Meson Spectroscopy in π^{-}p Interactions at 18 GeV/c –– Recent Results from Brookhaven E852

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on behalf of the Brookhaven E852 Collaboration

Overview

- BNL–E852 Introduction
- Data Analyses
  - Review of Earlier Results
  - New and Preliminary Results
  - Survey of New Analyses
- Summary

The E852 Collaboration

Brookhaven	Moscow State
Carnegie Mellon	Notre Dame
Indiana	Northwestern
IHEP Protvino	Rensselaer
Jefferson Lab	Umass–Dartmouth

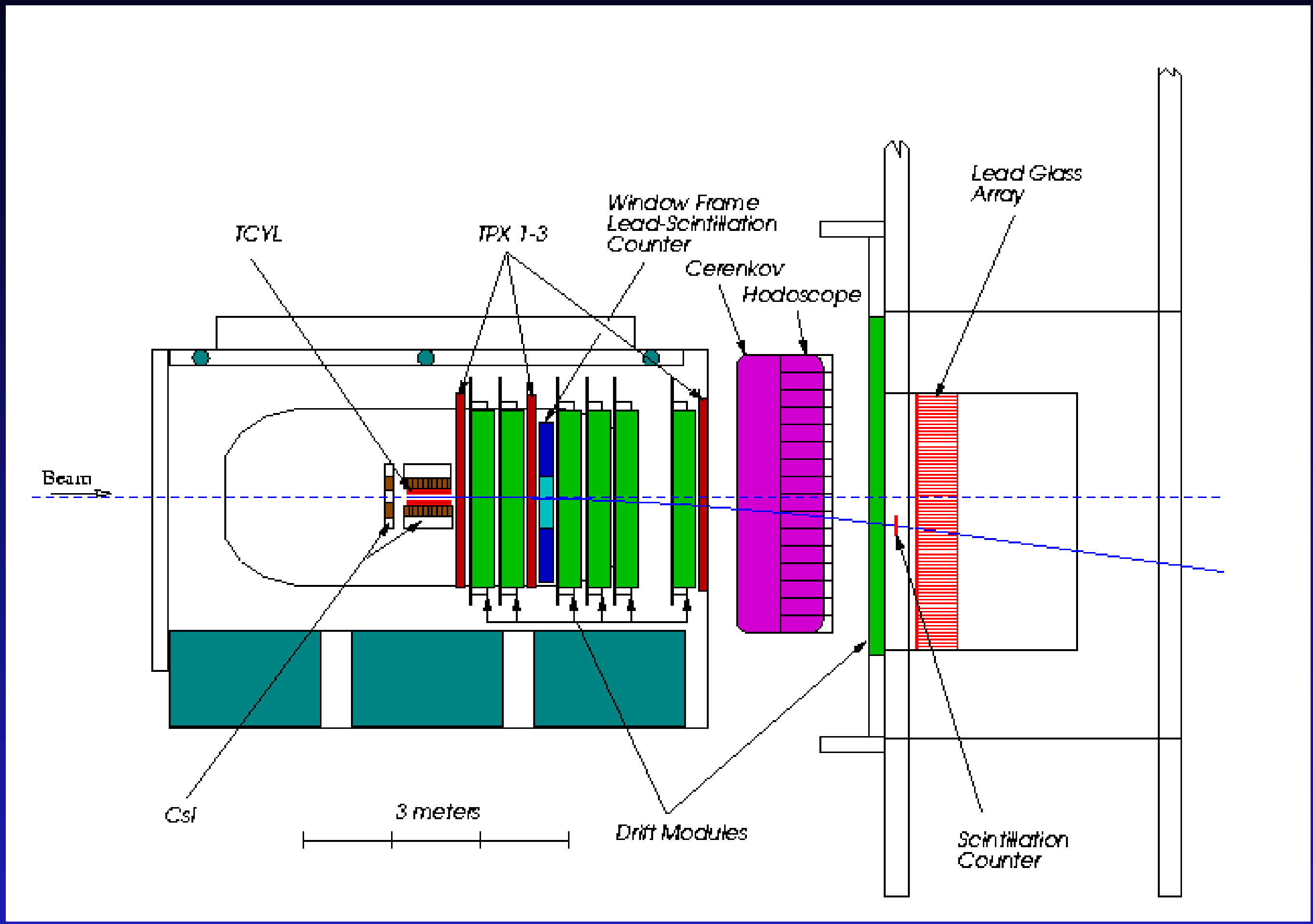
Experimental Features

- $\pi^- p \rightarrow X^o n$ & $\pi^- p \rightarrow X^- p$
- Large acceptance for charged particles and photons
- Kaon identification
- Exclusive Final States
  - Charged and neutral detection provide near hermetic coverage
- Simultaneous acquisition of overlapping channels
  - example: $\eta \rightarrow \gamma\gamma, \pi^+\pi^-\pi^o, \pi^o\pi^o\pi^o$

E852 Apparatus

- 18 GeV/*c* beam on hydrogen target
- Charged particle detection
  - MultiParticle Spectrometer
    - Cylindrical Drift Chamber
    - Large Downstream Drift Chamber
- Photon detection
  - 3000 element Lead Glass Array
  - CsI Barrel
  - Lead–scintillator sandwich
- Kaon identification via Cerenkov/Hodoscope
- Multiple triggering system & high–rate DAQ

E852 Plan View



Data Totals

Trigger Notation

(TCYL)–(TPX1)–(TPX2)–<LGD>   [Kaon]

Trigger	1994	1995	14 GeV/c
0–0–0–E	14M	94M	44M
1–1–1–η	47M	147M	27M
0–2–2–η	48M	108M	16M
0–3–3–η	46M		
1–3–3	88M	265M	12M
0–4–4	4M	96M	3M

> 1 billion triggers

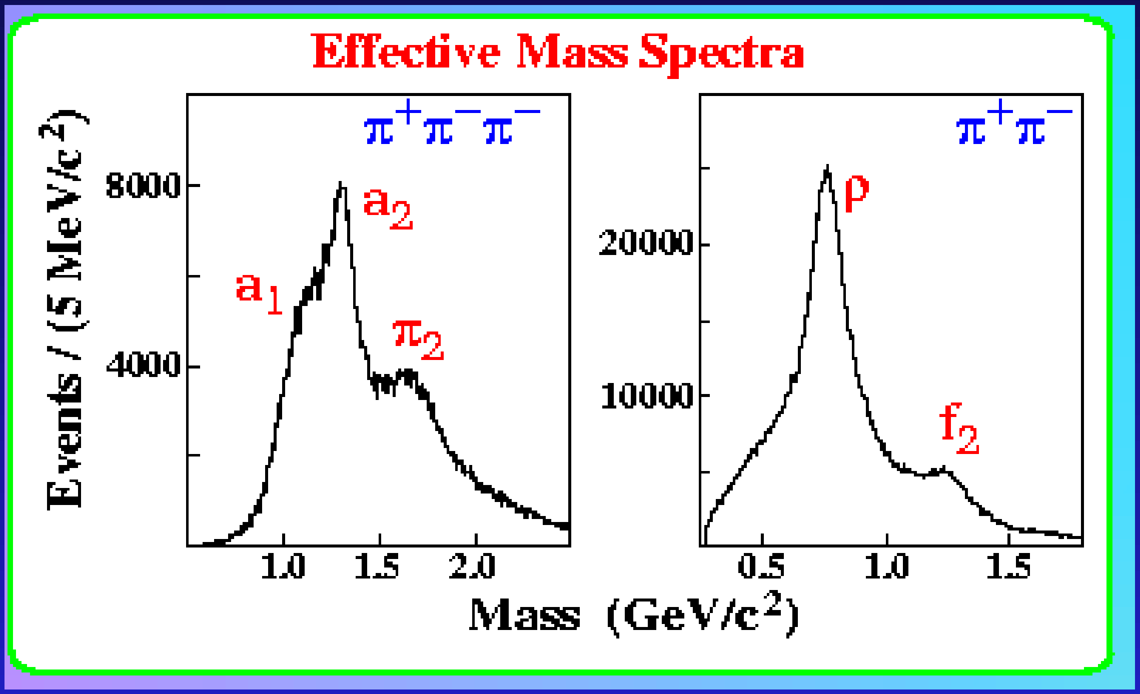
Trigger	1997	1998
0–2–2 K+ and K–	23M	53M
1–3–3 All	30M	46M
K–		100M
K+ and K–	36M	63M
0–2–4 K+ or K–	8M	32M
All	6M	
0–4–4 K+ or K–	73M	160M
K+ and K–	42M	81M
1–3–5 K+ or K–	6M	21M
1–5–5 K+ or K–	32M	67M

≈ 1 billion triggers

Observation of a New $J^{PC} = 1^{-+}$ Exotic State in the Reaction

$\pi^- p \to \pi^+ \pi^- \pi^- p$

Phys. Rev. Lett. **81** 26 5760 (1998)



Data Analysis

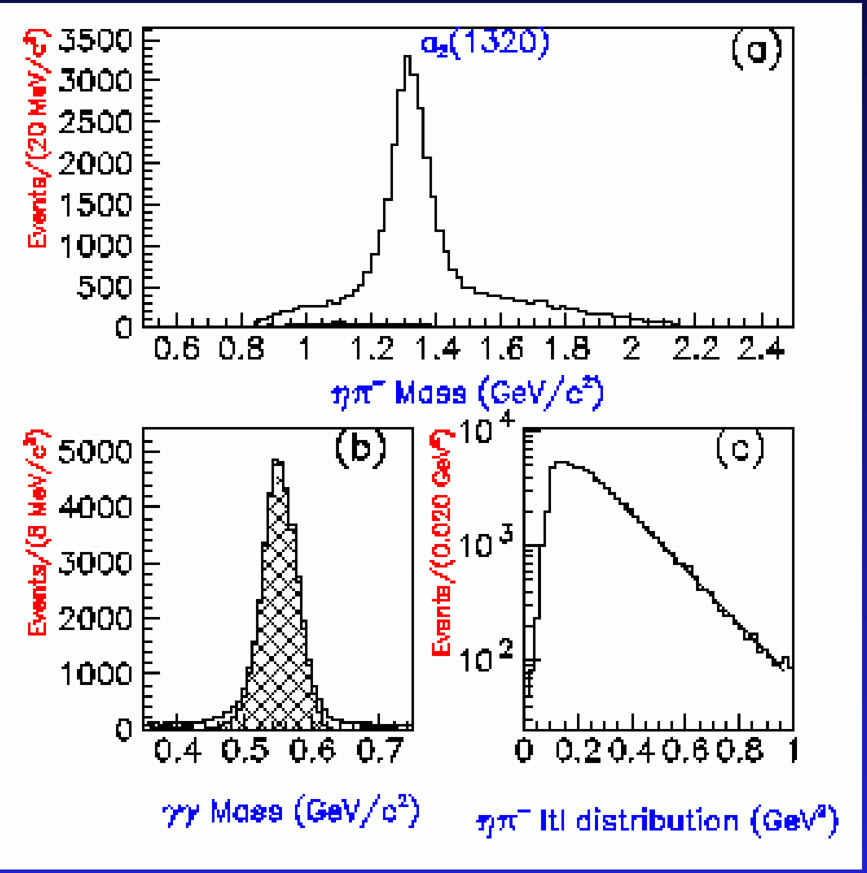
Review of
Earlier and Recent
Results

- ☞ $\pi_1(1400) \rightarrow \eta\pi^-$
- ☞ $\rightarrow \eta\pi^o$
- ☞ $\pi_1(1600) \rightarrow \pi^+\pi^-\pi^-$
- ☞ $\rightarrow \eta'\pi^-$

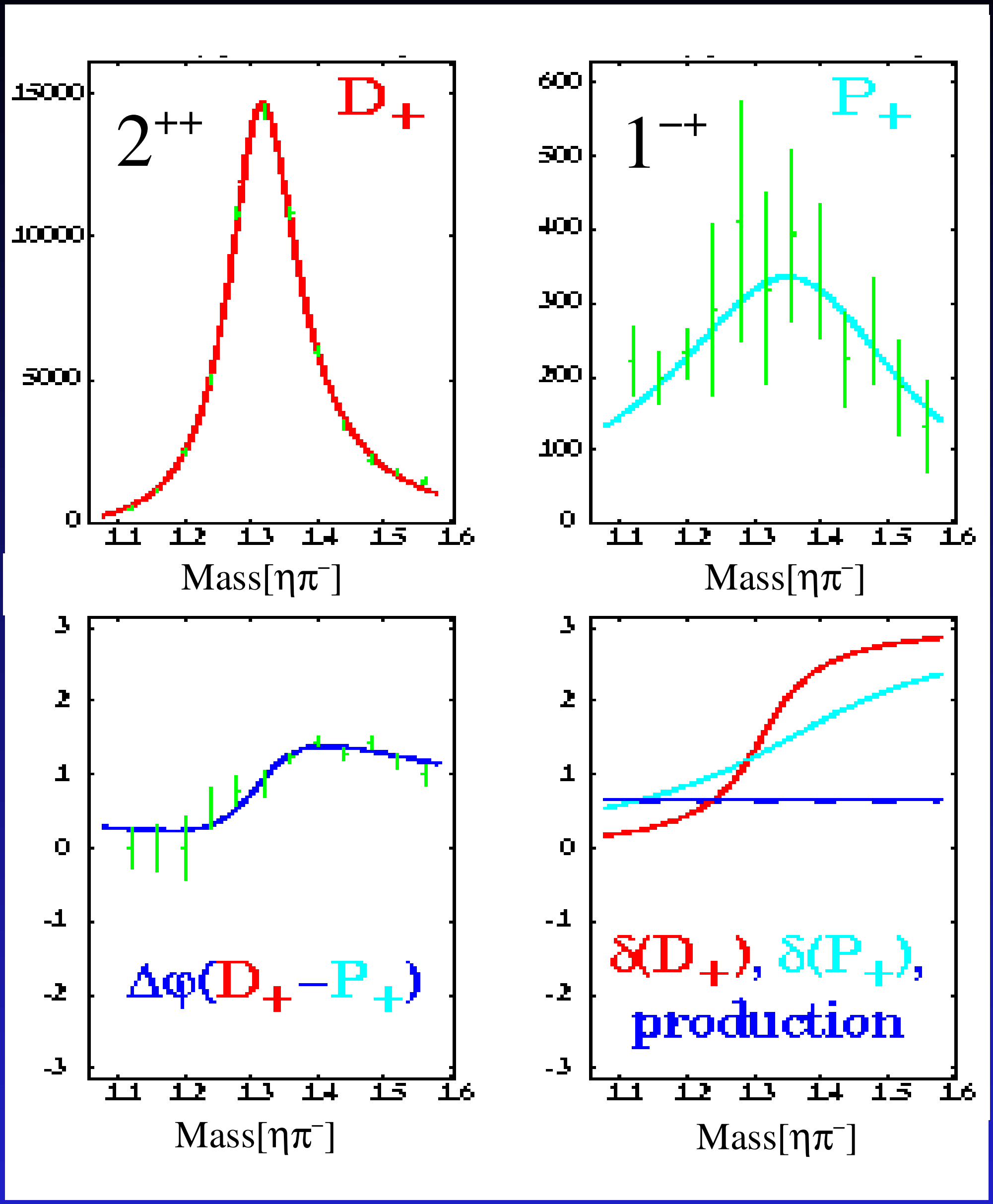
Evidence for Exotic Meson Production in the Reaction $\pi^- p \rightarrow \eta\pi^- p$ at 18 GeV/*c*

Phys. Rev. Lett. **79** 9 1630 (1997)

Accepted for publication Phys. Rev. D.



PWA & Mass Dependency



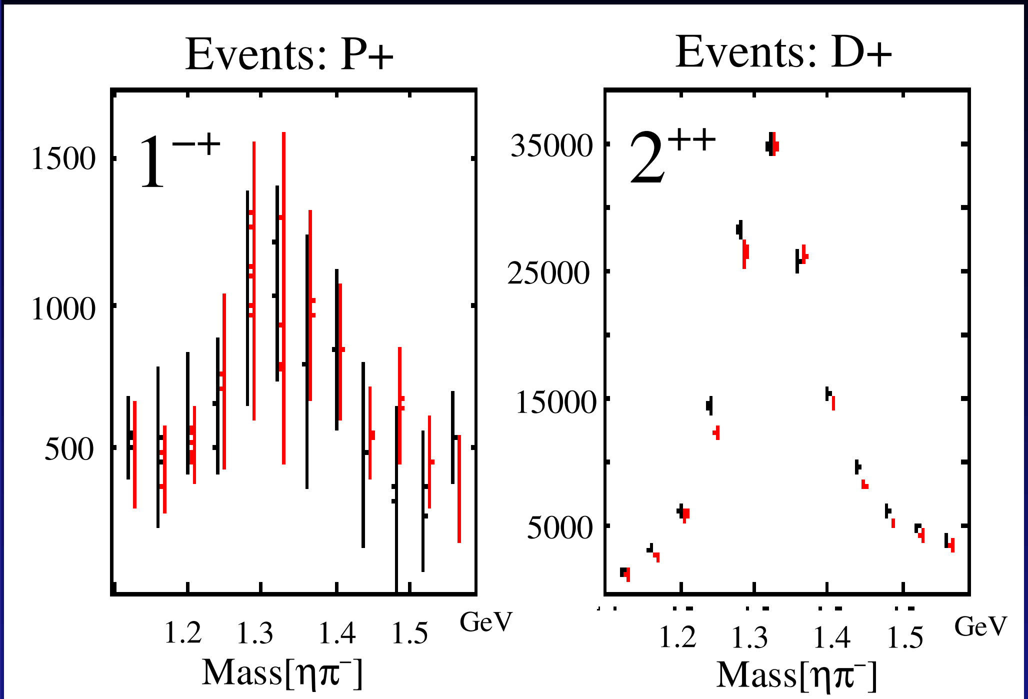
χ^2/DoF = 1.49

$J^{PC} = 1^{-+}\ \pi_1(1400)$

$M = 1370 \pm 16^{+50}_{-30}$ MeV/c^2

$\Gamma = 385 \pm 40^{+65}_{-105}$ MeV/c^2

$\eta\pi^-$ Analysis of 1995 Data

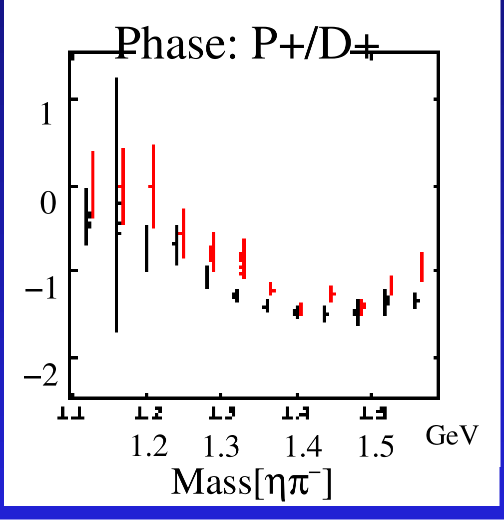


χ^2/DoF = 1.68

$J^{PC} = 1^{-+}\ \pi_1(1400)$

$M = 1369 \pm 11^{+6}_{-15}$ MeV/c^2

$\Gamma = 257 \pm 19^{+5}_{-34}$ MeV/c^2



95 $\eta\pi^-$ analysis (black points)

94 $\eta\pi^-$ analysis (red points)

Renormalization Factor 2.422

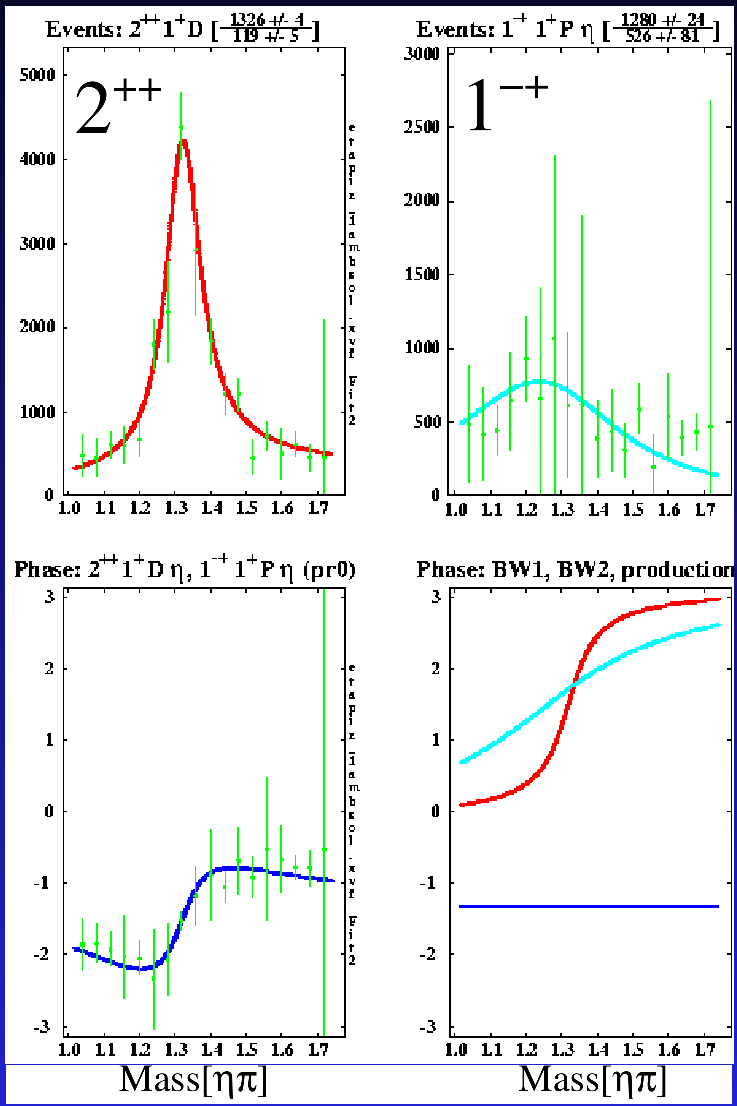
Observation of $\pi_1(1400)\rightarrow\eta\pi^o$ in the Reaction $\pi^- p \rightarrow \pi^+\pi^-\pi^o\pi^o n$

$\chi^2/\mathrm{DoF} = 0.924$

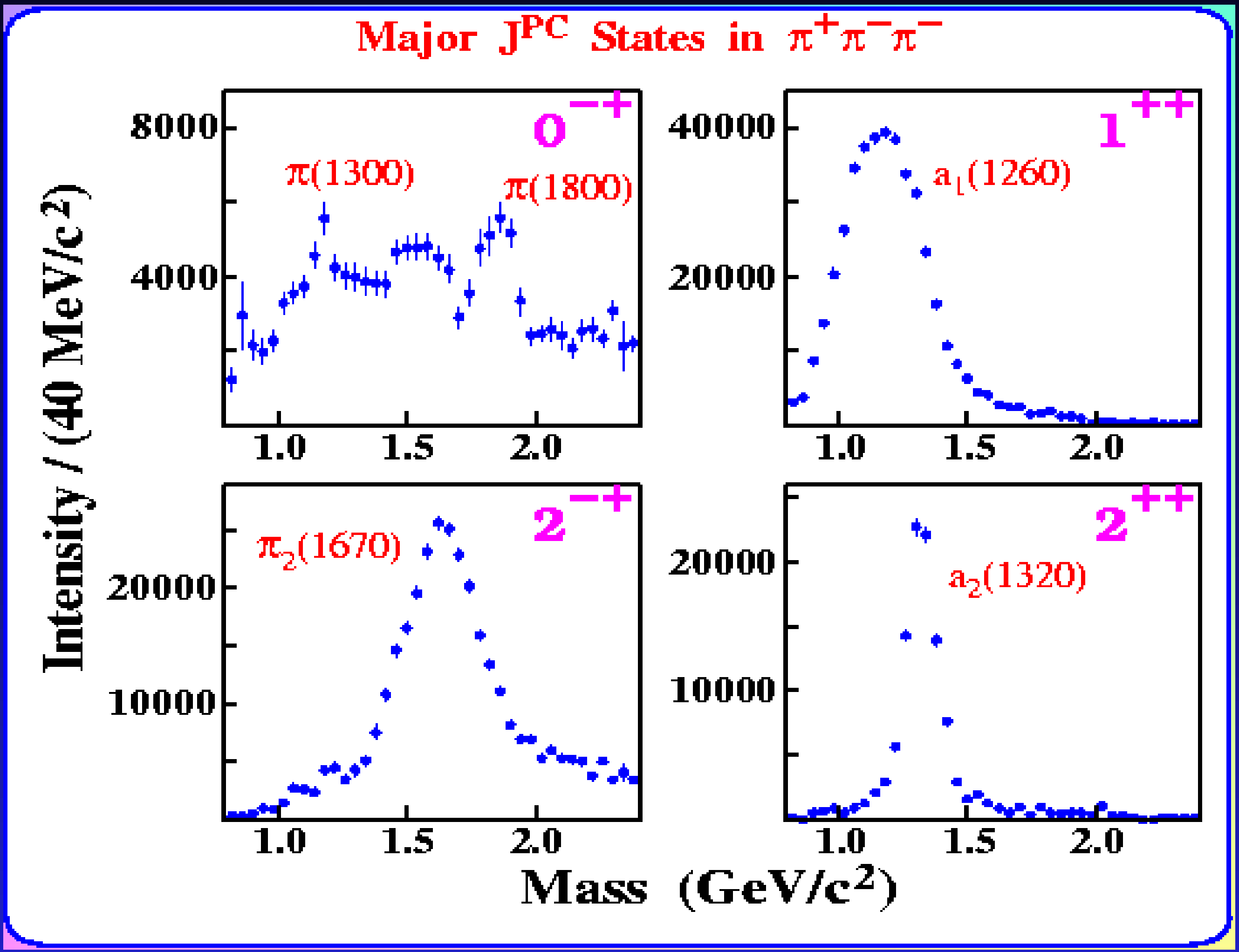
$J^{PC} = 1^{-+}\ \pi_1(1400)$

$M=1280\pm24\pm?\ \mathrm{MeV}/c^2$

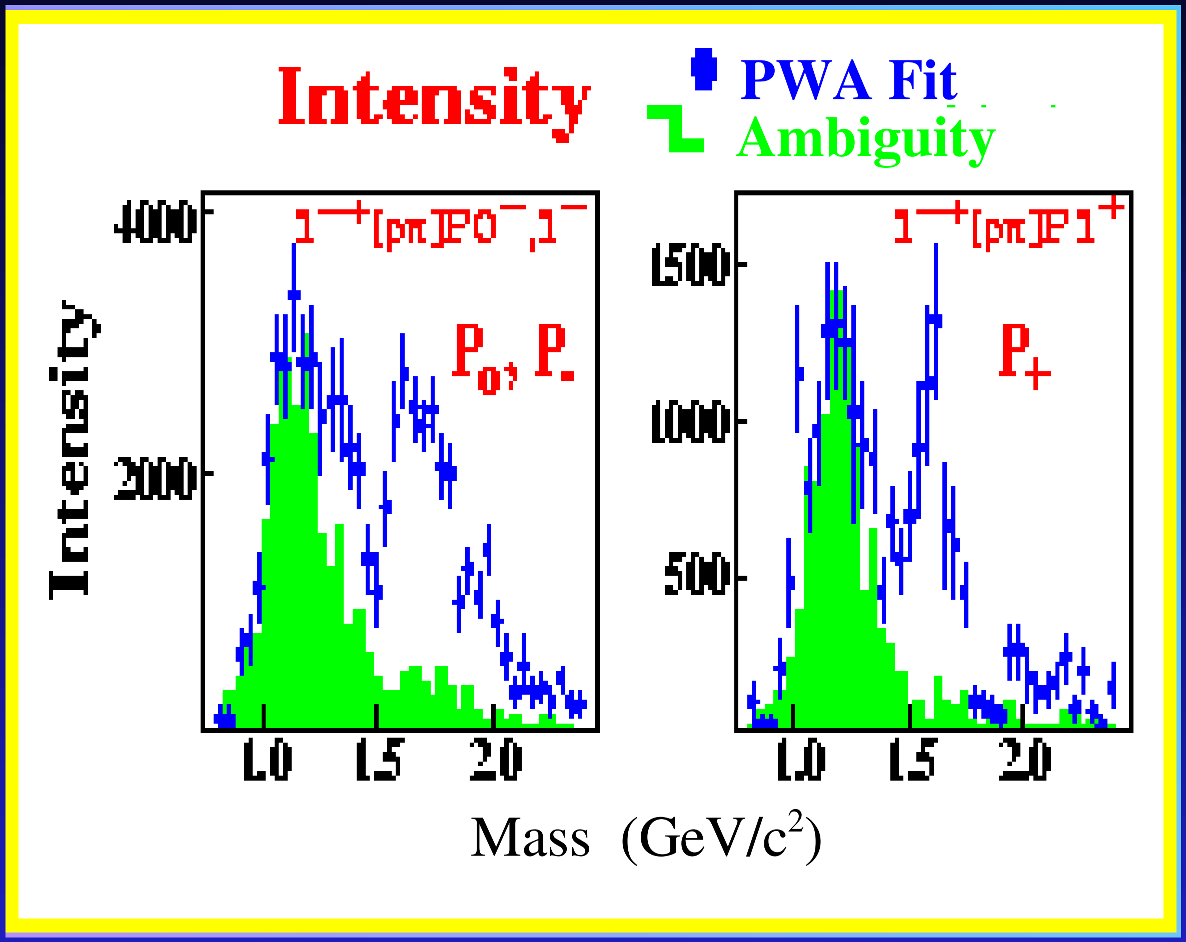
$\Gamma=526\pm81\pm?\ \mathrm{MeV}/c^2$



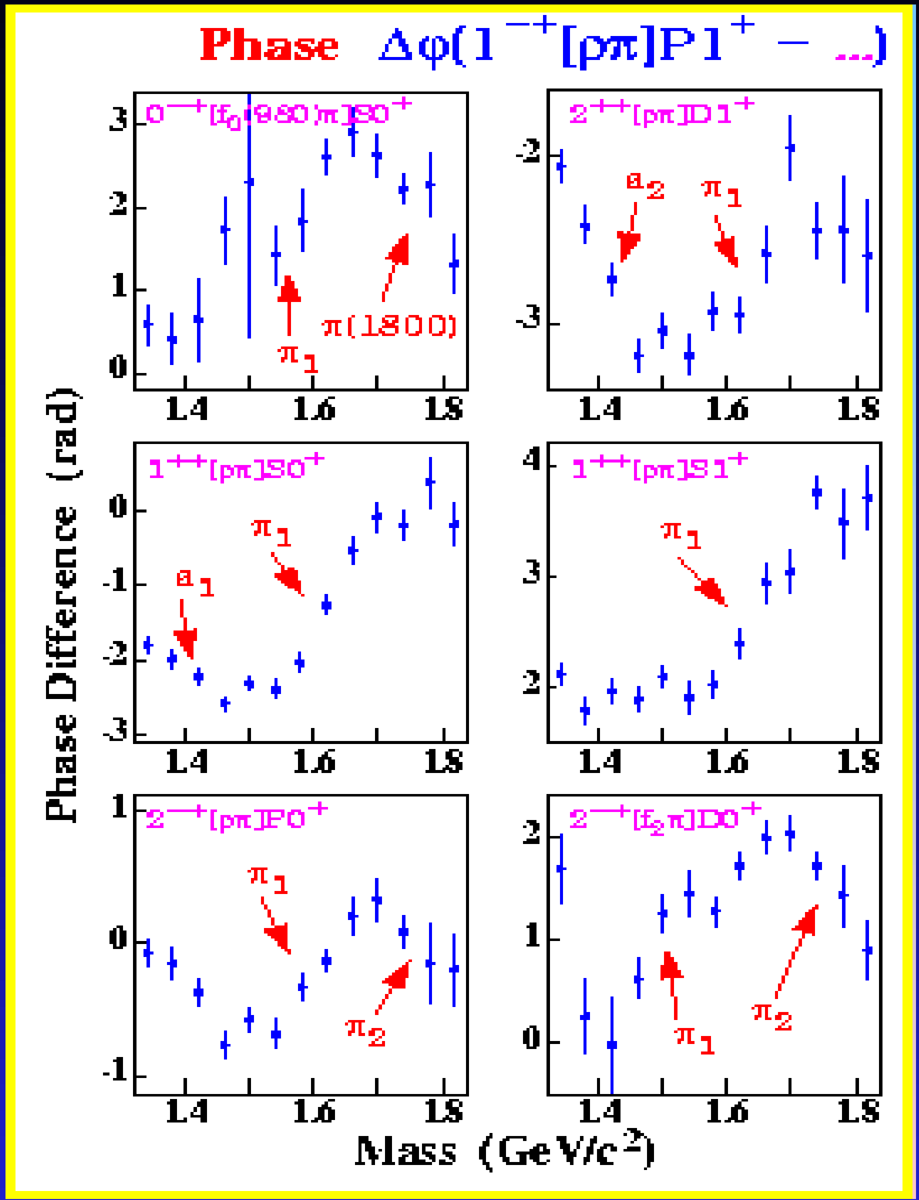
NonExotic Partial Wave Intensities



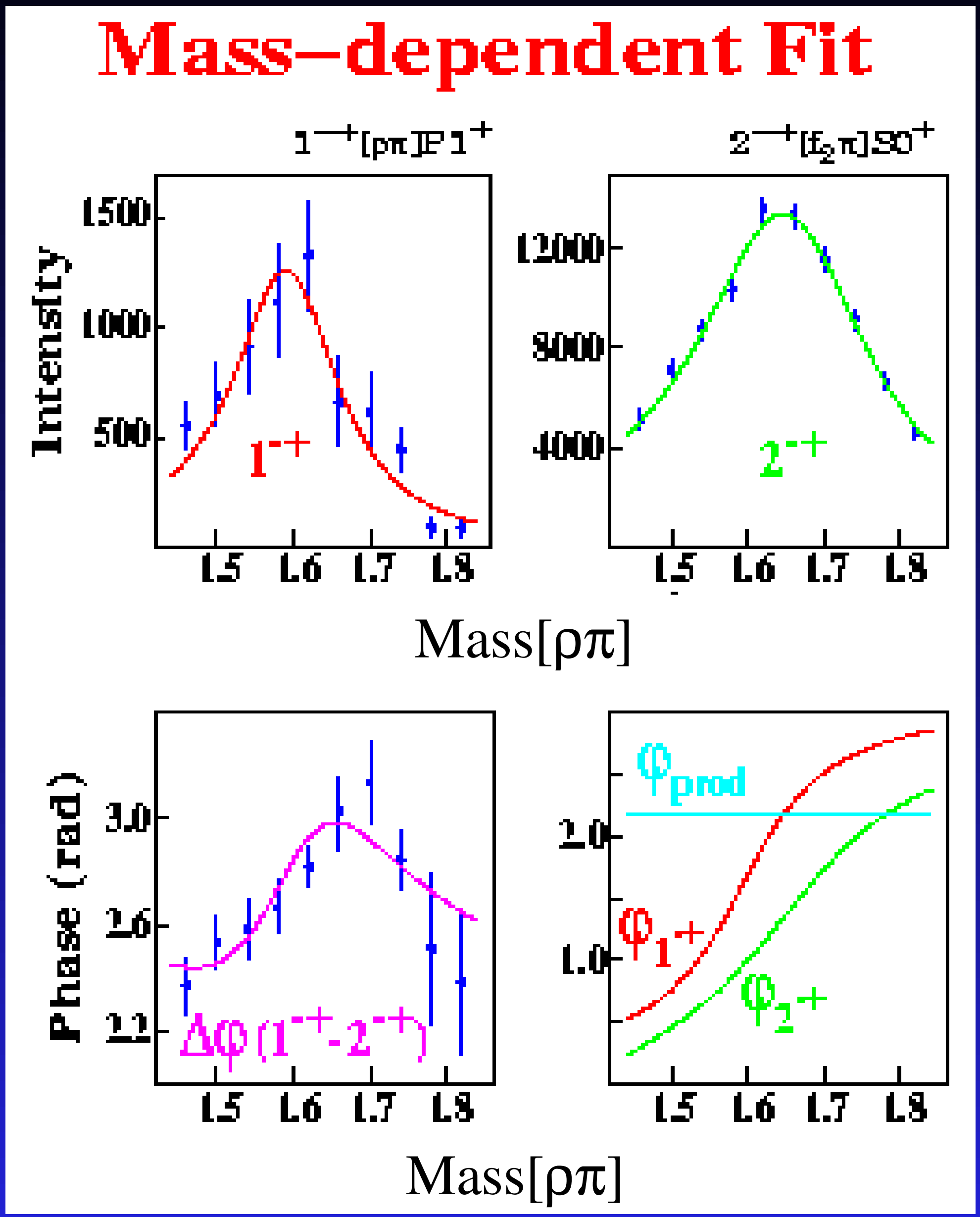
1^{-+} Exotic Partial Wave Intensities



Relative Phase Motion



Mass Dependency



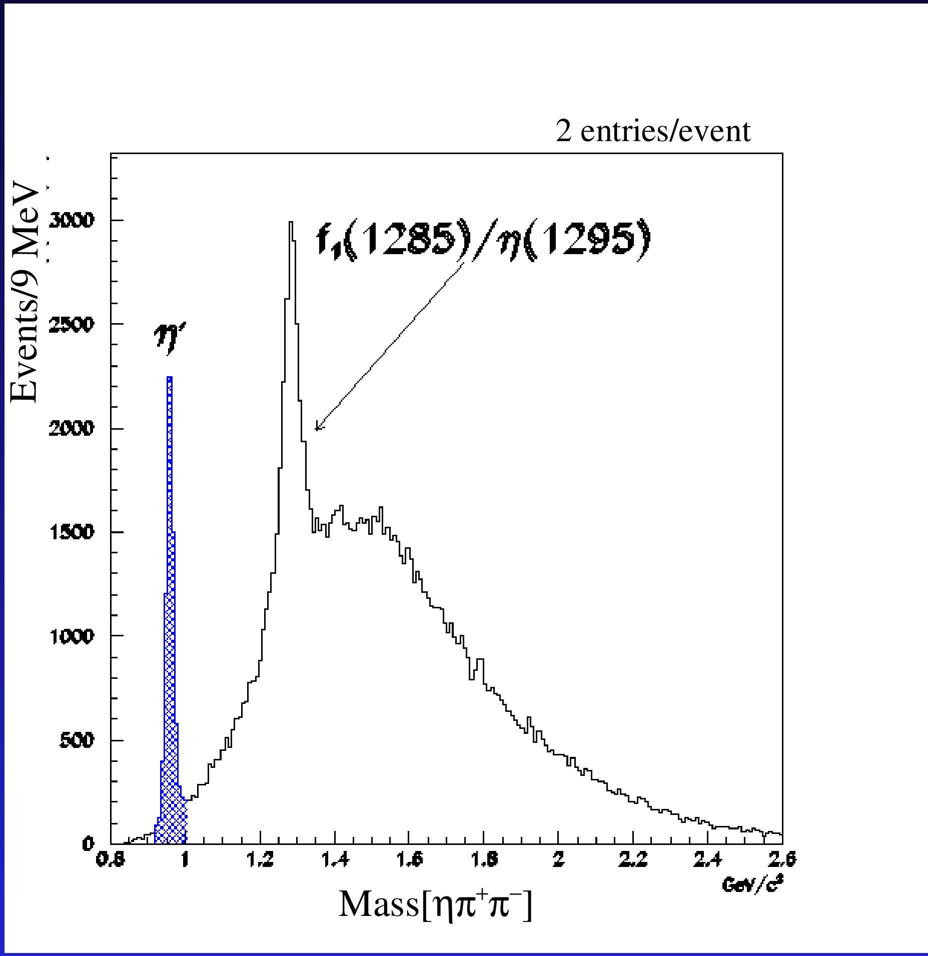
χ^2/DoF = 1.17

$J^{PC} = 1^{-+}$ $\pi_1(1600)$

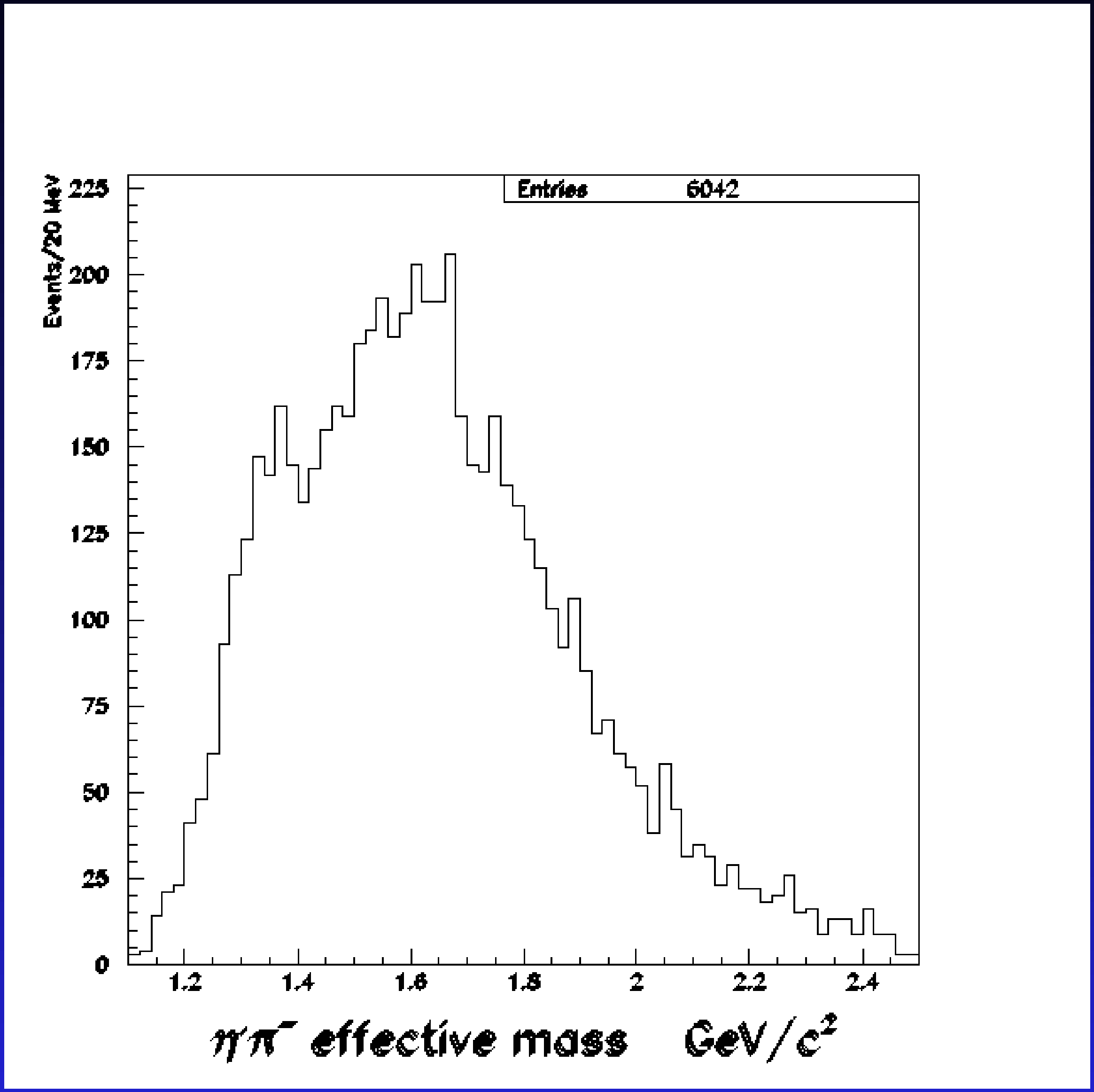
$M = 1593 \pm 8^{+29}_{-47}$ MeV/c^2

$\Gamma = 168 \pm 20^{+150}_{-12}$ MeV/c^2

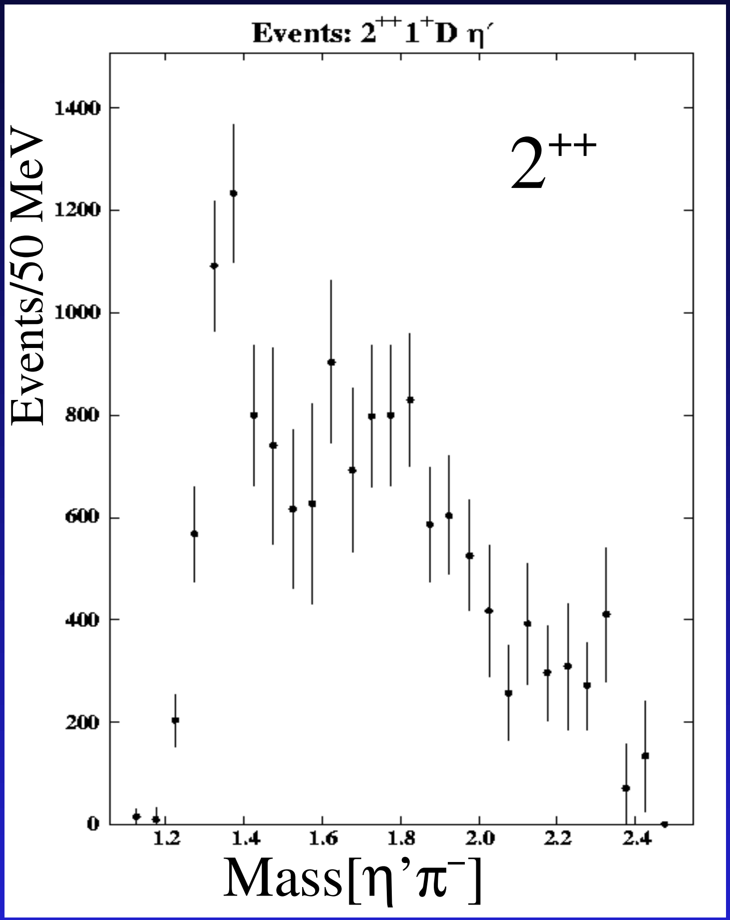
A Study of the $\eta'\pi^-$ System Produced in the Reaction $\pi^- p \to \eta\pi^+\pi^-\pi^- p$ at 18 GeV/*c*

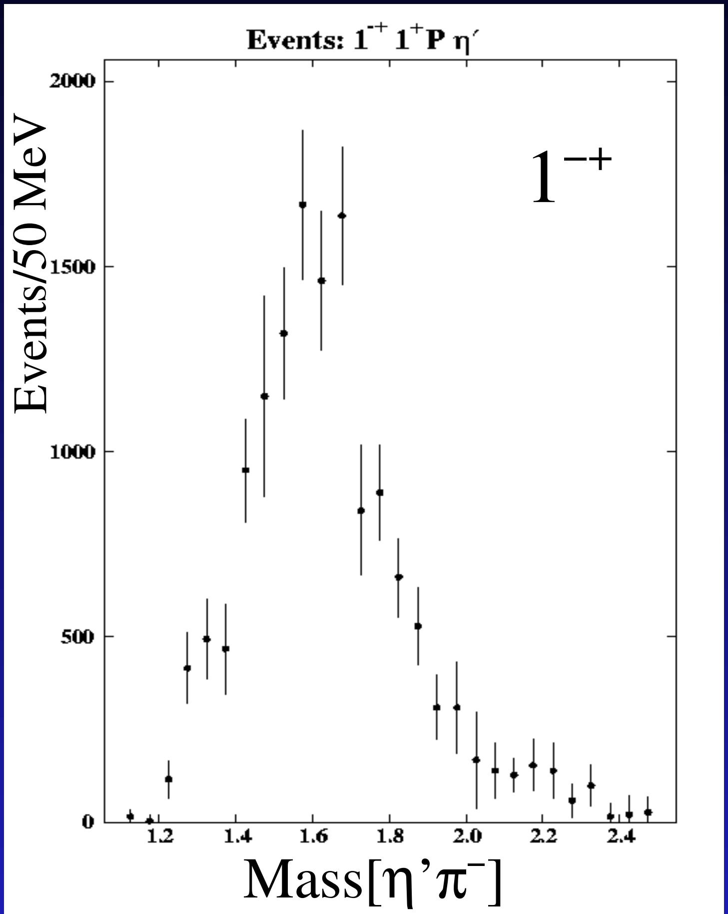


η' π⁻ Effective mass

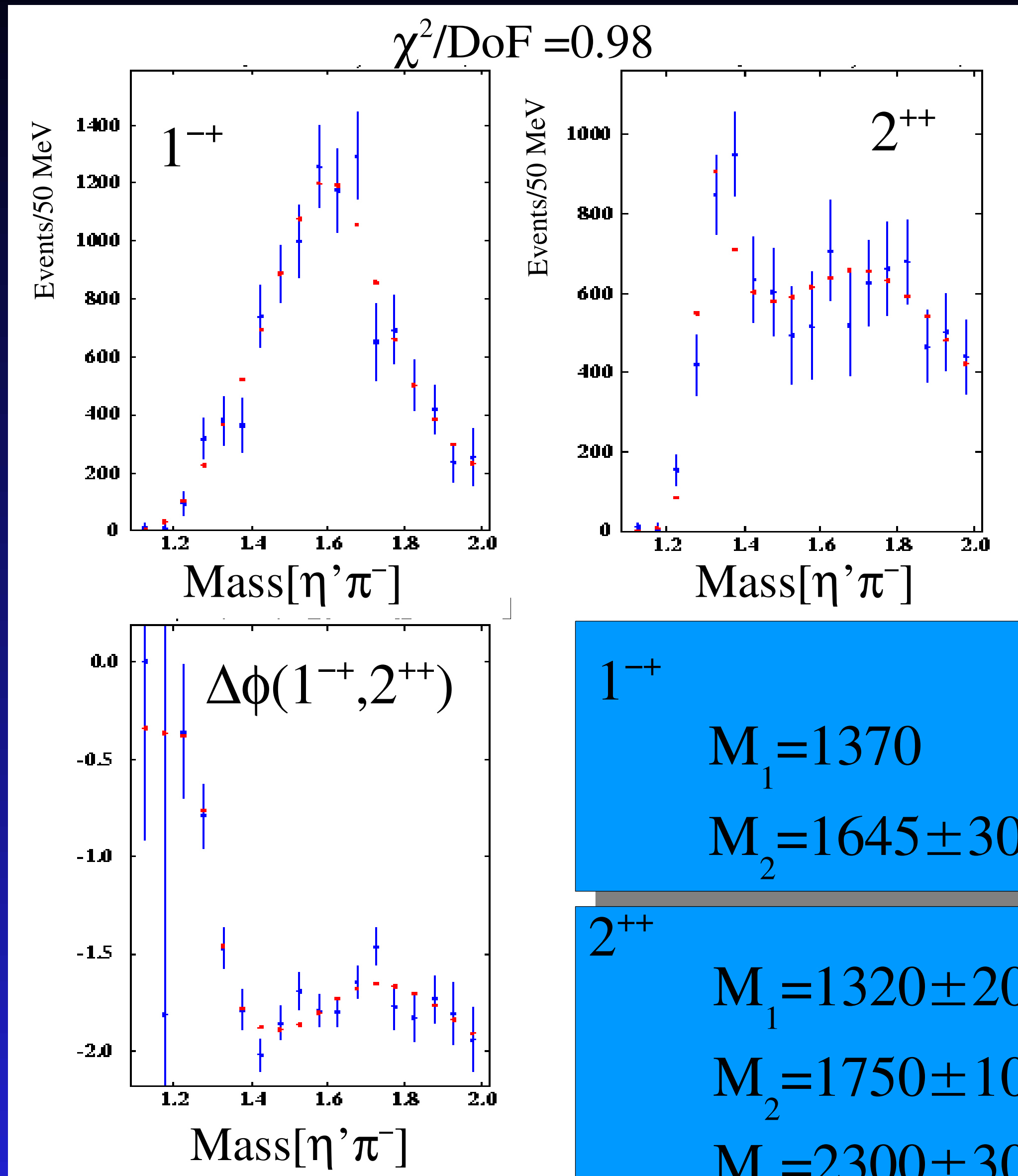


Dominant Partial Waves





$\eta' \pi^-$ Mass Dependence



1 or 2 P+ Poles?

Preliminary

1^{-+}

$M_1 = 1370$ $\Gamma_1 = 385 \pm 220$

$M_2 = 1645 \pm 30$ $\Gamma_2 = 400 \pm 70$

2^{++}

$M_1 = 1320 \pm 20$ $\Gamma_1 = 133 \pm 20$

$M_2 = 1750 \pm 100$ $\Gamma_2 = 250 \pm 100$

$M_3 = 2300 \pm 30$ $\Gamma_3 = 400 \pm 100$

Estimates of Ratios

$$R\left(\frac{\pi^- p \to p\, [\pi_1(1400) \to \eta\pi^-]}{\pi^- p \to p\, [a_2(1320) \to \eta\pi^-]}\right) = 0.0495 \pm 0.010 \pm 0.004$$

$$R\left(\frac{\pi^- p \to p\, [\pi_1(1400) \to \eta'\pi^-]}{\pi^- p \to p\, [a_2(1320) \to \eta'\pi^-]}\right) = 0.6 \pm 0.3 \pm 0.4$$

$$BR\left(\frac{\pi_1(1400) \to \eta'\pi^-}{\pi_1(1400) \to \eta\pi^-}\right) = 0.5 \pm 0.3 \pm 0.4$$

$$R\left(\frac{\pi^- p \to p\, [\pi_1(1600) \to \eta'\pi^-]}{\pi^- p \to p\, [a_2(1320) \to \eta'\pi^-]}\right) = 4.5 \pm 0.4 \pm 2.4$$

Preliminary

Data Analysis

- New and Preliminary Results

☞ $X \rightarrow \eta\pi^+\pi^-$

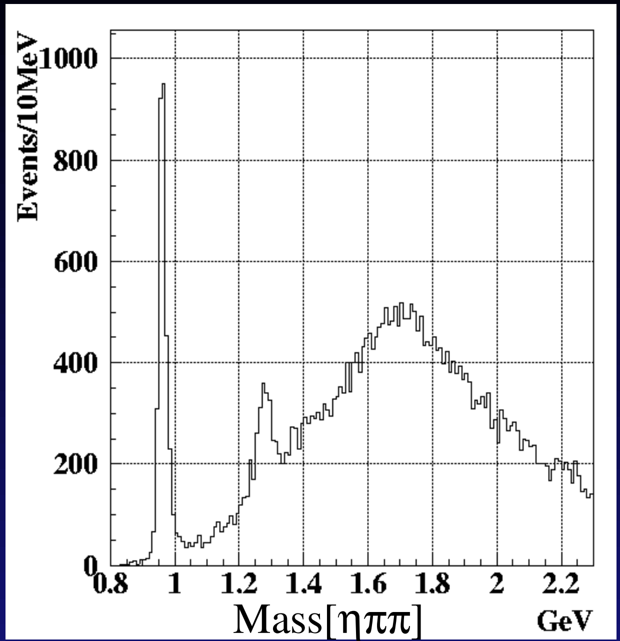
☞ $X \rightarrow \omega\eta$

☞ $X \rightarrow K^+K^-\pi^o$

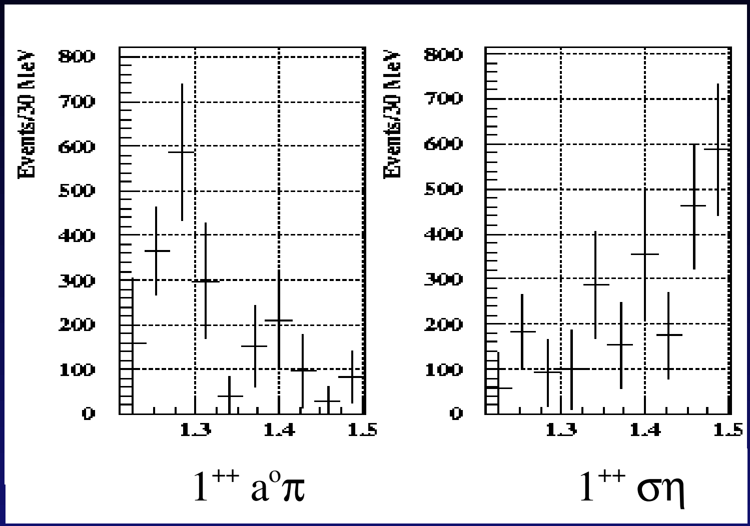
☞ $X \rightarrow \eta\eta\pi^-$

☞ $X \rightarrow \omega\eta\pi^-$

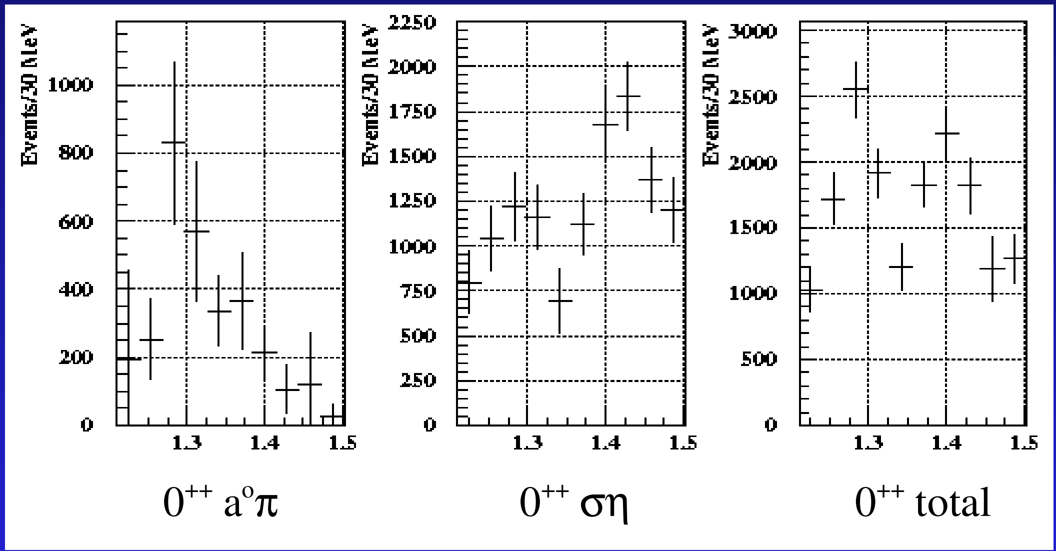
$\eta\ \pi^+\pi^-$



1^{++} Intensity



0^{++} Intensity

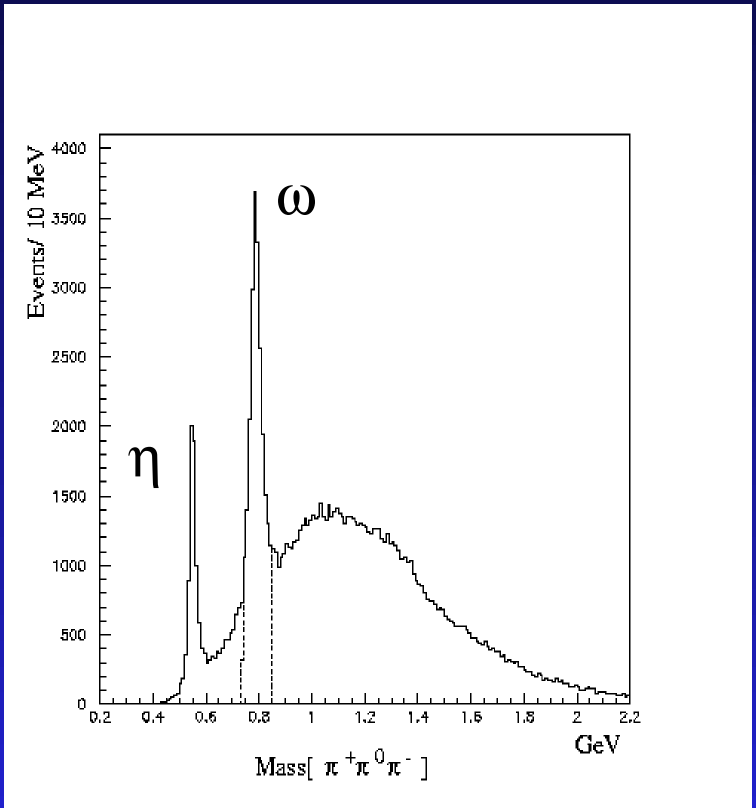


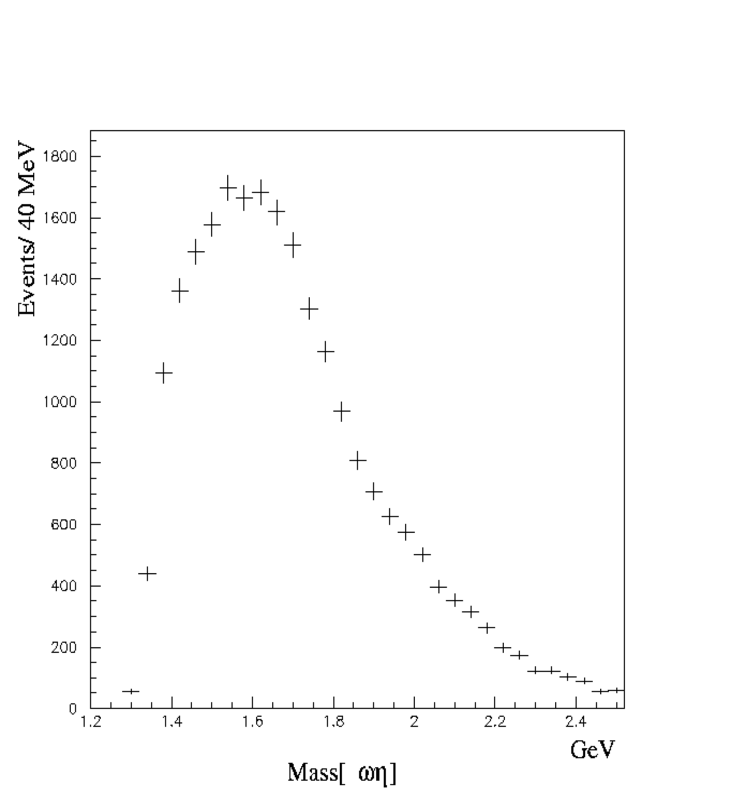
f_1 Branching Fractions†

Decay Mode	PDG	BNL–E852
4π	29±6%	59±17%
$\eta\pi\pi$	54±15%	8±3%
$\gamma\pi^o$	6.6±1.3%	13±13%
$K\bar{K}\pi$	10±2%	20±7%

† Using results with Corden *et al*, Nucl. Phys. B 144, 153 (1978)

A Study of the ωη System Produced in the Reaction $\pi^- p \rightarrow \pi^+\pi^-\pi^o\eta\, n$ at 18 GeV/c



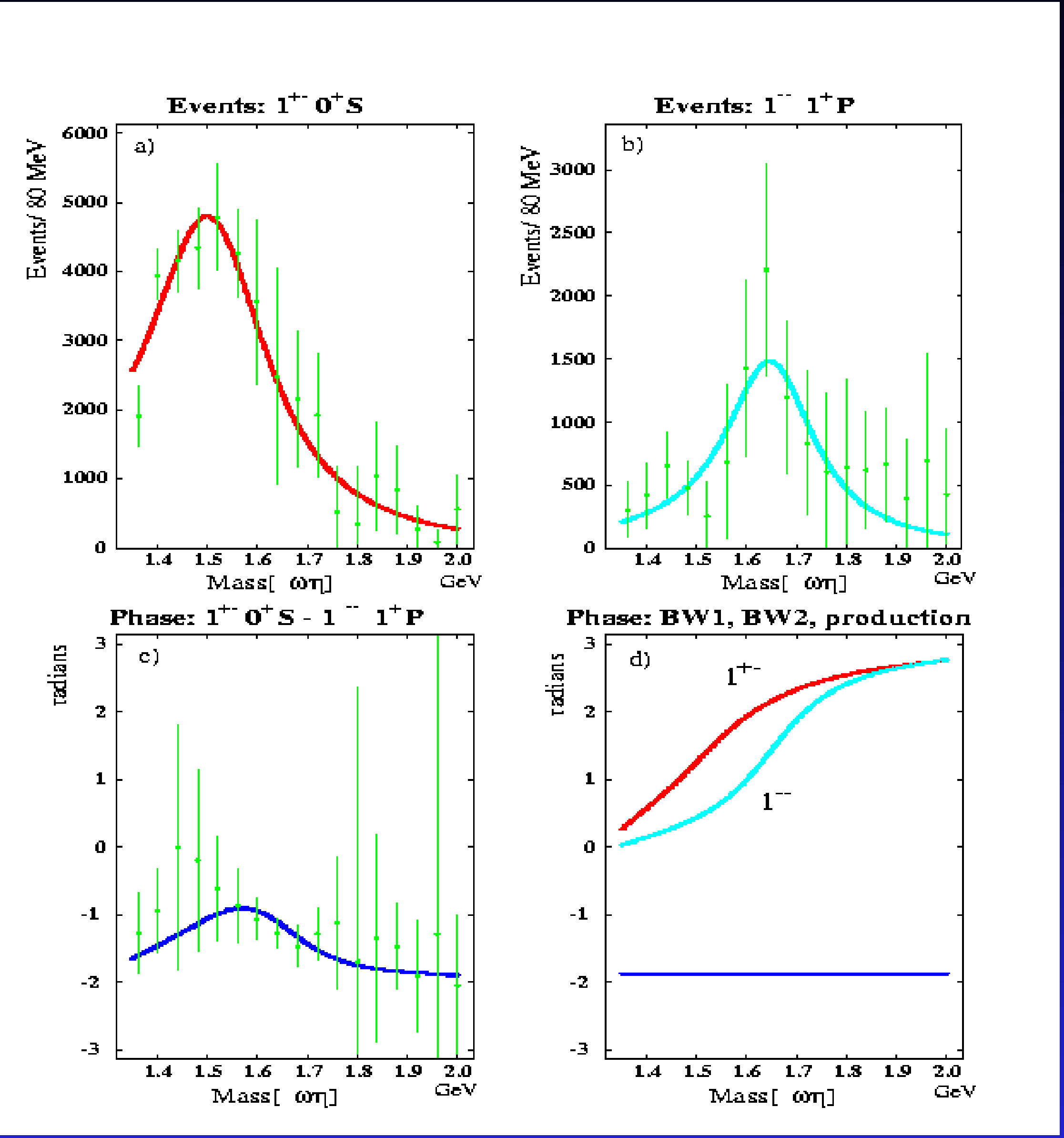


PWA & Mass Dependency

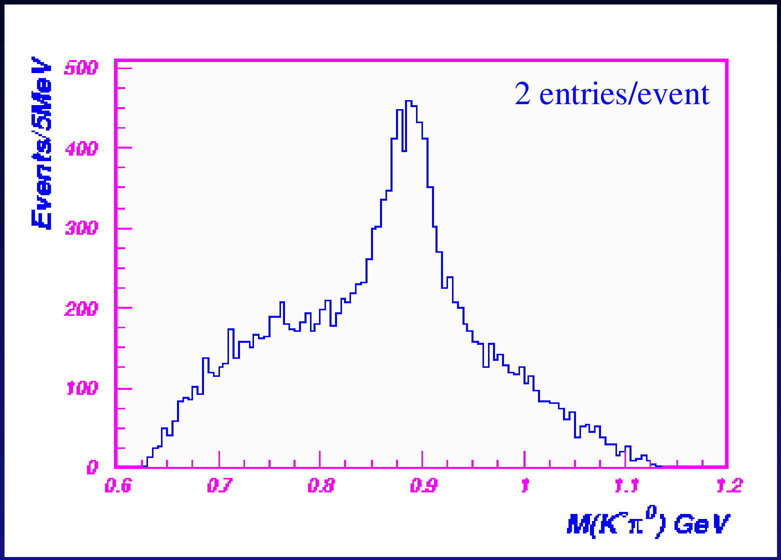
1^{+-} wave
Mass = 1542±13 MeV
Γ = 285±30 MeV

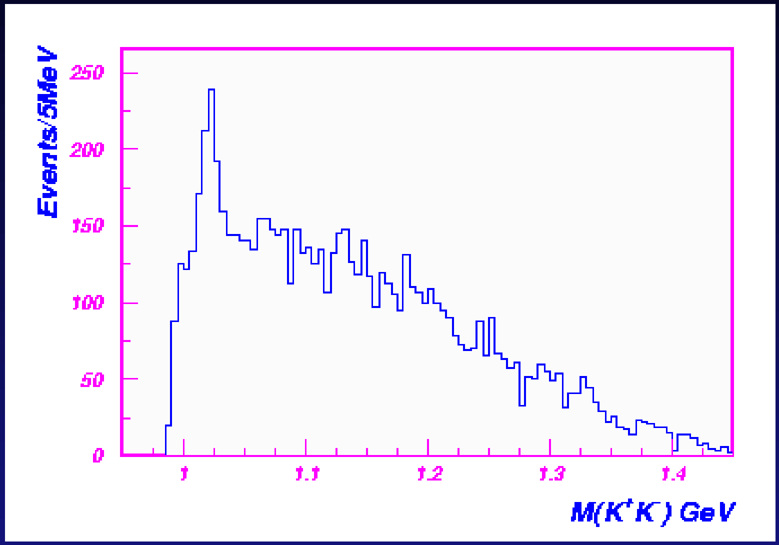
1^{--} wave
Mass = 1664±24 MeV
Γ = 219±63 MeV

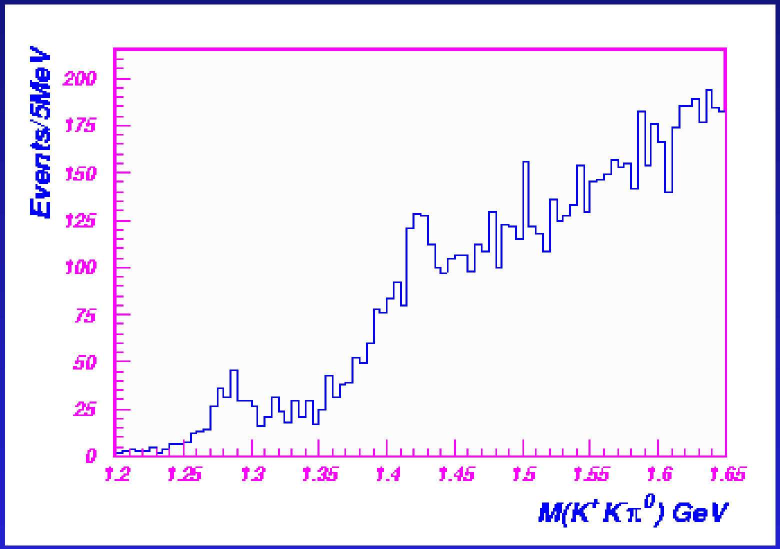
PDG ω(1600)
Mass = 1649±24 MeV
Γ = 220±35 MeV



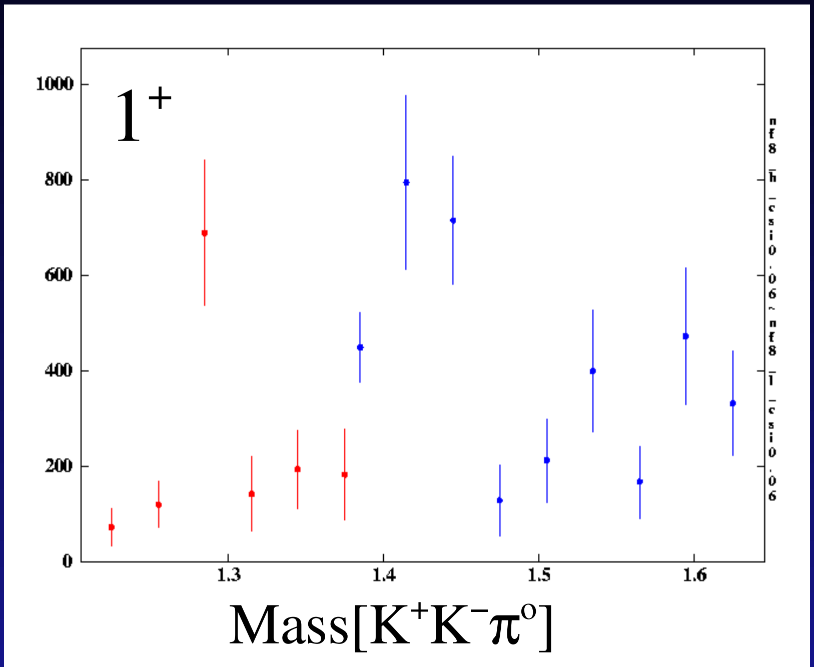
A Survey of the $K^+ K^- \pi^o$ System

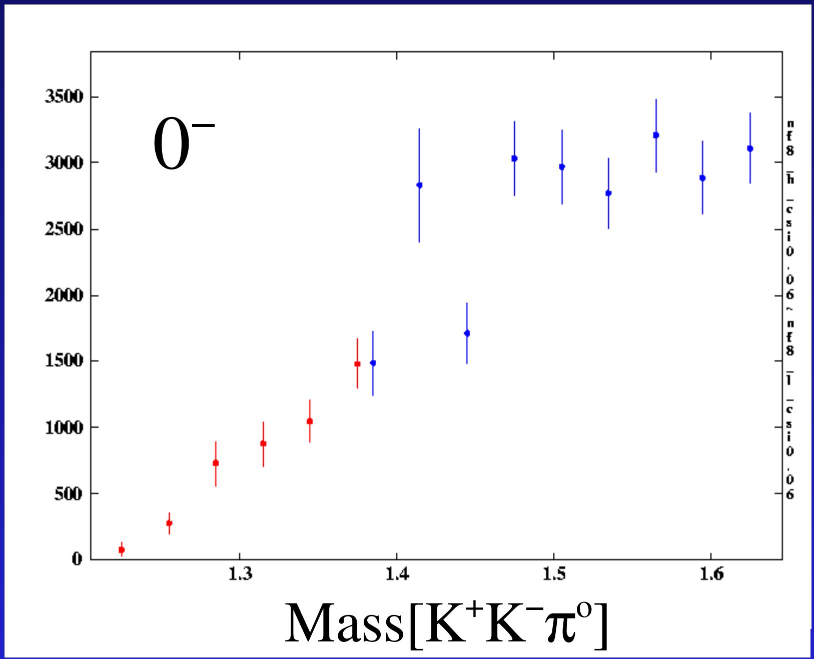




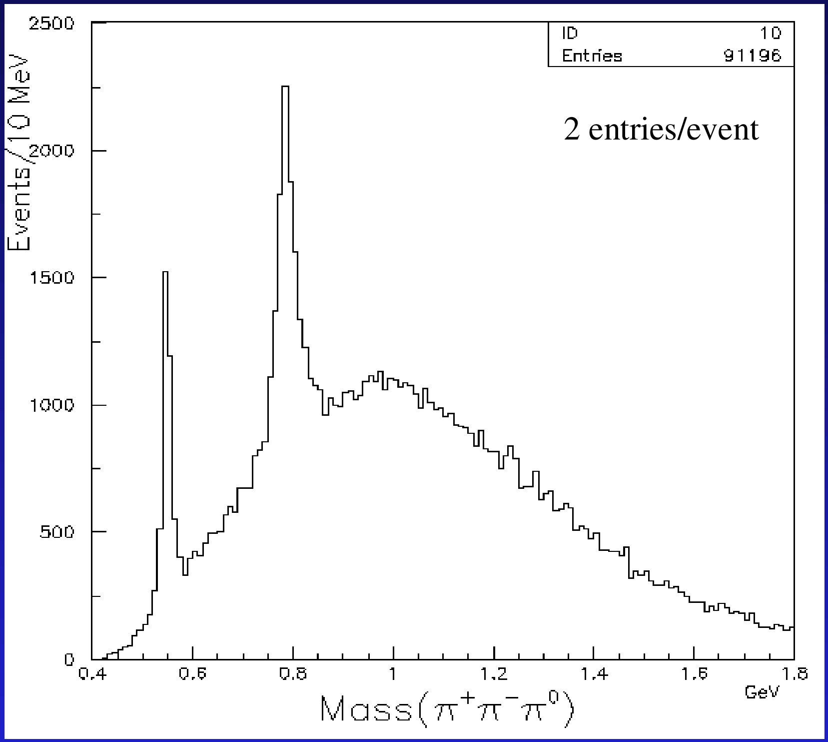


Preliminary $K^+ K^- \pi^o$ PWA

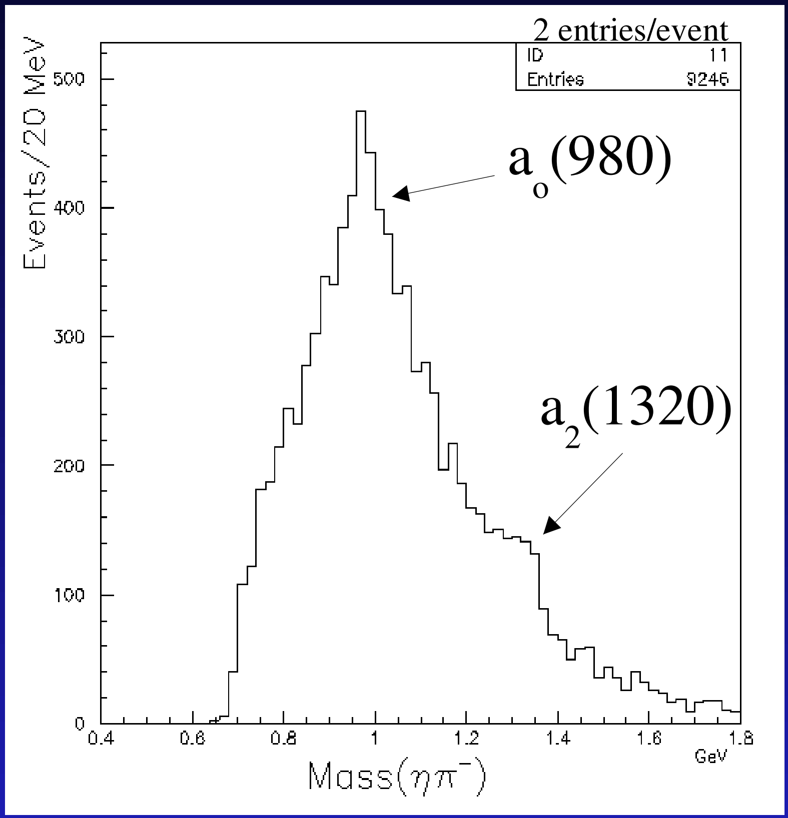


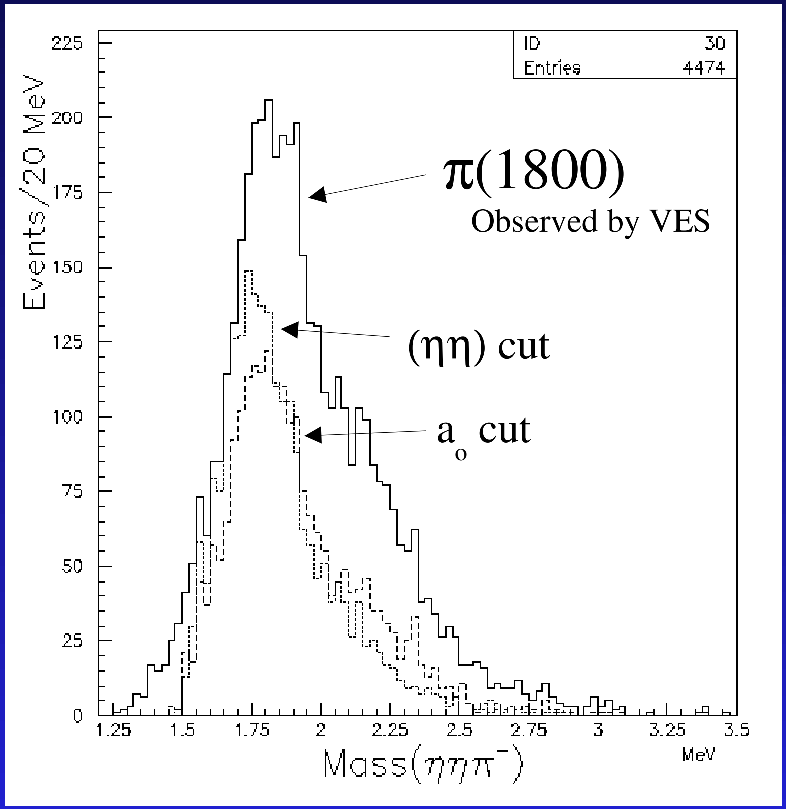


Survey of the $\eta\eta\pi^-$ & $\omega\eta\pi^-$ Systems Produced in the Reaction $\pi^- p \rightarrow \pi^+\pi^-\pi^-\pi^0\eta\, p$ at 18 GeV/c

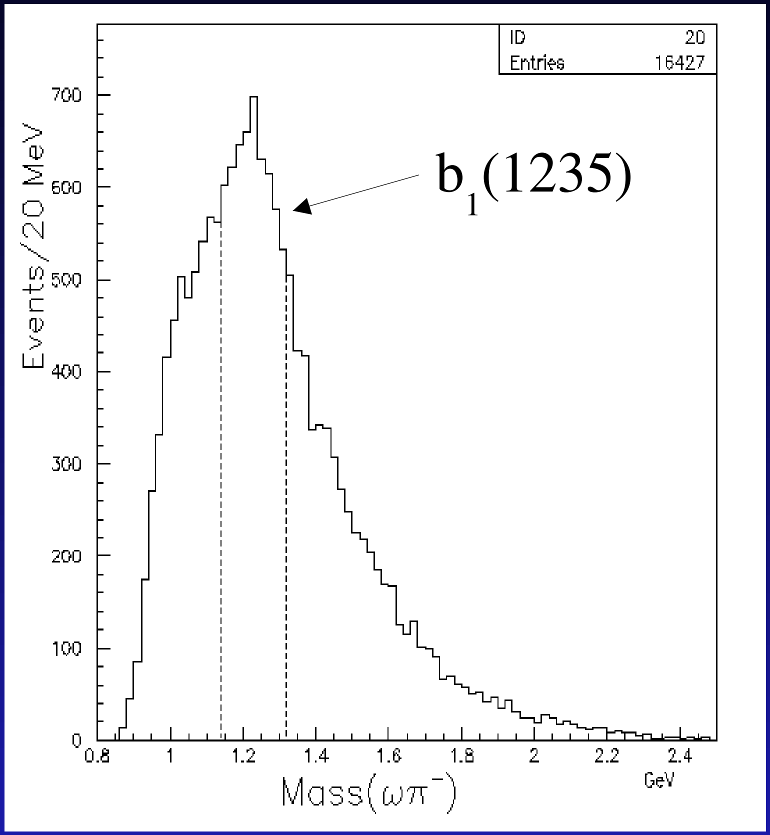


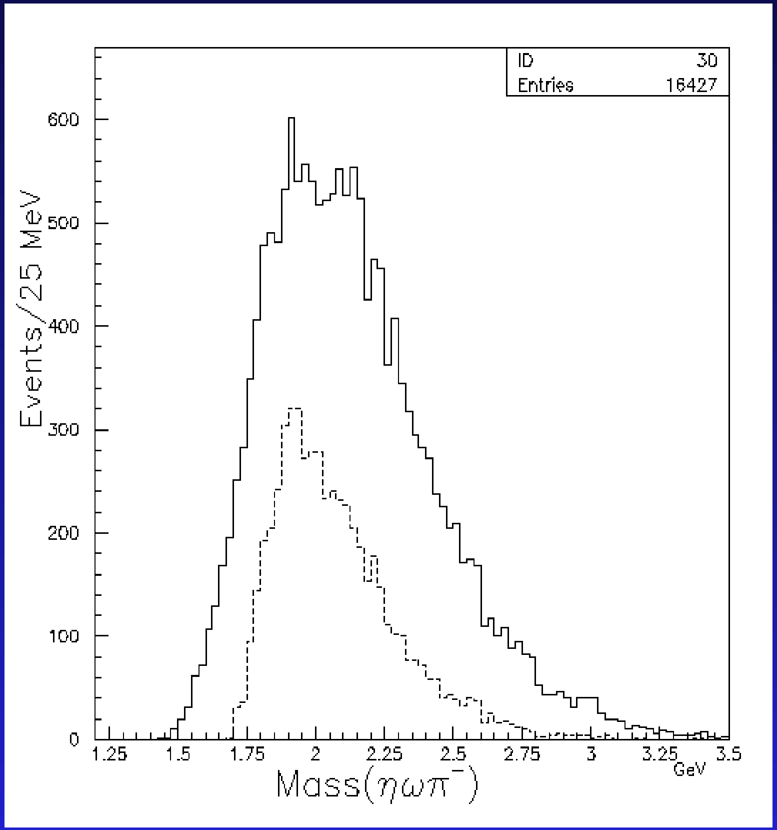
$\eta\ \eta\ \pi^-$ System





$\omega\,\eta\,\pi^-$ System





Summary

- Over 2 billion triggers being analyized.
- $\pi_1(1400)$ observed:
  - 94 & 95 $\eta\pi^-$analyses
  - in charge–exchange $\eta\pi^o$ channel where $\eta\to3\pi$
  - possible in $\eta'\pi^-$
- $\pi_1(1600)$ observed in $\rho\pi^-$ and $\eta'\pi^-$(Dominant Wave!)
- $f_1(1285)$ main decay branch to 4π (not $\eta\pi\pi$)
- $\omega\eta$ dominant 1^{+-} and 1^{--} signals
- Analysis of $KK\pi^o$, $\eta\eta\pi^-$, $\omega\eta\pi^-$, and others in progress.