NNLO corrections for Drell-Yan and more

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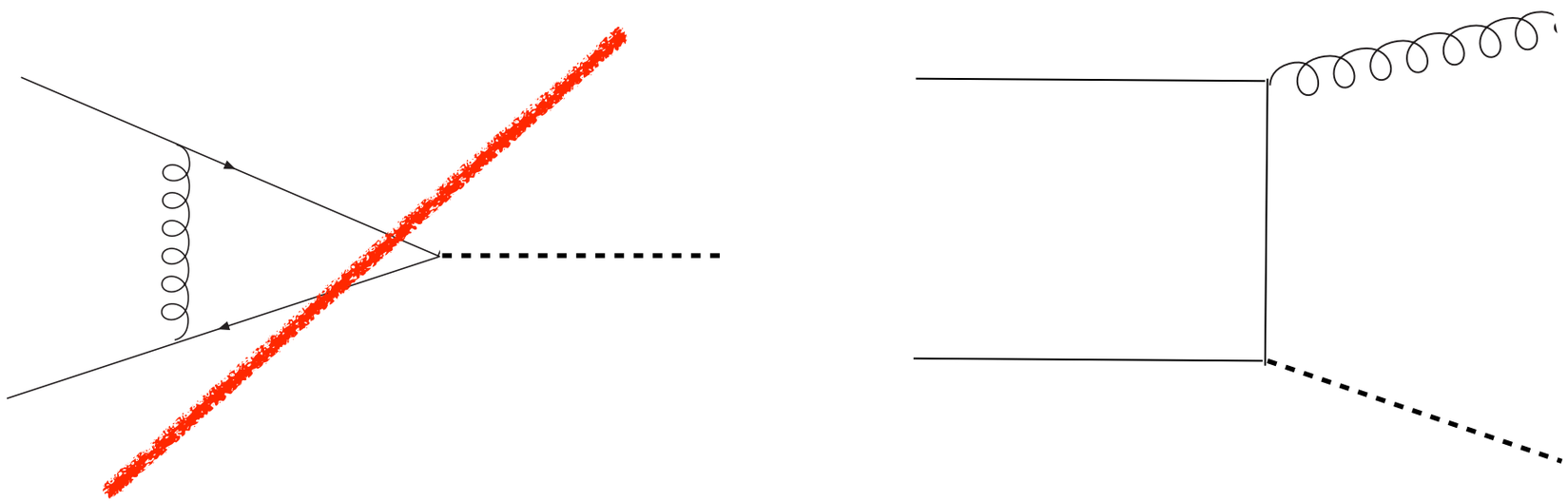
  complicated pattern of IR (soft/collinear) singularities

- For some observables the situation can be dealt with a simpler extension of the subtraction method

Drell-Yan:
no partons in
final state
@LO $q_T = 0$

$$d\sigma^{V}_{(N)NLO}\Big|_{q_T \neq 0} = d\sigma^{V+\mathrm{jet}}_{(N)LO}$$

S.Catani, L.Cieri, G.Ferrera,
DdeF, M.Grazzini



remaining singularities appear only at $q_T = 0$

Missing one(two) loop contributions and factorization term : born-like kinematics

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- All other singularities already handled by the (N)LO V+jet calculation
- If $q_T = 0$ included "NLO V+jet" → full "NNLO V" (exclusive) computation
- At $q_T = 0$ regularize singularity with countertem
  add suitable contribution at $q_T = 0$

$$d\sigma^V_{(N)NLO} = \mathcal{H}^V_{(N)NLO} \otimes d\sigma^V_{LO} + \left[d\sigma^{V+\text{jet}}_{(N)LO} - d\sigma^{CT}_{(N)LO} \right]$$

born-like

finite

- Counterterm should match the $q_T \to 0$ behaviour

Resummation of large logarithms at small transverse momentum

$$d\sigma^{CT} \sim d\sigma^{(LO)} \otimes \Sigma^H(q_T/Q)$$

$$\Sigma^H(q_T/Q) \sim \sum_{n=1}^{\infty} \left(\frac{\alpha_S}{\pi}\right)^n \sum_{k=1}^{2n} \Sigma^{H(n;k)} \frac{Q^2}{q_T^2} \ln^{k-1} \frac{Q^2}{q_T^2}$$

DdeF, M.Grazzini

Coefficients known at NNLO: universal structure
for any process with non-colored particles in final state

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DdeF, M.Grazzini

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- Coefficient $\mathcal{H}^V_{(N)NLO}$ to restore normalization from same program

$$\mathcal{H}^V = 1 + \frac{\alpha_S}{\pi} \mathcal{H}^{V(1)} + \left(\frac{\alpha_S}{\pi}\right)^2 \mathcal{H}^{V(2)} + \dots$$

G.Bozzi, S.Catani, DdeF, M.Grazzini

from $\int_0^{p_T^2} dq_T^2 \frac{d\hat{\sigma}^V}{dq_T^2}$ $\qquad p_T^2 \ll M_V^2$

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DdeF, M.Grazzini

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G.Bozzi, S.Catani, DdeF, M.Grazzini

from $$\int_0^{p_T^2} dq_T^2 \frac{d\hat{\sigma}^V}{dq_T^2} = \hat{\sigma}^V_{\text{inclusive}} - \int_{p_T^2}^{\infty} dq_T^2 \frac{d\hat{\sigma}^V}{dq_T^2} \qquad p_T^2 \ll M_V^2$$

Up to now, Inclusive needed for Exclusive

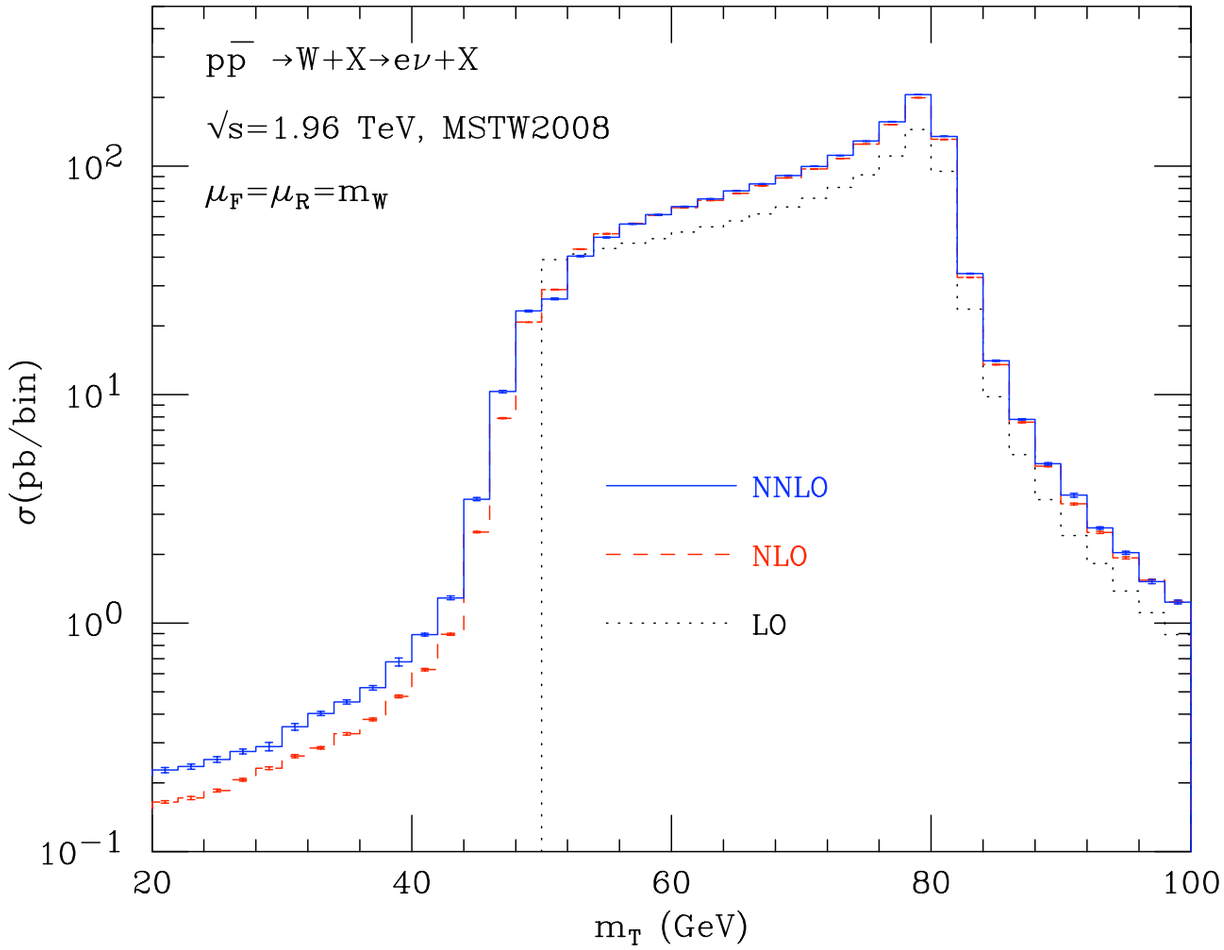
- Just one example

NLO from MCFM

$$m_T = \sqrt{2 p_T^l p_T^{\rm miss} (1 - \cos\phi)}$$

Cuts: $p_T^{\rm miss} > 25\,{\rm GeV}$

$p_T^l > 20\,{\rm GeV} \quad |\eta| < 2$



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- Exclusive Higgs calculation implemented with the same procedure

S.Catani, M.Grazzini

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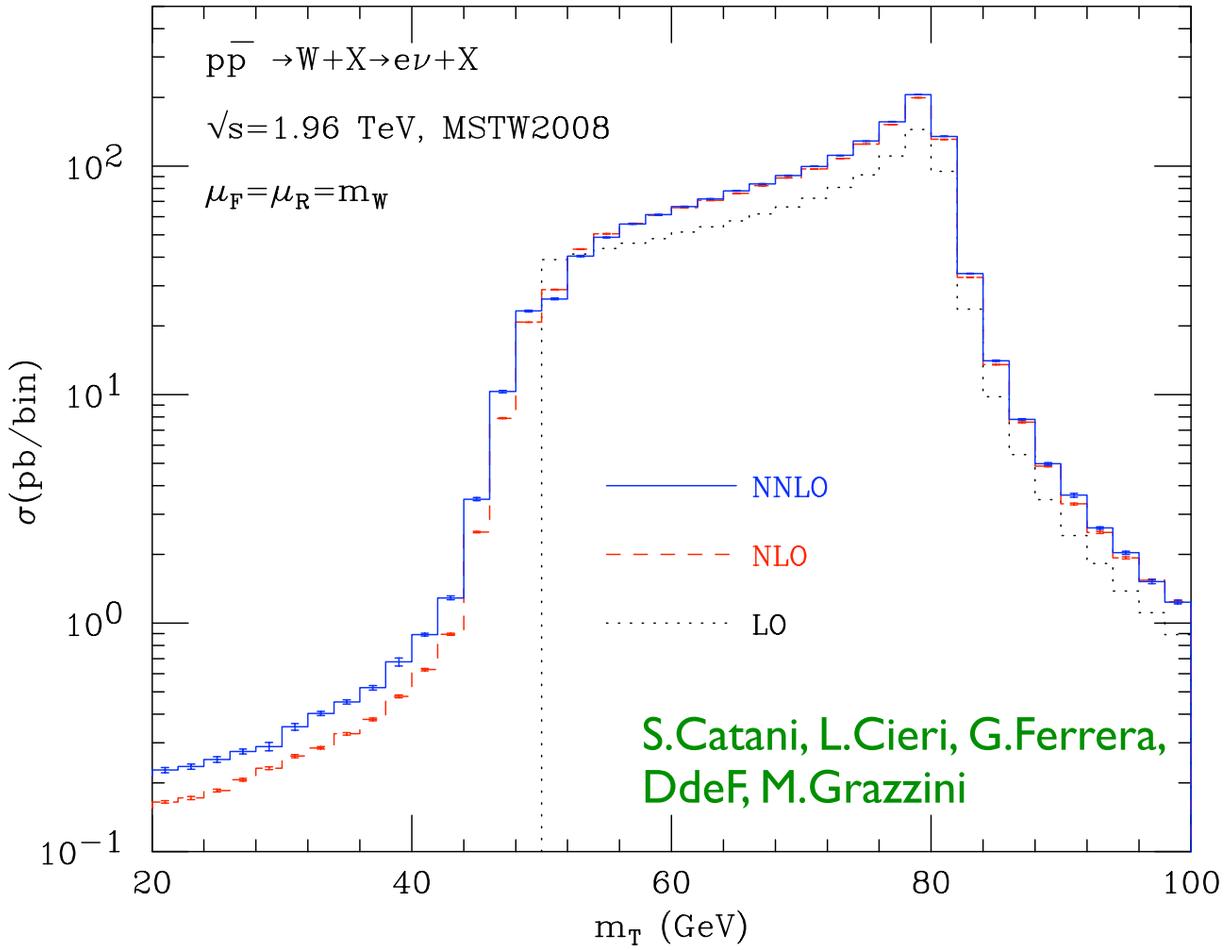

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- Work in progress

Use universal structure of soft/collinear emission to find $\mathcal{H}$ coefficient for any process without partons in final state

pp ⟶ any number of gauge/Higgs bosons