CMS Papers

Transverse-momentum and pseudorapidity distributions of charged hadrons in pp collisions at

$\sqrt{s}$ = 0.9 and 2.36 TeV

Abstract

- Measurements of inclusive charged-hadron transverse-momentum and pseudorapidity distributions
- Data were collected during the commissioning in December 2009.
- For non-single-difractive interactions, the average charged-hadron transverse momentum is measured
  - 0.46 ± 0.01 (stat.) ± 0.01 (syst.) GeV/c at 0.9 TeV and
  - 0.50 ± 0.01 (stat.) ± 0.01 (syst.) GeV/c at 2.36 TeV,

for pseudorapidities between – 2.4 and +2.4.

- Measured pseudorapidity densities in the central region, dNch=d\eta (|\eta|<0:5)
  - 3.48 ± 0.02 (stat.) ± 0.13 (syst.)
  - 4.47 ± 0.04 (stat.) ± 0.16 (syst.),
- Results at 0.9 TeV are in agreement with previous measurements
- Confirm the expectation of near equal hadron production in pp and ppbar collisions.
- Results at 2.36 TeV represent the highest-energy measurements at a particle collider to date.

Introduction

- The majority of pp collisions are soft, i.e., without any hard scattering of the partonic constituents of the proton. In contrast to the higher-pT regime, well described by perturbative QCD, particle production in soft collisions is generally modelledphenomenologically to describe the dierent pp scattering processes: elastic scattering, single-diractive and double-diractive dissociation, and inelastic non-difractive scattering

$$(dN_{\mathrm{ch}}/dp_{\mathrm{T}} \text{ and } dN_{\mathrm{ch}}/d\eta) \qquad |\eta| < 2.4,$$

  - pT is the momentum of the particle transverse to the beam axis,
  - Nch is the number of charged hadrons in any given eta or pT interval
- Important for understanding the mechanisms of hadron production and the relative roles of soft and hard scattering contributions in the LHC energy regime.
- Primary charged hadrons:
  - Defined as all charged hadrons produced in the interactions, including the products of strong and electromagnetic decays, but excluding products of weak decays and hadrons originating from secondary interactions.

- Multiplicity densities are measured for
  - Inelastic non-single-difractive (NSD) interactions to minimize the model dependence of the necessary corrections for the event selection, and to enable a comparison with earlier experiments.
- Event selection designed to retain large fraction of
  - inelastic double-difractive (DD) and
  - non-difractive (ND) events,
- while rejecting
  - all elastic and
  - most single-diractive dissociation (SD) events.

MC and Reco

	PYTHIA				PHOJET			
Energy	0.9 TeV		2.36 TeV		0.9 TeV		2.36 TeV	
	Frac.	Sel. Eff.	Frac.	Sel. Eff.	Frac.	Sel. Eff.	Frac.	Sel. Eff.
SD	22.5%	16.1%	21.0%	21.8%	18.9%	20.1%	16.2%	25.1%
DD	12.3%	35.0%	12.8%	33.8%	8.4%	53.8%	7.3%	50.0%
ND	65.2%	95.2%	66.2%	96.4%	72.7%	94.7%	76.5%	96.5%
NSD	77.5%	85.6%	79.0%	86.2%	81.1%	90.5%	83.8%	92.4%

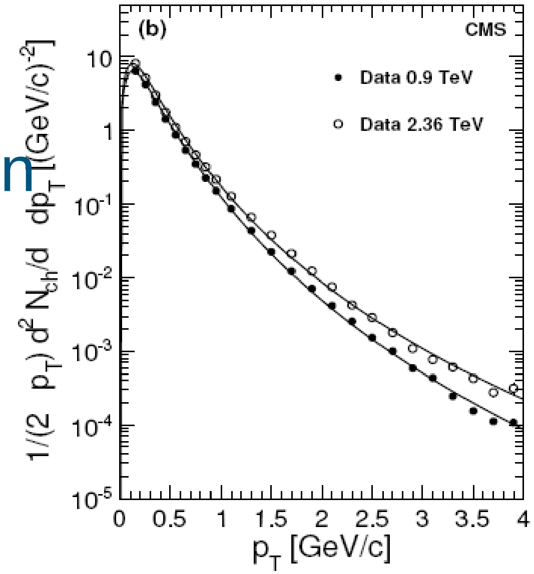
- Rapidity distribution = counting of
  - (i) reconstructed clusters in the pixel barrel detector;
  - (ii) pixel tracklets composed of pairs of clusters in dierent pixel barrel layers; and
  - (iii) tracks reconstructed in the full tracker volume, combining the pixel and strip hits.

(called also Tsallis distributions)^2:

$$\exp\left(-\frac{X}{\lambda}\right) \Rightarrow \exp_q\left(-\frac{X}{\lambda}\right) = \left[1-(1-q)\frac{X}{\lambda}\right]^{\frac{1}{1-q}}$$

1/1-q → -n

$$E\frac{d^3N_{\rm ch}}{dp^3} = \frac{1}{2\pi p_T}\frac{E}{p}\frac{d^2N_{\rm ch}}{d\eta dp_T} = C(n,T,m)\frac{dN_{\rm ch}}{dy}\left(1+\frac{E_T}{nT}\right)^{-n},$$



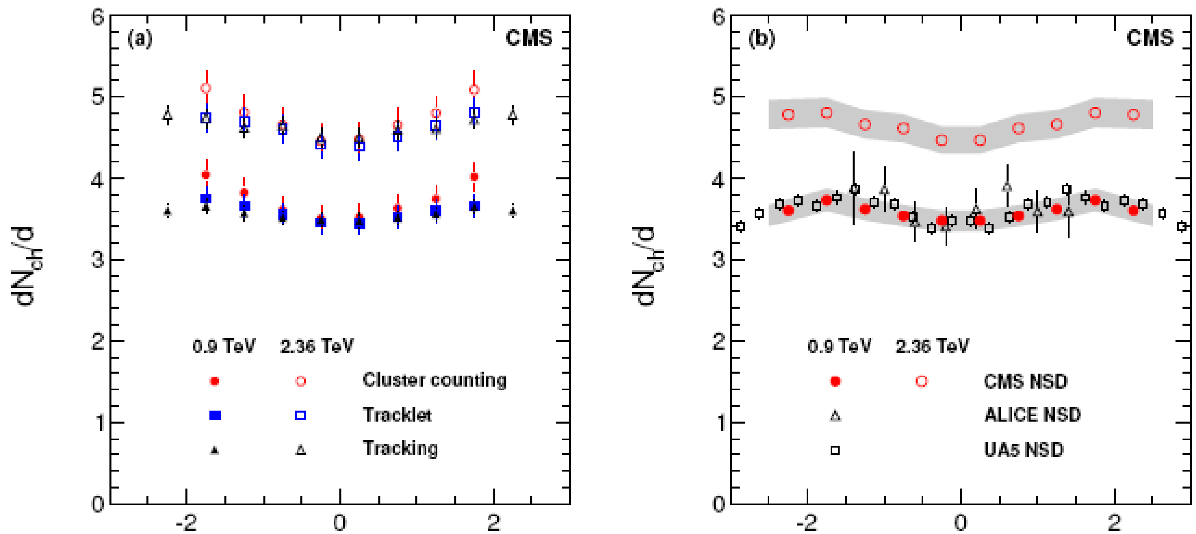


Figure 6. (a) Reconstructed $dN_{\rm ch}/d\eta$ distributions obtained from the cluster counting (dots with error bars), tracklet (squares) and tracking (triangles) methods, in pp collisions at 0.9 TeV (filled symbols) and 2.36 TeV (open symbols). The error bars include systematic uncertainties (as discussed in the text), excluding those common to all the methods. (b) Reconstructed $dN_{\rm ch}/d\eta$ distributions averaged over the cluster counting, tracklet and tracking methods (circles), compared to data from the UA5 [24] (open squares) and from the ALICE [23] (open triangles) experiments at 0.9 TeV, and the averaged result over the three methods at 2.36 TeV (open circles). The CMS and UA5 data points are symmetrized in η. The shaded band represents systematic uncertainties of this measurement, which are largely correlated point-to-point. The error bars on the UA5 and ALICE data points are statistical only.

Kinematics - Rapidity

- One Body Phase Space
- Non Relativistic

$$d\vec{P} = P^2 dP d\Omega = dP_\parallel P_T dP_T d\phi$$

Relativistic

$$= \pi dy d\left(P_T^2\right)$$

$$dy = dP_\parallel / E$$

If transverse momentum is limited by dynamics, expect a uniform distribution in y

Rapidity

$$E = m_T \cosh y$$

$$m_T^2 = m^2 + P_T^2$$

$$\max y \; at \; P_T = 0, beam \; momentum$$

$$pp \; @ \; 2, \quad 14 \, TeV,$$

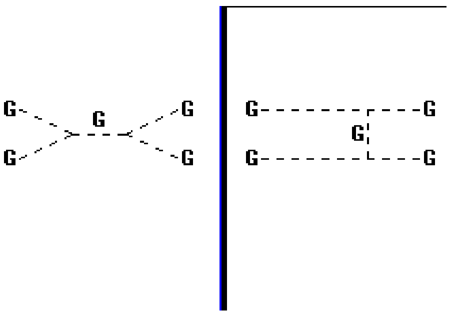
$$y_{\max} = 7.7, \quad 9.6$$

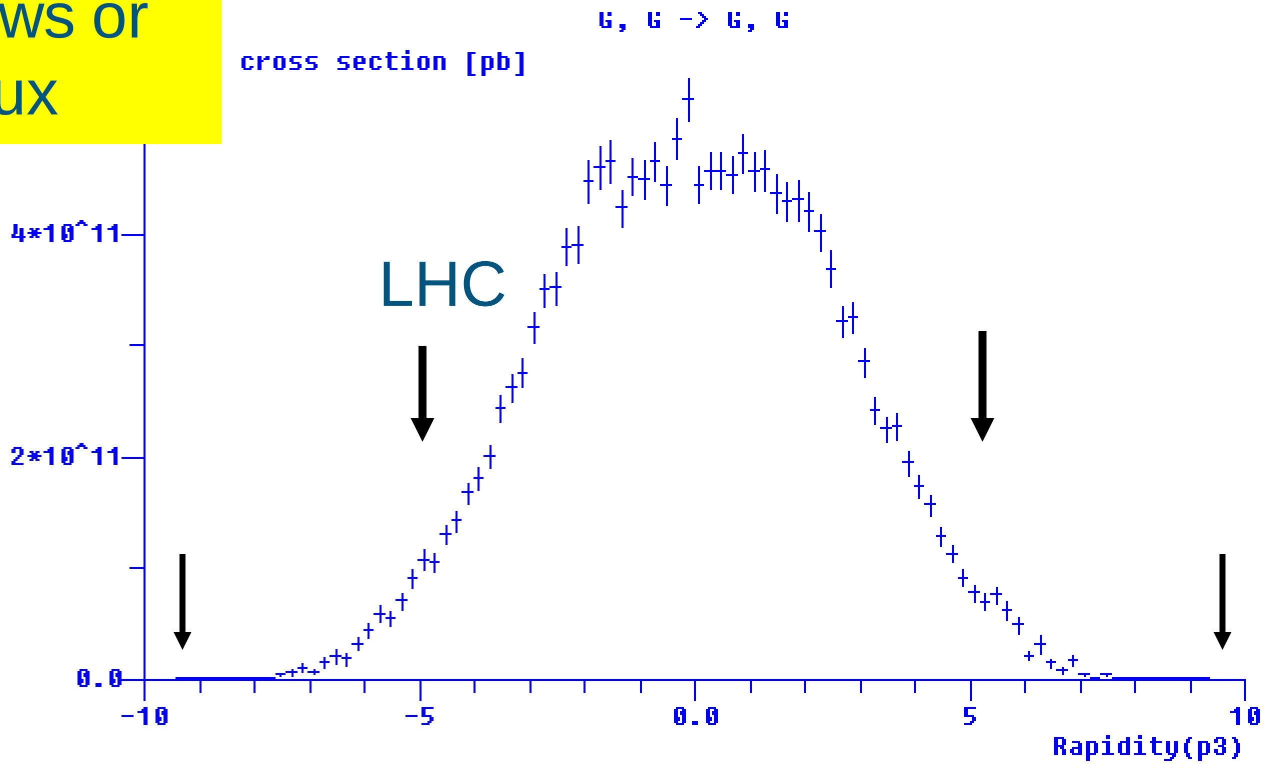
Kinematically allowed range in y of a proton with P_T=0

Rapidity "Plateau"

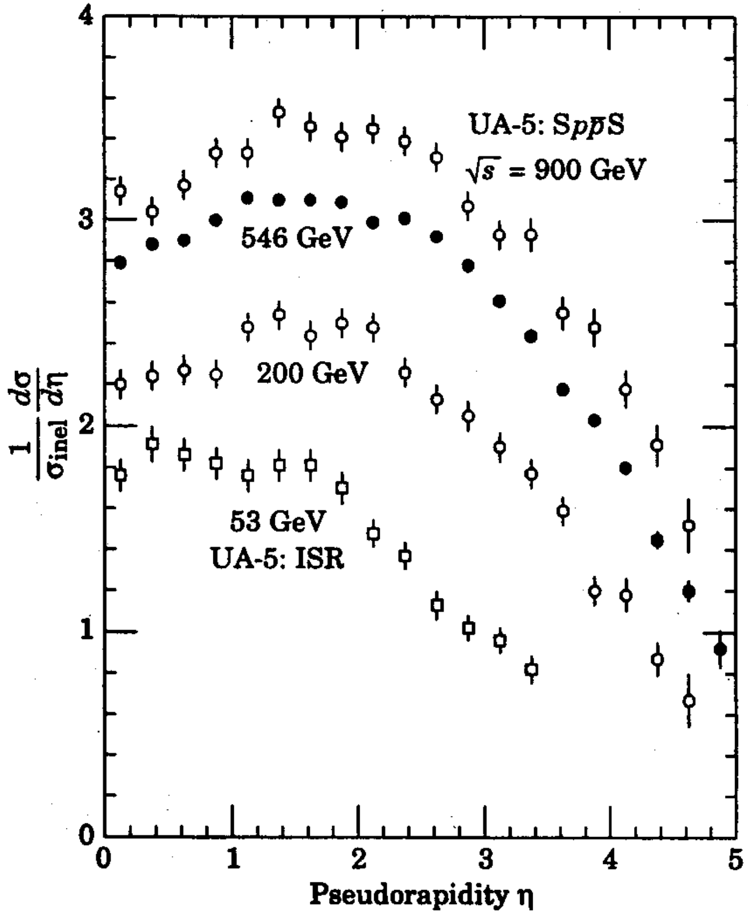
Monte Carlo results are from COMPHEP - running under Windows or Linux

Region around y=0 (90 degrees) has a "plateau" with widthΔy~ 6 for LHC





Rapidity Plateau - Tevatron



Existing data exhibits a plateau in rapidity.