The Compact Muon Solenoid Experiment

Conference Report

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19 February 2017 (v3, 22 February 2017)

Extraction of the strong coupling constant from the measurement of inclusive multijet event cross-sections in pp collisions at center of mass energy of 8 TeV

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Abstract

A measurement of inclusive multijet event cross sections is presented from proton-proton collisions recorded at 8 TeV with the CMS detector and corresponding to an integrated luminosity of 19.7/fb. Jets are reconstructed with the anti-kt clustering algorithm for a jet size parameter $R=0.7$ in a phase space region ranging up to jet transverse momenta p_T of 2.0 TeV and rapidity of $|y| \leq 2.5$. The inclusive 2-jet and 3-jet event cross sections are measured as a function of the average p_T of the two leading jets. The results are compared to fixed-order predictions of perturbative QCD and to simulations using various Monte Carlo event generators including parton showers, hadronisation, and multiparton interactions. A fit of the strong coupling constant is performed with the ratio of the 3-jet over 2-jet event cross section.

Presented at *DAE-HEP Symposium XXII DAE-BRNS High Energy Physics Symposium*

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Abstract. A measurement of inclusive multijet event cross sections is presented from proton-proton collisions recorded at 8 TeV with the CMS detector and corresponding to an integrated luminosity of 19.7/fb. Jets are reconstructed with the anti- k_t clustering algorithm for a jet size parameter $R = 0.7$ in a phase space region ranging up to jet transverse momenta p_T of 2.0 TeV and rapidity of $|y| < 2.5$. The inclusive 2-jet and 3-jet event cross sections are measured as a function of the average p_T of the two leading jets. The results are compared to fixed-order predictions of perturbative QCD and to simulations using various Monte Carlo event generators including parton showers, hadronisation, and multiparton interactions. A fit of the strong coupling constant is performed with the ratio of the 3-jet over 2-jet event cross section.

Keywords: QCD, jets

1 Introduction

Quantum Chromodynamics (QCD) is theory which describes the strong interactions between the partons, the (anti-)quarks and gluons. In the collision of hadrons such as protons (p), the scattered partons hadronize into highly collimated bunches of particles called jets. These jets preserve energy and momentum of the initial partons. Within the context of perturbative QCD, the cross section of a high transverse momentum (p_T) scattering can be expressed as a sum of terms with increasing powers of the strong coupling constant, α_S , convoluted with the parton momentum distribution functions (PDFs) of the proton. The lowest-order α_S^2 and higher-order α_S^3 terms represent the production of two-parton and multi-parton final states respectively.

The investigation of the inclusive multijet event cross sections $\sigma_{i\text{-jet}}$ for the process $pp \rightarrow i \text{ jets} + X$, as a function of jet p_T and rapidity y , is proportional to α_S^i . Hence, provides essential information about the PDFs and $\alpha_S(M_Z)$. The cross section ratios, $R_{mn} = \frac{\sigma_{m\text{-jet}}}{\sigma_{n\text{-jet}}}$ ($m > n$), where numerous theoretical and experimental uncertainties cancel, provide an ideal tool to determine $\alpha_S(M_Z)$.

A measurement of inclusive 2- and 3-jet event cross sections is presented [1] using an event sample collected by the Compact Muon Solenoid (CMS) experiment [2] during 2012 at the LHC and corresponding to an integrated luminosity of 19.7 fb^{-1} of pp collisions at a centre-of-mass energy of 8 TeV.

2 Results and discussion

The inclusive 2-jet and 3-jet event cross sections are measured as a function of the average p_T of the two leading jets, referred to as $H_{T,2}/2$ here. After unfolding for detector effects, these are compared to the NLOJET++ predictions using the CT10 PDF set, corrected for non-perturbative (NP) and in addition for electroweak (EWK) effects in the 2-jet case. The comparison is also made to predictions from MADGRAPH5 + PYTHIA6 with tune Z2*, corrected for EWK effects in the 2-jet case. The data are in agreement with the NLO predictions over the whole range of $H_{T,2}/2$ from 300 GeV up to 2.0 (2-jet) and 1.68 TeV (3-jet) respectively.

In Fig.1 [1], left plot presents the cross section ratio, R_{32} obtained from unfolded data in comparison to that from NLO pQCD. The error bars correspond to the total experimental uncertainty. The NLO predictions using the CT10 NLO PDF set corrected with NP corrections are shown for a series of values assumed for $\alpha_S(M_Z)$ (dashed lines) together with the central prediction (solid line) where $\alpha_S(M_Z) = 0.118$. The assumption on $\alpha_S(M_Z)$ is varied in steps of 0.001 in the range of 0.112–0.127. The value of $\alpha_S(M_Z)$ is determined from the measured inclusive 2-jet and 3-jet event cross sections and their ratio, by minimizing the χ^2 between the experimental measurement and the theoretical predictions. The fit procedure follows closely the one used in Refs. [3] and [4].

Using the MSTW2008 PDF set, which dates from before the LHC start, the $\alpha_S(M_Z)$ from R_{32} is finally determined to

$$\begin{aligned} \alpha_S(M_Z) &= 0.1150 \pm 0.0010 (\text{exp}) \pm 0.0013 (\text{PDF}) \pm 0.0015 (\text{NP}) {}^{+0.0050}_{-0.0000} (\text{scale}) \\ &= 0.1150 \pm 0.0023 (\text{all except scale}) {}^{+0.0050}_{-0.0000} (\text{scale}). \end{aligned}$$

From the extracted $\alpha_S(M_Z)$ value for each range in $H_{T,2}/2$, the $\alpha_S(Q)$ values are evolved, with total uncertainty, to the respective cross-section averaged scale $\langle Q \rangle$. The evolution is performed for five flavours at 2-loop order with the RUNDEC program. The obtained $\alpha_S(Q)$ points are illustrated in right plot of Fig. 1 [1] together with the world average [8] and results from other experiments [3–7].

3 Summary

A measurement of the inclusive 2-jet (3-jet) event cross sections has been presented in a range of $0.3 < H_{T,2}/2 < 2.0 \text{ TeV}$ ($0.3 < H_{T,2}/2 < 1.68 \text{ TeV}$) for the average p_T of the two leading jets at central rapidity of $|y| < 2.5$. The data are found to be well described by calculations at NLO in pQCD complemented with NP corrections that are important at low $H_{T,2}/2$. NLO QCD

provides an adequate description of R_{32} in the accessible range of $H_{T,2}/2$. In contrast, LO tree-level MC predictions exhibit significant deviations. Based on the observed agreement, the $\alpha_S(M_Z)$ is determined in a fit to the R_{32} measurement to $\alpha_S(M_Z) = 0.1150^{+0.0055}_{-0.0023}$, using the MSTW2008 PDF set. The result for $\alpha_S(M_Z)$ is in agreement with previous determinations obtained by the CMS collaborations [3–7] and with the world average value of $\alpha_S(M_Z) = 0.1181 \pm 0.0011$ derived in Ref. [8].

Fig. 1. Left : Cross section ratio R_{32} as a function of $H_{T,2}/2$ calculated from data (solid circles) in comparison to that from NLO pQCD (lines). Right : The running $\alpha_S(Q)$ as a function of the scale Q is shown as obtained by using the MSTW2008 NLO PDF set.

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