α_s Determination via the Differential 2-Jet-Rate at LHC

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Jets are an important component for several physics analyses (QCD, Top-quark, Higgs, SUSY, etc.). The large statistics make analyses with first data at LHC possible. The presented analysis describes an α_s measurement via the differential 2-jet-rate.
A number of algorithms has been established to reconstruct jets - each based on different physical and theoretical motivations. At hadron collider experiments, the so called Cone-algorithms are in favor. Unfortunately, not all variants of these algorithms are infrared- and collinearsafe.
The so called k_T-jetalgorithms [1] (here in the exclusive mode) are on the contrary infrared- and collinearsafe. The assignment of an object to a jet happens via the distance in momentum space. If the distance between an object k and an object l $d_{kl} = min(p_{Tk}^2, p_{Tl}^2) * R^2$ is larger than a given parameter d_{cut}, the clustering process is stopped. In this way, the d_{cut}-value directly affects the jetmultiplicity in the final state. This analysis deals with the d_{cut}-values where the jetmultiplicity flips from 3 to 2 jets (d_{23}).
For the determination of α_s processes are needed where gluons participate, because gluons couple with strength α_s to quarks.
The exclusive 3-jet-rate is defined by

$$R_3 = \frac{\sigma_{3Jets}}{\sigma_{2Jets} + \sigma_{3Jets}},$$

which is in leading-order (LO) proportional to α_s. For a more exact determination of α_s from the 3-jet-rate the theoretical calculations have to be used in next-to-leading-order (NLO).
For this analysis the NLO predictions of the program NLOJet++ [2] by Zoltan Nagy with the parton density function CTEQ6.1 were used to generate inclusive 3 parton production.
In NLO the 3-jet-rate becomes

$$R_3(d_{23}) = A(d_{23}) * \alpha_s + B(d_{23}) * \alpha_s^2.$$

As the entries of the R_3-distribution are correlated, it is preferable to take the uncorrelated, differential distribution.
With $R_2 = 1 - R_3 - R_4$ the differential 2-jet-rate[1] becomes

$$D_{23} = \frac{\Delta R_2}{\Delta d_{23}} = -\frac{\Delta R_3}{\Delta d_{23}} = \frac{\Delta A(d_{23})}{\Delta d_{23}} * \alpha_s + \frac{\Delta B(d_{23})}{\Delta d_{23}} * \alpha_s^2.$$

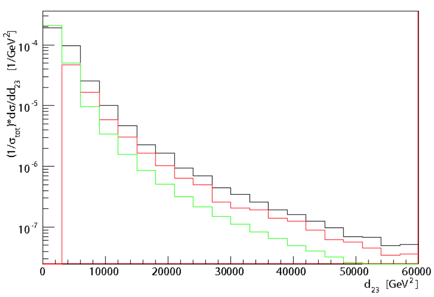

Fig. 1: d_{23}-distribution in LO (green), NLO (red) and full (black)

Figure 1 shows the d_{23}-distribution in LO (green) and NLO (red). The shape of the two distributions differ due to higher terms of α_s. Therefore it is possible to determine α_s from the shapes.
In the next step, the d_{23}-distributions were divided in p_T-intervalls of the leading jets, because α_s depends on Q^2, which can be approximated by $p_{T,leadingjet}^2$.

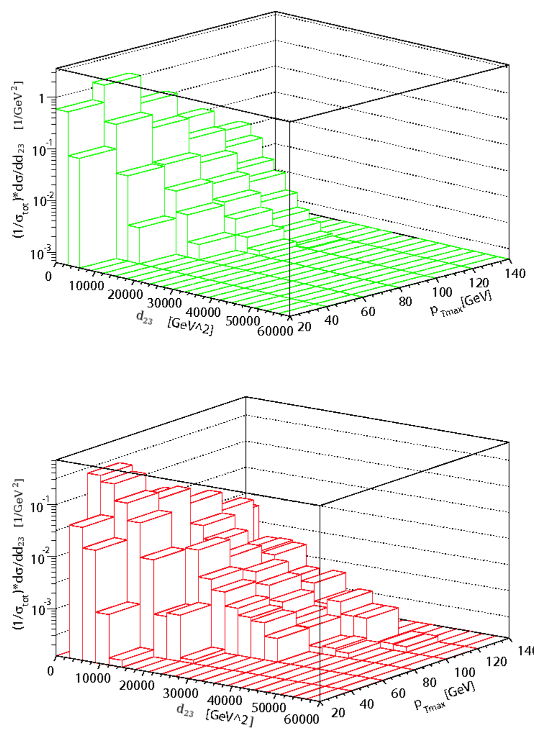

Fig. 2: d_{23}-distribution in LO (green) and NLO (red) in p_T-intervalls of the leading jets

With these distributions (Fig. 2) (notice that the LO-(green) and NLO-distributions (red) differ in the according p_T-intervalls) it is now possible to determine $\alpha_s(Q^2)$:

$$D_{23} = \frac{\Delta A(d_{23}, Q^2)}{\Delta d_{23}} * \alpha_s(Q^2) + \frac{\Delta B(d_{23}, Q^2)}{\Delta d_{23}} * \alpha_s^2(Q^2)$$

$$= \frac{1}{N} * \frac{\Delta N(Q^2)}{\Delta d_{23}}$$

where $\frac{\Delta A(d_{23},Q^2)}{\Delta d_{23}}$ (=LO) and $\frac{\Delta B(d_{23},Q^2)}{\Delta d_{23}}$ (=NLO) can be obtained from NLOJet++ and $\frac{1}{N} * \frac{\Delta N(Q^2)}{\Delta d_{23}}$ from measured data. Fits of the D_{23}-distribution then yield α_s.

References

[1] J. Butterworth, J. Couchman, B. Cox and B. Waugh, "KtJet: A C++ Implementation of the k_T clusterinm algorithm", 2002, hep-ph/0210022

[2] NLOJet++, http://nagyz.web.cern.ch/nagyz/Site/NLOJet++.html

[1] R_4 cannot be calculated in NLO with NLOJet++. Hence in experiment regions of phase space should be measured where R_4 is negligible.