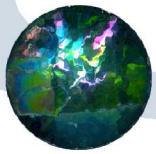


Non Exotic Hybrids

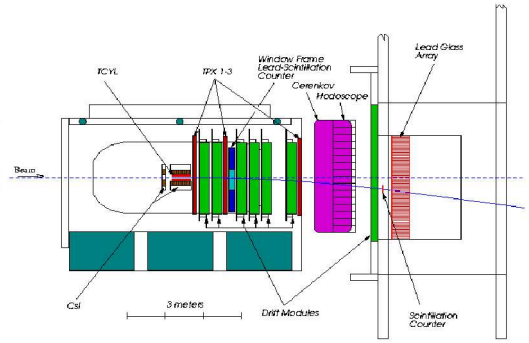
Paul Eugenio

on behalf of the BNL-E852 Collaboration

Workshop on Gluonic Excitations
May 14-16, 2003
Jefferson Lab/Institute for Nuclear Theory
Newport News, VA

Jefferson Lab

Overview



BNL-E852 Results*

$\pi(1800)$

$\pi_2(1900)$

$a_1(2000)$

$h_1(1595)$

$\pi^- p \to p\eta\eta\pi^-$

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

$\pi^- p \to p\omega\pi^0\pi^-$

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

$\pi^- p \to n\omega\eta$

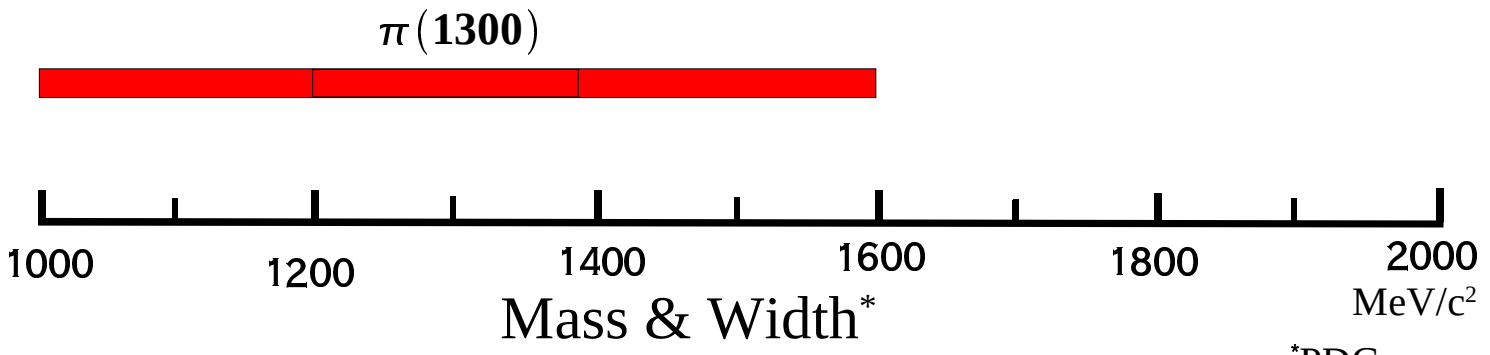
18 GeV/c π^- beam

$\pi(1800)$

Rather narrow for 2nd excitation of π

Does not decay to ρπ &K*K

1st radial excitation of the π

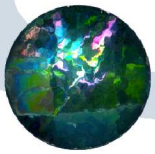


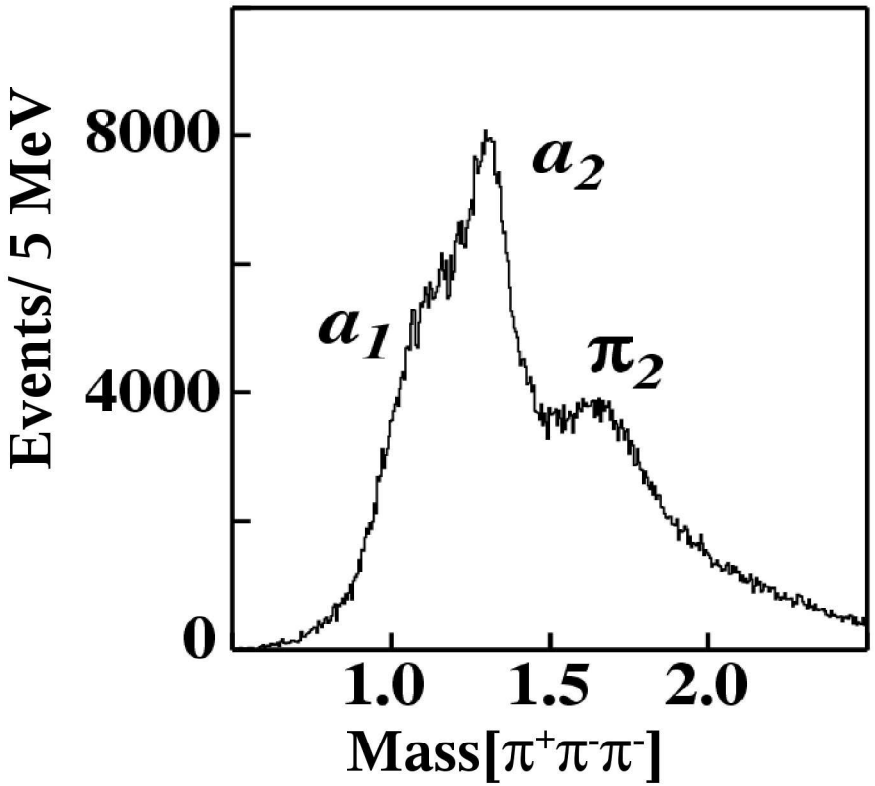
*PDG mass and width values

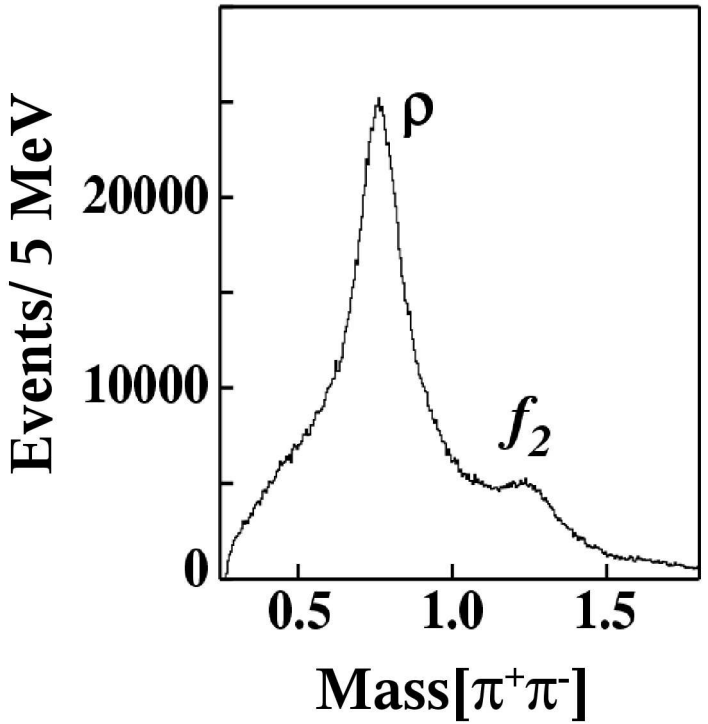
Many† have suggested that the π(1800) is a 0^{-+} hybrid meson

†See for example T. Barnes, F. E. Close, P. R. Page, & E. S. Swanson Phys. Rev. D55 4157 (1997)

$\pi(1800) \rightarrow \pi^+ \pi^- \pi^-$

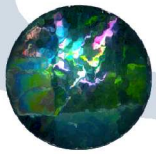




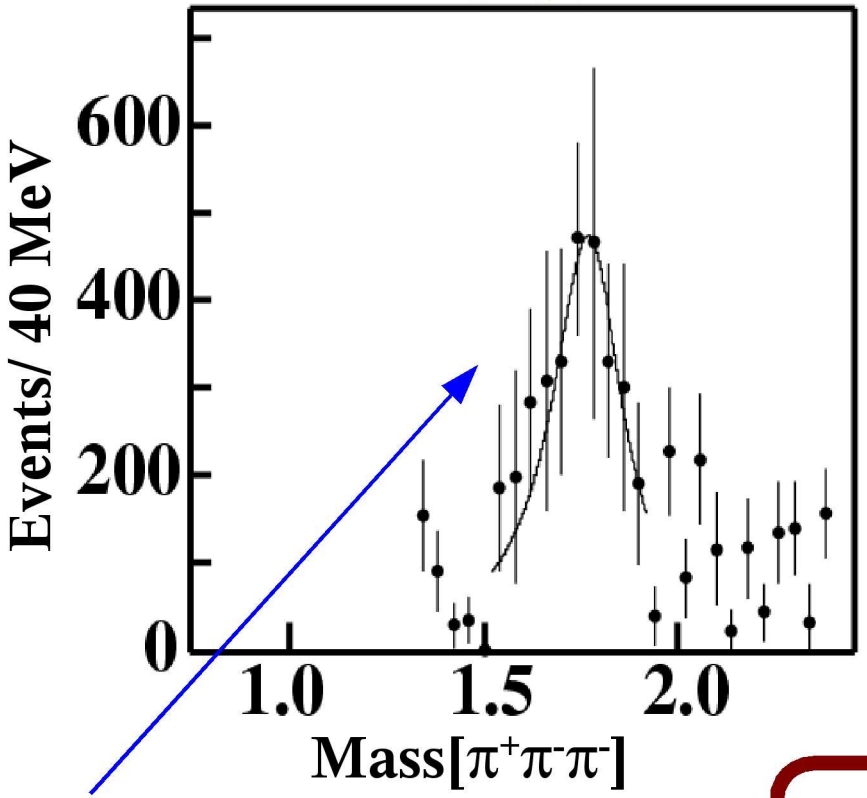


Phys. Rev. D65 072001 (2002)

$\pi(1800) \to \pi^+ \pi^- \pi^-$



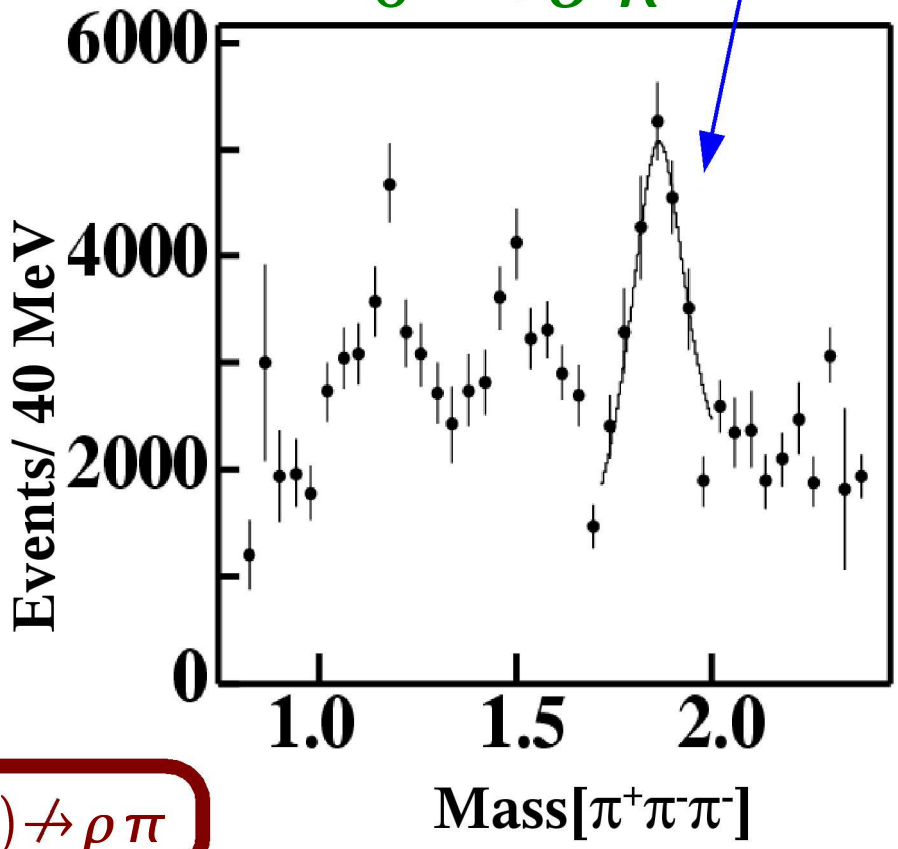
$0^{-+} \to f_0(980)\pi$



M=1774±18±20 MeV/c^2
Γ=223±48±50 MeV/c^2

M=1863±9±10 MeV/c^2
Γ=191±21±20 MeV/c^2

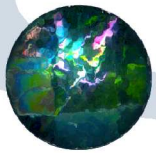
$0^{-+} \to \sigma\pi$

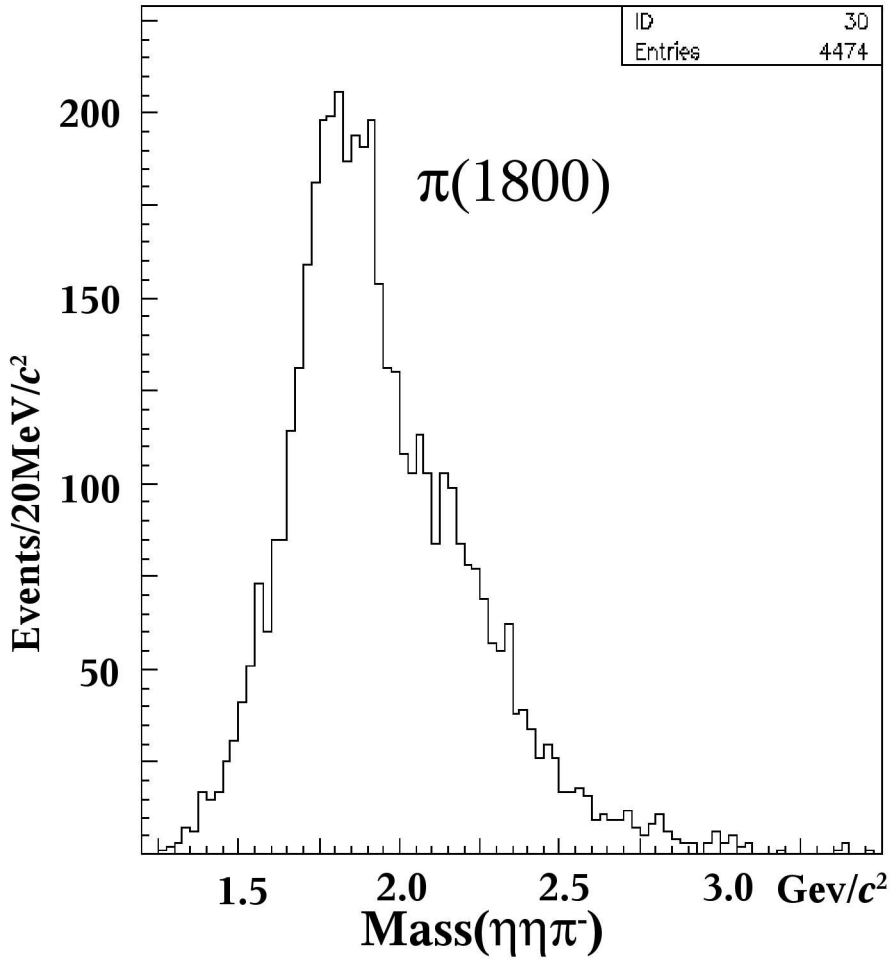


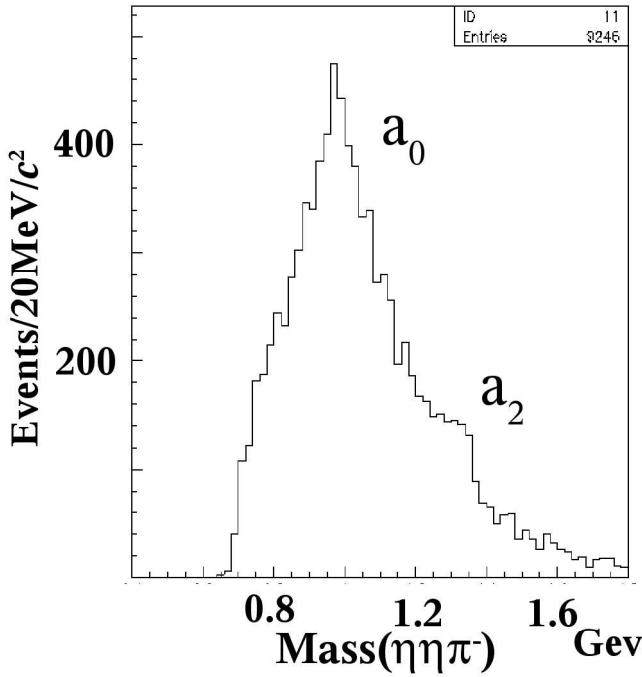
$\pi(1800) \not\to \rho\pi$

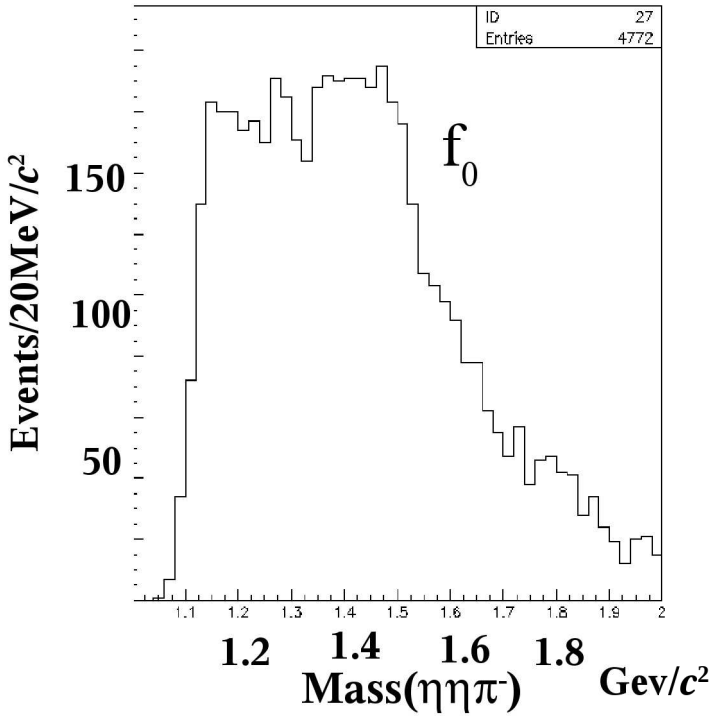
$$\frac{BR[\pi(1800) \to f_0(980)\pi,\ f_0 \to \pi\pi]}{BR[\pi(1800) \to \sigma\pi, \sigma \to \pi\pi]} = 0.44 \pm 0.08 \pm 0.38$$

$\pi(1800) \rightarrow \eta\eta\pi^-$



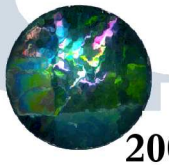




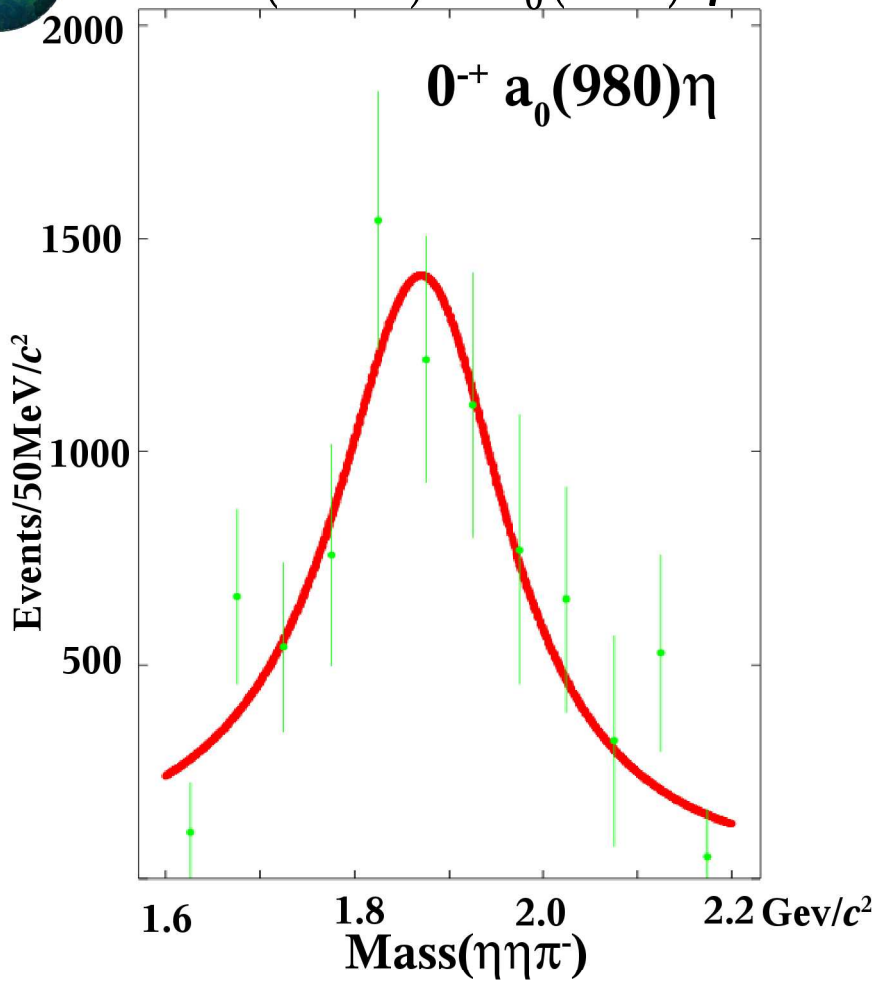


Preliminary, to be published
P. Eugenio *et al. BNL-E852*

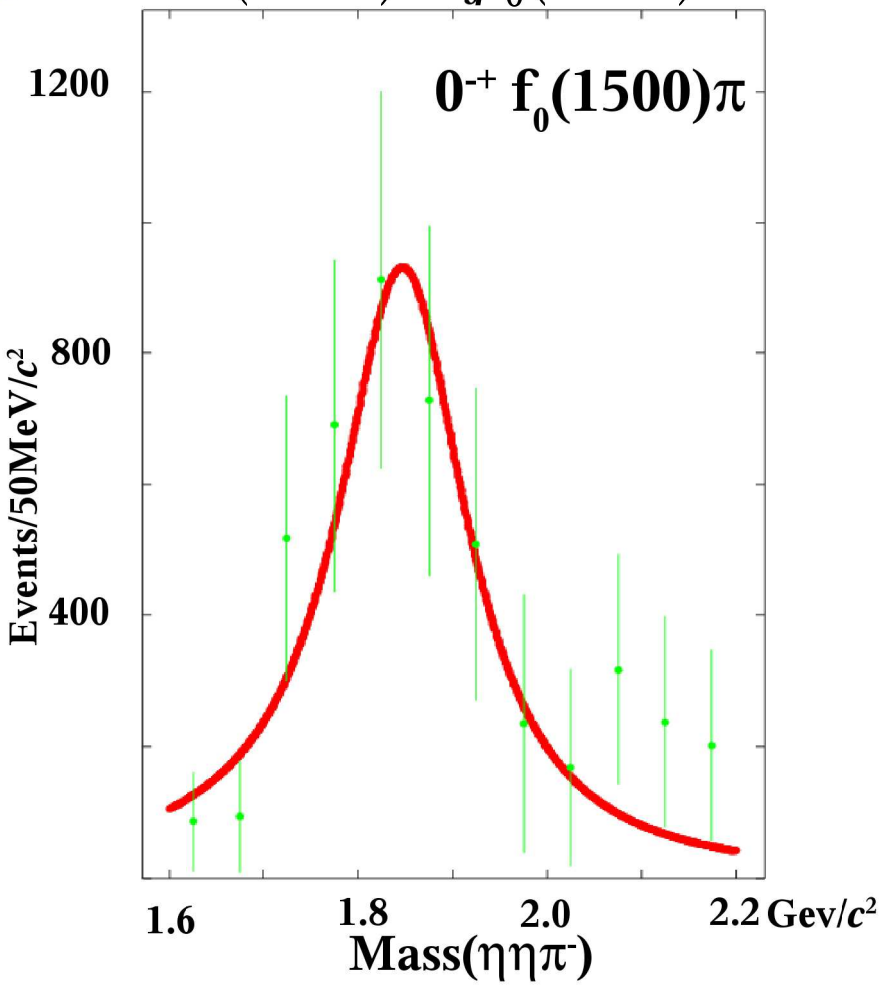
$\pi(1800) \to \eta\eta\pi^-$



$\pi(1800) \to a_0(980)\eta$



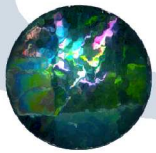
$\pi(1800) \to f_0(1500)\pi$

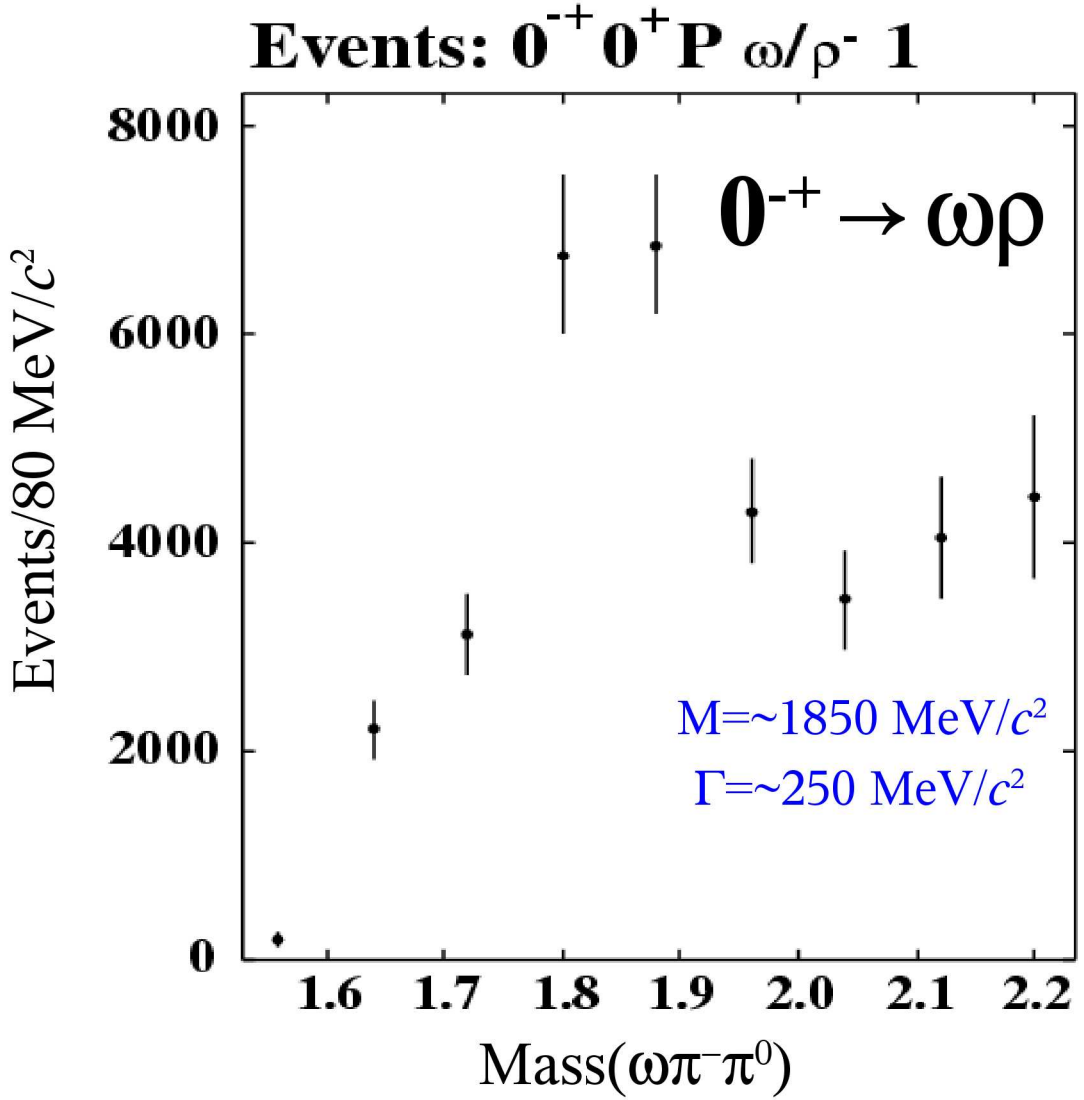


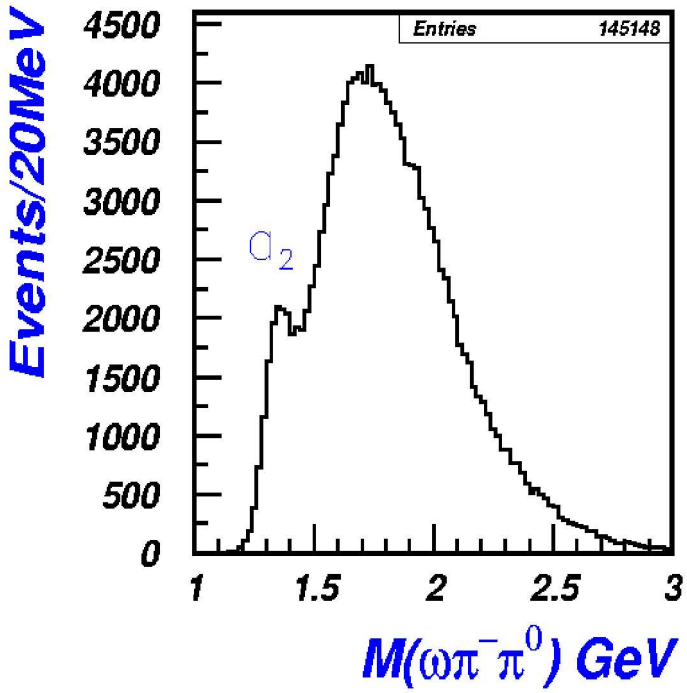
$M = 1884 \pm 19(stat) \pm ?(sys)\, MeV/c^2$
$\Gamma = 222 \pm 39(stat) \pm ?(sys)\, MeV/c^2$

$M = 1862 \pm 24(stat) \pm ?(sys)\, MeV/c^2$
$\Gamma = 166 \pm 46(stat) \pm ?(sys)\, MeV/c^2$

$\pi(1800) \to \omega \pi^- \pi^0$

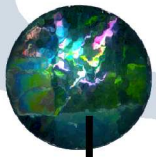


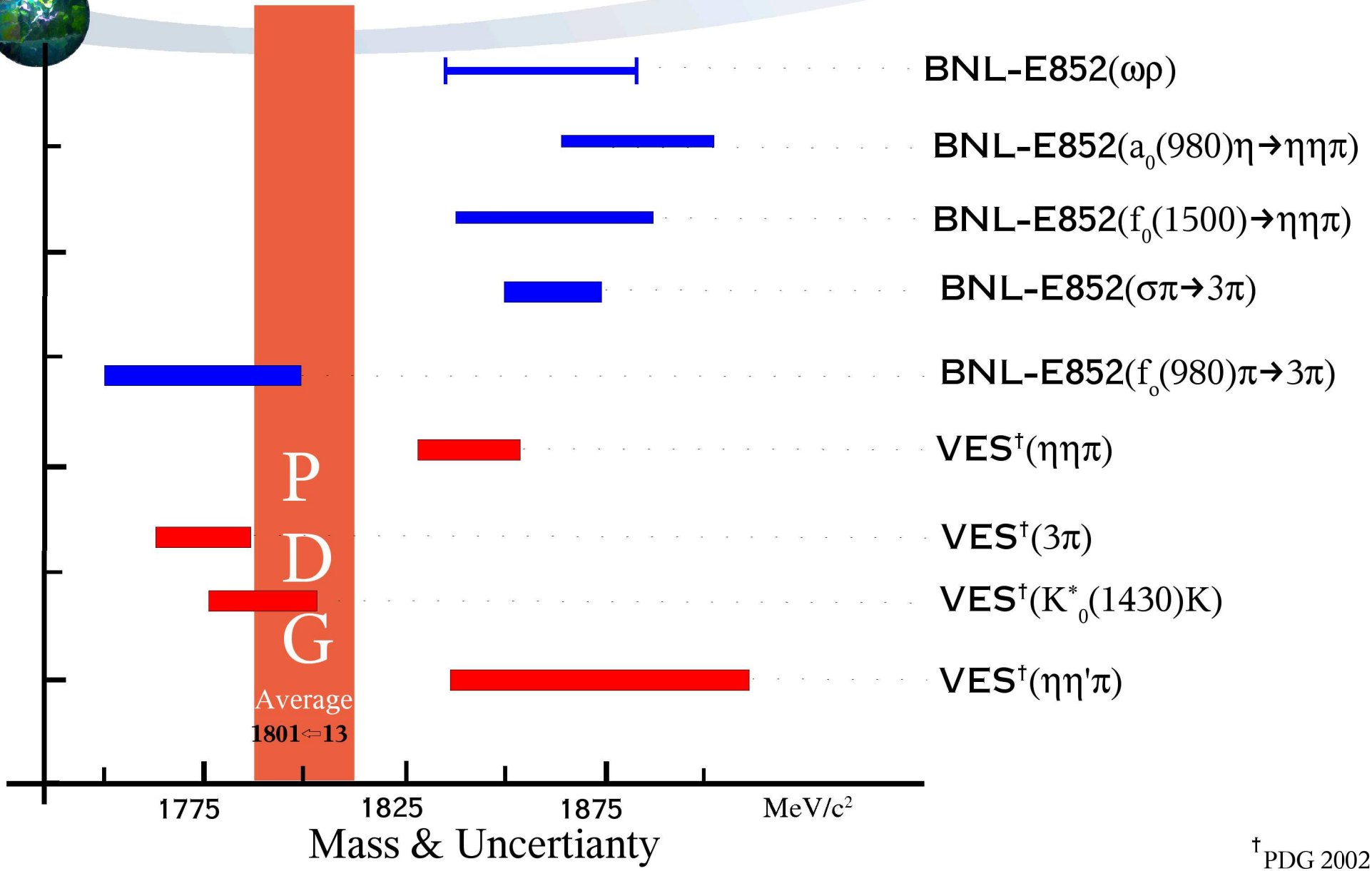




Preliminary, to be published
M. Lu *et al. BNL-E852*

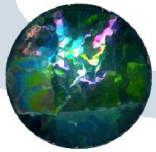
The Mass of the π(1800)





† PDG 2002

Is the π(1800) a Hybrid?



$\text{Hybrid} \rightarrow q\bar{q}(L=1)+q\bar{q}(L=0)$

$\pi(1800) \rightarrow f_0(980)\pi$	✔ ?
$\rightarrow \sigma\pi[f_0(1370)\pi]$	✔ ?
$\rightarrow f_0(1500)\pi$	✔ ?
$\rightarrow a_0(980)\eta$	✔ ?
$\rightarrow \omega\rho$	✘
$\rightarrow \eta\eta'\pi$	
$\rightarrow K_0^*(1430)K$	✔

$\text{Hybrid} \not\rightarrow q\bar{q}(L=0)+q\bar{q}(L=0)$

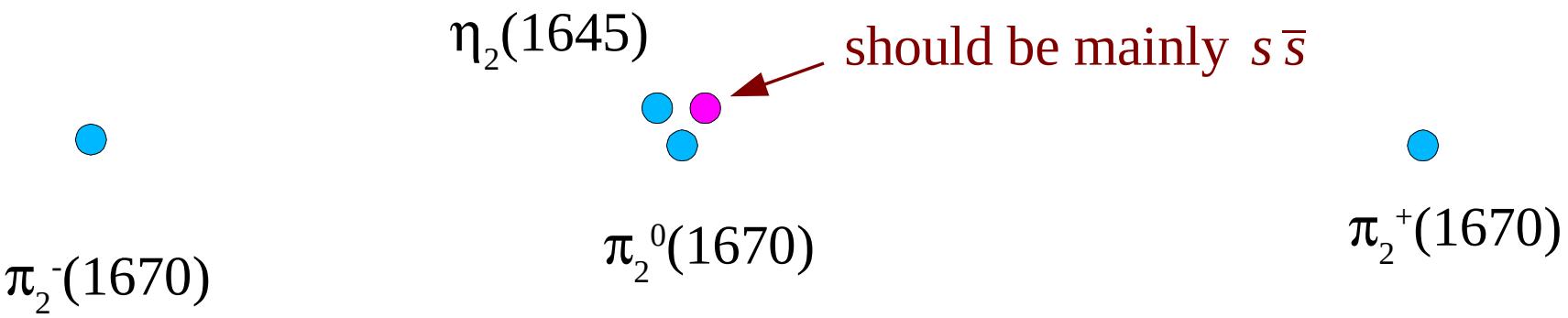
$\pi(1800) \not\rightarrow \rho\pi$	✔
$\not\rightarrow K^*K$	✔

$\pi_2(1900)$

Recently, a $\pi_2(1900)^{\dagger}$ state has been observed

† Anisovich et al., Phys. Lett. B500 222 (2001)

M=1880±20 MeV/c^2
Γ=255±45 MeV/c^2

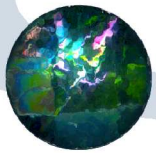


$\eta_2(1870)$ has been reported
in $\gamma\gamma$ interactions, $p\bar{p}$ interactions,
& central production

However,

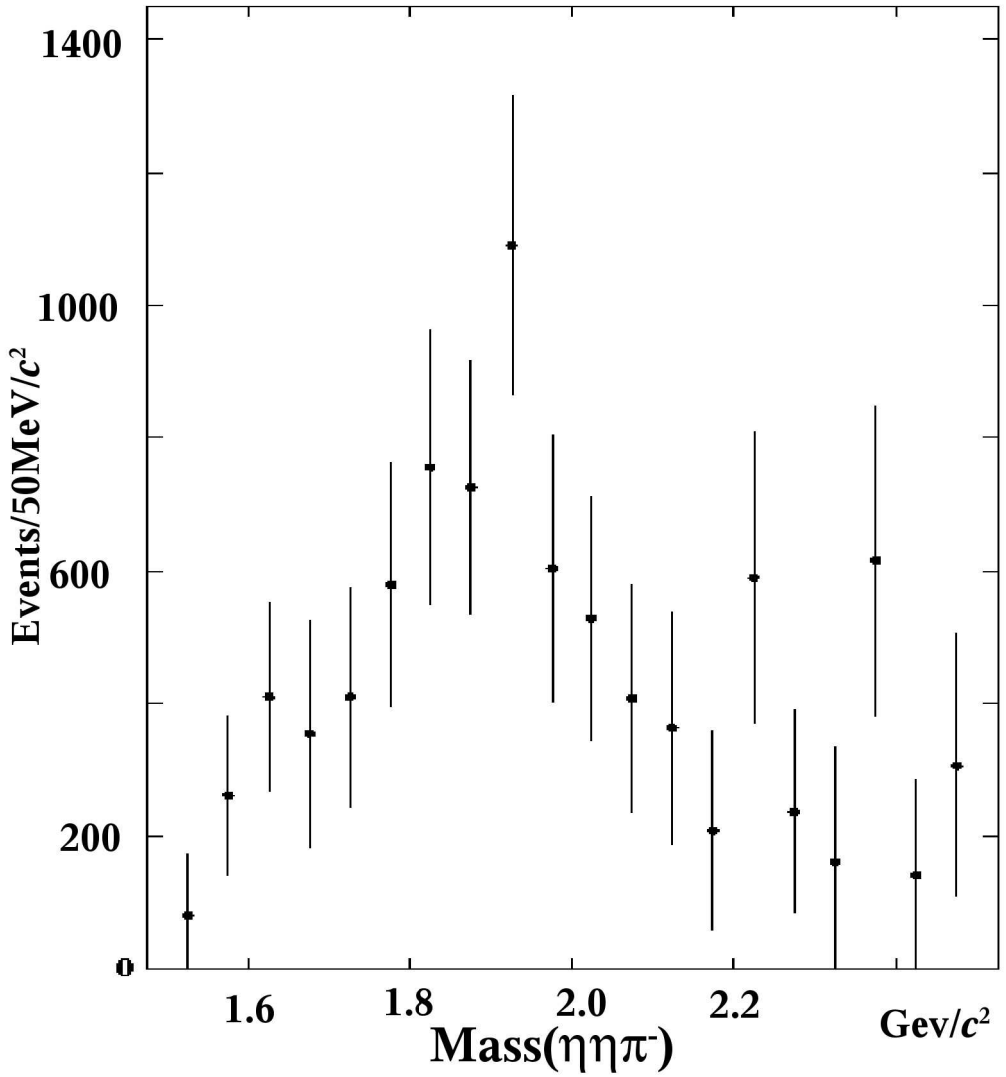
$$\eta_2(1870) \to a_2(1320)\pi$$
$$\to f_2(1270)\pi$$

$\pi_2(1900)$



$\pi^- p \to p \eta \eta \pi^-$

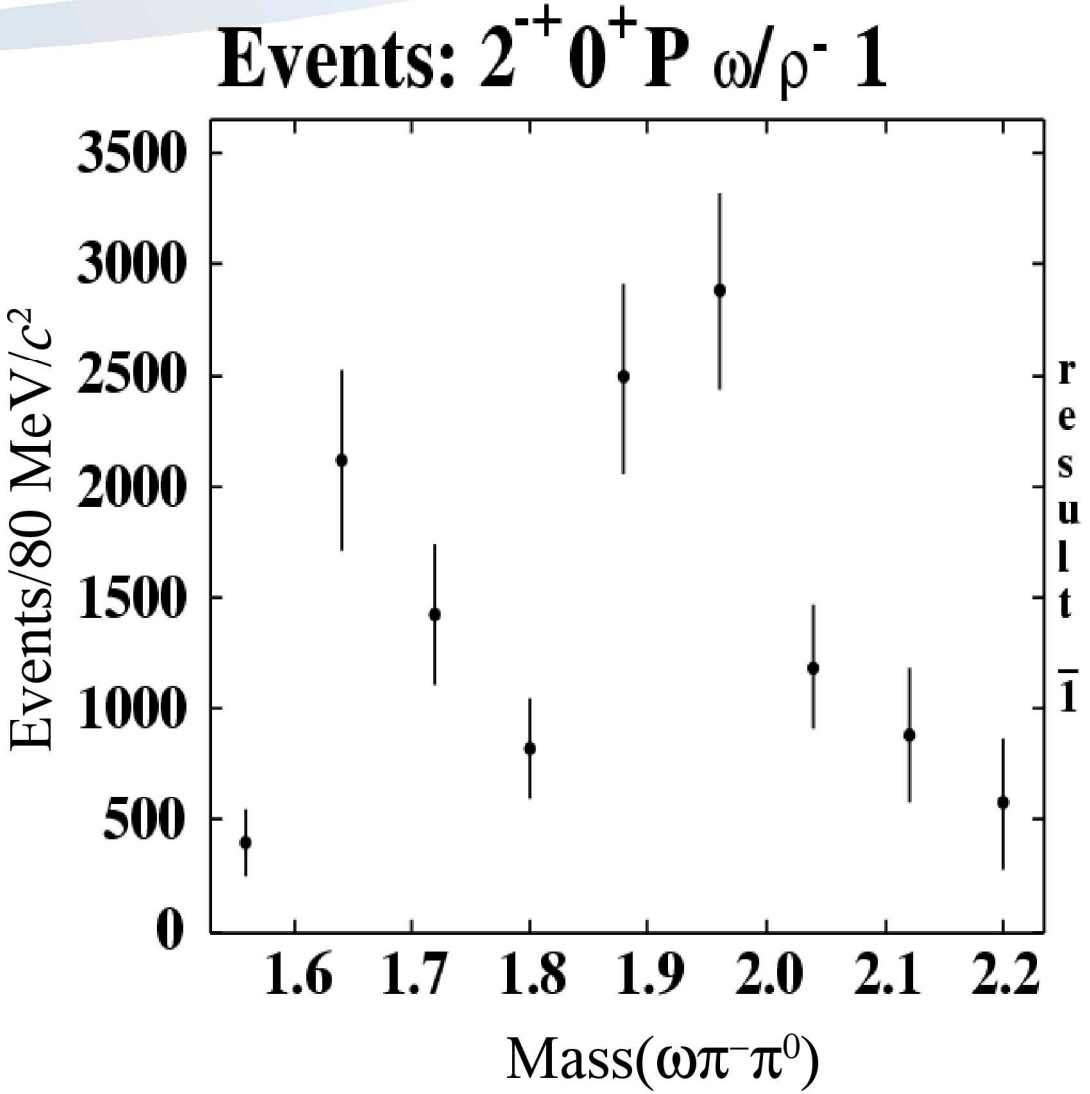
$2^{-+}\ 0^+\ a_2(1320)\ \eta$



$2^{-+} \to \omega \pi^- \pi^0$

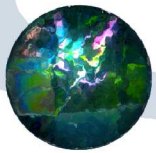
$\pi_2(1670) \to \omega \rho$

$\pi_2(1900) \to \omega \rho$



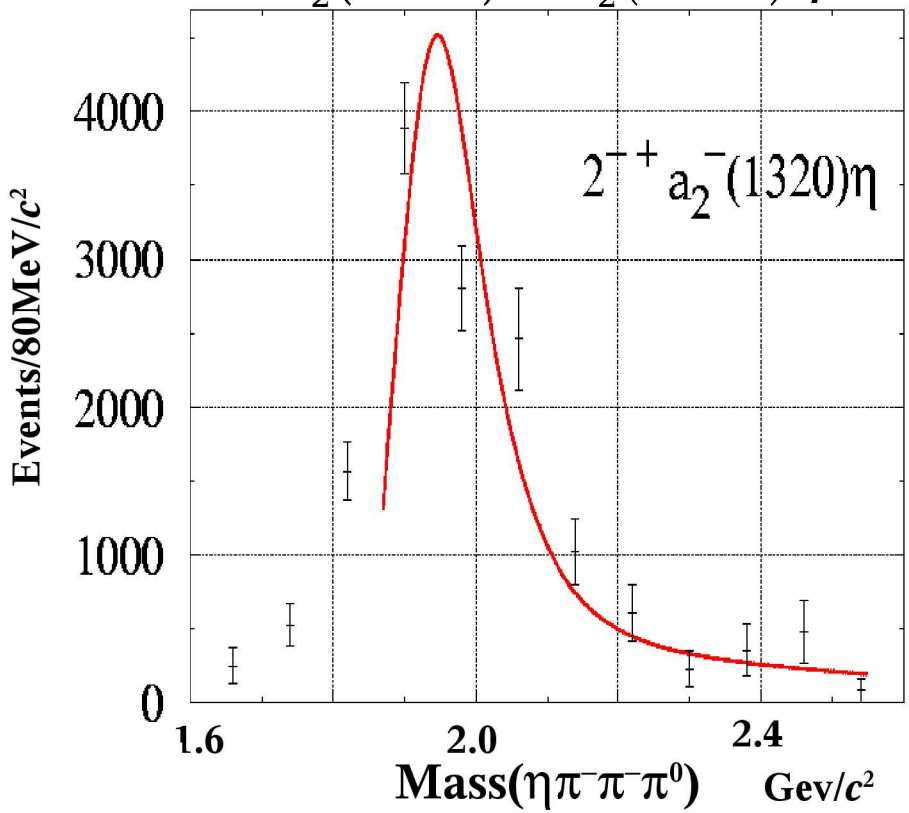
$\pi_2(1900) \to \eta\pi^-\pi^-\pi^0$

M~2000±100 MeV/c^2
Γ~300±150 MeV/c^2



$$R = \frac{BR[\pi_2(1900) \to a_2(1320)\eta]}{BR[\pi_2(1900) \to f_1(1285)\pi]} \sim 38$$

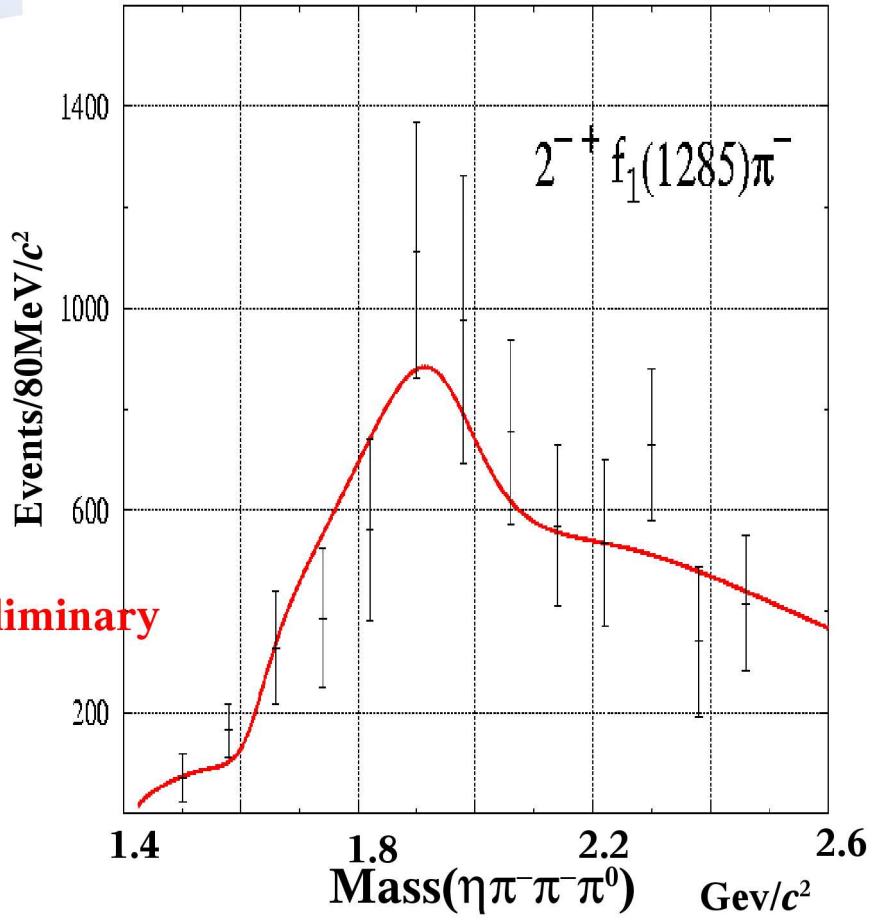
$\pi_2(1900) \to a_2(1320)\eta$



preliminary, to be published
J. Kuhn *et al. BNL-E852*

preliminary

$2^{-+} \to f_1(1285)\pi$

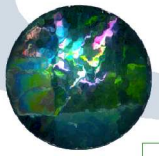


Flux Tube Model Prediction

R = 23

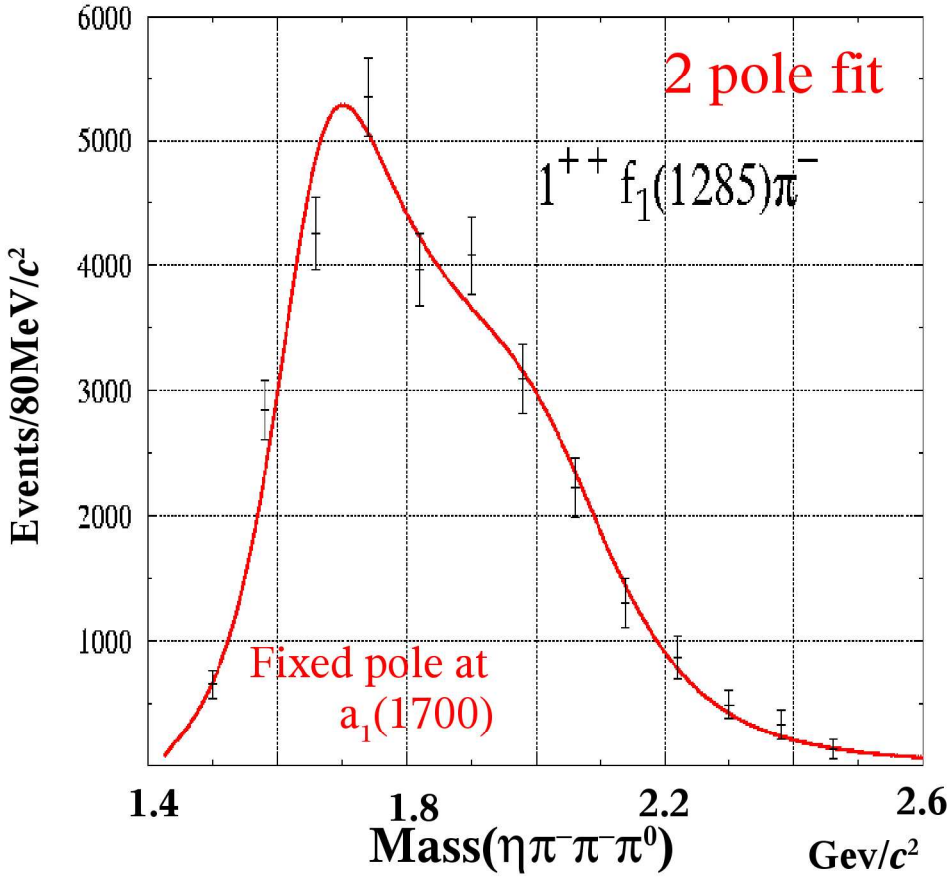
P. Page *et al.*, Phys. Rev. D59, 34016 (1999)

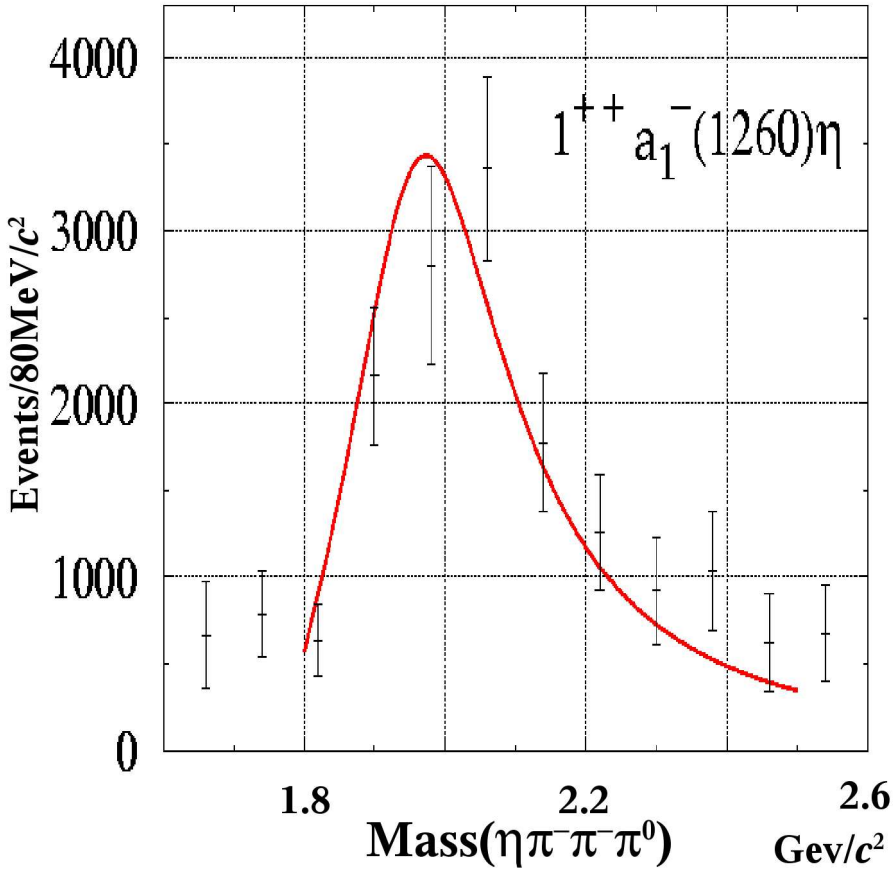
$a_1(2000) \to \eta \pi^- \pi^- \pi^0$



M~2000 MeV/c^2
Γ~450 MeV/c^2

$$R = \frac{BR[a_1(2000) \to f_1(1285)\pi]}{BR[a_1(2000) \to a_1(1260)\eta]} \simeq 2$$



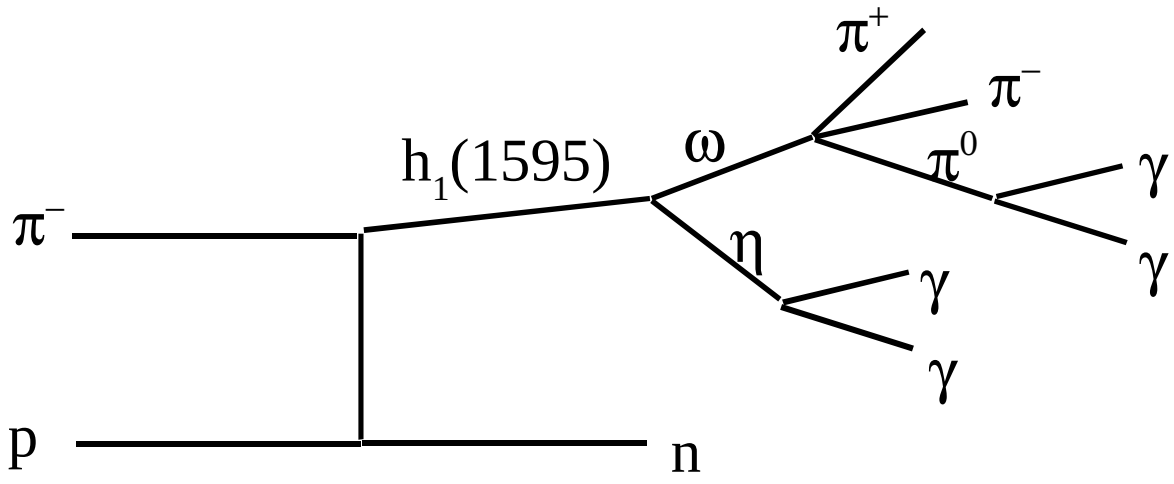


Flux Tube Model Prediction

R = 3

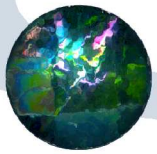
P. Page *et al.*, Phys. Rev. D59, 34016 (1999)

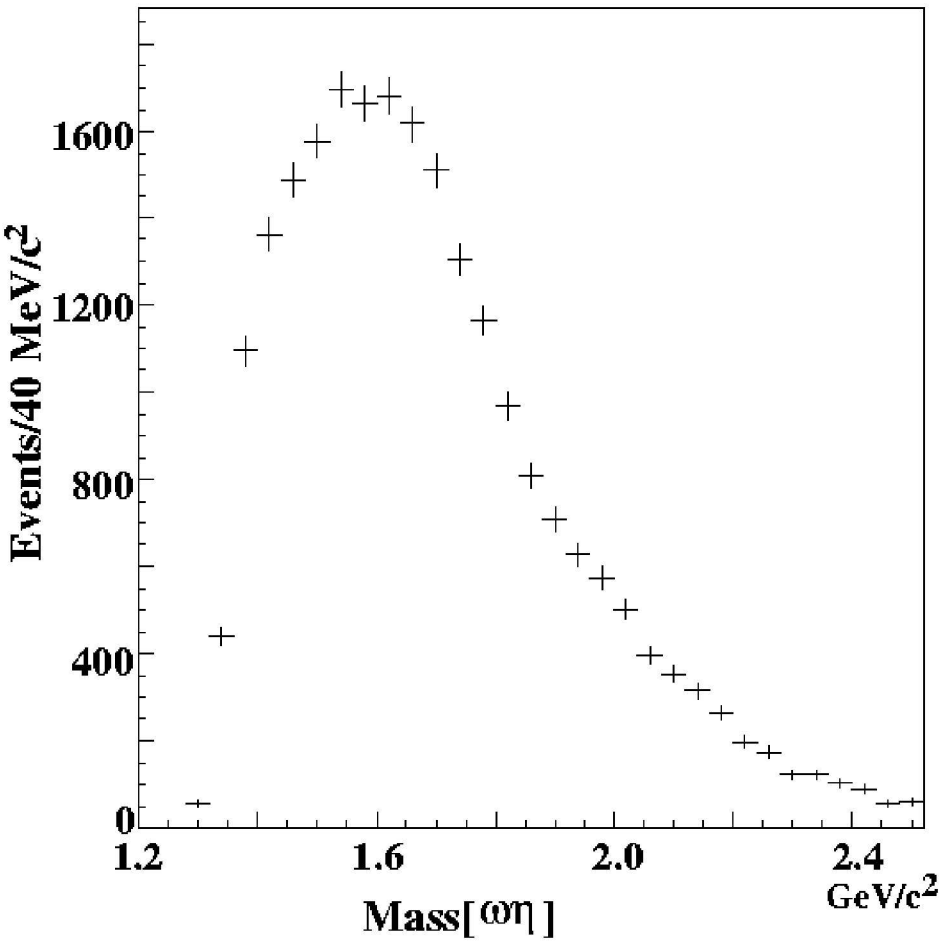
Observation of a New $J^{PC}=1^{+-}$ Isoscalar State in the Reaction $\pi^- p \to \omega\eta n$ at 18 GeV/*c*

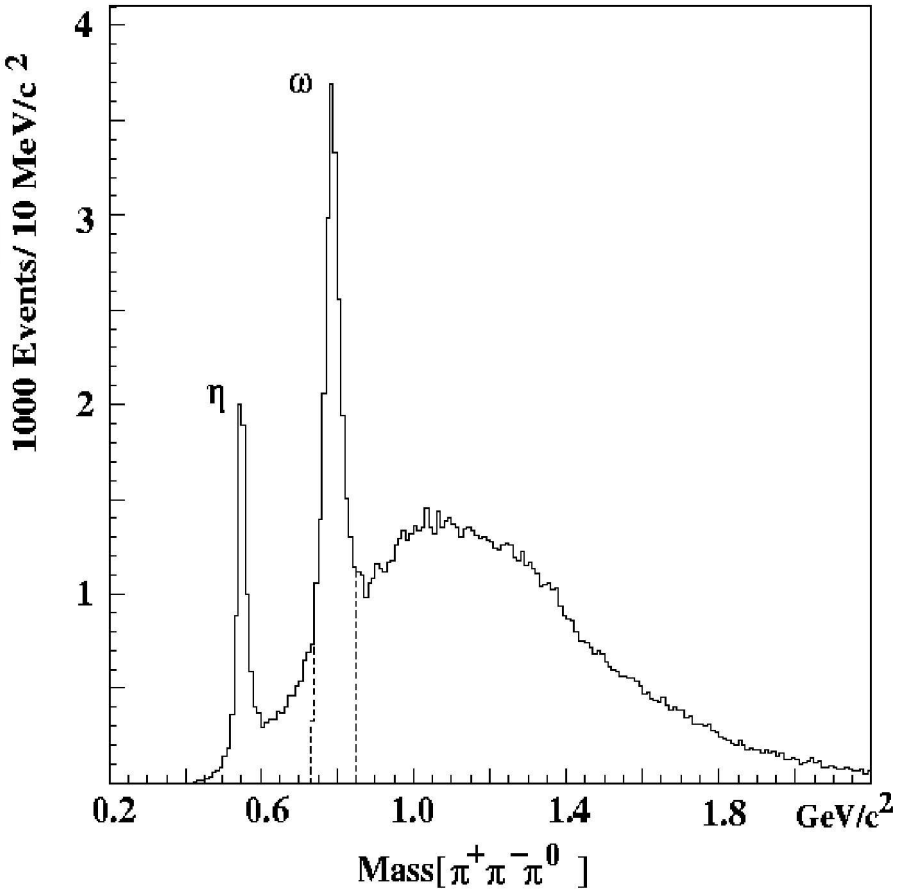


Phys. Lett. B497, 190, (2001)

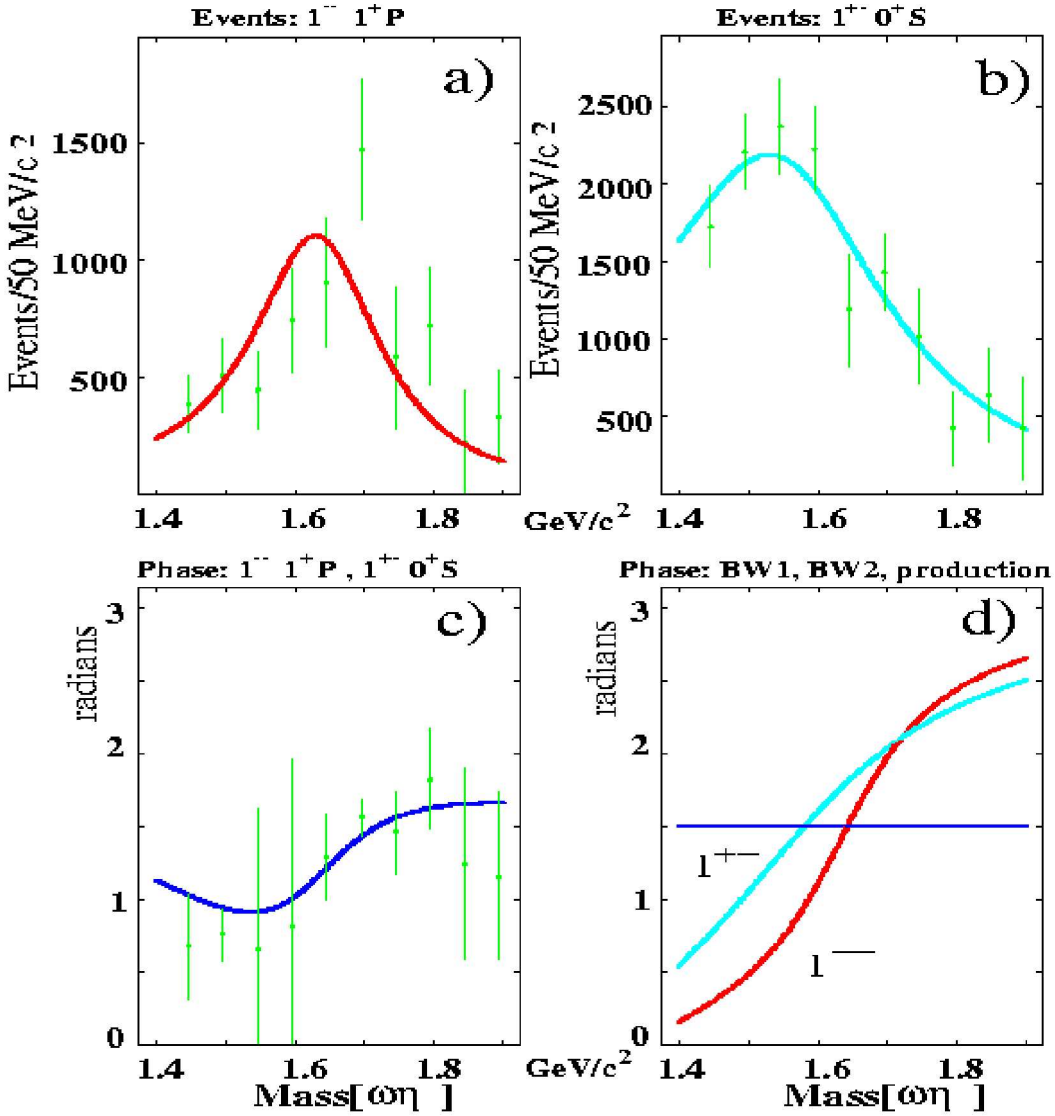
$h_1(1595)$




Events/40 MeV/c²
1600
1200
800
400
0
1.2
1.6
2.0
2.4
GeV/c²
Mass[ωη]


1000 Events/ 10 MeV/c²
4
3
2
1
ω
η
0.2
0.6
1.0
1.4
1.8
GeV/c²
Mass[π⁺π⁻π⁰]

$h_1(1595)$

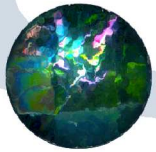


$$J^{PC} = 1^{+-}$$

$$Mass = 1594(\pm 15)\left(^{+10}_{-60}\right) MeV/c^2$$

$$\Gamma = 384(\pm 60)\left(^{+70}_{-100}\right) MeV/c^2$$

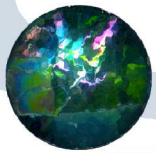
$$\chi^2/DoF = 1.28$$



Single Resonance Interpretations

- 2^1P_1 h_1 Radial Excitation
  - Godfrey-Isgur predict a mass of 1780 MeV/c^2 but ...
  - Barnes *et. al.* predict 2^1P_1 h_1 to decay equally via S and D Waves
- h_1 Gluonic Excitation
  - Flux-tube predicts hybrid near 1900-2000 MeV/c^2
  - Exotics have been reported at masses lower than Flux-tube predictions
- h_1 Gluonic-Radial Mixture

Summary



$\pi(1800)$

+ more likely $\pi(1850)$
+ cannot rule out 2 possible states
+ does not look like $q\bar{q}$

$\pi_2(1900)$

+ confirmation at hand
+ signal in: $\eta\eta\pi$, $\eta\pi\pi\pi$, & $\omega\pi\pi$
+ hybrid partner to $\eta_2(1880)$

$a_1(2000)$

+ observed in $f_1\pi$ and $a_1(1260)\eta$
+ consistent with flux-tube hybrid predictions
  - both decay products & ratio

$h_1(1595)$

+ inconsistent with $q\bar{q}$ expectations