Highlights of BESIII results and hadronic vacuum polarization

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LAL-IHEP Joint Project

- HVP, g-2
- σ(ee→hadrons)
- τ mass/decay
- ……

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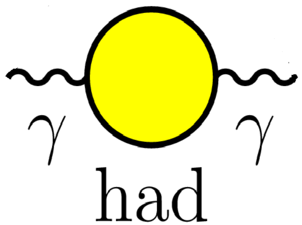
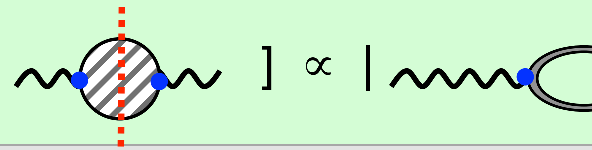
Hadronic Vacuum Polarization (HVP)



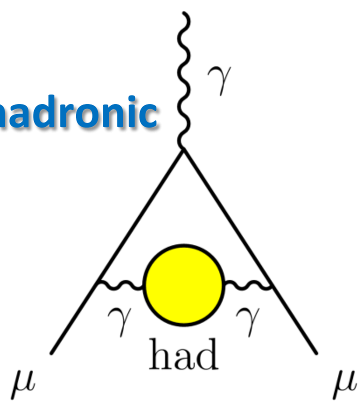
$$12\pi\ \mathrm{Im}\Pi_\gamma(s) = \frac{\sigma^0\,[e^+e^- \rightarrow \text{hadrons}\ (\gamma)]}{\sigma_{pt}[e^+e^- \rightarrow \mu^+\mu^-]} \equiv R(s)$$

Im[] ∝ | hadrons |^2

Muon anomalous magnetic moment

$$a_\mu^{\mathrm{SM}} = a_\mu^{\mathrm{QED}} + a_\mu^{\mathrm{EW}} + a_\mu^{\mathrm{Had}}$$

LO hadronic



SM prediction
vs
measurement

Running electromagnetic coupling constant

$\alpha(Q^2)=\alpha(0)/(1-\Delta\alpha(Q^2))$

$\Delta\alpha(Q^2)=\Delta\alpha_l(Q^2)+\Delta\alpha_{top}(Q^2)+\Delta\alpha^{(5)}_{had}(Q^2)$

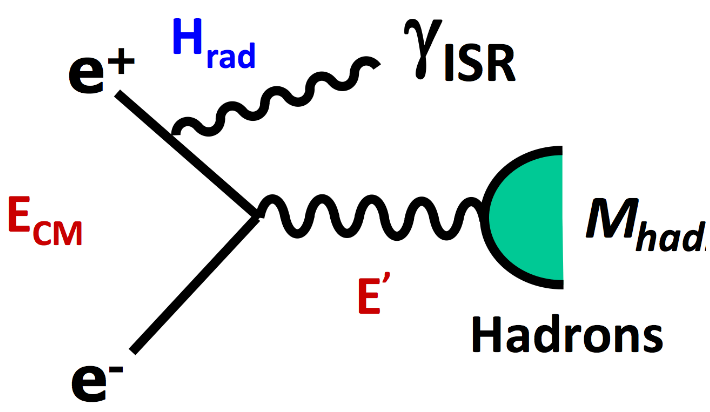
↓ leptons ↓ Top quark

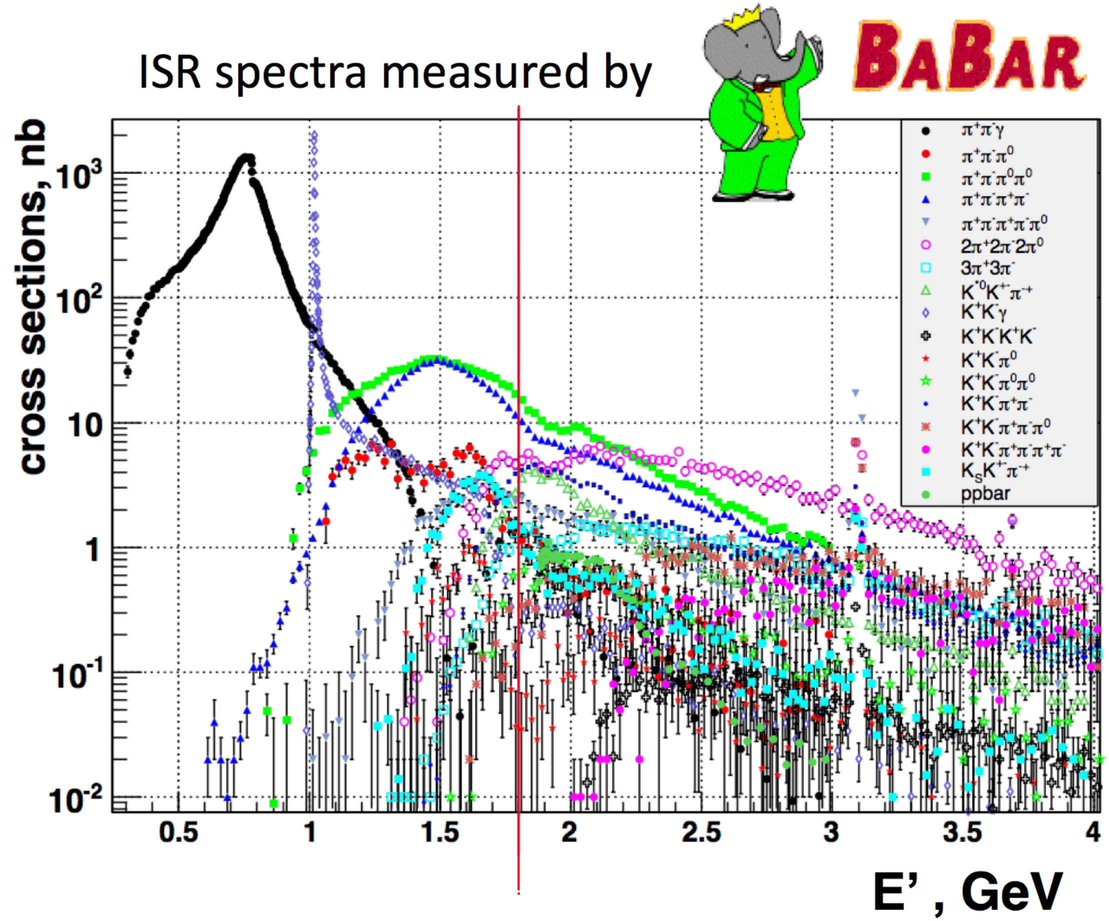
the precision electroweak tests need!

Quick review of the activities for the joint project

- Precision measurement of $\sigma(e^+e^- \rightarrow \pi^+\pi^-/K^+K^-)$ through ISR at BaBar
  (dominant contribution/error to $a_\mu^{had}(LO)$)
  PRL 109, 042003 (2012)
  PRD 86, 032013 (2012)
  PRD 88, 032013 (2013)
- ISR-FSR interference in $e^+e^- \rightarrow \pi^+\pi^-/\mu^+\mu^-$
  (using the same BaBar data) τ workshop2014
- Revision τ spectral function at ALEPH (new unfolding)
  EPJC74 3, 2803 (2014)
- Vacuum polarization and muon g-2 (combining all existing e+e- and τ data to calculate HVP, $a_\mu^{had}(LO)$, $\alpha_{QED}(M_Z^2)$)
  EPJC71,1515 (2011)

ISR method

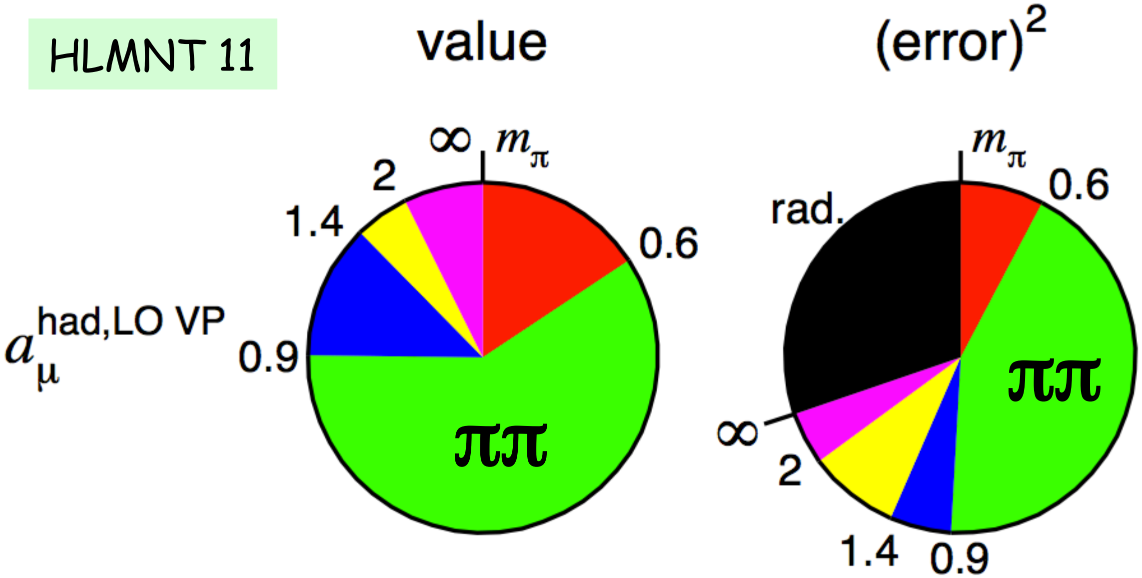




- Ecm fixed
- Effective annihilation energy E' from threshold to Ecm
- Radiative function needed
- One experiment => a spectrum e.g. BaBar ISR project

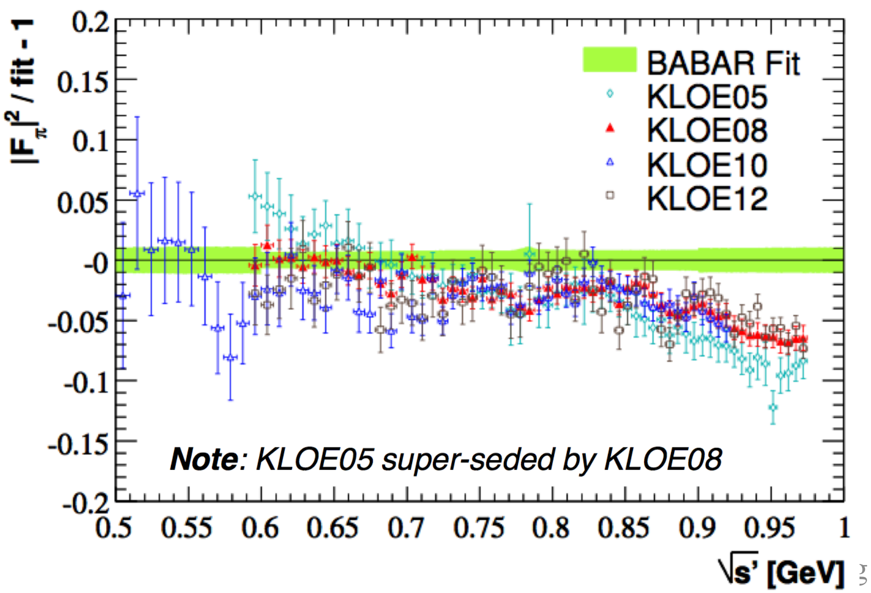
Why $\sigma(e^+e^- \rightarrow \pi^+\pi^-)$ important?

HLMNT 11



➔ Energy region 0.6-0.9 GeV dominates

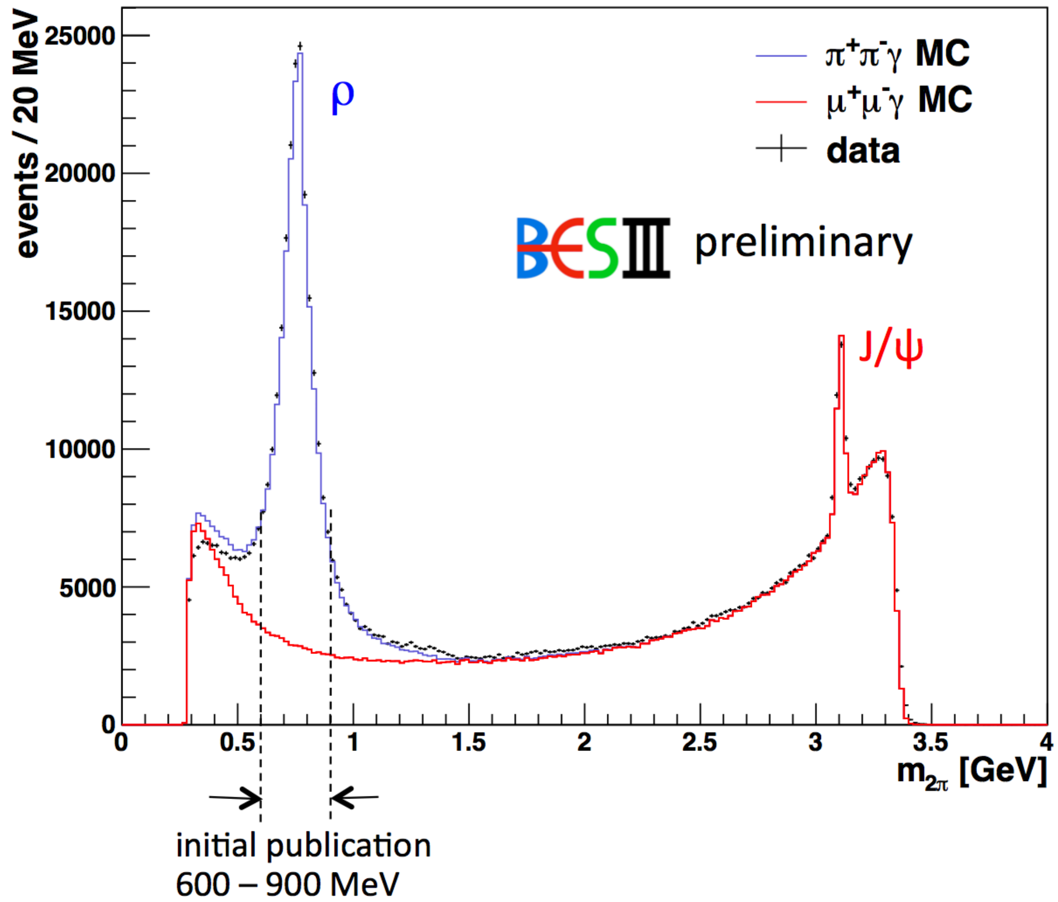
➔ 2π channel contributes more than 70%



- BABAR and KLOE dominate the world average
- Relatively large systematic differences, esp. above ρ peak
- Knowledge of a_μ^{had} dramatically limited due to this difference

Analysis of $e^+e^- \rightarrow \pi^+\pi^-\gamma_{ISR}$ at BESIII

Event yield after basic event selection (acceptance only!)



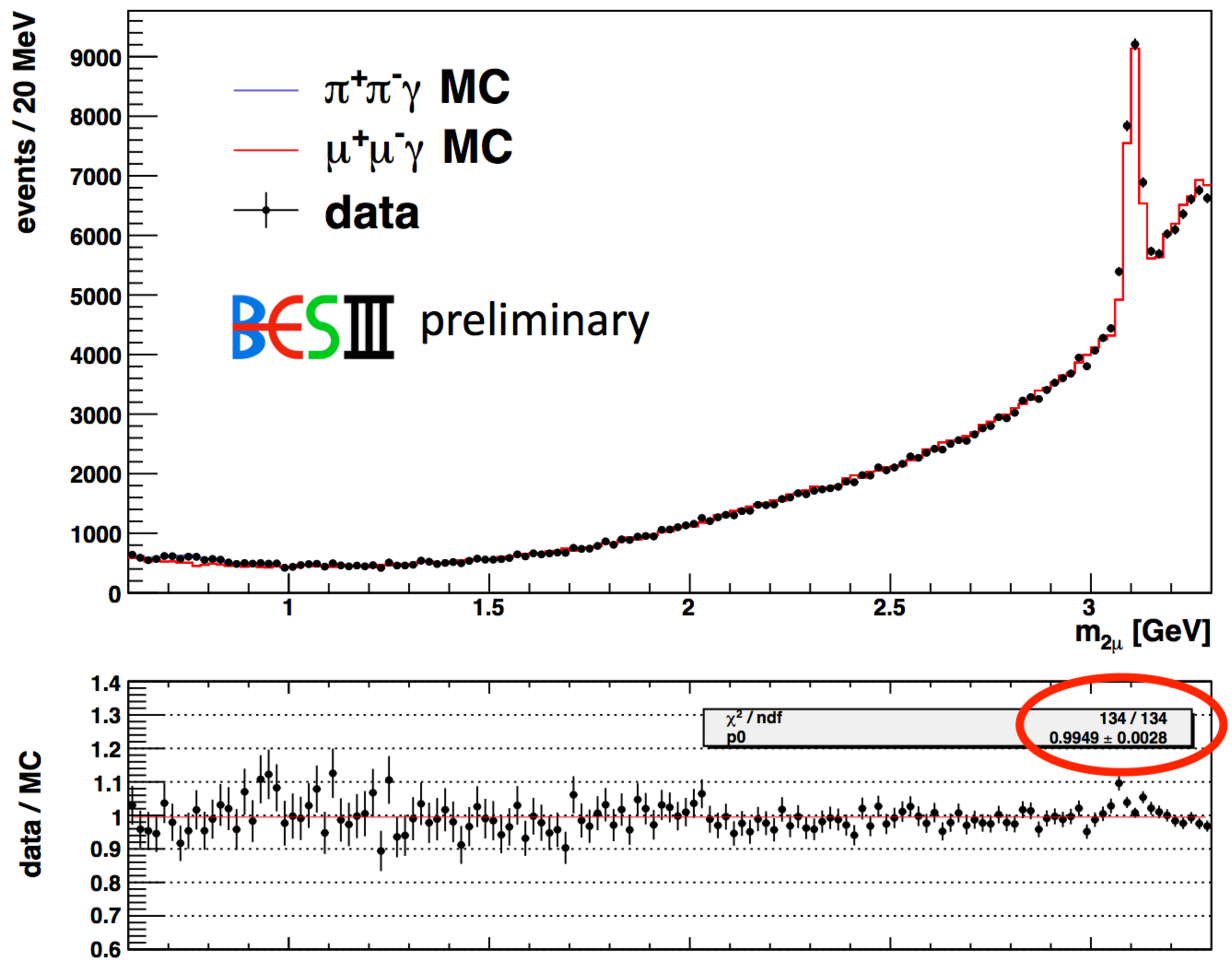
Features:

- ψ(3770) data only (2.9 fb^{-1})
- no background subtraction
- PHOKHARA event generator
- tagged ISR photon

→ large statistics of ππγ events
→ background dominated by μμγ
→ data – MC differences observed

QED test with $\mu^+\mu^-\gamma$ events

Event yield $\mu\mu\gamma$ after π-μ separation



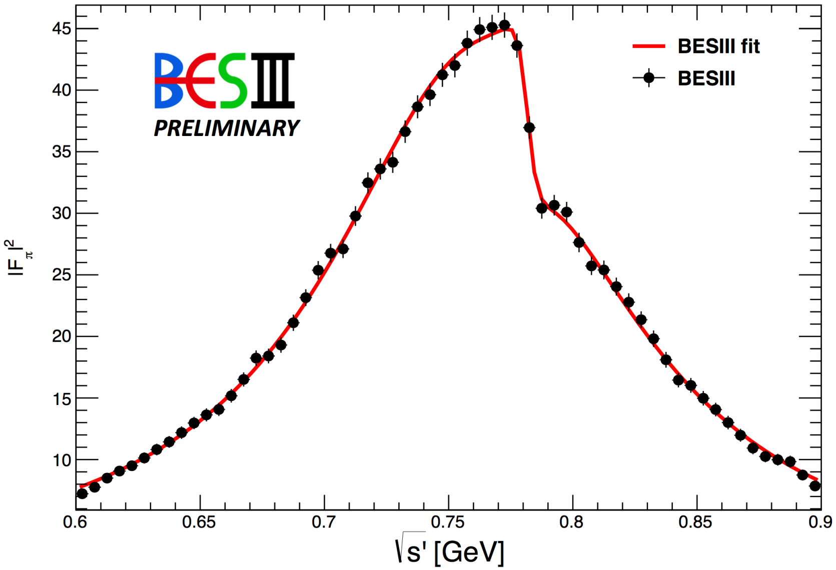
Features:

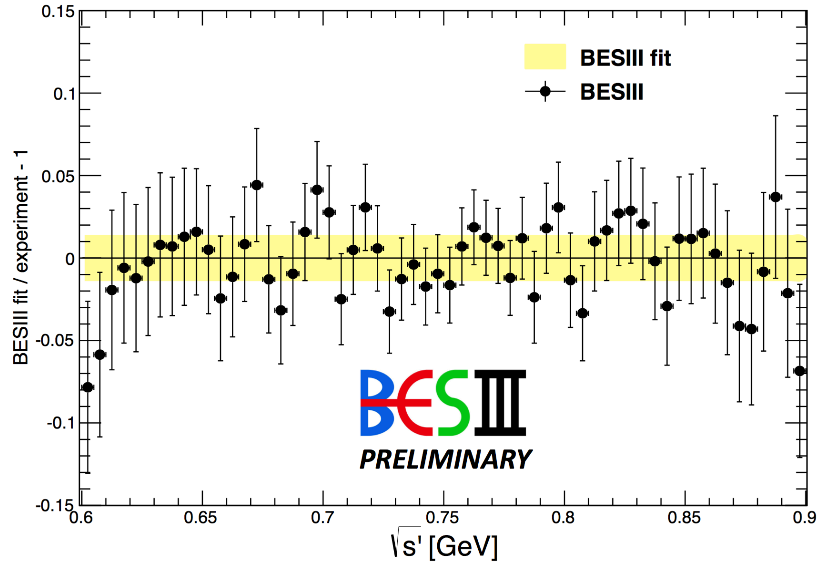
- all efficiency corrections applied
- background from $\pi\pi\gamma$ small
- PHOKHARA accuracy <0.5%
- normalized to L_{int} measurement 1% accuracy

→ excellent agreement with QED **Δ(MC-data) = (0.51 ± 0.28) %**

→ accuracy on 1% level as needed to be competitive !

Results of $|F_\pi|^2$

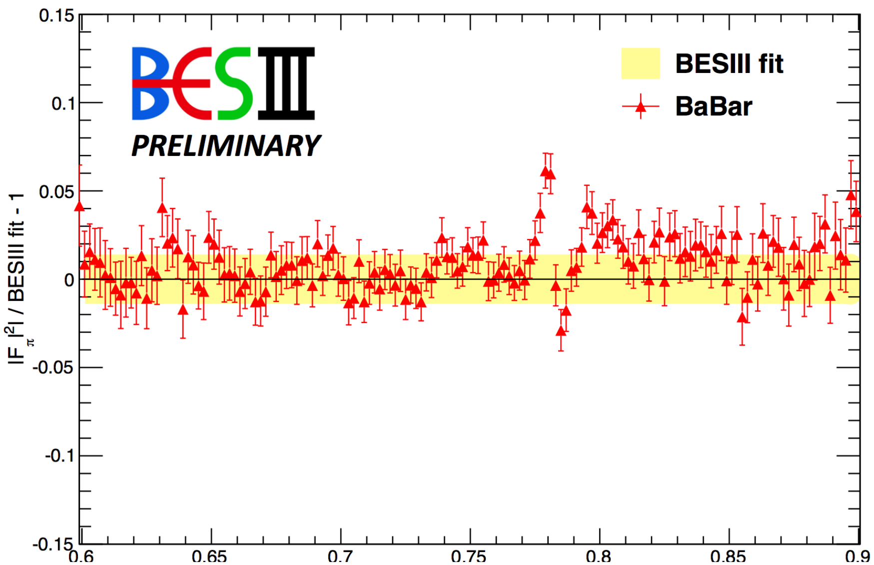


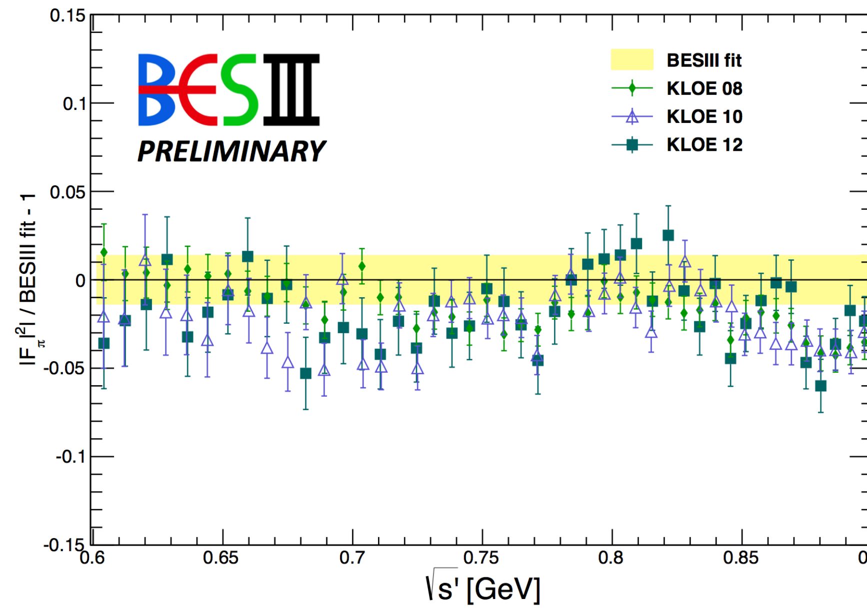


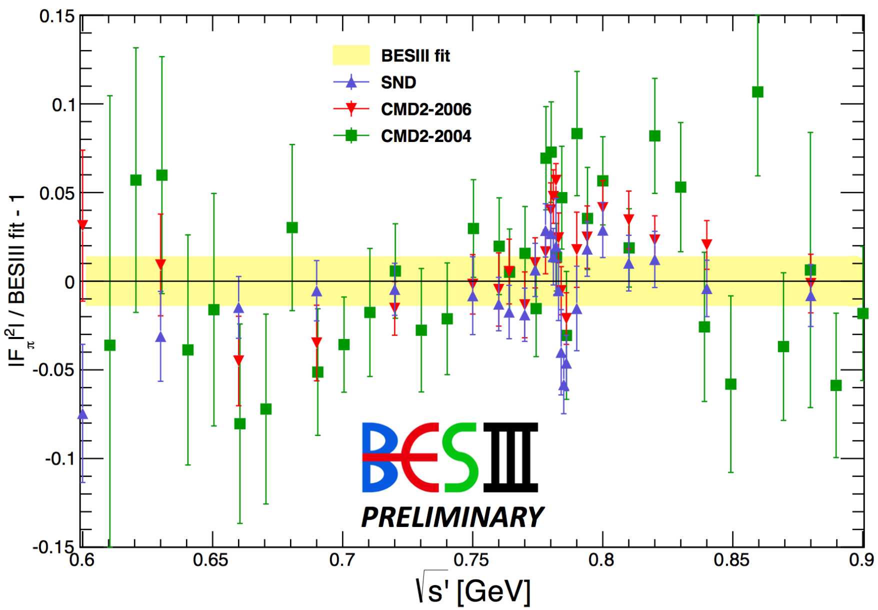
- Fit to a VDM model (same as BaBar)
- Including ρ−ω interference
- the Gounaris-Sakurai (GS) model used to describe ρ, ρ', ρ'' and ρ'''
- Parameters for ρ', ρ'' and ρ''' are fixed to BaBar results

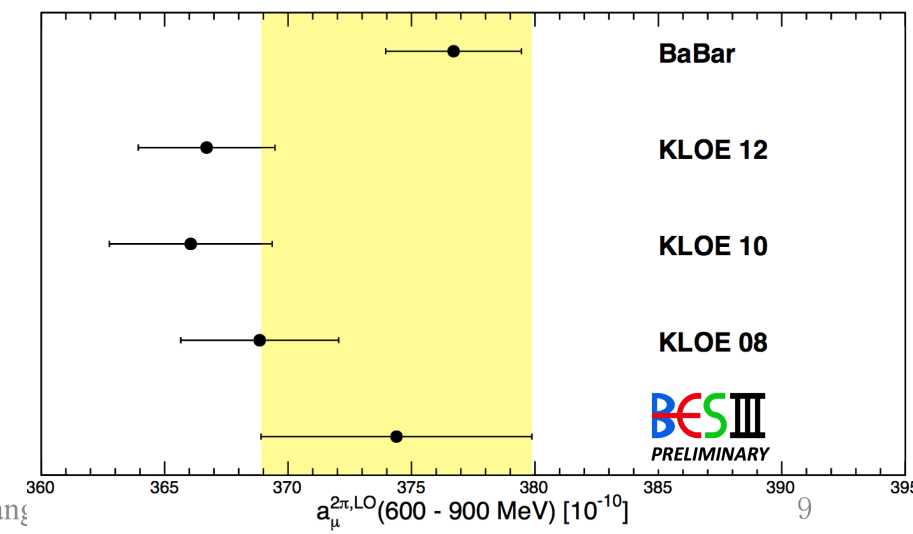
Parameter	PDG	BaBar	KLOE	BESIII
m_ρ (MeV)	775.49 ± 0.34	775.02 ± 0.31	774.3 ± 0.1	775.1 ± 0.5
Γ_ρ (MeV)	149.1 ± 0.8	149.59 ± 0.67	146.9 ± 0.2	150.6 ± 0.8
m_ω (MeV)	782.65 ± 0.12	781.91 ± 0.18	782.7 ± 0.2	781.6 ± 1.1
Γ_ω (MeV)	8.49 ± 0.08	8.13 ± 0.36	7.0 ± 0.4	10.4 ± 2.3
$\lvert c_\omega \rvert$ (10^{-3})		1.644 ± 0.061	1.45 ± 0.04	2.1 ± 0.3
ϕ_ω (rad)		-0.011 ± 0.037	0.18 ± 0.03	-0.02 ± 0.15

Comparison of $|F_\pi|^2$ to previous measurements and impact on a_μ^{had}

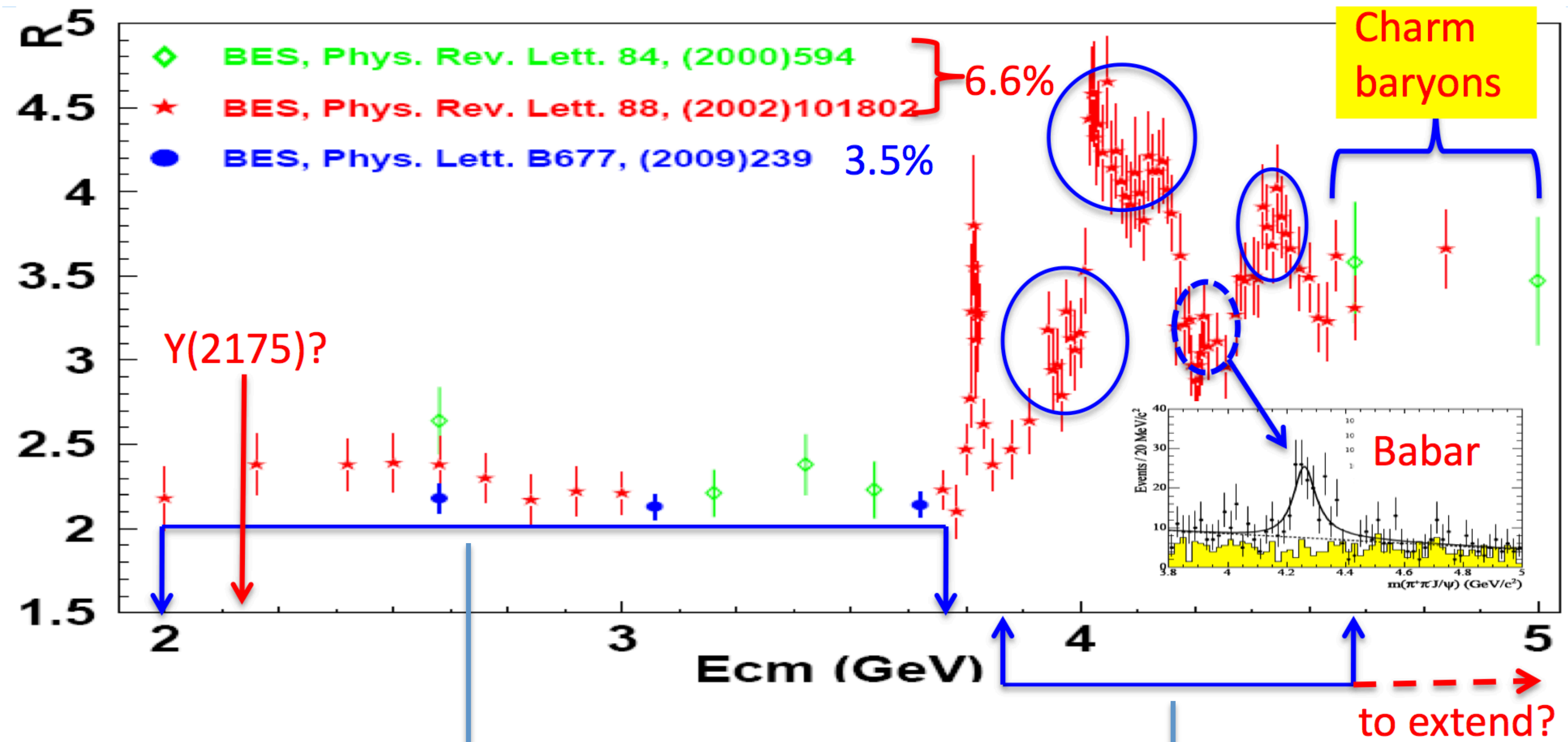








R-scan project BESIII



$0.5 fb^{-1}$ 19 energy points (on going)

$0.8 fb^{-1}$ 104 energy points

Measurement of R at BESIII

$$R = \frac{1}{\sigma_{\mu+\mu-}} \cdot \frac{N_{had} - N_{bg}}{L \cdot \varepsilon_{had} \cdot (1+\delta)}$$

Our goal:
< 3% precision

N_{had}: observed hadronic events — >100k events => ~0.3%

N_{bg}: background events

L: integrated luminosity — <1%

ε_{had}: detection efficiency for N_{had}

δ: radiative correction factor

BESII: 2~3% (attempt to improve)

$\sigma_{\mu\mu}$: **Cross section for ee to point-like muon pair**

Except for controlling each item to the precision requested, stable long term machine and detector performance is crucial.

Precision τ mass measurement

- Fundamental parameter in the Standard Model

test $$\frac{B(\tau \to e\nu\bar{\nu})}{\tau_\tau} = \frac{g_\tau^2 m_\tau^5}{192\pi^3}$$

- Test lepton universality $g_e = g_\mu = g_\tau$

$$\left(\frac{g_\tau}{g_\mu}\right)^2 = \frac{\tau_\mu}{\tau_\tau}\left(\frac{m_\mu}{m_\tau}\right)^5 \frac{B(\tau \to e\nu\bar{\nu})}{B(\mu \to e\nu\bar{\nu})}(1+F_W)(1+F_\gamma)$$

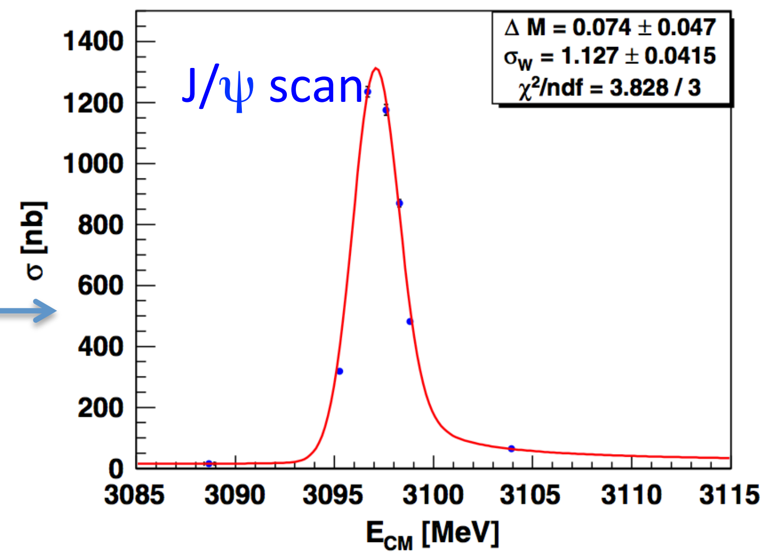
- BESIII: ττ threshold scan method

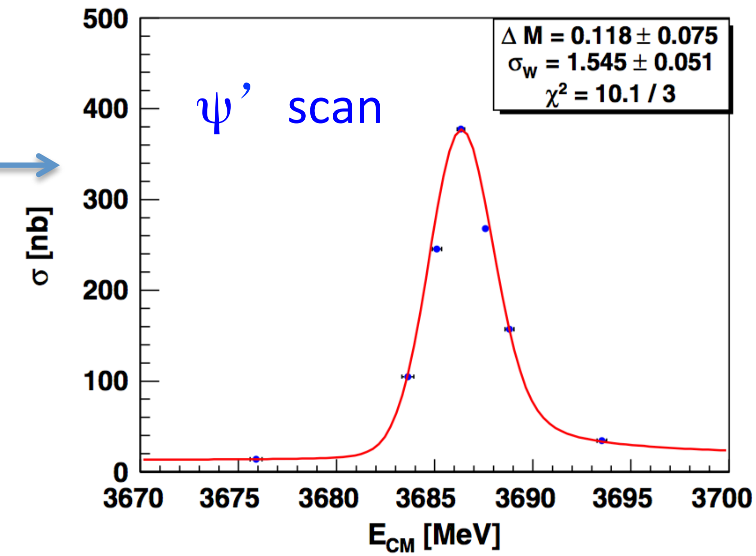
τ mass scan

Bhabha & two gamma events

Scan	$E_{c.m.}$ (MeV)	$\mathcal{L}$ (nb^{-1})
J/ψ	3088.7	78.5 ± 1.9
	3095.3	219.3 ± 3.1
	3096.7	243.1 ± 3.3
	3097.6	206.5 ± 3.1
	3098.3	223.5 ± 3.2
	3098.8	216.9 ± 3.1
	3103.9	317.3 ± 3.8
τ	3542.4	4252.1 ± 18.9
	3553.8	5566.7 ± 22.8
	3561.1	3889.2 ± 17.9
	3600.2	9553.0 ± 33.8
ψ'	3675.9	787.0 ± 7.2
	3683.7	823.1 ± 7.4
	3685.1	832.4 ± 7.5
	3686.3	1184.3 ± 9.1
	3687.6	1660.7 ± 11.0
	3688.8	767.7 ± 7.2
	3693.5	1470.8 ± 10.3

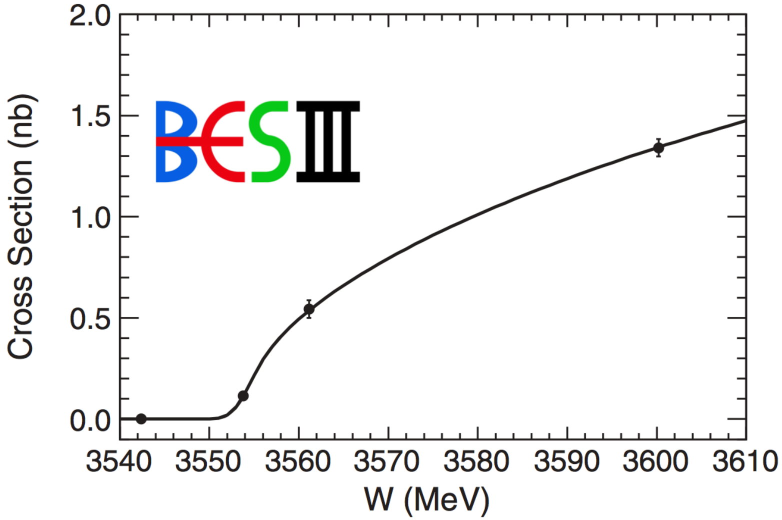
Beam Energy Measurement System (BEMS)

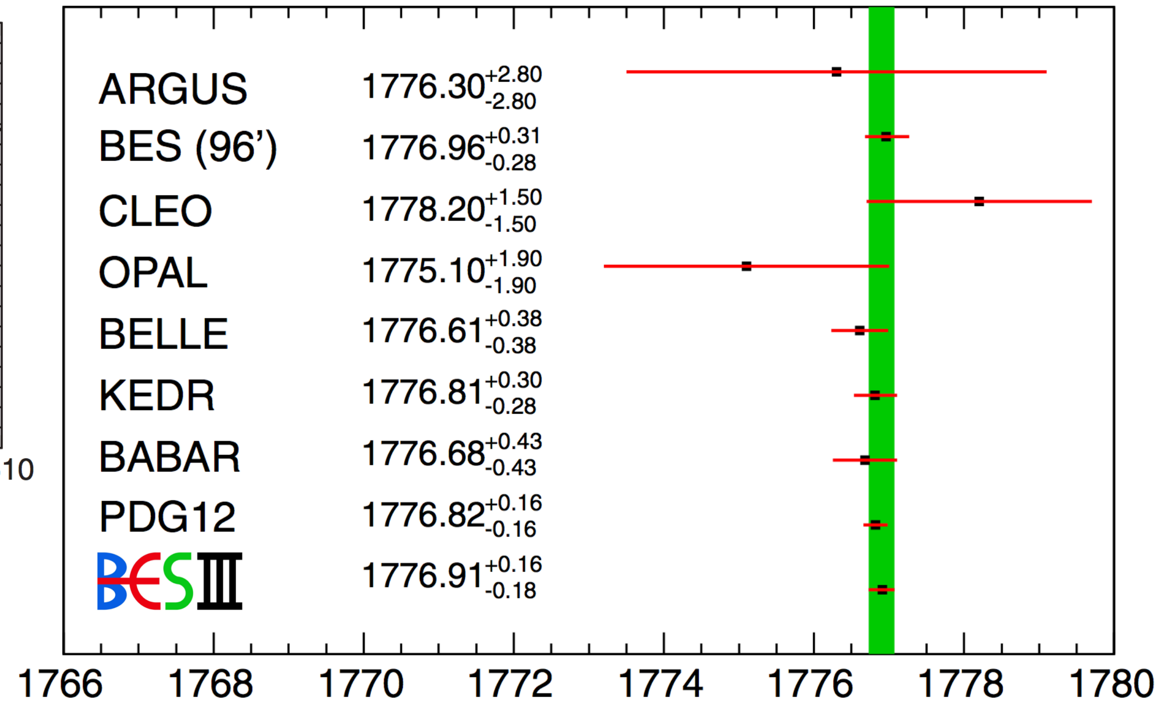




Mass calibration/energy spread

Result on the τ mass





- Maximum likelihood fit
- τ mass, BG, data/MC difference are floating in the fit
- Expected number of events: Theoretical cross section + radiative correction + vacuum polarization + energy spread + efficiency

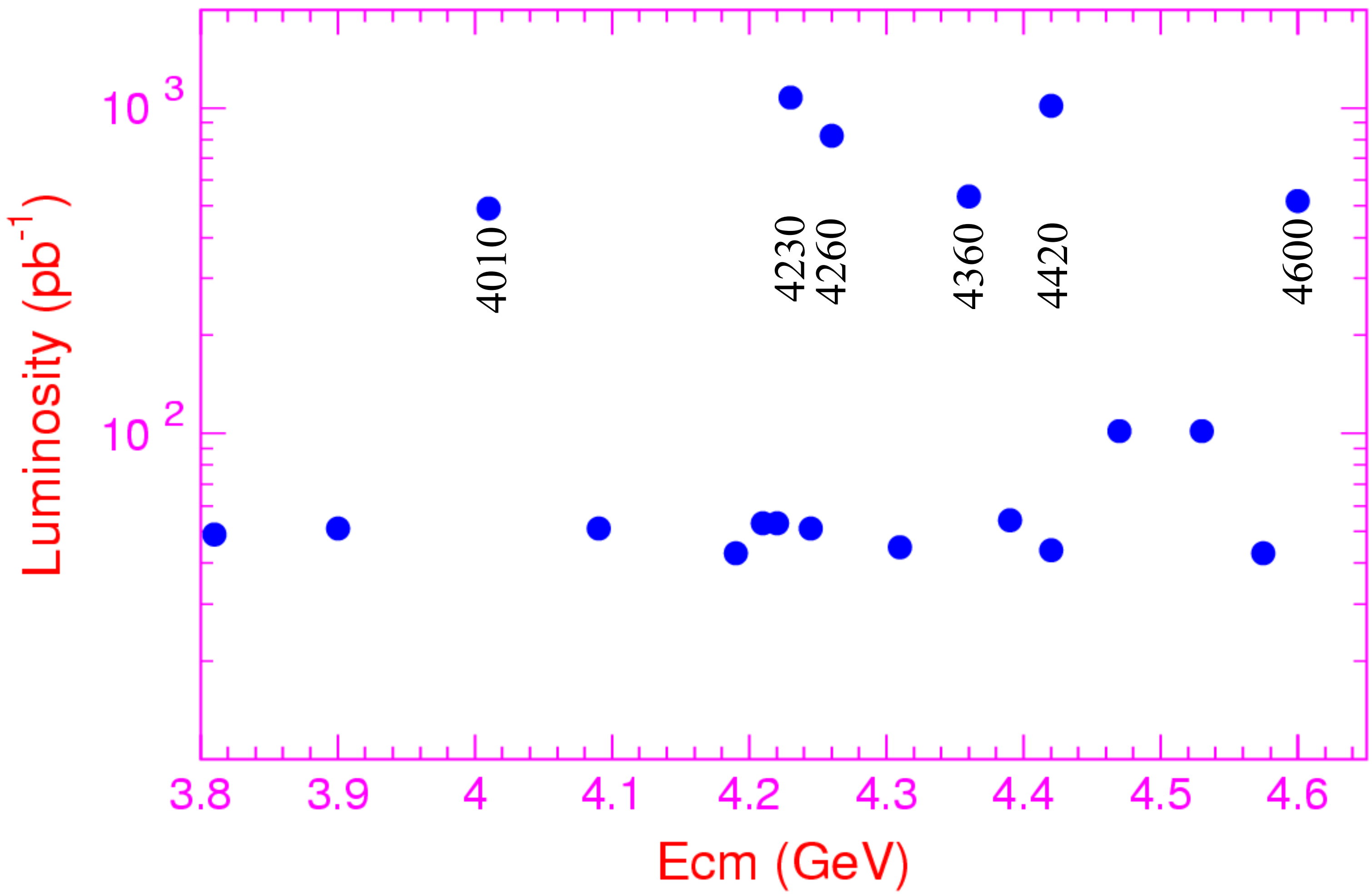
$$m_\tau = (1776.91 \pm 0.12^{+0.10}_{-0.13})\ \mathrm{MeV}/c^2$$

$$\left(\frac{g_\tau}{g_\mu}\right)^2 = 1.0016 \pm 0.0042$$

PRD 90, 012001

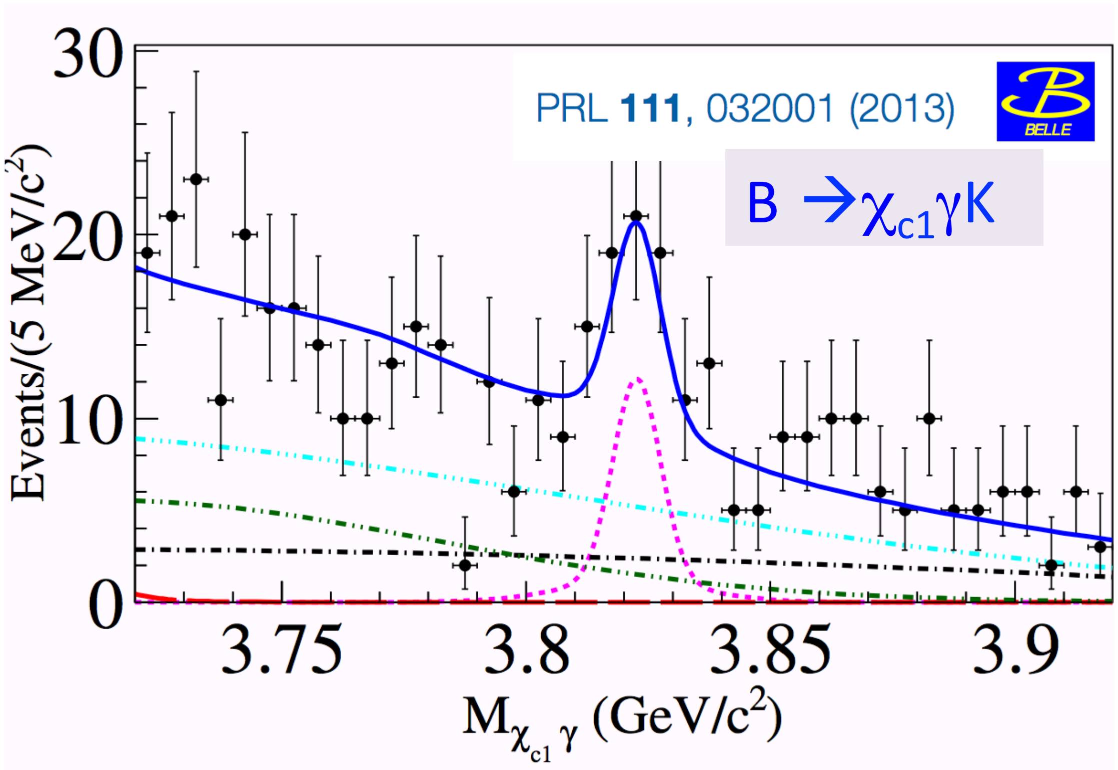
4~4.6GeV: XYZ studies

Up to now: total ~3.3 fb^{-1}



The X states

X(3823)

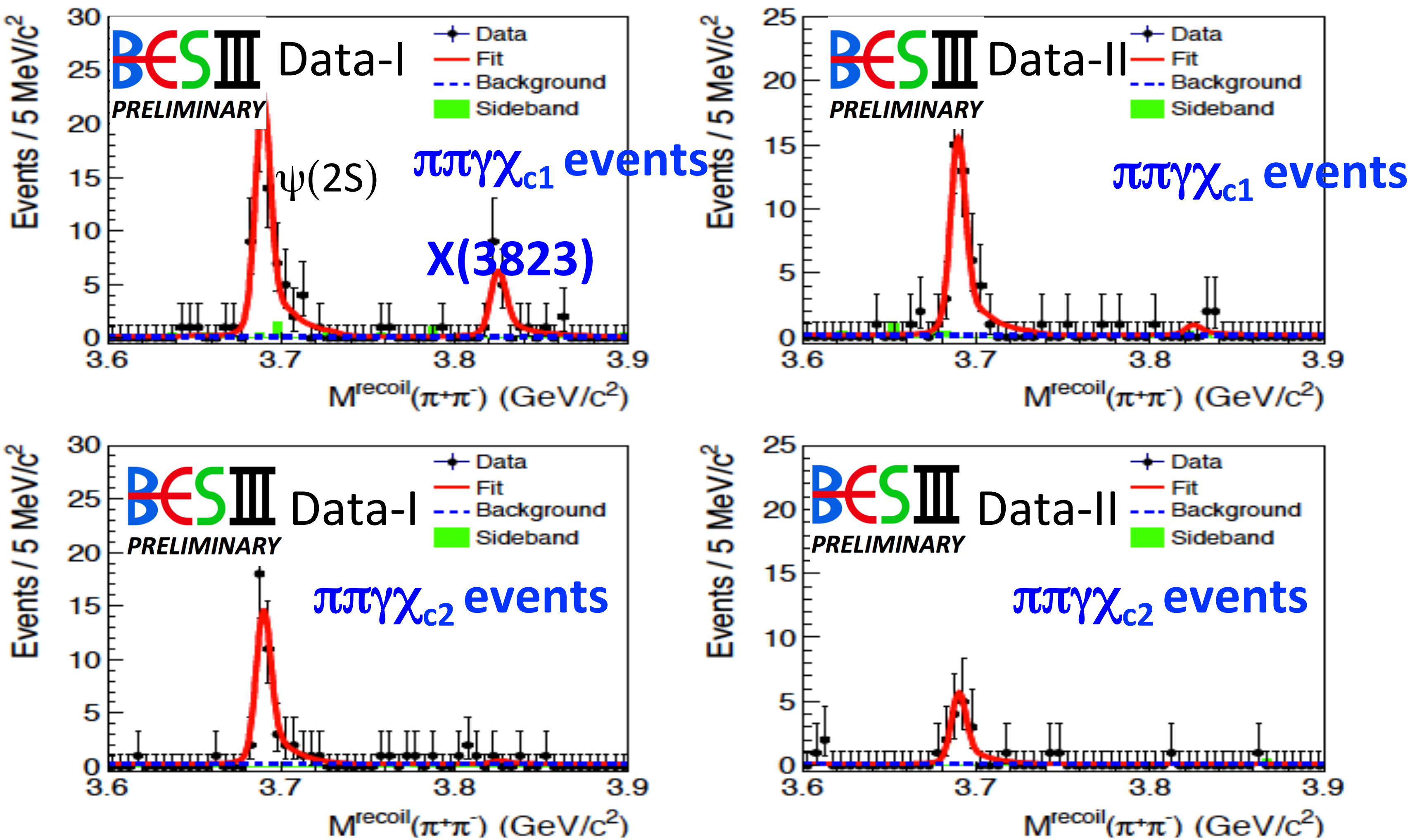


- Evidence at Belle (significance **3.8σ**)
- Process B→K($\chi_{c1}\gamma$) using 772×10^6 BB pairs
- M(X(3823))=3823.1±1.8±0.7MeV
- Consistent with the $\psi_2(1^3D_2)$ state

  Conventional charmonium state

BESIII may search for it!

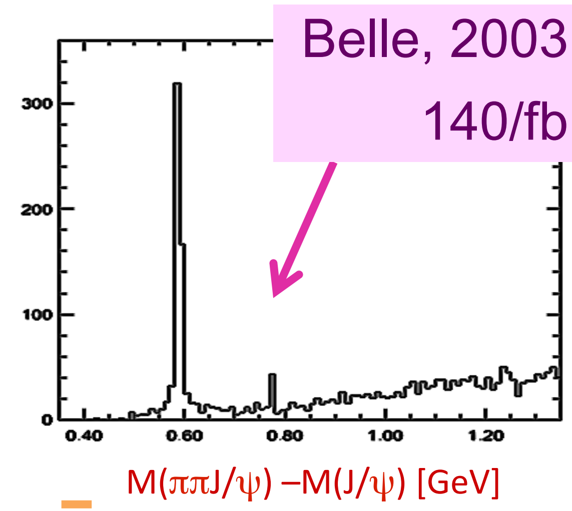
Observation of $e^+e^- \rightarrow \pi^+\pi^- X(3823)$, $X(3823) \rightarrow \chi_{c1}\gamma$



- Simultaneous fit: data-I (4.36, 4.42, 4.60 GeV) & data-II (4.23, 4.26 GeV)
- Signal: MC simulated shape + Background: linear
- M=3821.7±1.3±0.7 MeV; Significance: 6.7σ, observation !

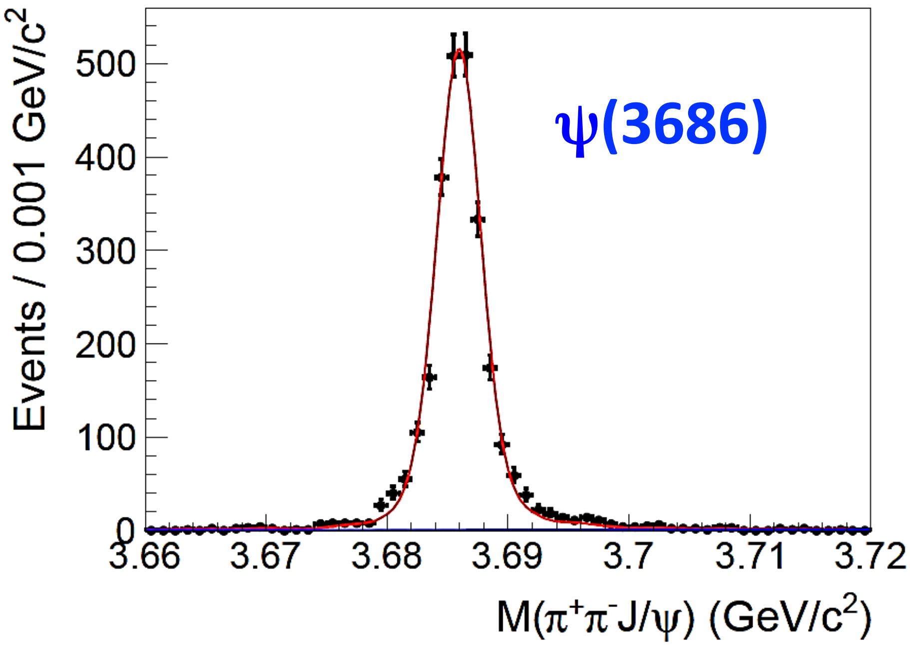
X(3872)

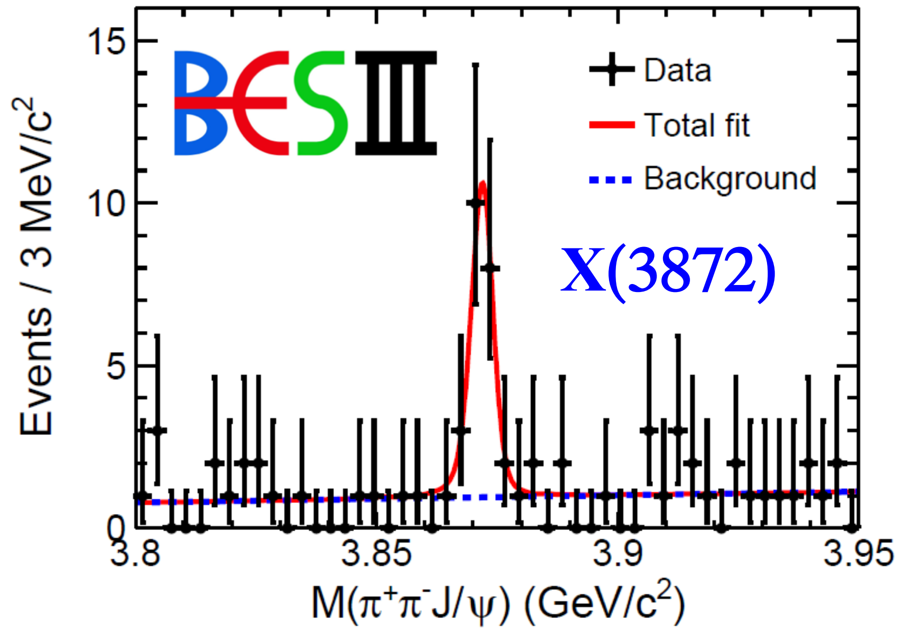
- Mass: Very close to $D^0\bar{D}^{*0}$ threshold
- Width: Very narrow, < 1.2 MeV
- $J^{PC}=1^{++}$
- Production
  - in $p\bar{p}$/pp collison – rate similar to charmonia
  - In B decays – KX similar to $c\bar{c}$, K*X smaller than $c\bar{c}$
  - Y(4260)→γ+X(3872)
- Decay BR: open charm ~ 50%, charmonium~O(%)
- Nature (very likely **exotic**)
  - Loosely $\bar{D}^0D^{*0}$ bound state (like deuteron?)?
  - Mixture of excited χ_{c1} and $\bar{D}^0D^{*0}$ bound state?
  - Many other possibilities (if it is not χ'_{c1}, where is χ'_{c1}?)



Observation of X(3872) at BESIII

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





ISR ψ' signal is used for mass, and resolution calibration.

N=1818; ΔM=0.34±0.04 MeV; $\Delta\sigma_M$=1.14 ±0.07 MeV

N(X(3872)) = 20.1±4.5 **6.3σ** PRL 112, 092001 (2014)

M(X(3872)) = 3871.9±0.7±0.2 MeV [PDG: 3871.68 ±0.17 MeV]

The Z_c states

Discovery of $Z_c(3900)^{\pm}$ via $ee \rightarrow \pi^+\pi^- J/\psi$@4.26GeV

BESIII: PRL 110, 252001 (2013)

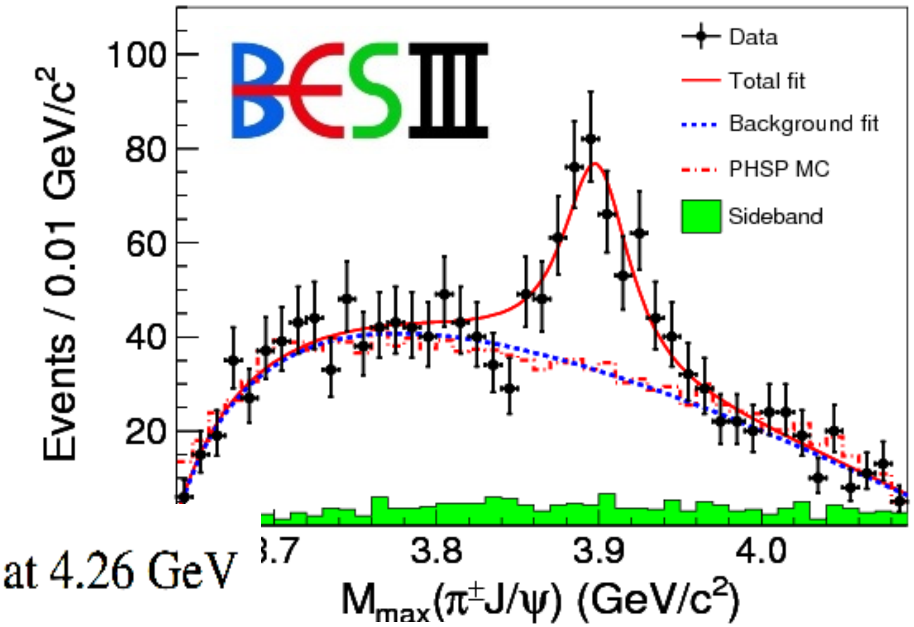
$Z_c(3900)^+$:

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

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

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

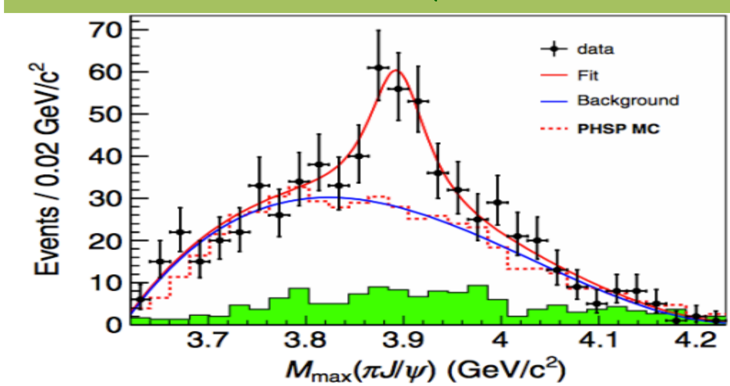
Decays to J/ψ → contains $c\bar{c}$
Electric charge → contains $u\bar{d}$



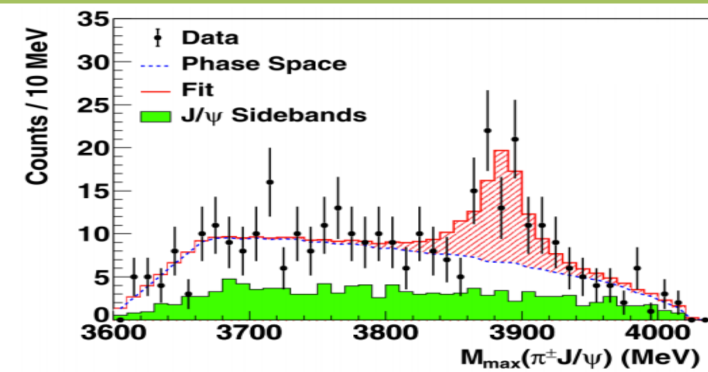
$$\sigma[e^+e^- \rightarrow \pi^+\pi^- J/\psi] = 62.9 \pm 1.9 \pm 3.7\ \mathrm{pb\ at\ 4.26\ GeV}$$

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

Belle with ISR data (PRL 110, 252002)

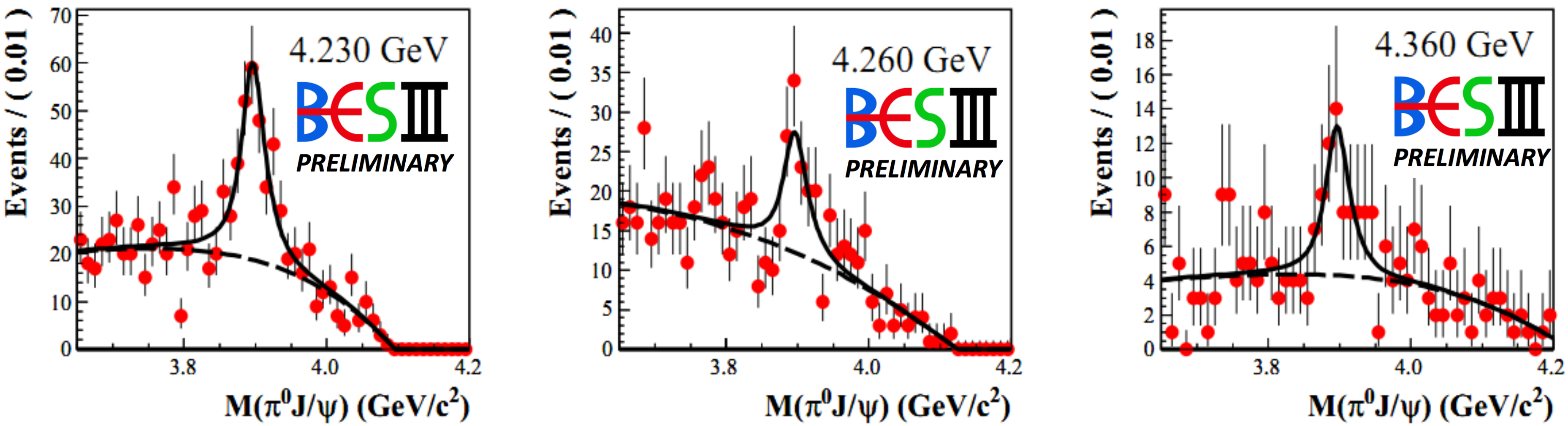


CLEOc data at 4.17 GeV (PLB 727, 366)

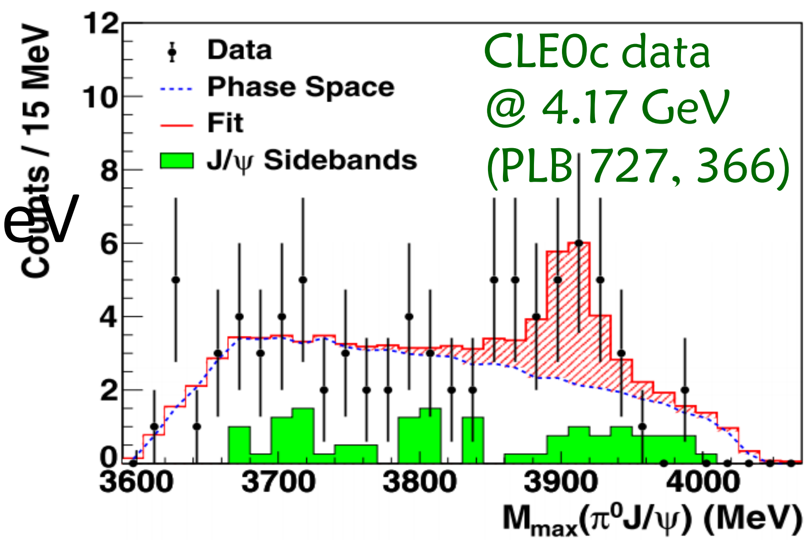


Neutral isospin partner $Z_c(3900)^0$

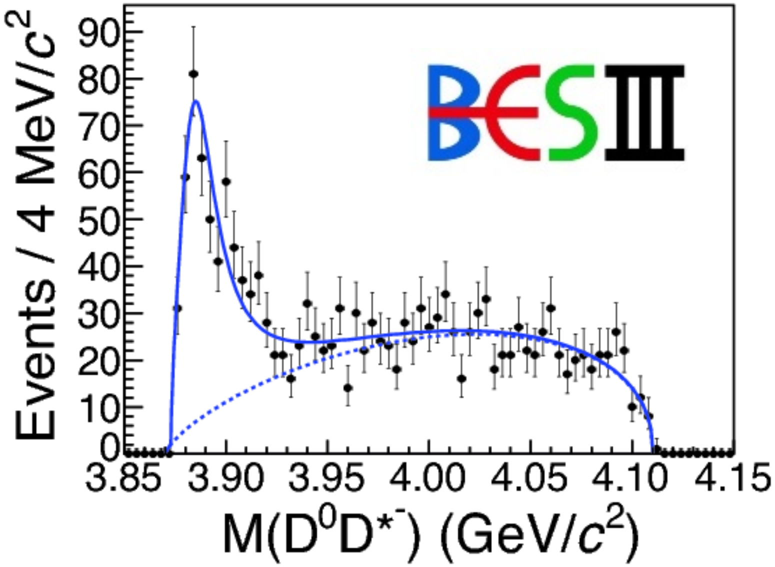
via $\pi^0\pi^0 J/\psi$

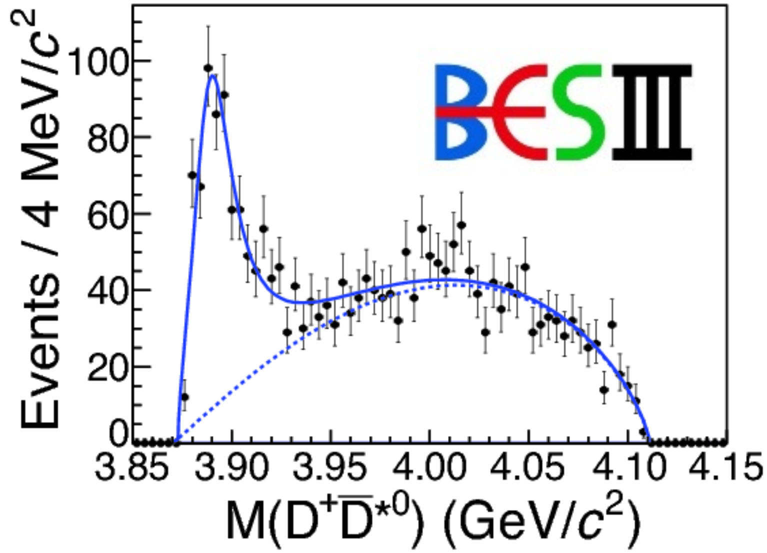


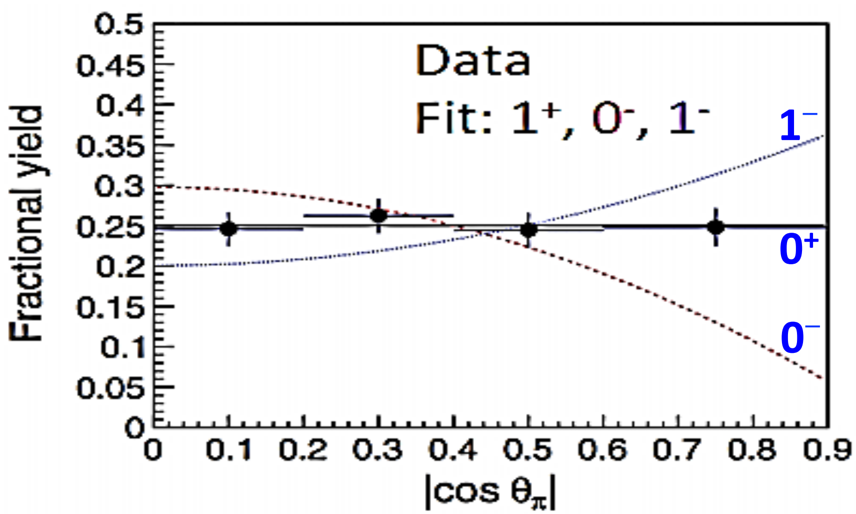
- 10.4σ significance
- $M(Z_c(3900)^0) = 3894.8 \pm 2.3 \pm 2.7$ MeV
- $\Gamma(Z_c(3900)^0) = 29.6 \pm 8.2 \pm 8.2$ MeV



$Z_c(3885)^{\pm}$ in $e^+e^- \rightarrow \pi^+(DD^*)^-$ by single D-tag





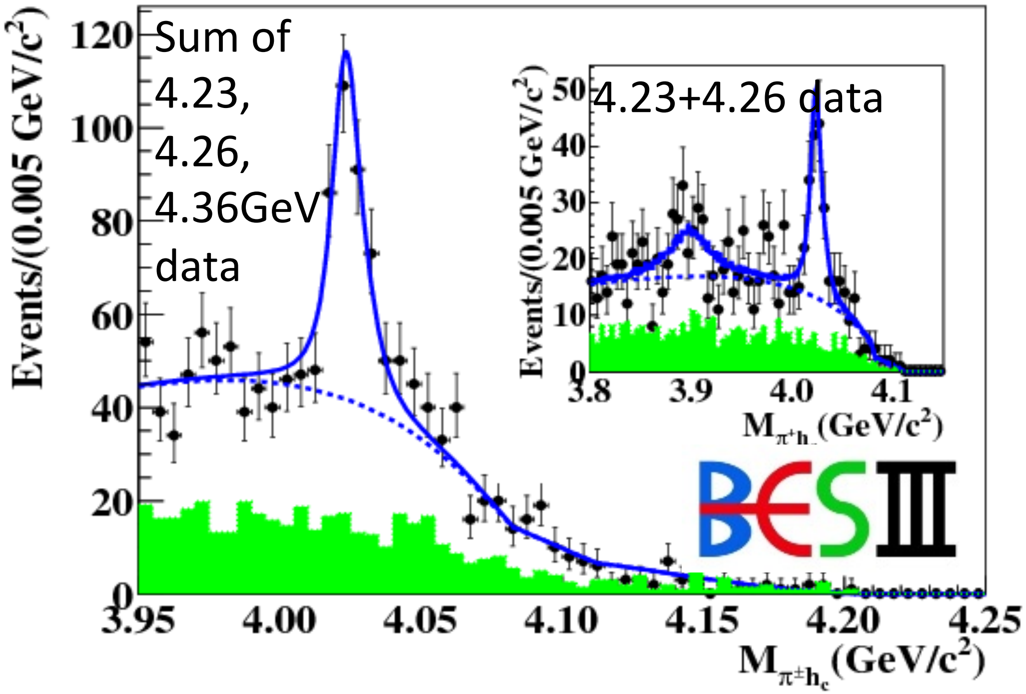


Fit to angular distribution favors $J^P = 1^+$ over 0^- and 1^-

525/pb data @4.26GeV
PRL 112, 022001(2014)

BW fit to the enhancement near DD* threshold in the two channels
=>
Mass = 3883.9±1.5±4.2 MeV
Width = 24.8±3.3 ±11.0 MeV

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



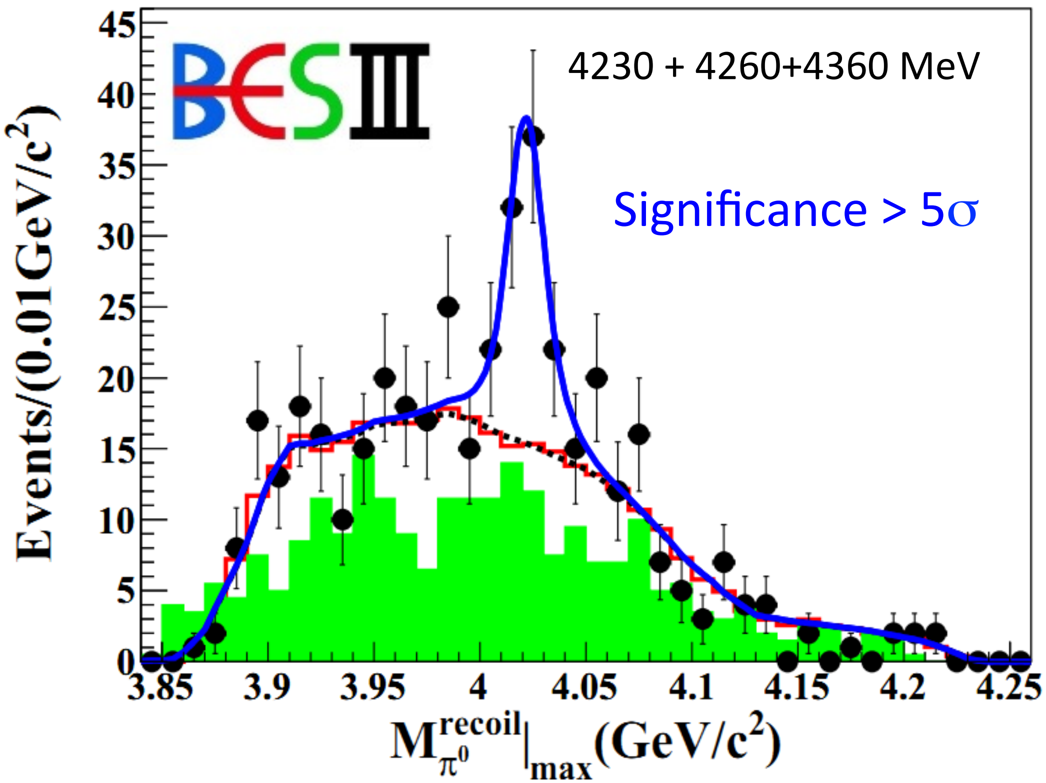
PRL 111, 242001(2013)

- Data sets 3.9~4.42GeV
- exclusive reconstruction of the final states:
  $e^+e^- \to \pi^+\pi^- h_c$
  $h_c \to \gamma\eta_c$
  $\eta_c \to$ 16 hadronic decay modes

- **Discovery of $Z_c(4020)^{\pm} \to \pi^{\pm} h_c$ near D*D* threshold**
- **Mass = 4022.9±0.8 ±2.7 MeV**
- **Width = 7.9±2.7 ±2.6 MeV**
- **No significant signal for $Z_c(3900)^{\pm} \to \pi^{\pm} h_c$**

Neutral isospin partner $Z_c(4020)^0$

via $e^+e^- \rightarrow \pi^0\pi^0 h_c$

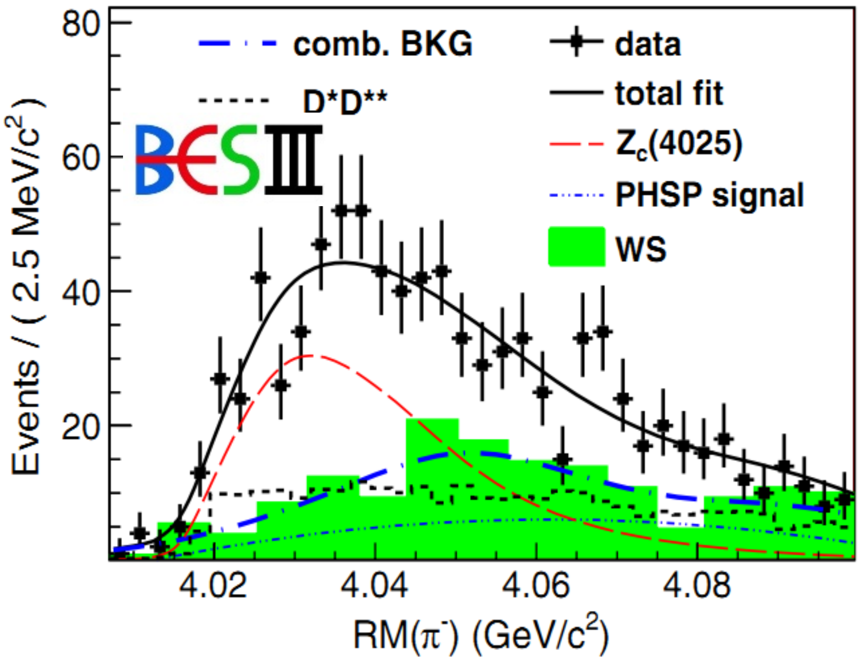


PRL113, 212002

Mass = 4023.9±2.2 ±3.8 MeV

Width is fixed to be same as its charged partner

$Z_c(4025)^{\pm}$ in e+e-→$\pi^+(D^*D^*)^-$ (or $\pi^-(D^*D^*)^+$)



PRL 112, 132001 (2014)

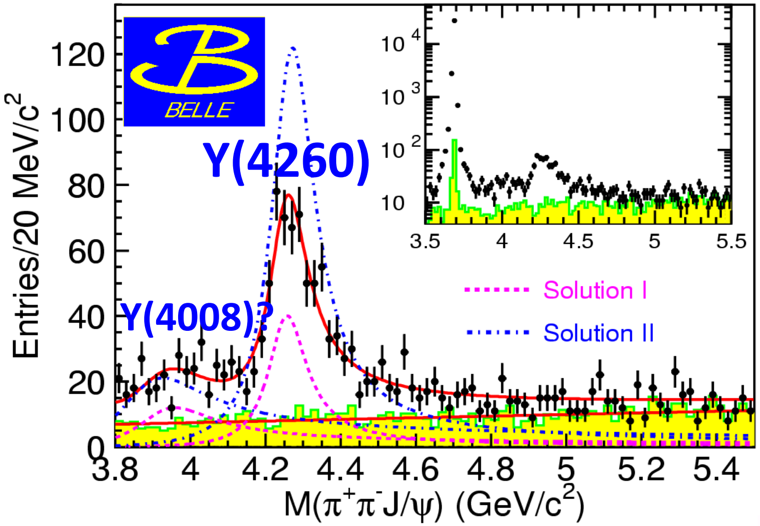
- Data set: 4.26GeV
- Tag a D^+ and a bachelor π^-, reconstruct one π^0 to suppress the background.
- A structure, named as Zc(4025), can be observed in the recoil mass of the bachelor π^-
- $M(Z_c(4025)) = 4026.3\pm2.6\pm3.7$ MeV
  $\Gamma(Z_c(4025)) = 24.8\pm5.6\pm7.7$ MeV

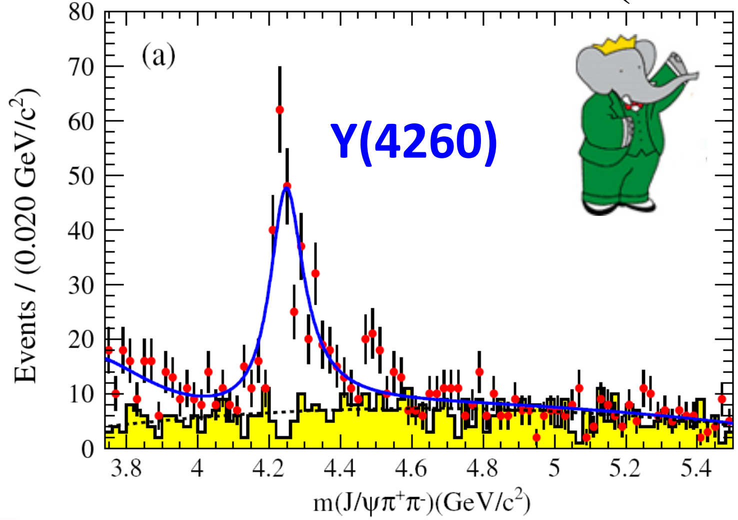
$$\sigma[e^+e^- \to (D^*\bar{D}^*)^{\pm}\pi^{\mp}] = 137 \pm 9 \pm 15 \text{ pb at } 4.26 \text{ GeV}$$

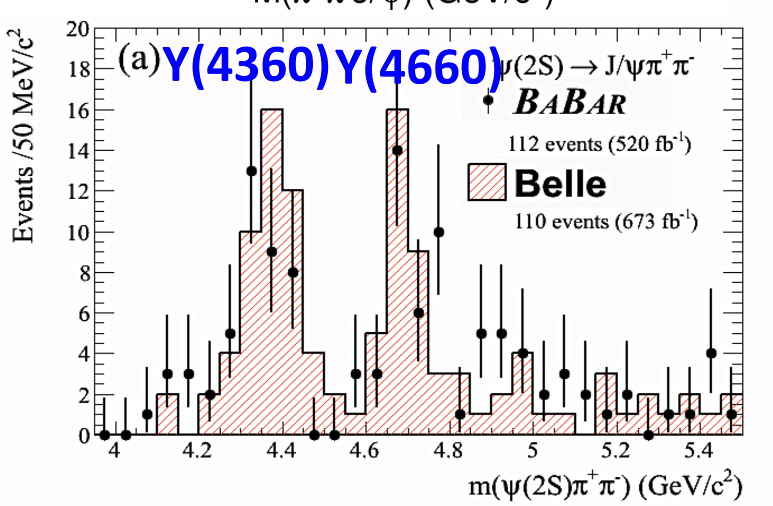
$$\frac{\sigma[e^+e^- \to \pi^{\pm} Z_c(4025)^{\mp} \to (D^*\bar{D}^*)^{\pm}\pi^{\mp}]}{\sigma[e^+e^- \to (D^*\bar{D}^*)^{\pm}\pi^{\mp}]} = 0.65 \pm 0.09 \pm 0.06 \text{ at } 4.26 \text{ GeV}$$

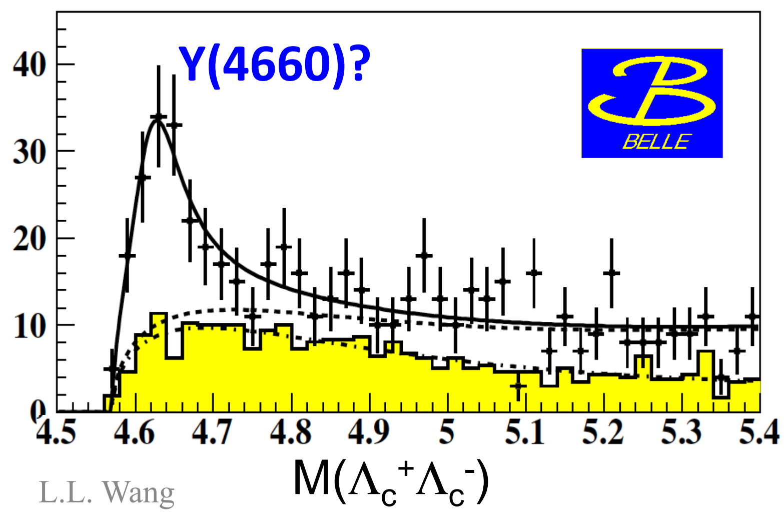
The Y states (vectors)

- Can be directly produced in e+e- annihilation
- Can not be seen from the inclusive hadronic cross section (R-scan)



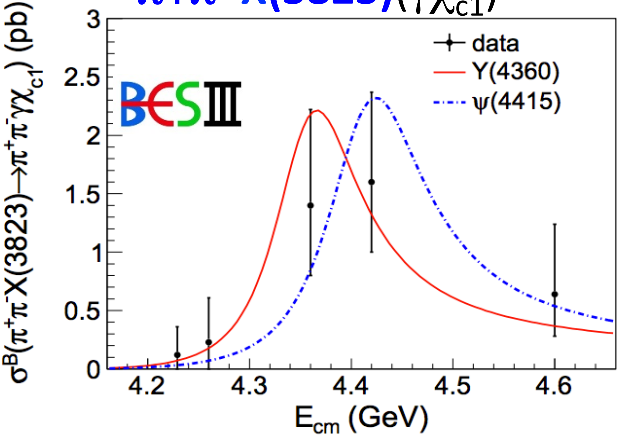




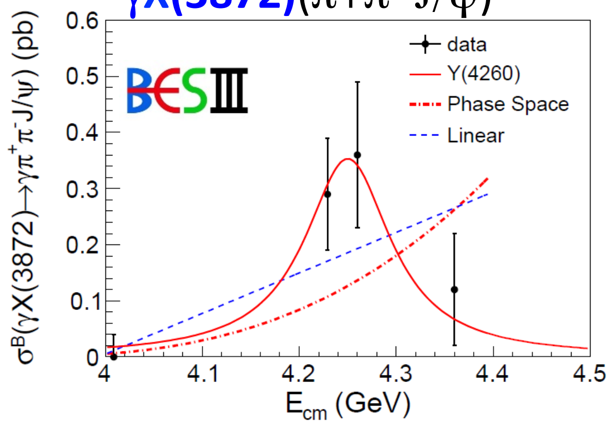


Study of Y states @ BESIII?

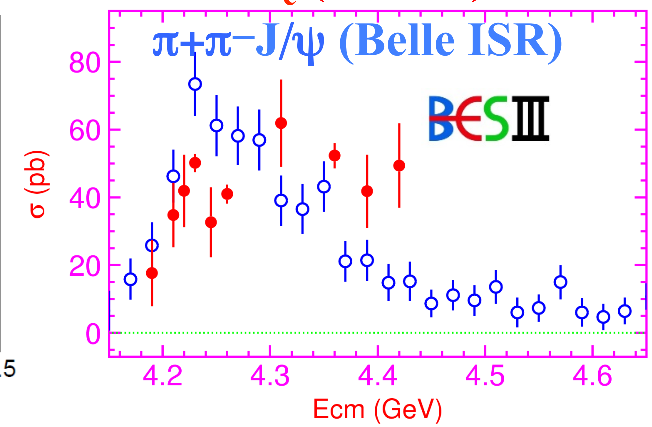
$\pi^+\pi^- X(3823)(\gamma\chi_{c1})$



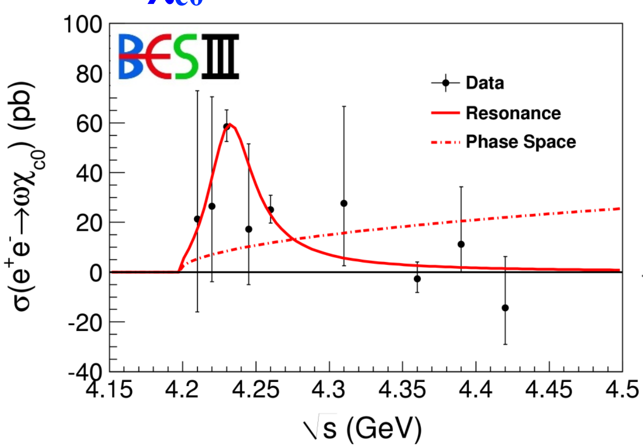
$\gamma X(3872)(\pi^+\pi^- J/\psi)$



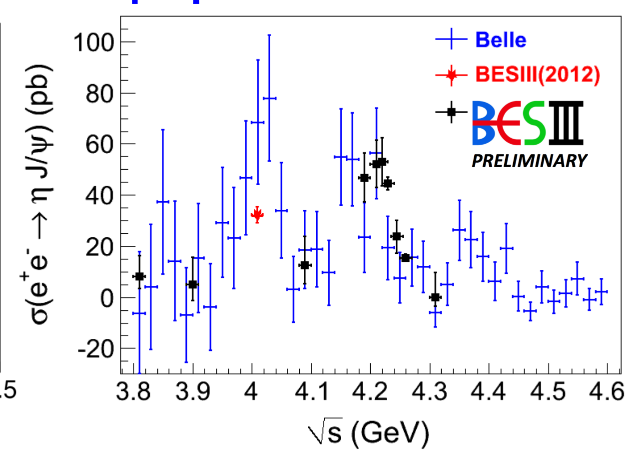
$\pi^+\pi^- h_c$ (BESIII)



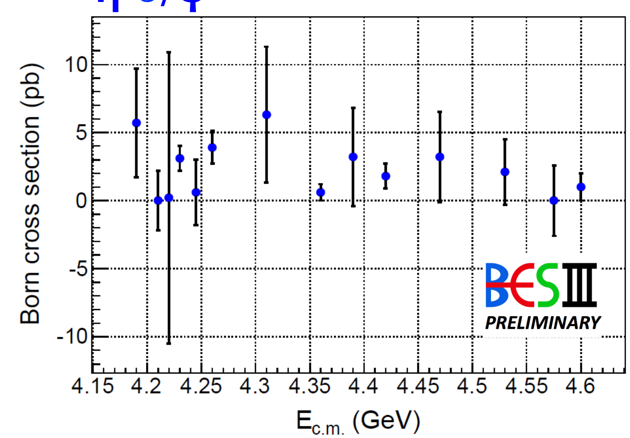
$\omega\chi_{c0}$



$\eta J/\psi$



$\eta' J/\psi$



Connection between XYZ?…… Open charm cross sections? **Need: fine scan, high luminosity!**

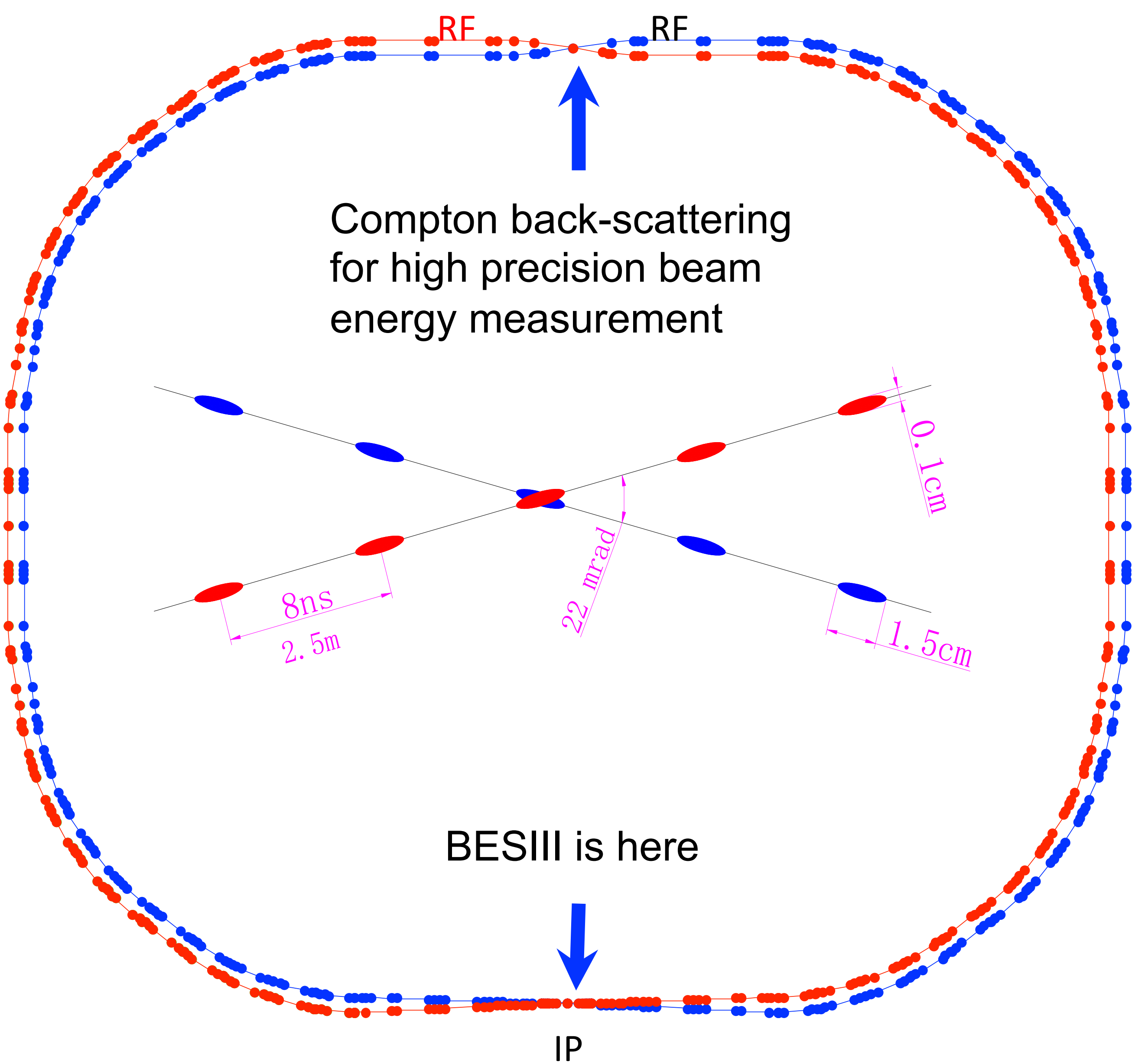
Summary

- BESIII and Hadronic Vacuum Polarization
  ISR to access energy <2GeV, e.g. $e^+e^- \to \pi^+\pi^-$
  direct R-scan: 2~5GeV
  impact on a_μ and $\alpha_{QED}(M_Z)$ evaluation
- τ mass scan
  fundamental parameter in SM, lepton universality
- XYZ data between 4 and 4.6GeV
  X(3823), X(3872), Z_c(3900), Z_c(4020) and Y states
- Other nice results (not covered by this talk)
  light hadrons, conventional charmoia transition/decay, charm …
- More exciting results expected at BESIII!

Merci! 谢谢！

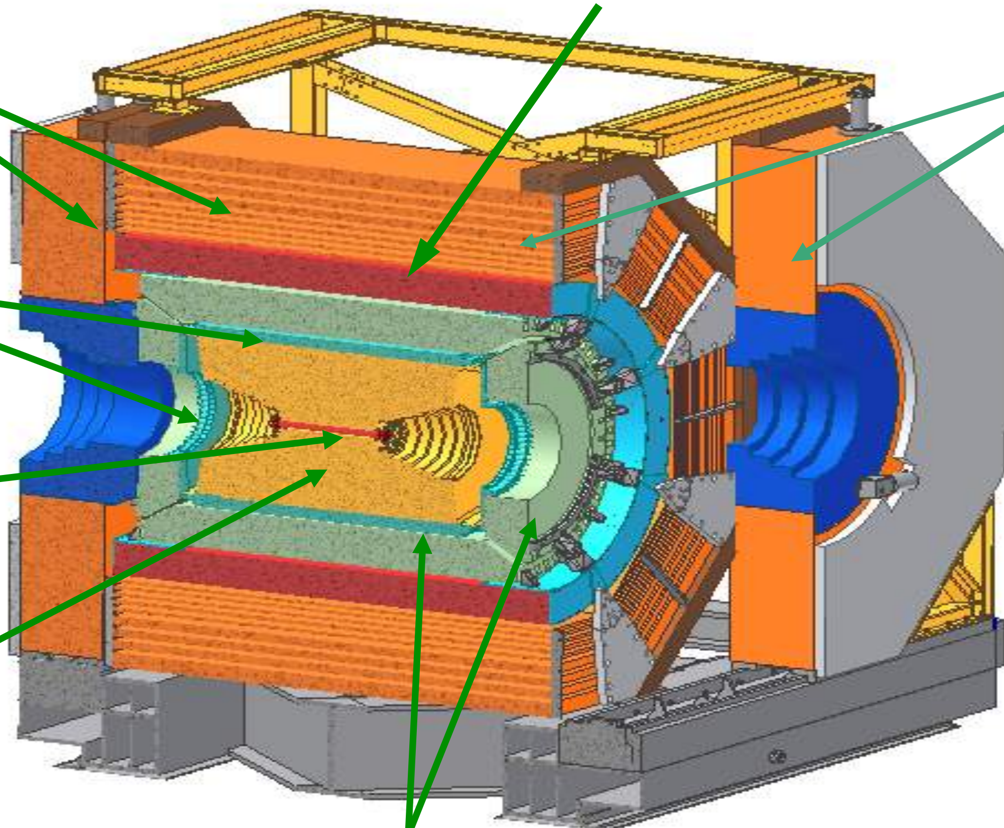
backups

BEPC II: a double-ring machine



Beam energy:
1-2.3 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

The BESIII Detector



Magnet yoke

SC magnet, 1T

RPC

TOF, 90ps

Be beam pipe

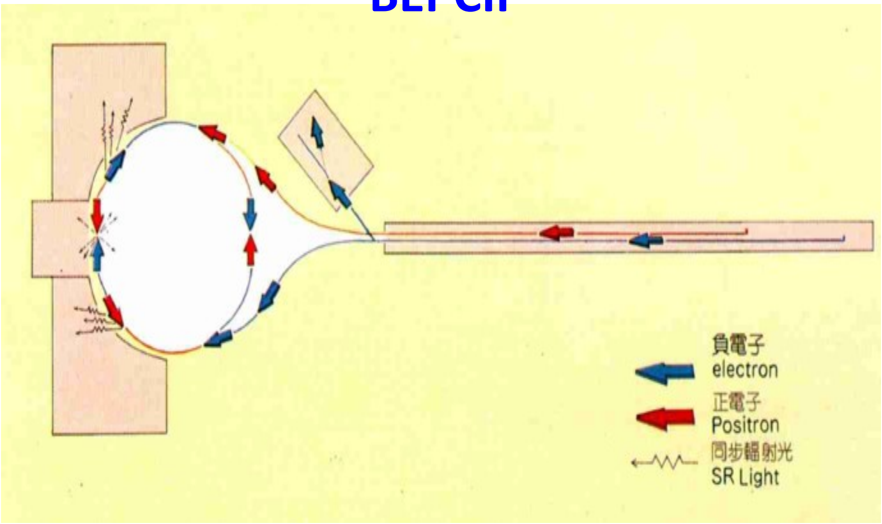
MDC, 120 μm

CsI(Tl) calorimeter, 2.5 %@ 1 GeV

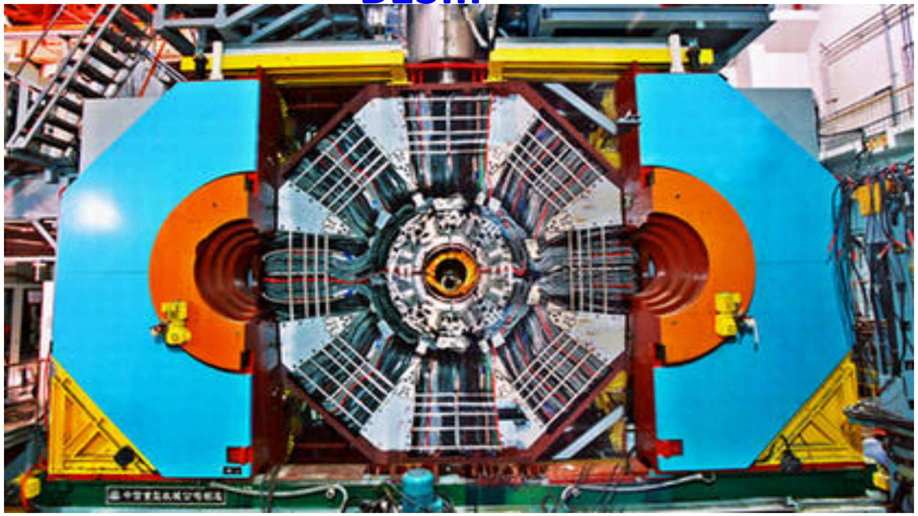
A total weight of 730t, ~40,000 readout channels, data rate 6,000Hz ~50Mb/s

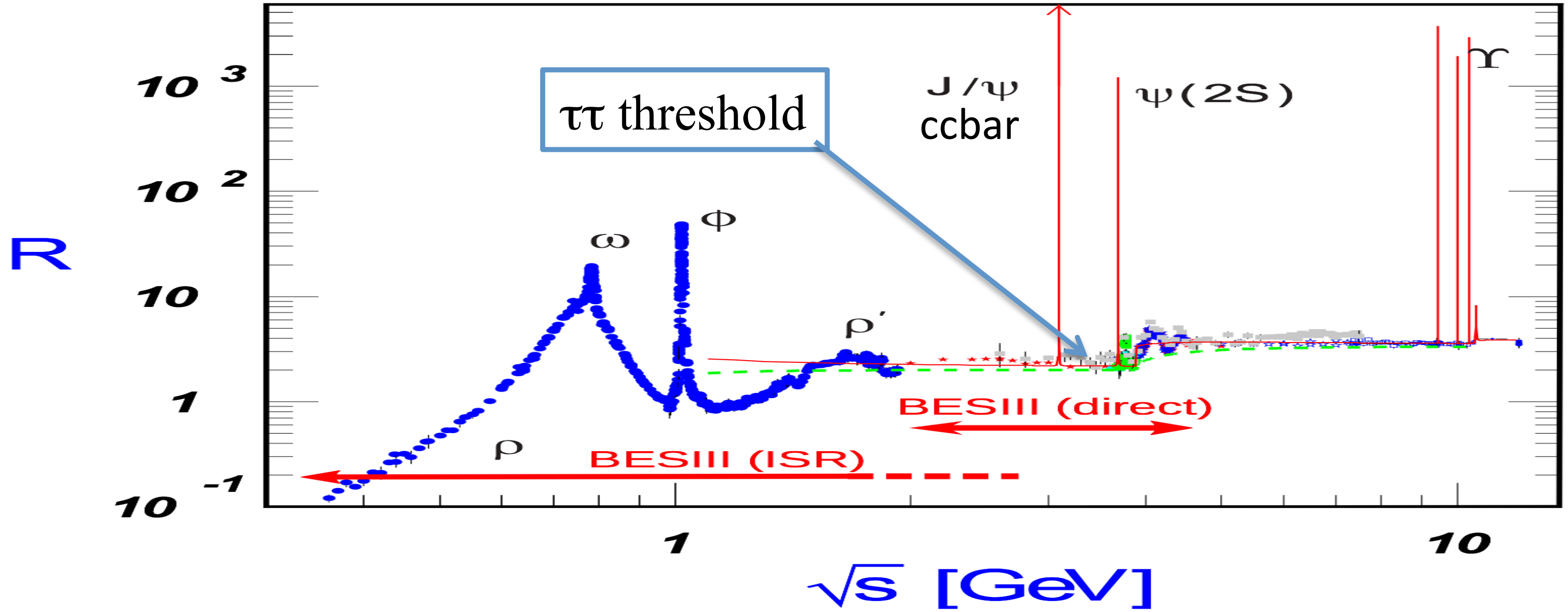
BESIII: a τ-charm factory

BEPCII

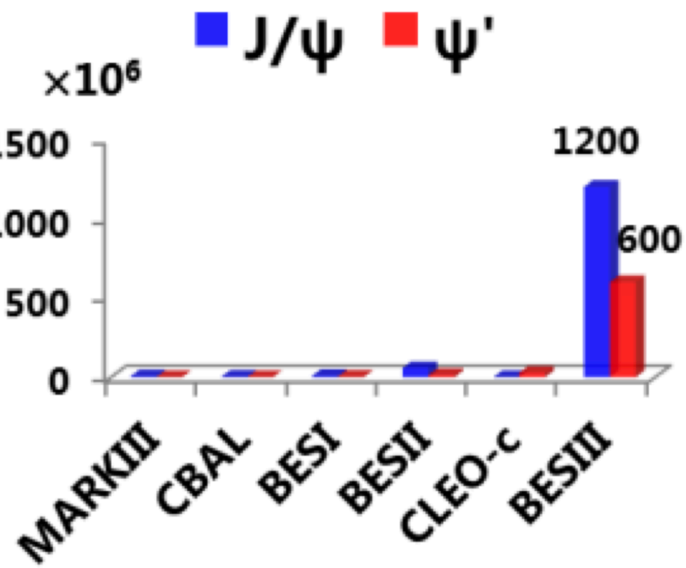


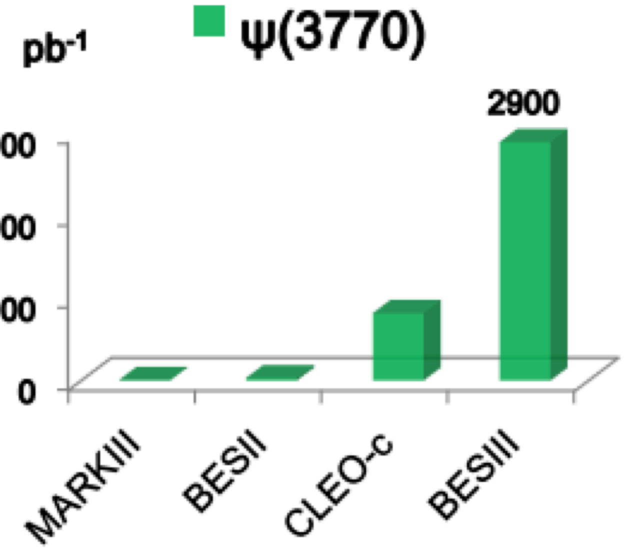
BESIII

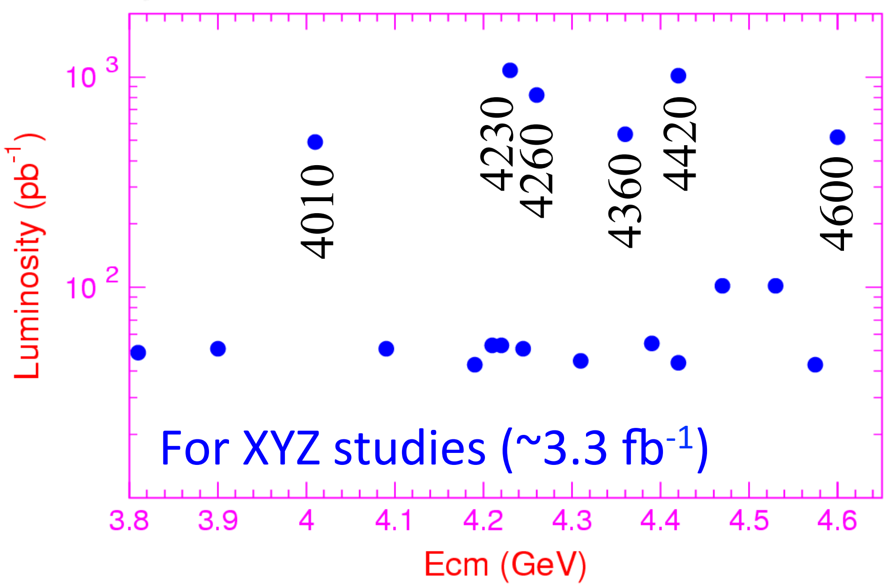




Current data sets @ BESIII







- τ mass scan: ~5pb^{-1} near ττ threshold
- R-scan:
  ~0.8fb^{-1} 104 energy points 3.85-4.59GeV
  on going:
  ~0.5fb^{-1} 19 energy points 2-3GeV

BESIII Collaboration

US (5)

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

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

Korea (1)

Seoul Nat. Univ.

Japan (1)

Tokyo Univ.

Pakistan (2)

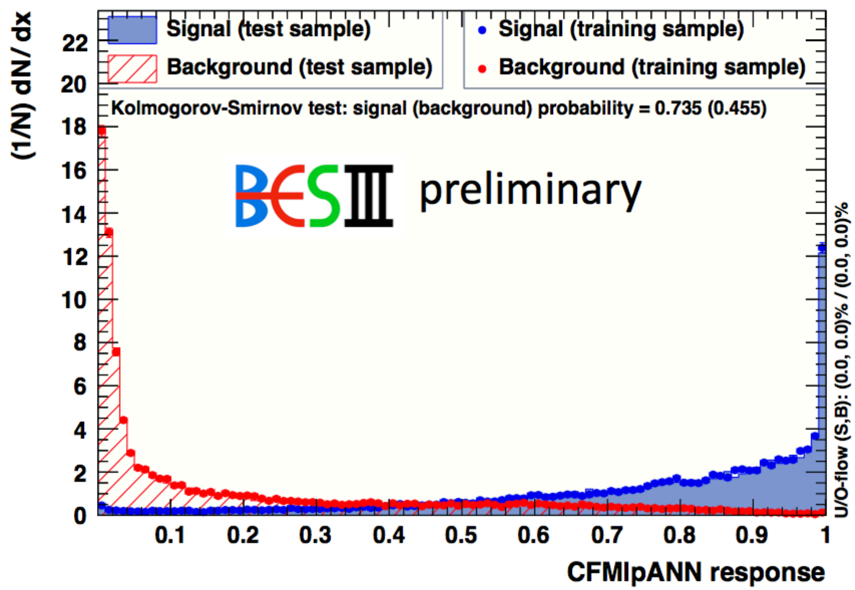
Univ. of Punjab
COMSAT CIIT

China(31)

IHEP, CCAST, GUCAS, Shandong Univ.,
Univ. of Sci. and Tech. of China
Zhejiang Univ., Huangshan Coll.
Huazhong Normal Univ., Wuhan Univ.
Zhengzhou Univ., Henan Normal Univ.
Peking Univ., Tsinghua Univ. ,
Zhongshan Univ.,Nankai Univ.
Shanxi Univ., Sichuan Univ., Univ. of South China
Hunan Univ., Liaoning Univ.
Nanjing Univ., Nanjing Normal Univ.
Guangxi Normal Univ., Guangxi Univ.
Suzhou Univ., Hangzhou Normal Univ.
Lanzhou Univ., Henan Sci. and Tech. Univ.
Beihang Univ., Beijing Petrol Chemical Univ.

~400 members
53 institutions from 11 countries

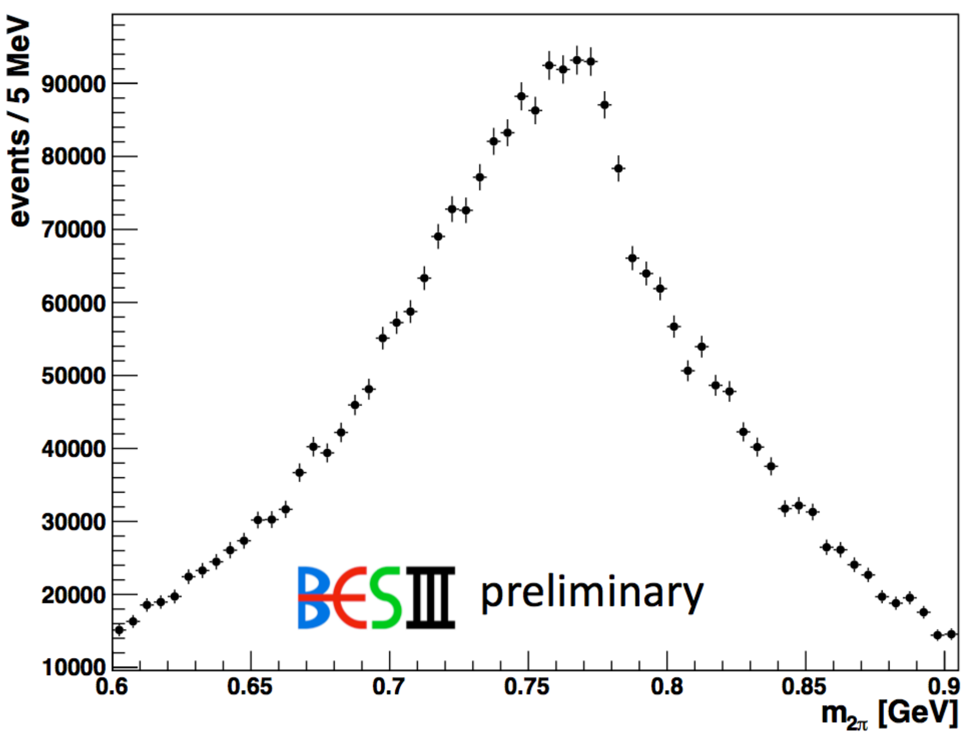
$e^+e^- \rightarrow \pi^+\pi^-\gamma_{ISR}$: π - μ Separation



TMVA method (Neural Network):

- trained using μμγ and ππππγ MC events
- information based on track level
- efficiency matrix (p,Θ) for data, MC
- correct for data - MC differ. on track level
- cross check for different TMVA methods

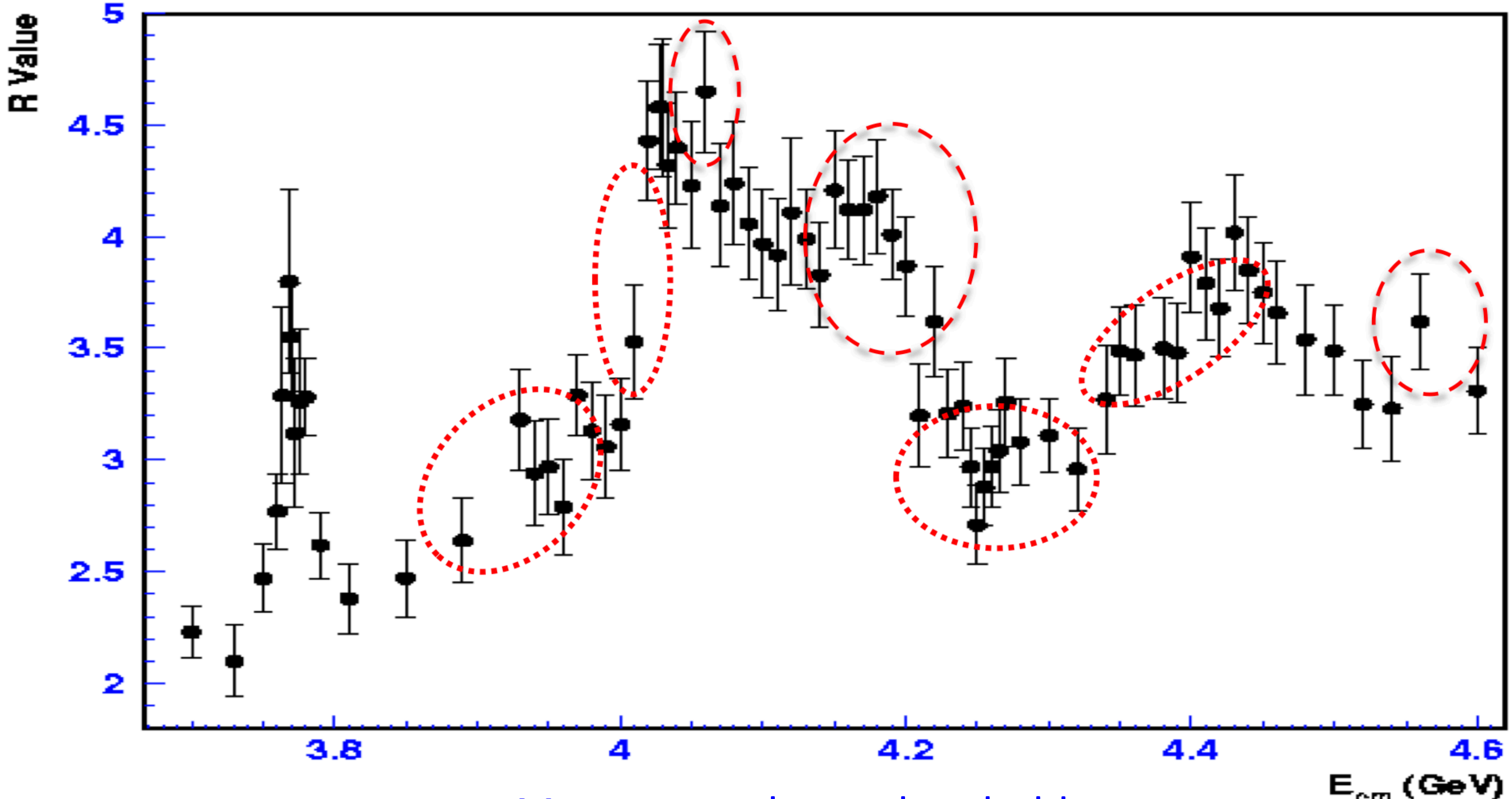
Event yield ππγ after π-μ separation



Beyond R measurement

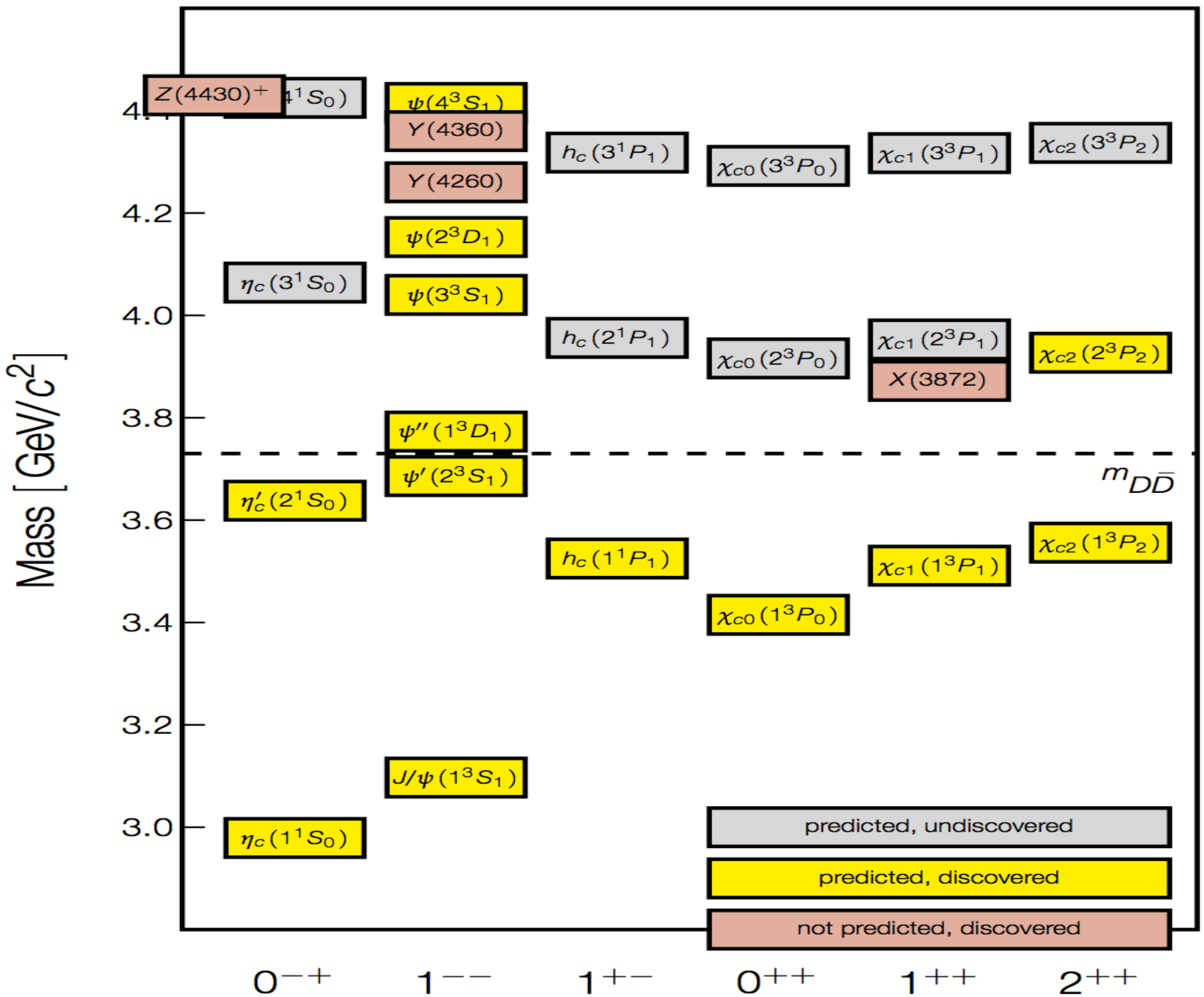
- Nucleon form factors: 9-15% accuracy. For proton $|G_E/G_M|$, top BaBar results
- Suspicious structures in the *pp* invariant mass
- Hyperon form factor studies
- Studies of threshold effects (Λ, S, Ξ)
- Determination of α_s and charm quark mass
- Quark fragmentation functions
- ......

4~4.6GeV: XYZ studies



Many open charm thresholds

4~4.6GeV: XYZ studies



X(3823) as the $\psi(1^3D_2)$

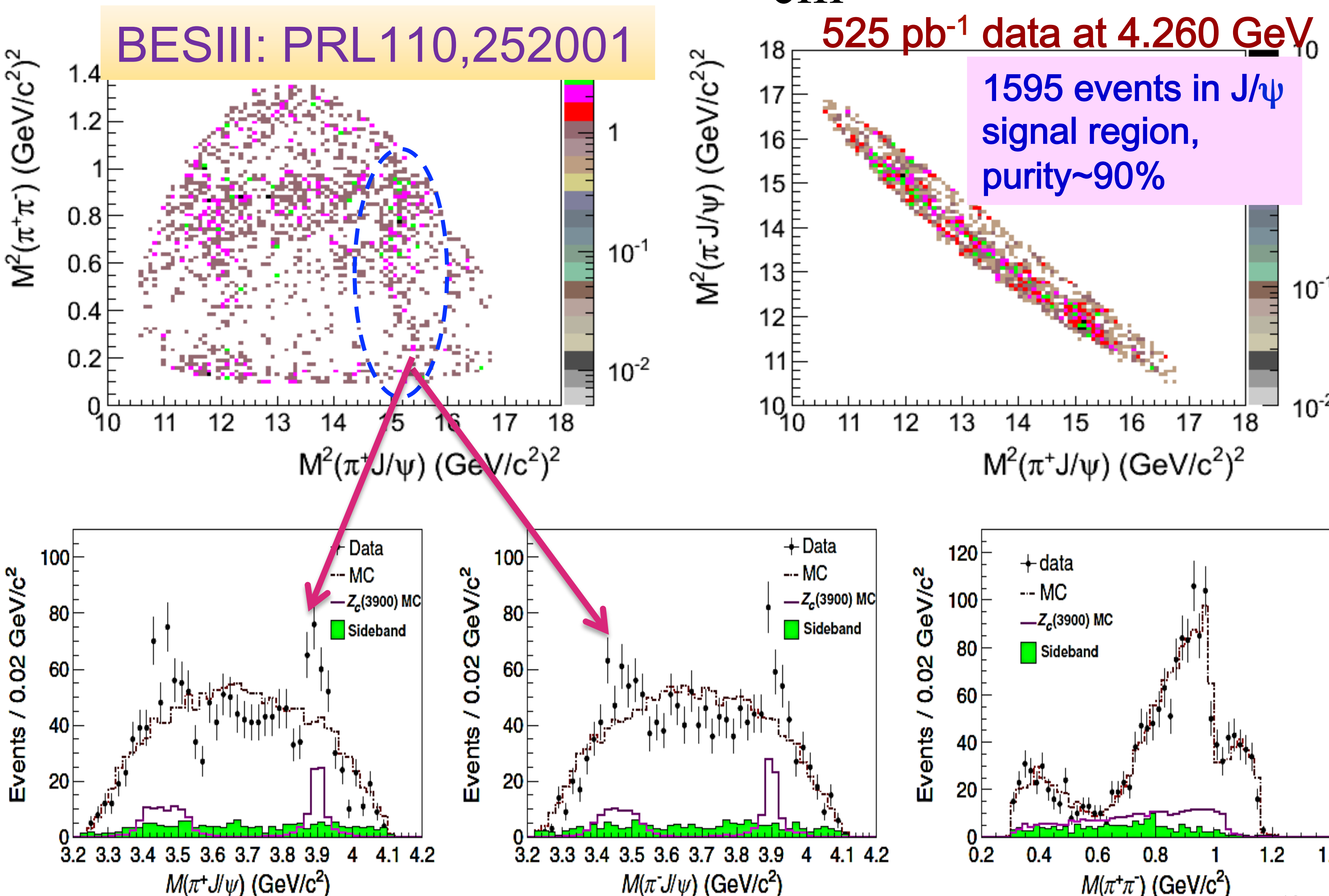
- Mass: D-wave ~3.810-3.840 GeV by potential model.
- X(3823) mass agree with $\psi(1^3D_2)$ prediction.

- Width: narrow
- X(3823) should be narrow (<16 MeV @ 90% C.L.).

- Production ratio:
- $R=B[X(3823)\rightarrow\gamma\chi_{c2}]/B[X(3823)\rightarrow\gamma\chi_{c1}]<0.43$ @ 90% C.L.
- Agree with prediction R~0.2.

- Exclusions: $1^1D_2\rightarrow\gamma\chi_{c1}$ forbidden; $1^3D_3\rightarrow\gamma\chi_{c1}$ amplitude=0.

$e^+e^- \to \pi^+\pi^- J/\psi$ at E_{cm}=4.26 GeV



Comparison between $Z_c(3885)^{\pm}$ and $Z_c(3900)^{\pm}$

Single D tag results, PRL 112, 022001(2014)

	$Z_c(3885) \to D\bar{D}^*$	$Z_c(3900) \to \pi J/\psi$
Mass (MeV/c^2)	$3883.9 \pm 1.5 \pm 4.2$	$3899.0 \pm 3.6 \pm 4.9$
Γ (MeV)	$24.8 \pm 3.3 \pm 11.0$	$46 \pm 10 \pm 20$
$\sigma \times \mathcal{B}$ (pb)	$83.5 \pm 6.6 \pm 22.0$	$13.5 \pm 2.1 \pm 4.8$

- The mass and width are consistent within **2σ!**
- If this is $Z_c(3900)^+$, open charm decays are suppressed, since

$$\frac{\mathcal{B}(Z_c \to D^* \bar{D})}{\mathcal{B}(Z_c \to J/\psi\,\pi)} = 6.2 \pm 1.1 \pm 2.7$$

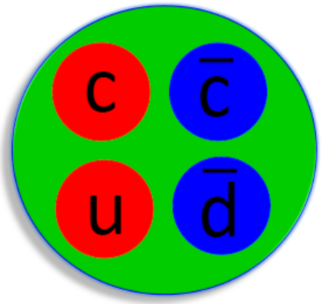
Compared to e.g.

$$\frac{\mathcal{B}(\psi(4040) \to D^{(*)}\bar{D}^{(*)})}{\mathcal{B}(\psi(4040) \to J/\psi\,\eta)} = 192 \pm 27$$

⇒ Different dynamics in Y(4260)-Zc(3900) system!

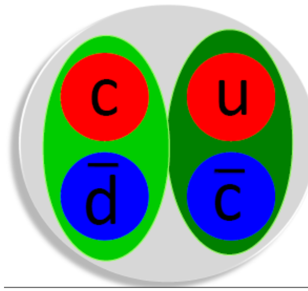
What's the nature of these Z_c states?

- At least 4 quarks, not a conventional meson
- Tetraquark state? →



Phys. Rev. D87,125018(2013); Phys. Rev. D88, 074506(2013);
Phys. Rev. D89,054019(2014); Phys. Rev. D90,054009(2014); etc

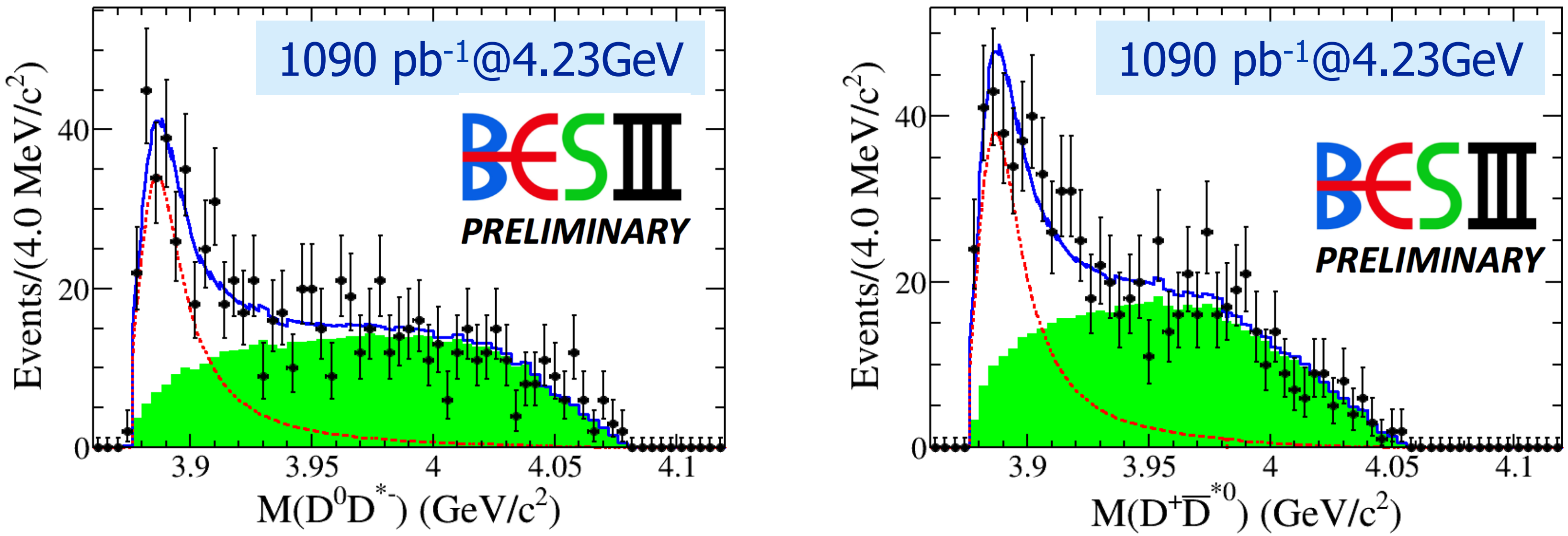
- $D^{(*)}D^{(*)}$ molecule state? →



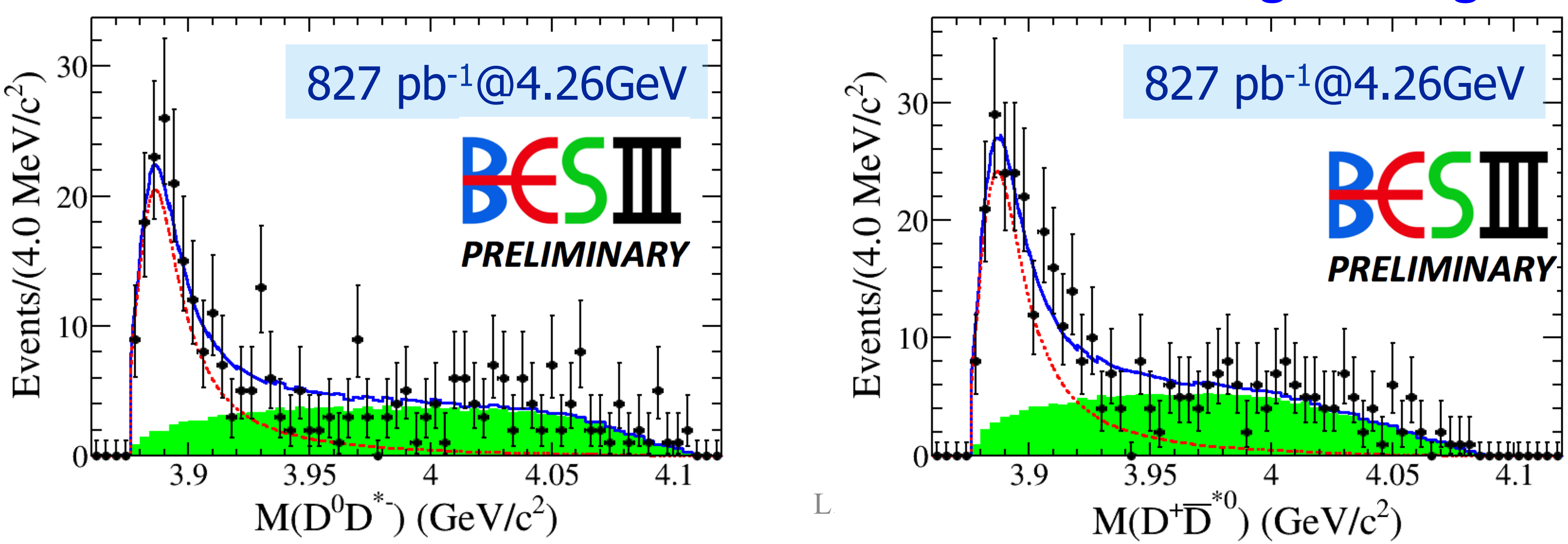
Phys. Rev. Lett. 111, 132003 (2013); Phys. Rev. D 89, 094026 (2014)
Phys. Rev. D 89, 074029 (2014); Phys. Rev. D 88, 074506 (2013); etc

- FSI?
- Cusp?
- …

$Z_c(3885)^{\pm}$ in $e^+e^- \rightarrow \pi^+(DD^*)^-$ by double D-tag



Confirmed the results obtained with single D-tag



Summary on Z_c states

The BESIII experiment discovered several Z_c states.

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