BEPC II status and prospects

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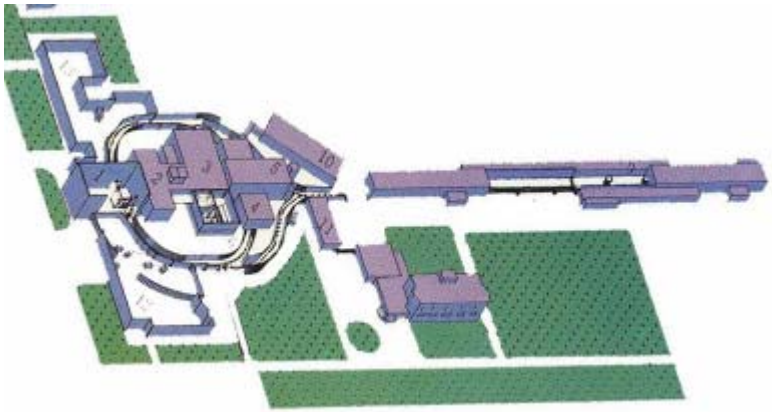
- **Introduction**
- **Construction**
- **Commissioning**
- **Physics at BESIII**
- **Summary**

Beijing Electron Positron Collider (BEPC) at IHEP

E_{beam}~ 1-2.5 GeV

τ-charm energy region



BESI: run from 1989-1998

BESII: run from 1999-2004

BESIII: construction completed, running now

A unique e^+e^- machine in the τ-charm energy region from 1989 – till CLEOc (2003).

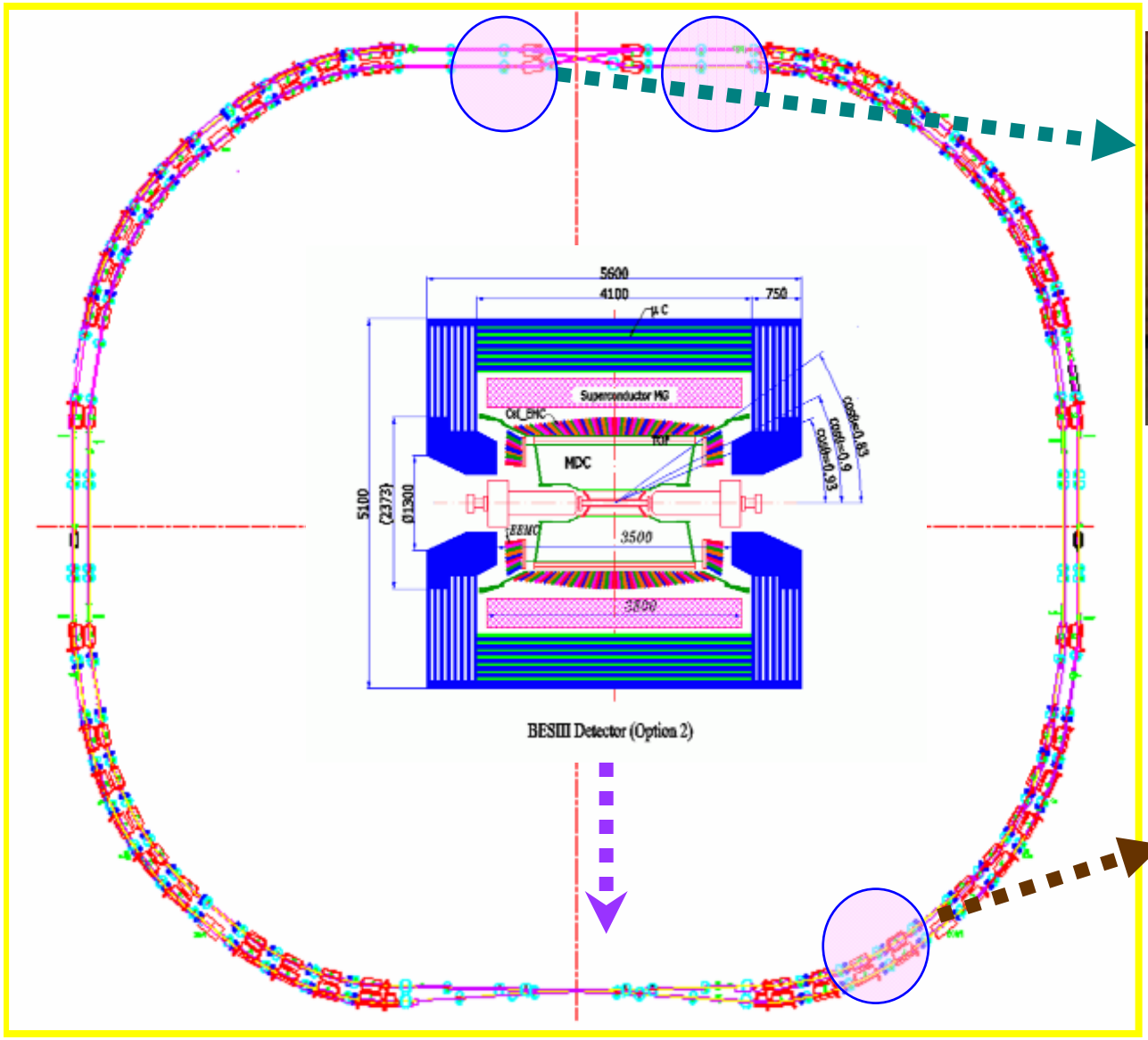
With BESI and BESII data:

- precision measurement of τ mass: 10 times improved. Lepton universality!
- R measurements improve uncertainties by a factor of 2-3 ($\Delta R/R \sim 6$ %). Have great impact to M_H. $\alpha(M_z^2)$, g-2
- Some new particles (X(1835) observed. Hard to be interpreted as conventional hadrons.

Precision measurement requires high statistics and small sys. errors →

Major upgrade: BEPCII / BESIII (2004-2008)

BEPCII: a high luminosity double-ring collider



SC RF

Beam magnets

BEPCII design goal

Energy range	1 – 2.1 GeV
Optimum energy	1.89 GeV
Luminosity	1×10^{33} $cm^{-2}s^{-1}$ @ 1.89 GeV
Injection	Full energy injection upto 1.89 GeV Positron injection rate > 50 mA/min
# of bunches	93
Beam Current	0.91 A
Bunch length	1.5 cm
Synchrotron mode	250 mA @ 2.5 GeV

Beam energy can reach 2.3GeV.

The Milestones


May 2004


July 2005

January 2004	Construction started
May. 4, 2004	Dismount of 8 linac sections started
Dec. 1, 2004	Linac delivered e^- beams for BEPC
July 4, 2005	BEPC ring dismount started
Mar. 2, 2006	BEPCII ring installation started
Nov. 13, 2006	Phase 1 commissioning started
Aug. 3, 2007	Shutdown for installation of IR-SCQ's
Oct. 24, 2007	Phase 2 commissioning started
Mar.28, 2008	Shutdown for installation of detector
June 24, 2008	Phase 3 commissioning started


Sep. 2004

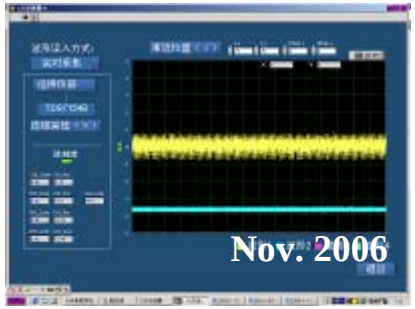

July 2005


Oct. 2005


May 2006


Oct. 2006


Oct. 2006


Nov. 2006


Nov. 2006.

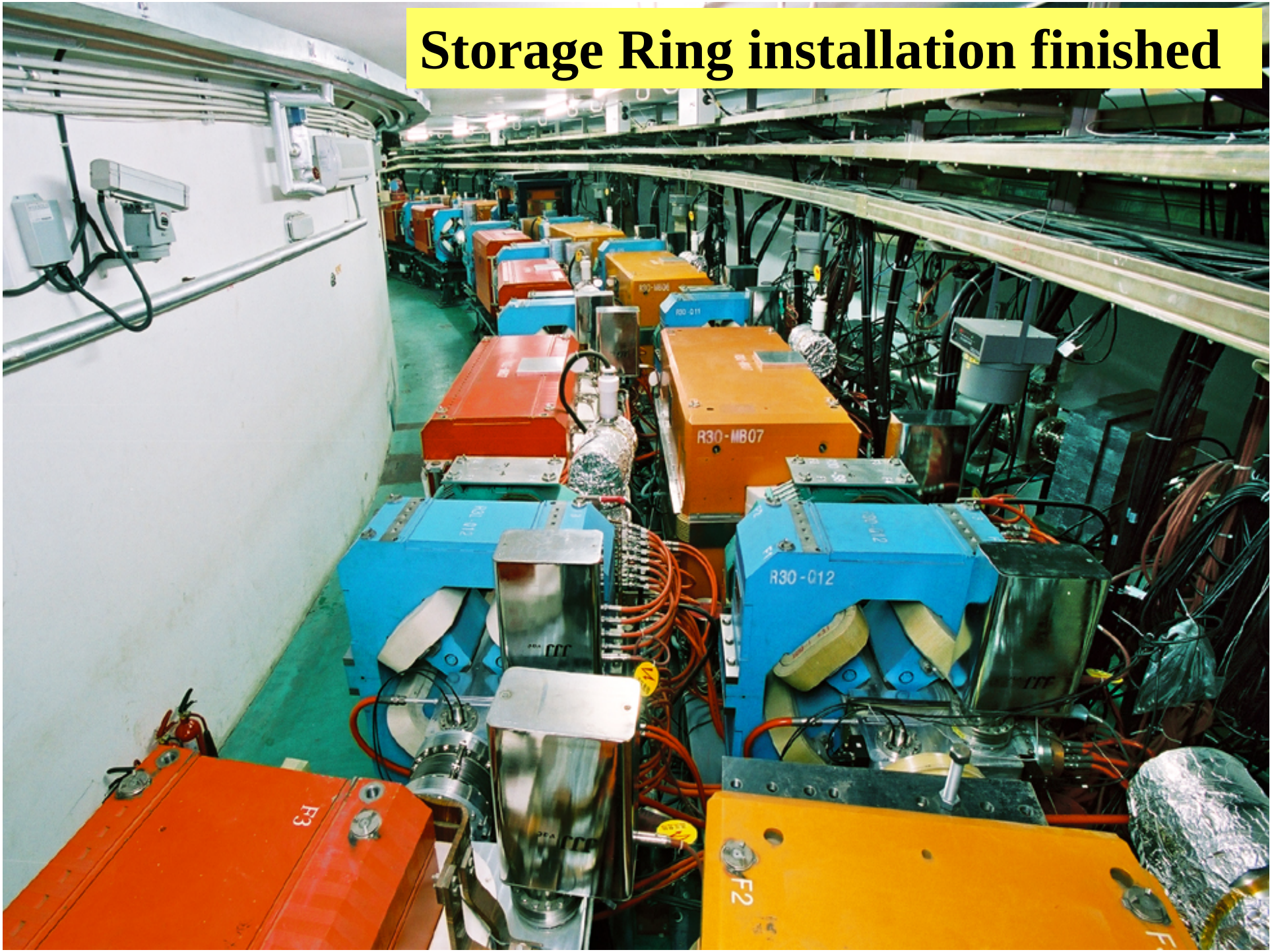

Oct. 2007


May 2008

Linac performance reached design goals and runs stable

	Design	Measured	BEPC
Energy (e+ / e-) (GeV)	1.89	1.89	1.30-1.55
Current (e+) (mA)	37	61	~ 5
Current (e-) (mA)	500	> 500	~300
Emittance (e+) (1 σ, mm-mrad)	0.40 (37 mA)	0.39~0.41 (40~46 mA)	----
Emittance (e-) (1 σ, mm-mrad)	0.10 (500 mA)	0.09~0.11 (600 mA)	----
Pulse Repe. Rate (Hz)	50	50	12.5
Energy Spread (e-) (%) **	± 0.50 (500 mA)	± 0.44 (600 mA)	± 0.80
Energy Spread (e+) (%) **	± 0.50 (37 mA)	± 0.50 (≥37 mA)	± 0.80

Storage Ring installation finished



Commissioning of BEPCII

Oct. 2006 Installation completed with NSCQ@IR

Nov 18, 2006 first beam first stored

Dec. 25, 2006 first SR running started

Mar 26, 2007 First collisions

May 14, 2007 Lumi $10^{32}cm^{-2}s^{-1}$ (as BEPC)

2007 July 31 SR mode 250mA

Phase 1

Oct. 2007 Installation completed with SCQ@IR

2007 Nov. 18 First collision

2008 Jan. 29 500mA*500mA,Lum. >1×10^{32}

2008 Feb. 25-Mar. 28 SR operation

Phase 2

2008 June. Installation completed with SCQ-IR

→ **Phase 3**

The BESIII Detector

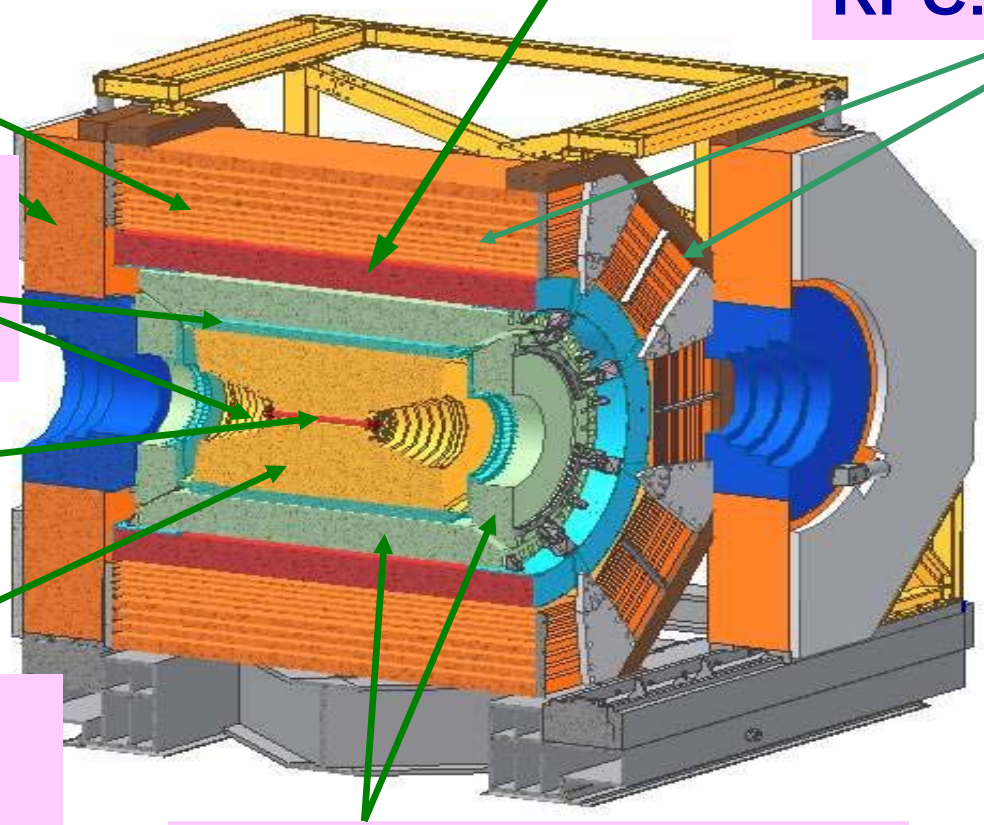
Magnet yoke

SC magnet, 1T

RPC: 9 layers

TOF,
σ_T (ps) = 100 ps Barrel
110 ps Endcap

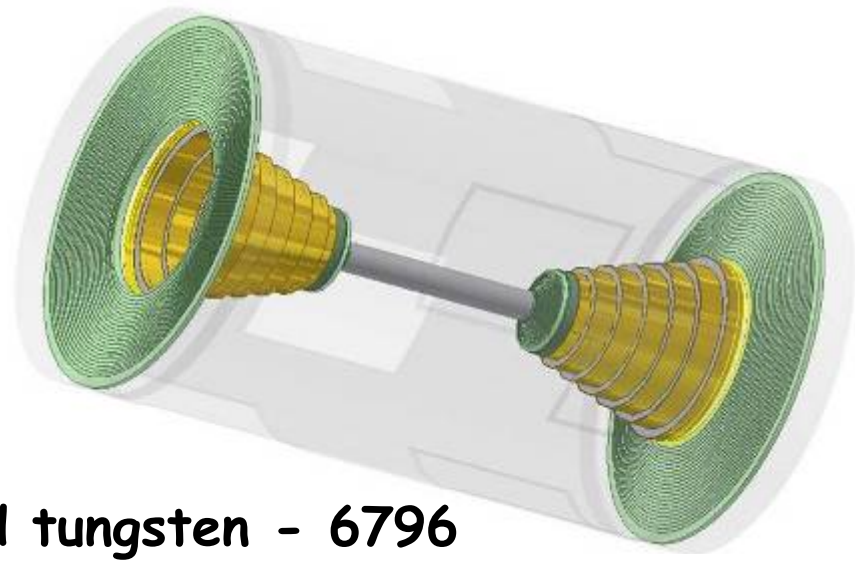
Be beam pipe



MDC,
σ_{XY} (μm) = 130
$\triangle P/P$ = 0.5 % (1 GeV)
$\sigma_{dE/dx}$ = 6-7 %

CsI(Tl) calorimeter,
$\triangle E/\sqrt{E}$ = 2.5 % (1 GeV)
σ_z,ϕ(cm) = 0.5cm/$\sqrt{E}$

Drift chamber (MDC)



Parameters

R inner: 63mm ; R outer: 810mm

Length (out.): 2582 mm

Sense wire : 25 micron gold-plated tungsten - 6796

Layers (Sense wire): 43 (19 axial, 24 stereo)

Field wire: 110 micron gold-plated Aluminum --- 21884

Gas: He + C3H8 (60/40)

Cell: inner chamber --- 6 mm

outer chamber --- 8.1 mm

Polar angle: |cos θ| < 0.93

Expected performance

$$\sigma_x \sim 130 \ \mu m$$

$$\frac{\sigma_P}{P} \sim 0.5\% \text{ @1GeV/C}$$

$$\frac{\sigma_{\frac{dE}{dx}}}{\frac{dE}{dx}} \sim 6\%$$

CsI(Tl) crystal calorimeter (EMC)

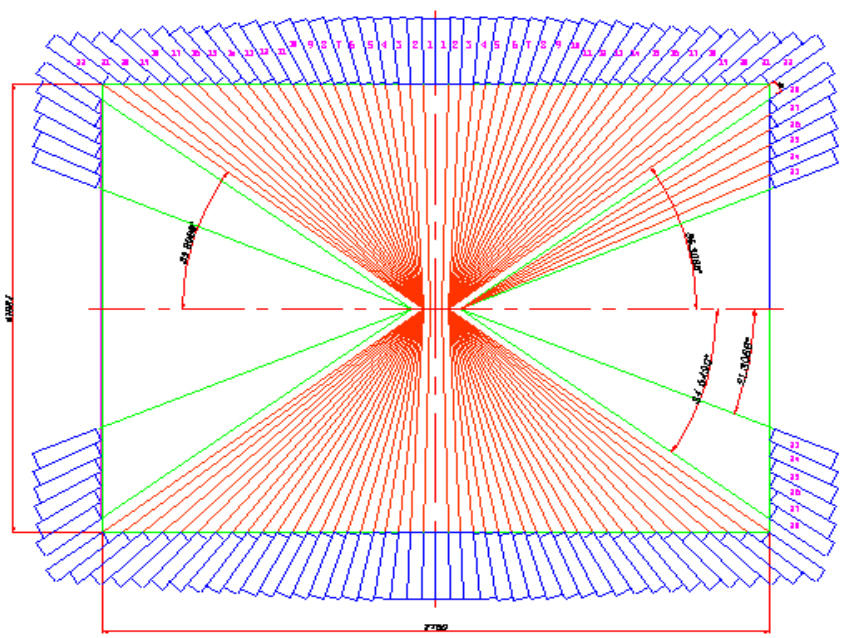
- Crystals:
  - L = 28 cm (15 X_0)
  - A = (5.2 x 5.2 – 6.4 x 6.4) cm^2
  - Barrel: 5280 w: 21564 kg
  - Endcaps: 960 w: 4051 kg
  - Total: 6240 w: 25.6 T

Design goals:

- Energy: 2.5% @ 1GeV

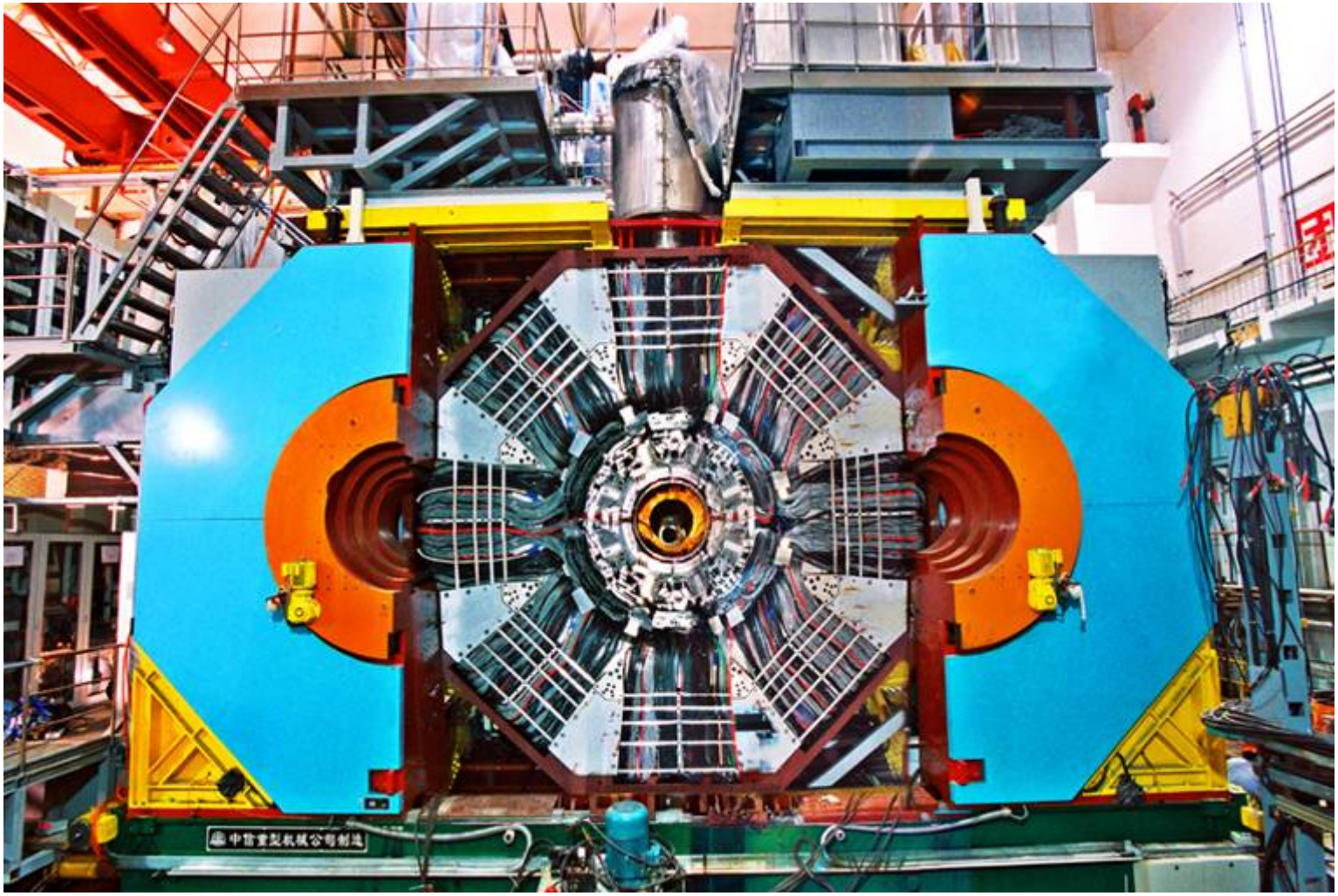
- Energy range: 20 MeV-2 GeV

- Spatial: 0.6cm @ 1GeV



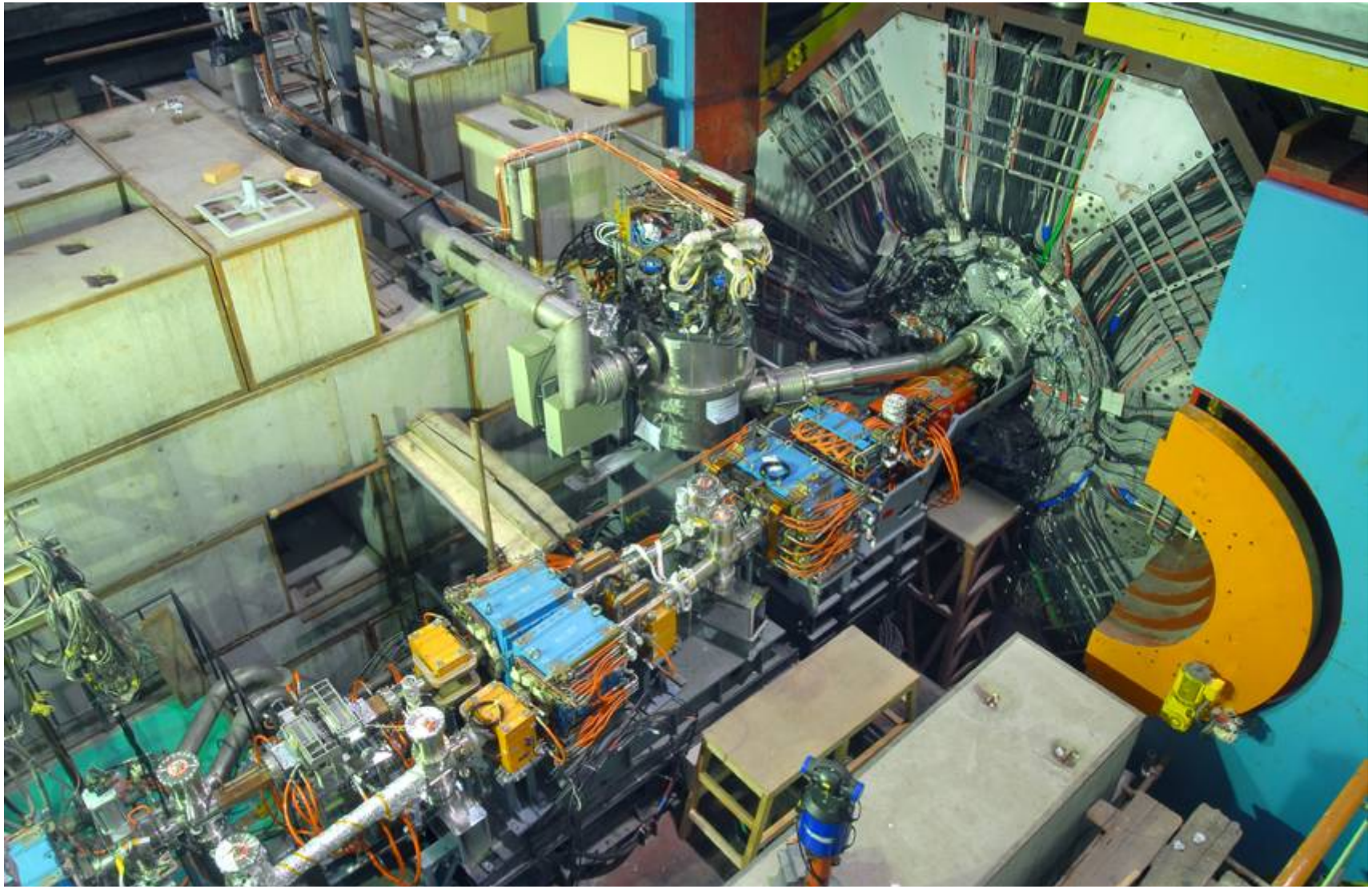
BESIII installation

Detector installation completed this April, and moved to IR in May, 2008.



Joint Commissioning

- BESIII detector moved into the IR in May
- Joint commissioning started 22 June.



Phase #3 commissioning

June. Installation completed with SCQ @ IR

Jul. 16 First collisions without detector SC magnet

Jul. 19 First collisions with detector SC magnet

Aug. 9 100mA*100mA in 20 bunches

Aug. 16 200mA*200mA in 52 bunches

Sept. 1 300mA*300mA collision in 71 bunches

Sept. 7 400mA*400mA collision in 80 bunches

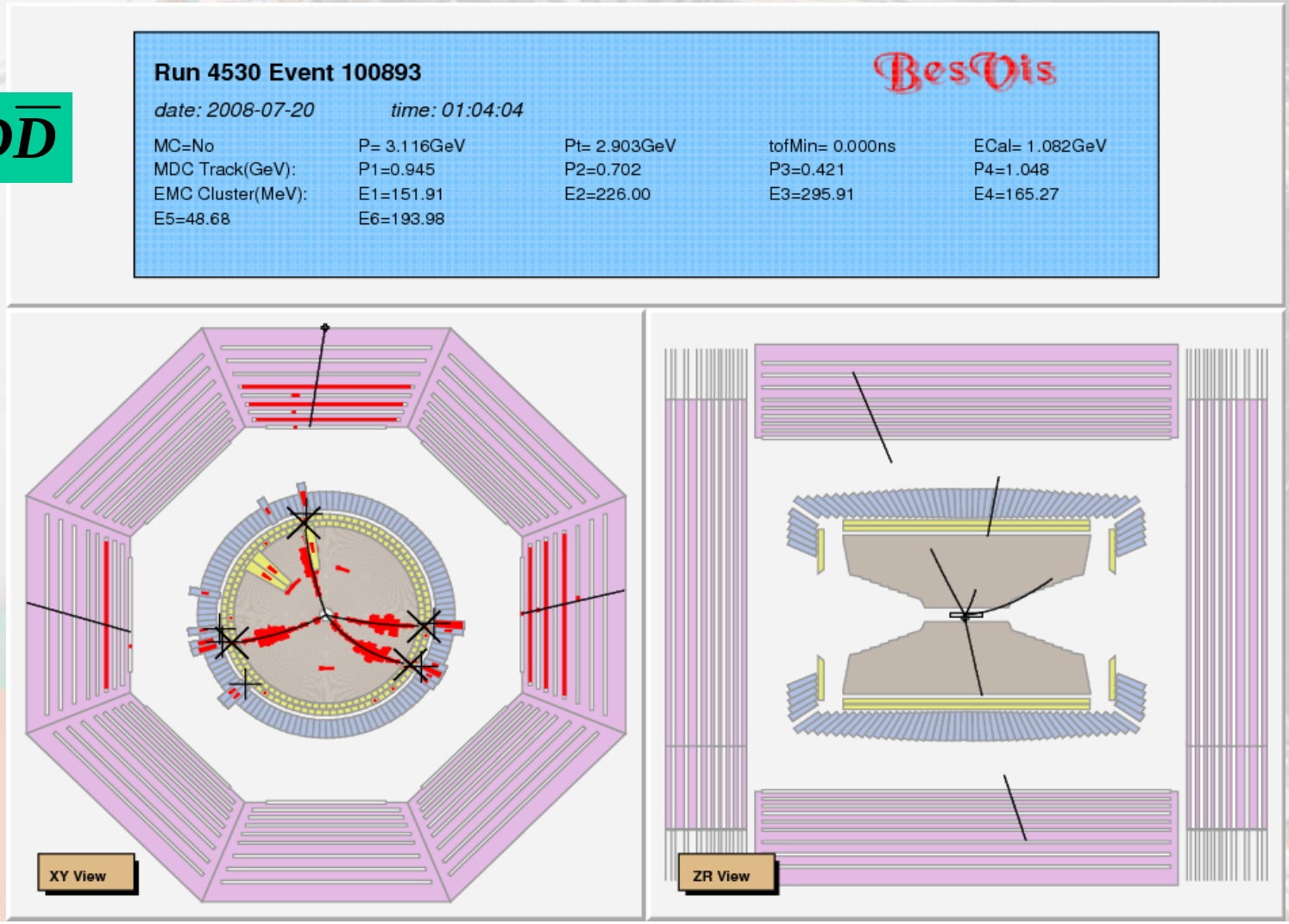
Oct.7, e+ both e+/e- reach 600mA

Luminosity Record：

Sept. 17, 370×370mA (71bunches)=> $1.15\times10^{32}cm^{-2}s^{-1}$

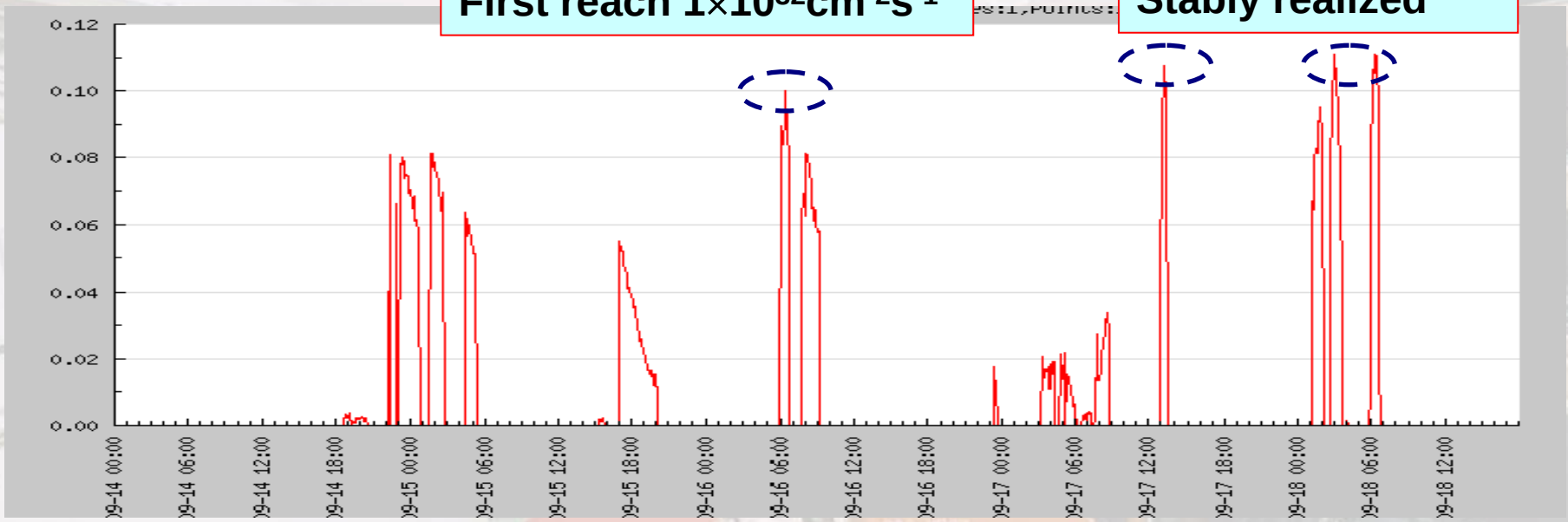
- **First physics event was detected at BESIII in July 19, 2008.**
- **MDC noise problem was solved.**
- **10M ψ‘ events collected for calibration**

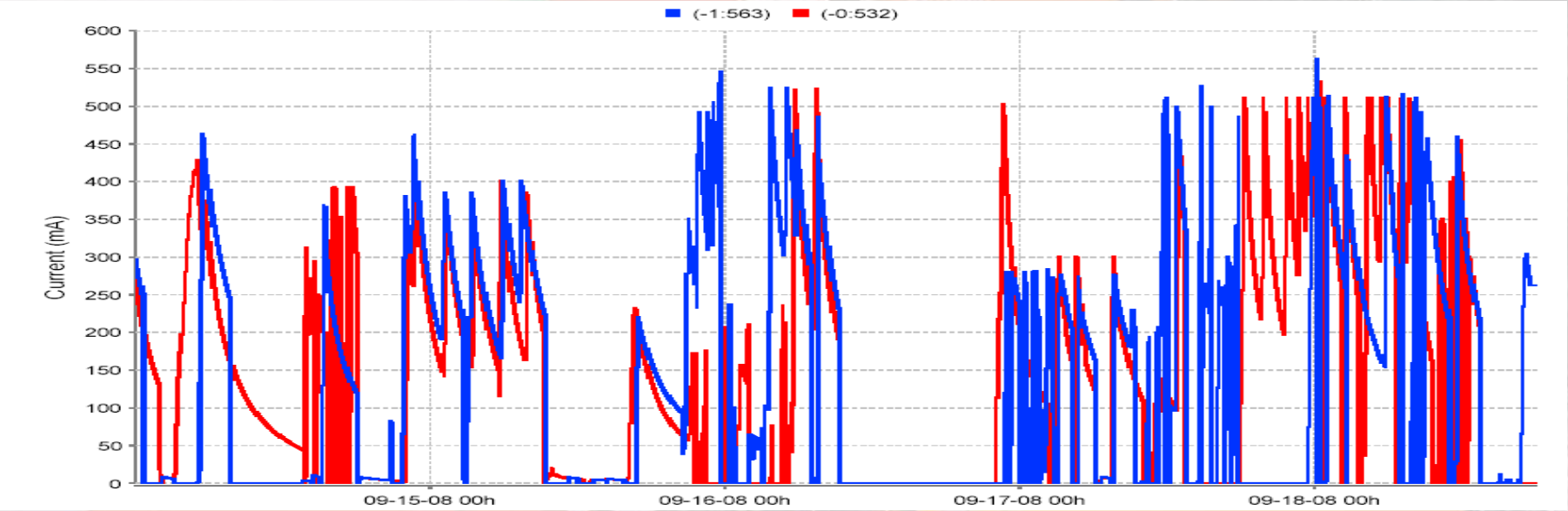
$$\psi(3770) \rightarrow D\overline{D}$$



First reach $1\times10^{32}cm^{-2}s^{-1}$

Stably realized





Main parameters achieved in collision mode

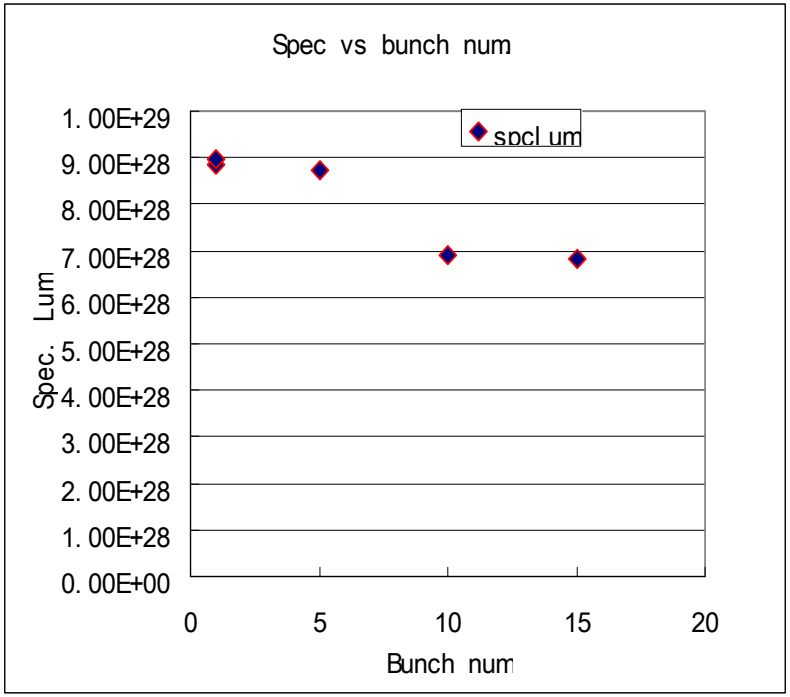
parameters	design	Achieved	
		BER	BPR
Energy (GeV)	1.89	1.89	1.89
Beam curr. (mA)	910	630	700
Bunch curr. (mA)	9.8	>10	>10
Bunch number	93	93	93
RF voltage	1.5	1.5	1.5
$*\nu_s$ @1.5MV	0.033	0.032	0.032
β_x^*/β_y^* (m)	1.0/0.015	~1.0/0.016	~1.0/0.016
Inj. Rate (mA/min)	200 e^-/ 50 e^+	>200	>50
Lum. ($\times 10^{33} cm^{-2} s^{-1}$)	1	0.11	

Bottleneck to increase luminosity

- Specific Lum. $[L/(n*I_b*I_b)]$

For multi-bunch, ideally
Lum=Lbunch*Nb

But Spec. L decreased while bunch number increase, i.e. Lum<Lbunch*Nb



? Coupled bunch instability

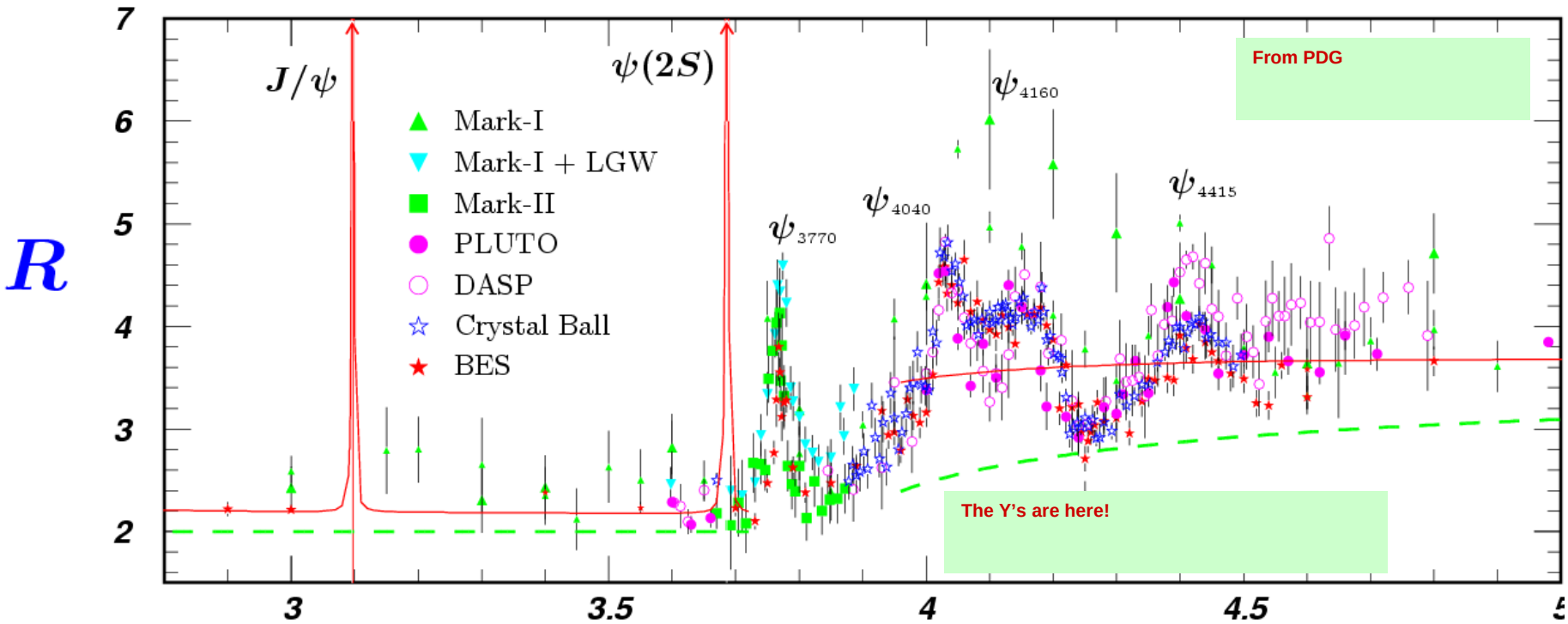
? Bunch size increase due to ECI

=> Systematic observation is under way

=> Cure method (solenoid winding, feedback, etc)

Physics at BEPCII/BESIII

- Precision measurement of CKM matrix elements
- Precision test of Standard Model
- QCD and hadron production
- Light hadron spectroscopy
- Charmonium production/decays
- Search for new physics/new particles



Physics at BEPCII/BESIII

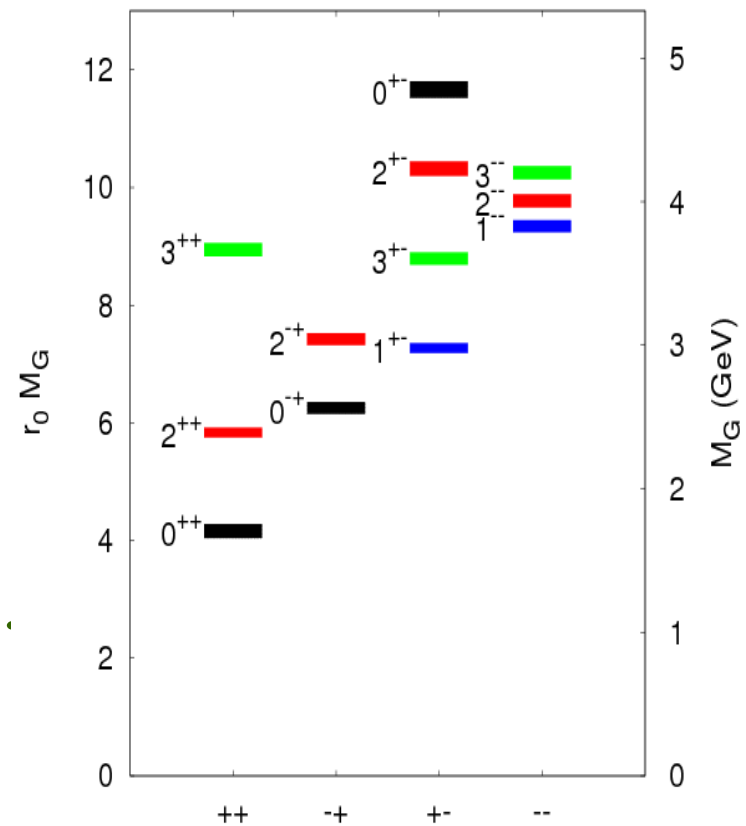
Statistics at BESIII at peak Luminosity

(assuming 10^7s data taking time each year)

Physics	Energy (GeV)	Peak Luminosity (10^{33} cm^{-2}s^{-1})	Events/year	Existing data
J/ψ	3.097	0.6	10×10^9	60×10^6 (BESII)
τ	3.67(?)	1.0	12×10^6	--
ψ'	3.686	1.0	3×10^9	27×10^6 (CLEOc) 14×10^6 (BESII)
D	3.77	1.0	3×10^6	5×10^6 (CLEOc)
Ds	4.03	0.6	1×10^6	4×10^3 (BESI)
Ds	4.17	0.6	3×10^6	0.3×10^6 (CLEOc)
R scan	3.0-4.6	0.6(?)-1.0	--	--

Search for glueballs

- LQCD predicts the lowest glueball state is 0^{++}. The mass is around 1.5 GeV – 1.7 GeV.
- LQCD predicts the next lightest glueball is 2^{++}. The mass is around 2.4 GeV.
- LQCD predicts the 0-+ glueball mass in the range of 2.3-2.6 GeV.
- The mix of glueball with ordinary $q\bar{q}$ meson makes the situation more difficult.



Y. Chen et al., PRD 73 (2006) 014516

Glueball candidates: $f_0(1500)$, $f_0(1700)$, $f_J(2220)$, ...

Glueball search and study at BESIII

0^{++}

study $f_0(1370)$, $f_0(1500)$, $f_0(1710)$ and $f_0(1790)$ in

$$J/\psi \to \gamma + \{\pi\pi, K\bar{K}, \eta\eta, \ldots\}$$

0^{-+}

- study 1.4 GeV 0^{-+}'s (η_L, η_H) in

$$J/\psi \to \gamma + \{\rho\rho, \eta\pi\pi, K\bar{K}\pi, \ldots\}$$

- study high mass 0^{-+}'s in

$$J/\psi \to \gamma + \{\omega\omega, \rho\rho, \eta\pi\pi, K^*\bar{K}^*, \ldots\}$$

2^{++}

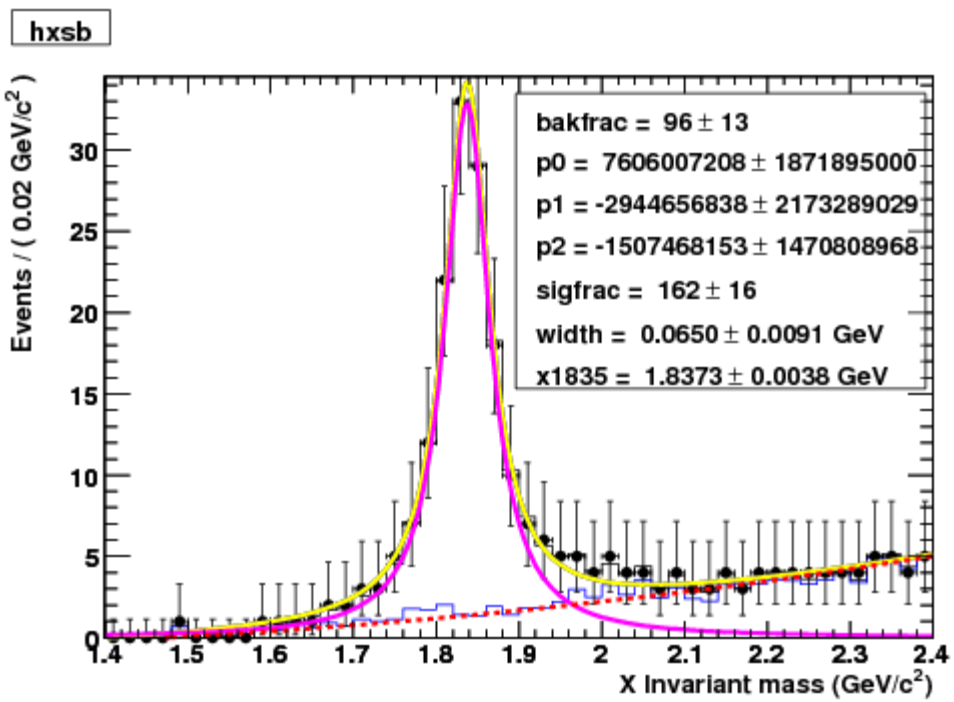
study $f_J(2220)$ in

$$J/\psi \to \gamma + \{\pi\pi, K\bar{K}, p\bar{p}, \phi\phi, \omega\omega, \eta\eta, \eta\eta' \ldots\}$$

Example: X(1835) at BESIII (58M J/ψ)

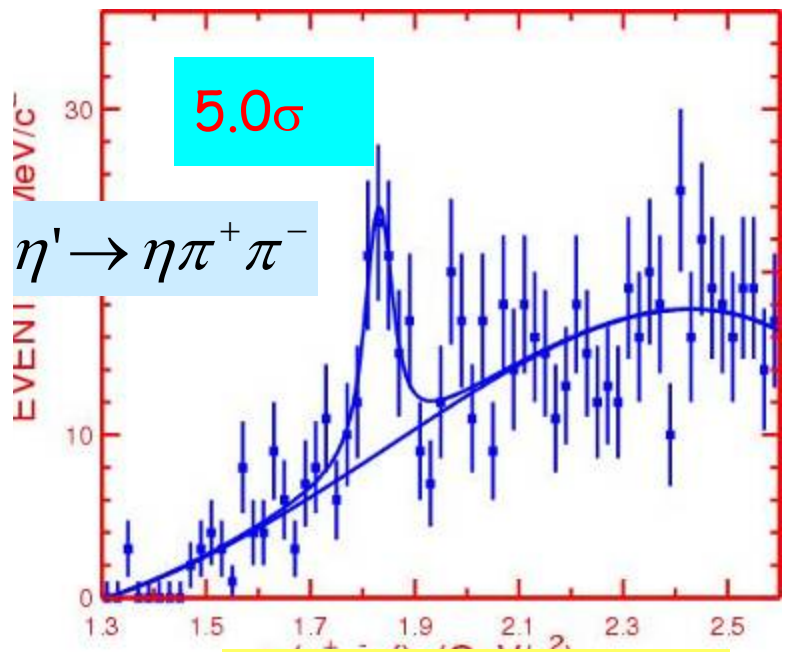
2 years' data taking

at BESIII



M(η'ππ) GeV/c²

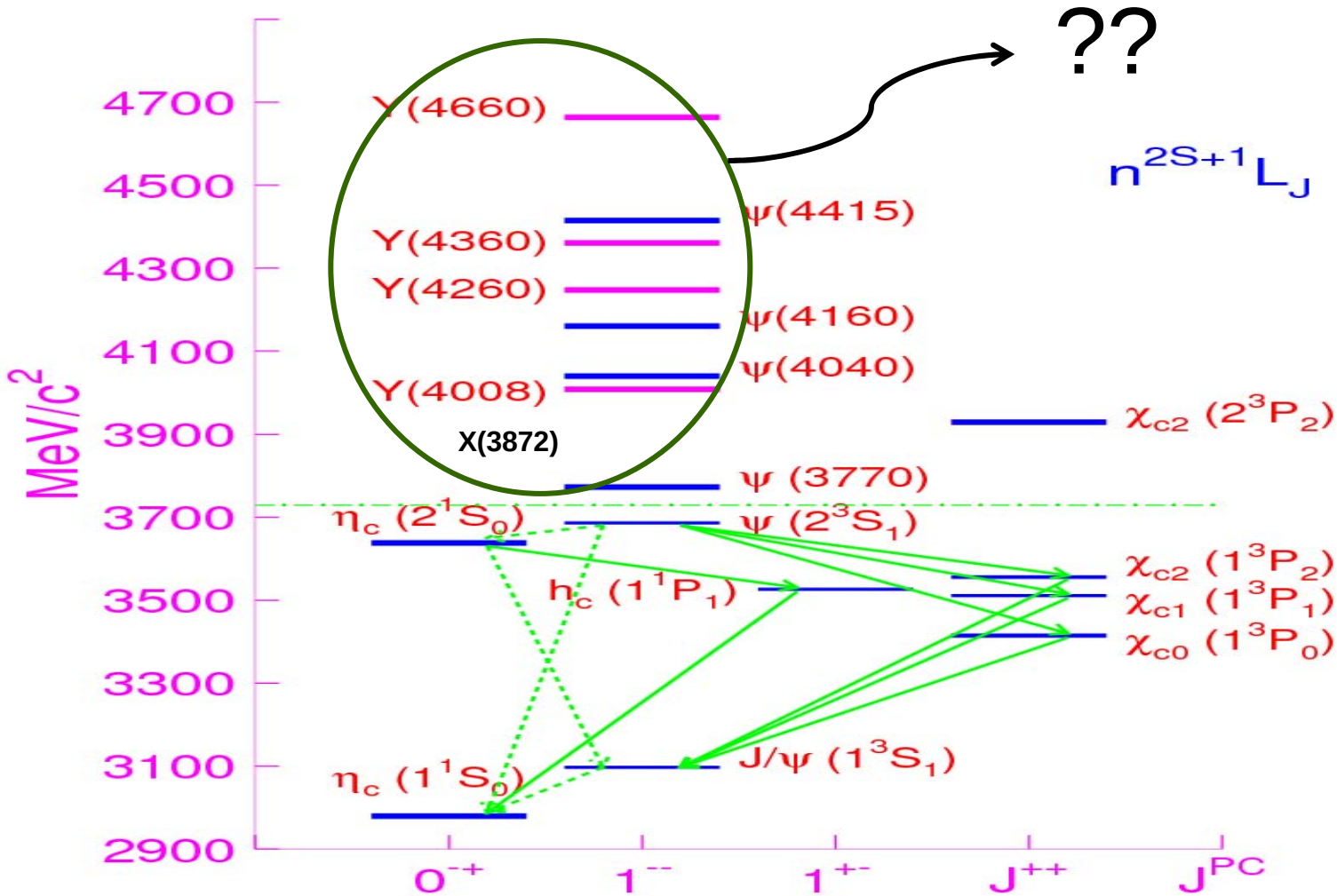
at BESII



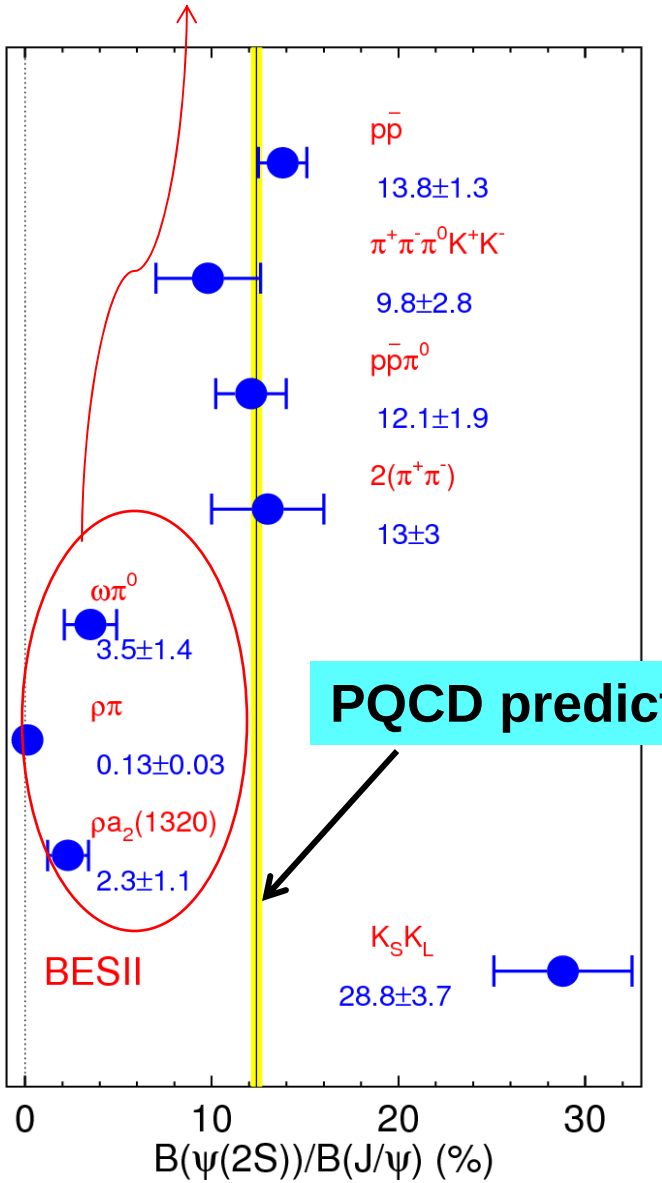
M(η'ππ) GeV/c²

Charmonium production and decay

Charmonium spectroscopy



"ρπ puzzle"

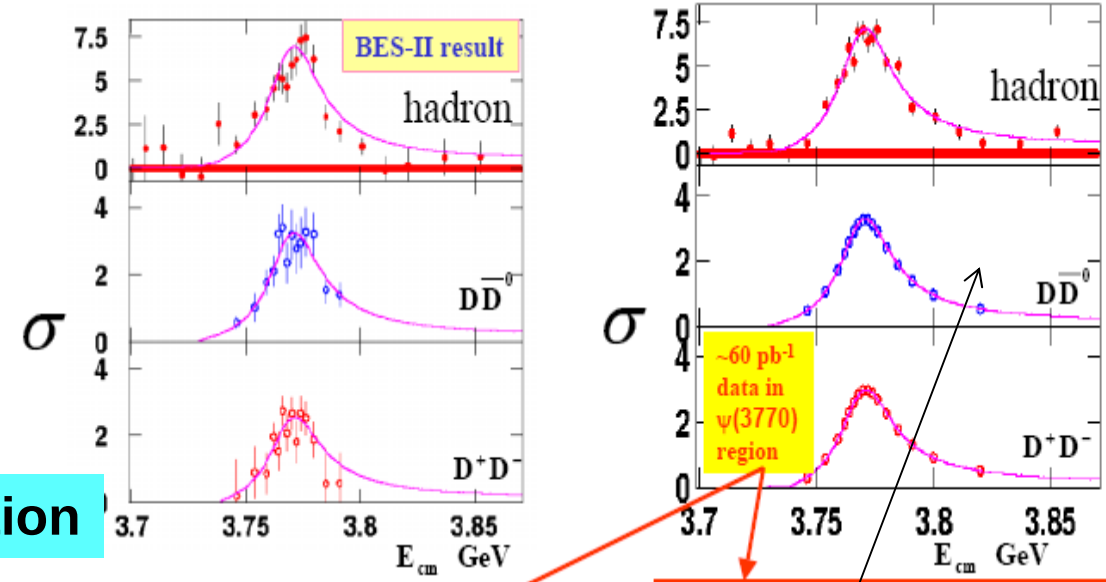


PQCD prediction

ψ(3770) non- $D\bar{D}$ decay

BESII : ~ 30 pb^{-1}

BESIII : ~ 60 pb^{-1}



$\Gamma^{tot}_{\psi(3770)}$	26.8 ± 0.5 MeV	26.9 MeV
$\Gamma^{ee}_{\psi(3770)}$	256±9 eV	251 eV
	Measured value	Input value

$B[\psi(3770) \to D\bar{D}]$	
(88.2 ± 2.4 ± ~ 2.0) %	Measured value
89 %	Input value

BES-III MC simulation

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BESIII Monte - Carlo simulation

Impact of Charm Physics - I

- **Precision CKM**

~5% ~10%

PDG06

|Vus|	|Vus|	|Vub|	|Vcd|	|Vcs|	|Vcb|	|Vtd|	|Vts|	|Vtb|
0.97377 ± 0.00027	0.2257 ± 0.0021	0.00431 ± 0.00030	0.230 ± 0.011	0.957 ± 0.017 ± 0.093	0.0416 ± 0.0006	0.0074 ± 0.0008		>0.78

BES accuracy

- For leptonic D decays

$$\sigma(|V_{cd}|)/(|V_{cd}|) = 2.3\%$$
$$\sigma(|V_{cs}|)/|V_{cs}| = 1.7\%$$
$$\frac{\sigma(|V_{cd}|/|V_{cs}|)}{|V_{cd}|/|V_{cs}|} = 1.3\%$$

- For semileptonic D decays ($D_s \to K$ and $D_s \to \phi$):

$$\sigma(|V_{cd}|)/(|V_{cd}|) = 2.4\%$$
$$\sigma(|V_{cs}|)/|V_{cs}| = 1.3\%$$

BESIII: < 2%

$|V_{td}/V_{ts}|$=0.208+-0.007

BESIII improves precision indirectly

Impact of Charm Physics - II

- **Search for New Physics in Charm Sector**
  - **Rare Charm Decays**
    - **FCNC decays only occur in loop diagrams in the SM:**
  - **Charm Mixing (Large CPV in mixing indicates New Physics)**

$$R_M < 1.5 \times 10^{-4} \text{ @ 90\% C.L.}$$

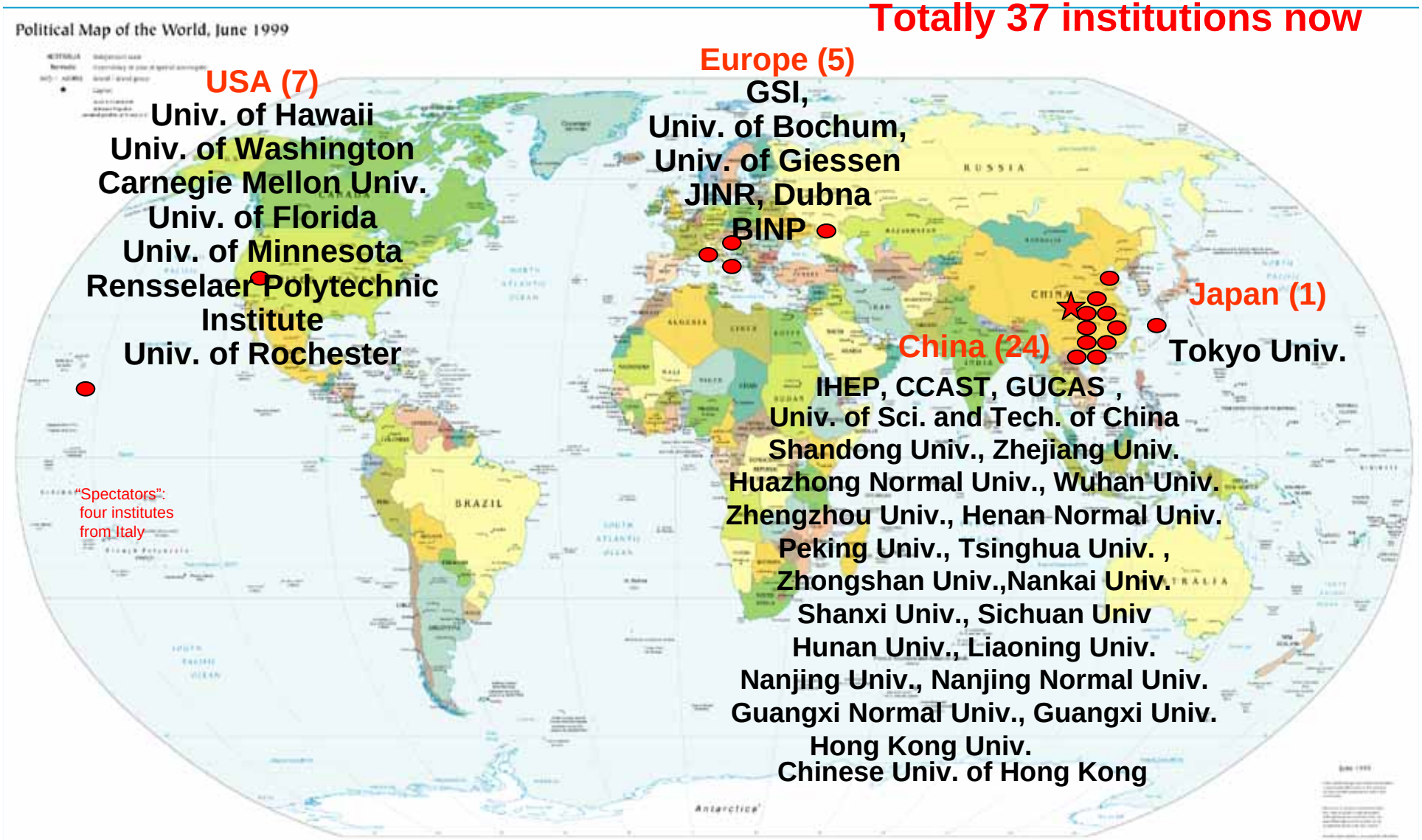
for 20 fb^{-1} BESIII $\psi(3770)$

  - **CP Violation**

$$A_{CP} < 2.5\text{x}10^{-2} \text{ @ 90\% C.L. for 4 } fb^{-1}$$

BESIII collaboration

Totally 37 institutions now



Summary

- **The construction of BEPCII/BESIII fully completed on schedule and within budget.**
- **Commissioning of machine and detector goes smoothly, Lumi. of 1.15×10^{32} obtained. Detector works well, its performance satisfactory, and noise problem solved.**
- **Synchrotron radiation running started by end of 2006.**
- **More efforts on increasing Lumi. And reducing dark current of MDC.**
- **10M ψ‘ events collected. Calibration are under way.**
- **Physics data taking will be started soon.**
- **Expecting exciting physics results coming out.**

Thank you !