Blois VI : Experimental Summary.

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Abstract.

The experimantal contributions to the conference are summarised. New data, which are to a large extent still preliminary, were presented. An update on total cross sections for proton proton scattering up to cosmic ray energies was given. The bulk of the data came, however, from lepton proton scattering experiments, in particular from the new ep collider HERA at DESY operating in the 100 GeV c.m. energy range. Total cross sections for real and virtual photon proton interactions are now available in a wide range of center of mass energies. It is observed that cross sections for virtual photons rise faster than the ones for real photons with increasing c.m. energy. Measurements of the photoproduction cross sections for vector mesons and the observation of rapidity gap events in deep inelastic lepton scattering introduce new aspects into the interpretation of diffractive processes and will contribute to a better understanding of the pomeron. A remarkable similarity between hadronic processes and photoproduction is observed when comparing the energy flow in the central rapidity region, which supports the universality of wee parton interactions. New data on the partonic structure of the proton and the spin structure of the nucleon were also discussed in this conference.

1 Introduction

The Blois series of meetings on elastic and diffractive scattering is traditionally a workshop where hadron reactions are in the focus of interest. The 1995 meeting is the first one, where a remarkable change can be observed. The community engaged in deep inelastic scattering experiments (DIS) and structure function measurements had for the first time a significant impact on the discussions about total cross sections and diffractive phenomena. Previously the two fields of physics were pretty much separated and had little overlap, but it became apparent in Blois that DIS reactions and the interaction of virtual photons with protons open up a new window to study diffraction and the Regge behaviour of cross sections at high energy. The new aspects, which were discussed at the present meeting, are related to the fact that through deep inelastic scattering a hard scale, the photon virtuality, is introduced giving rise to an additional degree of freedom, which can be interpreted in terms of perturbative QCD calculations. In this spirit on mass shell reactions can be understood as limiting processes for vanishing virtuality. The fact that new aspects of diffractive scattering were introduced is reflected in the distribution of contributed experimental papers. The dominant input came from experiments engaged in with lepton nucleon scattering.

2 Common view of hadronic reactions and DIS.

The basic diagram describing deep inelastic charged lepton proton scattering is displayed in Fig. 1a. To a good approximation the photon flux can be factorised such that the lepton acts only as a source of real and virtual photons, which interact with the incident proton. The diagram thus symbolizes the total cross section for real or virtual photon proton scattering. In the scaling limit of deep inelastic scattering the process can be interpreted as an interaction between the virtual photon and one of the charged proton constituents carrying the fraction x_{Bj} of the proton's momentum as indicated in the lefthand part of Fig. 1b. This very simple description within the quark parton model is valid for $x_{Bj} \simeq O(0.1)$, typically for valence quarks. it has, however, to be upgraded by the diagram shown on the right hand side of Fig. 1b, the photon gluon fusion process, which gives a significant contribution to the observed cross section in certain kinematic regions. Further improvements are necessary to model the observed scaling violations and for cases, where the virtual photon interacts with a parton carrying only a small fraction of the proton's momentum $x_{Bj} \leq O(10^{-3})$. Both cases can be described by introducing a QCD evolution, which includes the diagrams of the type shown in Fig. 2 a and b. Two different evolution equations DGLAP and BFKL with re-summation parameters ln Q^2 and ln $(1/x_{Bj})$ respectively are used to describe the parton densities inside the proton as a function of $x_{Bj}$and Q^2. .

The physics interpretation in particular of the diagram in Fig. 2b is not unique. Reading the diagram from the bottom it describes a gluon which is emitted by the proton losing longitudinal momentum in a cascade of gluons before it splits into a quark anti-quark pair, which then interacts with the virtual photon. Reading the diagram from the top it looks as if the photon disintegrates into a quark anti-quark pair, which then couples via a gluon cascade to the proton. These two aspects of the same physics process correspond to the space time evolution of the reaction in two different Lorentz frames, the infinite momentum frame and the proton rest system.

In the infinite momentum frame the proton at low x_{Bj} appears as an assembly of comoving

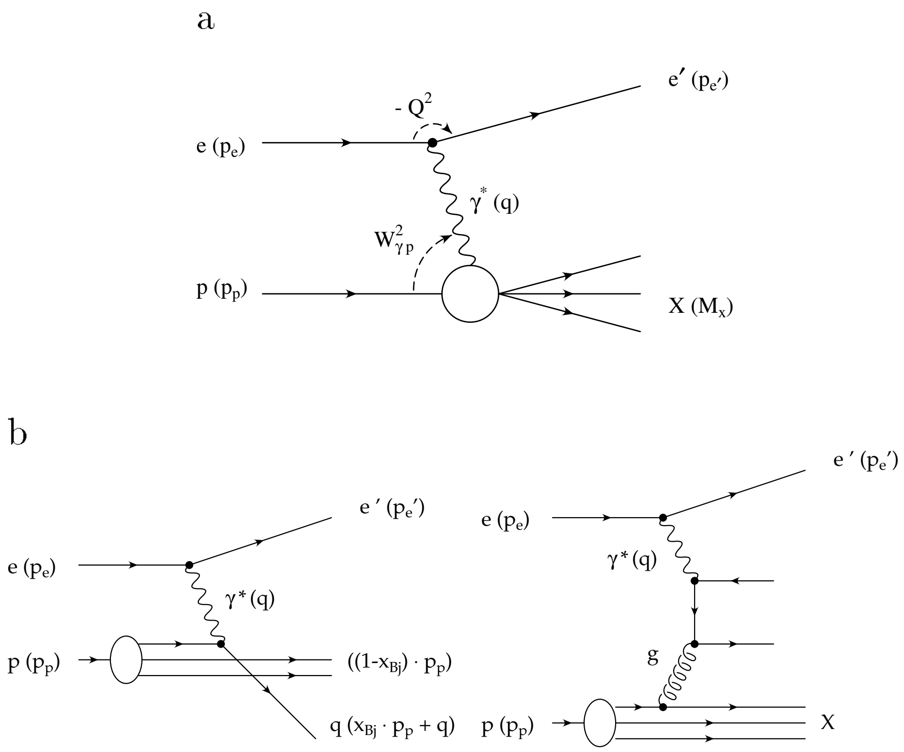

Figure 1: Deep inelastic lepton proton scattering. a)basic diagram b)parton model picture of a virtual photon interacting with a quark or gluon inside the nucleon.

quarks and gluons originating from parton cascades and the virtual photon probes the charged component of the parton distribution with a resolution given by $\lambda \approx 1/\sqrt{Q^2}$. Already at moderate virtuality of $Q^2 = 10$ GeV^2 the resolution of the incoming photon is with $\lambda = 0.06$ fm an order of magnitude smaller than the proton radius. In the proton rest frame the proton may be viewed as a sphere with a strong colour field inside. The incident photon before it hits the target proton disintegrates into a quark anti-quark pair, which may emit a cascade of gluons on its way to and through the proton. The colour forces initiate a rearrangement of partons and colours, which form after fragmentation the final state hadrons. The coherence length of such a photon fluctuation is approximately independent of Q^2 and proportional to the Ioffe time. It is $\lambda_{Ioffe} \sim 1/(x_{Bj} \cdot M_P)$, where M_P is the proton mass. For large $x_{Bj}= O(10^{-1})$ the coherence length is of the same order of magnitude as the size of the proton. At small $x_{Bj}= 10^{-4}$, however, the coherence length is with $\lambda_{Ioffe} = 2 \cdot 10^5$ fm much bigger than the proton radius and the picture of a quark – anti-quark pair traveling through the proton becomes valid. But it should be stressed again that both aspects describe the same physics process.

According to these considerations any measurement of the proton structure function in deep inelastic electron or muon scattering experiments has a contribution, which can be considered as stemming from the hadronic structure of the photon. Therefore it is not obvious, whether these structure functions can be applied without modifications to hadron scattering e.g. at colliders. The QCD tests by the D0 experiment at FNAL which were reported to this conference by S. Lim [1] were performed at $x_{Bj} \geq 10^{-2}$ in a region, where the influence of the photon structure is negligible small, because there is not sufficient phase space available to develop a parton

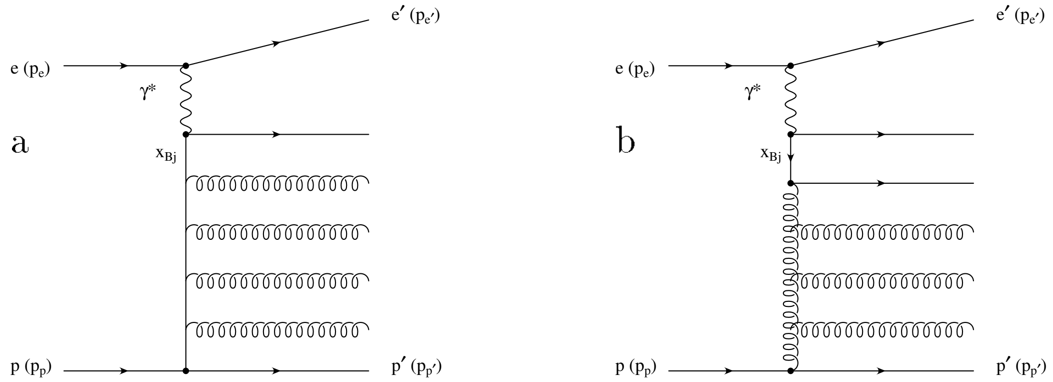

Figure 2: Deep inelastic lepton proton scattering at small $x_{Bj}$with parton ladders initialized by a quark (a) and a gluon (b).

cascade and the structure functions which describe the most recent DIS data can be used to analyze hadron data.

Experiments at low x_{Bj} should be more sensitive to the photon structure and only if wee partons are universal and do not remember their origin, DIS structure functions may be applied to hadronic processes. Therefore it is of interest to compare structure functions measured at the Tevatron with those from HERA at $x_{Bj} \simeq O(10^{-4})$ in order to test the impact of the photon structure. According to the preceding arguments small x physics is dominated by wee partons and if they are universal, common features may be discovered in reactions with different beam and target particles including real and virtual photons. This idea dates back to 1973 when it was discussed in a paper by Bjorken and Kogut [2]. In the center of mass system high energy reactions can be divided into three different kinematic regions as a function of the rapidity variable. The beam and target fragmentation regions with a width of about two units in rapidity and a universal central plateau, which is independent of the beam and target particles. The presence of a central plateau can be interpreted as a result of short range correlations by which the impact of beam and target particles is confined to a restricted rapidity interval about 2 units wide. All the rest, and in particular the central plateau, can be attributed to the interaction of wee partons, which are assumed to be universal.

3 Total cross - sections and structure functions.

The most recent measurements of the total $p\bar{p}$ cross section were sumarised by S. Pruss [1]. The new data smoothly extrapolate from lower energies according to a $(\ln s)^2$ or $s^{0.08}$ behaviour in spite of the fact that a discrepancy between the CDF and E710 measurements still awaits clarification. Also the cosmic ray data at a center of mass energy around 10^4 GeV follow this smooth extrapolation as demonstrated by J. Torii [1] , who presented an evaluation of extended air showers.

New data on the total cross section for γ p – scattering have been reported to this conference, which clearly show in Fig. 3 that at high energies the photon behaves very much like a hadron. The measured total γp cross section at $\sqrt{s_{\gamma p}}$ = 200 GeV, is compatible with an $s^{0.08}$ extrapolation from lower energy. The exponent is the same fitting hadron data. K. Wacker

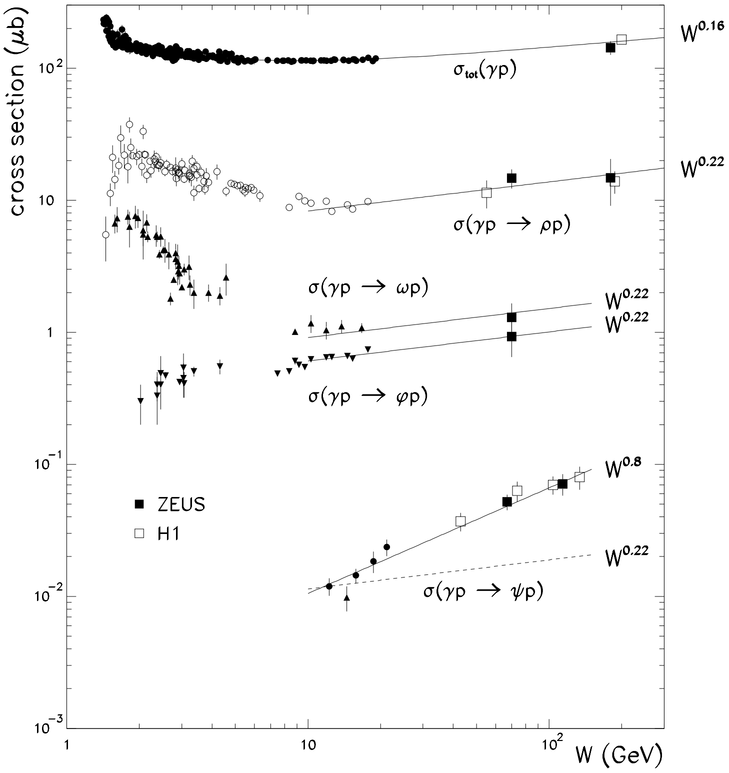

Figure 3: Photoproduction cross sections for vector mesons.cd

[1] reported an update of the total γ p cross section measurement by the H1 collaboration at HERA with $\sigma_{\gamma P}^{tot} = (165 \pm 2 \pm 11)\mu$b [5]. This value agrees within errors with a previous measurement [4] previous measurement and the published value from the ZEUS group [6]. The main difficulty in these measurements at the electron proton collider HERA is due to the fact that a major fraction of the total cross section is not observable, because all secondaries escape at small angles through the beam pipe. This fraction can only be estimated with a considerable uncertainty.

The hadronic nature of the photon can be interpreted in terms of the vector meson dominance model, where it is assumed that the photon fluctuates into a vector meson, in particular into a $\rho(770)$, which travels over a distance $\lambda_V = 2 \cdot E_\gamma / m_V^2$ before it hits a proton. At high enough energy this distance is large compared with the proton radius so that photon proton scattering is equivalent to vector meson proton scattering. It is estimated [7] that this type of interaction is responsible for about 80% of the cross section. The rest is shared between direct interactions, where the photon interacts electro-magnetically with one of the constituents, and so called anomalous interactions, where the photon disintegrates into a quark – anti-quark pair, which then undergoes a strong interaction.

This conference saw for the first time a nearly complete set of data on exclusive vector meson photo-production from HERA. The experiments H1 (I. Kenyon [1]) and ZEUS (J. Whitmore [1]) presented preliminary data on ρ, ω, ϕ and J/ψ production at center of mass energies above 100 GeV. It is interesting to observe that the light vector mesons obey a behaviour, which is compatible with the universal increase of total hadron cross sections. For elastic vector meson photoproduction one finds $\sigma(\gamma P \rightarrow V + P) \sim s^{0.11}$, i.e. it exhibits a Regge type extrapolation with a soft pomeron. This is corroborated by the observation that shrinkage of the elastic peak persists with a measured slope parameter of b$\sim$ 10 GeV^{-2} at 150 GeV center of mass energy. The same gentle cross section increase is observed for the vector mesons ω and ϕ displayed in Fig. 3. It is interesting to note that the J/ψ photo-production cross section increases faster than $s^{0.11}$ roughly like $\sigma(\gamma P \to J/\psi + P) \sim s^{0.4}$ indicating that soft pomeron exchange cannot be the whole story and additional effects like QCD corrections have to be taken into account at higher vector meson masses.

Photo-production of ρ mesons by virtual photons of Q$^2 \geq 4$ GeV^2 exhibits a completely different behaviour (I. Kenyon, J. Whitmore [1]). As a function of $s_{\gamma^* P}$ it increases much faster than allowed by a simple extrapolation of the soft pomeron ansatz. Furthermore it is observed that the production is as expected dominated by the longitudinal component of the virtual photon.

According to the observations made in exclusive vector meson photo-production one may conclude that as soon as one of the scales involved, the meson mass or the photon virtuality Q^2, becomes large, the simple picture of soft pomeron physics fails to describe the data. Hard scattering contributions to be described by perturbative QCD calculations could be responsible for the deviations from the Regge behaviour. Particular attention should be paid to ϕ production as mentioned by A. Donnachie [1] , because the pomeron is the only exchange particle possible and virtual photons will offer the unique possibility to study hard parton contributions. Also the J/ψ family deserves special attention, because two scales are large Q^2 and $m_{J/\psi}$. The ongoing analyses in the two HERA collaborations may soon reveal interesting results, which could contribute to a better understanding of diffractive phenomena.

This transition from virtual to real photons can also be studied in inclusive processes, where a comparison is being made between the total cross sections for γP and γ^*P scattering. The differential cross section for deep inelastic lepton scattering can be written in terms of a kinematic factor multiplied by the proton structure function F$_2$.

$$\frac{d^2\sigma}{dQ^2 d\mathrm{x}_{Bj}} = \frac{\pi\alpha^2}{Q^4 \mathrm{x}_{Bj}} \left\{ 1 - y + \frac{y^2}{2[1+R]} \right\} F_2(x, Q^2)$$
$$R = \sigma_\ell / \sigma_t$$

Here y is the inelasticity variable and R is the ratio between the longiyudinal and transverse cross section.
The physics interpretation of F$_2$ as a total cross section becomes more obvious after rewriting the above equation.

$$\sigma^{\mathrm{tot}}(\gamma * p) \approx \frac{4\pi^2\alpha}{Q^2(1-x)} \cdot F_2(x, Q^2)$$

Updates on structure function measurements at lower energies from experiments E665 at FNAL and NMC at CERN have been presented to this meeting by H. Schellman [1] and from HERA by H. Kasemann for ZEUS [1] and E. Peppel for H1 [1] . A few general comments concerning the new data can be made:

- Whenever there is an overlap between the data of different experiments, they are consistent with each other, which is a nontrivial statement considering the experimental difficulties that have to be mastered in an F$_2$ measurement.

- The HERA data show a strong rise of F$_2$ at low x_{Bj} values ($\mathrm{x}_{Bj} \leq 10^{-3}$ for all values of Q^2 (2 GeV$^2 \leq Q^2 \leq 16000$ GeV^2) as demonstrated in Fig.4.

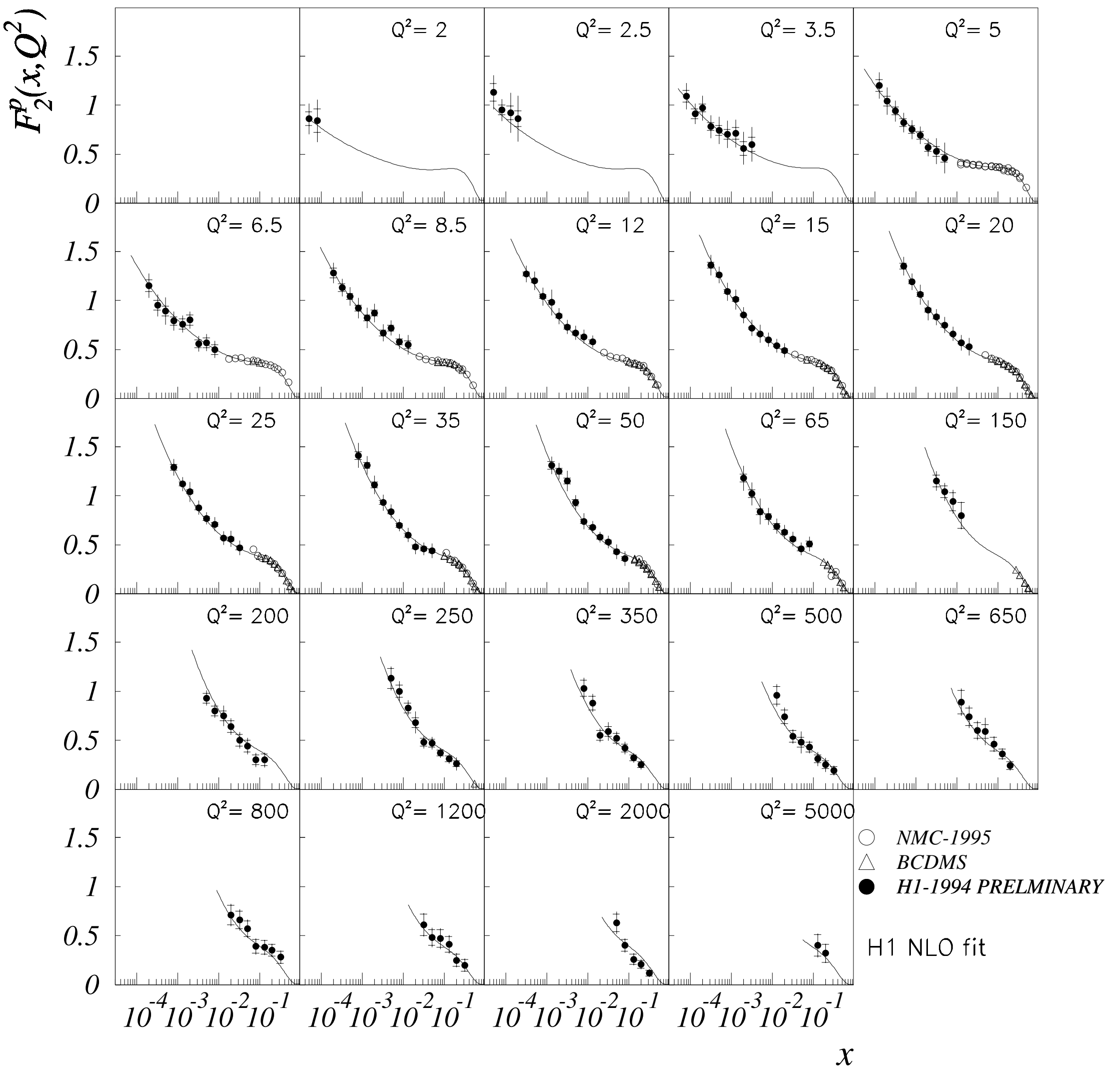

Figure 4: The proton structure function F_2 with a next to leading order QCD fit.

- Scaling violations are observed, which can be attributed to QCD radiation.
- At center of mass energies around 10 GeV a smooth transition from virtual to real photo-production is observed by the E665 experiment which is compatible with a Regge based vector meson dominance ansatz (Fig. 5).

The available data on F_2 from DIS experiments, some of which are shown in Fig. 4 are the basis for multi parameter QCD inspired fits using DGLAP or BFKL evolution equations. A subset of the fitting parameters can be attributed to the gluon distribution inside the proton, which as expected rises steeply with decreasing x_{Bj}.

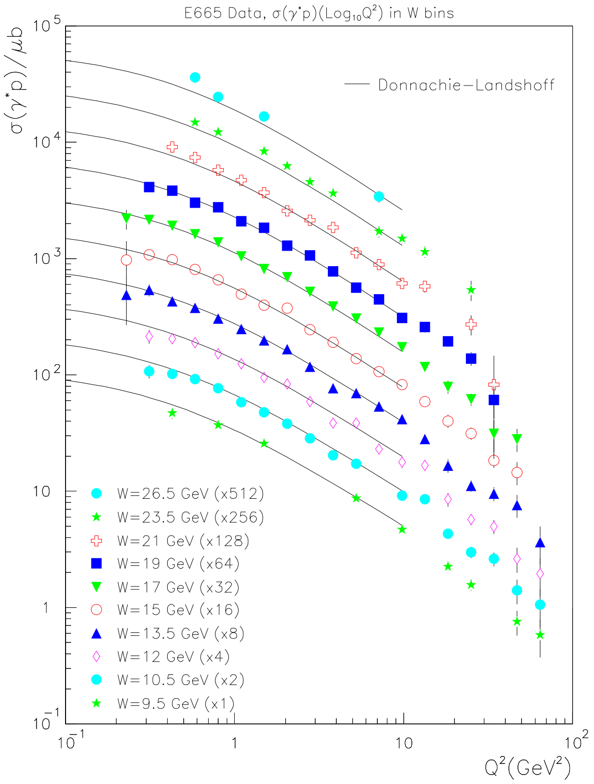

Figure 5: Total cross section for γ^* proton scattering extrapolating to photo-production at $Q^2 = 0$.

A display of F_2 converted into a total cross section $\sigma(\gamma^* P)$ as a function of the center of mass energy $W_{\gamma^* P}$ in Fig. 6 is more inspiring than a plot of F_2 itself. The steep rise of F_2 is reflected in a rising total cross section at large center of mass energy. At $W_{\gamma^* P} = 100$ GeV, in a regime where on shell hadron reactions have reached a quasi asymptotic behaviour with slowly rising cross sections like the photo-production cross section at the top of Fig. 6, $\sigma(\gamma^* P)$ experiences a dramatic rise for all values of Q^2. The analytical form of the rise can be estimated by observing that $F_2 \propto {x_{Bj}}^{0.3 \to 0.4}$, which is not far from $F_2 \propto 1/sqrt x_{Bj}$. Thus with $W_{\gamma^* P} \approx Q^2/\ x_{Bj}$ one finds $F_2 \propto W_{\gamma^* P}/Q$ and thus $Q^2 \cdot \sigma(\gamma^* P) \propto W_{\gamma^* P}/Q$. That means one expects a rise with the center of mass energy close to being linear .
Of course this rise cannot go on forever, however, to investigate this question an eP collider beyond HERA is required, collisions between the LHC and LEP beams at CERN for example.

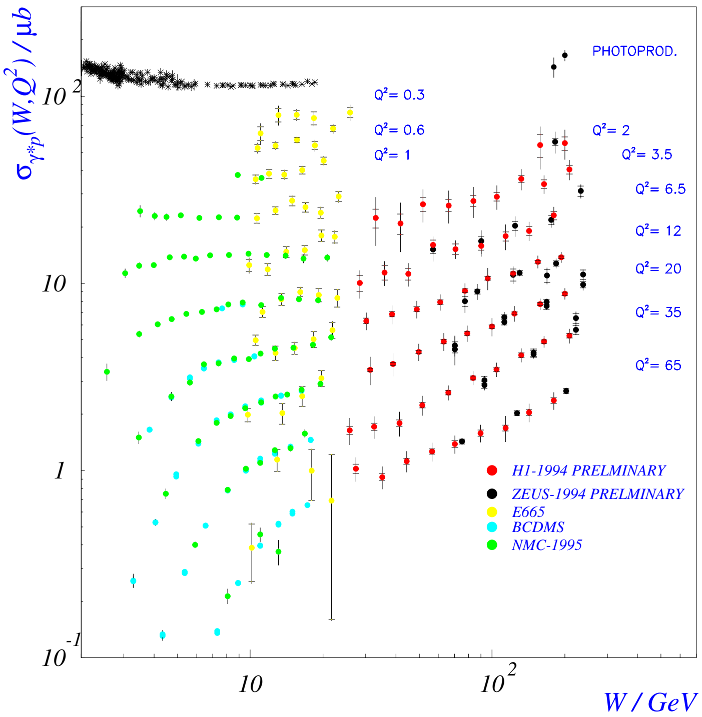

Figure 6: Total cross section for γ^* proton scattering.

An interesting aspect of deep inelastic scattering can be studied in the transition from finite Q^2 cross sections to photo-production at $Q^2 = 0$ with real photons, because again like for exclusive vector meson production the simple Regge behaviour of total cross sections appears as a limiting case, where all hard processes have died out. This question has been addressed by the Fermilab experiment E665. H. Schellman [1] has shown in Fig. 5 that an ansatz a la Donnachie and Landshoff based on a vector dominance model implemented by a soft pomeron approach fits the data very well and extrapolates smoothly to the photo-production cross section. This experiment covers energies up to 26.5 GeV and it would be interesting to study the transition region also at higher center of mass energies at HERA.

According to the Bjorken conjecture of short range correlations confining the fragmentation region to a limited range of about 2 units in rapidity, a universal central plateau should develop also in photo-production with real and virtual photons. Both HERA collaborations H1 and ZEUS have addressed this question. J. Hartmann [1] has presented data, which show that the transverse energy flow in the central rapidity region between the virtual photon and proton fragmentation regions is independent of Q^2 and x_{Bj} and from V. Shekelyian [1] a comparison of the central energy flow between DIS events at different values of Q^2 and hadron scattering data has been presented. A remarkable similarity between hadronic reactions and DIS is observed in Fig. 7 with respect to the transverse energy flow around $\eta = 0$, where η is the rapidity variable. This result may be interpreted as a first indication for the existence of a universal central plateau also in deep inelastic scattering equivalent to the universality of wee partons. Further studies should be made and an obvious first step is the investigation of short range correlations in deep inelastic scattering.

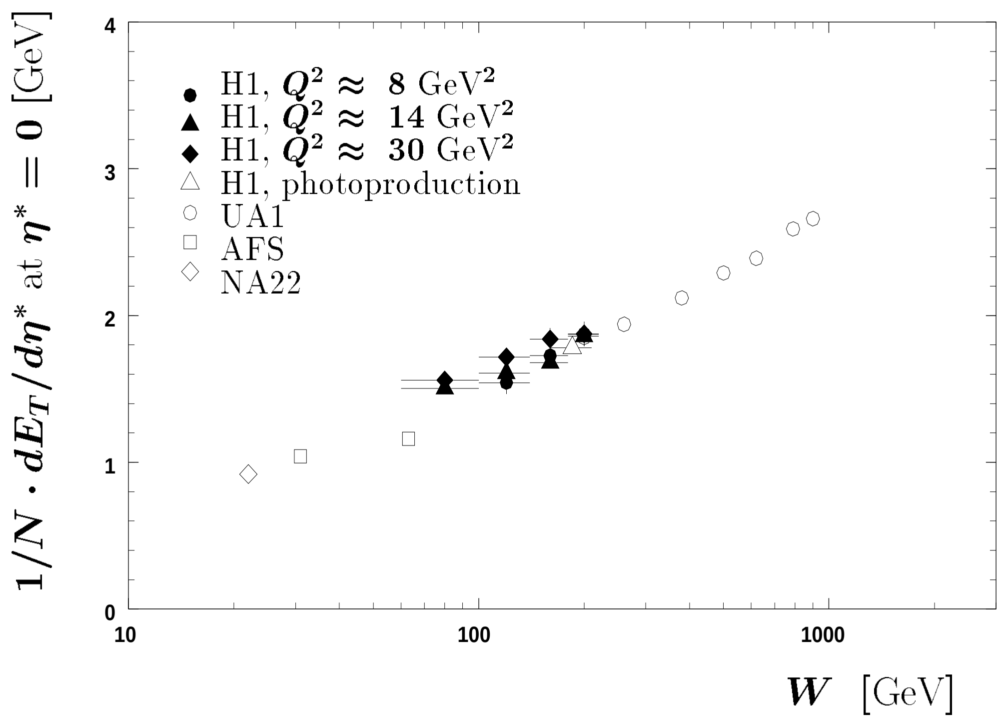

Figure 7: The transverse energy flow per unit of pseudo-rapidity in the central region as a function of the hadronic CMS energy. The DIS data are compared with photo-production data and with data from hadron-hadron collisions ($p\overline{p}$ for UA1; pp for NA22 and AFS). Systematic point-to-point errors of 6% and an overall scale error of 9% for the H1 data are not shown, neither are the global scale uncertainties for the other experiments.

4 Spin Structure Functions.

The structure function $F_2(x)$ is closely related to the distribution of quarks and anti-quarks inside the proton. Neglecting the anti-quark component inside the proton, $F_2(x)$ is equal to the sum of spin up and spin down quarks weighted by their electric charges squared.

$$F_2\,(x) \;=\; \frac{1}{2}\sum_i e_i^2 \quad \left(q_i^{\uparrow}(x) + q_i^{\downarrow}(x)\right)$$

On the other hand the spin structure function $g_1(x)$ is defined as the difference between spin up and spin down quarks.

$$g_1\,(x) \;=\; \frac{1}{2}\sum_i e_i^2 \quad \left(q_i^{\uparrow}(x) - q_i^{\downarrow}(x)\right)$$

In the scaling limit the spin structure functions of the proton and neutron obey the so called Bjorken sum rule

$$\begin{aligned}\int dx\,(g_1^p(x) - g_1^n(x)) \;&=\; \frac{1}{6}\left|\frac{g_A}{g_V}\right| \left\{1 - \frac{\alpha_s}{\pi} + c_2\left(\frac{\alpha_s}{\pi}\right)^2 + \ldots\right\} \\ &=\; 0.189 \pm 0.003 \ @ \ Q^2 = 10\ \mathrm{GeV}^2\end{aligned}$$

which is derived by assuming the validity of QCD implemented by isospin invariance. g_A and g_V are the vector and axial vector couplings measured in nuclear beta decay and α_s is the strong coupling constant of QCD. The coefficient c_2 has been calculated to second order in the strong QCD coupling constant α_s.

The additional assumption of a symmetric strange sea inside the proton makes it possible to derive the Ellis – Jaffe sum rule, which refers to protons and neutrons separately.

$$\begin{aligned}
\Gamma_1^p = \int dx\ g_1^p(x) &= \frac{1}{12}\left|\frac{g_A}{g_V}\right| \cdot \left\{1 + \frac{5}{3}\ \frac{3\ F/D - 1}{F/D + 1}\right\} + 0(\alpha_s) \\
&= 0.172\ @\ Q^2 = 5\ \mathrm{GeV}^2 \\
\Gamma_1^n = \int dx\ g_1^n(x) &= \frac{1}{2}\left|\frac{g_A}{g_V}\right| \cdot \left\{-1 + \frac{5}{3}\ \frac{3\ F/D - 1}{F/D + 1}\right\} + 0(\alpha_s) \\
&= 0.070 \pm 0.004\ @\ Q^2 = 10\ \mathrm{GeV}^2
\end{aligned}$$

Experimentally the structure functions $g_1^{p,n}(x)$ are derived from cross section asymmetries scattering polarized leptons (electrons or muons) off polarized hydrogen or deuterium targets with the nucleon spin parallel or anti-parallel to the lepton spin.

$$A_\parallel = \frac{\sigma^{\uparrow\downarrow} - \sigma^{\uparrow\uparrow}}{\sigma^{\uparrow\downarrow} + \sigma^{\uparrow\uparrow}}$$

New results on measurements of spin structure functions from SMC at CERN represented by S. Bueltmann and the experiments E142, E154 and E155 at SLAC represented by P. Grenier have been reported to this workshop. In both cases the validity of the fundamental Bjorken sum rule has been verified within the experimental errors.

$$\begin{aligned}
\Gamma_1^p - \Gamma_1^n &= 0.199 \pm 0.038 \quad (SMC) \\
&= 0.163 \pm 0.010 \pm 0.016 \quad (SLAC)
\end{aligned}$$

These numbers have to be compared to an expectation of $\Gamma_1^p - \Gamma_1^n = 0.171 \pm 0.008$ at $Q^2 = 3\ \mathrm{GeV}^2$. On the other hand both groups observe a significant violation of the Ellis – Jaffe sum rule, which could be interpreted in terms of an asymmetric strange sea contribution to the spin structure. Here the experimental numbers

$$\begin{aligned}
\Gamma_1^d &= 0.034 \pm 0.009 \pm 0.006 \quad SMC \\
&= 0.042 \pm 0.003 \pm 0.004 \quad SLAC
\end{aligned}$$

should be compared with a prediction of $\Gamma_1^d = 0.07$, where Γ_1^d is the integrated deuterium spin structure function.

5 Diffractive Processes.

Diffraction is a well known phenomenon in hadronic processes. Thus it came as a surprise to the HERA experiments that a sizable fraction of the observed DIS events showed the typical pattern of diffractive interactions with a rapidity gap between the outgoing proton and the rest of the

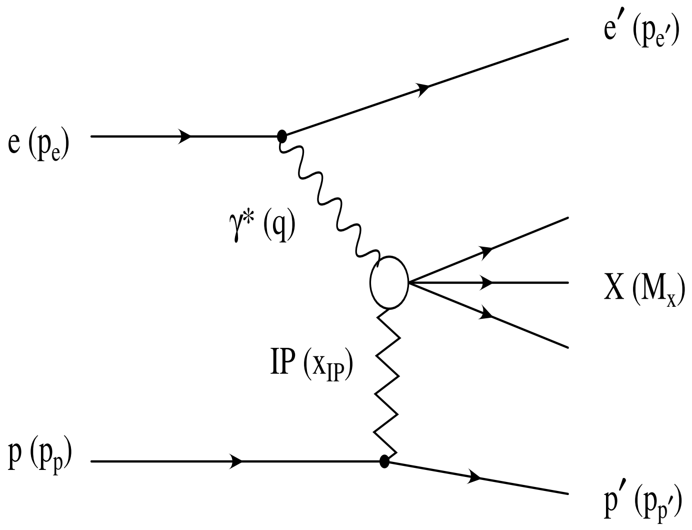

Figure 8: Rapidity gap events in DIS initialized by an interaction of the virtual photon with the charged components of the pomeron.

hadronic final state [8]. 10% of the DIS cross section is diffractive, a typical order of magnitude for hadron hadron scattering,however, surprisingly high for deep inelastic processes. A possible physics origin of rapidity gap events in deep inelastic lepton proton scattering may be inferred from the diagram in Fig. 8. Instead of coupling directly to one of the (coloured) partons inside the proton, the virtual photon couples to a (colourless) component, which mediates diffractive interactions and will be termed pomeron in the present context. This assumption takes care of the two observations, the diffractive nature of the process and the existence of a rapidity gap between the outgoing beam particle and the final state hadrons, which is due to the fact that no colour quantum numbers are exchanged between the proton and the diffractively produced hadrons. DIS thus offers a new window to diffractive physics. According to Fig. 8 the basic process is electron pomeron scattering with the possibility of investigating the partonic structure of the pomeron where one profits from the high resolution power of virtual photons.

In order to describe the kinematics of diffractive processes, a set of new variables is introduced: $x_{I\!P}$, the momentum fraction carried by the pomeron inside the proton and β, which is equivalent to x_{Bj} corresponding to the momentum fraction carried by the interacting parton in the scaling limit.

$$x_{I\!P} = \frac{Q^2 + M_x^2 - t}{Q^2 + W^2 - M_P^2}$$

$$\beta = \frac{x_{Bj}}{x_{I\!P}} = \frac{Q^2}{Q^2 + M_X^2}$$

M_P is the proton mass, M_X the mass of the diffractively produced hadronic system and W the mass of the hadronic final state including the proton debris. The quantity t denotes the momentum transfer from the incoming to the outgoing proton and can in general be neglected. As t is not measured in present experiments measured cross sections refer to an integral over t.

The deep inelastic cross section for diffractive lepton proton scattering depends thus on one additional variable $x_{I\!P}$, the momentum fraction carried by the pomeron.

$$\frac{d^3\,\sigma^D_{ep}}{dx_{Bj}\;dQ^2 dx_{I\!P}} \;=\; \frac{4\pi\;\alpha^2}{x_{Bj}\;Q^4}\left\{1-y+\frac{y^2}{2}\right\}\,F_2^{D(3)}\;\left(x_{Bj},\;Q^2,\;x_{I\!P}\right)$$

Experimentally it has been observed by H1 and ZEUS [9] that the data are consistent with factorization into a universal pomeron flux factor $f_{I\!P/P}\;(x_{I\!P})$ and a cross section for electron pomeron scattering:

$$\frac{d^3\sigma^D(\beta,\;Q^2,\;x_{I\!P})}{d\beta\;dQ^2\;dx_{I\!P}} \;=\; \frac{d\sigma_{eI\!P}}{d\beta dQ^2}\;f_{I\!P/P}\;(x_{I\!P})$$

The universality of the pomeron flux factor i.e. its independence on Q^2 and β is demonstrated in Fig. 9, where a straight line is fitted to the measured cross sections corresponding to a behaviour:

$$f_{I\!P/P}\;\sim\;\frac{1}{x^n_{I\!P}}$$

The exponents n quoted by H1 $n_{H1} = 1.19 \pm 0.06 \pm 0.07$ and ZEUS $n_{ZEUS} = 1.30 \pm 0.08^{+0.08}_{0.14}$ are still compatible with the assumption that the pomeron which is being probed in DIS is the same soft pomeron which is responsible for the universal increase of total cross sections observed by Donnachie and Landshoff [10]. In that case one would expect $\int dte^{bt}/x_{I\!P}^{2\alpha(t)-1} = 1.09$, where $\alpha(t)$ is the slope of the soft pomeron with an intercept at t = 0 of $\alpha(0) = 1.08$.

The cross section in its factorised form is equivalent to the assumption that a pomeron structure function $\tilde{F}_2^D$ can be defined as:

$$\tilde{F}_2^D(\beta, Q^2) = \int F_2^{D(3)}(\beta, Q^2, x_{I\!P})dx_{I\!P}$$

Fig. 10 shows the pomeron structure function with Q^2 and β as independent variables. The independence of $\tilde{F}_2^D$ on the momentum transfer Q^2 is a strong indication for a partonic substructure, while the β dependence, which is completely different from the proton structure as a function of x_{Bj}, is a first hint of a large gluon component in the pomeron. Both HERA collaborations have made an attempt to determine the gluon content, H1 (J. Dainton [1]) by a leading log QCD fit with an estimate of 70 – 80 % and ZEUS (H. Abramowicz [1]) by a method [11] where they make use of the jet rate in rapidity gap photo-production events with 30 – 80 % gluon contribution.

Deep inelastic lepton proton scattering offers a new approach to study the nature of the pomeron and to assess its partonic structure. The investigations have just started and basic questions are still waiting for an answer. In particular it has not yet been established that in deep inelastic scattering we really see the same pomeron as in hadron hadron scattering. One has to keep in mind that events, which enter the pomeron structure analysis are typically low x_{Bj} processes where the photon structure may play an essential role. Buchmüller and collaborators have designed a model [12] in which a photon after disintegrating into a quark – anti-quark pair travels through the strong colour field of the proton fluctuating between colour octet and singlet states. The singlet states, when they survive, lead to rapidity gap events, while octets

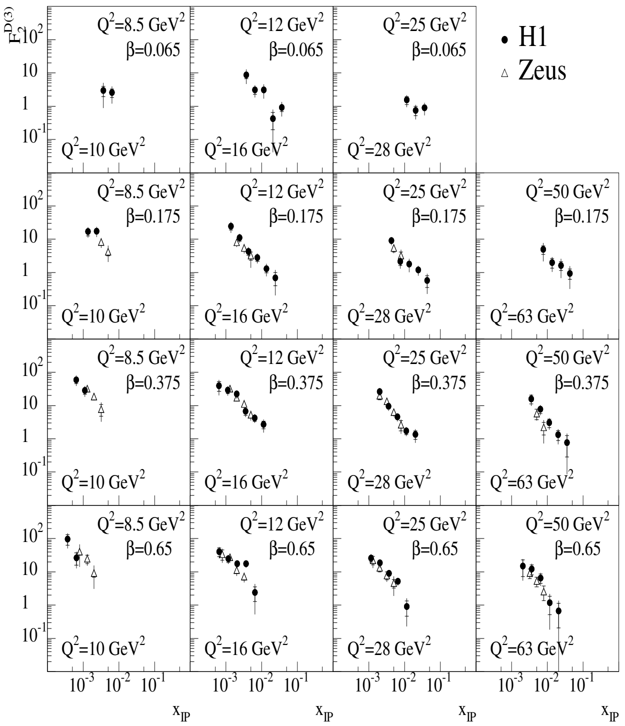

Figure 9: Evidence for factorization. The data are consistent with a universal slope independent of Q^2.

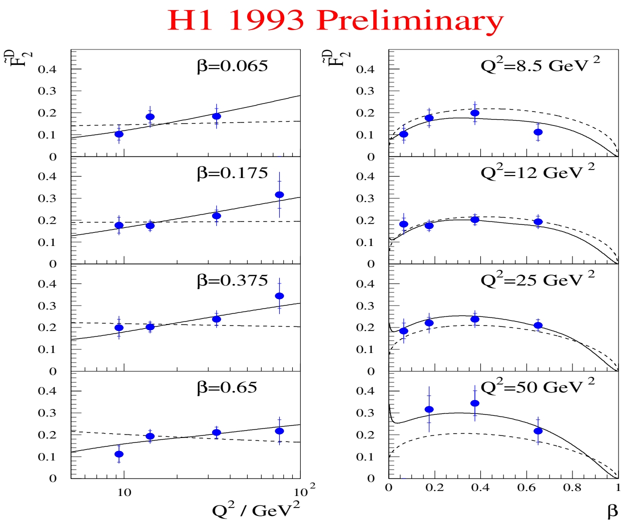

Figure 10: Pomeron structure as a function of Q^2 and β.

represent normal DIS reactions. Until now no gross discrepancies with this ansatz have been discovered. A similar approach without a pomeron but colour rearrangements inside the proton has been proposed by G. Ingelman and collaborators [13]. Their model is available as a special version of the LEPTO Monte Carlo generator and it fits the experimental data as well.

A study of charm production in rapidity gap events could give further insight into the nature of diffractive phenemena in deep inelastic scattering. It is known from a search for diffractive charm production in proton lithium reactions by the E653 collaboration [14] that the charm content of the proton and thus of the pomeron is smaller than 0.2 %. Therefore charm production in diffractive DIS events can only proceed through a photon gluon fusion process if the gluon is part of the pomeron or alterantively it could emerge from a fluctuation of the photon into a $c\bar{c}$ pair surviwing as a colour singlet after its passage through the proton. These two mechanisms are kinematically very different and distinguishable. A first indication of a D^* signal in rapidity gap events has been shown by J. Dainton [1]at this conference and with more data a detailed analysis on the origin of these events may become possible.

Also collider data from Fermilab can be used to study the pomeron properties in hard collisions. F. Borcherding [1] has shown D0 data with first evidence for a rapidity gap between jets. These events emerge from processes, where the interaction between the constituents of the proton and anti-proton is mediated by a pomeron instead of a gluon or another gauge boson.

6 Conclusion.

I have only one conclusion to summarize the Blois meeting. A new type of experiment has entered the diffractive club. Deep inelastic lepton proton scattering at high energy has a 10 % diffractive contribution and the introduction of a new scale, the virtuality of the photon, offers the possibility to study the partonic structure of diffraction and the application of perturbative QCD methods to model the reaction. This will give new life to a field, which was not in the focus of high energy physics during the last years.

Acknowledgment.

I would like to thank the organizers for an interesting and stimulating conference and for their excellent support during the workshop. I would like to thank all speakers for their help in providing transparencies. I am very greatful to my colleagues working at DESY for very useful discussions in particular to J. Bartels, J. Dainton, A. Levy and J. Whitmore.

References

[1] Contribution to this conference.

[2] J.D. Bjorken and J. Kogut, Phys. Rev. D8 (1973) 1341

[3] UA4/2 Collaboration C. Augier et al., Phys. Lett. B316(1993)448

[4] H1 Collaboration T. Ahmed et al., Phys. Lett. B299(1993)374

[5] H1 Collaboration S. Aid et al., DESY preprint DESY 95 – 162, submitted to Z. Phys. Aug. 1995

[6] ZEUS Collaboration M. Derrik et al., Phys. Lett. B293(1992)465;
Z. Phys. C63(1994)391

[7] G.A. Schuler and T. Sjostrand, Nucl. Phys. B407(1993)539

[8] ZEUS Collaboration M. Derrik et al. Phys. Lett. B315(1993)481
H1 Collaboration T. Ahmed et al., Nucl. Phys. B429(1994)477

[9] H1 Collaboration T. Ahmed et al., Phys. Lett. B348(1995)681 ZEUS Collaboration M. Derrik et al., DESY 95 – 093

[10] A. Donnachie and P. Landshoff, Nucl. Phys. B303(1988)634

[11] ZEUS Collaboration M. Derrik et al., Phys. Lett. B356(1995)129

[12] W. Buchmüller and A. Hebecker Phys., Lett. B355(1995)573

[13] A. Edin, G. Ingelman, J. Rathsman, DESY preprint DESY 95 – 145 A. Edin, G. Ingelman, J. Rathsman, DESY preprint DESY 95 – 163

[14] E653 Collaboration K. Kodama et al., Phys. Lett. B316(1993) 188