N-jettiness at NNLO accuracy in electron-positron annihilation

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N-jettiness

- Jet vetos are essential at the LHC for many Higgs and new physics analyses. (e.g. Higgs production in VBF)

- The cuts on phasespace coming from the veto lead to logarithmically enhanced terms.

- N-jettiness is a global event shape introduced to veto undesired jets using a single variable. (Stewart, Tackmann and Waalewijn, arXiv: 1004.2489)

- Using N-jettiness the large logs coming from the phasespace restrictions are resummed using SCET.

- N-jettiness slicing has recently been introduced to compute higher order corrections.

N-jettiness

- Definition of N-jettiness for M particles in e^+e^- collisions:

$$\tau_N(\Phi_M) = \sum_{k=1}^{M} \min_{i\in\{1,\ldots,N\}} \left\{ \frac{2q_i \cdot p_k}{Q^2} \right\}$$

- The p_k are the momenta of the M final state particles.
- The q_i are a fixed set of massless reference momenta for the N signal jets.
- For M=N, $\tau_N=0$
- $\tau_N<<1$ corresponds to an N-jet-like configuration. (M>N)
- We compute N-jettiness distributions in e^+e^- collisions in Next-to-Next-to Leading Order.

Method: CoLoRFulNNLO

- CoLoRFulNNLO is a general subtraction scheme for computing NNLO QCD corrections to fully differential IR-safe observables.

$$\sigma^{NNLO} = \int_{m+2} d\sigma^{RR}\; J_{m+2} + \int_{m+1} d\sigma^{RV}\; J_{m+1} + \int_{m} d\sigma^{VV}\; J_{m}$$

$$\sigma^{NNLO} =$$

$$\int_{m+2} \left\{ \mathrm{d}\sigma^{RR}_{m+2} J_{m+2} - \mathrm{d}\sigma^{RR,A_2}_{m+2} J_m - \left[\mathrm{d}\sigma^{RR,A_1}_{m+2} J_{m+1} - \mathrm{d}\sigma^{RR,A_{12}}_{m+2} J_m \right] \right\}_{\epsilon=0} +$$

$$\int_{m+1} \left\{ \left[\mathrm{d}\sigma^{RV}_{m+1} + \int_1 \mathrm{d}\sigma^{RR,A_1}_{m+2} \right] J_{m+1} - \left[\mathrm{d}\sigma^{RV,A_1}_{m+1} + \left(\int_1 \mathrm{d}\sigma^{RR,A_1}_{m+2} \right)^{A_1} \right] J_m \right\}_{\epsilon=0} +$$

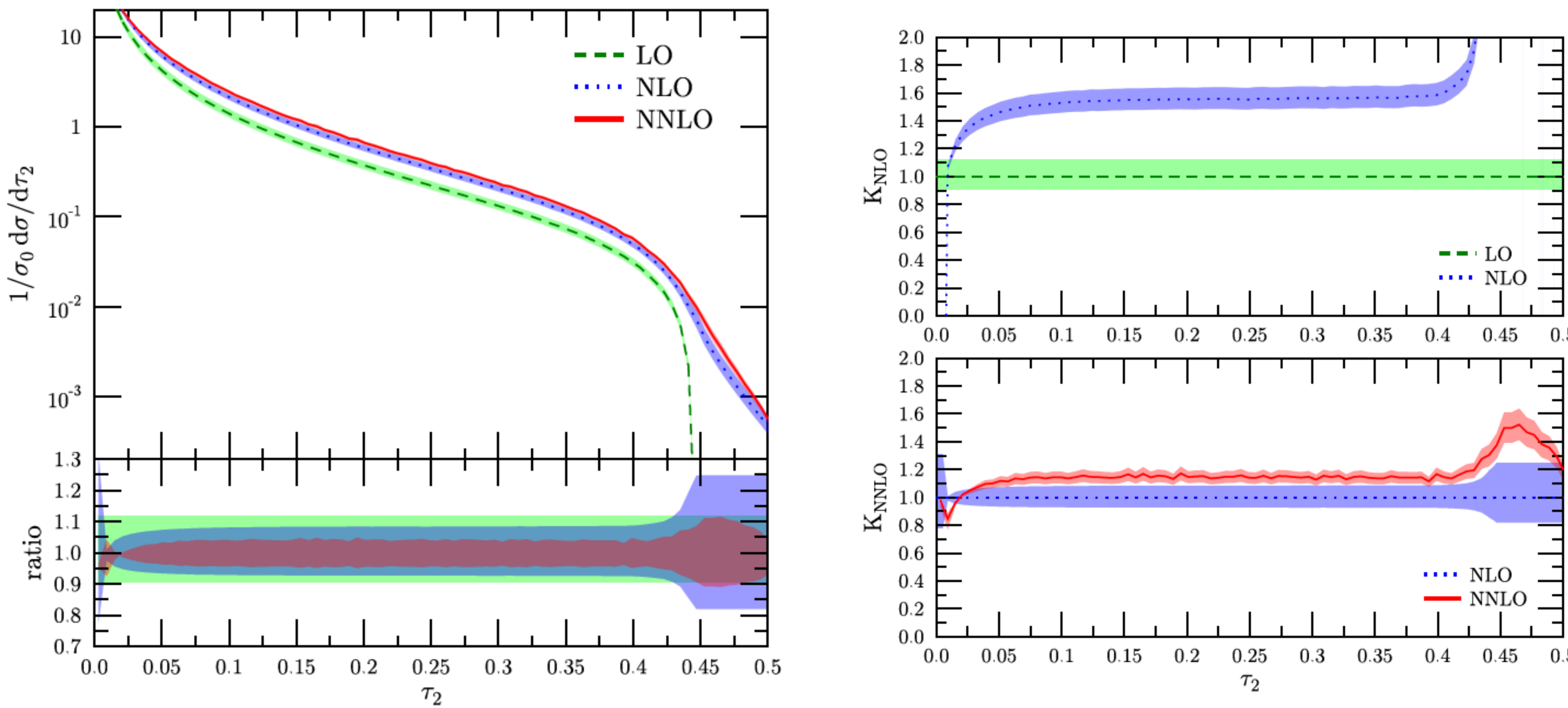
$$\int_{m} \left\{ \mathrm{d}\sigma^{VV}_{m} + \int_2 \left[\mathrm{d}\sigma^{RR,A_2}_{m+2} - \mathrm{d}\sigma^{RR,A_{12}}_{m+2} \right] + \int_1 \left[\mathrm{d}\sigma^{RV,A_1}_{m+1} + \left(\int_1 \mathrm{d}\sigma^{RR,A_1}_{m+2} \right)^{A_1} \right] \right\}_{\epsilon=0} J_m$$

Method: CoLoRFulNNLO

- Implemented in a F90 program library.
- Already applied to $H \to b\bar{b}$ (Del Duca, Duhr, Somogyi, Tamontano and Trócsányi, arXiv: 1501.07226) and $e^+e^- \to$ 3jets. (Del Duca, Duhr, Kardos, Somogyi and Trócsányi, arXiv: 1603.08927)

Predictions

2-jettiness distribution calculated in $e^+e^- \longrightarrow$ 3jets and K-factors



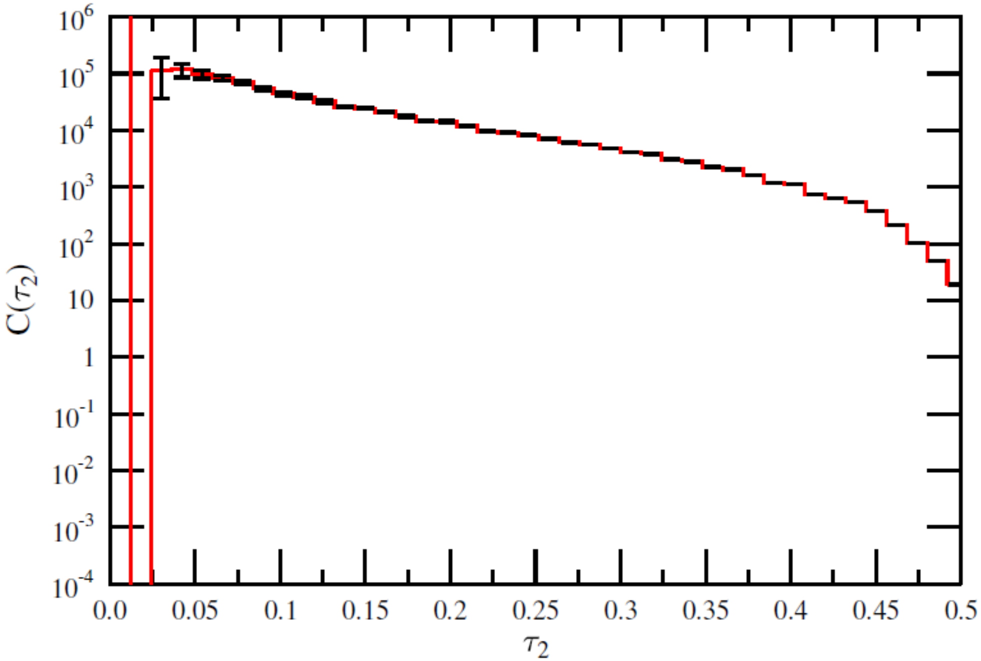
Scale variation between Q/2 and 2Q

Preliminary

Predictions

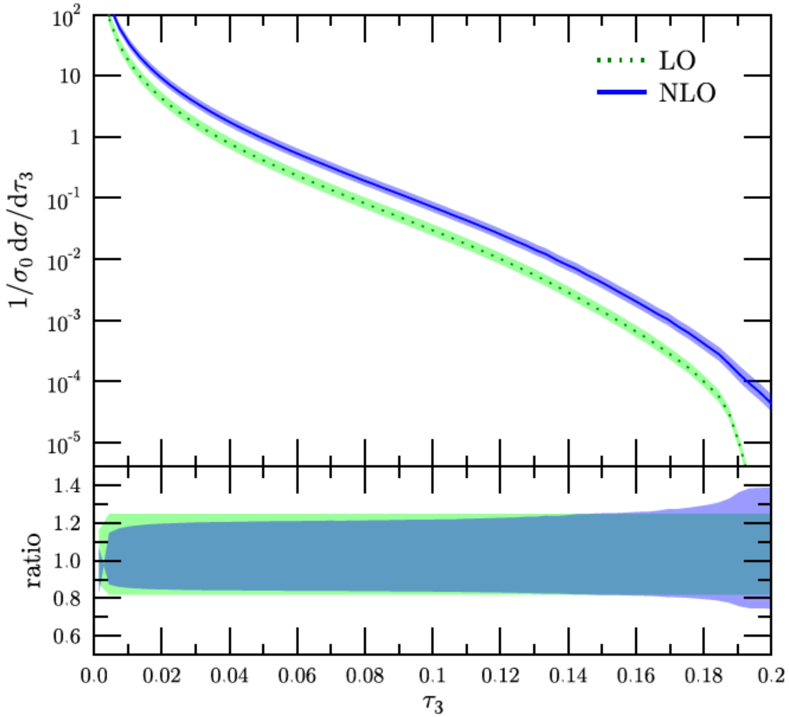
NNLO contribution

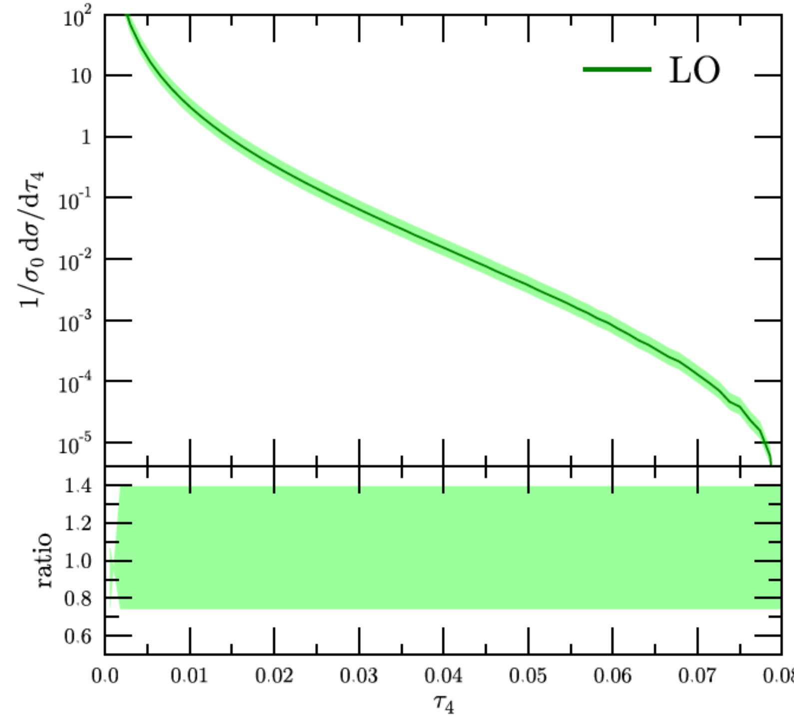
$$\frac{1}{\sigma_0}\frac{d\sigma}{d\tau_2} = \left(\frac{\alpha_S}{2\pi}\right) A(\tau_2) + \left(\frac{\alpha_S}{2\pi}\right)^2 B(\tau_2) + \left(\frac{\alpha_S}{2\pi}\right)^3 C(\tau_2) + \mathcal{O}(\alpha_S^4)$$



Predictions

3- and 4-jettiness distributions calculated in $e^+e^- \to$ 3jets





Preliminary

Conclusions

- Presented first computation of 2-, 3- and 4-jettiness up to NNLO for e^+e^- collisions.

- The NLO K factor for 2-jettiness is sizeable (~1.6) and the LO scale variation badly underestimates the size of the neglected higher order terms.

- Going to NNLO, the perturbative prediction is stabilized.

- Results are obtained using CoLoRFulNNLO. We observe a good numerical convergence of our code.

- Stay tuned for more.

Code performance

- The NNLO contribution on one core: 10 million PS points in 20 hrs.
- The code runs on 2x48 Intel Xeon cores.
- 5 billion PS points in total: ~4.3 days