Recent Results from BESIII

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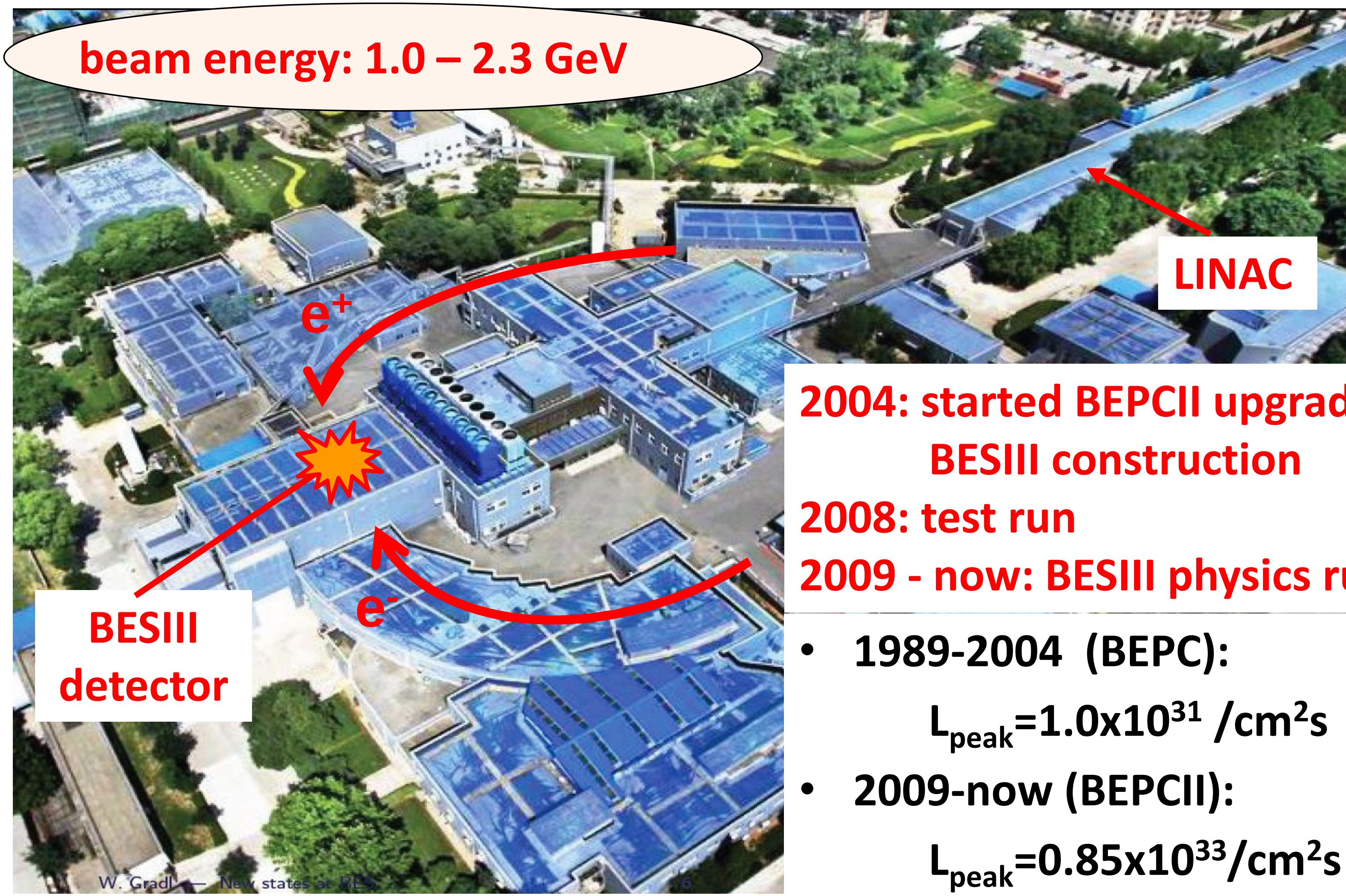
Outline

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

Beijing Electron Positron Collider (BEPC)



2004: started BEPCII upgrade, BESIII construction

2008: test run

2009 - now: BESIII physics run

- **1989-2004 (BEPC):** $L_{peak}=1.0\times10^{31}\ /cm^2s$
- **2009-now (BEPCII):** $L_{peak}=0.85\times10^{33}/cm^2s$

Upgraded BEPC-BEPCII

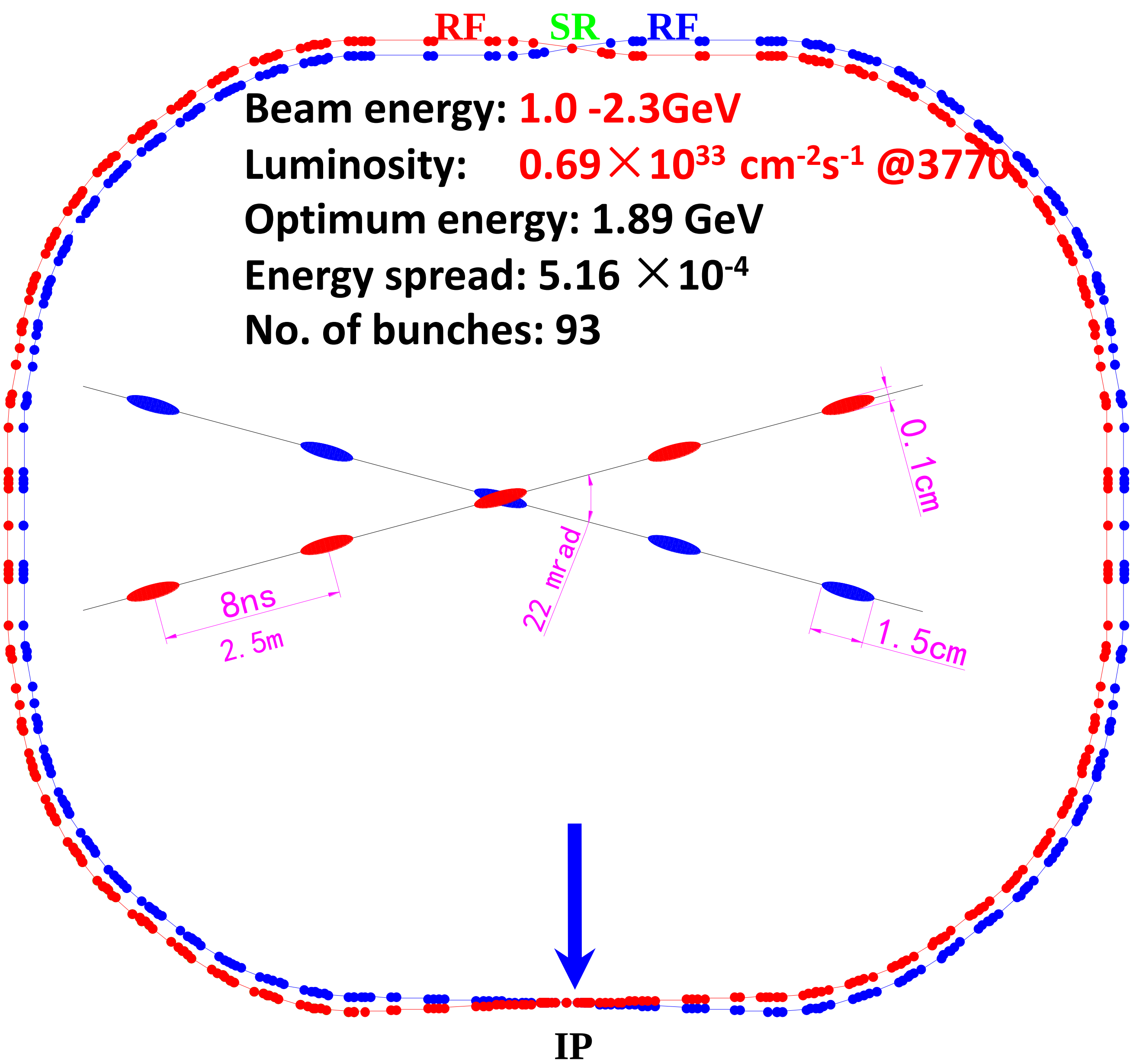
Beam energy: 1.0 -2.3GeV

Luminosity: 0.69×10^{33} $cm^{-2}s^{-1}$ @3770

Optimum energy: 1.89 GeV

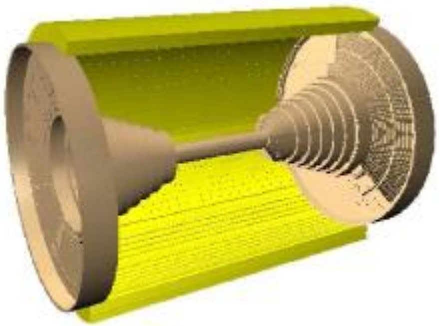
Energy spread: 5.16 ×10^{-4}

No. of bunches: 93



BESIII Detector

MDC

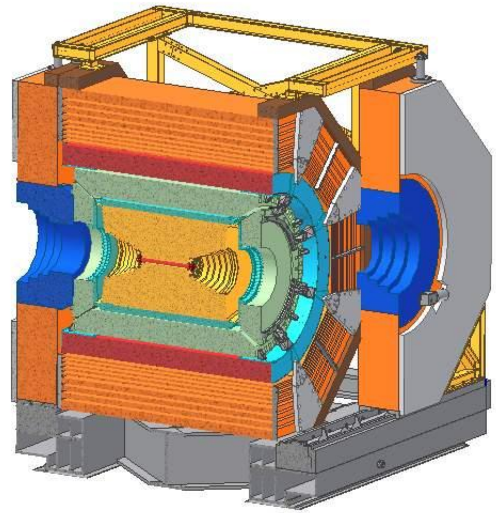


R inner: 63mm ;

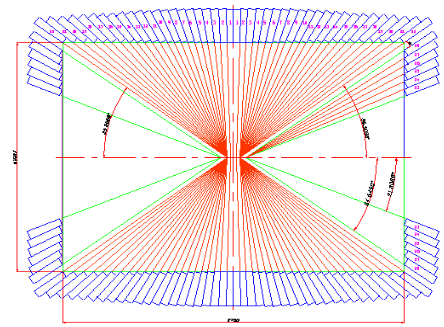
R outer: 810mm

Length: 2582 mm

Layers: 43



CsI(Tl) EMC



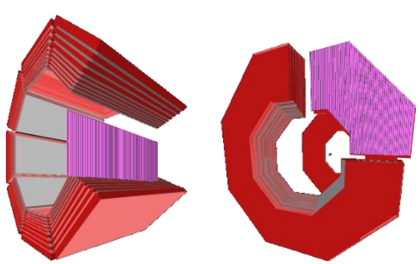
Crystals: 28 cm(15 X_0)

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

Endcap:

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

RPC MUC



BMUC: 9 layers – 72 modules

EMUC: 8 layers – 64 modules

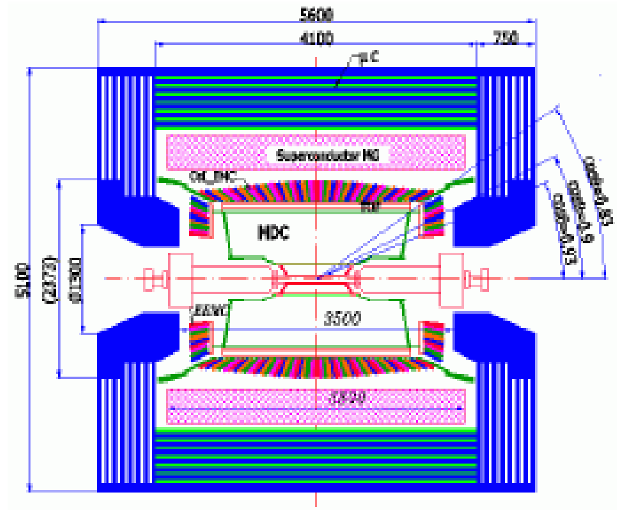
TOF

BTOF: two layers

ETOF: 48 crys. 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%

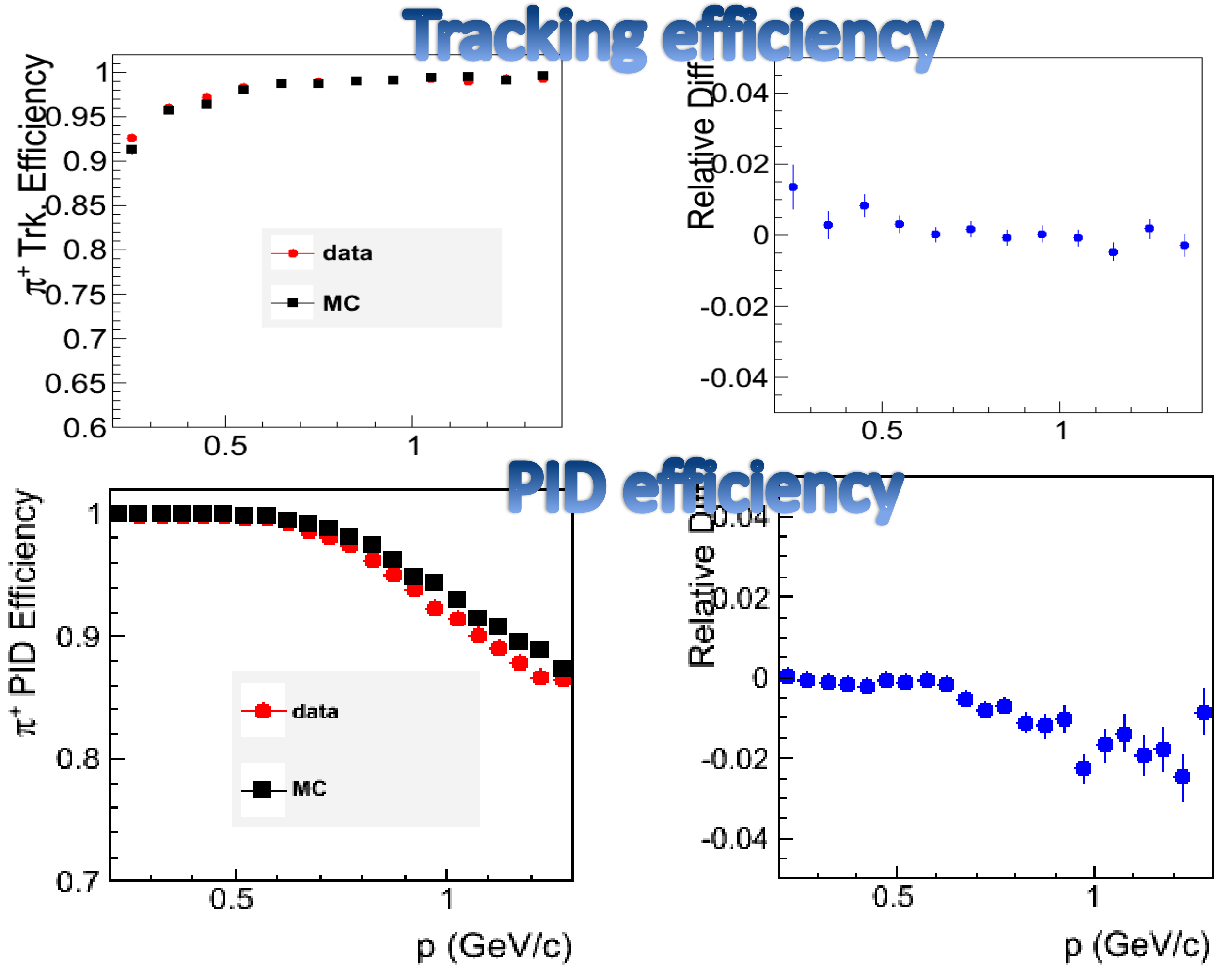


Exps.	TOF time resolution
CDFII	100 ps
Belle	90 ps
BESIII (XYZ data)	68 ps (BTOF) 100 ps (ETOF)

- New ETOF (MRPC), will be installed
- New Inner MDC, being built

Data/Monte-Carlo Consistency

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



BESIII Collaboration

Europe (13)

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, Ferrara Univ.
Netherland: KVI/Univ. of Groningen
Sweden: Uppsala Univ.
Turkey: Turkey Accelerator Center

US (5)

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

Mongolia (1)

Institute of phys. & Tech.

Korea (1)

Seoul Nat. Univ.

Japan (1)

Tokyo Univ.

Pakistan (2)

Univ. of Punjab
COMSAT CIIT

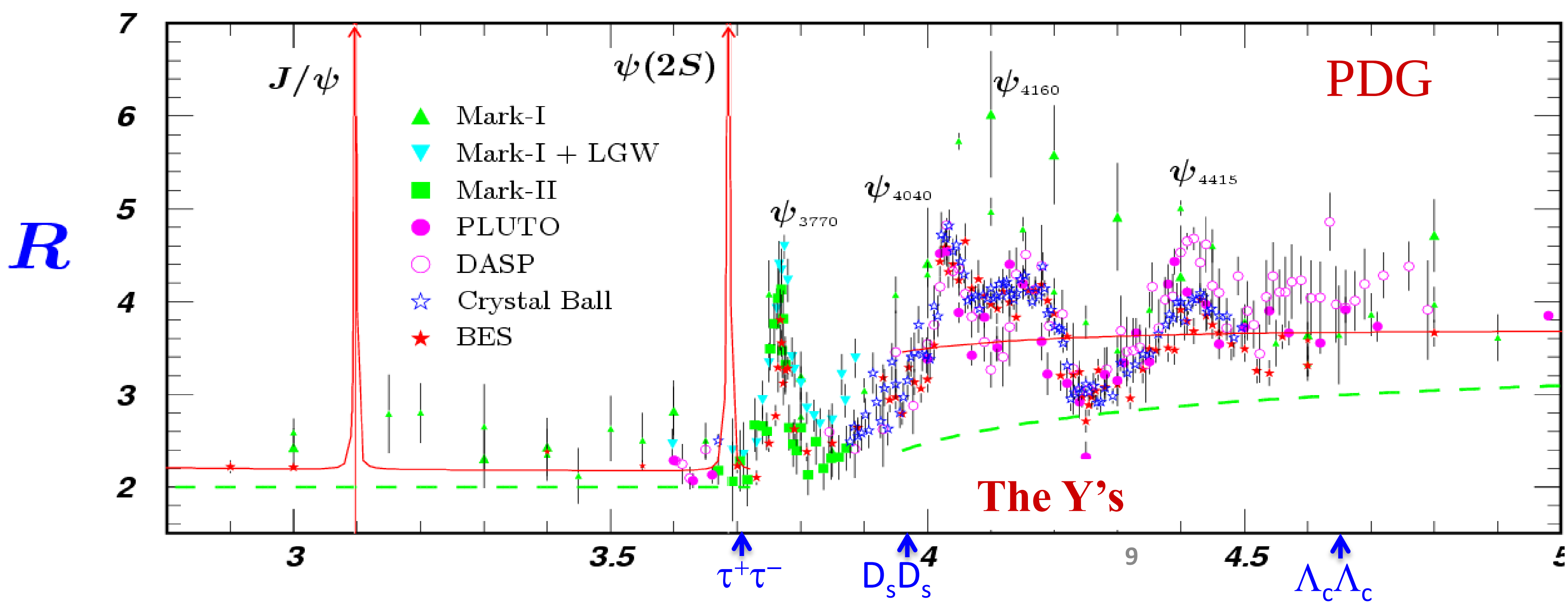
China(32)

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., Beihang 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.
Univ. of Sci. & Tech. Liaoning

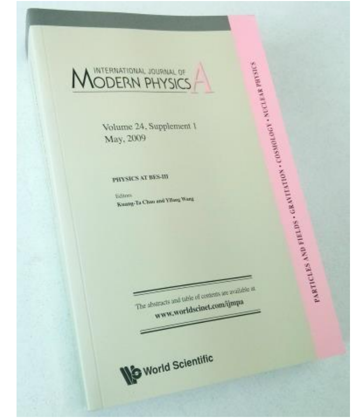
~400 members
from 55 institutions in 12 countries

Features of the BEPC Energy Region

- Rich of **resonances:** charmonia and charmed mesons
- **Threshold** characteristics (pairs of 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



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

- Hadron spectroscopy
  - search for the new forms of hadrons
  - meson spectroscopy
  - baryon spectroscopy
- Study of the production and decay mechanisms of charmonium states: J/ψ, $\psi(2S)$, $\eta_c(1S)$, $\chi_{C\{0,1,2\}}$, $\eta_c(2S)$, $h_c(^1P_1)$, $\psi(3770)$, etc.

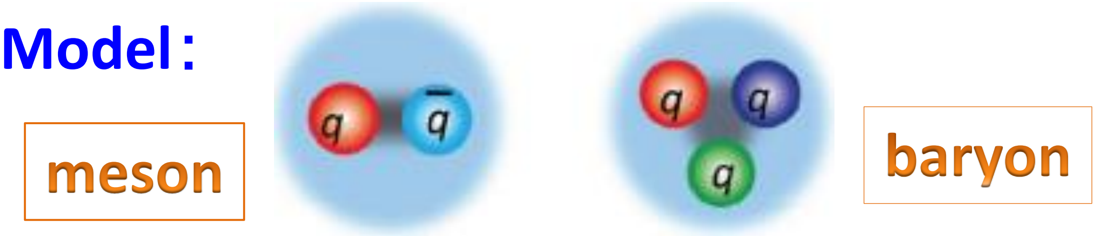
  Calibrate QCD

  XYZ states
- Precise measurement of R values, τ mass, hadron FF
- Precise measurement of CKM matrix
- Search for DDbar mixing, CP violation, etc.

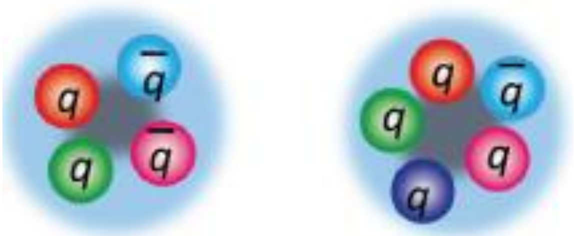
New forms of hadrons

- Conventional hadrons consist of 2 or 3 quarks：

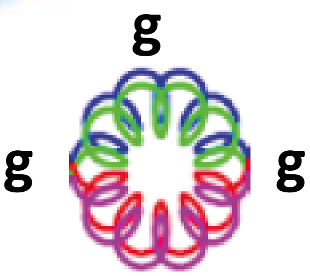
Naive Quark Model：

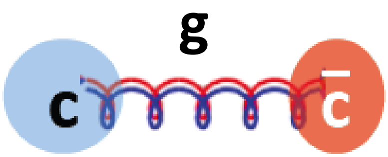


- QCD predicts the new forms of hadrons:
  - Multi-quark states： Number of quarks >＝ 4



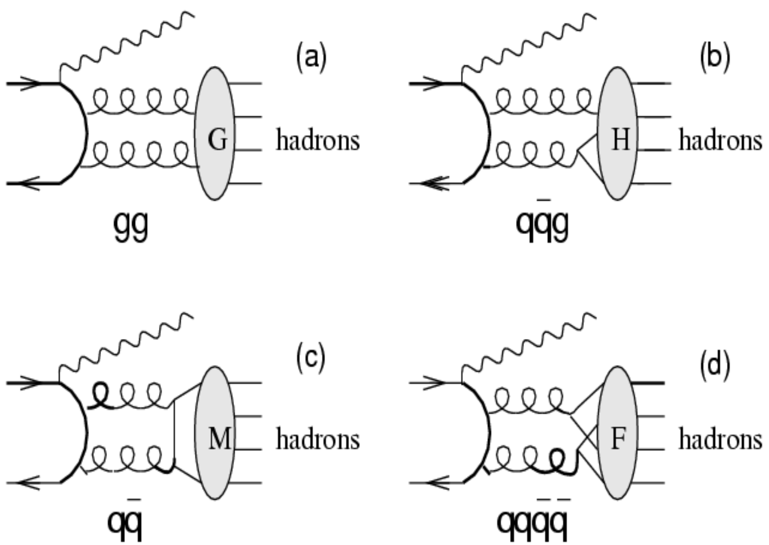
  - Hybrids： $q\bar{q}g$， qqqg …
  - Glueballs： gg， ggg …





None of the new forms of hadrons is settled！

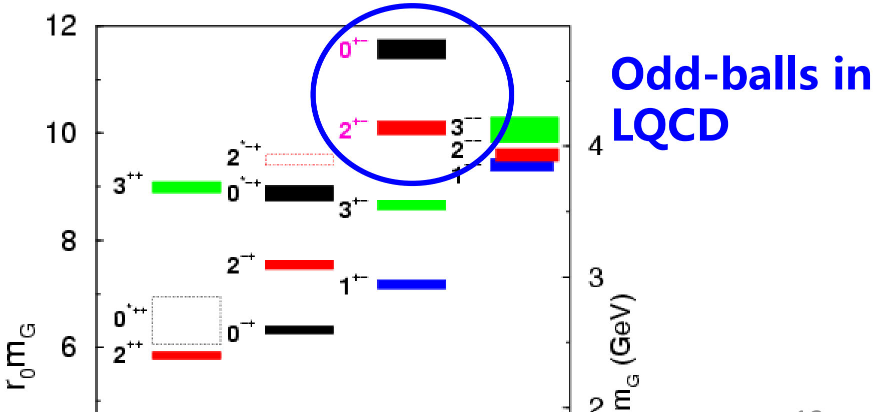
Charmonium decays provide ideal hunting ground for light glueballs and hybrids



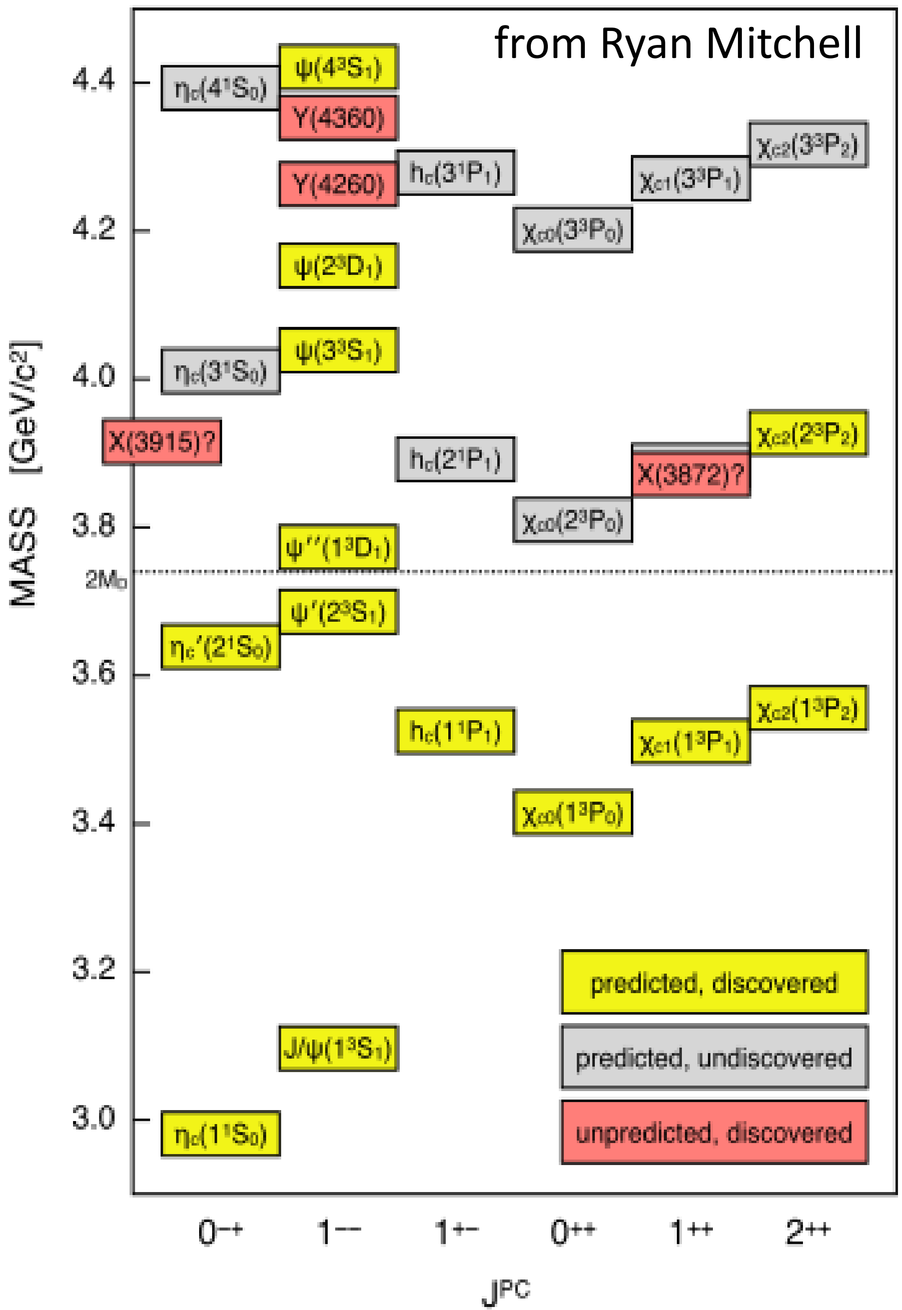
$\Gamma(J/\psi \to \gamma G) \sim O(\alpha\alpha_s^2), \Gamma(J/\psi \to \gamma H) \sim O(\alpha\alpha_s^3),$

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

- "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)
Z(4250)
Z(4050)
Z(3900)

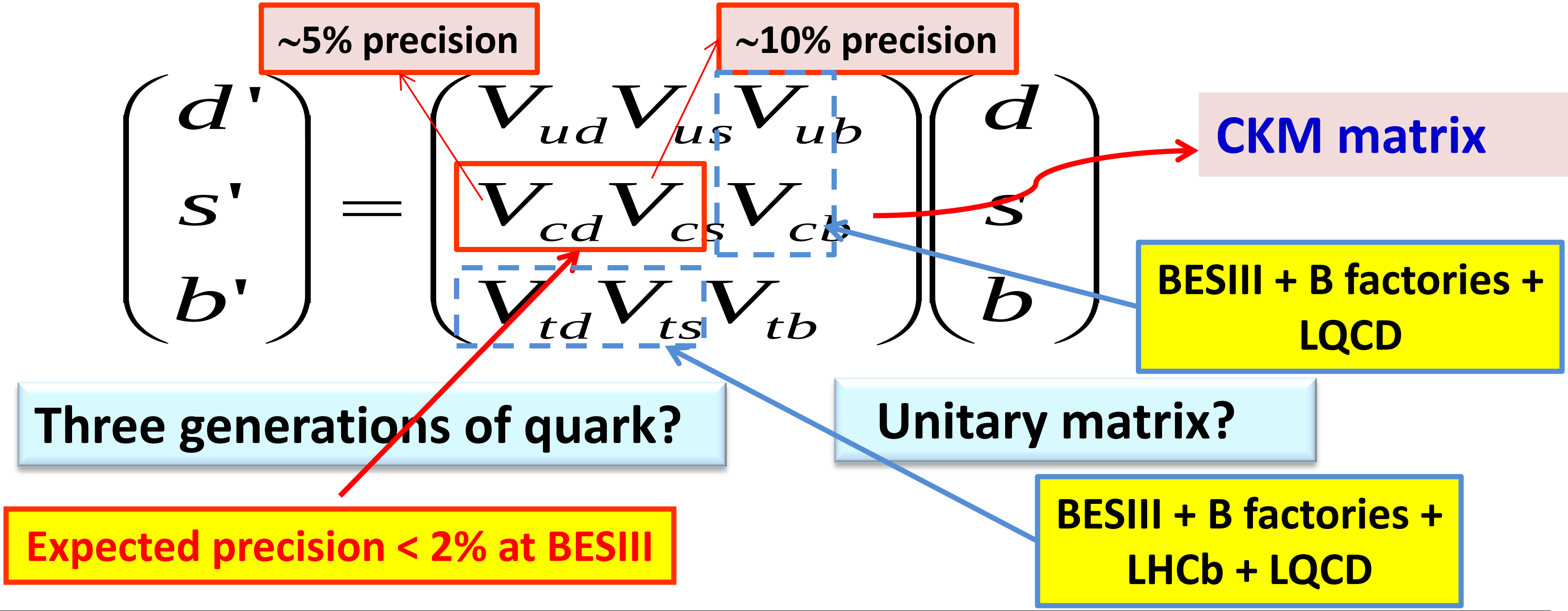
X(3872)
XYZ(3940)

X(3915)
X(4160)
Y(4008)
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.

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



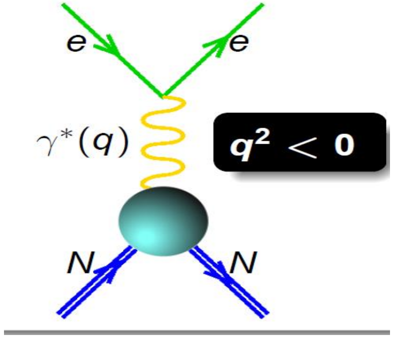
Precision measurement of CKM matrix elements
-- a precise test of SM model
New physics beyond SM?

Nucleon Form Factor

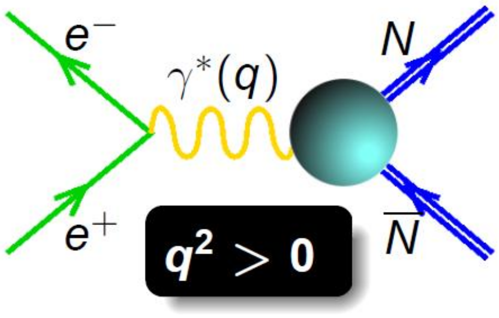
- Fundamental properties of the nucleon
  - Connected to charge, magnetization distribution
  - Crucial testing ground for models of the nucleon internal structure
  - Necessary input for experiments probing nuclear structure, or trying to understand modification of nucleon structure in nuclear medium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

$eN \longrightarrow eN$

Space-like: FF real

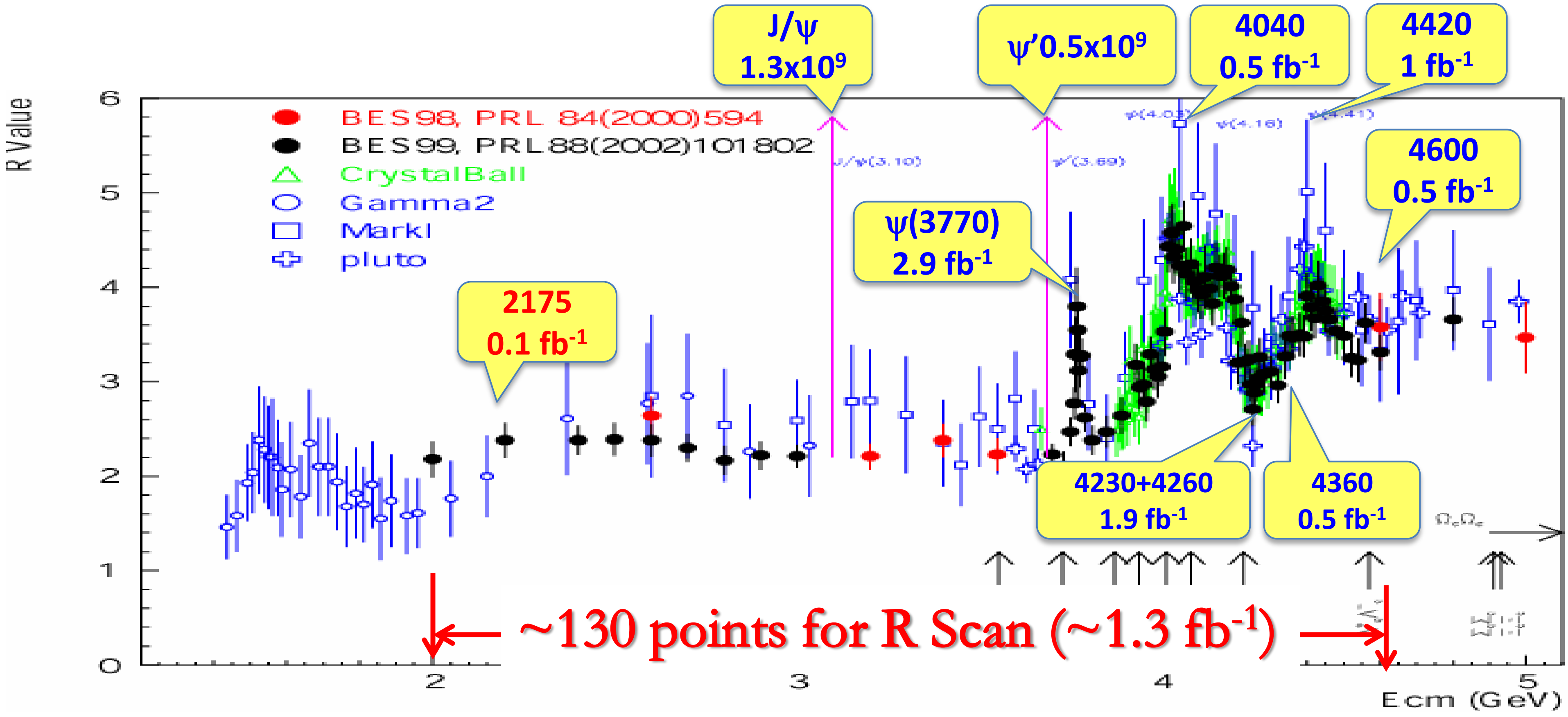


$e^+e^- \leftrightarrow N\bar{N}$, $\Lambda\bar{\Lambda}$



Time-like: FF complex

BESIII data samples



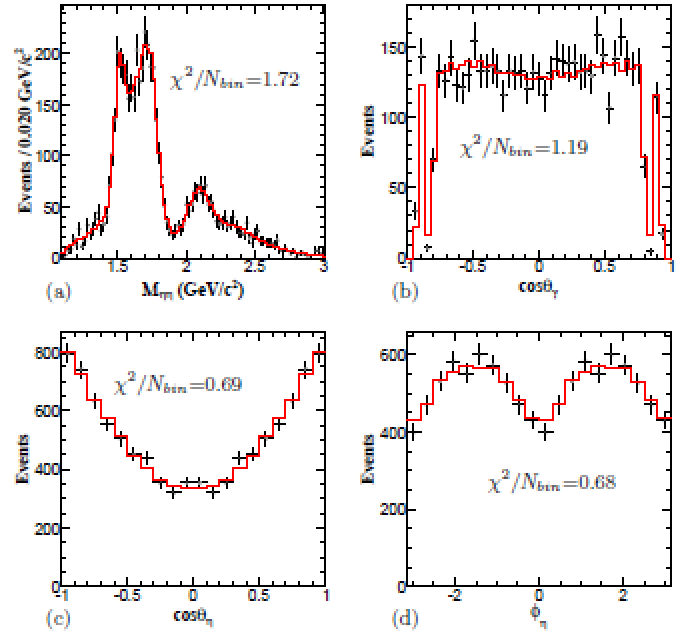
World largest J/ψ, ψ(2S), ψ(3770), Y(4260), … produced directly from e^+e^- collision

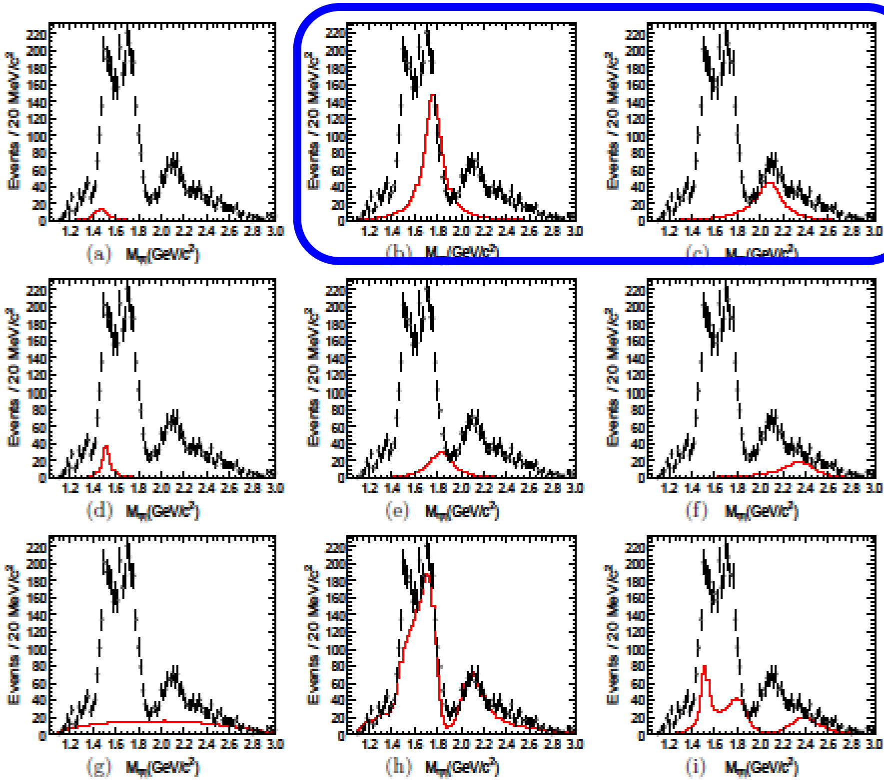
PWA of $J/\psi \to \gamma\eta\eta$

BESIII

(Phys. Rev. D87 092009 (2013)

Resonance	Mass(MeV/c^2)	Width(MeV/c^2)	$\mathcal{B}(J/\psi \to \gamma X \to \gamma\eta\eta)$	Significance
$f_0(1500)$	1468^{+14+23}_{-15-74}	$136^{+41+28}_{-26-100}$	$(1.65^{+0.26+0.51}_{-0.31-1.40}) \times 10^{-5}$	8.2 σ
$f_0(1710)$	$1759 \pm 6^{+14}_{-25}$	$172 \pm 10^{+32}_{-16}$	$(2.35^{+0.13+1.24}_{-0.11-0.74}) \times 10^{-4}$	25.0 σ
$f_0(2100)$	$2081 \pm 13^{+24}_{-36}$	273^{+27+70}_{-24-23}	$(1.13^{+0.09+0.64}_{-0.10-0.28}) \times 10^{-4}$	13.9 σ
$f_2'(1525)$	$1513 \pm 5^{+4}_{-10}$	75^{+12+16}_{-10-8}	$(3.42^{+0.43+1.37}_{-0.51-1.30}) \times 10^{-5}$	11.0 σ
$f_2(1810)$	1822^{+29+66}_{-24-57}	$229^{+52+88}_{-42-155}$	$(5.40^{+0.60+3.42}_{-0.67-2.35}) \times 10^{-5}$	6.4 σ
$f_2(2340)$	$2362^{+31+140}_{-30-63}$	$334^{+62+165}_{-54-100}$	$(5.60^{+0.62+2.37}_{-0.65-2.07}) \times 10^{-5}$	7.6 σ





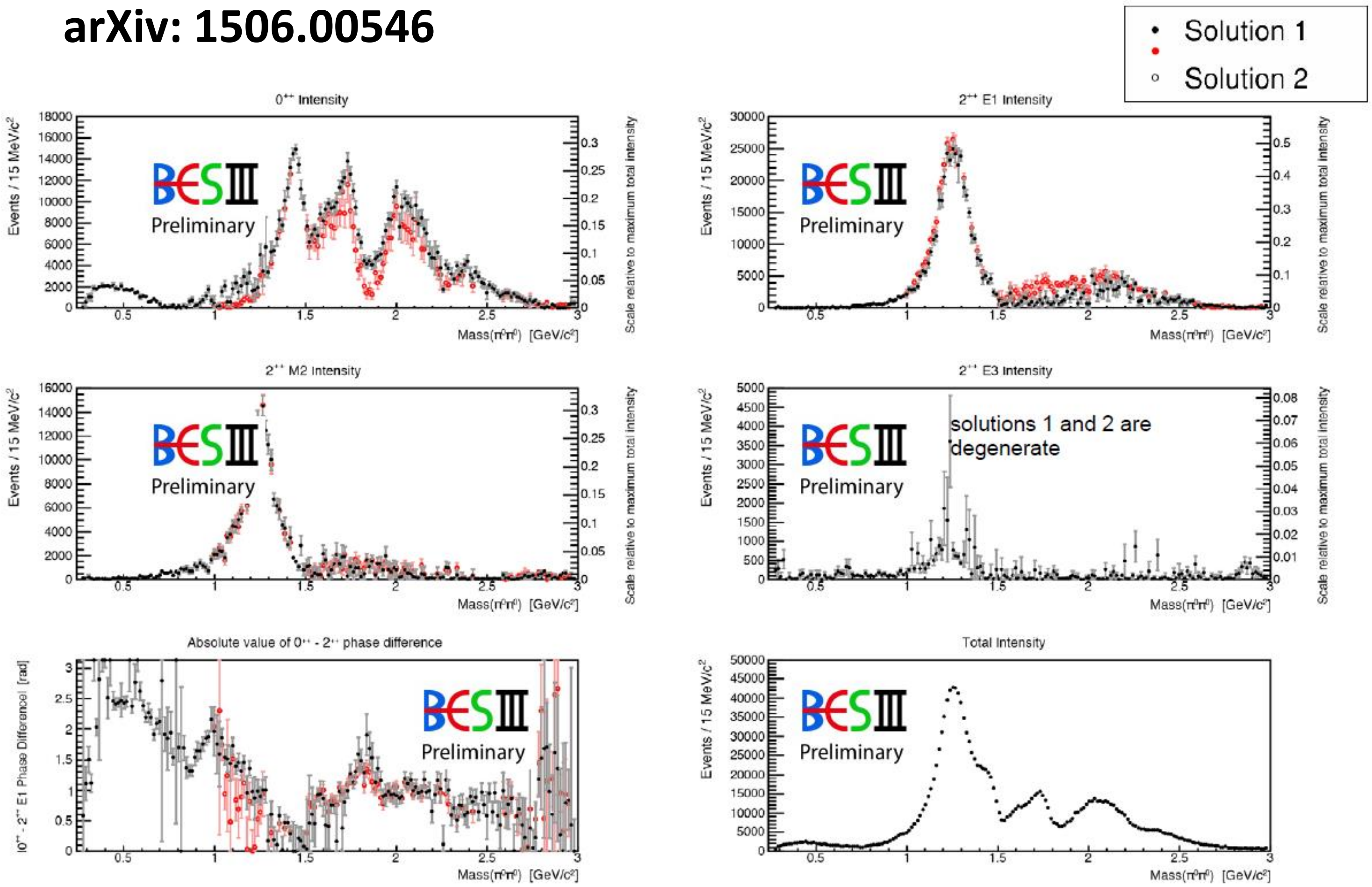
- **Br of $f_0(1710)$ and $f_0(2100)$ are ~10x larger than that of $f_0(1500)$**
- **Possible large overlap with LQCD predictions of 0+ Glueball:**

  PRL 110 021601 (2013)

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

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

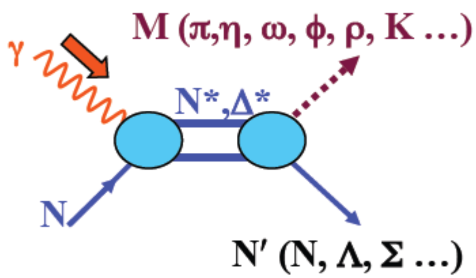
arXiv: 1506.00546



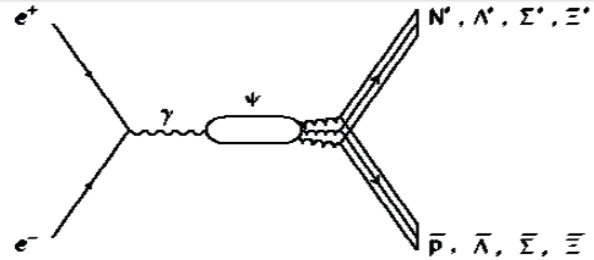
Significant features of the scalar spectrum include structures near 1.5, 1.7, and 2.0 GeV/c^2

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

JLAB, MAMI, ELSA, ...



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

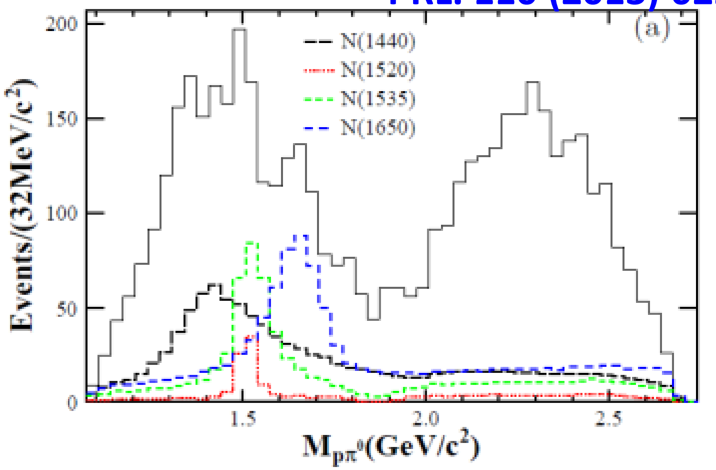


- ✓ Isospin 1/2 filter: $\psi \to N\bar{N}\pi, \psi \to N\bar{N}\pi\pi$
- ✓ Missing N* with small couplings to πN & γN , but large coupling to gggN : $\psi \to N\bar{N}\pi/\eta/\eta'/\omega/\phi, \bar{p}\Sigma\pi, \bar{p}\Lambda K$ ...
- ✓ Not only N*, but also $\Lambda^*, \Sigma^*, \Xi^*$
- ✓ Gluon-rich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

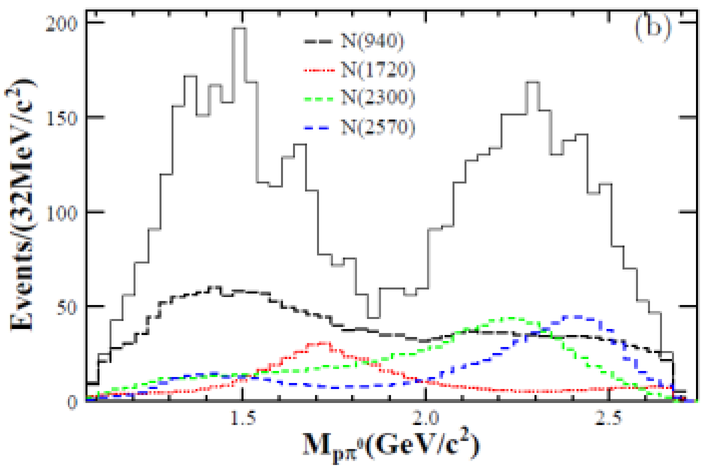
Study of N* and Ξ*

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

PRL. 110 (2013) 022001

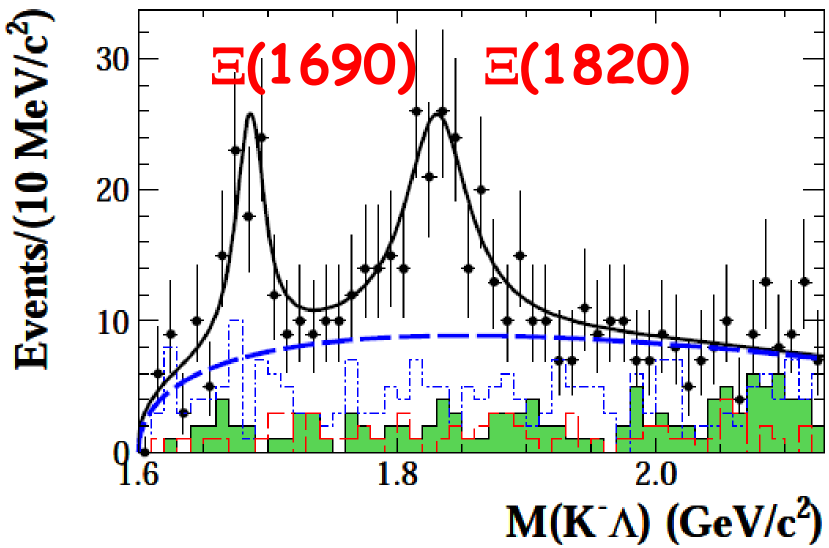


New N*s： N(2300) and N(257



Ξ* in $\psi' \to K\Lambda\Xi$

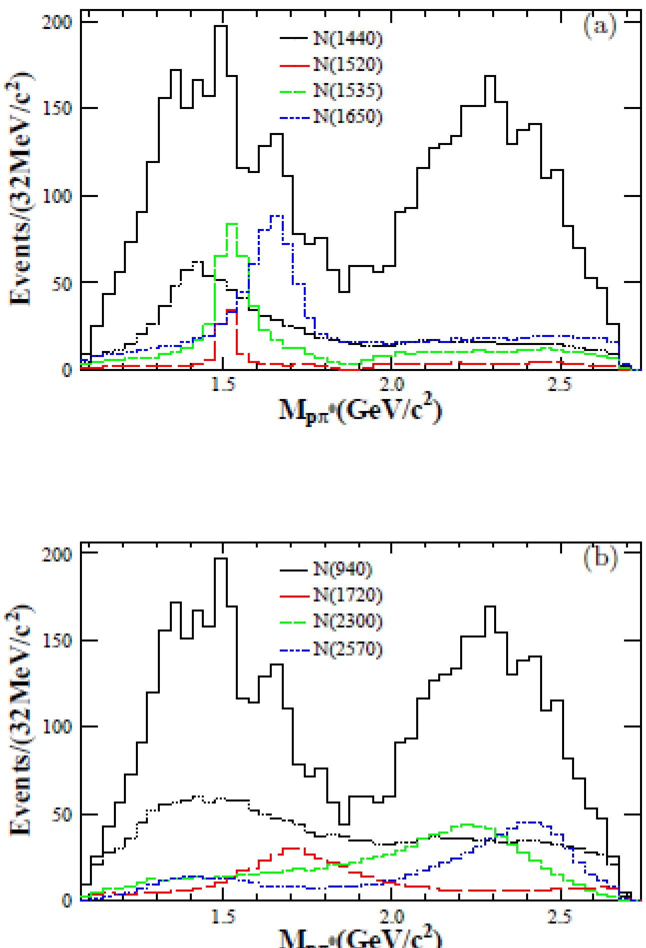
arXiv:1504.02025



- PWA of
  - $J/\psi(\psi') \to \pi^0 p \bar{p}$
  - $J/\psi(\psi') \to \eta p \bar{p}$
  - $J/\psi(\psi') \to pK\bar{\Lambda}$
  - …

PWA of $\psi' \to \pi^0 p\bar{p}$

BESIII, Phys.Rev.Lett. 110 (2013) 022001



2 New N* are found (1/2+, 5/2-)

Resonance	M(MeV/c^2)	Γ(MeV/c^2)	ΔS	ΔN_{dof}	Sig.
$N(1440)$	1390^{+11+21}_{-21-30}	$340^{+46+70}_{-40-156}$	72.5	4	11.5σ
$N(1520)$	1510^{+3+11}_{-7-9}	115^{+20+0}_{-15-40}	19.8	6	5.0σ
$N(1535)$	1535^{+9+15}_{-8-22}	120^{+20+0}_{-20-42}	49.4	4	9.3σ
$N(1650)$	1650^{+5+11}_{-5-30}	150^{+21+14}_{-22-50}	82.1	4	12.2σ
$N(1720)$	1700^{+30+32}_{-28-35}	$450^{+109+149}_{-94-44}$	55.6	6	9.6σ
$N(2300)$	$2300^{+40+109}_{-30-0}$	$340^{+30+110}_{-30-58}$	120.7	4	15.0σ
$N(2570)$	2570^{+19+34}_{-10-10}	250^{+14+69}_{-24-21}	78.9	6	11.7σ

The energy dependent width BW for

$$\Gamma_{N(1440)} \to \Gamma_{N(1440)}(0.7\frac{B_1(q_{\pi N})\rho_{\pi N}(s)}{B_1(q_{\pi N}^{N*})\rho_{\pi N}(M_{N*}^2)} + 0.3\frac{B_1(q_{\pi\Delta})\rho_{\pi\Delta}(s)}{B_1(q_{\pi\Delta}^{N*})\rho_{\pi\Delta}(M_{N*}^2)})$$

$$\Gamma_{N(1520)} \to \Gamma_{N(1520)}\frac{B_2(q_{\pi N})\rho_{\pi N}(s)}{B_2(q_{\pi N}^{N*})\rho_{\pi N}(M_{N*}^2)}$$

$$\Gamma_{N(1535)} \to \Gamma_{N(1535)}(0.5\frac{\rho_{\pi N}(s)}{\rho_{\pi N}(M_{N*}^2)} + 0.5\frac{\rho_{\eta N}(s)}{\rho_{\eta N}(M_{N*}^2)})$$

The other N* : constant width BW

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

BESIII: PRL 110, 252001 (2013)

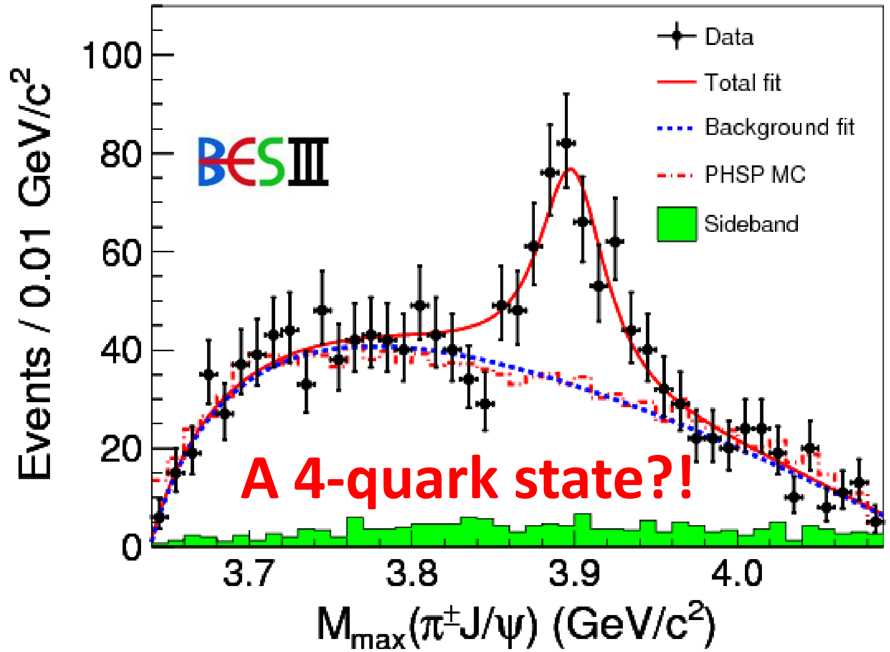
$Z_c(3900)^+$:

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

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

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

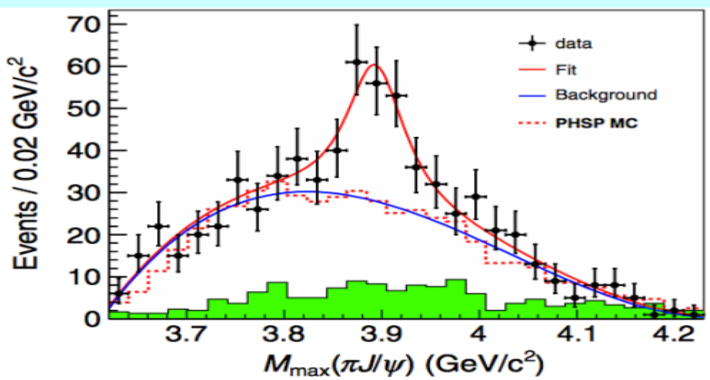
Decays to J/ψ → contains $c\bar{c}$
Electric charge → contains $u\bar{d}$



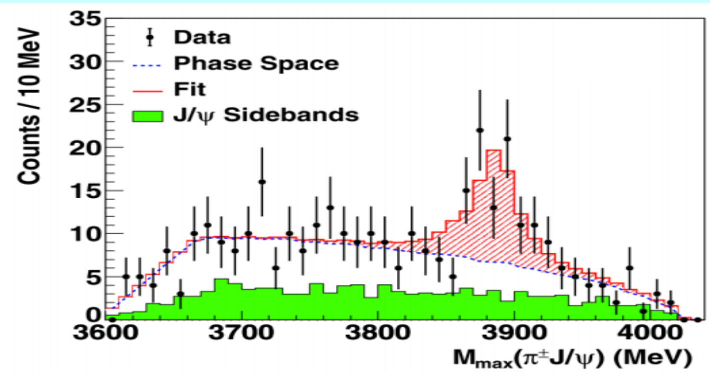
$$\sigma[e^+e^- \to \pi^+\pi^- J/\psi] = 62.9 \pm 1.9 \pm 3.7\ \text{pb at } 4.26\ \text{GeV}$$

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

Belle with ISR data (PRL 110, 252002)

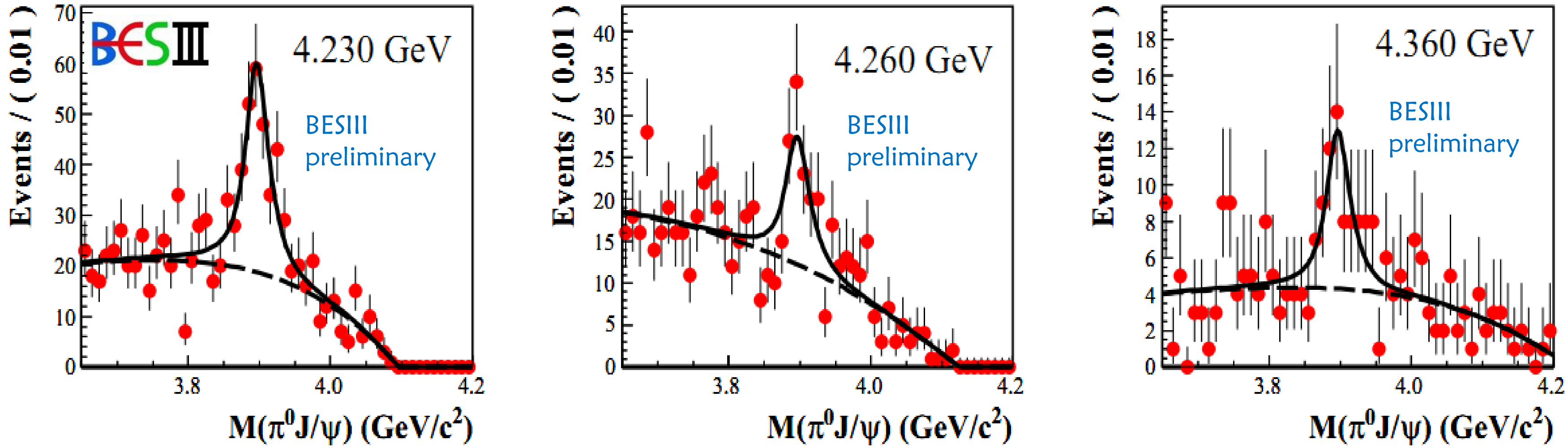


CLE0c data at 4.17 GeV (PLB 727, 366)



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

Studying the $e^+e^- \to \pi^0\pi^0 J/\psi$ process

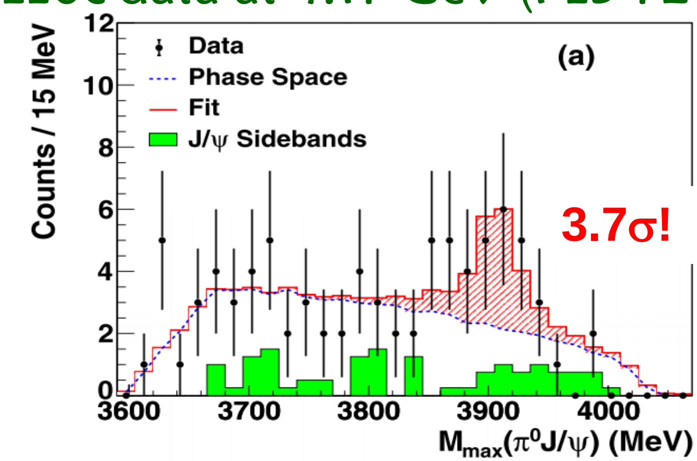


A structure on $\pi^0 J/\psi$ invariant mass spectrum can be observed:

Mass = 3894.8 ± 2.3 ± 2.7 MeV
Width = 29.6 ± 8.2 ± 8.2 MeV
Significance = 10.4 σ

Isospin triplet is established!

CLEOc data at 4.17 GeV (PLB 727, 366)



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

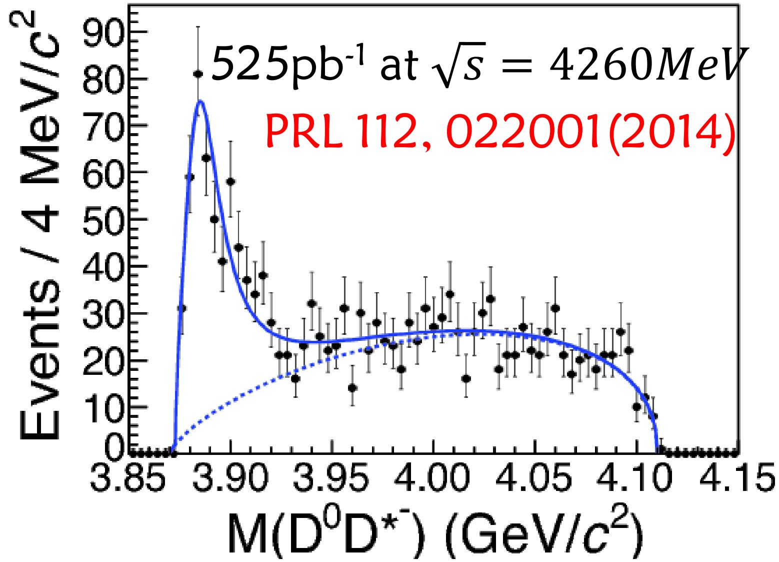
Reconstruct the π^+ and $D^0 \to K^-\pi^+$ and infer the D^{*-}.

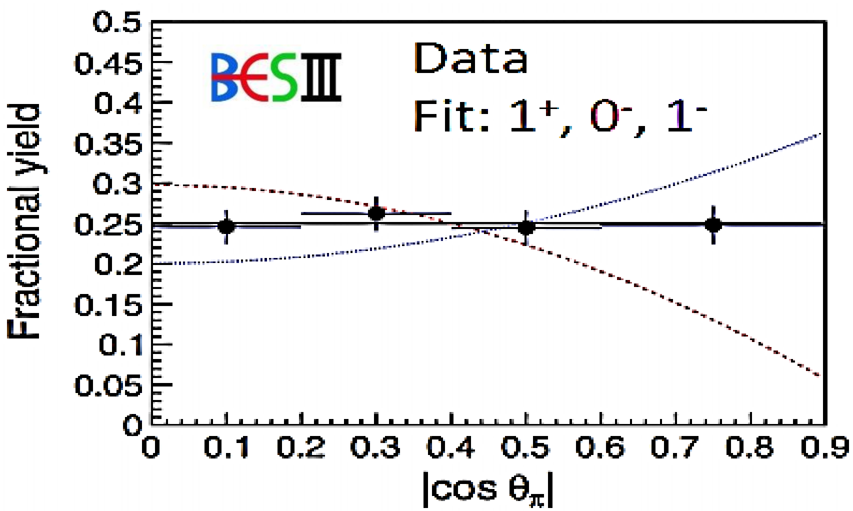
(Also analyze $\pi^+D^-D^{*0}$ with the same method.)

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

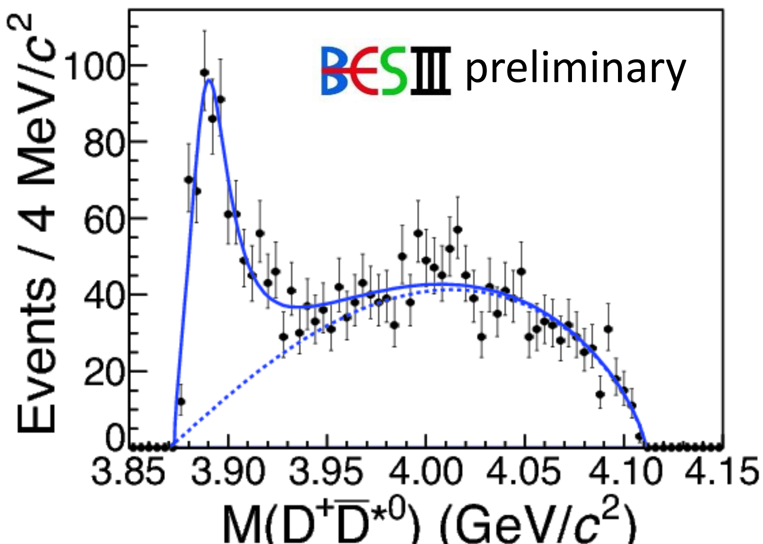
Mass = 3883.9 ± 1.5 ± 4.2 MeV, (fit with BW function)

Width = 24.8 ± 3.3 ± 11.0 MeV





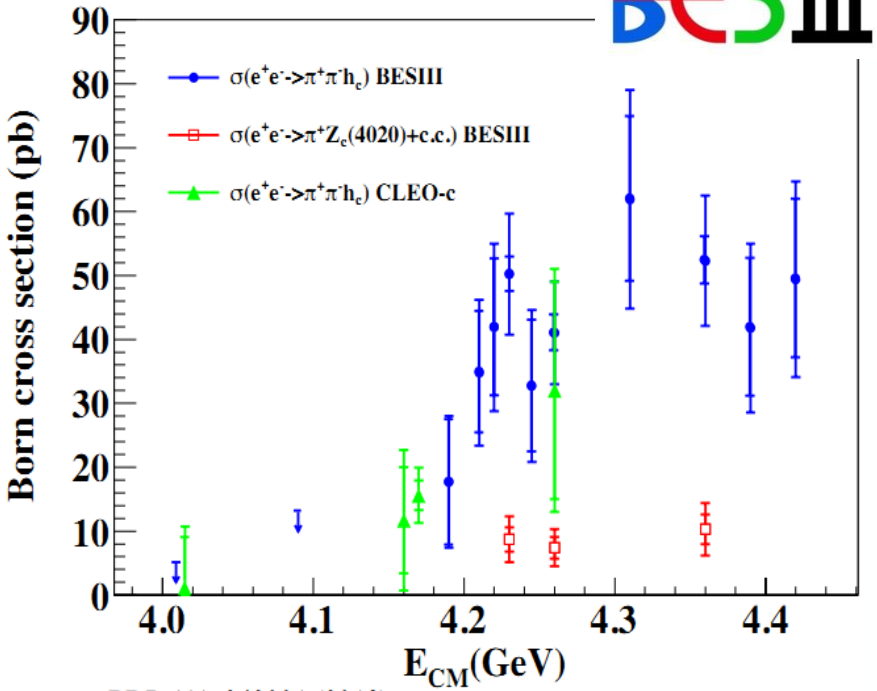
Fit to angular distribution favors $J^P = 1^+$ over 0^- and 1^-



Observation of $Z_c(4020)^{\pm}$ in $e^+e^- \to \pi^+\pi^- h_c$

PRL 111, 242001(2013)

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

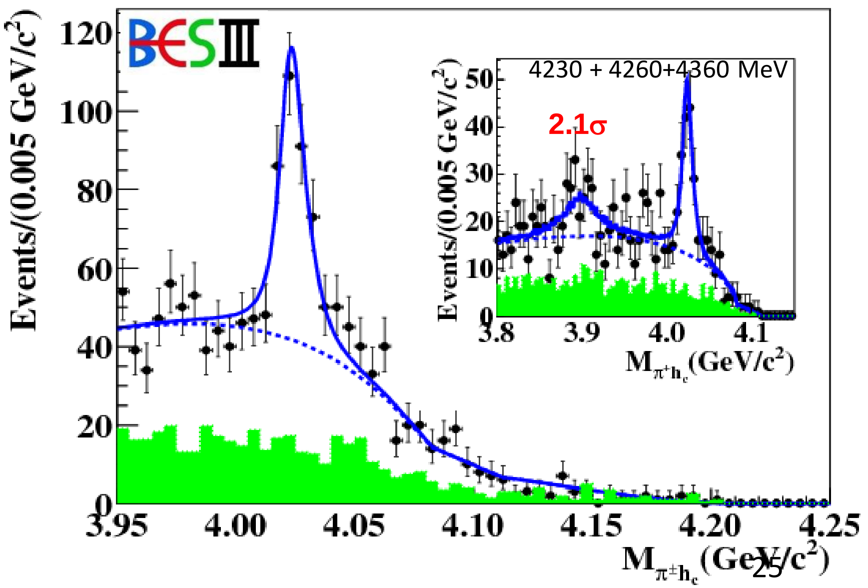


The cross section of $e^+e^- \to \pi^+\pi^- h_c$ is measured, and the shape is not trivial.

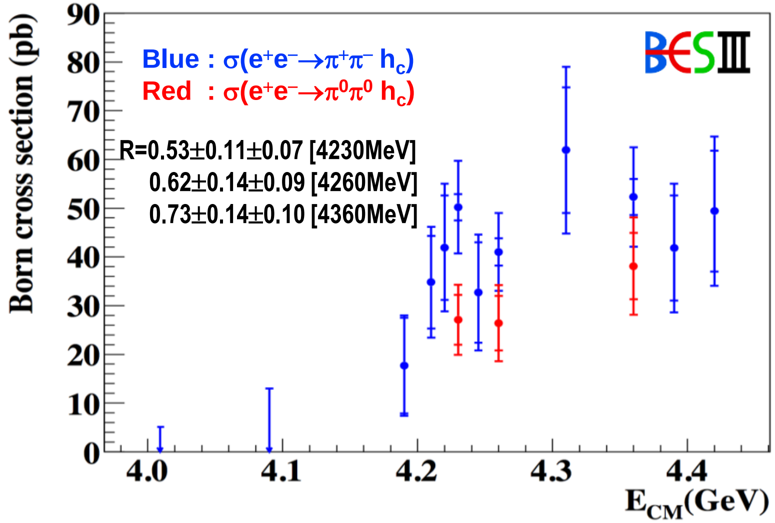
A structure, $Z_c(4020)^{\pm}$, is observed.

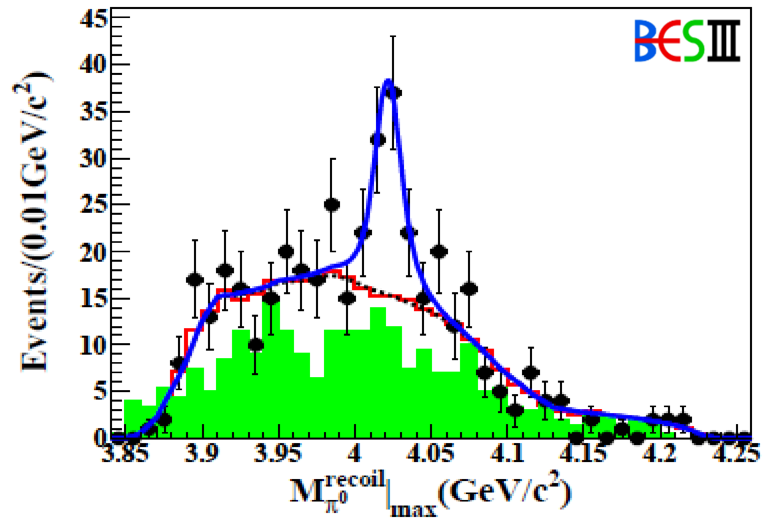
Mass = 4022.9±0.8 ±2.7 MeV,
Width = 7.9±2.7 ±2.6 MeV

A weak evidence for $Z_c(3900)^{\pm} \to \pi^{\pm}h_c$



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





$M[Z_c(4020)^0] = 4023.6\pm2.2\pm3.9$ MeV

[$M[Z_c(4020)^\pm] = 4022.9\pm0.8\pm2.7$ MeV]

–Width fixed to charged $Z_c(4020)$

–Significance : $>5\sigma$

Observation of neutral $Z_c(4020)$ → **Isovector nature of Z_c states established**

BESIII: PRL113, 212002 (2014)

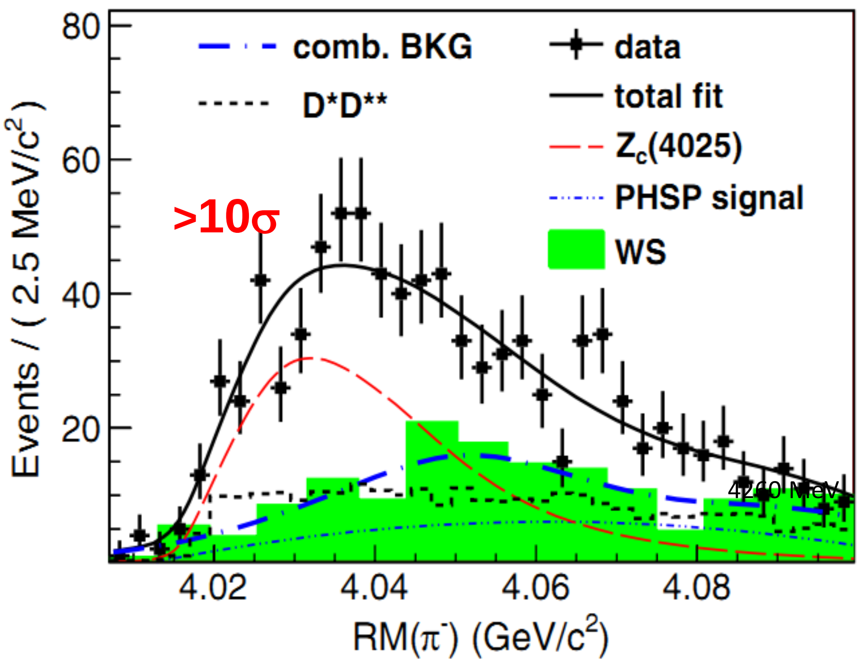
Observation of $Z_c(4025)^{\pm}$

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

BESIII

PRL 112, 132001 (2014)

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



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

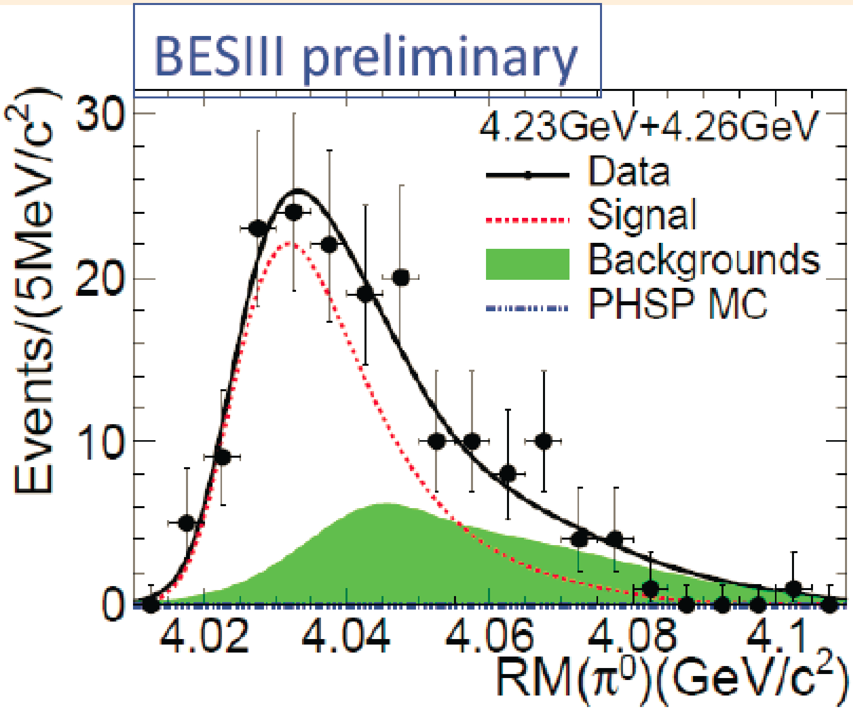
$M(Z_c(4025)) = 4026.3 \pm 2.6 \pm 3.7$ MeV;
$\Gamma(Z_c(4025)) = 24.8 \pm 5.6 \pm 7.7$ MeV

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

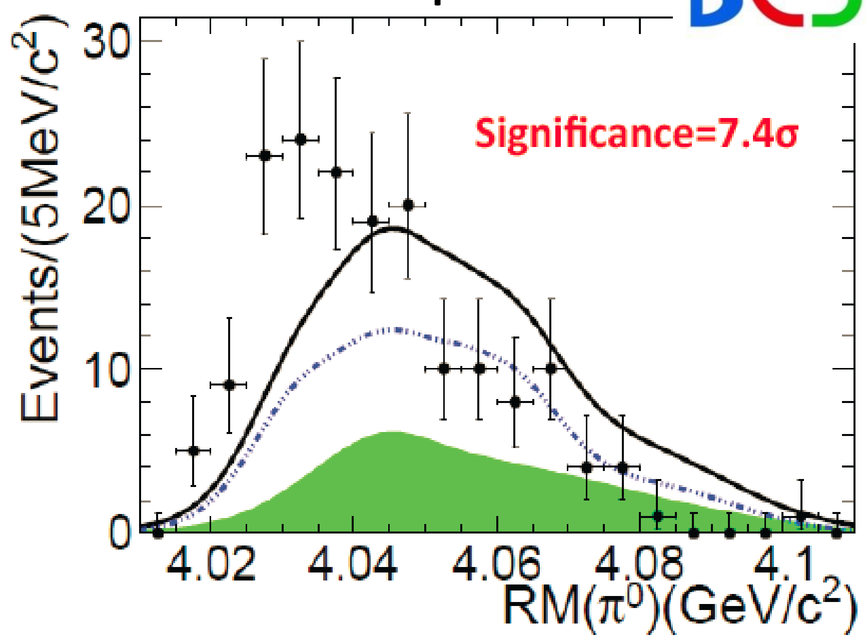
$$\frac{\sigma[e^+e^- \rightarrow \pi^{\pm} Z_c(4025)^{\mp} \rightarrow (D^*\bar{D}^*)^{\pm}\pi^{\mp}]}{\sigma[e^+e^- \rightarrow (D^*\bar{D}^*)^{\pm}\pi^{\mp}]} = 0.65 \pm 0.09 \pm 0.06 \text{ at } 4.26 \text{ GeV}$$

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

Zc(4025)^0 observed with $e^+e^- \to \pi^0 (D^* \overline{D}^*)^0$



Phase space + BG

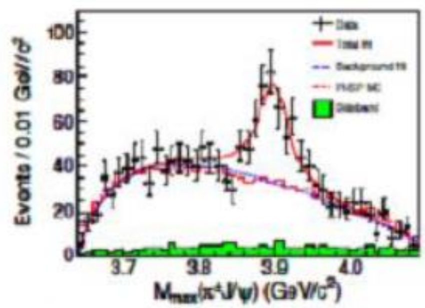


- ❑ Measured with data at Ecms=4.23GeV and 4.26GeV
- ❑ A simultaneous fit for two energy points gives

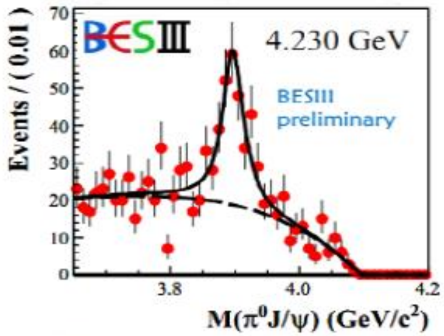
Data sample	Mass(MeV/c^2)	Width(MeV/c^2)	$\sigma(e^+e^- \to Z_c(4025)^0\pi^0 \to D^*\bar{D}^*\pi^0)$(pb)
@4.23GeV	$4025.5^{+2.0}_{-4.7} \pm 3.1$	$23.0 \pm 6.0 \pm 1.0$	$61.6 \pm 8.2 \pm 9.0$
@4.26GeV			$43.4 \pm 8.0 \pm 5.4$

Summary on Z_c states

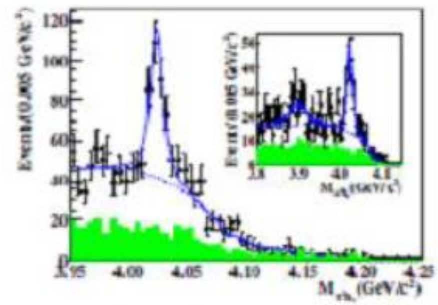
From Kornicer CHARM 2015



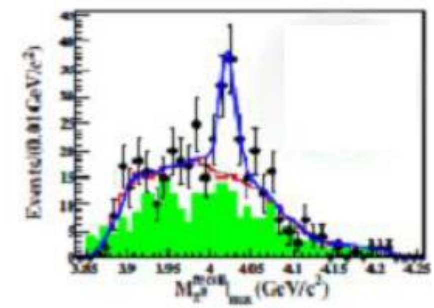
$e^+e^- \to \pi^-\pi^+ J/\psi$



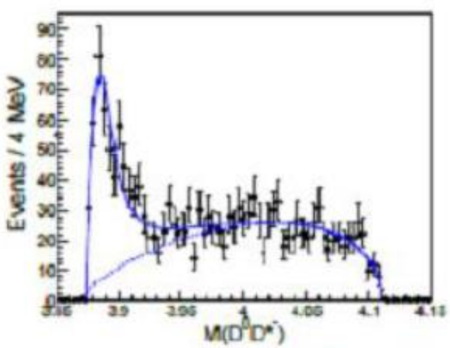
$e^+e^- \to \pi^0\pi^0 J/\psi$



$e^+e^- \to \pi^-\pi^+ h_c$



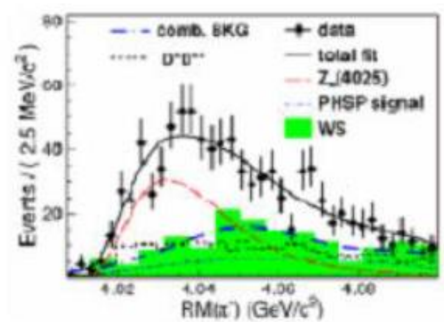
$e^+e^- \to \pi^0\pi^0 h_c$



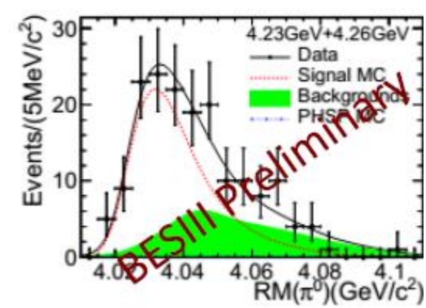
$e^+e^- \to \pi^-(D\bar{D}^*)^+$

preliminary

soon …



$e^+e^- \to \pi^-(D^*\bar{D}^*)^+$



$e^+e^- \to \pi^0(D^*\overline{D^*})^0$

$Z_c(3900)^+$? $Z_c(3900)^0$? $Z_c(4020)^+$? $Z_c(4020)^0$?

Summary on Z_c states

From Kornicer CHARM 2015

State	Mass(MeV)	Width(MeV)	Decay mode	Process
$Z_c(3900)^{\pm}$	$3899.0 \pm 3.6 \pm 4.9$	$46 \pm 10 \pm 20$	$\pi^{\pm} J/\psi$	$e^+e^- \to \pi^+\pi^- J/\psi$
$Z_c(3900)^0$	$3894.8 \pm 2.3 \pm 2.7$	$29.6 \pm 8.2 \pm 8.2$	$\pi^0 J/\psi$	$e^+e^- \to \pi^0\pi^0 J/\psi$
$Z_c(3885)^{\pm}$	$3883.9 \pm 1.5 \pm 4.2$ [single D tag] $3884.3 \pm 1.2 \pm 1.5$ [double D tag]	$24.8 \pm 3.3 \pm 11.0$ [single D tag] $23.8 \pm 2.1 \pm 2.6$ [double D tag]	$D^0 D^{*-}$ $D^- D^{*0}$	$e^+e^- \to \pi^+ D^0 D^{*-}$ $e^+e^- \to \pi^+ D^- D^{*0}$
$Z_c(4020)^{\pm}$	$4022.9 \pm 0.8 \pm 2.7$	$7.9 \pm 2.7 \pm 2.6$	$\pi^{\pm} h_c$	$e^+e^- \to \pi^+\pi^- h_c$
$Z_c(4020)^0$	$4023.9 \pm 2.2 \pm 3.8$	fixed	$\pi^0 h_c$	$e^+e^- \to \pi^0\pi^0 h_c$
$Z_c(4025)^{\pm}$	$4026.3 \pm 2.6 \pm 3.7$	$24.8 \pm 5.6 \pm 7.7$	$D^{*0} D^{*-}$	$e^+e^- \to \pi^+(D^* \bar{D}^*)^-$
$Z_c(4025)^0$	$4025.5^{+2.0}_{-4.7} \pm 3.1$	$23.0 \pm 6.0 \pm 1.0$	$(D^*D^*)^0$	$e^+e^- \to \pi^0(D^*D^*)^0$

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

[BESIII RPL112,092001]

- Search for $\gamma X(3872)$ with $X(3872) \to \pi\pi J/\psi$ at E_{cm}=4.23, 4.26 and 4.36 GeV

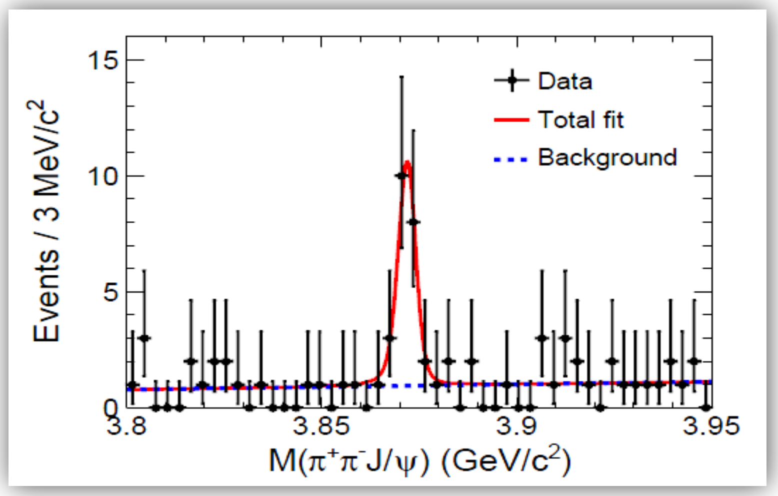
- summed over all data

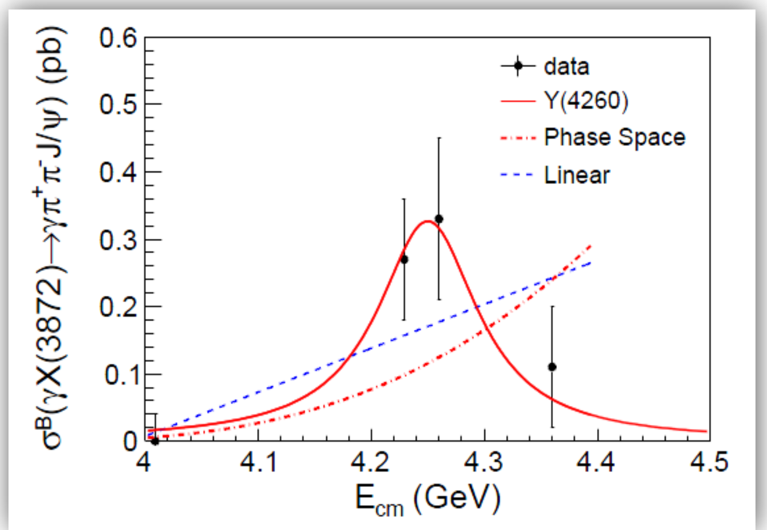
  X(3872) significance = 6.3 σ

- Production in Y(4260) decay suggestive, but not conclusive

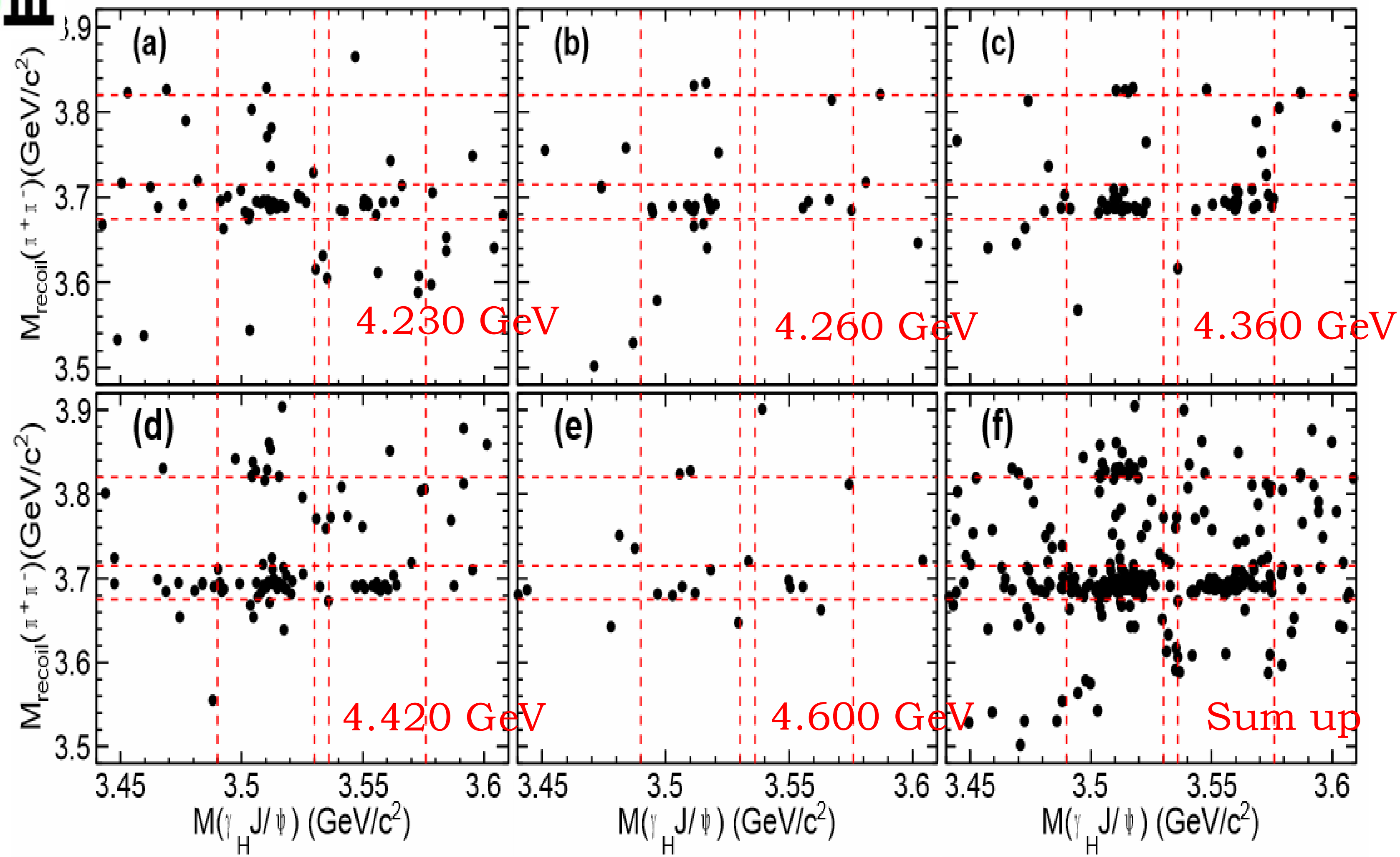
- If from Y(4260)

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





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



arXiv:1503.08203

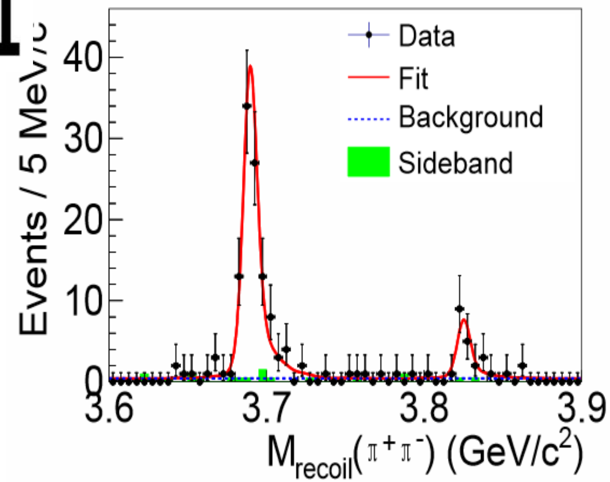
$\psi(1\ ^3D_2)$

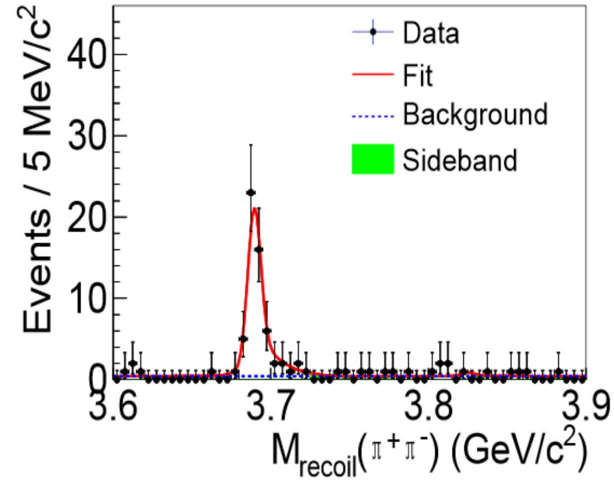
arXiv:1503.08203

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

BESIII

arXiv:1503.08203



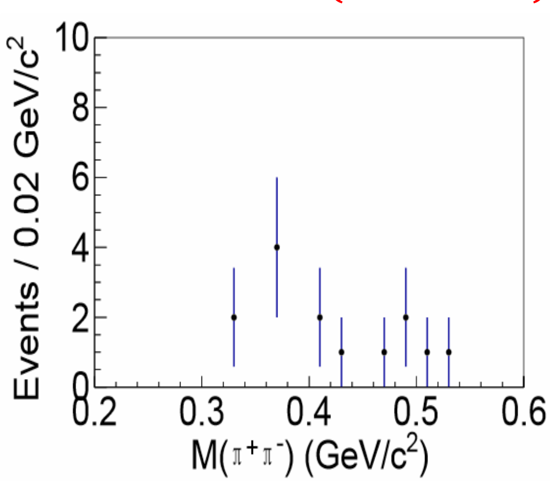


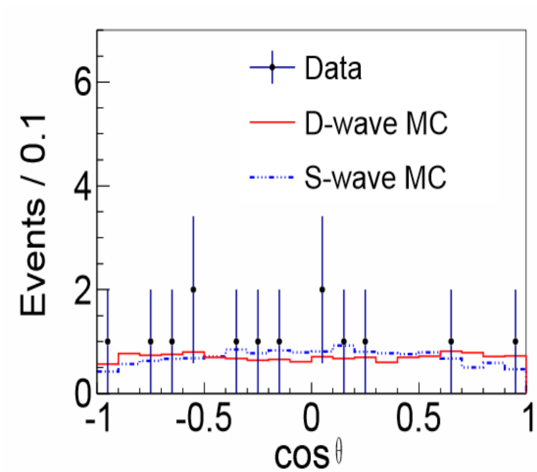
$\psi(1\,^3D_2)$

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

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

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





D-wave is expected.

Limited statistics

limited information

Charm physics at BESIII

Advantage of open charm at threshold

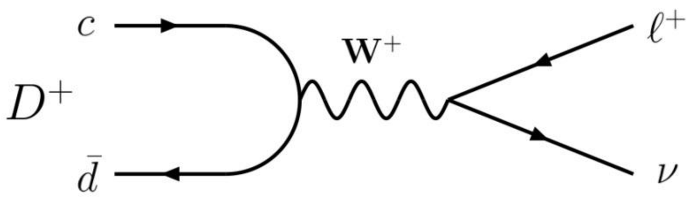
e^+e^- colliders@threshold:

$$e^+e^- \to \psi(3770) \to D^0\overline{D}^0 \;\; [C=-1] \quad \text{OR} \quad e^+e^- \to \gamma^* \to D^0\overline{D}^0\gamma \;\; [C=+1]$$

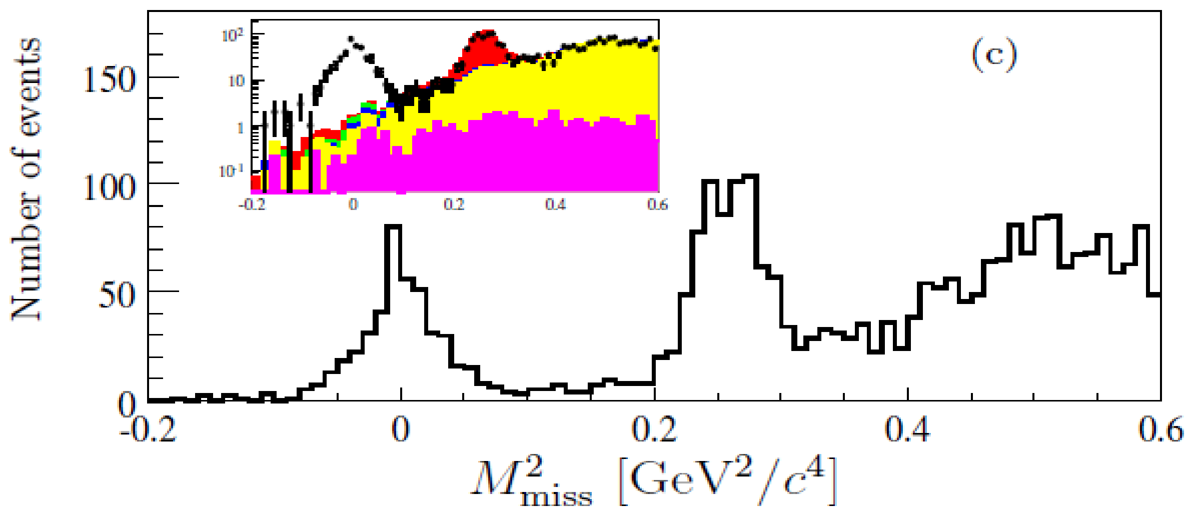
Good for charm flavor physics:

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

$f_{D(s)+}$: Leptonic decays



$$\Gamma\left(D^+ \rightarrow \ell^+ \nu_\ell\right) = f_D^2 \left|V_{cd}\right|^2 \frac{G_F^2}{8\pi} m_D m_\ell^2 \left(1 - \frac{m_\ell^2}{m_D^2}\right)^2$$



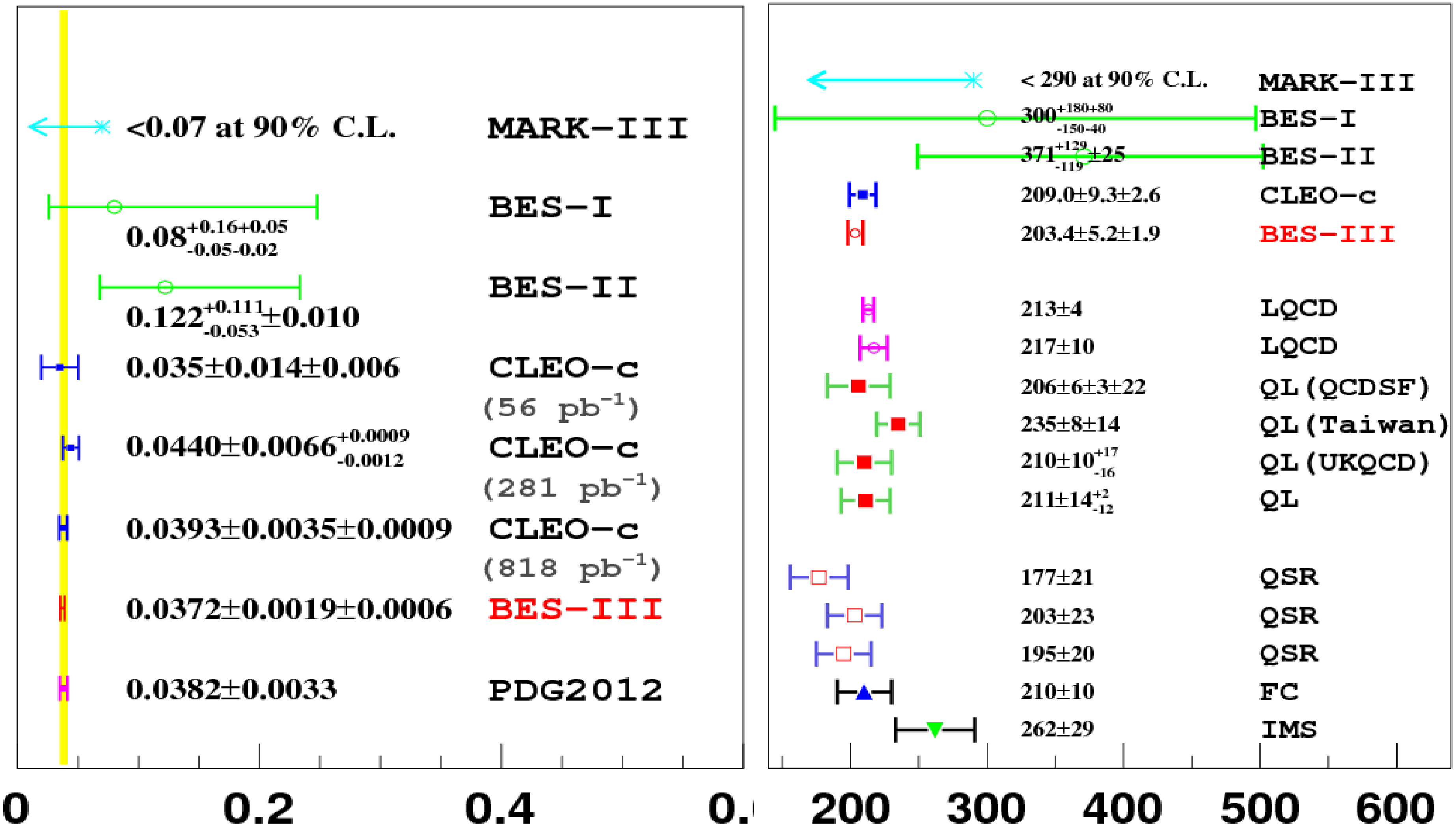
$B(D^+ \rightarrow \mu^+\nu) = (3.72 \pm 0.19 \pm 0.06) \times 10^{-4}$

f_{D+} = （203.4 ± 5.2 ± 1.9) MeV

|Vcd|=0.2212 ±0.0056 ±0.0047

⇐ LQCD calculated f_D = 207±4 MeV [PRL100(2008)062002]

$B(D^+ \to \mu^+\nu)$ f_{D+}



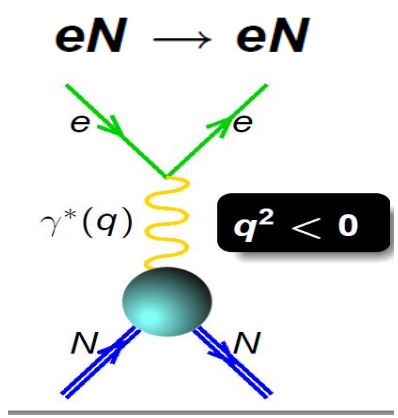
BESIII: 2.7% with 2.92fb^{-1}

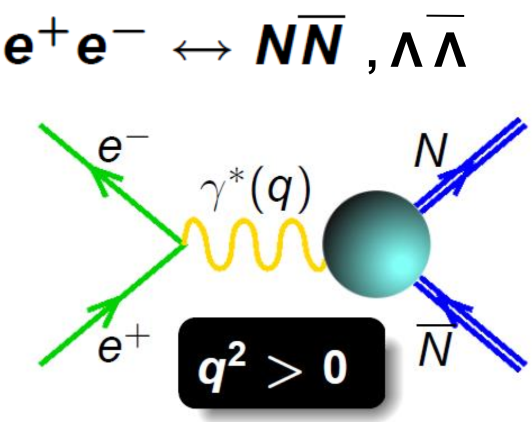
BESIII final: 1.5% with 10 fb^{-1}

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) (precision 1%) or time-like process (e+e- annihilation) (precision 10%-30%)**

Space-like:
FF real





Time-like:
FF complex

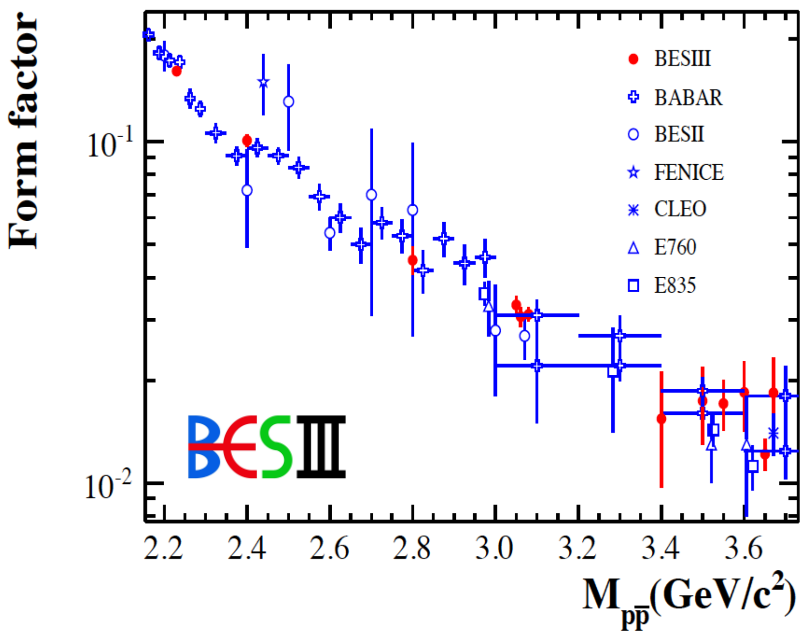
Proton FF measurement at BESIII

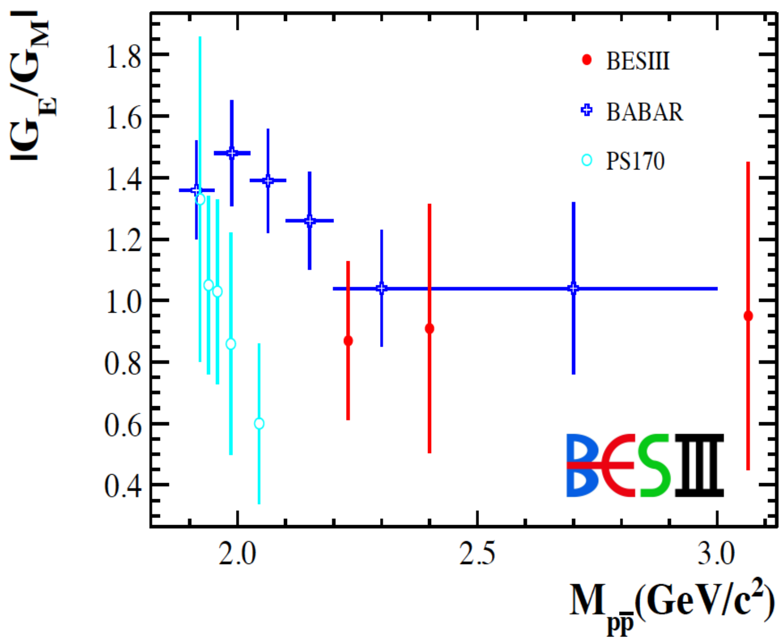
Phys.Rev. D91 (2015) 11, 112004 .

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

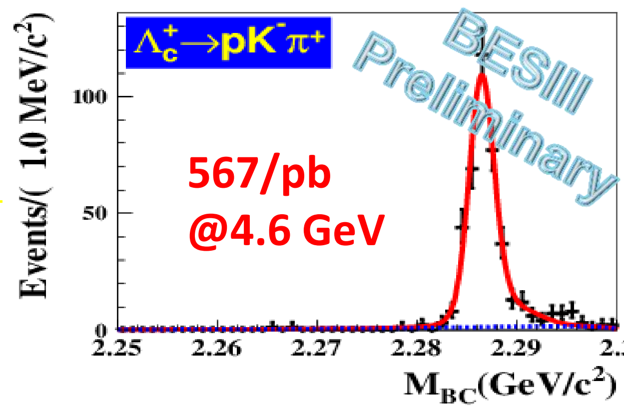




- # Precise study of Λ_c decays

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	

BESIII Preliminary

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

BESIII upgrade

- ☐ MDC: Malter effect found in inner chamber in 2012,
  add water vapor to the chamber to cure the aging problem.
- New inner chamber is being built at IHEP. Will be 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) will be installed this summer to improve the time resolution (100ps →55ps)

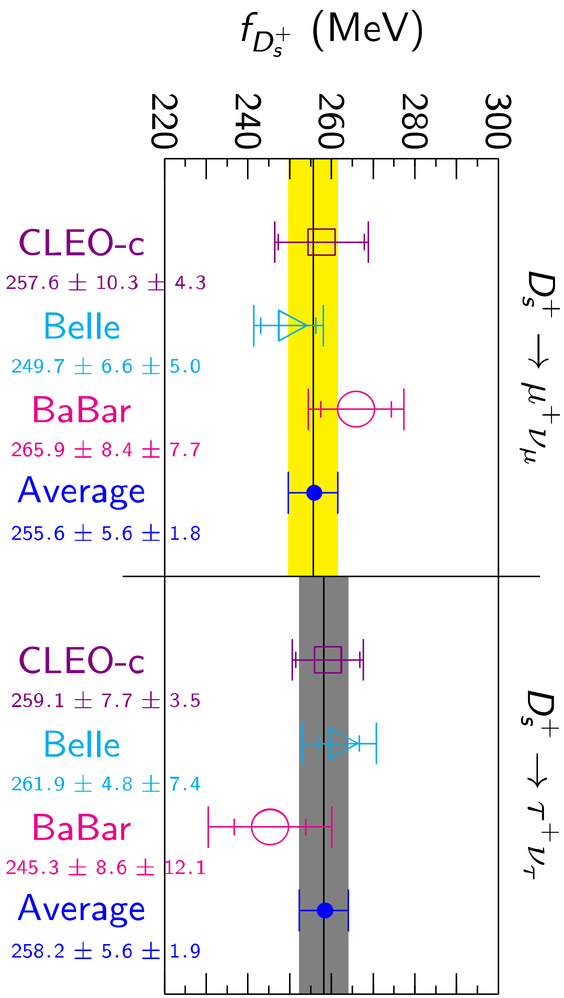
BESIII data taking status & plan (run ~8 years)

	Previous data	BESIII present & future	Goal
J/ψ	BESII 58M	1.2 B 20* BESII	10 B
ψ'	CLEO： 28 M	0.5 B 20* CLEOc	3B
ψ''	CLEO： 0.8/fb	2.9/fb 3.5*CLEOc	20 /fb
Above open charm threshold	CLEO： 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 at 105 energy points 2.0-3.1 GeV at 20 energy points	
Y(2175)		100 pb^{-1} (taking data now)	
$\psi(4170)$		3 fb^{-1} (next run)	

Thank you!

Backup slides

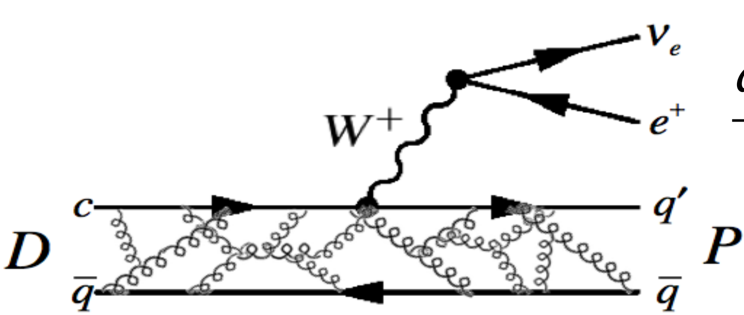
f_{Ds}



CLEO-c: 2.5% with 0.68fb^{-1}

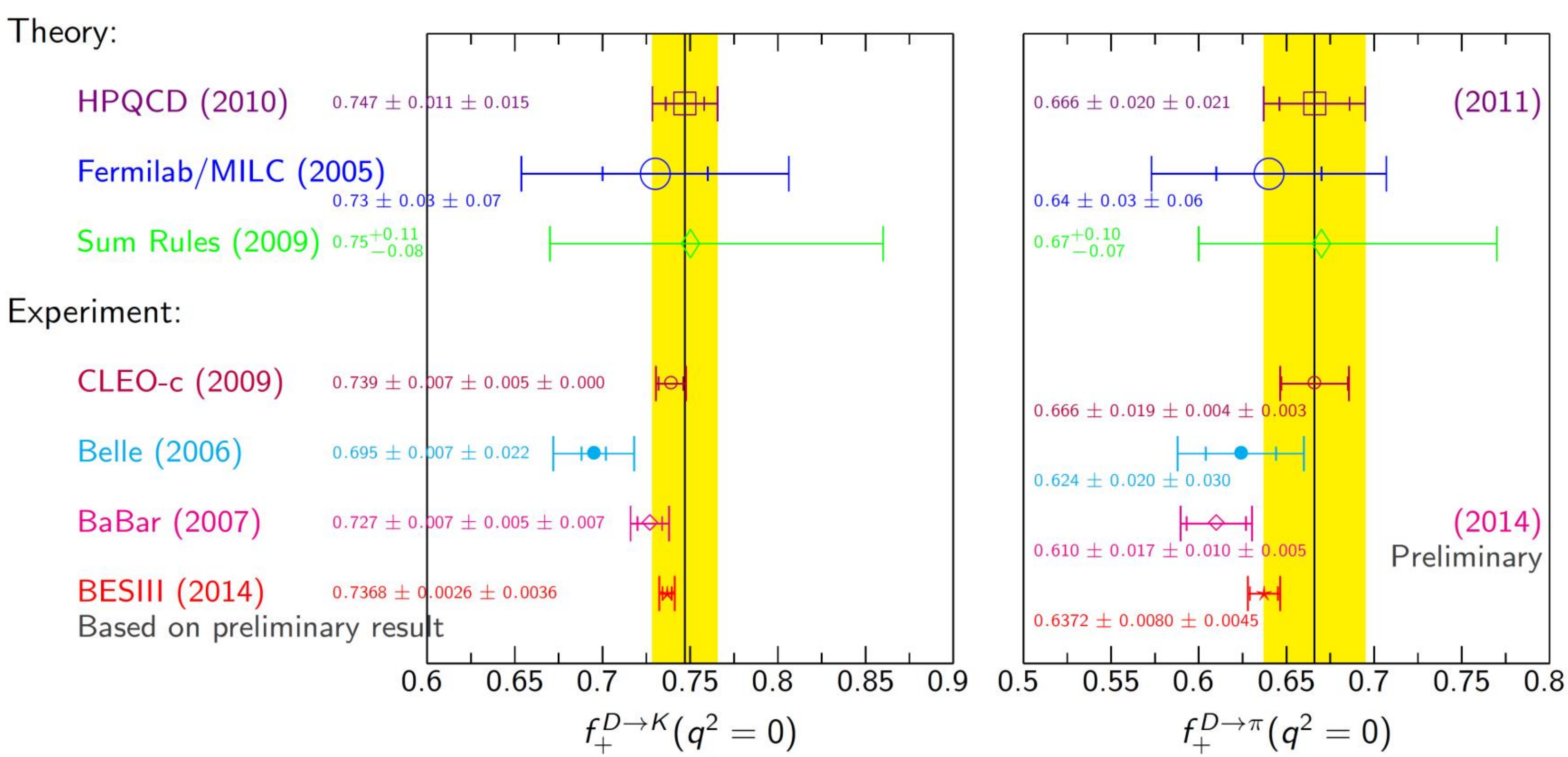
BESIII final: 1.25% with 5 fb^{-1}

Form Factors: Semileptonic decays

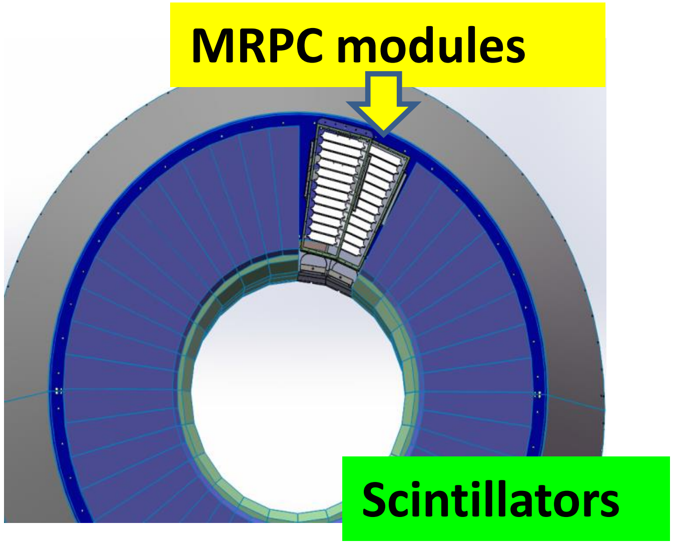


$$\frac{d\Gamma(D \to K(p) e\nu)}{dq^2} = \frac{G_F^2 |V_{cs(d)}|^2 P_{K(p)}^3}{24\pi^3} |f_+(q^2)|^2$$

Gang Rong
CKM2014



Endcap MRPC-TOF



- In summer of 2014, two MRPC modules were installed to replace previous scintillators. Real data obtained in Feb., 2015.