

Theoretical results for electroweak boson and single-top production

Nikolaos Kidonakis
(Kennesaw State University)

- Higher-order corrections
- W and Z distributions at large p_T
- Single-top production cross sections
- Single-top p_T distributions
- FCNC top production

Higher-order corrections

Soft-gluon corrections are important for electroweak-boson and single-top production

Soft terms:

$$\left[\frac{\ln^k(s_4/p_T^2)}{s_4} \right]_+ \text{ for electroweak-boson production}$$
$$\left[\frac{\ln^k(s_4/m_t^2)}{s_4} \right]_+ \text{ for single-top production}$$

with $k \leq 2n - 1$, s_4 distance from threshold

Resum these soft corrections - factorization and RGE

NNLL accuracy—two-loop soft anomalous dimensions

Approximate NNLO (aNNLO) differential cross sections from expansion of resummed expressions

Calculation is for the **double differential cross section near partonic threshold** using the standard moment-space resummation in pQCD

W and Z production at large p_T - parton processes

W and Z hadroproduction useful in testing the SM and in estimates of backgrounds to Higgs production and new physics (new gauge bosons)

p_T distribution falls rapidly as p_T increases

Partonic channels at LO

$$q(p_a) + g(p_b) \longrightarrow W(Q) + q(p_c)$$

$$q(p_a) + \bar{q}(p_b) \longrightarrow W(Q) + g(p_c)$$

Define $s = (p_a + p_b)^2$, $t = (p_a - Q)^2$, $u = (p_b - Q)^2$ **and** $s_4 = s + t + u - Q^2$

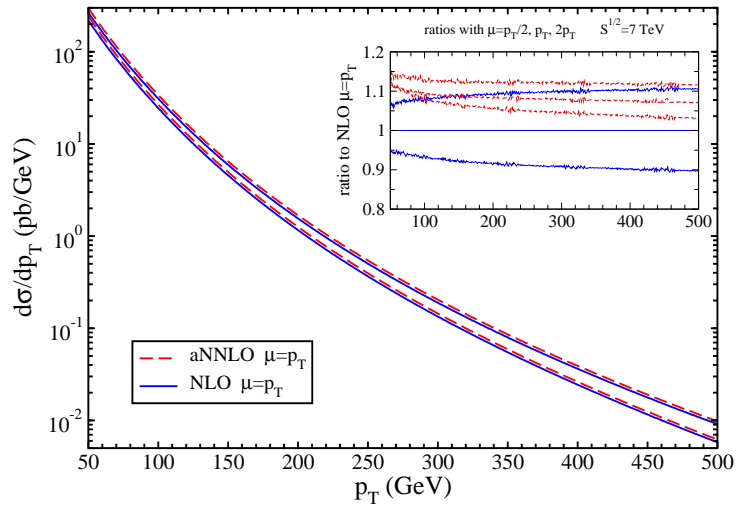
At threshold $s_4 \rightarrow 0$ **Soft corrections** $\left[\frac{\ln^k(s_4/p_T^2)}{s_4} \right]_+$

Latest aNNLO results at NNLL accuracy:

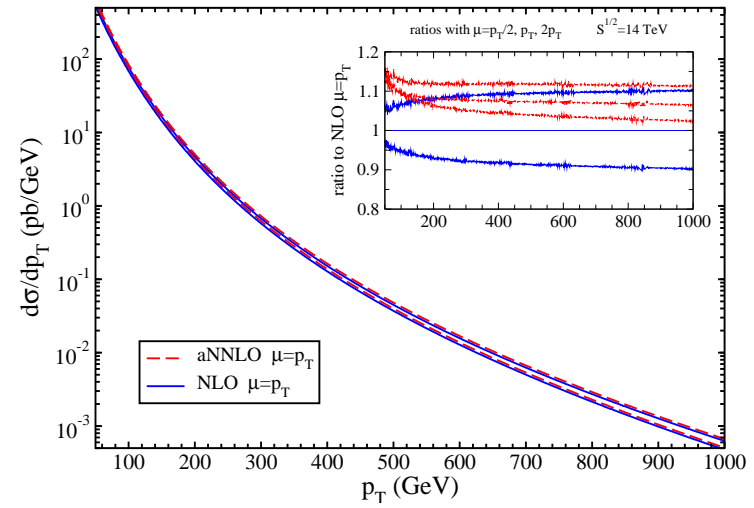
N. Kidonakis and R.J. Gonsalves, Phys. Rev. D 89, 094022 (2014)

W production at large p_T

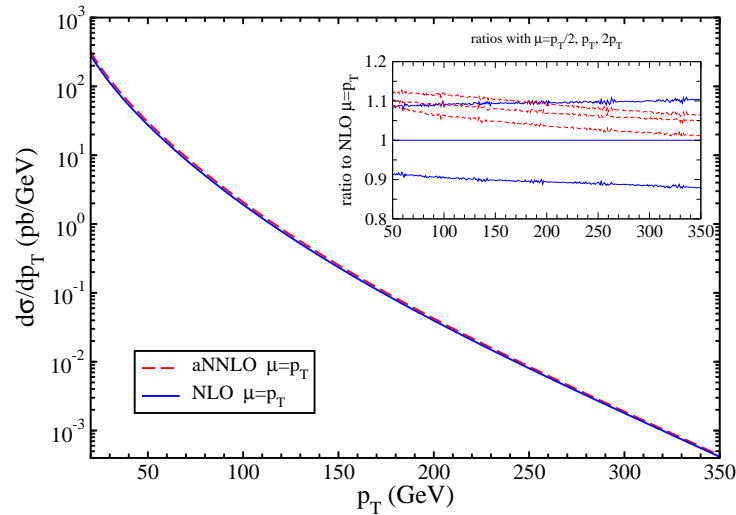
W-boson p_T distribution at the LHC $S^{1/2}=7$ and 8 TeV



W-boson p_T distribution at the LHC $S^{1/2}=13$ and 14 TeV

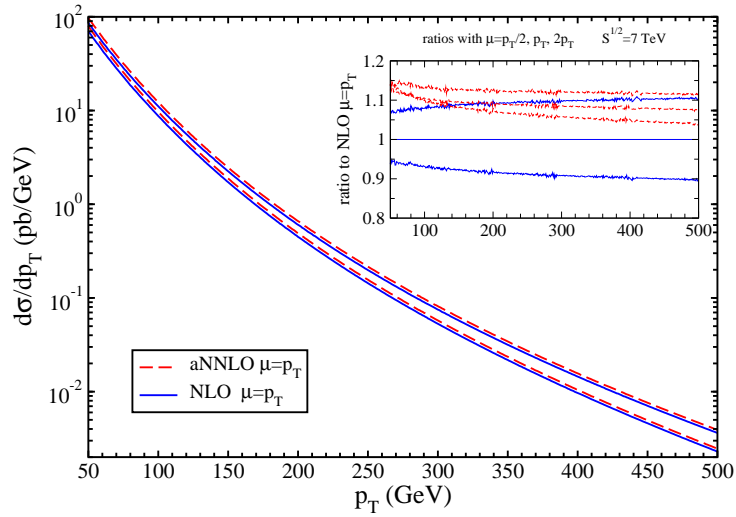


W-boson p_T distribution at the Tevatron $S^{1/2}=1.96$ TeV

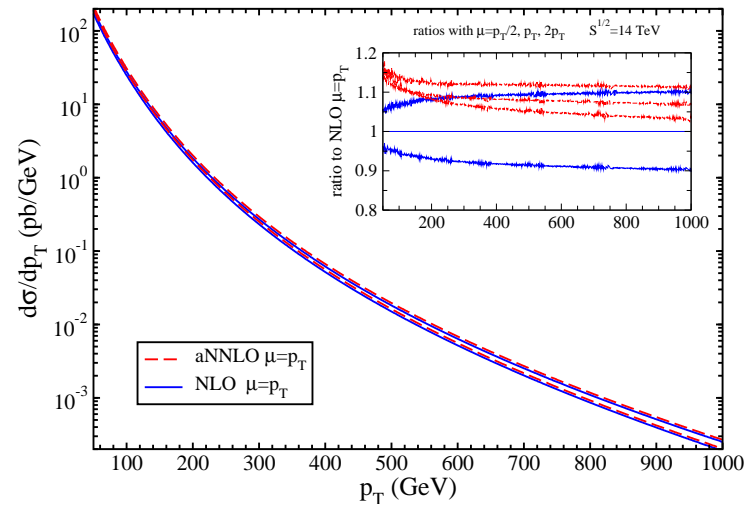


Z production at large p_T

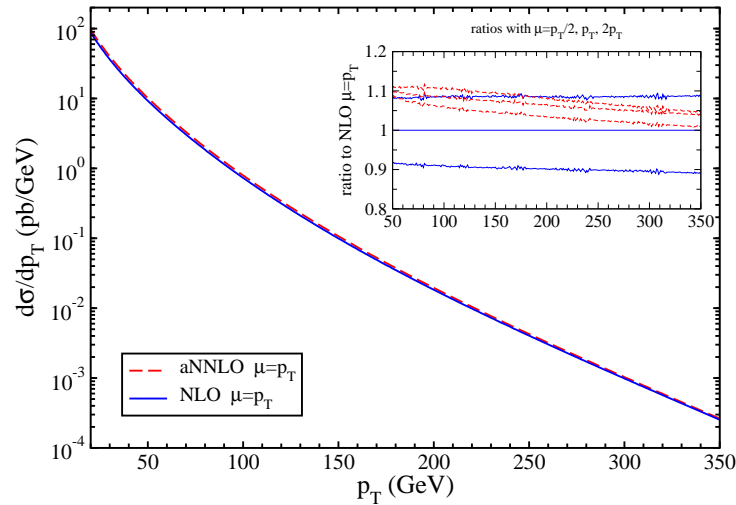
Z-boson p_T distribution at the LHC $S^{1/2}=7$ and 8 TeV



Z-boson p_T distribution at the LHC $S^{1/2}=13$ and 14 TeV

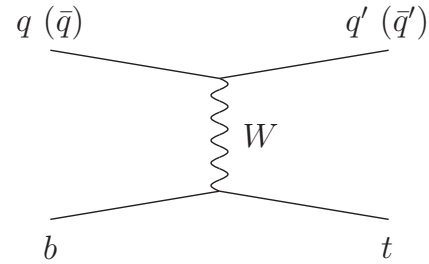


Z-boson p_T distribution at the Tevatron $S^{1/2}=1.96$ TeV

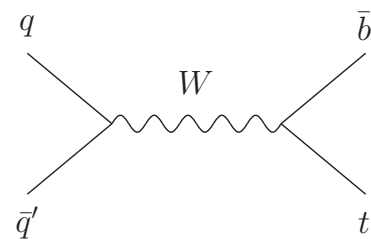


Single-top partonic processes at LO

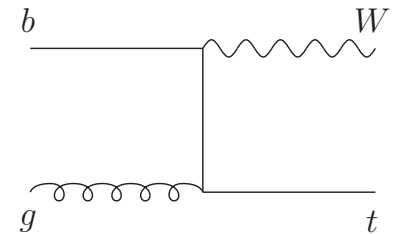
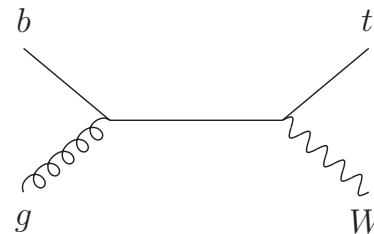
- t channel:** $qb \rightarrow q't$ and $\bar{q}b \rightarrow \bar{q}'t$
dominant at Tevatron and LHC



- s channel:** $q\bar{q}' \rightarrow \bar{b}t$
small at Tevatron and LHC



- associated tW production:** $bg \rightarrow tW^-$
very small at Tevatron, significant at LHC



Single top t -channel production at aNNLO at the LHC

$m_t = 173.3 \text{ GeV}$

LHC	t	\bar{t}	Total (pb)
8 TeV	$55.9^{+2.1}_{-0.3} \pm 1.1$	$30.6 \pm 0.7^{+0.9}_{-1.1}$	$86.5^{+2.8+2.0}_{-1.0-2.2}$
13 TeV	$136^{+3}_{-1} \pm 3$	$82^{+2}_{-1} \pm 2$	$218^{+5}_{-2} \pm 5$
14 TeV	$154^{+4}_{-1} \pm 3$	94^{+2+2}_{-1-3}	248^{+6+5}_{-2-6}

\pm scale \pm pdf errors with MSTW2008 NNLO pdf 90% CL

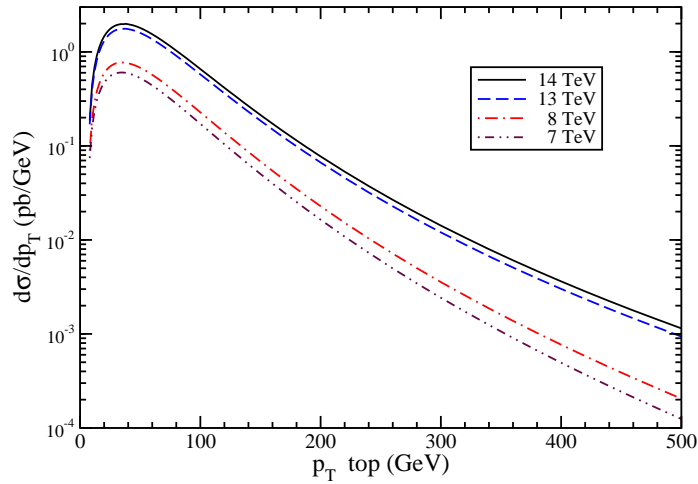
ratio $\sigma(t)/\sigma(\bar{t}) = 1.82^{+0.10}_{-0.09}$ at 8 TeV

- compares well with CMS result $1.95 \pm 0.10 \pm 0.19$

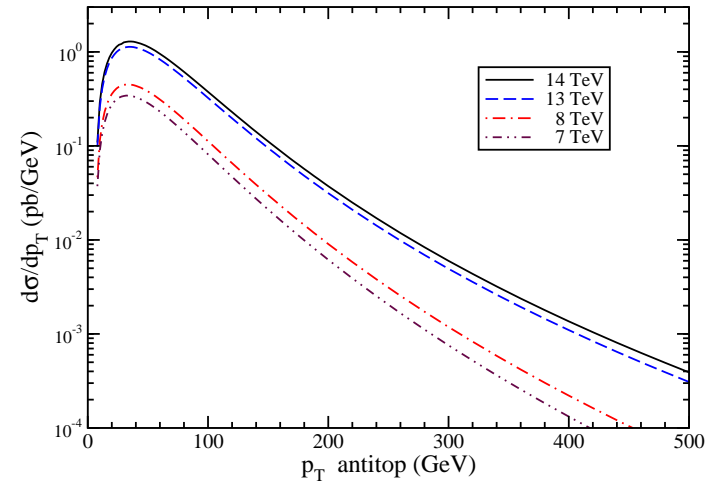
agrees with NNLO result in 1404.7116 [hep-ph]

Single top t -channel aNNLO p_T distributions at the LHC

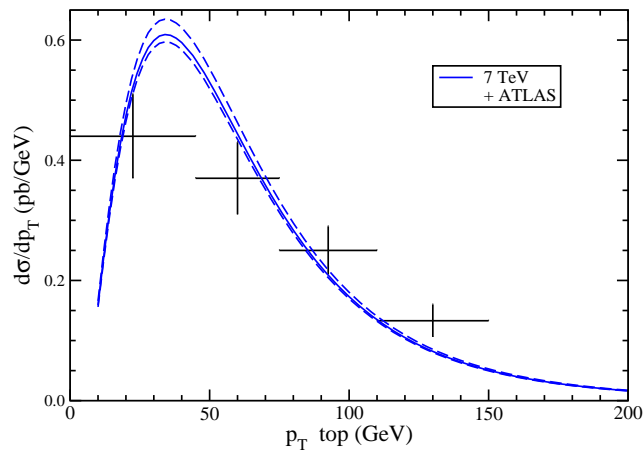
t-channel top p_T distribution at LHC aNNLO $m_t=173.3$ GeV



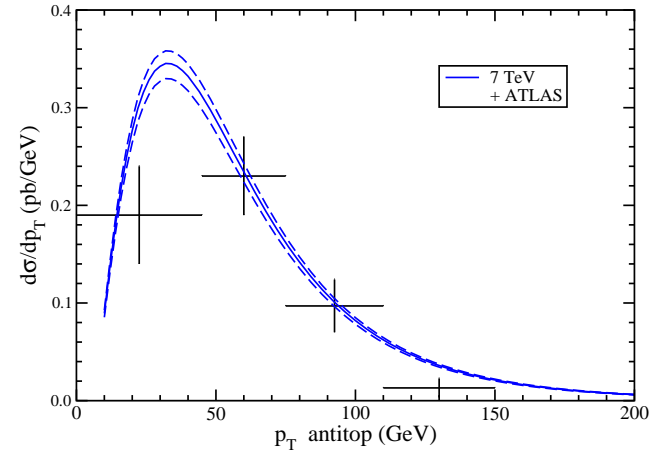
t-channel antitop p_T distribution at LHC aNNLO $m_t=173.3$ GeV



t-channel top p_T distribution at LHC aNNLO $m_t=172.5$ GeV



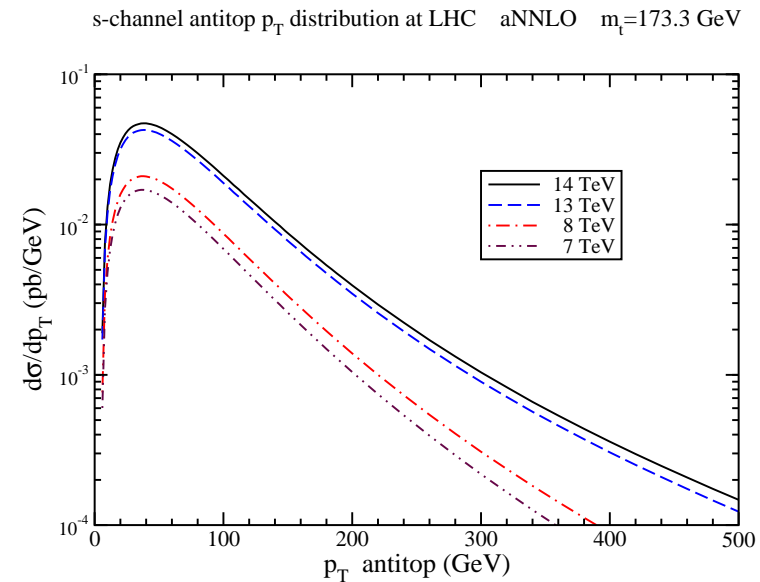
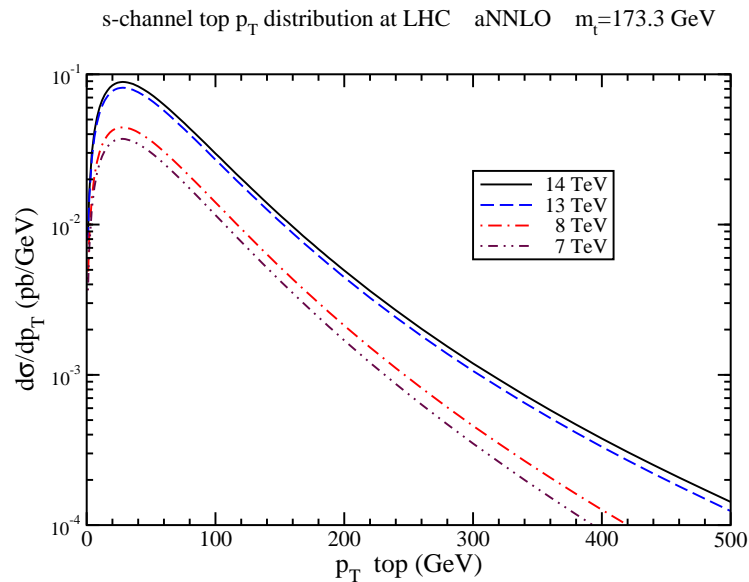
t-channel antitop p_T distribution at LHC aNNLO $m_t=172.5$ GeV



Single top s -channel production at aNNLO at the LHC

LHC	t	\bar{t}	Total (pb)
8 TeV	$3.75 \pm 0.07 \pm 0.13$	$1.90 \pm 0.01 \pm 0.08$	$5.65 \pm 0.08 \pm 0.21$
13 TeV	$7.07 \pm 0.13^{+0.24}_{-0.22}$	$4.10 \pm 0.05^{+0.14}_{-0.16}$	$11.17 \pm 0.18 \pm 0.38$
14 TeV	$7.79 \pm 0.14^{+0.31}_{-0.24}$	$4.57 \pm 0.05^{+0.18}_{-0.17}$	$12.35 \pm 0.19^{+0.49}_{-0.41}$

($m_t = 173.3$ GeV) \pm scale \pm pdf errors with MSTW2008 NNLO pdf 90% CL



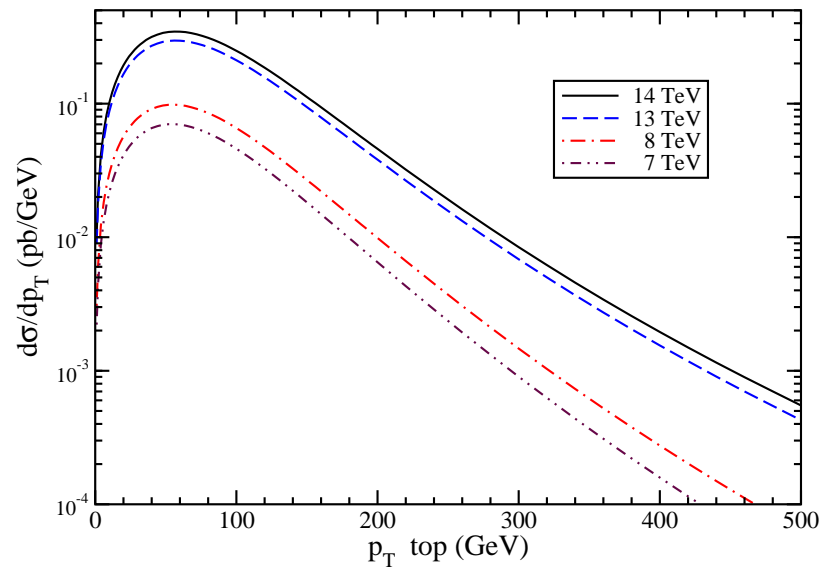
Associated tW^- production at aNNLO at the LHC

$m_t = 173.3 \text{ GeV}$

LHC	tW^-	$tW^- + \bar{t}W^+$ (pb)
8 TeV	$11.0 \pm 0.3 \pm 0.7$	$22.0 \pm 0.6 \pm 1.4$
13 TeV	$35.20 \pm 0.9^{+1.6}_{-1.7}$	$70.40 \pm 1.8^{+3.2}_{-3.4}$
14 TeV	$41.6 \pm 1.0^{+1.5}_{-2.3}$	$83.1 \pm 2.0^{+3.1}_{-4.6}$

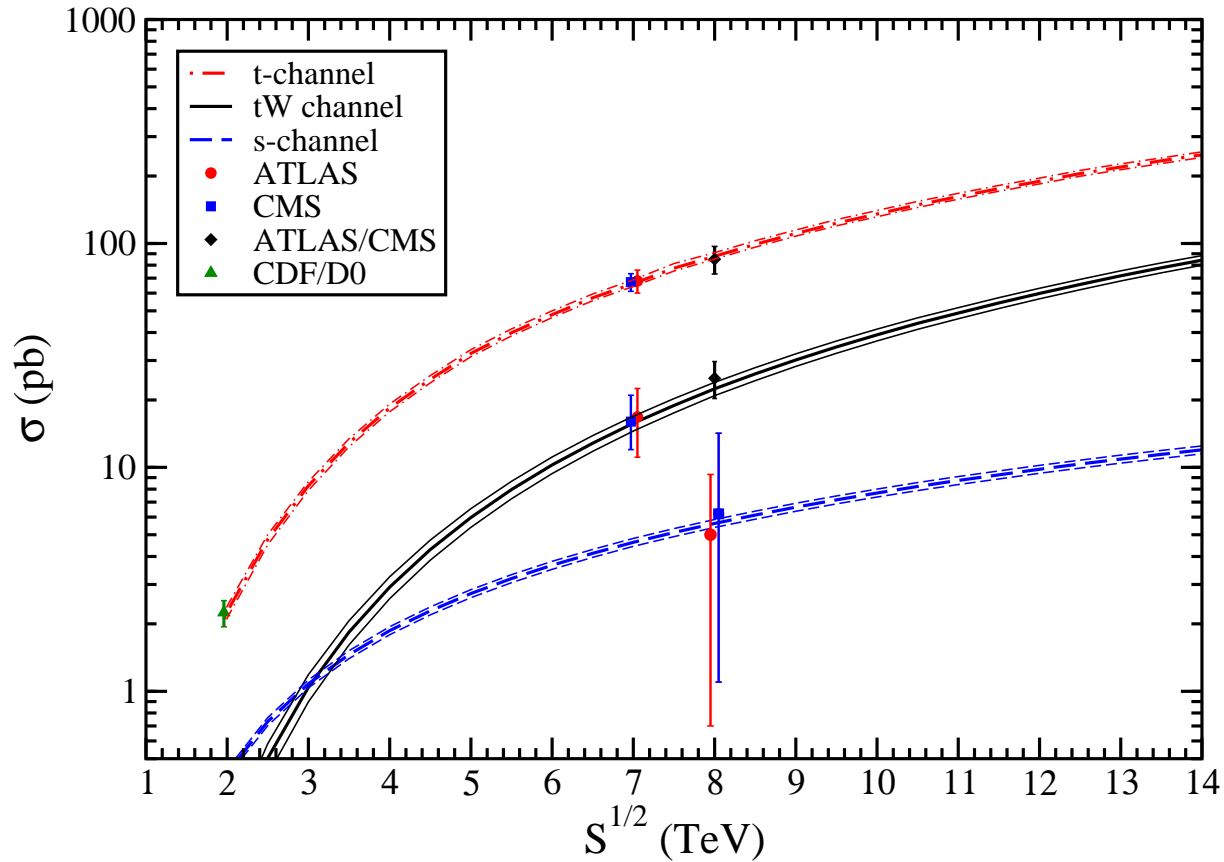
\pm scale \pm pdf errors with MSTW2008 NNLO pdf 90% CL

Top p_T distribution in tW^- production at LHC aNNLO $m_t=173.3 \text{ GeV}$



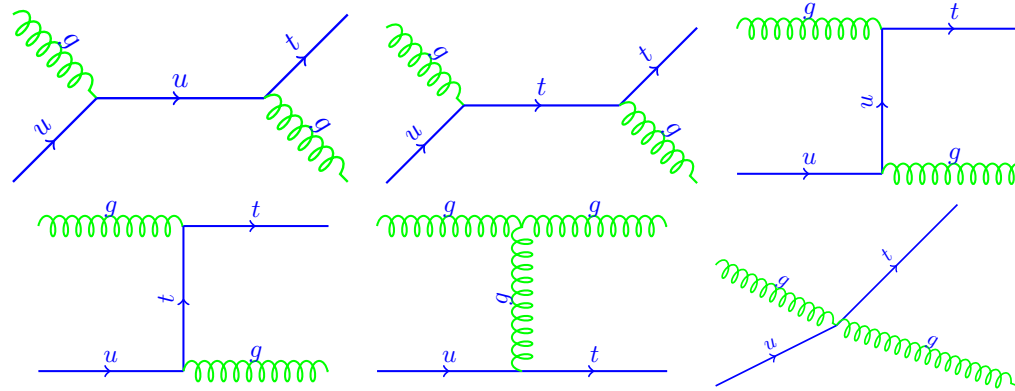
Single-top cross sections

aNNLO single-top cross sections +-scale&pdf $m_t=172.5$ GeV

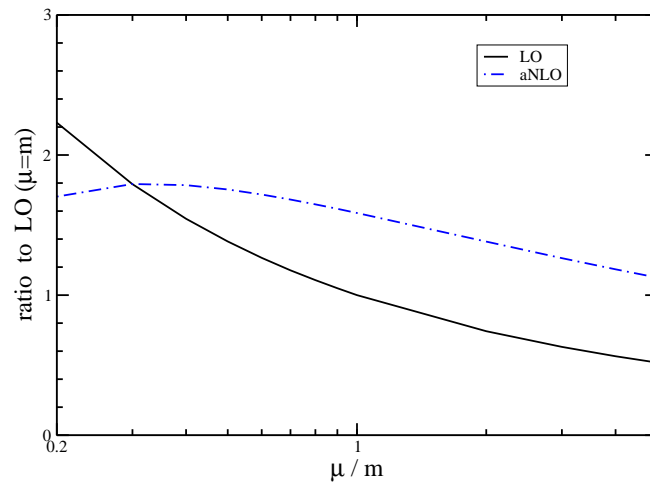


Excellent agreement of theory with data for all three channels

FCNC top production anomalous gluon couplings



$gu \rightarrow tg$ at the LHC $S^{1/2} = 7 \text{ TeV}$



N. Kidonakis and E. Martin, Phys. Rev. D 90, 054021 (2014)

Summary

- NNLL soft-gluon corrections for electroweak-boson and single-top production
- total cross sections
- top quark p_T distributions
- aNNLO corrections are significant at the LHC and the Tevatron
- excellent agreement with LHC and Tevatron data
- future work on more differential distributions and aN³LO