Recent Results at BESIII

Hongxun Yang

(for BESIII Collaboration)

Institute of High Energy Physics

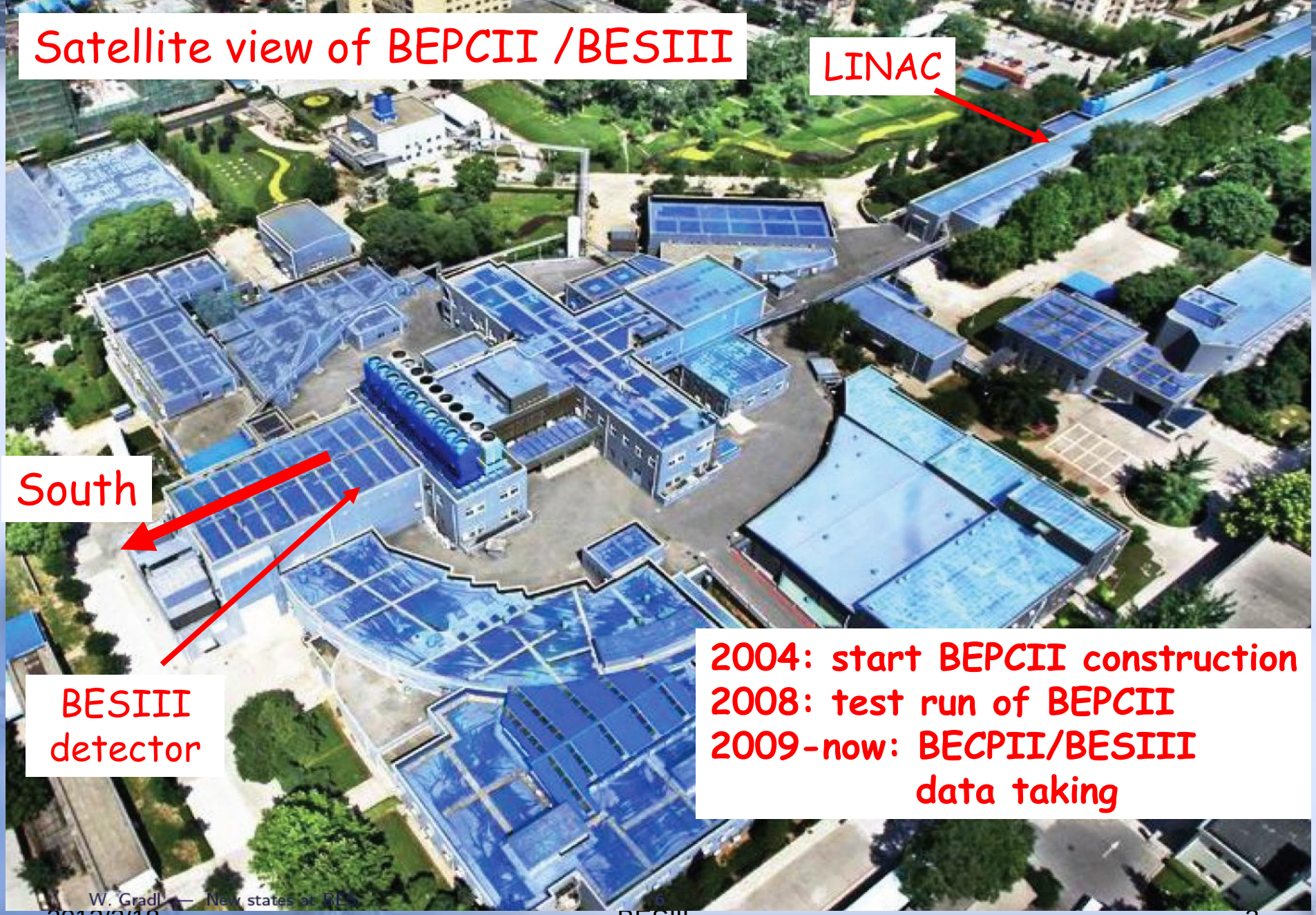
KPS-CPS Joint Session of FMKPS

Busan Korea, Oct. 20, 2011

Outline

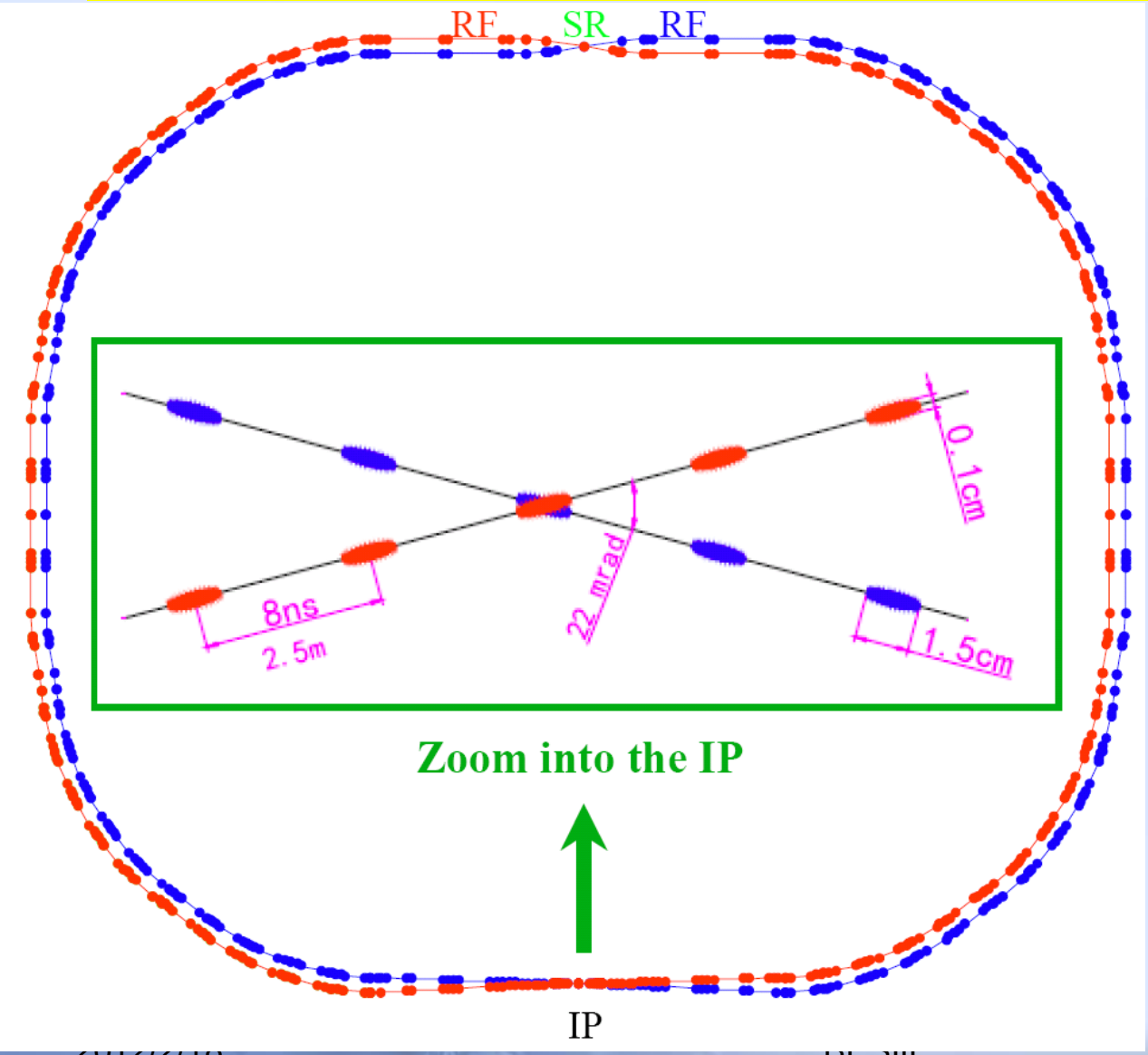
- Introduction to the BESIII experiment
- Latest results on light hadron spectroscopy
- Latest results on charmonium spectroscopy
- Summary and prospects

Satellite view of BEPCII /BESIII



2004: start BEPCII construction
2008: test run of BEPCII
2009-now: BECPII/BESIII
data taking

BEPCII storage rings



Beam energy:
1.0-2.3 GeV

Design Luminosity:
1×10^{33} $cm^{-2}s^{-1}$

Achieved Luminosity:
0.65×10^{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

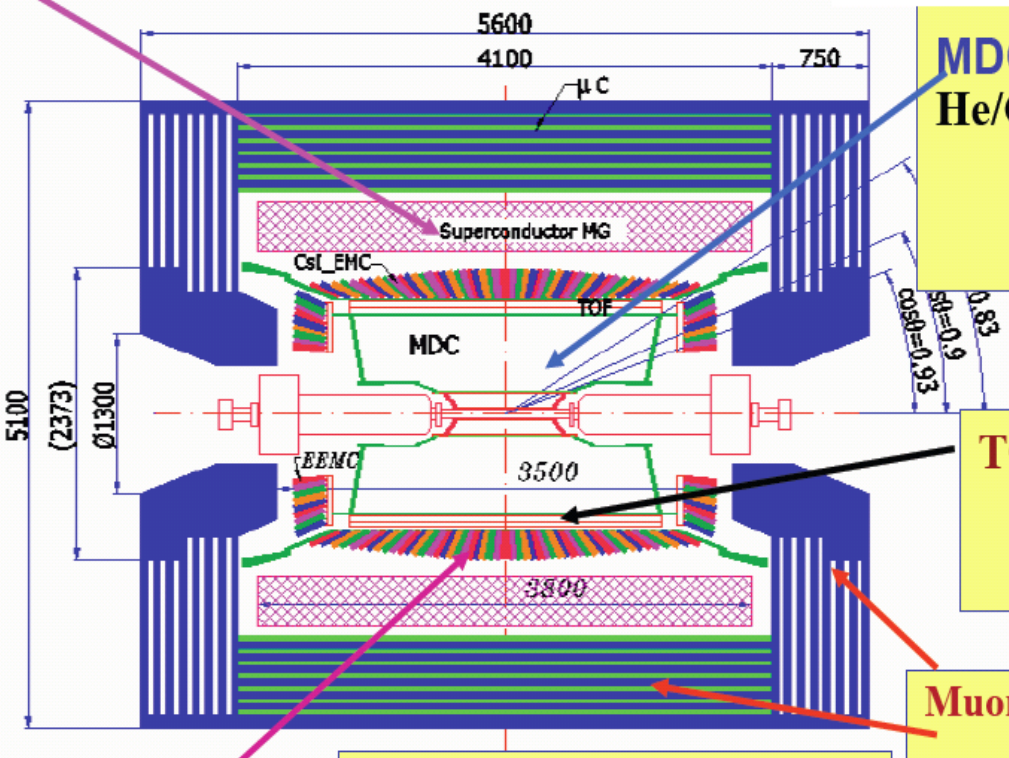
Circumference：
237m

BESIII Detector

BESIII detector: all new !

CsI calorimeter
Precision tracking
Time-of-flight + dE/dx PID

Magnet: 1 T Super conducting



MDC: small cell & Gas:
He/C_3H_8 (60/40), 43 layers
σ_{xy}=130 μm
σ_p/p = 0.5% @1GeV
dE/dx=6%

TOF:
σ_T = 100 ps Barrel
110 ps Endcap

Muon ID: 9 layers RPC
8 layers for endcap

EMC: CsI crystal, 28 cm
ΔE/E = 2.5% @1 GeV
σz = 0.6 cm/√E

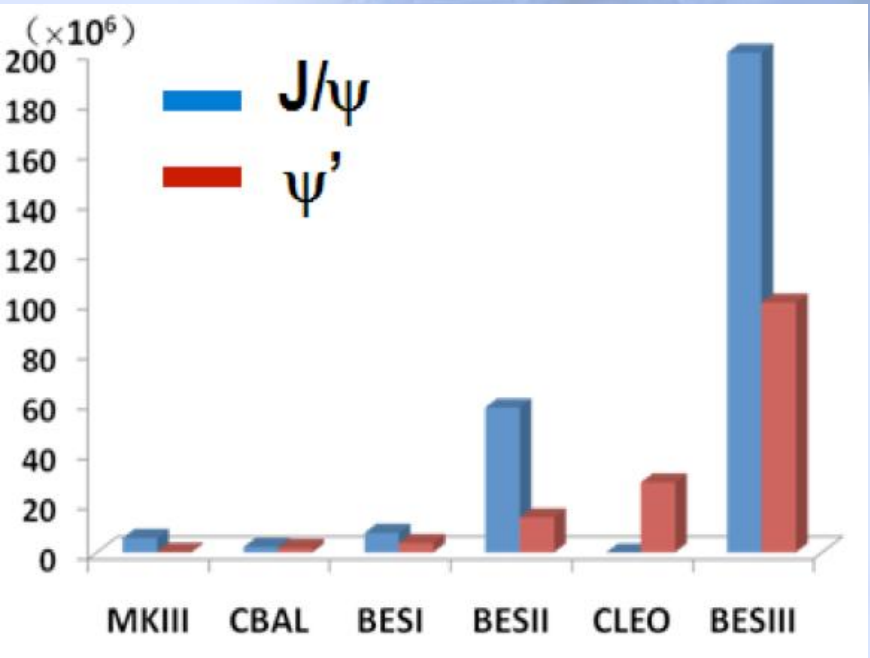
Data Acquisition:
Event rate = 4 kHz
Total data volume ~ 50 MB/s

Data samples

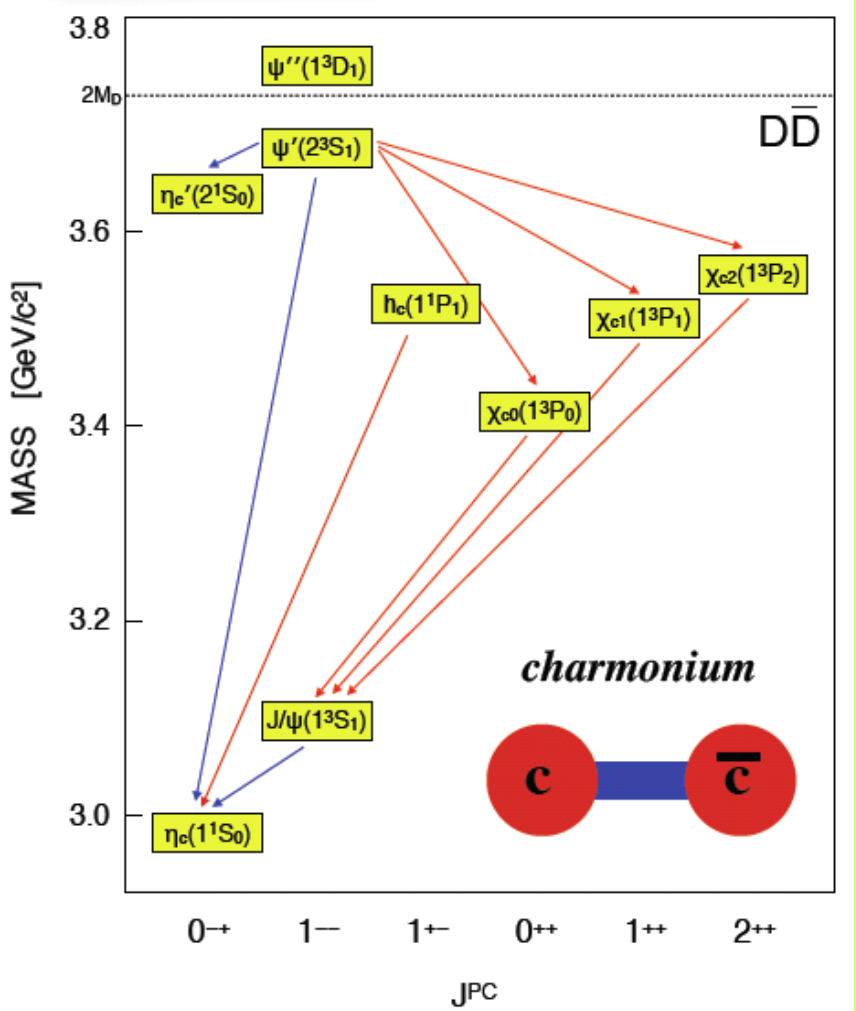
- **So far BESIII has collected :**
  - **2009: 225 Million J/ψ**
  - **2009: 106 Million ψ'**
  - **2010-11: 2.9 fb^{-1} ψ(3770)**

  (3.5 × CLEO-c 0.818fb^{-1})

  - May 2011: 0.48fb^{-1} @4010 MeV (one month) for Ds and XYZ spectroscopy
- **BESIII will also collect:**
  - **more J/ψ, ψ', ψ(3770)**
  - **data at higher energies （for XYZ searches, R scan and Ds physics）**



BESIII Physics



Charmonium physics:

- Spectroscopy
- transitions and decays

Light hadron physics:

- meson & baryon spectroscopy
- glueball,hybrid & multiquarks
- two-photon physics
- e.m. form factors of nucleon

Charm physics:

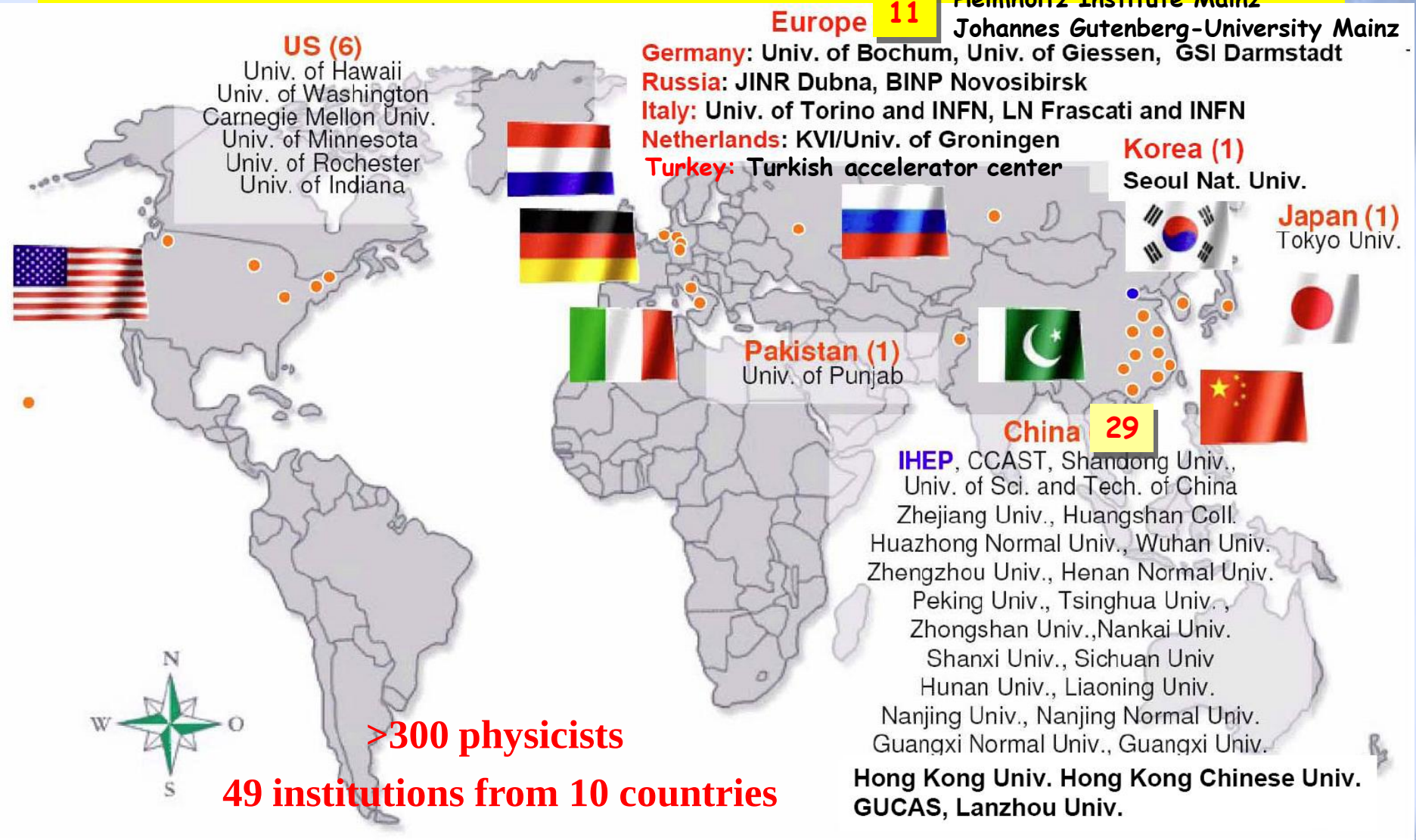
- (semi) leptonic + hadronic decays
- decay constant, form factors
- CKM matrix: Vcd, Vcs
- D^0-D^0bar mixing and CP violation
- rare/forbidden decays

Tau physics:

- Tau decays near threshold
- tau mass scan

…and many more.

BESIII Collaboration



Physics results at BESIII

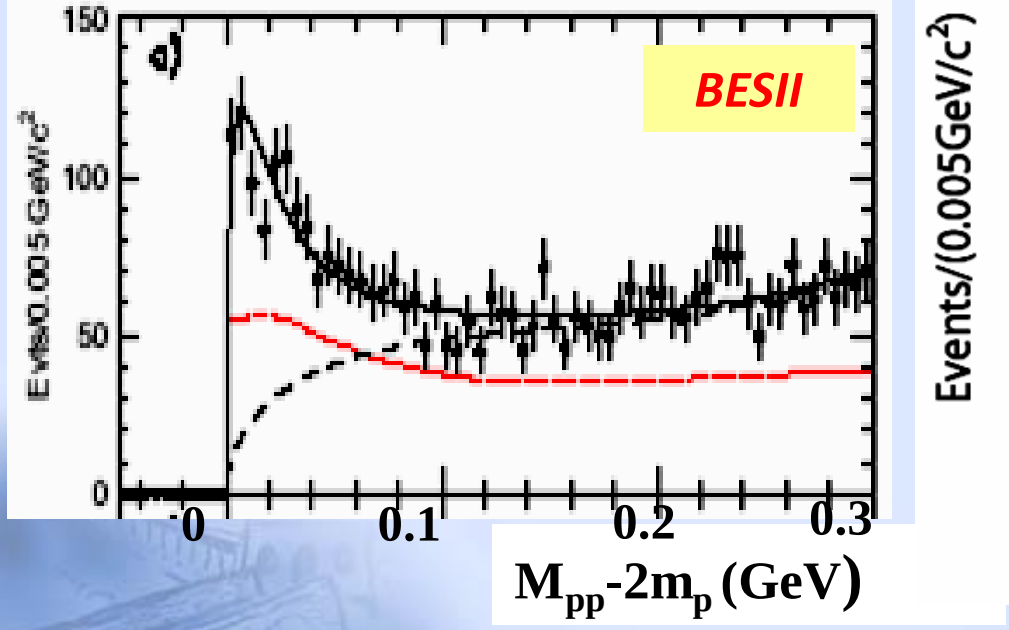
publications

- Charmonium Spectroscopy and Transitions
  - Properties of the h_c *(PRL 104, 132002 (2010))*
  - $\psi' \to \gamma\gamma J/\psi$ *(to be submitted soon)*
- Charmonium Decays
  - $\psi' \to \gamma\pi^0, \gamma\eta, \gamma\eta'$ *(PRL 105, 261801 (2010))*
  - $\chi_{cJ} \to \pi^0\pi^0, \eta\eta$ *(PRD 81, 052005 (2010))*
  - $\chi_{cJ} \to \gamma\rho, \gamma\omega, \gamma\phi$ *(PRD83,112005(2011))*
  - $\chi_{cJ} \to \omega\omega, \phi\phi, \omega\phi$ *(PRL 107, 092001(2011))*
  - $\chi_{cJ} \to 4\pi^0$ *(PRD 83, 012006 (2011))*
  - $\chi_{cJ} \to p\bar{p}K^+K^-$ (PRD 83, 112009(2011))
  - $\eta' \to \eta\pi^+\pi^-$ matrix element *(PRD 83, 012003 (2011))*
  - *Search for CP/P violation process pseudoscalar decays into pipi* (PRD 84, 032006(2011)).
- Light Quark States
  - $a_0(980) - f_0(980)$ mixing *(PRD 83, 032003 (2011))*
  - X(1860) in $J/\psi \to \gamma p\bar{p}$ *(Chinese Physics C 34, 4 (2010))*
  - X(1835) in $J/\psi \to \gamma\eta'\pi^+\pi^-$ *(PRL 106, 072002 (2011))*
  - X(1870) in $J/\psi \to \omega\eta\pi^+\pi^-$ *(accepted by PRL)*
  - *PWA on* $J/\psi \to \gamma p\bar{p}$ *(to be submitted soon)*
  - *PWA on* $\psi' \to \eta p\bar{p}$ *(to be submitted soon)*

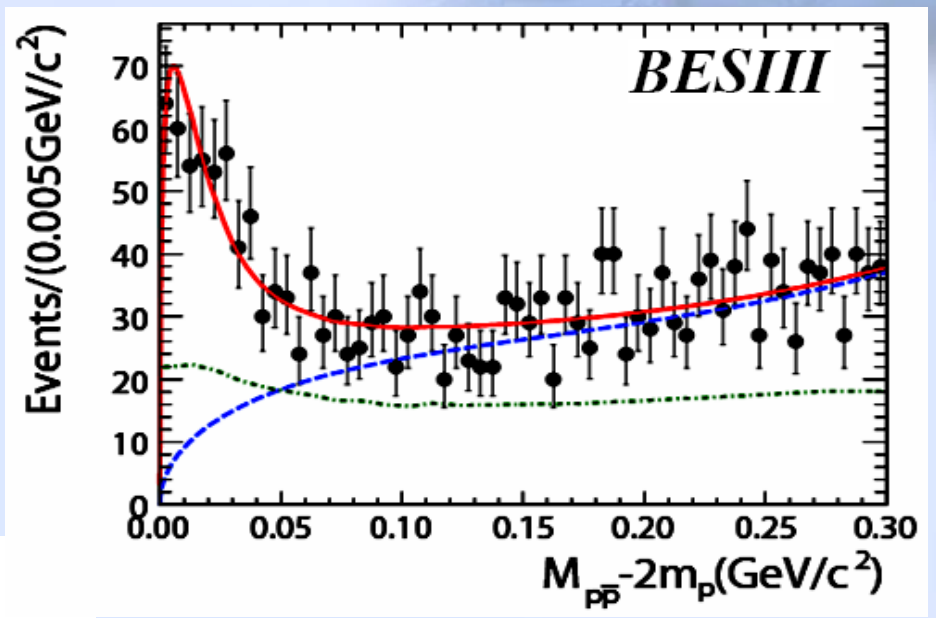
Latest results on light hadron spectroscopy

Observation of $p\bar{p}$ mass threshold enhancement at BESII and BESIII

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



$\psi' \to \pi^+\pi^- J/\psi, J/\psi \to \gamma p\bar{p}$



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

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

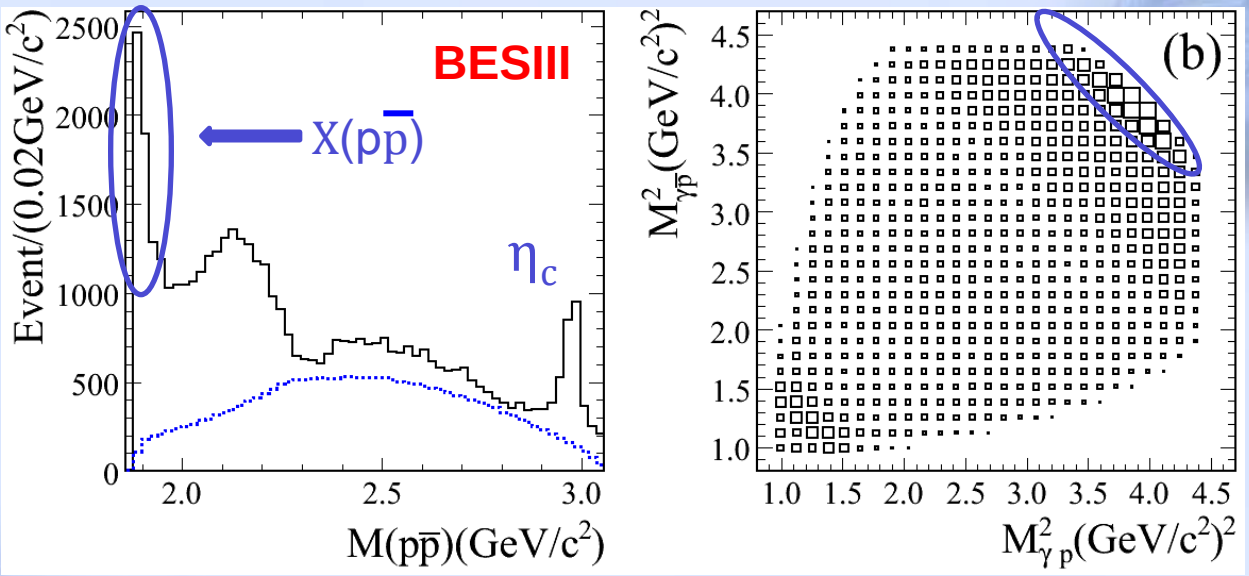
PRL 91 (2003) 022001

$M = 1861^{+6}_{-13}{}^{+7}_{-26}$ MeV/c^2

$\Gamma < 38$ MeV/c^2 (90% CL)

Chinese Physics C 34, 421 (2010)

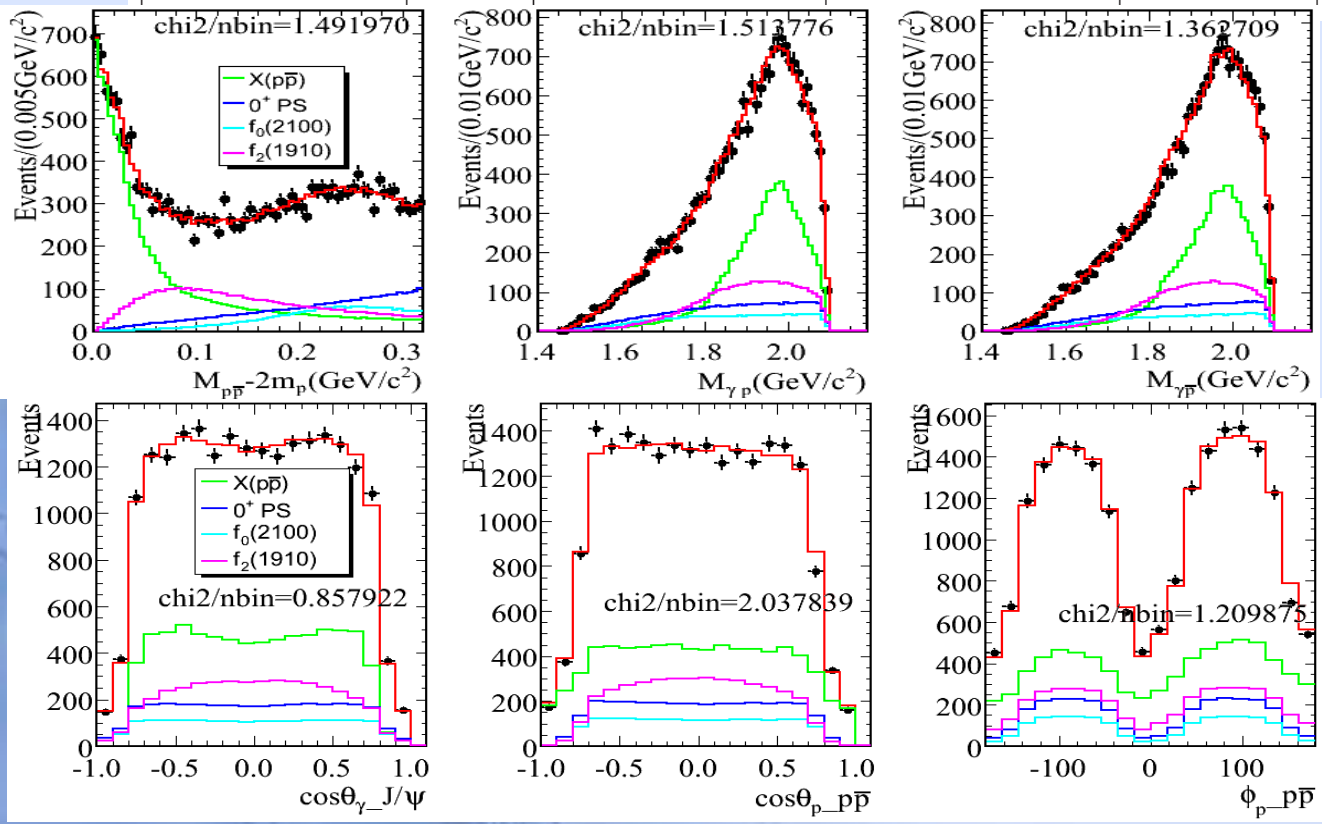
PWA on the $p\bar{p}$ mass threshold structure in $J/\psi \to \gamma p\bar{p}$



- **Evident narrow ppbar mass threshold enhancement in J/ψ decays.**
- **Partial Wave Analysis (PWA):**
  - Concentrate on dealing with the $p\bar{p}$ mass threshold structure, especially to determine the J^{PC} .
  - Convariant tensor amplitudes (S. Dulat and B. S. Zou, Eur.Phys.J A 26:125, 2005).
  - Include the Juich-FSI effect (A. Sirbirtsen et al. Phys.Rev.D 71:054010, 2005).

PWA results and projections in $J/\psi \to \gamma p\bar{p}$

Component	J^{PC}	M (GeV)	Γ (GeV)	Stat.sig.
$X(p\bar{p})$	0^{-+}	1.832 ± 0.005	0.013 ± 0.020	$\gg 30\sigma$
$f_0(2100)$	0^{++}	2.103	0.209	11.2σ
$f_2(1910)$	2^{++}	1.903	0.196	7.7σ
phase space	0^{++}	–	–	6.3σ



- The fit with a BW and S-wave FSI(I=0) factor can well describe ppb mass threshold structure.
- It is much better than that without FSI effect, and $\Delta 2\ln L=51 \Rightarrow 7.1\sigma$.

Measurement for X($p\bar{p}$)

- PWA results are carefully checked from different aspects:
  - Contribution of additional resonances
  - Solution with different combinations
  - Different background levels and fitting mass ranges
  - Different BW formula
  - … …

  All uncertainties are considered as systematic errors.
- Different FSI models →Model dependent uncertainty
- Spin-parity, mass, width and B.R. of X($p\bar{p}$):

$J^{pc} = 0^{-+}$ → >6.8σ better than other J^{pc} assignments.

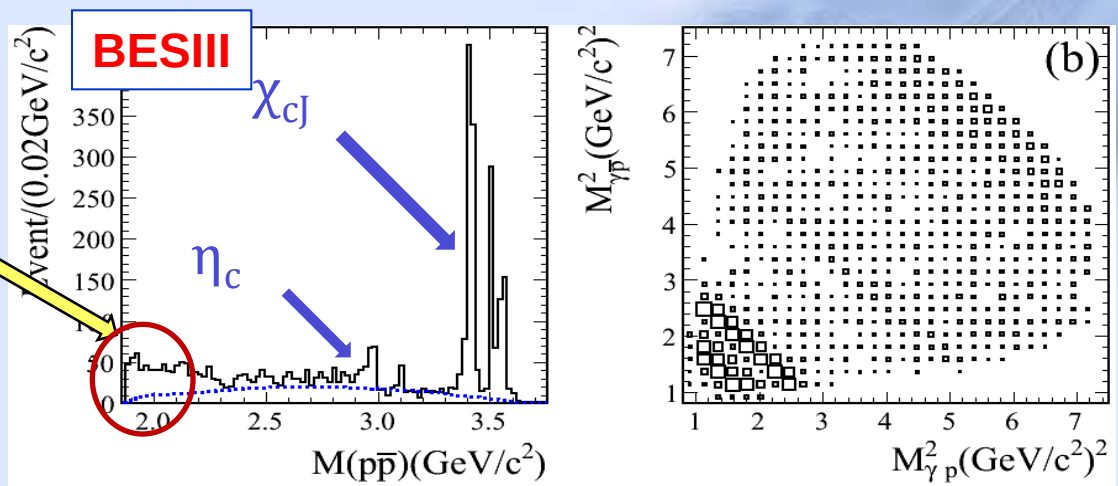
$$M = 1832 \pm 5(\text{stat})^{+19}_{-17}(\text{syst}) \pm 19(\text{mod})\ \text{MeV/c}^2$$

$$\Gamma = 13 \pm 20(\text{stat})^{+11}_{-33}(\text{syst}) \pm 4(\text{mod})\text{MeV/c}^2 \ \text{ or } \Gamma < 48\text{MeV/c}^2\ @90\%\, C.L.$$

$$B(J/\psi \to \gamma X(p\bar{p}))B(X(p\bar{p}) \to p\bar{p}) = (9.0 \pm 0.7(\text{stat})^{+1.5}_{-5.1}(\text{syst}) \pm 2.3(\text{mod})) \times 10^{-5}$$

PWA on the pp mass threshold structure in $\psi' \to \gamma p\bar{p}$

Obviously different line shape of ppbar mass spectrum near threshold from that in J/ψ decays



PWA results:

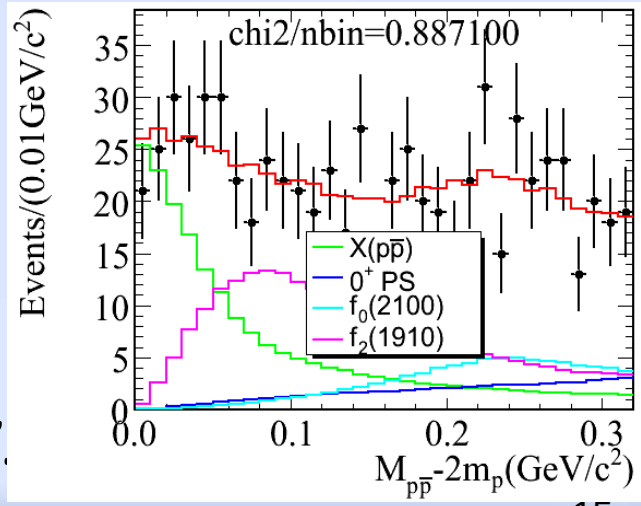
- Significance of X(pp) is larger than 6.9σ.
- The production ratio R: first measurement

$$R = \frac{B(\psi' \to \gamma X(p\bar{p}))}{B(J/\psi \to \gamma X(p\bar{p}))}$$

$$= (5.08 \pm 0.56(\text{stat})^{+0.72}_{-3.83}(\text{syst}) \pm 0.12(\text{mod}))\%$$

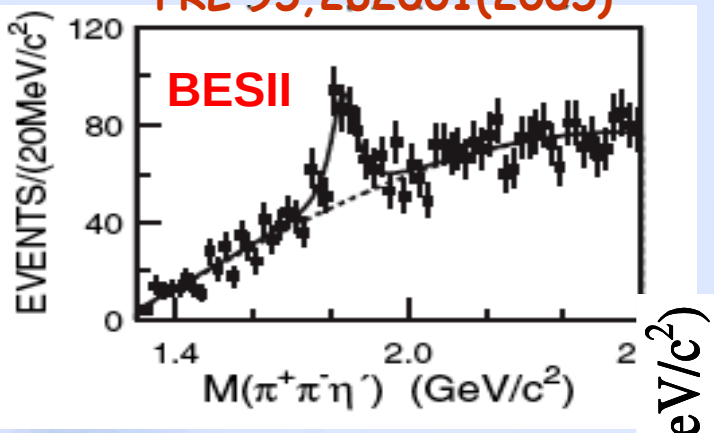
- It is suppressed compared with "12% rule".

PWA Projection:



Confirmation of X(1835) and Observation of two new structures

PRL 95,262001(2005)



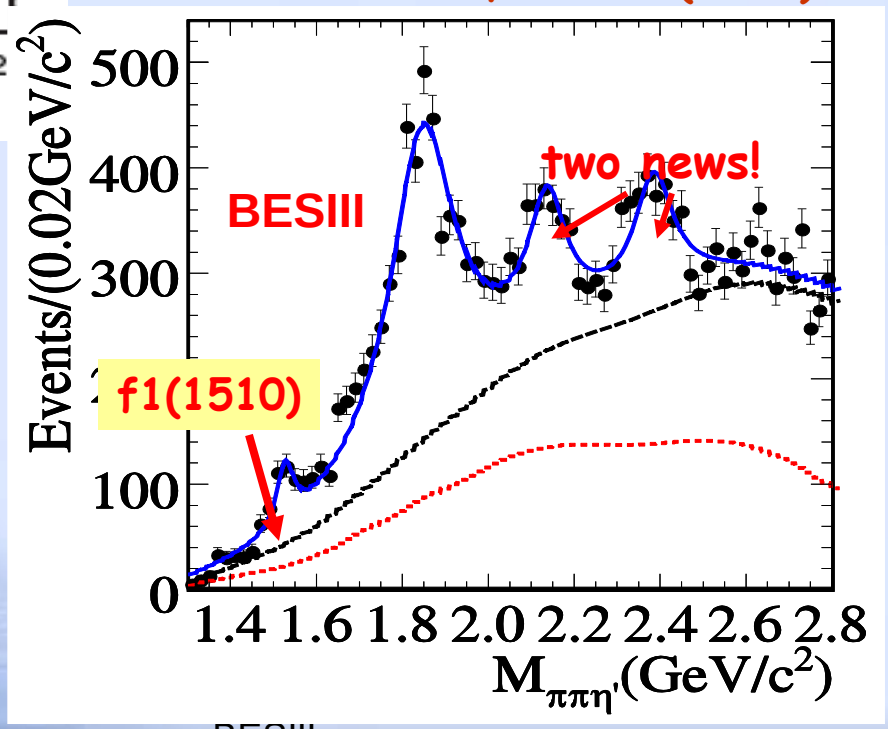
$$BESII\ result(\text{Stat. sig.} \sim 7.7\sigma):$$
$$M = 1833.7 \pm 6.1(stat) \pm 2.7(syst) MeV$$
$$\Gamma = 67.7 \pm 20.3(\text{stat}) \pm 7.7(\text{syst})\text{MeV}$$

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

$\eta' \to \eta\pi^+\pi^-$

$\eta' \to \gamma\rho$

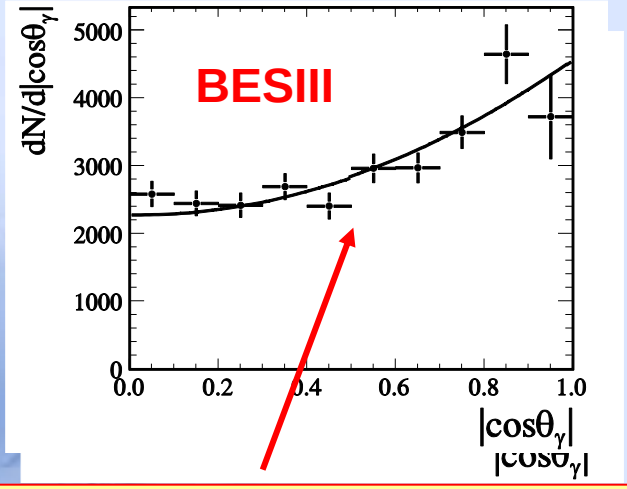
PRL 106, 072002(2011)



Confirmation of X(1835) and Observation of two new structures

BESIII fit results:

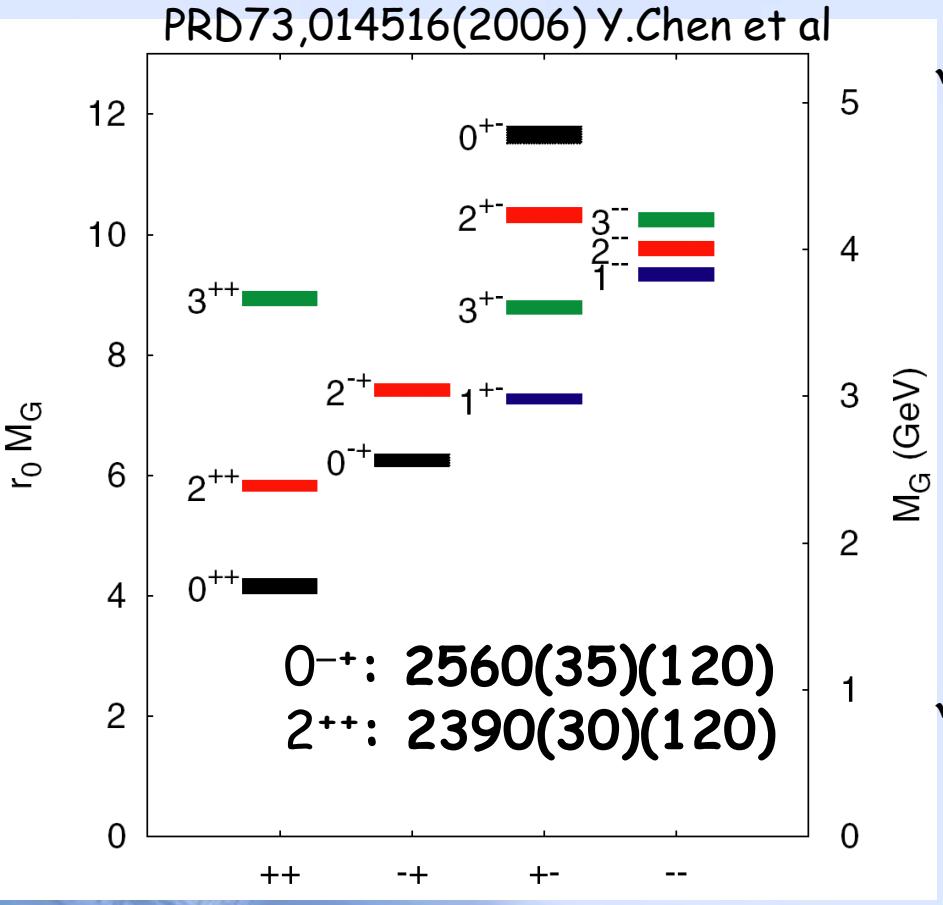
Resonance	M(MeV/c^2)	Γ(MeV/c^2)	Stat.Sig.
X(1835)	$1836.5 \pm 3.0^{+5.6}_{-2.1}$	$190.1 \pm 9.0^{+38}_{-36}$	>20σ
X(2120)	$2122.4 \pm 6.7^{+4.7}_{-2.7}$	$83 \pm 16^{+31}_{-11}$	7.2σ
X(2370)	$2376.3 \pm 8.7^{+3.2}_{-4.3}$	$83 \pm 17^{+44}_{-6}$	6.4σ



PWA is needed to understand these structures.

X(1835) consistent with 0^{-+}

What's the nature of new structures?



- ✓It is the first time resonant structures are observed in the 2.4 GeV/c^2 region, it is interesting since:

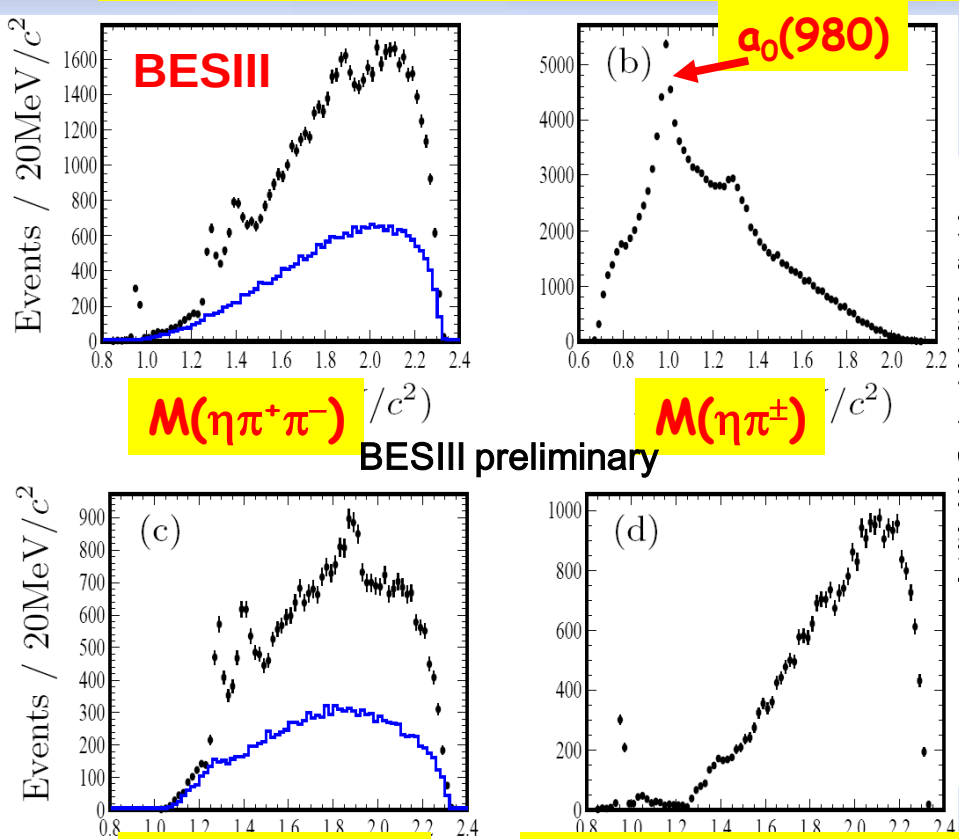
  LQCD predicts that the lowest lying pseudoscalar glueball: around 2.4 GeV/c^2.

  $J/\psi \to \gamma\pi\pi\eta'$ decay is a good channel for finding 0^{-+} glueballs.

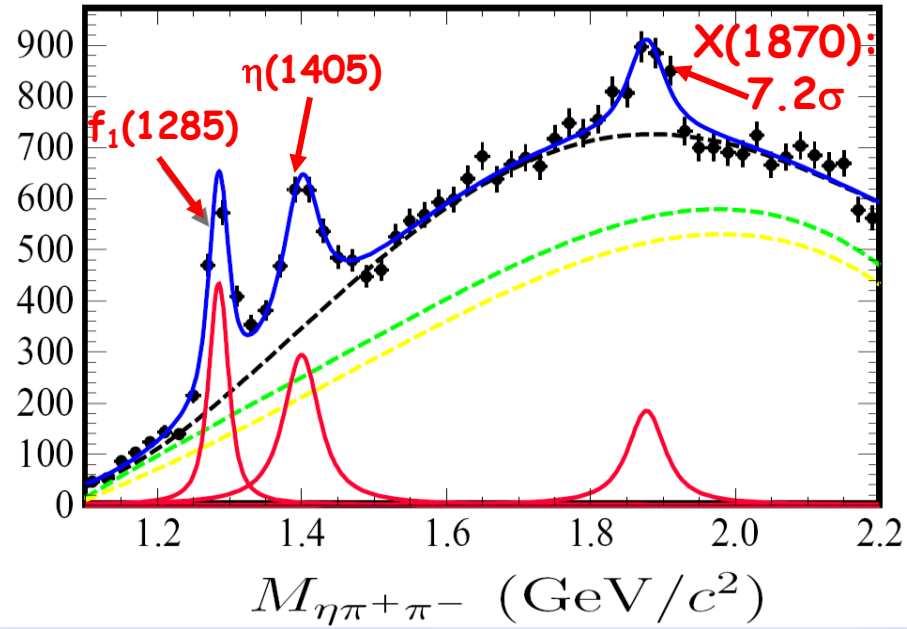
- ✓Nature of X(2120)/X(2370)
  pseudoscalar glueball ?
  η/η' excited states?

PRD82,074026,2010 (J.F. Liu, G.J. Ding and M.L.Yan)
PRD**83:114007,2011** (J.S. Yu, Z.-F. Sun, X. Liu, Q. zhao),
and more…

X(1870) in J/ψ→ωX, X→$a_0^{\pm}(980)\pi^{\mp}$



J/ψ→ωηπ⁺π⁻,
$a_0(980)$ reconstructed in $\eta\pi^{\pm}$

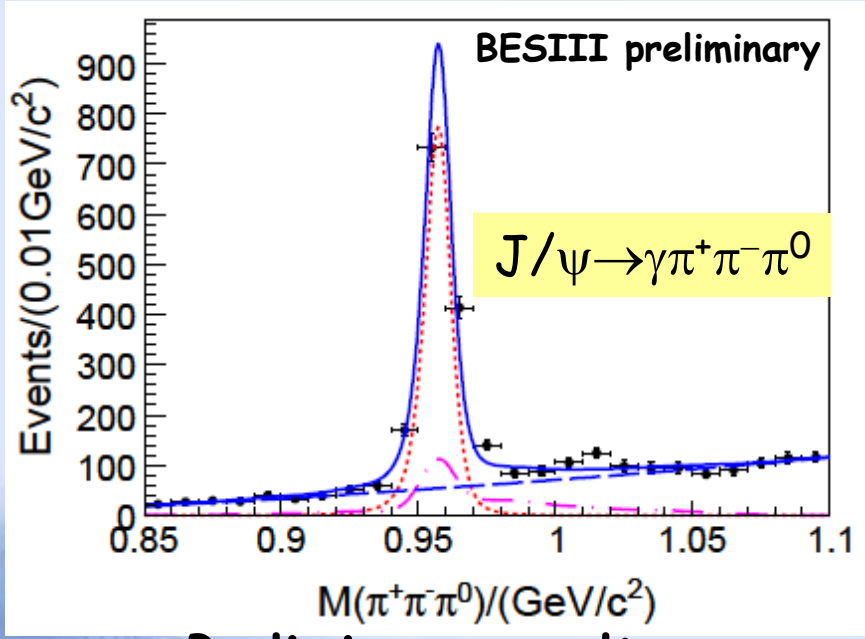


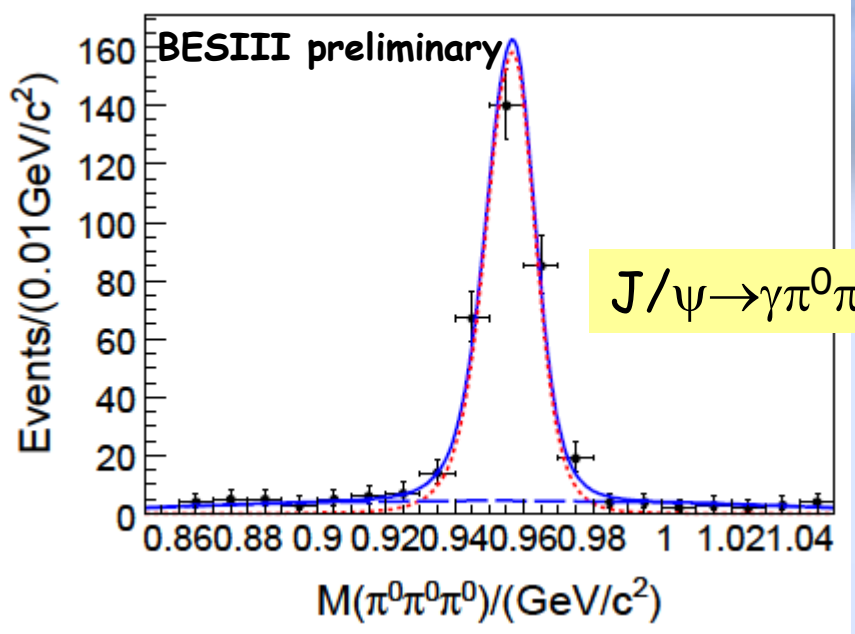
BR(J/ψ→ωX, X→ $a_0^{\pm}(980)\pi^{\mp}$)

Resonance	Mass (MeV/c^2)	Width (MeV/c^2)	Branch ratio (10^{-4})
$f_1(1285)$	$1285.1 \pm 1.0^{+1.6}_{-0.3}$	$22.0 \pm 3.1^{+2.0}_{-1.5}$	$1.25 \pm 0.10^{+0.19}_{-0.20}$
$\eta(1405)$	$1399.8 \pm 2.2^{+2.8}_{-0.1}$	$52.8 \pm 7.6^{+0.1}_{-7.6}$	$1.89 \pm 0.21^{+0.21}_{-0.23}$
$X(1870)$	$1877.3 \pm 6.3^{+3.4}_{-7.4}$	$57 \pm 12^{+19}_{-4}$	$1.50 \pm 0.26^{+0.72}_{-0.36}$

Identification of X(1870): 0^{-+}(?)
It is X(1835)?
Need PWA!

New results on $\eta' \to 3\pi$ in $J/\psi \to \gamma\pi\pi\pi$





Preliminary results:

$$Br(\eta' \to \pi^+\pi^-\pi^0) = (3.83 \pm 0.15(stat.) \pm 0.39(sys.)) \times 10^{-3}$$

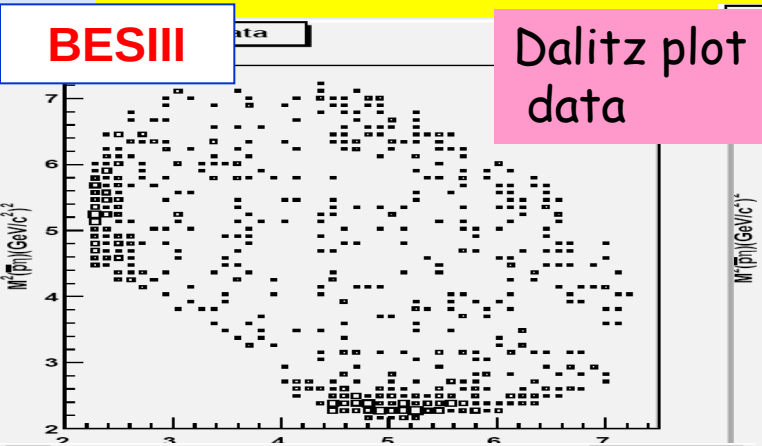
PDG2010: $(3.6^{+1.1}_{-0.9})\times 10^{-3}$ **(2009 CLEO-c)**

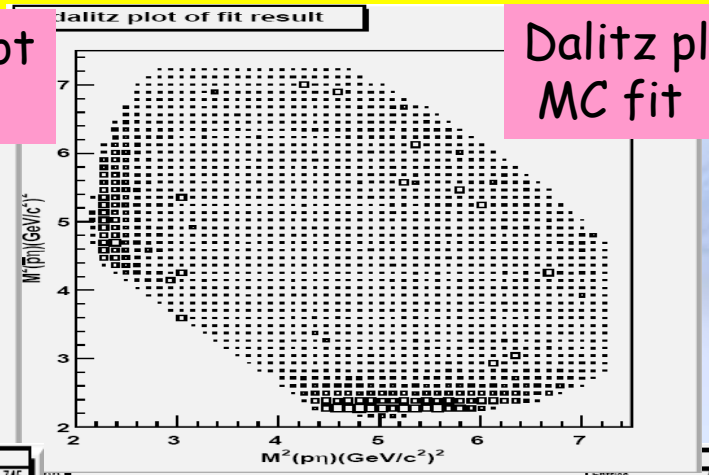
$$Br(\eta' \to 3\pi^0) = (3.56 \pm 0.22(stat.) \pm 0.34(sys.)) \times 10^{-3}$$

PDG2010: $(1.68\pm 0.22)\times 10^{-3}$ (1984: GAM2)

Preliminary results on N* baryon in $\psi' \to \eta p\bar{p}$ decay

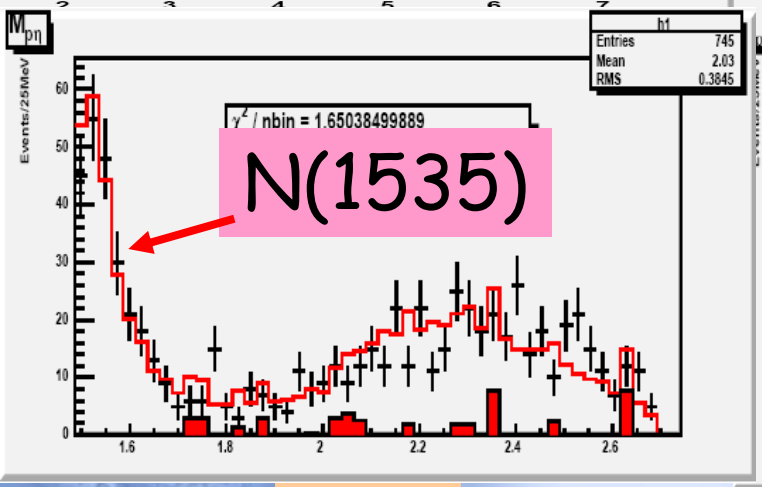
BESIII

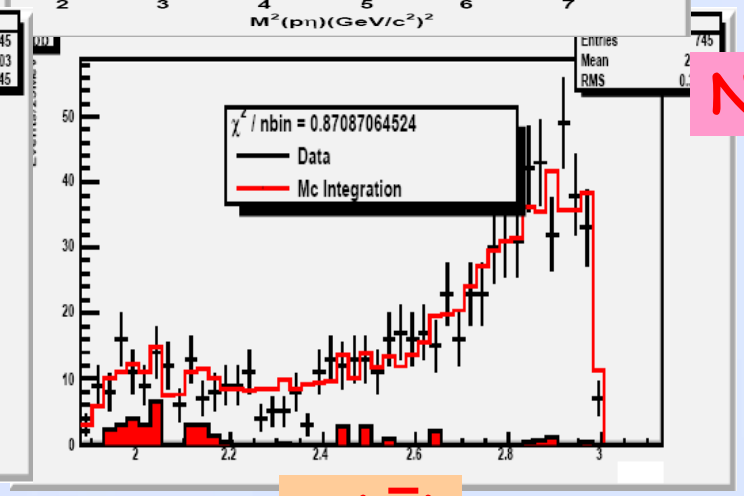




A full PWA is performed.

Background clean!





N(1535) is 1/2⁻

Mass:

$1.524^{+0.005+0.010}_{-0.005-0.004}$ GeV/C²

Width:

$0.130^{+0.027+0.061}_{-0.027-0.014}$ GeV

M(pη)

M(p$\bar{p}$)

$Br(\psi' \to pp\eta) = (6.6 \pm 0.2 \pm 0.6) \times 10^{-5}$

$Br(\psi' \to N(1535)p) \times Br(N(1535) \to p\eta + c.c.)$

$= 5.5^{+0.3+7.4}_{-0.3-1.1} \times 10^{-5}$

PDG2010: $(6.0 \pm 1.2) \times 10^{-5}$

Latest results on charmonium spectroscopy

Property of h_c (1p1)

PRL104, 132002 (2010)

Study isospin forbidden transition

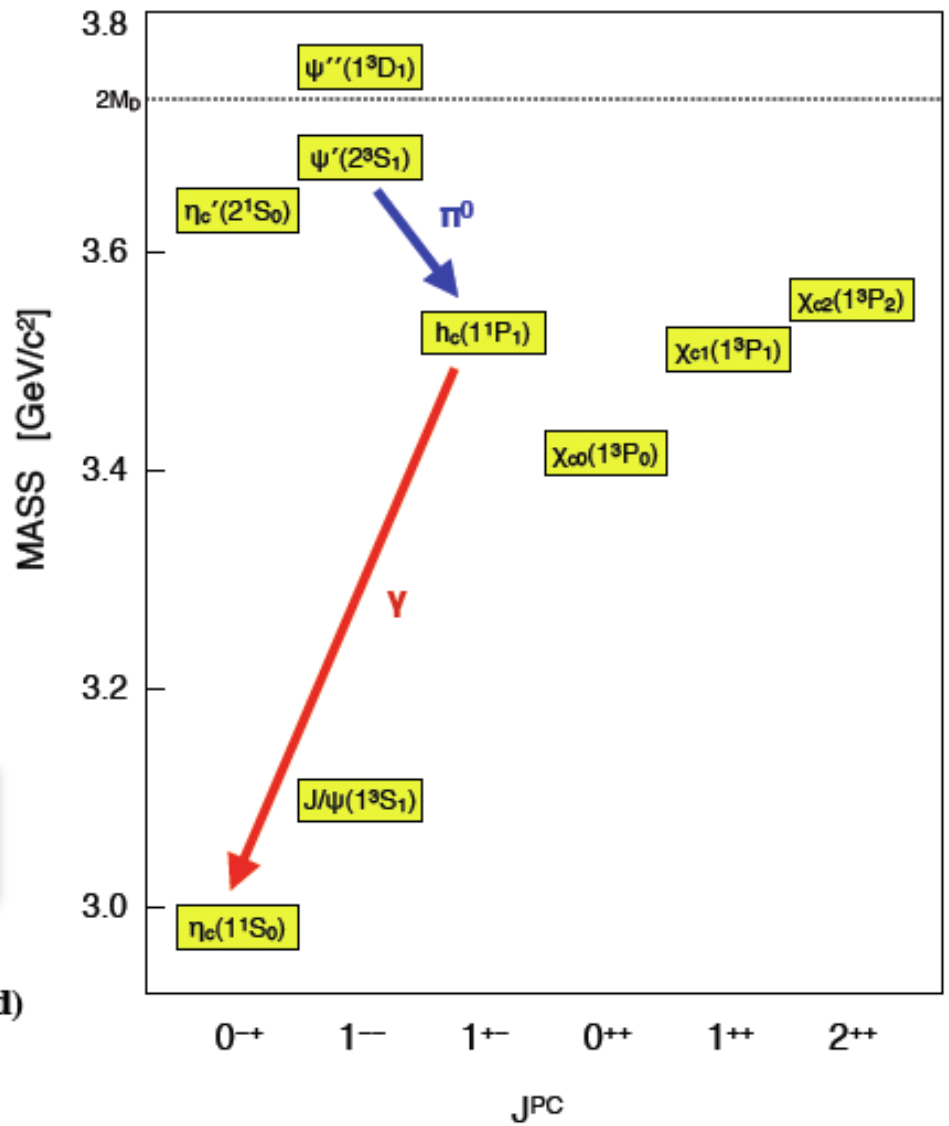
$$B(\Psi' \to \pi^\circ h_c)$$

Measure as well the E1 transition

$$B(h_c \to \gamma \eta_c)$$

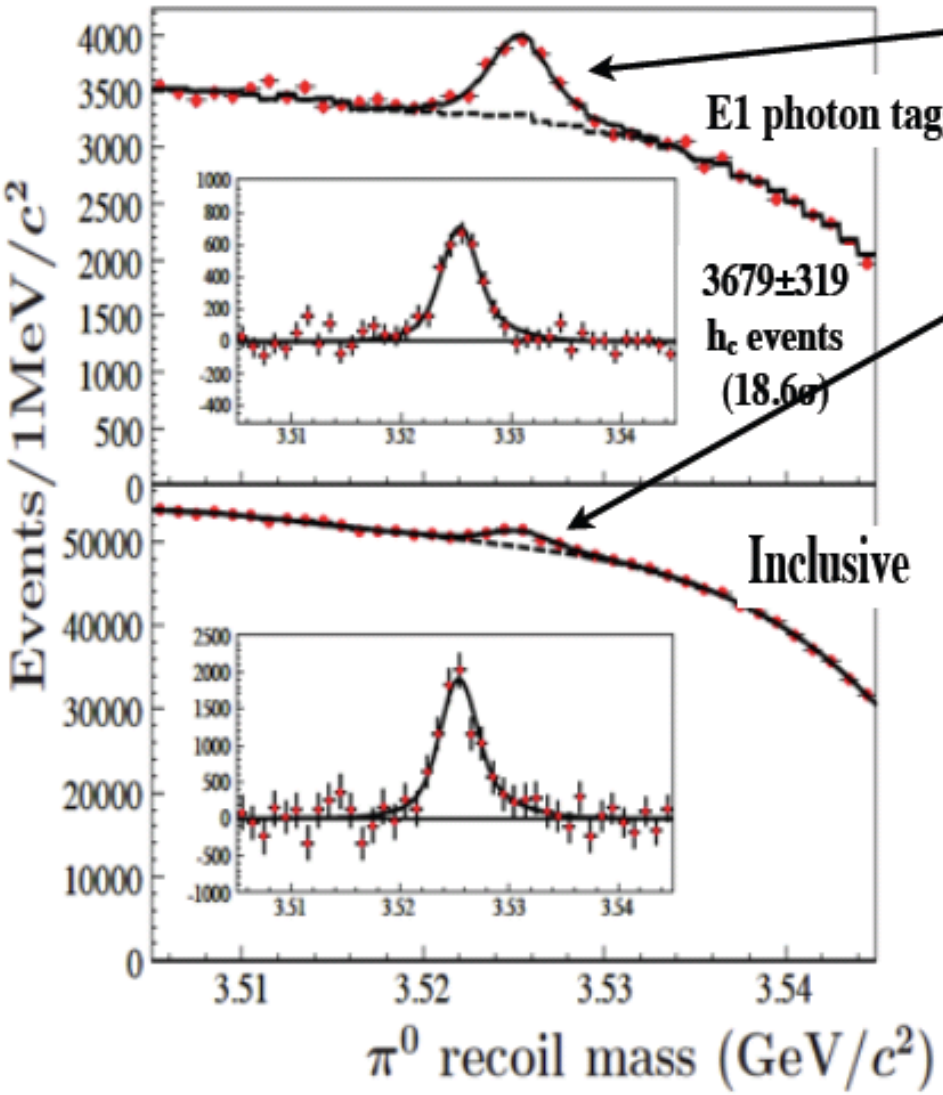
Hyperfine splitting of the 1P states (spin-spin interaction term):

$$M(h_c(1P)) - \langle M(\chi_{cJ}(1P))\rangle_{(\text{spin-weighted})}$$



Observation of h_c in inclusive modes

PRL104, 132002 (2010)



Tag the E1 photon, yields:

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

(consistent with CLEO-c)

Inclusive analysis provides:

$B(\psi(2S) \to \pi^0 h_c)$ (first measurement)
$= (8.4 \pm 1.3 \pm 1.0) \times 10^{-4}$

Combining the two results:

$B(h_c \to \gamma\eta_c) = (54.3 \pm 6.7 \pm 5.2)\%$

(first measurement)

Natural width of h_c:

$\Gamma(h_c) = 0.73 \pm 0.45 \pm 0.28\,\mathrm{MeV}/c^2$

(first measurement)

Hyperfine splitting:

$\Delta M_{hf} = -0.10 \pm 0.13 \pm 0.18\,\mathrm{MeV}/c^2$

(consistent with zero)

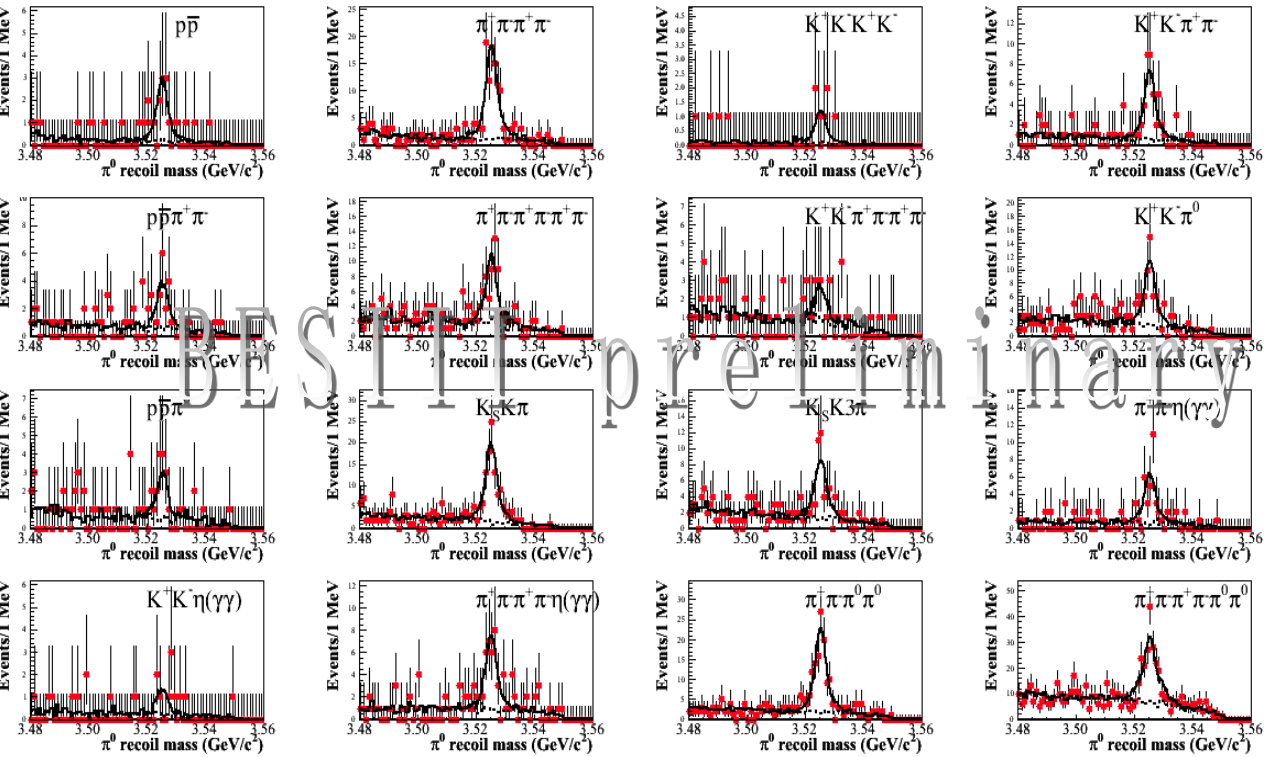
$h_c(1P1)$ in $\psi' \to \pi^0 h_c$, $h_c \to \gamma\eta_c$, $\eta_c \to X_i$ (exclusive)

$\psi' \to \pi^0 h_C$, $h_C \to \gamma\eta_C$, η_C is reconstructed exclusively with 16 decay modes

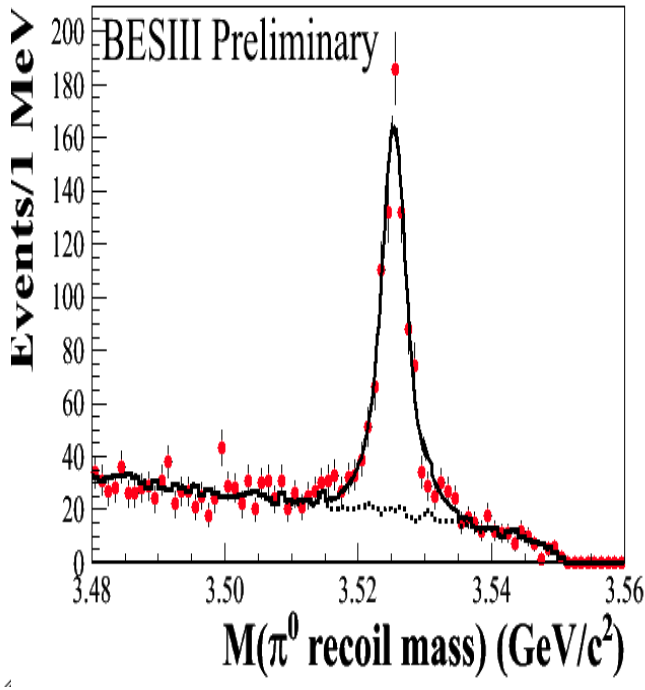
Black from PDG2010,
blue from estimation of $\psi' \to \gamma\eta_c$

16 Decay modes	$BR(\eta_c \to X)$
$\eta_c \to pp^-$	~0.13%
$\eta_c \to \pi^+\pi^- pp^-$	~0.45%
$\eta_c \to 2(\pi^+\pi^-)$	~1.20%
$\eta_c \to 2K^+2K^-$	~0.16%
$\eta_c \to \pi^+\pi^- k^+k^-$	~1.50%
$\eta_c \to 3(\pi^+\pi^-)$	~1.50%
$\eta_c \to K^+K^- 2(\pi^+\pi^-)$	~0.71%
$\eta_c \to k^+k^-\pi^0$	~1.17%
$\eta_c \to pp^{bar}\pi^0$	~0.18%
$\eta_c \to k_s kp;$	~2.33%
$\eta_c \to k_s k3\pi$	~2.40%
$\eta_c \to \pi^+\pi^-\eta;\ \eta \to \gamma\gamma$	~3.27%
$\eta_c \to k^+k^-\eta$	~0.57%
$\eta_c \to 2(\pi^+\pi^-)\eta$	~2.70%
$\eta_c \to \pi^+\pi^-\pi^0\pi^0$	~2.40%
$\eta_c \to 2(\pi^+\pi^-)\pi^0\pi^0$	~11.0%

π^0 recoil mass in $h_c \rightarrow \gamma\eta_c$, $\eta_c \rightarrow X_i$



Sum of π^0 recoil mass



Simultaneous fit to π^0 recoiling mass (preliminary results):

$M(h_c) = 3525.31 \pm 0.11_{(stat)} \pm 0.15_{(sys)}$ MeV/c^2

$\Gamma(h_c) = 0.70 \pm 0.28_{(stat)} \pm 0.25_{(sys)}$ MeV

N = 832±35

χ^2/d.o.f. = 32/46

Consistent with BESIII inclusive results PRL104,132002(2010)

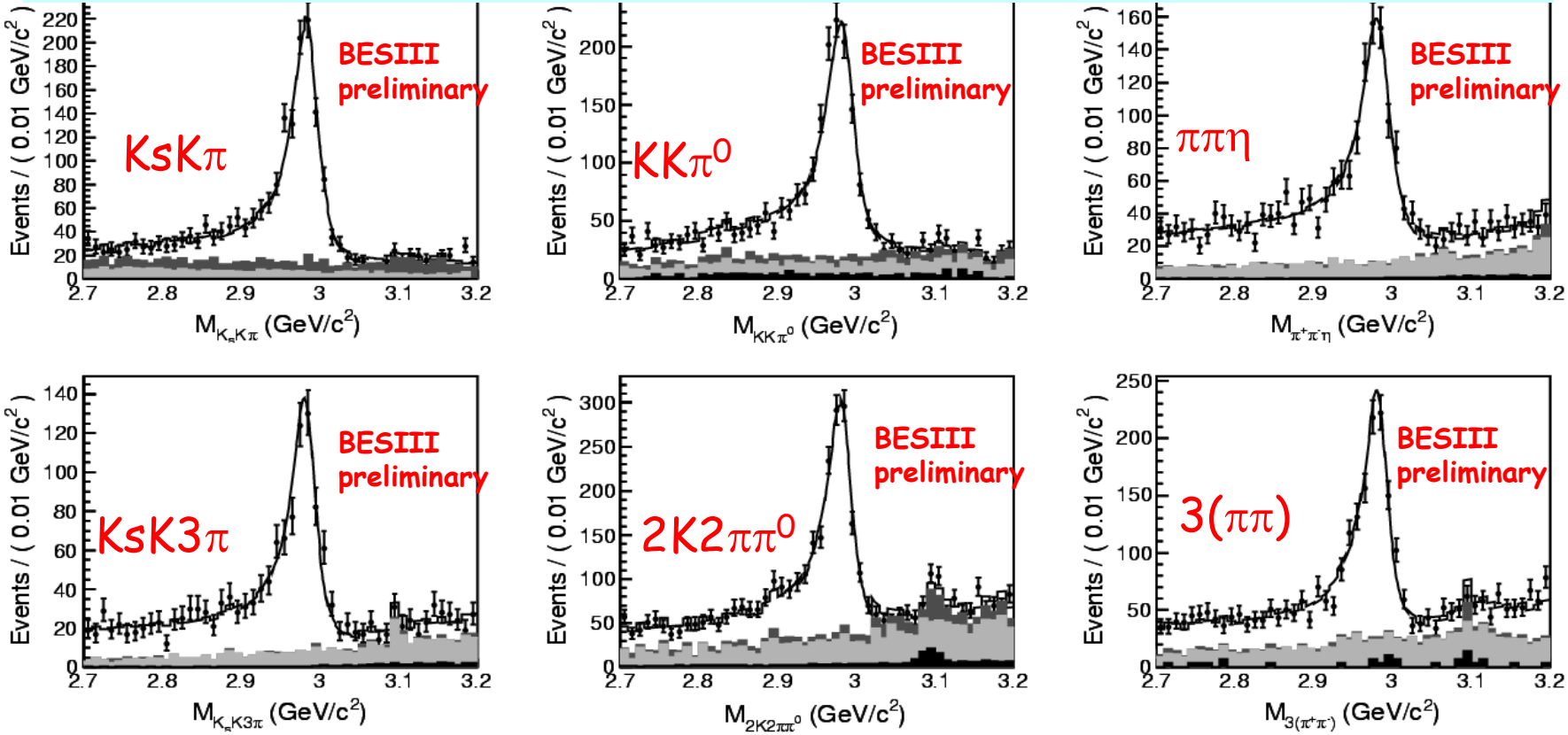
CLEOc exlusive results

$M(h_c) = 3525.21 \pm 0.27 \pm 0.14$ MeV/c^2

N = 136±14

PRL101, 182003(2008)

η_c resonance parameters from $\psi' \to \gamma \eta_c$



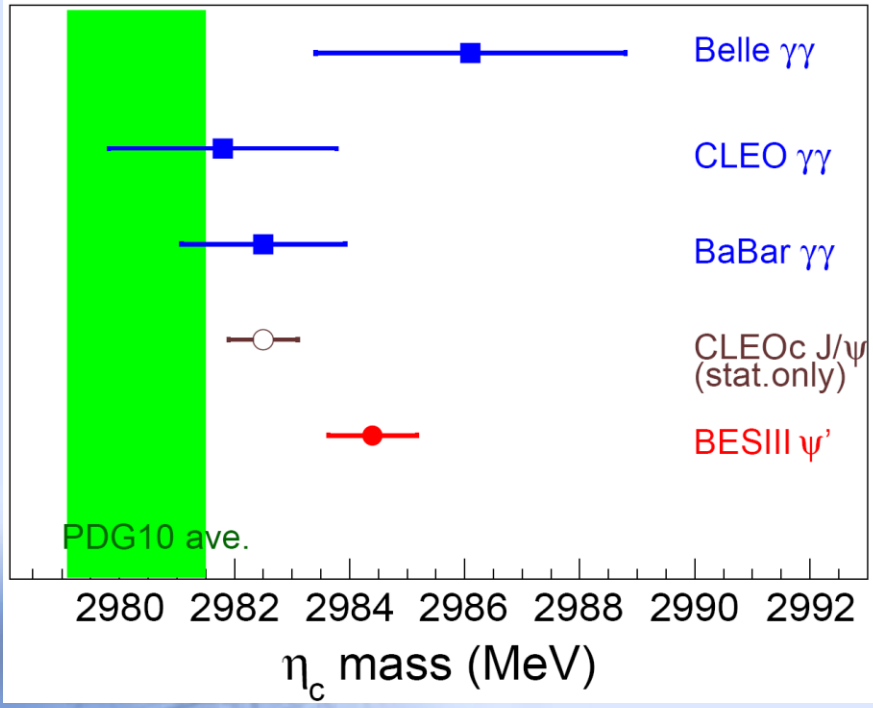
Simultaneous fit with BW by considering **the interference between η_c and non-η_c decays**, as well as the energy dependence of phase space:

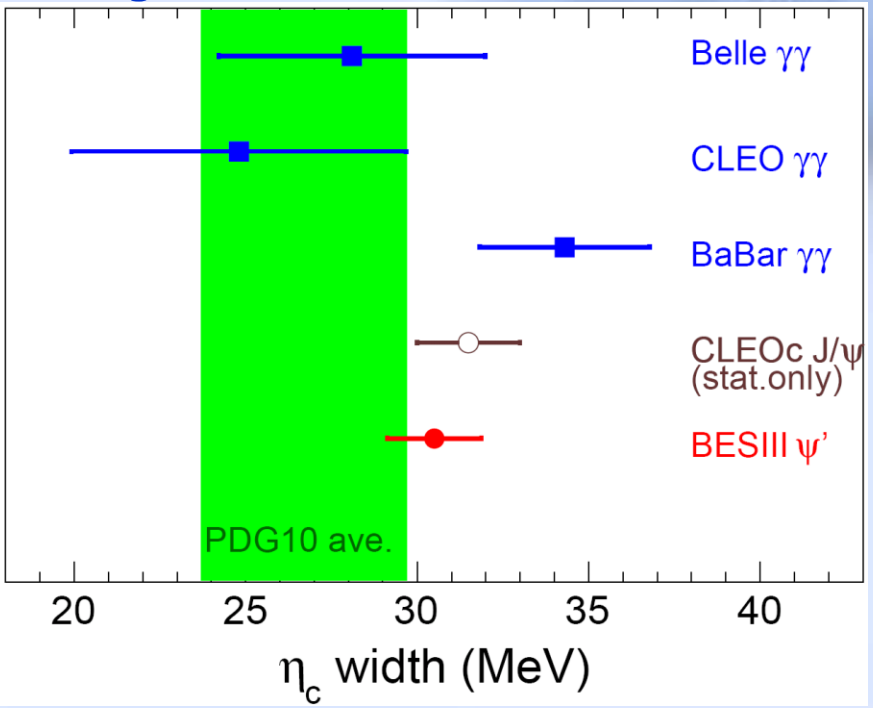
mass: $2984.4 \pm 0.5_{stat} \pm 0.6_{sys}$ MeV/c^2
width: $30.5 \pm 1.0_{stat} \pm 0.9_{sys}$ MeV
ϕ: $2.35 \pm 0.05_{stat} \pm 0.04_{sys}$ rad

ϕ: relative phase between η_c decay and non-resonant component under the signal region by assuming all non-η_c is 0^{-+}, and an universal phase for different modes is used.

Comparison of the mass and width for η_c

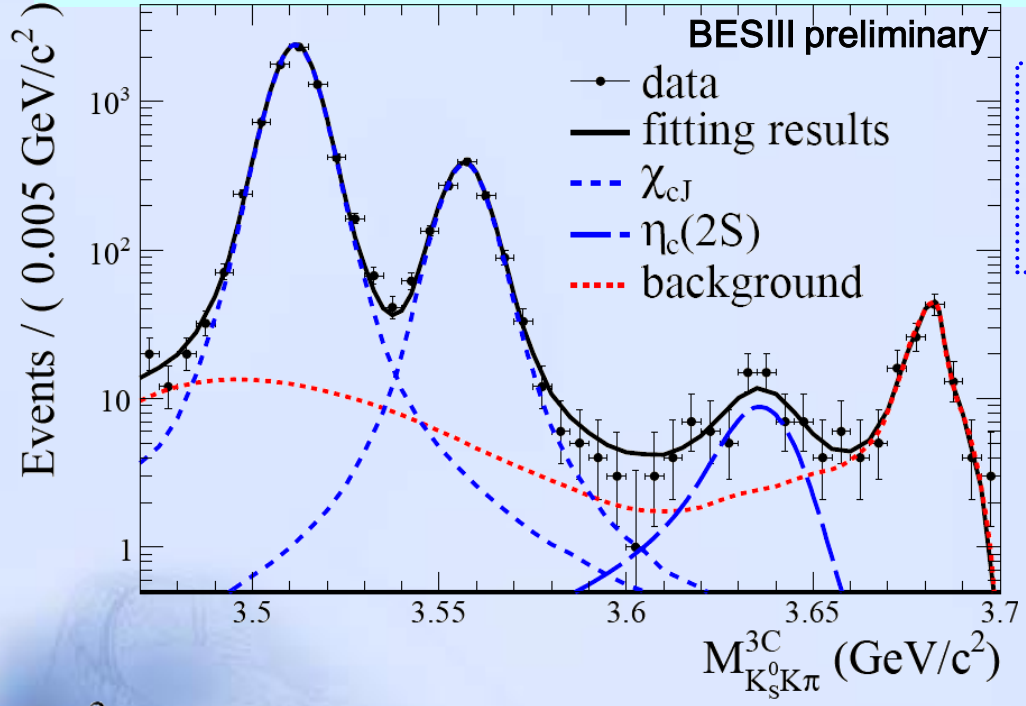
The world average in PDG2010 was using earlier results





BESIII results include both stat. and syst. errors, which is the most precision measurement, the interference between η_c decay and non-resonance is important.

Observation of $\eta_c(2S)$ in $\psi' \to \gamma\eta_c(2S), \eta_c(2S) \to K_s K\pi$



$M(\eta_c(2S)) = (3638.5 \pm 2.3 \pm 1.0)$ MeV/c^2
$N(\eta_c(2S)) = 50.6 \pm 9.7$
Statistical significance larger than 6.0s!

$Br(\psi' \to \gamma\eta_c(2S) \to \gamma K_s K\pi)$
$= (2.98 \pm 0.57_{stat} \pm 0.48_{sys}) \times 10^{-6}$

+

$Br(\eta_c(2S) \to KK\pi) = (1.9 \pm 0.4 \pm 1.1)\%$
From BABAR(PRD78,012006)

$Br(\psi' \to \gamma\eta_c(2S))$
$= (4.7 \pm 0.9_{stat} \pm 3.0_{sys}) \times 10^{-4}$

$$(E_\gamma^3 \times BW(m) \times damping(E_\gamma)) \otimes Gauss(0, \sigma)$$

M1 transition

$$\frac{E_0^2}{E_\gamma E_0 + (E_\gamma - E_0)^2}$$

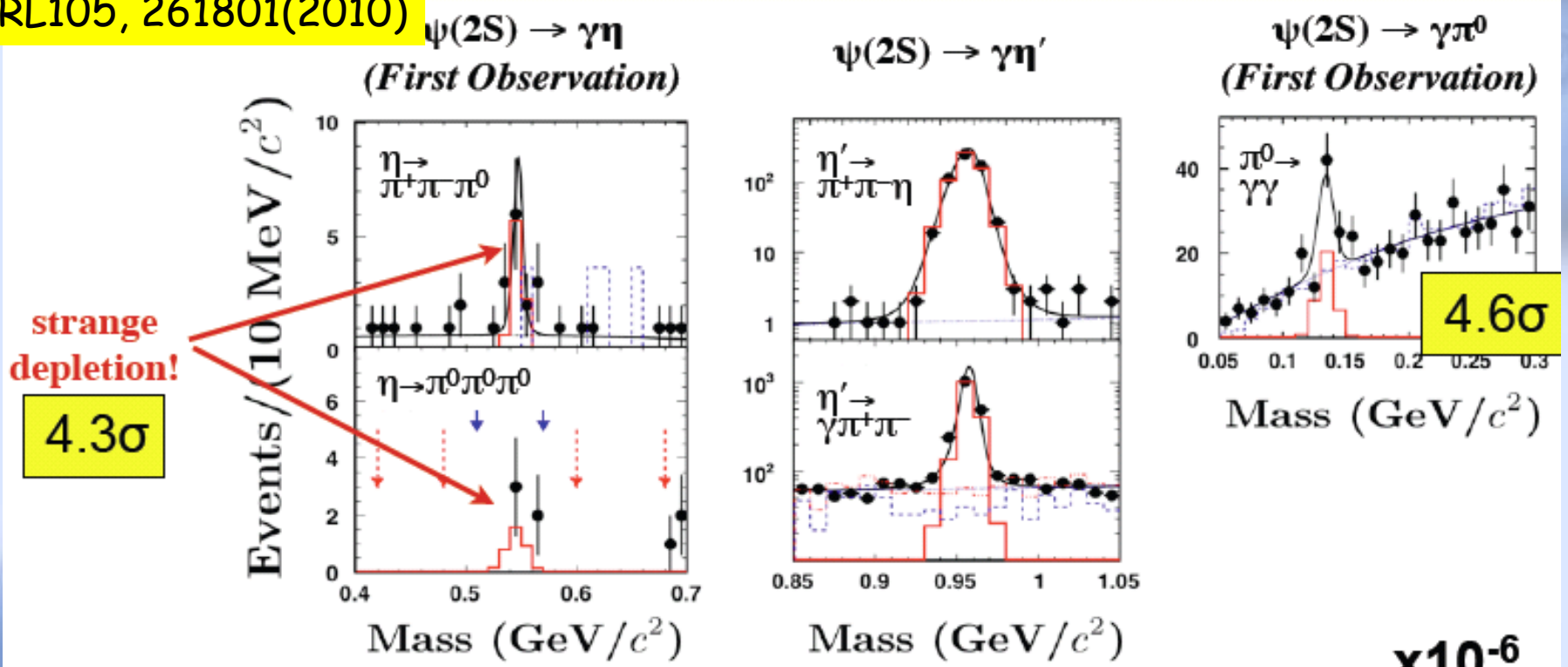
$\Gamma(\eta_c(2S))$ fixed to 12MeV (world average)

CLEO-c: $<7.6\times10^{-4}$ PRD81,052002(2010)

Potential model: $(0.1-6.2)\times10^{-4}$
PRL89,162002(2002)

Evidence for ψ′ decays into γπ and γη

PRL105, 261801(2010)

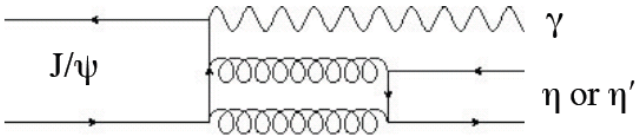


x10^{-6}

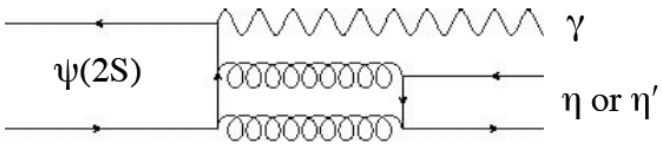
BR $[10^{-6}]$	BESIII	Combined BESIII	PDG10
$\psi' \to \gamma\pi^0$	$1.58 \pm 0.40 \pm 0.13$	$1.58 \pm 0.40 \pm 0.13$	≤ 5
$\psi' \to \gamma\eta(\pi^+\pi^+\pi^0)$	$1.78 \pm 0.72 \pm 0.17$		
$\psi' \to \gamma\eta(\pi^0\pi^0\pi^0)$	$1.07 \pm 0.65 \pm 0.08$	$1.38 \pm 0.48 \pm 0.09$	≤ 2
$\psi' \to \gamma\eta'_{(958)}(\pi^+\pi^+\eta)$	$120 \pm 5 \pm 8$		
$\psi' \to \gamma\eta'_{(958)}(\pi^+\pi^+\gamma)$	$129 \pm 3 \pm 8$	$126 \pm 3 \pm 8$	121 ± 8

Some surprises

PRL105, 261801(2010)



VS



Theory

$$R_{(c\bar{c})} = \frac{Br((c\bar{c})\to\gamma\eta)}{Br((c\bar{c})\to\gamma\eta')}$$

LO-pQCD

$\Downarrow$

$$R_{\psi'} \simeq R_{J/\psi}$$

PRP 112,173 (1984)

Experiment

CLEO-c

PRD79, 111101 (2009)

$$R_{J/\Psi} = \frac{B(J/\psi\to\gamma\eta)}{B(J/\psi\to\gamma\eta')} = (21.1 \pm 0.9)\ \%$$

(consistent with other measurements of η-η′ mixing angle and LO-pQCD)

BESIII

$$R_{\Psi'} = \frac{B(\psi(2S)\to\gamma\eta)}{B(\psi(2S)\to\gamma\eta')} = (1.10 \pm 0.38 \pm 0.07)\ \%$$

(consistent with upper limit from CLEO-c)

$\Rightarrow$ $R_{\psi'} << R_{J/\psi}$

Difference?: Other processes contributing? Related to ρπ puzzle, ... ??

Q. Zhao, PLB697(2011)52

Summary and Prospects

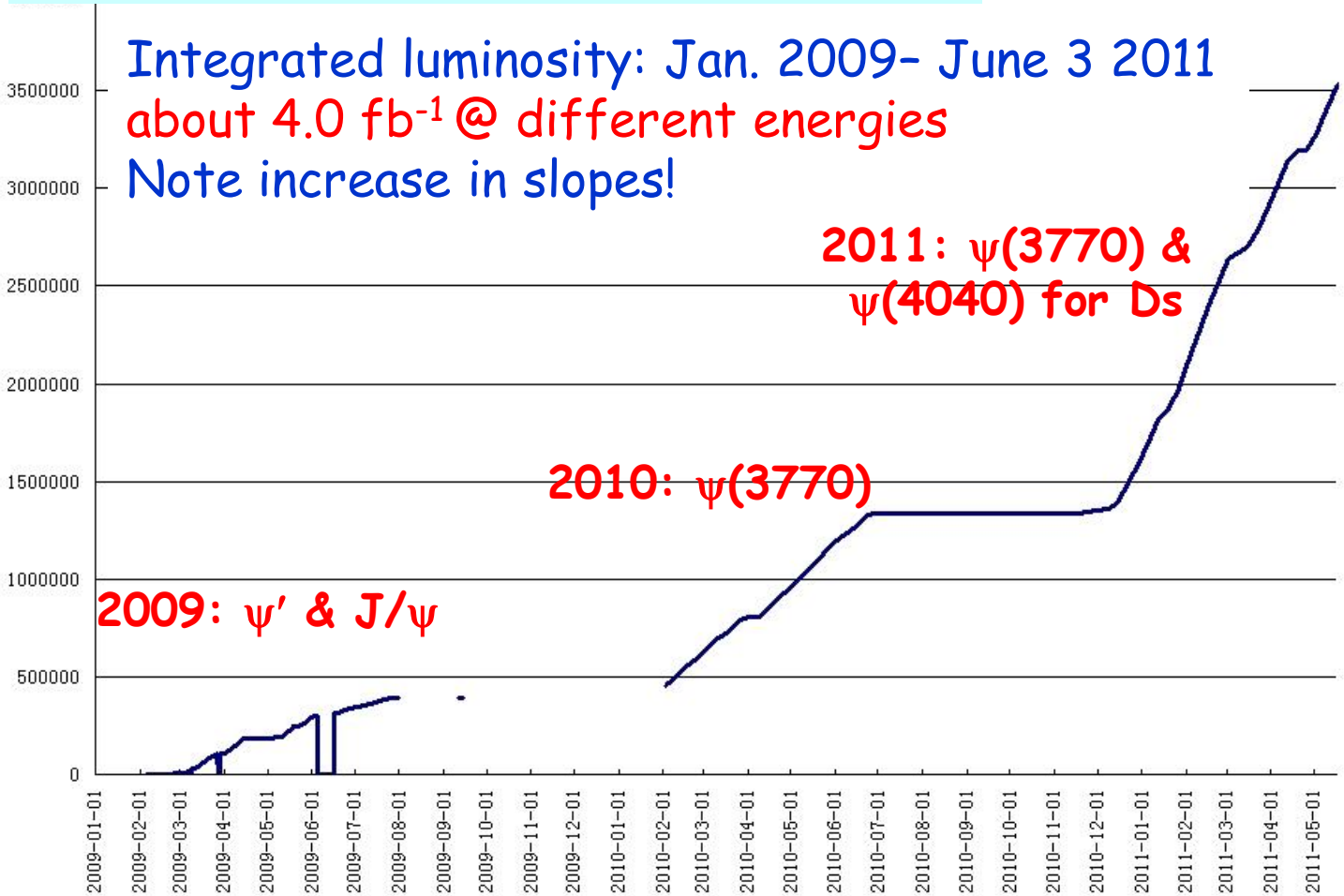
- **Huge data samples collected for charmonium decays at BESIII. A lot of results have been obtained.**
  - The spin-parity of the ppbar mass threshold enhancement in J/psi→gamma ppbar was first determined as 0^{-+}.
  - Confirmation of X(1835) in $J/\psi \to \gamma\eta'\pi^+\pi^-$ and observation of two new structures X(2120) and X(2370) in $J/\psi \to \gamma\pi\pi\eta'$ decays.
  - Observation of new structure X(1870) in $J/\psi\to\omega\pi\pi\eta$.
  - The first observation of $\eta_c(2S)$ in $\psi'\to\gamma\eta_c(2S)$ decay.
  - Precision measurements of $\eta_c(1S)$ parameters in $\psi'\to\gamma\eta_c(1S)$.
- **We expect rich physics results in the coming years from BESIII.**

THANK YOU!

Back up slides

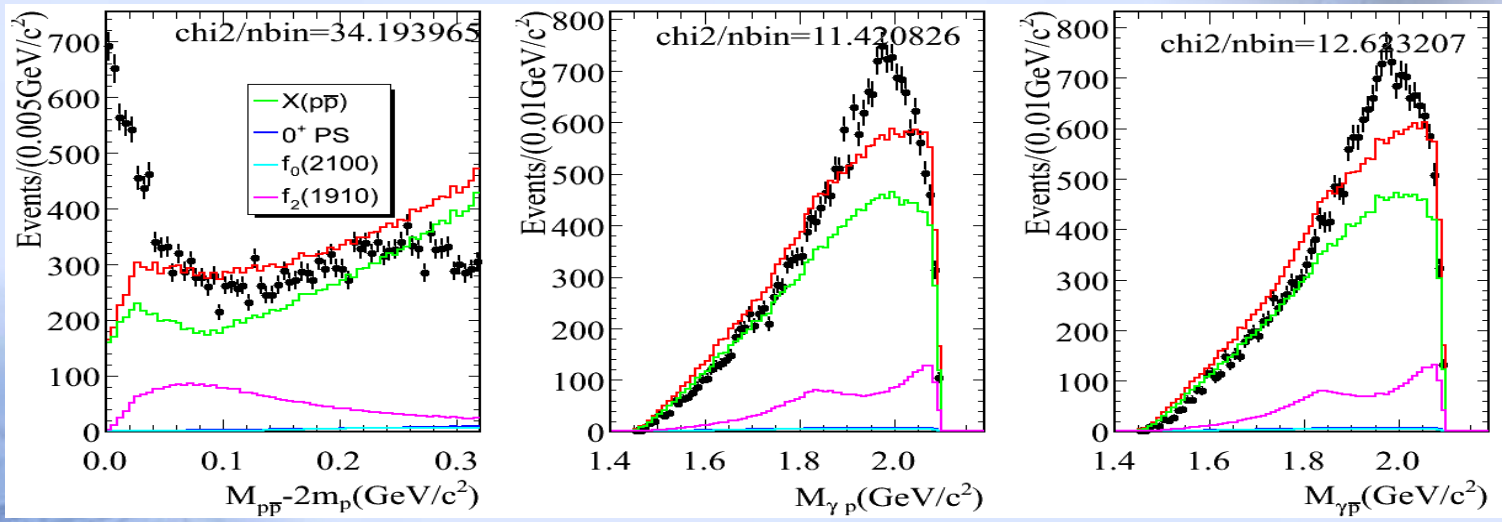
luminosity since startup

Note that luminosity is lower at J/ψ, and machine is optimal near ψ(3770)



PWA projections in $J/\psi \to \gamma p\bar{p}$

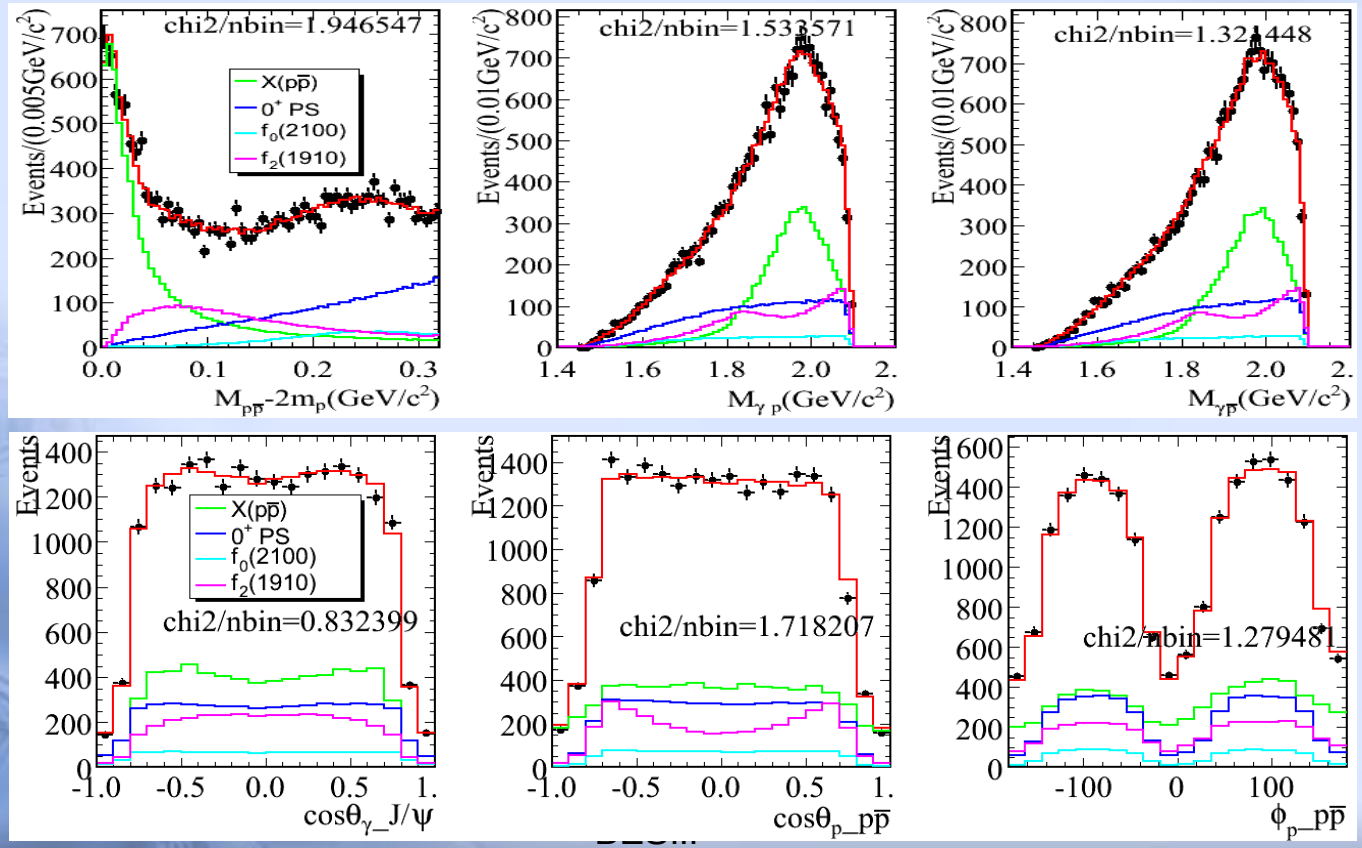
Fit $p\bar{p}$ mass threshold structure with pure FSI effect



- **It is hard to fit the $p\bar{p}$ threshold structure with pure FSI effect.**

PWA results (without FSI) of $J/\psi \to \gamma p\bar{p}$

Component	J^{PC}	M (GeV)	Γ (GeV)	Stat.sig.
$X(p\bar{p})$	0^{-+}	1.861 ± 0.001	0.001 ± 0.006	$\gg 30\sigma$
$f_0(2100)$	0^{++}	2.103	0.209	11.2σ
$f_2(1910)$	2^{++}	1.903	0.196	9.8σ
phase space	0^{++}	–	–	6.4σ



Measurement of X($p\bar{p}$) without FSI

- Spin-parity, mass, width and B.R. of X($p\bar{p}$):

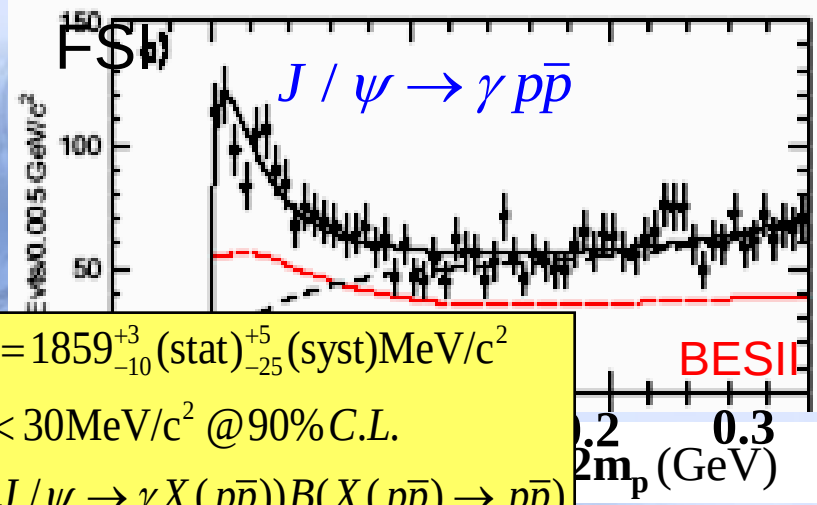
$$J^{PC} = 0^{-+}$$

$$M = 1861 \pm 1(\text{stat})^{+13}_{-4}(\text{syst})\text{MeV/c}^2$$

$$\Gamma = 1 \pm 6(\text{stat})^{+18}_{-0}(\text{syst})\text{MeV/c}^2 \text{ or } \Gamma < 32\text{MeV/c}^2 @90\% C.L.$$

$$B(J/\psi \to \gamma X(p\bar{p}))B(X(p\bar{p}) \to p\bar{p}) = (8.6 \pm 0.3(\text{stat})^{+2.4}_{-4.1}(\text{syst})) \times 10^{-5}$$

- Consistent with BESII and BESIII published results without FSI

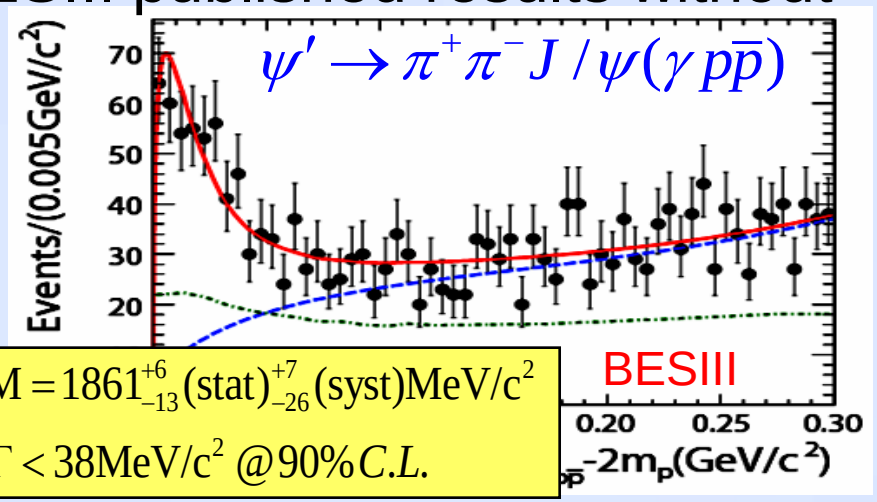


$$M = 1859^{+3}_{-10}(\text{stat})^{+5}_{-25}(\text{syst})\text{MeV/c}^2$$

$$\Gamma < 30\text{MeV/c}^2 @90\% C.L.$$

$$B(J/\psi \to \gamma X(p\bar{p}))B(X(p\bar{p}) \to p\bar{p})$$

$$= (7.0 \pm 0.4(\text{stat})^{+1.9}_{-0.8}(\text{syst})) \times 10^{-5}$$



$$M = 1861^{+6}_{-13}(\text{stat})^{+7}_{-26}(\text{syst})\text{MeV/c}^2$$

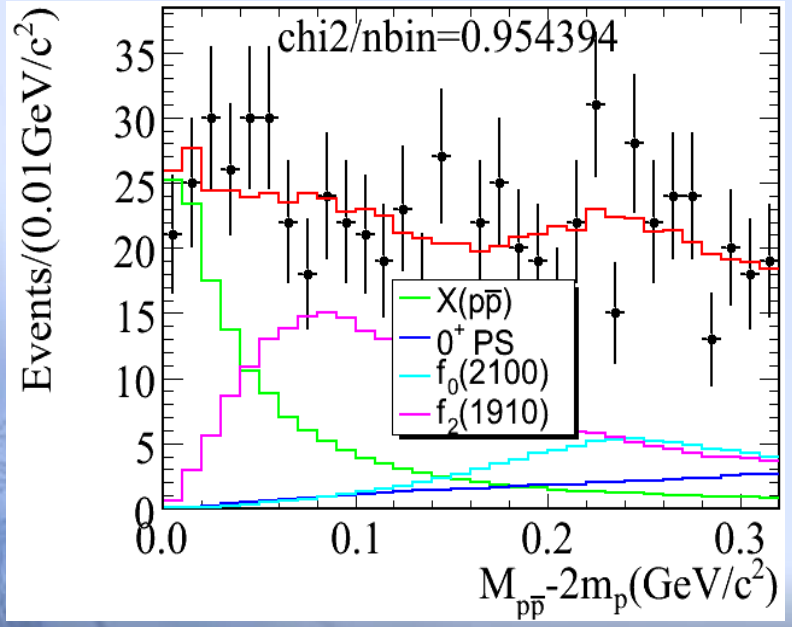
$$\Gamma < 38\text{MeV/c}^2 @90\% C.L.$$

PWA results (without FSI) of $\psi' \to \gamma p\bar{p}$

- Significance of X($p\bar{p}$) is > 10σ.
- The production ratio R:

$$R = \frac{B(\psi' \to \gamma X(p\bar{p}))}{B(J/\psi \to \gamma X(p\bar{p}))} = (4.80 \pm 0.47(\text{stat})^{+3.51}_{-1.29}(\text{syst}))\%$$

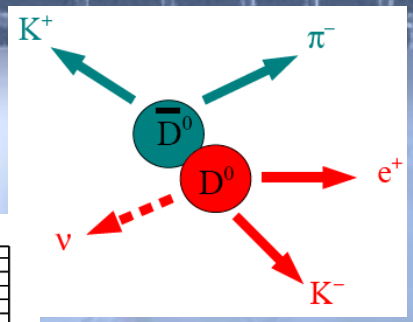
- It is suppressed compared with "12% rule".

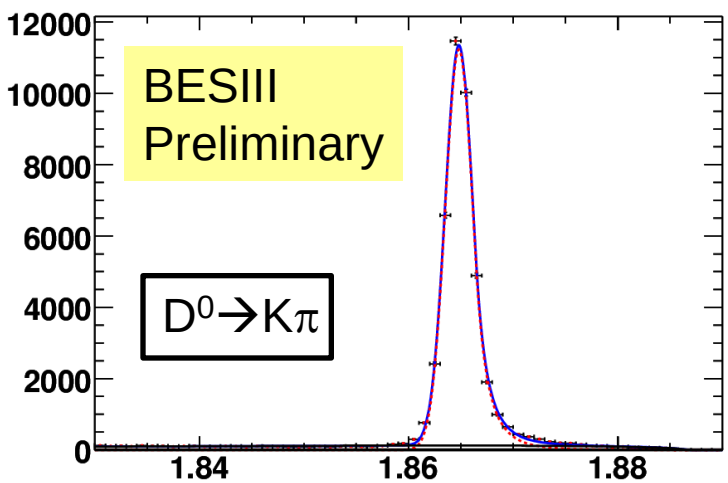


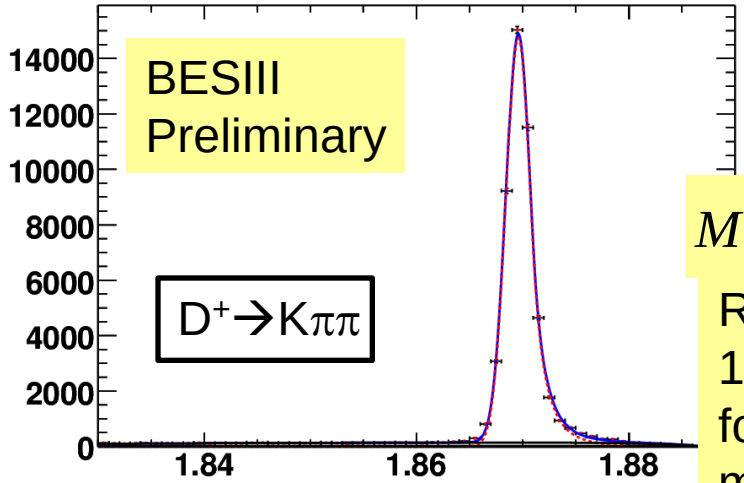
Prospect of charm physics at BESIII

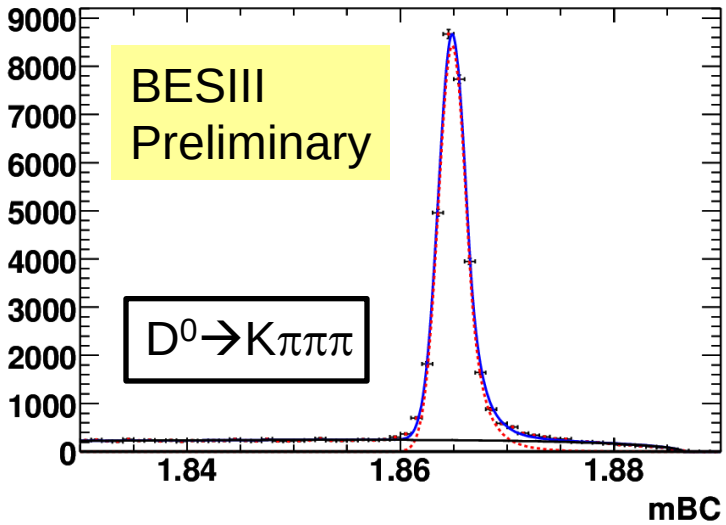
Clean single tag at BESIII

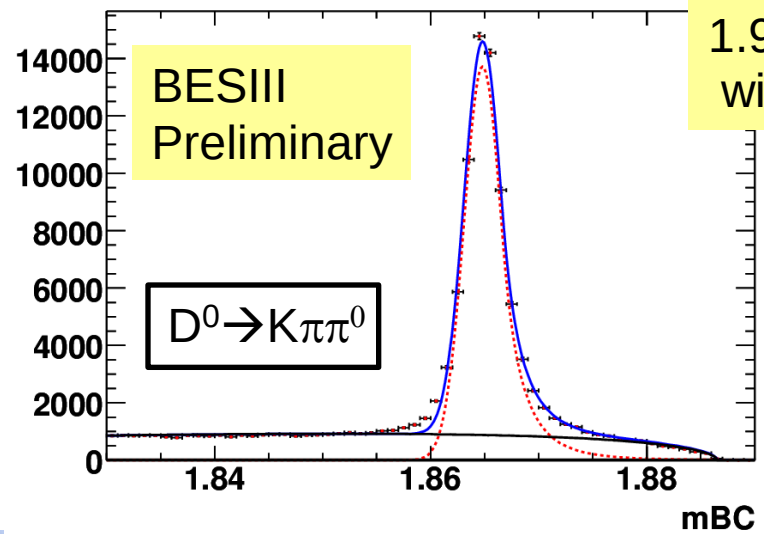
@ψ(3770) with 420pb^{-1} first clean single tagging sample:











$$M_{BC} = \sqrt{E_{beam}^2 - |p_D|^2}$$

Resolution:
1.3 MeV
for pure charged modes;
1.9 MeV for modes with one π^0.