Laboratori Nazionali di Frascati

LNF-68/59

M. Greco, A. Tenore and A. Verganelakis : VIRTUAL PROTON COMPTON EFFECT ON THE WIDE ANGLE BREMSSTRAHLUNG AND POLARIZATION PHENOMENA.

Estratto da : Phys. Letters 27B, 317 (1968)

VIRTUAL PROTON COMPTON EFFECT ON THE WIDE ANGLE BREMSSTRAHLUNG AND POLARIZATION PHENOMENA

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Received 17 June 1968

It is shown that the virtual proton Compton contribution on the wide angle bremsstrahlung may change appreciably the QED predictions, when the intermediate lepton is far off its mass shell. We encourage polarization measurements as providing a new source of information about virtual proton Compton effect.

There are many very important experiments (photoproduction of large-angle pairs, wide angle bremsstrahlung, pion electro-production, etc.) in which contributions arise from the virtual proton Compton amplitude. Fig. 1 shows this for the particular case of wide angle bremsstrahlung. Due to the well known difficulties of explicitly evaluating this amplitude, its precise effect on the above experiments is not yet well understood; this has introduced appreciable uncertainties into their interpretation.

We have studied the virtual proton Compton effect by approximating the blob of fig. 1 by the contributions of a single virtual proton and a 3-3 resonance. The purpose of the present letter is a) to give explicite results on the contribution of the virtual proton Compton amplitude to the wide angle bremsstrahlung and to show that its importance depends strongly on the kinematical configuration of the experiment and may change appreciably the results expected from pure QED, at critical points at which the intermediate electron or muon is far off its mass shell and b) to suggest that the study of polarization phenomena in the above mentioned experiments provides us with a new source of information and helps us to gain a better understanding of the virtual proton Compton effects.

Our calculations have been carried out as follows: adopting the particle labels indicated in fig. 1, where ϵ is the polarization four-vector of the real photon, we write the amplitude of the diagram of fig. 1 as

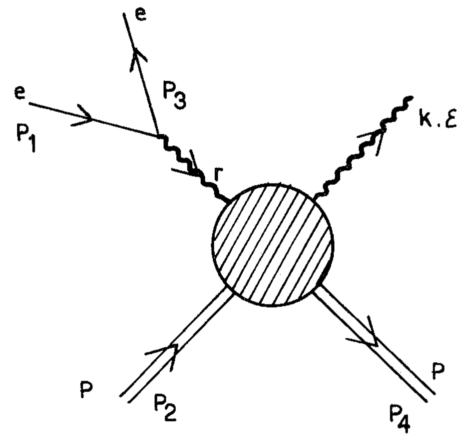

Fig. 1. Diagram for virtual proton Compton contribution to the wide-angle bremsstrahlung cross sections.

$$F = \bar{u}(p_4)\, \bar{\epsilon}^{\mu}\, M_{\mu\nu}\, \epsilon^{\nu} u(p_2) \;, \tag{1}$$

where the index ν refers to the real photon,

$$\bar{\epsilon}^{\mu} = e\frac{1}{r^2}\bar{u}(p_3)\,\gamma^{\mu} u(p_1) \;, \tag{2}$$

and $M_{\mu\nu}$ denotes the virtual proton Compton amplitude. For $M_{\mu\nu}$ we have chosen the expression given in ref. 1, written in terms of twelve manifestly gauge invariant amplitudes f_i ($i = 1, \ldots, 12$).

The contribution of the single nucleon inter-

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high momentum transfer. Instead the exponential form factor gives more reasonable results confirming the different behaviour of the γNN^* and γNN form factors, as has been observed previously in the analysis of electroproduction of pions [8]. A measurement in coincidence of the wide angle bremsstrahlung in the kinematical configuration of fig. 2b for example, in which the B.H. contribution is negligible by comparison to the virtual proton Compton term, may confirm more clearly the above conclusion.

In addition we have evaluated explicitly what to expect in future experiments on wide angle bremsstrahlung involving polarized proton targets or measurements of the polarization of the recoil proton.

Let us define the quantity

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

where $d\sigma(\uparrow,\downarrow)$ is the differential cross section of wide angle bremsstrahlung in the laboratory frame with the two possible target spin states along $\hat{s}$.

In figs. 3a and 3b, R is plotted as a function of u_1 when $\hat{s}$ is perpendicular to the momentum of the incoming beam and the rest of the kinematics is as in figs. 2a and 2b respectively.

As we see from these figures, large polarization effects arise, which are due to the electroexcitation of the recoil proton into the 3-3 resonance. In fact is easy to see that only the virtual proton Compton amplitude and its interference with the Bethe-Heitler term do contribute to the difference $[d\sigma(\uparrow) - d\sigma(\downarrow)]$. We observe again that in the large momentum transfer region, R is strongly dependent on $G(r^2)$ and a measurement of R can provide information about this form factor as well as the imaginary part of the virtual proton Compton amplitude. We found similar results when the initial protons are unpolarized but the polarization at the final recoil protons is observed.

In experimentes in which e^+ and e^- are available, also the interference between Bethe-Heitler and virtual proton Compton amplitude is avoided in the difference $[d\sigma(\uparrow) - d\sigma(\downarrow)$, provided that the polarization of the target remains the same. Thus the wide angle bremsstrahlung experiments with polarized targets or in which the polarization of the recoil protons is measured, provide us a good source of information about virtual proton Compton amplitude.

This aim can be better achieved in the large-angle pair photo-production experiments, if similar polarization measurements are made ‡. In this case, in a symmetrical arrangement where charges and polarization, of the final leptons are not observed, the difference $[d\sigma(\uparrow) - d\sigma(\downarrow)]$ depends only on the virtual proton Compton amplitude.

We hope that such experiments can be realized in near future. They would give supplementary information about the behaviour of the γNN^* form factor at high momentum transfers, and provide a valuable insight into the virtual proton Compton effect.

Particularly, a clarification of the importance of the virtual proton Compton term to the large-angle pair production experiments would be valuable, because in many current theoretical interpretations of these measurements, the contribution of the nucleon isobars has been considered, in poorly justified approximations, negligibly small [12].

The details of our calculations will be published elswhere.

We wish to thank Professor Nicola Cabibbo and Professor Bruno Touschek for many stimulating discussions. One of us (A.V.) is grateful to the Istituto di Fisica dell'Università di Roma and to the Laboratori Nazionali di Frascati del CNEN for their support and kind hospitality. He is also indebted to Professor B. De Tollis for several interesting and helpful discussions.

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‡ Measurements involving large-angle asymmetrical electron-positron pair production to yield information on virtual proton Compton amplitude have already been performed by Asbury et al. [11].