The BESIII experiment at BEPCII

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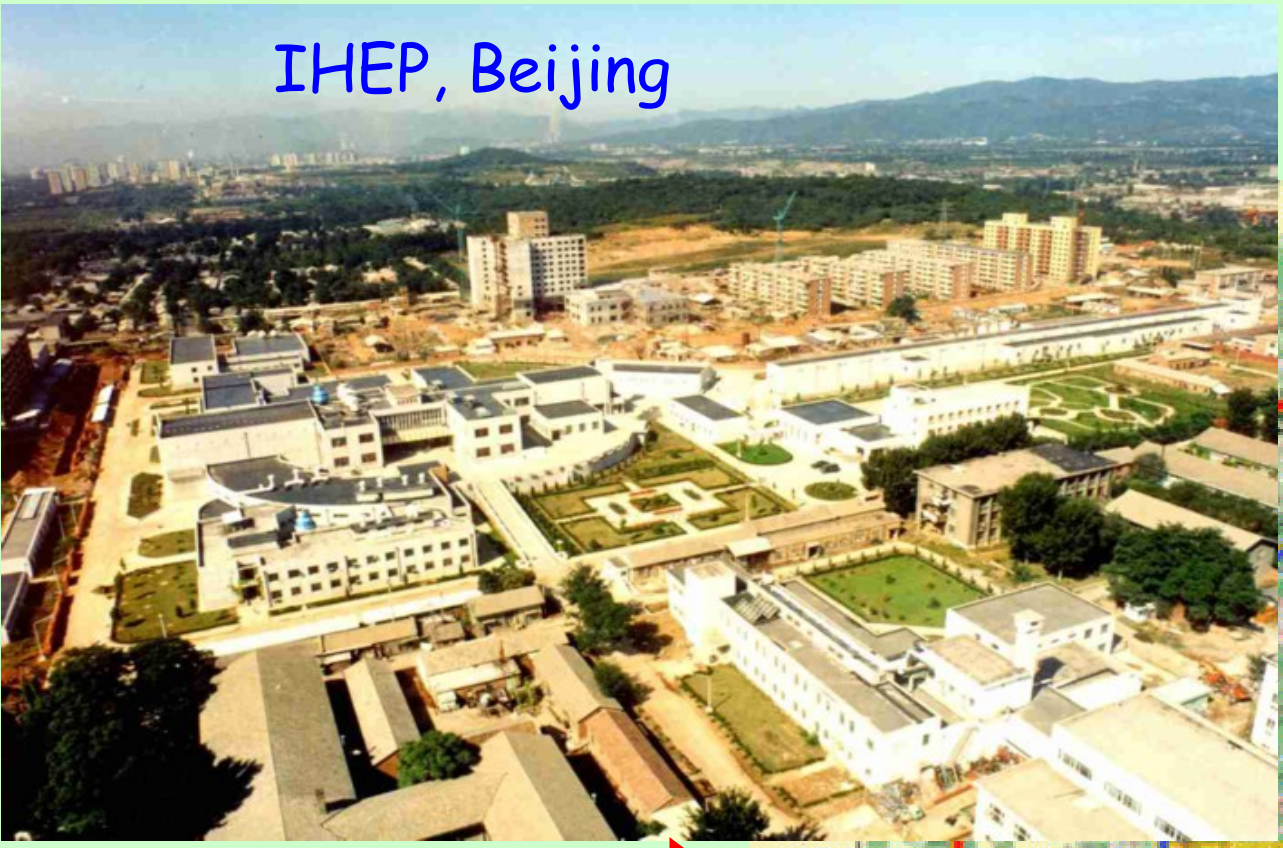
IHEP, Beijing
(for the BESIII Collaboration)

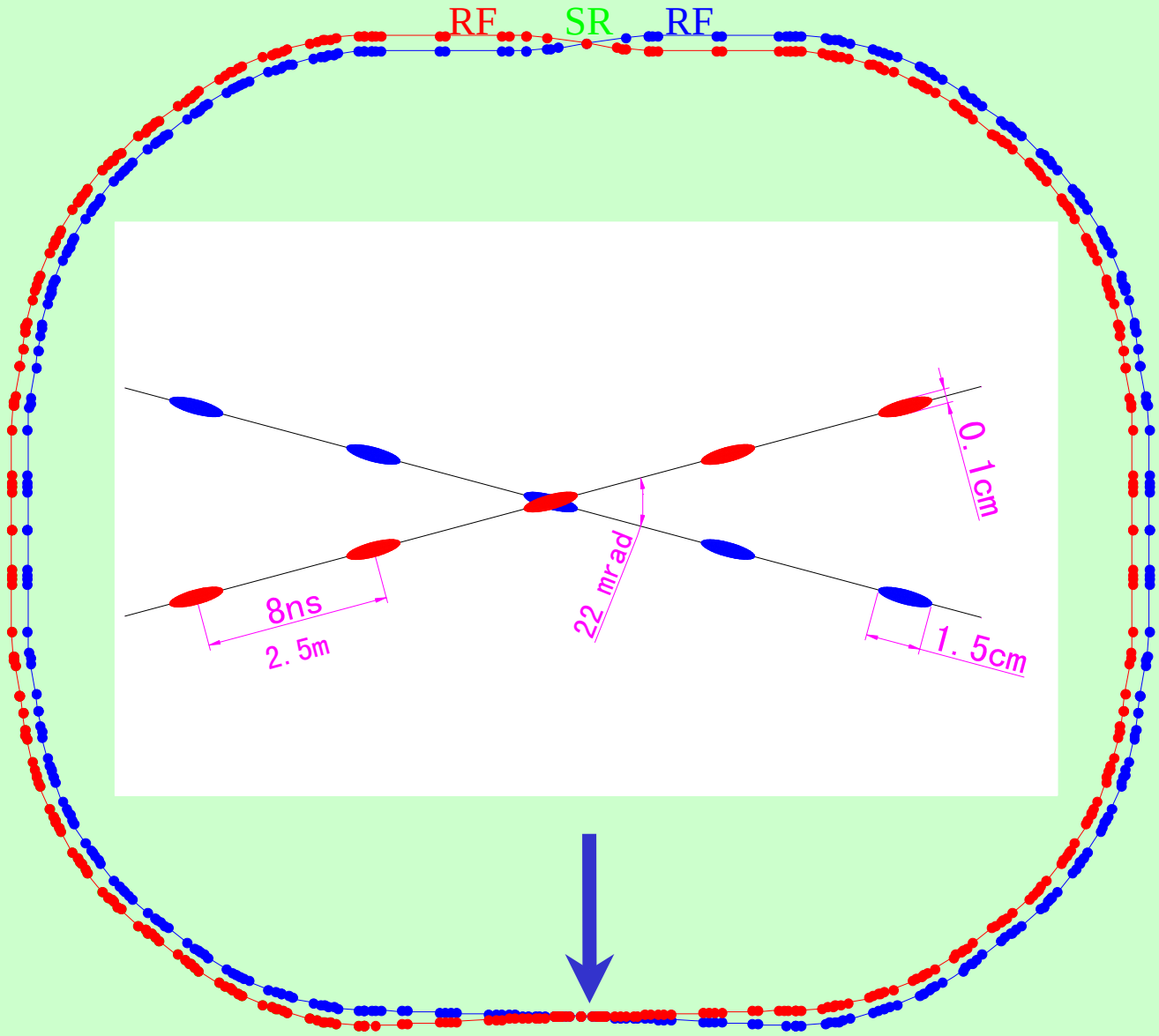
QWG workshop
Oct. 17-21, 2007, Hamburg

The Beijing Spectrometer (BESI/II) at BEPCI



1989-2005
Ecm=2-5 GeV
$L_{peak}=10\times10^{30}/cm^2s$
@ 3.7 GeV

BEPC II Storage ring: Large angle, double-ring

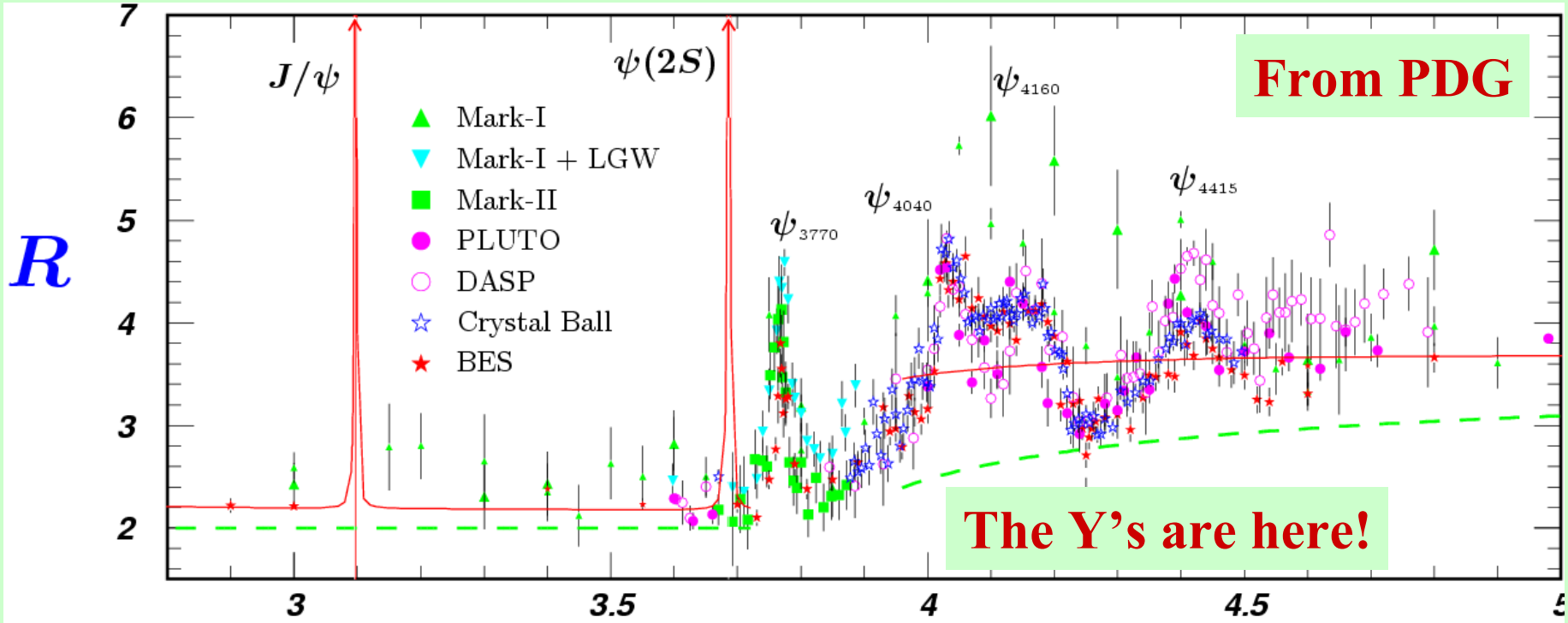


Beam energy:
1.0-2.1 (2.3)GeV
Magnet, RF power
Luminosity:
1×10^{33} $cm^{-2}s^{-1}$
Optimum energy:
1.89 GeV
Energy spread:
5.16×10^{-4}
No. of bunches:
93
Bunch length:
1.5 cm
Total current:
0.91 A
SR mode:
0.25A @ 2.5 GeV

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**

A review book on
"tau-charm physics at BESIII"
~ 800 pages, to be completed this year (great contribution from QWG members!)



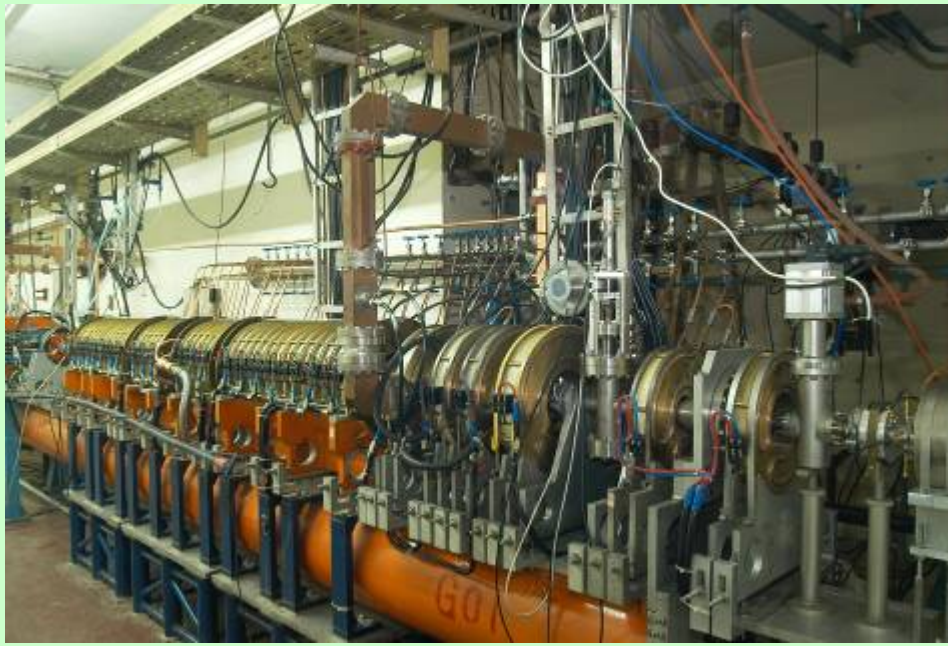
Physics at BEPCII/BESIII

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	--	--

Current status of BEPCII/BESIII construction

Installation of linac was completed



Summary of the Linac commissioning

Parameters		Goal	Measured
Beam energy (GeV)		1.89	1.89 (e-); 1.89 (e+)
Beam current (mA)	e^+	40	40 - 63
	e^-	500	> 500
Repetition rate (Hz)		50	50
Emittance (1σ) (mm·mrad)	e^+	0.53	0.32 ~ 0.20
	e^-	0.067	0.080 ~ 0.096
Energy spread (%)	e^+	± 0.50	±0.73@1.30GeV (±0.50@1.89GeV)
	e^-	± 0.50	< ±0.80@1.30GeV < (±0.55@1.89GeV)

The BEPCII storage ring installation was completed in the beginning of Nov. 2006

Conventional magnets were installed at IR to start ring commissioning and SR operation

Milestone of BEPCII storage ring commissioning

Nov. 2006 Beam commissioning start

Nov. 2006 Beam was stored in the storage ring

Dec. 2006 Accumulated beam ~ 6 A·hrs.,
beam life time ~ 1.5 hrs @ 60mA.

Dec. 2006 Start to provide SR beams for users

Mar. 2007 First e^+e^- collision, Lumi ~ 10^{30} cm^{-2} s^{-1} (normal Q)
collision of 100 mA + 100 mA , lumi ~ 10^{31} cm^{-2} s^{-1}

June 2007 Provide SR beams for users at 2.5GeV,
200 mA with a lifetime of 5.5 hr

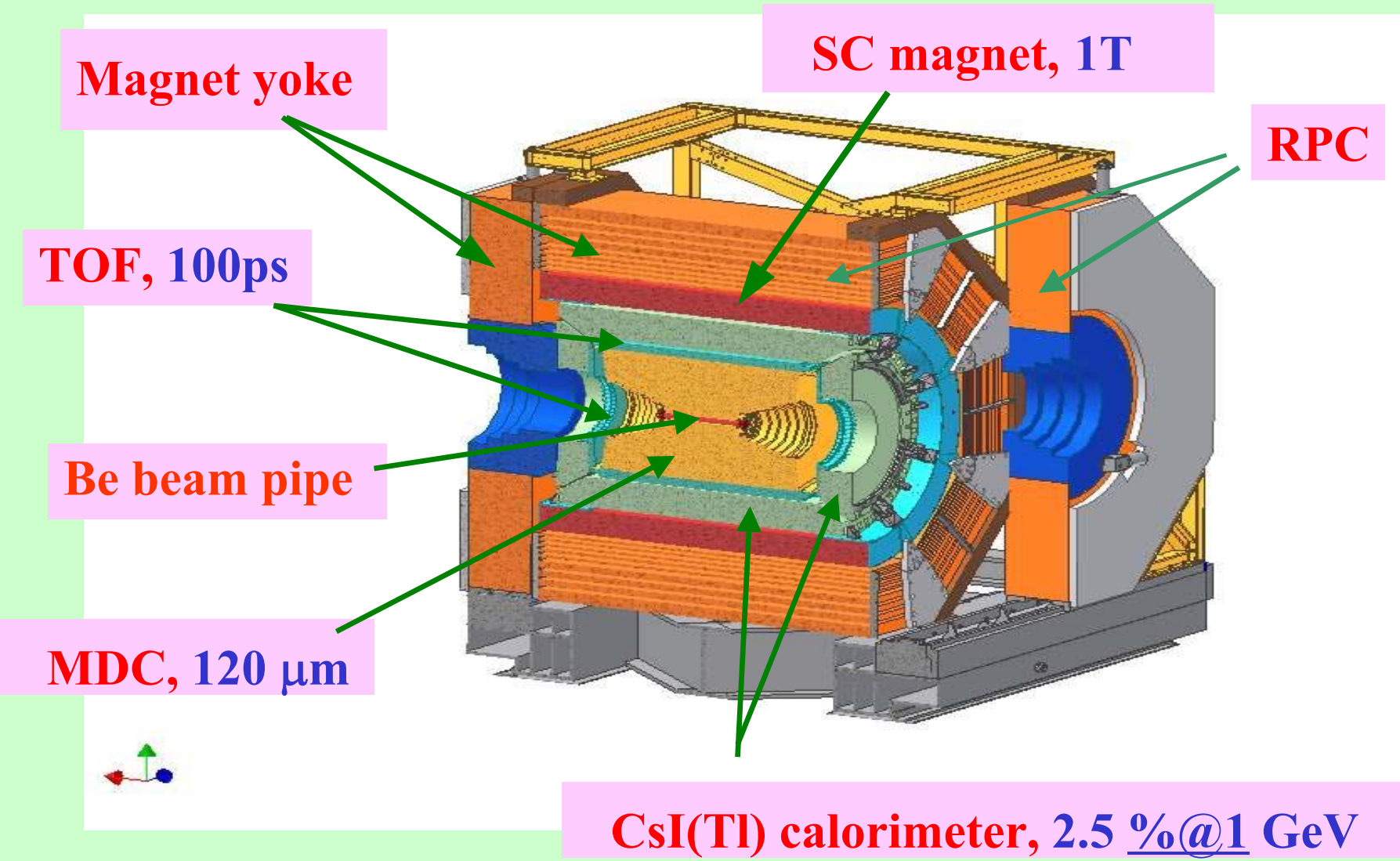
Aug. 2007 Beam current reached 500 mA

SCQ magnet mapped and now at the interaction region (was a serious problem)

Future plan

- **Machine study will start on Oct. 24, 2007**
- **Another SR run is planed at the end of 2007**
- **By march 2008, luminosity shall reach ~10^{32} cm^{-2} s^{-1} and backgrounds acceptable**
- **The BESIII detector will be moved to the interaction region by March 2008**
- **The goal is that BEPCII should reach a lumi. around 3 $\times 10^{32}$ cm^{-2} s^{-1} by the end of 2008**

The BESIII Detector



- Drift chamber and its electronics (IHEP, Sichuan, Tsinghua)
- CsI(Tl) calorimeter and its electronics (IHEP, Tsinghua)
- TOF（IHEP, USTC，Tokyo，Hawaii）
- TOF electronics （USTC）
- RPC（IHEP, Uni. of Washington）
- RPC electronics（USTC）
- Trigger（IHEP, USTC）
- DAQ & online software (IHEP, Tsinghua)
- Offline software （IHEP, Peking，Shangdong，Nanjing）
- Superconducting magnet （IHEP，Wang NMR）
- Mechanics (IHEP)
- Technical support (IHEP, Tsinghua）

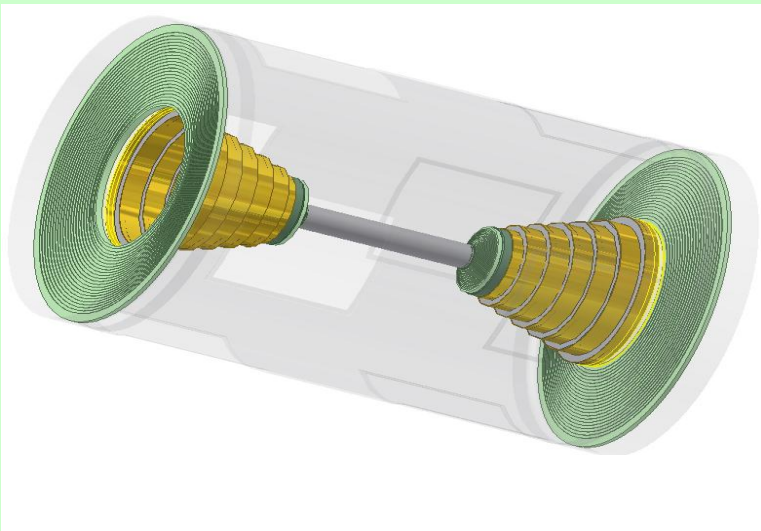
Drift chamber

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

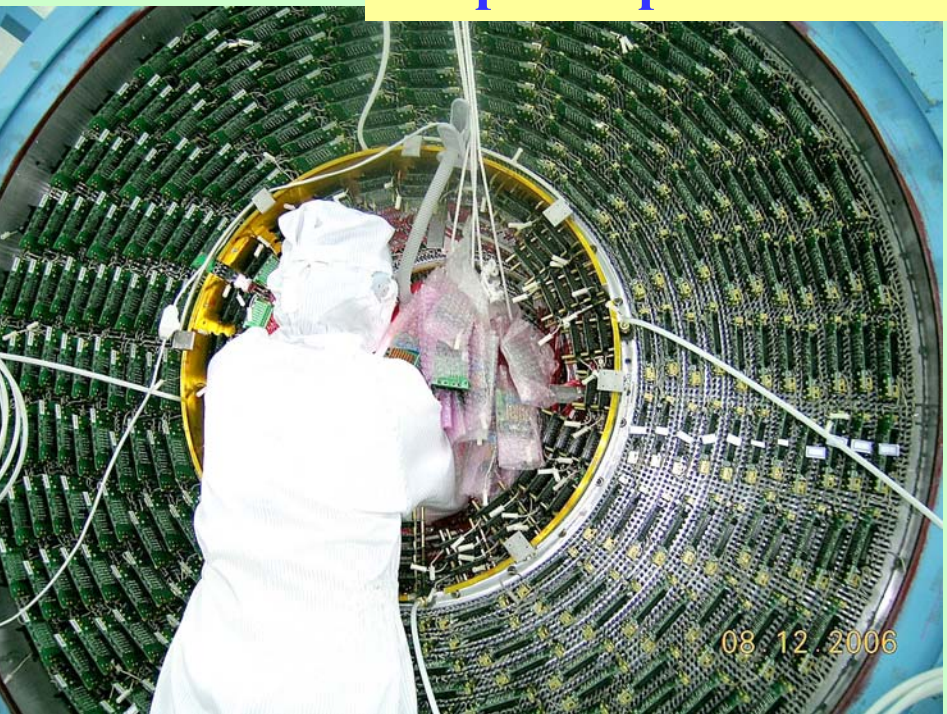
	Single wire reso.	dE/dx reso.
CLEO:	~110μm,	5.7%
Babar:	~110μm,	6.2%
Belle:	~130μm,	5.7%
BESIII	~120μm	6 %

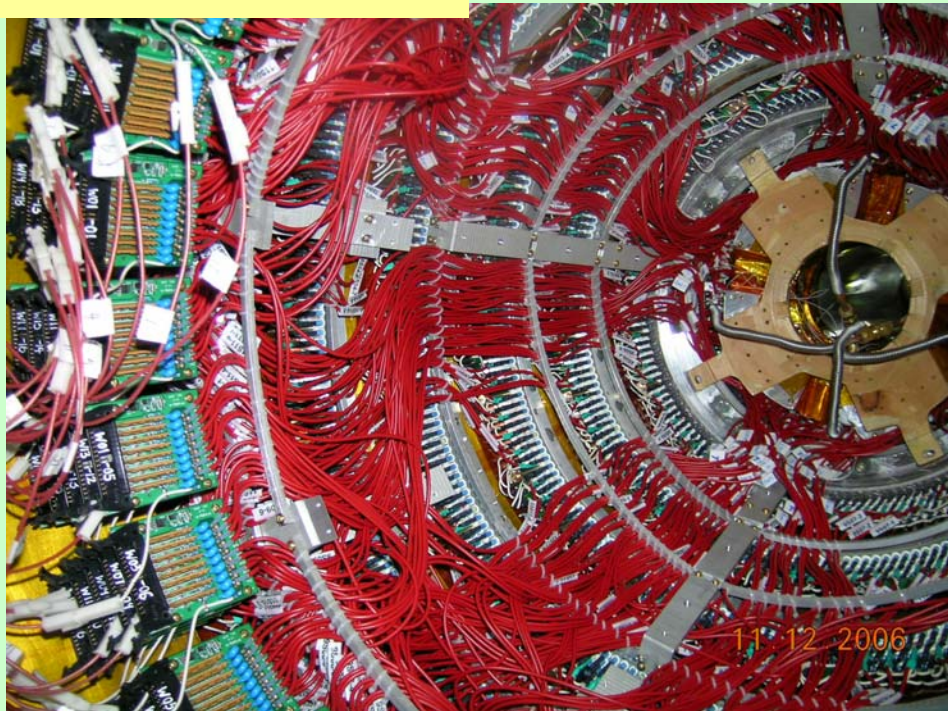
- R_{in} = 63mm; R_{out} = 810mm; length = 2400 mm
- 7000 Signal wires: 25(3% Rhenium) μm gold-plated tungsten
- 22000 Field wires: 110 μm Al
- Gas: He + C_3H_8 (60/40)
- Momentum resolution@1GeV: 0.5%

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

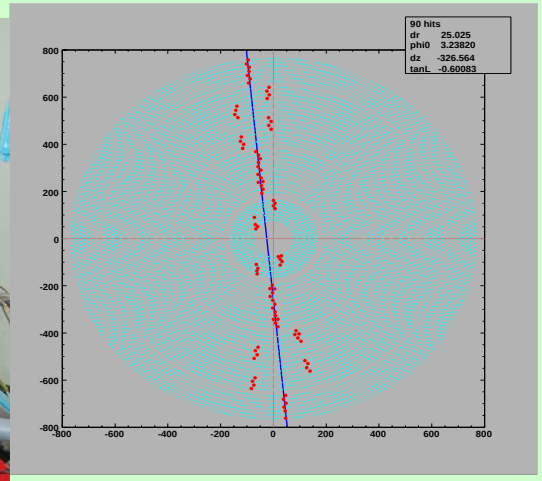


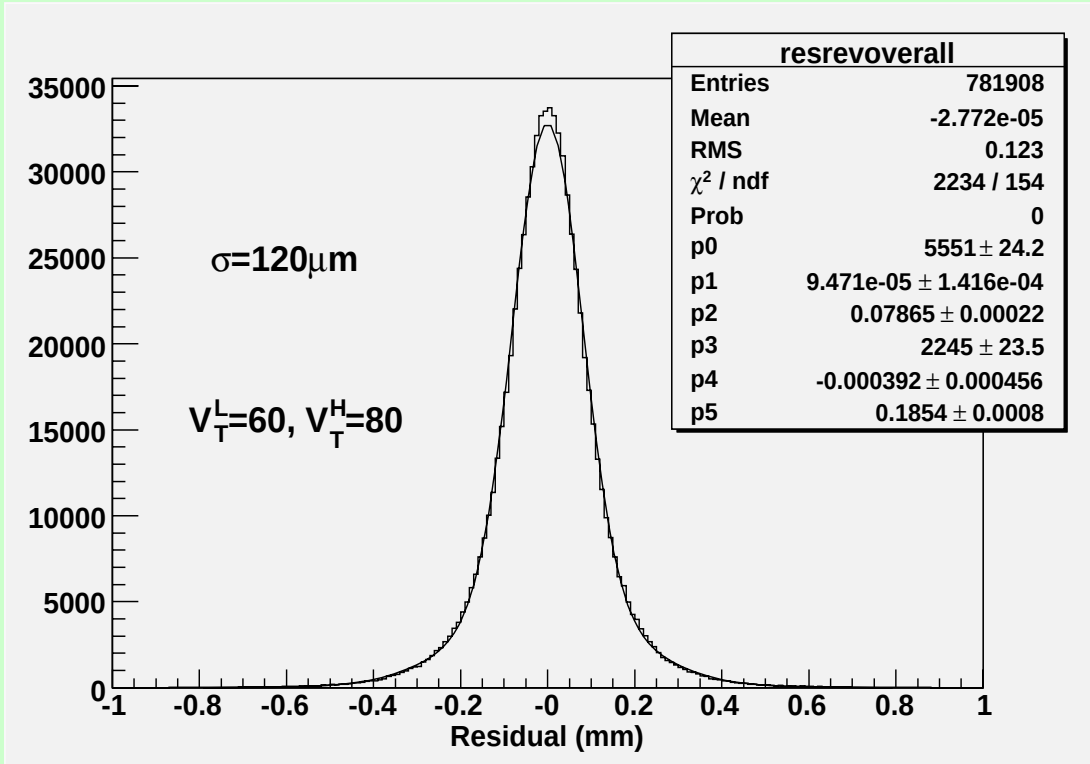
All preamplifiers are mounted and tested





Cosmic-ray tests completed





BESIII CsI(Tl) crystal calorimeter

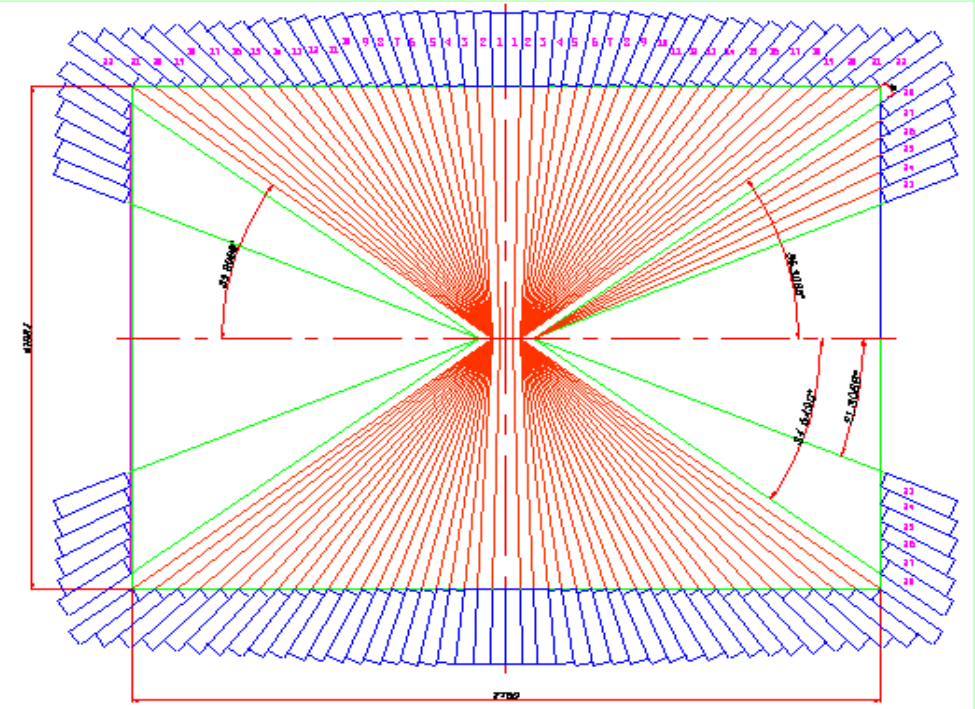
- To measure the energy of electromagnetic particles
- Barrel: 5280 crystals，Endcap: 960 crystals
- Crystal: (5.2x 5.2 – 6.4 x 6.4) x 28cm^3
- Readout: ~13000 Photodiodes, 1cm×2cm,
- Energy range：20MeV – 2 GeV
- position resolution: 6 mm@1GeV
- Tiled angle: theta ~ 1-3^o, phi ~ 1.5^o

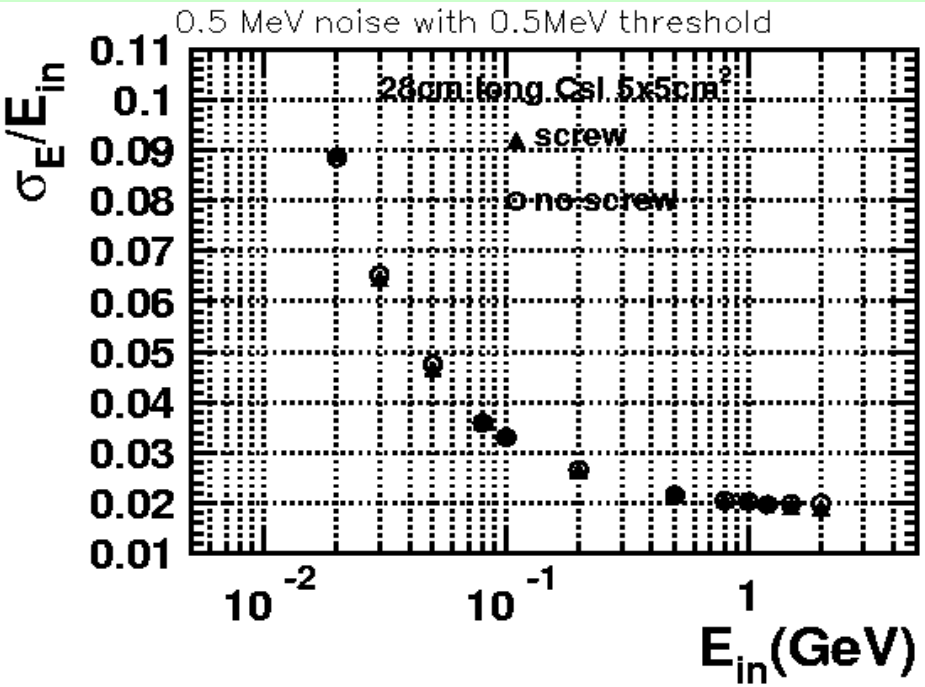
Babar: 2.67% @1GeV

BELLE: 2.2% @1GeV

CLEO: 2.2% @1GeV

BESIII: 2.5%@1GeV

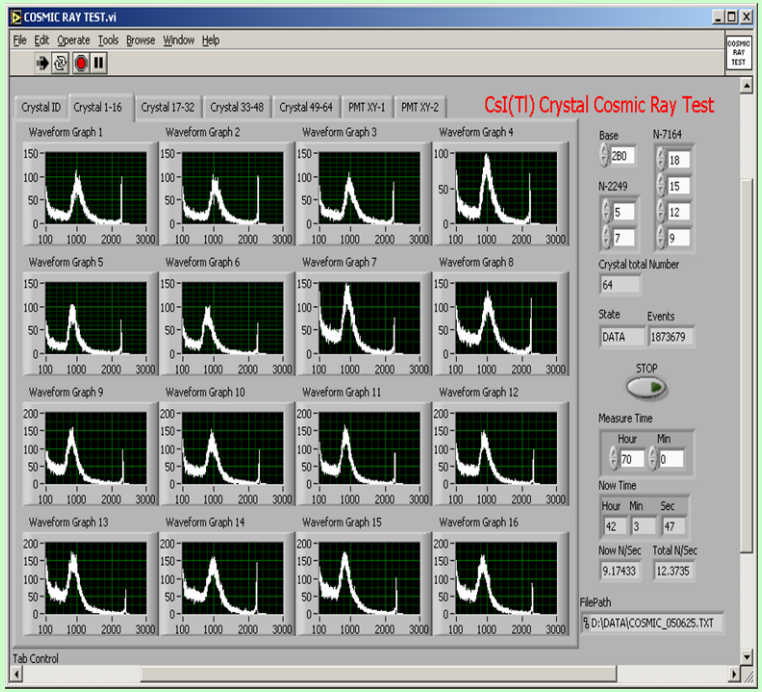




CsI Calorimeter

Testing:

- Size
- Source tests (^{137}Cs)
- LED tests
- PD tests
- Preamp tests
- Cosmic ray tests
- Beam tests (6 x 6 array):

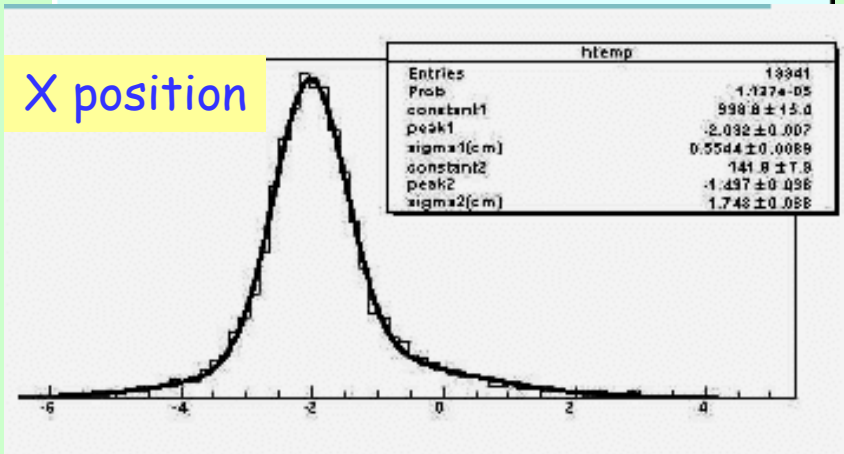


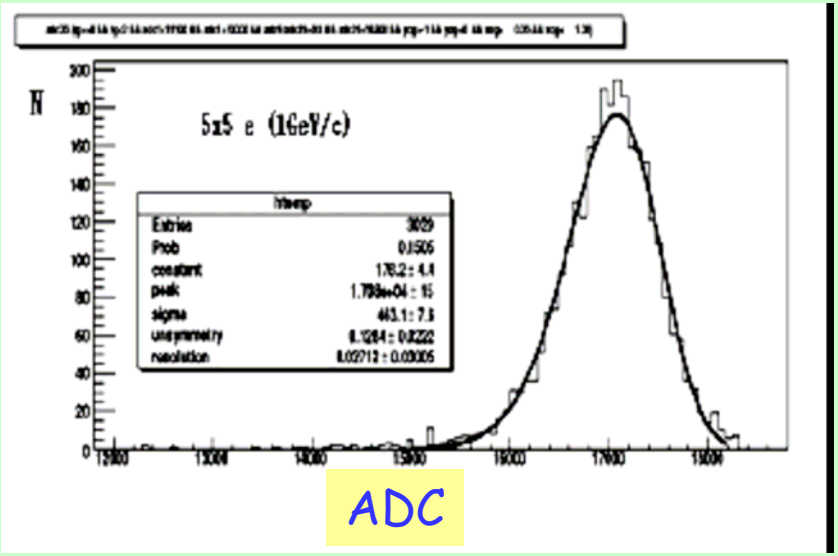
Energy resolution (1GeV)

$\sigma_E = 2.62\ \%$

position resolution (1GeV)

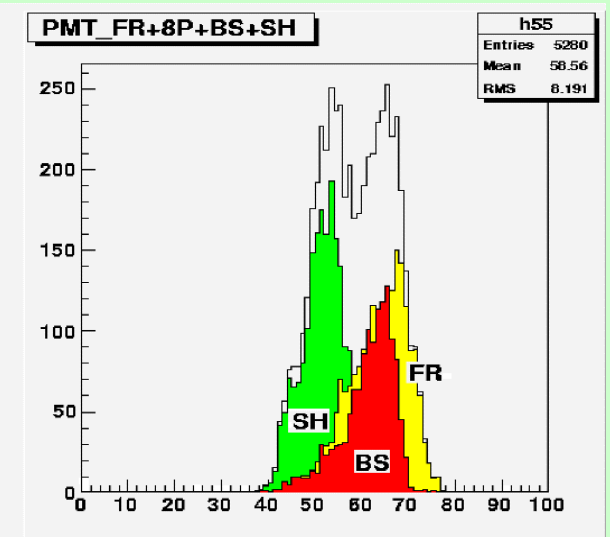
$\sigma_{x-y} = 6\ mm$

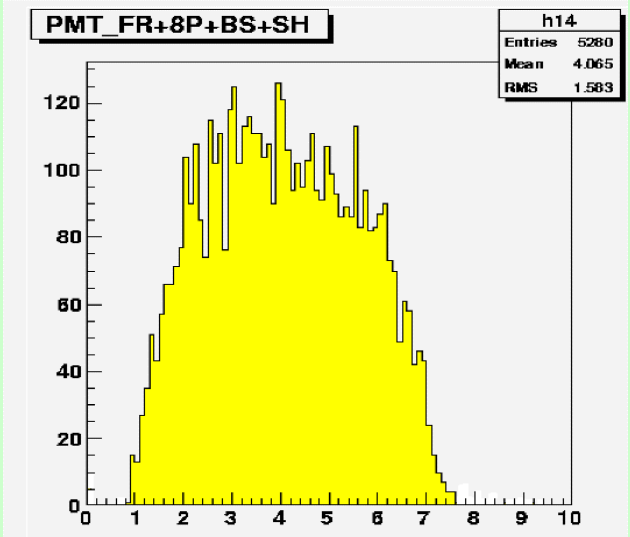


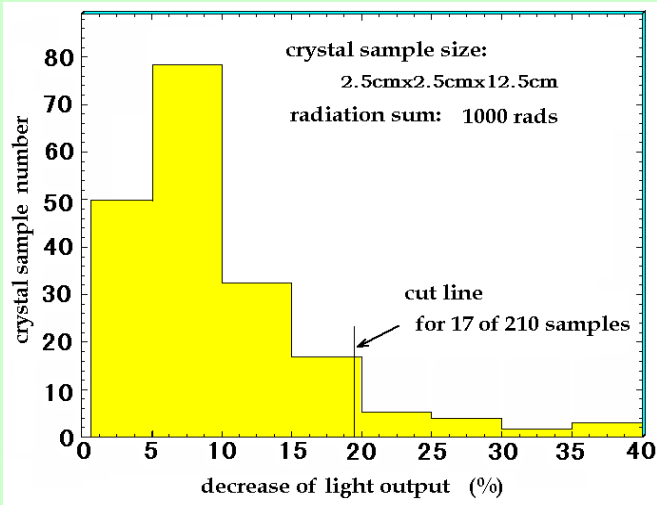


Crystal production and tests completed

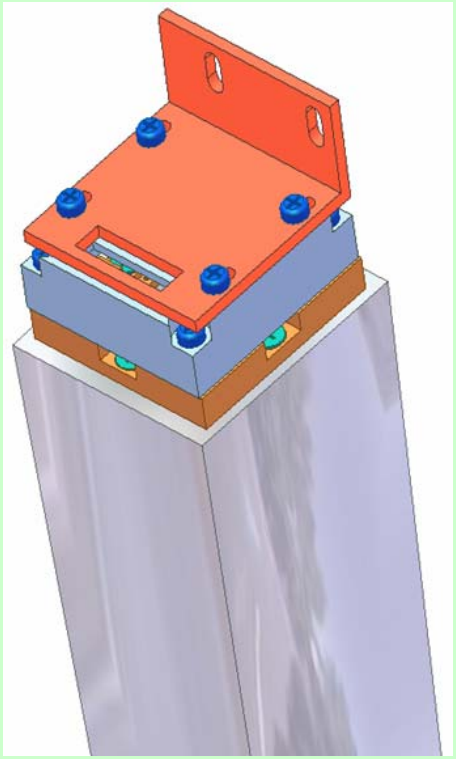
	France Sanit -Gobain	Shanghai Institute of Ceramics	Beijing Hamamatsu	Total
Ordered	2040(960)	1920	1320	5280(960)
Replaced	87(4)	316	79	482(4)

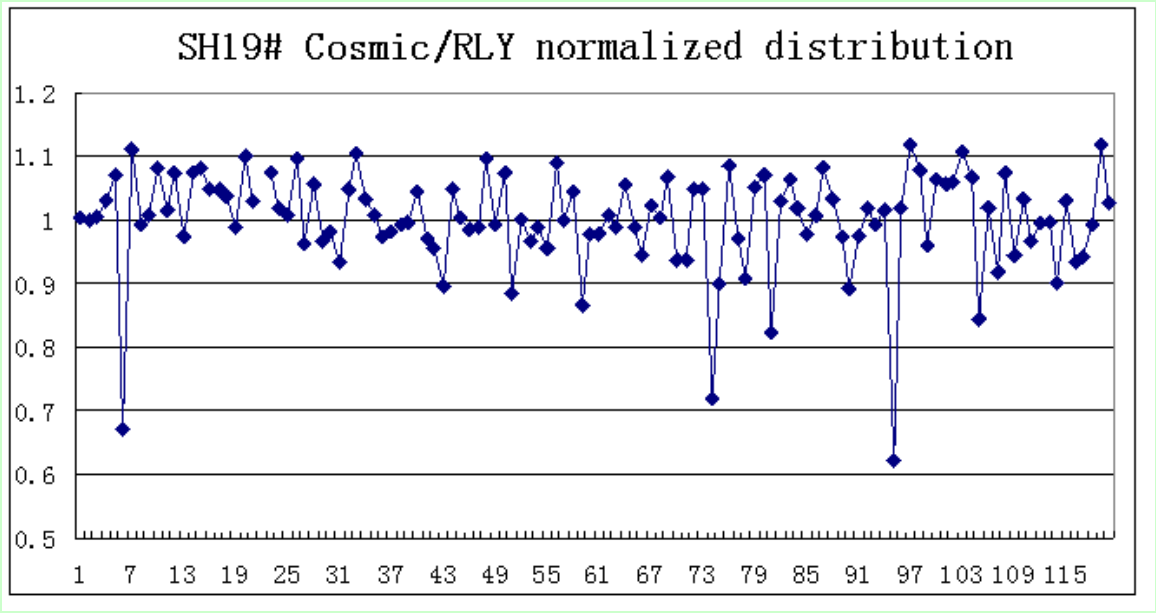




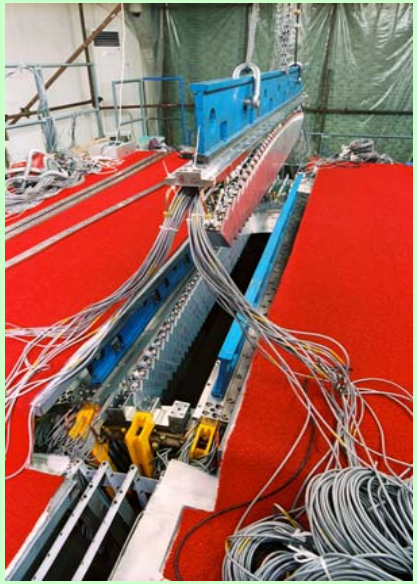


Crystal assembly completed



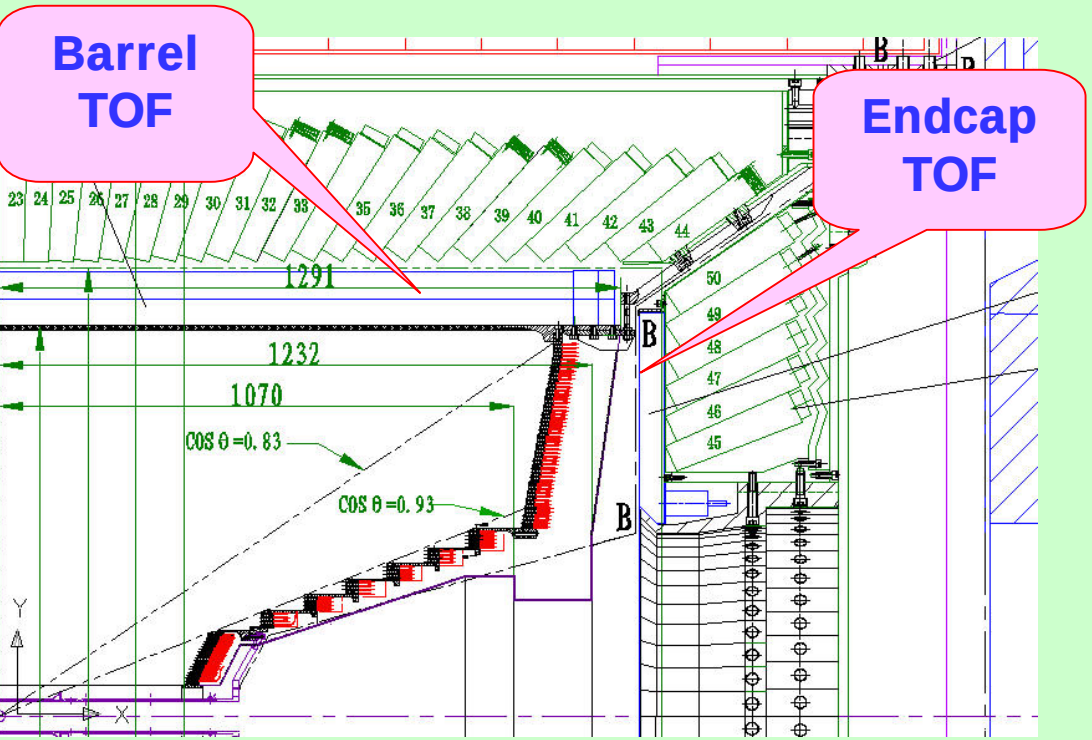


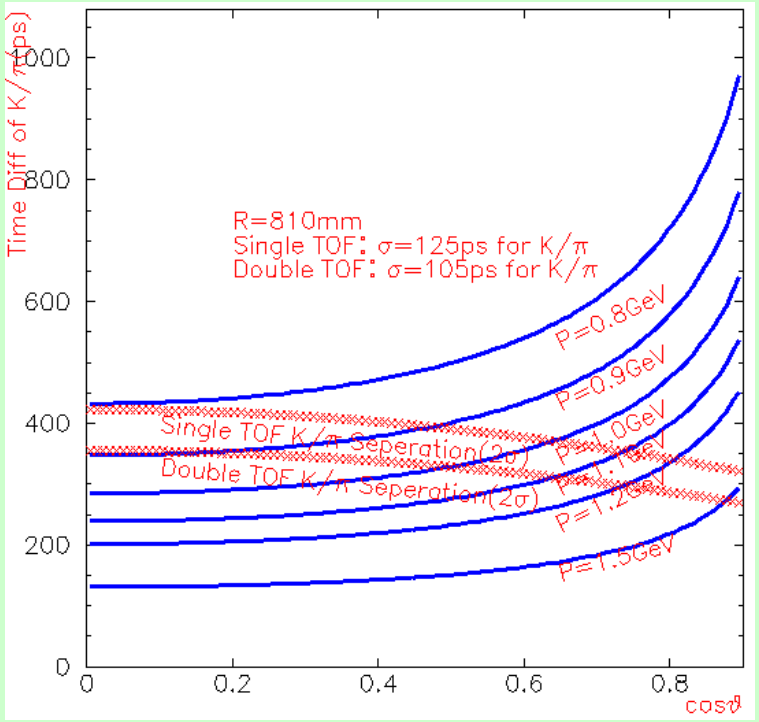
Barrel assembly completed



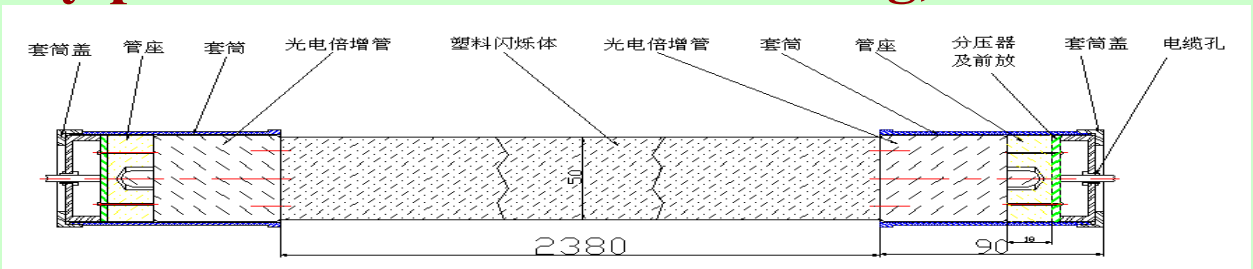
PID: Time-Of-Flight counters

- To measure the flight time of particles in order to identify them: m=P/(L/t)

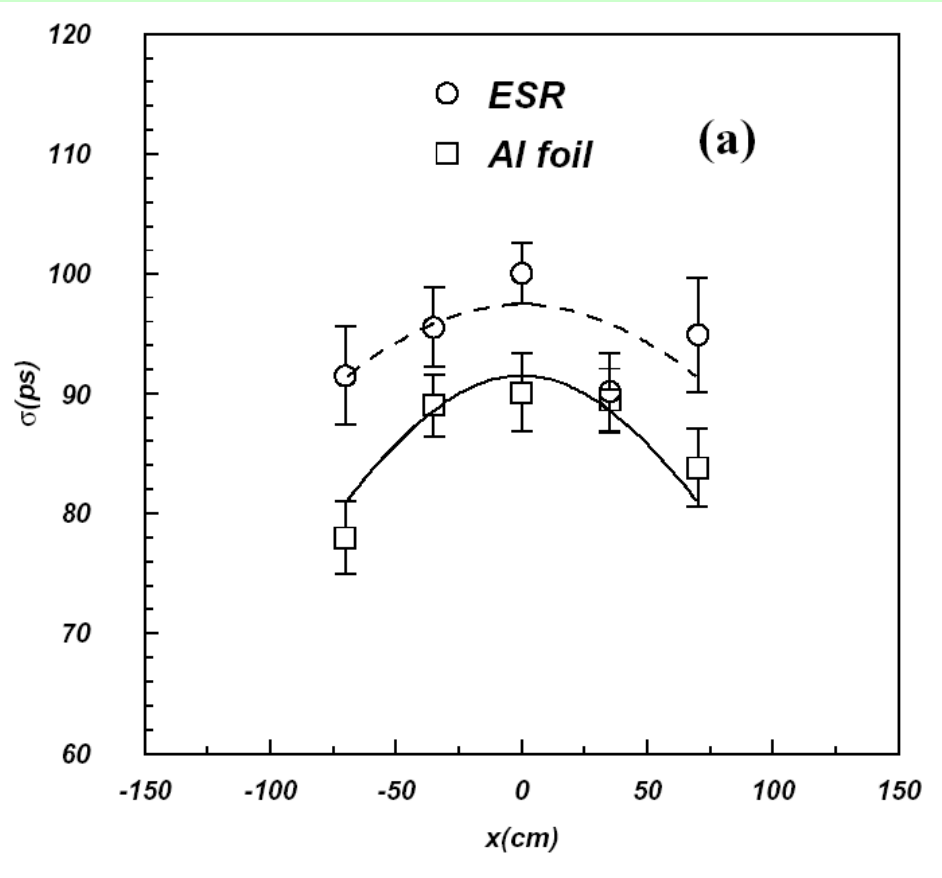


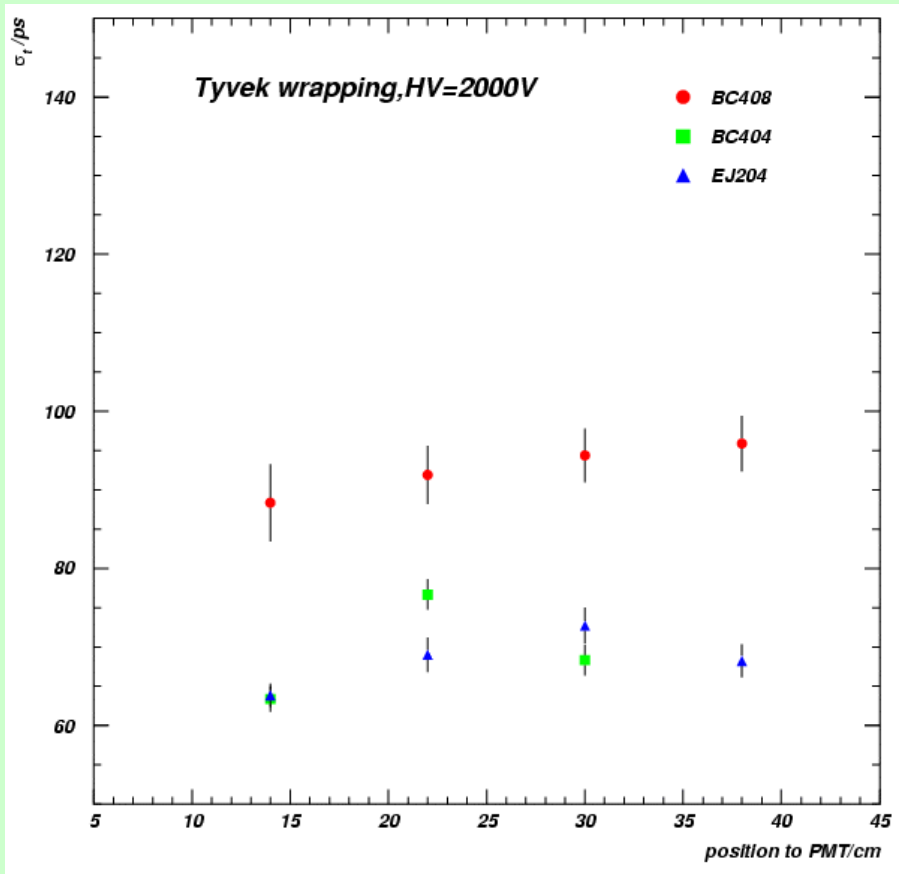


High quality plastic scintillator: 2.4 m long, 5 cm thick



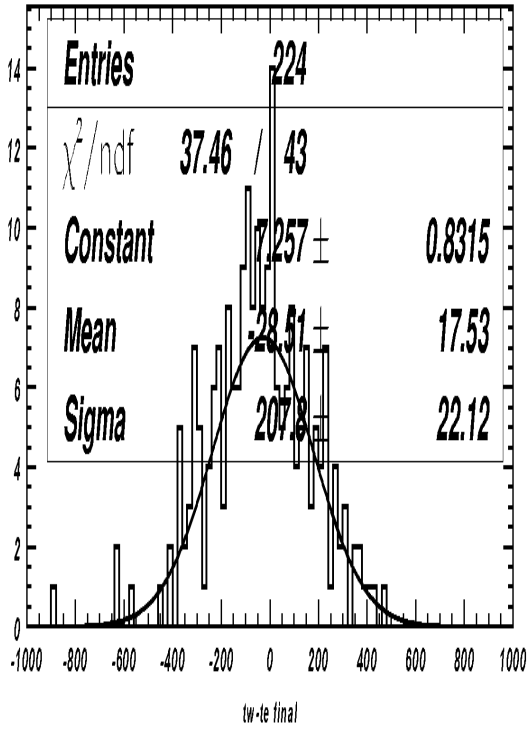
Test beam at IHEP: for various types of scintillators, thickness, wrapping materials, …

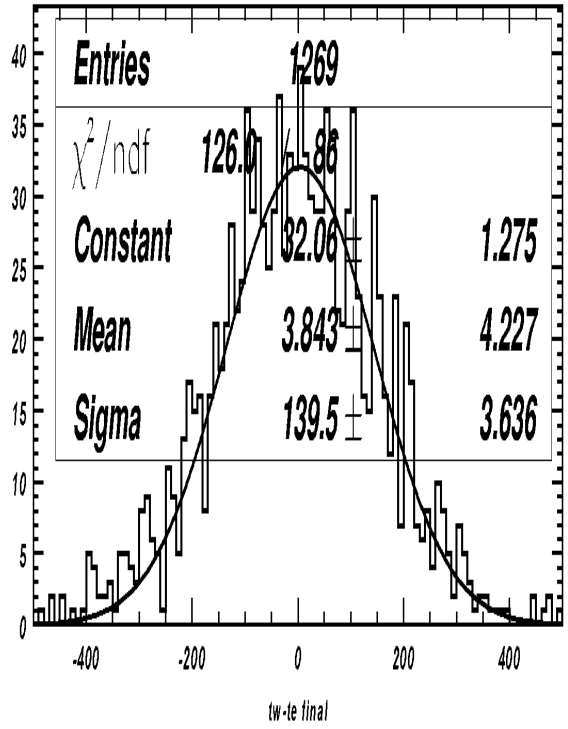


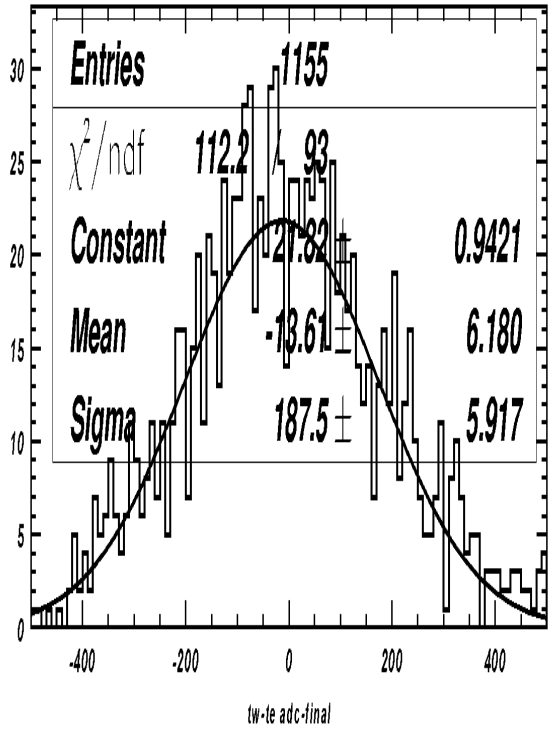


Barrel **Endcap**

Test beam at IHEP: for various types of scintillators, thickness, wrapping materials, …







pions

104±11ps

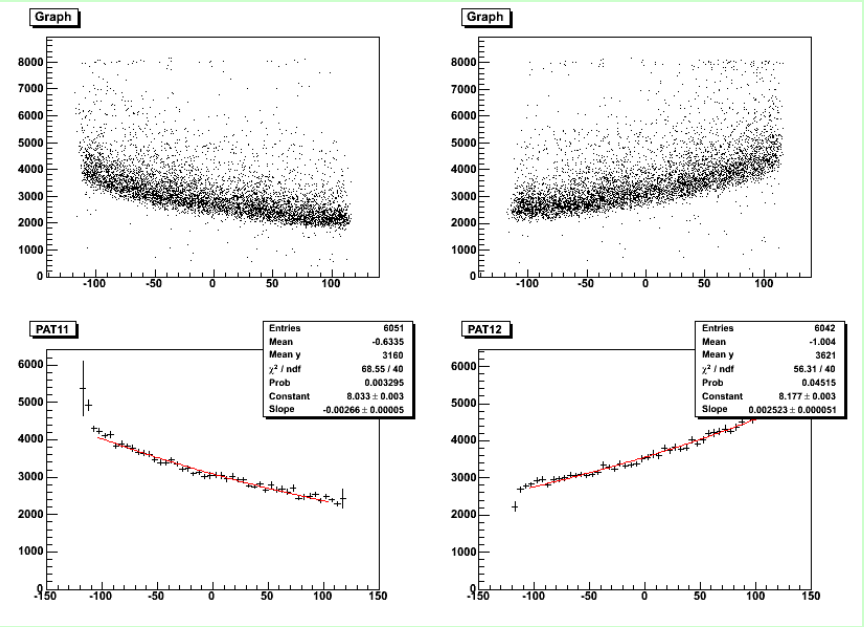
protons

70±2ps

electrons

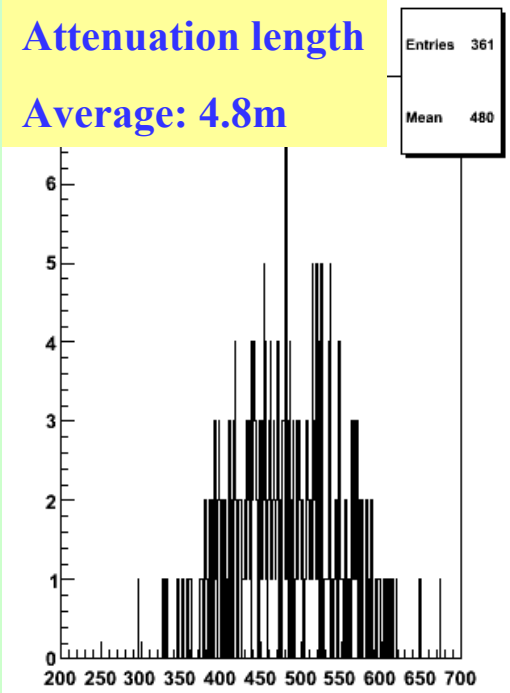
94±3ps

Scintillator tests completed

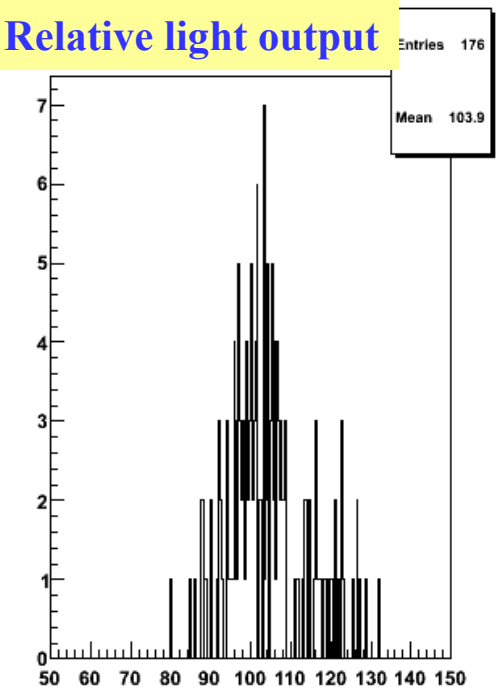


Attenuation length

Average: 4.8m



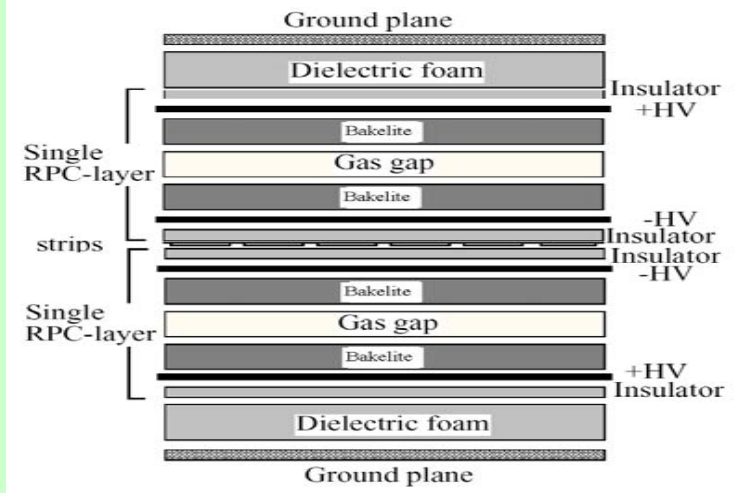
Relative light output

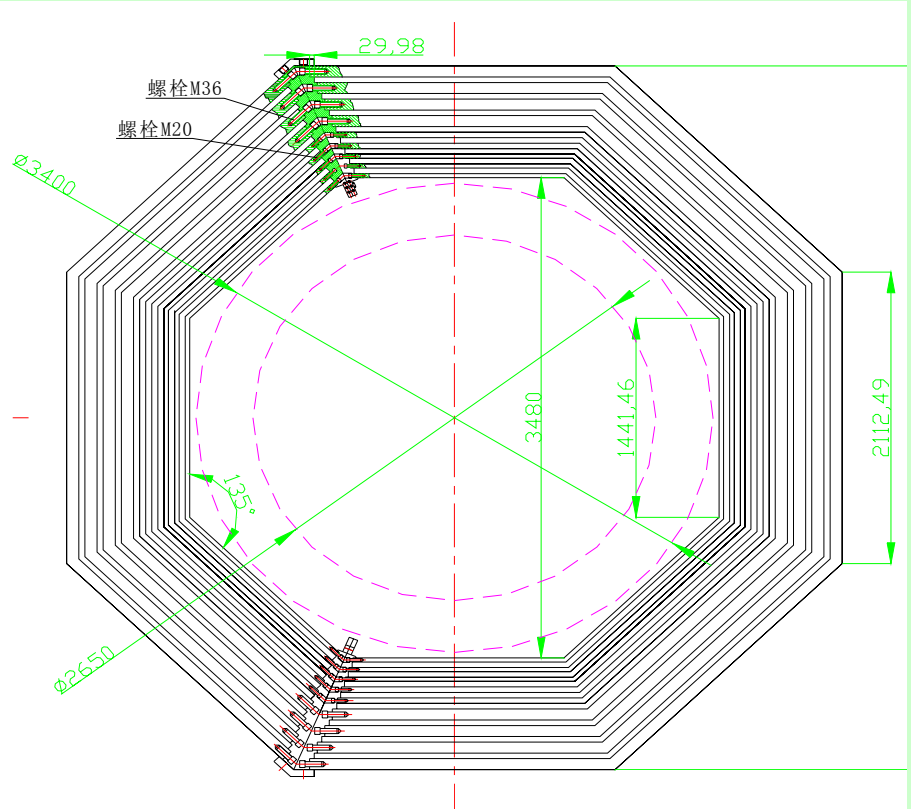


- **PMT test completed at Tokyo University**
- **Preparation for installation completed**
- **Monitor system by Hawaii University completed**

μ system : RPC

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

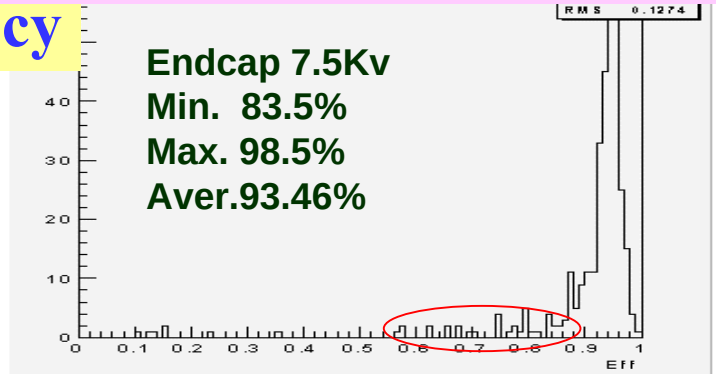


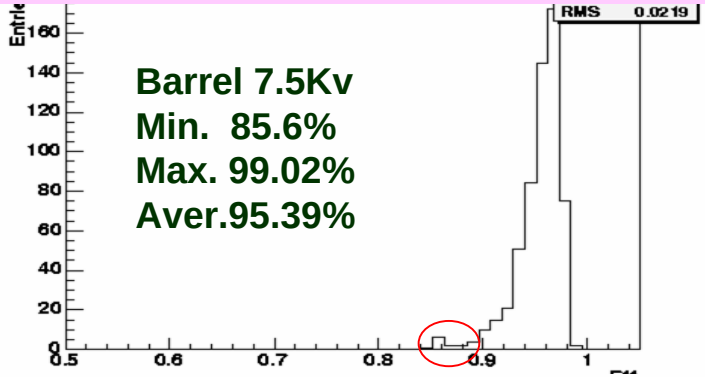


Mass production ---- Bare chamber test

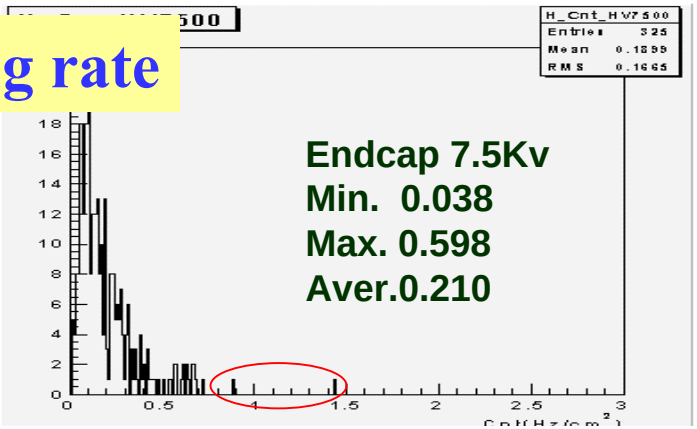
Training time : 1 - 3days; endcap 320RPCs, barrel 590RPCs

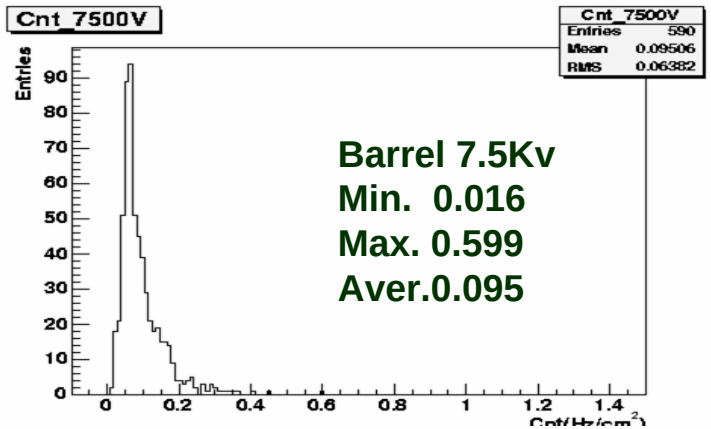
efficiency



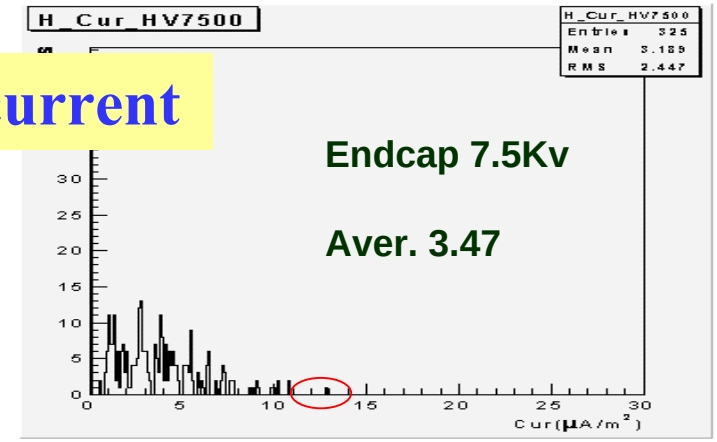


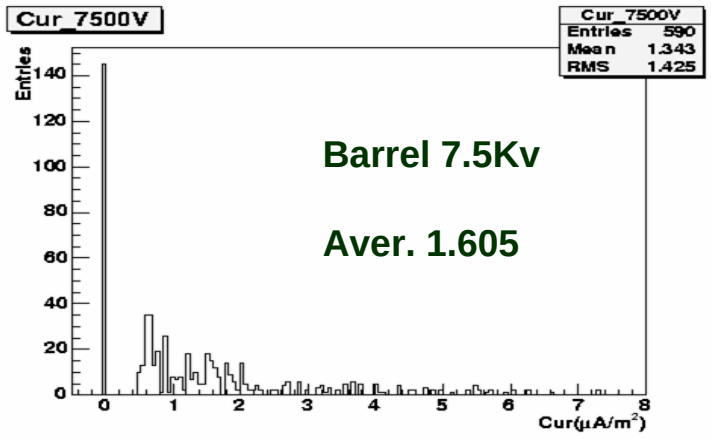
counting rate



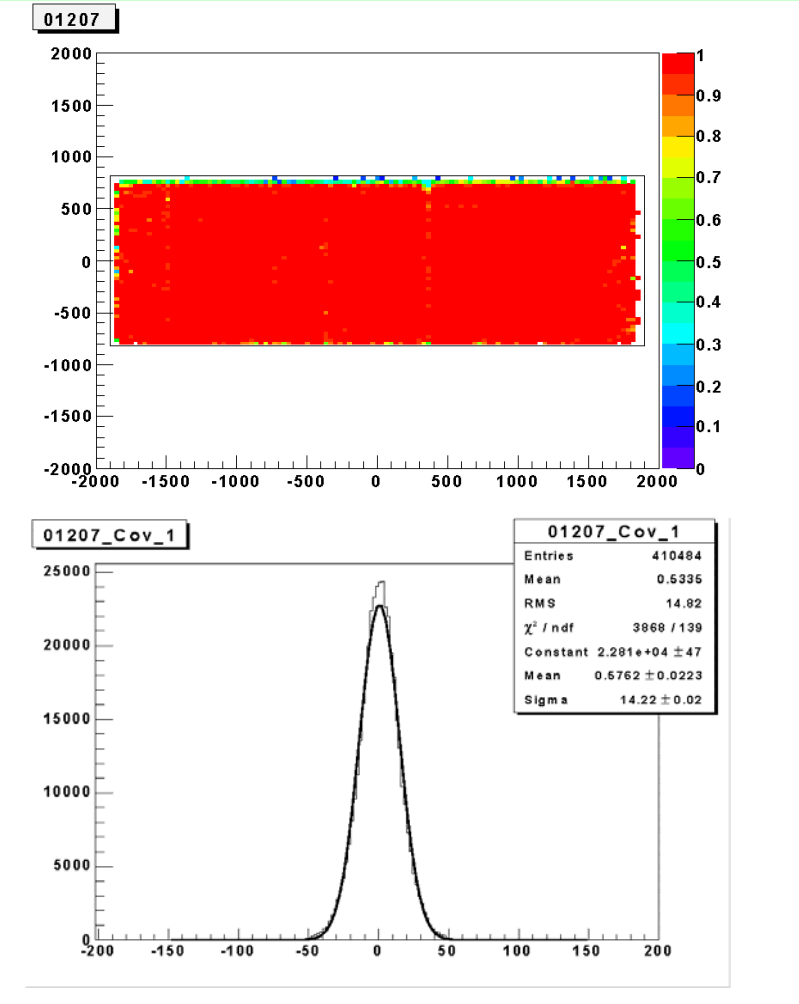


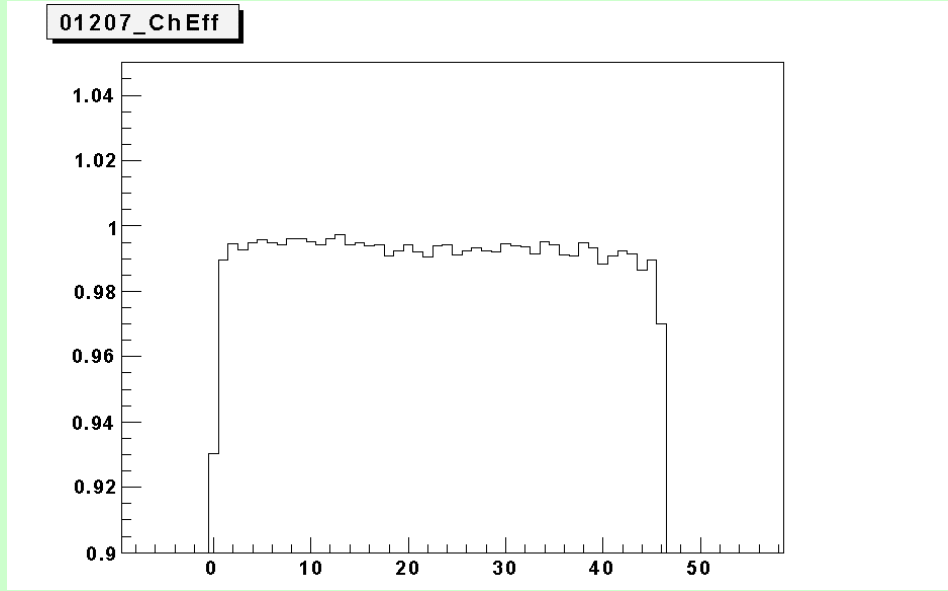
Dark current





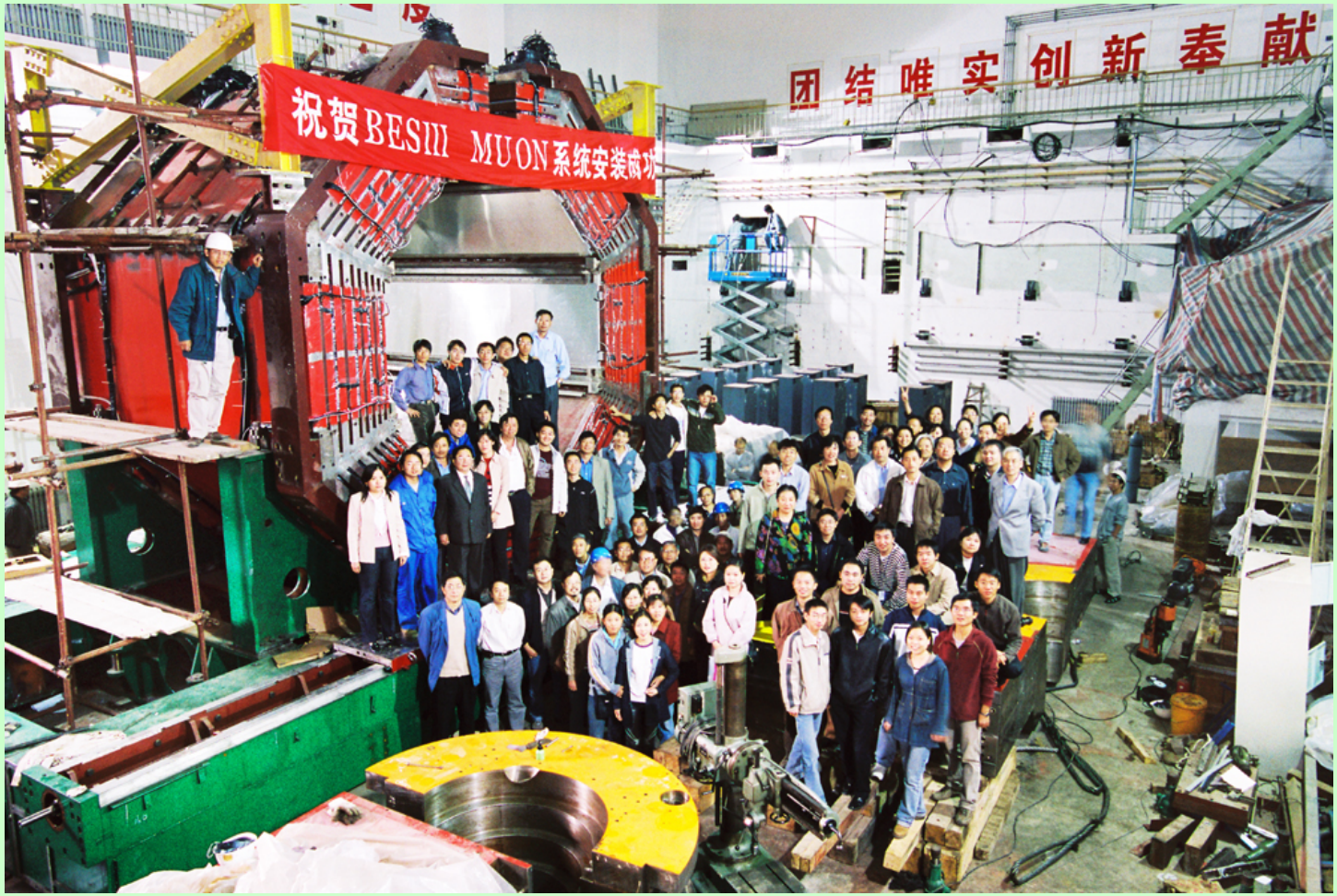
Test results after installation





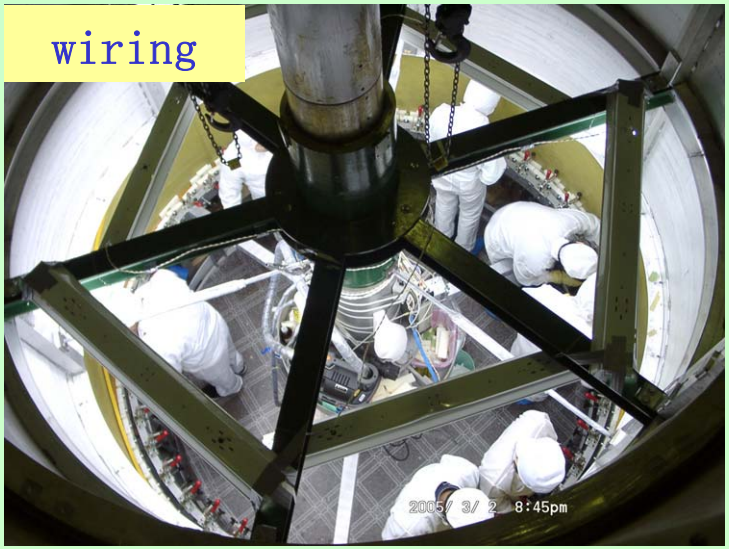
Module size:
3800mm*1640mm
Strip length: 3800mm
Strip width: 33mm
Average strip efficiency: 0.99
Spatial resolution: 14.2mm

Muon chamber installation completed



Super-conducting magnet: 1T@3400 A

wiring



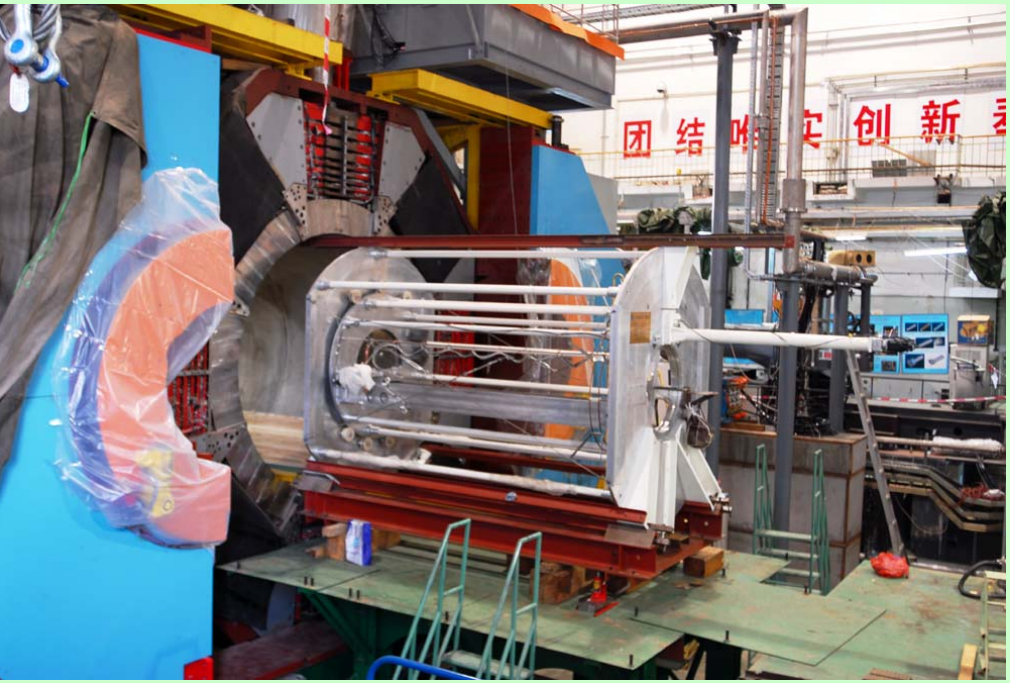
Thermal insulation

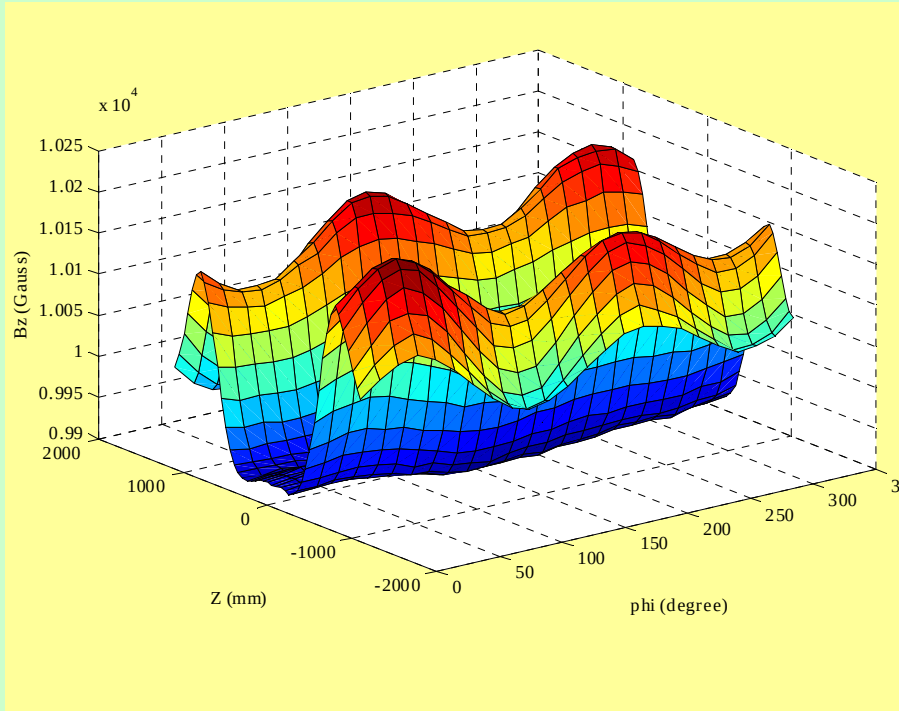
assembly

transportation

installation

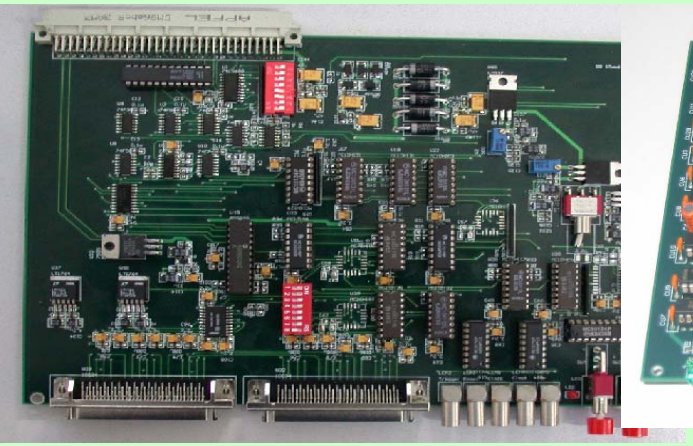
The magnet reached super-conducting status and 1T magnetic field at 3364A. Field mapping with SCQ completed Aug., 07

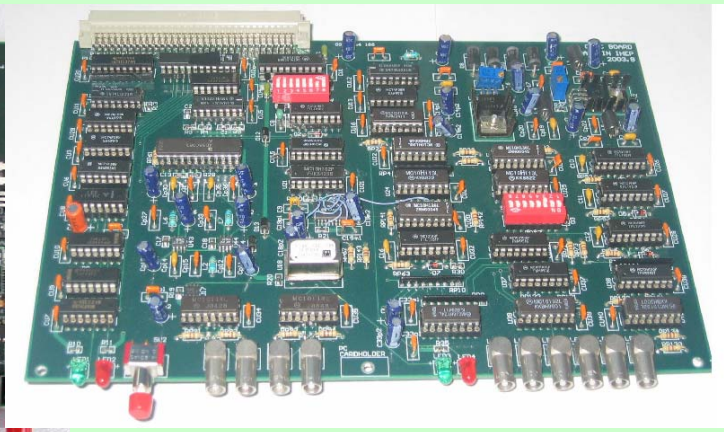




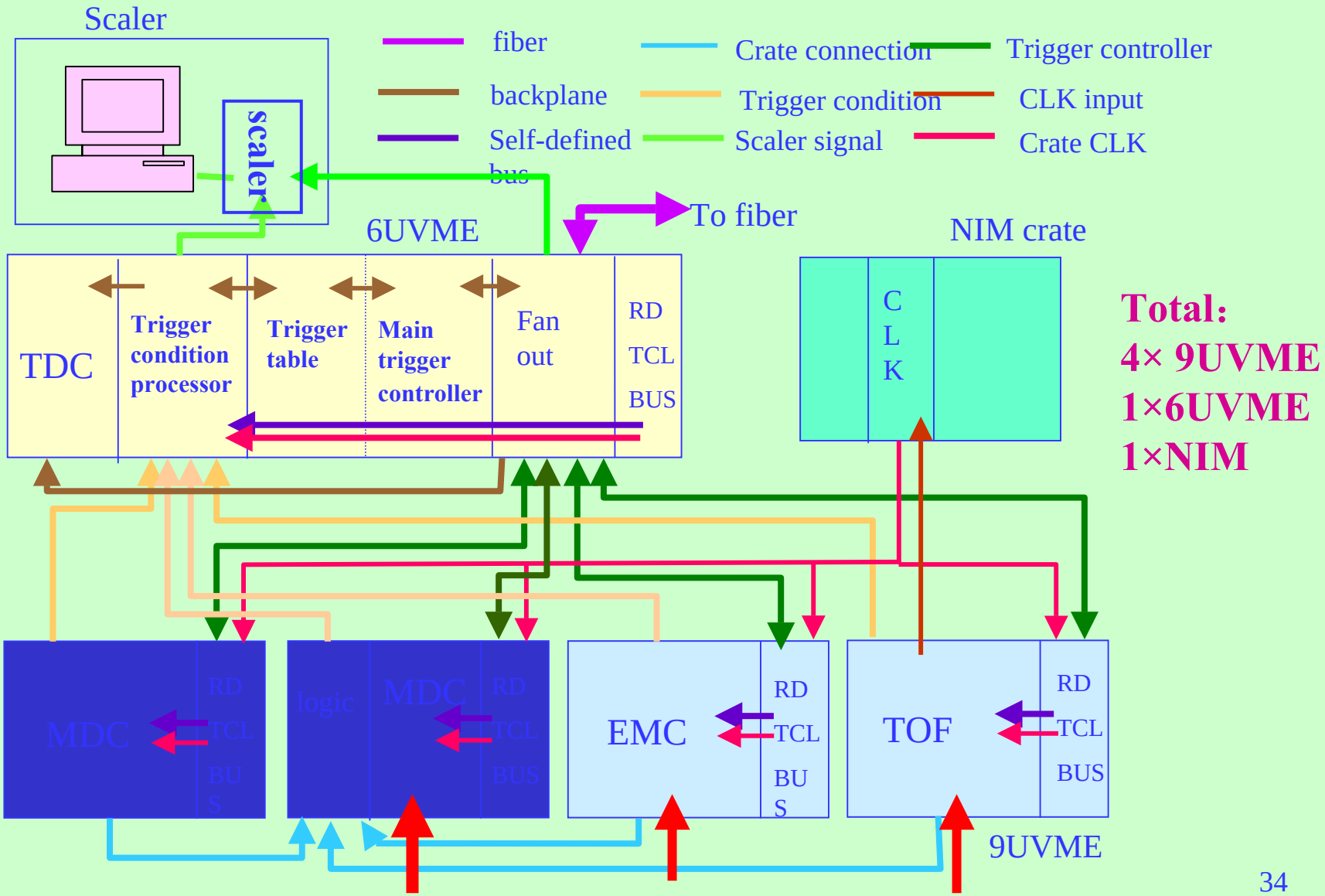
Electronics

- Drift chamber: 6500ch, $s_t \sim 500$ps, $s_q \sim 5$ fc, 10bit ADC **IHEP**
- calorimeter: 6300ch,$s_q \sim 0.5$fc, 3×10bit ADC,noise < 1000ENC
- TOF: 500ch, $s_t \sim 20$ ps, 10bit ADC **USTC**
- RPC: 10000ch, bit map
- Prototype and beam test all meet the design spec.
- Mass production completed
- Some tested with full trigger/DAQ system

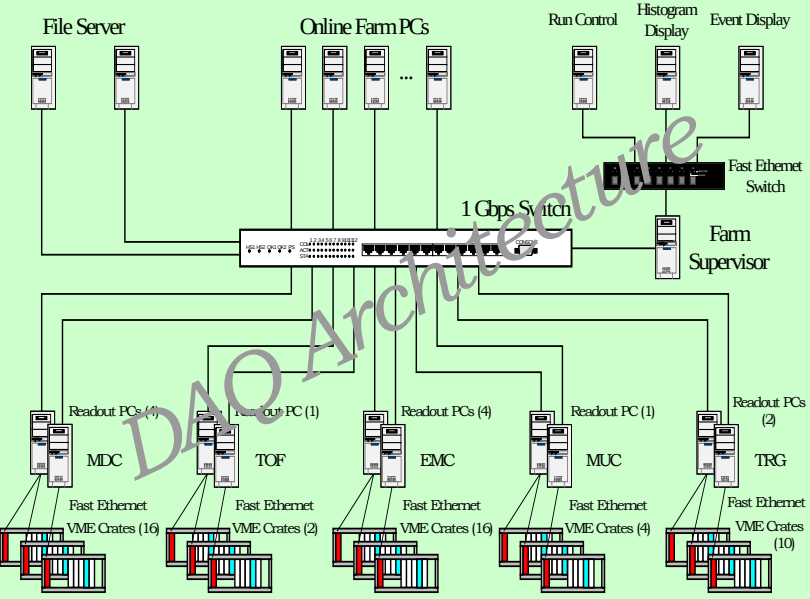


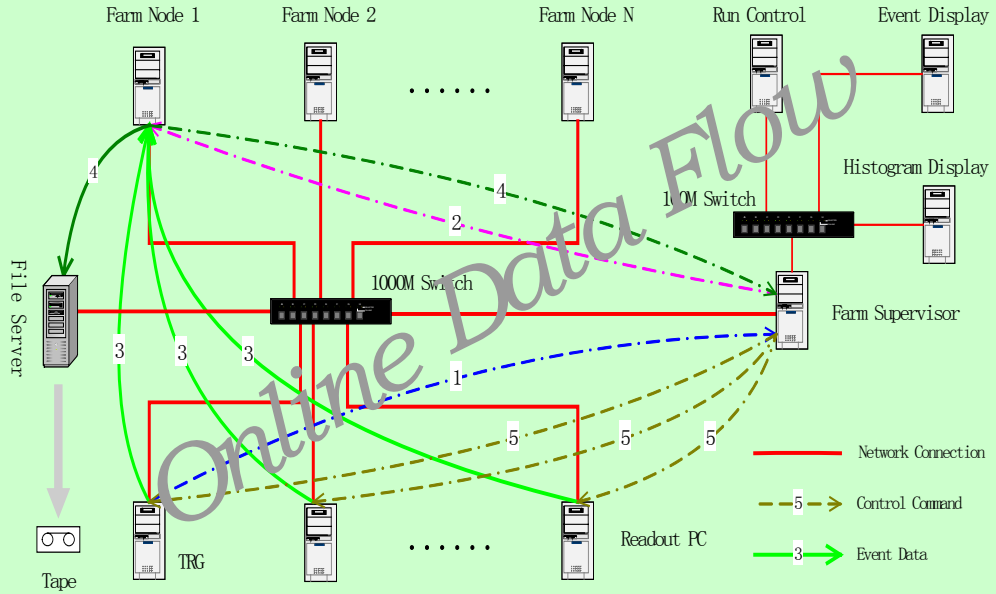


Trigger system hardware structure



DAQ & online software



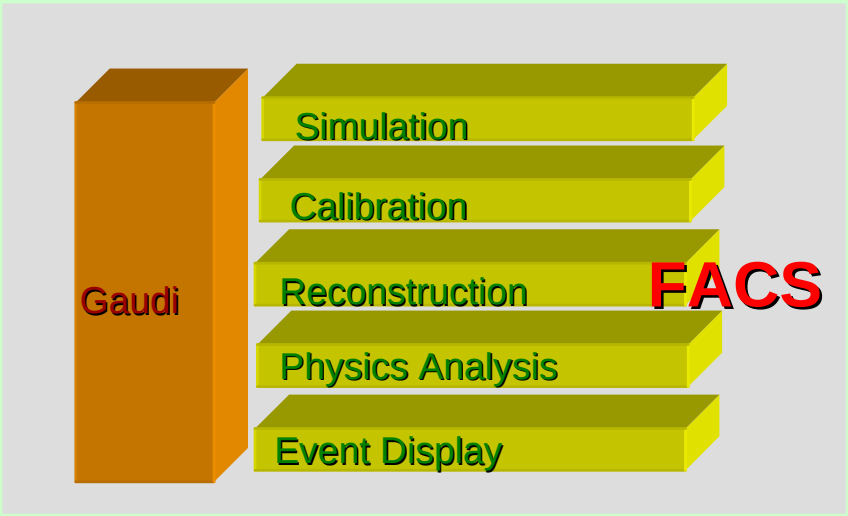


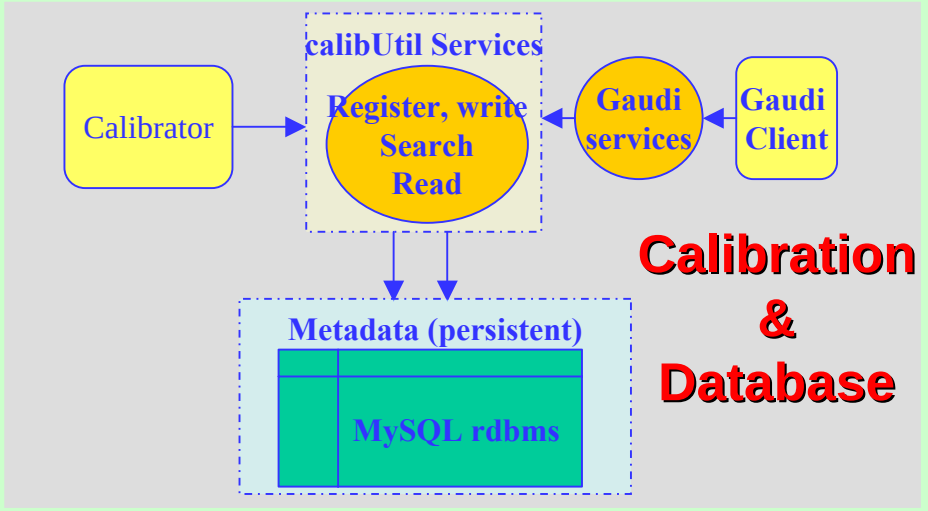
Key technical issued solved(speed, network, CPU, etc…)

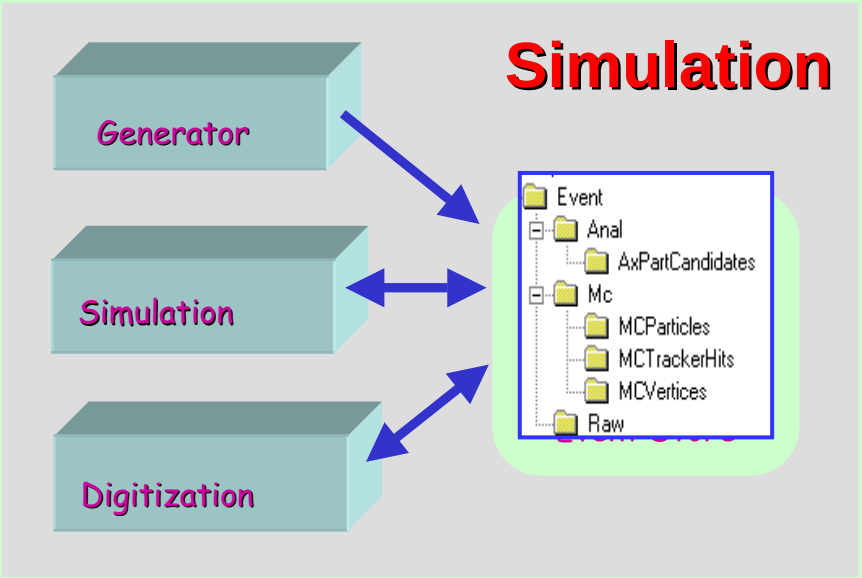
specification: ~50Mb/s, 4000 Hz,

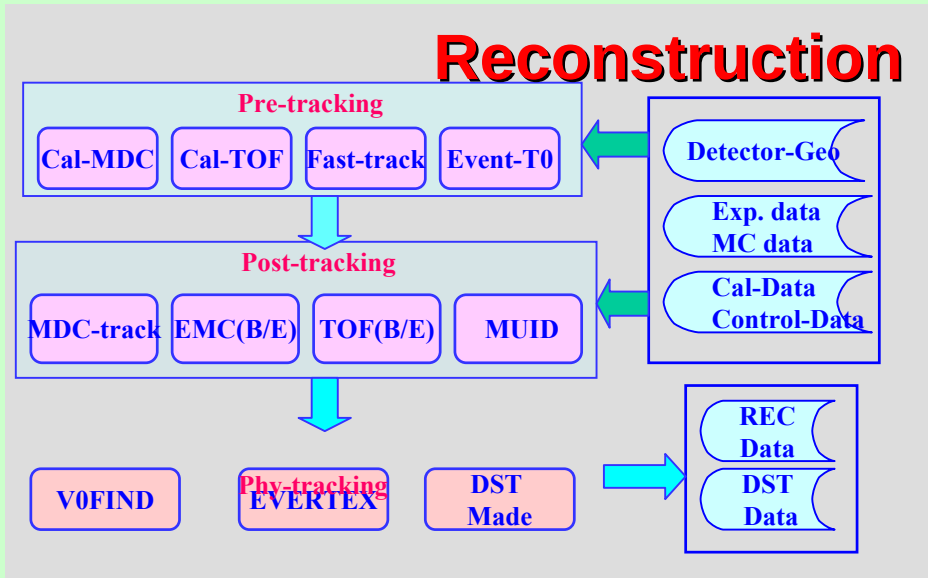
10 ×B-factory, 1000 × BESII

Offline software system



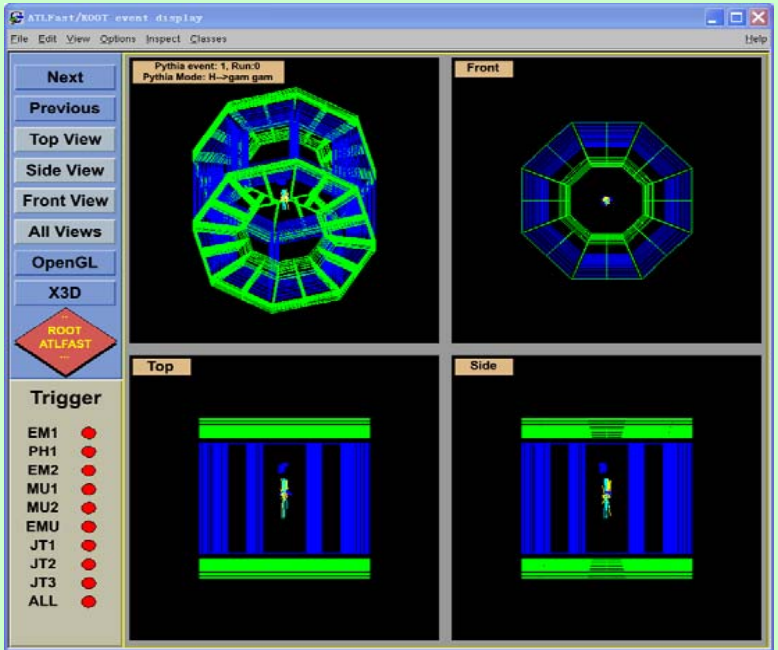


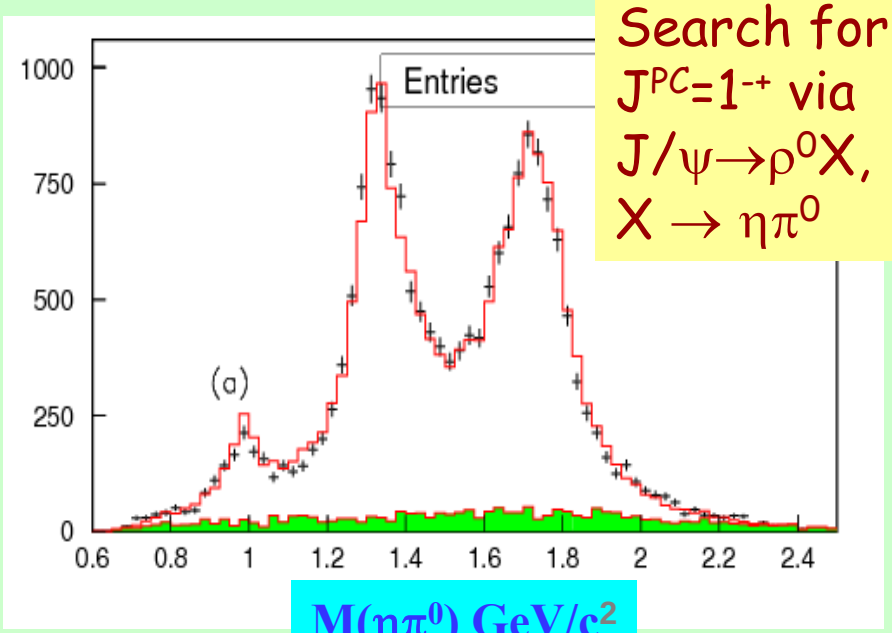




Monte Carlo simulation

- **GEANT4 based simulation framework completed**
- **Geometry, material and detector response completed**
- **Real detector response including 3D magnetic field, noise, trigger, bunch size etc completed**
- **All tested by reconstructed physics events**
- **Many generators, some are new for tau-chram physics**
- **Stable operation, large data sample generated**

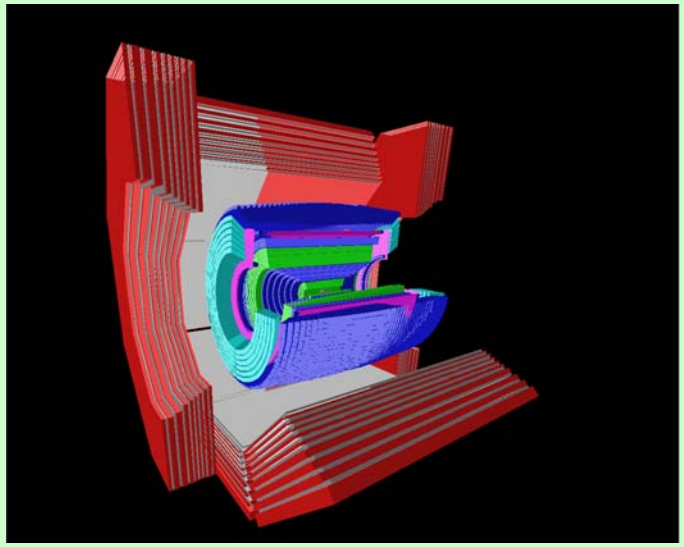


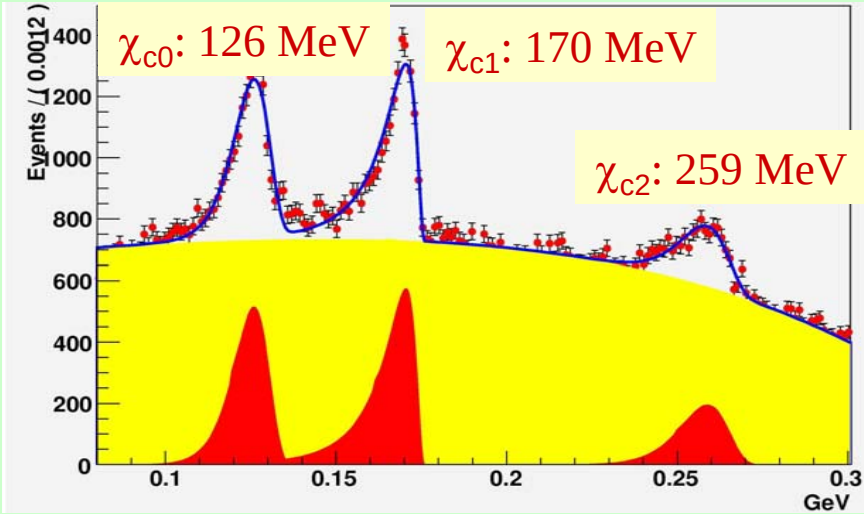


Search for $J^{PC}=1^{-+}$ via $J/\psi \to \rho^0 X$, $X \to \eta\pi^0$

Event reconstruction and calibration

- Gaudi based framework completed
- Sub-detector reconstruction and calibration almost completed:
  - Kalman-filter based track fitting
  - Basic calibration algorithm established
  - No-bias Event reconstruction
  - Resolution in agreement with specification
  - Timing zero can be reconstructed
  - Secondary vertex can be reconstructed
  - Online event filter
  - Stable operation for physics studies





Inclusive γ spectrum in ψ(2S) decays

Schedule

- 2/2003: Official approval of the project
- 7/2004: BESII detector shutdown
- 5/2005: Magnet yoke & muon chamber installation
- 9/2006: Super-conducting magnet cool down
- 8/2007: Magnetic field mapping finished
- 10/2007: EMC installation done
- 10/2007: MDC/TOF installation starts
- 1/2008: Cosmic-ray tests
- 3/2008: BESIII detector in beam line
- Summer 2008: Start data taking (test run)

Barrel EMC installed in the yoke

Now mounting barrel TOF to MDC, assembling endcap EMC

BESIII collaboration

USA (2)

University of Hawaii

University of Washington

Europe (4)

GSI, Germany

University of Bochum, Germany

University of Giessen, Germany

JINR, Dubna, Russia

Japan (1)

Tokyo University

China (22)

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.

Summary

- **BEPCII/BESIII construction is close to completion**
- **BESIII assembly and installation will be finished this year, physics run will start next summer**
- **Physics and software preparation underway**
- **We are excited about the great physics opportunities at BESIII (will contribute a lot to Quarkonium Physics), and we welcome new collaborators**

Thanks a lot!

What is the first running energy?

- Easy to collide (accelerator)
- High event rate (detector collibration)
- Good for physics