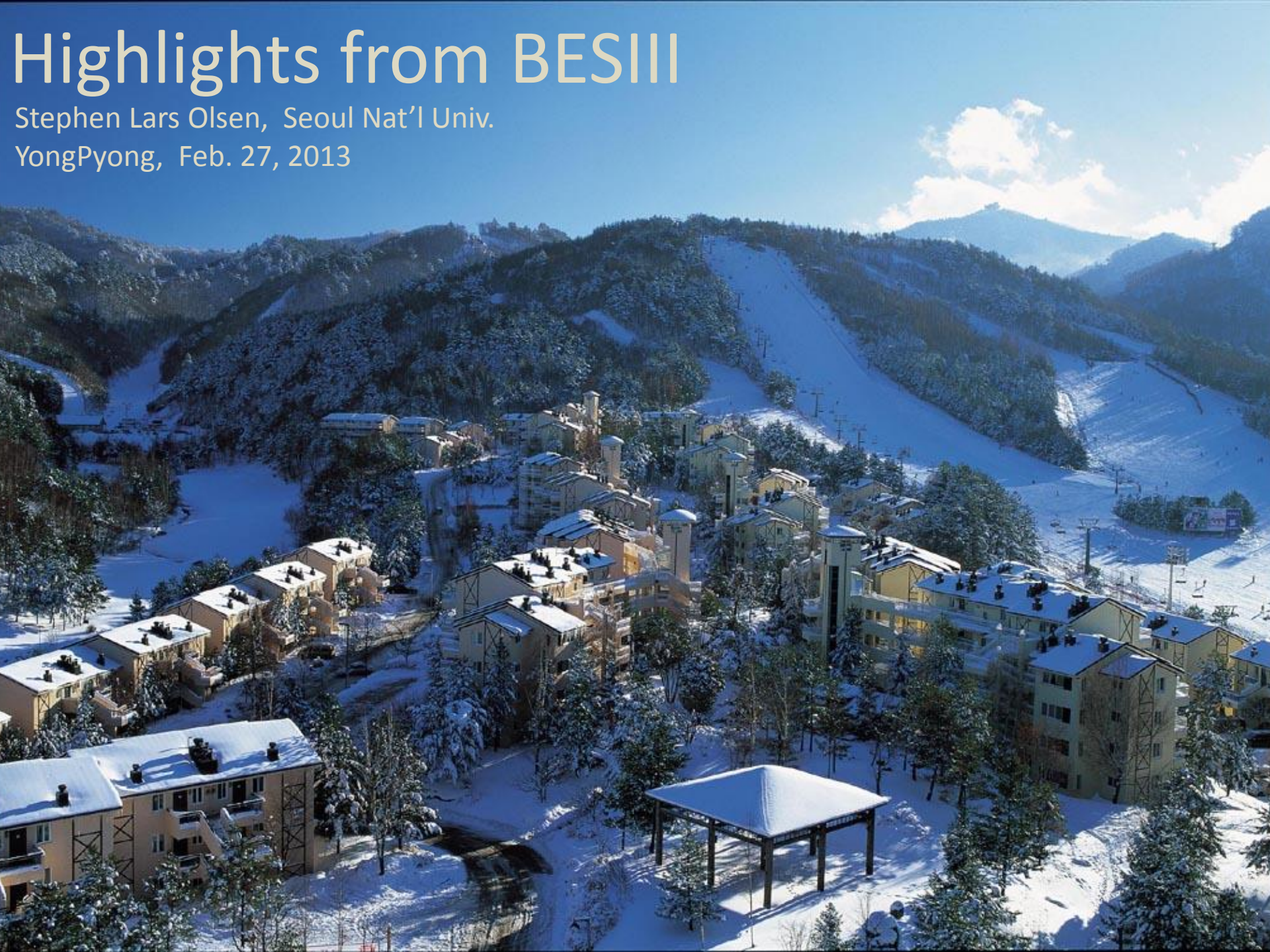
Highlights from BESIII

Stephen Lars Olsen, Seoul Nat'l Univ.

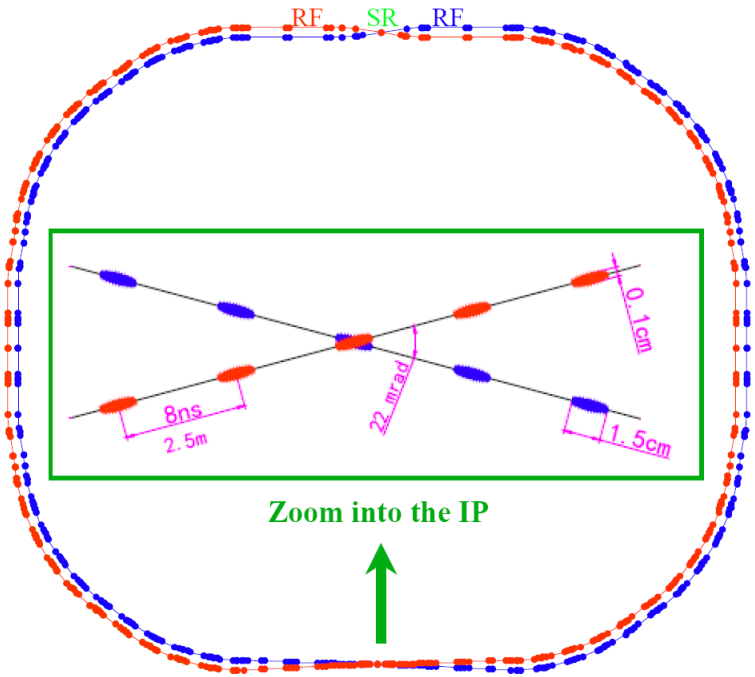
YongPyong, Feb. 27, 2013



The Beijing Electron Positron Collider
-- BEPCII --

To Tiananmen Square (~10 km)

BEPCII storage rings



Beam energy: 1.0 – 2.3 GeV

Peak Luminosity:

Design: 1×10^{33} $cm^{-2}s^{-1}$

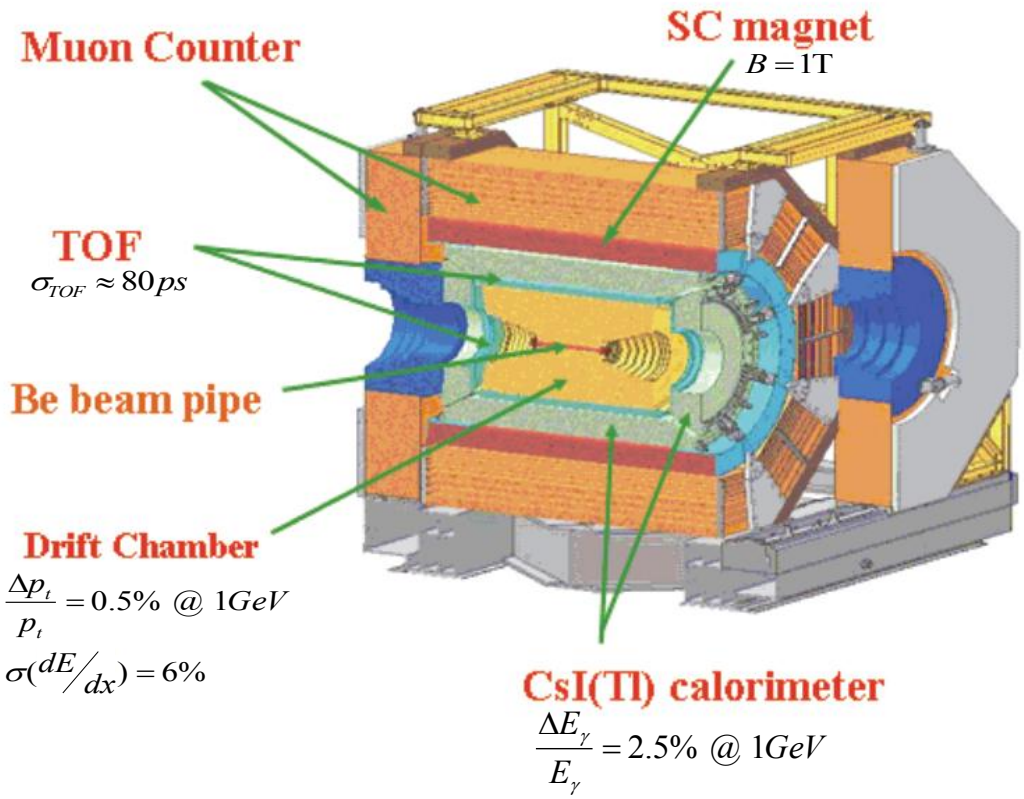
Achieved: 0.65×10^{33} $cm^{-2}s^{-1}$

Beam energy measurement: Using Compton backscattering technique.

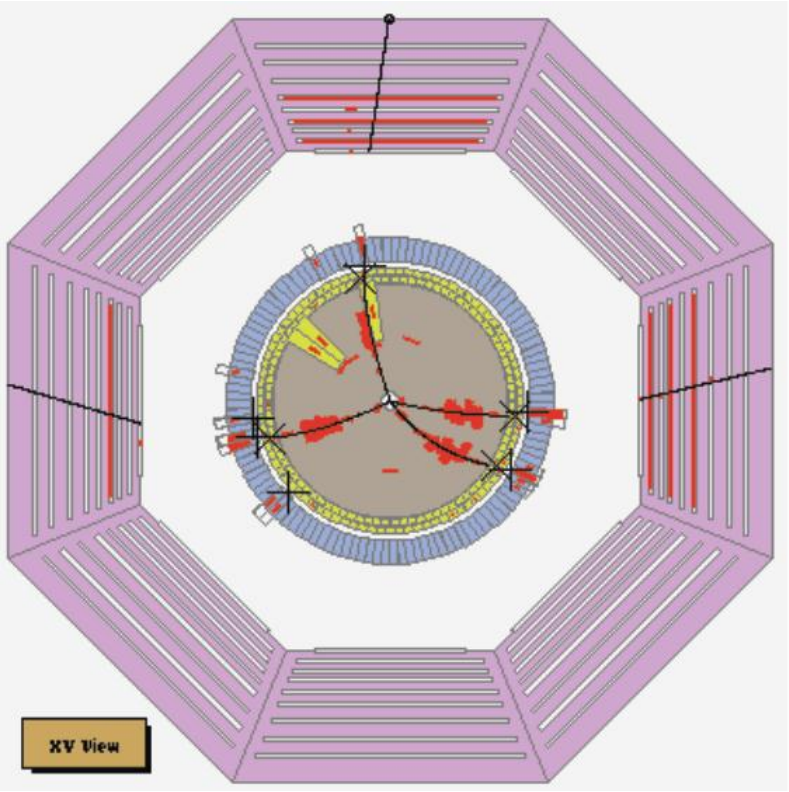
Accuracy: $\delta E_{beam}/E_{beam} \approx 5\times10^{-5}$

➔ $\delta E_{beam} \approx 50$ KeV @ $E_{beam} \approx m_{\tau}$

The BESIII Detector



BESIII's 1st event



BESIII Collaboration

US (6)

Univ. of Hawaii
Univ. of Washington
Carnegie Mellon Univ.
Univ. of Minnesota
Univ. of Rochester
Univ. of Indiana

Europe (12)

Germany: Univ. of Bochum,
Univ. of Giessen, GSI
Univ. of Johannes Gutenberg
Helmholtz Ins. In Mainz
Russia: JINR Dubna; BINP Novosibirsk
Italy: Univ. of Torino, Frascati Lab
Netherland: KVI/Univ. of Groningen
Sweden: Uppsala Univ.
Turkey: Turkey Accelerator Center

Korea (1)

Seoul Nat. Univ.

Japan (1)

Tokyo Univ.

Pakistan (2)

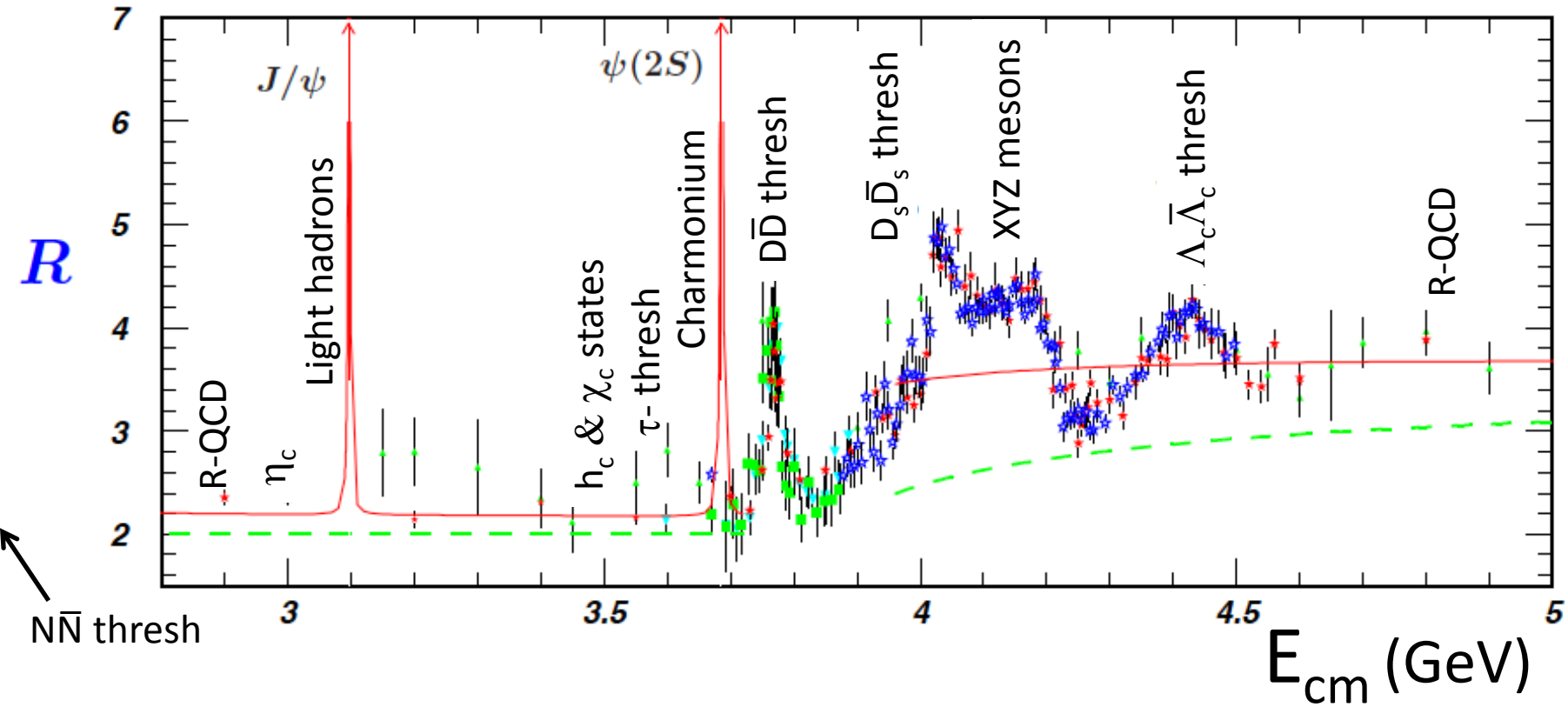
Univ. of Punjab
COMSAT CIIT

China(30)

IHEP, CCAST, GUCAS, 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., Univ. of South China
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 members
52 institutions from 11 countries

e^+e^- annihilations at $2.0 < E_{cm} < 4.6$ GeV



Large and diverse suite of physics topics

Physics program @ BESIII

Light hadron physics

-meson & baryon spectroscopy
-multiquark states
-threshold effects
-glueballs & hybrids
-two-photon physics
-*p* & *n* form-factors

Charmonium physics:

- precision spectroscopy
- transitions and decays

QCD & τ-physics:

- precision *R*-measurement
- τ decays

Charm physics:

- semi-leptonic form factors
- f_D & f_{D_s} decay consts.
- CKM matrix: V_{cd}, V_{cs}
- D^0-D^0 mixing and *CPV*
- strong phases

Precision mass measurements:

- τ mass
– D^0 , D^+ & D_s masses

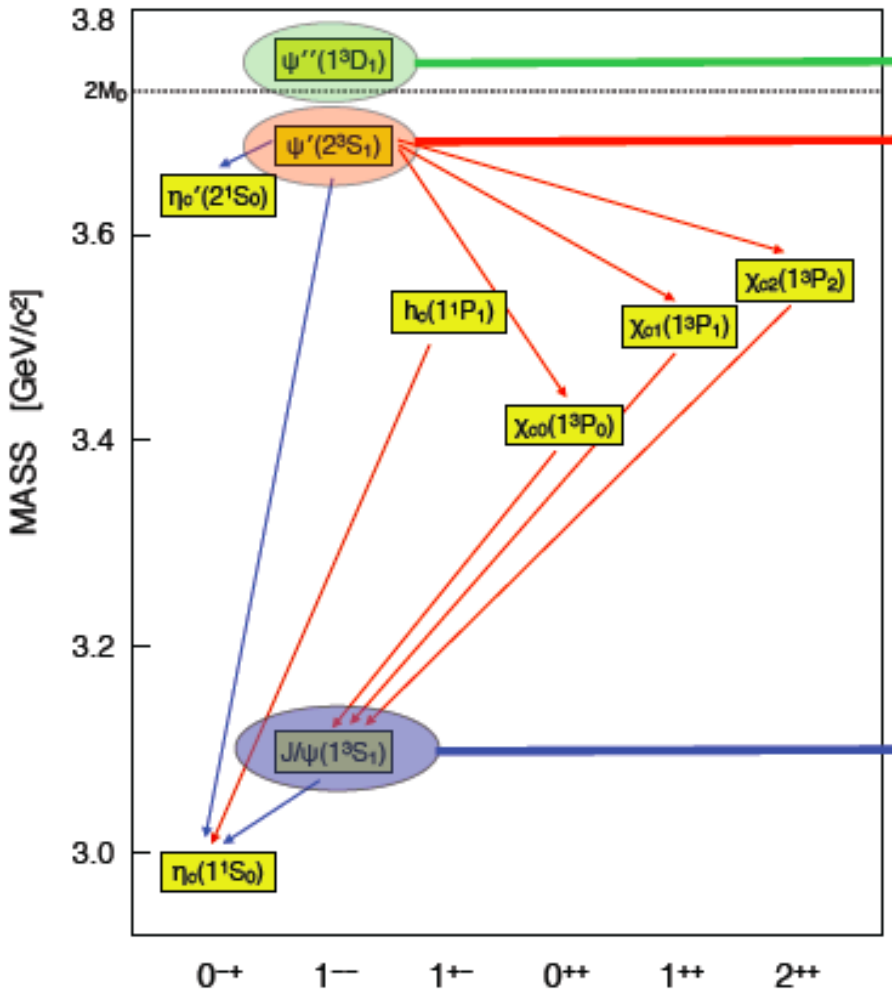
XYZ meson physics:

-$Y(4260) \rightarrow \pi\pi h_c$ & other decays
- searches for new states

…

BESIII data samples

(+data taken at 3.65 GeV and resonance scans)



~2.9 fb^{-1}

~106 million (+more)

NEW

0.5 fb^{-1} @4010 MeV
0.5 fb^{-1} @4260 MeV
0.5 fb^{-1} @4360 MeV (ongoing!)

≈1.2 billion (225M analyzed)

~10-20x previous generation charmonium factories

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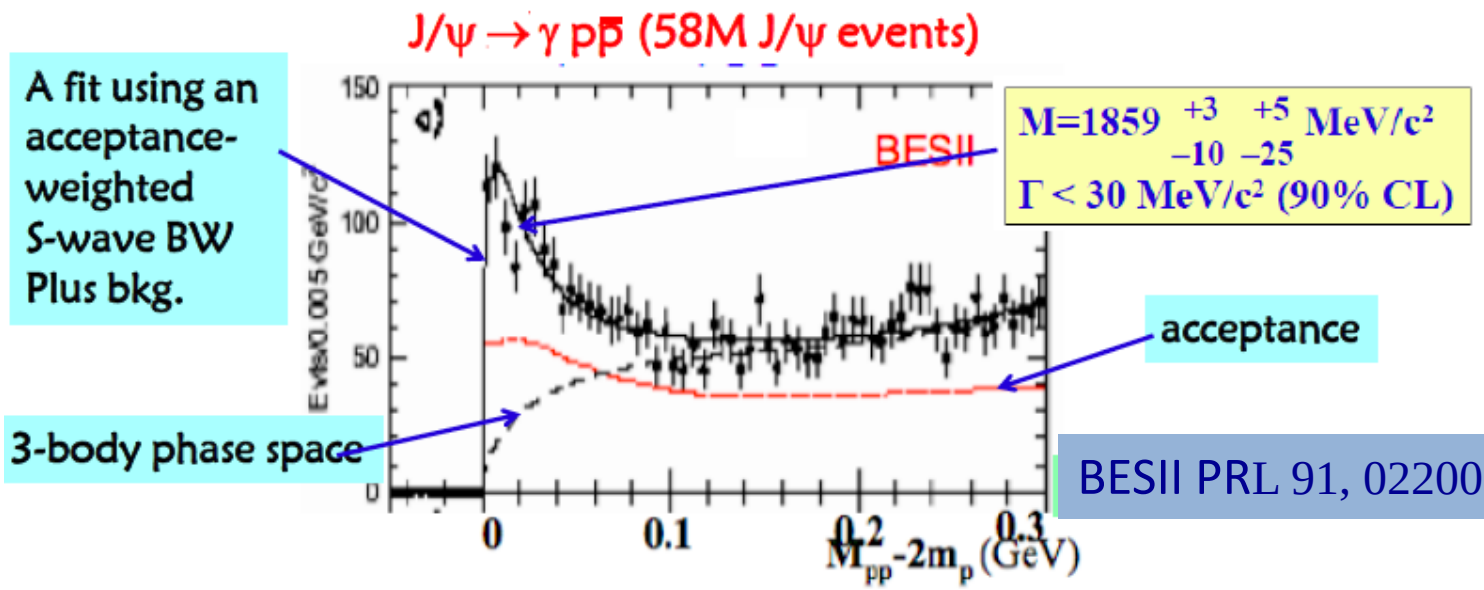
XYZ meson physics:

-$Y(4260) \rightarrow \pi\pi h_c$ decays
- searches for new states
- …,

related to?

Mesons near the $p\bar{p}$ threshold

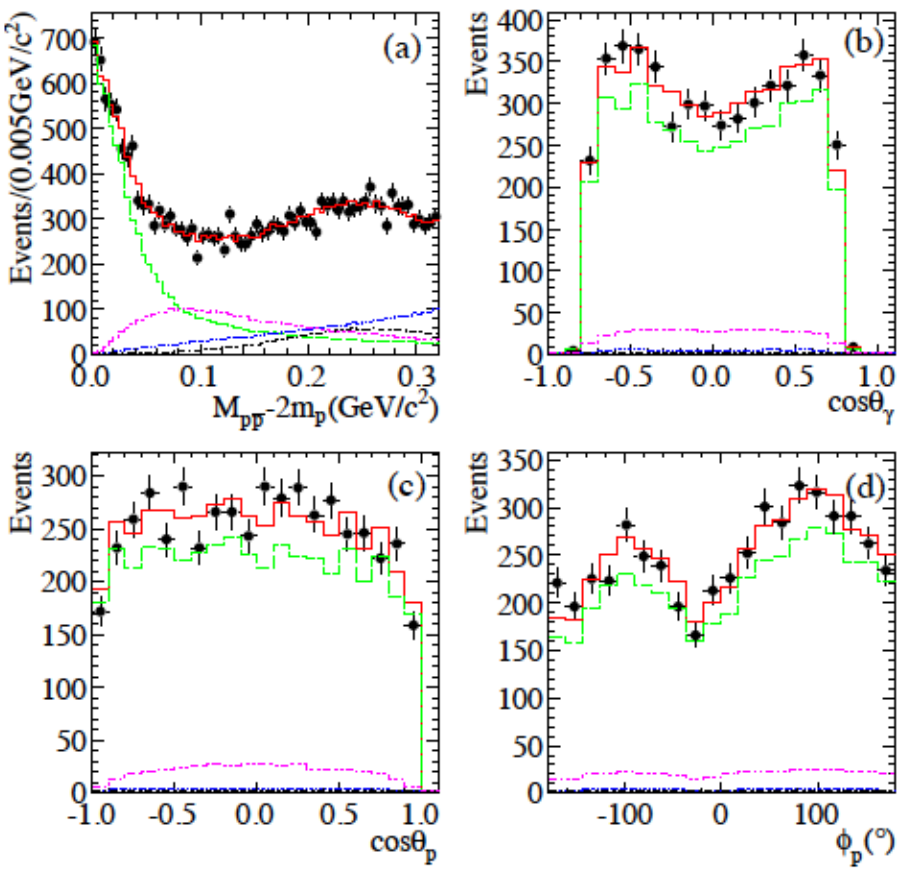
BESII -- 10 years ago --



BESII PRL 91, 022001 (2002)

BESIII, in 2012, with 5x more data

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



BESIII PRL 108, 112003 (2012)

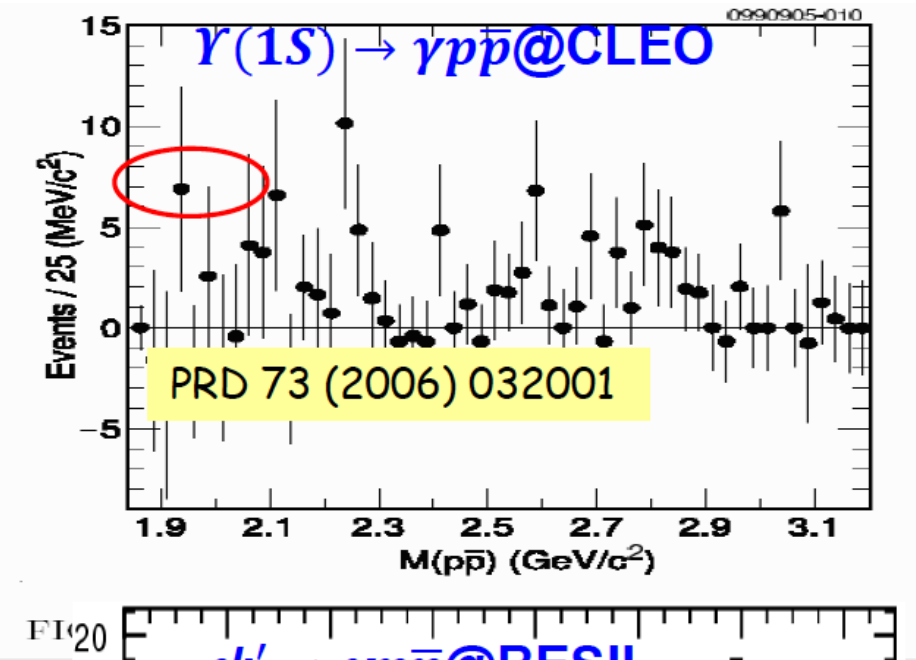
Partial Wave Analysis:

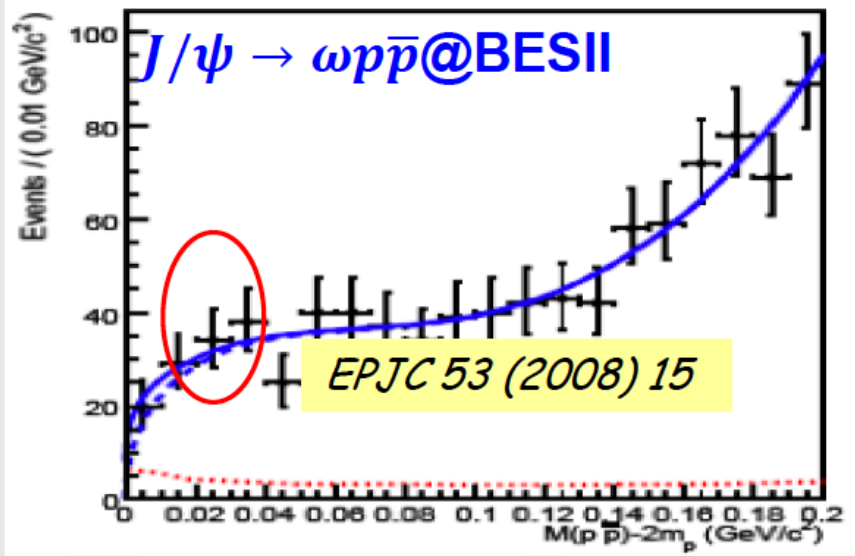
- $J^{PC} = 0^{-+}$ >6.8σ better than other assignments
- I=0 FSI (Juelich) improves the fit quality by ~7σ
- $M = 1832^{+19}_{-5}{}^{+18}_{-33} \pm 19_{model}$ MeV

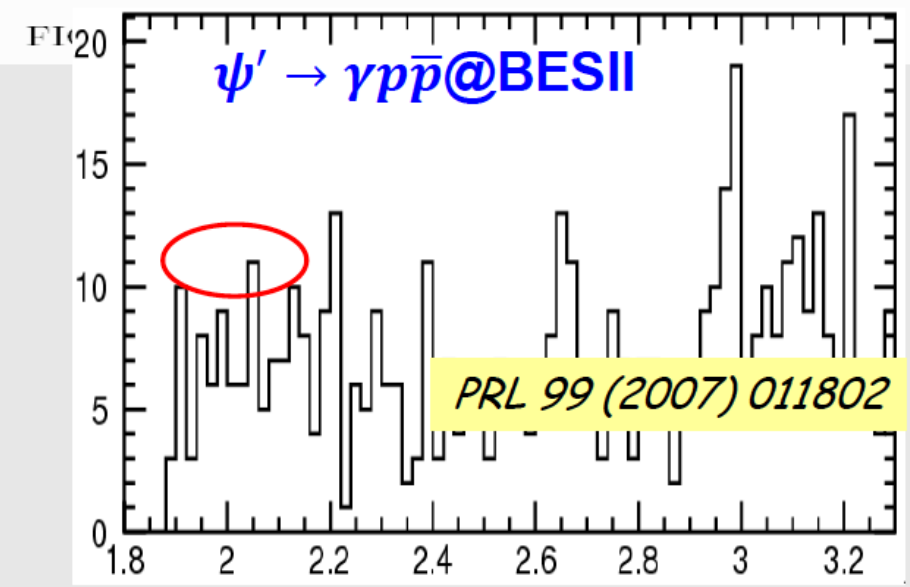
  $\approx 2m_p$-40 MeV
- $\Gamma = 13 \pm 20_{-33}$ MeV; < 76 MeV
- $Bf(J/\psi \rightarrow \gamma X) \times Bf(X \rightarrow pp) = (9.0^{+0.4}_{-1.1}{}^{+1.5}_{-5.0} \pm 2.3_{model}) \times 10^{-5}$

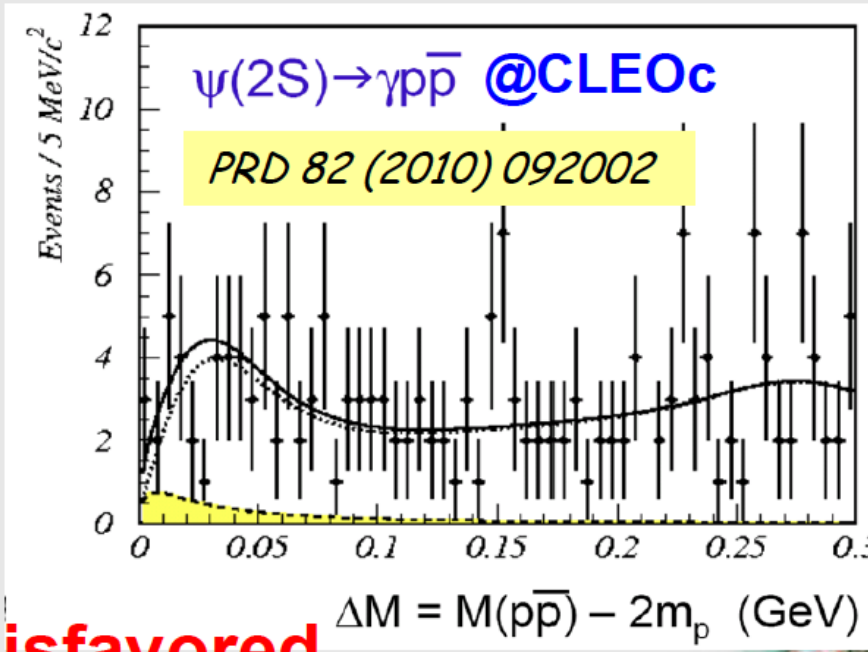
➔suggests $Bf(X \rightarrow pp)$~large

Some non-observations









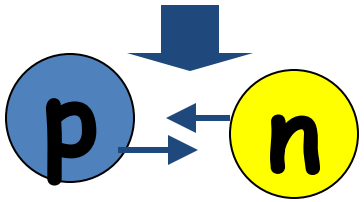
Pure FSI interpretation is disfavored

A $p\bar{p}$ bound state (baryonium)?

There is lots & lots of literature about this possibility

deuteron:

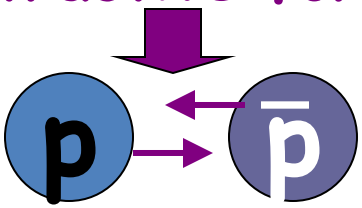
attractive nuclear force



loosely bound
3-q & 3-q color
singlets with
$M_d = 2m_p - \varepsilon$

baryonium:

attractive force?



loosely bound
3-q & 3-$\bar{q}$ color
singlets with
$M_b = 2m_p - \delta$?

An old idea

Fermi & Yang in 1949 (7 years before $\bar{p}$ discovery):

If $N\bar{N}$ potential is attractive, they could bind to form π-like states.

THE

PHYSICAL REVIEW

A journal of experimental and theoretical physics established by E. L. Nichols in 1893

SECOND SERIES, VOL. 76, NO. 12 DECEMBER 15, 1949

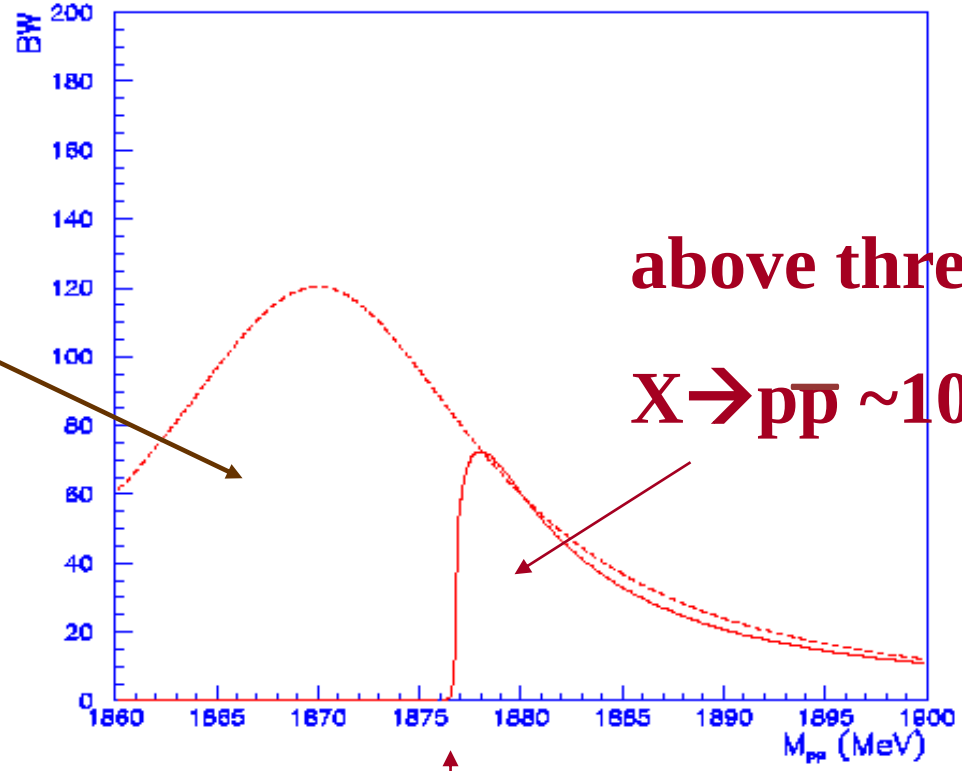
Are Mesons Elementary Particles?

E. FERMI AND C. N. YANG*
Institute for Nuclear Studies, University of Chicago, Chicago, Illinois
(Received August 24, 1949)

The hypothesis that π-mesons may be composite particles formed by the association of a nucleon with an anti-nucleon is discussed. From an extremely crude discussion of the model it appears that such a meson would have in most respects properties similar to those of the meson of the Yukawa theory.

Expectation for $p\bar{p}$ bound state meson

below-threshold:
p and $\bar{p}$
annihilate to
mesons



above threshold:

$X \rightarrow p\bar{p}$ ~100%

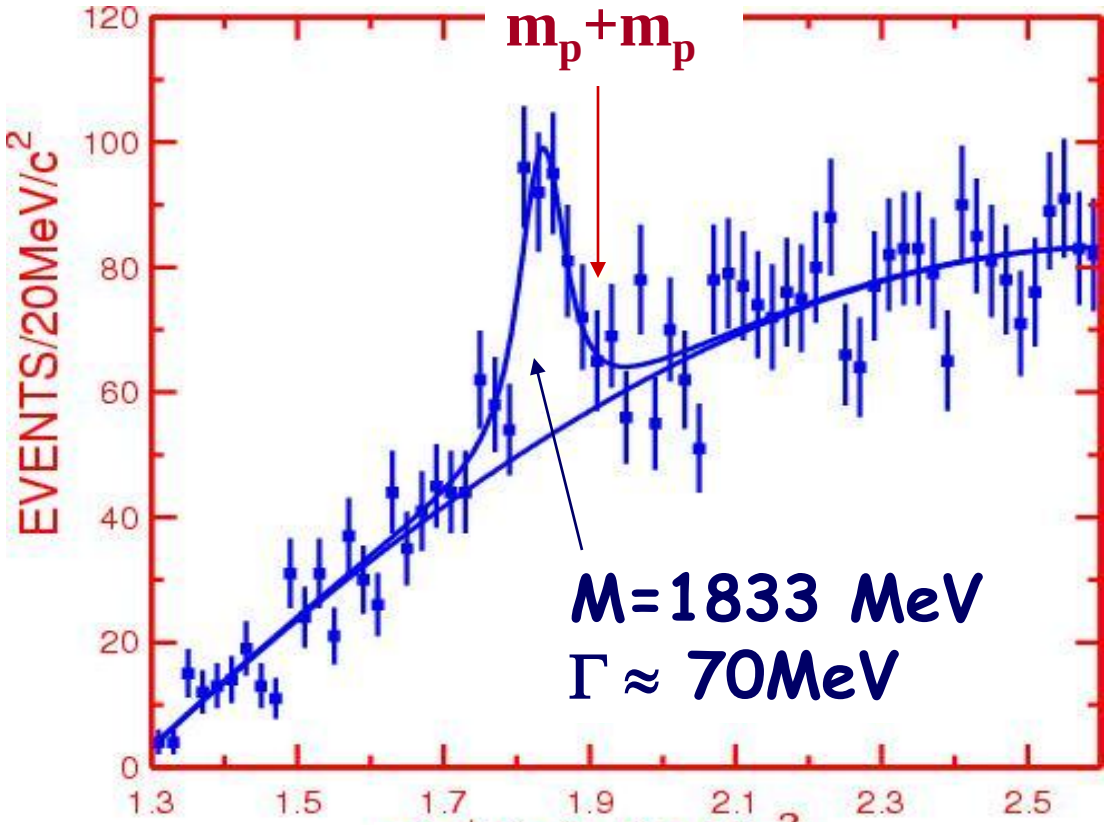
$m_p + m_p$

I=0, $J^{PC}=0^{-+}$ init. state:
$p\bar{p} \rightarrow \pi^+\pi^-\eta'$ is common

Phys. Rev. C **72**, 015208 (2005) G.J. Ding and M.L.Yan
Comm. Theor. Phys. 42, 844 (2004) C.S. Gao and S.L. Zhu

$J/\psi \rightarrow \gamma X(1835) \rightarrow \gamma(\pi^+\pi^-\eta')$

BESII -- 8 years ago --



$M(\pi^+\pi^-\eta')$

BESII PRL 95, 262001 (2005)

X(1835) confirmed at BESIII

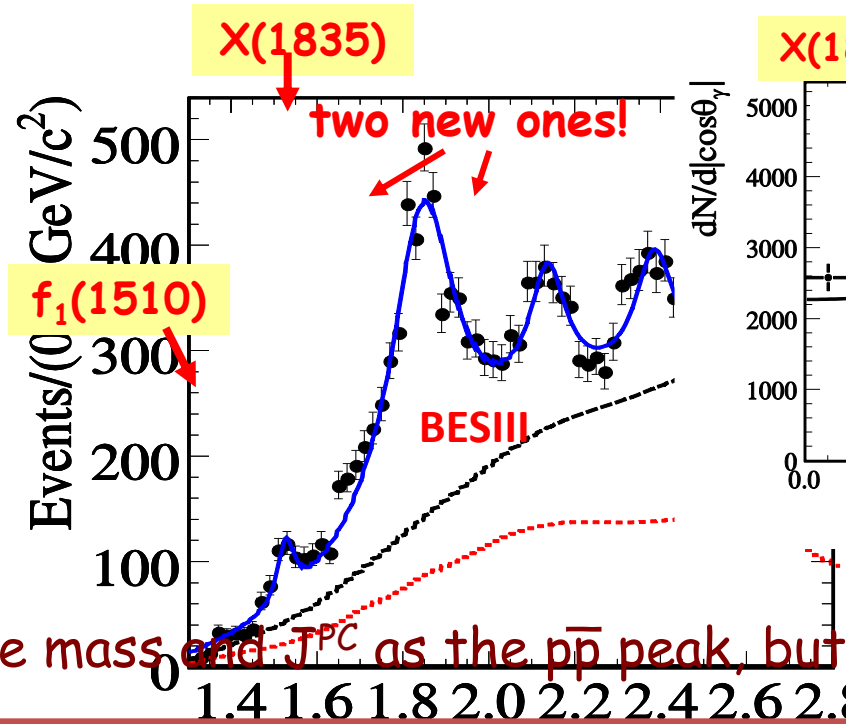
(+ two new structures with M>2GeV)

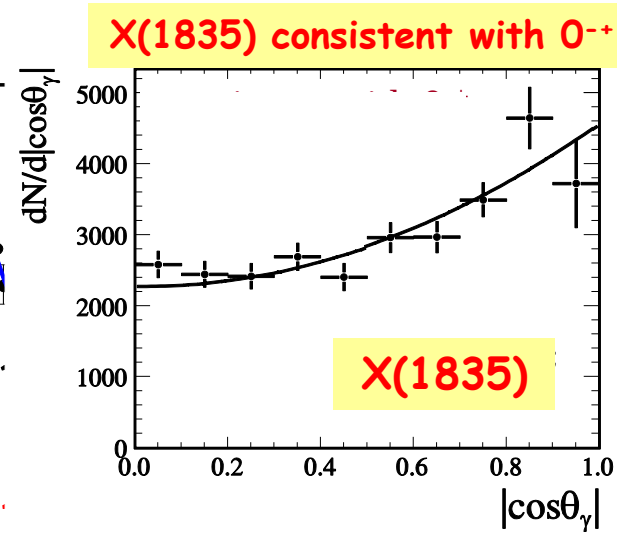
$J/\psi \to \gamma\eta'\pi^+\pi^-$

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

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

PRL 106, 072002 (2011)





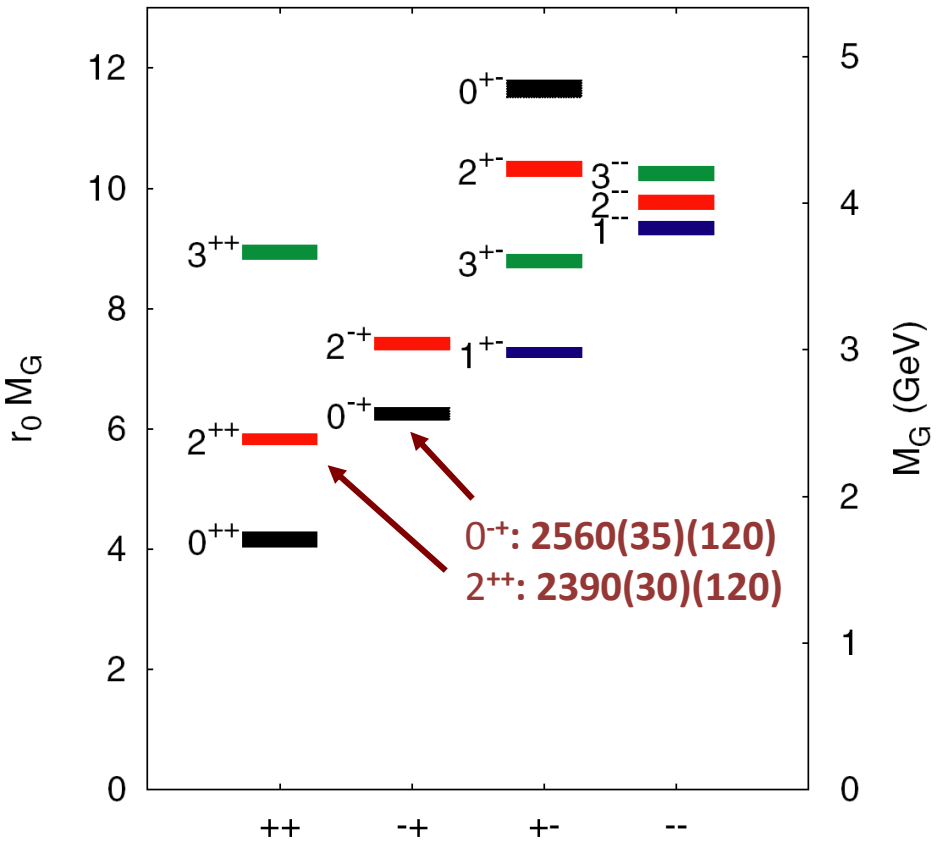
X(1835): same mass and J^{PC} as the $p\bar{p}$ peak, but larger width

Resonance	M(MeV/c²)	Γ(MeV/c²)	Stat.Sig.
X(1835)	$1836.5 \pm 3.0^{+5.6}_{-2.1}$	$190.1 \pm 9.0^{+38}_{-36}$	>20σ
X(2120)	$2122.4 \pm 6.7^{+4.7}_{-2.7}$	$83 \pm 16^{+31}_{-11}$ narrow!!	7.2σ
X(2370)	$2376.3 \pm 8.7^{+3.2}_{-4.3}$	$83 \pm 17^{+44}_{-6}$	6.4σ

What are these 2 new structures?

way above threshold, but narrow (Γ<100 MeV)

PRD73,014516(2006) Y.Chen et al



- ✓ first distinct resonant structures observed above 2 GeV:

  -LQCD predicts that the lowest –lying pseudoscalar glueball: around 2.3 GeV

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

- ✓ X(2120)/X(2370) possibilities:
  - -pseudoscalar & tensor glueballs?
  - -η/η' excited states?

- ✓ Need spin-parity analyses

PRD82,074026,2010 J.F. Liu, G.J. Ding and M.L.Yan
PRD83:114007,2011 (J.S. Yu, Z.-F. Sun, X. Liu, Q. Zhao)

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XYZ meson physics:

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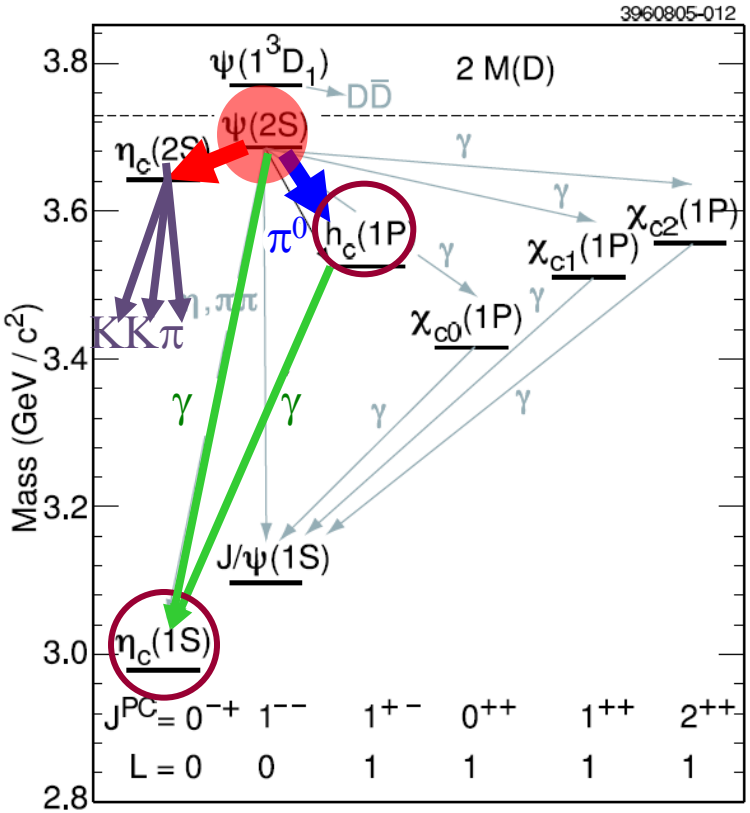
- …,

Precision charmonium

- mass of the η_c ← charmonium ground state
- properties of the h_c ← most recently discovered charmonium state
- M1 transition $\psi' \rightarrow \gamma \eta_c'$ ← first observation



$\eta_c(1S)$

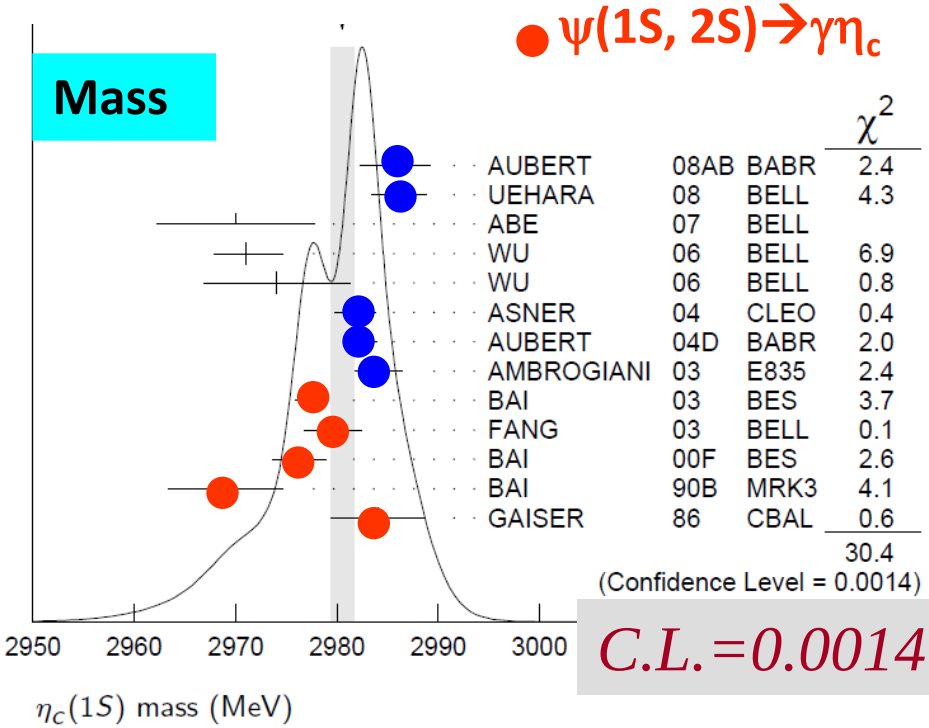
- The S-wave spin-singlet charmonium ground state, found in 1980
- M & Γ measurements:

-J/ψ radiative transitions: M ~ 2978.0 MeV, Γ ~ 10 MeV

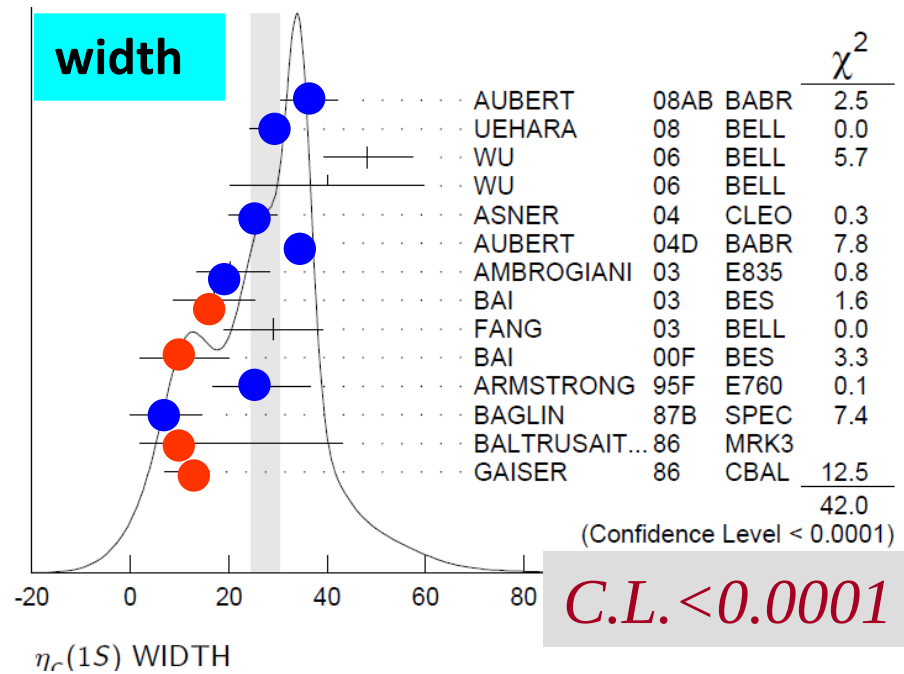
-γγ processes / B→Kη_c: M = 2983.1±1.0 MeV/, Γ = 31.3±1.9 MeV

● γγ, $p\bar{p}$, B decay

● ψ(1S, 2S)→γη_c



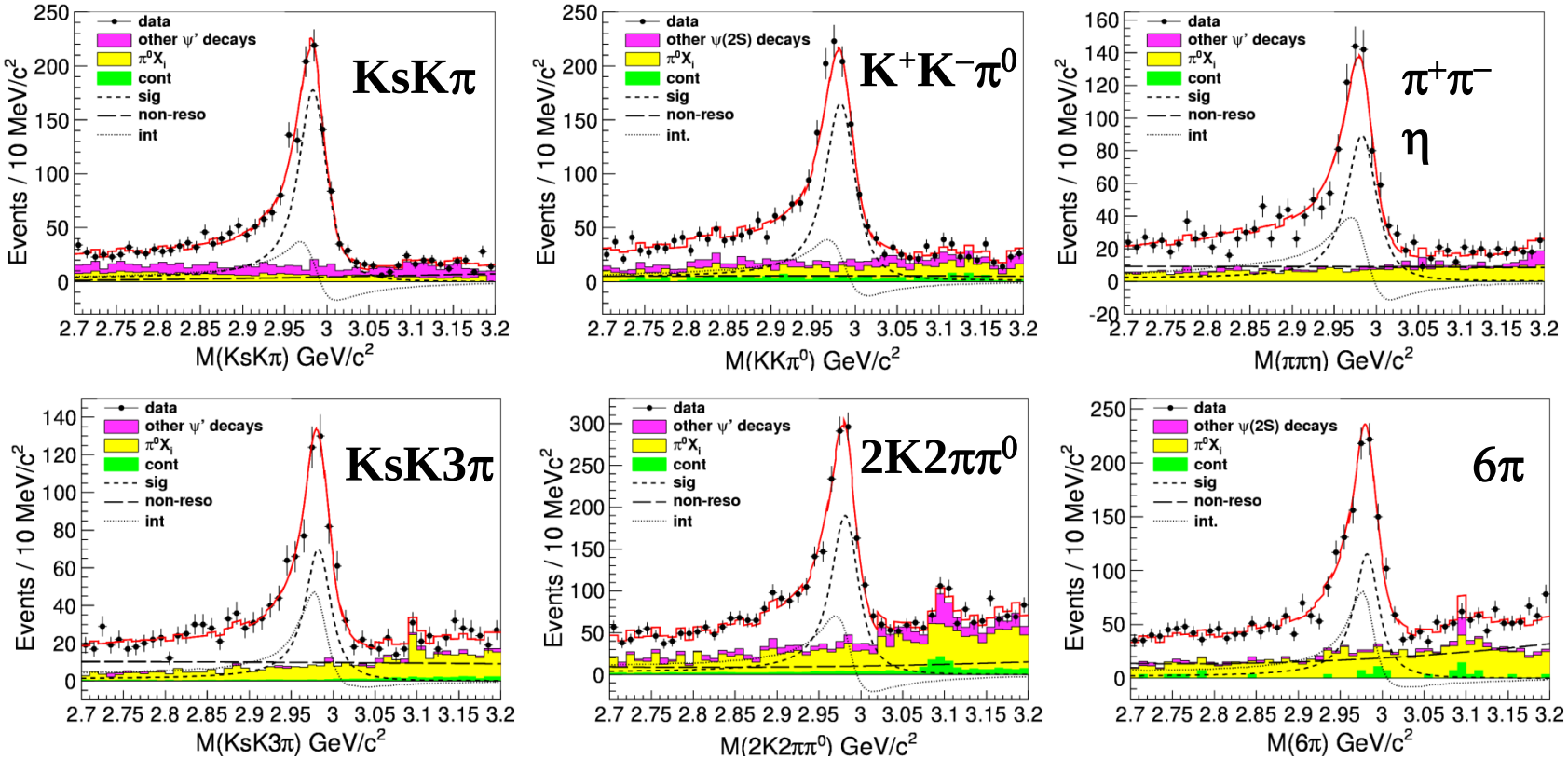
C.L.=0.0014



C.L.<0.0001

$\psi' \rightarrow \gamma\eta_c$, $\eta_c \rightarrow$ *exclusive* decays

interference with non-resonant background is significant!!



Relative phase ϕ values from each mode are consistent within 3σ,

➔ use a common phase value in the simultaneous fit.

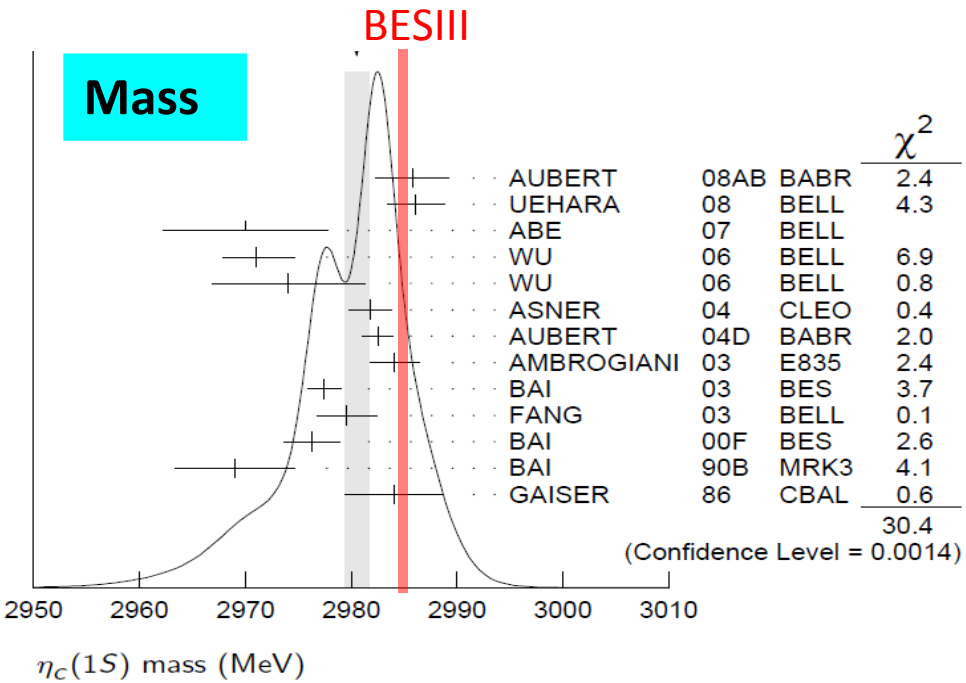
M: **2984.4 ± 0.5 ± 0.6** MeV

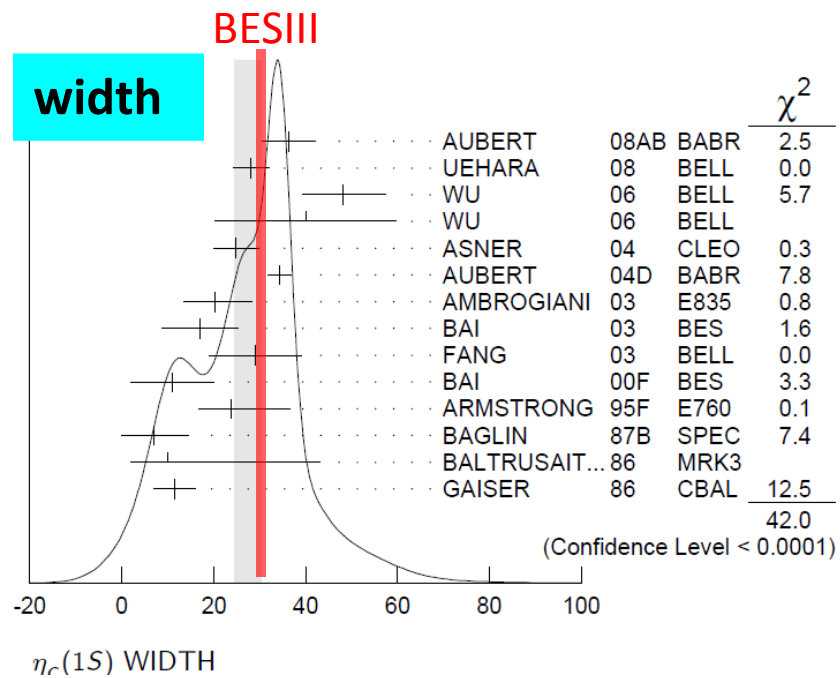
Γ: **30.5 ± 1.0 ± 0.9** MeV

$\measuredangle$: **2.35 ± 0.05 ± 0.04** rad

BESIII PRL 108, 222002 (2012)

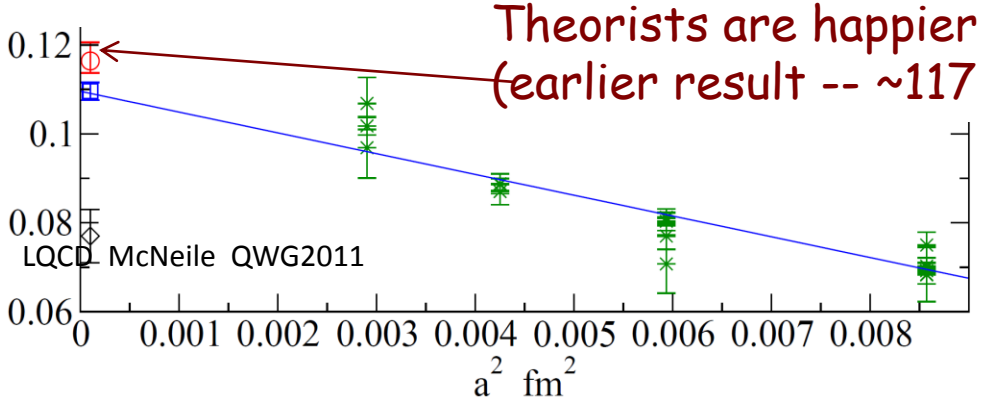
Comparison with previous η_c results





Hyperfine splitting (BESIII alone): $\Delta M(1S)$ = **112.5 ± 0.8** MeV

Theorists are happier with this value
(earlier result -- ~117 MeV -- was too large for them)



$h_c(^1P_1)$

- Spin singlet *P* wave (S=0, L=1)
- Potential model: if non-zero *P*-wave spin-spin interaction,

  $\Delta M_{hf}(1P) = M(h_c) - \langle m(1\ ^3P_J)\rangle \neq 0$

  where $\langle m(1\ ^3P_J)\rangle = [(M(\chi_{c0})+3M(\chi_{c1})+5M(\chi_{c2})]/9$,
- CLEOc 1st observed h_c in $ee \rightarrow \psi' \rightarrow \pi^0 h_c$, $h_c \rightarrow \gamma\eta_c$

  $\Delta M_{hf}(1P)=0.08\pm0.18\pm0.12$ MeV/c^2

  Consistent with 1P hyperfine splitting = 0.

<u>Theoretical prediction:</u>

$BF(\psi(2S) \rightarrow \pi^0 h_c) = (0.4\text{-}1.3)\times10^{-4}$

$BF(h_c \rightarrow \gamma\eta_c)$ =48% (NRQCD)

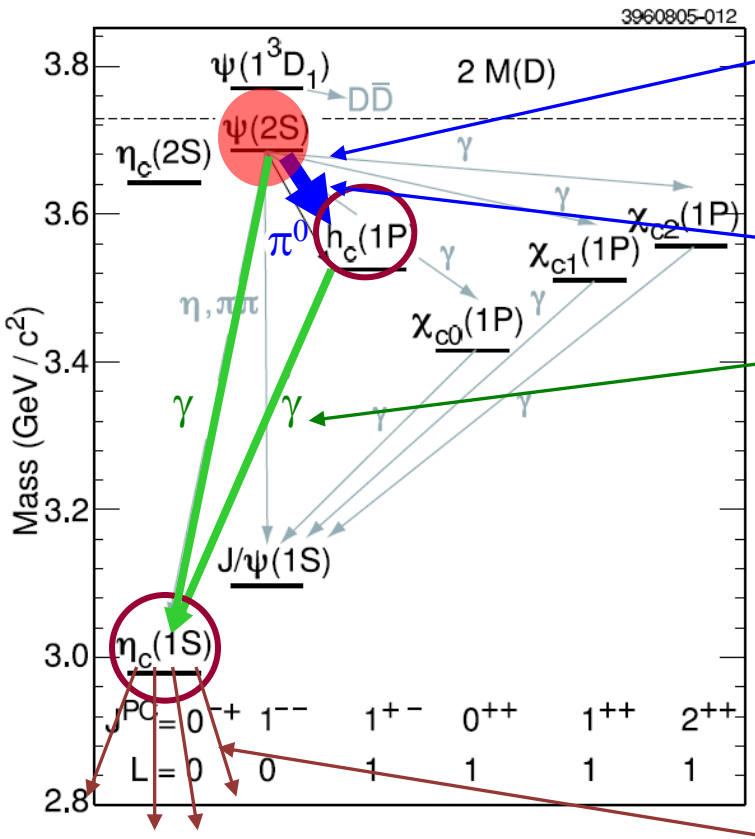
$BF(h_c \rightarrow \gamma\eta_c)$ =88% (PQCD)

Kuang, PR D65 094024 (2002)

$BF(h_c \rightarrow \gamma\eta_c)$ =38%

Godfrey and Rosner, PR D66 014012(2002)

methods for studying the h_c



hadrons

only detect the π^0 → "inclusive"
(compute M_{h_c} from kinematics)

$$Rate \propto Bf(\psi' \to \pi^0 h_c)$$

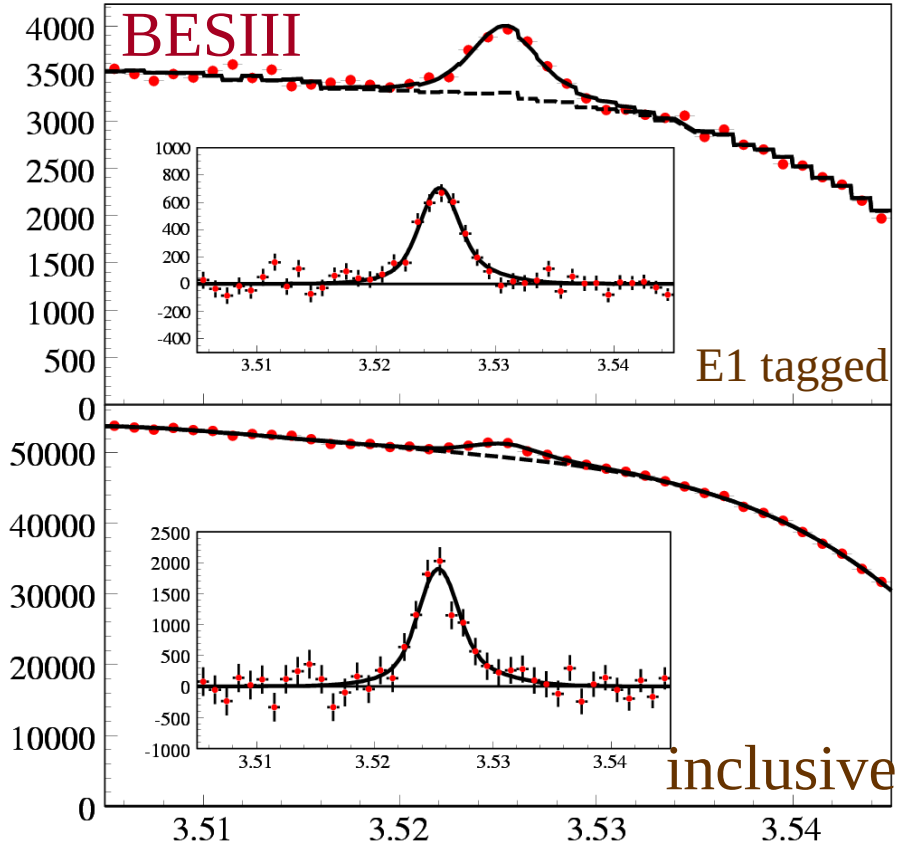
detect the π^0 & γ → "E_1-tagged"
(compute M_{h_c} from kinematics)

$$Rate \propto Bf(\psi' \to \pi^0 h_c) \times Bf(h_c \to \gamma \eta_c)$$

detect the π^0 , γ & *all* η_c → X_i decay products → "exclusive"
(compute M_{h_c} from 4-C kinematic fit)

$$Rate \propto Bf(\psi' \to \pi^0 h_c) \times Bf(h_c \to \gamma \eta_c) \times Bf(\eta_c \to X_i)$$

$\psi' \to \pi^0 h_c$, $h_c \to \gamma \eta_c$



BESIII: PRL 104 132002 (2010)

Mass = **3525.40±0.13±0.18** MeV/c^2

Width = **0.73±0.45±0.28** MeV

<1.44 MeV @90%

CLEOc: PRL 101 182003 (2008)

Mass = **3525.28±0.19±0.12** MeV

Width: fixed at 0.9 MeV

Hyperfine mass splitting

$\Delta M_{hf}(1^1P) = M(h_c) - \langle m(1^3P_J) \rangle$

BESIII: ***0.10±0.13±0.18*** MeV/c^2

CLEOc: ***0.02±0.19±0.13*** **MeV/c^2**

<u>By combining inclusive results with E1-photon tagged results</u>

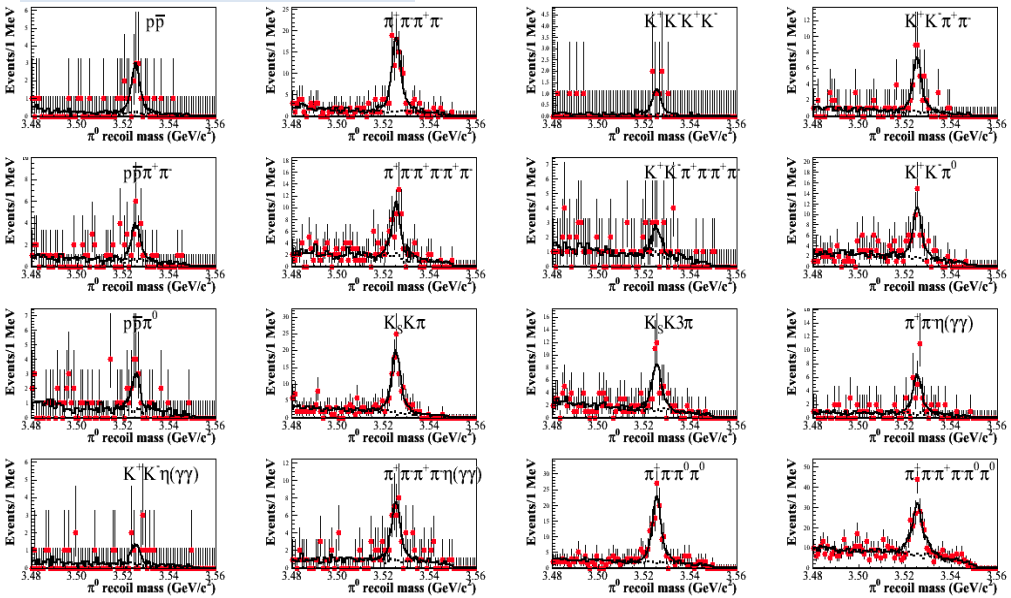
BF($\psi' \to \pi^0 h_c$) = **(8.4±1.3±1.0) ×10^{-4}**

BF($h_c \to \gamma \eta_c$) = **(54.3±6.7±5.2)%**

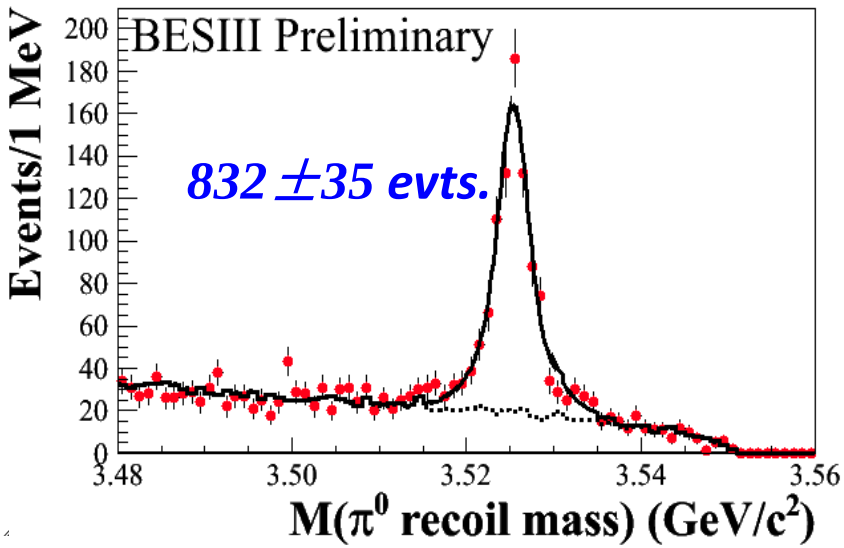
<u>Agrees with prediction</u> from Kuang, Godfrey, Dude et al.

$\psi' \rightarrow \pi^0 h_c$, $h_c \rightarrow \gamma \eta_c$, η_c *exclusive* decays

BESIII Preliminary



Summed distribution



16 different η_c decay channels

Simultaneous fit to π^0 recoiling mass

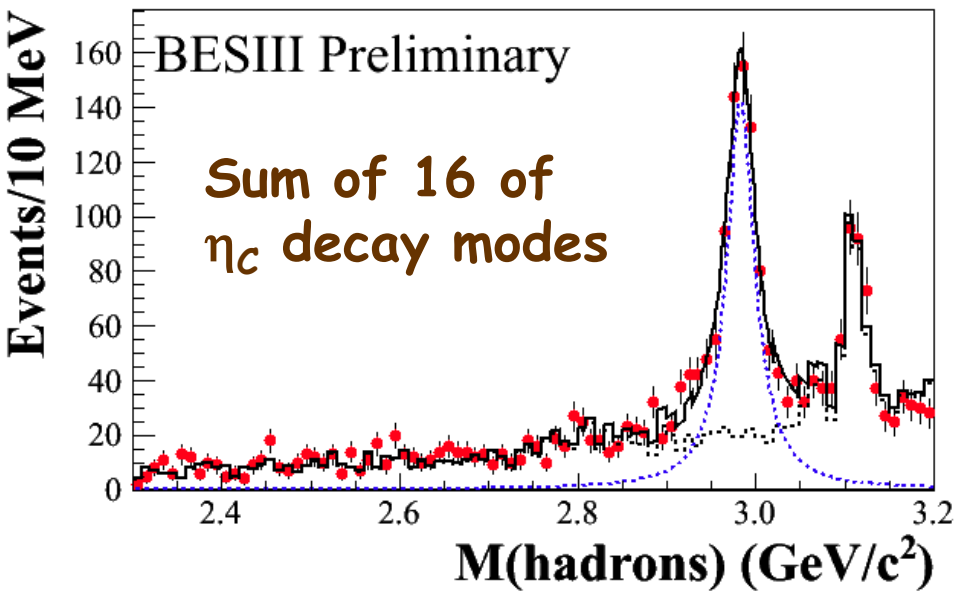
χ^2/d.o.f. = 32/46

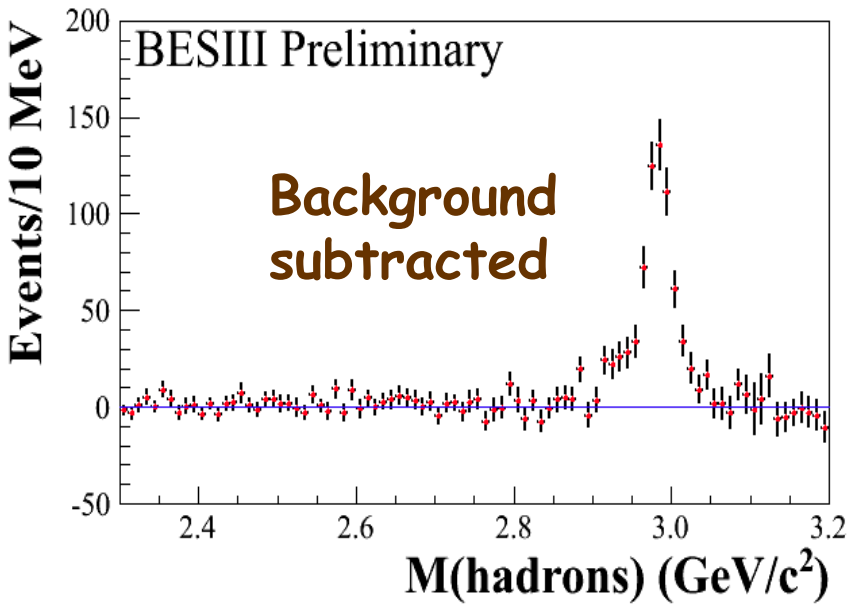
Mass = **3525.31 ± 0.11 ± 0.15** MeV/c^2

Width = **0.70 ± 0.28 ± 0.25** MeV

} consistent with BESIII E_1-tagged results

η_c lineshape from $\psi' \rightarrow \pi^0 h_c$, $h_c \rightarrow \gamma \eta_c$





The η_c lineshape in $h_c \rightarrow \gamma \eta_c$ is not as distorted as in $\psi' \rightarrow \gamma \eta_c$ decays; the non-resonant interfering bkg is small (non-existent?). Ultimately, this channel will be best suited to determine η_c resonance parameters.

yesterday's search → today's discovery → tomorrow's calibration

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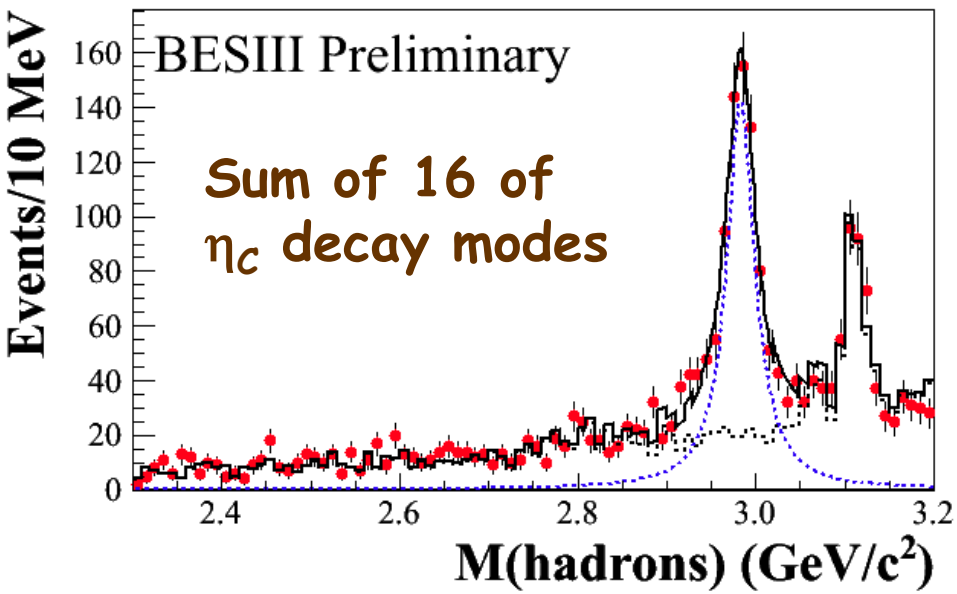

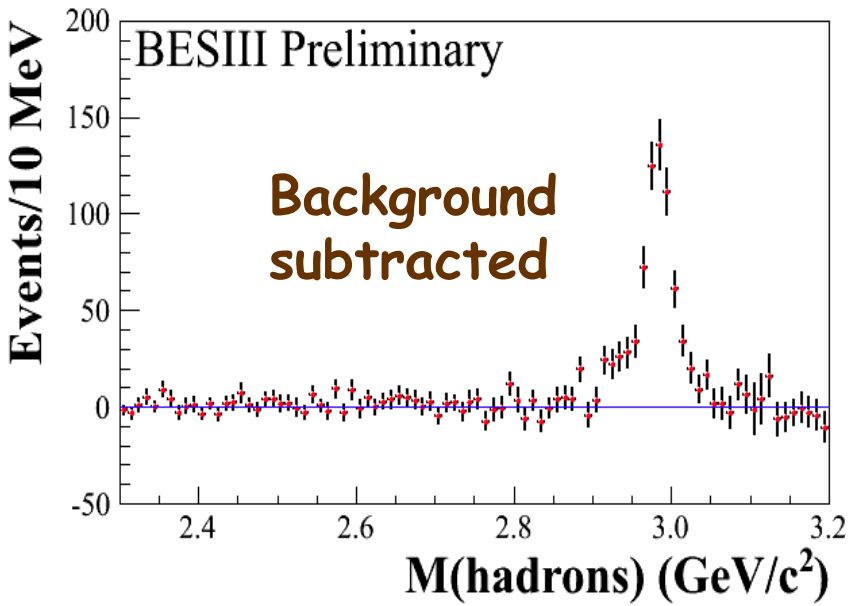

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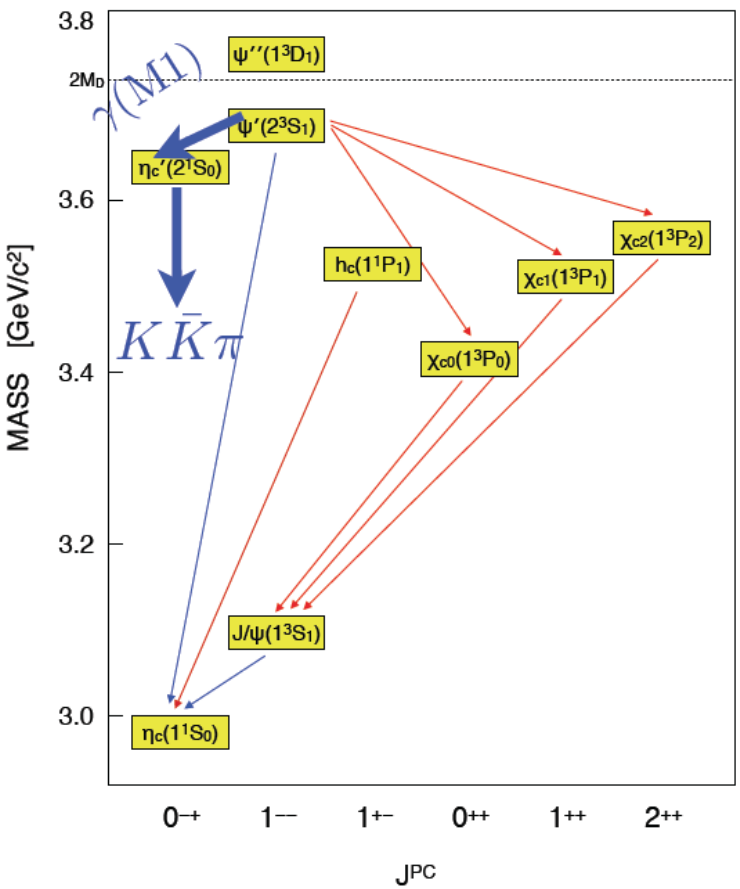
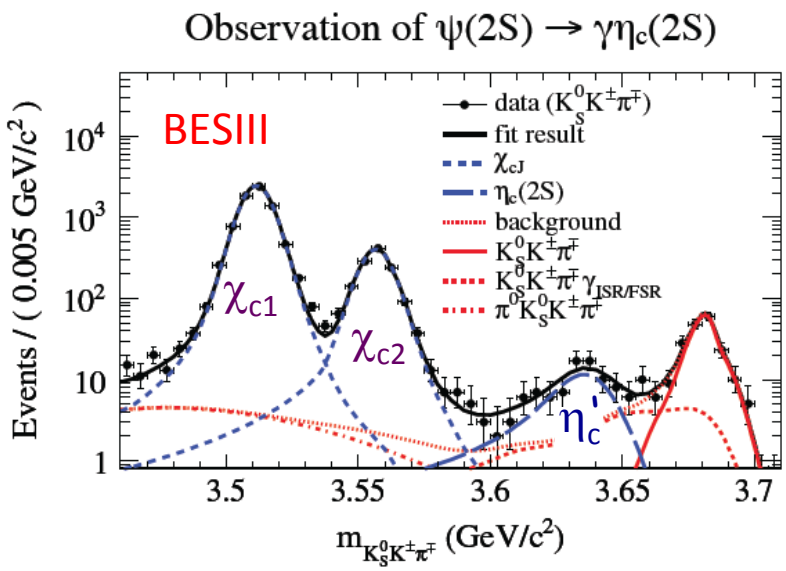
yesterday's search → today's discovery → tomorrow's calibration

$\psi' \rightarrow \gamma \eta_c'$

1st observation

PRL 109, 042003 (2012)





$M = 3637.6 \pm 2.9 \pm 1.6$ MeV

$\Gamma = 16.9 \pm 6.4 \pm 4.8$ MeV

$\mathbf{B(\psi(2S) \rightarrow \gamma\eta_c(2S)) = (6.8 \pm 1.1 \pm 4.5) \times 10^{-4}}$

Physics program @ BESIII

Light hadron physics

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-multiquark states
-threshold effects
-glueballs & hybrids
-two-photon physics
-*p* & *n* form-factors

Charmonium physics:

- precision spectroscopy
- transitions and decays

QCD & τ-physics:

- precision *R*-measurement
- τ decays

Charm physics:

- semi-leptonic form factors
- f_D & f_{D_s} decay consts.
- CKM matrix: V_{cd}, V_{cs}
- D^0-D^0 mixing and *CPV*
- strong phases

Precision mass measurements:

- τ mass
– D^0 , D^+ & D_s masses

XYZ meson physics:

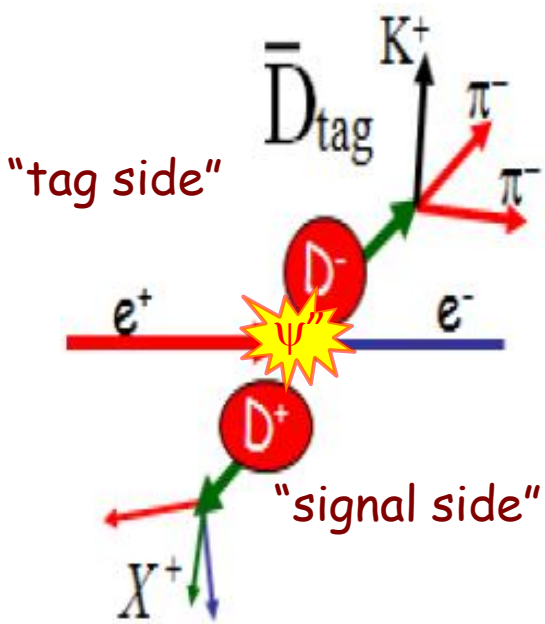
-$Y(4260) \rightarrow \pi\pi h_c$ decays
- searches for new states
- …,

Charmed meson physics at BESIII

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

currently @ ψ'':	$\int Lum\, dt = 2.9\, fb^{-1}$
ultimate goal :	$\approx 20\, fb^{-1}$

Tag a D meson by reconstructing the accompanying $\bar{D}$
---and vice versa--



In the CM:

$$E_D^* = E_{\bar{D}}^* = \tfrac{1}{2} E_{\rm cm} \Rightarrow$$

cm energy difference: $\longrightarrow \Delta E \equiv E^* - \tfrac{1}{2} E_{\rm cm} = 0$

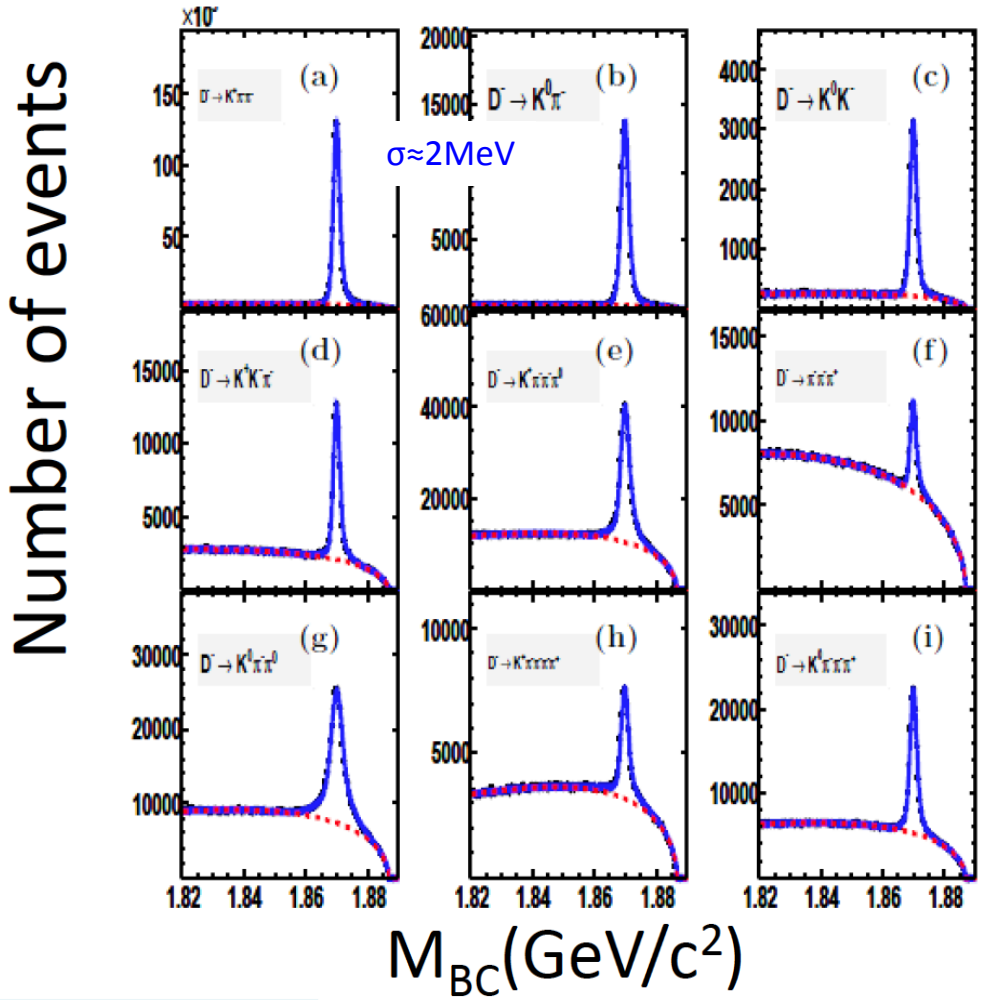
beam-energy constr. mass $\longrightarrow M_{\rm bc} = \sqrt{(\tfrac{1}{2} E_{\rm cm})^2 - (\Sigma \vec{p}_i)^2}$

produce a "beam" of D mesons

D^- tag side

Nine *D* tag modes:

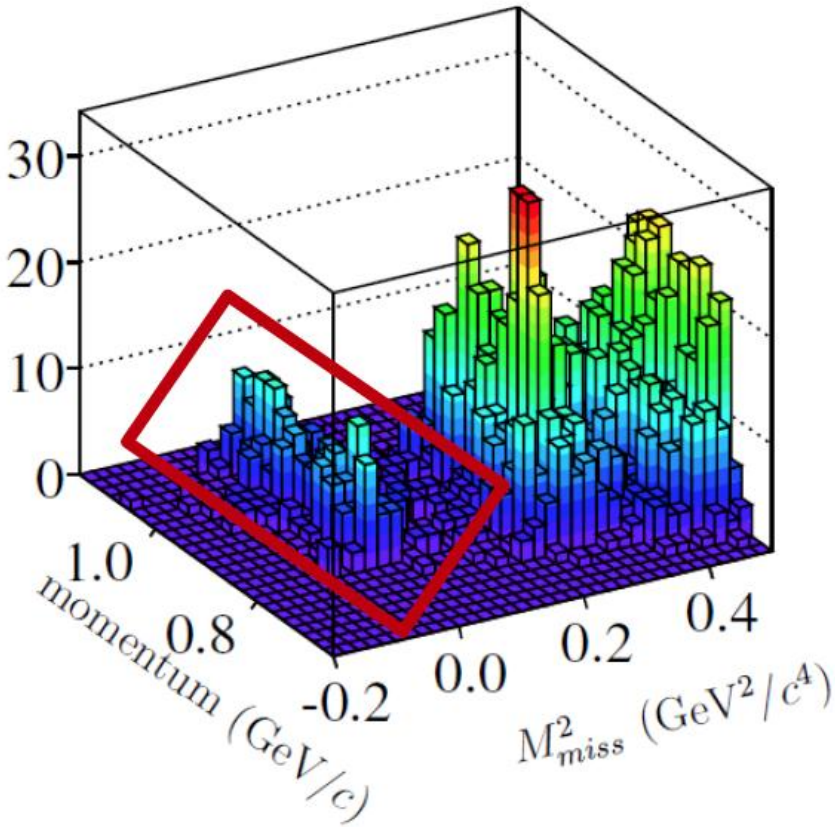
$K^+\pi^-\pi^-$
$K_S^0\pi^-$
$K_S^0K^-$
$K^+K^-\pi^-$
$K^+\pi^-\pi^-\pi^0$
$\pi^+\pi^-\pi^-$
$K_S^0\pi^-\pi^0$
$K^+\pi^-\pi^-\pi^-\pi^+$
$K_S^0\pi^-\pi^-\pi^+$

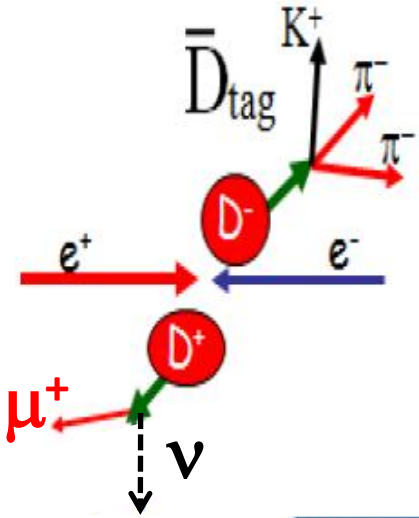


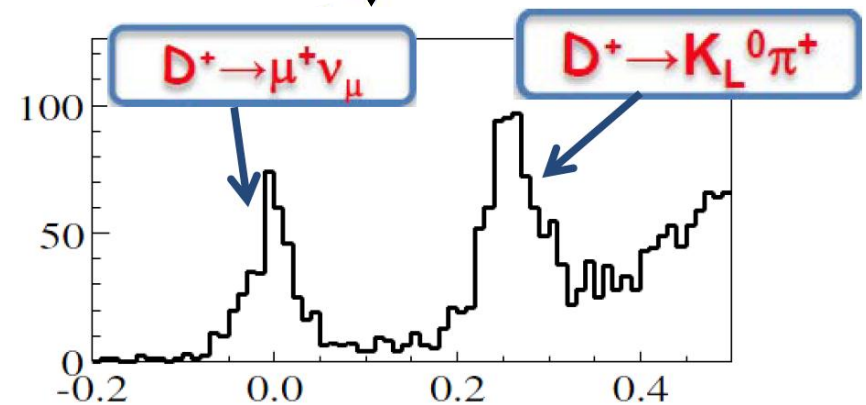
$$N_{D^-}^{tag} = (1.566 \pm 0.002) \times 10^6 \text{ in } 2.9 \text{ fb}^{-1}$$

$D^+ \rightarrow \mu^+\nu$ signal side

- only one charged track
- positively identified as a μ^+
- no isolated photons

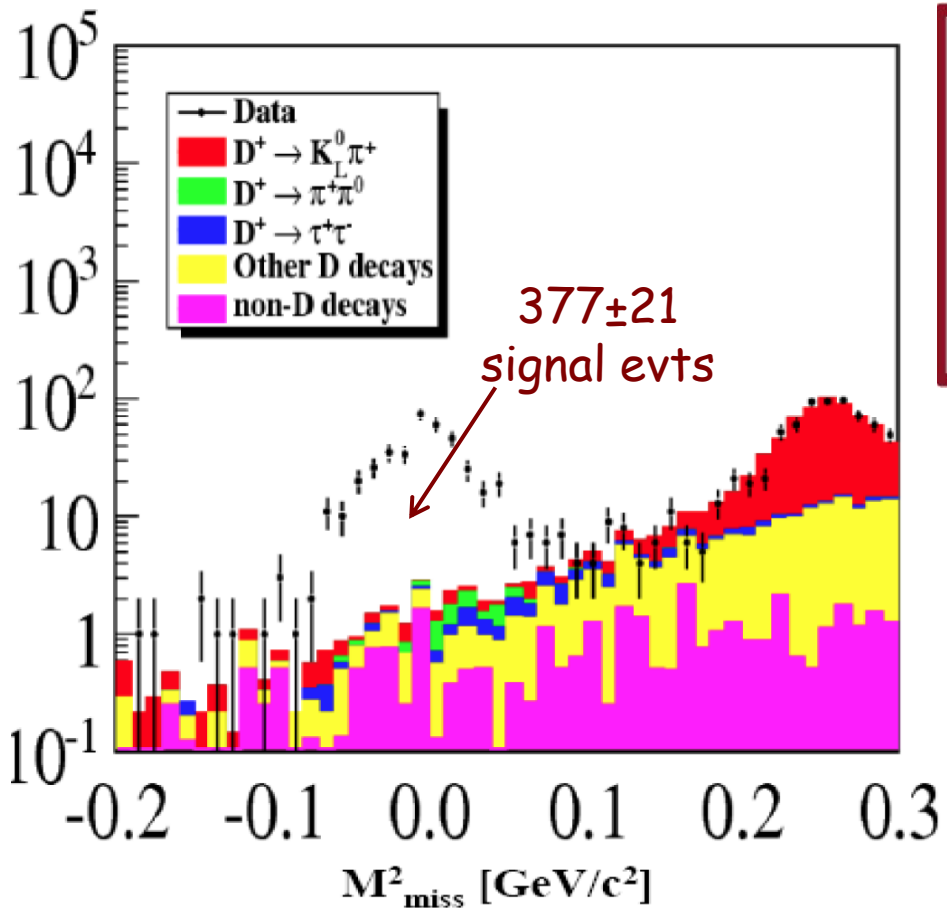






$$M^2_{\text{miss}} = (\tfrac{1}{2}E_{\text{cm}} - E_\mu)^2 - (-\vec{p}_{\text{tag}} - \vec{p}_\mu)^2$$

$D^+ \rightarrow \mu^+\nu$ backgrounds



Event type	Number
$N(D^+ \to \mu^+\nu_\mu)^{\text{candidate}}$	425
N_b *(from MC)*	$47.7 \pm 2.3 \pm 1.3$
$N(D^+ \to \mu^+\nu_\mu)$	$377.3 \pm 20.6 \pm 2.6$

Background determined from data:

N_b = 48.9 ± 4.8 evts

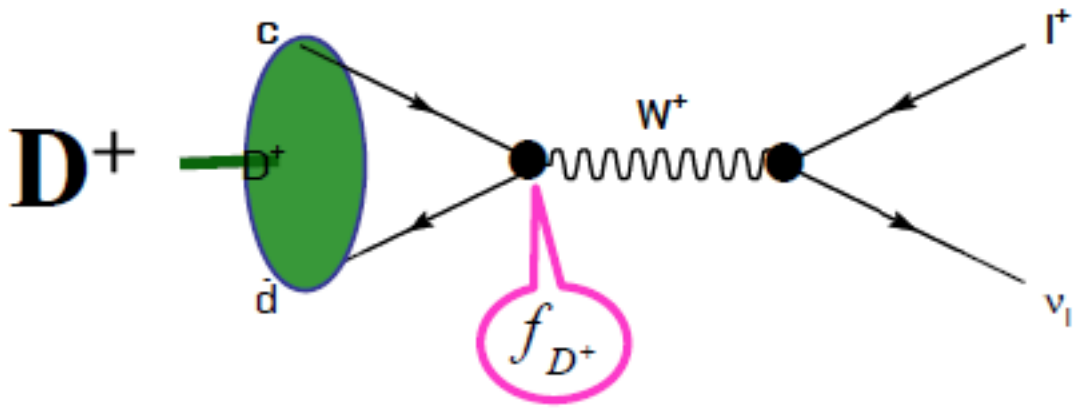
$$Bf(D^+ \to \mu^+\upsilon) = \frac{N_{D^+\to\mu^+\upsilon}}{N_{D^-_{tag}}\,\varepsilon_{D^+\to\mu^+\upsilon}}$$

$$= (3.74 \pm 0.21 \pm 0.06) \times 10^{-4}$$

Preliminary

CLEOc : $(3.82 \pm 0.32 \pm 0.09) \times 10^{-2}$

f_D determination



$$\Gamma_{SM}(D^+_{(s)} \to l^+\nu) = \frac{G_F^2}{8\pi} m_l^2 m_{D_{(s)}} \left(1 - \frac{m_l^2}{m_{D_{(s)}}^2}\right)^2 |V_{cd(s)}|^2 f_{D^+_{(s)}}$$

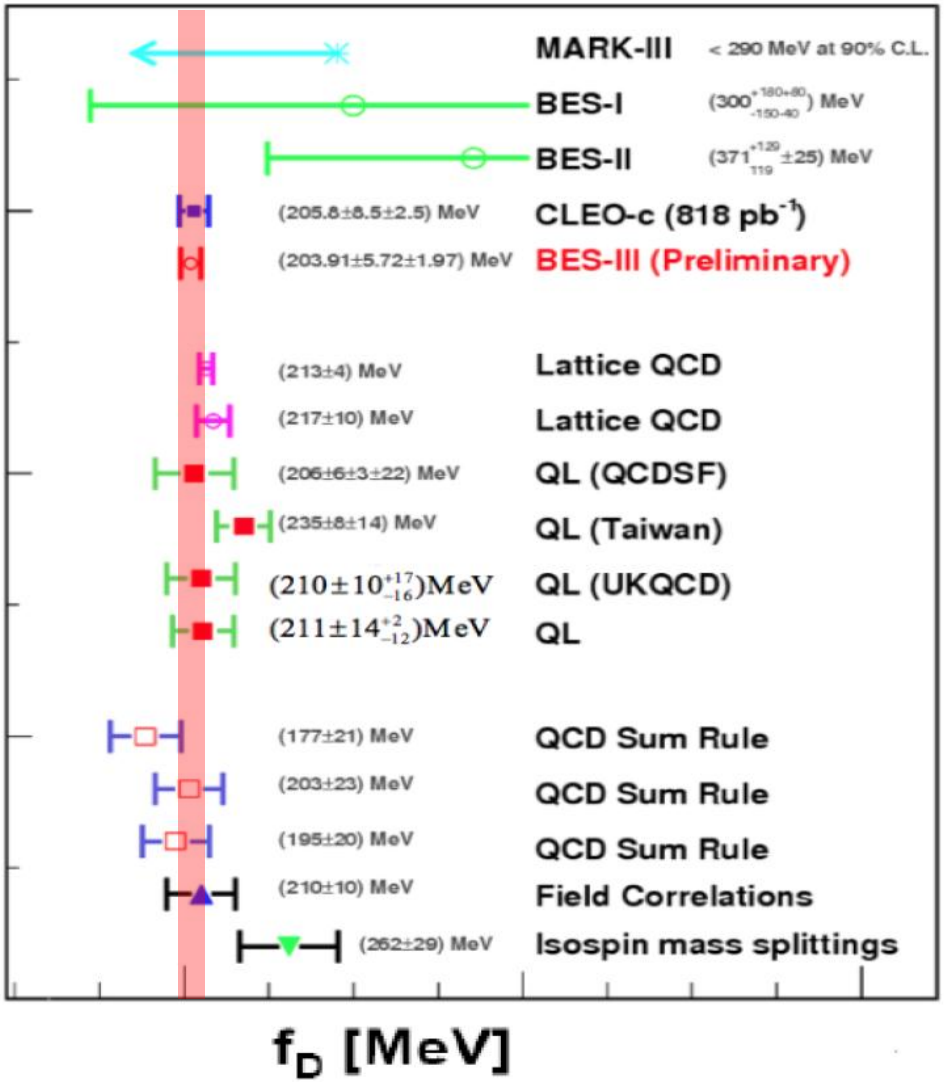
from CKM fitter

$$\text{BESIII } (2.9\, fb^{-1}): f_D = (203.91 \pm 5.72 \pm 1.97)\ \text{MeV}$$

Preliminary

Compare with theory

(Input τ_{D+}, m_{D+}, $m_{\mu+}$ of PDG10 and V_{cd} of CKM-Fitter)



or: $|V_{cd}|$ determination

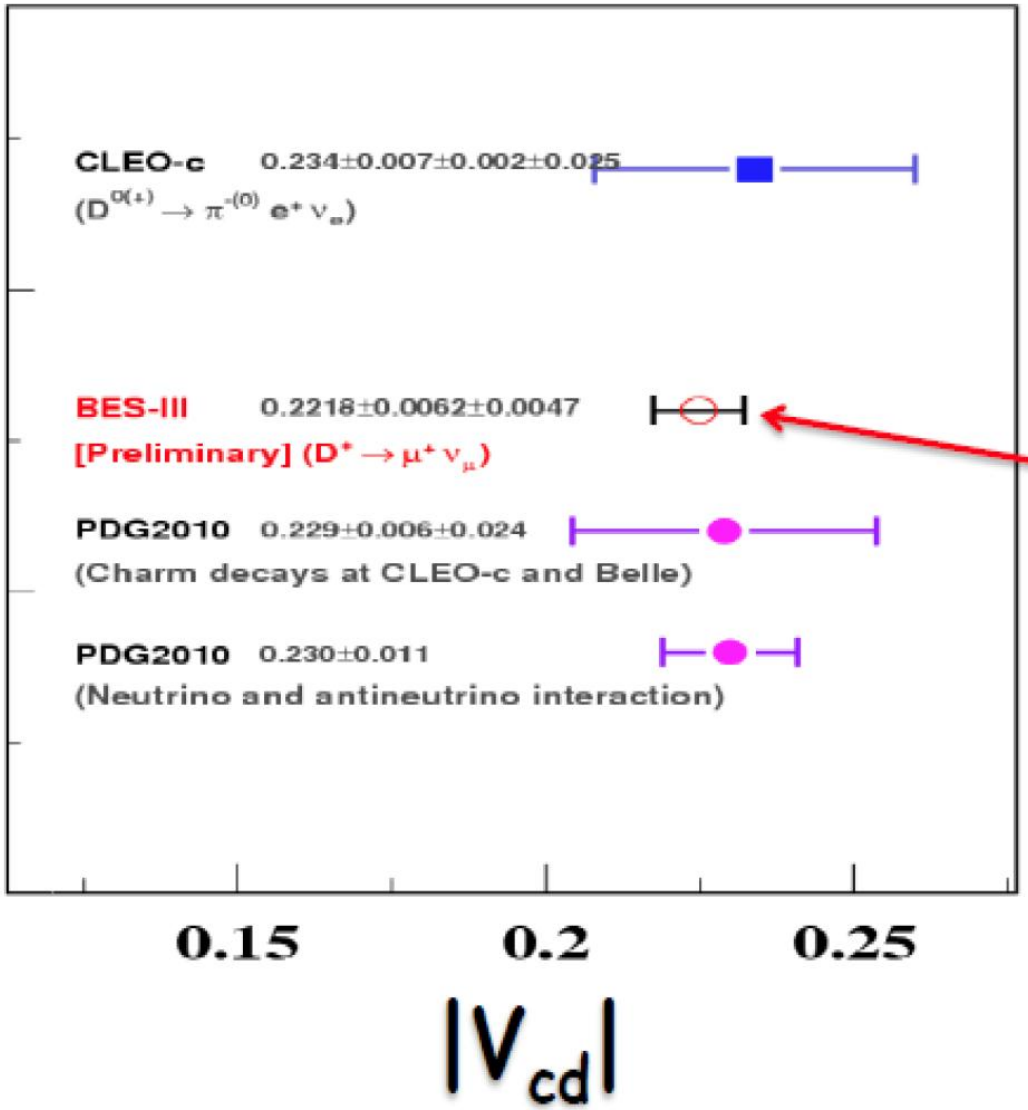
fromLQCD

$$\Gamma_{\mathrm{SM}}(D^+_{(s)} \to l^+\nu) = \frac{G_F^2}{8\pi} m_l^2 m_{D_{(s)}} \left(1 - \frac{m_l^2}{m_{D_{(s)}}^2}\right)^2 |V_{cd(s)}|^2 \boxed{f_{D^+_{(s)}}}$$

$$\mathrm{BESIII}\ (2.9\ fb^{-1}):\ |V_{cd}| = 0.2218 \pm 0.0062 \pm 0.0047$$

Preliminary

$|V_{cd}|$ results



The most precise determination of |Vcd| is from the BESIII

$D^+ \to \ell^+ \nu$ prospects

- $D^+ \to \tau^+ \nu$ with current (2.9 fb^{-1}) data
  - Larger signal Bf + larger bkg → comparable sensitivity
- Ultimately D^+ (& D_s) → $\mu^+ \nu$ and $\tau^+ \nu$ with 20 fb^{-1}

Strong challenges to LQCD

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- searches for new states
- …,

Precision mass measurements

m_τ

Particle	Mass, MeV	σ_m/m
e	$0.510998910 \pm 0.000000013$	$2.5 \cdot 10^{-8}$
μ	$105.6583668 \pm 0.0000038$	$3.6 \cdot 10^{-8}$
τ	1776.82 ± 0.16	$9.0 \cdot 10^{-5}$

factor of ~3000 disparity

lepton universality: $r = \left(\frac{G_\tau}{G_\mu}\right)^2 = \left(\frac{G(\tau^- \to e^- \nu_\tau \bar{\nu}_e)}{G(\mu^- \to e^- \nu_\mu \bar{\nu}_e)}\right)^2 = \left(\frac{m_\mu}{m_\tau}\right)^5 \left(\frac{t_\mu}{t_\tau}\right) \mathcal{B}(\tau \to e \nu_\tau \bar{\nu}_e) \frac{F_{\rm cor}(m_\mu, m_e)}{F_{\rm cor}(m_\tau, m_e)}$

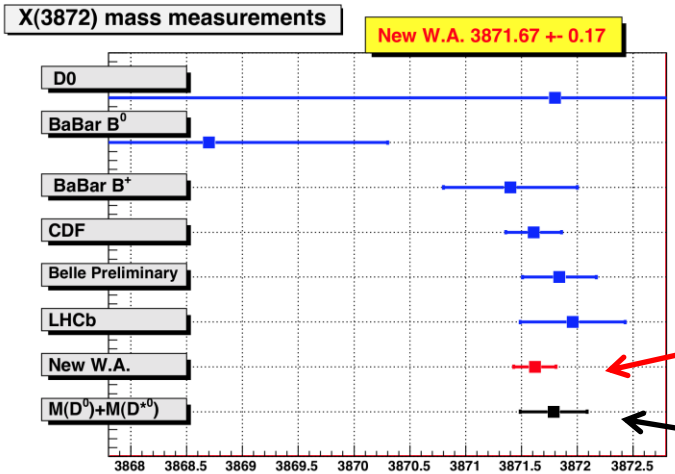
Koide's formula:
PRD 28, 252 (1983)

$$\frac{(\sqrt{m_e} + \sqrt{m_\mu} + \sqrt{m_\tau})^2}{(m_e + m_\mu + m_\tau)} = 1.4999973^{+0.0000395}_{-0.0000304}$$

numerology?

m_{D^0}

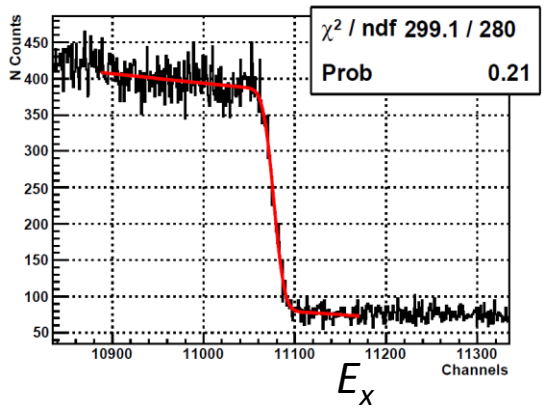
is $M_{X(3872)}$ above or below $m_{D^0}+m_{D^{*0}}$?



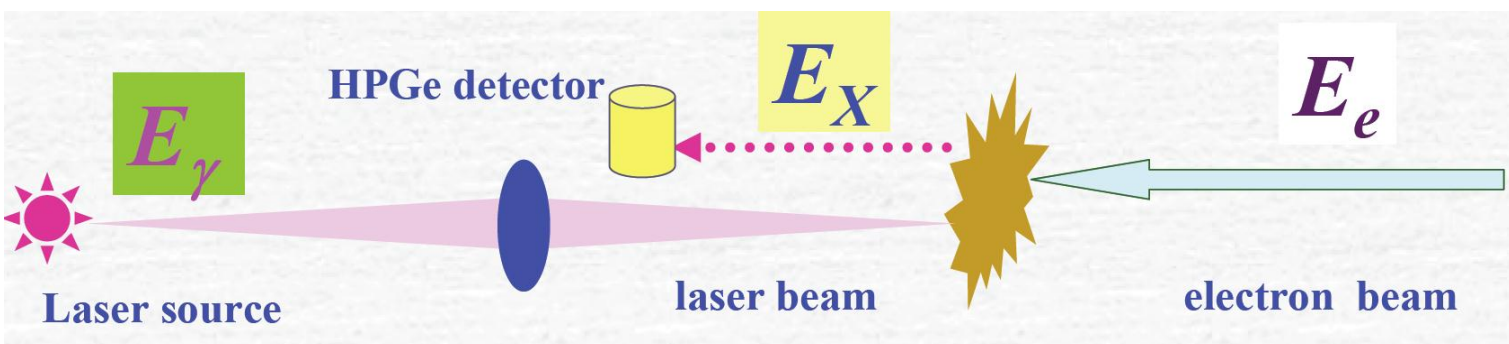
$M_{X(3872)}$

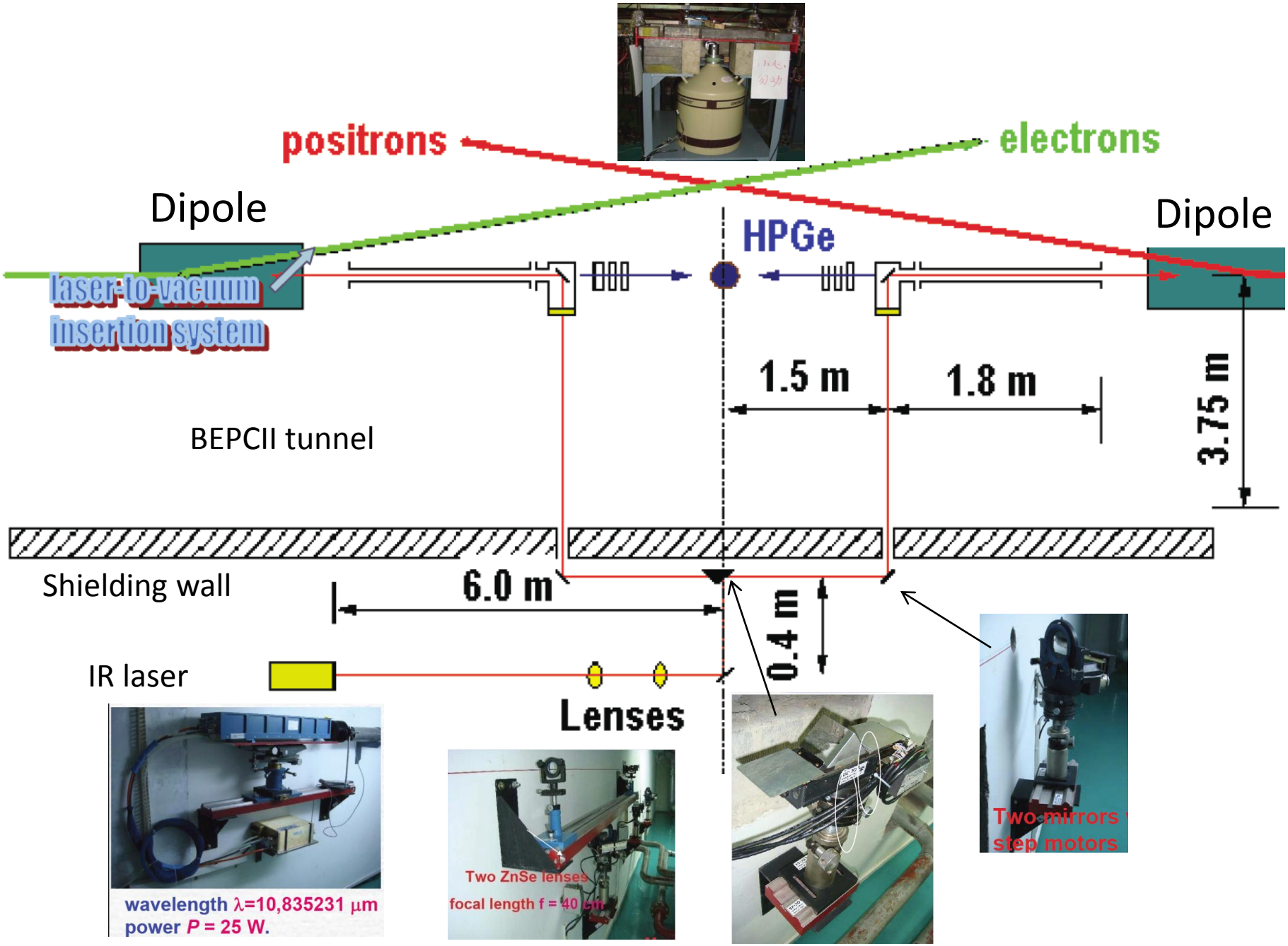
$m_{D^0} + m_{D^{*0}}$

BEPCII beam energy monitor



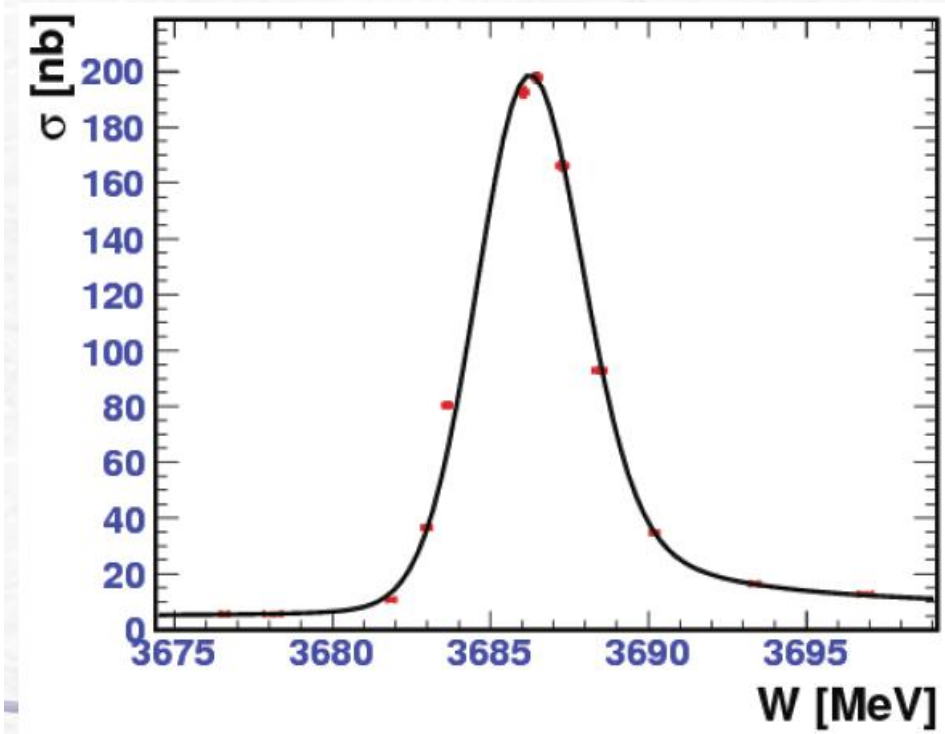
$$E_e = \frac{E_X}{2}\left[1 + \sqrt{1 + \frac{m_e^2}{E_\gamma E_X}}\right]$$




positrons
electrons
Dipole
Dipole
HPGe
laser-to-vacuum
insertion system
1.5 m
1.8 m
3.75 m
BEPCII tunnel
Shielding wall
6.0 m
0.4 m
IR laser
Lenses
wavelength λ=10,835231 μm
power P = 25 W.
Two ZnSe lenses
focal length f = 40 cm
Two mirrors
step motors
steerer

Validate at the ψ' peak

The accuracy of beam energy measurement was studied by comparison of ψ(2s) resonance mass 3686.09 ± 0.040 MeV, with its value obtained using the energy obtained using BEMS data.



Two scans of ψ(2s) with integrated luminosity about 4 pb^{-1}.

Mass difference:

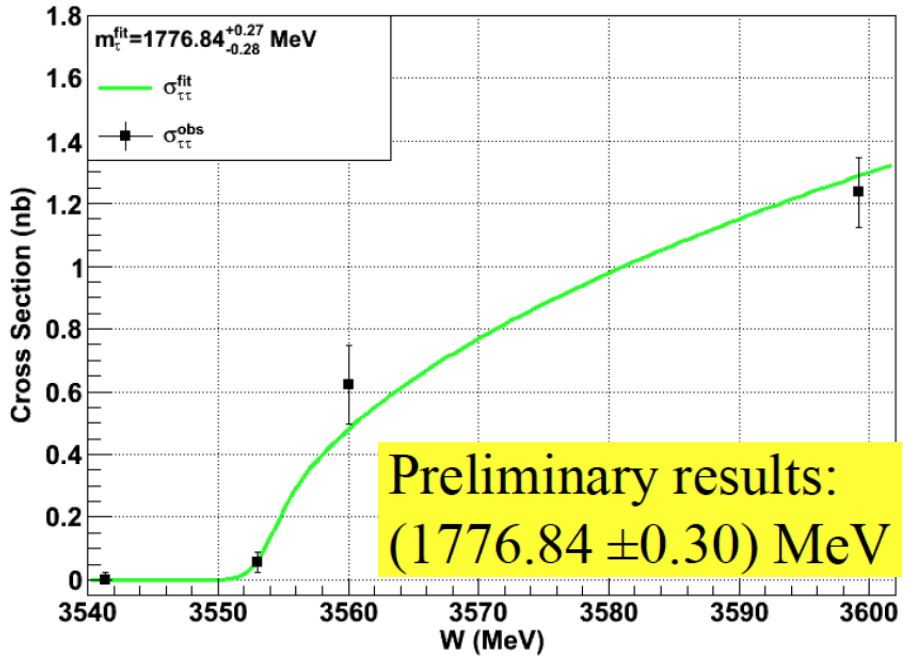
$$\Delta m = m - m_{\psi} = 0.02 \pm 0.05 MeV$$

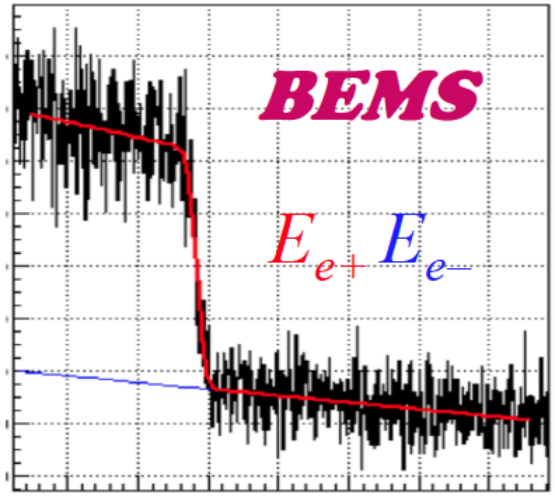
Deviation of the measured beam energy of the beam from true value:

$$\delta\varepsilon = \frac{\Delta m}{2} = 0.01 \pm 0.03$$

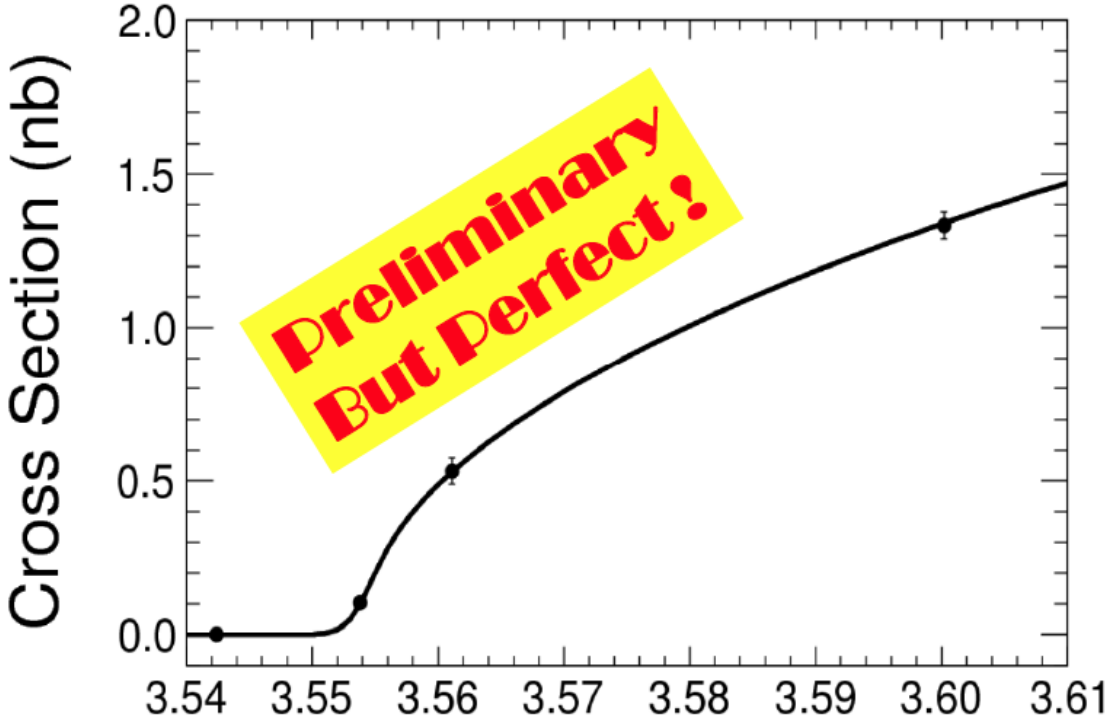
Accuracy of the BEMS: $\delta\varepsilon/\varepsilon \sim 2 \times 10^{-5}$

Results from a 5pb^{-1} "pilot" run





Data from 30.5 pb^{-1}



Results: m_τ = 1776. will be open soon MeV

ultimate goal, with ~100pb^{-1} ➔ $\delta m_\tau \leq \pm 0.1$ MeV

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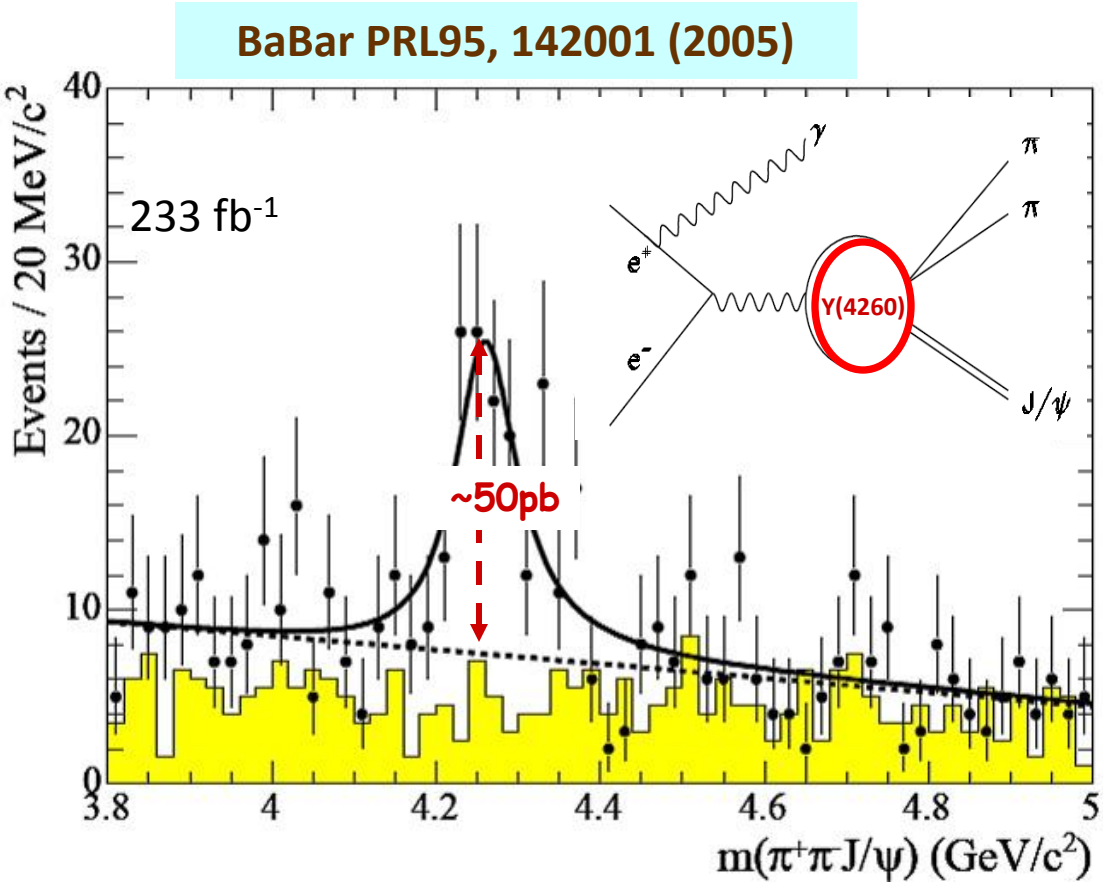
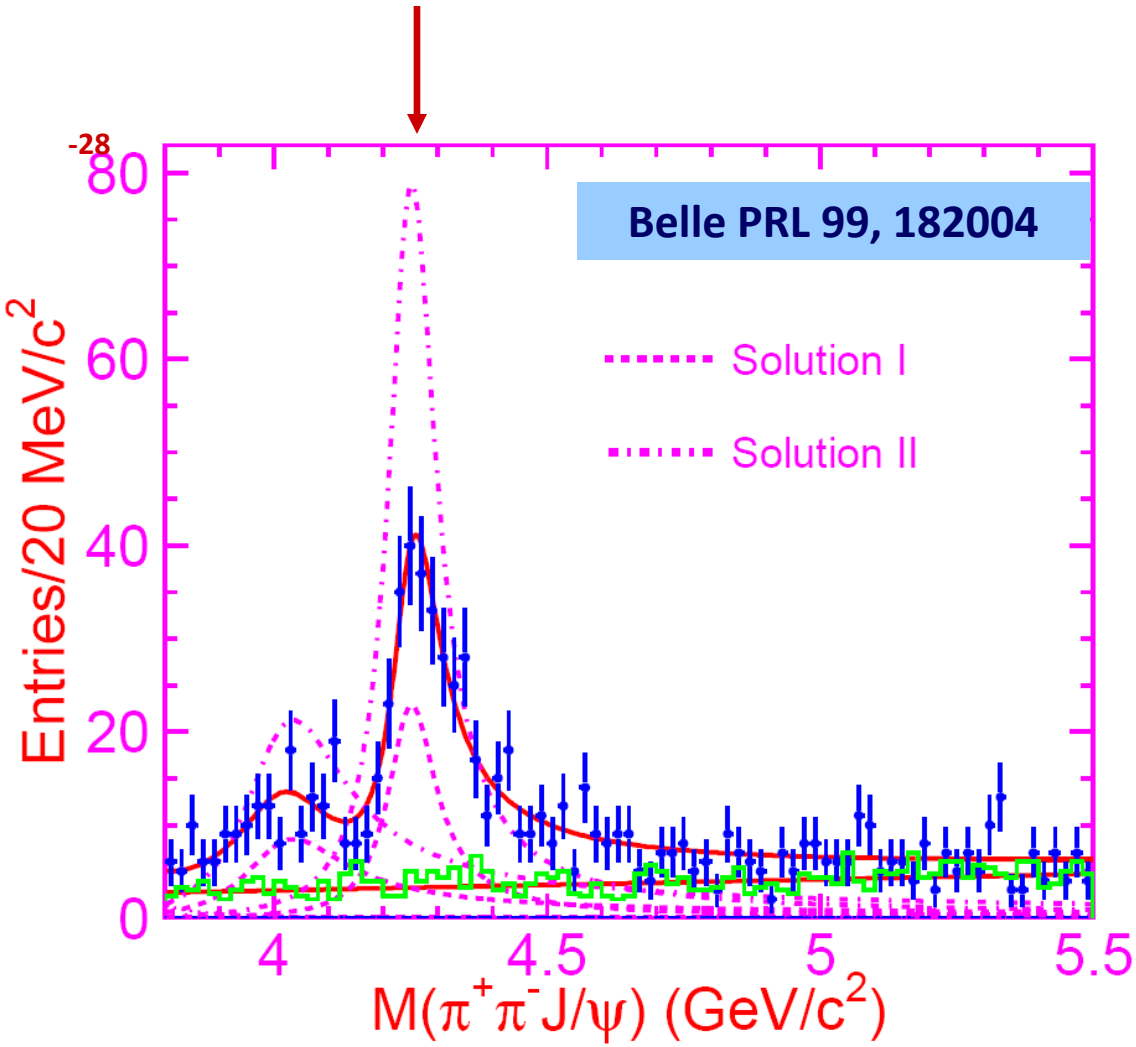
XYZ meson physics:

-$Y(4260) \rightarrow \pi\pi h_c$ decays
- searches for new states
- …,

Y(4260) (& Y(4350)) studies @ BESIII



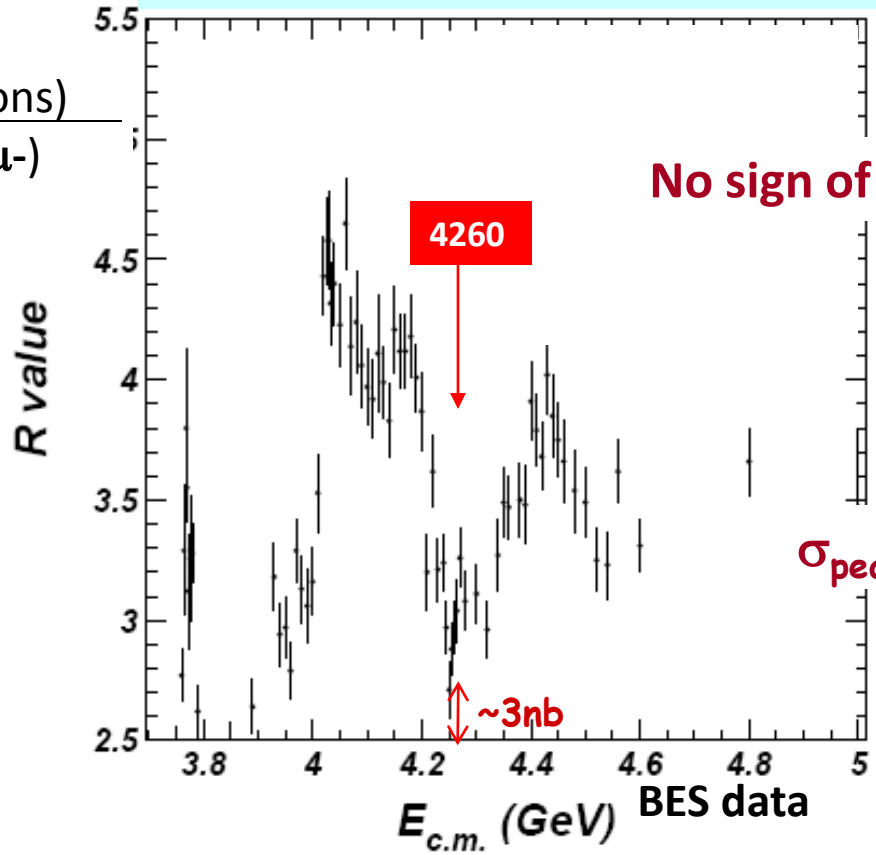
Y(4260) confirmed by Belle



Not seen in e^+e^- → hadrons

J.Z.Bai *et al* (BES), PRL 88, 101802 (2006)

$$\frac{\sigma(e+e- \rightarrow \text{hadrons})}{\sigma(e+e- \rightarrow \mu+\mu-)}$$



No sign of $Y(4260) \rightarrow D^{(*)}D^{(*)}$

$\sigma_{peak}(Y(4260) \rightarrow \pi^+\pi^- J/\psi) \sim 50$ pb

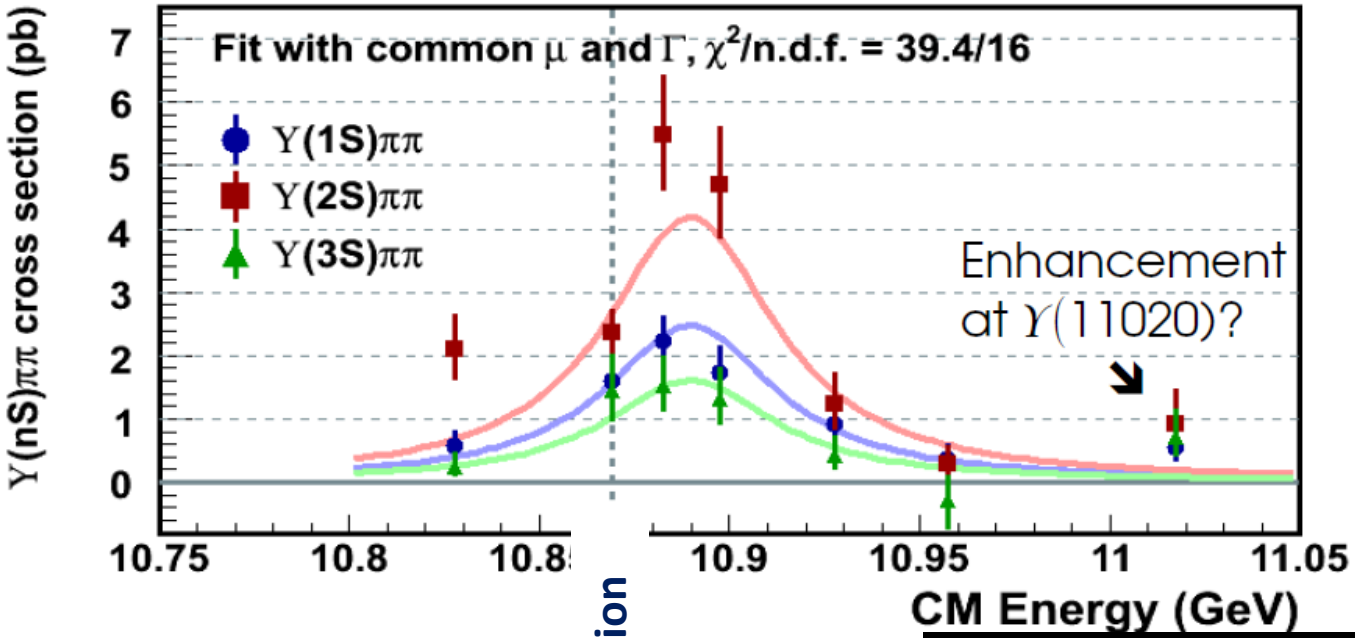
Huge by charmonium standards

$\Gamma(Y_{4260} \rightarrow \pi^+\pi^- J/\psi) > 1.6$ MeV @ 90% CL

X.H. Mo *et al*, PL B640, 182 (2006)

Belle saw a curious $\pi^+\pi^-$®(nS) structure in the bottomonium system

$\sigma(e+e- \rightarrow \pi^+\pi^-\Upsilon_{nS})$ from a cm energy scan



Υ_{5S} peak position

Fitted parameters

$10889.6 \pm 1.8 \pm 1.5$ MeV

$54.7^{+8.5}_{-7.2} \pm 2.5$ MeV

Belle PRD 82, 091106 (2010)

PDG(Υ_{5S}): $\mu = 10865 \pm 8$ MeV, $\Gamma = 110 \pm 13$ MeV

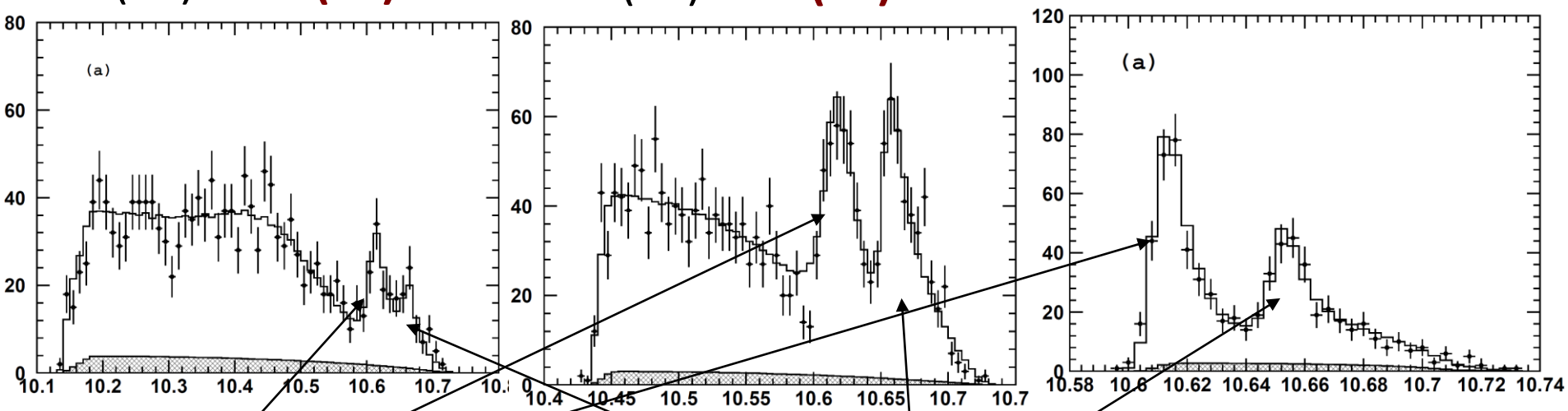
This is a strong source of "$Z_b^{\pm}$" mesons

Belle PRL 99, 182004 (2007)

"$\Upsilon(5S)$" $\rightarrow$ **$\Upsilon(1S)\pi^+\pi^-$**

"$\Upsilon(5S)$" $\rightarrow$ **$\Upsilon(2S)\pi^+\pi^-$**

"$\Upsilon(5S)$" $\rightarrow$ **$\Upsilon(3S)\pi^+\pi^-$**



$M(\Upsilon(1S)\pi)_{max}$

$M(\Upsilon(2S)\pi)_{max}$

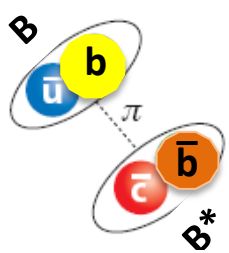
$M(\Upsilon(3S)\pi)_{max}$

$Z_b(10610)$ **M=10608.1±1.7 MeV**
Γ=15.5±2.4 MeV

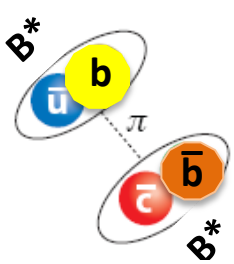
PDG: $M_B + M_{B^*} = 10604.5 \pm 0.6$ MeV

$Z_b(10650)$ **M=10653.3±1.5 MeV**
Γ=14.0±2.8 MeV

$2M_{B^*} = 10650.2 \pm 1.0$ MeV



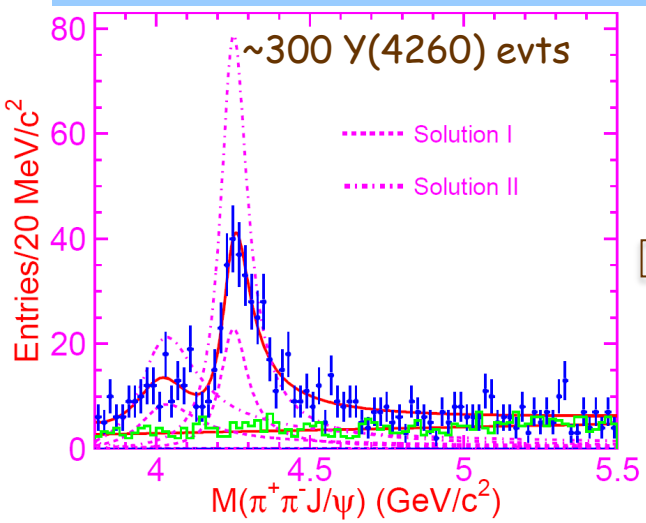
B-$\bar{B}$* "molecule"?



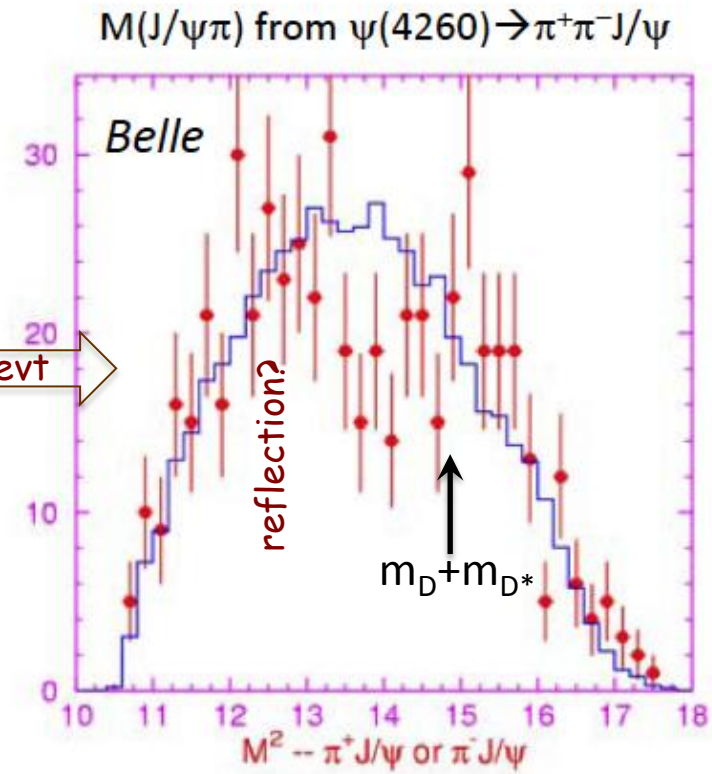
B*-$\bar{B}$* "molecule"?

Is the Y(4260) a source of "$Z_c^{\pm}$" mesons?

Belle PRL 99, 182004 (2007)



2 entries/evt



BESIII now has ~1300 Y(4260)→$\pi^+\pi^-J/\psi$ events

--& has just accumulated a similar sample of Y(4360)→$\pi^+\pi^-\psi$□ evts--

We expect to have lots of interesting results on the Y(4260) & Y(4360) for Yongpyong 2014

Please invite us again

Concluding remarks

- BEPCII is operating near design luminosity & BESIII is performing at state-of-art levels

- $p\bar{p}$ threshold peak in $J/\psi \rightarrow \gamma p\bar{p}$ confirmed; J^{PC} established as 0^{-+}; $M \approx 2m_p$-40 MeV
  - $X(1835) \rightarrow \pi^+\pi^-\eta'$ in $J/\psi \rightarrow \gamma\pi^+\pi^-\eta'$ confirmed at the same mass & J^{PC}
  - additional narrow ($\Gamma \approx 80$ MeV) $\pi^+\pi^-\eta'$ mass peaks seen at ~2120 & 2375 MeV
    - glueballs?

- Precision measurements of η_c and h_c charmonium-state properties are made
  - interference with non-resonant bkg is significant

- World's largest sample ever of $\psi'' \rightarrow D\bar{D}$ decays already collected
  - precision measurements of f_D, $|V_{cs}|$ and $|V_{cd}|$ & strong phases in progress
  - corresponding high-statistics D_s measurements are planned

- a τ-mass measurement with ~±100keV precision is underway

- High statistics studies of the Y(4260) and Y(4360) are underway
  - Search for charged Z_c "molecule-like" states

- Excellent detector, excellent machine, interesting program of physics for the next 10 yrs