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Virtual Compton Scattering under π^0 threshold at Q^2=0.33 GeV^2. Preliminary results.

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We have measured the absolute unpolarized cross sections for photon electro-production off the proton $ep \rightarrow ep\gamma$ with the Three-Spectrometer-Setup at MAMI at a momentum transfer q=600 MeV/c and a virtual photon polarization ϵ=0.62. The momentum q' of the outgoing real photon range from 33 to 111 MeV/c. We extracted two combinations of the recently introduced generalized polarizabilities [1,2].

1. VIRTUAL COMPTON SCATTERING AND GENERALIZED POLARIZABILITIES.

VCS at low energy can be understood as electron scattering off a target which is in the quasi-constant electric and magnetic fields of the emitted photon [3].
In the elastic case, one measures charge and current distributions inside the nucleon, that is the form factors. In the VCS case, one measures the deformation of those distributions by an electromagnetic perturbation. The rigidity of the nucleon is then probed. The observables are called Generalized Polarizabilities (GPs) and they are functions of Q^2 the squared quadri-momentum of the virtual photon. They generalize the concept of electric ($\bar{\alpha}$) and magnetic ($\bar{\beta}$) polarizabilities already measured in real Compton scattering ($Q^2 = 0$).

2. FORMALISM TO EXTRACT POLARIZABILITIES FROM CROSS SECTIONS.

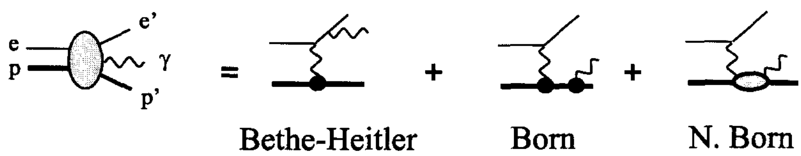

Figure 1. *The three processes contributing to the photon electro-production. Crossed processes are omitted for clearness.*

The VCS process is accessed through photon electro-production. Three types of processes contribute to the final state (see fig. 1). The dominating contributions are the bremstrahlung process on the electron (Bethe-Heitler) and the equivalent process on the proton (Born). They are exactly calculable in QED once the proton form factors are known. The signal of GPs is obtained by substracting this known part from the absolute coincidence cross section :

$$d^5\sigma^{exp} - d^5\sigma^{BH+Born} = \Phi q' \left((\mathcal{M}_0 - \mathcal{M}_0^{BH+Born}) + \mathcal{O}(q') \right) \quad (1)$$

where $d^5\sigma^{BH+Born}$ refers to the cross section calculated only with the Bethe-Heitler and Born amplitudes. $\mathcal{O}(q')$ refers to higher terms. $\Phi q'$ is the phase space factor. It has been shown[1,2] that :

$$\frac{\mathcal{M}_0 - \mathcal{M}_0^{BH+Born}}{v_{LT}} = \frac{v_{LL}}{v_{LT}}(P_{LL}(Q^2) - \frac{1}{\epsilon}P_{TT}(Q^2)) + P_{LT}(Q^2) \quad (2)$$

where the P_{IJ} are structure functions which are linear combinations of the GPs, and v_{LL} and v_{LT} are known kinematical coefficients.

3. EXPERIMENTAL RESULTS.

For the measurement of the absolute cross sections, the scattered electron was detected in coincidence with the recoiling proton in two high-resolution spectrometers. The photon emission process was then selected by a cut on the missing mass around zero [4]. From the five independent kinematical variables, three were fixed that is q=(600±20)MeV/c, the out-of-plane angle $\varphi = 0^0 \pm 22^0$, and $\epsilon = 0.62 \pm 0.02$. The given ranges are due to the acceptances of the spectrometers. The two remaining variables are the momentum q' and the angle $\theta_{\gamma\gamma}$ of the outgoing real photon. Varying the energy beam (750÷855 MeV) and the settings of the electron spectrometer (momentum and angle), we chose 5 values of q' (see fig 2). For each value of q', $\theta_{\gamma\gamma}$ varies by changing settings of the proton spectrometer.

Figure 2 presents differential cross sections as a function of $\theta_{\gamma\gamma}$ for five values of q'. At low q', our data are in agreement with the QED calculation ($d^5\sigma^{BH+Born}$). When q'

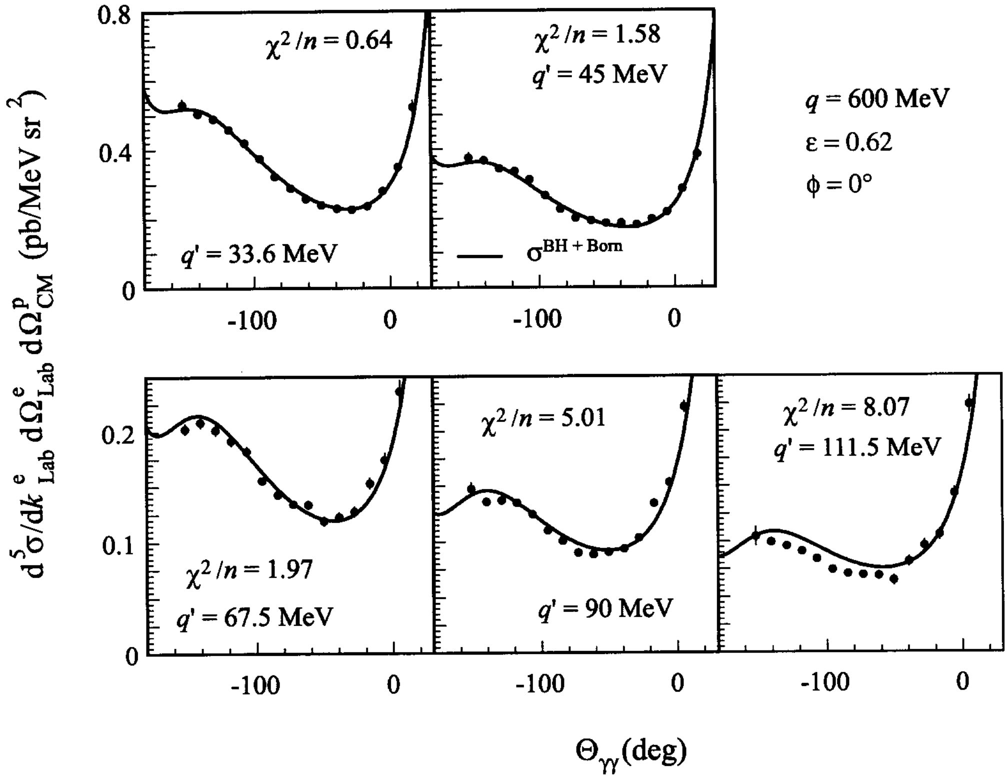

Figure 2. *Differential cross sections as a function of $\theta_{\gamma\gamma}$ for five domains in momentum of q'. The deviation between the data and QED (curve) is evaluated by a χ^2 calculation. When q' increases χ^2 also increases. This shows the effect of the GPs.*

Preliminary results.		
$Q^2 = 0.33\mathrm{GeV}^2$ $\epsilon = 0.62$	$(P_{LL}(Q^2) - \frac{1}{\epsilon}P_{TT}(Q^2))$ GeV^{-2}	$P_{LT}(Q^2)$ GeV^{-2}
This experiment	27 ± 3 (± 12)	-7 ± 1 (± 4)
HBChPT [5]	26.3	-5.7
LSM [6]	10.9	0.
ELM [7]	5.9	-1.9
NRQCM [8]	17.0	-1.7

Table 1
Our prelimary results are compared to theoretical predictions : HBChPT for Heavy Baryon Chiral Perturbation Theory, LSM for Linear Sigma Model, NRQCM for Non Relativistic Quark Constituent Model and ELM for Effective Lagrangian Model.

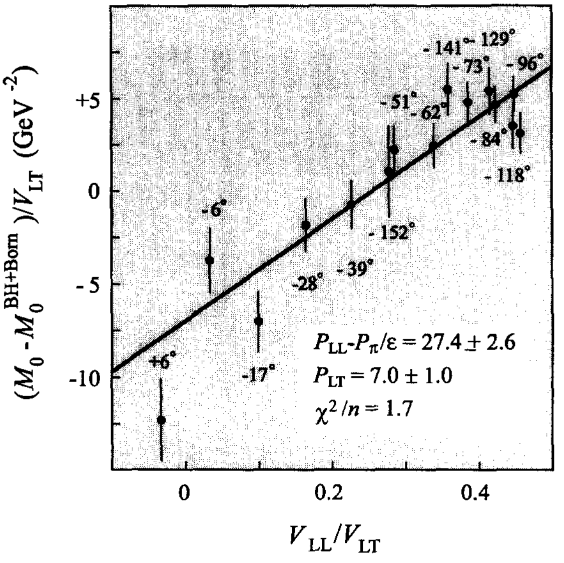

Figure 3. *The 15 experimental values of* $(\mathcal{M}_0 - \mathcal{M}_0^{BH+Born})/v_{LT}$ *versus* v_{LL}/v_{LT}. *Only statistical errors are plotted. The intercept at origin and the slope are the investigated structure functions related to the GPs.*

increases, the deviation from $d^5\sigma^{BH+Born}$ is related to the effect of the GPs. For each value of $\theta_{\gamma\gamma}$, we extract the leading term of right hand side of equation 1. The resulting values of $\mathcal{M}_0 - \mathcal{M}_0^{BH+Born}$ obtained for 15 photon angles $\theta_{\gamma\gamma}$ should satisfy the equation 2. The slope and the intercept at origin are the structure functions we are looking after. Figure 3 shows the agreement with a linear fit and the extracted values are presented in table 1. The first error is the statistical one, and the second one is systematic dominated by the extraction method of the leading term in equation 1. This last error will decrease in the final analysis. These experimental values are compared to different theoretical predictions. The best agreement is obtained for the Heavy Baryon Chiral Perturbation Theory [5].

4. CONCLUSIONS.

Our experiment at Mainz demonstrates that it is possible to measure two structure functions related to the GPs. These observables wich are linked to the internal structure of the nucleon are very efficient to disentangle models. Two similar experiments at higher (Jefferson Lab) and smaller (MIT-Bates) Q^2 are forthcoming. To go further and measure independently all the polarizabilities, it is necessary to perform a experiment with a polarized beam and a measurement of the recoiled proton polarization.

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