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by

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2 HAMBURG 52 · NOTKESTIEG 1

RESULTS ON TWO-BODY DECAYS OF THE (3100)-RESONANCE (+)

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Abstract

The two-body decay modes $\psi(3100) \to \mu^+\mu^-$ and $\to \bar{p}p$ were observed with the magnetic detector PLUTO at the storage ring DORIS. We obtain the relative branching ratios $\Gamma_{ee}\Gamma_{\mu\mu}/\Gamma = 0.32 \pm 0.08$ keV and $\Gamma_{p\bar{p}}/\Gamma_{\mu\mu} = 0.051 \pm 0.02$. In addition we find the μ pair forward-backward asymmetry $\frac{F-B}{F+B} = 0.06 \pm 0.07$ in the angular range $0.6 \leq |\cos\theta| \leq 0.85$, indicating the absence of a dominant $V \pm A$ term in the decay process.

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The magnetic detector PLUTO uses a superconducting solenoid with the field parallel to the e^+e^- beams in the storage ring DORIS. The action of this field on the stored beams is compensated by two smaller solenoids on either end of the main coil. The operation of the storage ring was found to be uncritical up to the highest field of 2 Tesla tried out during the runs.

Final state particles are detected by a set of cylindrical multi-wire proportional chambers within the useful volume of the magnet (1.4 m diameter, 1 m in length). In the first runs the detector covered about 85% of the complete solid angle. Photon detection is provided by a lead converter of 0.41 radiation lengths at a radius of 39 cm. Muons are identified by two sets of plane wire chambers - one set around a polar angle of $\theta = 90^0$ relative to the beam axis and covering the full azimuth (the total solid angle coverage is $0.34 \times 4\pi$); the individual chambers are arranged in slots of the iron yoke. A second set of chambers close to the forward and backward directions placed outside the yoke (50 cm iron) covers an additional solid angle of $0.06 \times 4\pi$.

The detector is triggered by combining the wire signals from the cylindrical chambers and demanding specific hardware patterns in two successive stages. The first stage selects track elements in two closely spaced chambers thereby accepting tracks with fairly large curvatures. The second, slower stage, recognizes and counts tracks over several chambers with the aid of shift register memories associated with each chamber and a predefined set of coincidence patterns. The trigger demands one of the following conditions: (a) two coplanar tracks, (b) two tracks with an azimuthal angle difference between 40^0 and 140^0, (c) three or more tracks with no restriction on angles.

We present here our first results on the two-body decays of the J(3100) resonance. The data samples taken with fields of 1.6 Tesla and 1.0 Tesla were used in this analysis. The events are selected by an initial search for a chamber having two sparks with an azimuthal angle difference close to 180^{o}, the total number of sparks in this detector being less than a predefined maximum. The remaining sparks on the two tracks are then picked up and this entire set is fitted to a single track in order to obtain a high momentum resolution. During the fitting procedure corrections are applied to account for the nonzero crossing angle of the $e^{+}e^{-}$ beams and the consequent center of mass motion. To achieve a significant reduction of the cosmic ray and beam gas background the events are constrained to originate from the interaction region.

MUON PAIRS: Fig. 1 shows the observed momentum distribution of collinear events from the reaction:

$$e^{+} + e^{-} \rightarrow J(3100) \rightarrow \mu^{+}\mu^{-}$$

obtained from the 1.6 Tesla data. The muons are identified by demanding a clear signal from the muon chambers along one of the two tracks. The cosmic ray muons passing very close to the interaction region lead to a non-removeable background under the peak. Most of the events detected are in the range $|\cos\theta| \lesssim 0.35$, θ being the polar angle between the incident e^{+} and the outgoing μ^{+}. Fig. 2 shows the muon pair yield as a function of the center of mass energy for muons in the above angular range (after background subtraction). The energy dependence of the data has been fitted to a constant (QED contribution) plus a Gaussian.

To obtain the true energy integral over the resonance the area under the Gaussian after subtracting the QED part is corrected for the limited solid angle for muon detection assuming a uniform ϕ distribution and a $1+\cos^2\theta$ polar angle distribution. Radiative corrections (factor 1.6) were also applied. The true energy integral over the resonance is then

$$\int_{3100} \sigma_{\mu\mu}(E_{cm})\, dE_{cm} \qquad = \qquad 770 \pm 190 \text{ nb MeV}$$

The error is dominated by systematic effects which come mainly from an insufficient knowledge of the precise shape of the excitation curve and radiative corrections. In terms of the widths the above result reads

$$\frac{\Gamma_{ee}\Gamma_{\mu\mu}}{\Gamma} = \frac{M^2}{2(2J+1)\pi^2} \cdot \int \sigma_{\mu\mu} dE \quad = \quad 0.32 \pm 0.08 \text{ keV}$$

The events observed in the front and back muon chambers lead to a sensitive determination of the forward-backward asymmetry. This ratio is in addition almost independent of the detection efficiency due to the small curvature of the tracks. Averaged over the resonance peak and utilizing the data from the 1.6 Tesla and 1.0 Tesla runs we obtain:

$$\frac{F-B}{F+B} \quad = \quad 0.06 \pm 0.07$$

for $0.6 \leq |\cos\theta| \leq 0.85$. This value argues against a significant $V \pm A$ part in this decay process.

PROTON ANTIPROTON PAIRS: An attempt was made to select hadronic pairs among the collinear events in the 1.6 Tesla data by looking for particles which neither penetrated the muon shield nor produced a shower in the lead absorber. This sample is still dominantly composed of electrons.

Demanding a minimum of ten sparks in the entire event improves the momentum resolution and the separation of the hadrons. Fig. 3 shows the reciprocal momentum distribution for events identified as muons and not muons respectively. An indication of a group of particles around the expected momentum ($1/p = 0.812$) for $p\bar{p}$ pairs is seen in the not muon spectrum. Separation from the background is made difficult by the bremsstrahlung losses of the electrons. However, if we now eliminate events with large differences in the measured transverse momenta of the two tracks, all of the bonafide $p\bar{p}$ events (20 events) remain whereas the electron-positron background is significantly reduced (Fig. 4). The corresponding sample of muon pair events obtained with the same criteria (388 events) leads to the branching ratio:

$$\Gamma_{p\bar{p}} / \Gamma_{\mu\mu} = 0.051 \pm 0.02$$

Using the ratio $\Gamma_{ee}/\Gamma = \Gamma_{\mu\mu}/\Gamma = 0.069$ obtained from the SPEAR detector[1)] the result can also be stated as

$$\Gamma_{p\bar{p}} / \Gamma = 0.0036 \pm 0.0015$$

for the angular interval $|\cos\theta| \leq 0.34$.

1) A.M. Boyarski et al., Phys.Rev.Lett. 34, 1357 (1975)

Acknowledgements

We thank all engineers and technicians who have participated in the construction of PLUTO, magnet and detector. The cooperation with the technical support groups and the computer center of DESY is gratefully acknowledged. We are indebted to the DORIS machine group for their excellent support during the experiment. Substantial contributions to the detector and to the experiment are due to W. Krechlock, H. Mehrgardt, H. Fischer and H. Meyer.

Figure Captions

Fig. 1 Distribution of 1/p (p = momentum) for collinear muon pairs

Fig. 2 Yield of muon pairs from $e^+e^- \to \mu^+\mu^-$ as a function of the CM energy

Fig. 3 Distribution of 1/p a) for muon pairs b) for collinear pairs, which do not satisfy criteria for muon

Fig. 4 Same as Fig. 3b), but excluding events with a large energy loss in one track (shaded histogram)

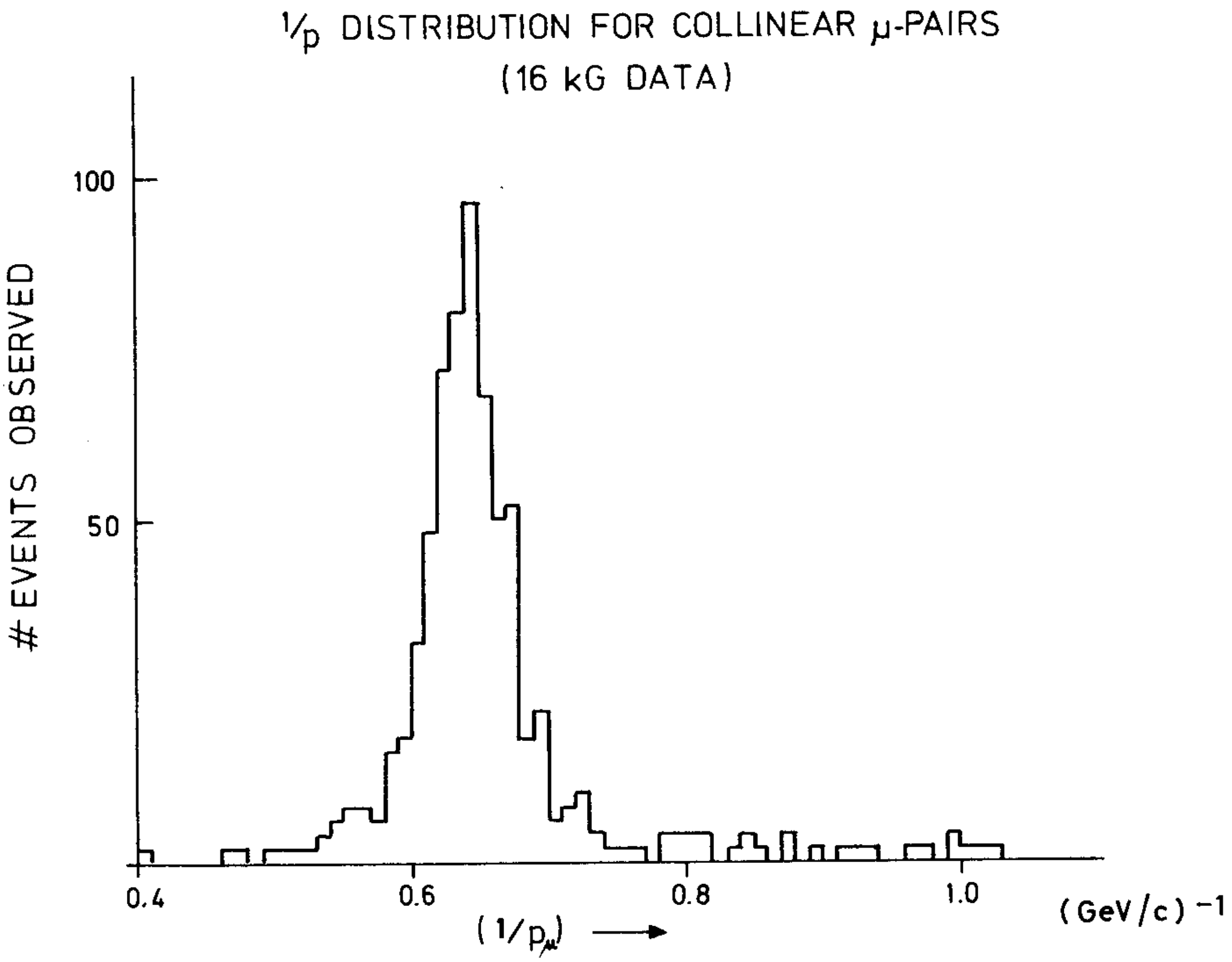
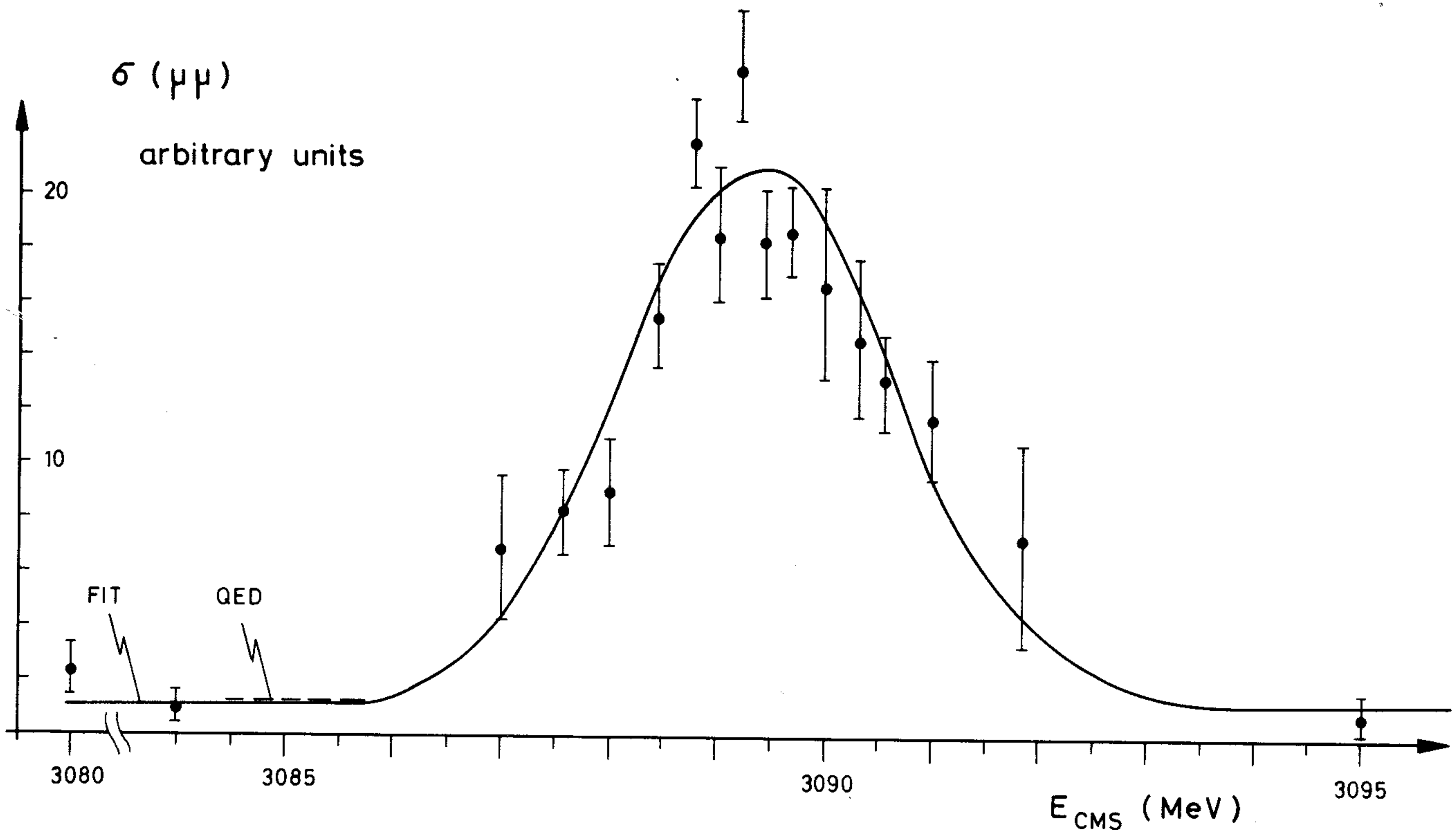


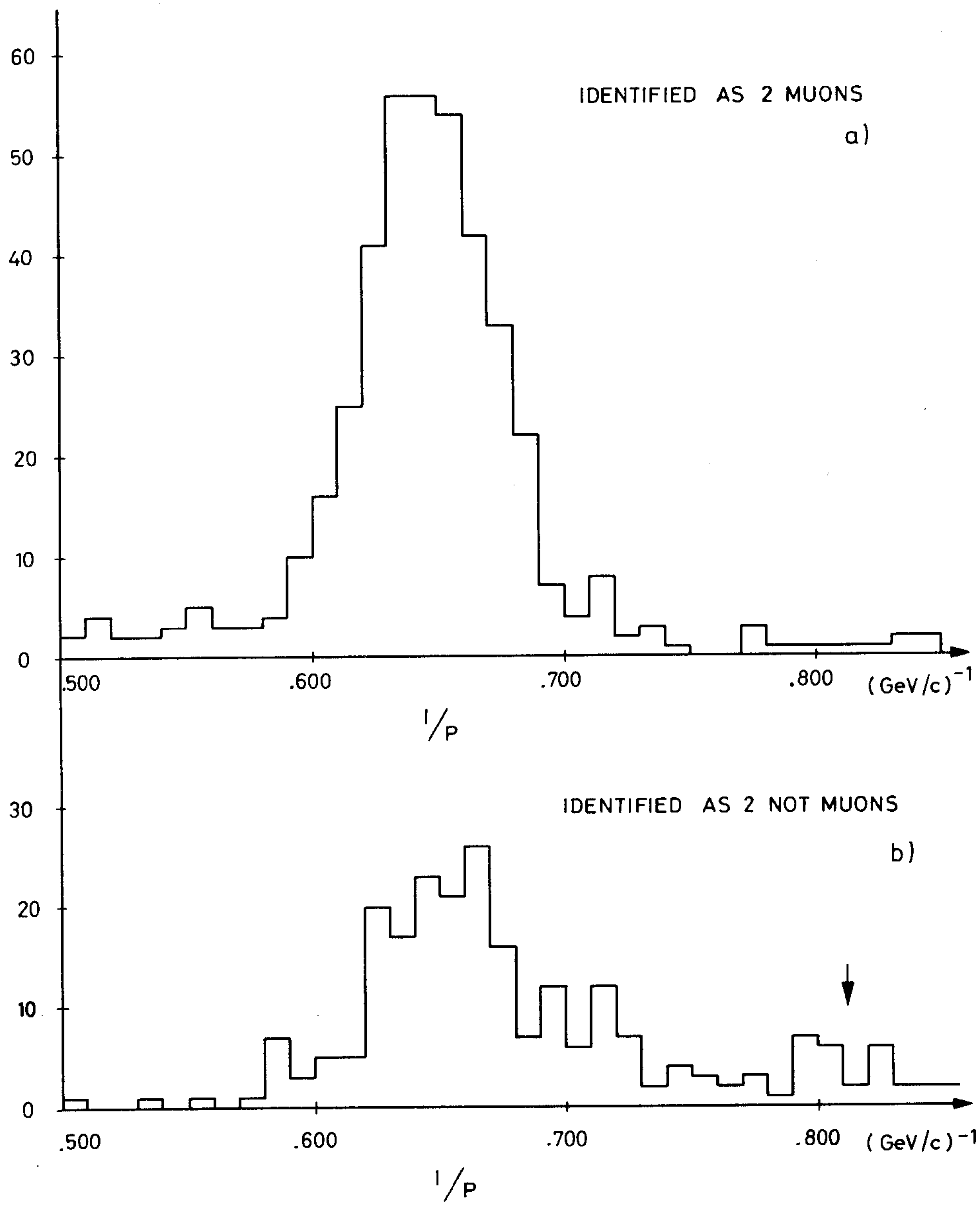
FIG.1 Distribution of $^1/p$ for collinear μ-pairs from J (3100 MeV)
The background below the peak is from cosmic ray μ's which survive the collinearity cuts

FIG. 2



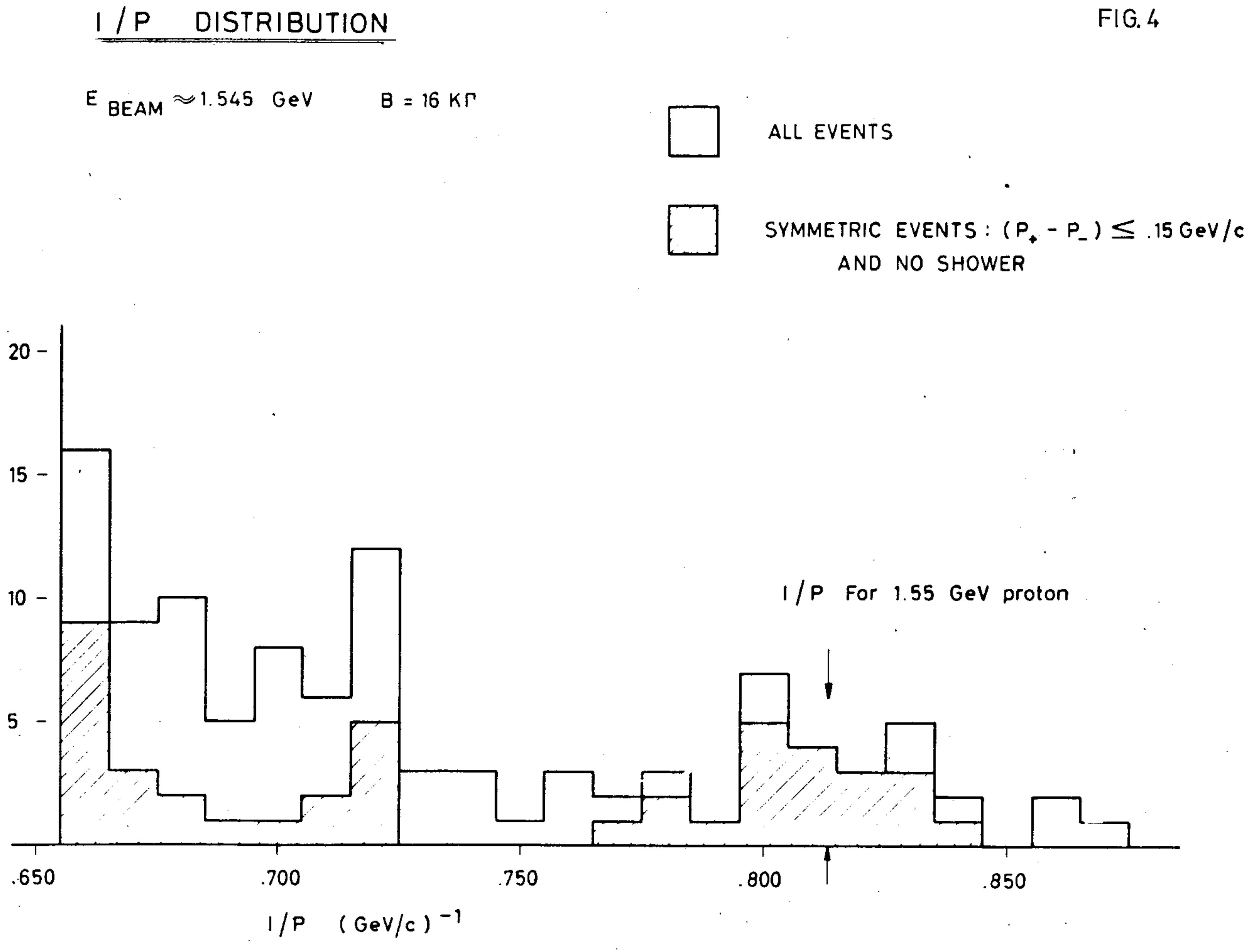
σ (μμ)
arbitrary units
20
10
FIT
QED
3080
3085
3090
3095
E CMS (MeV)

Fig. 3



60
50
40
30
20
10
0
IDENTIFIED AS 2 MUONS
a)
.500
.600
.700
.800
(GeV/c)$^{-1}$
1/P
30
20
10
0
IDENTIFIED AS 2 NOT MUONS
b)
.500
.600
.700
.800
(GeV/c)$^{-1}$
1/P

FIG. 4



1/P DISTRIBUTION
E BEAM ≈ 1.545 GeV
B = 16 KΓ
ALL EVENTS
SYMMETRIC EVENTS : (P+ - P-) ≤ .15 GeV/c
AND NO SHOWER
1/P For 1.55 GeV proton
20
15
10
5
.650
.700
.750
.800
.850
1/P (GeV/c) -1