Erratum: Soft-drop thrust

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ABSTRACT: This note corrects the definition of soft-drop thrust presented in ref. [1] so that it is collinear safe for all values of the soft-drop angular parameter $\beta \geq 0$.

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Collinear safety of soft-drop thrust

We have come to realise, while working on a follow-up paper [2], that the definition of soft-drop thrust proposed in eq. (2.5) and eq. (2.6) of ref. [1] is not collinear safe when soft drop is used with $\beta = 0$. The issue starts at $\mathcal{O}(\alpha_s^2)$ and it originates from the following configuration. Let us imagine to have two particles in the left hemisphere and one in the right hemisphere. The thrust axis is then aligned with the three-momentum of the particle in the right-hand hemisphere. We now consider radiative corrections to this configuration. Virtual corrections cannot clearly change the value of thrust. If the observable is infra-red and collinear safe, then soft emissions and/or collinear splittings cannot change said value either. However, a collinear emission in the right hemisphere that is groomed away forces the system to recoil, thus altering the value of the soft-drop thrust. This leads to an uncancelled collinear singularity. This situation can be cured by considering two modifications:

1. We change the normalisation of eq. (2.5) and eq. (2.6) to the sum of the magnitudes of the three-momenta before soft-drop (and not after soft-drop as initially proposed).
2. We account for the contribution of groomed-away particles by adding a suitable contribution.

The new IRC safe definition then reads:

$$T'_{\text{SD}} = \frac{\sum_{i \in \mathcal{H}_{\text{SD}}^L} |\vec{n}_L \cdot \vec{p}_i|}{\sum_{i \in \mathcal{E}} |\vec{p}_i|} + \frac{\sum_{i \in \mathcal{H}_{\text{SD}}^R} |\vec{n}_R \cdot \vec{p}_i|}{\sum_{i \in \mathcal{E}} |\vec{p}_i|} + \frac{\sum_{i \notin \mathcal{E}_{\text{SD}}} |\vec{p}_i|}{\sum_{i \in \mathcal{E}} |\vec{p}_i|}.$$

We note that this amounts to rescaling the variable τ'_{SD} by the factor $\frac{\sum_{i \in \mathcal{E}_{\text{SD}}} |\vec{p}_i|}{\sum_{i \in \mathcal{E}} |\vec{p}_i|}$.

The difference between the two definitions is suppressed by powers of z_{cut} . Therefore the resummed formulae, which were computed to leading power in z_{cut} remain formally unchanged. The Monte Carlo plots (figures 2, 3 and 4) obtained with the new definition exhibit very little (almost invisible) difference with respect to the original ones.

The LO curves that appear in figures 1 and 8 are correct because the effect we are discussing starts at $\mathcal{O}(\alpha_s^2)$. However, the NLO curves bear no physical meaning as one cannot calculate an IRC unsafe observable at fixed-order. As a consequence the numerical distributions that we plotted in the original paper depended on the artificial cut-off of the numerical integrator. It is worth noticing that the NLO curves obtained with the IRC safe definition are almost identical to the old ones, showing that the dependence on the unphysical cut-off was numerically very small.

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References

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- [2] S. Marzani, D. Reichelt, S. Schumann, G. Soyez and V. Theeuwes, *Fitting the strong coupling constant with soft-drop thrust*, to appear.