PROCEEDINGS OF SCIENCE

Charged particle multiplicities at sqrt(s) = 0.9, 2.36 and 7.0 TeV with the CMS detector at LHC

Romain Rougny*†
Universiteit Antwerpen, Belgium
E-mail: romain.rougny@cern.ch

Measurements of primary charged hadron multiplicity distributions are presented for non-single-diffractive events in proton-proton collisions at centre-of-mass energies of $\sqrt{s} = 0.9$, 2.36, and 7 TeV, in five pseudorapidity ranges from $|\eta| < 0.5$ to $|\eta| < 2.4$. The data were collected with the minimum-bias trigger of the CMS experiment during the LHC commissioning runs in 2009 and the 7 TeV run in 2010. The multiplicity distribution at $\sqrt{s} = 0.9$ TeV is in agreement with previous measurements. At higher energies the increase of the mean multiplicity with $\sqrt{s}$ is underestimated by most event generators. The average transverse momentum as a function of the multiplicity is also presented. The measurement of higher-order moments of the multiplicity distribution confirms the violation of the Koba-Nielsen-Olesen scaling that has been observed at lower energies.

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*Speaker.
†on behalf of the CMS collaboration.

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1. Introduction

We report measurements of the charged hadron multiplicity distribution, P_n, in intervals of increasing extent in pseudorapidity from $|\eta| < 0.5$ up to $|\eta| < 2.4$, for non-single-diffractive (NSD) [1] proton-proton collisions, at centre-of-mass energies $\sqrt{s} = 0.9$, 2.36, and 7 TeV. The measurements are based on events recorded with the minimum bias trigger of the Compact Muon Solenoid (CMS) [2] detector at the Large Hadron Collider (LHC) [3], in the end of 2009 for collisions at $\sqrt{s} = 0.9$ and 2.36 TeV, and in March 2010 for $\sqrt{s} = 7$ TeV. The trigger and offline event selection favor NSD events, while rejecting background events. The CMS tracker, composed of the silicon strip detector and the pixel detector, is the main subdetector used, and a specific tracking algorithm allowing to reconstruct low p_T tracks was preferred. Tracks were associated to a primary vertex to avoid contamination from secondary tracks. A more detailed description of the analysis can be found in [4].

2. Results

The charged hadron multiplicity distributions for NSD events at $\sqrt{s} = 0.9$, 2.36, and 7 TeV in pseudorapidity intervals from $|\eta| < 0.5$ to 2.4 is presented in Fig. 1. It has been fully corrected to hadron level using an unfolding method [5] combined with a trigger and event selection efficiency correction based on Monte-Carlo simulation. The errors presented are both statistical, for which a resampling technique was used, and sytematics, composed of the uncertainty in using Monte Carlo for modeling single-diffractive events, the uncertainty on tracking and acceptance efficiency, the model dependence of the response matrix used in the unfolding, and lastly the uncertainty of the trigger and event selection efficiency. The measurements agree well with the ones of UA5 [6, 7] and ALICE [8].

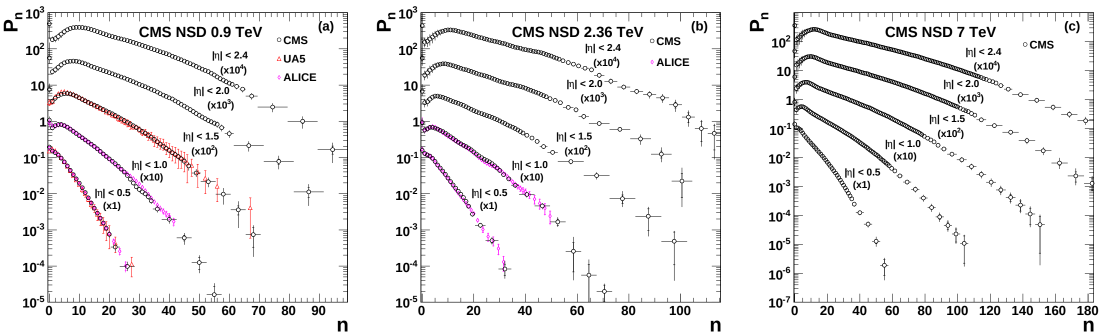

Figure 1: Fully corrected charged hadron multiplicity distributions for NSD events at (a) $\sqrt{s} = 0.9$ TeV, (b) 2.36 TeV, and (c) 7 TeV in pseudorapidity intervals from $|\eta| < 0.5$ to 2.4.

In Fig. 2, the multiplicity distributions are compared with MC models at the three obtained energies for $|\eta| < 2.4$ and two p_T ranges: $p_T > 0$ and $p_T > 500$ MeV. The MC generators were chosen because of their very different physical description of the soft particle production mechanism. No MC model is able to predict correctly the multiplicity for both p_T ranges at all three energies. A comparison of the measured $\langle p_T \rangle$ evolution versus the multiplicity for $|\eta| < 2.4$ and $p_T > 0$ with the MC models, as well as their linear fit in $\sqrt{n}$ and their ratios, is also shown in Fig. 2. The data rises slowly and rather energy-independently, and is again not well reproduced by the generators. It seems that in general the generators do not produce enough low p_{T} particles.

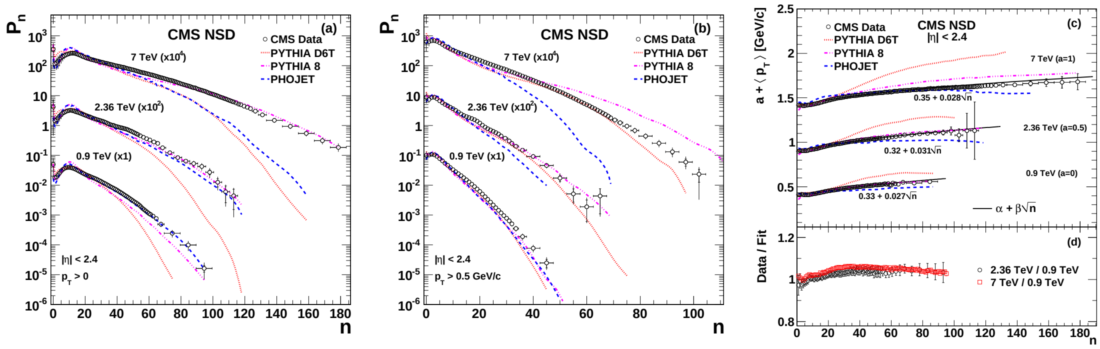

Figure 2: Comparison of the charged hadron multiplicity distributions with MC models at the three obtained energies for $|\eta| < 2.4$ and (a) $p_{\mathrm{T}} > 0$, (b) $p_{\mathrm{T}} > 500\,\mathrm{MeV}$. A comparison of the measured $\langle p_{\mathrm{T}} \rangle$ evolution wrt. the multiplicity for $|\eta| < 2.4$ and $p_{\mathrm{T}} > 0$ with the MC models, as well as their linear fit in $\sqrt{n}$, is also shown in (c), while their ratios are presented in (d).

KNO scaling is formally a characteristic of the multiplicity distribution in cascade processes of a single jet with self-similar branchings and fixed coupling constant. The KNO variables are defined as $\psi(z) = P_n \cdot \langle n \rangle$ with $z = n/\langle n \rangle$. The normalized moments C_q of the multiplicity distributions, defined as $\langle n^q \rangle / \langle n \rangle^q$, allow to better quantify this scaling behavior. Figure 3 shows that the scaling is violated for large η range, as further illustrated by the linear rise of the moments with $\sqrt{s}$, but seems to hold for $|\eta| < 0.5$, which is confirmed by the moments remaining constant while $\sqrt{s}$ increases.

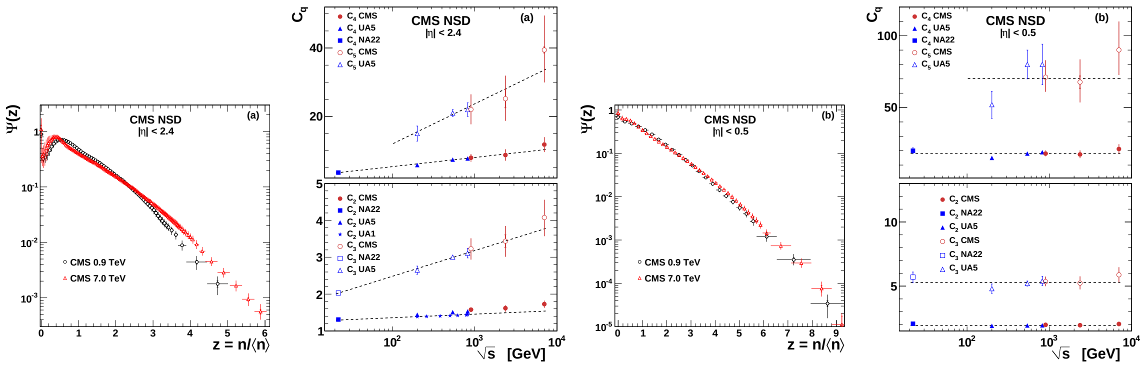

Figure 3: KNO and normalised moments C_q distributions for $p_{\mathrm{T}} > 0$ and (a) $|\eta| < 2.4$, (b) $|\eta| < 0.5$. The fits of the moments were done assuming a linear dependence in (a) and no dependence in (b), and include data from lower energy experiments [9, 10, 11]

3. Conclusion

The fully corrected charged hadron multiplicity in different pseudorapidity ranges at $\sqrt{s} = 0.9$, 2.36, and 7 TeV is shown here, and agrees well with other experiments. No MC models presented is able to reproduce correctly at the three energies both the multiplicity and the $\langle p_{\mathrm{T}} \rangle$ evolution. Finally, the KNO scaling violation observed in previous experiments is confirmed for a large rapidity range, but seems to hold for $|\eta| < 0.5$.

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