Search for $f_0(1500)$ and $f_J(1710)$ in $\gamma\gamma$ Collisions

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- **Introduction**
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- **Conclusion**

Introduction

- **Glueball candidates:**

  0^{++}: $f_0(1500)$ and $f_J(1710)$

  2^{++}: $\xi(2230)$

- **Signatures of a pure glueball**

  — Flavor symmetric decay

  — Narrow width

  — Copious production in gluon rich reactions such as J/ψ radiative decay and $p\bar{p}$ annihilation

  — Suppressed coupling to $\gamma\gamma$

Introduction

- For 2^{++} glueball candidate $\xi(2230)$
  - Theoretical prediction:

    $\Gamma_{\gamma\gamma} \cdot B (\xi \rightarrow K\bar{K}) \sim 1eV$
    (if ξ is a 2^{++} glueball)

    (See E. H. Kada , Phys. Rev. D39 (1989) 2657)

  - Upper limit from CLEO :

    $\Gamma_{\gamma\gamma} \cdot B (\xi \rightarrow K\bar{K}) < 5.6$ eV @ 95%CL

- For 0^{++} glueball candidates
  - Many model-dependent predictions
  - ALEPH has performed a search of 0^{++} glueball candidates in :

    $\gamma\gamma \rightarrow f_0(1500), f_J(1710) \rightarrow \pi^+\pi^-$

Data and MC

Data: LEP I 160.9 pb^{-1} data
$\sim\sqrt{s} = 91$ GeV
from 1990 to 1995

MC:

- **Signals:** PHOTO 02

$$\gamma\gamma \rightarrow f_0(1500),\ f_J(1710) \rightarrow \pi^+\pi^-$$

- **Backgrounds:**

— PHOTO 02:

$$\gamma\gamma \rightarrow e^+e^-,\ \mu^+\mu^-,\ \tau^+\tau^-$$

— KORALZ

$$e^+e^- \rightarrow Z \rightarrow \tau^+\tau^-$$

\+ JETSET and TAUOLA
for hadronisation and correct handing of the τ polarisation

Event Selection

- **Photon collisions, suppress three or more body decay**
  - — 2 good tracks
  - — primary vertex
  - — $E_{tot} < 30$ GeV, $M_{vis} < 10$ GeV
  - — $P_T \leq 0.1$ GeV
  - — $|\cos\theta^*_{1,2}| \leq 0.9$

- **Rejecting $\mu^+\mu^-$ final state**

  Using combined information from Muon Chamber ECAL and HCAL

$M_{\pi^+\pi^-} > 3$GeV ~100% $\mu^+\mu^-$ rejection

≥ 1GeV ~ 45% $\mu^+\mu^-$ rejection

≈ 1GeV ~ 20% $\mu^+\mu^-$ rejection

Event Selection (Continued)

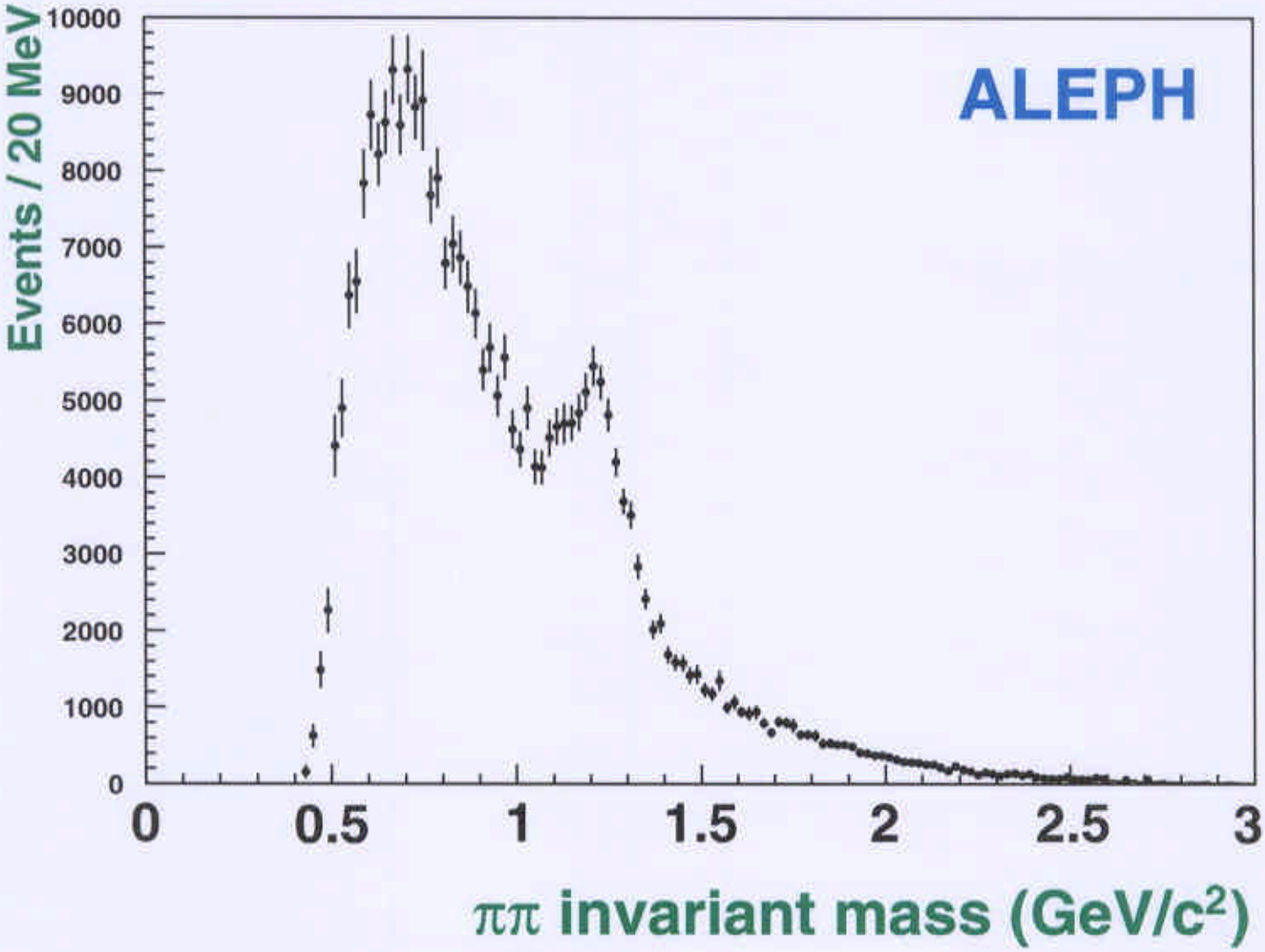
- Rejecting e^+e^-, K^+K^- by using dE/dx

  $f_2'(1525) \rightarrow K^+K^-$

  residual contamination ~0.05%

- Backgrounds from beam gas, $\gamma\gamma \rightarrow \tau^+\tau^-$, and $Z \rightarrow \tau^+\tau^-$ are negligible

Mass Spectrum of $\pi^+\pi^-$



294141 $\pi^+\pi^-$ candidates selected

No structure seen above 1.5 GeV/c^2

Fitting the Mass Spectrum

Breit-Wigner functions for resonances + polynomial background

- **Fixed masses and widths for $f_0(1500)$ and $f_J(1710)$**

  $f_0(1500)$: M=1500 MeV Γ=112 MeV

  $f_J(1710)$: M=1712 MeV Γ=133 MeV

- **Assume J=0 for $f_J(1710)$; No attempt to resolve two objects for $f_J(1710)$**

- **No interference**

- **Four cases have been studied**

  (i) $f_2(1270)$ only

  (ii) $f_2(1270) + f_0(1500)$

  (iii) $f_2(1270) + f_J(1710)$

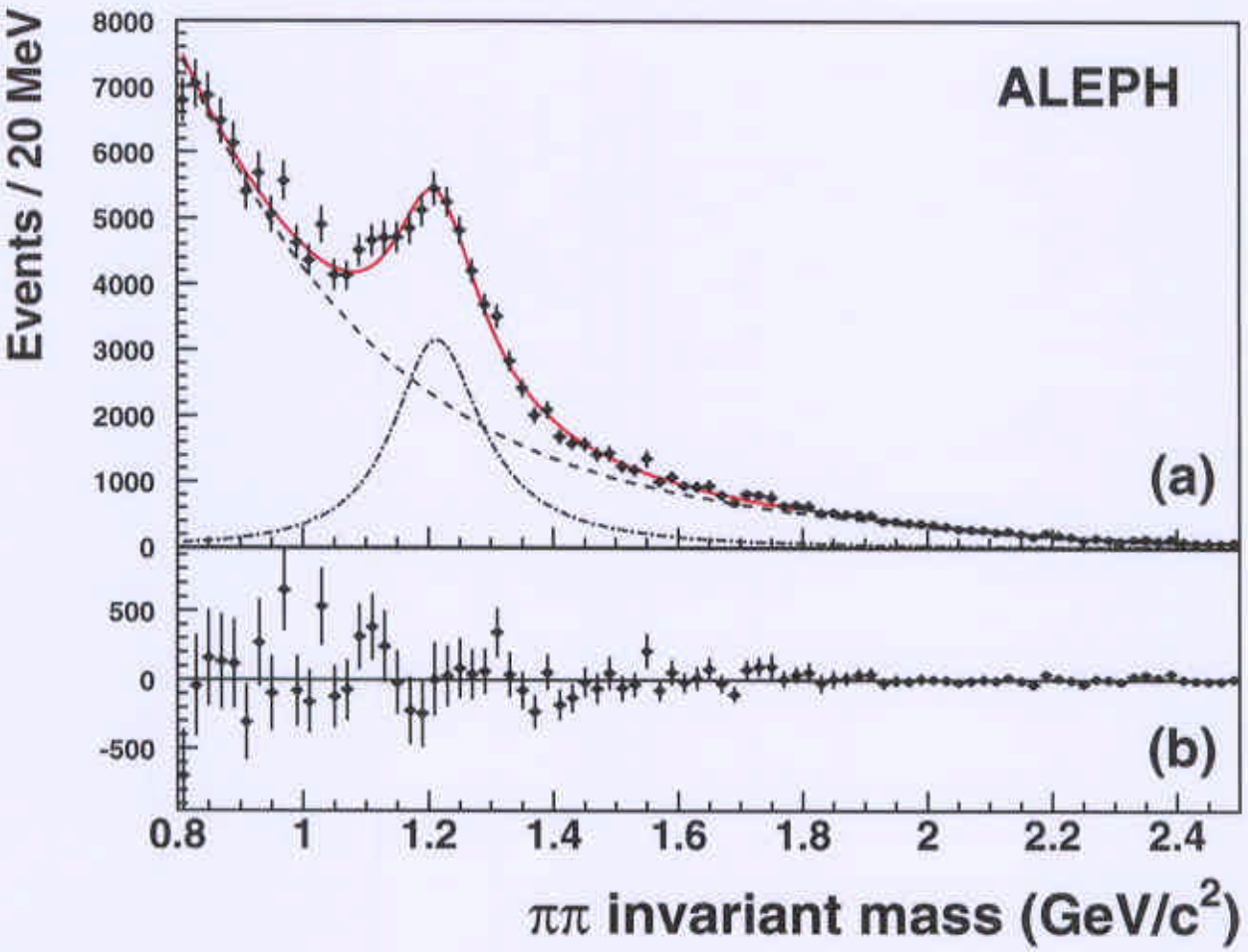
  (iv) $f_2(1270) + f_0(1500) + f_J(1710)$

Fitted Result

	(i) Fit for $f_2(1270)$ only
χ^2	74.96
Degrees of freedom	76
Fitted mass of $f_2(1270)$ (MeV/c^2)	1213.5 ± 3.7
Fitted width of $f_2(1270)$ (MeV/c^2)	178.3 ± 12.8
	(ii) Fit for $f_2(1270)+f_0(1500)$
χ^2	73.33
Degrees of freedom	75
Fitted mass of $f_2(1270)$ (MeV/c^2)	1214.1 ± 3.8
Fitted width of $f_2(1270)$ (MeV/c^2)	173.9 ± 13.8
No. of $f_0(1500)$ signal events	-808.3 ± 602.6
	(iii) Fit for $f_2(1270)+f_J(1710)$
χ^2	74.02
Degrees of freedom	75
Fitted mass of $f_2(1270)$ (MeV/c^2)	1213.9 ± 3.9
Fitted width of $f_2(1270)$ (MeV/c^2)	180.2 ± 15.9
No. of $f_J(1710)$ signal events	468.3 ± 476.6
	(iv) Fit for $f_2(1270)+f_0(1500)+fJ(1710)$
χ^2	73.21
Degrees of freedom	74
Fitted mass of $f_2(1270)$ (MeV/c^2)	1214.2 ± 3.8
Fitted width of $f_2(1270)$ (MeV/c^2)	175.5 ± 14.2
No. of $f_J(1510)$ signal events	-671.0 ± 690.0
No. of $f_J(1710)$ signal events	198.6 ± 541.9

Numbers of $f_0(1500)$, $f_J(1710)$ events are consistent with zero

Problem for $f_2(1270)$ Mass ?



Γ ~ 180 MeV OK

M ~ 1214 MeV ?

World Average: 1275.0 ± 1.2 MeV

* **Interference of the resonant amplitude with other components in the backgrounds**
* **Also observed by MARK II and CELLO collaborations**

Upper Limits on $\Gamma_{\gamma\gamma}$ BR($\pi^+\pi^-$)

95% C.L. Upper Limits are obtained from fitted numbers of signal events and their errors by using Bayesian Approach

(a) From individual fits

$\Gamma_{\gamma\gamma}$ BR($\pi^+\pi^-$) < 0.25 keV for $f_0(1500)$

$\Gamma_{\gamma\gamma}$ BR($\pi^+\pi^-$) < 0.59 keV for $f_J(1710)$

(b) From combined fit:

$\Gamma_{\gamma\gamma}$ BR($\pi^+\pi^-$) < 0.31 keV for $f_0(1500)$

$\Gamma_{\gamma\gamma}$ BR($\pi^+\pi^-$) < 0.55 keV for $f_J(1710)$

* **Results from alternative fits such as including possible 1.1 GeV structure and other expressing of Breit-Wigner fit are consistent with the above limits**

Stickiness

$$S_X(0^{++}) = N \frac{m_x}{k_{J/\psi \to \gamma x}} \frac{\Gamma(J/\psi \to \gamma X)}{\Gamma(X \to \gamma\gamma)}$$

Where $k_{J/\psi \to \gamma x} = (m_{J/\psi} - m_X) / 2m_{J/\psi}$

and N is the normalisation factor
(Stickiness of $f_2(1270)$ is nomalised to 1)

Using BR($f_0(1500) \to \pi^+\pi^-$) = 0.30 ± 0.07

BR($f_J(1710) \to \pi^+\pi^-$) = $0.026^{+0.001}_{-0.016}$

=> $S_{f_0(1500)} > 1.4$

$S_{f_J(1710)} > 0.3$ @95%C.L.

Conclusion

- Neither $f_0(1500)$ nor $f_J(1710)$ is observed in $\gamma\gamma$ collisions

- Upper Limits at 95% C.L. :

$$\Gamma_{\gamma\gamma}\, BR(\pi^+\pi^-) < 0.31 \text{ keV} \quad \text{for } f_0(1500)$$

$$\Gamma_{\gamma\gamma}\, BR(\pi^+\pi^-) < 0.55 \text{ keV} \quad \text{for } f_J(1710)$$

from a simultaneous fit for both resonances