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In a spark-chamber experiment on the electroproduction of pions on hydrogen described earlier[1], a large contribution of multiple-pion production was found, besides of one-pion-production events.

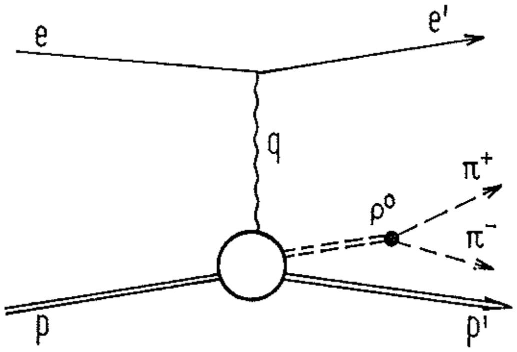
In general, only the scattered electron and one produced pion were measured in coincidence in our apparatus. There were also events in which at least the direction of a third particle was measured.

In the earlier experiment we have shown that electroproduction of pions can be described as photoproduction of pions with virtual photons[2]. Since ρ^0 production is the dominating process in photoproduction above 1.5 GeV, we expect the same behaviour in electroproduction. We, therefore, analyzed the events with three detected particles to get information about electroproduction of ρ^0 mesons.

This process

$$e + p \rightarrow e' + \rho^0 + p' \qquad \rho^0 \rightarrow \pi^+ + \pi^-$$

is described by the following diagram:



The four-momenta are written as e for the incoming electron, e' for the scattered electron, q for the virtual photon, ρ^0 for the produced ρ^0 meson, $\pi\pm$ for the decay pions, p and p' for the incoming and recoiling protons, respectively.

The energy of the primary electron was 4.9 GeV, the energy q_o of the virtual photon varied between 2.7 and 4.0 GeV. The squared four-momentum q^2 of the virtual photon was $|q^2| \leq 0.3$ GeV^2.

The analysis was done assuming that no further particles were produced in the reaction. Using this assumption we verified also that in more than 90% of all events the third particle was a pion and not the recoil proton; this was done by means of a rough momentum analysis of the third particle with a brooming magnet between the target and the first spark chamber.

For each event an acceptance factor A was calculated, taking into consideration the transversal polarisation of the virtual photon and the results about decay angular distributions from photoproduction of two-pion system in the forward direction[3].

Fig. 1 shows the spectrum of the invariant mass of the two-pion system for the electroproduced events, weighted with the acceptance A. The distribution shows a clear peak around the mass of the ρ^0 meson. The dashed curve results from a fit to the invariant dipion mass spectrum of two-pion photoproduction, which was measured simultaneously in our apparatus[4]. The photons causing this process were due to bremsstrahlung of the incoming electrons inside the hydrogen-target. The fit was obtained assuming a Breit-Wigner function[5] which was multiplied by an additional factor $m_\rho^4/m_{\pi\pi}^4$ stemming from a photon-dissociation model[6]. We found a resonant mass $m_\rho = 763 \pm 15$ MeV/c^2, and a width $\Gamma_\rho = 126 \pm 20$ MeV/c^2 (see Fig. 2).

Fig. 3 shows the differential cross section $\frac{d\sigma}{dt}$ obtained for electroproduction of ρ^0 mesons as a function of the momentum transfer t to the nucleon, in the accepted regions of q^2 and q_0.

The distribution was fitted, assuming a diffractionlike behaviour as in photoproduction:

$$\frac{d\sigma}{dt} = a \cdot e^{bt} \qquad (1)$$

with $a = (0.14 \pm 0.04)$ μb/GeV^2
and $b = (10 \pm 5)$ GeV^{-2}.

In the limit $q^2 \to 0$, the connection between the electroproduction of pions and the photoproduction of pions by unpolarized photons is given[2] by

$$\left(\frac{d^3\sigma}{ds'\,dq^2\,dt}\right)_{\text{electroproduction}} = \frac{\alpha}{2\pi}\,\frac{(s' - M_p^2)}{(s - M_p^2)^2}\,\frac{1}{|q^2|}\left(1 + \frac{2(s - M_p^2)(s - s')}{(s' - M_p^2)^2}\right)\left(\frac{d\sigma}{dt}\right)_{\text{photoproduction}} \tag{2}$$

with $s = (e + p)^2$ and $s' = (q + p)^2$.

Our data lie in this limiting range of small q^2, as can be seen from the predicted $\frac{1}{|q^2|}$ behaviour shown in Fig. 4. The solid curve is the calculated accepted phase space for electroproduction of ρ^0 mesons, assuming a $\frac{1}{|q^2|}$ dependence of the cross section[2].

Using Equation (2), we predict, from our experimental results for electroproduction of ρ^0 mesons, the following differential cross section for the photoproduction of ρ^0 mesons:

$$\left(\frac{d\sigma}{dt}\right)_{\gamma+p\to\rho^0+p} = (120 \pm 34) \cdot e^{(10 \pm 5)t}\ \mu b/GeV^2$$

These values are in good agreement with the experimental results for the photoproduction of ρ^0 mesons[3,7]; for example, one of these measurements[7] gives:

$$\left(\frac{d\sigma}{dt}\right) = (125 \pm 15) \cdot e^{(8.1 \pm 1.5)t}\ \mu b/GeV^2$$

This agreement indicates that, within the accuracy obtained in our experiment, the contribution of the small longitudinal field component of the virtual photon to the cross section does not cause a significant shift of the cross-section behaviour in the case of ρ^0 electroproduction.

Acknowledgements

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Figure Captions

Fig. 1 $(\pi^+\pi^-)$ mass spectrum for the electroproduction of two pions: Number of events N divided by the acceptance factor A is plotted as a function of the two-pion mass. Dashed curve shows fit of a Breit-Wigner distribution multiplied by $(m_\rho{}^4/m_{\pi\pi}{}^4)$ to photoproduction of two pions (as shown in Fig. 2, with height normalized to the electroproduction data). Solid curve shows phenomenological background distribution.

Fig. 2 $(\pi^+\pi^-)$ mass spectrum for photoproduction of two pions: Number of events N divided by the acceptance factor A is plotted as a function of the two-pion mass. Dashed curve shows fit of a Breit-Wigner distribution multiplied by $(m_\rho{}^4/m_{\pi\pi}{}^4)$. Solid curve shows phenomenological background distribution.

Fig. 3 Differential cross section $\frac{d\sigma}{dt}$ as a function of the four-momentum transfer t for electroproduction of ρ^0 mesons in the range $0.015 \leq |q^2| \leq 0.25$ GeV^2 and $2.7 \leq q_o \leq 4.0$ GeV.

Fig.4 Number of events N as a function of q^2 for electroproduction of ρ^0 mesons.

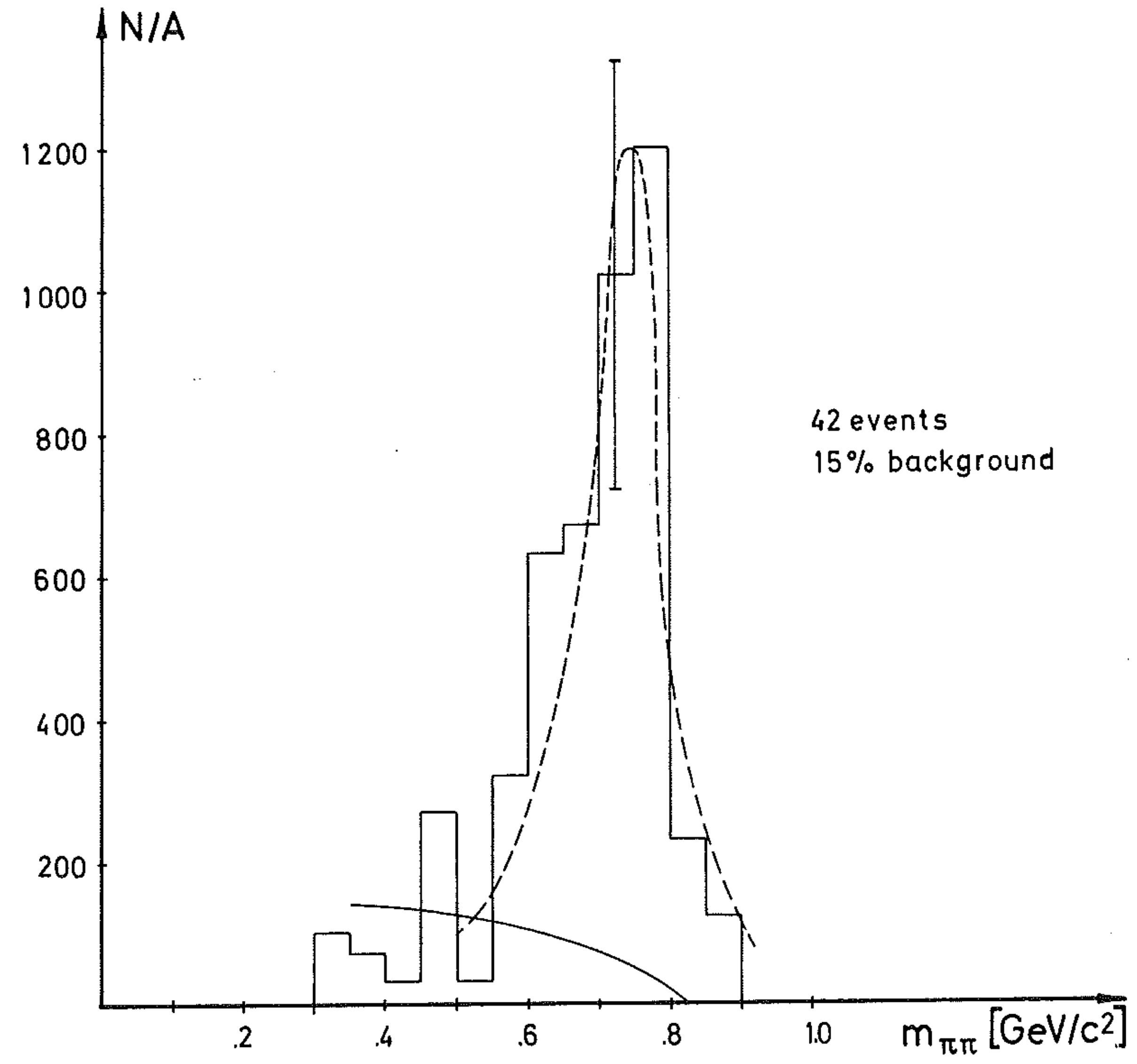
N/A
1200
1000
800
600
400
200
.2
.4
.6
.8
1.0
$m_{\pi\pi}$ [GeV/c²]
42 events
15% background

Fig.1

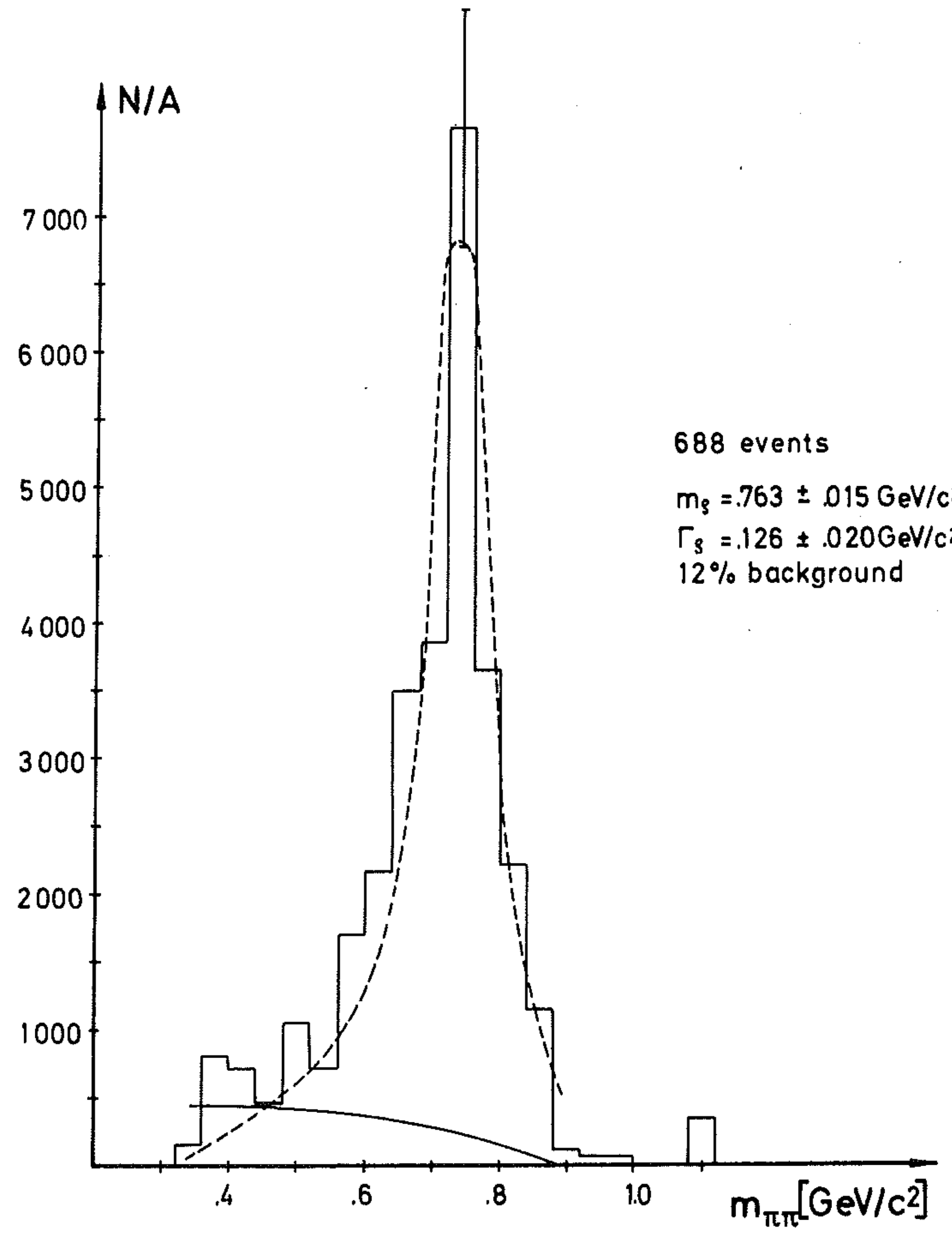
N/A
7000
6000
5000
4000
3000
2000
1000
688 events
m_ρ =.763 ± .015 GeV/c²
Γ_ρ =.126 ± .020 GeV/c²
12% background
.4
.6
.8
1.0
$m_{\pi\pi}$ [GeV/c²]

Fig.2

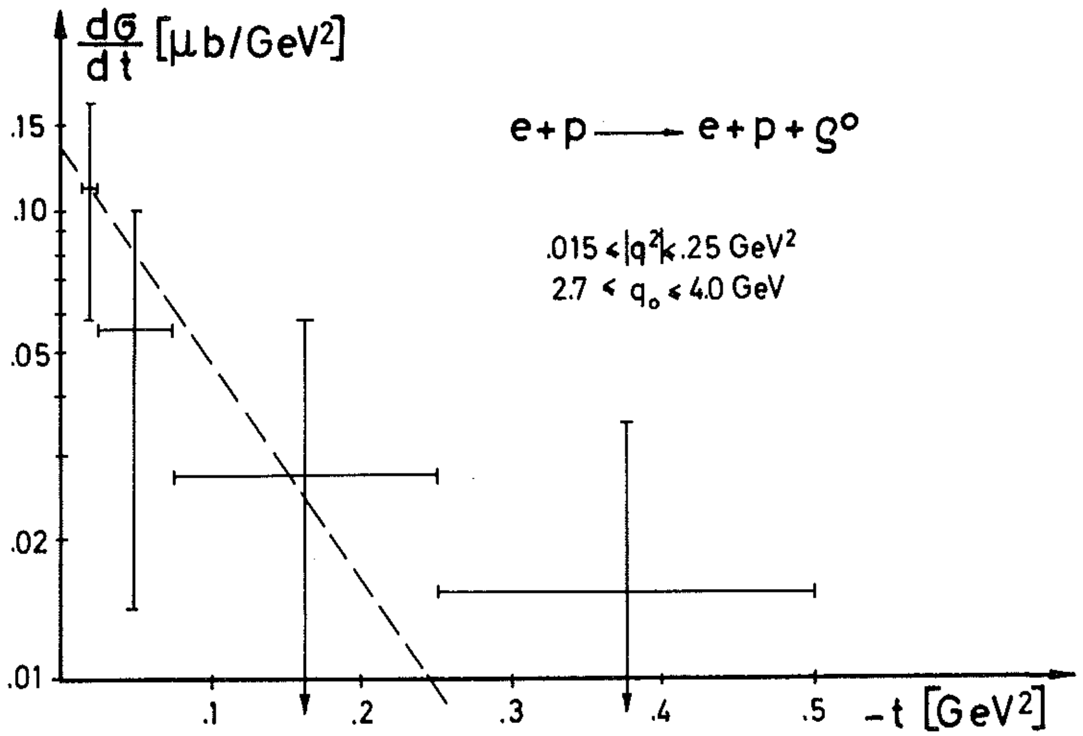
dσ/dt [μb/GeV²]
e+p → e+p+ρ°
.015 < |q²| < .25 GeV²
2.7 < q₀ < 4.0 GeV
.15
.10
.05
.02
.01
.1
.2
.3
.4
.5
-t [GeV²]

Fig.3

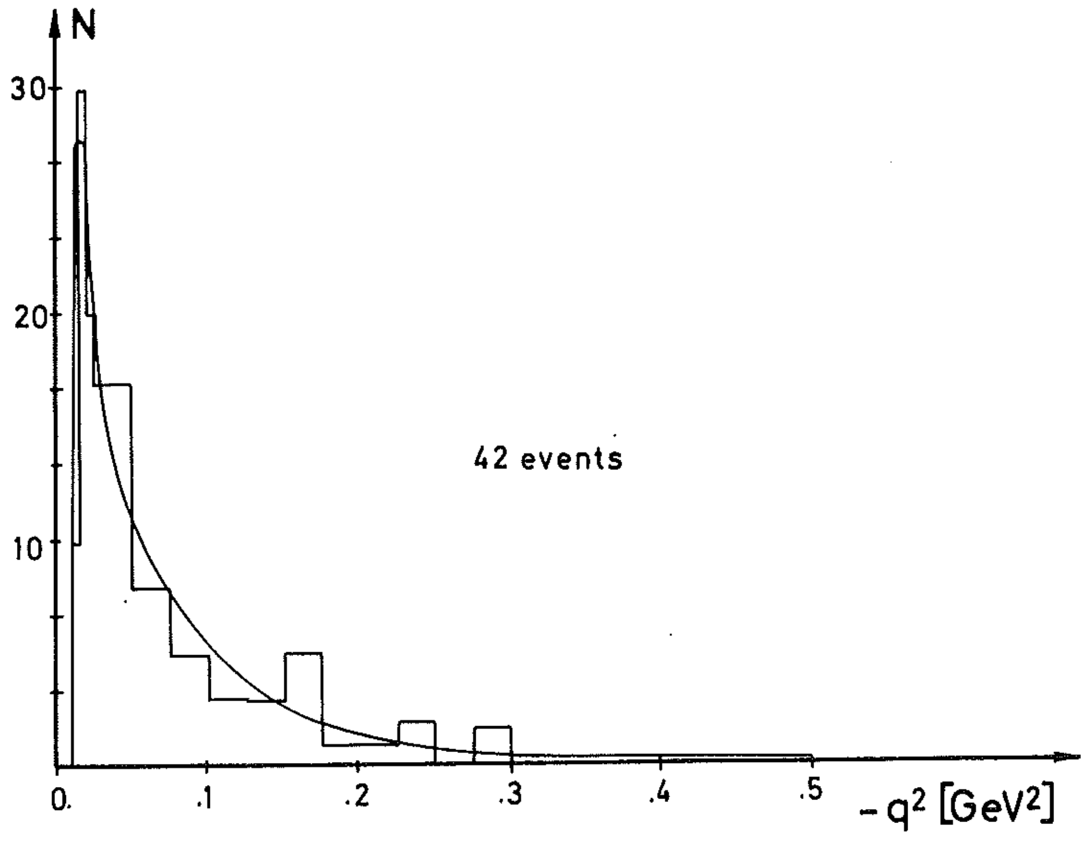
N
30
20
10
42 events
0.
.1
.2
.3
.4
.5
-q² [GeV²]

Fig.4