BESIII Experiment

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Real time Conference

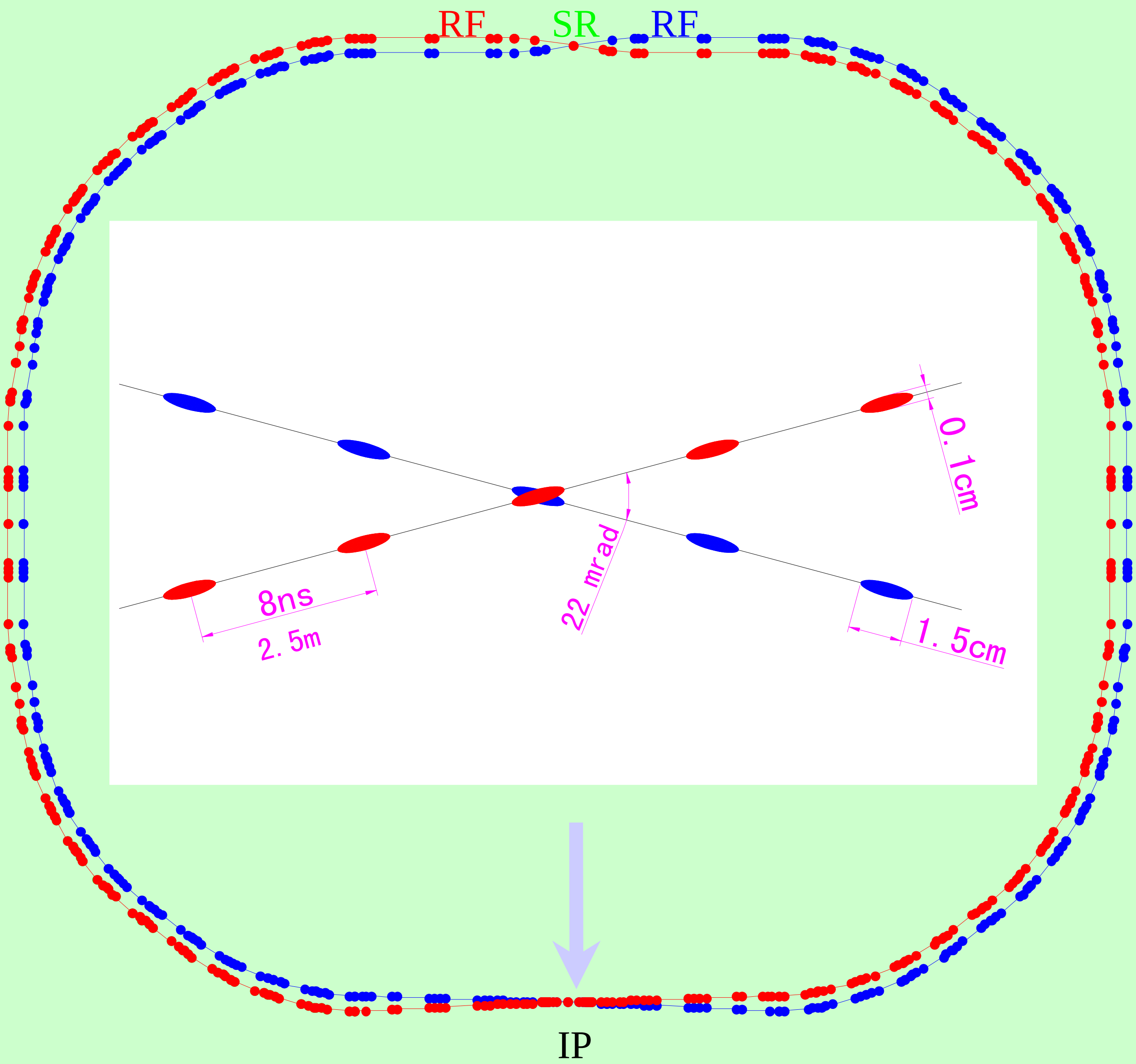
May 11, 2009

IHEP, Beijing

Outline

- BEPCII
- BES-III detector
- Summary

BEPC II Storage ring: Large angle, double-ring



Beam energy:
1.0-2.3 GeV
Luminosity:
1×10^{33} $cm^{-2}s^{-1}$
Optimum beam 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

BEPCII luminosity strategy

DR: multi-bunch k_{bmax}~400, k_b=1 ➔ 93

Choose large ε_x & optimum param.: I_b=9.75mA, ξ_y=0.04

$$L(\mathrm{cm}^{-2}\mathrm{s}^{-1}) = 2.17\times10^{34}(1+R)\xi_y \frac{E(GeV)k_b I_b(A)}{\beta_y^*(cm)}$$

Micro-β: β_y^* =5cm ➔ 1.5 cm
SC insertion quads

Reduce impedance +SC RF
σ_z =5cm ➔ <1.5cm

$(L_{BEPCII}/L_{BEPC})_{D.R.}$=(5.5/1.5) ×93 × 9.8/35=96

L_{BEPC}=1.0×10^{31} cm^{-2}s^{-1} ➔ L_{BEPCII} =1×10^{33} cm^{-2}s^{-1}

Milestone of BEPCII storage ring commissioning

Nov. 2006 Beam stored in the storage ring

Mar. 2007 First e^+e^- collision, Lumi ~ 10^{30} cm^{-2} s^{-1}

Jan. 2008 BEPCII: collision with 500mA×500mA and 93 bunches in each ring， the luminosity is about $1*10^{32}cm^{-2}s^{-1}$

June 20 2008 The first physics collision at ψ(2S) peak with BESIII detector;

Till now, ~100M ψ(2S) obtained;

Peak luminosity reached, ~2.3 $*10^{32}cm^{-2}s^{-1}$, in April.

Now bunch space is 8 ns, usually with 80-90 bunches.

Before Sep. 2009 aim for 3 $*10^{32}cm^{-2}s^{-1}$ (30% of the design luminosity).

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. ($\times 10^{33} cm^{-2}s^{-1}$)	1	0.23	

Machine will continue to tune for higher luminosity,

- **with higher single beam current;**

Now the luminosity does not follow the expectation

L ~ beam current squared

- **more bunches;**

For detector, it is possible to use 6 ns bunch spacing

The hope is to reach 3.0 $*10^{32} cm^{-2} s^{-1}$ before the summer, so can pass government review in September.

- **install longitudinal feedback system in the summer.**

Events productions per year at BEPCII

Average Lum: L = 0.5 × Peak Lum.; One year data taking: T =

$$\sigma_{exp}(W) = \int_0^\infty dW' \sigma_{r.c.}(W') G(W', W)$$

$$N_{event}/year = \sigma_{exp} \times L \times T$$

Resonance	Mass(GeV) CMS	Peak Lum. ($10^{33}cm^{-2}s^{-1}$)	Physics Cross Section (nb)	#Nevents/year
J/ψ	3.097	0.6	3400	10×10^9
$\tau^+\tau^-$	3.670	1.0	2.4	12×10^6
$\psi(2S)$	3.686	1.0	640	3.2×10^9
D^0D^0bar	**3.770**	**1.0**	**3.6**	**18×10^6**
D^+D^-	**3.770**	**1.0**	**2.8**	**14×10^6**
DsDs	**4.030**	**0.6**	**0.32**	**1.0×10^6**
DsDs	**4.170**	**0.6**	**1.0**	**2.0×10^6**

BES-III

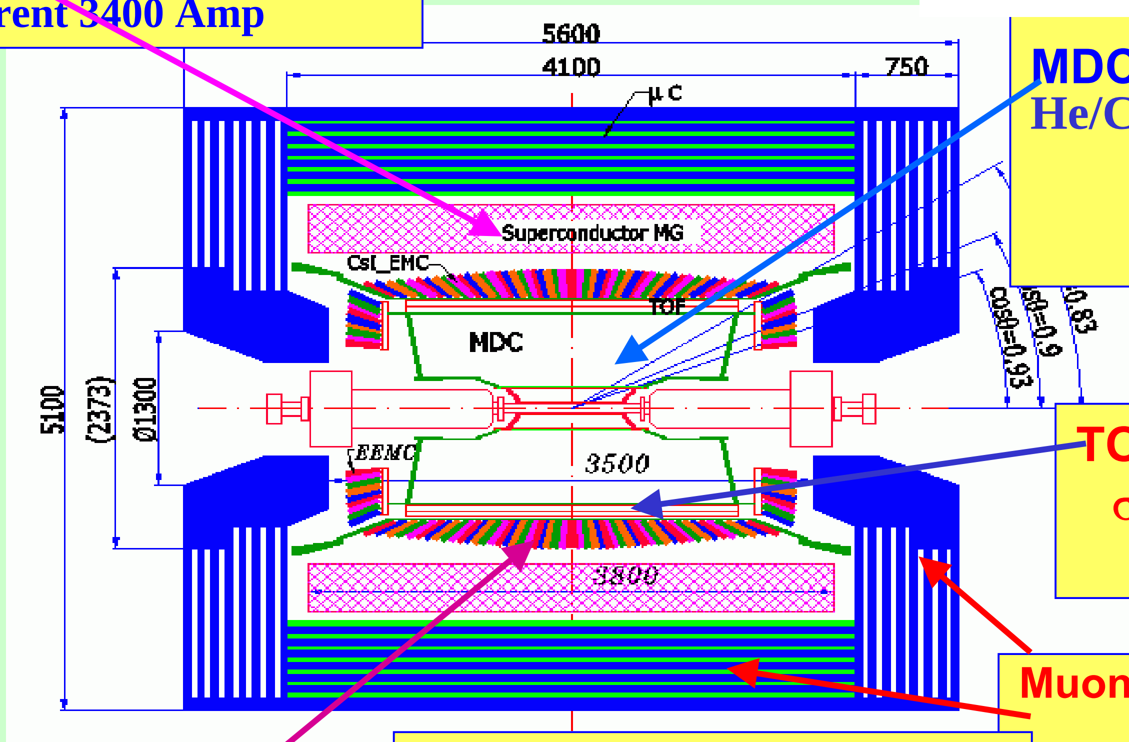
BESIII detector: all new !

CsI calorimeter

Precision tracking

Time-of-flight + dE/dx PID

Magnet: 1 T Super conducting
current 3400 Amp



MDC: small cell & Gas:
He/C3H8 (60/40)
σ_{xy}=130 μm
σ_p/p = 0.5% @1GeV
dE/dx=6%

TOF:
σ_T = 100 ps Barrel
110 ps Endcap

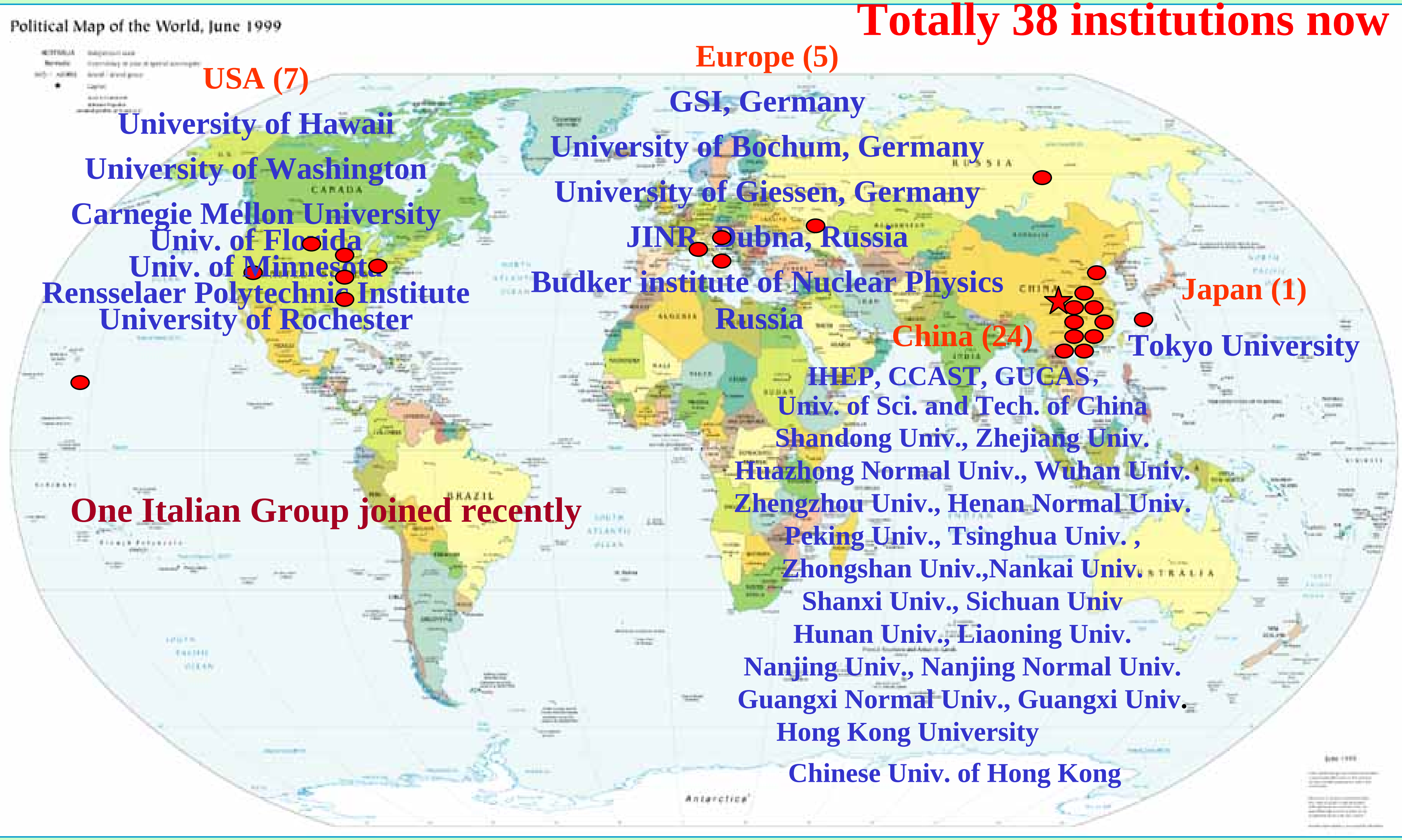
Muon ID: 9 layers RPC
8 layers for endcap

EMC: CsI crystal
$\Delta E/E$ = 2.5% @1 GeV
$\sigma z = 0.6\ \mathrm{cm}/\sqrt{E}$

Data Acquisition:
Event rate = 4 kHz
Total data volume ~ 50 MB/s

The detector is hermetic for neutral and charged particle with excellent resolution, PID, and large coverage.

BESIII collaboration



Totally 38 institutions now

USA (7)

University of Hawaii
University of Washington
Carnegie Mellon University
Univ. of Florida
Univ. of Minnesota
Rensselaer Polytechnic Institute
University of Rochester

Europe (5)

GSI, Germany
University of Bochum, Germany
University of Giessen, Germany
JINR, Dubna, Russia
Budker institute of Nuclear Physics Russia

Japan (1)

Tokyo University

China (24)

IHEP, CCAST, GUCAS,
Univ. of Sci. and Tech. of China
Shandong Univ., Zhejiang Univ.
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.
Hong Kong University
Chinese Univ. of Hong Kong

One Italian Group joined recently

BESIII Status

- ✓ Finish the installation of all the detector components.

  Beam pipe, MDC, Barrel and endcap TOF, barrel and endcap EMC, all muon chambers.

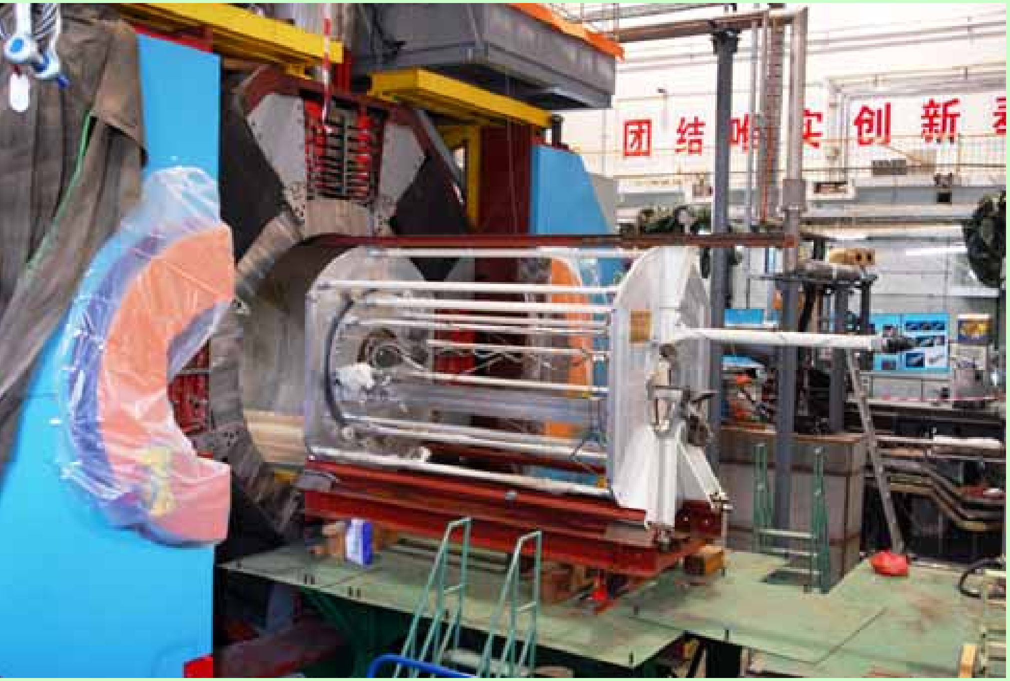
- ✓ Cosmic ray data from Dec. 2007 to March 15 2008, with DAQ, Trigger, and Slow control, fixing problems.
- ✓ BESIII detector into beam-line on May 6, 2008
- ✓ Collision on July 20, 2008
- ✓ In Oct. 2008, 11 million $\psi(2S)$ events for calibration

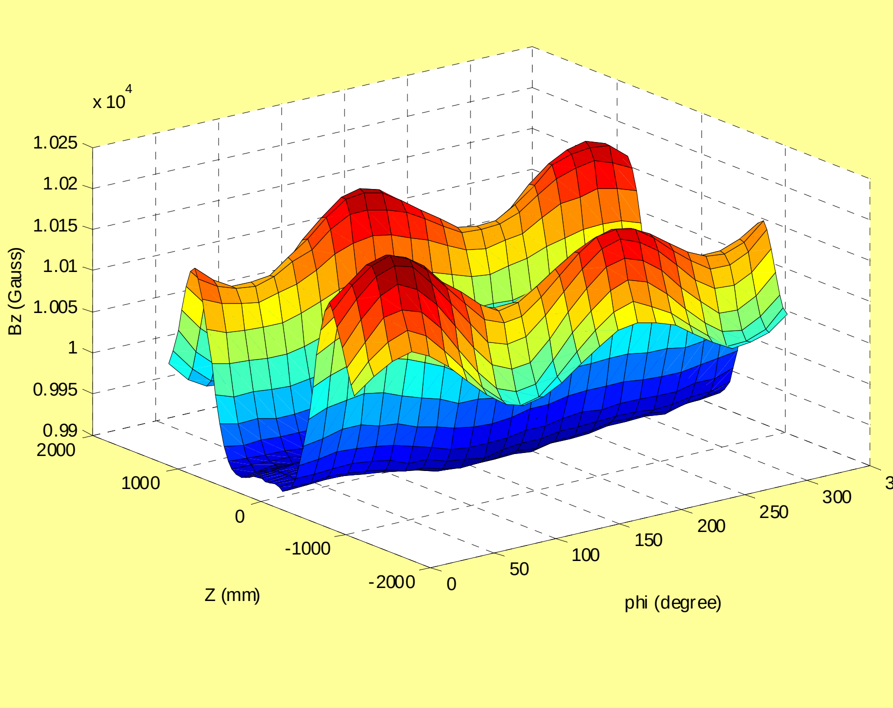
  Performances meet the design

- ✓ Collect more than 100 M $\psi(2S)$ data in April, 2009

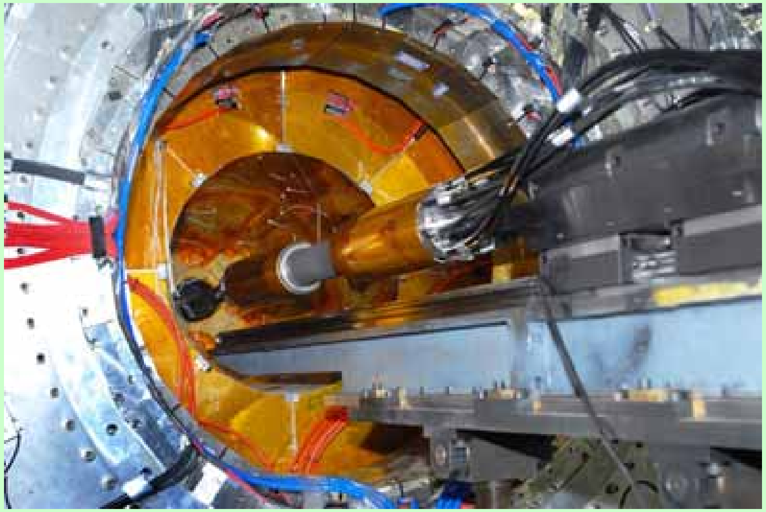
For main system of BESIII Detector

Magnet reached 1 tesla （3368A)





Be beam pipe



- Two Be cylinders (0.8 mm and 0.5 mm thick, 0.8mm gap), cold by paraffine-1
- 14.6 μm gold at the inner surface.
- The beam pipe was put in the place on March 27, 2008, it is the last component of the BES-III detectors installed.

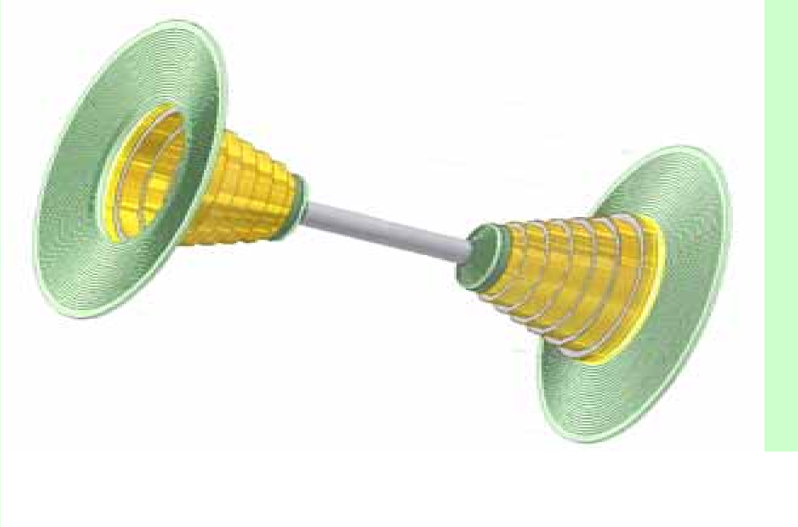
Drift chamber

- **To measure the momentum of charged particles**
- **Design spec.:**

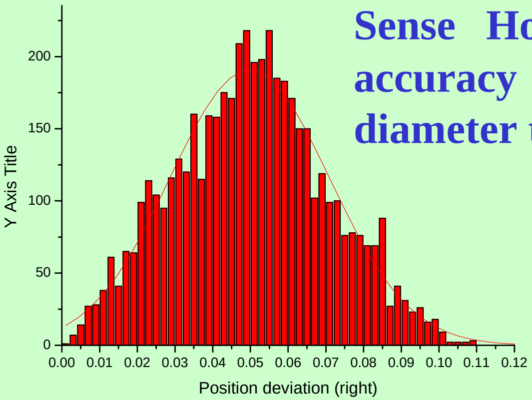
	Single wire reso.	dE/dx reso.
CLEO:	~110μm,	5.7%
Babar:	~110μm,	6.2%
Belle:	~130μm,	5.7%
BESIII	~120μm	6 .0%

- **R_{in} = 63mm; R_{out} = 810mm; length = 2400 mm**
- **6796 Signal wires: 25(3% Rhenium) μm gold-plated tungsten**
- **21884 Field wires: 110 μm Al**
- **Gas: He + C_3H_8 (60/40)**
- **Momentum resolution@1GeV: 0.5%**

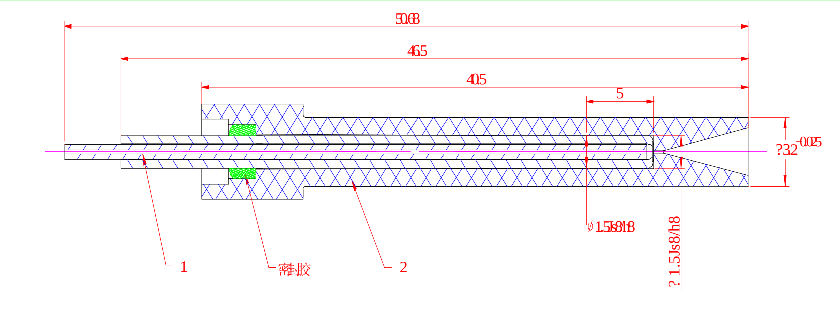
$$\frac{\sigma_{P_t}}{P_t} = 0.32\% \oplus 0.37\%$$



MDC Construction



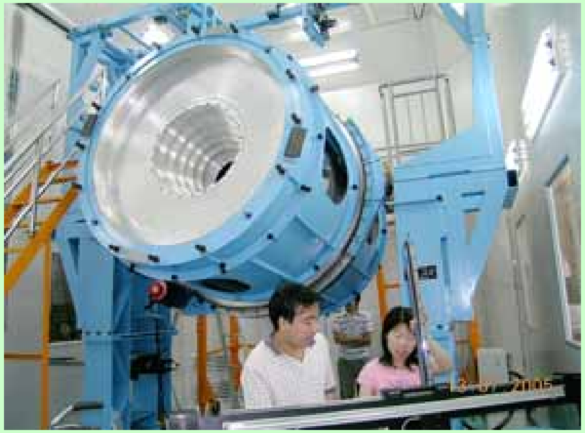
Sense Hole position accuracy 50 μm, diameter to 10 μm



100K feedthroughs, 4 kinds

Diameter: 3.2mm$^{-0.025mm}$, the concentricity of inner hole and outer diameter < 25 μm
Leakage current < 1 nA at - 2.5kV, in a humidity of 55% .

Wiring



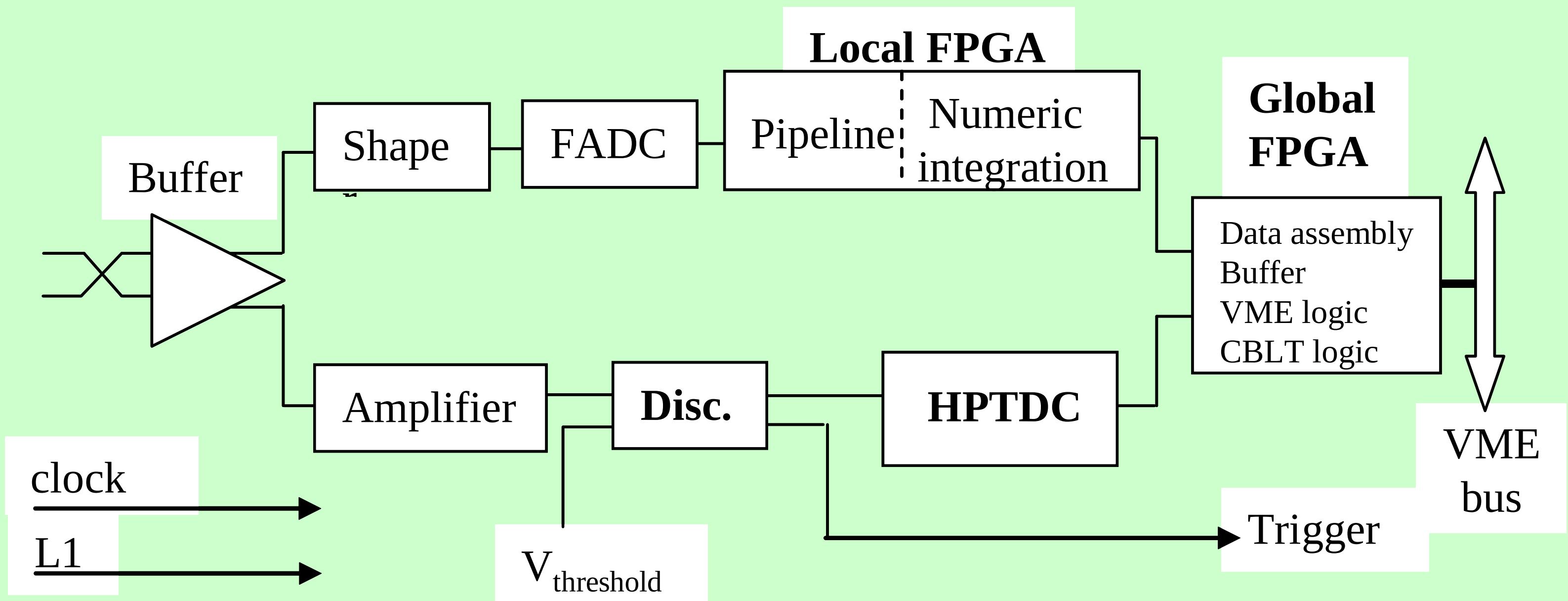
Wire tension to 5%；

Leakage current to the specs;

He gas leakage： 20mL/Min, ~1% of the gas flux, better than other detectors

In BESIII DAQ, pipeline and FPGA are widely used

MDC Electronics

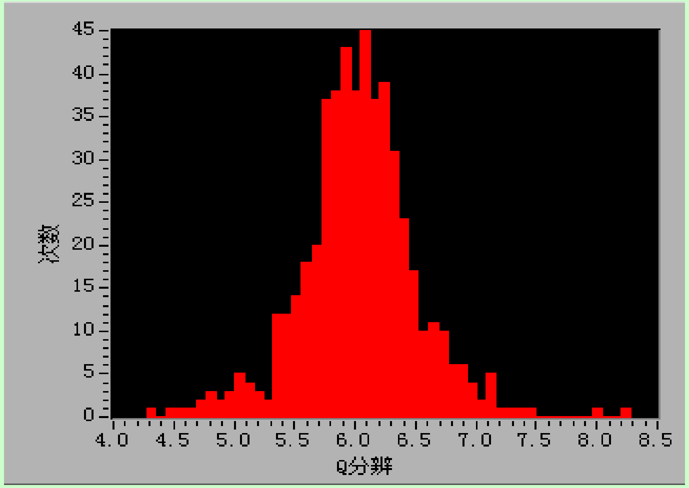


Block Diagram of the MQT module (32 channels/board)

Time is measured based on HPTDC (100ps), dual thresholds

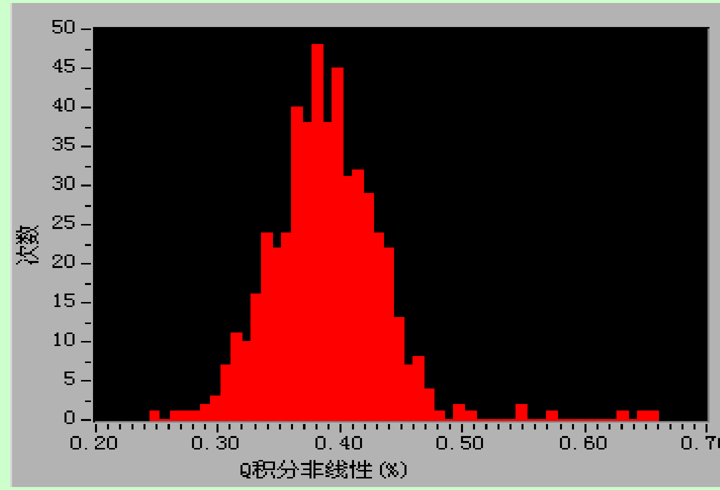
Charge is measured by FADC of 41.65 MHz, 10 bit AD9215

MDC electronics



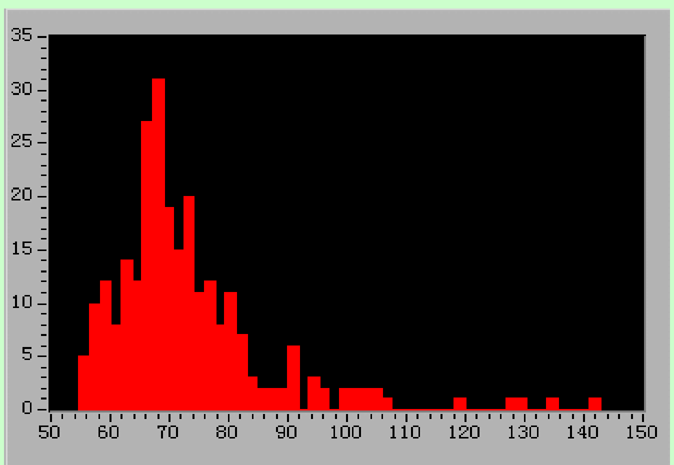
Q resol. (σ_Q):

Results: typical, 6 fc /design： 8fc



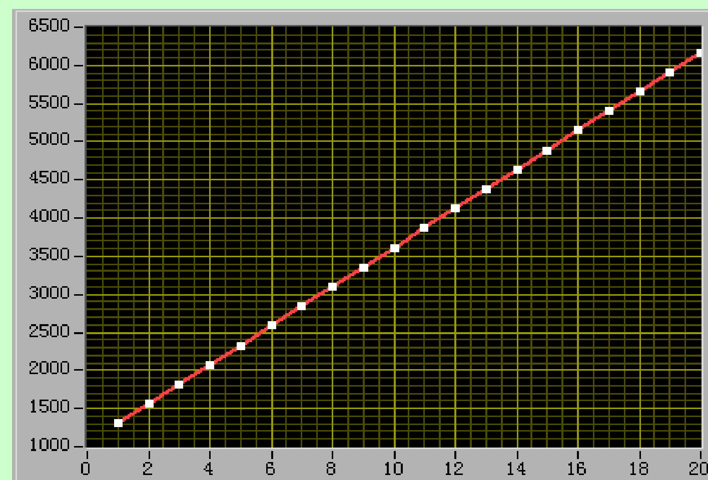
Q integral non-linearity

results：typical: 0.4%/design： 2%



T resol. (σt):

results： typical 70ps /design： 0.5ns



Time integral non-linearity:

results：typical 0.015%/design: 0.5%

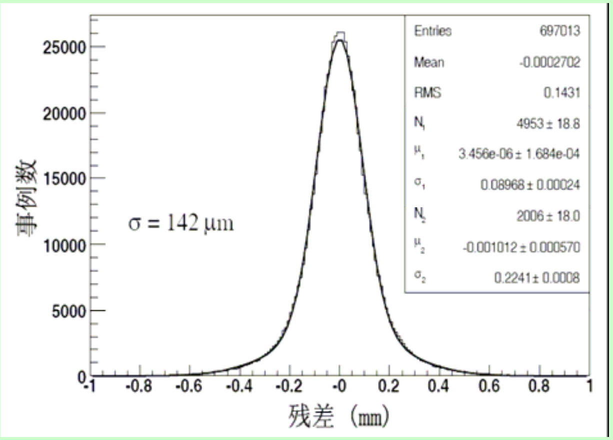
MDC electronics performance specifications and measured results

Items	Required	Test results
Time resolution	0.5 ns	0.1 ns
Time dynamic range	0 - 500 ns	0 - 500 ns
Time integral non-linearity	0.05%	0.015%
Charge resolution	8 fC	6 fC
Charge dynamic range	15 - 1,800 fC	15 - 1,800 fC
Charge integral non-linearity	2%	0.5%

MDC Performance

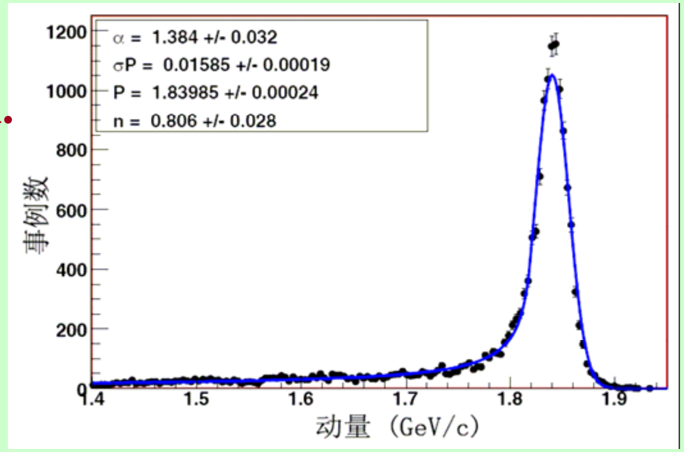
Condition:

- **HV: 2150V, 1st layer: 95%， 2nd: 96%， 3rd: 97%， 4th: 98%**
- **Timing threshold： inner 100/130, step 80/110, outer 70/90**



Wire resol.

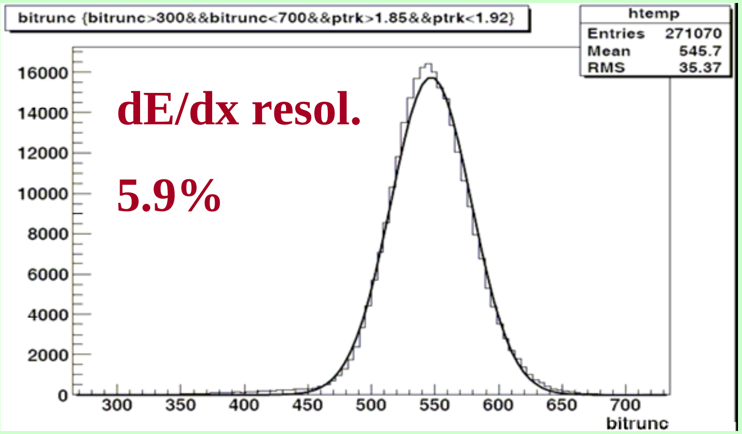
142 μm

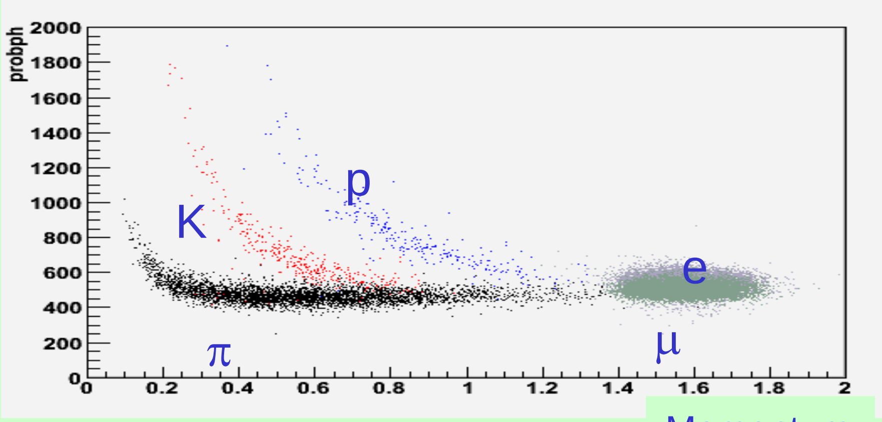


Mom. Resol.

15.9 MeV/c

~0.86%





Momentum (GeV/c)

BESIII CsI(Tl) crystal calorimeter

- To measure the energy of electromagnetic particles
- Barrel: 5280 crystals， Endcap: 960 crystals
- Crystal: (5.2x 5.2 – 6.4 x 6.4) x 28cm^3
- Readout: ~13000 Photodiodes, 1cm×2cm,
- Energy range： 20MeV – 2 GeV
- position resolution: 6 mm@1GeV
- Tiled angle: theta ~ 1-3^o, phi ~ 1.5^o

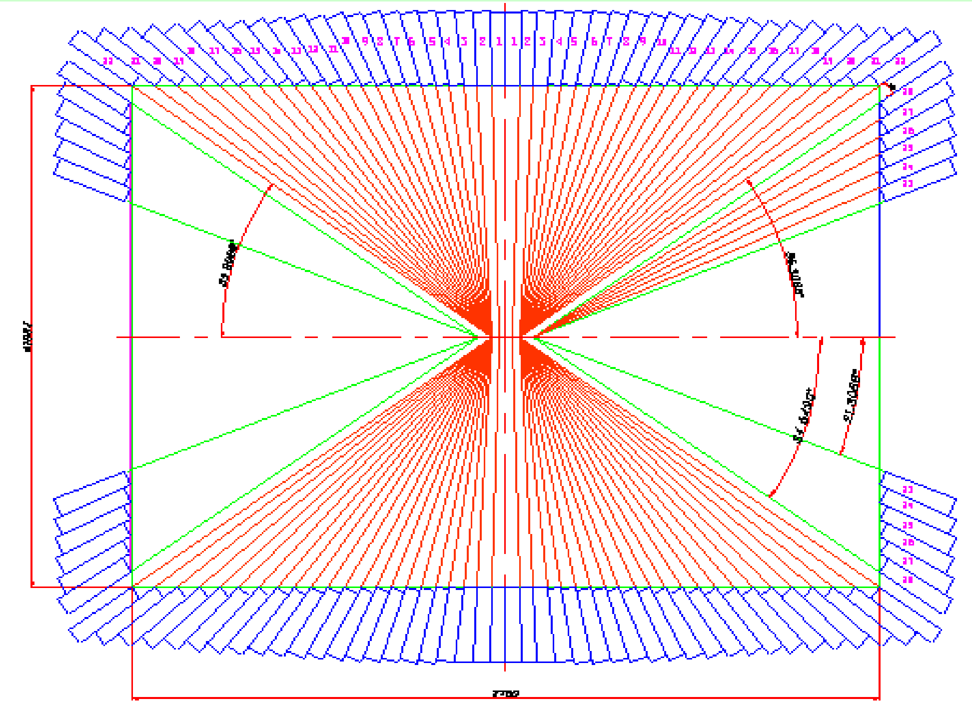
Energy resolution

Babar: 2.67% @1GeV

BELLE: 2.2% @1GeV

CLEO: 2.2% @1GeV

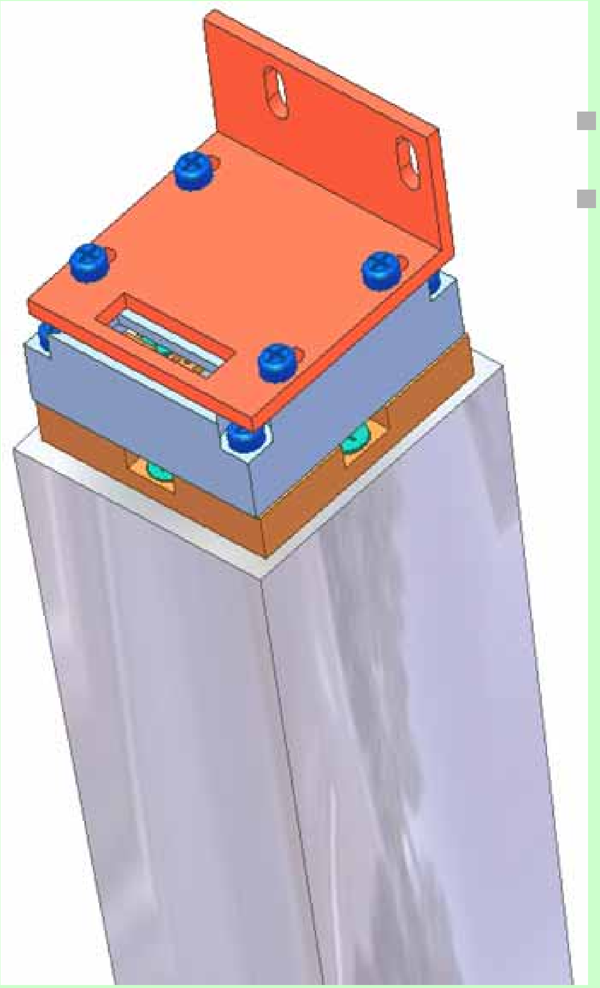
BESIII: 2.5%@1GeV

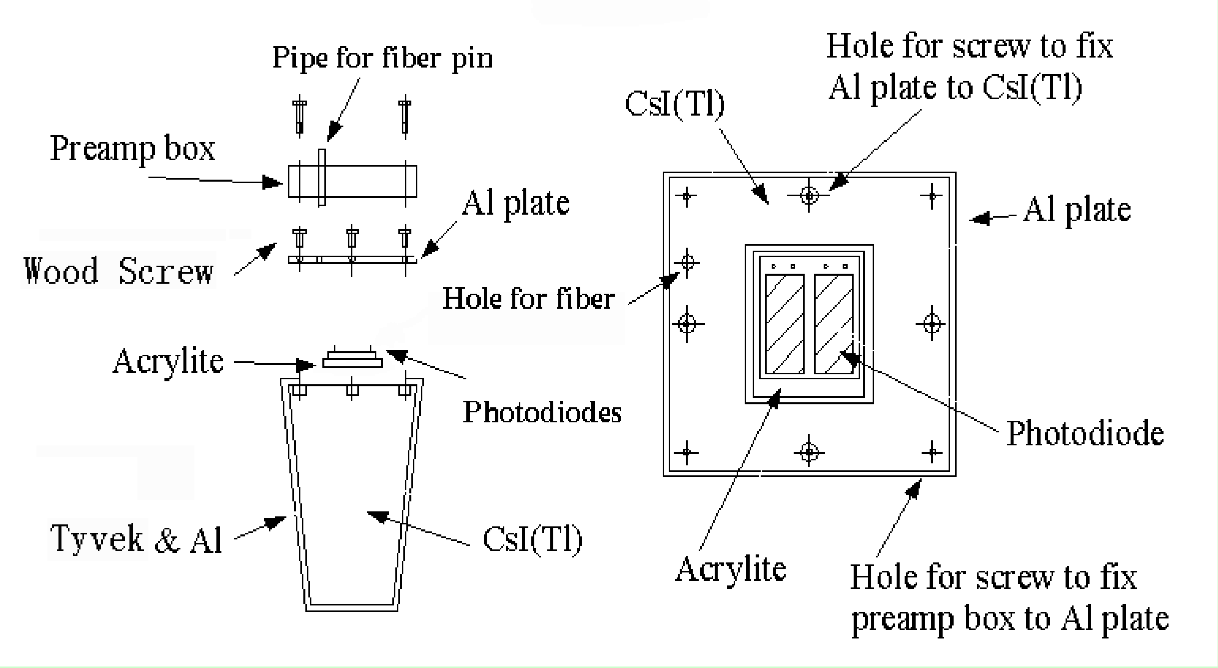


Crystal calorimeter without supporting wall between crystals

Single crystal unit

- 2 Photodiode + 2 Preamplifier + (1 Amplifier)
- Photodiode(PD): Hamamatsu S2744-08 (1cm x 2cm)
- Preamplifier noise: < 1100 e (~220kev)
- Shaping time of amplifier: 1μs





Crystal Production

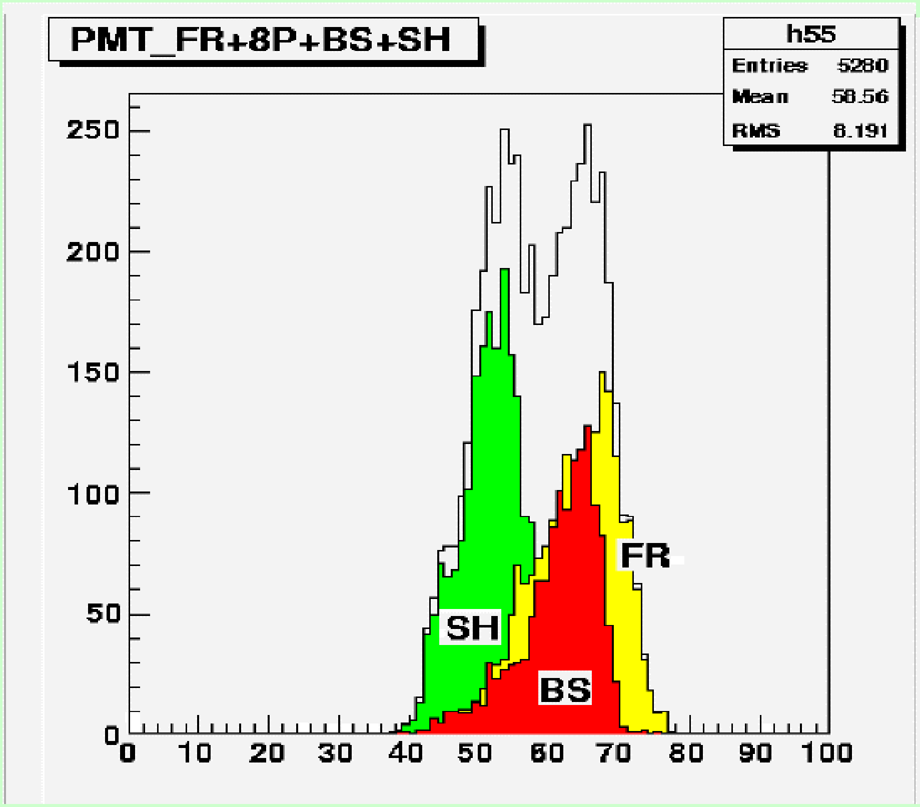
	France Sanit -Gobain	Shanghai Institute of Ceramics	Beijing Hamamatsu	Total
Ordered	2040(960)	1920	1320	5280(960)
Arrived	2040(960)	1920	1320	5280(960)
Rejected	87	316	79	482
Replaced	87	316	79	482

Have to check the crystal dimensions, light output, radiation dose resistivity,

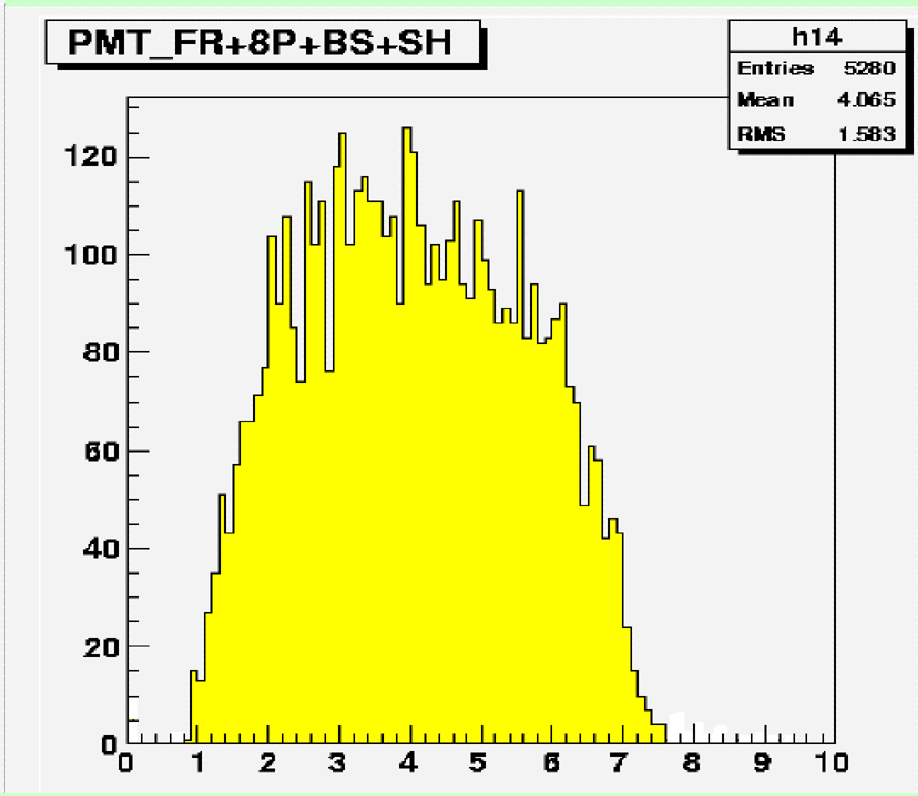
Light output and uniformity along crystal

barrel: 5280 pieces

- By PMT + ^{137}Cs
- Requirement: LO > 33%; Uniformity < 7%
- Quality control : LO > 35%; Uniformity < 7%



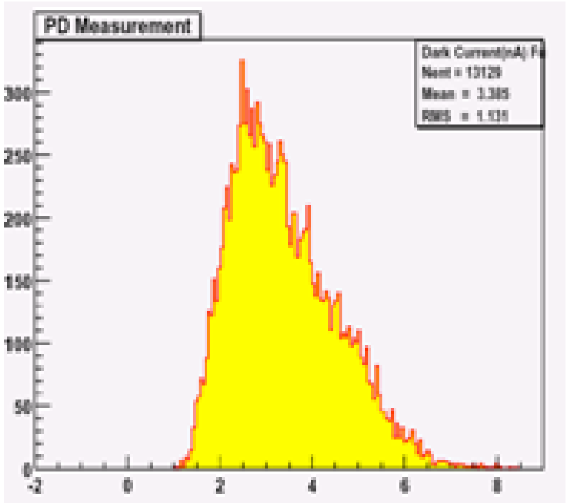
- Light-output



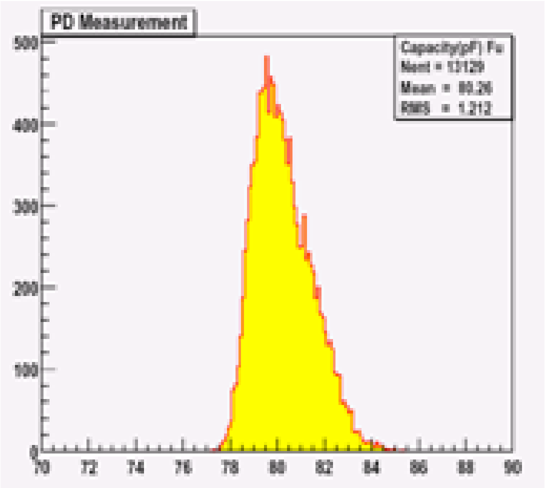
- uniformity

Photo diode (PDS2744-08,13200) checkout

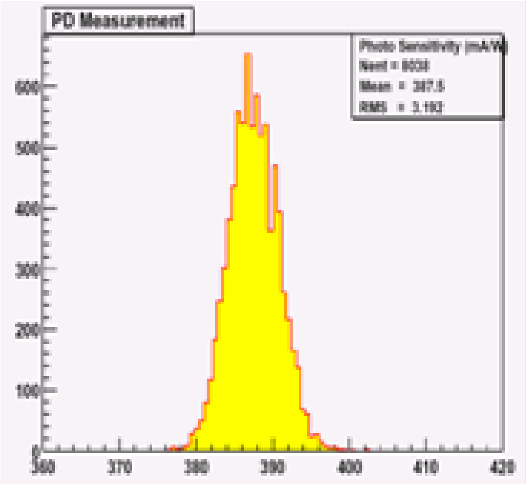
Measure the dark current, capacitance and quantum efficiency of each PD



Dark current



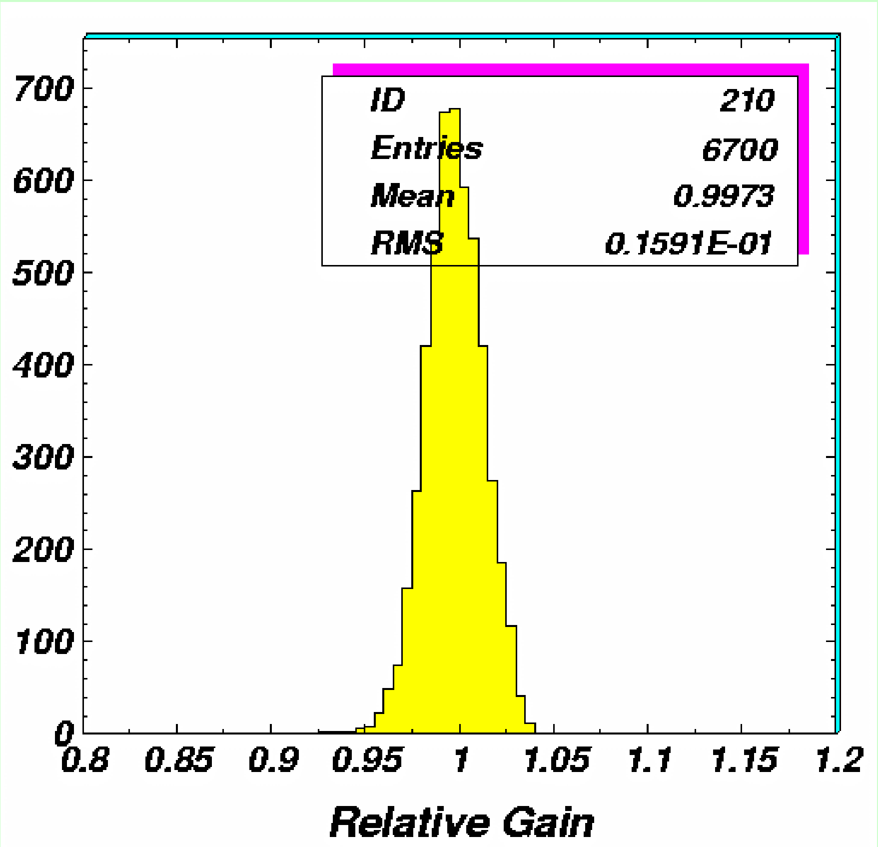
capacitance

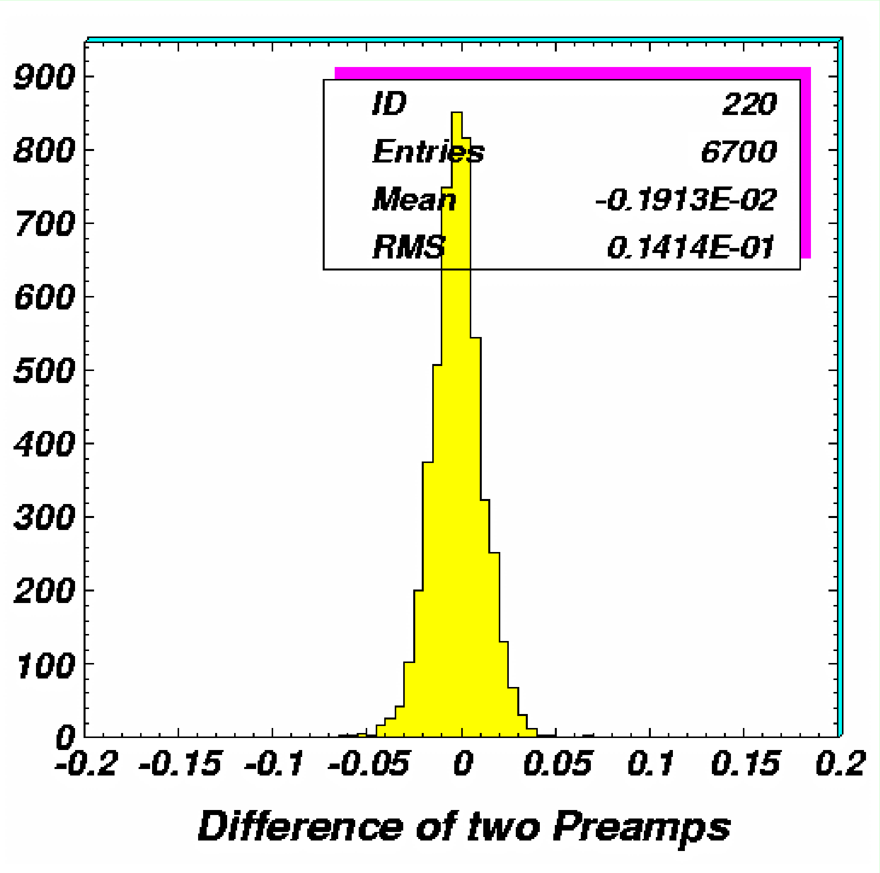


quantum efficiency

There is a LED-optical fiber system to monitor every crystal during construction and data taking

Checkout of pre-amplifier , and match two in one crystal to similar gains

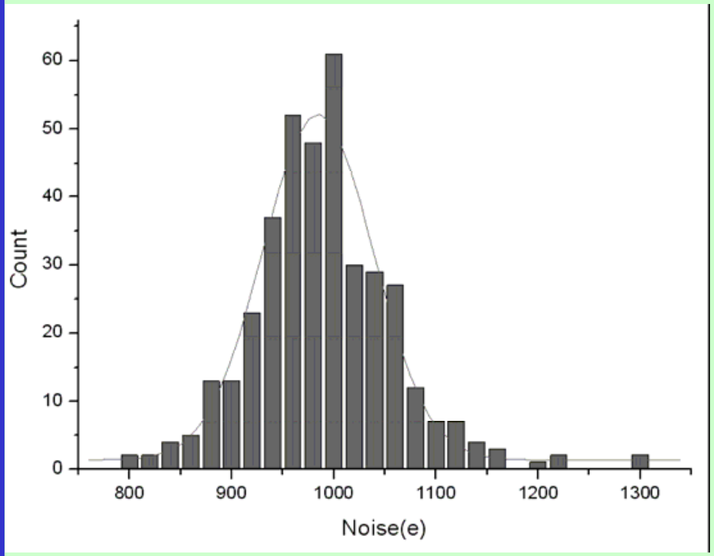




The difference between the two preamps in the same crystal should be < 3% .

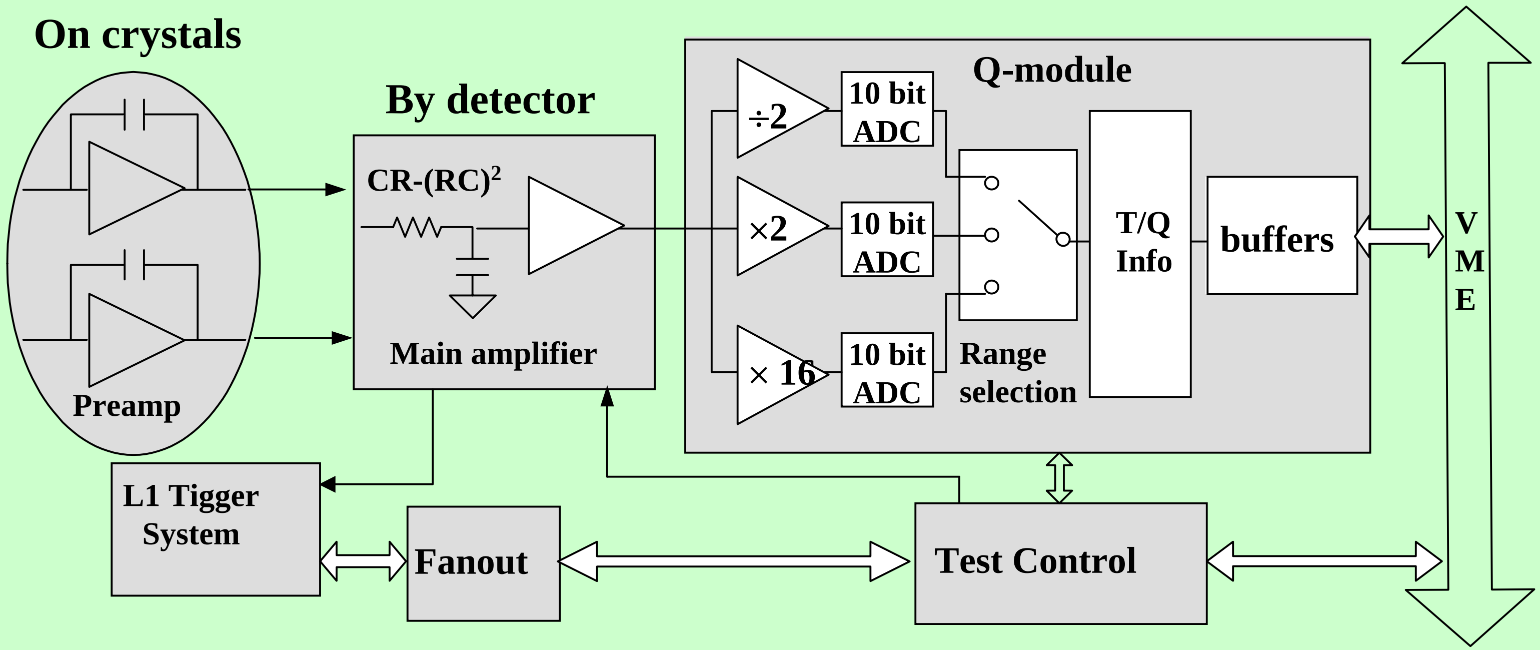
Electronics Design parameters

Parameter	Values
Number of channels	6,240
System clock	20.8 MHz
L1 trigger latency	6.4 μs
Max single channel hit rate	⩽ 1 kHz
Equivalent noise charge (energy)	0.16 fC (200 keV) @80 pF
Integral nonlinearity	⩽ 1% (before corrections)
Cross talk	⩽ 0.3%
Dynamic range	15 bits
Information to trigger	Analog sum of 16 channels
Gain adjustment range for triggers	⩽ 20 %



average noise of 384 channels 973e.

EMC Electronics



Use three 20.8 MHz 10 bit ADCs to cover

15 bits required dynamic range, and provide

6 bits peaking time

Barrel EMC assembly

Installation Barrel and endcap

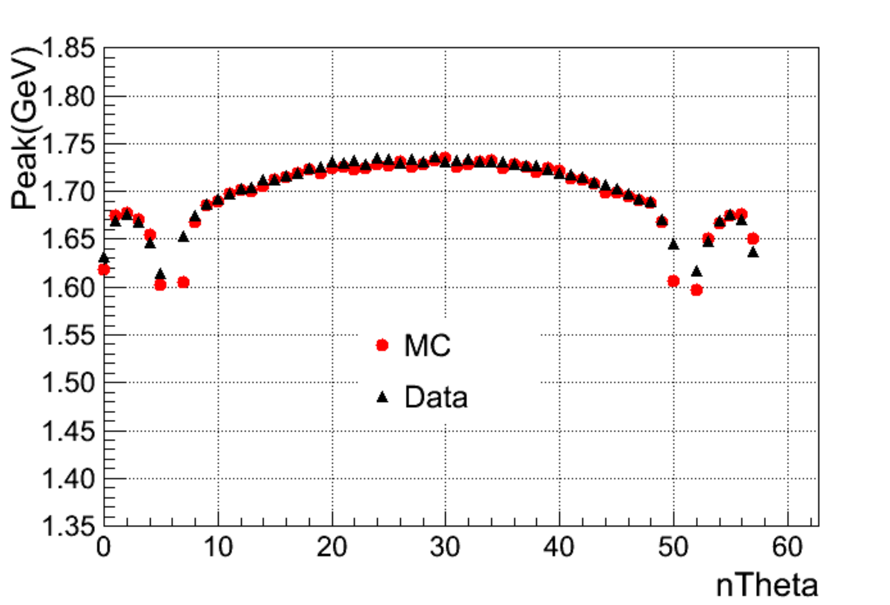
barrel weight : 54 ton

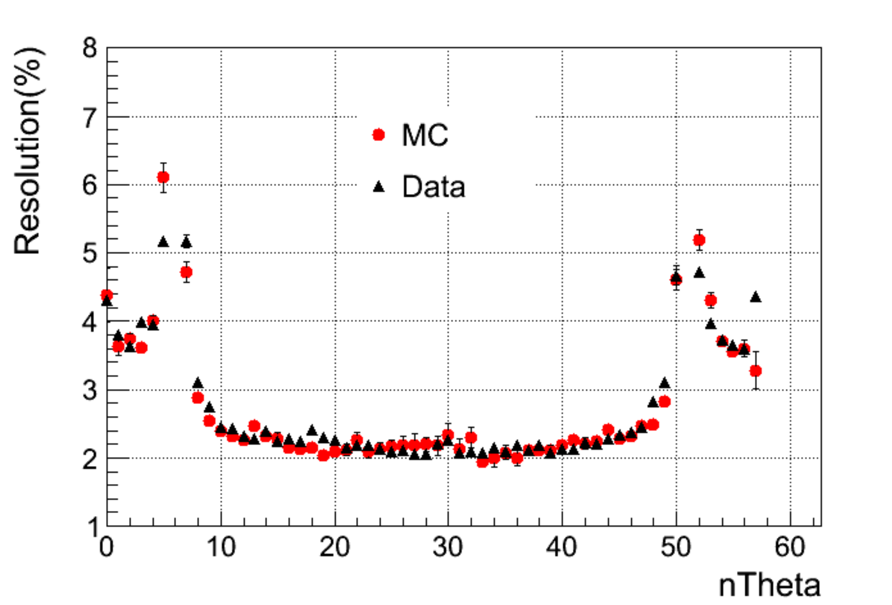
No gap between crystals

Endcap assembly

EMC Performance

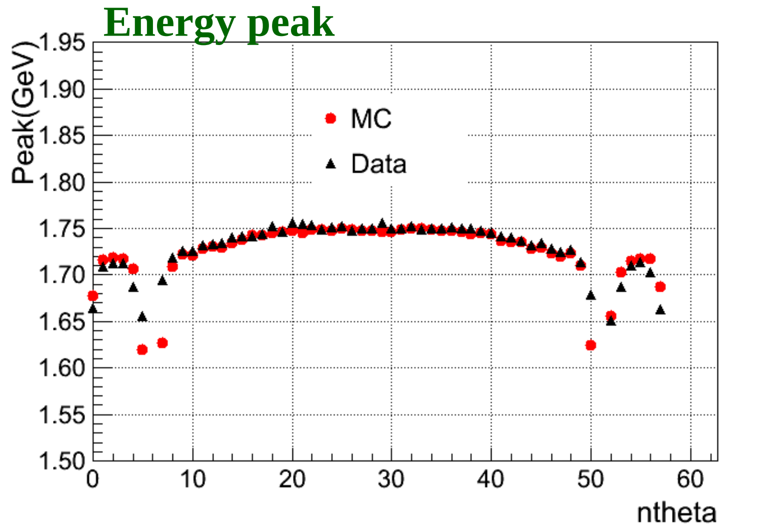
Bhabha - Energy Peak and Resolution

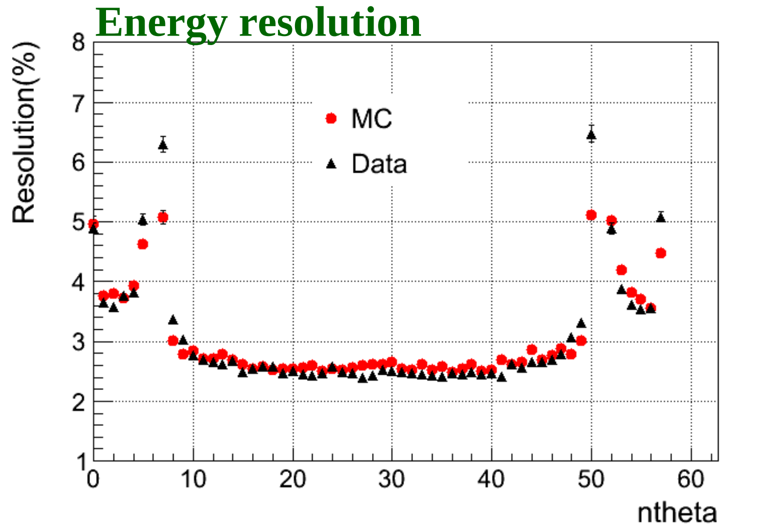


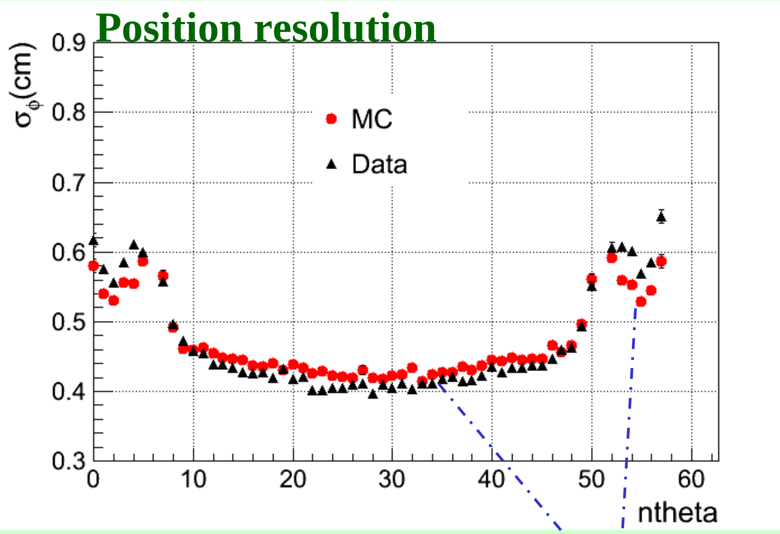


σ_E/E	Barrel	East End	West End
MC	2.4%	3.9%	4.2%
Data	2.4%	4.0%	4.1%

Diphoton





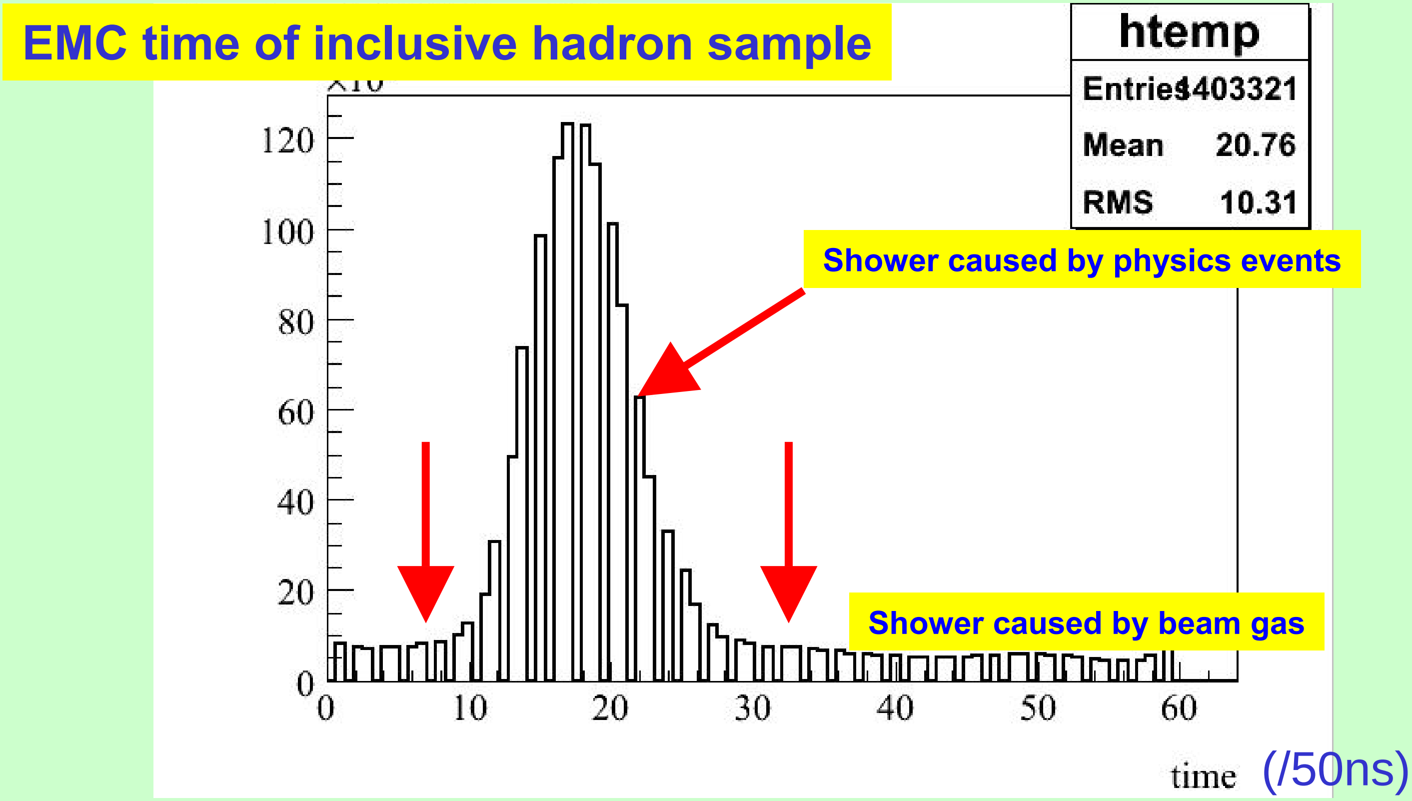


σ_E/E	Barrel	East End	West End
MC	2.8%	4.1%	4.1%
Data	2.8%	4.1%	4.1%

σ_{pos}(mm)	Barrel	East End	West End
MC	4.5	5.6	5.6
Data	4.3	6.0	5.9

Still some difference

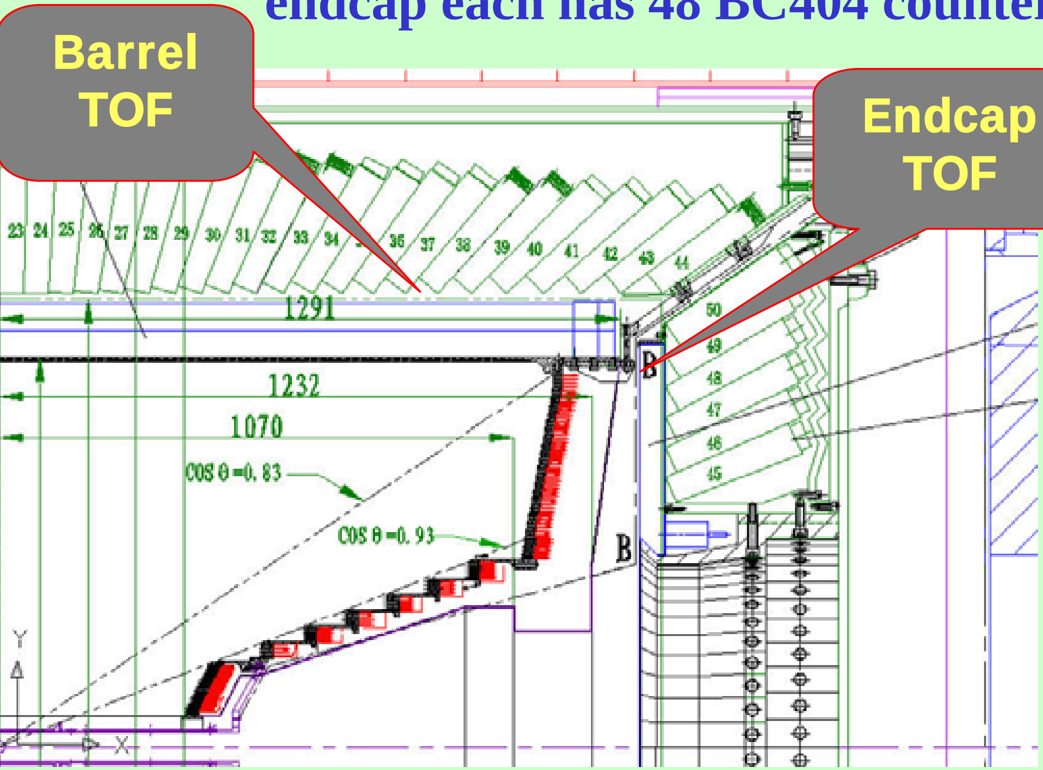
Fake photon veto using EMC TDC

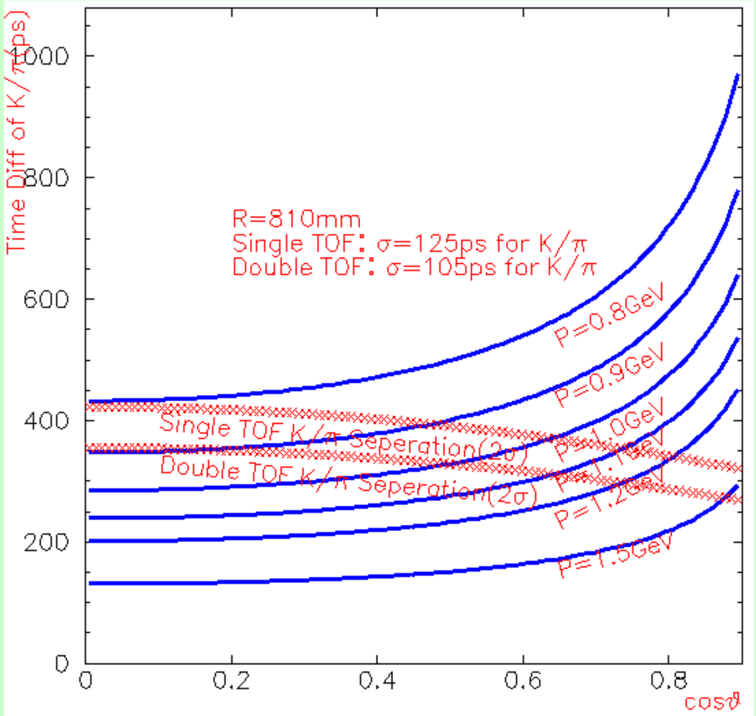


The width and center value of TDC signal vary with trigger and photon energy,
→Smear the TDC signal
The time window is set to 5-35 now
Calibration it can improve the performance of fake photon veto

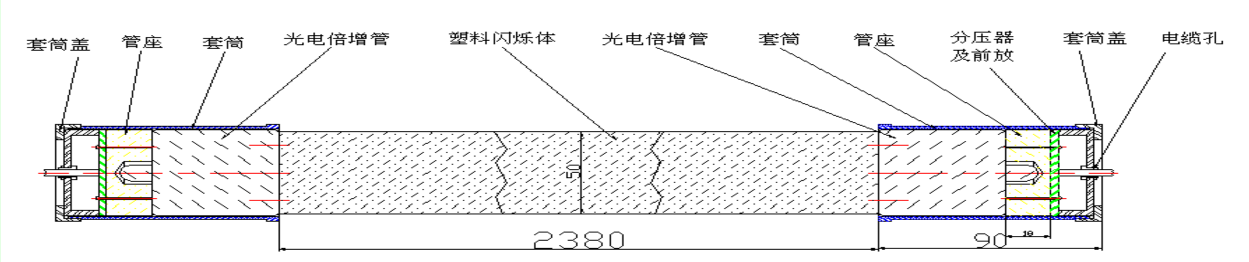
PID: Time-Of-Flight counters

Double layers at barrel of 88 BC408 counters/layer, readout at both ends, endcap each has 48 BC404 counters, readout at the inner end.





High quality plastic scintillator: 2.4 m long, 5cm thick



PMT R5924

Test in the Magnet

TOF time resolution

Uncertainty	Barrel (ps)	Endcap (ps)
Intrinsic	80-90	80
Electronics	25	25
Beam length	15 (mm) 35	15 (mm) 35
Time mark	~20	~20
MDC track extrapolation	(5 mm) 25	(10 mm) 50
Expected time of flight	30	30
Overall single layer resolution	100~110	110~120
Double layer	90	

Electronics

Front amplifier

Gain 10

Raise time < 2 ns

Readout electronics

Timing < 25 ps

Dynamical range 60 ns

Using HPTDC, dual

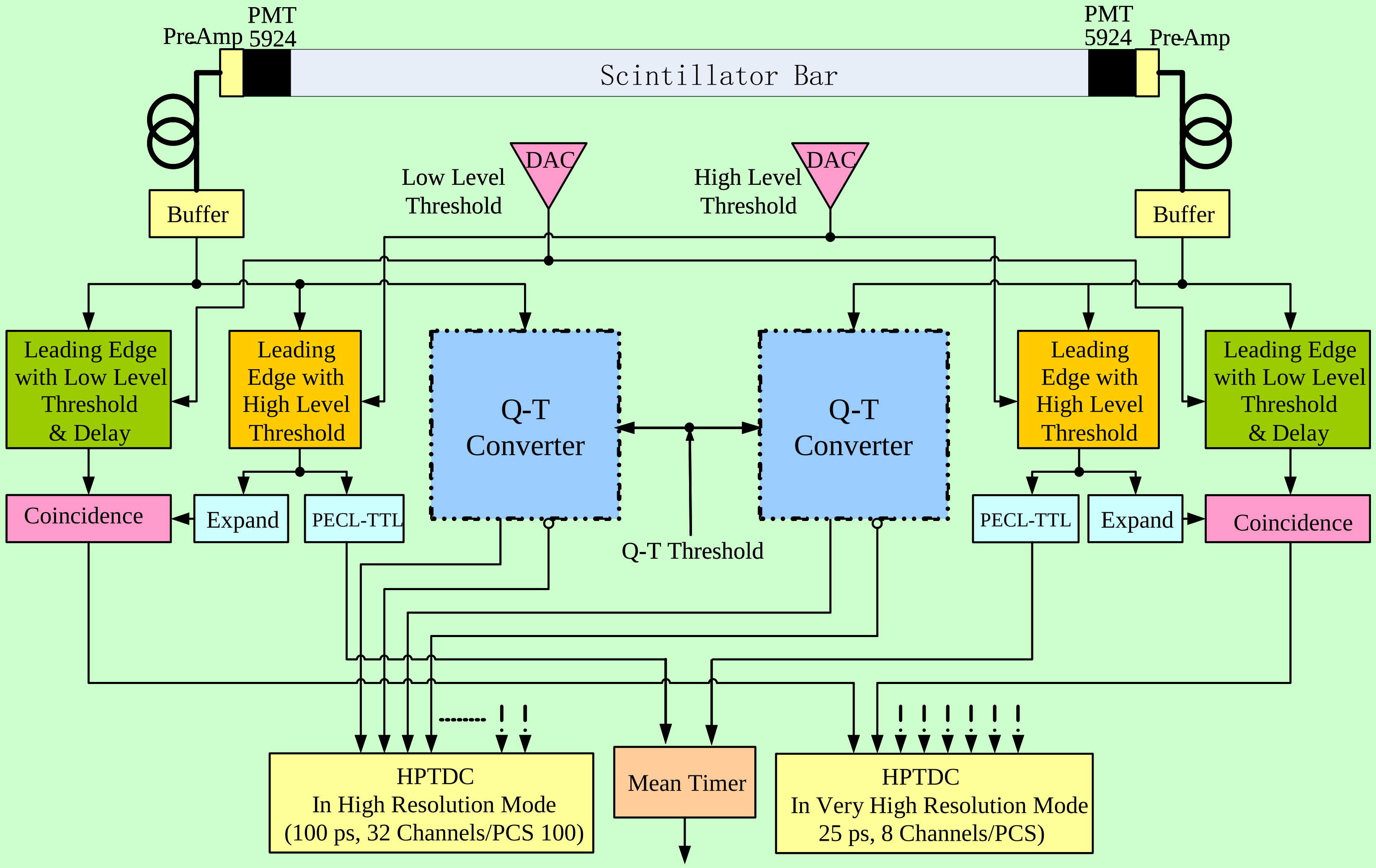
Thresholds

Charge < 10 mV

Range 200mV - 4V

QTC

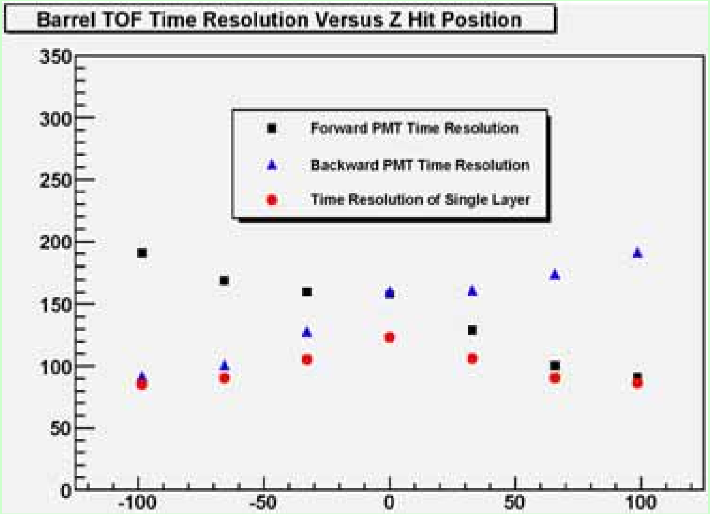
TOF Electronics

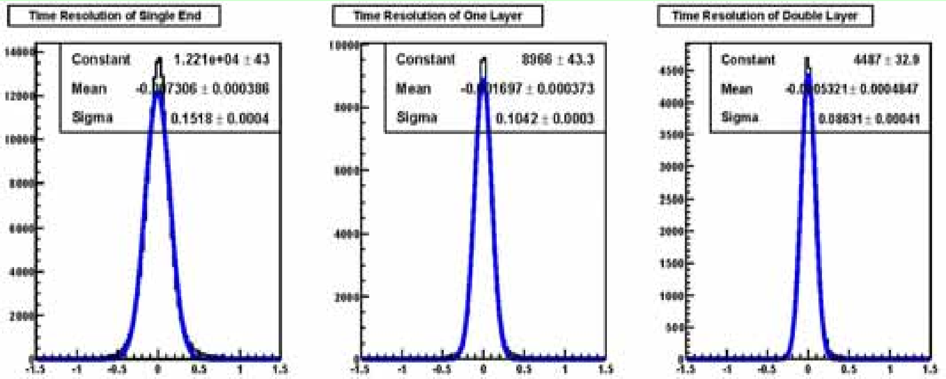


Time: 8 channels/board, HPTDC(25 ps), dual thresholds;

Charge: QTC, time over threshold

TOF performance from data



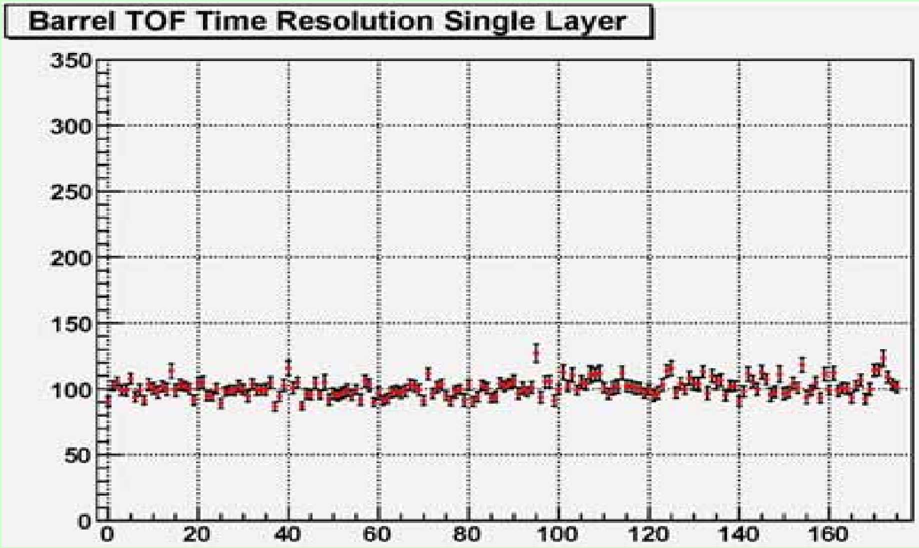


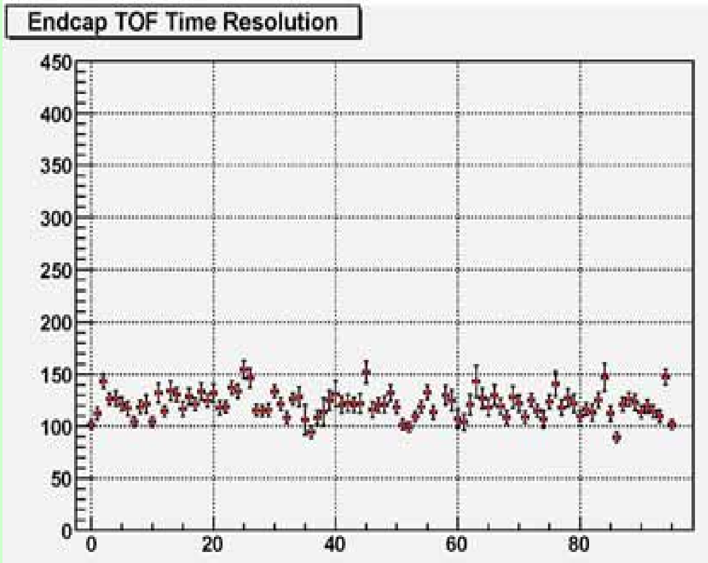
One end of one layer: 152 ps;

Both ends of a layer: 104 ps;

Two layers: 86 ps;

Time resol. From each end and combined

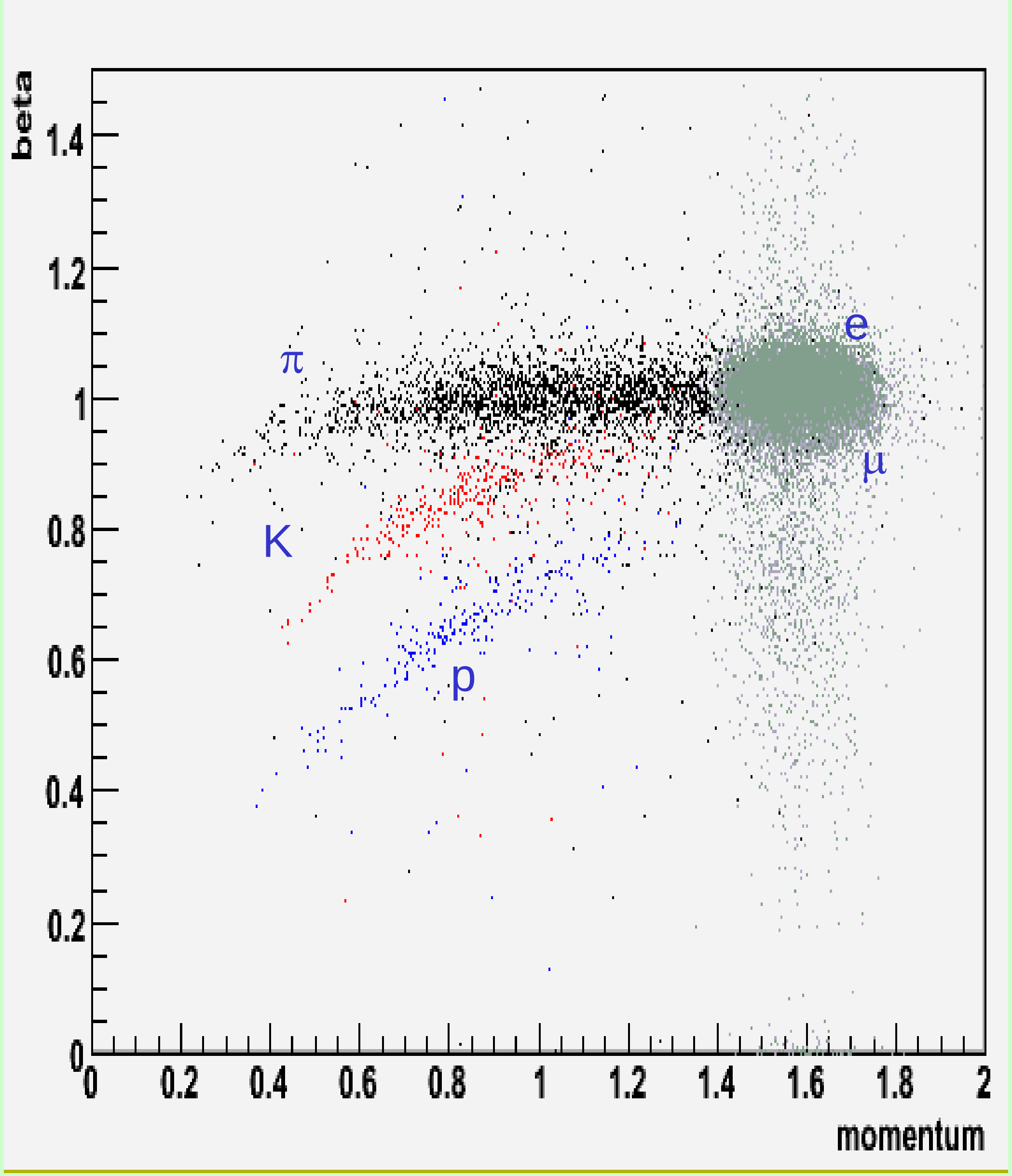




Endcap, 126 ps

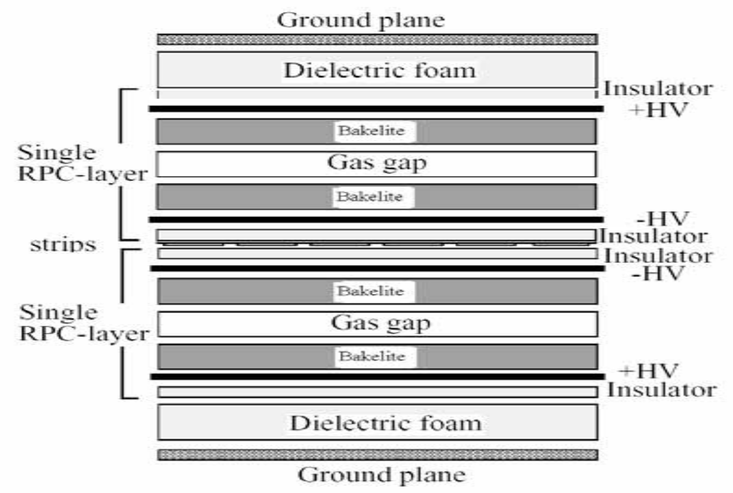
Time resol. vs counter number

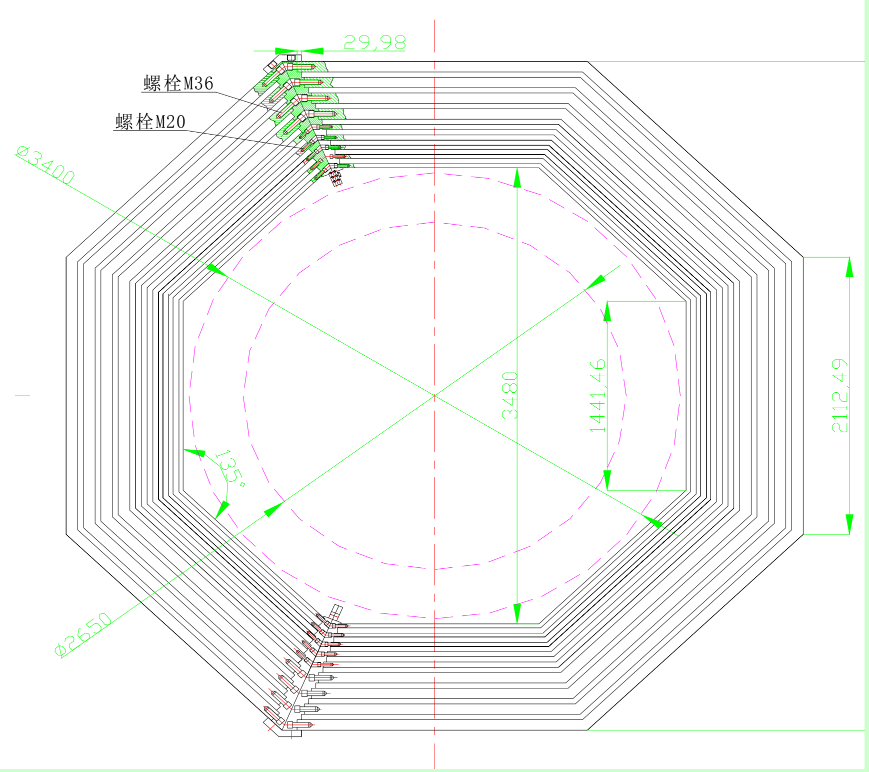
Particle ID



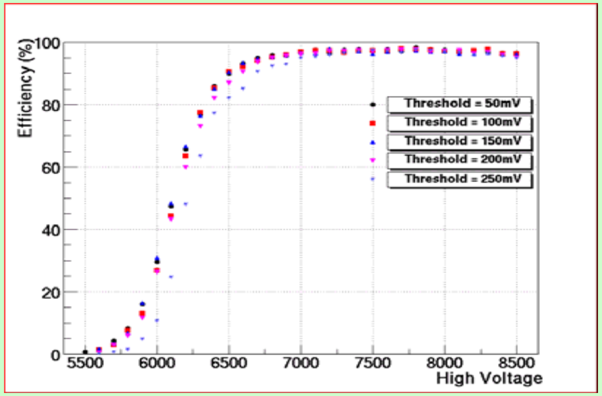
μ system : RPC

- 9 layer, 2000 m^2
- Special bakelite plate w/o linseed oil
- 4cm strips, ~10000 channels
- Noise less than 0.1 Hz/cm^2
- Gas: $Ar/C_2F_4H_2/C_4H_{10}$ 50:42:8

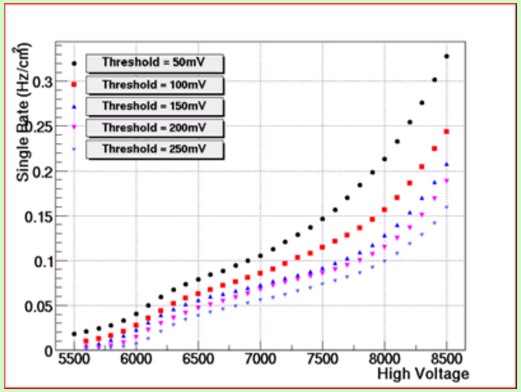




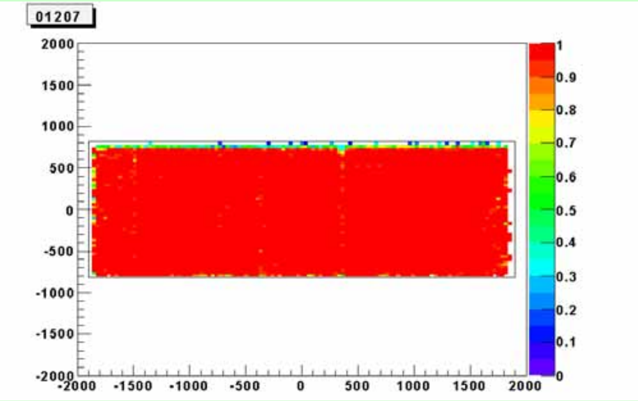
RPC testing



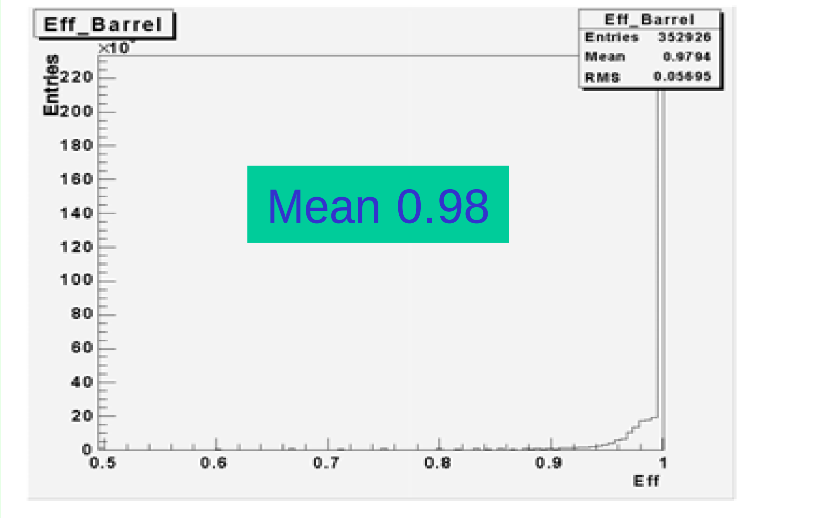
Efficiency vs HV



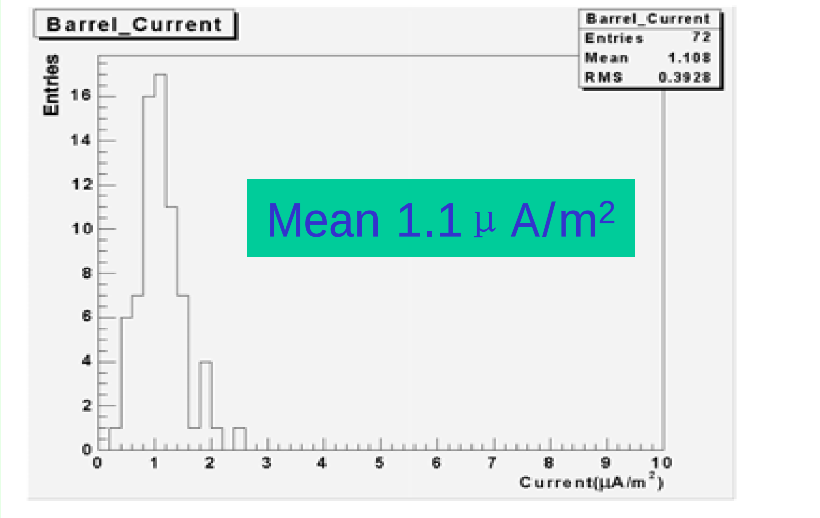
Single rate vs HV



Efficiency map of one RPC

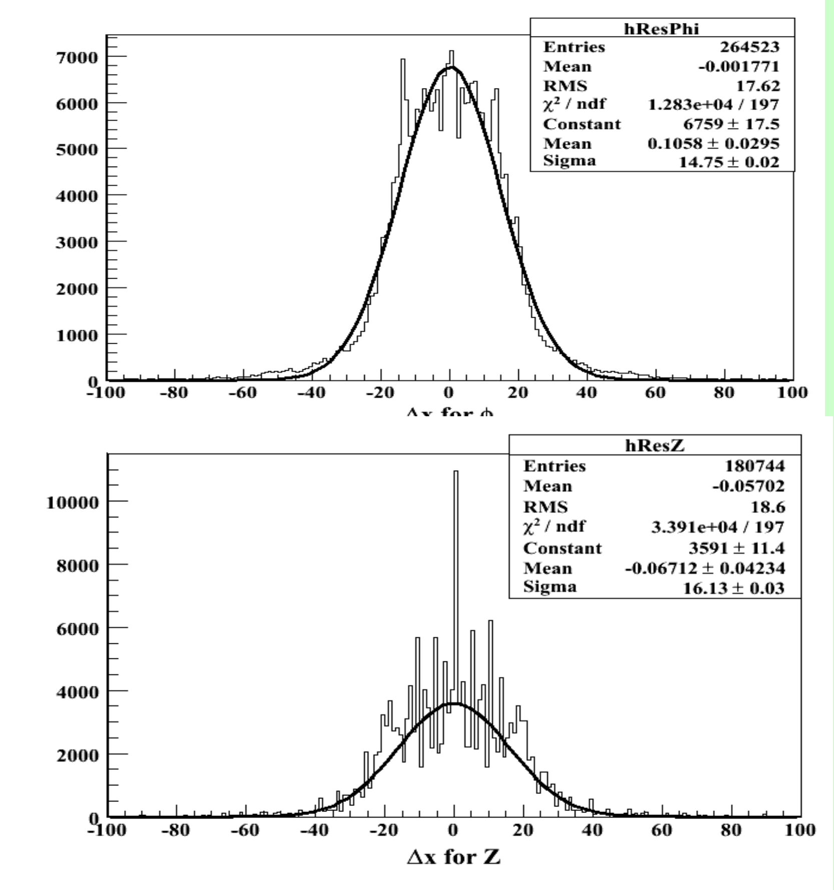


Efficiency of Barrel RPCs



Dark current of Barrel RPCs

Barrel RPC performance



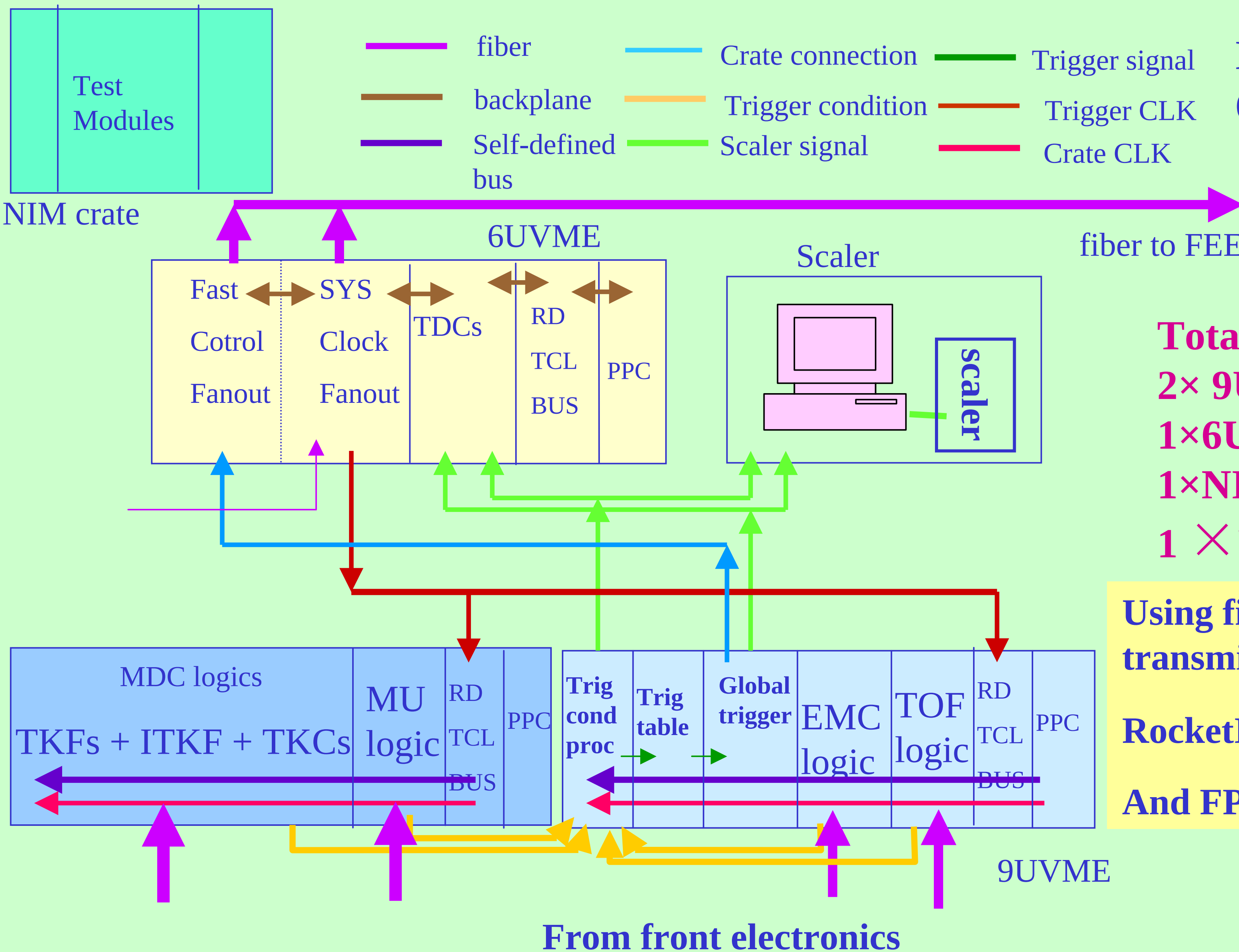
Electronics use daisy chain to read out the hits

In data taking, HV: 7200 ±200V, Threshold: 100 mV

Analyzing events, studying the residual of tracks formed in muon RPCs

$\sigma_{r\phi} = 14.75$mm; $\sigma_z = 16.13$mm

Trigger



Latency 6.4μs

Total:
2× 9U VME
1×6U VME
1×NIM
1 × PC

Using fibers to transmit data,

RocketIO, 1.75 G,

And FPGA

Trigger system

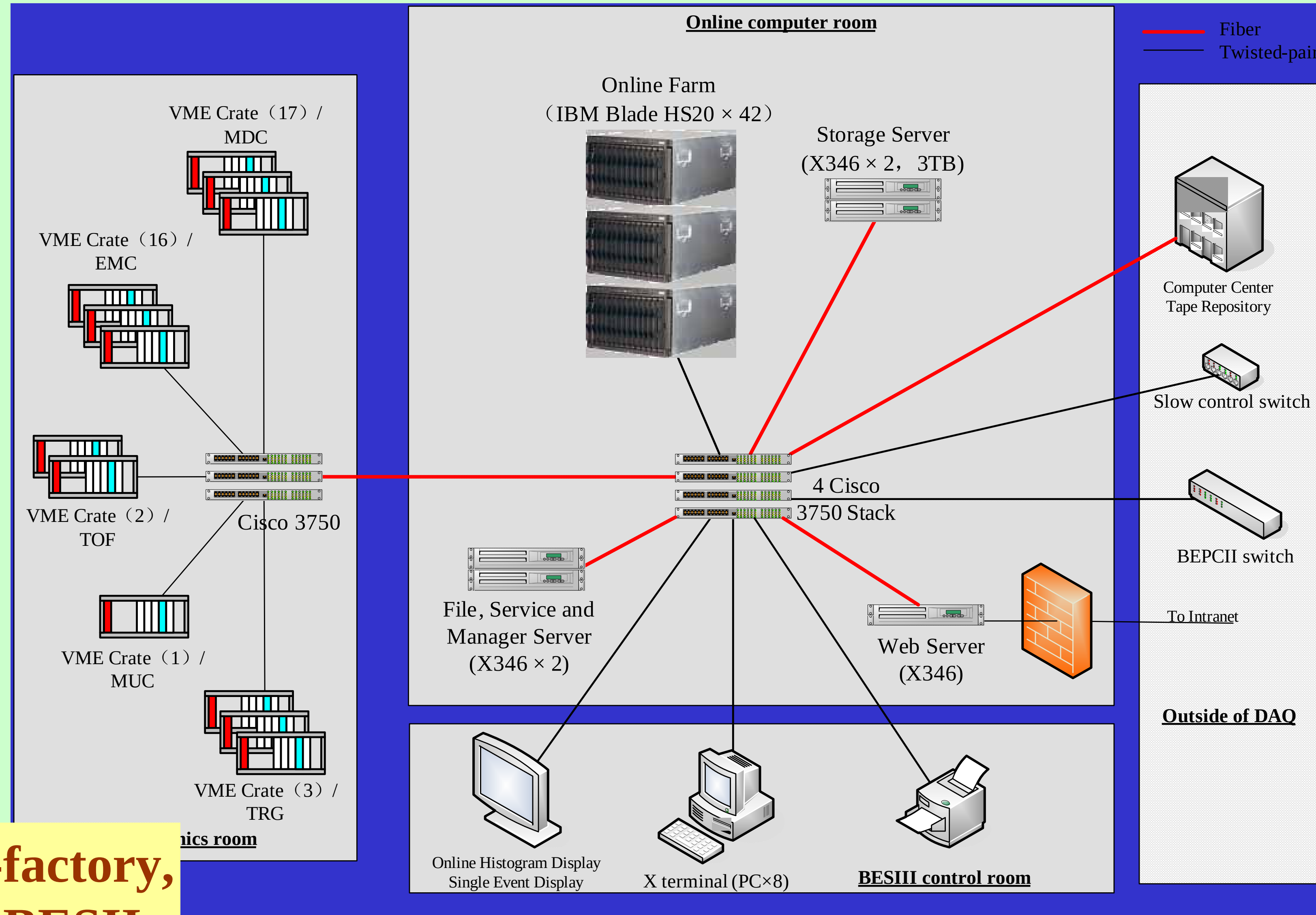
- Trigger uses a clock of 41.65MHz, a L1 decision is made every clock cycle (24 ns)
- Trigger latency, 6.4μs →7.6 μs
- TOF, barrel mean time for each counter
- MDC using axial layers (3,4,5, 10) to find tracks,

  each layer requires 3 out 4 hits
- EMC provides Clusters, energy balance, and total energy
- Trigger efficiency for good events ~ 100%

- Still large background rate, will test the track matching with other detectors

DAQ

event rate: 4000Hz



10 ×B-factory,
1000 × BESII

The BESIII online computer system

Functions	Model	Quantity	Software
VME controller	Motorola MVME5100 PowerPC 750 CPU	39	VxWorks 5.4
Online computer farm	IBM eServerBlade HS20 (dual 3.0 G Xeon CPU)	42	SLC3
File server	IBM 346 2U server (dual 3.0 G Xeon CPU)	5	SLC3
Monitoring PCs	Lenovo dual CPU 2.4G	4	SL5
Temporary storage	Raid 5	10TB	

The technique of multiple storages, parallel processing and network are used.

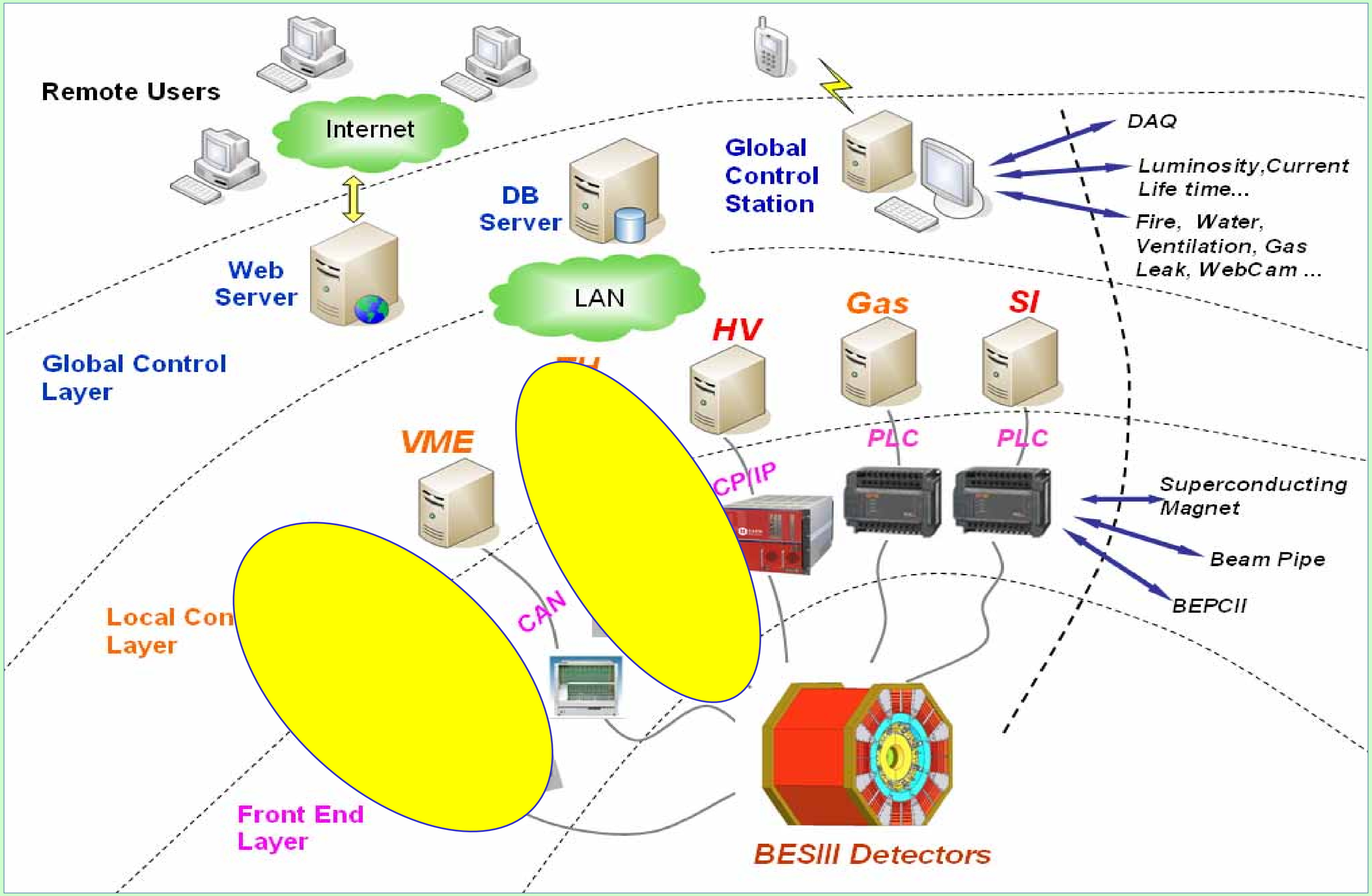
BESIII DAQ front-end parameters

Sub-detector	No. of VME Crates	No. of Channels	Occupancy	Data (kB)	L1 rate (MB/s)
MDC (T+Q)	17	6796+6796	0.10	6.4	25.6
EMC	16	6240	0.17	5.6	22.4
TOF (T+Q)	2	448+448	0.10	0.4	1.6
MU	1	9152	0.01	0.2	0.8
L1 trigger	3	400	1	1.6	5.6
Total	39	~ 30K		14.2	~56.8

Also provide online control software; data base;distributed processes; messages; running monitoring and error reports.

Online event filter can suppress backgrounds further

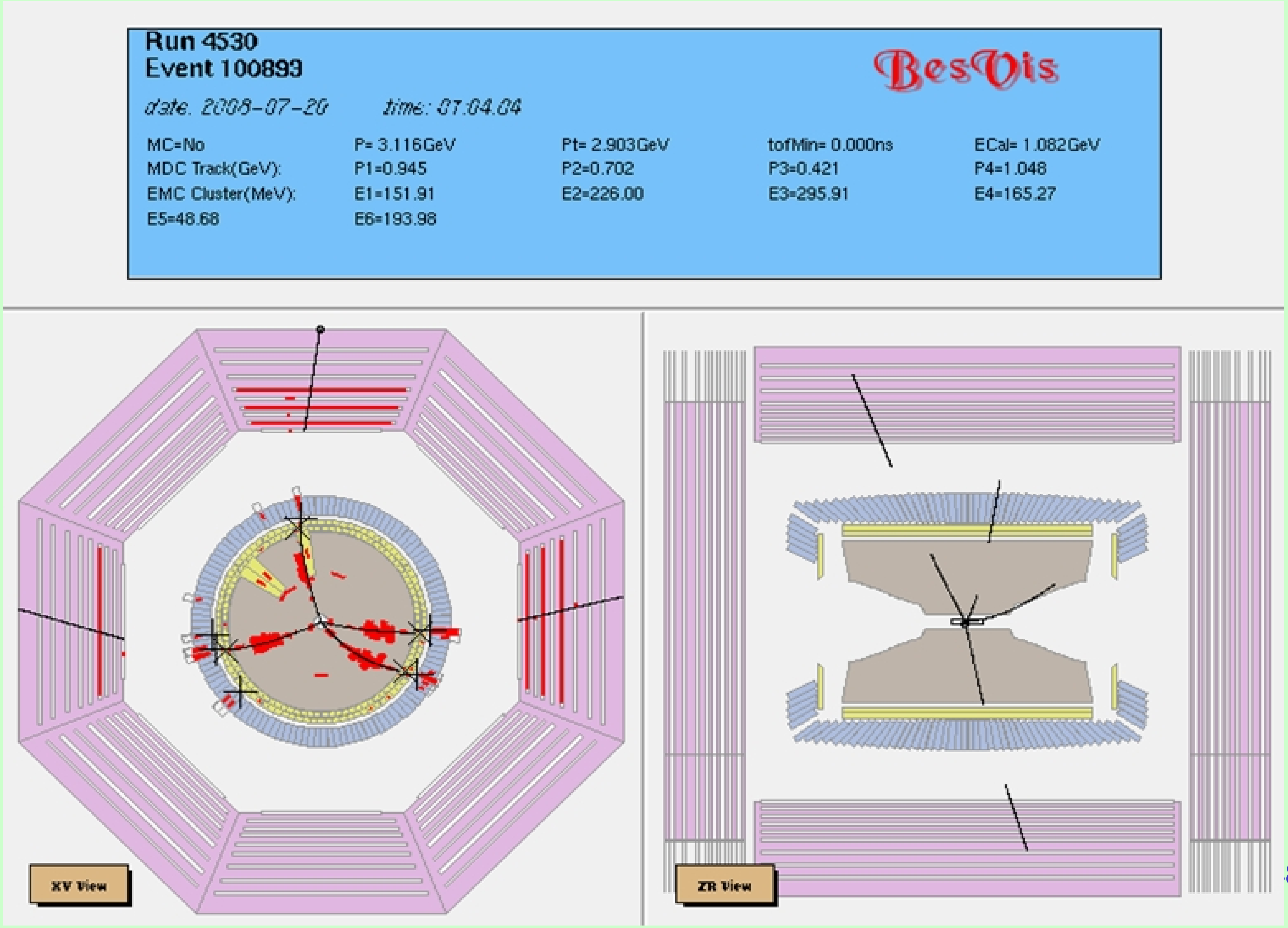
BES-III slow control



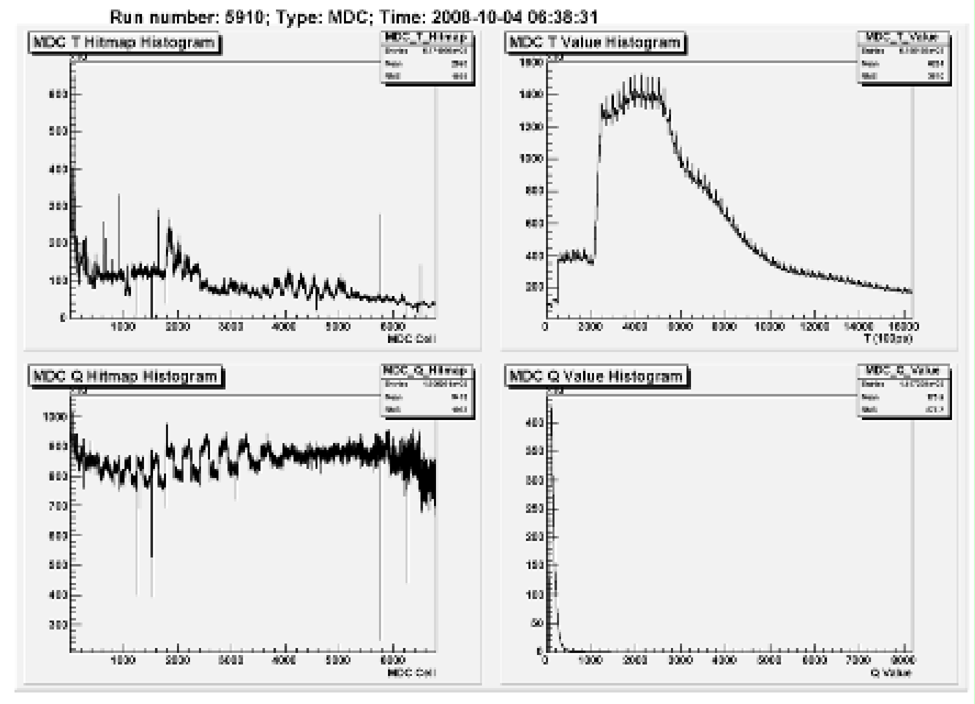
–USB / 1 Wire Bus control
–USB / RS485 converters
–RS485 / 1 Wire Bus

3000 probes
9000 measurements

The first hadronic event seen in BESIII, July 20, 2008

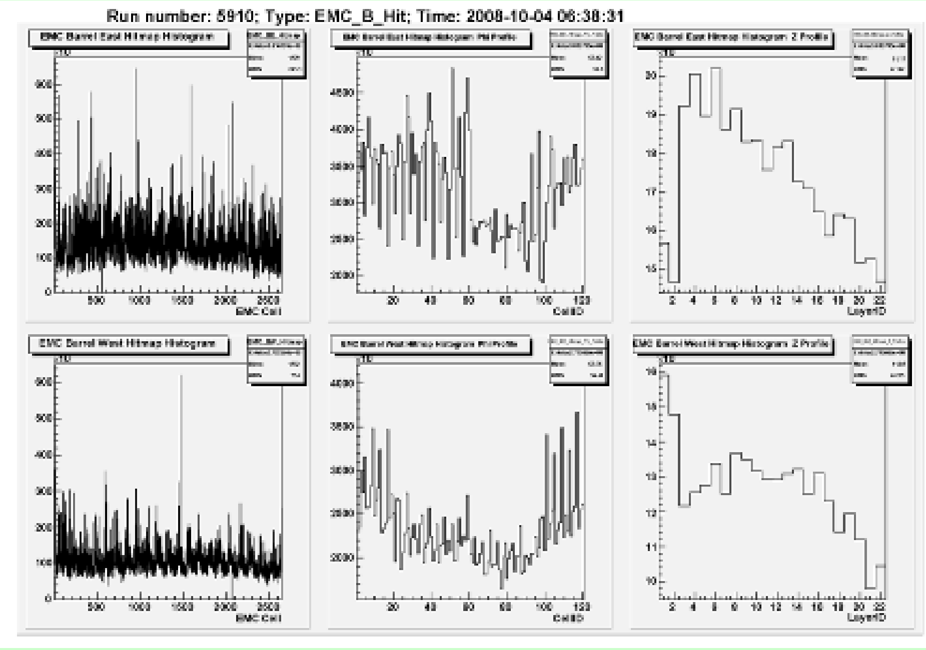


Typical online detector histograms



There are small number of dead channel in MDC.

No dead channel in EMC, a few with one photo diode reading.



There is one dead phototube in the barrel (outer layer)

Some muon readout electronics problem in the endcap.

Try to fix in the summer.

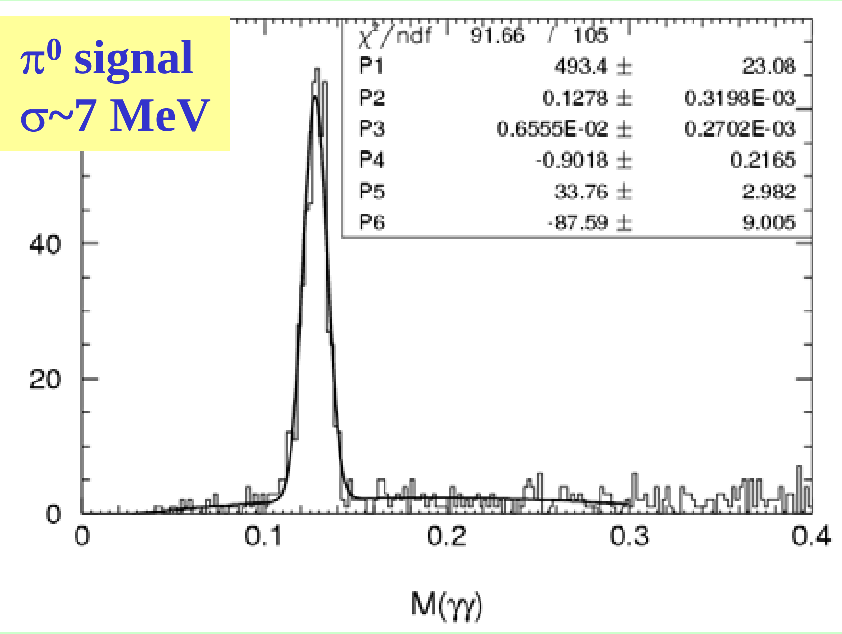
Data quality check using physics channels

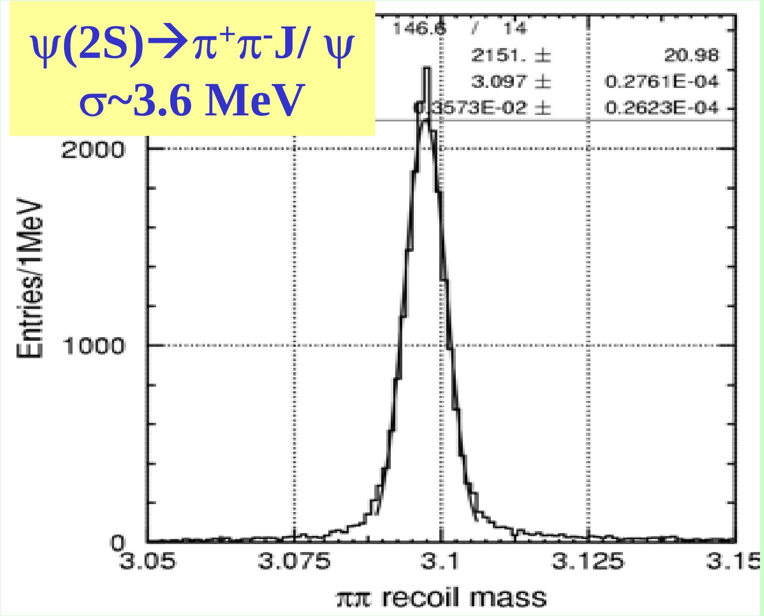
Mainly use Bhabha events to calibrate the detector,

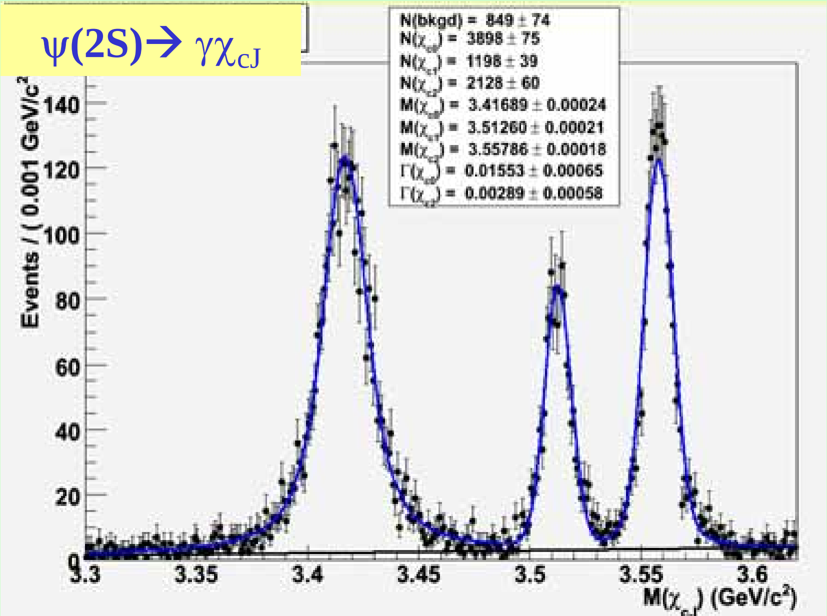
EMC energy scale by π^0;

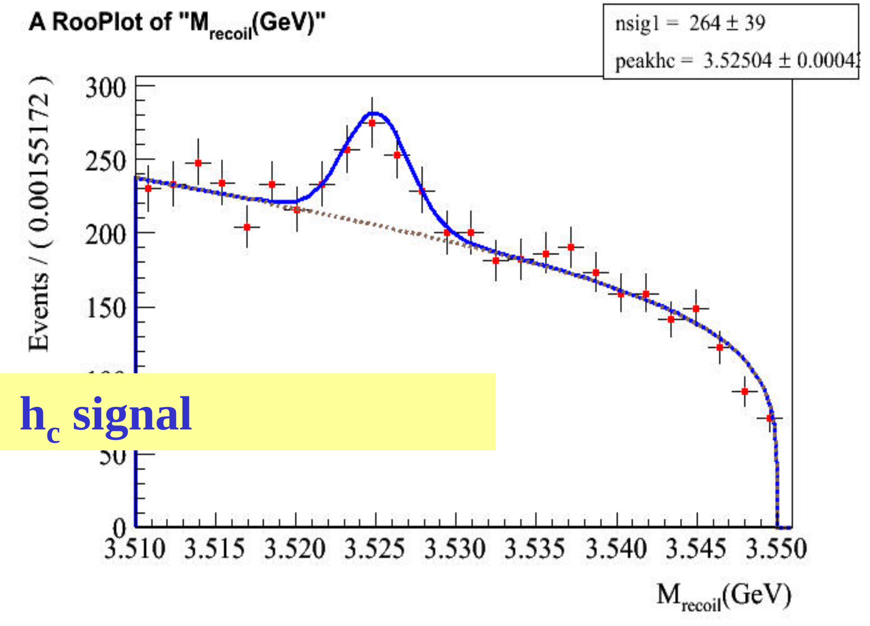
Use some $\psi(2S)$ decays to check the data quality

First Physics signals









Data Taking in 2009

- **Feb. – April: ψ'**
  - **~ 30 M events = CLEOc = 2*BESII**

    ==〉 ~ 90 M collected, total 100 M
- **June -July: J/ψ**
  - **~ 270 M events = 5*BESII**

    or more
- **June： a few days at 3.0 & 3.65 GeV**
- **After summer:**
  - **ψ' during machine study**
  - **Possibly ψ" scan if beam energy is stable and/or beam energy monitor is in place**

Assume L_{peak} ~ $1\times10^{32} cm^{-2}s^{-1}$

The focus of data checking and prepare for physics analysis

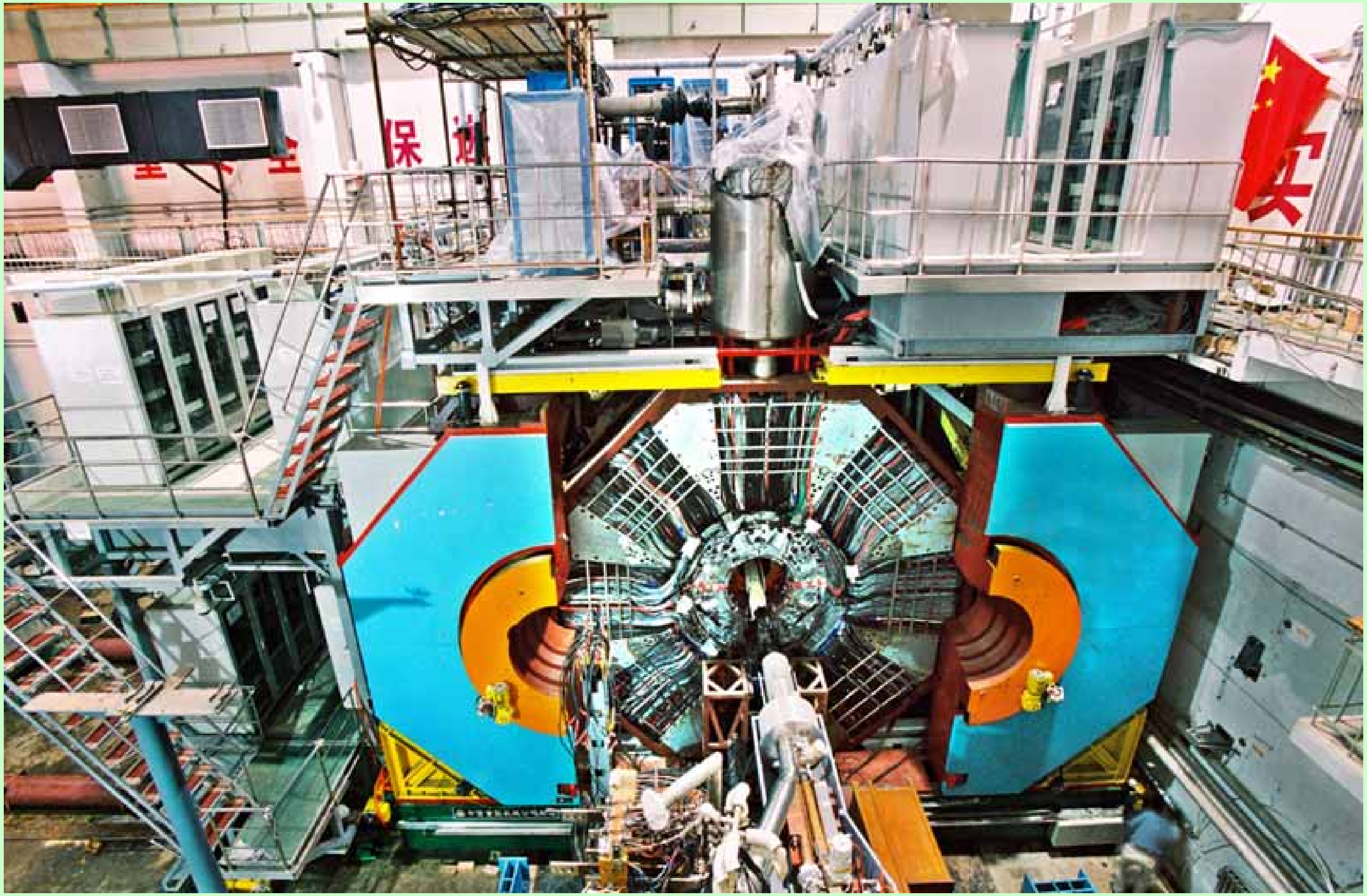
- ➢ Improve the MDC calibration and alignment to improve momentum resolution and uniformity;
- ➢Checking the tracking efficiency, including K_S and Λ, etc;
- ➢Checking the trigger efficiency, no loss of good events;

  now the trigger rate can reach ~ 5000 Hz;
- ➢Improve detector simulation, Data and MC comparison; Especially for MDC and TOF;
- ➢Partial Wave analysis and Dalitz plot analysis, and other analysis methods and tools;

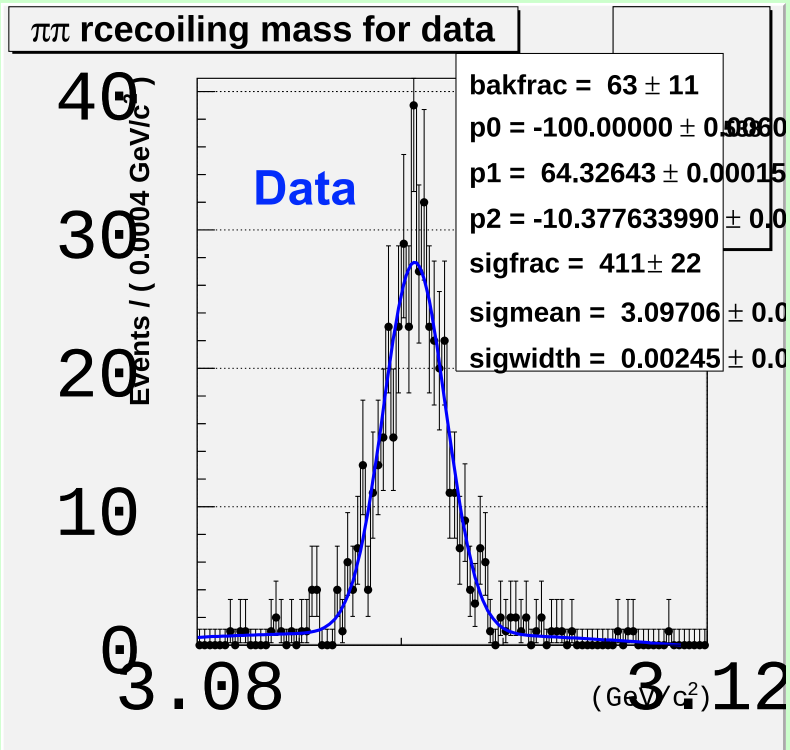
Summary

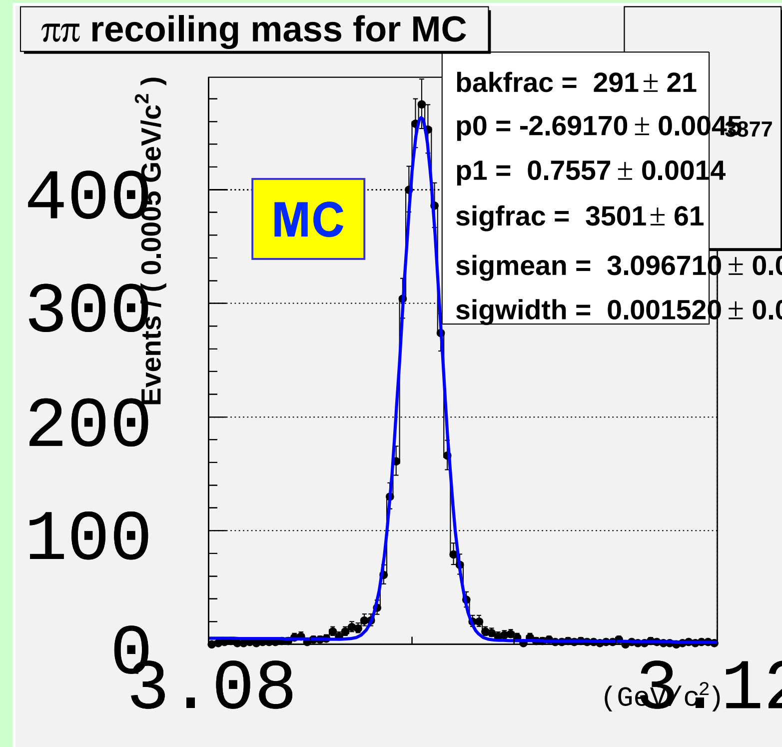
- **Machine and detector are in good shape, large physics data are collected,**
- **More understanding of the detector, through calibration and physics analysis, data/MC consistent is important to reach measurement precision needed,**
- **Many interesting physics can be obtained in the coming years, this year 100 M ψ(2S), 250 M J/ ψ, and scan of ψ (3770) are likely to be collected. Large data sample for charm physics will follow as the machine luminosity keeps increasing.**

Thank you!



M(π+π-) recoiling J/ψ

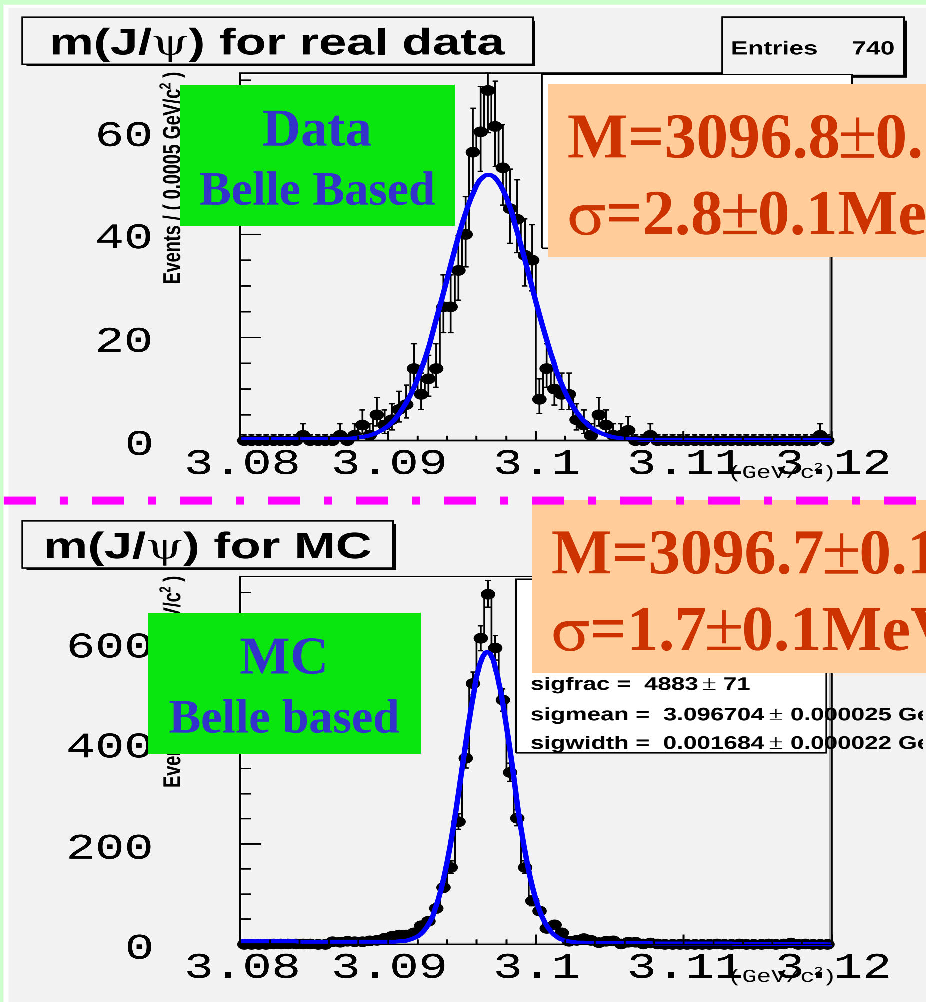




M=3097.1± 0.1MeV
σ=2.5±0.1MeV

M=3096.7± 0.1MeV
σ=1.5±0.1MeV

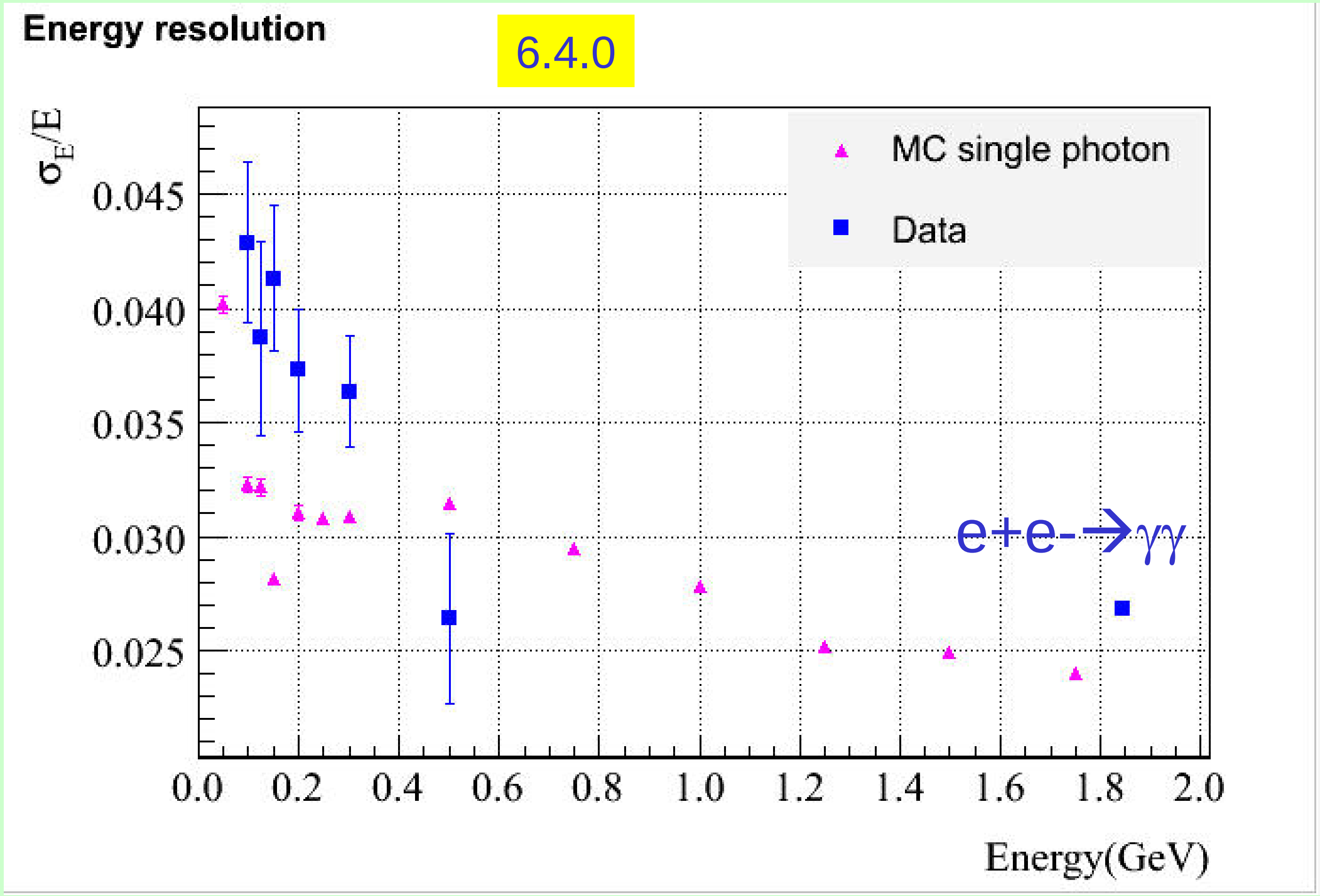
$M(\pi^0\pi^+\pi^-)$ Distribution



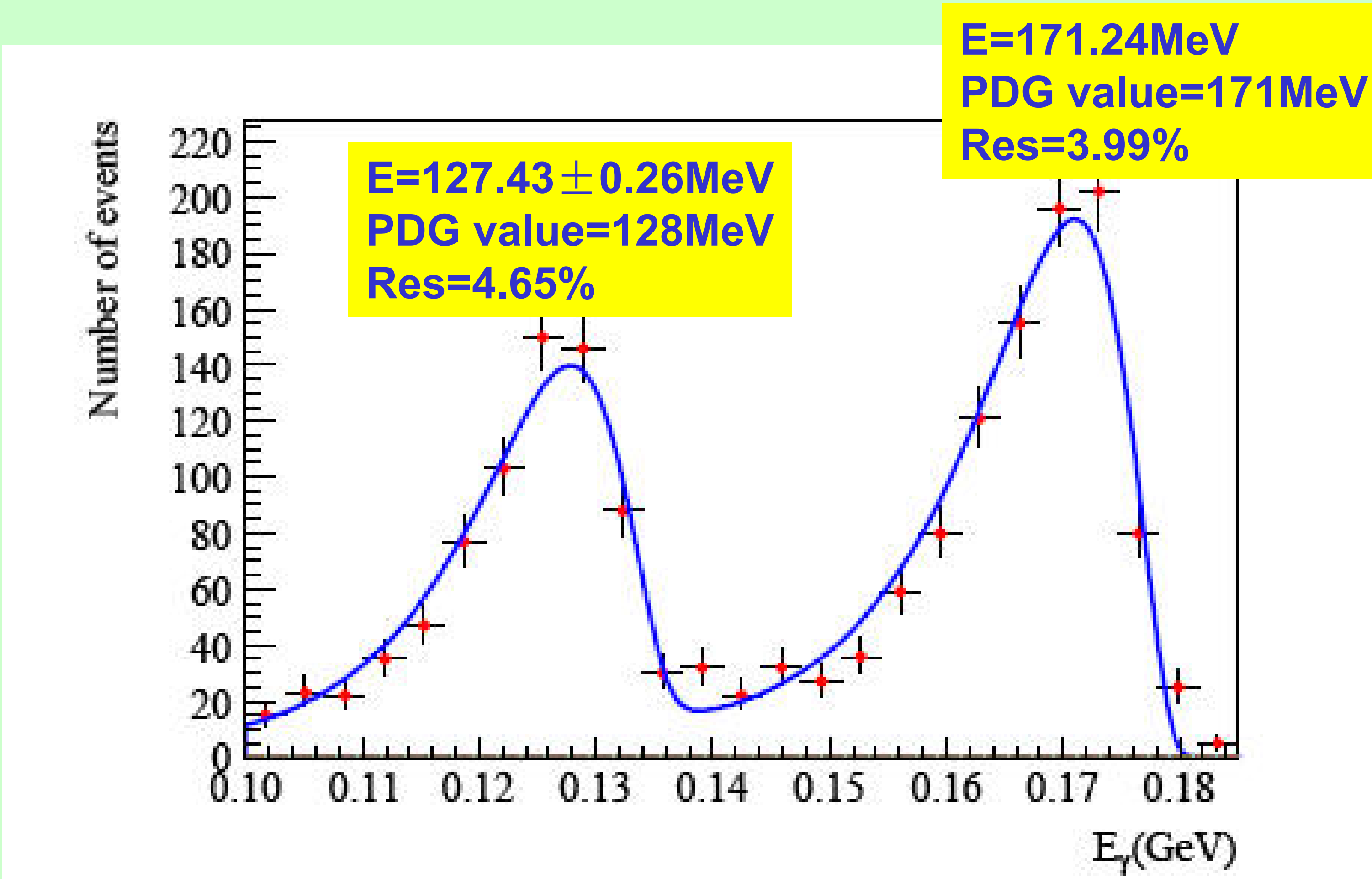
Data (Belle Based):
$M = 3096.8 \pm 0.2$ MeV
$\sigma = 2.8 \pm 0.1$ MeV

MC (Belle based):
$M = 3096.7 \pm 0.1$ MeV
$\sigma = 1.7 \pm 0.1$ MeV

Energy resolution in barrel obtained from π^0



Signal of $\chi_{c1,2}$



Transition photon energies consist with PDG value after π^0 calibration