Overview on BESIII Experiment

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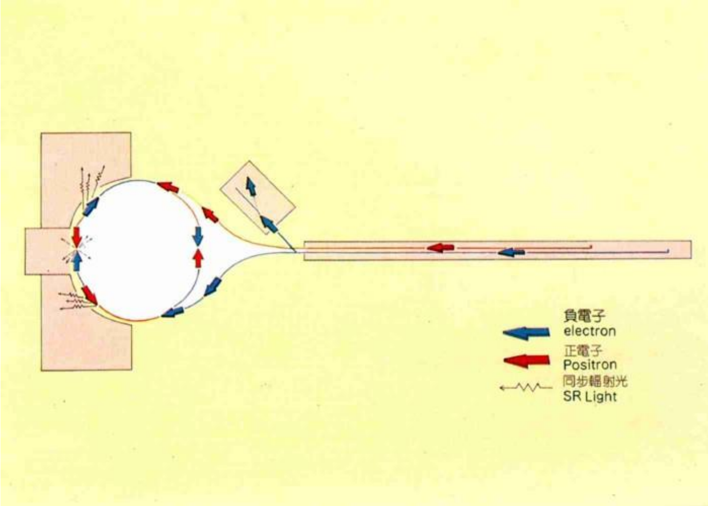
Outline

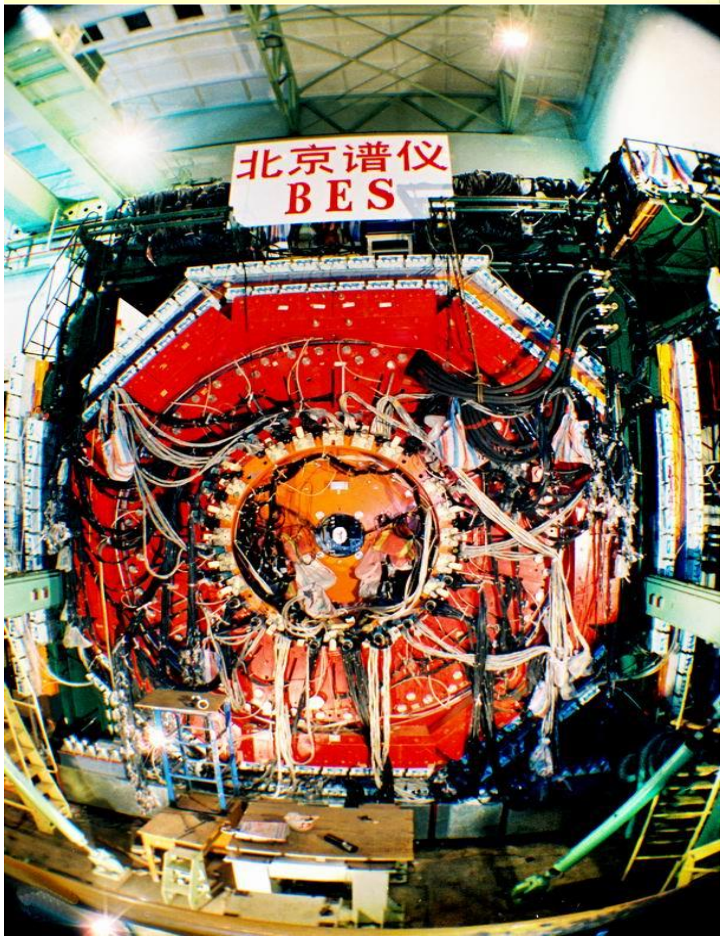
- History of BEPC/BES
- Physics accomplishments
- Future upgrades
- Summary

Beijing Electron Positron Collider(BEPC)

- April 1983, the State Council officially approved the proposal to construct the Beijing Electron Positron Collider (BEPC)
- October 1984, the groundbreaking ceremony for the BEPC project

Bird view of BEPC





BEPC constructed in 1984 -1988

Beam energy: 1 – 2.8 GeV

Run: Luminosity $10^{31}cm^{-2}s^{-1}$ @ 1.89GeV

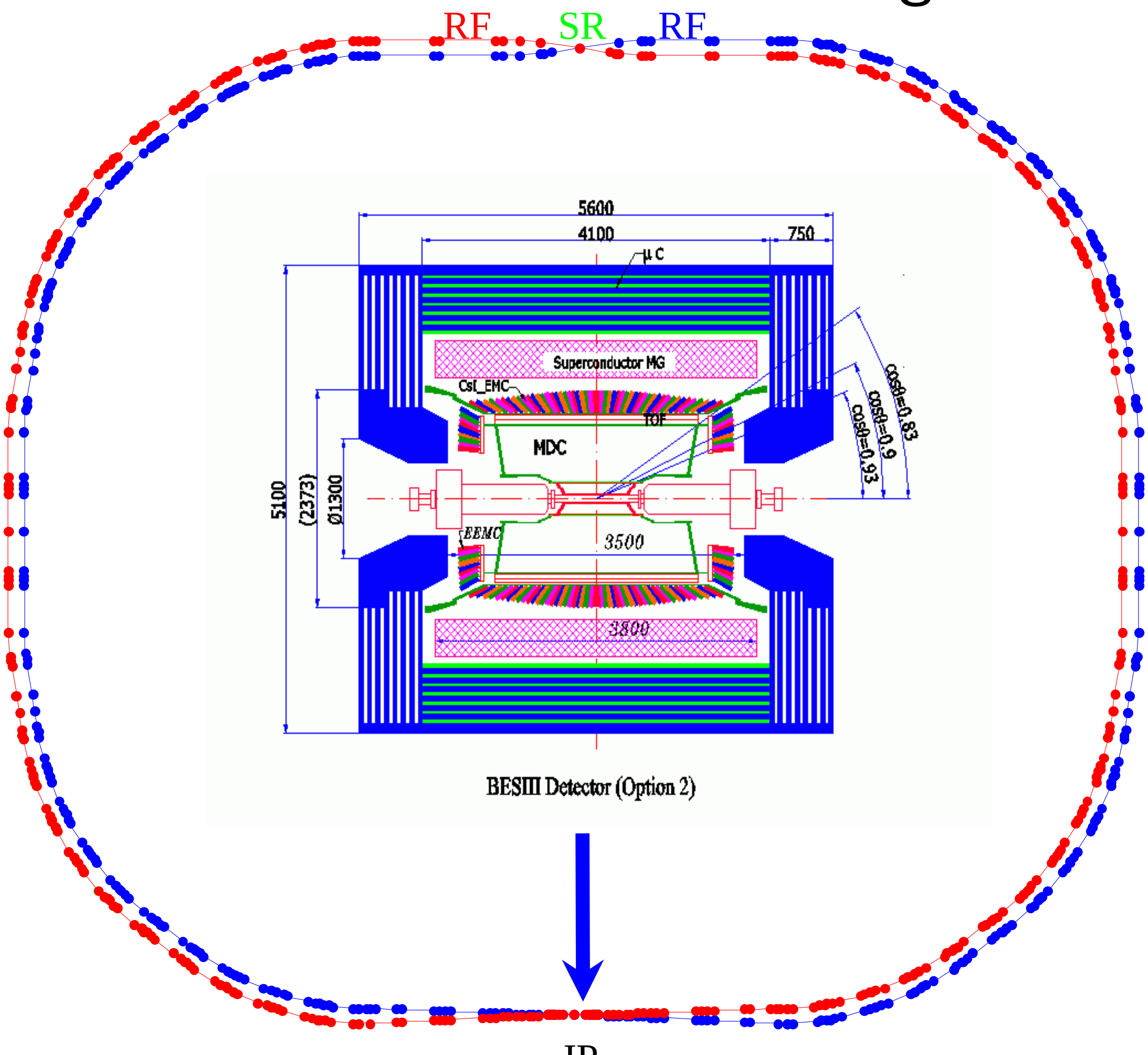
Upgrade in 1996–1998

（BES→BESII）

BEPCII and BESIII

- BEPC (Beijing Electron-Positron Collider)
  - BESI/BESII detector worked on it from 1988 to 2004
  - Beam energy: 1.5 - 2.8GeV
- BEPC → BEPCII
  - Luminosity:
    - $1.0\times10^{31}cm^{-2}s^{-1}$ → $1.0\times10^{33}cm^{-2}s^{-1}$
  - Number of beam bunches:
    - 1→ 93
- BESIII: a new spectrometer to be working on BEPCII
  - Very good energy and angle resolution for photon measurement
  - Accurate 4-momenta measurement of charged particles with low momentum
  - Good hadron identification capabilities

BEPC II Storage ring: Large angle, double-ring



Beam energy:
1-2 GeV

Luminosity:
1×10^{33} $cm^{-2}s^{-1}$

Optimum energy:
1.89 GeV

Energy spread:
5.16×10^{-4}

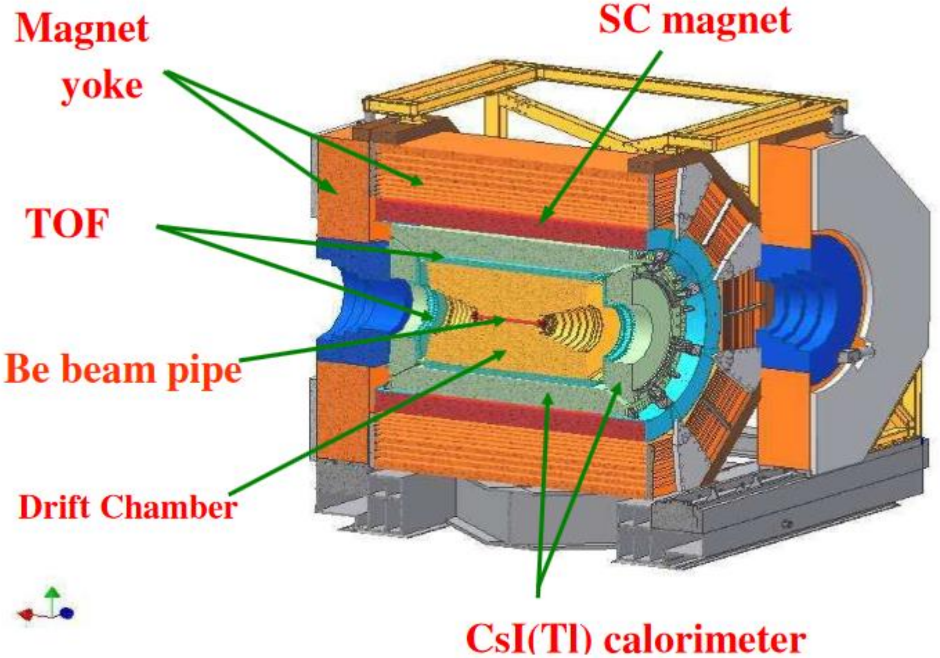
No. of bunches:
93

Bunch length:
1.5 cm

Total current:
0.91 A

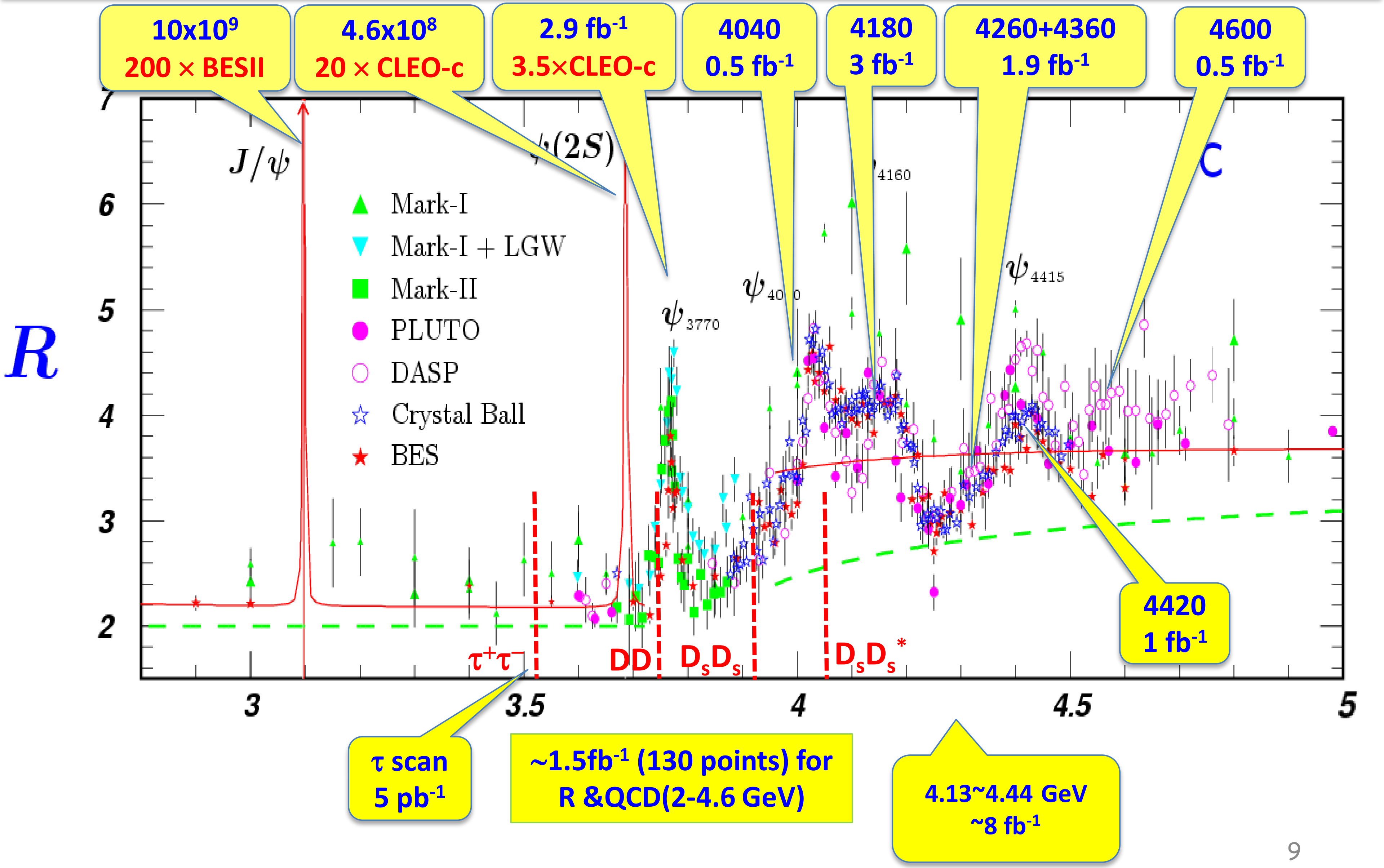
SR mode:
0.25A @ 2.5 GeV

BESIII detector



Sub-system	BESIII		BESII
MDC	$\sigma_{xy} = 130\ \mu$m		250 μm
	$\Delta P/P = 0.5\%$ @ 1 GeV	SC magnet	2.4% @ 1 GeV
	$\sigma_{dE/dx} = (6-7)\%$		8.5%
EM Calorimeter	$\Delta E/E = 2.5\%$ @ 1 GeV $\sigma_z = 0.6$ cm @ 1 GeV		20% @ 1 GeV 3 cm @ 1 GeV
TOF Detector	$\sigma_T =$ 100 ps barrel 110 ps endcap		180 ps barrel 350 ps endcap
μ Counters	9 layers		3 layers
Magnet	1.0 Tesla		0.4 Tesla

World largest data sample directly collected in the tau-charm region

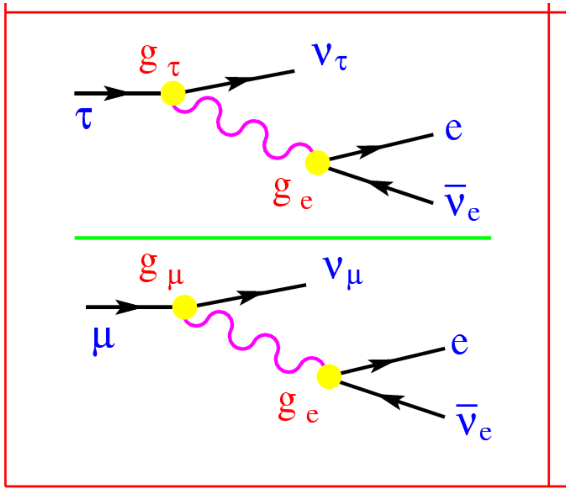


Physics accomplishments

- τ mass measurement
- Charm physics
- Hyperon physics
- Exotic hadrons (Light hadron +XYZ states)

τ mass measurement

τ mass measurement



- Lepton Universality relation

$$\frac{g_\tau^2}{g_\mu^2} = \frac{m_\mu^5}{m_\tau^5}\frac{B(\tau \to e\bar{\nu}_e\nu_\tau)}{B(\mu \to e\bar{\nu}_e\nu_\mu)}\frac{\tau_\mu}{\tau_\tau}$$

- It should be ~1 if universality holds
- PDG1992:

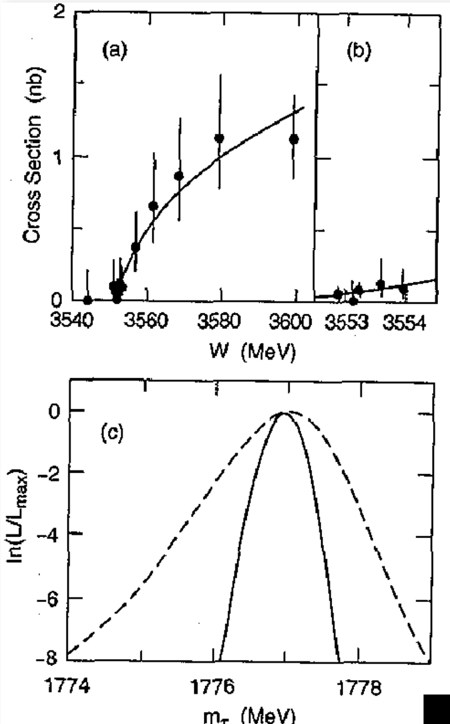
$$\frac{g_\tau}{g_\mu} = 0.941 \pm 0.025$$

- **τ mass: DASP, SPEC,DELCO,MARK-II**

$$m_\tau = 1784.1^{+2.7}_{-3.6}\, MeV$$

- More likely **τ mass** come down in case of lepton universality

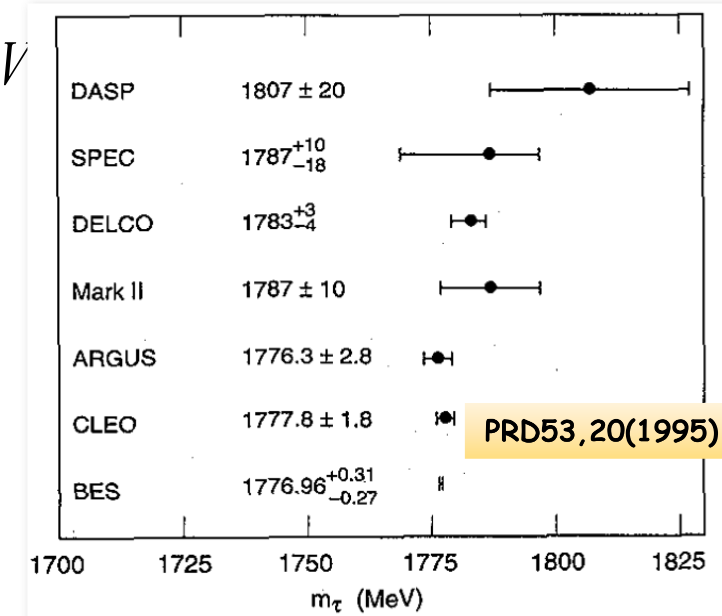
τ mass: eμ +other events （BESI）

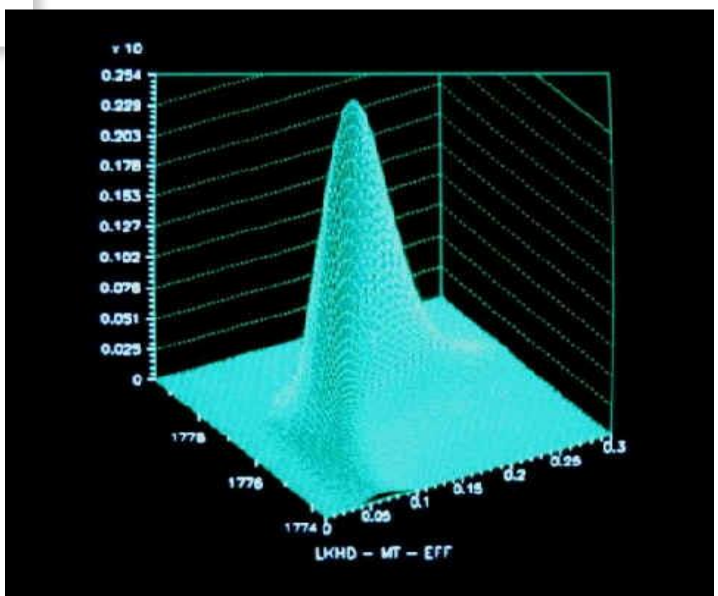


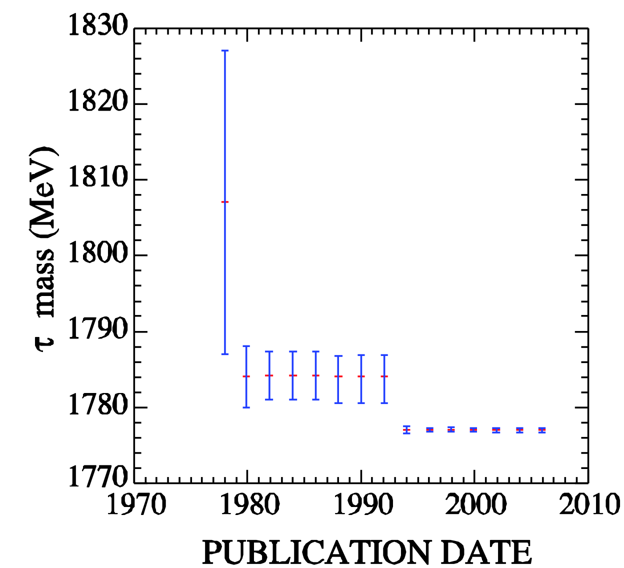
$$m_\tau = 1776.96^{+0.18+0.25}_{-0.21-0.17}\, MeV$$

$$\frac{g_\tau}{g_\mu} = 0.9886 \pm 0.0085$$

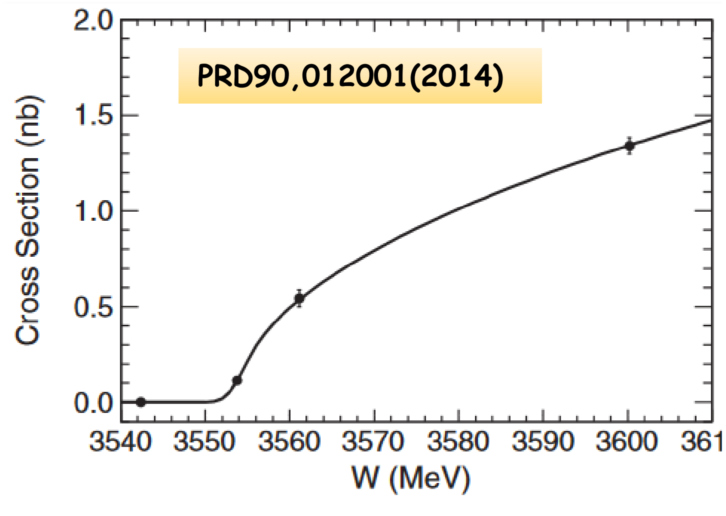
- Lepton universality !

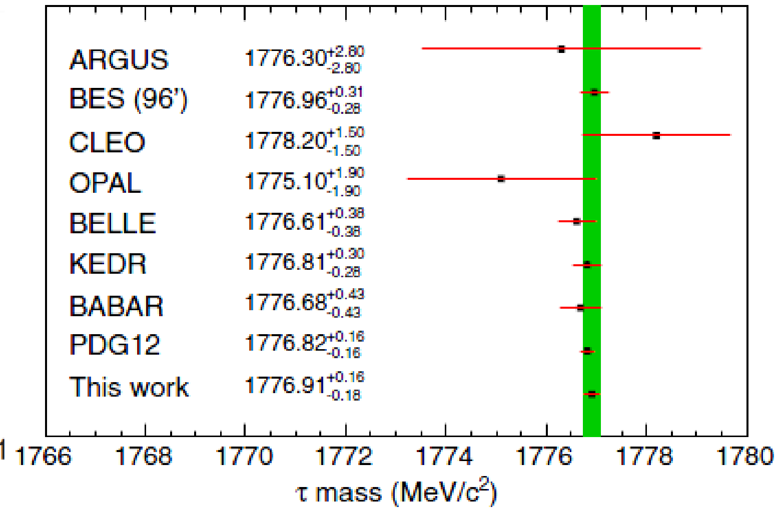


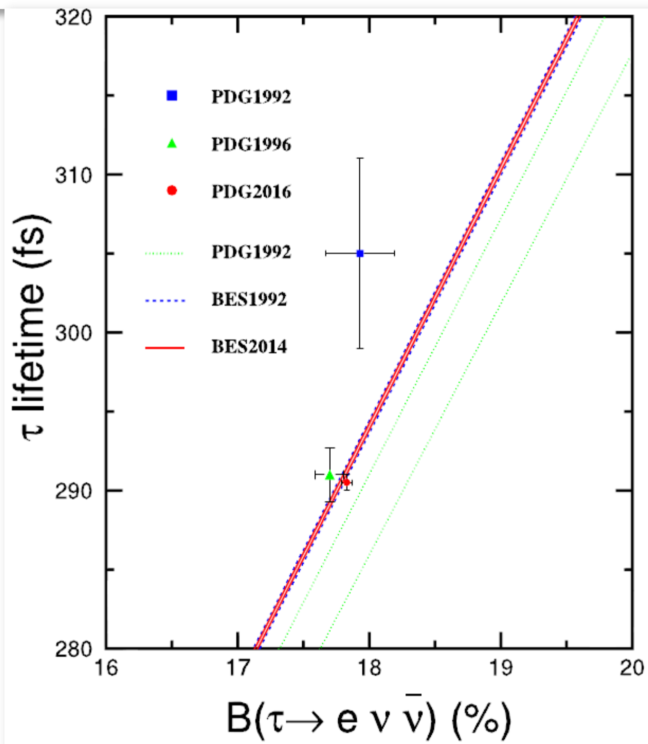




τ mass measurement at BESIII







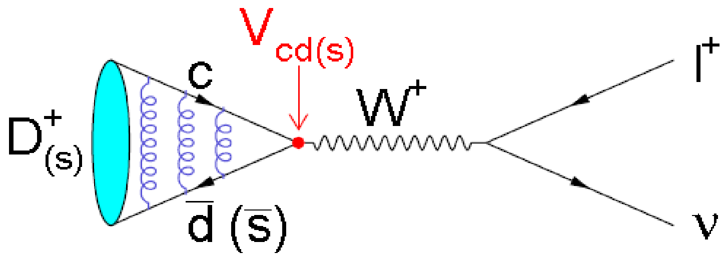
$$m_\tau = 1776.91 \pm 0.12^{+0.10}_{-0.13}\, MeV$$

$$\frac{g_\tau}{g_\mu} = 1.0016 \pm 0.0042$$

- A fine scan was performed again in 2018
- ~136pb^{-1}
- Expected to be < 0.1 MeV

Charm physics

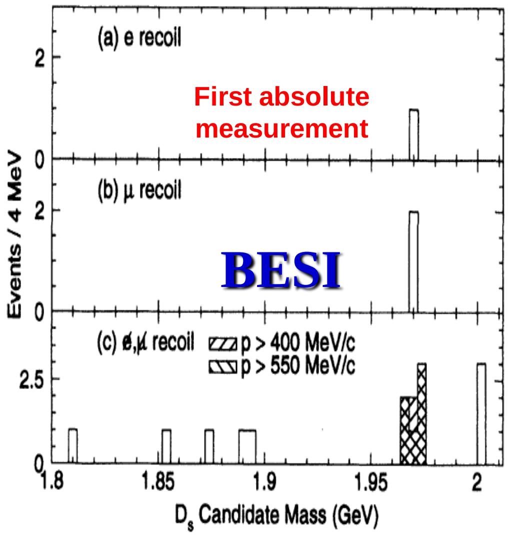
$D_{(s)}^+ \to l^+\nu$ at BESI/II



$$\Gamma(D^+_{(s)} \to \ell^+\nu_\ell) = \frac{G_F^2 f^2_{D^+_{(s)}}}{8\pi}|V_{cd(s)}|^2 m_\ell^2 m_{D^+_{(s)}} \left(1 - \frac{m_\ell^2}{m^2_{D^+_{(s)}}}\right)^2$$

22.3 pb^{-1} at 4.03 GeV

3 $D_s^+ \to \mu^+\nu$

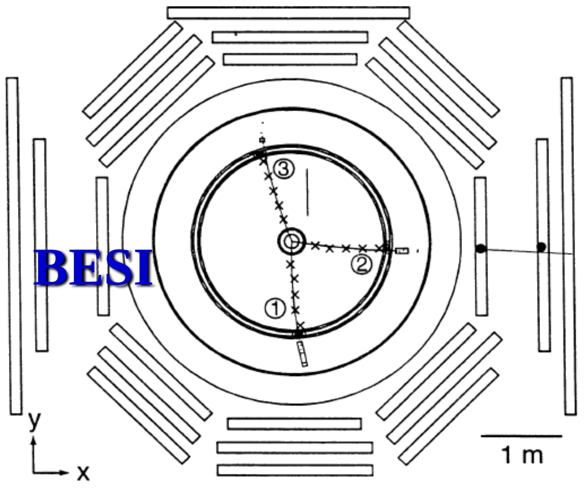


PRL74(1995)4599

$f_{D_s^+} = (430^{+150+40}_{-130-40})$ MeV

22.3 pb^{-1} at 4.03 GeV

1 $D^+ \to \mu^+\nu$

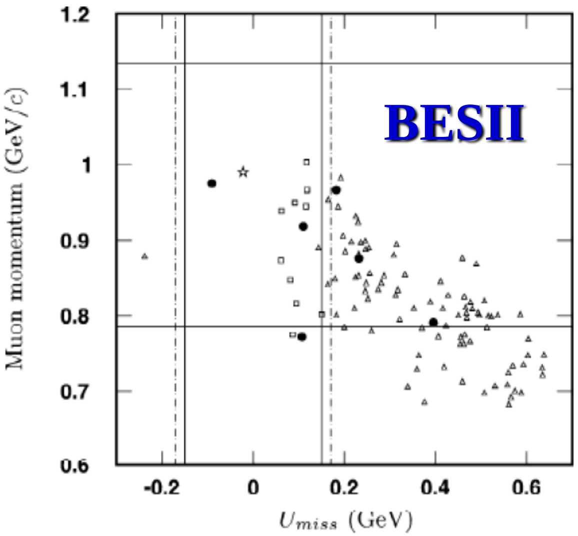


PLB429(1998)188

$f_{D^+} = (300^{+180+80}_{-150-40})$ MeV

33 pb^{-1} around ψ(3770)

3 $D^+ \to \mu^+\nu$



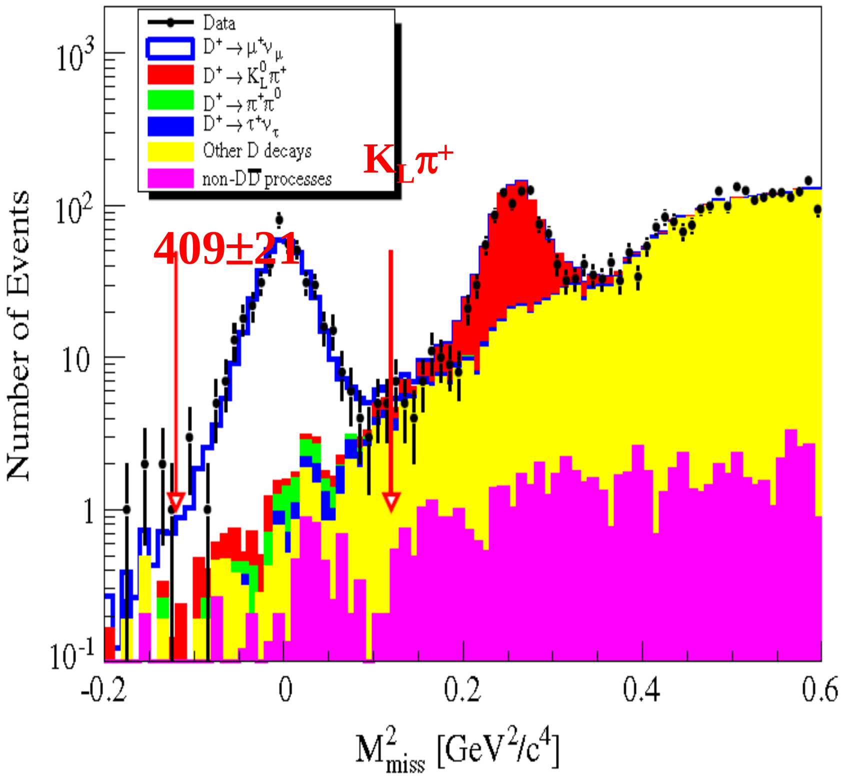
PLB610(2005)183

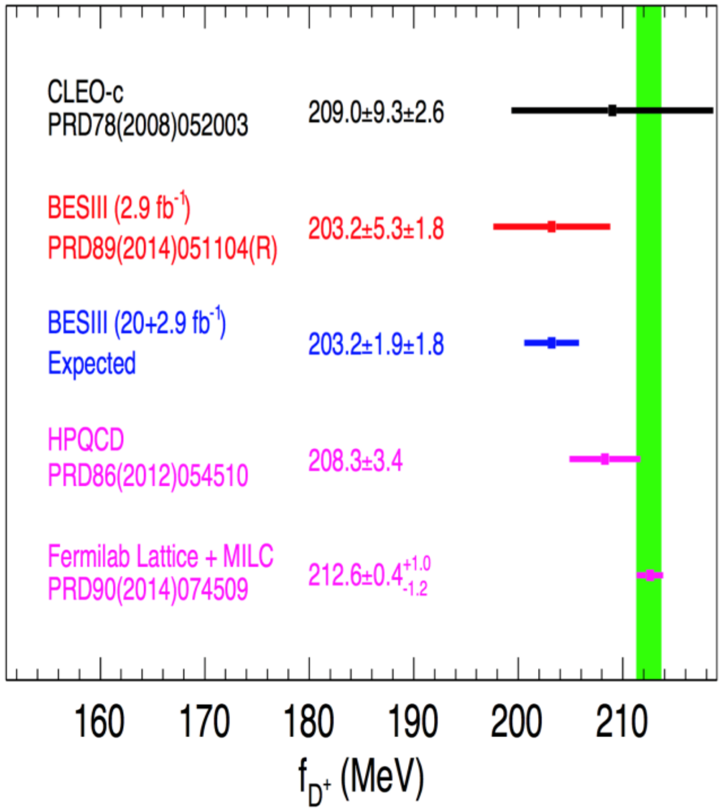
$f_{D^+} = (371^{+129}_{-119} \pm 25)$ MeV

$D^+ \to l^+ \nu$ at BESIII

2.93 fb^{-1} data@ 3.773 GeV

PRD89(2014)051104R

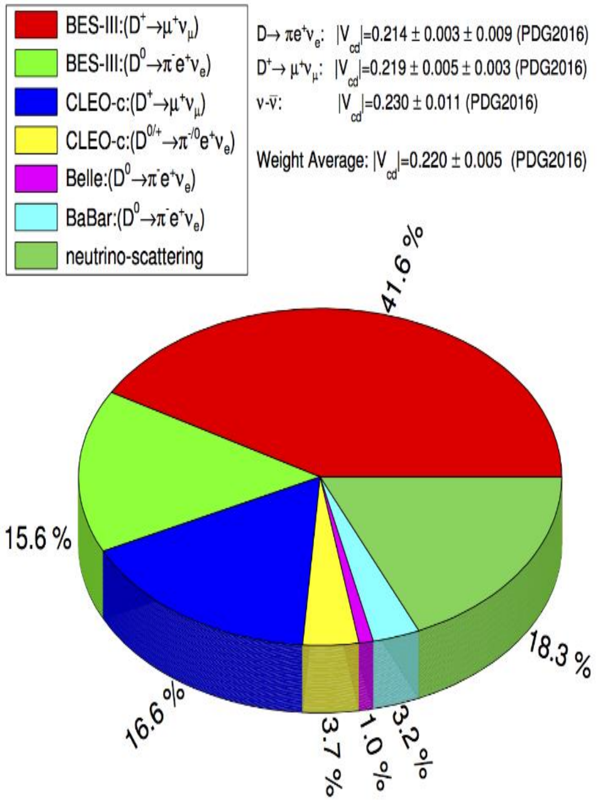


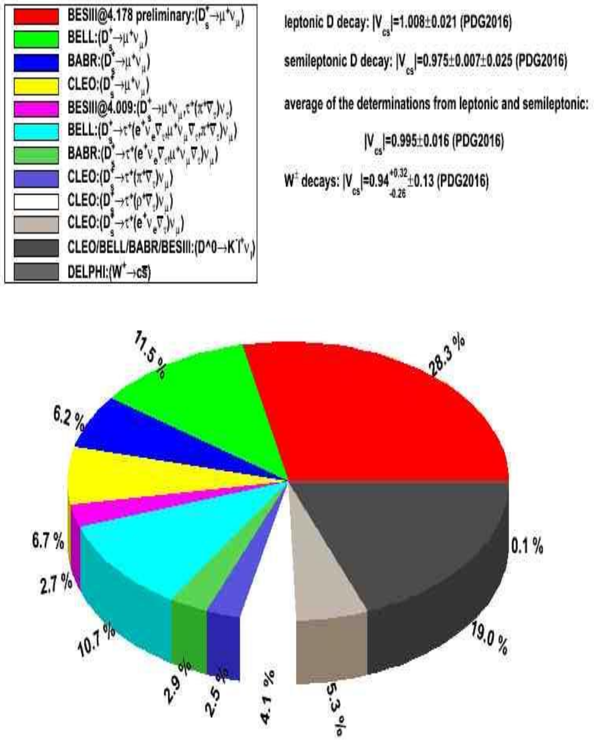


f_{D+}=(203.2±5.3±1.8) MeV

$|V_{cd}|$=0.2210±0.0058±0.0047

BESIII's contribution to $|V_{cs(d)}|$

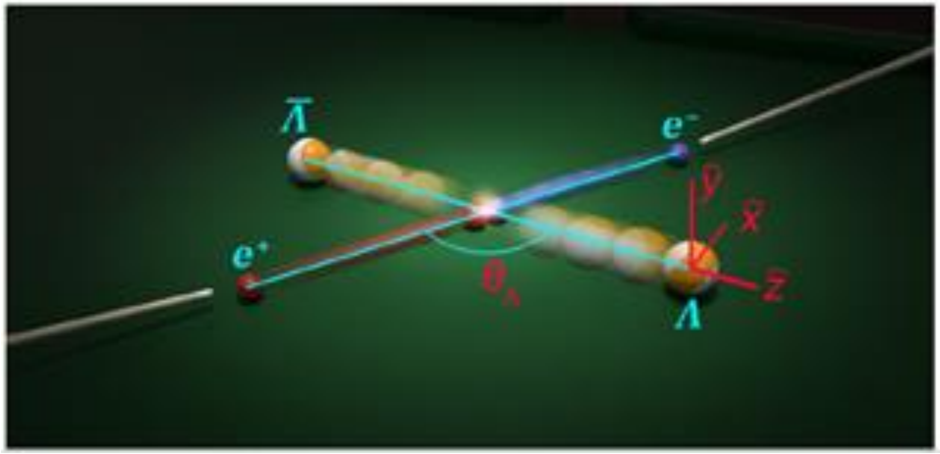


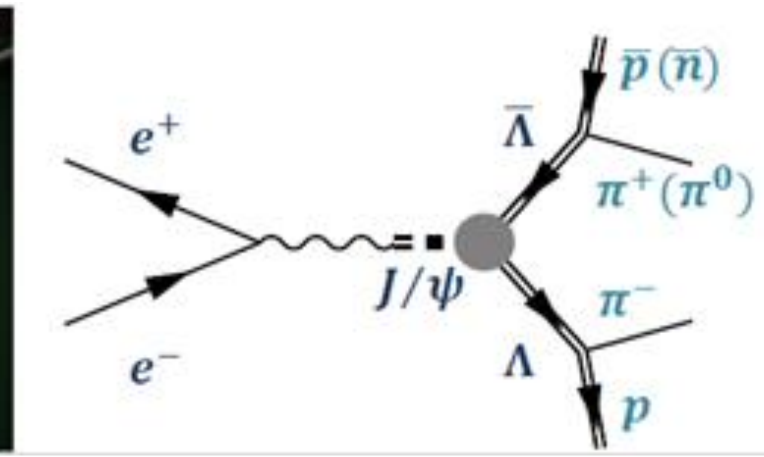


After combining $D_s^+ \to \tau^+ \nu$ $|V_{cs}|$, the weight of BESIII will be greater than 50%

Hyperon physics

Λ polarization in $J/\psi \to \Lambda\ \bar{\Lambda}$



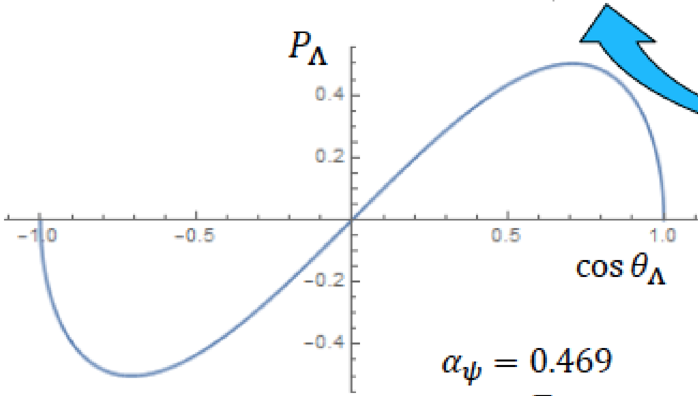


Transition between e+e- and $\Lambda\ \bar{\Lambda}$ including helicity conserving and –flip amplitudes

For unpolarized e+e- beams

$$\bar{P}_\Lambda(\theta_\Lambda) = \frac{\sqrt{1-\alpha_\psi}\cos\theta_\Lambda \sin\theta_\Lambda}{1+\alpha_\psi \cos^2\theta_\Lambda} \sin(\Delta\Phi)\hat{y}$$

$\Delta\Phi \neq 0$



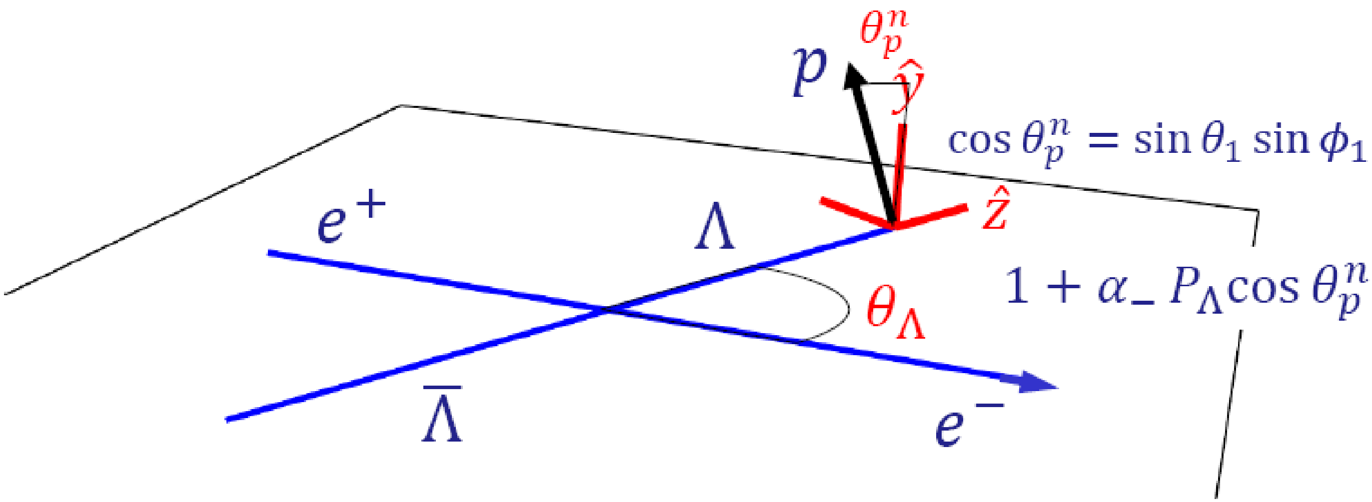
$\alpha_\psi = 0.469$

$\Delta\Phi = \frac{\pi}{2}$

G. Faldt EPJA51,74(2015), A52,141(2016)

20

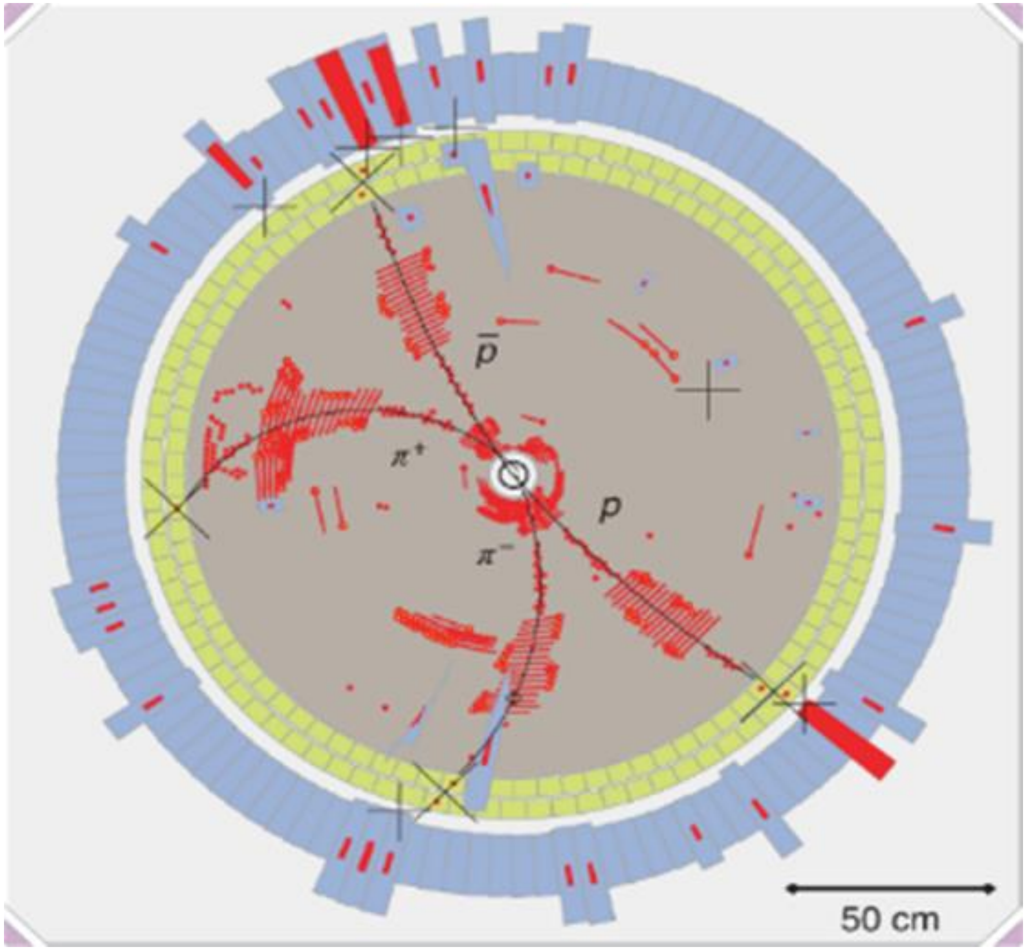
$e^+e^- \to (\Lambda \to p\pi^-)\,\overline{\Lambda}$



Hyperon polarization determined using
angular distribution of the baryon from weak decay

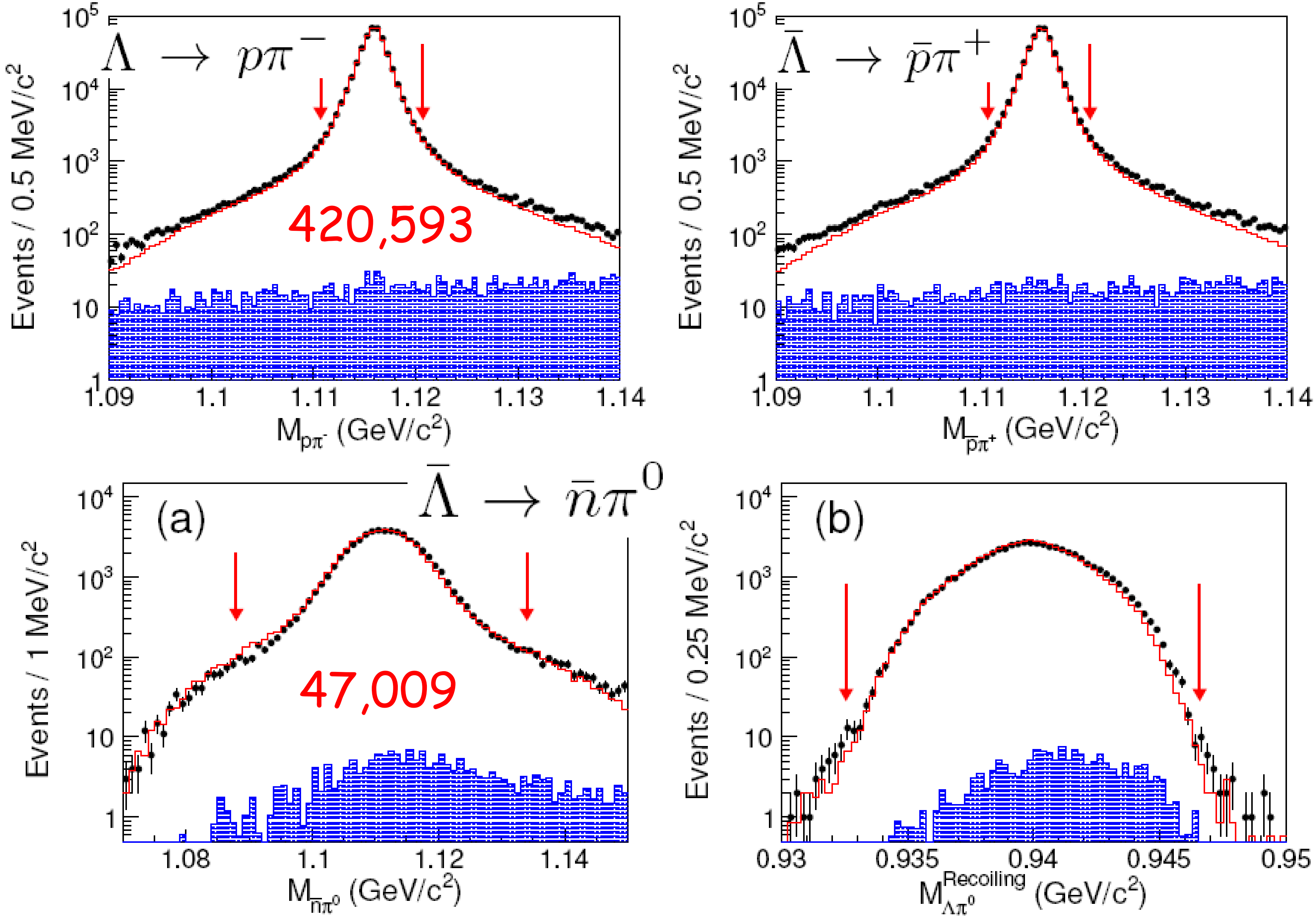
$$\begin{aligned}
\mathcal{W}(\xi;\alpha_\psi,\Delta\Phi,\alpha_-,\alpha_+) =& 1+\alpha_\psi\cos^2\theta_\Lambda \\
&+\alpha_-\alpha_+\left[\sin^2\theta_\Lambda\left(n_{1,x}n_{2,x}-\alpha_\psi n_{1,y}n_{2,y}\right)+\left(\cos^2\theta_\Lambda+\alpha_\psi\right)n_{1,z}n_{2,z}\right] \\
&+\alpha_-\alpha_+\sqrt{1-\alpha_\psi{}^2}\cos(\Delta\Phi)\sin\theta_\Lambda\cos\theta_\Lambda\left(n_{1,x}n_{2,z}+n_{1,z}n_{2,x}\right) \\
&+\sqrt{1-\alpha_\psi{}^2}\sin(\Delta\Phi)\sin\theta_\Lambda\cos\theta_\Lambda\left(\alpha_- n_{1,y}+\alpha_+ n_{2,y}\right),
\end{aligned}$$

A typical J/ψ→ $\Lambda \bar{\Lambda}$ event



$J/\psi \to \Lambda\ \bar{\Lambda}$

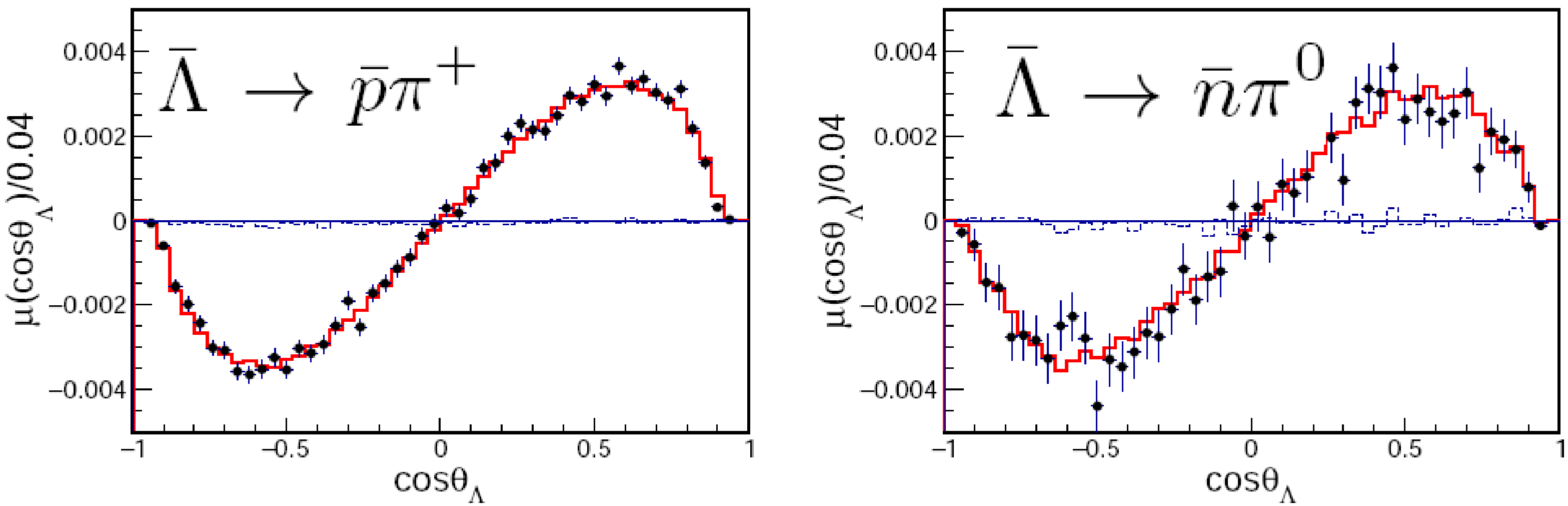
1.3 B J/ψ events



First observation Λ polarization in $J/\psi \rightarrow \Lambda \bar{\Lambda}$

Nature physics (2019) arXiv:1808.08917

$$\Delta\Phi = (42.4 \pm 0.6 \pm 0.5)^\circ$$



Decay asymmetry

$$A_{CP} = \frac{\alpha_- + \alpha_+}{\alpha_- - \alpha_+}$$

Parameters	This work	Previous results
α_ψ	$0.461 \pm 0.006 \pm 0.007$	0.469 ± 0.027 [25]
$\Delta\Phi$	$(42.4 \pm 0.6 \pm 0.5)^\circ$	–
α_-	$0.750 \pm 0.009 \pm 0.004$	0.642 ± 0.013 [27]
α_+	$-0.758 \pm 0.010 \pm 0.007$	-0.71 ± 0.08 [27]
$\bar{\alpha}_0$	$-0.692 \pm 0.016 \pm 0.006$	–
A_{CP}	$-0.006 \pm 0.012 \pm 0.007$	0.006 ± 0.021 [27]
$\bar{\alpha}_0/\alpha_+$	$0.913 \pm 0.028 \pm 0.012$	–

Summary

Extraction of the N^* and Δ spectrum from experimental data:

- new information from photoproduction data
- also electroproduction
- recent results from different PW analysis groups

Jülich-Bonn model:

- extension of the coupled-channel approach to kaon photoproduction
- $\gamma p \to K\Sigma$ especially interesting for $I = 3/2$ states
- impact of a new value of the Λ decay parameter α_-:
  - many resonances more or less stable
  - some exceptions with major changes in the resonance parameters
  - photo couplings at the pole more sensitive than other parameter

Future plans JüBo:

- electroproduction (already in progress)
- inclusion of the further channels, e.g. photoproduction on the neutron

D. Ronchen's talk at NSTAR2019

D.G. Ireland's talk at NSTAR2019

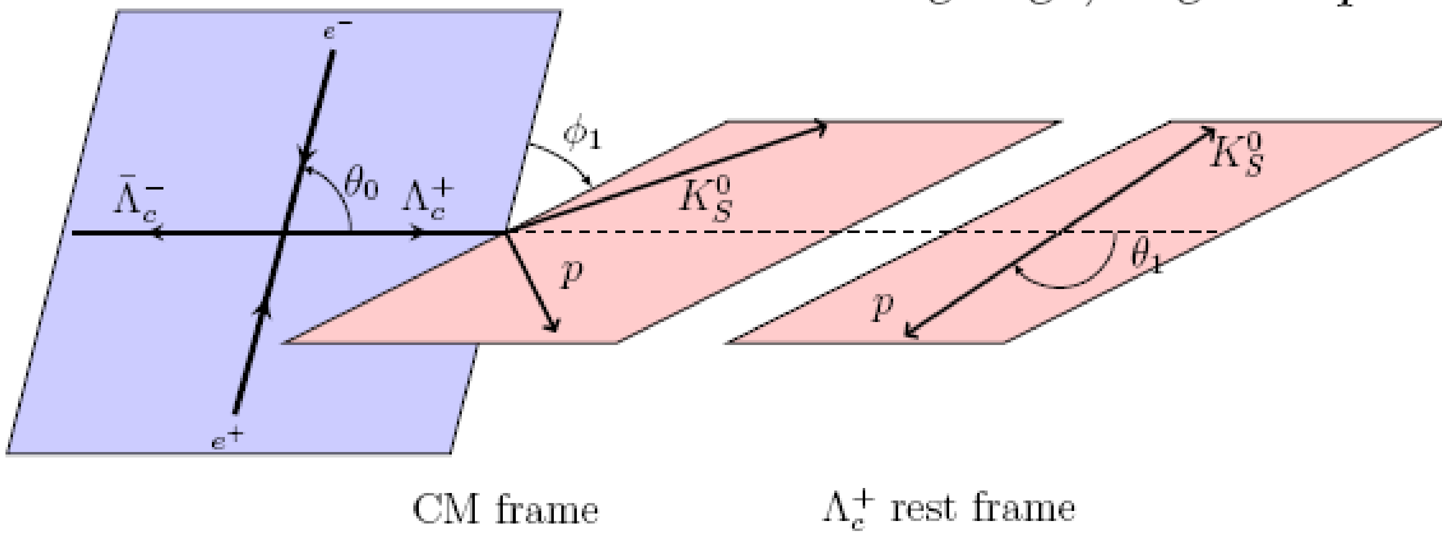
Summary

- New BES III result for α_- is 17% higher than PDG value
- Affects all recoil observables relying on Λ weak decay
- Kaon photoproduction data can independently determine α_-
- Our result: $\alpha_- = 0.721 \pm 0.006$ (stat.) ± 0.005(sys.)
- Other analyses will have to be reviewed!

Λ_c decay asymmetry parameters

arXiv:1905.04707, submitted to PRL

$$e^+e^- \to \Lambda_c^+\bar{\Lambda}_c^-,\ \Lambda_c^+ \to pK_S^0$$

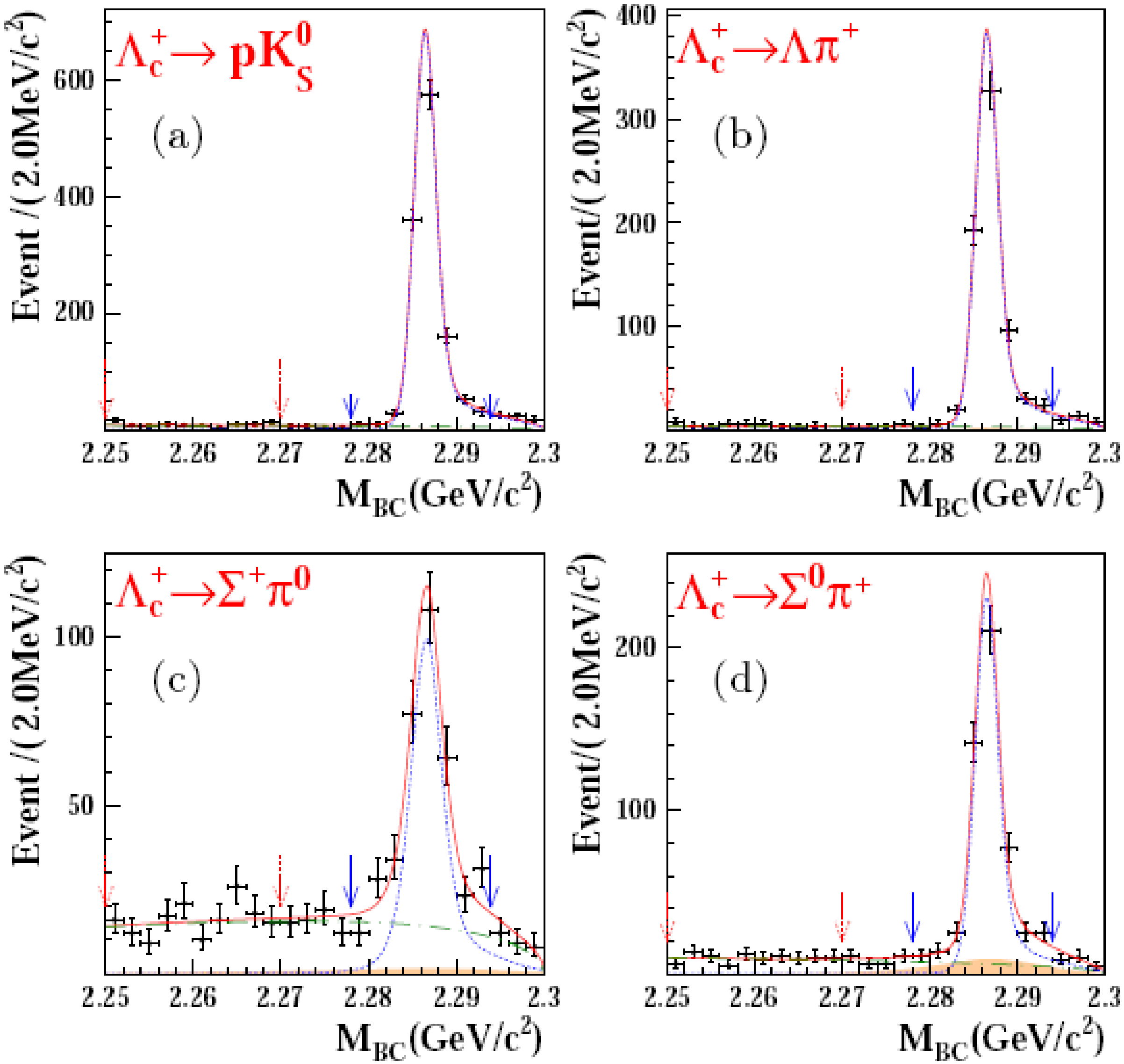


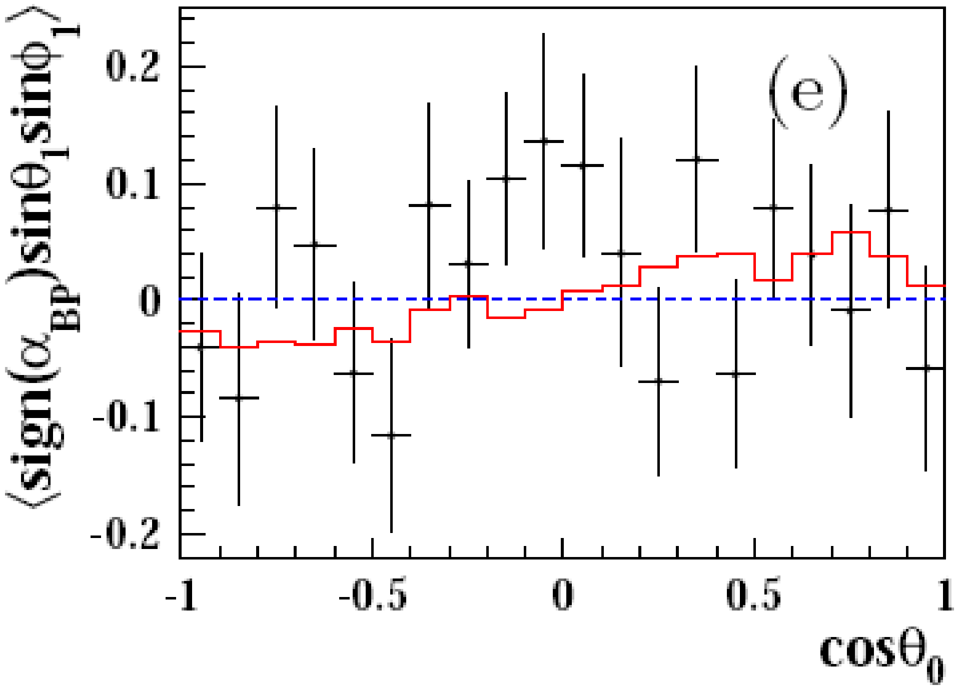
Goran Fald, arXiv:1709.0180

$$\frac{d\Gamma}{d\cos\theta_0 d\cos\theta_1 d\phi_1} \propto 1 + \alpha_0\cos^2\theta_0 + \mathcal{P}_T\alpha^+_{pK_S^0}\sin\theta_1\sin\phi_1,$$

$$\mathcal{P}_T = \sqrt{1-\alpha_0^2}\cos\theta_0\sin\theta_0\sin\Delta_0,$$

Λc signals 567fb-1 @4.6 GeV



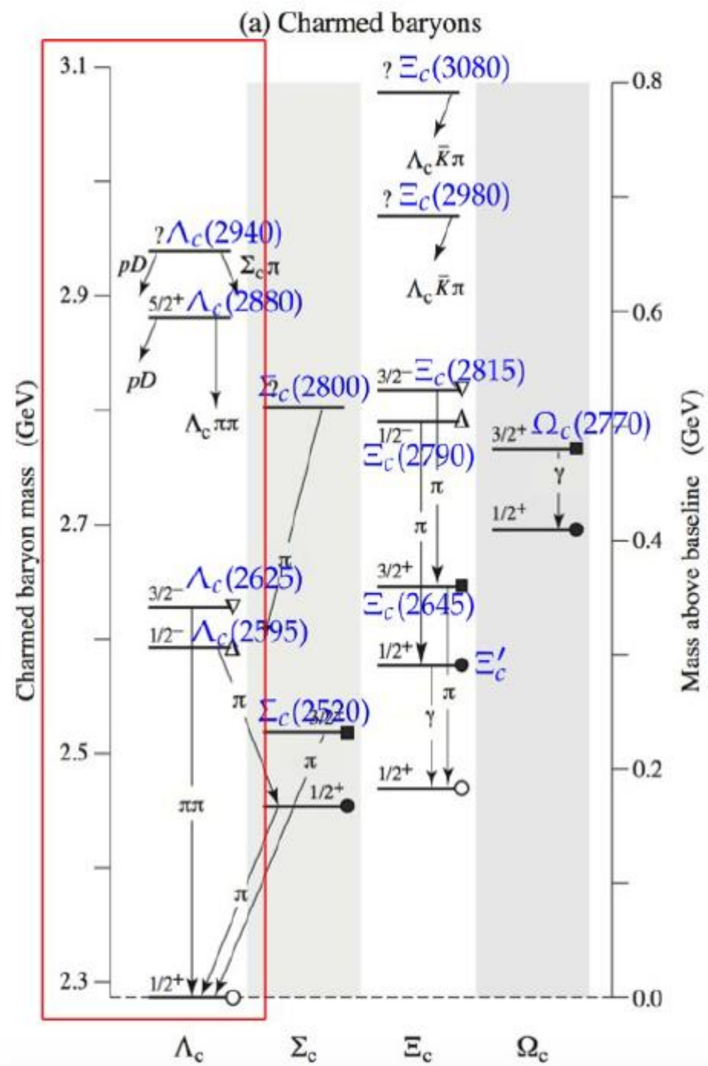


No evident Λ_c polarization

$$\Delta_0 = -0.28 \pm 0.13 \pm 0.03$$

$\Lambda_c^+ \to$		pK_S^0	$\Lambda\pi^+$	$\Sigma^+\pi^0$	$\Sigma^0\pi^+$
$\alpha_{BP}^{\Lambda_c^+}$	Predicted	−1.0 [16], 0.51 [11]	−0.70 [16], −0.67 [11]	0.71 [16], 0.92 [11]	0.70 [16], 0.92 [11]
		−0.49 [10], −0.90 [10]	−0.95 [10], −0.99 [10]	0.79 [10] −0.49 [10]	0.78 [10], −0.49 [10]
		−0.49 [17], −0.97 [18]	−0.96 [17], −0.95 [18]	0.83 [17], 0.43 [18]	0.83 [17], 0.43 [18]
		−0.66 [19], −0.90 [30]	−0.99 [19], −0.86 [30]	0.39 [19], −0.76 [30]	0.39 [19], −0.76 [30]
		−0.99 [20], −0.91 [31]	−0.99 [20], −0.94 [31]	−0.31 [20], −0.47 [31]	−0.31 [20], −0.47 [31]
	PDG [2]		-0.91 ± 0.15	-0.45 ± 0.32	
	This work	$0.18 \pm 0.43 \pm 0.14$	$-0.80 \pm 0.11 \pm 0.02$	$-0.57 \pm 0.10 \pm 0.07$	$-0.73 \pm 0.17 \pm 0.07$
Δ_1^{BP}(rad)	This work		$3.0 \pm 2.4 \pm 1.0$	$4.1 \pm 1.1 \pm 0.6$	$0.8 \pm 1.2 \pm 0.2$
β_{BP}	This work		$0.06^{+0.58+0.05}_{-0.47-0.06}$	$-0.66^{+0.46+0.22}_{-0.25-0.02}$	$0.48^{+0.35+0.07}_{-0.57-0.13}$
γ_{BP}	This work		$-0.60^{+0.96+0.17}_{-0.05-0.03}$	$-0.48^{+0.45+0.21}_{-0.42-0.04}$	$0.49^{+0.35+0.07}_{-0.56-0.12}$

Λ_c decay before 2014



- Λ_c^+ was observed in 1979
- All decays of Λ_c^+ were measured with high energy data and relative to $pK^-\pi^+$, which suffers an error of 25%. No absolute measurement using threshold Λ_c^+ data
- Only about 60% decays are known

Λ_c^+ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Hadronic modes with a p: $S = -1$ final states				
$p\overline{K}^0$		(2.3 ± 0.6) %		873
$pK^-\pi^+$	[a]	(5.0 ± 1.3) %		823
$p\overline{K}^*(892)^0$	[b]	(1.6 ± 0.5) %		685
$\Delta(1232)^{++}K^-$		(8.6 ± 3.0) $\times 10^{-3}$		710
$\Lambda(1520)\pi^+$	[b]	(1.8 ± 0.6) %		627
$pK^-\pi^+$ nonresonant		(2.8 ± 0.8) %		823
$p\overline{K}^0\pi^0$		(3.3 ± 1.0) %		823
$p\overline{K}^0\eta$		(1.2 ± 0.4) %		568

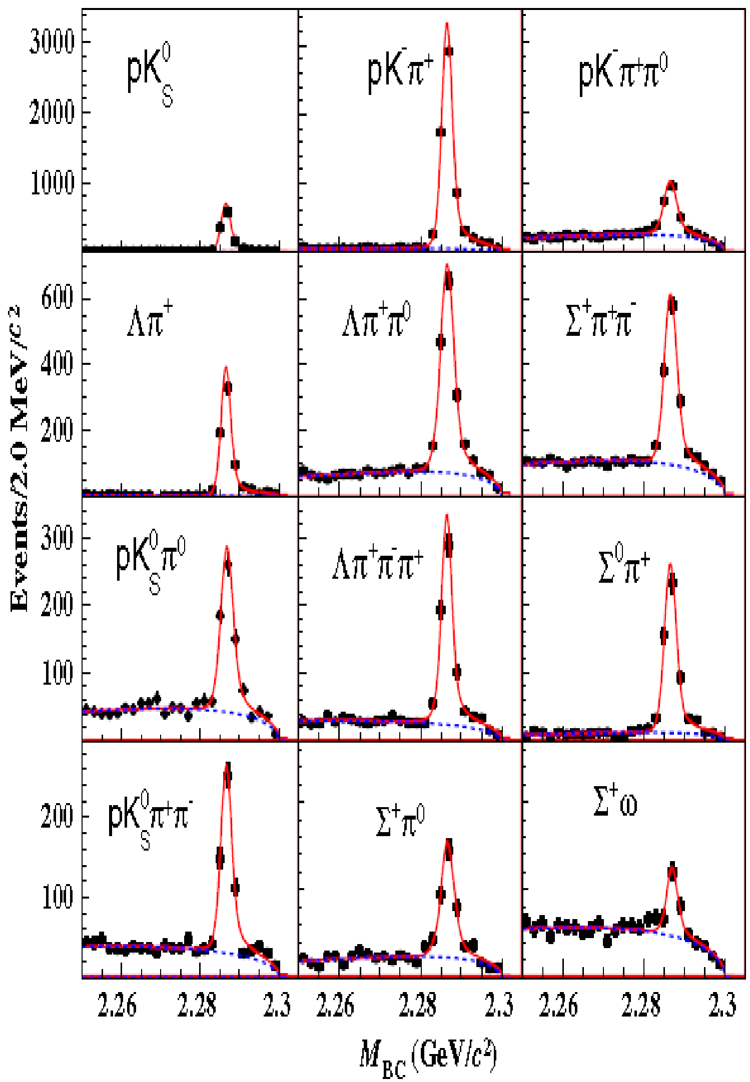
Systematic studies of Λ_c^+, search for new decays, absolute BF measurements are important to explore Λ_c^+ decay mechanisms

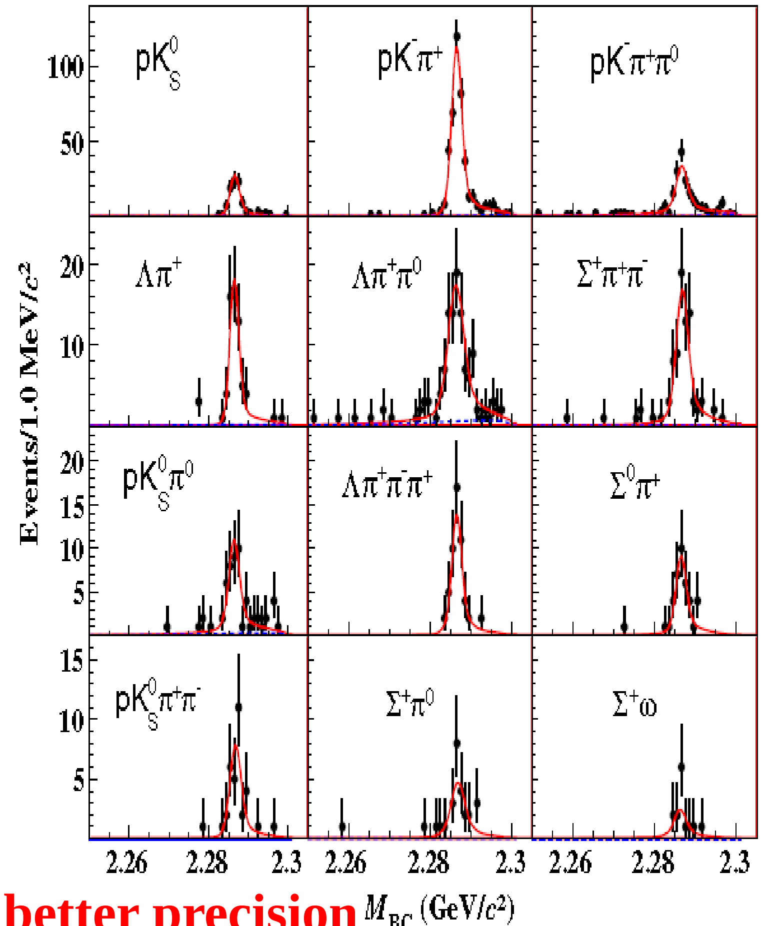
Λ_c^+ hadronic decays

BESIII, PRL116(2016)052001

ST: ~15000

DT: ~1000



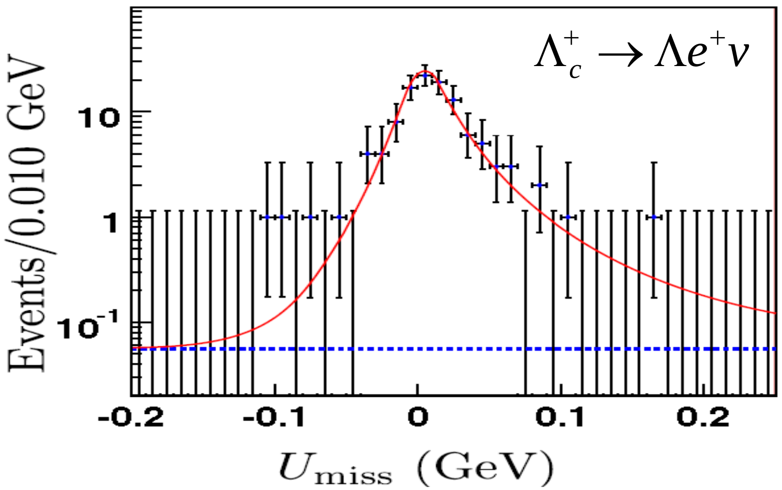


Much better precision

Mode	This work (%)	PDG (%)
pK_S^0	$1.52 \pm 0.08 \pm 0.03$	1.15 ± 0.30
$pK^-\pi^+$	$5.84 \pm 0.27 \pm 0.23$	5.0 ± 1.3
$pK_S^0\pi^0$	$1.87 \pm 0.13 \pm 0.05$	1.65 ± 0.50
$pK_S^0\pi^+\pi^-$	$1.53 \pm 0.11 \pm 0.09$	1.30 ± 0.35
$pK^-\pi^+\pi^0$	$4.53 \pm 0.23 \pm 0.30$	3.4 ± 1.0
$\Lambda\pi^+$	$1.24 \pm 0.07 \pm 0.03$	1.07 ± 0.28
$\Lambda\pi^+\pi^0$	$7.01 \pm 0.37 \pm 0.19$	3.6 ± 1.3
$\Lambda\pi^+\pi^-\pi^+$	$3.81 \pm 0.24 \pm 0.18$	2.6 ± 0.7
$\Sigma^0\pi^+$	$1.27 \pm 0.08 \pm 0.03$	1.05 ± 0.28
$\Sigma^+\pi^0$	$1.18 \pm 0.10 \pm 0.03$	1.00 ± 0.34
$\Sigma^+\pi^+\pi^-$	$4.25 \pm 0.24 \pm 0.20$	3.6 ± 1.0
$\Sigma^+\omega$	$1.56 \pm 0.20 \pm 0.07$	2.7 ± 1.0

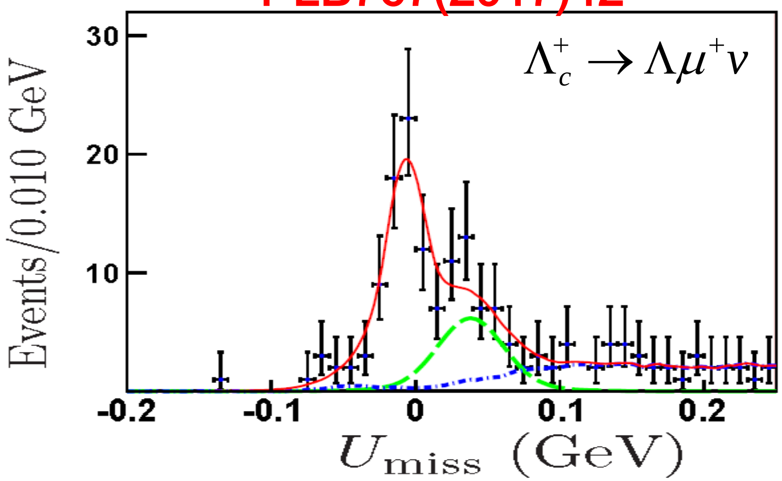
Semi-leptonic decay $\Lambda_c^+ \to \Lambda l^+ \nu$

PRL115(2015)221805



$$B[\Lambda_c^+ \to \Lambda e^+ \nu] = (3.63 \pm 0.38 \pm 0.20)\%$$

PLB767(2017)42

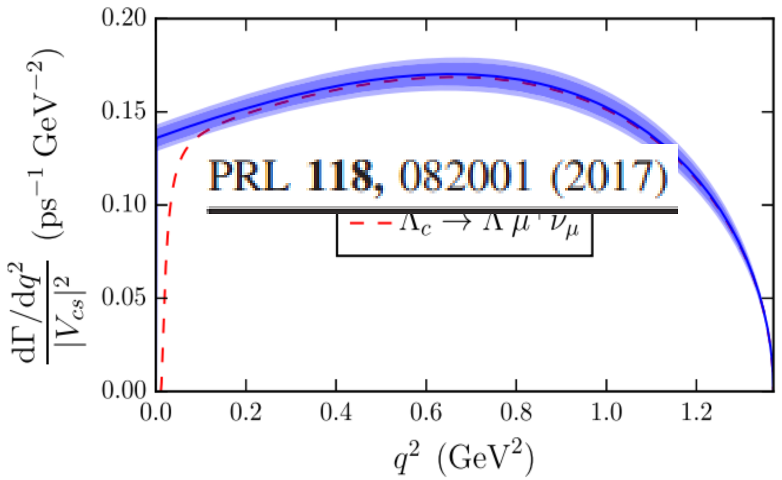


$$B[\Lambda_c^+ \to \Lambda \mu^+ \nu] = (3.49 \pm 0.46 \pm 0.26)\%$$

Lepton universality:

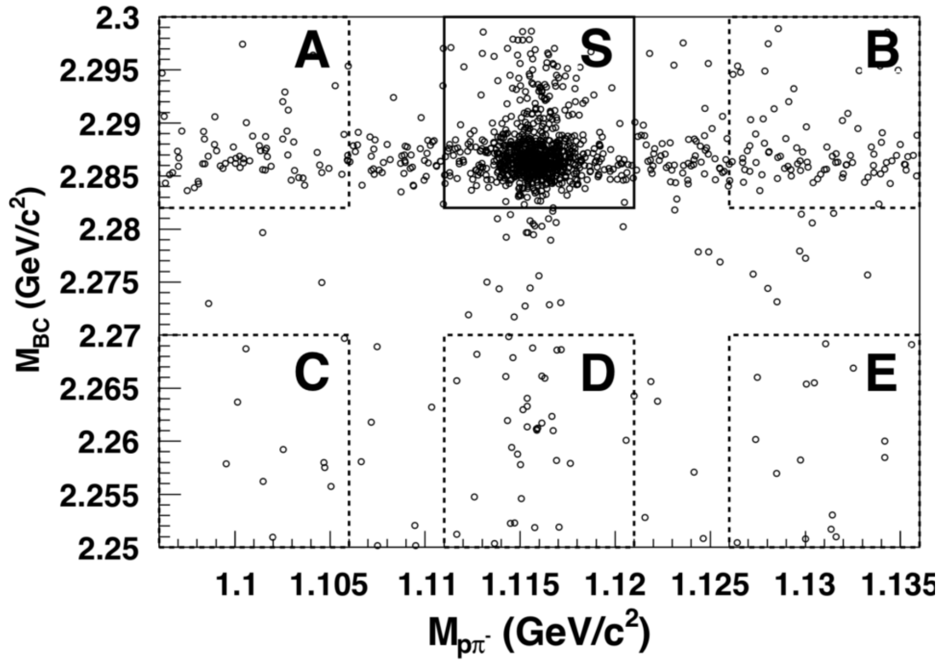
$$\frac{\Gamma[\Lambda_c^+ \to \Lambda \mu^+ \nu]}{\Gamma[\Lambda_c^+ \to \Lambda e^+ \nu]} = 0.96 \pm 0.16 \pm 0.04$$

LQCD results : consistent with BESIII



Absolute measurement of $\Lambda c \rightarrow \Lambda + anything$

PRL 121, 062003 (2018)



PDG: (33±11)%

$$\mathcal{B}(\Lambda_c^+ \to \Lambda + X) = (38.2^{+2.8}_{-2.2} \pm 0.8)\%.$$

Sum of excl. decays: ~25%, 13% of them still unknown

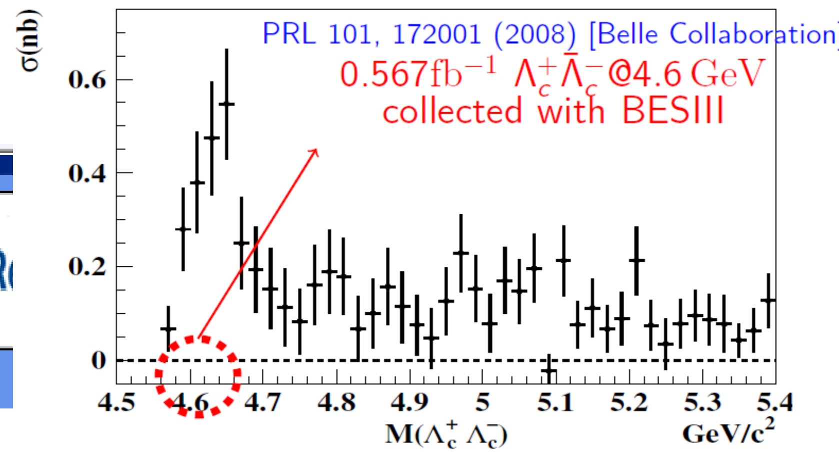
$$A_{CP} \equiv \frac{\mathcal{B}(\Lambda_c^+ \to \Lambda + X) - \mathcal{B}(\bar{\Lambda}_c^- \to \bar{\Lambda} + X)}{\mathcal{B}(\Lambda_c^+ \to \Lambda + X) + \mathcal{B}(\bar{\Lambda}_c^- \to \bar{\Lambda} + X)}$$

$A_{cp} = (2.1^{+7.0}_{-6.6} \pm 1.4)\%$

(No CPV is observed.)

Larger threshold Λ_c^+ data at BESIII

BESIII open a new window to study Λ_c^+ decays



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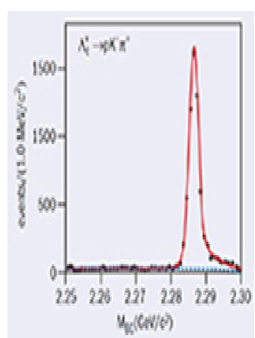
Mar 18, 2016

BESIII makes first direct measurement of the Λ_c at threshold

The charmed baryon, Λ_c, was first observed at Fermilab in 1976. Now, 40 years later, the Beijing Spectrometer (BESIII) experiment at the Beijing Electron-Positron Collider II (BEPCII) has measured the absolute branching fraction of $\Lambda^+_c \to pK^-\pi^+$ at threshold for the first time.



Beam-constrained mass distribution

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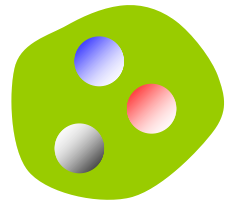
KEY SUPPLIERS

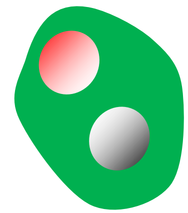
Exotic hadrons

Conventional & Exotic hadrons

- Quark Model

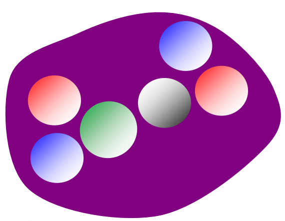


baryon

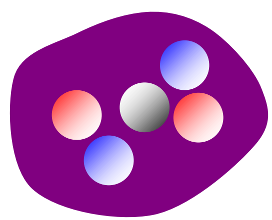


meson

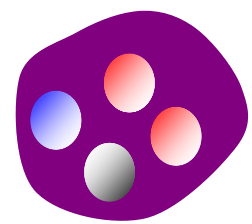
- QCD allows for hadrons beyond Quark Model



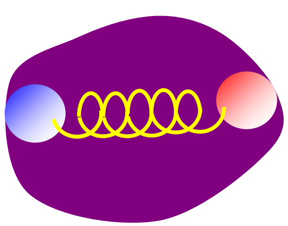
dibaryon



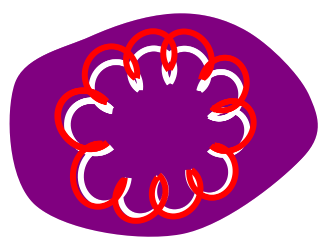
Pentaquark



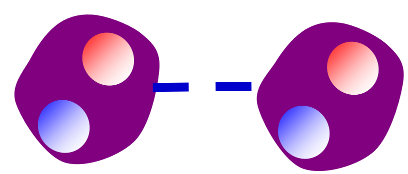
tetraquark



hybrid

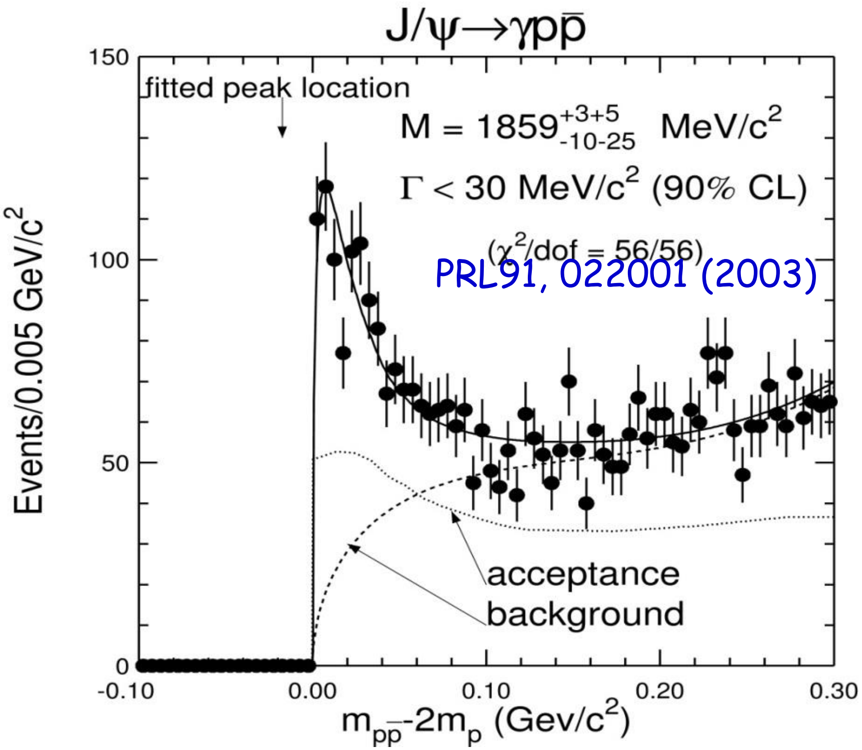


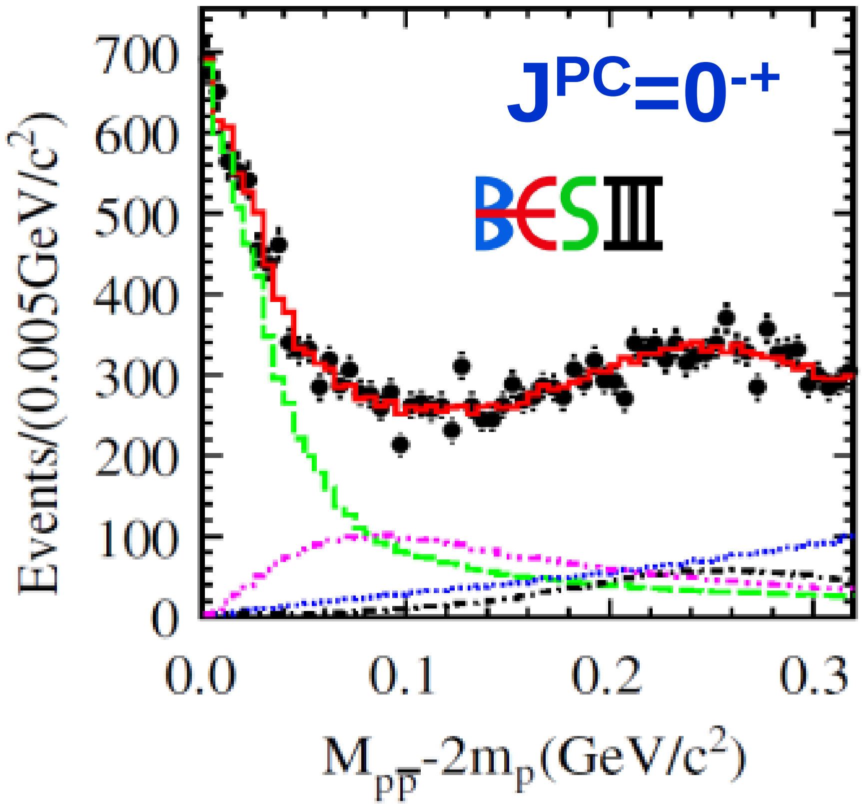
glueball



molecule

Threshold enhancement in $J/\psi \rightarrow \gamma p\bar{p}$



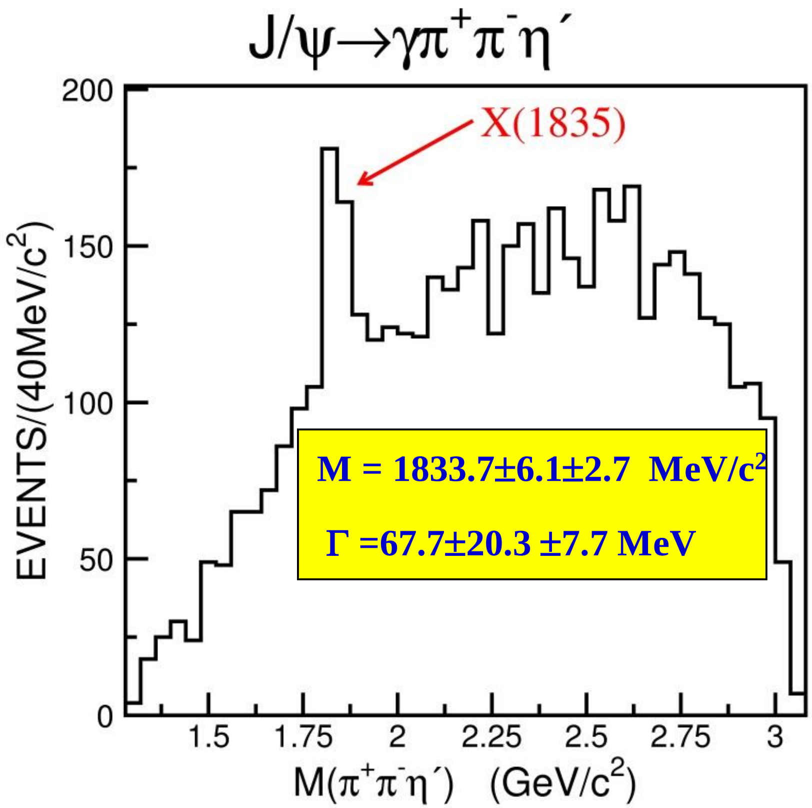


$$M = 1859^{+3}_{-10}{}^{+5}_{-25}\ \mathrm{MeV}/c^2$$

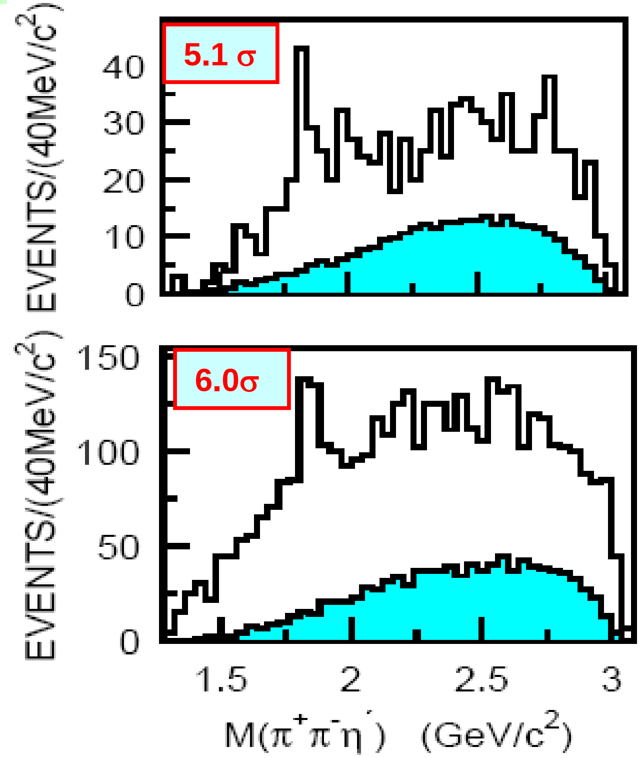
$$\Gamma < 30\ \mathrm{MeV}/c^2\ (90\%\ \mathrm{CL})$$

Baryonium ?? New decay modes ?

Observation of X(1835) at BESII



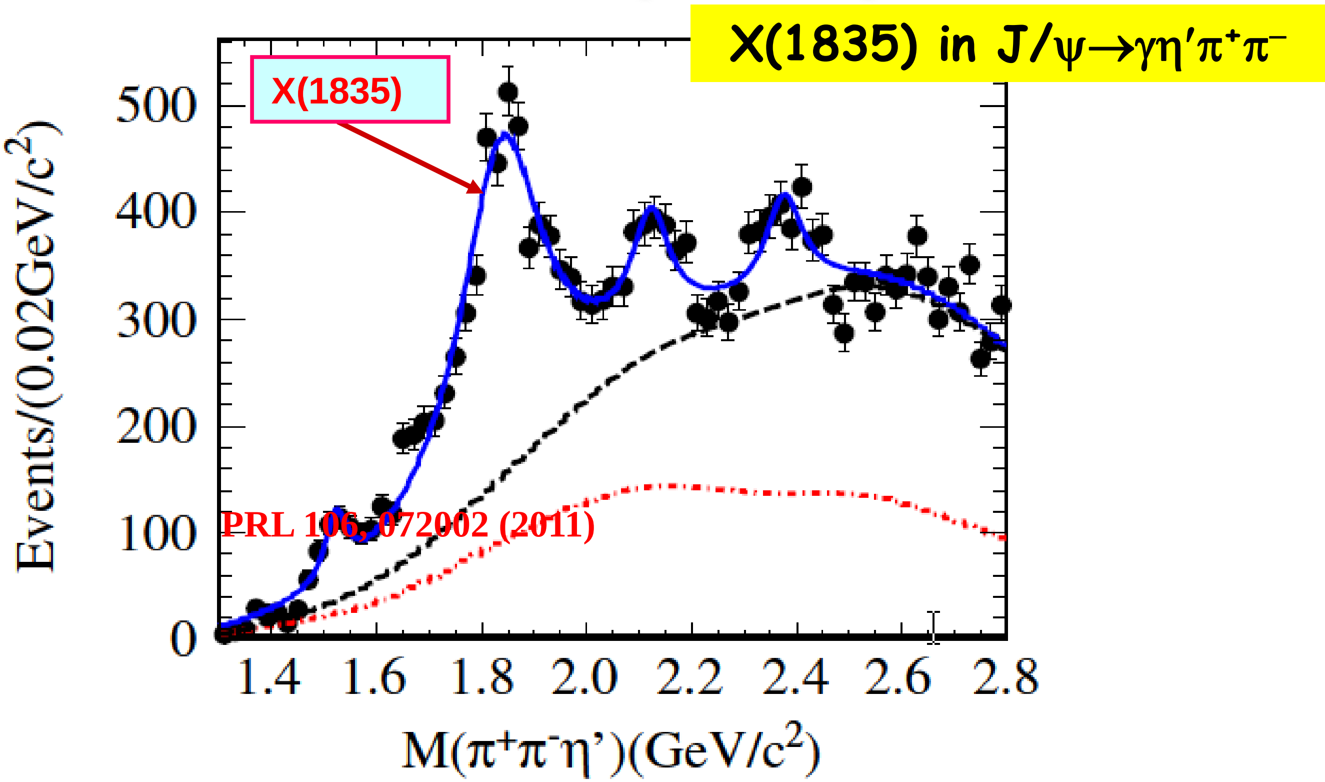
The $\pi^+\pi^-\eta'$ mass spectrum for η' decaying into $\eta'\to\pi^+\pi^-\eta$ and $\eta'\to\gamma\rho$



X(1835) same as $p\bar{p}$ mass threshold enhancement?

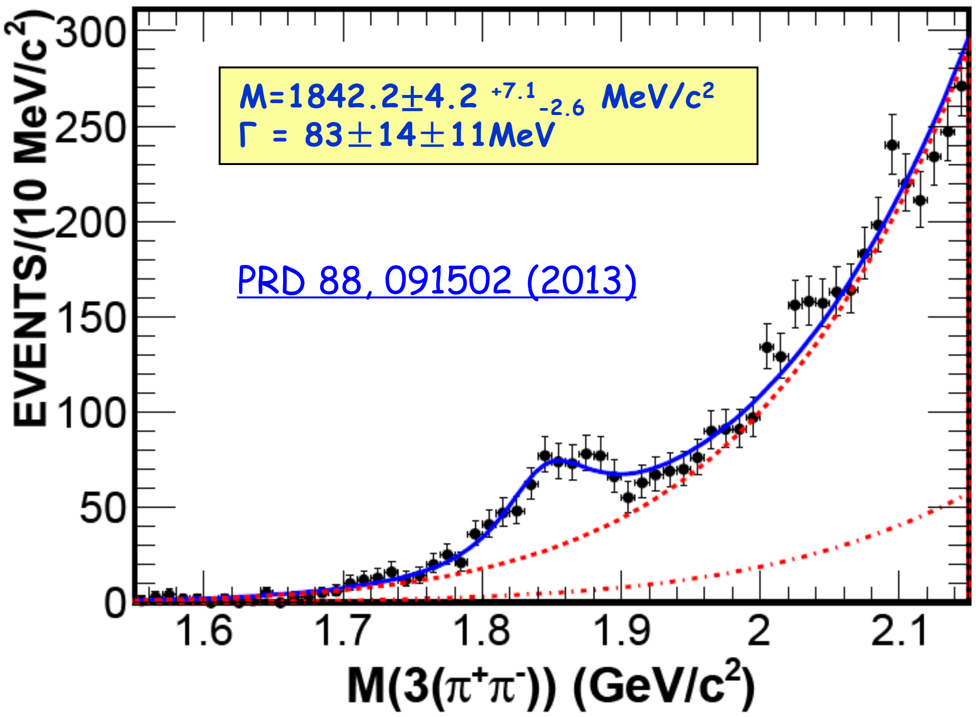
PRL95, 262001 (2005)

Confirmation of X(1835) at BESIII



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

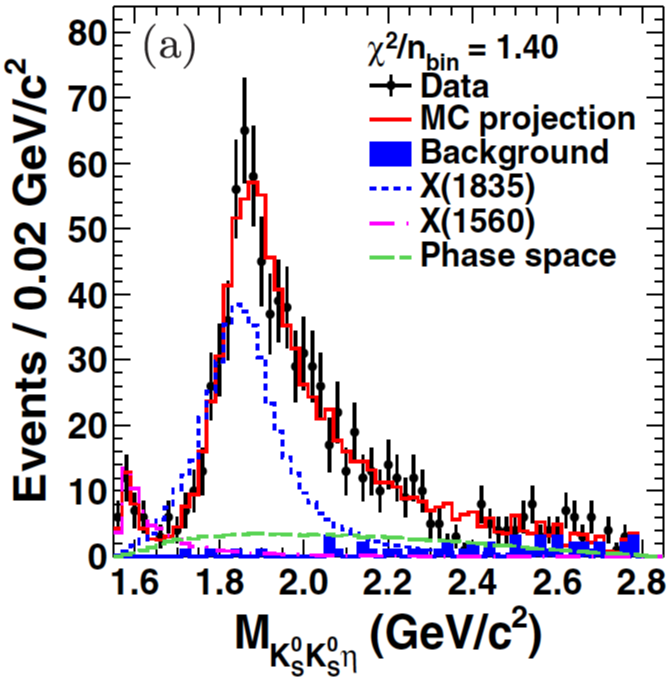
Observation of X(1840) in $J/\psi \to \gamma 3(\pi^+\pi^-)$



- *Mass is consistent with that of X(1835), but the width is much smaller than* $\Gamma_{X(1835)} = 190.1 \pm 9.0^{+38}_{-36}$ MeV
- *A new decay modes of X(1835)?*

Observation of X(1835) in $J/\psi \to \gamma K_S K_S \eta$

Phys.Rev.Lett. 115 091803(2015)



PWA for $M(K_S K_S)$<1.1 GeV/c^2

- **X(1835)→$K_S K_S \eta$**

$M=1844 \pm 9^{+16}_{-25}$ MeV/c^2

$\Gamma=192^{+20}_{-17}{}^{+62}_{-43}$ MeV

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

- **X(1560) → $f_0(980)\eta$: $J^{PC}=0^{-+}$**

$M=1565 \pm 8^{+0}_{-63}$ MeV/c^2

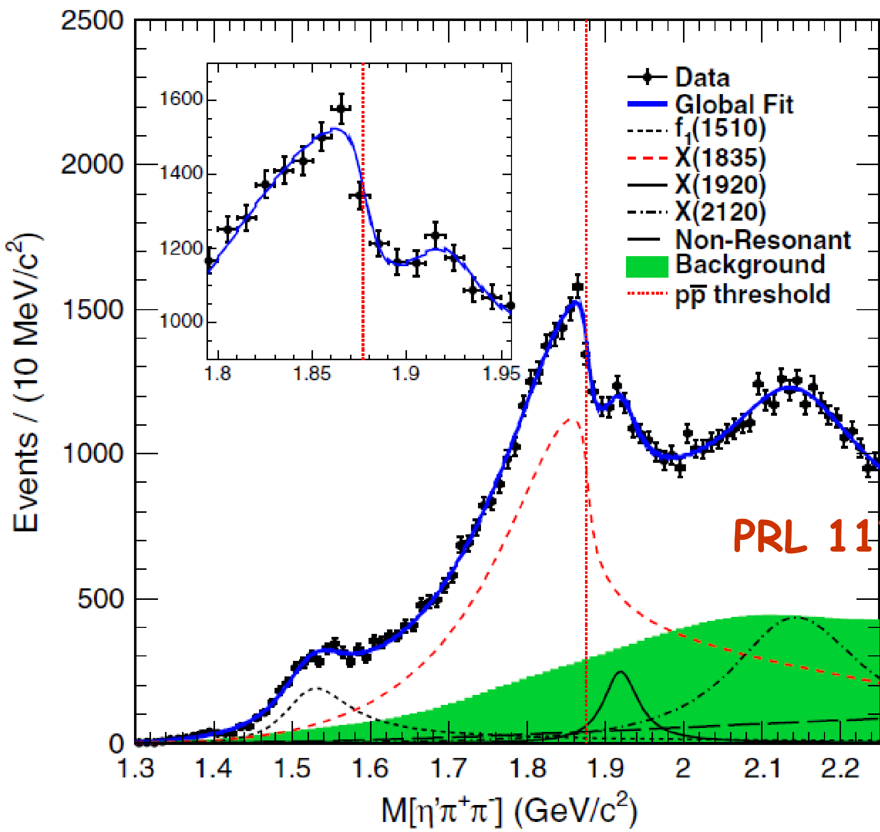
$\Gamma=45^{+14}_{-13}{}^{+21}_{-28}$ MeV

$\eta(1405)$ / $\eta(1475)$ within 2.0 $\boldsymbol{\sigma}$

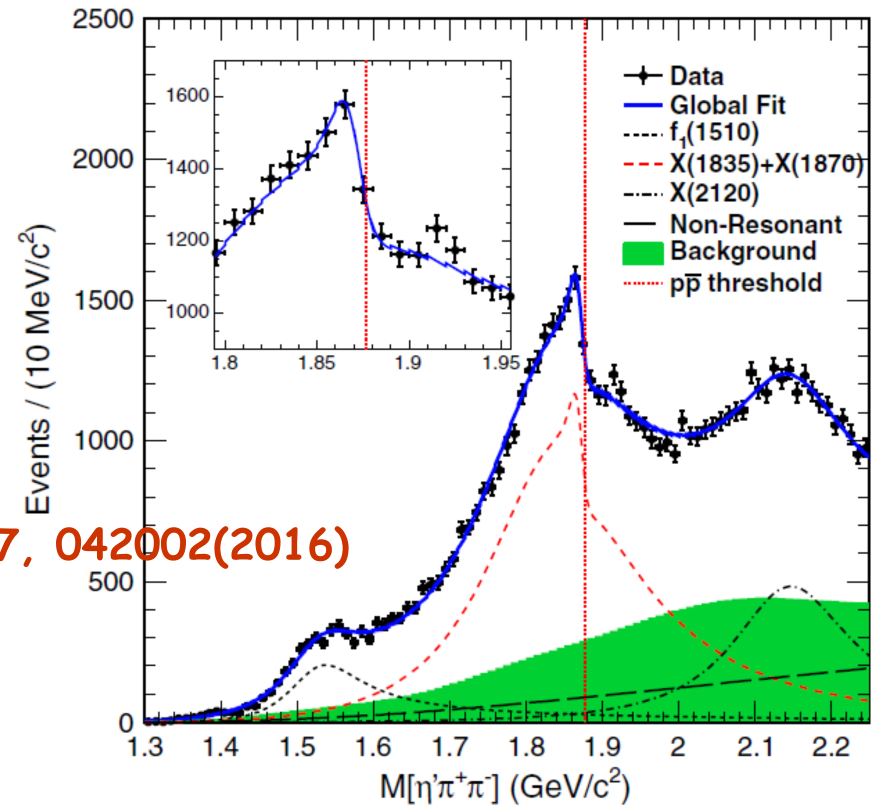
Consistent with X(1835) observed in $J/\psi \to \gamma\pi^+\pi^-\eta'$!

Latest result on X(1835) from $J/\psi \to \gamma \eta' \pi^+ \pi^-$

Faltte formula



Two BWs



PRL 117, 042002(2016)

$M=1638.2\pm121.9\ ^{+127.8}_{-254.3}$ MeV/c²
$g^2_0 = 93.7\pm35.4\ ^{+47.6}_{-43.9}$ GeV/c²
$g^2_{p\bar{p}}/g^2_0 = 2.31\pm0.37\ ^{+0.83}_{-0.60}$

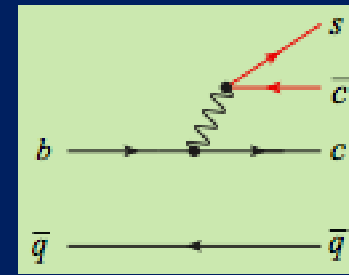
$M_1=1825.3\pm2.4\ ^{+17.2}_{-2.4}$ MeV/c²
$\Gamma_1 = 245.2\pm13.1\ ^{+4.6}_{-9.6}$ MeV

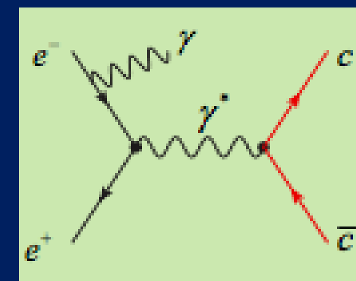
$M_2=1870.2\pm2.2\ ^{+2.3}_{-0.7}$ MeV/c²
$\Gamma_2 = 13.0\pm6.1\ ^{+2.1}_{-3.8}$ MeV

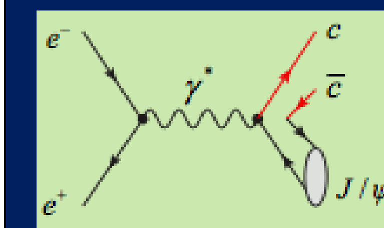
existence of a structure strongly coupling to $p\bar{p}$!

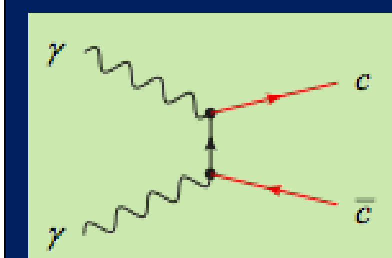
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

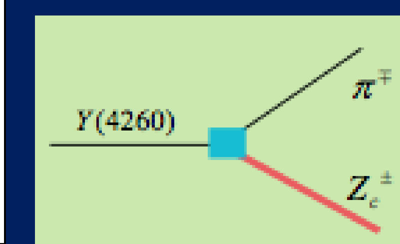
State	Observed	Confirmed
X(3872)	Belle	
X(3872)		CDF, D0
X(3915) [as Y(3940)]		Belle
Y(4260)		BaBar
χ_{c2}(2P) [as Z(3930)]	Belle	
Y(4260)		CLEO-c
X(3940), Y(4008), Y(4660)	Belle	
Y(4360)	BaBar	
Y(4360)		Belle
X(3915) [as Y(3940)]		BaBar
X(3940)		Belle
Z^+(4050), X(4160), Z^+(4250), Z^+(4430), X(4630)	Belle	
Y(4140)		CDF
X(3915), X(4350), Y_b(10888)	Belle	
χ_{c2}(2P) [as Z(3930)]		BaBar
Y(4274)	CDF	
X(3915)		BaBar
Z_b^+(10610)		Belle
Z_b^+(10650)		Belle
X(3823), Z_b^0(10610)	Belle	
Z_c^+(3900), Z_c^+(4020)	BESIII	
Z_c^+(3900)		Belle
Z_c^0(3900)	CLEO-c	
Z_c^0(4020)	BESIII	
Y(4140)		D0, CMS
Y(4274)		CMS
Y(4660)		BaBar
Z_c^+(4020)	BESIII	
Z^+(4200)		Belle
Z^+(4240)		LHCb
Z^+(4430)		LHCb
X(3823), Z_c^0(3900), Z_c^0(4020)		BESIII
Z_c^+(4055)	Belle	
Y(4230)	BESIII	
P_c^+(4380), P_c^+(4450)	LHCb	
Y_b(10880)		NOT Belle
X^+(5568)	D0	
X^+(5568)		NOT LHCb
Y(4140), Y(4274)		LHCb
X(4500), X(4700)	LHCb	







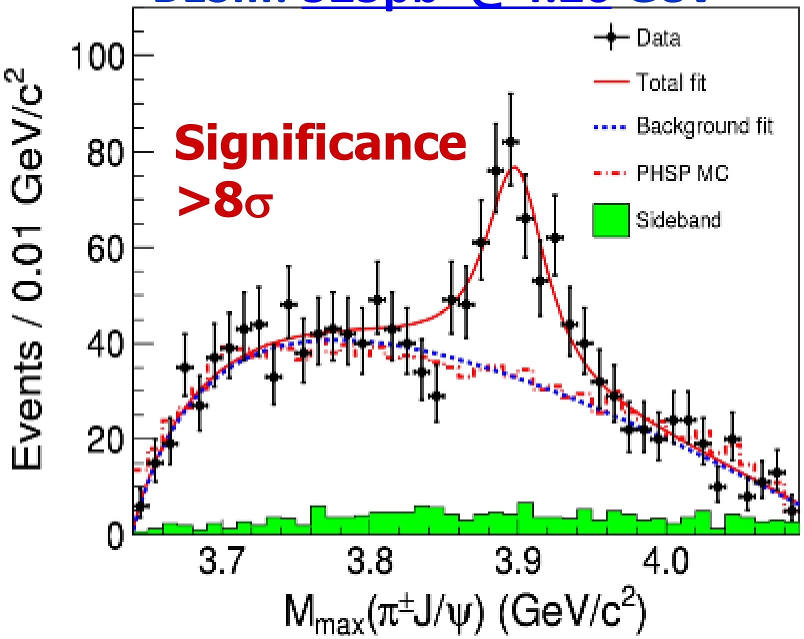




PPNP,143(2017), Phys.Rept.1(2016)

Observation of Zc(3900) in $e^+e^- \to \pi^+\pi^- J/\psi$

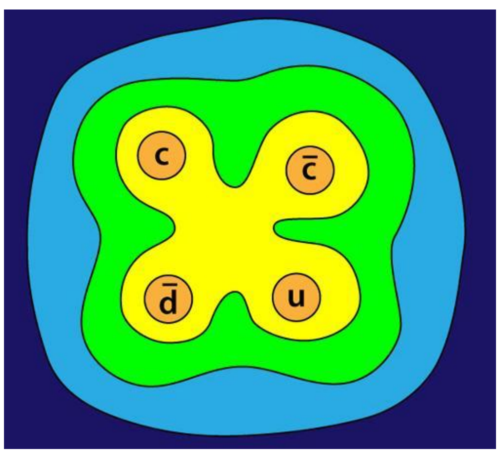
BESIII: 525pb^{-1}@4.26 GeV



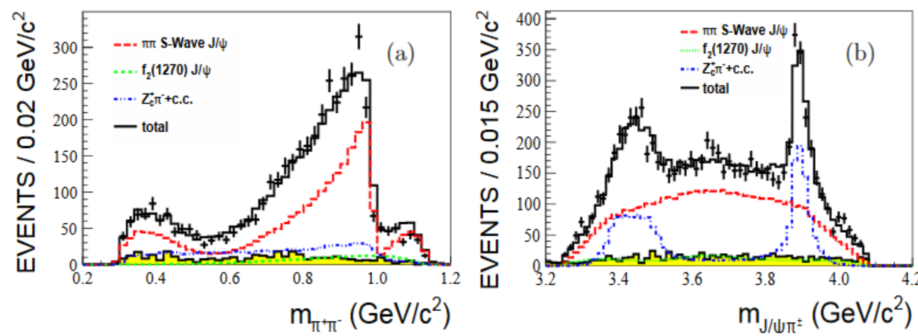
PRL110, 252001 (2013)

- **M = 3899.0±3.6±4.9 MeV**
- **Γ = 46±10±20 MeV**

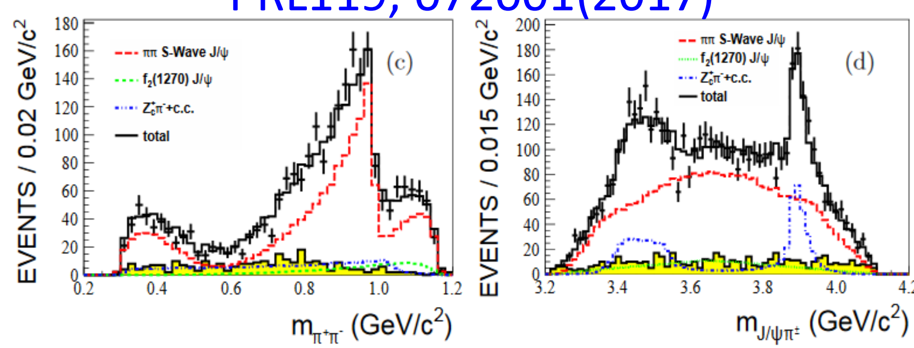
Confirmed by Belle and CLEOc: established!



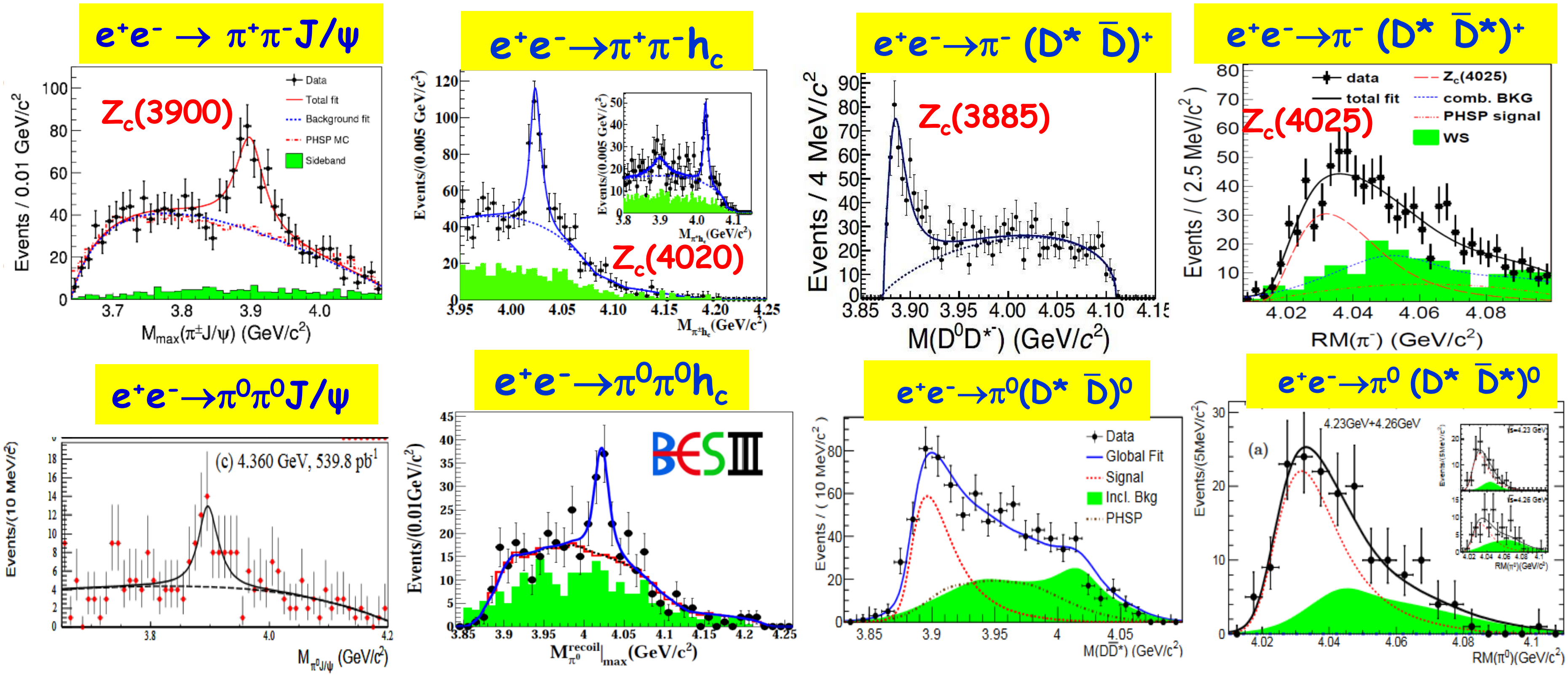
PWA indicates $J^P=1^+$



PRL119, 072001(2017)



Zc(3900), Zc(4020)

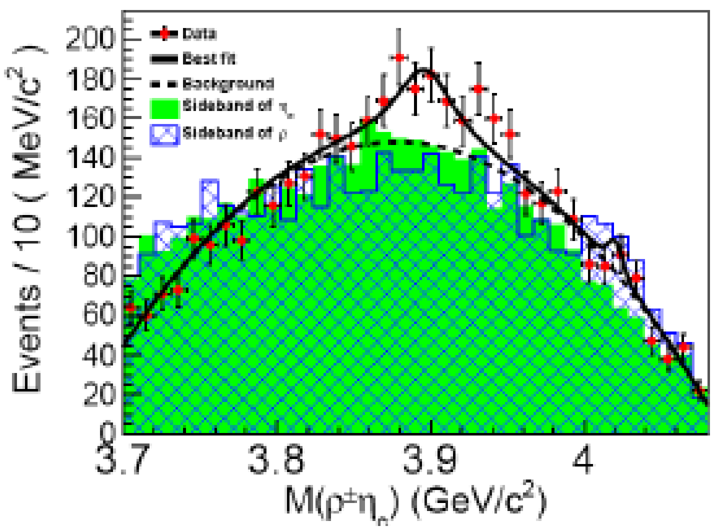


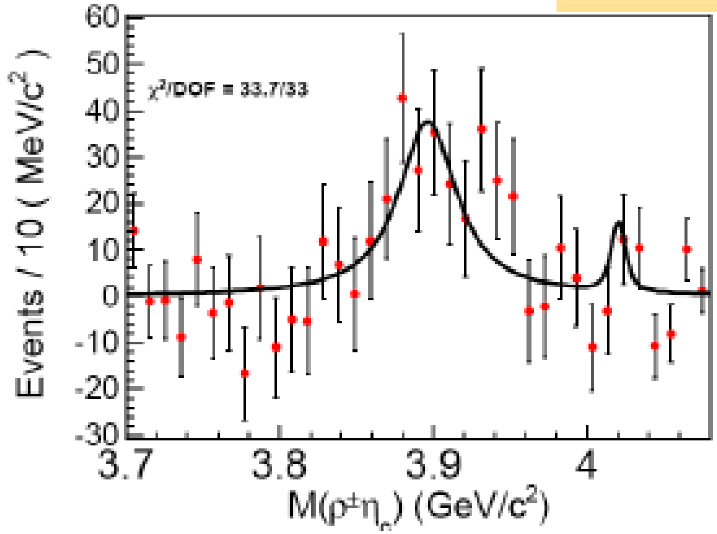
- Observed in different processes
- $Z_c(3900)$: J^P favors 1^+
- Strongly coupling $D\bar{D}^*$, $D^*\bar{D}^*$
- Molecule states ?
- **Two isospin triplets established !**

PRL110, 252001 (2013)
PRL115, 112003 (2015)
PRL111, 242001 (2013)
PRL113, 212002 (2014)
PRL112, 022001 (2014)
PRL115, 222002 (2015)
PRL112, 132001 (2014)
PRL115, 182002 (2015)
PRL119, 072001 (2017)

Evidence of Zc(3900) → $\rho\eta_c$

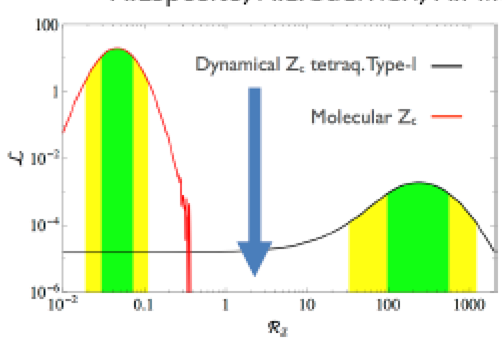
arXiv:1906.00831

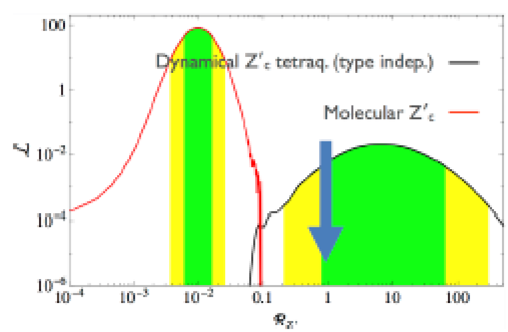




	$\sqrt{s} = 4.226$ GeV	$\sqrt{s} = 4.258$ GeV	$\sqrt{s} = 4.358$ GeV	Type-I	Type-II	Molecule
$R_{Z_c(3900)}$	2.2 ± 0.9	< 5.6	...	230^{+330}_{-140}	$0.27^{+0.40}_{-0.17}$	$0.046^{+0.025}_{-0.017}$
$R_{Z_c(4020)}$	< 1.6	< 0.9	< 1.4	$6.6^{+56.8}_{-5.8}$		$0.010^{+0.006}_{-0.004}$

A.Esposito, A.L.Guerrieri, A.Pilloni, Phys. Lett. B 746, 194 (2015)



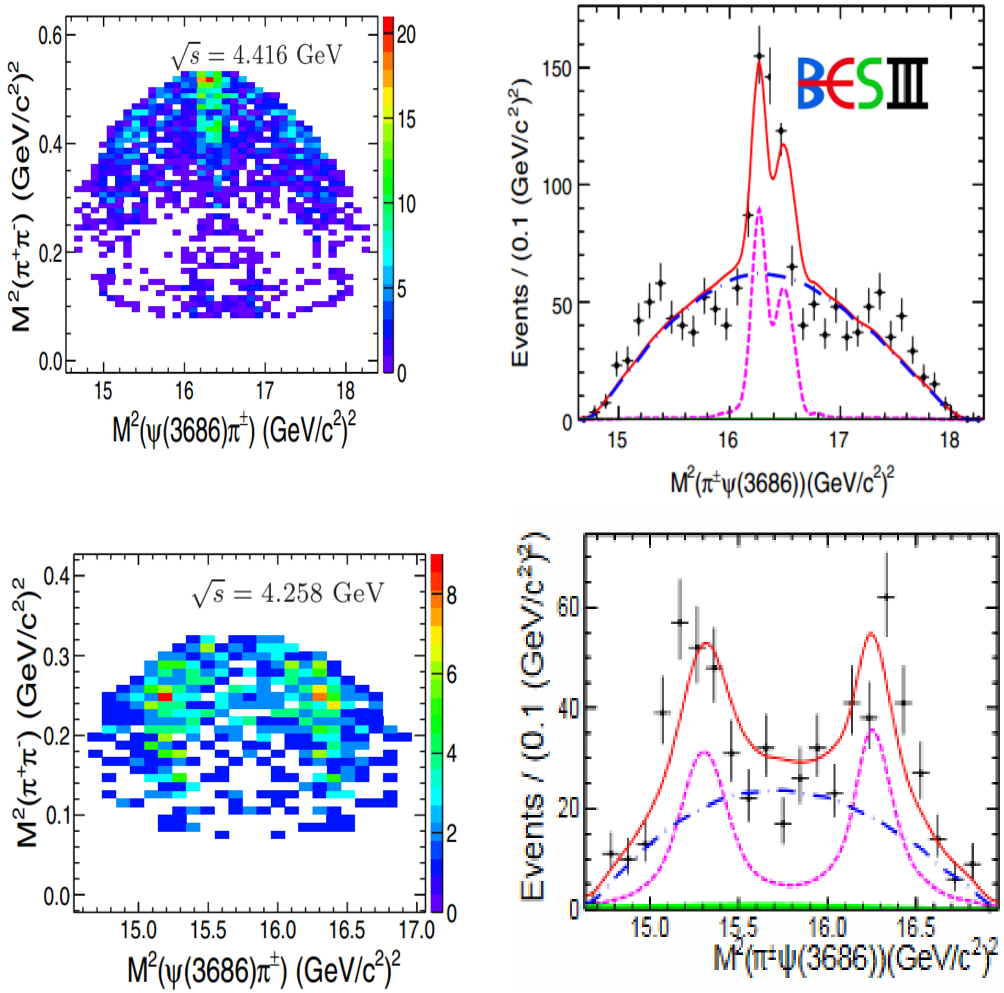


$$R_z = \frac{B(Z_c \to \rho\eta_c)}{B(Z_c \to \pi J/\psi)}$$

$$R_{z'} = \frac{B(Z'_c \to \rho\eta_c)}{B(Z'_c \to \pi h_c)}$$

Zc(4030) in $e^+e^- \rightarrow \pi^+\pi^-\psi(3686)$

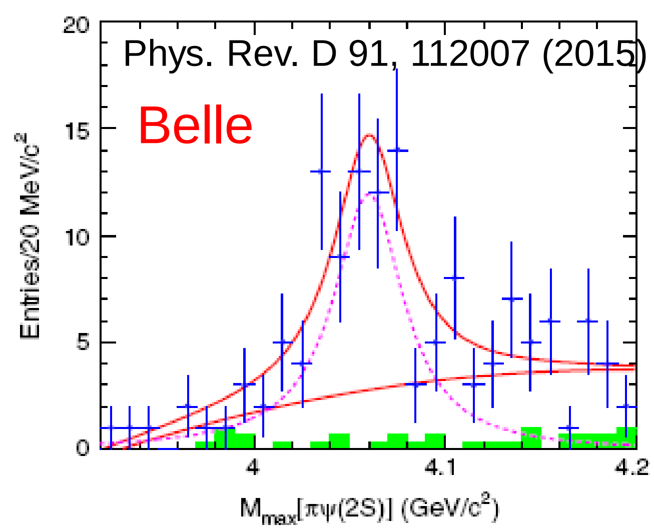
PRD96,032004(2017)



Charge structure in $M(\pi^\pm\psi(3686))$

Mass = (4032.1 ± 2.4) MeV/c²

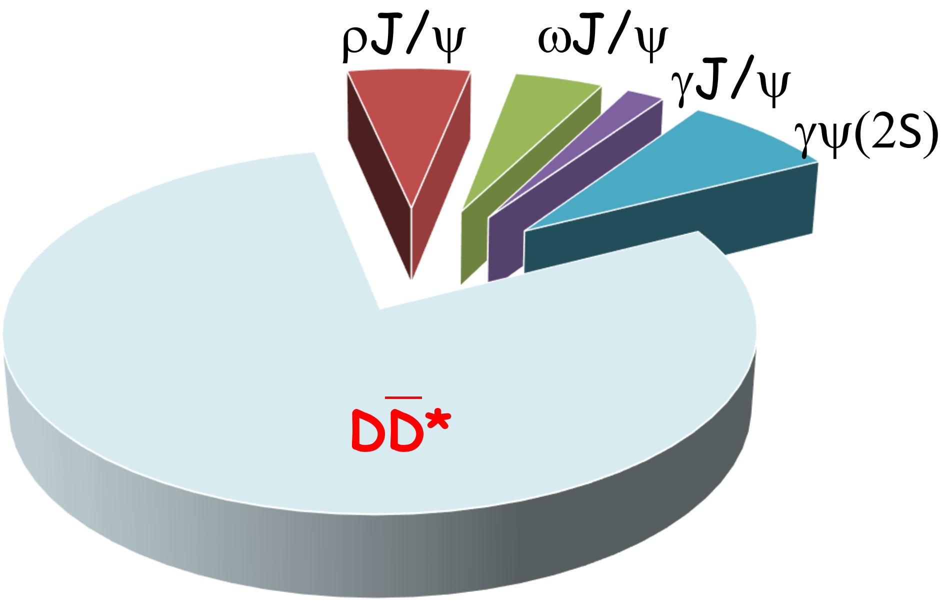
Width = (26.1±5.3) MeV



Mass = $(4054 \pm 3 \pm 1)$ MeV/c²

Width = (45±11±6) MeV

X(3872)



- Properties

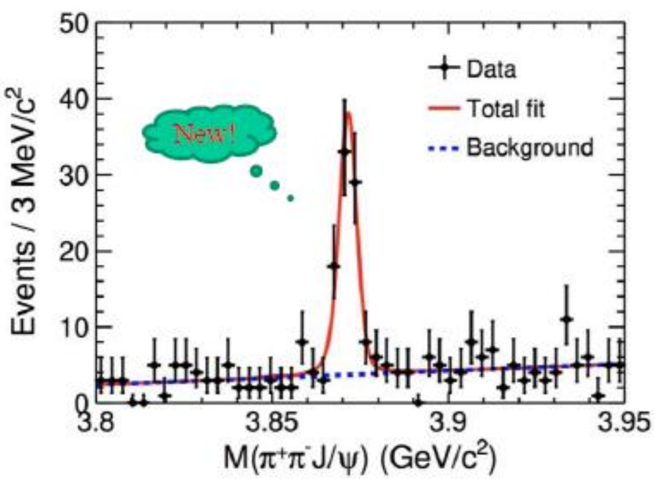
  M-M($D^0\bar{D}^{*0}$)=0.01±0.18 MeV

  Γ<1.2 MeV I=0, $J^{PC}=1^{++}$
- I=0, $J^{PC}=1^{++}$
- Production

  B decays, hadron collisions,

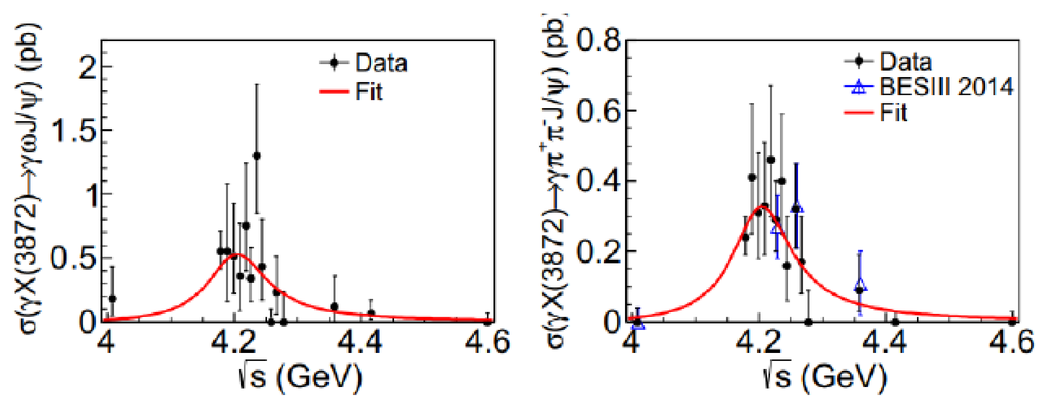
  Y(4260) decays?,?

arXiv: 1903.04695, PRL122, 232002



σ(e^+e^-→γX(3872))

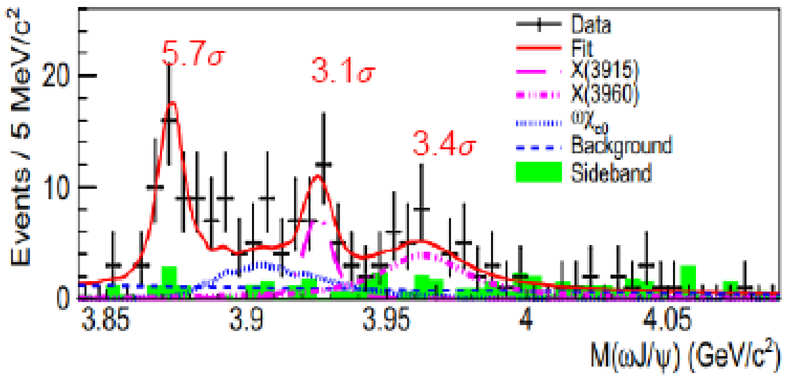
PRL122, 232002 (2019)

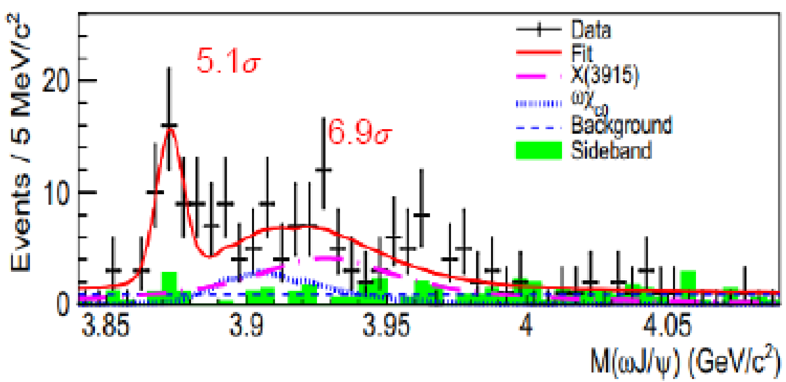


$X(3872) \to \omega J/\psi$ and $\pi^+\pi^- J/\psi$

Observation of X(3872) →ωJ/ψ

PRL122, 232002 (2019)

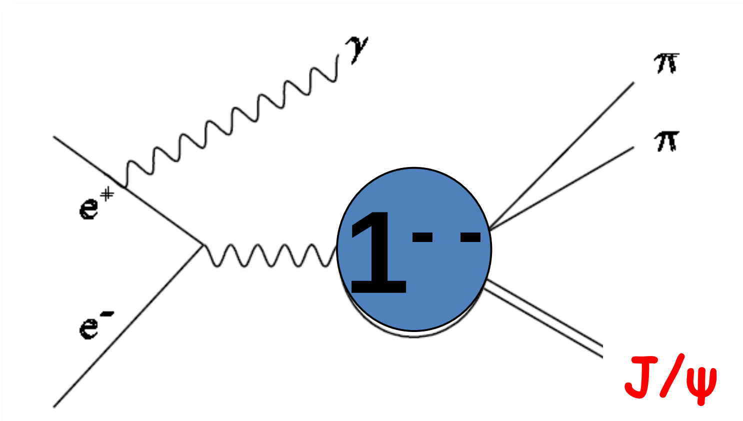


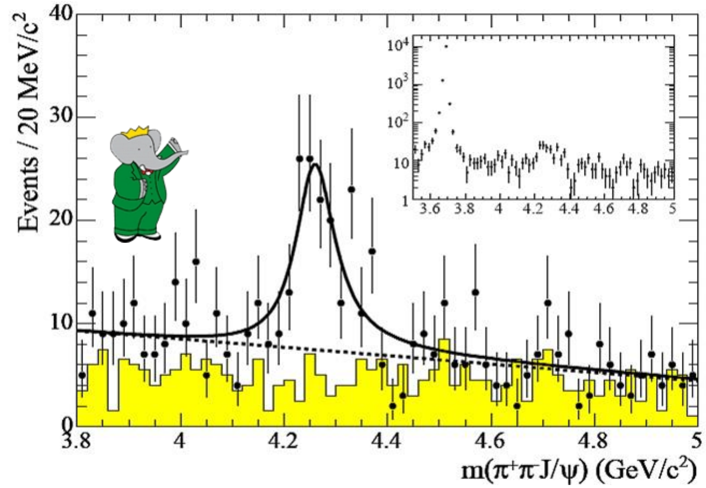


	Mass	Width
$X(3872)$	3873.3 ± 1.1 (3872.8 ± 1.2)	1.2 (1.2)
$X(3915)$	3926.4 ± 2.2 (3932.6 ± 8.7)	3.8 ± 7.5 (59.7 ± 15.5)
$X(3960)$	3963.7 ± 5.5	33.3 ± 34.2

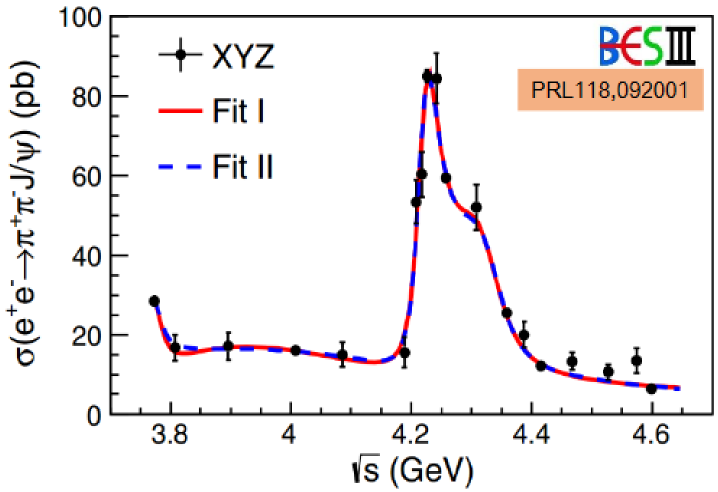
Y(4260)

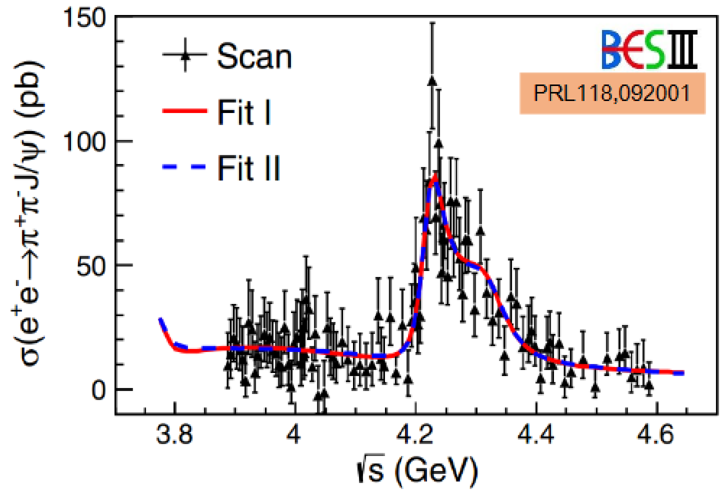
PRL95, 142001 (2005)





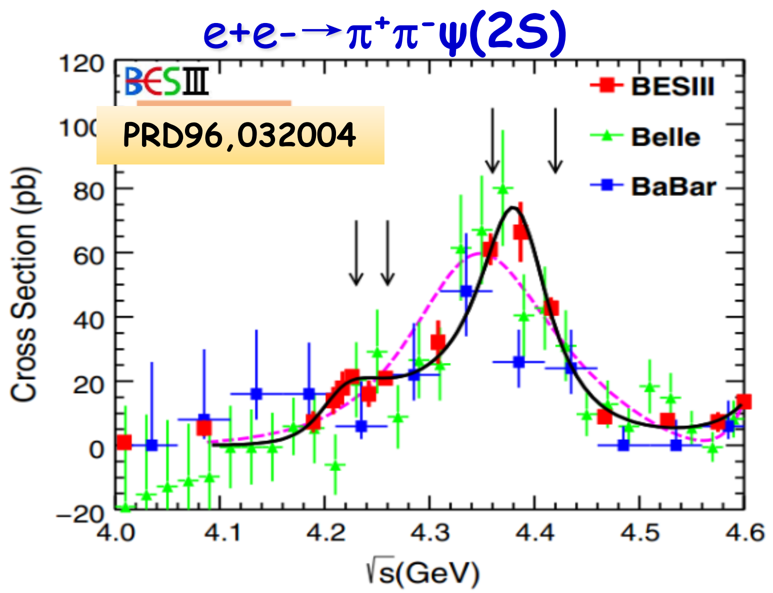
-9

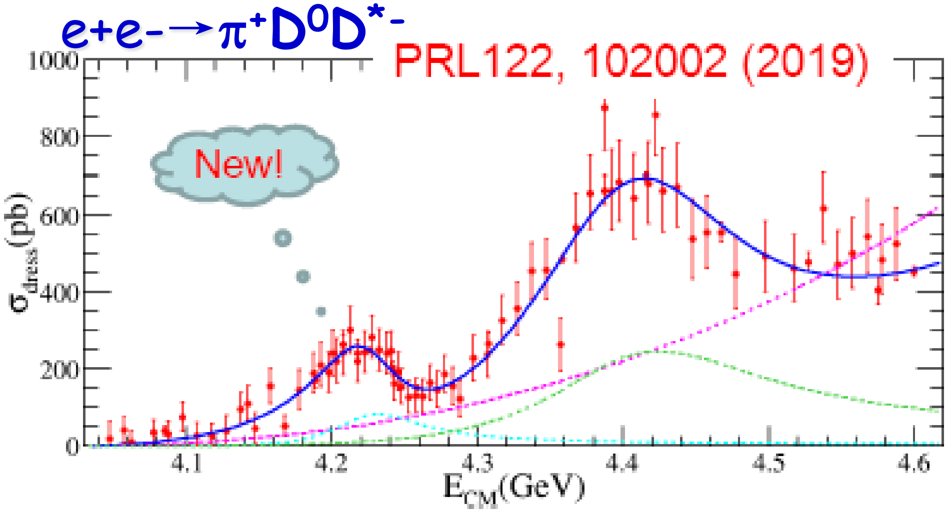


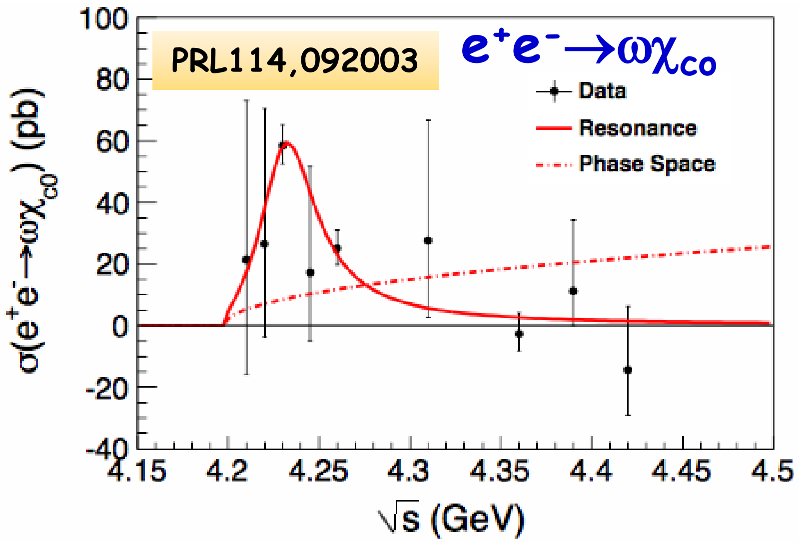


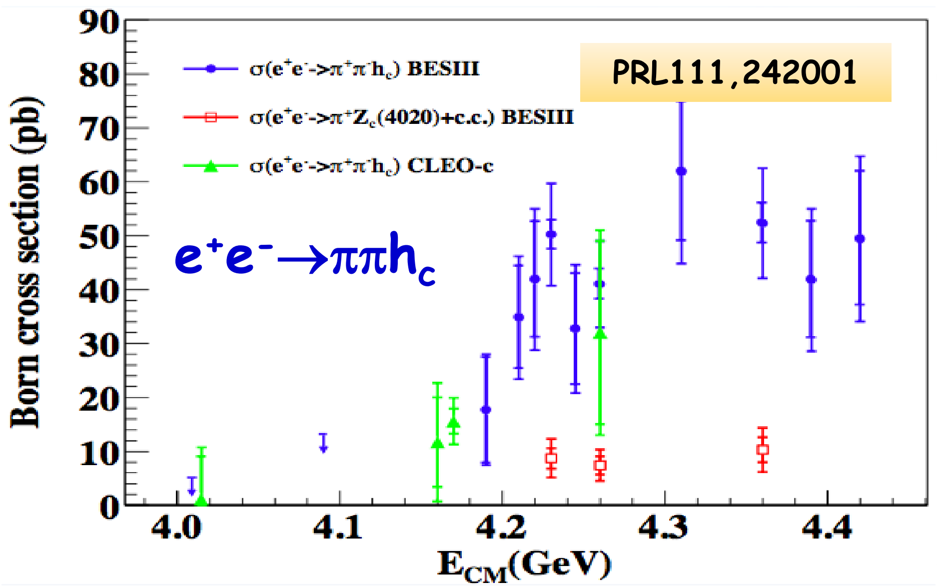
A shoulder around 4.3 GeV is observed (7.9σ). A new state?

Fit results: Y(4220) and Y(4360)









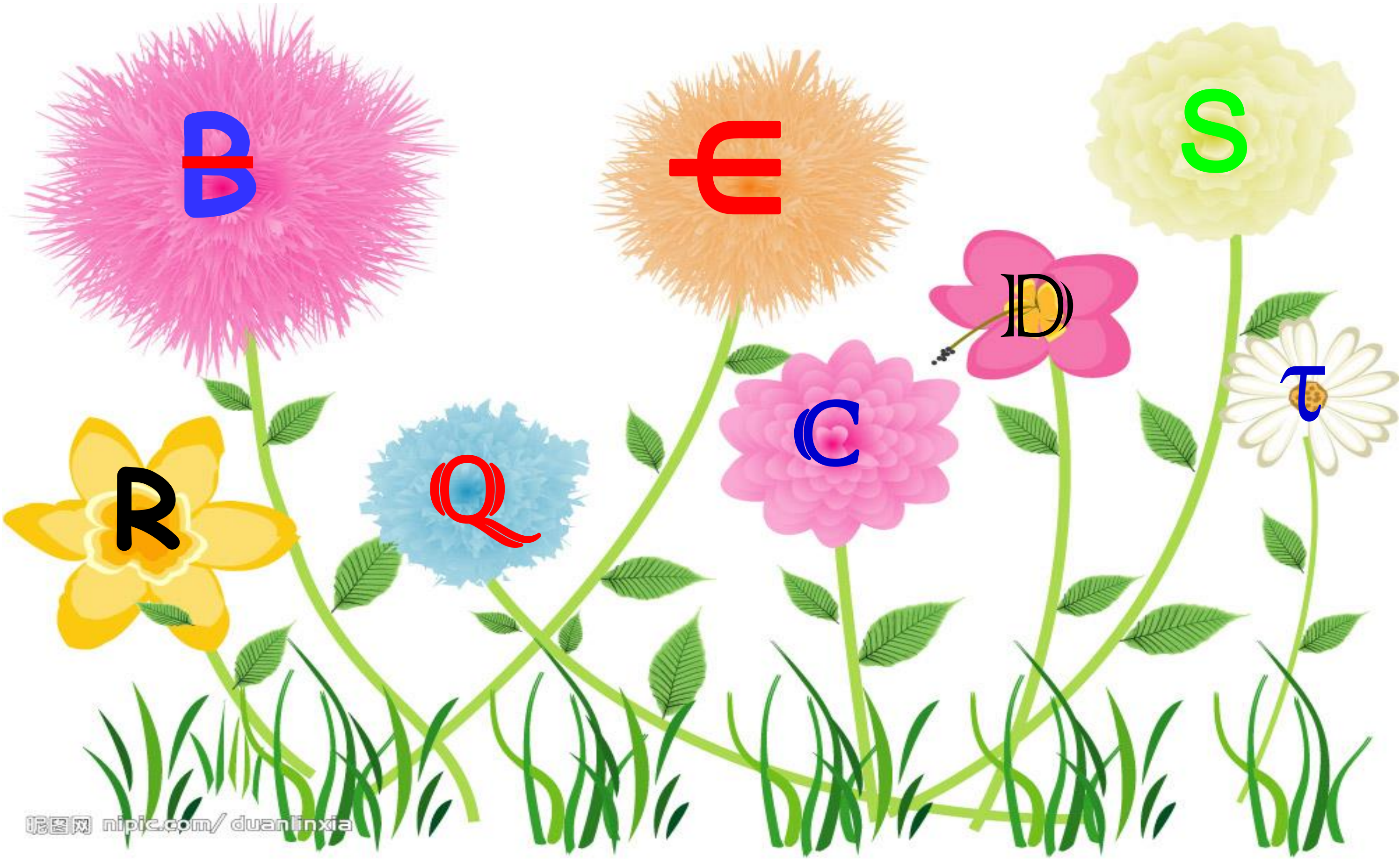
- ✓ Line-shapes are different from that of $\pi^+\pi^- J/\psi$
- ✓ Both Y(4220) and Y(4360) seem significant

Upgrades on BEPCII/BESIII

- Beam energy
  - Ebeam = 2.3→2.35 GeV in 2019
  - Ebeam = 2.35→2.45 GeV in 2020-21
- Top-up injection
  - Data taking efficiency increases by 20-30%
- Inner tracker →CGEM inner tracker
  - Construction by Italian group
  - Will be shipped to IHEP this summer, installation in summer 2020
- Super conducting magnet
  - New valve box of SC magnet

Summary

- ~30 (10) years of BEPC(II)/BES(III)
  - 1988: First collision at BEPC/BES
  - 2008: First collision at BEPCII/BESIII
- Lots of important results were achieved
  - Mass measurement
  - R-value measurement
  - Charm physics
  - Exotic hadrons
  - ....
- Competitions from LHCb, BelleII
- Will continue to play an vital role in tau-charm physics



More important results are expected from BESIII !

Thank you !