объединенный
институт
ядерных
исследований
дубна

E2-83-367

A.V.Efremov, S.V.Ivanov*

PHOTOPRODUCTION OF HIGH P_T PHOTONS AS A TEST OF COLOR SYMMETRY

Submitted to "Ядерная физика"

* The Rostov State University, USSR.

1983

The preliminary data on the process $\gamma N \to \gamma X$ reported by the NA-14 collaboration /1/ at CERN and analysis of the gathered statistics make us closer to the answer: does either the colour symmetry is exact or it is broken by electromagnetic interaction: which are the true charges of quarks, fractional or integer /2/? In this connection we would like to reexamine the results of ref. /2/ where this process has been proposed as a test for the model of electrostrong interactions (ES) with integer charged quarks and gluons (and also the calculations of /3/ for NA-14 experiment) and rewrite its cross section in a form suitable for interpreting the NA-14 experiment.

The region of applicability of the hard parton scattering picture in terms of the variables $x \approx \frac{t}{s-u}$ and $y \approx u/s$ is given by

$$\begin{aligned} &(1-y)\,(1-x) \gg m^2_{agp}/s \quad (M_x^2 \gg m^2_{agp}), \\ &xy\,(1-y) \gg m^2_{agp}/s \qquad (P_T^2 \gg m^2_{agp}). \end{aligned} \tag{1}$$

The dimensionless variables x and y are connected with P_T as

$$P_T^2 \simeq \frac{ut}{s} = sxy\,(1-y). \tag{2}$$

The interval in which the parton distribution functions are best known is $x = 0.2\text{-}0.8$. According to (2) this corresponds to the region of P_T from 2.5 GeV/c ($y = 0.2$) to 6.32 GeV/c ($y = 0.5$).

The most serious correction which has to be introduced in the work /2/ is to take into account the fact that the system X is formed by color singlet hadrons (up to a small, of order $\alpha = 1/137$, admixture of the color octet part in the wave function of each hadron). Due to this the projection onto the singlet of the product of two quark and gluon currents in the subprocesses $\gamma_q \to \gamma_q$ and $\gamma_g \to \gamma_g$ is necessary /4/. This reduces the distinction between QCD and ES-theory.

In the Born approximation of quark diagrams the projection into the color singlet gives in the cross section the factor $\frac{1}{9}(\Sigma Q_{cf}^2)^2$ for each flavour f instead of Q_f^4 in QCD, where Q_{cf} is the charge of a quark of the color c and the flavour f. For

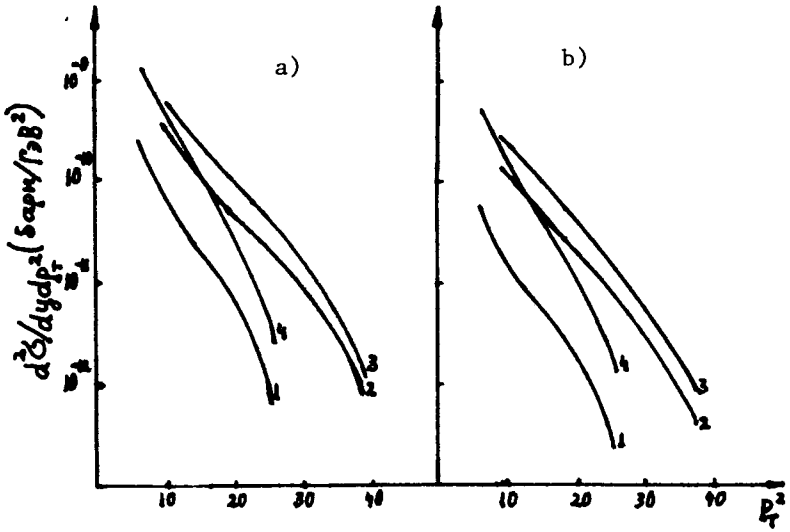

Fig.1. a) The predictions of the ES-model for the different values of $y=\epsilon_2/\epsilon_1$ parameters (ratio of energies of the initial and final photons in the laboratory f.r.); y = 0.2 (curve 1), y = 0.4 (curve 2), y = 0.6 (curve 3), y = 0.8 (curve 4). b) The same for QCD.

the gluon diagram the charge factor will be $\frac{1}{8}\left(\sum_{c>c'}(Q_c-Q_{c'}^2)^2\right)$.

So, the differential cross section of $\gamma N\to\gamma X$ has the form

$$\frac{d^2\sigma}{dx\,dy} = \frac{2\pi m_N^2\alpha^2\sum_f\left(\sum_c Q_{cf}^2\right)^2\left[q_f(x)+\bar{q}_f(x)\right]}{s^3y^2\sqrt{1-\left(\frac{2m_NP_T}{ys}\right)^2}\left(1-\sqrt{1-\left(\frac{2m_NP_T}{ys}\right)^2}\right)} \times$$

$$\left\{1+\frac{1}{3}R_N(x)\left[10\left(y+\frac{1}{y}\right)^{-1}+4\left(y+\frac{1}{y}\right)-8\right]\right\},$$

where $R(x)=\frac{\sigma_L}{\sigma_T}$ is determined from the deep inelastic ep-scattering and experimentally is of an order of 0.1 for the region of not too small values of x. In the ES-theory it is connected with the gluon distribution function

$$R_N(x) = \frac{1}{8}\left(\sum_{c>c'}(Q_c-Q_{c'})^2\right)^2\frac{G(x)}{\frac{1}{9}\sum_f\left(\sum_c Q_{cf}^2\right)^2\left[q_f(x)+\bar{q}_f(x)\right]}.$$

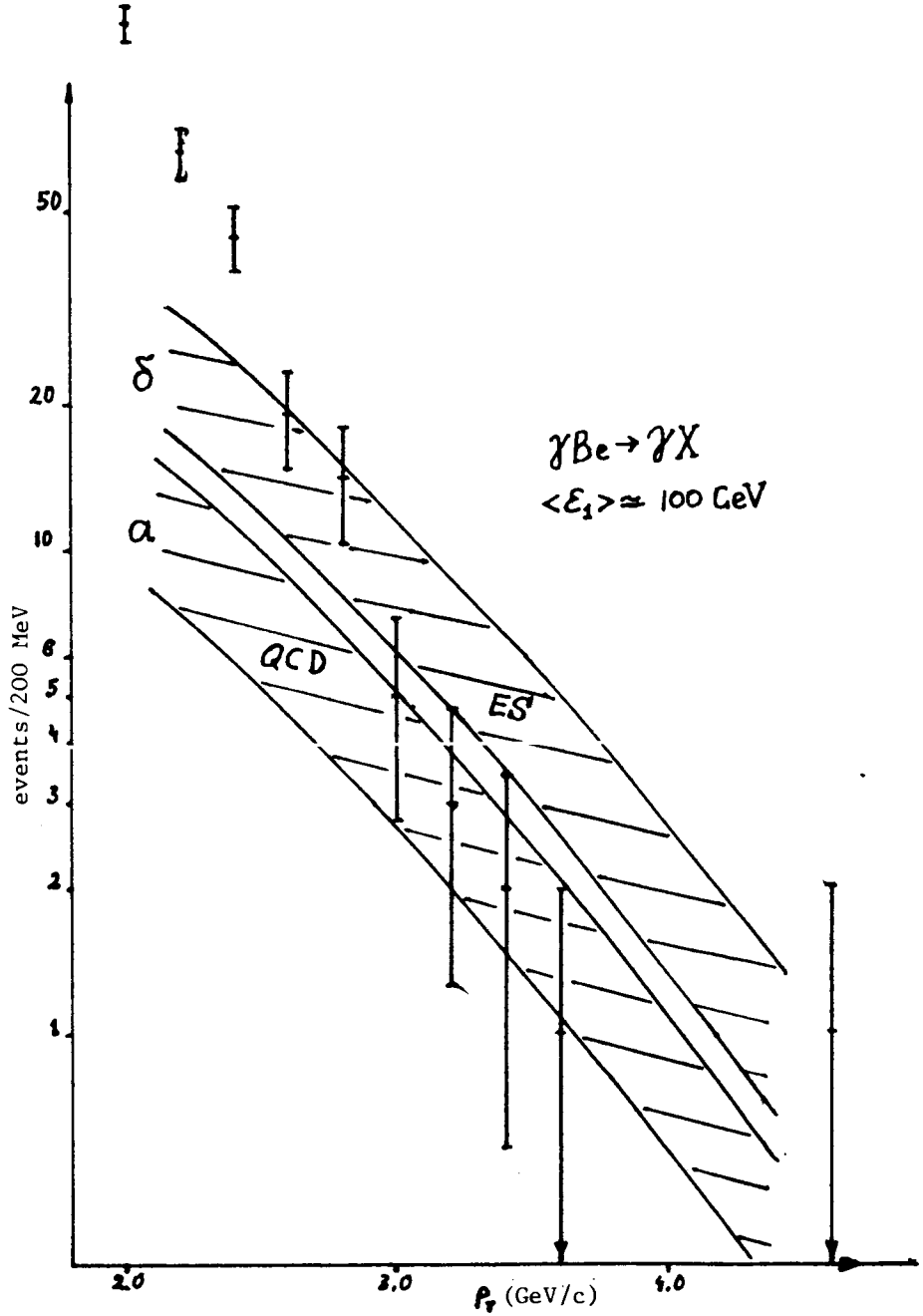

Fig.2. The comparison of the QCD and ES-theory with the preliminary result of NA-14 experiment[1].

As it was noticed in work[2], the γ-photoproduction on an isoscalar target M_{is} normalized to the deep inelastic eM cross section is independent of x in both the QCD and ES-theory in the region of $x \approx 0.4 \div 0.8$, where $R \simeq const$. This would allow us to avoid the uncertainty due to the error in determining the distribution functions. The projection into the color singlet channel preserves the same result for the proton target also in the ES-theory but not in QCD, where a weak dependence on x of the ratio $r(x) = d\sigma^{\gamma p}_{QCD} / d\sigma^{ep}$ has to be seen. This fact could serve as an additional test of color symmetry breaking.

With the distribution functions proposed in ref.[5], the curves for the cross section of $\gamma P \to \gamma X$ reaction for different values of $y = \epsilon_2/\epsilon_1$ (the ratio of energies of the outgoing to incident photons) are presented in Fig.1. The radiation corrections are expected to be of order 20-25%. One can see that the curves for the ES-theory are 2.5-5 times higher than those of QCD. Figure 2 shows the comparison of the preliminary data of the NA-14 group with the ES-theory prediction and QCD. As is seen, the accuracy of the data is not enough for a certain distinction between the theories. To obtain a definite conclusion, it is necessary to increase statistics by an order of magnitude in the region of $P_T \approx 2.5 \div 5$ GeV/c and also to calculate radiation corrections.

REFERENCES

1. Petroff P. (NA-14 Collaboration). Talk at XVIIth Rencontrede Morions, 1982, Prepr. LAL 82/14, 1982.
2. Efremov A.V., Ivanov S.V., Mikhailov S.V. JETP Lett., 1980, 32, p.669-673; JINR, E2-81-86, Dubna, 1981.
3. Gorski M. et al. Acta Phys.Polon., 1982, B13, p.511.
4. Efremov A.V., Ivanov S.V., Nesterenko V.A. JINR, E2-82-433, Dubna, 1982.
5. Fox G. Nucl.Phys., 1977, B131, p.107.

Received by Publishing Department
on June 6,1983.

Ефремов А.В., Иванов С.В.

E2-83-367

Фоторождения γ-квантов с большими P_T
как проверка цветовой симметрии

В калибровочной теории с нарушенной цветовой симметрией и целыми зарядами кварков вычислено сечение фоторождения γ-квантов с большими P_T в процессе $\gamma N \to \gamma X$ при условии, что система X является цветовым синглетом. Полученные сечения в 2,5-3 раза отличаются от предсказаний КХД.

Работа выполнена в Лаборатории теоретической физики ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1983

Efremov A.V., Ivanov S.V.

E2-83-367

Photoproduction of High P_T Photons
as a Test of Color Symmetry

In the gauge theory with broken color symmetry and integer charged quarks the high P_T photoproduction cross section $\gamma N \to \gamma X$ is calculated under the condition for the system X to be a color singlet. The distinction with QCD is of factor 2.5-3.

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

Preprint of the Joint Institute for Nuclear Research. Dubna 1983