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SMALL-ANGLE COMPTON SCATTERING ON HYDROGEN AND DEUTERIUM

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(Presented by D.Wegener,University of Karlsruhe)

We have measured Compton scattering on hydrogen at 6 GeV, and in a second, slightly modified experiment on hydrogen and deuterium at 5 GeV, both at particularly small momentum transfers ranging from -0.004 to -0.08 $(GeV/c)^2$ at 6 GeV and from -0.002 to -0.06 $(GeV/c)^2$ at 5 GeV.

The experimental set up and the analysis procedure is described in paper No. 1016 on this conference.

The differential cross sections determined in this way are shown in Fig. 1. Only statistical errors are shown. Systematic errors result mainly from the uncertainty of the background $\pi^0+\eta$ ($\pm$1%) of the converter position ($\pm$1.5%), and in the case of the 6 GeV data from the error in the telescope efficiencies ($\pm$1.5%). By quadratic addition to the normalization error we obtain a total systematic error of $\pm$2.5% at 5 GeV and $\pm$3.6% at 6 GeV.

Fig. 2. shows the data of this experiment together with those of other DESY and SLAC experiments[1,2].

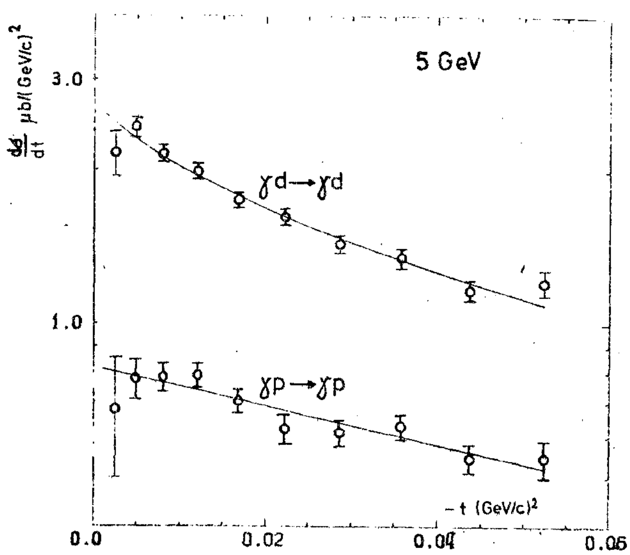

Fig. 1. Compton scattering on hydrogen and deuterium.

A fit to our data of the form $\frac{d\sigma}{dt} = A\exp(Bt)$ as suggested by diffraction theory, yields the results shown in Table 1. The errors include statistical errors as well as the total systematic error.

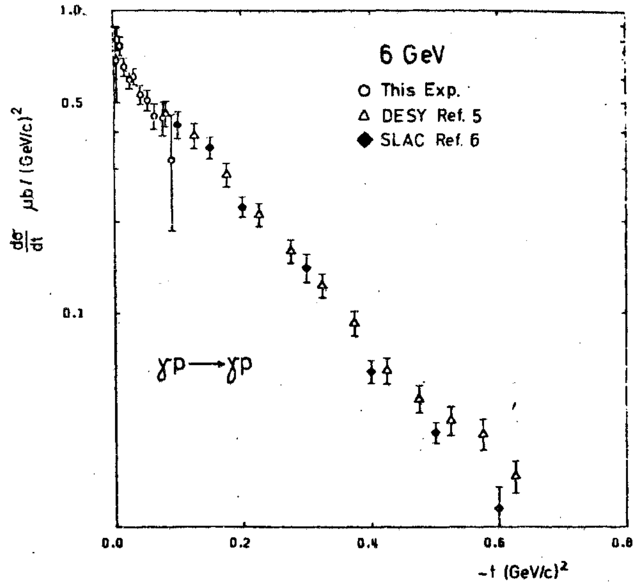

Fig. 2. Differential Compton cross section on hydrogen.

Table 1

	Photon energy GeV	$(GeV/c)^2$	$(GeV/c)^{-2}$
This experiment	5	0.82±0.04	8.5±1.5
	6	0.79±0.04	8.6±1.2
DESY[5]	4–6.2	0.84±0.08	5.7±0.35
SLAC[7]	8	0.82±0.04	7.7±0.5
VDM Prediction (see text)	5 6	0.46±0.05 0.44±0.04	- -

The extrapolated forward cross sections are shown as a function of energy in Fig. 3 together with those from other experiments[1-3]. The curve shows the contribution of the spin-independent amplitude f_1 in the standard decomposition

$$\frac{d\sigma}{dt}(0) = \frac{\pi}{k^2}\left(|f_1|^2 + |f_2|^2\right),$$

where f_2 is the spin-dependent amplitude, and k the photon energy, f_1 was calculated from the total cross section via optical theorem and dispersion relation[4]. Our extrapolated forward cross sections are 10% smaller than the predictions, but consistent within the errors. They are compatible with a vanishing spin dependent amplitude f_2 at both energies.

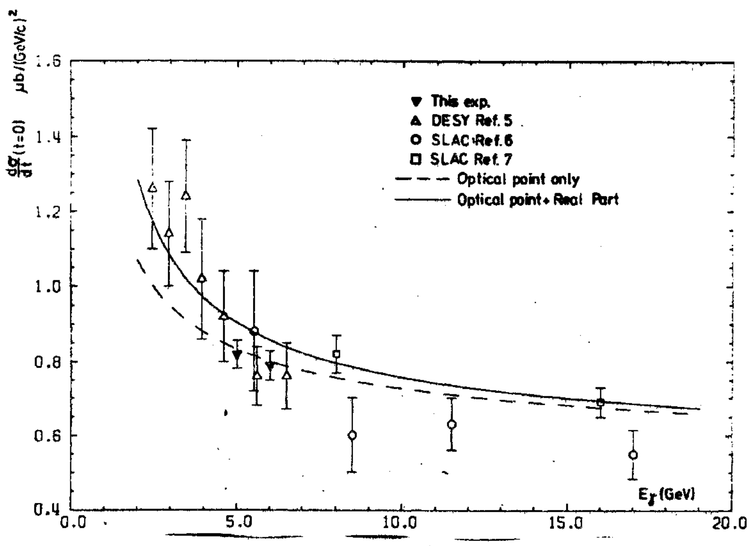

Fig. 3. Differential forward Compton cross section on hydrogen.

For comparison with the predictions of the vector dominance model, VDM, the forward cross sections have been calculated using the sum rule

$$\frac{d\sigma}{dt}(\gamma p \to \gamma p) = \left[\sum_V \frac{\alpha}{4}\frac{4\pi}{\gamma_V^2}\left(\frac{d\sigma}{dt}(\gamma p \to V p)\right)^{1/2}\right]^2$$

with recent values for the vector meson cross sections[5] and the Orsay values for the coupling constants $\frac{\alpha}{4}\frac{4\pi}{\gamma_V^2}$ [6]. Table 1 demonstrates the well known discrepancy: The data are higher by about 40% than the VDM predictions. This discrepancy can be removed by including the higher vector mesons $\rho'(1600)$, $\psi(3100)$ and $\psi(3700)$ and by extending the VDM to the GVDM[7].

The differential cross section for the deuteron (Fig. 1) shows the transition from coherent scattering at low $|t|$ to incoherent scattering at higher $|t|$ values. Neglecting spin effects the cross section can be written in closure approximation as

$$\left(\frac{d\sigma}{dt}\right)_d = \frac{2\pi}{k^2}\left[|a_0|^2(1+F(t)) + |a_1|^2(1-F(t))\right] G(t)$$

where is the proton energy. $F(t)$ and $G(t)$ denote the deuteron form factor and the Glauber correction factor[8]. a_0 and a_1 are the amplitudes of isospin 0 and 1 exchange. The influence of the Fermi motion[9] is smaller than the Glauber correction, according to our own calculations[10]. The corresponding differential proton cross section is given by

$$\left(\frac{d\sigma}{dt}\right)_p = \frac{\pi}{k^2}\left(|a_0|^2 + |a_1|^2 + 2\,\mathrm{Re}\,(a_0 a_1^*)\right)$$

From the deuteron and the proton cross sections one can deduce the two isospin ratios $|a_1|^2/|a_0+a_1|^2$ and $Re(a_0 a_1^*)/|a_0+a_1|^2$. By a fit to our experimental data we obtain the values listed in Table 2. Systematic errors resulting mainly from the uncertainty in the $\pi^0+\eta$ background component and in the precise converter position, amount to about half of the statistical errors, while normalization errors common to both targets should have no effect.

The isospin ratios depend however sensitively on the assumed shape of $F(t)$ and $G(t)$. We have used a deuteron wave function following Reid and calculated $G(t)$ in the ρ-dominance approximation. If we analyse the data starting from a Hulthen wave function[12], we obtain consistent, although numerically different ratios. For comparison we have also calculated these parameters from the data[3] using our Glauber corrections. The values are then changed slightly in Table 2.

Table 2

Ratios of isospin amplitudes with statistical errors. *Calculation with Hulthen wave function. ** Analysis of the data from Ref.[3]) using a deuteron wave function by Reid[10,11]

	$\frac{\|a_1\|^2}{\|a_0+a_1\|^2}$	$\frac{Re(a_0 a_1^*)}{\|a_0+a_1\|^2}$
This experiment, 5 GeV	0.13±0.09 (0.08±0.10	0. ±0.03 0.02±0.03)*
SLAC[7] 8 and 16 GeV	0.03±0.10 (0.04±0.11)	-0.049±0.012 (0.007±0.018)**
DESY[17] $\frac{Im\, a_1}{Im\, a_0}$	= 0.042±0.008	

All the ratios are compatible with a vanishing or at least small isospin 1 exchange contribution to photon nucleon interaction. They are also compatible with the measured[13] ratio

$$\frac{Im\, a_1}{Im\, a_0} = \frac{\sigma(\gamma p) - \sigma(\gamma n)}{\sigma(\gamma p) + \sigma(\gamma n)}$$

as listed in Table 2, if one assumes equal real to imaginary part of the a_1 amplitude as predicted for A_2 Regge exchange.

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