Soft gluons in $t\bar{t}$ and tW processes at high energies

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- **Higher-order soft-gluon corrections**
- **Top-antitop pair production**
- **tW production**

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Soft-gluon corrections

partonic processes (in general $2 \to n$)

$$f_1(p_1) + f_2(p_2) \to t(p_t) + X$$

define $s = (p_1 + p_2)^2$, $t = (p_1 - p_t)^2$, $u = (p_2 - p_t)^2$ and $s_4 = s + t + u - p_t^2 - p_X^2$

At partonic threshold $s_4 \to 0$

Soft corrections $\left[\frac{\ln^k(s_4/m_t^2)}{s_4}\right]_+$ with $k \leq 2n-1$ for the order α_s^n corrections

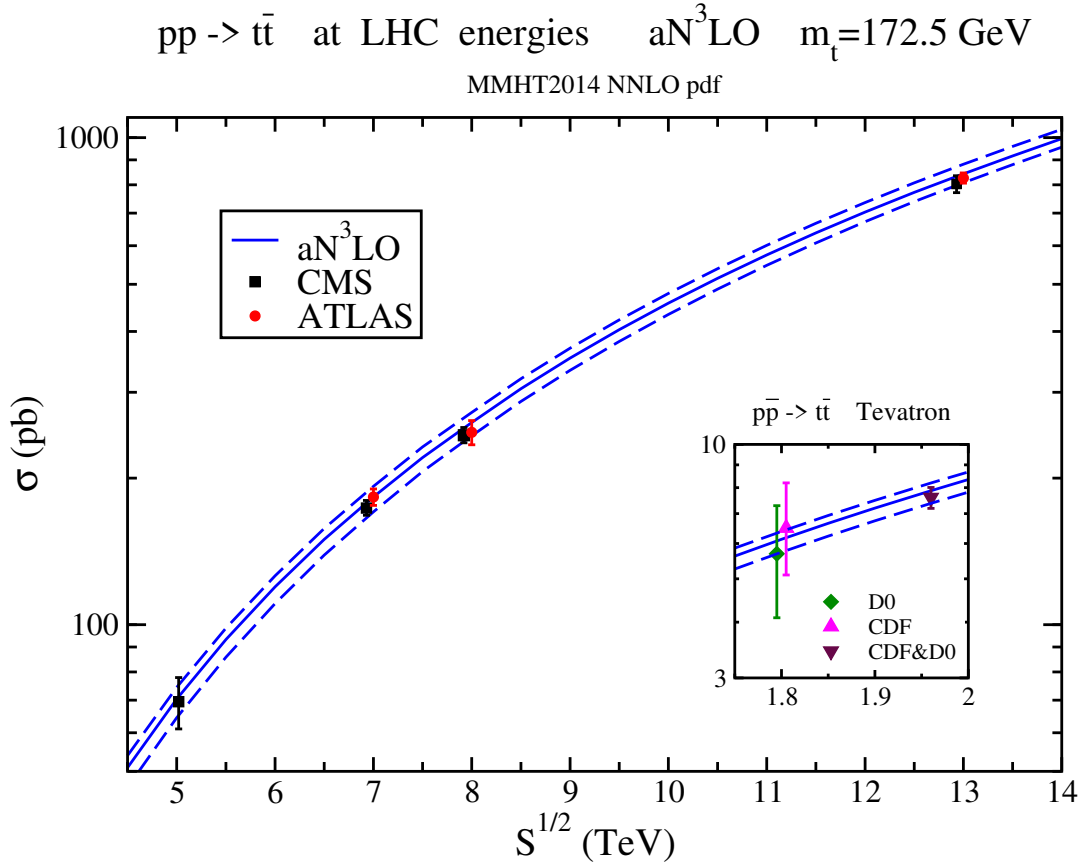
Resum these soft corrections $\to$ finite-order expansions-no prescription needed

Approximate NNLO (aNNLO) and N^{3}LO (aN^{3}LO) predictions
for cross sections and differential distributions (single and double)

Soft anomalous dimension $\Gamma_S^{f_1 f_2 \to tX}$ controls the evolution of the soft function

At NLL, NNLL, and N^{3}LL accuracy we need, respectively,
one-loop, two-loop, three-loop soft anomalous dimensions

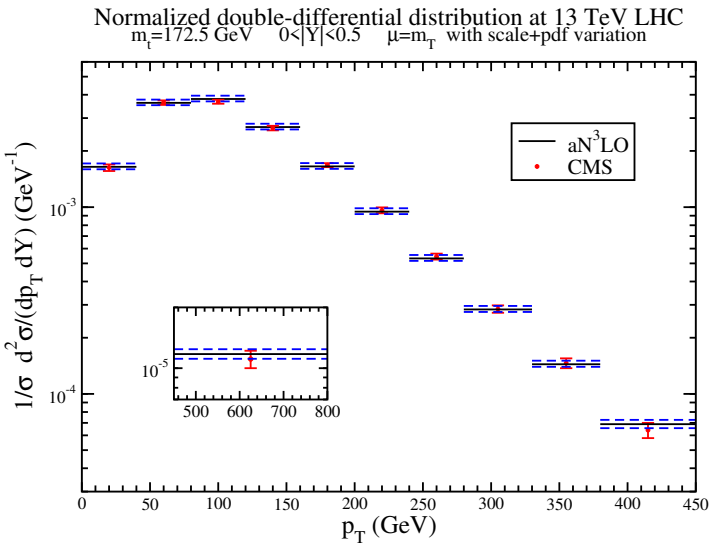
Top-antitop pair production

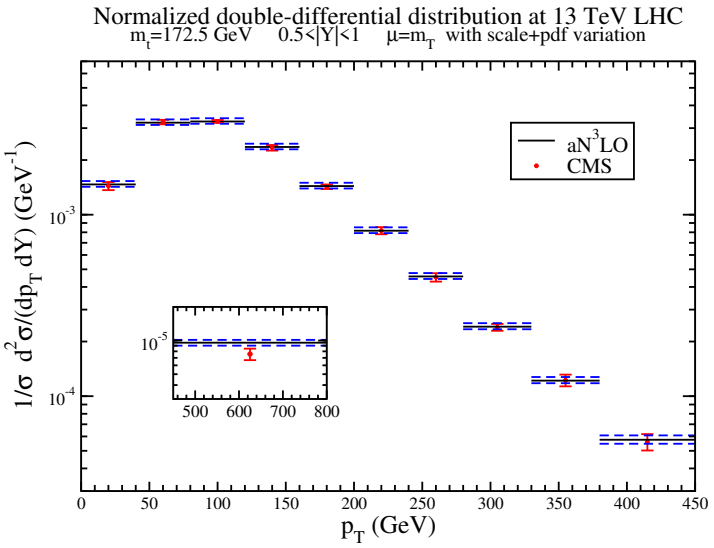


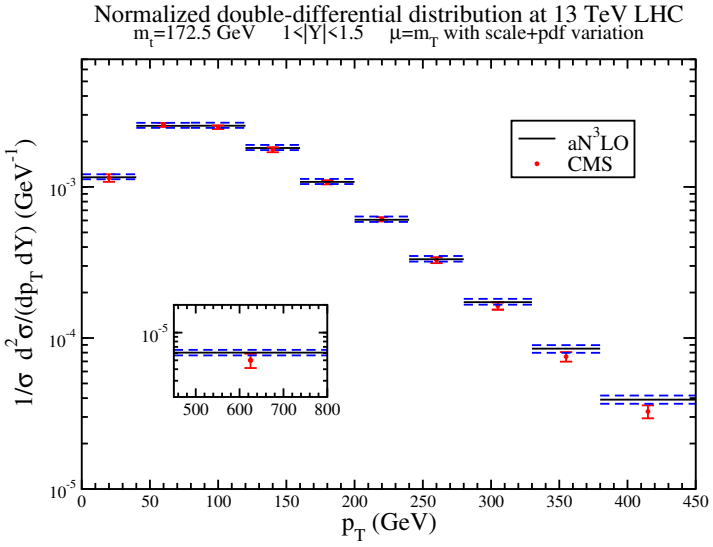
soft-gluon corrections dominant at LHC for total & differential cross sections

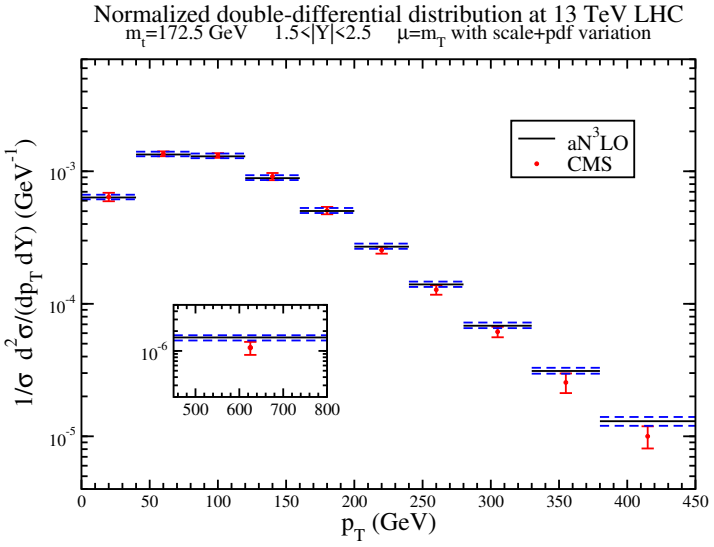
also dominant at higher energies at future colliders → more studies

Top double-differential distributions in $t\bar{t}$ production









$t\bar{t}$ at high energies - preliminary results ($\mu = m_t$, same pdf)

	14 TeV	20 TeV	30 TeV	40 TeV	50 TeV	100 TeV
NLO/LO	1.50	1.51	1.52	1.53	1.54	1.58
aNLO/NLO	0.99	0.98	0.97	0.96	0.95	0.92
NNLO/NLO	1.11	1.11	1.11	1.11	1.11	1.10
aNNLO/NNLO	1.00	1.00	0.99	0.99	0.99	0.98
aN^{3}LO/NNLO	1.03					

where

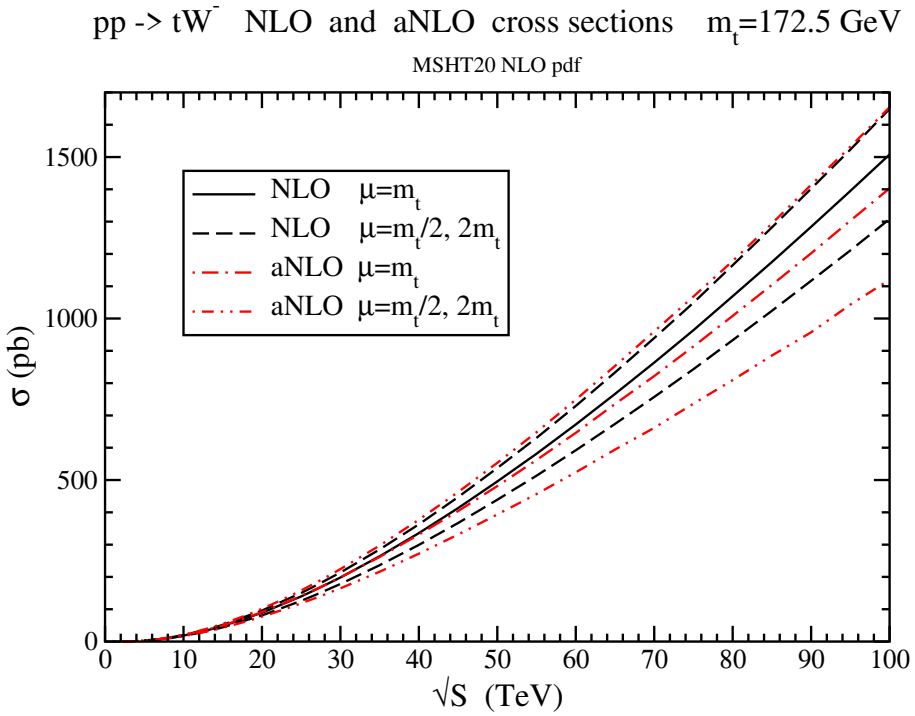
aNLO = LO + soft-gluon NLO corrections

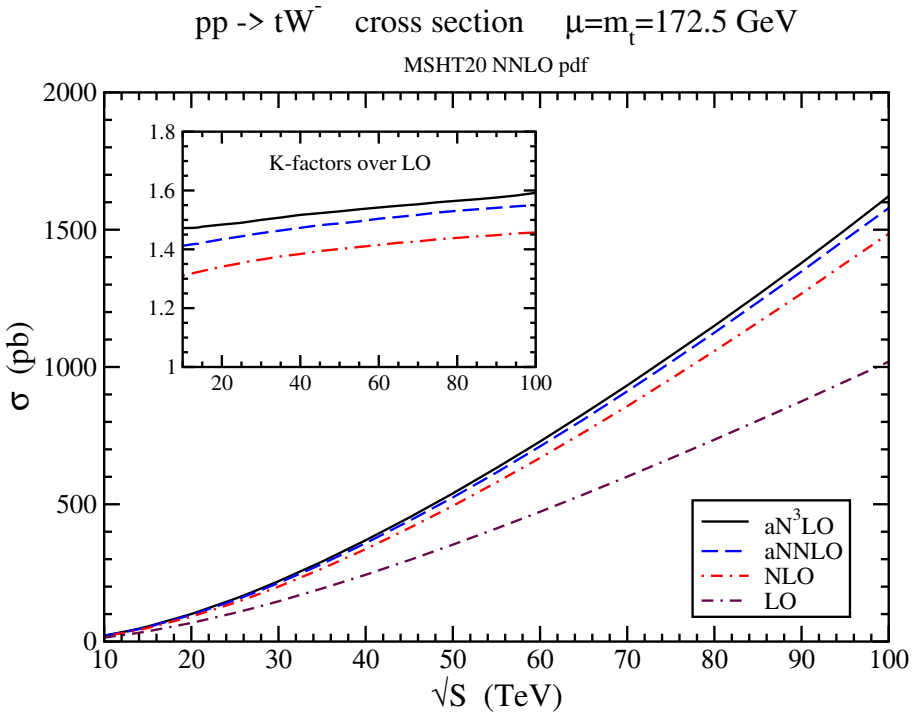
aNNLO = NLO + soft-gluon NNLO corrections

aN^{3}LO = NNLO + soft-gluon N^{3}LO corrections

tW production at high-energy colliders

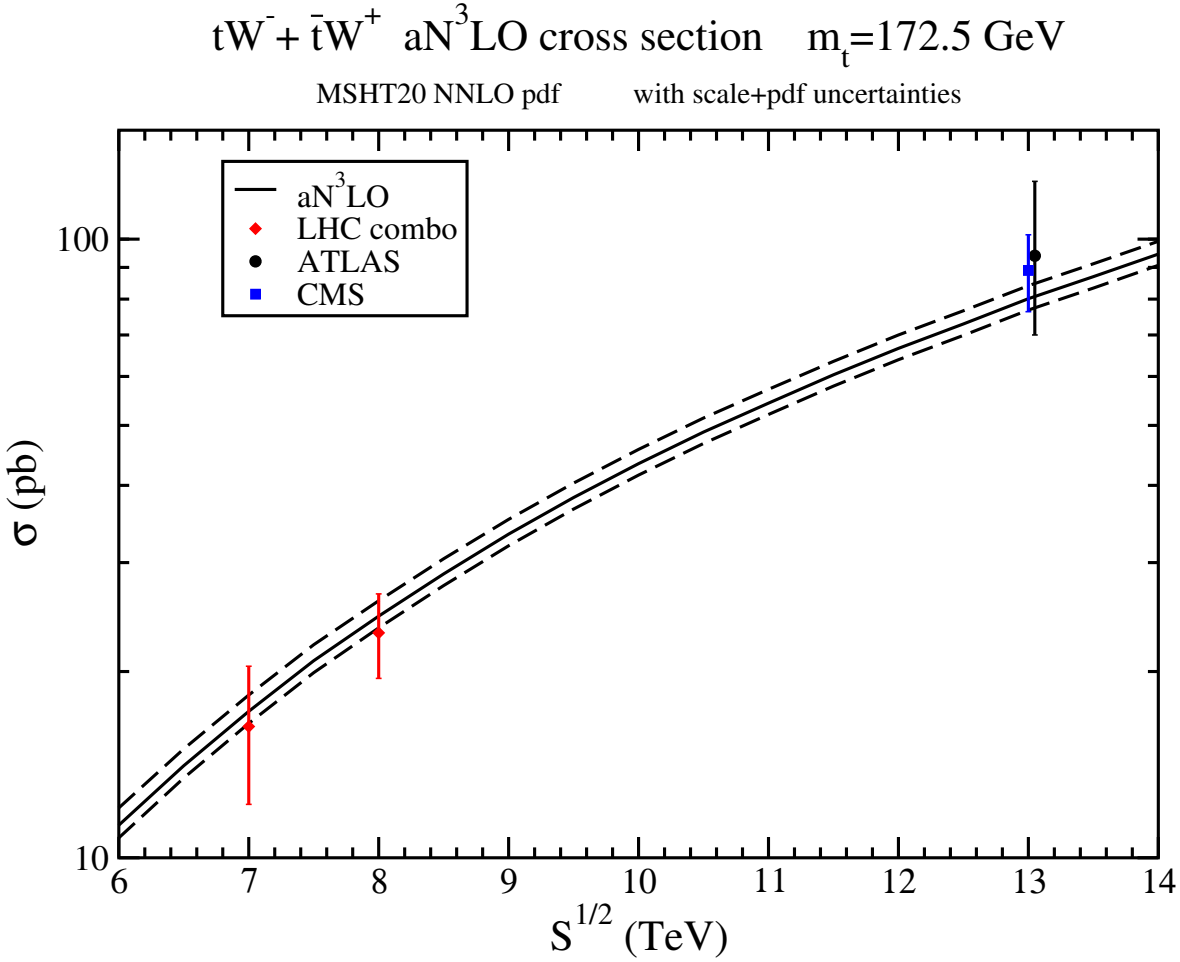
(with Nodoka Yamanaka, JHEP 05, 278 (2021))





The aNLO cross section is a very good approximation to the complete NLO result for all forseeable collider energies
$\rightarrow$ the soft-gluon corrections are dominant

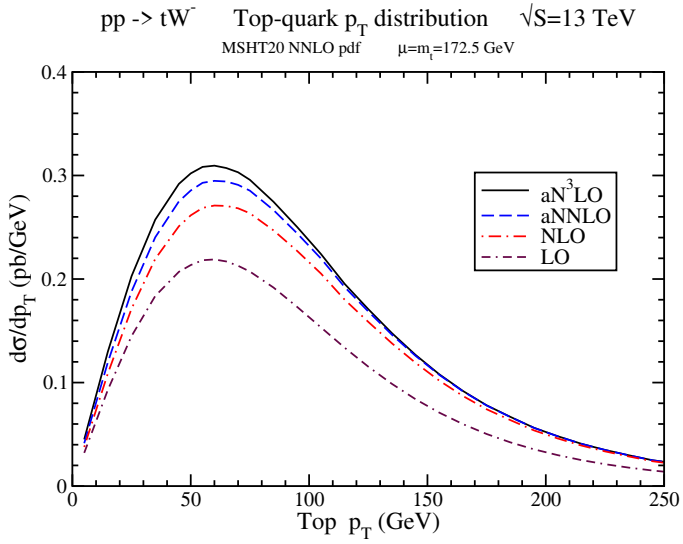
The aNNLO and aN^{3}LO corrections (at NNLL) are also significant

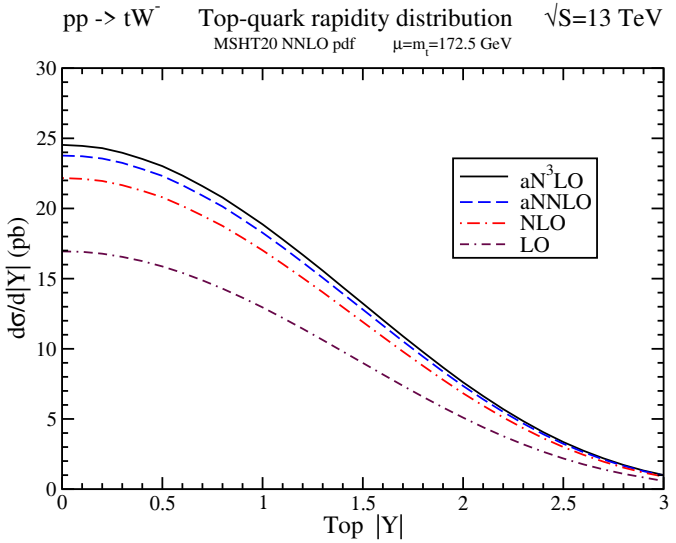


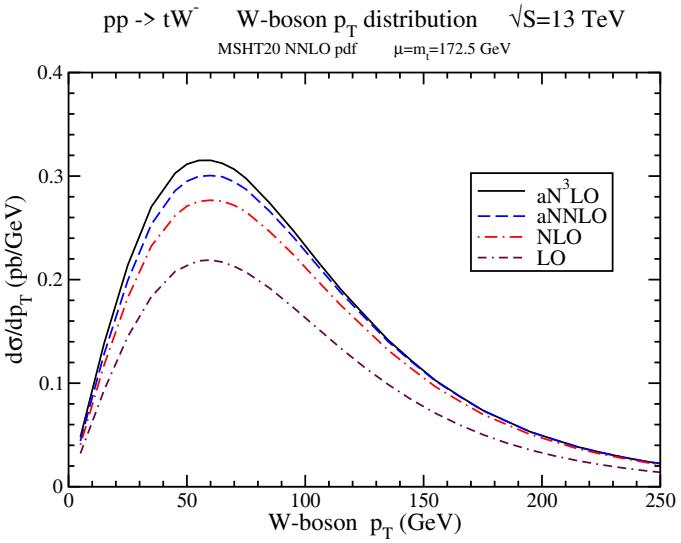
The aN^{3}LO cross section with scale and pdf (MSHT20) uncertainty is

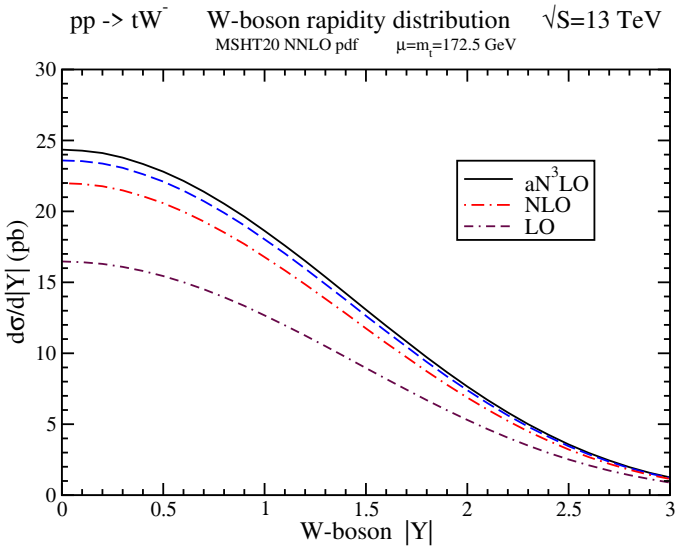
at 13 TeV: $79.5^{+1.9+2.0}_{-1.8-1.4}$ **pb** **at 14 TeV** $94.0^{+2.2+2.2}_{-2.1-1.6}$ **pb**

Top-quark and W-boson distributions in tW production









Summary

- **quality of soft-gluon approximation at high energies**
- **top-antitop pair production**
- **top-quark double-differential distributions in $t\bar{t}$ production**
- **tW cross sections and top-quark, W-boson distributions**
- **soft-gluon corrections are dominant and they are significant through aN^{3}LO**