# 1 Resummation of Large Logarithms

## 1.1 Soft-gluon effects in QCD cross sections

This problem is reviewed in [2] and [3], here i summarize the main points.

The finite energy resolution of any particle detector mpli1es that physical cross sections, the one sperimetally measured, are always inclusive over arbitrarily soft particles produced in the final state, in other words, since we cannot resolve the energy of soft particles, we cannot physically distinguish between the presence or absence of those soft particles in our calculations, and so we must sum over all possible final states.

This inclusiveness is essential in QCD calculations. Higher order perturbative contributions due to *virtual* gluons are infrared divergent and the divergences are exactly cancelled by radiation of undetected *real* gluons. speaking the cancellation does not necessarily take place *order by order* in perturbative theory. In particular kinematic configurations, *e.g* Thrust in the dijet limit $T- > 1$ , real and virtual contributions can be highly unbalanced, because the emission of real radiation is inhibited by kinematic constrainsts, spoiling the cancellation mechanism. As a result, soft gluon contribution to QCD cross sections can still be either large or singular.

In these cases, the cancellation of infrared divergences bequeaths higher order contributions of the form:

$$C_{nm}\alpha_s^n \ln^m\left(\frac{1}{1-T}\right), \quad \text{with } m \leq 2n, \tag{1}$$

that can become large, $\alpha_s \ln^2(1-x) \lesssim 1$, even if the QCD coupling $\alpha_s$ is in the perturbative regime $\alpha_s \ll 1$. The logarithmically enhanced terms in eq. (1) are certainly relevant near the dijet limit $T- > 1$. In these cases, see [1],[4], the theoretical predictions can be improved by evaluating soft gluon contributions to high orders and possibly resumming to all of them in $\alpha_s$.

## References


[1] S. Catani et al. "Resummation of large logarithms in e+e− event shape distributions". In: *Nuclear Physics B* 407.1 (1993), pp. 3–42. ISSN: 0550-3213. DOI: https://doi.org/10.1016/0550-3213(93)90271-P. URL: https://www.sciencedirect.com/science/article/pii/055032139390271P.

[2] Stefano Catani. "Higher-order QCD corrections in hadron collisions: Soft-gluon resummation and exponentiation". In: *Nuclear Physics B - Proceedings Supplements* 54.1–2 (Mar. 1997), pp. 107–113. ISSN: 0920-5632. DOI: 10.1016/s0920-5632(97)00024-8. URL: http://dx.doi.org/10.1016/S0920-5632(97)00024-8.

[3] Stefano Catani. *Soft-Gluon Resummation: a Short Review*. 1997. arXiv: hep-ph/9709503 [hep-ph].

[4] Stefano Catani et al. "Soft gluon resummation for Higgs boson production at hadron colliders". In: *JHEP* 07 (2003), p. 028. DOI: 10.1088/1126-6708/2003/07/028. arXiv: hep-ph/0306211.