DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY

DESY 74/48
October 1974

The Components of νW_2 and $SU(6)_W$ Breaking in Deep Inelastic Scattering

by

B. Flume-Gorczyca and S. Kitakado
Deutsches Elektronen-Synchrotron DESY, Hamburg

2 HAMBURG 52 · NOTKESTIEG 1

To be sure that your preprints are promptly included in the
HIGH ENERGY PHYSICS INDEX ,
send them to the following address (if possible by air mail) :

DESY
Bibliothek
2 Hamburg 52
Notkestieg 1
Germany

The components of νW_2 and $SU(6)_W$ breaking in deep inelastic scattering

B. Flume-Gorczyca and S. Kitakado[+]

Deutsches Elektronen-Synchrotron DESY, Hamburg

Abstract: Two independent components of the non-diffractive part of the structure functions are isolated, using the data from deep inelastic eN scattering and some preliminary results from neutrino experiments.
This enables us

(i) to resolve the problem of the apparent non-scaling of the Δ-resonance in the Bloom-Gilman sense and

(ii) to estimate D/F for the Reggeon coupling to baryons in hadronic reactions.

+ On leave of absence from the Institute of Physics, University of Tokyo, Komaba, Tokyo

1. Introduction

Recent experiments[1] on neutrino (antineutrino) - hadron scattering have revealed the surprising fact that the diffractive contribution (anti-quark contribution in the quark proton terminology) to the structure function is very small compared to the non-diffractive one in the region of $0.2 \leq x \leq 1$, where the former can practically be neglected. This enables us to isolate the two independent components of the non-diffractive part of the structure functions using the data for $F_2^{ep}(x)$ and $F_2^{en}(x)$, which has to be corrected only in the region of $0 \leq x \leq 0.2$, taking into account the contribution from the diffractive part.

There are several ways of expressing the two independent components of the non-diffractive part of the structure functions. The simplest one is probably to use the quark parton picture[2] and express them in terms of the distribution functions for the valence u- and d-quarks[3]. In the light cone approach[4] they can be expressed as the Fourier transforms of F- and D-coupled matrix elements of bilocals[5]. These functions (F(x) and D(x)) can in turn be related[6], by using some arguments of duality, to the contributions from the s-channel resonances belonging to the normal parity trajectory (N(x)) and those belonging to the abnormal parity one (A(x)). We shall use the last separation of the two independent components of the non-diffractive part of the structure functions in resolving the problem of the apparent non-scaling of the Δ-resonance in the Bloom-Gilman[7] sense. Namely we find that N(x) and A(x) behave differently as a function of x (or x')* and if we compare the contribution from the Δ-resonance with the abnormal parity component** A(x) of the scaling function (instead of the whole νW_2 as is done in Refs. 7 and 8) we find that the Δ-resonance scales as do the other two prominent resonances (D_{13} and F_{15}).

$SU(6)_w$-symmetry, which allows only for F-type coupling of the vector

---

* We use the scaling variables $x = -q^2/2pq$ and $x' = (1 - \frac{s}{q^2})^{-1}$.

** The Δ-resonance belongs to the abnormal parity trajectory.

bilocals to the nucleons requires $N(x) = A(x)$ for all x, which gives the famous $SU(6)_W$ result[2] of $F^{en}(x)/F^{ep}(x) = \frac{2}{3}$. Plotting $N(x)$ and $A(x)$ as a function of x, one explicitly sees how the $SU(6)_W$-prediction is violated for each values of x. For example, near $x = 1$ we find different threshold behaviours for $N(x)$ and $A(x)$, which implies through the Drell-Yan-West[9] relation different behaviour of the transition form factors of resonances belonging to different trajectories. On the assumption that this different x-dependence of the two components is the only effect of the $SU(6)_W$-symmetry breaking in deep inelastic scattering, we are able to predict the behaviour of the polarization assymmetry on nucleons as a function of x.

As is well known, $SU(6)_W$ is broken also in purely hadronic reactions and it is interesting to see whether this can be explained in our picture of $SU(6)_W$-violation in the deep inelastic region. The parton picture[10] enables us to estimate the D/F for the Reggeon coupling to baryons in purely hadronic reactions, using the empirical x-dependence of the two components which explicitly violate $SU(6)_W$. Thus we have a consistent picture of $SU(6)_W$-breaking[+].

In sect. 2, after briefly describing the notation for the structure functions, we separate out the two components of the non-diffractive part of the latter using the data for the proton and the neutron structure functions. In sect. 3 we examine various consequences of the empirical x-dependence of the two components, which violate $SU(6)_W$-symmetry. In sect. 4 we apply this information to estime the D/F ratio for the Reggeon coupling to baryons in purely hadronic reactions.

Finally, in sect. 5, we try to understand the origin of the different x-dependence of the two components in the quark parton model. We end this final section with a few remarks.

\+ $SU(6)_W$ predicts $(D/F)_{Reggeon} = 0$.

2. The components of $\nu W_2(x)$

We start this section by fixing our notation[5]. The scaling structure functions which are measured in deep inelastic lepton-hadron scattering are determined by the absorptive part of the current-hadron forward scattering amplitude

$$b + \beta \to a + \alpha \,, \tag{1}$$

where a and b (α and β) are the SU(3) quantum numbers of the current (the baryon target).

The parton model or the light cone approach suggests the absence of exotic exchanges in the t-channel ($a\bar{b}$-channel), which we assume. Hadronic duality on the other hand would lead us to expect two components in the amplitude of (1) :

a) non-exotic s-channel contributions generated by non-exotic t-channel exchanges,

b) diffractive contributions associated with Pomeron exchange.

This allows us to express the structure functions in terms of three independent functions[5]:

$$\begin{aligned} F^{ab}_{i,\alpha\beta}(x) = (if^{abc} + d^{abc}) \Big[& F_i(x)\ i\, f_{\alpha c\beta} + D_i(x)\ d_{\alpha c\beta}\ (1-\delta_{co}) \\ & + (\tfrac{3}{2} F_i(x) - \tfrac{1}{2} D_i(x) + S_i(x))\ d_{\alpha o\beta}\ \delta_{co} \Big] \,, \end{aligned} \tag{2}$$

where i = 1,2 or 3 and the functions F(x) and D(x) describe the component (a) and S(x) describes (b). The normalization is such that the Gottfried sum rules read

$$\int_0^1 F_i(x)\ dx = \frac{1}{2}, \qquad \int_0^1 D_i(x)\ dx = 0 \tag{3}$$

The structure functions of proton and neutron can be expressed as

$$F_i^{ep}(x) = 2F_i(x) - \frac{2}{9} D_i(x) + \frac{8}{9} S_i(x)$$
$$F_i^{en}(x) = \frac{4}{3} F_i(x) - \frac{8}{9} D_i(x) + \frac{8}{9} S_i(x) \qquad (4)$$

$i = 1,2.$

The functions F(x) and D(x), which are independent of each other, correspond for example in the quark parton picture to the distribution functions of the valence u- and d-quarks within the nucleon, while S(x) describes the sea.

Instead of F and D, which are the t-channel quantities, we can also specify the independent contributions in terms of s-channel quantum numbers[6]. In Regge theory the s-channel baryon resonances of meson-baryon scattering are classified into the following two groups:

1) the normal parity resonances with

$J^P = \frac{1}{2}^+, \frac{5}{2}^+, \ldots$ (α-sequence)

$J^P = \frac{3}{2}^-, \frac{7}{2}^-, \ldots$ (γ-sequence)

2) the abnormal parity resonances with

$J^P = \frac{3}{2}^+, \frac{7}{2}^+, \ldots$ (δ-sequence)

$J^P = \frac{1}{2}^-, \frac{5}{2}^-, \ldots$ (β-sequence),

which consist of exchange degenerate trajectories accompanied by series of daughter trajectories. Thus we can use for example the "normality" in specifying the two components, isolating the contributions from the s-channel resonances belonging to normal and abnormal parity trajectories. This is achieved to some extent by using the so-called duality solutions for meson-baryon scattering found some years ago[11]. These are the solutions to the constraints of duality - i.e. non-existence of exotics in two channels which are dual to each other. We consider the two simplest solutions consisting of the following exchange degenerate sequences:

A) $\mathbf{8} - (\mathbf{8}+\mathbf{1})$ and (B) $(\mathbf{10} + \mathbf{8}) - \mathbf{8}$, with definite relations among the couplings of resonances of each sequence to the M-B-system. They satisfy the constraints of duality separately. Surprisingly enough the solutions (A) and (B) were found to reproduce approximately the observed SU(3)-pattern of the sequences belonging to each group (1) and (2) in the following way:

normal parity trajectories	:	$\mathbf{8}_\alpha - (\mathbf{8} + \mathbf{1})_\gamma$
abnormal - " -	:	$(\mathbf{10} + \mathbf{8})_\delta - \mathbf{8}_\beta$

Another important property of these solutions is that the relative amount of contributions from each group is controlled by the D/F ratio of the couplings[12] to baryons of the nonet exchanged in the t-channel. If we denote by N(x) and A(x) the contributions from the whole* normal and abnormal parity trajectories respectively, we can express them in terms of F(x) and D(x) as follows[6,12]:

$$\begin{aligned} N(x) &= 3F(x) + D(x), \\ A(x) &= 3(F(x) - D(x)), \end{aligned} \tag{5}$$

and in terms of these the structure functions of the nucleons are expressed as:

$$\begin{aligned} F^{ep}(x) &= \frac{4}{9}\,N(x) + \frac{2}{9}\,A(x) + \frac{8}{9}\,S(x), \\ F^{en}(x) &= \frac{1}{9}\,N(x) + \frac{1}{3}\,A(x) + \frac{8}{9}\,S(x). \end{aligned} \tag{6}$$

Although the identification of the two solutions (A) and (B) with (1) and (2) is approximate, the decomposition of the non-diffractive part of the structure functions into N(x) and A(x) is well defined and has no ambiguity and we shall use this decomposition in analysing the data.

---

* By trajectories we mean not only the parents but also all the daughter trajectories belonging to them.

Taking into account that the diffractive part (S(x) in our notation) can be neglected in the region of $0.2 \le x \le 1$ we can make a plot of $N_2(x)$ and $A_2(x)$ using the data[13] for $F_2^{ep}(x)$ and $F_2^{en}(x)$, which we show in Fig. 1. Already here we see a clear difference in x-dependence of the two components N(x) and A(x). In Fig. 2 we show the curves which were corrected in the region $0 \le x \le .2$ taking into account the contribution from the diffractive part taken from preliminary results[1] of neutrino (antineutrino)-proton- scattering. We would like to stress here that although we got important information from the neutrino experiments, the data we used to obtain N(x) and A(x) as functions of x were essentially from deep inelastic eN scattering.

To end this section we would like to emphasize that in building the s-channel picture of deep inelastic scattering we tried to avoid using the classification in terms of SU(6)-representations[14] because, as we saw, the latter scheme is completely broken in deep inelastic region. Instead we have used the classifications in terms of the baryon Regge-trajectories, which unlike the SU(6)-scheme, enables us to develop the arguments in a completely relativistic way. However, one has to be careful in using the idea that the contribution from the resonances belong to a definite trajectory (including daughters), because after all in the scaling region we are dealing with a continuum, which might of course be a superposition of many resonances.

3. $SU(6)_W$ breaking in deep inelastic scattering

a. Bloom-Gilman scaling of Δ-resonance

The interesting idea of scaling s-channel resonances in inelastic electron-nucleon scattering was suggested some time ago by Bloom and Gilman[7]. They observed that the prominent resonance bumps can be averaged by the scaling structure function $\nu W_2(x')$ or in other words contributions from resonances to $\nu W_2(x')$ are a constant fraction of the latter. This can be seen more clearly if we take the ratio of the height of the resonances to the scaling function[7,8], plotted for a given x' as a function of q^2

(see Fig. 3). Although approximate constancy of the ratio is seen for the second (D_{13}) and the third (F_{15}) resonances, the ratio of the first resonance (P_{33}) to the scaling curve falls as $-q^2$ increases, thus showing the non-scaling behaviour of the latter.

We show that this non-scaling of the first resonance (in the Bloom-Gilman sense) is only apparent and we have to take into account the existence of two components in the non-diffractive part of scaling functions which behave differently as a function of x. Namely we have to compare the contribution from the first resonance $\left[P_{33}(1232),\ J^P = \frac{3+}{2}\right]$ with the abnormal parity component $A_2(x')$ of the scaling function, while the contributions from the second $\left[D_{13}(1520),\ J^P = \frac{3-}{2}\right]$ and from the third $\left[F_{15}(1688),\ J^P = \frac{5+}{2}\right]$ resonances must be compared with $N_2(x')$. This is done[15] in Fig. 4. As is seen, scaling of all three resonances is quite satisfactory*. Thus we conclude that all the three prominent resonances do scale in the Bloom-Gilman sense.

b. Transition form factors of resonances belonging to different trajectories

The most direct consequence of the different behaviours of N(x) and A(x) can be seen in the threshold region of large x. Namely we can see in Fig. 1 that as $x \to 1$, A(x) dies out faster compared with N(x) which implies through the eq. (6) a famous behaviour[13] of

$$\frac{F_2^{en}(x)}{F_2^{ep}(x)} \to \frac{1}{4} \qquad \text{as} \quad x \to 1. \tag{7}$$

This can be stated more quantitatively in terms of the transition form factors of resonances belonging to different trajectories[6,16].

Bloom-Gilman duality[7] implies a close connection between the threshold behaviour of the structure function and the behaviour of the transi-

* Points below $Q^2 \lesssim 0.5\ (\text{GeV})^2$ (for Δ-resonance) and $Q^2 \lesssim 0.8\ (\text{GeV})^2$ (for the 2nd and 3rd resonances) should not be taken too seriously because of possible sea corrections, which would slightly raise the points.

tion form factor of resonances in the s-channel. Namely, if we write the threshold behaviour of the structure function as

$$F_2(x') \sim (1-x')^a \tag{8}$$

for $x' \simeq 1$ and the power-behaviour of the transition form factor as

$$G(q^2) \sim (-q^2)^n \tag{9}$$

for large values of $-q^2$, we have the relation

$$a = 2n-1, \tag{10}$$

which was originally found by Drell and Yan[10) and West[9) in composite models.

From the analysis of the previous section we can expect that

$$a_A > a_N, \tag{11}$$

which implies that the resonances belonging to the abnormal parity trajectory die out faster as $-q^2 \to \infty$, compared with those of normal parity. We can estimate the approximate values of a for each trajectories as

$$a_A \simeq 4 \quad \text{and} \quad a_N \simeq 3. \tag{12}$$

This gives the following values for the powers of transition form factors of resonances of each group:

$$n_A \simeq 2.5 \quad \text{and} \quad n_N \simeq 2. \tag{13}$$

The latter is compatible with the dipole behaviour of the nucleon form factor. For the former[+] we have some evidence[8)] that the transition form factor of the Δ-resonance has a bigger power compared with the nucleon form factor and also the transition form factors of the second and the third resonances.

c. Structure functions of polarized nucleons

We saw in the previous section how $SU(6)_w$-symmetry, which requires

$$N(x) = A(x), \tag{14}$$

is violated for all x except $x \simeq \frac{1}{3}$.

On the other hand we know that $SU(6)_w$ gives predictions for the structure functions of polarized targets[2)]. Namely the polarization asymmetry for the nucleons is predicted to be

$$A_p(x) = \frac{5}{9} \quad \text{and} \quad A_n(x) = 0, \tag{15}$$

where A(x) can be expressed as

$$A(x) = \frac{\overline{F}_1(x)}{F_1(x)}, \tag{16}$$

where we define $\overline{F}_1(x)$ by

$$\overline{F}_1(x) = \frac{1}{4\pi M}\left(\nu d(x) + M\nu^2 g(x)\right) \tag{17}$$

in terms of the spin-dependent structure functions of Kuti and Weiskopf[2)]. Similarly to eq. (6) we can express $\overline{F}_1^{ep,en}(x)$ in terms of $\overline{N}_1(x)$ and $\overline{A}_1(x)$

+ Determination of the form factor powers is not unambigous, because it is affected, at present q^2, by the choice of the scaling mass. If we take $\mu^2 \simeq 0.71\ (\mathrm{GeV})^2$ (we parametrise the form factors by $(1-\frac{q^2}{\mu^2})^{-n}$) as for the nucleon and use the fit of R.C.E. Davenish and D.H. Lyth (Phys. Rev. D5 (1972) 47) to determine the power,we get approximately $n_A \simeq 2.2$. If on the other hand $\mu^2 \simeq (1.236)^2$ (scaling form factor idea) then $n_A \simeq 3$ (F. Close). We thank F. Close for an informative correspondence on this point.

also defined as in eq. (5). Thus the asymmetries of nucleons can be expressed as

$$A_p(x) = \frac{2\overline{N}(x) + \overline{A}(x)}{2N(x) + A(x)} \quad \text{and} \quad A_n(x) = \frac{\overline{N}(x) + 3\overline{A}(x)}{N(x) + 3A(x)} . \tag{18}$$

As is seen in Figs. 1 and 2, near* $x \simeq \frac{1}{3}$ we have a point at which the $SU(6)_W$-prediction eq. (14) is satisfied.

Let us assume (1) that the $SU(6)_W$-predictions for asymmetries eq. (15) are also valid at this particular point and (2) that for $\frac{1}{3} \leq x \leq 1$ $\overline{N}(x)$ and $\overline{A}(x)$ follow the same pattern of $SU(6)_W$-breaking. Namely we assume a simple proportionality between $\overline{N}(x)$ and $N(x)$ ($\overline{A}(x)$ and $A(x)$). These are enough to express the asymmetries in terms of $N(x)$ and $A(x)$:

$$A_p(x) = \frac{2N(x) - \frac{1}{3}A(x)}{2N(x) + A(x)} \quad \text{and} \quad A_n = \frac{N(x) - A(x)}{N(x) + 3A(x)} . \tag{19}$$

The first assumption we need in order to fix the absolute values of $\overline{N}(x)$ and $\overline{A}(x)$. The second assumption is not unreasonable because for large x the s-channel picture is reliable and the breaking of $SU(6)_W$ is totally determined by the properties of s-channel resonances belonging to normal and abnormal parity trajectories which determine also $\overline{N}(x)$ and $\overline{A}(x)$.

However, we cannot extend this assumption into the region $0 \leq x \leq \frac{1}{3}$ because of the following two reasons:

1) for small x the t-channel exchange becomes important and the different meson trajectories (f-A_2) and (A_1-D) controlling respectively $F(x)$ and $\overline{F}(x)$, require different x-dependences for these functions. Namely $F_2(x) \sim \sqrt{x}$ and $\overline{F}_2(x) \sim x$ for $x \to 0$;

2) if we extend the second assumption to the whole region of x, we can calculate g_A by using the Bjorken sum rule[17)]

---

* It is quite amusing to note that this point corresponds in the quark parton picture to the situation where each of the three valence quarks carries an equal fraction of the momentum (ignoring the $\overline{q}q$ sea and gluon contributions). Namely all the three quarks are on the same footing at this particular point and this might be the reason why the 56-plet (totally symmetric) assignment of SU(6) is valid here.

$$g_A = 3\int_0^1 (\overline{F}_1^{ep}(x) - \overline{F}_1^{en}(x)\ dx = \int_0^1 (\overline{N}_1(x) - \frac{1}{3}\overline{A}_1(x))\ dx$$

$$= \int_0^1 (N_1(x) + \frac{1}{9} A_1(x))\ dx = \frac{5}{3} \tag{20}$$

which is the well known $SU(6)_w$-result (here we used eq. 3). Thus the contribution to the integral in eq. (20) must be much smaller in the region of $0 \leq x \leq \frac{1}{3}$, where actually the dominant contribution comes from (see Fig. 2).

The predicted asymmetries for proton and neutron are shown in Fig. 5. As $x \to 1$ both asymmetries tend to unity, which is consistent with the predictions made in Ref. 4 and in Ref. 14 based upon the quark parton picture. A similar expression for the polarization asymmetry has been obtained recently by F. Close[18)] using a different broken $SU(6)_w$ scheme. His predictions are, however, suppressed by a factor $\frac{3}{5}\ g_A$ compared with ours.

4. $SU(6)_w$ breaking in hadronic reactions

In this section we would like to discuss the problem of $SU(6)_w$-breaking in hadronic reactions and particularly its consistency with the breaking pattern found in deep inelastic region. The parton picture for high energy hadronic reactions as described by Feynman[10)] enables us to relate the behaviour of N(x) and A(x) for small x to the properties of Reggeon couplings to baryons in hadronic reactions. We assume in this section that the parton distributions appearing in Feynman's description of hadronic reactions are in fact those measured in deep inelastic scattering. This clearly goes beyond the parton model description of deep inelastic scattering itself.

In order to describe hadronic processes we need the functions N(x) and A(x) for small x, where the contribution from the diffractive part is non-negligible. However, it is clearly seen in Figs. 1 and 2 that in this region, unlike the case of large x, A(x) dominates over N(x) and this property leads to a consistent pattern of $SU(6)_w$-breaking in hadronic reactions.

First we note that in the language of the quark-parton model the functions $N_1(x)$ and $A_1(x)$ would correspond to the distribution functions* of a parton in the infinite momentum frame defined as follows[6,15]:

$N_1(x)$: distribution of a valence quark within the nucleon, when the remainder (two spectator quarks with possible gluons and quark-antiquark pairs) is in I=0 state (the antisymmetric state in SU(3)-indices);

$A_1(x)$: the same as above when the remainder is in I=1 state (symmetric state).

This can most easily be seen if we remember that there is no decuplet (singlet) in the s-channel when the spectator diquark system is in an antisymmetric (symmetric) state and that the normal parity series (the abnormal parity series) consists of 8-8-1 (8-10-8) representations.

Let us consider an exclusive scattering of a hadron, say a meson, on the nucleon. In the parton picture[10], the hadronic Regge exchange reaction is considered to occur via the exchange of wee partons, i.e. partons with very small x. Because the small x-behaviour of the parton distribution has to join the wee x-behaviour of $\sim x^{-\alpha}$ (α is the intercept of the Regge trajectory and is approximately equal to ~ 0.5) in a continious fashion, we can get information on the latter from the knowledge of the former**. Namely, if we write

$$\begin{aligned} N_2(x) &\sim nx^{-\alpha+1} \\ A_2(x) &\sim ax^{-\alpha+1} \qquad \text{for } x \to 0 , \end{aligned} \tag{21}$$

the D/F of the Reggeon coupling to baryons can be obtained by

$$\left[\frac{3(F-D)}{3F+D}\right]_{\text{Regge}} = \frac{a}{n} . \tag{22}$$

---

* The normalization is such that $\int N_1(x)dx = \int A_1(x)dx = \frac{3}{2}$. So the total number of valence quarks within the nucleon is 3 (see eq. (3)).

** Note that the parton distribution within the scattered hadron does not affect the D/F ratio.

It is quite difficult to extract from the data the real behaviour of $N_2(x)$ and $A_2(x)$ for small x, because of the non-negligible contribution from the diffractive part. However, we can definitely see in Fig. 1 that

$$a > n \tag{23}$$

which implies the negative D/F for the Reggeon coupling, compatible with experiment.

Although not without ambiguity, we have extracted the diffractive contribution using the neutrino data and subtracted it from $N_2(x)$ and $A_2(x)$ (Fig. 2). Extrapolating the resulting functions using $n\,x^{-\alpha+1}$ and $a\,x^{-\alpha+1}$ respectively,we get

$$\frac{n}{a} \sim 0.65 \tag{24}$$

which gives through the relation (22) the following value* for D/F

$$(D/F)_{Regge} \sim -0.36 \tag{25}$$

which is in reasonable agreement with what is measured in Regge phenomenology[19),]

$$(D/F)_{exp} \sim -0.2 \sim -0.5 \tag{26}$$

Clearly, better neutrino data for small x is necessary to check the conjecture that deep inelastic parton distributions can be used also for certain features of hadronic reactions.

---

* The result strongly depends on how much of the diffraction we have to substract in the region of small x. We used the preliminary neutrino data, which includes big errors. Considering the extreme cases D/F can be constrained at least by the following bounds:

$$-0.6 \leq D/F \leq 0.$$

We can also evaluate D/F using various fits proposed for the structure functions. For example, V. Barger and R.J.N. Philipps (University of Wisconsin, COO-881-390 (1973)) gives D/F≃ - 0.07.R.Mc-Elhaney and S.F. Tuan (Phys. Rev. D8(1973)2267) give D/F ≃ -.24.

5. Discussions and Conclusions

Accepting the empirical behaviour of N(x) and A(x) as functions of x, which violates the prediction of $SU(6)_W$ in a definite fashion, we tried to construct a consistent picture of $SU(6)_W$-breaking in deep inelastic scattering as well as in hadronic reactions. The question then arises whether we can understand the observed behaviour of N(x) and A(x) as a function of x. This we would like to try using the usual three quark pictures for the baryons.

As is clear, it is most convenient for our purposes to consider a nucleon to consist of a quark (which is hit by the virutal photon) and a spectator diquark. By the latter we imply a quasi-bound system of two quarks with specific quantum numbers. Let us now compare the energy of the two diquarks with isospin 1 and 0, other conditions being equal.

We know from our experience with the three quark systems, which are of course the familiar baryons, that the states with symmetric configurations concerning their internal quantum numbers like isospin or SU(3) (and not spin or SU(6)) lie higher+ in energy compared with those having less symmetry so far as the quark contets of the systems are the same (i.e. we have to avoid a complication coming from mass difference due to λ-quarks). Thus we are lead to expect that

$$E_{I=1} > E_{I=0}. \tag{27}$$

Even the existence of the deuteron (I=0) as a bound state and the non existence of a two-nucleon system with I=1 also suggests a similar rule. Eq. (27) provides us with a good reason why the distribution function A(x), where the diquark system is in I=1 state is pushed towards small x compared to the function N(x) as is seen in Figs. 1 and 2.

Let us finally add a speculative remark concerning the problem of possible deviations from scaling. It is natural to expect that the effect of a breakdown of scaling, if any, would be different for the components

+ compare e.g. $\Sigma(\frac{1}{2}^+)$ and $\Lambda(\frac{1}{2}^+)$ or Δ and the nucleon.

N(x) and A(x). The observed rise[20] with q^2 at small x and fall at large x suggest rise for A(x) and fall for N(x) with increasing q^2. Thus it would be interesting to analyse the effect of scaling breakdown separately for each components.

Acknowledgements

We would like to thank T. Walsh for many helpful discussions and remarks and for reading the manuscript. We are grateful to R. Davenish and F. Gutbrod for discussions. It is a pleasure to thank H. Joos, H. Schopper and G. Weber for the generous hospitality at DESY.

References

1. D.H. Perkins, Lectures given at the Fifth Hawaii Topical Conference in Particle Physics, August, 1973

   F.J. Sciulli, "Total and Differential Corss-Sections in Deep Inelastic Neutrino Scattering", Caltech. Preprint, CALT-68-450

2. J.D. Bjorken and E.A. Paschos, Phys. Rev. 185 (1969) 1975

   J. Kuti and V.F. Weisskopf, Phys. Rev. D4 (1971) 3418

3. P.V. Landshoff and J.C. Polkinghorne, Nucl. Phys. B28 (1971) 225

4. M. Fritzsch and M. Gell-Mann, Proc. of the Coral Gable Conf. on Fundamental Interactions at High Energy (1971)

5. M. Chaichian et al., Nucl. Phys. B51 (1973) 221

6. M. Chaichian and S. Kitakado, Nucl. Phys. B59 (1973) 285

   S. Kitakado, Talk presented at the IXth Recontre de Mariond 1974

7. E.D. Bloom and F.J. Gilman, Phys. Rev. Letters 25 (1970) 1140; Phys. Rev. D4 (1971) 2901

8. F.E. Close, Daresbury Lecture Note Series No. 12 (1973)

9. S.D. Drell and T.M. Yan, Phys. Rev. Letters 24 (1970) 181; G. West, Phys. Rev. Letters 24 (1970) 1206

10. R.P. Feynman, Proc. of the 3rd High Energy Conf. Stony Brook (Gordon and Breach, 1970)

11. J. Mandulá, J. Weyers and G. Zweig, Ann. Rev. Nucl. Sc. 20 (1970) 289

12. J.L. Rosner, Phys. Rev. Letters 24 (1970) 173

13. J.S. Pucher et al., Phys. Rev. Letters 32 (1974) 118; A. Bodek, Ph.D. Thesis, MIT Report COO-3069-116 (1972)

    A. Bodek et al., SLAC preprint SLAC-PUB-1399 (1974)

14. F.E. Close, F.J. Gilman and I. Karliner, Phys. Rev. D6 (1972) 2533; F.E. Close and F.J. Gilman, Phys. Rev. D7 (1973)2258; F.E. Close, Phys. Letters 43B (1973) 422

15. Values for the height of the resonance bumps are taken from M. Breidenbach, Ph. D. Thesis, MIT, LNS-MIT 2098-635 (1970) and M. Köbberling et al., DESY 74/32 (1974)

16. S. Pallua and B. Renner, Phys. Letters 38B (1972) 105

17. J.D. Bjorken, Phys. Rev. 148 (1966) 1467

18. F.E. Close, CERN-preprint Ref. TH.1875-CERN (1974)

19. C. Michael, Springer Tracts in Modern Physics 55 (1970) 173

20. D.J. Fox et al, CLNS-278, MSU-16 (1974)

Figure captions

1. Plots of $\frac{10}{9} A_2 + \frac{8}{3} S$ and $\frac{10}{9} N_2 + \frac{8}{9} S$ as a function of x.

2. "Eye-ball" fits to the data in Fig. 1. (We use the abbreviation $\frac{8}{9} S$ = sea.)
Additionally: sea, 3 sea, $\frac{10}{9} A_2$ and $\frac{10}{9} N_2$ as a function of x.

3. The ratio of the heights of the P_{33}, D_{13} and F_{15} resonances to the νW_2 plotted for a given x' as a function of q^2. (Ref. 8 and DESY-points of Ref. 15)

4. The ratio of the height of the Δ-resonance to the $\nu W_2(A) \equiv \frac{2}{9} A_2$ and the heights of the D_{13} and F_{15} resonances to the $\nu W_2(N) \equiv \frac{4}{9} N_2$ plotted for a given x' as a function of q^2.

5. Predictions for polarization asymmetries on proton and neutron targets.

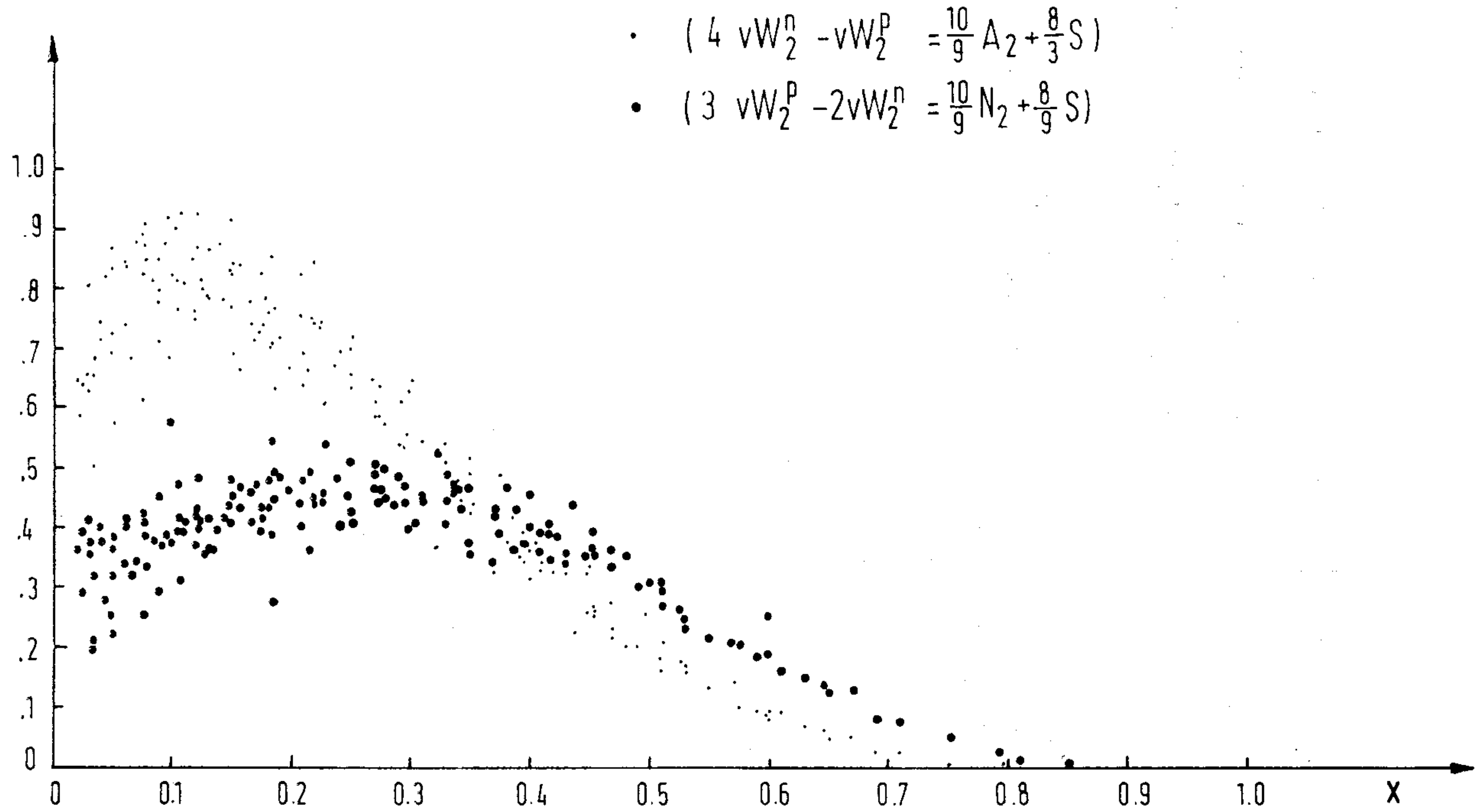
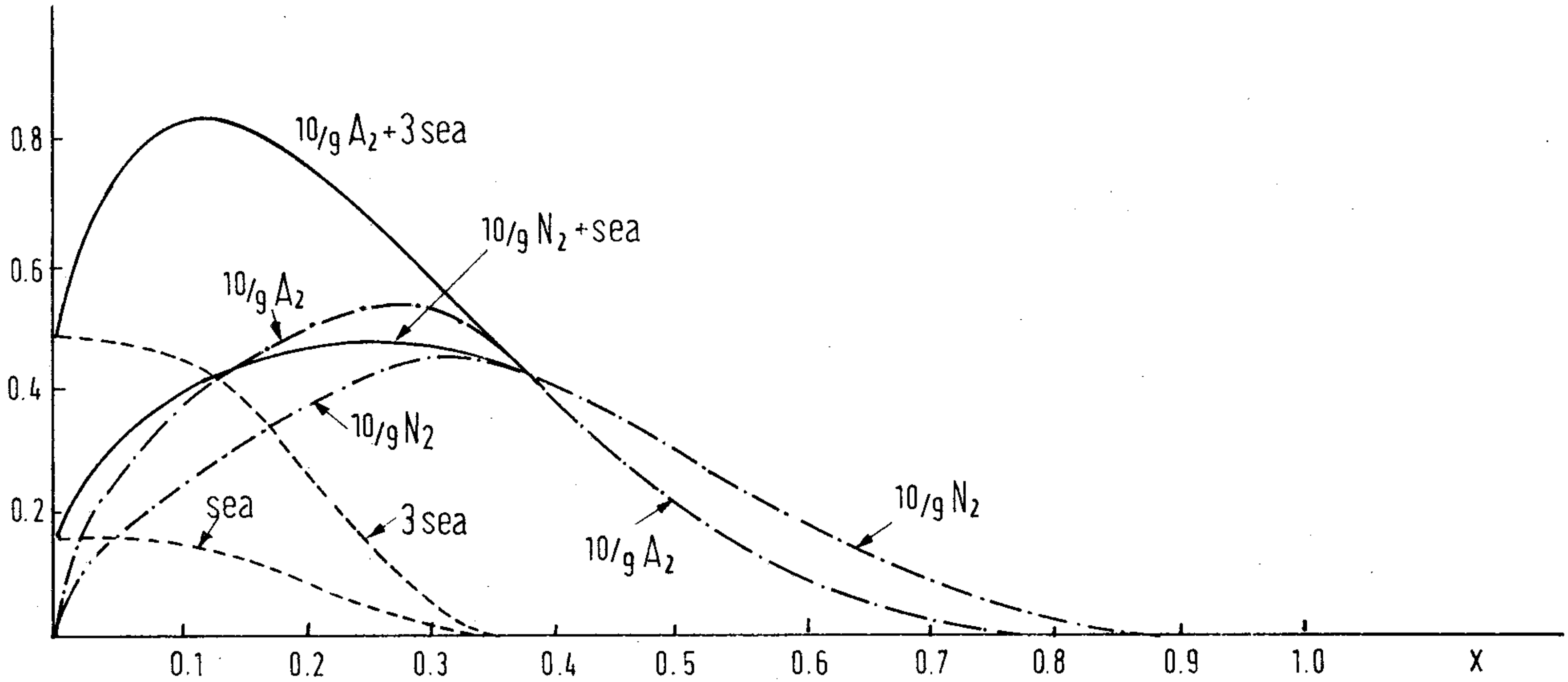
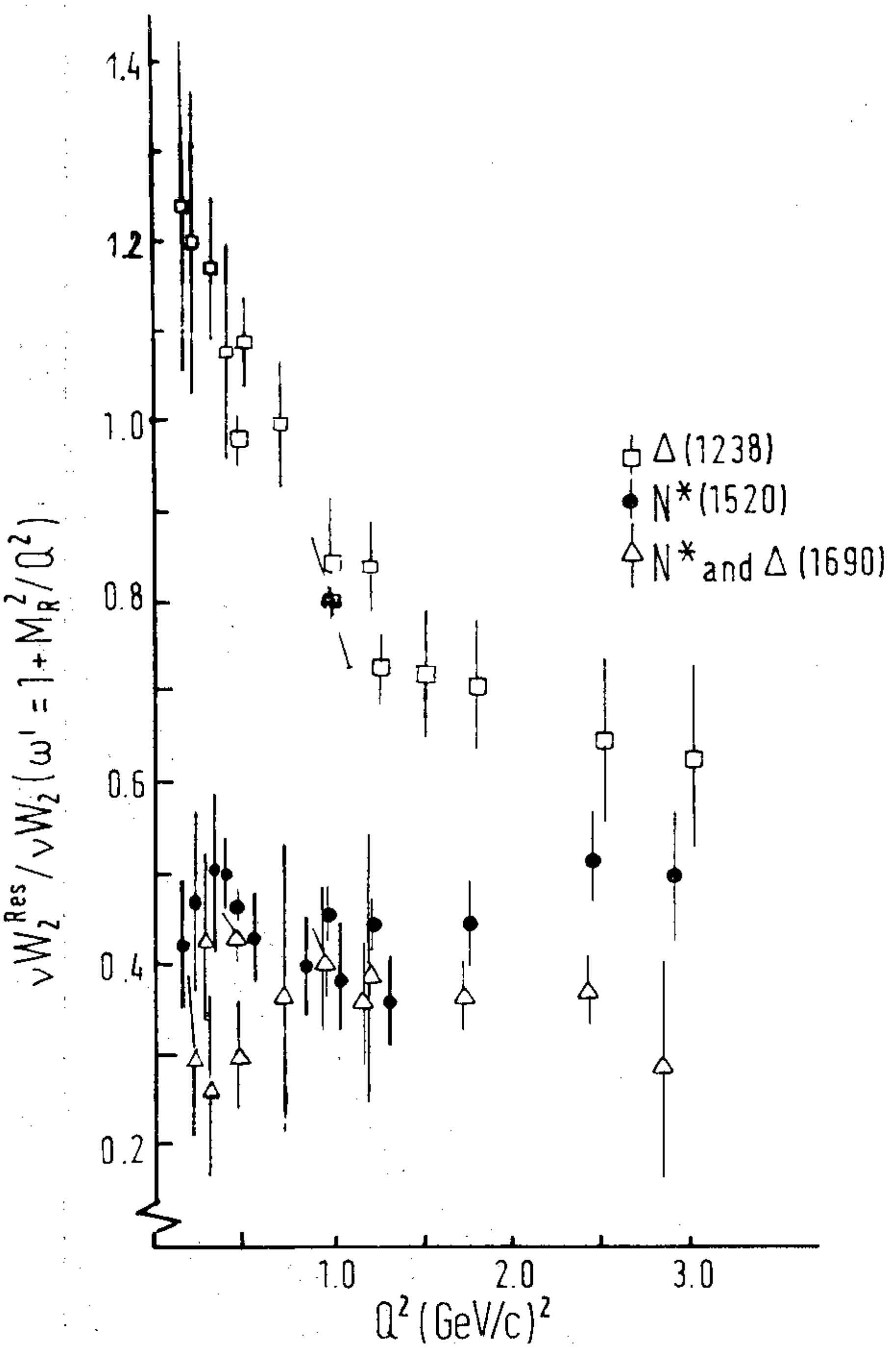

· (4 vW2n -vW2p = 10/9 A2 + 8/3 S)
• (3 vW2p -2vW2n = 10/9 N2 + 8/9 S)
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
X

Fig.1



10/g A2+3sea
10/g N2+sea
10/g A2
10/g N2
sea
3sea
10/g N2
10/g A2
0.8
0.6
0.4
0.2
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
X

Fig. 2



1.4
1.2
1.0
0.8
0.6
0.4
0.2
1.0
2.0
3.0
Q² (GeV/c)²
νW₂^Res / νW₂ (ω' = 1 + M_R²/Q²)
Δ (1238)
N* (1520)
N* and Δ (1690)

Fig. 3

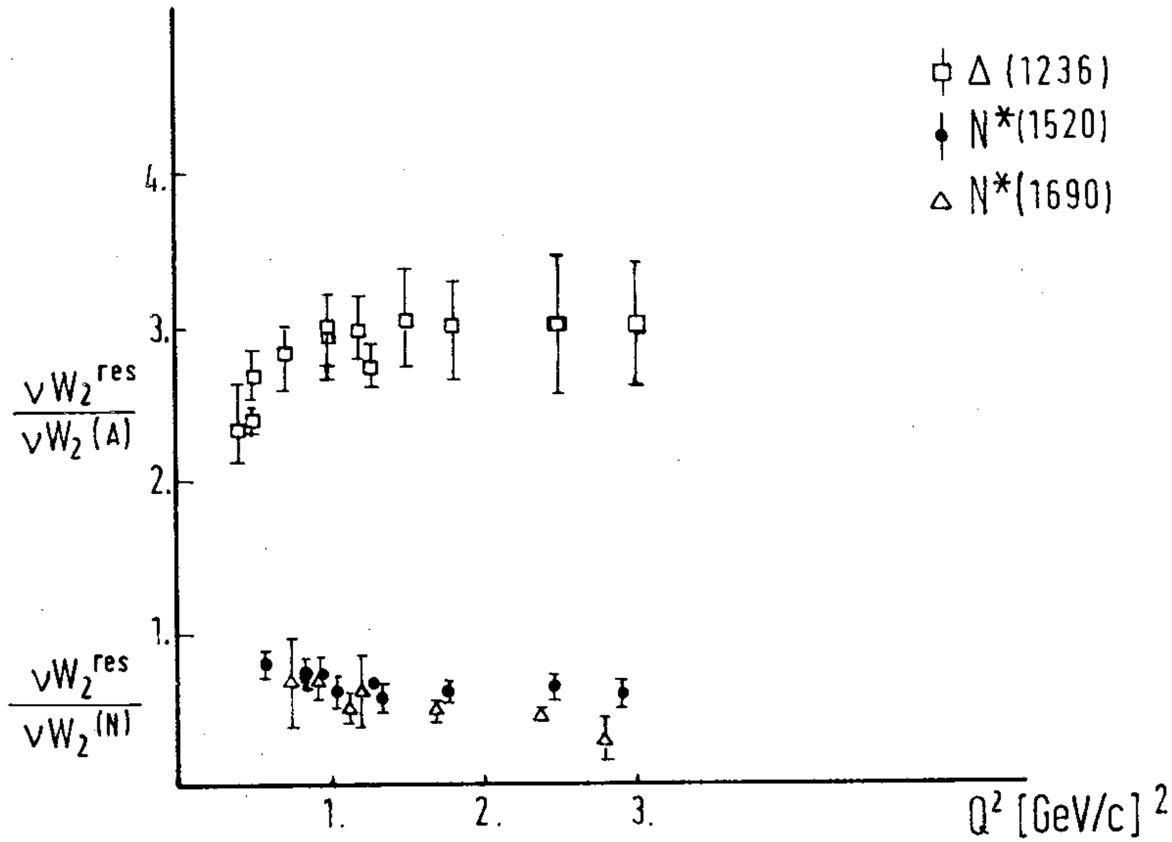

Δ (1236)
N*(1520)
N*(1690)
4.
3.
2.
1.
$\frac{\nu W_2^{res}}{\nu W_2(A)}$
$\frac{\nu W_2^{res}}{\nu W_2(N)}$
1.
2.
3.
Q^2 [GeV/c] 2

Fig.4

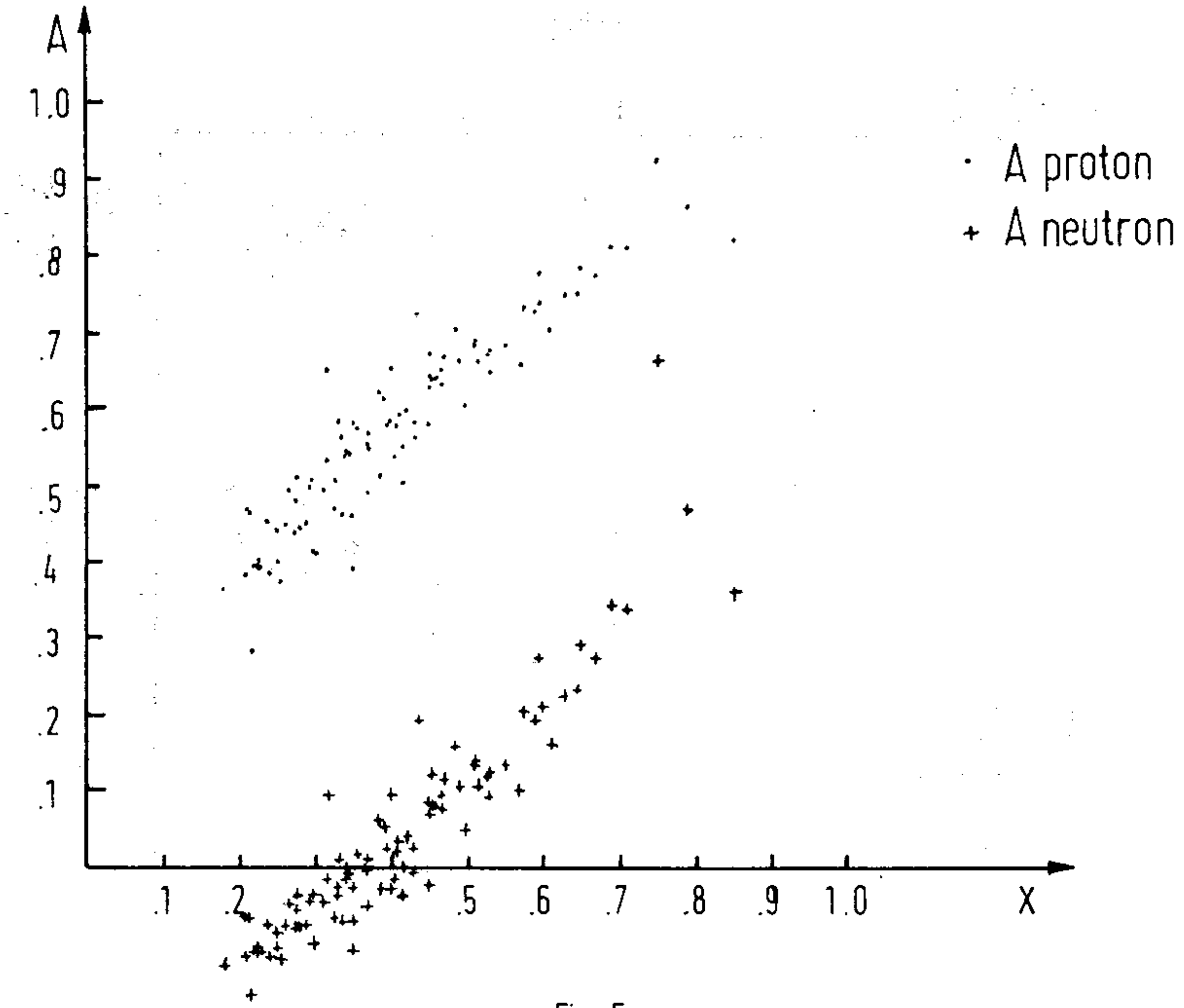


Fig. 5