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EVIDENCE FOR A CHANGE OF SLOPE IN LARGE-t ELASTIC PROTON-PROTON SCATTERING AT $\sqrt{s}$ = 53 GeV

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ABSTRACT

New experimental results are presented on proton-proton elastic scattering in the range of momentum transfer 4 GeV^2 < −t < 10 GeV^2 at the centre-of-mass energy of $\sqrt{s}$ = 53 GeV. The data have been obtained using the Split-Field Magnet detector at the CERN Intersecting Storage Rings. We observe another change of slope of the differential cross-section near −t = 6.5 GeV^2.

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We have extended our previous measurements [1] of large-t elastic proton-proton scattering in the range 4 $GeV^2 < -t < 10$ GeV^2 in order to investigate with better sensitivity the open question whether further diffraction-like minima exist at large values of the momentum transfer. The data have been obtained using the Split-Field Magnet detector (SFM) at the CERN Intersecting Storage Rings (ISR). We report here results obtained at a centre-of-mass energy of $\sqrt{s}$ = 53 GeV for an integrated luminosity of 4.87×10^9/mb. We observe a new break in the t-dependence near $t = -6.5$ GeV^2 followed by an exponential decrease of the cross-section with a slope of $b = (0.88 \pm 0.13)$ GeV^{-2} in the t-range from 6 to 10 GeV^2.

The SFM detector has been described before [2]. It consists of two forward telescopes, each equipped with 12 multiwire proportional chambers, 1 m high, 2 m wide, and having 2 mm wire spacing. Each chamber has a vertical and a horizontal wire plane. The average magnetic field is 1.0 T, providing a momentum resolution of $\Delta p/p = \pm 7\%$ for scattered protons. Events are selected by requiring two charged tracks (one in each telescope) at the trigger level, and by a cut on the deviation from collinearity, after having performed the geometrical reconstruction and a kinematical fit with four constraints. In terms of χ^2 this cut corresponds to accepting events at the 1% confidence level.

The value of the differential cross-section at $t = -10$ GeV^2 is about 10^{10} times smaller than at $t = 0$. A careful study of possible contamination by background is therefore required. We have investigated the collinearity distribution, expressed in terms of χ^2, as a function of momentum transfer. A scatter diagram for events selected by the criteria described above is shown in Fig. 1. Attributing events with $\chi^2 > 9$ to background, we estimate a residual contamination of less than 5% for accepted events with $\chi^2 < 9$ at all t-values. This residual background has been neglected.

We have determined absolute differential cross-sections by correcting for the t-dependent acceptance of the detector and by applying an over-all normalization factor. The detailed procedure is described in Ref. 2; the acceptance at large t has been improved over the previous experiment [1] and has now a value larger than 40% for $-t > 3$ GeV^2.

The momentum transfer t is measured with a resolution of $\sigma_t = \pm 0.04$ GeV^2 at $t = -4$ GeV^2 increasing linearly to $\sigma_t = \pm 0.10$ GeV^2 at $t = -10$ GeV^2.

The over-all normalization factor is obtained by collecting monitor counts simultaneously with data taking. The monitoring telescope has been calibrated using the van der Meer method [3]; we estimate the systematic uncertainty of this monitor to be ±5%.

The results*) are shown in Fig. 2. Describing the differential cross-section by a single exponential with slope b we observe a succession of changing slopes; $b_1 = (10.3 \pm 0.02)$ GeV^{-2} for $0.25 < -t < 0.6$ GeV^2 **), followed by a narrow minimum at $-t = 1.34$ GeV^2 and a second maximum at $-t = 1.8$ GeV^2; $b_2 = (1.81 \pm 0.02)$ GeV^{-2} for $2.2 < -t < 6$ GeV^2, followed by a break near $-t = 6.5$ GeV^2 and a third slope $b_3 = (0.88 \pm 0.13)$ GeV^{-2} for $6 < -t < 10$ GeV^2 ***).

Several authors have predicted a second diffraction-like minimum in the t-range near 4 GeV^2 and an associated change in slope, by using optical models [4], constituent models [5] or exchange models [6]. To our knowledge none has predicted this set of slope values and breaks [7]. Wakaizumi and Tanimoto [8] have shown that a model of multiple scattering of constituents with suitably chosen form factors and wave functions can describe this data. Van Hove [9], using a quark-glue model, predicts a continuous change of slope with $b = 1.4$ GeV^{-2} at $t = -8$ GeV^2.

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*) Tables of the differential cross-sections are available from the authors.

**) This value has been obtained at $\sqrt{s} = 23$ GeV and 62 GeV, see Ref. 2.

***) Restricting the maximum likelihood fit to the range $7 < -t < 10$ GeV^2, we find $b_3 = (0.39 \pm 0.23)$ GeV^{-2}.

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Figure captions

Fig. 1 : Scatter diagram of collinearity in terms of χ^2 as a function of momentum transfer. Events with $\chi^2 < 9$ are selected. The residual background contamination is less than 5% at all t-values.

Fig. 2 : Differential cross-sections as a function of momentum transfer t. The error bars represent statistical and systematic errors. An overall scale uncertainty of ±5% has to be added.

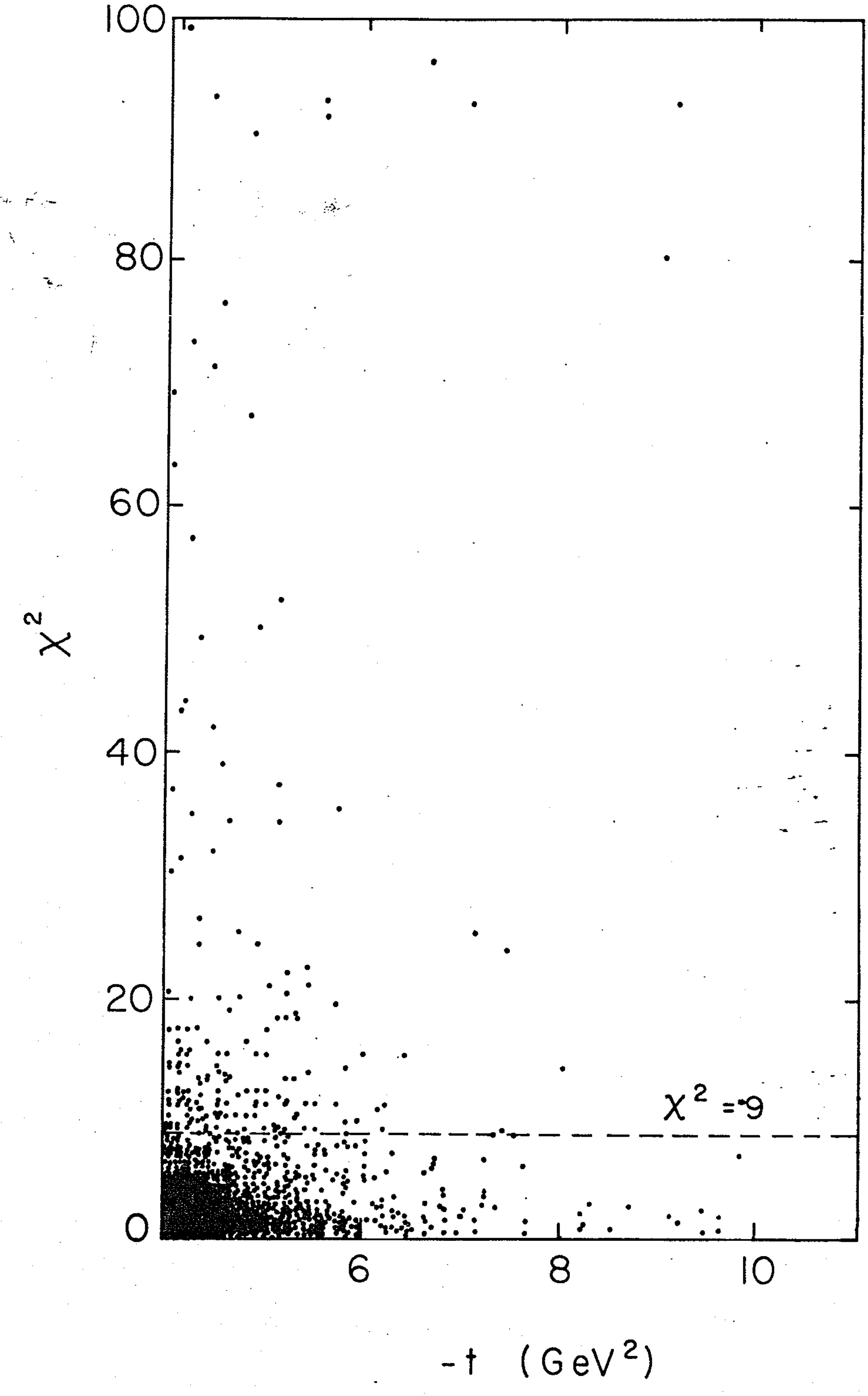

Fig. 1

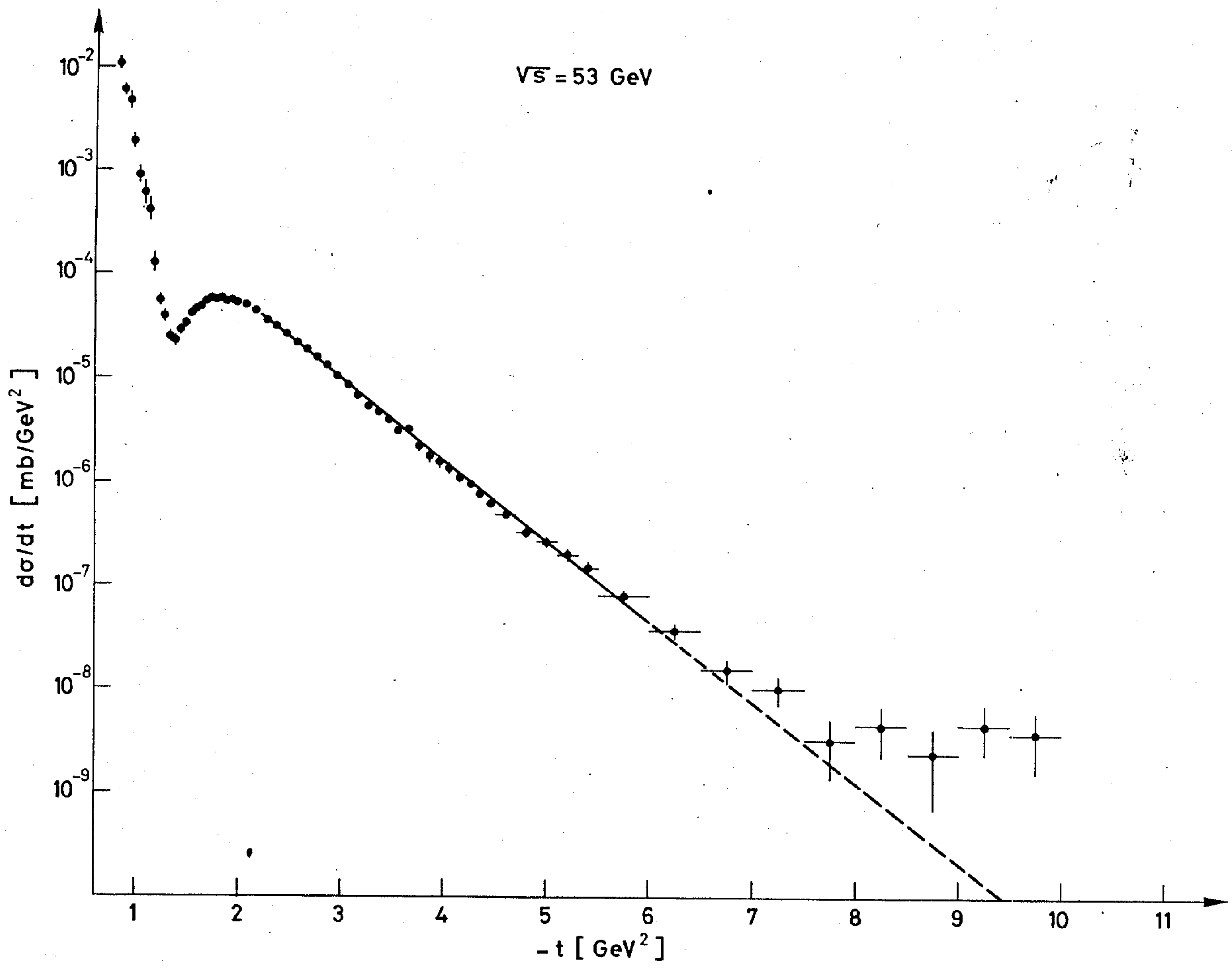
√s = 53 GeV
dσ/dt [mb/GeV²]
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
1
2
3
4
5
6
7
8
9
10
11
-t [GeV²]

Fig. 2