A new phase of tau-charm physics

——Recent results and future plans of BESIII

Yifang Wang

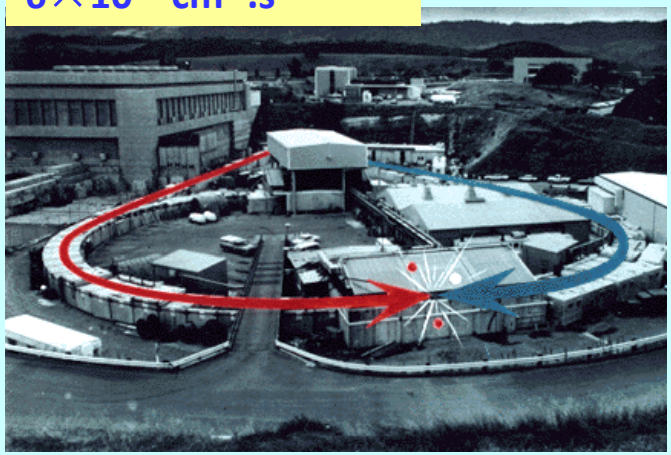
Institute of High Energy Physics

Tau & charm from dedicated colliders

ADONE, FRASCATI ’69-’90

SPEAR, SLAC, ’72-’90

6×10^{29} cm^{-2}.s^{-1}

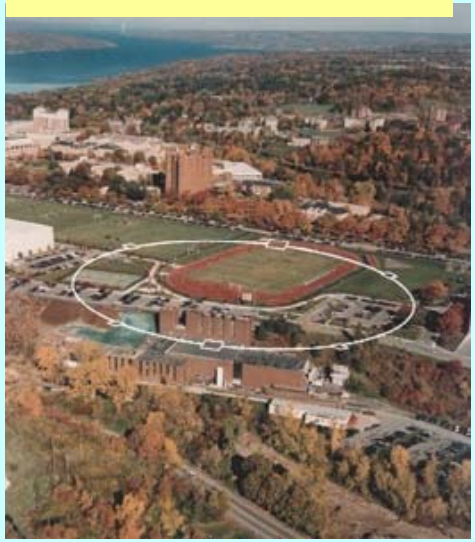


BEPC, IHEP, ’90-’04

5×10^{30} cm^{-2}.s^{-1}

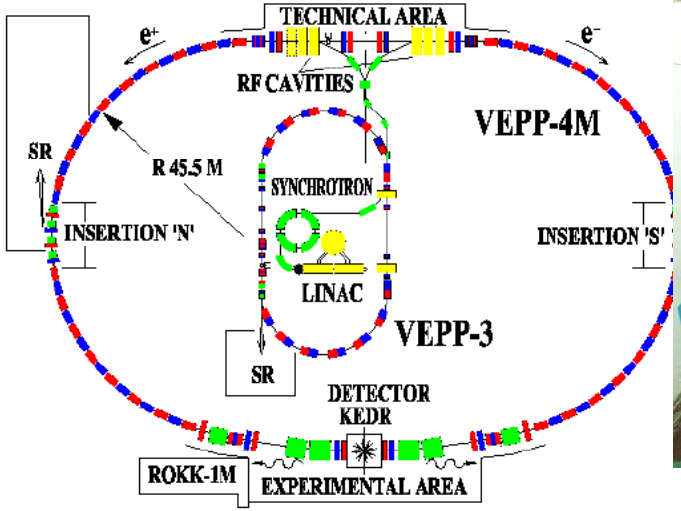
CESRc, Cornell, ’04-’08

7×10^{31} cm^{-2}.s^{-1}



VEPP-4M, Novosibisk, ’02-’12(?)

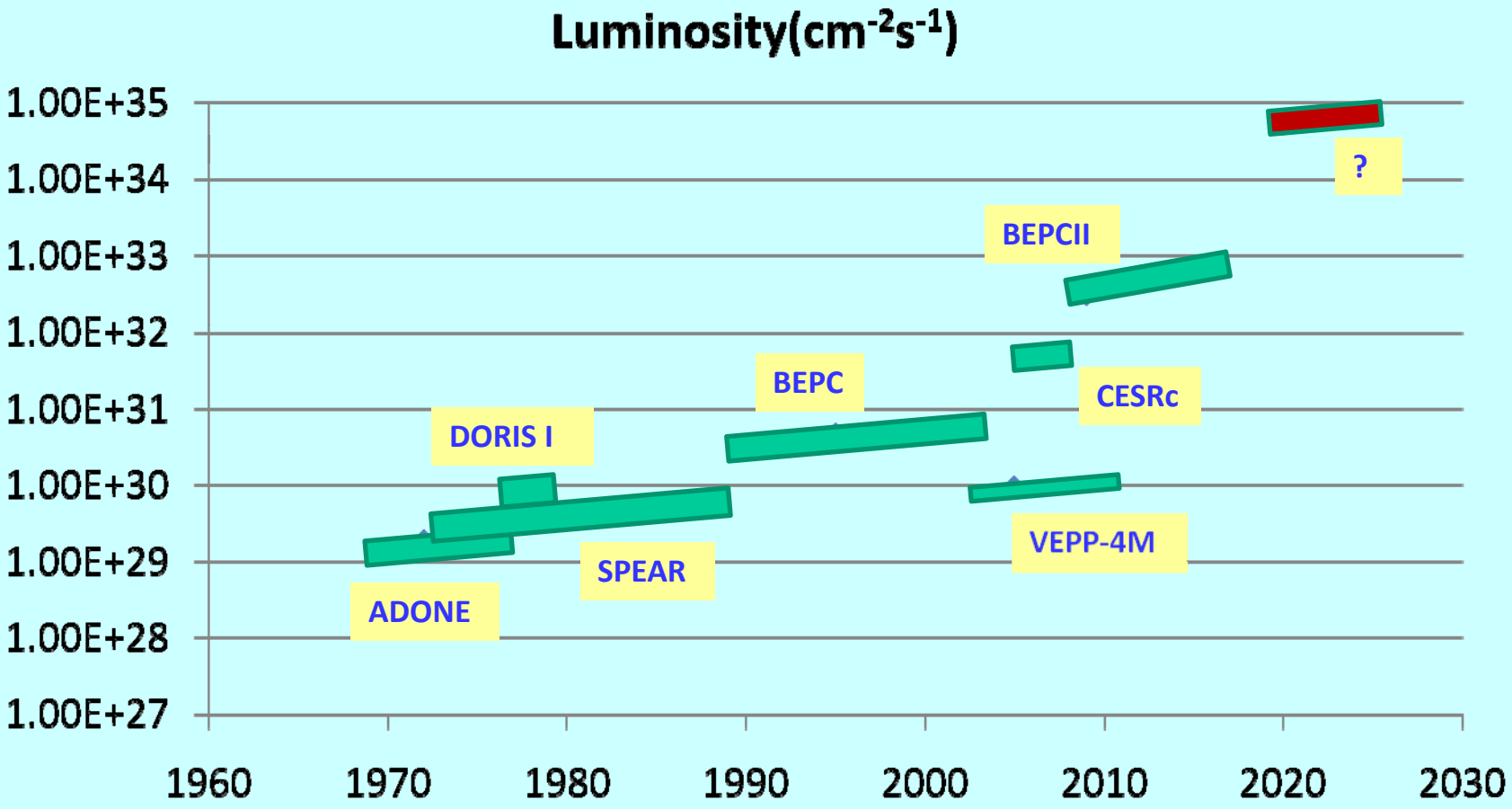
1×10^{30} cm^{-2}.s^{-1}



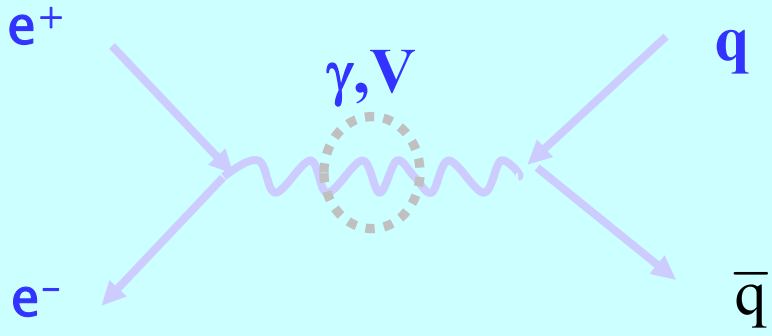
BEPCII, IHEP, ’08-’18(?)

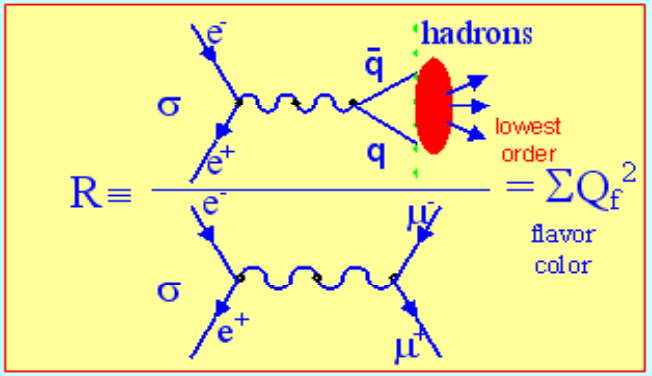
1×10^{33} cm^{-2}.s^{-1}

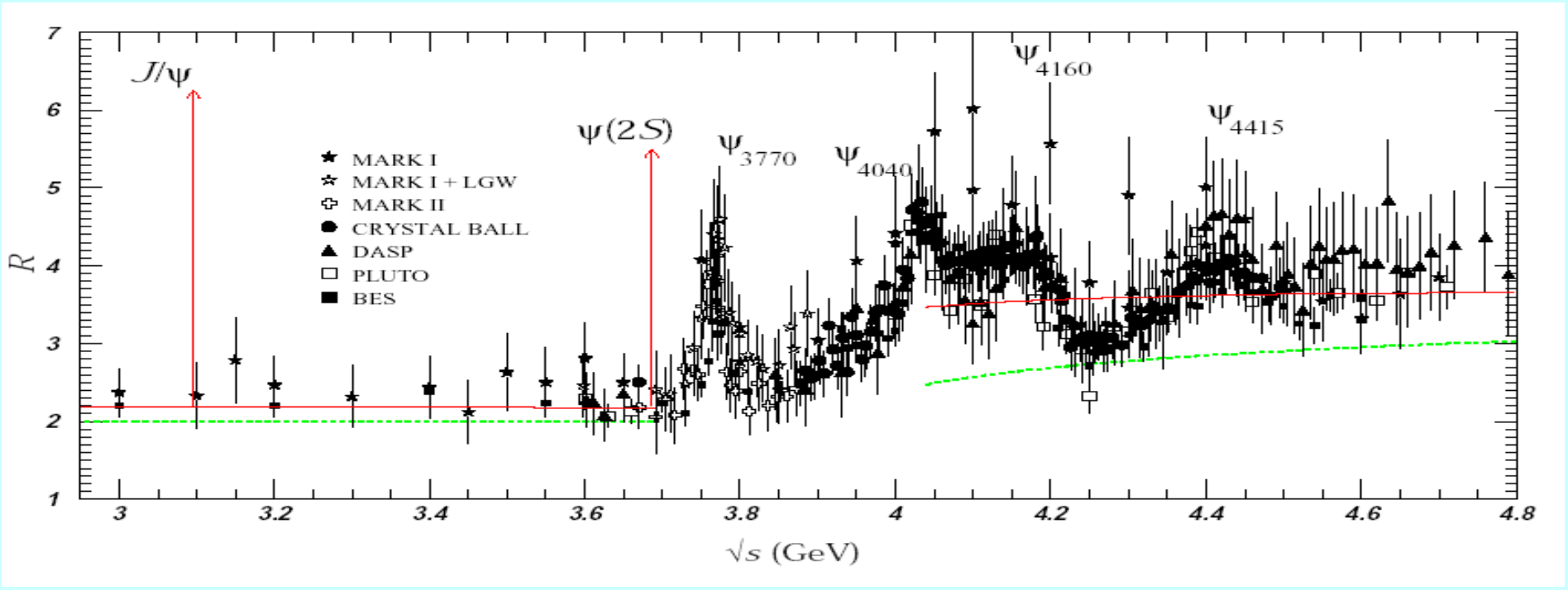
A very long history



Tau-charm production: e+e- collision



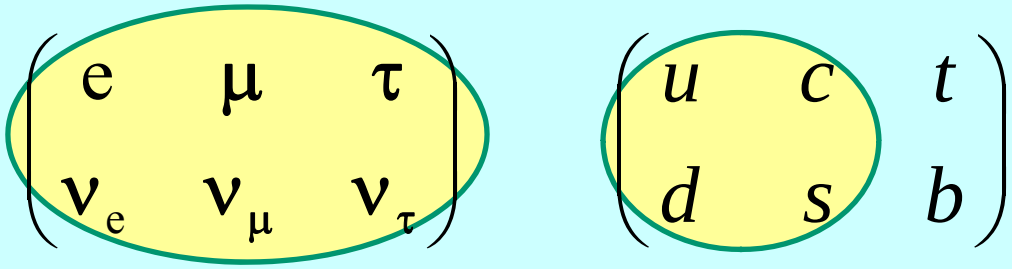




Why it is interesting

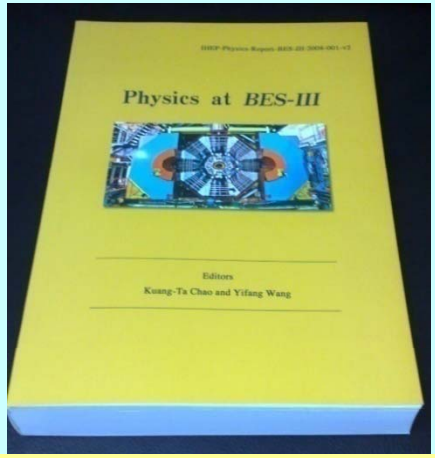
in the past
in the era of LHC
in the future

- Abundant resonances(J/ψ family, huge Xsections)
- Tau-charm threshold production(in pairs➔ tagging ➔ background free, no fragmentation, kinematic constraints, quantum coherence,…)
- Charm quark: A bridge between pQCD and non-pQCD
- A ruler for LQCD
- J/ψ decay ➔ Gluon rich environment
- Flavor physics ➔Complementary to LHC: virtual vs real
- A broad spectrum & efficient machine:



What (highlight) physics interested us

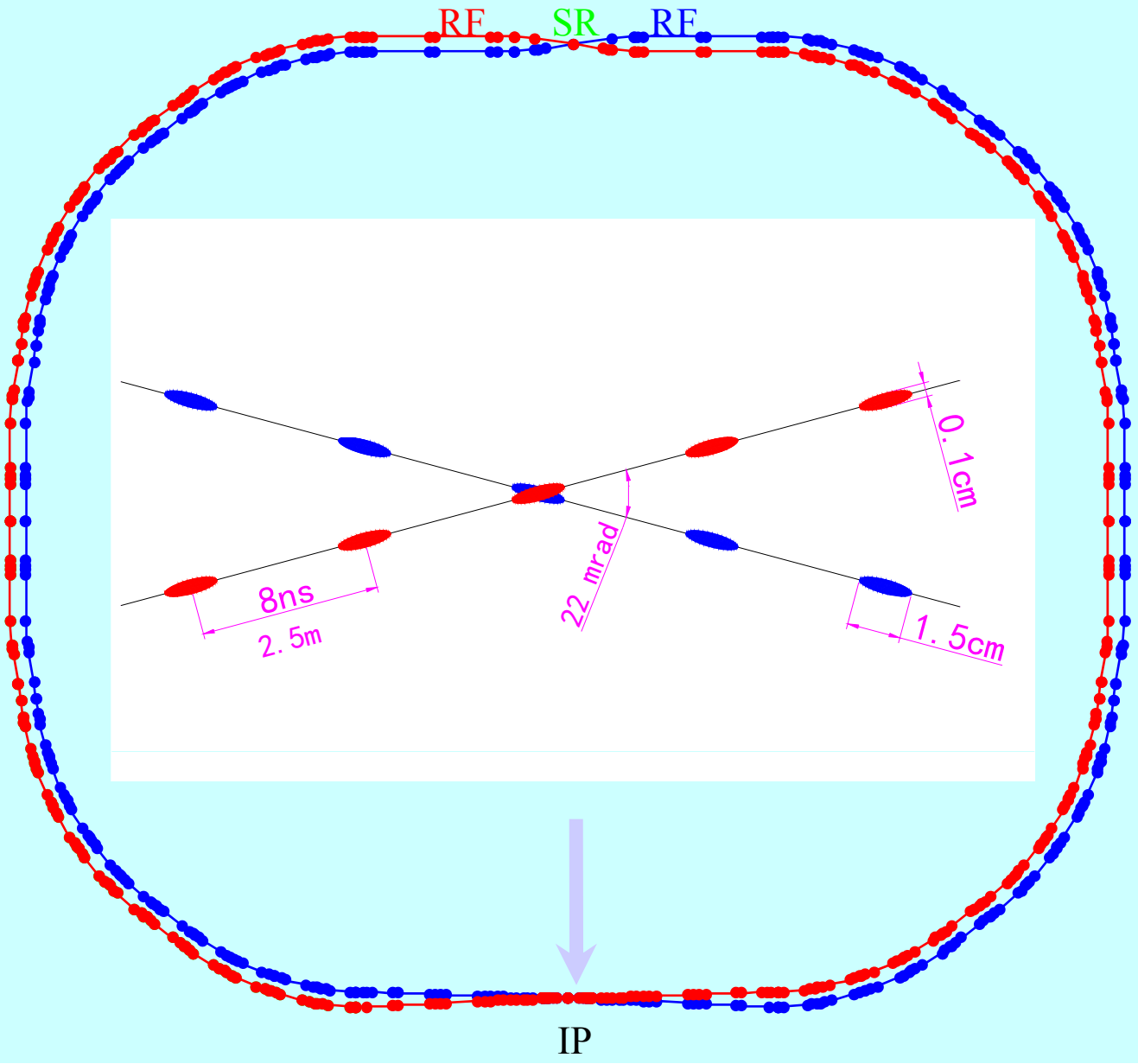
- **Light hadron spectroscopy**
  - **Full spectra: normal & exotic hadrons QCD**
  - **How quarks form a hadron ? non-pQCD**
- **Charm physics**
  - **CKM matrix elements ➔ SM and beyond**
  - **$D\overline{D}$ mixing and CPV ➔ SM and beyond**
- **Charmonium physics**
  - **Spectroscopy and transition ➔ pQCD & non-pQCD**
  - **New states above open charm thresholds ➔ exotic hadrons ?**
  - **pQCD: ρπ puzzle ➔ a probe to non-pQCD or ?**
- **Tau physics and QCD**
  - **Precision measurement of the tau mass and R value**
- **Search for rare and forbidden decays**



hep-ex/0809.1869
IJMP A V24,No 1(2009) supp

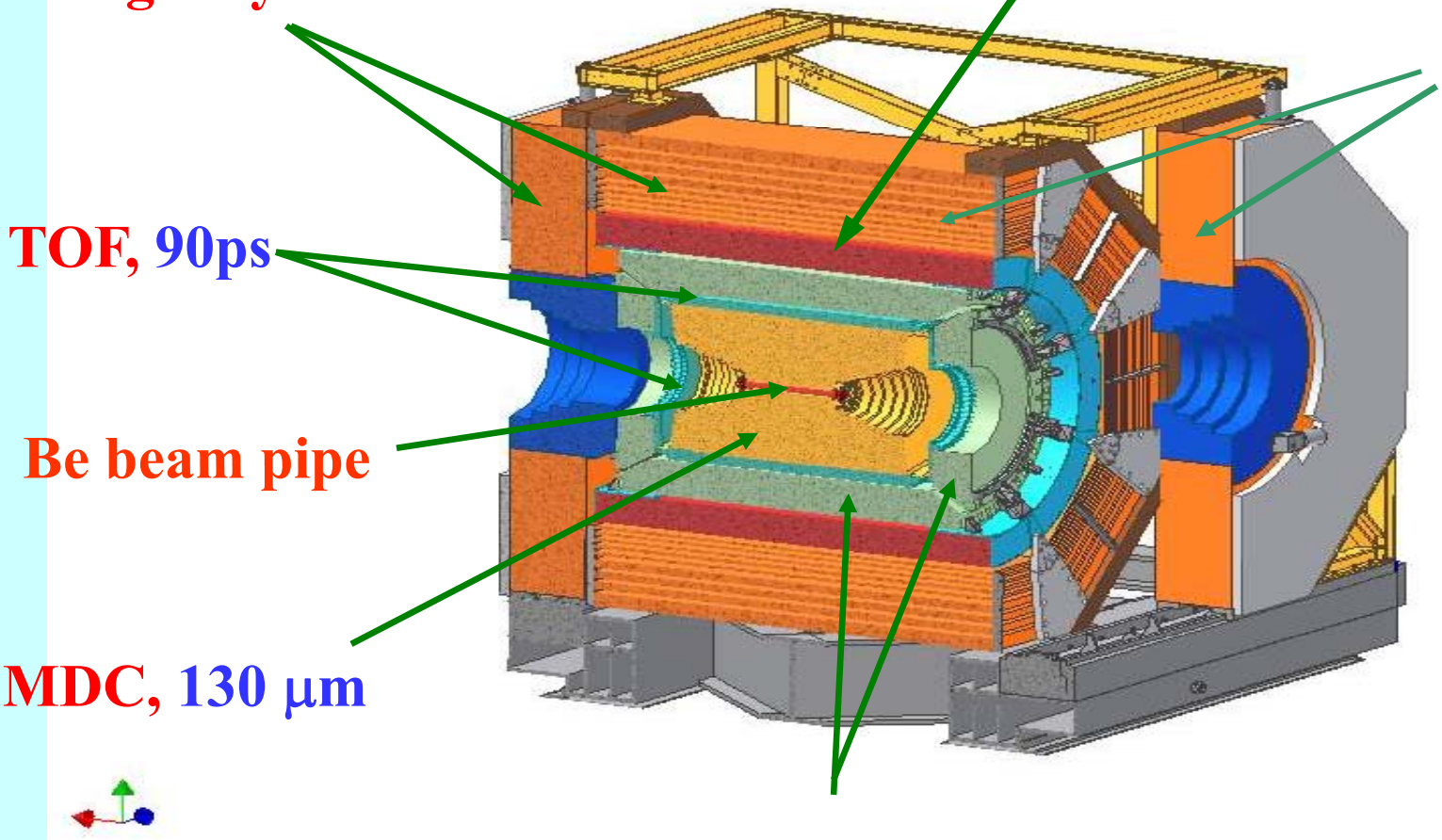
Precision test of SM and search for new physics

BEPC II Storage ring: Large angle, double-ring

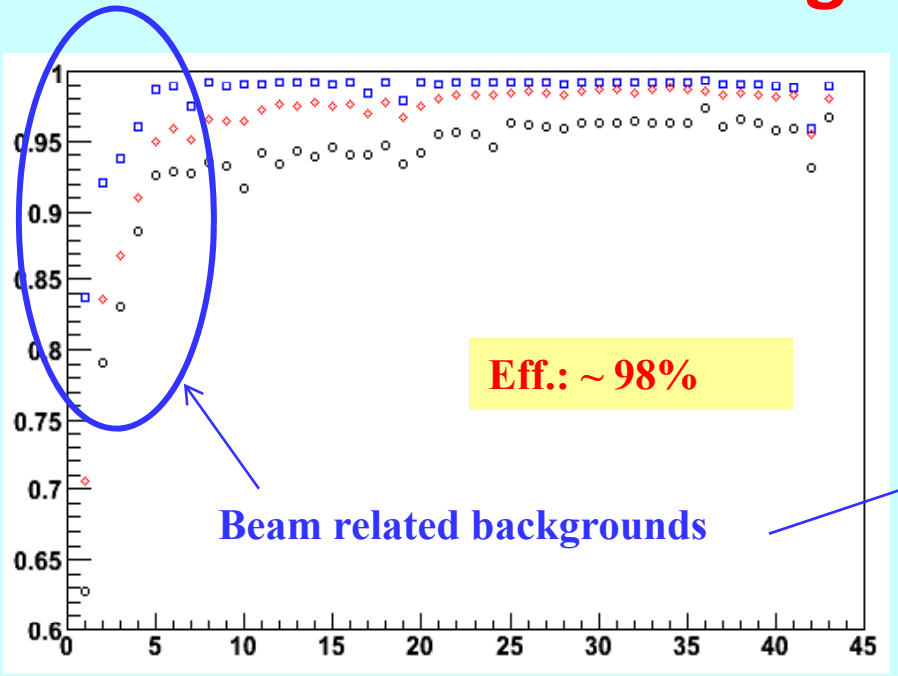


Beam energy:
1.0-2.3 GeV
Luminosity:
1×10^{33} $cm^{-2}s^{-1}$
Optimum energy:
1.89 GeV
Energy spread:
5.16×10^{-4}
No. of bunches:
93
Bunch length:
1.5 cm
Total current:
0.91 A
SR mode:
0.25A @ 2.5 GeV

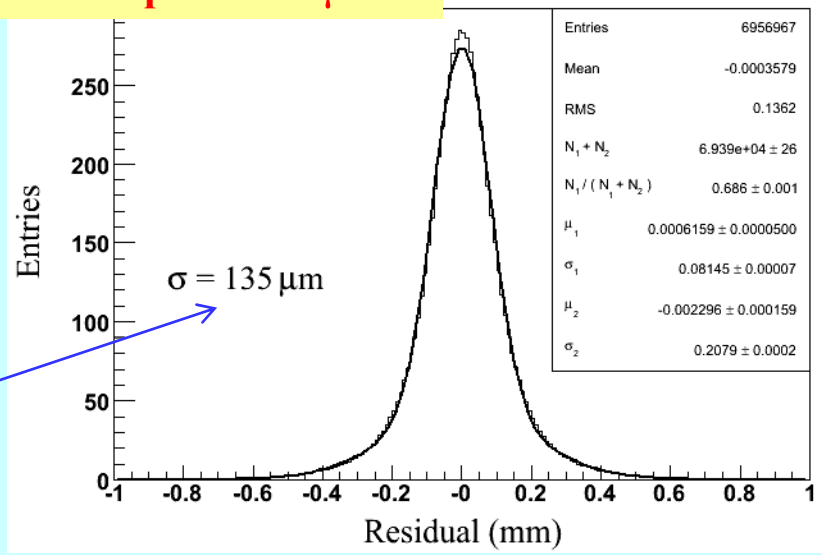
BESIII detector



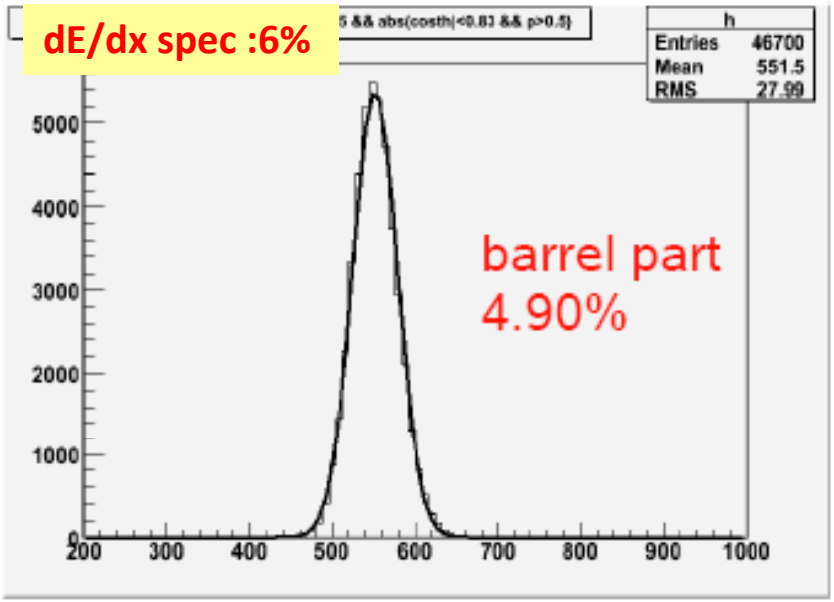
Drift Chamber： great performance



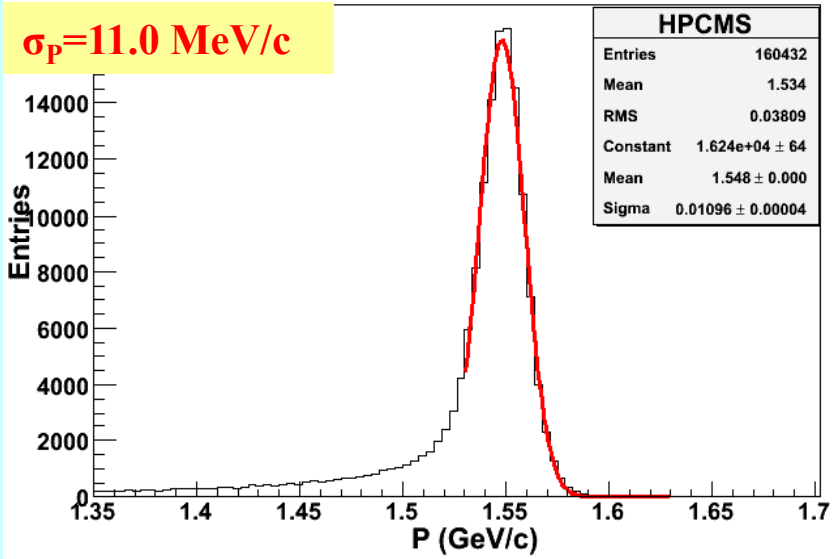
Reso. Spec.： 130μm



dE/dx spec :6%

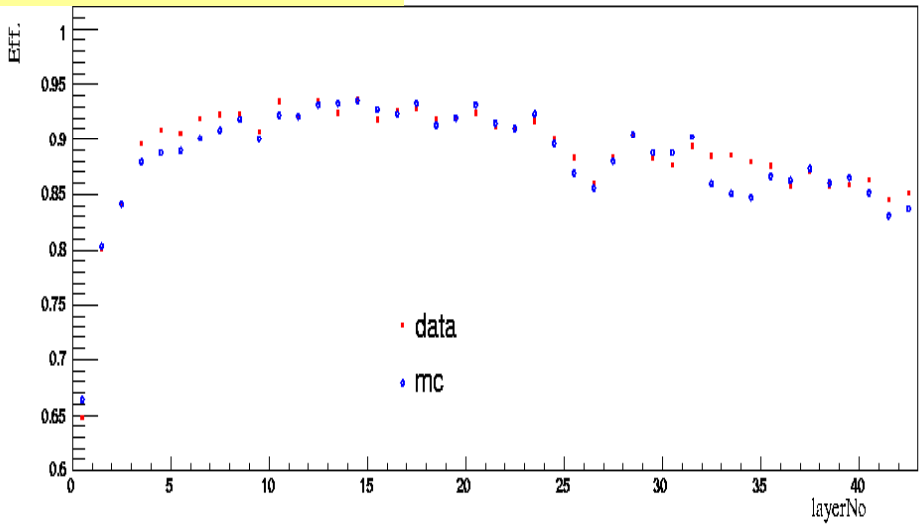


σ_P=11.0 MeV/c

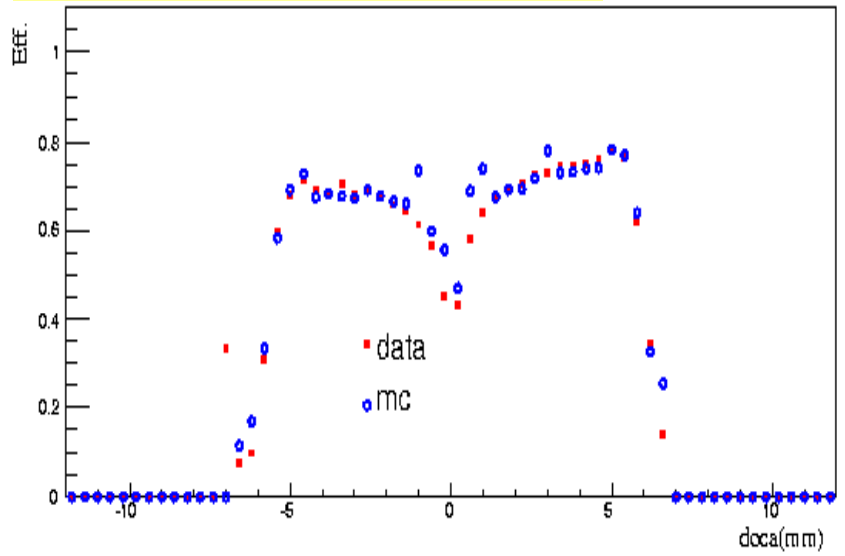


Drift chamber： data & MC comparison

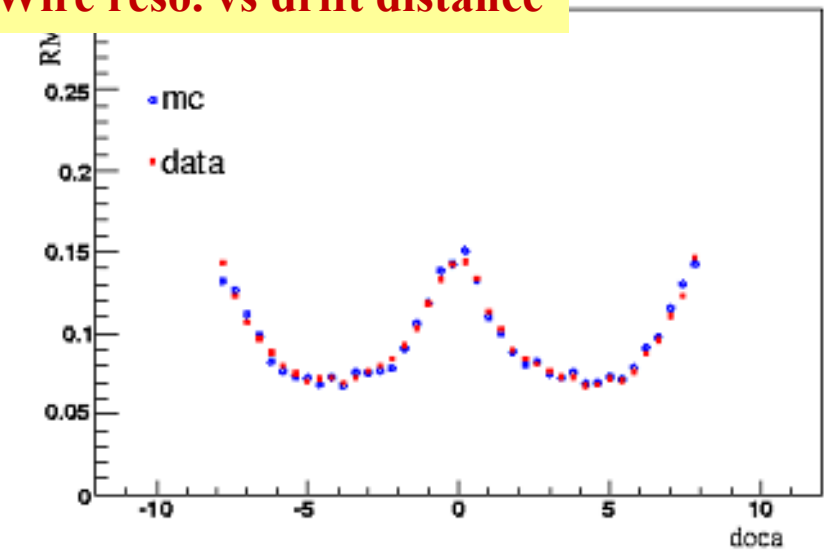
Efficiency vs layer



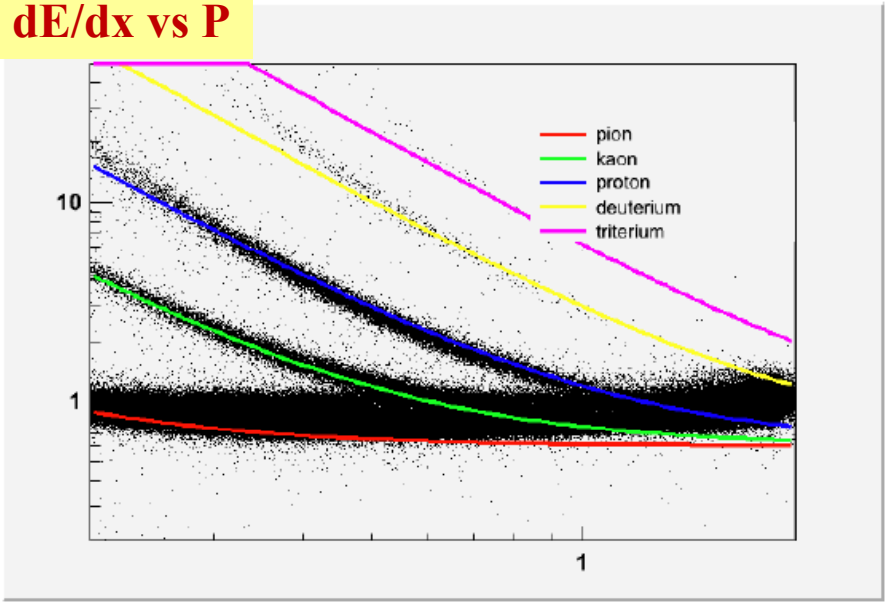
Efficiency vs drift distance



Wire reso. vs drift distance

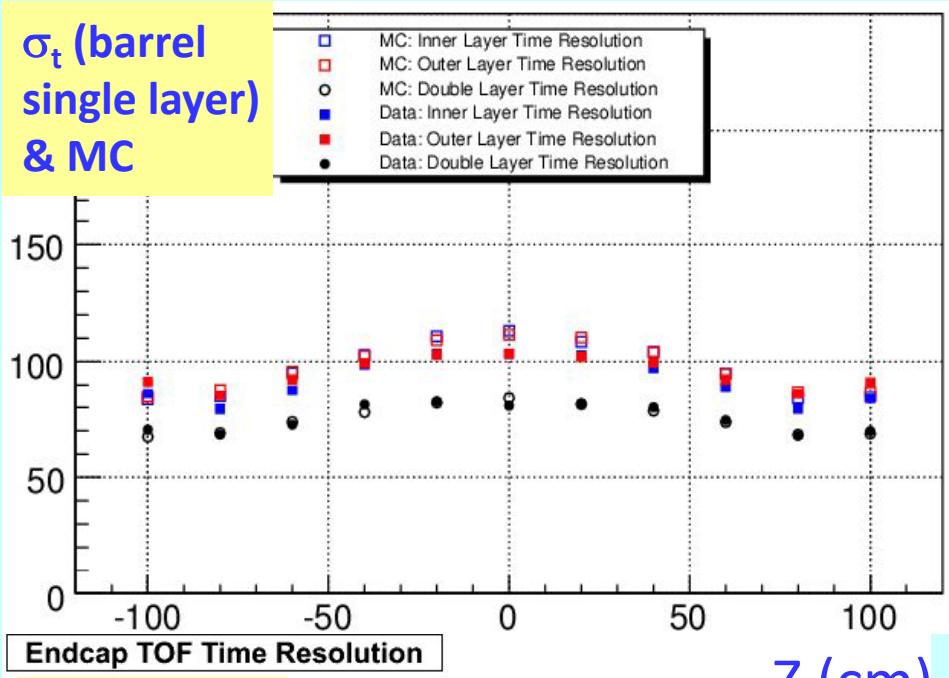


dE/dx vs P

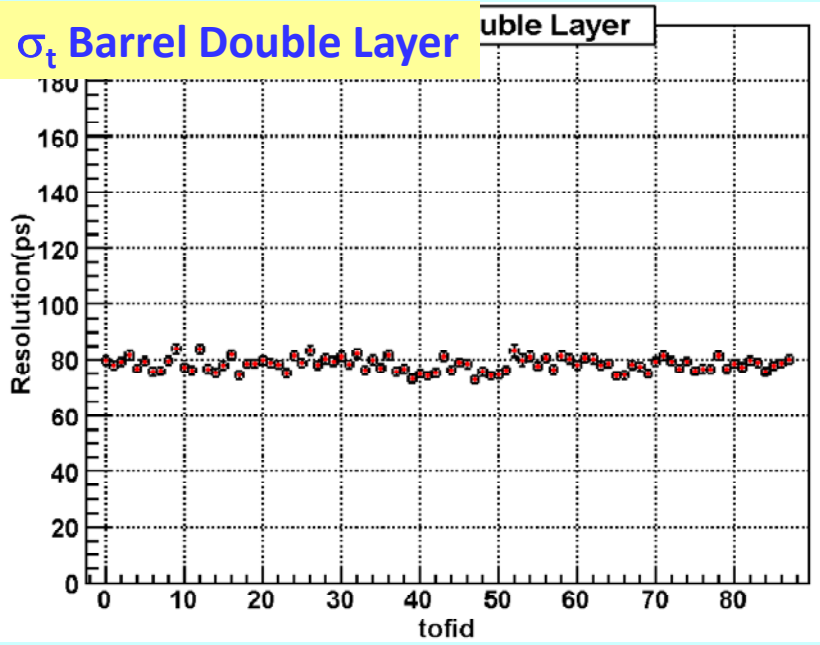


TOF： best time resolution

σ_t (barrel single layer) & MC



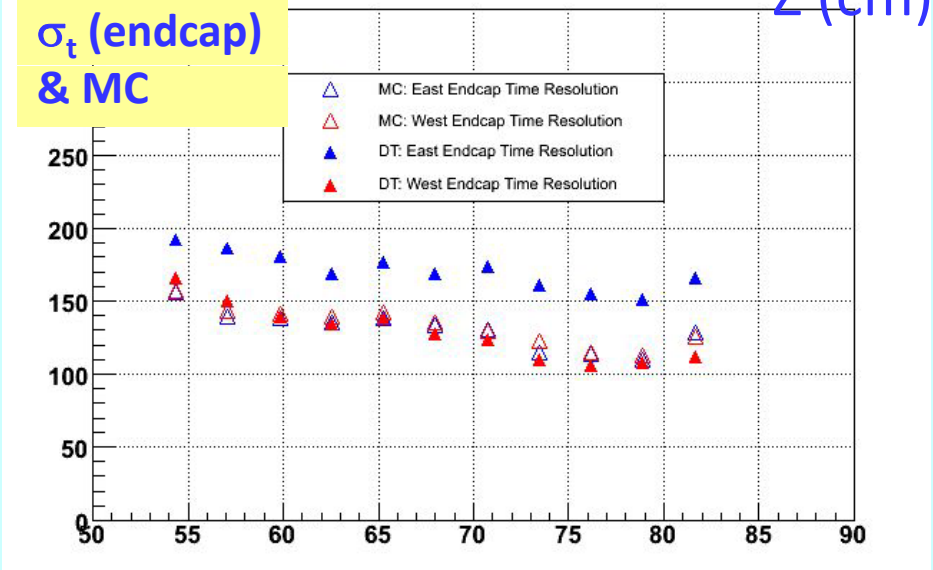
σ_t Barrel Double Layer



Endcap TOF Time Resolution

Z (cm)

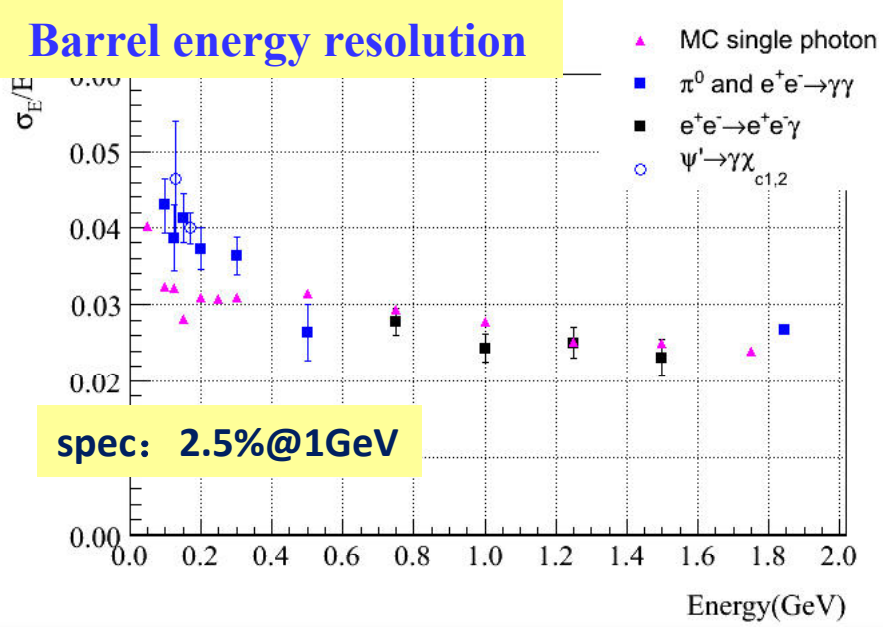
σ_t (endcap) & MC



Time Resolution (ps)	Design Target	Bhabha	Dimu
Barrel Single Layer	100~110	98.0	95.3
Barrel Double Layer	80~90	78.9	76.3
Endcap	110~120	136.4	95.0

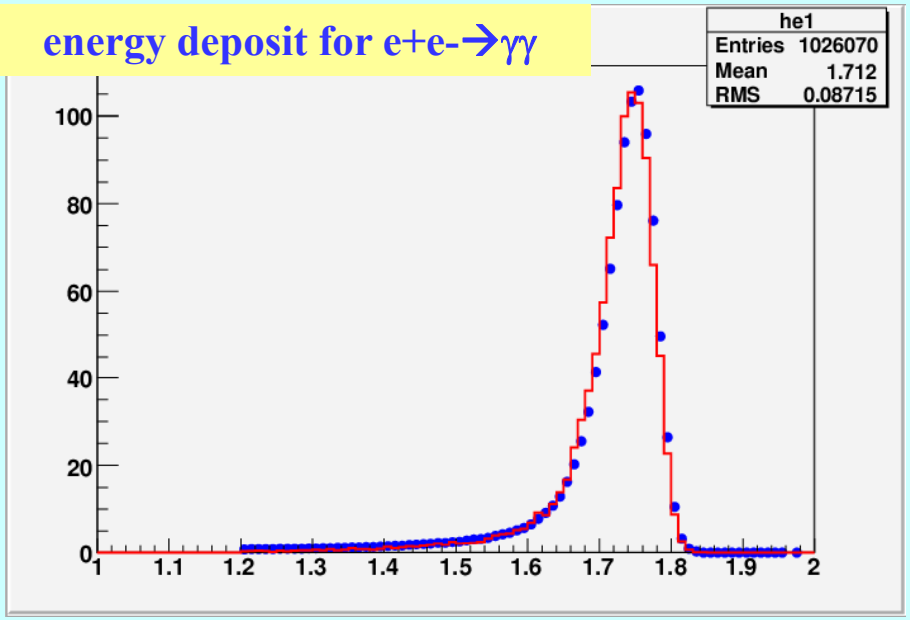
EMC: Excellent performance & data/MC agreement

Barrel energy resolution

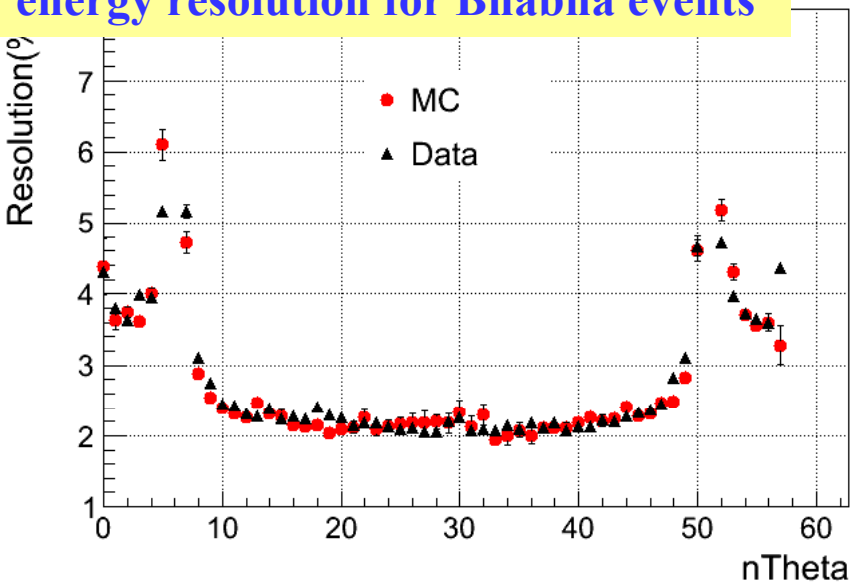


spec： 2.5%@1GeV

energy deposit for e+e-→γγ



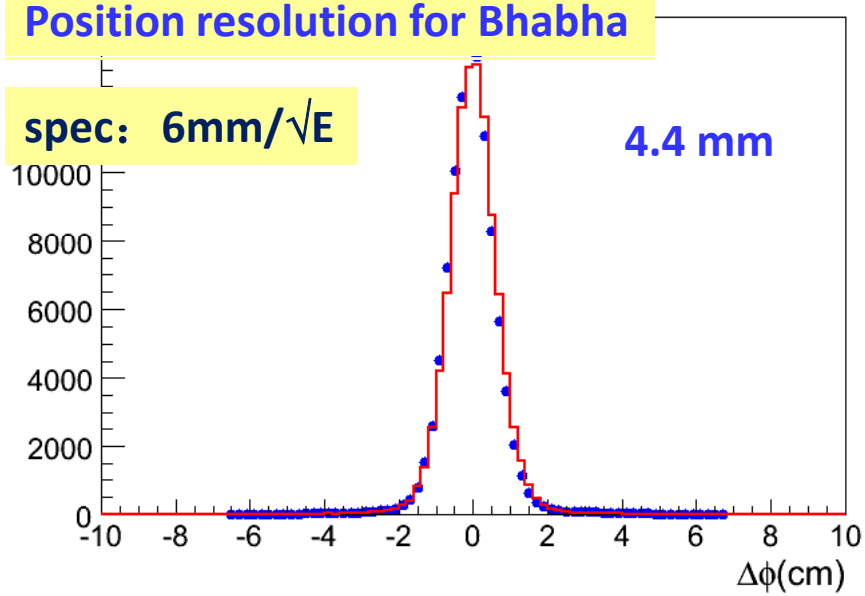
energy resolution for Bhabha events



Position resolution for Bhabha

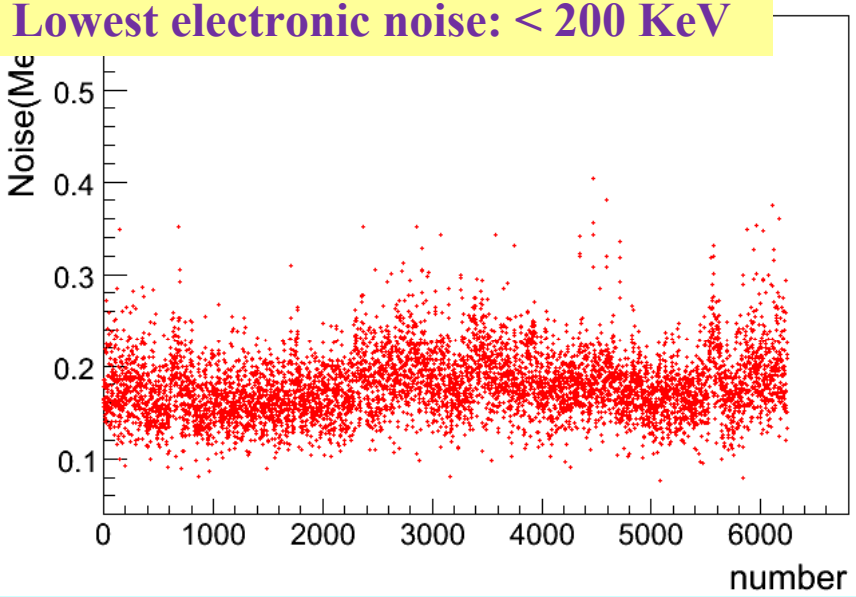
spec： 6mm/√E

4.4 mm

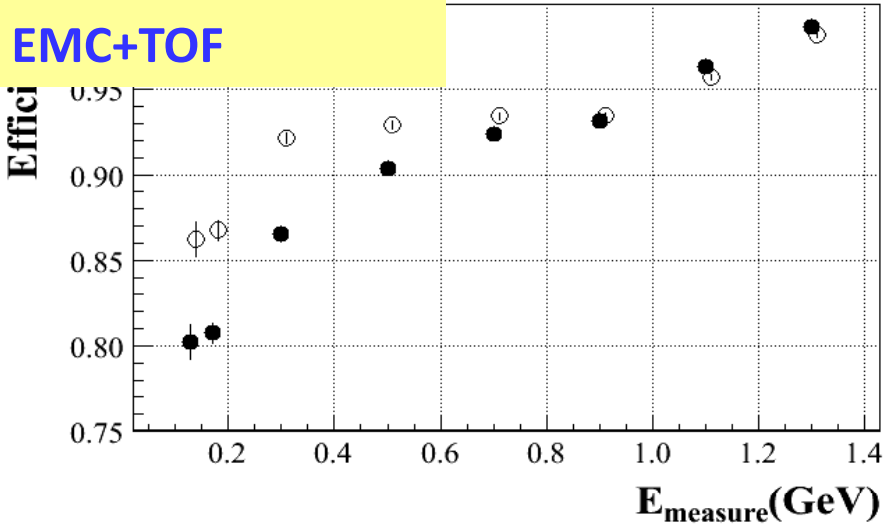


Many great features

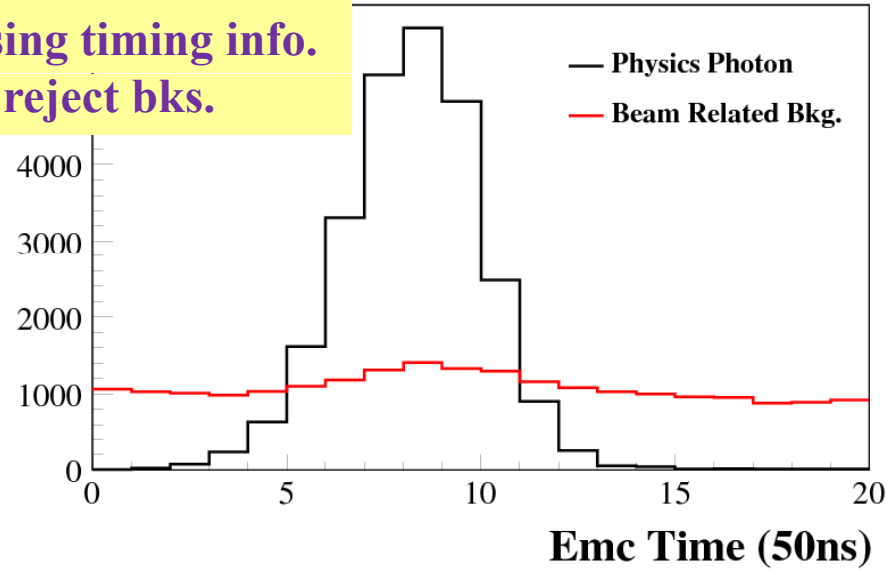
Lowest electronic noise: < 200 KeV

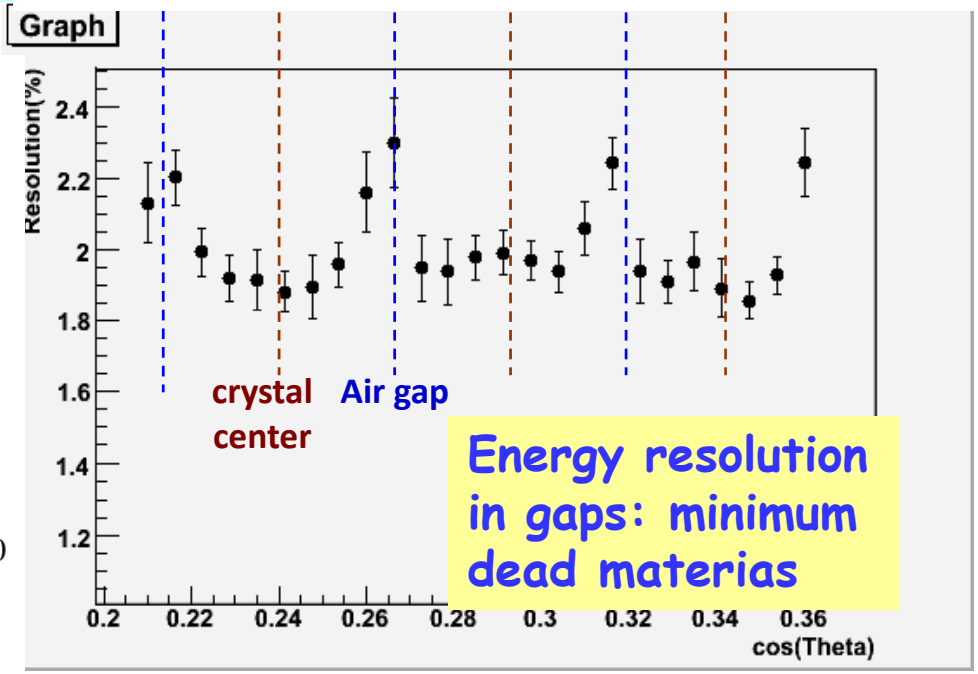


Photon detection: EMC+TOF



Using timing info. to reject bks.

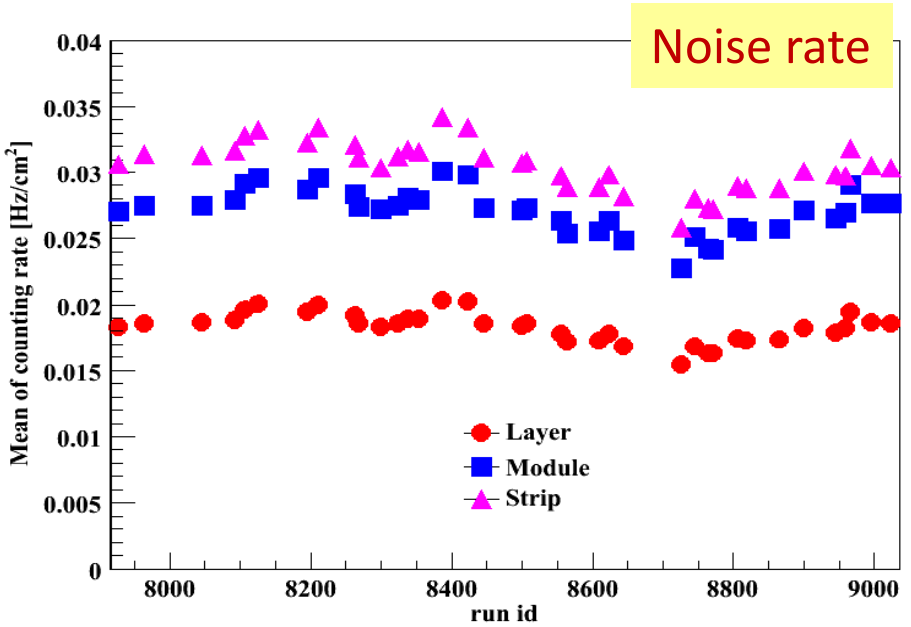


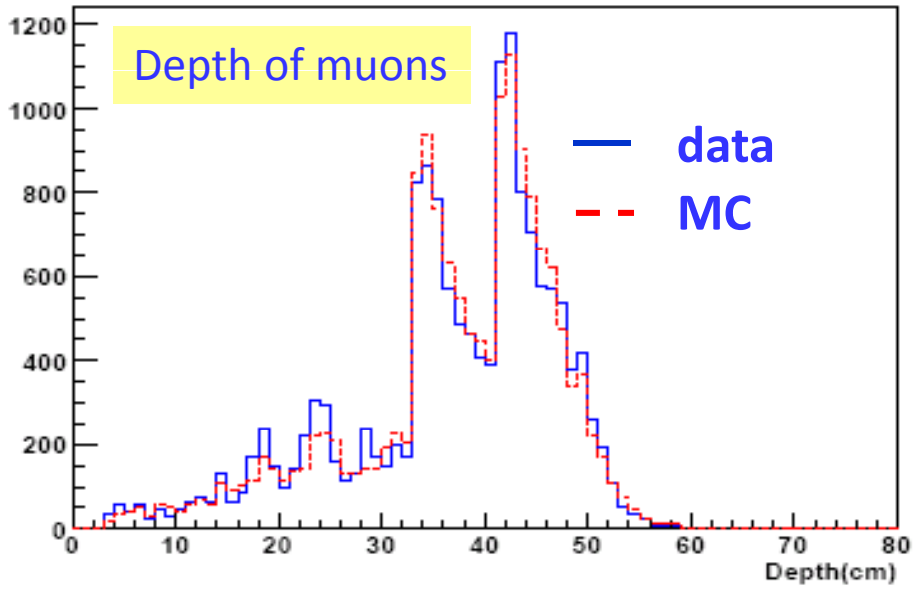


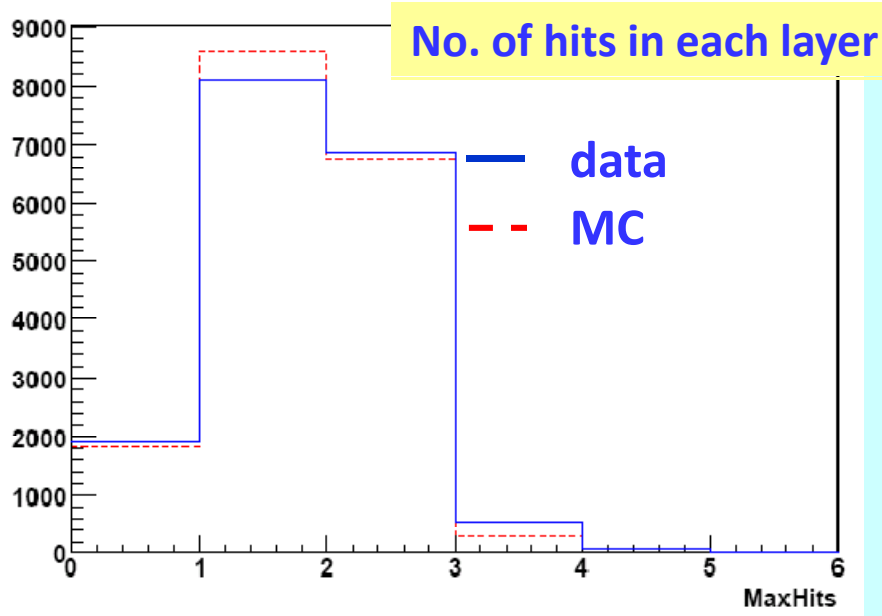
Energy resolution in gaps: minimum dead materias

μ Chamber

- Position resolution:
- $\sigma_{r\varphi}$=14.8 mm，σ_z=16.1 mm
- No technology for bakelite surface treatment: no linseed oil
- Good performance





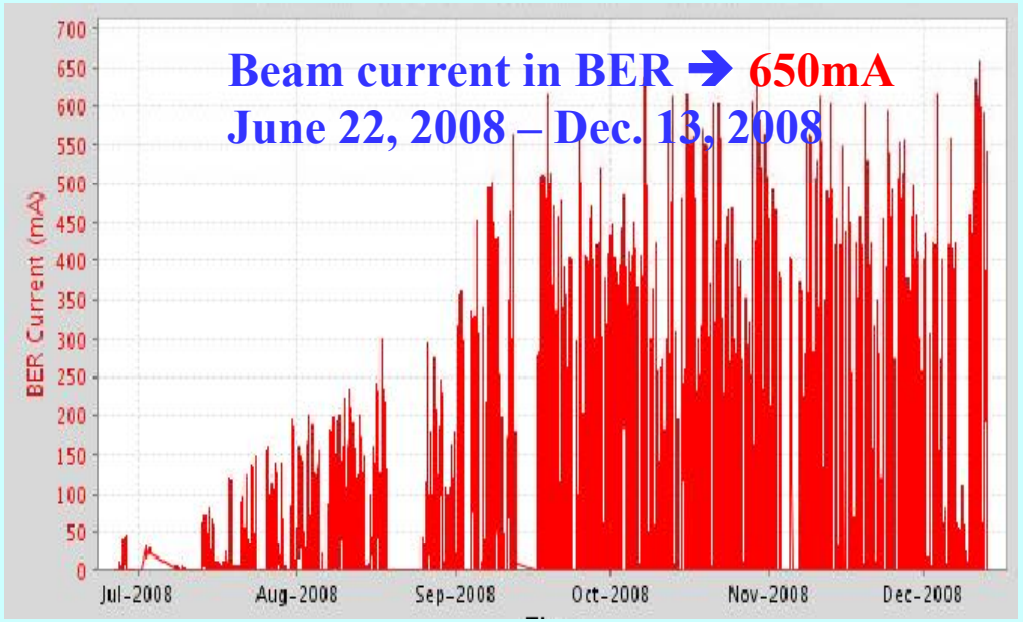


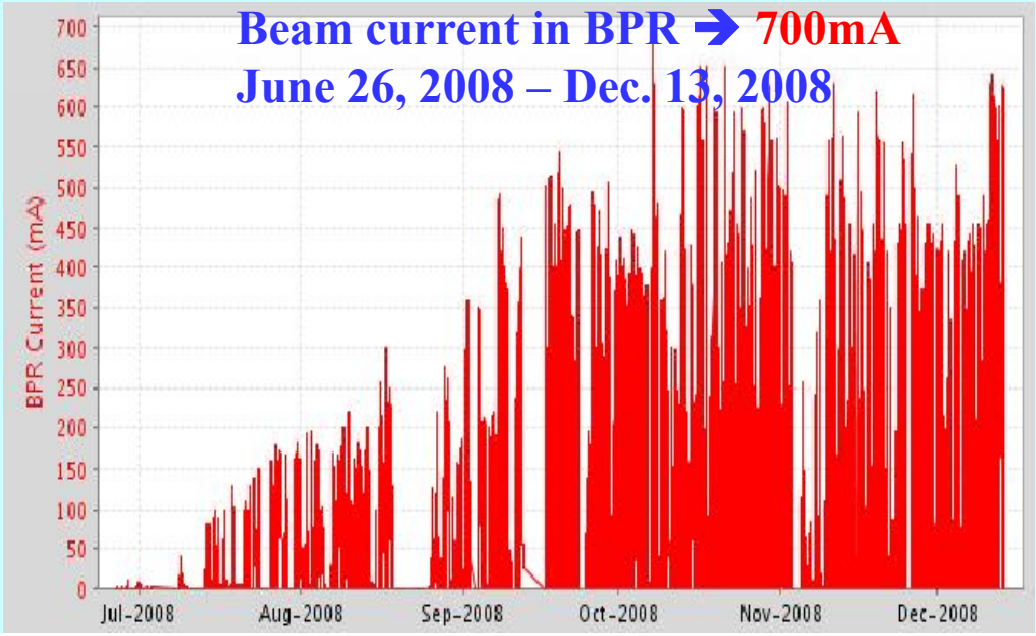
BEPCII/BESIII physics running

- July 18, 2008， first collision event
- Nov. 2008, 13M ψ(2S) events
- Jan.-Mar., 2009： complete detector calibration, reconstruction, software tuning and physics preparation
- Mar.-Apr., 2009： 100M ψ(2S) events
- May, 2009： 45 pb^{-1} at 3.65 GeV
- June-July, 2009： 200 M J/ψ events
- Aug.-Oct., 2009： summer maintanance
- Jan. 2010： ψ” data taking， ~400 pb^{-1}

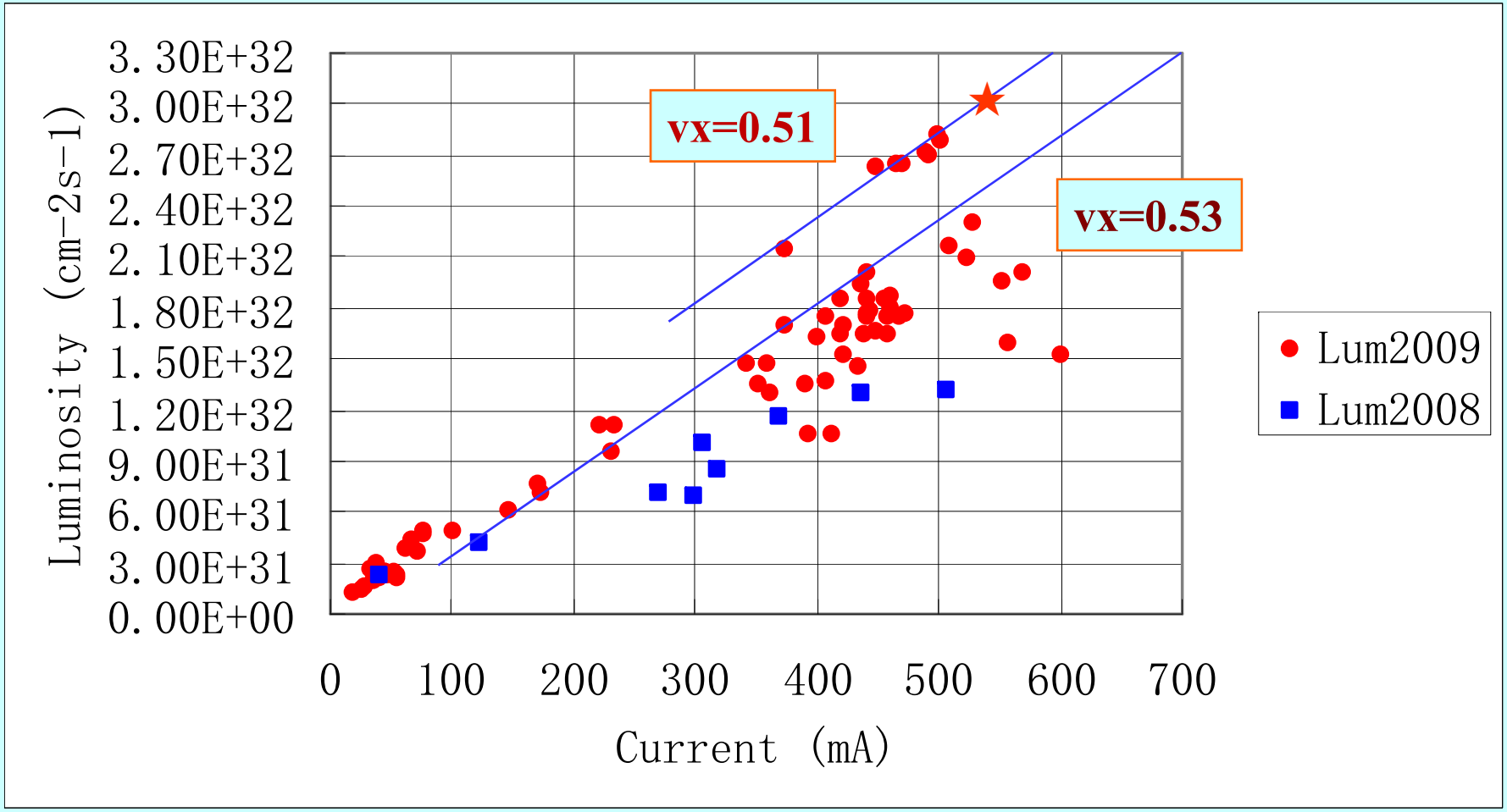
BEPCII commissioning: continual improvement

- ✓ **Lattice optimization : matching with designed values**
- ✓ **Debug systems: beam obstacles, vacuum leak, etc…**
- ✓ **Increase current gradually : improve vacuum**
- ✓ **Increase luminosity : Improve collision parameters**

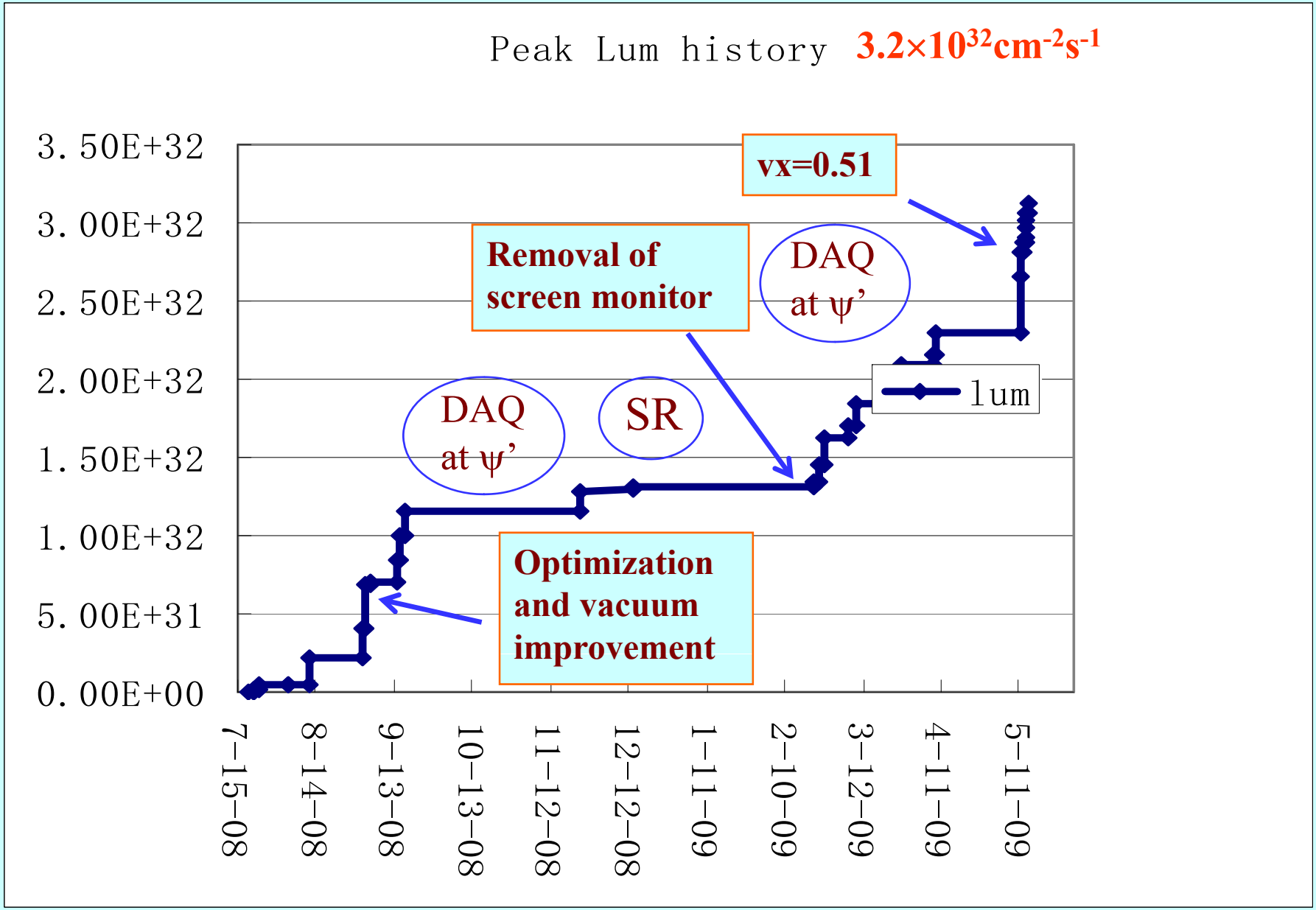




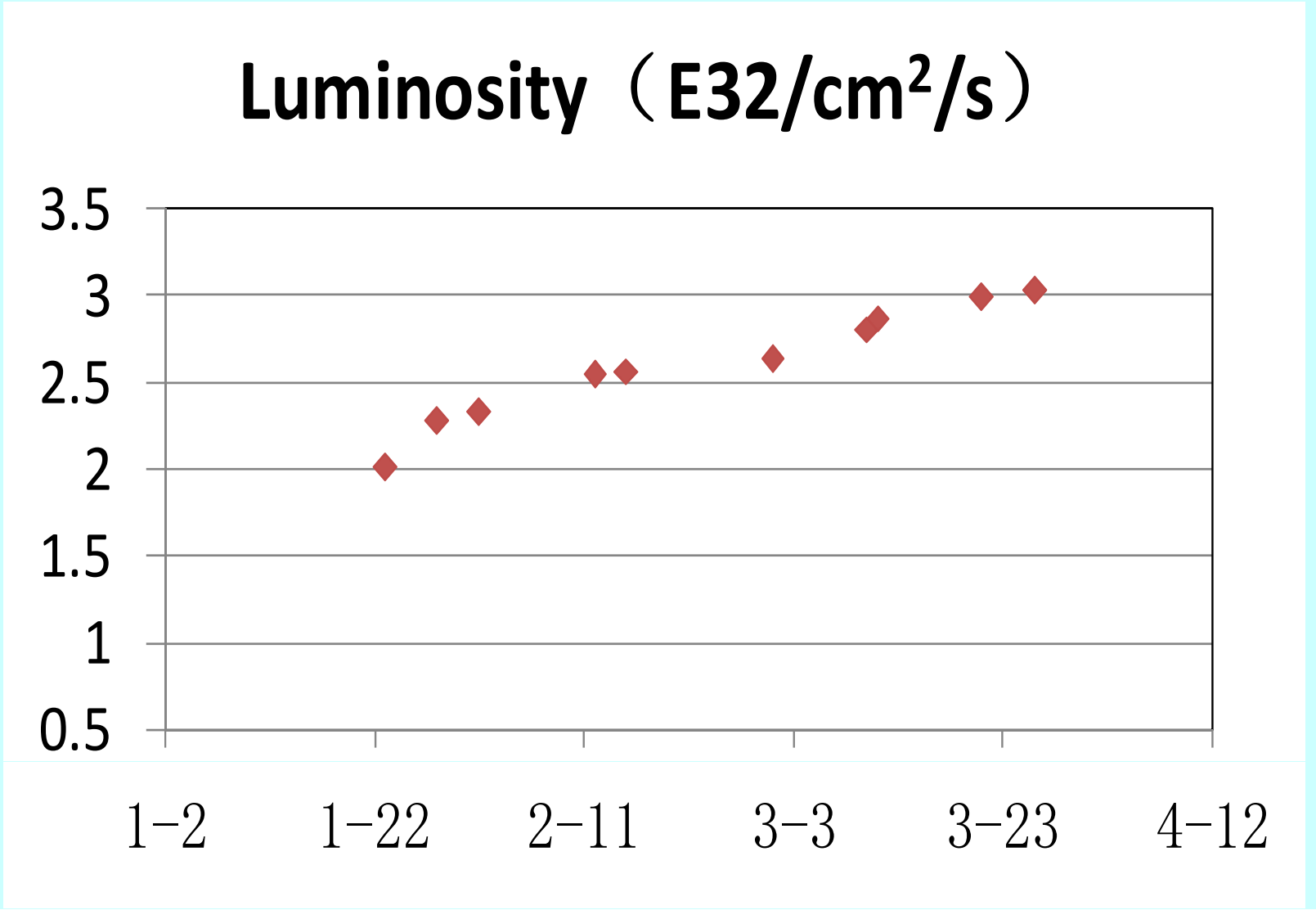
Luminosity improvement



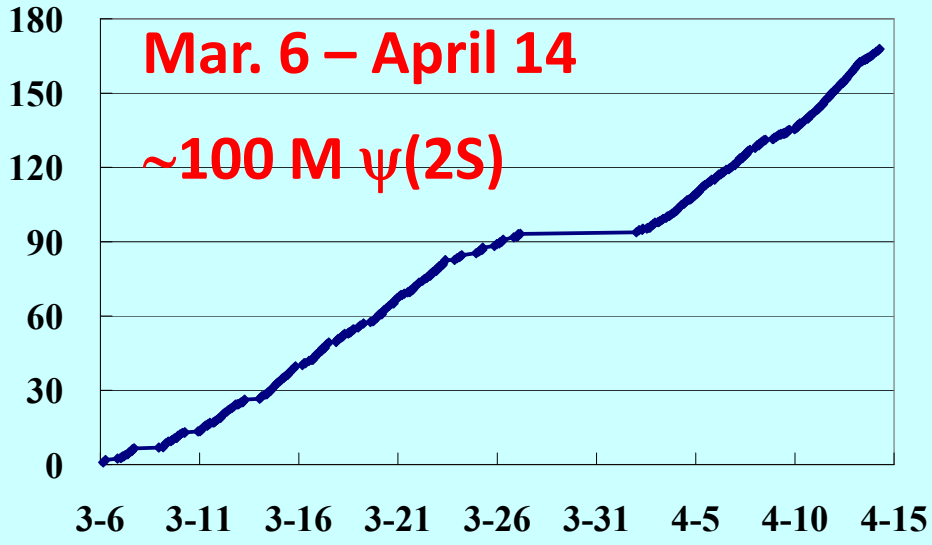
BEPCII Peak Luminosity evolution

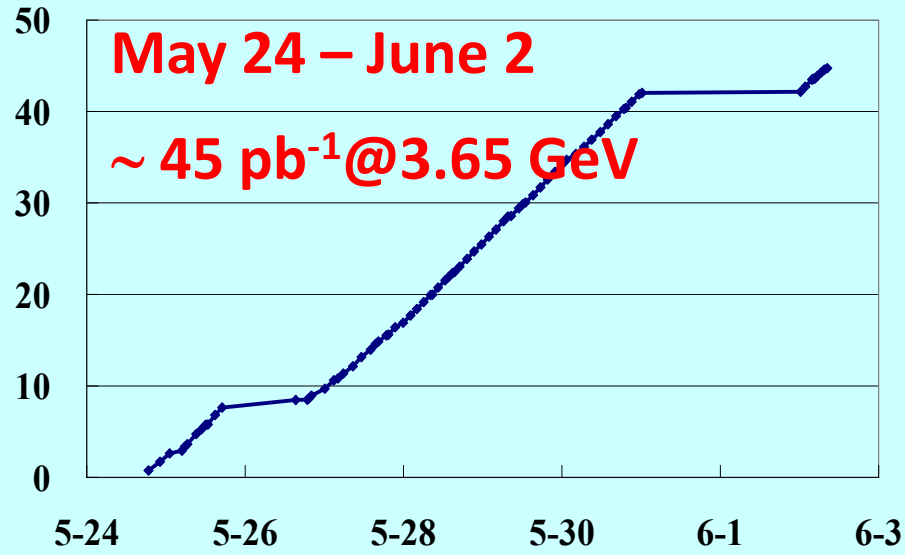


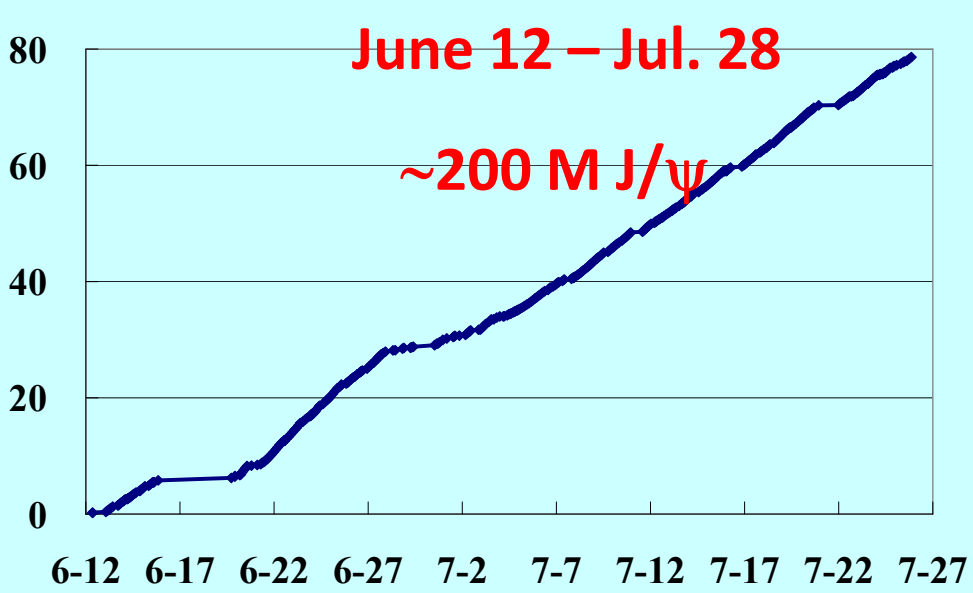
Luminosity improvement in 2010: with 1W2 for SR application

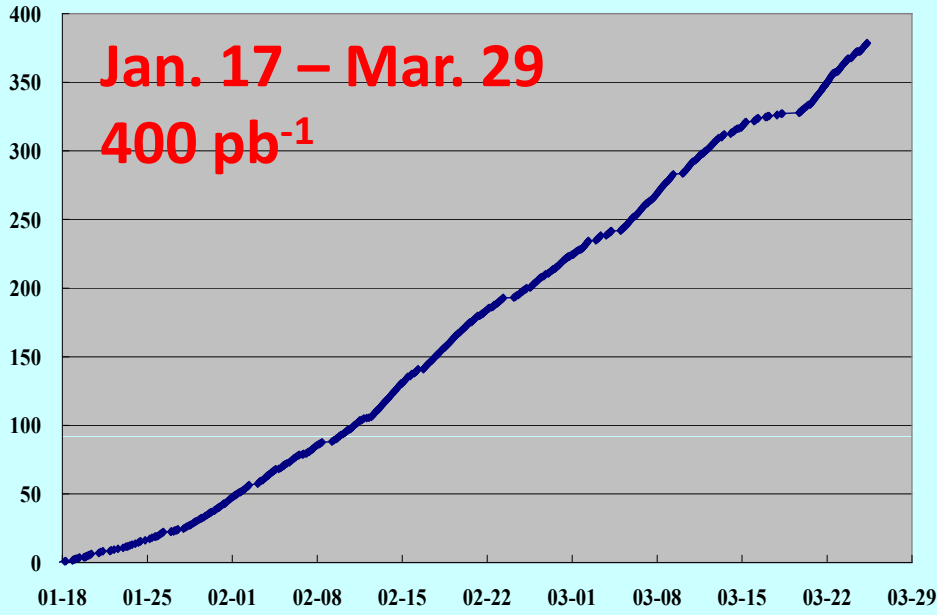


Stable data taking of BESIII: eff. > 80%









Primary physics results of BESIII

- **Confirmation of BESII results**
  - threshold enhancement $\gamma p\bar{p}$, $\gamma\omega\phi$, X(1835), …
- **New improved measurements**
  - h_c, η_c, χ_{cJ}, , …
- **New observations**
  - χ_{cJ} decays
  - h_c decays
  - Light hadrons, …

Exp.	Months from the first event to the first paper
LEP	1
BELLE	17
Babar	20
BESI	39
BESII	18
BESIII	18

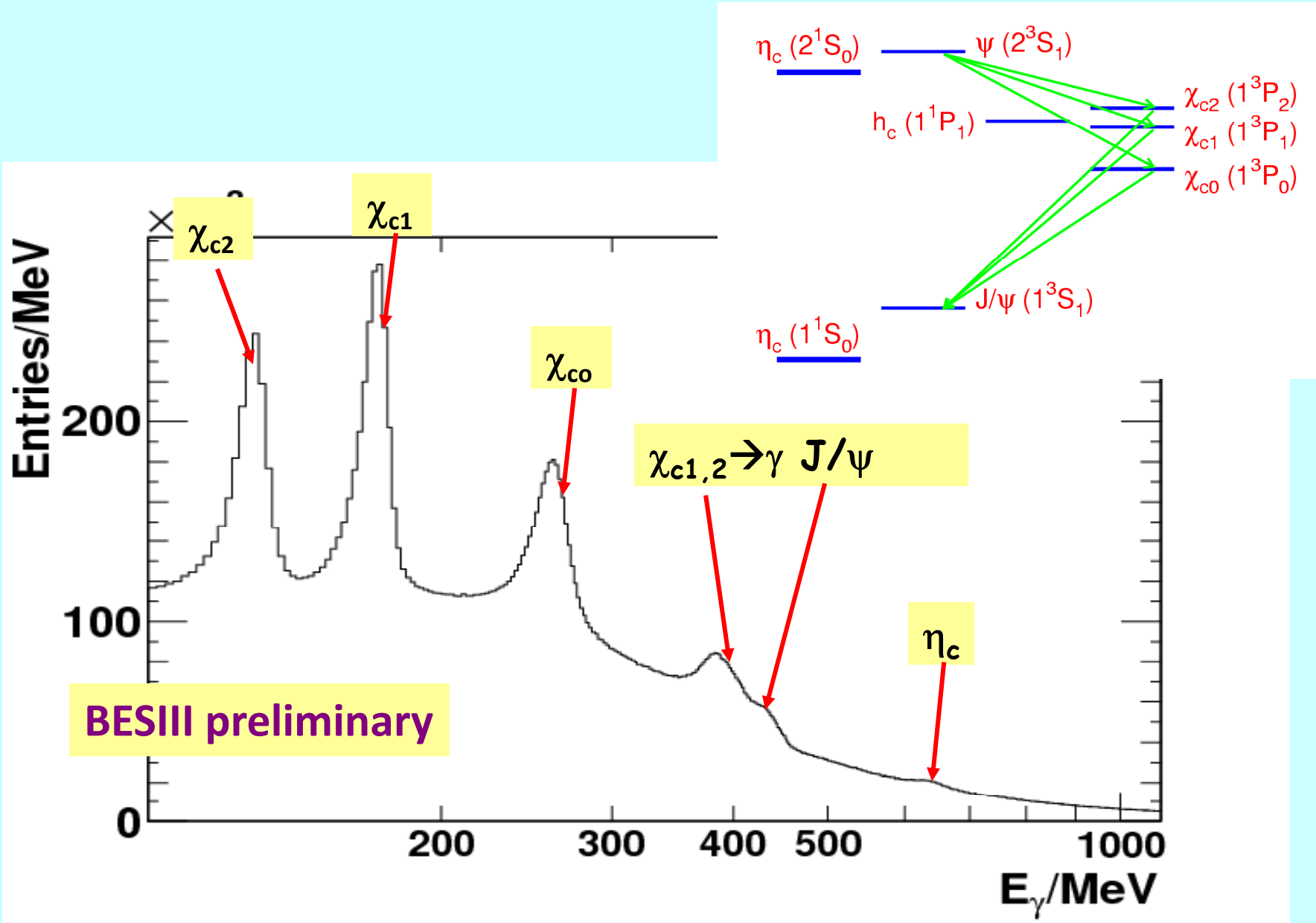
Three papers published

8 papers in memo stage

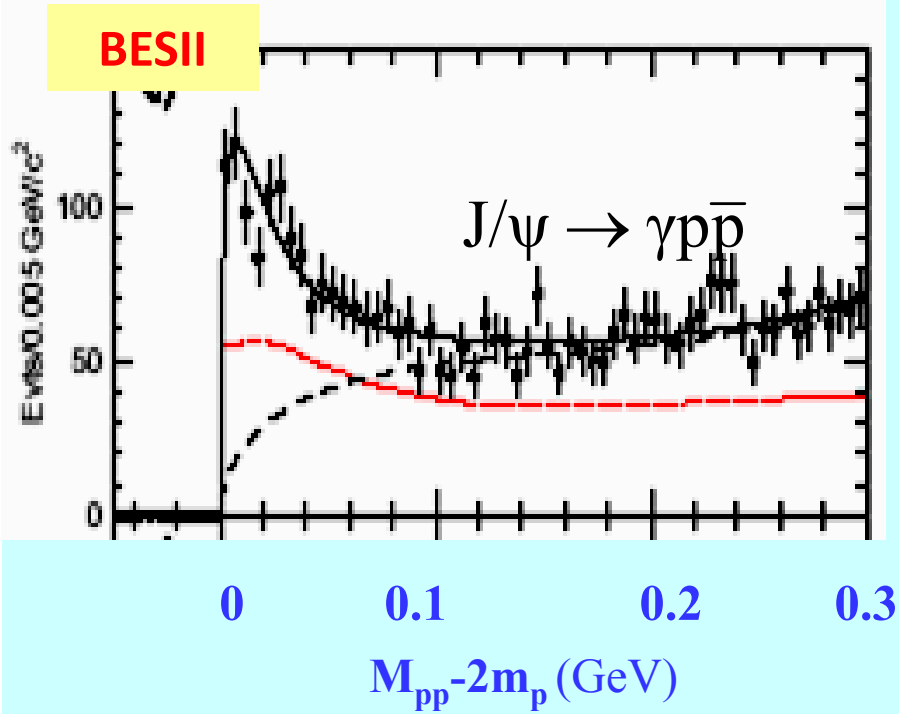
Many more analysis on going

Only a few approved results to be shown here

EM transitions: inclusive photon spectrum

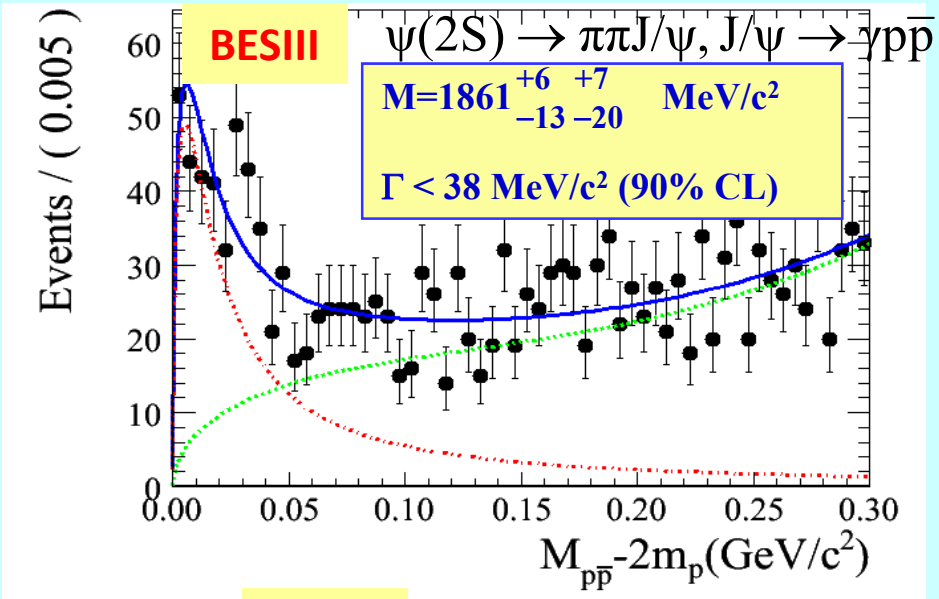


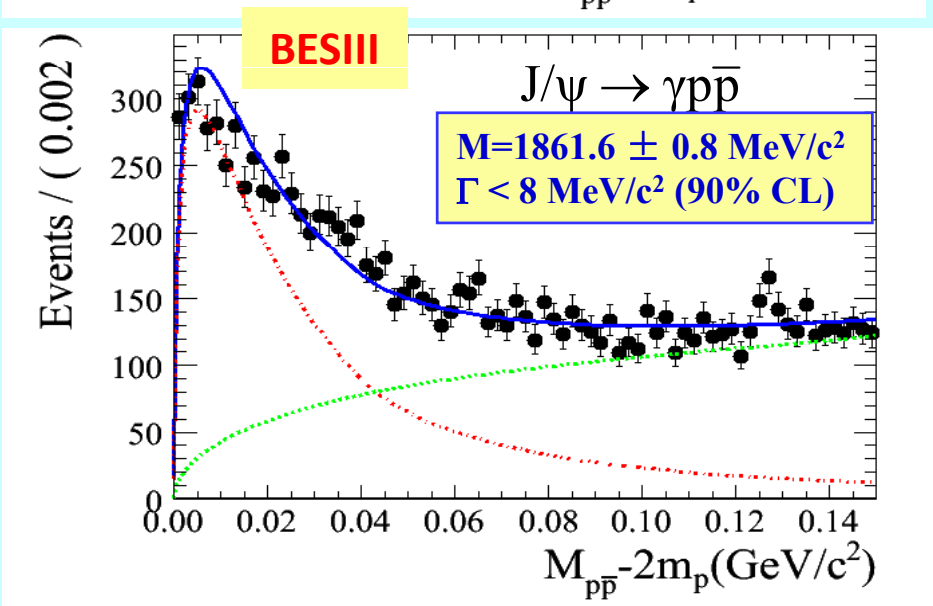
Confirmation of the BESII observation: $p\bar{p}$ threshold enhancement in J/ψ decays



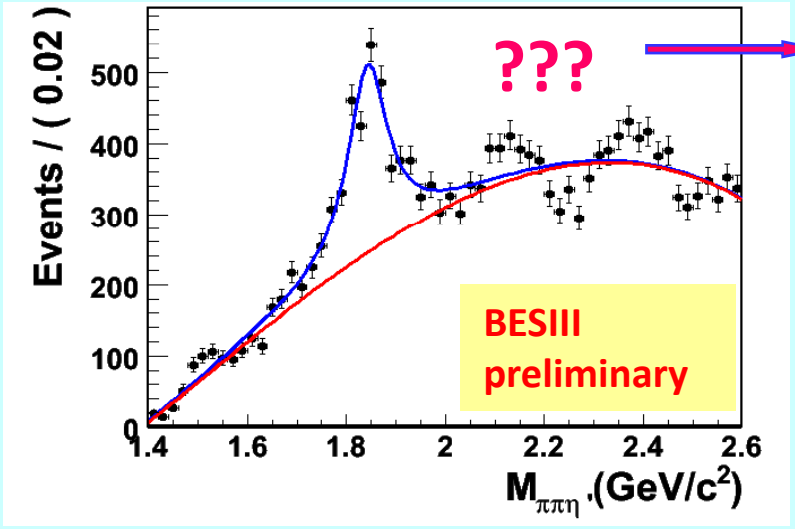
M=1859 $^{+3}_{-10}$ $^{+5}_{-25}$ MeV/c²
Γ < 30 MeV/c² (90% CL)

arXiv:1001.5328, accepted by Chinese Phys. C





Confirmation of BESII observation: X(1835) in J/ψ →γη'ππ

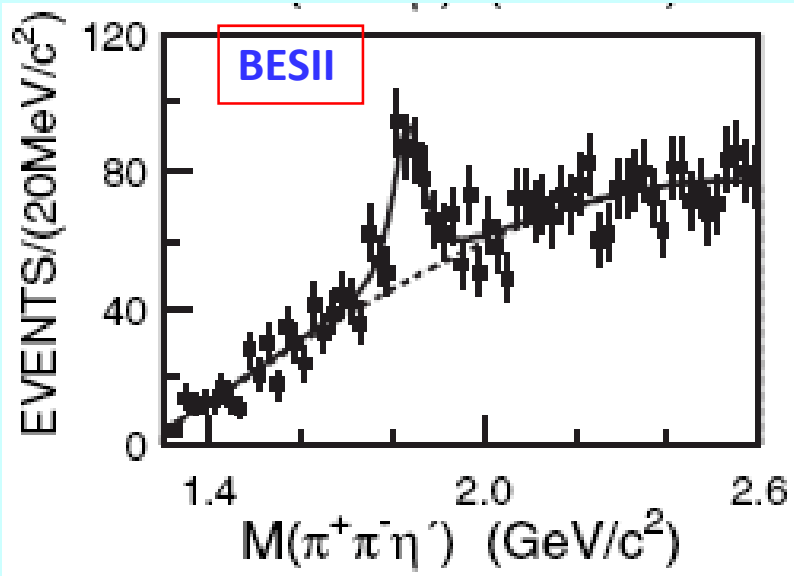


Two new resonance ?

significance: 21σ

$M = 1842.4 \pm 2.8(\text{stat})$ MeV

$\Gamma = 99.2 \pm 9.2$ MeV



significance: 7.7σ

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

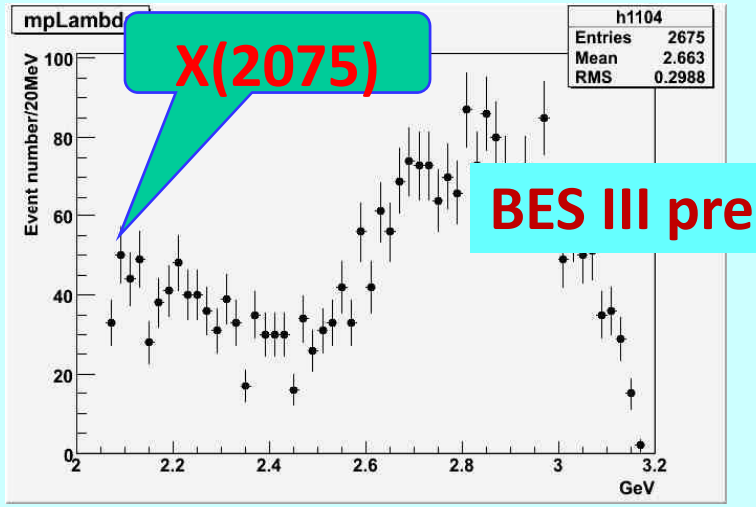
$\Gamma = 67.7 \pm 20.3\,(\text{stat}) \pm 7.7(\text{syst})$ MeV

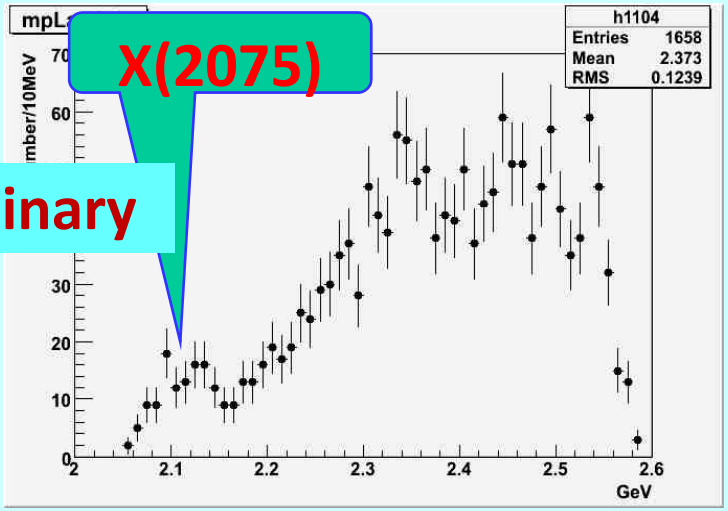
Confirmation of BESII observation: X(2075)

$\psi' \to pK\bar{\Lambda} + c.c.$ $\quad$ $J/\psi \to pK\bar{\Lambda} + c.c.$

$M_{p\Lambda}$

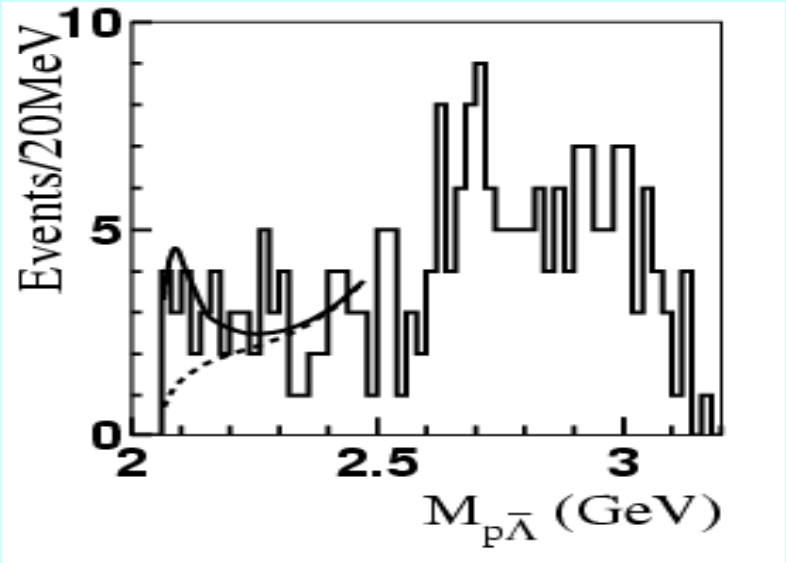
BESIII

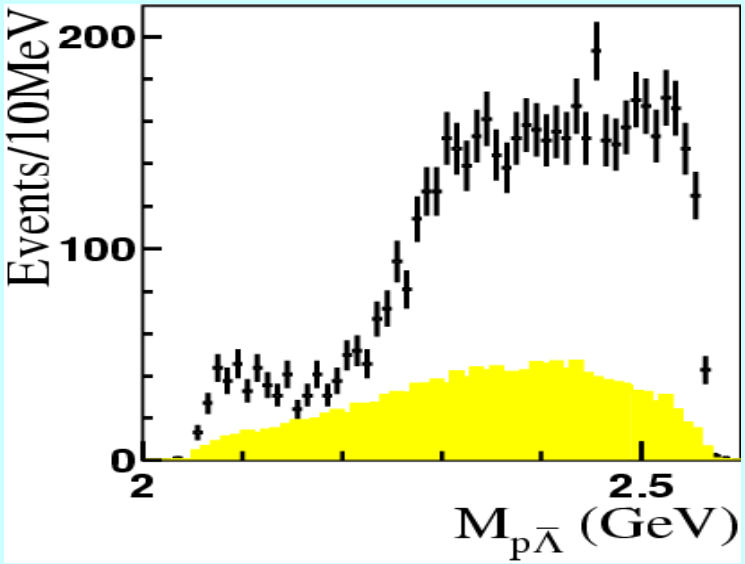




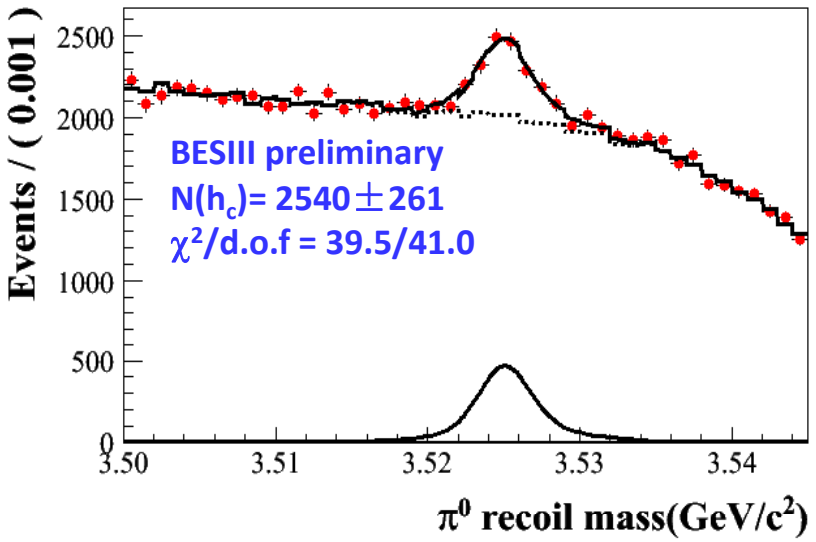
BES III preliminary

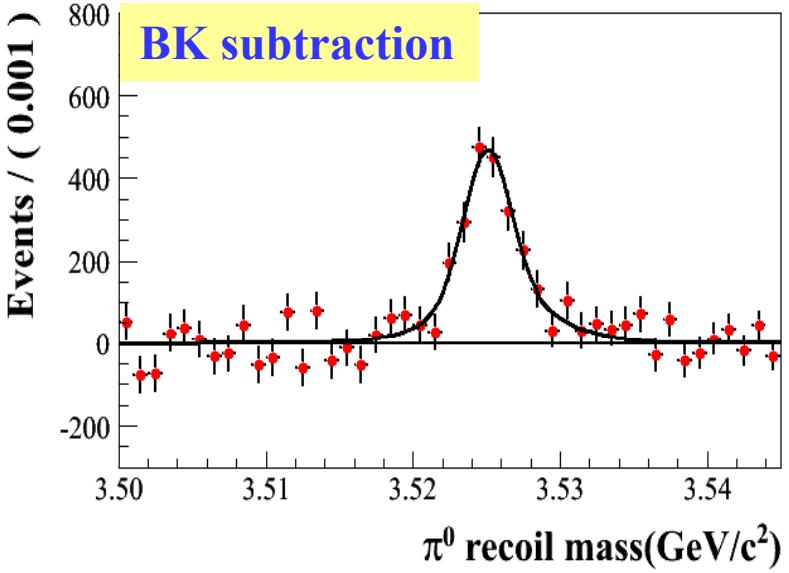
BESII





Observation of h_c in $\psi(2S)\to\pi^0 h_c, h_c\to\gamma\eta_c$





$M(h_c)^{Inc} = 3525.40 \pm 0.13 \pm 0.18$ MeV

$\Gamma(h_c)^{Inc} = 0.73 \pm 0.45 \pm 0.28$ MeV

$Br(\psi' \to \pi^0 h_c) \times Br(h_c \to \gamma\eta_c)^{Inc}$

$= (4.58 \pm 0.40 \pm 0.50) \times 10^{-4}$

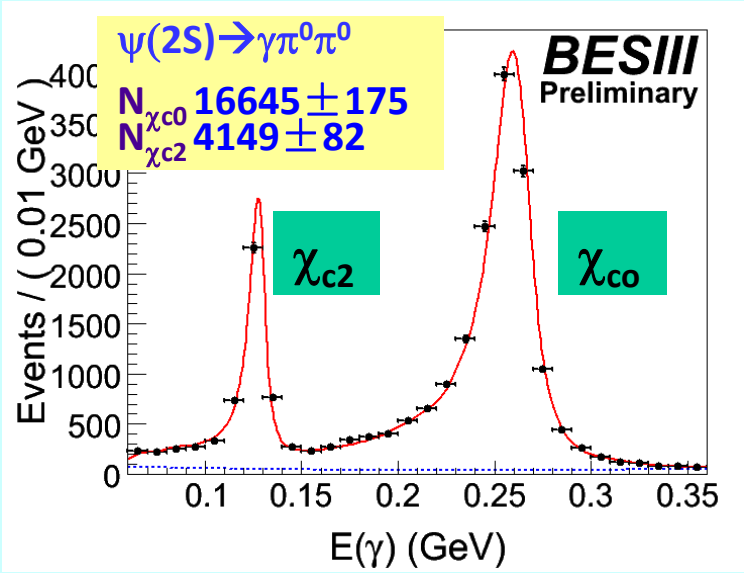
$Br(\psi' \to \pi^0 h_c) = (8.4 \pm 1.3 \pm 1.0) \times 10^{-4}$

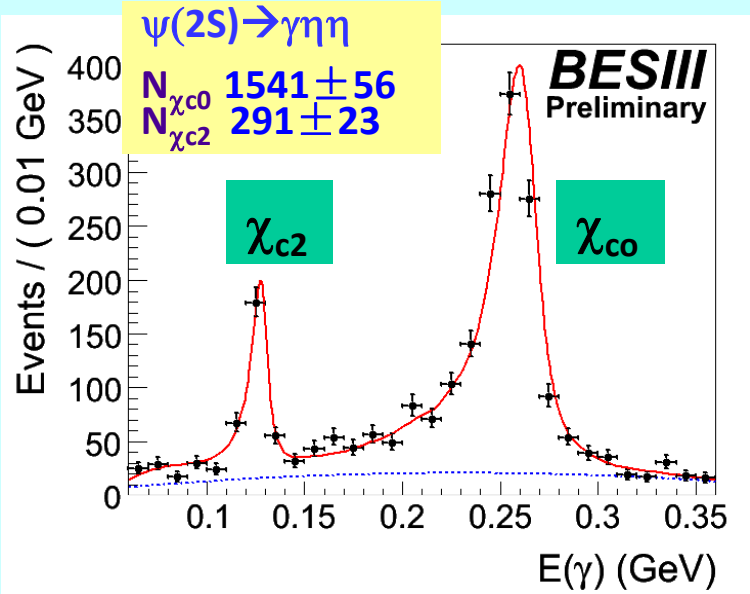
$Br(h_c \to \gamma\eta_c) = (54.3 \pm 6.7 \pm 5.2)\ \%$

arXiv:1002.0501
accepted
by Phys.Rev.Lett.

BESIII Confirmed the CLEOc observation, new measurements of $\Gamma(h_c)^{Inc}$, $Br(\psi' \to \pi^0 h_c)$ & $Br(h_c \to \gamma\eta_c)$

$\psi(2S)\rightarrow \gamma\pi^0\pi^0$, $\gamma\eta\eta$ ($\eta \rightarrow \gamma\gamma$, $\pi^0 \rightarrow \gamma\gamma$)

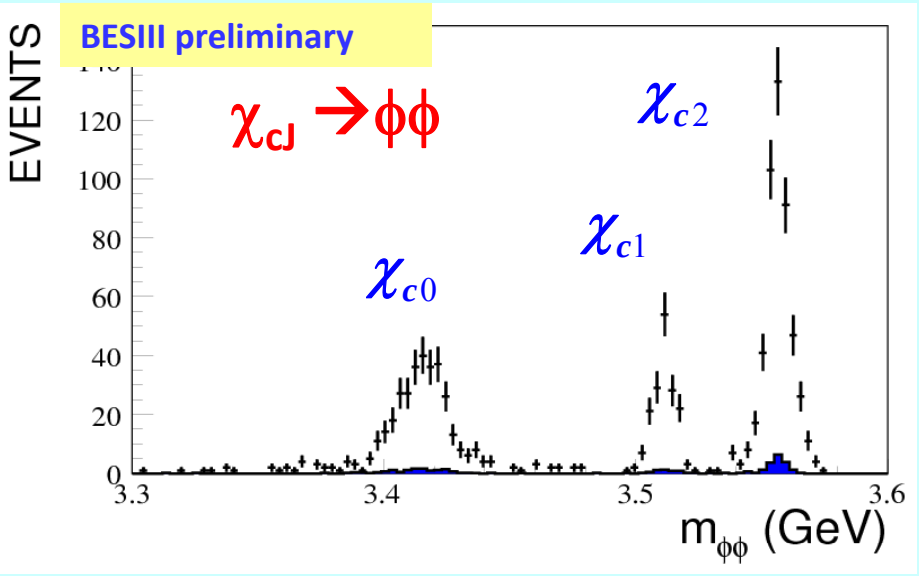


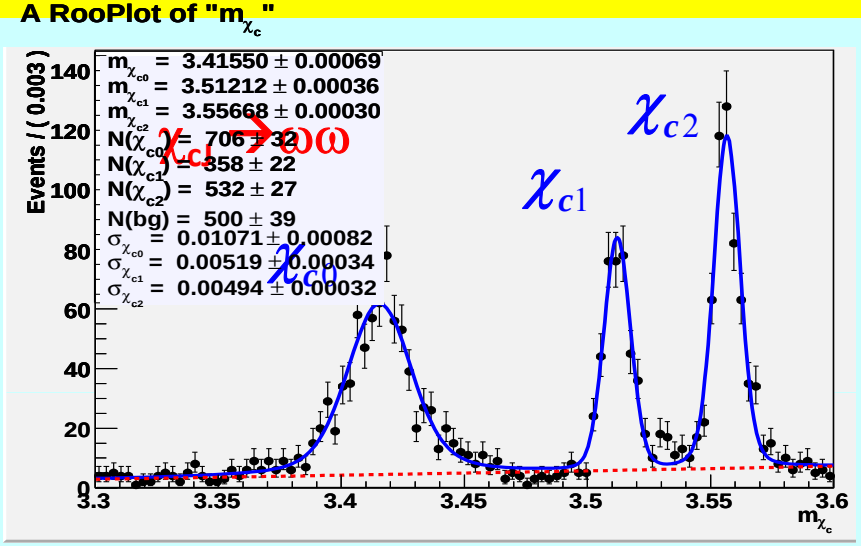


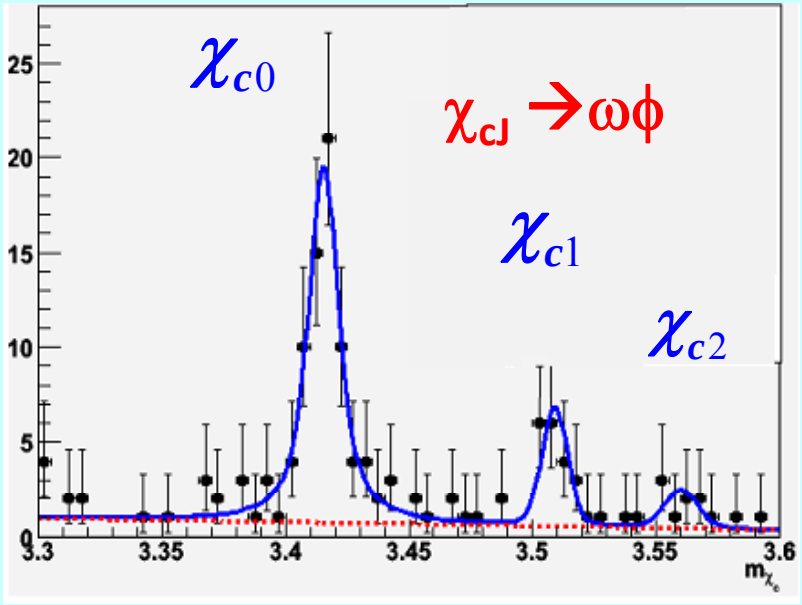
BR (10^{-3})		χ_{c0}	χ_{c2}
$\pi^0\pi^0$	BESIII	3.23±0.03±0.23±0.14	0.88±0.02±0.06±0.04
	PDG08	2. 43±0.20	0.71±0.08
	CLEO-c	2.94±0.07±0.35	0.68±0.03±0.08
$\eta\eta$	BESIII	3.44±0.10±0.24±0.20	0.65±0.04±0.05±0.03
	PDG08	2.4±0.4	<0.5
	CLEO-c	3.18±0.13±0.35	0.51±0.05±0.06

Phys. Rev. D 81, 052005 (2010)

Study of $\chi_{cJ} \rightarrow VV$ (V=ω,ϕ)





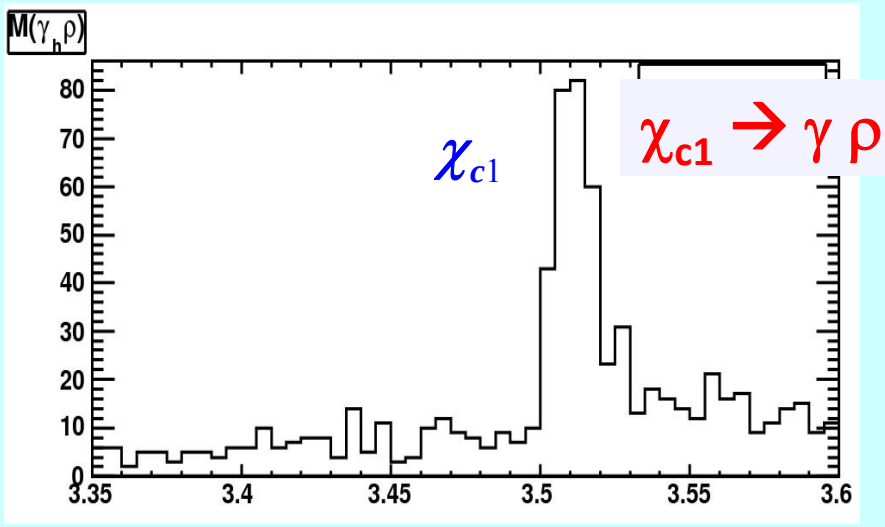


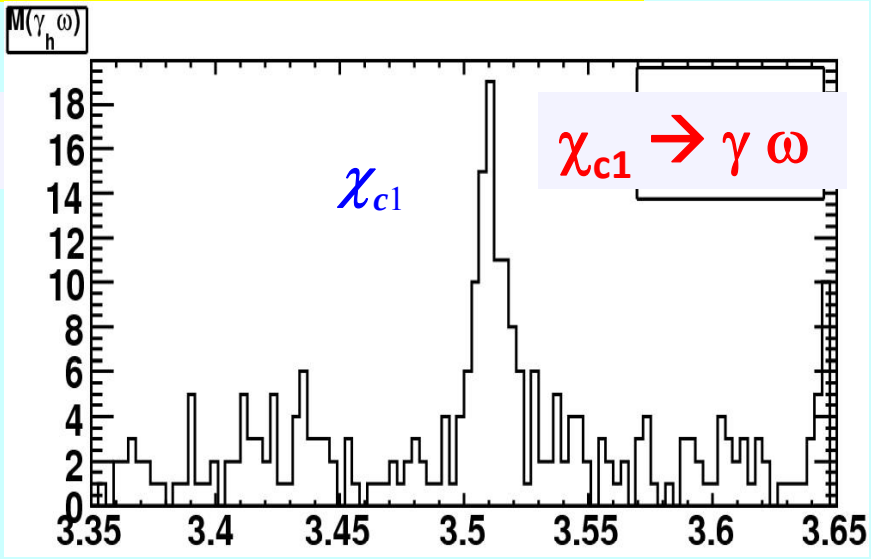
- Test QCD-based theory at χ_{cJ} decays
- Puzzles for $\chi_{c0} \rightarrow VV$: no helicity suppress
- $\chi_{c1} \rightarrow \phi\phi, \omega\omega$ is only allowed for L=2, suppressed ?
- $\chi_{cJ} \rightarrow \phi\omega$ OZI doubly suppressed

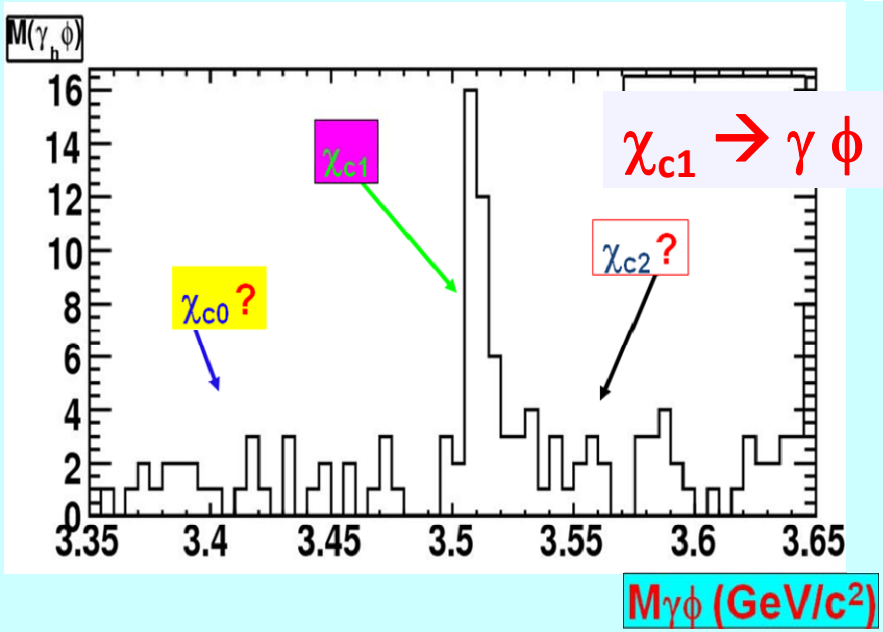
First observation:

- $\chi_{c1} \rightarrow \phi\phi$ and $\omega\omega$
- $\chi_{cJ} \rightarrow \omega\phi$

Study of $\chi_{cJ} \rightarrow \gamma\phi, \gamma\rho, \gamma\omega$







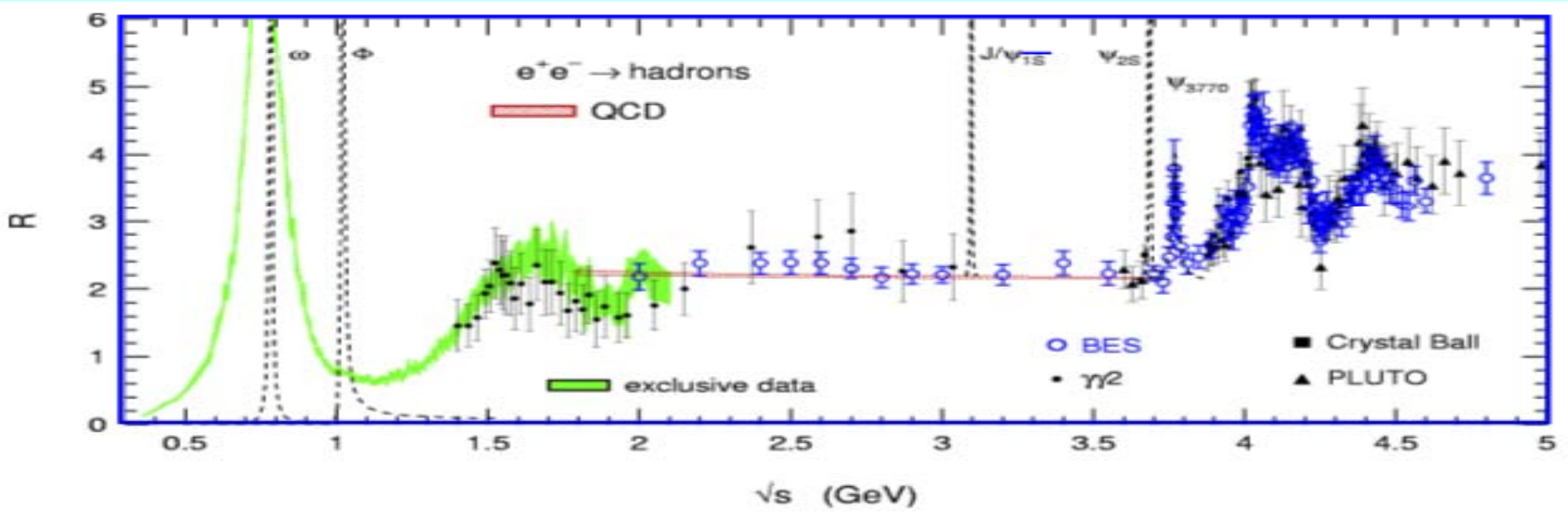
BESIII preliminary

First observation:

$\chi_{c1} \rightarrow \gamma\phi$

BESIII data taking plan

	Previous Data set	BESIII Near future	BESIII target
J/psi	BESII 58M	2009：200M，2011：1 B	10B
Psi’	CLEO：28 M	2009：100M，2011：0.5B	3 B
Psi”	CLEO：0.8 /fb	2010：1.2/fb，2012：2.8/fb	20 /fb
ψ(4040)/ψ(4160) & scan	CLEO	2013：5/fb	
R scan & Tau	BESII	2014	



Prospects: reach charm programs

- **BESIII (2008 – 2018 ?)**
- **Future charm programs**
  - **LHCb at CERN（now @3.5TeV, 2010-2011）**
  - **BELLE II at SuperB factory（~2014）**
  - **PANDA at GSI（~2015）**
- **New machines under discussion:**
  - **Frascati(super flavor factory)**
  - **Novosibirsk(super tau-charm factory)**
  - **Fermilab: fixed targe exp. under discussion**

2020 ?

$L \sim 10^{35}$ $cm^{-2}s^{-1}$

Expand the life time of tau-charm colliders to > 50 years !

BESIII collaboration: new members

Summary

- Physics at tau-charm threshold are very rich
- BESIII is operational since 2008:
  - Detector performance excellent, ready for physics
  - High quality data samples in hand
  - Analysis in progress, papers coming out
- In the next few years, there will be great leap on physics of light hadron spectroscopy, charm, charmonium, tau and QCD
  - 2010: ~10 papers
  - 2011: ~20 papers
  - > 2012: ~30 papers
- We are very excited about it