ELECTROPRODUCTION OF Φ-MESON ON PROTON AND DEUTERON

$s-\bar{s}$ CONTENT OF THE NUCLEON
HIDDEN COLOR COMPONENT IN NUCLEI

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- INTRODUCTION

During the Mainz Workshop, it has been proposed {1} to measure the exclusive photo and electroproduction of Φ-mesons at relatively large P_T on the proton and the deuteron. For the proton case, the physics motivation is to test the two gluons (perturbative pomeron) exchange mechanisms. The new idea is to get information on the $s-\bar{s}$ component of the proton and its contribution to the spin of the nucleon using the spin observables as a filter to suppress, at least partially, the dominant VDM process. As far as the mechanisms are concerned, in this kinematical domain, the perturbative Pomeron exchange is expected to dominates. Any other exchange process like $s-\bar{s}$ or ***uud*** knock out has to be emphasized either by a good choice of kinematical conditions where the Pomeron exchange is expected to be minimized{2,3} or by extension of measurements to spin observables able to disentangle processes beyond VDM. For the deuteron case, the mechanisms of Φ-meson production on the proton being once well understood, it is aimed to use the two gluons exchange as a tool to explore hidden color components in nuclei, each gluon being coupled to different nucleon in the target.

The purpose of this contribution is to present the ideas which are contained in these spin observables on the nucleon able to filter and eliminate, at least partially, the dominant VDM. It is shown than the measurements have to be done for two different transverse/longitudinal ratios implying electroproduction around 15 to 20 GeV at two Q^2 values. The status of simulations, with a new Φ-meson generator which have been developed, is presented defining the feasibility criteria for the experimental device. The present contribution is limited to the case of a proton target.

- WHY Φ-MESON ELECTROPRODUCTION?

A fair understanding of the exclusive electro and muon production of ρ-meson at $\sqrt{s}$ around 10 GeV has been well interpreted in a model where the pomeron exchange is expressed as to be dominantly a perturbative two gluons exchange {4,5} for Q^2 extending from 1 to 10 $(GeV/c)^2$. At low energy, quark-interchange mechanisms may compete in the light-quark sector. These exchanges are strongly suppressed in the heavy-quark sector to the extent that the strange or charmed component of the proton ground state is small. In this respect, Φ-meson production appears to be a much clearer test for the two-gluons exchange model when compared to ρ-production: the Φ-meson being mainly made of a $s-\bar{s}$ pair, quark interchange is suppressed. Laget and Mendez-Galin {6} have applied with success a two-gluon exchange model to the Φ-meson photo and electroproduction data available in the few GeV domain at $-t< 1$ $(GeV/c)^2$ {7a, 7b}. This model has stressed an important feature concerning a destructive interference between the two main graphs where in one the two gluons are exchanged by one quark of the photon and in the other each gluon is emitted by either the quark or the anti-quark from the photon fluctuation: in the limit of an infinite energy, a dip, independent on Q^2, appears around $-t = 2$ to 3 $(GeV/c)^2$. New calculations taking into account the energy dependence of the transition amplitude show that the minimum is partially filled and appears enough to identify the mechanisms only for a γ^* energy higher than about 15 GeV. Others processes can also be observed like $s-\bar{s}$ or ***uud*** knock out from the proton as already mentioned. A possible observation in favor of this kind of mechanisms has been reported by D.P. Barber. {8} A possible strategy to separate those mechanisms, could be the study of the p(e, e'Φ) at medium Q^2 values (1 to 3 GeV/c^2) over an extended $|t|$ domain (1 to 4 GeV/c^2) to observe the dip or at least a change of slope. Once the two gluons exchange mechanism is identified one will have to measure other observables to separate this process from the knock-out processes. The interest to separate the uud knock-out process in the domain of large |t|, is that the $s-\bar{s}$ pair in the Φ meson appears as it was in the proton, giving then information on its strangeness contents. Titov calculations {3} predict, at low energy, a strong enhancement of this mechanism at large |t| values. Calculations have to be done for the ELFE energy domain. One straight forward way to identify this kind of mechanism, is the observation of the angular distribution of the two Kaons coming from the Φ decay to disclose a non natural parity exchange. A more sophisticated technique, which was already used with hadron probes {9} on nuclei, is the measurement of helicity transfer from the virtual γ to the Φ meson, which in fact corresponds to study the $K\bar{K}$ distribution for opposite incident γ^* tensor polarization P_{ZZ}. The study of the azimuthal distribution of Φ meson in electroproduction is also a good way to separate the contributions of the interference terms σ_{TT} and σ_{TL} which inform us on the non conservation of the "leptonic" helicity.

- THE SPIN OBSERVABLES.

The Leptonic Helicity-flip Probability

The idea to use the spin observables as a filter to separate the mechanisms with and without leptonic helicity conservation is an extension of a technique already used in nuclear physics to study the spin strength distribution in nuclei {9}. A set of spin 1 particles is statistically known if the helicity states populations are known, or equivalently, if the total population and the vector and tensor polarizations are known. Those quantities may be defined as well in the initial state as in the final state. Because the final and the initial state are connected by the scattering amplitude matrix, the population and polarizations in the final state are related to those of the initial state by linear relations {10}. The coefficients of those relations are the spin observables, as the analyzing power A_{zz} which gives the effect of the initial polarization on the cross-section, the polarizing power $P^{z'z'}$ which gives the polarization in the final state when the initial state has no polarization, and the polarization transfer parameters $K_{zz}^{z'z'}$ which gives the effect of the initial polarization on the polarization in the final state. Using those observables, the longitudinal spin-flip probabilities (or the leptonic helicity-spin probabilities) can be obtained. Only the single leptonic helicity-spin probability S_1^z, which correspond to a change of one unit of the helicity from the γ^* to the Φ, is given here as an example:

$$S_1^z = \frac{1}{9}(4 - A_{zz} - P^{z'z'} - 2K_{zz}^{z'z'})$$

For all mechanisms conserving the helicity, (where the SCHC rule is verified), S_1^z must be equal to 0. Therefore $S_1^z \neq 0$ is a strong signature of an SCHC violation. This property may be used as a filter to suppress, at least partially, the diffractive mechanisms at low |t| and then separate a possible $s-\bar{s}$ knock-out contribution. At large |t|, it can be used to separate the two gluons exchange mechanism from a possible uud knock-out, or to separate the contribution of the scalar from the vector part of the diquark state in the diquark model.

The Target Polarization.

If the $s-\bar{s}$ pair is coming from the γ^* it may be expected than the target polarization has only a small effect on the Φ polarization, but, if the $s-\bar{s}$ pair is coming from the proton, the Φ polarization is expected strongly depends on the target polarization which then appears also as a good tool to disentangle the knock-out mechanisms from the diffractive production. Moreover in the case of the uud knock-out, the measurement of the Φ polarization for two opposite values of the target polarization may give directly the polarization of the $s-\bar{s}$ pair in the proton.

- <u>HOW TO MEASURE THE HELICITY-FLIP PROBABILITY.</u>

The measurement of the spin transfer parameters need the measurement of the tensor polarization of the Φ (trough the analyze of the azimuthal distribution of the Kaons coming from the Φ decay), for two opposite values of the tensor polarization of the incident γ. Plotting the tensor asymmetry versus the vector asymmetry on a graph. (Fig 1a), it appears that the tensor asymmetry is always equal to 1 for a real γ (the 0 helicity state is forbidden), and then this asymmetry cannot be reversed. So the measurement of the helicity-flip probability must be done in electroproduction at two values of Q^2 associated with opposite values of ε_T. In a crude model where the transverse and longitudinal cross-sections are supposed respectively proportional to the population of the ±1 and 0 helicity states, and if we suppose that, as in VDM, we have $\sigma_L/\sigma_T=0.33(Q^2/M_\Phi^2)$, the correlation between the two values $Q^2(1)$ and $Q^2(2)$ where the measurements have to be done is shown on Fig 1b. Due to the lower limit introduced by the detection in the electron scattering angle, the domain where the spin observables may be measured is limited at $0.5 < Q^2 < 3$ $(GeV/c)^2$.

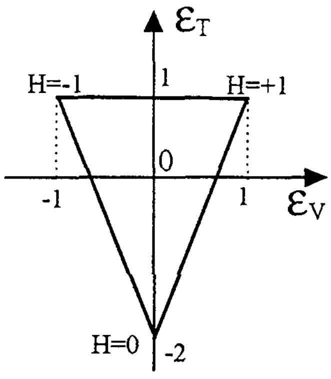


Fig. 1a

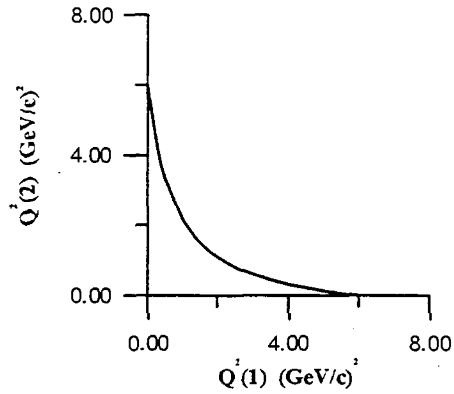
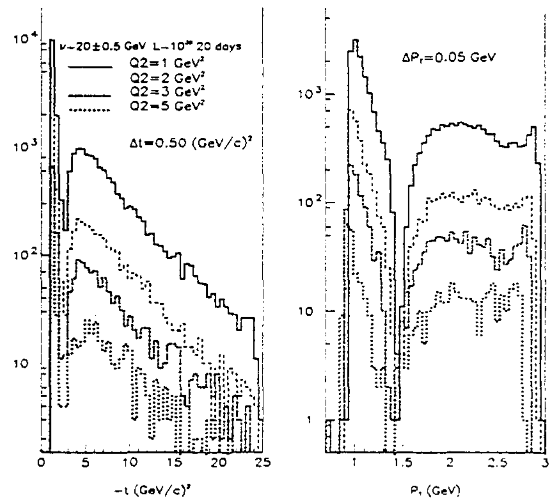


Fig 1b

- <u>THE Φ GENERATOR AND THE EXPECTED COUNTING RATE</u>

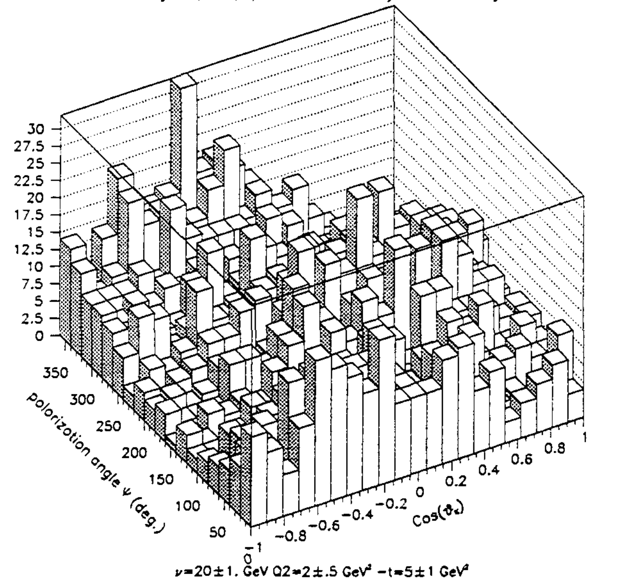
A new events generator for the exclusive photo and electroproduction of Φ meson has been developed at the IPN Orsay. The photoproduction cross-section is taken according to the Kemp's and Marshall's parametrization {see ref in 7b} in the diffractive domain, then according to the two gluons exchange model for $|t| > 1(GeV/c)^2$. In electroproduction, the Q^2 dependence of the diffractive domain is given by the Φ propagator {7b} and by the two gluons exchange prediction in the "hard" region. Because this dependence is not the same in the two domain, the transition from the diffractive production to the "hard" production was done by a Fermi function between $|t|=0.8$ and $|t|=1$ $(GeV/c)^2$ to avoid a discontinuity. It has been also taking into account of the σ_{TT} and σ_{TL} interference terms as well as of the electronic analyzing power. The calculations are in progress but predictions are not yet available for those quantities. The virtual photon flux was calculated according to the usual way with a cut off on Q^2 at 0.15 $(GeV/c)^2$. The K^+K^- decay channel of the Φ meson has been included in the generator, up to now in the hypothesis of the helicity conservation with the VDM prediction for the ratio σ_L/σ_T. A calculation of this ratio in the two gluons exchange model is in progress. The simulations using this events generator show that, with 20 GeV γ^*, a transverse momentum P_T= 3 (GeV/c) can be reached. The counting rates expected in electroproduction are given in Fig 2 for ν=20 GeV with E_{inc}= 25 GeV and a luminosity $\mathcal{L} = 10^{36}$ $cm^{-2}s^{-1}$ and 20 days of measurement for different values of Q^2. The binning was $\Delta\nu$= 1 GeV, ΔQ^2= $1(GeV/c)^2$, and Δt= 0.5 $(GeV/c)^2$ or ΔP_T= 0.05 GeV/c. With this binning the measurements are possible up to Q^2= 3 $(GeV/c)^2$ at least. The polar and azimuthal distribution of the Kaons coming from the Φ

Fig 2



decay has been performed in those conditions with a binning of $\Delta(\cos\theta)=0.1$ for the polar angle (in laboratory) and $\Delta(\psi)\cong 20$ deg. for the polarization angle (azimuthal distribution) (see Fig 3). It appears that the polarimetry is still possible with this binning at $Q^2=2$ $(GeV/c)^2$ but it becomes difficult to have enough precision for $Q^2 > 3$ $(GeV/c)^2$ at large |t| values.

Fig. 3 ψ/cos(ϑ) K+ L=2. 10** 20 days of data taking



- CONCLUSION

In exclusive photo and electroproduction of vector mesons at large P_T perturbative calculations becomes possible. One of the "hard-like" mechanism is the two gluons exchange mechanism (perturbative Pomeron exchange). Already used in exclusive ρ photo and electro production, it lead to a good agreement with data for the Q^2 dependence and for the t dependence if |t| is not too large. At large |t|, the quark interchange dominates. Due to the purely strange nature of the Φ, the quark interchange must be strongly suppressed relative to the light sector in the Φ production. The exclusive photo and electroproduction of Φ meson off the proton at large transverse momentum transfer then appears as a much clearest test of the hard-like mechanisms as in the case of lighter vector mesons. A new idea is to extend the study of the Φ exclusive electroproduction to the spin observables and to use the helicity-flip probability to filter and eliminate (at least partially), the diffractive processes and other processes conserving the helicity to separate possible knock-out mechanisms. At large |t| values the ***uud*** knock-out could be important and may give us informations on the $s-\bar{s}$ pair in the proton. In that case, the utilization of a polarized target lead to the (tensor) polarization of the (vector state) of this pair in the proton. Calculations have still to be done at the ELFE energies. First simulation shows the feasibility of the experiment up to $Q^2=3$ $(GeV/c)^2$ even with the spin observables measurement, which appears difficult but not impossible. A possible extension of the exclusive Φ photo and electroproduction on the deuteron may give an access to hidden color component in the deuteron. First calculation, not presented here, are already done {6} and shows the feasibility of the measurements of the cross-sections, but the polarimetry don't seems possible in a reasonable time in that case. Some of the ideas given here are still intuitive and much work as well theoretical as experimental is still needed.

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