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FORWARD PP-ELASTIC SCATTERING AT 35.7 GeV/*c*

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Abstract. The results from measurement on differential cross-section for pp-elastic scattering at incident momenta of 35.7 GeV/c in the four momentum transfer squared range $0.10 < -t < 0.46\,(\mathrm{GeV}/c)^2$ are presented. The absolute value at $t = 0$ of the ratio of real to imaginary parts $|\rho| = 0.33 \pm 0.23$ and slope parameter for the differential cross-section slope $= (11.5 \pm 0.7)\,(\mathrm{GeV}/c)^{-2}$ were determined using the analytical properties of the scattering amplitude in the $\cos\theta$-plane. The slope parameter of the differential cross-section was found to increase with decreasing $|t|$.

In this paper are presented the results on the investigation of pp-elastic scattering at momenta 35.7 GeV/c. The experimental data were obtained on pictures in the JINR-Dubna 2 m hydrogen bubble chamber "Ludmila" exposed to a beam of diffraction scattering protons at the Serpukhov accelerator.

All events were measured using semiautomatic devices and processed by means of geometric reconstruction programs (MDTHRESH, HYDRA geometry) and the kinematic fitting program GRIND. Visual estimates of ionization were made of all tracks with momentum less than 1.5 GeV/c. Weights were introduced to account for scanning, measuring and computational losses. The elastic events were selected applying a cut in the missing mass to the identified proton $M^2 < 1.4\,\mathrm{GeV}^2$ and the momentum of the fast particle $P_{\mathrm{lab}} > 28$ GeV/c. The two prongs events were accepted as elastic scatters when in the program GRIND was obtained $X^2 < 18$ for elastic scattering hypothesis. Events which are in a plane nearly parallel to the optic axis are difficult to reconstruct. They can be missed at the scanning level, especially when the recoiling proton has a short range.

The momentum transfer distribution for the differential cross-section of the pp-elastic scattering at 35.7 GeV/c is shown in Fig. 1.

The experimental data on differential cross section were taken in the analysis in the interval $0.10 < t < 0.46\ (\mathrm{GeV}/c)^2$ in order to keep out the region of Coulumb interference and of the losses due to slow recoil protons. The differential cross section was analyzed using a method [1] which is based on the optimal use of the analytical properties of the scattering amplitude in the $\cos\theta$-plane. Its mathematical apparatus could be found elsewhere [2]. After a conformal mapping of the $\cos\theta$-plane into the unifocal ellipse in the z-plane so as the region $\cos\theta_1 < \cos\theta < \cos\theta_2$ gets mapped into the interval $-1 \le z \le 1$ and the cuts onto the ellipse $d\sigma/dt$ are expanded in a series of the Chebychev polynomials $T_m(z)$:

$$\frac{d\sigma[z(t)]}{dt} = \sum_{m=1}^{M} A_m B_m T_m[z(t)] \,. \tag{1}$$

Here B_m are the quantities connected with the ellipse dimensions; A_m are the expansion coefficients used to construct function Φ that controls the series convergence; M is the number of terms of the expansion used in the fitting. The minimization of the quantity $X = \chi^2 + \Phi$ [3] determines the series of truncation.

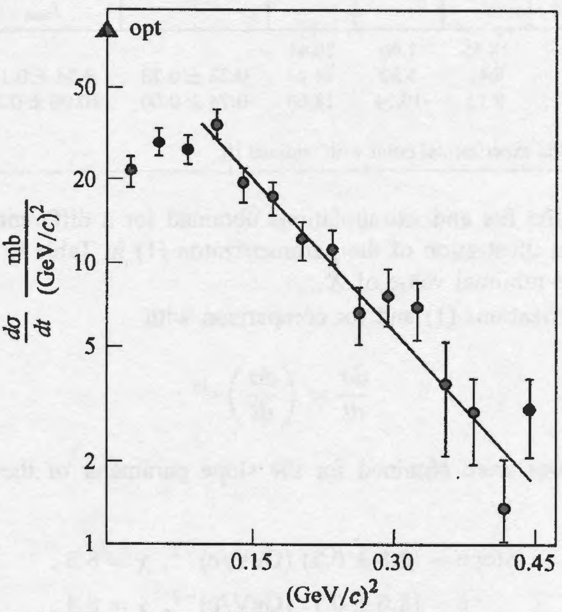

Fig. 1. Differential cross-section $d\sigma/dt$ for pp-forward elastic scattering at 37.5 GeV/c versus t — (•). The straight line is the fitted from $d\sigma/dt = (d\sigma/dt)_0\, e^{bt}$ in the $|t|$ interval $0.10 < |t| < 0.46$ (GeV/c)^2. ▲ — optical point

The absolute value of the ratio to the imaginary part of the elastic scattering amplitude was calculated by the expression:

$$|\rho| = \sqrt{\frac{(d\sigma/dt)_0}{(d\sigma/dt)_{opt}} - 1} \tag{2}$$

where the differential cross-section $(d\sigma/dt)_0$ at $t=0$ was determinated after extrapolation of series (1) at point $z(0)$ and the value of the optical point was determined from the optical theorem using experimental data on the total cross-section in this energy region $\sigma_{tot} = 38.49$ mb [4].

The slope parameter of the differential cross-section was difined by the expression:

$$\text{slope} = \frac{d}{dt} \ln \left(\frac{d\sigma}{dt} \right)_{\text{nuclear}} \tag{3}$$

where instead of $(d\sigma/dt)_{\text{nuclear}}$ series (1) was used.

Table 1.

M	$\left.\frac{d\sigma}{dt}\right\|_{t=0}$ mb/(GeV/c)^2	χ^2	Φ	X	$\|\rho\|$	slope (GeV/c)$^{-2}$	
						t_{max}	$t=0$
2	41.1 ± 2.5	18.45	1.96	20.41			
3	81 ± 12	8.41	5.82	14.23	0.33 ± 0.23	8.54 ± 0.17	11.52 ± 0.71
4	118 ± 56	8.13	10.54	18.66	0.74 ± 0.50	10.00 ± 0.31	15.8 ± 3.4

t_{max} corresponds to the experimental point with minimal $|t|$.

The results of the fits and extrapolations obtained for a different number of terms M are given as an illustration of the parametrizaton (1) in Table 1. The series should be truncated at the minimal value of X.

By the parametrizations (1) and for comparison with

$$\frac{d\sigma}{dt} = \left(\frac{d\sigma}{dt} \right) e^{bt} \tag{4}$$

the following values were obtained for the slope parameter of the differential cross section:

$$\text{slope} = (8.5 \pm 0.2)\ (\text{GeV}/c)^{-2},\ \chi = 8.5\ ;$$
$$b = (8.6 \pm 0.7)\ (\text{GeV}/c)^{-2},\ \chi = 8.4\ .$$

In the region of measurements both fits are practically indistinguishable. As they are shown, in the experimental data accuracy limit, the values of the slope and b-fitted parameters coincide in work [5].

The absolute value of the ratio of real to imaginary part of the pp-forward elastic scattering amplitude and the slope of $d\sigma/dt$ at $z(t=0)$ obtained by series (1) are calculated

$$|\rho| = 0.33 \pm 0.23\ ,$$
$$\text{slope}(t=0) = (11.5 \pm 0.7)\ (\text{GeV}/c)^{-2}\ .$$

The errors of the physical quantities of ρ and slope essentially reflect only the errors of $d\sigma/dt$ in the region of measurement and are not connected with errors originating from the truncation of the series (1).

It has been found that the slope of the differential cross-section increases continuously as the forward direction is approached (see Table 1 and works [1, 2, 6]). The slope at $t = 0$ differs from those commonly accepted. It is significantly larger.

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