Universality of inclusive rapidity distributions

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It is shown that all the distributions $E(d^3\sigma/d^3p)$ for the inclusive reactions $a+b\rightarrow c+X$ in the rapidity region $Y_{\rm lab} \ll \ln(\sqrt{s}/m_p)$ are described by a single function of the rapidity $Y_{\rm lab}$, accurate to within a shift $Y_{\rm lab}\rightarrow Y_{\rm lab}$ +const.

We have shown earlier[1] that the transverse scaling observed in the measurement of large transverse momenta $p>2$ at ISR energies[2] takes place in all probability at low energies and small transverse momenta.

The use of the Mueller-Regge representation for the inclusive cross section $a+b\rightarrow c+X$ in the central region with allowance for the transverse scaling has led to the following expression for the cross section

$$E\frac{d^3\sigma}{d^3p} = \phi(m_\perp)\,\psi_1(\alpha_1 u)\psi_2(\alpha_2 v), \tag{1}$$

where

$$\psi_1(0)=\psi_2(0)=1;\quad u=(z e^{y})^{1/2};\quad v=(z e^{-y})^{1/2};\quad z=\frac{m_\perp}{\sqrt{s}}$$

y is the rapidity in the c.m.s. and α_1 and α_2 are connected by simple relations with the total cross sections for the scattering of the particle a by c and for the scattering of b by c. In a small rapidity interval near $y\approx 0$ we have $\psi_e(\alpha x)\approx 1-\alpha x$, and formula (1) corresponds to the two-reggeon representation for the cross section in the central region with allowance for the RR term.[3,4]

One can assume, however, that the regime of the central region can be continuously extended into the region of large y, i.e., the region $x=2p_L/\sqrt{s}\approx 0.5$. Favoring the latter is, e.g., the growth of $\langle p_\perp\rangle$ up to $x\approx 0.5$, which is characteristic of small x near $x=0$. Naturally, in such a continuation we cannot confine ourselves only to the first terms of the expansion in the representation for the ψ_i, which generally speaking are experimental functions of their arguments. Let us examine the consequences of such a hypothesis within the framework of the representation (1).

We carry out a coordinate transformation $y_{\rm lab}=y_{\max}-y$, corresponding to a transition into the laboratory system of coordinates, where $y_{\max}\ll\ln(\sqrt{s}/m_p)$. In this case, Eq. (1) takes the form

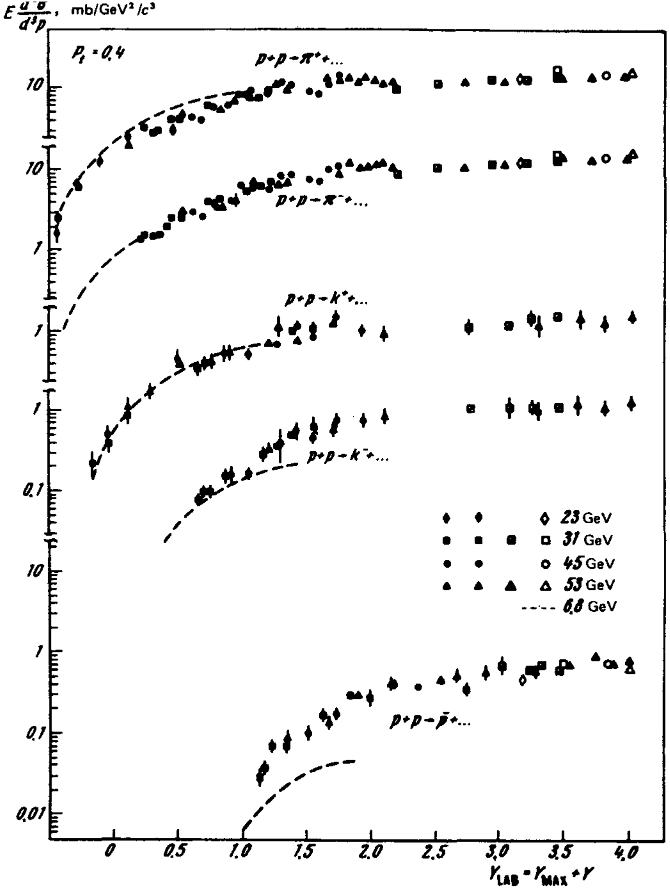

FIG. 1.

$$E\frac{d^3\sigma}{d^3p} = \phi(m_\perp)\psi_1\left(a_1\sqrt{\frac{m_\perp}{m_p}}\, e^{-y_{lab}/2}\right)\psi_2\left(a_2\sqrt{\frac{m_\perp m_p}{s}}\, e^{y_{lab}/2}\right). \quad (2)$$

It follows from (2) that ψ_1 leads to a scaling expression, and ψ_2 determines the degree of violation of the scaling. At high energies and small $y_{1ab} \ll \ln(\sqrt{s}/m)$, the dependence of the spectrum on y_{1ab} is determined by the function $\psi_1[(\alpha\sqrt{m_\perp/m_p})\exp(-y_{1ab}/2)]$, and this function is the envelope for the spectra at lower energies. We note furthermore that the difference in the sort of the registered particle c is determined by the pre-exponential factor $\alpha\sqrt{m_\perp/m_p}$. This means that the envelope should be the same for all particles, accurate to within a shift $y_0 = 2\ln\alpha\sqrt{m_\perp/m_p}$ and a common normalization factor $\phi(m_\perp)$.

Figure 1 shows the experimental data for the reactions $pp \to c + X$ ($c = \pi^\pm$, $K^\pm$, $\bar{p}$) for different energies, starting with $\sqrt{s} = 6.8$ GeV and ending with $\sqrt{s} = 53$

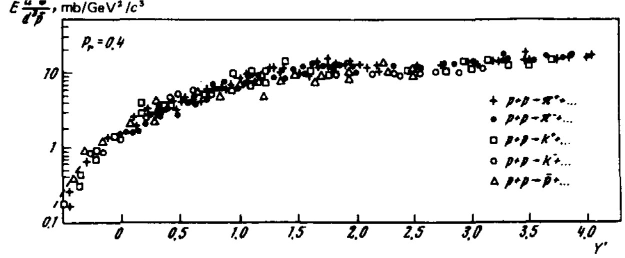

FIG. 2.

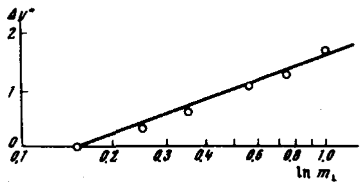

FIG. 3.

GeV.[5] In Fig. 2, the same data are reduced by a suitable shift $y_0 = 2\ln\alpha\sqrt{m_\perp/m_p}$ and by multiplication by $\phi(m_\perp)$ to a single curve.

Thus, accurate to within a certain function $\phi(m_\perp)$ and a parameter α, all the distributions of $E(d^3\sigma/d^3p)$ for the reactions $pp \to c + X$ are described by a single function of y_{1ab}, the shift being given by the formula

$$y_0 = \ln\frac{m_\perp}{m_p} + 2\ln a = \ln m_\perp + C .$$

This dependence of the shift of y_0 on $m_\perp$ is demonstrated in Fig. 3 for the reaction $pp \to \gamma + X$. It is interesting that the γ-quantum distribution is described by the same function of y_{1ab} as the initial π^0 mesons whose decay has produced the γ quanta. This allowance for the decay leads only to a redefinition of the constant α in the argument of ψ_i.

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