PROC. 19th INT. CONF. HIGH ENERGY PHYSICS
TOKYO, 1978

B 3 Introduction, a_L/a_T

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s LAC

A decade ago the 14th International Conference was held in Vienna. In the sessions on electromagnetic interactions you would have seen e-p inelastic scattering data for the first time, and a very beautiful experiment on é$^{+}$e"->/t>° from the Orsay linac. Neutrino induced reactions were represented by one of the earliest measurements of the toal *v* and *v* cross section. There were hints of what we are hearing about in Sessions B 1-10 this week, but they were not very broad hints. Not many of the attenders would have guessed that in ten years results from e^{+}e~ rings would assume such a dominant role in hadron physics, that we would see neutrino deep inelastic scattering data comparable in accuracy with the e-p data at Vienna, or that we would hear a talk about the deep inelastic scattering of polarized electrons on polarized protons, and so on. It has been a great ten years for leptons and for electricity, and I suspect there are more good years to come.

Before we begin the session, I would like to take three minutes to bring you up to data on measurements of $R=a_Lja_T$ for the proton, a parameter that we have been trying to determine to higher and higher accuracy ever since Vienna. Small values of *R* were crucial to the quark-parton ideas, and *R* is needed to determine the nucléon structure functions well enough to study fine features like scale breaking. QCD should be able to predict *R*, but the estimates have usually been smaller than the experimental numbers. Several experiments[1"5] which provide data on *R* have been performed at SLAC over the past eight years. The Hand[6] structure functions, a_L and o_T can be obtained from cross section measurements for different angles when Q^2 and W^2 are held fixed. In Fig. 1 we show an example of data at g^2=9(GeV/c)^2 and W^2=7(GeV)^a taken from the various experiments. Small interpolation from the measured cross sections are necessary to obtain these points at exactly the same g^2, W^2. Both statistical and systematic errors are shown. Values of *R* are determined by fits to this and 21 similar plots, over a range of £^{2}<18 (GeV/c)^2, W^2<*15* (GeV).^{2}

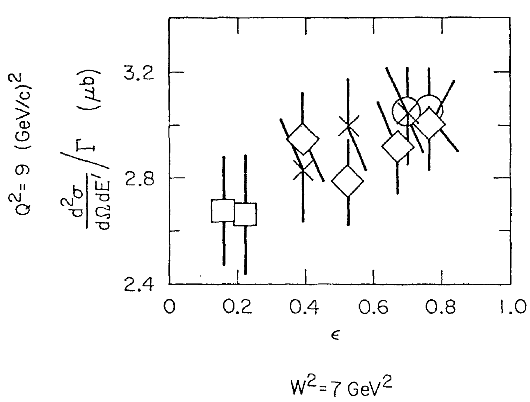

Fig. 1. Plot of inelastic ep cross sections taken at various angles and interpolated to Q^2=9 (GeV/c)^2, W^2=*l* (GeV)^2. Crosses are data taken from refs. 1 and 2, diamond from ref. 3, squares from ref. 4 and circles from ref. 5. Errors include both statistical and systematic uncertainties.

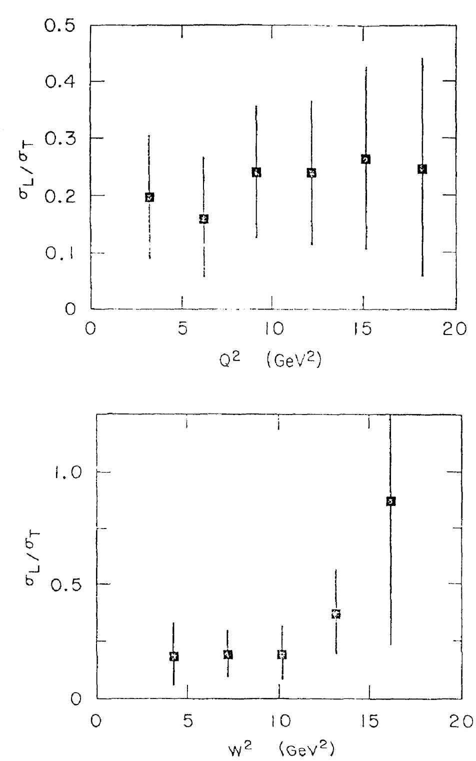

Fig. 2. Results for *R vs* Q^2 averaged over W^2 and for *R vs* W^2 averaged over Q^2. Statistical errors are small, so the error bars reflect systematic uncertainties.

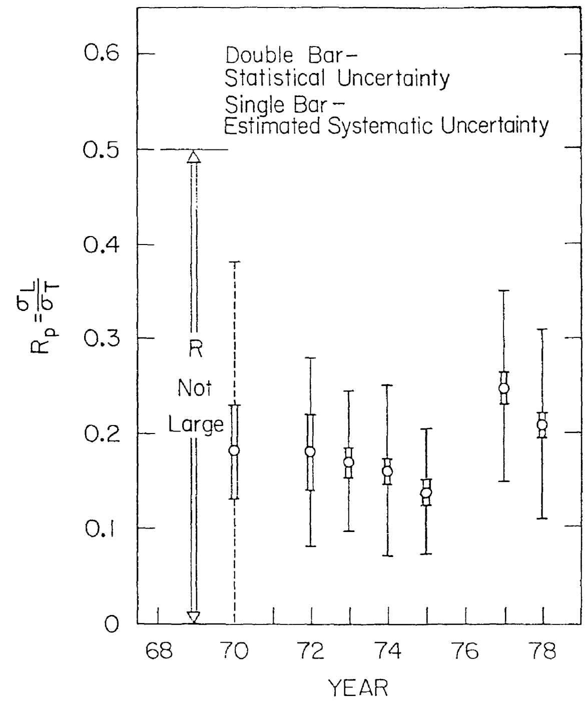

Fig. 3. Values of *R* are in deep inelastic electron scattering as quoted at various conferences or in publications.

The different experiments are consistent within systematic errors at angles where there is overlapping data. If one assumes that *R* is constant over the region covered by the experiments, the best value for the constant is i?=0.21, using this combined data set. Because of the presence of systematic errors it is difficult to estimate the error on JR. We quote the smallest error obtained for any one of the individual determinations of *R* which gives:

£=0.21±0.10 (proton)

This seems like a conservative estimate because the errors are partially statistical and because systematic errors can be quite different for plots at different *Q\ W** points.

The possible dependence of *R* on Q^2 is of some interest in QCD. The results of this analysis are shown in Fig. 2 along with a similar plot against W^2. In general QCD would predict somewhat smaller values of *R*, and values of *R* which decrease with $Q^{\%}$.

The final figure shows the history of *R* measurements based on electron scattering. The experiments improve, but the value of *R*, and its error seem to stay about the same.

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B 3 Polarized Electroproduction

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A new type of information on proton structure, its internal spin structure, has recently become available from a new type of experiment, polarized electroproduction ,[1,3] Participants in the SLAC experiment are from the University of Bielefeld, SLAC SFG group, University of Tsukuba, and Yale University.

We measure the scattering of longitudinally polarized electrons by longitudinally polarized protons. Only the scattered electrons are observed in an inclusive scattering experiment. The quantity measured is the asymmetry *A*,

Table I. Crosss section and asymmetry

$$\frac{d^2\sigma}{d\Omega dE'}=\left(\frac{\alpha^2\cos^2(\theta/2)}{4E^2\sin^4(\theta/4)}\right)\left[W_2+2\tan^2\frac{\theta}{2}W_1\right.$$

$$\pm 2\tan^2\frac{\theta}{2}(\varepsilon+E'\cos\theta)MG_1$$

$$\left.\pm 8EE'\tan^2\frac{\theta}{2}\sin^2\frac{\theta}{2}G_2\right]$$

$$+(A)$$
$$-(P)$$

$$\frac{d^2\sigma}{d\Omega dE'}=\left(\frac{d\sigma}{d\Omega}\right)_M\left(\frac{1}{\varepsilon(1+\nu^2/Q^2)}\right)W_1\{1+\varepsilon R$$

$$\pm(1-\varepsilon^2)^{1/2}\cos\phi A_1\pm[2\varepsilon(1-\varepsilon)]^{1/2}\sin\phi A_2\}$$

$$\varepsilon=\left[1+(1+\nu^2/Q^2)\tan^2\frac{\theta}{2}\right]^{-1}$$

$$R=\sigma_L/\sigma_T\,;\ \sigma_T=(\sigma_{1/2}+\sigma_{3/2})/2$$

$$A=\frac{d\sigma(\uparrow\downarrow)-d\sigma(\uparrow\uparrow)}{d\sigma(\uparrow\downarrow)+d\sigma(\uparrow\uparrow)}$$

$$A=D(A_1+\eta A_2)$$

$$D=\frac{E-E'\varepsilon}{E(1+\varepsilon R)}=\frac{(1-\varepsilon^2)^{1/2}\cos\phi}{(1+\varepsilon R)}$$

$$\eta=\frac{\varepsilon(Q^2)^{1/2}}{E-E'\varepsilon}=\left(\frac{2\varepsilon}{1+\varepsilon}\right)^{1/2}\tan\phi\simeq\tan\phi$$

$$A_1=\frac{\sigma_{1/2}-\sigma_{3/2}}{\sigma_{1/2}+\sigma_{3/2}}$$

$$A_2=\frac{2\sigma_{TL}}{\sigma_{1/2}+\sigma_{3/2}}$$

$$|A_1|\leq 1;\ |A_2|\leq\sqrt{R}$$

the normalized difference between the differential scattering cross sections for the antiparallel and parallel spin configurations. Data have been obtained for elastic, deep inelastic, and resonance region scattering.

For deep inelastic scattering the expression for the differential cross section (Table I) now includes, in addition to the familar spin-averaged proton structure functions W_x and W_2, two new spin-dependent structure functions Gi and G_2 which can only be determined from polarized electroproduction. Alternatively, we can consider A_x and A_2 which refer to the virtual photon-proton interaction as the spin dependent quantities. Our measured electron-proton scattering asymmetry is related to A_x and A_2. D is a kinematic depolarization factor of the virtual photon, and *r]* is a small kinematic factor. *Ax* is the normalized difference between $<j_{V2}$ and 0-3/2, where $a_{1/2}$ is the total absorption cross section of the virtual photon by the proton when the *z* component (z is the direction of the virtual photon momentum) of angular momentum of the virtual photon plus proton is 1/2, and for (J3/2 it IS 3/2. The quantity a_{TL} arises from the interference between transverse and longitudinal photon-nucleon amplitudes. Positivity limits on A_x and A_2 are indicated. To a good approximation our experiment determines A_x.

Polarized electrons are obtained[4-6] by photoionization of a polarized Li atomic beam with plused UV light. The electron polarization direction is determined by the direction of the static magnetic field in the photoionization region and can be reversed by reversing the current direction in the polarizing coil.

The important characteristics of the polarized electron beam are an intensity of 10^9 e"/ 1.5 //sec pulse (about 1/100 of usual unpolarized beam at SLAC) at a repetition rate of 120 pps, and a polarization of 0.85:^0.08, which is measured at high energy by Moller scattering.[7] The electron beam helicity is reversed typically every 2 min in a reversal time of 3 sec.

The polarized proton target is based on the usual method of dynamic nuclear orientation. It uses a hydrocarbon butanol target and involves a temperature of 1 °K, a static magnetic field of 50KG, and a microwave magnetic field of 140 GHz. The free protons, *i.e.,* those not bound in carbon nuclei, constitute about 0.1 of the total number of nucléons. Considering radiation damage to the target, the average polarization of the free protons is 0.5.

The method of the experiment was checked by measuring the asymmetry *A* in e-p elastic scattering where the theoretical value is predicted from the measured proton form factors G_E and G_M (Table II). The measured quantity is the counting rate asymmetry *A* between the antiparallel and parallel spin configurations. It is related to the intrinsic electon proton scattering asymmetry *A* by the factors P_e, the electron polarization, P_P, the free proton polarization, and F, the fraction of the scattered electrons originating from free protons. At our kinematic point *E= 6A1* GeV, 0=8°, and Q^2*=0J6* $(\mathrm{GeV/c})^2$, ^theor=0.112^0.001, in excellent agreement with the experimental value, $^4{}_e$xp=0.103±

Table II. Asymmetry in elastic scattering

$$A=\frac{\left.\frac{d^2\sigma}{dpd\Omega}\right|_A-\left.\frac{d^2\sigma}{dpd\Omega}\right|_P}{\left.\frac{d^2\sigma}{dpd\Omega}\right|_A+\left.\frac{d^2\sigma}{dpd\Omega}\right|_P}$$

$A_{\rm theor}$

$$=\frac{G_M}{G_E}\frac{\tau\left\{2\frac{M}{E}+\frac{G_M}{G_E}\left[2\tau\frac{M}{E}+2(1+\tau)\tan^2\frac{\theta}{2}\right]\right\}}{1+\tau\left(\frac{G_M}{G_E}\right)^2\left[1+2(1+\tau)\tan^2\frac{\theta}{2}\right]}$$

E=Initial electron energy; $\tau=\frac{Q^2}{4M^2}$

$G_E(G_M)$=electric (magnetic) form factors of proton: $G_E(0)=1$; $G_M(0)=2.79$.

For kinematic point

$E=6.47$ GeV, $\theta=8.0°$, $\theta^2=0.76$ (GeV/c)^2

$A_{\rm theor}=+0.112\pm0.001$

$$\left(\left|\frac{\mu G_E}{G_M}\right|=+0.98\pm0.04\right),$$

$$\Delta=P_eP_pFA \qquad \left(\Delta=\frac{N_{\uparrow\downarrow}-N_{\uparrow\uparrow}}{N_{\uparrow\downarrow}+N_{\uparrow\uparrow}}\right)$$

Experiment

E80(75)

$P_e=0.51\pm0.06$

$P_p=0.34\pm0.03$

$F=0.27\pm0.02$

$\Delta=0.0063+0.0010$

$A=0.138\pm0.031(0.019)$

E80(76)

$P_e=0.85\pm0.08$

$P_p=0.51\pm0.04$

$F=0.33\pm0.03$

$\Delta=0.0127\pm0.0015(899<W<999$ MeV)

$A=0.092\pm0.017(0.010)$

$A_{\rm expt}=0.103\pm0.015$

$A_{\rm expt}-A_{\rm theor}=-0.009\pm0.015$

0.015 within the 15% experimental error. Our measurement determines the sign of G_MJG_E to be positive, which had not been measured previously.

Figure 1 indicates our measured data points. The solid dots are seven deep inelastic points with missing mass W between 2 and 4 GeV, Q^2 between 1 and 4 (GeV/c)^2, and $a>$ between 2 and 10. The unfilled squares are seven resonance region points. The crossed point is the elastic point. The open circles are data points planned in our upcoming SLAC

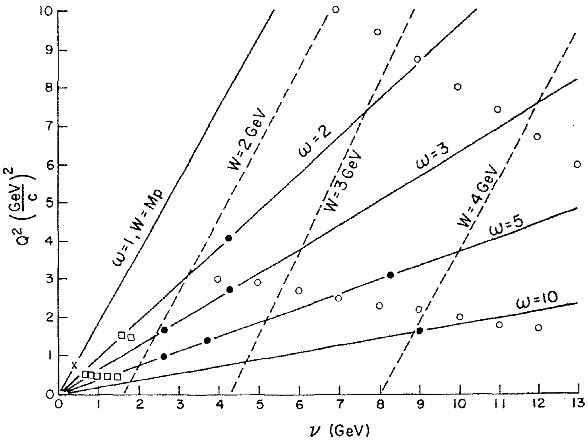

Fig. 1. Data points in E80 and planned for El30. •? deep inelastic points, E80; •, resonance points, E80; x, elastic point, E80; Q, deep inelastic points, E130.

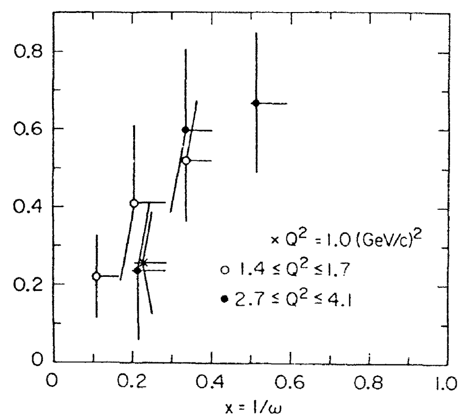

Fig. 2.

El30 experiment.

Figure 2 shows our measured asymmetry values A/D~A_{l9} the virtual photon-proton asymmetry, for the deep inelastic data, in which the errors (vertical bars) are due principally to counting statistics and are typically about 25% of the measured values, whereas systematic errors in P_{e9} P_P and F are 5% to 10%. Radiative corrections, which are relatively small, are included in the plotted points; the horizontal bars give the range in x associated with the radiative corrections. Note that intrinsically the spin dependent effect is large, with A_x being a large fraction of its positivity limit of 1. On the other hand our measured counting rate asymmetries *à* are small, 0.5% to 1 %, due to the small value of the product P_eP_PF (-0.05, with F alone -0.1) and the depolarization factor D~1/3, which relate A and A_x. However, our asymmetry measurement is rather free of systematic errors associated with electron beam helicity, and hence the error has been limited principally by counting statistics which are about 0.1% in J.

There are several implications of these data I would like to mention: 1) test of Bjorken sum rule, 2) scaling, 3) models of proton structure. Note that values of A_x are all positive, which is a firm prediction of the quark-parton model. Scaling is predicted for spin dependent structure functions, in particular, $A_\pm$ scales:

Ai(v, <2^2)-^i(<^) as vig^2^oo with ^constant. Note that our data are consistent with scaling within their rather large errors, *i.e.,* for a fixed *x, Ai* is independent of Q^2.

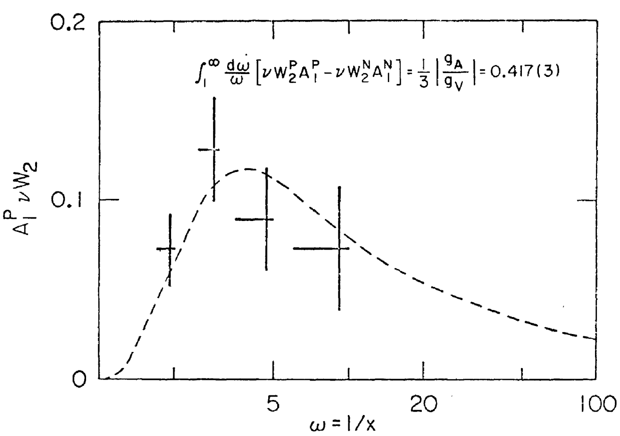

Fig. 3. Evaluation of Bjorken sum rule from polarized electroproduction.

$$\int_2^{10}\frac{d\omega}{\omega}A_1^P\nu W_2^P=0.16(3)$$

$$\int_1^{\infty}\frac{d\omega}{\omega}A_1^P\nu W_2^P=0.34(5),\ \text{extrapolating } A_1^P\infty 1/\sqrt{\omega}$$

The Bjorken sum rule (Fig. 3) predicts equality in the scaling limit between an integral over *a)* of a product of the spin-averaged nucléon structure function W_2 and the spin dependent function A_x and the ratio of axial vector to vector weak coupling constants of beta decay. The difference of the proton and neutron structure function products appears on the left hand side. This remarkable relation is based on quark current algebra and incorporates the general quark model of the nucléon and the view that the same weak current applies for quarks as for leptons. In the absence of experimental information on *A?* for the neutron we approximate *A?* =0, since quark-parton models of the neutron predict that *A?* is small. Using known values of *Wl* and our measured values of *Ax((Ù)* we obtain the plotted points. Over our measured interval from *co=2* to a)=10 we obtain the value of 0.16±0.O3 for the integral which saturates 40 % of the sum rule. We fit our data to the form *A₁=cj^ w* with c=0.78, which represents a satisfactory fit to our data and is suggested by Regge theory at large *a).* If we then extrapolate to small and large values of *to,* we obtain the value for the full integral of 0.34±0.05, where the error includes only our measured errors in A_x. This result is very consistent with the sum rule and indeed saturates 82% of the predicted value.

With regard to proton structure our asymmetry measurements in deep inelastic scattering probe the internal structure associated with both spin and momentum distributions. We consider the simple symmetrical quark-parton model of the proton for the spin-unitary spin part of the wavefunction only, and note that in the impulse approximation a virtual photon can be absorbed by a quark only when their spins are antiparallel and that the absorption probablity will be proportional to the square of the quark charge. Then we find *A[= 5/9* and *A?=0.* Consideration of the momentum distribution of the quarks and other assumptions about the spin

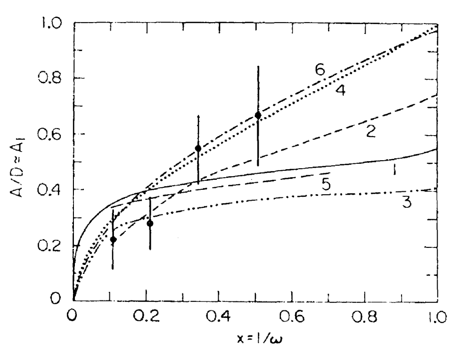

Fig. 4. Experimental values of *A/D~Ax* compared to theoretical predictions for $A_\pm$. The models are as follows: 1, a relativistic symmetric valence-quark model of the proton ;[9,13] 2, a model incorporating the Melosh transformation which distinguishes between constituents and current quarks;[10] 3, a model introducing nonvanishing quark orbital angular momentum;[14] 4, an unsymmetrical model[15] in which the entire spin of the nucléon is carried by a single quark in the limit of *x=l;* 5, the MIT bag model of quark confinement;[16] 6, source theory.[17]

wavefunction alter this simple prediction and lead to predictions for the *x* dependence of *Af* and *A?.*

Figure 4 shows our four deep inelastic points $A_x(x)$, obtained with the scaling assumption, compared with some modern quark-parton models of the nucléon. There is general agreement of the data with the trend of the model predictions, but with present experimental errors we do not distinguish well the different models. In our next experiment our errors are expected to be about 1/3 of great and hence should confront the models much better.

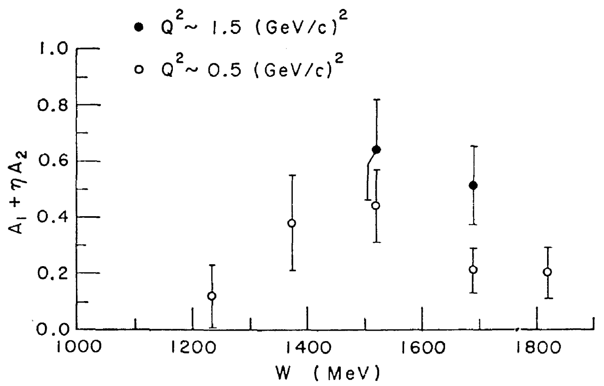

Fig. 5. Measured asymmetry values in the resonance region. (No radiative corrections are made to the plotted points.)

Figure 5 shows preliminary asymmetry data[18] in the resonance region from WK=1200 to 1800 MeV for $Q^2=0.5$ and 1.5 (GeV/c)^2, without radiative corrections. When radiative corrections are made, the asymmetry value at the 1230 MeV *A* resonance point becomes about —0.5, which is the value expected for *A*± for an Ml transition. After radiative corrections have been made to the data and also a decomposition has been done to separate background and resonances, these results should help to clarify the multipole analysis of electroproduction and also to test some theoretical ideas based on duality as to how A_x should vary from the photo-production limit of $Q^2=0$ *to* higher Q^2. These data on asymmetries in deep inelastic and resonance region scattering will make possible the evaluation of a famous old problem—the effect of proton polarizability on the hyperfine structure interval in hydrogen.[19]

As to the future, an experiment El30 is planned soon at SLAC which should reduce the errors in determining the asymmetries *A{* in the deep inelastic region by about a factor of 3 and also extend the kinematic range, principally by use of a larger acceptance spectrometer. Also in this experiment *A*± for the neutron will be determined by measuring deuteron asymmetries. Although it is not yet planned, it should be possible to measure the other virtual photon-necleon asymmetry factor A_2 by use of a target with transverse polarization. The A_2 term, which involves an interference between amplitudes for longitudinal and transverse photons, is somewhat similar to *R* for the spin-averaged structure functions. It will of course be most interesting to compare our electron results with the anticipated high energy results from CERN on polarized muon-polarized proton scattering with regard to scaling, the Bjorken sum rule, and nucléon models.

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B 3 Hadron Production in Charged Lepton-Nucleon Interactions (Up to 20 GeV)

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§1. Introduction

Since the last review/ new experimental results have become available which lead to a significant clarification in particular of the power of quark parton ideas for an understanding of the final states in hard scattering processes. This summary presents results from the UCSC-SLAC streamer chamber group (1976-1079), the SLAC-MIT forward spectrometer group, from the 'LAME' multiwire spectrometer experiment at Cornell (267), the Harvard-Cornell Collaboration (382) and the Cornell-DESY streamer chamber experiment (765, 766, 1095).

§2. Diffractive Production of Meson States

In Fig. 1 results on the slope of the diffractive *p*° production peak are compiled.[2] A tendency towards a decrease of slope with increasing Q^2 is suggested by the new 'LAME' data, indicating a shrinkage of the transverse size of the virtual hadronic state of the photon. (Note however that the longitudinal and transverse polarization states have not been separated.)

UCSC-SLAC and 'LAME' further find that above the resonance region *p*° and *co* production show quite similar Q^2 and *W* dependencies, indicating similar coheren-diffractive mechanisms. In the reaction ep->eXp, 'LAME' reports possible states X(1800)-»;r$^+$7r~~7r$^+$7r~ (and perhaps^K+K-TT+TT") and X(2020)-^pp.

§3. Tests of the Quark Parton Model

The basic relation of the model for /$^\pm$N-> **/*Xis**

$$\frac{1}{\sigma_{\rm tot}}\frac{d\sigma^h}{dz}=\sum_i \varepsilon_i(x)D_i^h(z),$$

$$\varepsilon_i(x)=\frac{e_i^2 q_i(x)}{\sum_k e_k^2 q_k(x)}$$

with $x=Q^2\backslash 2mv$, $z=E^h/vzzx_F$, v=lab energy transfer, e_t=quark charge, *Si(x)*=probability that the lepton interacted with quark *i* of density *qi(x),* and *D\(z)*=fragmentation function of quark /. Neglecting interaction with strange quarks one gets

$$\frac{1}{\sigma_{\rm tot}}\left[\frac{d\sigma^{\pi^+}}{dz}+\frac{d\sigma^{\pi^-}}{dz}\right]\approx D_u^{\pi^+}(z)+D_u^{\pi^-}(z).$$

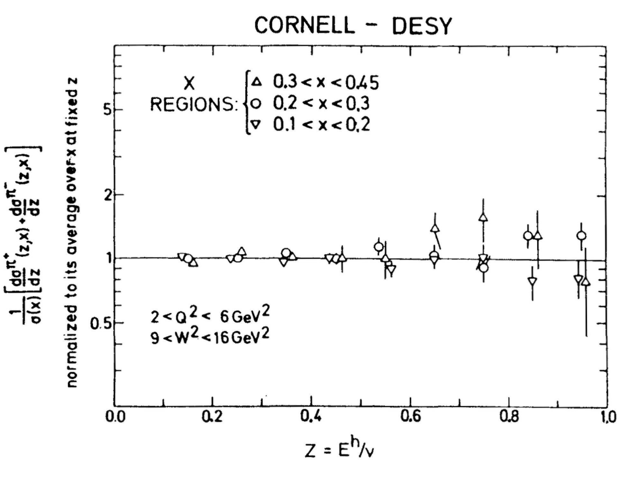


Fig. 1. Slope of forward elastic *p*° production by virtual photons as a function of g^2.

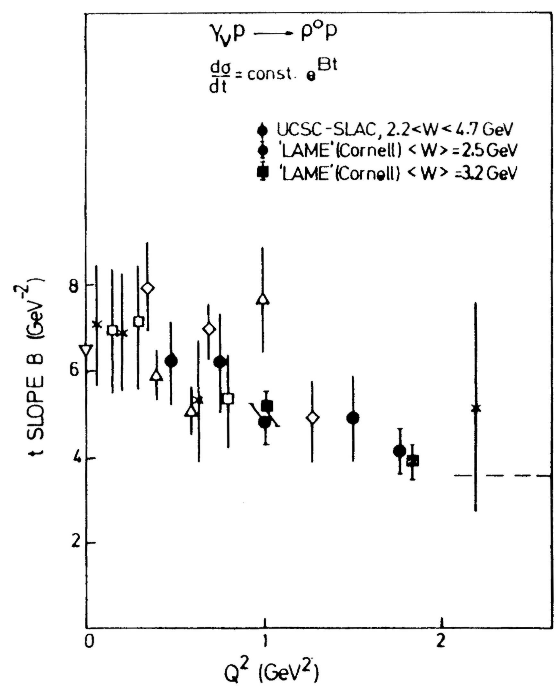


Fig. 2. Test of the x-independence of the distribution of charged pions in electroproduction.

The left-hand side is indeed found to be *W* independent between Cornell and Fermilab energies, and Fig. 2 shows its *x* independence in a fixed *W* region.

A comparison between rc* or *rc*° production from ep and e+e"3 initial states (below charm

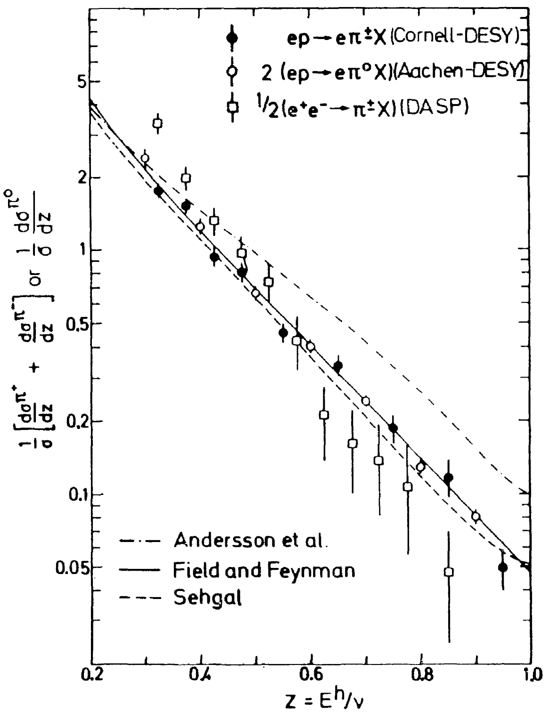


Fig. 3. Comparison of pion z distributions for different deep-inelastic reactions. (Pions from coherent *p*° and *co* production in ep are subtracted.)

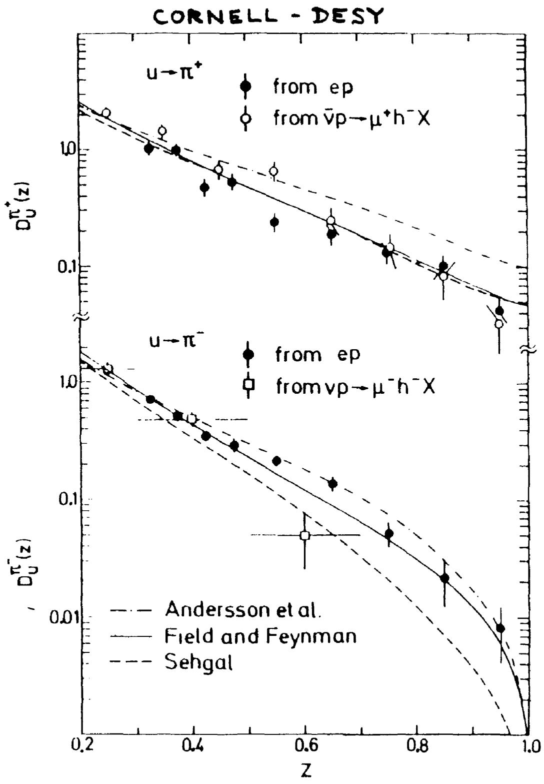
threshold) is shown in Fig. 3. There is excellent agreement between *r^* and x^0 production by ep. The differences in *i&* production by ep *vs* e+e~ may perhaps be blamed on finite energy effects making the comparison of kinematically different processes somewhat ambiguous. From ep-^e^X the fragmentation functions *Dt"(z)* have been determined. They are compared in Fig. 4 with results from neutrino experiments.[4] Satisfactory agreement is found.

§4. SU(3) Breaking

Harvard-Cornell, SLAC-MIT and Cornell-DESY find for a *z* range -0.3-1 the K/TT ratios to be of order

$$K^+/\pi^+ \sim 0.2-0.3,\ K^-/\pi^- \sim 0.15-0.05,$$
$$K^0/\pi^0 \sim 0.1-0.05.$$

The absolute number of *K%* per *event* (and fragmenting *q)* is 3-5 times smaller in ep than in e+e~ annihilation (below charm threshold).



This indicates strong SU(3) breaking in the fragmentation process, such that (u, d-»kaons)/(u, d-^pions)~0.12. Fragmentation models can reproduce this if one assumes that *qq* pairs created out of the vacuum appear in a ratio uu: *dd\ sl~4:4:\.*

§5. Inclusive V Meson Production, V/PS Ratio

USCS-SLAC has observed (l/tf_{tot})d^°/dzto decrease strongly with increasing Q^2 for x_F « 1 (coherent part), but to be independent of $<2^2$ for $x_F<0.9$ from $Q^2=0$ into the deep-inelastic region. A comparison of *(l/a_{tot})da/dz* (ep-^e/>°X)«i)£^{0}(z) measured by UCSC-SLAC and Cornell-DESY, with *(l/2a_{tot})da/*dz(e+e--^X)^(5/6)Z>£°(z)[6] shows reasonable agreement in view of the errors (Fig. 5). The *Tijp* ratio (not counting TTS from *p* decay) in the quark fragmentation region is ~1.5.

§6, Charge Correlations

Figure 6 shows evidence from SLAC-MIT that fast particles in the forward cascade produced by ep or ed scattering tend to have charge opposite to the charge of the leading particle, as expected in the process of quark fragmentation. Checks indicate that the effect is not explained by kinematics and charge

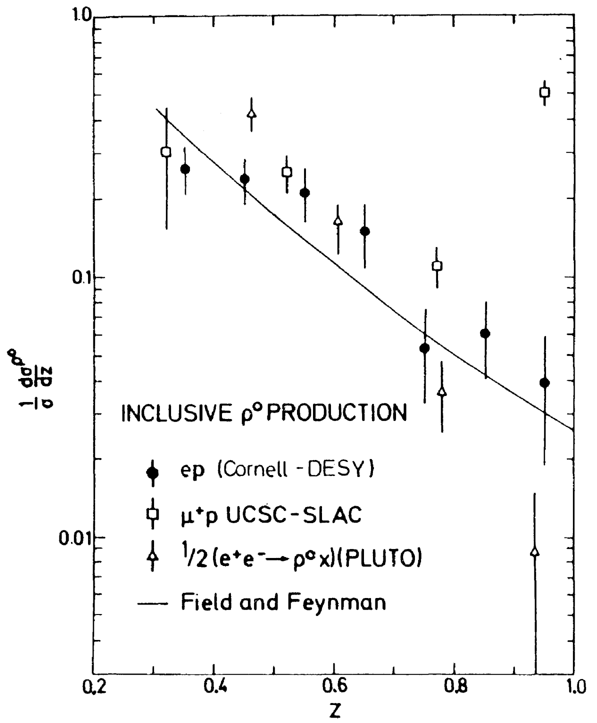


Fig. 5. z distribution for $p°$ production by ep and e^+e~. (In the Cornell-DESY data elastic coherent $p°$ production is subtracted.)

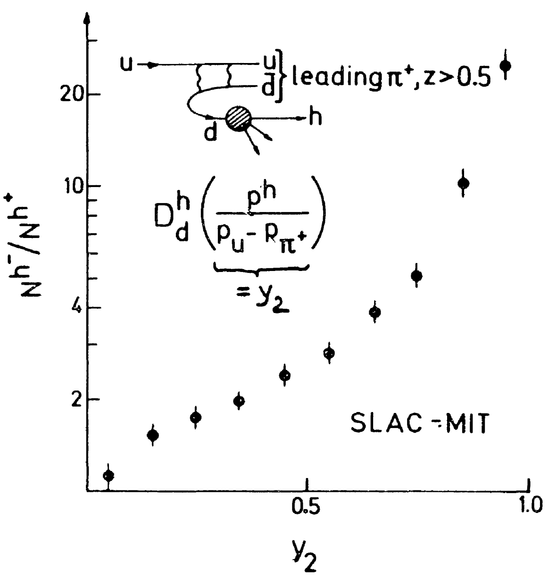


Fig. 6. Ratio of negative to positive hadrons observed with fractional momentum y_2, when the leading hadron is TT^+.

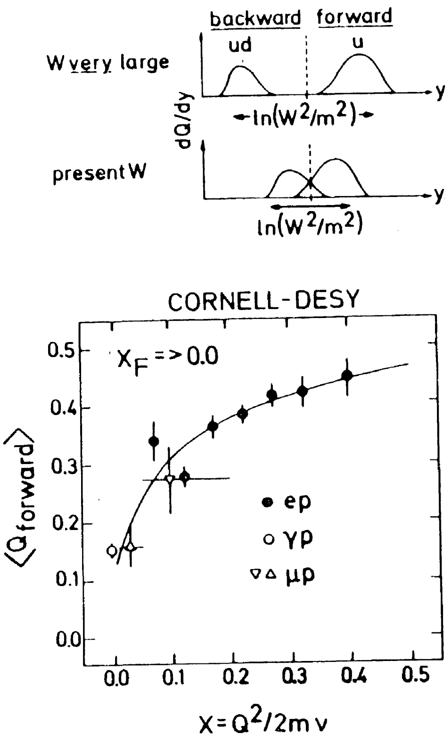


Fig. 7. Mean charge of the hadrons with $x_F>0$ (forward in the cms) in photoproduction, ep and */ip* reactions as a function of *x*.

conservation alone. Figure 7 illustrates an attempt by Cornell-DESY to see the charge of the struck quark being retained in the *q* fragmentation region. At fixed *W*, $x=Q^2/2mv$ is varied, thus keeping the rapidity overlap of the quark and target fragmentation regions fixed while the u/d ratio of the quark is varied. The charge of the forward hadrons indeed follows the expectation from the quark-parton model with fractionally charged quarks (curve).

§7. Transverse Momentum

At small z or x_F in ^ p - ^ h X , a superposition of at least 2 exponentials is needed to describe the *p* distributions of the hadrons, with slopes ~ 10 and ~ 5 GeV^2. On the other hand, for z or $x_F>0.3$ a single exponential *da/* d/^ooexp *(—Bp\)* gives a good fit, the slope in this region being fairly universally 5~4 $GeV"^2$ for $n^\pm$ *TT* *p* K^+, and $K°_s$. Assuming that this reflects the actual *p* distribution of 'primary' quark fragments, these would have </>±> ~430 MeV/c (at W^2 ~ 10-20 GeV^2). This compares well with results from vp[4] and e^+e~[7] interactions (Fig. 8). In the Q^2 range up to 10 GeV^2 no significant Q^2 dependence of </>!> has been observed while </>!> in the region of large z or x_F increases approximately oc In W^2.

§8, Baryon Production, Target Fragmentation

The x_F distribution of the leading baryon may reflect the distribution of the remaining 2 valence quarks plus gluons from the target nucléon, after removal of one of the valence quarks by scattering on the lepton. Proton

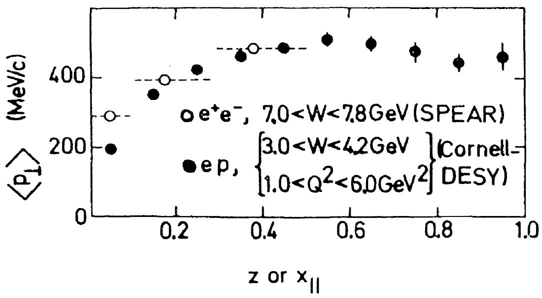


Fig. 8. Comparison of the average transverse momentum of charged hadrons from ep and e^+e^- interactions $(x''=2p''/E_{cm}$, $P\pm$ relative to jet axis). Note that for z<0.1 in ep there are strong contributions of target fragments.

and *A* distributions have been measured by SLAC-MIT, Harvard-Cornell and Cornell-DESY. They are similar in shape but differ in magnitude by a factor 5-10. Assuming dominant target fragmentation (suggested by the *W* dependence) one may estimate from this result that an (ud) diquark recombines with an s *vs* u from the sea in a ratio ~0.15—0.3.

§9. Conclusions

The longitudinal and transverse distributions as well as various correlations within the hadron cascades produced in $/^{\pm}N_?$ *vN*, and e^+e^- interactions show remarkable similarity. Quark fragmentation models can relate these properties, and the input parameters of these models, viz. the amount of SU(3) breaking and the V/PS ratio of the fragmentation products, are already severely constrained by the eN and //N data. No established fact contradicts the quark-parton picture. Questions of interest in connection with QCD, like the Q^2 dependencies of </?j_> and of the fragmentation functions *D*, and the role played by *(p±)N-+q* of the taret quarks, need to be investigated at higher Q^2 and W^2.

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