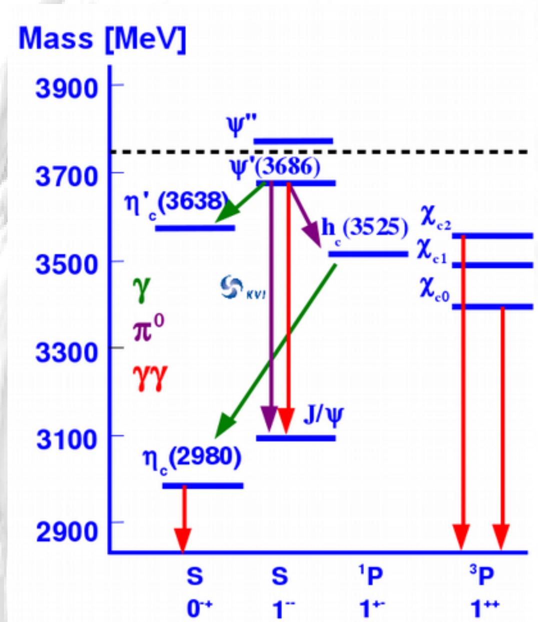
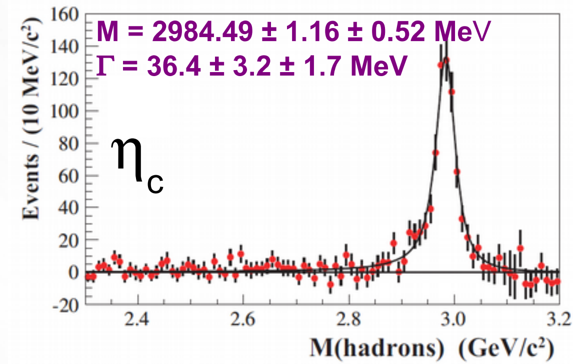
Physics at BESIII: recent highlights

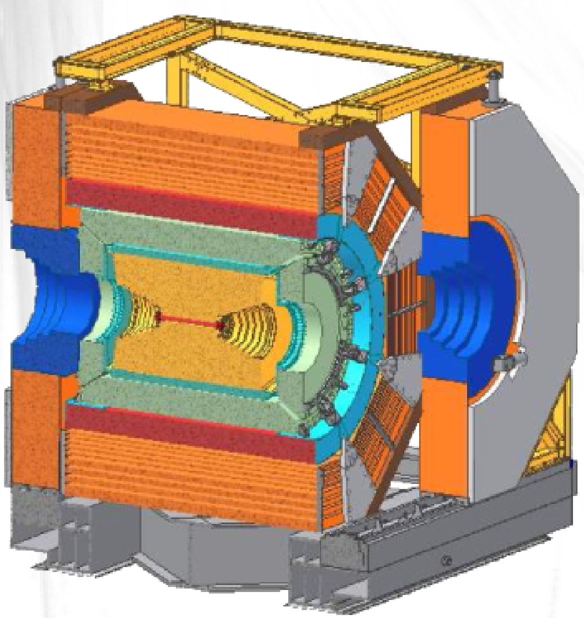
Myroslav Kavatsyuk

KVI, University of Groningen

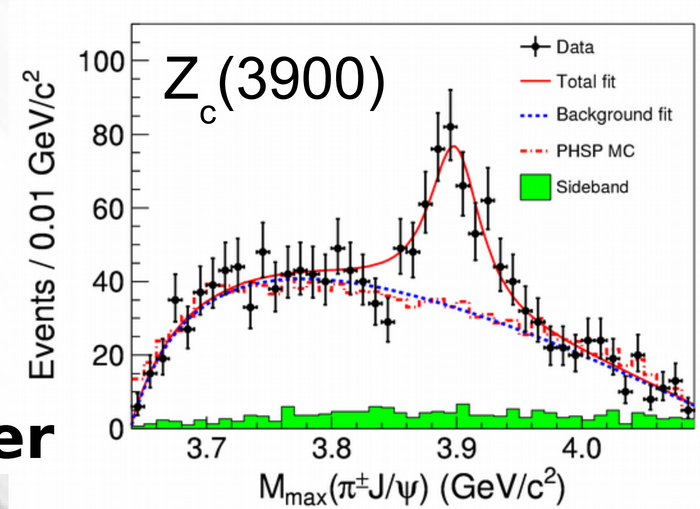
For the BESIII collaboration



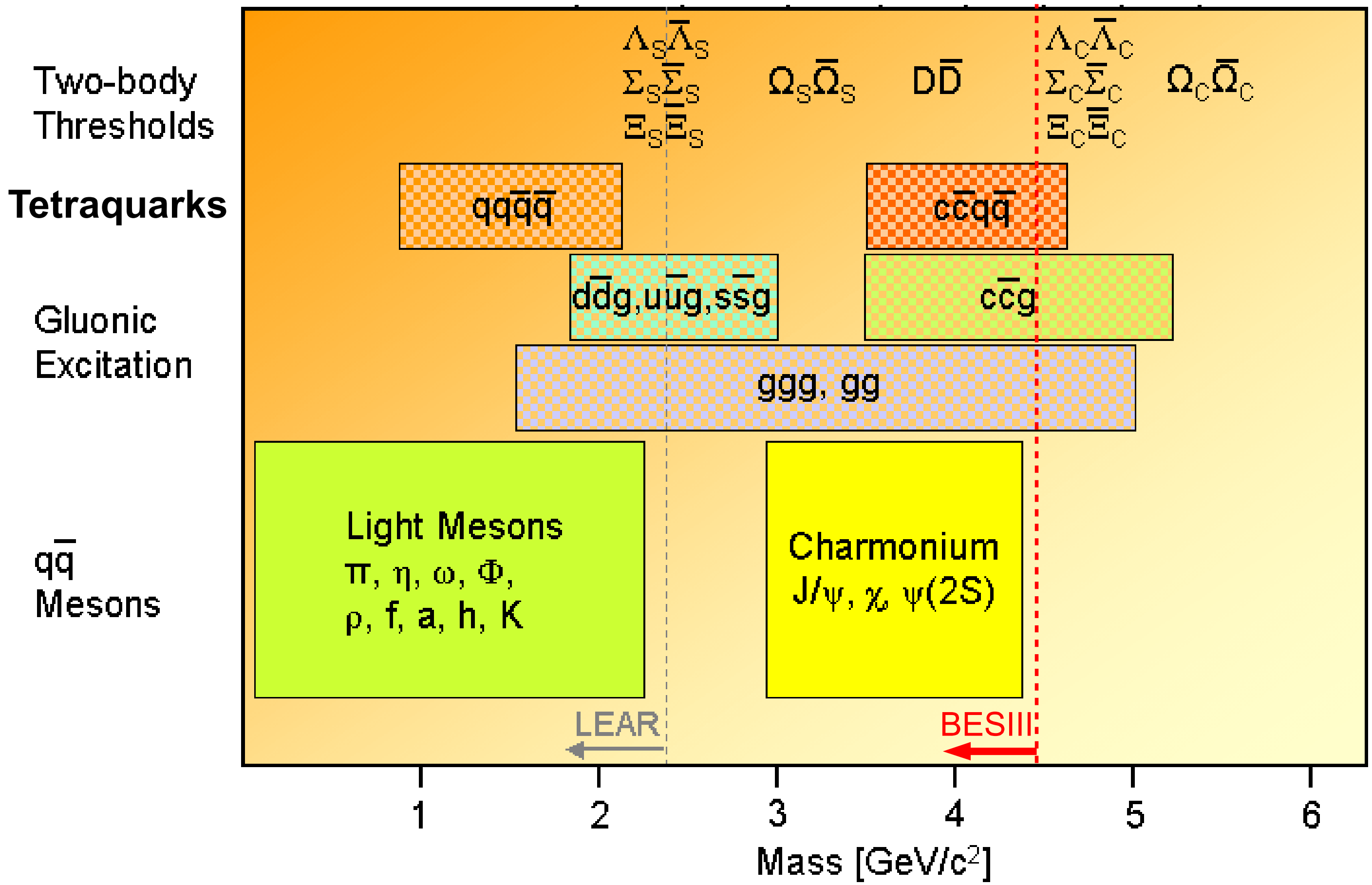




- **BESIII and physics goals**
- **Precision charmonium spectroscopy**
- **Exotic hadron matter**



Hadron Landscape



Hadron-physics challenges:

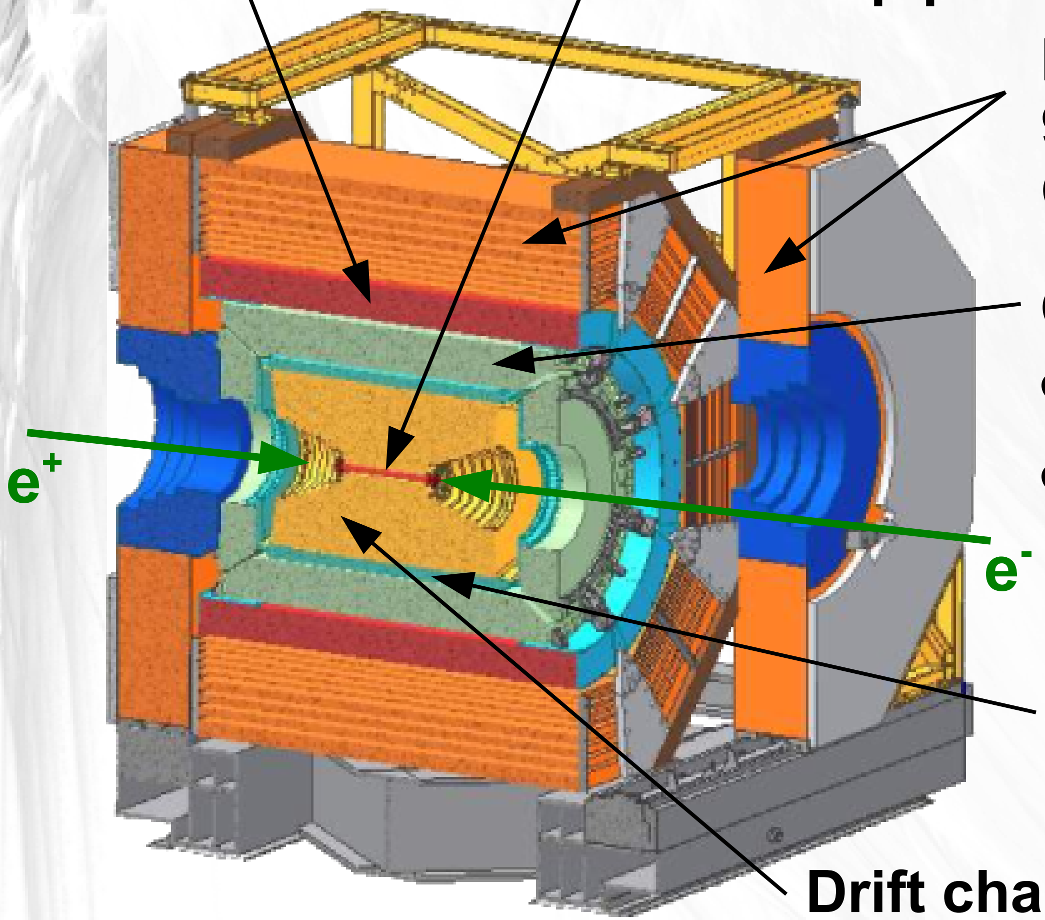
- Understanding of established states: precision spectroscopy
- Nature of exotic states: search and spectroscopy of unexpected states

BESIII has rich physics and high discovery potential

BESIII Detector

1.0 Tesla **super-conducting magnet**

Be beam pipe



Muon counters:
9/8 RPC layers (barrel/endcaps)
Cut-off momentum: 0.4 GeV/c

CsI(Tl) **ElectroMagnetic Calorimeter:**
σ_E/E (at 1 GeV): 2.5 %
$\sigma_{z,\phi}$ (at 1 GeV): 6 mm

Time Of Flight (TOF):
σ_T: 100/110 ps (barrel/endcaps)

Drift chambers (MDC):
σ_p/p (at 1 GeV): 0.5 %
$\sigma_{dE/dx}$: 6 %

M. Ablikim *et al.*, Nucl. Instr. and Meth. **A 614** (2010) 345–399

BESIII Milestones

Used in presented analysis

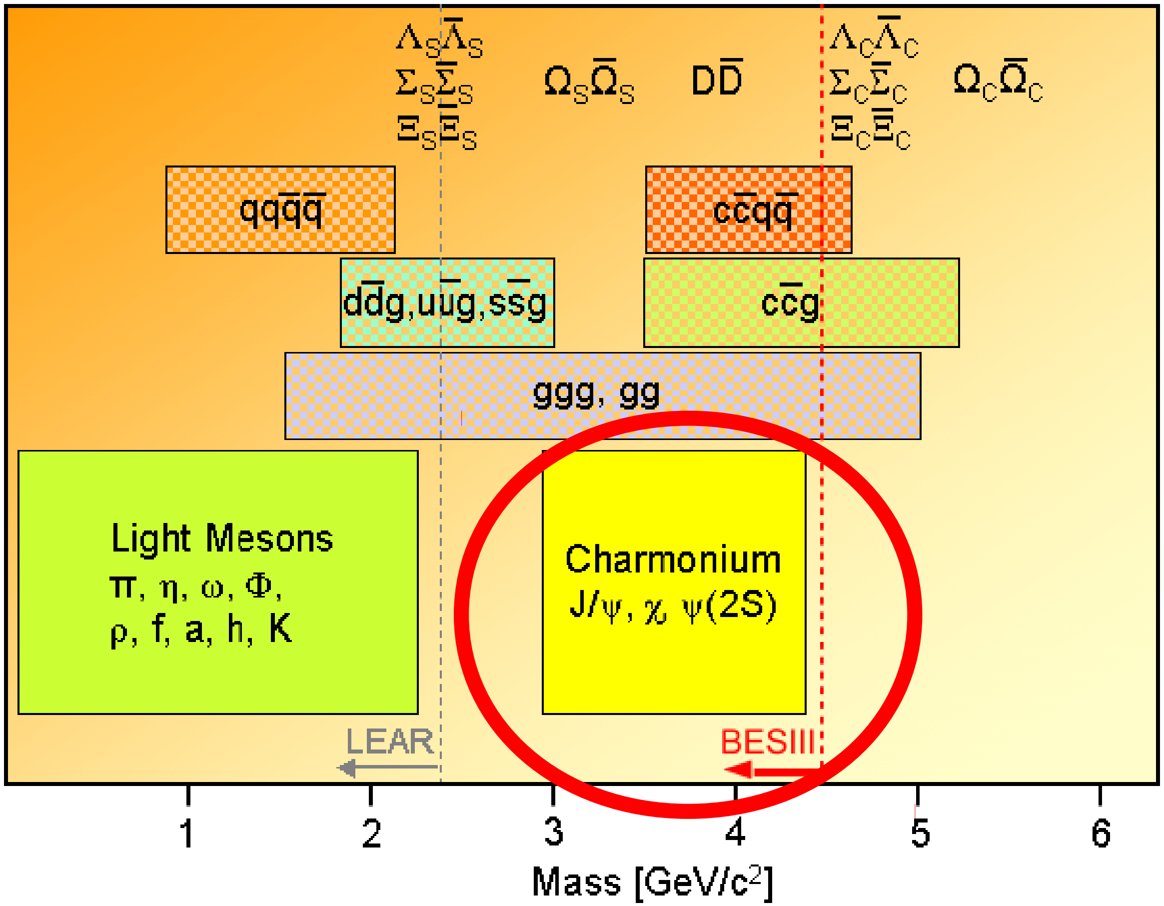
New Data

- **July 18, 2008** — First $e^+ e^-$ collision event in BESIII
- **Apr. 14, 2009** — ~ 108 M Ψ' events ~ 4×CLEO-c
  ~ $42 pb^{-1}$ at 3.65 GeV)
- **July 28, 2009** — ~ 225 M J/Ψ events ~ 4×BESII
- **2010-2011** — ~ $2.9 fb^{-1}$ Ψ'' ~ 11×CLEO-c
  ~ $70 pb^{-1}$ scanning of the Ψ'' region
- **May 2011** — ~ $0.5 fb^{-1}$ 4.01 GeV (D_s and XYZ spectroscopy)
- **2012** — ~ 0.4 B Ψ' events ~ 16×CLEO-c
  ~ 1 B J/Ψ events ~ 18×BESII
  ~ $525 pb^{-1}$ E_{cm}=4.26 GeV
- **2013** — ~ $520 pb^{-1}$ E_{cm}=4.36 GeV
  ~ $0.8 fb^{-1}$ E_{cm}=4.26 GeV

Record Luminosity so far: **7×10^{32} cm^{-2} s^{-1}** (**8×CESRc** or **45×BEPC**)

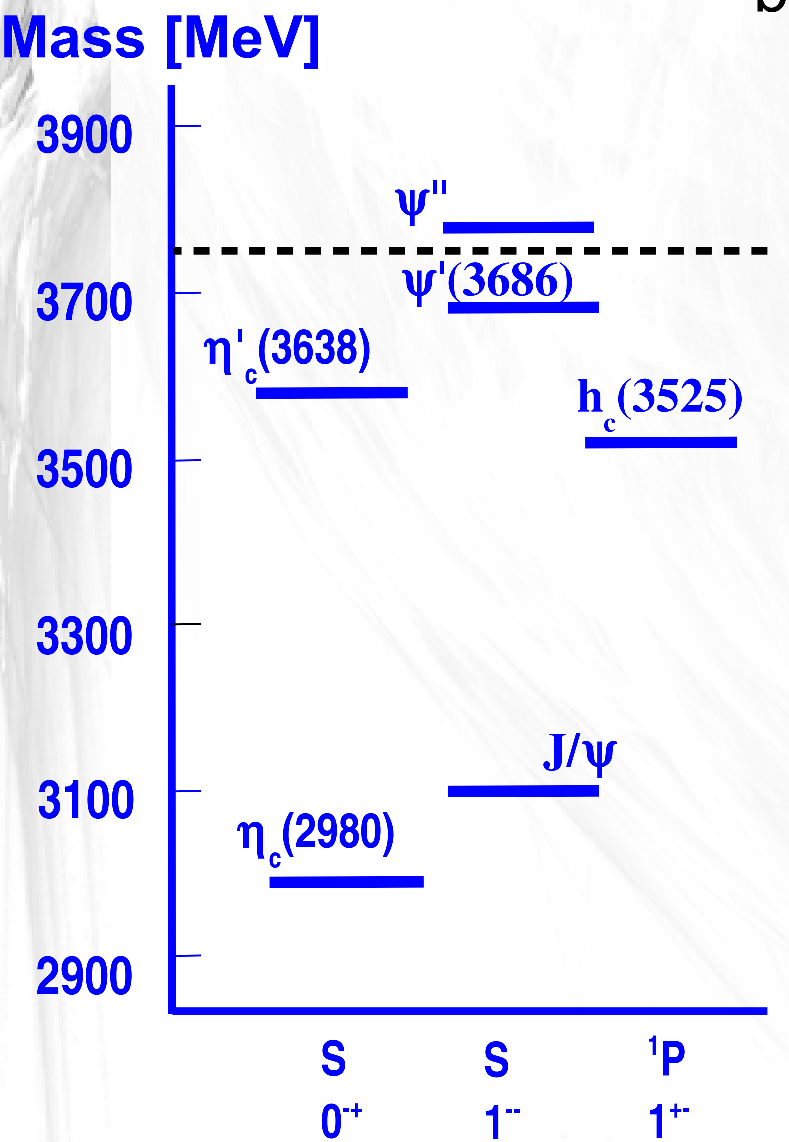
High luminosity, clean environment → Access to weakly populated channels of particular interest

Precision charmonium spectroscopy

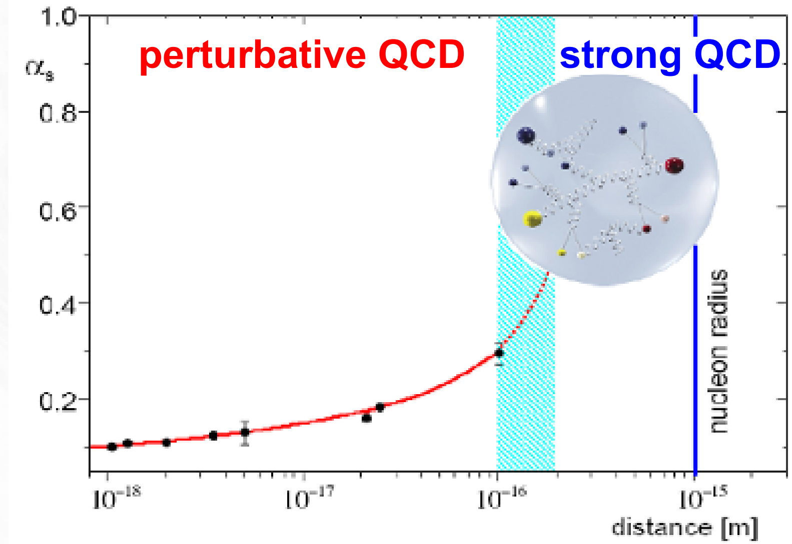


Charmonium Physics

Charmonium (a bound state of $c\bar{c}$ quarks) –
bridge between perturbative and strong QCD



Strong-interaction coupling constant



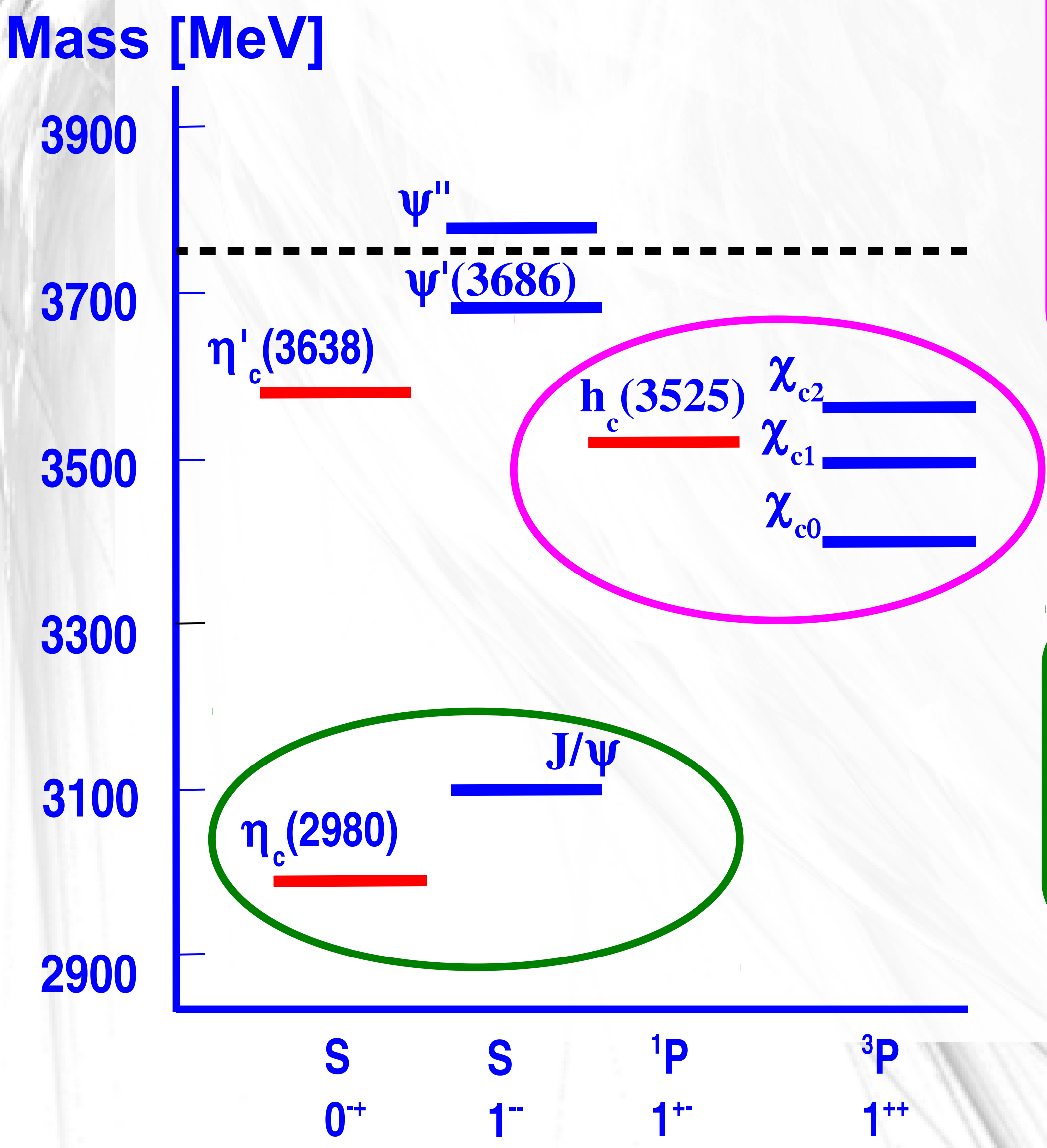
<u>Precise</u> data on the key charmonium states and <u>transitions</u>

⇩

Insight into the strong interactions at long-distance scales (test of Potential models, lattice QCD, EFT)

State Properties as a Probe

Precise measurement of charmonium masses and widths → **Test of potential models and lattice QCD**



Potential model: if P-wave spin-spin interaction is non-zero:

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

$$\langle m(1^3P_J)\rangle = \sum_{J=0}^{2} M_{\chi_{cJ}}(2J+1)/9$$

Expected value $\Delta M_{hf}(1P) = 0$

Hyperfine splitting: **$M(J/\Psi) - M(\eta_c)$**: important input to test lattice QCD, **dominated by error on $M(\eta_c)$!**

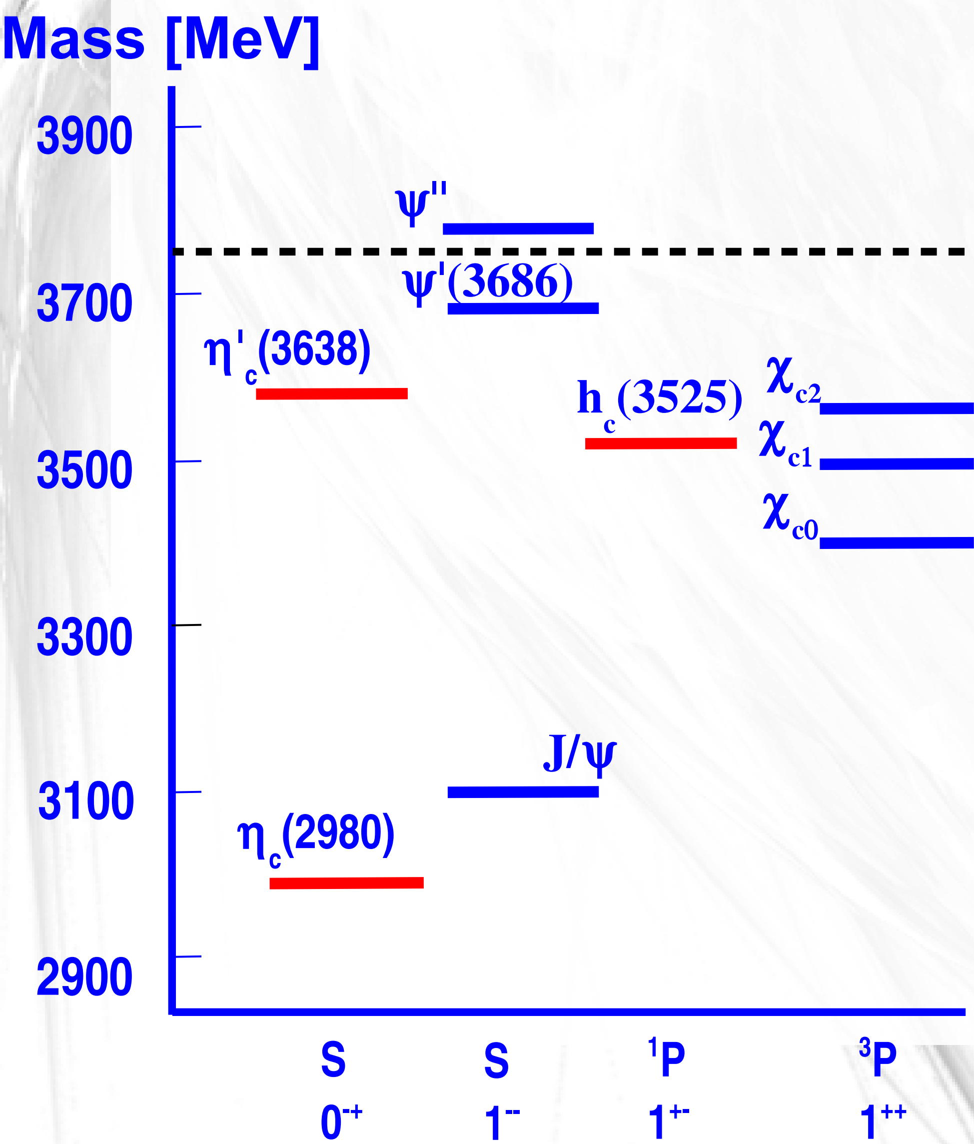
LQCD prediction:

$\Delta M(1S) = 116.5 \pm 3.2$ MeV

[Phys. Rev. D 86, 094501 (2012)]

State Properties as a Probe

Mass and width measured with comparable or better precision:



$\eta_c'(3638)$

[Phys. Rev. Lett. 109, 042003 (2012)]

- **M = 3637.6 ± 2.9 ± 1.6 MeV**
- **Γ = 16.9 ± 6.4 ± 4.8 MeV**

$h_c(3525)$

[Phys. Rev. Lett. 104, 132002 (2010)]

- **M = 3525.40 ± 0.13 ± 0.18 MeV**
- **Γ = 0.73 ± 0.45 ± 0.28 MeV**

first measurement!

[Phys. Rev. D 86, 092009 (2012)]

- **M = 3525.31 ± 0.11 ± 0.14 MeV**
- **Γ = 0.7 ± 0.28 ± 0.22 MeV**

$\eta_c(2980)$

[Phys. Rev. Lett. 108, 222002 (2012)]

- **M = 2984.3 ± 0.6 ± 0.6 MeV**

understood resonance shape!

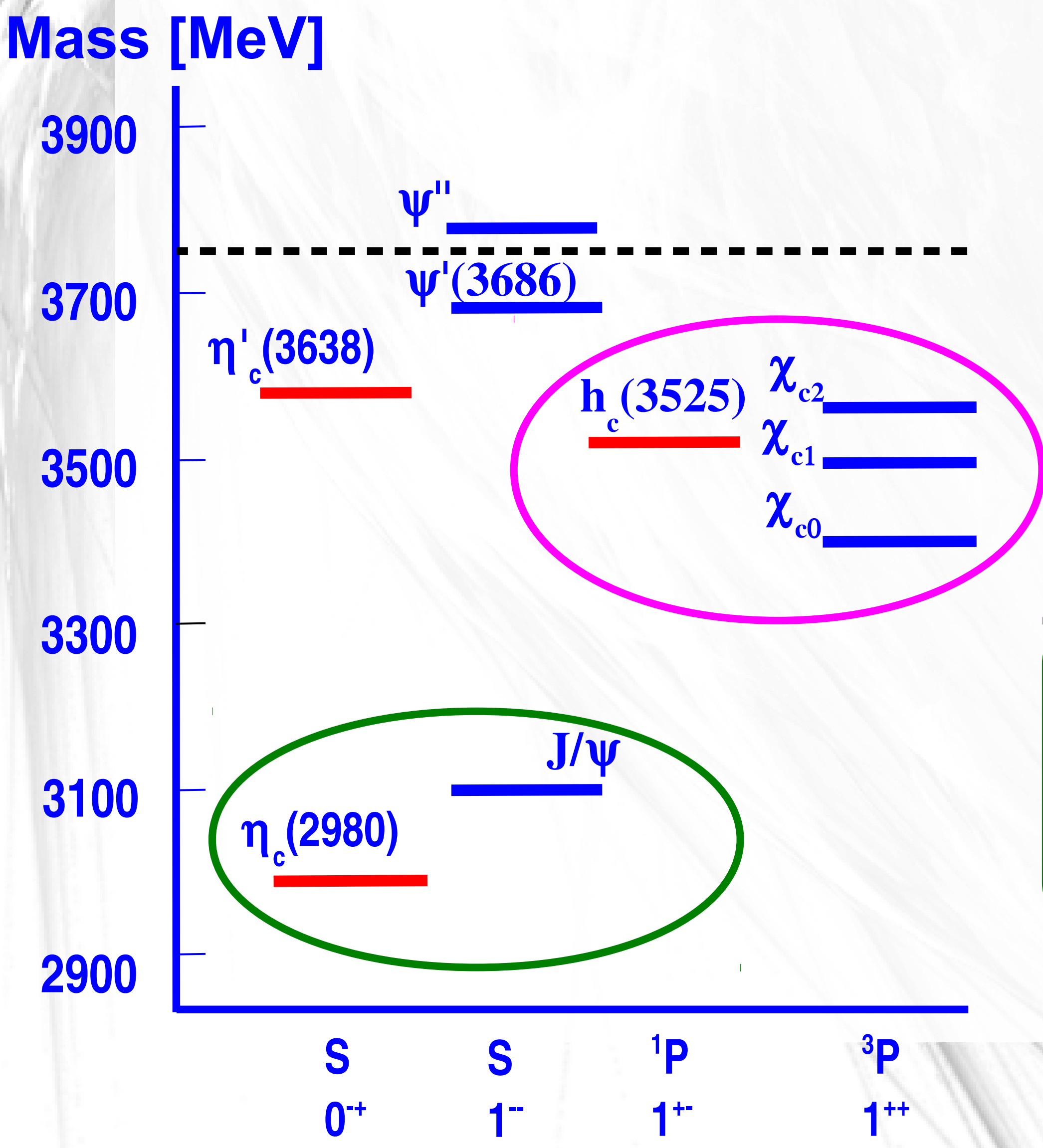
- **Γ = 32.0 ± 1.2 ± 1.0 MeV**

[Phys. Rev. D 86, 092009 (2012)]

- **M = 2984.49 ± 1.16 ± 0.52 MeV**
- **Γ = 36.4 ± 3.2 ± 1.7 MeV**

State Properties as a Probe

Precise measurement of charmonium masses and widths → **Test of potential models and lattice QCD**



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$$\langle m(1^3P_J)\rangle = \sum_{J=0}^{2} M_{\chi_{cJ}}(2J+1)/9$$

$\Delta M_{hf}(1P) = -0.19 \pm 0.11 \pm 0.14$ MeV

Consistent with zero!

Hyperfine splitting: **M(J/Ψ) – M(η_c)**: important input to test lattice QCD, **dominated by error on M(η_c)!**

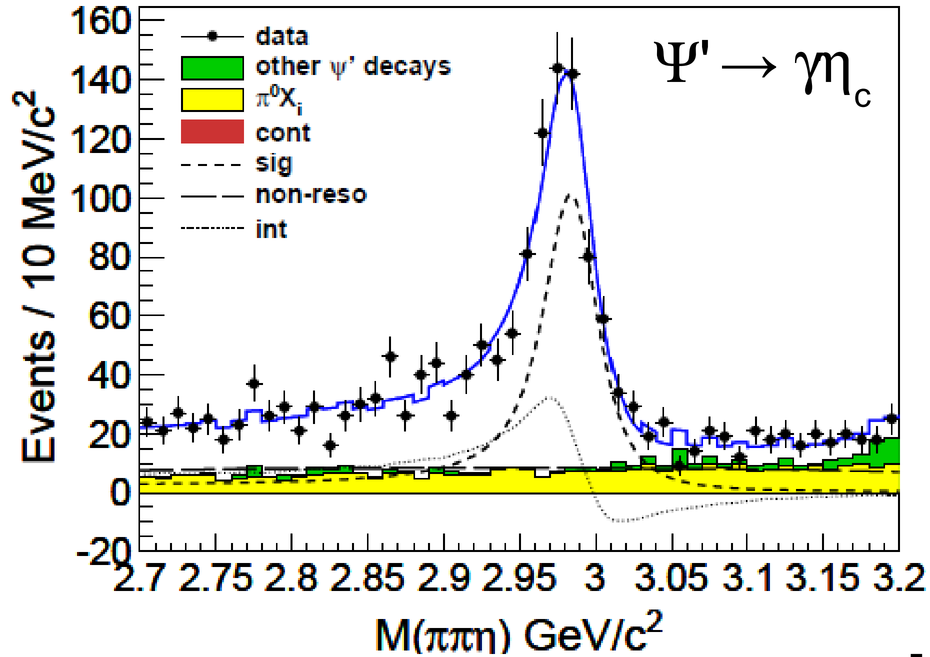
$\Delta M(1S) = 112.5 \pm 0.8$ MeV

Good agreement with LQCD

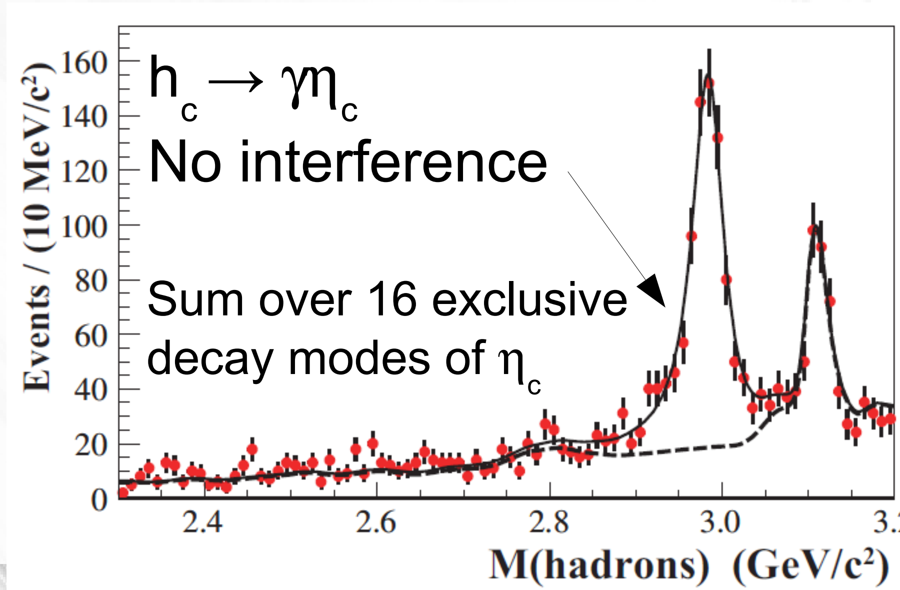
Better precision than LQCD!

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

- η_c-resonance: interference with non-resonant backgrounds → difficult to measure
- Only recently consistent results were obtained [Phys. Rev. Lett. 102, 011801 (2009), Phys. Lett. B 706, 139 (2011), Phys. Rev. D 84, 012004 (2011), **Phys. Rev. Lett. 108, 222002 (2012)**]
- $h_c \to \gamma\eta_c$ E1 transition: small non-resonant background → the η_c line shape is less distorted
- Consistent and precise measurement of h_c and η_c parameters
- Determined branching ratios for 16 exclusive η_c decays (5 measured for the first time)



[Phys. Rev. Lett. 108, 222002 (2012)]



[Phys. Rev. D 86, 092009 (2012)]

Transitions as a Probe

- In the potential approach:

$$R=\frac{\Gamma(J/\Psi\to\gamma\gamma\gamma)}{\Gamma(J/\Psi\to ee)}=\frac{64(\pi^2-9)}{243\pi}\alpha\left(1-7.3\frac{\alpha_s}{\pi}\right)$$

[M. B. Voloshin, Prog. Part. Nucl. Phys. 61, 455 (2008)]

assuming $\alpha_s=0.19 \rightarrow R=3\times10^{-4}$

- The rates ratio – sensitive only to QCD radiative corrections:

Test of understanding of the QCD radiative effects

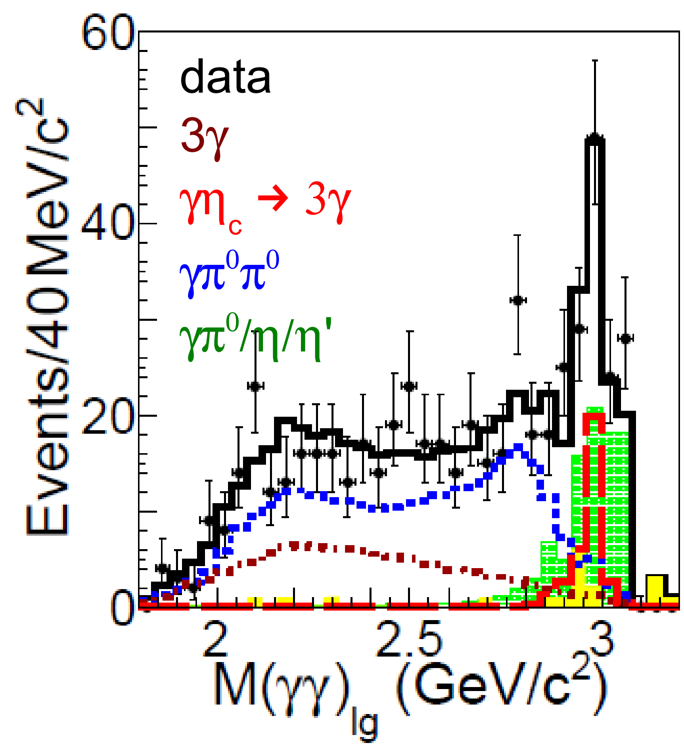
- $B(J/\Psi \to 3\gamma)$ = **$(11.3\pm1.8\pm2.0)\times10^{-6}$**
- $B(\eta_c \to 2\gamma)$ = **$(2.6\pm0.7\pm0.7)\times10^{-4}$**

Measured R=$(1.95\pm0.37)\times10^{-4}$
Consistent with the CLEOc result:
$R=(2.0\pm0.6)\times10^{-4}$

$\Psi' \to \pi^+\pi^-\ J/\Psi \to \gamma\gamma\gamma$

$\Psi' \to \pi^+\pi^-\ J/\Psi \to \gamma\,\eta_c \to \gamma\gamma\gamma$

Two-photon mass

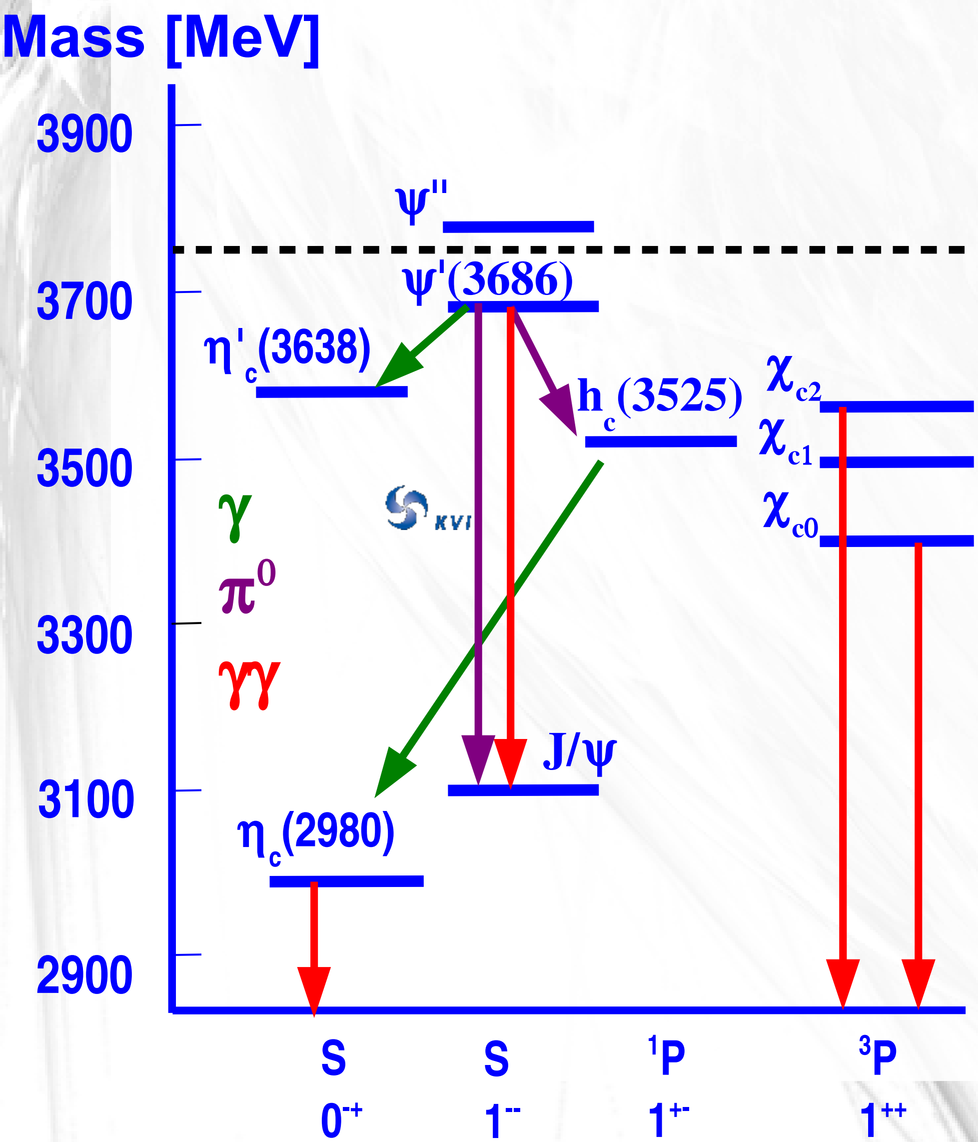


[Phys. Rev. D87 032003 (2013)]

Measurement of transition rates yields necessary information for development of models

Transitions as a Probe

Transition rates measured with better precision or for the first time:



$B(\Psi' \to \gamma \eta_c' \to KK\pi) =$
$(1.30 \pm 0.20 \pm 0.30)\times 10^{-5}$

[Phys. Rev. Lett. 109, 042003 (2012)]

$B(\Psi' \to \pi^0 h_c) = (8.4 \pm 1.3 \pm 1.0)\times 10^{-4}$

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

[Phys. Rev. Lett. 104, 132002 (2010)]

$B(\Psi' \to \gamma\gamma J/\Psi) =$
$(3.3 \pm 0.6 +0.8 -1.1)\times 10^{-4}$

[Phys. Rev. Lett 109, 172002 (2012)]

$\Gamma(\chi_{c2} \to \gamma\gamma) = 0.63 \pm 0.04 \pm 0.04$ keV

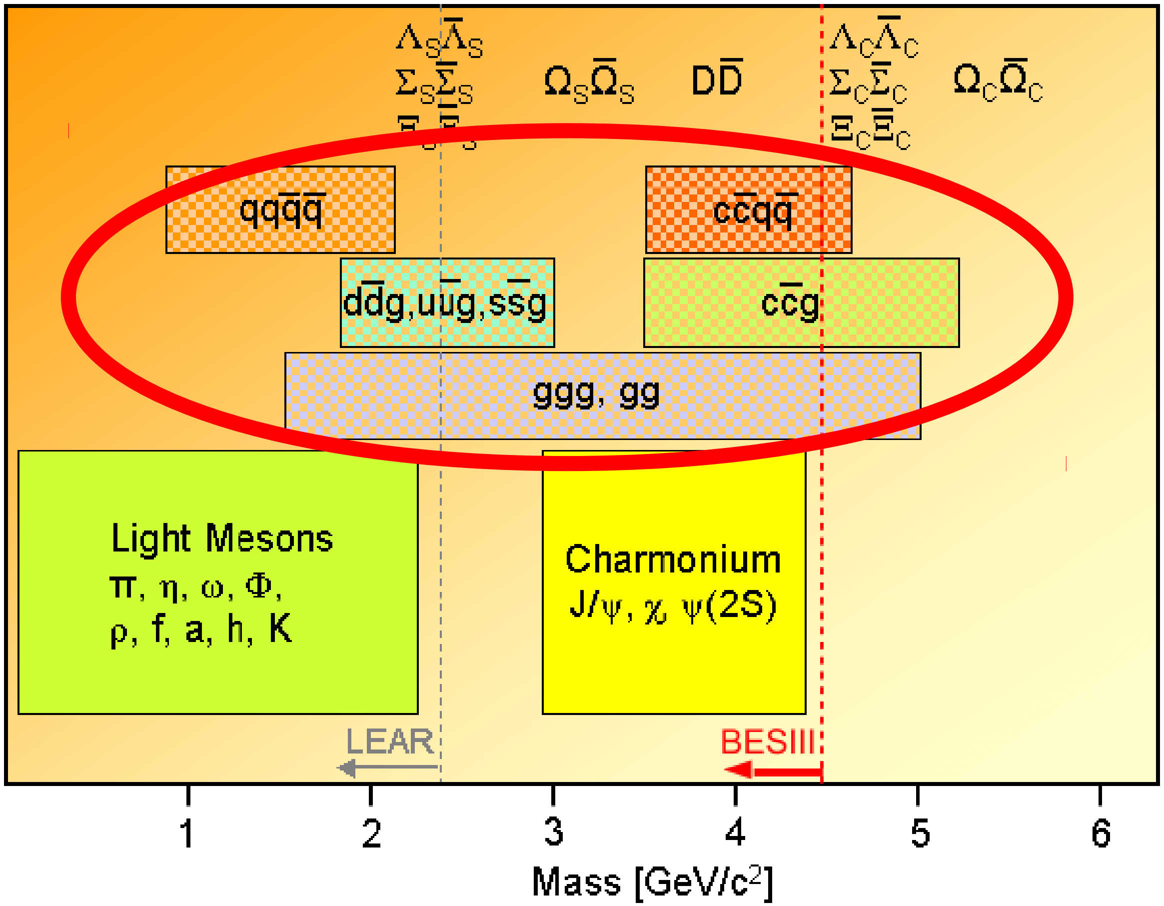
$\Gamma(\chi_{c0} \to \gamma\gamma) = 2.33 \pm 0.20 \pm 0.13$ keV

[Phys. Rev. D 85, 112008 (2012)]

BESIII can access suppressed transitions of interest

Talk by Olga Bondarenko (Thursday, 14:30)

Exotic hadron matter

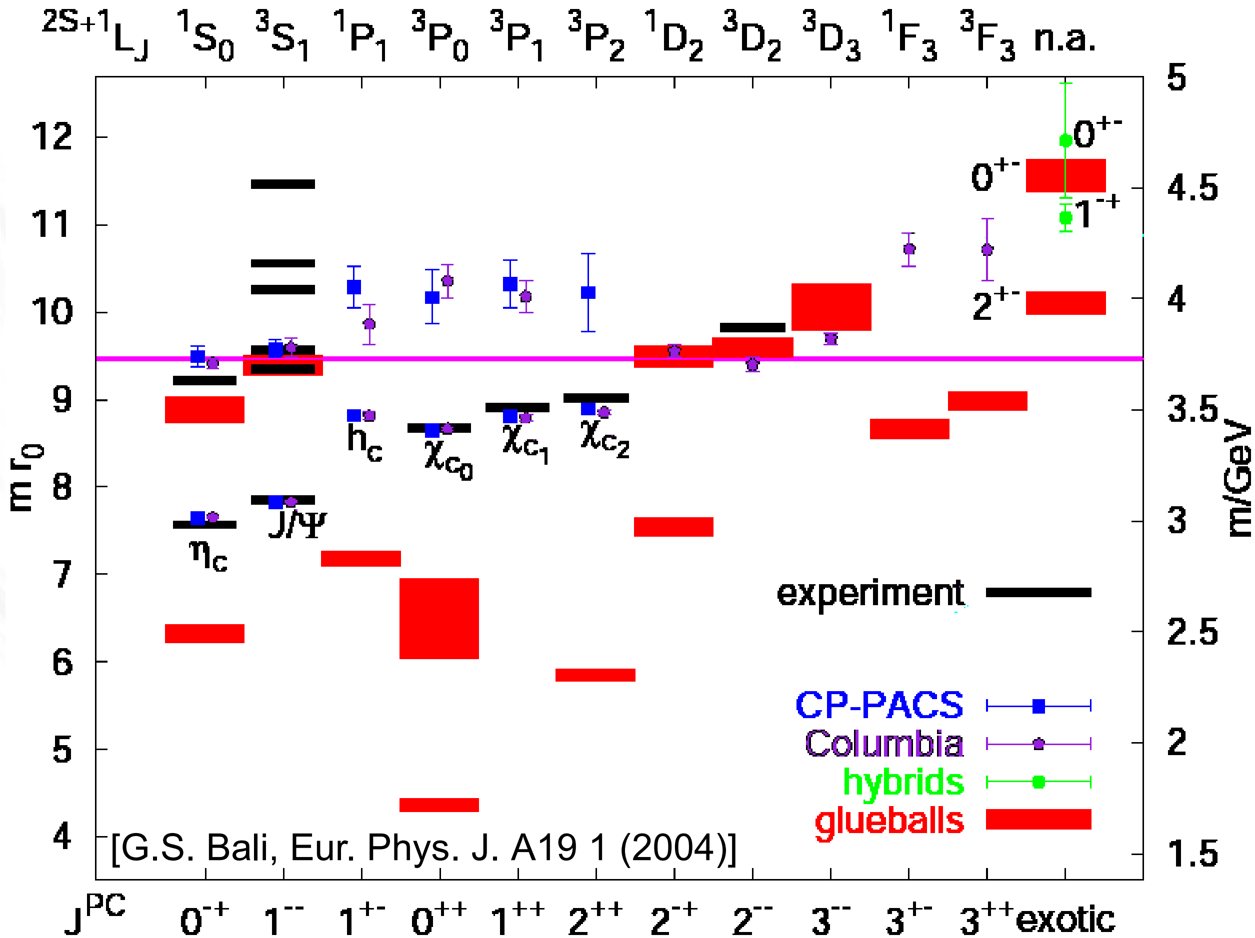


Other QCD Exotic Objects

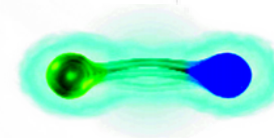
QCD predicts exotic objects:

- hybrids (resonances of quark-antiquark and excited glue)
- glueballs (excited states of glue)

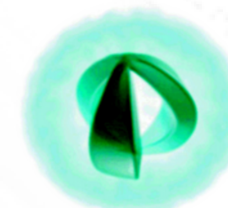
$D\bar{D}$ threshold →



$|\bar{c}\,c\rangle$



$|\bar{c}\,c\,g\rangle$



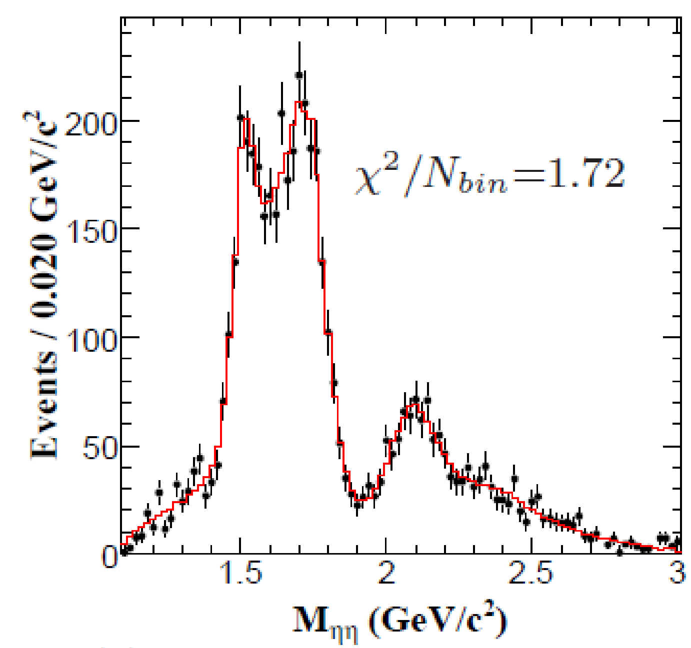
$|g\,g\,g\rangle$

Glueballs and hybrids properties are determined by the long-distance features of QCD → Insight into QCD vacuum

Glueball Searches with BESIII
PWA of $J/\Psi \rightarrow \gamma\eta\eta$

Radiative J/Ψ decay – a gluon-rich process →
one of the most promising hunting grounds for glueballs

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}	$136^{+41+28}_{-26-100}$	$(1.65^{+0.26+0.51}_{-0.31-1.40}) \times 10^{-5}$	$8.2\ \sigma$
$f_0(1710)$	$1759\pm6^{+14}_{-25}$	$172\pm10^{+32}_{-16}$	$(2.35^{+0.13+1.24}_{-0.11-0.74}) \times 10^{-4}$	$25.0\ \sigma$
$f_0(2100)$	$2081\pm13^{+24}_{-36}$	273^{+27+70}_{-24-23}	$(1.13^{+0.09+0.64}_{-0.10-0.28}) \times 10^{-4}$	$13.9\ \sigma$
$f_2'(1525)$	$1513\pm5^{+4}_{-10}$	75^{+12+16}_{-10-8}	$(3.42^{+0.43+1.37}_{-0.51-1.30}) \times 10^{-5}$	$11.0\ \sigma$
$f_2(1810)$	1822^{+29+66}_{-24-57}	$229^{+52+88}_{-42-155}$	$(5.40^{+0.60+3.42}_{-0.67-2.35}) \times 10^{-5}$	$6.4\ \sigma$
$f_2(2340)$	$2362^{+31+140}_{-30-63}$	$334^{+62+165}_{-54-100}$	$(5.60^{+0.62+2.37}_{-0.65-2.07}) \times 10^{-5}$	$7.6\ \sigma$



[arXiv:1301.0053 , Accepted by PRD]

- Scalar contributions mainly from $f_0(1500)$, $f_0(1710)$ and $f_0(2100)$
- Production rate of $f_0(1710)$ consistent with predicted glueball production **[Phys. Rev. Lett. 110, 021601 (2013)]** →
  $f_0(1710)$ has a larger overlap with the glueball compared to other glueball candidates

Mysterious XYZ States...

… **unexpectedly narrow for mesons in the open-charm region, strongly coupled to charmonium: What is their nature?**

State	m (MeV)	Γ (MeV)	J^{PC}	Process (mode)	Experiment (#σ)	Year	Status
$X(3872)$	3871.52±0.20	1.3±0.6	$1^{++}/2^{-+}$	$B \to K(\pi^+\pi^- J/\psi)$	Belle [85, 86] (12.8), BABAR [87] (8.6)	2003	OK
		(<2.2)		$p\bar{p} \to (\pi^+\pi^- J/\psi) + ...$	CDF [88–90] (np), DØ [91] (5.2)		
				$B \to K(\omega J/\psi)$	Belle [92] (4.3), BABAR [93] (4.0)		
				$B \to K(D^{*0}\bar{D}^0)$	Belle [94, 95] (6.4), BABAR [96] (4.9)		
				$B \to K(\gamma J/\psi)$	Belle [92] (4.0), BABAR [97, 98] (3.6)		
				$B \to K(\gamma\psi(2S))$	BABAR [98] (3.5), Belle [99] (0.4)		
$X(3915)$	3915.6 ± 3.1	28±10	$0/2^{?+}$	$B \to K(\omega J/\psi)$	Belle [100] (8.1), BABAR [101] (19)	2004	OK
				$e^+e^- \to e^+e^-(\omega J/\psi)$	Belle [102] (7.7)		
$X(3940)$	3942^{+9}_{-8}	37^{+27}_{-17}	$?^{?+}$	$e^+e^- \to J/\psi(D\bar{D}^*)$	Belle [103] (6.0)	2007	NC!
				$e^+e^- \to J/\psi\ (...)$	Belle [54] (5.0)		
$G(3900)$	3943 ± 21	52±11	1^{--}	$e^+e^- \to \gamma(D\bar{D})$	BABAR [27] (np), Belle [21] (np)	2007	OK
$Y(4008)$	4008^{+121}_{-49}	226±97	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^- J/\psi)$	Belle [104] (7.4)	2007	NC!
$Z_1(4050)^+$	4051^{+24}_{-43}	82^{+51}_{-55}	?	$B \to K(\pi^+\chi_{c1}(1P))$	Belle [105] (5.0)	2008	NC!
$Y(4140)$	4143.4 ± 3.0	15^{+11}_{-7}	$?^{?+}$	$B \to K(\phi J/\psi)$	CDF [106, 107] (5.0)	2009	NC!
$X(4160)$	4156^{+29}_{-25}	139^{+113}_{-65}	$?^{?+}$	$e^+e^- \to J/\psi(D\bar{D}^*)$	Belle [103] (5.5)	2007	NC!
$Z_2(4250)^+$	4248^{+185}_{-45}	177^{+321}_{-72}	?	$B \to K(\pi^+\chi_{c1}(1P))$	Belle [105] (5.0)	2008	NC!
$Y(4260)$	4263 ± 5	108±14	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^- J/\psi)$	BABAR [108, 109] (8.0)	2005	OK
					CLEO [110] (5.4)		
					Belle [104] (15)		
				$e^+e^- \to (\pi^+\pi^- J/\psi)$	CLEO [111] (11)		
				$e^+e^- \to (\pi^0\pi^0 J/\psi)$	CLEO [111] (5.1)		
$Y(4274)$	$4274.4^{+8.4}_{-6.7}$	32^{+22}_{-15}	$?^{?+}$	$B \to K(\phi J/\psi)$	CDF [107] (3.1)	2010	NC!
$X(4350)$	$4350.6^{+4.6}_{-5.1}$	$13.3^{+18.4}_{-10.0}$	$0,2^{++}$	$e^+e^- \to e^+e^-(\phi J/\psi)$	Belle [112] (3.2)	2009	NC!
$Y(4360)$	4353 ± 11	96±42	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^-\psi(2S))$	BABAR [113] (np), Belle [114] (8.0)	2007	OK
$Z(4430)^+$	4443^{+24}_{-18}	107^{+113}_{-71}	?	$B \to K(\pi^+\psi(2S))$	Belle [115, 116] (6.4)	2007	NC!
$X(4630)$	4634^{+9}_{-11}	92^{+41}_{-32}	1^{--}	$e^+e^- \to \gamma(\Lambda_c^+\Lambda_c^-)$	Belle [25] (8.2)	2007	NC!
$Y(4660)$	4664±12	48±15	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^-\psi(2S))$	Belle [114] (5.8)	2007	NC!
$Y_b(10888)$	10888.4±3.0	$30.7^{+8.9}_{-7.7}$	1^{--}	$e^+e^- \to (\pi^+\pi^-\Upsilon(nS))$	Belle [37, 117] (3.2)	2010	NC!

[EPJ C71, 1534 (2011)]

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$X(4350)$	$4350.6^{+4.6}_{-5.1}$	$13.3^{+18.4}_{-10.0}$	$0,2^{++}$	$e^+e^- \to e^+e^-(\phi J/\psi)$	Belle [112] (3.2)	2009	NC!
$Y(4360)$	4353 ± 11	96±42	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^-\psi(2S))$	BABAR [113] (np), Belle [114] (8.0)	2007	OK
$Z(4430)^+$	4443^{+24}_{-18}	107^{+113}_{-71}	?	$B \to K(\pi^+\psi(2S))$	Belle [115, 116] (6.4)	2007	NC!
$X(4630)$	4634^{+9}_{-11}	92^{+41}_{-32}	1^{--}	$e^+e^- \to \gamma(\Lambda_c^+\Lambda_c^-)$	Belle [25] (8.2)	2007	NC!
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$Y_b(10888)$	10888.4±3.0	$30.7^{+8.9}_{-7.7}$	1^{--}	$e^+e^- \to (\pi^+\pi^-\Upsilon(nS))$	Belle [37, 117] (3.2)	2010	NC!

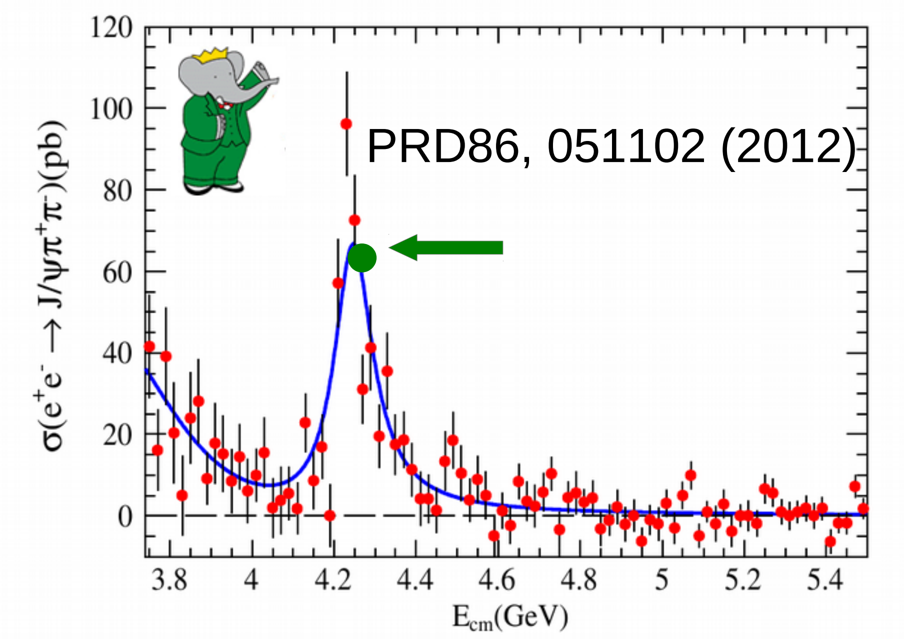
Systematic studies at BESIII of Y(4260), Y(4360)

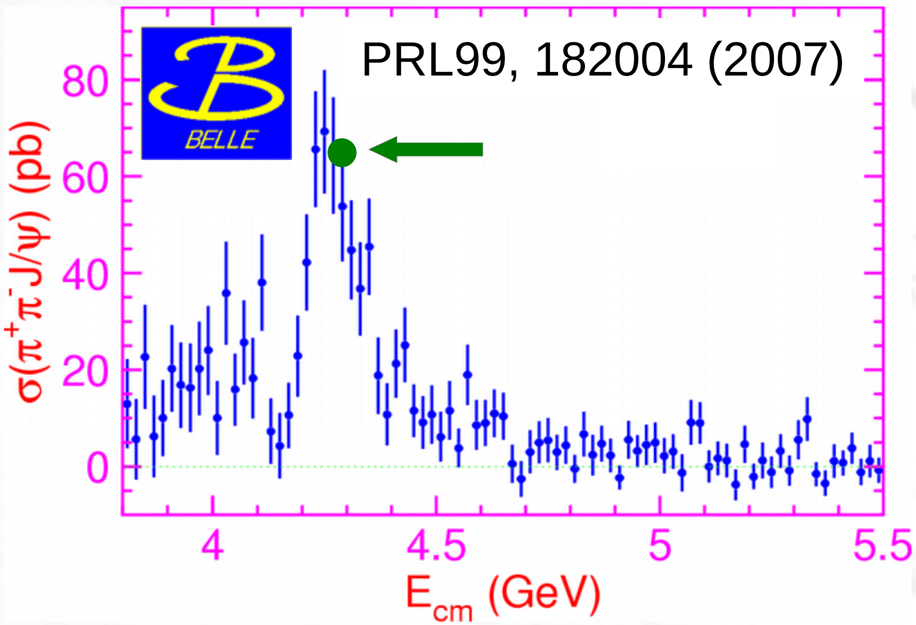
[EPJ C71, 1534 (2011)]

Studies of Y(4260) at BESIII

Y(4260):

- Does not fit any potential model.
- Has a small coupling to open charm
- $J^{PC} = 1^{--}$
- A hybrid candidate according to Lattice QCD calculations!
  [JHEP 1207, 126 (2012)]

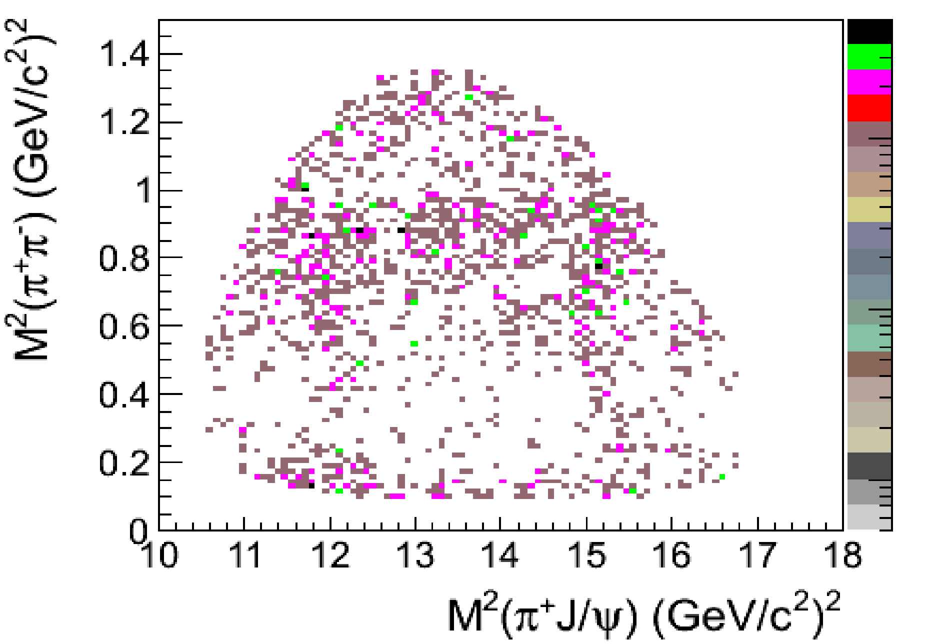




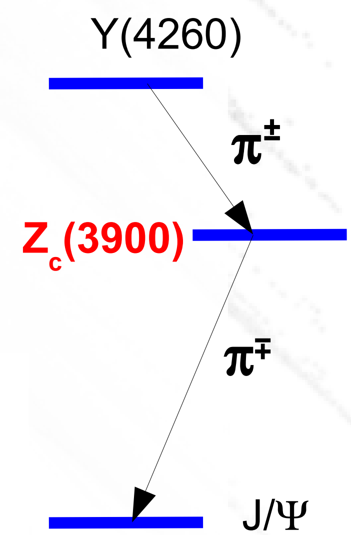
BESIII: $\sigma^B = 62.9 \pm 1.9 \pm 3.7$ pb

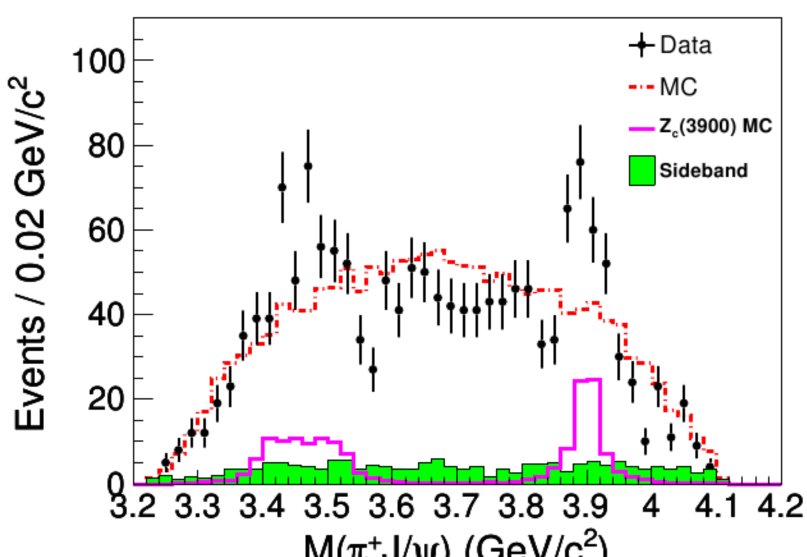
[Phys. Rev. Lett. 110, 252001 (2013)]

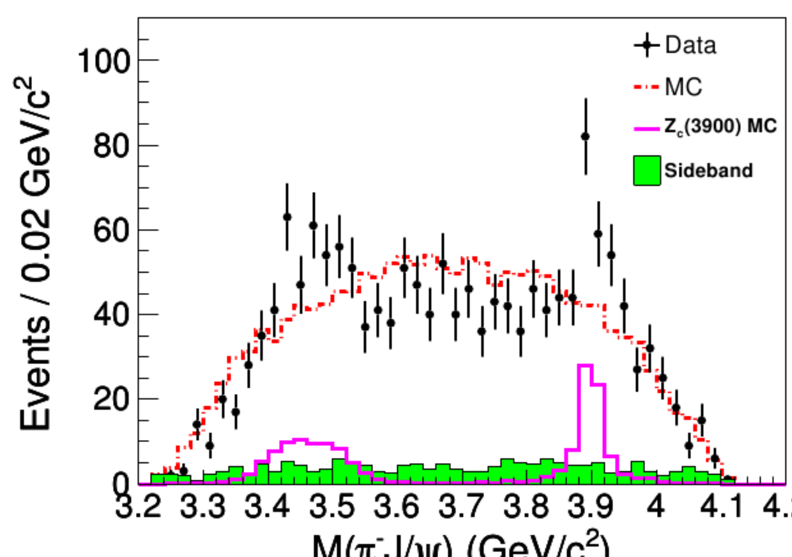
Dalitz Plot: $e^+e^- \to \pi^+\pi^- J/\psi$



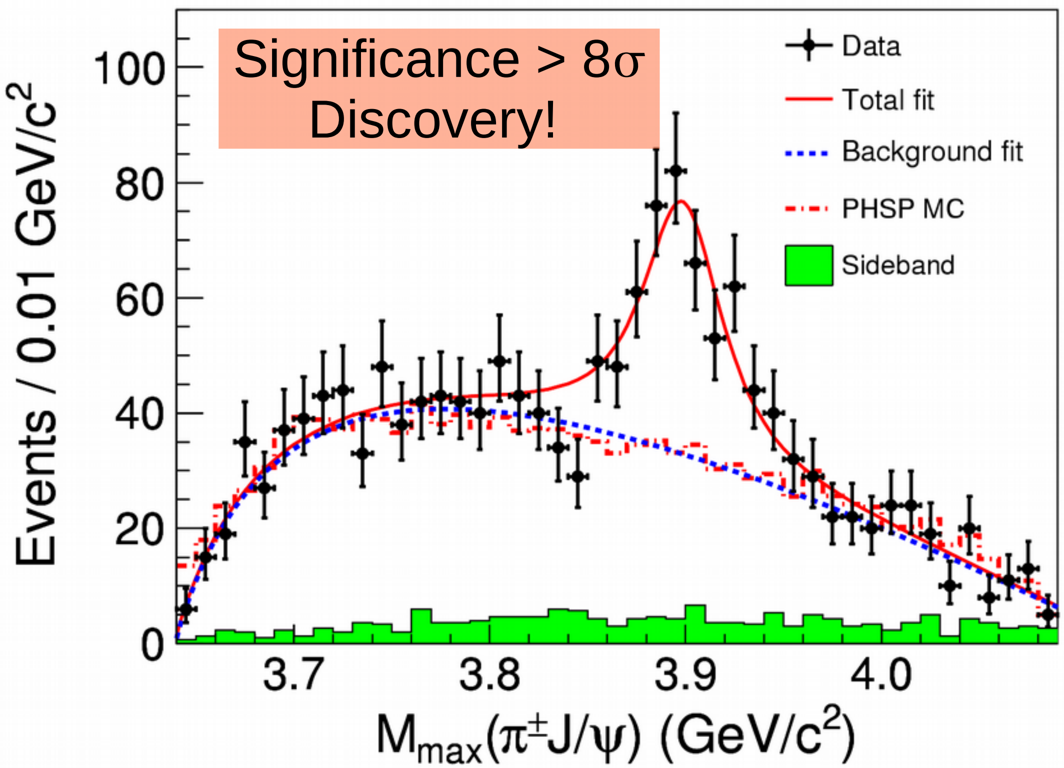
- **Clear peak at 3.9 GeV:** **$Z_c^{\pm}(3900)$,**
- Peak at lower energy – kinematic reflection (changes its position with e^+e^- CM energy)







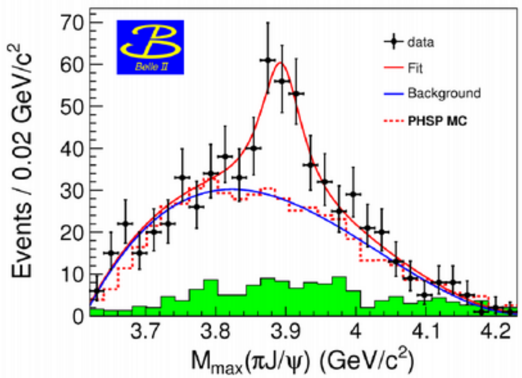
The $Z_c(3900)$



[Phys. Rev. Lett. 110, 252001 (2013)]

- Fit with S-wave Breit-Wigner
- **M = (3899.0±3.6±4.9) MeV/c^2**
- **Γ = (46±10±20) MeV**

Discovered by BESIII, promptly confirmed by:



Belle: **[Phys. Rev. Lett. 110, 252002 (2013)]**

$M = 3894.5 \pm 6.6 \pm 4.5$ MeV/c^2
$\Gamma = 63 \pm 24 \pm 26$ MeV

Cleo-c: **[arXiv:1304.3036]**

Mysterious XYZ States...

… **unexpectedly narrow for mesons in the open-charm region, strongly coupled to charmonium: What is their nature?**

State	m (MeV)	Γ (MeV)	J^{PC}	Process (mode)	Experiment (#σ)	Year	Status
$X(3872)$	3871.52±0.20	1.3±0.6	$1^{++}/2^{-+}$	$B \to K(\pi^+\pi^- J/\psi)$	Belle [85, 86] (12.8), BABAR [87] (8.6)	2003	OK
		(<2.2)		$p\bar{p} \to (\pi^+\pi^- J/\psi) + ...$	CDF [88–90] (np), DØ [91] (5.2)		
				$B \to K(\omega J/\psi)$	Belle [92] (4.3), BABAR [93] (4.0)		
				$B \to K(D^{*0}\bar{D}^0)$	Belle [94, 95] (6.4), BABAR [96] (4.9)		
				$B \to K(\gamma J/\psi)$	Belle [92] (4.0), BABAR [97, 98] (3.6)		
				$B \to K(\gamma\psi(2S))$	BABAR [98] (3.5), Belle [99] (0.4)		
$X(3915)$	3915.6 ± 3.1	28±10	$0/2^{?+}$	$B \to K(\omega J/\psi)$	Belle [100] (8.1), BABAR [101] (19)	2004	OK
				$e^+e^- \to e^+e^-(\omega J/\psi)$	Belle [102] (7.7)		
$X(3940)$	3942^{+9}_{-8}	37^{+27}_{-17}	$?^{?+}$	$e^+e^- \to J/\psi(DD^*)$	Belle [103] (6.0)	2007	NC!
				$e^+e^- \to J/\psi\ (...)$	Belle [54] (5.0)		
$G(3900)$	3943 ± 21	52±11	1^{--}	$e^+e^- \to \gamma(DD)$	BABAR [27] (np), Belle [21] (np)	2007	OK
$Y(4008)$	4008^{+121}_{-49}	226±97	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^- J/\psi)$	Belle [104] (7.4)	2007	NC!
$Z_1(4050)^+$	4051^{+24}_{-43}	82^{+51}_{-55}	?	$B \to K(\pi^+\chi_{c1}(1P))$	Belle [105] (5.0)	2008	NC!
$Y(4140)$	4143.4 ± 3.0	15^{+11}_{-7}	$?^{?+}$	$B \to K(\phi J/\psi)$	CDF [106, 107] (5.0)	2009	NC!
$X(4160)$	4156^{+29}_{-25}	139^{+113}_{-65}	$?^{?+}$	$e^+e^- \to J/\psi(DD^*)$	Belle [103] (5.5)	2007	NC!
$Z_2(4250)^+$	4248^{+185}_{-45}	177^{+321}_{-72}	?	$B \to K(\pi^+\chi_{c1}(1P))$	Belle [105] (5.0)	2008	NC!
$Y(4260)$	4263 ± 5	108±14	1^{--}	$e^+e^- \to \gamma(\pi^+\pi^- J/\psi)$	BABAR [108, 109] (8.0)	2005	OK
					CLEO [110] (5.4)		
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				$e^+e^- \to (\pi^+\pi^- J/\psi)$	CLEO [111] (11)		
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$Z_c(3900)$ – first confirmed Z state!

[EPJ C71, 1534 (2011)]

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Z states:

- Charged states
- Strongly coupled to charm

can not be conventional mesons

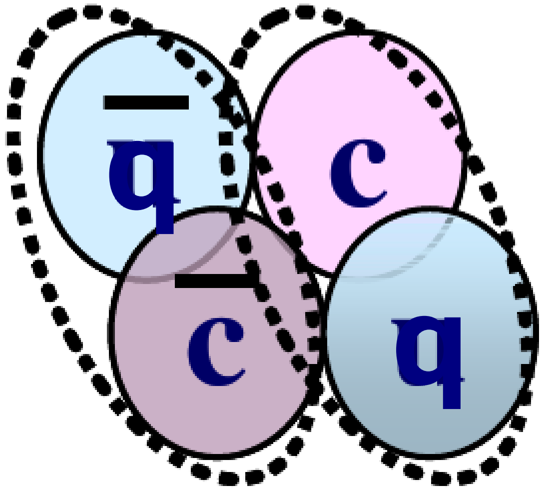
?

[EPJ C71, 1534 (2011)]

Nature of the $Z_c(3900)$

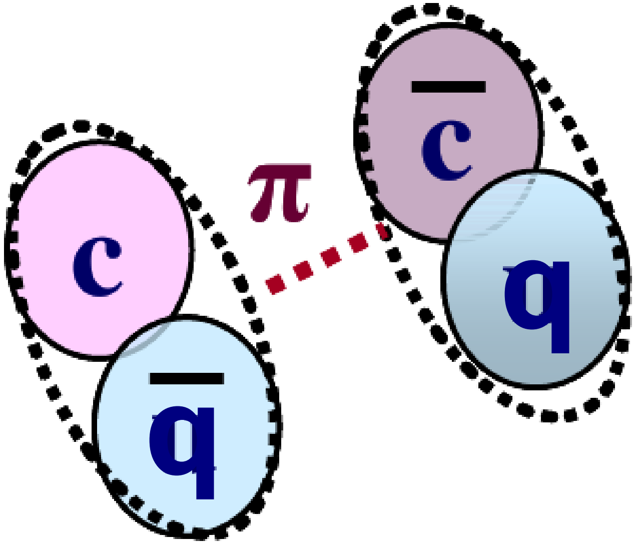
Most popular models

Tetraquark



Interact by gluonic color force
[arXiv:1303.6857]
[arXiv:1304.0345, 1304.1301]

Hadronic molecule



2 color-neutral mesons
Interact by pion exchange
[arXiv:1303.6608]
[arXiv:1304.2882, 1304.1850]

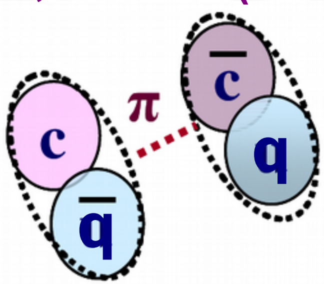
[arXiv: 1304.0380]

Other models:
- Meson loop **[arXiv: 1303.6355, 1304.4458]**
- Initial State Pion Emission (ISPE) model **[arXiv: 1303.6842, 1304.5845]**

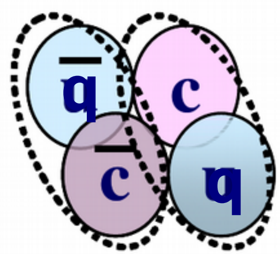
Nature of the $Z_c(3900)$

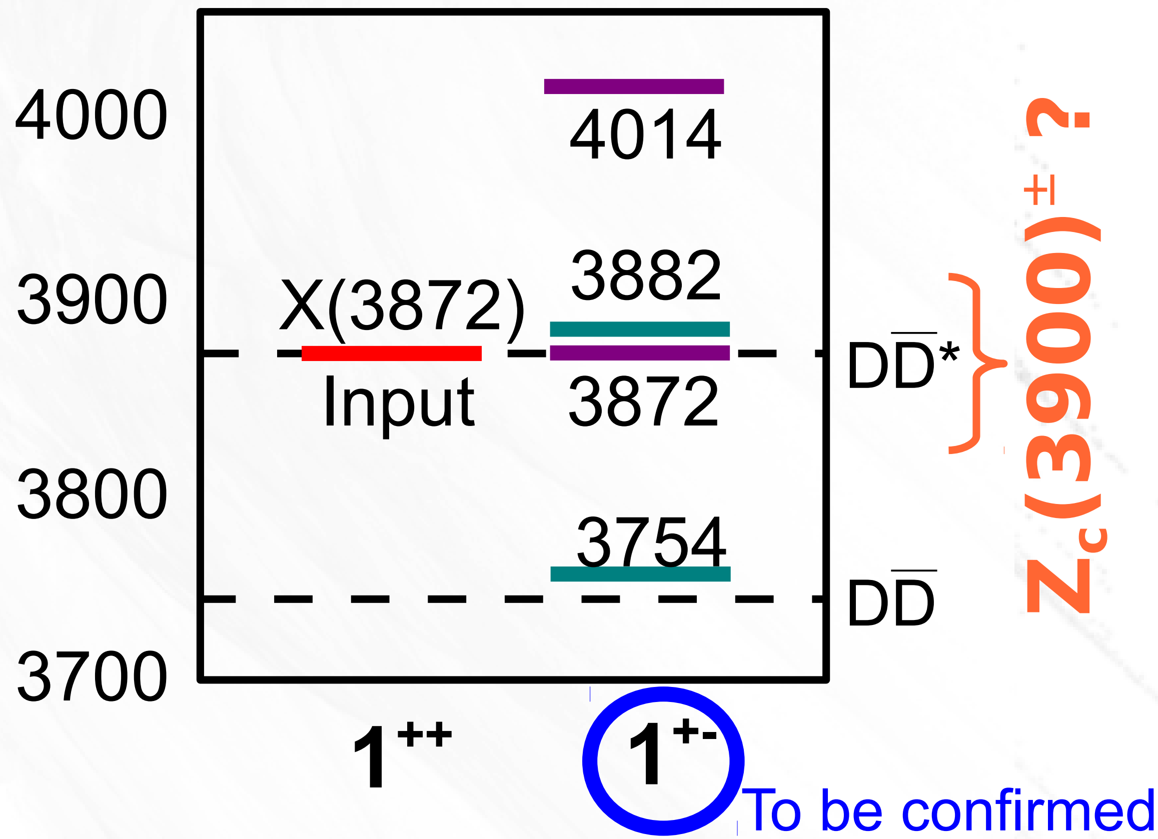
Sensitive probes?

- **Heavier/lighter states**
  - **Hadronic molecule**
    [PRD 77, 014029 (2008)]



  - **Tetraquark**
    [arXiv:1303.6857]





- **Decay modes and rates**
  - **Hadronic molecule:**
    decays mainly to its constituents
  - **Tetraquark:** $\Gamma(Z_c^+ \to \pi^+ J/\psi) \approx$ **29 MeV**
    $\Gamma(Z_c^+ \to D^+\bar{D}^{*0}, \bar{D}^0 D^{*+}) \approx$ **4 MeV**

Measurement coming soon... Stay tuned!

A lot of interesting results are already published by the BESIII collaboration

New exciting results are coming soon!

Summary

- BESIII is operational since 2008
  and already has world's largest data samples of various Υ and charmonium states

- BESIII – an ideal tool for precision studies of suppressed channels:
  - clean environment
  - well controlled systematics

- A lot of interesting results have been obtained:
  - Precise measurements of resonance properties
  - Discovery of unexpected states

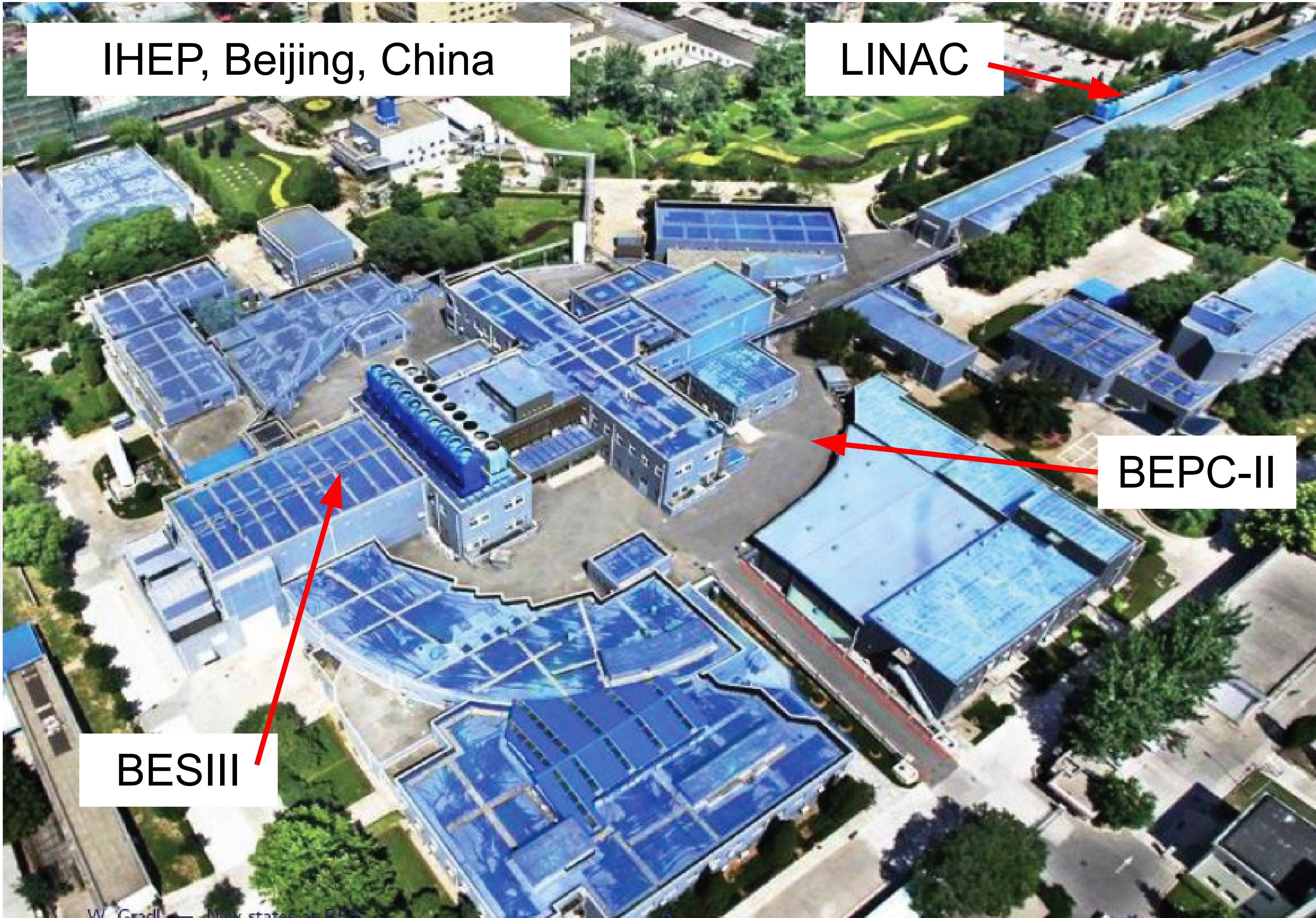
- ... and we are looking forward to the future:
  - More data available than presented in current analysis

Stay tuned!

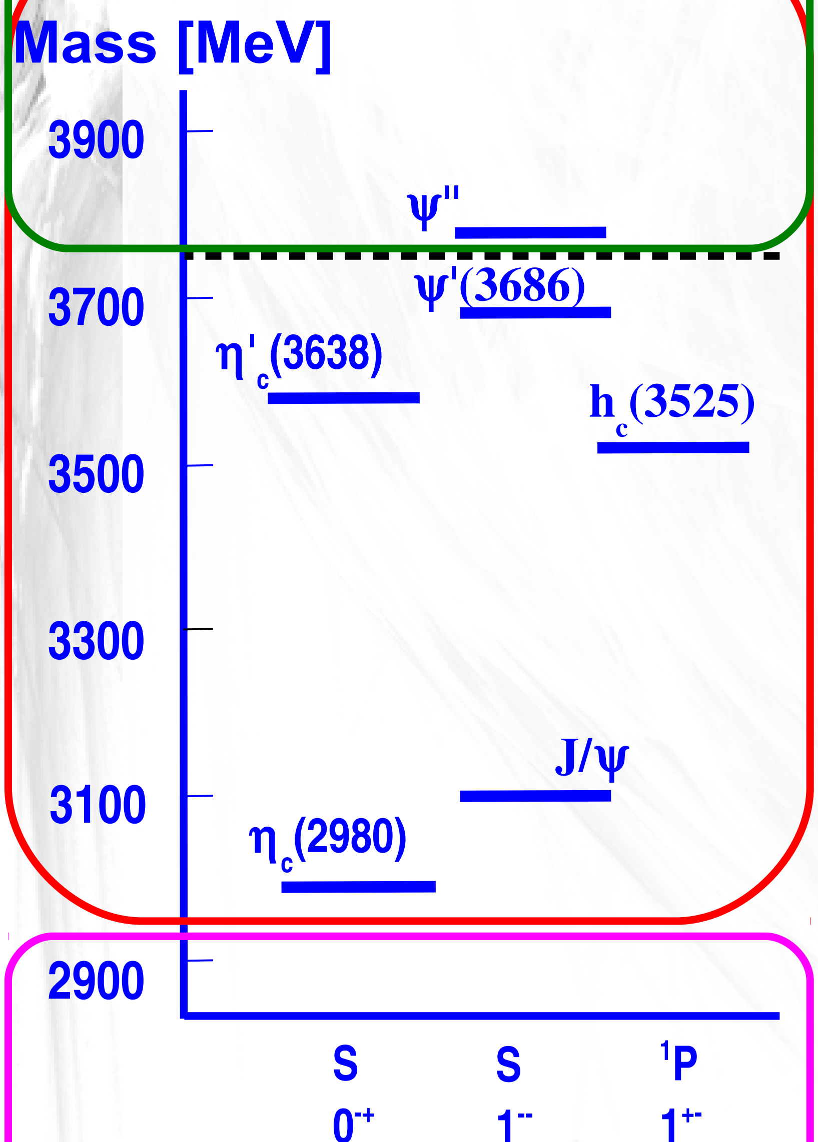
Thank you for your attention
and
to the BESIII collaboration!

BESIII collaboration: >360 members in 53 institutions from 11 countries

BESIII at BEPC-II



Physics at BESIII



Charm physics:
- (semi)leptonic + hadronic decays
- decay constant, form factors
- CKM matrix: Vcd, Vcs
- D_0-D_0 mixing and CP violation
- rare/forbidden decays

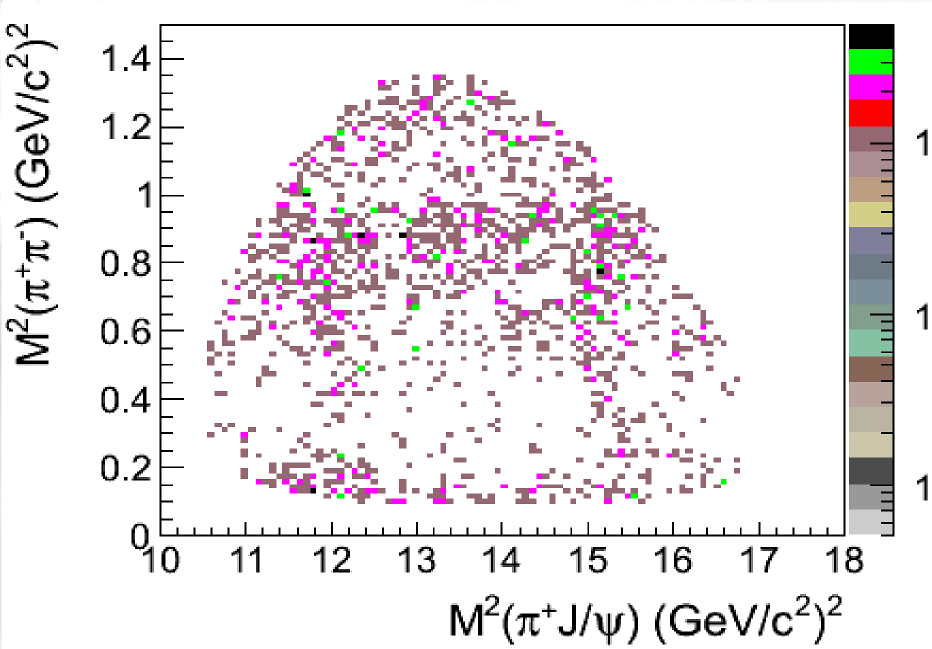
Charmonium physics:
- transitions and decays
- spectroscopy of exotic states

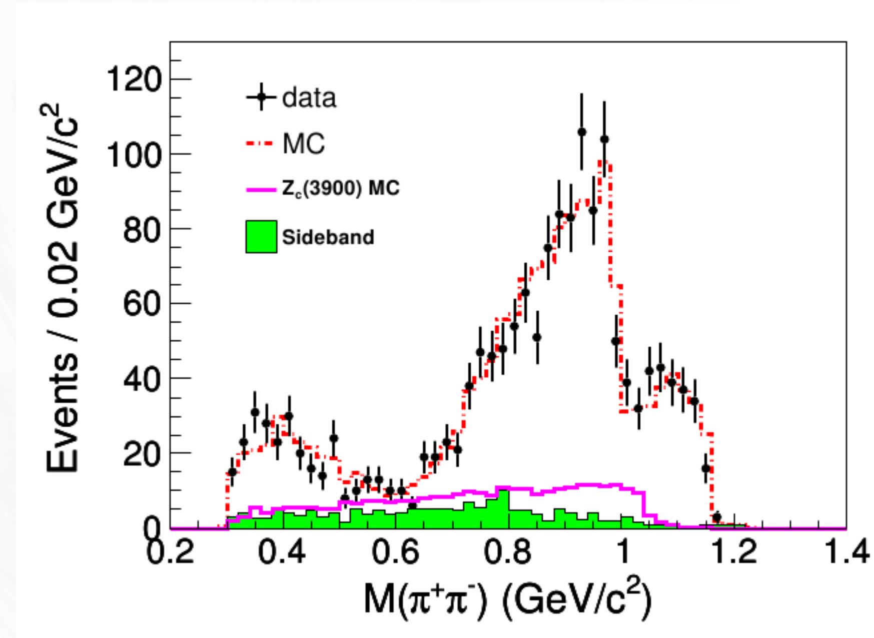
Light hadron physics:
- meson & baryon spectroscopy
- glueball & hybrid
- two-photon physics
- e.m. form factors of nucleon

Tau physics:

systematics under control → high precision
- tau decays near threshold
- tau mass scan

Dalitz Plot: $e^+e^- \rightarrow \pi^+\pi^- J/\psi$





- Decay via $f_0(980)$ and $\sigma(500)$
- No peak is generated by these resonances in the $\pi^+ J/\Psi$ spectrum