By comparing the results given in Table I with those obtained by a standard analysis,[4] one sees that the effect remains of the same order of magnitude. We therefore feel that it would be worthwhile to extend this kind of analysis to other interactions such as K^+p.

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Effect of Resonance Production on Angular Correlation Between Pions

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We have studied, in the P_t plane, the angular correlations between pions produced in the six-prong interactions of K^+p at 12.7 GeV/c in order to suppress the influence of peripherally produced resonances. These results are compared with the values previously determined using space angles.

In a low-energy $\bar{p}p$ annihilation experiment, Goldhaber *et al.*[1] discovered that the distribution of the c.m. angle between two pions depends on the charges of the pions. The average angle between pions of equal charges ($\pi^\pm\pi^\pm$) was smaller than in the case of pairs of opposite charge ($\pi^+\pi^-$) (this is known as the GGLP effect). As a measure of the effect the parameter γ was introduced, where

$$\gamma = \frac{\text{number of pairs with } \theta_{\pi\pi} > 90^\circ}{\text{number of pairs with } \theta_{\pi\pi} < 90^\circ}$$

such that $\gamma^{+-} > \gamma^{\pm\pm}$. Bose-Einstein statistics were invoked to explain these results, but were found to be inadequate. The GGLP effect has been studied in many experiments[2] and is found to be dependent on the leading particle; for example, (i) $\gamma^{++} > \gamma^{--}$ for primary π^+ and (ii) $\gamma^{--} > \gamma^{++}$ for primary π^-. To avoid the leading-particle effect, we recently[3] studied the interaction $K^+p \to K^+p2\pi^+2\pi^-$ at 12.7 GeV/c. We found that the abundant production of two resonances, N^{*++} and K^{*0}, influences considerably the distribution of the angles between the pions momenta. In Tables I and II are shown the revised values of the γ parameter and the asymmetry parameter A defined by $A = (\gamma-1)/(\gamma+1)$ for different pairs of particles in the reaction $K^+p \to K^+p2\pi^+2\pi^-$. We find that the γ values for exotic combinations of ($\pi^\pm\pi^\pm$) and ($K^+\pi^+$) were larger than for nonexotic pairs ($\pi^+\pi^-$) and ($K^+\pi^-$), respectively. For the K^+p interaction at 8.25 GeV/c, Eskreys *et al.*[4] have recently concluded that the GGLP effect could be a reflection of the differences in two-particle effective-mass distributions, which are different for like and unlike pairs. We know that the differences in the mass distributions for different pairs of pions are also observed when resonances are produced, which we have already discussed in our previous paper.[3] We do agree with Eskreys *et al.* that the GGLP effect is due to the difference between the mass distributions for like and unlike pairs. However, we believe that the difference in the mass distributions is a result of the resonant effects. We have demonstrated[3] that the presence of resonances plays an important part in determing the GGLP effect.

Recently Schlesinger[5] has pointed out that in order to minimize the influence of the resonances N^{*++} and K^{*0}, which are produced peripherally, the angular distribution should be studied in the

TABLE I. Values of the γ parameter for different pairs of particles using angles in the transverse plane and in space for the reaction $K^+p \rightarrow K^+p2\pi^+2\pi^-$.

	Resonances not removed		Resonance N^{*++} removed	
	In transverse plane	In space	In transverse plane	In space
$\gamma(\pi^+\pi^+)$	1.50 ± 0.31	1.95 ± 0.41	1.43 ± 0.50	1.12 ± 0.39
$\gamma(\pi^-\pi^-)$	1.31 ± 0.27	1.23 ± 0.25	1.40 ± 0.49	1.27 ± 0.44
$\gamma^L(\pi^\pm\pi^\pm)$	1.40 ± 0.20	1.54 ± 0.23	1.42 ± 0.35	1.19 ± 0.29
$\gamma^U(\pi^+\pi^-)$	1.41 ± 0.14	1.22 ± 0.12	1.40 ± 0.24	0.93 ± 0.16
$\gamma(K^+\pi^-)$	1.56 ± 0.23	0.99 ± 0.14	1.83 ± 0.46	0.95 ± 0.23
$\gamma(K^+\pi^+)$	1.48 ± 0.22	1.50 ± 0.22	1.12 ± 0.27	0.99 ± 0.24
$\gamma(p\pi^+)$	1.38 ± 0.20	1.16 ± 0.17	2.10 ± 0.54	3.85 ± 1.11
$\gamma(p\pi^-)$	1.70 ± 0.25	1.94 ± 0.29	1.36 ± 0.34	1.91 ± 0.49
	Resonance K^{*0} removed		Resonances N^{*++} and K^{*0} removed	
	In transverse plane	In space	In transverse plane	In space
$\gamma(\pi^+\pi^+)$	1.99 ± 0.54	1.90 ± 0.52	2.70 ± 1.37	0.85 ± 0.40
$\gamma(\pi^-\pi^-)$	1.25 ± 0.33	1.34 ± 0.35	0.84 ± 0.39	1.18 ± 0.55
$\gamma^L(\pi^\pm\pi^\pm)$	1.57 ± 0.30	1.59 ± 0.30	1.46 ± 0.48	1.00 ± 0.33
$\gamma^U(\pi^+\pi^-)$	1.42 ± 0.19	1.17 ± 0.15	1.14 ± 0.27	0.85 ± 0.20
$\gamma(K^+\pi^-)$	1.54 ± 0.27	1.29 ± 0.24	1.92 ± 0.66	1.27 ± 0.42
$\gamma(K^+\pi^+)$	1.45 ± 0.29	1.48 ± 0.28	1.01 ± 0.33	1.00 ± 0.33
$\gamma(p\pi^+)$	1.24 ± 0.23	1.29 ± 0.24	2.30 ± 0.80	6.52 ± 2.89
$\gamma(p\pi^-)$	1.78 ± 0.34	1.56 ± 0.29	1.55 ± 0.52	1.51 ± 0.50

transverse-momentum plane. He studied the GGLP effect in the transverse-momentum plane for the reaction $\bar{p}p \rightarrow \bar{p}p\,2\pi^+2\pi^-$ at 6.94 GeV/c and found that the values of the γ parameter in the P_t plane gave practically the same values as were obtained using space angles without removing any resonances. We have studied all the angular correlations in the P_t plane with and without the presence of the resonances in the K^+p interactions, and the values are given in Table I. It is quite interesting that the values of γ^{++}, γ^{--}, and γ^{+-} are close to one another in the P_t plane but their corresponding values using space angles do not agree with one another. However, when the resonances N^{*++} and K^{*0} are removed, the γ values calculated using space angles for like and unlike pions become closer. Thus we see that in the reaction $K^+p \rightarrow K^+p2\pi^+2\pi^-$ at 12.7 GeV/c resonances do play an important part in the GGLP effect.

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TABLE II. The values of the parameter A for different particles.

Lab momentum (GeV/c)	Reaction	A^{++}	A^{--}	$A^{+-}=A^U$	A^L	A^U-A^L
12.7	K^+p	0.32 ± 0.21	0.10 ± 0.14	0.10 ± 0.06	0.21 ± 0.12	-0.11 ± 0.17
12.7	K^+p (resonances K^{*0} and N^{*++} removed)	-0.08 ± 0.14	0.08 ± 0.19	-0.08 ± 0.13	0.00 ± 0.20	-0.08 ± 0.33

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Comment on the Energy Dependence of Charged-Particle Multiplicity

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The energy dependence of the inclusive cross sections in the central region is used to predict the energy dependence of the charged-particle cross sections in high-energy hadron collisions.

Recently, data have become available on the charged-particle multiplicity $\langle n_{\rm ch}\rangle$ at incident laboratory energies of 100 GeV (Ref. 1) and 200 GeV (Ref. 2) in p-p collisions. These, combined with the data from the CERN Intersecting Storage Rings (ISR) and lower-energy accelerator data, provide a complete spectrum of $\langle n_{\rm ch}\rangle$ over the complete range of available energies.[3] As a very good first approximation one can consider that only π mesons are produced in high-energy collisions. It is known for the π mesons that the invariant inclusive cross sections for not-too-small values of x ($\equiv 2p_{\parallel}^{\rm c.m.}/\sqrt{s}$, where $p_{\parallel}$ is the longitudinal momentum and $\sqrt{s}$ is the total c.m. energy), say $x>0.07$, are remarkably constant with energy all the way from $s\approx 40$ GeV^2 to $s\approx 3000$ GeV^2. Data for the very-small-x region are relatively sparse, but they show far more variation with energy than for large x. If one considers the multiplicity equation

$$\langle n_{\rm ch}\rangle \approx \langle n_{\pi^+}+n_{\pi^-}\rangle = \int_{-1}^{1} dx \int \frac{d^2p_\perp}{[x^2+4(p_\perp{}^2+\mu^2)/s]^{1/2}} \times \left(\omega\frac{d\sigma}{d^3p}\right)^{\pi^+ + \pi^-}, \tag{1}$$

it is clear that the contribution $\langle n_{\rm ch}\rangle$ coming from the region $x>0.07$ will stay constant with energy. The variation of $\langle n_{\rm ch}\rangle$ with s thus provides indirect information about the variation of the one-particle distribution function in the small-x region; this is the subject of the present note.

If the one-particle distribution function can be represented for a *finite* but small range of x around $x=0$, as

$$\frac{1}{\sigma_{\rm tot}}\left(\omega\frac{d^3\sigma}{d^3p}\right)^{\pi^+ + \pi^-} = a_1(p_\perp{}^2)+f(x)s^\alpha a_2(p_\perp{}^2), \tag{2}$$

then, following Mueller,[4] the behavior of $\langle n_{\rm ch}\rangle$ is easily seen to be, for a smooth $f(x)$,

$$\langle n_{\rm ch}\rangle = \langle n_{\rm ch}\rangle^f + [a_1+a_2 f(0)s^\alpha]\ln s + \dots, \tag{3}$$

where $\langle n_{\rm ch}\rangle^f$ is the constant contribution coming from the fragmentation region and

$$a_i = \int a_i(p_\perp{}^2)d^2p_\perp. \tag{4}$$

The coefficient of the $\ln s$ term is thus the structure function at $x=0$,

$$\langle n_{\rm ch}\rangle = \langle n_{\rm ch}\rangle^f + \left[\int \frac{\omega}{\sigma_t}\frac{d\sigma}{d^3p}\, d^2p_\perp\right]^{\pi^+ + \pi^-}_{x=0} \ln s. \tag{5}$$

The energy dependence of $\langle n_{\rm ch}\rangle$ is thus directly related to the energy dependence of the single-particle inclusive cross section in the pionization region, subject to Eq. (1) being valid. Ferbel[5] has compiled data on inclusive π^- cross sections at the point $x=0$. We make the following two observations: (i) The experimental data entering the compilation are flat over a range of x, so that the energy dependence of the inclusive cross sec-