Conf-760719--

COO-1545-191

Submitted

for The XVIII International Conference

on High Energy Physics

Tbilisi, 15 - 21 July, 1976

A High-Statistics Search for A_1^o and H^o in $\pi^- p \rightarrow \pi^+ \pi^- \pi^o$ at 8.4 GeV/c*

K.W. Edwards and D. Legacey
Department of Physics, Carleton University, Ottawa, Ontario, Canada

P. Brockman, J. Gandsman, P.M. Patel and C. Zanfino
Department of Physics, McGill University, Montreal, Quebec, Canada

N.R. Stanton
Physics Department, The Ohio State University, Columbus, Ohio, USA

J.A. Dankowych, J.F. Martin and J.D. Prentice
Department of Physics, University of Toronto, Toronto, Ontario, Canada

ABSTRACT

We are searching for the hitherto unobserved neutral $J^P = 1^+$ objects A_1^o and H^o produced in the reaction $\pi^- p \rightarrow \pi^+ \pi^- \pi^o n$ ($\pi^o \rightarrow \gamma\gamma$) at 8.4 GeV/c. Both charged pions and both γ's are measured in the Charged and Neutral Spectrometer at the Argonne ZGS. We report here preliminary results from a first-pass analysis of 45% of the data, containing $\sim$ 900 events/10MeV/c^2 mass bin at 1100 MeV/c^2. Strong peaks at the η, ω, A_2, and $\omega(1670)$ dominate the spectrum. The possible presence of less prominent structure is discussed.

*Work sponsored in part by ERDA and NRC/IPP (Canada)

CONTRACT NO. E(11-1)-1545

DISCLAIMER

Although the quark model has enjoyed remarkable success in classifying hadronic states, puzzling gaps in the observed states remain an embarrassment to the theory. The two predicted meson nonets with $J^{PC} = 1^{++}$ and 1^{+-} have proved especially troublesome. The situation is epitomized by the prototype of axial vectors, the A_1. It is now nearly certain[1] that the broad, diffractively-produced bump at 1.1 GeV/c^2 in the charged $\rho\pi$ final state is not resonant in character, and no strong candidate for a neutral A_1 has ever been found. There is similar lack of experimental support for the two isoscalars (often called H and H') associated with the well-established isovector B(1240). Both the A_1 and the H are expected to decay predominantly into $(\rho\pi)^o$, and the H' should also be seen in this mode if this nonet does not have magic mixing.

We report here preliminary results from a search for previously unseen neutral mesons produced in the reaction $\pi^- p \rightarrow \pi^+\pi^-\pi^o n$ at 8.4 GeV/c, based on a first-pass analysis of 45% of our data. The full data sample will provide a sensitivity about 20 times that of any previous[2,3] search.

The experiment was conducted with the Charged and Neutral Spectrometer at the Argonne ZGS, which is pictured in Figure 1 and described in more detail elsewhere[4]. This apparatus measures the vector momenta of both charged pions and both γ's in the $\pi^+\pi^-\pi^o$ final state; the recoil neutron is not detected. Momentum analysis of the π^+ and π^- is performed in a large aperture magnetic spectrometer using conventional magnetostrictive spark chambers. Immediately downstream is a thin (1½ radiation length) lead converter followed by three magnetostrictive spark chambers to record the shower conversion points. A rather coarse-grained array of 56 lead glass Cerenkov counters measures the shower energies. The whole apparatus is made as short and wide as possible to maximize the acceptance for this multiparticle final state: the magnet is less than a meter deep, and the 1.52 x 1.52 m^2 lead glass array is only 3.8 m from the hydrogen target. Scintillator hodoscopes allow approximate selection of charged and shower multiplicities, and scintillator-lead sandwiches surrounding the target reject most recoils other than neutrons.

The apparatus has previously been used to study the production of ω^o and η^o mesons at 6 GeV/c.[4,5] Only minor changes have been made for this experiment except for the higher beam momentum, which results in a greatly improved acceptance at larger 3π masses at the expense of some loss of resolution.

Before presenting any mass spectra we re-emphasize the preliminary nature of the data: 1) It is derived from less than half our total sample. 2) We believe the mass resolution can be significantly improved by further analysis. 3) Many checks of systematic effects have not yet been done. 4) The Monte Carlo acceptance calculations used here give only a very crude first-order correction, since phase space decay into 3π was assumed throughout.

In Figure 2 we show the $\gamma\gamma$ effective mass and nucleon missing mass for events in the ω region of $\pi^+\pi^-\pi^o$ mass. Cuts defining the accepted limits for these masses are shown by arrows. The π^o peak is very clean with a full width at half maximum of 22 MeV/c^2; $\gamma\gamma$ spectra for other regions of $\pi^+\pi^-\pi^o$ mass are very similar. The neutron peak in the missing mass spectrum is also quite clean. There is somewhat more non-neutron background at higher $\pi^+\pi^-\pi^o$ mass; we estimate typically $\sim$ 25% within the cuts shown.

Figure 3 displays the $\pi^+\pi^-\pi^o$ mass spectrum for events passing the cuts shown in Figure 2. Figure 4 displays dipion mass histograms for the three possible charge states; ω and η events have been excluded. In Figure 5 the $\pi^+\pi^-\pi^o$ mass spectra are replotted subject to cuts chosen to select ρ^-, ρ^+ and ρ^o. Raw spectra uncorrected for acceptance are shown as histograms in these figures while spectra with an approximate acceptance correction (arbitarily normalized to unity at 0.9 GeV/c^2) are shown with heavy dots and statistical error flags.

Several features of the data are apparent from Figures 3, 4 and 5. The level of statistics, $\sim$ 1000 events per 10 MeV/c^2 bin for 3π masses below 1.4 GeV/c^2, already approaches an order of magnitude improvement over existing data.

The 3π spectrum is dominated by strong peaks at the η, ω, A_2 and ω_g(1670) masses. These peaks are much cleaner than those seen in deuterium bubble chamber experiments.

Except for the η and the ω, no narrow structures in Figures 3 or 5 have statistical significance above $\sim$3 standard deviations. We expect our sensitivity to narrow structure to improve when our resolution is fully optimized. This improvement, together with the twofold increase in statistics from the full data sample, should suffice to decide whether any of the marginally significant narrow structure in Figures 3 and 5 is real. Our present sensitivity to such effects is about 2% of the ω cross-section, or $\sim$ 0.8 μbarn.

The mass spectrum of Figure 3 has a broad shoulder near 1.0 GeV/c^2. Figure 5 shows that this shoulder is confined almost entirely to the $\rho^-\pi^+$ charge combination. It is also mostly responsible for the very strong ρ^- excess in Figure 4. The absence of a comparable effect in $\rho^+\pi^-$ implies that this effect cannot arise from the square of a resonant amplitude. It might be qualitatively explained by a Deck-type diagram involving pion exchange (Figure 6a), but the absence of a comparable effect in $\rho^o\pi^o$ (Figure 6b) is puzzling.

In summary, very preliminary analysis of our partial data sample provides a 10-fold increase in sensitivity over previous experiments without yielding any compelling A_1^o or H^o signals in the $\pi^+\pi^-\pi^o$ mass spectra. More sophisticated analysis using the isobar model must be performed to fully exploit the high statistics, and it is our intention to pursue this approach in the near future.

REFERENCES

1. See e.g. G. Ascoli, Proceeding of the XVI International Conference on High Energy Physics (Chicago and NAL, 1972), Vol. 1, p 3.

2. F. Wagner, M. Tabak and D.M. Chew, Phys. Lett. 58B, 201 (1975).

3. M.J. Emms et al, Phys. Lett. 60B, 109 (1975).

4. M. H. Shaevitz et al, Phys. Rev. Lett. 36, 5 (1976).

5. M. H. Shaevitz et al, Phys. Rev. Lett. 36, 8 (1976).

FIGURE CAPTIONS

Figure 1. Layout of the experiment. The scale along the beam direction has been slightly expanded for clarity, and the spark chambers which measure the beam direction are not shown.

Figure 2. $\gamma\gamma$ effective mass (a) and nucleon missing mass (b) for events from the ω region of $\pi^+\pi^-\pi^o$ mass. The arrows denote the cuts used to produce the histograms in Figures 3, 4 and 5.

Figure 3. $\pi^+\pi^-\pi^o$ mass spectrum. Raw events are shown by the histogram, and acceptance-corrected events (arbitrarily normalized at 0.9 GeV/c^2) by large dots with statistical error flags.

Figure 4. Dipion mass spectra for a) $\pi^-\pi^o$, b) $\pi^+\pi^o$, and c) $\pi^+\pi^-$ combinations. The ρ cuts used for Figure 5 are indicated by arrows.

Figure 5. $\pi^+\pi^-\pi^o$ mass spectra, subject to the ρ cuts shown in Figure 4. a) ρ^- cut; b) ρ^+ cut, c) ρ^o cut.

Figure 6. Deck-type diagrams for a) ρ^- and b) ρ^o production via pion exchange.

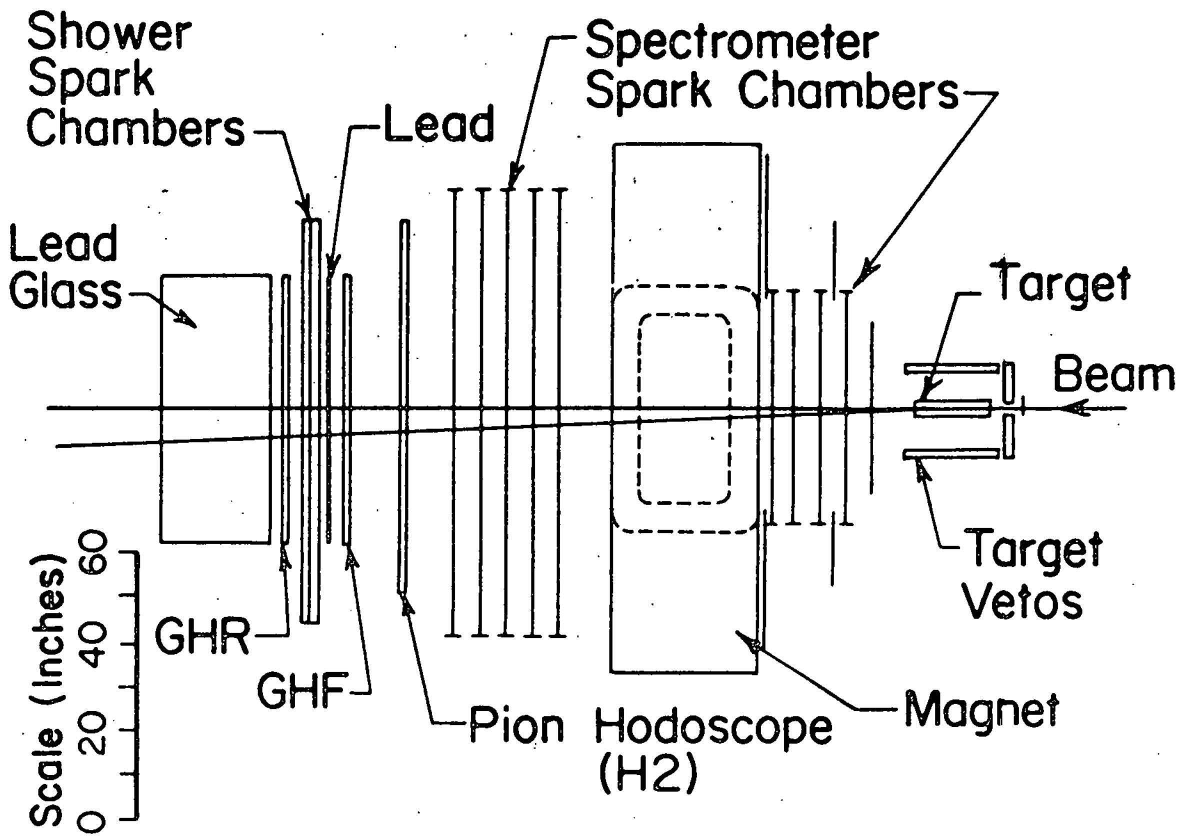
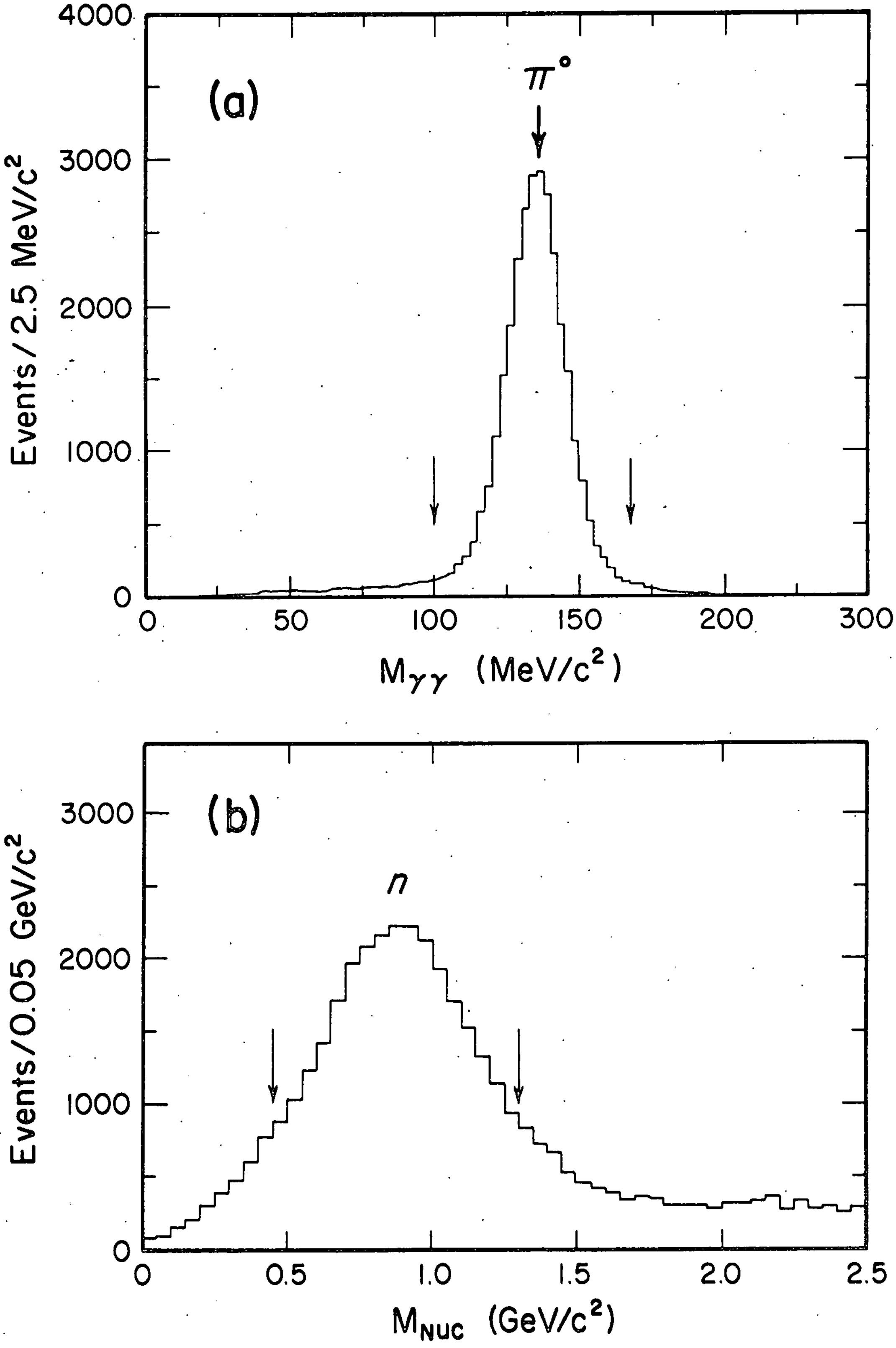
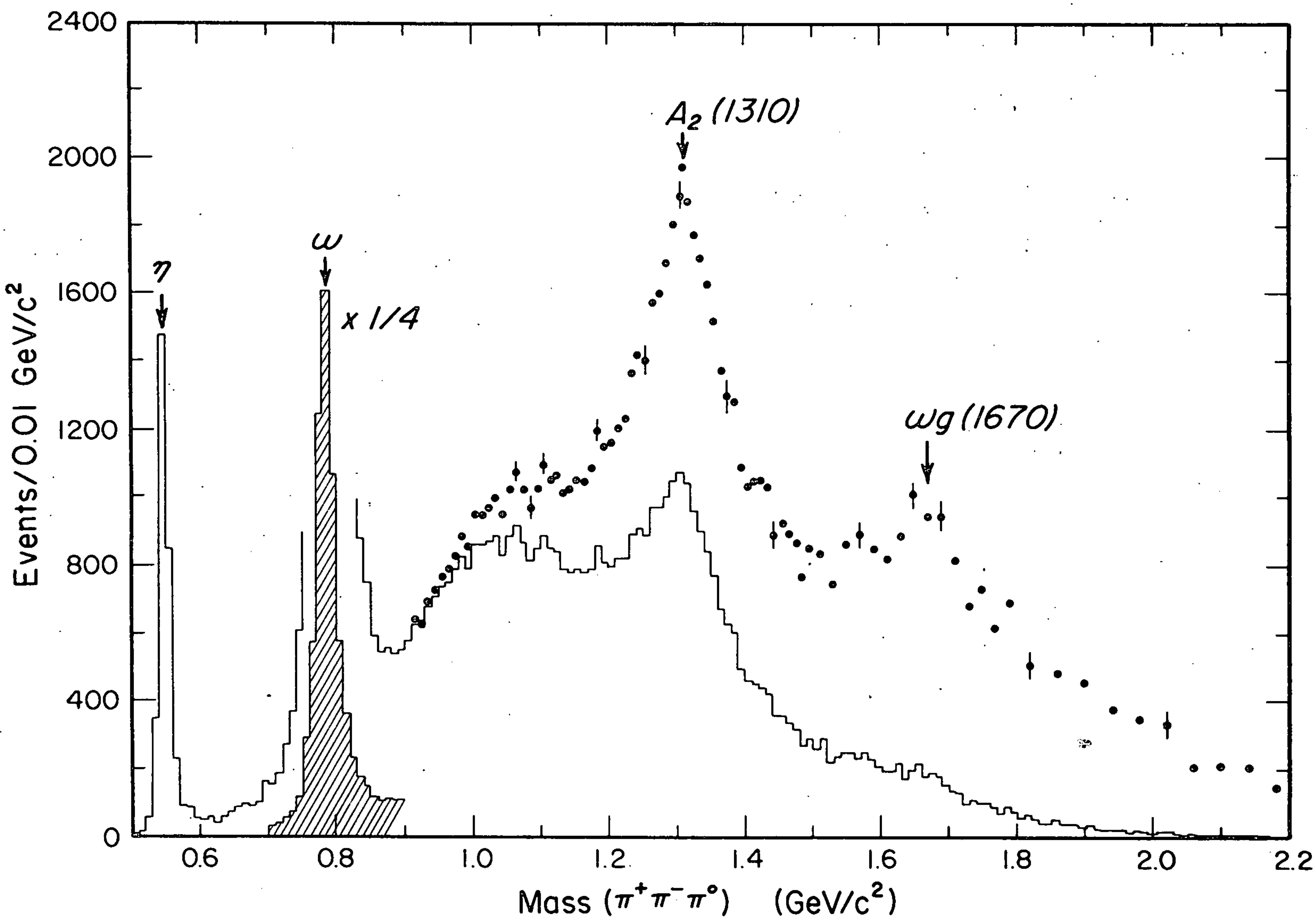

Shower
Spark
Chambers
Lead
Spectrometer
Spark Chambers
Lead
Glass
Target
Beam
Target
Vetos
Scale (Inches)
0
20
40
60
GHR
GHF
Pion Hodoscope
(H2)
Magnet

Figure 1.



(a)
π°
Events / 2.5 MeV/c²
4000
3000
2000
1000
0
0
50
100
150
200
300
$M_{\gamma\gamma}$ (MeV/c²)
(b)
n
Events/0.05 GeV/c²
3000
2000
1000
0
0
0.5
1.0
1.5
2.0
2.5
M_{Nuc} (GeV/c²)

Figure 2.



2400
2000
1600
1200
800
400
0
Events/0.01 GeV/c^2
η
ω
x 1/4
A_2 (1310)
ωg (1670)
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
Mass ($\pi^+\pi^-\pi^\circ$) (GeV/c^2)

Figure 3.

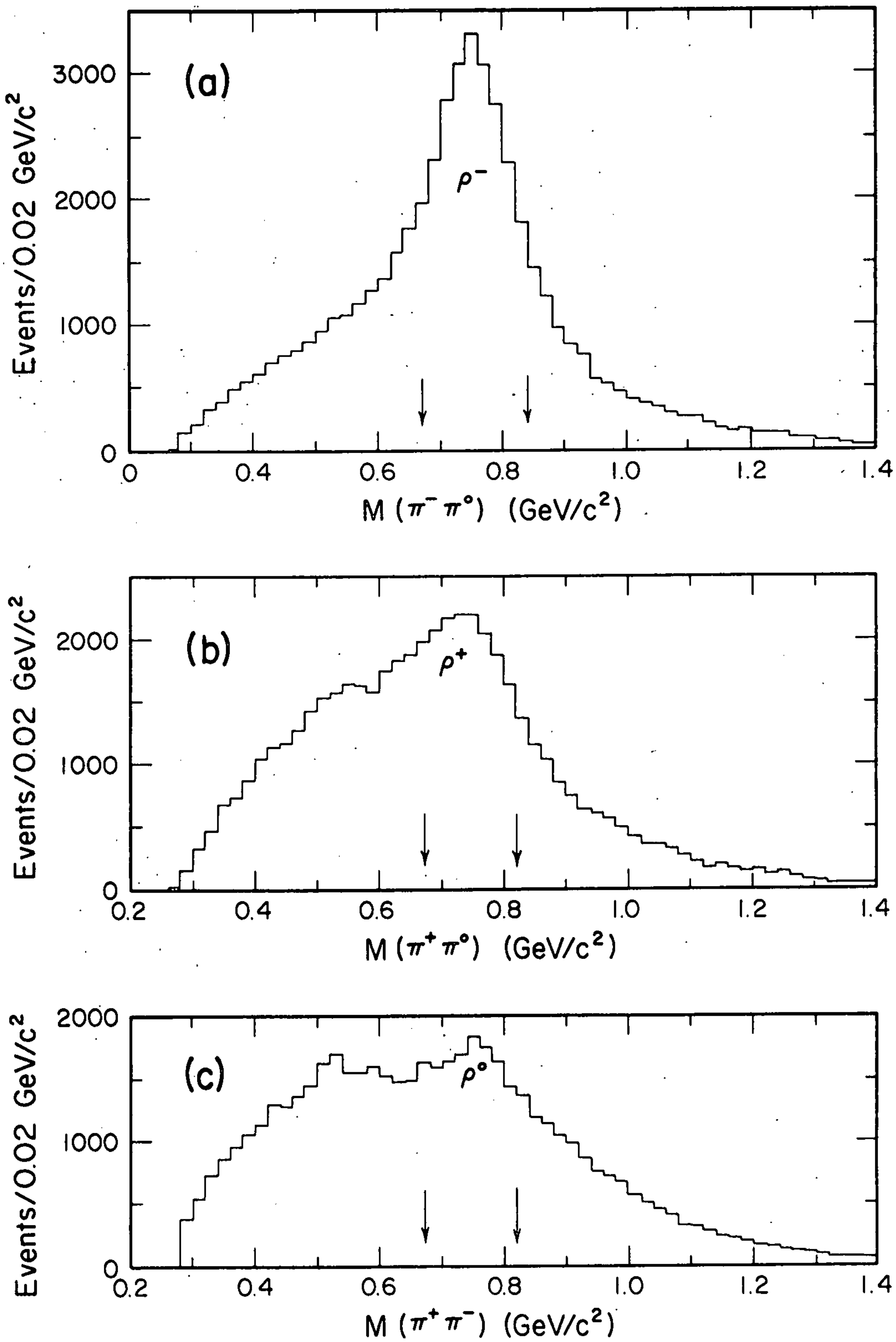
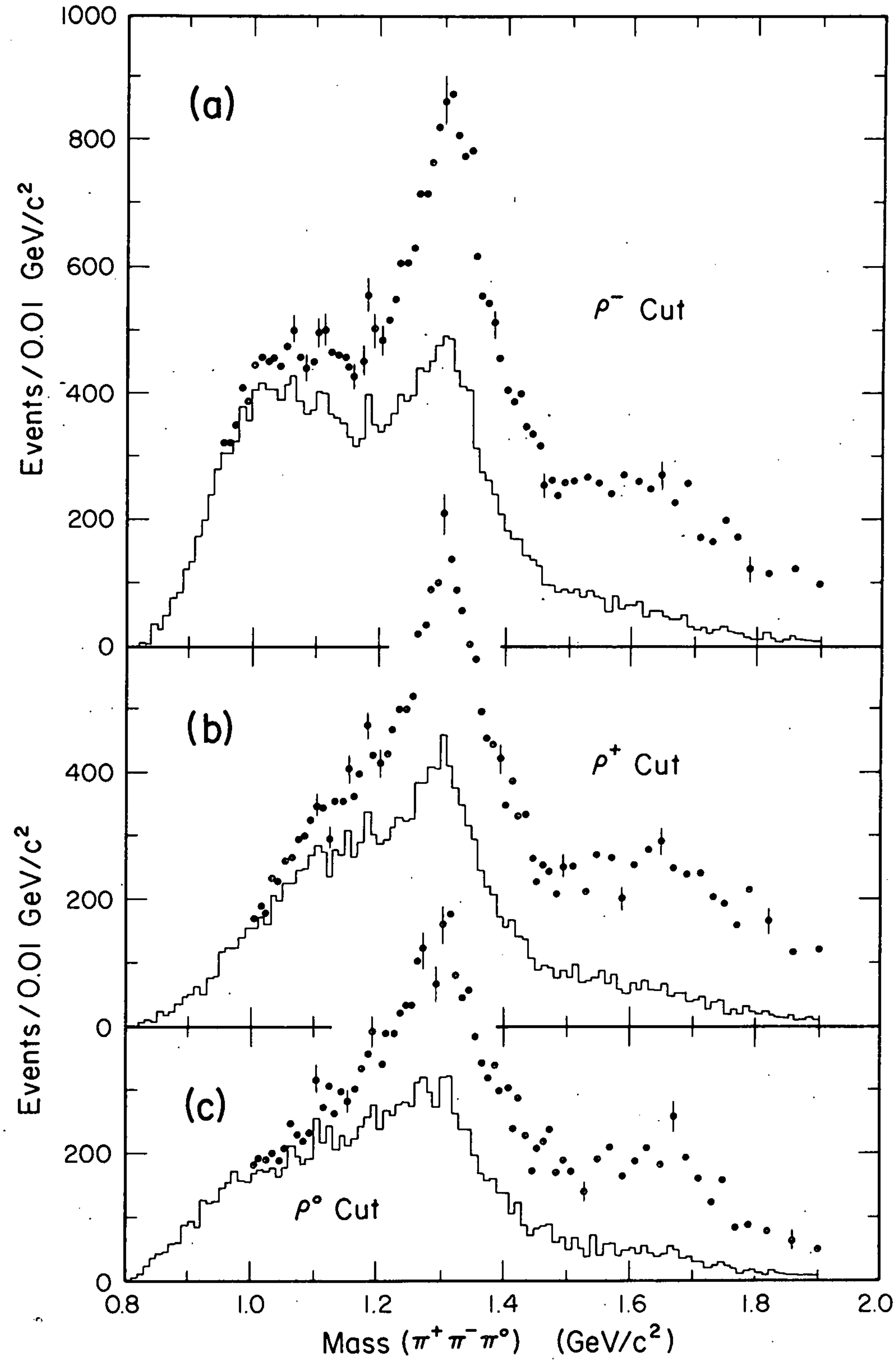

(a)
ρ^-
Events/0.02 GeV/c^2
0
1000
2000
3000
0
0.4
0.6
0.8
1.0
1.2
1.4
M ($\pi^-\pi^\circ$) (GeV/c^2)
(b)
ρ^+
Events/0.02 GeV/c^2
0
1000
2000
0.2
0.4
0.6
0.8
1.0
1.2
1.4
M ($\pi^+\pi^\circ$) (GeV/c^2)
(c)
ρ°
Events/0.02 GeV/c^2
0
1000
2000
0.2
0.4
0.6
0.8
1.0
1.2
1.4
M ($\pi^+\pi^-$) (GeV/c^2)

Figure 4.



(a)
ρ⁻ Cut
(b)
ρ⁺ Cut
(c)
ρ° Cut
Events/0.01 GeV/c²
Events/0.01 GeV/c²
Mass (π⁺π⁻π°) (GeV/c²)
1000
800
600
400
200
0
400
200
0
200
0
0.8
1.0
1.2
1.4
1.6
1.8
2.0

Figure 5.

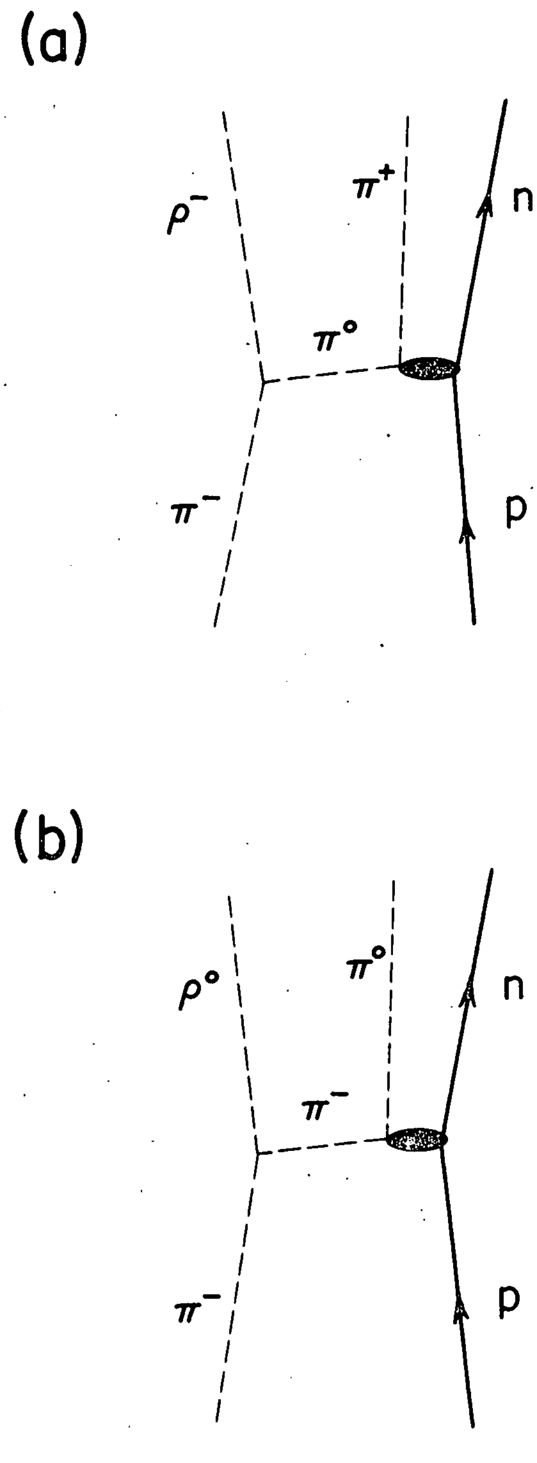


Figure 6.