Report on J/ψ Physics Project (1999 - 2001)

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Outline

- J/ψ data sample and analysis method
- Results with BES J/ψ data
  - hunting for non-$q\bar{q}$ states
  - study of σ and κ
  - study of the excited baryon states
  - rare dedays
  - more topics
- Publications and PDG entries
- Students' training
- Future work

I. Data sample

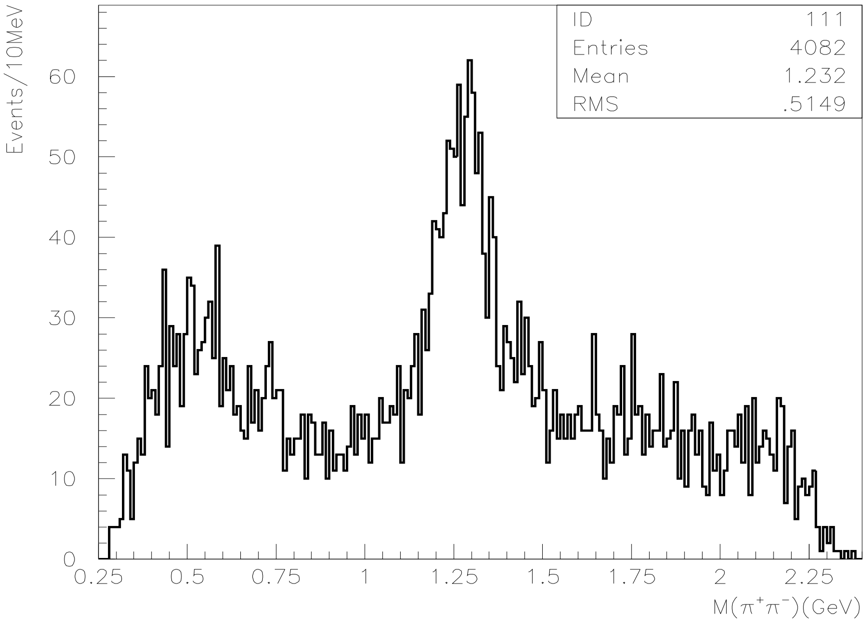
- BESI 7.8×10^6 J/ψ data
- BESII 24×10^6 J/ψ data
  (Nov. 29, 1999 – May of 2000)
- BESII 16×10^6 J/ψ data
  (Nov. of 2000 – now)

Exp.	Total J/ψ number
MarkII	1.3×10^6
Crystal Ball	2.2×10^6
MarkIII	5.8×10^6
DM2	8.6×10^6
BESI	7.8×10^6
BESII	$\sim 40 \times 10^6$ $\sim 50 \times 10^6$

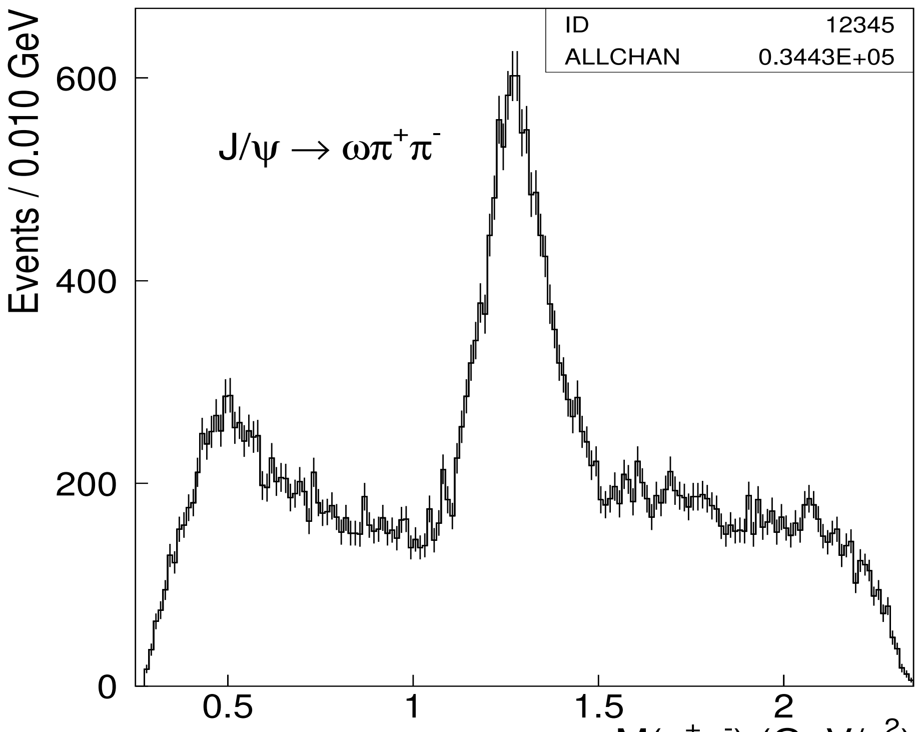
Analysis methods

- Helicity amplitude method
- Moment analysis method
- Partial wave amplitude method

BESI 7.8M J/ψ data



BESII 24.0M J/ψ data



II. Results with BES J/ψ data

1. Hunting for non-$q\bar{q}$ states

- Constituent-quark model works surprisingly well in describing most observed states.
- Problems and puzzles exist, that might signal physics beyond quark model.
- QCD predicts the existence of other types of hadrons with explicit gluonic degrees of freedom – glueball, hybrid.
- The identification of non-$q\bar{q}$ state is a direct test of QCD.
- Many QCD-based models and calculations make predictions.

– glueballs in J/ψ radiative decays.

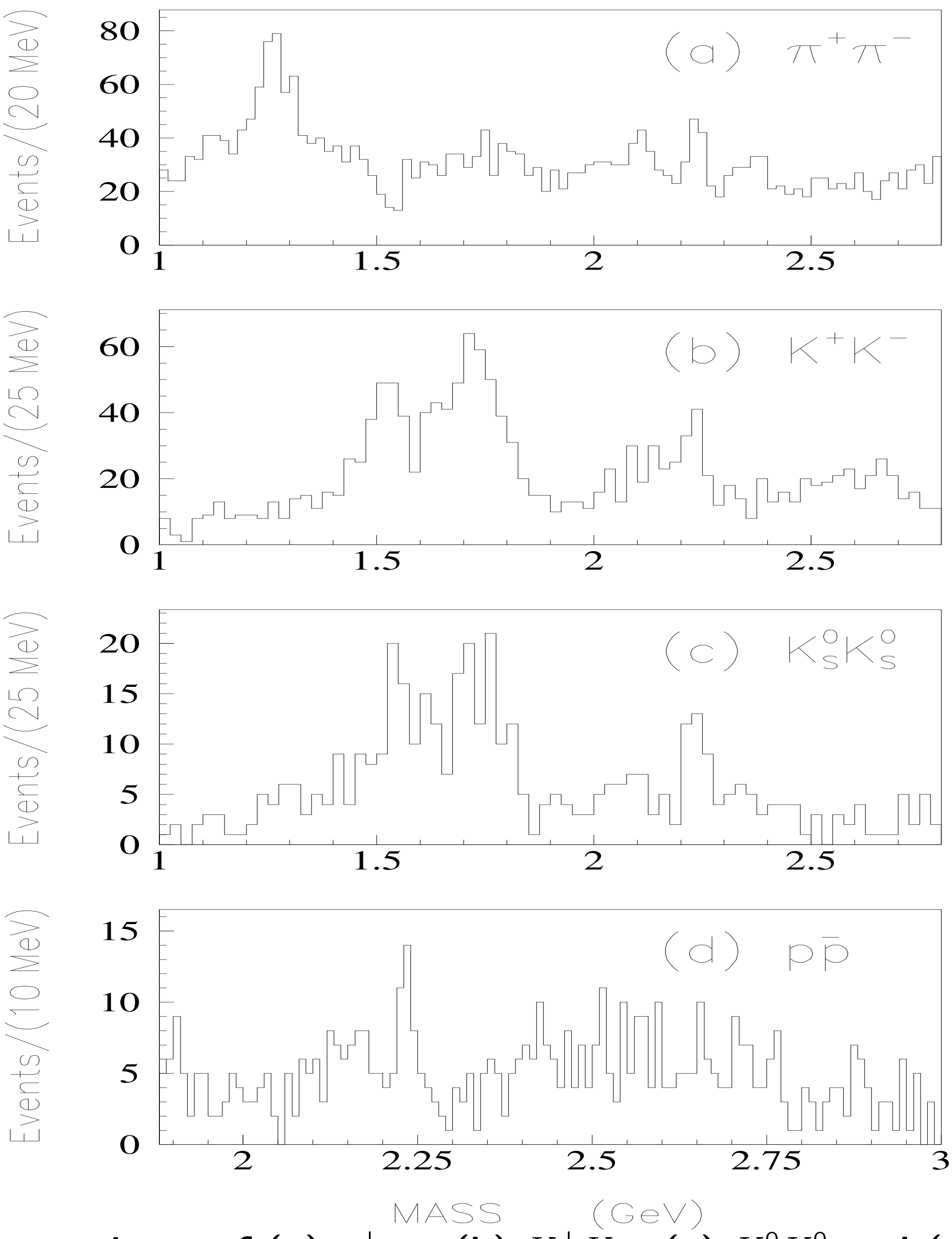
– hybrids in J/ψ hadronic decays.

$\xi(2230)$

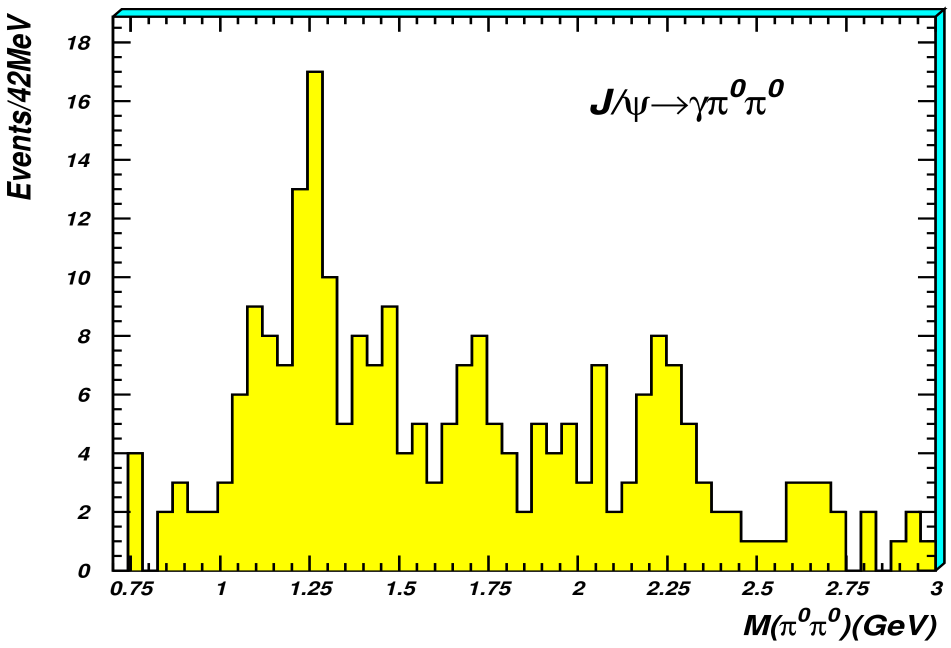
- MARKIII(1986) observed $\xi(2230)$ in $J/\psi \to \gamma K\overline{K}$ for the first time.
- DM2 didn't find a narrow signal in 2230 MeV mass region.

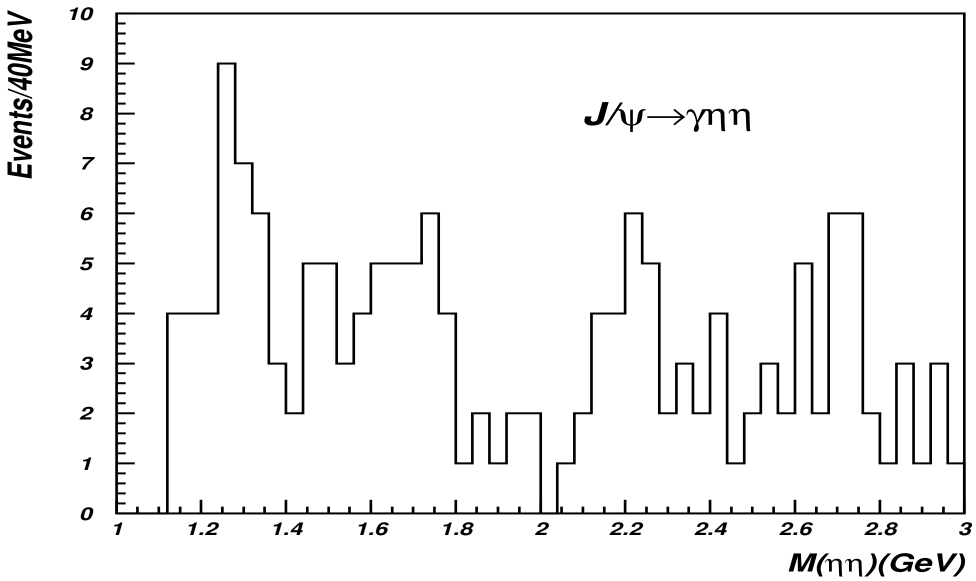
%%%

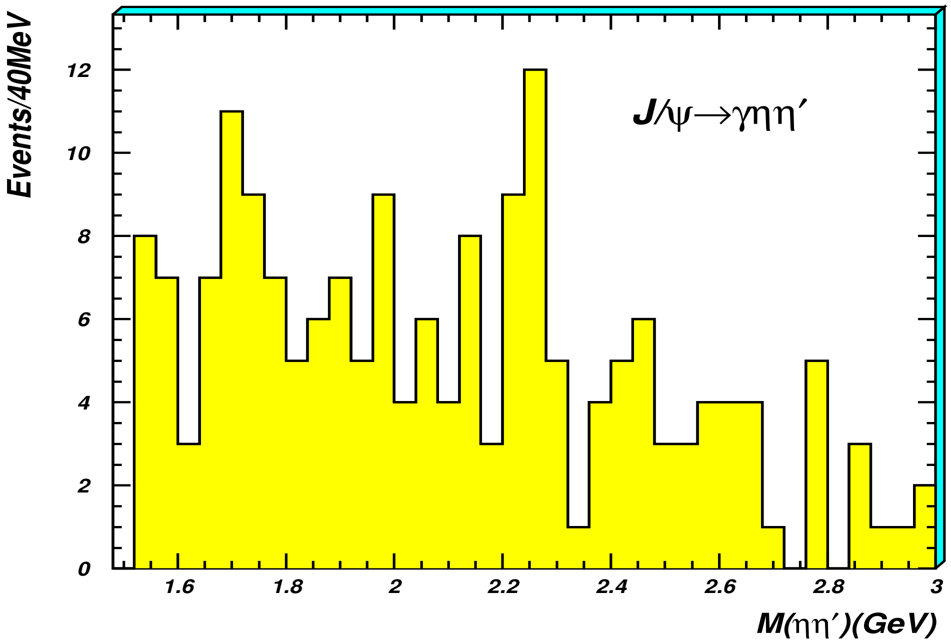
- BESI results(1996) confirmed the existence of $\xi(2230)$ in $J/\psi \to \gamma K\overline{K}$.
- BES(1996) observed the non-strange decay modes of $\xi(2230)$ to $\pi^+\pi^-$, $\pi^0\pi^0$ and $p\bar{p}$.
- Found evidence for the existence of $\xi(2230)$ in $\eta\eta$, $\eta\eta'$ and $\eta'\eta'$ invariant mass spectra (1997).
- Found evidence for the existence of $\xi(2230)$ in the inclusive γ spectrum (BESII 24M J/ψ data).
- BESII $J/\psi \to \gamma K^+K^-$ spectrum.

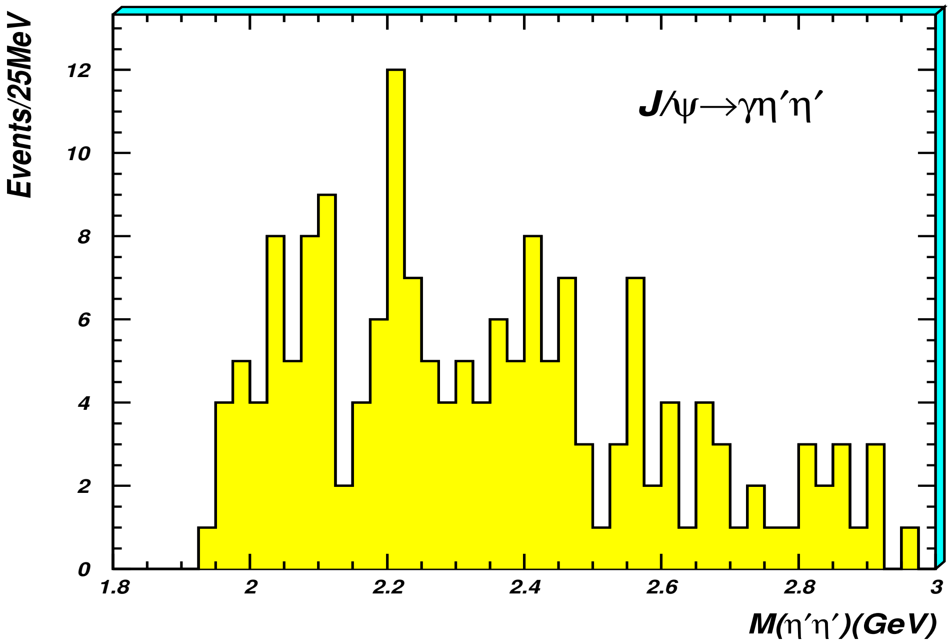


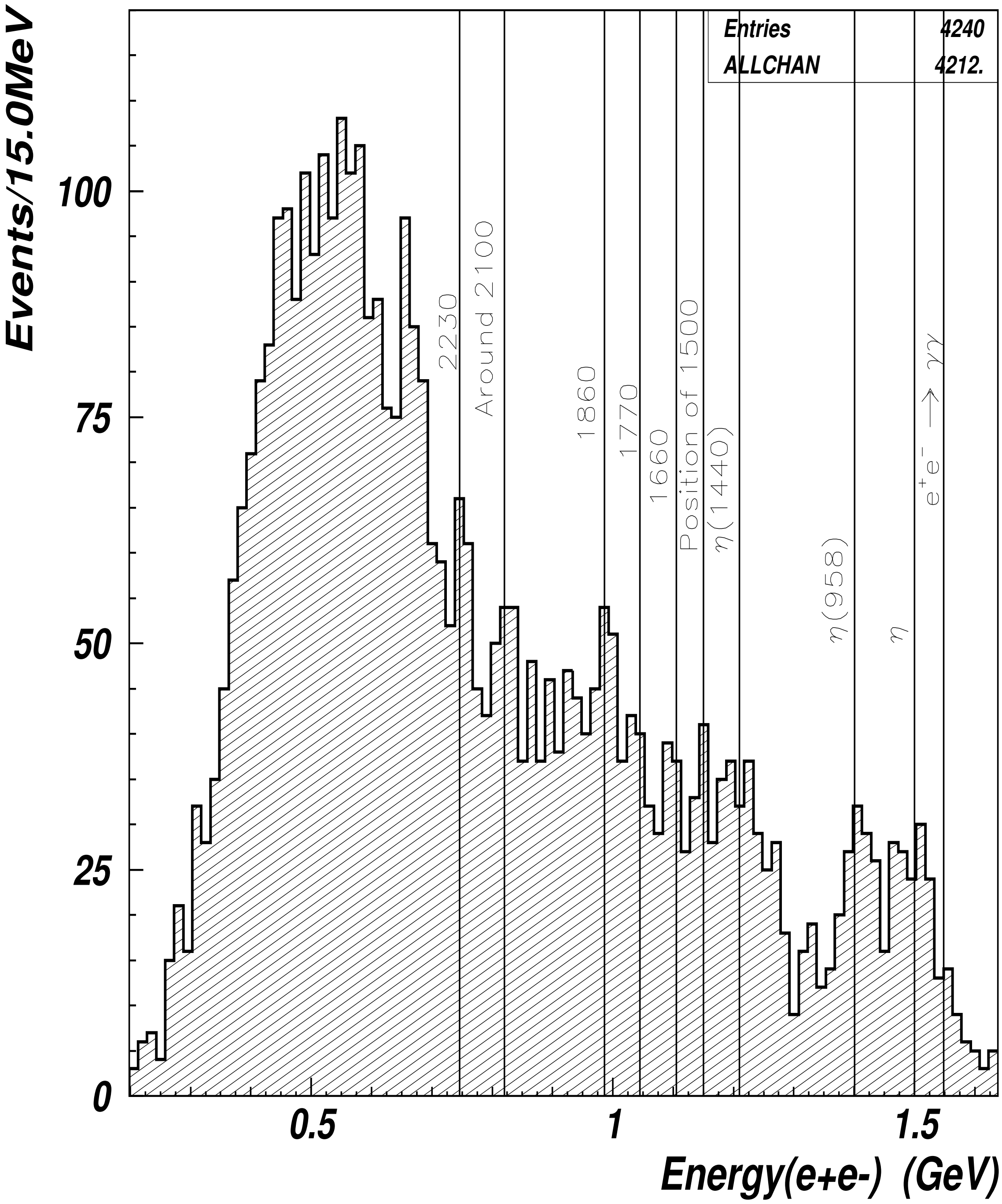
Mass spectrum of (a) $\pi^+\pi^-$**, (b)** K^+K^-**, (c)** $K^0_sK^0_s$ **and (d)** $p\bar{p}$


Events/42MeV
J/ψ→γπ⁰π⁰
M(π⁰π⁰)(GeV)


Events/40MeV
J/ψ→γηη
M(ηη)(GeV)


Events/40MeV
$J/\psi \to \gamma\eta\eta'$
$M(\eta\eta')$(GeV)

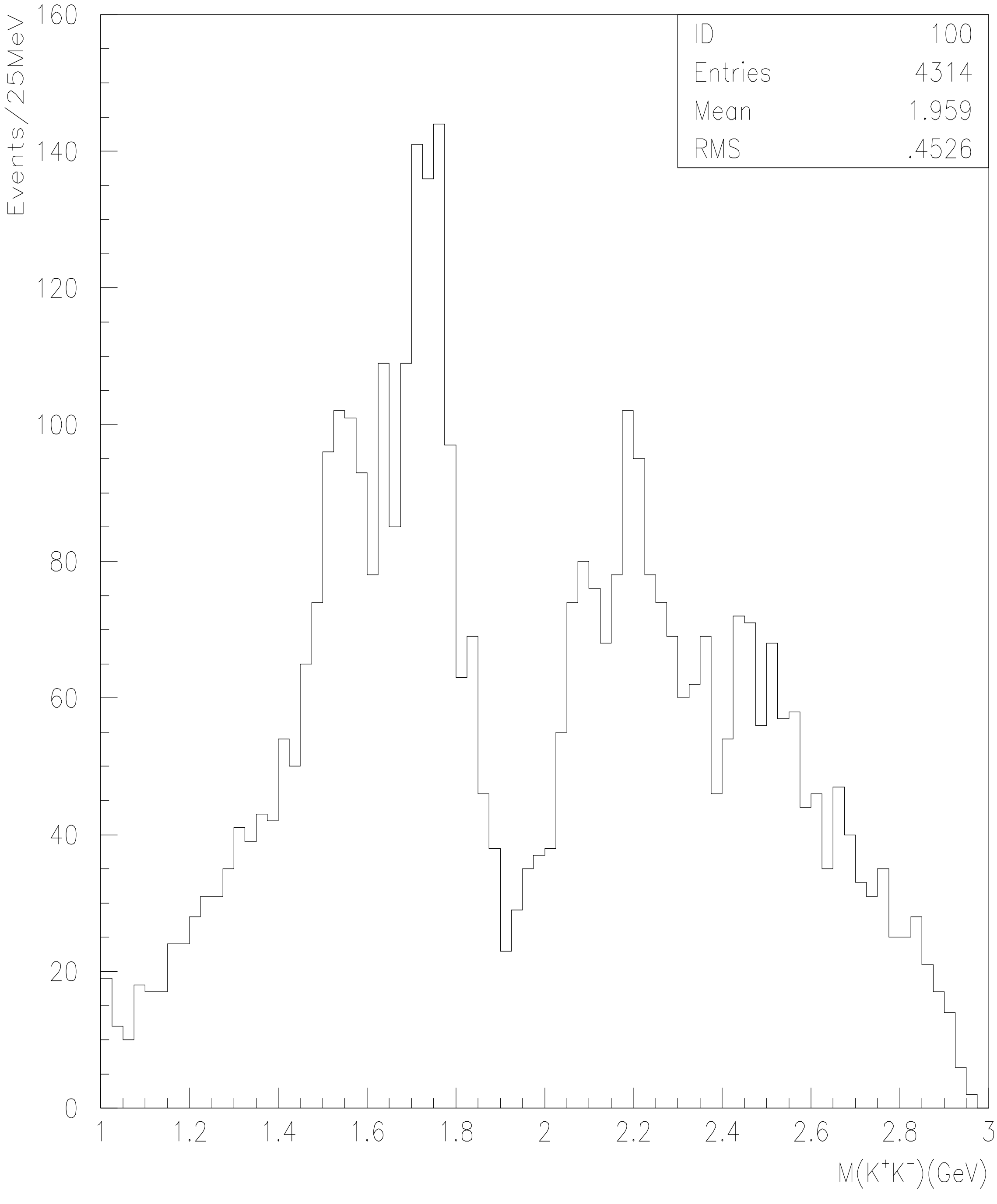

Events/25MeV
$J/\psi \to \gamma\eta'\eta'$
$M(\eta'\eta')$(GeV)



Events/15.0MeV
Energy(e+e-) (GeV)
Entries 4240
ALLCHAN 4212.
0
25
50
75
100
0.5
1
1.5
2230
Around 2100
1860
1770
1660
Position of 1500
η(1440)
η(958)
η
e⁺e⁻ → γγ

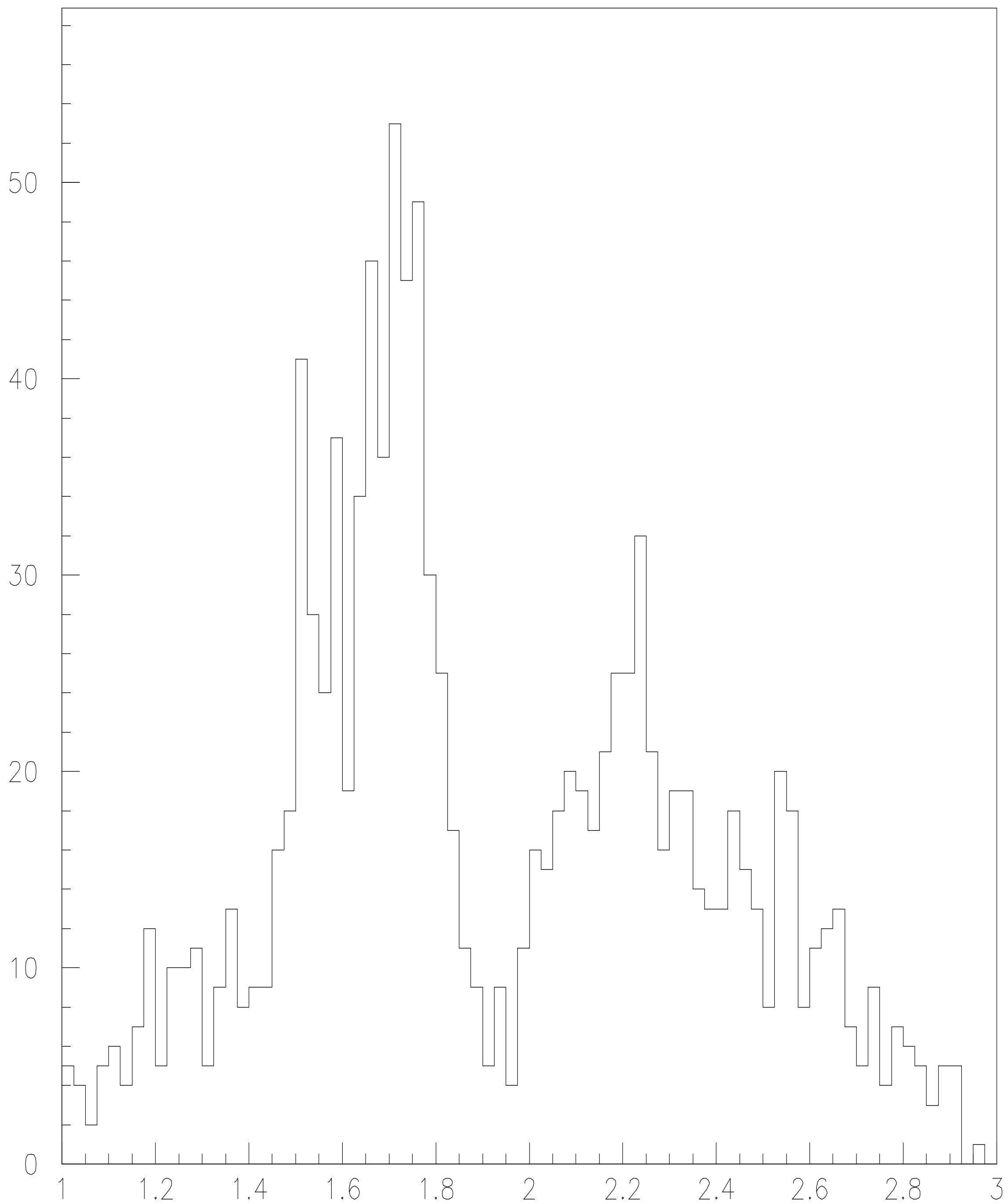
$J/\psi \to \gamma K^+ K^-$:

BESII 24M J/ψ data (run13692 - 16835)



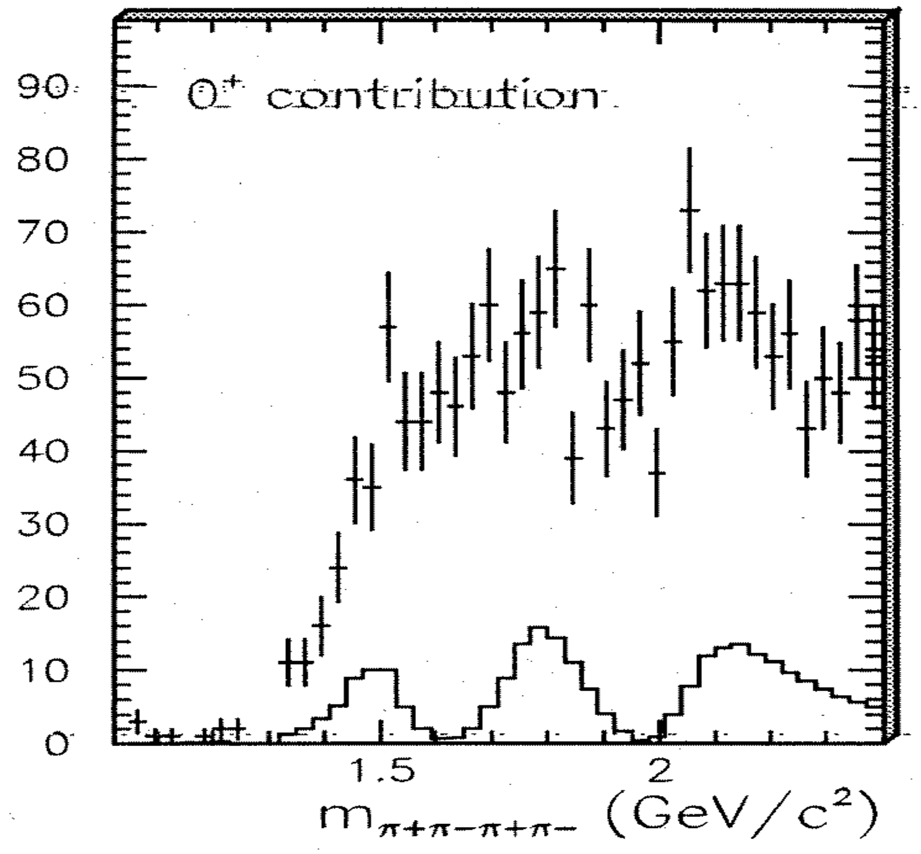
$J/\psi \to \gamma K^+ K^-$:

BESII 9M J/ψ data (run17423 - 18000)



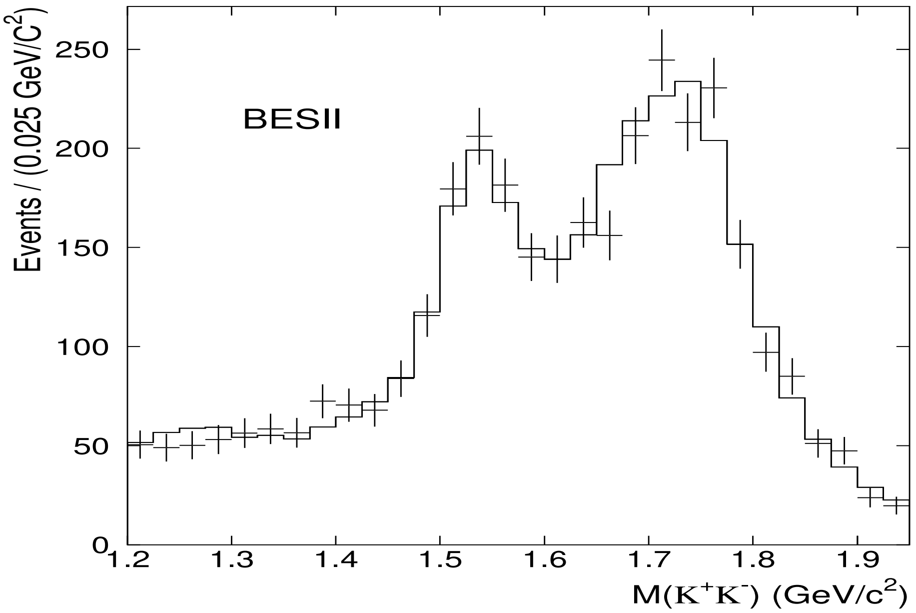
$f_0(1500)$

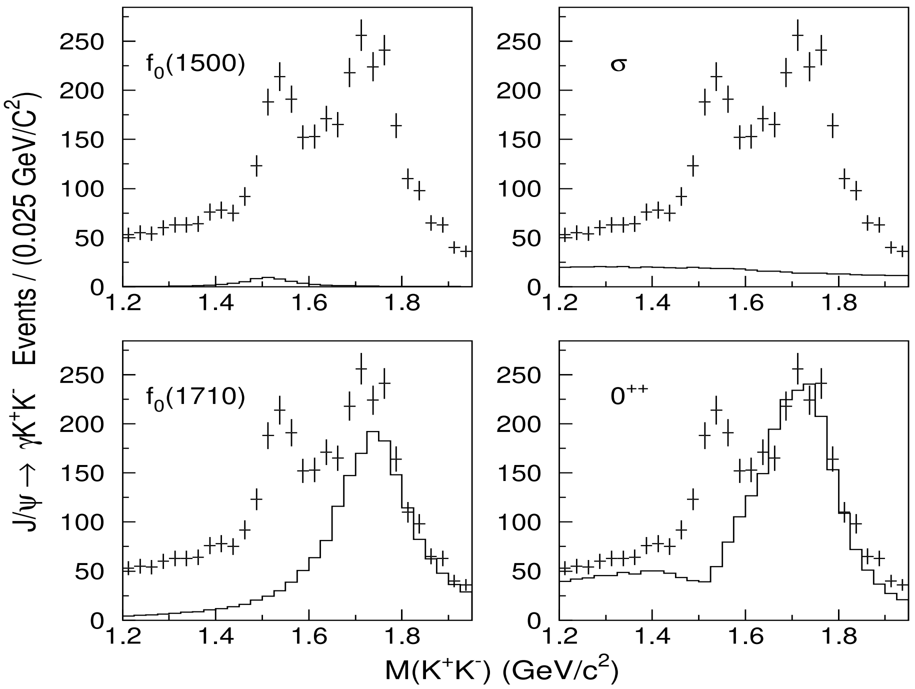
- Most of the data on $f_0(1500)$ is from CBAR $p\bar{p}$ annihilation to $\pi^0\pi^0$, $\eta\eta$, $\eta\eta'$, $K_L K_L$, $4\pi^0$,...
- Some other experiments observed $f_0(1500)$ too through $\bar{n}p$ reaction and pp central production.
- BES analyzed $J/\psi \to \gamma\pi^+\pi^-\pi^+\pi^-$. Introduced $\sigma(\pi\pi - S$ wave) in PWA analysis and considered $\sigma\sigma$ decay mode in addition to $\rho\rho$ mode and yielded a 0^{++} at the mass of 1.5 GeV in 4π mass.



$\underline{f_0(1710)}$

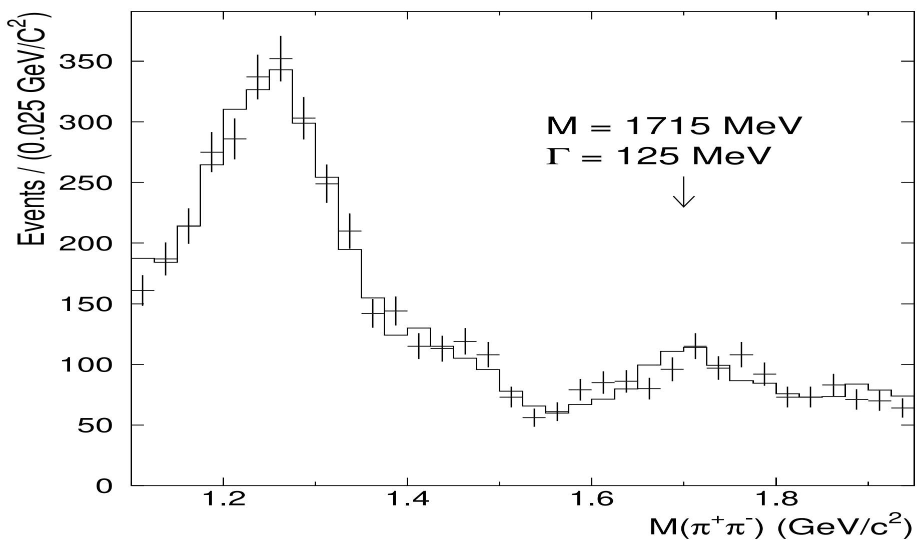
- Observed a dominant 0^{++} in 1.7 GeV mass region from $J/\psi \to \gamma K^+K^-$ by PWA analysis.

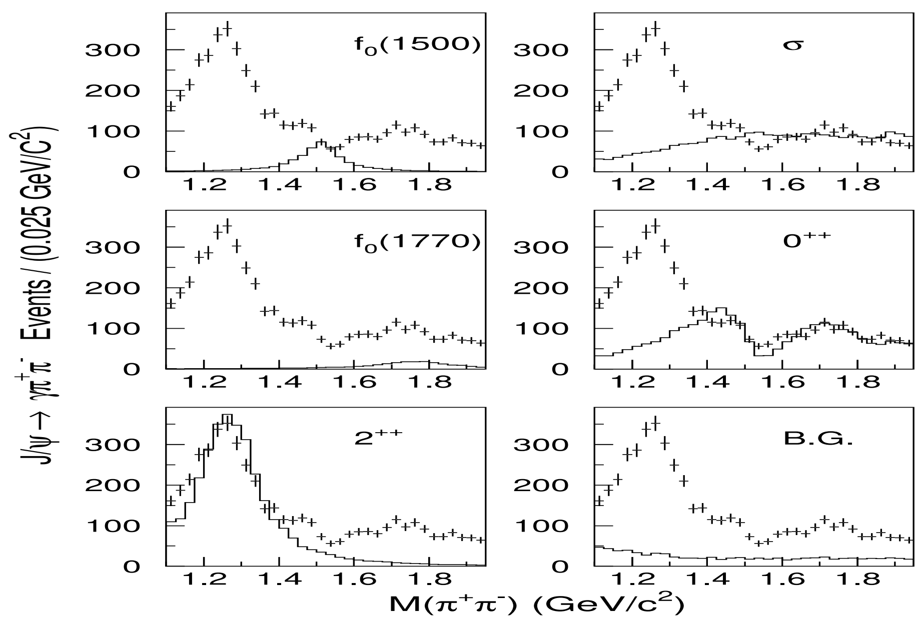




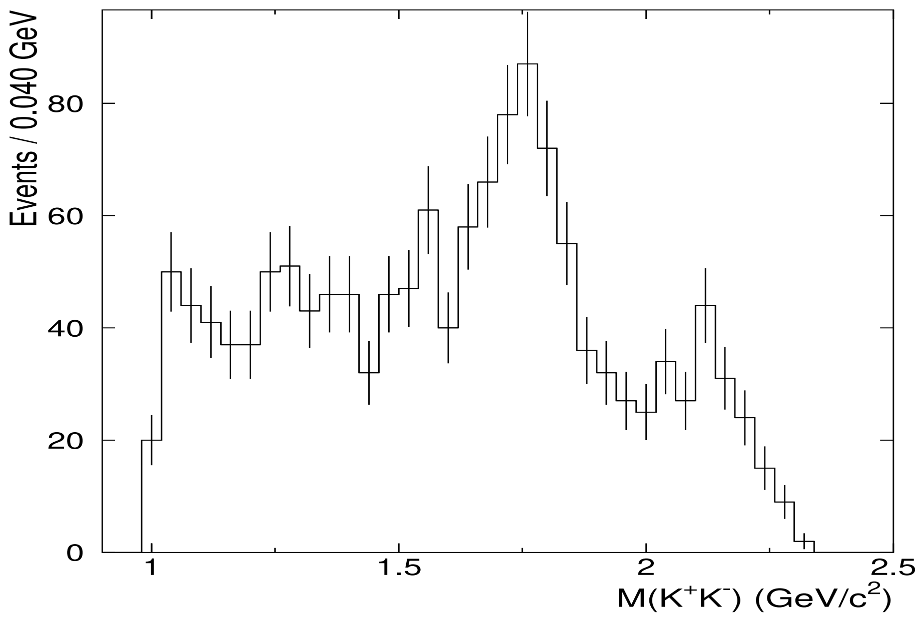
- Observed a 0^{++} at 1.74 GeV in 4π mass spectrum from $J/\psi \to \gamma\pi^+\pi^-\pi^+\pi^-$.

- In $J/\psi \to \gamma\pi\pi$ channel:





- $J/\psi \to \omega K^+K^-$.



2. Study of σ and κ

motivation and exp. status

- The possible existence of σ theoretically and phenomenologically.
- Linear σ model predicts:

$$M_\sigma = 2M_g \sim 500 - 600 MeV$$

$$\Gamma_\sigma \sim 400 - 800 MeV$$

- σ is required as $\pi\pi$ S-wave.
- However the existence of σ as a resonance has not been generally accepted.
- DM2, MARKIII and BES all found a broad structure in $J/\psi \to \omega\pi^+\pi^-$
- No exp. results for κ exist.

3. Study of excited baryon states

motivation

- to probe the internal structure of light-quark baryons.
- search for missing baryons predicted by Quark Model.
- to obtain a better understanding of the strong interaction force in the non-perturbative regime.

Experimental status

- the present knowledge came almost entirely from the old generation of πN experiments more than 20 years ago.
- CEBAF electroproduction & photoproduction experiments started several years ago.
- the electron accelerator facility CB-ELSA at Bonn Univ. for photoproduction experiments are being carried on.
- the relatively large branching ratios in J/ψ decays.

4. Rare decays

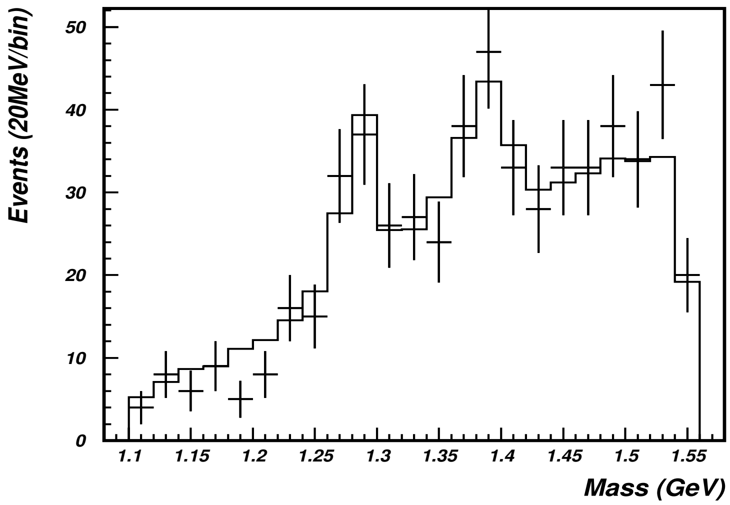
- $J/\psi \to e\mu,\ \mu\tau\ \ldots$
- $J/\psi \to DX$

5. More interesting topics

- $J/\psi \to \gamma\eta\pi^+\pi^-$

  The peak at $\sim$ 1285MeV favors 1^{++} over 0^{-+}, e.g. $f_1(1285)$, dominantly decays through $a_0(980)\pi$.

  The peak at $\sim$ 1400MeV prefers 0^{-+} over 1^{++}. Decays through both $\eta\sigma$ and $a_0(980)\pi$ modes.



- $J/\psi \to \gamma K_s^0 K^{\pm}\pi^{\mp}$

  A strong 0^- peaks at around 1.44 GeV decaying to K^*K and κK.

- $J/\psi \to \gamma K^+K^-\pi^+\pi^-$

  A broad 0^- at 1.8 GeV and a broad 2^+ at 2.02 GeV are observed in $K^+K^-\pi^+\pi^-$ spectrum.

- $J/\psi \to \gamma\gamma V(\rho,\phi,\omega)$

  A peak around 1.43 GeV is observed in both $\gamma\rho$ and $\gamma\phi$ mass spectra.

- The measurement of η_c mass.

III. Publications and PDG entries

Publications and conf. talks

- 1 paper in Phys. Rev. D.
- 5 papers in Phys. Lett. B
- 1 paper in Chinese High Energy and Nucl. Phys.
- 5 talks in the international conferences

No. of citations:

96

PDG 2000 entries

33

IV. Students' training

1 master degree, 3 Ph.D degrees, 5 post-doctors

V. Future work

- Search for the possible 2^{++} glueball in $J/\psi \to \gamma KK$, $\gamma\pi\pi$, $\gamma\eta\eta$, $\gamma\eta\eta'$, $\gamma\eta'\eta'$, $\gamma\phi\phi$, $\gamma\omega\omega$ ....
- Analyze $J/\psi \to \gamma 4\pi$, $\gamma\pi\pi$, γKK for the study of 0^{++} glueball.
- Hunt for the possible 1^{-+} exotic state from $J/\psi \to \rho\eta\pi$.
- PWA analyze $J/\psi \to \omega\pi\pi$ and $K^*K\pi$ for the study of σ and κ.
- Continue the study of the rare decays $J/\psi \to e\mu, \mu\tau$, ...
- PWA analyze $J/\psi \to p\bar{p}\pi^0$, $p\bar{p}\eta$, $p\bar{p}K\pi$, $p\pi^-\bar{n}$, $p\bar{p}\omega$, $p\bar{p}\phi$ ... for the study of the excited baryon states.
- Systematically study $J/\psi \to$ Vector + Pseudoscalar decays.
- ...