PI kinematics for a $2 \rightarrow 3$ process
- Soft-gluon resummation continues to yield good approximations to exact results at LHC energies
- The NNLO soft corrections are still significant
- We foresee many more possible applications to $2 \rightarrow 3$ processes and beyond