Summary

Measurements of eD scattering at large values of q^2 as presented and discussed here, should enrich both nuclear and particle physics. In particular, the data[1,4,12] should provide important guidance for connecting the two fields of physics at the microscopic level. The constraints of quark-fermion currents and normal hadronic states must be simultaneously imposed and consistently satisfied. Measurement of elastic electromagnetic form factors to even larger q^2 will continue to play a unique role in physics.

References

1. R.Arnold, B.Chertok, E.Dally, A.Grigorian, C.Jordan, W.Schütz, R.Zdarko, F.Martin, B.Mecking. Phys.Rev.Lett., 35, 776 (1975); SLAC-PUB, 1596.
2. S.Brodsky. In "Proc. Int. Conf. on Few Body Problems in Nuclear and Particle Physics", edited by R.Slobodrian, B.Cujec, R.Ramavataram, p. 676, Les Presse de l'Univ. Laval, Quebec (1975), SLAC-PUB, 1497.
3. S.Brodsky, B.Chertok. SLAC-PUB. 1757 and 1759, submitted for publication.
4. W.Schütz and Collaboration of ref.1, submitted for publication.
5. J.S.Poucher et al. Phys.Rev.Lett., 32, 118 (1974).
6. For comparison with refs. 5 and 7, we calculated W^2 with $M_N = .938$ GeV. Our data are then in the range $-2.12 \le W^2 \le 0.76$ GeV^2. For comparison of νW_2 with F_d we defined W^2 with M_d = = 1.876 GeV ($3.52 \le W^2 \le 5.02$ GeV^2).
7. E.M.Riordan. Thesis, MIT Report No. COO-3069-176.
8. L.Frankfurt, M.Strikman. This Conference, 265/B2
9. S.D.Drell, T.M.Yan. Phys.Rev.Lett., 24, 181 (1970).
10. G.B.West. Phys.Rev.Letters 24, 1206 (1970).
11. E.D.Bloom and F.J.Gilman. Phys.Rev.Letters 25, 1140 (1970).
12. F.Martin and collaboration of ref. 1, submitted for publication.
13. R.Rand et al., Phys.Rev., D8, 3229 (1973).
14. F.Iachello, A.Jackson and A.Lande. Phys.Lett., 43B, 191 (1973).

THE MEASUREMENT OF THE NUCLEON AND PION FORM FACTORS IN THE REGION OF TIME-LIKE 4-MOMENTUM TRANSFERS FROM 1.5 F^{-2} TO 3.0 F^{-2}

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The experimental investigations[1-3] of the reaction of inverse electroproduction of pions (IEP)

$$\pi^- + p \to e^+ + e^- + n \qquad (1)$$

have been made at the pion energy of 275 MeV. The study [4] of reaction (1) was continued by means of a new experimental device, that permitted to detect 1043±46 events. The cross section of that part of the reaction which is determined by the geometry of the experimental device with the additional restriction $E_1, E_2 > 50$ MeV ($E_{1,2}$ is electron energy) is

$$\Delta\sigma = (4.80 \pm 0.43)\cdot 10^{-33}\ \mathrm{cm}^2.$$

All events were separated into 5 groups according to the kinematic variable K^2, the average values of K^2 in each interval is 0.058, 0.0.73, 0.088, 0.103 and 0.119 (GeV/c)^2. The distributions of events as the function of $\cos\theta^\gamma$ between the pion and photon momenta (c.m.s) πN were plotted for each group.

To analyse the experimental data the dispersion[6] model **has** been used. The formfactors $F_1^V(K^2)$ and $F_\pi(K^2)$ were taken as varying parameters upon which the differential cross sections are greatly dependent. The remaining form factors F_1^S, F_2^S, F_2^V and G_M^* affecting weakly the differential cross sections were calculated by means of the dipole formula. All the parameters were considered real. When determining the formfactors $F_1^V(K^2)$ and $F_\pi(K^2)$ the experimental cross sections $d\sigma/d\cos\theta^\gamma$ were fitted by theoretical ones calculated under the assumption that the formfactors should be equal.

Calculations performed by using the dispersion model describe very well all the experimental data. The results of determining the form factor $F_1^V(K^2)$ and $F_\pi(K^2)$ under the condition of their equality are presented in Table 1.

Table 1

$K^2\left(\frac{GeV}{c}\right)^2$	0.058	0.073	0.088	0.103	0.119
Dispersion Model	0.90± ±0.07	1.00 ± ± 0.05	1.06± ± 0.05	1.12±0.05	1.26 ± ±0.04

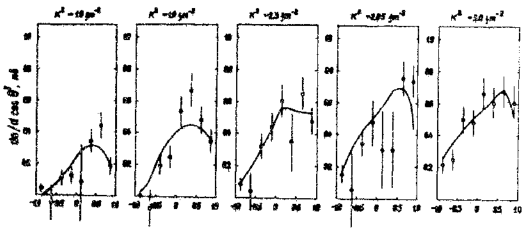

Fig.1 shows the distribution of experimental events as the functions of the $\cos\theta^\gamma$ variable. Theoretical curves have been obtained when determining the form factors $F_1^V(K^2)$ and $F_\pi(K^2)$ (see Table 1) by using the dispersion model.

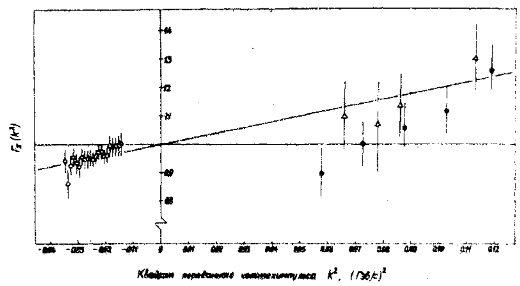

Fig.2. Results of pion formfactor measurements in experiments on pion scattering on electrons /8/ ($K^2<0$) and in the experimental studies of the $\pi^-p\to e^+e^-n$ process ($K^2>0$): ▲ -/2/, Δ -/3/, ● - the présent investigation. Solid curve is the result of calculations in the superpropagator model /9/.

The data were (χ^2=13.7 with $\overline{\chi^2}$=4) approximated by the function $F_1^V(K^2)$=1+1/6 $\tau_1^2 K^2$ with $\tau_1 = \tau_\pi =$ 0.75 ± 0.09 f.

For the part of statistics the phenomenological analysis of data on reaction (1) is presented. It allowed to determine the contributions of states with various photon polarizations to the IEP differential cross section. In one-photon approximation the IEP cross section is written as /5/

$$\frac{d\sigma}{d\Omega_\gamma\, d\Omega_e\, dK^2}=\sum_{i=1}^{4} R_i T_i=\sum_i \sigma_i , \qquad (2)$$

where K^2 is the square of the 4-momentum transferred, Ω_e, Ω_γ are solid angles of gamma-quantum and electron scattering, i is the index determining photon polarization, T_1 describes the process

$$\pi^-p\to\gamma^*+n \qquad (3)$$

with transverse nonpolarized virtual gamma-quanta, T_2 corresponds to processes with transversely polarized photons, T_4 corresponds to processes with longitudinally polarized photons, T_3 describes interference longitudinally and transversely polarized photons, σ_i corresponding differential cross section, the coefficient R_i is the known functions of variables K^2, $\cos\varphi$, and $\cos\theta_e$.

The particular form of the parameter T_{1-4} depends upon the applied theoretical model. In the phenomenological analysis the two-dimensional distribution of IEP events of the variables $\cos\varphi$ and $\cos\theta_e$ was approximated by function (2) with varied parameters T; the coefficients R_i as functions of variable $\cos\varphi$ and $\cos\theta_e$ were calculated by the Monte-Carlo method with the account of real experimental conditions. All the experimental statistics was distributed into five groups on K^2 with average values of equal to 1.48 f^{-2}, 1.88 f^{-2}, 2.26 f^{-2}, 2.65 f^{-2}, 3.05 f^{-2}. For each group the phenomenological analysis was performed. The obtained evaluations are shown in Fig.3 (a,b,c). The same Figs. show the results of theoretical calculations (solid curve). It is seen that the model /6/ well describes the **behaviour** of cross sections corresponding to the radiation of the **transverse** nonpolarized and longitudinal photons.

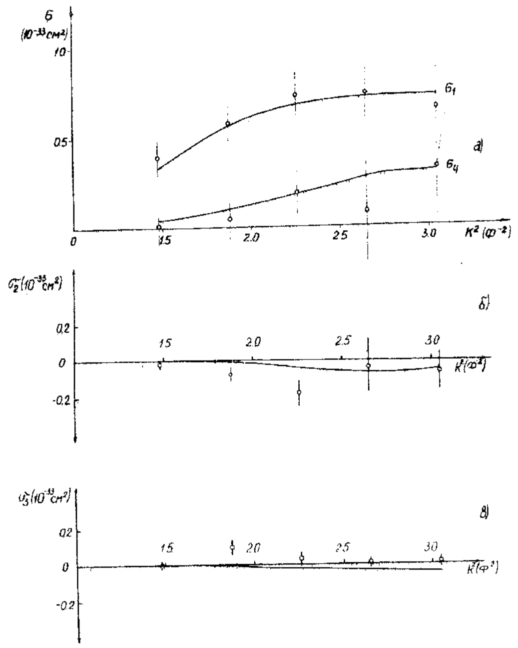

Fig.3

As has been shown by calculations, the σ_1 cross section depends equally on the Dirac isovector formfactor F_1^V of the nucleon and the pion formfactor F_π. The value of σ_4 depends, mainly, upon F_1^V : the variation of F_1^V within 10% changes σ_4 by 14%,2%, while a 10% change of F_π changes σ_4 only by 3.8%. Thus if the value of σ_4 is known with a small error, F_1^V can be determined with a good accuracy even when a rough estimation of the formfactor F_π is used. Since σ_4 is determined only by Born terms/6/, the obtained value is not dependent upon model uncertainties.

References

1. Yu.K.Akimov, L.S.Vertogradov, A.V.Demyanov et al. Yad.Phys., 13, 748 (1971).
2. S.F.Berezhnev, L.S.Vertogradov, A.V.Demyanov et al. Yad.Phys., 16, 185 (1972).
3. S.F.Berezhnev, A.V.Demyanov, A.V.Kulikov et al. Yad.Phys., 18, 102 (1973).
4. S.F.Berezhnev, T.D.Blokhintseva, A.V.Demyanov et al. JINR, P1-9575, Dubna, 1976.
5. Yu.S.Surovtsev, F.G.Tkebuchava. JINR,P2-4524, Dubna, 1969.
6. T.D.Blokhintseva, Yu.S.Surovtsev, F.G.Tkebuchava. Yad.Phys., 21, 850 (1975).
7. G.Adylov, F.Aliev, D.Bardin et al. Phys.Lett., 51B, 402 (1974).
8. M.K.Volkov, V.N.Pervushin. Nuovo Cim., 27A, 277 (1975).