W-boson production with large transverse momentum at the LHC

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- W production with large Q_T at the LHC
- NLO corrections
- Soft-gluon corrections
- NNLO-NNNLL cross section

R.J. Gonsalves, N. Kidonakis, and A. Sabio Vera, Phys. Rev. Lett. 95, 222001 (2005)

W production with large Q_T at the LHC

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

Q_T distribution falls rapidly as Q_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 $s_2 = s + t + u - Q^2$

At threshold $s_2 \to 0$

Soft corrections $\left[\frac{\ln^l(s_2/Q_T^2)}{s_2}\right]_+$

Virtual corrections $\delta(s_2)$

NLO corrections

The NLO cross section can be written as

$$E_Q \frac{d\hat{\sigma}_{f_a f_b \to W(Q)+X}}{d^3Q} = \delta(s_2)\alpha_s(\mu_R^2)\left[A(s,t,u) + \alpha_s(\mu_R^2)B(s,t,u,\mu_R)\right] + \alpha_s^2(\mu_R^2)C(s,t,u,s_2,\mu_F)$$

The coefficient functions A, B, and C depend on the parton flavors

The coefficient $A(s,t,u)$ arises from the LO processes

$B(s,t,u,\mu_R)$ is the sum of virtual corrections and of singular terms $\sim\delta(s_2)$ in the real radiative corrections

$C(s,t,u,s_2,\mu_F)$ is from real emission processes away from $s_2 = 0$

P.B. Arnold and M.H. Reno, Nucl. Phys. B 319, 37 (1989); (E) B 330, 284 (1990)

R.J. Gonsalves, J. Pawlowski, C.-F. Wai, Phys. Rev. D 40, 2245 (1989); Phys. Lett. B 252, 663 (1990)

Soft-gluon corrections

$$\mathcal{D}_l(s_2) \equiv \left[\frac{\ln^l(s_2/Q_T^2)}{s_2}\right]_+$$

For the order α_s^n corrections $l \leq 2n-1$

At NLO, $\mathcal{D}_1(s_2)$ and $\mathcal{D}_0(s_2)$ terms

LL NLL

At NNLO, $\mathcal{D}_3(s_2)$, $\mathcal{D}_2(s_2)$, $\mathcal{D}_1(s_2)$, and $\mathcal{D}_0(s_2)$ terms

LL NLL NNLL NNNLL

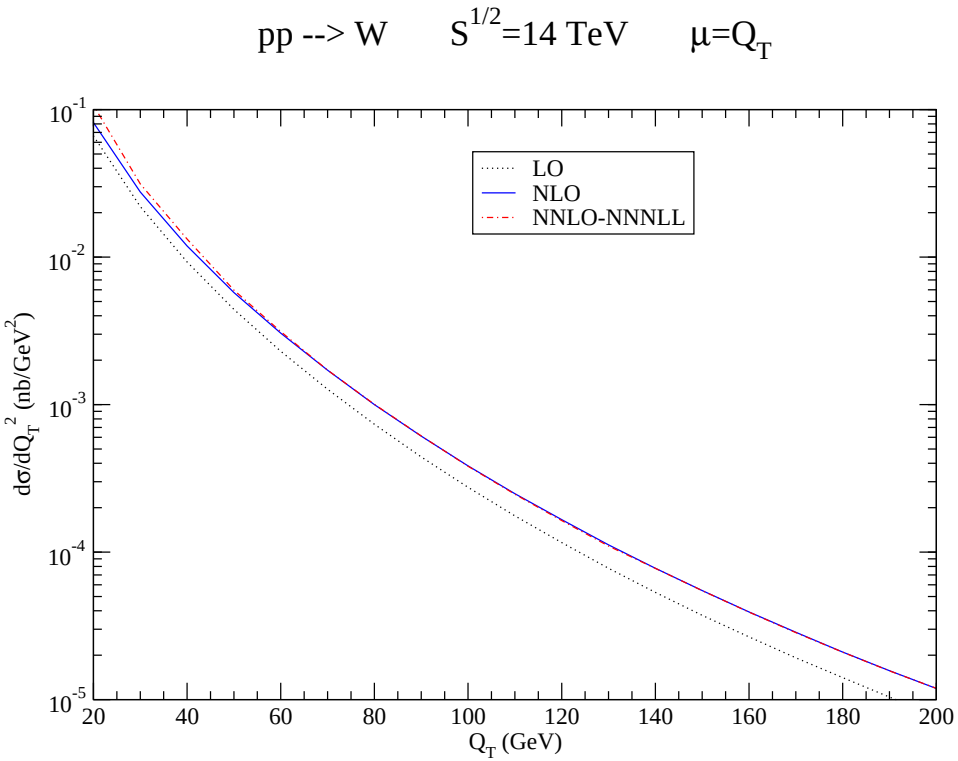
We can formally resum these logarithms for W production at large Q_T to all orders in α_s **N. Kidonakis and V. Del Duca, Phys. Lett. B 480, 87 (2000)**

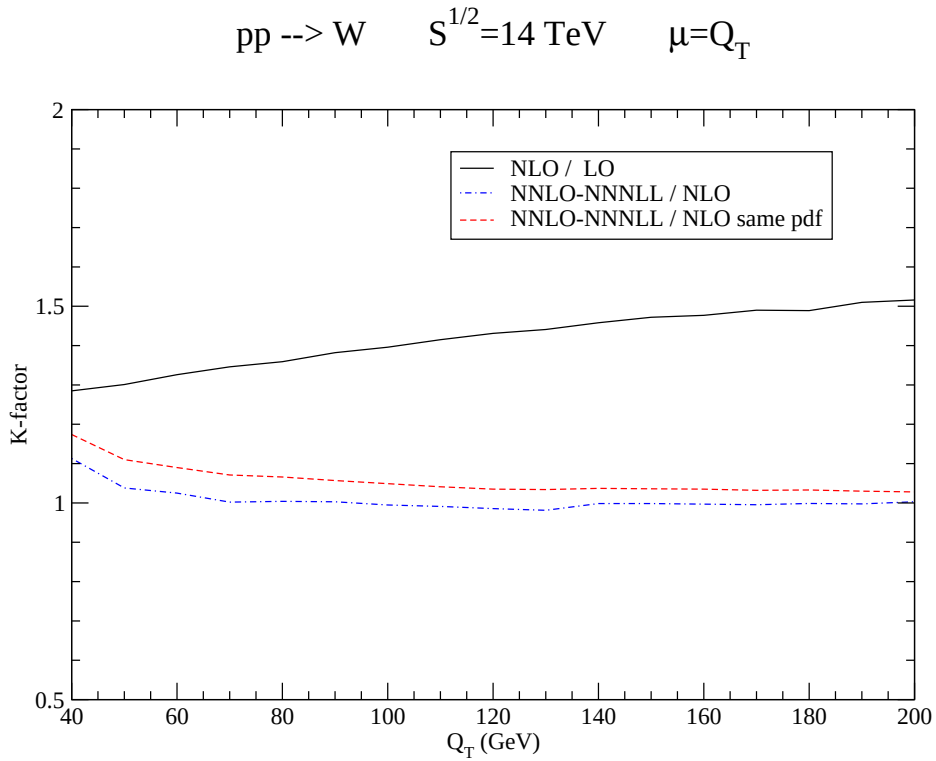
Applied to W production at the Tevatron

N. Kidonakis and A. Sabio Vera, JHEP 02, 027 (2004)

NLO and NNLO-NNLL cross section

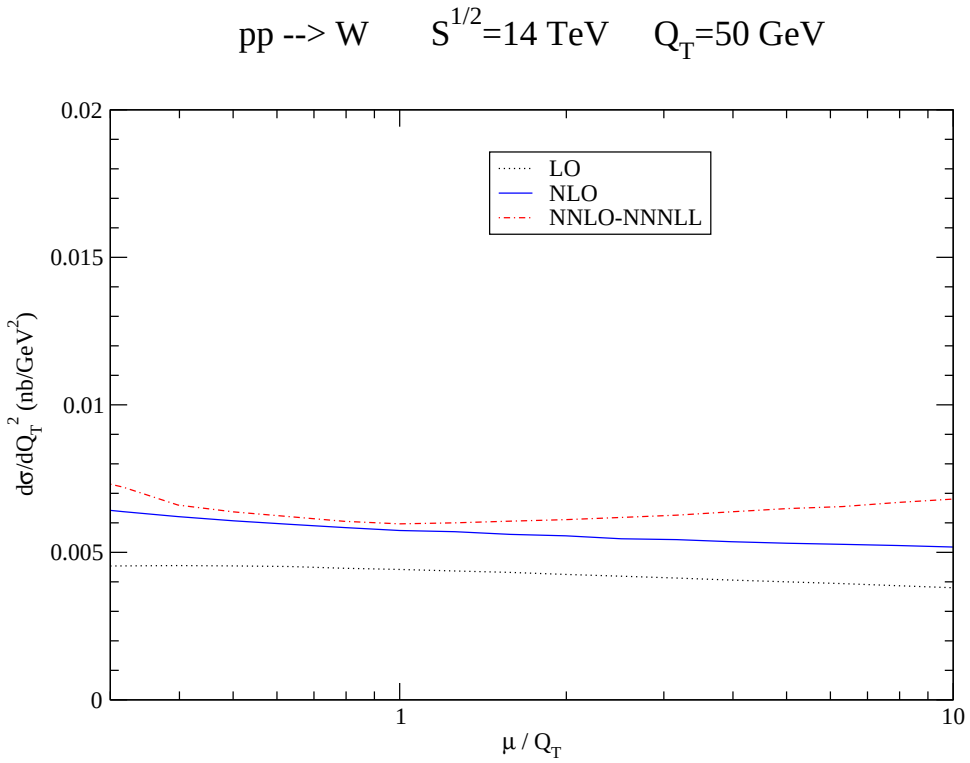
W production with large Q_T at the LHC

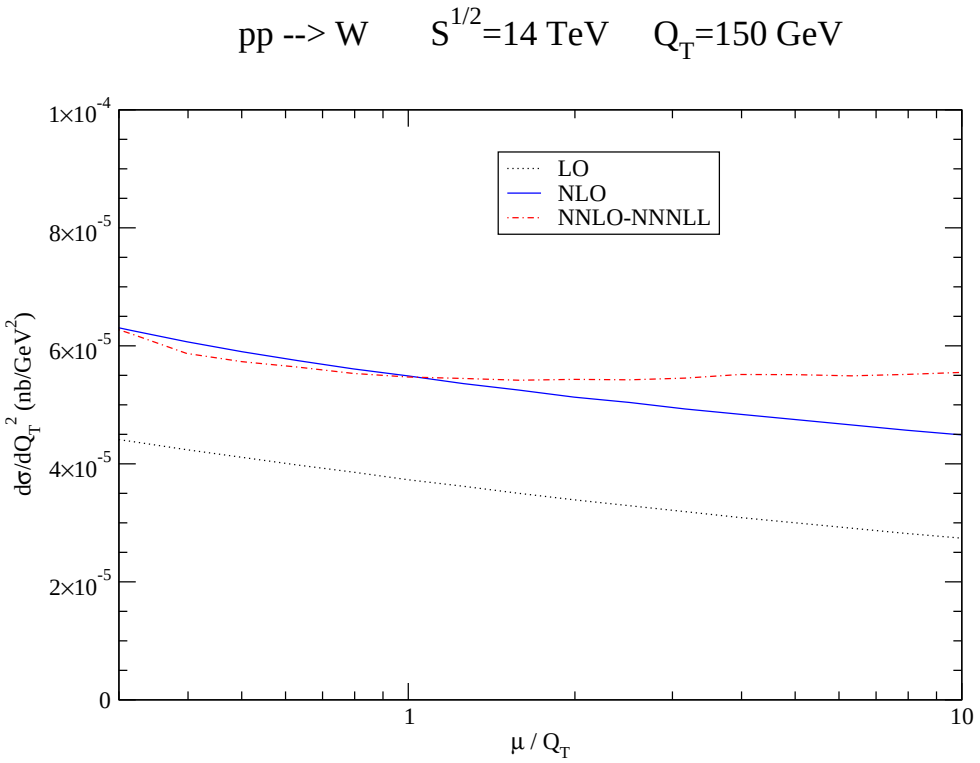




NLO corrections are large; NNLO-NNLL corrections small for $\mu = Q_T$

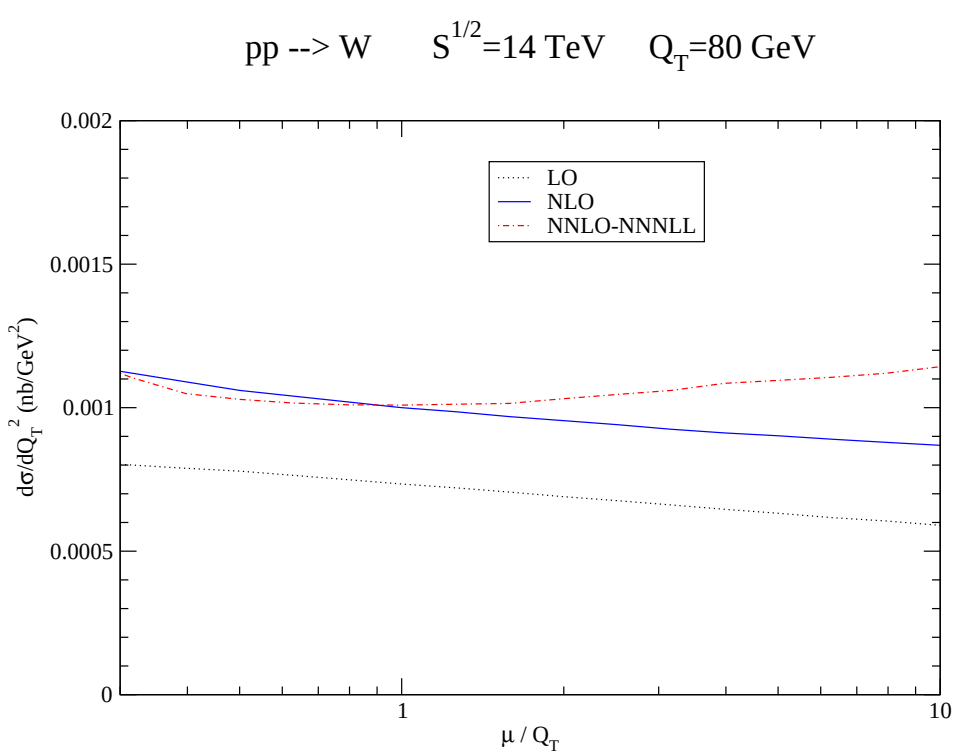
W production with large Q_T at the LHC

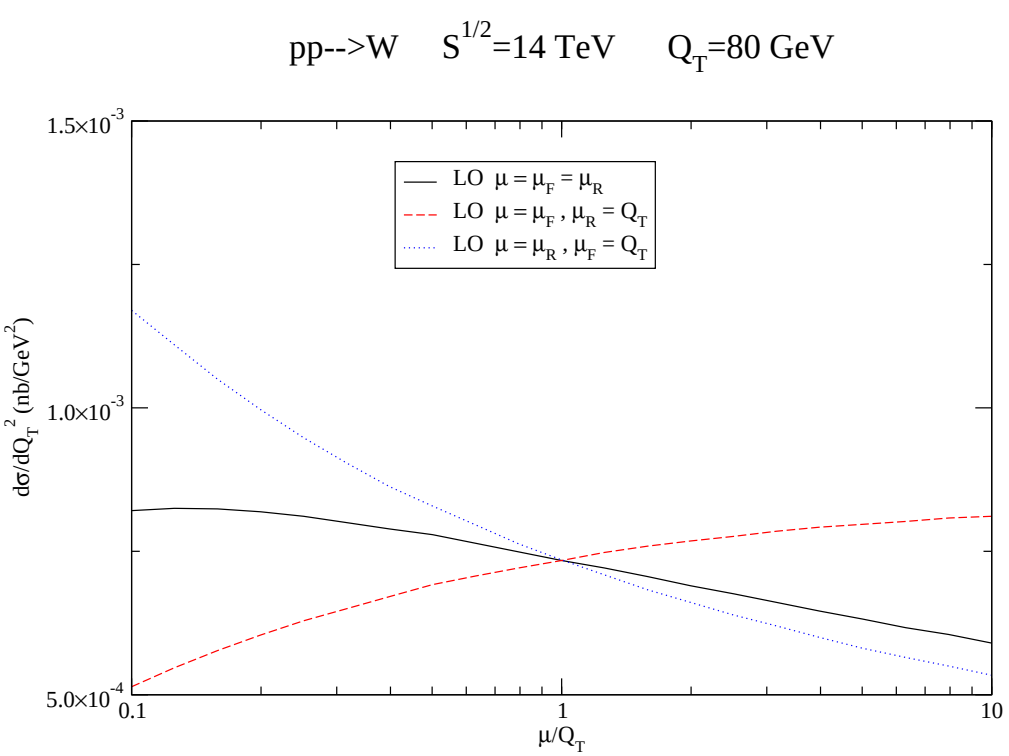




LO and NLO scale dependence similar; better at NNLO-NNLL

W production with large Q_T at the LHC

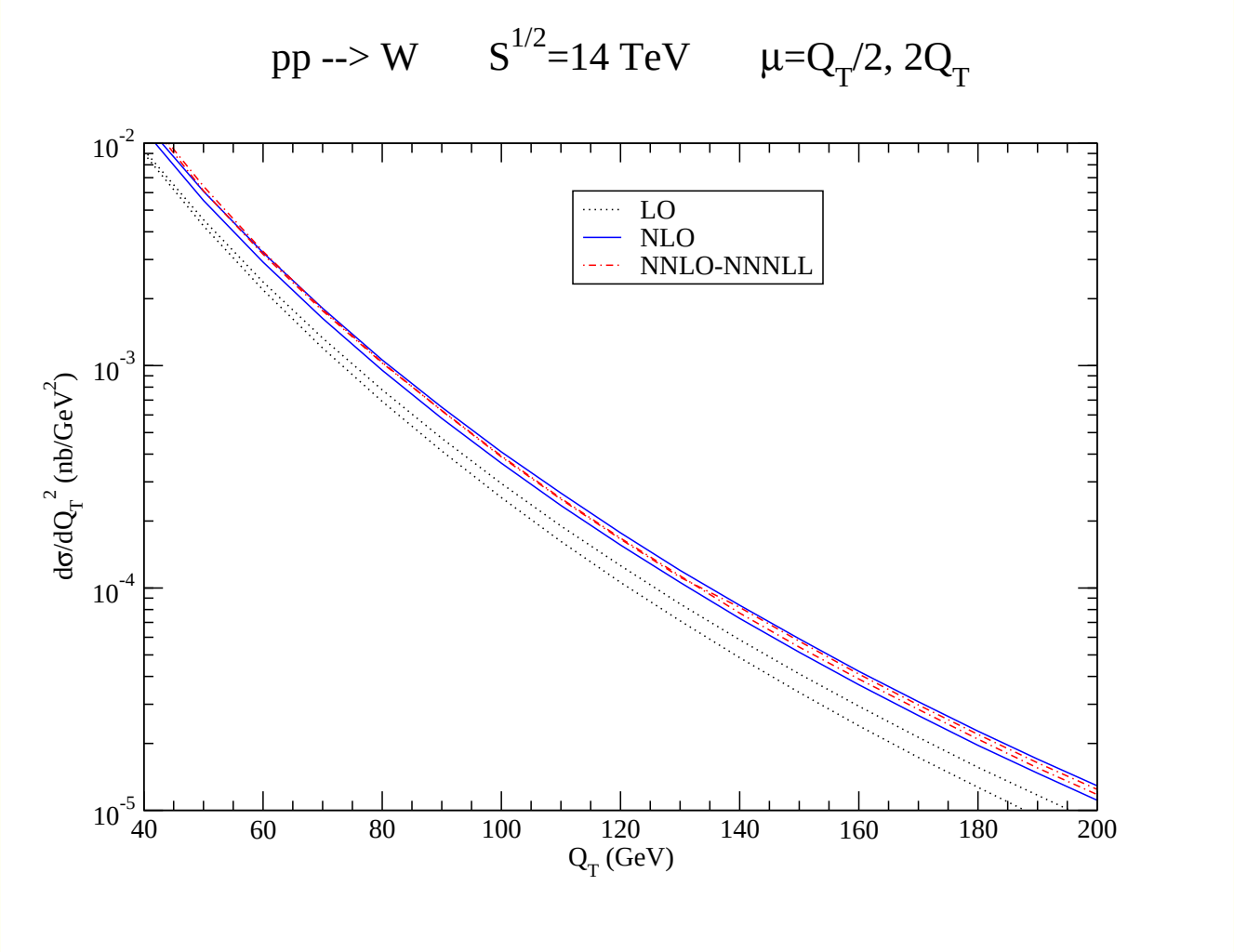




At LO μ_F and μ_R dependence largely cancel each other

gluon-initiated process $qg \to Wq$ dominant

W production with large Q_T at the LHC



Summary

- W production at large-Q_T in pp interactions at the LHC
- Complete NLO corrections
- Soft-gluon threshold corrections
- NNLO threshold corrections have been calculated
- Important for greater theoretical accuracy
- Reduced scale dependence