BESIII status and results

Xiaoyan SHEN
(Representing BESIII Collaboration)

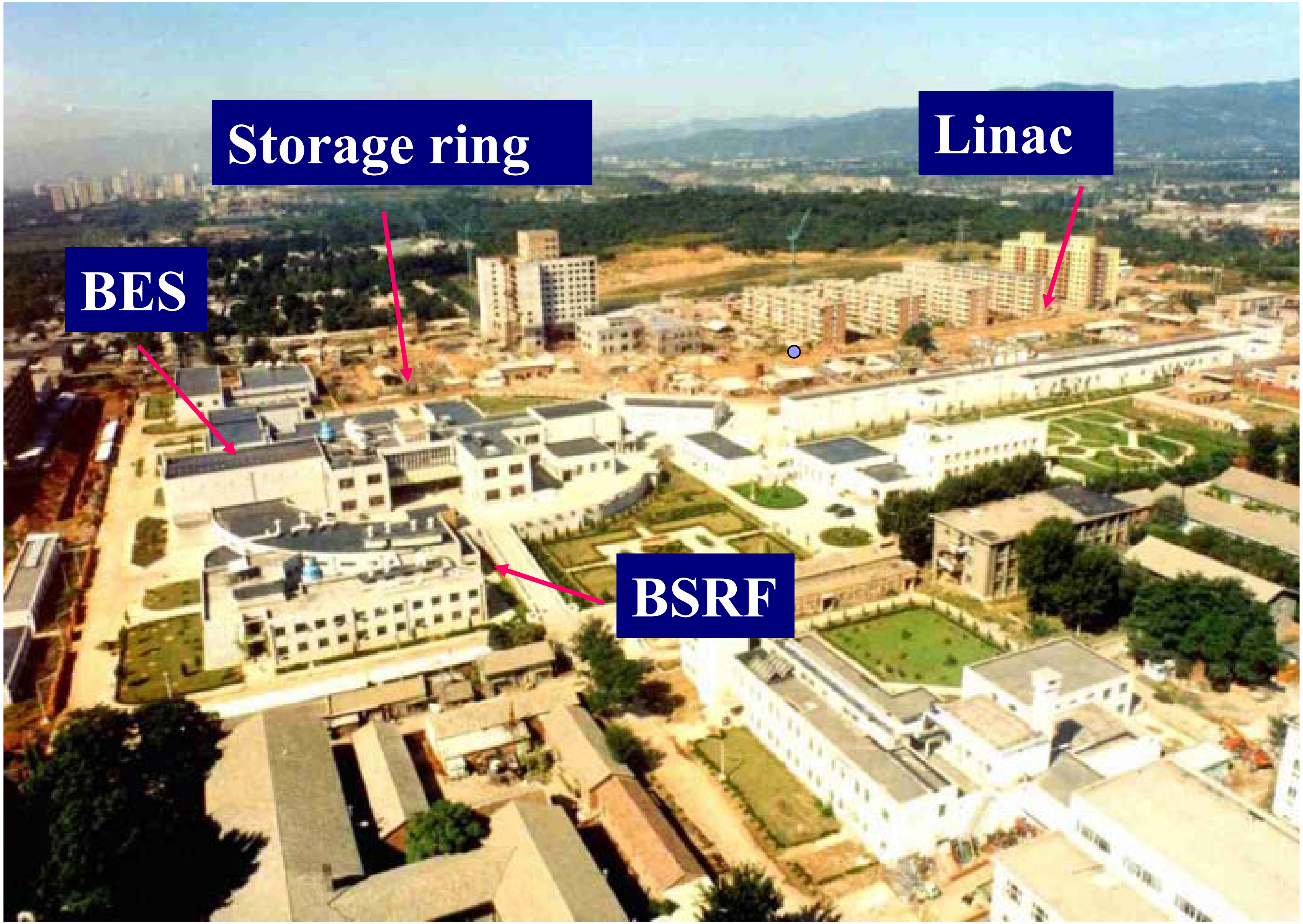
Institute of High Energy Physics, Beijing

Workshop on Hadron Physics, July 27-31, 2010, Tsinghua University

Outline

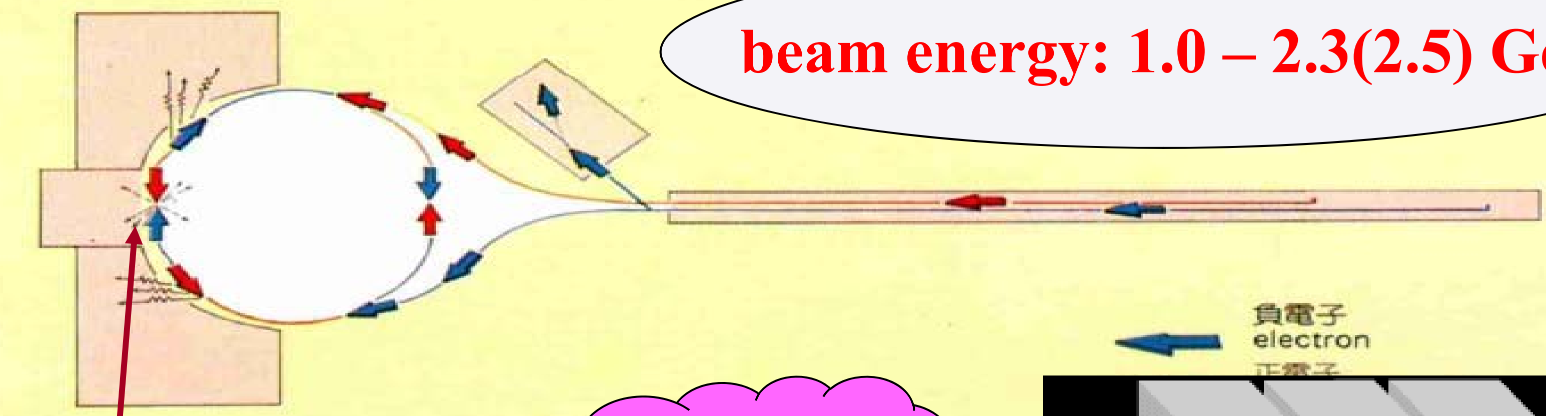
- Introduction
- Status of BESIII
- Recent results from BESIII
- Summary

Beijing Electron Positron Collider (BEPC) at IHEP



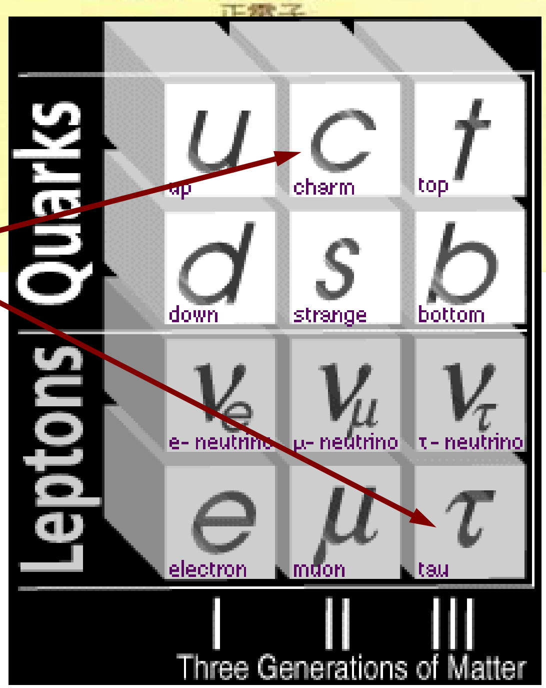
（BEPC/BES）

beam energy: 1.0 – 2.3(2.5) GeV



BES

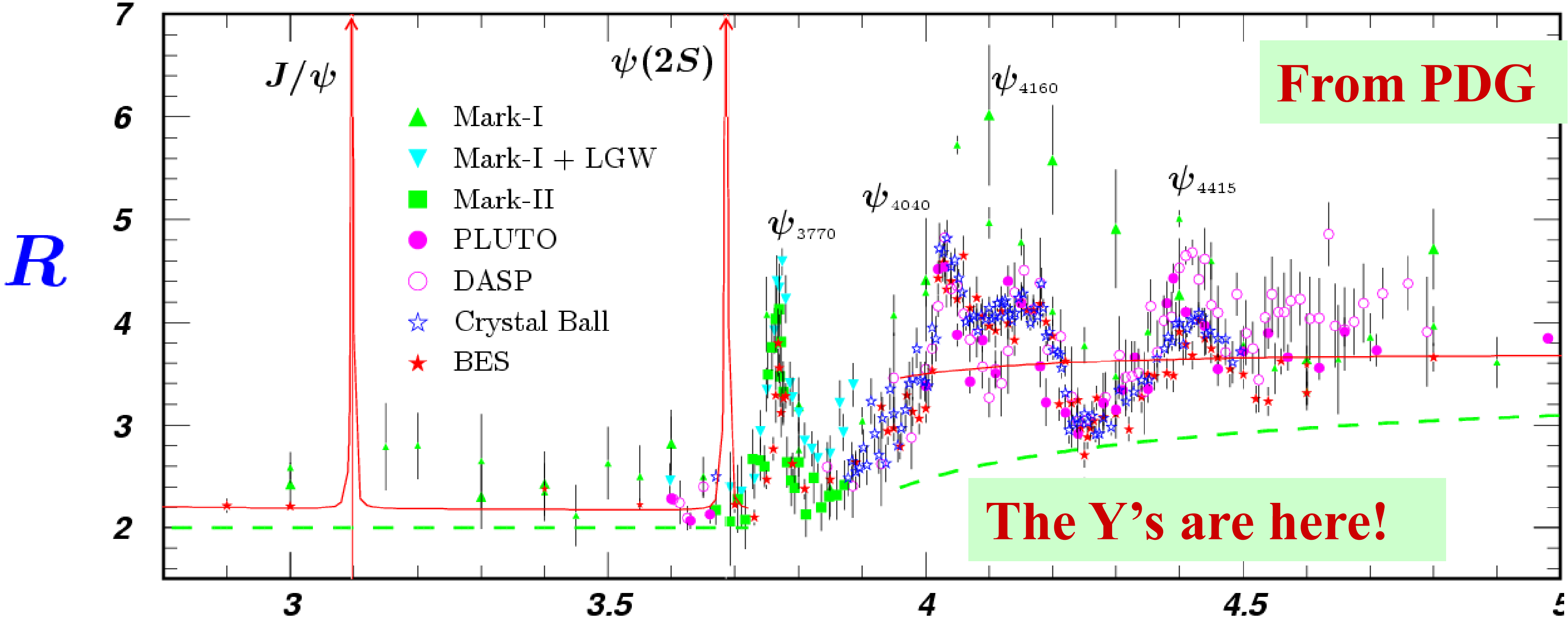
Physics goal



1-2.3GeV e+ e- collisions produce charmonium states （J/ψ， ψ(2S), χ_{cJ} and ψ(3770) etc.), charm mesons and τ lepton.

4

Physics at BEPC/BES



- In transition region between pQCD and non-pQCD.

BEPCII/BESIII

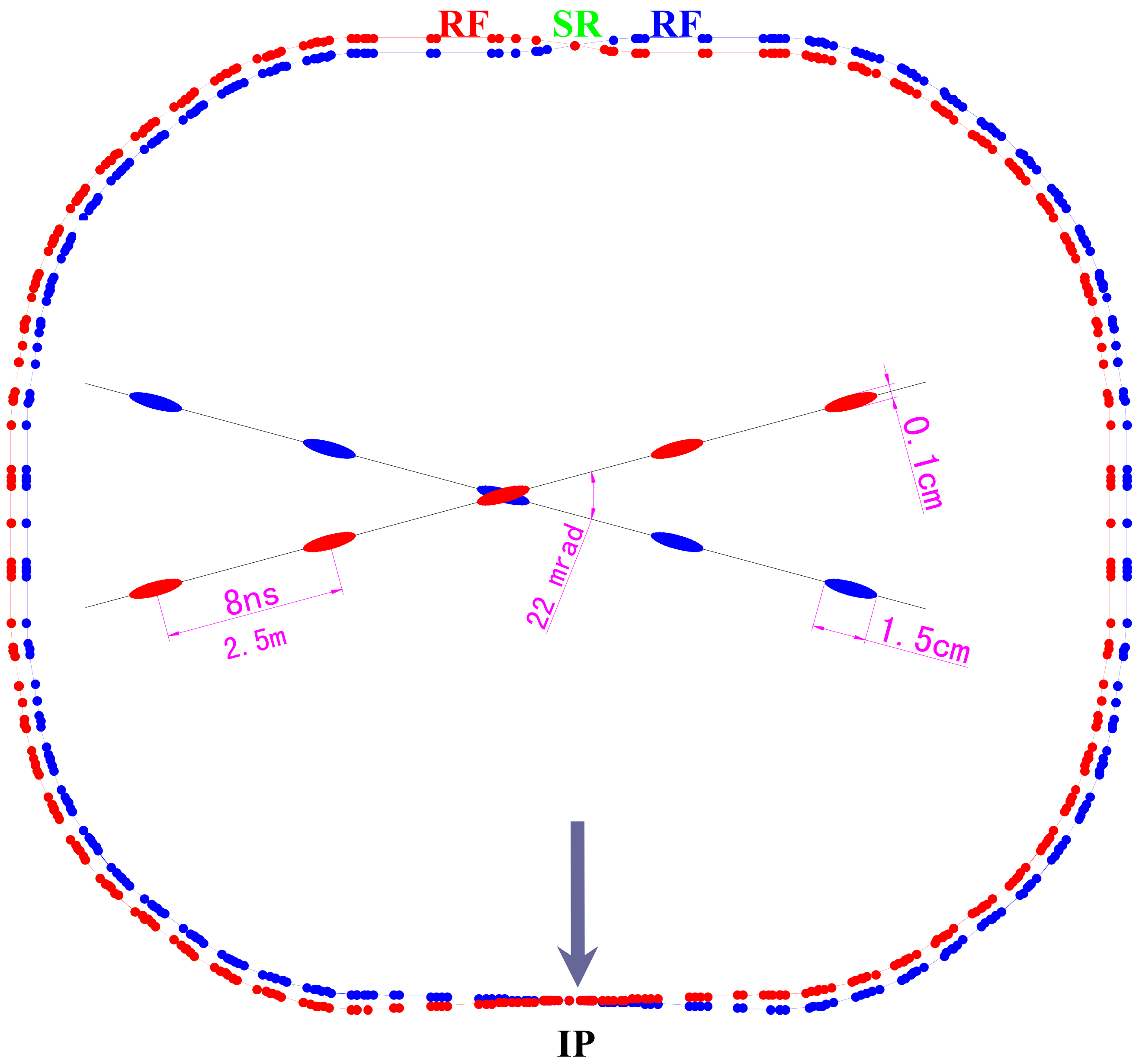
- In the 1990s, there was discussion of the future. The conclusion was to continue tau-charm physics with a major upgrade of the accelerator and detector (BEPCII/BESIII). Officially approved in 2003.

- The physics window is precision charm physics and the search for new physics.

  - ☐ High statistics: high luminosity machine + high quality detector.

  - ☐ Small systematic error: high quality detector.

BEPCII Storage Ring: Double-ring



Beam energy:
1.0-2 .3GeV

Luminosity:
1×10^{33} $cm^{-2}s^{-1}$

Optimum energy:
1.89 GeV

Energy spread:
5.16×10^{-4}

No. of bunches:
93

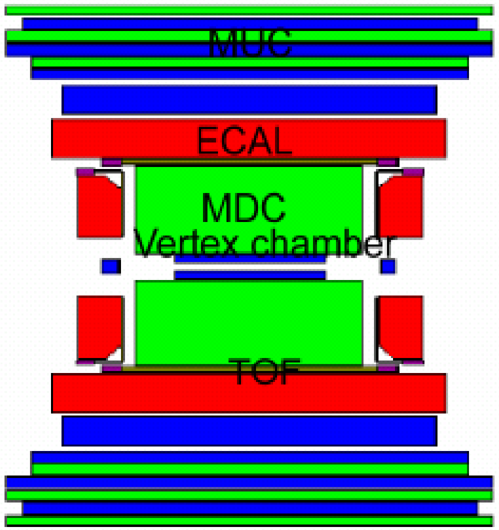
Bunch length:
1.5 cm

Total current:
0.91 A

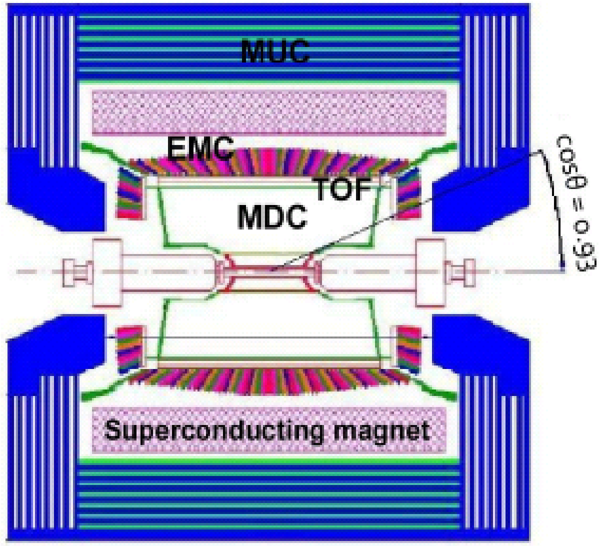
SR mode:
0.25A @ 2.5 GeV

From BESII to BESIII

BES II @ BEPC

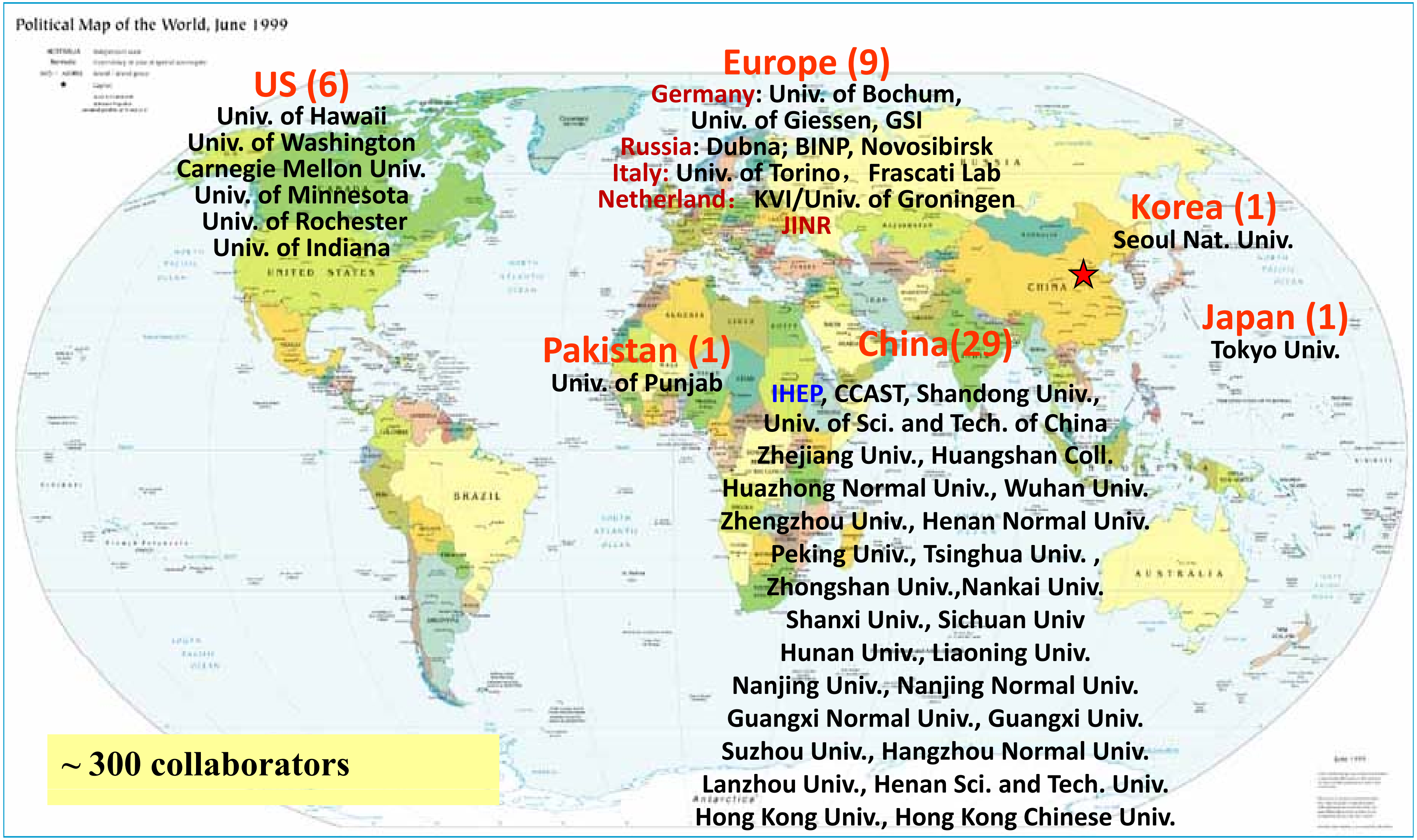


BES III @ BEPC II



	BESII	BESIII
MDC	$\sigma(p)/p = 1.78\% \cdot \sqrt{1+p^2}$ $dE/dx_{reso} = 8\%$	$\sigma(p_t)/p_t = 0.32\% \cdot p_t$ $dE/dx_{reso} < 6\%$
TOF	180 ps (for bhabha)	90 ps (for bhabha)
EMC	$\sigma(E)/E = 22\% \cdot \sqrt{E}$	$\sigma(E)/E = 2.3\% \cdot \sqrt{E}$
MUC	3 layers for barrel	9 layers for barrel, 8 for endcap

BESIII collaboration： 46 Institutes



US (6)
Univ. of Hawaii
Univ. of Washington
Carnegie Mellon Univ.
Univ. of Minnesota
Univ. of Rochester
Univ. of Indiana

Europe (9)
Germany: Univ. of Bochum,
Univ. of Giessen, GSI
Russia: Dubna; BINP, Novosibirsk
Italy: Univ. of Torino，Frascati Lab
Netherland: KVI/Univ. of Groningen
JINR

Korea (1)
Seoul Nat. Univ.

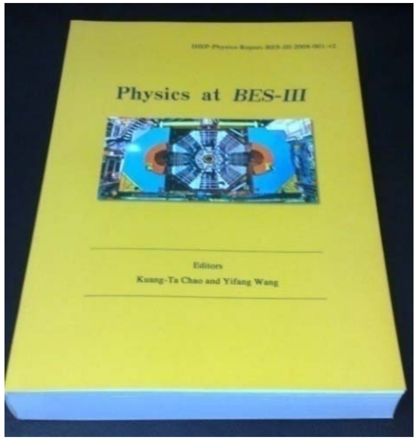
Japan (1)
Tokyo Univ.

Pakistan (1)
Univ. of Punjab

China(29)
IHEP, CCAST, Shandong Univ.,
Univ. of Sci. and Tech. of China
Zhejiang Univ., Huangshan Coll.
Huazhong Normal Univ., Wuhan Univ.
Zhengzhou Univ., Henan Normal Univ.
Peking Univ., Tsinghua Univ. ,
Zhongshan Univ.,Nankai Univ.
Shanxi Univ., Sichuan Univ
Hunan Univ., Liaoning Univ.
Nanjing Univ., Nanjing Normal Univ.
Guangxi Normal Univ., Guangxi Univ.
Suzhou Univ., Hangzhou Normal Univ.
Lanzhou Univ., Henan Sci. and Tech. Univ.
Hong Kong Univ., Hong Kong Chinese Univ.

~ 300 collaborators

Physics Topics at BES



arXiv: 0809.1869

- **Study of Light hadron spectroscopy**
  - search for non-$q\bar{q}$ or non-qqq states
  - meson spectroscopy
  - baryon spectroscopy

- **Study of the production and decay mechanisms of charmonium states:** J/ψ, $\psi(2S)$, $\eta_c(1S)$, $\chi_{C\{0,1,2\}}$, $\eta_c(2S)$, $h_c(^1P_1)$, $\psi(3770)$, etc.

New Charmonium states above open charm threshold.

- **Precise measurement of R values, τ mass, ...**

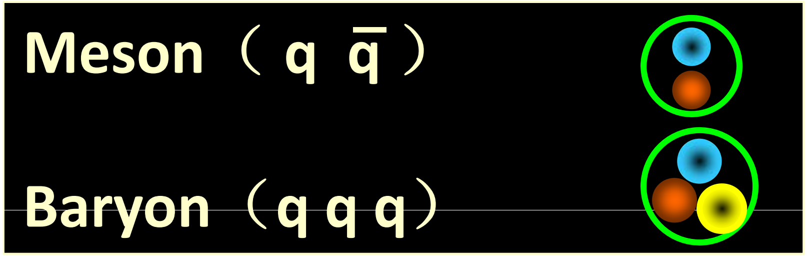
- **Precise measurement of CKM matrix**

- **Search for DDbar mixing, CP violation, etc.**

New forms of hadrons

- **Hadrons consist of 2 or 3 quarks：**

Naive Quark Model：



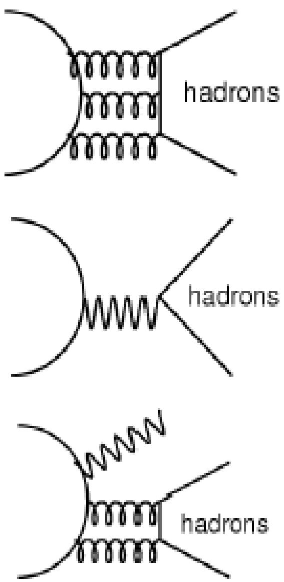
- **QCD predicts the new forms of hadrons:**
    - **Multi-quark states： Number of quarks >＝ 4**
    - **Hybrids： $q\bar{q}g$， qqqg …**
    - **Glueballs： gg， ggg …**

Study of the spectroscopy – a way of understanding the internal structure

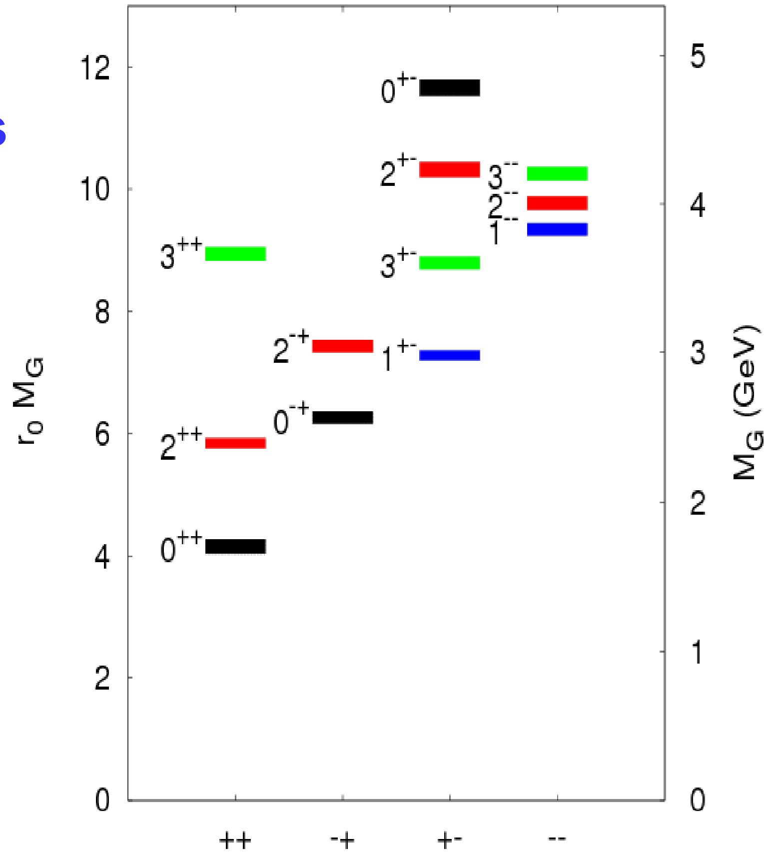
glueball spectrum from LQCD

- **Motivation:**
  - Establish spectrum of light hadrons
  - Search for non-conventional hadrons
  - Understand how hadrons are formed

- **Why at a τ-charm collider ?**

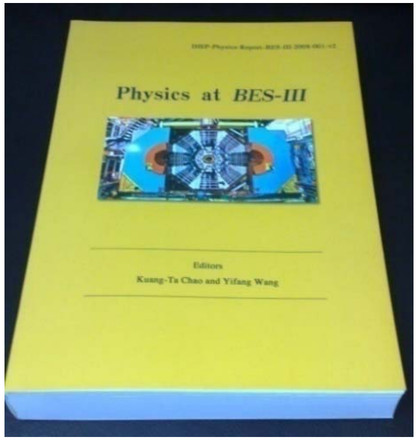


  - Gluon rich
  - Clean environment
  - J^{PC} filter , isospin filter



Y. Chen et al., PRD 73 (2006) 014516

Physics Topics at BES



arXiv: 0809.1869

- Study of Light hadron spectroscopy
  - search for non-qqbar or non-qqq states
  - meson spectroscopy
  - baryon spectroscopy

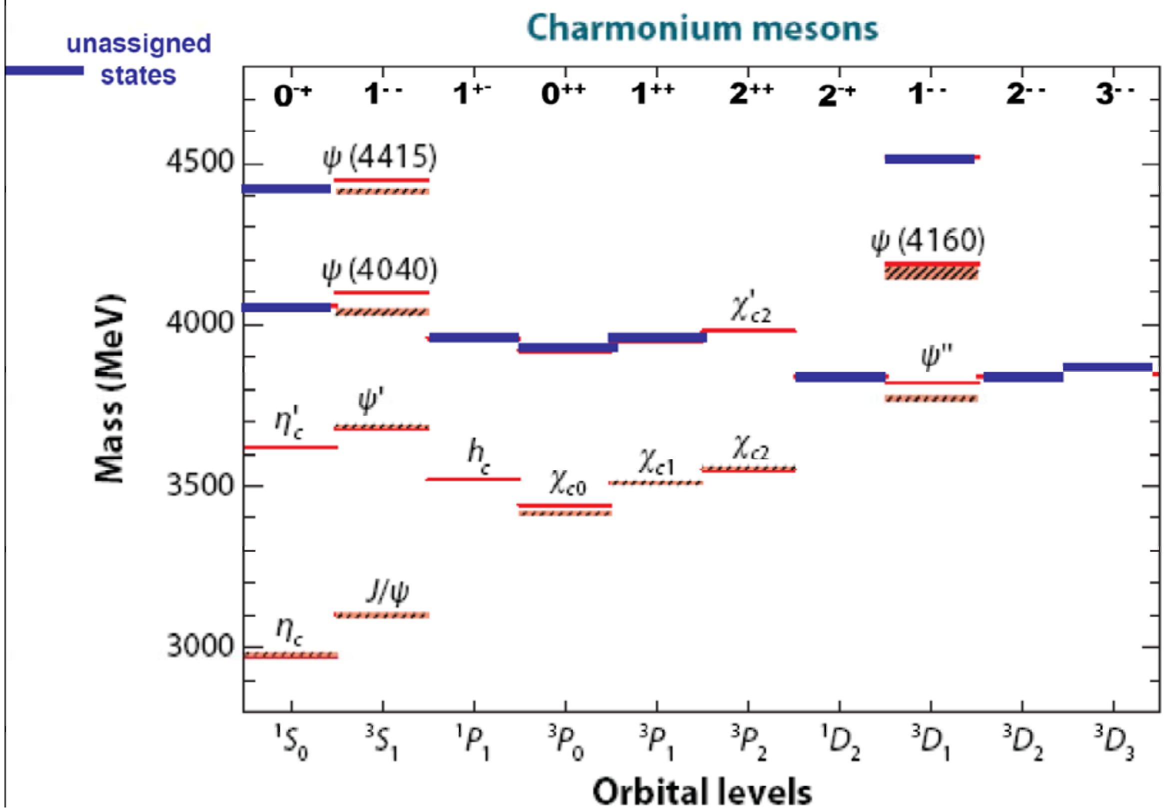
- **Study of the production and decay mechanisms of charmonium states: J/ψ, $\psi(2S)$, $\eta_C(1S)$, $\chi_{C\{0,1,2\}}$, $\eta_C(2S)$, $h_C(^1P_1)$, $\psi(3770)$, etc.**

New Charmonium states above open charm threshold.

- Precise measurement of R values
- Precise measurement of CKM matrix
- Search for DDbar mixing, CP violation, etc.

Charmonium physics

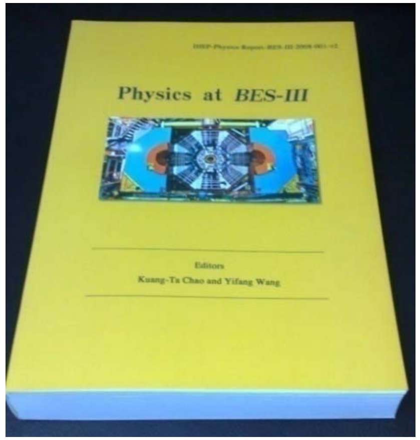
- **What to study ?**
  - **Production, decays, transition, spectrum**
- **For what ?**
  - **A lab for pQCD and non-pQCD**
  - **Calibrate LQCD**
  - **How quarks form a hadron ?**
- **Why at a tau-charm collider ?**
  - **A clean environment**
  - **Tagging possible**
  - **Abundantly produced**



Examples of interesting/long standing issues:

- **ρπ puzzle**
- **Missing states ?**
- **Mixing states ?**
- **New states above open charm thre.(X,Y,Z,…)**

Physics Topics at BES



arXiv: 0809.1869

- Study of Light hadron spectroscopy
  - search for non-qqbar or non-qqq states
  - meson spectroscopy
  - baryon spectroscopy

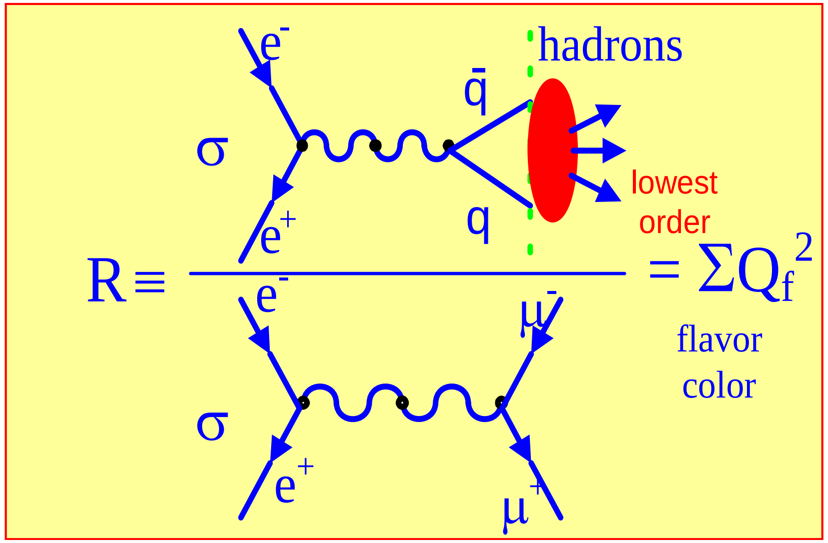
- Study of the production and decay mechanisms of charmonium states: J/ψ, $\psi(2S)$, $\eta_C(1S)$, $\chi_{C\{0,1,2\}}$, $\eta_C(2S)$, $h_C(^1P_1)$, $\psi(3770)$, etc.

  New Charmonium states above open charm threshold.

- **Precise measurement of R values**
- Precise measurement of CKM matrix
- Search for DDbar mixing, CP violation, etc.

R measurement

R : one of the most important and fundamental quantities in particle physics.

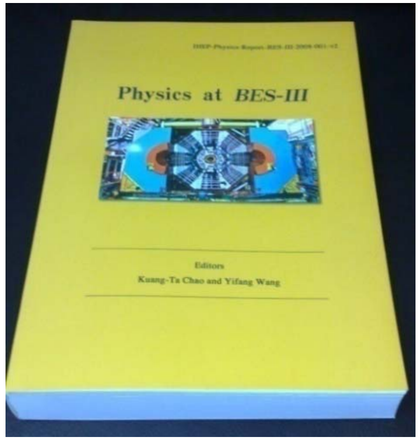


Why precise R important?

Essential for precise tests of SM.

- **the global fit of Higgs mass**
- **anomalous μ magnetic moment from g-2**

Physics Topics at BES



arXiv: 0809.1869

- Study of Light hadron spectroscopy
  - search for non-qqbar or non-qqq states
  - meson spectroscopy
  - baryon spectroscopy

- Study of the production and decay mechanisms of charmonium states: J/ψ, $\psi(2S)$, $\eta_C(1S)$, $\chi_{C\{0,1,2\}}$, $\eta_C(2S)$, $h_C(^1P_1)$, $\psi(3770)$, etc.

  New Charmonium states above open charm threshold.

- Precise measurement of R values

- **Precise measurement of CKM matrix**

- **Search for DDbar mixing, CP violation, etc.**

Precise measurement of CKM elements
-- Test EW theory

CKM matrix elements are fundamental SM parameters that describe the mixing of quark fields due to weak interaction.

~5% precision

~10% precision

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$

CKM matrix

Three generations of quark?

Unitary matrix?

Expect precision < 2% at BESIII

Improve the precision at BESIII

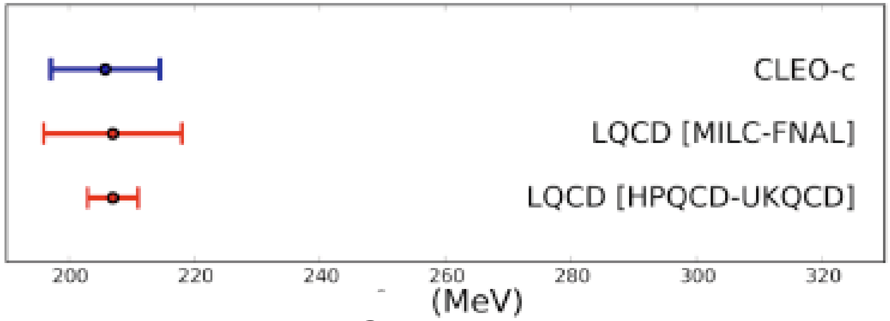
Precision measurement of CKM matrix elements
--a precise test to SM model
New physics beyond SM?

Decay constants vs LQCD

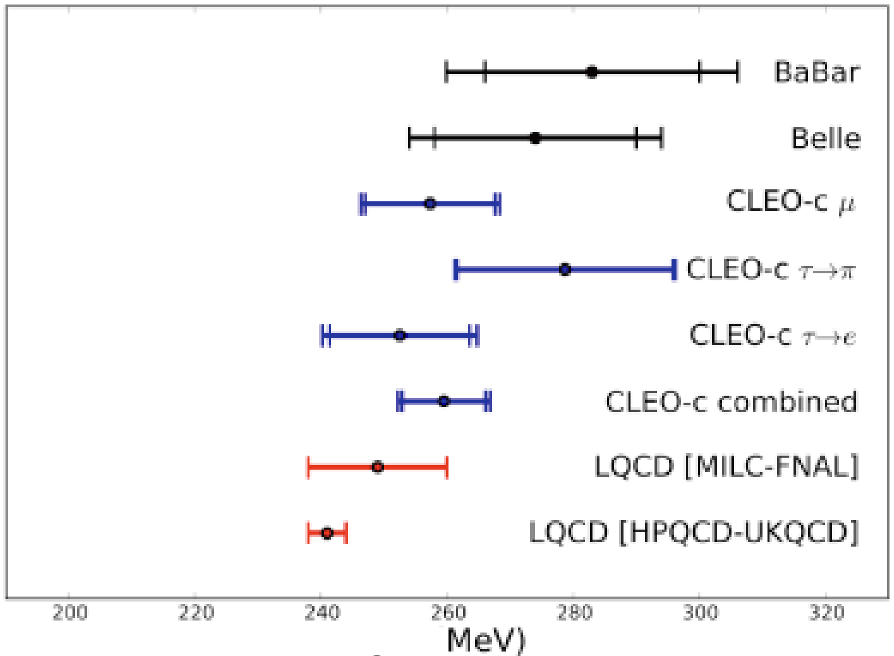
CLEO-c f_{Ds} = 259.5 ± 6.6 ± 3.1 MeV
Lattice: 241 ± 3 MeV [HPQCD-UKQCD]
249 ± 11 MeV [Fermilab-MILC]

CLEO-c f_D = 205.8 ± 8.5 ± 2.5 MeV
Lattice: 208 ± 4 MeV [HPQCD-UKQCD]
207 ± 11 MeV [Fermilab-MILC]

CLEO-c f_{Ds}/f_D = 1.26 ± 0.06 ± 0.02
Lattice: 1.162 ± 0.009 [HPQCD-UKQCD]
1.200 ± 0.027 [Fermilab-MILC]



f_D



f_{Ds}

2.3 σ difference for f_{Ds}. Real ?
BESIII may resolve this issue, reach the precision of LQCD.

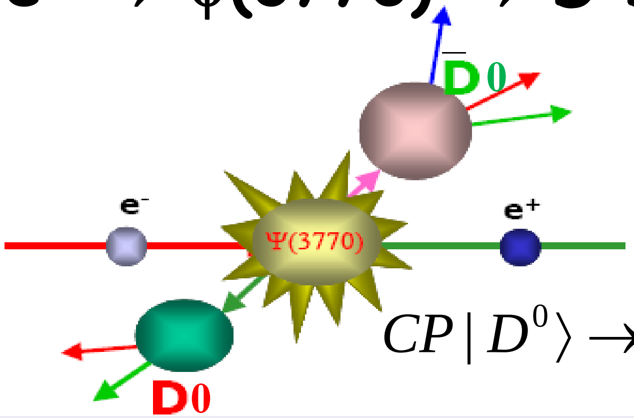
CP violation and $D^0 - \overline{D}^0$ mixing

CP violation is regarded as the origin of asymmetry of the matter and anti-matter.

- **CP violation predicted by theoretical models is not big enough to describe the asymmetry.**
- **CP violation is observed in K and B decays, but has never been in charm sector.**

$e^+e^- \rightarrow \psi(3770) \rightarrow D^0\overline{D}^0$

In SM, the mixing is very small.



At BESIII, the sensitivity of the mixing rate: 1.5×10^{-4}

$CP|D^0\rangle \rightarrow |\overline{D}^0\rangle$

$D^0 - \overline{D}^0$ **mixing : a good place to search for CP violation**

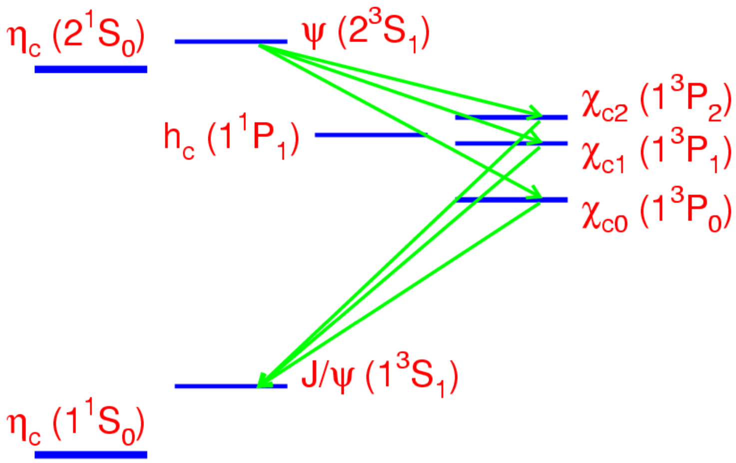
BESIII commissioning and data taking milestones

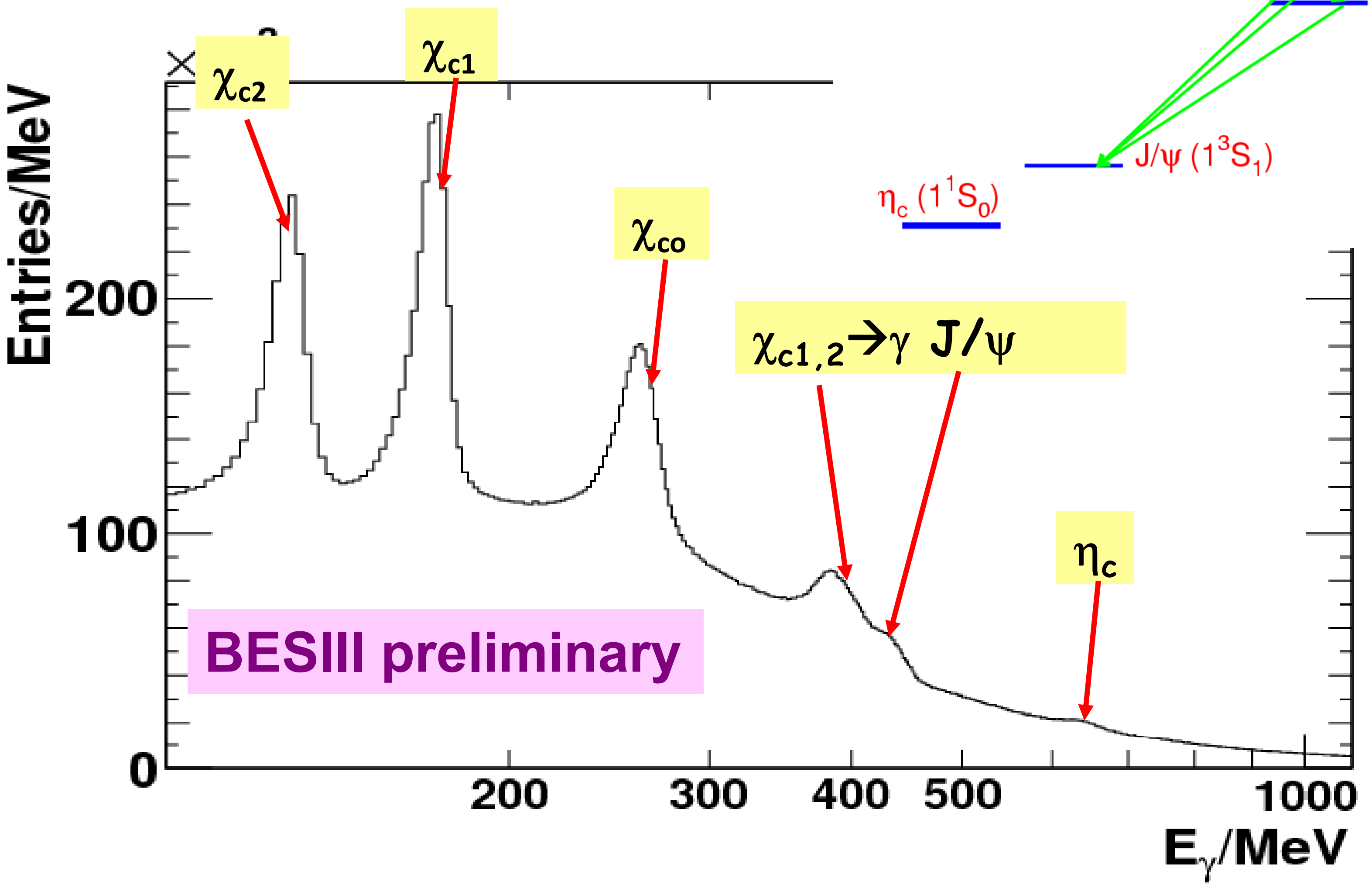
- Mar. 2008: first full cosmic-ray event
- April 30, 2008: Move the BESIII to IP
- July 19, 2008: First e^+e^- collision event in BESIII
- Nov. 2008: ~ 14M ψ(2S) events
- April 14, 2009: ~106M ψ(2S) events
- May 30, 2009: ~42 pb^{-1} at continuum (3.65 GeV)
- July 28, 2009: ~226M J/ψ events
- Aug. – Dec., 2009: summer maintenance, SR run
- Jan. 2010 – June 25 2010: ~ 900 pb^{-1} at 3770 MeV
- June 2-15, 2010: scan at around 3770 MeV

Peak Lumi. @ May 2009: $3.2\times10^{32} cm^{-2}s^{-1}$

Inclusive photon spectrum of $\psi(2S)$

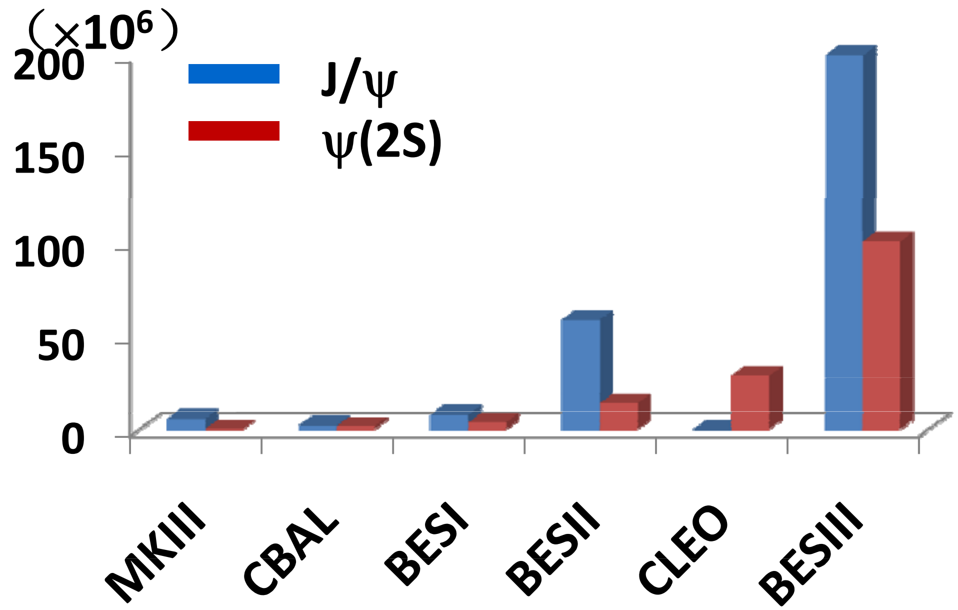
Excellent photon resolution





Results from BESIII

- **Confirm BESII results**
  - **threshold enhancement in $\gamma p\bar{p}$, X(1835), …**
- **New improved measurements**
  - **h_c, η_c, χ_{cJ}, , …**
- **New observations**
  - **χ_{cJ} decays**
  - **h_c decays**
  - **Light hadrons, …**



About $h_c(^1P_1)$ state

- The charmonium family has been studied for many years, the knowledge on $h_c(^1P_1)$ is limited.
- E835 made scans of $\bar{p}$ energy for the reaction
  $p\bar{p} \to h_c \to \gamma\eta_c,\ \eta_c \to \gamma\gamma$, $\sim 3\sigma$ level

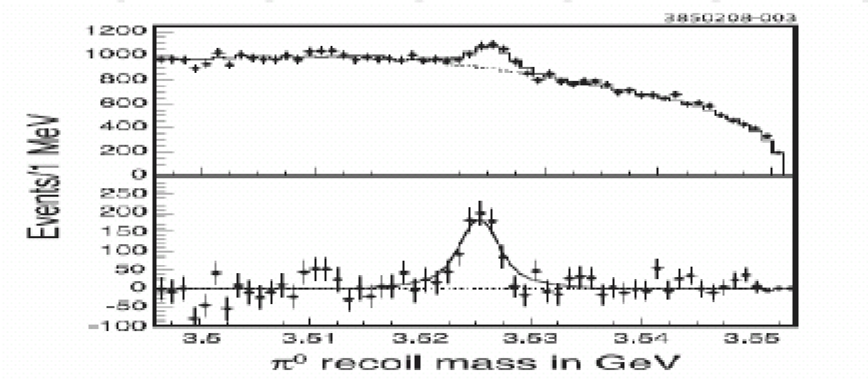
  The results from the year 1997 scan and the year 2000 scan were combined to obtain M(hc)=3525.8±0.2±0.2 MeV.

  No evidence was found for hc in the previously reported reaction
  $p\bar{p} \to hc \to \pi^0 J/\psi$ (E760, 1992)

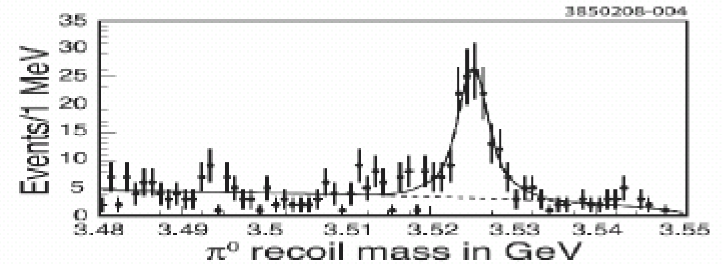
- The $h_c(^1P_1)$ state was observed by CLEO_c in 2005.
- For $\psi(2S)$, only observed in $\psi(2S) \to \pi^0 h_c$
  The main decay mode of h_c: E1 transition $h_c \to \gamma\eta_c$

h_c at CLEOc (with whole data set)

CLEOc's Result –$\psi' \rightarrow \pi^0 h_c$, $h_c \rightarrow \gamma\eta_c$, E1-tagged



CLEOc's Result – $\psi' \rightarrow \pi^0 h_c$, $h_c \rightarrow \gamma\eta_c$ exlusive

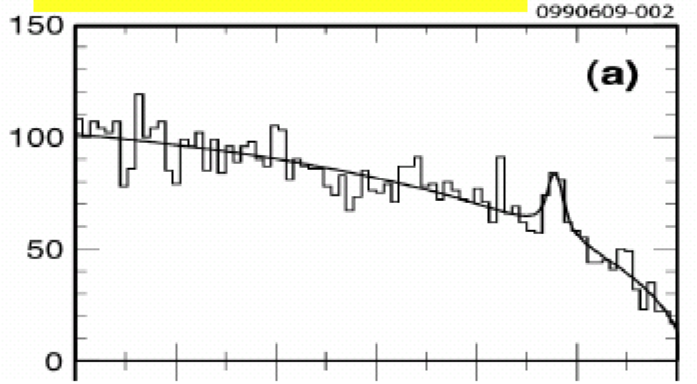


	Inclusive	Exclusive
Counts	1146 ± 118	136 ± 14
Significance	10.0σ	13.2σ
$M(h_c)$ (MeV)	$3525.35 \pm 0.23 \pm 0.15$	$3525.21 \pm 0.27 \pm 0.14$
$\mathcal{B}_1 \times \mathcal{B}_2 \times 10^4$	$4.22 \pm 0.44 \pm 0.52$	$4.15 \pm 0.48 \pm 0.77$

PRL101,182003(2008)

CLEOc's Result – $\psi' \rightarrow \pi^0 h_c$, $h_c \rightarrow 2(\pi^+\pi^-)\pi^0$

PRD80, 051106(2009).



Mode	efficiency (%)	Yield	$B_1 \times B_2 \times 10^5$
$\pi^+\pi^-\pi^0$	27.0	$1.6^{+6.7}_{-5.9}$	< 0.19
$2(\pi^+\pi^-)\pi^0$	18.8	92^{+23}_{-22}	$(1.88^{+0.48+0.47}_{-0.45-0.30})$
$3(\pi^+\pi^-)\pi^0$	11.5	35 ± 26	$(1.2 \pm 0.9 \pm 0.3)$ (< 2.5)

In previous experiments, the absolute branching ratio $B(\psi(2S) \rightarrow \pi^0 h_c)$ and $B(h_c \rightarrow \gamma\eta_c)$ has not been measured.

h_c at BESIII

- **Inclusive analysis of $\psi(2S) \rightarrow \pi^0 h_c$**

  identify h_c in the inclusive recoiling mass spectrum of π^0.

- **E1-tagged analysis of $\psi(2S) \rightarrow \pi^0 h_c$, $h_c \rightarrow \gamma\eta_c$**

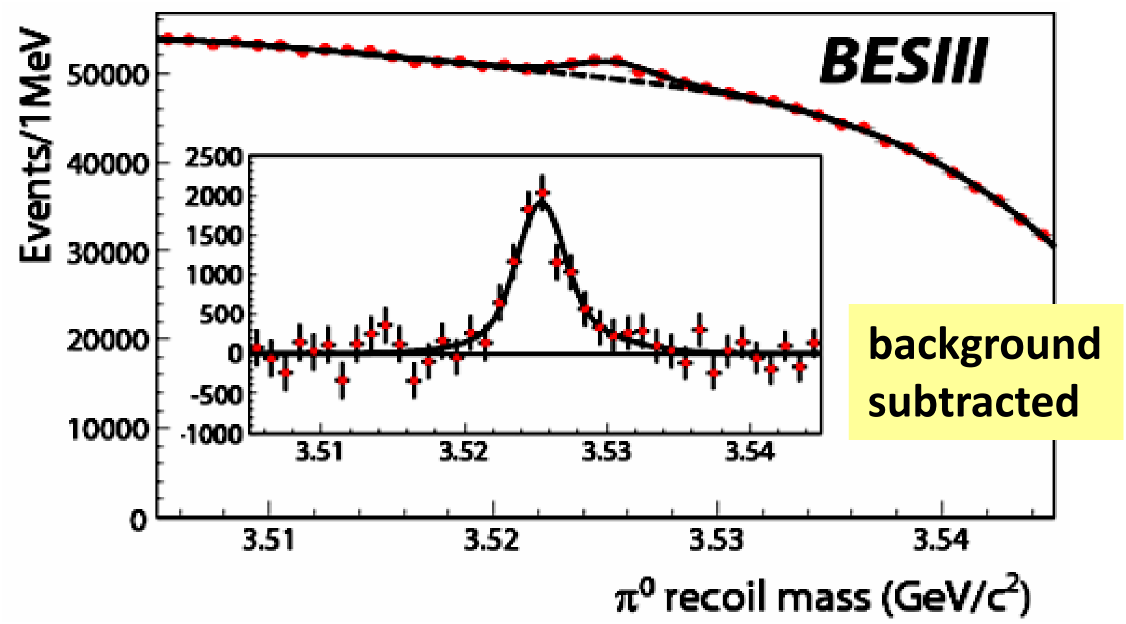
  tag E1 photon (~503 MeV) in $h_c \rightarrow \gamma\eta_c$

  h_c significance improved in inclusive π^0 spectrum

- **Exclusive analysis of $\psi(2S) \rightarrow \pi^0 h_c$, $h_c \rightarrow \gamma\eta_c$**

  fully reconstruct the exclusive η_c decays

Observation of h_c : Inclusive $\psi(2S)\rightarrow\pi^0 h_c$

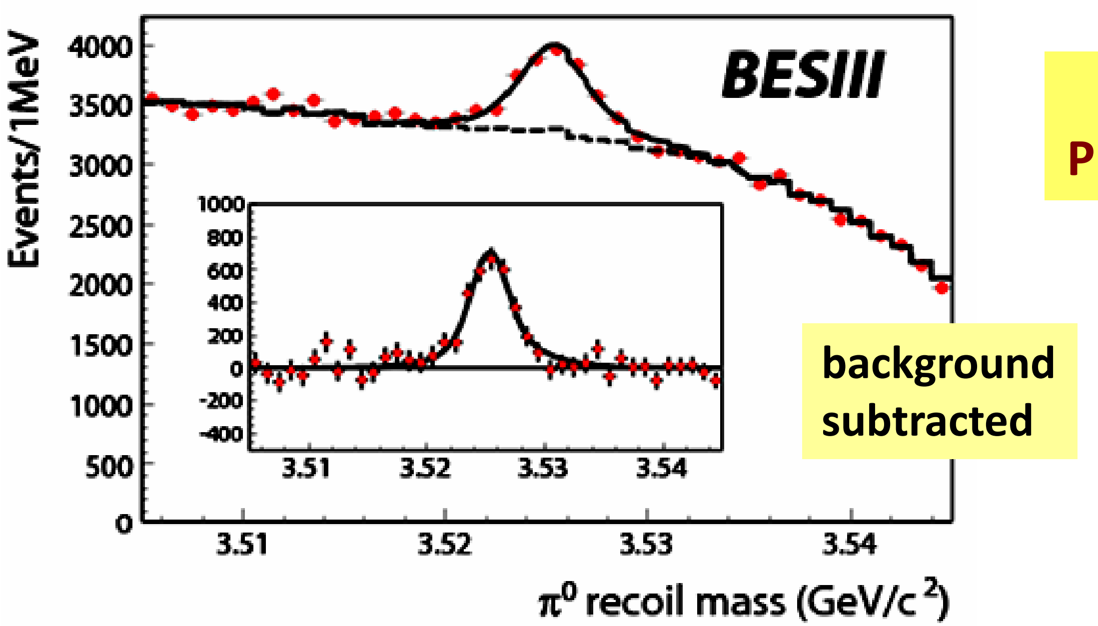


- Select inclusive π^0
- A fit of D-Gaussian signal + 4th Poly. bkg
- Combined inclusive and E1-photon-tagged spectrum

$Br(\psi(2S)\rightarrow\pi^0 h_c) = (8.4 \pm 1.3 \pm 1.0) \times 10^{-4}$ **(First measurement)**

$Br(h_c\rightarrow\gamma\eta_c) = (54.3 \pm 6.7 \pm 5.2)\ \%$ **(First measurement)**

Observation of h_c: E1-tagged $\psi(2S)\to\pi^0 h_c, h_c\to\gamma\eta_c$



BESIII
PRL 104, 132002 (2010)

- Select E1-photon to tag h_c
- A fit of D-Gaussian signal+ sideband

$M(h_c) = 3525.40 \pm 0.13 \pm 0.18$ MeV/c^2

$\Gamma(h_c) = 0.73 \pm 0.45 \pm 0.28$ MeV/c^2 (< 1.44 MeV/c^2 @ 90% CL)
(First measurement)

$Br(\psi(2S)\to\pi^0 h_c) \times Br(h_c\to\gamma\eta_c) = (4.58 \pm 0.40 \pm 0.50) \times 10^{-4}$

χ_{cJ} study at BESIII

The χ_{cJ} decays provide good place to:

- **study gluonium: $\chi_c \to gg \to (q\bar{q})(q\bar{q})$**

  C. Amsler and F. E. Close,Phys. Rev. D 53, 295 (1996).

- **test COM**

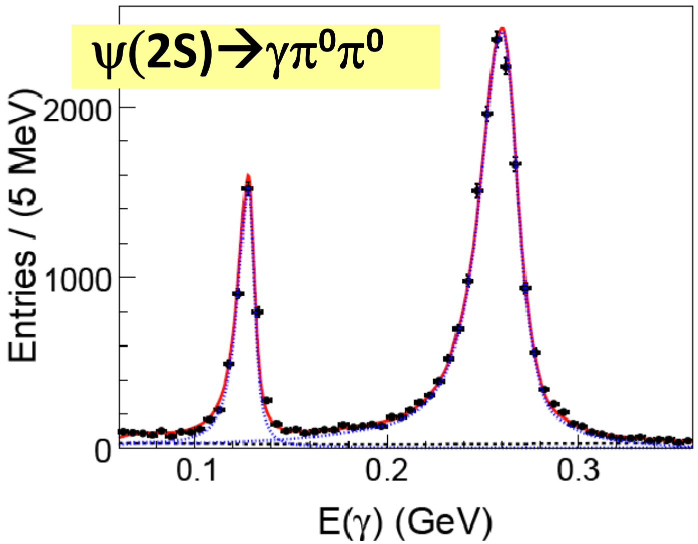
  G. T. Bodwin *et al*., Phys Rev. Lett. D51, 1125 (1995).
  H.-W. Huang and K.-T. Chao, Phys. Rev. D54, 6850 (1996).
  J. Bolz *et al*., Eur. Phys. J. C 2, 705 (1998).

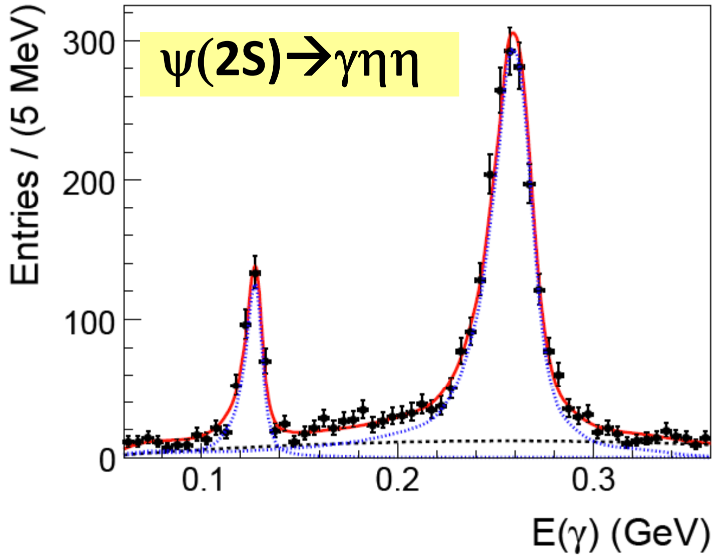
- **Improved measurement of $\chi_{cJ} \to \pi^0\pi^0, \eta\eta$, ……**
- **First measurement of $\chi_{cJ} \to \omega\phi$**
- **First measurement of $\chi_{c1} \to \omega\omega, \phi\phi$**
- **First measurement of $\chi_{cJ} \to \gamma\phi$**

Study of $\psi(2S) \to \gamma\chi_{cJ}$; $\chi_{cJ} \to \pi^0\pi^0$, $\eta\eta$

$(\eta,\ \pi^0 \to \gamma\gamma)$

BESIII:
PRD 81, 052005 (2010).





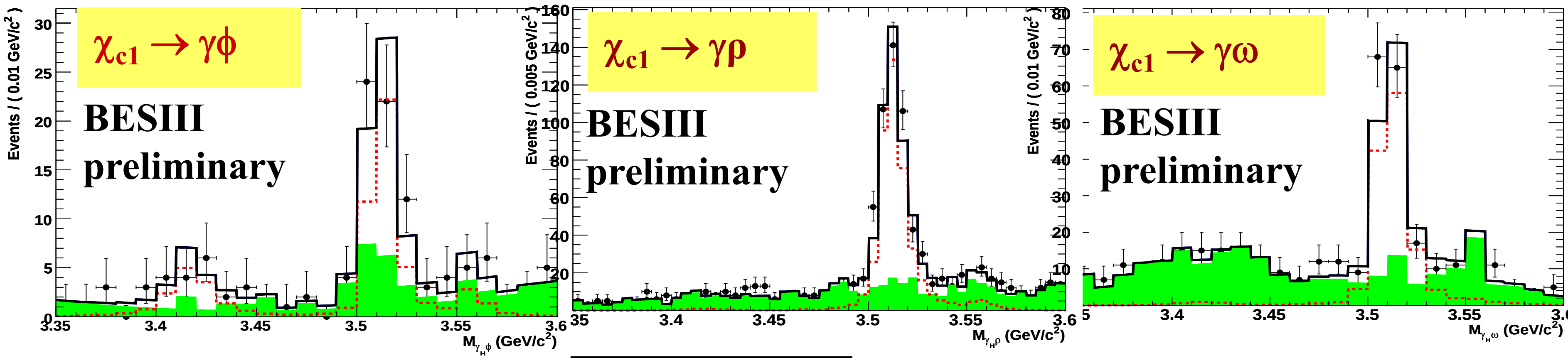
$\chi_{c1} \to \pi\pi$, $\eta\eta$ not allowed by parity conservation.

CLEOc:
PRD 79, 072007 (2009).

Decay mode		χ_{c0} (10^{-3})	χ_{c2} (10^{-3})
$\pi^0\pi^0$	BESIII	$3.23\pm0.03\pm0.23\pm0.14$	$0.88\pm0.02\pm0.06\pm0.04$
	PDG08	2.43 ± 0.20	0.71 ± 0.08
	CLEOc	$2.94\pm0.07\pm0.32\pm0.15$	$0.68\pm0.03\pm0.07\pm0.04$
$\eta\eta$	BESIII	$3.44\pm0.10\pm0.24\pm0.20$	$0.65\pm0.04\pm0.05\pm0.03$
	PDG08	2.4 ± 0.4	< 0.5
	CLEOc	$3.18\pm0.13\pm0.31\pm0.16$	$0.51\pm0.05\pm0.05\pm0.03$

CLEOc used their own branching ratios for $\psi' \to \gamma\chi_{cJ}$.

$\chi_{cJ} \to \gamma V$, V=ϕ,ρ,ω



B (10^{-6})	BESIII	CLEOc	pQCD
$\chi_{c0} \to \gamma\phi$	< 14.8	< 6.4	0.46
$\chi_{c1} \to \gamma\phi$	$27.3 \pm 5.5_{stat}$	< 26	3.6
$\chi_{c2} \to \gamma\phi$	< 7.8	< 13	1.1
$\chi_{c0} \to \gamma\rho^0$	< 9.5	< 9.6	1.2
$\chi_{c1} \to \gamma\rho^0$	$241 \pm 14_{stat}$	$243 \pm 19 \pm 22$	14
$\chi_{c2} \to \gamma\rho^0$	< 19.7	< 50	4.4
$\chi_{c0} \to \gamma\omega$	< 11.7	< 8.8	0.13
$\chi_{c1} \to \gamma\omega$	$73.5 \pm 7.6_{stat}$	$83 \pm 15 \pm 12$	1.6
$\chi_{c2} \to \gamma\omega$	< 5.8	< 7.0	0.5

- **$\chi_{c1} \to \gamma\phi$ observed for the first time.**
- **pQCD predictions too low.**
- **Difference may be explained by non-perturbative QCD "loop corrections".**

D.Y Chen *et al*, arXiv:1005.0066v2.

CLEOc: PRL 101, 151801 (2008)

pQCD: Y.J. Gao et al., hep-ph/0701009

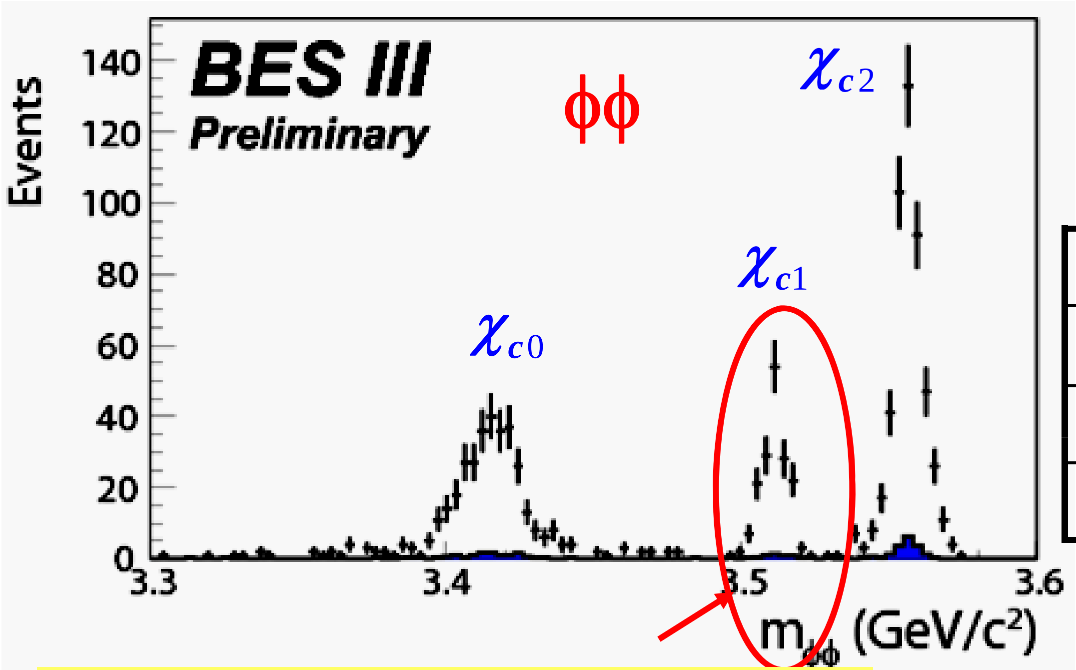
Study of $\chi_{cJ} \to VV$, $V = \omega,\phi$

BR(10^{-3})	χ_{c0}	χ_{c2}
$\to \phi\phi$	0.94±0.21±0.13	1.70±0.30±0.25
$\to \omega\omega$	2.29±0.58±0.41	1.77±0.47±0.36

BESII, PLB 642, 197 (2006)

BESII, PLB 630, 7 (2005)

- $\chi_{c1} \to \phi\phi$ (and $\omega\omega$) should be highly suppressed because C-parity requires L = 2.



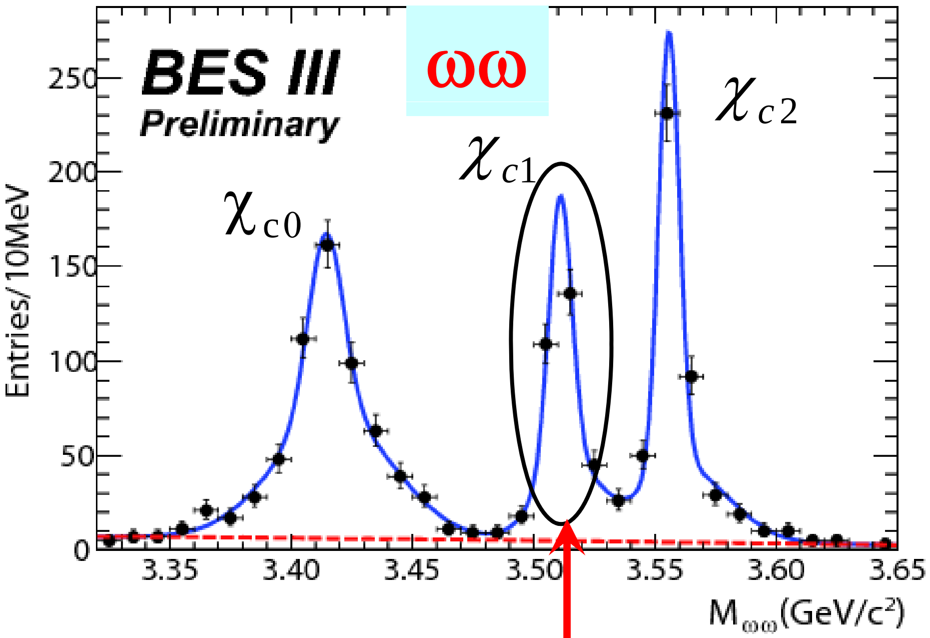
First observation of $\chi_{c1} \to \phi\phi$

BESIII sees clear $\chi_{cJ} \to \phi\phi$
$\to$ 4K signals

BR(10^{-3})	BESIII	PDG08
$\chi_{c0} \to \phi\phi$	0.80 ± 0.04	0.93 ± 0.20
$\chi_{c1} \to \phi\phi$	0.42 ± 0.03	----
$\chi_{c2} \to \phi\phi$	1.15 ± 0.04	1.54 ± 0.30

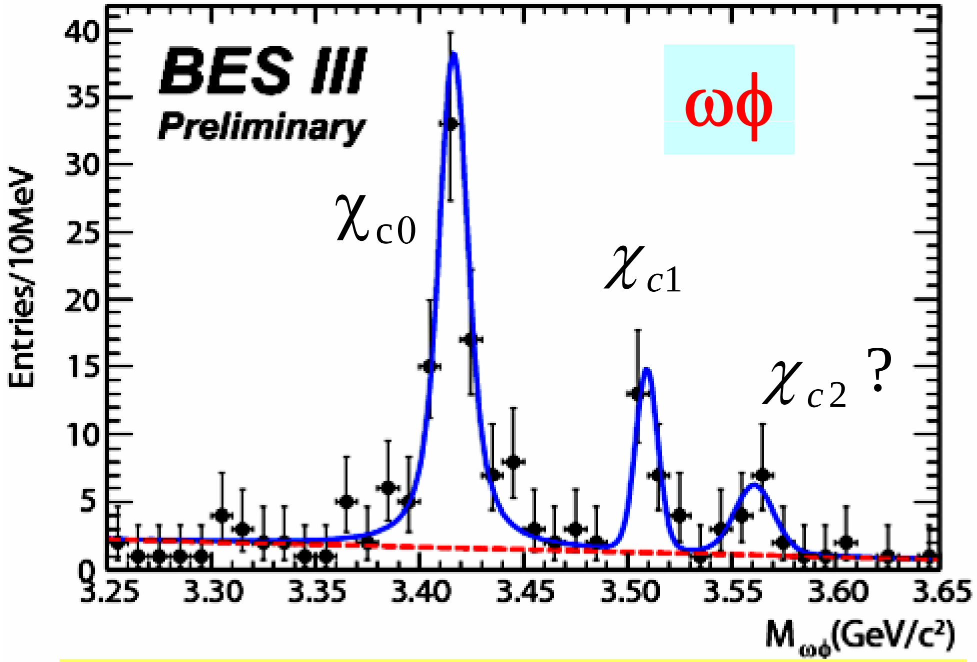
Errors: statistical only.

clear $\chi_{cJ} \to \omega\omega$
$\to 2(\pi^+\pi^-\pi^0)$



First observation of $\chi_{c1} \to \omega\omega$.

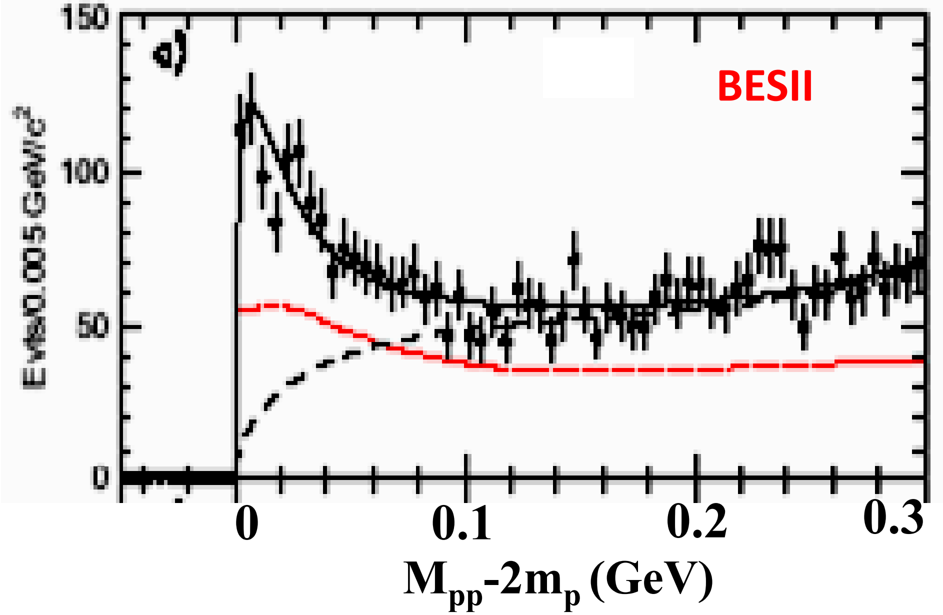
clear $\chi_{cJ} \to \omega\phi$
$\to (\pi^+\pi^-\pi^0)(KK)$



Doubly OZI suppressed $\chi_{cJ} \to \omega\phi$ observed for the first time.

$p\bar{p}$ mass threshold study at BES

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



theoretical speculation:

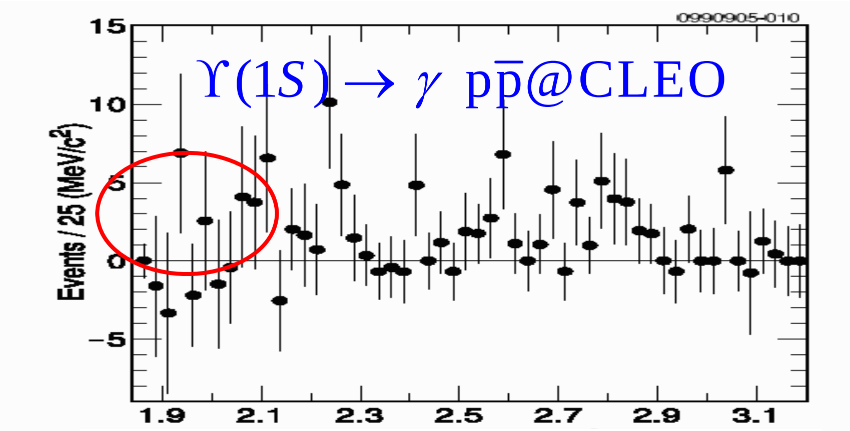
- $p\bar{p}$ **bound state (baryonium)**
- **FSI effect**
- **……**

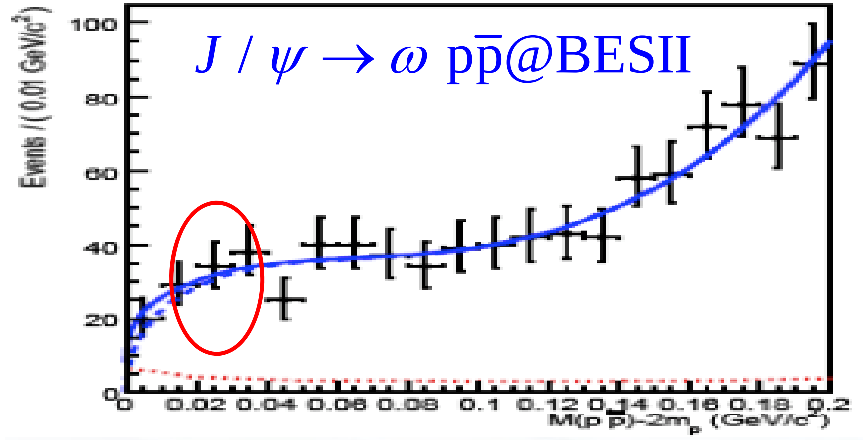
Observation of an anomalous enhancement near the threshold of $p\bar{p}$ mass spectrum

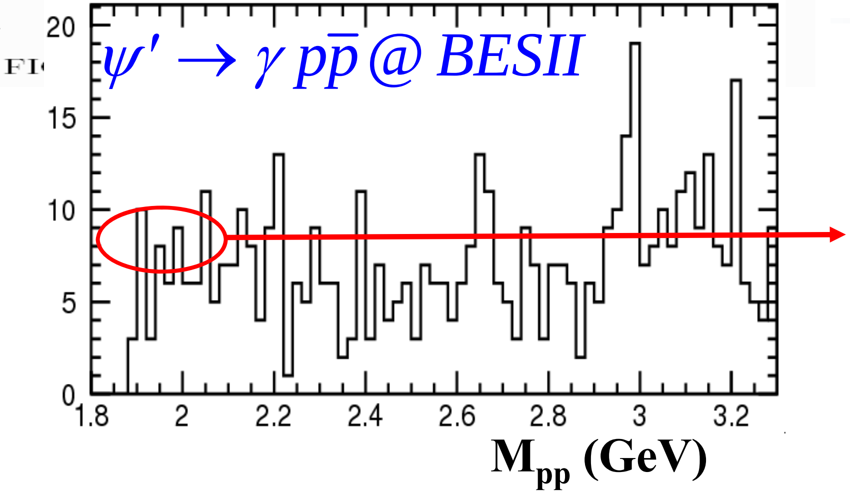
PRL 91 (2003) 022001

$p\bar{p}$ mass spectrum in other channels

The narrow threshold enhancement is not observed in those channels







No significant narrow strong enhancement near threshold (~2σ if fitted with X(1860))

$p\bar{p}$ threshold enhancement @ CLEOc

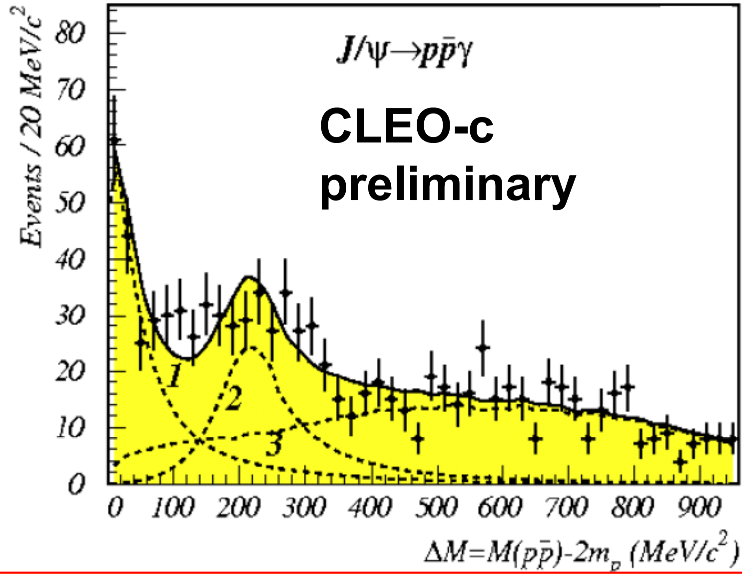
QWG2010
Z. Metreveli

- fit with one resonance as BES did:

$M(R_{thr}) = 1861^{+6}_{-16}$ (MeV), $\Gamma(R_{thr}) = 0^{+32}_{-0}$ (MeV),

$B_1(J/\psi \to \gamma R_{thr}) \times B_2(R_{thr} \to p\bar{p}) = (5.9^{+2.8}_{-3.2}) \times 10^{-5}$

agree with BESII results



The central value of the mass is close to the sub-threshold resonance mass reported by BES with $M(R) = 1833.7 \pm 6.1 \pm 2.7$ (MeV), observed in $J/\psi \to \gamma R$, $R \to \pi^+\pi^-\eta'$ [PRL 95 (2005) 262001].

- fit with three contributions:

$R_{thr} + f_0(2100) + PS$
(1) (2) (3)

$M(R_{thr}) = 1837^{+10}_{-12}{}^{+9}_{-7}$ (MeV),

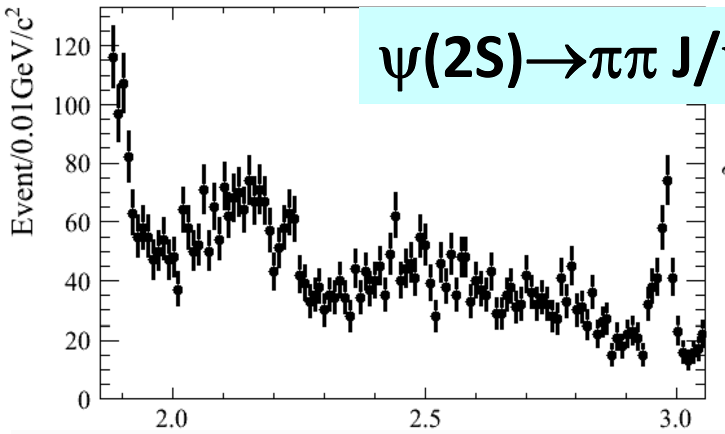
$\Gamma(R_{thr}) = 0^{+44}_{-0}$ (MeV), CL = 26.1%

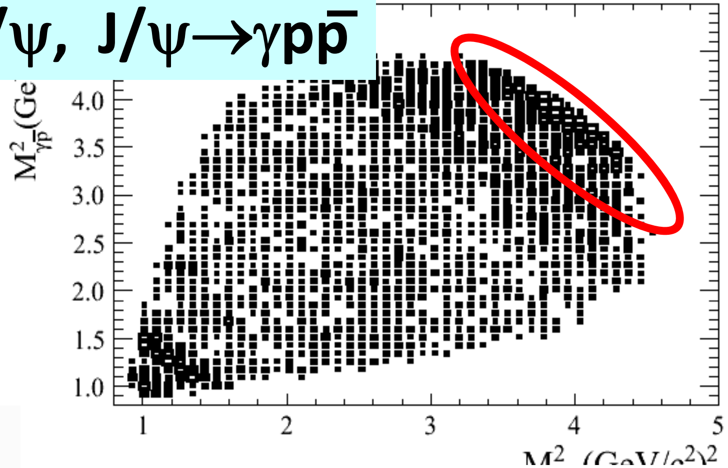
$B_1(J/\psi \to \gamma R_{thr}) \times B_2(R_{thr} \to p\bar{p}) = (11.4^{+4.3}_{-3.0}{}^{+4.2}_{-2.6}) \times 10^{-5}$

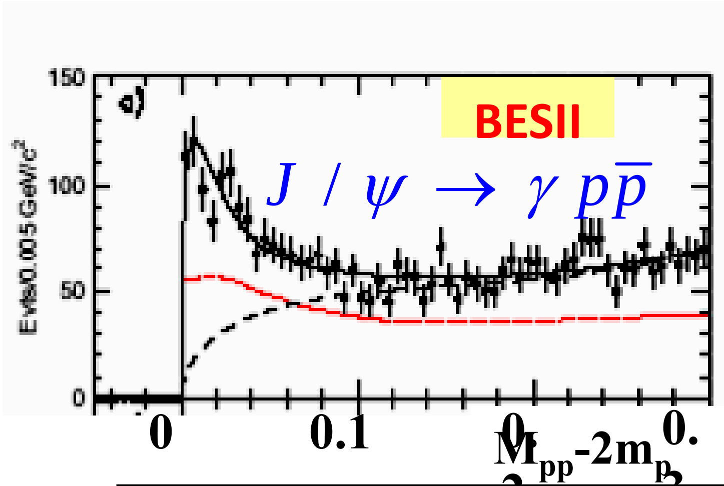
BES considered these (2) and (3) as systematic errors.

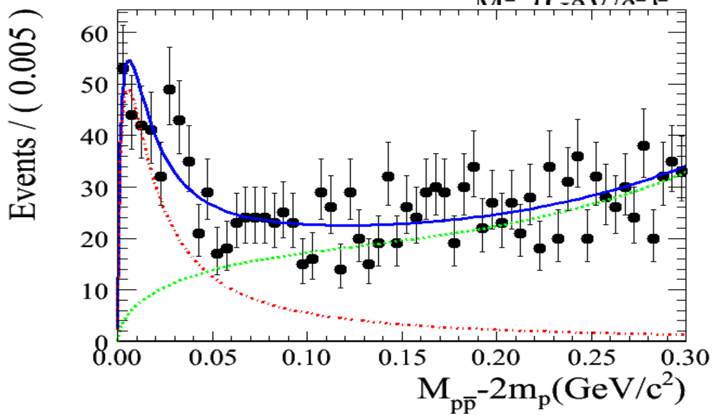
$p\bar{p}$ mass spectrum and Dalitz plot at BESIII

$\psi(2S)\to\pi\pi J/\psi$, $J/\psi\to\gamma p\bar{p}$









$M=1859^{+3}_{-10}{}^{+5}_{-25}$ MeV/c²

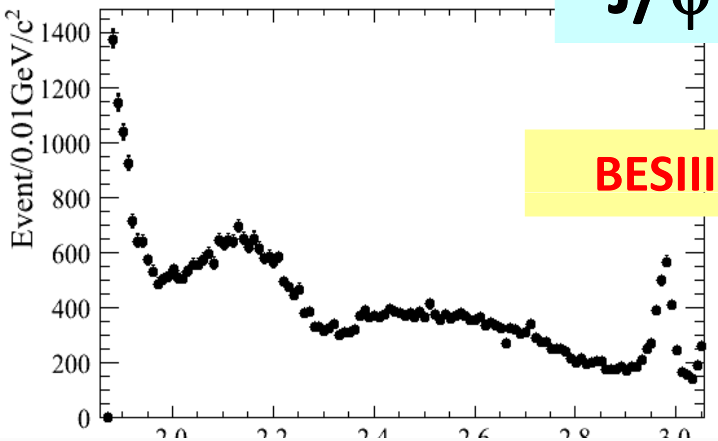
$\Gamma < 30$ MeV/c² (90% CL)

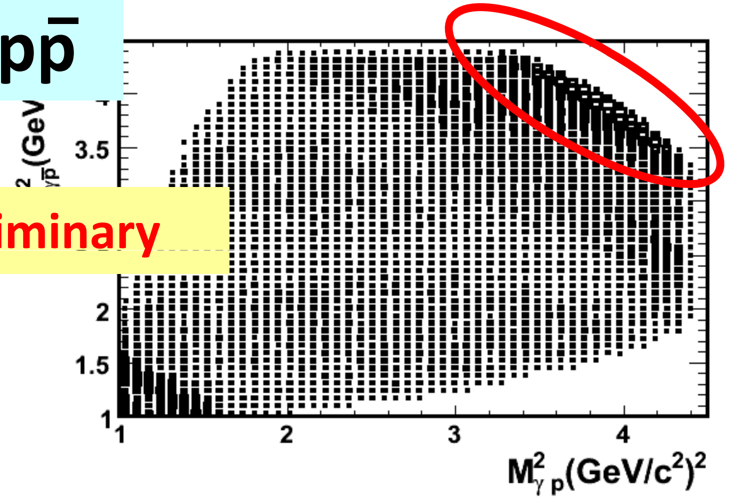
$M=1865\pm5$ MeV/c²

$\Gamma < 33$ MeV/c² (90% CL)

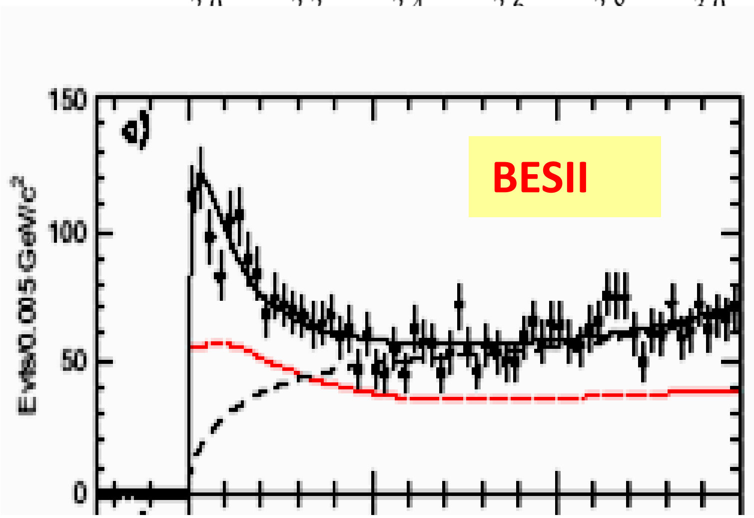
PRL 91 (2003) 022001

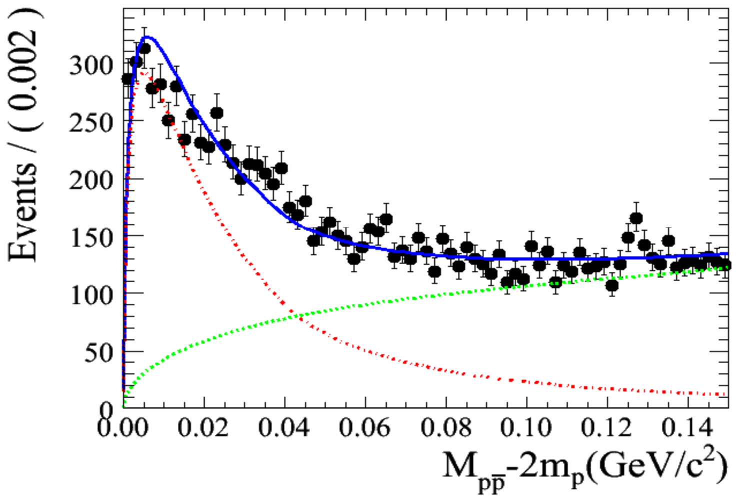
$J/\psi \to \gamma p\bar{p}$





BESIII preliminary





$M = 1859^{+3}_{-10}{}^{+5}_{-25}\ \mathrm{MeV}/c^2$

$\Gamma < 30\ \mathrm{MeV}/c^2$ (90% CL)

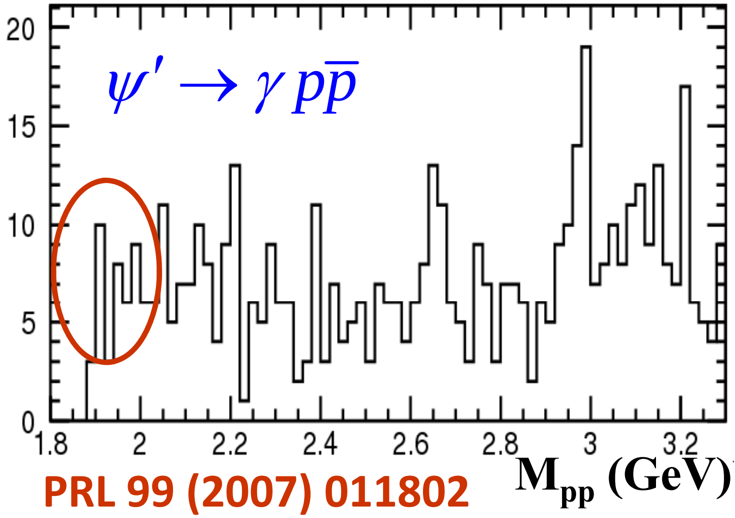
Fit result:

$\mathrm{Mass} = 1861.6 \pm 0.8\, MeV/c^2$

$\Gamma < 8\ \mathrm{MeV}$ (90% CL)

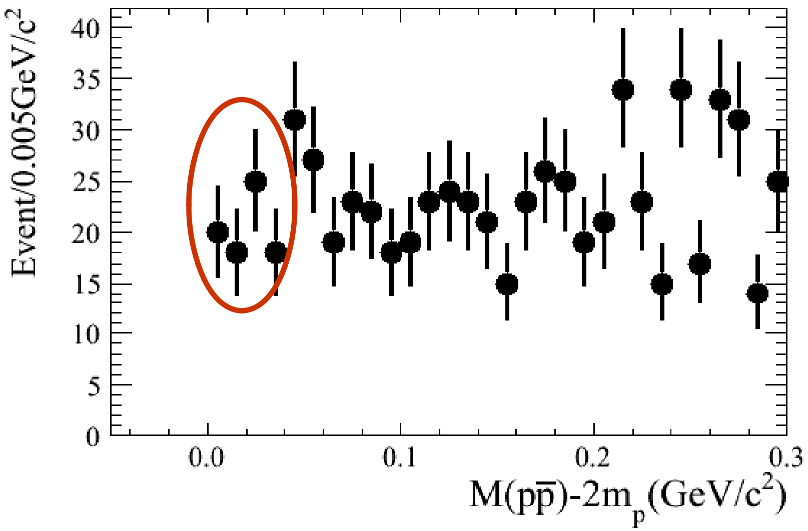
$p\bar{p}$ threshold mass spectrum in ψ' radiative decay

BESII



PRL 99 (2007) 011802

BESIII preliminary



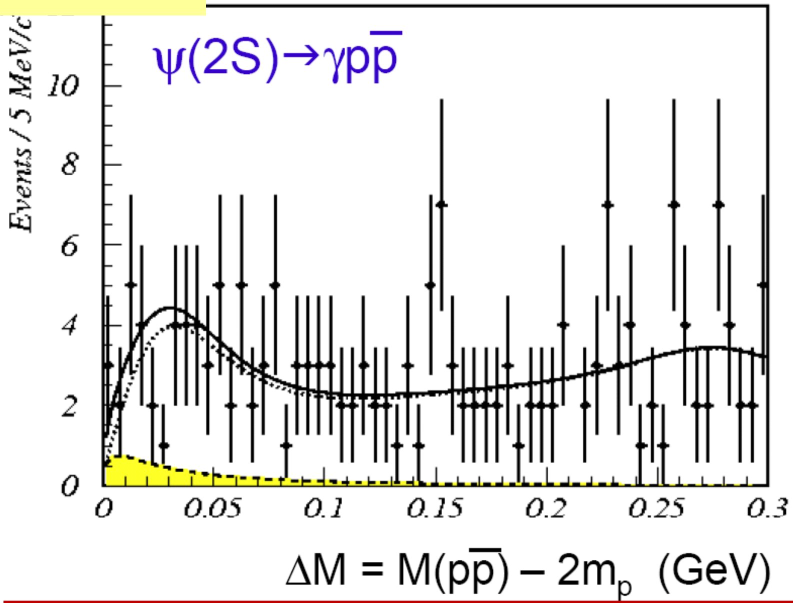
No significant narrow strong enhancement near threshold (~2σ if fitted with X(1860))

No significant narrow threshold enhancement

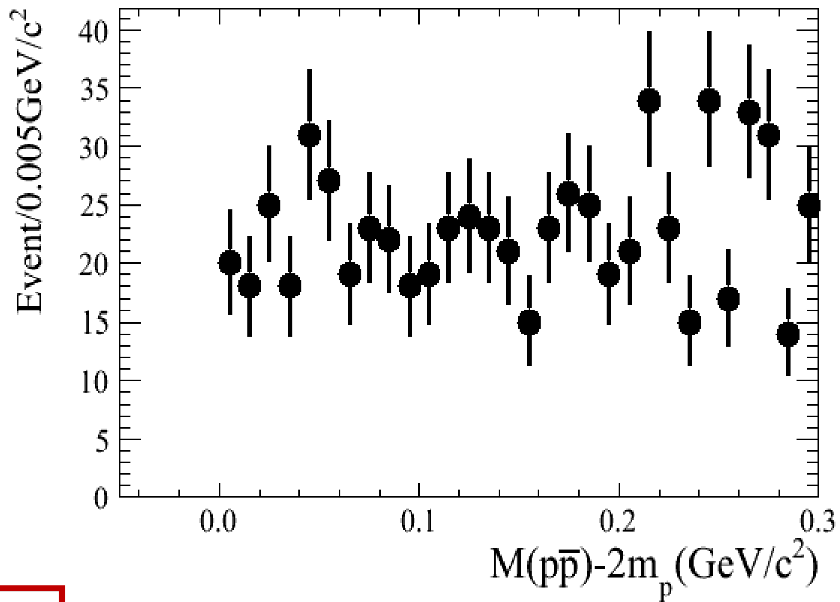
FSI interpretation of the narrow and strong $p\bar{p}$ threshold enhancement is disfavored.

QWG2010
Z. Metreveli

CLEO-c preliminary



BESIII preliminary



CLEO:

$N_{ev} = 9^{+10}_{-9}$, χ^2/d.o.f. = 53/58

$B(\psi(2S)\to\gamma R) \times B(R\to p\bar{p}) = (0.66^{+0.73}_{-0.66}) \times 10^{-6}$

$B(\psi(2S)\to\gamma R) \times B(R\to p\bar{p}) < 1.6 \times 10^{-6}$ 90% CL

BES(2007) PRL 99 (2007) 011802

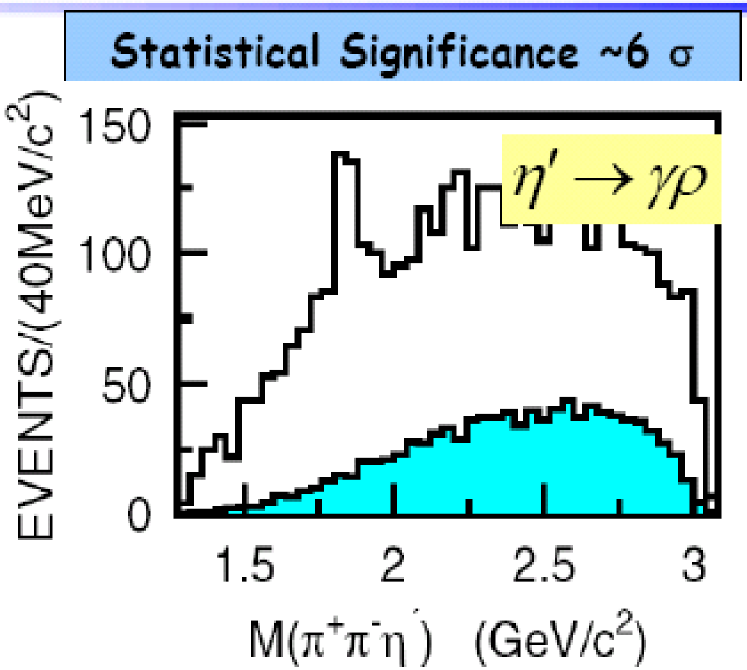
$N_{ev} = 11.7 \pm 6.7$, sig.=2.0s

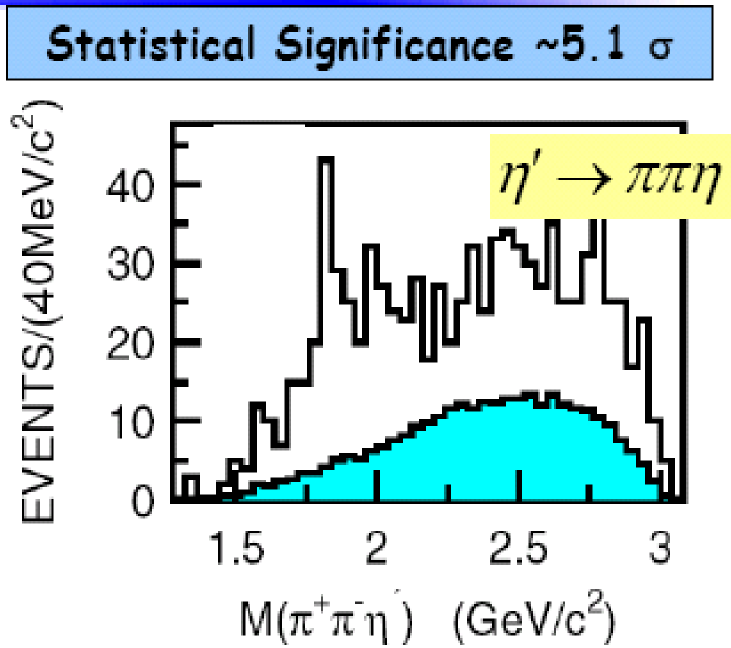
$B(\psi(2S)\to\gamma R) \times B(R\to p\bar{p}) < 5.4 \times 10^{-6}$

- **Confirm the no observation of enhancement in ψ(2S) channel**

⇒pure FSI effect unlikely

X(1835) @BESII





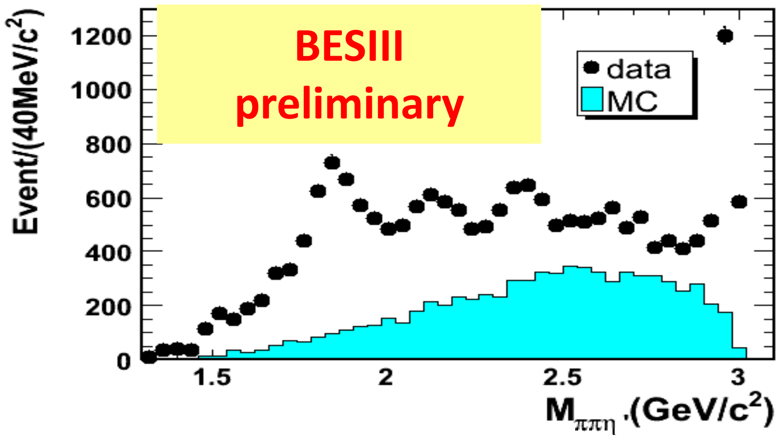
PRL 95,262001(2005)

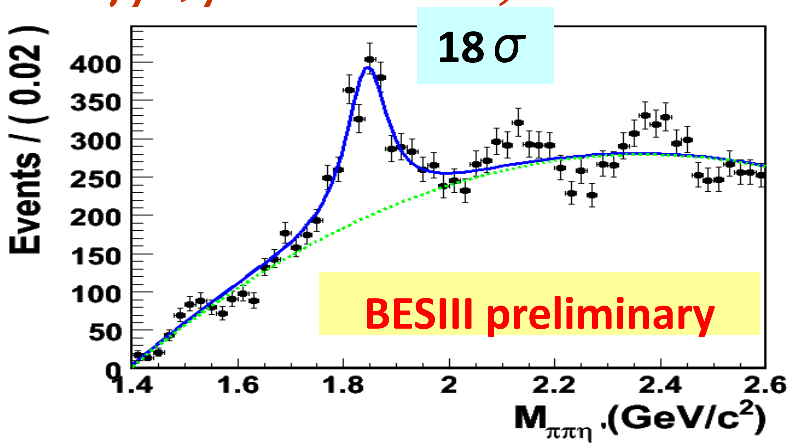
- **LQCD predicts the glueball mass of 0^{-+} is ~2.3GeV**
- **For 0^{-+} glueball, it may have similar property as η_c (mainly decay to $\pi\pi\eta'$)**
- **$J/\psi \to \gamma\pi\pi\eta'$ is specially interested and was studied with 57M J/ψ @BESII**

Need to confirm it with BESIII ~220M J/ψ data !!!

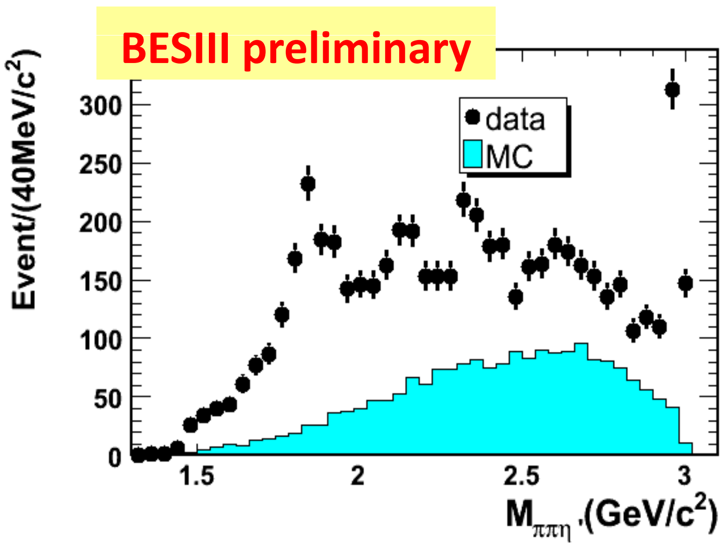
X(1835) @ BESIII

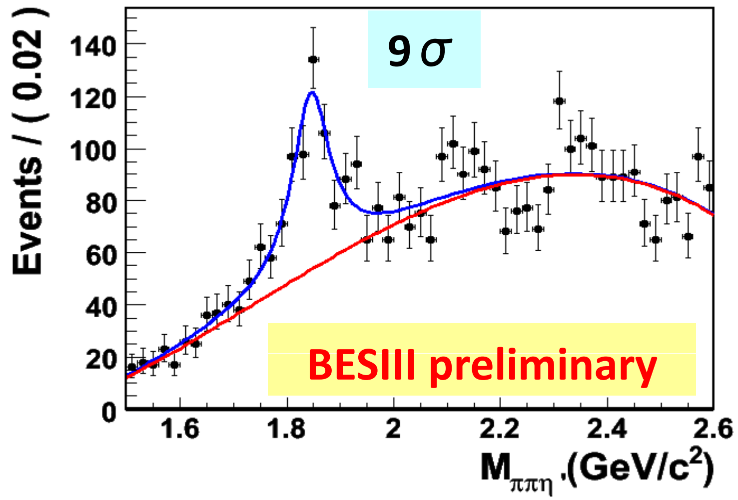
$$J/\psi \to \gamma\pi^+\pi^-\eta'(\eta' \to \gamma\rho, \rho \to \pi^+\pi^-)$$



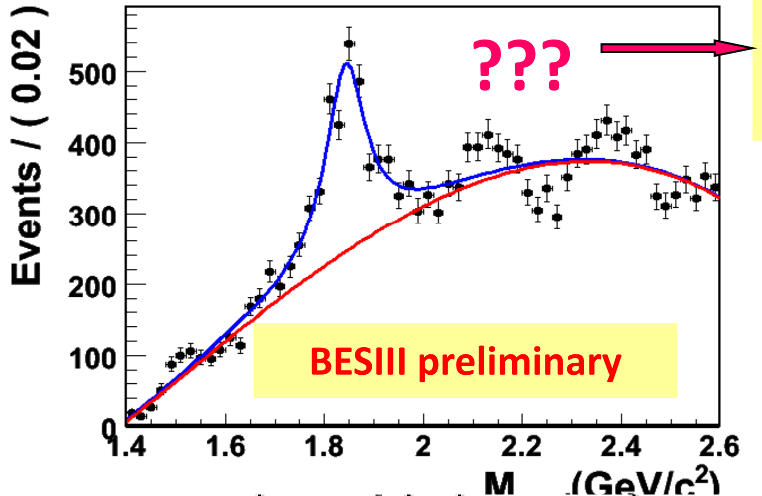


$$J/\psi \to \gamma\pi^+\pi^-\eta'(\eta' \to \pi^+\pi^-\eta)$$





Mass spectrum fit

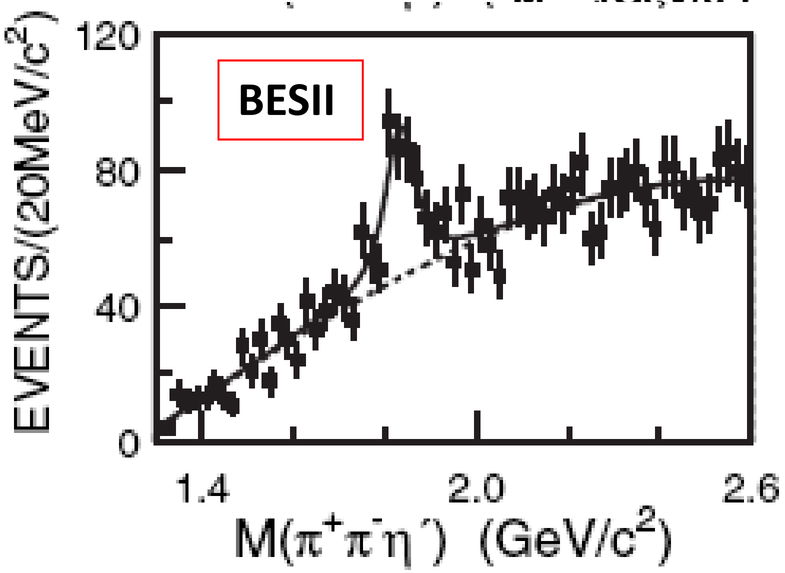


Whether there are two new resonances, further careful study is needed.

Fit result(Statistic significant~21σ):

$M = 1842.4 \pm 2.8(stat) MeV$

$\Gamma = 99.2 \pm 9.2(stat) MeV$



BESII result(Statistic significant ~ 7.7σ):

$M = 1833.7 \pm 6.1(stat) \pm 2.7(syst) MeV$

$\Gamma = 67.7 \pm 20.3(\text{stat}) \pm 7.7(\text{syst})\text{MeV}$

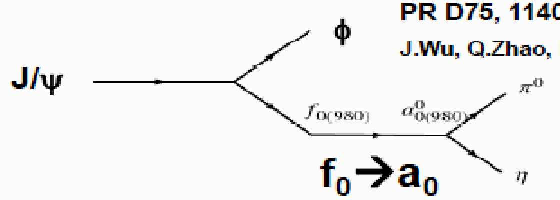
Study of $a_0(980)$ – $f_0(980)$ mixing from

$J/\psi \to \phi f_0 \to \phi a_0 \to \phi\eta\pi$

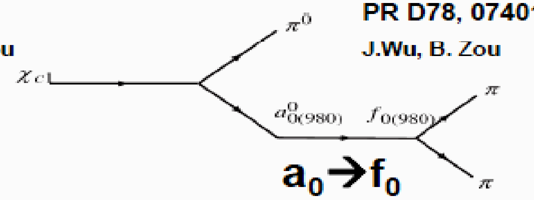
$\chi_{c1} \to a_0\pi^0 \to f_0\pi^0 \to \pi^+\pi^-\pi^0$

- Mixing intensity provides important information in understanding the nature of $a_0(980)$ and $f_0(980)$.
- Narrow peak (8 MeV) at around 980 MeV can be expected in $\eta\pi$ ($J/\psi \to \phi f_0 \to \phi a_0 \to \phi\eta\pi$ case) or $\pi^+\pi^-$ ($\chi_{c1} \to a_0\pi^0 \to f_0\pi^0 \to \pi^+\pi^-\pi^0$ case) invariant mass spectra.

PR D75, 114012
J.Wu, Q.Zhao, B.Zou



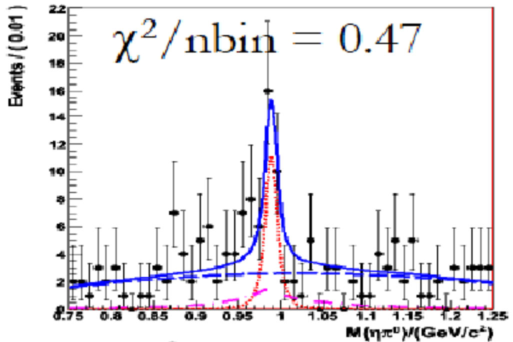
PR D78, 074017
J.Wu, B. Zou



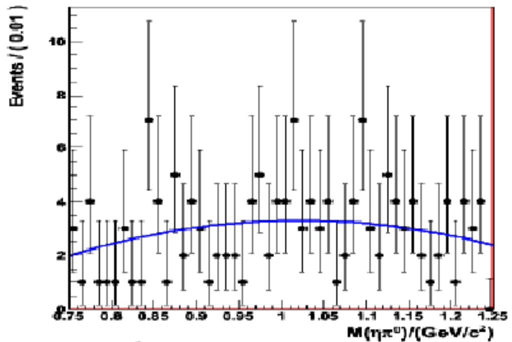
$$\xi_{fa}(s) = \frac{d\Gamma_{X\to Yf_0(980)\to Ya_0^0(980)\to Y\pi^0\eta(s)}}{d\Gamma_{X\to Yf_0(980)\to Y\pi\pi(s)}} = \left|\frac{g_{a_0^0K^+K^-}g_{f_0K^+K^-}}{g_{a_0^0\pi^0\eta}g_{f_0\pi^0\pi^0}}\right|^2 \frac{|\rho_{K^+K^-}(s)-\rho_{K^0\bar{K}^0}(s)|^2}{3\rho_{\pi\pi}(s)\rho_{\pi\eta}(s)} \times \frac{1}{|\frac{m_a^2-s}{\Gamma^a_{\pi\eta}\sqrt{s}} - i[|\frac{g_{a_0^0K^+K^-}}{g_{a_0^0\pi^0\eta}}|^2(\frac{\rho_{K^+K^-(s)}}{\rho_{\pi\eta(s)}}+\frac{\rho_{K^0\bar{K}^0}}{\rho_{\pi\eta}})+1]|^2}$$

$$\xi_{af}(s) = \frac{d\Gamma_{X\to Ya_0^0(980)\to Yf_0(980)\to Y\pi\pi(s)}}{d\Gamma_{X\to Ya_0^0(980)\to Y\pi^0\eta(s)}} = \left|\frac{g_{a_0^0K^+K^-}g_{f_0K^+K^-}}{g_{a_0^0\pi^0\eta}g_{f_0\pi^0\pi^0}}\right|^2 \frac{|\rho_{K^+K^-}(s)-\rho_{K^0\bar{K}^0}(s)|^2}{3\rho_{\pi\pi}(s)\rho_{\pi\eta}(s)} \times \frac{1}{|\frac{m_f^2-s}{\Gamma^f_{\pi\pi}\sqrt{s}} - i[|\frac{g_{f_0K^+K^-}}{g_{f_0\pi^0\pi^0}}|^2(\frac{\rho_{K^+K^-(s)}}{3\rho_{\pi\pi(s)}}+\frac{\rho_{K^0\bar{K}^0(s)}}{3\rho_{\pi\pi(s)}})+1]|^2}$$

$J/\psi \rightarrow \phi\, f_0 \rightarrow \phi\, a_0$



M($\eta\pi^0$) in ϕ signal region



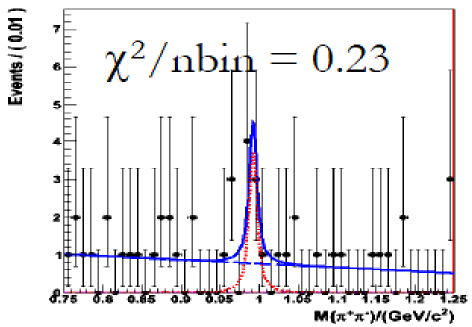
M($\eta\pi^0$) in ϕ sideband region

- N(mixing) = 24.7 ± 8.6 (< 36.7 @ 90% C.L.), S = 3.3 σ ;

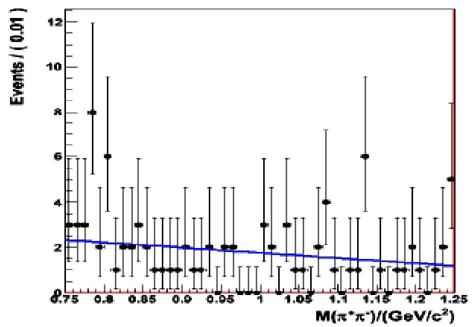
ξ_{fa} = Br($J/\psi \rightarrow \phi f_0(980) \rightarrow \phi a_0(980) \rightarrow \phi\eta\pi^0$) / Br($J/\psi \rightarrow \phi f_0(980) \rightarrow \phi\pi\pi$)

= (0.6 ±0.2(stat.) ±0.2(sys.))% (< 1.1% @ 90% C. L.)

$\chi_{c1} \rightarrow a_0\pi^0 \rightarrow f_0\pi^0$



M($\pi^+\pi^-$) in χ_{c1} signal region

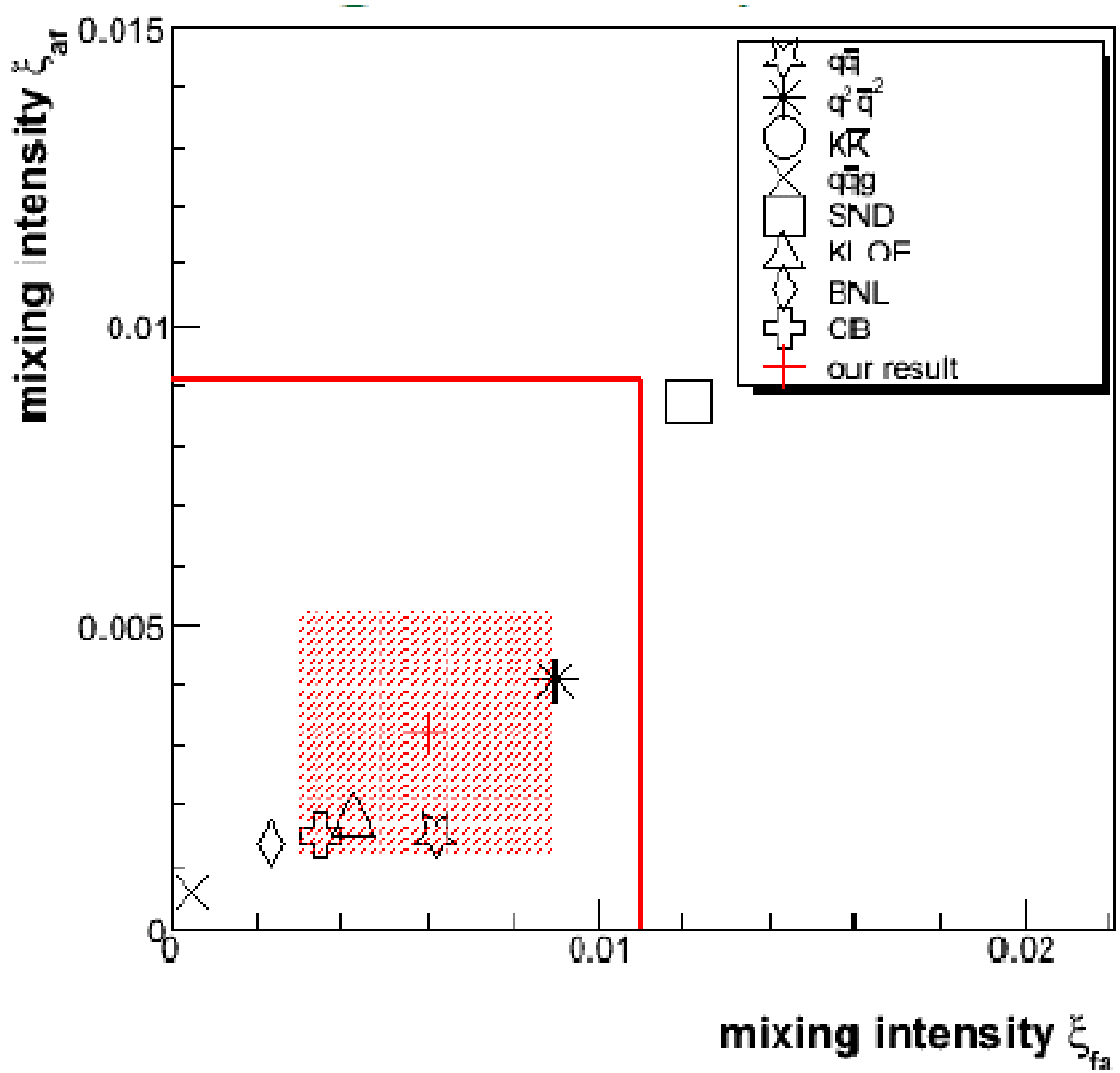


M($\pi^+\pi^-$) in χ_{c1} sideband region

- N(mixing) = 6.5 ± 3.2 (< 12.1 @ 90% C.L.), S = 2.0 σ ;

ξ_{af} = (0.32 ±0.16(stat.) ±0.12(sys.))% (< 0.91% @ 90% C. L.)

Comparison of BESIII results with others

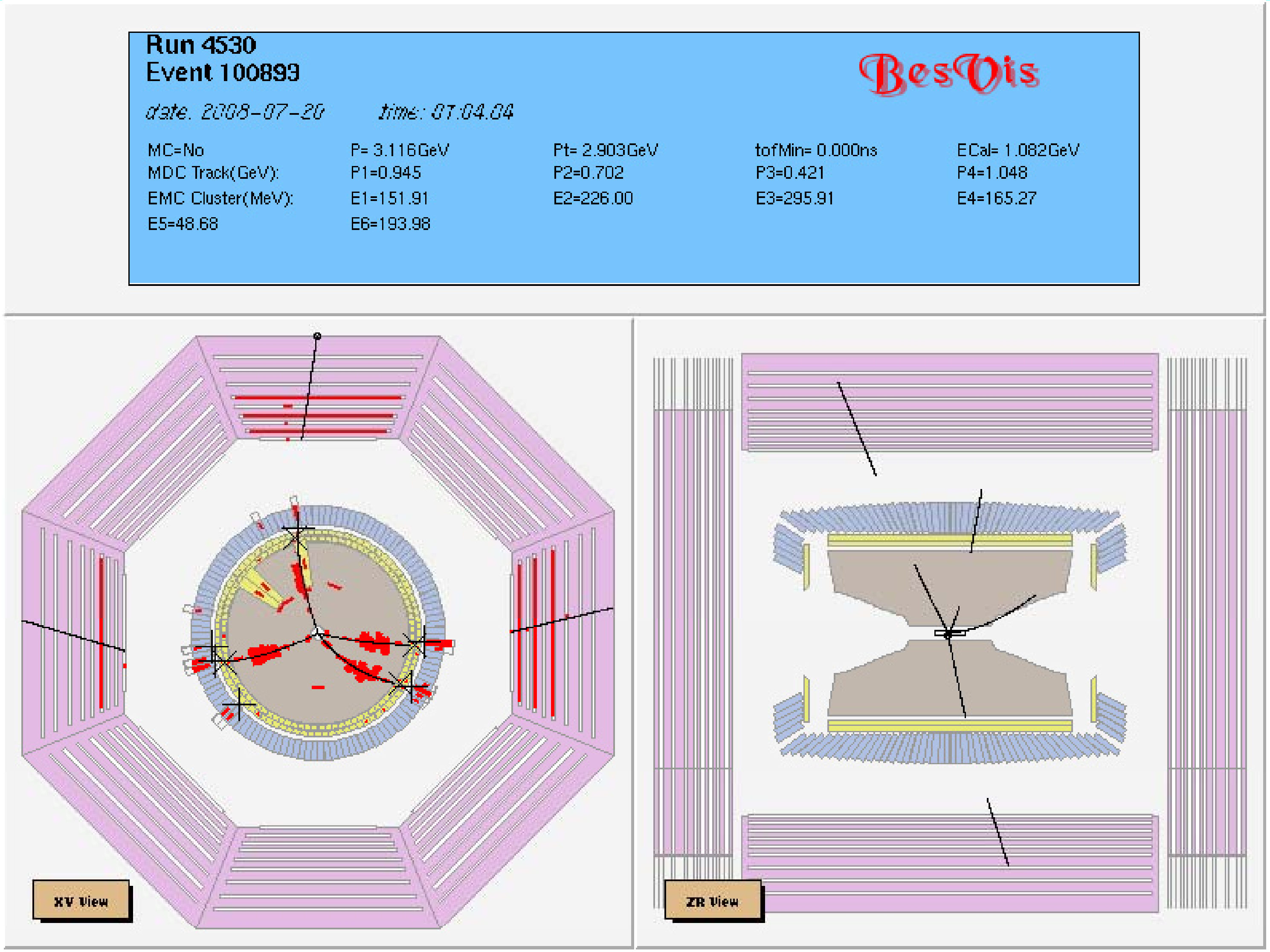


Summary

- **BEPCII/BESIII upgrade completed successfully:**
  - **Peak Luminosity of $3.2*10^{32}$ achieved.**
  - **~106 M $\psi(2S)$ and ~226 M J/ψ events obtained in 2009.**
  - **~950 pb^{-1} at $\psi(3770)$ so far in 2010.**
- **Nice results are obtained**
- **More results will come soon**

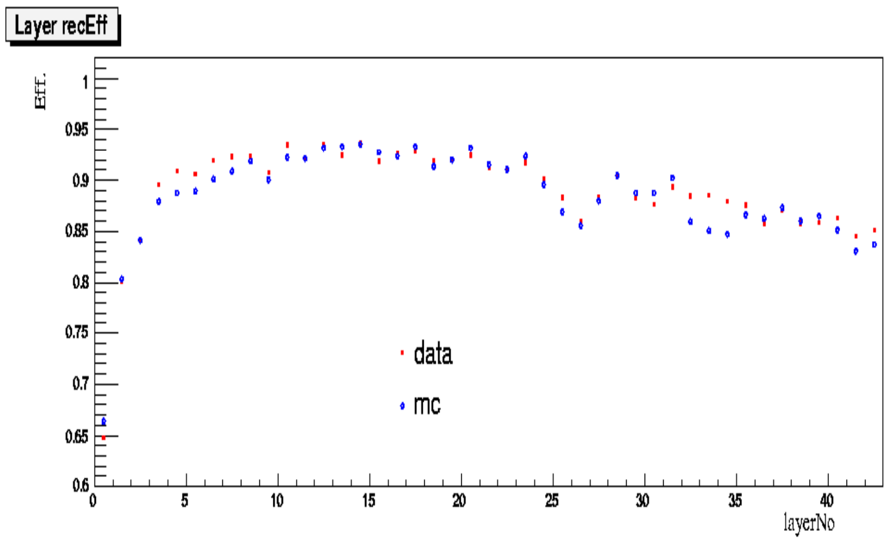
Thank you!

First collision event on July 19, 2008

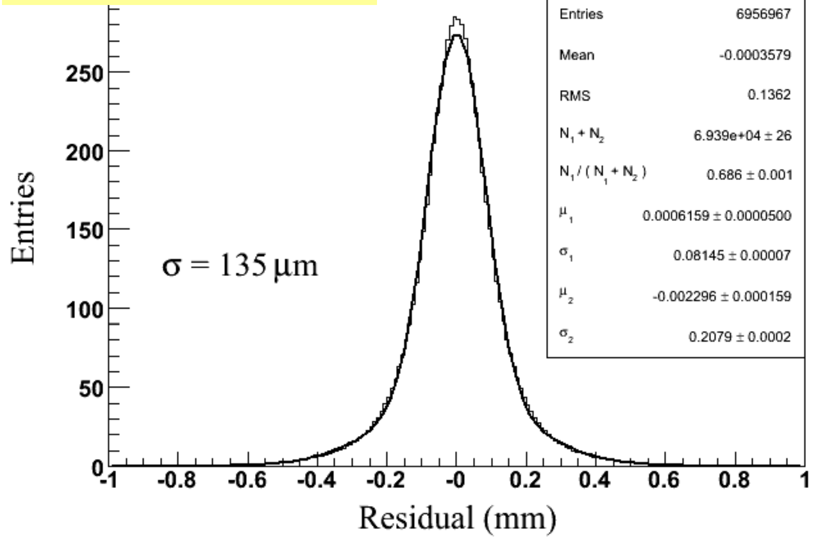


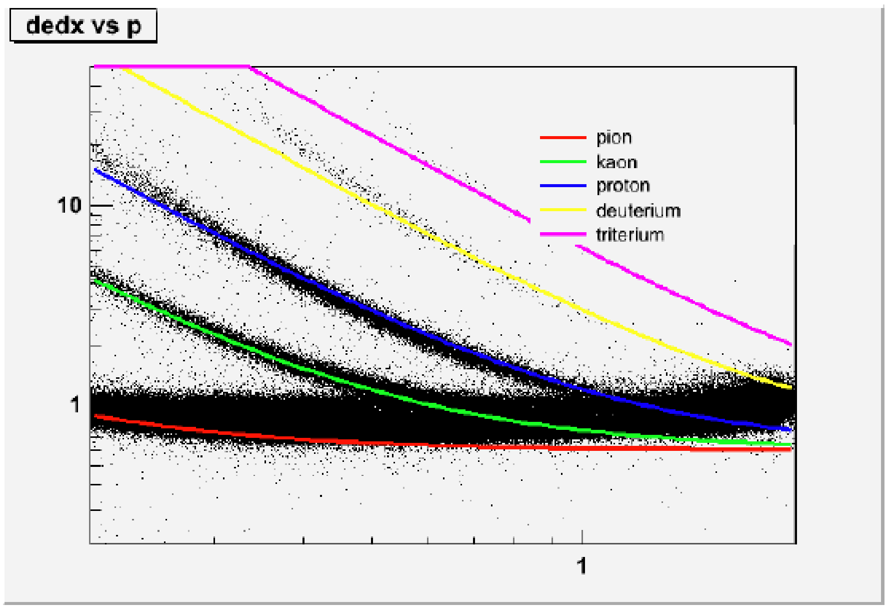
$e^+e^- \rightarrow \psi(3770) \rightarrow D^0\bar{D}^0$

MDC performance & data/MC

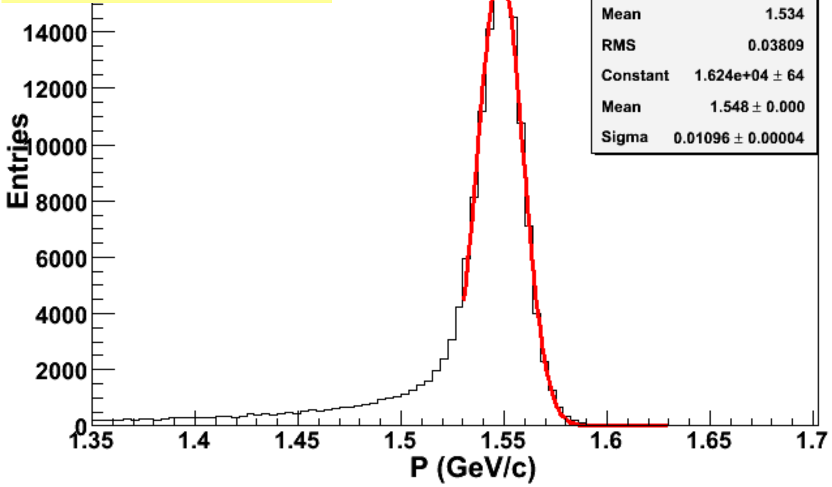


Reso. 135 μm

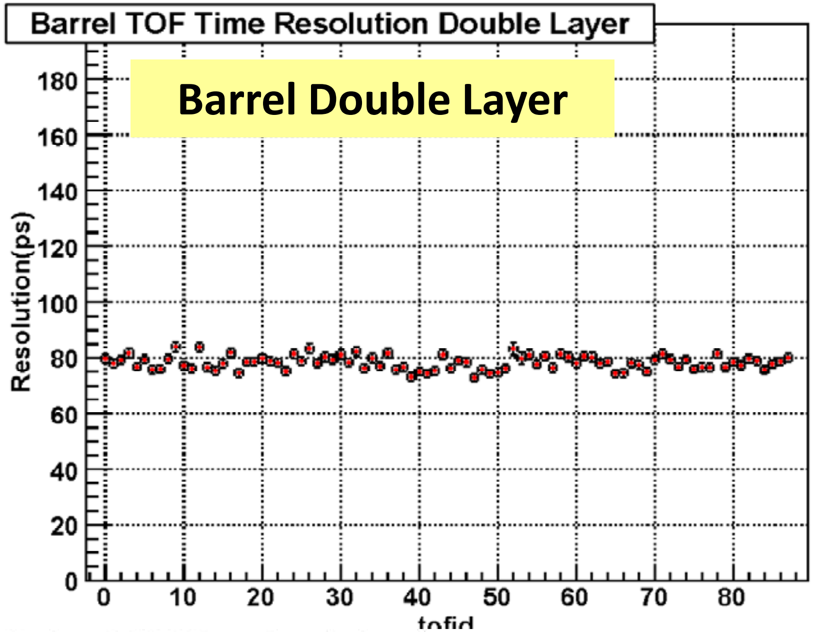


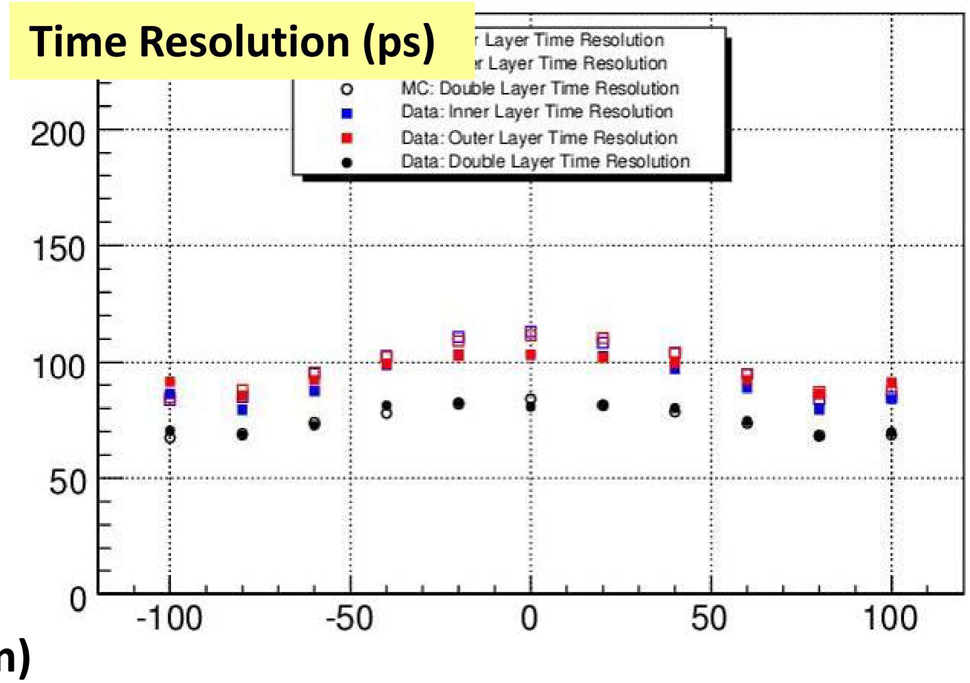


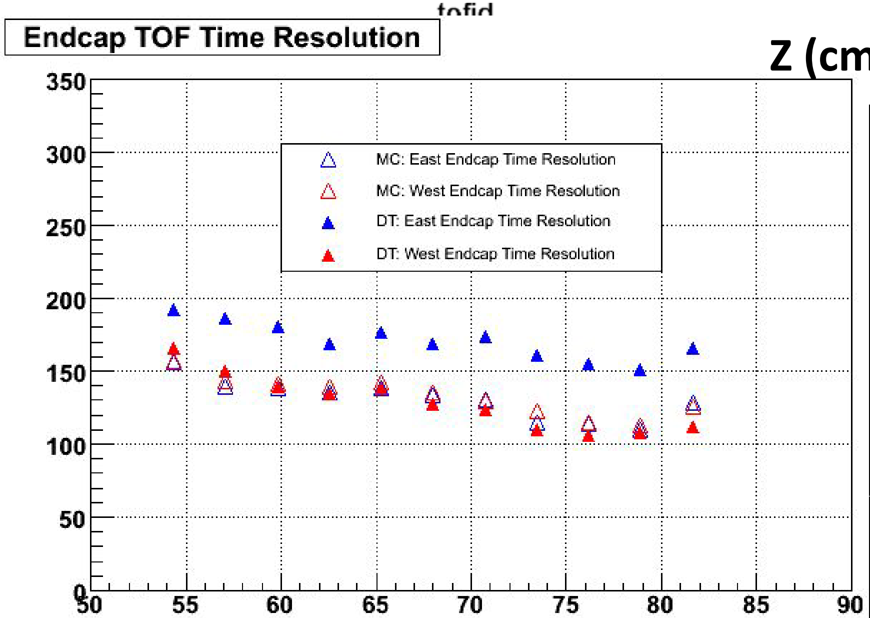
σ_P=11.0 MeV/c



Double-layer TOF



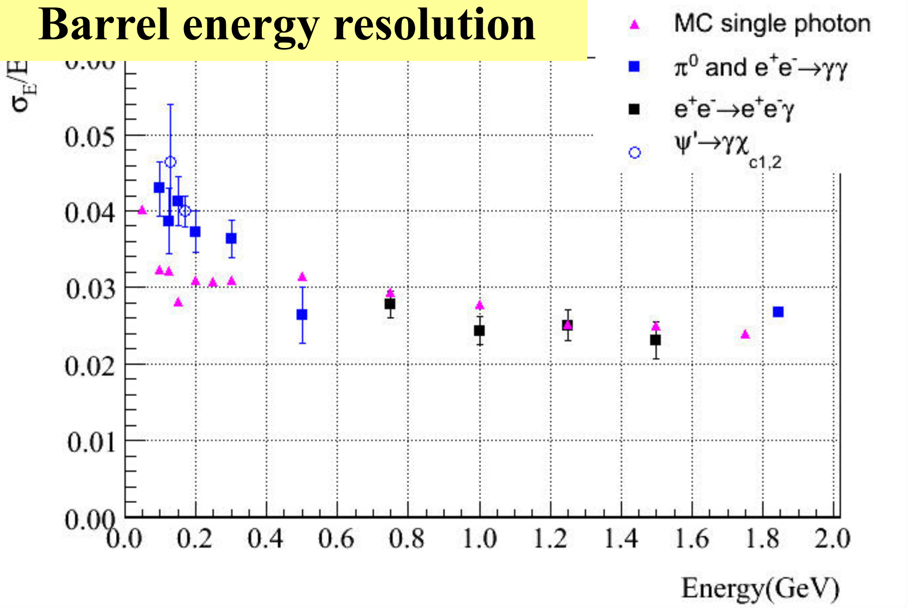




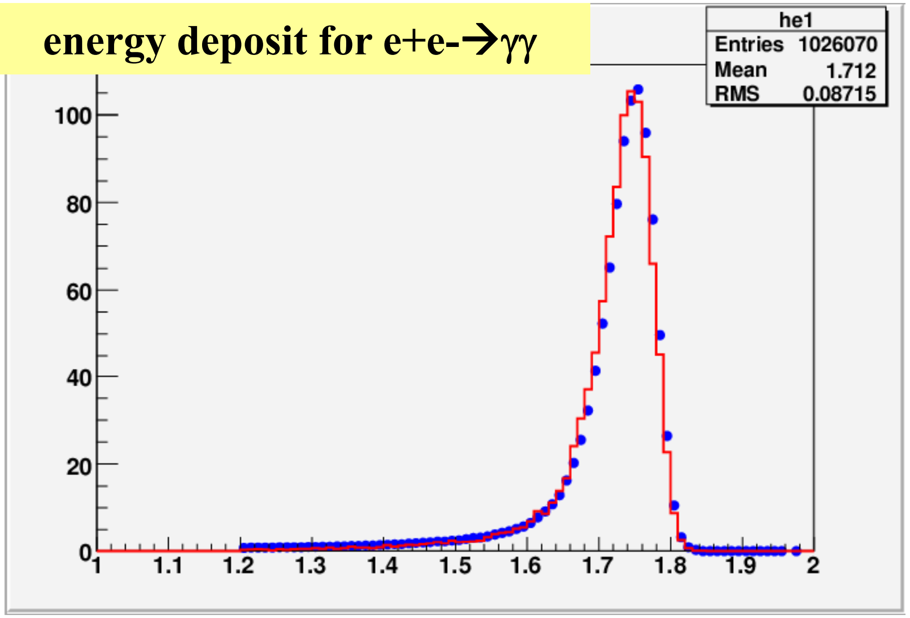
Time Resolution (ps)	Design Target	Bhabha	Dimu
Barrel Single Layer	100~110	98.0	95.3
Barrel Double Layer	80~90	78.9	76.3
Endcap	110~120	136.4	95.0

EMC (CsI(Tl))

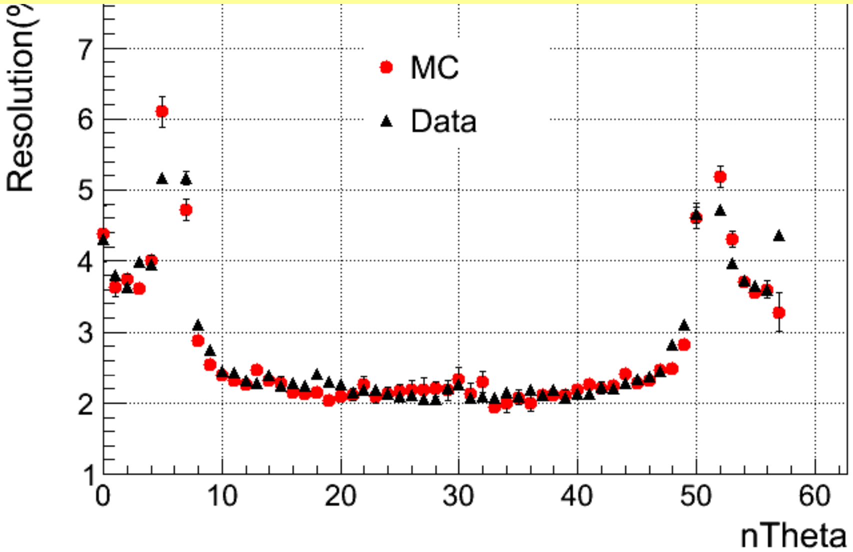
Barrel energy resolution



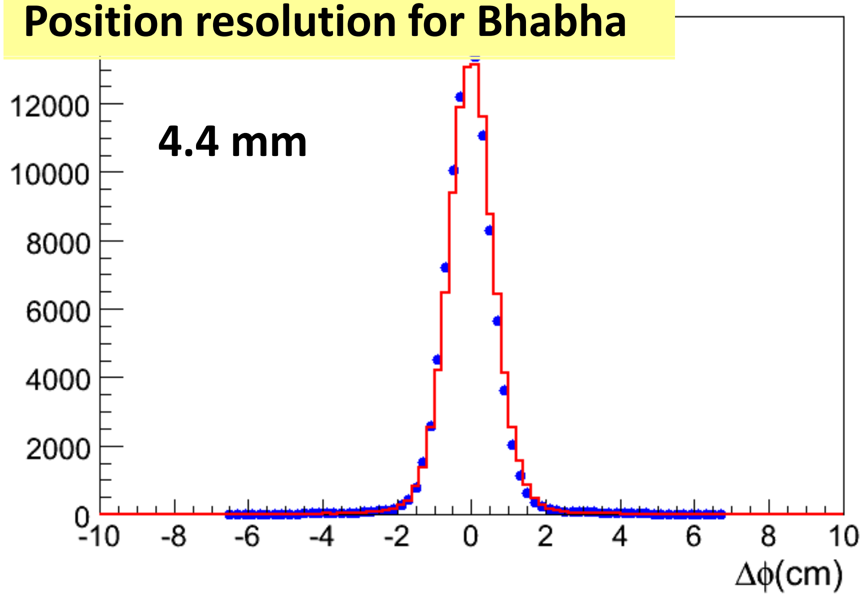
energy deposit for e+e-→γγ



energy resolution for Bhabha events



Position resolution for Bhabha



First observation of $\psi(2S) \to \gamma\gamma J/\psi$

- Two photon transitions are well known in excitations of molecules, atomic hydrogen, and positronium.

  A. Quattropani *etal,* PRA 25, 3079 (1982).

  F. Bassani *etal,* PRL 39, 1070 (1977).

  A. Quattropani *etal,* PRL 50, 1258 (1983).

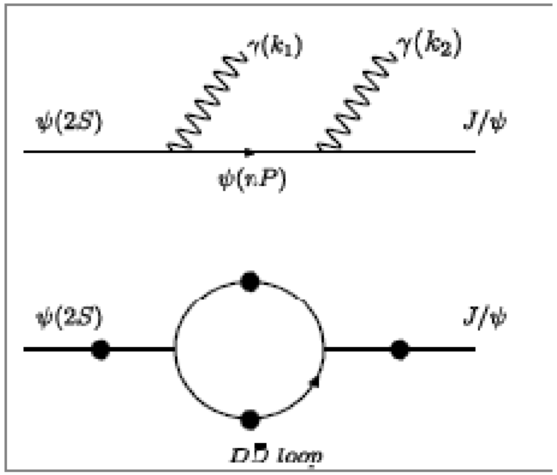
- CLEO observed two photon transitions in $\Upsilon(3S) \to \Upsilon(2S)$.

  F. Butler *etal,* PRD 49, 40 (1994).

- Never been observed in the charmonium system.
- Observation helpful to understand QCD.

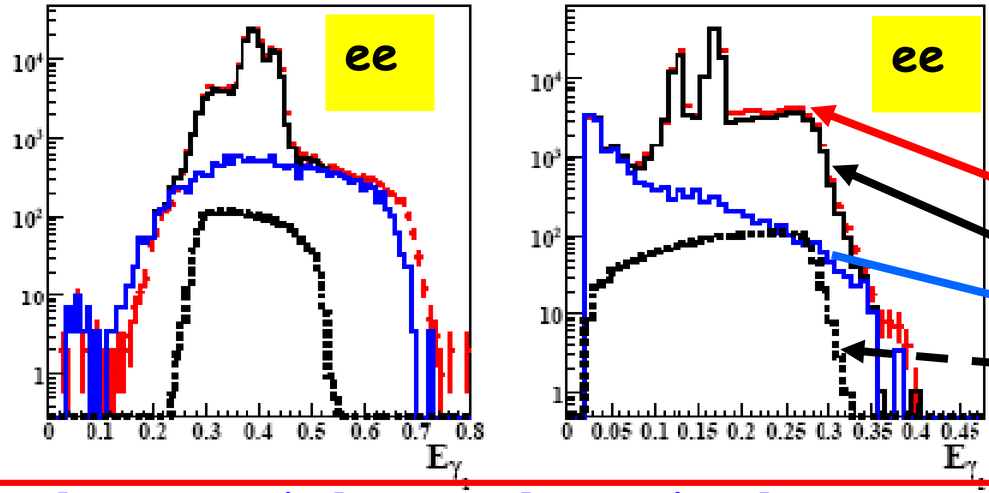
Theoretically:

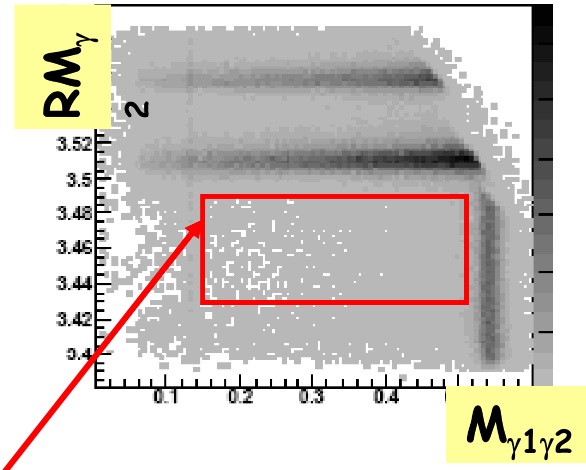
- potential models give discrete spectra ($\psi(2S) \to \gamma\chi_{cJ}, \chi_{cJ} \to \gamma J/\psi$)
- coupled channel models can give continuous spectra.
- theoretical work ongoing.



- select $\psi(2S) \to \gamma\gamma J/\psi$, $J/\psi \to l^+l^-$ events.
- $J/\psi \to ee$ channel ($\mu\mu$ similar):

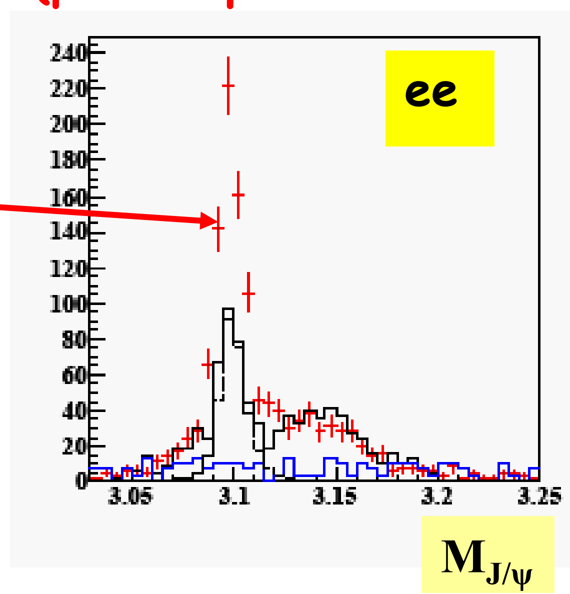
γ_1 - high energy gamma, γ_2 - low energy gamma





- select events in box to enhance signal.
- see clear excess over BG + continuum in $M_{J/\psi}$ distribution. Significance > 10σ

$B(\psi(2S) \to \gamma\gamma J/\psi)$ [both ee and $\mu\mu$]
$= (1.02 \pm 0.05\ ^{+0.19}_{-0.20}) \times 10^{-3}$



BESIII preliminary