Radiative J/ψ Decays and Searches for Glueballs

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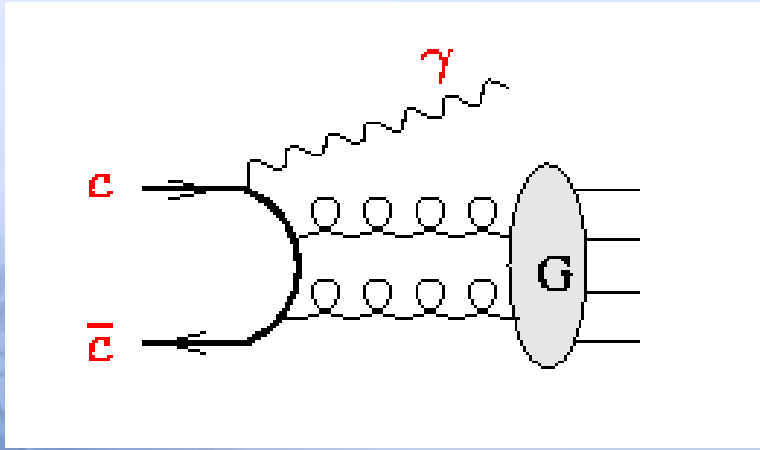
Outline

- PWA of $J/\psi \to \gamma K\bar{K}$, $\gamma\pi^+\pi^-$ at BES II
- Observation of an enhancement near $p\bar{p}$ threshold in $J/\psi \to \gamma p\bar{p}$ at BESII
- Anti-search for glueball candidates in two photon collisions at CLEO and L3
- Summary

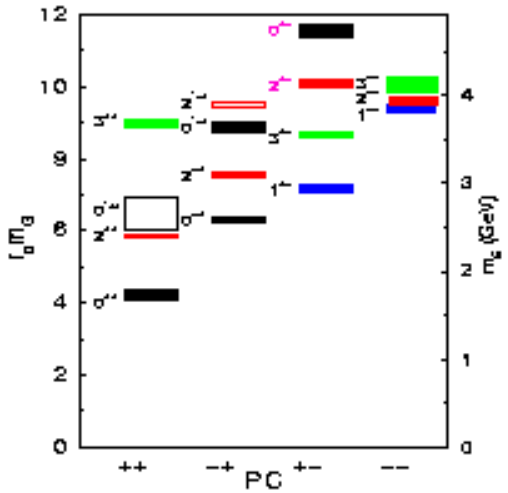
PWA of $J/\psi \to \gamma K\bar{K}$, $\gamma\pi^+\pi^-$ at BES II

Introduction

- QCD predicts the existence of glueballs.
- Radiative J/ψ decays are suggested as promising modes of glueball searches.



- Lattice QCD: The ground scalar glueball should be in the mass range 1.5 – 1.7 GeV.



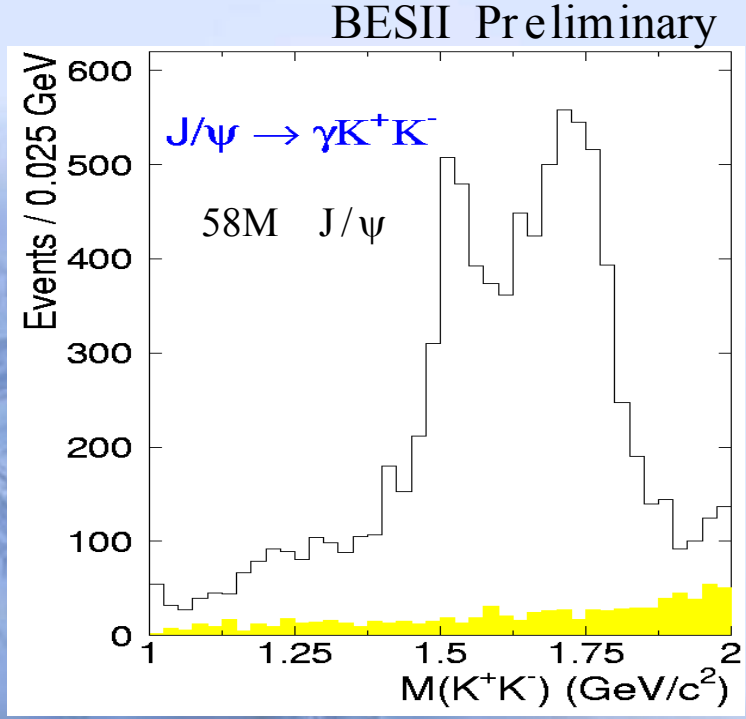
C. Morningstar and M. Peardon, PR D60, (1999)

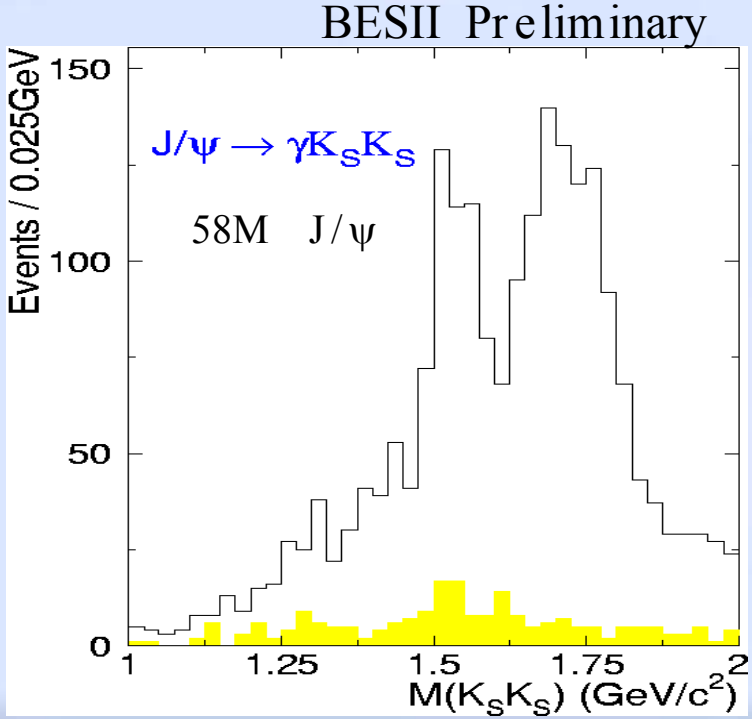
- Long history of uncertainty on $f_0(1710)$

Process	Collaboration	M(MeV)	Γ(MeV)	J^{PC}
$J/\psi \to \gamma\eta\eta$	CBAL (82)	1640 ± 50	220^{+100}_{-70}	2^{++}
$\pi^- p \to K^0_S K^0_S n$	BNL (82)	1771^{+77}_{-53}	200^{+156}_{-9}	0^{++}
$\pi^- N \to K^0_S K^0_S n$	FNAL (84)	1742 ± 15	57 ± 38	—
$\pi^- p \to \eta\eta N$	GAMS (86)	1755 ± 8	< 50	0^{++}
$J/\psi \to \gamma K^+ K^-$	MARKIII (87)	1720 ± 14	130 ± 20	2^{++}
$J/\psi \to \gamma K\overline{K}$	DM2 (88)	1707 ± 10	166 ± 33	—
$\gamma\pi^+\pi^-$		1698 ± 15	136 ± 28	
$pp \to ppK^+K^-$	WA76 (89)	1713 ± 10	181 ± 30	2^{++}
$ppK^0_S K^0_S$		1706 ± 10	104 ± 30	
$J/\psi \to \gamma K\overline{K}$	MARKIII (91)	1710 ± 20	186 ± 30	0^{++}
$p\overline{p} \to \pi^0\eta\eta$	E760 (93)	1748 ± 10	264 ± 25	$(\text{even})^{++}$
$J/\psi \to \gamma 4\pi$	MARKIII data D. Bugg et al. (95)	1750 ± 15	160 ± 40	0^{++}
$J/\psi \to \gamma K^+ K^-$	BES (96)	$1696 \pm 5^{+9}_{-34}$	$103 \pm 18^{+30}_{-11}$	2^{++}
		$1781 \pm 8^{+10}_{-31}$	$85 \pm 24^{+22}_{-19}$	0^{++}
$J/\psi \to \gamma K\overline{K}$	MARKIII data W. Dunwoodie (97)	1704^{+16}_{-23}	124^{+52}_{-44}	0^{++}
$pp \to p_f(K^+K^-)p_s$	WA102 (99)	1730 ± 15	100 ± 25	0^{++}
$pp \to p_f(\pi^+\pi^-)p_s$	Wa102 (99)	1750 ± 25	105 ± 34	0^{++}
$pp \to K^+K^-\pi^+\pi^-$	Wa102 (99)	1710 ± 16	126 ± 24	0^{++}
$pp \to p_f(K^+K^-)p_s$	WA76 (99)	1710 ± 25	105 ± 34	0^{++}
$pp \to p_f\eta\eta p_s$	WA102 (00)	1698 ± 18	120 ± 26	0^{++}
$J/\psi \to \gamma 4\pi$	BES (00)	1740^{+20}_{-25}	135^{+40}_{-25}	0^{++}

PWA of $J/\psi \to \gamma K^+K^-$ and $\gamma K_S^0 K_S^0$.

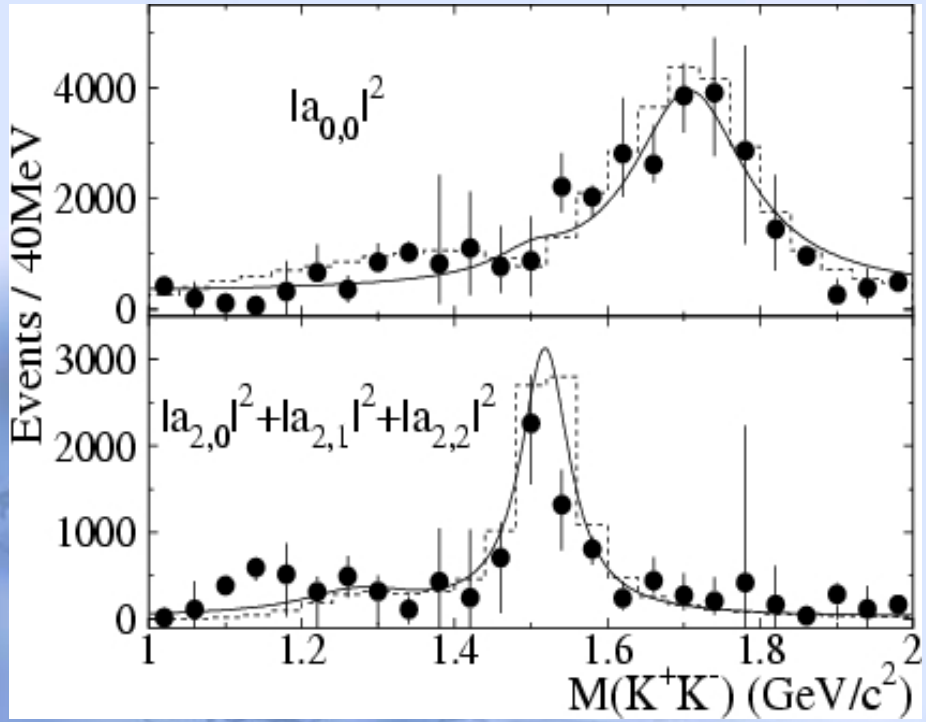
- $J/\psi \to \gamma K\bar{K}$ is a very important channel to investigate the $f_0(1710)$

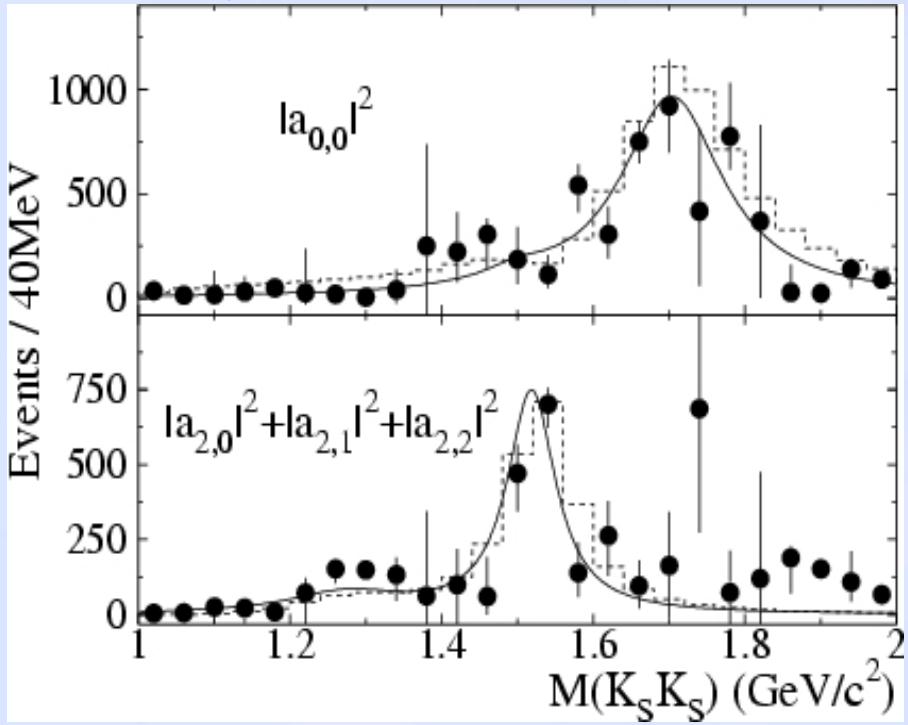




- Global fit and bin-by-bin fit are performed

BES II Preliminary





Preliminary Results

$$(\ J/\psi \to \gamma K\bar{K} \ )$$

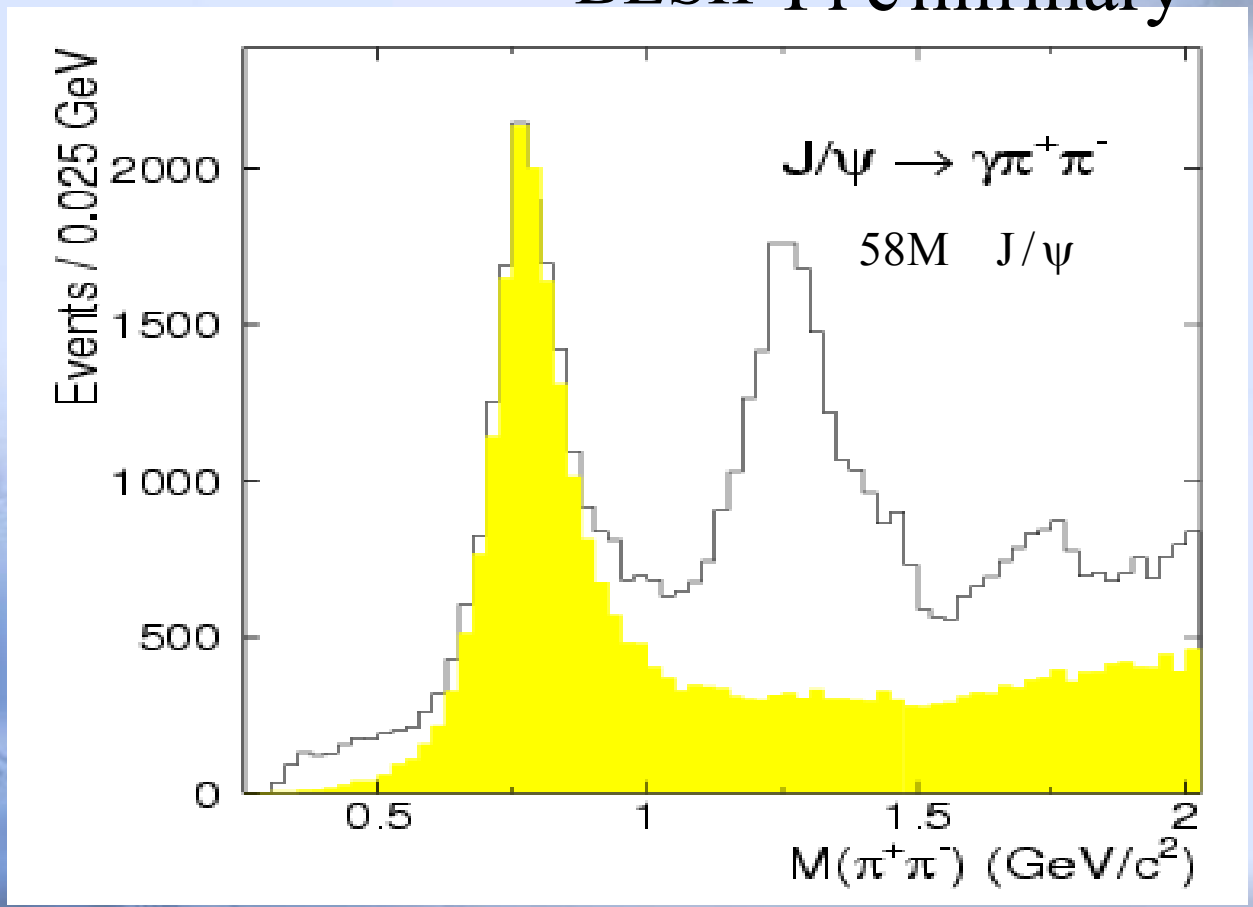
- Clear $f_2'(1525)$ signal.
- Evidence of $f_2(1270)$.
- 0^{++} is dominant in 1.7GeV mass region
- Masses and Widths (statistical error only):

$f_2'(1525)$ $M = 1518 \pm 6$ MeV, $\Gamma = 84^{+28}_{-24}$ MeV.

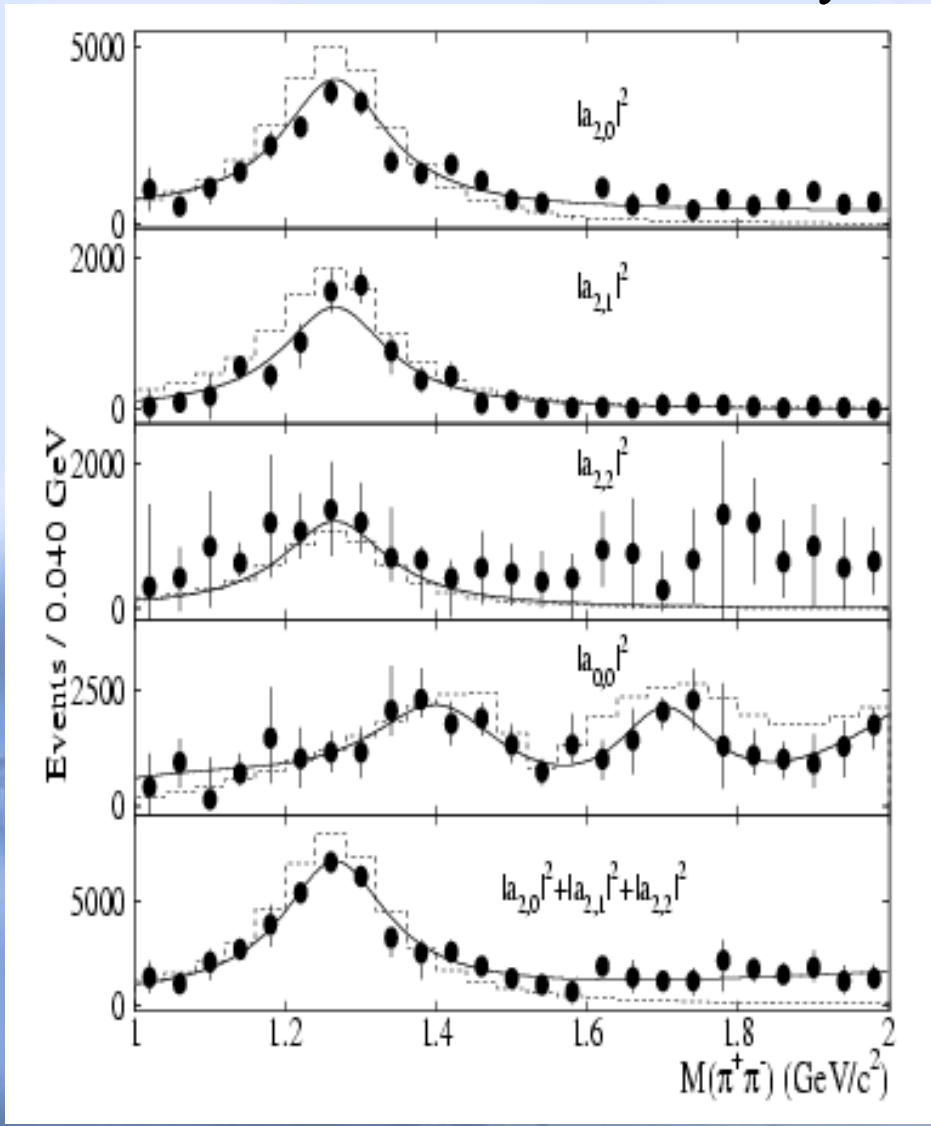
$f_0(1710)$ $M = 1703^{+8}_{-10}$ MeV, $\Gamma = 163^{+27}_{-22}$ MeV.

PWA of $J/\psi \to \gamma \pi^+ \pi^-$.

BESII Preliminary



BESII Preliminary



Preliminary Results

($J/\psi \to \gamma\pi^+\pi^-$)

- well known $f_2(1270)$
- two 0^{++} at around 1.4 and 1.7 GeV mass regions, for $f_0(1710)$:

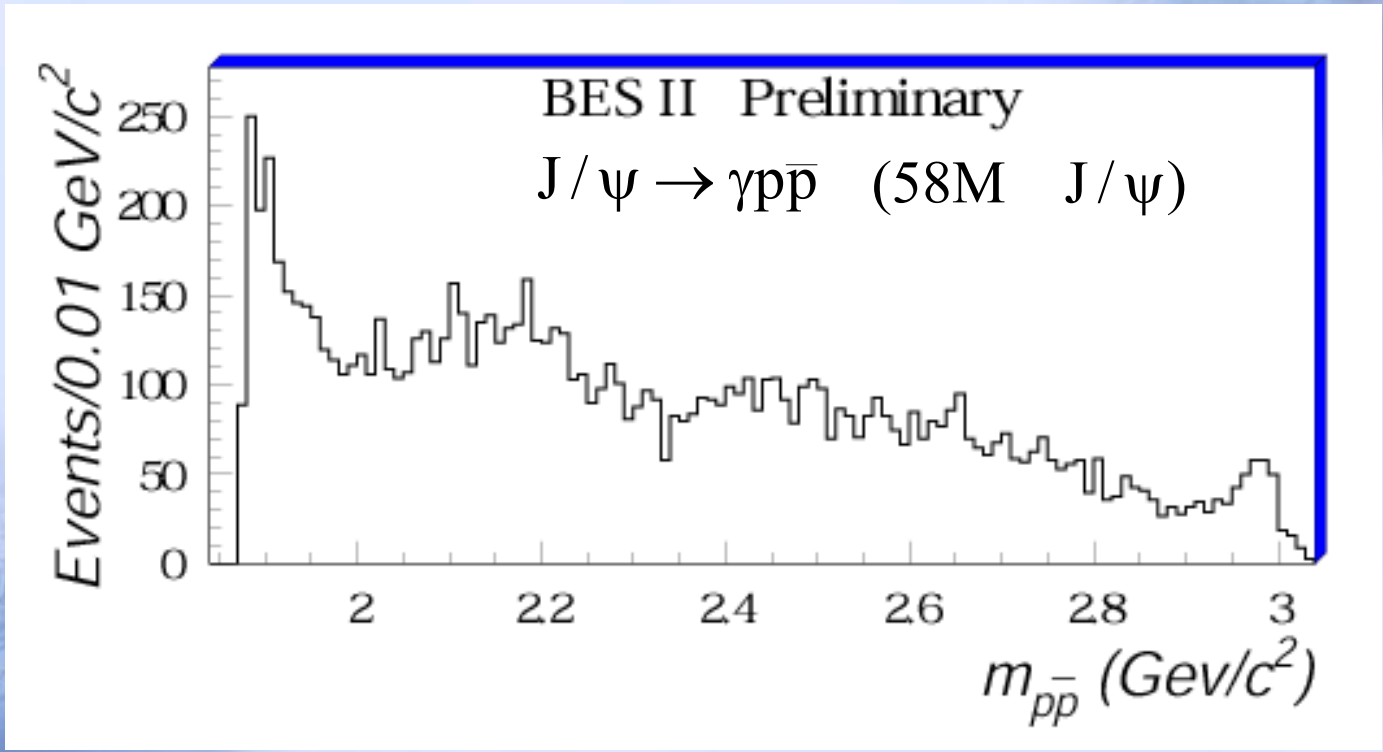
$$\frac{\Gamma(\pi\pi)}{\Gamma(K\bar{K})} \sim 30\%$$

Observation of an enhancement near $p\bar{p}$ threshold in $J/\psi \to \gamma p\bar{p}$ at BESII

Event Selection

- 2 good charged tracks
- $\geq 1\gamma$ (isolated from charged tracks)
- Particle ID
- 4C-fits
  - $\mathrm{CL}(\gamma p\bar{p}) > 0.05$
  - $\mathrm{CL}(\gamma p\bar{p}) > \mathrm{CL}(\gamma K^{+}K^{-})$

$p\bar{p}$ masses for selected events

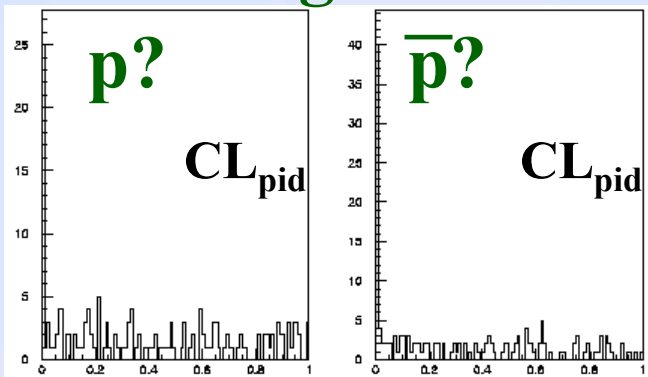


Besides η_c peak, there is a clear enhancement near threshold.

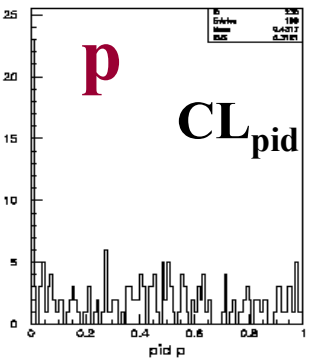
Are these really p and $\bar{p}$'s? (Yes!)

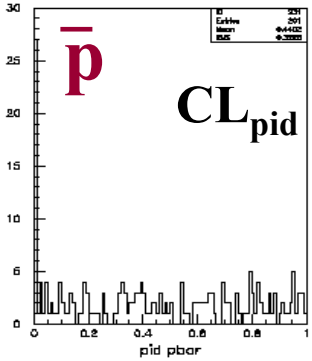
signal

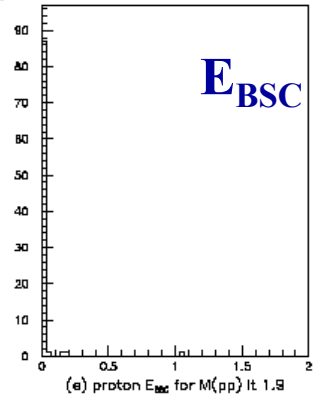
Tagged p & $\bar{p}$ from $J/\psi \rightarrow \Xi^-\Xi^+$

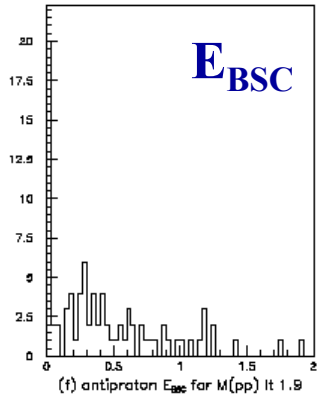


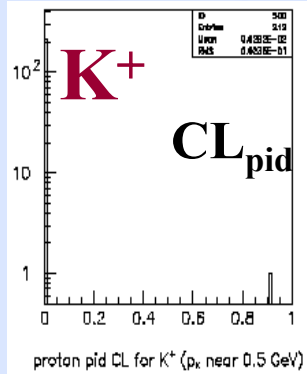
Tagged K^+& $K^-$from $J/\psi \rightarrow K^{*+}K^-$

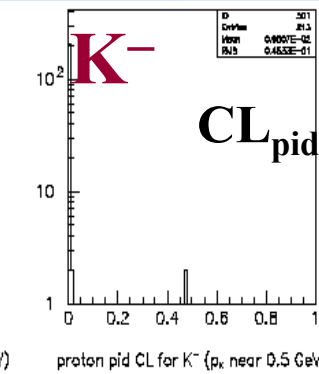


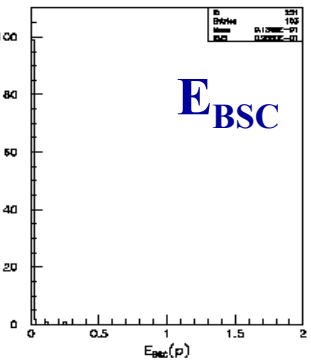


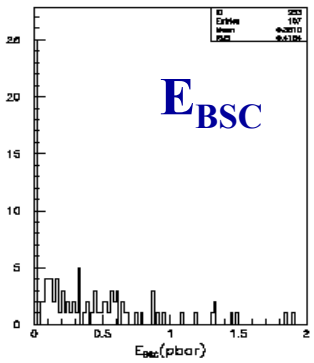


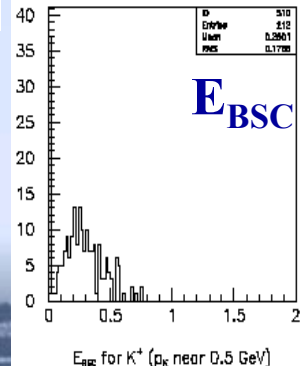


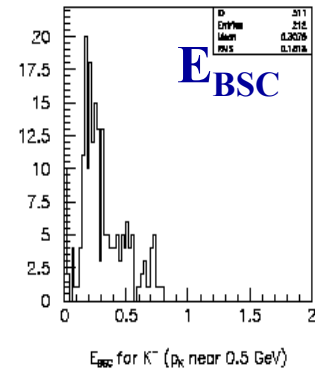








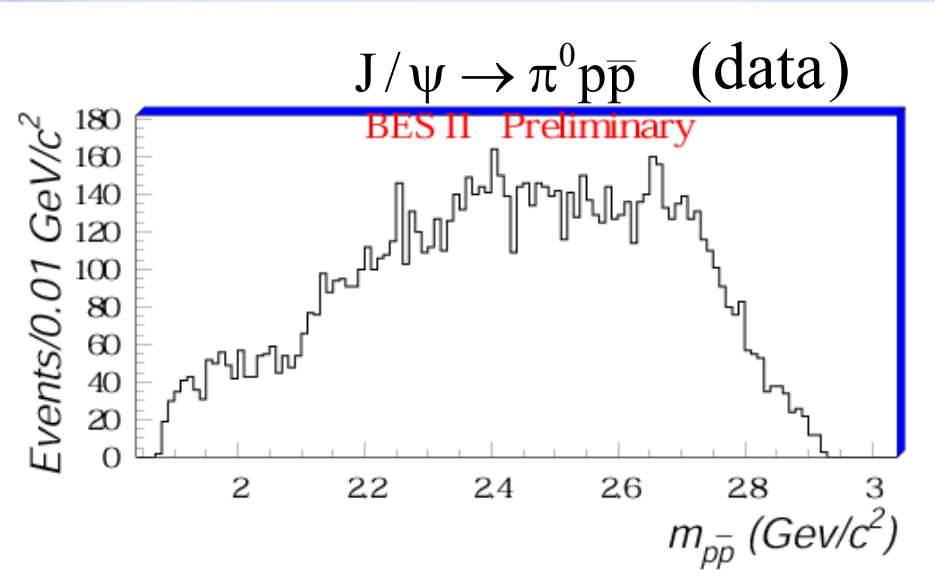




Backgrounds

Main backgrounds remained after selection for the mass peak near threshold(almost equal contribution):

- $J/\psi \to \gamma p\bar{p}$ phase space
- $J/\psi \to \pi^0 p\bar{p}$



No clear enhancement near threshold

S-wave Breit-Wigner function

If the enhancement is treated as a resonance:

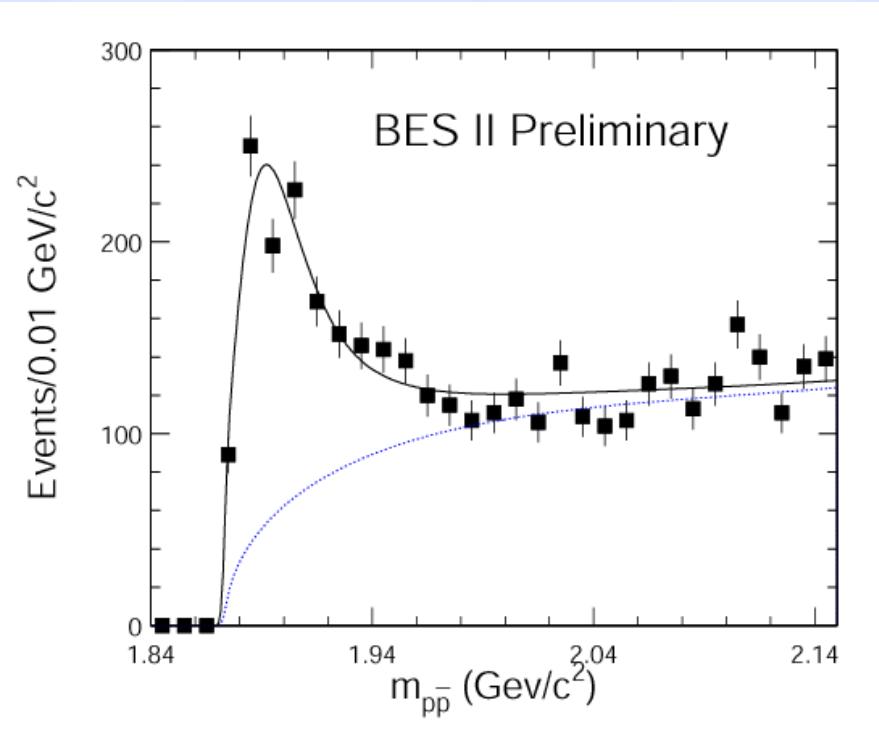
$$BW \propto \frac{M_0\Gamma_0 \bullet (q/q_0)}{(M^2 - M_0^2)^2 + (M_0\Gamma_0 \bullet (q/q_0))^2}$$

q = daughter momentum

q_0 = daughter momentum @ peak

Weight the BW function with mass-dependent acceptance

BW fit to the structure near threshold



- Background shape from $J/\psi \to \pi^0 p\bar{p}$ MC
- Preliminary results:

(statistical error only)

$$M = (1896 \pm 2)\mathrm{MeV}/c^2$$

$$\Gamma = (57 \pm 8)\mathrm{Mev}/c^2$$

Statistical significance:

$\sim 16\sigma$

What is it?

- $p\bar{p}$ molecular state?
- 0^{-+} glueball?
  - ➡ *why so close to* $2m_p$*?*
- Dynamical effect?
  - ➡ *no evidence in* $\gamma\Lambda\bar{\Lambda}$ *or* $\gamma\Xi^+\Xi^-$
- ????

⟹ Searches for other decay modes

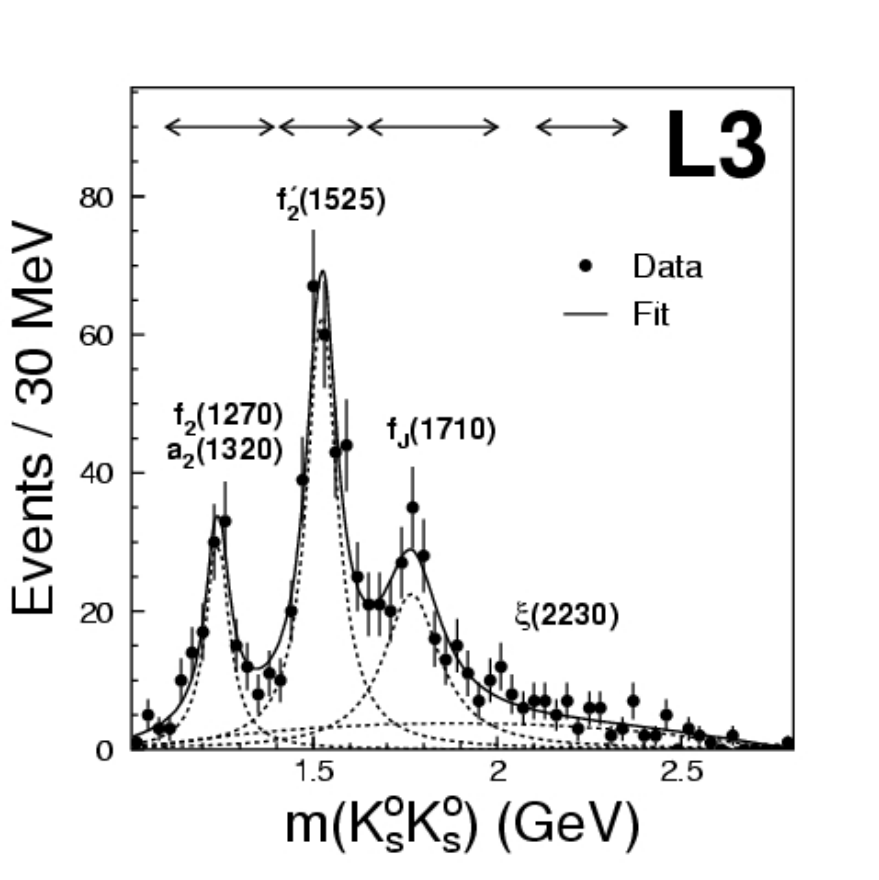
Anti-search for glueball candidates in two photon collisions at CLEO and L3

- $\Gamma_{\gamma\gamma}$ of a glueball is expected to be very small.

$\Longrightarrow$ A state which is observed in a gluon rich environment but not in two photon fusion has the typical signature of a glueball

- Both experiments studied $\gamma\gamma \to K_S^0 K_S^0$

Results from L3



- The $f_2'(1525)$ tensor meson

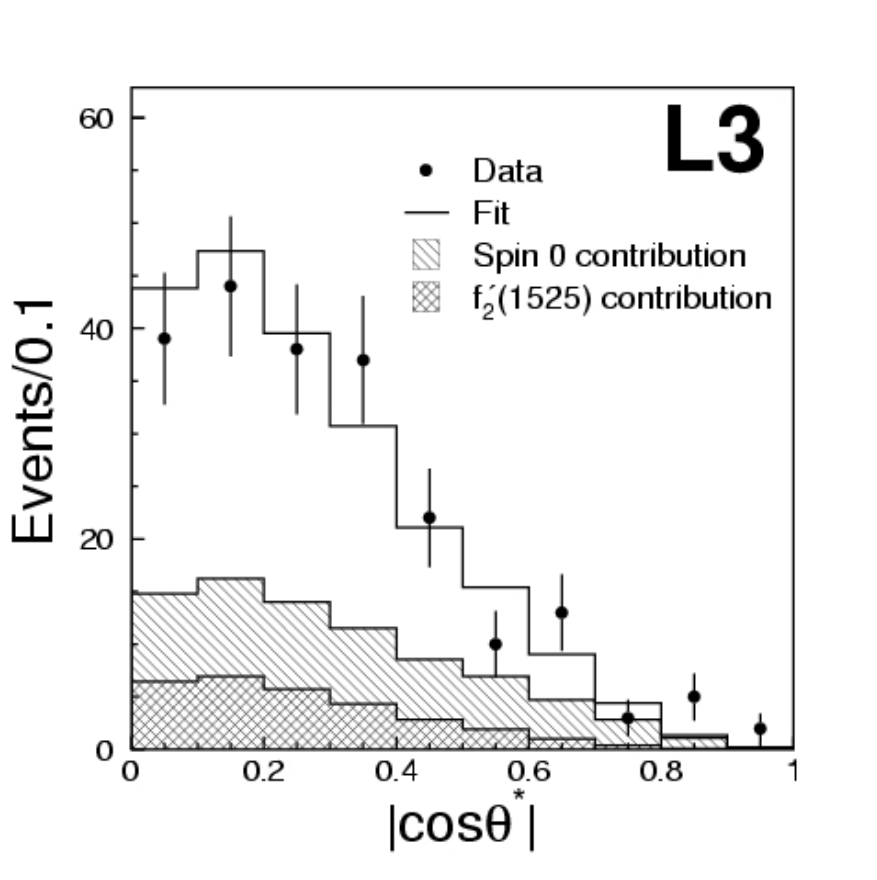
$$\Gamma_{\gamma\gamma}(f_2'(1525)) \bullet B(f_2'(1525) \to K\bar{K}) = 76 \pm 6 \pm 11\ \text{eV}$$

- The 2230 mass region

$$\Gamma_{\gamma\gamma}(\xi(2230)) \bullet B(\xi(2230) \to K_S^0 K_S^0) < 1.4\text{eV} \quad (95\%\text{C.L.})$$

(assume $J = 2, \lambda = 2$)

Results from L3 (continued)

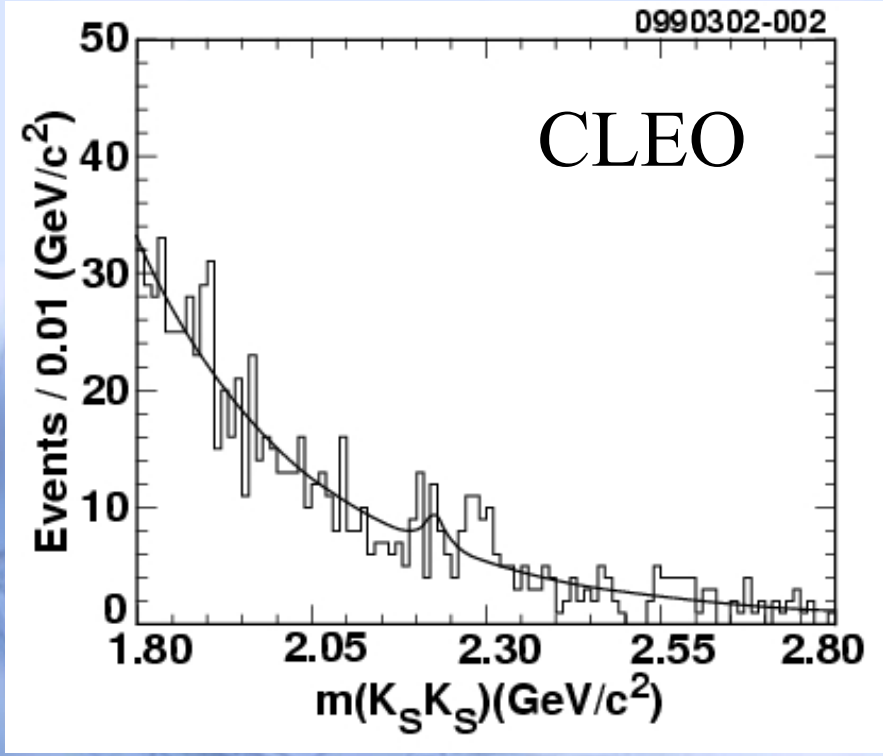


- The 1750 MeV mass region

⇐ $(J = 2, \lambda = 2)$ wave dominant

$$\Gamma_{\gamma\gamma}(f_2(1750)) \bullet B(f_2(1750) \to K\bar{K})$$
$$= 49 \pm 11 \pm 13 \ \text{eV}$$

Results from CLEO



- Assume J=2:

$$\Gamma_{\gamma\gamma}(\xi(2230)) \bullet B(\xi(2230) \to K_S^0 K_S^0)$$
$$< 1.1\text{eV} \quad (95\%\text{C.L.})$$

Summary

- PWA of BES II 58M J/ψ data show strong production of $f_0(1710)$ in $J/\psi \to \gamma K\bar{K}, \gamma\pi^+\pi^-$ with $\Gamma(\pi\pi)/\Gamma(K\bar{K}) \sim 30\%$.

- A significant near-threshold $p\bar{p}$ enhancement is observed in $J/\psi \to \gamma p\bar{p}$ at BES II. If treated as a resonance:

$$M = (1896 \pm 2)\text{MeV}, \quad \Gamma = (57 \pm 8)\text{MeV}$$

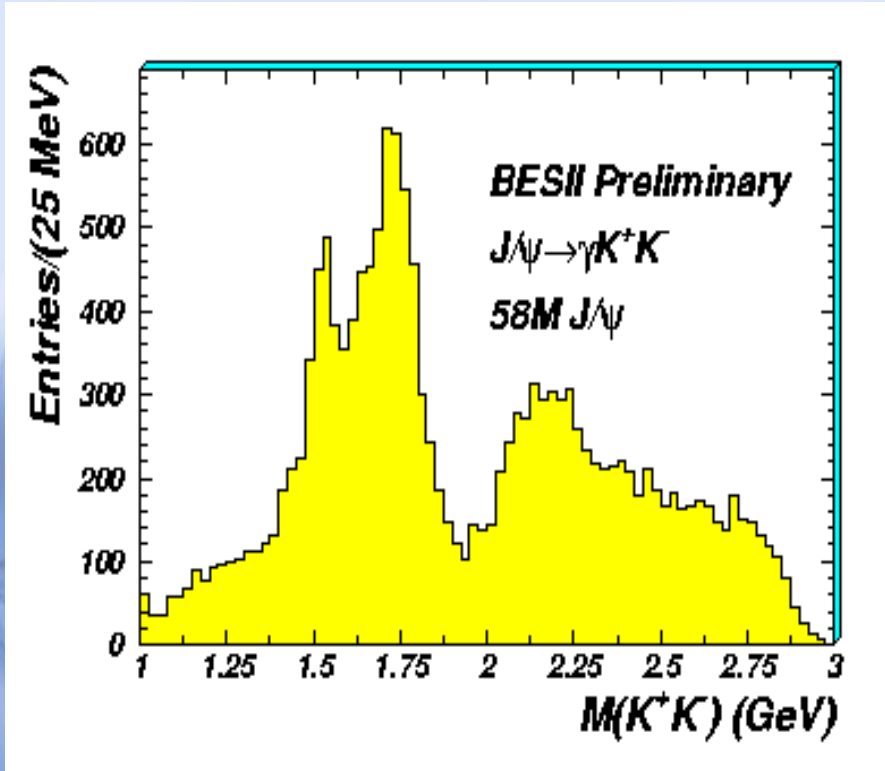
- In $\gamma\gamma \to K_S^0 K_S^0$ at L3 and CLEO:

$$\Gamma_{\gamma\gamma}(f_2(1750)) \bullet B(f_2(1750) \to K\bar{K}) = (49 \pm 11 \pm 13)\text{eV} \qquad \text{(L3)}$$

$$\Gamma_{\gamma\gamma}(\xi(2230)) \bullet B(\xi(2230) \to K_S^0 K_S^0) < 1.4\text{eV} \quad (95\%\text{C.L.}) \qquad \text{(L3)}$$

$$\Gamma_{\gamma\gamma}(\xi(2230)) \bullet B(\xi(2230) \to K_S^0 K_S^0) < 1.1\text{eV} \quad (95\%\text{C.L.}) \qquad \text{(CLEO)}$$

Status of $\xi(2230)$ at BES II



- So far, no clear signal of $\xi(2230)$ has been observed.
- All possible problems are still being checked.