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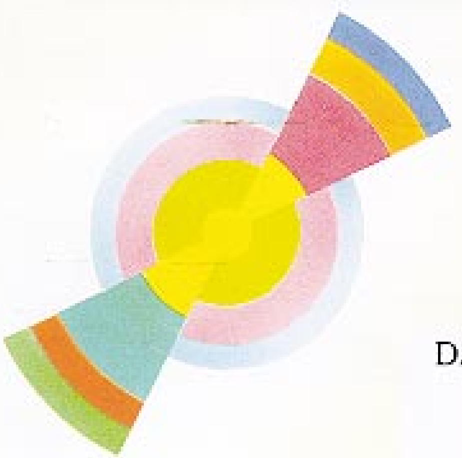

DAPNIA/SPhN-96-30 10/1996

Virtual Compton Scattering

$\gamma^* p \rightarrow \gamma' p'$

A1 Collaboration at MAMI

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DAPNIA

Département d'Astrophysique, de Physique des Particules, de Physique Nucléaire et de l'Instrumentation Associée
CEA/Saclay F-91191 Gif-sur-Yvette Cédex

Contribution to the XIV International Conference
on Particles and Nuclei,
WILLIAMSBURG, Etats-Unis, May 22-28, 1996

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The Virtual Compton Scattering allows us to measure for the first time the generalized polarizabilities of the proton. The experimental method used to extract these new observables is presented as well as some preliminary results obtained at MAMI.

Virtual Compton Scattering is a foundamental exclusive reaction off the proton which provides us with a new insight of the internal structure of the nucleon. Below π^0 production threshold ($M_p < \sqrt{s} < M_p + M_\pi$, but arbitrary Q^2), this experiment measures the generalized polarizabilities of the proton[1]. These are new electromagnetic observables, functions of Q^2 the mass of the incoming virtual photon, which enlarge the concept of electric (α) and magnetic (β) polarizabilities already defined in real compton scattering ($Q^2 = 0$)[2]. At MAMI, we measure for the first time the VCS in order to deduce generalized polarizabilities at $Q^2 = 0.33$ GeV^2.

We can experimentally access VCS by the electroproduction of photons : $ep \to e'p'\gamma$. In this reaction, the final photon can be emitted either by the

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electron or by the proton. The first process is described by the Bethe-Heitler (BH) amplitude which is calculable from Quantum Electro-Dynamics (QED). The second process is described by the Virtual Compton Scattering (VCS) amplitude, that can be split in two parts : the Born term containing only the nucleon and anti-nucleon contributions (exactly calculable) and the Non-Born term related to the excited states and parametrized by 10 polarizabilities. The probability $\mathcal{M}^{exp}$ (which is the differential cross section divided by a phase space factor) is therefore a coherent sum of the different amplitudes,

$$\mathcal{M}^{exp} = \frac{1}{4}\sum_{spin} |T^{BH} + T^{VCS}|^2 = \frac{1}{4}\sum_{spin} |T^{BH} + T^{Born} + T^{NonBorn}|^2$$

The low energy theorem from Low[3] says that in an expansion in powers of the outgoing photon energy (q$'$) in the final photon-proton center of mass system, the two first terms of the probability $\mathcal{M}$, of the order ${q'}^{-2}$ and ${q'}^{-1}$ are only due to the interference of the BH and Born amplitudes and are completely calculable. The effect of the polarizabities appears from the ${q'}^{0}$ term. The experimental method (see Fig.1) is to study the evolution of ${q'}^{2}\mathcal{M}^{exp}$ at small values of q$'$.

The experiment is performed in the A1 Hall at MAMI. The scattered proton and electron are detected in coincidence in two magnetic spectrometers and the final photon is tagged by the reconstructed missing mass: $M_X^2 = 0$. With the high duty cycle available at MAMI, one is not limited by the accidental counting rates and one can use a typical luminosity of $\mathcal{L} = 2.10^{37}$ cm^{-2}s^{-1}. Thanks to the excellent resolution of the facilities ($\Delta E/E = 10^{-4}$ for the energy of the incident electrons, $\Delta P/P = 10^{-4}$ for the momenta of the two spectrometers and an angular resolution better than 3 mrad) the contribution of the π^0 in the missing mass is very clearly separated from the events characterized by the photon mass (see Fig.2).

Fig.3 shows preliminary results obtained from data acquired in spring 1996. At small *q'* the expected effect of polarizabilities is very small (see Fig.1). Data points which have still to be corrected for radiative effects, have hence to reproduce the predictions for an on-shell nucleon, that is the contribution from BH and Born terms. The radiative corrections are beeing calculated for the first time at Saclay taking into account all the diagrams of order α^4 in the cross section[4]. Their implementation will provide us very soon with the first test of the low energy theorem for the VCS which represents a severe check of our analysis method and will ensure a reliable extraction of the polarizabilities in the energy domain q$'$=100 MeV.

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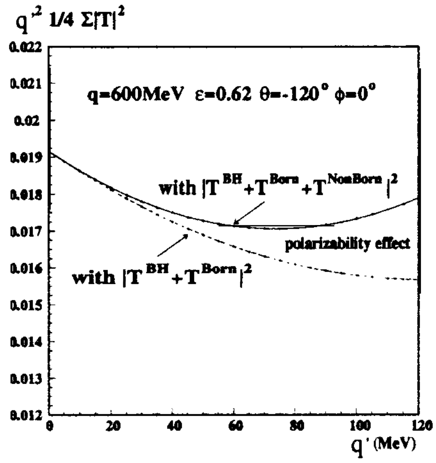

Figure 1: Evolution of $q'^2 \times \mathcal{M}^{exp}$ from calculations of P.A.M. Guichon. et al. The ordinate and slope at $q' = 0$ are due only to the interference between BH and Born, while the polarizability effect appears in the second order of the expansion.

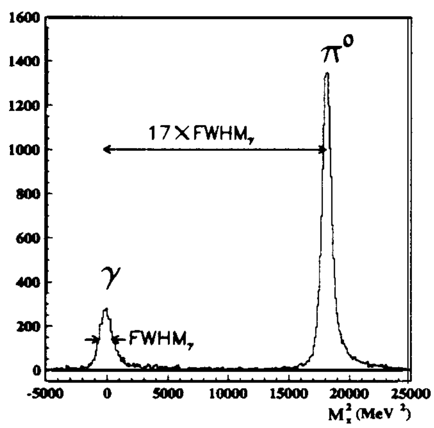

Figure 2: Experimental spectrum of the missing mass in the reaction p(e,e'p)X with a very good separation between Compton and π^0 electroproduction events.

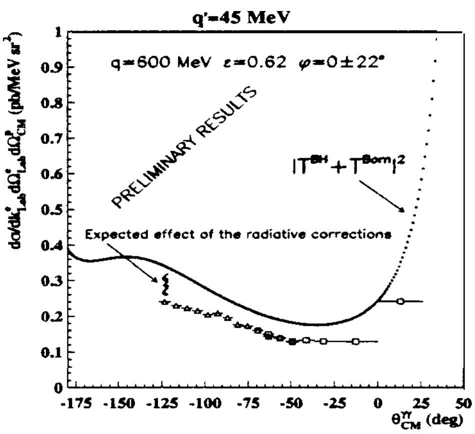

Figure 3: Preliminary results at q'=45 MeV. The two sets of points are obtained with two different positions for the proton spectrometer (but the same electron setting) and are in good agreement in the region of same kinematics. Full radiative corrections are likely to be very soon implemented. At small q' they will provide the first test of the low energy theorem for the VCS. The generalized polarizabilities will be extracted from data at higher q'.

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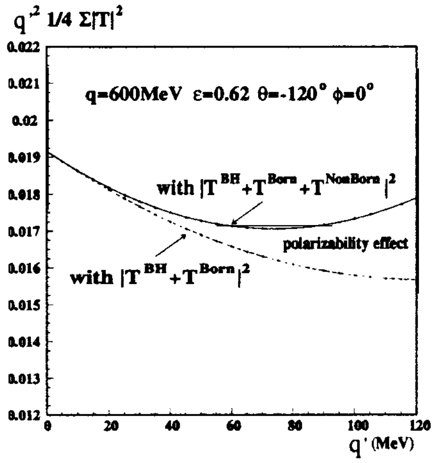

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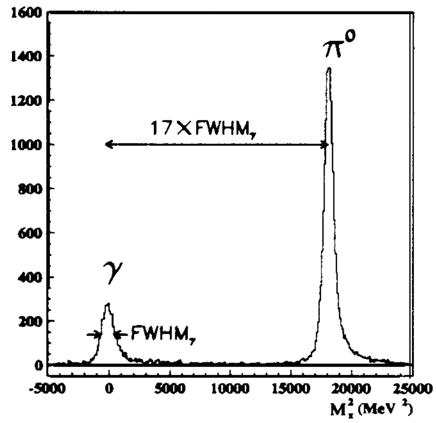

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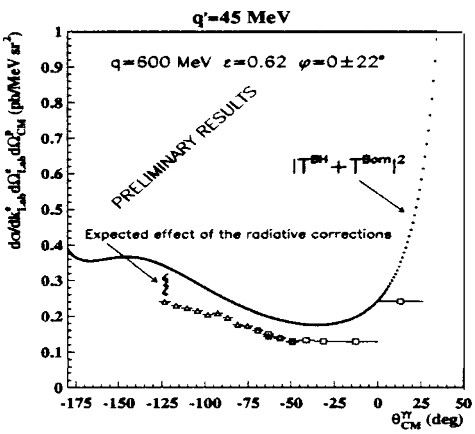

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