BES III @ BEPC 2

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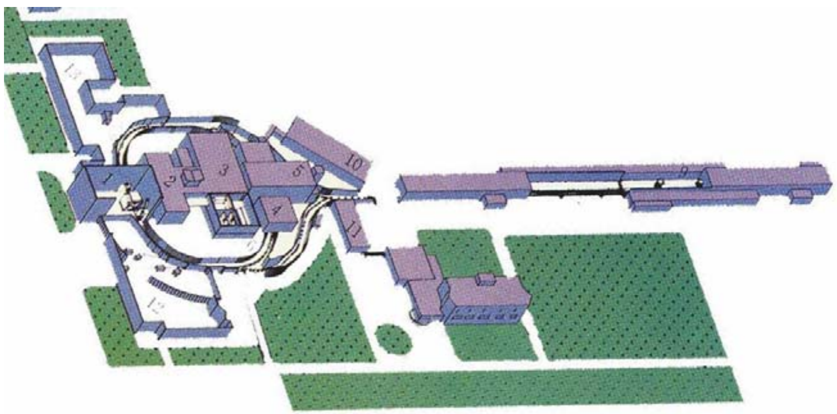
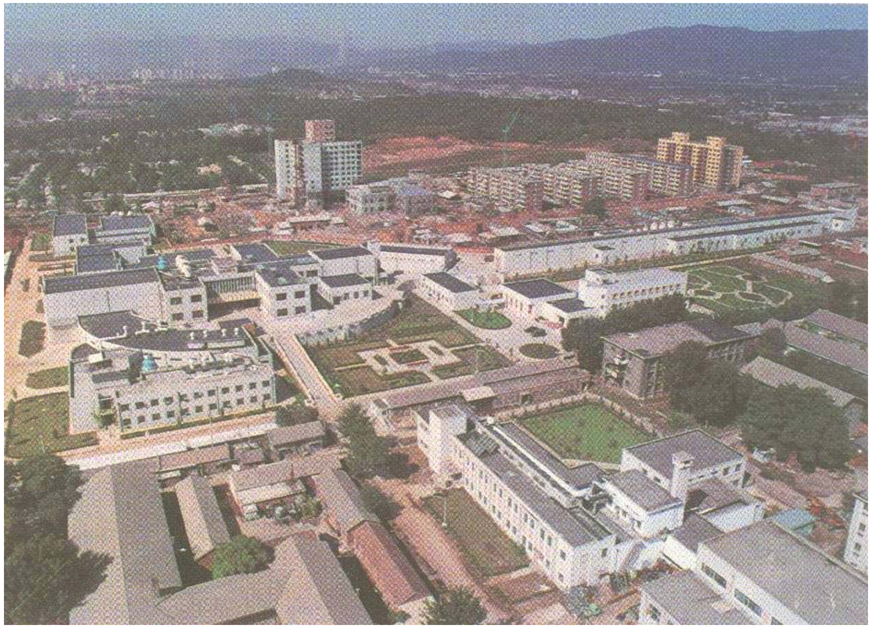
DESY, Hamburg, 19.12.2006

The "old" Beijing Electron Positron Collider BEPC

$L \sim 5 \times 10^{30} /cm^2 \cdot s$ @ J/ψ peak

$E_{cm} \sim$ 2-5 GeV



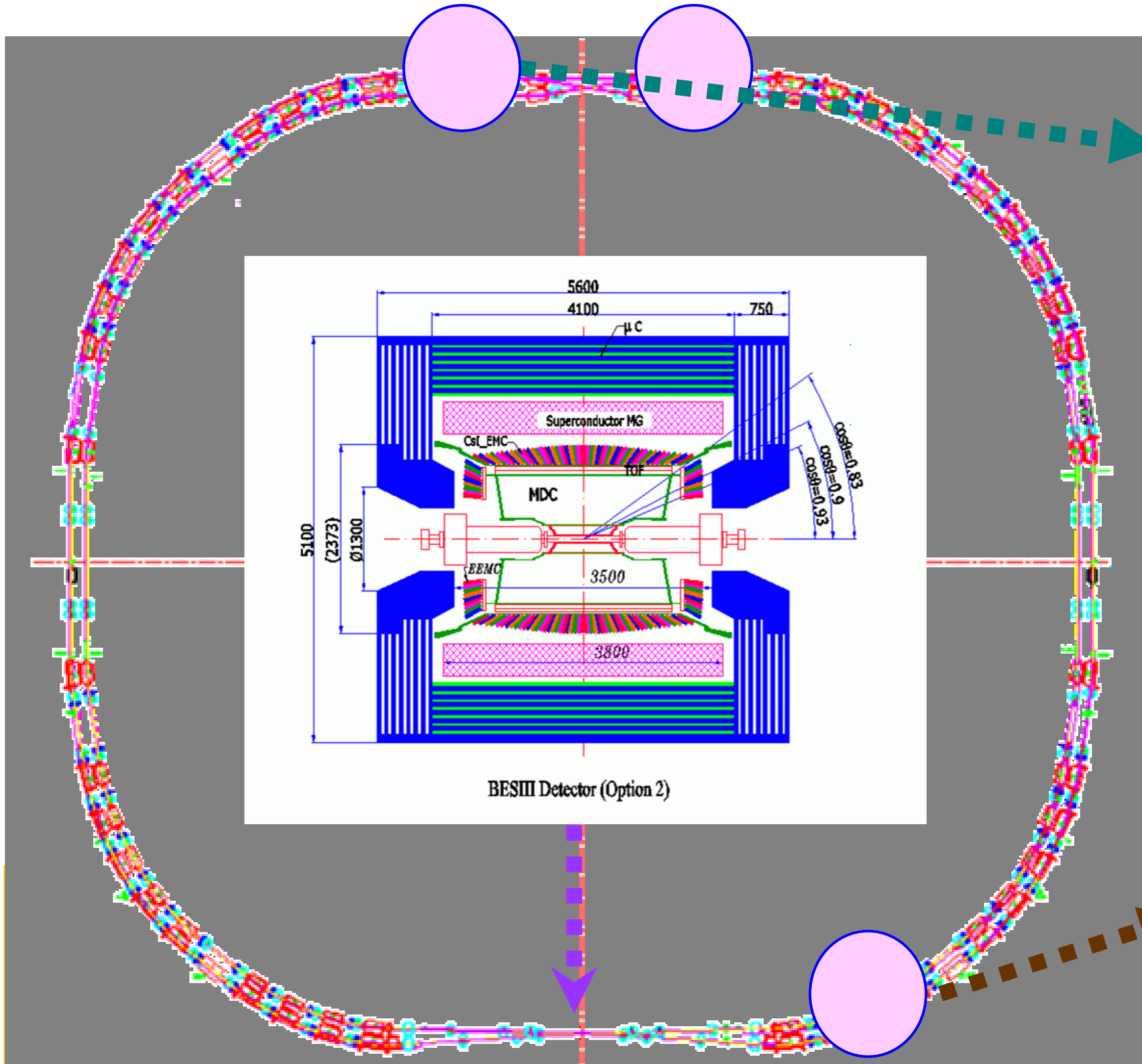


A unique e^+e^- machine in the τ–charm energy region since 1989.

BEPCII Design Goals

Energy range	1 – 2 GeV
Optimum energy	1.89 GeV
Luminosity	1×10^{33} cm^{-2}s^{-1} @ 1.89 GeV
Injection	Full energy injection: 1.55 - 1.89 GeV Positron injection speed > 50 mA/min
Synchrotron mode	250 mA @ 2.5 GeV

BEPCII: a high luminosity double–ring collider

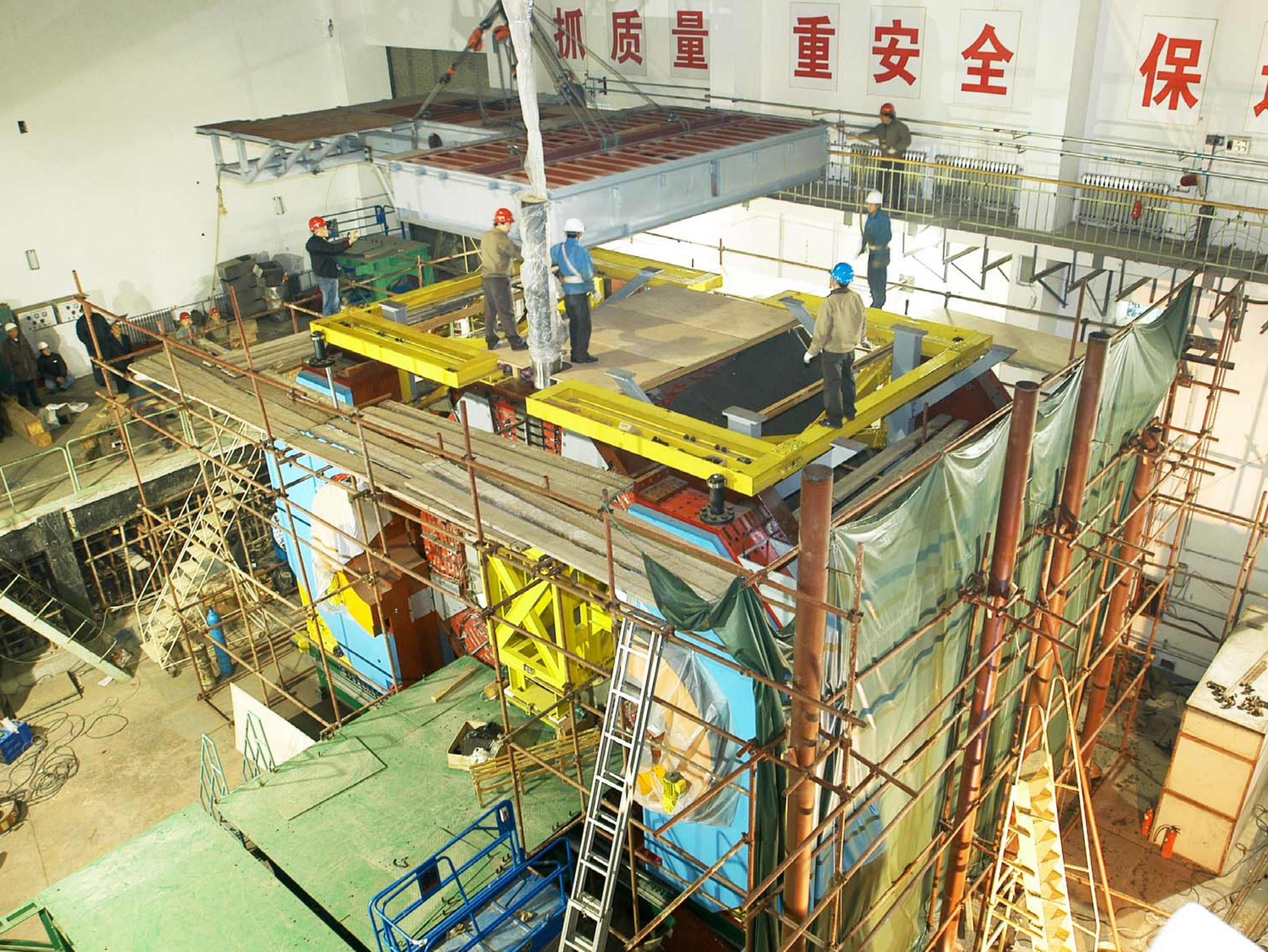


SC RF

Beams

BEPCII Status

• BEPCII linac installation completed in 2005; most design specifications reached.
• Storage ring: Major magnets, superconducting RF cavities and quadrupole magnets, as well as the cryogenics system have been completed, and their installation is complete.
•Beam collisions expected in summer/fall 2007.


抓质量 重安全 保

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Expected Event statistics at BESIII

Physics Channel	Energy (GeV)	Luminosity (10^{33} $cm^{-2}s^{-1}$)	Events/year
J/ψ	3.097	0.6	1.0×10^{10}
τ	3.67	1.0	1.2×10^{7}
ψ'	3.686	1.0	3.0×10^{9}
D	3.77	1.0	2.5×10^{7}
D_s	4.03	0.6	1.0×10^{6}
D_s	4.14	0.6	2.0×10^{6}

Average $\mathcal{L}$ = 0.5×Peak $\mathcal{L}$; One year T = 10^7s

CLEO-c : the context (Ian Shipsey)

This Decade

Flavor Physics: “the sin2β era” Precision !
Over constrain CKM matrix with precision measurements. Limiting factor: non-pert. QCD.

The Future

LHC may uncover strongly coupled sectors in the physics that lies beyond the Standard Model
The ILC will study them. Strongly-coupled field theories are an outstanding challenge to theoretical physics. Critical need for reliable theoretical techniques & detailed data to calibrate them.

The Lattice

Complete definition of pert & non. Pert.QCD. Matured over last decade, can calculate to 1-5% B, D, Y, ψ,…

Charm at threshold can provide the data to calibrate QCD techniques

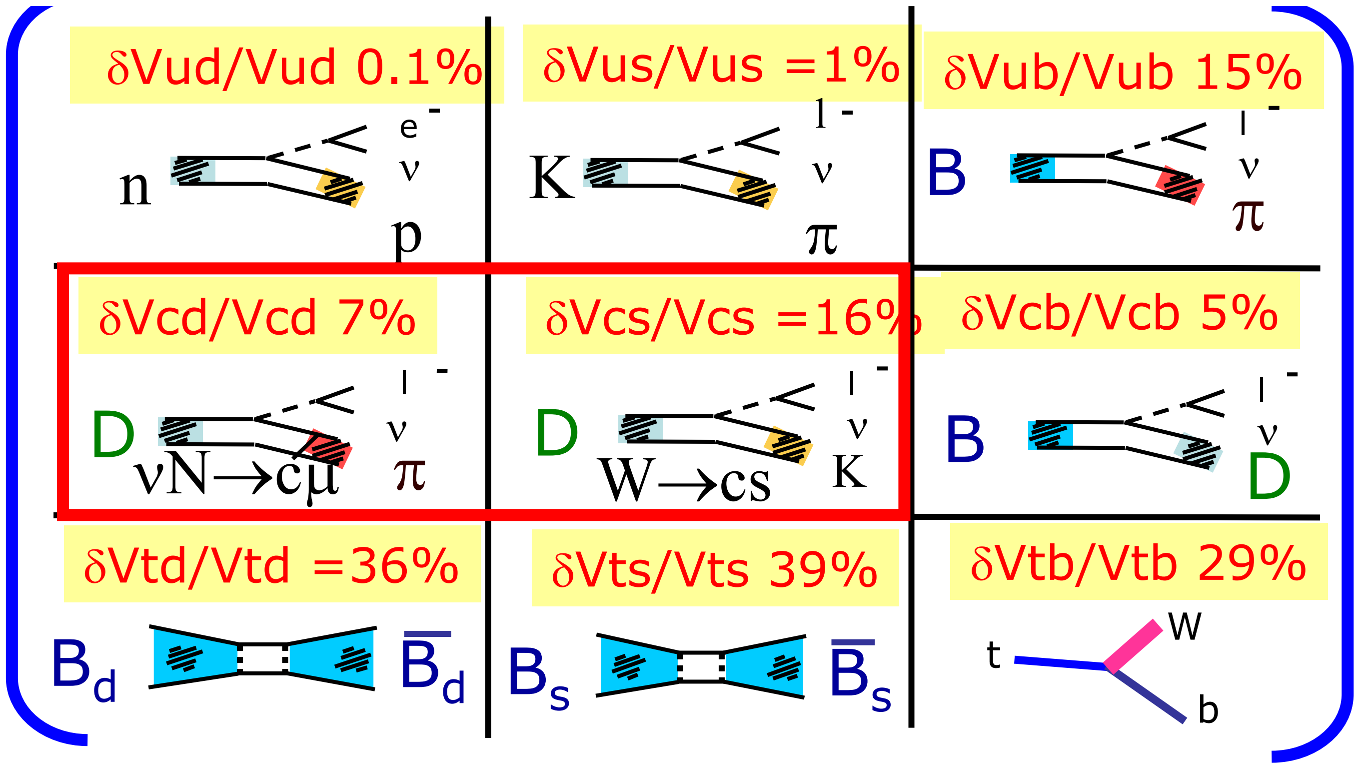
Precision Quark Flavor Physics

Goal for the decade: high precision measurements of V_{ub}, V_{cb}, V_{ts}, V_{td}, V_{cs}, V_{cd}, & associated phases.

Over-constrain the "Unitarity Triangles"

Inconsistencies □ New physics !

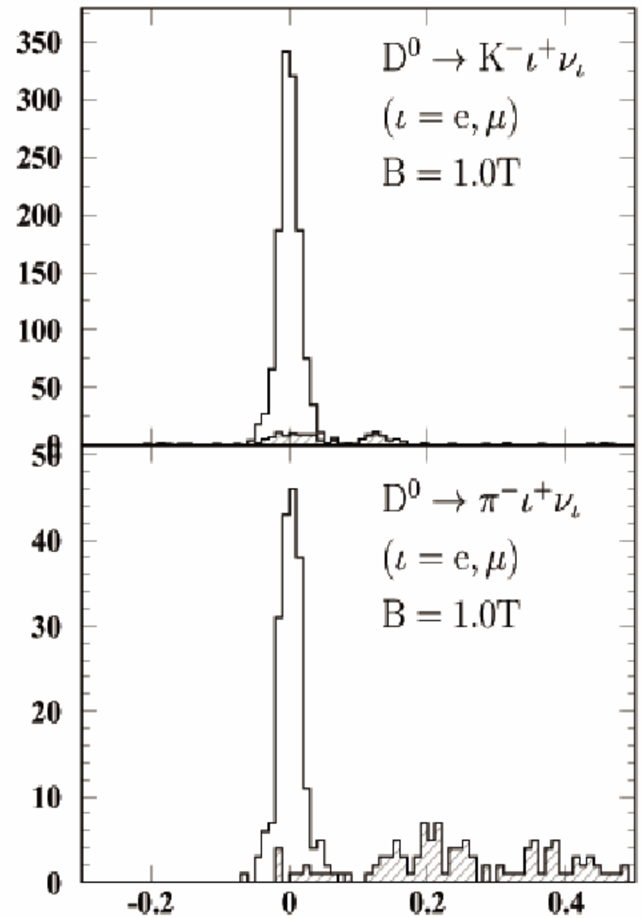
CKM Matrix Current Status:



Many experiments will contribute. Measurement of absolute charm branching ratios will enable precise 1st column unitarity test & new measurements at B-factories/Tevatron/LHC to be translated into greatly improved CKM precision.

semi-leptonic decays

Decay Mode	Input Br(%)	Eff.	Stat. Errors	CKM Elements
$D^0 \rightarrow K^- e^+ \nu_e$	3.4%	54.6%	0.6 %	V_{cs}
$D^0 \rightarrow K^- \mu^+ \nu_\mu$		30.5%		
$D^0 \rightarrow \pi^- e^+ \nu_e$	0.4%	62.2%	1.6%	V_{cd}
$D^0 \rightarrow \pi^- \mu^+ \nu_\mu$		44.3%		
$D^+ \rightarrow \overline{K^0} e^+ \nu_e$	8.5%	6.7%	1.6%	V_{cs}
$D^+ \rightarrow \overline{K^0} \mu^+ \nu_\mu$		3.7%		



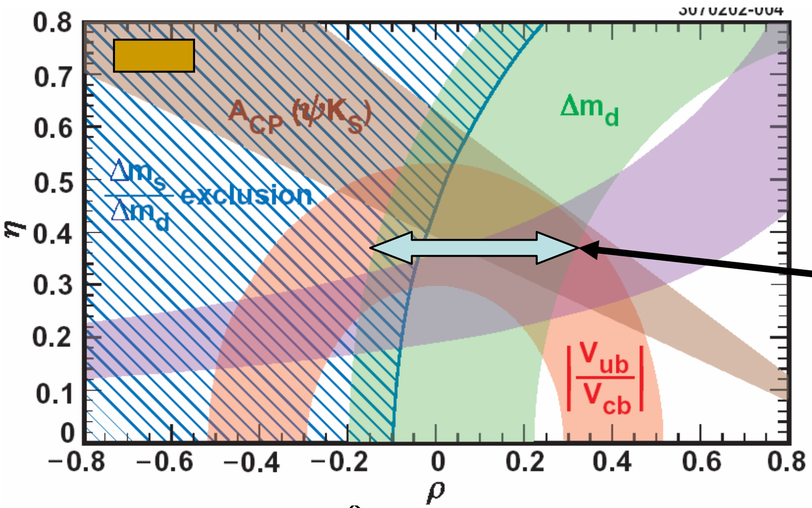
$E_{missing}$-$P_{missing}$ [GeV]

$$\Delta V_{cs} / V_{cs} = 1.6\%,$$

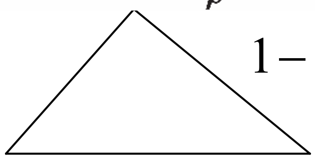
$$\Delta V_{cd} / V_{cd} = 1.8\%$$

Importance of measuring absolute charm leptonic branching ratios: f_D & f_{Ds} → V_{td} & V_{ts}

η



ρ



$$\Delta M_d = 0.50\, ps^{-1} \left[\frac{\sqrt{B_{B_d}}\, f_{B_d}}{200 MeV} \right]^2 \left[\frac{|V_{td}|}{8.8 \times 10^{-3}} \right]^2$$

$$\frac{\sigma(\rho)}{\rho} = 0.5 \frac{\sigma(\Delta M_d)}{\Delta M_d} \oplus \frac{\sigma(f_B \sqrt{B_{B_d}})}{f_B \sqrt{B_{B_d}}}$$

(LP03) 1.2%   ~15% (LQCD)

~5-7% $$\frac{\Delta M_d}{\Delta M_s} \propto \left[\frac{\sqrt{B_{B_d}}\, f_{B_d}}{\sqrt{B_{B_s}}\, f_{B_s}} \right]^2 \left[\frac{|V_{td}|}{|V_{ts}|} \right]^2$$

Lattice predicts f_B/f_D & f_{Bs}/f_{Ds} with small errors
If precision measurements of f_D & f_{Ds} existed
We could obtain precision estimates of f_B & f_{Bs}
and hence precision determinations of V_{td} and V_{ts}
Similarly f_D/f_{Ds} checks f_B/f_{Bs}

$$\frac{\delta f_{D_c}}{f_{D_c}} \sim 14\%$$

$$\frac{\delta f_{D_c}}{f_{D_c}} \sim 100\%$$

Pure Leptonic decays

Decay Modes	Decay Constant	Branching ratios	Life time	CKM Elements	Precision of decay constants
$D^+ \to \mu^+ \nu$	f_D	2.4%	1.2%	1.8%	3.0%
$D^+_s \to \mu^+ \nu$	f_{Ds}	1.7%	1.8%	0.1%	2.5%

One year of running
One year of running

DDbar Mixing at BESIII

- D⇆ mixing in SM $\sim 10^{-3}$ - 10^{-10}
- D⇆ mixing sensitive to "new physics"
- Our sensitivity : $\sim 10^{-4}$
- D^0 ⇆^{0} ♑ $(K^-\pi^+)(K^+\pi^-)$

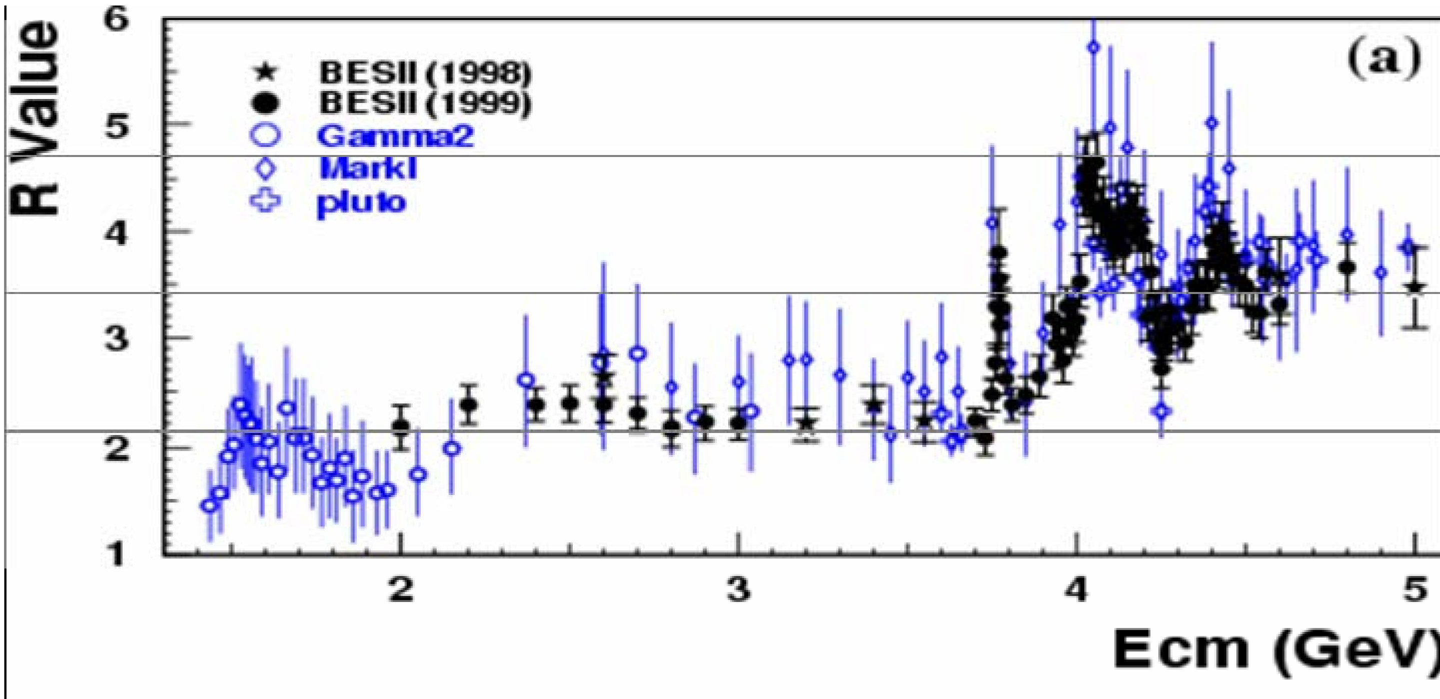
  Acceptance: $\sim$ 40%

  Background: $\sim 10^{-4}$

QCD and hadron production

- R-value measurement
- pQCD and non-pQCD boundary
- Measurement of α_s at low energies
- Hadron production at J/ψ, ψ', and continuum
- Multiplicity and other topology of hadron event
- BEC, correlations, form factors, resonance, etc.

R-value measurement



Error on R	$\Delta\alpha^{(5)}_{had}(M_Z^2)$
5.9%	0.02761 ±0.00036
3%	0.02761 ±0.00030
2%	0.02761 ±0.00029

R-value below
2 GeV is important,

via radiative return

Scan of the resonance region @ 3.7 - 4.6 GeV

Test isospin symmetry far away from open charm threshold!
Since the EM effect may be significant far away from DD threshold!

$$f(E_{cm}) = \frac{\sigma(e^+e^- \to D^+\overline{D^{-(*)}})}{\sigma(e^+e^- \to D^0\overline{D^{0(*)}})},$$

Could possible EM contribution affect the ratio?
Interference effect:

$$\sigma \propto \left| A(e^+e^- \to \gamma^* \to D\overline{D^*}) + A(e^+e^- \to c\bar{c} \to D\overline{D^*}) \right|^2$$

If a relatively narrow glueball or exotic state I =0 with a vector 1^{--} occurs somewhat above the DD* threshold, it would manifest itself via variation or deviation from QCD prediction.

 scan @ 3.7 - 4.6 GeV may indicate existence of 1^{--} exotic states.

It will be very helpful to make a fine scan of the ratio @ 3.7 - 4.6 GeV, so that one can understand the formation of DD system near or above the threshold

Scan of the resonance region @ 3.7 - 4.6 GeV

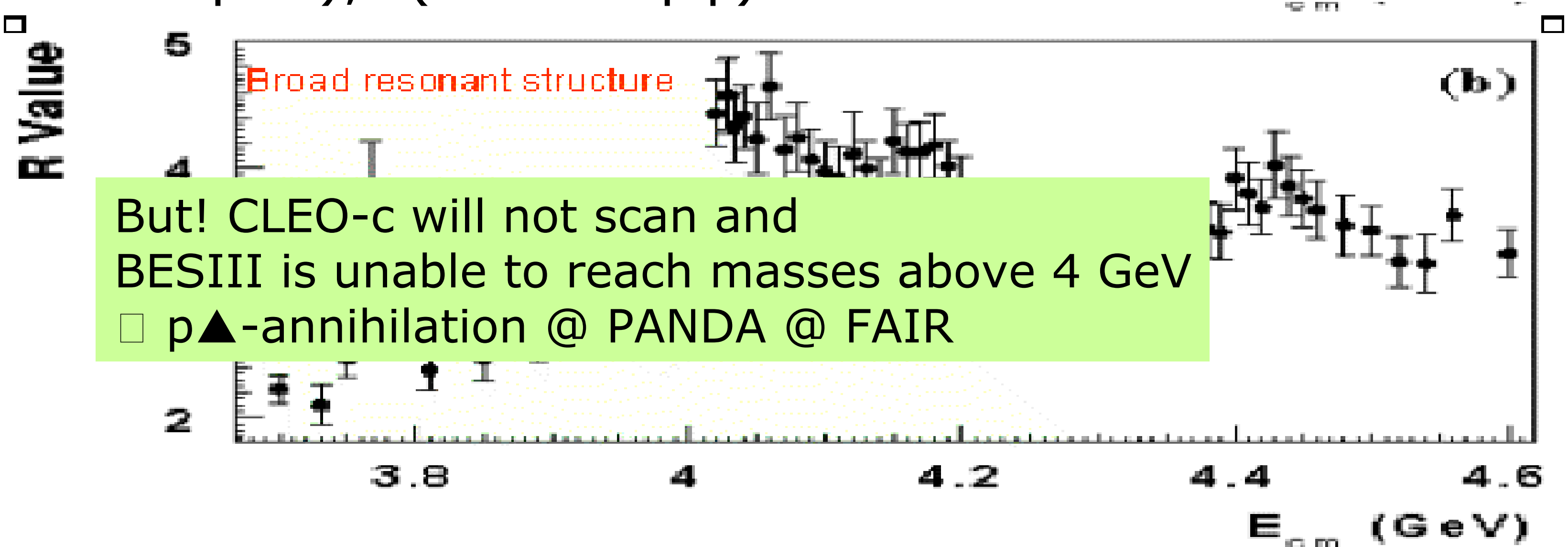
$\sigma(e^+e^- \to D\overline{D}^{(*)}), \sigma(e^+e^- \to D_S^+ D_S^{-(*)}),$ → Test QCD @ 3.7 ÷ 4.6 GeV

$\sigma(e^+e^- \to J/\psi\pi^+\pi^-), \sigma(e^+e^- \to \chi_{cJ}\rho(\omega))$ → Search for exotic c⇨, Y(4260)

$\sigma(e^+e^- \to \varphi\pi\pi), \sigma(e^+e^- \to \eta' J/\psi)$

$\sigma(e^+e^- \to \varphi KK), \sigma(e^+e^- \to \eta'\varphi)$

→ Probe gluon enhanced hidden c⇨ states



But! CLEO-c will not scan and
BESIII is unable to reach masses above 4 GeV
□ p▲-annihilation @ PANDA @ FAIR

Light hadron spectroscopy

- Baryon spectroscopy
- Charmonium spectroscopy
- Glueball searches, rad. J/ψ
- Search for non-$q\bar{q}$ states

- Not forgeting the huge field of

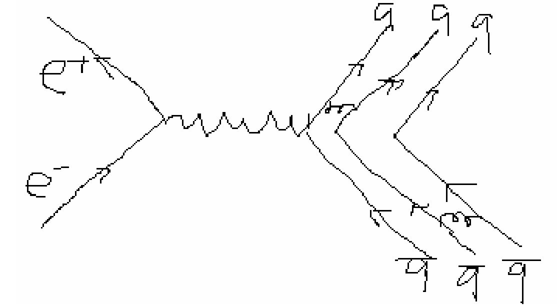
τ–Physics

QCD and $e^+e^- \to B\bar{B}$ 1.88-2.8 GeV

Experimental data from FENICE collaboration near the threshold:

$$\frac{\sigma(e^+e^- \to p\bar{p})}{\sigma(e^+e^- \to n\bar{n})} = 0.66^{+0.16}_{-0.11}$$

A.Antonelli et al Nucl. Phys. B 517, 3(1998)



However, exact QCD predict :

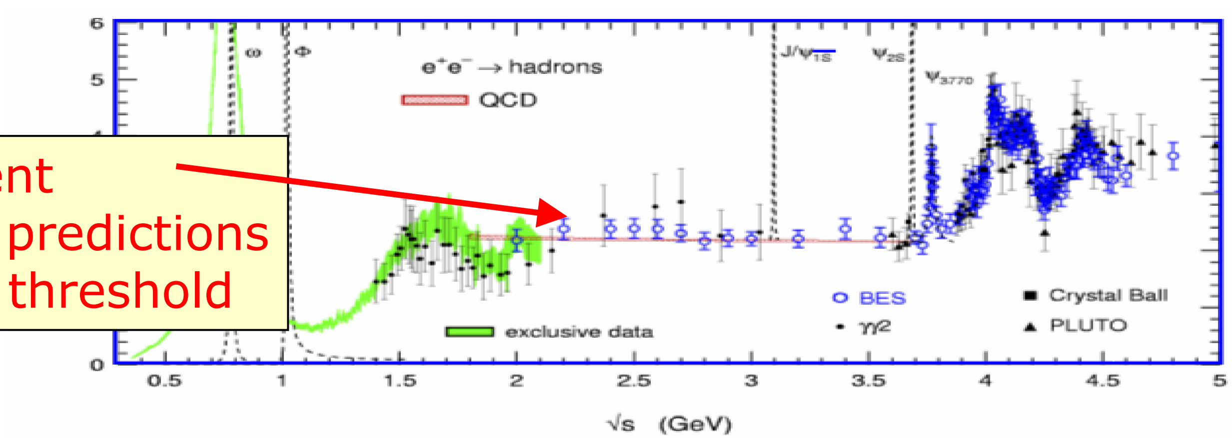
$$\frac{\sigma(e^+e^- \to p\bar{p})}{\sigma(e^+e^- \to n\bar{n})} \to \approx \frac{Q_u^2}{Q_d^2} = 4$$

Puzzle!

Especially when uubar are primary quark pairs from time like photon for proton pair production !

Precise measurements of
e^+e^- □ p▲, n↔, n(p)
n(K) will be very useful
at BESIII.

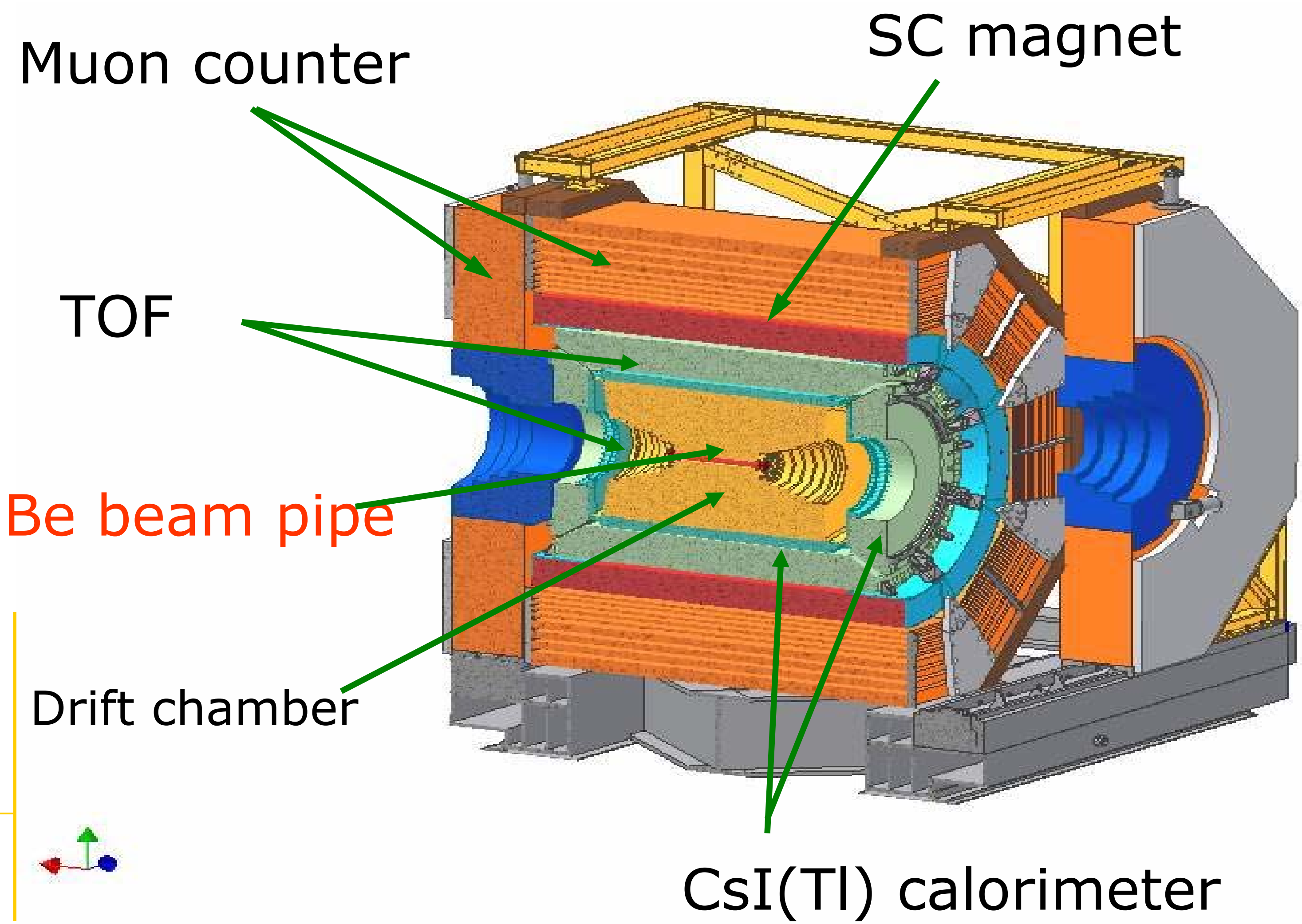
BESII R measurement
1σ above the pQCD predictions
above the BB open threshold



Errors on R at BESIII

Error sources	BESII (%)	BESIII (%)
Luminosity	2 - 3	1
Detection efficiency	3 - 4	1 - 2
Trigger efficiency	0.5	0.5
Radiative corrections	1 - 2	1
Hadron decay model	2 - 3	1 – 2
Statistics	2.5	--
Total	6 – 7	2 - 3

BESIII Detector

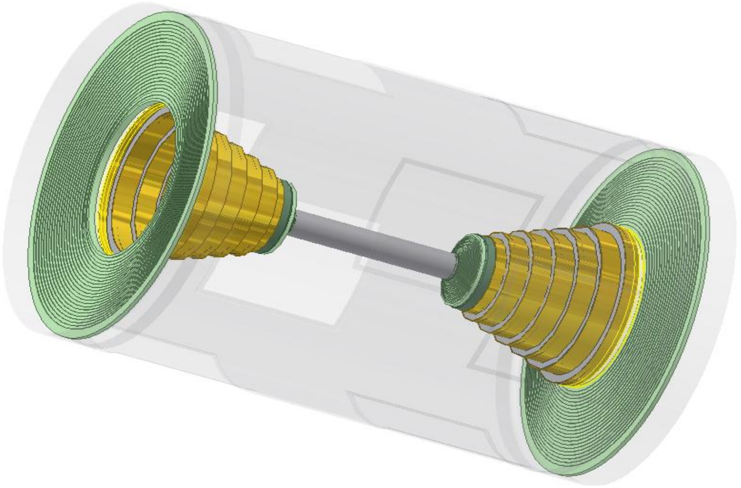


Main Drift Chamber

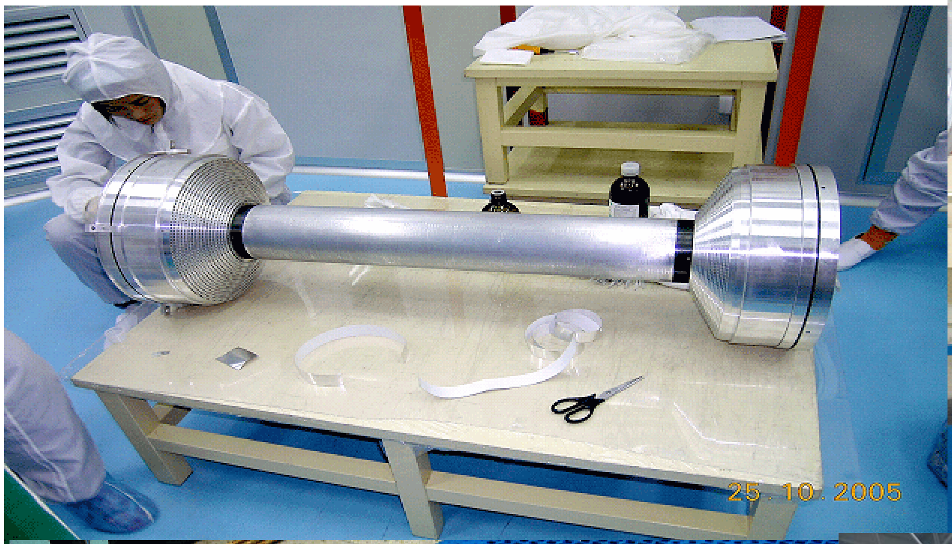
- Size ø 63 mm - 810 mm length: 2400 mm
  - inner cylinder: 1 mm Carbon fiber
  - outer cylinder: 10 mm CF with 8 windows
- End flange: 18 mm thick Al 7075 (6 steps)
- 7000 Signal wires : 25 (3% Rhenium) um gold-plated tungsten
- 22000 Field wires: 110 um gold-plated Aluminum
- Small cell: inner 6*6 mm^2, outer 8.2 *8.2 mm^2,
- Gas: He + C_3H_8 (60/40)
- Momentum resolution (@ 1 GeV/c)

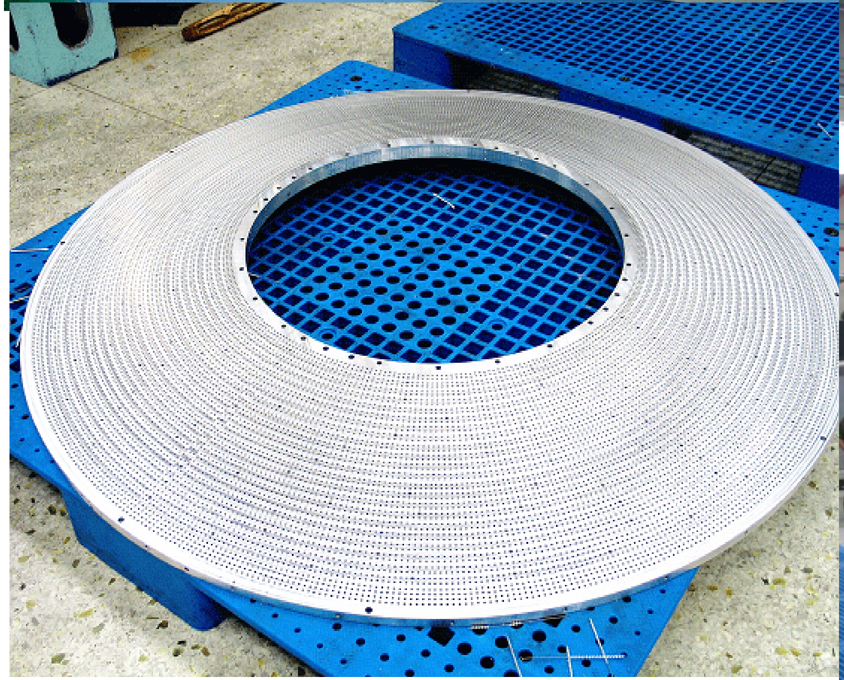
$$\frac{\sigma_{P_t}}{P_t} = 0.32\% \oplus 0.37\%$$

- dE/dX resolution: 6-7%



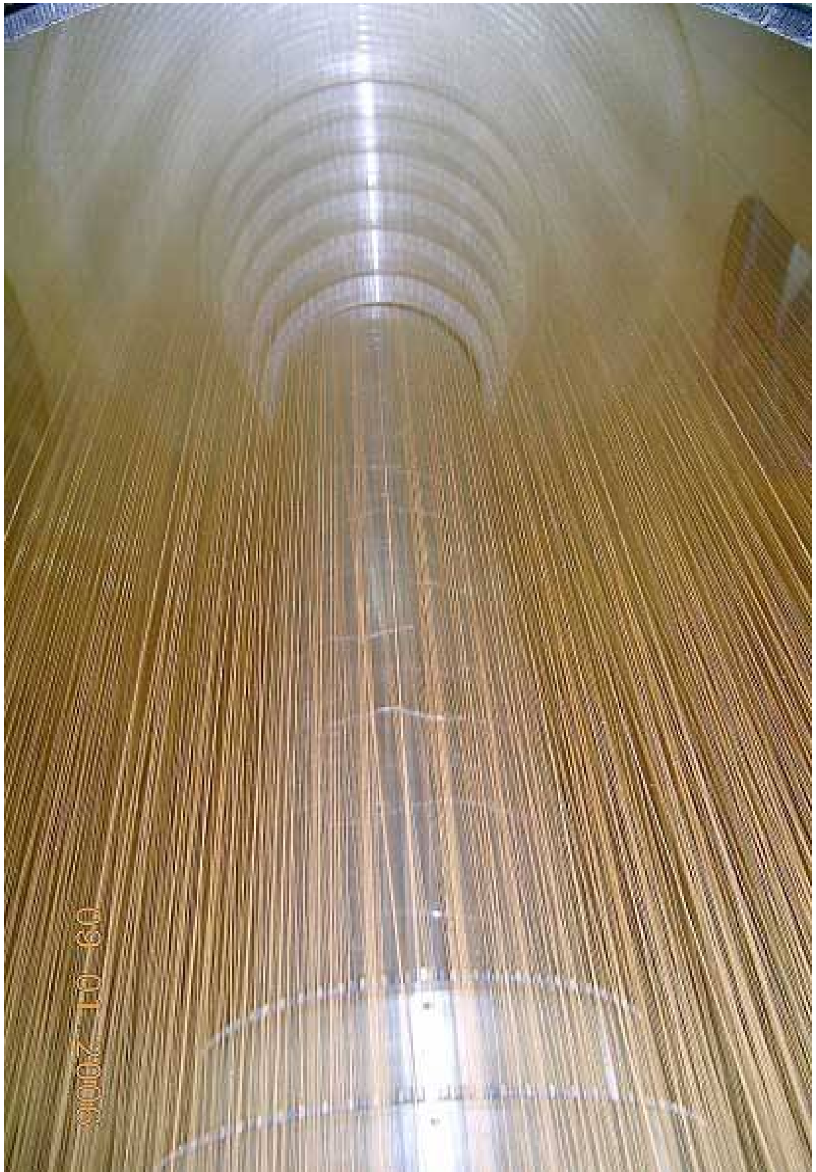
Main Drift Chamber





Main Drift Chamber

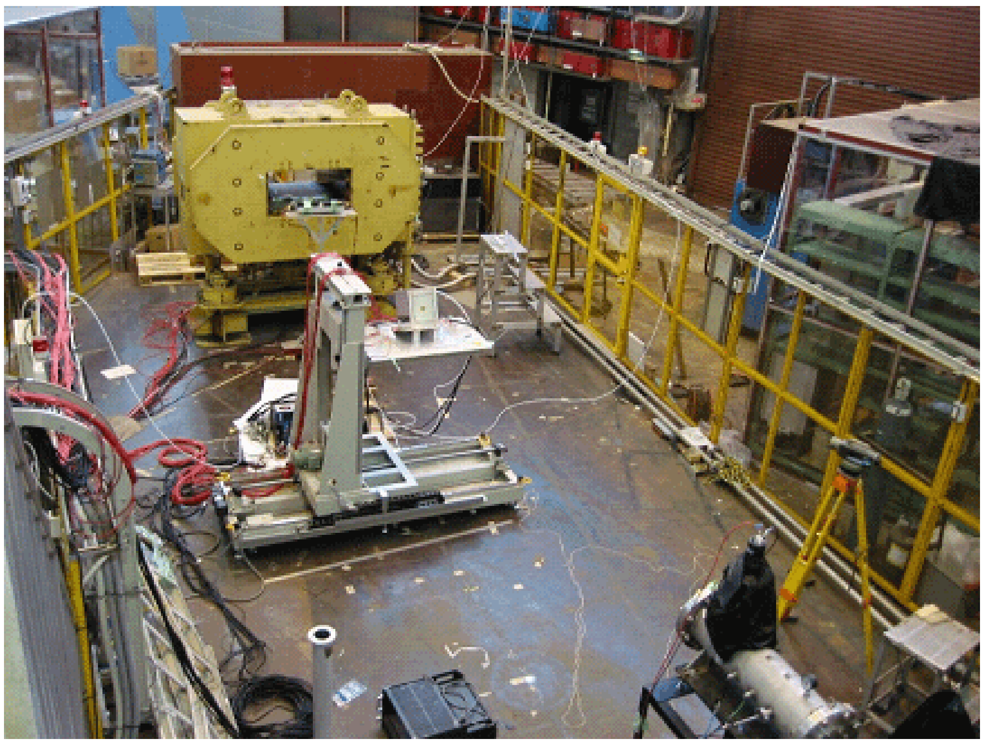
MDC Status: Wire stringing complete
Preamp installation complete
Cosmic ray running in progress

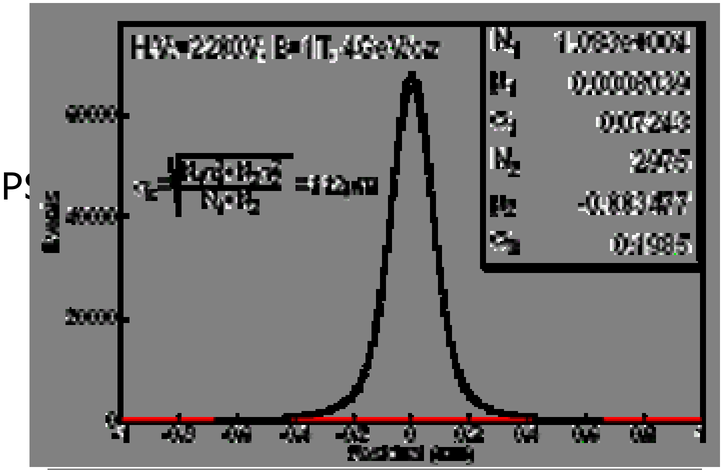


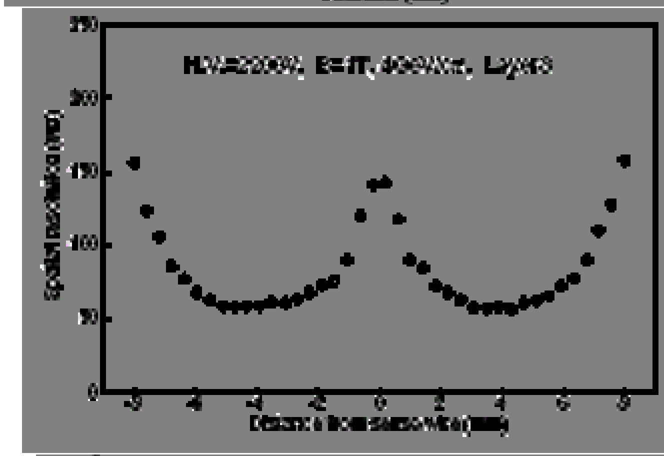
Beam test at KEK

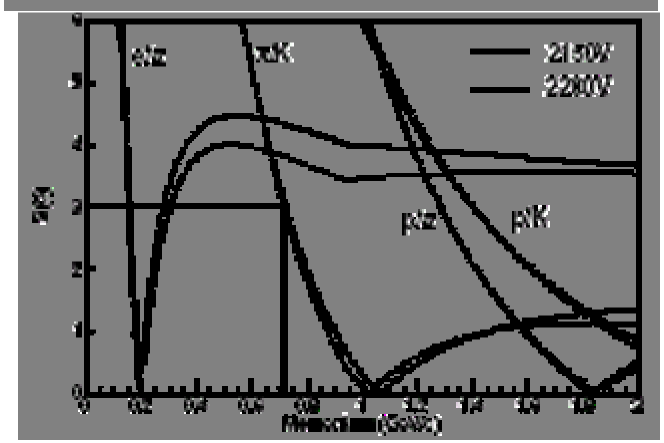
Prototype tested in a 1T magnetic field at KEK 12GeV PS
Results:

- spatial resolution better than 130 μm
- cell efficiency over 98%
- dE/dX resolution better than 5%
  (3σπ/K separation exceeding 700MeV/c).



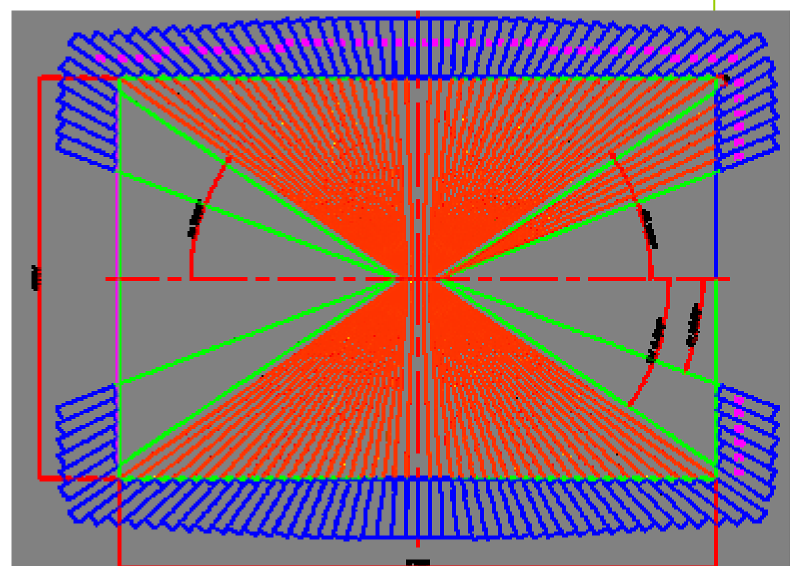




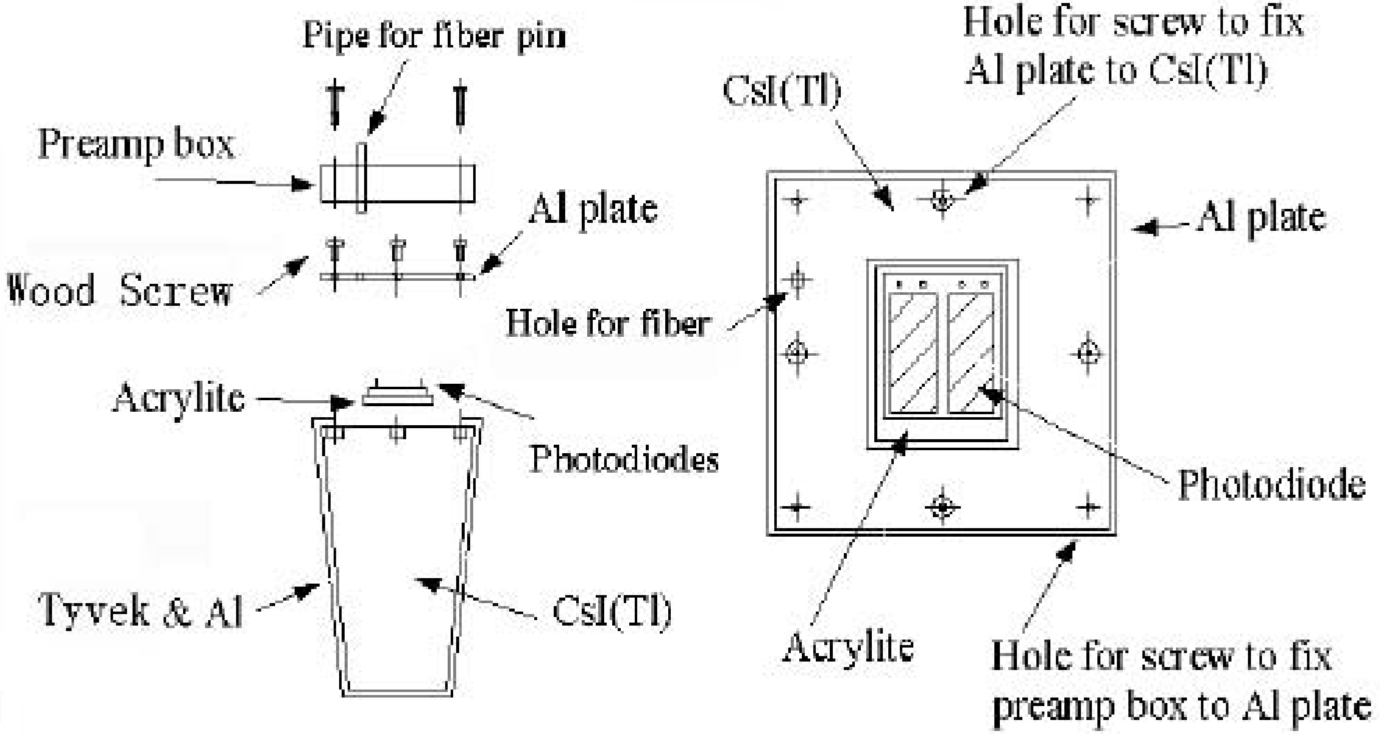


EMC: CsI(Tl) crystals

- 6300 crystals, (5.2x 5.2 – 6.4 x 6.4) x 28cm^3 (15 X_0)
- PD readout, noise ~1100 ENC
- Energy resolution: 2.5%@1GeV
- Position resolution: 5mm@1GeV
- Tiled angle: theta ~ 1.3^o, phi ~ 1.5^o
- Minimum materials between crystals



CsI(Tl) crystal detector cell

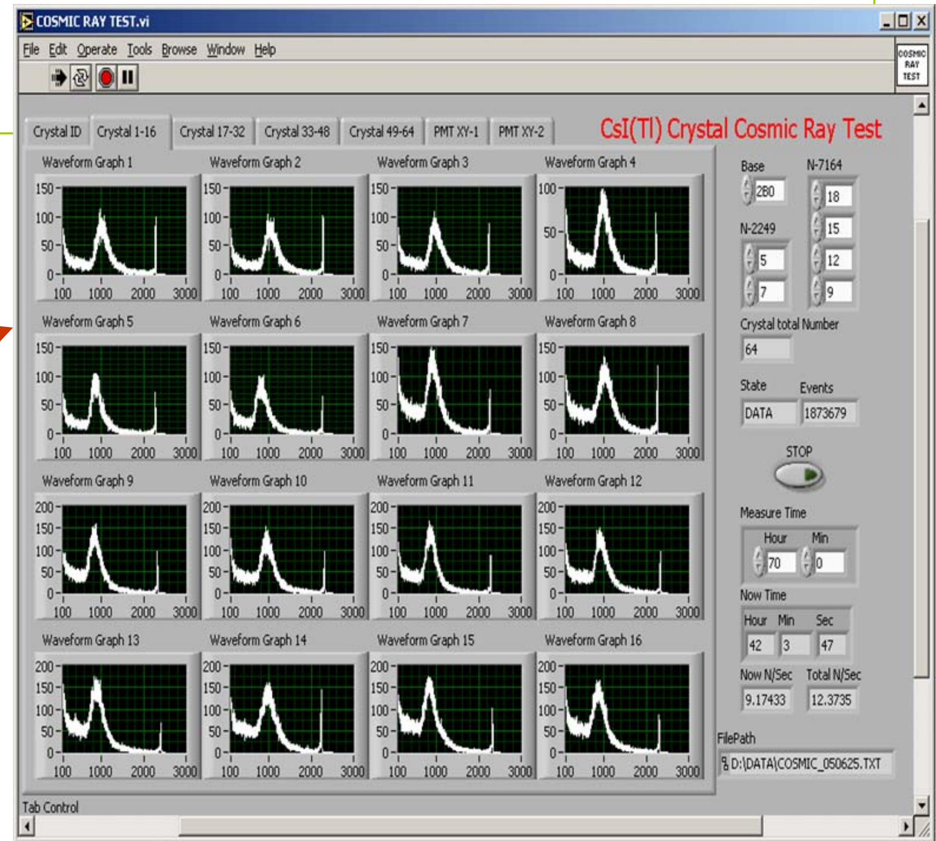


Readout: Two Hamamatsu S2744-08 10 mm x 20 mm photodiodes

CsI Calorimeter

Testing:

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



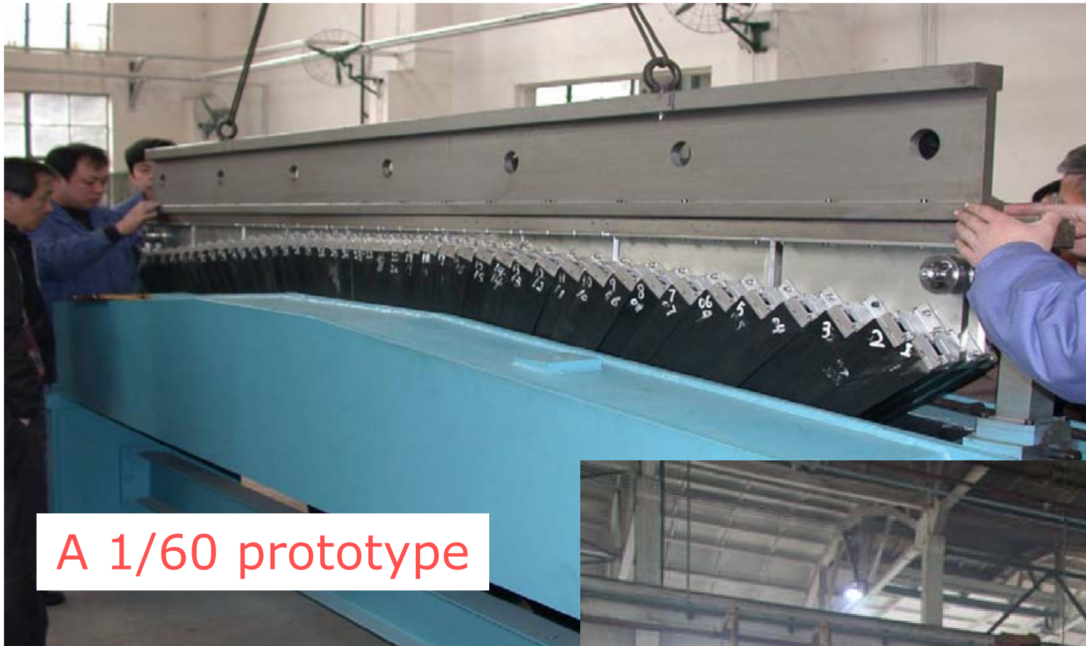
Energy resolution (1GeV)

$$\sigma_E = 2.62\ \%$$

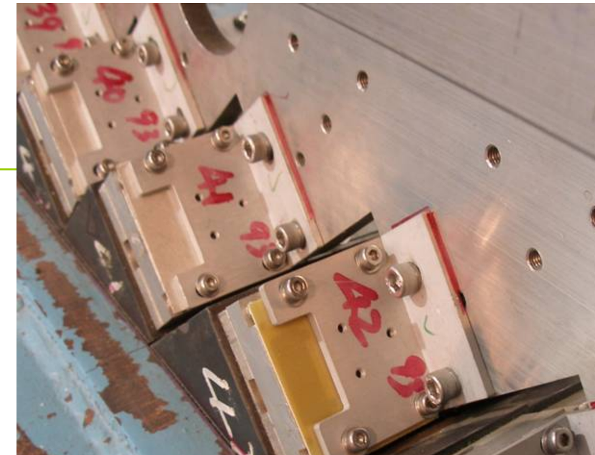
position resolution (1GeV)

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

Mechanical structure



A 1/60 prototype



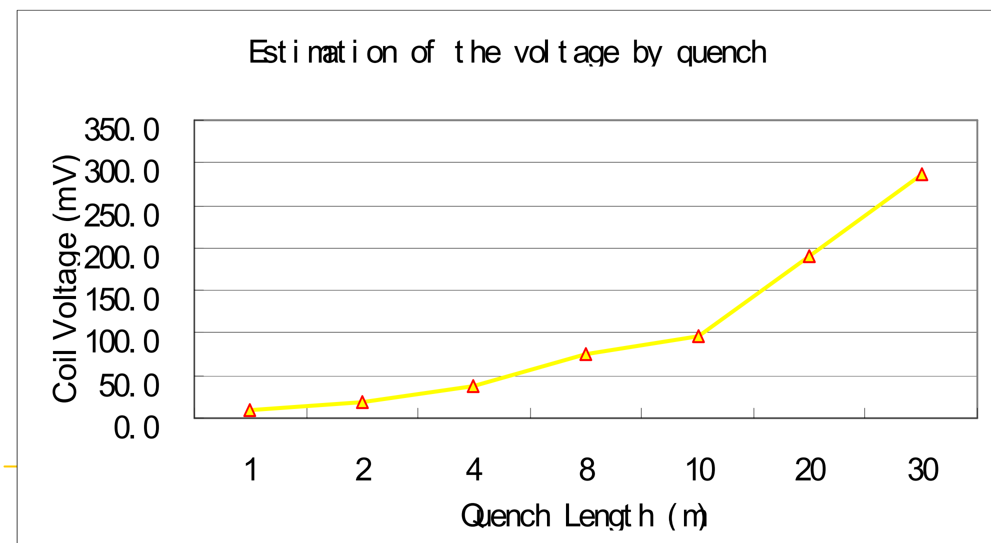
Status:

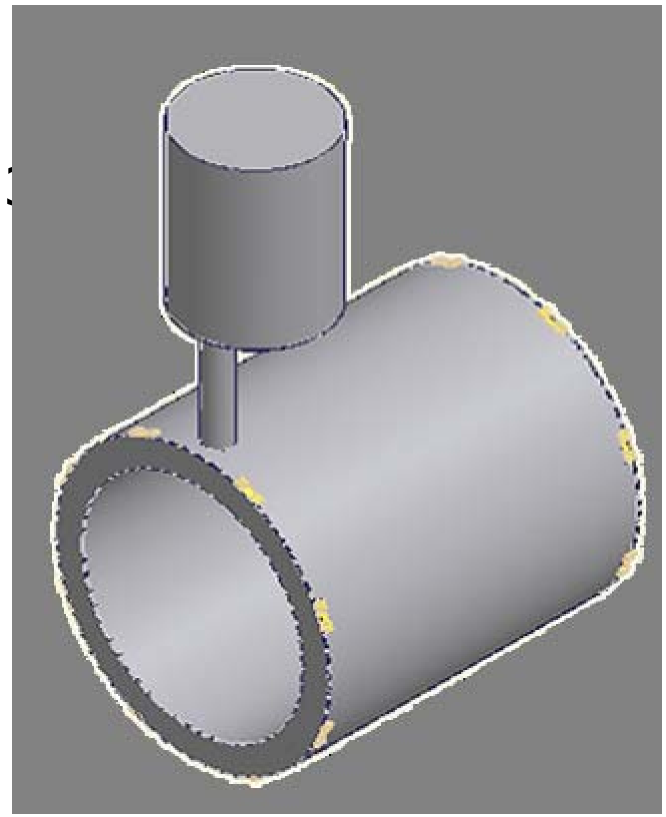
- Assembly starts soon
- Barrel completed by April 07

Mechanical structure now at IHEP

Super-conducting magnet

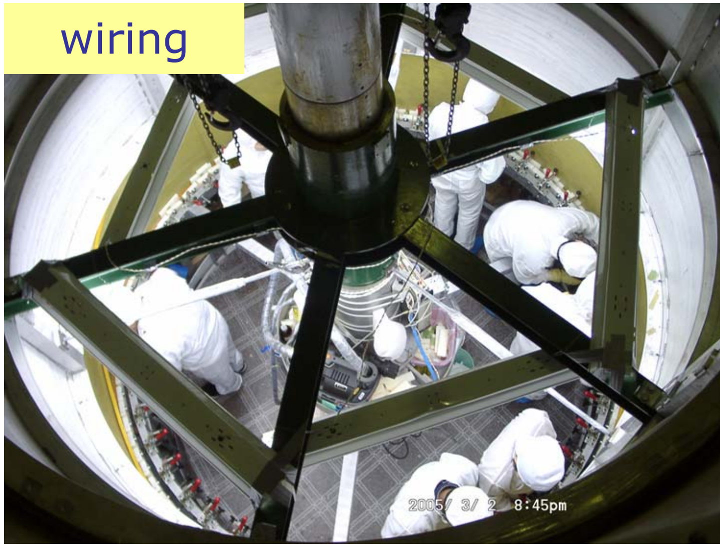
- Al stabilized NbTi/Cu conductor from Hitachi
- 1.0 T, <5% non-uniformity
- 921 turns, 3150A @4.5K
- R = 1.475 m, L=3.52m, cold mass
- Thickness: 1.92 X_0
- Inner-winding method





BESIII Magnet Progress

wiring



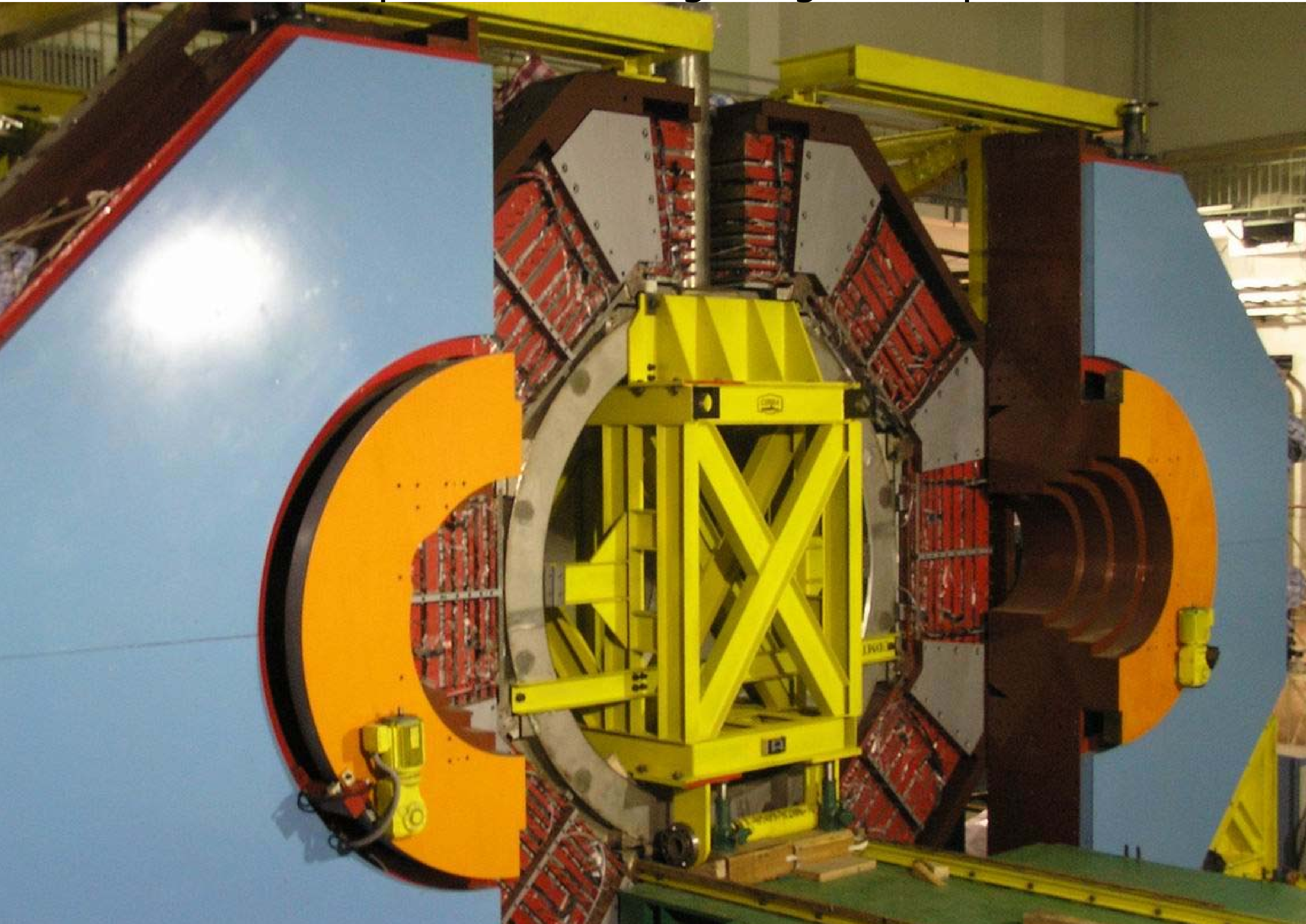
thermal insulation

assembly

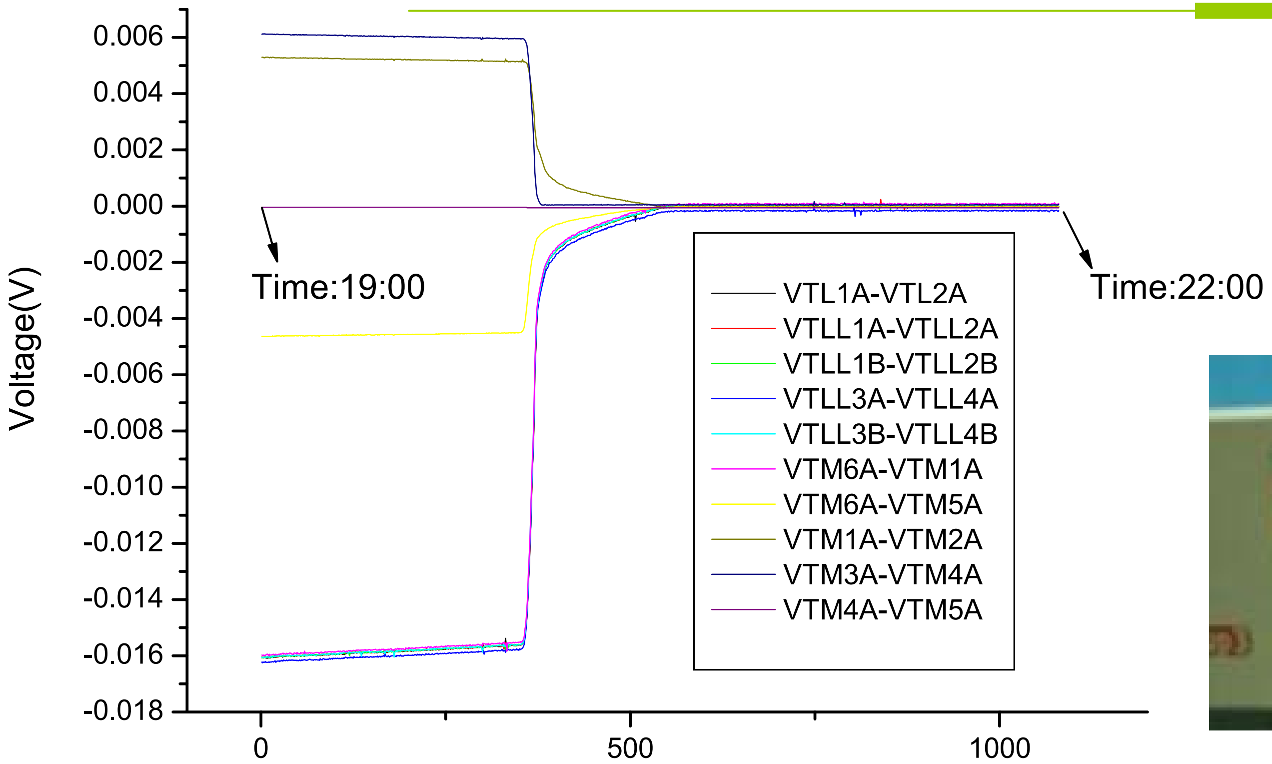
transportation

installation

The super-conducting magnet in place



BESIII Magnet Progress
Sept. 19, 2006

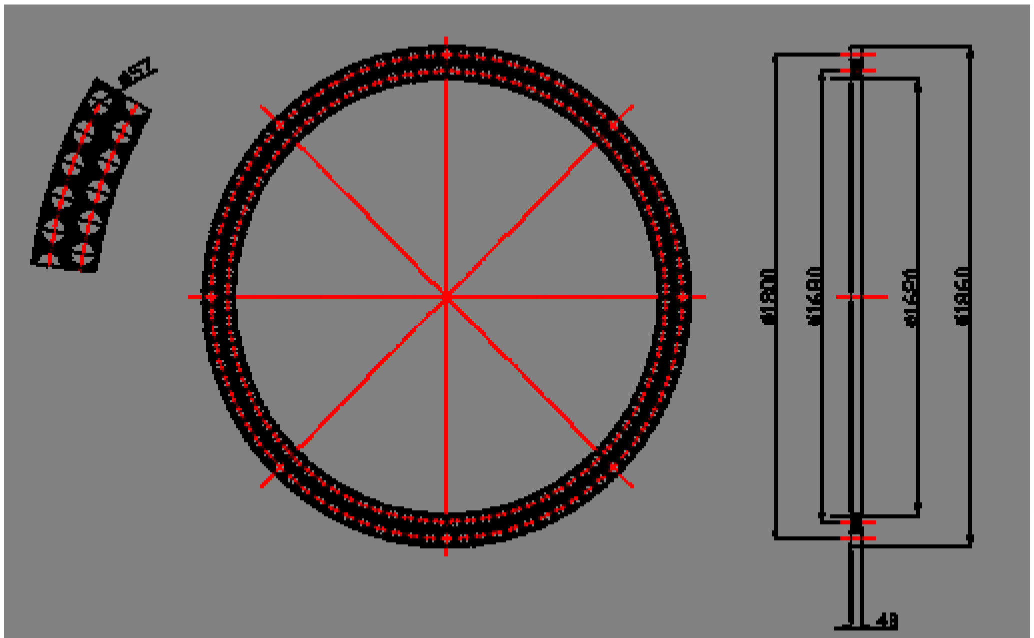


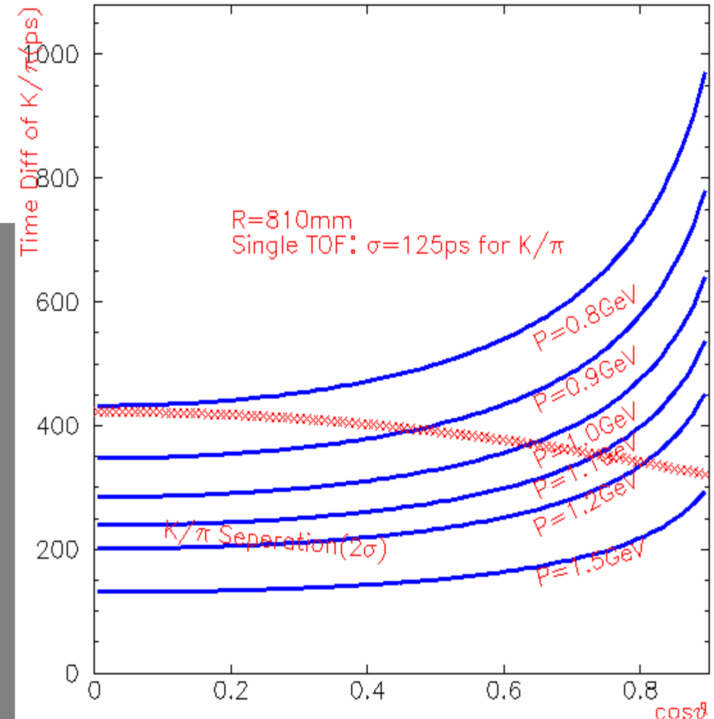
Voltage curve shows that the magnet is in super-conducting state.

Magnetic field 10029.8 Gauss.

Particle ID: TOF system

- 392 pieces BC408, 2.4 m long, 5cm thick
- Time resolution 100-110 ps/layer
- PMT: Hamamatsu R5942





TOF

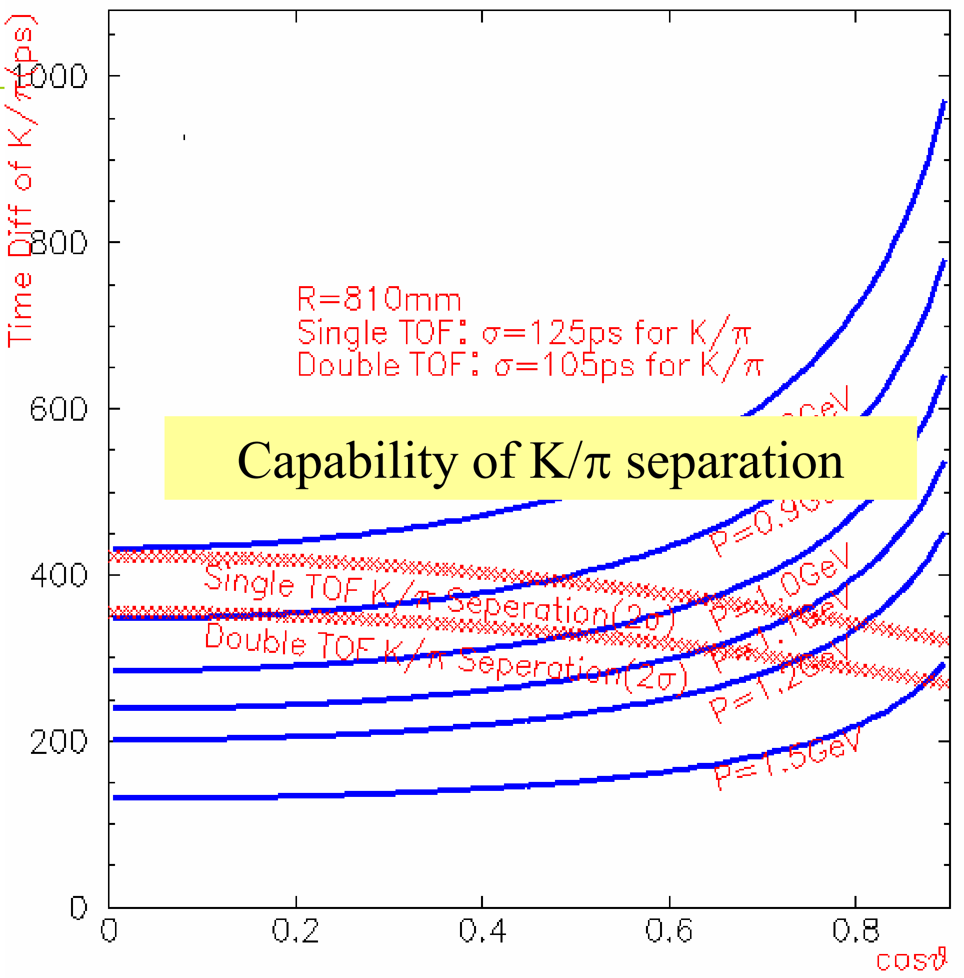
- TOF electronics (USTC):
  - Whole system reached a resolution of < 25 ps in the beam test
  - Preamp. under mass production
  - The third version of FEE board under design
  - Fast clock system almost completed
- PMT are under testing in Tokyo Uni.
- Scintilator are ordered and to be delivered in May.
- Monitoring system under preparation in Hawaii
- By the end of the year, complete all the testing and be ready for the installation next year.

TOF Performance

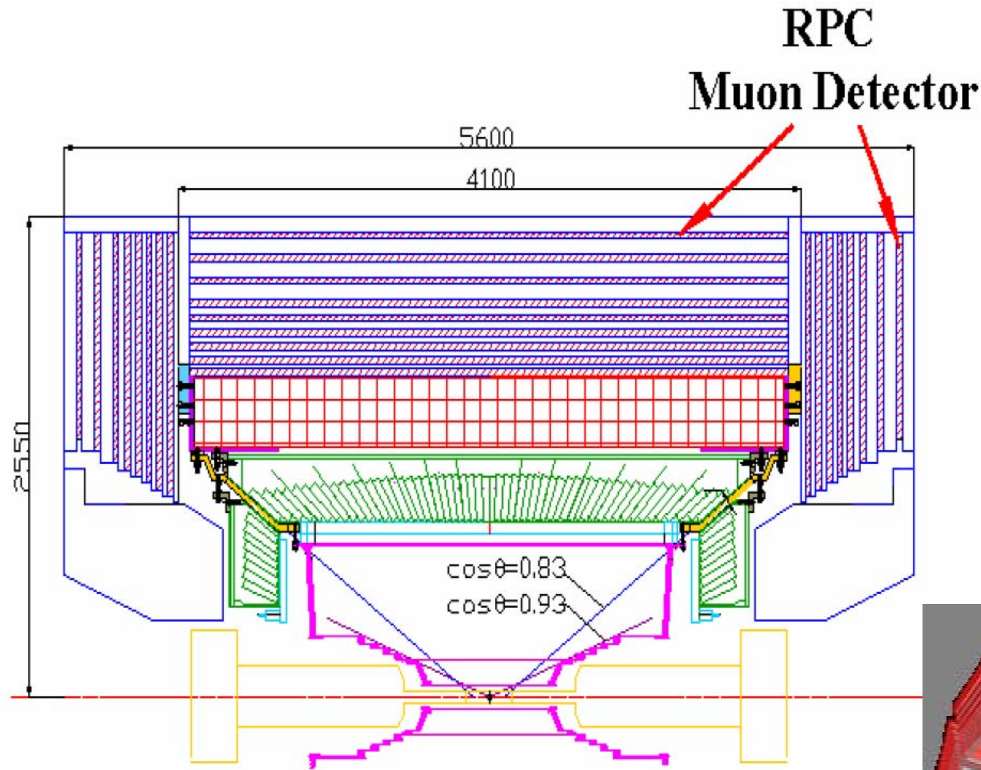
- Time resolution 1-layer (intrinsic):
  - Belle: 70 to 80 ps
  - Beam tests: < 90 ps
  - Simulation: < 90 ps

- Time resolution of two layers is 100ps to 110ps
  for kaon and pions.

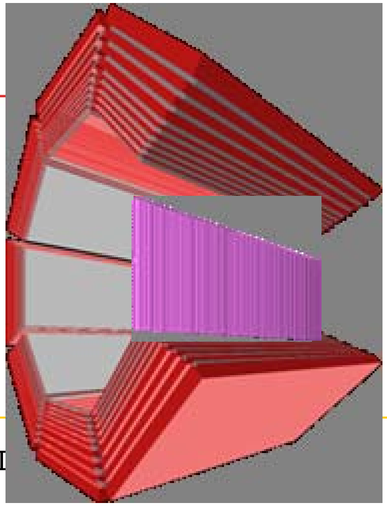
- K/π separation: 2 σ separation up to 0.9 GeV/c.

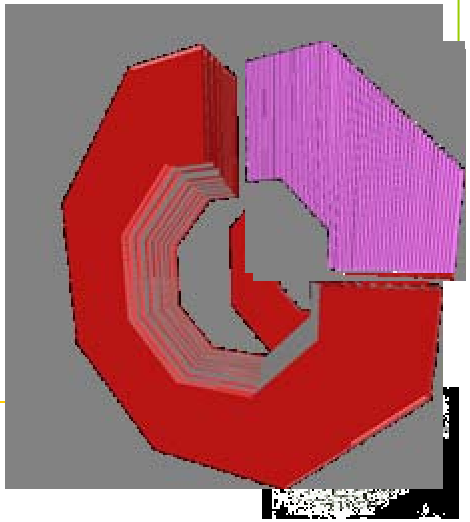


Muon Chamber



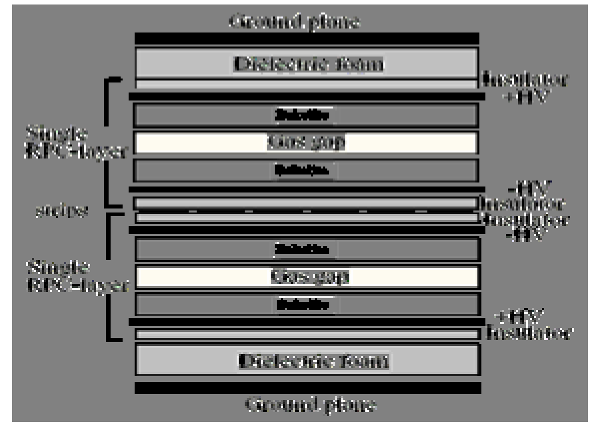
- 9 (8) layers, 2000 m^2
- Bakelite, no linseed oil
- 4cm strips, 10000 channels
- Tens of prototypes (up to 1*0.6 m^2)
- Noise less than 0.2 Hz/cm^2

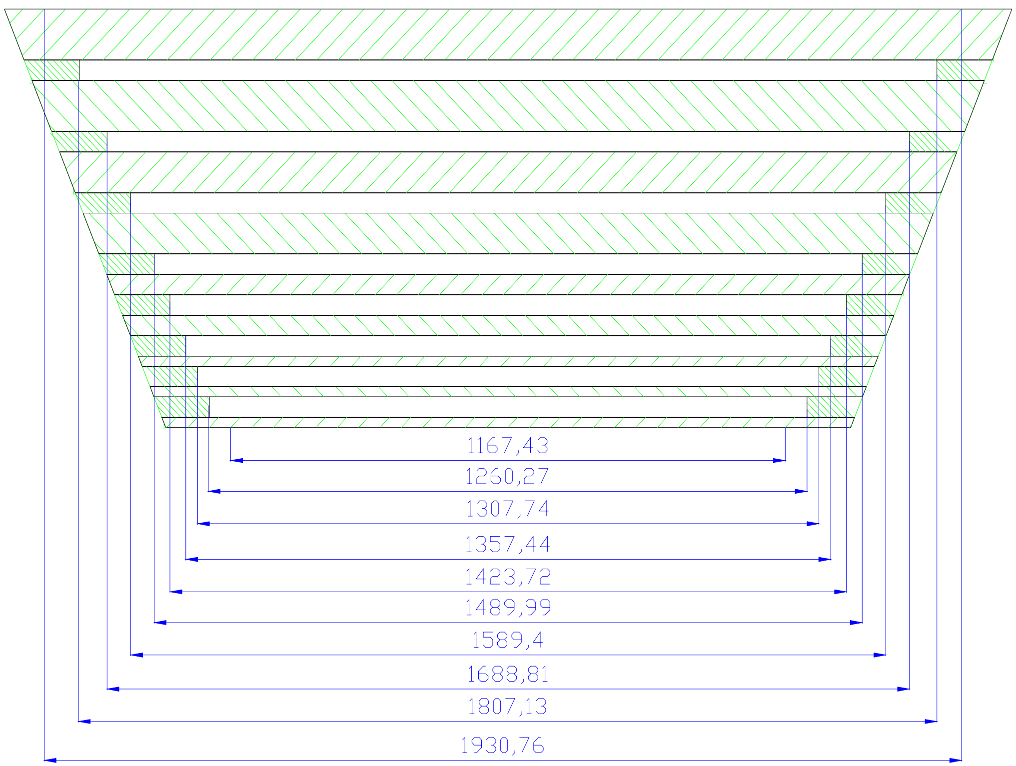


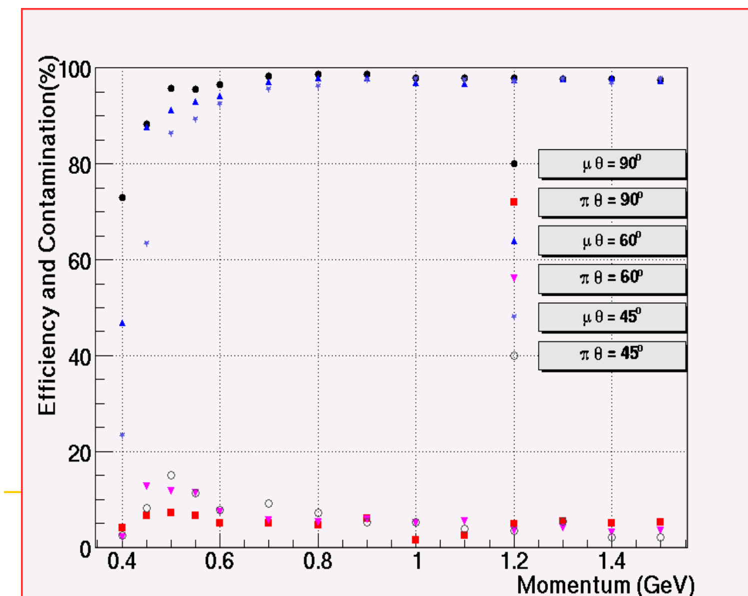


μ system : RPC

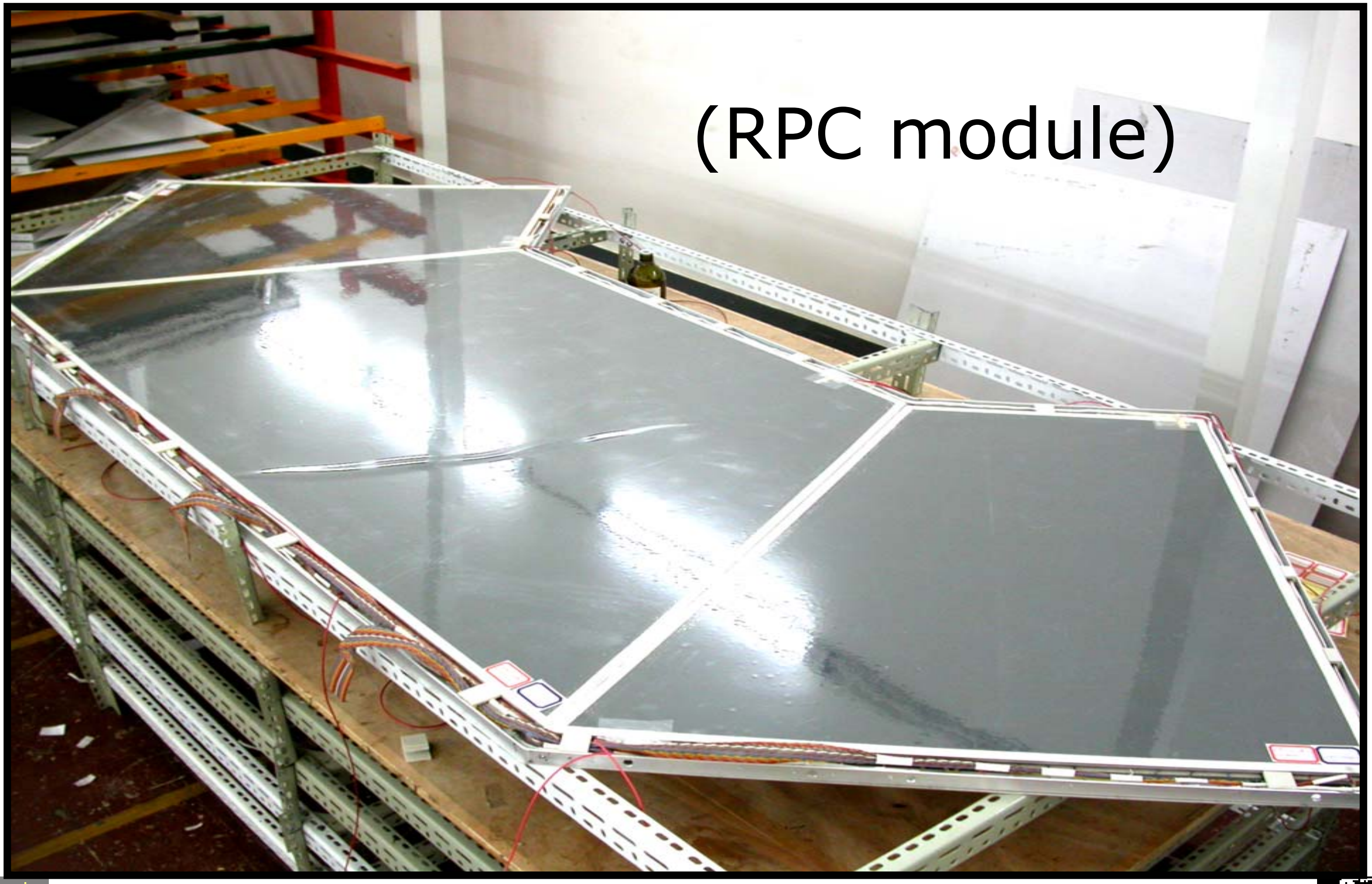
- 9 layers, 2000 m^2
- Bakelite, no linseed oil
- 4cm strips, 10000 channels
- Tens of prototypes (up to 1*0.6 m^2)





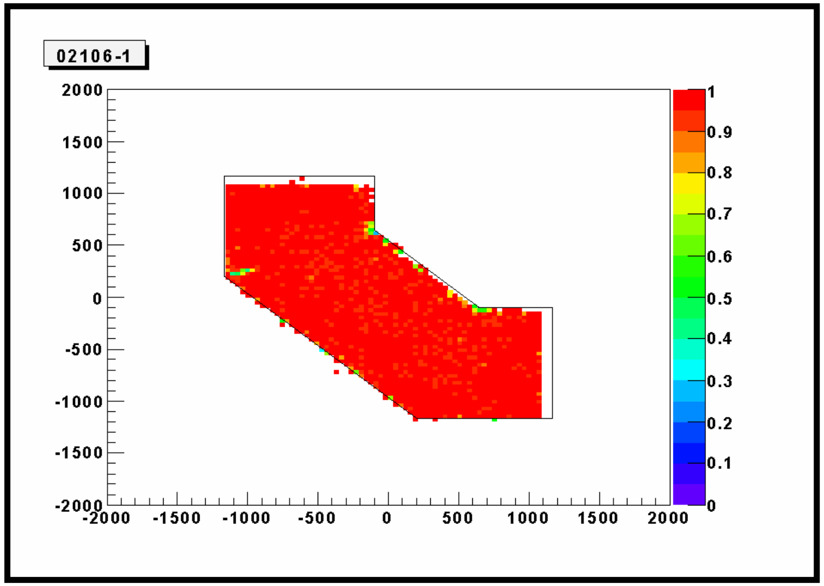


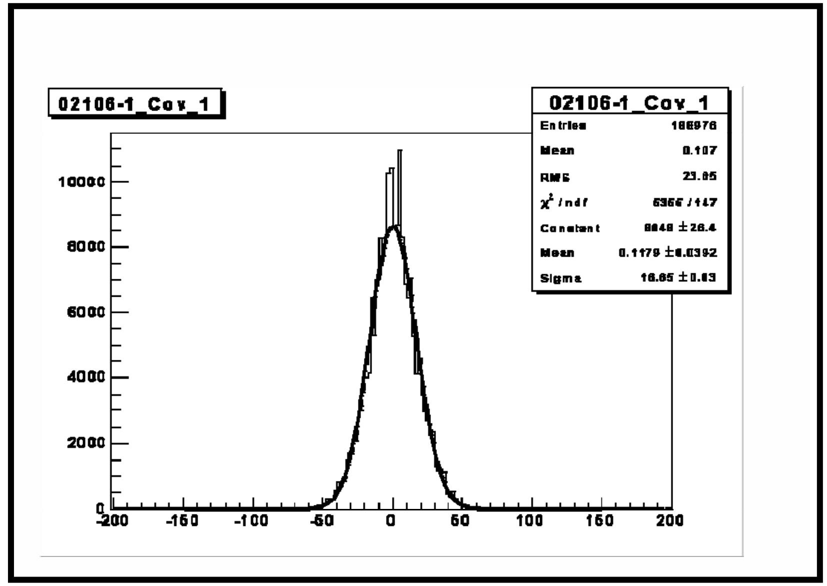
- Total of 64 endcap modules, 72 barrel modules;
- Gas: Ar:$C_2H_2F_4$:Isobutane = 50:42:8
- HV voltage: 8000V;
- One module contains two RPC layers and one readout layer.

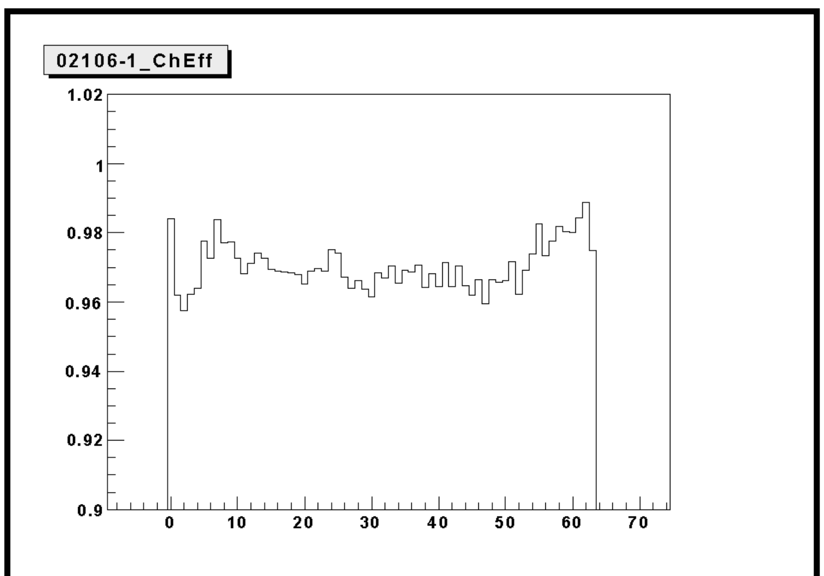


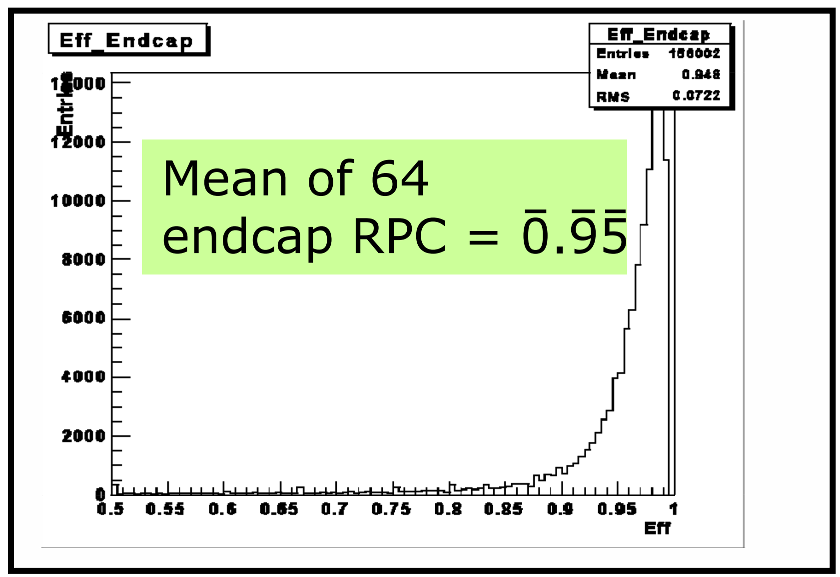
Test Result after installation - Endcap

Average strip efficiency: 0.97 Spatial resolution: 16.6mm









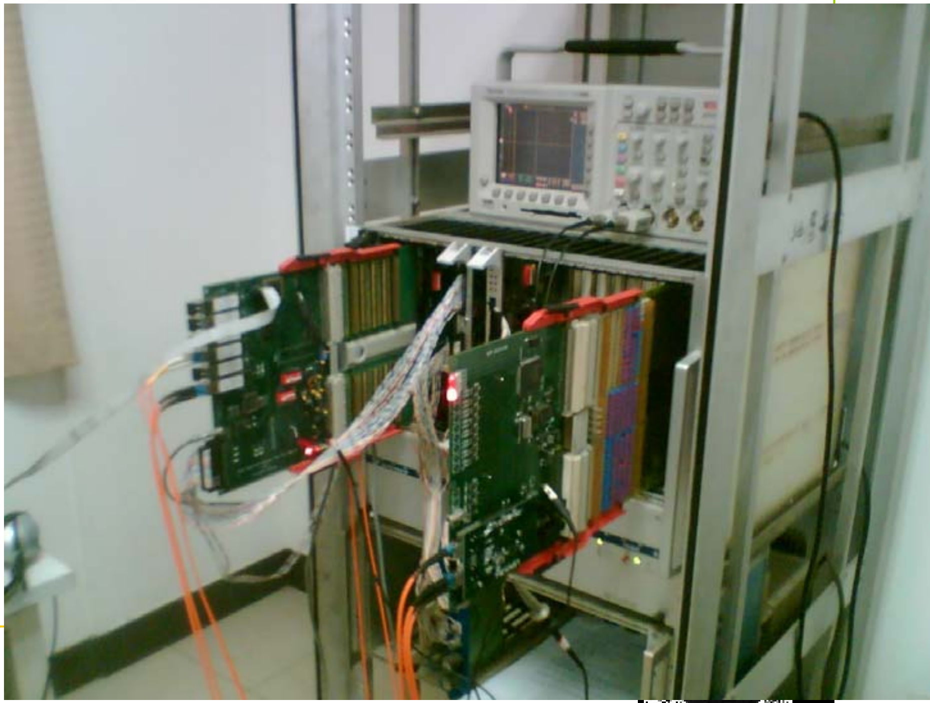

祝贺BESIII MUON系统安装成功
团结唯实创新奉

Other systems

- Electronics design have been almost finished, several prototypes have been successfully tested
- Trigger system largely based on FPGA technology have been designed, prototypes underway
- DAQ system based on VME/PowerPC and PC farm have been designed, mini-version setup, software underway
- Offline computing environment based on a large scale PC farm is under study
- MC based on GEANT4, first reconstruction framework released, sub-detector reconstruction code underway

Trigger and DAQ

- Using the latest technology of FPGA, the trigger design is almost finalized.
- No. of types of trigger boards are reduced from 23 to 17
- All the boards are tested, some for several prototyping.
- By the end of the year, all the boards should be tested and installed.
- The whole DAQ system tested to 8K Hz for the event size of 12Kb, a factor of two safety margin
- The whole DAQ system tested during beam test with MDC and EMC



The detectors of BES III and CLEO-c

Subdetector	BES III	CLEOc
MDC	σ_{XY} (μm) = 130	90 μm
	$\Delta P/P$ ($^0/_0$) = 0.5 % (1 GeV)	0.5 %
	$\sigma_{dE/dx}$ ($^0/_0$) = 6 - 7 %	6 %
EMC	$\Delta E/\sqrt{E}$ ($^0/_0$) = 2.5 % (1 GeV) σ_z(cm) = 0.5cm / $\sqrt{E}$	2.0 % 0.3 cm / $\sqrt{E}$
TOF	σ_T(ps) = 100-110 / layer Double layer	Rich
μ counter	9 layers	----
magnet	1.0 T	1.0 T

Future

In US:

- CLEOc stops in 2008.
- BaBar stops running in 2008.
- Fermilab stops collider physics in 2009.

In China:

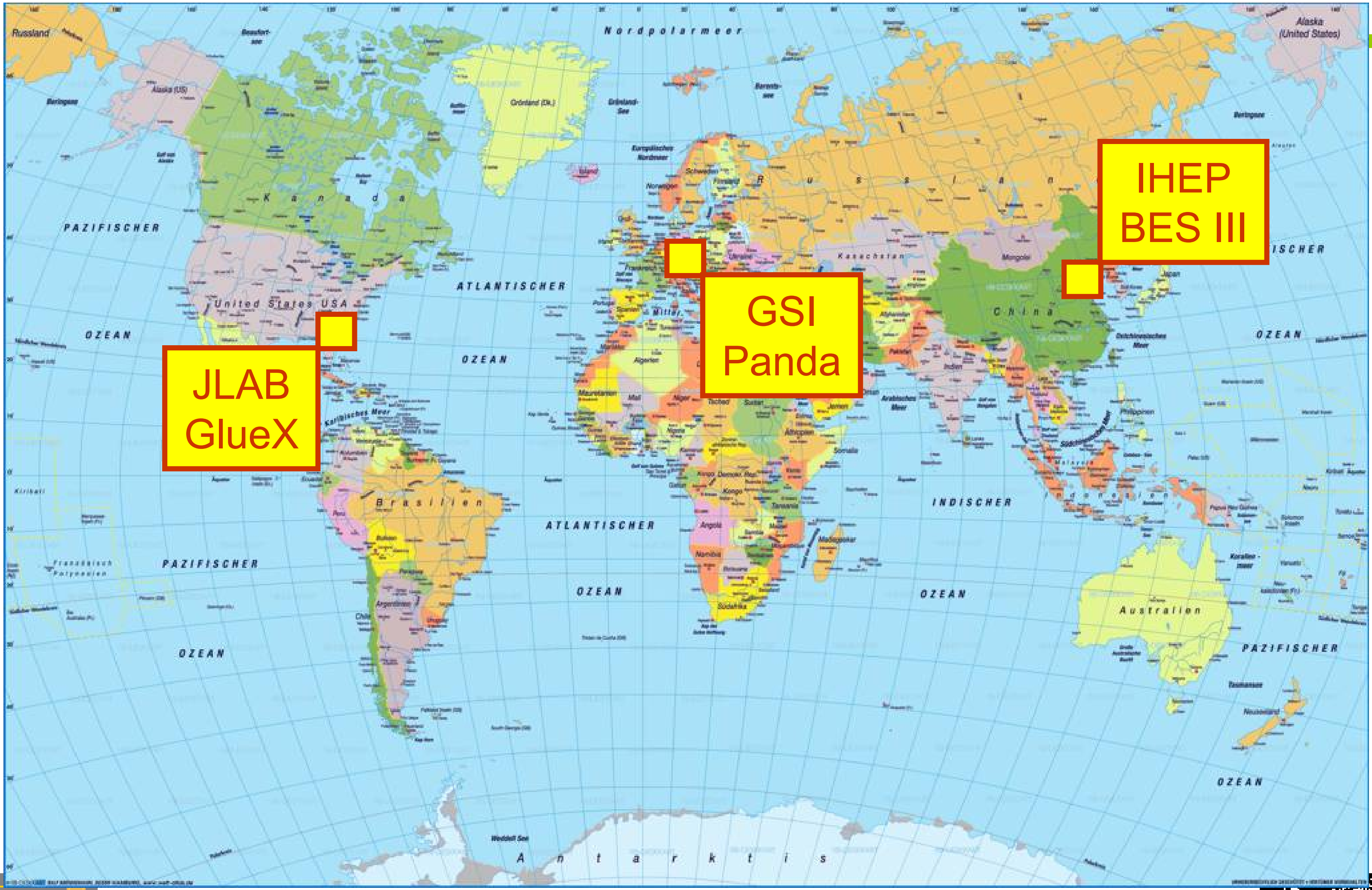
BESIII commissioning in fall 2007.

BESIII will be a unique facility.

In Germany:

FAIR finished construction 2015.

Hadron Spectroscopy – Leading Labs 201x



Summary

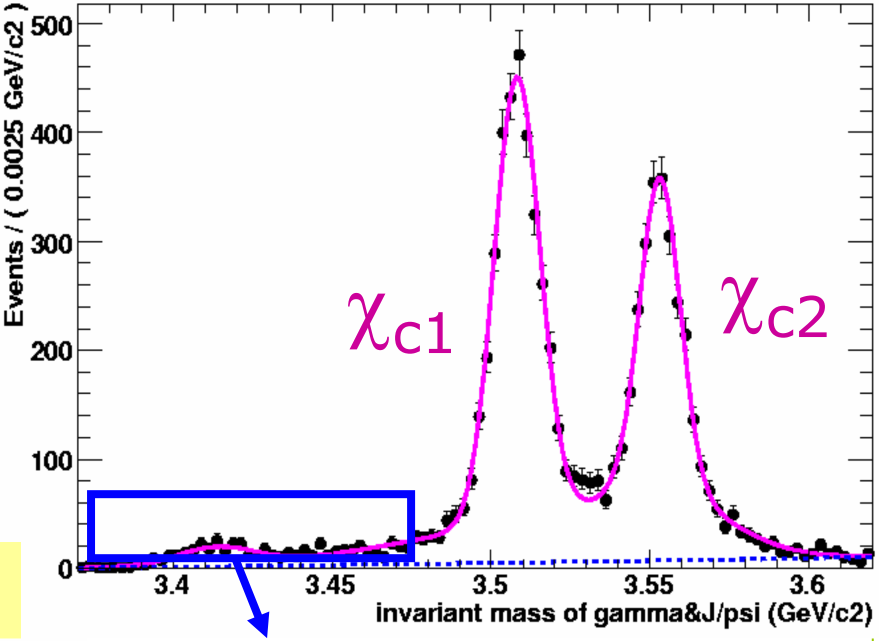
- BEPCII linac installation complete.
- Installation of collider nearly complete; ready for synchrotron running.
- BESIII hardware and software progressing rapidly, although still much to do.
- Commissioning ongoing.
- Rich physics program after CLEO-c. Complementary to B-factories.

Thank you！谢谢！

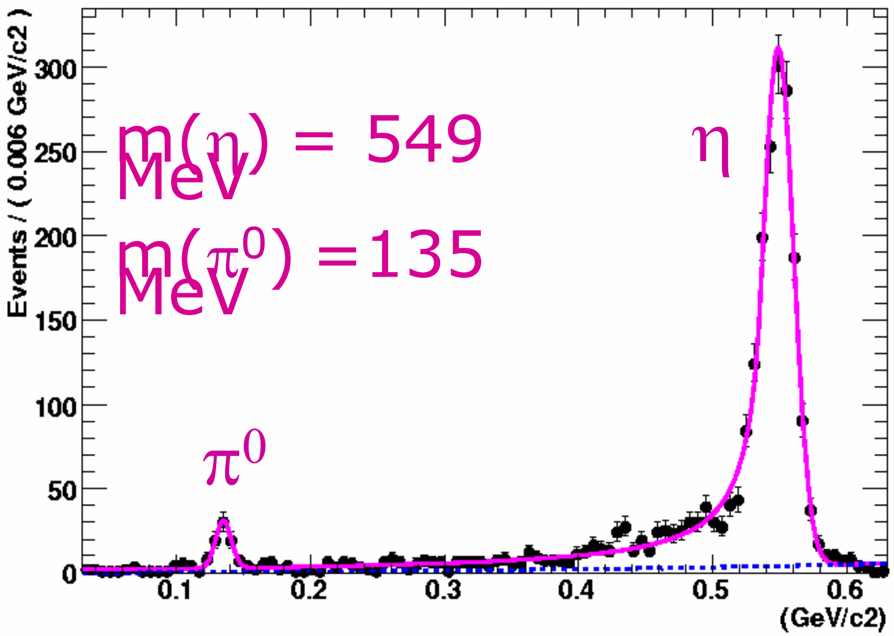
- BACKUP
  - Comparison BESIII/CLEO
  - Resultion studies

$\Psi' \square \gamma\chi_{cJ}$, $\chi_{cJ} \square \gamma J/\psi$

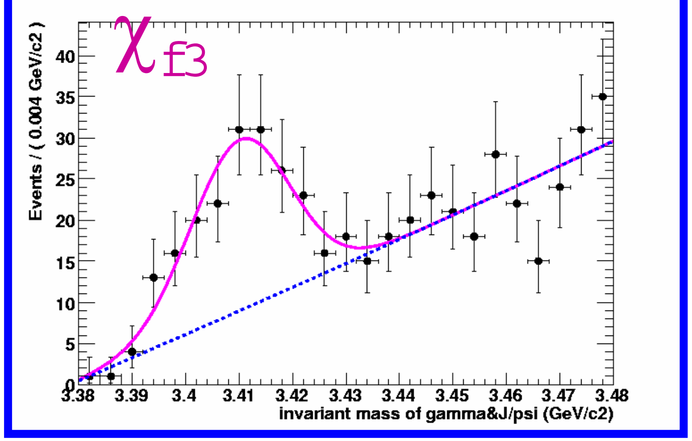
BESIII: *(8M , M.C.)*
$m(\chi_{c1})$ = 3.508GeV,
$m(\chi_{c2})$ = 3.553GeV;
$\sigma(\chi_{c1})$ = 8.1MeV,
$\sigma(\chi_{c2})$ = 9.4MeV.



$\Psi' \square J/\psi(\pi^0, \eta), (\pi^0, \eta) \square \gamma\gamma$

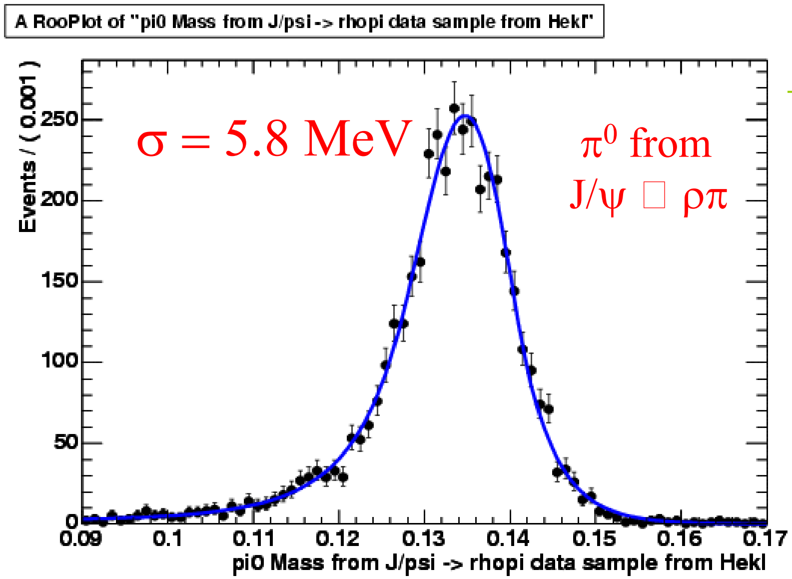


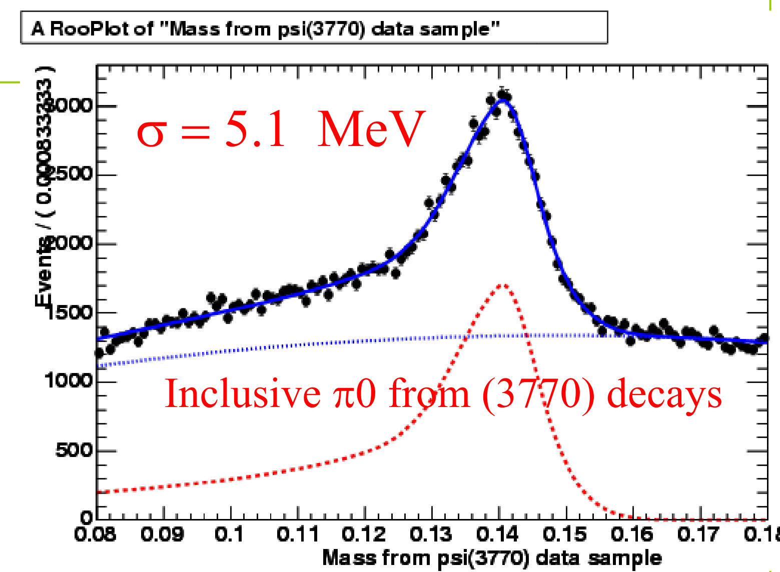
$m(\eta)$ = 549 MeV
$m(\pi^0)$ =135 MeV

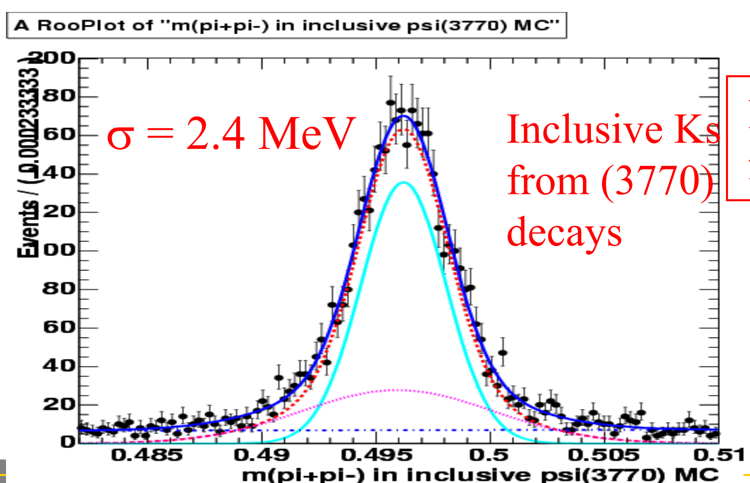


$m(\chi_{c-})$ =3.413GeV,
$\sigma(\chi_{c0})$ =9.0MeV.

Performance of State-of-the-Art BESIII detector
Neutral object





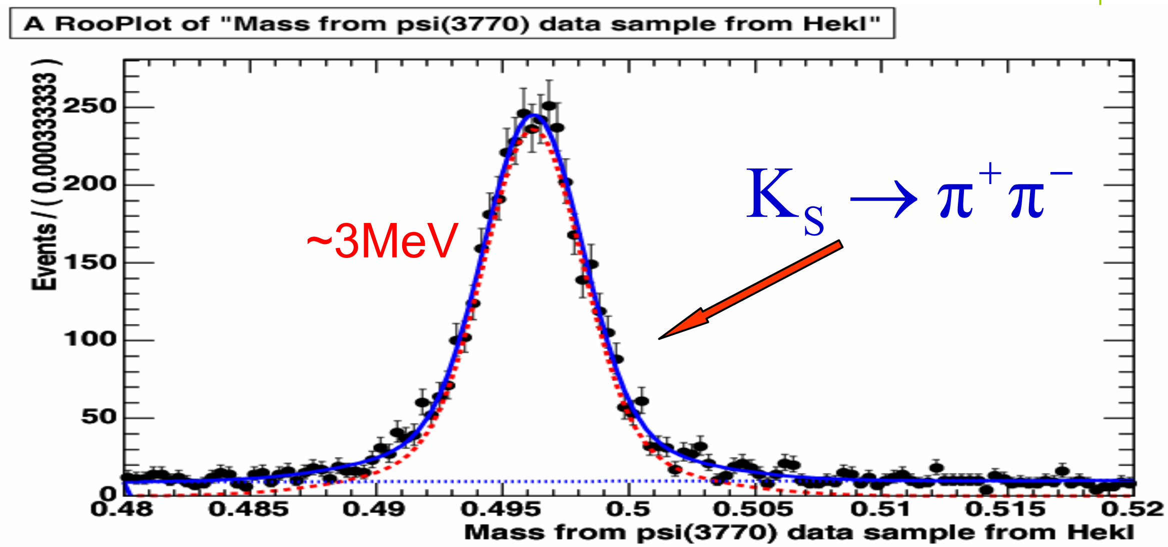


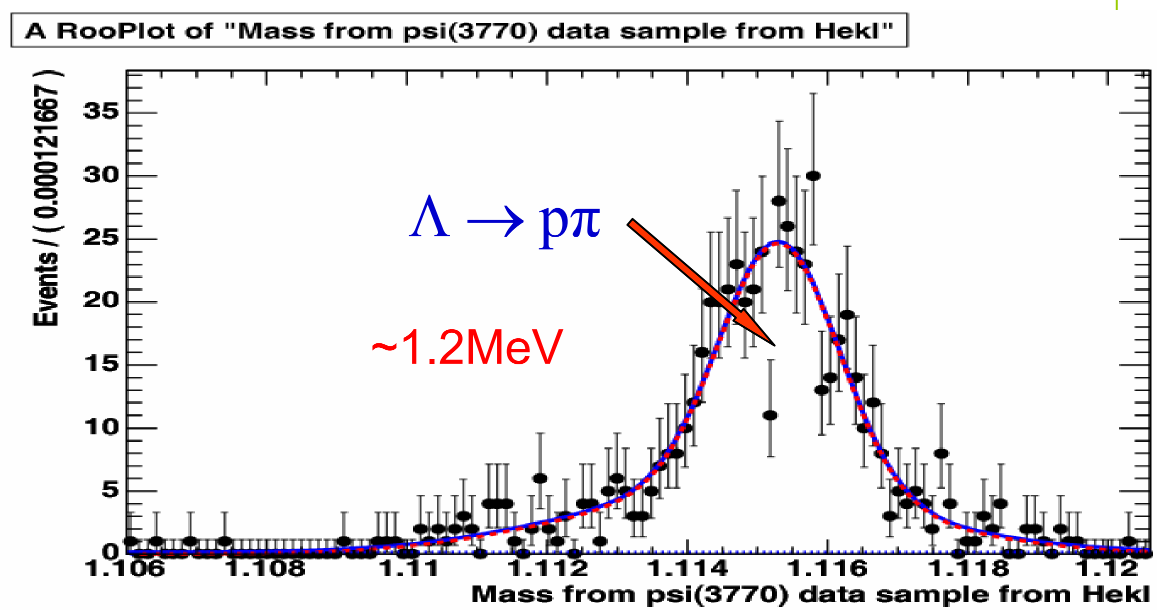
length/error_length > 2
from Vertex fit

New muon counter
(9 layers) RPC for KL
and μ ID,
double layers TOF for PID

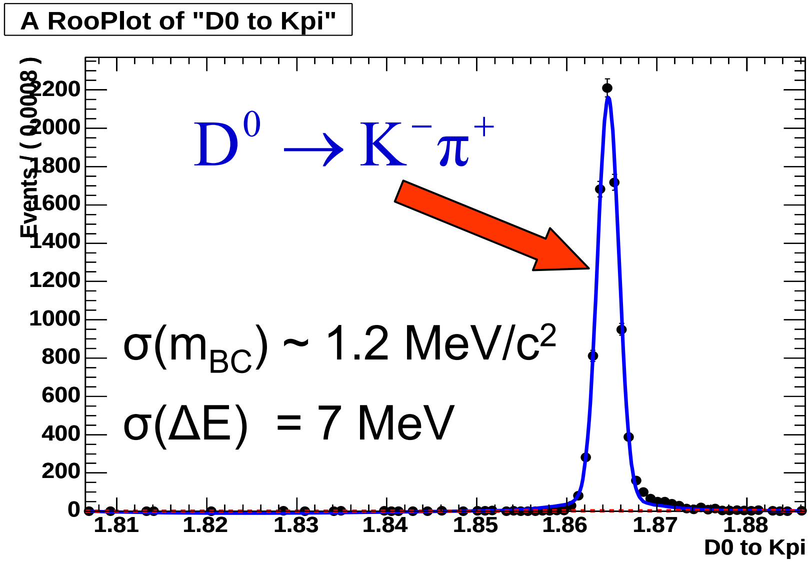
Physics Simulations

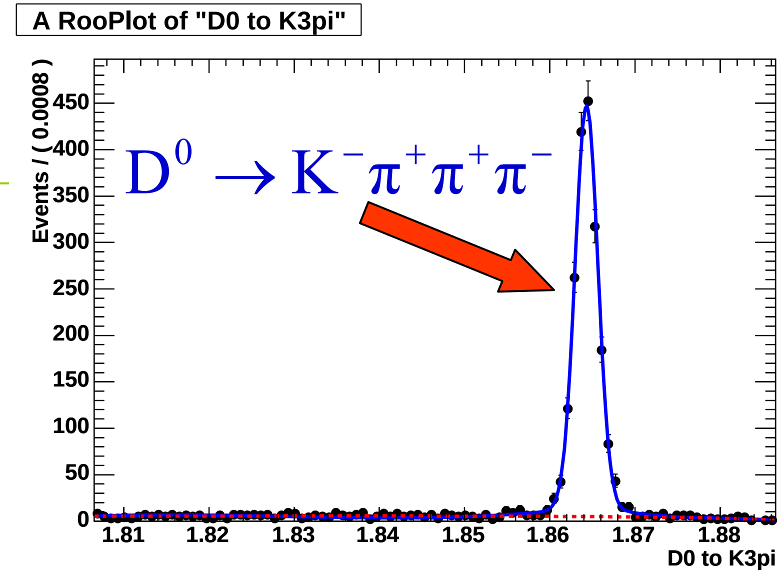
50, 000 ψ″ Inclusive event sample.



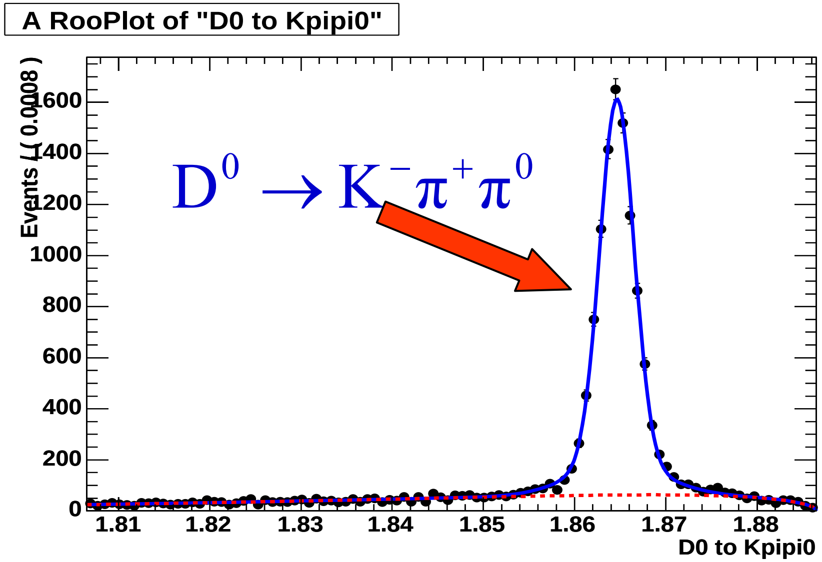


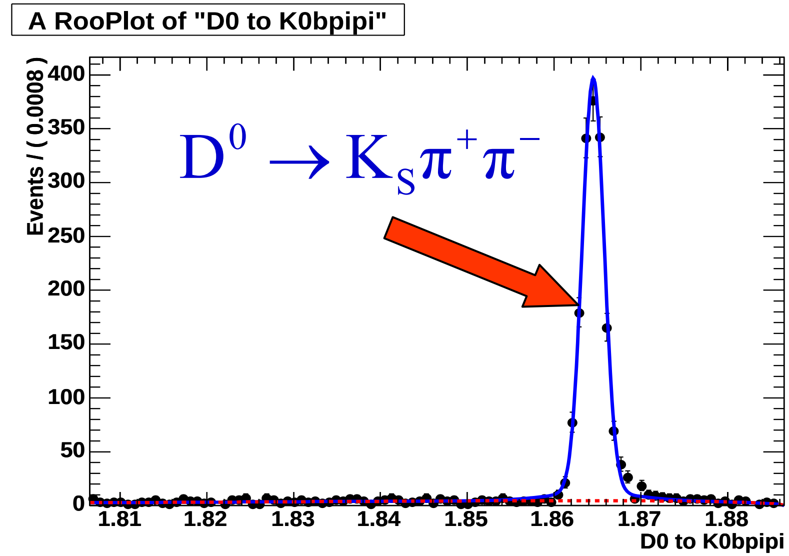
50, 000 ψ″ Inclusive event sample.



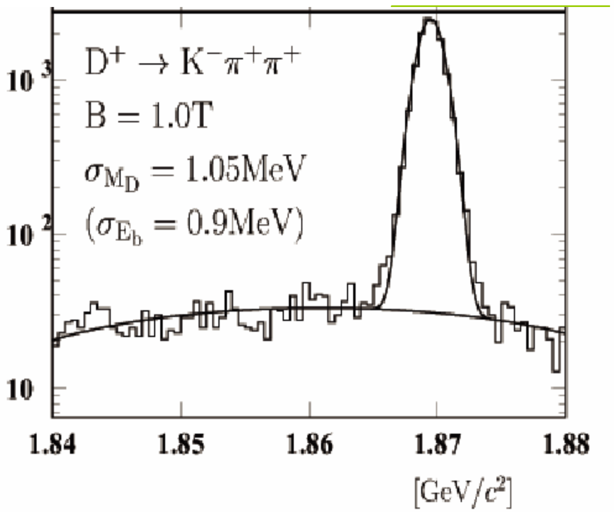


π^+

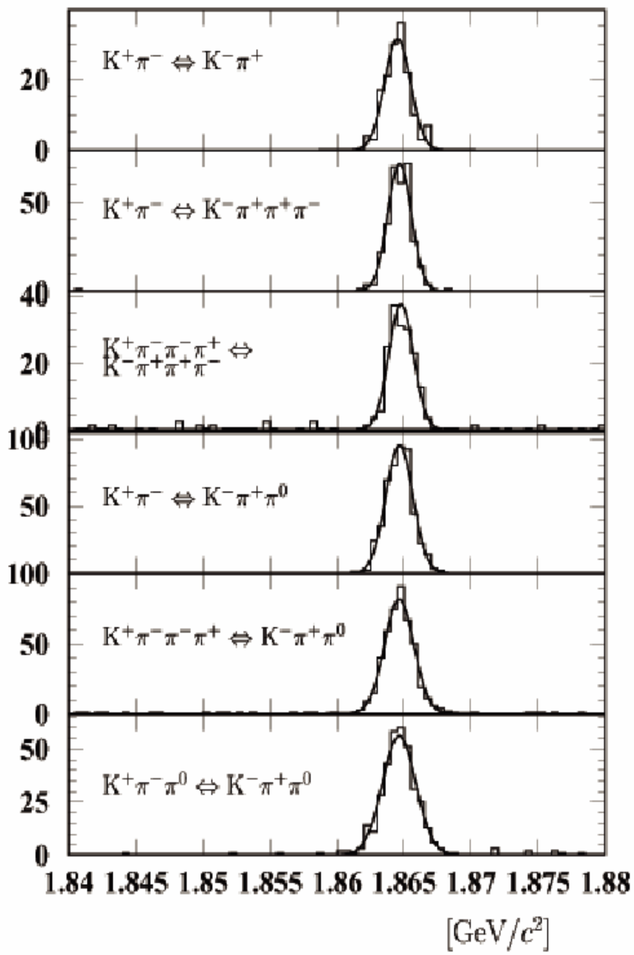


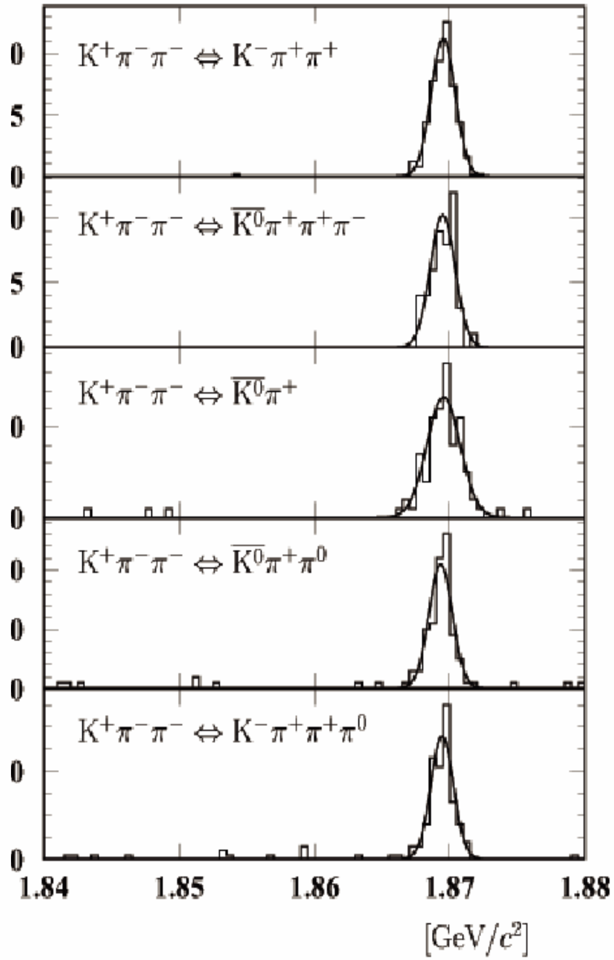


Absolute Br measurement: clear D tagging



beam energy spread important





Non-leptonic decays

Decay Mode	Input Br(%)	Detection efficiency	Statistical Error ($\Delta B/B$)
$D^0 \rightarrow K^-\pi^+$	3.7	72.2%	~ 0.4%
$D^0 \rightarrow K^-\pi^+\pi^+\pi^-$	~7.8	34.0%	
$D^0 \rightarrow K^-\pi^+\pi^0$	~12.0	32.0%	
$D^+ \rightarrow K^-\pi^+\pi^+$	~7.7	52.0%	~ 0.6%
$D^+ \rightarrow \bar{K}^0\pi^+$	2.8	12.5%	
$D^+ \rightarrow \bar{K}^0\pi^+\pi^+\pi^-$	~5.6	9.2%	
$D^+ \rightarrow \bar{K}^0\pi^+\pi^0$	~8.6	7.9%	
$D^+ \rightarrow K^-\pi^+\pi^+\pi^0$	~5.0	22.5%	
$D^+_s \rightarrow \phi\pi^+$	~3.0	60.0%	~ 1.2%

One year of running

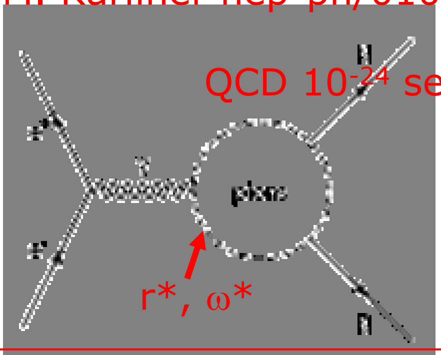
One year of running

QCD and $e^+e^- \rightarrow B\bar{B}$ 1.88-2.8 GeV

An intermediate coherent isovector state serving as an intermediary between e+e- and BB

J. Ellis and M. Karliner hep-ph/0108259

$$f = \frac{\sigma(e^+e^- \rightarrow p\bar{p})}{\sigma(e^+e^- \rightarrow n\bar{n})} = \left|\frac{A_1 + e^{i\alpha}A_0}{A_1 - e^{i\alpha}A_0}\right|^2 = \left|\frac{1 + e^{i\alpha}\varepsilon}{1 - e^{i\alpha}\varepsilon}\right|^2$$



Proposed mechanism by J. Ellis and M. Karliner

A_1 and A_0 are I = 1 and 0 amplitudes, and dominated by single states r*, ω*,φ*