FR 86000 52

LAL/85-15
April 1985

Laboratoire de l'Accélérateur Linéaire

THE PION FORM FACTOR IN THE TIME LIKE REGION $1.38 < \sqrt{s} < 2.28$ GeV

D. BISELLO, G. BUSETTO, S. LIMENTANI, C. MILANI, M. NIGRO, M. PENZO, L. PESCARA, M. POSOCCO, P. SARTORI, L. STANCO

Dipartimento di Fisica dell'Università and INFN, Padova, Italy

J.E. AUGUSTIN, S. CALCATERRA, G. COSME, F. COUCHOT, B. DUDELZAK, P. ESCHSTRUTH, F. FULDA, B. GRELAUD, G. GROSDIDIER, B. JEAN-MARIE, S. JULLIAN, D. LALANNE, V. LEPELTIER, F. MANE, C. PAULOT, R. RISKALLA, Ph. ROY, F. RUMPF, G. SZKLARZ

Laboratoire de l'Accélérateur Linéaire, Orsay, France

Z. AJALTOUNI, A. FALVARD, B. JOUSSET, B. MICHEL, J.C. MONTRET, D. PALLIN,

Laboratoire de Physique Corpusculaire, Univ. Clermont-Ferrand, France

R. BALDINI, G. CAPON

Laboratori Nazionali di Frascati dell'INFN, Italy

*Talk presented by L. STANCO at the XXth Rencontre de Moriond
Les Arcs, March 10-17, 1985*

U.E.R
de
l'Université Paris-Sud

Institut National
de Physique Nucléaire
et
de Physique des Particules

Bâtiment 200 - 91405 ORSAY Cedex

LAL/85-15
April 1985

THE PION FORM FACTOR IN THE TIME LIKE REGION 1.38 < $\sqrt{s}$ < 2.28 GeV

Luca Stanco
Dipartimento di Fisica and INFN, Padova, Italy

DM2 Collaboration*

Abstract

Preliminary results from the DM2 experiment at DCI on the pion form factor are presented. Almost 200 events have been selected, 7 times the previous world statistics in the time like squared momentum transfer $(1.38)^2<q^2<(2.28)^2$ $(GeV/c)^2$.

The events exhibit a clear interference effect of the ρ tail with a $\rho'(1600)$.

---

* The members of DM2 Collaboration are:

D. Bisello, G. Busetto, S. Limentani, C. Milani, M. Nigro, M. Penzo, L. Pescara, M. Posocco, P. Sartori, L. Stanco
Dipartimento di Fisica dell'Università and INFN, Padova, Italy.
J.E. Augustin, S. Calcaterra, G. Cosme, F. Couchot, B. Dudelzak, P. Eschstruth, F. Fulda, B. Grelaud, G. Grosdidier, B. Jean Marie, S. Jullian, D. Lalanne, V. Lepeltier, F. Mané, C. Paulot, R. Riskalla, Ph. Roy, F. Rumpf, G. Szklarz
Laboratoire de l'Accélérateur Linéaire, Orsay, France.
Z. Ajaltouni, A. Falvard, B. Jousset, B. Michel, J.C. Montret, D. Pallin
Laboratoire de Physique Corpusculaire, Univ. Clermont-Ferrand, France.
R. Baldini, G. Capon
Laboratori Nazionali di Frascati dell'INFN, Italy

1. Detector

The DM2 detector[1] is a large solid angle magnetic spectrometer operating at DCI, the Orsay colliding ring. In the central part, the charged particles solid angle covered is .87x4 π steradians with a momentum resolution of σ_p/p=.03xp. The particle identification is made by 36 time of flight counters and 36 water Cerenkov counters. The time of flight resolution is 550 ps. Single pions and kaons are separated by both methods up to 600 MeV/c. The photon detector is segmented into 8 octants of 5 (+1 of the coil) radiation lengths each. It has been designed to have a good efficiency and spatial resolution for detecting low energetic photons. In addition, 120 (15x8) scintillation counters give information on the photon energy and provide time of flight measurements used for an on-line rejection of the cosmic rays.
Particle identification can be done with the nuclear interaction in the γ detector (λ=0.75 nuclear absorption length).

A total integrated luminosity L=1300 nb^{-1} has been used for this analysis with the energy distribution of Fig. 1. L=500 nb^{-1} are still available for the final results.

2. Events selection

We accept, as candidates, two-prong colinear events with correct source, correct time of flight and in time with the bunches.

The kinematical requirements are on the missing momentum

$$P_{missing} \leq 10\% \times \sqrt{S}$$

and on the reconstructed energy in the 2 pion hypothesis

$$.92 \leq \frac{E_R}{\sqrt{S}} \leq 1.08$$

In order to take into account the radiative tail, the lower bound decreases linearly with the missing momentum up to a value of .82 for $p_{missing}=10\% x\sqrt{S}$.

These cuts allow a complete rejection of the cosmic rays and $\bar{p}p$ events. The K^+K^- are also rejected below 1.95 GeV at the 99% of confidence level.

In order to separate the $\pi^+\pi^-$ events from the large background due to bhabha and $\mu^+\mu^-$, we look to the behaviour of the tracks in the γ detector. The possible topologies of the nuclear interaction in this detector have been studied with $2x10^4$ pions coming from

$$\Psi \rightarrow \rho \pi$$

The results are summarized in Tab. 1. The retained topologies give a nuclear interaction probability of 50%, constant with the energy. This value is well reproduced by the Montecarlo simulation.

Since a shower can simulate a nuclear interaction, the events are asked to exhibit one track with a nuclear interaction and the other one without any interaction. Finally, the events with the nuclear interaction classified as shower are rejected.

The rest contamination is deeply reduced by those requirements. A Montecarlo calculation indicates that we have

$$e^+e^- < 3 \text{ events}$$
$$\mu^+\mu^- < 5 \text{ events}$$

in our final sample.

The retained 202 candidates have been eye scanned. A forgotten source of contamination, namely the $\mu^+\mu^-\gamma$ channel, has been observed: six events of this type have been subtracted. The residual background has been calculated to be less than 3 events.

At $\sqrt{S}$ = 1.95 GeV the $\pi^+\pi^-$ and the K^+K^- comes to be confused in our detector. No further separation having been made, at present the final results above 1.95 GeV are the sum for these two channels.

3. Normalization and efficiency

In order to reduce the systematic errors, the normalization is done with the $\mu^+\mu^-$ events. The electromagnetic interactions with the matter are nearly the same for muons and pions, then the tracking and trigger efficiency can be assumed identical for the two channels.

The measured $e^+e^-\to\mu^+\mu^-$cross section is in good agreement with QED. An S^{-1} fit (Fig. 2) to our data gives an experimental efficiency for this channel of .43 in front to a Montecarlo calculated value of .42.

For the $e^+e^-\to\pi^+\pi^-$ channel the final efficiency is calculated via Montecarlo to be

$$\varepsilon = .14 \pm .02$$

where the error is due to the $\pi^\pm$ identification. Value and error are constant with the energy.

4. Results

The cross section is calculated from

$$\sigma_{e^+e^- \to \pi^+\pi^-} = \sigma_{e^+e^- \to \mu^+\mu^-} \frac{\varepsilon_\mu}{\varepsilon_\pi} \frac{N_{\pi^+\pi^-}}{N_{\mu^+\mu^-}}$$

and it is reported in Table 2 and Fig. 3.

The errors reported in the figure are statistical only: as previously seen a systematic error of the order of 15%, constant in the energy range, has to be added.

The electromagnetic pion form factor is simply related to the process cross section by

$$|F_\pi|^2 = \frac{s}{21.71\ \beta^3}\ \sigma$$

In Fig. 4 we present our data with the previous ones in this energy region. The lowest energy point agrees very well with the good statistics points of Novosibirsk. The further points are the first significant measurement of $|F_\pi|$ in this momentum transfer range.

They disagree with a simple Gounaris-Sakurai and indicate a strong interference effect of a $\rho'(1600)$ with the ρ tail.

References

(1) J.E. Augustin et al., Physica Scripta 23 (1981) 623.
(2) G. Barbiellini et al., Lettere al Nuovo Cimento 6 (1973) 557.
(3) D. Bollini et al., Lettere al Nuovo Cimento 14 (1975) 418.
(4) B. Esposito et al., Physics Letters B67 (1977) 239.
(5) I.A. Koop et al. Report at International Symposium on Lepton and Photon Interactions, Batavia (1979).
(6) B. Esposito et al., Lettere al Nuovo Cimento 28 (1980) 337.

TABLE 1

NUCLEAR INTERACTION PROBABILITY

Absorption in the coil or in the first planes of tubes	6.6%
Nuclear interaction (*at least two associated* tracks in γ-detector)	11.7%
Shower-like behaviour	17.9%
Large angle scattering ($\sigma_{min}=10°$)	13.4%
Total	49.7%
μ-like behaviour	50.3%

TABLE 2

$\sqrt{s}$	$L(nb^{-1})$	N_L	$N_{\bar{L}}$	σ(nb)	Δσ
1375.0	20.04	550	21	5.64	1.25
1425.0	74.16	1503	21	1.02	0.42
1475.0	60.00	1237	13	1.36	0.38
1525.0	32.70	550	3	0.65	0.38
1575.0	42.14	656	3	0.51	0.30
1625.0	87.78	1156	7	0.64	0.24
1675.0	81.77	1060	10	0.94	0.30
1725.0	61.04	770	10	2.31	0.54
1775.0	103.20	1233	20	1.44	0.32
1825.0	81.25	942	21	1.07	0.41
1875.0	50.01	625	13	1.65	0.46
1925.0	76.51	822	12	1.10	0.32
1975.0	40.50	454	1	0.16	0.16
2025.0	96.02	945	7	0.50	0.19
2075.0	90.33	826	5	0.30	0.10
2125.0	94.67	796	4	0.31	0.16
2175.0	101.00	736	10	0.88	0.26
2225.0	57.06	416	4	0.54	0.27

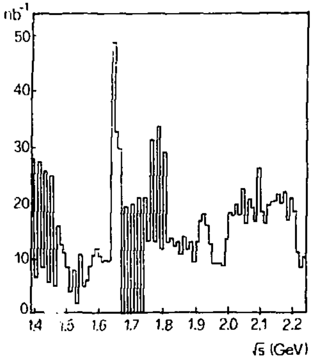

Fig. 1 Integrated bhabha luminosity vs $\sqrt{S}$.

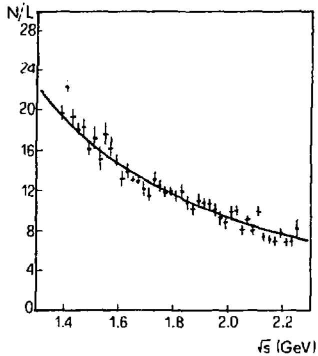

Fig. 2 $\mu^+\mu^-$ yield normalized to the bhabha luminosity vs $\sqrt{S}$.

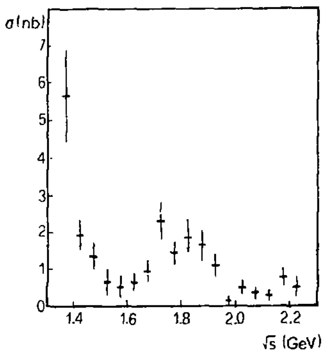

Fig. 3 $e^+e^-\to\pi^+\pi^-$ cross section vs $\sqrt{S}$.

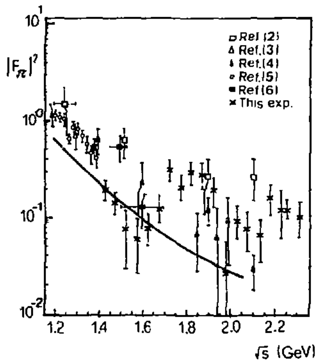

Fig. 4 $|F_\pi|^2$ vs $\sqrt{S}$. The solid line is the Gounaris-Sakurai tail.