The Tsallis Distribution at LHC Energies

M. Danish Azmi[1*] and Jean Cleymans[1†]
[1] *UCT - CERN Research Center, Department of Physics, R W James Building, University of Cape Town, Rondebosch - 7701, Cape Town, South Africa*

Introduction

In high energy physics power law distributions have been widely used [1–5] to the description of transverse momenta of secondary particles produced in $p-p$ collisions. Indeed the available range of transverse momenta has expanded considerably with the advent of the Large Hadron Collider (LHC).

Collider energies up to 7 TeV are now available in $p-p$ collisions and transverse momenta of hundreds of GeV are a common occurrence. In this presentation the focus will be on a distribution first proposed by C. Tsallis about twenty-five years ago [6].

Tsallis Distribution

For high energy physics a consistent form of Tsallis statistics (see e.g. [7–9] and references therein) for the particle number is given by the following expression:

$$N = gV \int \frac{d^3p}{(2\pi)^3} \left[1 + (q-1)\frac{E-\mu}{T}\right]^{-\frac{q}{q-1}} \quad (1)$$

where T and μ are the temperature and the chemical potential, V is the volume and g is the degeneracy factor.

The corresponding momentum distribution deduced from the above equation is given by:

$$E\frac{dN}{d^3p} = gVE\frac{1}{(2\pi)^3} \left[1 + (q-1)\frac{E-\mu}{T}\right]^{-\frac{q}{q-1}} \quad (2)$$

At mid-rapidity, $y = 0$, and for $\mu = 0$, as is relevant at LHC, this reduces to:

$$\left.\frac{d^2N}{dp_T\ dy}\right|_{y=0} = gV\frac{p_T m_T}{(2\pi)^2} \left[1 + (q-1)\frac{m_T}{T}\right]^{\frac{-q}{(q-1)}} \quad (3)$$

A detailed discussion is presented in [9].

Results

The transverse momentum distributions of primary charged particles measured by the ALICE collaboration [3] in $p-Pb$ collisions at $\sqrt{s} = 5.02\ TeV$ for different pseudorapidity ranges are shown in Fig. 1. The Tsallis distribution, given in equation (3), is used to fit the data points.

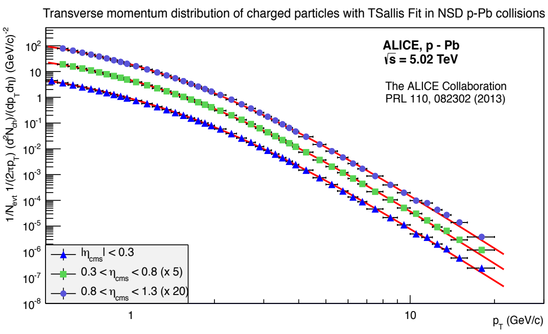

FIG. 1: Transverse momentum distributions of charged particles measured by the ALICE collaboration in $p-Pb$ collisions at $\sqrt{s} = 5.02\ TeV$ for different η ranges fitted with Tsallis distribution.

The results obtained from the fit shown in Fig. 1 are presented in the Table I.

TABLE I: Fitted values of the q and T parameters measured in $p-Pb$ collisions [3].

Pseudorapidity	q	T (MeV)
- 0.3 < η < 0.3	1.140 ± 0.001	112.8 ± 2.3
0.3 < η < 0.8	1.139 ± 0.001	113.3 ± 2.5
0.8 < η < 1.3	1.138 ± 0.001	111.9 ± 2.6

Fig. 2 shows Tsallis fits to the transverse momentum distributions of primary charged particles in $p-p$ collisions measured by the

*Electronic address: danish.hep@gmail.com
†Electronic address: jean.cleymans@uct.ac.za

CMS [5] and ATLAS [4] collaborations at $\sqrt{s}$ = 0.9, 2.36, 7 TeV and by the ALICE collaboration [3] for three different event multiplicities at $\sqrt{s}$ = 0.9 TeV.

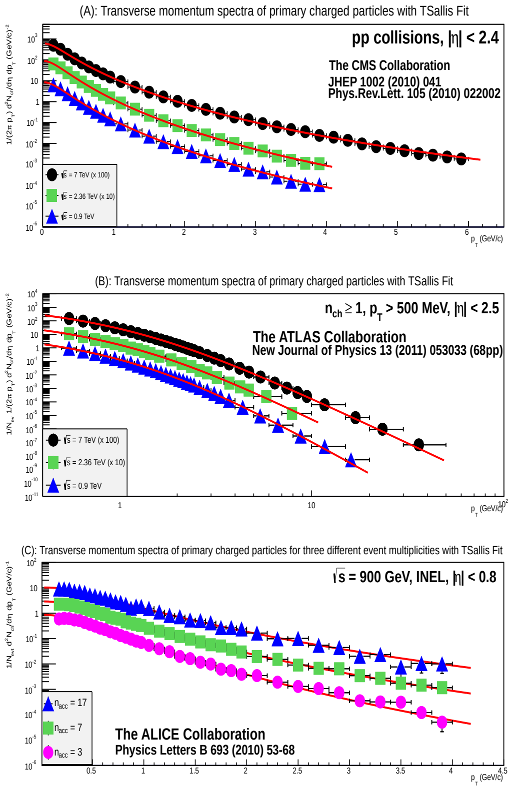

FIG. 2: Transverse momentum distributions of charged particles as measured by the (A) CMS, (B) ATLAS and (C) ALICE collaborations. The fits use the Tsallis distribution described in the text.

Summary

It is clear from Table I that the parameters q and T are not changing with change in pseudorapidity ranges.

Moreover, the results shown in Fig. 3 describes that the Tsallis parameter q shows a clear increase with beam energy while the Tsallis temperature T is almost consistent with being independent of beam energy.

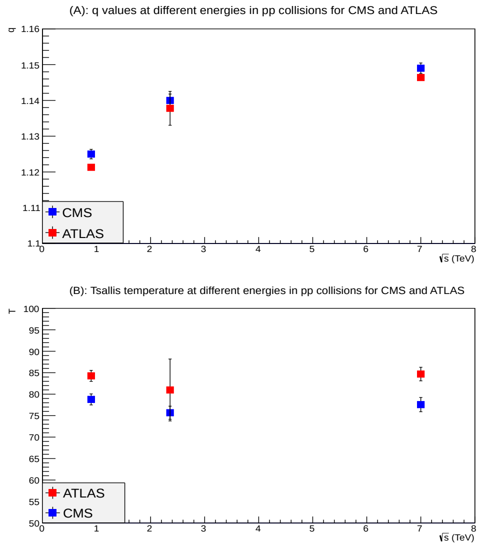

FIG. 3: Values of the Tsallis parameters (A) q and (B) T obtained from the fits of CMS and ATLAS data presented in Fig. 2.

Acknowledgments

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