Recent BES Results on Spectroscopy

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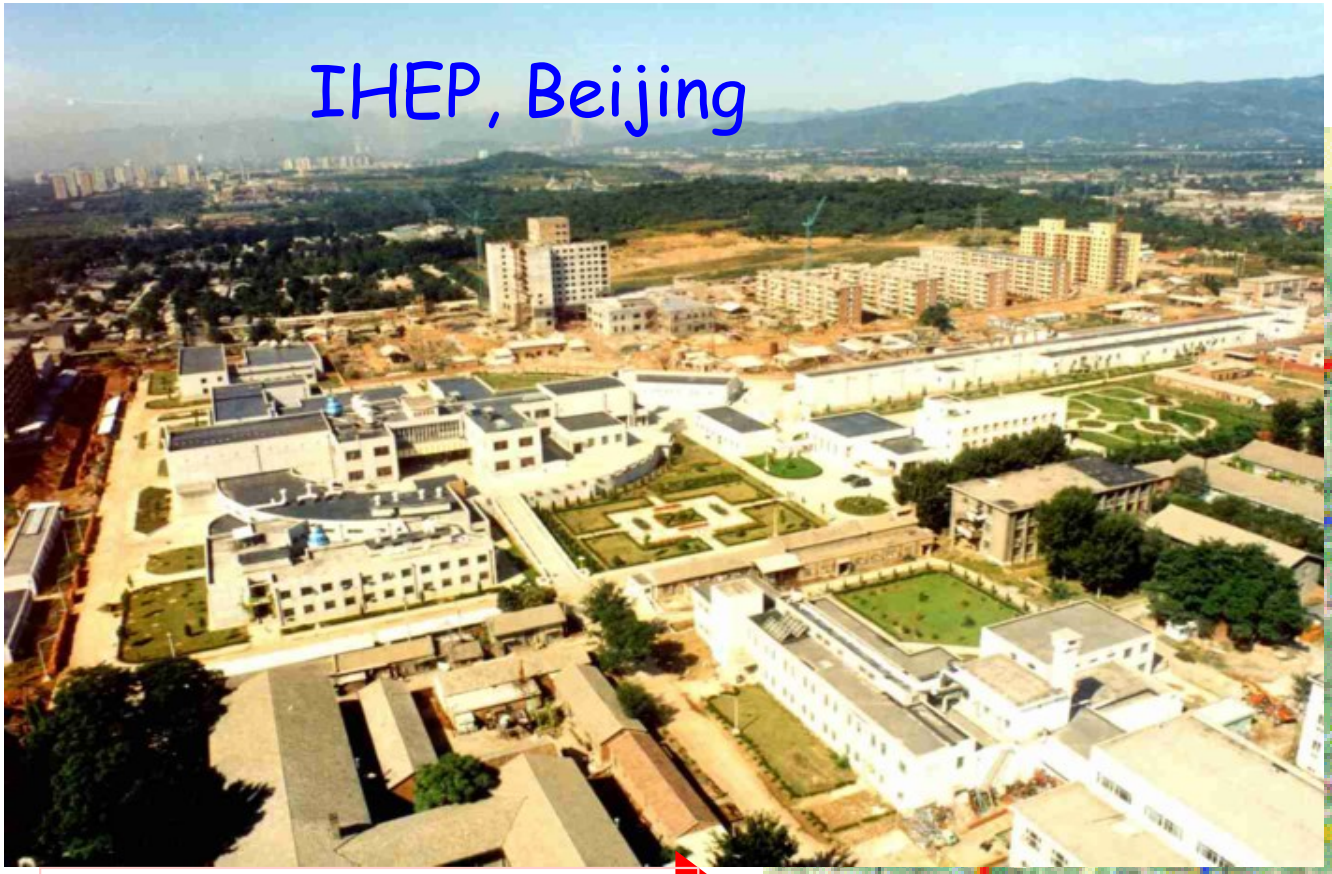
(For the BES Collaboration)
IHEP, Beijing

From Phi to Psi
LNF, 7 - 10 April 2008

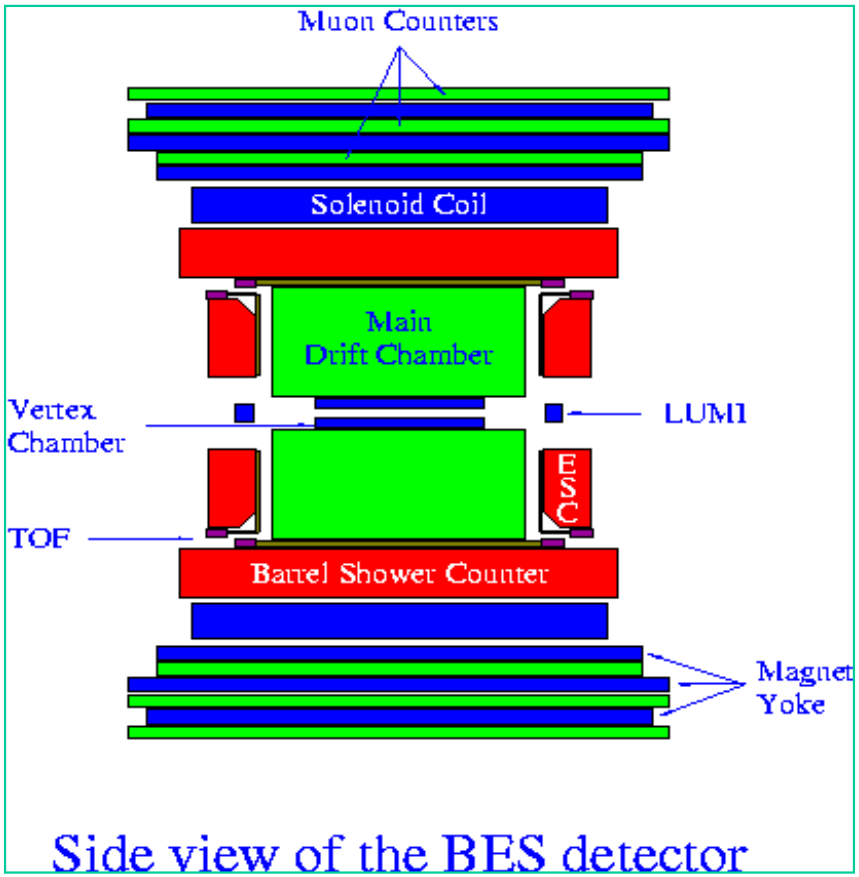
BEPC at IHEP, Beijing



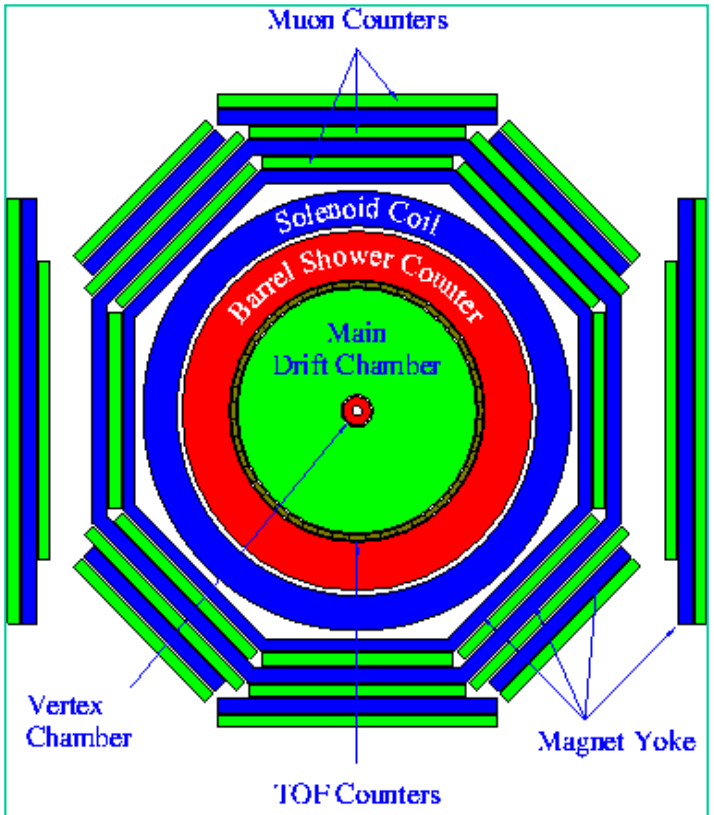
airport

1989-2005
Ecm=2-5 GeV
$L_{peak}=10\times10^{30}/cm^2s$
@ ψ′ energy

BESII @ BEPC



Side view of the BES detector



End view of the BES detector

VC: σ_{xy} = 100 μm TOF: σ_T = 180 ps μ counter: $\sigma_{r\phi}$ = 3 cm

MDC: σ_{xy} = 220 μm BSC: $\Delta E/\sqrt{E}$ = 22 % σ_z = 5.5 cm

$\sigma_{dE/dx}$ = 8.5 % σ_ϕ = 7.9 mr B field: 0.4 T

$\Delta p/p = 1.7\%\sqrt{(1+p^2)}$ σ_z = 3.1 cm

BESII data samples in this talk

Data	BESII	CLEOc
J/ψ	58 M	--
ψ'	14 M	25 M

I will talk about -

- Y(2175)
- $\eta(2225) \rightarrow \phi\phi$
- $X(1440) \rightarrow KK\pi$
- ψ' radiative decays

BESIII (See Jia-Wen Zhang's talk)

The Y(2175)

Babar measured $e^+e^- \rightarrow \phi\pi^+\pi^-$ and $\phi f_0(980)$ observed the Y(2175)→ $\phi f_0(980)$.

L=232 fb^{-1}

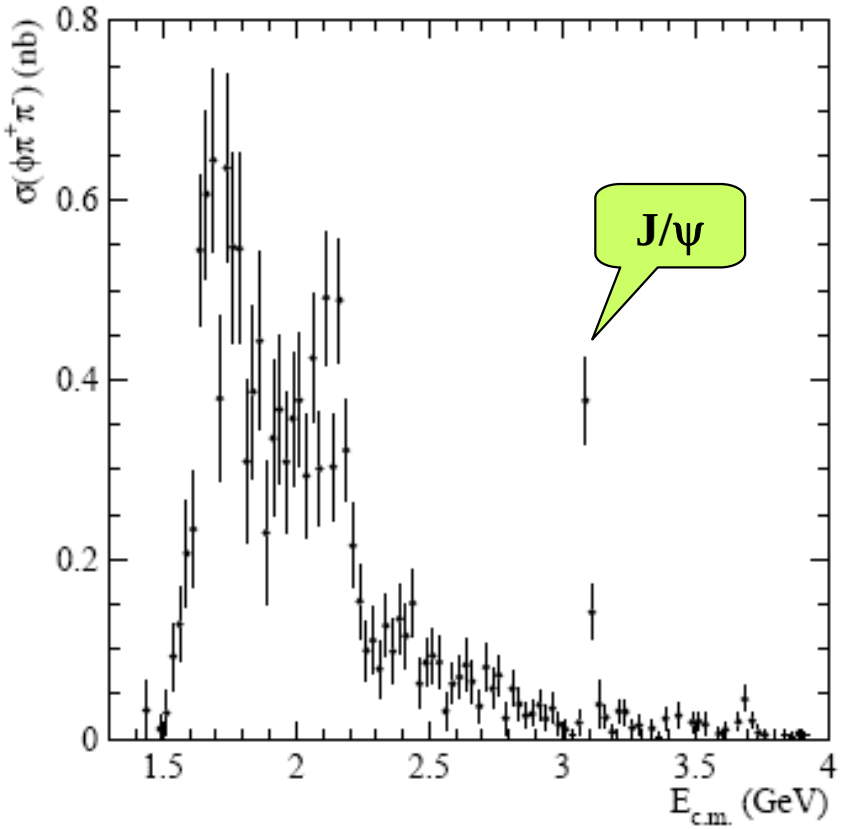


FIG. 11: The $e^+e^- \rightarrow \phi\pi^+\pi^-$ cross section as a function of the effective e^+e^- c.m. energy.

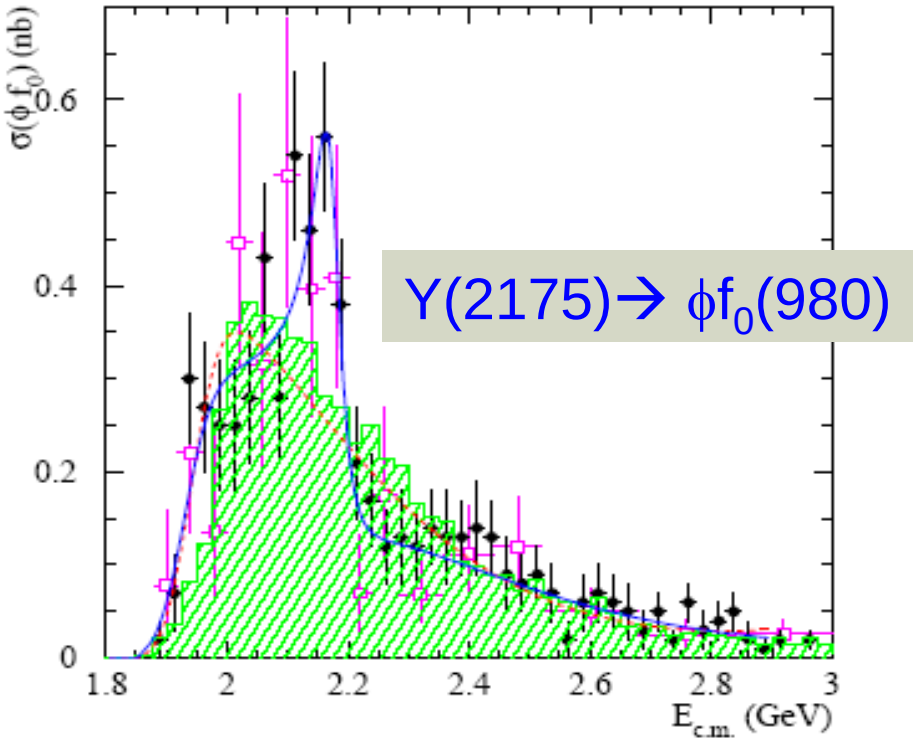


FIG. 27: The $e^+e^- \rightarrow \phi(1020)f_0(980)$ cross section measured in the $K^+K^-\pi^+\pi^-$ (circles) and $K^+K^-\pi^0\pi^0$ (squares) final states. The hatched histogram shows the simulated cross section, assuming no resonant structure. The solid (dashed) line represents the result of the one-resonance (no-resonance) fit described in the text.

M = 2175 ± 10 MeV

Γ = 58 ± 16 MeV

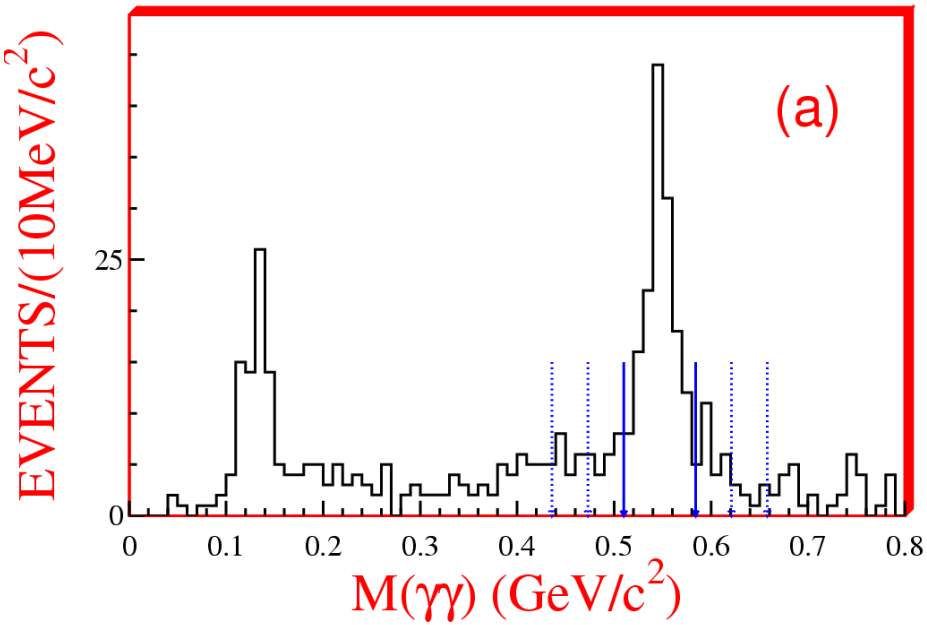
Phys. Rev. D 76, 012008 (2007)

Y(2175) in J/ψ → ηφf_0(980)

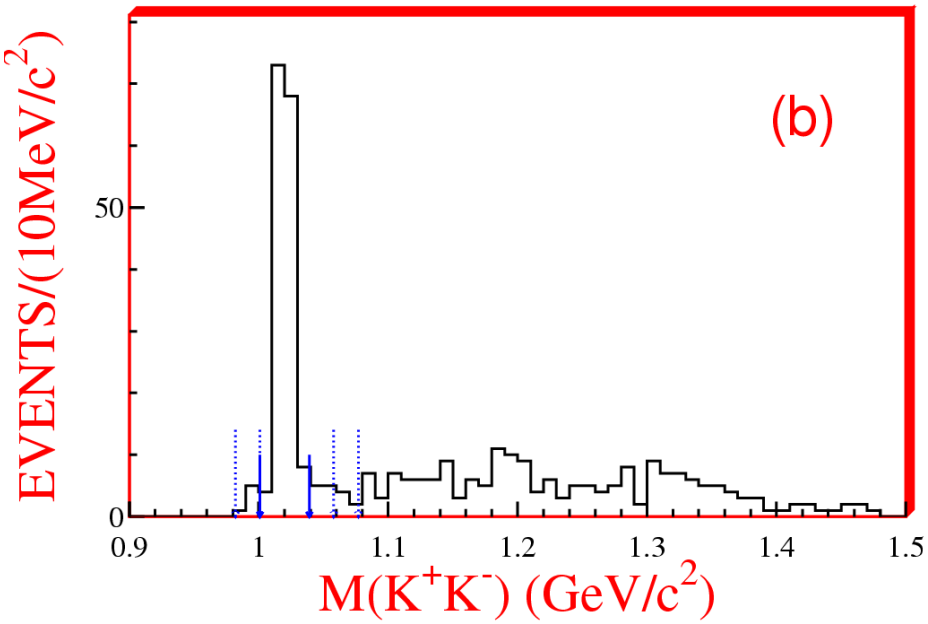
- Final states:

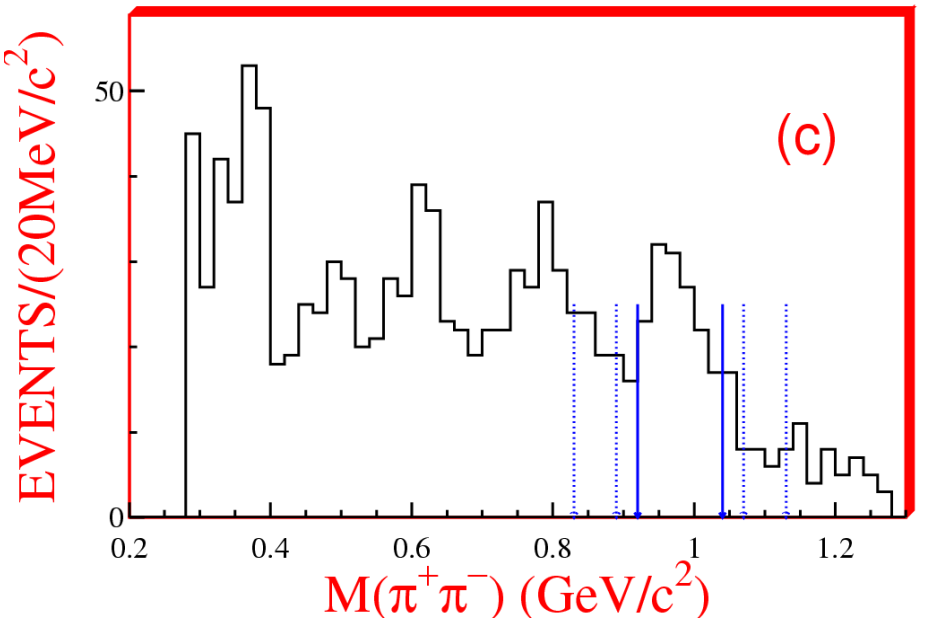
  η→γγ, φ→K^+K^-, f_0(980)→$\pi^+\pi^-$

58 M J/ψ decays



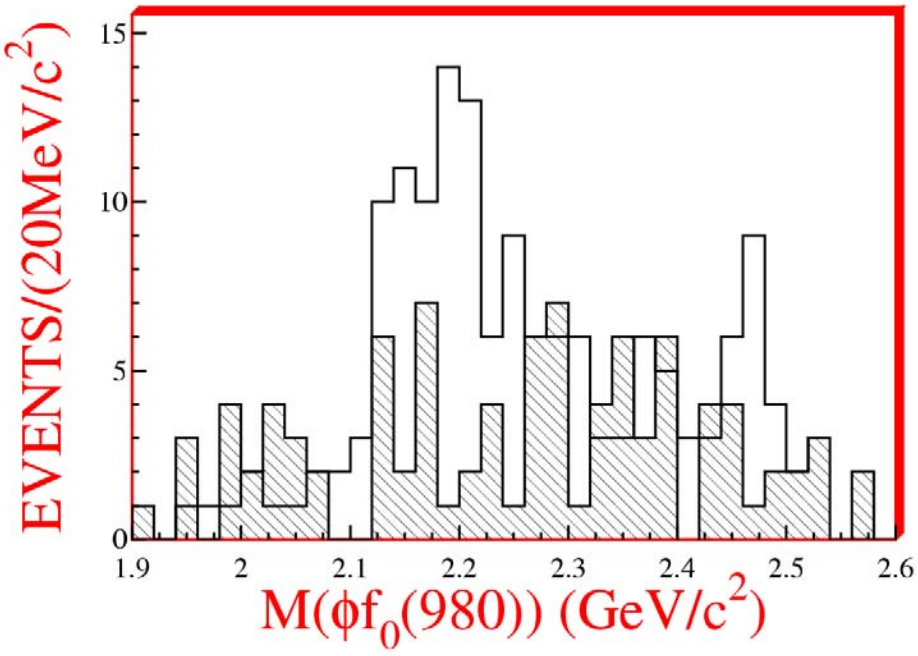
Define η, φ, f_0(980) signal regions and sideband regions.

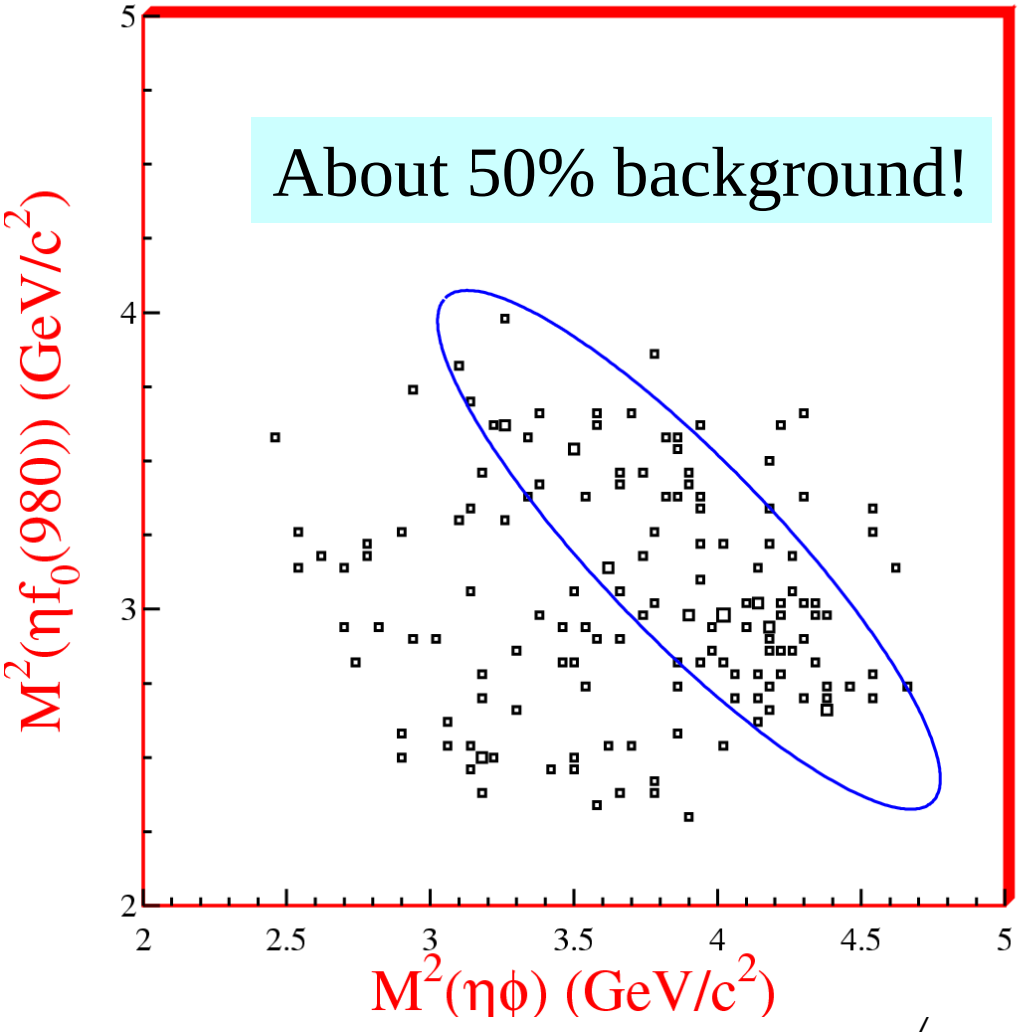




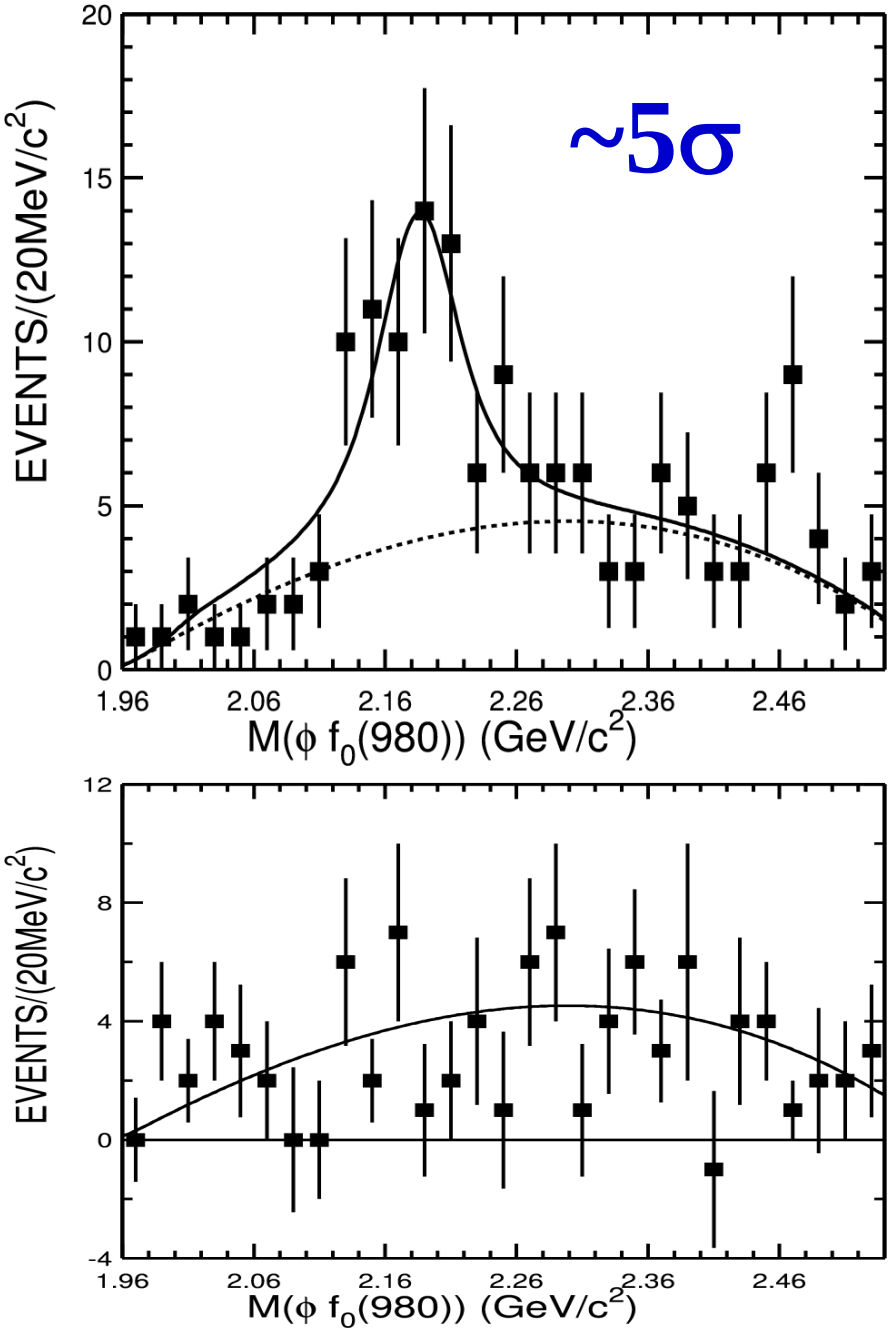
Y(2175) in J/ψ →ηϕf_0(980)

Clear enhancement at around 2.2 GeV in ϕf_0(980) invariant mass, band shows in Dalitz plot.





Y(2175) in $J/\psi \rightarrow \eta\phi f_0(980)$



Simultaneous fit to signal and sideband events with BW+p3

$M = 2186 \pm 10 \pm 6$ MeV

$\Gamma = 65 \pm 23 \pm 17$ MeV

$B(J/\psi \rightarrow \eta Y \rightarrow \eta\phi f_0(980) \rightarrow \eta\phi\pi\pi)$

$= (3.23 \pm 0.75 \pm 0.73) \times 10^{-4}$

Nature of the Y?

Very likely it is an excited ϕ state,

$Y \rightarrow \phi f_0(980)$ is an OZI allowed decay.

arXiv: 0712.1143; PRL100, 102003 (2008)

η(2225) in J/ψ → γϕϕ

W.-M. Yao *et al.* (Particle Data Group), J. Phys. G 33, 1 (2006) and 2007 partial update for edition 2008 (URL: http://pdg.lbl.gov)

η(2225)

$I^G(J^{PC}) = 0^+(0^{-+})$

OMITTED FROM SUMMARY TABLE

Seen in $J/\psi \to \gamma\phi\phi$. Needs confirmation.

η(2225) MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
2220±18 OUR AVERAGE				
2230±25±15	BAI	90B	MRK3	$J/\psi \to \gamma K^+K^-K^+K^-$
2214±20±13	BAI	90B	MRK3	$J/\psi \to \gamma K^+K^-K^0_S K^0_L$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
~ 2220	BISELLO	86B	DM2	$J/\psi \to \gamma K^+K^-K^+K^-$

η(2225) WIDTH

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
$150^{+300}_{-60}\pm60$	BAI	90B	MRK3	$J/\psi \to \gamma K^+K^-K^+K^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
~ 80	BISELLO	86B	DM2	$J/\psi \to \gamma K^+K^-K^+K^-$

η(2225) REFERENCES

BAI	90B	PRL 65 1309	Z. Bai *et al.*	(Mark III Collab.)
BISELLO	86B	PL B179 294	D. Bisello *et al.*	(DM2 Collab.)

MarkIII, PRL65 (1990)

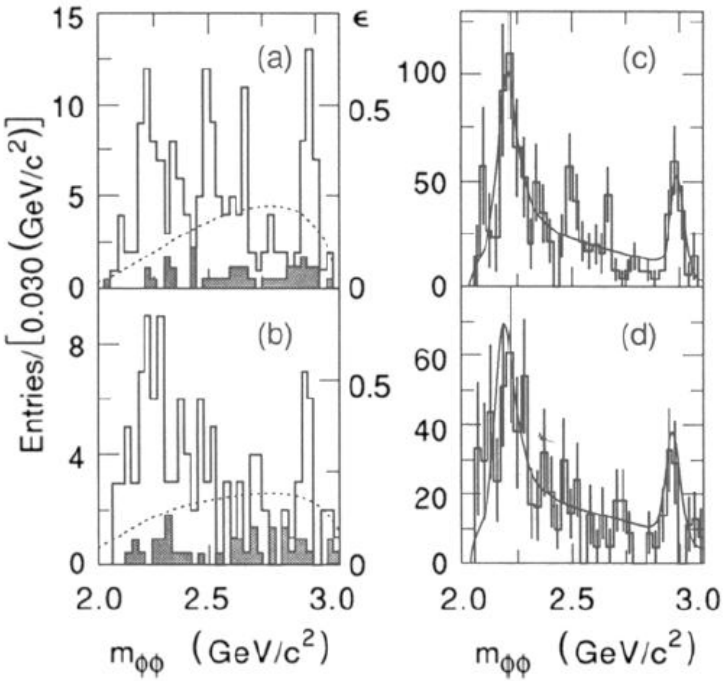
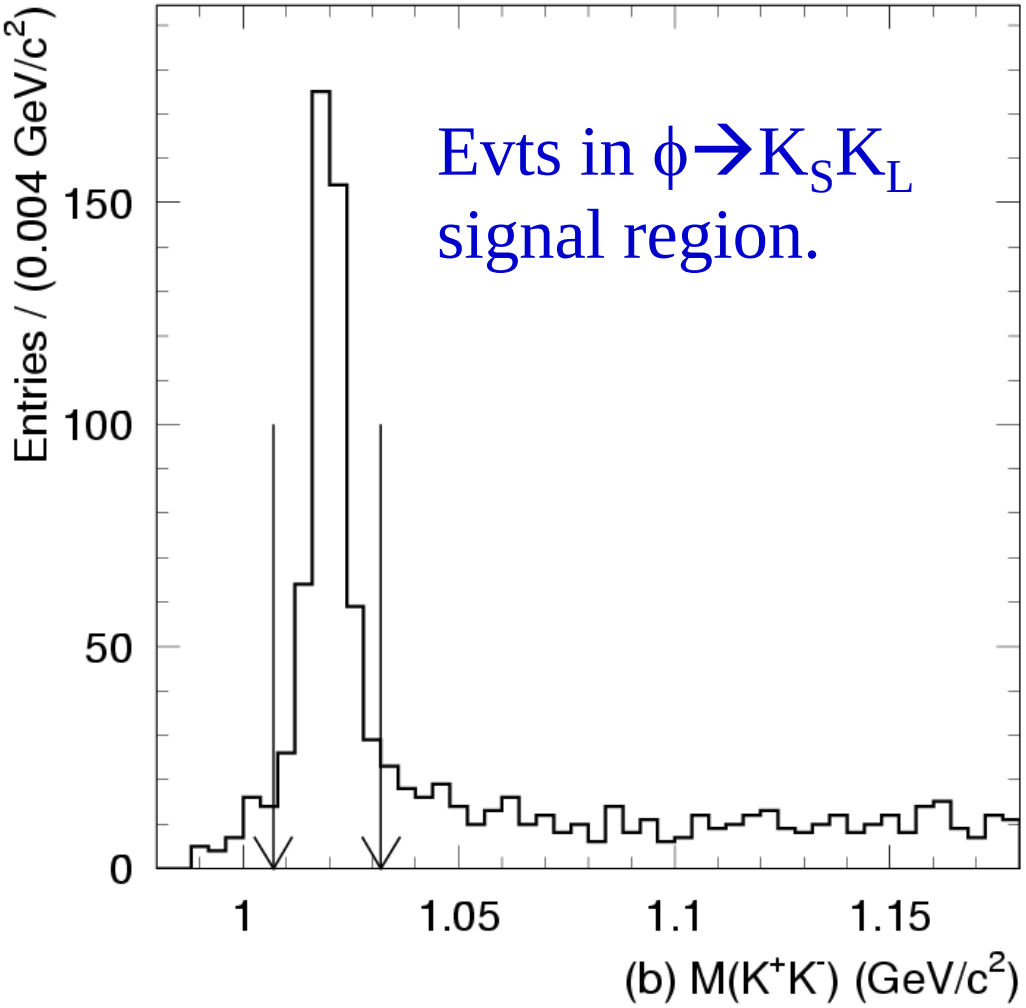


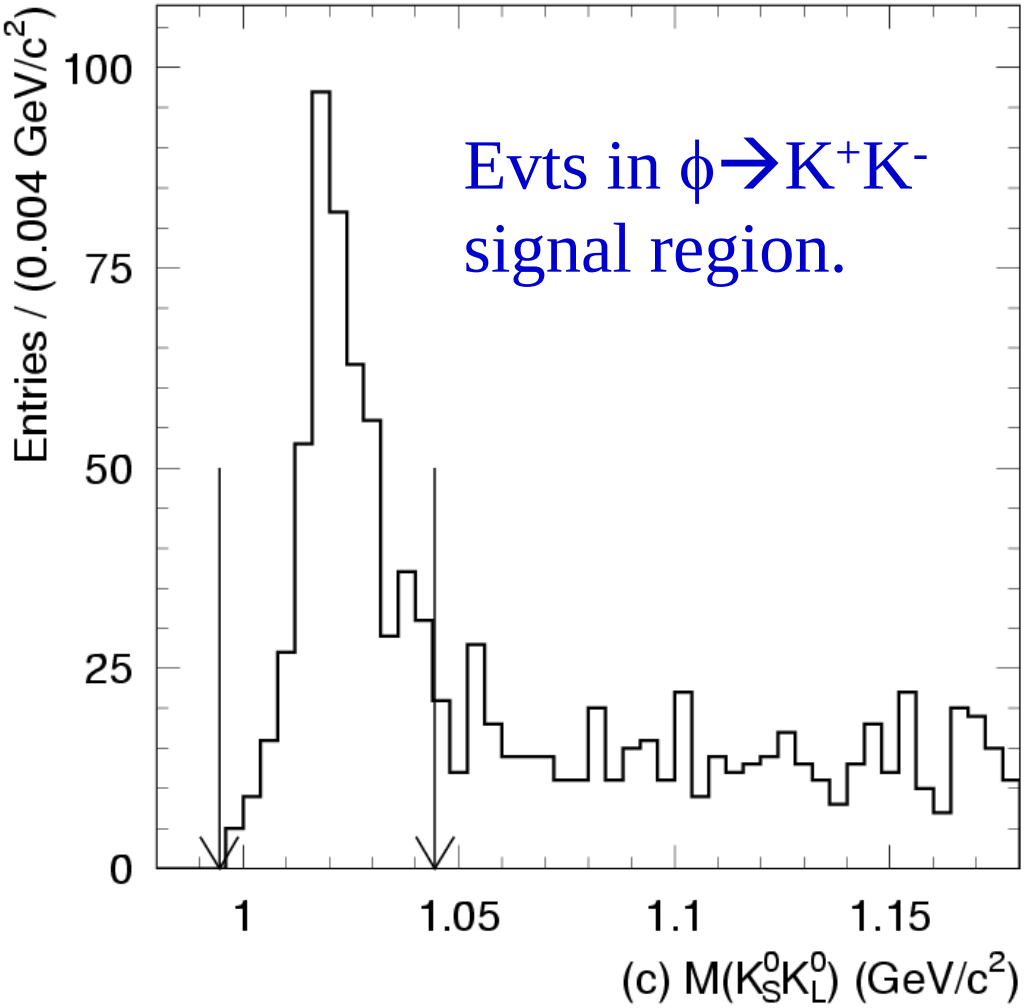
FIG. 2. The observed $\phi\phi$ invariant-mass spectra from (a) $J/\psi \to \gamma K^+K^-K^+K^-$ and (b) $J/\psi \to \gamma K^+K^-K^0_S K^0_L$; (c),(d) the corresponding $\phi\phi$ invariant-mass spectra after efficiency correction. Shaded histograms show background estimates; dashed curves show detection efficiencies denoted by ϵ; solid curves show fits described in the text.

$\eta(2225)$ in $J/\psi \rightarrow \gamma\phi\phi$

Final states:

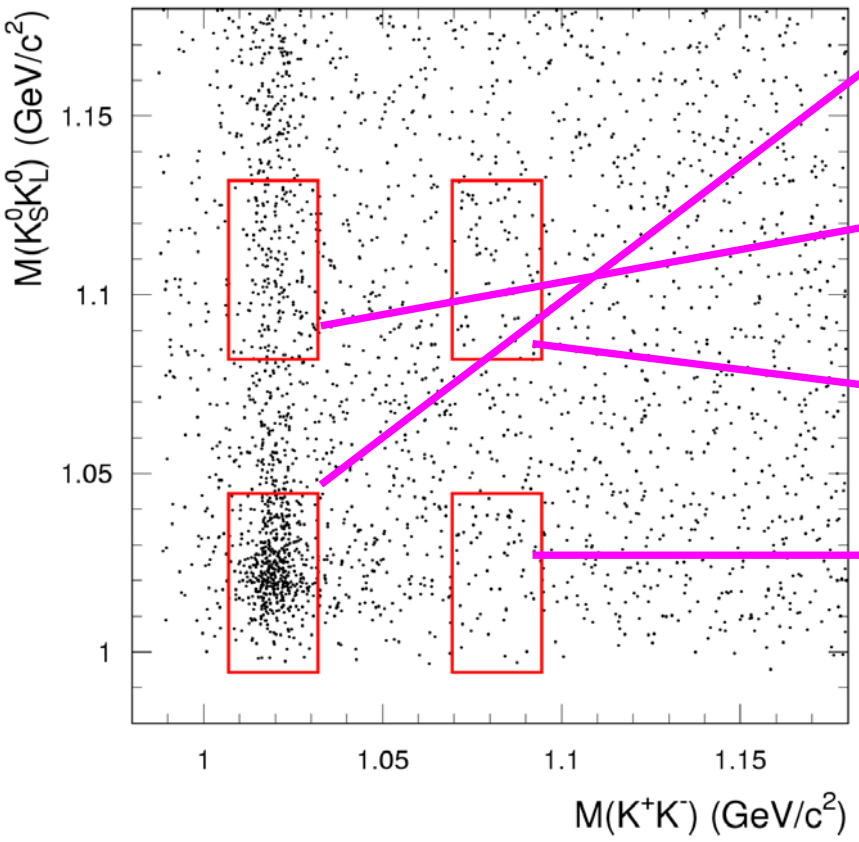
$\phi_1 \rightarrow K^+K^-$, $\phi_2 \rightarrow K_SK_L$ ($K_S \rightarrow \pi^+\pi^-$, K_L is missing) 2C-fit is applied.

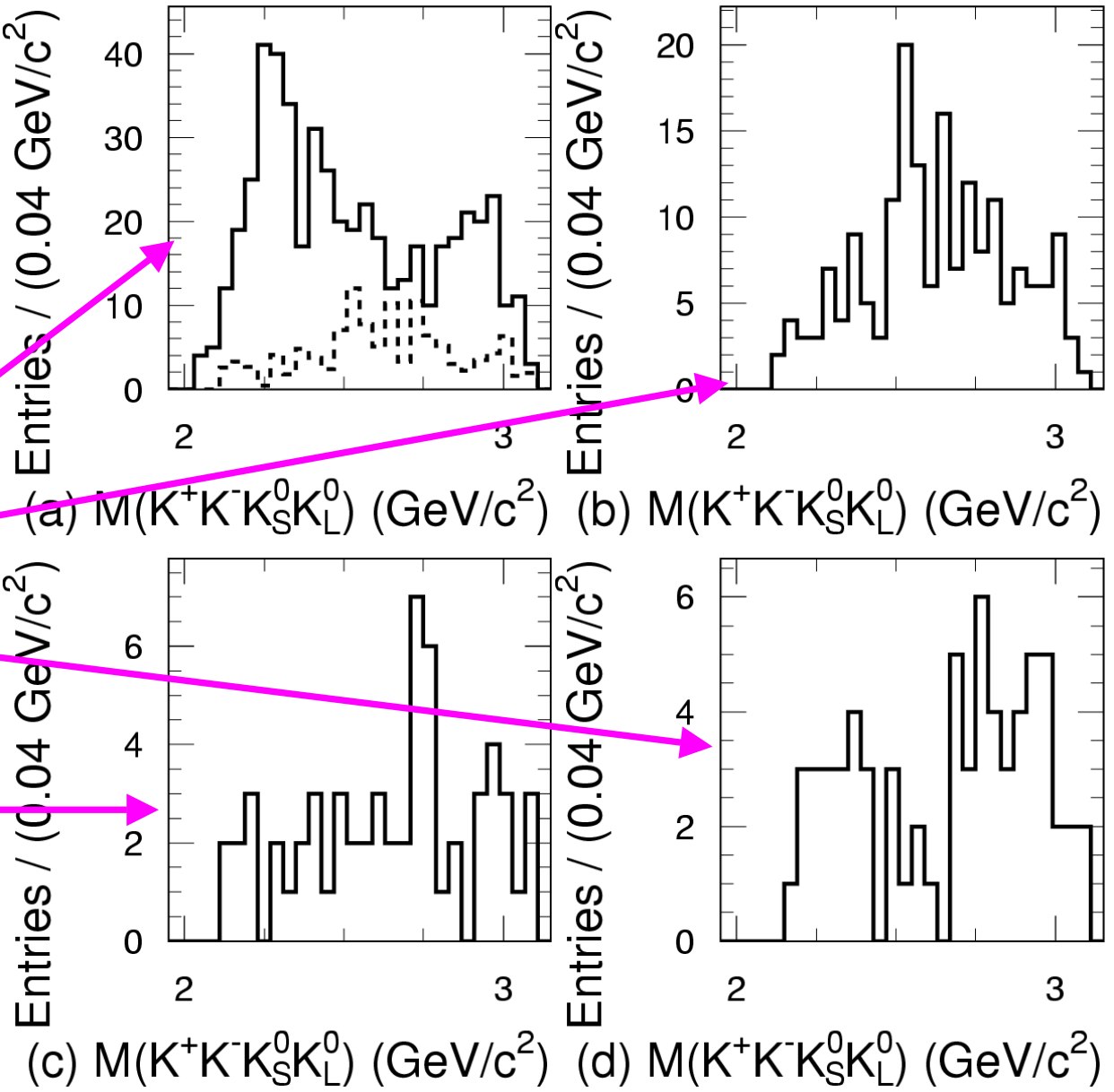




η(2225) in J/ψ → γϕϕ

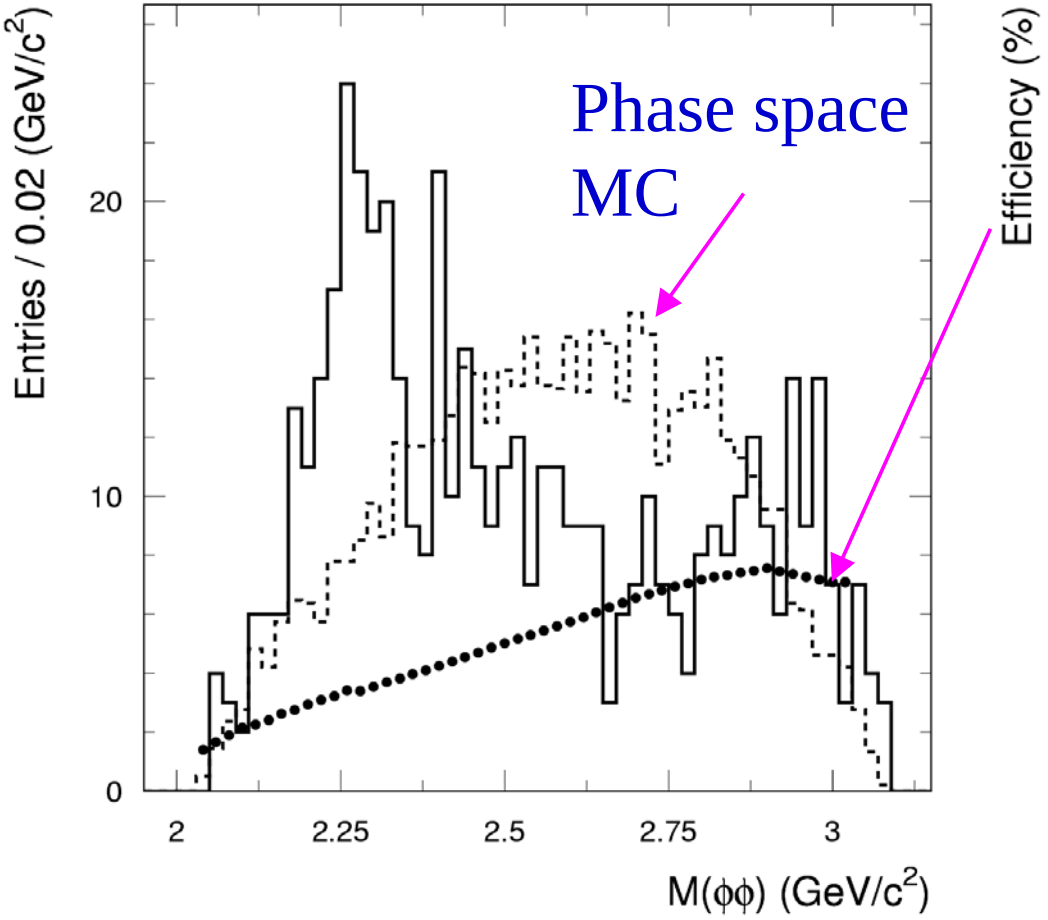
Signal and background in data sample.

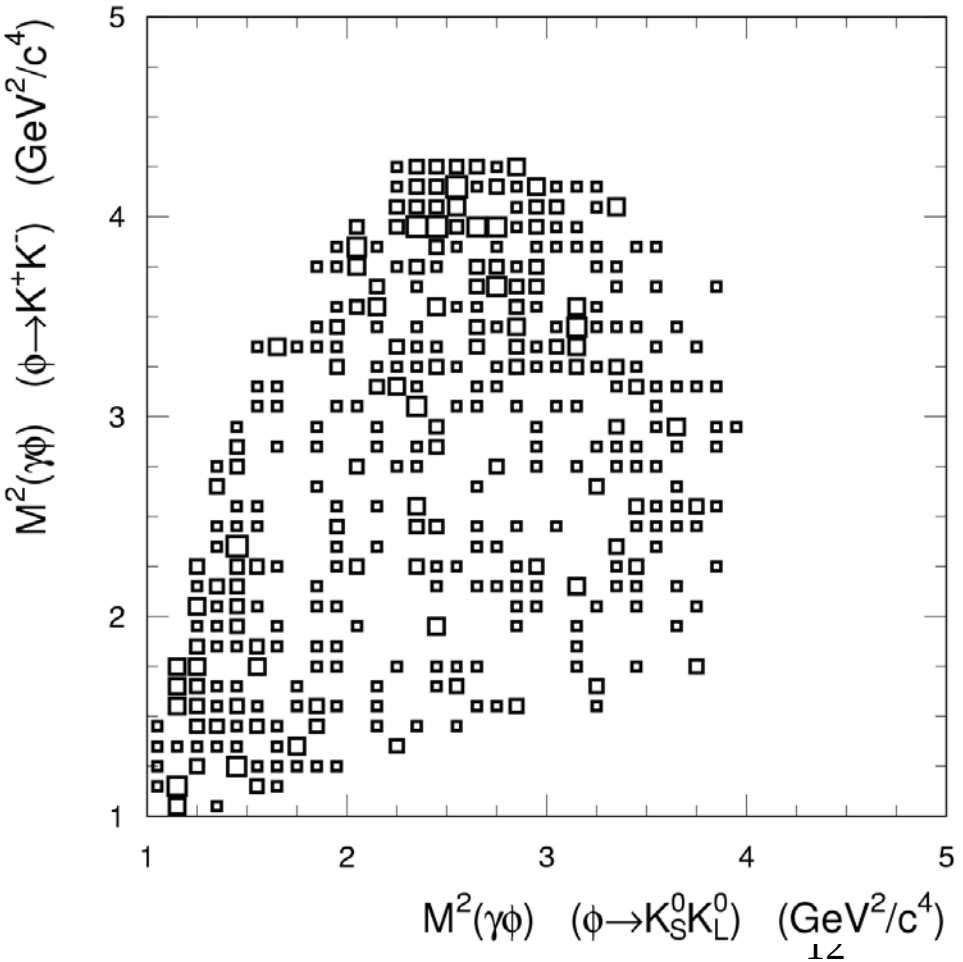




η(2225) in J/ψ → γϕϕ

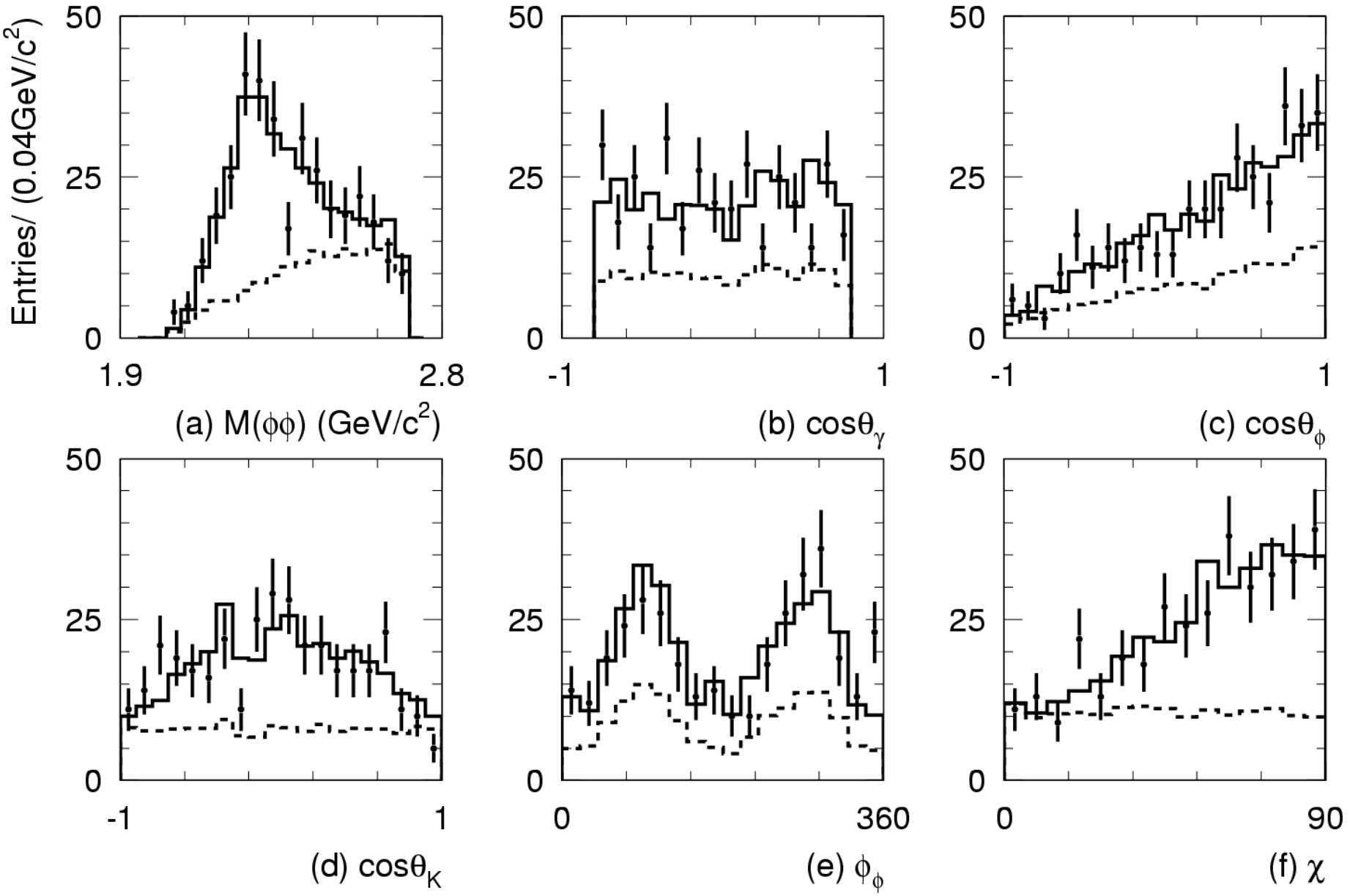
Signal is very different from phase space distribution, enhancement close to threshold.





η(2225) in J/ψ → γϕϕ

Fit with a pseudoscalar state is better than scalar or tensor.



$\eta(2225)$ in $J/\psi \rightarrow \gamma\phi\phi$

Resonance parameters of a pseudoscalar:

$$m = 2.24^{+0.03+0.03}_{-0.02-0.02}\ \text{GeV}$$

$$\Gamma = 0.19 \pm 0.03^{+0.06}_{-0.04}\ \text{GeV}$$

$$B(J/\psi \rightarrow \gamma\eta(2225))B(\eta(2225) \rightarrow \gamma\phi\phi)$$

$$= (4.4 \pm 0.4 \pm 0.8) \times 10^{-4}$$

In good agreement with Mark-III measurement.

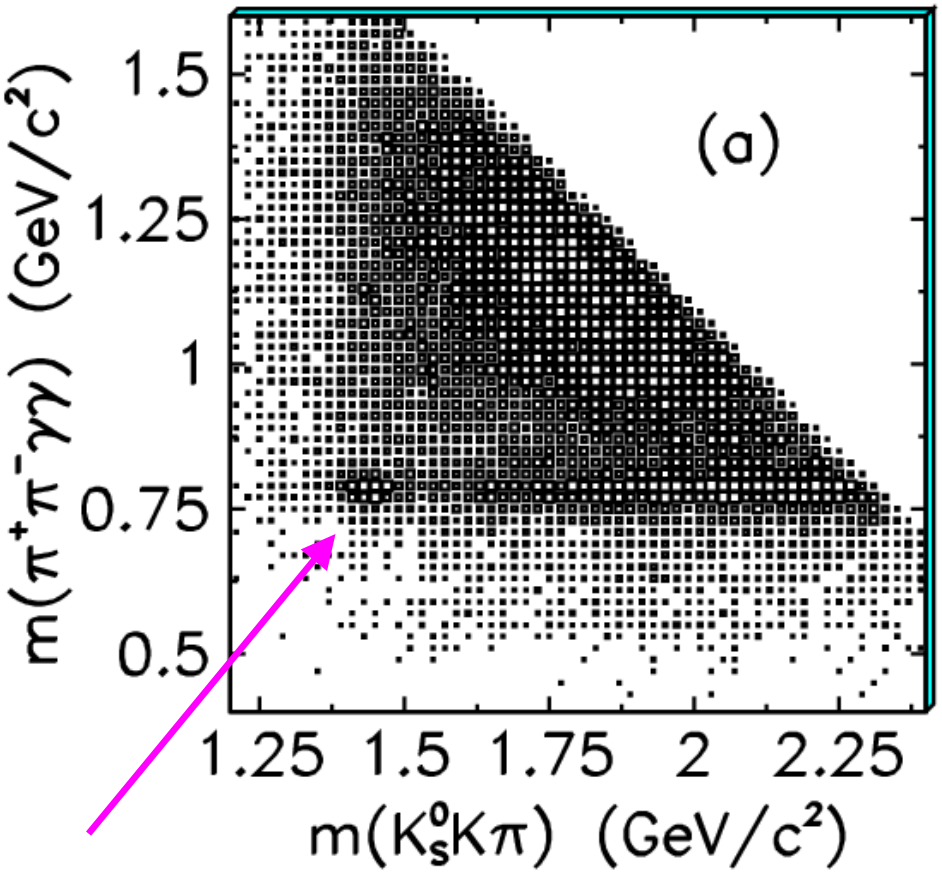
arXiv: 0801.3885; PLB (in press)

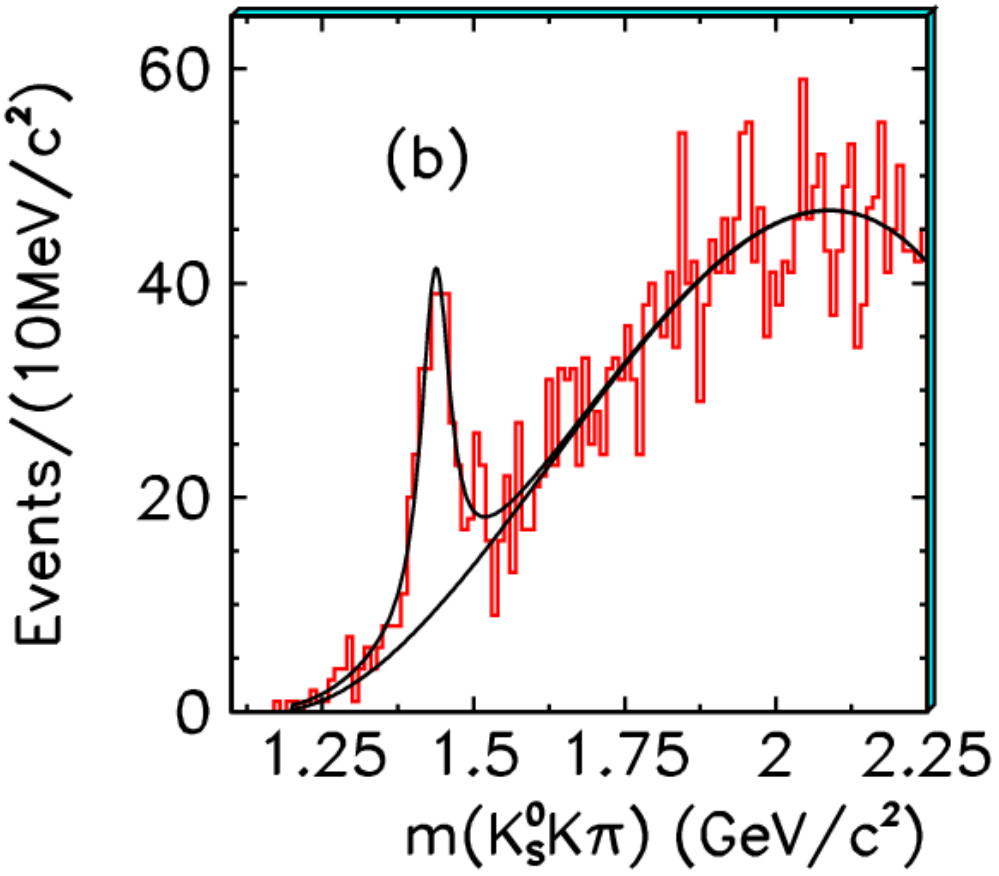
E/ι(1440), η(1405), η(1475)

- One structure near 1.44 GeV, may due to two states, one couples to a(980)π and KKπ, the other couples to K^*K.
- Mass and width are not well measured.
- Radial excited η or η' state? Pseudoscalar glueball?
- BES measurements:
  - J/ψ→γX(1440)→ γ KKπ, γ ηππ
  - J/ψ→ ω/ϕ X(1440)→ ω/ϕ KKπ (this talk)
  - J/ψ→ ω/ϕ X(1440)→ ω/ϕ ηππ

X(1440) in J/ψ → ω+KKπ

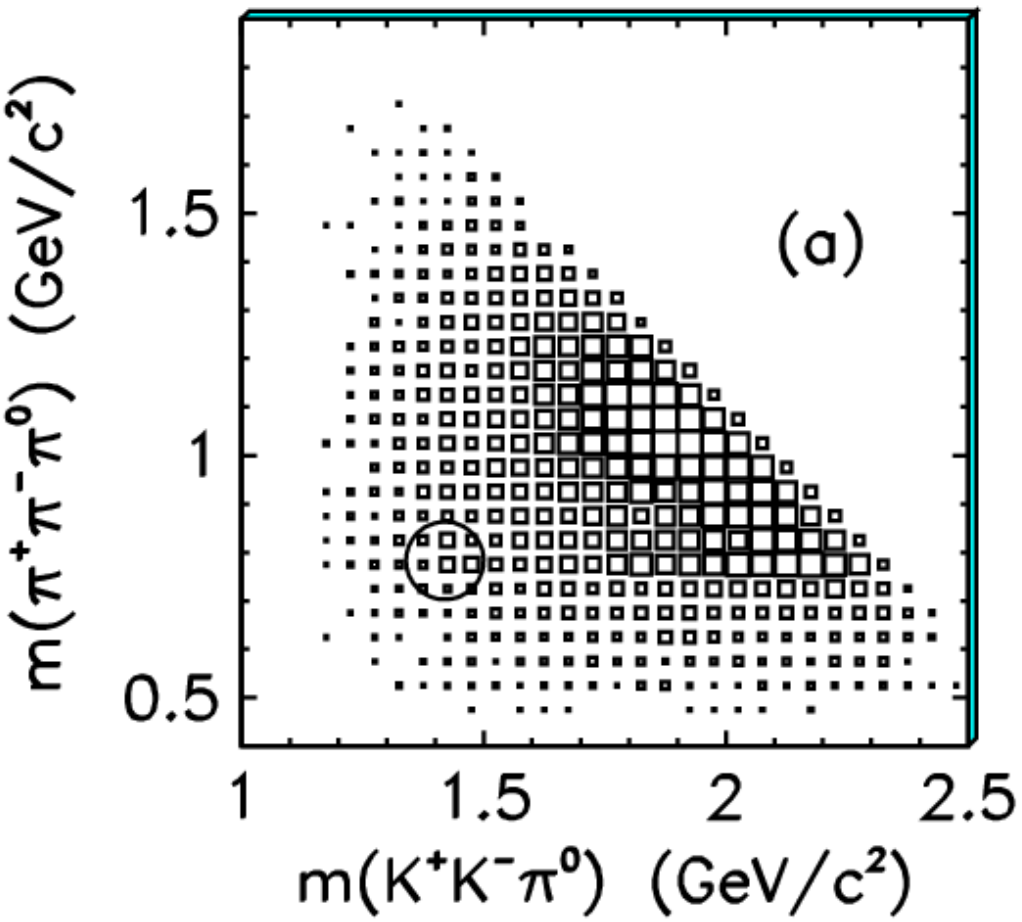
- Final states: $\omega \rightarrow \pi^+\pi^-\pi^0$, $KK\pi = K_S K\pi$

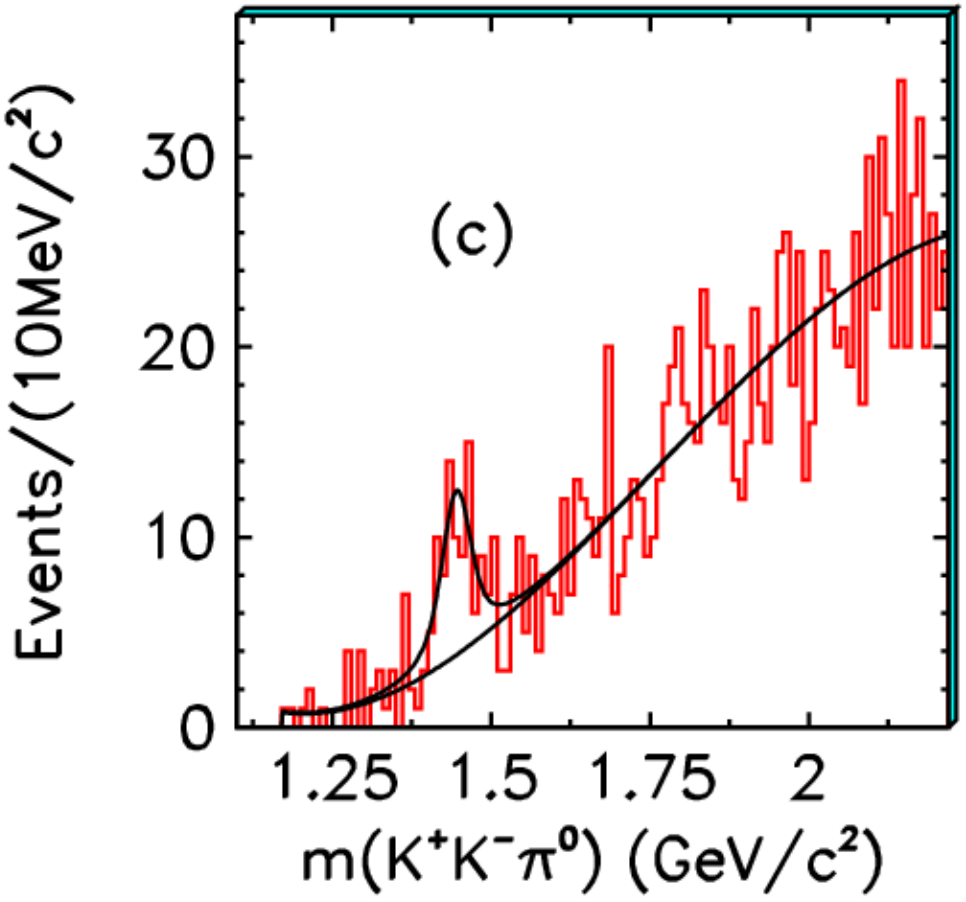




X(1440) in J/ψ → ω+KKπ

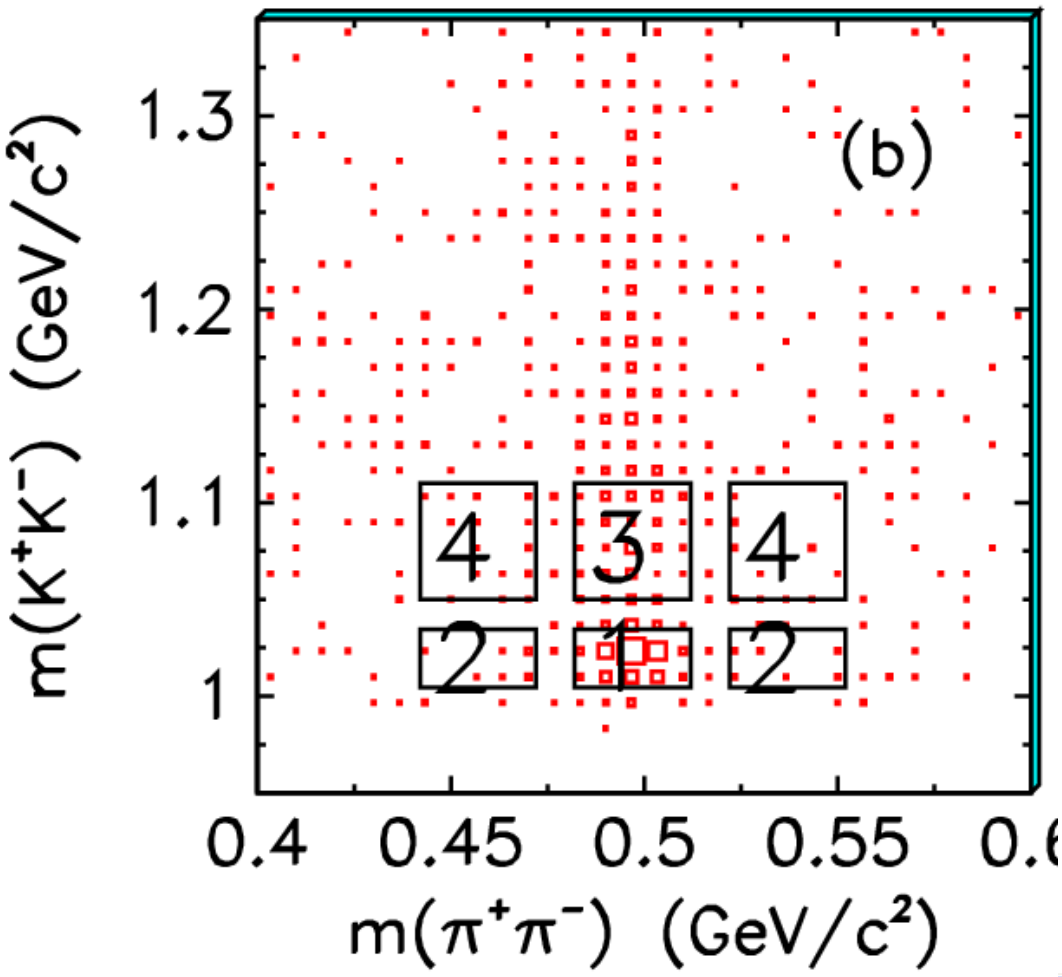
- Final states: $\omega \rightarrow \pi^+\pi^-\pi^0$, $KK\pi = K^+K^-\pi^0$

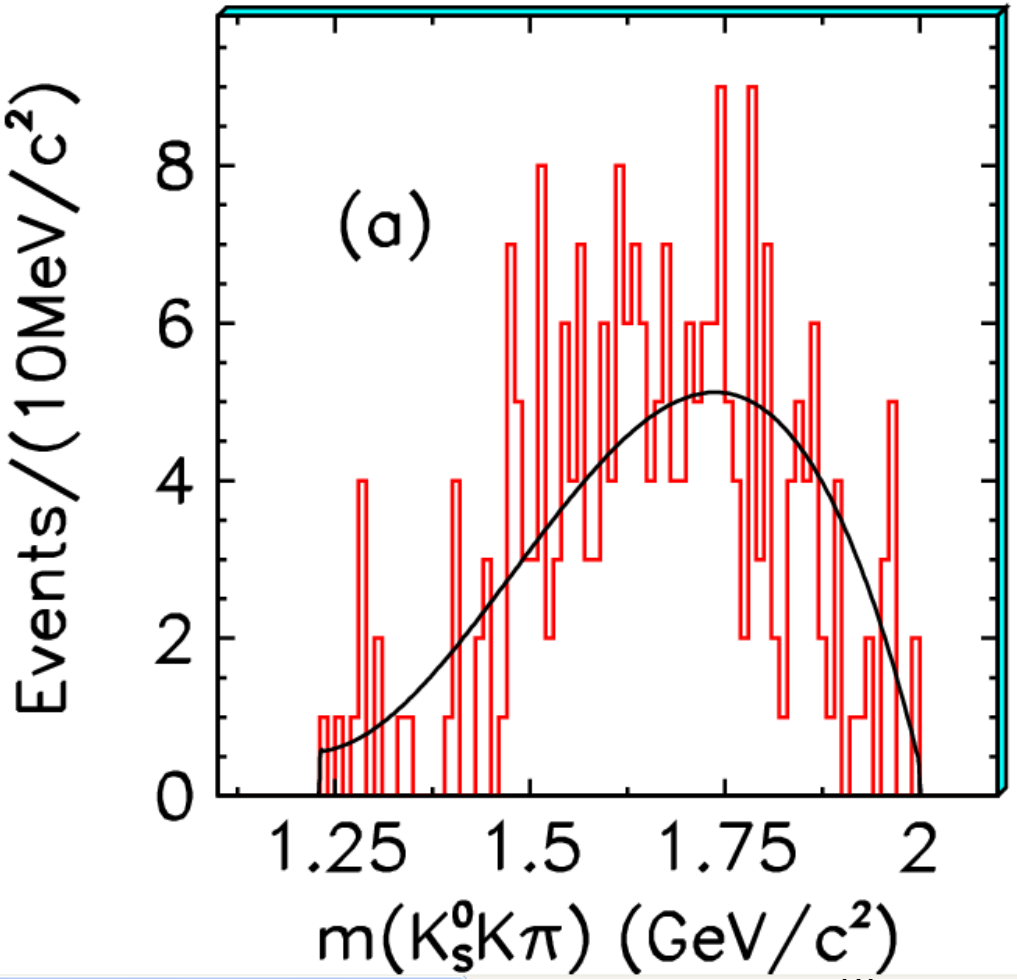




X(1440) in J/ψ →ϕ+KKπ

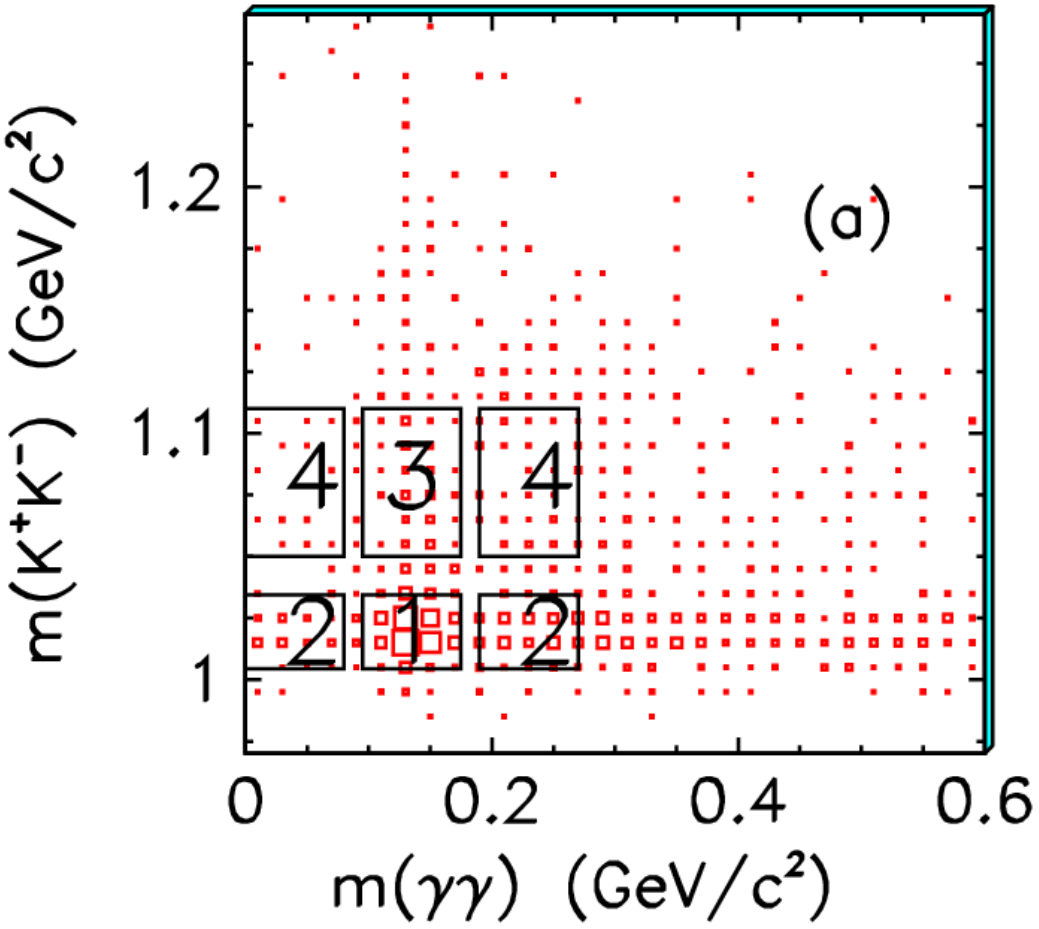
- Final states: $\phi \rightarrow K^+K^-$, $KK\pi = K_S K\pi$

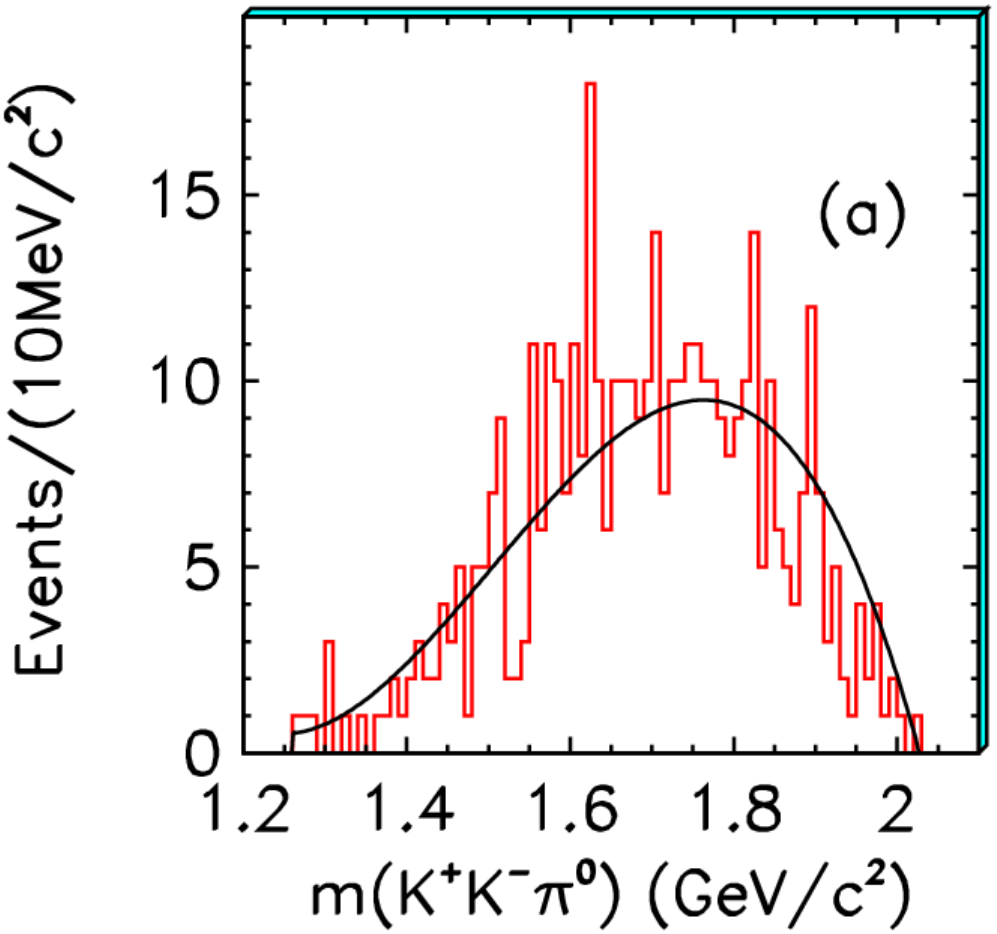




X(1440) in J/ψ →ϕ+KKπ

- Final states: $\phi \rightarrow K^+K^-$, $KK\pi = K^+K^-\pi^0$





X(1440) in J/ψ → ω/ϕ+KKπ

TABLE V. The mass, width, and branching fractions of J/ψ decays into $\{\omega, \phi\}X(1440)$.

$J/\psi \to \omega X(1440)$	$J/\psi \to \omega X(1440)$
$(X \to K_S^0 K^+ \pi^- + \text{c.c.})$	$(X \to K^+ K^- \pi^0)$
$M = 1437.6 \pm 3.2\ \text{MeV}/c^2$	$M = 1445.9 \pm 5.7\ \text{MeV}/c^2$
$\Gamma = 48.9 \pm 9.0\ \text{MeV}/c^2$	$\Gamma = 34.2 \pm 18.5\ \text{MeV}/c^2$

$B(J/\psi \to \omega X(1440) \to \omega K_S^0 K^+ \pi^- + \text{c.c.}) = (4.86 \pm 0.69 \pm 0.81) \times 10^{-4}$

$B(J/\psi \to \omega X(1440) \to \omega K^+ K^- \pi^0) = (1.92 \pm 0.57 \pm 0.38) \times 10^{-4}$

$B(J/\psi \to \phi X(1440) \to \phi K_S^0 K^+ \pi^- + \text{c.c.}) < 1.93 \times 10^{-5}$ (90% C.L.)

$B(J/\psi \to \phi X(1440) \to \phi K^+ K^- \pi^0) < 1.71 \times 10^{-5}$ (90% C.L.)

- B(ωX)/B(ϕX)>20!
- X(1440) couples to ω much stronger than to ϕ

  → it has large nnbar component
- Search for final states with nnbar.

PRD77, 032005 (2008)

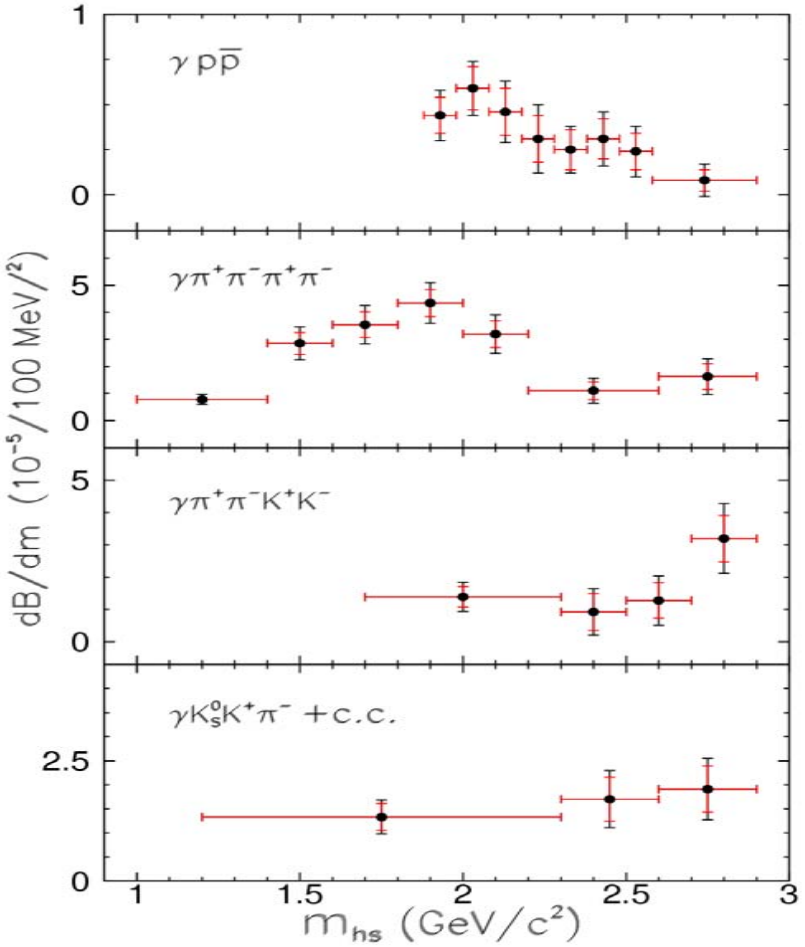
ψ' radiative decays

- Only limited modes measured by BESI
  - $\gamma\eta$, $\gamma\eta'$ [PRD58, 097101 (1998)]
  - γKK, $\gamma\pi\pi$ [PRD67, 032004 (2003)]
- Try to measure more modes
- $B(\psi' \rightarrow \gamma + X)$
  - 2-prong: $\pi^+\pi^-$, K^+K^-, ppbar, $\eta\pi^+\pi^-$
  - 4-prong:$2(\pi^+\pi^-)$, $\pi^+\pi^-K^+K^-$, $\pi^+\pi^-$ppbar, $2(K^+K^-)$, $K_SK^+\pi^-$+c.c.
  - 6-prong: $3(\pi^+\pi^-)$, $2(\pi^+\pi^-)K^+K^-$
- Published in
  - PRL99, 011802 (2007)
  - PRD74, 072001 (2006)

Observation of ψ' radiative decays

- Expected 1% BR, but only 0.05% observed.
- Potential channels for hadron spectroscopy study, including search for non-qqbar states, provided statistics is enough (BESIII?).
- ~ 0.1% more observed in this analysis.

Mode	BR ($\times 10^{-5}$) [m<2.9 GeV/c^2]
γ pp-bar	2.9 ± 0.4 ± 0.4
$\gamma\ \eta'$	12.6 ± 2.9 ± 1.5
$\gamma\ 2(\pi^+\pi^-)$	39.6 ± 2.8 ± 5.0
$\gamma\ K_S K^+\pi^-$+c.c.	25.6 ± 3.6 ± 3.6
$\gamma\ \pi^+\pi^- K^+K^-$	19.1 ± 2.7 ± 4.3
$\gamma\ \pi^+\pi^-$ppbar	2.8 ± 1.2 ± 0.7
$\gamma\ 2(K^+K^-)$	< 4.0
$\gamma\ 3(\pi^+\pi^-)$	< 17
$\gamma\ 2(\pi^+\pi^-)K^+K^-$	< 22



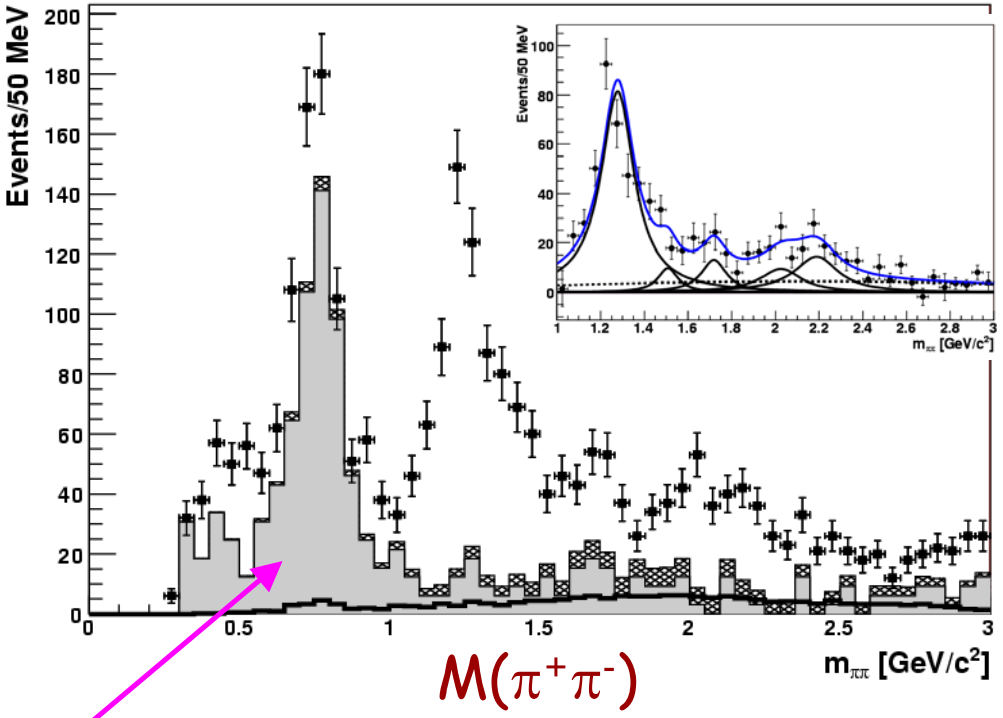
PRL99, 011802 (2007)

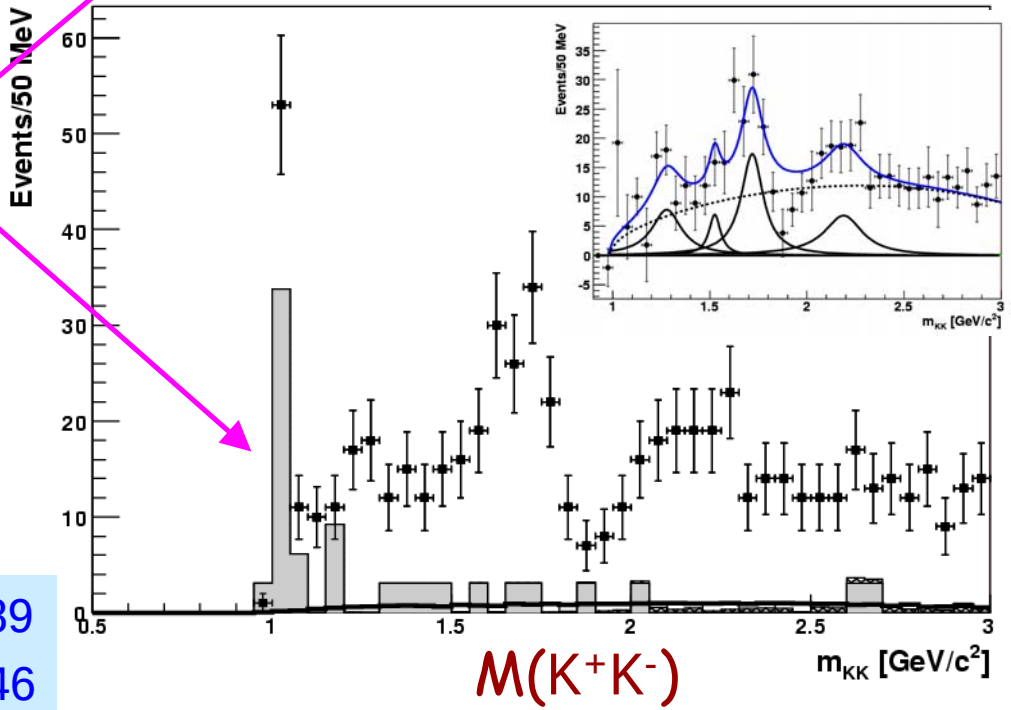
$\psi' \rightarrow \gamma\pi^+\pi^-$ and γK^+K^-

arXiv: 0710.2324

Mode	BR ($\times 10^{-5}$)
$\gamma f_2(1270) \rightarrow \gamma\pi^+\pi^-$	$22 \pm 1 \pm 2$
$\gamma f_0(1500) \rightarrow \gamma\pi^+\pi^-$	$1.5 \pm 0.7\ ^{+0.9}_{-0.4}$
$\gamma f_0(1710) \rightarrow \gamma\pi^+\pi^-$	$2.4 \pm 0.6\ ^{+0.8}_{-1.1}$
$\gamma f_4(2050) \rightarrow \gamma\pi^+\pi^-$	$2.8 \pm 0.9\ ^{+0.8}_{-0.6}$
$\gamma f_0(2200) \rightarrow \gamma\pi^+\pi^-$	$4.6 \pm 1.0\ ^{+4.5}_{-0.9}$
$\gamma f_2(1270) \rightarrow \gamma K^+K^-$	$1.9 \pm 0.6\ ^{+1.0}_{-0.6}$
$\gamma f'_2(1525) \rightarrow \gamma K^+K^-$	$0.69 \pm 0.44\ ^{+0.41}_{-0.21}$
$\gamma f_0(1710) \rightarrow \gamma K^+K^-$	$3.1 \pm 0.6\ ^{+1.1}_{-0.7}$

- Fit with incoherent BWs
- ISR produced ρ and ϕ consistent with prediction





$\gamma f_2(1270) \rightarrow \gamma\pi^+\pi^-$ helicity amplitudes

Positive solution	Negative solution
$x = 0.20 \pm 0.09 \pm 0.25$	$x = -0.26 \pm 0.09 \pm 0.24$
$y = -0.26 \pm 0.08 \pm 0.05$	$y = -0.25 \pm 0.09 \pm 0.06$
$\rho_{stat} = 0.53$	$\rho_{stat} = -0.43$
$\rho_{sys} = 0.44$	$\rho_{sys} = -0.41$

J/ψ: x=0.89
y=0.46

Summary

- Observation of Y(2175) in J/ψ decays.
- Measurement of η(2225) resonance parameters.
- X(1440) production with an ω or a ϕ.
- Observation of new ψ' radiative decay modes.
- More and better results are expected from BESIII in the near future (J. W. Zhang's talk).

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Thanks a lot !