BESIII: Status and Prospects

Roy A. Briere

Carnegie Mellon University

(+ CLEO & BESIII)

FPCP09 Lake Placid
29 May 2009

Outline

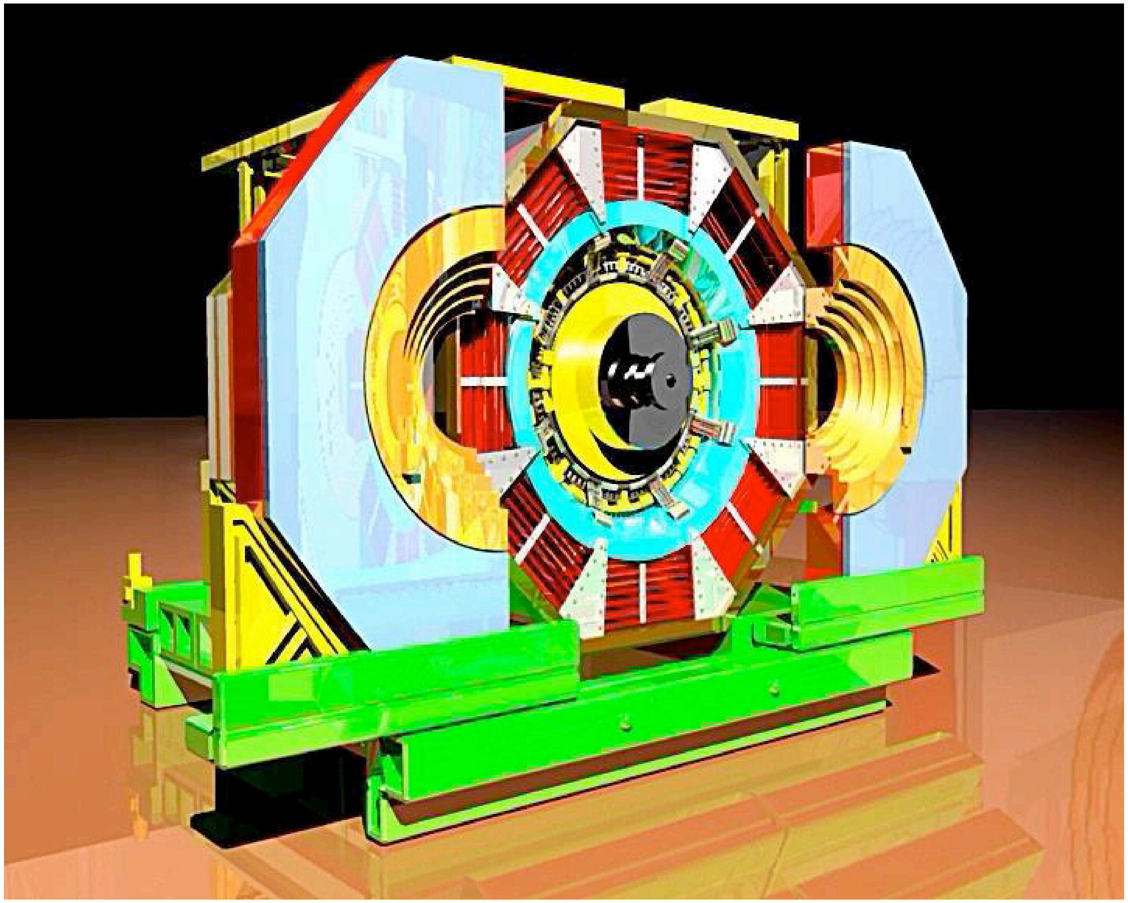
Introduction

BEPCII Accelerator

BESIII Detector

First Physics Plots

Outlook & Conclusions



The Landscape of Open Charm

B Factories:

-- (CLEOIII), BaBar, Belle: Dominate D^0 mixing
-- Super-B factories ?

Hadronic Production

-- Fixed target: FOCUS dominates lifetimes (key inputs !!!)
-- Collider: Some CDF work; LHCb very soon now

e+e- Colliders @ Threshold:

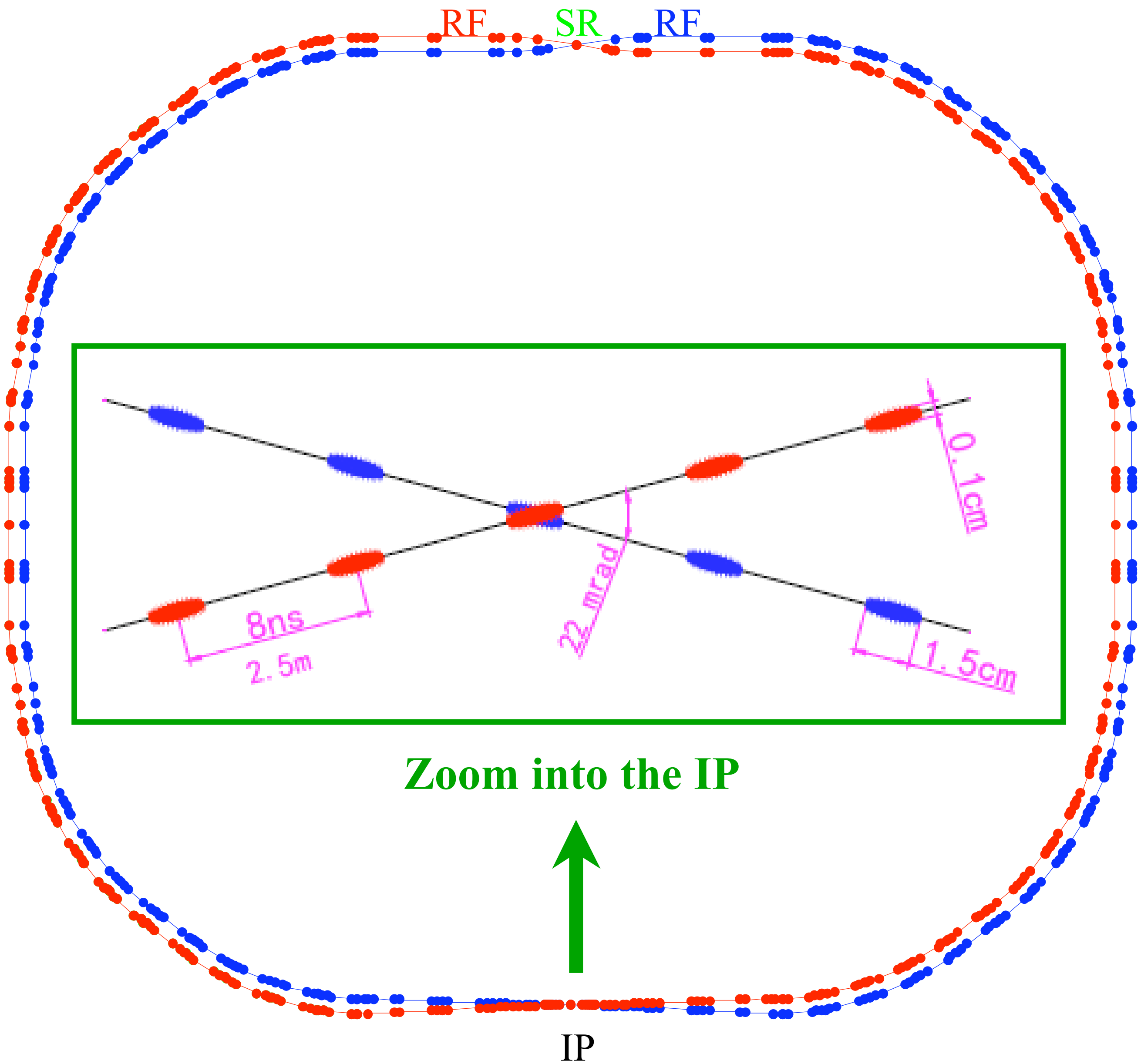
-- Many precision results dominated by CLEO-c
-- Quantum correlations and CP-tagging are unique

BEPCII overcomes the key limitation of CLEO-c:
Luminosity

But our first running will concentrate on charmonium:
very large $\psi(2S)$ and J/ψ samples !
This is OK, since we need to calibrate and simulate well first, to match CLEO-c systematics

BEPC II Storage ring:

Large crossing angle, double-ring



Beam energy:
1 - 2 GeV

Luminosity:
1 x 10^{33} $cm^{-2}s^{-1}$

Optimum energy:
1.89 GeV

Energy spread:
5.16 x 10^{-4}

No. of bunches:
93

Bunch length:
1.5 cm

Total current:
0.91 A

SR mode:
0.25A @ 2.5 GeV

Commissioning Milestones

Oct. 25-31, 2007: Accumulation of electron/positron beams

Nov. 18, 2007: First e^+e^- collision without BESIII detector

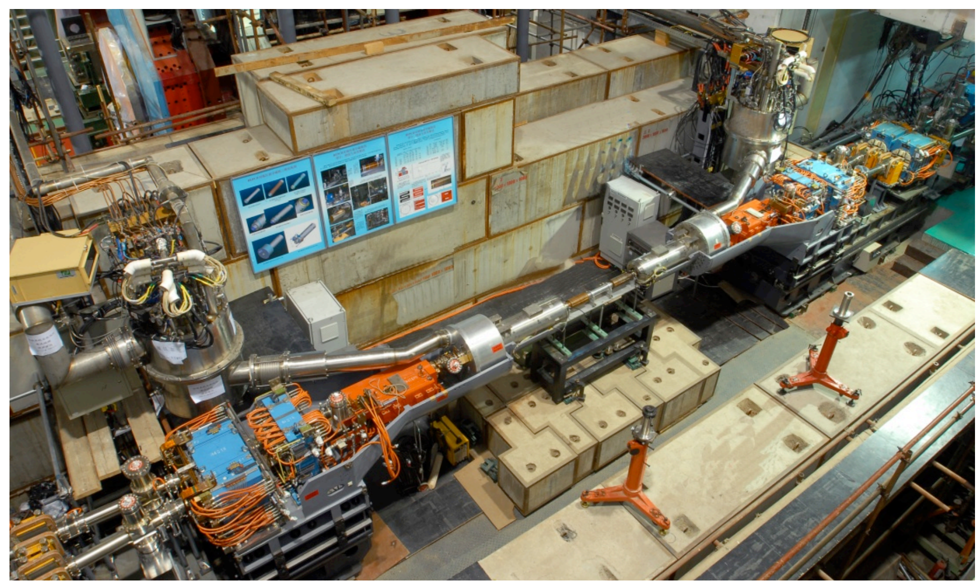
March 2008: Collisions @ 500 x 500 mA $\Rightarrow$ 1 x 10^{32} $cm^{-2}s^{-1}$

April 30, 2008: Move BESIII to IP

July 18, 2008: First event in BESIII

April 14, 2009: BESIII finishes collecting 100M $\psi(2S)$ events

May 14, 2009: Luminosity reaches 3 $\times$ 10^{32} $cm^{-2}s^{-1}$



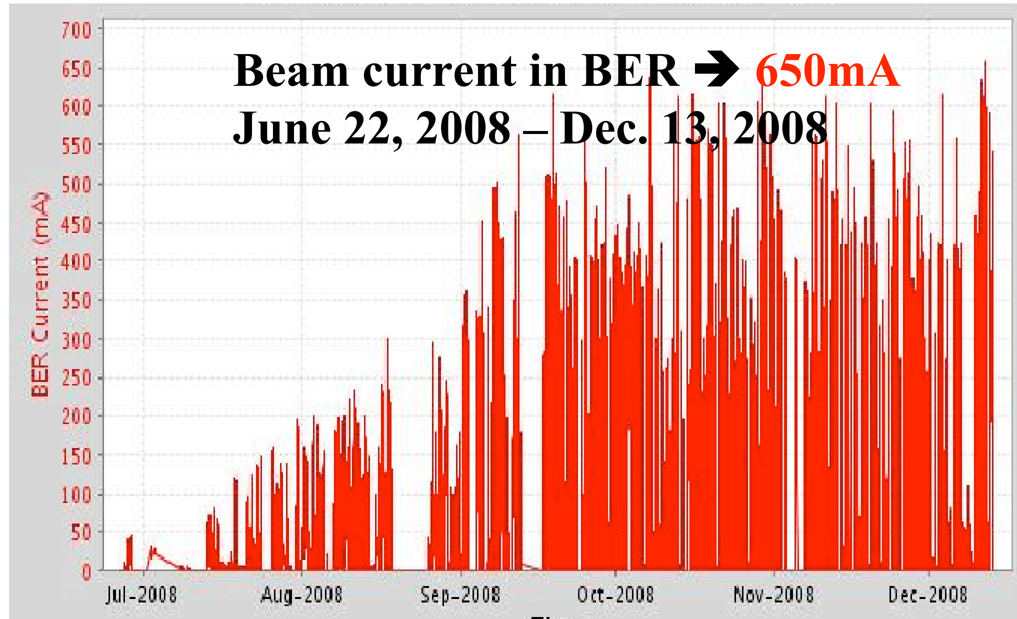
Machine commissioning

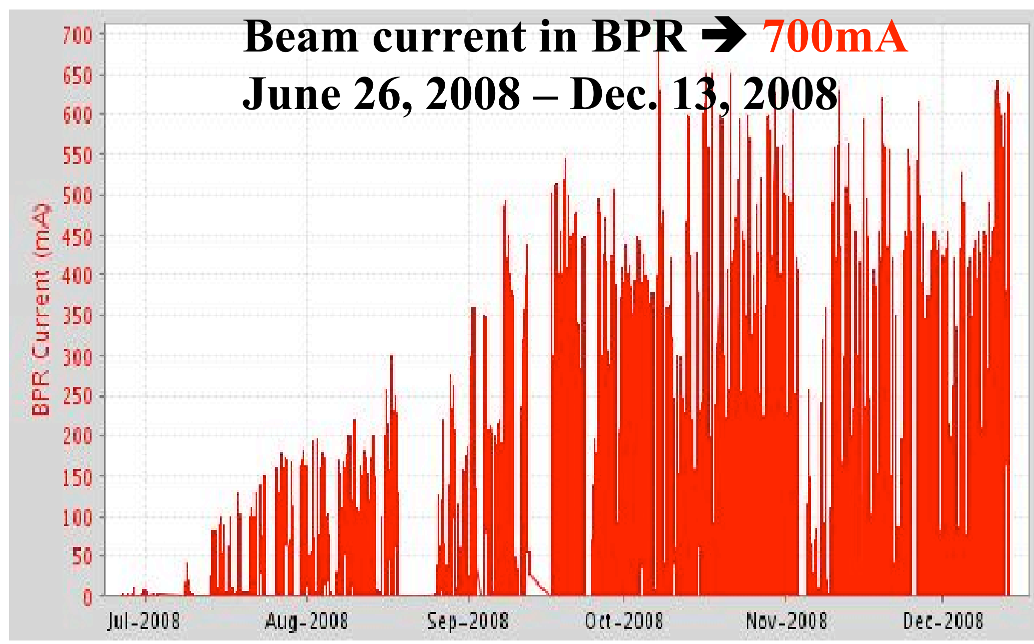
Lattice optimization:
matching with design values

Debug systems:
beam obstacles, vacuum leak, etc…

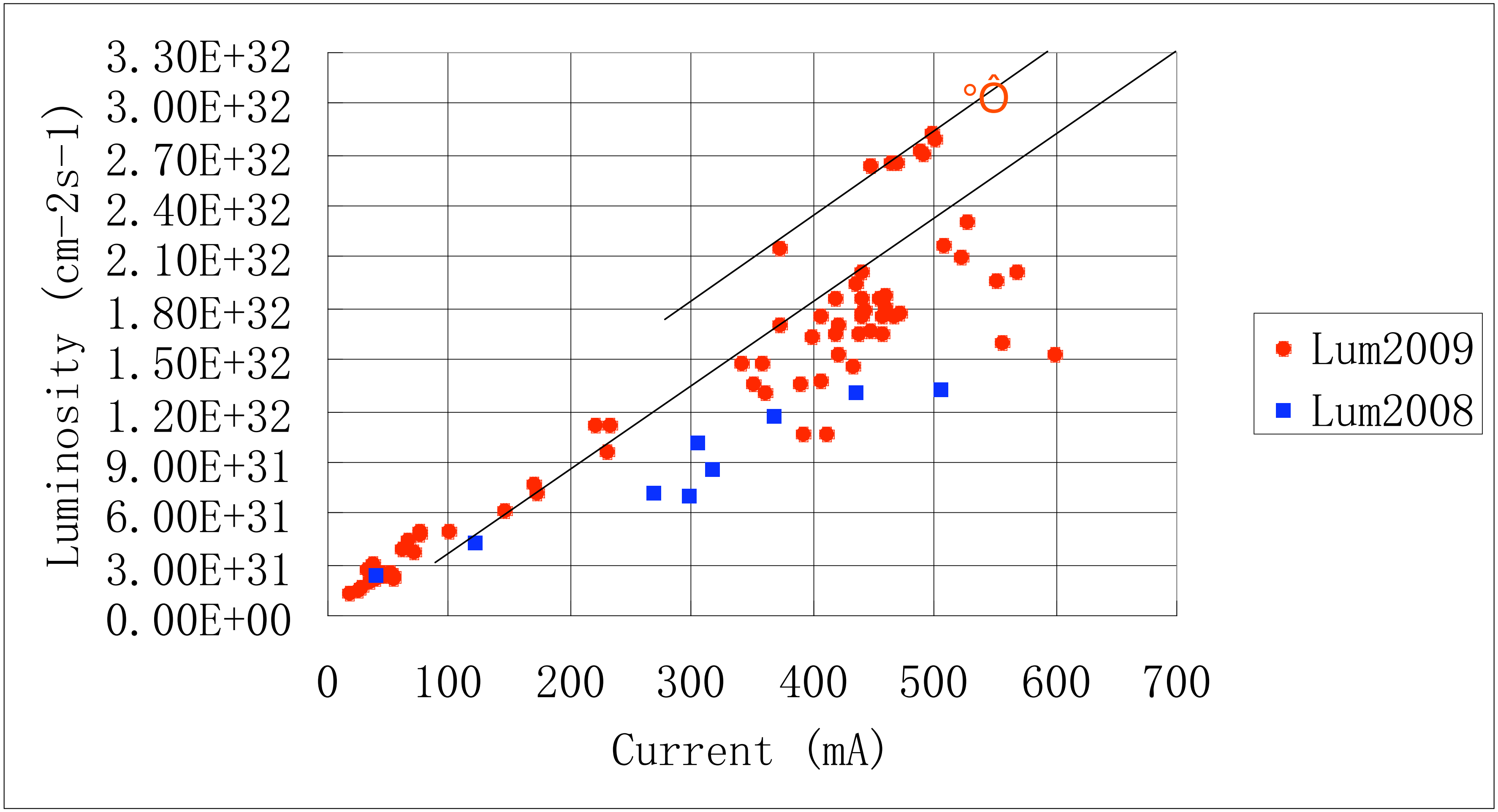
Increase current gradually:
improve vacuum

Increase luminosity:
improve collision parameters

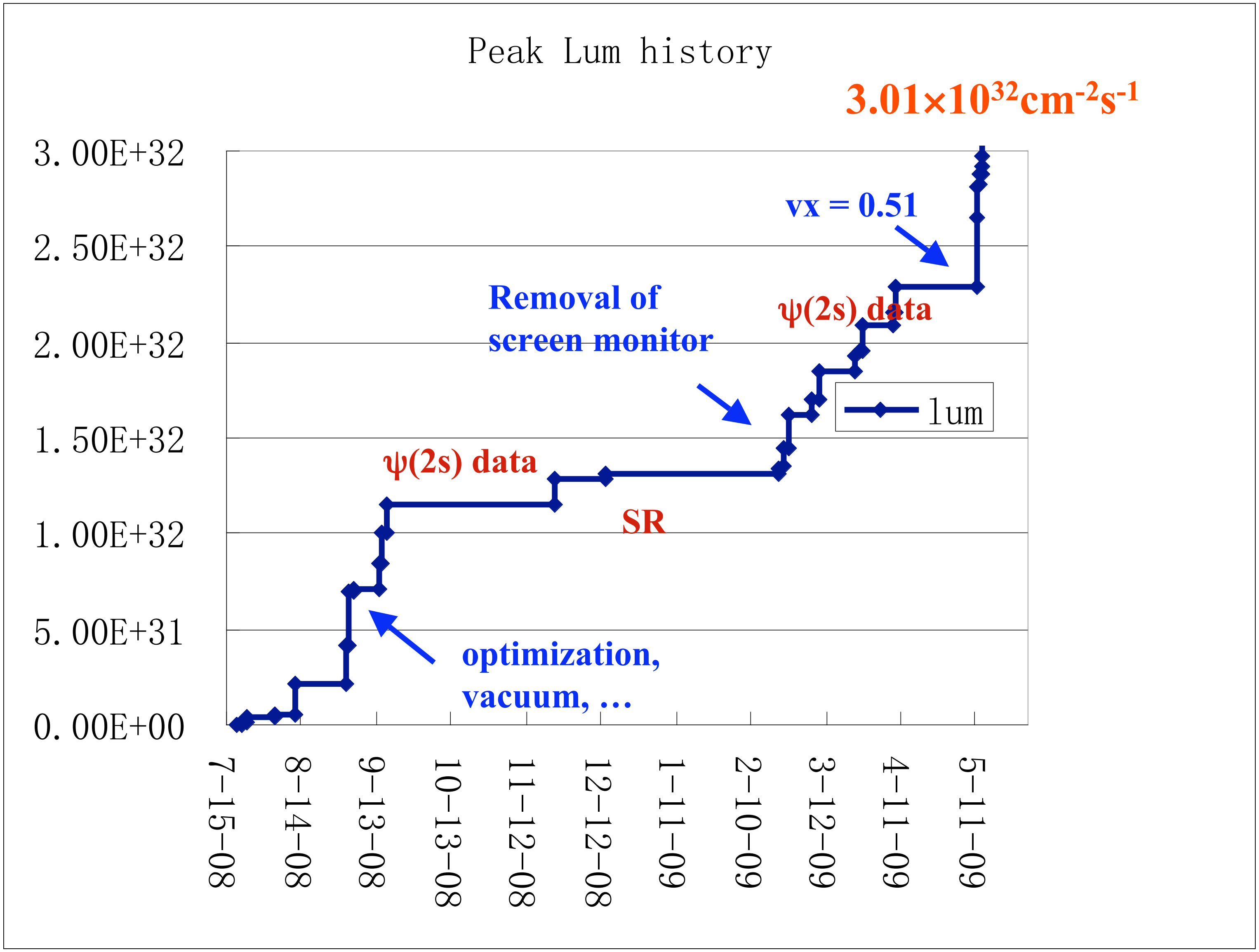




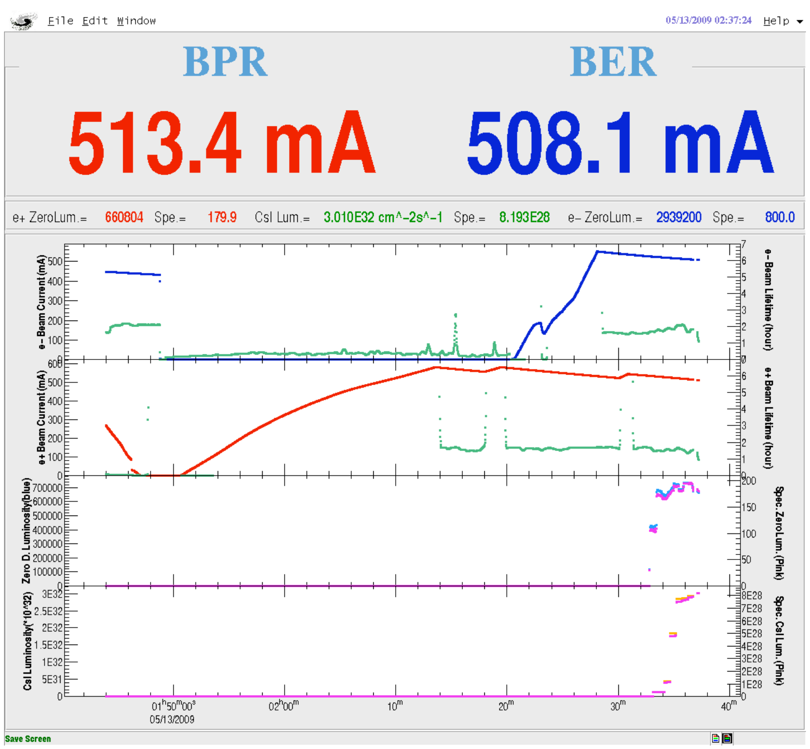
Luminosity improvement

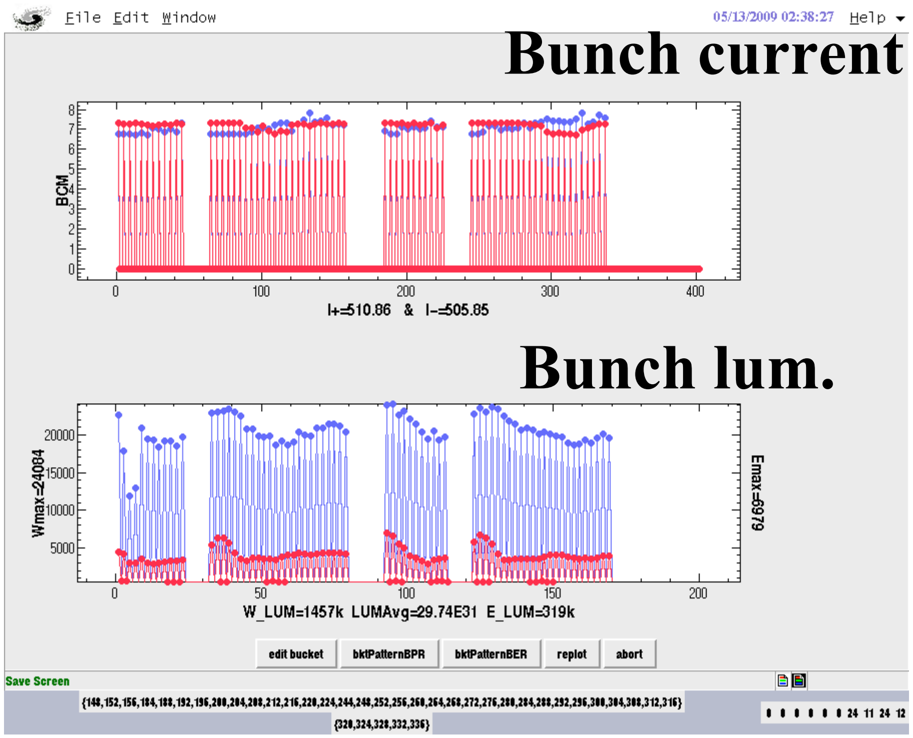


BEPCII Peak Luminosity trend (2008-7-15 to 2009-5-13)



Peak Luminosity of 3.0 x 10^{32} achieved on May 13 at about 2 x 500mA, with 71 bunches

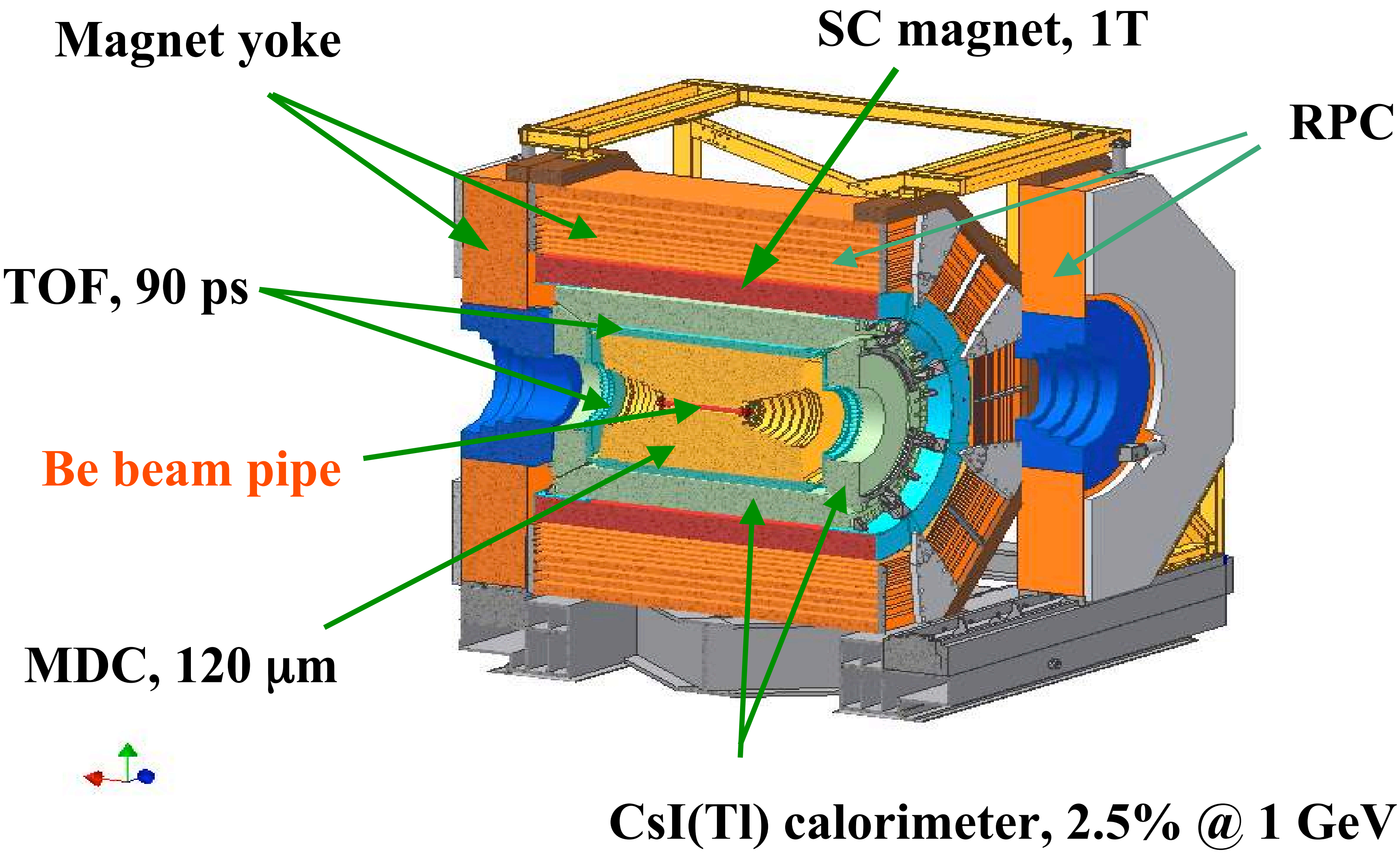




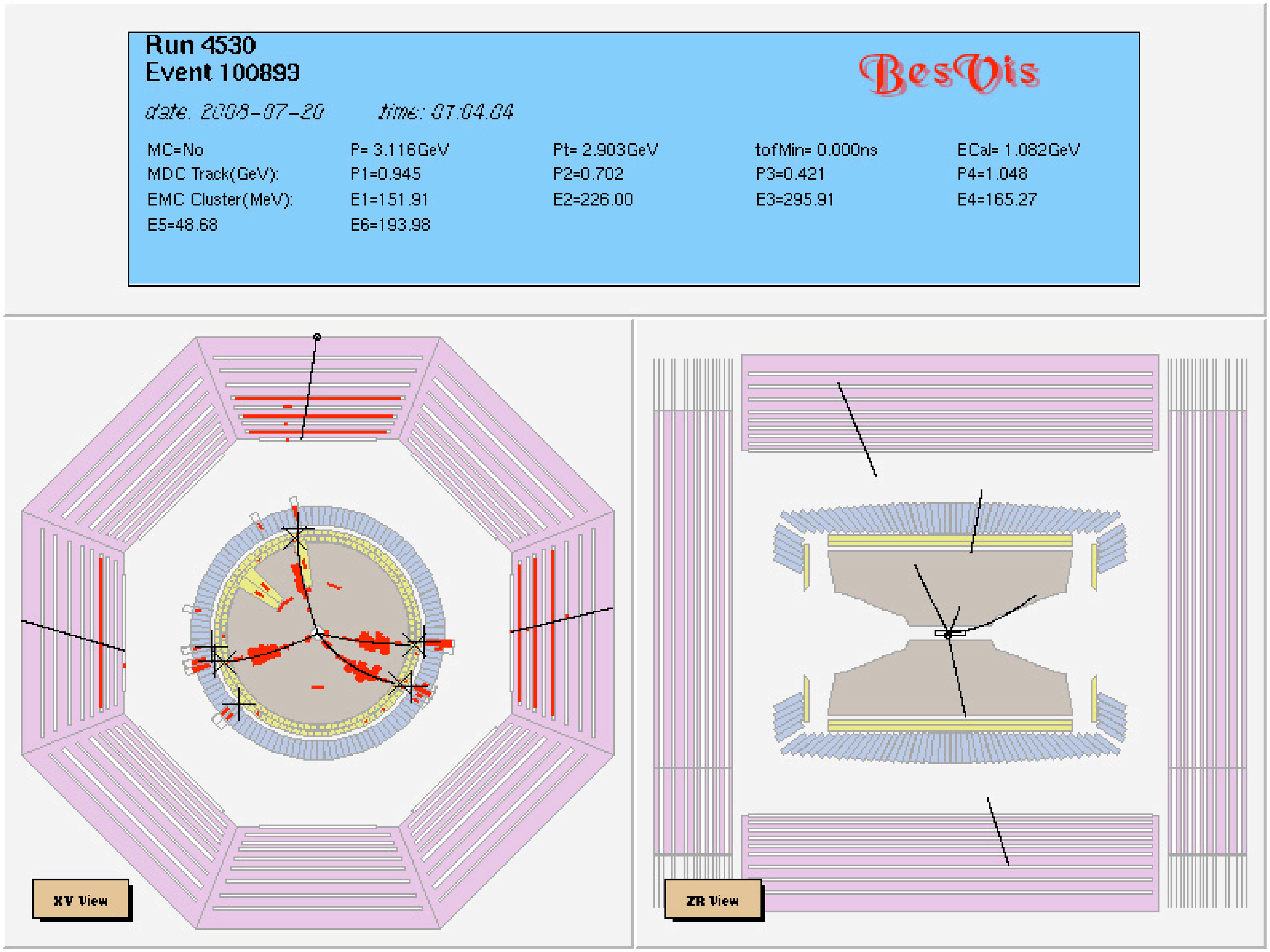
Main parameters achieved in collision mode

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 / 0.016	~1.0 / 0.016
Inj. Rate (mA/min)	200 e^- / 50 e^+	>200	>50
Lum. ($10^{33}cm^{-2}s^{-1}$)	1	0.30	

BESIII detector



First collision event on July 19, 2008



13 Million ψ(2S) events collected in 2008

Drift chamber

- **To measure the momentum of charged particles by its bended curvature in a magnetic field**
- **7000 Signal wires: 25 μm gold-plated tungsten**
- **22000 Field wires: 110 μm Al**
- **Gas: He + C_3H_8 (60/40)**
- **Momentum resolution@1GeV:**

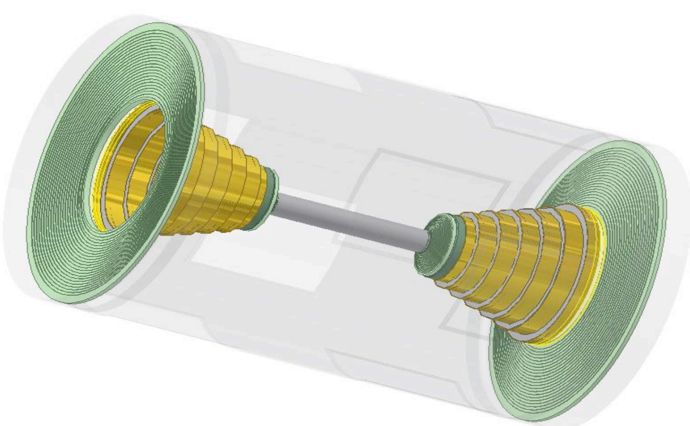
$$\frac{\sigma_{P_t}}{P_t} = 0.32\% \oplus 0.37\%$$

Babar: ~ 110 μm

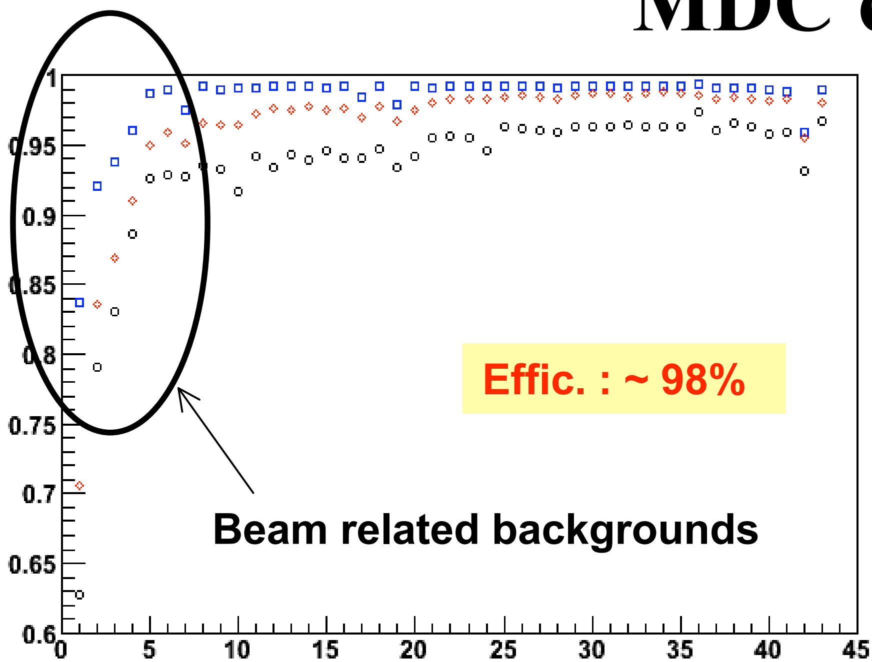
BELLE: ~ 130 μm

CLEO: ~ 110 μm

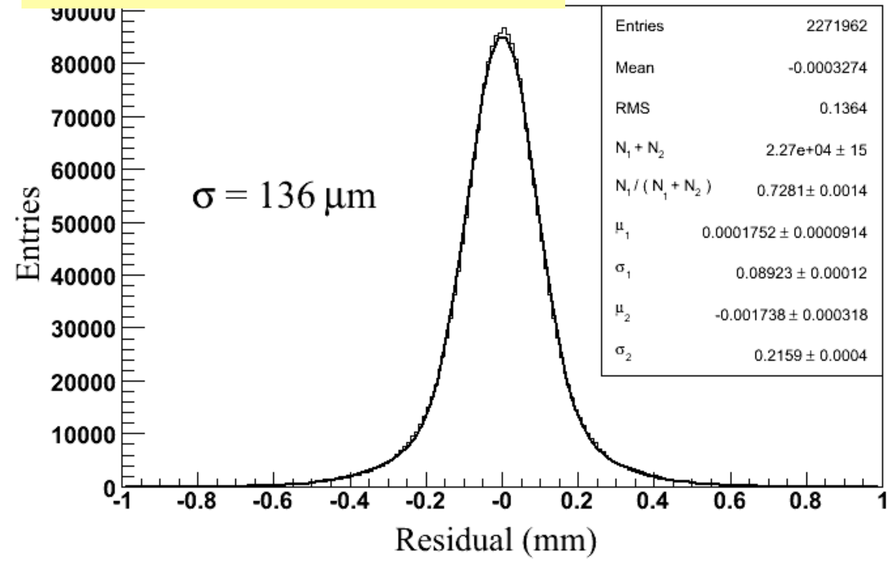
BESIII: ~ 130 μm



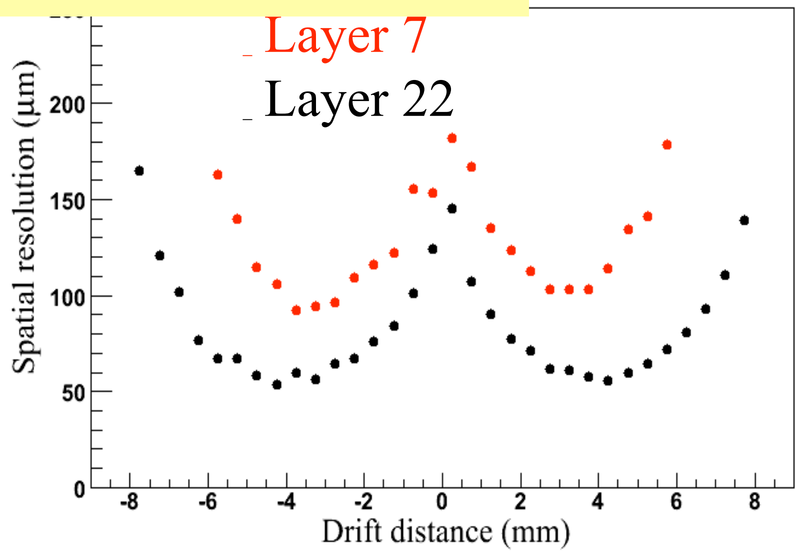
MDC calibration



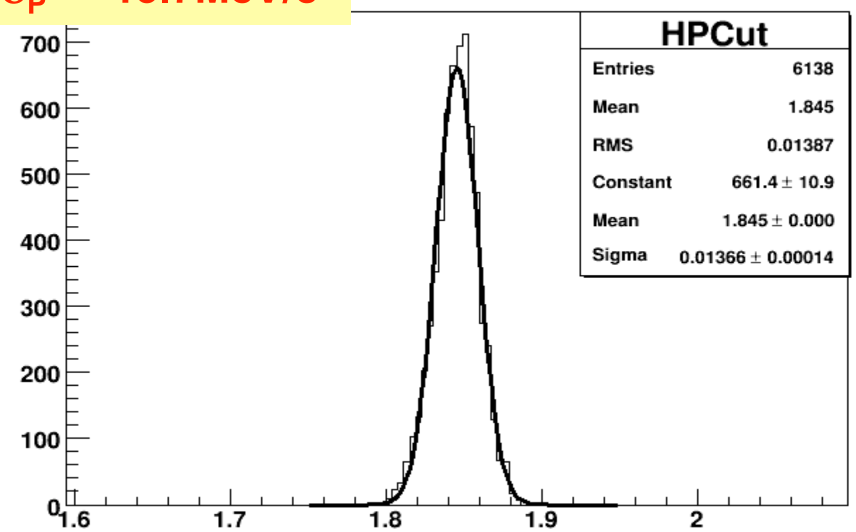
Hit Resolution: 136 μm



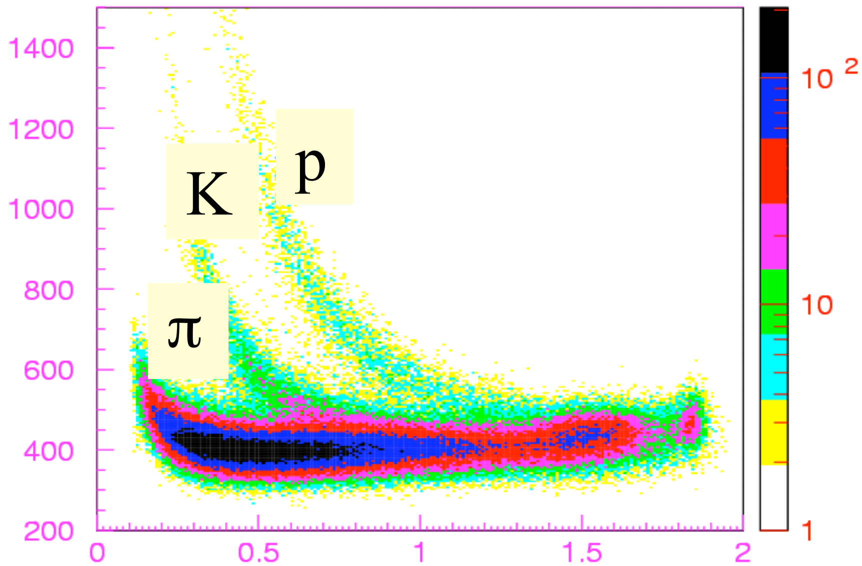
Resolution vs. Drift Dist.



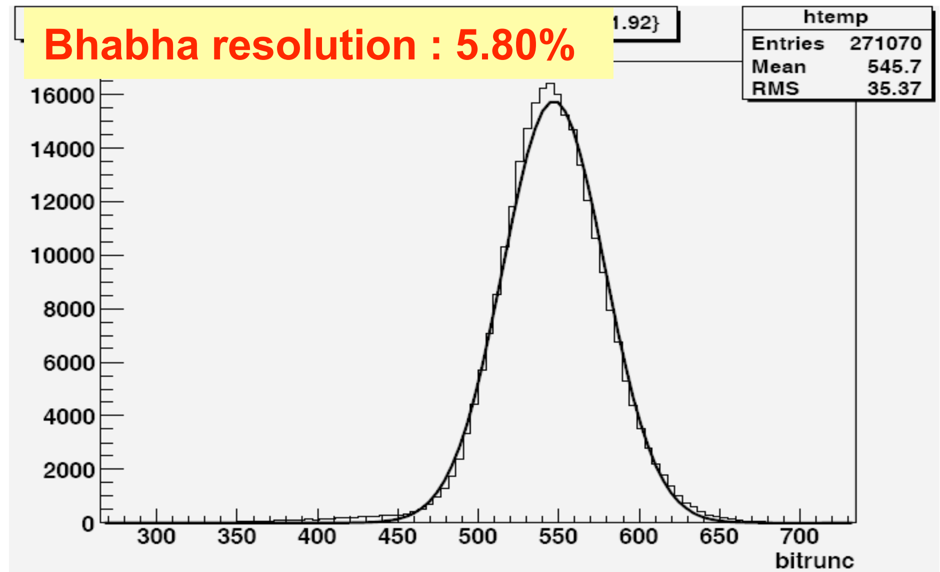
σ_P = 13.7MeV/c



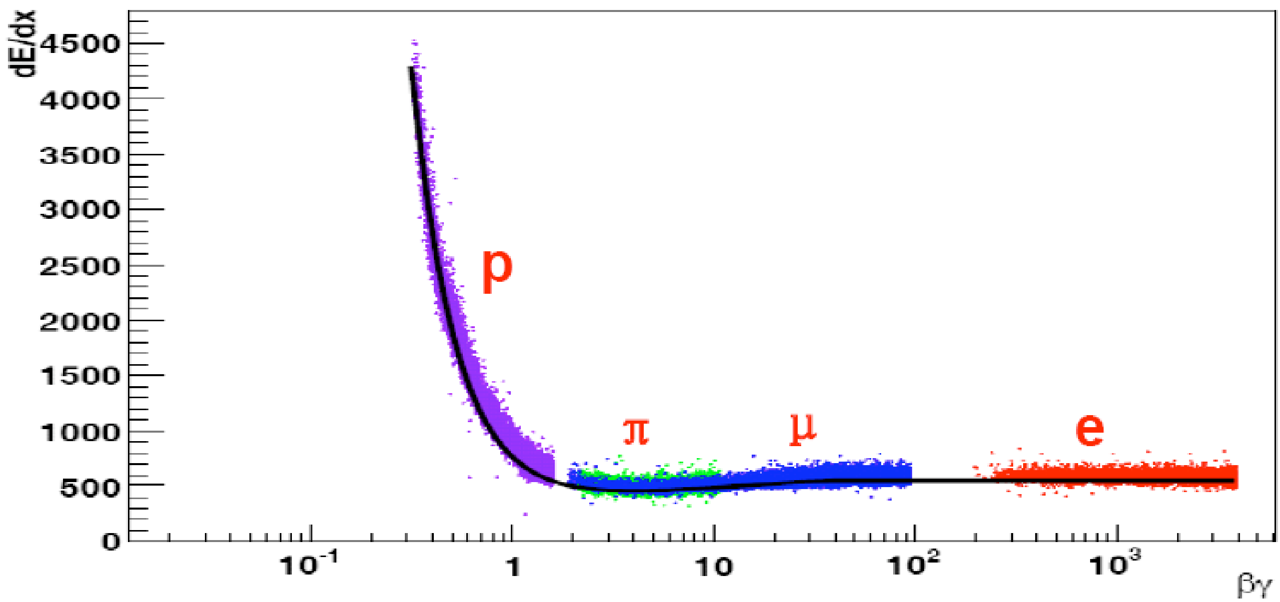
dE/dx Performance



Pulse Height versus Momentum



Current resolution closer to 5.0 %



BESIII CsI(Tl) crystal calorimeter

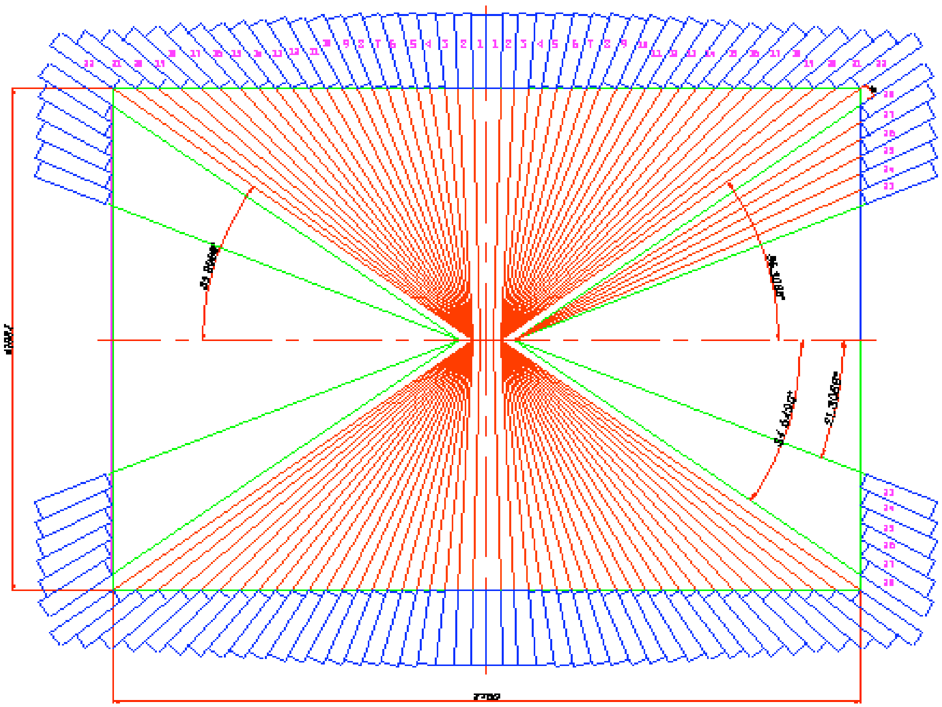
- To measure the energy of electromagnetic particles
- Barrel: 5280 crystals_Endcap: 960 crystals
- Crystal: (5.2 x 5.2 – 6.4 x 6.4) x 28 cm^3
- Readout: 13000 Photodiodes, 1 cm × 2 cm,
- Energy range_20MeV – 2 GeV
- position resolution: 6 mm @ 1 GeV
- Tiled angle: theta ~ 1 - 3^o, phi ~ 1.5^o

Babar: 2.67% @1GeV

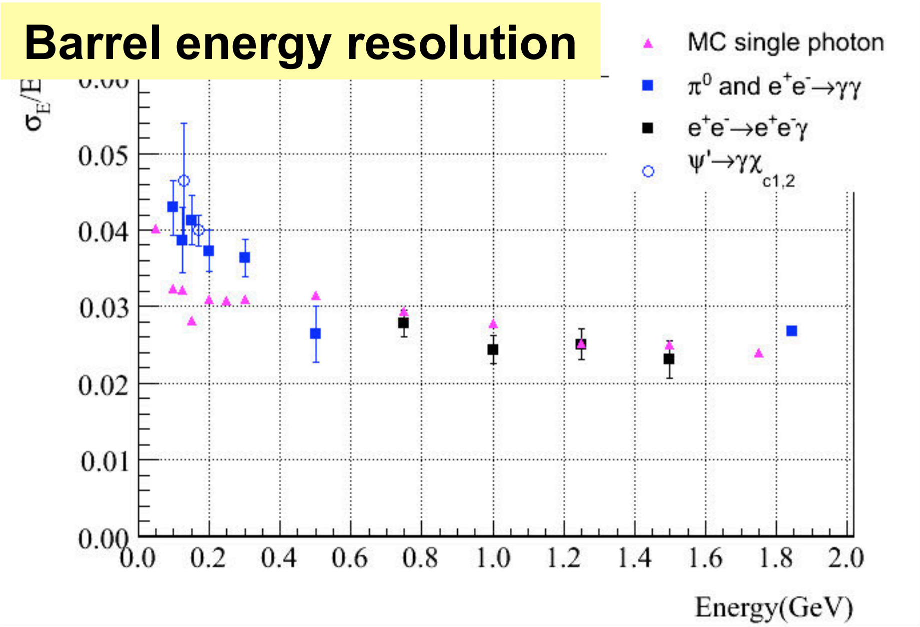
BELLE: 2.2% @1GeV

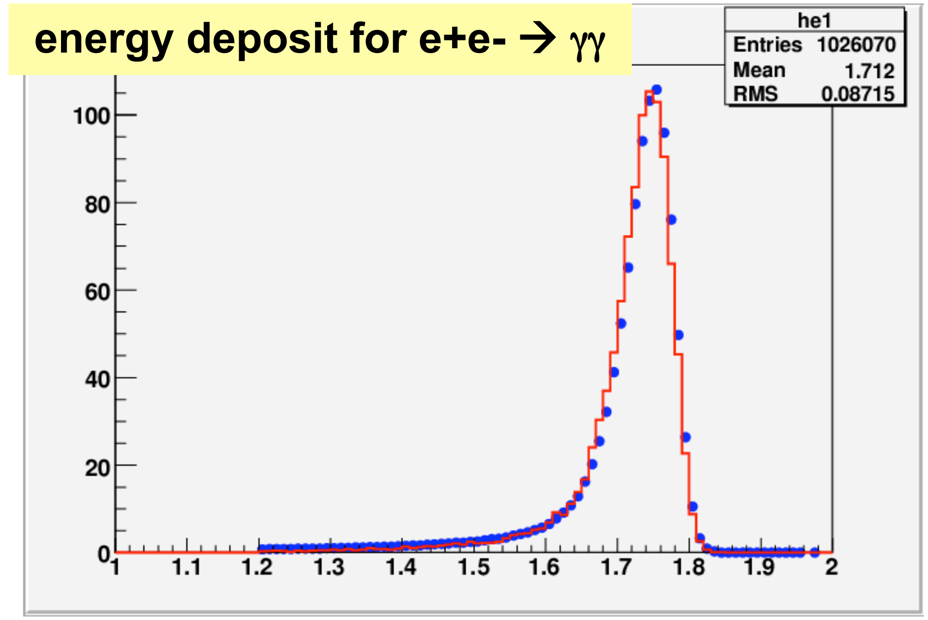
CLEO: 2.2% @1GeV

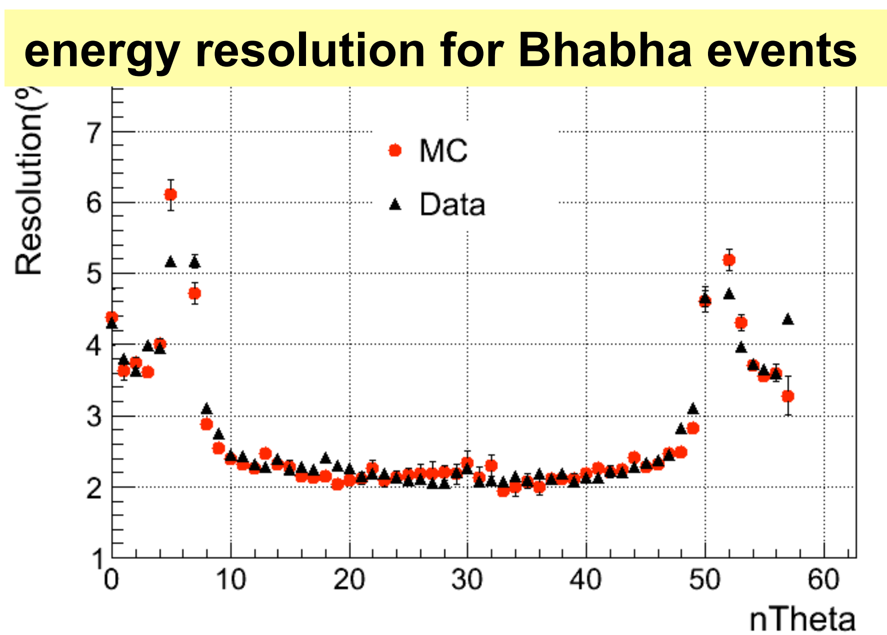
BESIII: 2.5%@1GeV

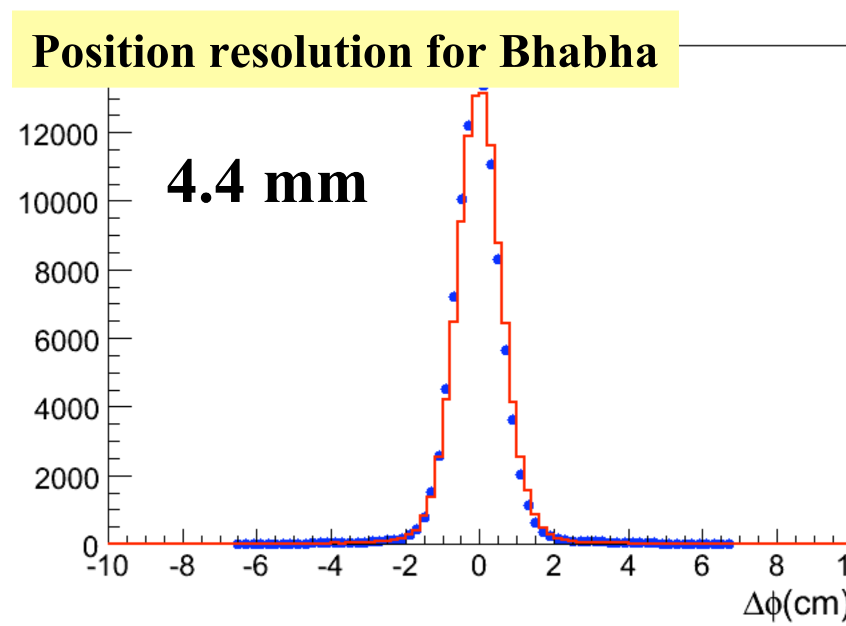


EMC calibration

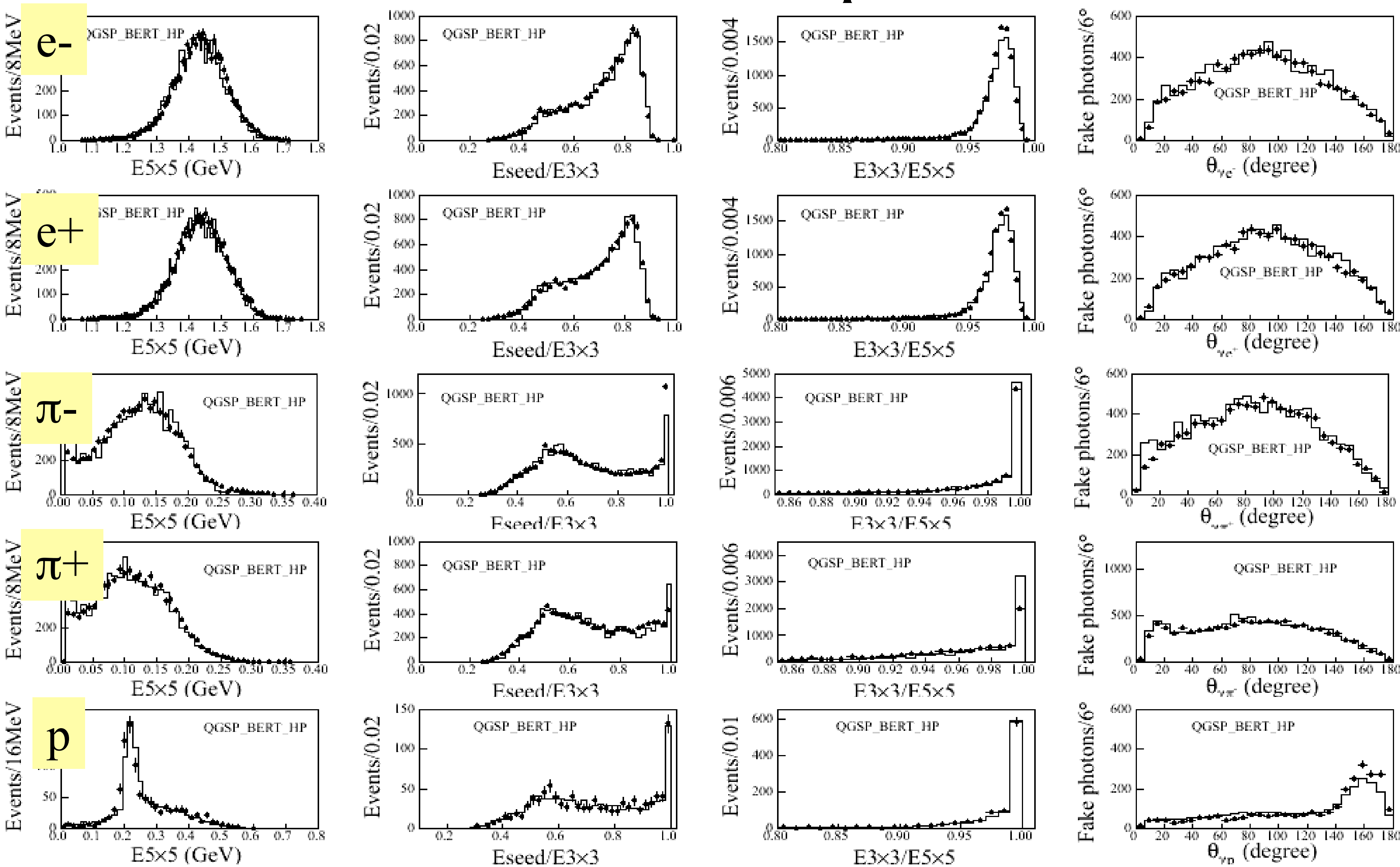








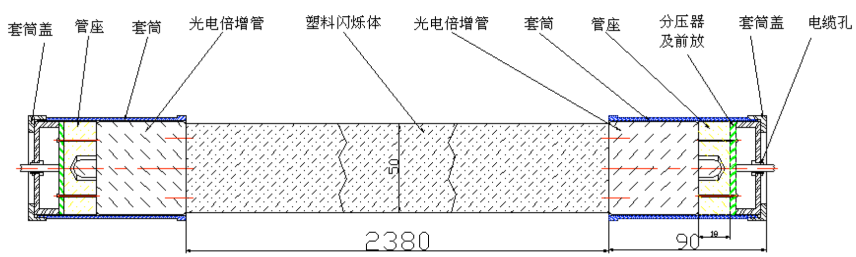
Data / MC comparison

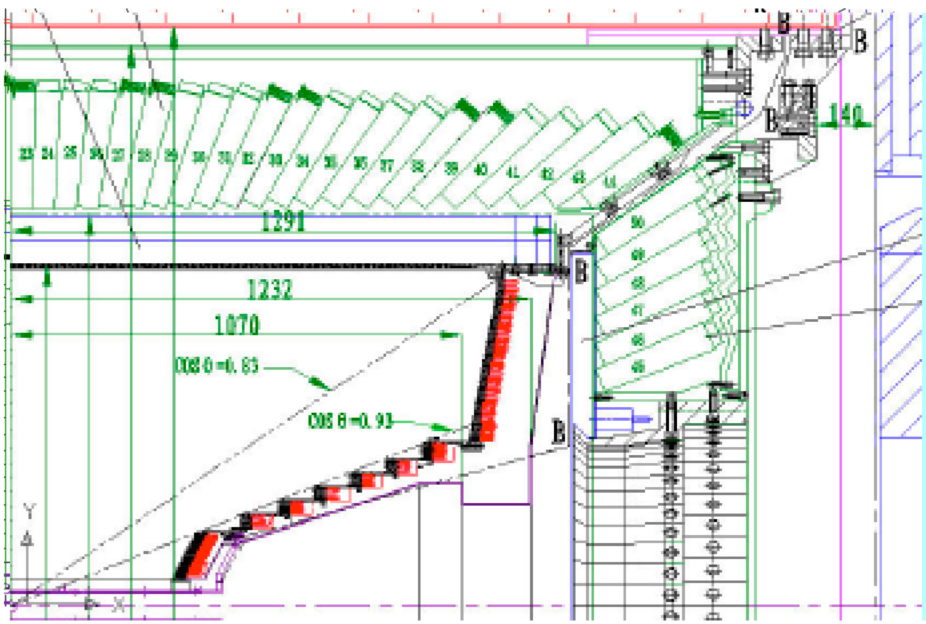


PID: TOF system

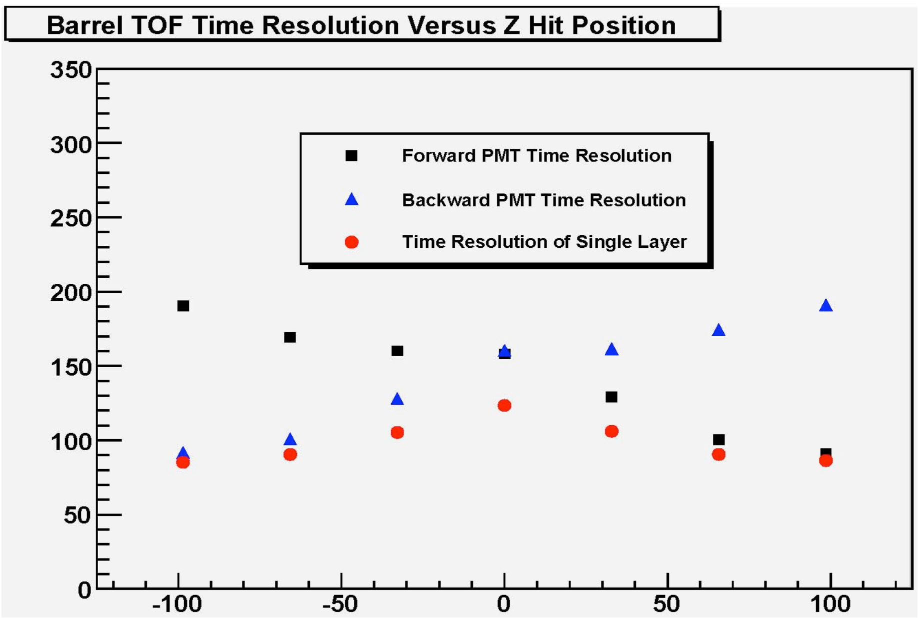
- **Barrel: 2 x 88 BC408, 2.4 m long x 5 cm thick**
- **Endcap: 2 x 48 BC408**
- **PMT: Hamamatzu R5942**

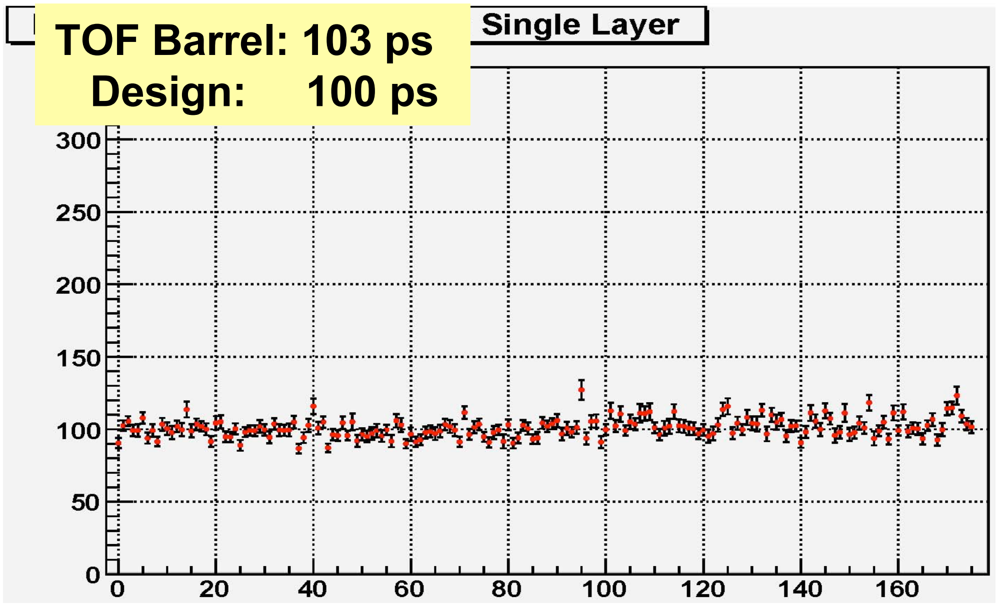
Expt.	L (cm)	Resolution
BESIII	240	90 ps
CLEOII	280	139 ps
OBELIX	300	170 ps
BELLE	255	90~100 ps
CDFII	279	100 ps
HARP	180-250	160 ps

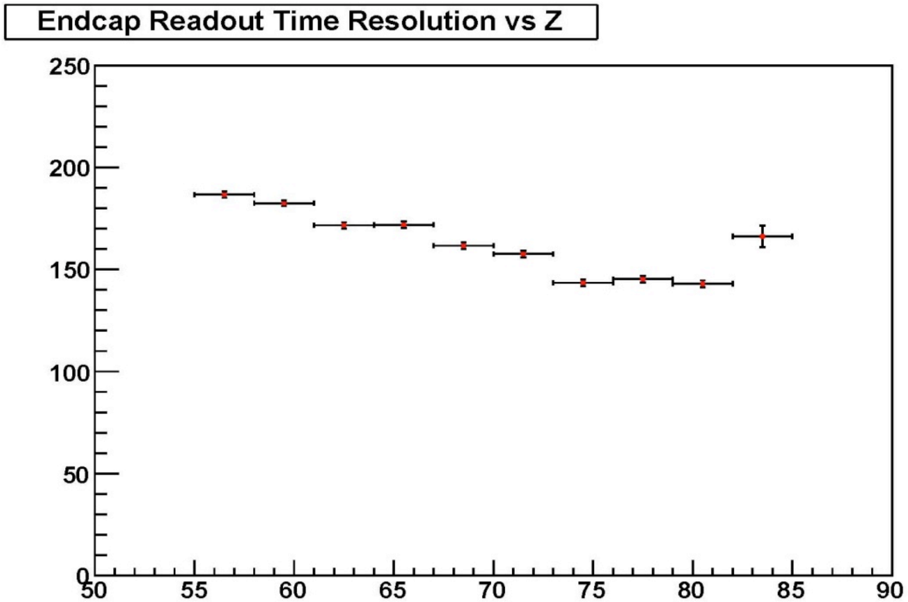


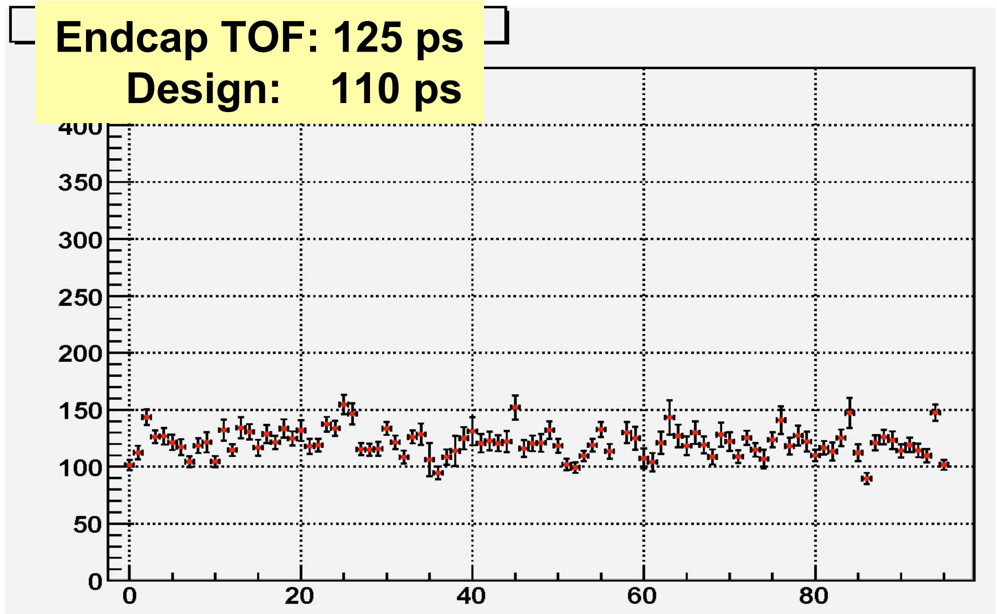


TOF calibration



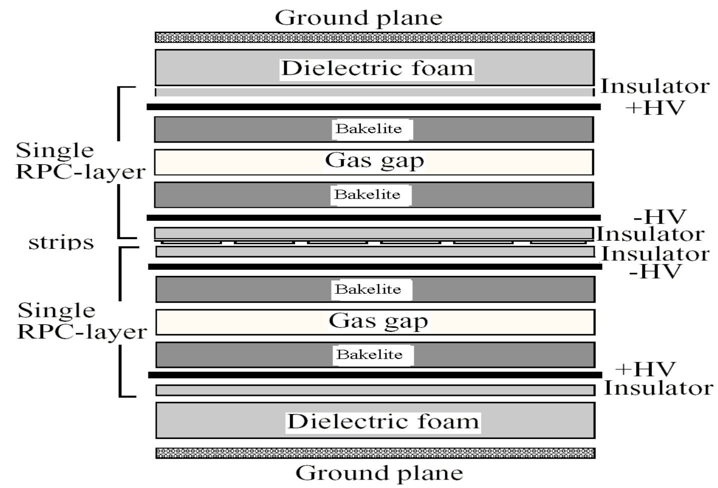


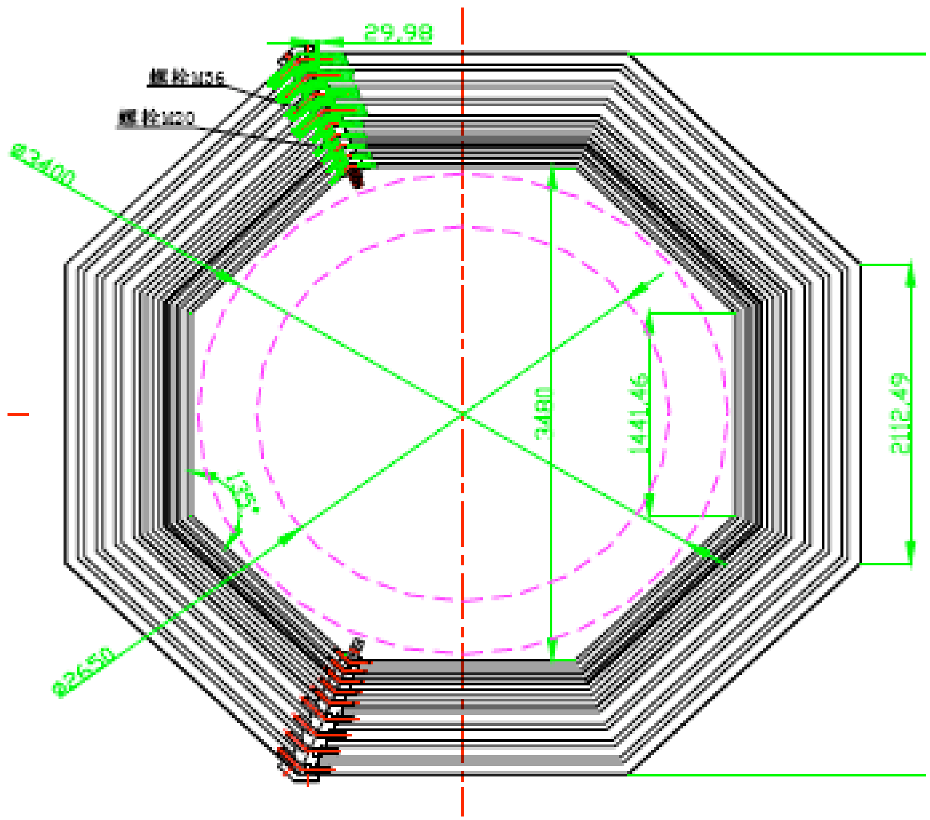


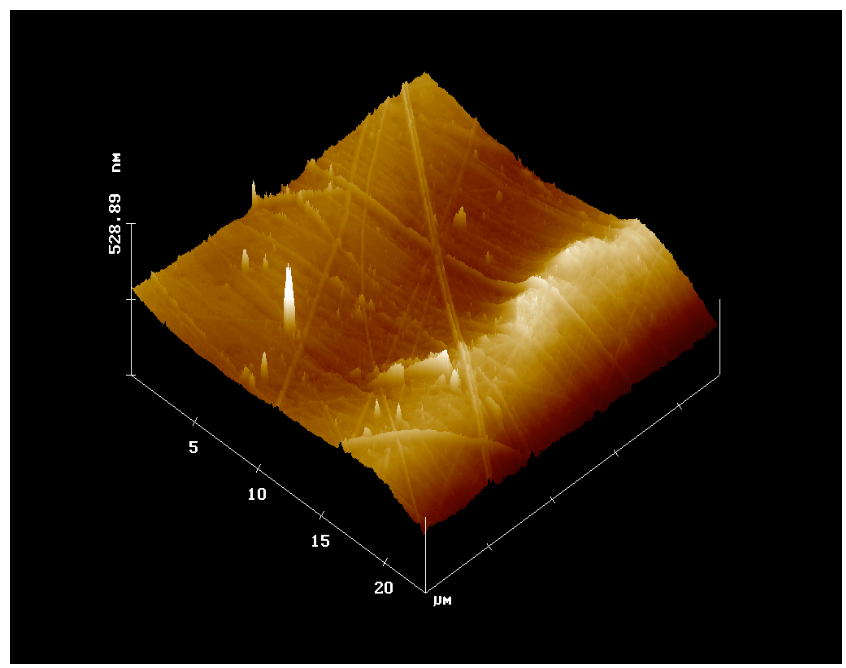


μ system : RPC

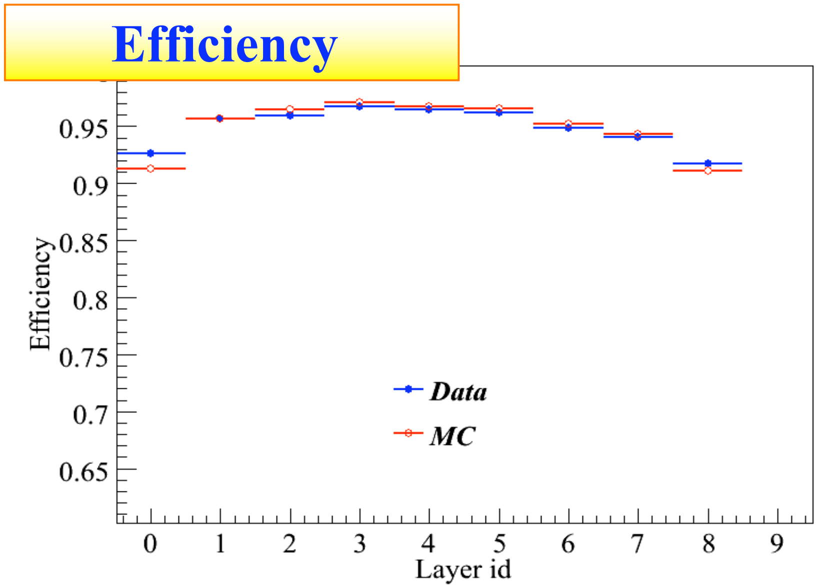
- **9 layer, 2000 m^2**
- **Special bakelite plate w/o lineseed oil**
- **4cm strips, 10000 channels**
- **Noise less than 0.1 Hz / cm^2**

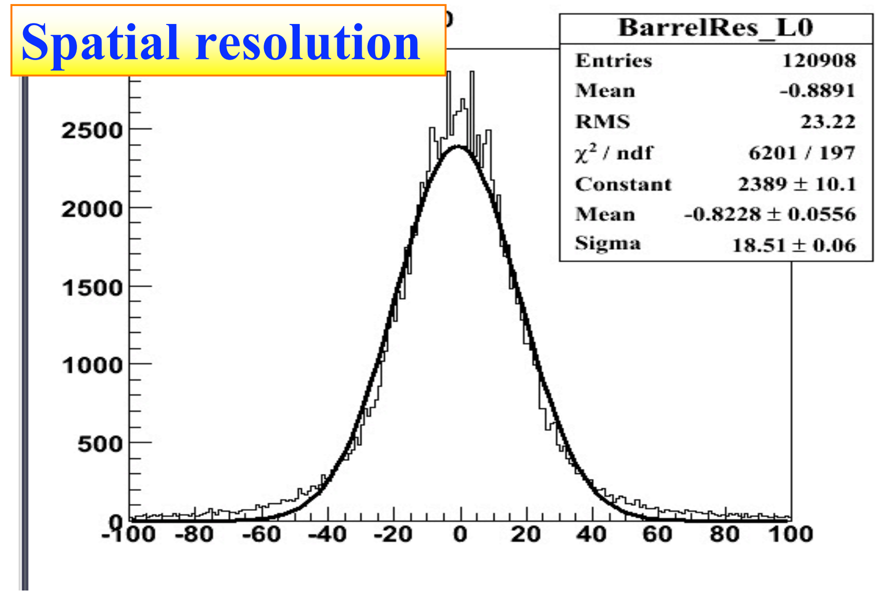


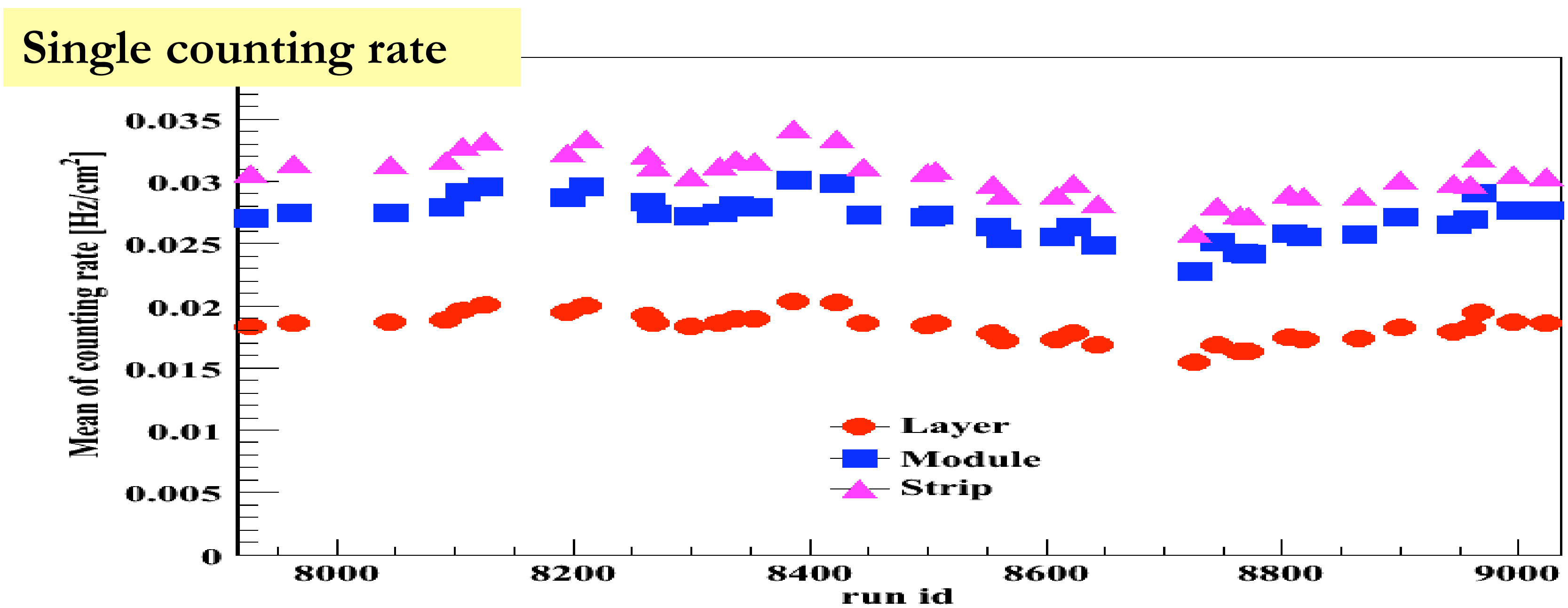




MUON Chamber







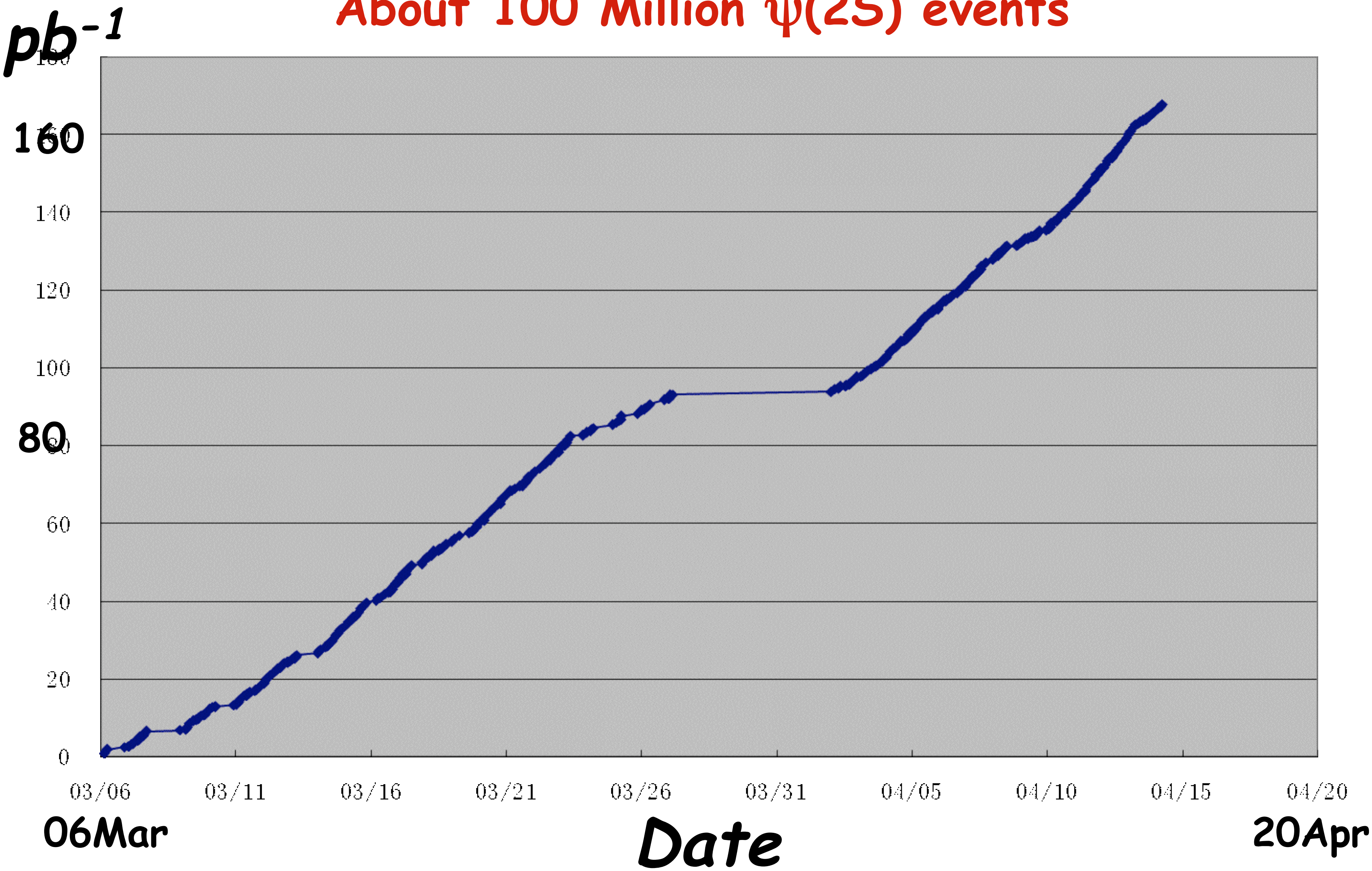
Physics Data

Data Taking in 2009

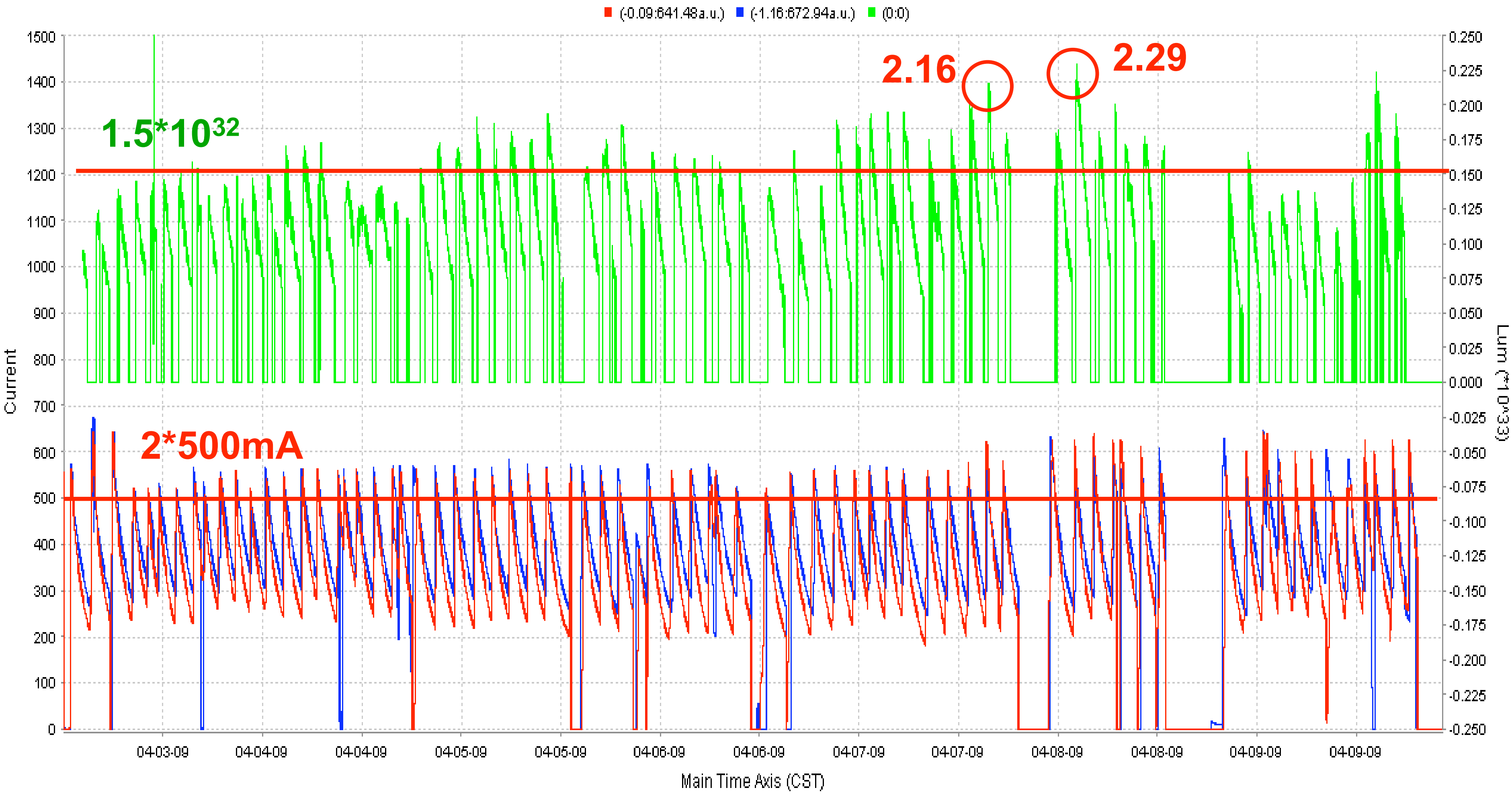
- **March – April: ψ(2S)**
  - **~ 100 M : ψ(2S) events** **4 x CLEOc = 7 x BESII**
- **June – July: J/ψ**
  - **~ 300 - 500 M J/ψ events** **= ~ 6 - 8 x BESII**
  - **a few days at 3.0 & 3.65 GeV (continuum)**
- **After summer:**
  - **Possibly ψ(3770) scan if beam energy is stable and/or beam energy monitor is in place**

Spring 2009 ψ(2S) Running

About 100 Million ψ(2S) events

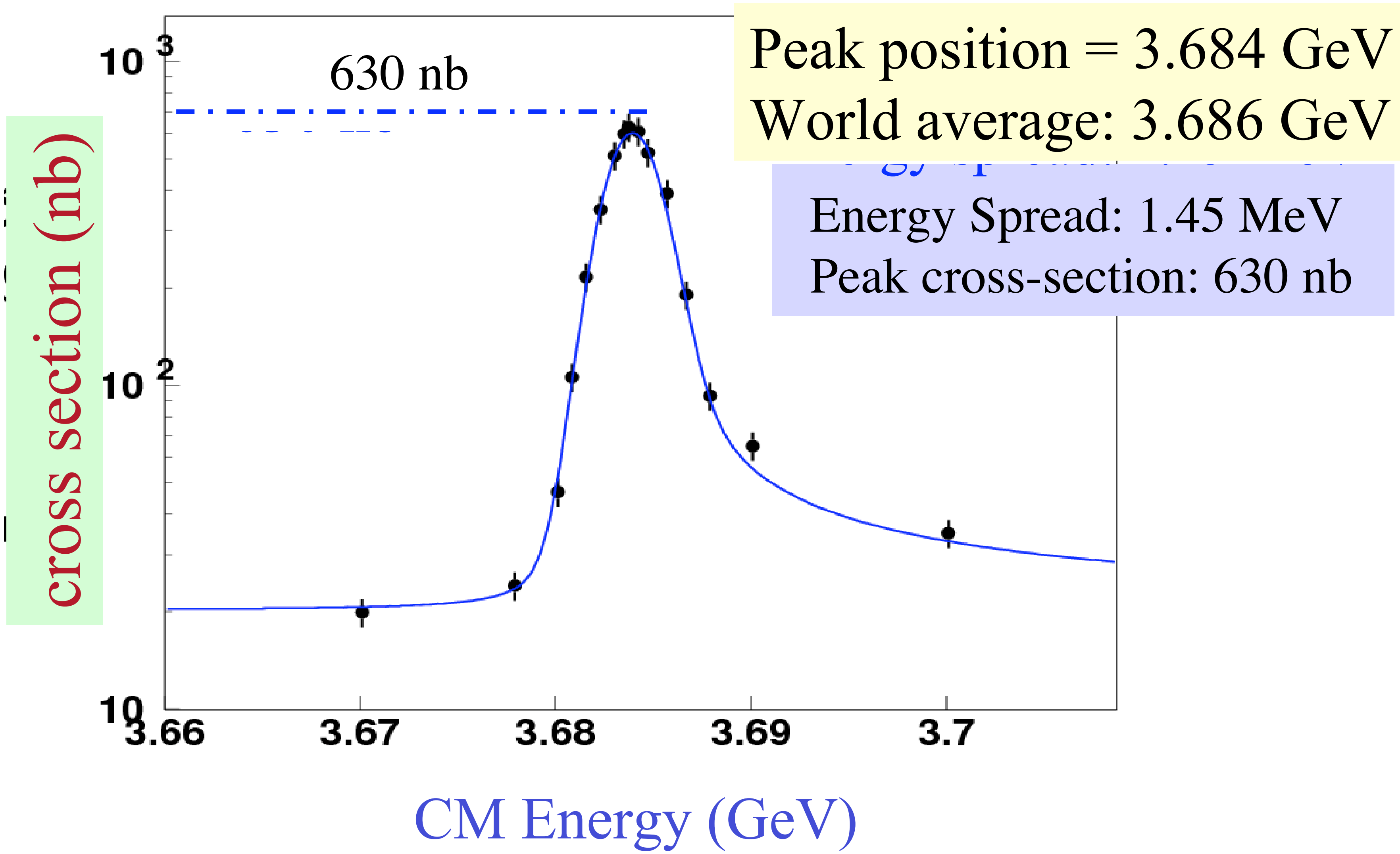


Luminosity vs beam current during ψ(2S) Run

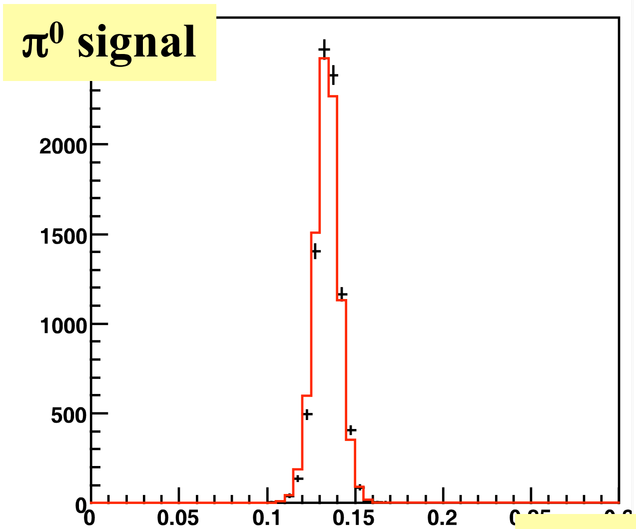


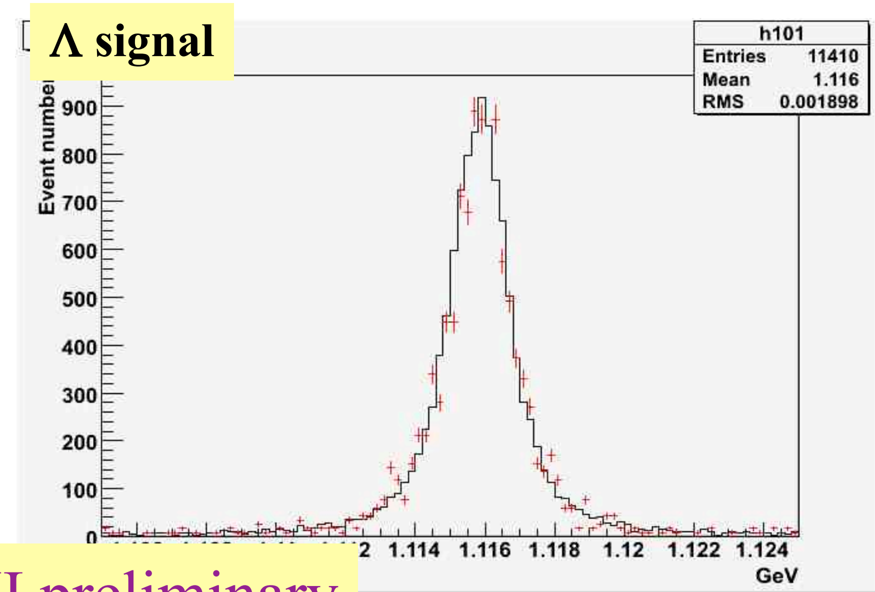
Machine is stable, data taking rate 15 times higher than BEPC. Peak luminosity continues to increase.

ψ(2S) energy scan

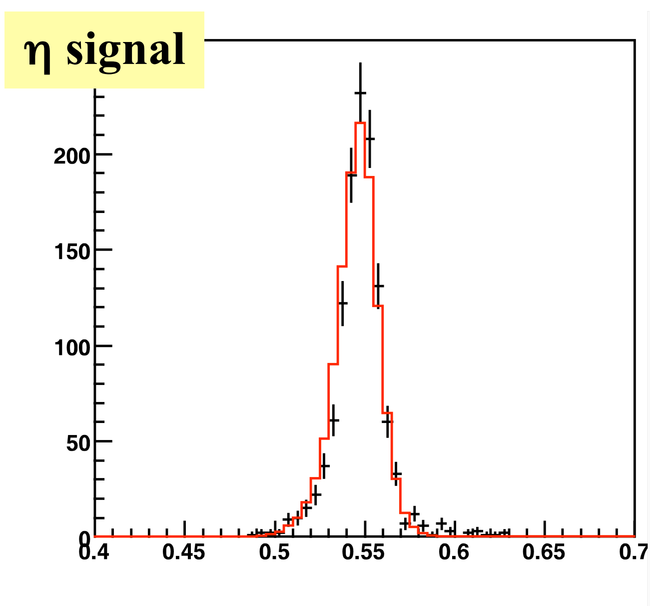


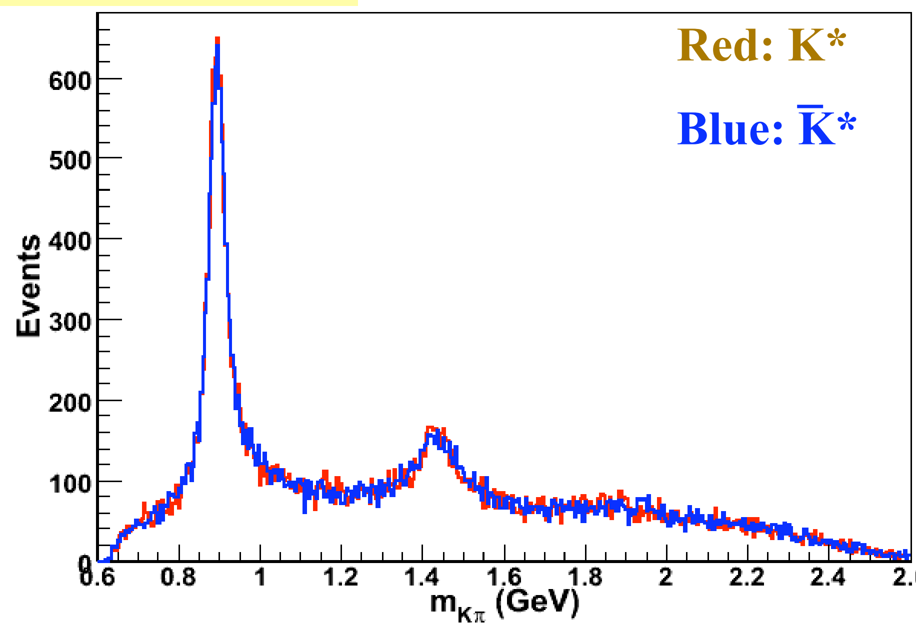
Some physics signals



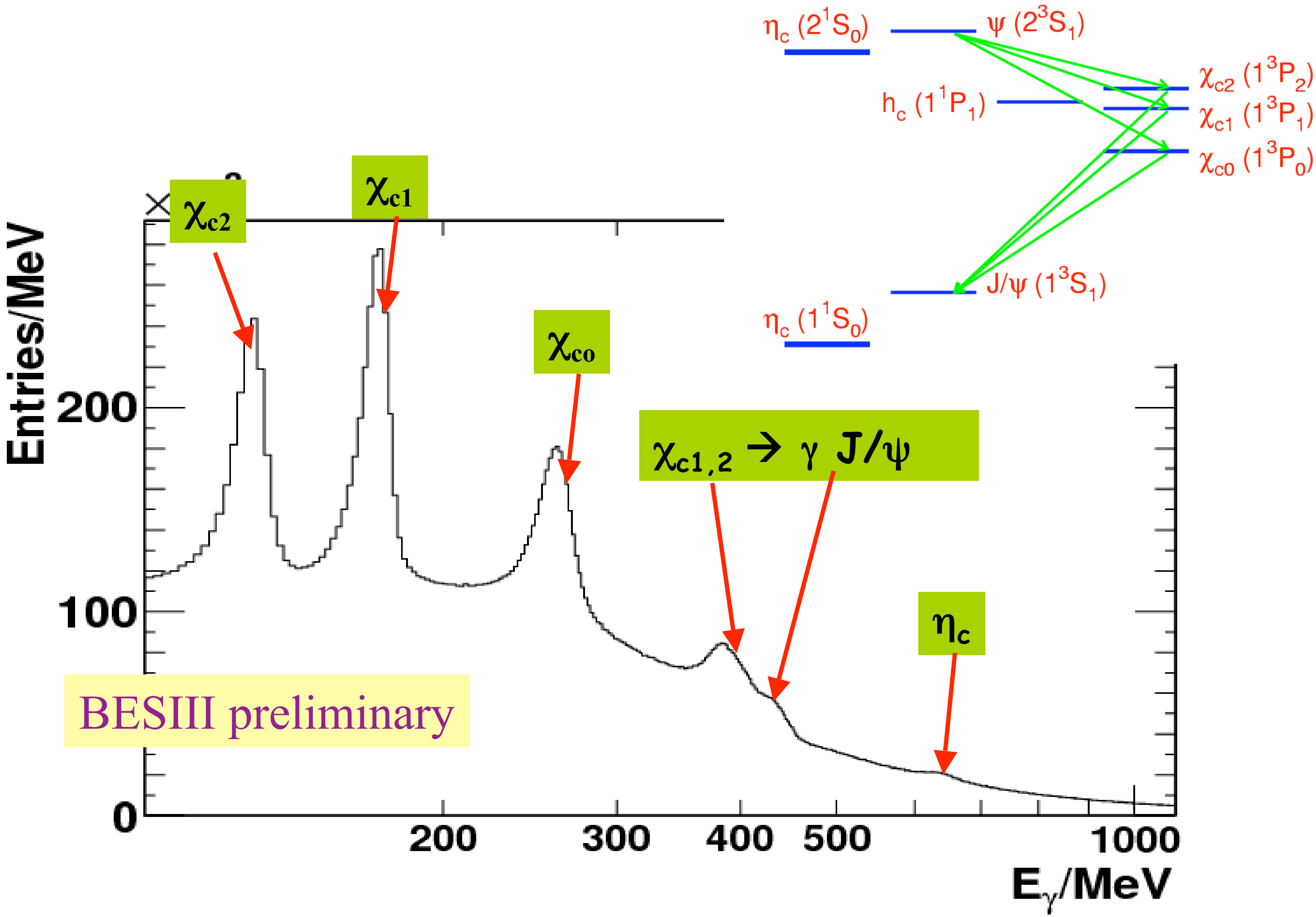


BESIII preliminary

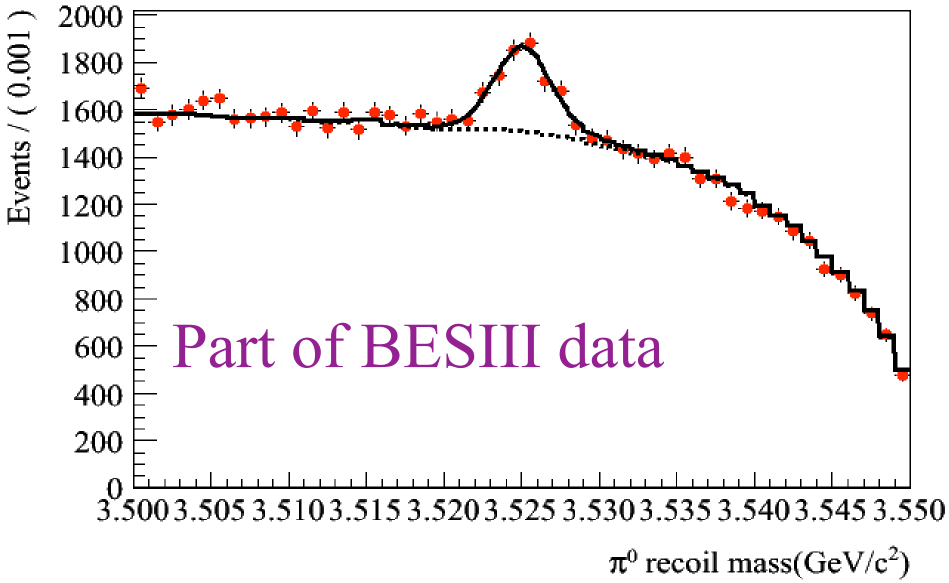


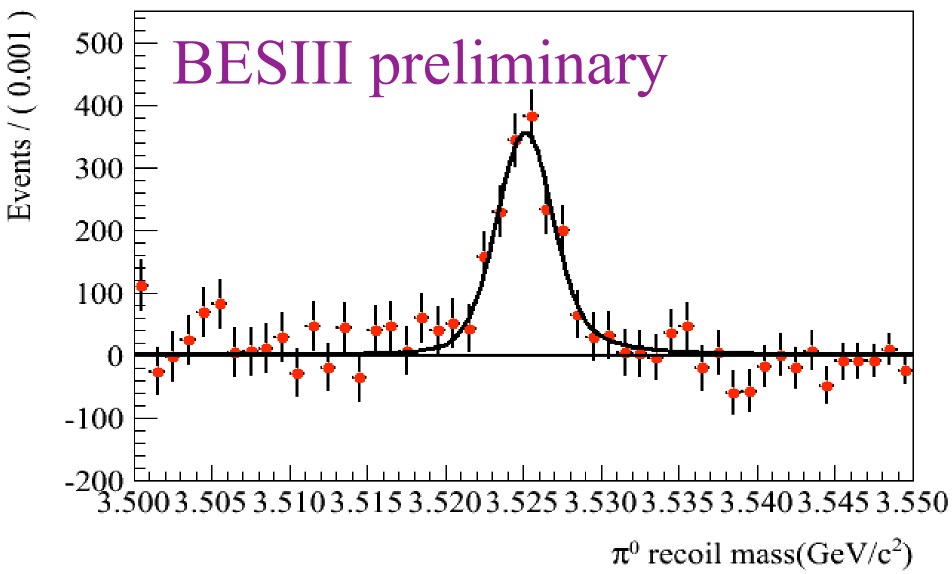


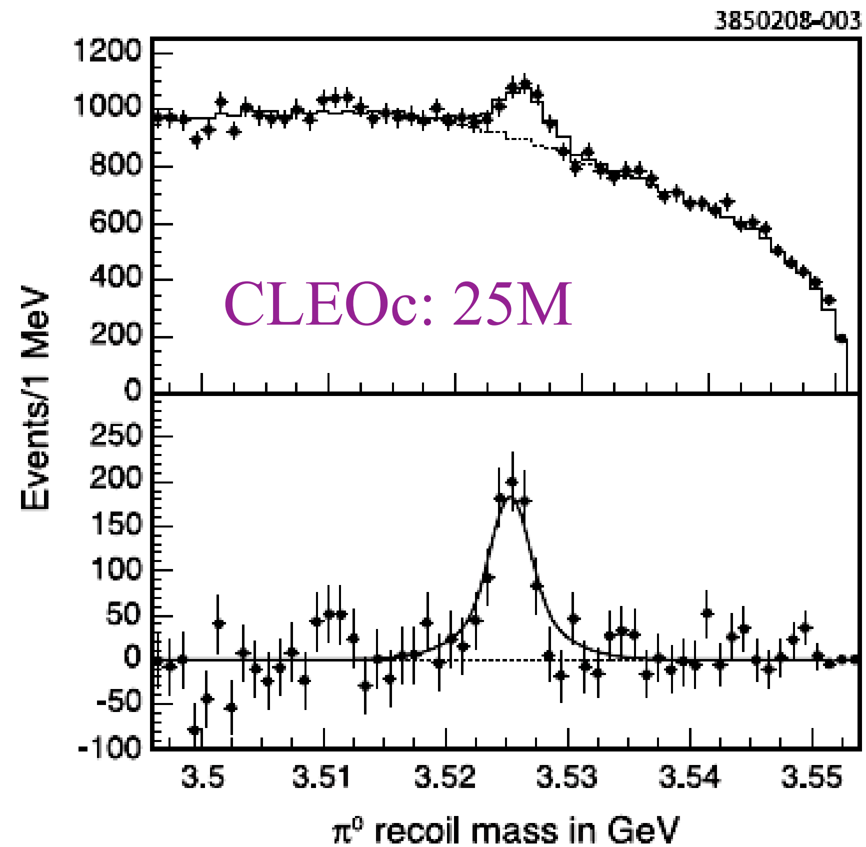
E1 transitions: inclusive photon spectrum



$\psi(2S) \rightarrow \pi^0 h_c ; h_c \rightarrow \gamma\eta_c$

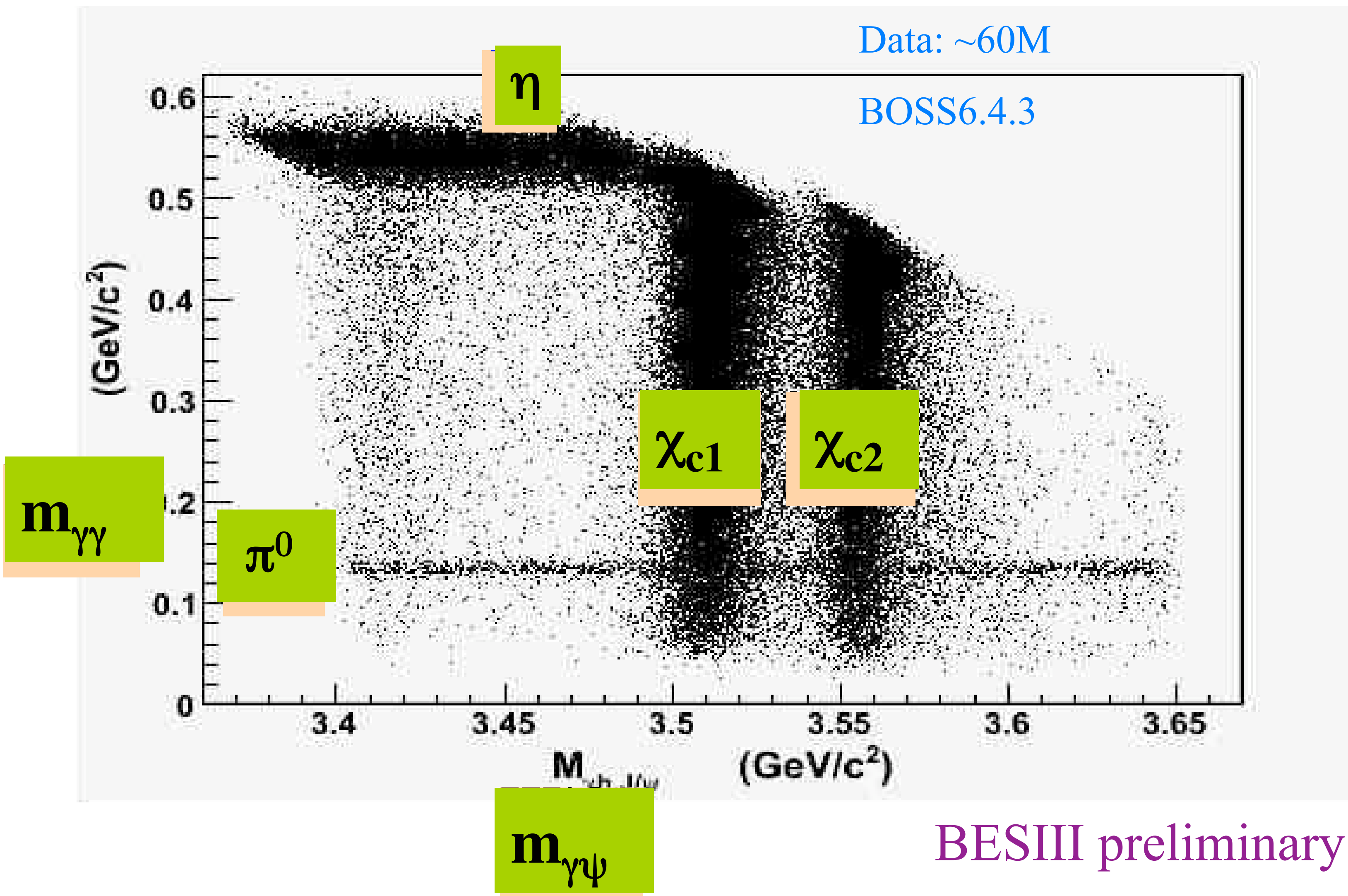






BES confirms the CLEOc observation, will improve the precisions of the measurements.

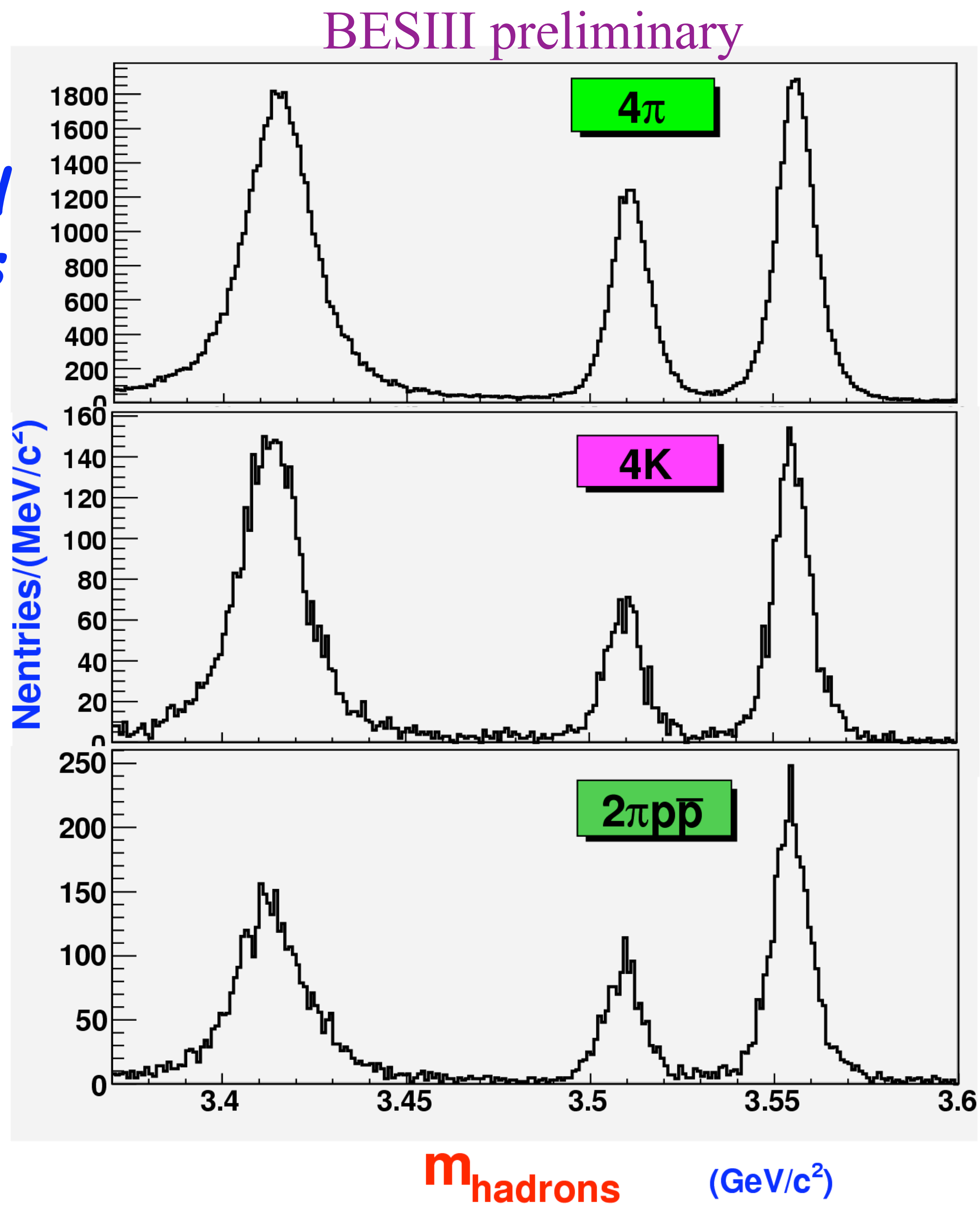
$\psi(2S) \rightarrow \gamma\gamma\, l^+l^-$:   see χ_{cJ}, π^0, and η



BESIII preliminary

Fully-reconstructed χ_{cJ} hadronic decays

Clean, well-separated signal peaks



Prospects for Flavor Physics

Look at the size of the stat / syst / FSR errors from CLEO-c

$\psi(3770)$: D^0 and D^+ physics with ~ 820 pb^{-1}

** f_D ($D^+ \rightarrow \mu\nu$): ± 4.1% ± 1.2%

** $f(q^2=0)$ ($D^0 \rightarrow \pi l \nu$): ± 5.3% ± 0.7 % [3-par. series fit]

Br($D^0 \rightarrow K\pi$): ± 0.9% ± 1.5% ± 0.9% [281 pb^{-1}]

Br($D^+ \rightarrow K\pi\pi$): ± 1.1% ± 1.8% ± 0.8% [281 pb^{-1}]

@4170 MeV: D_s physics with ~ 600 pb^{-1}

* f_{Ds} ($D_s^+ \rightarrow \mu\nu,\tau\nu$): ± 2.5% ± 1.2%

* Br ($D_s^+ \rightarrow KK\pi$): ± 4.2% ± 2.9%

Often significant gains to be made with increased data samples, even if systematic errors are simply matched, not improved.

ALSO: analyses using Quantum Correlation, C-tags, etc. are ALL statistics-starved at CLEO-c

Conclusions

BEPCII & BESIII have been successfully constructed and commissioned with very high quality;

In particular:

BEPCII reached a luminosity of 3×10^{32} cm^{-2} s^{-1}. This met a government review milestone, and moves us from the construction phase to the operation phase

The BESIII detector also performs as expected

100 M ψ' data has been taken, preliminary results obtained

500 M J/ψ data will be taken soon

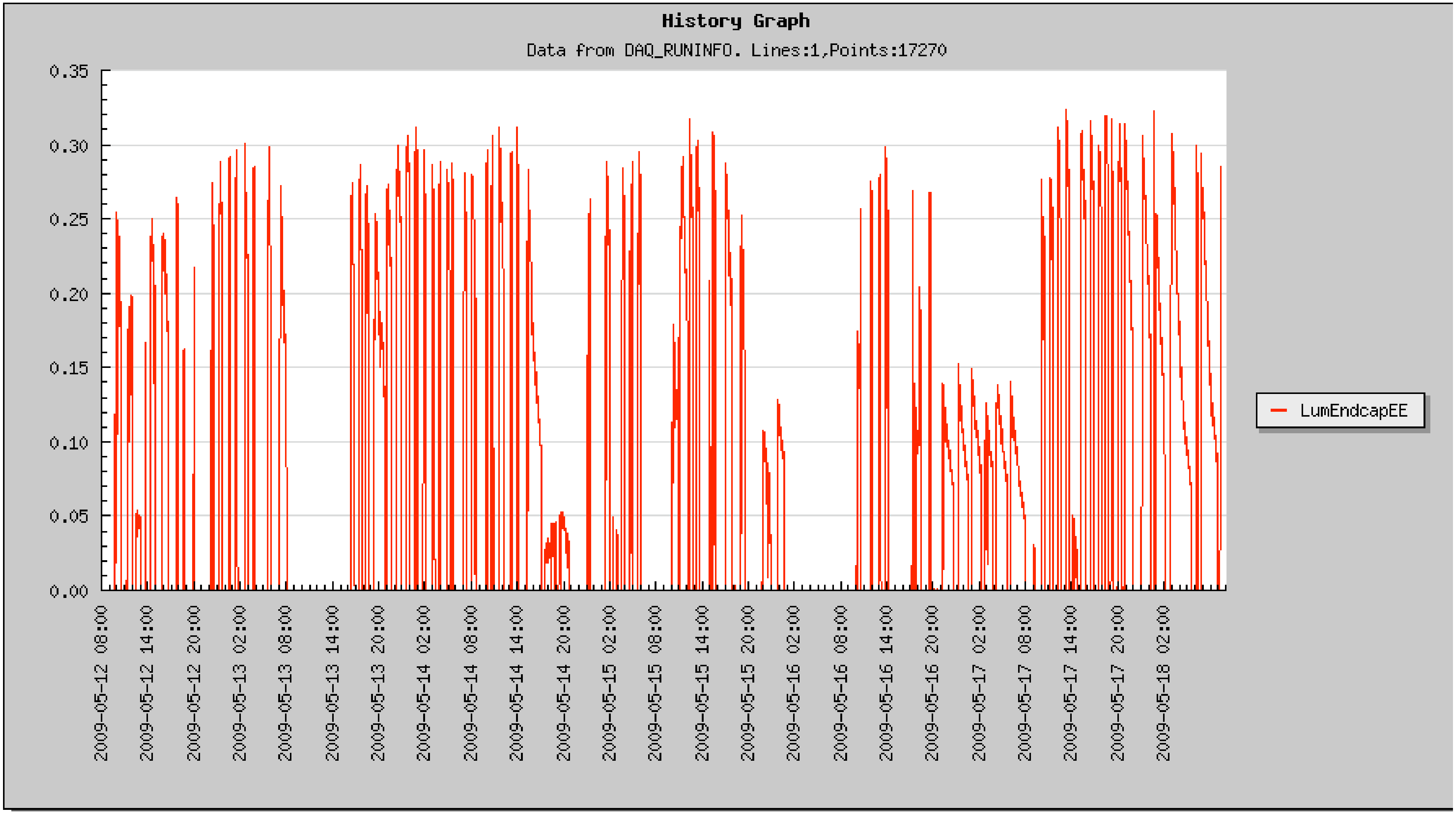
We expect great physics results in the coming months

Many thanks to my BESIII Colleagues

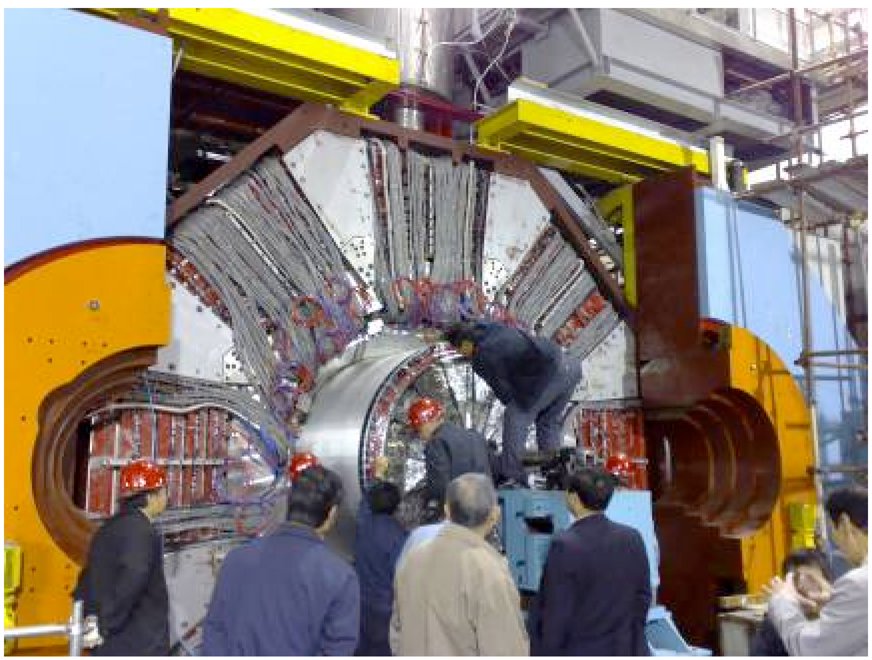
(especially to Yifang Wang, who collected most of this talk from our colleagues)

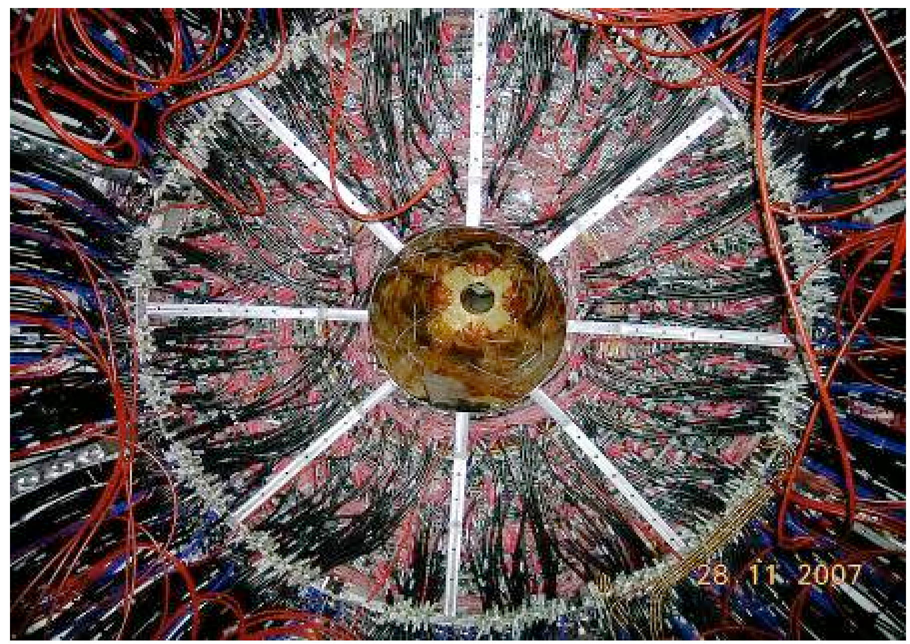
EXTRA SLIDES

Peak luminosity from May 12-18

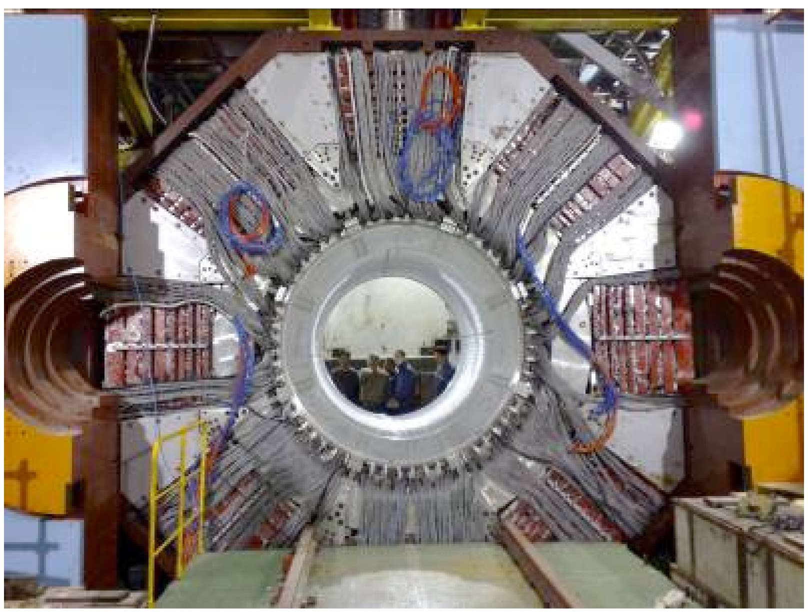


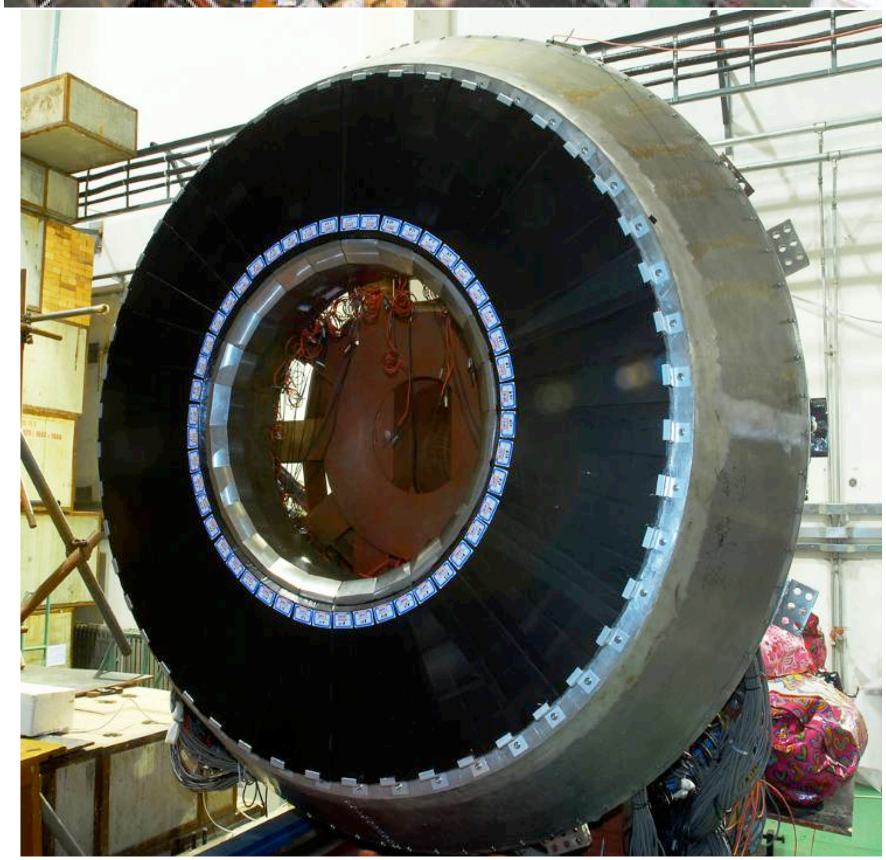
MDC and TOF installation: clearance < 10 mm



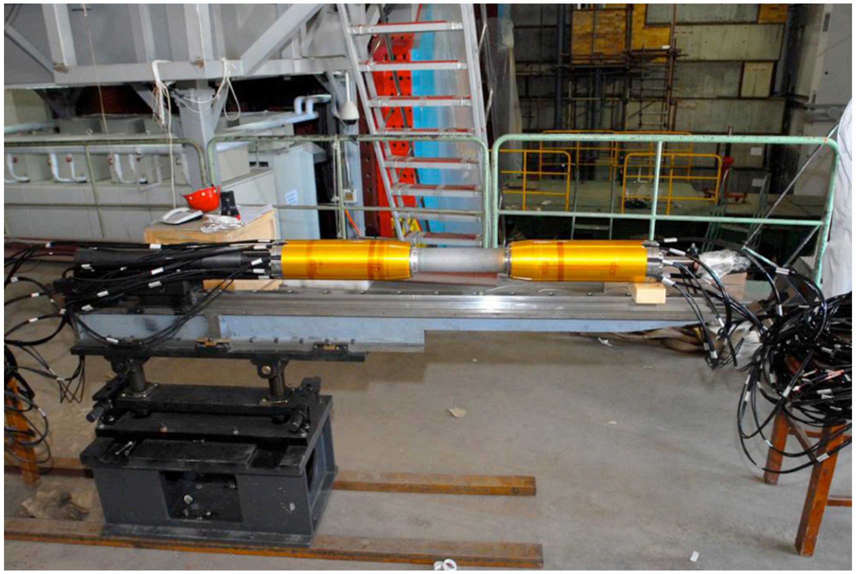


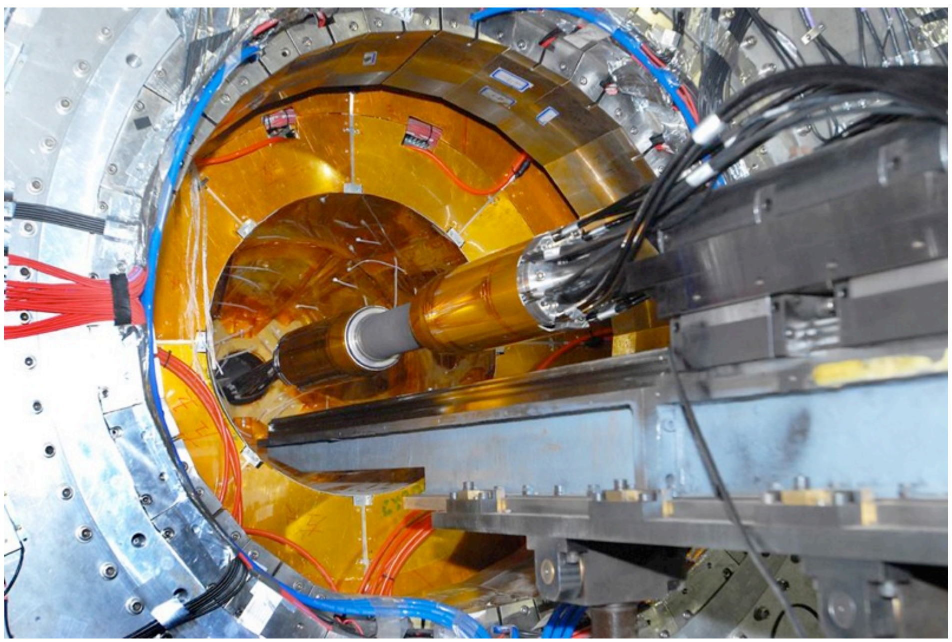
EMC installation:
clearance < 15 mm

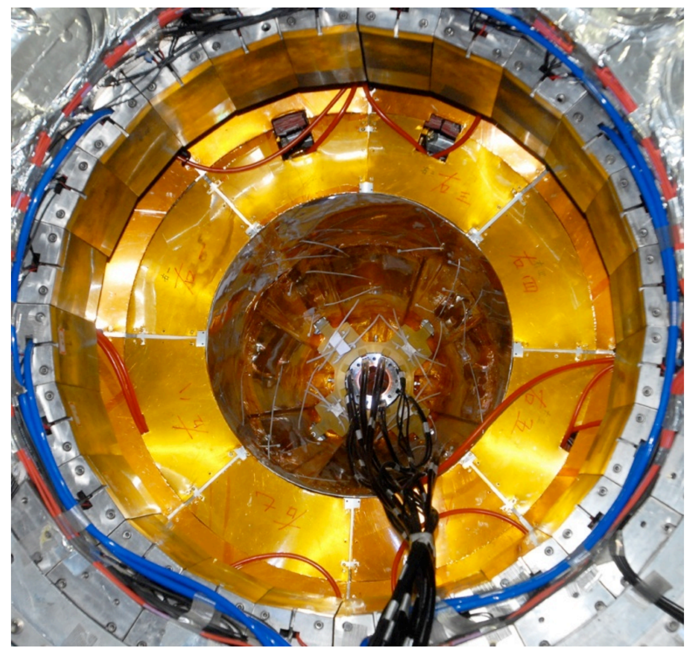




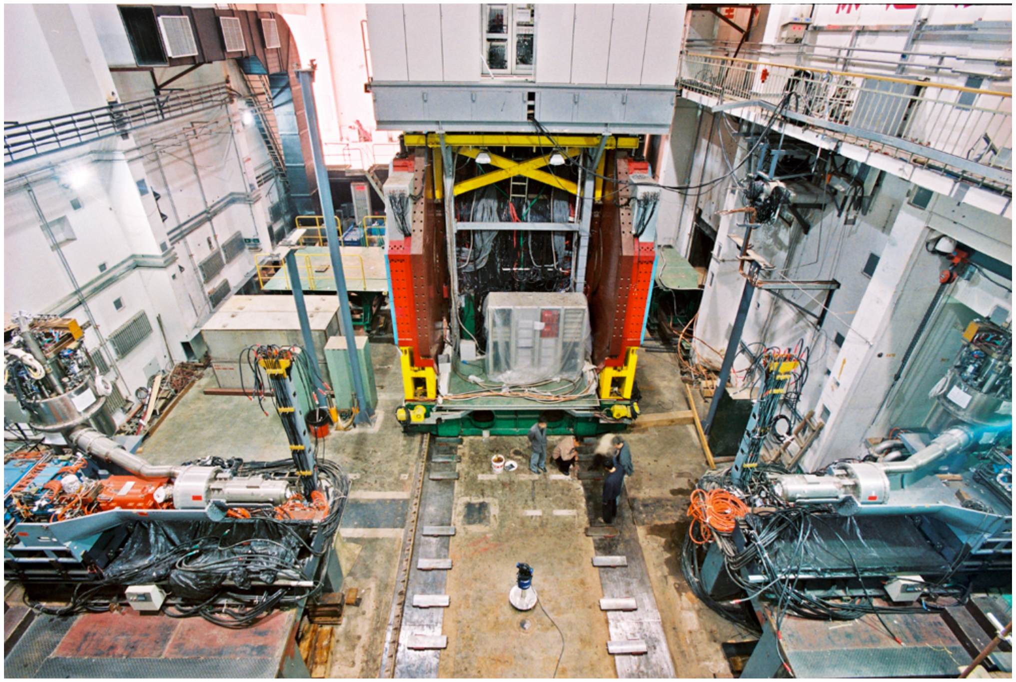
Be Beam-pipe installation

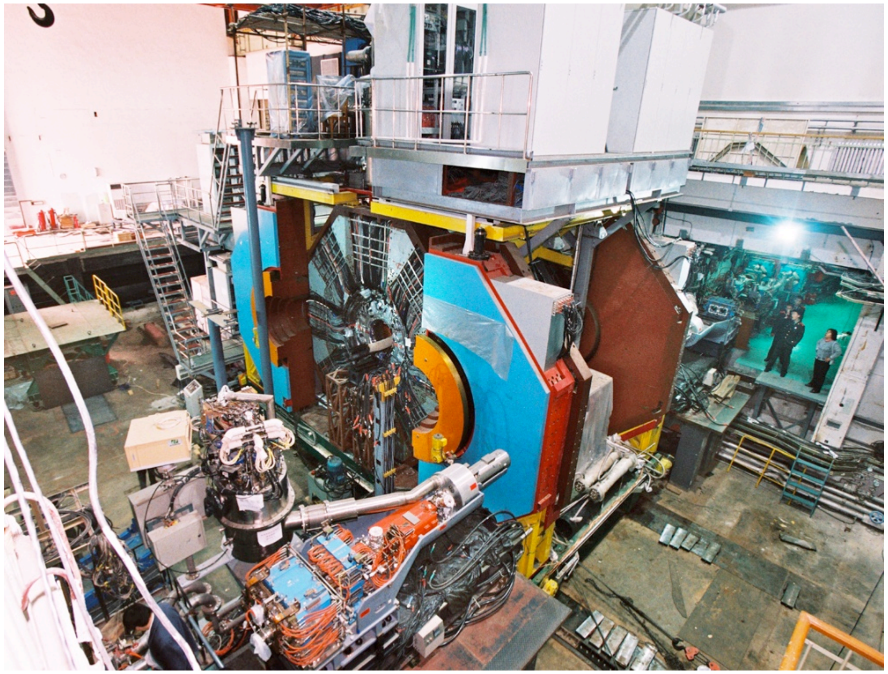


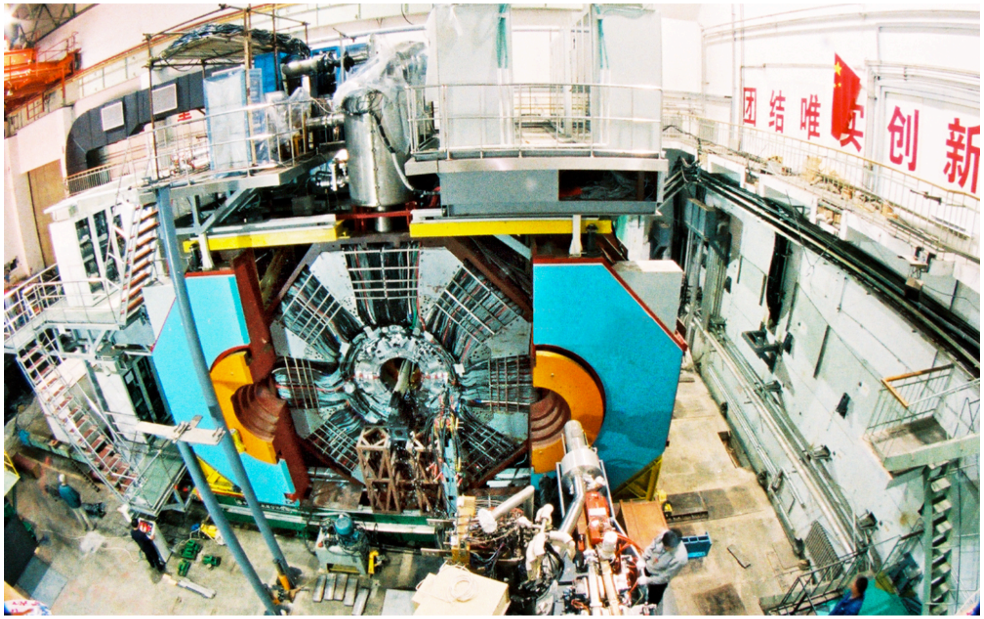


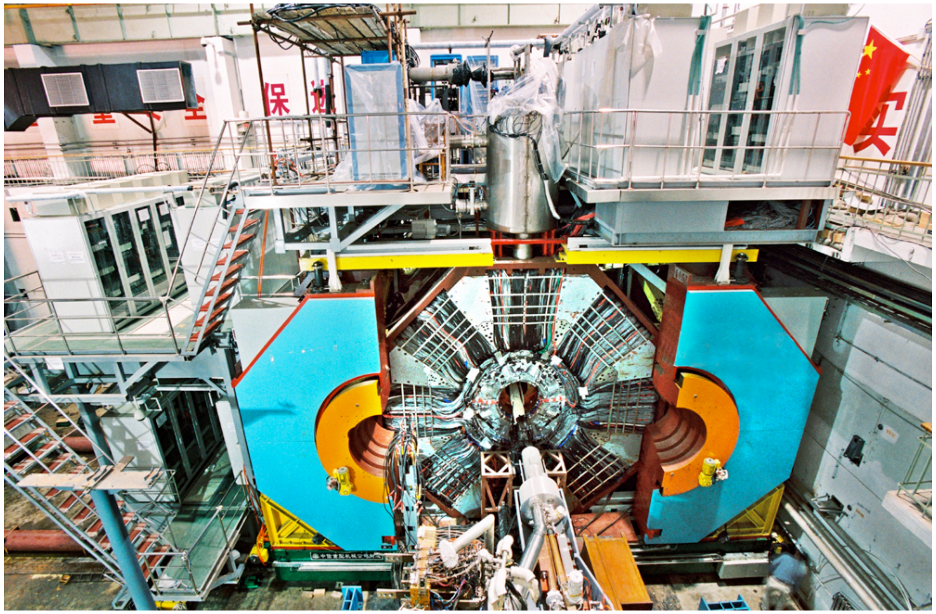


BESIII moved to IP: precision < 1 mm

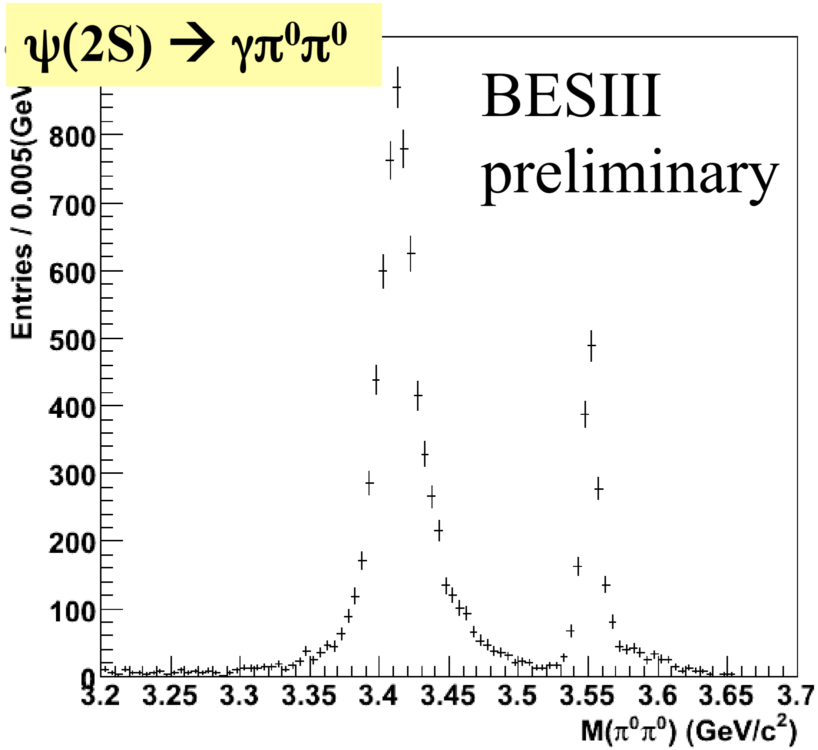


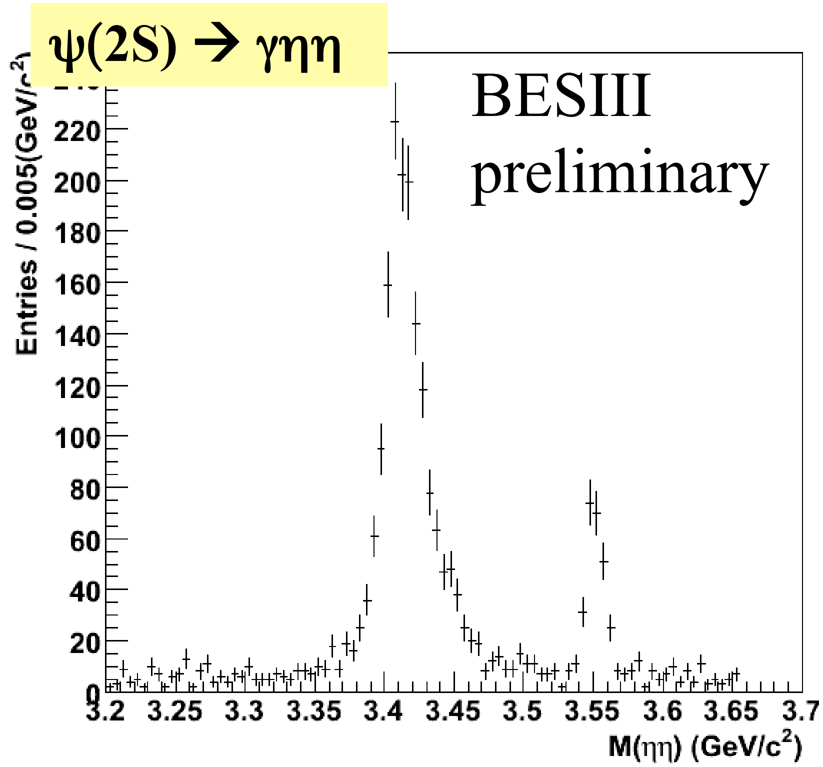






Study of $\psi(2S) \rightarrow \gamma\pi^0\pi^0$, $\gamma\eta\eta$ (η, $\pi^0 \rightarrow \gamma\gamma$)





Branching fractions (10^{-3})

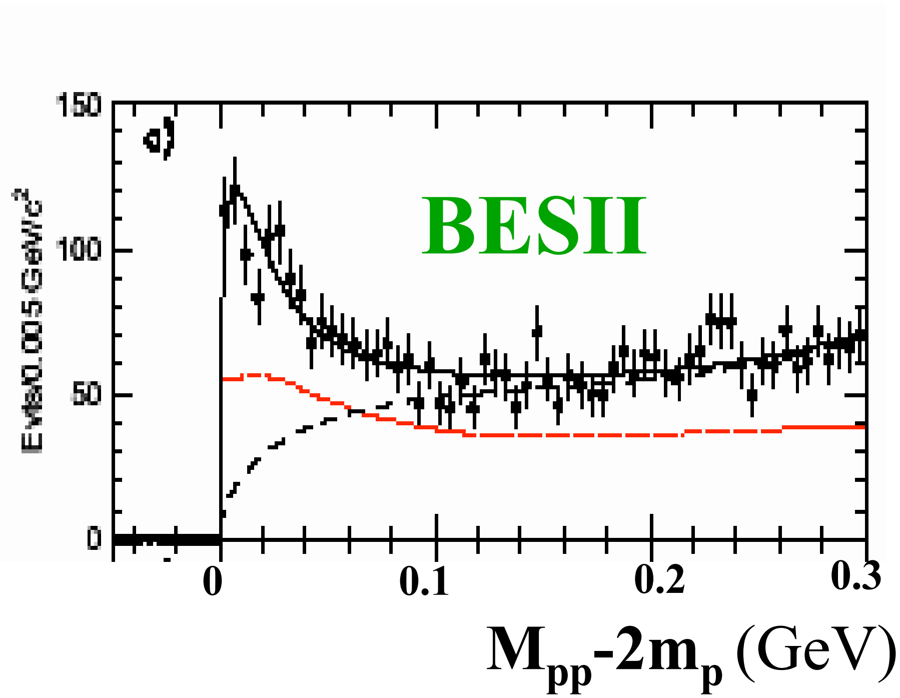
* CLEO-c arxiv:0811.0586

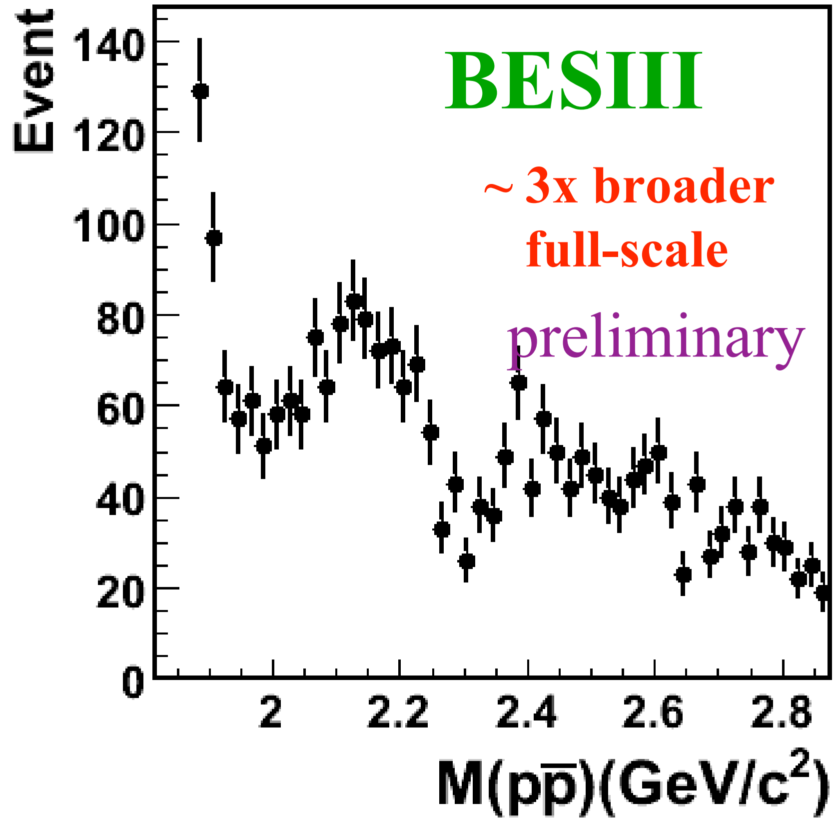
		χ_{c0}	χ_{c2}
$\pi^0\pi^0$	PDG	2. 43±0.20	0.71±0.08
	CLEO-c*	2.94±0.07±0.35	0.68±0.03±0.08
$\eta\eta$	PDG	2.4±0.4	<0.5
	CLEO-c*	3.18±0.13±0.35	0.51±0.05±0.06

Confirmation of BESII Observation

J/ψ → γ p pbar

threshold resonance



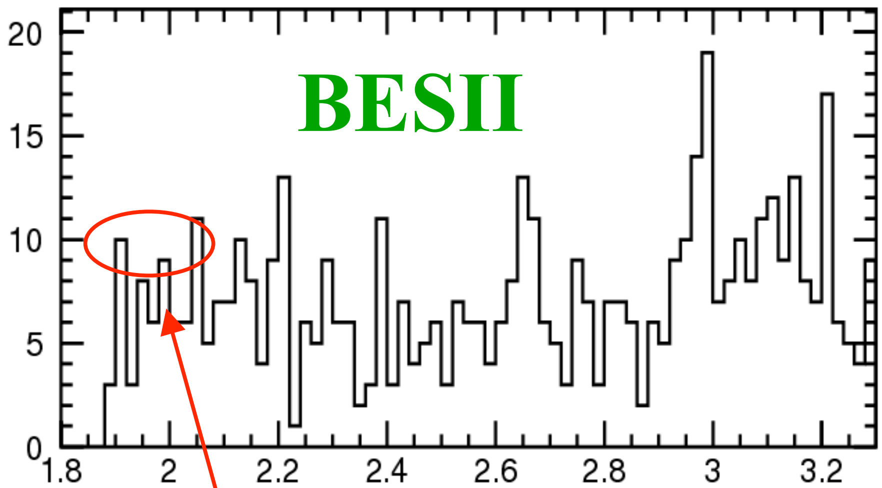


Observation of an anomalous enhancement near the threshold of mass spectrum at BES II

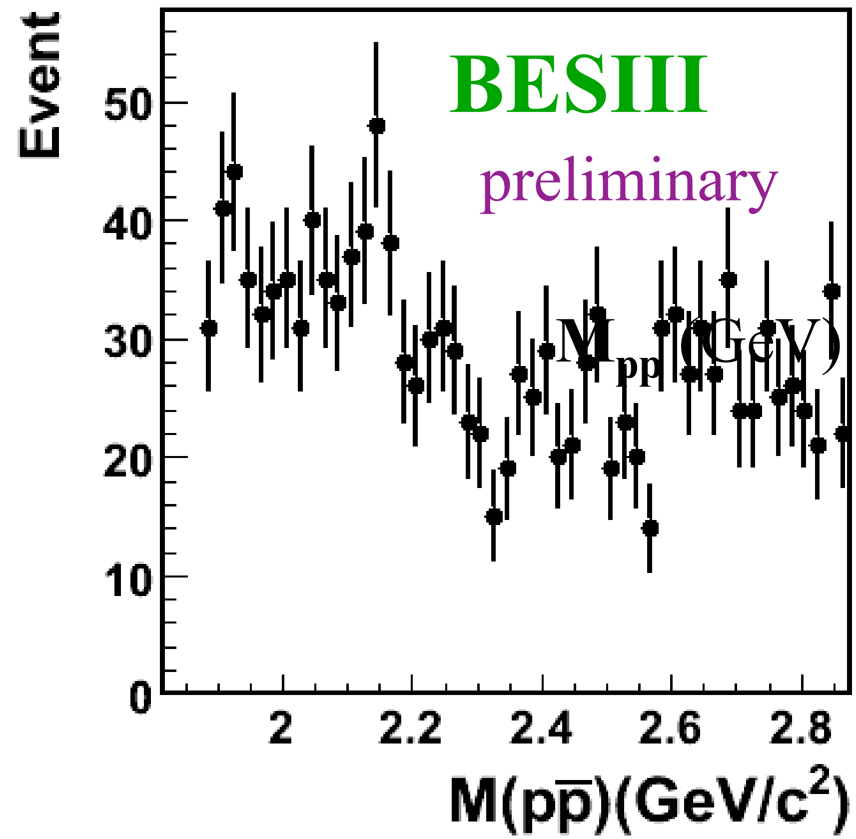
Confirmation of BESII Observation

$\psi(2S) \rightarrow \gamma\ p\ pbar$

shows NO enhancement

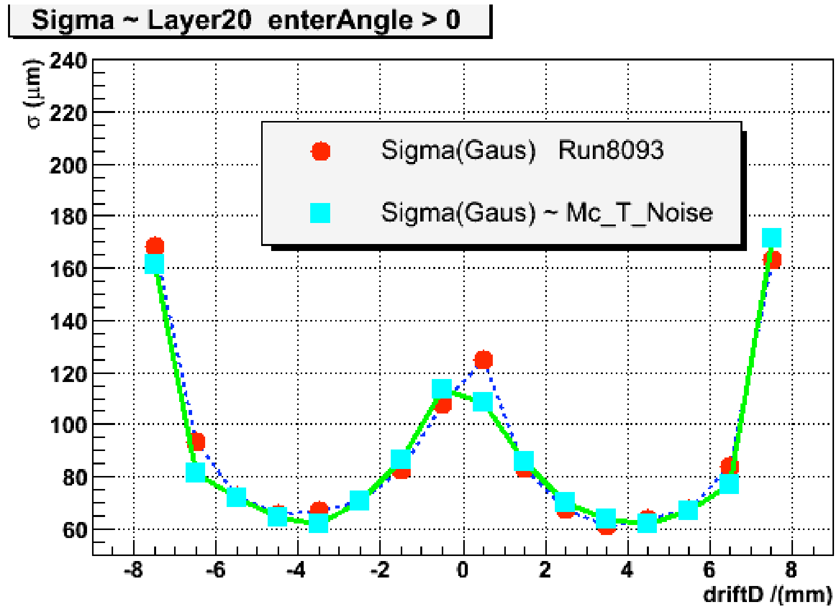


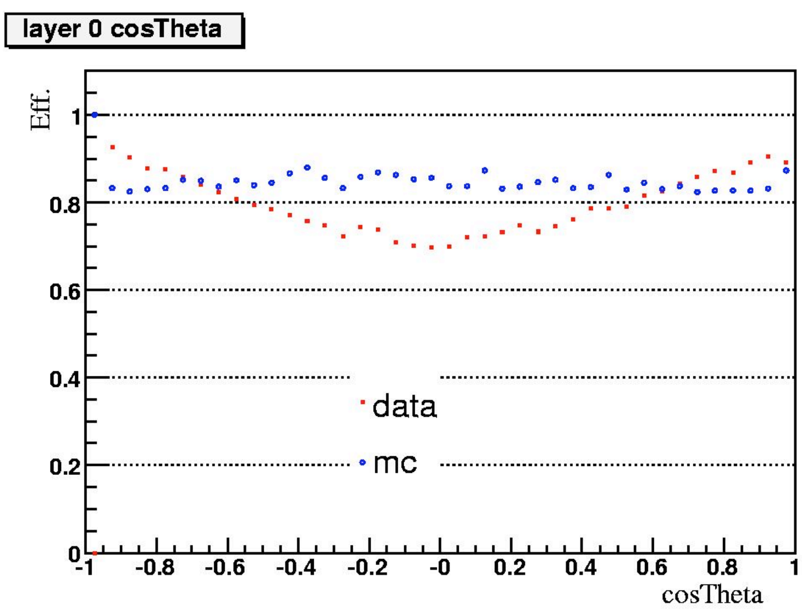
No significant narrow strong enhancement near threshold (~2σ if fitted with X(1860))

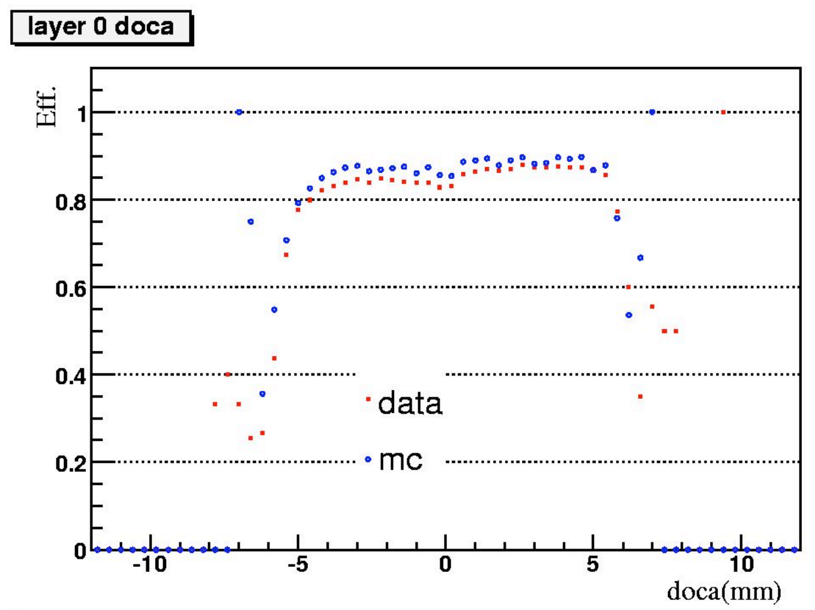


Data/MC comparison

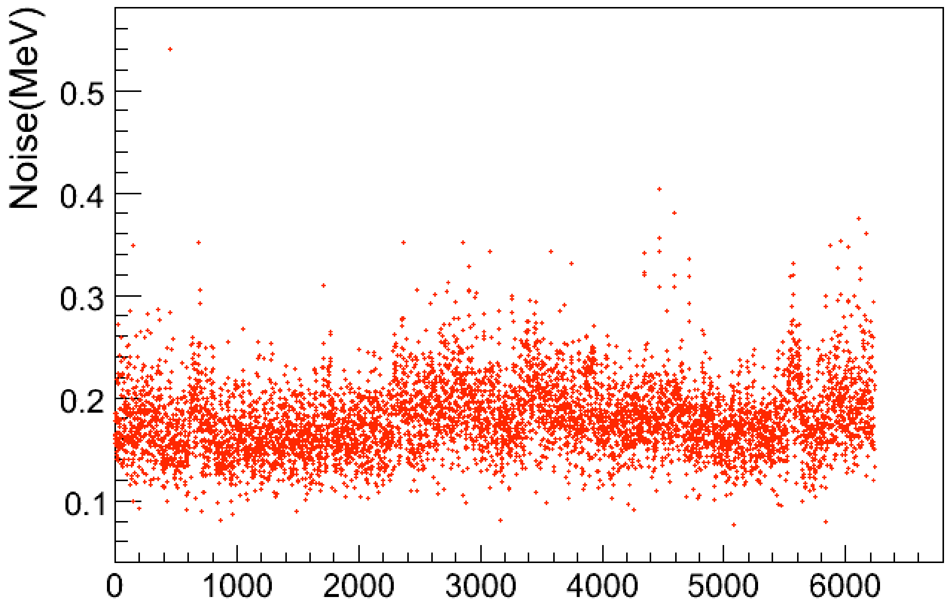
- **Detailed simulation:**
  - **Resolution/efficiency of each cell as a function of drift distance, DOCA, Q, HV, Noise, entrance angle, …**
- **Improvements: more data, better understanding, …**

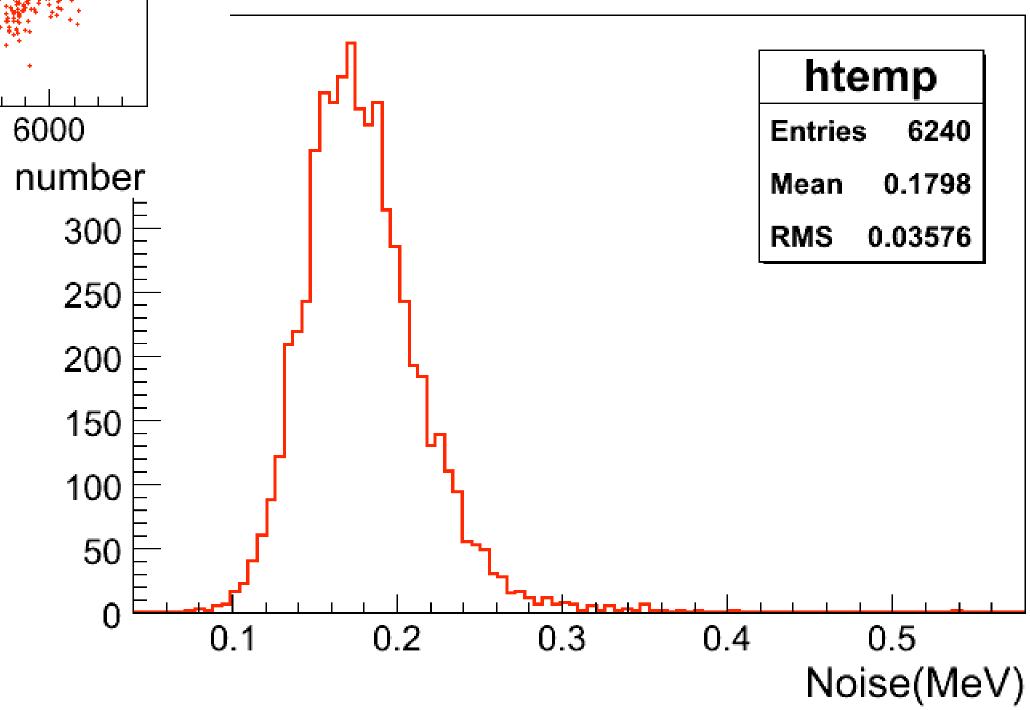




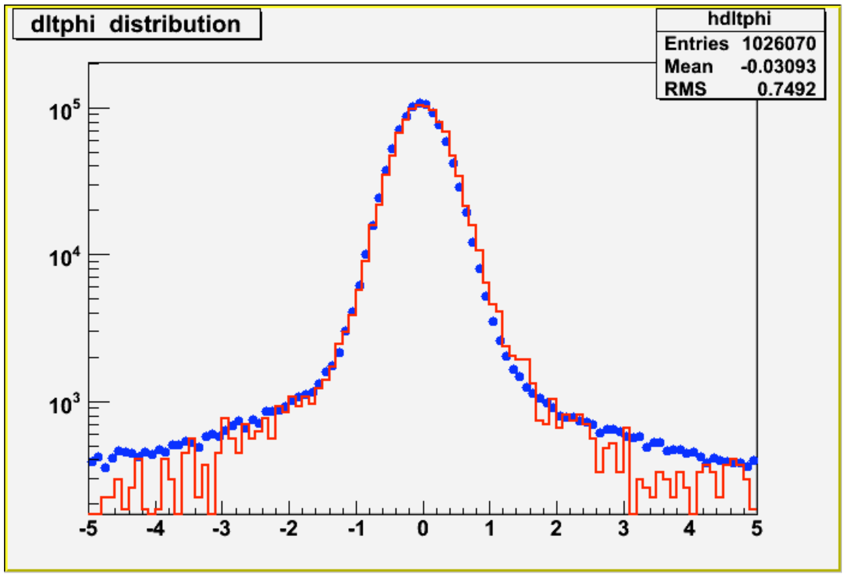


CsI: Very low electronics noise





Data / MC comparison for Bhabha events



Dots: data
Solid line: MC with background mixing
Dash line/shade: MC without background mixing