ANTIPROTON-PROTON ELASTIC SCATTERING AT 3.55 GeV/c

W.F. Baker[*], P.J. Carlson, V. Chabaud and A. Lundby

CERN, Geneva, Switzerland

J. Banaigs, J. Berger, C. Bonnel, J. Duflo,
L. Goldzahl and F. Plouin

Département Saturne, Saclay, France

ABSTRACT

Antiproton-proton elastic scattering has been measured at 3.55 GeV/c in the c.m. angular range from 20° to 77° and from 109° to 160°. Forward $\bar{p}p$ elastic scattering shows a structure near $t = -0.5$ $(GeV/c)^2$. In the backward region two events are observed.

[*] Now at the National Accelerator Laboratory, Batavia, Illinois, USA.

As part of an experimental programme to study the elastic scattering of hadrons on protons, we present in this letter the results of a measurement of the elastic scattering of antiprotons on protons at 3.55 GeV/c. The experiment was performed at the CERN Proton Synchrotron. The characteristics of the optical spark chamber system, and the digitization and analysis procedures have been described in previous publications[1].

A negative unseparated beam with a momentum dispersion of ±0.5% around the central value of 3.55 GeV/c, which was known to ±50 MeV/c, was used. The beam contained 0.5% $\bar{p}$, 1.7% K^-, and 97.8% π^-, μ^-, and e^-. Three threshold Čerenkov counters[2] were used in the incident beam, two of which were set to record pions, and their signals were used in anti-coincidence. The third Čerenkov counter was set to count kaons and pions, and the information from this counter was displayed on a data-box[1]. In this way the elastic scattering of K^- and $\bar{p}$ was studied during the same run. The results presented here are based on a total of 92,000 spark chamber photographs. The acceptance of the system permitted observation of elastic scattering events at c.m. scattering angles from 20° to 77° $[0.16 < -t < 2.0 \ (GeV/c)^2]$ and from 109° to 160° $[3.0 < -t < 5.0 \ (GeV/c)^2]$.

The results are given in Table 1 and Fig. 1, where we have also plotted the results of Katz et al.[3]. Quoted errors are statistical. There is an over-all uncertainty of scale of ±20%, arising mainly from an uncertainty of the abundance of antiprotons in the incident beam.

In Fig. 2 the energy dependence of forward $\bar{p}p$ elastic scattering is shown with data from several publications. We list here some of the prominent features, which have been noted by other authors:

i) The forward peak expands with energy (anti-shrinkage).

ii) There is a dip in the angular distribution, which shifts from $t = -0.4 \ (GeV/c)^2$ at low energy to $t = -0.6 \ (GeV/c)^2$ at high energy.

iii) The amplitude of the secondary maximum at about $t = -0.8 \ (GeV/c)^2$ decreases with energy.

These features are qualitatively accounted for by models for elastic scattering involving a superposition of amplitudes due to an infinite-energy diffraction process[4] and the exchange of meson Regge-poles[5].

The two elastic events found in the backward direction correspond to a differential cross-section of 5 ± 4 $\mu b/(GeV/c)^2$. This is of the same order of magnitude as for backward elastic K^-p scattering[1] but smaller than the backward differential cross-section for K^+p and $\pi^\pm p$ elastic scattering[1].

REFERENCES

1) W.F. Baker, P.J. Carlson, V. Chabaud, A. Lundby, J. Banaigs, J. Berger, C. Bonnel, J. Duflo, L. Goldzahl and F. Plouin, Nuclear Phys. **B8**, 31 (1968); **B9**, 640 (1969).

2) W.F. Baker, P.J. Carlson, V. Chabaud, A. Lundby, J. Banaigs, J. Berger, C. Bonnel, J. Duflo, L. Goldzahl and F. Plouin, Nuclear Phys. **B9**, 249 (1969).

3) W.M. Katz, B. Forman and T. Ferbel, Phys. Rev. Letters **19**, 265 (1967).

4) T.T. Chou and C.N. Yang, Phys. Rev. **170**, 1591 (1960).

5) C.B. Chiu and J. Finkelstein, Nuovo Cimento **57** A, 649 (1968).

6) J. Berryhill and D. Cline, Phys. Rev. Letters **21**, 769 (1968).

7) V. Domingo, G.P. Fisher, L. Marshall Libby and R. Sears, Phys. Letters **24** B, 642 (1967).

8) K. Böckmann, B. Nellen, E. Paul, B. Wagini, I. Borecka, J. Diaz, U. Heeren, U. Libermeister, E. Lohrmann, E. Raubold, P. Söding, S. Wolff, J. Kidd, L. Mandelli, L. Mosca, V. Pelosi, S. Ratti, and L. Tallone, Nuovo Cimento **42** A, 954 (1966).

9) D.P. Owen, F.C. Peterson, J. Orear, A.L. Read, D.G. Ryan, D.H. White, A. Ashmore, C.J.S. Damerell, W.R. Frisken and R. Rubinstein, to be submitted to Phys. Rev.; and Phys. Rev. Letters **21**, 387 (1968).

10) D. Birnbaum, R.M. Edelstein, N.C. Hien, T.J. McMahon, J.F. Mucci, J.S. Russ, E.W. Anderson, E.J. Bleser, H.R. Blieden, G.B. Collins, D. Garelick, J. Menes, F. Turkot, Paper submitted to the 14th Int. Conf. on High-Energy Physics, Vienna (1968) (CERN, Geneva, 1968).
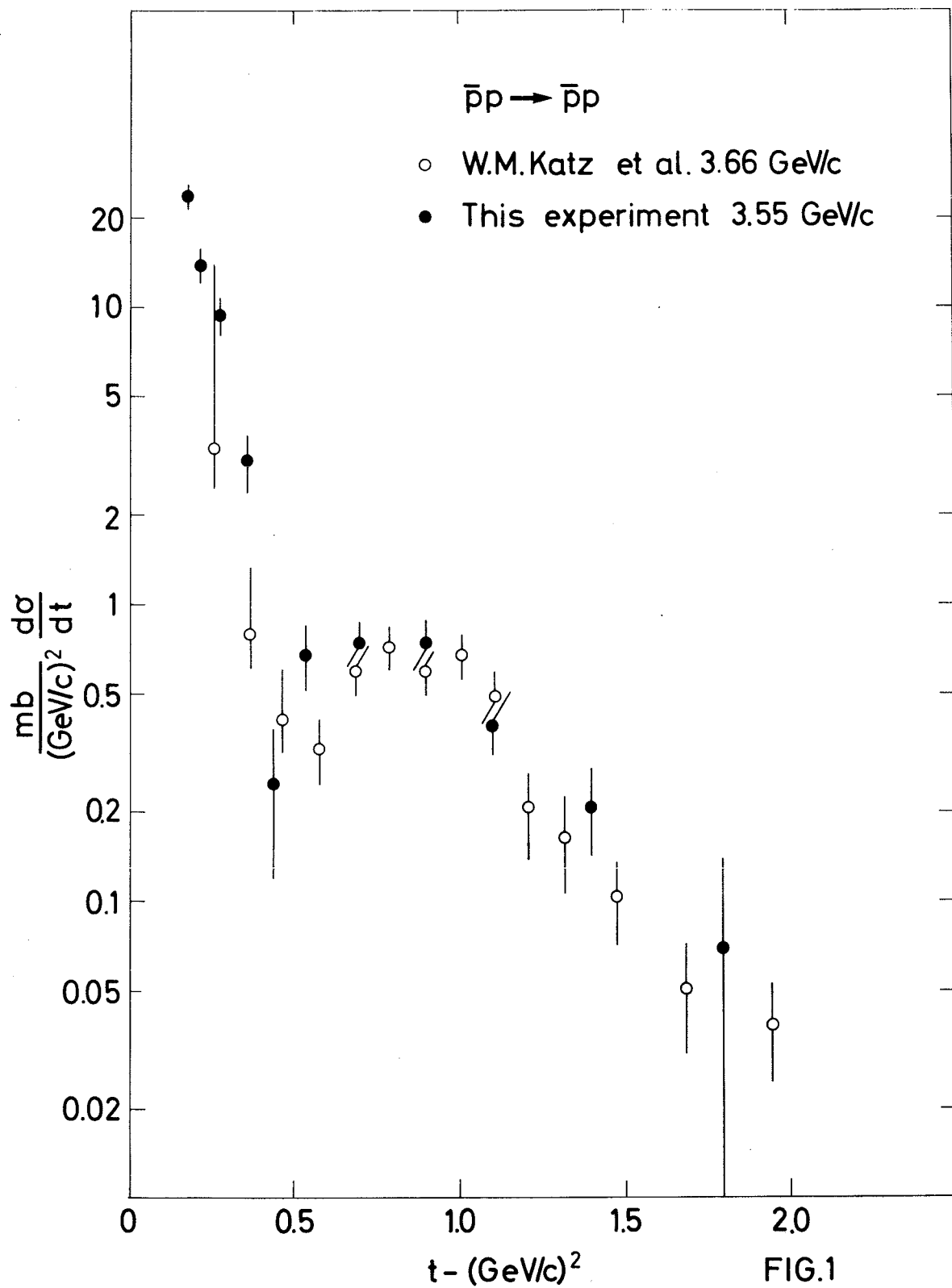
Table 1

Antiproton-proton elastic differential cross-sections at
3.55 GeV/c. Listed errors are statistical. There is an
over-all uncertainty of scale of 20%. $S = 8.65$ (GeV)^2,
$p^{c.m.} = 1.13$ GeV/c, and $t_{min} = -5.13$ (GeV/c)^2

cos $\theta_p^{c.m.}$	$-t$ (GeV/c)^2	Δt (GeV/c)^2	No. of events	$d\sigma/dt$ mb/(GeV/c)^2	$d\sigma/d\Omega$ mb/sr
0.9298	0.18	0.04	96	23.7 ± 2.4	9.69 ± 0.99
0.9142	0.22	0.04	53	13.9 ± 1.9	5.78 ± 0.78
0.8908	0.28	0.06	50	9.4 ± 1.3	3.84 ± 0.54
0.8596	0.36	0.08	19	3.04 ± 0.70	1.24 ± 0.28
0.8294	0.44	0.08	4	0.25 ± 0.13	0.10 ± 0.05
0.7895	0.54	0.12	16	0.68 ± 0.17	0.28 ± 0.07
0.7271	0.70	0.20	34	0.74 ± 0.13	0.30 ± 0.05
0.6491	0.90	0.20	30	0.75 ± 0.14	0.31 ± 0.06
0.5711	1.10	0.20	10	0.39 ± 0.12	0.16 ± 0.05
0.4542	1.40	0.40	8	0.21 ± 0.07	0.09 ± 0.03
0.2982	1.80	0.40	1	0.07 ± 0.07	0.03 ± 0.03
-0.5477	4.0	1	2	0.005 ± 0.004	0.002 ± 0.002

Figure captions

Fig. 1   :   The angular distribution of antiproton-proton elastic
                scattering at 3.55 GeV/c measured in this experiment.
                Also shown are the results of Katz et al.[3] at 3.66 GeV/c.

Fig. 2   :   Forward p̄p elastic scattering as function of t, the four-
                momentum transfer squared. Data at 1.4 GeV/c from Berryhill
                and Cline[6];   2.7 GeV/c, Domingo et al.[7]; 3.55 GeV/c,
                this experiment;   5.8-5.9 GeV/c, K. Böckmann et al.[8] and
                D.P. Owen et al.[9];   16 GeV/c, D. Birnbaum et al.[10].
                The curves are hand-drawn through the data points to guide
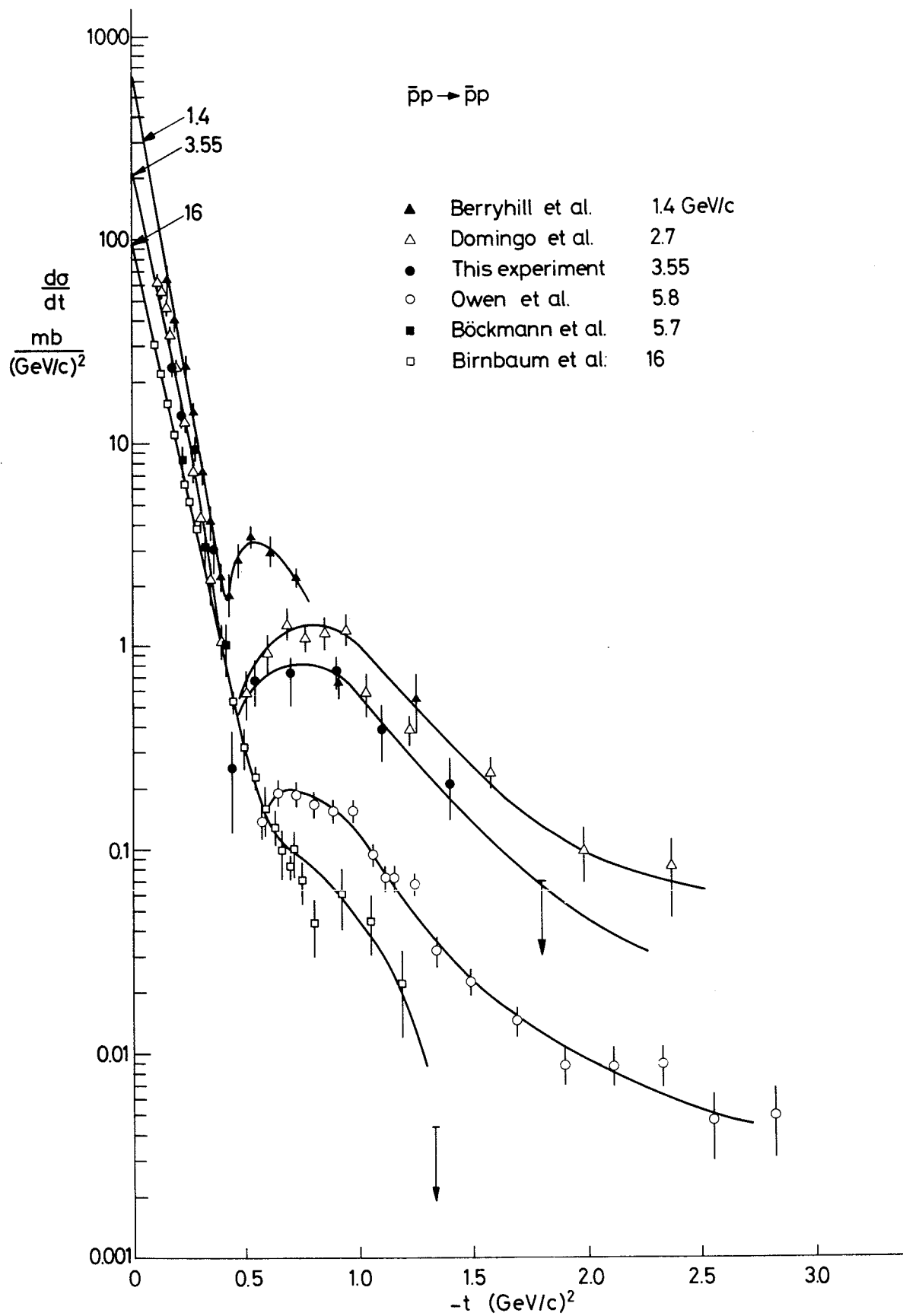   the eye.

$\bar{p}p \longrightarrow \bar{p}p$

○ W.M.Katz et al. 3.66 GeV/c

● This experiment 3.55 GeV/c

$\frac{mb}{(GeV/c)^2} \frac{d\sigma}{dt}$

t − (GeV/c)²

FIG.1

$$\frac{d\sigma}{dt}$$

$$\frac{mb}{(GeV/c)^2}$$

p̄p → p̄p

1.4
3.55
16

▲ Berryhill et al.   1.4 GeV/c
△ Domingo et al.   2.7
● This experiment   3.55
○ Owen et al.   5.8
■ Böckmann et al.   5.7
□ Birnbaum et al.   16

1000
100
10
1
0.1
0.01
0.001

0   0.5   1.0   1.5   2.0   2.5   3.0

−t (GeV/c)^2

FIG. 2