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INCLUSIVE PION SPECTRA AND COMPLEX REGGE POLES

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INCLUSIVE PION SPECTRA AND COMPLEX REGGE POLES

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ABSTRACT

A quantitative investigation predicts a strong high-energy decrease of $E\frac{d^3\sigma}{dp^3}$ at $y = 0$, if the large curvature of $E\frac{d^3\sigma}{dp^3}$ in the pionization region at ISR energies is attributed to complex Regge poles.

The rising pp total cross section, the increase of the pionization plateau, and the shape of single-pion inclusive spectra can be qualitatively correlated with complex Regge poles (1,2). The purpose of this article is to investigate more quantitatively the role of complex Regge poles in single-pion inclusive spectra, and to call attention to some specific characteristics of high energy inclusive spectra predicted by the complex Regge pole hypothesis.

Mueller's double-Regge expansion (3) connects the behavior of single particle inclusive cross section in the pionization region with the behavior of total cross sections. Furthermore it is supposed to explain simultaneously the energy dependence and the rapidity dependence of the inclusive spectra. Recent CERN ISR experiments on single-pion

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inclusive spectra from pp collisions reveal a large curvature in the inclusive spectra near the center of the rapidity space. We will see from our quantitative investigation that if the large curvature is attributed to complex Regge poles, severe oscillations in the energy dependence of the inclusive spectra should be expected beyond ISR energies, providing an excellent test for the hypothesis of complex Regge poles.

A simultaneous fit of pp and $p\bar{p}$ total cross sections, and the single-pion inclusive spectra from pp collisions has been made. Data on pp and $p\bar{p}$ total cross sections above $s \geqslant 30\ (\mathrm{GeV})^2$ have been employed, the corresponding interval for pion inclusive spectra being $s \geqslant (30)^2 = 900\ (\mathrm{GeV})^2$. Single π^- inclusive data are taken at $q_T = 0.4$ GeV/c, and at $s = 935$ and $2800\ (\mathrm{GeV})^2$ from a recent CERN ISR experiment (4). The region to be fitted excludes two units in rapidity from each end of the kinematical boundary. The total cross section data are taken from Serpukov (5), NAL (6,7), and CERN ISR (8) experiments. Since the available pion inclusive data are restricted to eleven data points, only a small number of arbitrary parameters can be determined. In a previous fit of pp and $p\bar{p}$ total cross sections (2) by a set of Regge singularities including complex Regge poles, the contribution of the P' pole turned out to be not very significant. Therefore we ignore the P' pole in the present fit. The contribution of the ρ Regge pole is also neglected due to the observed small difference between π^+ and π^- inclusive spectra at $q_T = 0.4$ GeV/c. We thus keep only the pomeron and one pair of complex Regge poles in Mueller's double Regge expansion. The double complex Regge pole term is also neglected in our fit; the effect of this neglect will be discussed at the end of the article.

The form of the single π^- inclusive spectrum used in our fit is

$$f_{\pi^-}(s,y,q_T \quad 0.4) \equiv E\,\frac{d^3\sigma}{dp^3}$$

$$= \gamma_{PP} + 4|\gamma_{CP}|\cdot \mathrm{Re}\left[e^{i\,\underline{|\gamma_{CP}}}\, s^{\frac{1}{2}(1-\alpha_C)} \cosh\{y(1-\alpha_C)\}\right], \quad (1)$$

where α_C is the position of the complex Regge pole. In the fit to pp and $p\bar{p}$ total cross sections, we keep the pomeron, the same pair of complex conjugate Regge poles and the ω Regge pole,

$$\sigma_{pp}^{total}(s) = \beta_P + 2|\beta_C| s^{\alpha_C - 1} \cos\left(\mathrm{Im}\,\alpha_C\, \ell_n\, s + \underline{|\beta_C}\right) - \beta_\omega\, s^{\alpha_\omega - 1} \quad (2)$$

and

$$\sigma_{p\bar{p}}^{total}(s) = \beta_P + 2|\beta_C| s^{\alpha_C - 1} \cos\left(\mathrm{Im}\,\alpha_C\, \ell n\, s + \underline{|\beta_C}\right) + \beta_\omega\, s^{\alpha_\omega - 1} . \quad (3)$$

A simultaneous least square fit yields the following parameters.

γ_{PP}	$\lvert\gamma_{CP}\rvert$	$\underline{\lvert\gamma_{CP}}$	Re α_C	Im α_C	β_P	$\lvert\beta_C\rvert$	$\underline{\lvert\beta_C}$	β_ω	α_ω
5.85	4.81	3.20	0.82	0.65	44.1	5.86	-0.78	58.3	0.32

The fitted curves of $f_\pi(s,y)$ at $s = 935$ and $2800\ (\mathrm{GeV})^2$ are plotted in Fig. 1 with the experimental data used in our fit denoted as crossed points. The fitted curves of $f_\pi(s,0)$, $\sigma_{pp}^{total}(s)$, and $\sigma_{p\bar{p}}^{total}(s)$ are shown in Fig. 2. From the curves of Fig. 2 we see that the period of the oscillation of $f_\pi(s,0)$ is twice that of the total cross sections, since the oscillation period of $f_\pi(s,0)$ is determined

by $\frac{1}{2}$ Im α_C in Eq. (1), and that of the total cross sections by Im α_C in Eqs. (2) and (3). The large amplitude of oscillation of $f_\pi(s,0)$ is partly due to the slow damping of the pomeron-complex Regge pole term and partly due to the largeness of $|\gamma_{CP}|$. Another important feature of this fit is the early onset of the first maximum of $f_\pi(s,0)$, which is almost reached at the highest ISR energy, in contrast to the behavior of the total cross sections. The large amplitude of oscillation in $f_\pi(s,0)$ is required by the large curvature of $f_\pi(s,y)$ at ISR energies, and means that the observation of the effect of the complex Regge poles should be easier in $f_\pi(s,0)$ than in total cross sections. Of course the large oscillation of $f_\pi(s,0)$ means that the observation of a flat pionization plateau, predicted by naive multiperipheral models, cannot be expected until enormously high energies.

The double complex Regge pole terms have been neglected in Eq. (1) in order to reduce the number of arbitrary parameters, but with the high intercept found for the complex Regge trajectories the double complex Regge pole terms can be important. If so, the presence of these terms may explain a part of the large curvature of $f_\pi(s,y)$ at ISR energies and thus reduce the contribution of the pomeron-complex Regge pole term. The oscillation period of the double complex pole term is determined by Im α_C (in contrast to $\frac{1}{2}$ Im α_C for the pomeron-complex Regge pole term), so $f_\pi(s,0)$ will have complicated interference pattern if the double complex Regge pole terms are added in Eq. (1). More extensive inclusive spectrum data are required before it becomes profitable to include the double complex Regge pole terms in our fit, since the number of arbitrary parameters would be increased by two.

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FIGURE CAPTIONS

Fig. 1. Fitted curves of $f_\pi(s,y)$ at $q_T = 0.4$ GeV/c. The experimental data used in the fitting are expressed by crossed points.

Fig. 2. Fitted curves of $f_\pi(s,0)$, $\sigma_{pp}^{total}(s)$, and $\sigma_{p\bar{p}}^{total}(s)$, and the experimental data (the crossed points) used in the fit.

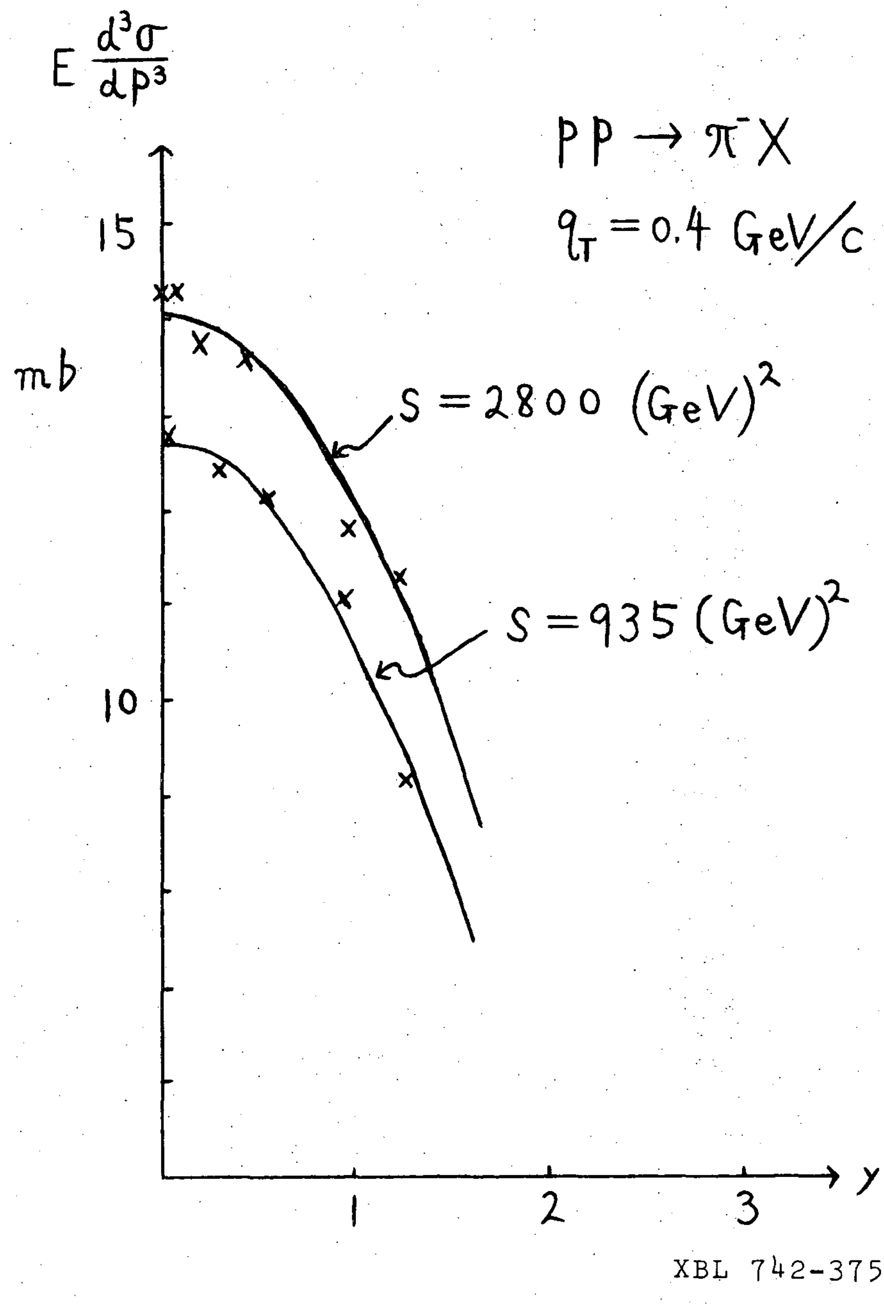
$E \frac{d^3\sigma}{dp^3}$
$pp \to \pi^- X$
$q_T = 0.4$ GeV/c
15
mb
$S = 2800\ (\mathrm{GeV})^2$
$S = 935\ (\mathrm{GeV})^2$
10
1
2
3
y
XBL 742-375

Fig. 1

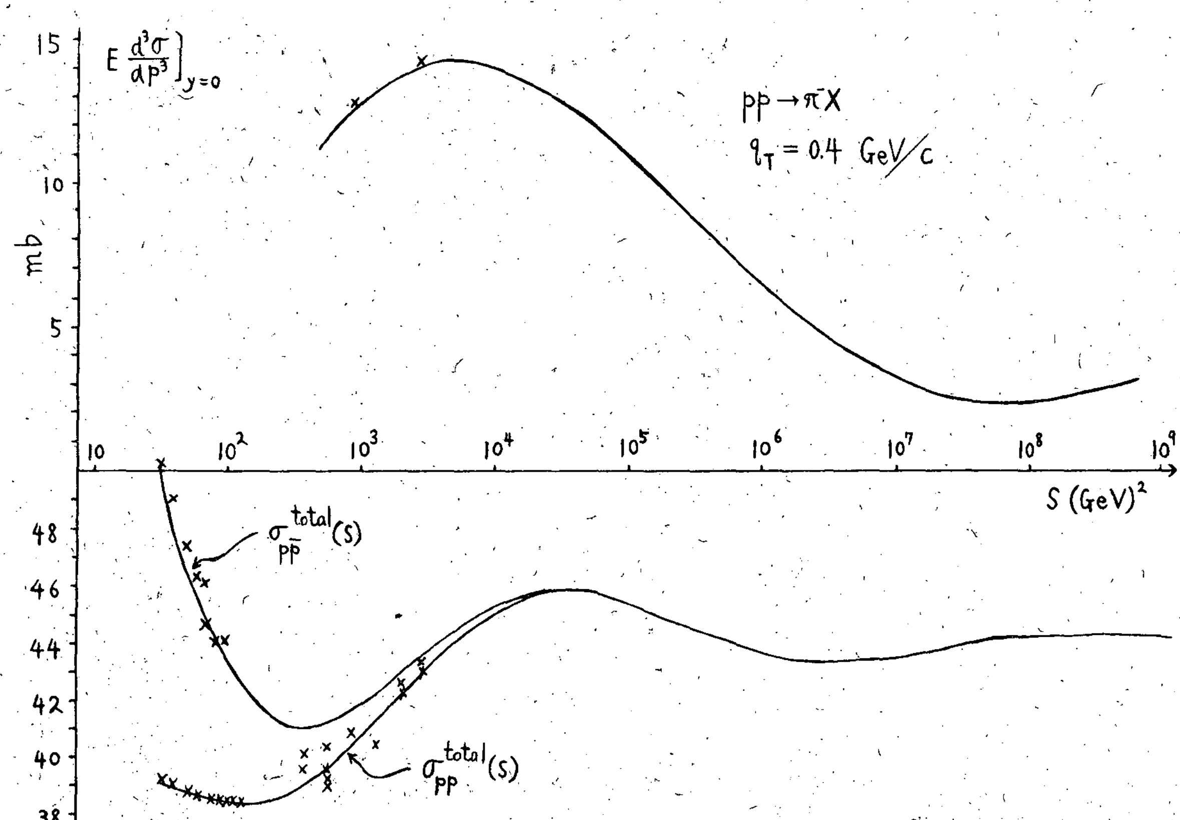

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Fig. 2