Charmonium States and the Hadronic Decays

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June 8, 2001

Genova, Italy

Outline

- **Introduction**
- **Parameters of the charmonium states**
- **Hadronic decays of $\psi(2S)$**
- χ_c **states**
- **Hadronic decays of J/ψ**
  - $J/\psi \rightarrow Vector + Pseudoscalar$
  - J/ψ's 3-body decays
  - Study of the excited baryon states.
- **Summary**

I. Introduction

- Some e^+e^- experiments for the study of J/ψ. Mark-I,II,III, Crystal Ball, DM2, BES.

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	50×10^6

- FNAL-E760, E835 for the study of charmonium states from $p\bar{p}$ annihilations.
- CLEO's measurements of charmonium $\gamma\gamma$ partial widths in two-photon collisions at high energy e^+e^- collisions.
- LEP two-photon collision data for $\gamma\gamma$ partial widths measurement.
- BES $\psi(2S)$ and χ_c studies. The measurements of the parameters of charmonium states.

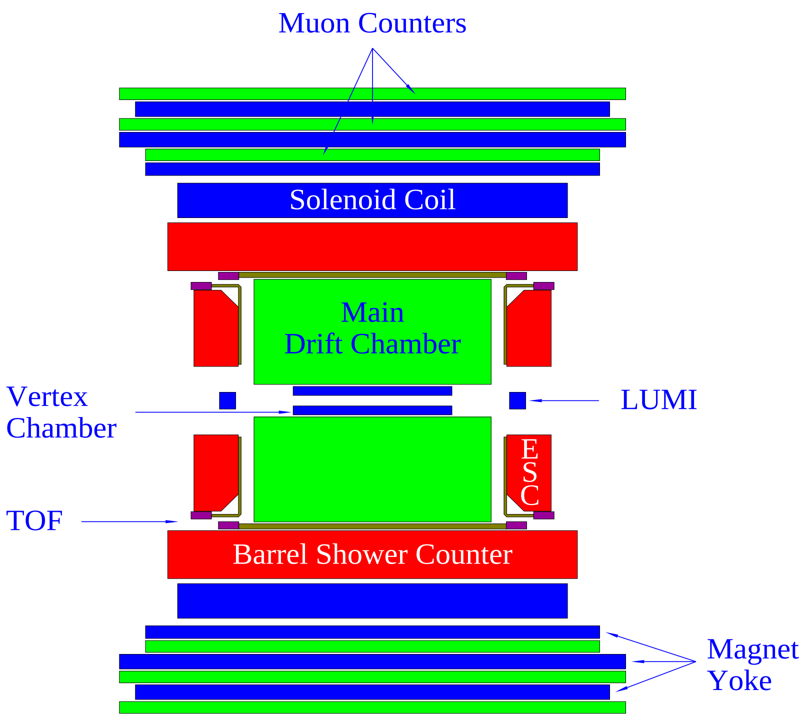
- BES is a large general purpose solenoidal detector at Beijing Electron Positron Collider (BEPC).
- Beam energy range from 1.0 to 2.8 GeV.

Table 1. Performance of BESI and BESII

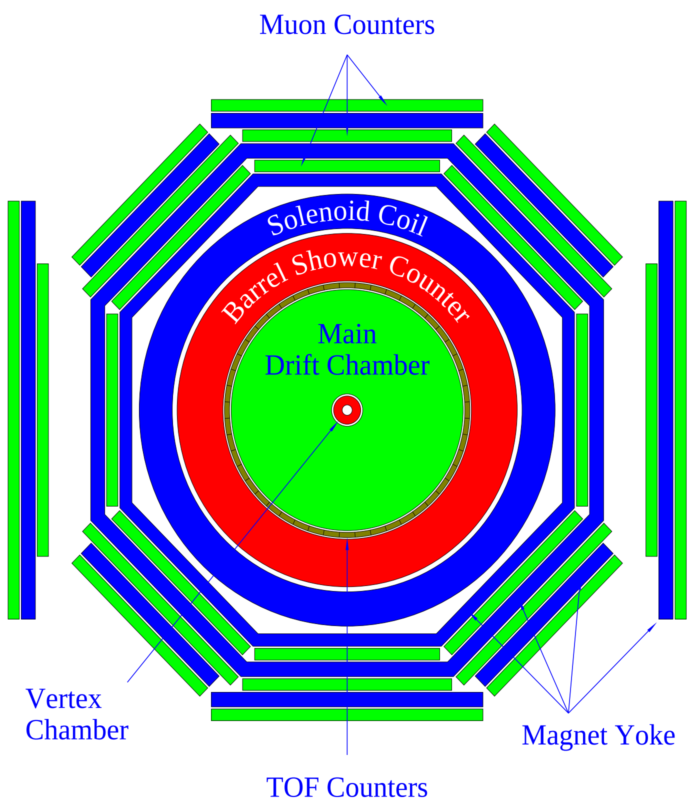
Detector	Parameter	BESI	BESII
VC(CDC)	$\sigma_{xy}(\mu)$	200	**100**
MDC	$\sigma_{xy}(\mu)$ $\Delta p/p$ (%) $\sigma_{dE/dx}$ (%)	200-250 $1.8\sqrt{1+p^2}$ 7.9	 $1.7\sqrt{1+p^2}$ 8.4
BTOF	σ_T (ps) L_{atten} (m)	375 1.0-1.2	**180** 3.5 - 5.5
ETOF	σ_T (ps)		720
BSC	$\Delta E/\sqrt{E}$ (%)	23.8	22
ESC	$\Delta E/\sqrt{E}$ (%)	24	22
MUON	σ_z(cm)	5.5	5.5
DAQ	Dead time (ms)	20	**8**

Table 2. Data Collected with BESI and BESII

Detector	E_{CM}(GeV)	Physics	Data Sample
BESI	3.097	J/ψ	7.8×10^6
	3.686	$\psi(2S)$	$\mathbf{3.96 \times 10^6}$
	4.03	D_S, D	$22.3pb^{-1}$
	3.55, m_τ scan	m_τ	$5pb^{-1}$
BESII	2-5 R scan	R, α_{QED}, g-2	6+85 points
	$\psi(2S)$ scan	res. para.	24 points
	3.097	J/ψ	$\mathbf{50 \times 10^6}$
	ψ'' scan	res. para.	

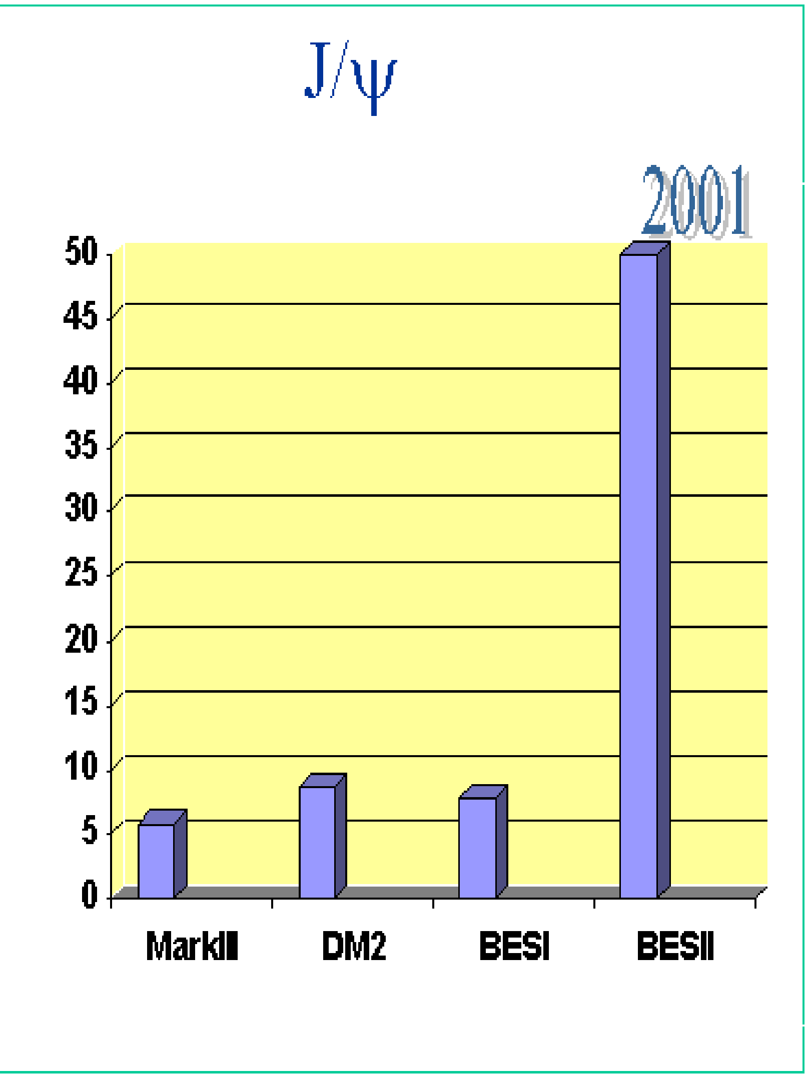


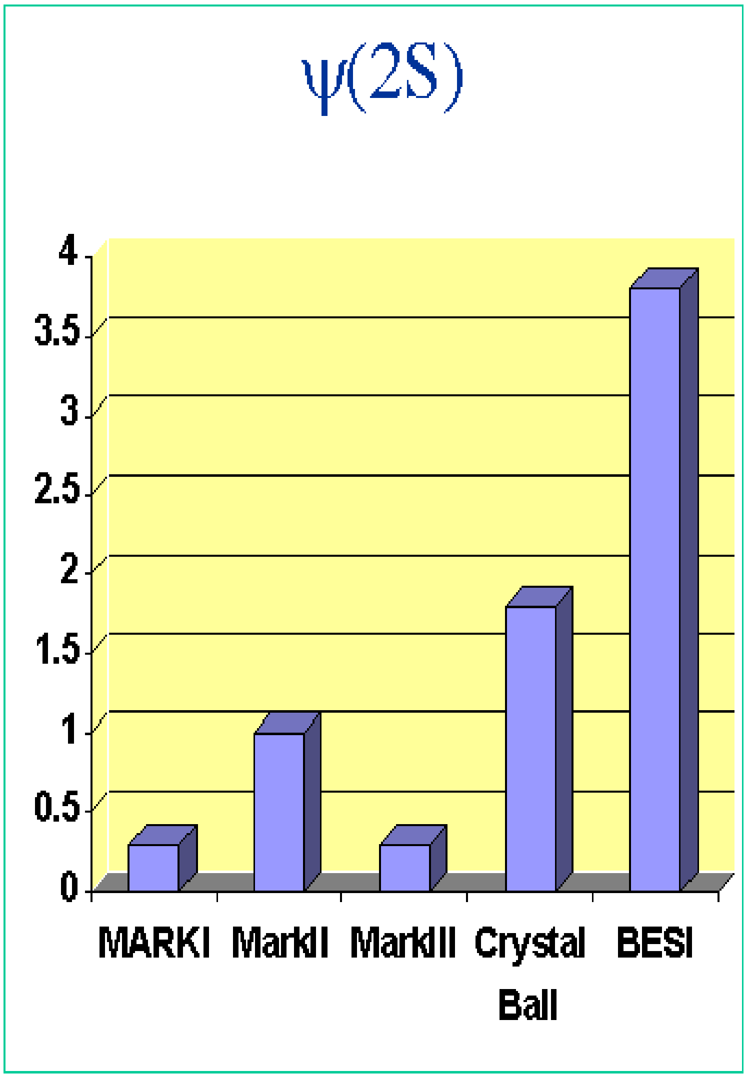
Side view of the BES detector



End view of the BES detector

World J/ψ and ψ(2S) Samples (/10^6)





II. Parameters of charmonium states

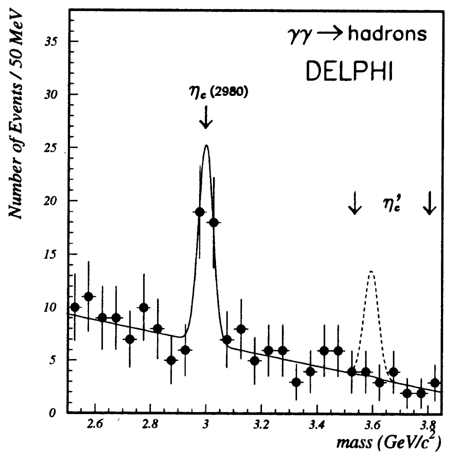
Table 3. η_c mass and width

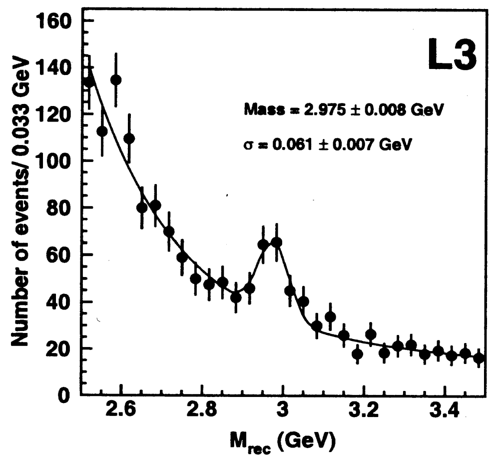
Process	Exp.	Mass (MeV)	Width (MeV)
e^+e^-	MRK2(80)	2982 ± 8	
$J/\psi, \psi' \to \gamma X$	CBAL(86)	$2984 \pm 2 \pm 4$	11.5 ± 4.5
$J/\psi \to \gamma\eta_c$	MRK3(86)	2980.2 ± 1.6	
$J/\psi \to \gamma p\bar{p}$	MRK3(86)		$10.1^{+37.0}_{-8.2}$
$p\bar{p} \to \gamma\gamma$	SPEC(87)	$2982.6^{+1.7}_{-2.3}$	$7.0^{+7.5}_{-7.0}$
$J/\psi \to \gamma 4K$	MRK3(90)	$2969 \pm 4 \pm 4$	
$J/\psi \to \gamma\eta_c$	DM2(91)	2979.4 ± 1.9	
$p\bar{p} \to \gamma\gamma$	E760(92)	$2988.3^{+3.3}_{-3.1}$	$23.9^{+12.6}_{-7.1}$
e^+e^-	DLPH(98)	2999 ± 8	
$\psi' \to \gamma\eta_c$	BES(99)	$2975.8 \pm 3.9 \pm 1.2$	
PDG2000		2979.8 ± 1.8	$13.2^{+3.8}_{-3.2}$

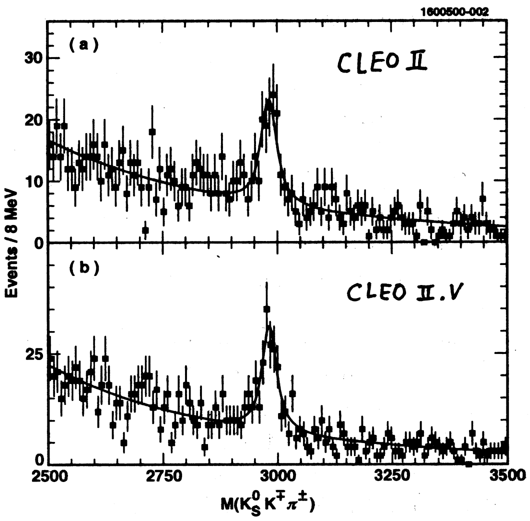
- L3(1999) measured η_c parameters.
- E835 $p\bar{p} \to \gamma\gamma$ data.

  $M = 2985^{+1.7}_{-1.8} MeV$, $\Gamma = 17.8^{+7.2}_{-6.9} MeV$.
- BESI(2000) $J/\psi \to \gamma\eta_c$, $\eta_c \to K^+K^-\pi^+\pi^-$, 4π, $KK\pi$ and $\phi\phi$. $M = 2976.3 \pm 2.3 \pm 1.2 MeV$, $\Gamma = 11.0 \pm 8.1 \pm 4.1 MeV$.
- CLEO(2000) 2-photon collision.

  $M = 2980.4 \pm 2.3 \pm 0.6 MeV$, $\Gamma = 27.0 \pm 5.8 \pm 1.4 MeV$.







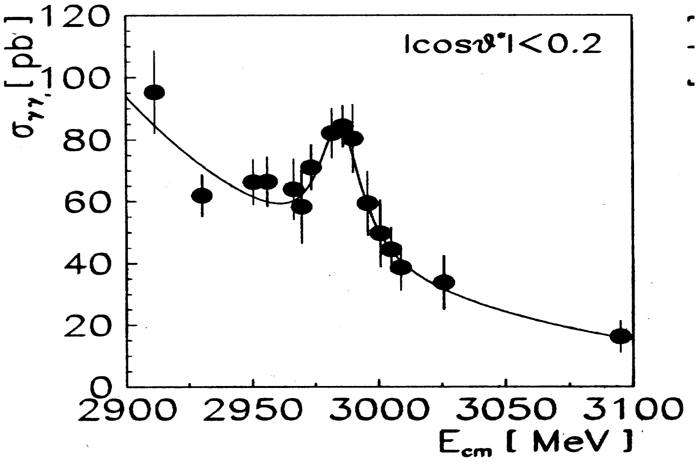


Table 4. J/ψ mass and width

Process	Exp.	Mass(MeV)	Width(keV)
$p\bar{p} \to e^+e^-X$	SPEC(87)	$3096.95 \pm 0.10 \pm 0.30$	
$p\bar{p} \to e^+e^-$	E760(93)	$3096.87 \pm 0.03 \pm 0.03$	$99 \pm 12 \pm 6$
e^+e^-	BES(95)		84.4 ± 8.9
$e^+e^- \to h$	OLYA(00)	3096.89 ± 0.09	
PDG2000		3096.87 ± 0.04	87 ± 5

Table 5. $\psi(2S)$ decay width and branching ratios

Exp.	Γ_t (keV)	$B(\mu\mu)$ (10^{-3})	$B(\pi^+\pi^- J/\psi)$	$B(J/\psi X)$
MRKI(75)	228 ± 56	9.3 ± 1.6	0.32 ± 0.04	0.57 ± 0.08
SPEC(75)		7.7 ± 1.7		
DASP(79)	202 ± 57	9.9 ± 3.2	0.36 ± 0.06	0.51 ± 0.12
E760(92)	306 ± 39			
E760(92)			0.283 ± 0.029	
PDG2000	277 ± 31	10.3 ± 3.5	0.318 ± 0.028	0.55 ± 0.05

- BES scanned 24 points in $E_{cm} = 3.67 \sim 3.71$ GeV region in 1999 for the measurements of $\psi(2S)$ decay widths.

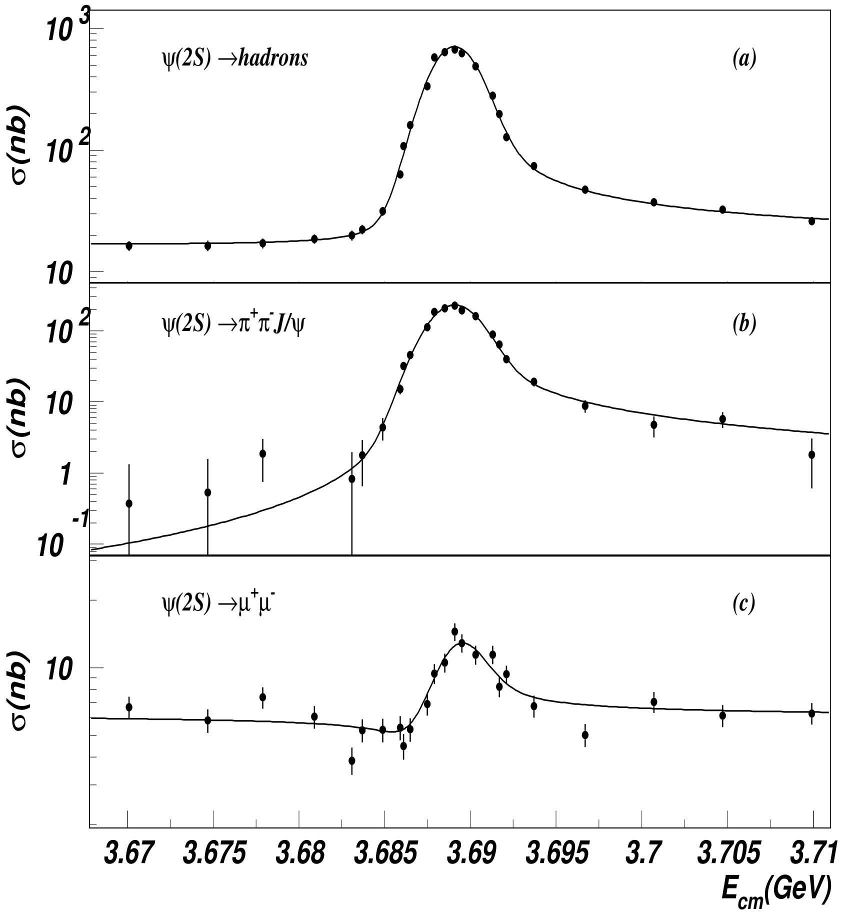


Table 6. χ_{c0} mass and width

Process	Exp.	Mass(MeV)	Width(KeV)
$e^+e^- \to \gamma X$	CNTR(77)	3415 ± 9	
e^+e^-	MRKI	$3416 \pm 3 \pm 4$	
$e^+e^- \to 2\gamma J/\psi$	CNTR(78)	3422 ± 10	
$\psi' \to \gamma X$	CBAL(86)	$3417.8 \pm 0.4 \pm 4.0$	$13.5 \pm 3.3 \pm 4.2$
$\psi' \to \gamma X$	BES(99)	$3414.1 \pm 0.6 \pm 0.8$	$14.3 \pm 2.0 \pm 3.0$
$p\bar{p} \to e^+e^-\gamma$	E835(99)	$3417.4^{+1.8}_{-1.9} \pm 0.2$	$16.6^{+5.2}_{-3.7} \pm 0.1$
PDG2000		3415.0 ± 0.8	$16.6^{+2.6}_{-2.3}$

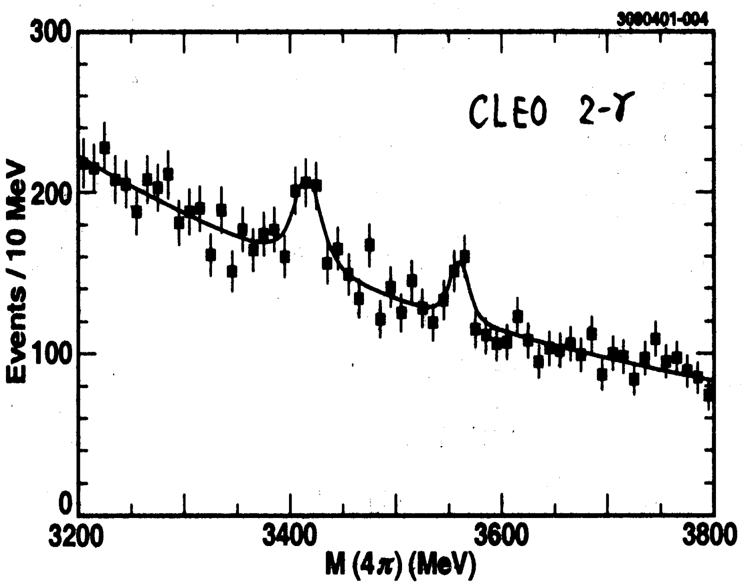
Table 7. χ_{c1} mass and width

Process	Exp.	Mass(MeV)	Width(KeV)
$\psi' \to J/\psi 2\gamma$	MRKII	3510.1 ± 1.1	
$\psi' \to \gamma X$	CBAL(86)	$3512.3 \pm 0.3 \pm 4.0$	
$p\bar{p} \to e^+e^-X$	SPEC(86)	$3511.3 \pm 0.4 \pm 0.4$	
$p\bar{p} \to e^+e^-\gamma$	E760(92)	$3510.53 \pm 0.04 \pm 0.12$	$0.88 \pm 0.11 \pm 0.08$
$\psi' \to \gamma X$	BES(99)	3509.4 ± 0.9	
PDG2000		3510.51 ± 0.12	$0.88 \pm 0.11 \pm 0.08$

Table 8. χ_{c2} mass and width

Process	Exp.	Mass(MeV)	Width(KeV)
$\psi' \to \gamma X$	CBAL	3555.9 ± 0.9	$2.8^{+2.1}_{-2.0}$
$p\bar{p} \to e^+e^-X$	SPEC(86)	$3556.9 \pm 0.4 \pm 0.5$	$2.6^{+1.4}_{-1.0}$
$p\bar{p} \to e^+e^-\gamma$	E760(92)	$3556.15 \pm 0.07 \pm 0.12$	$1.98 \pm 0.17 \pm 0.07$
$\psi' \to \gamma X$	BES(99)	3556.4 ± 0.7	
PDG2000		3556.18 ± 0.13	2.00 ± 0.18

- CLEO observed two-photon production of χ_{c0} and χ_{c2} to $\pi^+\pi^-\pi^+\pi^-$.



$$M_{\chi_{c0}} = 3416.5 \pm 3.0 \ MeV$$

$$\Gamma_{\gamma\gamma}(\chi_{c0}) = 3.76 \pm 0.65 \pm 0.41 \pm 1.69 \ KeV$$

$$M_{\chi_{c2}} = 3559.9 \pm 2.9 \ MeV$$

$$\Gamma_{\gamma\gamma}(\chi_{c2}) = 0.53 \pm 0.15 \pm 0.06 \pm 0.22 \ KeV$$

- CLEO also studied χ_{c1} and χ_{c2} production from B decays.

III. Hadronic decays of $\psi(2S)$

- Based on 3.96×10^6 $\psi(2S)$ data sample, BES studied $\psi(2S)$ hadronic decays systematically.
- According to PQCD, for any hadronic final state X_h,

$$Q_h \equiv \frac{B[\psi(2S) \to X_h]}{B[J/\psi \to X_h]} \approx \frac{B[\psi(2S) \to e^+e^-]}{B[J/\psi \to e^+e^-]}$$
$$\approx 15\%$$

Table. Branching ratios of $\psi(2S)$ decays (Upper limits at 90% C.L.)

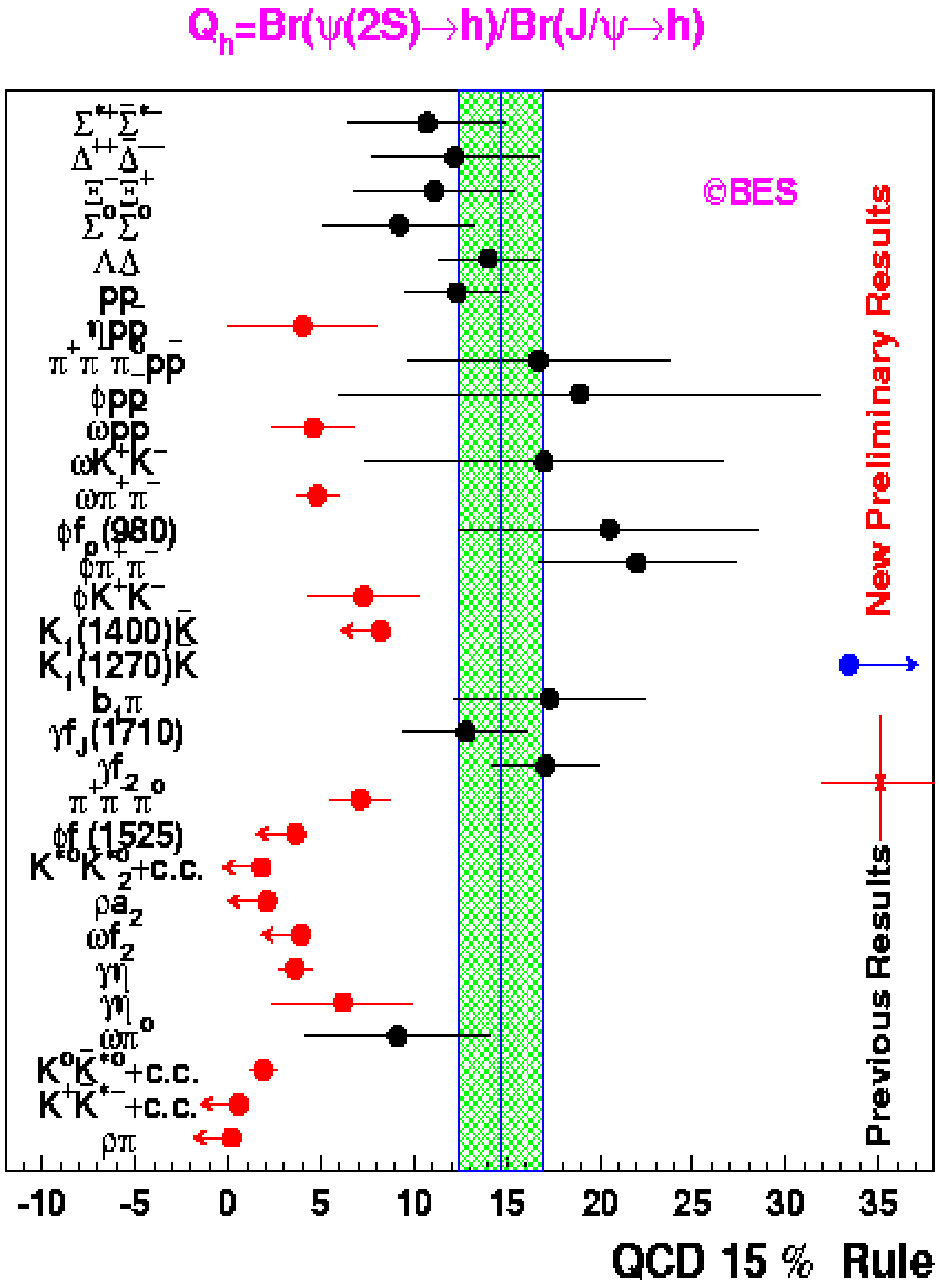
	Channel	B($\psi(2S)$) (10^{-4}) BES	B($\psi(2S)$) (10^{-4}) PDG98	Q_h (%)
AP	$b_1\pi$	$5.2 \pm 0.8 \pm 1.0$		17.3 ± 5.1
	$K_1^{\pm}(1270)K^{\mp}$	$10.0 \pm 1.8 \pm 2.1$		> 33.3
	$K_1^{\pm}(1400)K^{\mp}$	< 3.1		< 8.2
VT	ωf_2	< 1.7		< 4.0
	ρa_2	< 2.3		< 2.1
	$\phi f_2^{'}(1525)$	< 4.5		< 3.7
	$K^{*0}\overline{K_2}^{*0} + c.c$	< 1.2		< 1.8
$B\overline{B}$	$p\overline{p}$	2.16 ± 0.39	1.9 ± 0.5	10.1 ± 1.9
	$\Lambda\overline{\Lambda}$	1.81 ± 0.34	< 4	13.9 ± 2.9
	$\Sigma^0\overline{\Sigma^0}$	1.2 ± 0.6		9.4 ± 4.6
	$\Xi^-\overline{\Xi}^+$	0.94 ± 0.31	< 2	10.4 ± 4.1
	$\Delta^{++}\overline{\Delta}^{--}$	1.28 ± 0.35		11.6 ± 4.5
	$\Sigma^{*-}\overline{\Sigma}^{*+}$	1.1 ± 0.4		11 ± 4
	$\Xi^{*0}\overline{\Xi}^{*0}$	< 0.81		
	$\Omega^-\overline{\Omega}^+$	< 0.73		

- The Q_h values for many of the hadronic decays, including AP and $B\overline{B}$ modes, agree with PQCD's 15% rule.
- In $\psi(2S) \to VT$ decays, the measured branching ratios are lower than PQCD's prediction by a factor of $3 \sim 7$.
- For $\psi(2S) \to AP$ decays, we observed the first exclusive channel $\psi(2S) \to K_1(1270\overline{K}$, which is enhanced relative to the J/ψ; observed the flavor-$SU(3)$-violating $K_1(1270)$–$K_1(1400)$ asymmetries that have opposite character for the $\psi(2S)$ and J/ψ.

$$B(\psi(2S) \to K_1^{\pm}(1400)K^{\mu}) < B(\psi(2S) \to K_1^{\pm}(1270)K^{\mu})$$

$$B(J/\psi \to K_1^{\pm}(1400)K^{\mu}) > B(J/\psi \to K_1^{\pm}(1270)K^{\mu})$$

- Preliminary results observed the strong suppression of $\psi(2S) \to \rho\pi$ and $K^+\overline{K}^{*-} + c.c.$ for the VP mode.
- The branching ratio of $\psi(2S) \to K^0\overline{K}^{*0} + c.c.$ is much larger than that for charged channel. This means a strong isospin-symmetry violation.



Q_h=Br(ψ(2S)→h)/Br(J/ψ→h)
©BES
New Preliminary Results
Previous Results
QCD 15 % Rule
-10
-5
0
5
10
15
20
25
30
35

IV. χ_c states

- BES results.

Table Branching ratios of χ_c decays (Upper limits at 90% C.L.)

Channel	BES(10^{-3})	PDG98(10^{-3})
$\chi_{c0} \to \pi^+\pi^-$	$4.68 \pm 0.26 \pm 0.65$	7.5 ± 2.1
$\chi_{c2} \to \pi^+\pi^-$	$1.49 \pm 0.14 \pm 0.22$	1.9 ± 1.0
$\chi_{c0} \to K^+K^-$	$5.68 \pm 0.35 \pm 0.85$	7.1 ± 2.4
$\chi_{c2} \to K^+K^-$	$0.79 \pm 0.14 \pm 0.13$	1.5 ± 1.1
$\chi_{c0} \to p\overline{p}$	$0.159 \pm 0.043 \pm 0.053$	< 9.0
$\chi_{c1} \to p\overline{p}$	$0.042 \pm 0.022 \pm 0.028$	0.086 ± 0.012
$\chi_{c2} \to p\overline{p}$	$0.058 \pm 0.031 \pm 0.032$	0.100 ± 0.010
$\chi_{c0} \to \pi^+\pi^-\pi^+\pi^-$	$15.4 \pm 0.5 \pm 3.7$	37 ± 7
$\chi_{c1} \to \pi^+\pi^-\pi^+\pi^-$	$4.9 \pm 0.4 \pm 1.2$	16 ± 5
$\chi_{c2} \to \pi^+\pi^-\pi^+\pi^-$	$9.6 \pm 0.5 \pm 2.4$	22 ± 5
$\chi_{c0} \to \pi^+\pi^-K^+K^-$	$14.7 \pm 0.7 \pm 3.8$	30 ± 7
$\chi_{c1} \to \pi^+\pi^-K^+K^-$	$4.5 \pm 0.4 \pm 1.1$	9 ± 4
$\chi_{c2} \to \pi^+\pi^-K^+K^-$	$7.9 \pm 0.6 \pm 2.1$	19 ± 5
$\chi_{c0} \to \pi^+\pi^-p\overline{p}$	$1.57 \pm 0.21 \pm 0.54$	5.0 ± 2.0
$\chi_{c1} \to \pi^+\pi^-p\overline{p}$	$0.49 \pm 0.13 \pm 0.17$	1.4 ± 0.9
$\chi_{c2} \to \pi^+\pi^-p\overline{p}$	$1.23 \pm 0.20 \pm 0.35$	3.3 ± 1.3
$\chi_{c0} \to 3(\pi^+\pi^-)$	$11.7 \pm 1.0 \pm 2.3$	15 ± 5
$\chi_{c1} \to 3(\pi^+\pi^-)$	$5.8 \pm 0.7 \pm 1.2$	22 ± 8
$\chi_{c2} \to 3(\pi^+\pi^-)$	$9.0 \pm 1.0 \pm 2.1$	12 ± 8
$\chi_{c0} \to K^0_sK^0_s$	$1.96 \pm 0.28 \pm 0.52$	
$\chi_{c2} \to K^0_sK^0_s$	$0.61 \pm 0.17 \pm 0.16$	
$\chi_{c0} \to \phi\phi$	$0.92 \pm 0.34 \pm 0.38$	
$\chi_{c2} \to \phi\phi$	$2.00 \pm 0.55 \pm 0.61$	
$\chi_{c0} \to K^+K^-K^+K^-$	$2.14 \pm 0.26 \pm 0.40$	
$\chi_{c1} \to K^+K^-K^+K^-$	$0.42 \pm 0.15 \pm 0.12$	
$\chi_{c2} \to K^+K^-K^+K^-$	$1.48 \pm 0.26 \pm 0.32$	
$\chi_{c0} \to K^0_sK^+\pi^- + c.c$	< 0.71	
$\chi_{c1} \to K^0_sK^+\pi^- + c.c$	$2.46 \pm 0.44 \pm 0.65$	
$\chi_{c2} \to K^0_sK^+\pi^- + c.c$	< 1.06	
$\Gamma_{\chi_{c0}}(MeV)$	$14.3 \pm 2.0 \pm 3.0$	$13.5 \pm 3.3 \pm 4.2$

- E760 and E835 results.

	$B(\chi_{c0} \to p\bar{p})$ [10^{-4}]	$B(\chi_{c1} \to p\bar{p})$ [10^{-4}]	$B(\chi_{c2} \to p\bar{p})$ [10^{-4}]
E760		$0.86 \pm 0.10 \pm 0.11$	1.00 ± 0.08
BES	$1.59 \pm 0.43 \pm 0.53$	$0.42 \pm 0.22 \pm 0.28$	$0.58 \pm 0.31 \pm 0.32$
E835	$4.8 \pm 0.9 \pm 0.2$		
E835	$5.5 \pm 0.4 \pm ?$	$0.87 \pm 0.08 \pm ?$	$0.89 \pm 0.08 \pm ?$
PDG	2.2 ± 1.3	0.82 ± 0.13	0.98 ± 0.10

about η_c'

- Crystal Ball collaboration observed η_c' at $M = 3592 \pm 5$ MeV and $B(\psi(2S) \to \gamma\eta_c' \geq 1 \times 10^{-3}$.

- no other experiments confirm this existence yet.

about $^1P_1$ state

The mass shift of $^1P_1$ state to $^3P_1$ states is very important for establishing the nature of the spin-dependent forces in QCD.

- R704 at CERN observed a cluster of 5 events in an inclusive scan for $p\bar{p} \to J/\psi + X$. $M = 3525.4 \pm 0.8$ MeV.

- E760 at Fermilab searched for the $^1P_1$ state formed in $p\bar{p}$ annihilations to $J/\psi + \pi^0$ and $J/\psi + 2\pi$ final states. A statistically significant enhancement in the $p\bar{p} \to J/\psi + \pi^0$ was observed at $\sqrt{s} = 3526.2$MeV (59 events). No candidates for $p\bar{p} \to J/\psi + \pi^0\pi^0$ and $J/\psi + \pi^+\pi^-$.

- E705 at Fermilab observed a 2.5σ enhancement in the $J/\psi + \pi^0$ spectrum in 300GeV/c $\pi^\pm$ and proton beams to Li interactions. $M = 3527 \pm 8$ MeV. (42 events)

V. Hadronic decays of J/ψ

1. $J/\psi \to VP$

- The well measured set of all possible decays of the J/ψ into pairs of vector and pseudoscalar pairs allows:

  – systematically study quark and gluon contents of the pseudoscalar mesons;

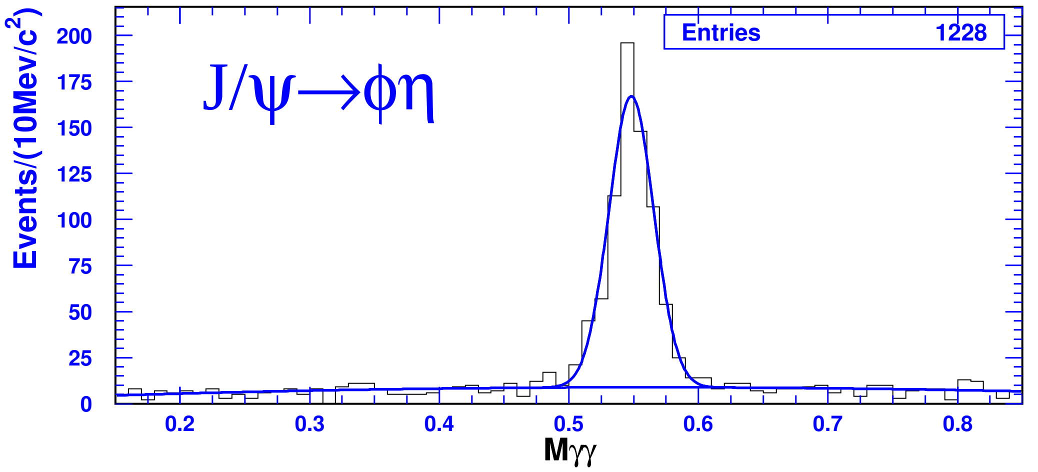
  – study the effect of SU(3) breaking and electromagnetic amplitudes in two-body decays of J/ψ.

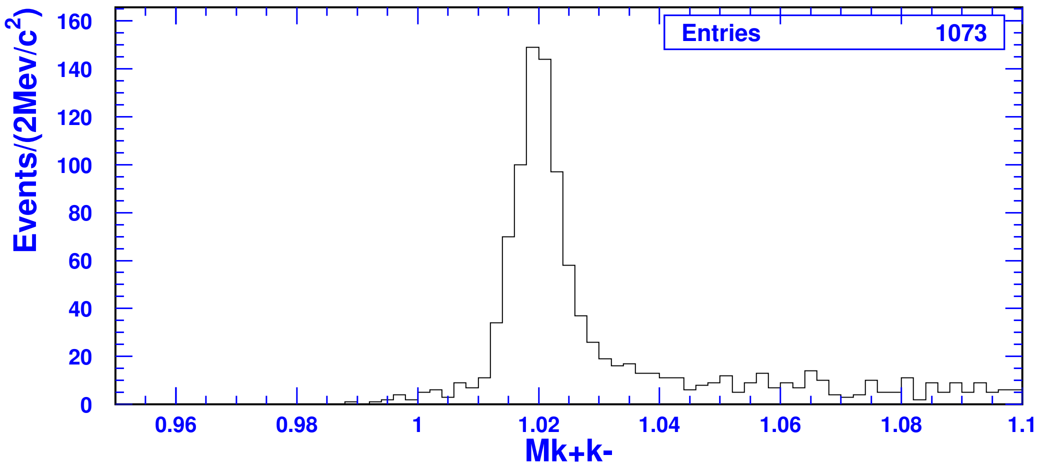
- MarkIII, DM2 and BESI systematically studied $J/\psi \to VP$ channels.

- Using 24×10^6 J/ψ events, BES studied $J/\psi \to VP$ channels again.

$J/\psi \to \phi\eta$ $(24 \times 10^6\ J/\psi)$

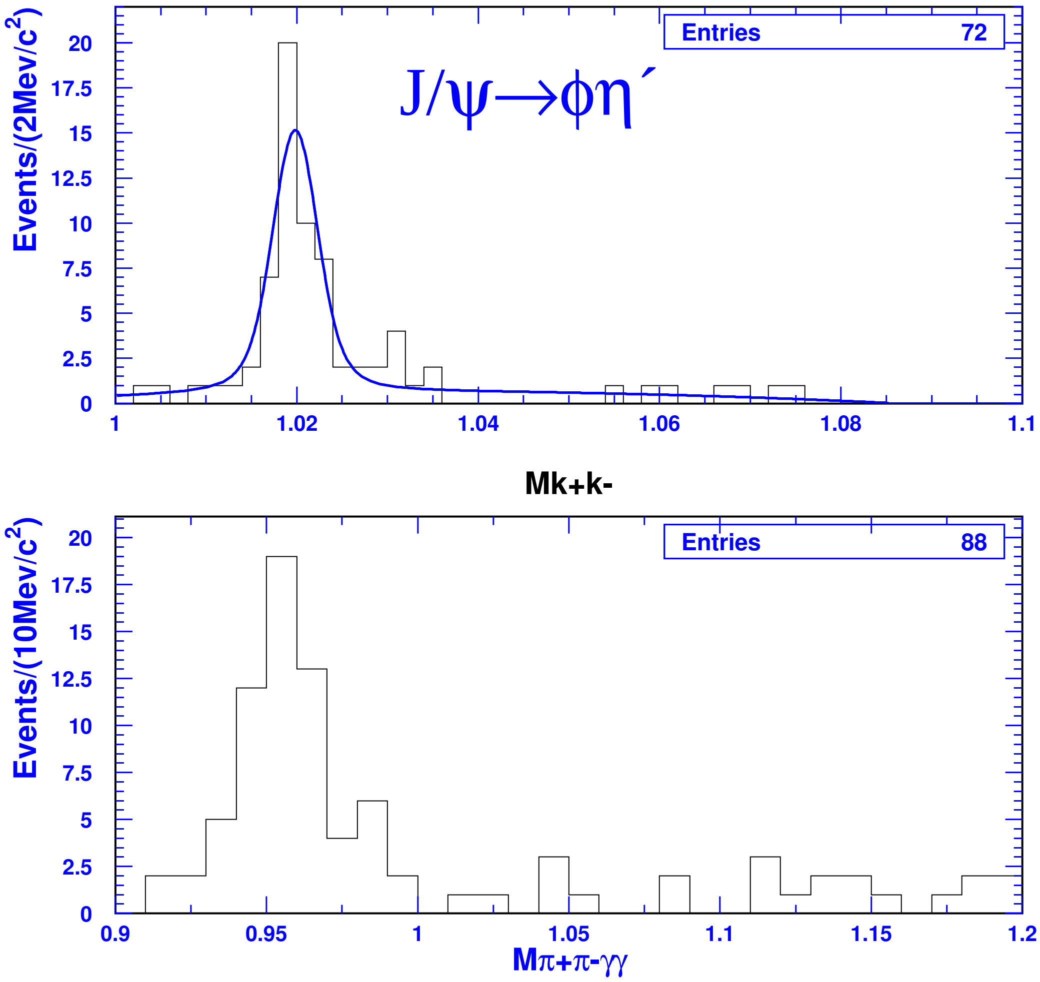
(Preliminary!)





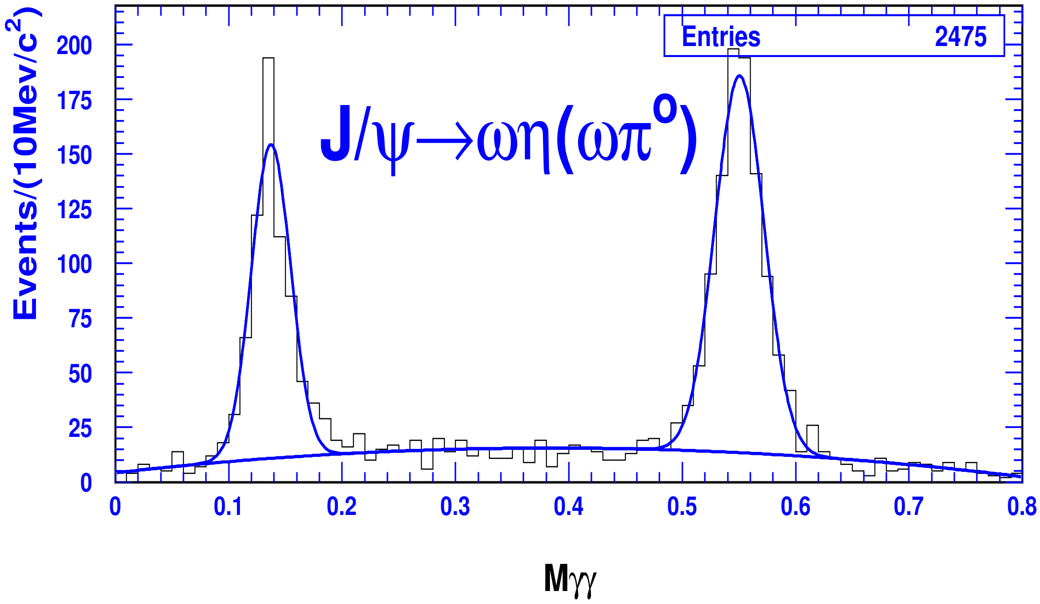
$J/\psi \to \phi\eta'$ (24×10^6 J/ψ)

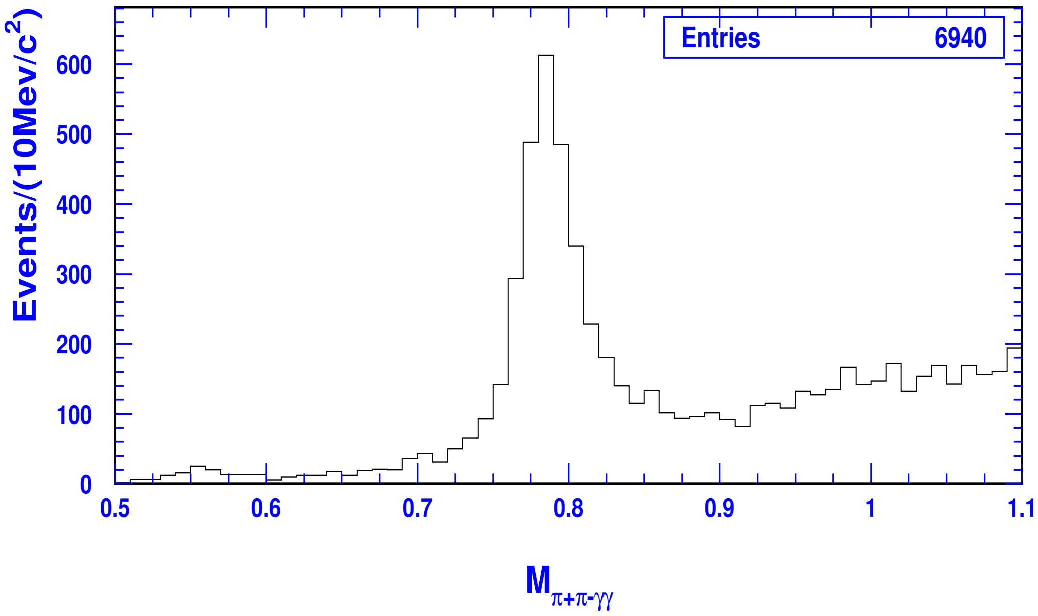
(Preliminary!)



$J/\psi \to \omega\pi^0(\omega\eta)$ $(24 \times 10^6\ J/\psi)$

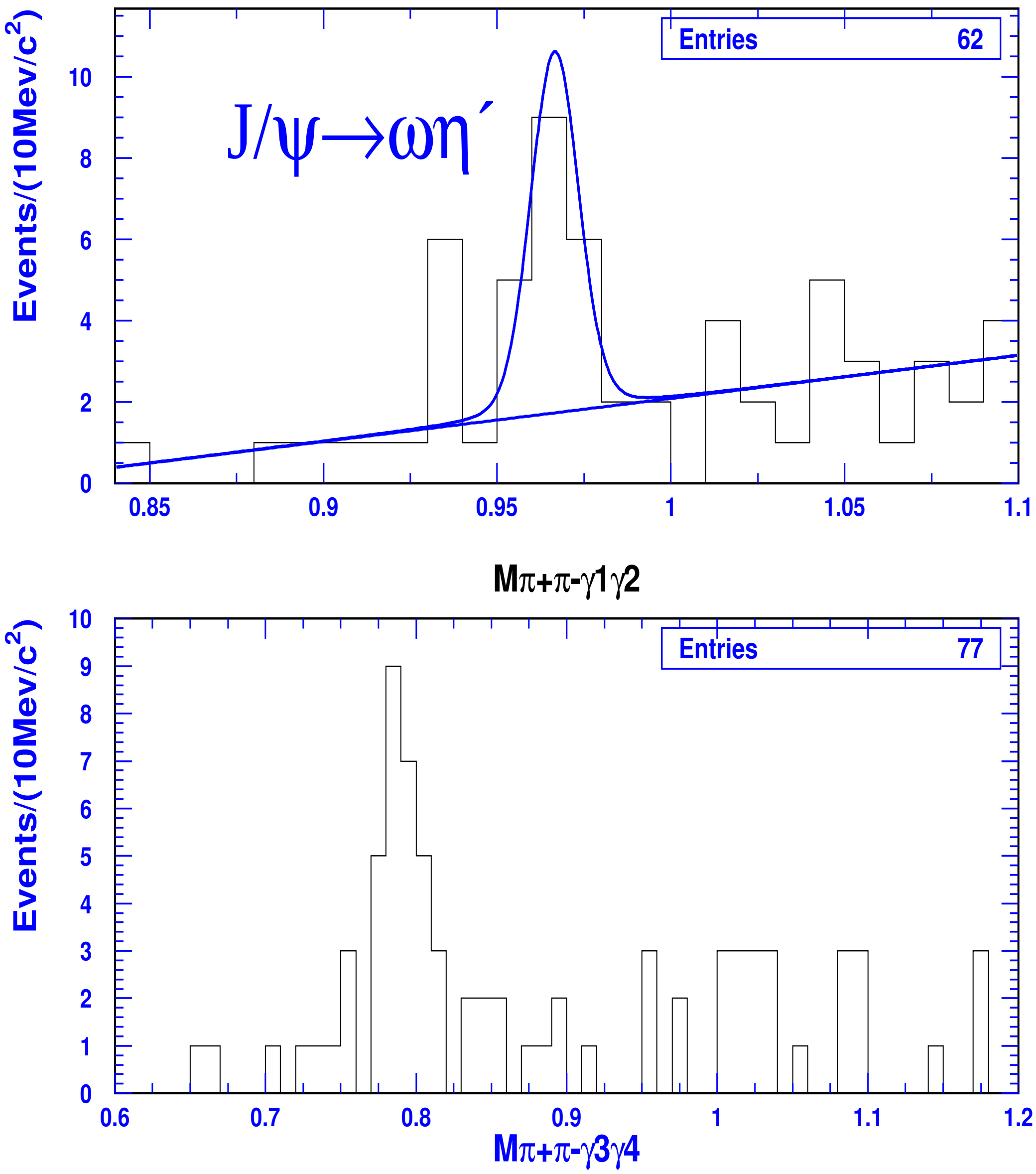
(Preliminary!)





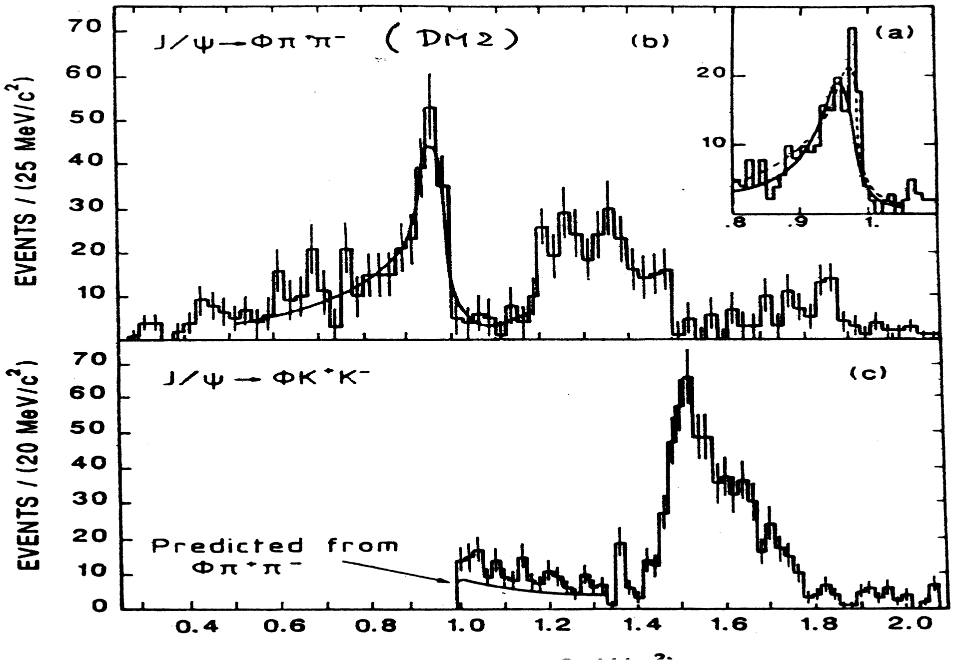
$J/\psi \to \omega\eta'$ $(24 \times 10^6 J/\psi)$

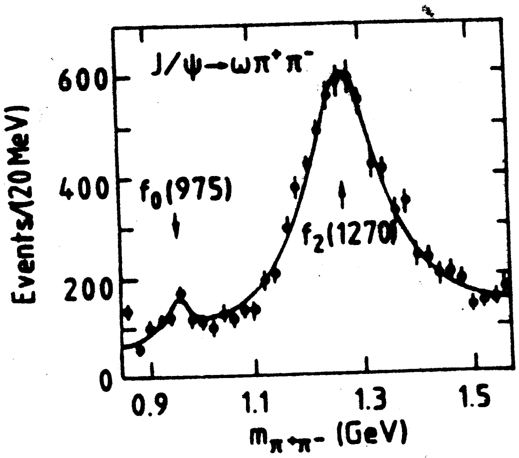
(Preliminary!)

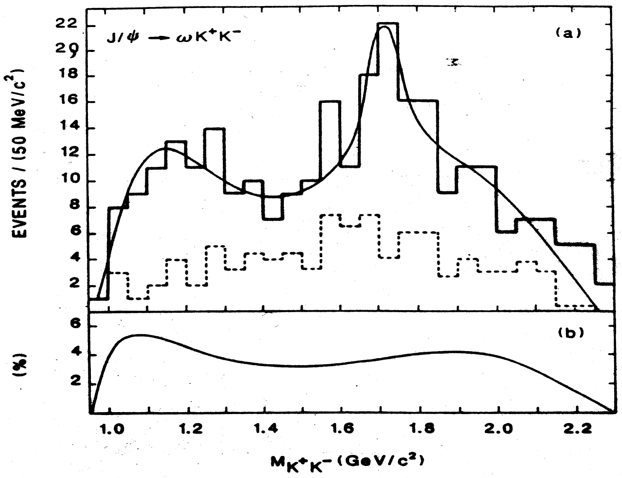


2. 3-body hadronic decays of J/ψ

Both MarkIII and DM2 analyzed $J/\psi \to \phi\pi^+\pi^-$, ϕK^+K^-, $\omega\pi^+\pi^-$ and ωK^+K^- for the study of $f_0(980)$, $f_2'(1525)$ and the structure around 1.7 GeV.







With 7.8×10^6 BESI and 24×10^6 BESII J/ψ events, BES analyzed $J/\psi \to \omega\pi^+\pi^-$, ωK^+K^-, $\phi\pi^+\pi^-$ and ϕK^+K^- channels.

$J/\psi \to \omega\pi^+\pi^-$

- The σ is required as $\pi\pi$ S-wave in $\pi\pi$ scattering exps.
- Linear σ model predicts:

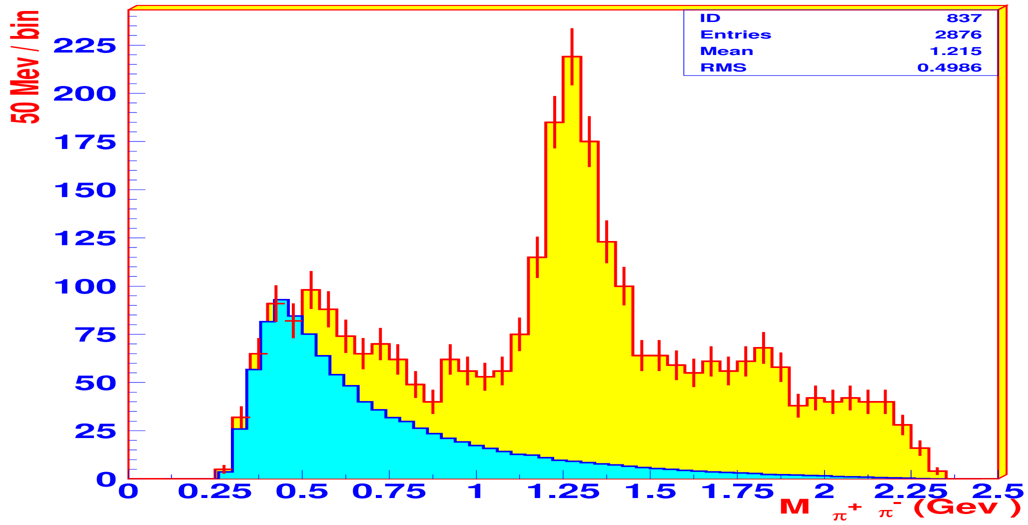
$$M_\sigma = 2M_g \sim 500 - 600 MeV$$

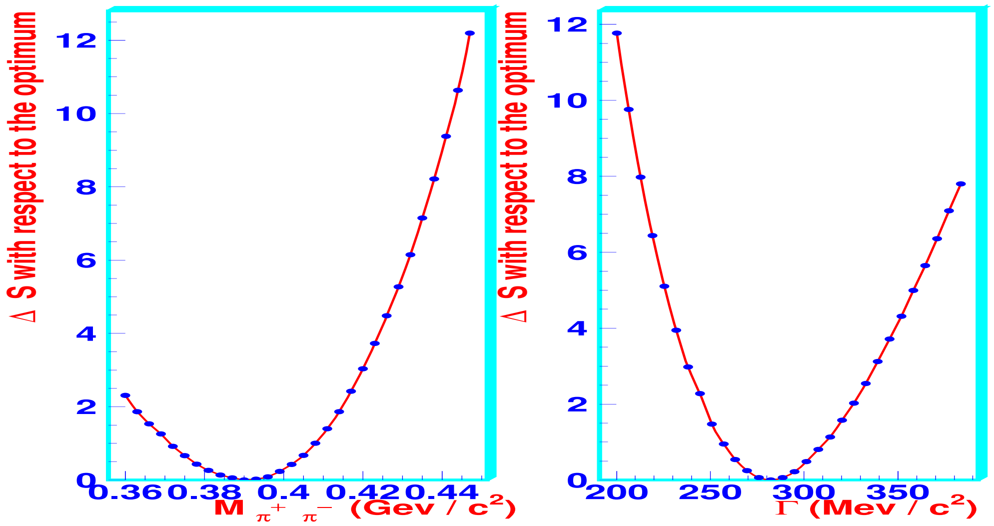
$$\Gamma_\sigma \sim 400 - 800 MeV$$

- However, the existence of σ as a resonance has not been generally accepted.
- DM2, MARKIII and BES all found a broad structure in $J/\psi \to \omega\pi^+\pi^-$

BESI $7.8 \times 10^6 J/\psi$ **data (PWA)**

(Preliminary!)



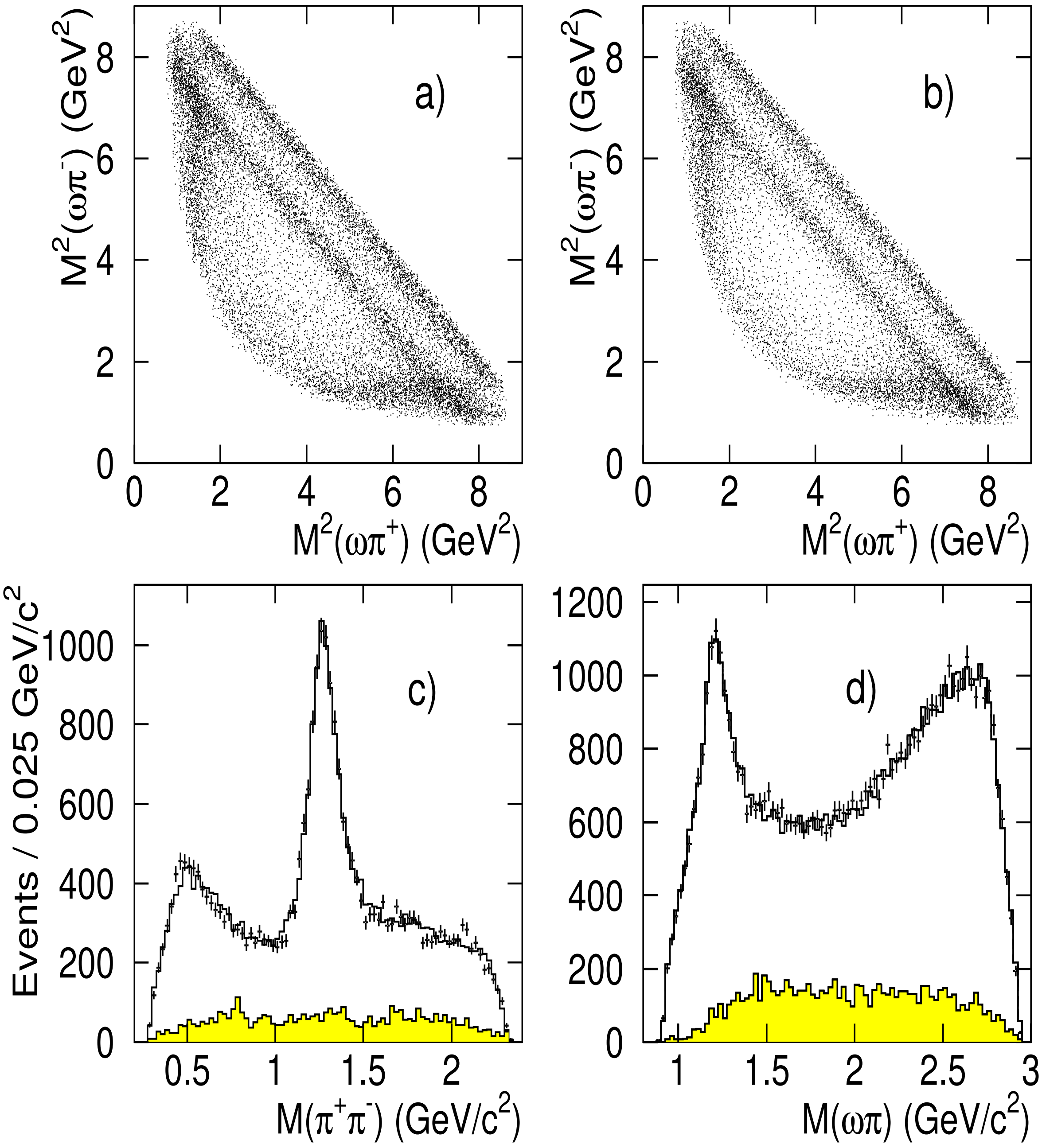


- a 0^{++} BW is required in the lower mass region.

- a strong $f_2(1270)$ with the mass and width being in good agreement with PDG values.

BESII $24 \times 10^6 J/\psi$ data (PWA)

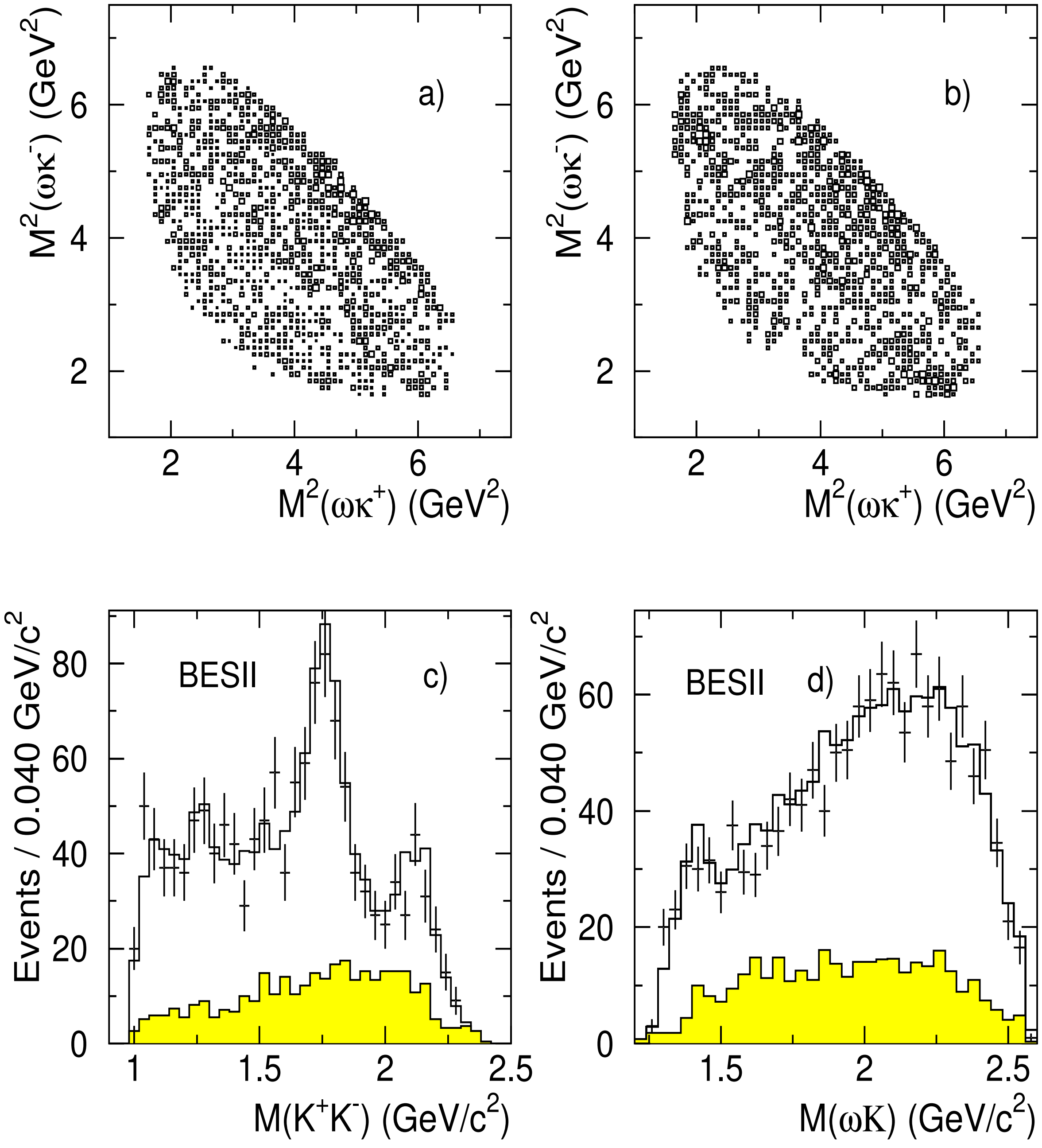
(Preliminary!)



$J/\psi \to \omega K^+K^-$ (BESII $24 \times 10^6 J/\psi$)

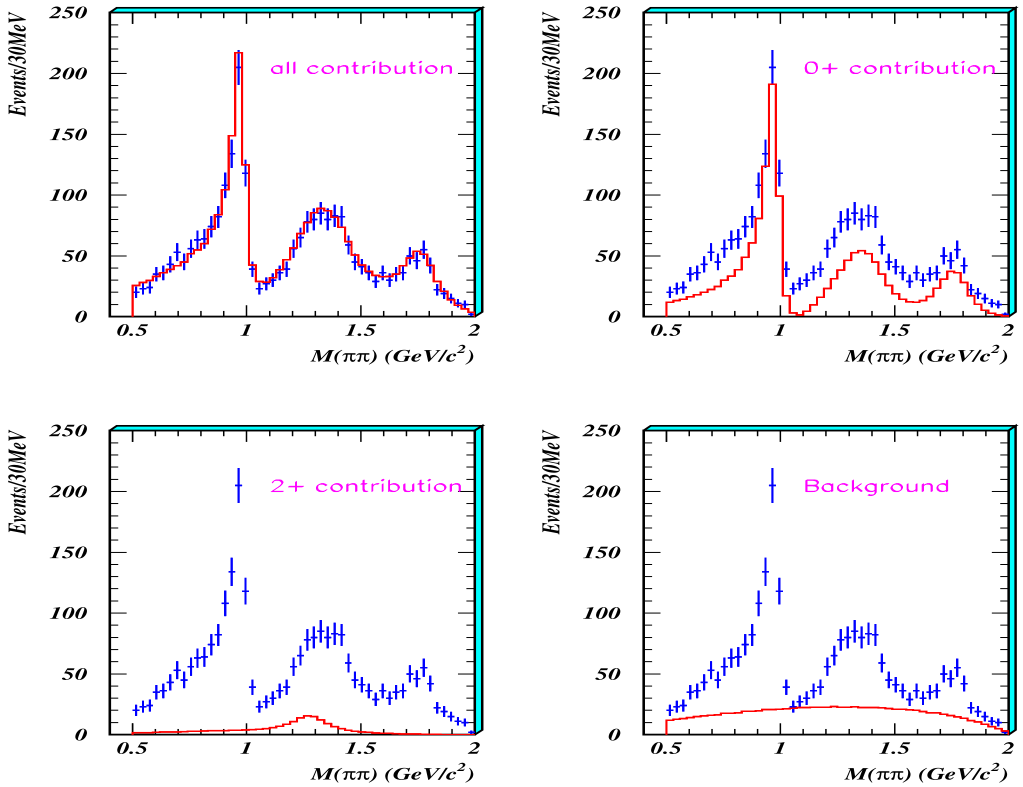
(Preliminary!)

This channel is important for the structure around 1.7 GeV.



$J/\psi \to \phi\pi^+\pi^-$ (BESII $24 \times 10^6 J/\psi$)

(Preliminary!)



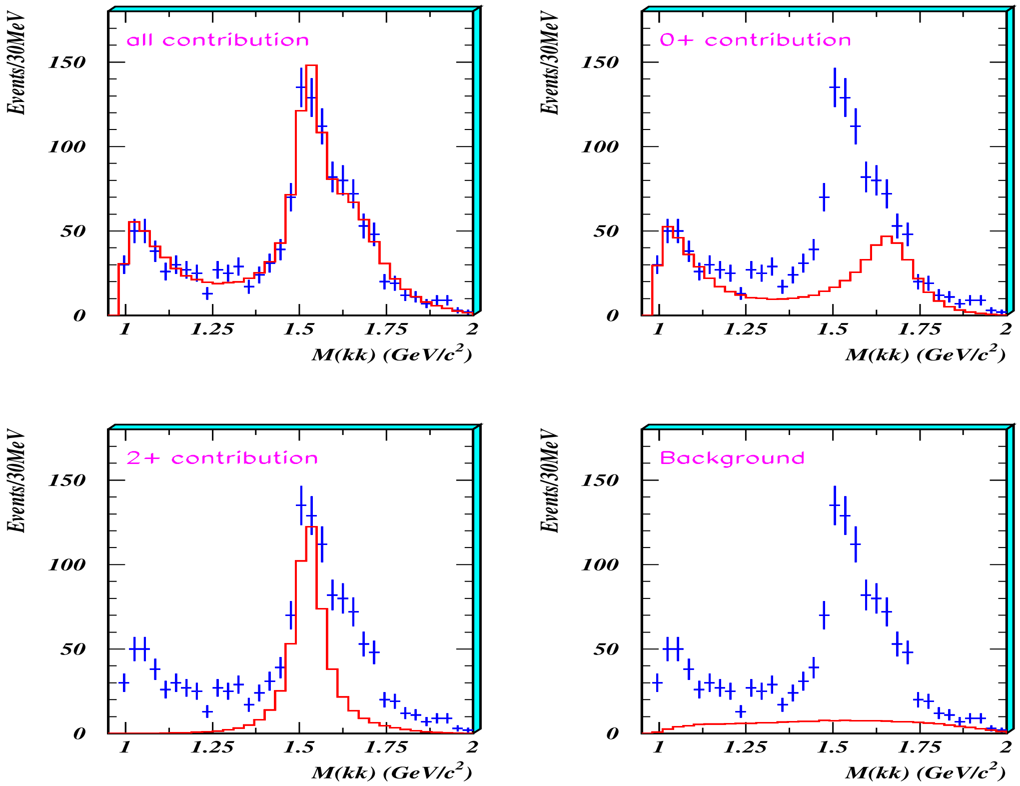
$\Longrightarrow$ a strong $f_0(980) \to \pi^+\pi^-$, peaked at the mass of 980 MeV.

$\Longrightarrow$ a 0^{++} signal at around M=1335 MeV,

$\Longrightarrow$ a 0^{++} at around M=1770 MeV.

$J/\psi \to \phi K^+K^-$ (BESII $24 \times 10^6 J/\psi$)

(Preliminary!)



$\Longrightarrow$ a tail of $f_0(980)$ around 1.0 GeV.

$\Longrightarrow$ a strong $f_2'(1525)$

$\Longrightarrow$ a component on the shoulder of $f_2'(1525)$ might come from the misidentifying of K.

3. Study of the excited baryon states

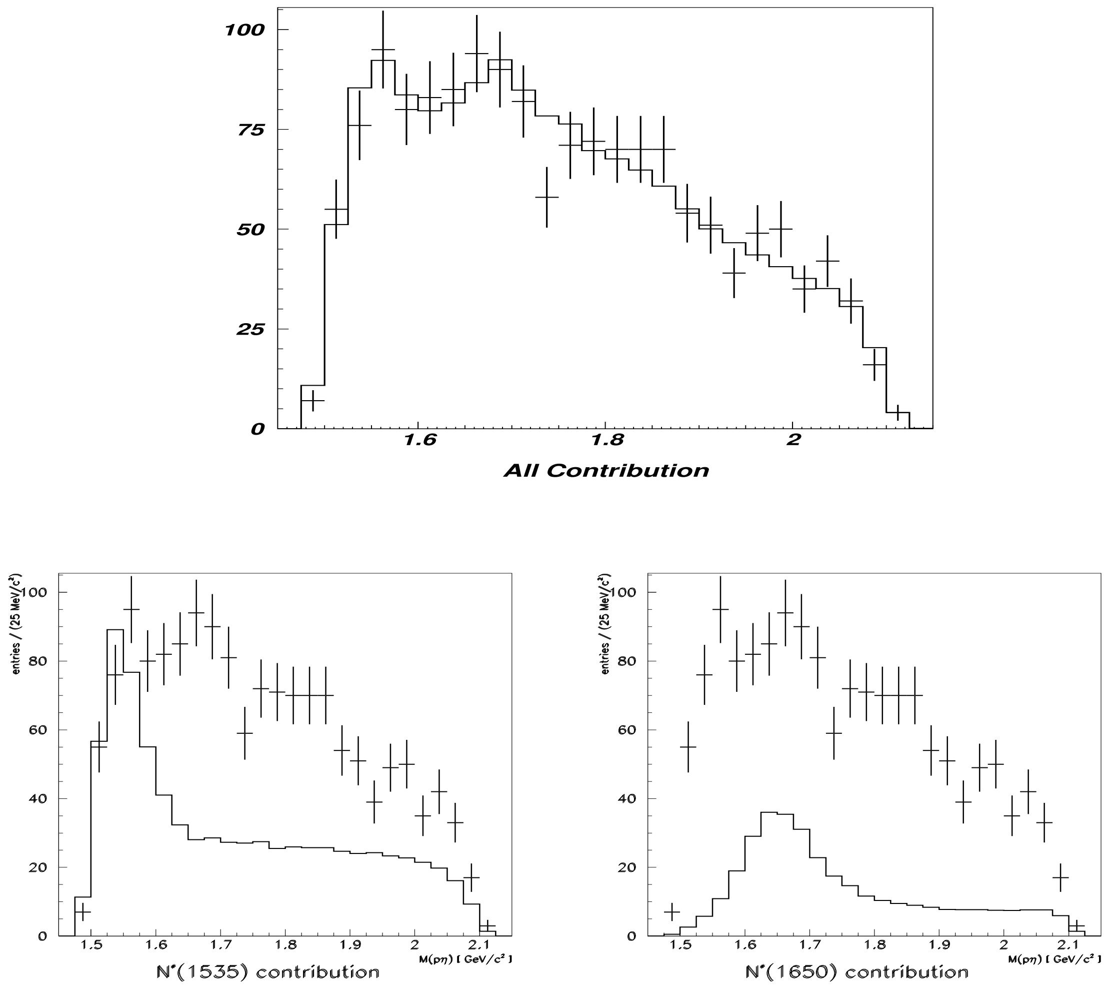
motivation

- 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.

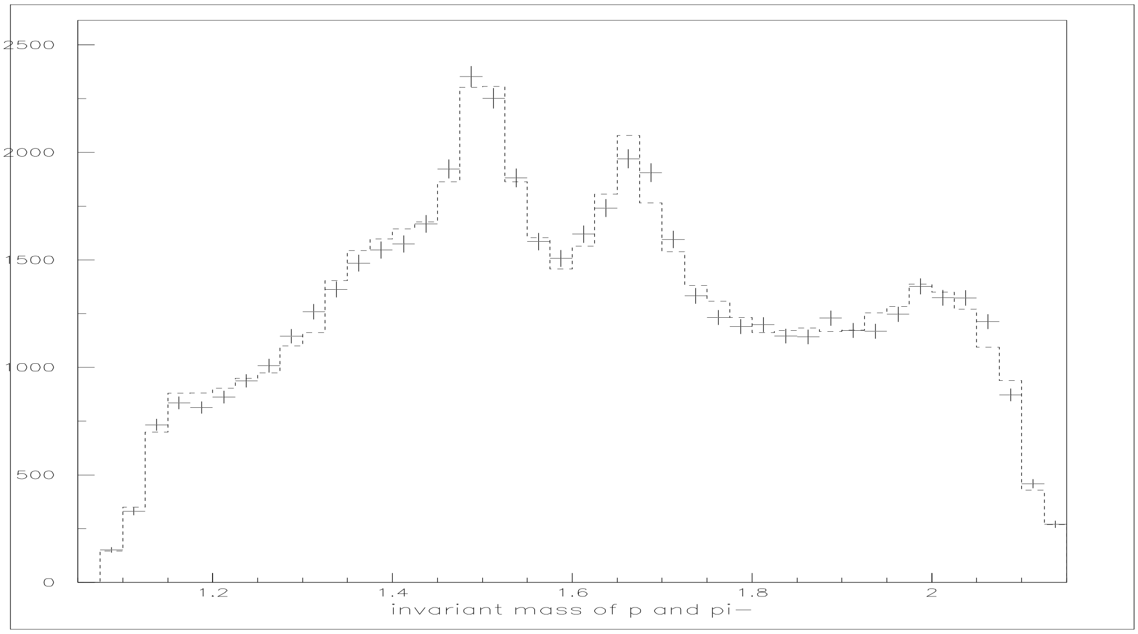
$J/\psi \to p\bar{p}\eta$ (BESI $7.8 \times 10^6 J/\psi$)



- A clear enhancement near $p\eta(\bar{p}\eta)$ threshold with $J^P = \frac{1}{2}^-$, $M = 1530 \pm 10$ MeV and $\Gamma = 95 \pm 25$ MeV.
- A peak at $M = 1647 \pm 20$ MeV and $\Gamma = 145^{+80}_{-45}$ MeV with $J^P = \frac{1}{2}^-$.
- These two N^* resonances are believed to be the two well established states $S_{11}(1535)$ and $S_{11}(1650)$.

$J/\psi \to p\pi^-\bar{n}$ (BESII $24 \times 10^6 J/\psi$)

(Very Preliminary!)



- The first peak are the contributions from $N^*(1535)(\frac{1}{2}^-)$ and $N^*(1520)(\frac{3}{2}^-)$.

- The second peak are mainly from $N^*(1675)(\frac{5}{2}^-)$ and $N^*(1680)(\frac{5}{2}^+)$.

VI. Summary

- the measurements of charmonium states' parameters mainly from E760, E835, CLEO, LEP and BES.

- recent ψ' scan results from BES.
- the hadronic decay results of $\psi(2S)$ from BES.
- the study of χ_{cJ} from BES $\psi(2S)$ data.

- the study of $J/\psi \to Vector + Pseudoscalar$ processes with BESII $24 \times 10^6 J/\psi$ events.
- PWA analyses of $J/\psi \to \phi\pi^+\pi^-$, ϕK^+K^-, $\omega\pi^+\pi^-$ and ωK^+K^- with BESI $7.8\times10^6 J/\psi$ and BESII $24 \times 10^6 J/\psi$ samples.
- the study of the excited baryon states from J/ψ decays.