Status of the BESIII Experiment

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For the BESIII Collaboration

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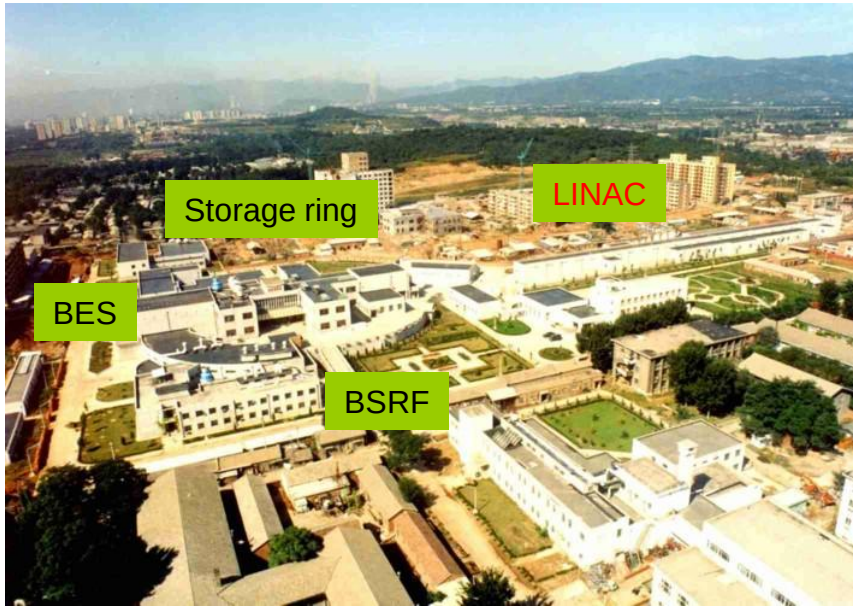
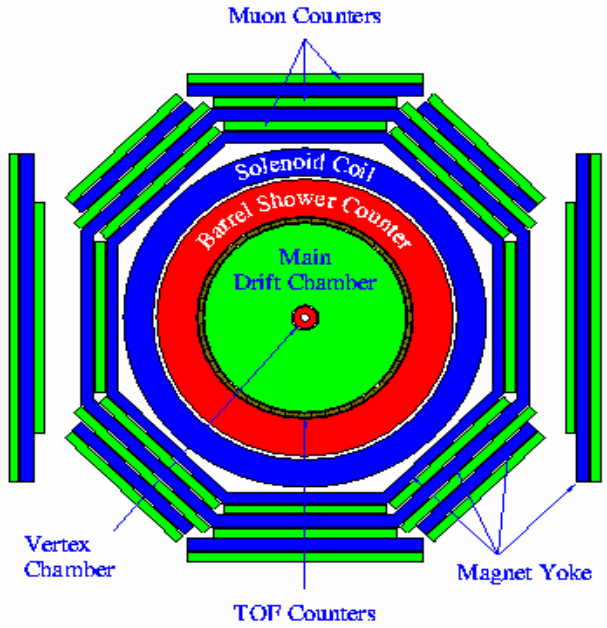
Outline

- BEPCII/BESIII performance
- Physics results
- Data-taking plan
- Detector upgrade
- Summary

The BEPC/BESII upgrade project started in 2004

BEPC (Beijing Electron Positron Collider)	BESII (Beijing Spectrometer)

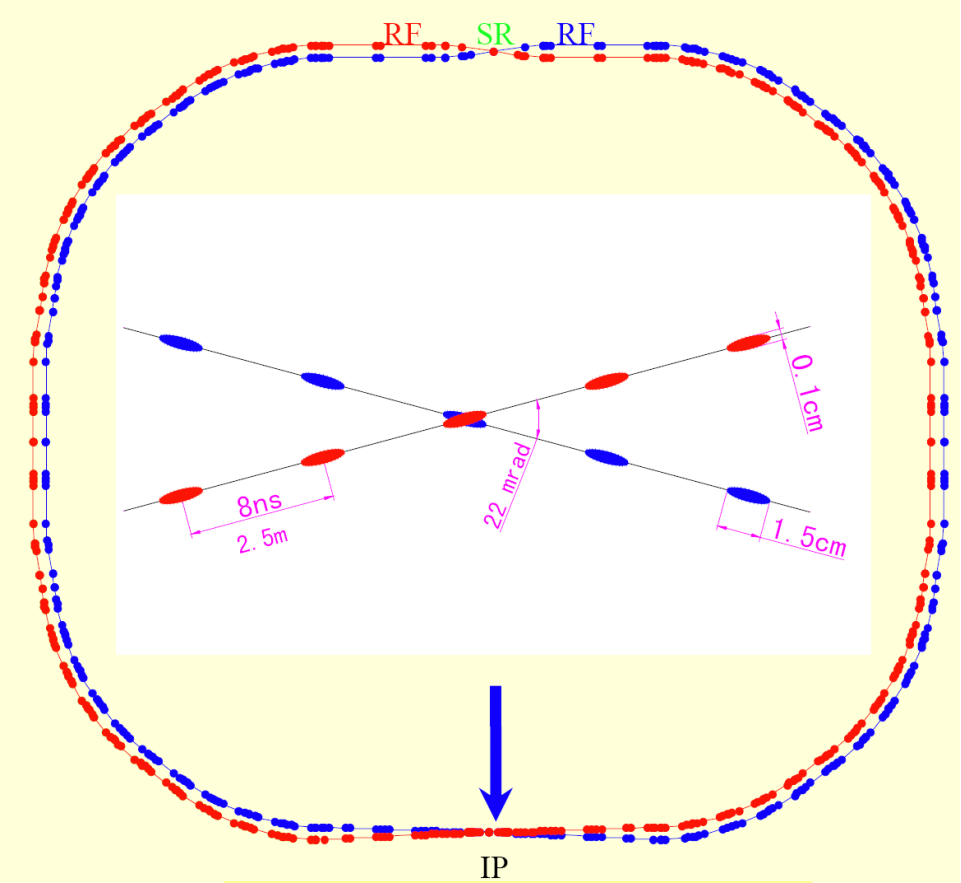




CM Energy ranges from 2 to 5 GeV

Luminosity at $J/\psi \sim 5 \times 10^{30}\ cm^{-2}\ s^{-1}$

BEPCII: a high luminosity double-ring collider



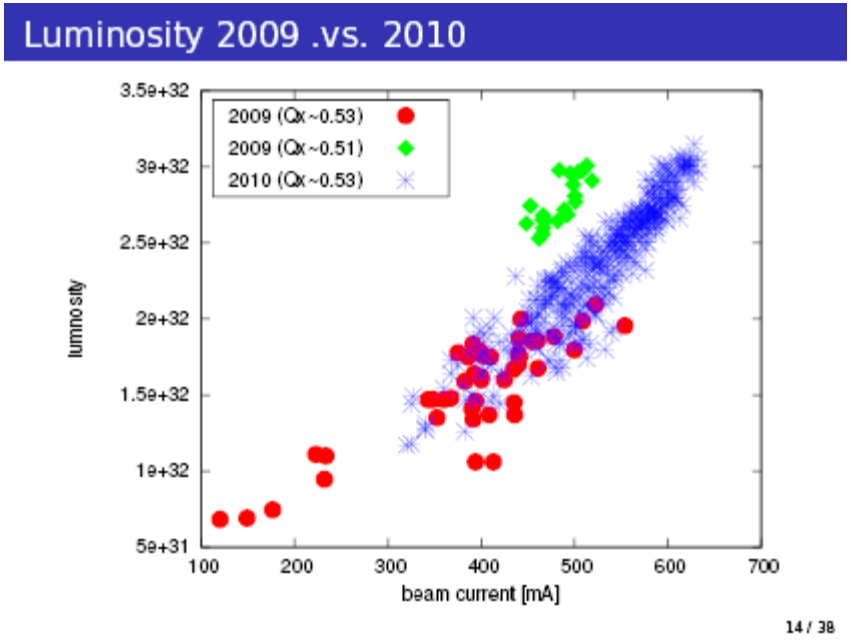
Use many bunches and SC mini-beta

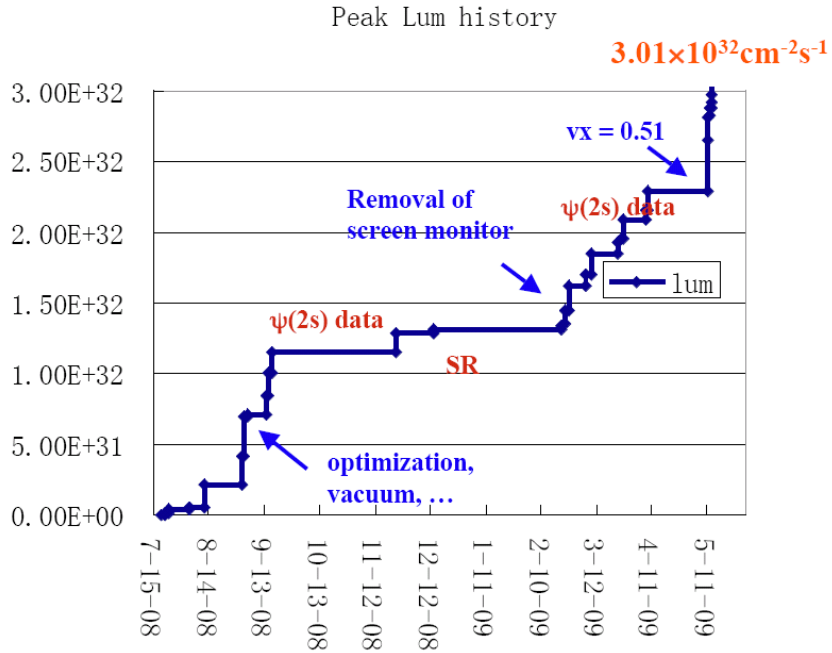
Beam energy:
1.0-2.3 GeV
Luminosity:
1×10^{33} $cm^{-2}s^{-1}$
Optimum energy:
1.89 GeV
Energy spread:
5.16×10^{-4}
No. of bunches:
93
Bunch length:
1.5 cm
Total current:
0.91 A
SR mode:
0.25A @ 2.5 GeV

Luminosity improvement

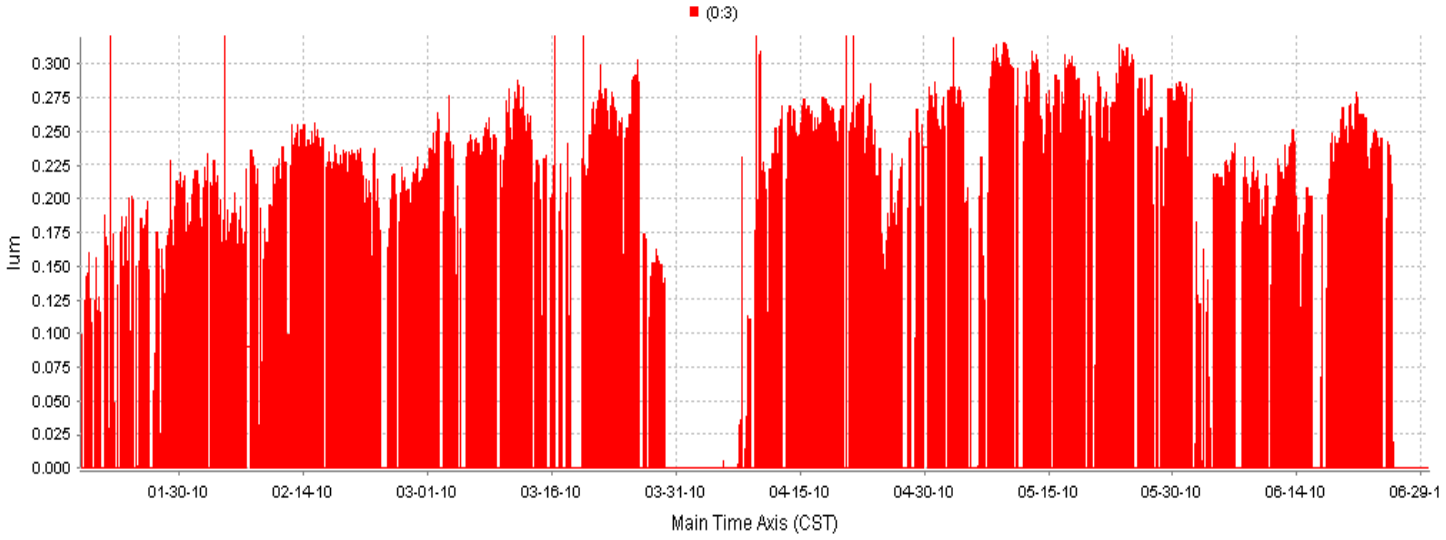
Optimization
Debug systems
Increase currents
Increase luminosity

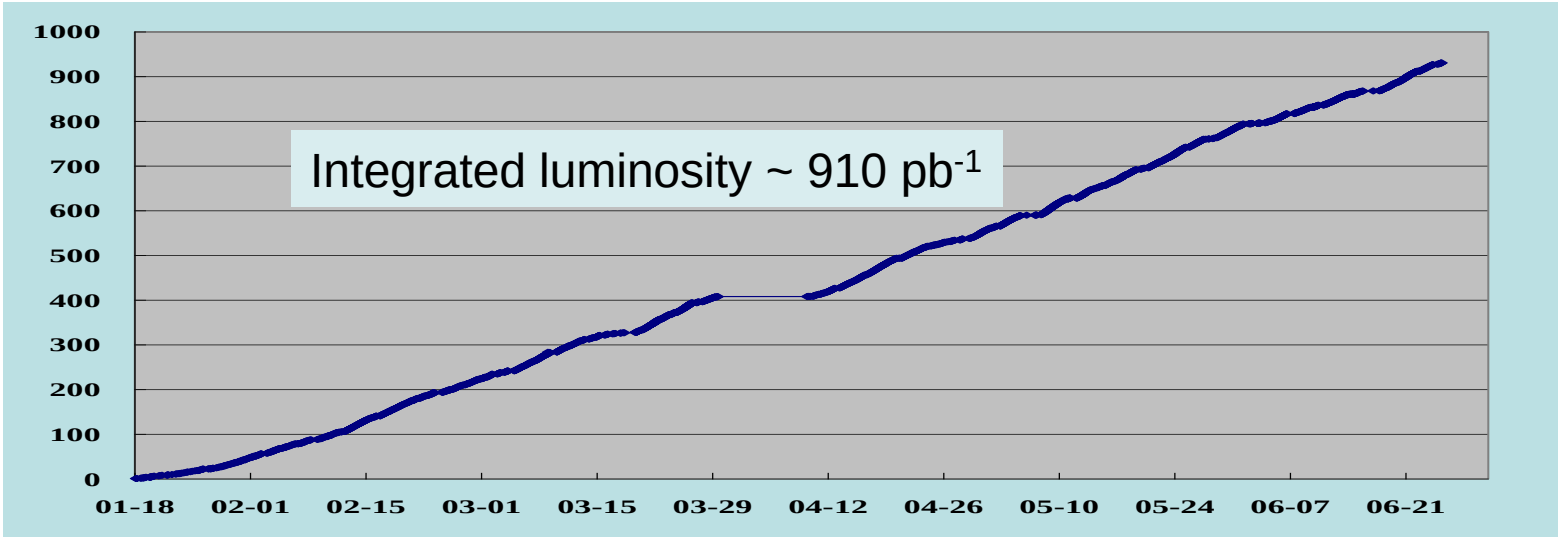
BEPCII peak luminosity trend
(2008-7-15 to 2009-5-13)
Peak luminosity of 3.0×10^{32}
achieved on May 13, 2009
at about 2×500mA, with 71 bunches.





Luminosity from Jan. 16- June 27 2010@ψ(3770)





Main parameters achieved in collision mode

parameters	design	Achieved	
		BER	BPR
Energy (GeV)	1.89	1.89	1.89
Beam curr. (mA)	910	650	700
Bunch curr. (mA)	9.8	>10	>10
Bunch number	93	93	93
RF voltage	1.5	1.5	1.5
* ν_s @1.5MV	0.033	0.032	0.032
β_x^*/β_y^* (m)	1.0/0.015	~1.0/0.0135	~1.0/0.0135
Inj. Rate (mA/min)	200 e^-/50 e^+	>200	>50
Lum. ($\times 10^{33} cm^{-2}s^{-1}$)	1	0.33	

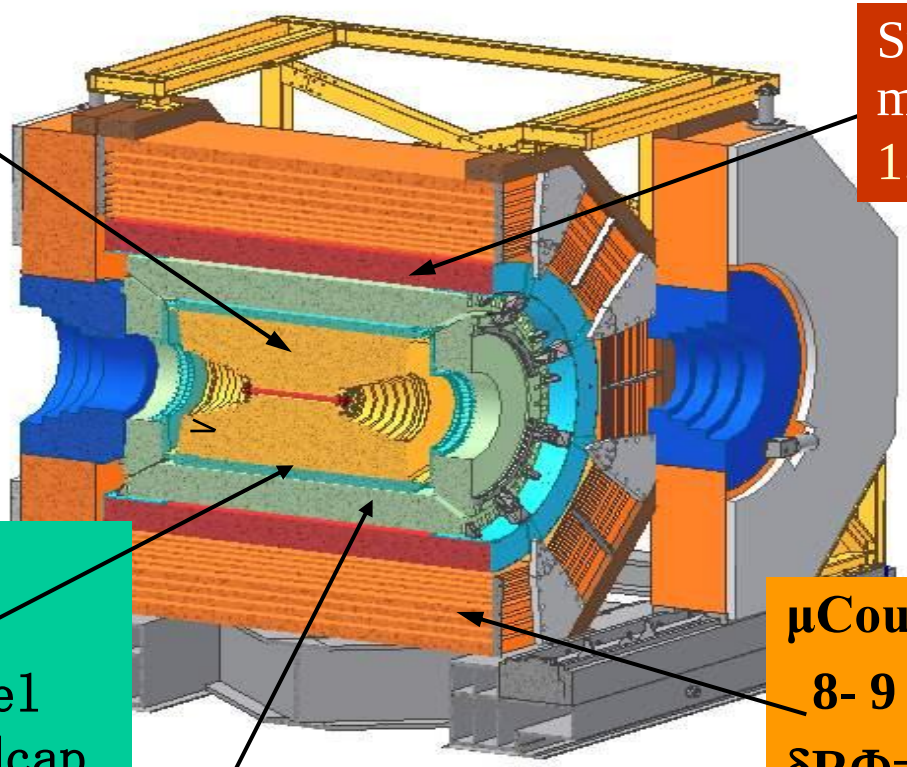
BESIII Detector

NIM A614 (2010)

Main Drift Chamber (MDC)

$\triangle P/P\ (^0/_0) = 0.5\text{-}0.7\ \%$ (1 GeV)

$\sigma_{dE/dx}\ (^0/_0) = 6\text{-}8\%$



Super-conducting magnet
1.0 tesla

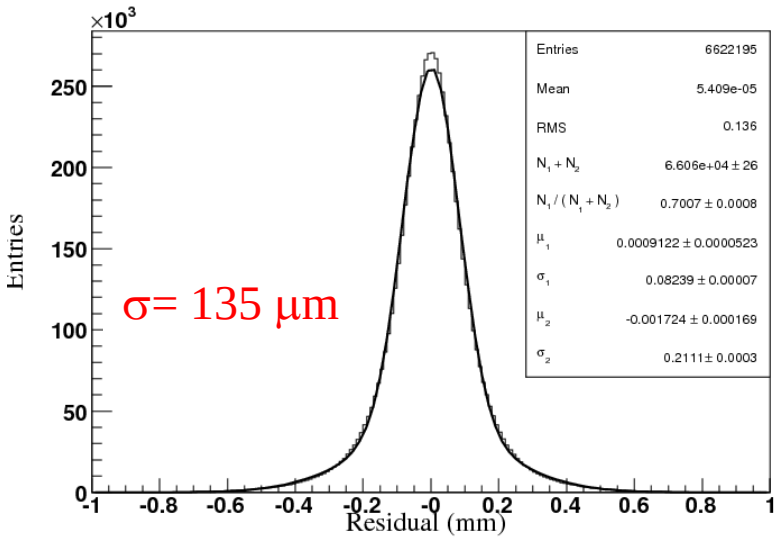
Time Of Flight (TOF)

σ_T (ps)=80−90 ps Barrel
100−110 ps endcap

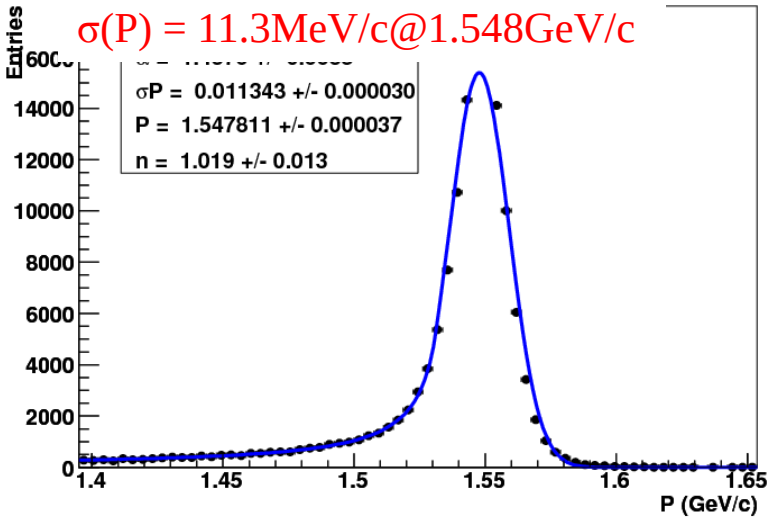
μCounter
8- 9 layers RPC
$\delta R\Phi$=1.4 cm~1.7 cm

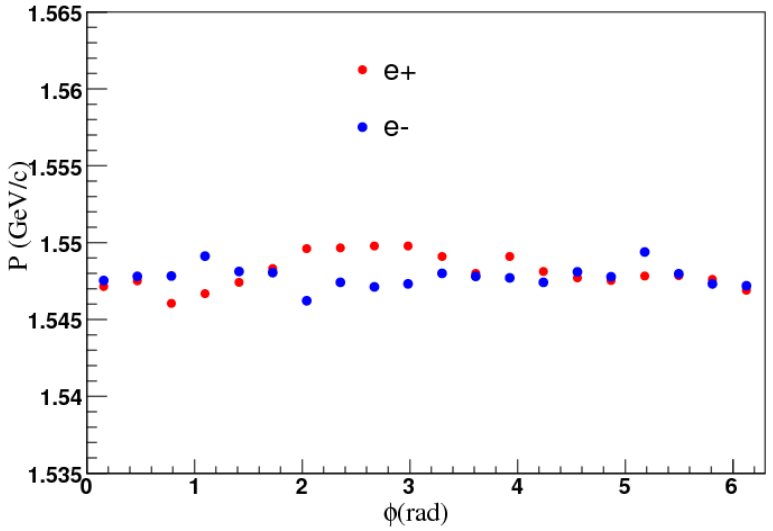
EMC: $\triangle E/\sqrt{E}(^0/_0) = 2.5\text{ -}3\ \%$ (1 GeV)
(CsI) $\sigma_{z,\phi}$(cm) = 0.5 - 0.7 cm/$\sqrt{E}$

MDC performance

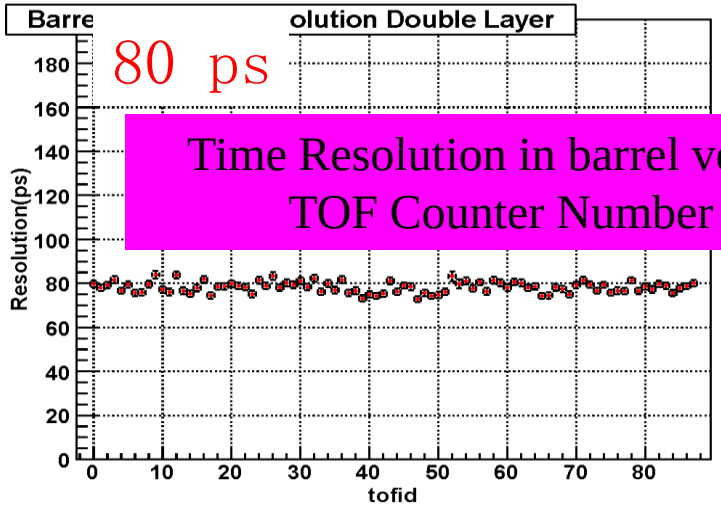


For Bhabhas in J/ψ data, spatial resolution is135μm and σ(P) is 11.3MeV/c.

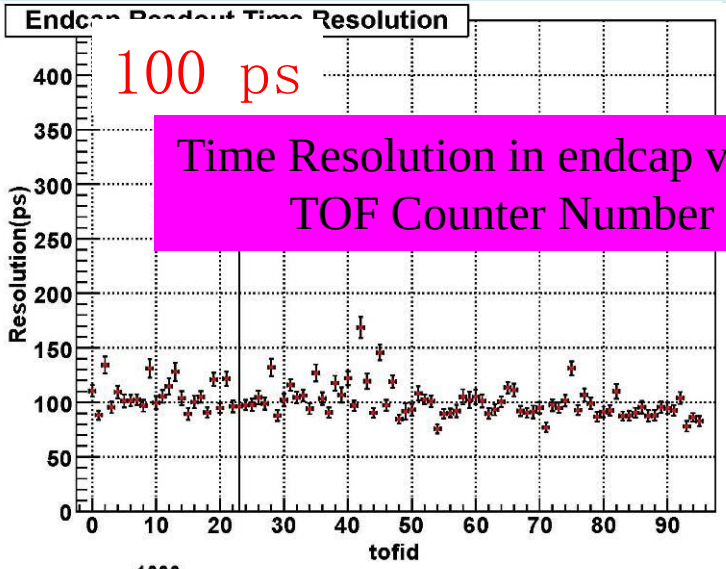




PID: time resolution in TOF

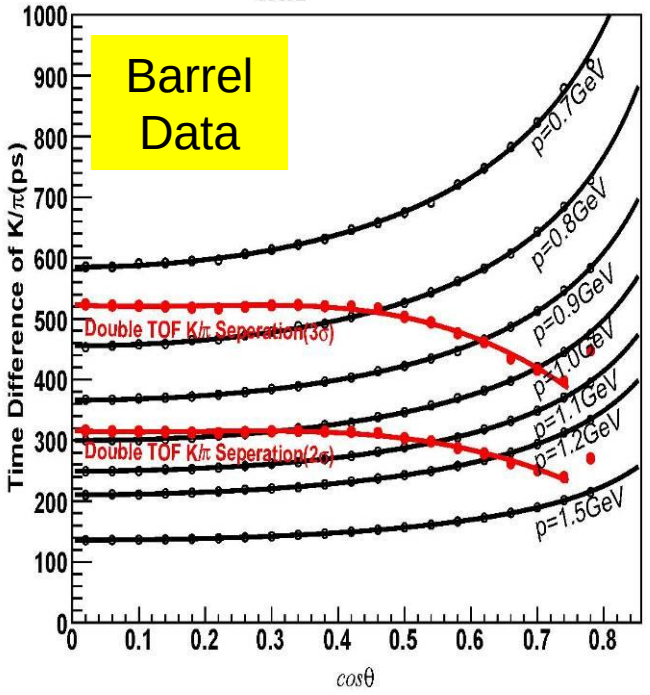


Time Resolution in barrel versus TOF Counter Number



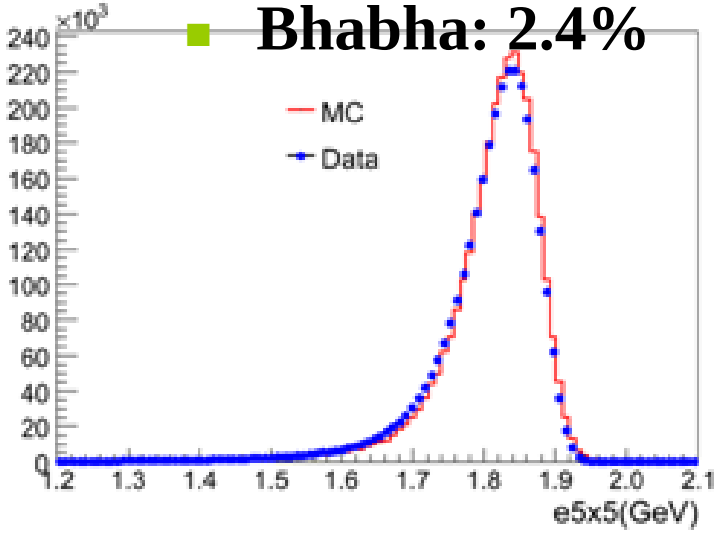
Time Resolution in endcap versus TOF Counter Number

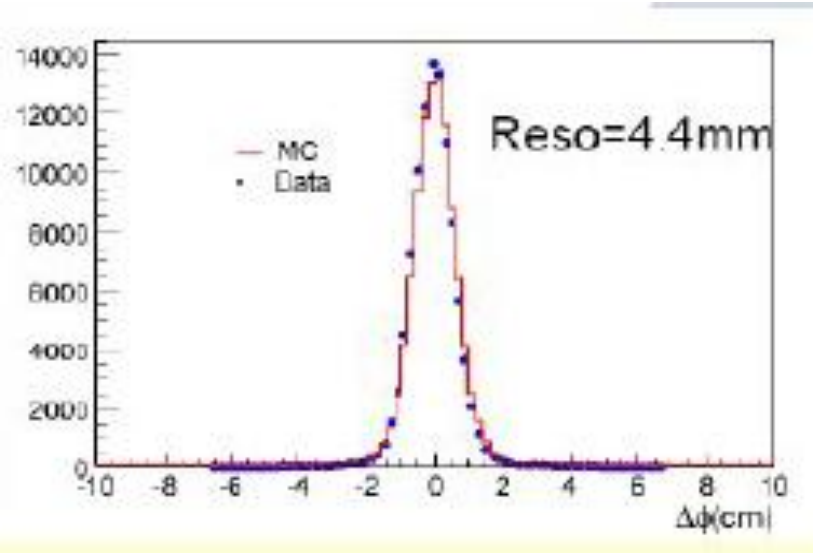
The momentum of 2σ K/π separation achieved 0.96GeV/c for barrel double layers TOF

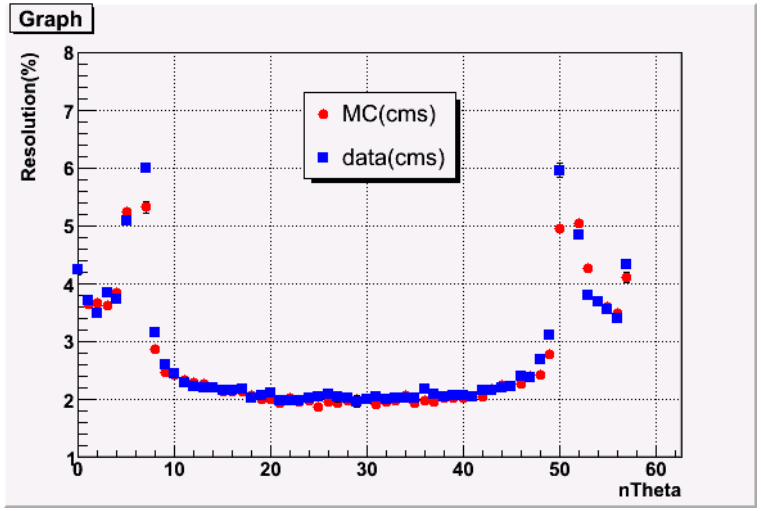


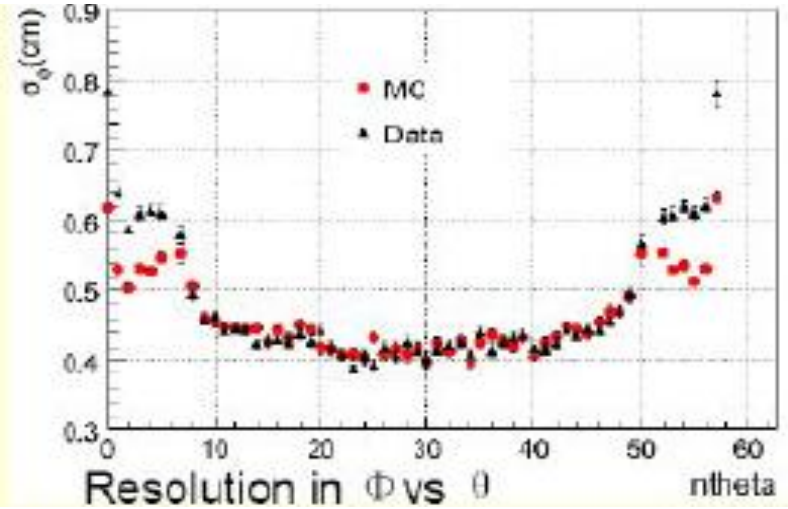
Resolutions in EMC from ψ(2S) data

- **Bhabha: 2.4%**







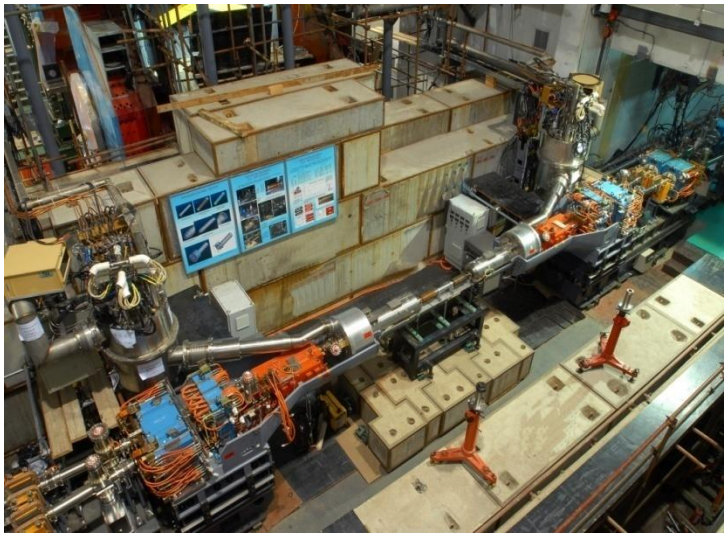


BESIII performance

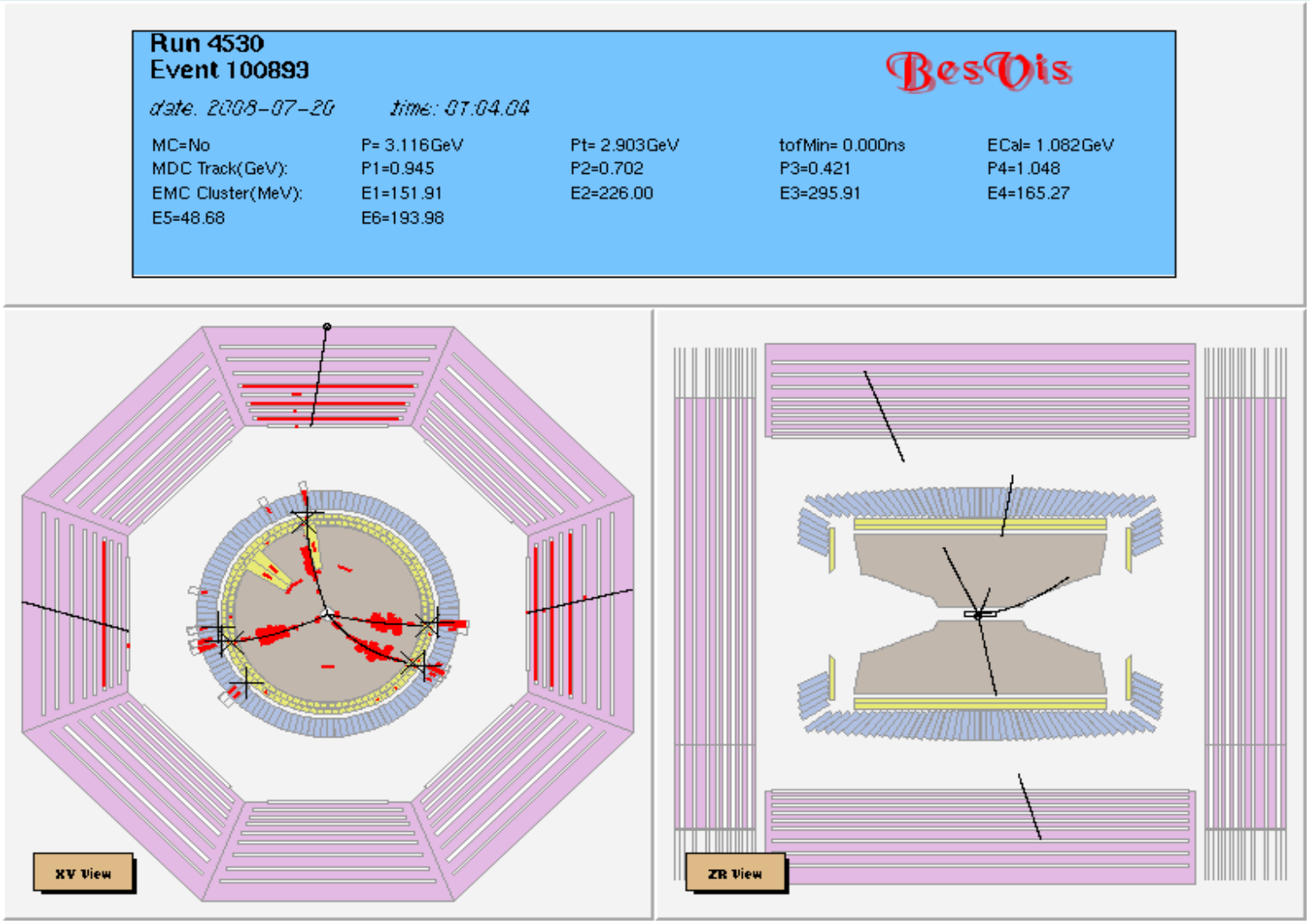
Sub-detectors			design	measurement
MDC	Momentum resolution (1 GeV)		0.5-0.7%	0.58 %
	dE/dx resolution		6-8%	6.0% (hadron) 5.3% (Bhabha)
EMC	Energy resolution (1 GeV)		2.5-3%	2.5 %
	Spatial resolution		5-7 mm	6.0 mm
TOF	Time resolution	Barrel	80-90 ps	80 ps (Bhabha)
		Endcap	100-110 ps	100 ps (dimuon)
μ counter	$\delta_{R\Phi}$=1.4 cm~1.7 cm			< 1.7 cm

BEPCII/BESIII Milestones

Oct. 25-31, 2007: accumulation of electron/positron beams
Nov. 18, 2007: first e+e- collision without BESIII detector
Mar. 2008: Collision at 500 mA × 500 mA, Lumi.: 1 ×10^{32} $cm^{-2}s^{-1}$
April 30, 2008: Move the BESIII to IP
July 20, 2008: First e+e- collision event in BESIII
April 14, 2009 BESIII 106M ψ(2S) events (~40 days)
May 14, 2009 BEPCII Lumi. ~ 3 X$10^{32}$$cm^{-2}s^{-1}$
July 28th, 2009 BESIII 226M J/ ψ events (41 days)
Jan. 16--June 27 2010, 910 pb^{-1} @ψ(3770), 77 pb^{-1} scan around ψ(3770)



First Hadronic Event on June 20, 2008



Data quality is good

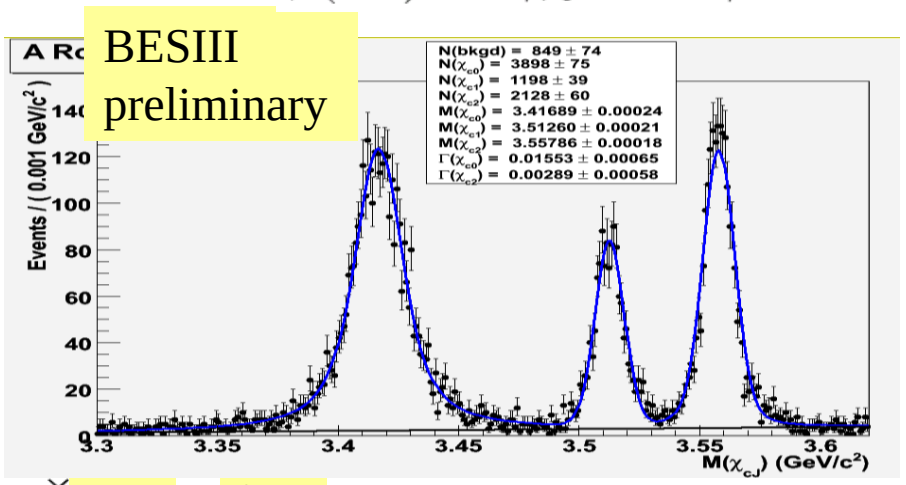
$$\psi(2S) \to \gamma\chi_{cJ} \to \gamma 2\pi^+ 2\pi^-$$

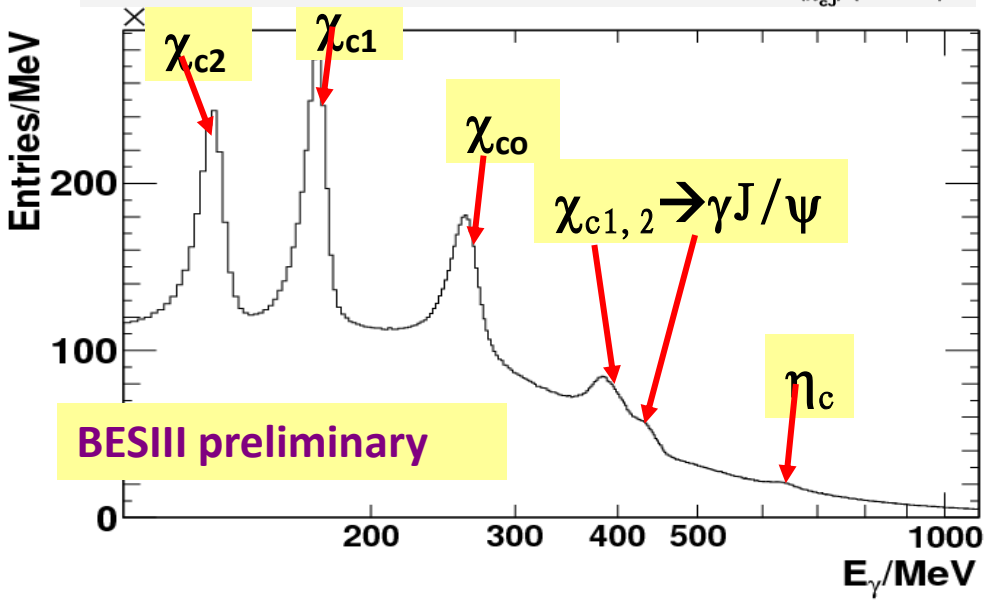
Clean exclusive signals

High statistics

Clear inclusive photon spectrum

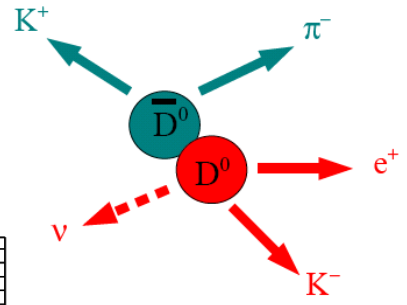
Excellent photon resolution

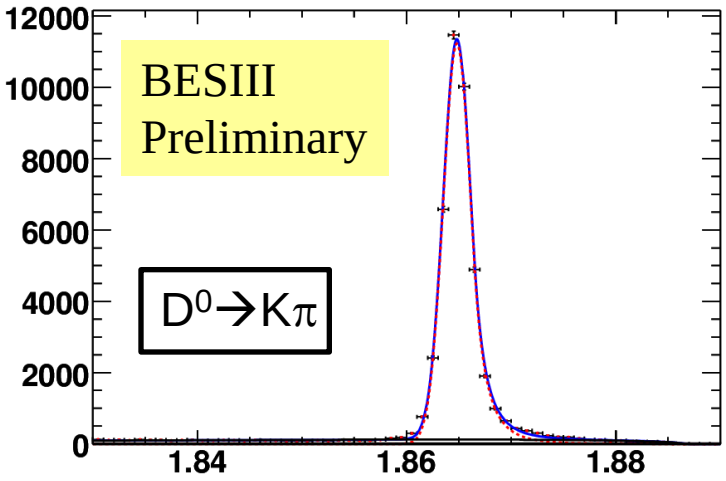


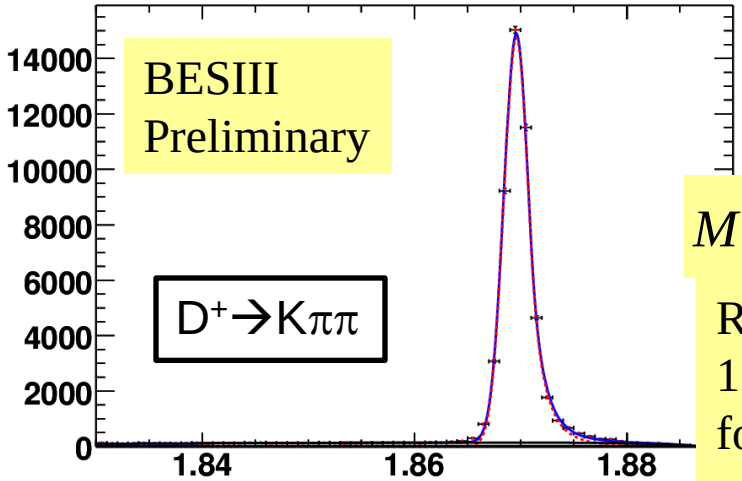


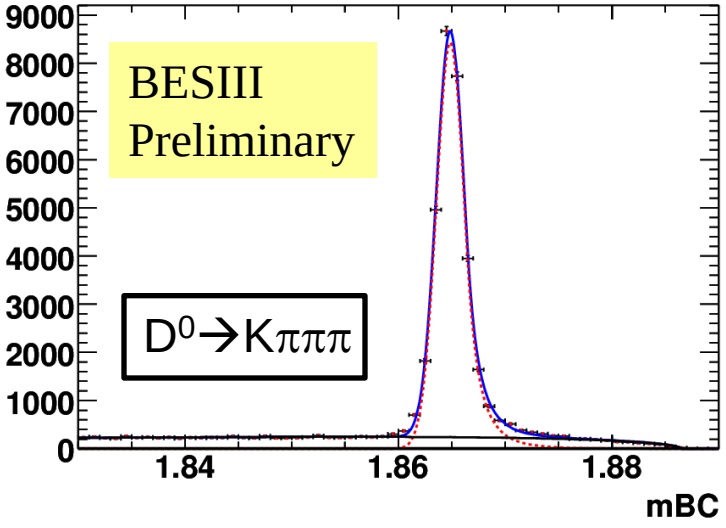
Clean single tag at BESIII

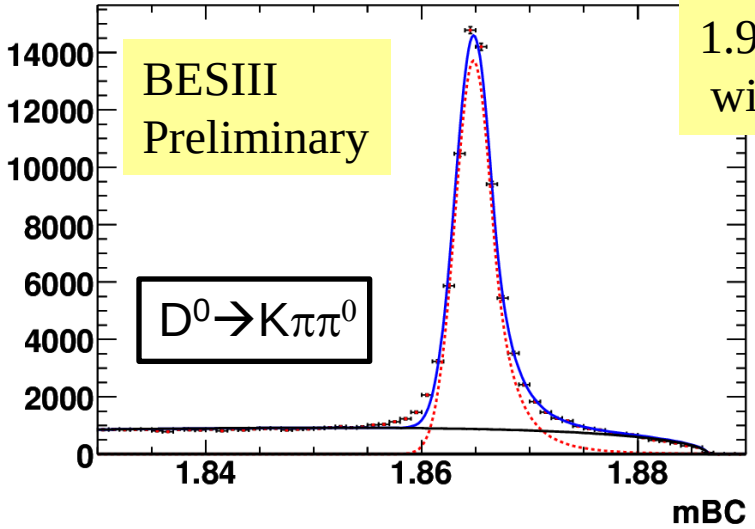
@ψ(3770) with 420pb^{-1} first clean single tagging signals:









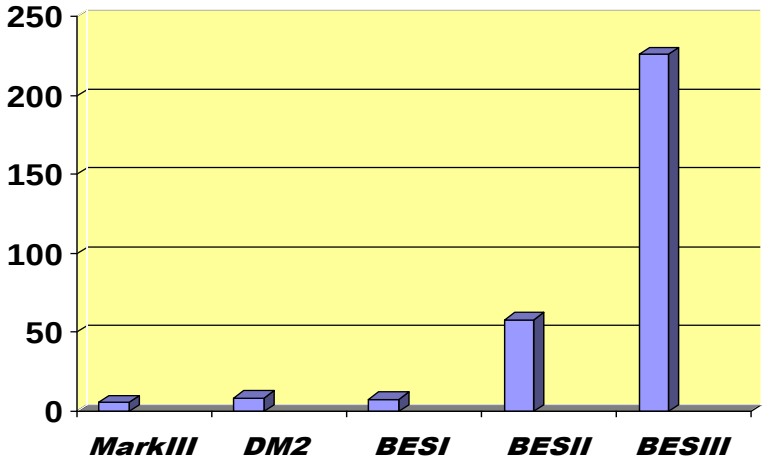


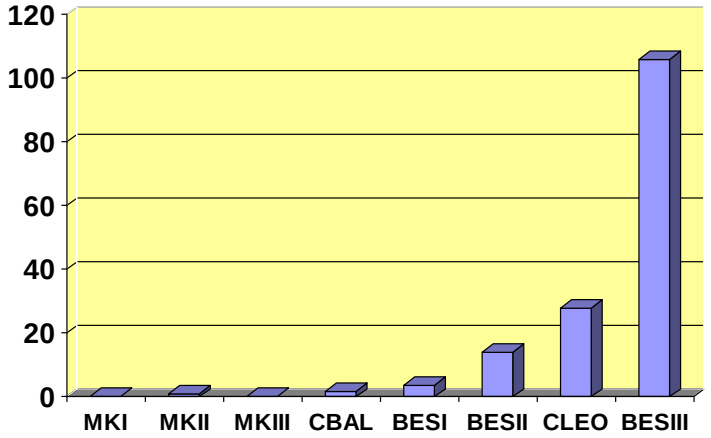
$$M_{BC} = \sqrt{E_{beam}^2 - |\, p_D \,|^2}$$

Resolution:
1.3 MeV
for pure charged modes;
1.9 MeV for modes with one π^0.

Data samples at BESIII

BESIII: J/ψ 2009 – 226M ψ(2S) 2009 – 106M

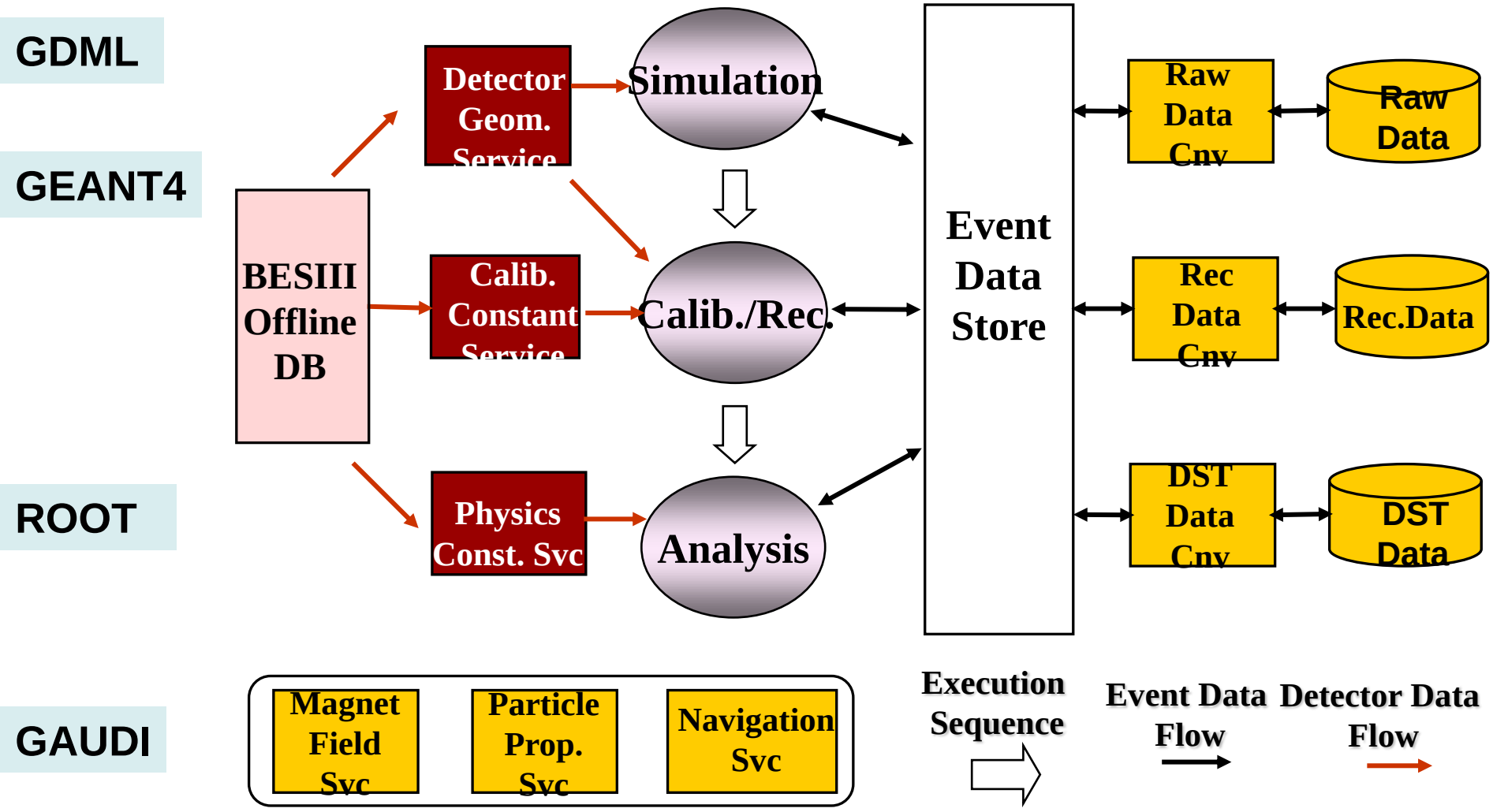




BESIII: ψ(3770) 2010 – 910pb^{-1}

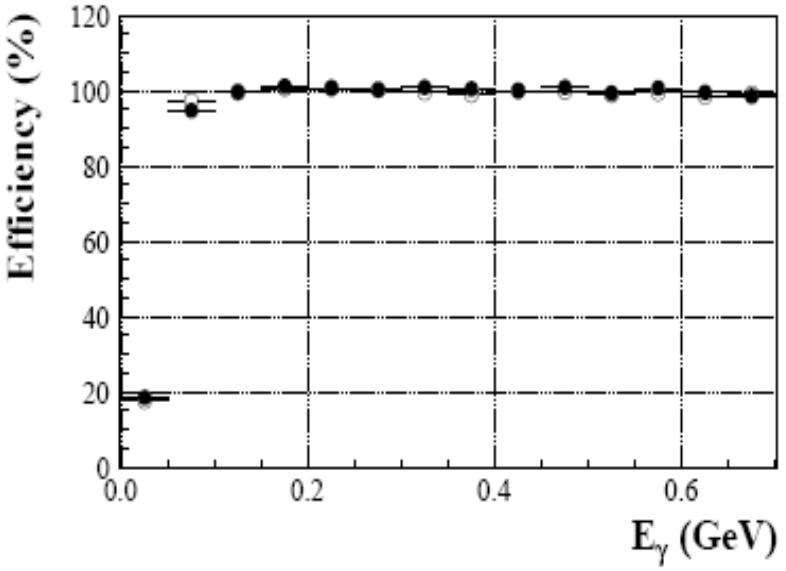
BESIII: 42pb^{-1} @3.65GeV in 2009, 77pb^{-1} scan @ψ(3770) in 2010

BESIII Offline Software System (BOSS)



Software improvement

- **More efforts on**
  - **Alignment**
  - **Calibration**
  - **Tracking algorithm**
  - **MC tuning**

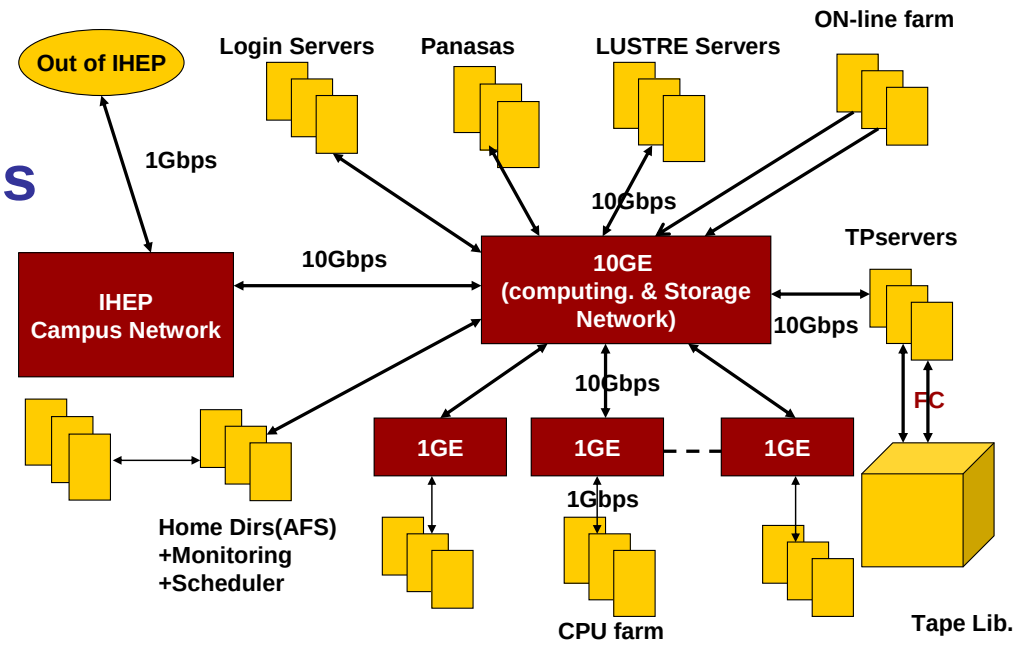


Data/MC difference: at a level of 1%
(tracking, PID, photon detection efficiencies)

Crucial to reduce systematic error !

Computing at IHEP

- **Much powerful**
  - **CPU: ~3000 cores**
  - **DISK: ~500 TB**
  - **TAPE: ~1.2PB**

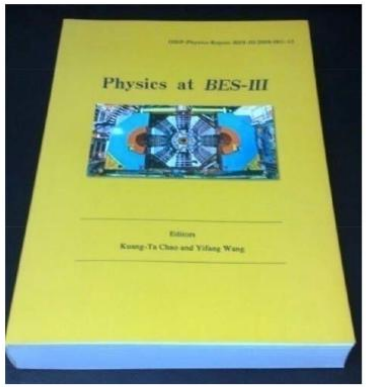


Disk space: 1.2 PB by the end of this year

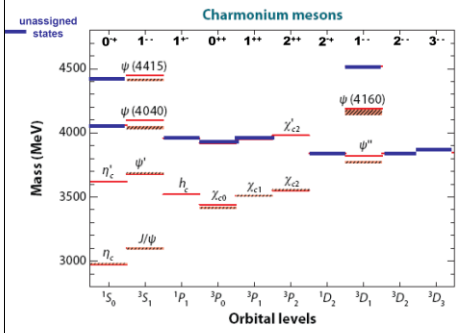
A PC farm (100 GPU) will be built for PWA

Physics program at BESIII

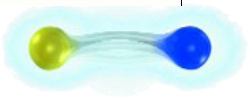
Charmonium physics
-- Spectroscopy and decays
-- New hidden charm



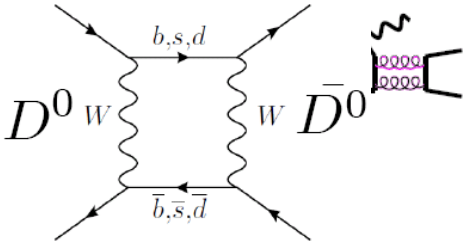
arXiv: 0809.1869

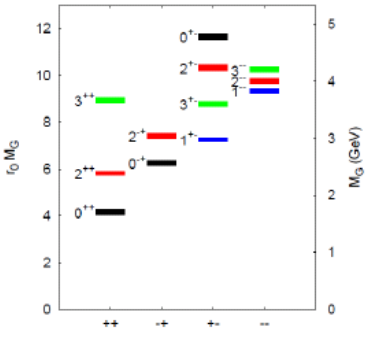


Light hadron
-- **Establish spectrum of light hadrons**
-- **Search for non-conventional hadrons**
-- **Understand how hadrons are formed**

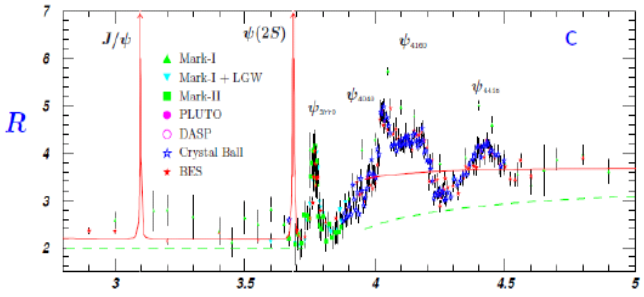


Charm physics
-- **Decay constant, form factors**
-- **D^0 $\bar{D}^0$ mixing and CPV**
-- **CKM: Vcs and Vcd**





Tau and QCD
-- **Tau mass and Tau decays**
-- **QCD: R values …**



BESIII physics results

- BESIII results published
  - **Branching fraction measurements of χ_{c0} and χ_{c2} to $\pi^0\pi^0$ and $\eta\eta$**

    PRD 81, 052005 (2010)
  - **Measurements of $h_c(^1P_1)$ in ψ' decays**

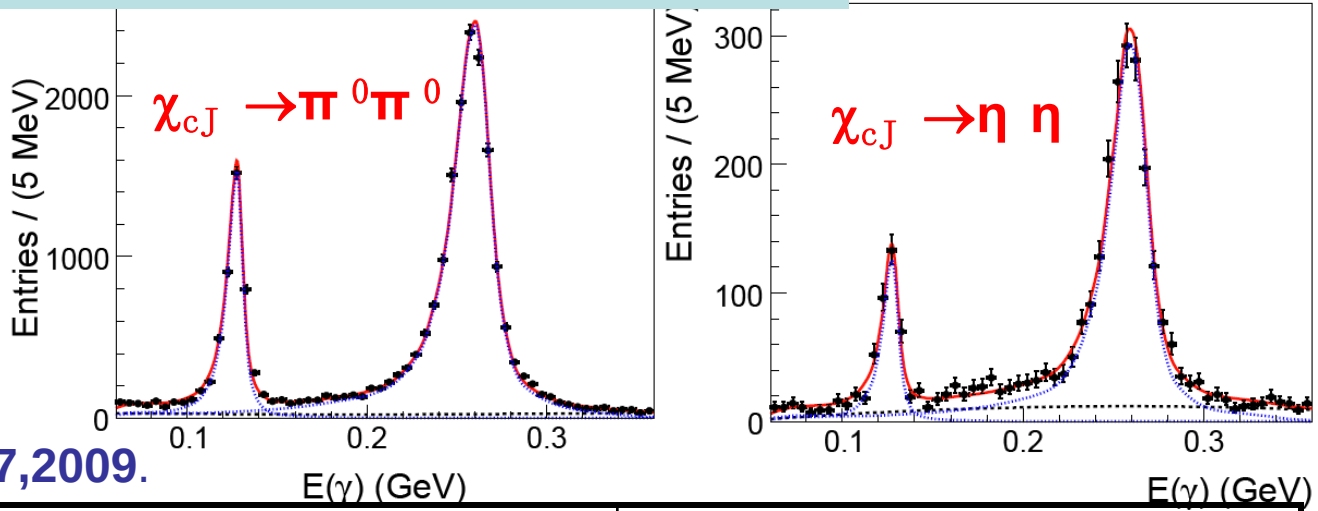
    PRL 104, 132002 (2010)
  - **Observation of a ppbar mass threshold enhancement in $\psi' \to \pi^+\pi^- J/\psi(J/\psi \to \gamma p\bar{p})$ decay**

    CPC 34 (2010)

$\chi_{cJ} \to \pi^0\pi^0$, $\eta\eta$ from $\psi' \to \gamma\chi_{cJ}$ decays

BESIII: PRD 81, 052005 (2010)

Radiative photon spectrum



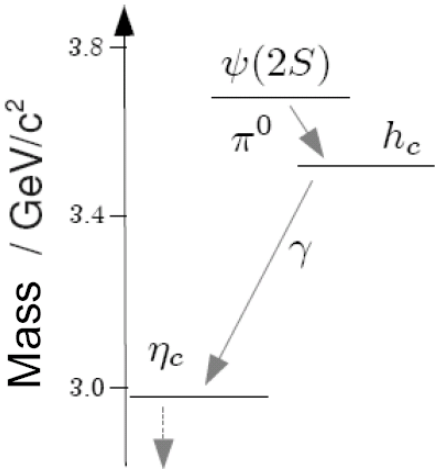
CLEO, PRD79:072007,2009.

Decay mode		χ_{c0} (10^{-3})	χ_{c2} (10^{-3})
$\pi^0\pi^0$	BESIII	$3.23 \pm 0.03 \pm 0.23 \pm 0.14$	$0.88 \pm 0.02 \pm 0.06 \pm 0.04$
	PDG08	2.43 ± 0.20	0.71 ± 0.08
	CLEOc	$2.94 \pm 0.07 \pm 0.32 \pm 0.15$	$0.68 \pm 0.03 \pm 0.07 \pm 0.04$
$\eta\eta$	BESIII	$3.44 \pm 0.10 \pm 0.24 \pm 0.20$	$0.65 \pm 0.04 \pm 0.05 \pm 0.03$
	PDG08	2.4 ± 0.4	<0.5
	CLEOc	$3.18 \pm 0.13 \pm 0.31 \pm 0.16$	$0.51 \pm 0.05 \pm 0.05 \pm 0.03$

CLEO-c used their own measured BRs for $\psi \to \gamma\chi_{cJ}$ decays.

Observation of h_c ($^1P_1$) : $\psi(2S) \rightarrow \pi^0 h_c \rightarrow \gamma\eta_c$

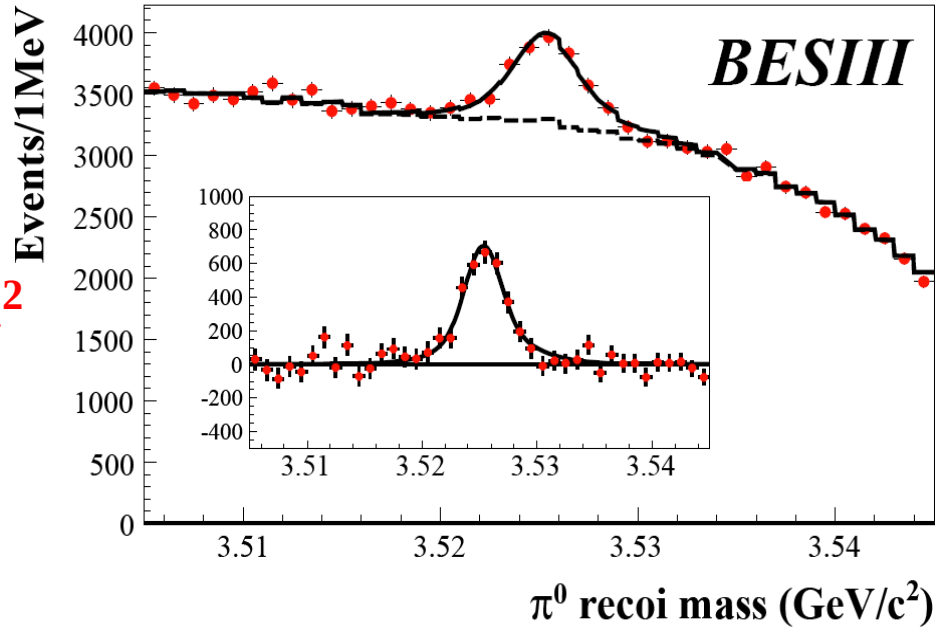
BESIII: PRL 104, 132002 (2010)



- Select inclusive π^0 ($\psi' \rightarrow \pi^0 h_c$)
- Select E1-photon γ to tag $h_c \rightarrow \gamma\ \eta_c$
- Double-Gaussian ⊗ BW signal + E1-photon sideband background.

Results:

- **Br($\psi' \rightarrow \pi^0 h_c$) × Br($h_c \rightarrow \gamma\eta_c$)= $(4.58 \pm 0.40 \pm 0.50) \times 10^{-4}$**
- **M = 3525.40 ±0.13±0.18 MeV/c^2**
- **Γ = 0.73±0.45±0.28 MeV (<1.44 MeV 90%C.L.)**



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

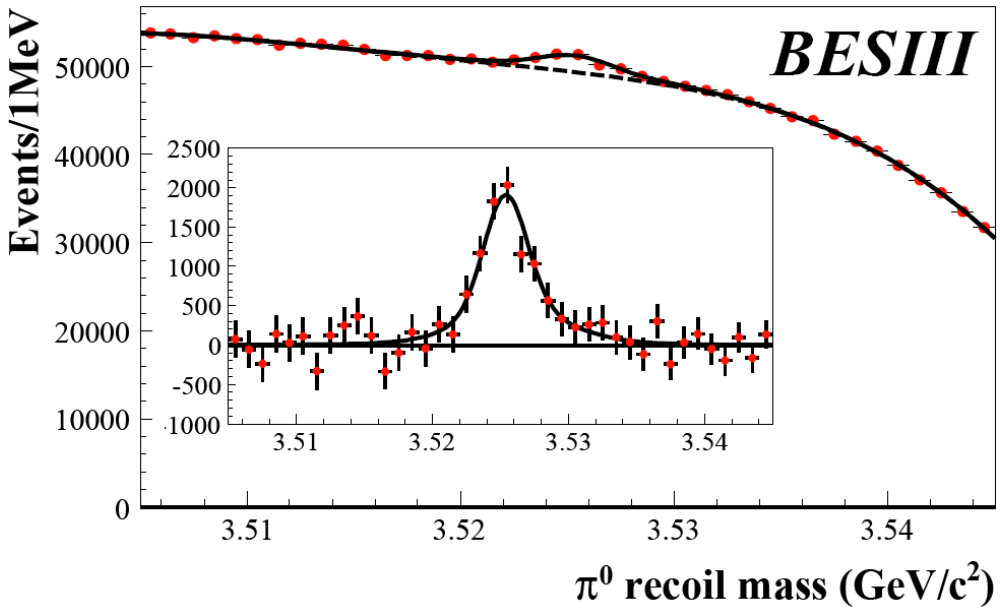
BESIII, PRL 104, 132002 (2010)

- Select inclusive π^0 ($\psi' \rightarrow \pi^0 h_c$)
- D-Gaussian $\otimes$ BW signal + 4th Poly. bkg
- Fit: mass and width fixed as tagged measurement

Combined with tagged results,

we firstly measured:

- **Br($\psi' \rightarrow \pi^0 h_c$) $=(8.4 \pm 1.3 \pm 1.0) \times 10^{-4}$**
- **Br($h_c \rightarrow \gamma \eta_c$) $=(54.3 \pm 6.7 \pm 5.2)\%$**



h_c : analysis summary

BESIII, PRL 104, 132002 (2010)

	BESIII	CLEOc
$Br(\psi' \to \pi^0 h_c) \times Br(h_c \to \gamma\eta_c)$ $[10^{-4}]$	$4.58 \pm 0.40 \pm 0.50$	$4.19 \pm 0.32 \pm 0.45$
M $[MeV/c^2]$	$3525.40 \pm 0.13 \pm 0.18$	$3525.80 \pm 0.23 \pm 0.15$
Γ [MeV]	$0.73 \pm 0.45 \pm 0.28$ <1.44 @ 90%CL	1.1 (NRQCD) Kuang 0.51 (PQCD) Kuang
$\Delta M_{hf}(1P)$ $[MeV/c^2]$	$0.10 \pm 0.13 \pm 0.18$	$0.08 \pm 0.18 \pm 0.12$

CLEO-c Collaboration, Phys.Rev.Lett.101:182003,2008

	BESIII	theoretical prediction
$Br(\psi' \to \pi^0 h_{c)}$ $[10^{-4}]$	$8.4 \pm 1.3 \pm 1.0$	4 - 13
$Br(h_c \to \gamma\eta_c)$	$54.3 \pm 6.7 \pm 5.2$	41 (NRQCD) Kuang 88 (PQCD) Kuang 38 Godfrey, Rosner

Theoretical predictions: PRD65, 094024 (2002) & PRD 66, 014012 (2002)

More charmonium results

- First evidence of $\psi' \rightarrow \gamma\gamma J/\psi$
- First evidence of $\psi' \rightarrow \gamma P$ ($P=\pi^0, \eta$)
- First measurement of $\chi_{cJ} \rightarrow 4\pi^0$
- Study of $\chi_{cJ} \rightarrow \gamma V$ ($V=\rho,\omega, \phi$)
- Study of $\chi_{cJ} \rightarrow VV$ ($V= \omega, \phi$)

For more details, see

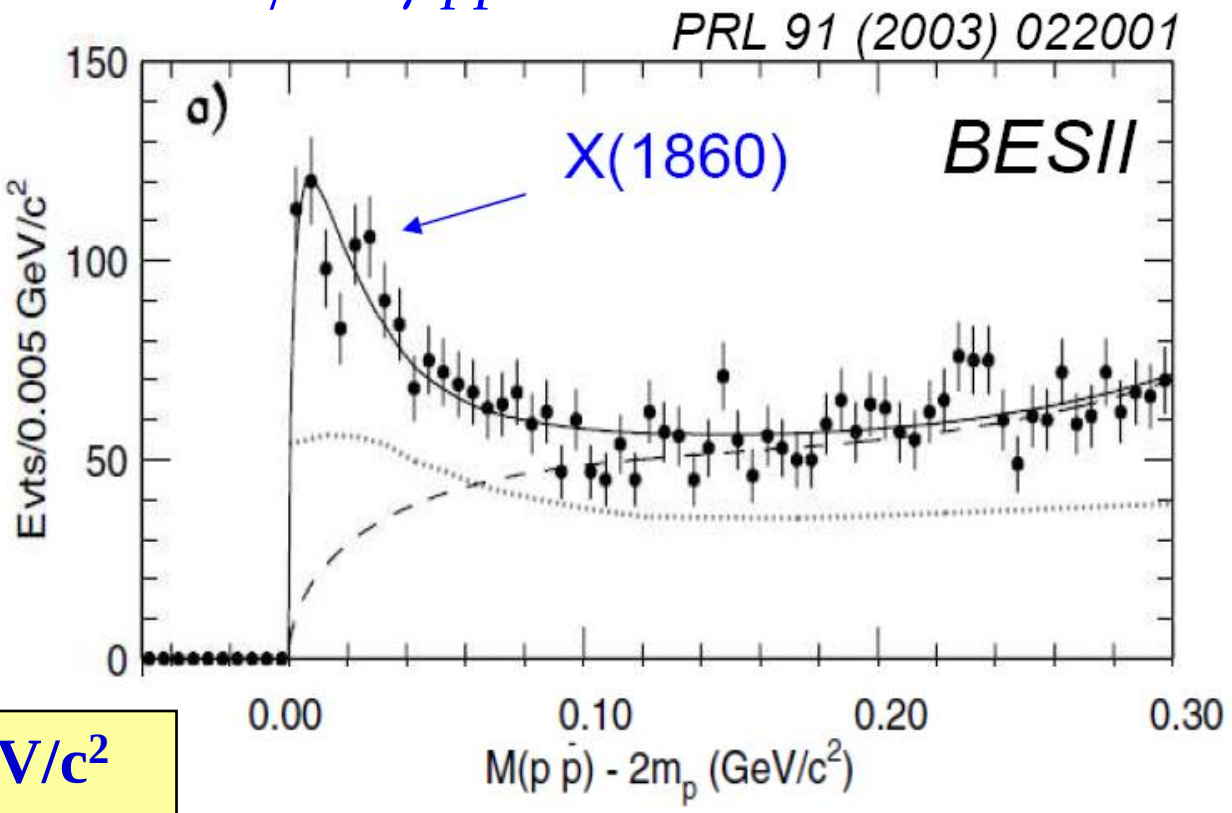
– **L.L. Wang (Saturday afternoon session)**

Recent results from Chamonium decays at BESIII

$p\bar{p}$ threshold enhancement @ BESII

- What could it be?
  - $p\bar{p}$ bound state? (baryonium)
  - FSI effect?
  - or some of both?

$J/\psi \to \gamma p\bar{p}$

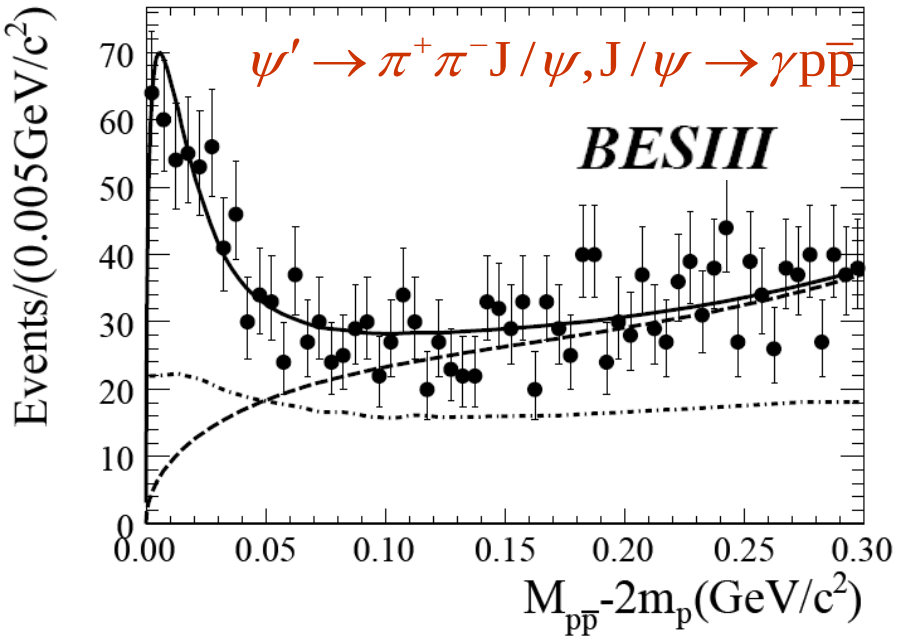


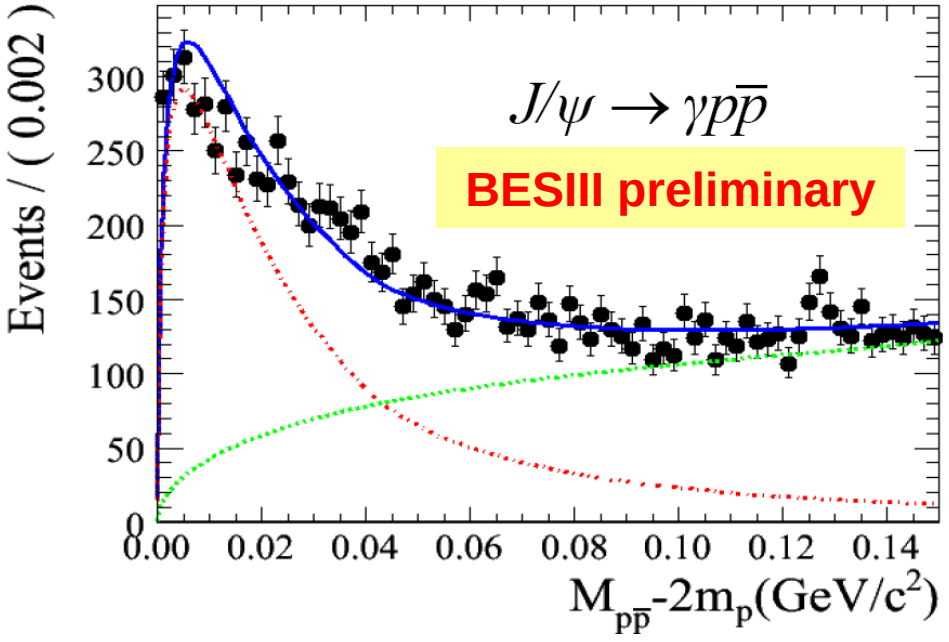
$M = 1859\ ^{+3}_{-10}\ ^{+5}_{-25}$ MeV/c^2

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

$p\bar{p}$ threshold enhancement @ BESIII

BESIII: Chinese Physics C 34(2010)421





$M = 1861\ ^{+6}_{13}\ ^{+7}_{-26}$ MeV/c²

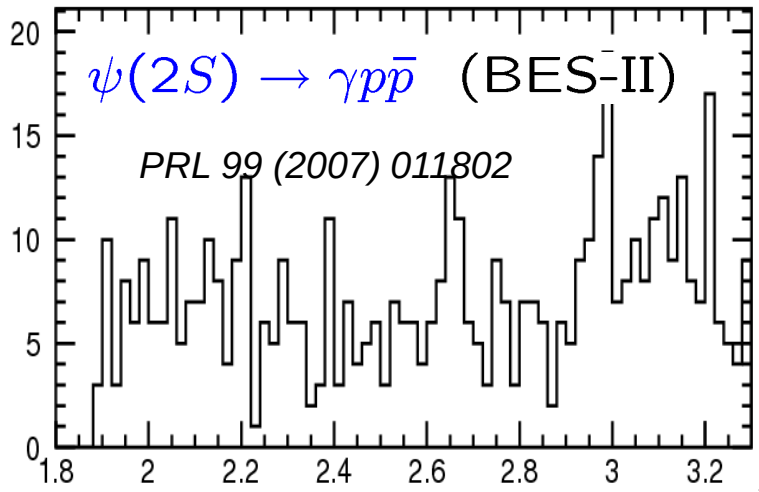
$\Gamma < 38$ MeV/c² (90% CL)

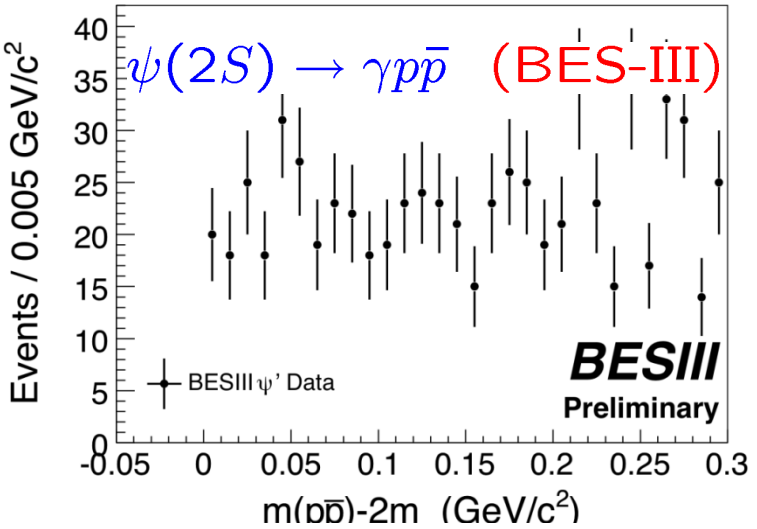
$M = 1861.6 \pm 0.8$ MeV/c²

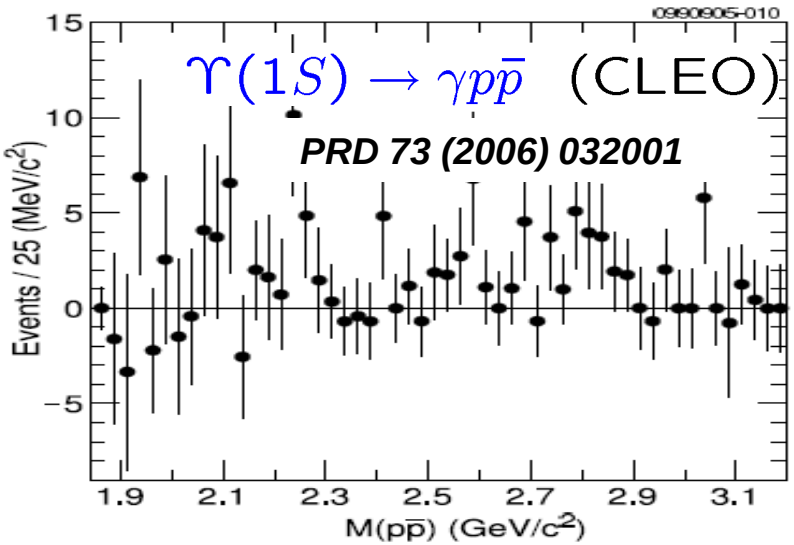
$\Gamma < 8$ MeV/c² (90% CL)

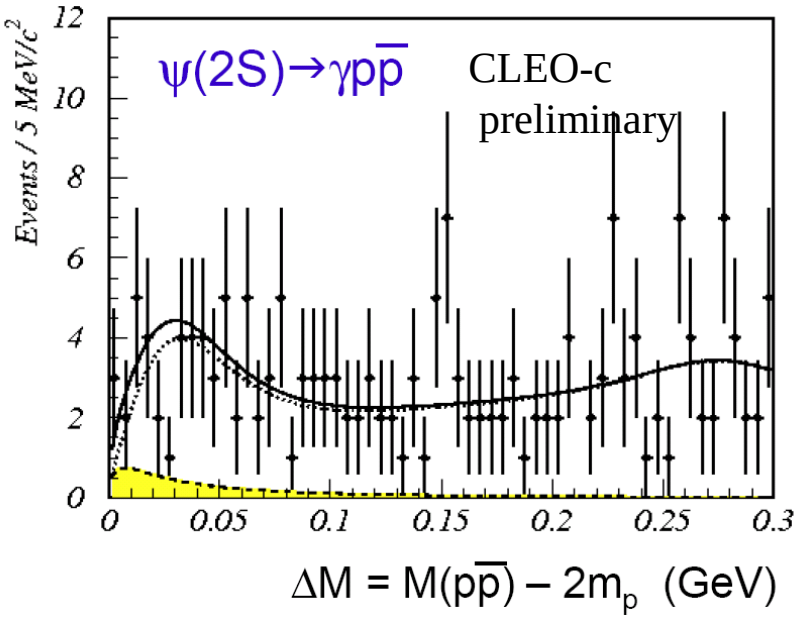
Consistent observation by BESIII !

X(1860) not found in other decays







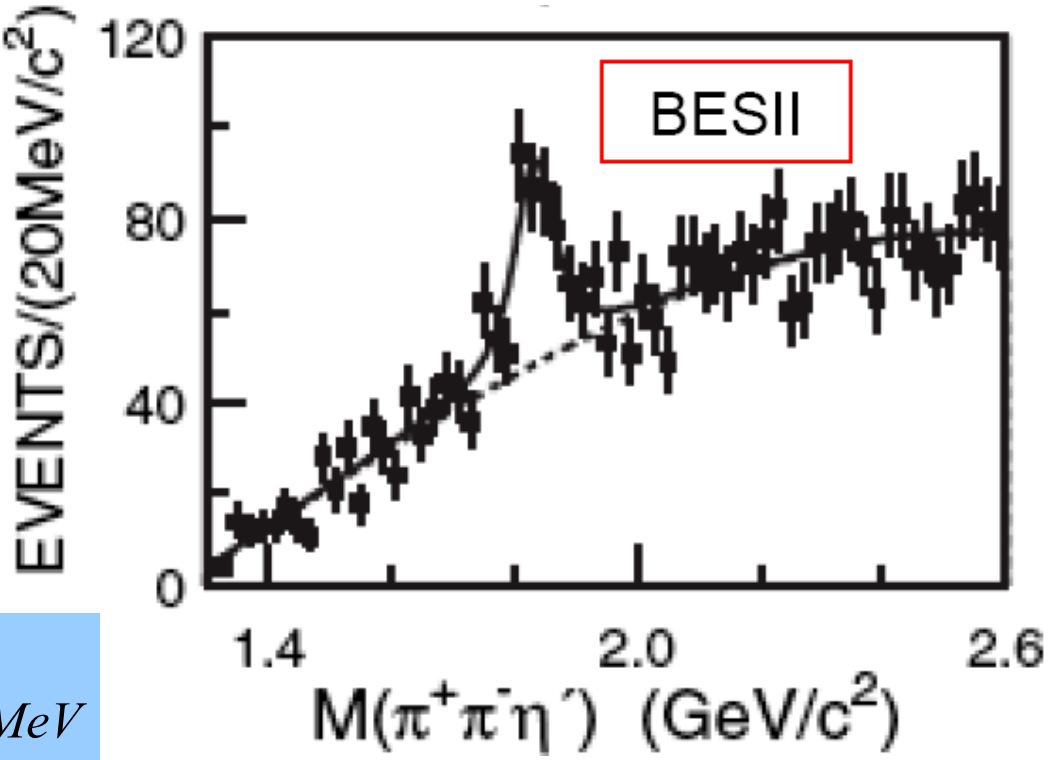


⇒pure FSI effect unlikely

X(1835) at BESII

BESII: PRL 95,262001(2005)

$$J/\psi \to \gamma \pi^+ \pi^- \eta'$$

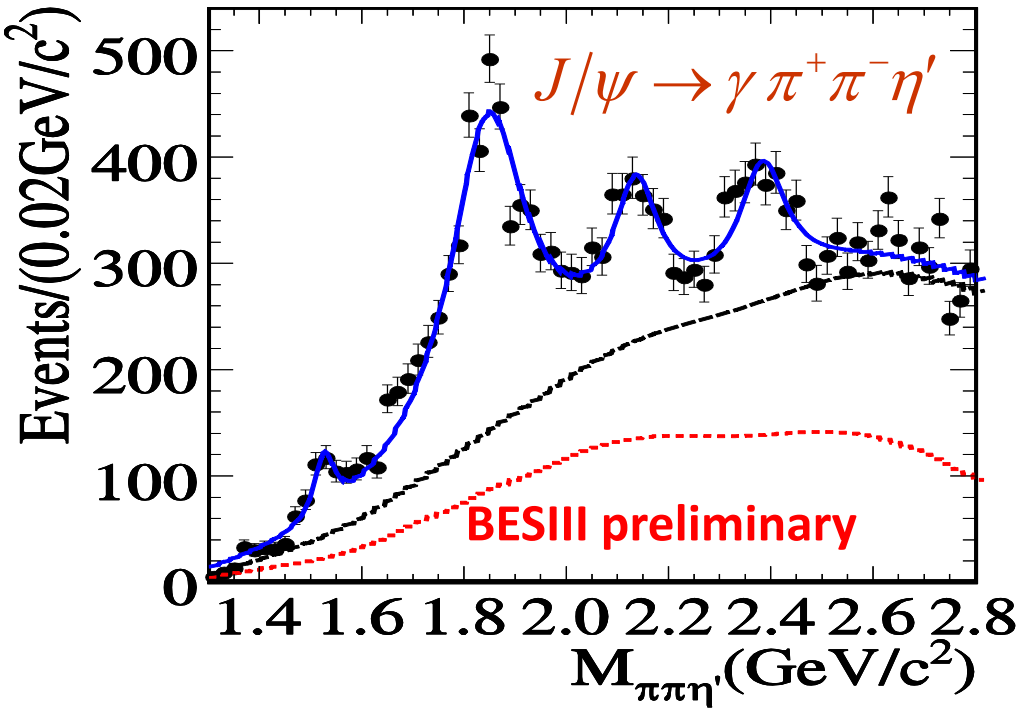


BESII result(Stat. sig. $\sim 7.7\sigma$):

$M = 1833.7 \pm 6.1(stat) \pm 2.7(syst) MeV$

$\Gamma = 67.7 \pm 20.3(\text{stat}) \pm 7.7(\text{syst})\text{MeV}$

Confirmation of X(1835) and observation of two new resonances at BESIII



resonance	$M(\ \mathrm{MeV}/c^2)$	$\Gamma(\ \mathrm{MeV}/c^2)$	Stat. sig.
X(1835)	1838.1 ± 2.8	179.5 ± 9.1	$> 25\sigma$
X(2120)	2124.8 ± 5.6	101 ± 14	$> 7.2\sigma$
X(2370)	2371.0 ± 6.4	108 ± 15	$> 6.7\sigma$

new

More light haron results

- Observation of $X(1870) \to a_0(980)\pi$ in $J/\psi \to \omega\pi^+\pi^-\eta$
- Study of $a_0(980)$ – $f_0(980)$ mixing from

$$\mathbf{J/\psi \to \phi f_0 \to \phi a_0 \to \phi\eta\pi}$$

$$\mathbf{\chi_{c1} \to a_0\pi^0 \to f_0\pi^0 \to \pi^+\pi^-\pi^0}$$

- Measurement of the matrix element from $\eta' \to \pi^+\pi^-\eta$

For more details, see

– **Y. Chen (Saturday afternoon session)**

Recent results on light hadron spectroscopy at BESIII

Charm physics at BESIII

- **ψ(3770) experimental data**
  being reprocessed with new software
- **Physics analysis**
  in progress
- **Physics prospects at BESIII, see talks of**
  Ron Poling, Roy Briere and
  Dan Hennessey on Friday

Data taking plan

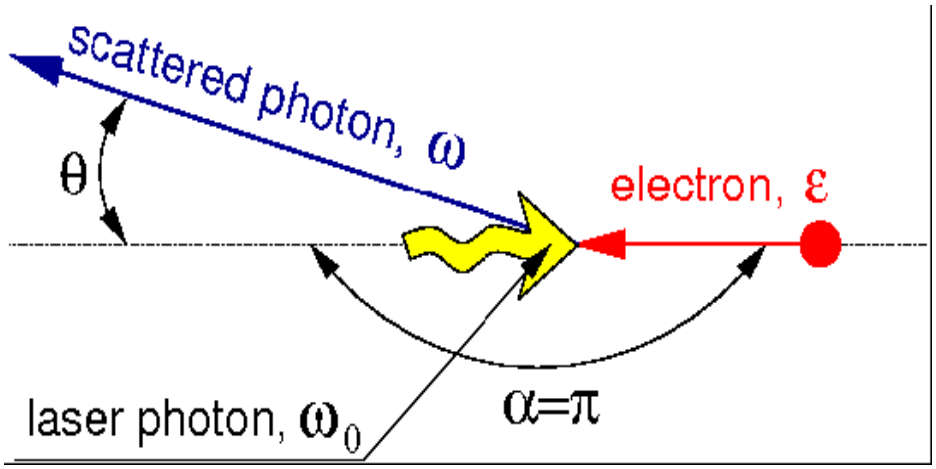
- Coming round (to be decided next week)
  - **1 billion J/ψ events (3~5 months)**
  - **200 pb^{-1} data at ψ(4040) for XYZ particles**
  - **ψ(3770)**
  - **Other proposals?**
- Long term plan
  - **10 B J/ψ events**
  - **3 B ψ(2S)**
  - **20 fb^{-1} ψ(3770) + ψ(4040) + ψ(4160)**
  - **R scan/resonance scan: 2 ~ 4.6 GeV**
  - **Tau physics**

Detector upgrade plan

- **Beam energy measurement system**
- **Inner tracker detector**
- **Endcap TOF counter**

BESIII Beam Energy Measurement

- First BESIII upgrade
- Collaboration by IHEP, BINP, and U. of Hawaii
- System to be tested and installed this year



Expected resolution at BESIII
$\Delta\varepsilon$ = 40 keV

$\rightarrow \Delta m_\tau \approx 0.08$ MeV/c^2 ;
PDG08, $\Delta m_\tau \approx 0.17$ MeV/c^2

Inner MDC upgrade

- **Much noisy at high beam current (<650mA)**
- **May not work in the future**

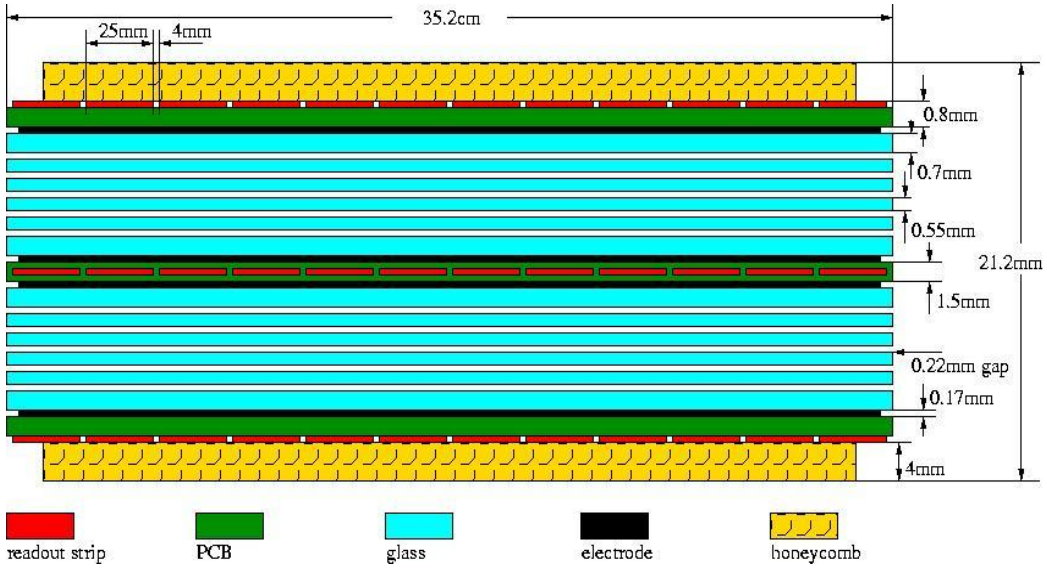
Upgrade options:

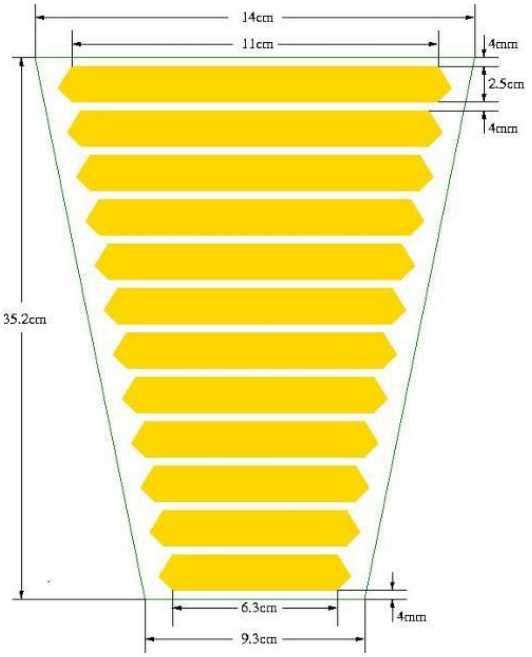
- **CGEM (CLOE2 inner tracker)**
- **Si pixel (STAR vertex / BELLEII pixel)**
- **Si micro strip (BELLEII vertex/SuperSVD)**

MC study was done with TRAERR

ETOF upgrade

- **A prototype of MRPC is made**
- **Beam test is prepared**
- **Expected time resolution 80 ps**





Summary

- **BEPCII/BESIII had been successfully constructed and commissioned with excellent performance**
- **BEPCII has reached a luminosity of $3.3\times10^{32}cm^{-2}s^{-1}$, hopefully there will be a big increase in the coming run**
- **BESIII detector has reached its designed goal. Large data samples of J/ψ, ψ(2S) and ψ(3700) and have been accumulated**
- **BESIII has obtained/published good physics results, much more will come soon**

BESIII Collaboration

http://bes3.ihep.ac.cn

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

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Univ. of Giessen, GSI
Russia: JINR Dubna; BINP Novosibirsk
Italy: Univ. of Torino， Frascati Lab
Netherland： KVI/Univ. of Groningen

Korea (1)
Seoul Nat. Univ.

Japan (1)
Tokyo Univ.

Pakistan (1)
Univ. of Punjab

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Huazhong Normal Univ., Wuhan Univ.
Zhengzhou Univ., Henan Normal Univ.
Peking Univ., Tsinghua Univ. ,
Zhongshan Univ.,Nankai Univ.
Shanxi Univ., Sichuan Univ
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.
Hong Kong Univ., Hong Kong Chinese Univ.

~300 members from 46 institutions

Thank you!