Recent Physics results from BESII and Future BEPCII/BESIII project

Changchun Zhang
Institute of High Energy Physics, Beijing
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3. J/ψ radiative decays
4. New measurements of $\psi(2s)$, η_c and χ_{cJ} states
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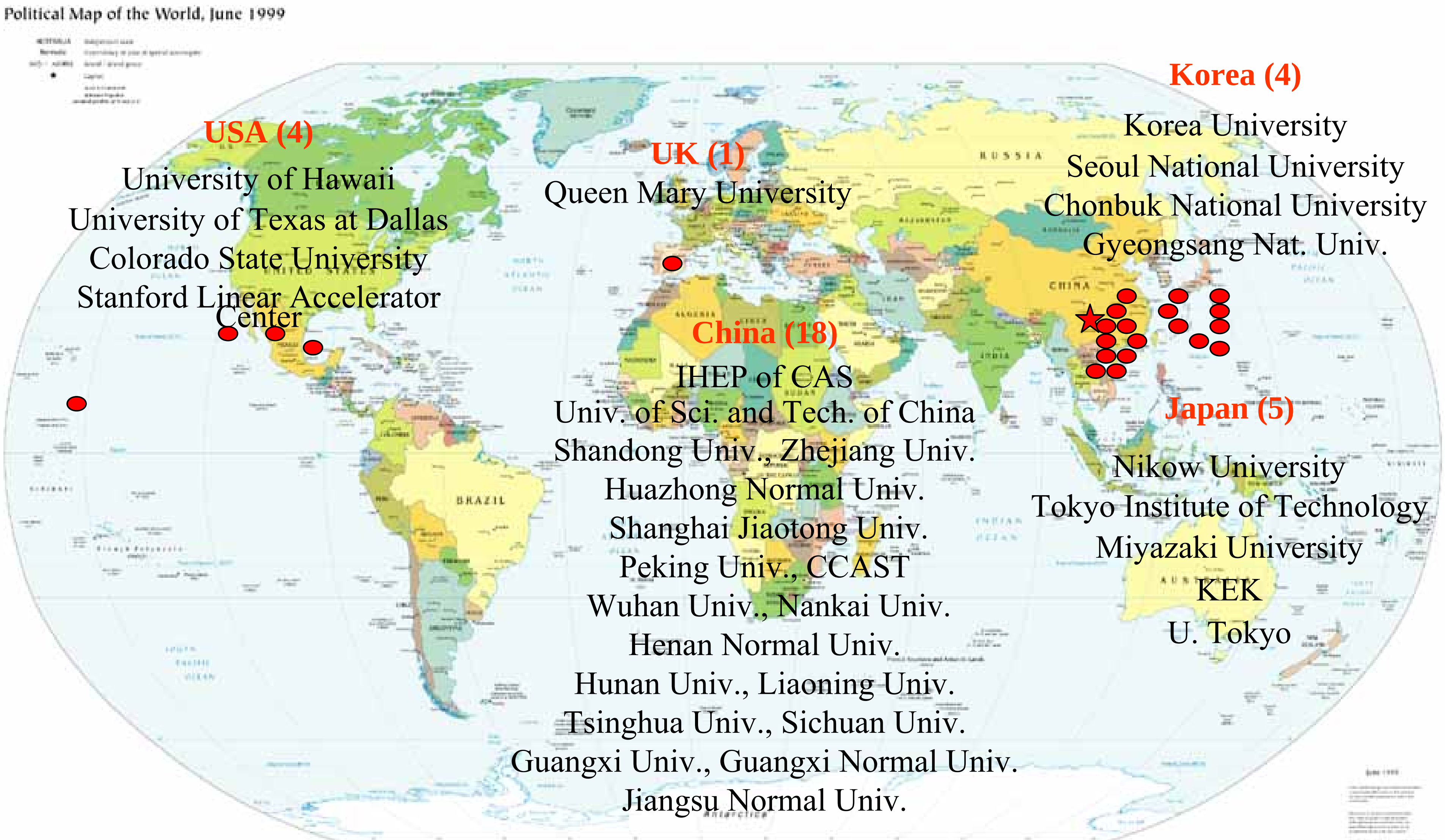
6. Summary

The Beijing Electron Positron Collider (BEPC)

- **Single bunch, E_{cm}~2-5 GeV,L ~ $1x10^{31}$ /cm^2·s at 3.68 GeV**
- **5-6 months/year for HEP**
- **140mA @ 2.2 GeV, 3 month/year for synchrotron radiation run**

The BES Collaboration



USA (4)

University of Hawaii
University of Texas at Dallas
Colorado State University
Stanford Linear Accelerator Center

UK (1)

Queen Mary University

China (18)

IHEP of CAS
Univ. of Sci. and Tech. of China
Shandong Univ., Zhejiang Univ.
Huazhong Normal Univ.
Shanghai Jiaotong Univ.
Peking Univ., CCAST
Wuhan Univ., Nankai Univ.
Henan Normal Univ.
Hunan Univ., Liaoning Univ.
Tsinghua Univ., Sichuan Univ.
Guangxi Univ., Guangxi Normal Univ.
Jiangsu Normal Univ.

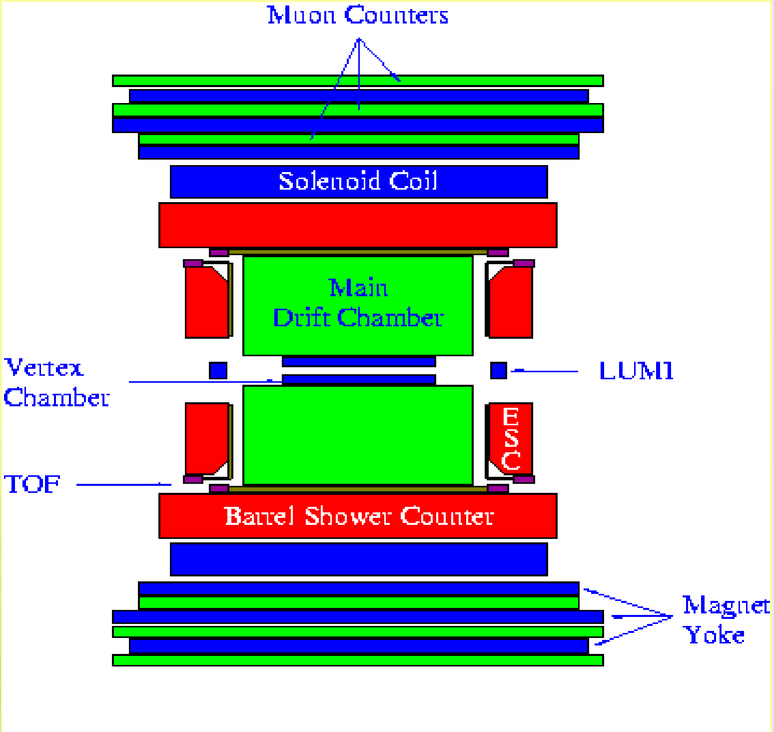
Korea (4)

Korea University
Seoul National University
Chonbuk National University
Gyeongsang Nat. Univ.

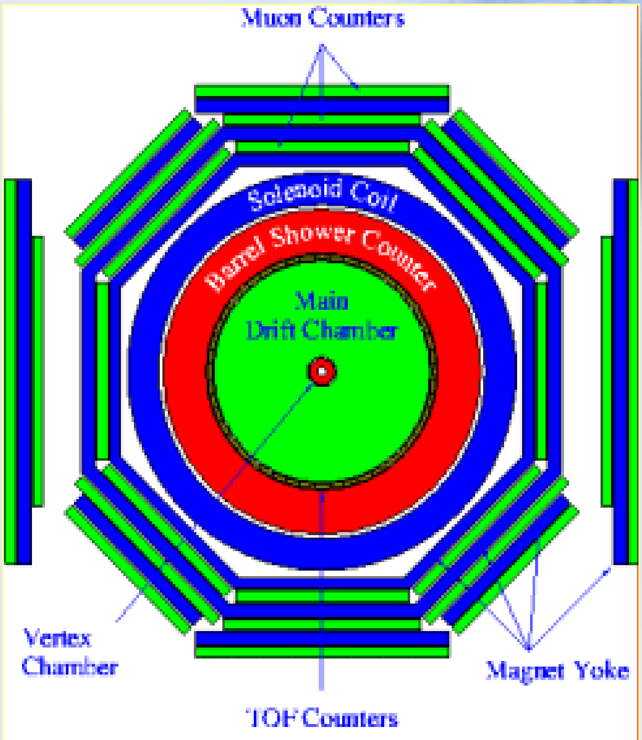
Japan (5)

Nikow University
Tokyo Institute of Technology
Miyazaki University
KEK
U. Tokyo

BESII Detector



Side view of the BES detector



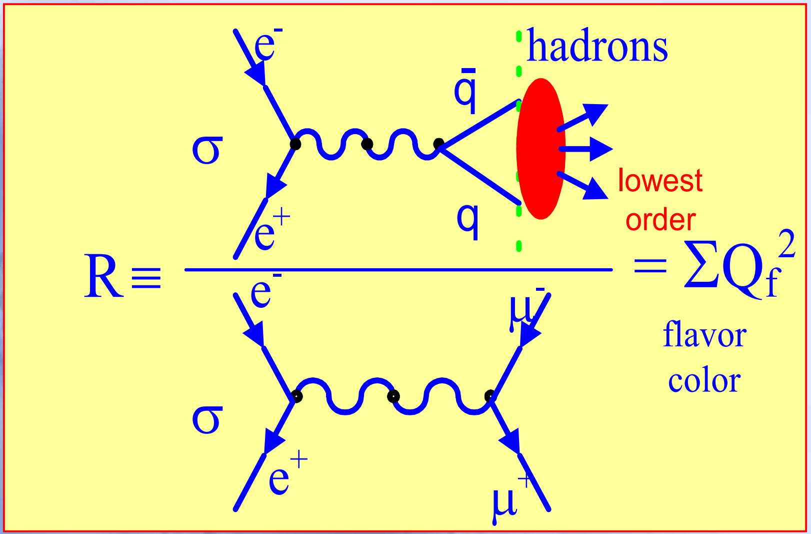
End view of the BES detector

VC:	$\sigma_{xy} = 100\ \mu m$	TOF:	$\sigma_T = 180$ ps	μ counter:	$\sigma_{r\phi} = 3$ cm
MDC:	$\sigma_{xy} = 220\ \mu m$	BSC:	$\Delta E/\sqrt{E} = 22\ \%$		$\sigma_z = 5.5$ cm
	$\sigma_{dE/dx} = 8.5\ \%$		$\sigma_\phi = 7.9$ mr	B field:	0.4 T
	$\Delta p/p = 1.7\sqrt{(1+p^2)}$		$\sigma_z = 2.3$ cm		

R Measurement in 2-5 GeV

R : directly counts

- * number of quarks
- * flavor
- * colors



Experimentally

$$R = \frac{1}{\sigma_{\mu^+\mu^-}} \cdot \frac{N_{had} - N_{bg}}{L \cdot \varepsilon_{had} \cdot (1+\delta)}$$

N_{had}: observed hadronic events

N_{bg}: background events

L: integrated luminosity

ε_{had}: detection efficiency for N_{had}

δ: radiative correction

Motivations

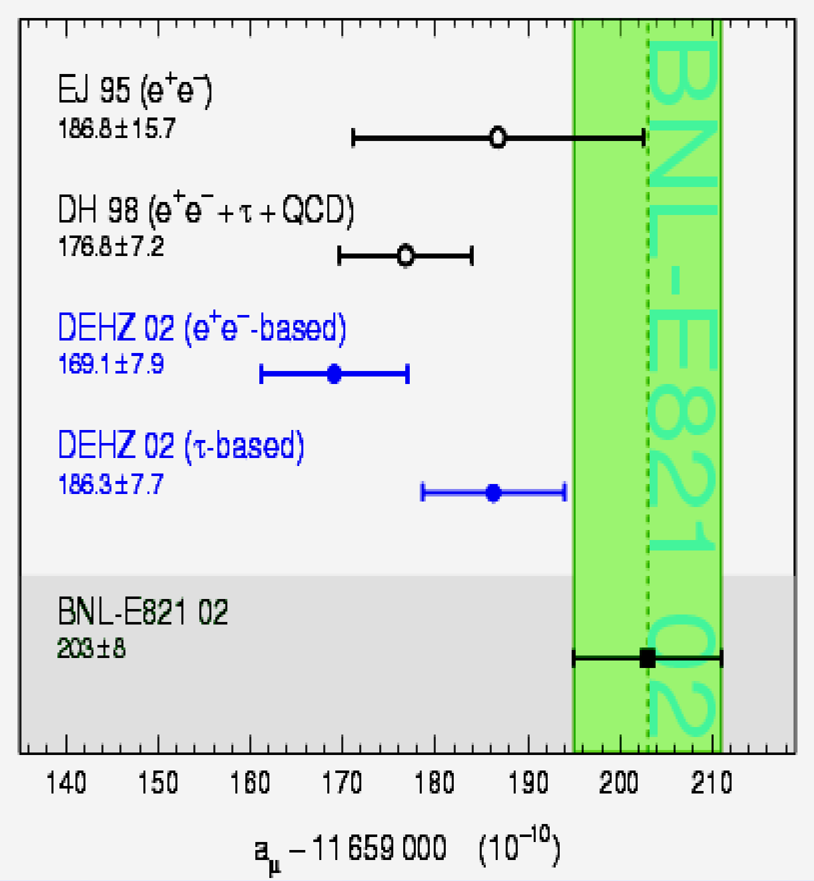
- Hunting for new physics from $a_\mu \equiv (g-2)/2$ (muon magnetic anomaly)

  derivation between →

  E821 at BNL and prediction

$$a_\mu^{SM} = a_\mu^{QED} + a_\mu^{had} + a_\mu^{weak}$$

$$a_\mu^{had,LO} = \frac{\alpha^2(0)}{3\pi^2} \int_{4m_\pi^2}^{\infty} ds \frac{K(s)}{s} R(s)$$



M. Davier et al., hep-ph/0208177.

- Uncertainty in calculation
  - mostly from S < 2 GeV region
  - 2nd largest of 2-5GeV

B.Pietrzyk et al., talks at ICHEP2000

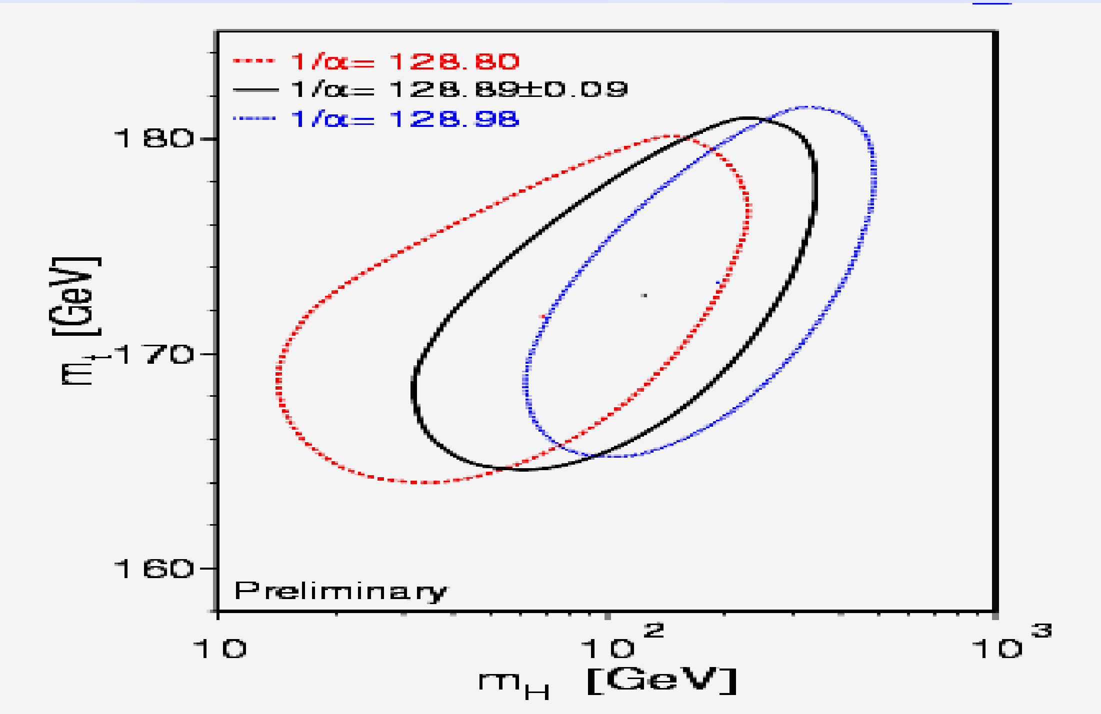
A.Martin et al., PLB 492,69(2000)

Motivations

- Perfect consistency between global fits and the SM

(B Pietrzyk, talk at ICHEP2000)

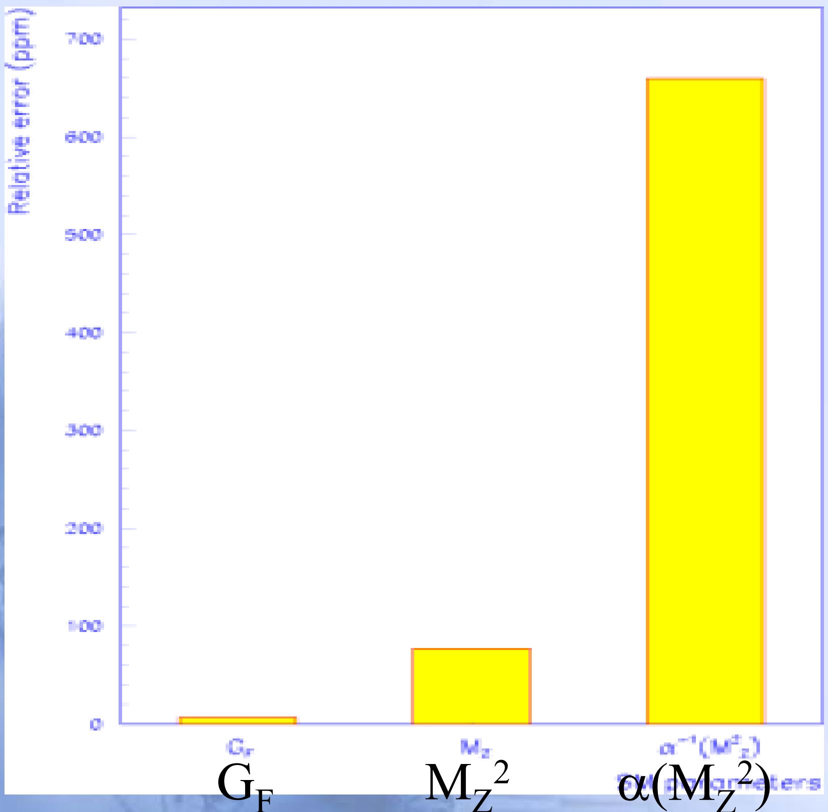
- The Higgs mass can be
  - determined from radiative corrections in the SM
  - mainly depends on the top mass and $\alpha(M^2_Z)$.



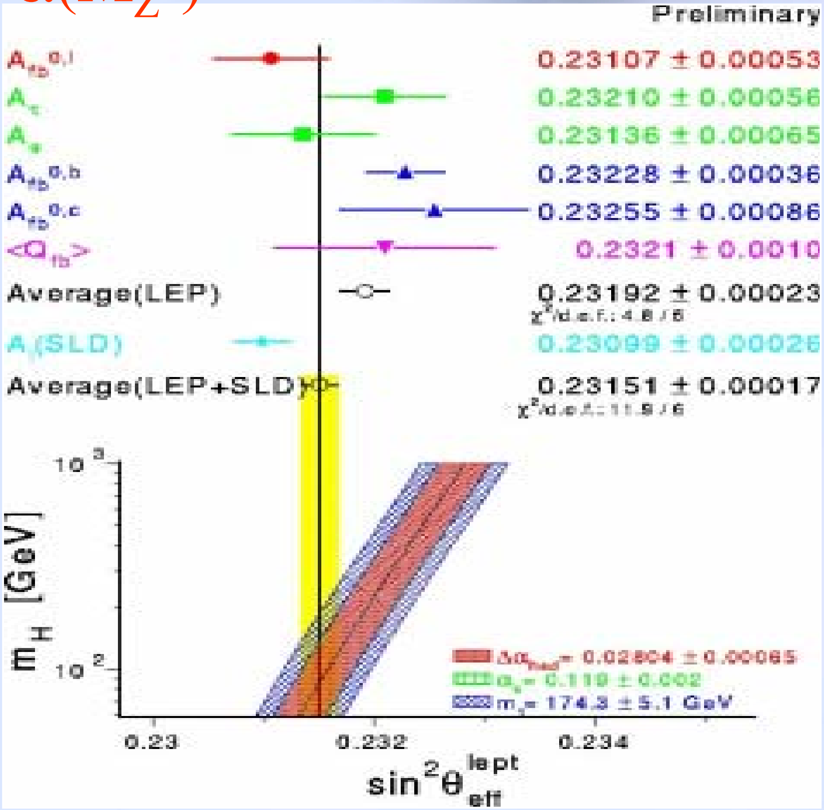
B. Pietrzyk and H. Burkhardt (1997).

Motivations

Relative uncertainties of three input parameters in the SM fit



Indirect determination of m_H depends critically on precision of $\alpha(M_Z^2)$



Motivations

- Reducing the uncertainty of $\alpha(M_Z^2)$
  - essential for precision tests of the SM

$$\alpha \equiv \alpha_0 / (1 - \Delta\alpha)$$

$$\Delta\alpha(s) = \Delta\alpha(s)_{lep} + \Delta\alpha(s)_{had}$$

	calculated	measured
at M_Z^2	0.03142	0.0280±0.0009

$$\Delta\alpha_{had}(M_Z^2) = -\frac{\alpha(0) M_Z^2}{3\pi} \mathrm{Re} \int_{4m_\pi^2}^{\infty} ds \frac{R(s)}{s(s - M_Z^2) - i\varepsilon}$$

- Dominant uncertainty due to effects of vacuum polarization
- Measured R values are input to dispersion integral

BES R Measurement

ISR: remove high order effects from σ_{had}^{obs}

Leading order [O(α^2)]

$$\sigma_{had}^{obs} = \sigma_{had}^{0} \cdot \bar{\varepsilon}_{had} \cdot (1+\delta)$$

all high order contributions

Runs

Year	E (GeV)	Pts	Single Beam Pts	Separated Beam Pts	Time Spent (days)
1998	2.6 - 5.0	6	1	6	40
1999	2.0 - 4.8	85	7	24	105

~ 1000 hadronic events per energy point

Initial States Radiative Correction

- Four schemes are compared to calculate ISR.

  (1) G. Bonneau and F. Martin, NP B 27(1971)387
  (2) F.A. Berends and R. Kleiss, NP B 178(1981)14
  (3) E. A. Kuraev and V.S. Fadin, Sov. J. NP 41(1985)3
  (4) A. Osterheld et al., SLAC-PUB-4160, 1986. (T/E)

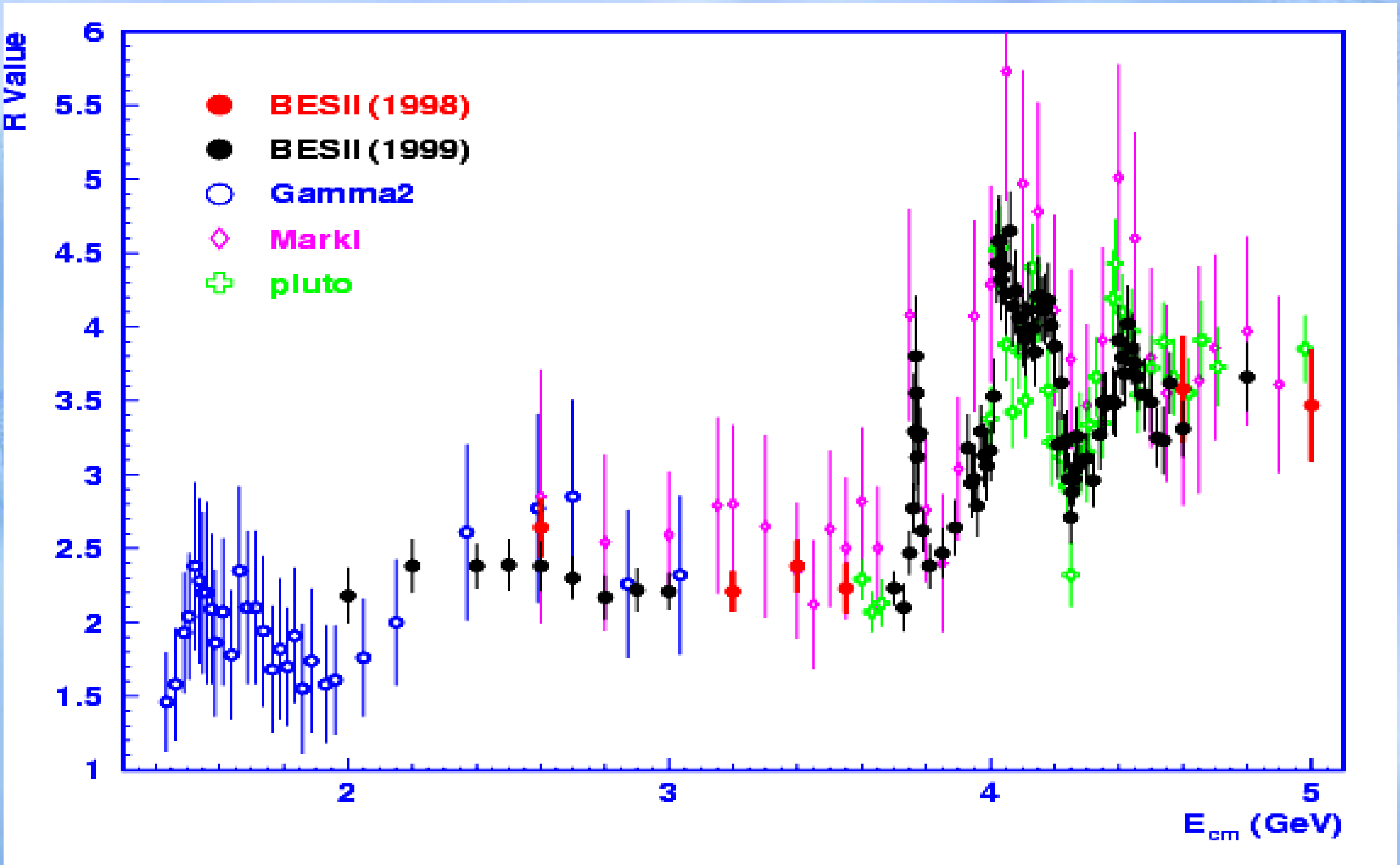
- (2) + multi-soft photon = (4)

- (1) and (4) are consistent

  within 1% in the continuum region,

  1-3% above charm threshold

BES R-scan



Results published:

J.Z. Bai et.al., Phys. Rev. Lett. **88**, 101802 (2002).

69 citations so far

Systematic Error in R

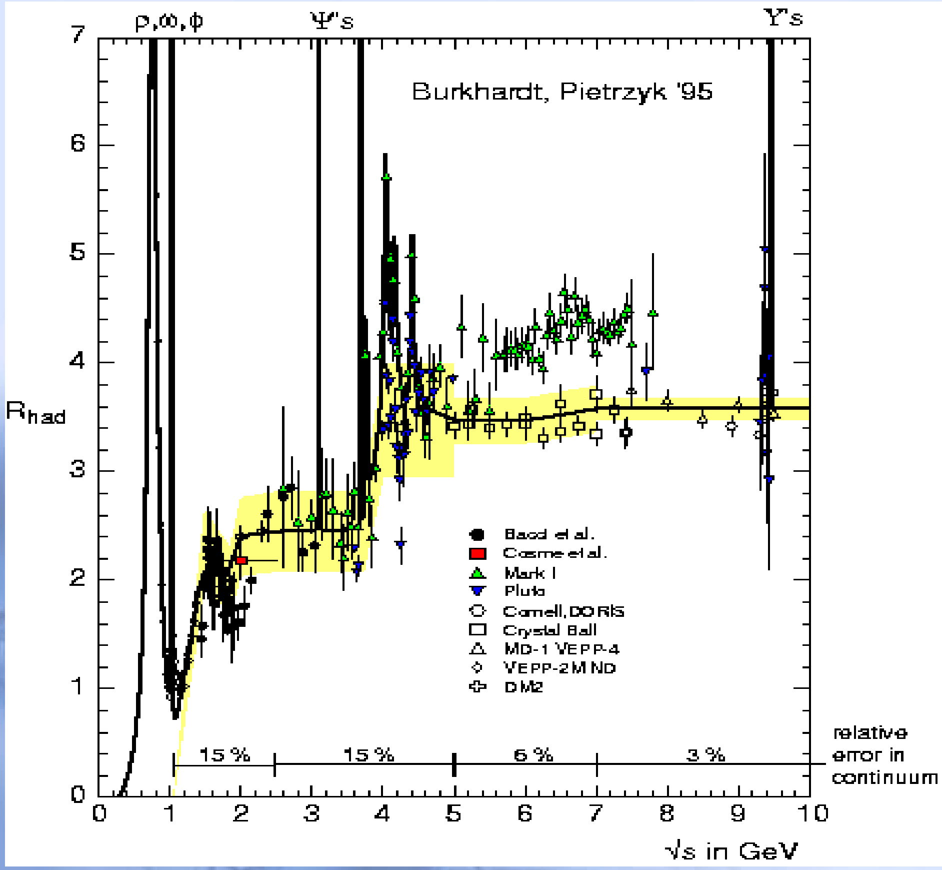
Contributions to systematic error in %

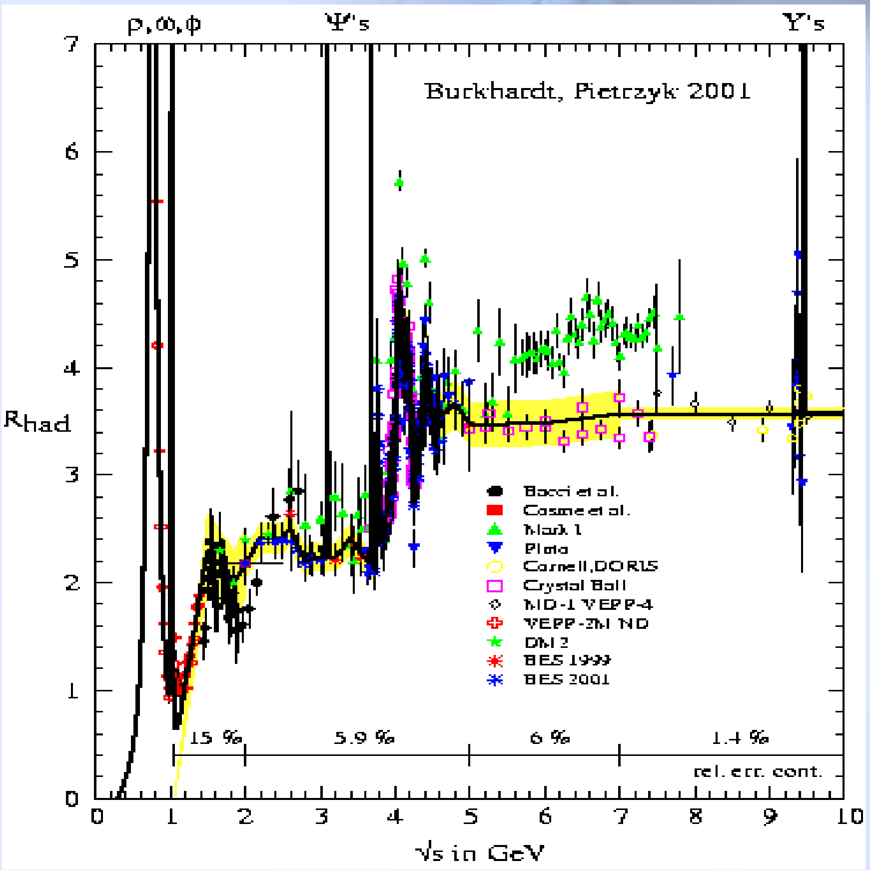
Ecm (GeV)	hadron selection	Lumi	MC modeling	trigger	Radiative correction	total
2.000	7.07	2.81	2.62	0.5	1.06	8.13
3.000	3.30	2.30	2.66	0.5	1.32	5.02
4.000	2.64	2.43	2.25	0.5	1.82	4.64
4.800	3.58	1.74	3.05	0.5	1.02	5.14

- error dominated by
    - hadron selection
    - luminosity
    - MC simulation
- big error in hadron selection at Ecm=2 GeV

R Below 10 GeV

BES reduces R errors from 15 – 20 % to an average of 6% in the 2 – 5 GeV region.





Before BES R Scan **After BES R Scan**

Current Status

Burkhardt and Pietryzk have updated analysis

[Phys. Lett. **B513**, 46 (2001).]

$$\alpha^{-1}(M_Z^2) = 128.936 \pm 0.046$$

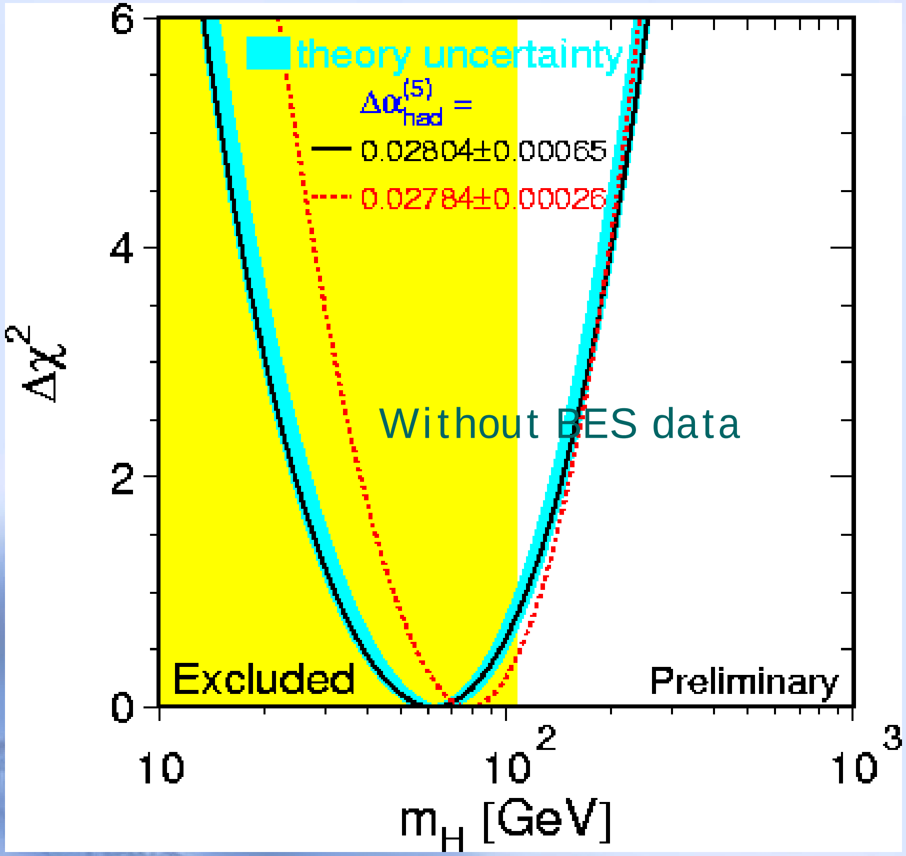
$$\Delta\alpha_{\text{had}}^{(5)} = 0.02761 \pm 0.00036$$

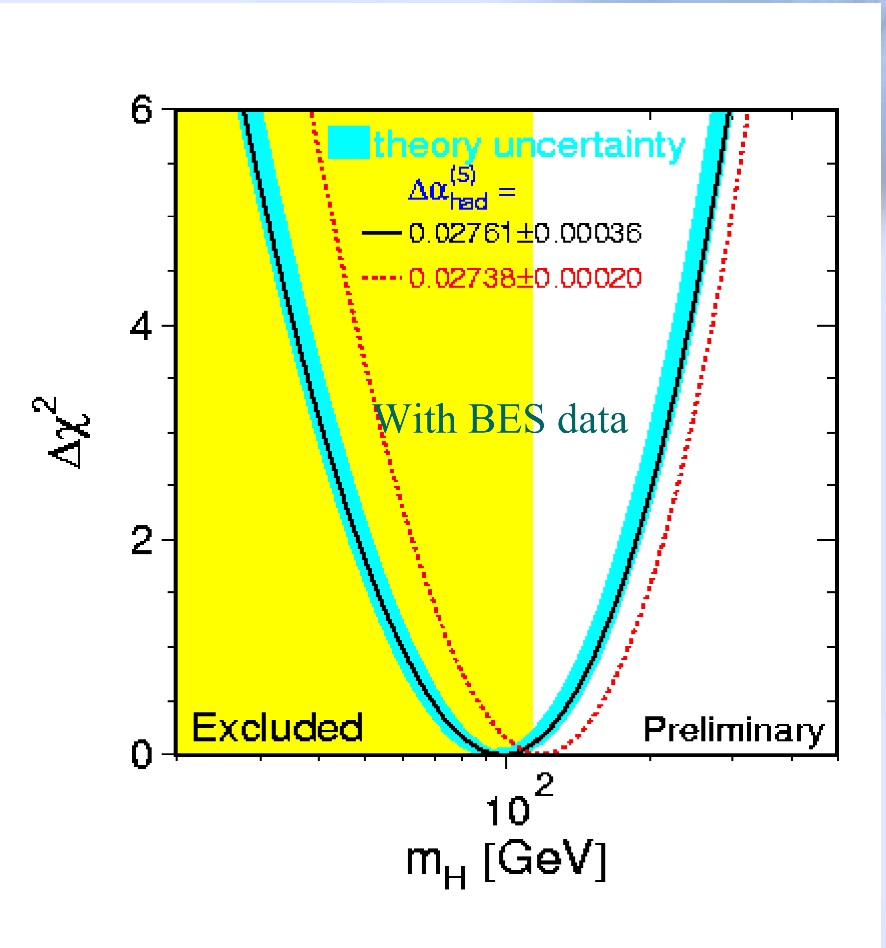
Previously:

$$\alpha^{-1}(M_Z^2) = 127.90 \pm 0.07 \text{ (PDG1998)}$$

Shifts Standard Model Higgs mass upward.

The SM Fit to m_H





$$m_H = 62^{+53}_{-30}\, GeV$$
$$m_H < 170 GeV$$

(95% C.L.)

$$m_H = 98^{+58}_{-38}\, GeV$$
$$m_H < 212 GeV$$

(95% C.L.)

Current status

- Low energy R values (< 10 GeV) including BES R data and pQCD used to determine $\alpha_s(M_Z)$:

$$\alpha_s(5\ \text{GeV}) = 0.235^{+0.047}_{-0.047}$$

$$\alpha_s(M_Z) = 0.124^{+0.011}_{-0.014}$$

(0.119(2) in PDG1998)

agrees with other determinations, but errors larger.

(J. H. Kühn and M. Steinhauser, Nucl. Phys. B619, 588, 2001)

- c quark mass is determined by input BES R data at charm threshold region

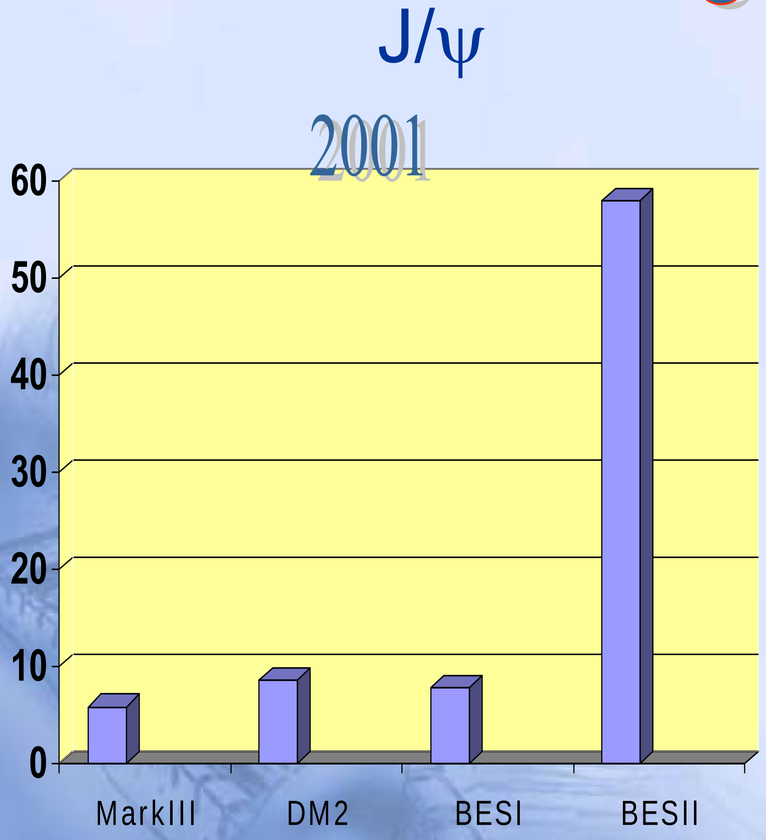
$$M_c = 1.304(27)\ \text{GeV}$$

more accurate than other recent determinations

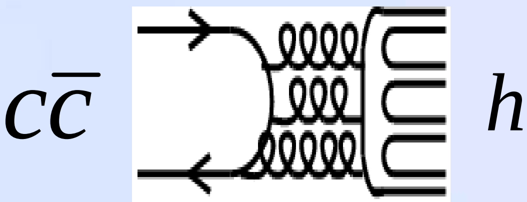
(J.H.Kuhn and M. Steinhauser, hep-ph/0209357)

World J/ψ and ψ(2S) Samples (10^6)

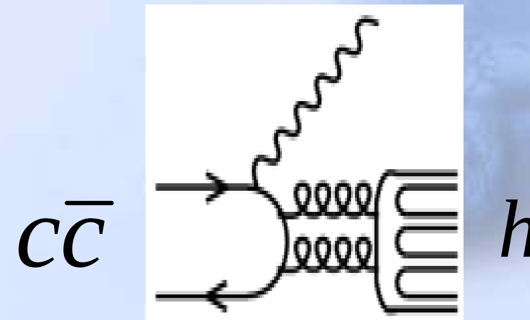
Largest from BES



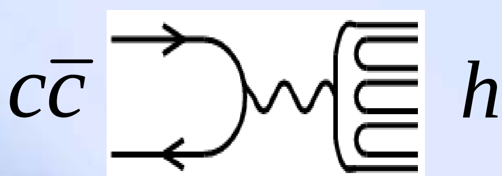
J/ψ Physics



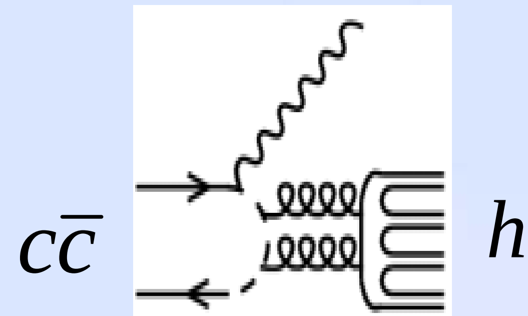
3-gluon



Radiative



Electromagnetic

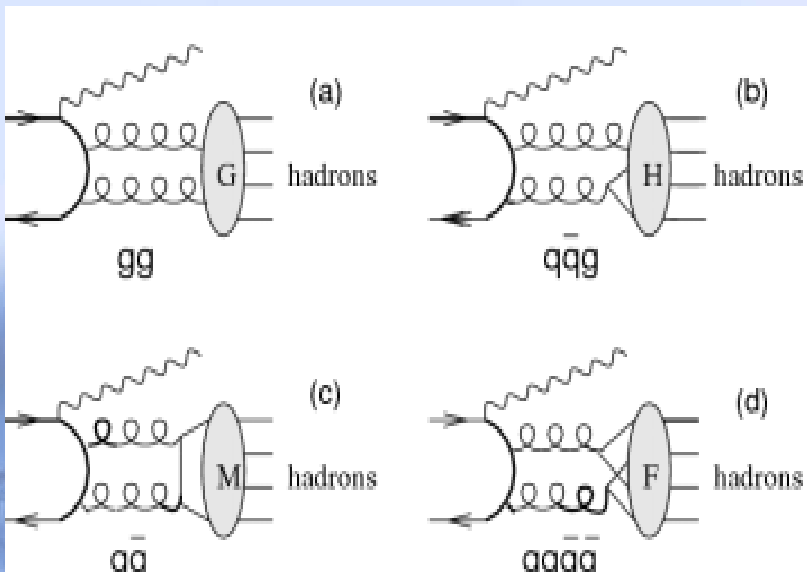


Via η_c

- good lab in studying hadron spectroscopy
- good lab for excited baryon states
- hunting for glueballs in J/ψ radiative decays

Glueballs

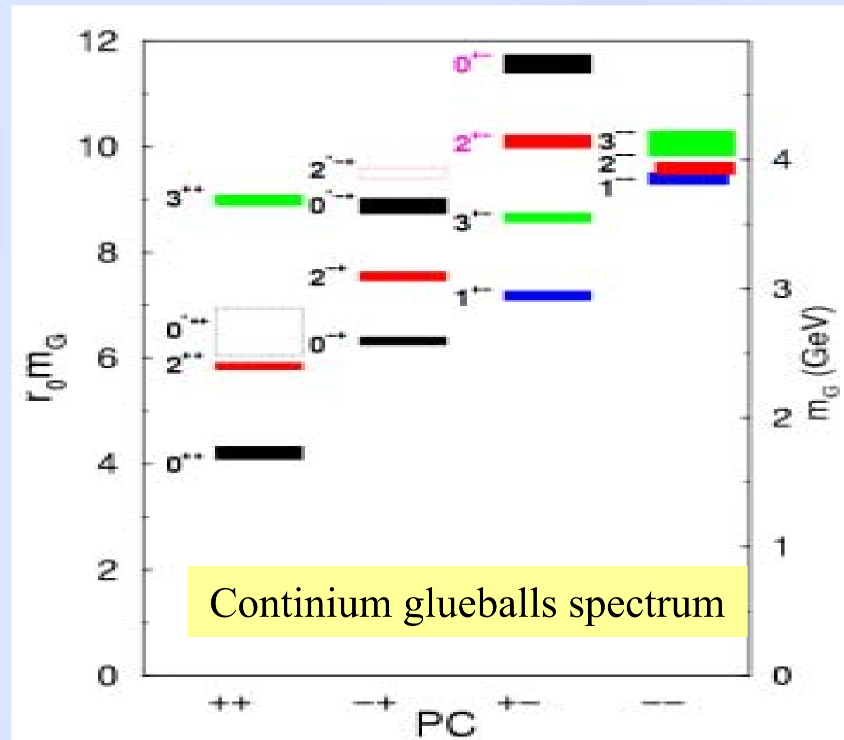
- predicted in QCD
- enhanced in J/ψ radiative decays
- Could mix with $q\bar{q}$



- candidates: $f_0(1500)$, $f_0(1710)$ $\xi(2230)$

LQCD calculations

- ground state (0^{++}) : 1611 ± 163 MeV
- first excited state (2^{++}) : 2232 ± 310 MeV



Continium glueballs spectrum

C.Michael : hep-ph/0101287 (2001)

J/ψ radiative decays at BES

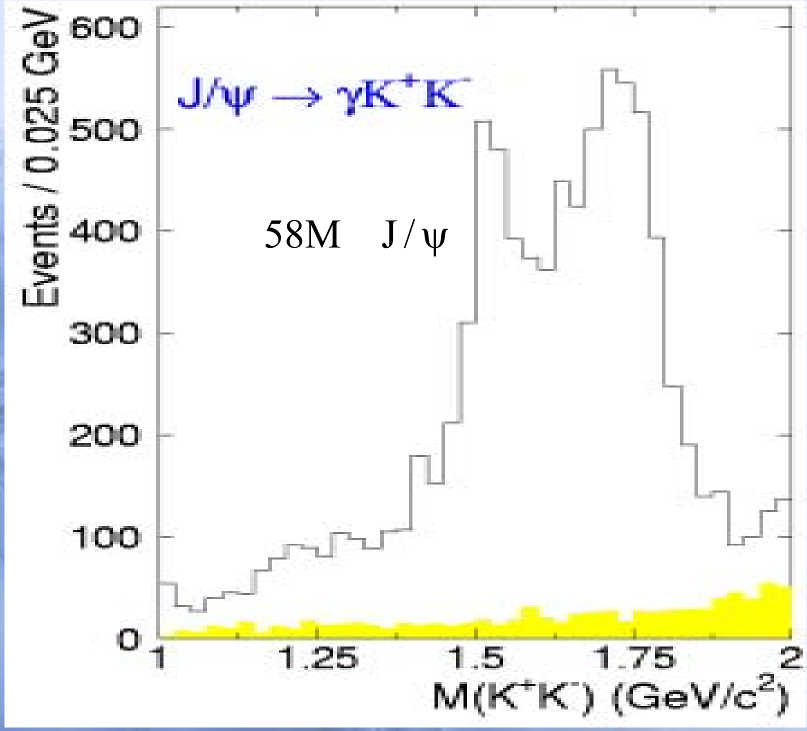
- Partial Wave Analysis(PWA) of $J/\psi \to \gamma K\bar{K}$,$\gamma\pi^+\pi^-$
- Enhancement near $p\bar{p}$ threshold from $J/\psi \to \gamma p\bar{p}$

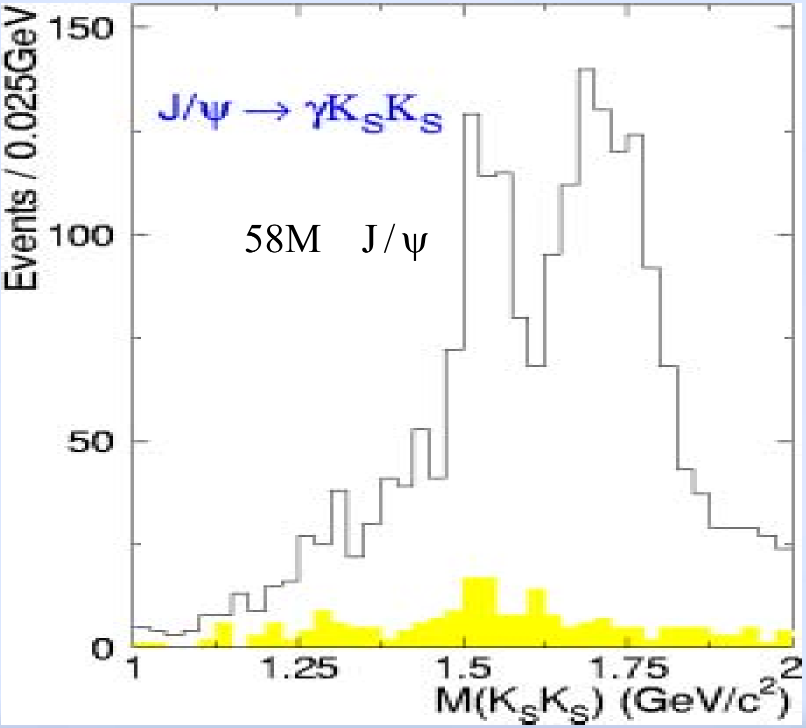
Based on 58M J/ψ events

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

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

BESII preliminary





measurements of $f_0(1710)$

Process	Collaboration	M(MeV)	Γ(MeV)	J^{PC}
$J/\psi \to \gamma\eta\eta$	CBAL (82)	1640 ± 50	220^{+100}_{-70}	2^{++}
$\pi^- p \to K_s^0 K_s^0 n$	BNL (82)	1771^{+77}_{-53}	200^{+156}_{-9}	0^{++}
$\pi^- N \to K_s^0 K_s^0 n$	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^{++}
$J/\psi \to \gamma K\bar{K}$ $\gamma\pi^+\pi^-$	DM2 (88)	1707 ± 10 1698 ± 15	166 ± 33 136 ± 28	—
$pp \to ppK^+K^-$ $ppK_s^0K_s^0$	WA76 (89)	1713 ± 10 1706 ± 10	181 ± 30 104 ± 30	2^{++}
$J/\psi \to \gamma K\bar{K}$	MARKIII (91)	1710 ± 20	186 ± 30	0^{++}
$p\bar{p} \to \pi^0\eta\eta$	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)	$1696 \pm 5^{+9}_{-34}$ $1781 \pm 8^{+10}_{-31}$	$103 \pm 18^{+30}_{-11}$ $85 \pm 24^{+22}_{-19}$	2^{++} 0^{++}
$J/\psi \to \gamma K\bar{K}$	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^{++}
$\gamma\gamma \to K_S^0 K_S^0$	L3(01)	1767 ± 14	187 ± 60	2^{++}

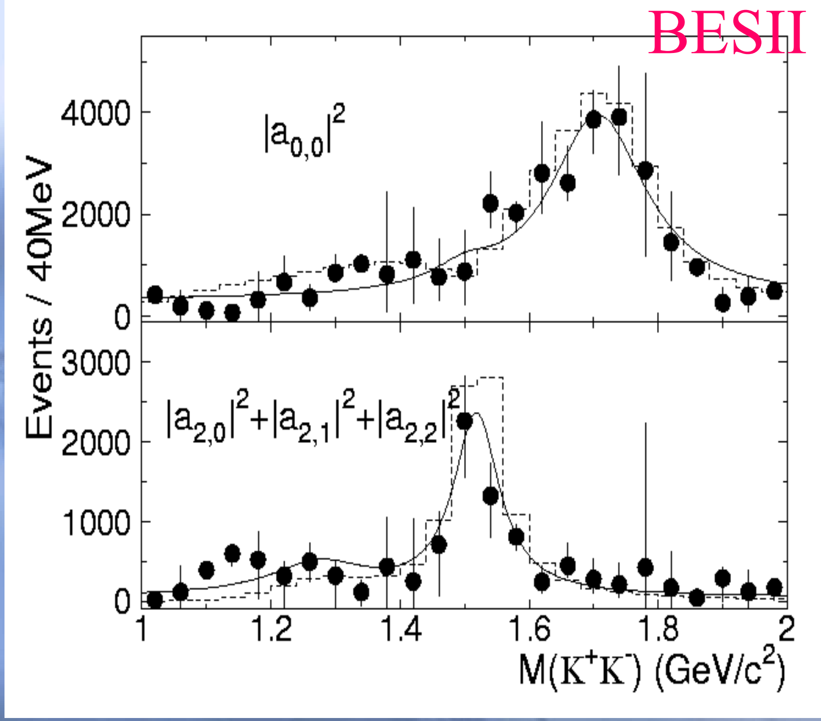
$f_0(1710)$:

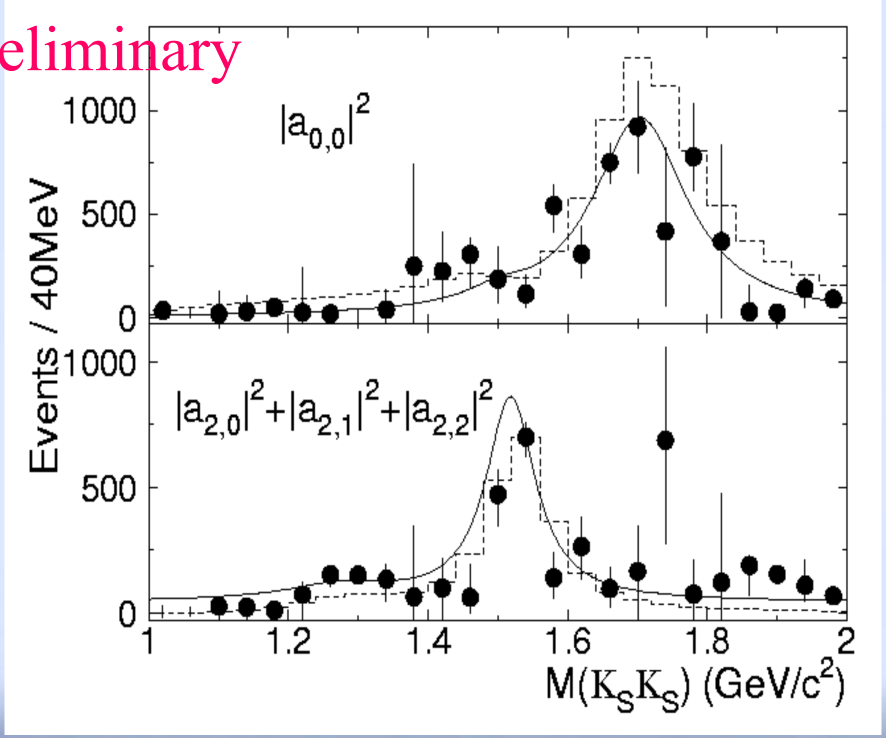
- long-standing ambiguity
  0^{++} or 2^{++}
- $J^{PC} = 0^{++}$ favored
- controversial in $q\bar{q}$ nonet
- small fraction of glue :
  $K\bar{K}$ dominant
  $\pi\bar{\pi}$ observed

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

- Global fit and bin-by-bin fit are performed
- 0^{++} is dominant in 1.7GeV region
- Clear $f_2^{'}(1525)$ 2^{++} signal
- Evidence of $f_2(1270)$ 2^{++} seen

BESII preliminary





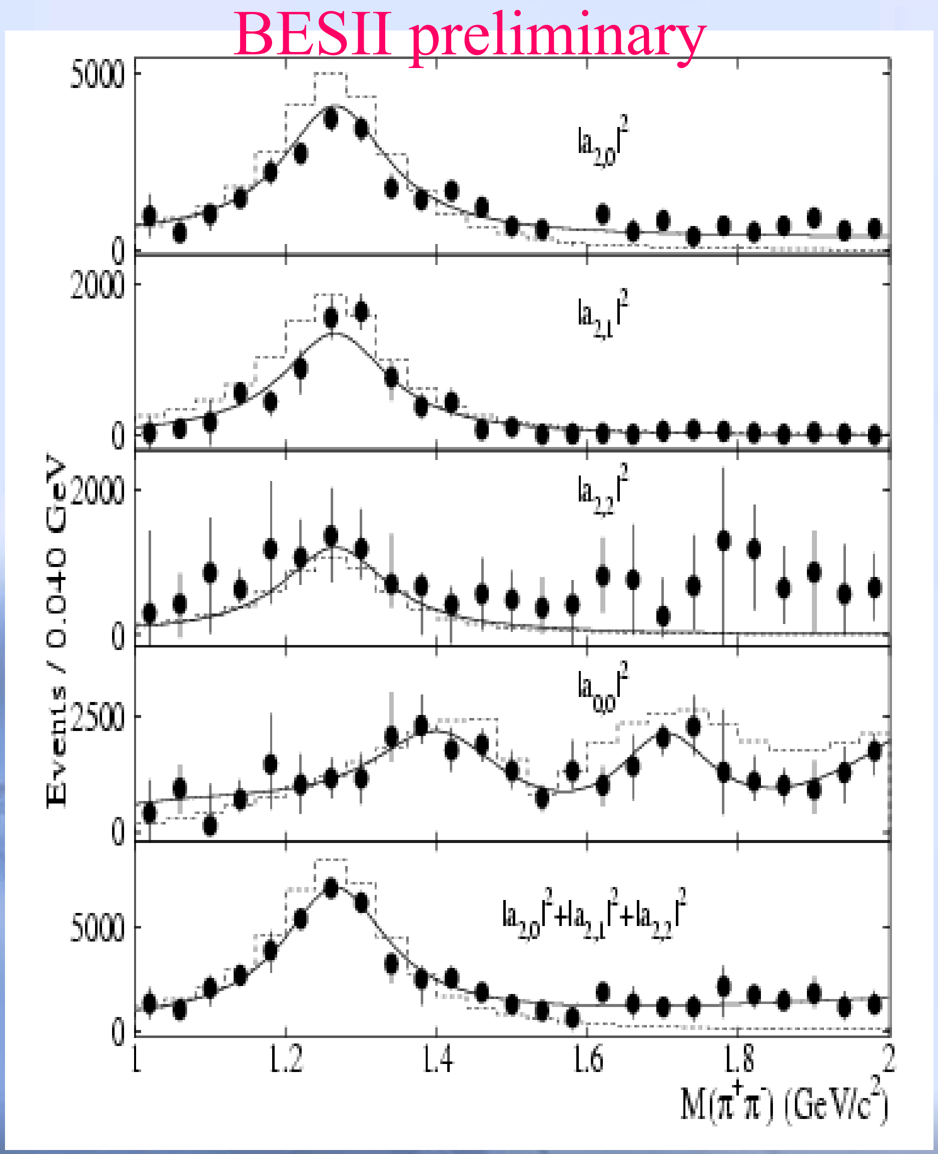
Preliminary Results
($J/\psi \to \gamma K\bar{K}$)

- Masses and Widths (statistical errors only):

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

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

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



- well known $f_2(1270)$ 2^{++}
- two 0^{++}'s at around 1.4 and 1.7 GeV mass regions.

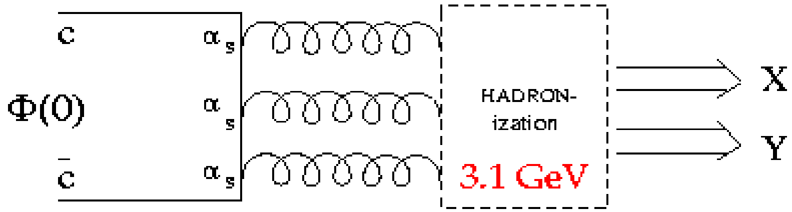
The ratio for $f_0(1710)$:

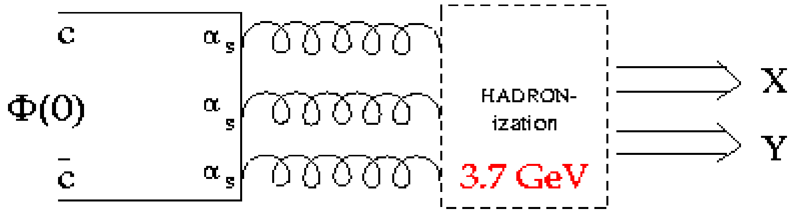
$$\frac{\Gamma(f_0(1710) \to \pi\pi)}{\Gamma(f_0(1710) \to K\bar{K})} \sim 30\%$$

ψ(2S) Hadronic Decays

Expectations: T. Applequist and D. Politzer, Phys. Rev. Lett. 51, 43 (1975).

$\Phi(0): c\bar{c}$ Wave function at origin

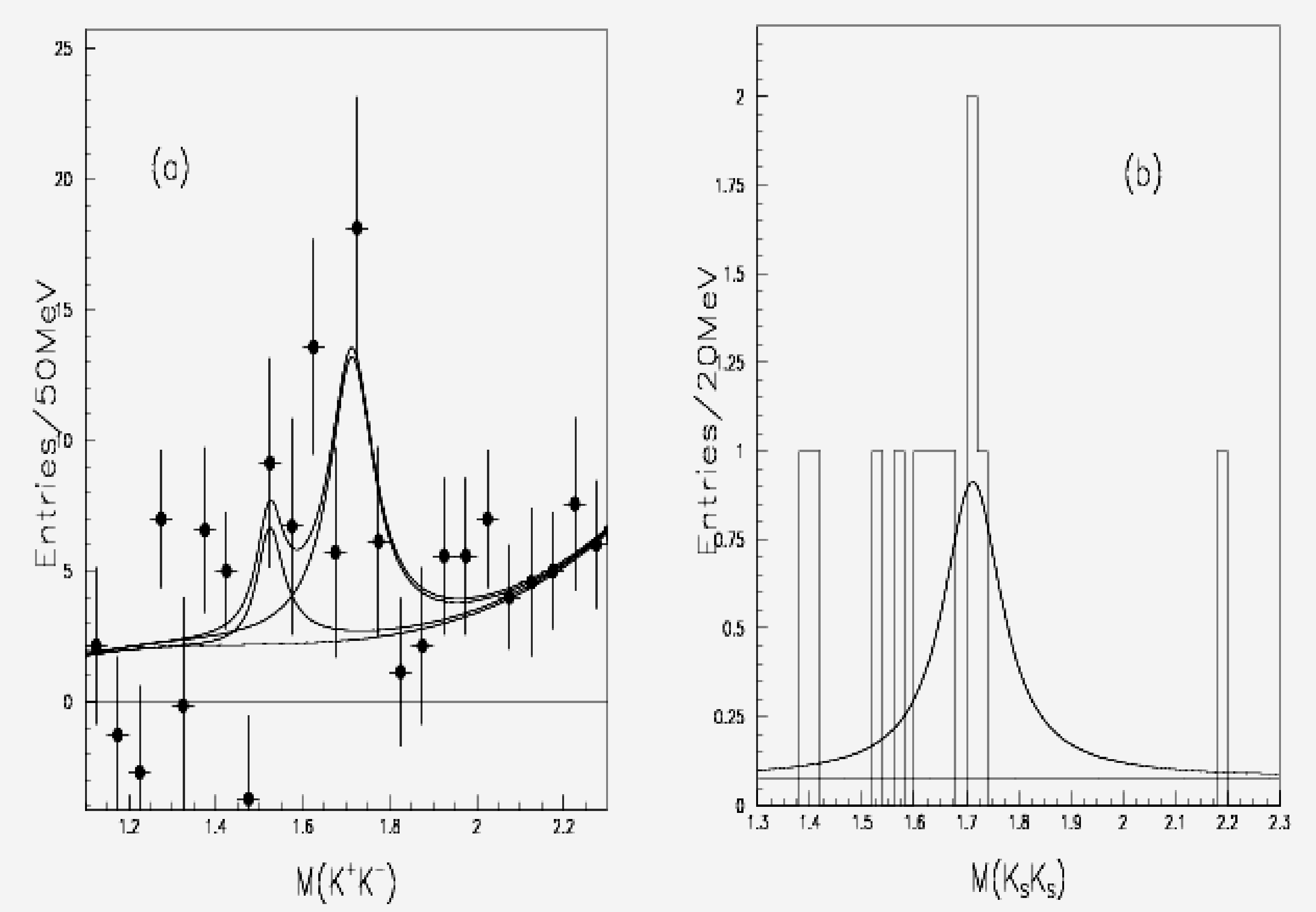




$$\mathcal{B}(\psi \to Final\ State) \propto \Gamma(\psi \to Final\ State)$$

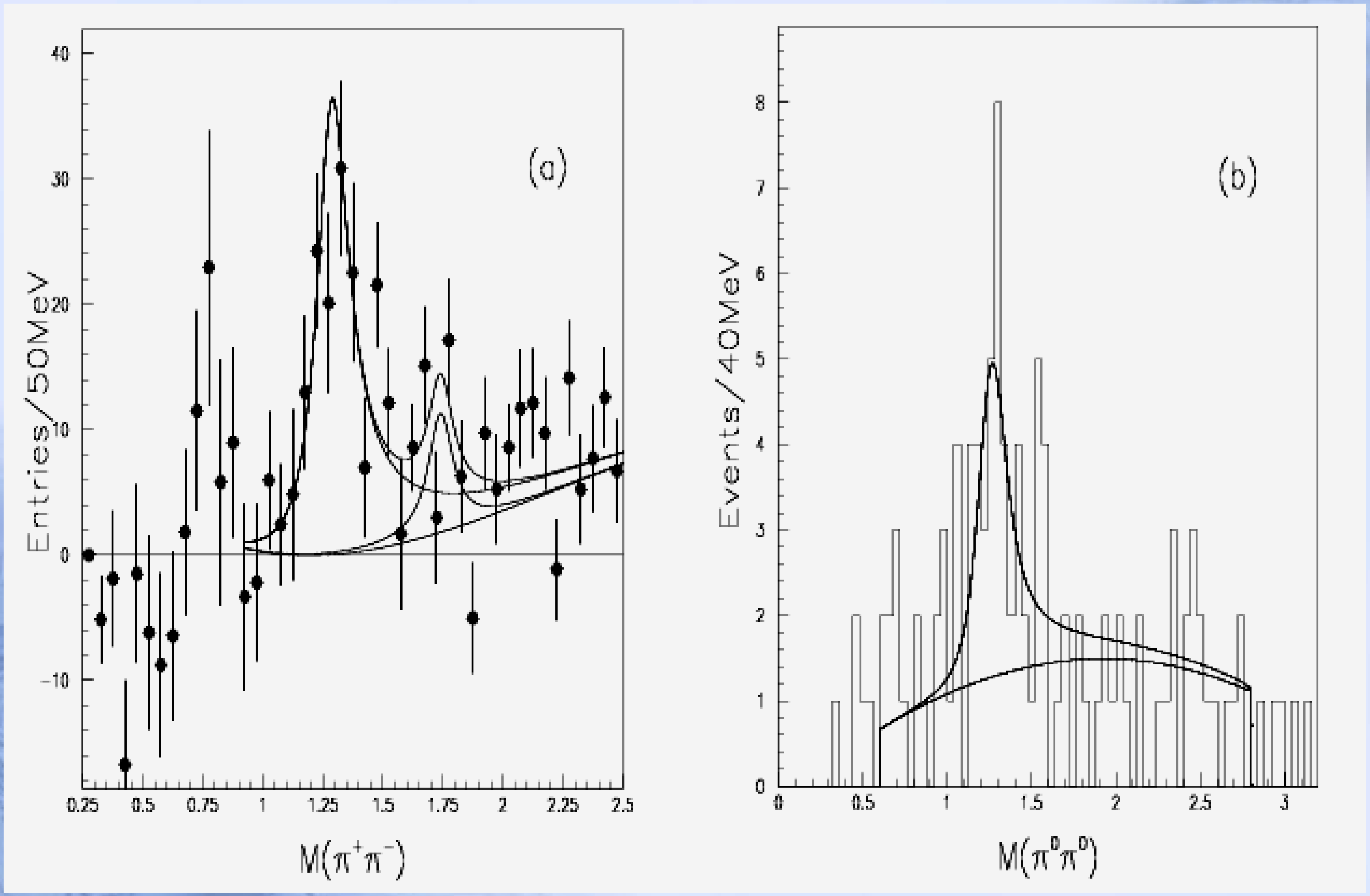
$$\frac{\mathcal{B}[\psi(2S) \to X+Y]}{\mathcal{B}[J/\psi \to X+Y]} = \frac{\mathcal{B}[\psi(2S) \to \mu^+\mu^-]}{\mathcal{B}[J/\psi \to \mu^+\mu^-]} f(\alpha_s(s)) = (12.2 \pm 2.0)\%$$

ψ(2S) Radiative decays into $f_2(1270)$, $f_0(1710)$



$f_0(1710)$ and hint of f'_2 (1525) in charged mode.

$\psi(2S)$ Radiative decays into $f_2(1270)$, $f_0(1710)$



$f_2(1270)$, $f_0(1710)$ in charged mode.

$f_2(1270)$ in neutral mode.

$\psi(2S)$ Radiative decays into $f_2(1270)$, $f_0(1710)$

Mode	BES $B(\times 10^{-4})$
$\psi(2S) \to \gamma f_2(1270)$ from $\gamma\pi^+\pi^-$	$2.08 \pm 0.19 \pm 0.33$
$\psi(2S) \to \gamma f_2(1270)$ from $\gamma\pi^0\pi^0$	$2.90 \pm 1.08 \pm 1.07$
$\psi(2S) \to \gamma f_2(1270)$ from $\gamma\pi\pi$	$2.12 \pm 0.19 \pm 0.32$
$\psi(2S) \to \gamma f_0(1710) \to \gamma\pi\pi$ from $\gamma\pi^+\pi^-$	$0.301 \pm 0.041 \pm 0.124$
$\psi(2S) \to \gamma f_0(1710) \to \gamma K^+K^-$	$0.302 \pm 0.045 \pm 0.066$
$\psi(2S) \to \gamma f_0(1710) \to \gamma K^0_S K^0_S$	$0.206 \pm 0.094 \pm 0.108$

Final state	BES $B(\psi(2S) \to)(\times 10^{-4})$	PDG $B(J/\psi \to)(\times 10^{-4})$	$B(\psi(2S))/B(J/\psi)$
$\gamma f_2(1270)$	$2.12 \pm 0.19 \pm 0.32$	13.8 ± 1.4	$(15.4 \pm 3.1)\%$
$\gamma f_0(1710) \to \gamma K^+K^-$	$0.302 \pm 0.045 \pm 0.066$	$4.25^{+0.60}_{-0.45}$ [8]	$(7.1^{+2.1}_{-2.0})\%$

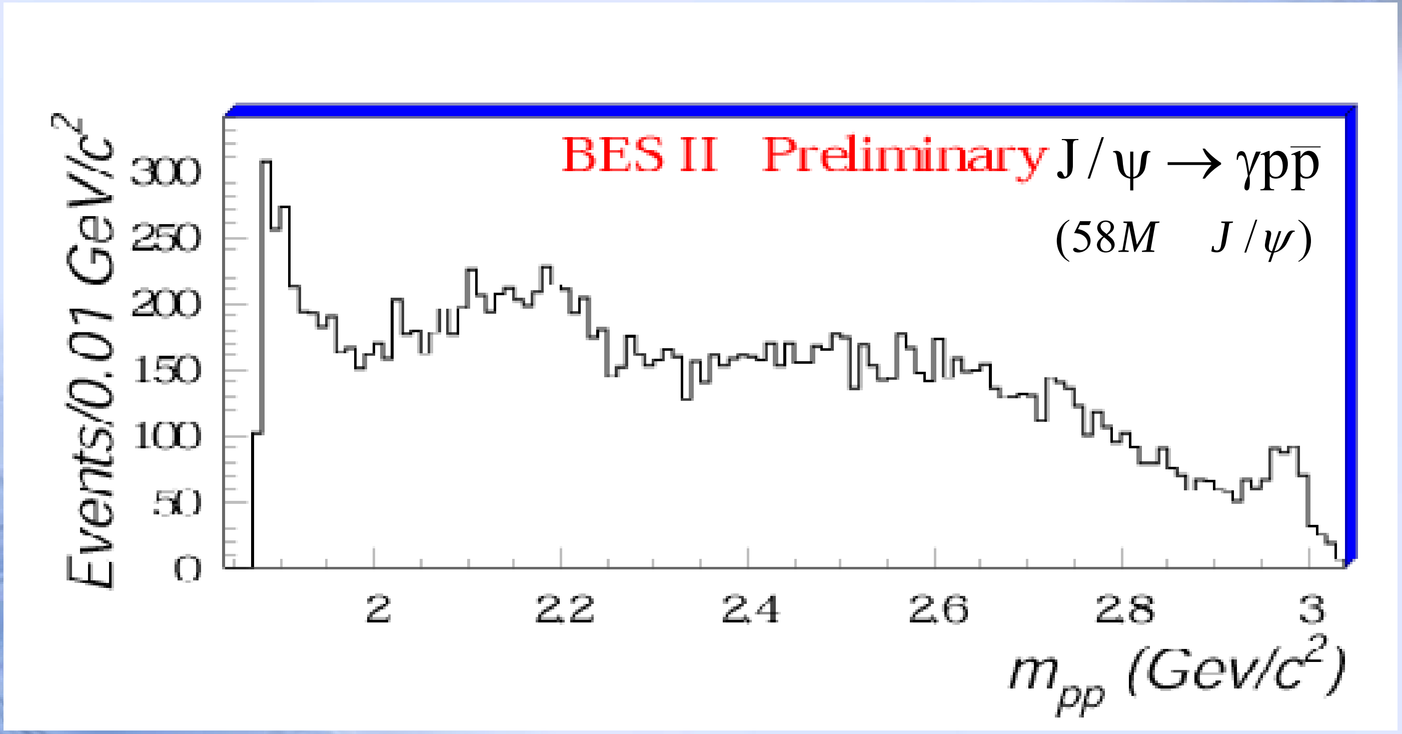
Decays are consistent with 12% rule.

Discussion

- PWA is performed
- for $J/\psi \to \gamma K^+K^-, \gamma K_s^0 K_s^0, \gamma\pi^+\pi^-$
- $f_0(1710)$ 0^{++} is confirmed with large statistics
- Both $\pi^+\pi^-$ and $K\overline{K}$ decays of $f_0(1710)$ are observed

- First observation of $f_0(1710)$
- in $\psi(2s)$ radiative decay
- Ratio of $\psi(2s)$ over J/ψ follow 12% rule

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

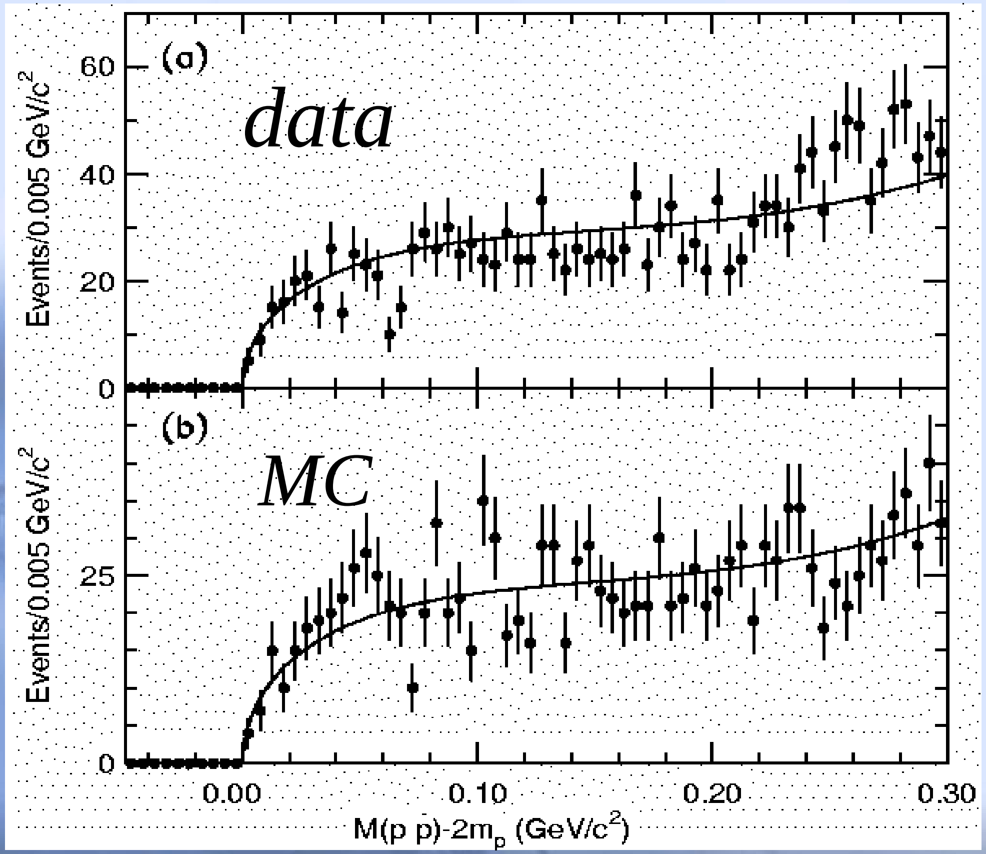


Besides η_c peak, there is a clear enhancement near threshold.

Backgrounds

Large background from $J/\psi \to \pi^0 p\bar{p}$

- With asymmetric $\pi^0 \to \gamma\gamma$ decay

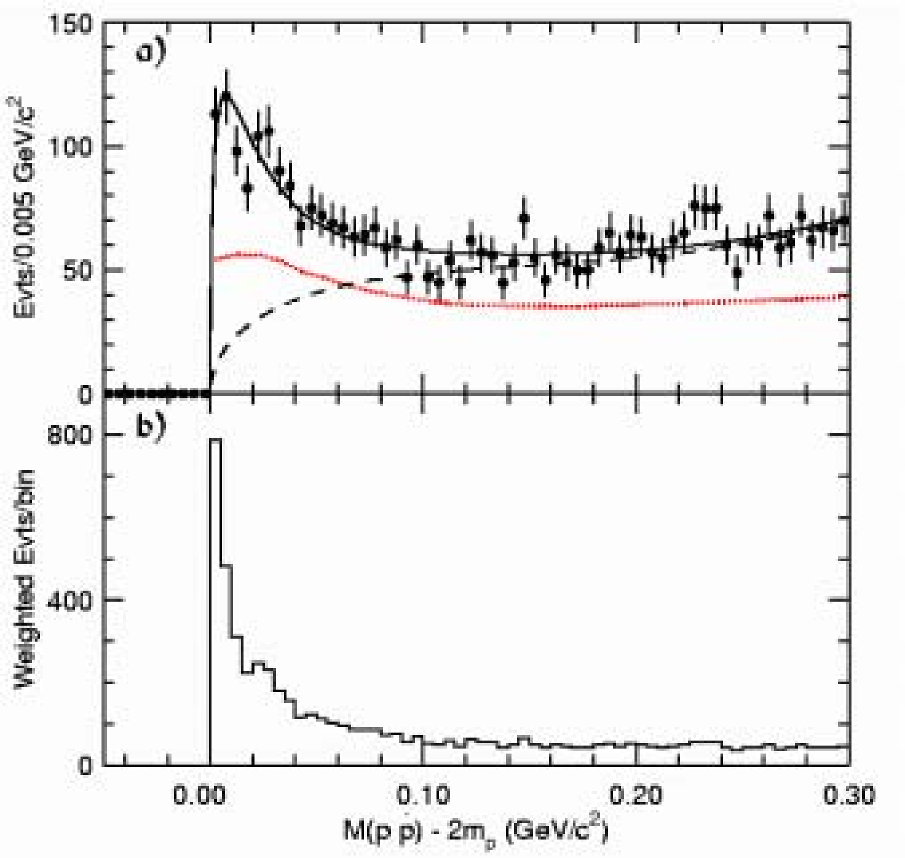


Selected $J/\psi \to \pi^0 p\bar{p}$ events

- from data sample and MC
- Suvived from $J/\psi \to \gamma p\bar{p}$ cuts

No clear enhancement near threshold

Fit to the structure near threshold



$M_{p\bar{p}} - 2m_p$ distribution :

a) data points

--- background shape from $J/\psi \to \pi^0 p\bar{p}$ MC

— fit with S-wave BW + bg

... detection efficiency

b) Weighted by q0/q

removing kinematic threshold behavior

(see : hep-ex/0303006, 3 Mar 2003)

- Its Mass $M = 1859 \pm^{3}_{10} (stat) \pm^{5}_{25} (sys) MeV$

  width $\Gamma < 30 Mev$ at 90% CL

Discussion

- An enhancement in $M_{p\bar{p}}$ distribution observed
- near $p\bar{p}$ threshold
- from J/ψ radiative decay

- $p\bar{p}$ molecular state?
- 0^{-+} glueball?
  - ➡ *why so close to* $2m_p$ *?*

- no similar structure in $J/\psi \to \pi^0 p\bar{p}$
- Dynamical effect?
  - ➡ *no evidence in* $\gamma\Lambda\bar{\Lambda}$ *or* $\gamma\Xi^+\Xi^-$

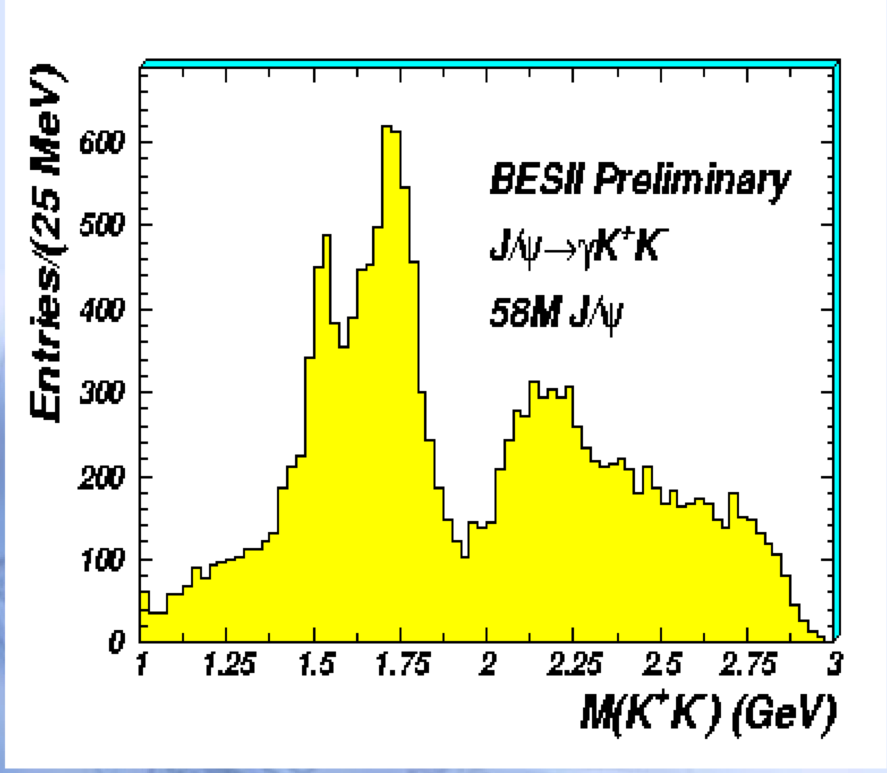
⟹ search for other decay modes

⟹ $p\bar{p}$ system with different quantum number

❖ Belle observed enhancement in $p\bar{p}$ invariant mass near $2m_p$ from $B^+ \to K^+ p\bar{p}$ and $\bar{B}^0 \to D^0 p\bar{p}$

(Phys.Rev.Lett. 88,181803(2002); Phys.Rev.Lett. 89, 151802(2002).)

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



- No clear evidence of $\xi(2230)$ was observed.
- All possible problems are still being checked

$\psi(2S)$ scan

Purpose: Improve accuracies of $\psi(2S)$ parameters: Γ, Γ_h, Γ_μ, $\Gamma_{\pi\pi\, J/\psi}$, $B(h)$, $B(\mu)$, and $B(\pi^+ \pi^- J/\psi)$.

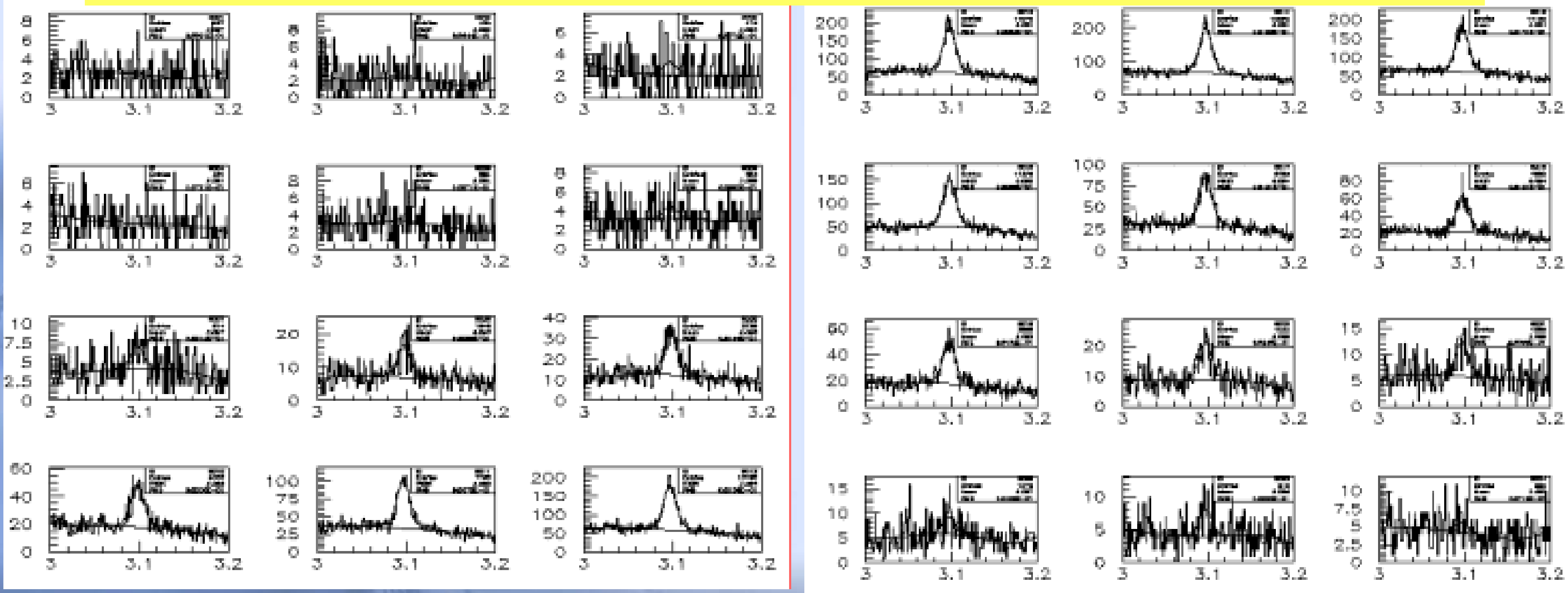
Group	yr	Γ(KeV)	Γ_h(KeV)	$B(\mu\mu)(10^{-3})$	$B(\pi^+\pi^- J/\psi)$ (%)
MARKI	75	228 ± 56	224 ± 56	9.3 ± 1.6	32 ± 4
SPEC	75			7.7 ± 1.7	
DASP	79	202 ± 57		9.9 ± 3.2	36 ± 6
E760	92	306 ± 39			
E760	97			8.3 ± 0.86	28.3 ± 2.9
E835	00			7.4 ± 0.53	
PDG	00	277 ± 31		10.3 ± 3.5	31.0 ± 2.8

$\Psi(2S) \to \mu^+ \mu^-$ and $\Psi(2S) \to \pi^+ \pi^- J/\psi$ are important for identifying $\Psi(2S)$ decays in B-factory and other experiments.

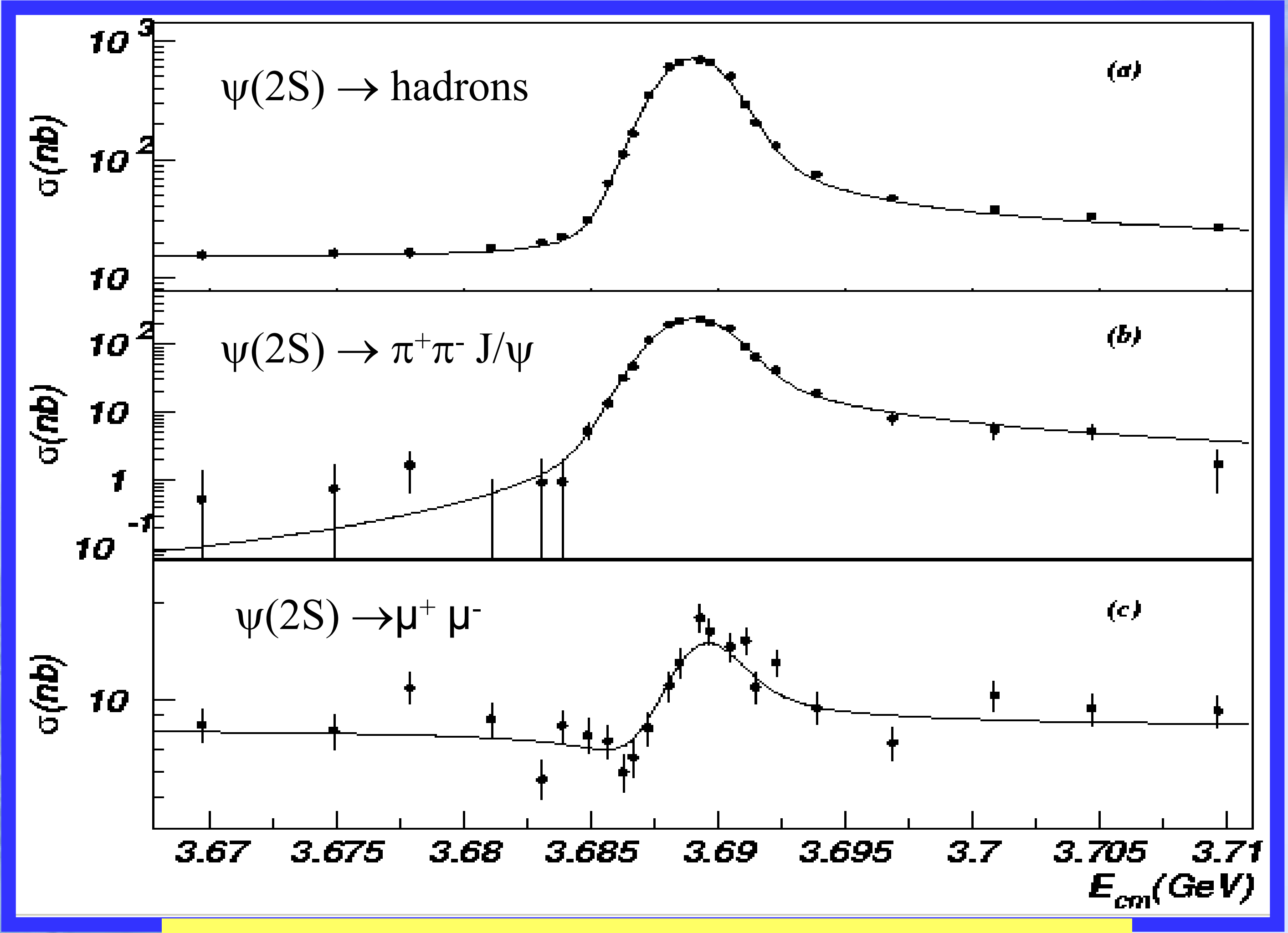
$\psi(2S)$ scan

- 24 energy points from 3.67 to 3.71 GeV
- Integrated luminosity : 1.15 pb^{-1}
- Four channels: $\psi(2S) \rightarrow$ hadrons, $\mu^+ \mu^-$, $e^+ e^-$, and $\pi^+\pi^- J/\psi$

$\pi^+\pi^-$ recoil mass from $\pi^+\pi^- J/\psi$ for each energy points



Scan of ψ(2S) resonance



Cross section at Ecm = 3.67 to 3.71 GeV

Fitting

- Fit with input of $\sigma_h(W)$, $\sigma_{\pi\pi\ J/\psi}(W)$, $\sigma_{ee}(W)$, and $\sigma_{\mu\mu}(W)$
- Include effects of

  resonance, continuum, interference,

  beam spread Δ, ISR and FSR
- Assume that

  a) $\Gamma_{ee} = \Gamma_{\mu\mu} = \Gamma_{\tau\tau} / 0.3885$

  b) $\Gamma_t = \Gamma_h + \Gamma_{\mu\mu} + \Gamma_{ee} + \Gamma_{\tau\tau}.$
- Fit Γ_h, $\Gamma_{\mu\mu}$, $\Gamma_{\pi\pi\ J/\psi}$, $M(\psi(2S))$, Δ, and R simultaneously
- Consistency check:
  - $R = 2.15 \pm 0.17$ consistent with

    $R = 2.25 \pm 0.06$ at 3.55 GeV from BES R measurement
  - $\Delta = 1.298 \pm 0.007$ agrees with expected beam spread

Fitting Result

Parameter	BES	MARK I	PDG2002
Γ_t (keV)	264 ± 27	228 ± 56	300 ± 25
Γ_h (keV)	258 ± 26	224 ± 56	
$\Gamma_{\pi\pi\ J/\psi}$ (keV)	85.4 ± 8.7		
Γ_μ (keV)	2.44 ± 0.21	2.1 ± 0.3	2.19 ±0.15
B_h (%)	97.8 ± 0.15	98.1±0.3	98.10 ±0.30
$B_{\pi\pi\ J/\psi}$ (%)	32.3 ± 1.4	32 ± 4	30.5 ± 1.6
B_μ (%)	0.93 ± 0.08	0.93 ±0.16	0.7 ±0.09

Phys. Lett. B550, 24 (2002)

Discussion

- $\psi(2S)$ total width shifted by 12%

  Γ_t : 300 KeV → 264 KeV

- Improved precision

  B_h error : 0.31 % → 0.16 %

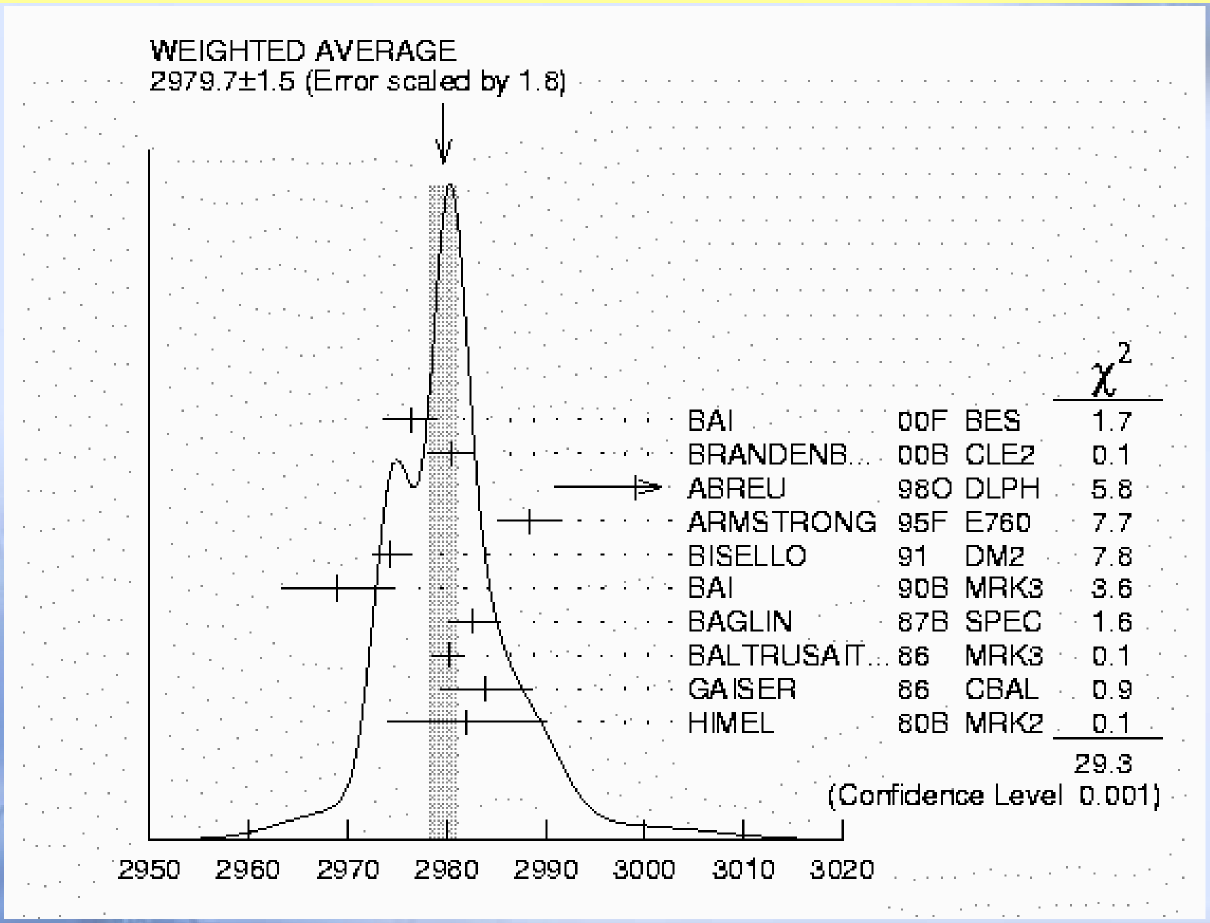
  $B_{\pi\pi J/\psi}$ error : 5.2 % → 4.4 %

  $B_{\mu\mu}$ error : 13 % → 8.5 %

- First measurement of $\Gamma_{\pi\pi J/\psi}$

η_c Parameters

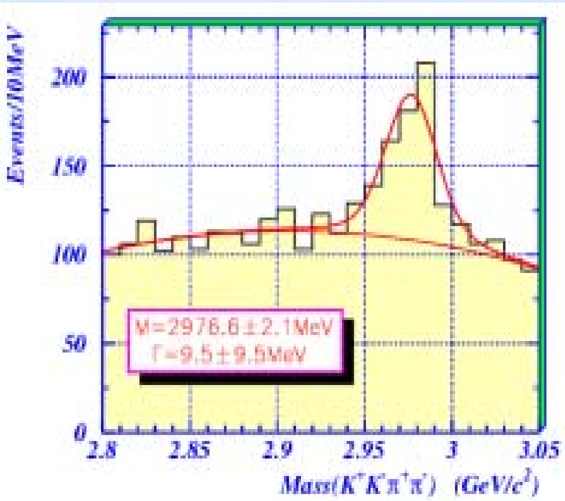
- Precise $m_{J/\psi}$ - $m_{\eta c}$ needed for QCD potential models
- But η_c mass not well determined: CL = 0.001 (PDG02)



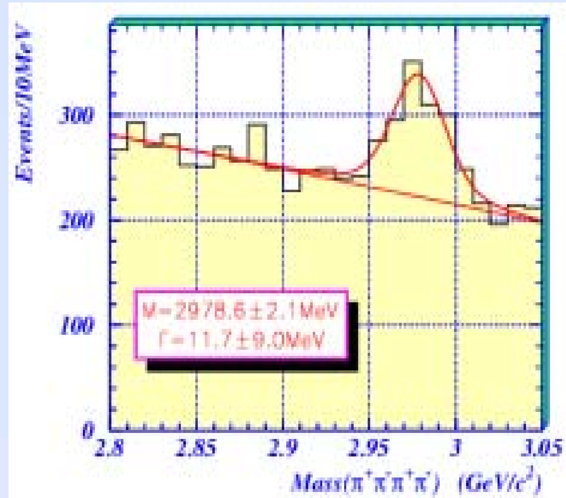
Measurement of η_c width

Exp.	Type	Year	Value (MeV)
Crys. Ball	$J/\psi, \psi(2S) \to \gamma X$	1986	11.5 ± 4.5
MARKIII	$J/\psi \to \gamma p\bar{p}$	1986	$10.1^{+33.0}_{-8.2}$
SPEC	$\bar{p}p \to \gamma\gamma$	1987	$7.0^{+7.5}_{-7.0}$
E760	$\bar{p}p \to \gamma\gamma$	1995	$23.9^{+12.6}_{-7.1}$
BESI	$J/\psi, \psi(2S) \to \gamma X$	2000	$11.0 \pm 8.1 \pm 4.1$
CLEO	$e^+e^- \to \gamma\gamma$	2000	$27.0 \pm 5.8 \pm 1.4$
PDG2002		2002	$16.0^{+3.6}_{-3.2}$

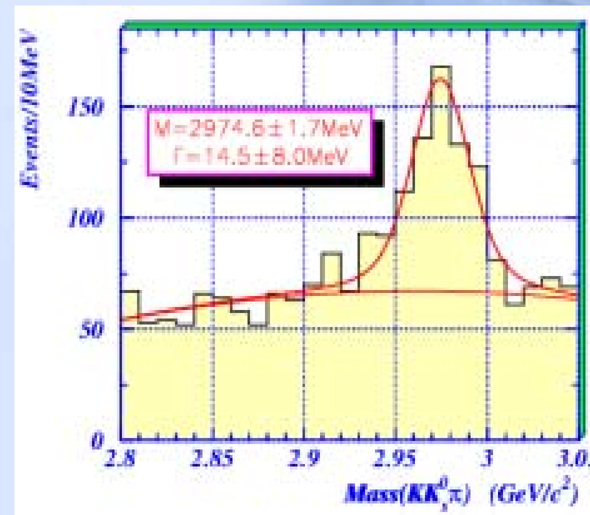
η_c signals in 5 decay channels



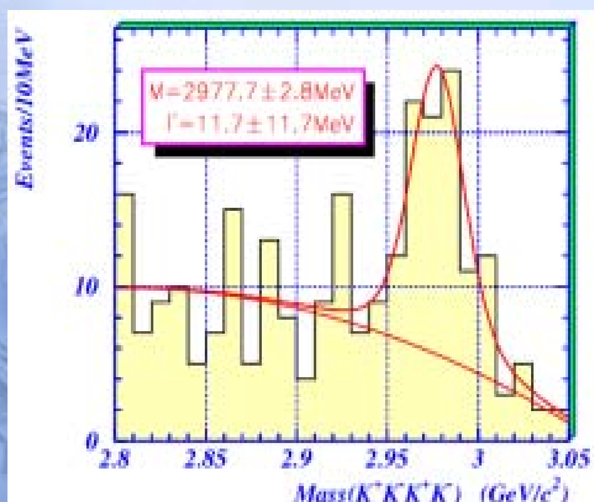
$J/\psi \to \gamma K^+K^-\pi^+\pi^-$



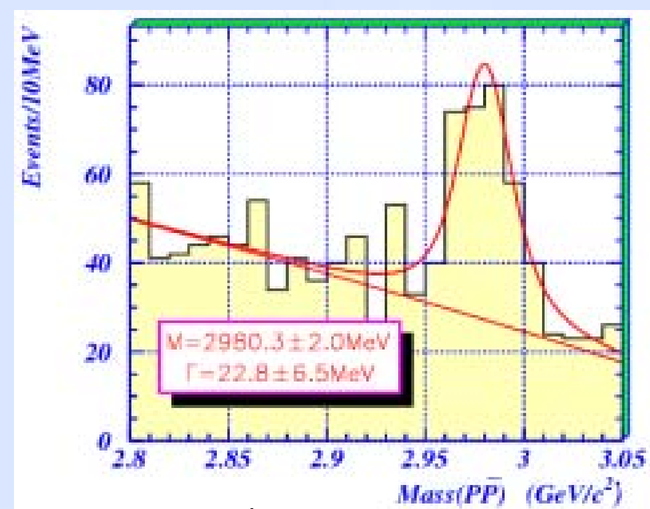
$J/\psi \to \gamma \pi^+\pi^-\pi^+\pi^-$



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



$J/\psi \to \gamma \phi \phi$



$J/\psi \to \gamma p\bar{p}$

Fit with 5 channels combined

BES :

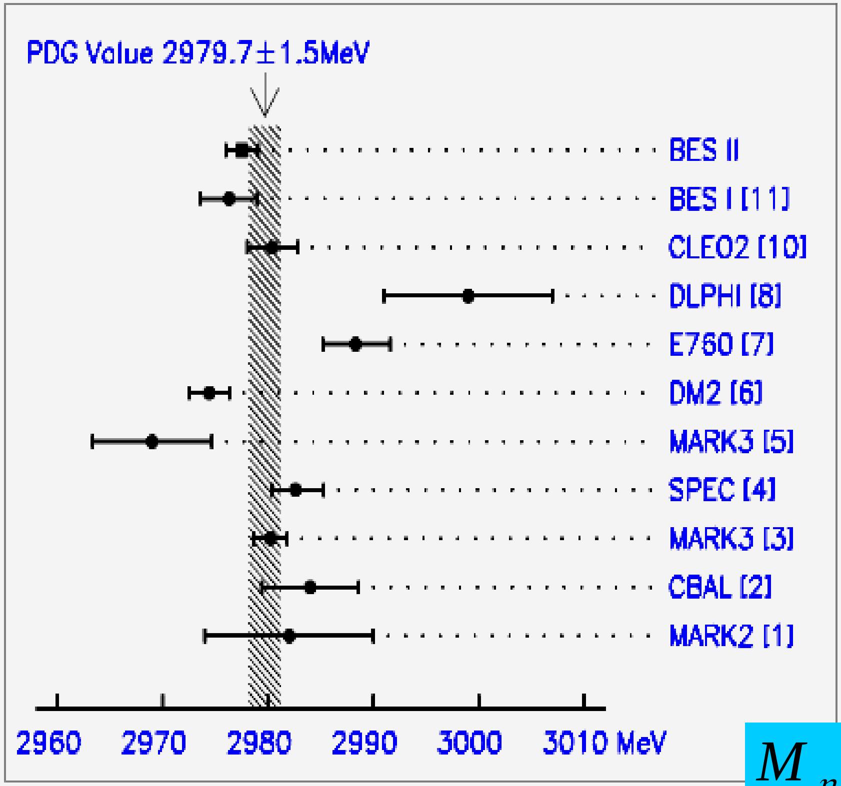
$$M_{\eta_c} = 2977.5 \pm 1.0 \pm 1.2\ \mathrm{MeV}/c^2$$

$$\Gamma_{\eta_c} = 17.0 \pm 3.7 \pm 7.4\ \mathrm{MeV}/c^2$$

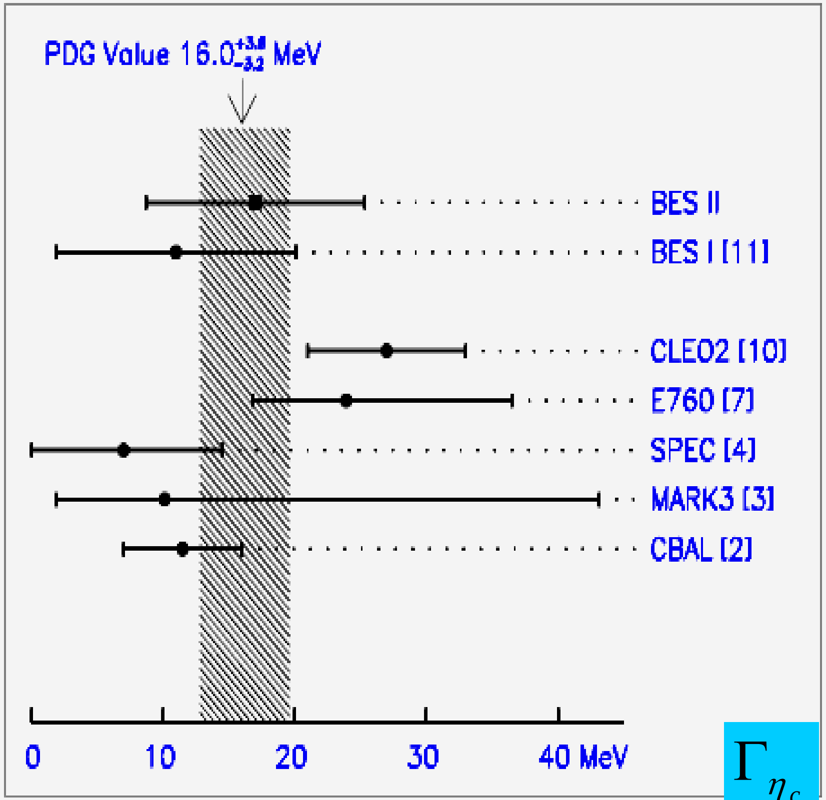
PDG values: (2002) :

$$M_{\eta_c} = 2979.7 \pm 1.5\ \mathrm{MeV}/c^2$$

$$\Gamma_{\eta_c} = 16.0^{+3.6}_{-3.2}\ \mathrm{MeV}/c^2$$



M_{η_c}



Γ_{η_c}

$\chi_{cJ} \to \Lambda\bar{\Lambda}$ from $\psi(2s) \to \gamma\chi_{cJ}$

- Color Octet Mechanism (COM) in QCD
  important for P-wave quarkonium decays

BBL, Phys.Rev. D51,1125(1995);
HC, Phys.Rev.D54,6850(1996);
BKS, Phys.Lett.B392,198(1997).

- BES $\Gamma(\chi_{c0})$ agrees with COM

Phys.Rev.Lett. 81,3091(1998)

- COM + baryon wave-function
  agree with existing measurements

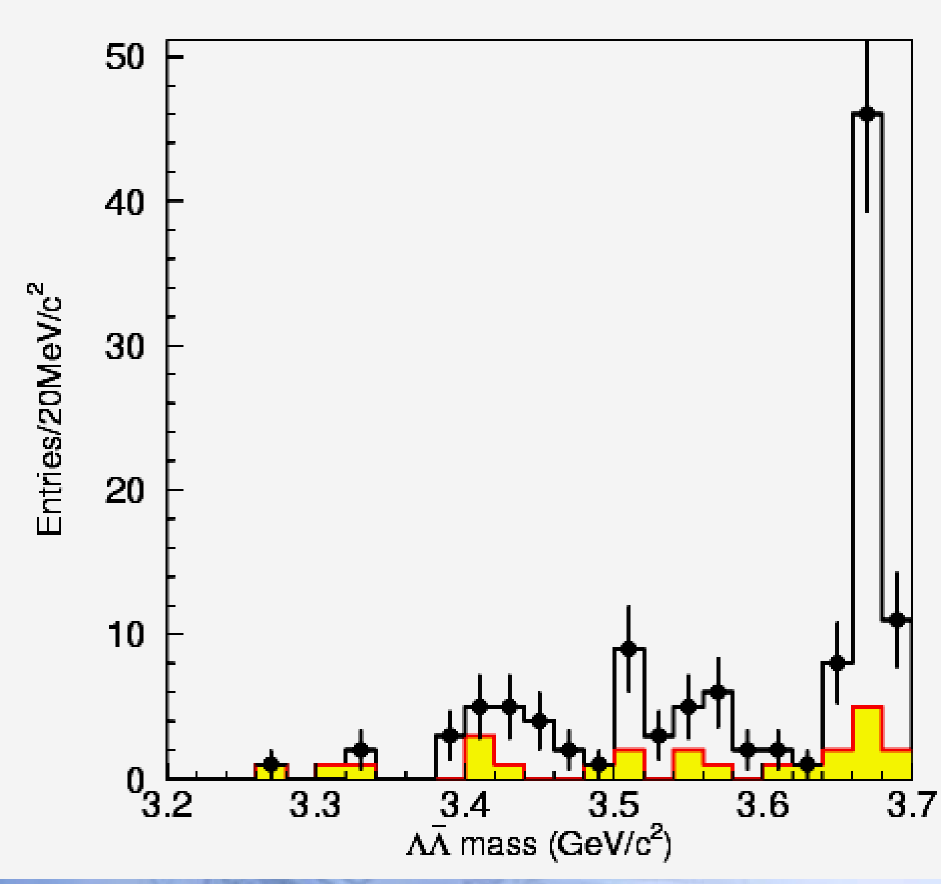
- Generalizing to other baryons, partial widths of other baryons can be predicted:

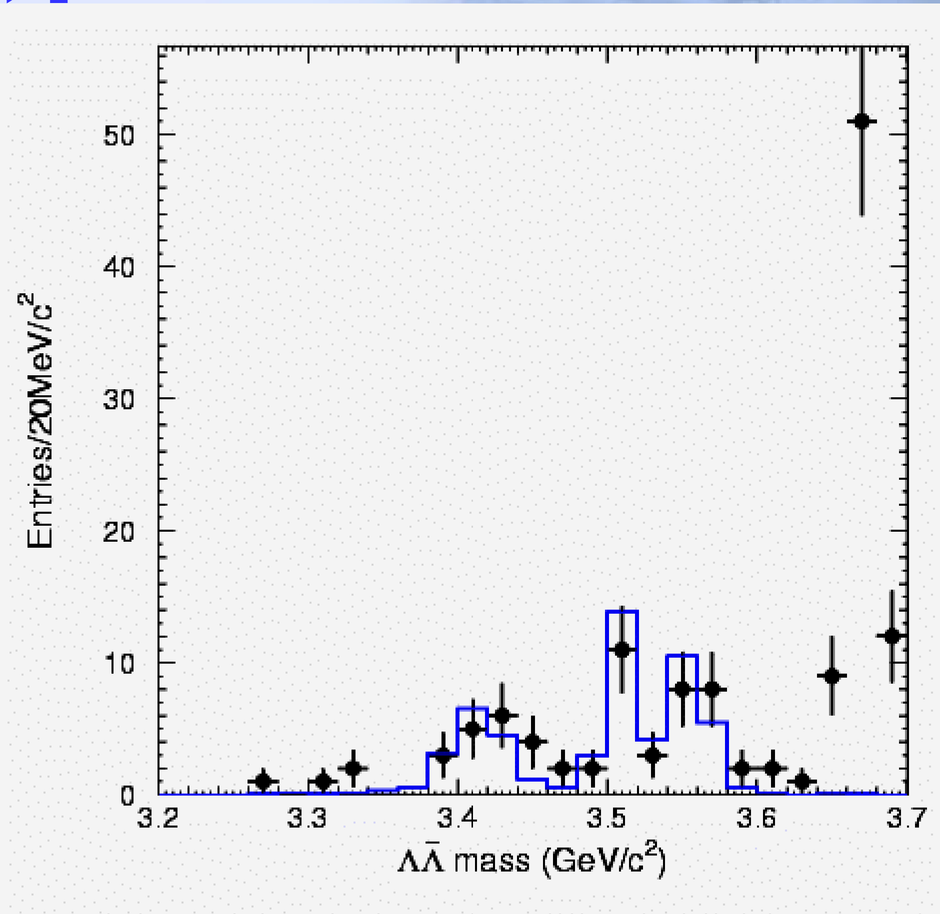
$$\Gamma(\chi_{cJ} \to \Lambda\bar{\Lambda}) \approx \Gamma(\chi_{cJ} \to p\bar{p})/2 \quad \textit{for } \chi_{c1} \textit{ and } \chi_{c2}$$

S.M.Wong,Eur.Phys.J C14,643(2000)

χ from $\psi(2s) \rightarrow \gamma\chi_{cJ}$

m(Λ Λ-bar) plot





data points

Sideband background

data points

MC signal

$\chi_{cJ} \to \Lambda\bar{\Lambda}$ from $\psi(2s) \to \gamma\chi_{cJ}$

Main backgrounds:

a) $\psi(2s) \to \Lambda\bar{\Lambda}, \Sigma^0\bar{\Sigma}^0$

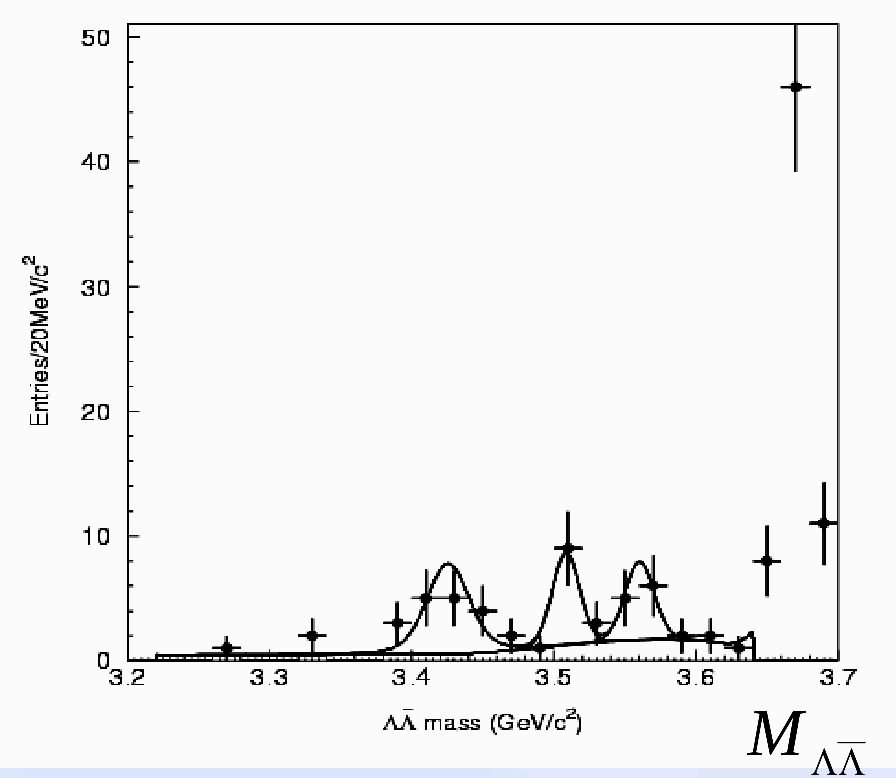
b) $\psi(2s) \to \gamma\chi_{cJ}$ with $\chi_{cJ} \to \Sigma^0\bar{\Sigma}^0$

fixed in fit :

- background shape (MC)
- detector resolutions (MC)
- χ_{cJ} widths to PDG

floating in fit :

Background level



Fitted masses agree with PDG

exp	$M(\chi_{c0})$ (MeV/c^2)	$M(\chi_{c1})$ (MeV/c^2)	$M(\chi_{c2})$ (MeV/c^2)
BES	3425.6 ± 6.3	3508.5 ± 3.9	3560.3 ± 4.6
PDG	3415.1 ± 0.8	3510.51 ± 0.12	3556.18 ± 0.13

$\chi_{cJ} \to \Lambda\bar{\Lambda}$ from $\psi(2s) \to \gamma\chi_{cJ}$

- $N_{\psi(2s)}$ estimated from $\psi(2s) \to \pi\pi J/\psi, J/\psi \to p\bar{p}$
- some systematic errors cancel

Results

	quantity	χ_{c0}	χ_{c1}	χ_{c2}
	n^{obs}	$15.2^{+4.2}_{-4.0}$	$9.0^{+3.5}_{-3.1}$	$8.3^{+3.7}_{-3.4}$
	ε (%)	6.07 ± 0.24	6.65 ± 0.25	6.09 ± 0.24
	$N_{\psi(2S)} (10^6)$		14.9 ± 1.2	
	$\mathcal{B}(\Lambda \to \pi^- p)$		0.639 ± 0.005	
	$\mathcal{B}(\psi(2S) \to \gamma\chi_{cJ})$ (%)	8.7 ± 0.8	8.4 ± 0.7	6.8 ± 0.6
BES	$\mathcal{B}(\chi_{cJ} \to \Lambda\bar{\Lambda})(10^{-4})$	$4.7^{+1.3}_{-1.2} \pm 1.0$	$2.6^{+1.0}_{-0.9} \pm 0.6$	$3.3^{+1.5}_{-1.3} \pm 0.7$
	$n^{obs}_{\pi^+\pi^- J/\psi}$		1826 ± 44	
	$\varepsilon_{\pi^+\pi^- J/\psi}$ (%)		17.88 ± 0.12	
PDG	$B(\chi_{CJ} \to p\ \text{p-bar})(10^{-4})$	2.2 ± 0.5	0.72 ± 0.13	0.74 ± 0.10

- BES central value is higher than COM/QCD prediction on $\Gamma(\chi_{cJ} \to \Lambda\bar{\Lambda}) \approx \Gamma(\chi_{cJ} \to p\bar{p})/2$ but big error
- More data is still required for clarification

BEPCII Double Ring Design

To compete with CESRc, the double ring as final design:

- Design Luminosity ~ 10^{33}cm^{-2} s^{-1}
- Estimated Cost ~ 80M US$
- Less technical challenges
- More physics potential: J/ψ and ψ(2s)

Beam energy range	1–2 GeV
Optimized beam energy region	1.89GeV
Luminosity @1.89 GeV	1×10^{33} cm^{-2}s^{-1}
Injection from linac	E_{inj}=1.55?1.89GeV 50mA/min for e^+
Dedicated SR operation	250 mA@2.5 GeV

Double Ring

- Build new ring inside existing BEPC tunnel
- Two rings cross at two IR
- large crossing angle: 11 mrad.
- 93 bunch / ring with total current ~ 1A
- Lumi. estimated ~ $10^{33}cm^{-2}s^{-1}$ @ 1.89 GeV

  ⇒ Competitive to CESRc
- SR run uses both RF systems: 250 mA @ 2.5 GeV

BEPCII Main Parameters

Parameters		Unit	BEPCII	BEPC
Operation energy (E)		GeV	1.0–2.0	1.0–2.5
Injection energy (E_{inj})		GeV	1.55–1.89	1.3
Circumference (C)		m	237.5	240.4
β^*-function at IP (β_x^*/β_y^*)		cm	100/1.5	120/5
Tunes ($\nu_x/\nu_y/\nu_s$)			6.57/7.61/0.034	5.8/6.7/0.02
Hor. natural emittance (ε_{x0})		mm·mr	0.14 @1.89 GeV	0.39 @1.89 GeV
Damping time ($\tau_x/\tau_y/\tau_e$)			25/25/12.5 @1.89 GeV	28/28/14@1.89 GeV
RF frequency (f_{rf})		MHz	499.8	199.533
RF voltage per ring (V_{rf})		MV	1.5	0.6–1.6
Bunch number (N_b)			93	2×1
Bunch spacing		m	2.4	240.4
Beam current	Colliding	mA	910 @1.89 GeV	~2×35 @1.89 GeV
	SR		250 @2.5GeV	130
Bunch length (cm) σ_l		cm	~1.5	~5
Impedance $\|Z/n\|_0$		Ω	~ 0.2	~4
Crossing angle		mrad	±11	0
Vert. beam-beam param. ξ_y			0.04	0.04
Beam lifetime		hrs.	2.7	6–8
luminosity@1.89 GeV		$10^{31}cm^{-2}s^{-1}$	100	1

Key Technologies

- Injector upgrading
- 500 MHz SC RF System
- SC Micro-b Quads and IR
- Low Impedance Kickers
- Vacuum System
- Cryogenic system
- Power Supply System
- Instrumentation Upgrade
- Control Upgrade: EPICS

BES III design

to adapt Lumi. $10^{33} cm^{-2} s^{-1}$ and bunch spacing 8ns，hardware trigger rate: 4000 Hz

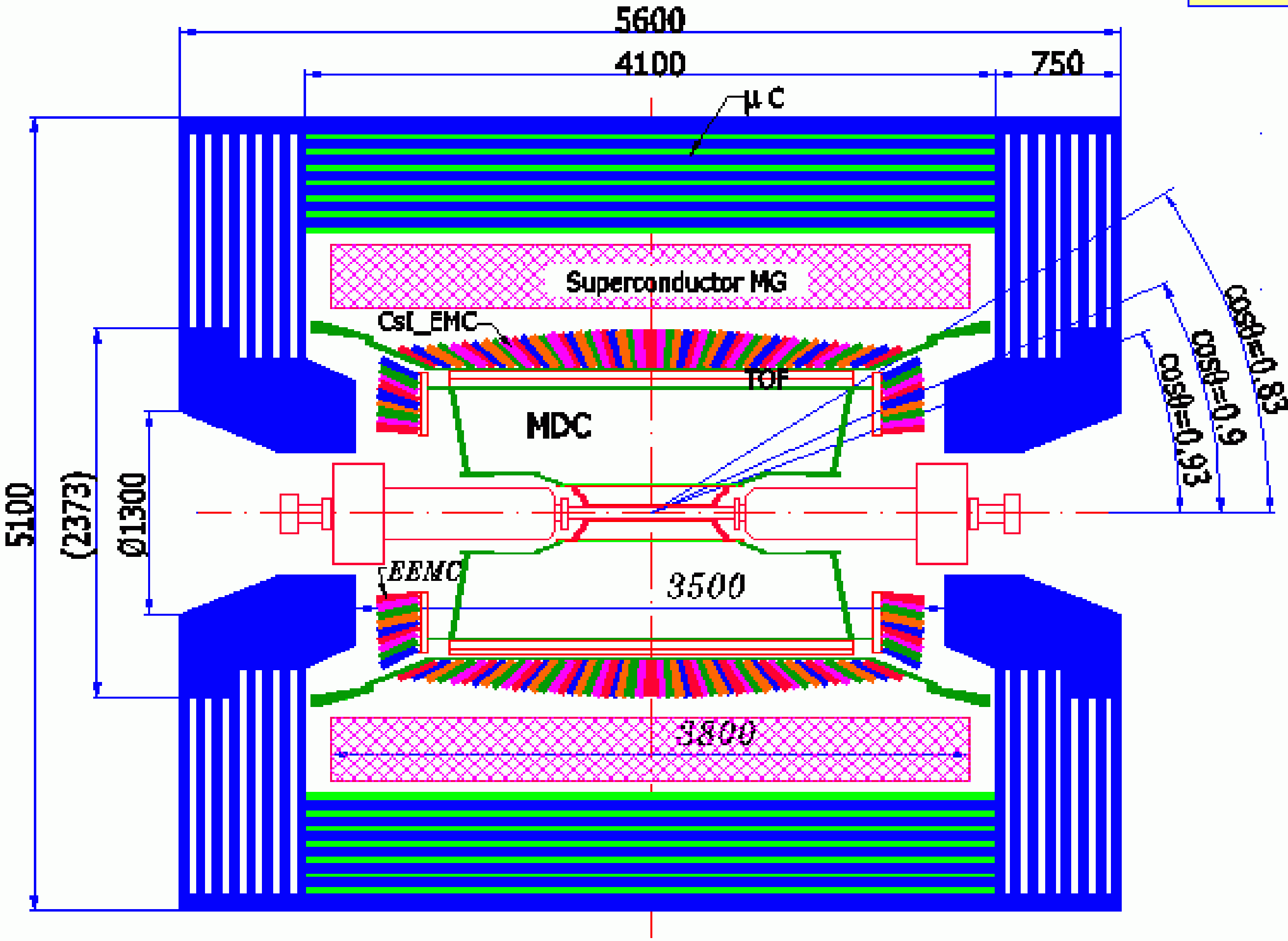
- New detector
- Performance significantly improved
  - Detection efficiency for photon
  - particle IDentification
  - detector solid angle acceptance
  - Interaction Region to fit SC Q magnets

BESIII may compete with CLEOc

BES III Expected Event Rates

Particle	Energy	Single Ring (1.2fb^{-1})	Double Ring (4fb^{-1})
D^0	ψ''	7.0×10^6	23×10^6
D^+	ψ''	5.0×10^6	17×10^6
Ds	4.14GeV	2.0×10^6	4×10^6
$\tau^+\tau^-$	3.57GeV 3.67GeV	0.6×10^6 2.9×10^6	2×10^6 9.6×10^6
J/ψ		$3\text{-}4\times10^9$	$6\text{-}10\times10^9$
ψ'		0.6×10^9	2×10^9

BESIII detector



SC Magnet : 1 Tesla
Rin = 1.32 m, L = 3.8 m

MDC:small cell,Al wire,He gas
σ_{xy}=130 μm
σ_p/p = 0.5% @1GeV
dE/dx=6%

TOF : σ_T = 90 ps Barrel
110 ps Endcap

EMCAL : CsI crystal
σ_E/E = 2.5% @1GeV
σ_z = 0.5 cm/√E

Muon ID: 9 layer RPC
Readout strip width : 4cm

LM : $\Delta L/L$ = 3 %
Readout strip width : 4cm

Trigger: Tracks & Showers
Pipelined; Latency = 2.4μs

DAQ: Event rate = 3KHz
Throuput ~ 50 MB/s

- Adapting BEPCII's high luminosity $10^{33}cm^{-2}\,s^{-1}$ and bunch spacing 8ns
- Reducing sys. error, getting high statistics photon measurement, PID…
- Increasing detector acceptance

Comparison between BESIII and CLEOc

Sub-system	BES III	CLEOc
MDC	σ_{XY} (μm) = 130	110-130
	$\triangle P/P$ ($^0/_0$) = 0.5 %(1 GeV)	0.5 %(1 GeV)
	$\sigma_{dE/dx}$ ($^0/_0$) = 6-7 %	6%
EMC	$\triangle E/\sqrt{E}$($^0/_0$) = 2.3 %(1 GeV) σ_z(cm) = 0.5cm/$\sqrt{E}$	2.3 %(1 GeV) 0.5 cm /$\sqrt{E}$
TOF	σ_T (ps) = 90 ps Barrel 110 ps endcap	RICH
μ counter	9 layers	3layers
magnet	1.0 tesla	1.0 tesla

Physics expected from BESIII

BEPCII's luminosity

- Increased by two-orders of magnitude from BEPC
- Factor of 3 – 7 of CLEOc's

BES III can obtain

important and interesting results in tau-charm physics

Examples:

- Precise measure CKM parameters
- Precise R measurement
- Search for glueballs, determine spin and parity
- Search h'_c and $^1P_1$

Precise measurement of CKM matrix

- Determine V_{cd} & V_{cs} from pure- and semi-leptonic decays of charmed mesons
- Determine V_{cb} from hadronic decays of charmed mesons
- Measure f_D and f_{Ds} for determining V_{td} and V_{ts}
- Measure semi-leptonic shape of D and Ds for V_{ub}
- CKM unitarity check

Br. Fractions of D decays（involving leptons）

Decay Mode	Input Br(%)	Measured Br(%)(80 pb $^{-1}$)	Relative Error (stat.)(5 fb $^{-1}$)
$D^0 \to K^- e^+ \nu_e$	**3.4**	3.36 ± 0.13	**0.6 %**
$D^0 \to K^- \mu^+ \nu_\mu$		3.59 ± 0.17	
$D^0 \to \pi^- e^+ \nu_e$	**0.4**	0.42 ± 0.04	**1.5%**
$D^0 \to \pi^- \mu^+ \nu_\mu$		0.41 ± 0.05	
$D^+ \to \overline{K^0} e^+ \nu_e$	**8.5**	8.8 ± 0.8	**1.5%**
$D^+ \to \overline{K^0} \mu^+ \nu_\mu$		7.7 ± 1.0	
$D^+ \to \mu^+ \nu_\mu$	**0.03**	$4 \pm \sqrt{4}$ **events**	**~ 340 events**
	$f_D = 220\text{MeV}$		$\delta f_D/f_D \approx 3\%$

Error in R measurement

Error Source	BESII reach(%)	BESIII goal(%)
Luminosity	2 - 3	1
Selection effi.	3 - 4	1 - 2
Trigger effi.	0.5	0.5
Radiation corr.	1 - 2	1
Model of hadron decay	2 - 3	1 – 2
Statistical	2.5	--
Total error	6 – 7	2 - 3

Glueball search xi(2230)

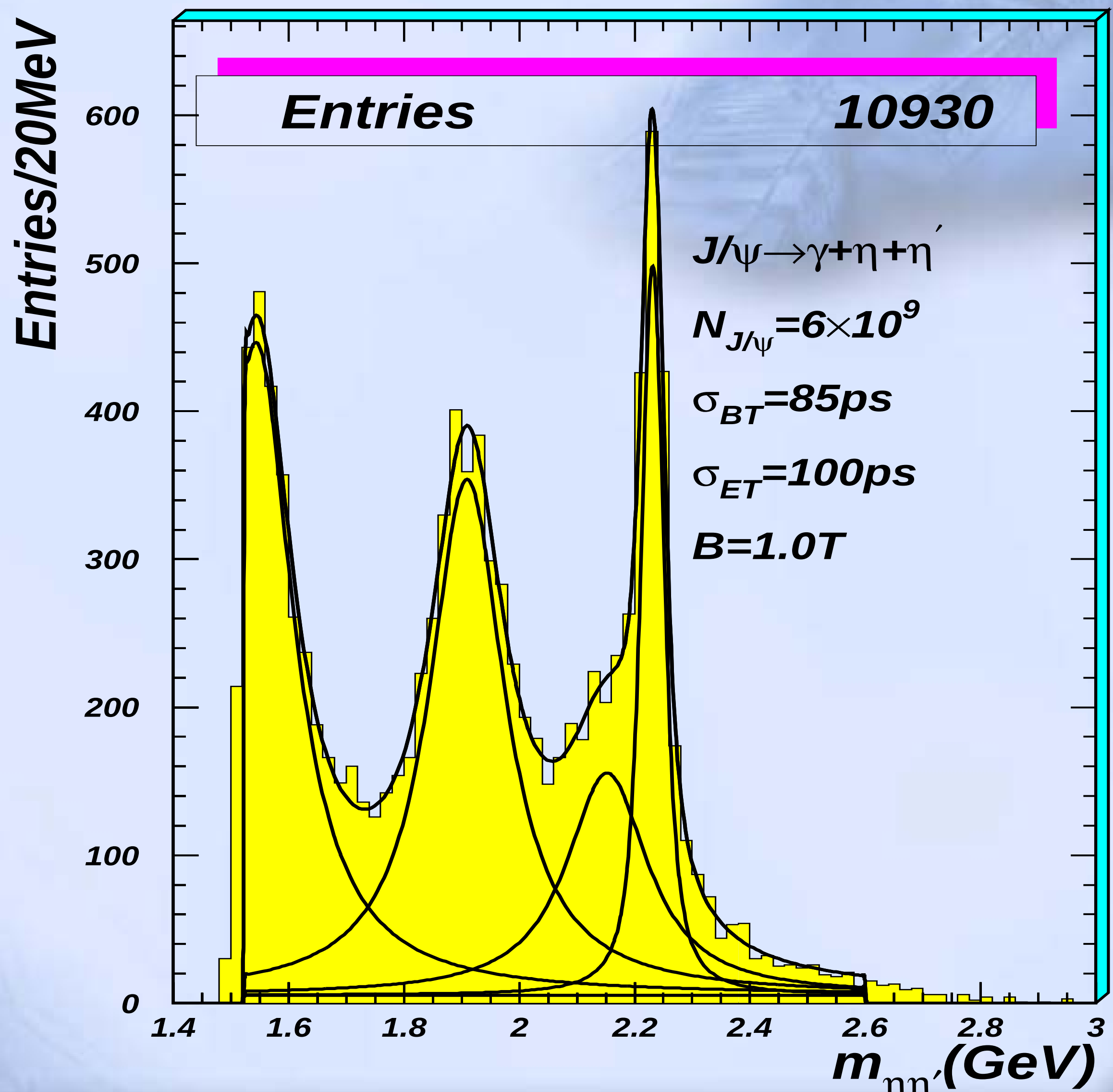
$J/\psi \rightarrow \gamma\eta\eta'$

$\eta \rightarrow \gamma\gamma$

$\eta' \rightarrow \gamma\rho^0 \rightarrow \gamma\pi^+\pi^-$

assuming four resonances:

f0(1500), X(1910), X(2150), ξ(2230)



Partial Wave Analyses:Spin-parity

- **J/ψ → γ KK**

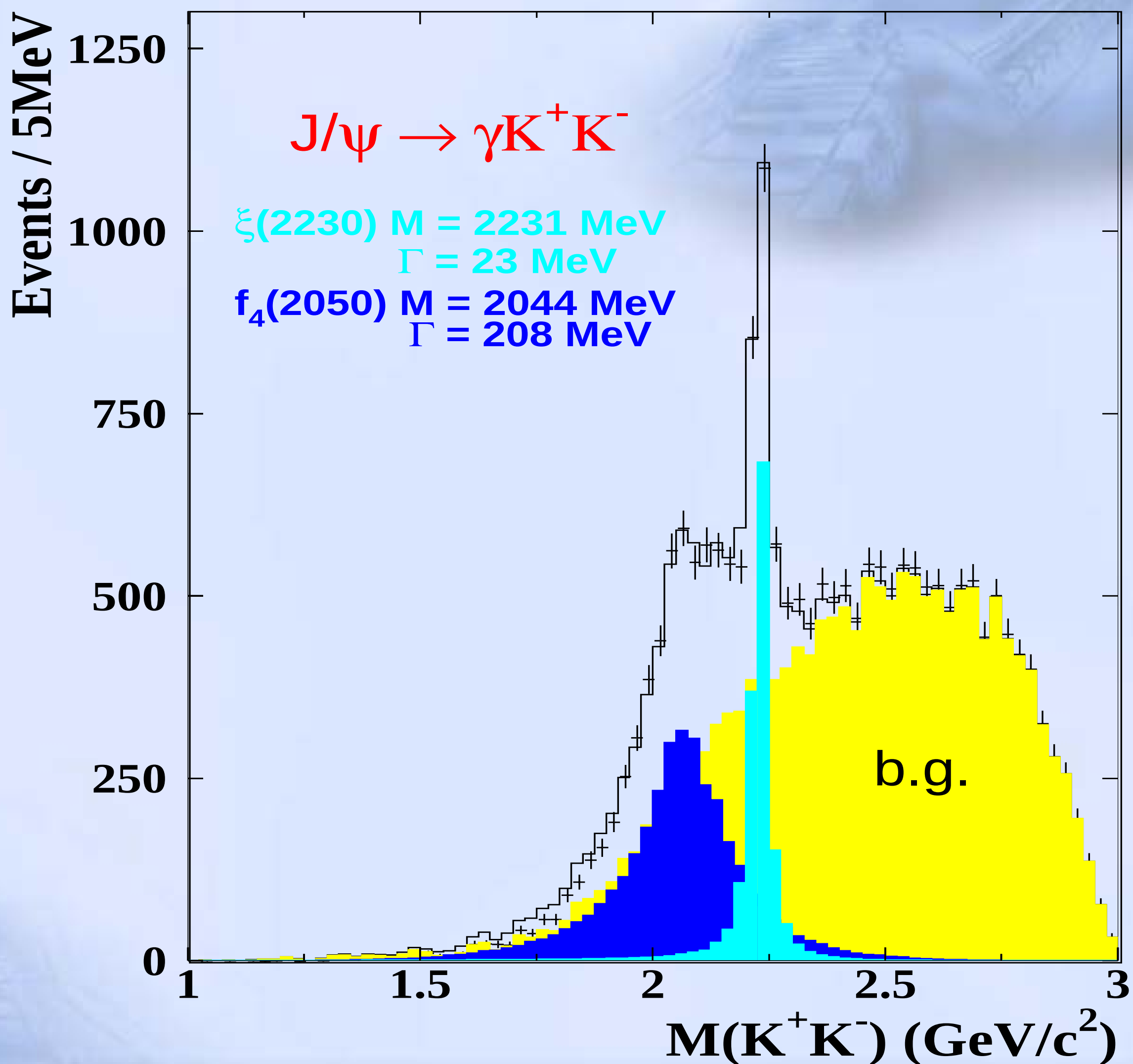
Can determine：

2++ ξ(2230)

4++ **f_4(2050)**

Background

mainly： K*K



Search for $^1P_1$

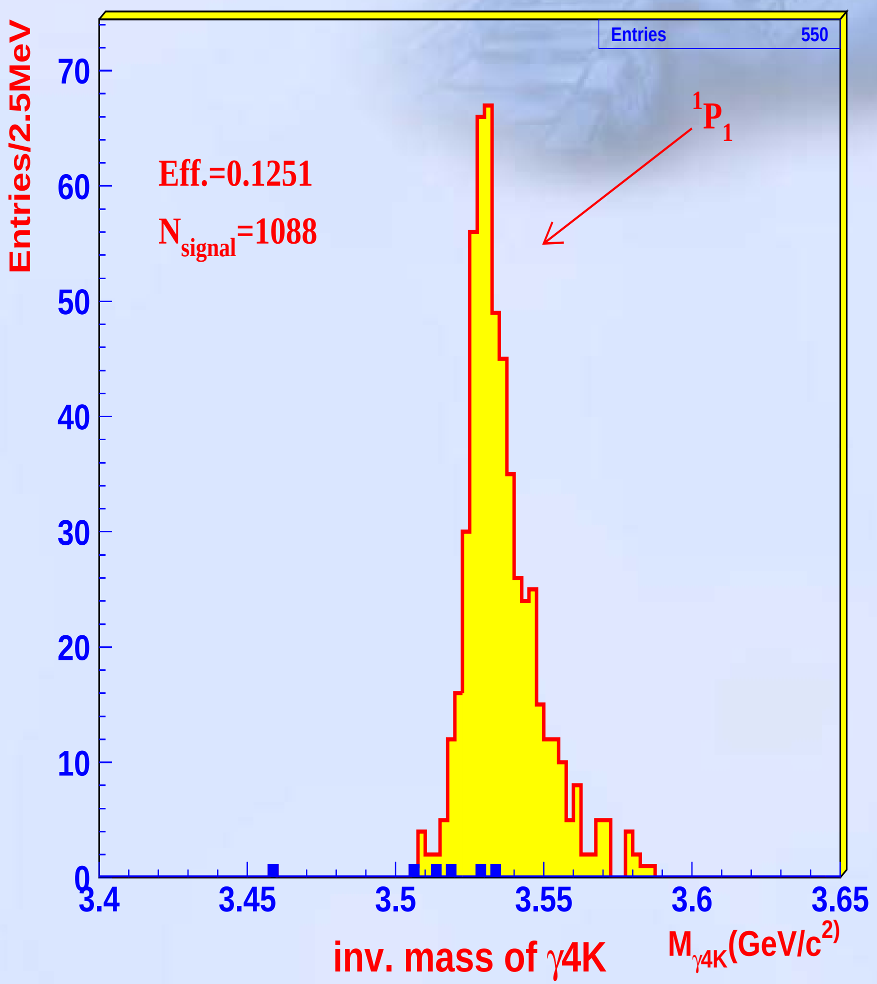
$\psi(2S) \rightarrow \pi^0\ {}^1P_1 \rightarrow \gamma\gamma\gamma\ \eta_c \rightarrow \gamma\gamma\gamma\ 4K$

Br = $(1.2 – 3.3)\times10^{-6}$

Background: $\psi(2S) \rightarrow \gamma\ \chi_{c1}$, $\gamma\chi_{c2}$,, $\eta\psi$, $\pi^0\pi^0\psi$

P_1^1

> 15000 evts/year 450-1200 evts/year



Schedule

- China government approved BEPCII Feb 2003
- Construction started by Spring of 2003
- Summer of 2004 : Linac upgrade + remove BESII detector
- BEPC shutdown for installation : Apr - Dec 2005
- Tuning of Machine without detector : Jan - May 2006
- BESIII detector moved into IR, Jun - Aug 2006
- Machine-detector tuning Sep - Dec 2006
- Physics run by end of 2006

Budget

- The budget estimated : 640M RMB (77M US$)
  - Linac: 46 M
  - Machine: 239 M
  - Detector: 219 M
  - Utility and infrastructure: 106 M
  - Contingency 30 M
- Funding agency and CAS : 600 M, covering most of cost of machine and about ¾ of the cost of the detector.
- Intl. Contribution and collaboration needed

Inter. Collab. on BEPCII / BESIII

- Inter. collaborators are encouraged to join in facing technical challenges, improving detector performance and extracting physics results
- BESIII is competitive in frontier field of tau-charm physics with its precise measurements
- Many physicists from Japan, US and EU show strong interest to join in both collaboration and technical transfer
- Major items for China – US HEP cooperation are made

Summary

- BES R has significant impact on Higgs mass expectation from the SM fit.
- Results of interesting states, f0(1710) and enhanced signal near pp_bar threshold, from J/ψ radiative decays are presented.
- Our measurements of ψ(2s), η_c and χ_{cJ} are new input data for test of QCD models.
- BESIII with high performance will face new challenge in precise measurement of tau-charm physics in 2006/2007

Thank You!