

Overview of the Experiment

Guangshun Huang

(On behalf of BESIII Collaboration)

University of Science and Technology of China

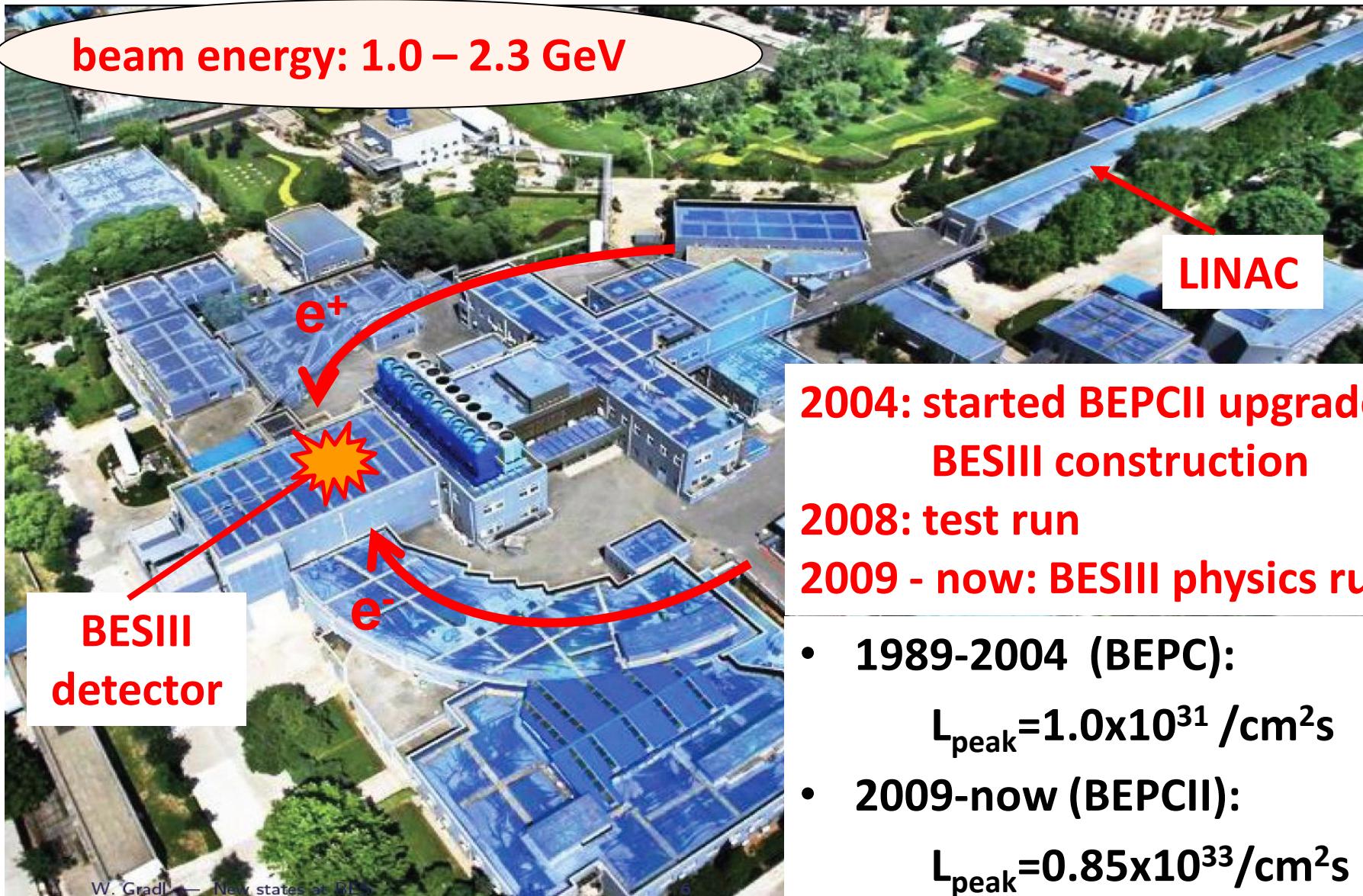
4th LNF Workshop on Cylindrical GEM Detectors

Nov.16, 2015, Frascati, Italy

Outline

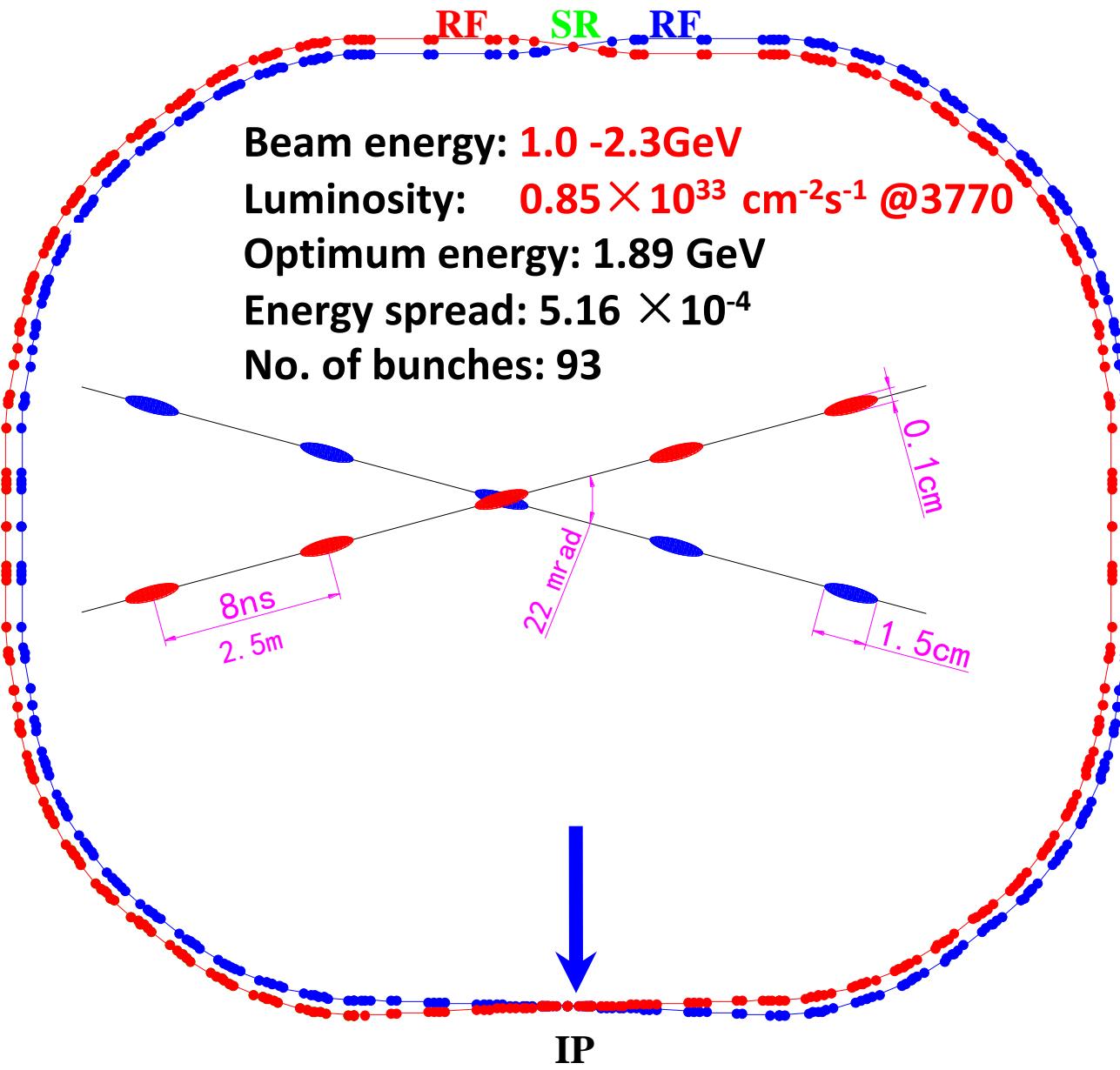
- **Introduction**
- **Status of BESIII**
- **Selected results from BESIII**
- **Summary**

Beijing Electron Positron Collider (BEPC)



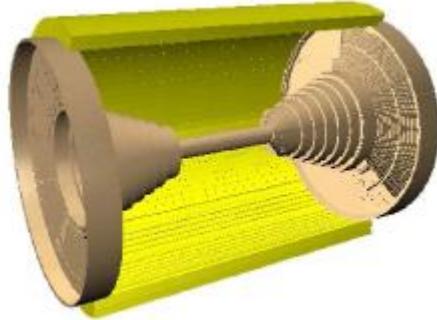
Upgraded BEPC-BEPCII

Beam energy: 1.0 -2.3GeV
Luminosity: $0.85 \times 10^{33} \text{ cm}^{-2}\text{s}^{-1}$ @3770
Optimum energy: 1.89 GeV
Energy spread: 5.16×10^{-4}
No. of bunches: 93



BESIII Detector

MDC

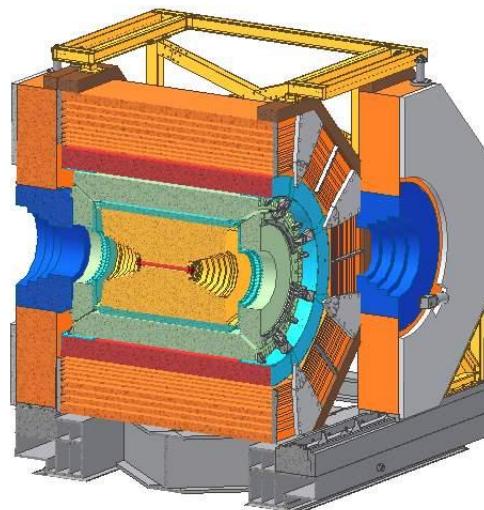


R inner: 63mm ;

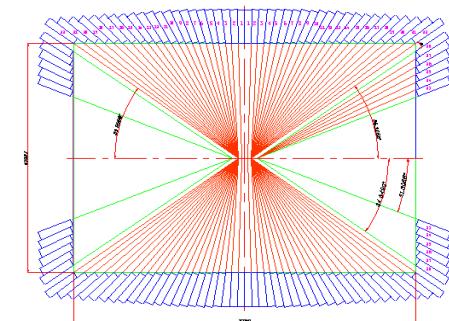
R outer: 810mm

Length: 2582 mm

Layers: 43



CsI(Tl) EMC



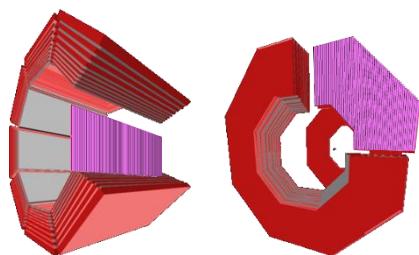
Crystals: 28 cm($15 X_0$)

Barrel: $|\cos\theta| < 0.83$

Endcap:

$0.85 < |\cos\theta| < 0.93$

RPC MUC



BMUC: 9 layers – 72 modules

EMUC: 8 layers – 64 modules

TOF

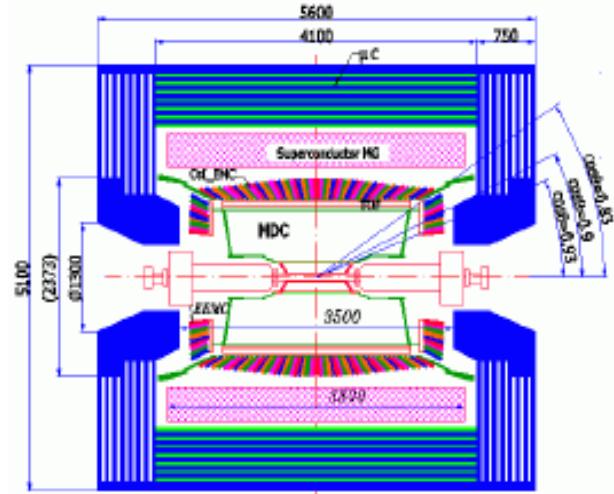
BTOF: two layers

ETOFT: 48 for each



BESIII Detector

Exps.	MDC Wire resolution	MDC dE/dx resolution	EMC Energy resolution
CLEO	110 μm	5%	2.2-2.4 %
Babar	125 μm	7%	2.67 %
Belle	130 μm	5.6%	2.2 %
BESIII (XYZ data)	115 μm	<5% (Bhabha)	2.3%



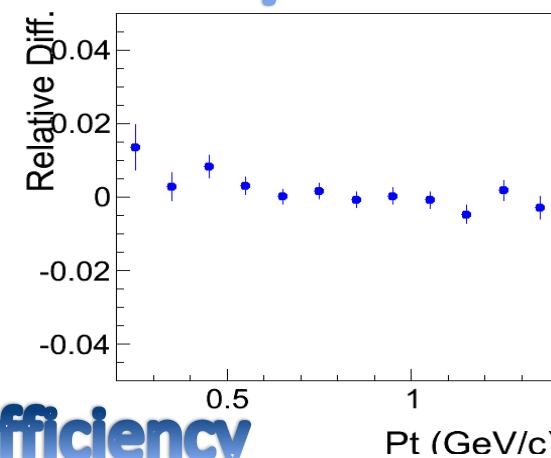
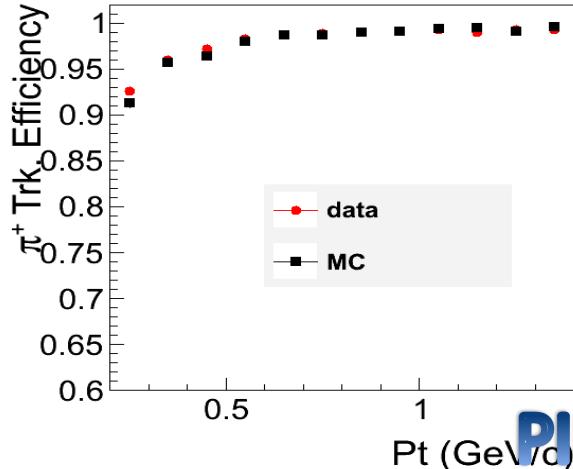
Exps.	TOF time resolution
CDFII	100 ps
Belle	90 ps
BESIII (XYZ data)	68 ps (BTOF) 100 ps (ETOFT)

- New ETOF (MRPC), just installed
- New Inner MDC, built at IHEP

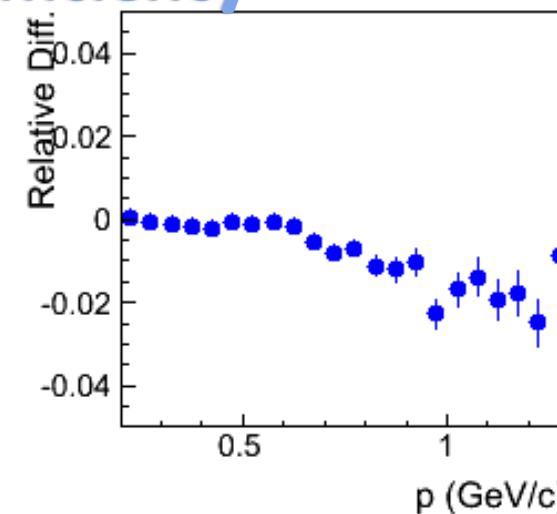
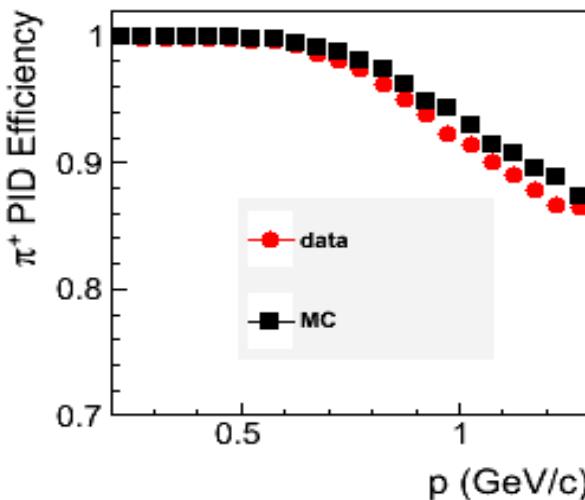
Data/Monte-Carlo Consistency

- For tracking efficiency, data/MC difference < 1%
- For particle identification efficiency, data/MC difference < 2%

Tracking efficiency

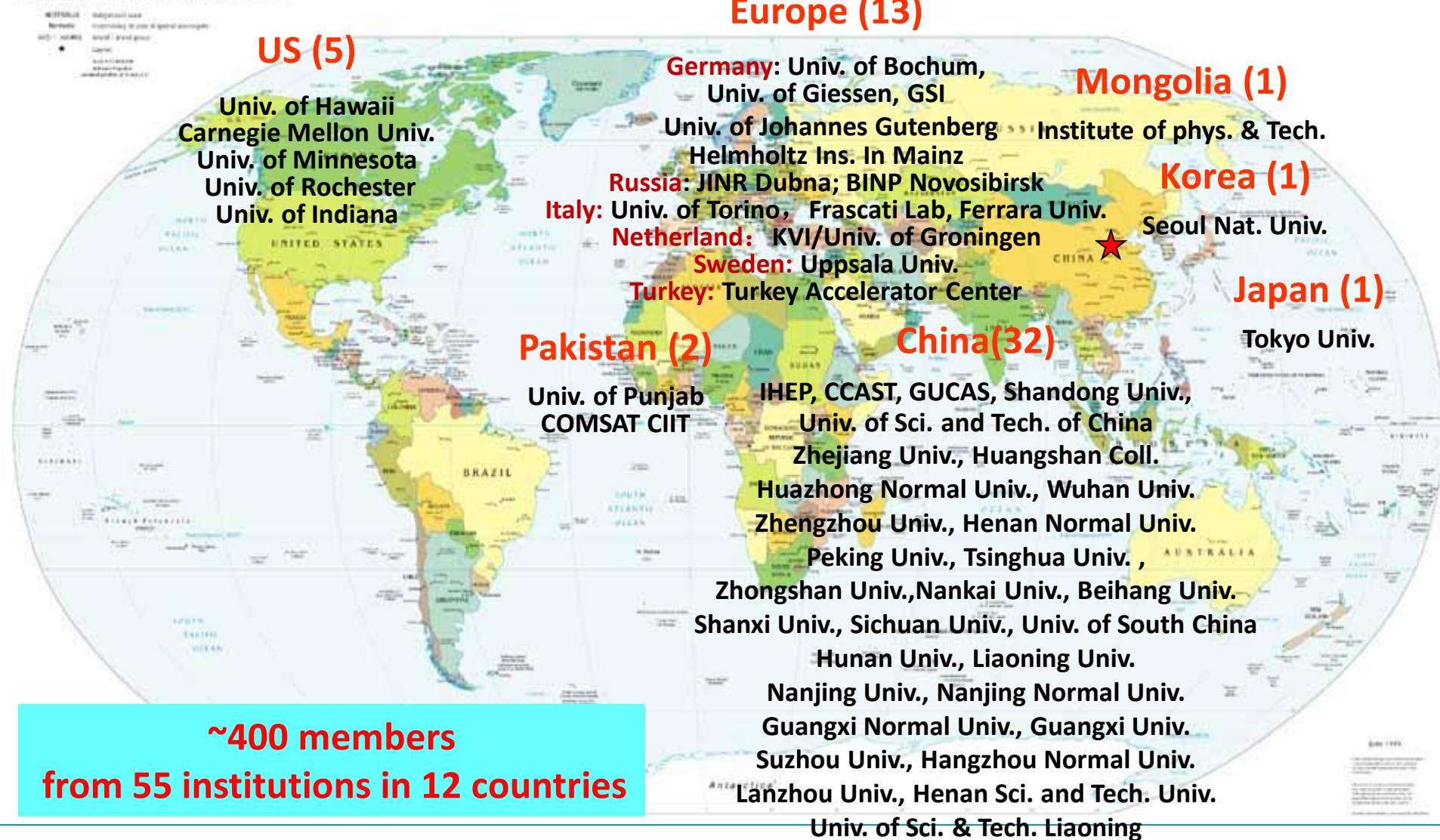


PID efficiency



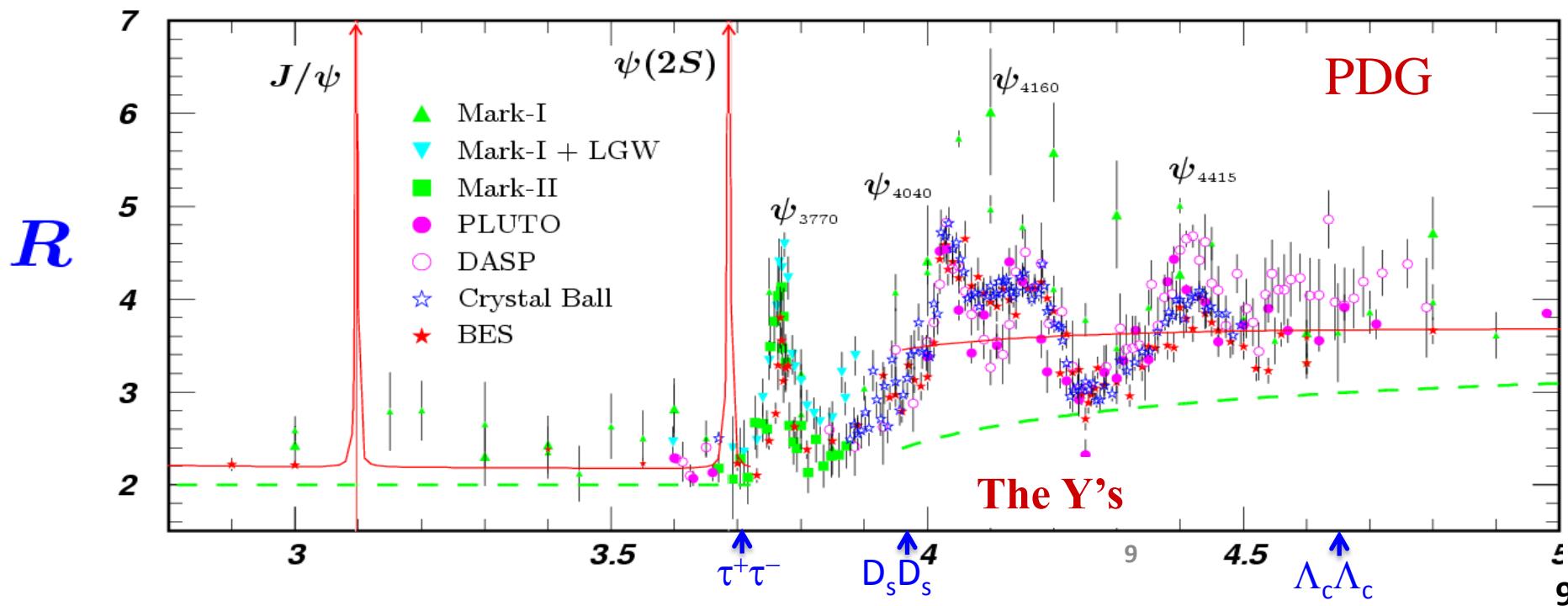
BESIII Collaboration

Political Map of the World, June 1999



Features of the BEPC Energy Region

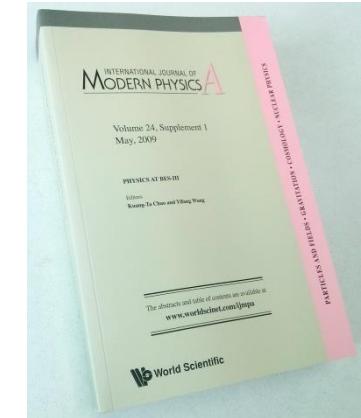
- Rich of **resonances**: charmonia and charm mesons
- **Threshold characteristics** (pairs of baryon, τ , D, D_s , ...)
- **Transition between** smooth and resonances, perturbative and non-perturbative QCD
- Energy location of the **new hadrons**: glueballs, hybrids, multi-quark states



Physics Topics at BESIII

◆ Hadron spectroscopy

- search for the new forms of hadrons
- meson spectroscopy
- baryon spectroscopy



Int. J. Mod. Phys. A, Vol. 24 (2009)

◆ 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.

Calibrate QCD

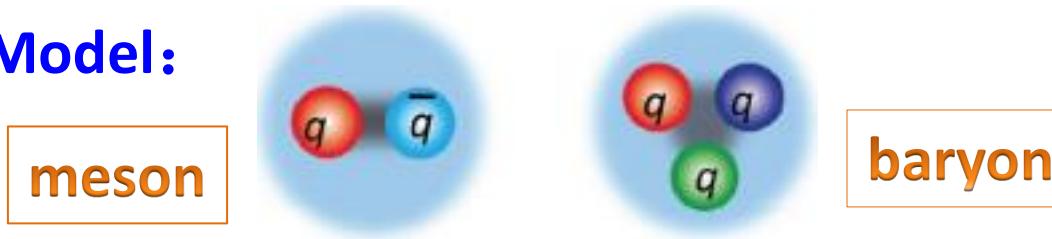
XYZ states

- ◆ Precision measurement of R values, hadron FF, ...
- ◆ Charm physics, charmed baryon
- ◆ Rare decays, new physics

New forms of hadrons

- Conventional hadrons consist of 2 or 3 quarks:

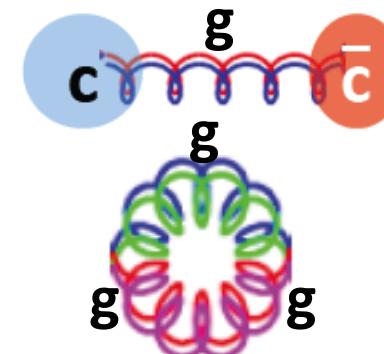
Naive Quark Model:



- QCD predicts the new forms of hadrons:

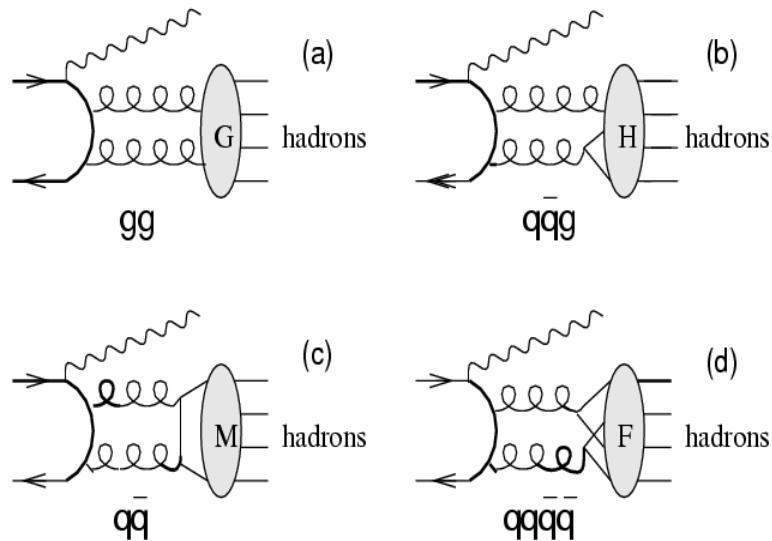
- Multi-quark states : Number of quarks ≥ 4

- Hybrids : $q\bar{q}g$, $qqqg$...
- Glueballs : gg , ggg ...



None of the new forms of hadrons is settled !

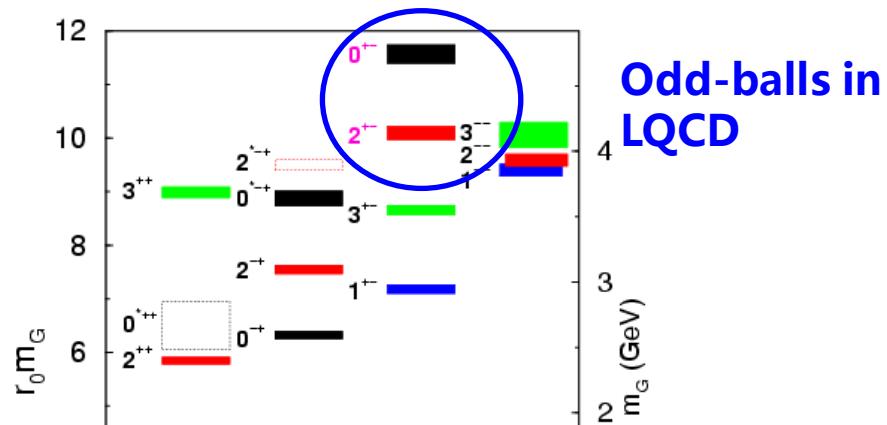
Charmonium decays provide ideal hunting ground for light glueballs and hybrids



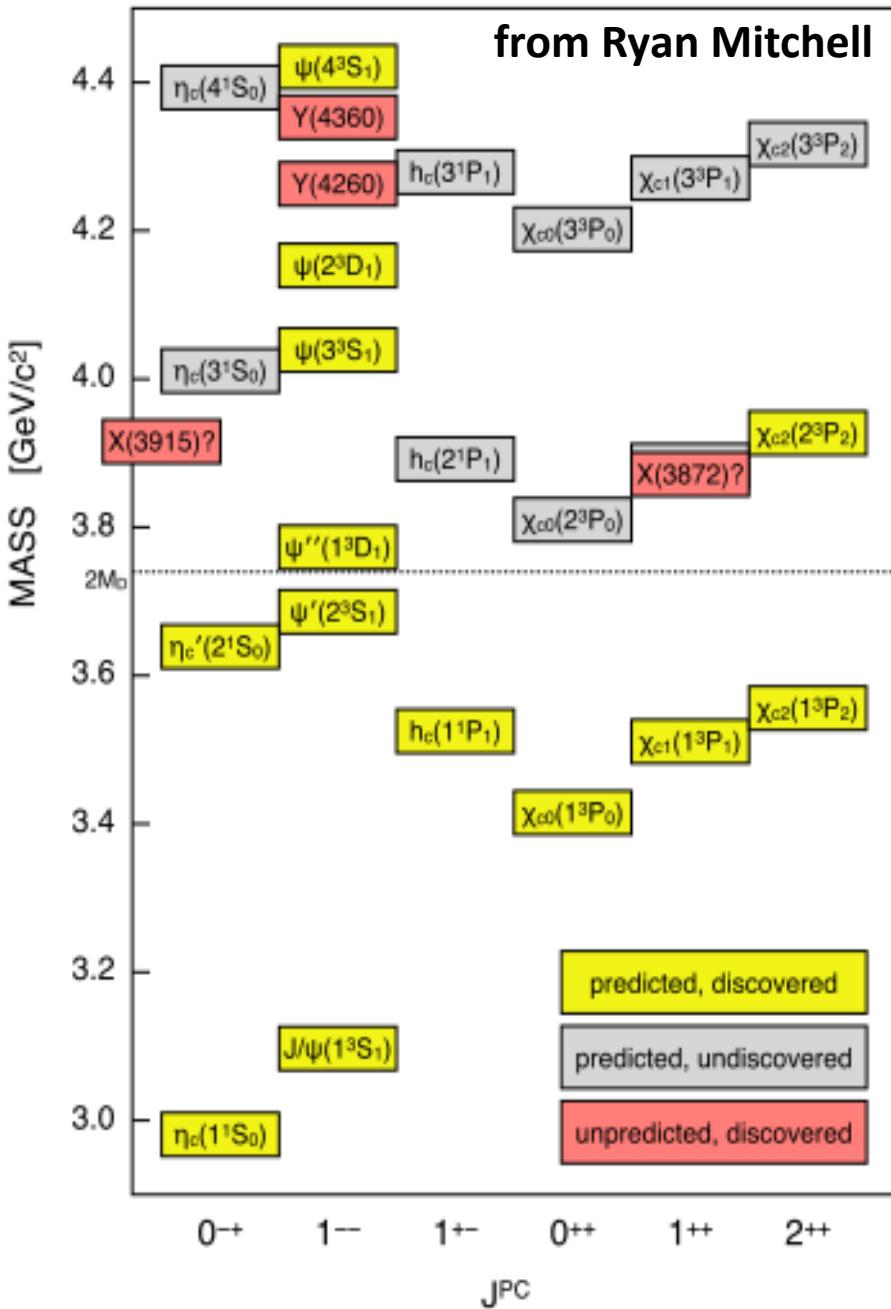
$$\Gamma(J/\psi \rightarrow \gamma G) \sim O(\alpha\alpha_s^2), \Gamma(J/\psi \rightarrow \gamma H) \sim O(\alpha\alpha_s^3),$$

$$\Gamma(J/\psi \rightarrow \gamma M) \sim O(\alpha\alpha_s^4), \Gamma(J/\psi \rightarrow \gamma F) \sim O(\alpha\alpha_s^4)$$

- “Gluon-rich” process
- Clean high statistics data samples from e^+e^- annihilation
- $I(J^{PC})$ filter in strong decays of charmonium



Charmonium spectroscopy



- Charmonium states below open charm threshold are all observed

Above open charm threshold:

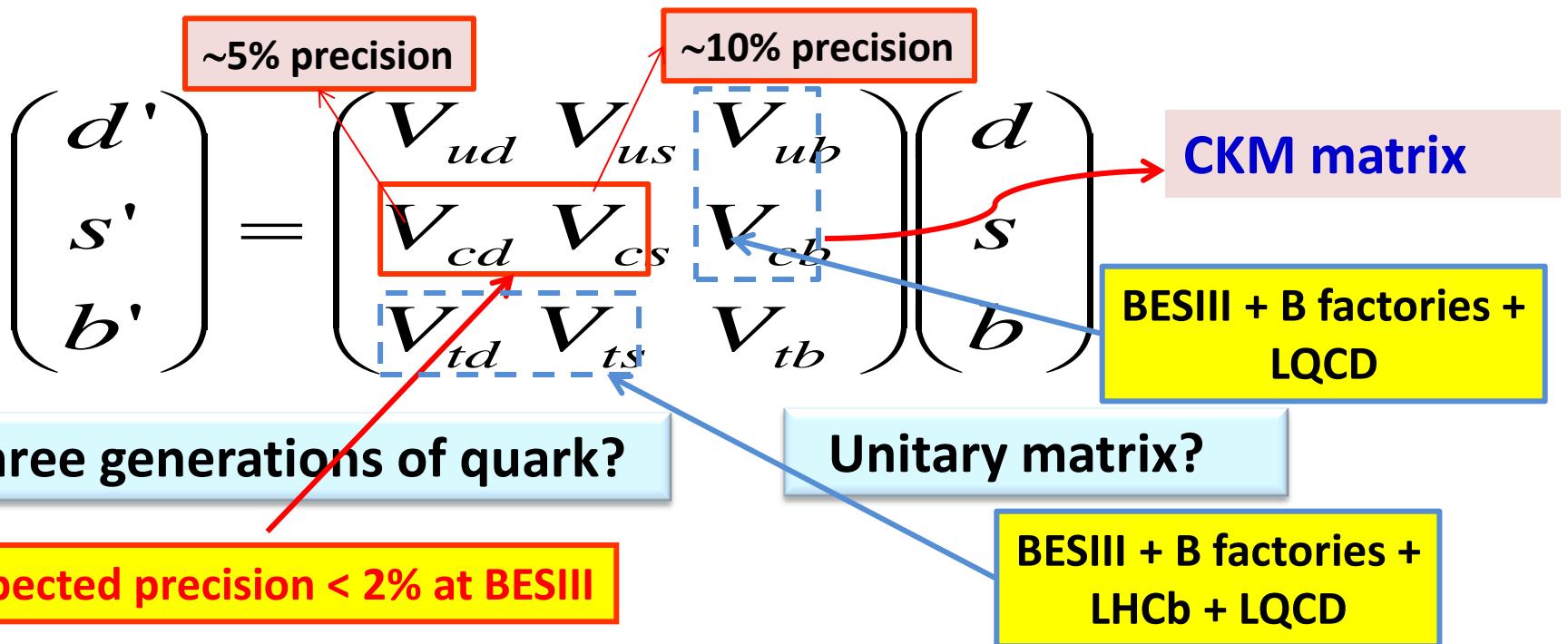
- many expected states not observed
- many unexpected observed

Z(4430)	X(3915)
Z(4250)	X(3872)
Z(4050)	Y(4008)
Z(3900)	XYZ(3940)
	Y(4140)
	Y(4260)
	Y(4360)
	X(4350)
	Y(4660)

Precision 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.

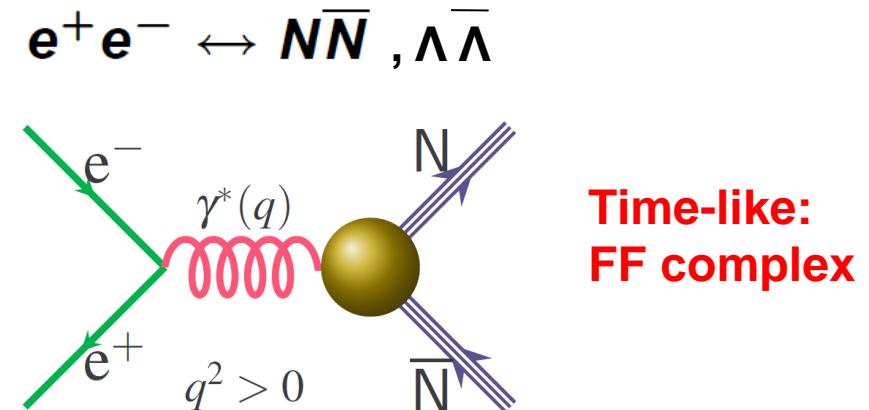
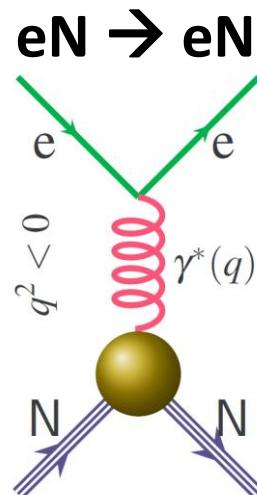


Precision measurement of CKM matrix elements
-- a precise test of SM model
New physics beyond SM?

Nucleon Form Factor

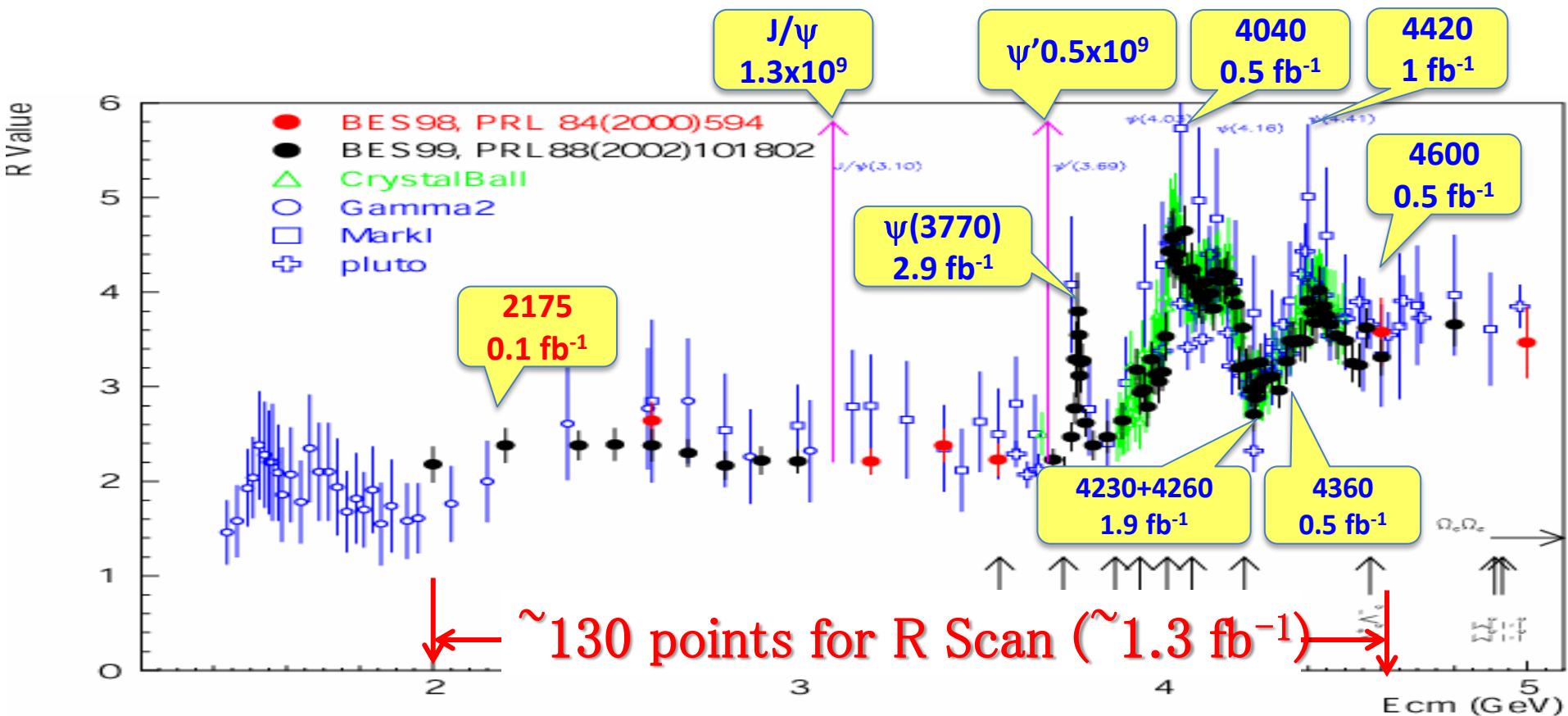
- Fundamental properties of the nucleon
 - Connected to charge, magnetization distribution
 - Crucial testing ground for models of the nucleon internal structure
 - Necessary input for experiments probing nuclear structure, or trying to understand modification of nucleon structure in nuclear medium
- Can be measured from space-like processes ($eN \rightarrow eN$) (precision 1%) or time-like process (e^+e^- annihilation) (precision 10%-30%)

Space-like:
FF real



Time-like:
FF complex

BESIII data samples



**World largest J/ψ , $\psi(2S)$, $\psi(3770)$, $\Upsilon(4260)$, ...
produced directly from e^+e^- collision**

Selected results

- XYZ studies
- Scalars
- Baryons
- Charm physics
- Λ_c absolute branching fractions
- Form factors

Observation of $Z_c(3900)^{\pm}$

$Z_c(3900)^{\pm}$:

$$m = (3899.0 \pm 3.6 \pm 4.9) \text{ MeV}/c^2$$

$$\Gamma = (46 \pm 10 \pm 20) \text{ MeV}$$

Mass close to $D\bar{D}^*$ threshold

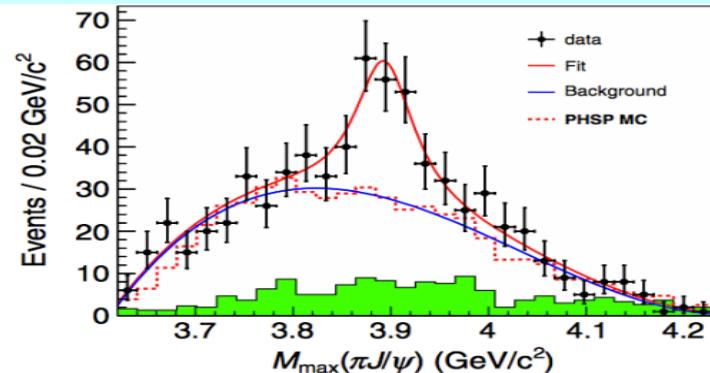
Decays to $J/\psi \rightarrow$ contains $c\bar{c}$

Electric charge \rightarrow contains $u\bar{d}$

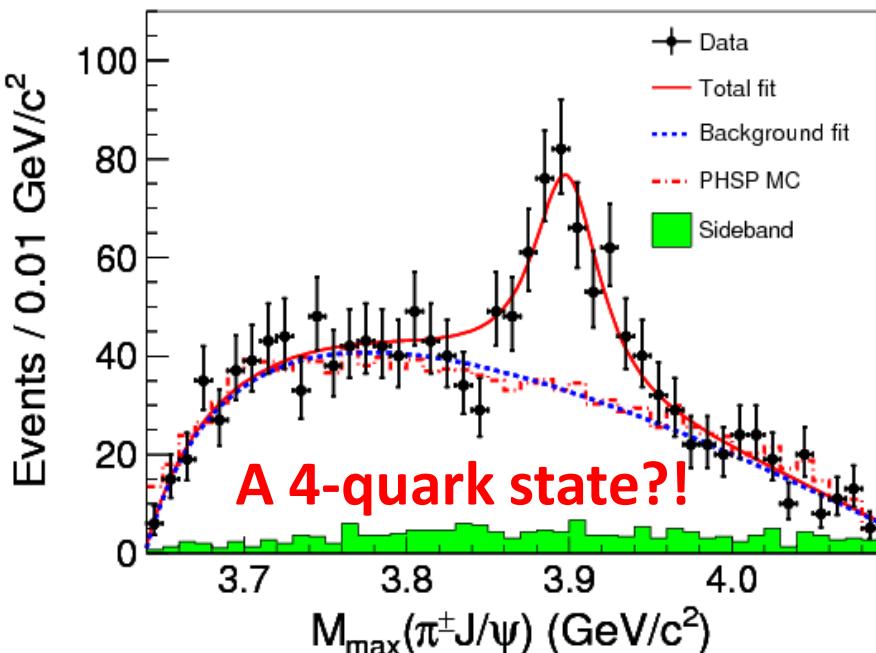
$$\sigma[e^+e^- \rightarrow \pi^+\pi^- J/\psi] = 62.9 \pm 1.9 \pm 3.7 \text{ pb at } 4.26 \text{ GeV}$$

$$\frac{\sigma[e^+e^- \rightarrow \pi^\pm Z_c(3900)^\mp \rightarrow \pi^+\pi^- J/\psi]}{\sigma[e^+e^- \rightarrow \pi^+\pi^- J/\psi]} = (21.5 \pm 3.3 \pm 7.5)\% \text{ at } 4.26 \text{ GeV}$$

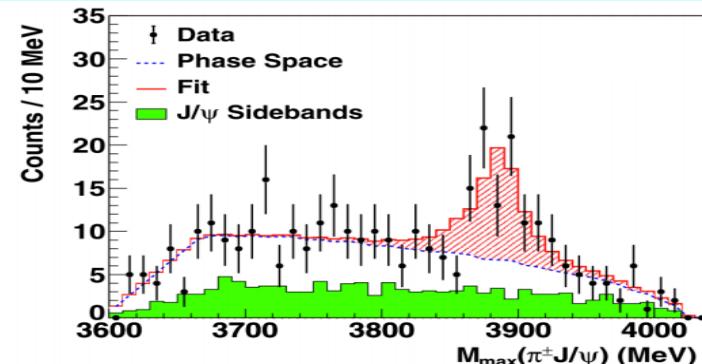
Belle with ISR data (PRL 110, 252002)



BESIII: PRL 110, 252001 (2013)



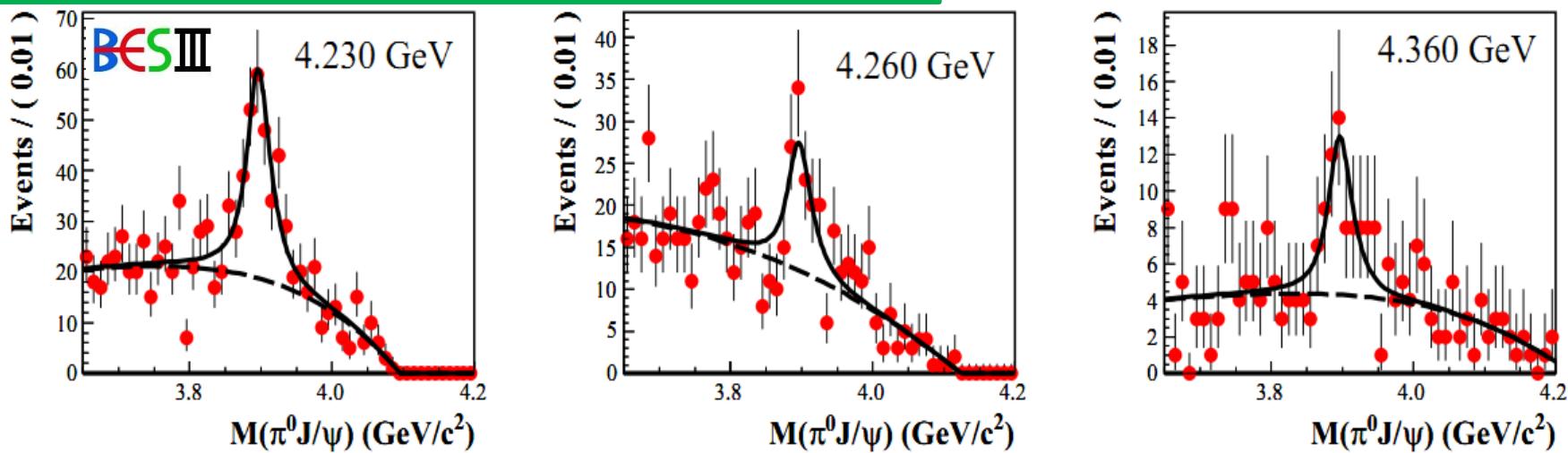
CLEO-c data at 4.17 GeV (PLB 727, 366)



The neutral isospin partner: $Z_c(3900)^0$

Search from $e^+e^- \rightarrow \pi^0\pi^0 J/\psi$

BESIII: PRL 115, 112003 (2015.9)



A structure on $\pi^0 J/\psi$ invariant mass spectrum can be observed:

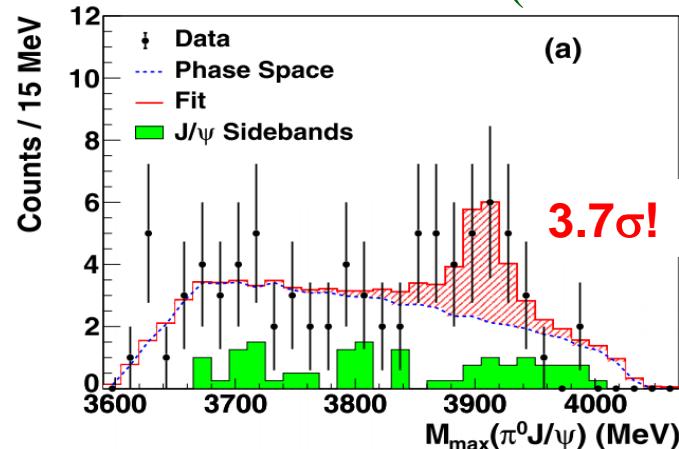
Mass = $3894.8 \pm 2.3 \pm 2.7 \text{ MeV}$

Width = $29.6 \pm 8.2 \pm 8.2 \text{ MeV}$

Significance = 10.4σ

Isospin triplet is established!

CLE0-c data at 4.17 GeV (PLB 727, 366)

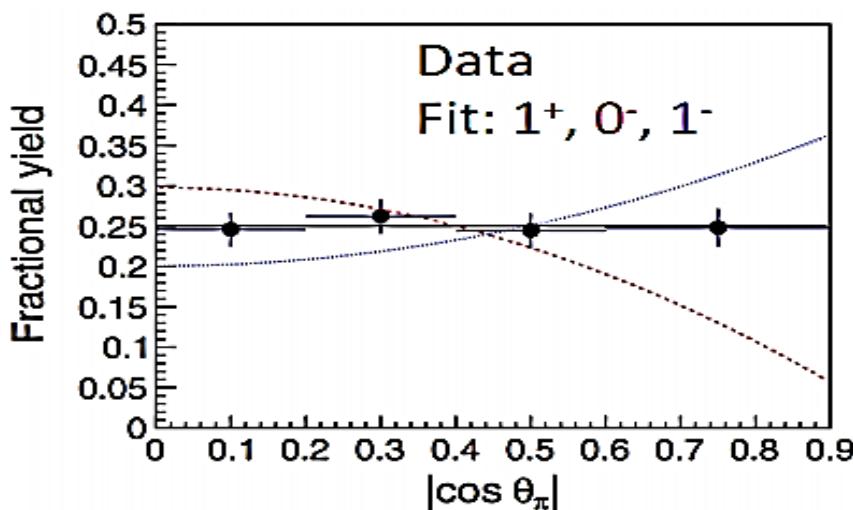


Observation of $Z_c(3885)^\pm$ in $e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$ at $\sqrt{s} = 4.26\text{GeV}$ using single D tag method

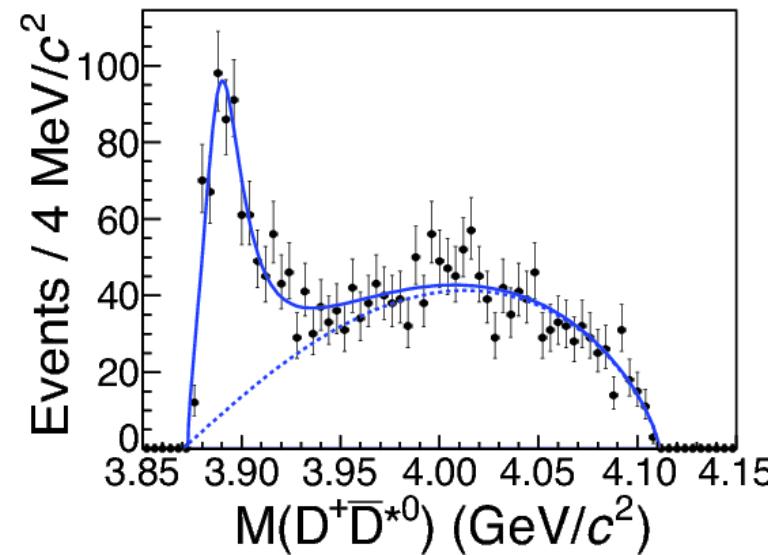
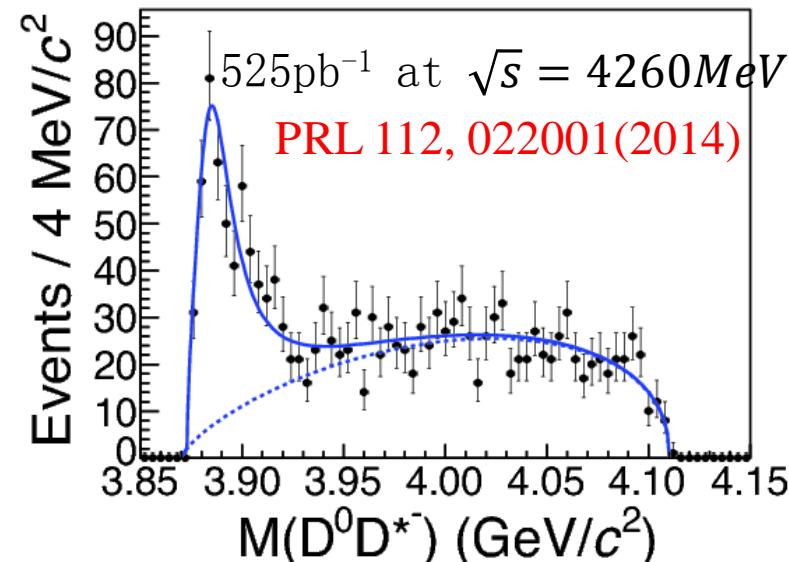
Reconstruct the π^+ and $D^0 \rightarrow K^-\pi^+$ and infer the D^{*-} .
(Also analyze $\pi^+D^-D^{*0}$ with the same method.)

Enhancement at $D\bar{D}^*$ threshold in both channels ($Z_c(3885)^+$):

Mass = $3883.9 \pm 1.5 \pm 4.2 \text{ MeV}$, (fit with BW function)
Width = $24.8 \pm 3.3 \pm 11.0 \text{ MeV}$



Fit to angular distribution
favors $J^P = 1^+$ over 0^- and 1^-



Observation of $Z_c(4020)^\pm$

in $e^+e^- \rightarrow \pi^+\pi^- h_c$

$h_c \rightarrow \gamma \eta_c$,
 $\eta_c \rightarrow 16$ hadronic decay modes

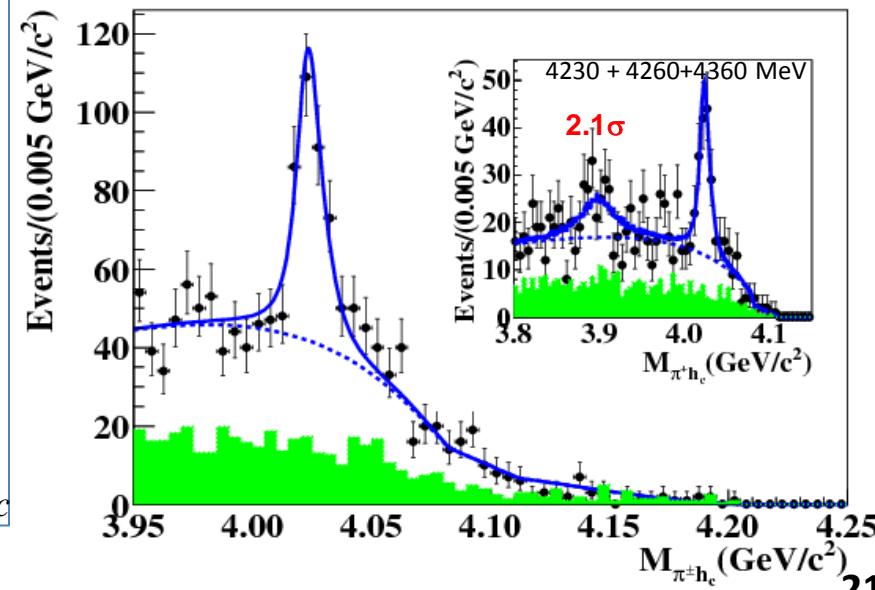
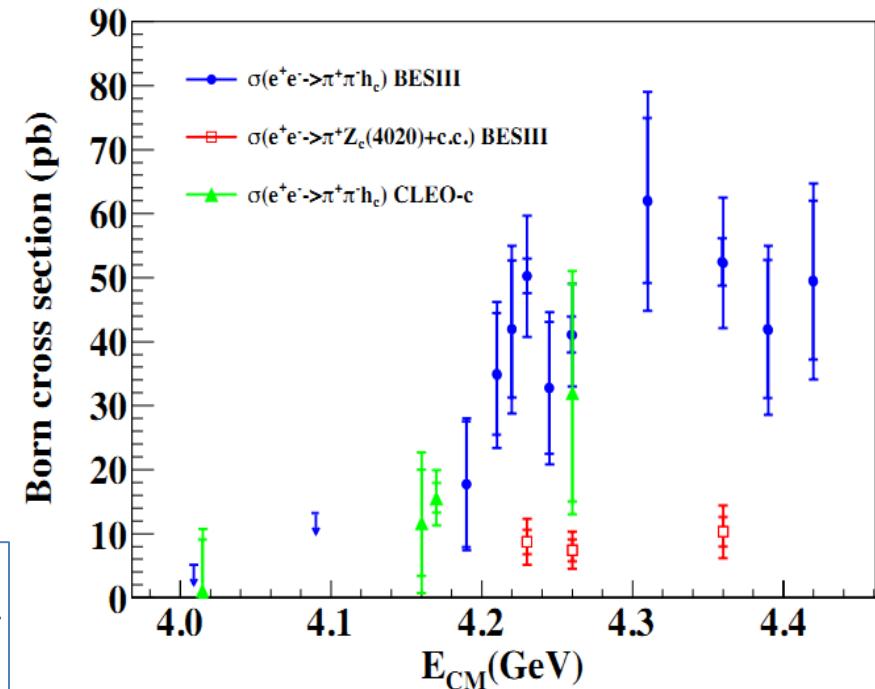
The cross section of $e^+e^- \rightarrow \pi^+\pi^- h_c$ is measured, and the shape is not trivial.

A structure, $Z_c(4020)^\pm$, is observed.

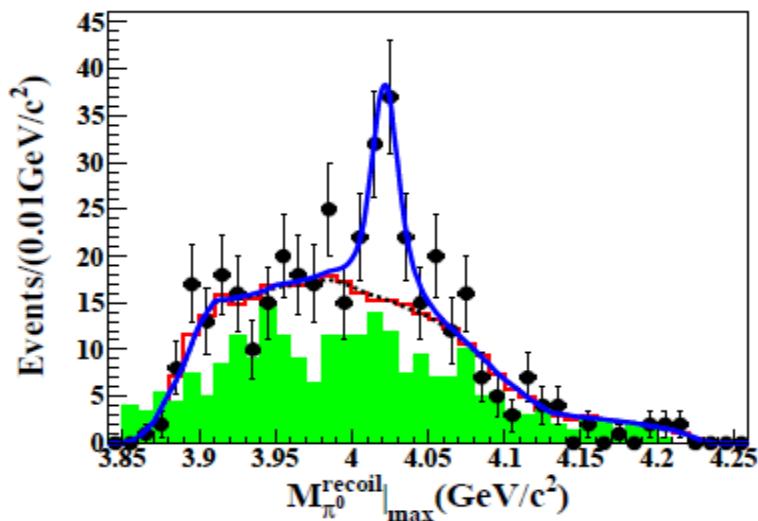
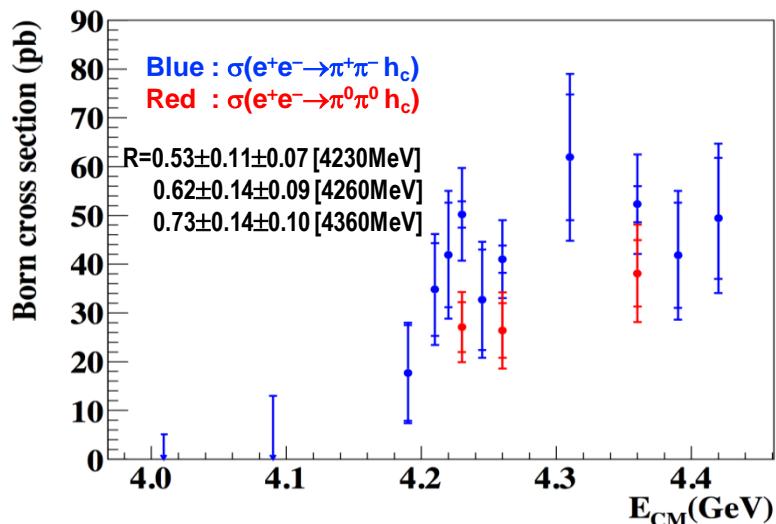
Mass = $4022.9 \pm 0.8 \pm 2.7$ MeV,
 Width = $7.9 \pm 2.7 \pm 2.6$ MeV

A weak evidence for $Z_c(3900)^\pm \rightarrow \pi^\pm h_c$

PRL 111, 242001(2013)



Observed neutral $Z_c(4020)^0$ in $e^+e^- \rightarrow \pi^0\pi^0 h_c$



$$M[Z_c(4020)^0] = 4023.6 \pm 2.2 \pm 3.9 \text{ MeV}$$

$$[M[Z_c(4020)^\pm]] = 4022.9 \pm 0.8 \pm 2.7 \text{ MeV}$$

–Width fixed to charged $Z_c(4020)$

–Significance : $>5\sigma$

Observation of
neutral $Z_c(4020)$

Isovector nature
of Z_c states
established

Observation of $Z_c(4025)^\pm$

$e^+e^- \rightarrow \pi^\pm(D^*\bar{D}^*)^\mp$ at $\sqrt{s} = 4.26\text{GeV}$

Tag a D^+ and a bachelor π^- , reconstruct one π^0 to suppress the background.

A structure, named as $Z_c(4025)$, can be observed in the recoil mass of the bachelor π^- .

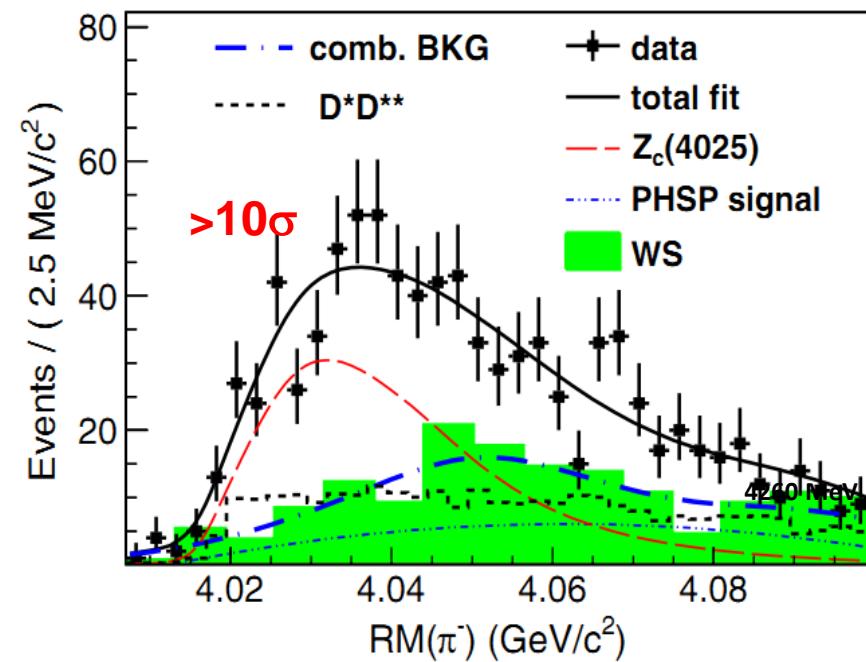
$$M(Z_c(4025)) = 4026.3 \pm 2.6 \pm 3.7 \text{ MeV};$$

$$\Gamma(Z_c(4025)) = 24.8 \pm 5.6 \pm 7.7 \text{ MeV}$$

$$\sigma[e^+e^- \rightarrow (D^*\bar{D}^*)^\pm\pi^\mp] = 137 \pm 9 \pm 15 \text{ pb at } 4.26 \text{ GeV}$$

$$\frac{\sigma[e^+e^- \rightarrow \pi^\pm Z_c(4025)^\mp \rightarrow (D^*\bar{D}^*)^\pm\pi^\mp]}{\sigma[e^+e^- \rightarrow (D^*\bar{D}^*)^\pm\pi^\mp]} = 0.65 \pm 0.09 \pm 0.06 \text{ at } 4.26 \text{ GeV}$$

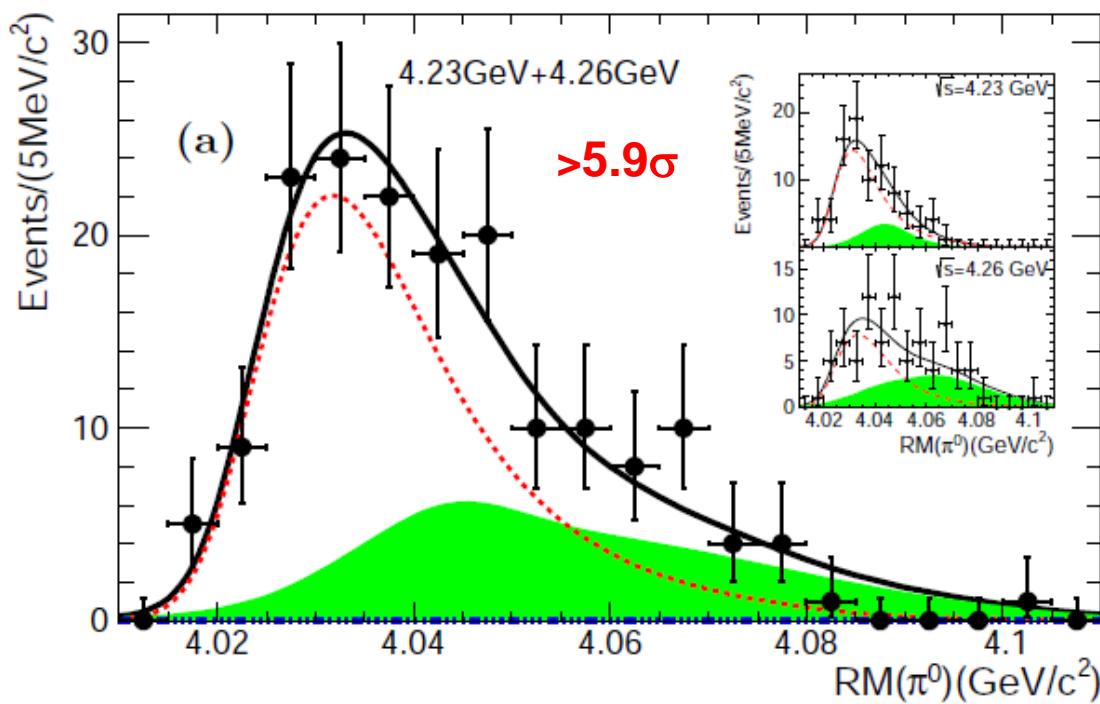
PRL 112, 132001 (2014)



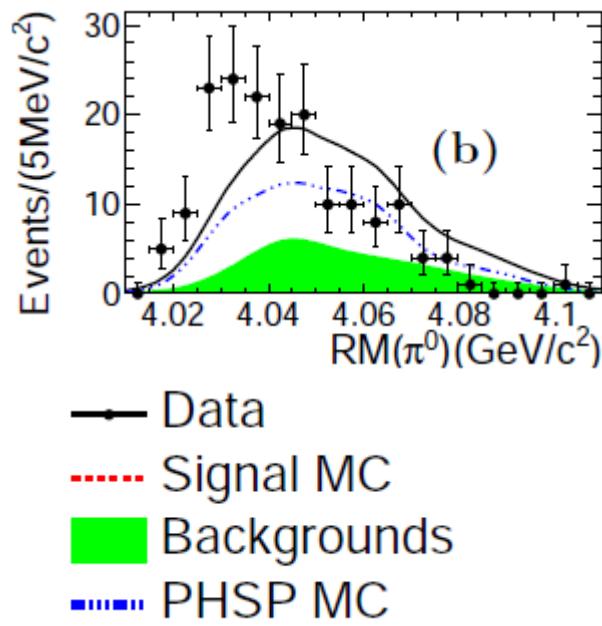
Coupling to \bar{D}^*D^* is much larger than to πh_c if $Z_c(4025)$ and $Z_c(4020)$ are the same state.

Observation of $Z_c(4025)^0$ in $e^+e^- \rightarrow \pi^0(D^*\bar{D}^*)^\mp$

PRL115, 182002 (2015.10)



Phase space + BG



- Data
- - - Signal MC
- Backgrounds
- · - PHSP MC

Data sample	Mass(MeV/c^2)	Width(MeV/c^2)	$\sigma(e^+e^- \rightarrow Z_c(4025)^0\pi^0 \rightarrow D^*\bar{D}^*(\pi^0))(\text{pb})$
@4.23GeV	$4025.5^{+2.0}_{-4.7} \pm 3.1$	$23.0 \pm 6.0 \pm 1.0$	$61.6 \pm 8.2 \pm 9.0$
@4.26GeV			$43.4 \pm 8.0 \pm 5.4$

$Z_c(4025)^{\pm/0}$: another isospin triplet

Zc's established so far

State	Mass (MeV/c ²)	Width (MeV)	Decay	Process	[Ref]
Z _c (3900) [±]	3899.0 ± 3.6 ± 4.9	46 ± 10 ± 20	$\pi^\pm J/\psi$	$e^+e^- \rightarrow \pi^+\pi^-J/\psi$	1*
Z _c (3900) ⁰	3894.8 ± 2.3 ± 2.7	29.6 ± 8.2 ± 8.2	$\pi^0 J/\psi$	$e^+e^- \rightarrow \pi^0\pi^0 J/\psi$	2*
Z _c (3885) [±]	3883.9 ± 1.5 ± 4.2 Single D tag	24.8 ± 3.3 ± 11.0 Single D tag	(D \bar{D}^*) [±]	$e^+e^- \rightarrow (D\bar{D}^*)^\pm\pi^\mp$	3*
	3881.7 ± 1.6 ± 2.1 Double D tag	26.6 ± 2.0 ± 2.3 Double D tag	(D \bar{D}^*) [±]	$e^+e^- \rightarrow (D\bar{D}^*)^\pm\pi^\mp$	4*
Z _c (3885) ⁰	3885.7 ^{+4.3} _{-5.7} ± 8.4	35 ⁺¹¹ ₋₁₂ ± 15	(D \bar{D}^*) ⁰	$e^+e^- \rightarrow (D\bar{D}^*)^0\pi^0$	5*
Z _c (4020) [±]	4022.9 ± 0.8 ± 2.7	7.9 ± 2.7 ± 2.6	$\pi^\pm h_c$	$e^+e^- \rightarrow \pi^+\pi^-h_c$	6*
Z _c (4020) ⁰	4023.9 ± 2.2 ± 3.8	fixed	$\pi^0 h_c$	$e^+e^- \rightarrow \pi^0\pi^0 h_c$	7*
Z _c (4025) [±]	4026.3 ± 2.6 ± 3.7	24.8 ± 5.6 ± 7.7	D [*] \bar{D}^*	$e^+e^- \rightarrow (D^*\bar{D}^*)^\pm\pi^\mp$	8*
Z _c (4025) ⁰	4025.5 ^{+2.0} _{-4.7} ± 3.1	23.0 ± 6.0 ± 1.0	D [*] \bar{D}^*	$e^+e^- \rightarrow (D^*\bar{D}^*)^0\pi^0$	9*

References:

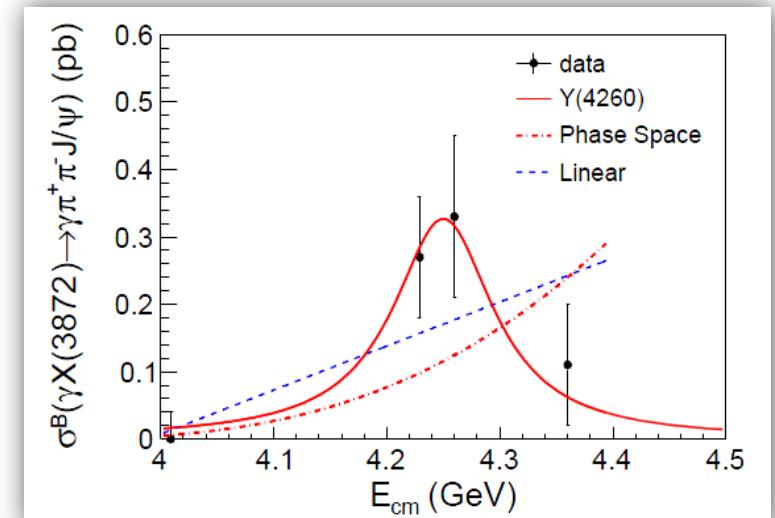
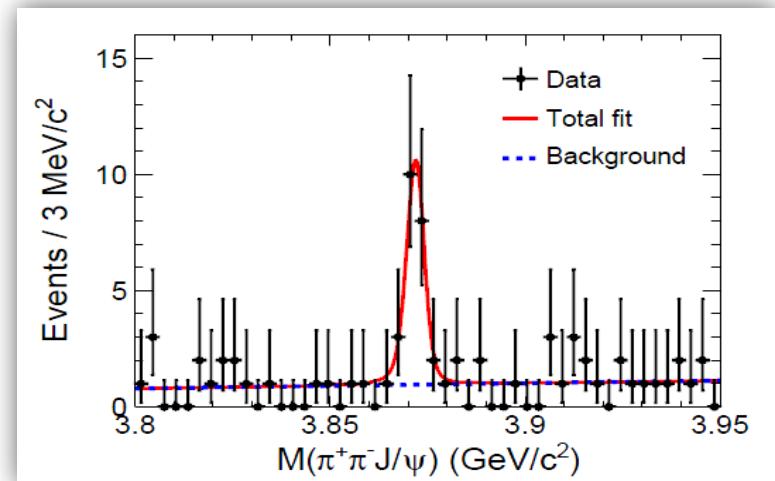
- 1*: PRL 110, 252001; 2*: PRL 115, 112003 ; 3*: PRL 112, 022001;
- 4*: PRD 92, 092006; 5*: arXiv:1509.05620; 6*: PRL 110, 252001;
- 7*: PRL 113, 212002; 8*: PRL 112, 132001 ; 9*: PRL 115, 182002

$$e^+ e^- \rightarrow \gamma X(3872)$$

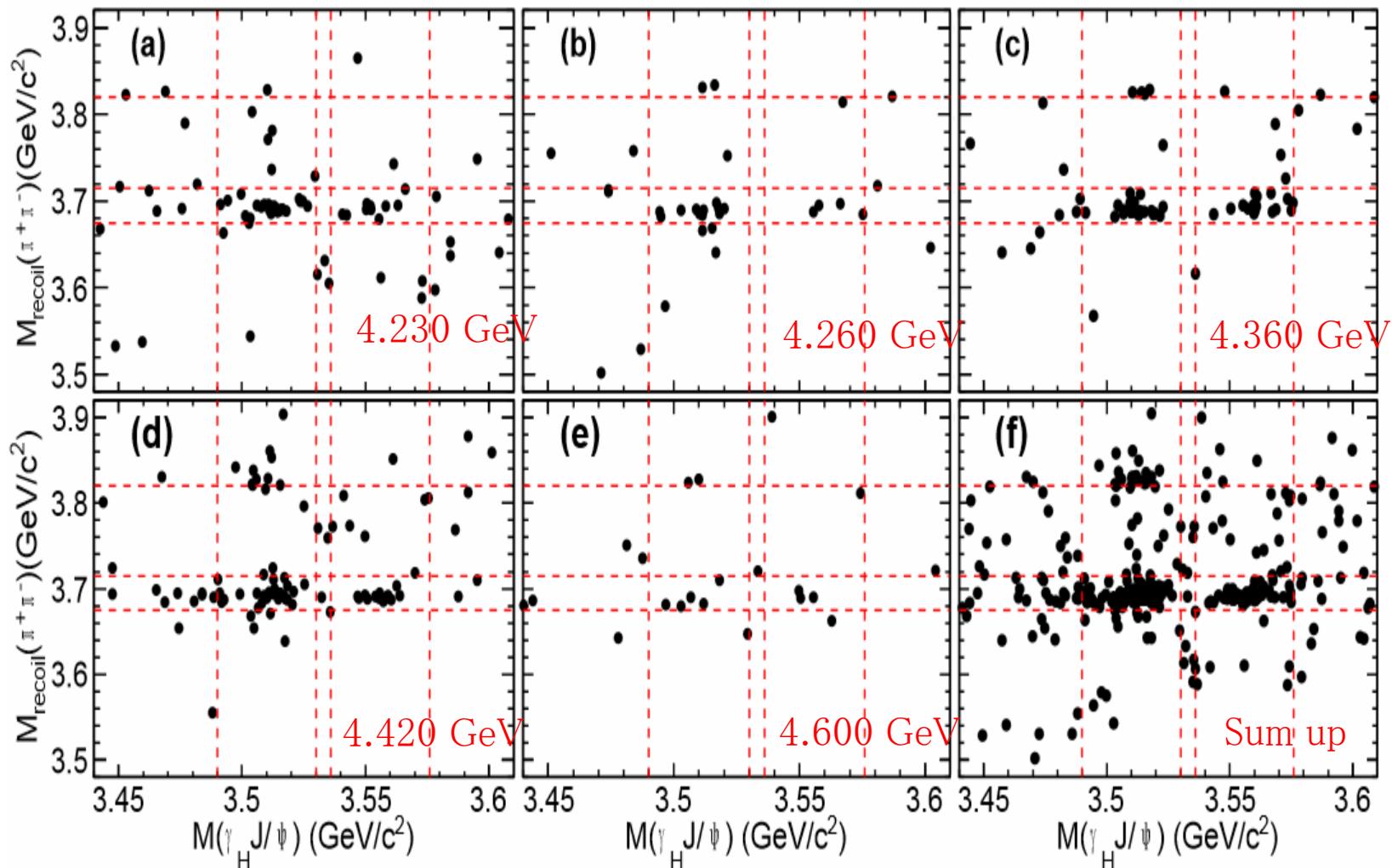
[BESIII RPL112,092001]

- Search for $\gamma X(3872)$ with $X(3872) \rightarrow \pi\pi J/\psi$ at $E_{cm} = 4.23, 4.26$ and 4.36 GeV
- summed over all data
 $X(3872)$ significance = 6.3σ
- Production in $Y(4260)$ decay suggestive, but not conclusive
- If from $Y(4260)$

$$\frac{B(Y(4260) \rightarrow \gamma X(3872))}{B(Y(4260) \rightarrow \pi^+ \pi^- J/\psi)} \sim 0.1$$



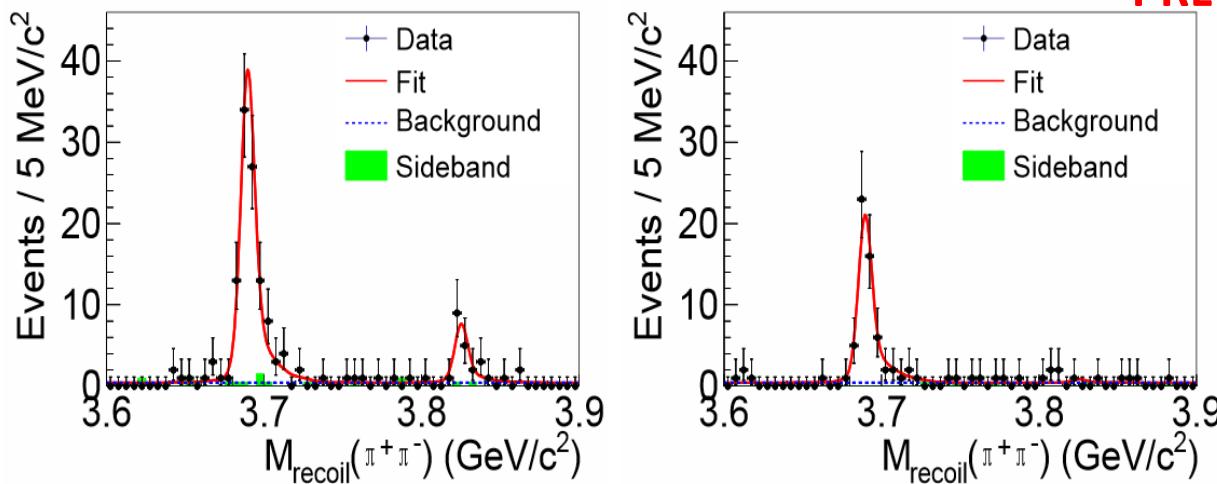
$$e^+ e^- \rightarrow \pi^+ \pi^- X(3823), X \rightarrow \gamma \chi_{cJ}, \chi_{cJ} \rightarrow \gamma J/\psi$$



$$e^+ e^- \rightarrow \pi^+ \pi^- X(3823), X \rightarrow \gamma \chi_{cJ}, \chi_{cJ} \rightarrow \gamma J/\psi$$

PRL 115, 011803 (2015)

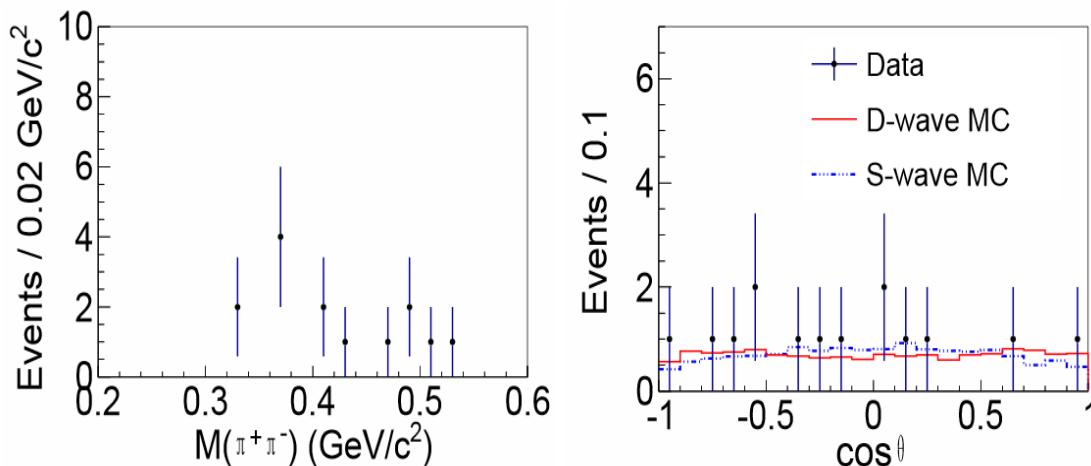
$\psi(1\ ^3D_2)$



Simultaneous fit of $\gamma \chi_{c1}$ (left) and $\gamma \chi_{c2}$ (right) events

$$M(X(3823)) = (3821.7 \pm 1.3(stat) \pm 0.7(syst)) \text{ MeV}/c^2$$

$$\Gamma(X(3823)) < 16 \text{ MeV at 90\% C.L. consist with Belle}$$

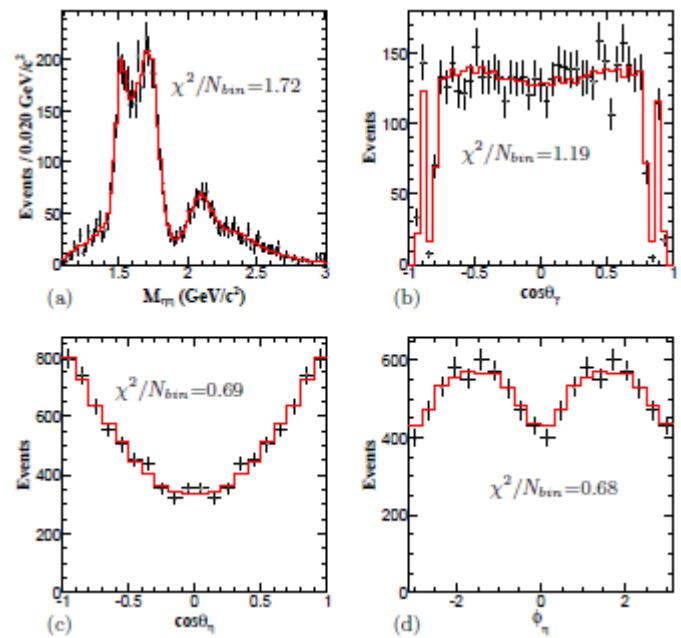
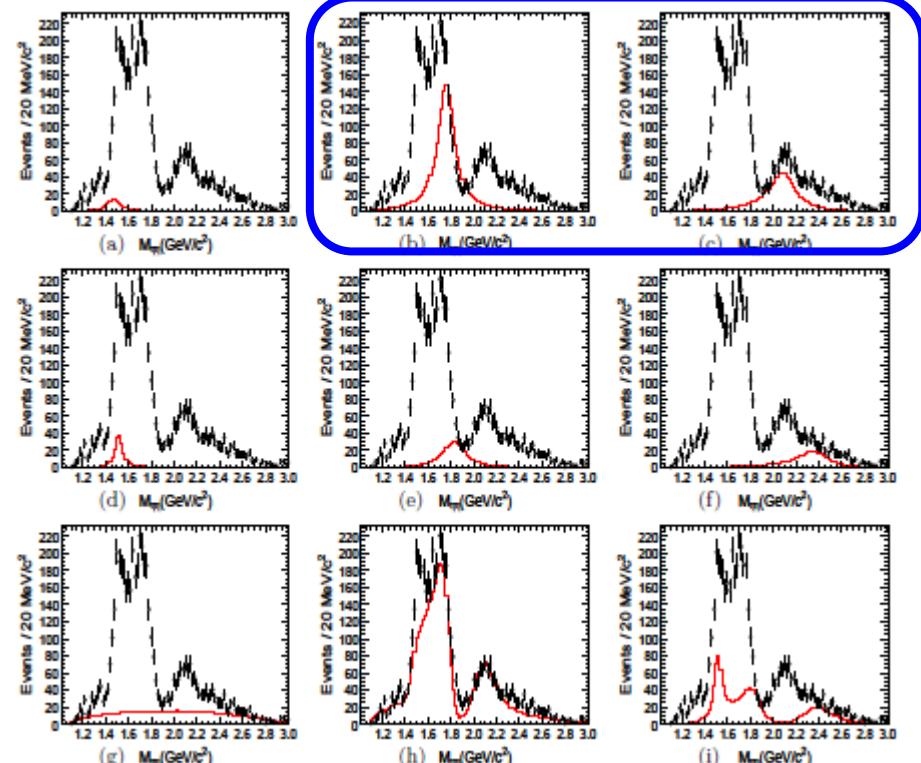


D-wave is expected.
Limited statistics
limited information

PWA of $J/\psi \rightarrow \gamma\eta\eta$

Phys. Rev. D87 092009 (2013)

	Resonance Mass(MeV/c^2)	Width(MeV/c^2)	$\mathcal{B}(J/\psi \rightarrow \gamma X \rightarrow \gamma\eta\eta)$	Significance
$f_0(1500)$	1468^{+14+23}_{-15-74}	$136^{+41+28}_{-26-100}$	$(1.65^{+0.26+0.51}_{-0.31-1.40}) \times 10^{-5}$	8.2σ
$f_0(1710)$	$1759 \pm 6^{+14}_{-25}$	$172 \pm 10^{+32}_{-16}$	$(2.35^{+0.13+1.24}_{-0.11-0.74}) \times 10^{-4}$	25.0σ
$f_0(2100)$	$2081 \pm 13^{+24}_{-38}$	273^{+27+70}_{-24-23}	$(1.13^{+0.09+0.64}_{-0.10-0.28}) \times 10^{-4}$	13.9σ
$f'_2(1525)$	$1513 \pm 5^{+4}_{-10}$	75^{+12+16}_{-10-8}	$(3.42^{+0.43+1.37}_{-0.51-1.30}) \times 10^{-5}$	11.0σ
$f_2(1810)$	1822^{+29+66}_{-24-57}	$229^{+52+88}_{-42-155}$	$(5.40^{+0.60+3.42}_{-0.67-2.35}) \times 10^{-5}$	6.4σ
$f_2(2340)$	$2362^{+31+140}_{-30-63}$	$334^{+62+165}_{-54-100}$	$(5.60^{+0.62+2.37}_{-0.65-2.07}) \times 10^{-5}$	7.6σ



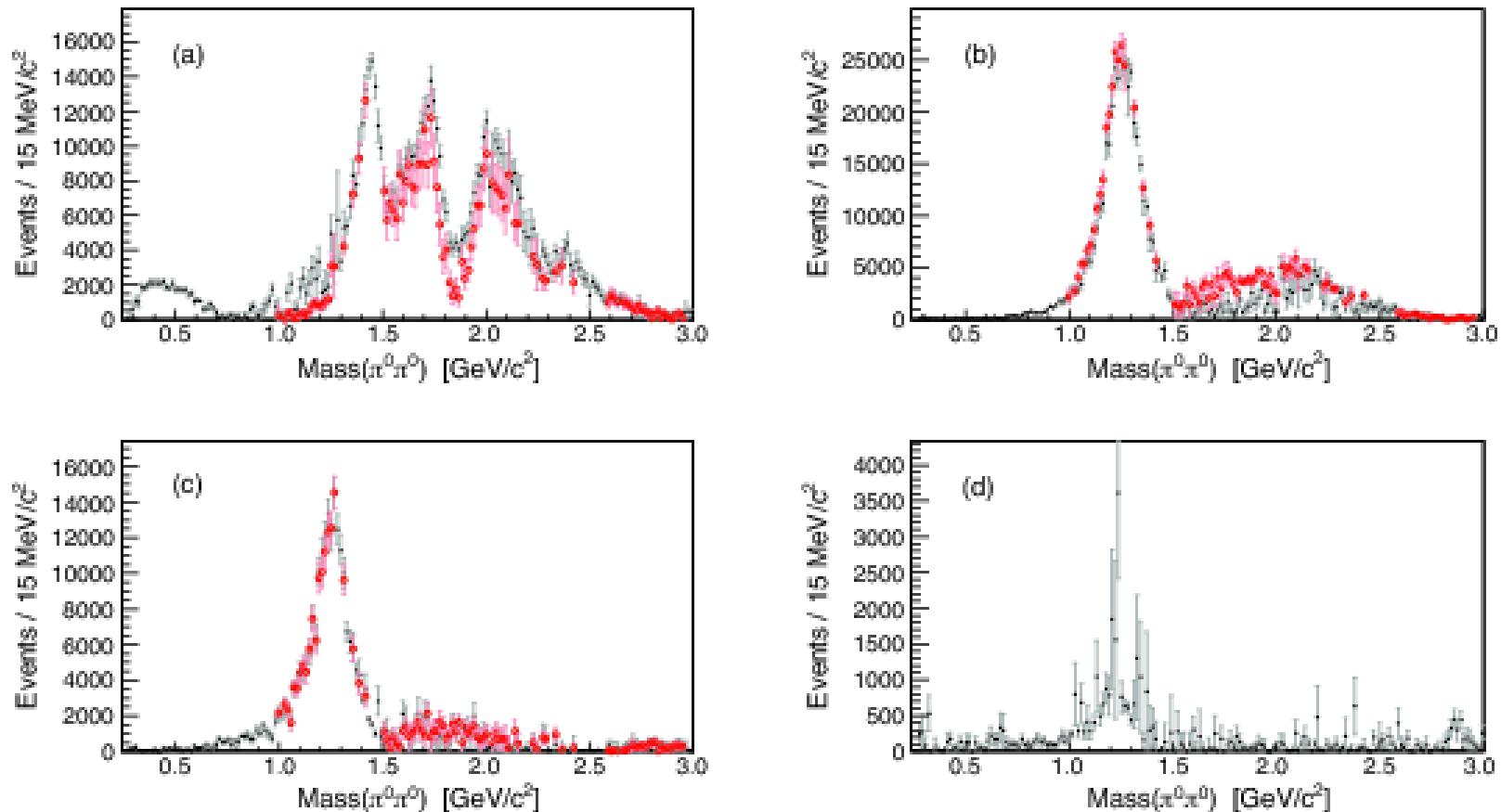
- Br of $f_0(1710)$ and $f_0(2100)$ are $\sim 10x$ larger than that of $f_0(1500)$
- Possible large overlap with LQCD predictions of 0^+ Glueball:

PRL 110 021601 (2013)

- Further studies of $J/\psi \rightarrow \gamma\eta\eta'$ and $J/\psi \rightarrow \gamma\eta'\eta'$ are crucial for glueball ID and solving the mixing scheme.

Model independent PWA of $J/\psi \rightarrow \gamma\pi^0\pi^0$

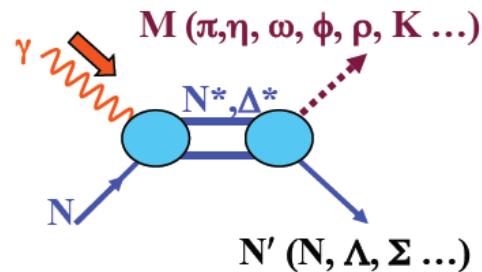
PRD 92, 052003 (2015.9)



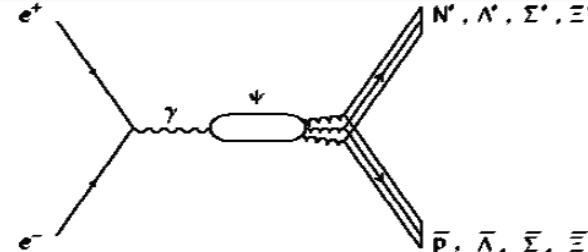
**Significant features of the scalar spectrum
include structures near 1.5, 1.7, and 2.0 GeV/ c^2**

Charmonium decays provide novel insights into baryons --- complementary to other experiments

JLAB, MAMI, ELSA,



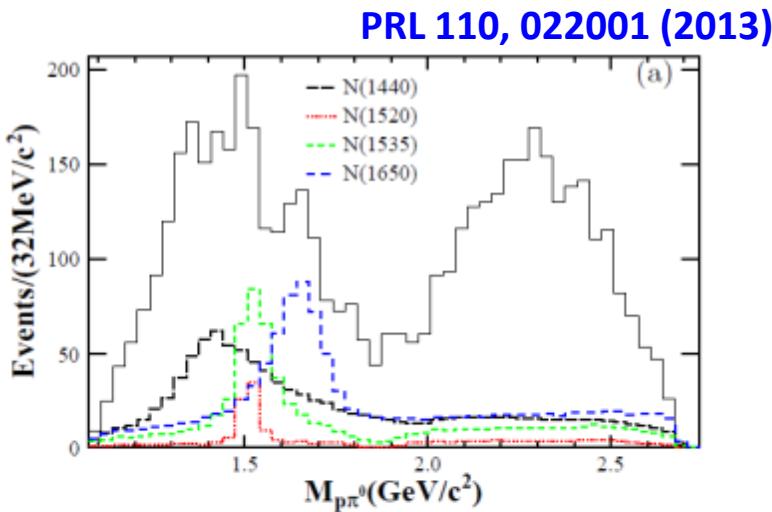
$J/\psi(\psi') \rightarrow \bar{B}BM \Rightarrow N^*, \Lambda^*, \Sigma^*, \Xi^*$



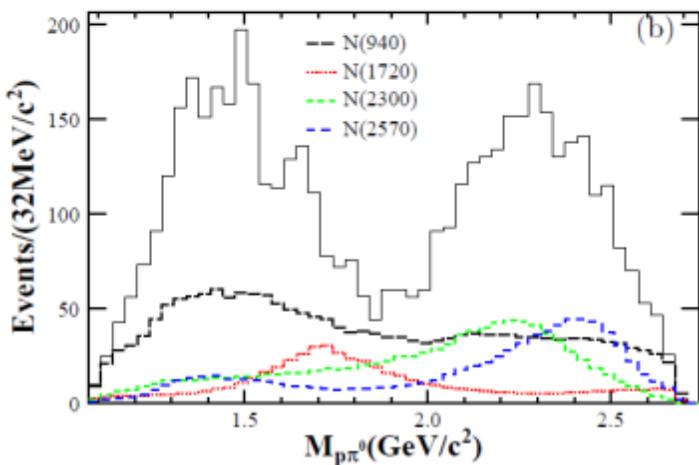
- ✓ Isospin 1/2 filter: $\psi \rightarrow N\bar{N}\pi, \psi \rightarrow N\bar{N}\pi\pi$
- ✓ Missing N^* with small couplings to πN & γN , but large coupling to $gggN$: $\psi \rightarrow N\bar{N}\pi/\eta/\eta'/\omega/\phi, \bar{p}\Sigma\pi, \bar{p}\Lambda K \dots$
- ✓ Not only N^* , but also $\Lambda^*, \Sigma^*, \Xi^*$
- ✓ Gluon-rich environment: a favorable place for producing hybrid (qqqg) baryons
- ✓ Interference between N^* and \bar{N}^* bands in $\psi \rightarrow N\bar{N}\pi$ Dalitz plots may help to distinguish some ambiguities in PWA of πN
- ✓ High statistics of charmonium @ BESIII

Study of N^* and Ξ^*

N^* in $\psi' \rightarrow \pi^0 p \bar{p}$

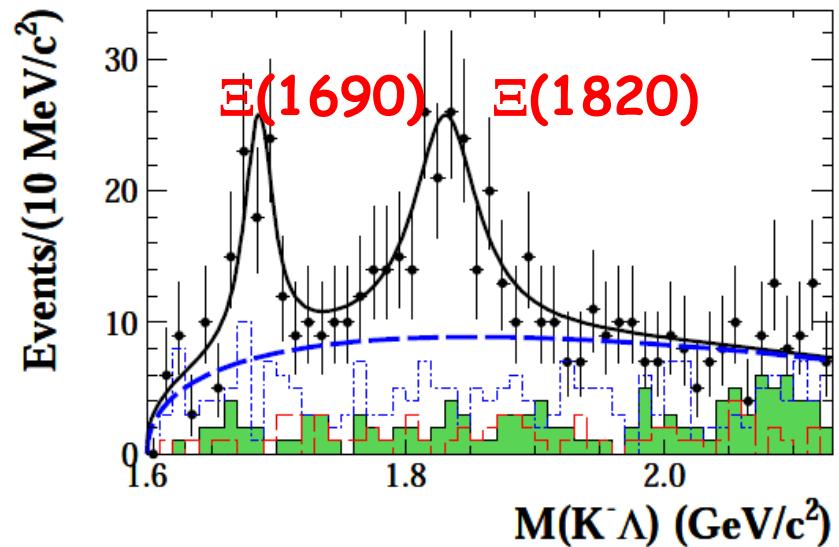


New N^* s: $N(2300)$ and $N(257$



Ξ^* in $\psi' \rightarrow K \Lambda \Xi$

PRD 91, 092006 (2015)



- PWA of

- $J/\psi(\psi') \rightarrow \pi^0 p \bar{p}$
- $J/\psi(\psi') \rightarrow \eta p \bar{p}$
- $J/\psi(\psi') \rightarrow p K \bar{\Lambda}$
- ...

Charm physics at BESIII

Advantage of open charm at threshold

e⁺e⁻ colliders@threshold:

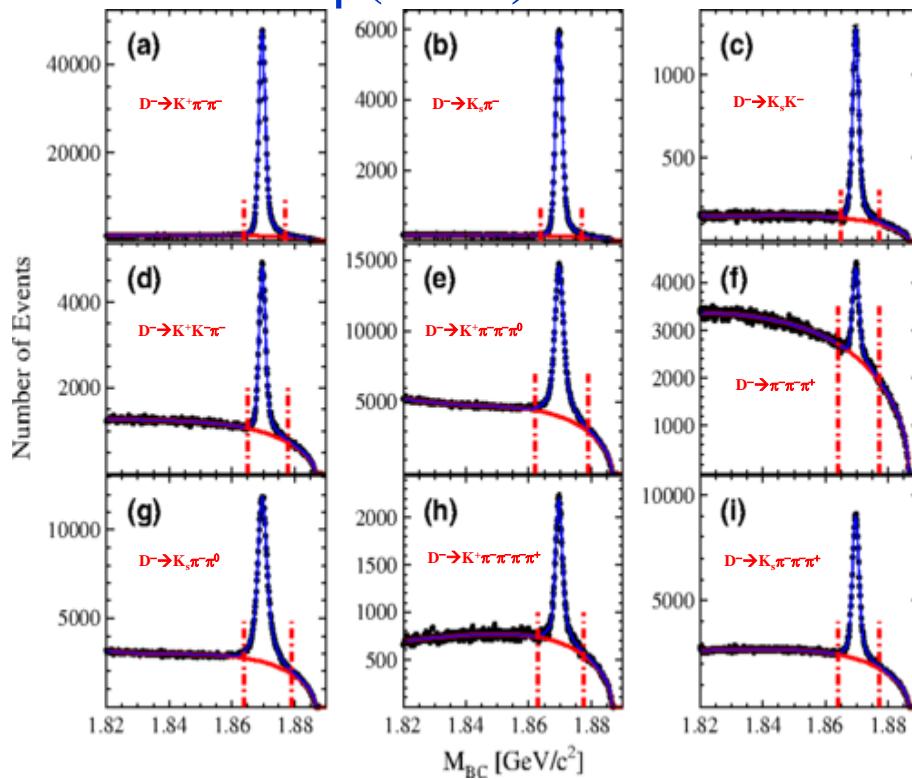
$$e^+e^- \rightarrow \Psi(3770) \rightarrow D^0\bar{D}^0 \quad [C = -1] \quad \text{OR} \quad e^+e^- \rightarrow \gamma^* \rightarrow D^0\bar{D}^0\gamma \quad [C = +1]$$

Good for charm flavor physics:

- **Threshold production: clean**
- **Known initial energy and quantum numbers**
- **Both D and Dbar fully reconstructed (double tag)**
- **Absolute measurements**

Measurement of $B[D^+ \rightarrow \mu^+ \nu]$, f_{D^+} and $|V_{cd}|$

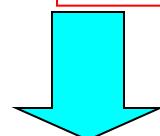
$e^+e^- \rightarrow \psi(3770) \rightarrow D^+D^-$



$$N_{D_s^+ \text{tag}} = (170.31 \pm 0.34) \times 10^4$$

$$B[D^+ \rightarrow \mu^+ \nu] = (3.71 \pm 0.19 \pm 0.06) \times 10^{-4}$$

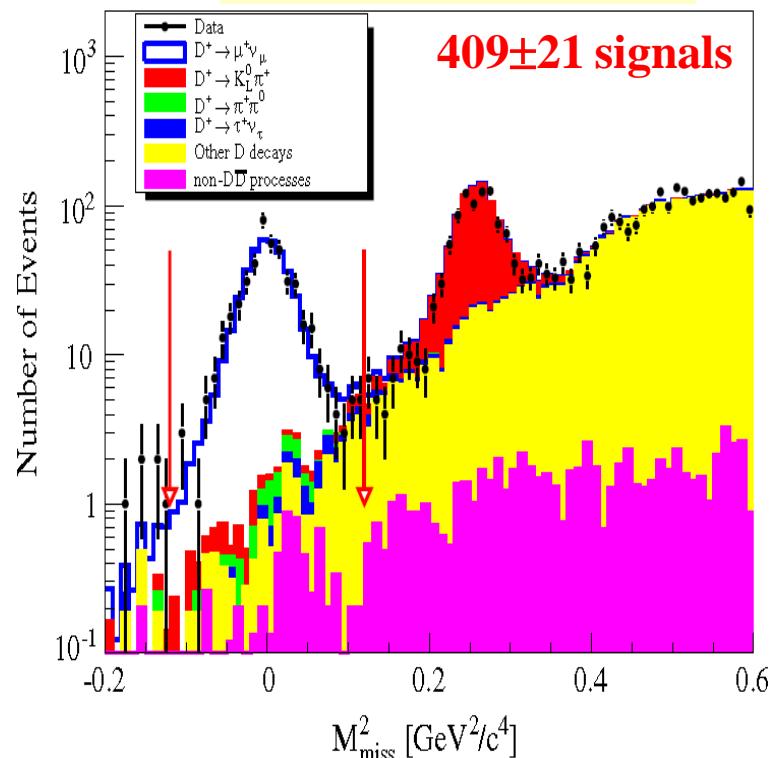
Input t_{D^+} , m_{D^+} , m_{μ^+} on PDG
and $|V_{cd}|$ of CKM-Fitter



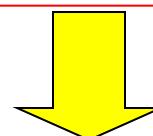
$$f_{D^+} = (203.2 \pm 5.3 \pm 1.8) \text{ MeV}$$

2.92 fb^{-1} data@ 3.773 GeV

PRD89(2014)051104R

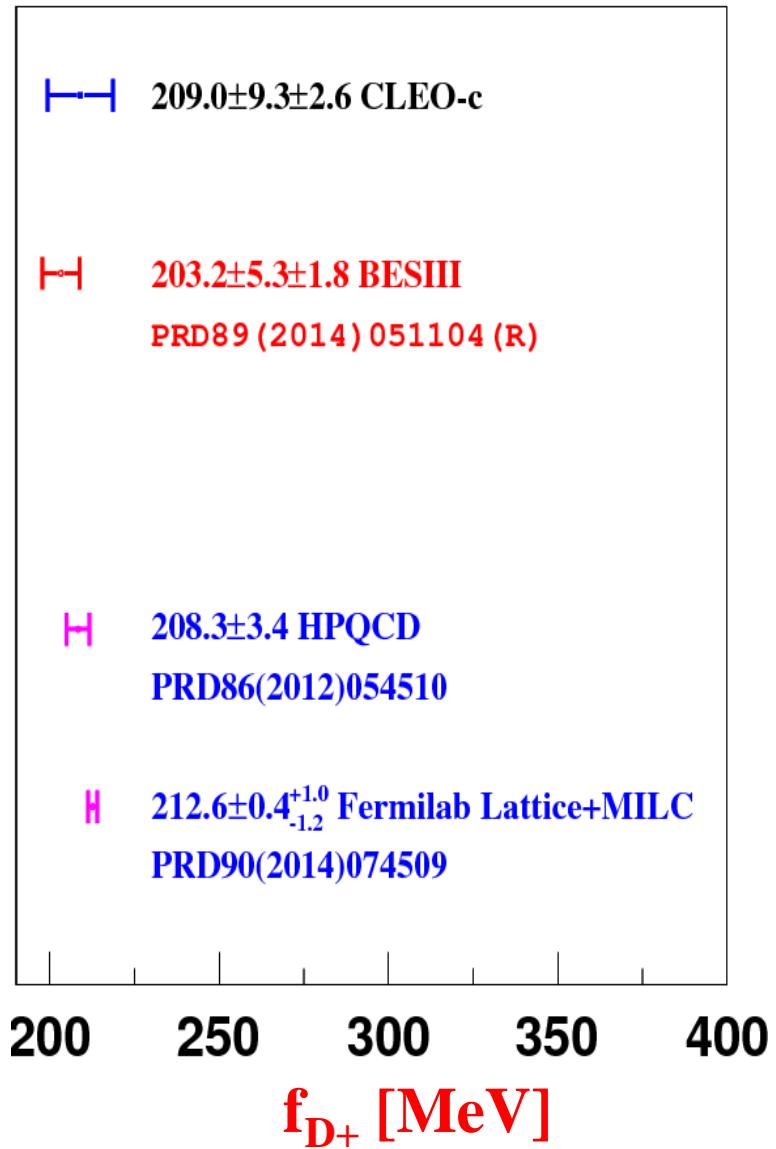
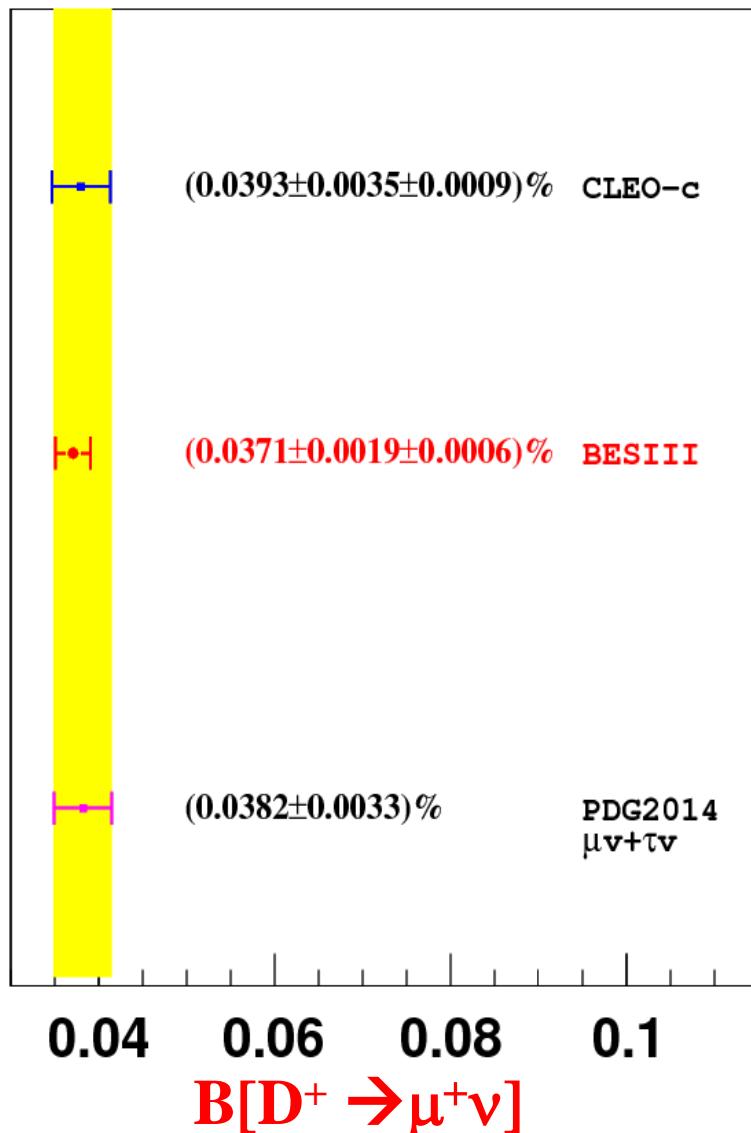


Input t_{D^+} , m_{D^+} , m_{μ^+} on PDG and
LQCD calculated $f_{D^+} = 207 \pm 4$
MeV[PRL100(2008)062002]

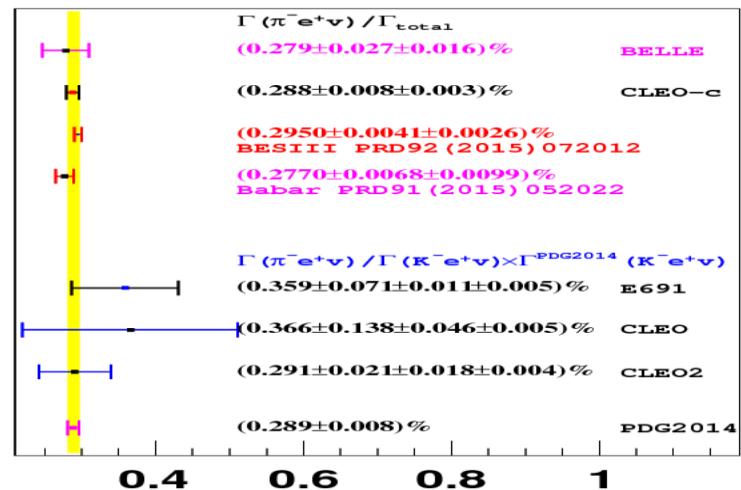
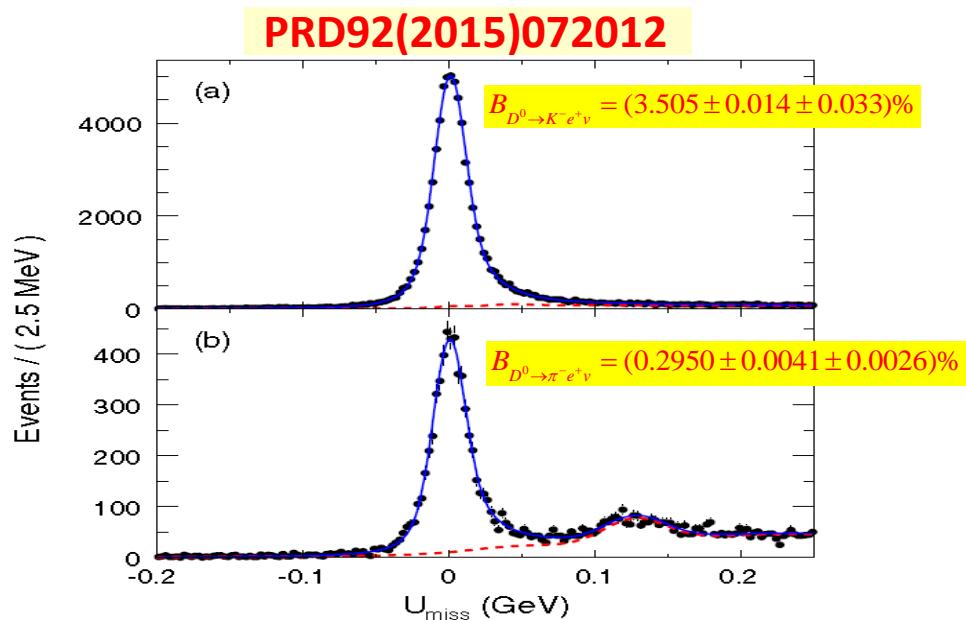
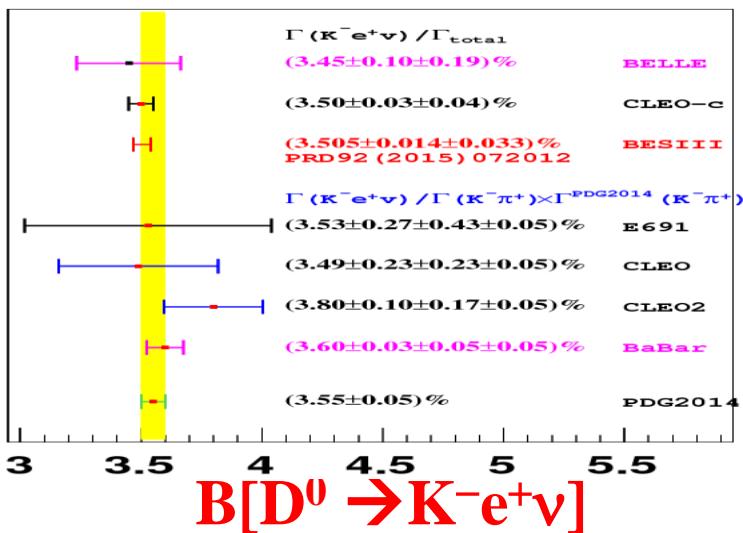
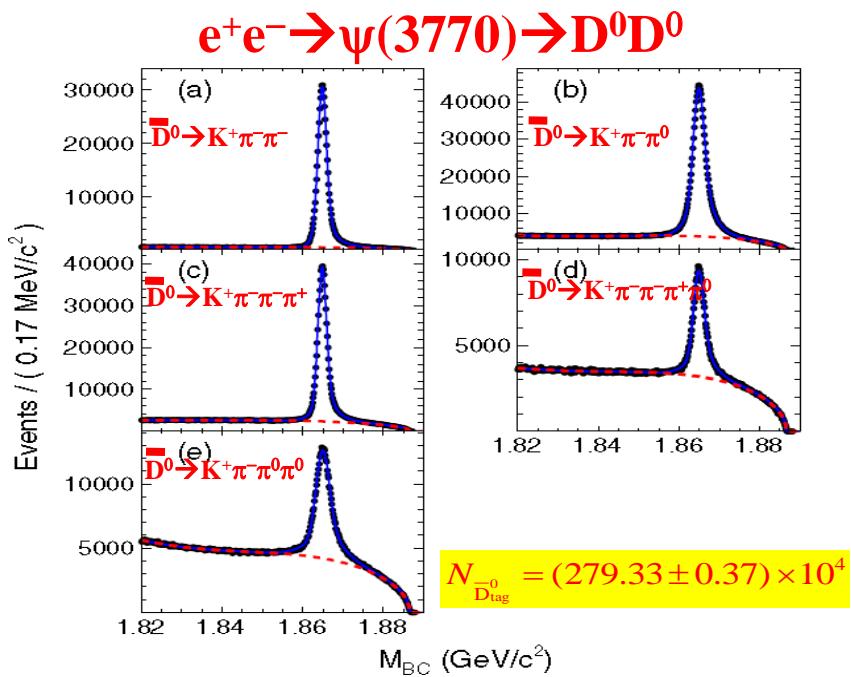


$$|V_{cd}| = 0.2210 \pm 0.0058 \pm 0.0047$$

Comparisons of $B[D^+ \rightarrow \mu^+ \nu_\mu]$ and f_{D^+}

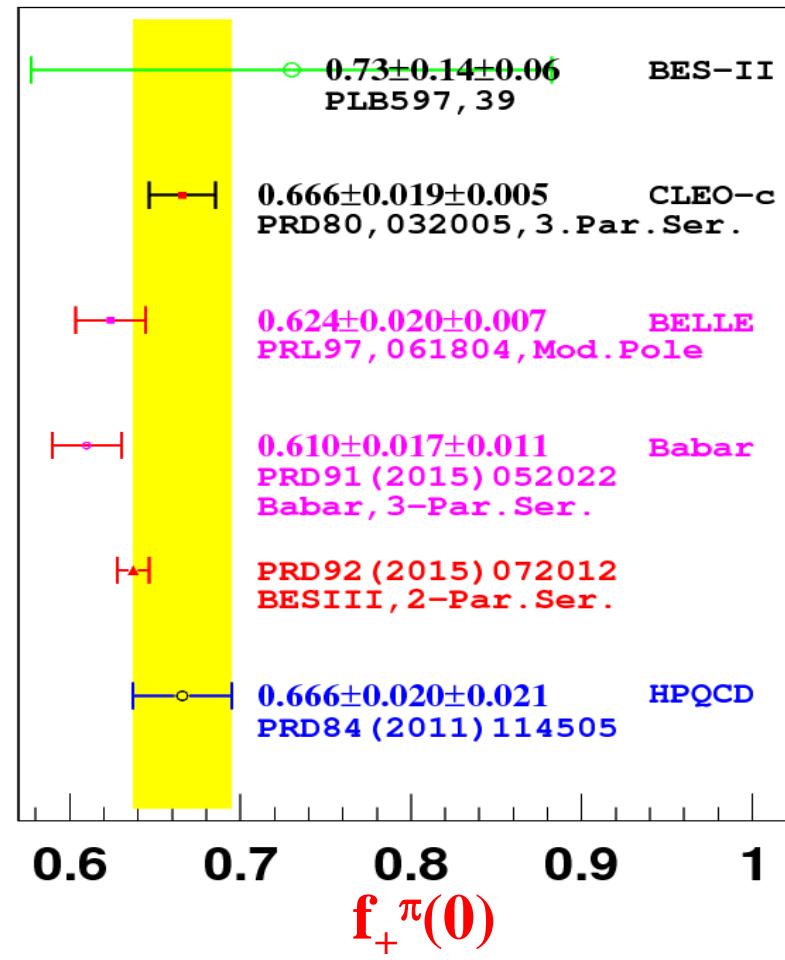
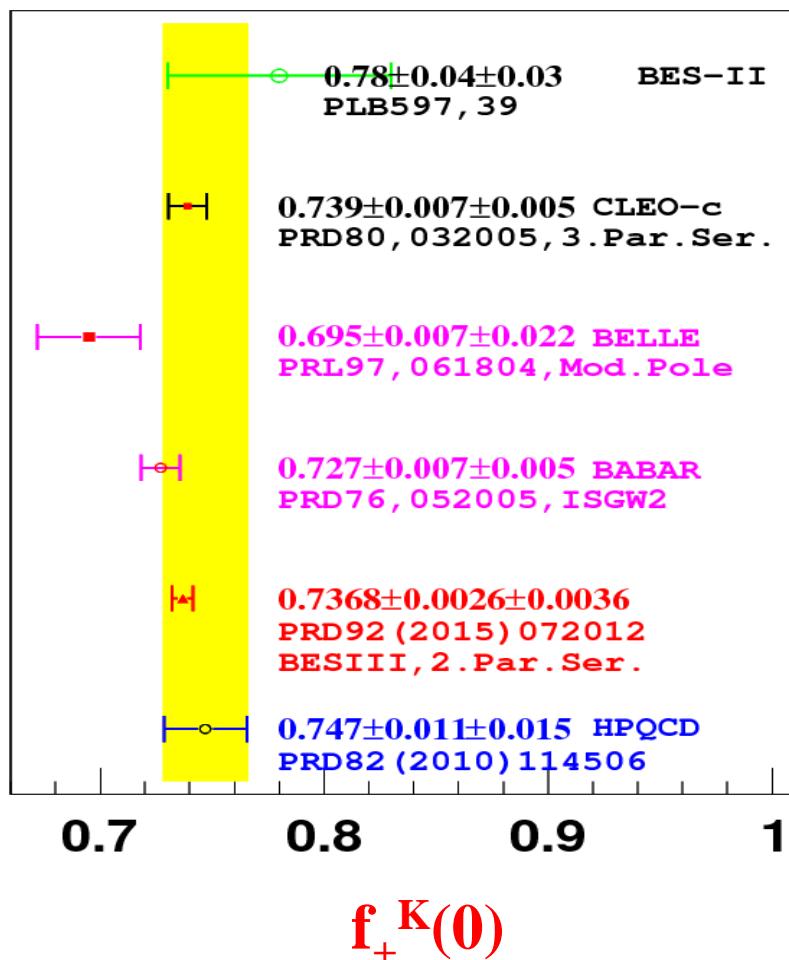


Measurement of $B[D^0 \rightarrow K(\pi)^- e^+ \nu]$



$B[D^0 \rightarrow \pi^-\bar{e}\nu]$

Measurement of $f_+ K(0)$



Measurement of $|V_{cs(d)}|$

Method 1

$$B[D_{(s)}^+ \rightarrow l^+ \nu]$$

Input $t_{D_s}, m_{D_s}, m_{\mu^+}$ on PDG and LQCD calculated $f_{D(s)+}$

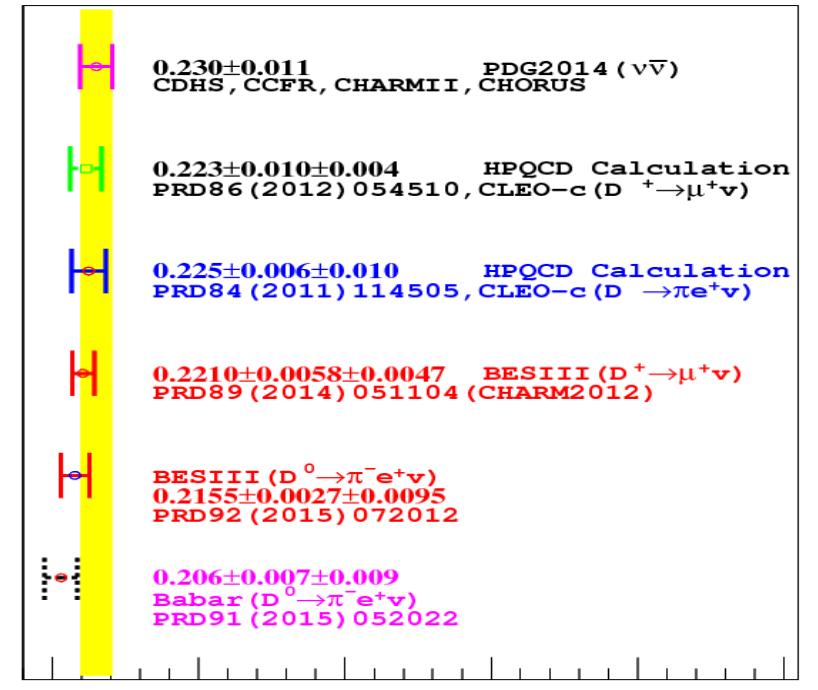
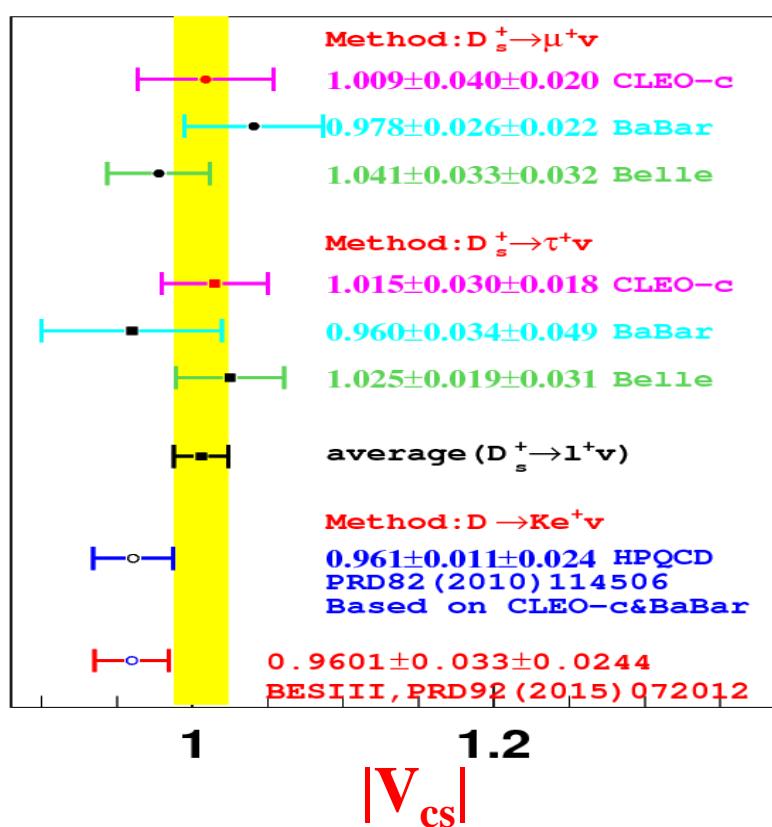
$$|V_{cd(s)}|$$

Method 2

$$f_{D \rightarrow K(\pi)_+}(0) |V_{cs(d)}|$$

Input $f_{D \rightarrow K(\pi)_+}(0)$ of LQCD

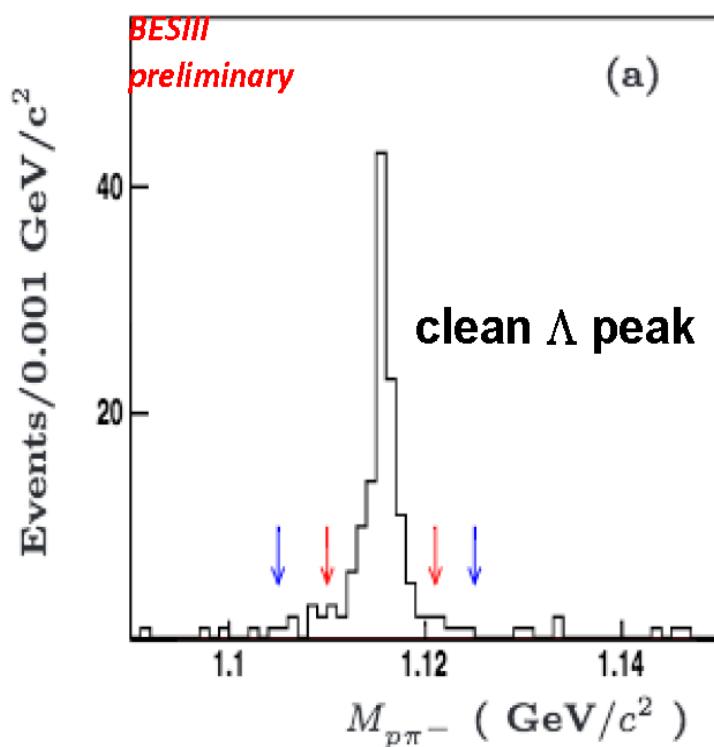
$$|V_{cs(d)}|$$



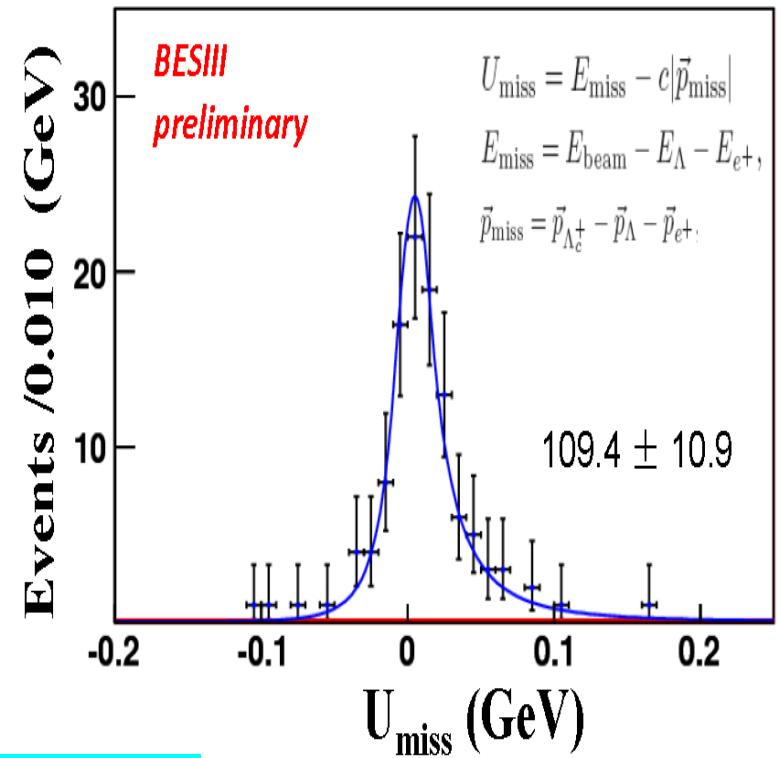
Method 2 suffers larger theoretical uncertainty in $f_{+}^{D \rightarrow K(\pi)}(0)$ [1.7(4.4)%]

Absolute BF for $\Lambda_c^+ \rightarrow \Lambda e^+ \nu$

LQCD calculations on the BF ranges from 1% to 9%



0.57 fb^{-1} data @ 4.599 GeV



$\mathbf{B[\Lambda_c^+ \rightarrow \Lambda e^+ \nu] = (3.76 \pm 0.35 \pm \Delta_{\text{sys}})\%}$ First absolute measurement

PDG: $(2.0 \pm 0.6)\%$

arXiv:1510.02610, Accepted by PRL

Test on LQCD calculations with significantly better precision

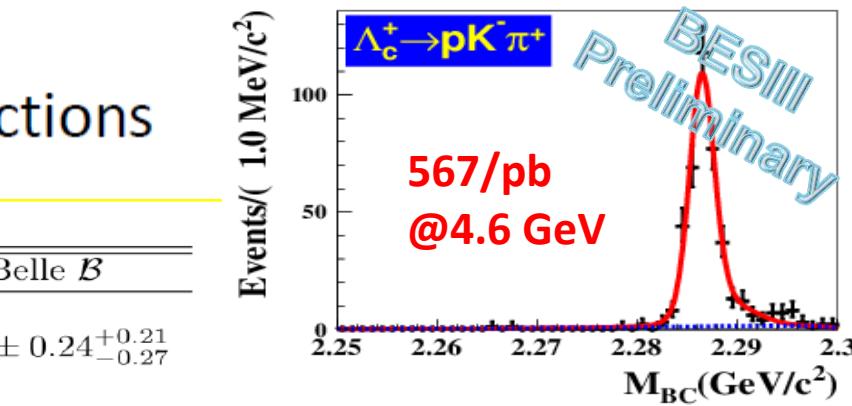
• Precise study of Λ_c decays

stringent test on Heavy Quark Effective Theory

- absolute branching fractions (BF) of Λ_c^+ decays suffers from large uncertainties since its discovery 30 years ago
- hadronic decays:
to explore as-yet-unmeasured channels and understand full picture of intermediate structures
- semi-leptonic decays:
test on form factor predictions

BESIII prel.			
Decay modes	global fit \mathcal{B}	PDG \mathcal{B}	Belle \mathcal{B}
pK_S	1.48 ± 0.08	1.15 ± 0.30	
$pK^-\pi^+$	5.77 ± 0.27	5.0 ± 1.3	$6.84 \pm 0.24^{+0.21}_{-0.27}$
$pK_S\pi^0$	1.77 ± 0.12	1.65 ± 0.50	
$pK_S\pi^+\pi^-$	1.43 ± 0.10	1.30 ± 0.35	
$pK^-\pi^+\pi^0$	4.25 ± 0.22	3.4 ± 1.0	
$\Lambda\pi^+$	1.20 ± 0.07	1.07 ± 0.28	
$\Lambda\pi^+\pi^0$	6.70 ± 0.35	3.6 ± 1.3	
$\Lambda\pi^+\pi^-\pi^+$	3.67 ± 0.23	2.6 ± 0.7	
$\Sigma^0\pi^+$	1.28 ± 0.08	1.05 ± 0.28	
$\Sigma^+\pi^0$	1.18 ± 0.11	1.00 ± 0.34	
$\Sigma^+\pi^+\pi^-$	3.58 ± 0.22	3.6 ± 1.0	
$\Sigma^+\omega$	1.47 ± 0.18	2.7 ± 1.0	

only stat. errors



- ✓ **$B(pK^-\pi^+)$: BESIII precision comparable with Belle's result**
- ✓ **BESIII rate $B(pK^-\pi^+)$ is smaller**
- ✓ **Improved precisions of the other 11 modes significantly**

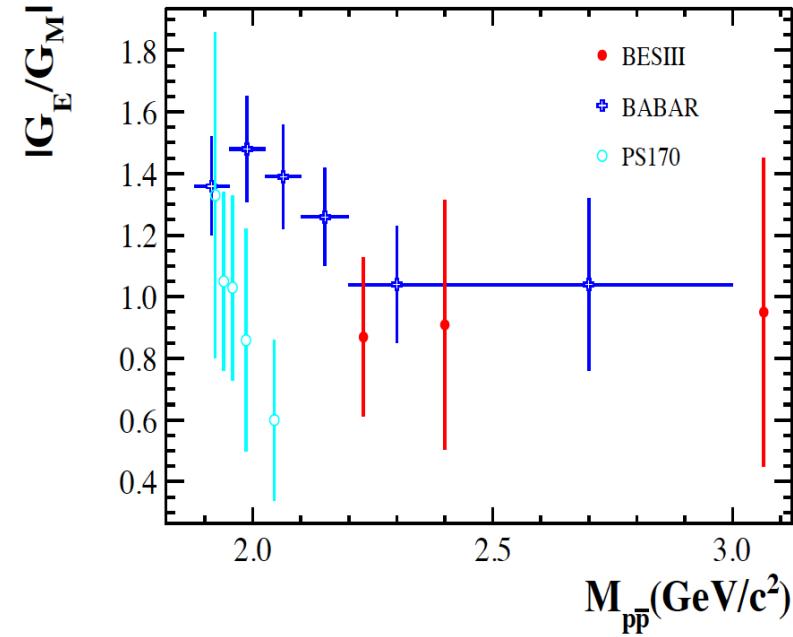
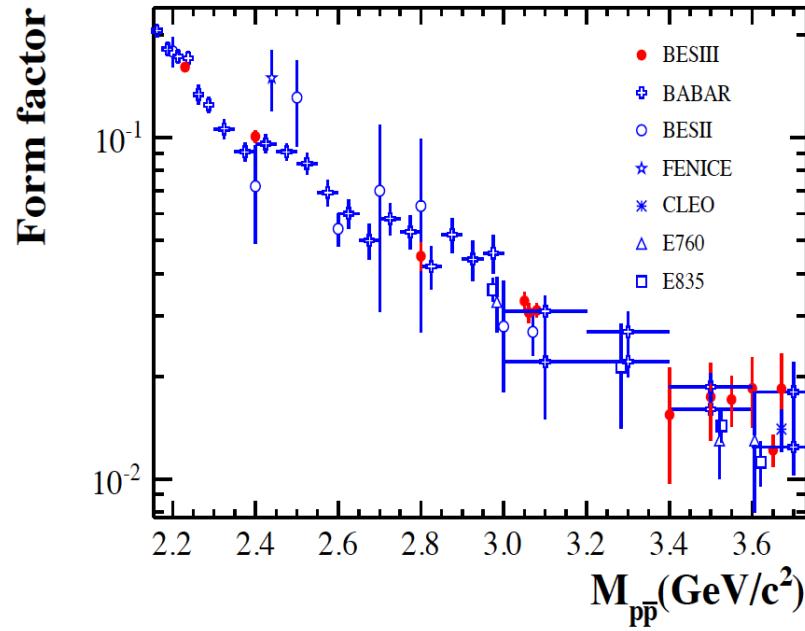
Proton form factor measurement

[Phys. Rev. D91, 112004 \(2015\)](#)

Analysis Features:

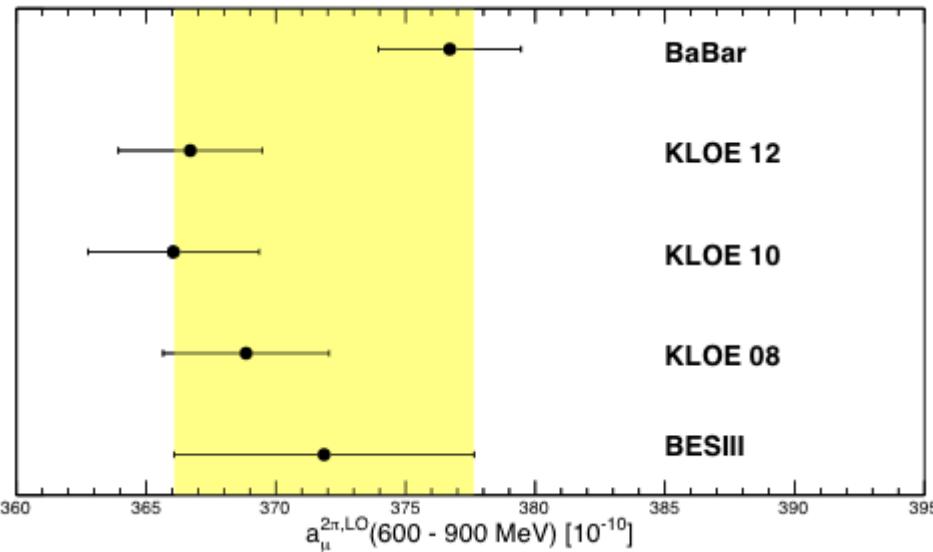
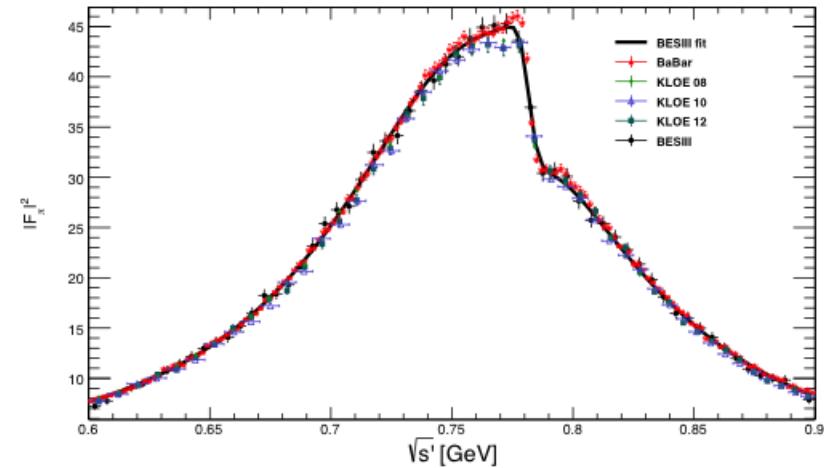
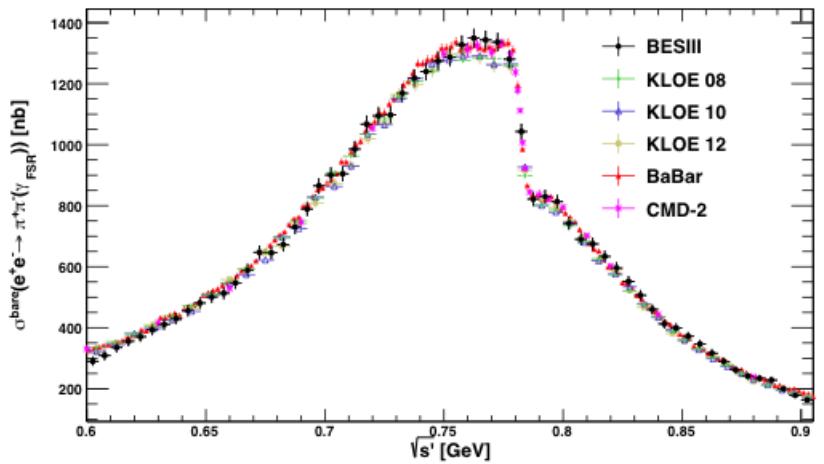
- Radiative corrections from Phokhara8.0 (scan)
- Normalization to $e^+e^- \rightarrow e^+e^-$, $e^+e^- \rightarrow \gamma\gamma$ (BABAYAGA 3.5)
- Efficiencies 60% (2.23 GeV) 3% (~ 4 GeV)
- $|G_E/G_M|$ ratio obtained for 3 c.m. energies

E_{cm}/GeV	L_{int} / pb^{-1}
2.23	2.6
2.40	3.4
2.80	3.8
3.05, 3.06, 3.08	60.7
3.40, 3.50, 3.54, 3.56	23.3
3.60, 3.65, 3.67	63.0



$\sigma(e^+e^- \rightarrow \pi^+\pi^-)$ and form factor

ISR Analysis using 2.9 fb⁻¹ data at $\Psi(3770)$: $e^+e^- \rightarrow \pi^+\pi^-\gamma_{ISR}$



Exp.	$a_\mu^{2\pi,\text{LO}} (600 - 900 \text{ MeV}) [10^{-10}]$
BaBar	$376.7 \pm 2.0_{\text{stat}} \pm 1.9_{\text{sys}}$
KLOE08	$368.9 \pm 0.4_{\text{stat}} \pm 2.3_{\text{sys,exp}} \pm 2.2_{\text{sys,theo}}$
KLOE10	$366.1 \pm 0.9_{\text{stat}} \pm 2.3_{\text{sys,exp}} \pm 2.2_{\text{sys,theo}}$
KLOE12	$366.7 \pm 1.2_{\text{stat}} \pm 2.4_{\text{sys,exp}} \pm 0.8_{\text{sys,theo}}$
BESIII	$371.9 \pm 2.6_{\text{stat}} \pm 5.2_{\text{sys}}$

BESIII upgrade

- MDC: Malter effect found in inner chamber in 2012,
water vapor added to the chamber to cure the aging
problem.
 - New inner chamber built at IHEP. Ready this summer.
 - CGEM as the inner chamber ongoing : Italy group in
collaboration with groups in Germany, Sweden and IHEP.

- New ETOF (built by USTC & IHEP) just installed successfully
this summer to improve the time resolution (100ps → 55ps)

BESIII data taking status & plan (run ~8 years)

	Previous data	BESIII present & future	Goal
J/ ψ	BESII: 58 M	1.2 B (20* BESII)	10 B
ψ'	CLEO-c: 28 M	0.5 B (20* CLEO-c)	3 B
ψ''	CLEO-c: 0.8/fb	2.9/fb (3.5*CLEO-c)	20/fb
Above open charm threshold	CLEO-c: 0.6/fb @ $\psi(4160)$	0.5/fb @ $\psi(4040)$ 2.3/fb @~4260, 0.5/fb @4360 0.5/fb @4600, 1/fb @4420	5-10/fb
R scan & Tau	BESII	3.8 – 4.6 GeV @105 energy points 2.0 – 3.1 GeV @ 20 energy points	
$\Upsilon(2175)$		100/pb	
$\psi(4170)$		3/fb (next run)	