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ЛАБОРАТОРИЯ ВЫСОКИХ ЭНЕРГИЙ

THE SLOPE PARAMETER OF THE DIFFERENTIAL CROSS-SECTION OF ELASTIC p-p-SCATTERING IN ENERGY RANGE OF 12 - 70 GEV

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THE SLOPE PARAMETER OF THE DIFFERENTIAL CROSS-SECTION OF ELASTIC p-p-SCATTERING IN ENERGY RANGE OF 12 - 70 GEV

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A very thin (≈ 3 μk $(CH_2)_n$) film target with multiple traversals of the internal beam of the Serpukhov accelerator was used in this experiment.

Eight semiconductor detectors registered the angle and the energy of recoil protons. Three scintillation counter telescopes registered the secondary particles emerged from the target. An on-line system was used in this experiment.

The measurements were performed for the time interval of 2 sec. in each pulse of the accelerator when the magnetic field was rising.

This makes it possible for us to obtain some information about the differential cross section of the elastic p-p scattering in the energy range of ≈ 45 GeV in each pulse.

The measurements were performed in the "t" interval as follows: $0.008 < |t| < 0.12\ (GeV/c)^2$.

In Fig.1 one can see an example of the measured differential cross section which was obtained at 58.1 GeV.

We have carried out 94 similar measurements in the energy region of 12-70 GeV.

As it follows from Bethe[1], the differential elastic p-p cross section can be described by the following formula (for a small value of t):

$$\frac{d\sigma}{dt} = C(A_J^2 + A_r^2 + A_c^2 - 2A_c (A_r + 2nA_J \ln\frac{\phi}{\theta})] .$$

$A_J = \sqrt{(\frac{d\sigma}{d(t)})_{opt}}\, e^{\frac{1}{2} b_J t}$ - the imaginary part of the elastic p-p scattering amplitude; b_J - the slope parameter; $A_r = \alpha A_J$ - the real part of elastic p-p scattering amplitude; $A_c = \frac{2nF(\theta)}{k\theta^2}$ - the Coulomb amplitude; $F(\theta) = e^{\frac{1}{2} b_J t}$ - the nuclear form factor of the nucleon. $n = \frac{1}{137\beta}$; $\phi = \frac{1.06}{kR}$; R - the nucleon radius, $t = -2p^2 (1-\cos\theta)$; θ, P, k - the scattering angle, the momentum and the wave number in the c.m.s. β - the speed of the incident proton in the l.s. We used $C = h = 1$.

Fig.2 gives 20 averaged values of the slope parameters as a function of the lab. energy of protons (see also Table 1) Fig.2 represents also the results of other experiments[2,3,4].

As is seen, the slope parameter is monotonously increasing when the proton energy rises in the 12-70 GeV range.

This means in the framework of the optical model that the interaction radius $R = 2\sqrt{b_J}$ is growing from 1.23 to 1.34 f.

We obtained the slope Pomeranchuk's pole from this data using the Ter-Martirosian's parametrisation for poles and residues[5]. We represented b_J as a function of $\ln(S/S_0)$.

$$b_J = b_0 + 2b_1 \ln S/S_0$$

($S_0 = 1\ GeV^2$) and found the parameters b_0 and b_1 from our experimental data:

$$\left.\begin{aligned} b_1 &= 0.47 \pm 0.09 \\ b_0 &= 6.8 \pm 0.3 \end{aligned}\right\} \qquad \chi^2 = 24.8 \text{ (20 experimental points).}$$

It follows from the value b_1 that $\alpha'_p = 0.40 \pm 0.09$.

One can compare our results with the predictions resulting from the basic principles of the modern theory. Many authors, for example /6/, have found that the increasing of the differential cross section slope parameter should not exceed $\ln^2 S$.

The results of our experiment are consistent with this prediction.

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Table 1

The Results of the Measurements of the Elastic p–p Scattering Slope Parameter b_J in the $|t|$ Region: $0.008 < |t| < 0.12 \left(\frac{GeV}{c}\right)^2$

E_{lab} kin GeV.	S $(GeV)^2$	b_J *) $(GeV/c)^{-2}$	R *) f
12.1	26.2	9.81 ± 0.35	1.236 ± 0.022
14.8	31.3	9.98 ± 0.12	1.247 ± 0.008
17.9	37.1	10.46 ± 0.12	1.276 ± 0.007
20.9	42.7	10.58 ± 0.12	1.284 ± 0.007
23.8	48.2	10.59 ± 0.11	1.284 ± 0.007
26.7	53.6	10.77 ± 0.11	1.295 ± 0.007
29.7	59.3	10.68 ± 0.11	1.290 ± 0.007
32.6	64.7	10.66 ± 0.11	1.288 ± 0.007
35.5	70.1	10.77 ± 0.11	1.295 ± 0.007
38.6	75.9	10.89 ± 0.10	1.302 ± 0.066
40.7	79.9	10.87 ± 0.14	1.301 ± 0.008
44.2	86.5	10.95 ± 0.10	1.306 ± 0.006
48.0	93.6	11.19 ± 0.11	1.320 ± 0.006
51.2	99.6	11.31 ± 0.11	1.327 ± 0.006
53.4	103.7	11.24 ± 0.12	1.323 ± 0.007
56.1	108.8	11.16 ± 0.10	1.319 ± 0.006
59.3	114.8	11.40 ± 0.09	1.333 ± 0.005
62.6	121.0	11.76 ± 0.12	1.353 ± 0.007
65.2	125.9	11.52 ± 0.12	1.339 ± 0.007
69.0	133.0	11.38 ± 0.11	1.331 ± 0.006

*) Δb_J (syst) = ± 0.3

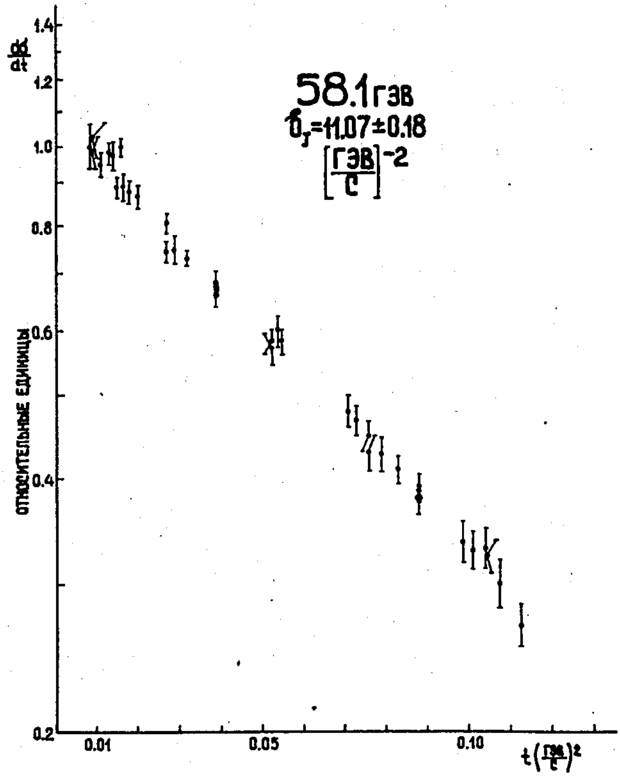

Fig. 1 . The differential elastic cross-section in the arbitrary units at 58.1 GeV.

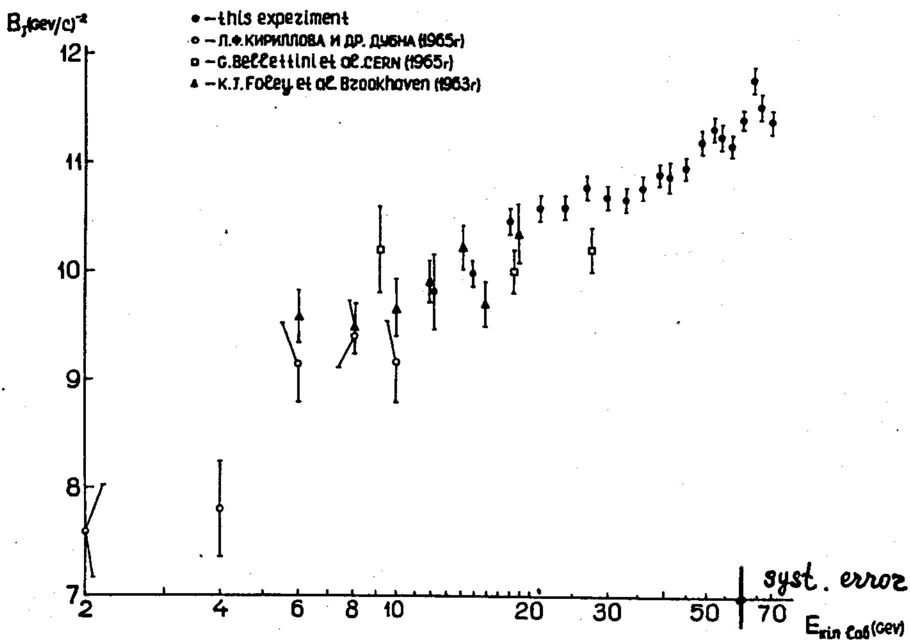

Fig.2. The results of the measurements of the slope parameter.