Charmonium results from BES

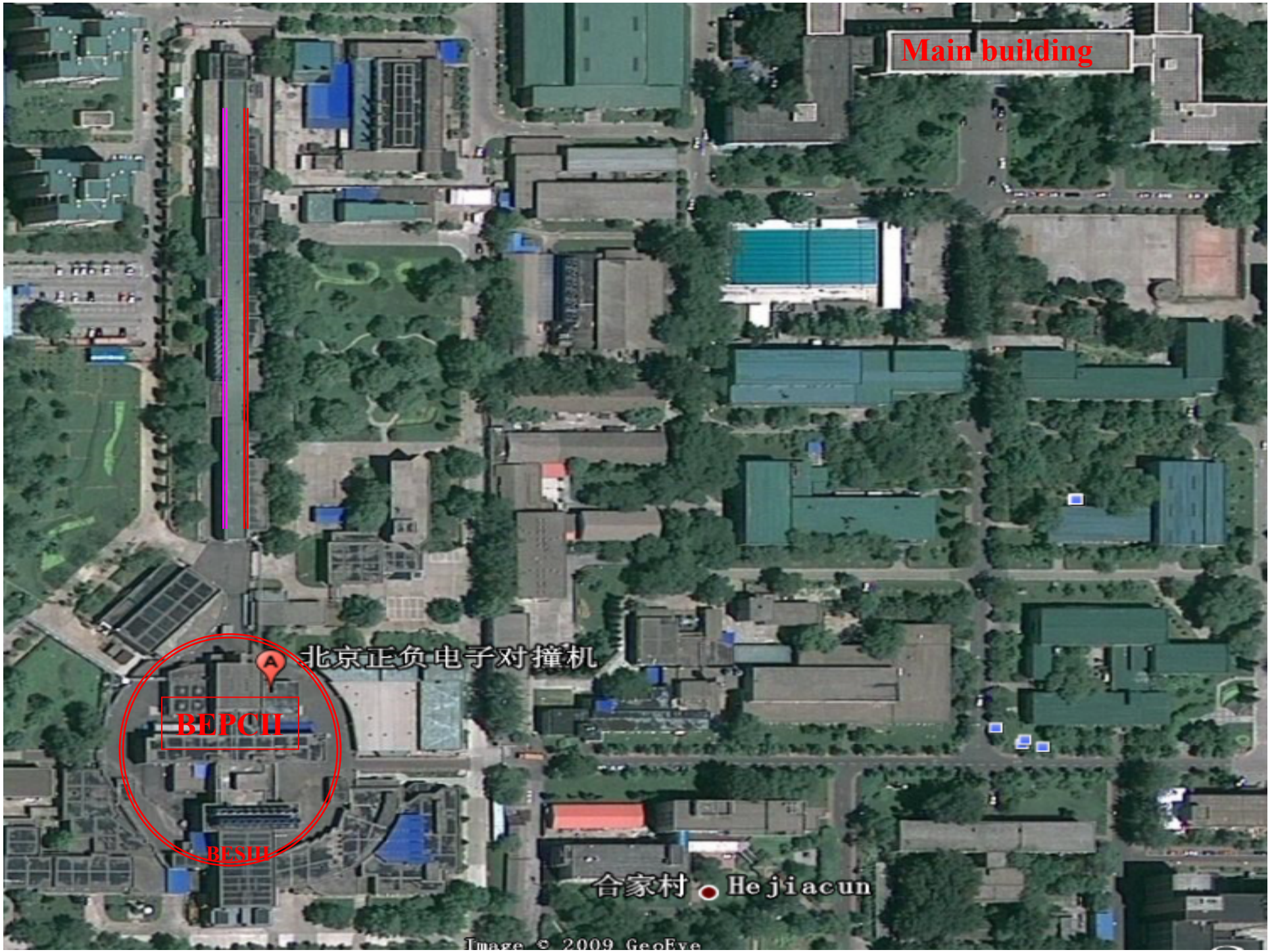
Ronggang PING

(For BES Collaboration)

International Workshop on e^+e^- collisions from Phi to Psi

OUTLINE

- Preliminary results from BESII
  - $\psi(2S) \to \Omega^- \bar{\Omega}^+$
  - Measurement of $\bar{\Lambda}$ decay parameters
  - Search for CP violation in $J/\psi \to \Lambda \bar{\Lambda}$
- Preliminary results from BESIII
  - EM transitions
  - h_c physics
  - $\chi_{cJ} \to \pi^0\pi^0, \eta\eta$
  - Observation of $\chi_{cJ} \to \phi\phi$, $\omega\omega$, $\phi\omega$
- Summary

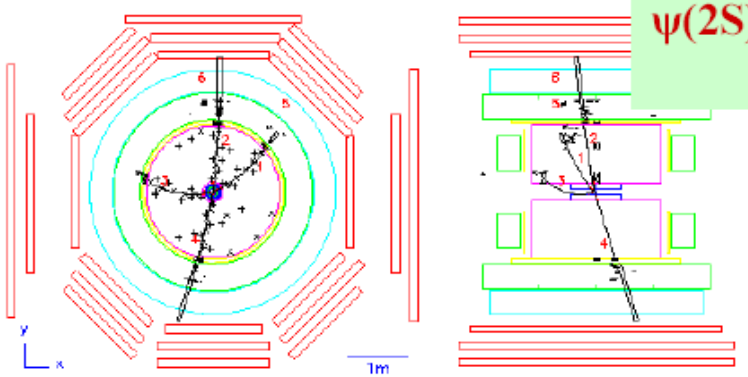

Main building
北京正负电子对撞机
BEPCII
BESIII
合家村 Hejiacun
Image © 2009 GeoEye

Preliminary results from BESII

Data	BESII	CLEOc
J/ψ	58 M	--
ψ'	14 M	27 M
ψ''	33 pb^{-1}	818 pb^{-1}
Continuum	6.4 pb^{-1} ($\sqrt{s}$=3.65 GeV)	21 pb^{-1} ($\sqrt{s}$=3.67 GeV)

	Performance
$\sigma p/p$	1.7%/$\sqrt{1+p^2}$
$\sigma E/E$	22% /$\sqrt{E}$
PartID	dE/dx+TOF
Coverage	80%

BESII



A typical event in BES detector
$\psi(2S) \rightarrow J/\psi\pi^+\pi^-$
$J/\psi \rightarrow e^+e^-$

First observation of $\psi(2S)\to\Omega^-\bar{\Omega}^+$

- Test of pQCD predictive power: gluon spin, quark distributio and helicity conservation
- Except for $\psi(2S)\to\Omega^-\bar{\Omega}^+$, $\psi(2S)\to B\bar{B}(B=p,\Lambda,\Xi^-)$ observed by BESII and CLEOc
- Upper limit: <7.3×10^{-5} @90% C.L. CLEOc:PRD72,051108R(2005)
- This decay mode is thought to be mainly produced from the annihilation of three gluons into $s\bar{s}$ pair.

$$\mathbf{B}(\psi(2S)\to\bar{\Omega}^+\Omega^-)$$

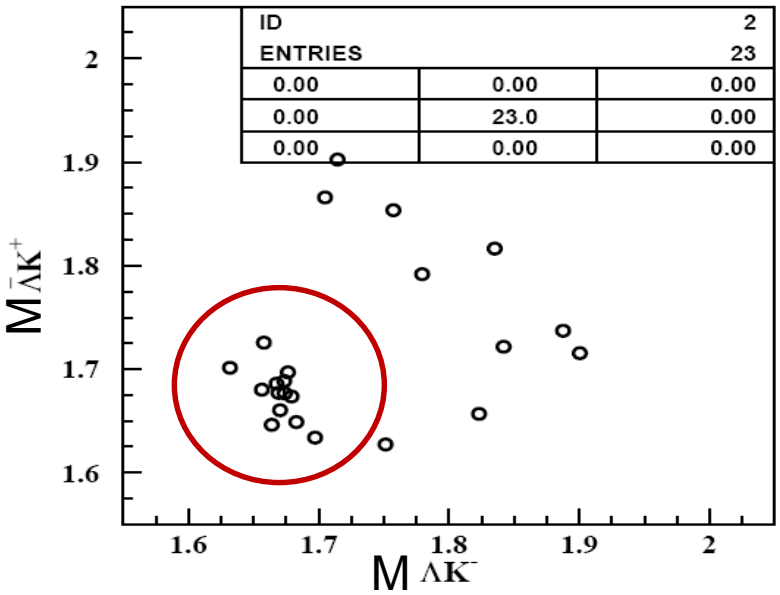
$$=\frac{\mathbf{N}^{data}_{obs}}{\mathbf{N}_{\psi(2S)}\cdot\mathbf{B}(\Omega\to\Lambda K)^2\cdot\mathbf{B}(\Lambda\to\pi p)^2\cdot\varepsilon}$$

$$=(3.21\pm1.25\pm0.86)\times10^{-5}$$

N_{obs}=4.5±1.8

Statistical significance ~ 5σ

BESII preliminary



Measurement $\bar{\Lambda}$ decay parameters using $J/\psi \to \Lambda\bar{\Lambda}$

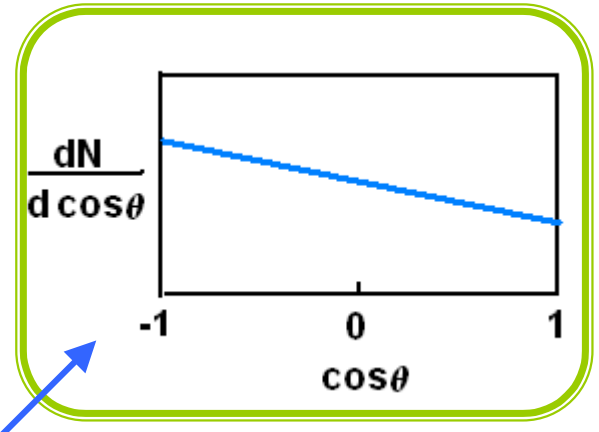
- **Hyperon non-leptoinc decays play an important role for people to understand parity violation in particle physics**

For example: $\Lambda \to p\pi^-$

$$\frac{dN}{d\Omega} = \frac{1}{4\pi}(1+\alpha_\Lambda \vec{P}.\hat{q}) = \frac{1}{4\pi}(1+\alpha_\Lambda P_\Lambda \cos\theta_p)$$

Λ decay parameter

Λ polarization



- $\alpha_\Lambda = 0.642 \pm 0.013$ (PDG08), $\alpha_{\bar{\Lambda}} = -0.63 \pm 0.13$ (DM2)

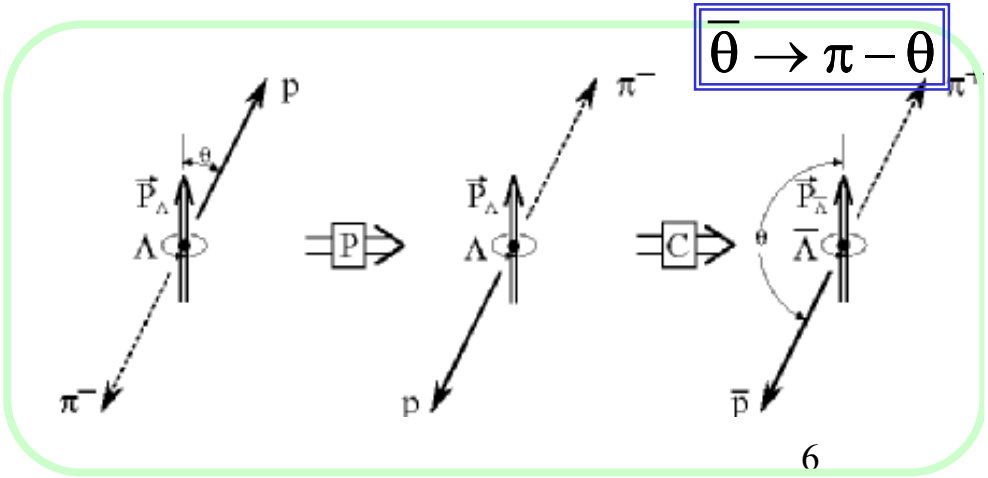
- CP violation test

$$\alpha_\Lambda = \frac{|B_+|^2 - |B_-|^2}{|B_+|^2 + |B_-|^2}, \alpha_{\bar{\Lambda}} = \frac{|\bar{B}_+|^2 - |\bar{B}_-|^2}{|\bar{B}_+|^2 + |\bar{B}_-|^2}$$

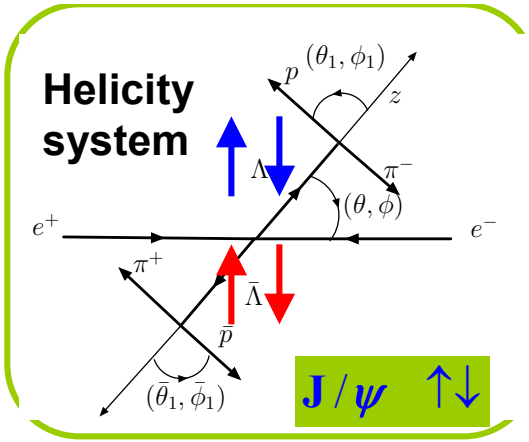
CP invariance:

$$\bar{B}_{-\lambda_p} = \eta_\Lambda \eta_p \eta_\pi (-1)^{s_\Lambda - s_p - s_\pi} B_{\lambda_p} = -B_{\lambda_p}$$

$$\Rightarrow \alpha_{\bar{\Lambda}} = -\alpha_\Lambda$$

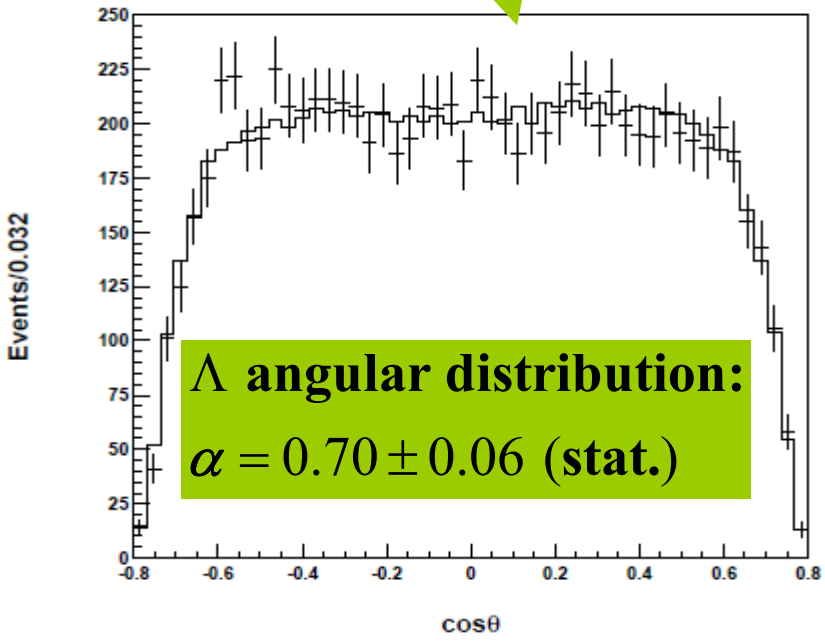


- Λ and $\bar{\Lambda}$ are un-polarized produced in J/ψ decays
- spins are correlated between Λ and $\bar{\Lambda}$
- allow us to extract the $\bar{\Lambda}$ decay parameters (PRDD76, 036005)



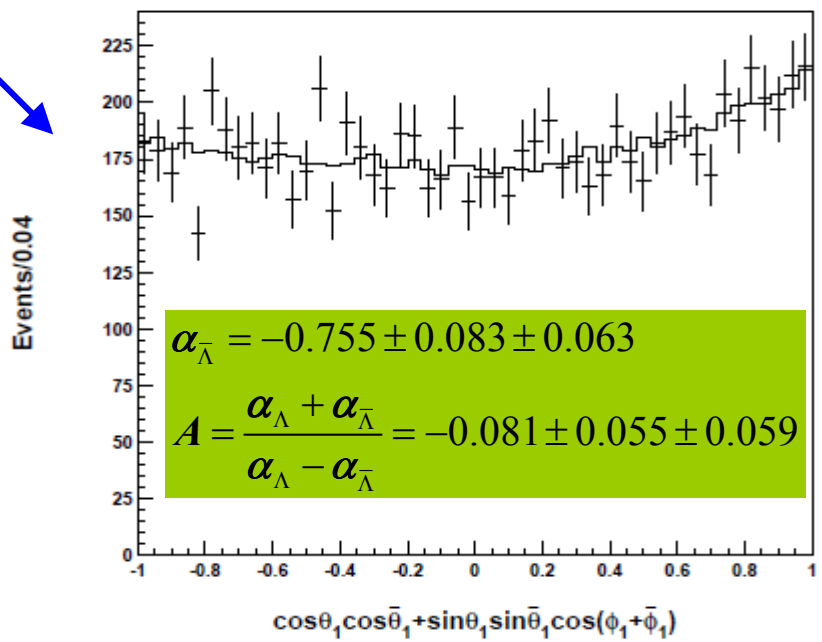
$$\frac{d|\mathcal{M}(\Omega_i)|^2}{d(\cos\theta)d\Omega_1 d\bar{\Omega}_1} \propto (1-\alpha)\sin^2\theta[1+\alpha_\Lambda\alpha_{\bar{\Lambda}}(\cos\theta_1\cos\bar{\theta}_1+\sin\theta_1\sin\bar{\theta}_1\cos(\phi_1+\bar{\phi}_1))]$$
$$-\ (1+\alpha)(1+\cos^2\theta)(\alpha_\Lambda\alpha_{\bar{\Lambda}}\cos\theta_1\cos\bar{\theta}_1-1),$$

~ 9000 **events selected**



Λ angular distribution:

$\alpha = 0.70 \pm 0.06$ **(stat.)**



$\alpha_{\bar{\Lambda}} = -0.755 \pm 0.083 \pm 0.063$

$A = \dfrac{\alpha_\Lambda + \alpha_{\bar{\Lambda}}}{\alpha_\Lambda - \alpha_{\bar{\Lambda}}} = -0.081 \pm 0.055 \pm 0.059$

- **insufficient to observe CP violation in Λ decay**

Search for CP violation in $J/\psi \to \Lambda\bar{\Lambda}$

- **CP violation due to $\Lambda/\bar{\Lambda}$ electric dipole moment (EDM)**

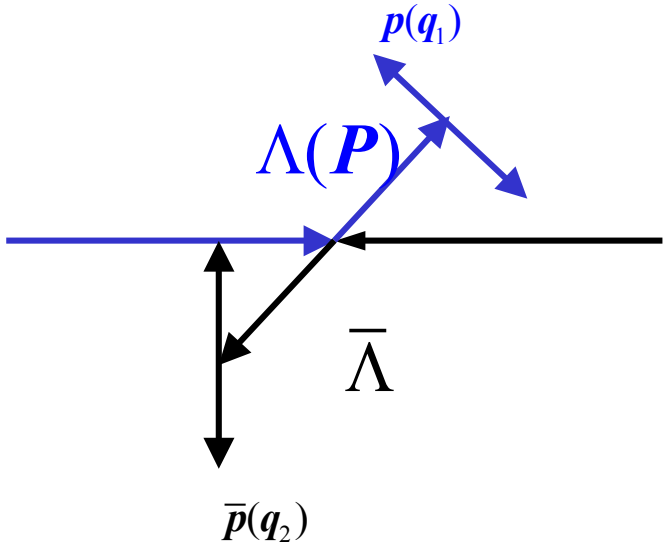
  $|\langle A_{CP} \rangle| = (0.56 \sim 1.25) \times 10^{-2}\ d_\Lambda / (10^{-16}\ e\ cm)$ **[PRD 47, R1744]**

- **Electric dipole moment (PDG08)**

  e: $d = (0.07 \pm 0.07) \times 10^{-26}\ e\ cm$

  n: $d < 0.29 \times 10^{-25}\ e\ cm$ **@90% C.L.**

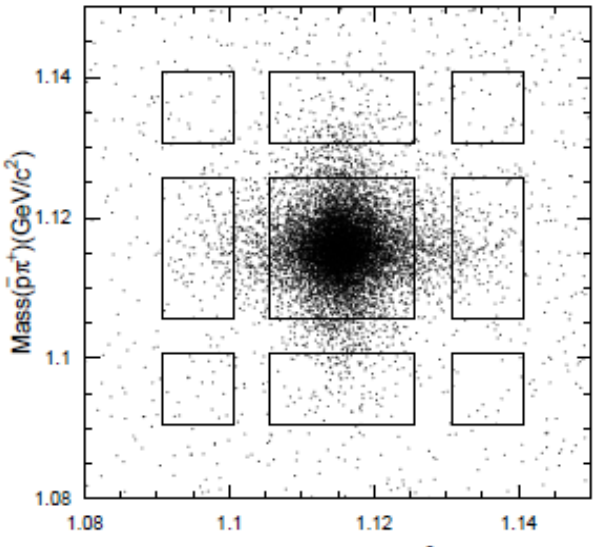
  Λ: $d < 1.5 \times 10^{-16}\ e\ cm$ **@95% C.L**



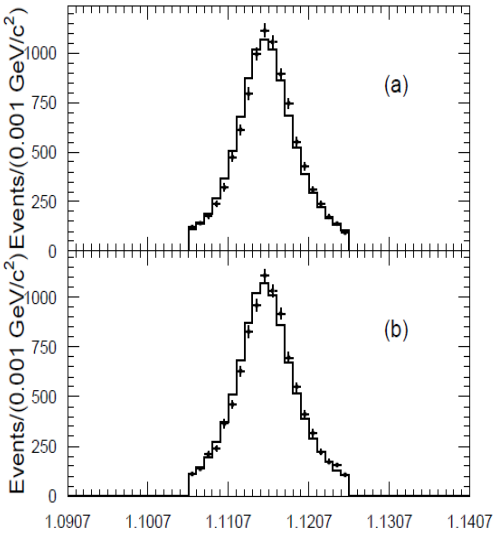
- **CP observable:**

$$A_{CP} = \frac{N^+ - N^-}{N^+ + N^-}$$

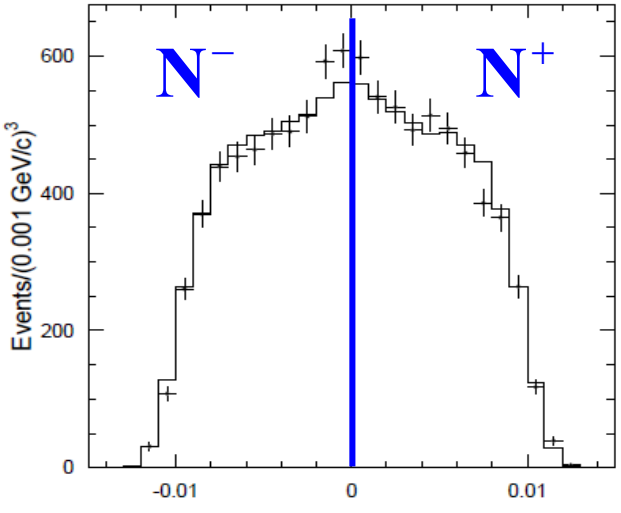
where $N^{\pm}$ defined by $\mathrm{sign}[\vec{P} \bullet (\vec{q}_1 \times \vec{q}_2)] = \pm$



$m_{p\pi^-}$ (GeV/c^2)



$m_{p\pi^-}$ or $m_{\bar{p}\pi^+}$ (GeV/c^2)



$\vec{P} \bullet (\vec{q}_1 \times \vec{q}_2)$

Events selected in 58M J/ψ data sample

9620 events selected

N^+ : 4801 N^-:4819

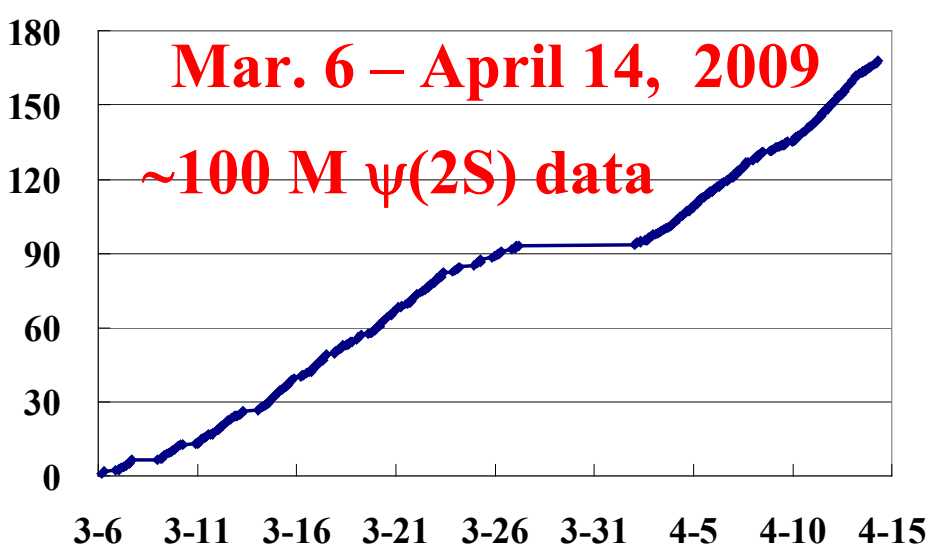
$A_{CP} = (-0.19 \pm 1.11(stat) \pm 0.18)\%$

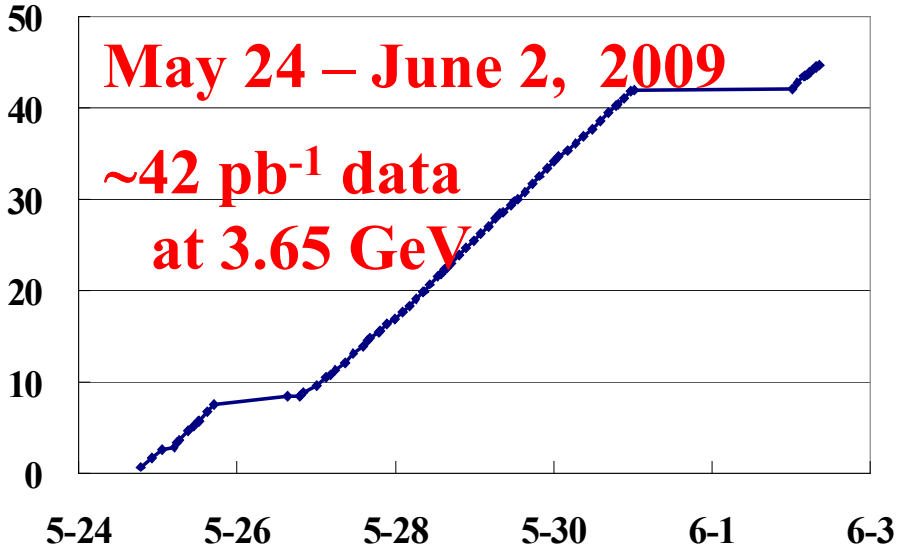
<2.87% @ 95% C.L.

$d_\Lambda < 2.3 \times 10^{-16}$ *e cm*

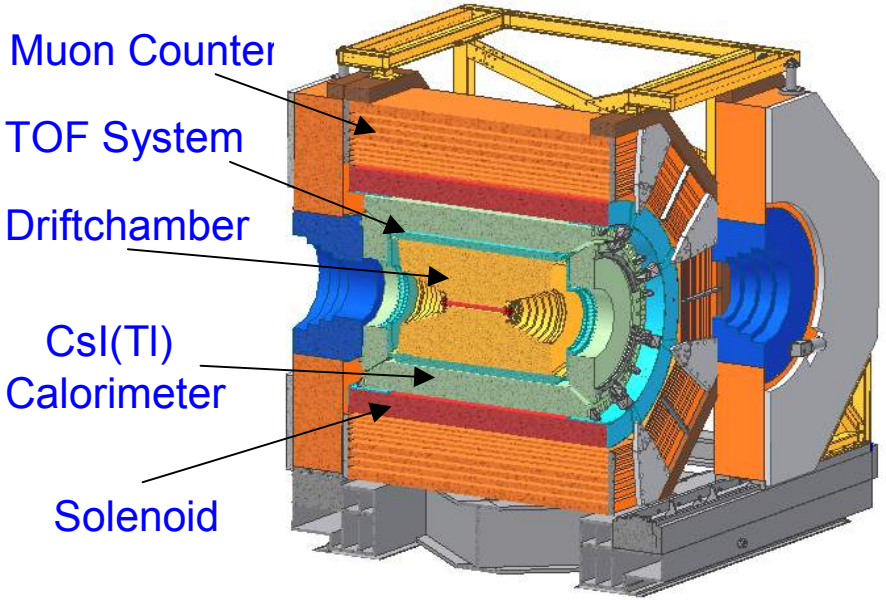
- **statistical error dominant**
- **insufficient to observe CP violation**
- **more stringent upper bounds for d_Λ @ BESIII**

Preliminary results from BESIII



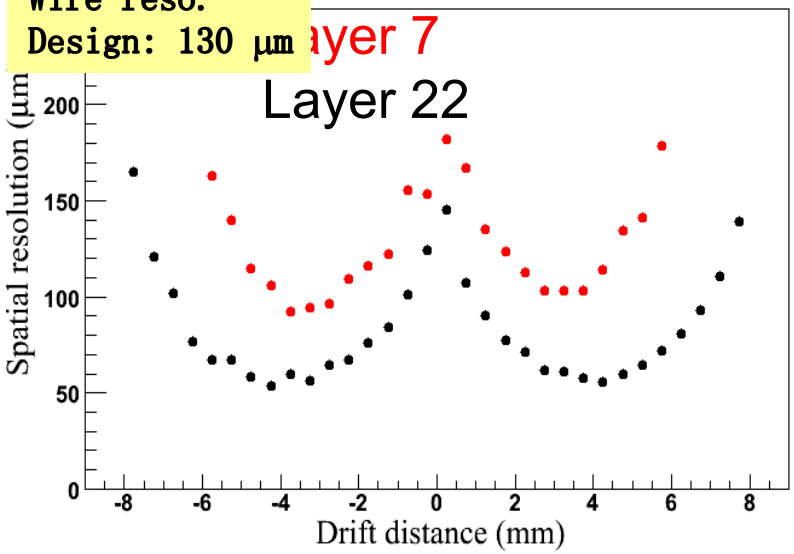


Device	*Performance*
MDC	$\sigma_{p_t}/p_t = 0.5\%,\ dE/dx < 6\%$
TOF	90 ps (bhabha)
EMC	$\sigma_E/E < 2.3\%/\sqrt{E}$
MUC	9 barrel + 8 endcap layers
Magnet	1 T Solenoidal

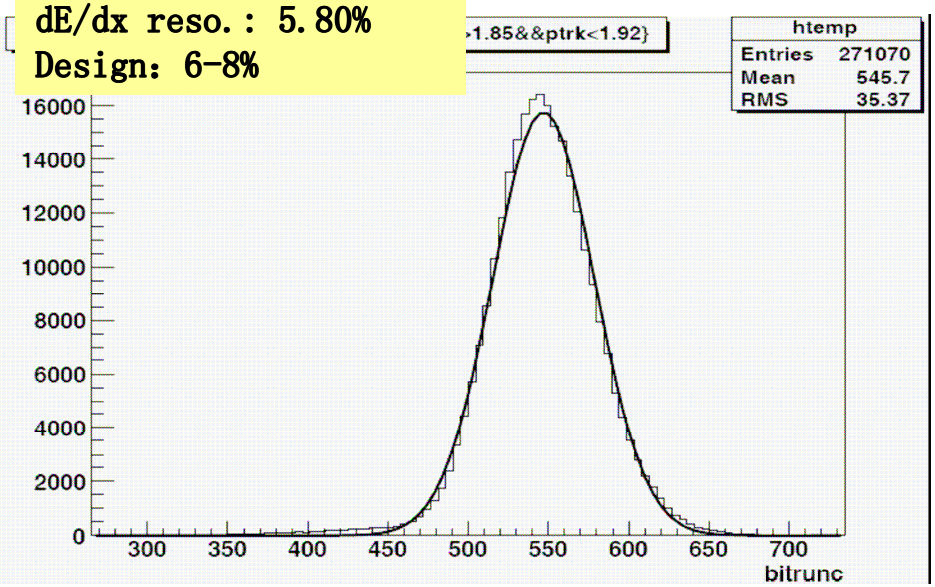


Detector performance and calibration

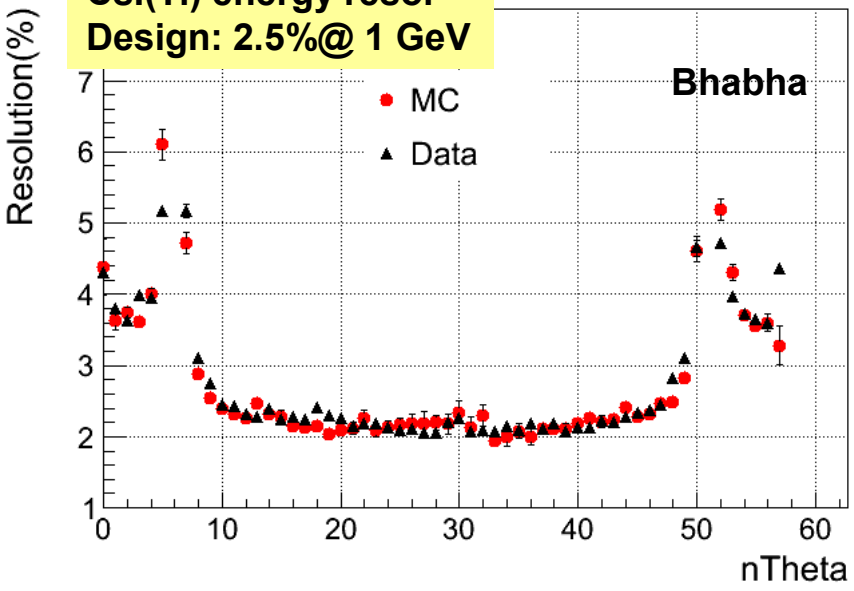
Wire reso.
Design: 130 μm



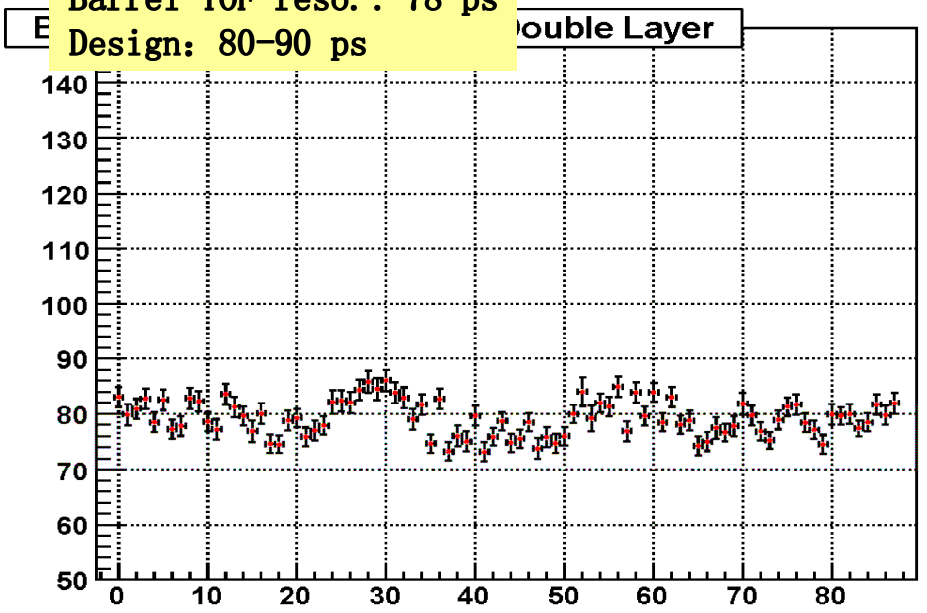
dE/dx reso.: 5.80%
Design: 6-8%



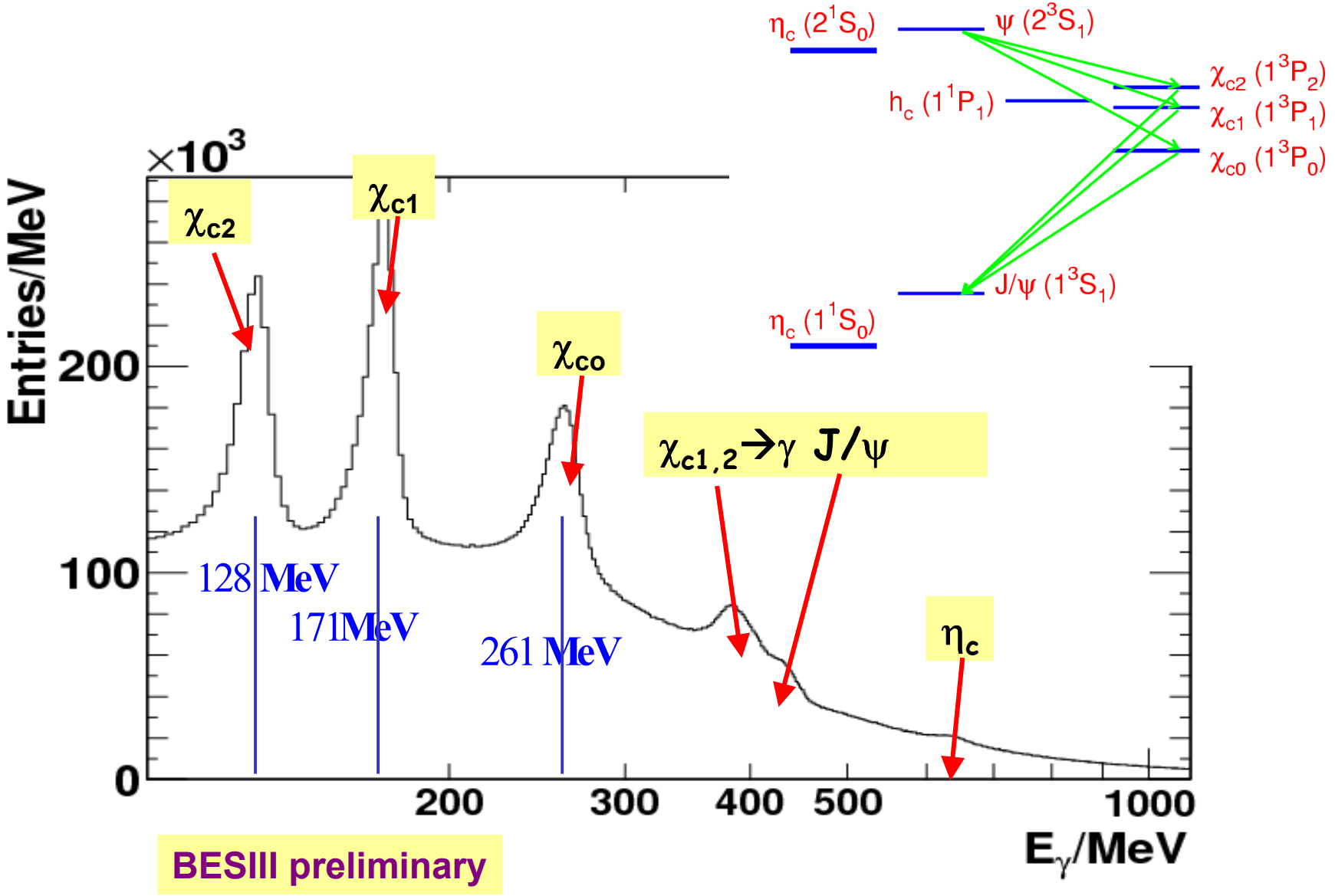
CsI(Tl) energy reso.
Design: 2.5%@ 1 GeV



Barrel TOF reso.: 78 ps
Design: 80-90 ps



EM transitions: inclusive photon spectrum



h_c physics at BESIII

PDG08

$h_c(1P)$ $I^G(J^{PC}) = ?^?(1^{+-})$

Mass $m = 3525.93 \pm 0.27$ MeV (S = 1.5)
Full width $\Gamma < 1$ MeV

$h_c(1P)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$J/\psi(1S)\pi\pi$	not seen	313
$\eta_c\gamma$	seen	503

- **h_c status**
  - **Assign as $J^{PC}=1^{+-}$**
  - **not well established in experiment**
  - **width? Decay modes?**
- **h_c production**
  - **Can generated by $p\bar{p}$ colliding, but the cross-section is small with high background level.**
  - **Highly suppressed in e^+e^- collider via $e^+e^- \rightarrow 3\gamma^* \rightarrow h_c$**
  - **Production via $\psi(2S)$ decay $\psi(2S) \rightarrow \pi_0 h_c$.**

- **challenges to search for h_c**
  - **Small production branching ratio;ambiguous decay modes.**
    - I: π^0 inclusive recoil mass

      $e^+e^- \to \psi(2S) \to \pi^0 h_c$

    - II: η_c inclusive decays (E1 tag)

      $\psi(2S) \to \pi^0 h_c$

      $|\to \gamma\eta_c$

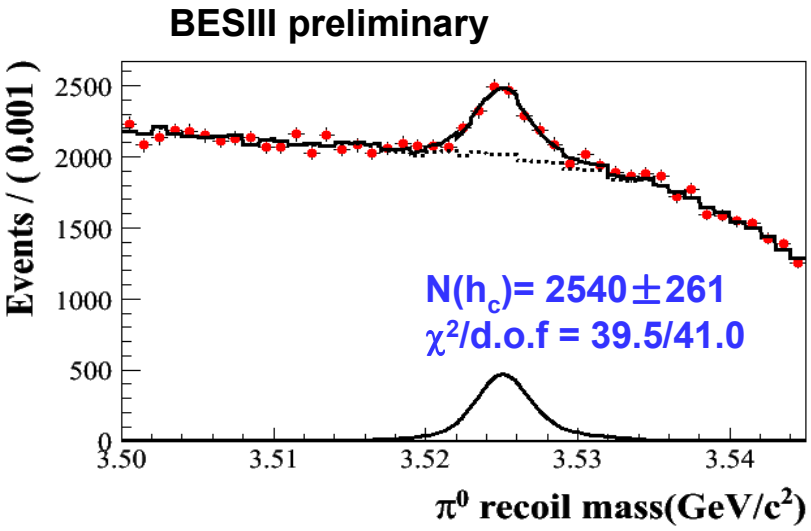
      $|\to$ **anything**

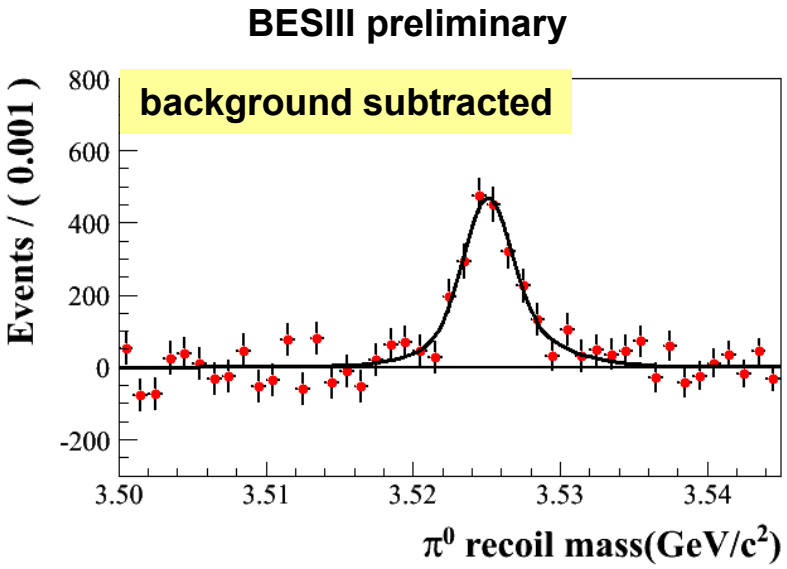
      or exclusive decays

    CLEOc: (PRL101,182003(2008))

    Br[ψ(2S) $\to\pi h_c$]Br[$h_c \to\gamma\eta$]=4.19±0.32 ±0.45)×10^{-4}
- **It requires:**
  - **Large ψ(2S) data sample**
  - **Good photon energy resolution.**
  - **High reconstruction efficiency for soft photon.**
- **High luminosity of BEPCII and high quality of photon detection of BESIII offer us opportunity to study h_c**

Observation of h_c: E1-tagged $\psi(2S)\to\pi^0 h_c, h_c\to\gamma\eta_c$





- Select inclusive π^0
- Select E1-photon to tag h_c
- A fit of BW⊗Res. signal+ sideband bkg. yield:

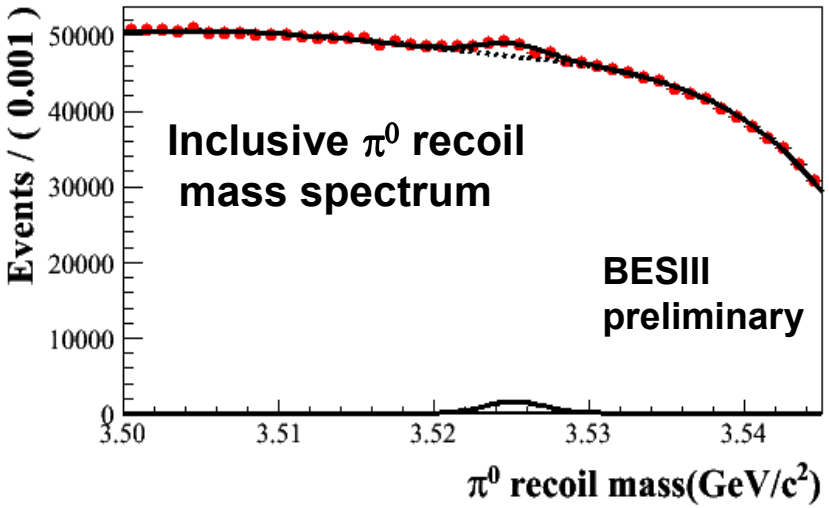
$M(h_c)^{Inc} = 3525.16\pm0.16$MeV

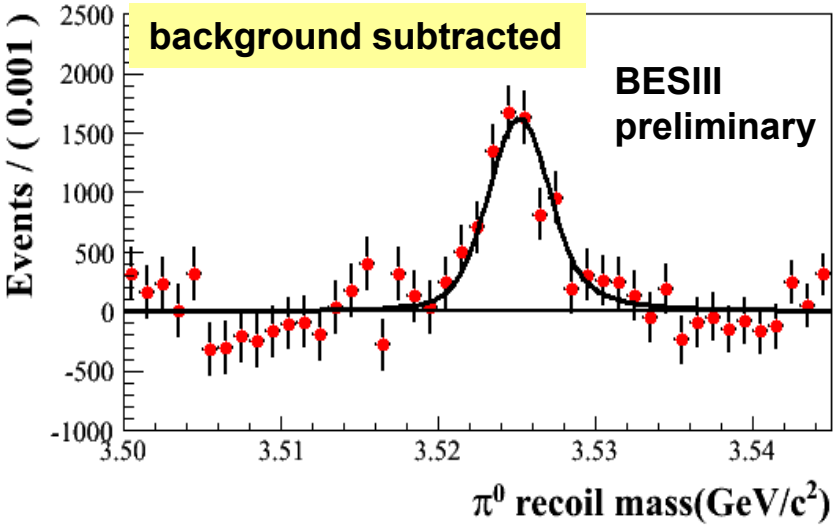
$\Gamma(h_c)^{Inc} = 0.89 \pm 0.57$MeV (First measurement)

$Br(\psi'\to\pi^0 h_c)\times Br(h_c\to\gamma\eta_c)^{Inc} = (4.69\pm0.48(stat))\times10^{-4}$ ($\Gamma(h_c)$ floated)

$= (4.69\pm0.29(stat))\times10^{-4}$ ($\Gamma(h_c)$ fixed at $\Gamma(\chi_{c1})$)

Observation of h_c : Inclusive $\psi(2S) \rightarrow \pi^0 h_c$





- Select inclusive π^0
- A fit of D-Gaussian signal + 4th Poly. bkg yield

  $N(h_c) = 9233 \pm 935$, χ^2/d.o.f = 38.8/38.0
- Combined inclusive and E1-photon-tagged spectrum

  $Br(\psi' \rightarrow \pi^0 h_c) = (8.42 \pm 1.29(stat)) \times 10^{-4}$ (First measurement)

  $Br(h_c \rightarrow \gamma \eta_c) = (55.7 \pm 6.3(stat))\ \%$ (First measurement)

16

Systematic errors

- **Sources**
  - **Background shape, fit range, width of bin**
  - **Absolute energy calibration**
  - **Instrument resolution shape**
  - **E1 photon efficiency**
  - **π^0 efficiency**
  - **Number of charged track**
  - **Number of π^0**
  - **Veto XJpsi**
  - **N(ψ(2S))**
  - **Mass of ψ(2S)(in the calculation of recoiling mass)**
  - **Modeling of signal shape**
- **Systematic errors under study**

Summary of h_c measurement

$M(h_c)^{Inc}$= 3525.16±0.16 (stat.) MeV
(3525.28±0.19±0.12 MeV PRL101,182003(2008),CLEOc)

$\Gamma(h_c)^{Inc}$= 0.89±0.57 (stat.) MeV
(First measurement)

Br(ψ (2S)→ $\pi^0 h_c$)
=(8.42±1.29 (stat.)) ×10^{-4}
(First measurement)

Br(ψ (2S)→ $\pi^0 h_c$)×Br(h_c→ $\gamma \eta_c$)^{Inc}
=(4.69±0.48 (stat.)) ×10^{-4}
((4.22±0.44±0.52) ×10^{-4} inc
(4.16±0.30±0.37) ×10^{-4} avg)

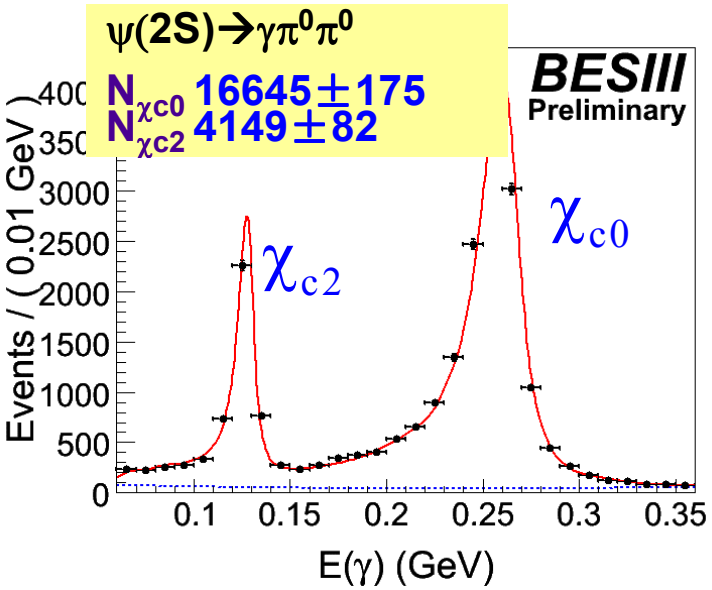
Br(h_c→ $\gamma \eta_c$)
=(55.7±6.3 (stat.))%
(First measurement)

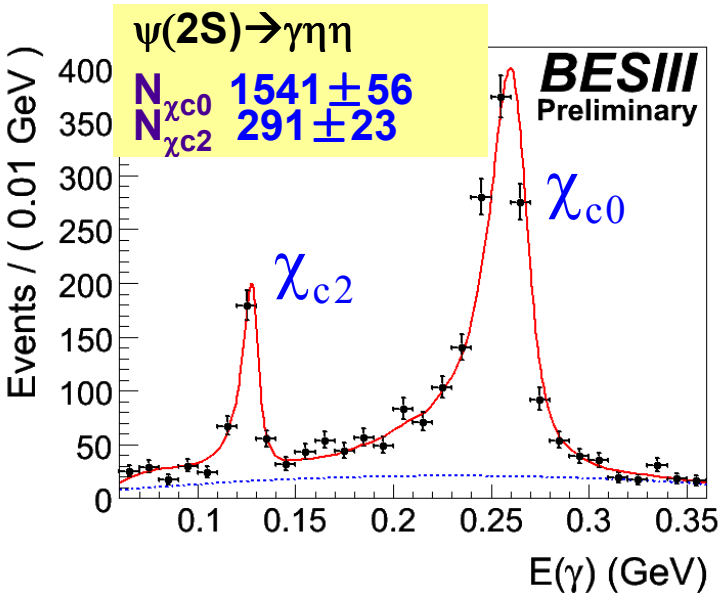
- BESIII preliminary results are consistent with CLEOc measurements
- Precision improved
- First measurements:

$\Gamma(h_c)$, Br[ψ(2S)→$\pi^0 h_c$], Br(h_c→ $\gamma \eta_c$)

Study of $\psi(2S) \to \gamma\pi^0\pi^0$, $\gamma\eta\eta$ ($\eta \to \gamma\gamma$, $\pi^0 \to \gamma\gamma$)

- Interesting channels for glueball searches
- Based on 100M $\psi(2S)$
- BK study from 100M inclusive MC sample and 42pb^{-1} continuum sample
- Unbinned Maximum Likelihood fit:
  - Signal: PDF from MC signal
  - Background: 2nd order Poly.



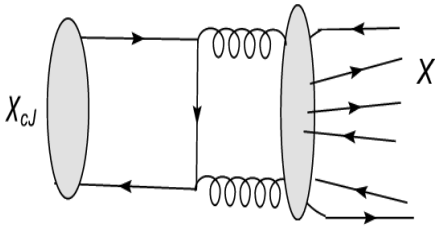


BR (10^{-3})		χ_{c0}	χ_{c2}
$\pi^0\pi^0$	BESIII	3.25±0.03(stat)	0.86±0.02(stat)
	PDG08	2. 43±0.20	0.71±0.08
	CLEO-c	2.94±0.07±0.35	0.68±0.03±0.08
$\eta\eta$	BESIII	3.1±0.1(stat)	0.59±0.05(stat)
	PDG08	2.4±0.4	<0.5
	CLEO-c	3.18±0.13±0.35	0.51±0.05±0.06

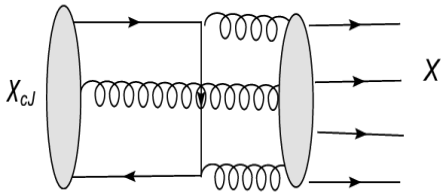
CLEO-c
arxiv:0811.0586

Observation of $\chi_{cJ} \rightarrow \phi\phi, \omega\omega, \phi\omega$

- **Test QCD-based theory at χ_{cJ} decays**



χ_{cJ} hadronic decays at QCD leading order



χ_{cJ} hadronic decays in the color octet theory

Eur.Phys.J.C2.705;
Eur.Phys.J.C14,643

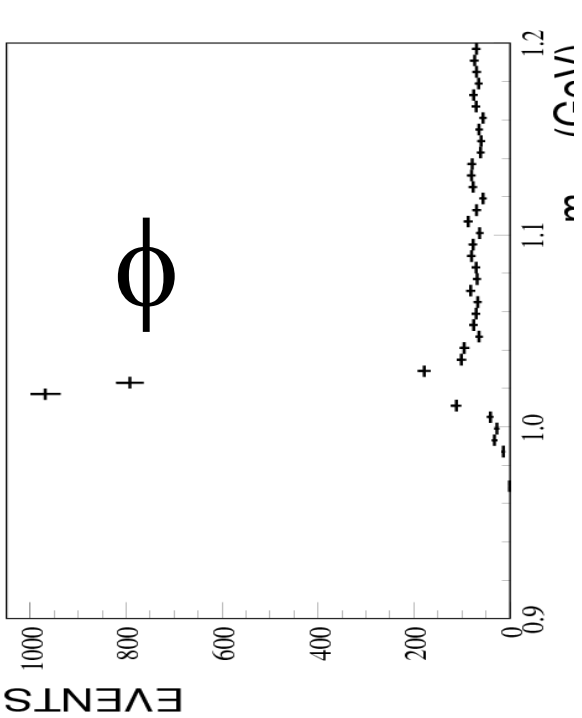
- **Puzzles for $\chi_{c0} \rightarrow$ VV: no helicity suppress**

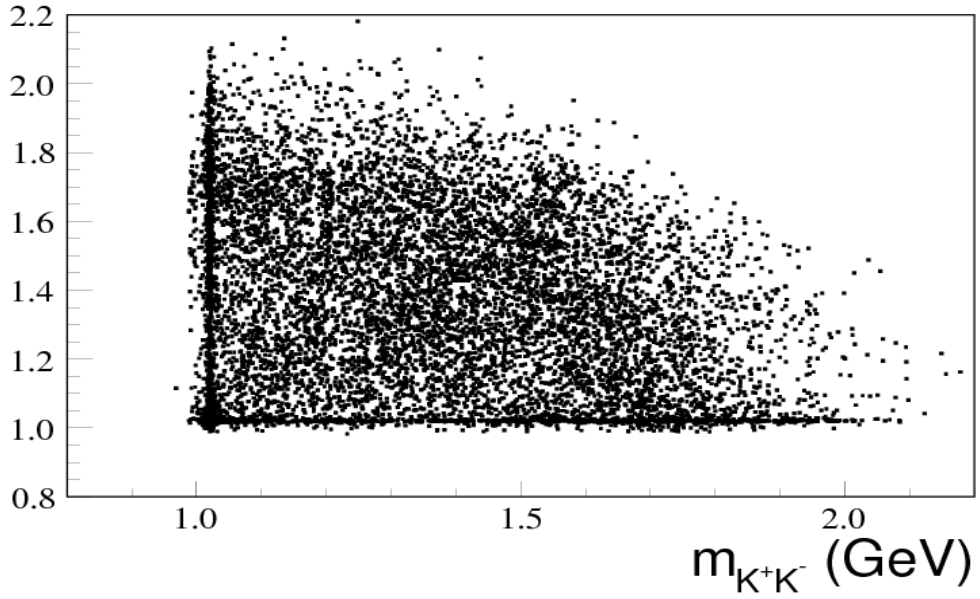
BESII results:		
BR(10^{-3})	χ_{c0}	χ_{c2}
$\phi\phi$	0.93±0.20	1.5±0.3
$\omega\omega$	2.3±0.7	2.0±0.7

PLB 642,197(2006)
PLB 630,7 (2005)

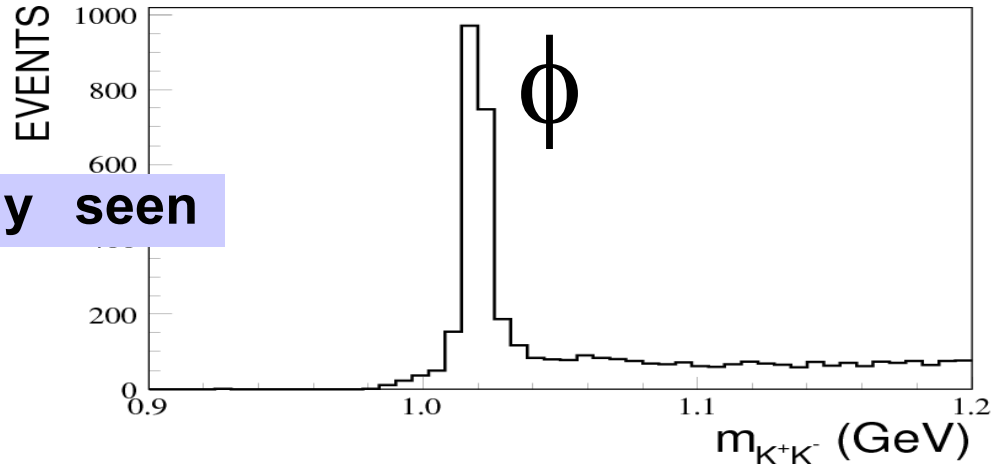
- **$\chi_{c1} \rightarrow \phi\phi, \omega\omega$ is only allowed for L=2, suppressed ?**
- **$\chi_{c1} \rightarrow \phi\omega$ OZI doubly suppressed**
- **surprisingly these decays observed at BESIII**

- Observation of $\chi_{cJ} \to \phi(K^+K^-)\phi(K^+K^-)$



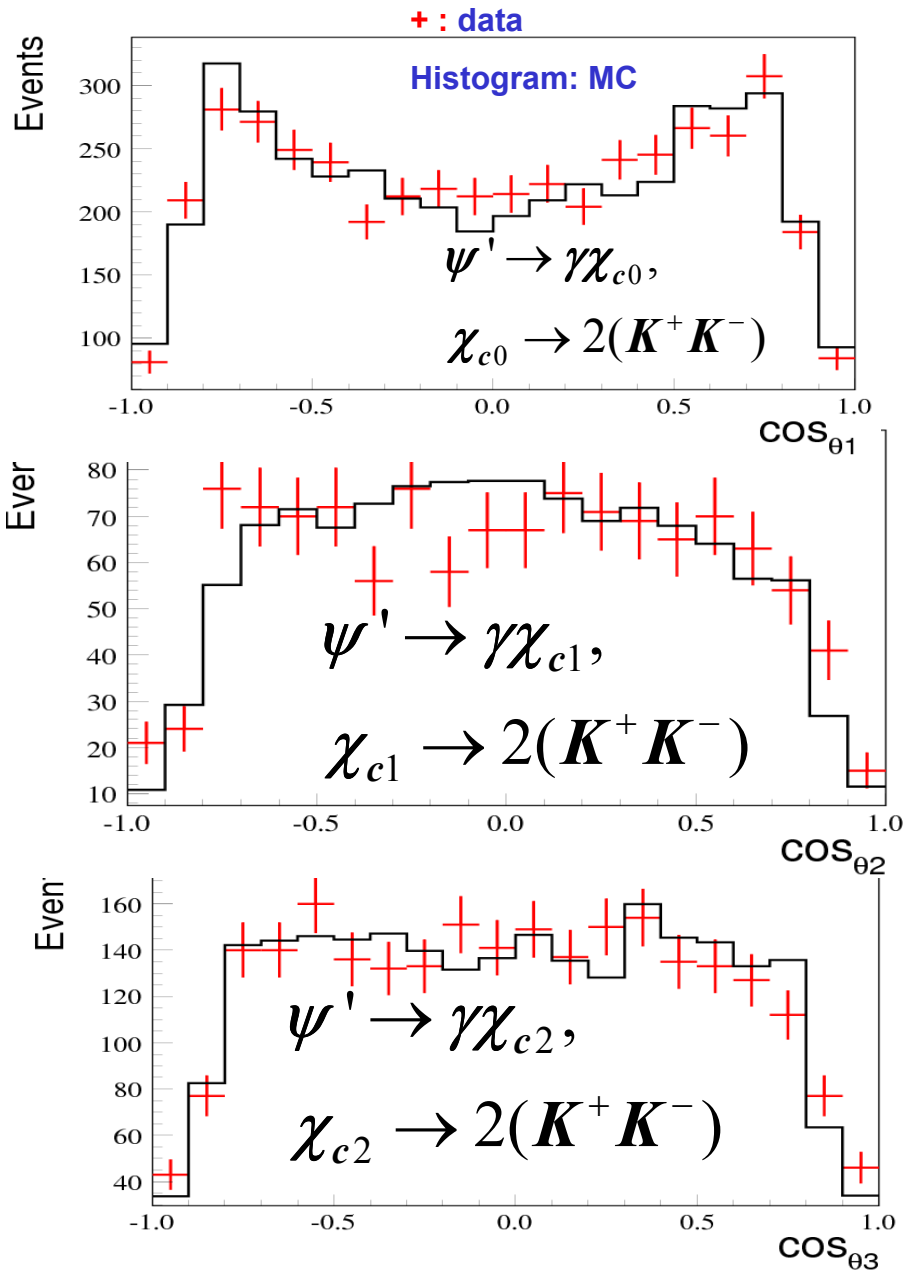


data: ~100 Million

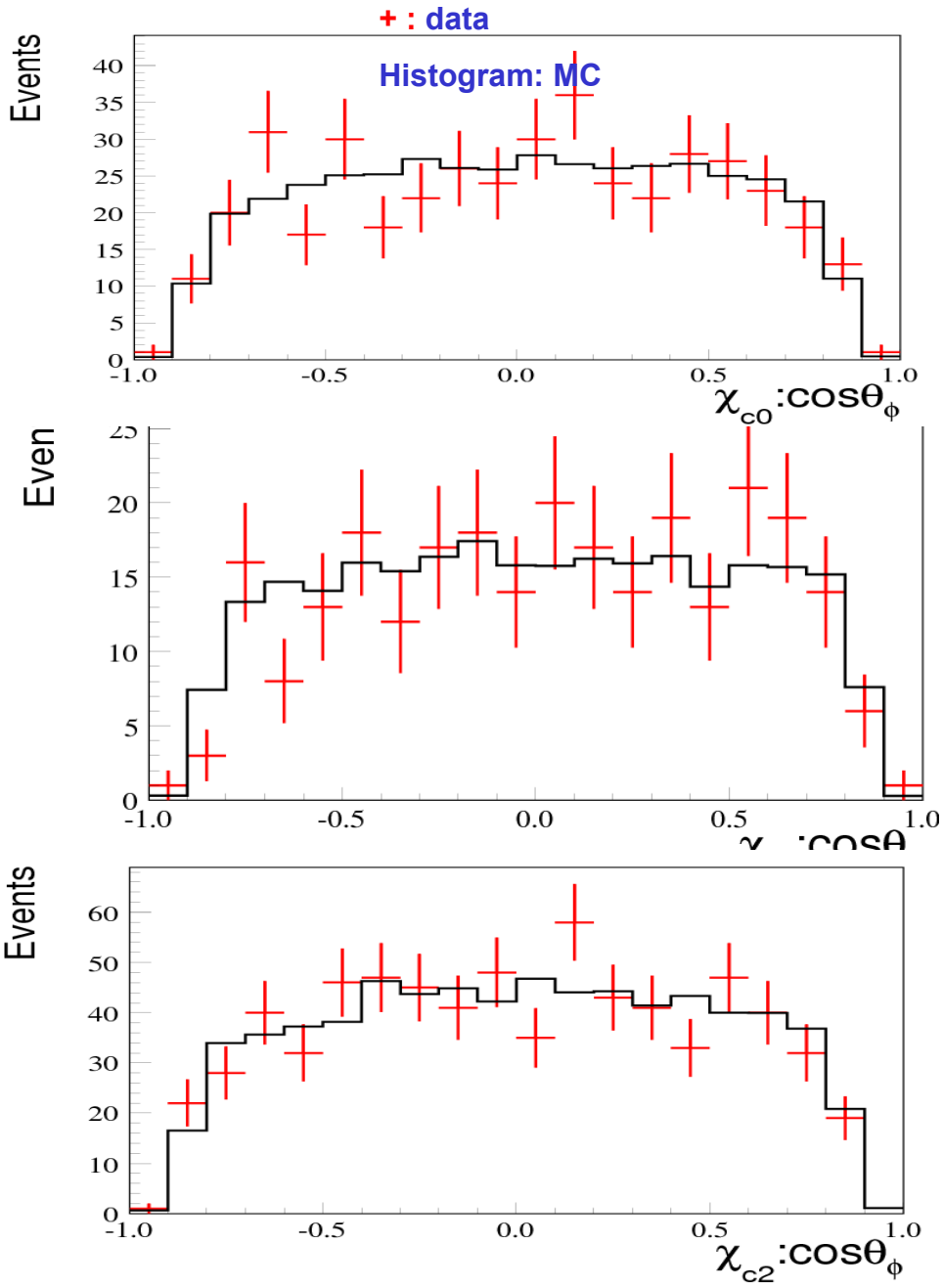


$\phi\phi$ signals are clearly seen

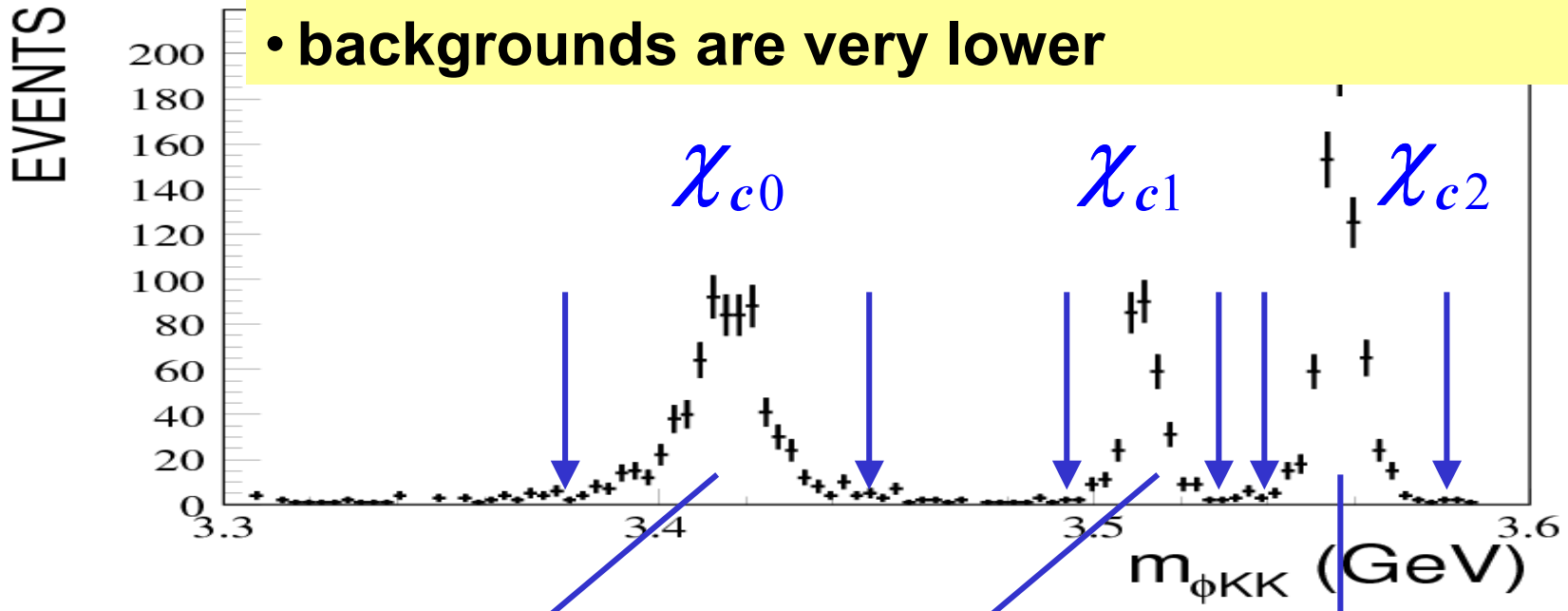
$E1$-photon angular distributions

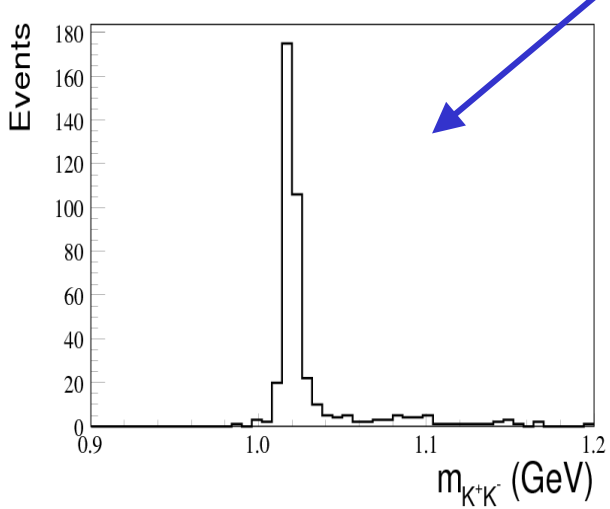


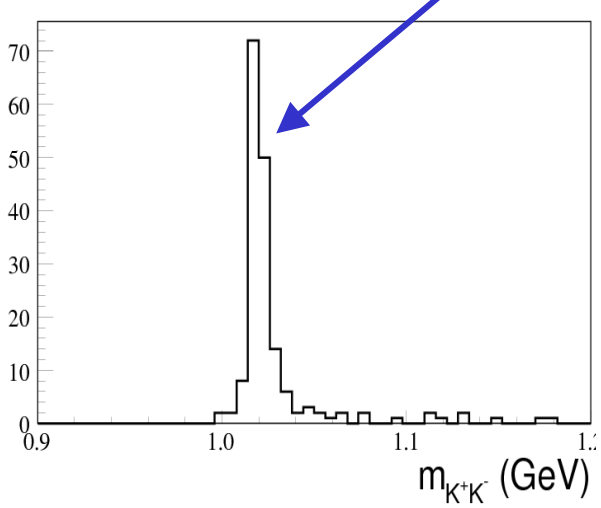
ϕ angular distributions

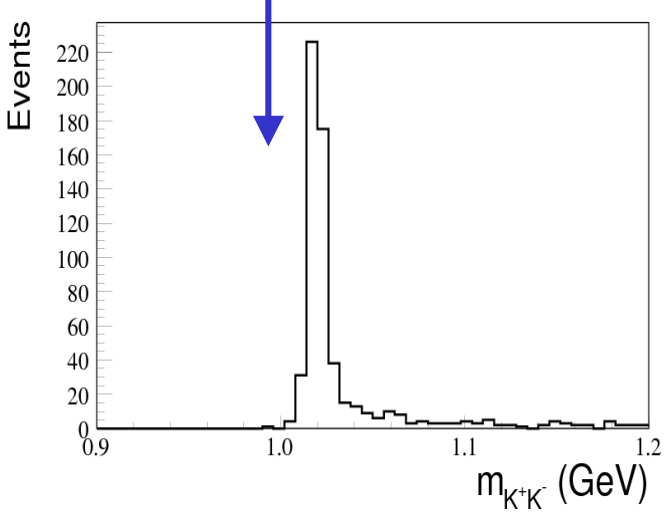


- ϕ signals are clearly observed in $\chi_{cJ} \to \phi K^+K^-$
- backgrounds are very lower



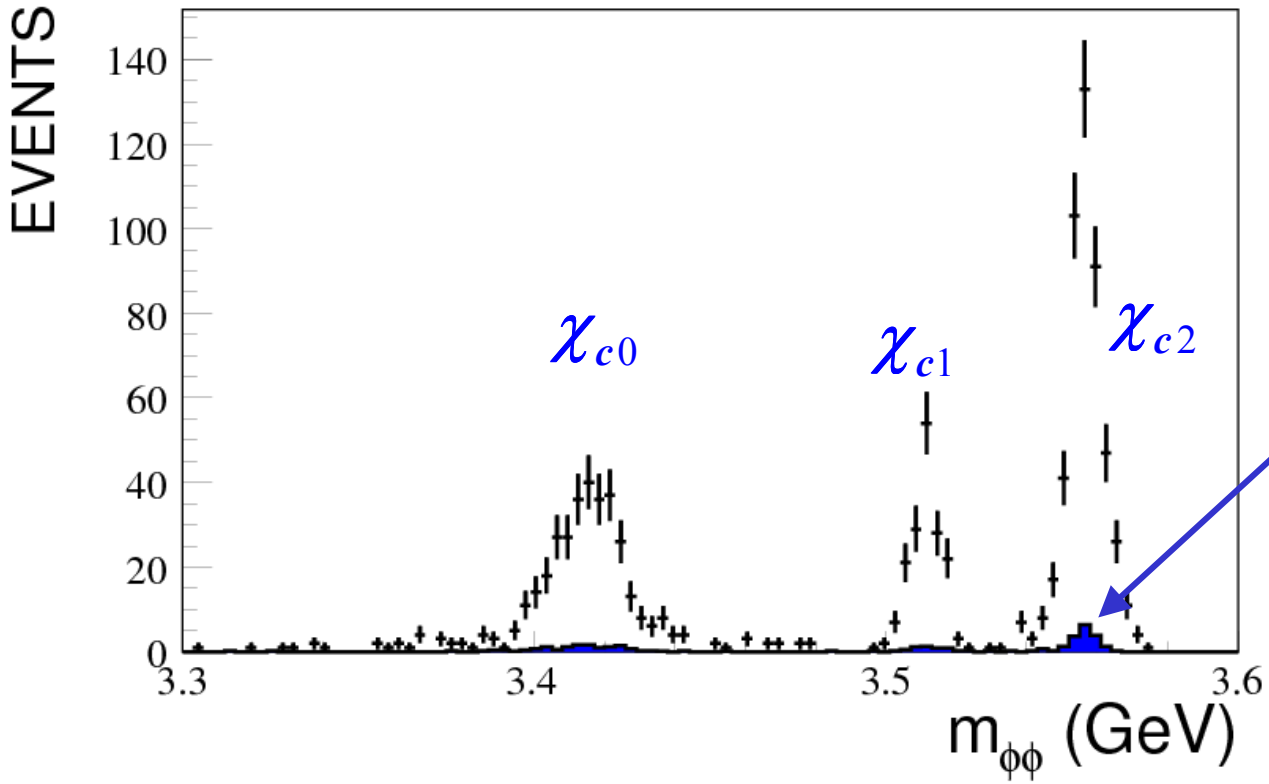






m_{KK} for $\chi_{c0} \to \phi K^+K^-$ m_{KK} for $\chi_{c1} \to \phi K^+K^-$ m_{KK} for $\chi_{c2} \to \phi K^+K^-$

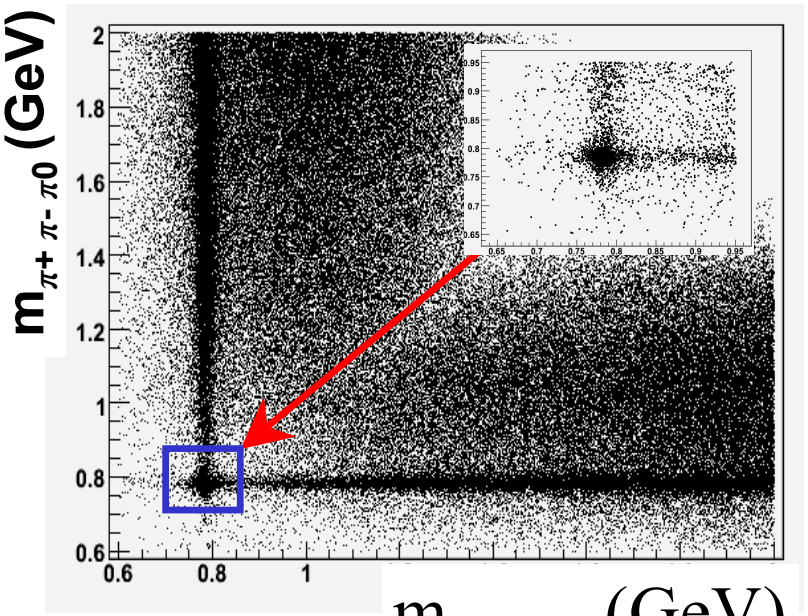
$m_{\phi\phi}$ distribution

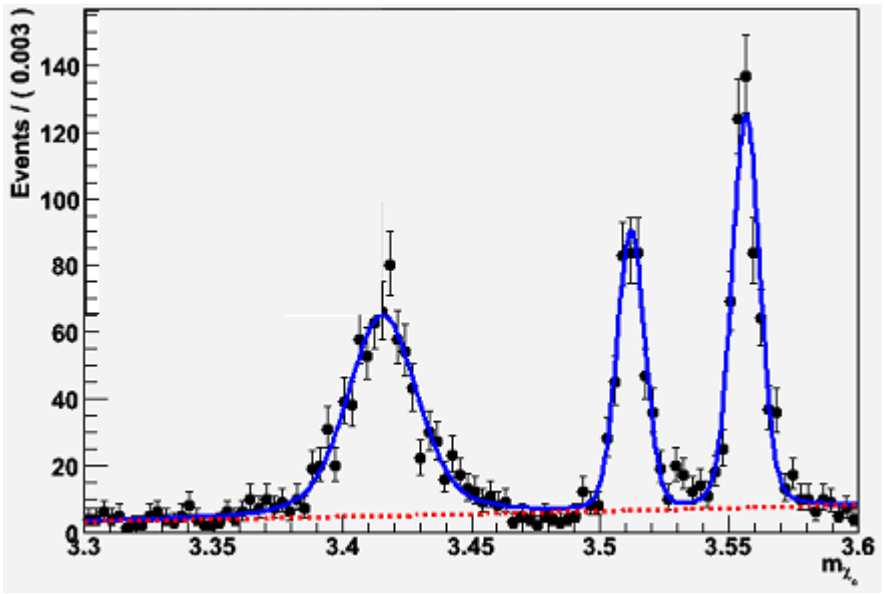


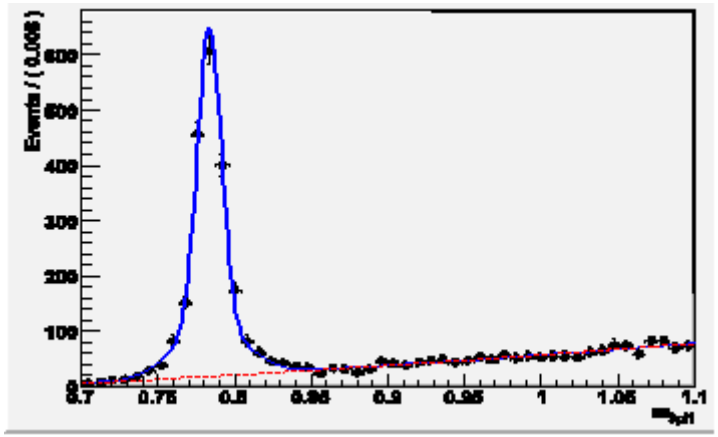
Two ϕ sideband

- **$\chi_{c1} \rightarrow \phi\,\phi$ signals are clearly observed**
- **backgrounds and non-resonance contributions are very lower**
- **Branching fraction measurements are ongoing**

- Observation of $\chi_{cJ} \to \omega(\pi^+\pi^-\pi^0)\omega(\pi^+\pi^-\pi^0)$



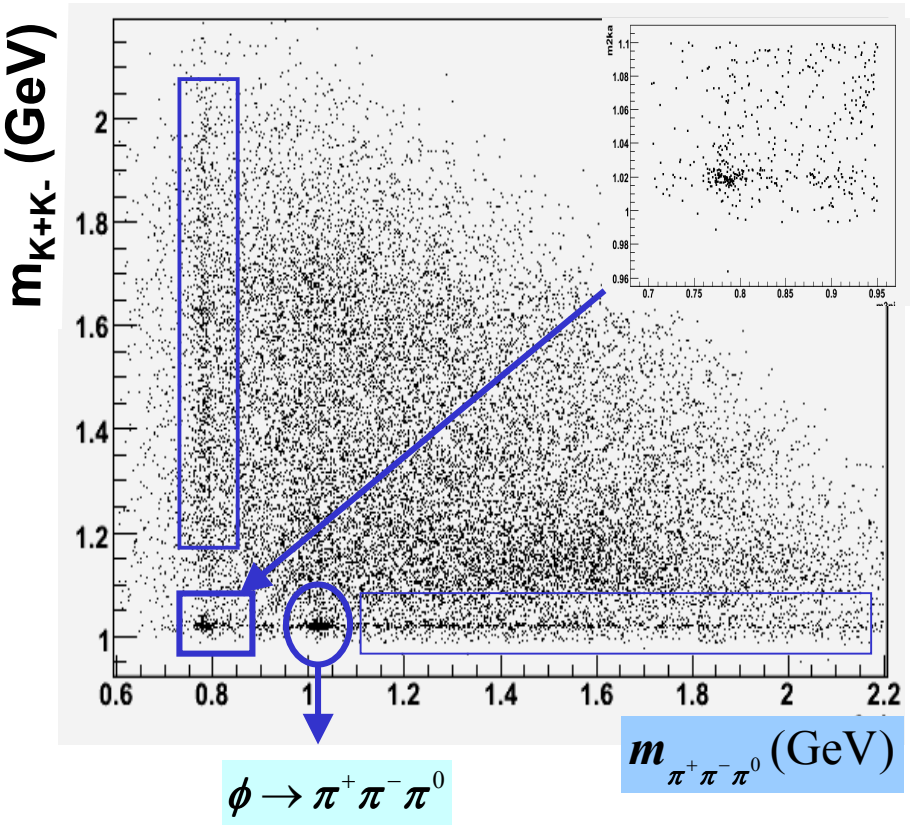


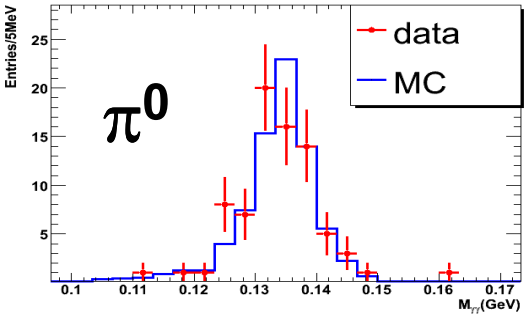


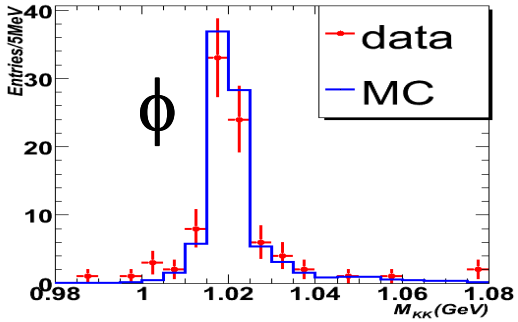
- $\chi_{c1} \to \omega\,\omega$ signals are clearly observed
- backgrounds and non-resonance contributions are studied with two-ω sidebands, very lower
- Branching fraction measurements are ongoing

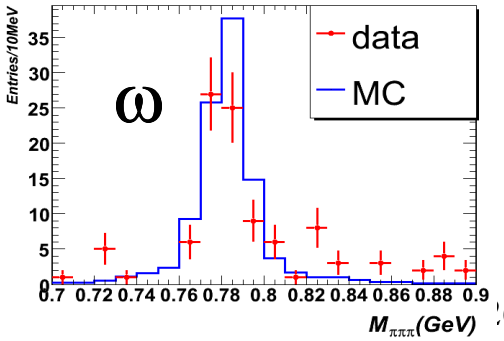
• Observation of $\chi_{cJ} \to \omega(\pi^+\pi^-\pi^0)\phi(K^+K^-)$

m_{KK} versus $m_{\pi\pi\pi}$ for Data

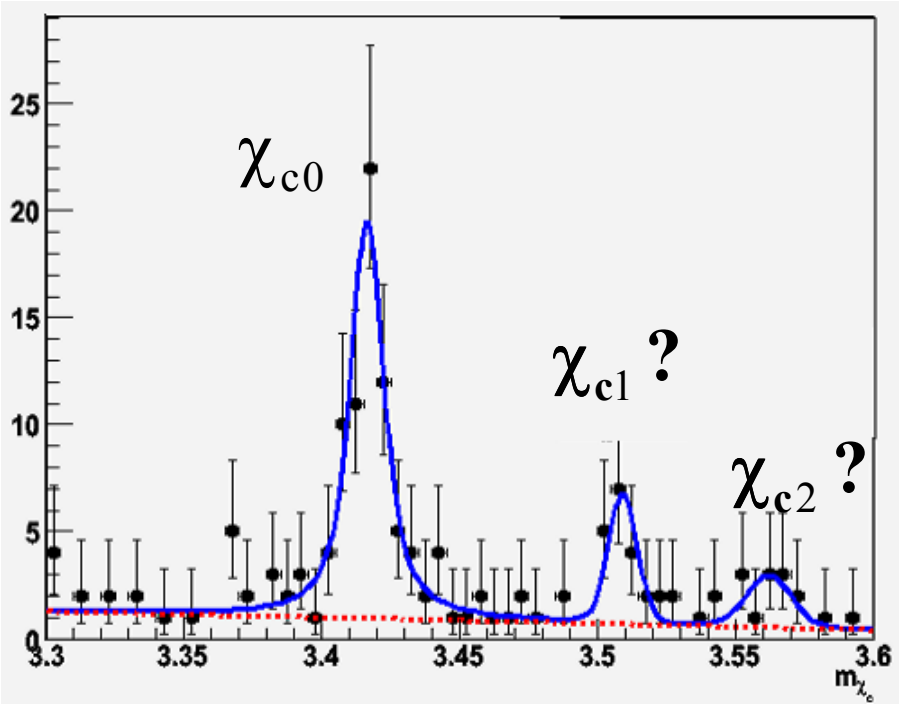








m_{ϕ} distribution



- $\chi_{c0} \rightarrow \omega\phi$ signals are clearly observed
- backgrounds and non-resonance contributions are studied with ϕ and ω sidebands, very lower
- Branching fraction measurements are ongoing

$m_{\phi}(\mathrm{GeV})$

Summary

- $\psi(2S) \to \Omega^- \bar{\Omega}^+$ observed at BESII
- Λ decay parameter and Λ EMD studied in $J/\psi \to \Lambda\bar{\Lambda}$ at BESII
- h_c signals observed in BESIII 100 M $\psi(2S)$ data sample.
  - resonance parameters:
  - Br($\psi(2S) \to \pi^0 h_c$)
  - Br($h_c \to \gamma\eta$)
- $\chi_{c1} \to \phi\phi$, $\omega\omega$, $\phi\omega$ observed
  branching fraction measurement ongoing
- BESIII detector performance excellent and work well

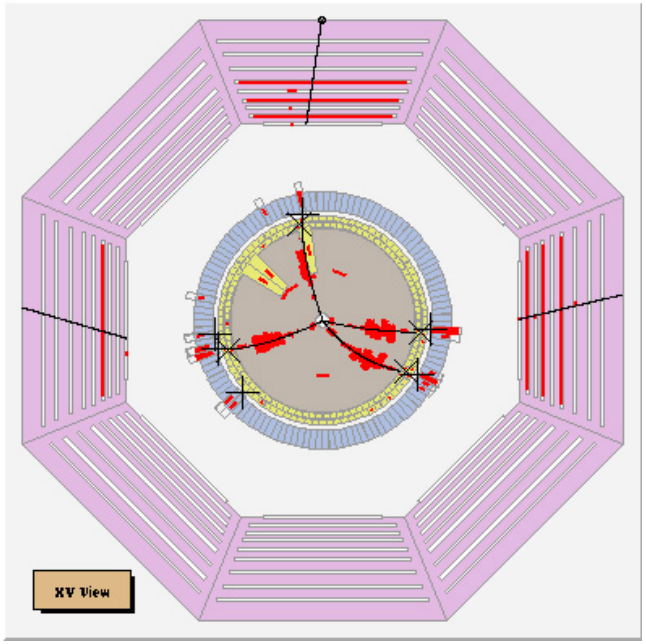
Thanks for your attention!

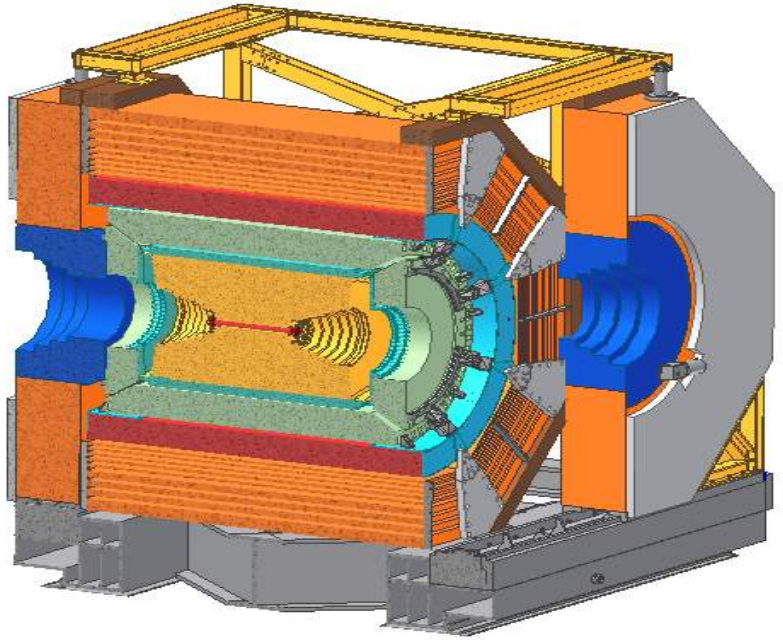
Backup slides

BESIII Commissioning and data taking milestones

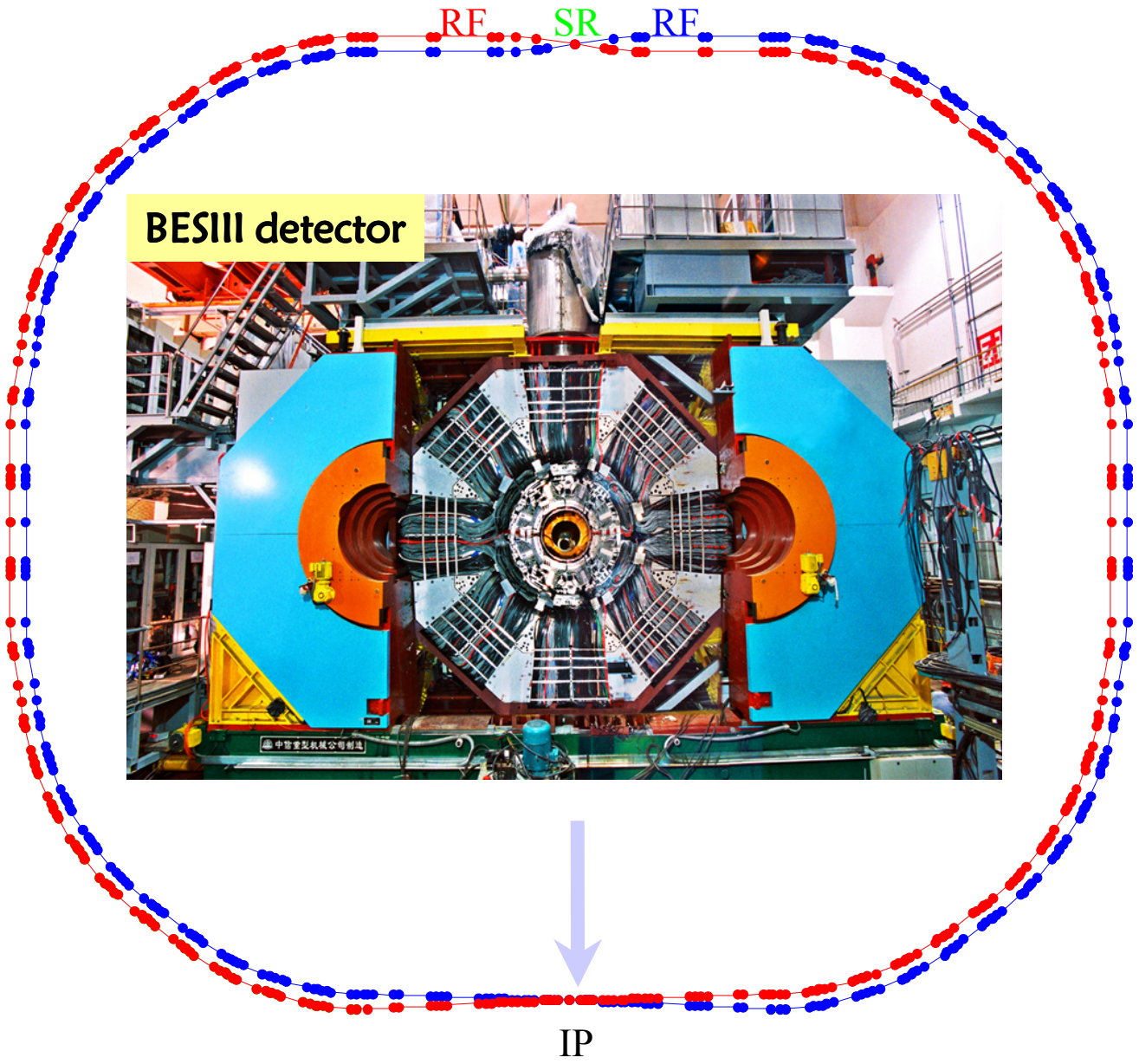
Mar. 2008: first full cosmic-ray event
April 30, 2008: Move the BESIII to IP
July 19, 2008: First e^+e^- collision event in BESIII
Nov. 2008: ~ 14M $\psi(2S)$ events collected
April 14, 2009 ~110M $\psi(2S)$ events collected
May 30, 2009 42 pb^{-1} at continuum collected
July 28, 2009 ~200M J/ψ events collected

Peak Lumi. @ Nov. 2008:
$1.2 \times 10^{32} cm^{-2} s^{-1}$
Peak Lumi. @ May 2009:
$3.2 \times 10^{32} cm^{-2} s^{-1}$



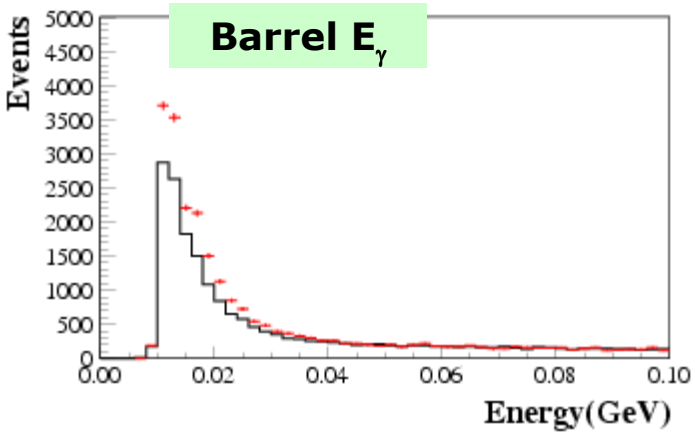


BEPC II Storage ring: Large angle, double-ring

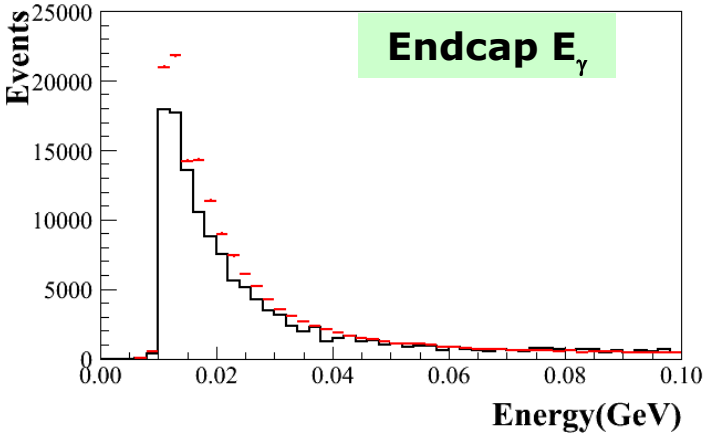


Beam energy:
1.0-2 .3GeV
Luminosity:
1×10^{33} $cm^{-2}s^{-1}$
Optimum energy:
1.89 GeV
Energy spread:
5.16×10^{-4}
No. of bunches:
93
Bunch length:
1.5 cm
Total current:
0.91 A

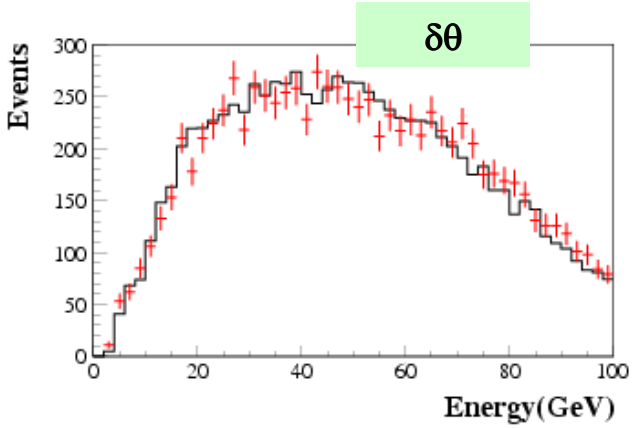
Good photon selection



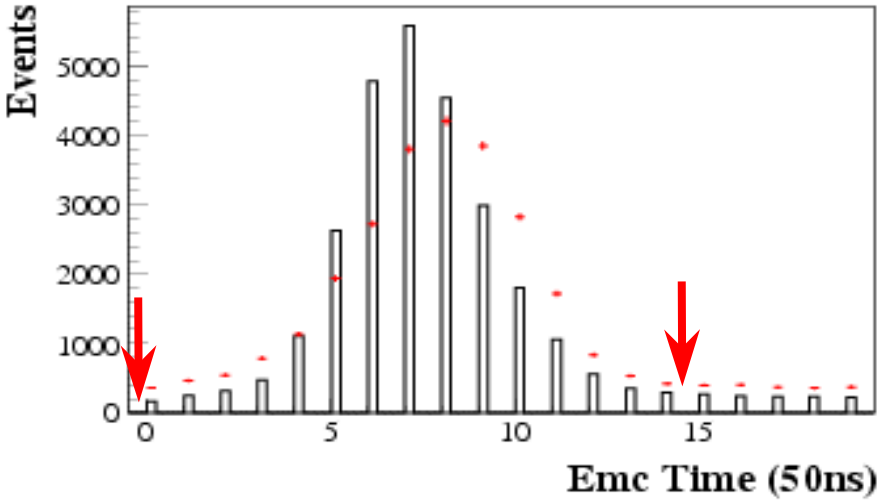
Barrel(|cosθ|<0.8): Eγ > 25MeV



Endcap(0.84<|cosθ|<0.92):
Eγ > 50MeV



Angle between neutral track and the nearest charged track δθ<20°



Time window for the EMC signals

Event selection – for $h_c \to \gamma\eta_c$

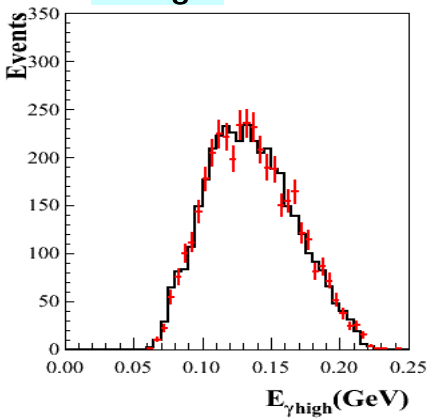
- **π^0 selection**
  - Photon polar angle: $|\cos\theta|<0.8$
  - Photon energy: $E_\gamma>40$MeV
  - Each photon belongs to only one π^0
  - $M_{\gamma\gamma} \in [0.12, 0.145]$GeV/$c^2$
  - Perform 1C kinematic fit for each π^0 candidate (no χ^2 requirement)

- **E1-photon tagging in $h_c \to \gamma\eta_c$**
  - $450\text{MeV}<E_\gamma<540\text{MeV}$
  - Veto π^0 (0.100–0.145GeV/c^2)
  - Veto η (0.530–0.560GeV/c^2)

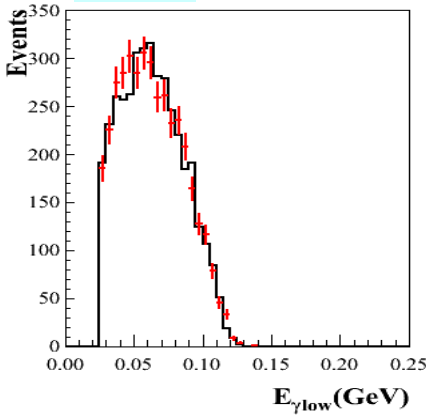
If the invariant mass of the E1 photon and any other photon in the event is compatible with either a π^0 or a η, the E1 photon candidate is rejected.

Distributions of π^0 candidate and $\pi\pi$ recoiling mass

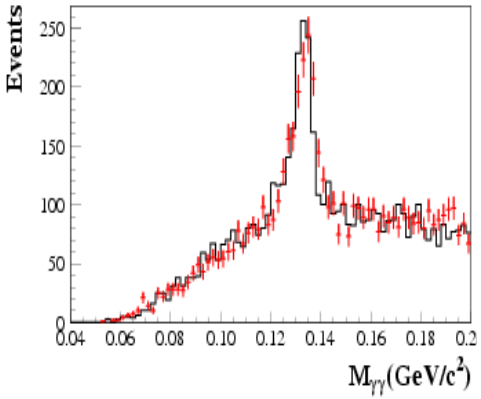
E_{high}



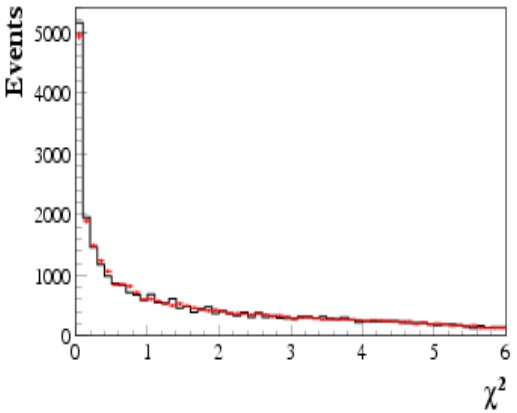
E_{low}



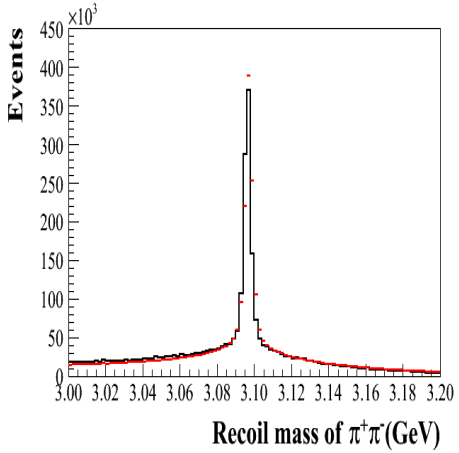
$M_{\gamma\gamma}$



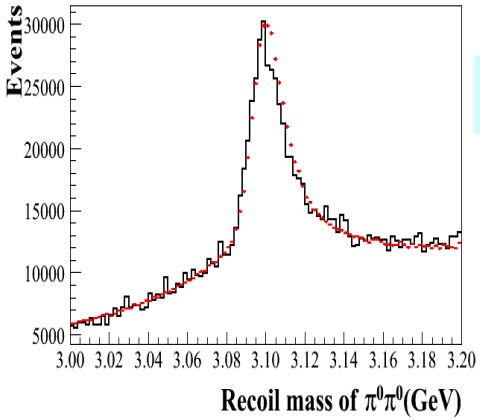
χ^2 of 1C



$\pi^+\pi^-$ recoil mass



$\pi^0\pi^0$ recoil mass



DATA/MC agree well

Mothed	**BESIII** preliminary results	CLEOc [PRL 101, 182003 (2008)]
E1-tag	Counts : 2540 ± 261	1146 ± 118
	significance : 16.5σ	10.0σ
	$M(h_c) = 3525.35 \pm 0.16 \pm 0.10$ MeV	$3525.35 \pm 0.23 \pm 0.15$ MeV
	• $\Gamma(h_c) = 0.89 \pm 0.57 \pm 0.23$ MeV	------
	$Br[\psi(2S) \to \pi^0 h_c] Br[h_c \to \gamma\eta_c]$	
	$= (4.69 \pm 0.48_{stat.}) \times 10^{-4}$	$(4.22 \pm 0.44 \pm 0.52) \times 10^{-4}$
π^0-recoil spectrum	• $Br[\psi(2S) \to \pi^0 h_c] = (8.42 \pm 1.29_{stat.}) \times 10^{-4}$	---------
	• $Br[h_c \to \gamma\eta_c] = (55.7 \pm 6.3_{stat.})\%$	---------

• indicate the first measurement

- **BESIII preliminary results are consistent with CLEOc**
- **measurements**
- **Precision is improved**
- **First measurements: $\Gamma(h_c)$, $Br[y(2S) \to p^0 h_c]$, $Br(h_c \to g h_c)$**

• Event selection $\psi(2S) \to \gamma\chi_{cJ} \to \gamma\phi\phi \to \gamma 2(K^+K^-)$

Common selection criteria:

– photon

$\delta\theta > 20^\circ$, $|\cos\theta| < 0.93, E_\gamma \geq 20$ MeV

– charged tracks

$|V_z| < 10$ cm && $|V_r| < 1$cm, $|\cos\theta| < 0.93$

Event selection for $\psi(2S) \to \gamma\chi_{cJ} \to \gamma\phi\phi \to \gamma 2(K^+K^-)$:

-- $N_{Charged} = 4$ && $\Sigma Q_i = 0$ && $N_\gamma \geq 1$

-- 4C loop over N_γ, γ cluster with minimum χ^2 remained

-- 2 ϕ reconstruction: minimize $\Delta = \sqrt{(M_{KK}^{(1)} - m_\phi)^2 + (M_{KK}^{(2)} - m_\phi)^2}$

-- ϕ selection: $|M_{KK}^{(i)} - m_\phi| < 0.015$ GeV ($\sigma = 0.003$ GeV)

-- $\chi^2 < 20$

Event selection for $\chi_{cJ} \to \omega\omega \to 2(\pi^+\pi^-\pi^0)$

-- $N_{Charged}=4$ && $\Sigma Q_i=0$

-- 4C loop over N_γ, γ cluster with minimum χ^2 remained

-- 2 π^0 reconstruction: minimize $\Delta=\sqrt{(M^{(1)}_{\gamma_1\gamma_2}-m_{\pi^0})^2+(M^{(2)}_{\gamma_3\gamma_4}-m_{\pi^0})^2}$

-- ω reconstruction: by minimizing the $|M^{(i)}_{\pi^+\pi^-\pi^0}-m_\omega|$ to reconstrut one one ω, and another ω is reconstructed with the rest three pions.

-- π^0 selection: $0.11<M_{\gamma\gamma}<0.15$ GeV

-- ω selection: $|M^{(i)}_{\pi^+\pi^-\pi^0}-m_\omega|<0.04$ GeV $(\sigma=0.013$ GeV$)$

-- $\chi^2<100$

-- veto $\psi(2S)\to\pi^+\pi^-J/\psi\to\gamma 2(\pi^+\pi^-\pi^0)$

$|m_{\pi\pi-rec}-m_{J/\psi}|>0.008$ GeV

Available online at www.sciencedirect.com
ScienceDirect
Physics Letters B 642 (2006) 197–202
PHYSICS LETTERS B
www.elsevier.com/locate/physletb

Measurements of $\chi_{cJ} \to K^+K^-K^+K^-$ decays

BES Collaboration

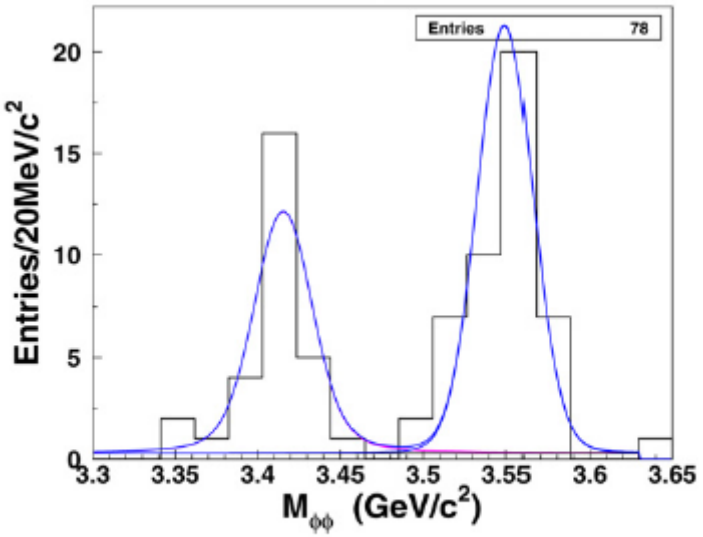


Fig. 8. Fit to χ_{cJ} signals in $\phi\phi$ final state.

Table 1
Systematic error (%). In the wire resolution row, the numbers from left to right correspond to $\psi(2S) \to 2(K^+K^-)$, ϕK^+K^-, and $\phi\phi$

Source		χ_{c0}	χ_{c1}	χ_{c2}
Wire resolution		8.9, 9.8, 10.0	9.3, 9.9, –	9.7, 9.6, 10.1
Particle ID		8	8	8
Photon efficiency		2	2	2
Background shape		negligible	negligible	negligible
Number of $\psi(2S)$		4	4	4
$\mathcal{B}(\psi(2S) \to \gamma\chi_{cJ})$		4.3	4.6	4.9
$\mathcal{B}(\phi \to K^+K^-)$		1.2	1.2	1.2
Total	$\chi_{cJ} \to 2(K^+K^-)$	13.5	13.9	14.3
	$\chi_{cJ} \to \phi K^+K^-$	14.1	14.3	14.2
	$\chi_{cJ} \to \phi\phi$	14.3	–	14.5