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A HIGH STATISTICS SEARCH FOR THE $\bar{p}p\pi^-$ MASS ENHANCEMENT AT 2.95 GeV

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ABSTRACT

An experiment has been undertaken at the CERN SPS, using the Omega spectrometer, aimed at confirming the enhancement observed in a $\bar{p}p\pi^-$ mass spectrum at 2.95 GeV [1]. With statistics of 12 times the original experiment no signal is seen. In the reaction $\pi^- p \to \bar{p}p\pi^- p$, the upper limit (4 standard deviations) for the production of a resonance in the $\bar{p}p\pi^-$ system at 2.95 GeV, with a width $\leqslant$ 30 MeV, is 50 nb.

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In a previous publication [1] evidence was presented for the observation of a narrow width boson ($\Gamma < 32$ MeV) of mass 2.95 GeV decaying to $\bar{p}p\pi^-$. The purpose of the present letter is to present the results of a subsequent experiment aimed at confirming the above observation.

The experiment was performed using the Omega spectrometer at CERN [2]. A π^- beam of 16 GeV/c momentum with a flux of 6×10^5 per burst was incident on a 60 cm hydrogen target resulting in a total of 3.10^6 triggers being recorded during 20 days of running time. The effective beam flux was 30 events/nanobarn for 100% acceptance. As in the original experiment, the trigger selected, by means of a downstream threshold Cerenkov counter, those interactions in the hydrogen target which produced a K^- with momentum between 2.8 and 9.8 GeV/c or a $\bar{p}$ with momentum greater than 2.8 GeV/c. In order to enrich the $\bar{p}p\pi^-p$ channel with which the previously observed structure was mainly associated and reduce the trigger rate so that a more intense beam could be used, three additions were made to the original trigger arrangement [3], as shown in fig. 1:

(a) a system of scintillator-lead-scintillator sandwich counters was used to partially veto events with single or multiple π^0;

(b) the charged multiplicity emerging from the hydrogen target was limited to three or four by combining the signals coming from a hodoscope (TS) around the target with those from MWPC I just downstream of the target;

(c) the charged particle multiplicity in MWPC III was restricted to 2,3 or 4.

The data were processed through the Omega pattern recognition and geometry program (ROMEO). This program differed from that used in the original experiment and checks were made to ensure that the two programs gave similar results by passing a sample of events through both programs and comparing the results.

In order to study the four-constraint channel

$$\pi^- p \rightarrow \bar{p} p_f \pi^- p_s, \quad (1)$$

(where the subscripts f and s refer to the faster and slower nucleon in the laboratory system) we first selected those events which balanced both the longitudinal and transverse momentum within certain limits (< 300 MeV/c and < 200 MeV/c respectively). We plotted the difference (Δ) between the missing mass squared to the slowest positive particle in the laboratory system, assumed to be a proton, and the effective mass squared of the recoiling three-particle system with mass assignment $\bar{p}p\pi^-$. A clear kinematical separation between reaction (1) and the competing reaction $\pi^- p \rightarrow K_f^+ K^- \pi^- p_s$ was seen. Events for reaction (1) were then selected if $|\Delta|$ was < 1.4 GeV². We obtained 26 147 events with an estimated contamination < 5%.

The reactions

$$\pi^- p \rightarrow \bar{p} p_f \pi^- \pi^0 p_s \quad (2)$$

and

$$\pi^- p \rightarrow \bar{p} p_f \pi^+ \pi^- n_s \quad (3)$$

were also observed in the data as the missing mass squared (MM^2) spectra to the charged tracks showed evidence for the π^0 or neutron with the particle mass assignments corresponding to reactions (2) or (3). The events were selected by assigning them to either channel if the missing momentum was < 2 GeV/c and, with the corresponding mass hypotheses, the MM^2 lay between the limits $-0.02 < MM^2 < 0.04$ or $0.74 < MM^2 < 1.0$ GeV² for reactions 2 and 3 respectively. Events ambiguous between reactions (2) and (3) were assigned to the latter. The samples obtained consisted of 30 307 and 48 595 events respectively with the ratio of the π^0 or neutron peak to background being about one to one in each case.

Figs 2(a,b,c) show the $\bar{p}p_f\pi^-$ mass spectra for the events asigned to the reactions (1), (2) and (3). No significant (> 4 σ) enhancement is observed. The sum of these spectra is shown in fig. 2(d). The $\bar{p}p_f$

effective mass distribution in 20 MeV and 5 MeV bins for reaction (1) is shown in fig. 3(a) and (b) respectively and again no significant enhancements can be seen. Selecting the events with a $\bar{p}p_f\pi^-$ effective mass in the region of 2.95 GeV we see no structures in the $\bar{p}p_f$ effective mass spectrum. Some measure of confidence that we are able to detect a narrow state is obtained by observing $\phi \to K^+K^-$ in the inclusive K^+K^- mass spectrum (fig. 3(c)).

Thus the conclusion of the present work is that we do not confirm the enhancement that was observed in the $\bar{p}p_f\pi^-$ mass spectrum at 2.95 GeV.

In view of this, it is important to consider the possibility that the additional trigger requirements in the present experiment could have excluded the events giving rise to the peak. Within the constraints of energy and momentum conservation and the resolution, the original signal could have been associated with a low energy γ or π^0. However it is unlikely that the γ veto would have removed such events since the γ veto covered mainly forward laboratory angles and did not detect single slow π^0 efficiently.

In another check the events from the original experiment were traced through the present experimental set-up in order to verify that the multiplicity requirements had no effect on the original signal.

The resolution of the present experiment was improved by the addition of two large drift chambers (I and II in fig. 1). The information provided decreased the width of the missing mass to the three forward particles ($\bar{p}p_f\pi^-$) of reaction (1) indicating that the resolution of the present experiment was better than that of the original one where σ was observed to be $\sim$ 15 MeV.

An estimate for the upper limit of the cross section x Branching Ratio (BR) for production of a $\bar{p}p\pi^-$ state with a width $\Gamma < 30$ MeV can be derived from channel (1). Here a 4 σ signal at 2.95 GeV would correspond to a ($\sigma \times$ BR) of 50 nb. This is to be compared to the cross section of $\sim$ 300 nb expected from the previous experiment.

REFERENCES

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FIGURE CAPTIONS

Fig. 1 Schematic layout of the apparatus.

Fig. 2 (a) $\bar{p}p_f\pi^-$ effective mass distribution in 20 MeV bins for reaction (1).

(b) $\bar{p}p_f\pi^-$ effective mass distribution in 20 MeV bins for the events assigned to the reaction (2).

(c) $\bar{p}p_f\pi^-$ effective mass distribution in 20 MeV bins for the events assigned to the reaction (3).

(d) $\bar{p}p_f\pi^-$ effective mass distribution in 20 MeV bins for reactions (1), (2) and (3).

Fig. 3 (a) $\bar{p}p_f$ effective mass distribution in 20 MeV bins for reaction (1).

(b) $\bar{p}p_f$ effective mass distribution in 5 MeV bins for reaction (1).

(c) K^+K^- effective mass distribution in 5 MeV bins for the inclusive reaction $\pi^-p \to K^+K^- + X$.

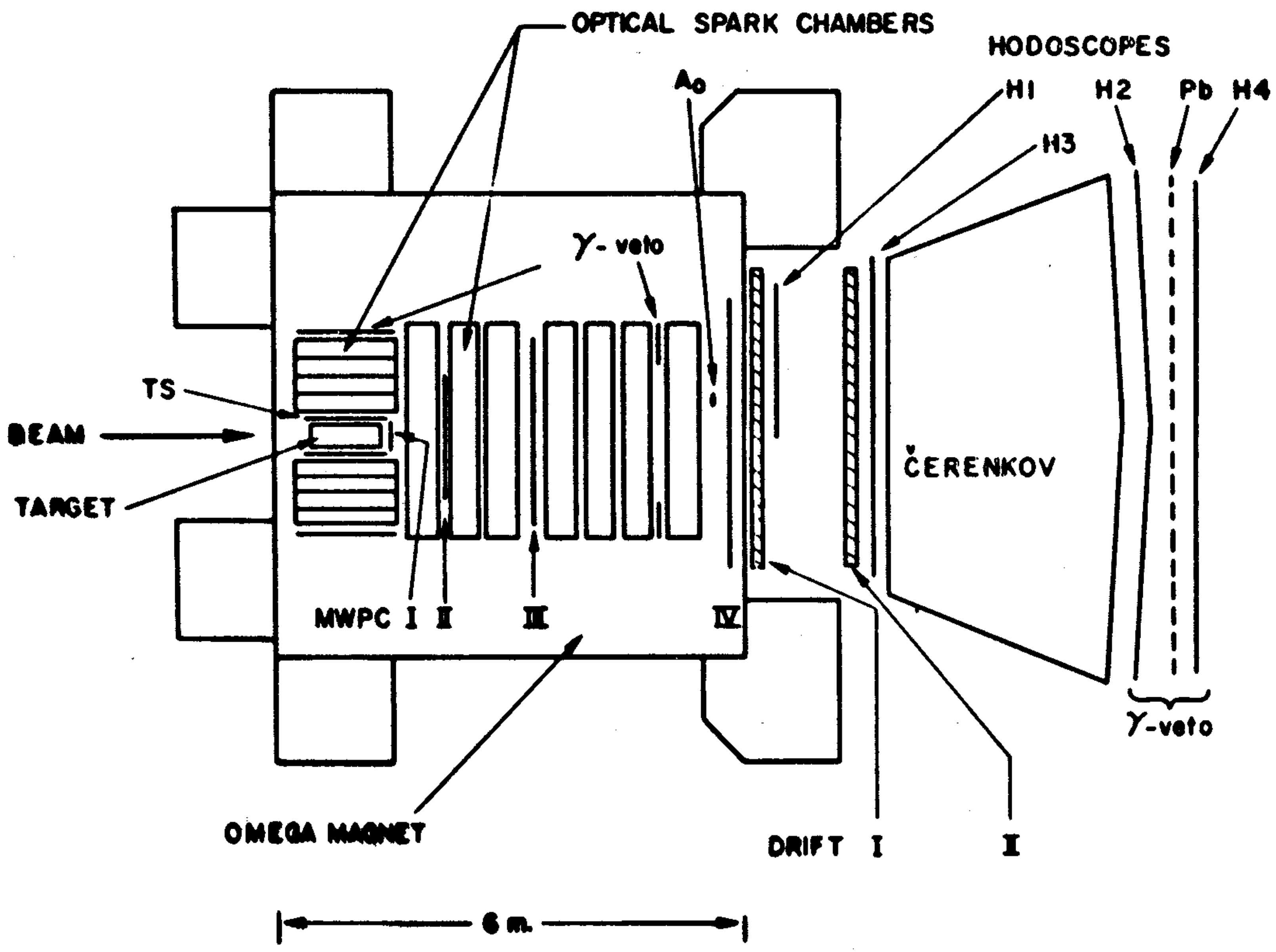
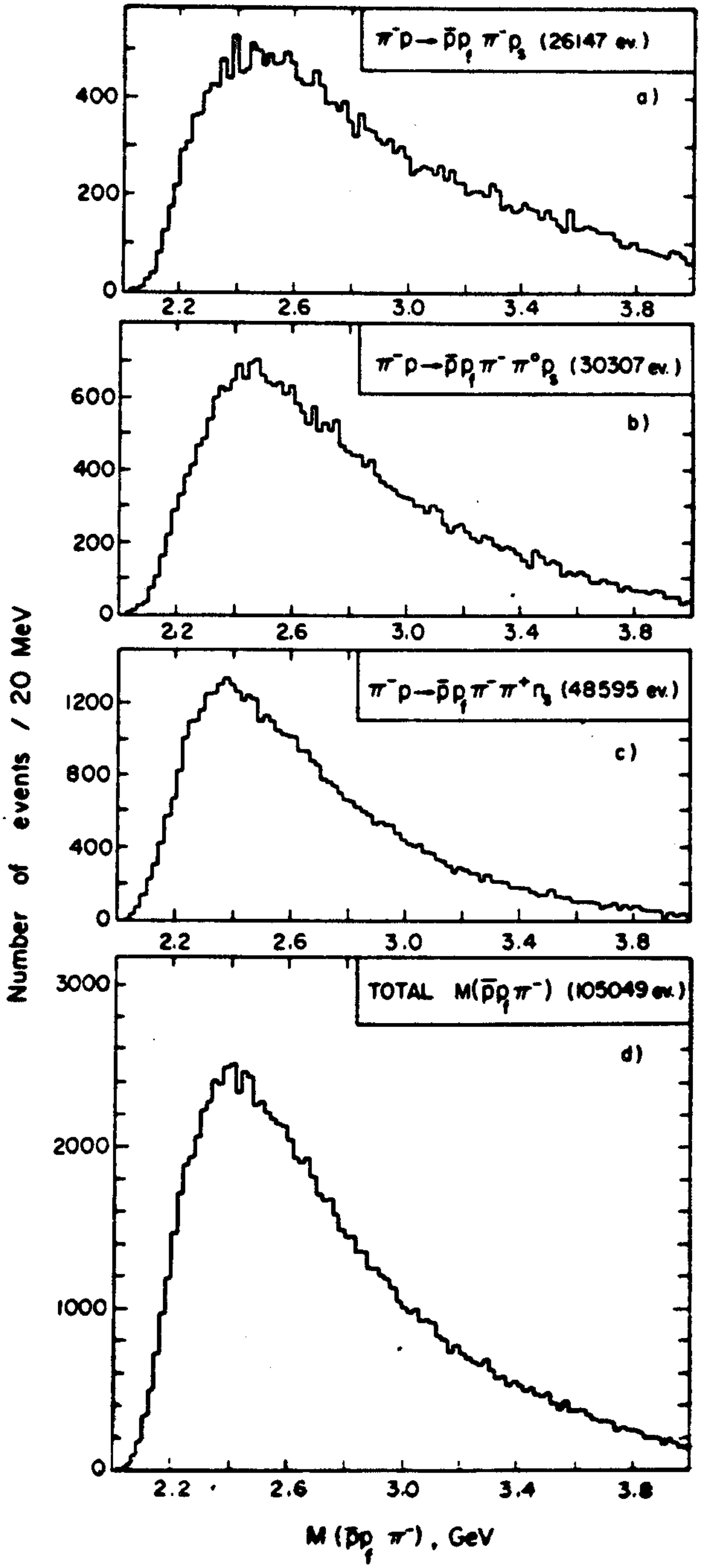

OPTICAL SPARK CHAMBERS
HODOSCOPES
H1
H2
Pb
H4
H3
A_0
γ- veto
TS
BEAM
TARGET
ČERENKOV
MWPC I II III IV
OMEGA MAGNET
DRIFT I II
γ-veto
6 m.

fig. 1



$\pi^- p \to \bar{p} p_f \pi^- p_s$ (26147 ev.)
a)
$\pi^- p \to \bar{p} p_f \pi^- \pi^0 p_s$ (30307 ev.)
b)
$\pi^- p \to \bar{p} p_f \pi^- \pi^+ n_s$ (48595 ev.)
c)
TOTAL $M(\bar{p} p_f \pi^-)$ (105049 ev.)
d)
Number of events / 20 MeV
$M(\bar{p} p_f \pi^-)$, GeV

fig.2

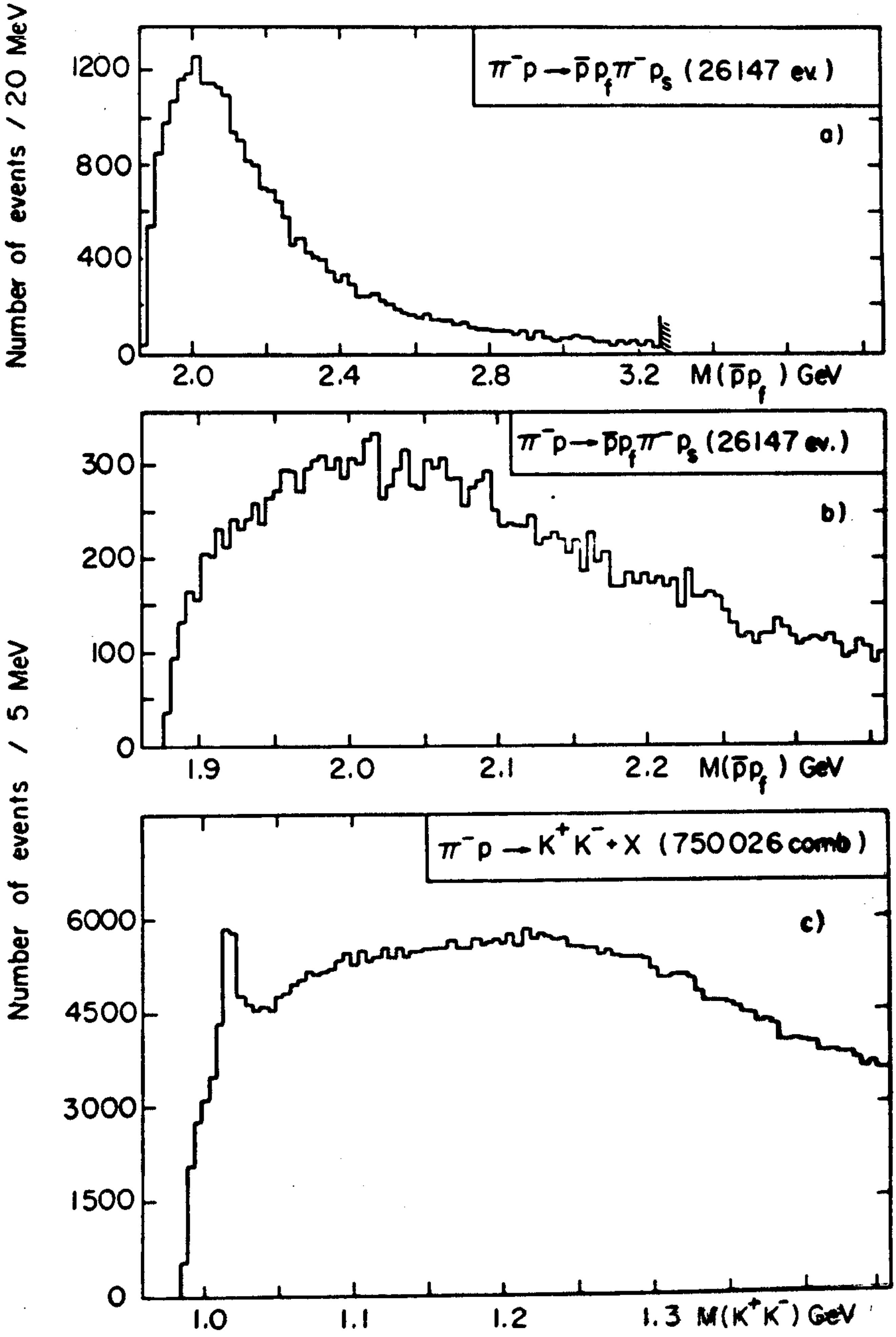

Number of events / 20 MeV
$\pi^- p \to \bar{p} p_f \pi^- p_s$ (26147 ev.)
a)
1200
800
400
0
2.0
2.4
2.8
3.2
$M(\bar{p}p_f)$ GeV
$\pi^- p \to \bar{p} p_f \pi^- p_s$ (26147 ev.)
b)
Number of events / 5 MeV
300
200
100
0
1.9
2.0
2.1
2.2
$M(\bar{p}p_f)$ GeV
$\pi^- p \to K^+ K^- + X$ (750026 comb)
c)
Number of events
6000
4500
3000
1500
0
1.0
1.1
1.2
1.3
$M(K^+K^-)$ GeV

fig. 3