SLAC-PUB-334
August 1967

STUDY OF $\pi^{\pm}$p 4-PRONG INTERACTIONS AT 16 GeV/c*

J. Ballam, A. D. Brody, G. B. Chadwick,
D. Fries, Z. G. T. Guiragossián, W. B. Johnson,
R. R. Larsen and D. W. G. Leith

Stanford Linear Accelerator Center
Stanford University, Stanford, California

We wish to report results from two experiments performed at 16 GeV/c in the Brookhaven National Laboratory 80-inch hydrogen bubble chamber. In the first experiment a beam of π^- mesons was prepared using the rf separated beam in an unseparated mode; the momentum resolution of this beam was ±0.3%. In the second experiment the rf beam was used in the separated mode to form a π^+ beam with momentum resolution of ±1%.

A portion of the film was scanned for all kinds of events in order to compare topological cross sections between π^+p and π^-p. As can be seen from Table I, their cross sections are strikingly similar. These data have been normalized to total cross section measurements.[1]

TABLE I

Class	$\sigma(\pi^-p)$ mb	$\sigma(\pi^+p)$ mb
2 prongs	8.7 ± 0.6	7.6 ± 0.6
4 prongs	8.8 ± 0.7	8.6 ± 0.6
6 prongs	4.6 ± 0.6	4.5 ± 0.5
8 prongs	1.5 ± 0.3	1.1 ± 0.3
10 prongs	0.2 ± 0.1	0.1 ± 0.05
Visible V°	1.6 ± 0.3	2.1 ± 0.3

*Work supported by the U. S. Atomic Energy Commission.

(Heidelberg International Conference on Elementary Particles, September 20-27, 1967)

We have measured slightly more than 10,000 events in the 4-prong topology in the $\pi^- p$ experiment and 5,000 events in the $\pi^+ p$ experiment. Kinematical fits have been made for the final states $p\pi^{\pm}\pi^+\pi^-$, $p\pi^{\pm}\pi^+\pi^-\pi^\circ$, and $n\pi^{\pm}\pi^+\pi^-\pi^+$. All fits with greater than 1% confidence level have been checked for consistency with track ionization. Table II lists cross sections for these final states.

TABLE II

Reaction	σ mb
$\pi^- p \longrightarrow p\pi^-\pi^+\pi^-$	1.08 ± 0.15
$\longrightarrow p\pi^-\pi^+\pi^-\pi^\circ$	1.24 ± 0.15
$\longrightarrow n\pi^-\pi^+\pi^-\pi^+$	0.62 ± 0.10
$\pi^+ p \longrightarrow p\pi^+\pi^+\pi^-$	1.28 ± 0.15
$\longrightarrow p\pi^+\pi^+\pi^-\pi^\circ$	1.28 ± 0.17
$\longrightarrow n\pi^+\pi^+\pi^-\pi^+$	0.35 ± 0.10

In the four body final states we observe strong signals for N^{*++}, $N^{*\circ}$, ρ°, and f°, and sizable enhancements in the A_1 and A_2 regions. Production cross sections for these processes are listed in Table III. In the case of A-meson

TABLE III

	$\sigma(\pi^- p)$ mb	$\sigma(\pi^+ p)$ mb
Total N^{*++}	0.24 ± 0.05	0.44 ± 0.10
Total $N^{*\circ}$	0.05 ± 0.02	0.15 ± 0.04
Total ρ°	0.49 ± 0.11	0.41 ± 0.10
Total f°	0.08 ± 0.02	0.14 ± 0.03
$\pi^{\pm} p \longrightarrow A_1^{\pm} p$	0.12 ± 0.03	0.04 ± 0.02
$\pi^{\pm} p \longrightarrow A_2^{\pm} p$	0.09 ± 0.03	0.05 ± 0.02

production, cross section estimates are based upon a fit of the $\rho^\circ \pi^\pm$ spectra to two Breit-Wigner forms with a background of the Deck type as calculated by Maor.[2]

Figure 1 depicts the mass spectra for the $\pi^\pm \pi^+ \pi^-$ system in each experiment. The shaded events are those with at least one $\pi^+\pi^-$ combination in the ρ-meson region and no πp mass in the N* region. There appears to be significantly less A_1 production in the $\pi^+ p$ experiment than in $\pi^- p$, as was indicated by the cross section in Table III. The A_2 signal also seems weaker, but limited statistics prevent a firm conclusion. The presence of a very strong N^{*++} signal in the $\pi^+ p$ data creates considerably more background in the uncut spectrum than is present in the π^- data and makes extraction of reliable A-meson cross sections considerably more difficult. These data point out once again the mysterious character of the A_1 enhancement whose production, if mediated by a neutral exchange in the t channel, one might expect to be equal in $\pi^- p$ and $\pi^+ p$ collisions if it is a true resonant state.

Spectra for the effective mass of the $\pi^+ p$ system are shown in Fig. 2. A strong N^{*++} signal is seen in both experiments but especially in the π^+ data where it accounts for about one-third of the cross section in this channel. In addition there is evidence in the π^+ experiment for some N* (1920) production.

Figure 3 shows the $\pi^+\pi^-$ mass spectra. Here strong ρ° and f° signals appear in both experiments. In the $\pi^- p$ data, exclusion of events in the A regions (three pion masses less than 1.4 GeV) reduces the data to the histogram shown in Fig. 4. The solid curve in Fig. 4 represents the prediction of the OPE model as calculated by Wolf. Agreement appears to be quite good. The success of this model in explaining the data outside the A regions gives us some confidence that its results will provide reliable estimates of the background in the A_1 and A_2 regions.

Since the level of background is relatively high in these regions, its presence seriously distorts the decay angular distributions of the A-mesons. We are working at present on subtraction of this background in order to obtain true distributions for these decays.

REFERENCES

1. William A. Love, Bulletin of the American Physical Society, Series II, Vol. 7, No. 4, p. 567.
2. U. Maor and T. A. O'Halloran, Physics Letters 15, 281, and subsequent preprint from U. Maor.

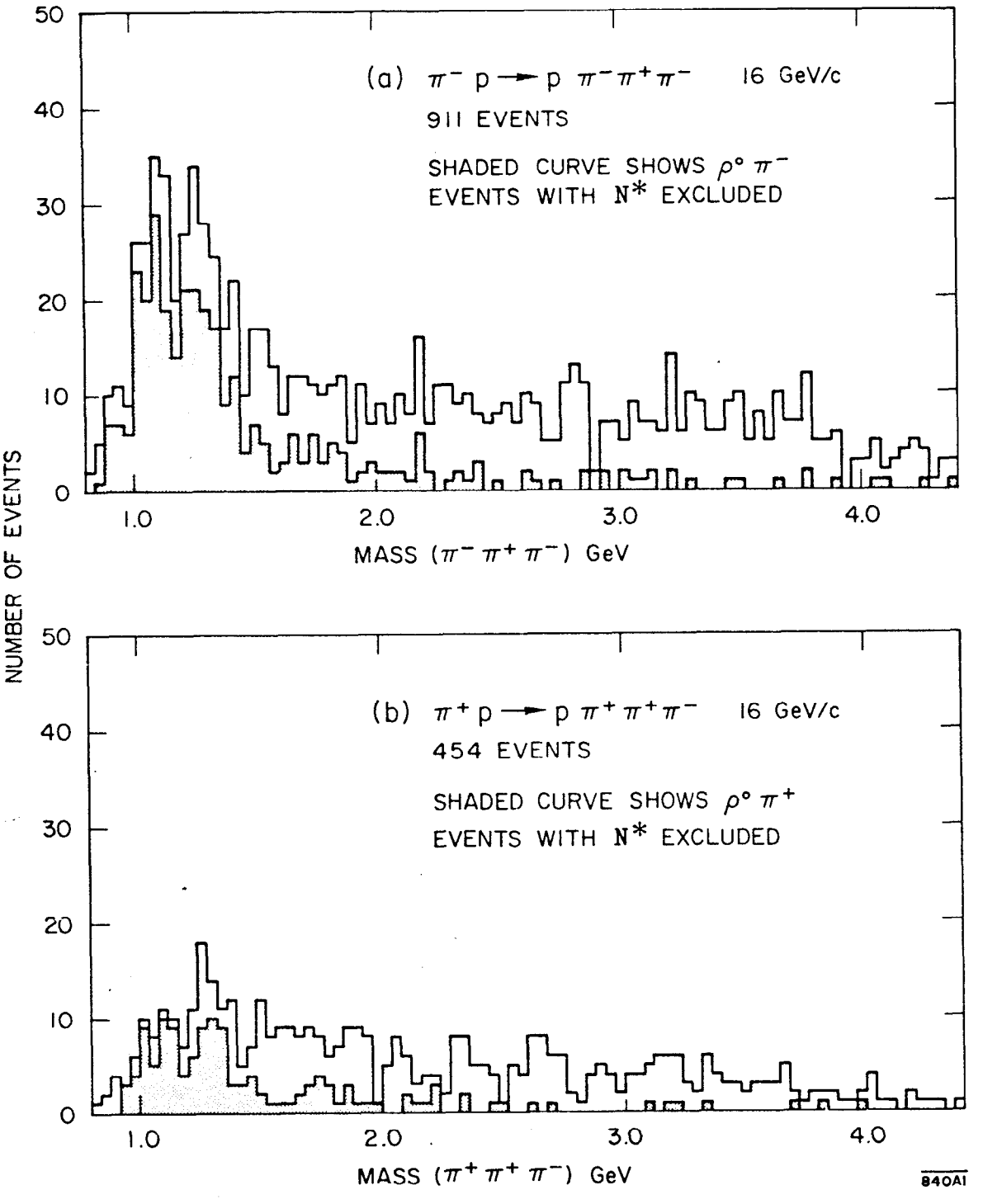
(a) $\pi^- p \rightarrow p\ \pi^-\pi^+\pi^-$ 16 GeV/c
911 EVENTS
SHADED CURVE SHOWS $\rho^\circ \pi^-$
EVENTS WITH N* EXCLUDED
NUMBER OF EVENTS
MASS $(\pi^-\pi^+\pi^-)$ GeV
(b) $\pi^+ p \rightarrow p\ \pi^+\pi^+\pi^-$ 16 GeV/c
454 EVENTS
SHADED CURVE SHOWS $\rho^\circ \pi^+$
EVENTS WITH N* EXCLUDED
MASS $(\pi^+\pi^+\pi^-)$ GeV
840A1

FIG. 1

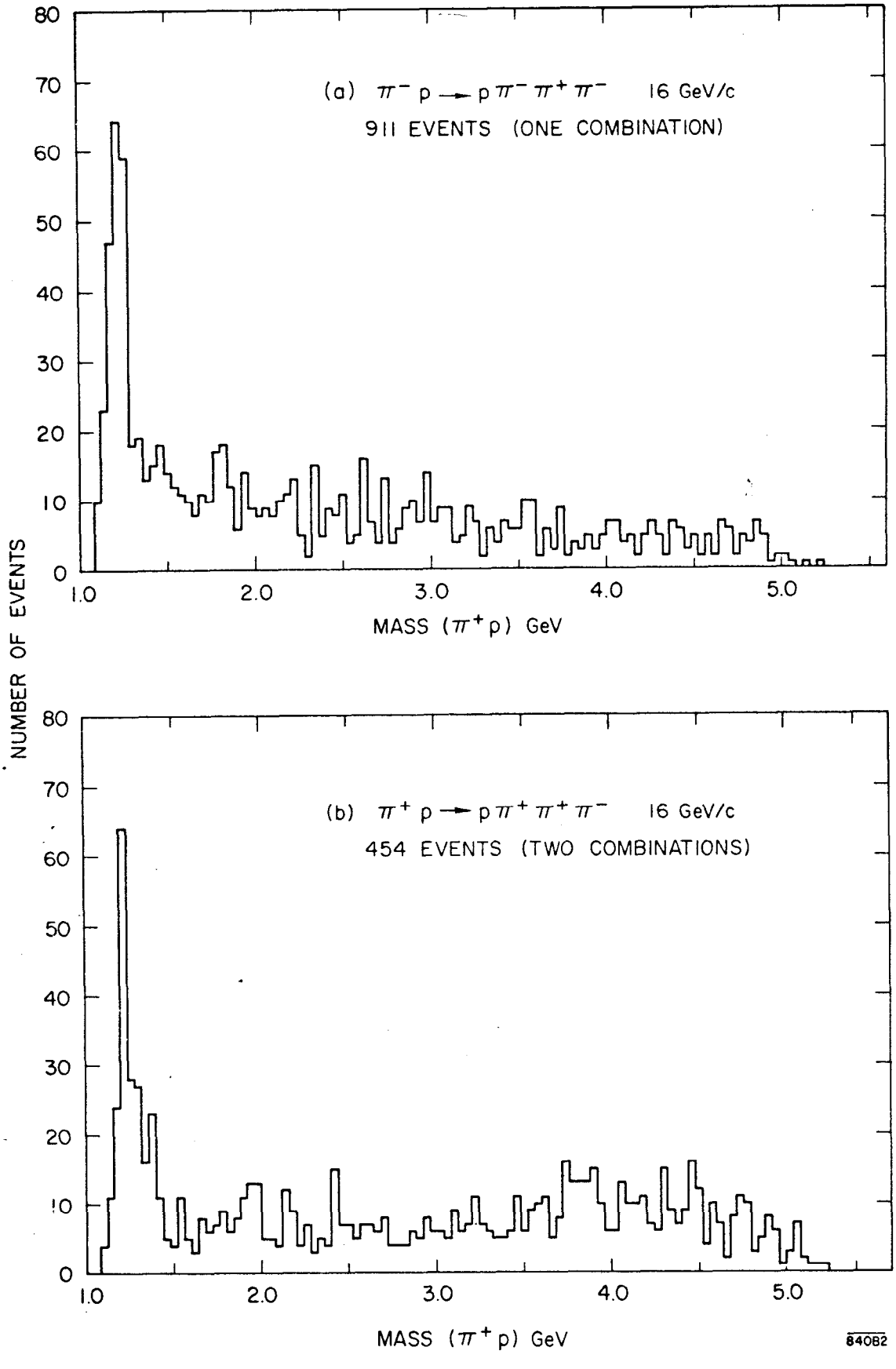
(a) $\pi^- p \rightarrow p\pi^-\pi^+\pi^-$ 16 GeV/c
911 EVENTS (ONE COMBINATION)
(b) $\pi^+ p \rightarrow p\pi^+\pi^+\pi^-$ 16 GeV/c
454 EVENTS (TWO COMBINATIONS)
NUMBER OF EVENTS
MASS $(\pi^+ p)$ GeV
MASS $(\pi^+ p)$ GeV
84082

FIG. 2

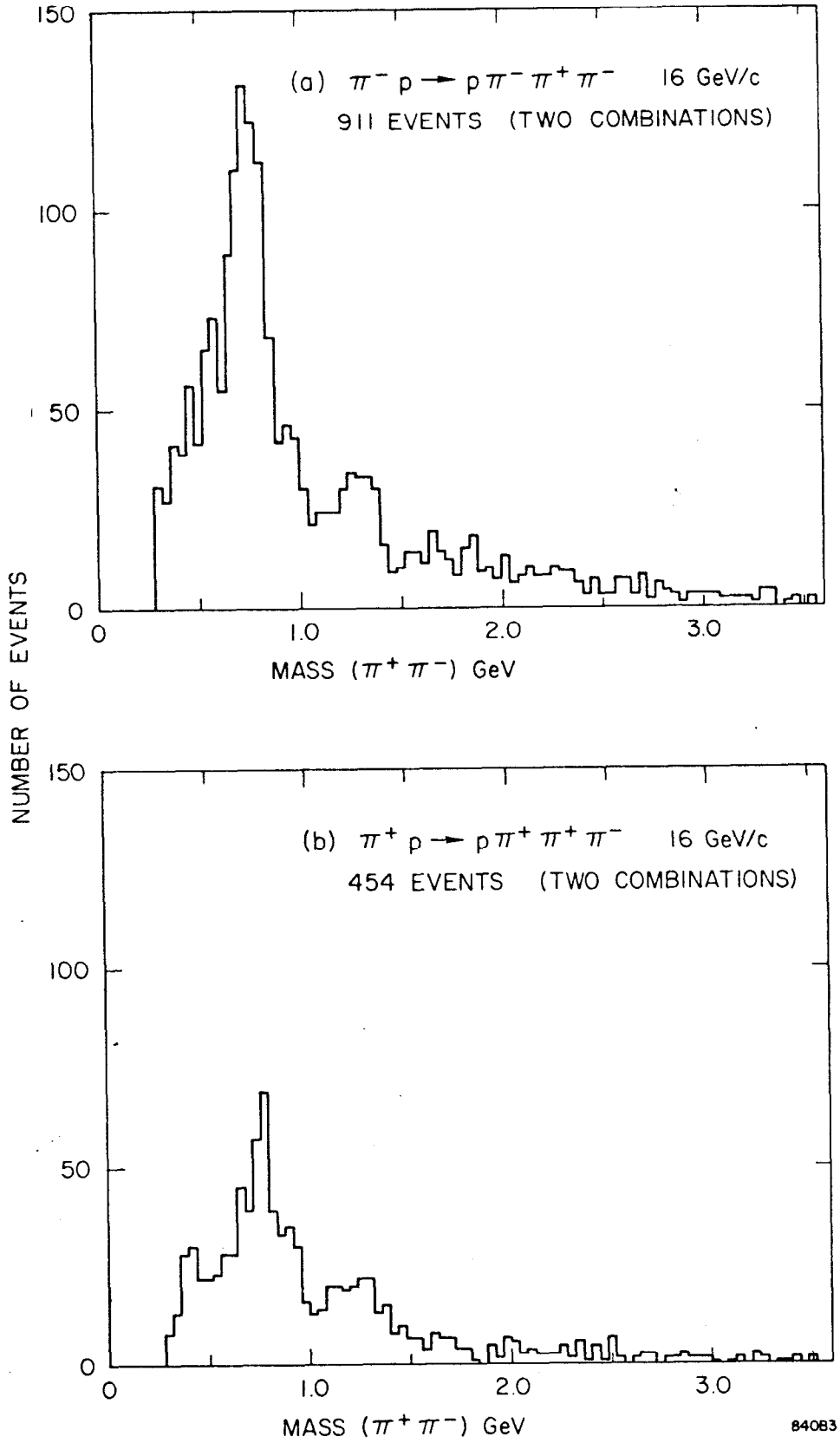
(a) $\pi^- p \rightarrow p\pi^-\pi^+\pi^-$ 16 GeV/c
911 EVENTS (TWO COMBINATIONS)
(b) $\pi^+ p \rightarrow p\pi^+\pi^+\pi^-$ 16 GeV/c
454 EVENTS (TWO COMBINATIONS)
NUMBER OF EVENTS
MASS $(\pi^+\pi^-)$ GeV
0
50
100
150
1.0
2.0
3.0
84083

FIG. 3

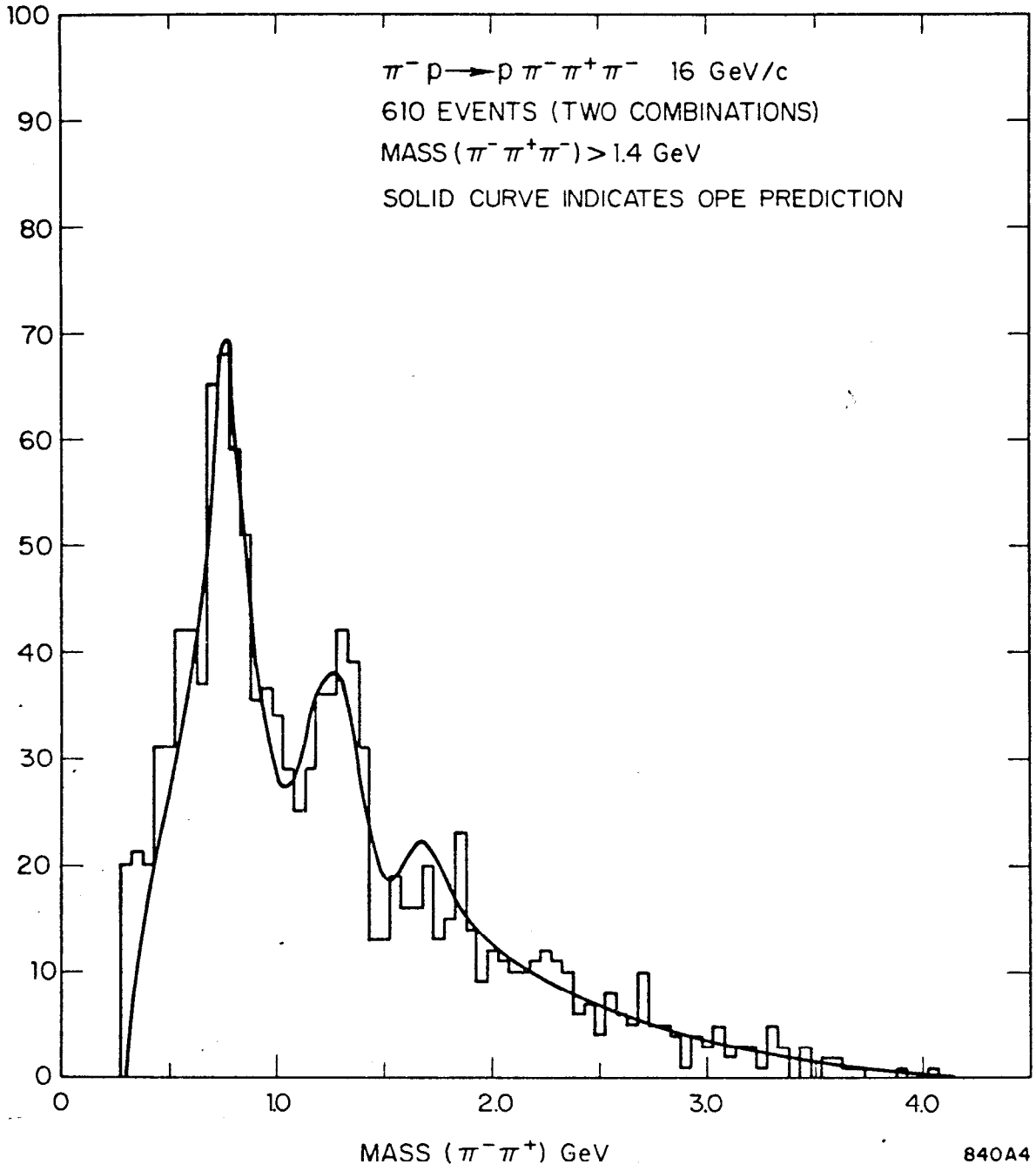
$\pi^- p \rightarrow p\,\pi^-\pi^+\pi^-$ 16 GeV/c
610 EVENTS (TWO COMBINATIONS)
MASS $(\pi^-\pi^+\pi^-) > 1.4$ GeV
SOLID CURVE INDICATES OPE PREDICTION
100
90
80
70
60
50
40
30
20
10
0
0
1.0
2.0
3.0
4.0
MASS $(\pi^-\pi^+)$ GeV
840A4

FIG. 4