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**EXPERIMENTAL COMMENTS ON THE SUPPRESSION
OF STRANGENESS AND DIQUARKS IN PARTON FRAGMENTATION**

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ABSTRACT

Data on production of kaons and antiprotons from e^+e^- annihilation, deep-inelastic lepton-hadron, and hadron-hadron scattering are compared on a qualitative level. Evidence for unfamiliar trends is found.

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1. Introduction

The concept of simplicity suggests that jets originating from a given type of parton look the same, to a good approximation, independent of the production process.

In this spirit data on kaon and antiproton production from e^+e^- annihilation, deep inelastic lepton-nucleon and hadron-hadron scattering are compared here in a qualitative way focussing on strangeness and diquark suppression factors.

These suppression factors λ_s and λ_{diq} (defined as the probability to create the respective pair of partons relative to a $u\bar{u}$ or $d\bar{d}$ pair) are usually determined experimentally from a measurement of stable hadrons which are very often decay products of directly produced resonances. Resonance decay tends to favor pion yields such that e.g. $\lambda_s > \sigma(K^+)/\sigma(\pi^+) := K^+/\pi^+$ for light quark (d,u) fragmentation. Hence, numerical values of suppression factors extracted from the data depend on assumptions concerning resonance production. The equality $\lambda_s = K^+/\pi^+$ should hold for large values of the fragmentation variable z (i.e. $z \rightarrow 1$) where contributions from resonances are suppressed due to decay kinematics.

The most detailed analyses of fragmentation processes were performed so far for e^+e^- annihilation and deep inelastic lepton scattering at moderate values of z . Typically one finds $\lambda_s \approx 0.3$ and $\lambda_{diq} \approx 0.075$ [1]. Due to small cross sections the high z range is not easily accessible in lepton induced reactions. There are, however, rather comfortable production rates for single particles at high transverse momentum p_T in hadron-hadron collisions. These particles are leading fragments of hard scattered partons [2] with $\langle z \rangle > 0.7$ for $x_T = 2p_T/\sqrt{s} > 0.1$ [3]. According to the kinematical arguments presented above, particle ratios at high p_T should therefore provide a rather direct measure of suppression factors.

2. Strangeness Suppression

In ref. [4] kaon-to-pion ratios were compared as function of jet energy E_{jet} (see fig. 1a). The K^0/π^- ratios (at $z > 0.2$) come from d quark current jets produced in $\bar{\nu}$ scattering [4], while K^+/π^+ ratios were obtained for $p_T \geq 3$ GeV/c at a polar angle $\theta \approx 50^\circ$ in pp collisions at $\sqrt{s} = 63$ GeV [5]. In the latter case the particle momenta $\vec{p}$ were converted into E_{jet} using the measured dependence of $\langle z \rangle$ on x_T [3]: $E_{jet} = |\vec{p}|/\langle z \rangle$. In ref. [2] it was shown that both

K^+ and π^+ are leading fragments of hard scattered u quarks in most of these cases. Therefore, the ratio K^+/π^+ at high p_T is a rather direct measure of strangeness suppression in u-quark fragmentation. The two data sets ($K^0/\pi^- \leq 0.2$ and $K^+/\pi^+ \approx 0.46$) do not seem to join smoothly as function of E_{jet} in fig. 1.

In fig. 1b further measurements of K^+/π^+ at $p_T \geq 2$ GeV/c from pp collisions are compiled [6]; they overlap with $\bar{\nu}$ data now in terms of E_{jet} , but are not compatible with them.

Also included are two measurements of K^+/π^+ from jets recoiling against high p_T ($p_T = 3 \div 4$ (GeV/c) particles which were produced at $\theta \approx 90^\circ$ in pp collisions at $\sqrt{s} = 27$ GeV. The latter ratios were obtained for $x_e = p_T/p_T(\text{trigger}) \geq 0.7$. Since one has, for two collinear jets with equal E_{jet} , $x_e = p_T / \langle z(\text{trigger}) \rangle \cdot E_{jet}$ $\approx 1 / \langle z(\text{trigger}) \rangle \cdot z$, it follows that $z \approx x_e \langle z(\text{trigger}) \rangle > 0.55$.

Most pp data are compatible. The ratio K^+/π^+ shows a slight increase with E_{jet} between 3 and 4 GeV. For $E_{jet} > 4$ GeV, K^+/π^+ levels off at about 0.46 [5]. In a more recent experiment at $\sqrt{s} = 39$ GeV, $K^+/\pi^+ \approx 0.46$ was found [7] as well for $p_T \geq 3.5$ GeV/c. It should be mentioned that, at least at $\sqrt{s} = 62$ GeV and for $p_T \geq 4$ GeV/c, the average transverse momentum q_T of the kaon or pion relative to the jet axis is small ($q_T < 0.2$ GeV/c, [8]) such that the observed ratio tends to be unbiased by q_T dependence.

From $K^+/\pi^+ = 0.46$ at high p_T it follows that $\lambda_s > 0.46$; in ref. [5] $\lambda_s = 0.55 \pm 0.05$ was obtained from this ratio using the fragmentation scheme of ref. [9] which includes resonances. In contrast, with $\lambda_s = 0.2$ the $\bar{\nu}$ data is well reproduced. For given E_{jet} , the most important kinematic difference between both data sets is the range in z : $z \geq 0.2$ (νN) and $\langle z \rangle > 0.7$ (pp).

Relative particle yields from e^+e^- annihilation at $\sqrt{s} \geq 29$ GeV were compared in ref. [1a] to a QCD shower model prediction. Whereas the kaon fraction from the TPC experiment is well reproduced by the model for $|\vec{p}| < 1$ GeV/c, there is a systematic excess over the prediction at higher momenta.

In fig. 2a [10] finally, a recent measurement of K^+/π^+ from u-quark current jets is displayed as function of Feynman x_F together with predictions from a model [11] using $\lambda_s = 0.3$. Large values of K^+/π^+ are found for large x_F , i.e. large z . There appears to be a consistent excess over the prediction, increasing

with x_F . From these data, combined with K^0 and π^+ yields from the same experiment, λ_s was determined in ref. [10] for $z \geq z_{\min}$ as function of $z_{\min}$ as shown in fig. 2b. The value of λ_s ($\lambda_s = 0.55 \pm 0.05$) derived from the pp data [5] is shown as well for $z_{\min} \approx \langle z \rangle = 0.78$.

From the trends observed in the data discussed above it is concluded that:

- i) either the values of λ_s derived at moderate z were, so far, underestimated (potentially due to incomplete knowledge of resonance production), or
- ii) λ_s increases as function of z up to $\lambda_s \approx 0.5$, the value used already in ref. [9].

The latter value of λ_s may also help to explain:

- i) the fact that the inclusive ratio K^+/π^+ at $p_T \approx 0.55$ GeV/c is increasing with x_F up to a value 0.5 at $x_F > 0.9$ in pp collisions at $\sqrt{s} = 44$ GeV [12];
- ii) the rather large relative production rate of Ξ^- at $p_T \geq 1.2$ GeV/c [13];
- iii) the suppression of the momentum fraction carried by strange sea quarks (0.52 ± 0.09 relative to u,d quarks) found in deep inelastic ν scattering [14].

3. Diquark Suppression

Analyses of (anti)proton production in e^+e^- annihilation suggest that $\lambda_{ud} \approx 0.065-0.09$ [1a] for moderate values of z .

In fig. 3a the inclusive ratio $\bar{p}/\pi^-$ at $\theta \approx 50^\circ$ from pp collisions at $\sqrt{s} = 63$ GeV is shown as function of p_T [15]. Again, the data correspond to $\langle z \rangle > 0.7$. The ratio $\bar{p}/\pi^-$ is smaller than 0.05 for $p_T > 4$ GeV/c. Probably, $\bar{p}$ are predominantly non-leading fragments of scattered u quarks, whereas π^- are leading fragments of d quarks and/or gluons [2]. In contrast to the case of K^+/π^+ discussed above, the diquark suppression factor cannot therefore be derived easily without a model. In ref. [16] it was concluded that $\lambda_{ud} = 0.035$ is needed to reproduce the measurements of fig. 3a. Earlier measurements of $\bar{p}/\pi^-$ are given in fig. 3b [6e]; for $p_T \geq 3.5$ GeV/c the measured ratios tend to be even smaller than in fig. 3a.

In this framework it is again instructive to consult the data on antiproton production in current jets from deep inelastic μ scattering [10] in fig. 3c. For $0 \leq x_F < 0.3$ (i.e. small z) the measured rates are rather well reproduced by the model, whereas for $x_F > 0.3$ (i.e. large z) the measurement seems to be consistently lower.

All these data imply therefore the question whether λ_{ud} decreases at large z . This may not be too surprising since baryon production at large z would correspond to large momentum transfers to bound diquark systems.

4. Summary

Trends of data from e^+e^- annihilation, deep inelastic lepton and hadron scattering on production of strange mesons and antiprotons were compared. There is evidence that, at least for large values of z , $\lambda_s \approx 0.5$, whereas λ_{ud} may decrease with increasing z .

The results presented here for the case of strangeness suppression are of particular importance for the interpretation of data on $B^0-\bar{B}^0$ mixing [17] and may become relevant for the understanding of quark-gluon plasma signatures [18] in high energy heavy ion collisions.

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Figure Captions

- Fig. 1a) The ratios K^0/π^- [4] and K^+/π^+ [5] as function of jet energy E_{jet} . Also shown is a prediction of the Lund model.
- Fig. 1b) The ratios K^+/π^+ from ref. [6] as function of E_{jet} .
- Fig. 2a) The ratio K^+/π^+ as function of x_F from the current jet in μN interactions [10] and a prediction from the Lund model.
- Fig. 2b) The strangeness suppression factor λ_s extracted from kaon and pion production in current jets from μN collisions [10] as function of z_{min} ; also shown is λ_s extracted from K^+/π^+ at high p_T from pp collisions [5].
- Fig. 3a) The ratio $\bar{p}/\pi^-$ as function of p_T [15] at (a) $\sqrt{s} = 63$ GeV and (b) $P_{lab} = 200 \div 400$ GeV/c [6e].
- Fig. 3b) The rate of $\bar{p}$ in current jets from μN collisions [10] and a prediction from the Lund model.

References

- [1] a) D. Saxon, Proceedings of the Int. Europhysics Conference on High Energy Physics, Bari, 1985.
H. Aihara et al., Phys. Rev. Lett. 53 (1984) 130,
b) see e.g. ref. [10],
c) For hadron-hadron collisions: J.L. Bailly et al., CERN/EP 87-99 and refs. therein.
- [2] A. Breakstone et al., Z. Phys. C25 (1984) 21.
- [3] See e.g. W.M. Geist, CERN/EP 82-184.
- [4] M. Aderholz et al., Z. Phys. C27 (1985) 43.
- [5] A. Breakstone et al., Phys. Lett. 135B (1984) 510.
- [6] a) see ref. [5], $\sqrt{s} = 45$ GeV,
b) $\sqrt{s}=63$ GeV, extracted from T. Lohse, Ph. D. thesis, Dortmund, 1985,
c) $\sqrt{s}=23.4$ GeV, B. Alper et al., Nucl. Phys. B100 (1975) 237,
d) $\sqrt{s}=63$ GeV, T. Akesson et al., Nucl. Phys. B246 (1984) 408,
e) $\sqrt{s}=27.4$ GeV, D. Antreasyan et al., Phys. Rev. D19 (1979) 764,
f) $\sqrt{s}=27.4$ GeV (away jet), R.J. Fisk et al., Phys. Rev. Lett. 40 (1978) 984.
- [7] A. Zieminski, Proc. of the XXIII Int. Conference on High Energy Physics, 16-23 July 1986, Berkeley, California.
- [8] A. Breakstone et al., Z. Phys. C23 (1984) 9.
- [9] R.D. Field, R.P. Feynman, Phys. Rev. D15 (1977) 2590,
Nucl. Phys. B136 (1978) 1
- [10] F. Montanet, Ph. D. thesis, Marseille, 1986.
- [11] B. Anderson et al., Z. Phys. C20 (1983) 317.
- [12] J. Singh et al., Nucl. Phys. B140 (1978) 181.
- [13] G.J. Alner et al., Phys. Lett. 151B (1985) 309.
- [14] H. Abramowicz et al., Z. Phys. C15 (1982) 19.
- [15] A. Breakstone et al., Phys. Lett. 147B (1984) 237.
- [16] A. Breakstone et al., Z. Phys. C28 (1985) 335.
- [17] C. Albajar et al., Phys. Lett. 186B (1987) 247.
- [18] See e.g. P. Koch et al., Phys. Rep. 142 (1986) 167 and
J. Rafelski and M. Danos, CERN-TH. 4686/87.

FIG. 1

FIG. 2

FIG. 3