Supplemental material

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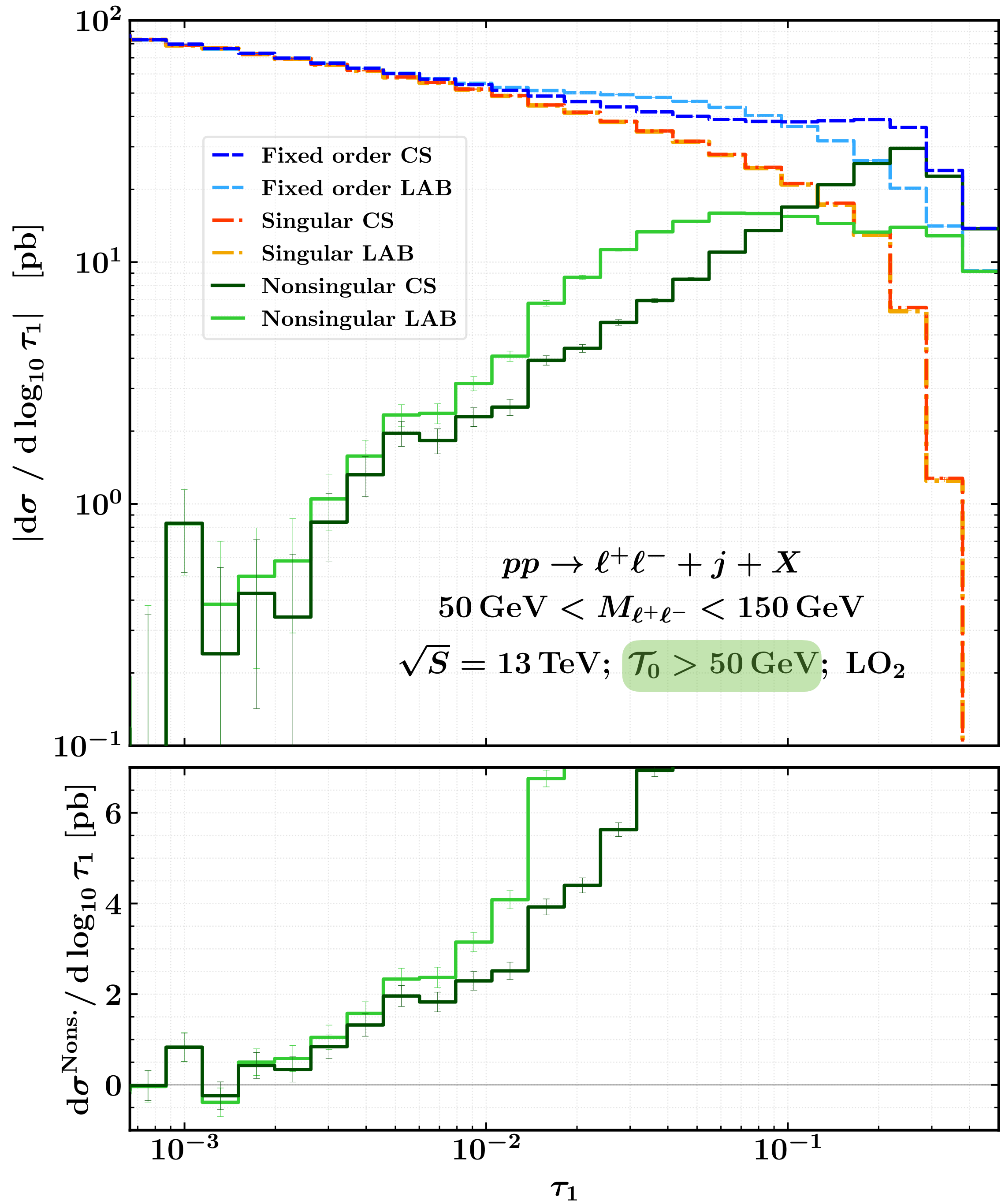
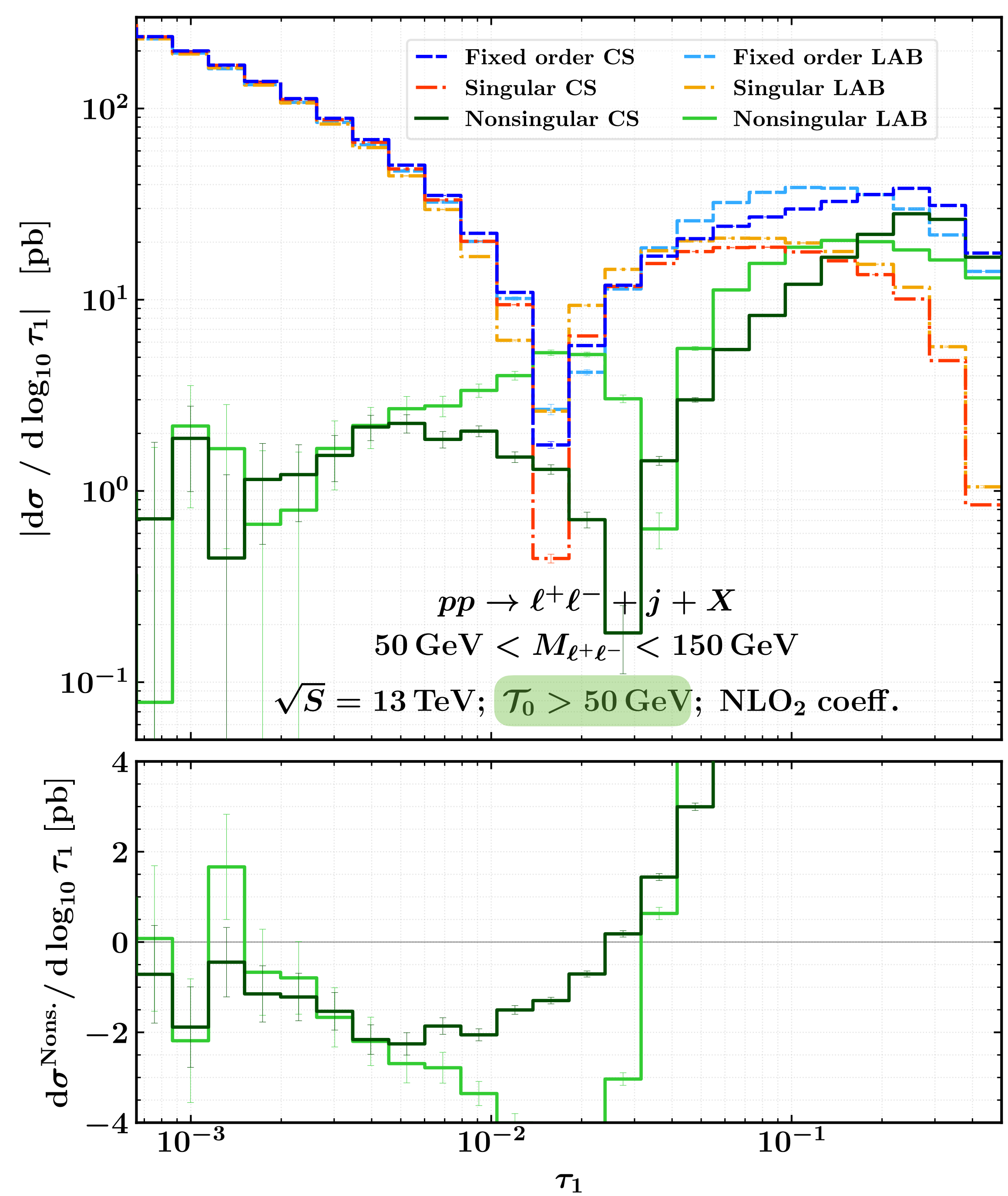
FO vs Singular vs Nonsingular

- Different frame definitions of one-jettiness have different size of power corrections

$$\mu_R = \mu_F = \mu_{\rm FO} = m_T \equiv \sqrt{M^2_{\ell^+\ell^-} + q_T^2}$$



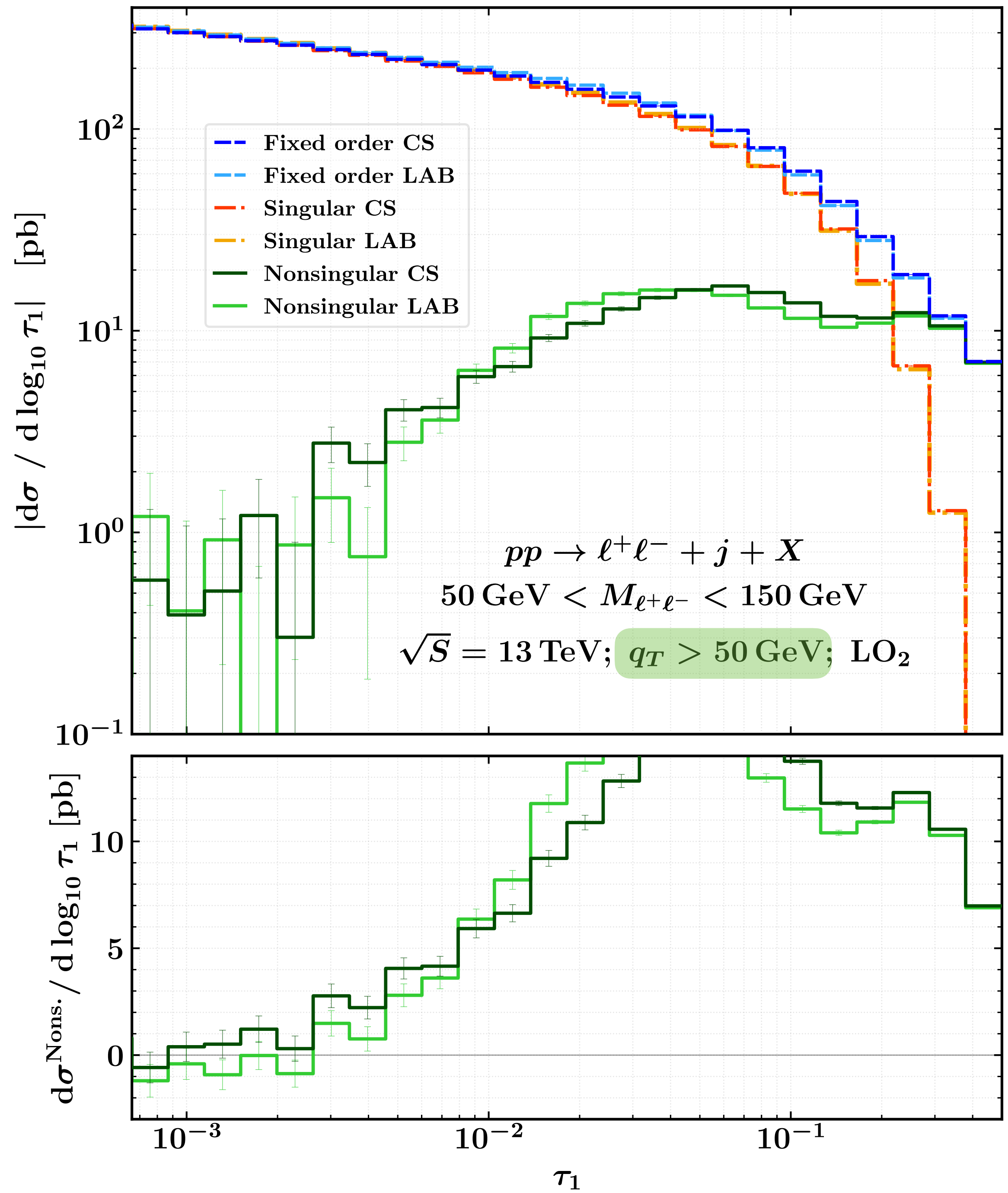


$\mathcal{O}(\alpha_s^2)$

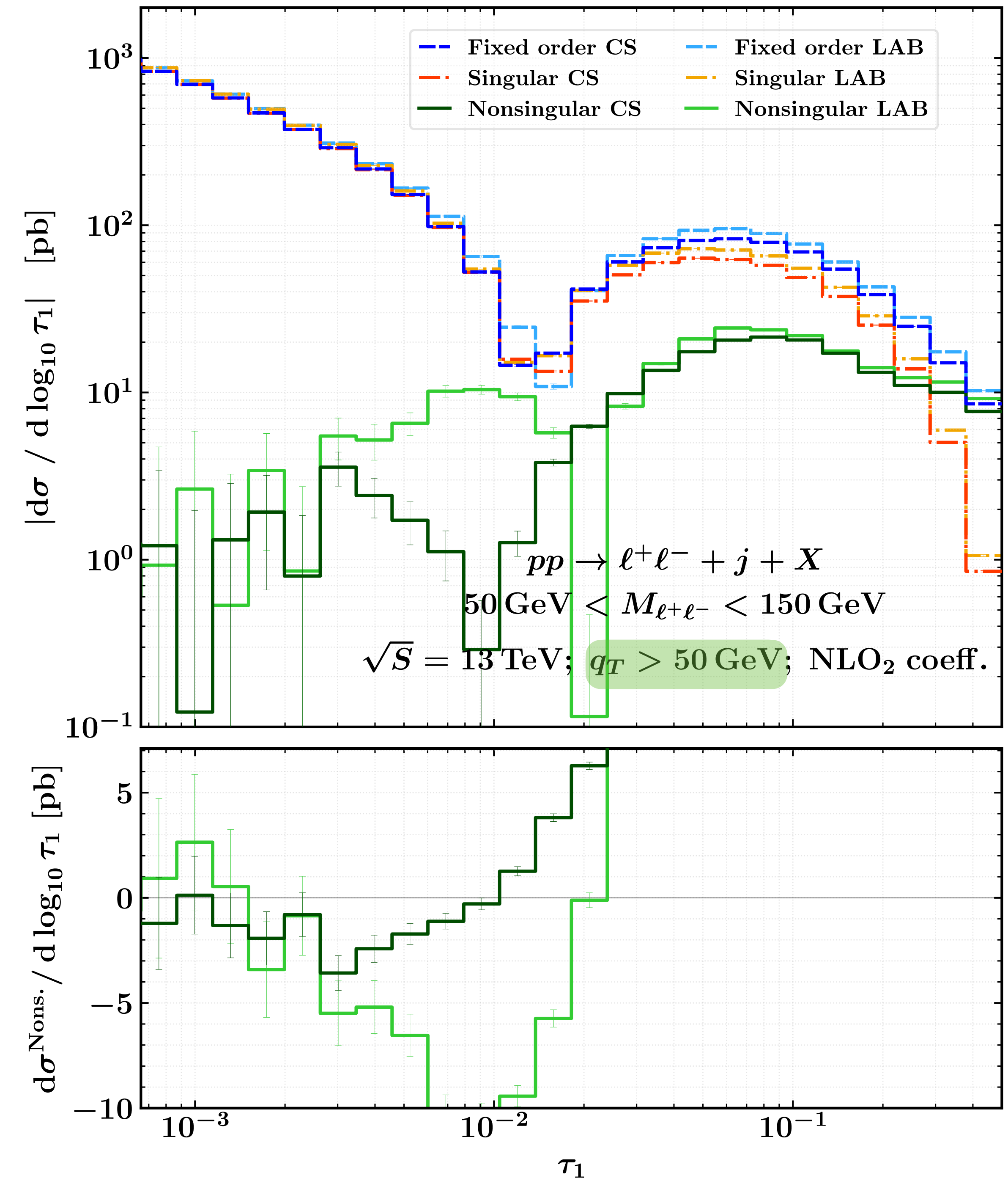
$\mathcal{O}(\alpha_s^3)$ $\qquad \tau_1 = \mathcal{T}_1/\sqrt{M^2_{l^+l^-} + q_T^2}$

FO vs Singular vs Nonsingular

- Using the Z boson transverse momentum q_T as Born process defining cut



$\mathcal{O}(\alpha_s^2)$



$\mathcal{O}(\alpha_s^3)$

Two-dimensional profile scales

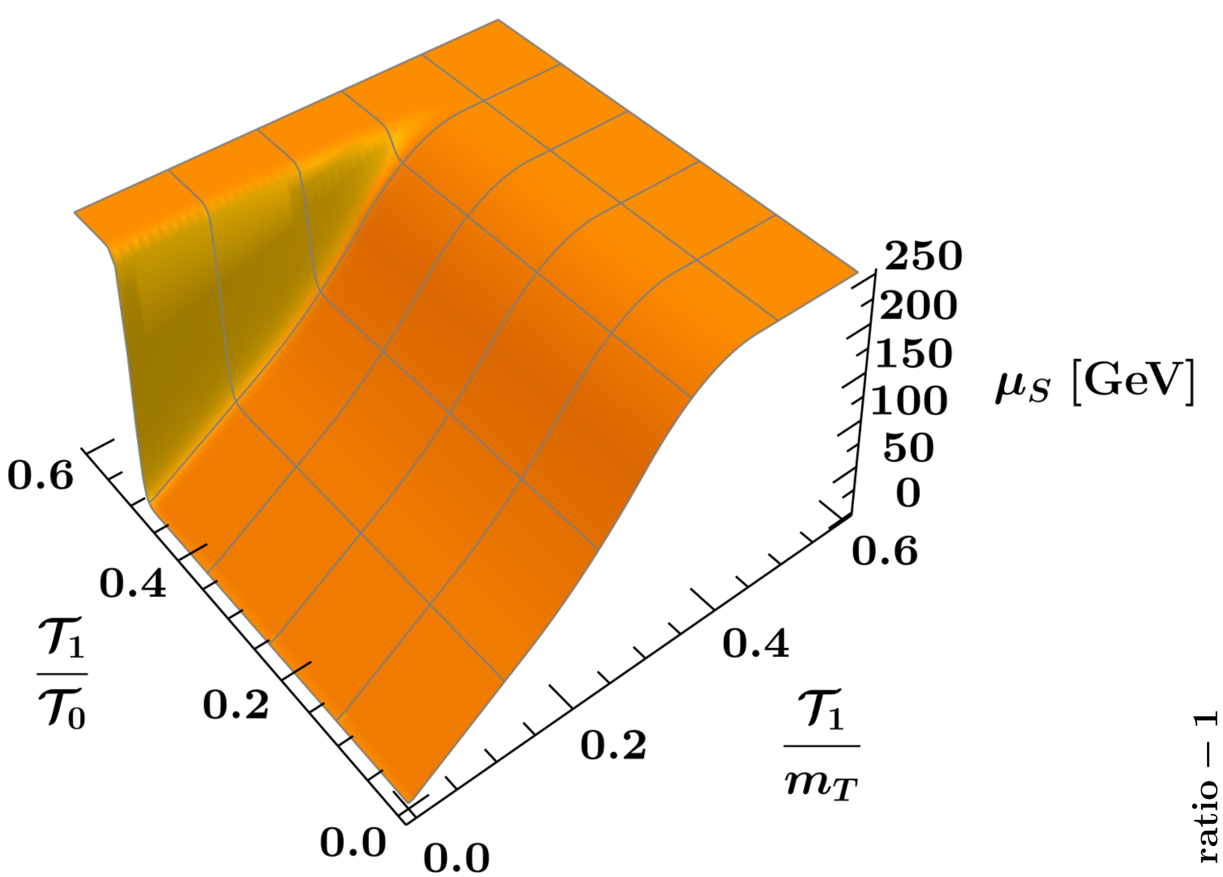
A final state with N particles is subject to the constraint

$$\frac{\mathcal{T}_1(\Phi_N)}{\mathcal{T}_0(\Phi_N)} \leq \frac{N-1}{N} = \begin{cases} 1/2\,, & N=2 \\ 2/3\,, & N=3 \end{cases}$$

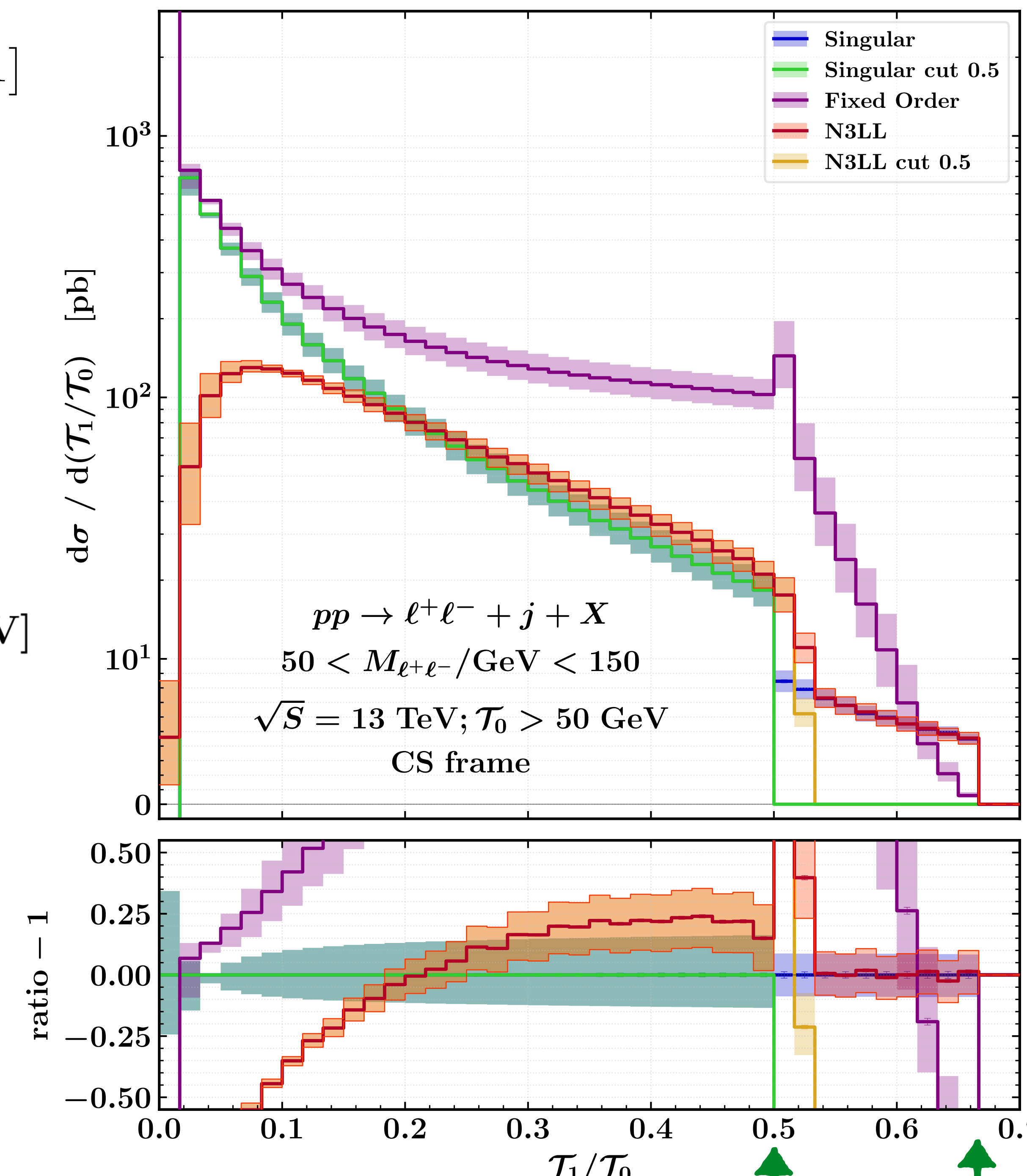
$$\mu_S(\mathcal{T}_1/\mu_{\rm FO}, \mathcal{T}_1/\mathcal{T}_0) = \mu_{\rm FO}\big[\big(f_{\rm run}(\mathcal{T}_1/\mu_{\rm FO}) - 1\big) s^{(p,k)}(\mathcal{T}_1/\mathcal{T}_0) + 1\big]$$

Behaves as smooth Theta function

$$s^{(p,k)}(\mathcal{T}_1/\mathcal{T}_0) = \frac{1}{1 + e^{pk(\mathcal{T}_1/\mathcal{T}_0 - 1/p)}}$$



We use $p = 2$ (determines the transition point) and $k = 100$ (slope of the transition)



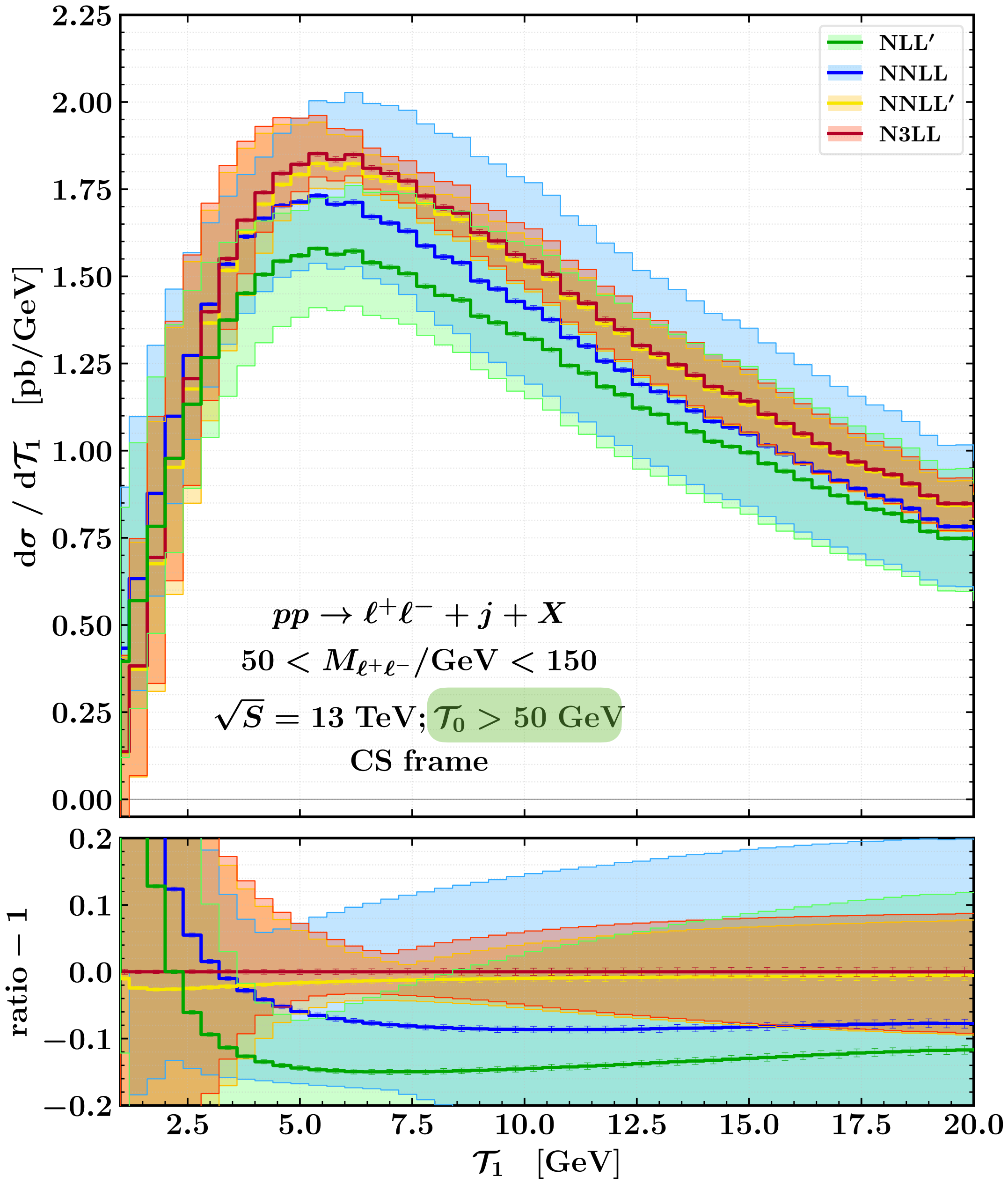
Kinematical boundaries

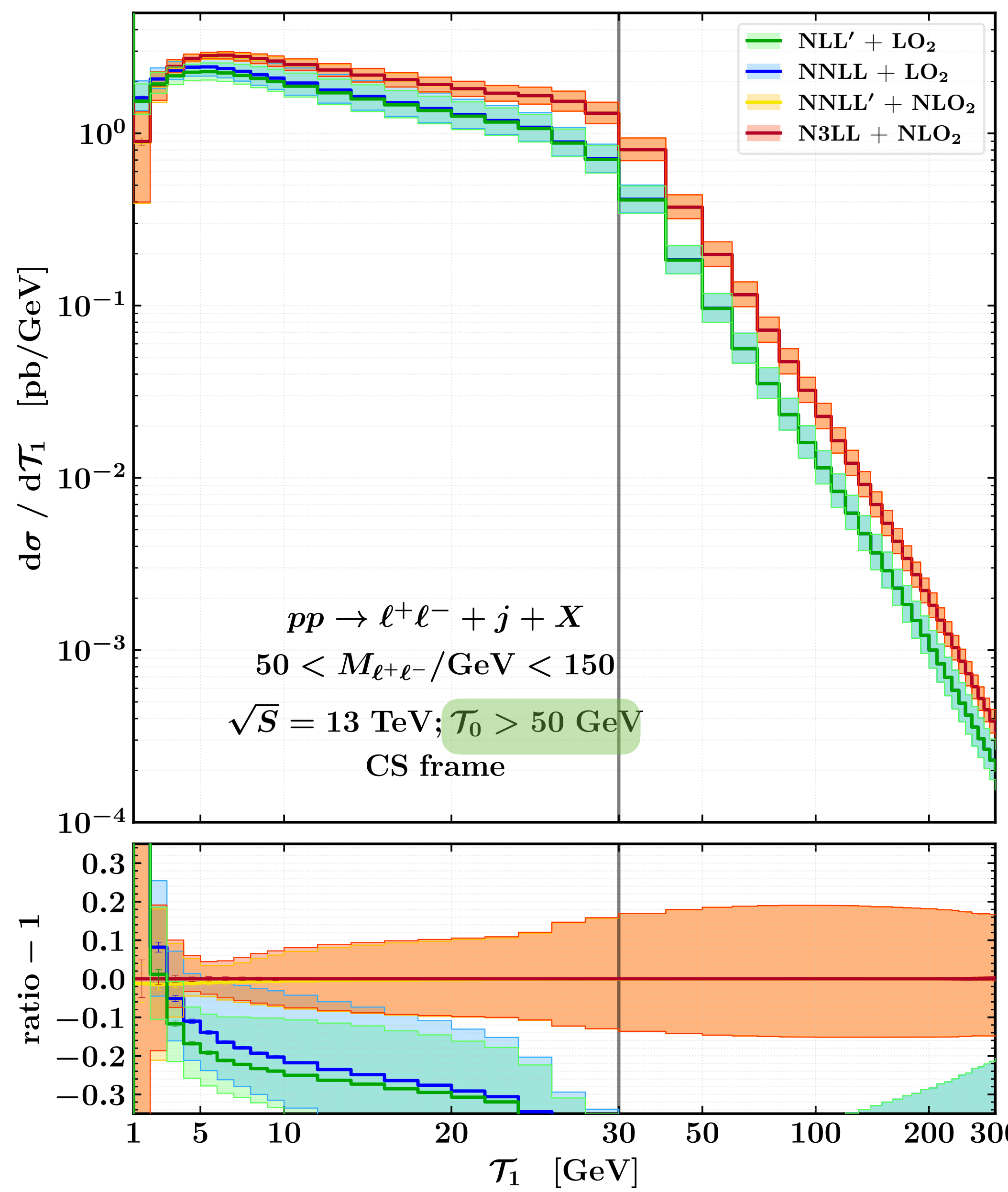
Resummed and matched results

Matching Formula

$$\frac{d\sigma^{\mathrm{N^3LL+NLO_2}}}{d\Phi_1 d\mathcal{T}_1} = \frac{d\sigma^{\mathrm{N^3LL}}}{d\Phi_1 d\mathcal{T}_1} + \frac{d\sigma^{\mathrm{Nons.}}}{d\Phi_1 d\mathcal{T}_1}$$

$$\frac{d\sigma^{\mathrm{Nons.}}}{d\Phi_1 d\mathcal{T}_1} = \left(\frac{d\sigma^{\mathrm{NLO_2}}}{d\Phi_1 d\mathcal{T}_1} - \frac{d\sigma^{\mathrm{N^3LL}}}{d\Phi_1 d\mathcal{T}_1}\bigg|_{\mathcal{O}(\alpha_s^2)} \right) \theta(\mathcal{T}_1)$$





Uncertainties evaluated by adding in quadrature μ_{FO} variations with soft, jet, beam variations

Resummed and matched results

Matching Formula

$$\frac{d\sigma^{N^3LL+NLO_2}}{d\Phi_1 d\mathcal{T}_1} = \frac{d\sigma^{N^3LL}}{d\Phi_1 d\mathcal{T}_1} + \frac{d\sigma^{Nons.}}{d\Phi_1 d\mathcal{T}_1}$$

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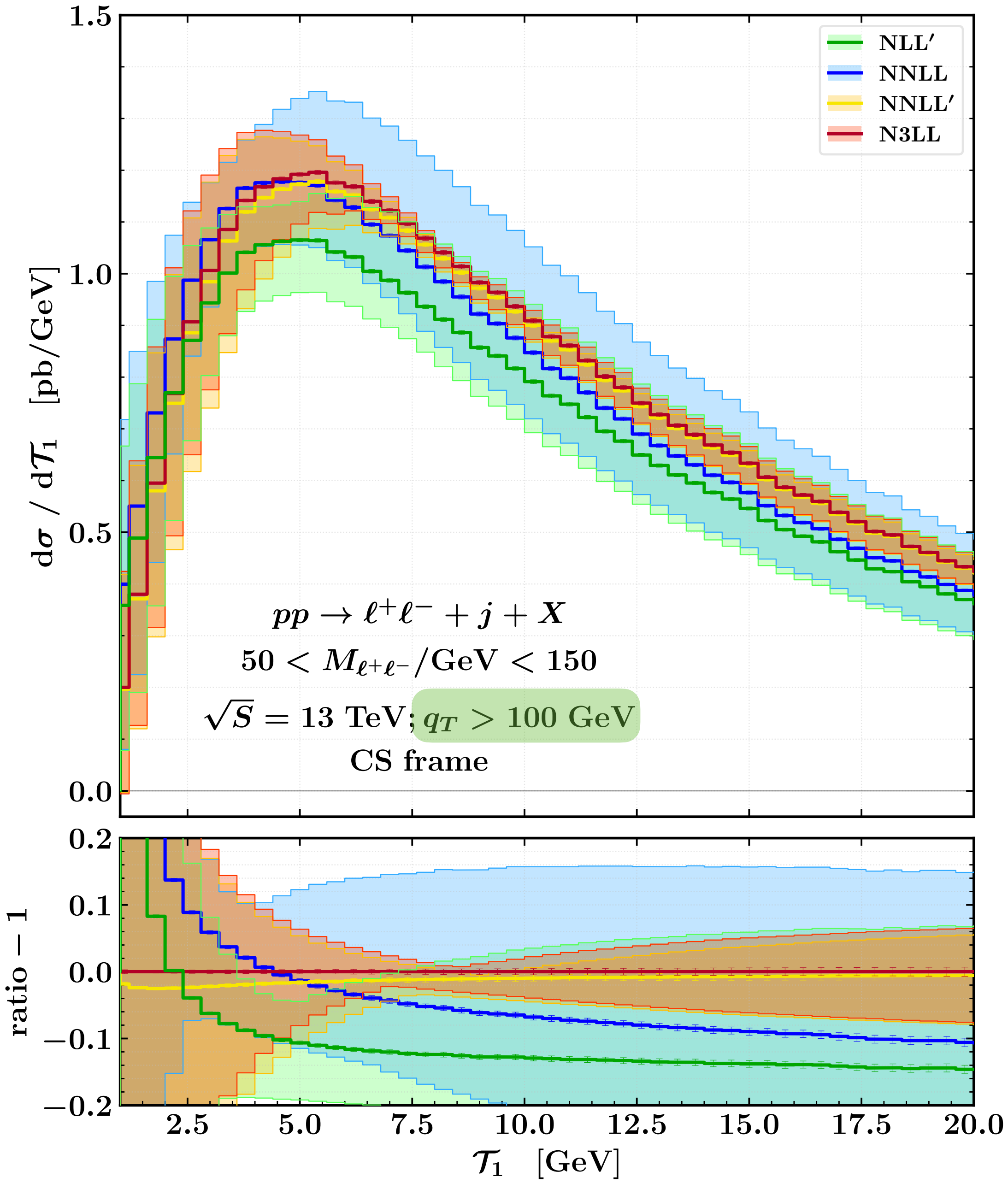
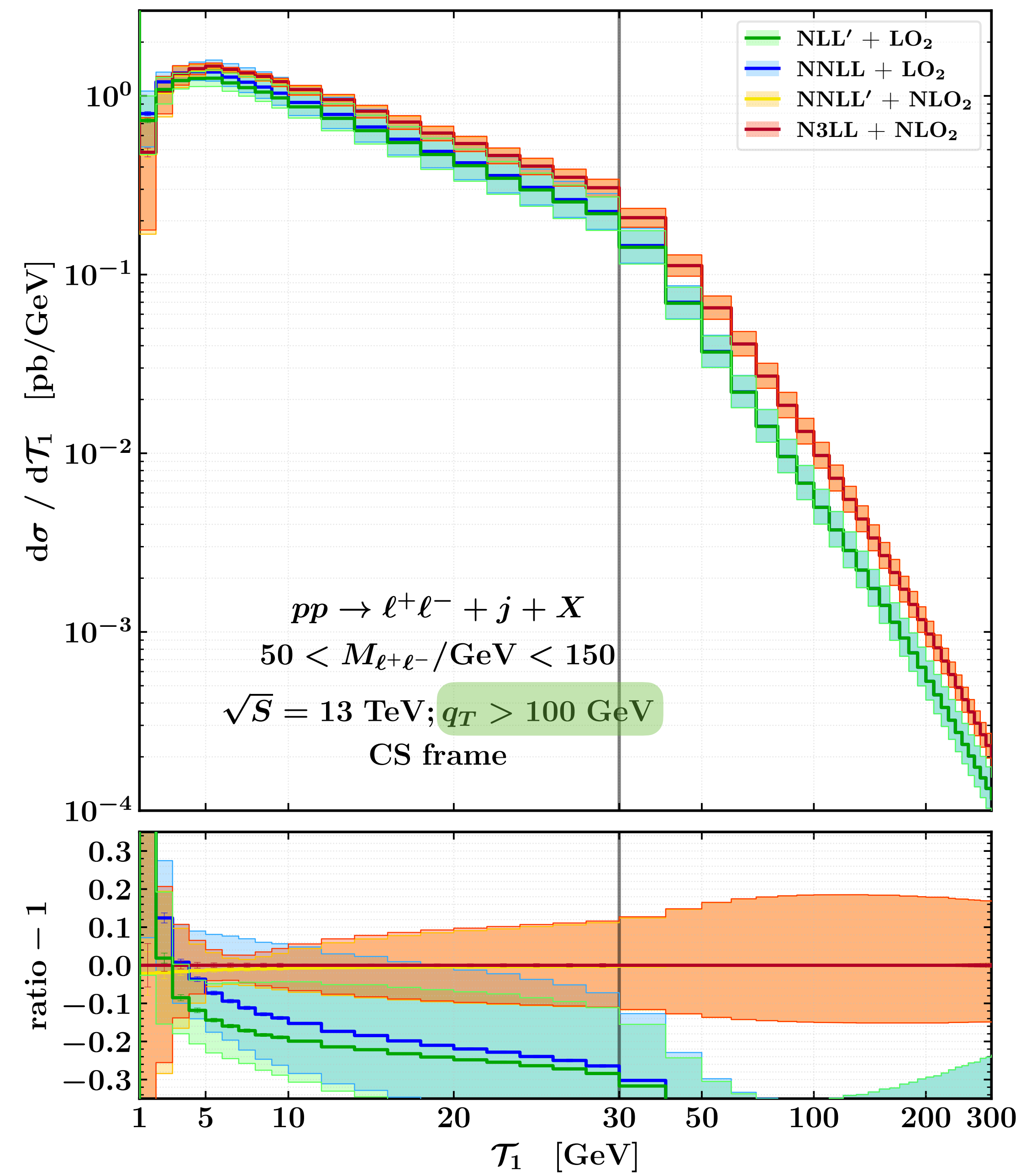




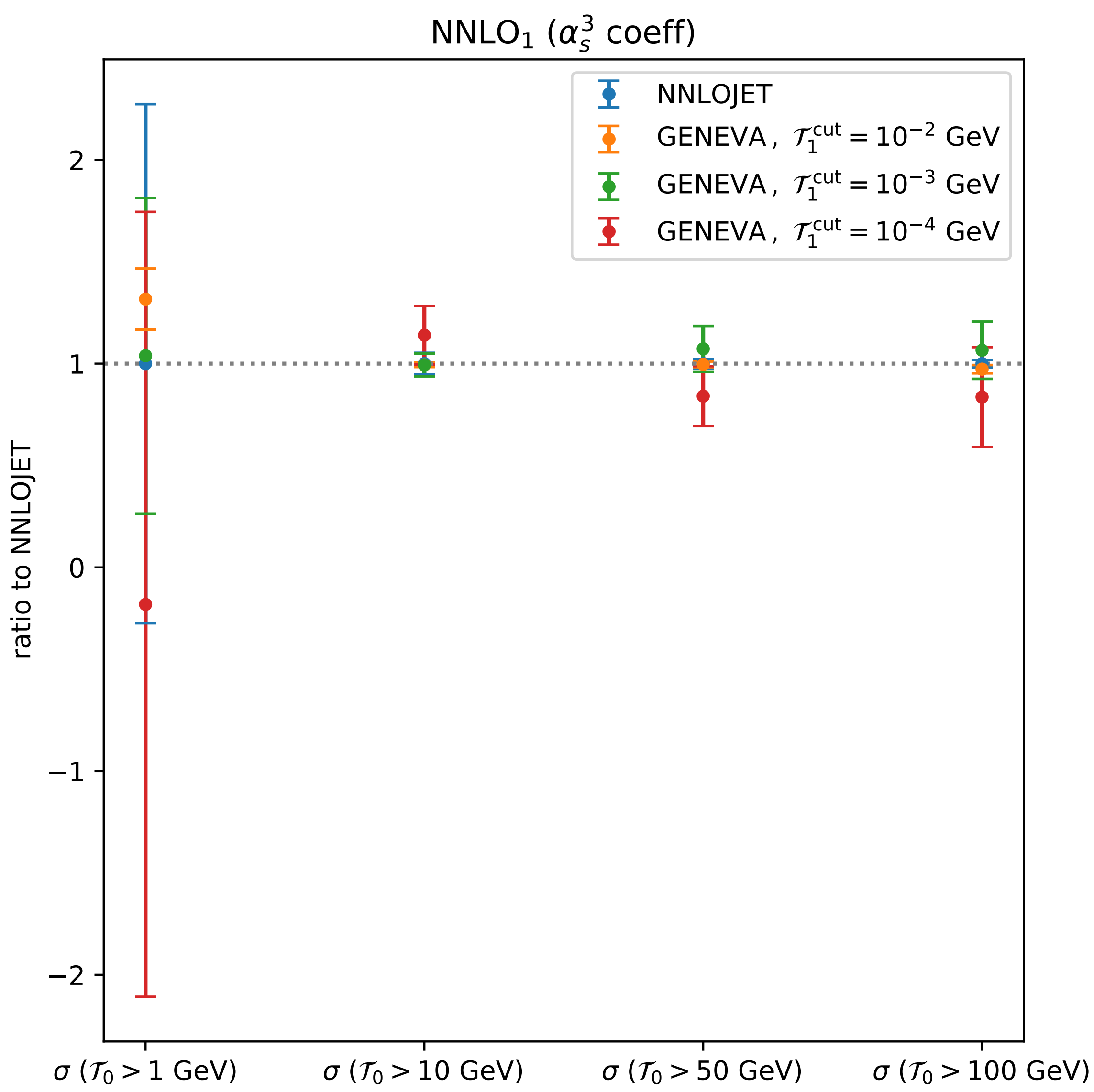
Uncertainties evaluated by adding in quadrature μ_{FO} variations with soft, jet, beam variations

NNLO results via 1-jettiness slicing

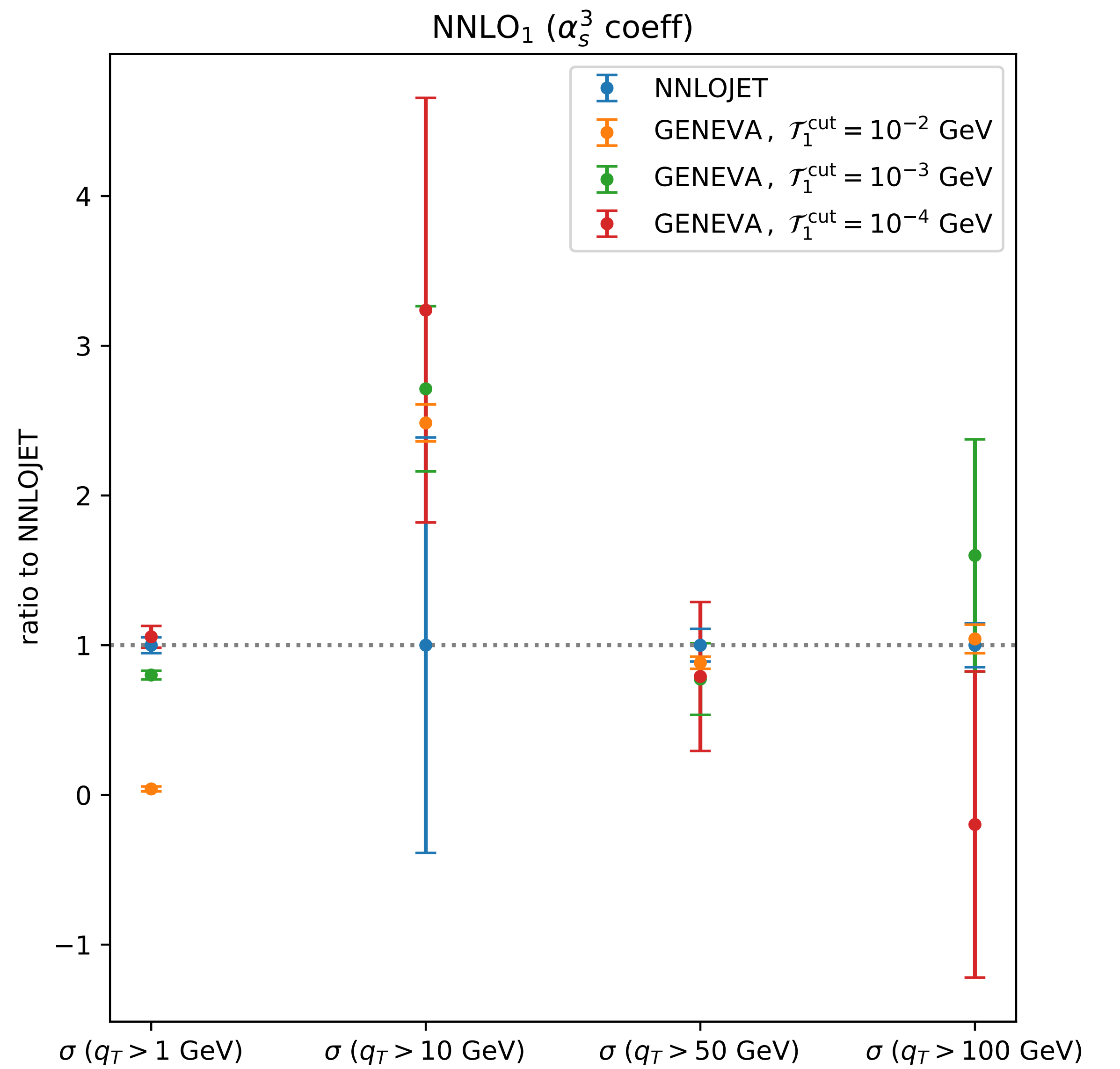
- Important to test the NNLO accuracy of the calculation: we expanded our matching formula to NNLO (one-jettiness slicing) and compared the pure $\mathcal{O}(\alpha_s^3)$ correction with NNLOJET

$$\frac{d\sigma^{\delta NNLO}}{d\Phi_1} = \frac{d\sigma^{N^3LL}(\mathcal{T}_1^{\rm cut})}{d\Phi_1}\Bigg|_{\mathcal{O}(\alpha_s^3)} + \int_{\mathcal{T}_1^{\rm cut}}^{\mathcal{T}_1^{\rm max}} d\mathcal{T}_1 \frac{d\sigma^{\delta \rm NLO_2}}{d\Phi_1 d\mathcal{T}_1}$$

Very Preliminary!!



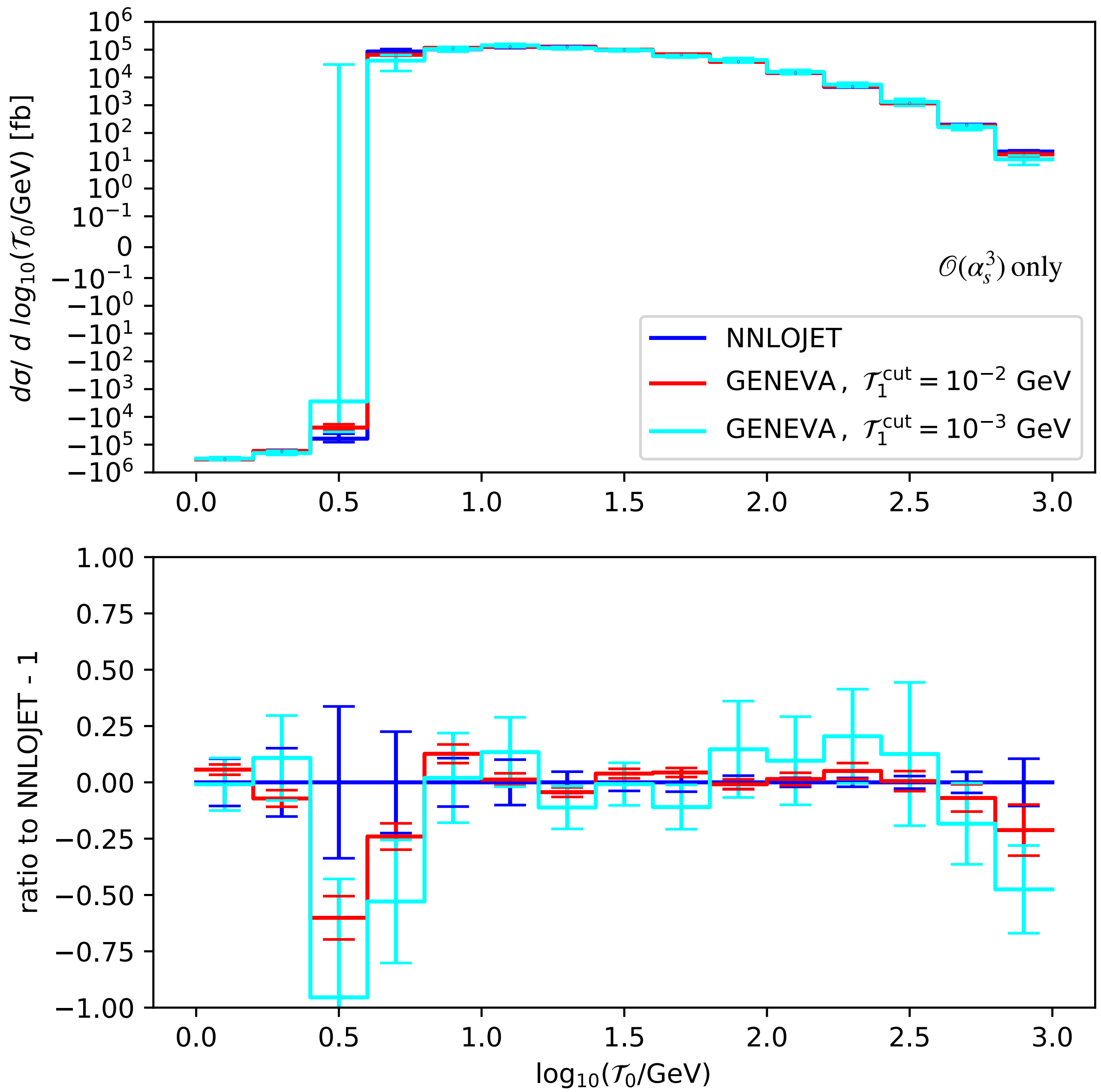
XS with $\mathcal{T}_0$ cuts



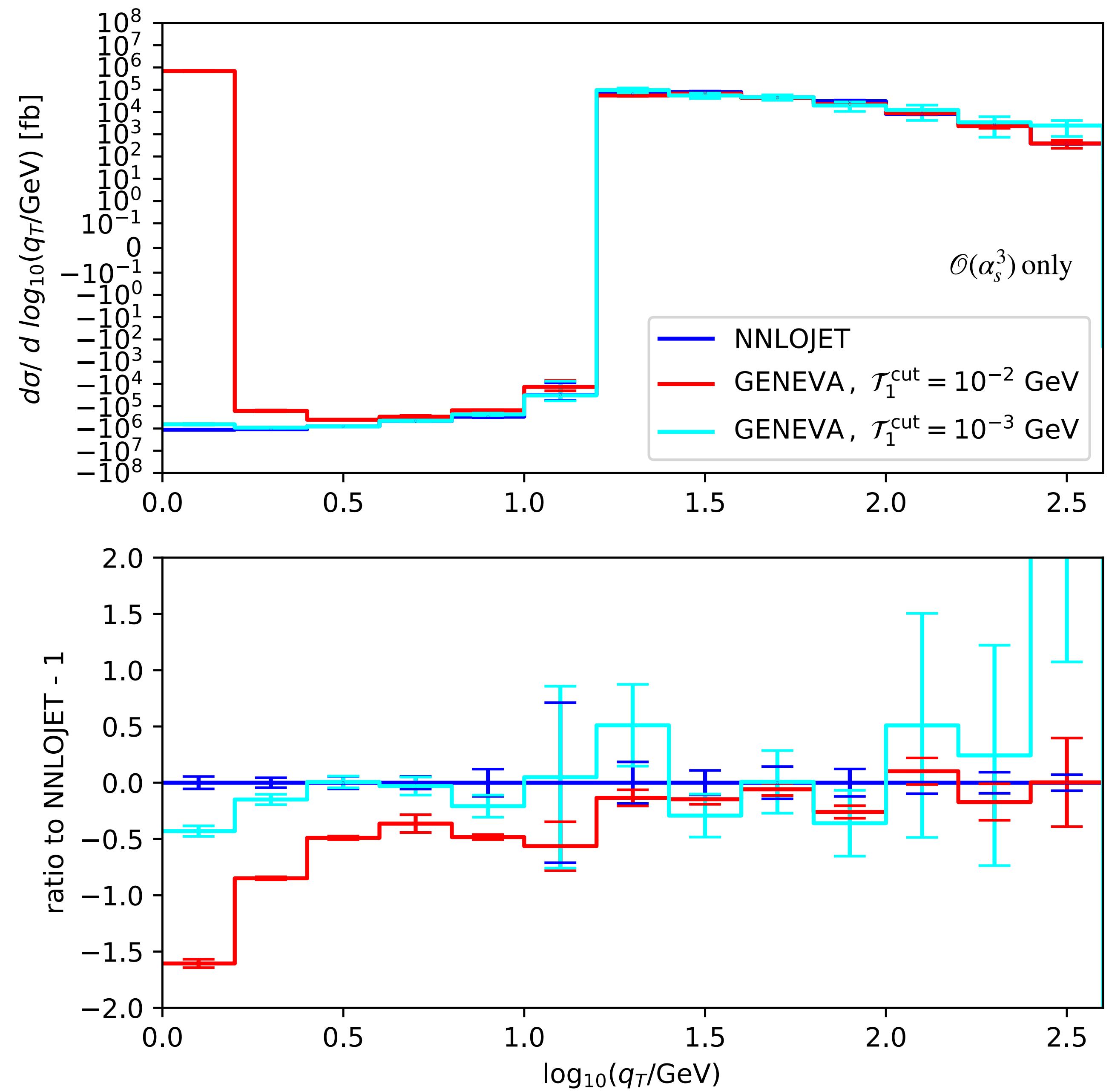
XS with q_T cuts

NNLO results differential distributions

Very Preliminary!!



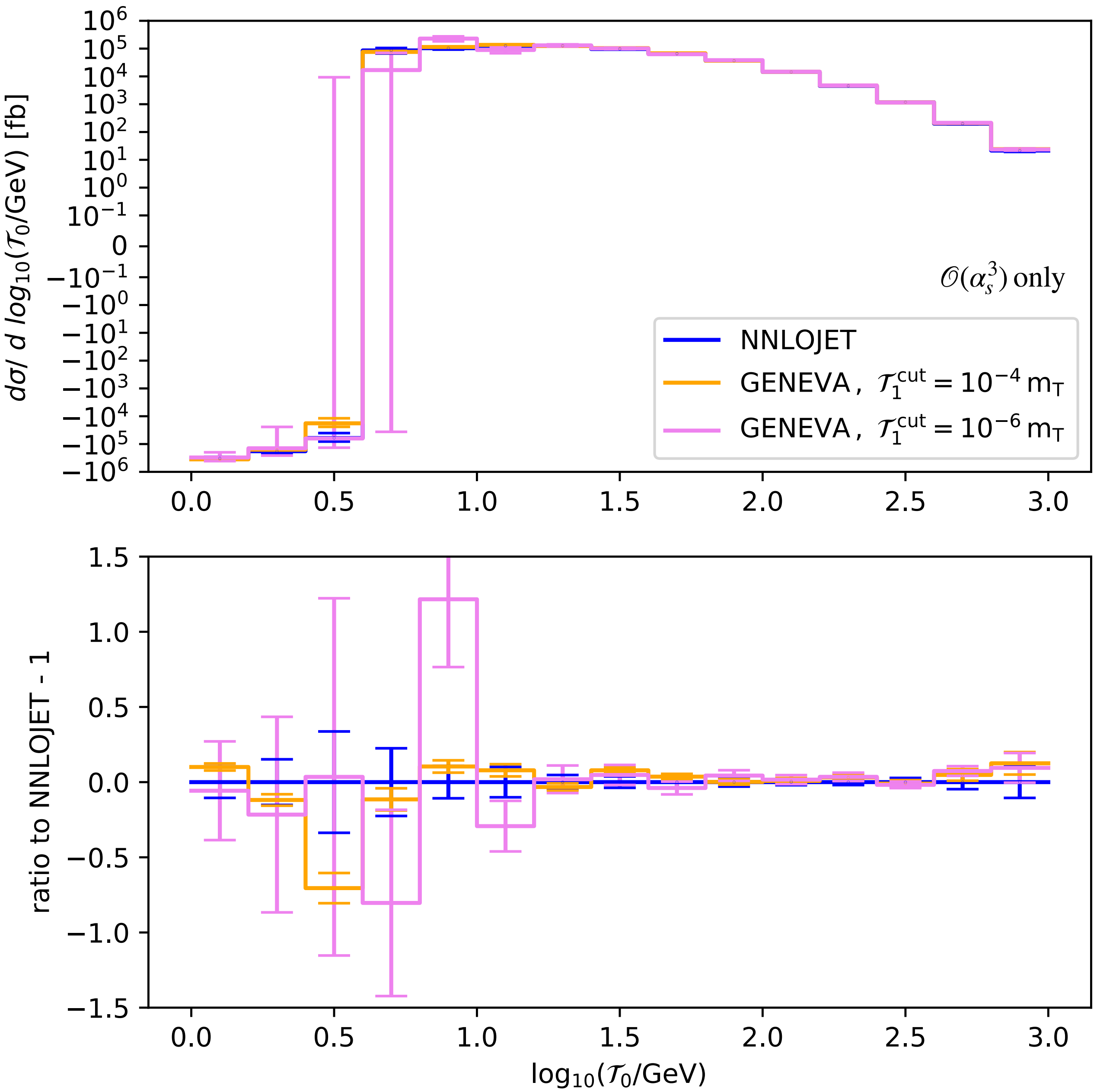
$\mathscr{T}_0$ distribution



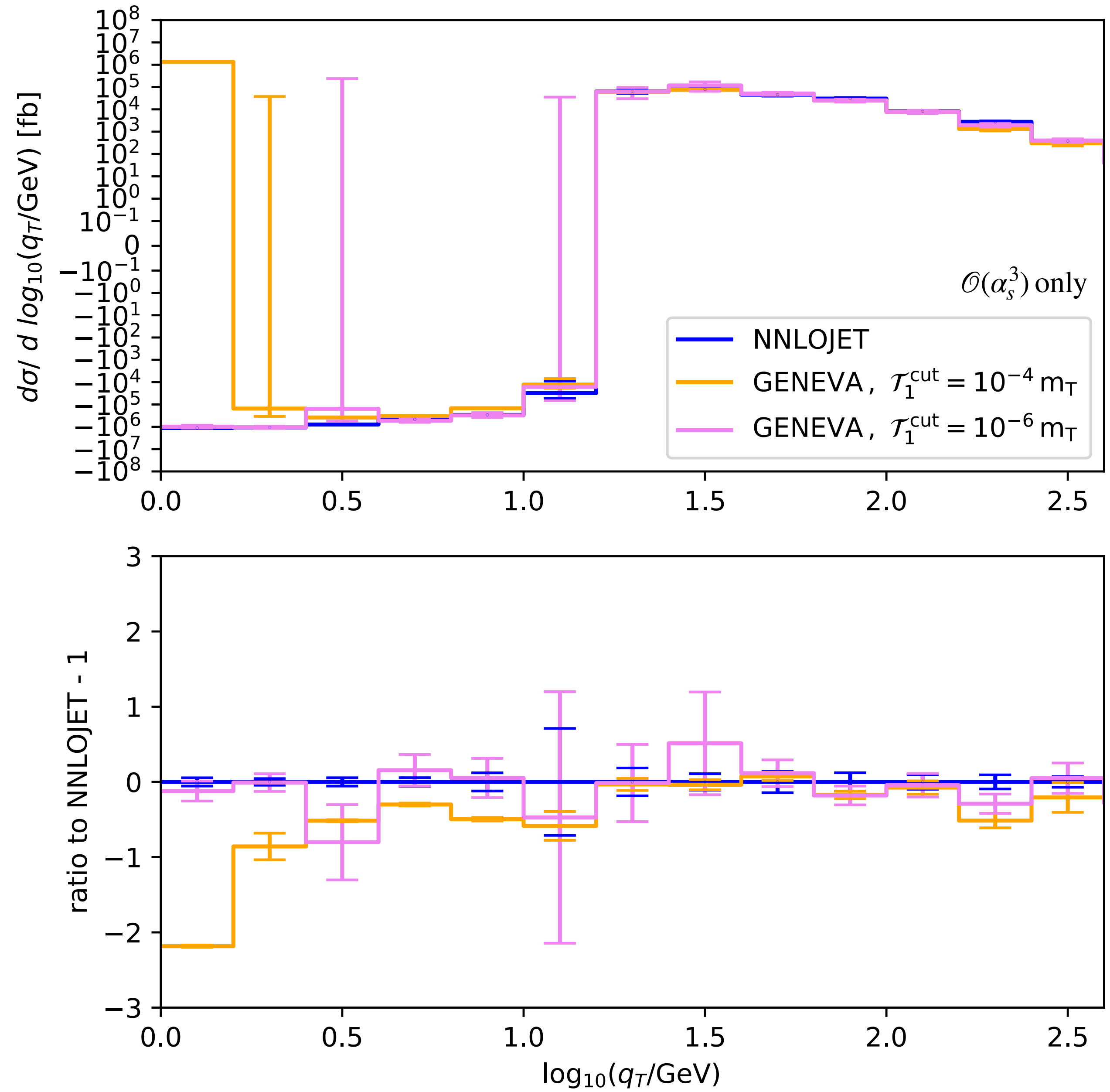
q_T distribution

NNLO results differential distributions

Very Preliminary!!



$\mathscr{T}_0$ distribution



q_T distribution