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N.B.Skachkov

WHAT IS THE INTEREST IN STUDYING THE FRAGMENTATION FUNCTIONS $\bar{D}_q^h(z, s)$ OF QUARKS INTO HADRONS IN THE PROCESSES $e^+e^- \to h + X$ AT LEP ENERGIES?

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1. Introduction

The study of QCD processes that take place in the hadron production in high-energy e^+e^- interactions is included into the program of the experiments at LEP [1,2].

To my opinion, this part of program can be supplemented with an interesting problem of studying the scaling violation in the fragmentation functions (FF) $D_q^h(z,S)$ that describe the transition of quarks q produced in e^+e^- annihilation into identified hadrons $h = \pi, K, p, \ldots$. These functions are measured in the processes of inclusive annihilation (IA) like $e^+e^- \to h + X$ and $e^+e^- \to h_1 + h_2 + X$.

The feasibility of such measurements at LEP has recently been demonstrated by the DELPHI collaboration [3] that has presented the data on single charge hadron inclusive distributions over $z = pq/q^2$ (in c.m.s. $z \equiv x_p = E_h/E_{beam}$) and $p_T^{in(out)}$ (p is the momentum of a single hadron, the sort of which, whether it is a pion, kaon or a proton, was not determined).

The aim of this paper is to present the physical arguments in favour of the selection of the events of inclusive annihilation with the identification of the sort of a single hadron in the final state in the course of analysis of the experimental material obtained at LEP. The most interesting physically are the events with the identified single protons in the final state.

From the physical point of view the distinguished role of the IA processes $e^+e^- \to h + X$ stems from the QCD prediction of the strengthening of scaling-violation effects in the annihilation channel as compared with those occurring in the processes of lepton-hadron deep-inelastic scattering. The check of this prediction at LEP energies would be very interesting.

The paper is organized as follows. Section 2 contains necessary definitions of the fragmentation functions (FF) and their connection with the cross section. The experimental situation is also discussed there. Section 3 is devoted to the QCD predictions for scaling violation in the FFs in IA. Section 4 contains the discussion of the physical results that can be obtained from the data analysis of the processes $e^+e^- \to h + X$ at the first stage of the measurements at LEP near the Z^0-peak.

2. Scaling violation in the fragmentation functions and experimental data

1. The process $e^+e^- \to h + X$ shown by the diagram in fig.1 can be treated as the lepton annihilation channel analog of the process $e^-h \to e^- + X$ that takes place in the lepton scattering channel (see fig.2 for $h = p$)

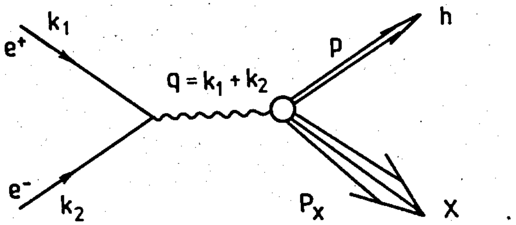

Fig.1. The diagram of process $e^+e^- \to h + X$ of the inclusive production of the identified hadron h $(h = \pi, K, p ...)$ in e^+e^- - annihilation.

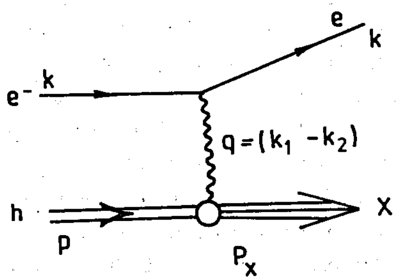

Fig.2. The diagram of deep-inelastic electron scattering on the hadron h $(h = p, N)$.

These two different processes differ by the geometrical nature of the vector of momenta transferred q from the leptonic block to the hadronic one. Namely, in the annihilation channel, i.e. for $e^+e^- \to h + X$ the vector of momenta transfer is time-like, i.e. $q^2 = (k_1 + k_2)^2 > 0$ while in the lepton-hadron scattering channel $e^-h \to e^- + X$ it is space-like, i.e. $q^2 = (k_1 - k_2)^2 < 0$.

The analytical continuation in q^2-variable from the space-like to the time-like region [4] performed in the QCD matrix elements of the scattering amplitude reveals similar features of these processes as well as their difference [5-7].

2. The cross section of the inclusive production $e^+e^- \to h + X$ of the identified hadron h with the mass $m_h = m$ and momentum $p_h = p$ has the following form

$$d\sigma = \frac{(4\pi\alpha)^2}{s^3} \cdot \bar{L}_{\mu\nu} \bar{W}^{\mu\nu} \cdot \frac{2\, d^3 p}{(2\pi)^3 p_0} , \tag{1}$$

where

$$\bar{L}_{\mu\nu} = k_{1\mu} k_{2\nu} + k_{1\nu} k_{2\mu} - g_{\mu\nu}(k_1 k_2), \tag{2}$$

and

$$\bar{W}_{\mu\nu} = \frac{1}{8} \sum_{n, \sigma_h} \langle 0 | J_\mu(0) | n, h \rangle \langle n, h | J_\nu(0) | 0 \rangle (2\pi)^4 \cdot \delta^{(4)}(q - P_X - p_h) . \tag{3}$$

Here $J_\mu(0)$ is the electromagnetic current, P_X is the 4-momentum of all not identified hadrons X whose variables are summed in (3). The sum is taken also over the polarizations σ_h of the separated hadron h .

In terms of the decomposition of the hadron tensor

$$\frac{1}{2\pi} \bar{W}_{\mu\nu} = \left(\frac{q_\mu q_\nu}{q^2} - g_{\mu\nu} \right) \bar{W}_1(z, s) + \tag{4}$$

$$+ \frac{1}{m^2} \left(p_\mu - \frac{pq}{q^2} q_\mu \right) \left(p_\nu - \frac{pq}{q^2} q_\nu \right) \bar{W}_2(z, s) ,$$

where $z = \frac{2pq}{s}$ and $q^2 = (k_1 + k_2)^2 = s$, the IA cross section (1) can be represented in the limit $s \to \infty$, $pq \to \infty$ in the form (see, for example, [7])

$$\frac{d\sigma}{dz\, d\cos\theta} = \frac{\pi\alpha^2}{s}\cdot z\left[\bar{F}_1(z,s) + \frac{1}{4} z\cdot s\sin^2\theta\cdot \bar{F}_2(z,s)\right]. \quad (5)$$

Here θ is the angle between the hadron momentum p and the beam direction in e^+,e^- – c.m.s., where $q=(q_0,\vec{0})$, $q_0 = 2E_{beam} = W$, $z = 2pq/q^2 = 2p_0/2E_b = E_h/E_{beam}$, and

$$\bar{F}_1(z,s) = \bar{W}_1(z,s)\ ;\ \bar{F}_2(z,s) = \frac{pq}{m^2}\bar{W}_2(z,s). \quad (6)$$

After the integration over the θ the formula (5) takes the form

$$\frac{d\sigma}{dz} = \sigma_{\mu\mu}\cdot z\left[3\bar{F}_1(z,s) + \frac{z}{2}\bar{F}_2(z,s)\right] = \quad (7)$$

$$= \sigma_{\mu\mu}\cdot z\left[\bar{F}_T(z,s) + \frac{1}{2}\bar{F}_L(z,s)\right],$$

where (s in GeV^2)

$$\sigma_{\mu\mu} \equiv \sigma(e^+e^-\to\mu^+\mu^-) = \frac{4\pi\alpha^2}{3s} = \frac{86.9}{s}\, nb \quad (8)$$

and

$$\bar{F}_T = 2\bar{F}_1\ ;\ \bar{F}_L = 2\bar{F}_1 + z\bar{F}_2. \quad (9)$$

3. In the parton limit, i.e. when the coupling constant of quarks to gluons $\alpha_s(q^2)$ is turned off, the following relations take place

$$\bar{F}_L(z) = 0, \qquad z\bar{F}_2(z) = 2\bar{F}_1(z) \quad (10)$$

$$z\bar{F}_T(z) = 3\sum_{i=1}^{f} e_i^2\left[\bar{D}_{q_i}^h(z) + \bar{D}_{\bar{q}_i}^h(z)\right] =$$

$$= 3\left[\frac{4}{9}\left(\bar{D}_u^h(z) + \bar{D}_{\bar{u}}^h(z)\right) + \frac{1}{9}\left(\bar{D}_d^h(z) + \bar{D}_{\bar{d}}^h(z)\right) + \right.$$

$$(11)$$

$$\left. + \frac{1}{9}\left(\bar{D}_s^h(z) + \bar{D}_{\bar{s}}^h(z)\right) + \frac{4}{9}\left(\bar{D}_c^h(z) + \bar{D}_{\bar{c}}^h(z)\right) + \ldots\right].$$

Here $\bar{D}_{q_i}^h(z)$ are the fragmentation functions (FF) that describe the distribution of the hadron h in the quark q_i. The FF's satisfy the following relations

$$\sum_h \int_0^1 dz\, I_3^h\, \bar{D}_{q_i}^h(z) = I_3^{q_i}, \quad (12)$$

$$\sum_h \int_0^1 dz\cdot z\cdot \bar{D}_{q_i}^h(z) = 1, \quad (13)$$

for each quark q_i with the third isospin component $I_3^{q_i}$. The relation (13) is the conservation law of the momentum of the jet of hadrons produced by the parton q_i.

4. The experimental data /8–11/ show quite a sizable effect of the s-dependence of the quantity $s\frac{d\sigma}{dz}$ that due to (7) and (8) must have, in the parton limit, a pure scaling behaviour. TASSO data /10,11/ plotted in fig.3 show the s-dependence of

$$s\frac{d\sigma}{dz} = \frac{4\pi\alpha^2}{3}\cdot z\cdot\left[\bar{F}_T(z,s) + \frac{1}{2}\bar{F}_L(z,s)\right] \quad (14)$$

that looks very similar to[x)] the analogous Q^2-dependence of deep-inelastic structure functions (see for example fig.4 with BCDMS data /12/).

5. It is important to note that the study of the reaction $e^+e^-\to h+X$ has made available, for the investigation (even before the LEP), the region with much higher values of the square of the momentum transfer $q^2(=s)$ than that one reached until now in the processes of deep-inelastic lepton-hadron scattering. Thus the BCDMS /12/ and EMC /13/ data belong to the interval $5\le Q^2\le 270$ GeV^2. As is seen from fig.3, where TASSO data /10,11/ are presented at energies $\sqrt{s} = 2E = 12;\ 14;\ 25;\ 30.5;\ 34.5$ and 41.5 GeV, even at PETRA energies there were obtained the data on $\bar{D}_q^h(z,q^2)$ that belong to the $\simeq 10^3$ GeV^2 region of $q^2(=s)$.

6. The scaling violation in TASSO data on FF's $\bar{D}_q^h(z,s)$ has, in agreement with the QCD, the logarithmic nature, which is shown in Table 1 taken from /10/. In this table the values of the parameters from the phenomenological formula (15) that describes these data are shown

x) The behaviour of (14) as a function of z is shown in fig.5.

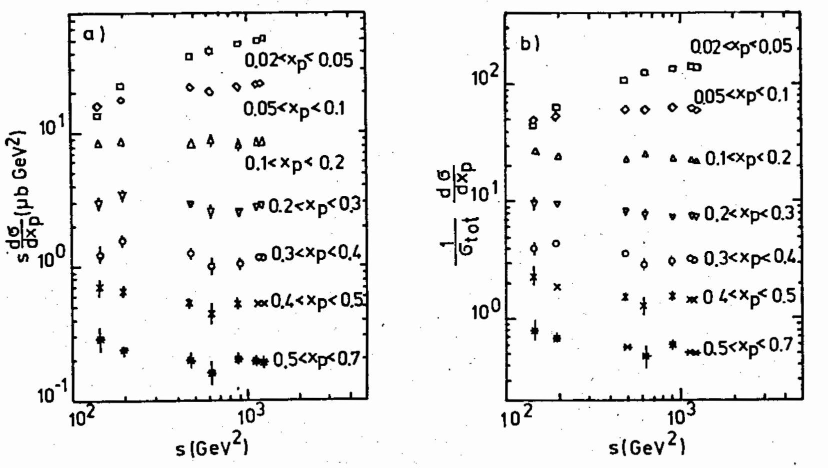

Fig.3. TASSO [10,11] data for the inclusive charged-particle production. a) The scaled cross section versus the square of the c.m.s. energy $s=W^2$, b) The normalized cross section $\sigma_{tot}^{-1}\cdot d\sigma/dz$ versus $s\ (z\equiv x_p)$.

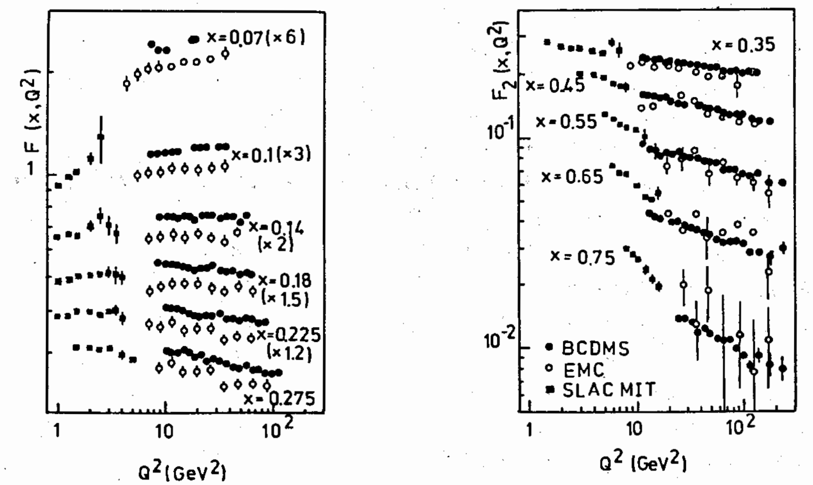

Fig.4. BCDMS proton data for $F_2^p(x,Q^2)$ [12] shown together with EMC and SLAC_MIT data.

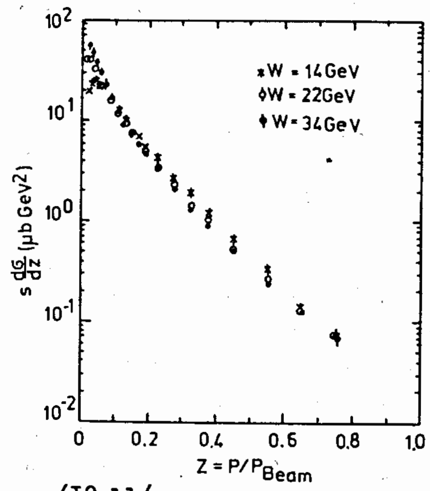

Fig.5. TASSO data [10,11] for the scaled cross section $s\cdot d\sigma/dz$ $(z=2p/W)$ for inclusive charged-particle production measured at W =14, 22 and 34 GeV $W=\sqrt{s}$.

$$\frac{1}{\sigma_{tot}}\cdot\frac{d\sigma}{dz}=c_1\left[1+c_2\ln(s/s_0)\right], \qquad (15)$$

$$s_0 = 1\ GeV^2.$$

Table 1. The results of the fit of the TASSO data [10] with the phenomenological formula (15)

z	c_1	c_2
0.02 – 0.05	0.50 ± 0.05	25.30 ± 2.490
0.05 – 0.10	1.97 ± 0.87	0.318 ± 0.080
0.10 – 0.20	26.80 ± 1.40	-0.022 ± 0.008
0.20 – 0.30	14.99 ± 0.81	-0.071 ± 0.005
0.30 – 0.40	7.27 ± 0.54	-0.081 ± 0.006
0.40 – 0.50	3.29 ± 0.37	-0.084 ± 0.008
0.50 – 0.70	1.09 ± 0.16	-0.075 ± 0.012

Results analogous to TASSO were got by some other collaborations [14,15]. All of them show the existence of the logarithmic deviation from scaling, which is expected in QCD [16-20]. The scaling violation in TASSO [10,11] and JADE [15] data achieves 20–25% for $x \geqslant 0.15$ and is much higher for low x .

3. QCD predictions for scaling violation in $\bar{\mathcal{D}}_q^h(z, q^2)$ in the annihilation channel

As was mentioned in the Introduction, QCD predicts a more strong effect of the scaling violation in the lepton annihilation channel as compared with the deep-inelastic lepton-hadron scattering (DIS). This difference occurs due to the contribution of the second order of perturbation theory /22-25/, the inclusion of which into the QCD-analysis only makes the procedure of extracting the value of Λ meaningful /21/. (One would also keep in mind that, as is known from the results of the QCD-analysis, the QCD scale parameter Λ is strongly correlated with the parameters that define the shape of the gluon distribution function).

The difference of the lepton annihilation (A) channel from the channel of their scattering (S) can be reproduced by the following quantity /22/

$$R(Q^2, Q_o^2, N) \equiv \frac{R^{(A)}(Q^2, Q_o^2, N)}{R^{(S)}(Q^2, Q_o^2, N)} , \qquad (16)$$

where $R^{(i)}(Q^2, Q_o^2, N)$, $i = A, S$ are the ratios

$$R^{(A)}(Q^2, Q_o^2, N) = \frac{\bar{\mathcal{F}}_2^{(A),NS}(Q^2, N)}{\bar{\mathcal{F}}_2^{(A),NS}(Q_o^2, N)} ; \quad R^{(S)} = \frac{\mathcal{F}_2^{(S),NS}(Q^2, N)}{\mathcal{F}_2^{(S),NS}(Q_o^2, N)} \qquad (17)$$

of the moments (N is the number of the moment) of nonsinglet (NS = $= \pi^+ - \pi^0, p-n \ldots$) combinations of the structure function in the annihilation (A):

$$\bar{\mathcal{F}}_2^{(A), \pi^+-\pi^0}(x, Q^2) = x^2 \left[\bar{F}_2^{e^+e^- \to \pi^+ + X}(x, Q^2) - \bar{F}_2^{e^+e^- \to \pi^0 + X}(x, Q^2) \right]_{Q^2 \equiv S = q^2} \qquad (18)$$

and deep-inelastic scattering (S)

$$\mathcal{F}_2^{(S), p-n}(x, Q^2) = \frac{1}{x} \left[F_2^{ep \to e + X}(x, Q^2) - F_2^{en \to e + X}(x, Q^2) \right]_{Q^2 = -q^2} \qquad (19)$$

channels. The numerical values of (16) are shown for different numbers of the moments N and for the choice $Q_o^2 = 5$ GeV^2 and $Q^2 = 200$ GeV^2 in fig.6, taken from /22/.

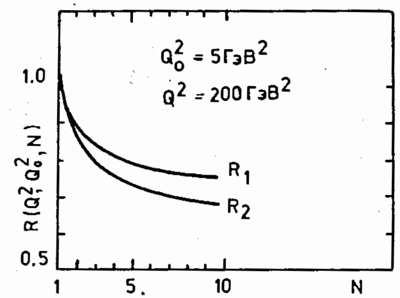

Fig.6. The ratio (16) of the moments of the structure functions (18), (19) in different channels (annihilation (A) and deep-inelastic scattering (S)). (To characterise the size of the difference in the scaling violation effects in these channels the value of Q^2 is taken $Q^2 = 200$ GeV^2 and the moments are normalized to their values at the reference point $Q_o^2 = 5$ GeV^2. R_2 and R_1 correspond to the traditional and exponentiated forms of the solution of the renormalization group equations (see ref. /22/).

This result shows that the effect of the scaling violation (with the same value of Λ) in the IA channel is much more stronger than that within QCD in the DIS-channel.

Analogous calculations performed in /23/ have shown that the FF's in the annihilation channel do evolve with $q^2 (= S)$ much stronger than the structure functions (SF's) in DIS. This is connected with the fact that in the time-like region $q^2 > 0$ the contribution of second-order terms (i.e. $\sim \alpha_s^2(q^2)$) to the FF's derivative with respect to q^2 reaches about 50-70% of the value of the leading order contribution /23/ while in the DIS channel the relation of the second and first order contributions does not exceed 20-30%.

As a result, the variety of the nonsinglet component of the FF $\bar{\mathcal{D}}_q^{h,NS}(z, S)$ at the evolution from $S = q^2 = 9$ GeV^2 to $S = q^2 = 100$ GeV^2 is equal to the variety of nonsinglet SF $F^{NS}(x, Q^2)$ in the interval from $Q^2 = -q^2 = 9$ GeV^2 to $Q^2 = -q^2 = 900$ GeV^2 /23/.

Herefrom it follows that QCD preducts (with the same value of

Λ) such a strong scaling violation effects in the IA processes $e^+e^- \to h+X$ in the region $10\ GeV^2 \leq s \leq 100\ GeV^2$ that can be reached in the channel of DIS $e^-h \to e^-+X$ only by passing to the region of the squared momentum transfer $-q^2 = Q^2 \approx 10^3\ GeV^2$.

In other words, the QCD-prediction can be imagined as the prediction of the effect of contraction in the annihilation channel of the q^2-axis, along which we study the evolution of the structure functions with the evolution of the running coupling constant $\alpha_s(q^2)$, as compared with the q^2-axis in deep-inelastic lepton--hadron scattering.

For this reason the study of the fragmentations functions behaviour in the IA process $e^+e^- \to h+X$ at energies attainable at LEP opens the possibility for a detailed study of the scaling violation in the FF's in the region of $q^2 \approx 10^4\ GeV^2$ that can be reached in deep-inelastic scattering only after a new generation of the proton accelerators would operate.

4. What can be measured at the first stage of the experiments at LEP near the Z^0-peak?

1. At the first stage of experiments at LEP when the e^+e^--beam energies would be fixed by the requirement $s = (k_1+k_2)^2 \simeq M_Z^2$ it will be interesting following /3/ to study the z-dependence of the fragmentation function $D_q^h(z,s)$ for different identified hadrons $h = \pi, K, p, \ldots$ at this value of s. Among this cases the most interesting one is the process with the identified proton in the final state, i.e. the process $e^+e^- \to p+X$. In this case the point $s \approx M_Z^2 \approx 8200\ GeV^2$ could play the same role as the point $Q^2 \doteq \langle -t \rangle \simeq 2000\ GeV^2$, at which the x-dependence of the proton structure function $F^p(x,Q^2)$ was measured by UA1 and UA2 collaborations /26/ (see fig.7).

It should be mentioned that the knowledge of $F^p(x, Q^2 = 2000\ GeV^2)$ is important for the QCD-analysis, as well as for improving the form of the QCD-motivated phenomenological expressions for the structure functions widely used for different estimates /27/. So the determination of the z-form of the fragmentation functions $D_q^h(z, s \simeq M_Z^2)$ for different identified hadrons $h = \pi, K, p\ldots$ would be quite useful in the phenomenology.

2. Among these possibilities there should be considered the possibility of using the well-known procedure of the analytical continuation of the structure function from the scattering to annihilation channel /4,28/ (the Gribov - Lipatov relation and its

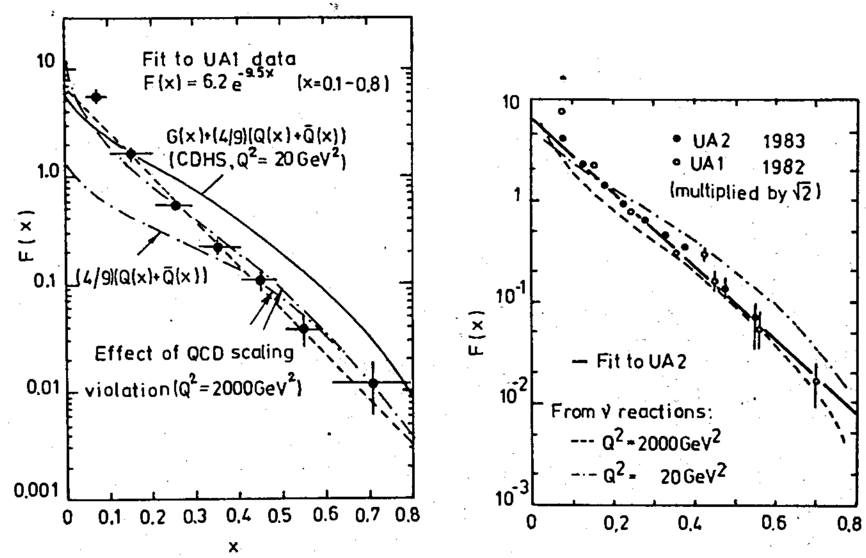

Fig.7. a) The UA1 data on the effective nucleon structure function $F(x)$ at $Q^2 = \langle -t \rangle \simeq 2000\ GeV^2$ /26/. The broken line represents the parametrization $F(x) = 6.2\exp(-9.5x)$. The solid curve represents a QCD parametrization of CDHS data at $Q^2 = 20\ GeV^2$, and the broken curves show its evolution up to $Q^2 = 2000\ GeV^2$. b) The UA2 data /26/ on the same $F(x)$ at $Q^2 = 2000\ GeV^2$. The full line represents the exponential fit $F(x) = A\exp(-\alpha \cdot x)$, $A = 6.2 \pm 0.1$, $\alpha = 8.3 \pm 0.1$, while the dashed lines are computed as the QCD evolution of the CDHS neutrino data.

modifications). This relation between the channels could be applied for instance to obtain from the knowledge of $D_q^p(z,s)$ the predictions for the behaviour of the proton structure functions in the region of $q^2 = Q^2 \approx 10^4\ GeV^2$.

3. The knowledge of $D_q^h(z, s \simeq M_Z^2)$ as a function of the z-variable even at one s-point would also allow us to check the QCD-prediction on the multigluon emission process /29-31/. QCD (and the natural assumption that the z-distribution of the final hadrons is defined mainly by the gluon distribution) lead to the following formula[x])

x) Formula (20) can be modified to take into account the contribution of the decay processes to the formation of light particles from heavier ones. The corrections to (20) as well as to the width and higher moments can be found in /32,33/.

$$z\frac{d\sigma}{dz} \sim \exp\left[-\left\{\frac{c\left[\ln(1/z)-\frac{1}{4}\ln(s/\mu^2)\right]^2}{\ln^{3/2}(s/\Lambda^2)-\ln^{3/2}(\mu^2/\Lambda^2)}\right\}\right], \quad (20)$$

where μ is some reference point, c is a constant and Λ is the QCD-scale parameter. The center of the distribution (20) in terms of the $\ln 1/z$-variable is at the point

$$\left(\ln 1/z\right)_{max} = \frac{1}{4}\ln\left(s/\mu^2\right). \quad (21)$$

The TASSO data /11/ testify to this dependence (see fig.8, where $W=\sqrt{s}=2E_\ell$).

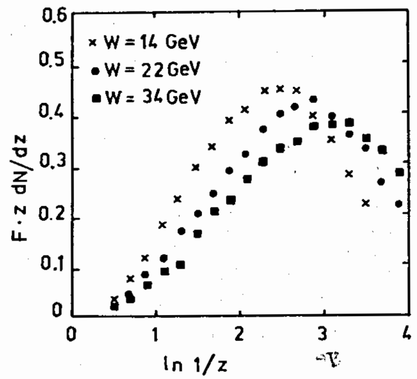

Fig.8. The TASSO data /11/ on the normalized quantity $z\cdot\sigma_{tot}^{-1}\cdot d\sigma/dz$ as a function of $\ln(1/z)$ for W = 14, 22 and 34 GeV, F is the normalization factor.

The addition of the curve corresponding to $W=\sqrt{s}=M_Z$ to that shown in fig.8 would allow us to check this interesting prediction of QCD (see also the discussion in /34/).

4. Up to now the problem of checking the QCD prediction was mainly discussed. For this reason we have not discussed the problem of the $\gamma-Z^o$ interference. The inclusion of electroweak interaction would result in appearance of the additional terms in the lepton (2) and hadron (4) tensors

$$\bar{L}_{\mu\nu}^{EW} = \frac{g^2}{4\pi}\cdot i\,\varepsilon_{\mu\nu\alpha\beta}\cdot k_1^\alpha k_2^\beta \quad (22)$$

$$\bar{W}_{\mu\nu}^{EW} = i\varepsilon_{\mu\nu\alpha\beta}\cdot\frac{p^\alpha q^\beta}{2m^2}\cdot\bar{W}_3(z,q^2). \quad (23)$$

The term $\bar{W}_3(z,q^2)$ that contains the contribution of parity-violating weak currents ($\nu = pq$)

$$\frac{z}{2m^2}\nu\bar{W}_3(z,q^2) = i\varepsilon_{\mu\nu\alpha\beta}\cdot\frac{p^\alpha q^\beta}{q^2}\cdot\bar{W}^{\mu\nu}(z,q^2) \quad (24)$$

can be separated experimentally by measuring the forward-backward asymmetry in the cross-sections of hadron production /25/

$$D(\theta) = p_0\frac{d\sigma}{d^3p}\Big|_\theta - p_0\frac{d\sigma}{d^3p}\Big|_{\pi-\theta} = \quad (25)$$

$$= \frac{\alpha q^2}{4\pi}\cdot\frac{\cos\theta}{q^2(M_Z^2-q^2)}\cdot\frac{2a\nu}{m^2}\cdot\bar{W}_3(z,q^2),$$

where $g^2 = 1-4\sin^2\theta_W$ (θ_W is the Weinberg angle) and $ga=-\frac{1}{2}$.

5. Summary

So the selection and the analysis of the $e^+e^-\to h+X$ events with different identified hadrons $h=\pi, K, p,\ldots$ would allow one:

1. To check the QCD predictions for the size of the scaling violation effects in the fragmentation functions $D_q^h(z,s)$ that:

a) are expected to be much more stronger than in deep-inelastic processes like $e^-p\to e^-+X$,

b) take place at LEP-1 energies in the region of $\approx 10^4$ GeV^2 values of the squared momentum transfer $q^2=s=4E_\ell^2$, i.e. 100 GeV$^2 \le q_z^2 \le$ 10 000 GeV^2, that lies much higher than the region of q^2 attainable up to now in the channel of deep-inelastic lepton-hadron scattering;

2. To make by the analytical continuation of $\bar{D}_q^p(z,s)$ from the annihilation to scattering channels the predictions for the

behaviour of the proton structure function $F^p(x, q^2)$ at SSC energies;

3. To check the picture of multigluon emission of the high-energy hadron production;

4. To measure and study the parity violating structure function $W_3^h(x,s)$ that contains the information about the neutral quark currents.

Subsequent publications will be devoted to the detailed theoretical consideration of the questions quoted in this summary and the predictions for the experiment.

References

1. Physics at LEP - CERN-86-02, v.1,2, CERN, Geneva, 1986.
   ECFA Workshop on LEP 200-CERN 87-08, v.1,2,
2. Z.Physics at LEP-1 - CERN, 89-08, v.1,2,3, CERN, Geneva, 1989.
3. P.Aarnio et al. DELPHI Collab. - CERN-EP/90-19, CERN, Geneva, 1990.
4. S.D.Drell, D.Levy, T.M.Yan - Phys.Rev. 187 (1969) 2159;
   D1 (1970) 1035, 1616, 2402.
5. A.J.Buras - Rev.Mod.Phys. 52 (1980) 199.
6. E.Reya - Phys.Rep. 69 (1981) 195.
7. G.Altarelli - Phys.Rep. 81 (1982) 1.
8. R.F.Schwitters - Proc. 1975 Intern. Symposium on Lepton and Photon Interactions by High Energies, SLAC, Stanford, Calif., 1975, p.5; Int. Conf. on High Energy Phys. Tbilisi, USSR, 1976, v.2, p.B34.
   R.F.Schwitters et al. - Phys.Rev.Lett. 35 (1975) 1320;
   R.F.Schwitters, K.Strauch - Ann.Rev.Nucl.Sci. 26 (1976) 89.
9. G.Hanson et al. - Phys.Rev.Lett. 35 (1975) 1609; Int.Conf. on High Energy Phys., Tbilisi, USSR, 1976, v.2, p.B1.
10. TASSO Collab., R.Brandelik et al. - Phys.Lett. B114 (1982) 65.
11. TASSO Collab., M.Althoff - Zeit. Phys. C22 (1984) 302.
12. BCDMS Collab., A.C.Benvenuti et al. - Phys.Lett. B223 (1969) 485, 490.
13. EMC Collab., J.J.Aubert et al. - Nucl.Phys. B272 (1986) 158.
14. DASP Collab., R.Brandelik et al. - Nucl.Phys. B148 (1979) 189.
15. JADE Collab., W.Bartel et al. - Zeit.Phys. C20 (1983) 187.
16. A.H.Mueller - Phys.Rev. D18 (1978) 3705.
17. H.Georgi, H.D.Politzer - Nucl.Phys. B136 (1978) 445.
18. J.F.Owens - Phys.Lett. B76 (1978) 85.
19. T.Uematsu - Phys.Lett. B79 (1978) 97.
20. G.Altarelli, R.K.Ellis, G.Martinelli, So-Young Pi - Nucl. Phys. B160 (1979) 301.

21. M.Bacé - Phys.Lett. B78 (1978) 132.
22. G.Curci, W.Furmanski, B.Petronzio - Nucl.Phys. B175 (1980) 27.
23. E.G.Floratos, C.Kounnas, R.Locaze - Nucl.Phys. B192 (1981) 417.
24. T.Munehisa, M.Okada, K.Kudoh, K.Kitani - Prog.Theor.Phys. 67 (1982) 609.
25. W.Furmanski, R.Petronzio - Phys.Lett. B97 (1989) 437.
26. UA1 Collab. G.Arnison et. al. - Phys.Lett. 136B (1984) 294.
    UA-2 Collab. Bagnaia et al. - Phys.Lett. B144 (1984) 283.
27. D.W.Duke, J.F.Owens - Phys.Rev. B30 (1984) 49.
28. V.N.Gribov, L.N.Lipatov - Sov.J.Nucl.Phys. 15 (1972) 436,675.
    N.Christ, B.Nasslacher, A.N.Mueller - Phys.Rev. D6 (1978) 3543.
    P.M.Fishbane, J.D.Sullivan - Phys.Rev. D6 (1972) 3568.
29. A.N.Mueller - Phys.Lett. 104B (1981) 161; Nucl.Phys. B 213 (1983) 85.
30. A.Bassetto, M.Ciafaloni, G.Marchesini, A.H.Mueller - Nucl. Phys. B207 (1982) 187.
31. Y.L.Dokhishitser, V.S.Fadin, V.A.Khoze - Phys.Lett. 115B (1982)
32. A.N.Mueller- Nucl.Phys. B213 (1983) 85; ibid. B241 (1984) 141.
33. C.P.Fong, B.R.Weber - Phys.Lett. B 229 (1989) 209.
34. Z.Kunst, P.Nason - Ref.3, vol.1, p.438-442.
35. N.Okada - Progr.Theor.Phys. 67 (1982) 894.

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Чем интересно изучение функций фрагментации $\bar{D}_q^h(z,s)$ кварков в адроны в процессе $e^+e^- \to h + X$ при энергиях ЛЭП?

В настоящей работе приведены физические аргументы в пользу проведения измерений функций фрагментации в процессах $e^+e^- \to h + X$ (где $h = \pi, K, p$ — идентифицированные адроны, а X — все остальные) при энергиях ЛЭП. Показано, что в силу существования предсказанного КХД эффекта сильного нарушения скейлинга в области времениподобных передач импульсов $q(q^2 > 0$, канал лептон-антилептонной аннигиляции в адроны, $q^2 = s)$, который существенно превосходит аналогичный эффект в пространственноподобной области ($q^2 < 0$, канал глубоконеупругого лептон-адронного рассеяния, $-q^2 = Q^2 > 0$), изучение этих функций фрагментации представляет большой интерес. Первая фаза экспериментов на ЛЭП-1 позволит определить вид $\bar{D}_{q_i}^h(z,s)$ $(h = \pi, K, p)$ как функции z при $s \simeq M_z^2$. Использование этих данных (также как и данных, полученных во второй фазе этих экспериментов при $s > M_z^2$) совместно с данными, полученными при энергиях на PETRA и PEP ($s \ll M_z^2$), позволит осуществить критическую проверку предсказаний КХД в области времениподобных передач импульса. Измерение асимметрии вперед-назад для адронов, рожденных в реакции $e^+e^- \to h + X$, позволит определить структурную функцию $\bar{W}_3(z,s)$, которая содержит вклад нейтральных кварковых токов, приводящих к эффектам нарушения четности.

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What is the Interest in Studying the Fragmentation Functions $\bar{D}_q^h(z,s)$ of Quarks into Hadrons in the Processes $e^+e^- \to h + X$ at LEP Energies?

In the present paper, physical arguments are given in favour of measuring the fragmentation functions $\bar{D}_q^h(z,s)$ in the process $e^+e^- \to h + X$ ($h = \pi$, K, p... is an identified hadron, X stands for all others) at LEP energies. It is shown that due to the QCD prediction of strong scaling violation in the region of time-like momentum tranfers q ($q^2 > 0$, the channel of the lepton-antilepton annihilation into the hadrons, $q^2 = S$), that is essentially more strong than the analogous effect in the space-like region ($q^2 < 0$, the deep-inelastic lepton-hadron scattering channel, $-q^2 = Q^2 > 0$), the study of these fragmentation functions is of great interest. The first stage of experiments at LEP will allow one to determine $\bar{D}_{q_i}^h(z,s)$ $(h = \pi, K, p...)$ as a function of z at $s \simeq M_z^2$. The use of these data (as well as the data of the second stage of the experiments with $s > M_z^2$) together with those obtained at PETRA and PEP energies ($s \ll M_z^2$) will allow a crucial check of QCD predictions in the region of time-like momentum transfers. The measurement of the forward-backward asymmetry for hadrons produced in the reaction $e^+e^- \to h + X$ will make it possible to determine the $\bar{W}_3(z,s)$ structure function that contains the contribution of the neutral quark currents leading to the parity-violation effects.

The investigation has been performed at the Laboratory of Theoretical Physics, JINR.

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