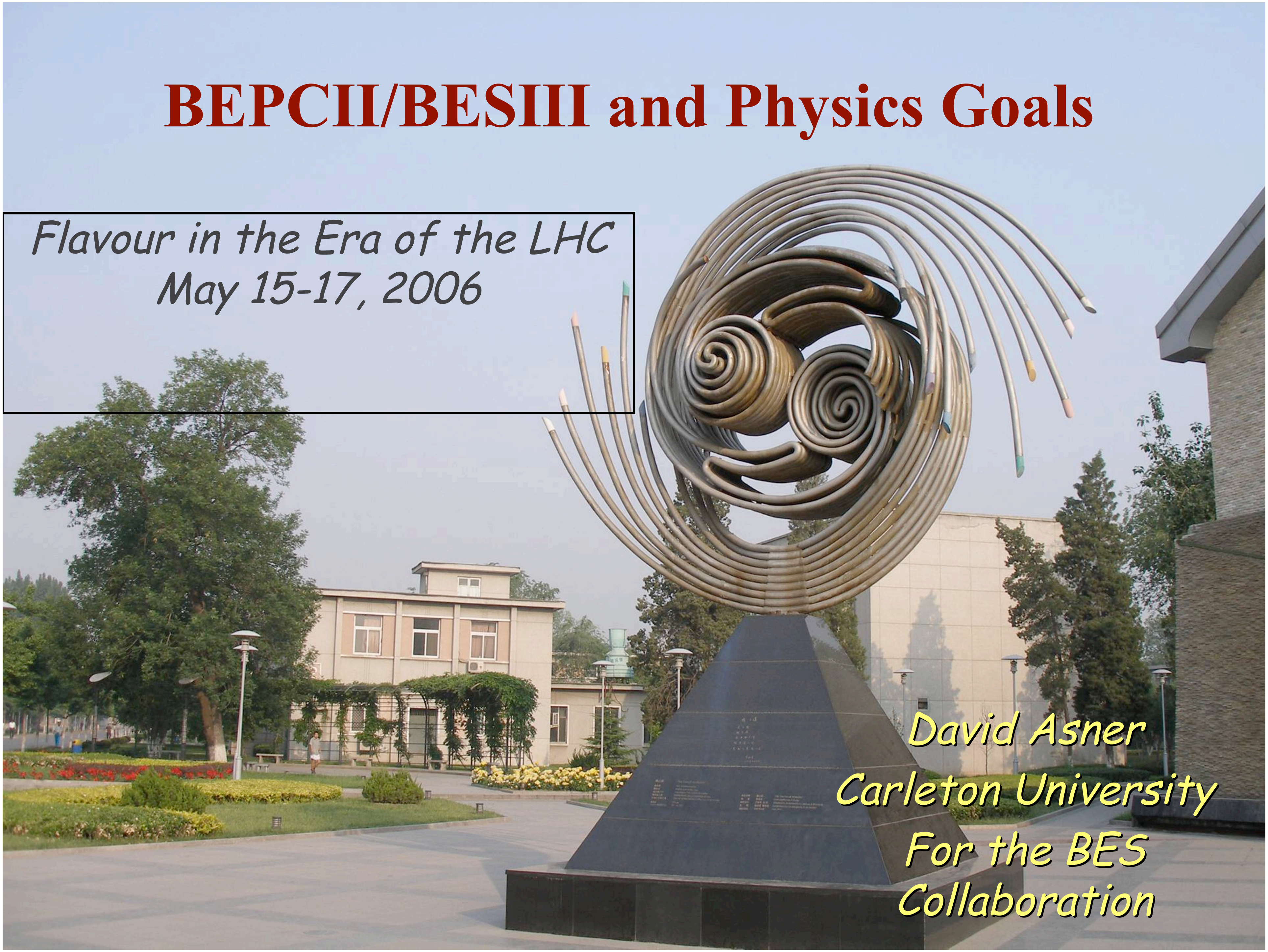
BEPCII/BESIII and Physics Goals

Flavour in the Era of the LHC
May 15-17, 2006

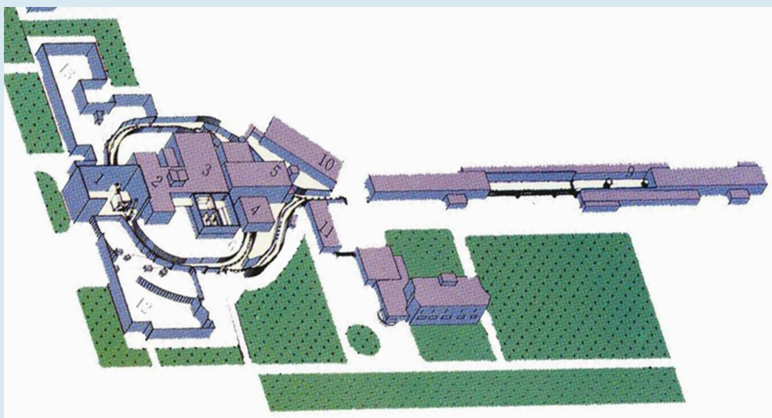


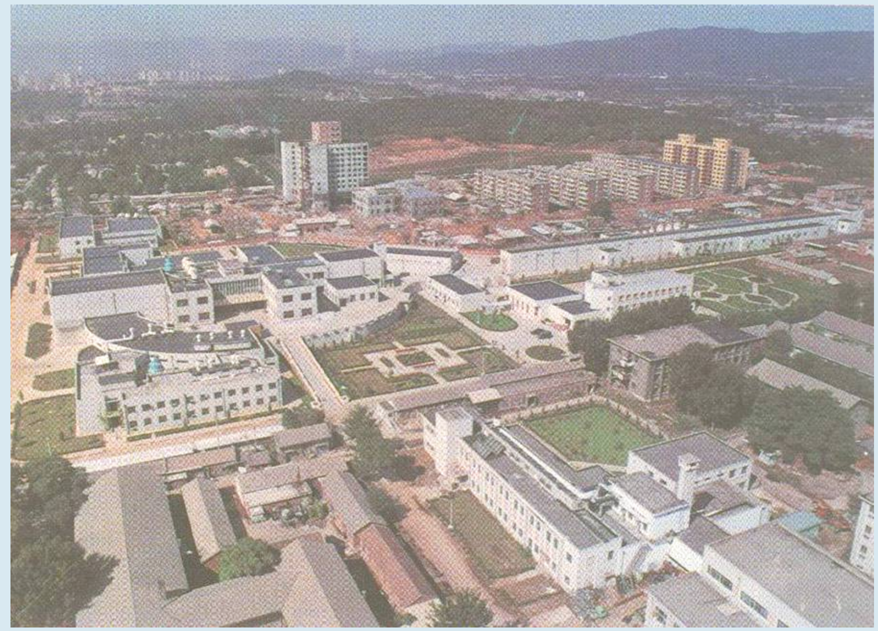
David Asner
Carleton University
For the BES Collaboration

The Beijing Electron Positron Collider (BEPC)

L ~ 5×10^{30} /$cm^2 \cdot s$ at J/ψ

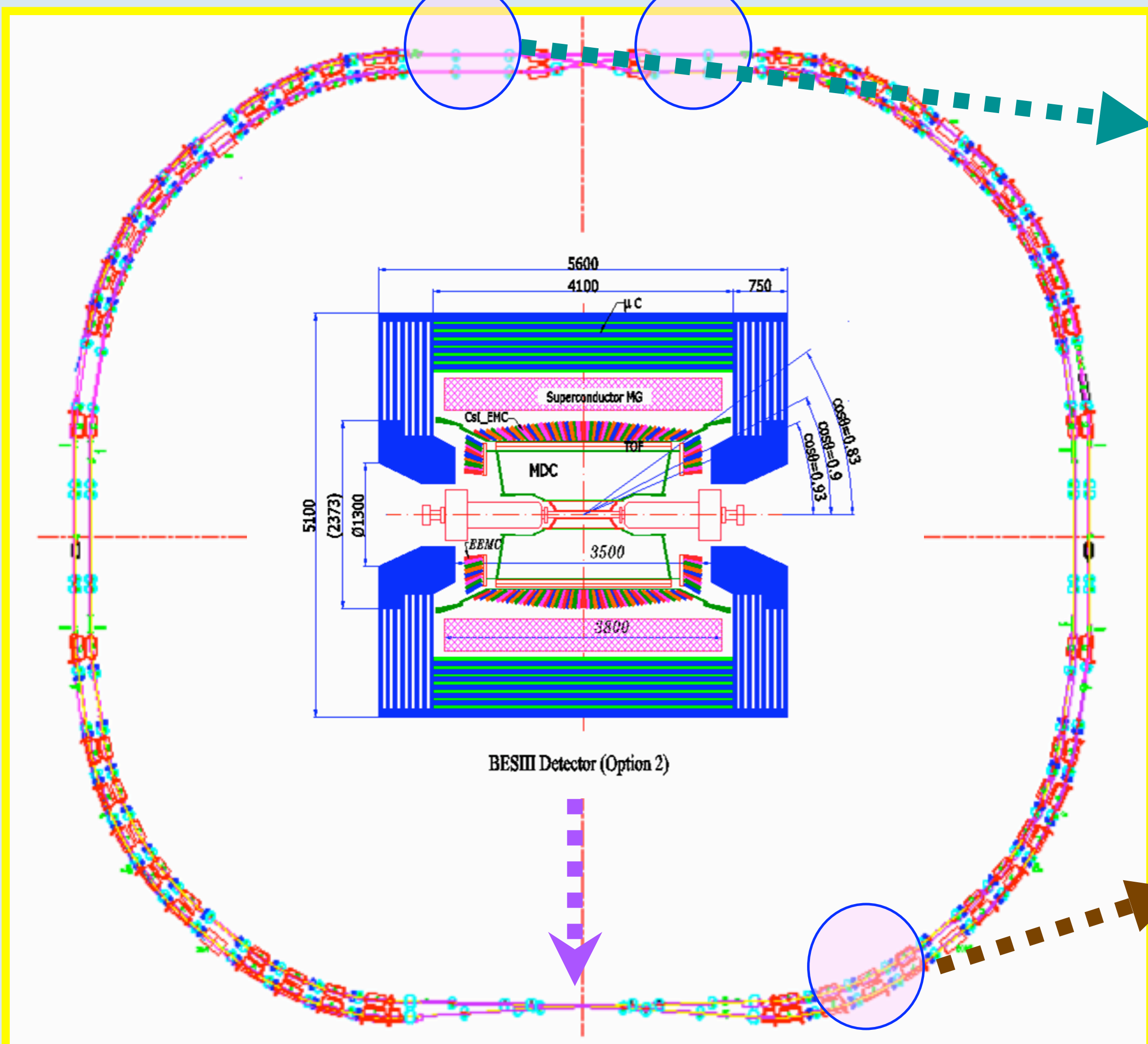
E_{cm}~ 2 - 5 GeV





A unique e^+e^- machine in the τ-charm energy region after CLEO-c.

BEPCII: a high luminosity double–ring collider



SC RF

Two rings tunnel

Government approved, and started construction at end of 2003

BEPCII Design goal

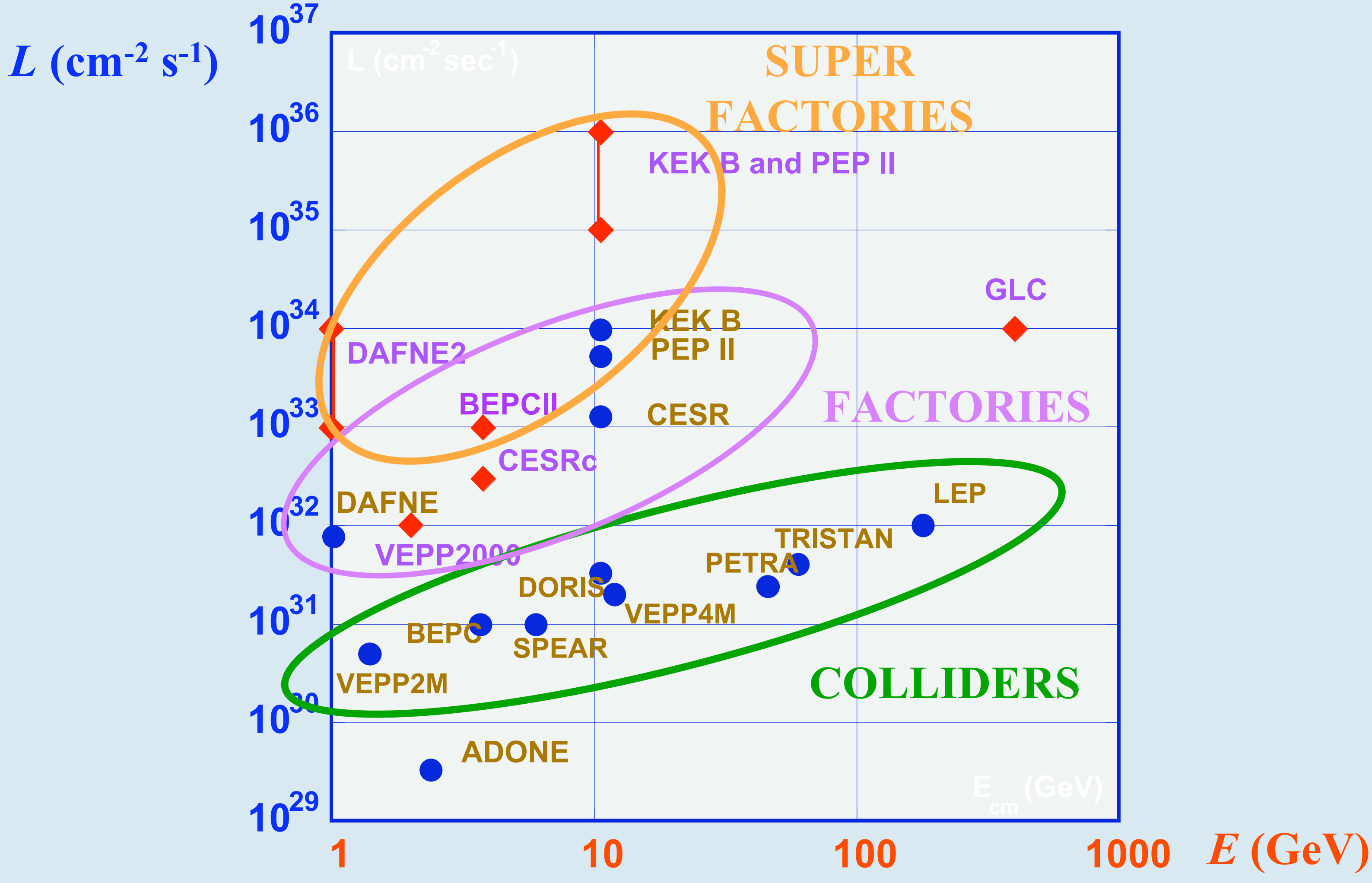
Energy range	1 – 2.1 GeV
Optimum energy	1.89 GeV
Luminosity	1×10^{33} $cm^{-2}s^{-1}$ @ 1.89 GeV
Injection	Full energy injection: 1.55 – 1.89 GeV Positron injection speed > 50 mA/min
Synchrotron mode	250 mA @ 2.5 GeV

Dual purpose machine

Design Goals and Main Parameters

Parameters		Unit	BEPCII	BEPC
Operation energy (E)		GeV	1.0–2.1	1.0–2.5
Injection energy (E_{inj})		GeV	1.55–1.89	1.3
Circumference (C)		m	237.5	240.4
β^*-function at IP (β_x^* / β_y^*)		cm	100/1.5	120/5
Tunes ($\nu_x/\nu_y/\nu_s$)			6.57/7.61/0.034	5.8/6.7/0.02
Hor. natural emittance (ε_{x0})		mm·mr	0.14 @1.89 GeV	0.39 @1.89 GeV
Damping time ($\tau_x/\tau_y/\tau_e$)			25/25/12.5 @1.89 GeV	28/28/14@1.89 GeV
RF frequency (f_{rf})		MHz	499.8	199.533
RF voltage per ring (V_{rf})		MV	1.5	0.6–1.6
Number of bunches (N_b)			93	2×1
Bunch spacing		m	2.4	240.4
Beam current	Colliding	mA	910 @1.89 GeV	~2×35 @1.89 GeV
	SR		250 @ 2.5GeV	130
Bunch length (cm) σ_l		cm	~1.5	~5
Impedance $\|Z/n\|_0$		Ω	~ 0.2	~4
Crossing angle		mrad	±11	0
Vert. beam-beam param. ξ_y			0.04	0.04
Beam lifetime		hrs.	2.7	6–8
luminosity@1. 89 GeV		$10^{31} cm^{-2} s^{-1}$	100	1

e^+-e^- Colliders: Past, Present and Future



BEPCII Major Milestones

- **In 2004, Completed**
  - **Upgrade of Linac；**
  - **Moved BES from beam line, and dismounted；**
  - **Improve infrastructure, including the power station。**
- **Resumed synchrotron run，till June, 05.**
- **July. 05 – Sep. 06：**

- Removed everything from ring，tunnel improvement，water pipe and power outlets。finished。

- Install the main ring components，from 2nd of March, 06.

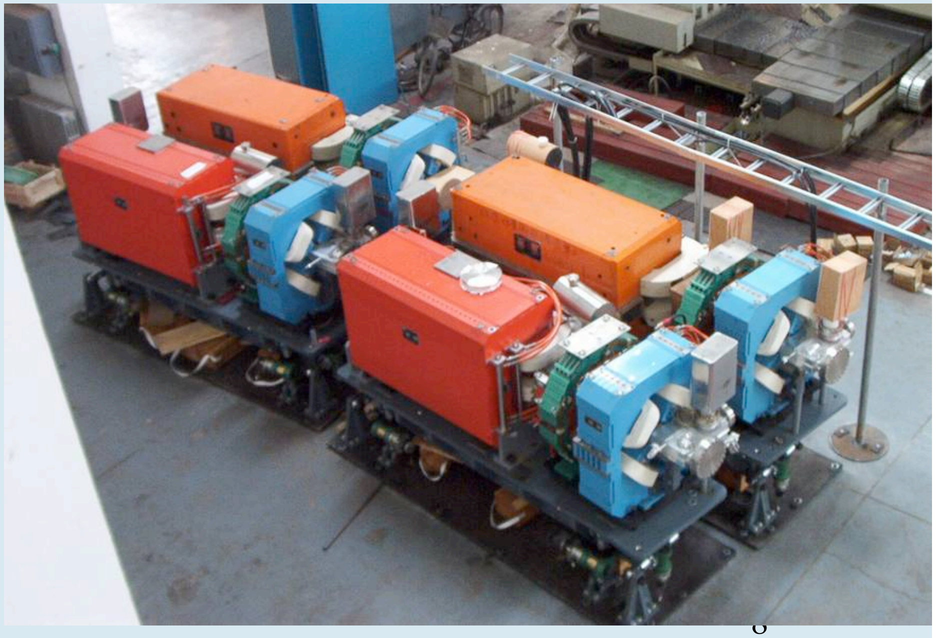
- **Sep. 06 – June. 07, ring commissioning, SCQ moved in later，**

  Some synchrotron run.
- **Aug. 07, BESIII moved to the beam line.**
- **Sep. 07 Commissioning ring and detector together.**
- **Dec. 07 test run。**
- **Dec. 08, to achieve a lum. of $3\times10^{32}cm^{-2}s^{-1}$.**

BEPCII Status

•BEPCII linac installation complete(new electron gun; new position source; new rf power (klystrons and modulators); and others.

Most design specifications reached at 1st test run.



BEPCII Linac achieved Performances

parameters		Design (BEPC)	Achieved
Beam energy （GeV）		1.89(1.55)	1.89 (e-); 1.55 (e+) [1)]
current (mA)	e+	40(4)	> 63
	e-	500(50)	> 500
Repetition rate (Hz)		50(25)	25 ~ 50
Emittance (mm· mrad）	e+	1.60(1.70)	0.93 @ 1.89 GeV [2)]
	e-	0.20(0.58)	0.30 @ 1.89 GeV [2)]
Energy spread （%）	e+	± 0.5(0.8)	± 0.50 @ 1.89 GeV [2)]
	e-	± 0.5(0.8)	± 0.55 @ 1.89 GeV [2)]

note：1）Two rf power stations were not in operation at the time.

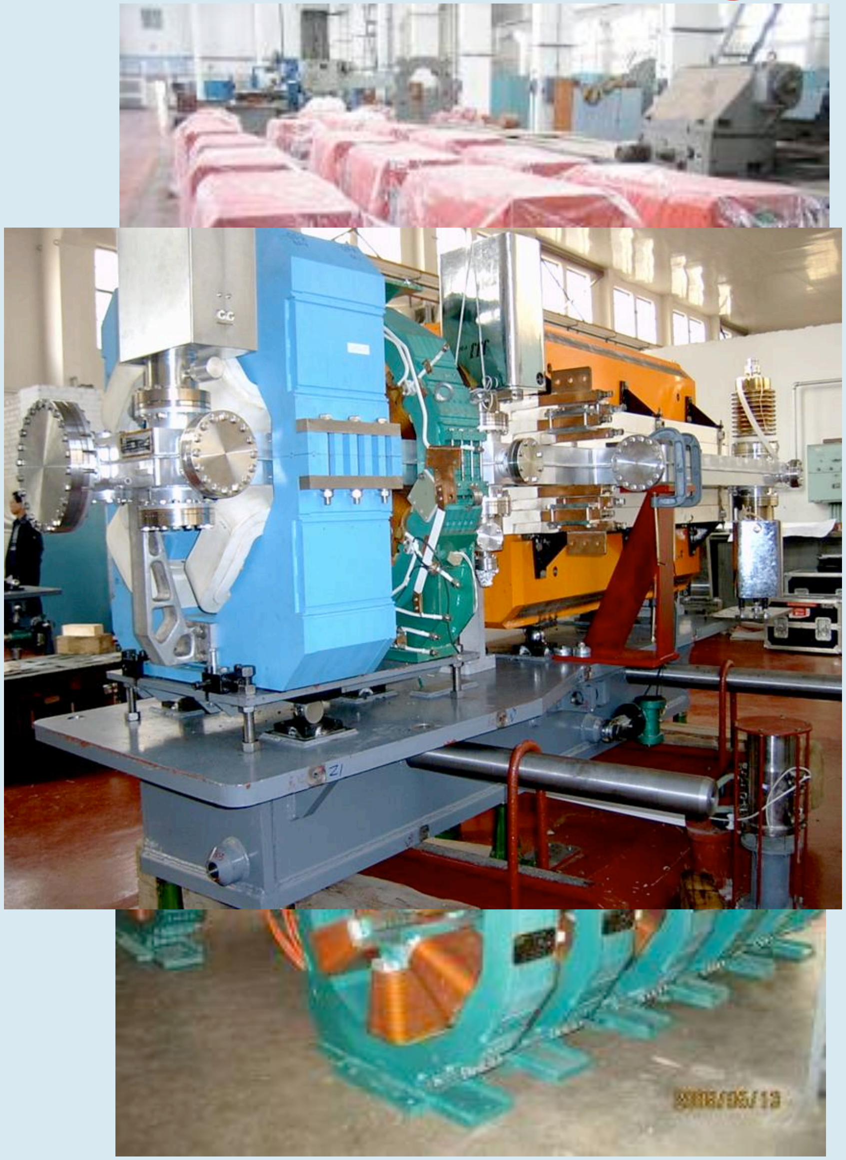
2）The values for 1.89 GeV is extrapolated from those of 1.30 GeV，should be measured when the energy is at 1.89 GeV.

Status of Storage ring

- **Major magnets; super-conducting RF cavities and super-conducting quadrupole magnets, beam pipes; kicker; beam instruments; control system; vacuum system as well as the cryogenics;**

  most of the systems have been completed;
- **Their installation is under way; ~ 14 magnet sets**
- **Testing ring in Sep. 2006, without SCQ first;**
- **Beam collisions expected in spring 2007.**

Magnet System

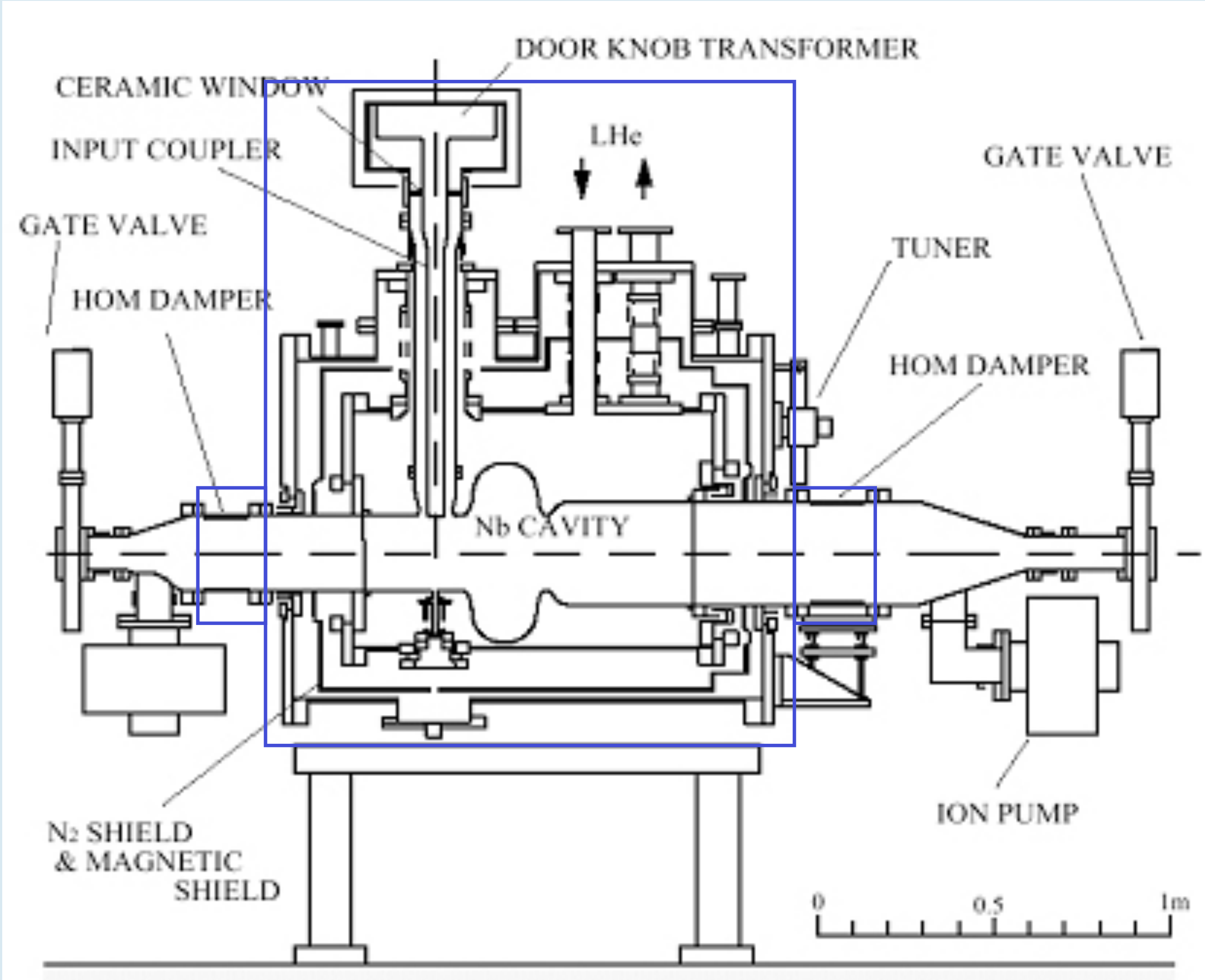


Sextupole magnets

Dipole correctors

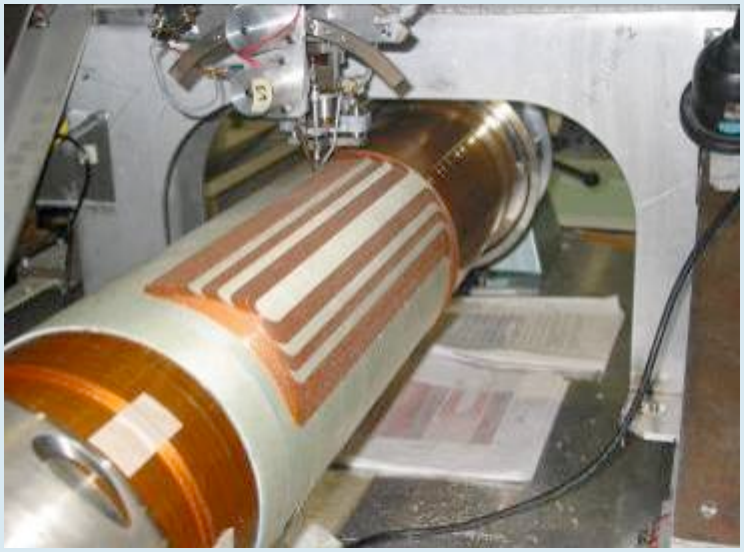
Started the installation of magnet sets

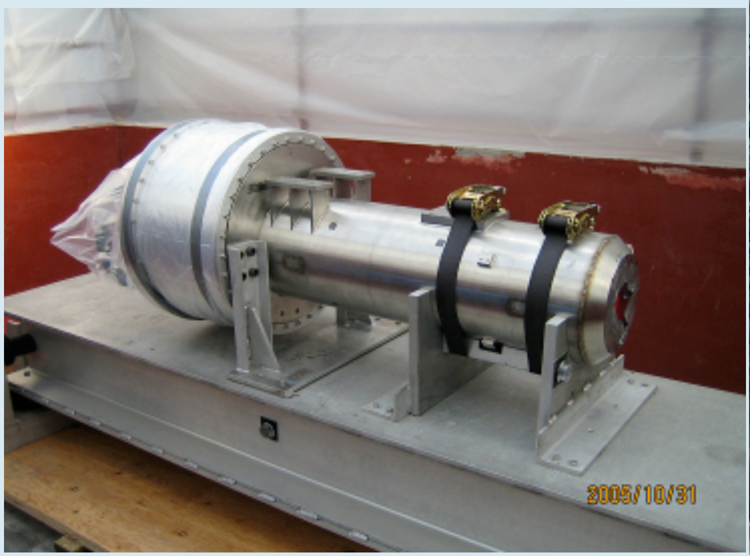
KEKB type SC Cavity



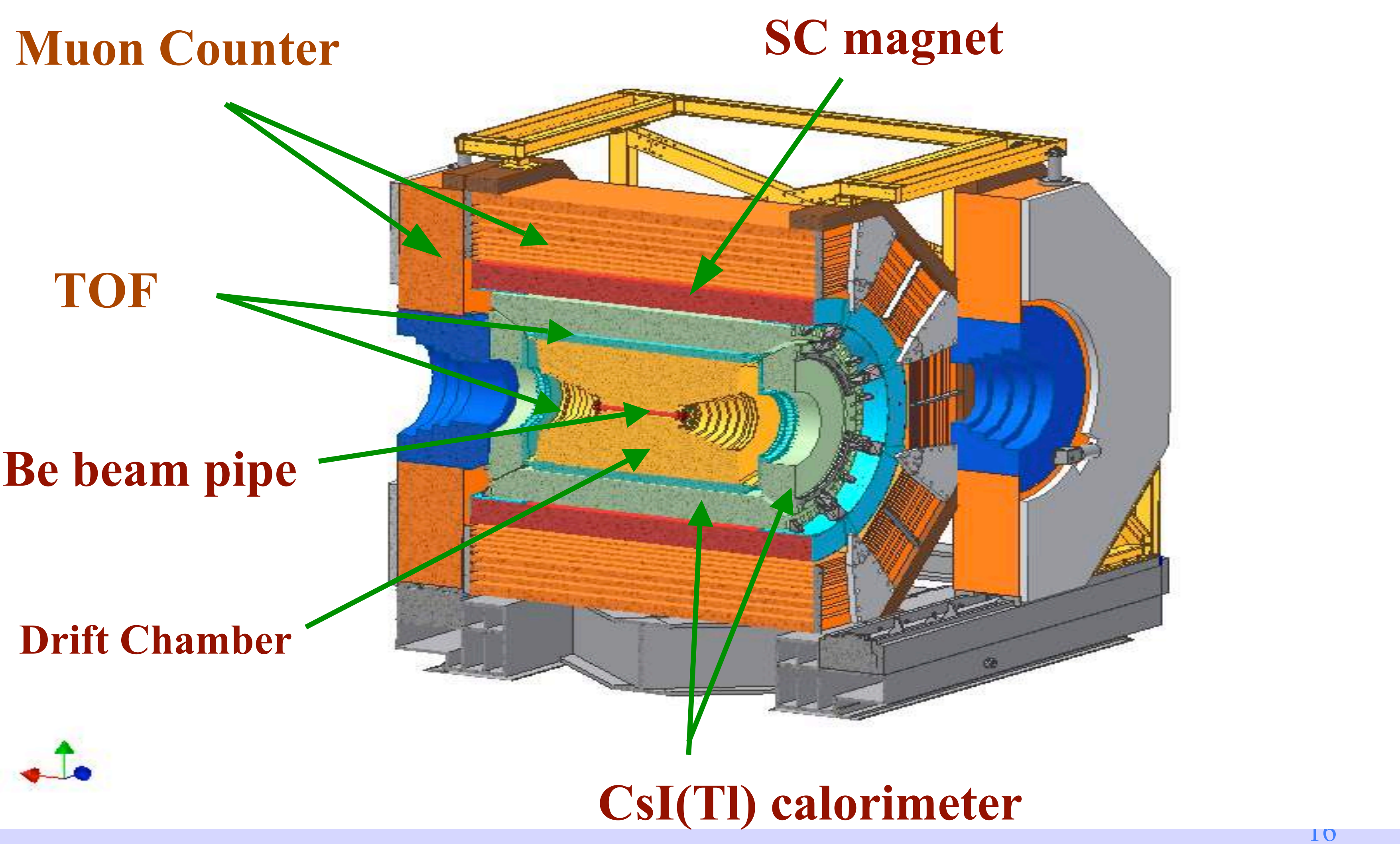
Cavities delivered and being tested

Super-conducting Quadra-pole





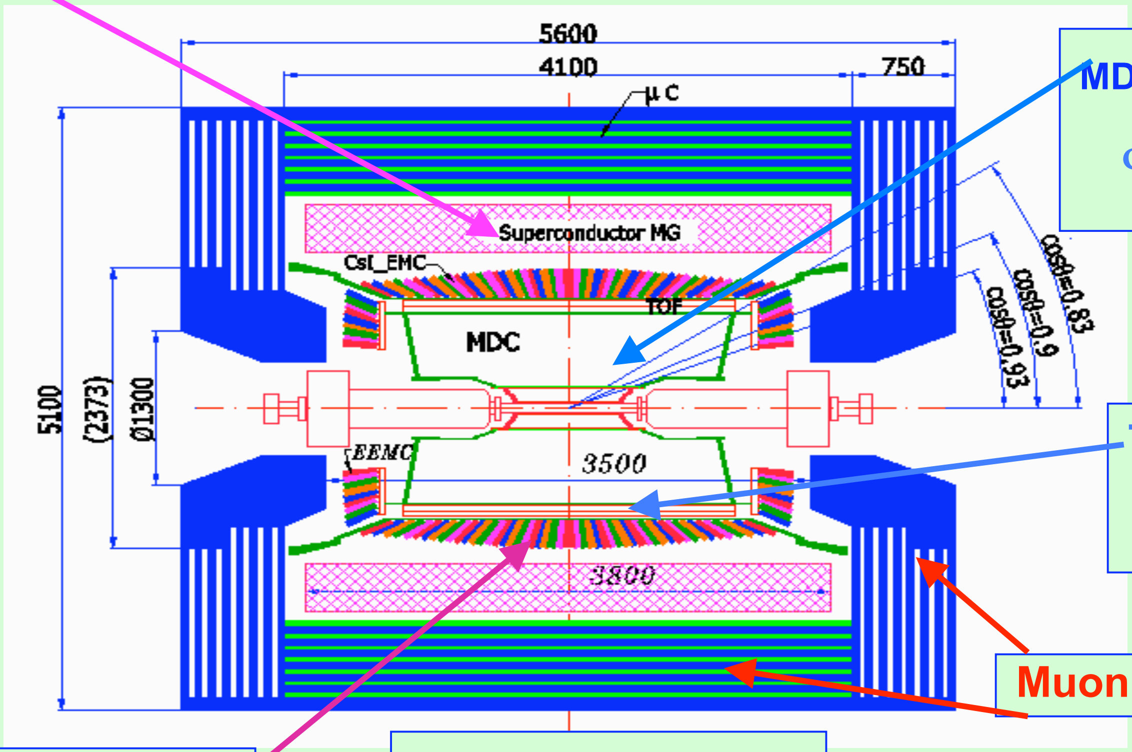
BESIII Detector



BESIII Detector

Two rings, 93 bunches:
- **Luminosity**
  - 10^{33} cm^{-2} s^{-1} @1.89GeV
  - 6×10^{32} cm^{-2} s^{-1} @1.55GeV
  - 6×10^{32} cm^{-2} s^{-1} @ 2.1GeV

Magnet: 1 T Super conducting



MDC: small cell & He gas
σ_{xy}=130 μm
σ_p/p = 0.5% @1GeV
dE/dx=6%

TOF:
σT = 100 ps Barrel
110 ps Endcap

Muon ID: 9 layer RPC

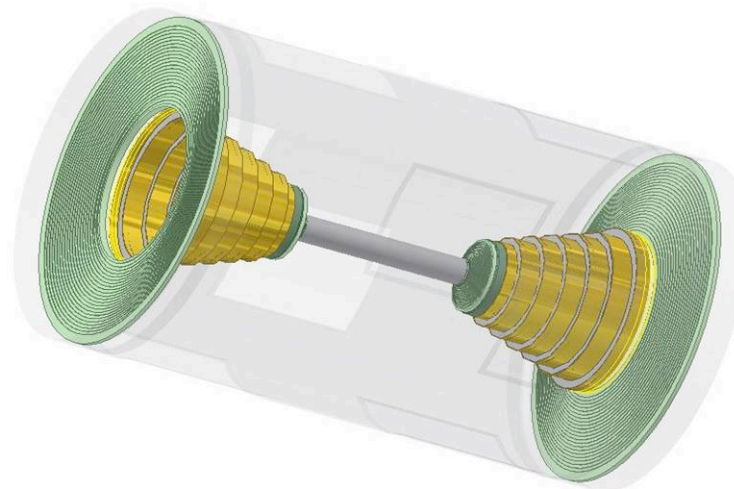
EMCAL: CsI crystal
$\Delta E/E$ = 2.5% @1 GeV
$\sigma z = 0.6\ \mathrm{cm}/\sqrt{E}$

Data Acquisition:
Event rate = 3 kHz
Thruput ~ 50 MB/s

Trigger: Tracks & Showers
Pipelined; Latency = 6.4 μs

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

MDC



Parameters

R inner: 63mm ; R outer: 810mm

Length (out.): 2582 mm

Inner cylinder: 1.2 mm Carbon fiber

Outer cylinder: 11.5 mm CF with 8 windows

Sense wire : 25 micron gold-plated tungsten (plus 3%Rhenium) --- 6796

Layers (Sense wire): 43

Field wire: 110 micron gold-plated Aluminum --- 21884

Gas: He + C3H8 (60/40)

Cell: inner chamber --- 6 mm

outer chamber --- 8.1 mm

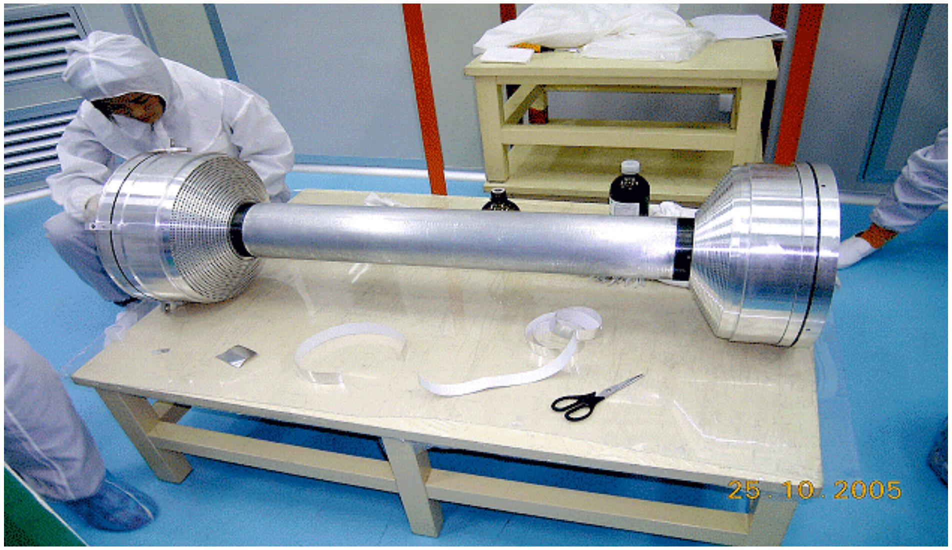
Expected performance

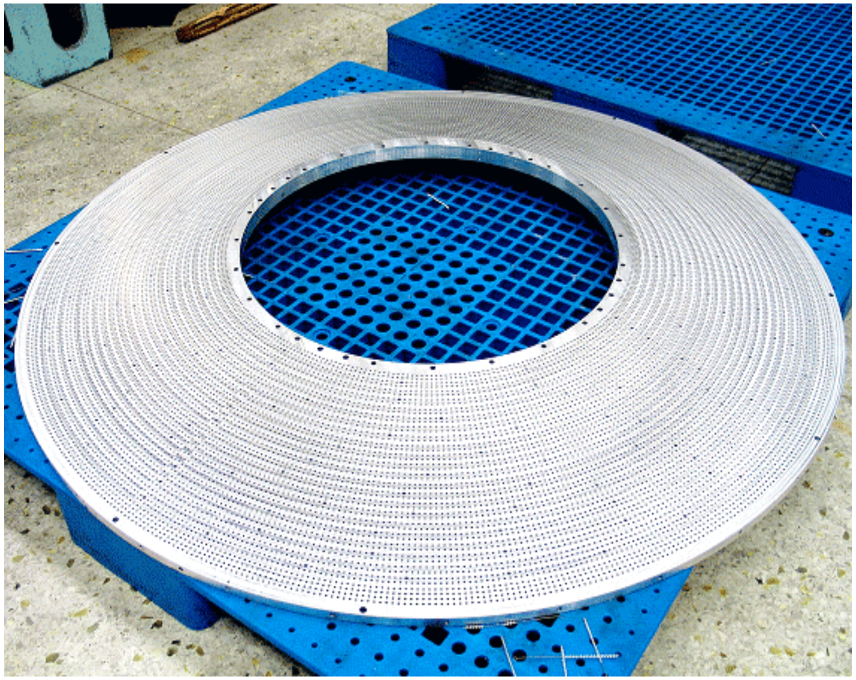
$$\sigma_x \sim 130\mu m$$

$$\frac{\sigma_P}{P} \sim 0.5\%@1\mathrm{GeV/C}$$

$$\frac{\sigma_{\frac{dE}{dx}}}{\frac{dE}{dx}} \sim 6\%$$

MDC





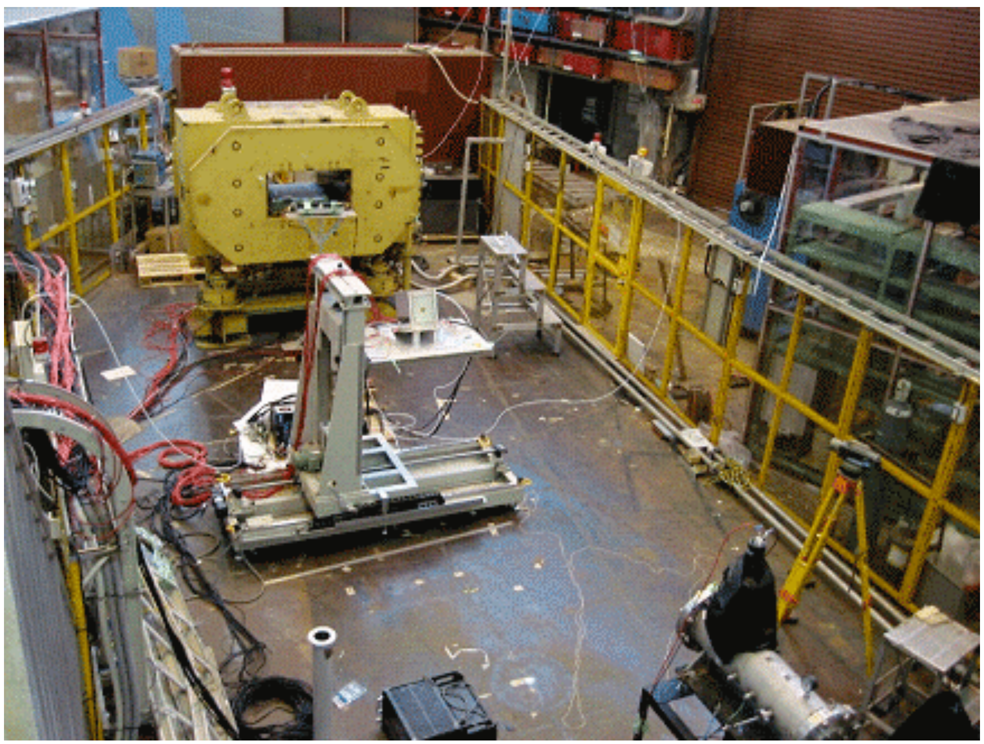
Wire Stringing Completed

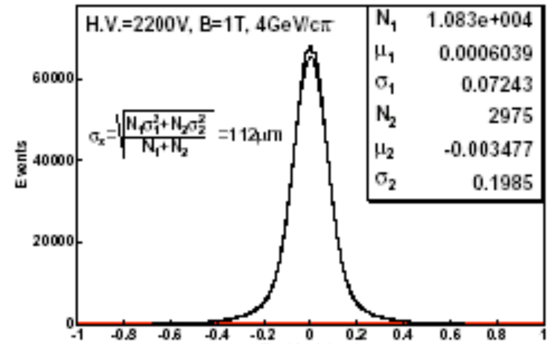
Beam test at KEK

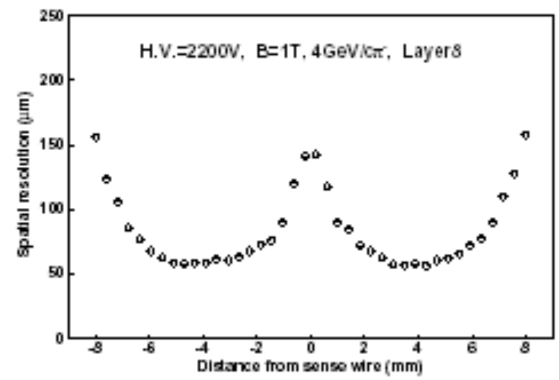
Prototype tested in a 1T magnetic field at KEK 12GeV PS last year.

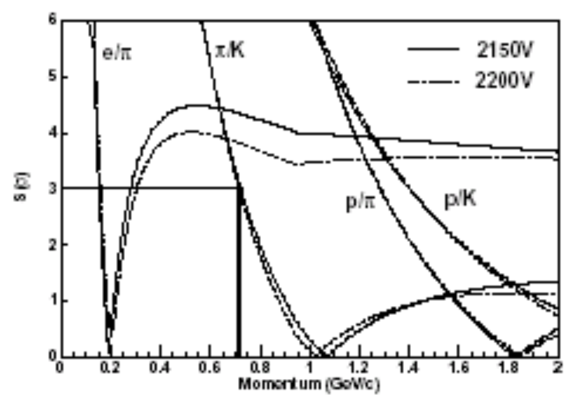
Results:

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





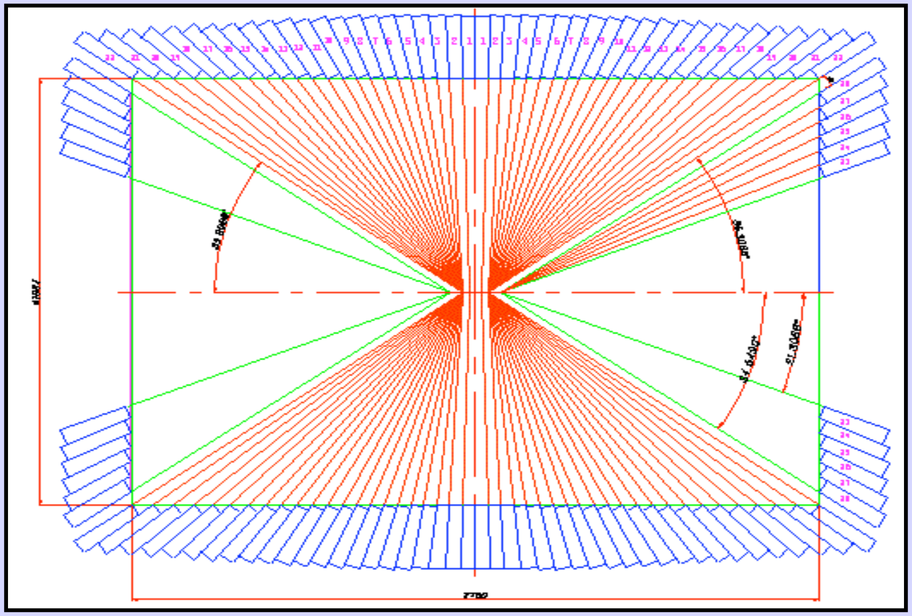




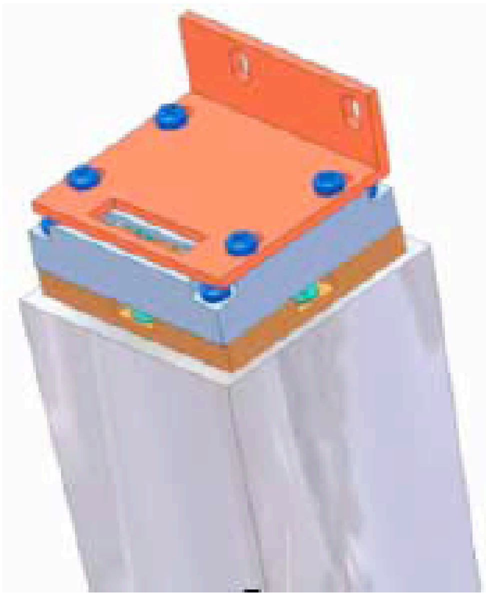
CsI(Tl) crystal calorimeter

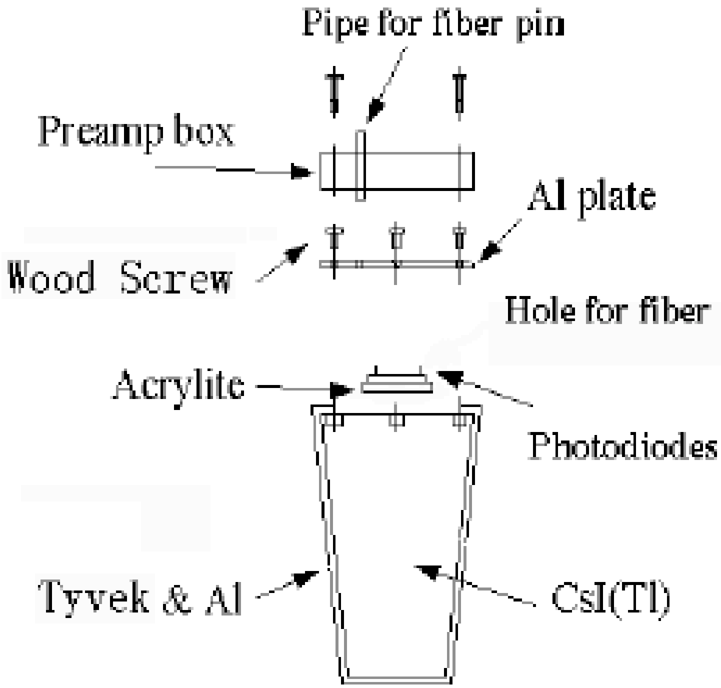
- Design goals:
  - Energy: 2.5% @ 1GeV
  - Spatial: 0.6cm @ 1GeV

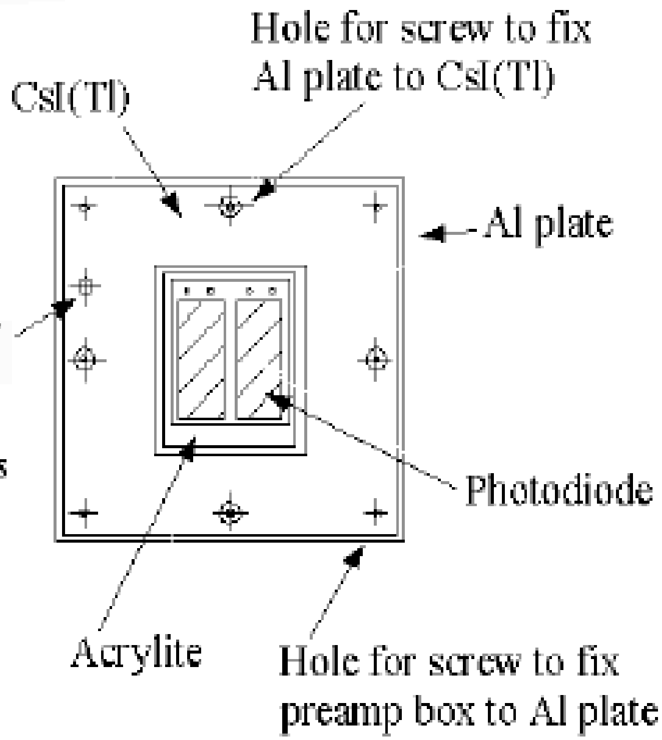
- Crystals:
  - Barrel: 5280 w: 21564 kg
  - Endcaps: 960 w: 4051 kg
  - Total: 6240 w: 25.6 T



CsI(Tl) crystal detector cell







CsI Calorimeter

Testing:

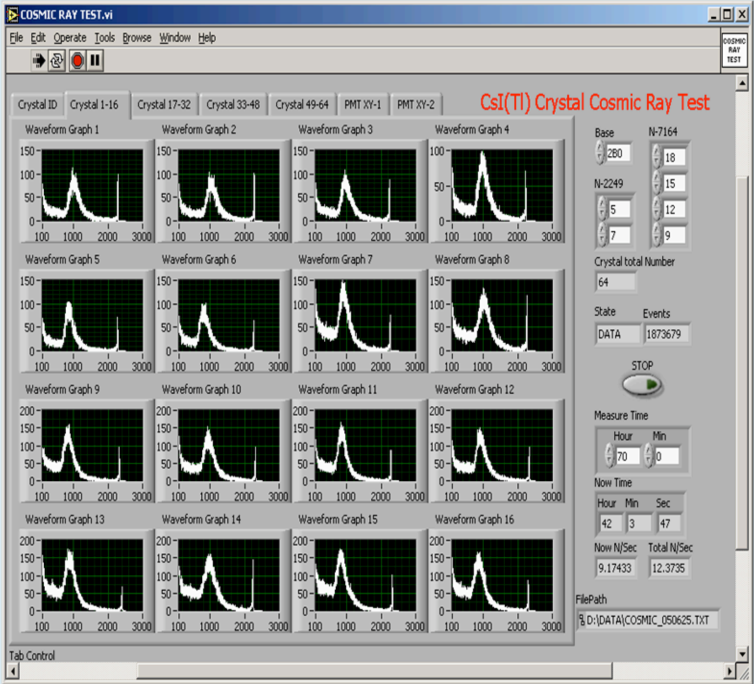
- Size
- Source tests (^{137}Cs)
- LED tests
- PD tests
- Preamp tests
- Cosmic ray tests
- Beam tests (6 x 6 array):

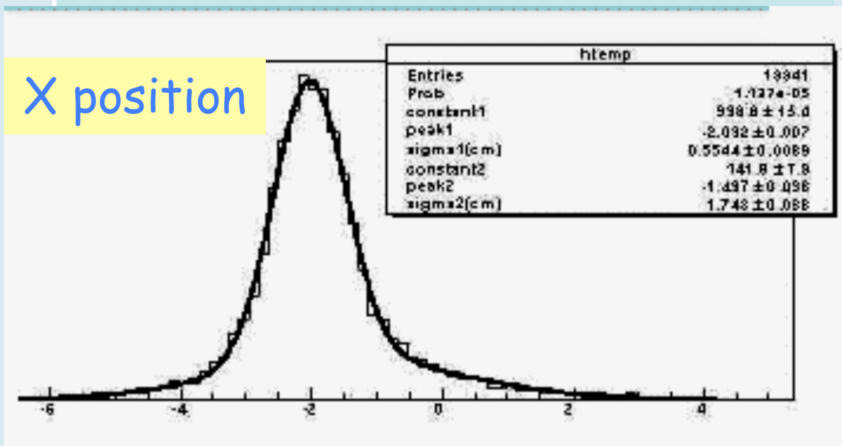
Energy resolution (1GeV)

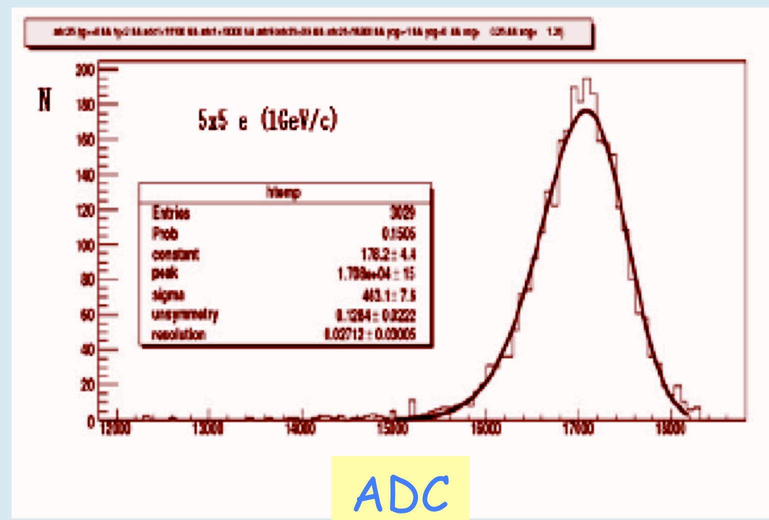
$$\sigma_E = 2.62\ \%$$

position resolution (1GeV)

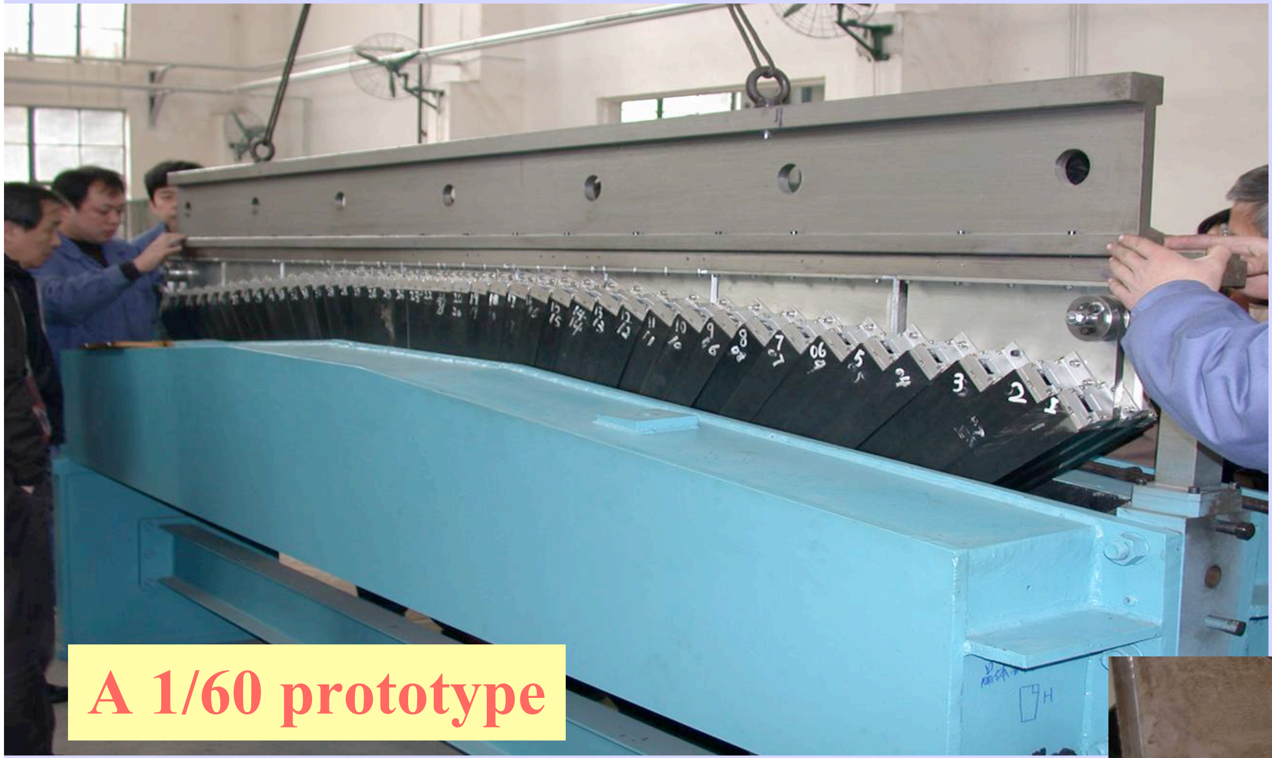
$$\sigma_{x-y} = 6\ \text{mm}$$

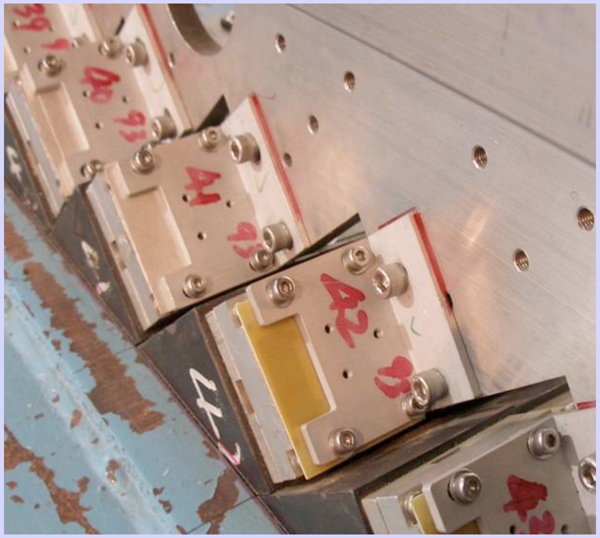






Mechanical structure

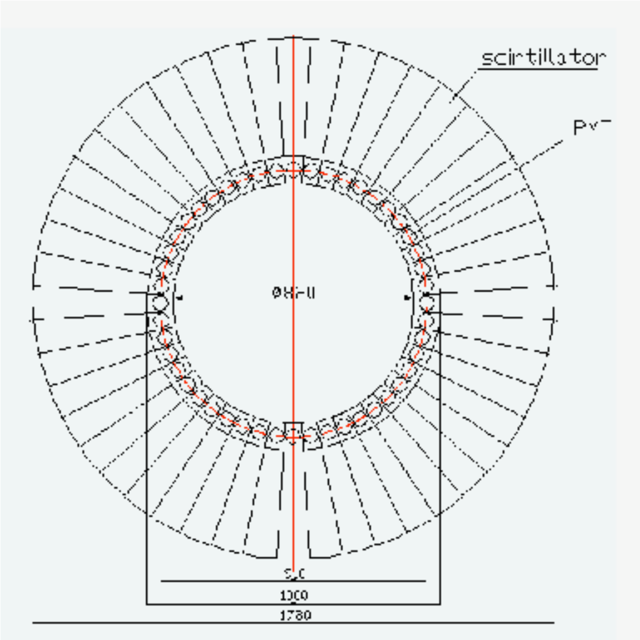

A 1/60 prototype



Status:

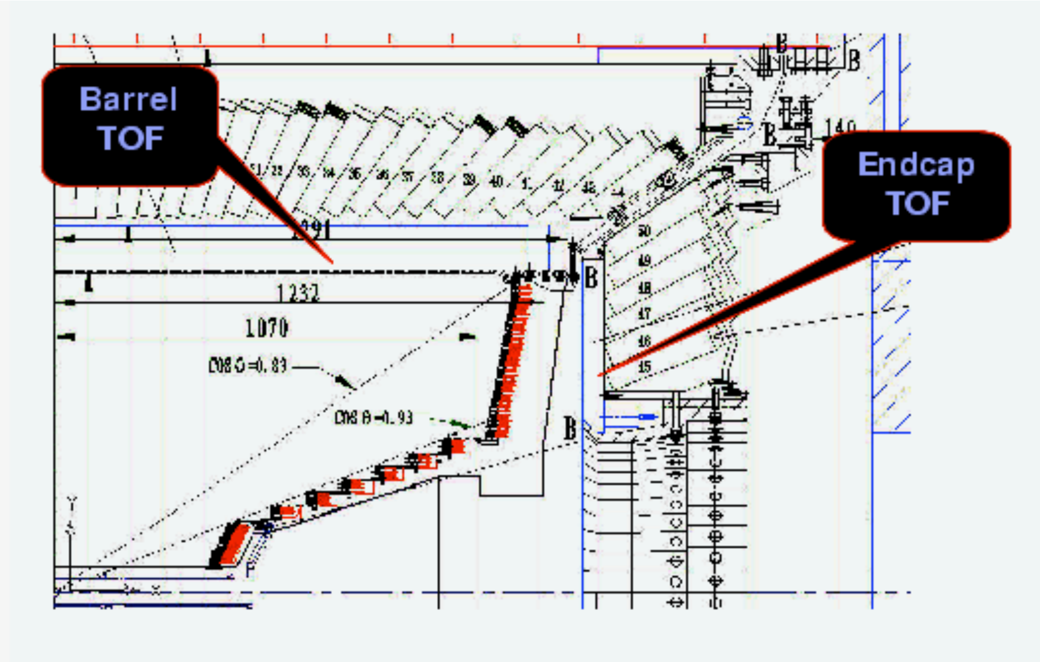
- Assembly will start soon. Should be completed by end of year.
- By the end of the year, all FED boards should be tested and installed.

TOF



Crucial for particle ID

- Barrel
  - 50mm x 60mm x 2320 mm (inner layer).
  - BC408
  - 2 layers 88x2
- Endcap
  - 48 fan shaped pieces – each end.
  - BC404
- PMT: Hamamatsu R5942

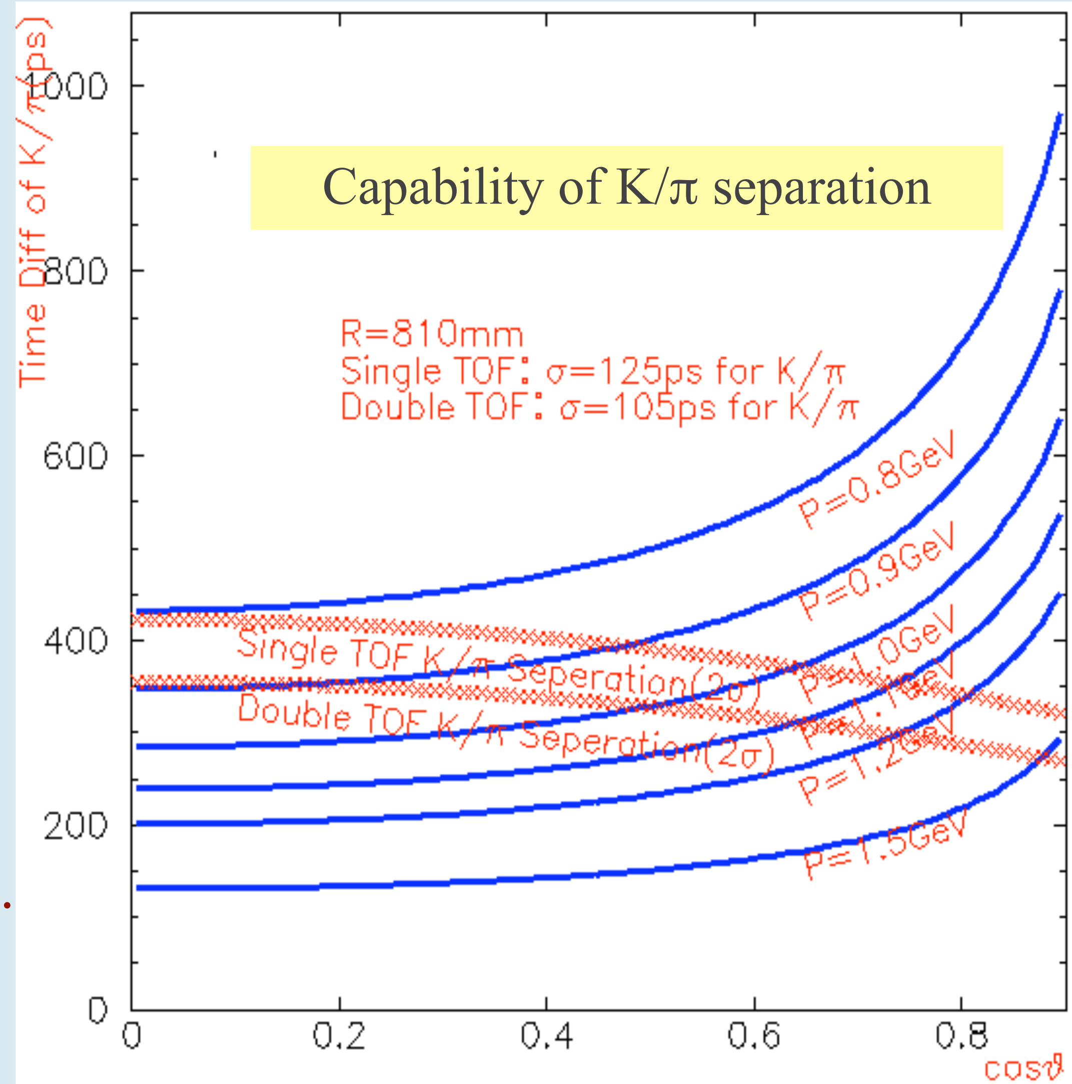


TOF Performance

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

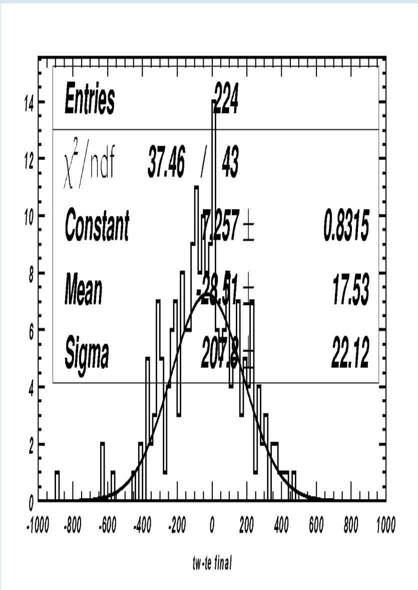
- Time resolution of two layers is 100ps to 110ps for kaon and pions.

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

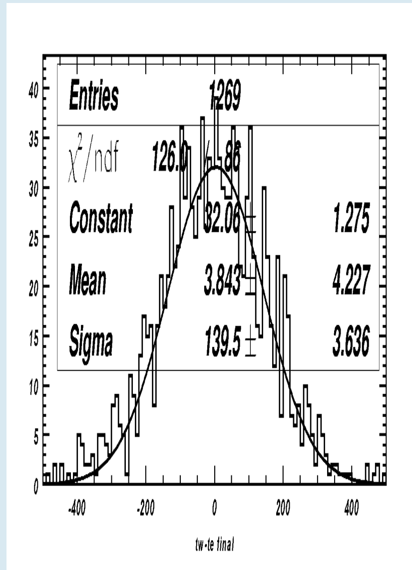


Beam tests of TOF module

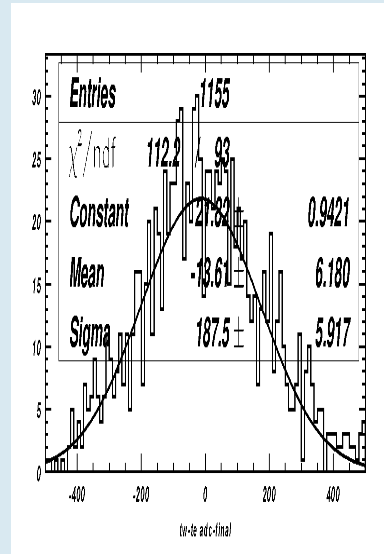
- TOF module includes: scintillator, PMTs, preamps, 18m cable, VME readout board of FEE.



Pion: 104±11ps



proton: 70±2ps

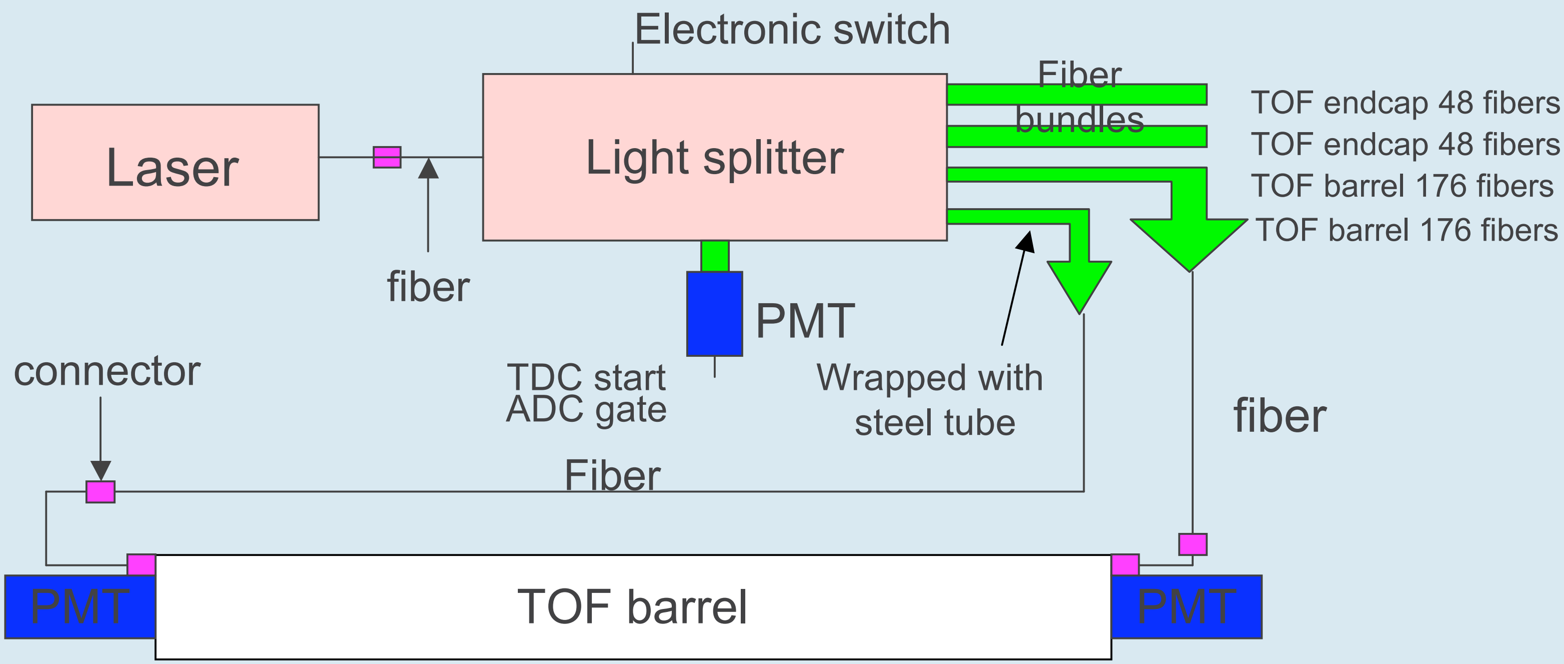


Electron: 94±3ps

Time resolution from beam test of prototype（including scintillator, PMT, preamp, electronics, cable).
Time difference of two TOF layers: no errors from reference time (T_0) or position.

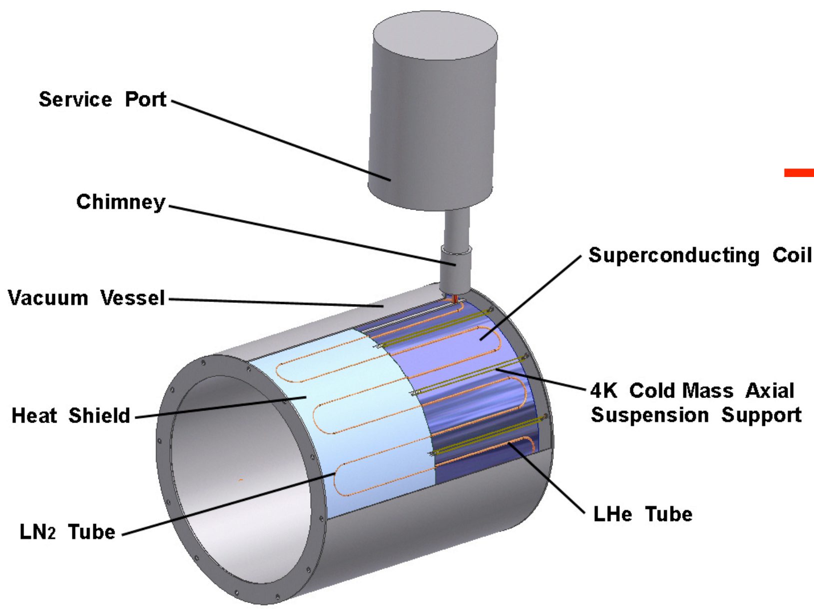
TOF Monitor System

- Monitor the amplitude and time performance of each channel including PMTs and electronics.
- U. Tokyo responsible for PMT testing in magnet
- Being designed by University of Hawaii. Just approved by DOE: 3/1/2006



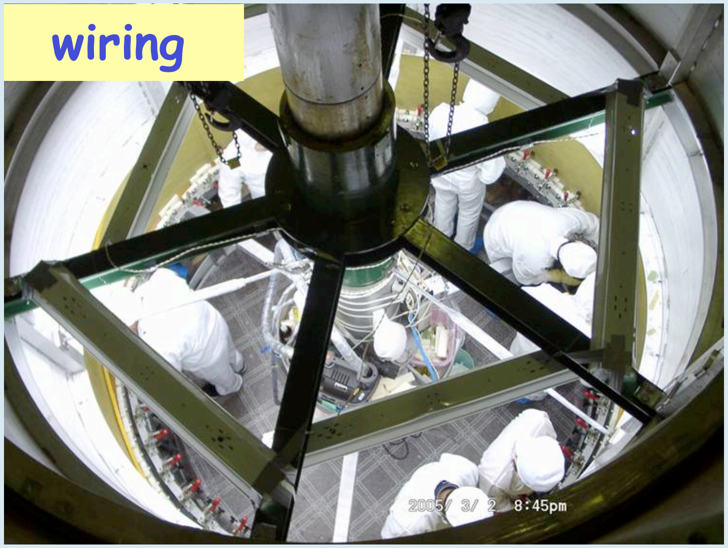
Superconducting Magnet

Coil: single layer solenoid
Cooling mode: two phase helium force flow
Superconductor: Al stabilized NbTi/Cu
Winding: inner winding
Cold mass support: tension rod
Thermal shield: LN_2 shield, MLI
Flux return: barrel/end yoke, pole tip



Cryostat	
Inner radius	1.375m
Outer radius	1.7m
Length	3.91m
Coil	
Mean radius	1.482m
Length	3.52m
Cable dimension	3.7mm*20mm
Electrical parameters	
Central field	1.0T
Nominal current	3650A
Inductance	2H
Stored energy	10MJ
Cold mass	3.6ton
Total Weight	15ton
Radiation thickness	$2X_0$

BESIII Magnet Progress


wiring

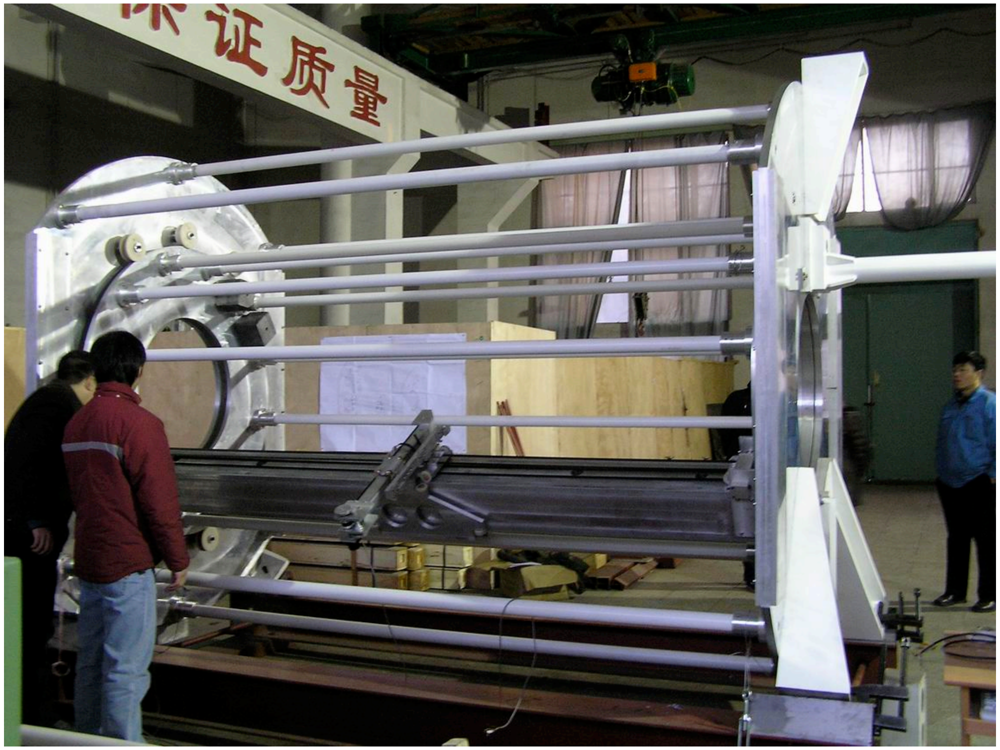

Thermal insulation


assembly


transportation


installation

Field mapping



Mapping device

Computer controlled 3D mapping machine is under development.

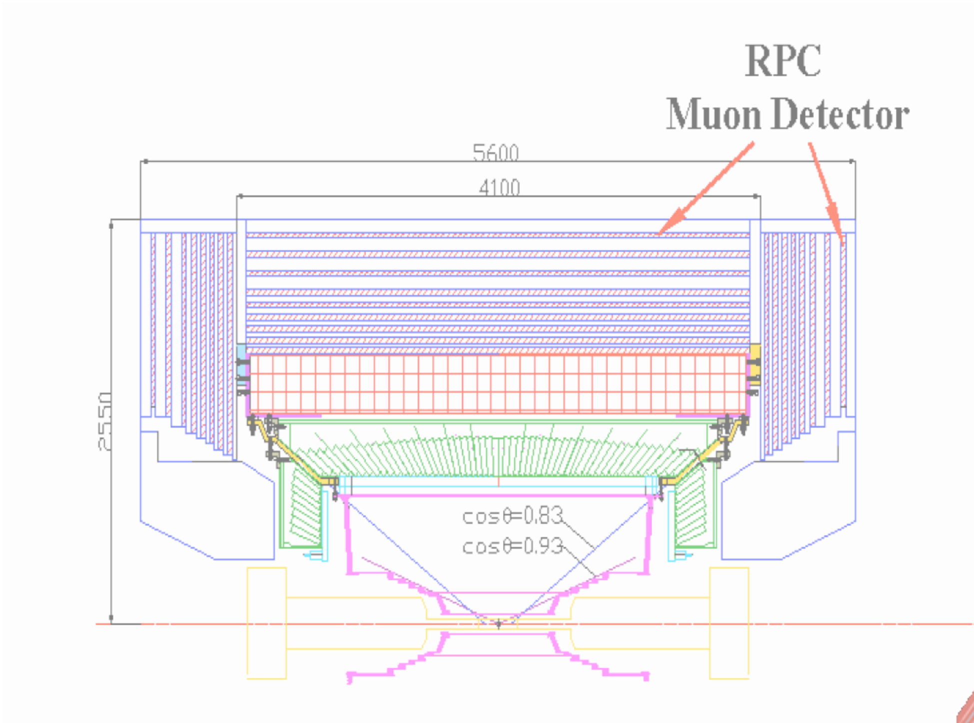
Field measuring accuracy < 0.25%.

Measure ~90000 points with 0.5 mm position accuracy.

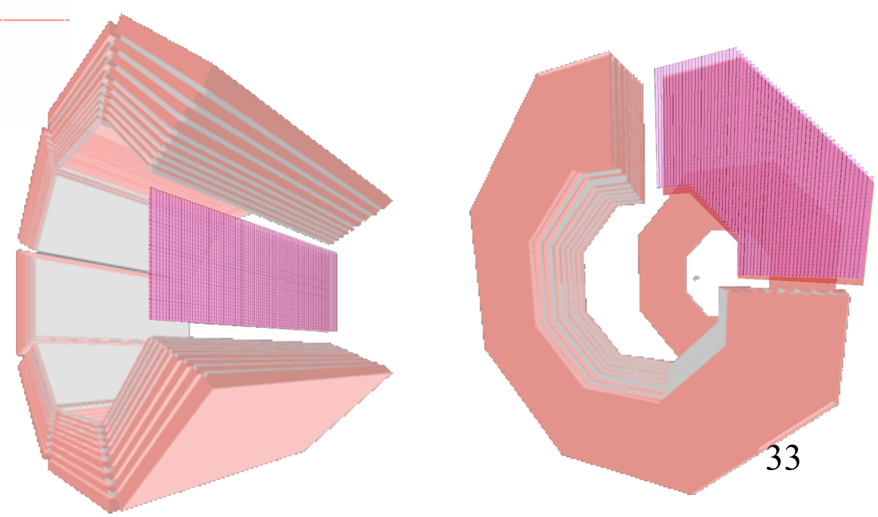
Status:

- Complete cooling test of the magnet before summer.
- Complete the field mapping together with SCQ before Dec. 31, 2006.

Muon Chamber

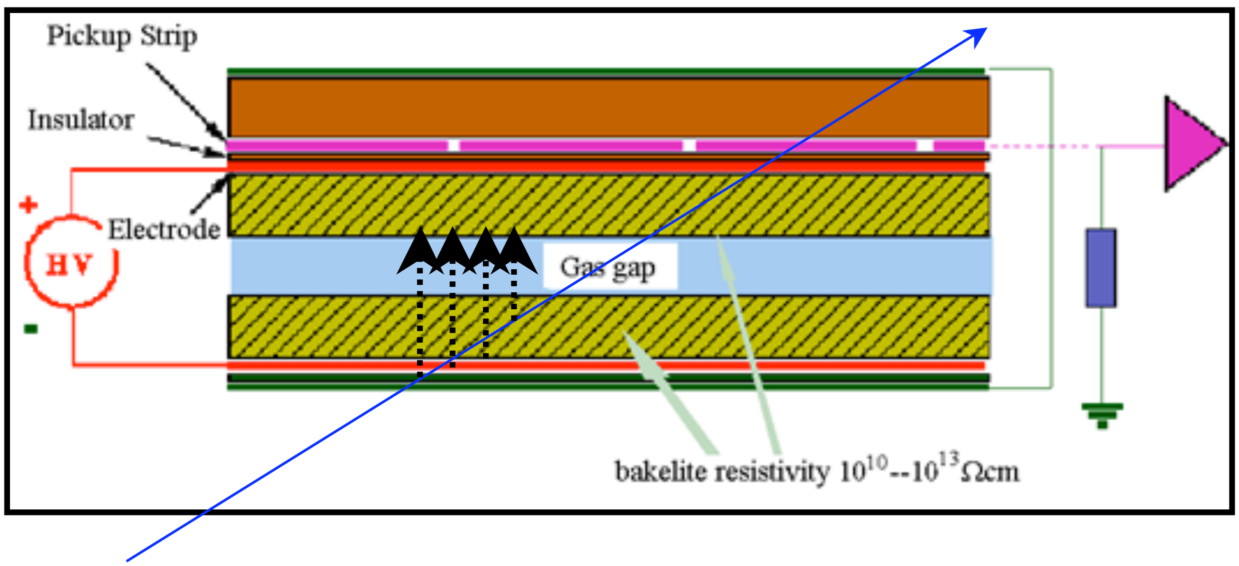


- Barrel + EndCap;
- RPC as μ detector;
  Barrel : 9 layers
  EndCap: 8 layers
- One dimension read-out strips;



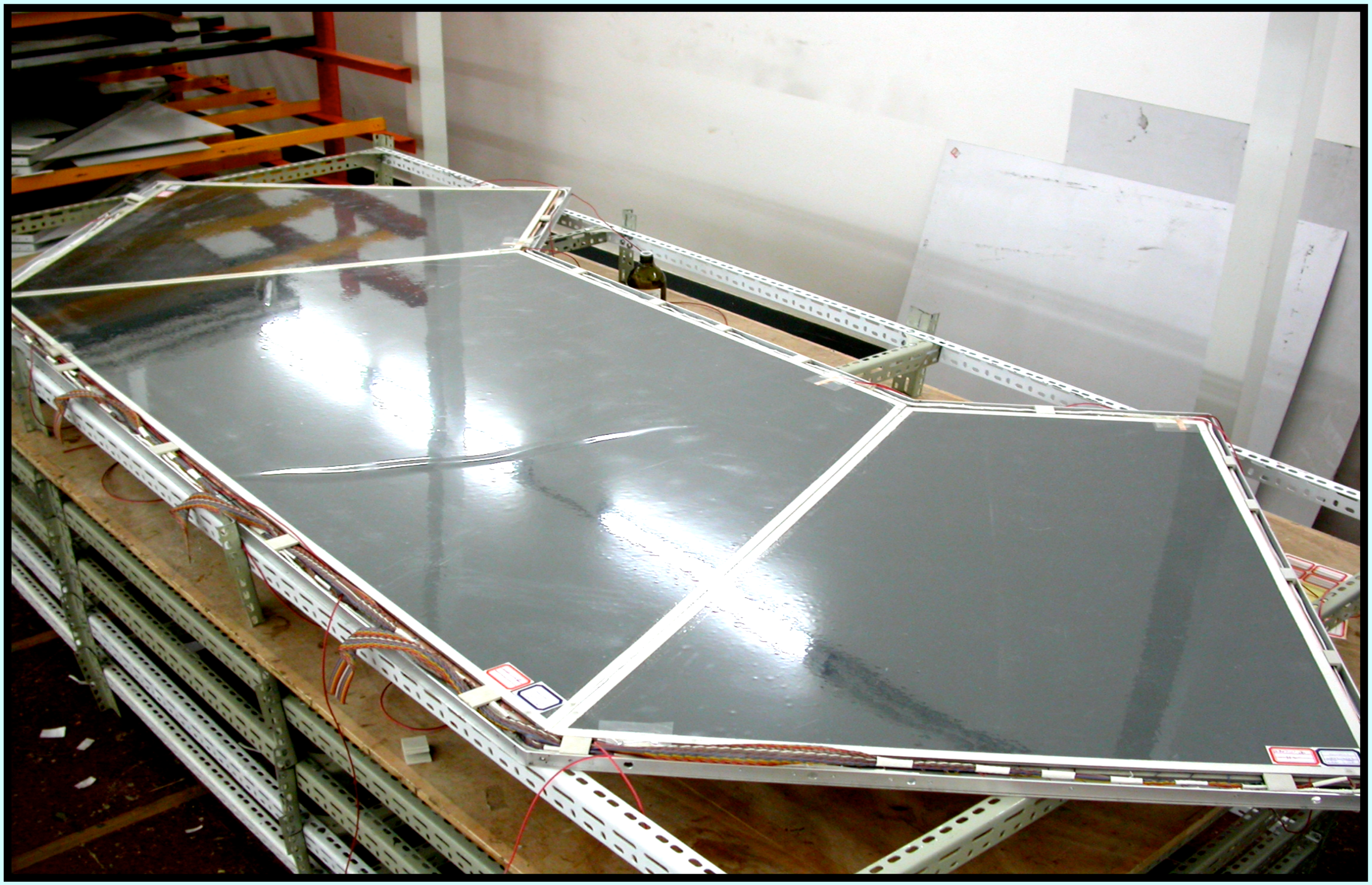
RPCs

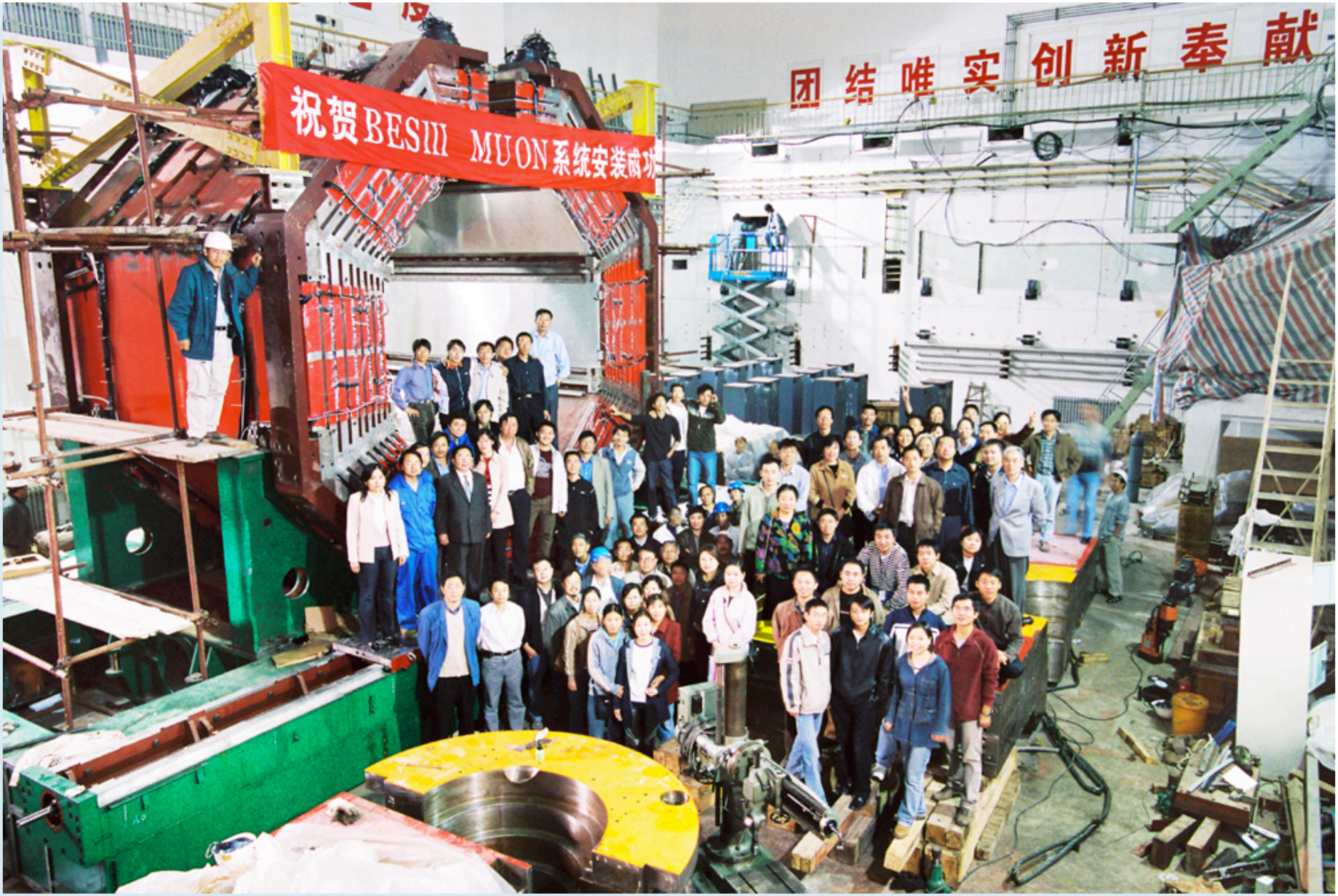
- Electrodes made from a special type of phenolic paper laminate on bakelite.
- Have good surface quality （~200nm).
- Extensive testing and long term reliability testing done.
- Have high efficiency, low counting rate and dark current, and good long-term stability .



(RPC module)

- Total of 64 endcap modules, 72 barrel modules;
- Gas: Ar:C2H2F4:Iso_Butane = 50:42:8
- HV voltage: 8000V;
- One module contains two RPC layers and one readout layer.

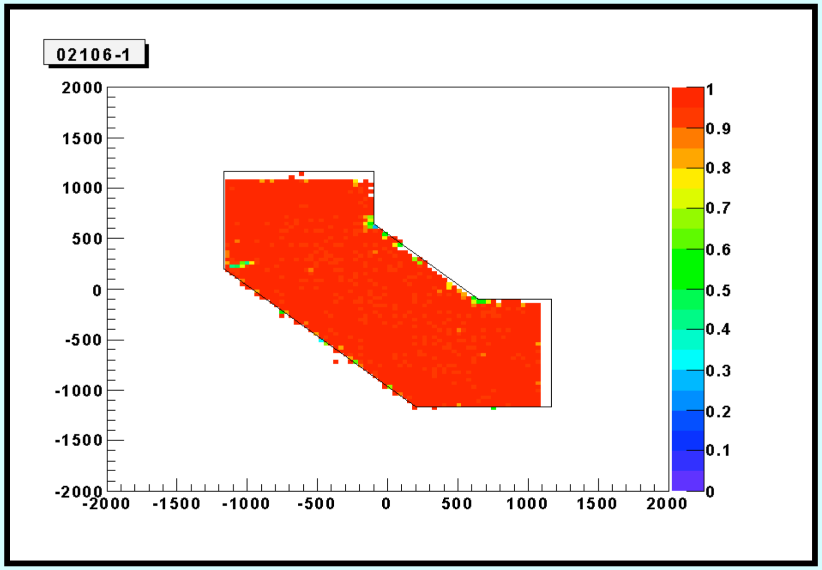


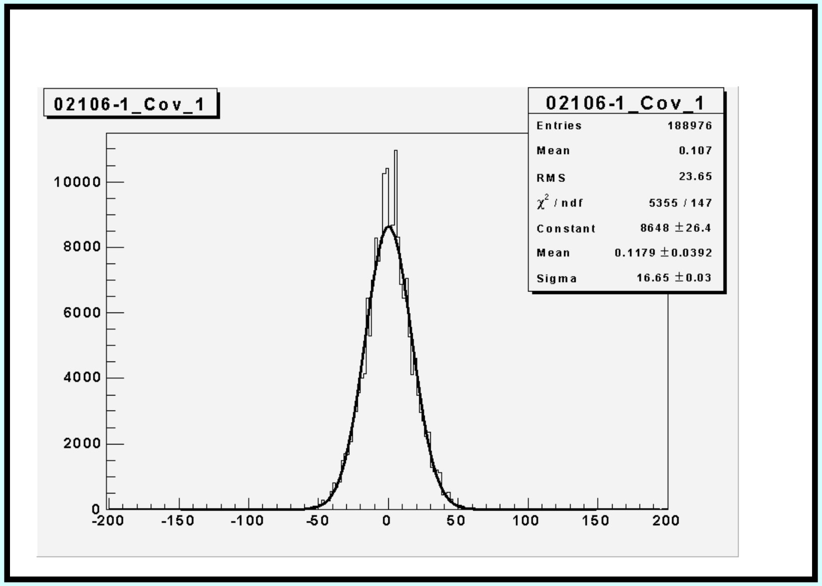


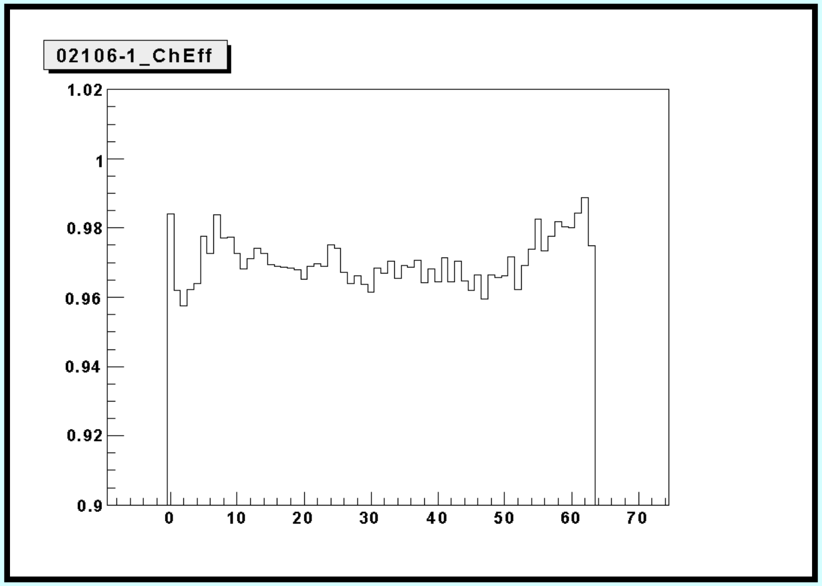
All RPC production, assembly, testing, and installation completed.

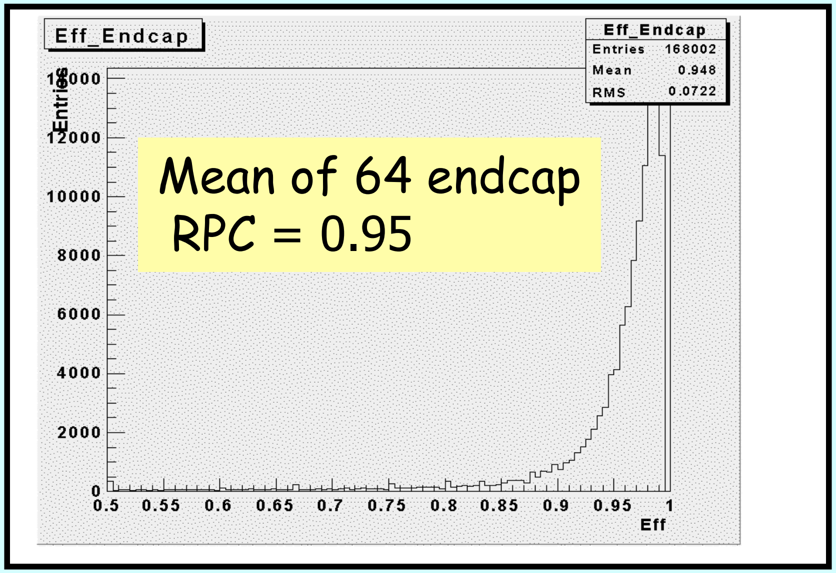
Test Result after installation - endcap

Average strip efficiency: 0.97 Spatial resolution: 16.6mm





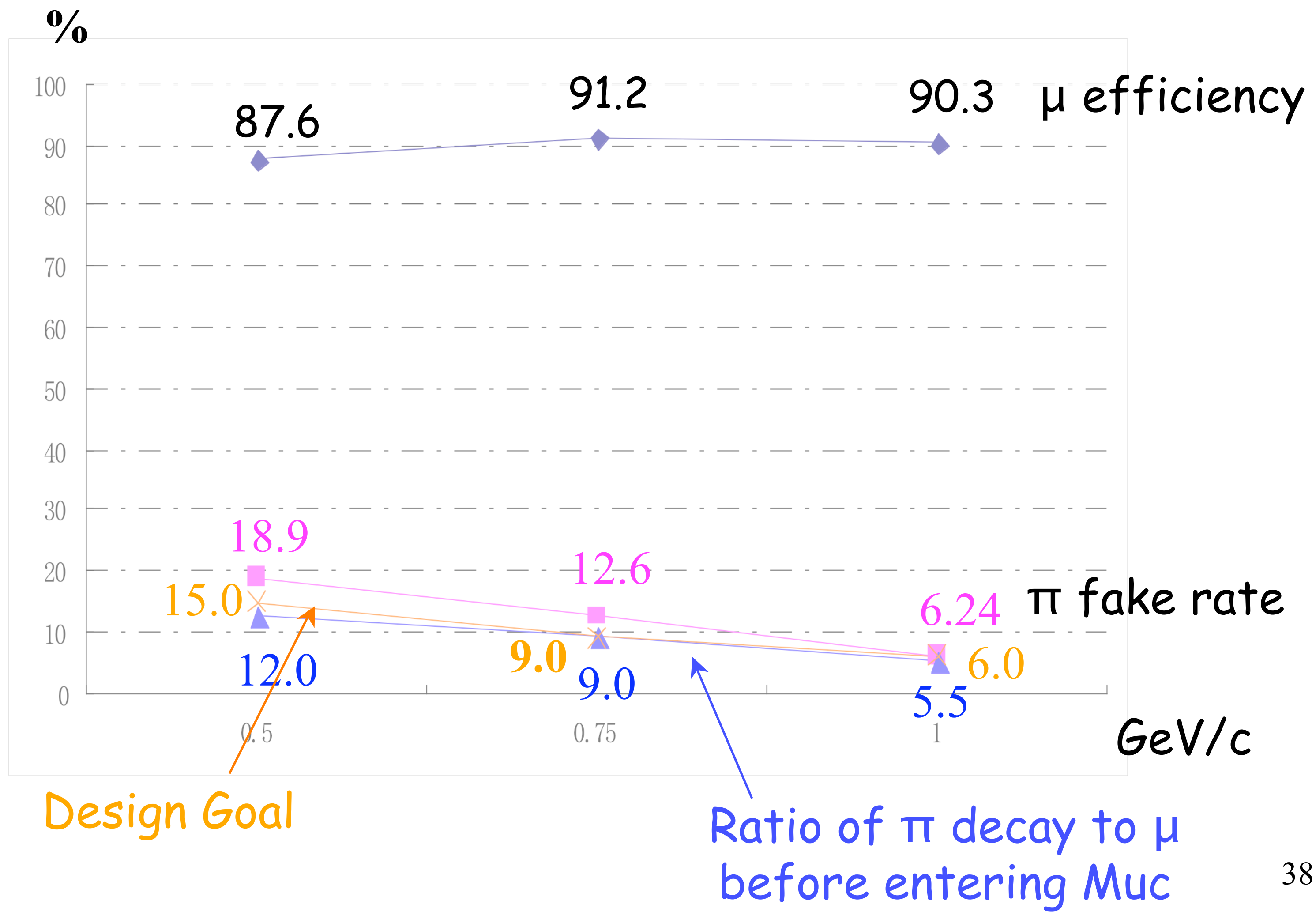




μ/π Identification Efficiency

From Simulation

Using Muc Info only

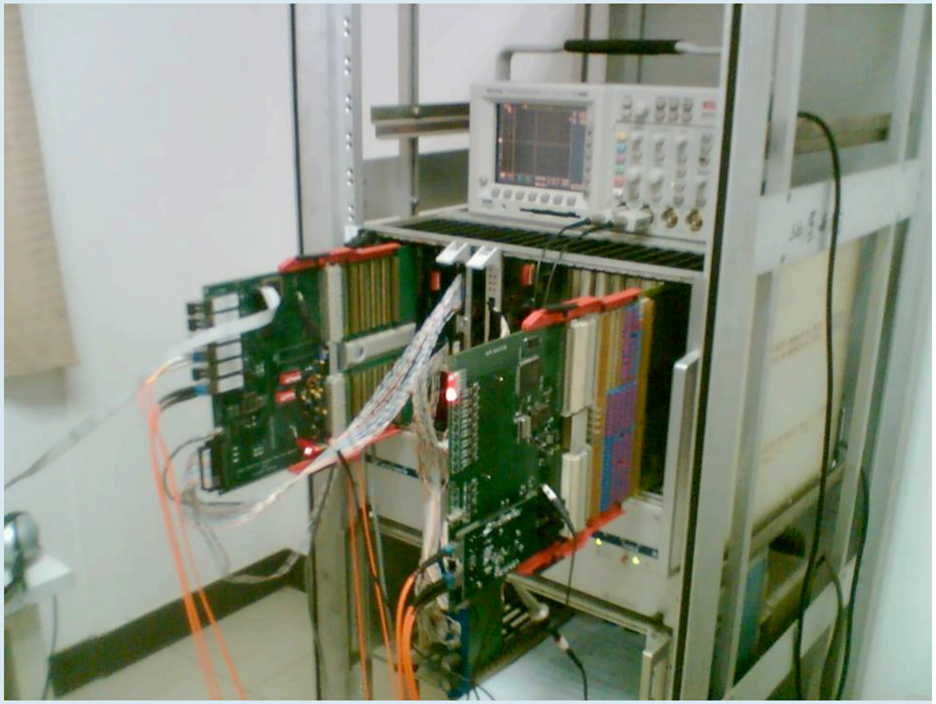


Trigger and DAQ

- The trigger design is almost finalized; uses FPGA.
- 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

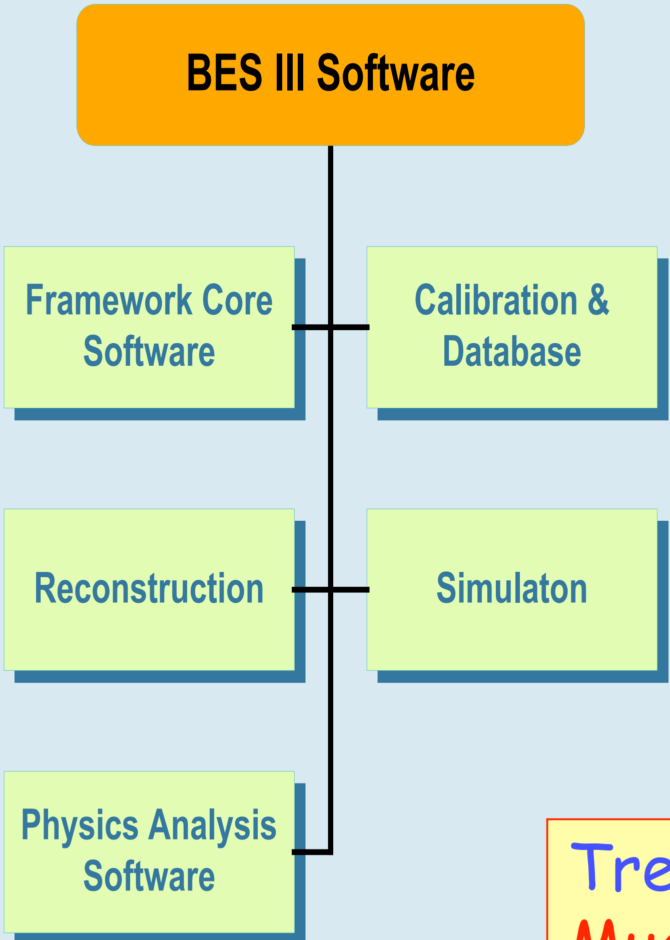
- L1 trigger rate: 4 KHz
- Event Size: 12 KBytes
- Bandwidth after L1: 48 MByte/sec
- Dead time: < 5%

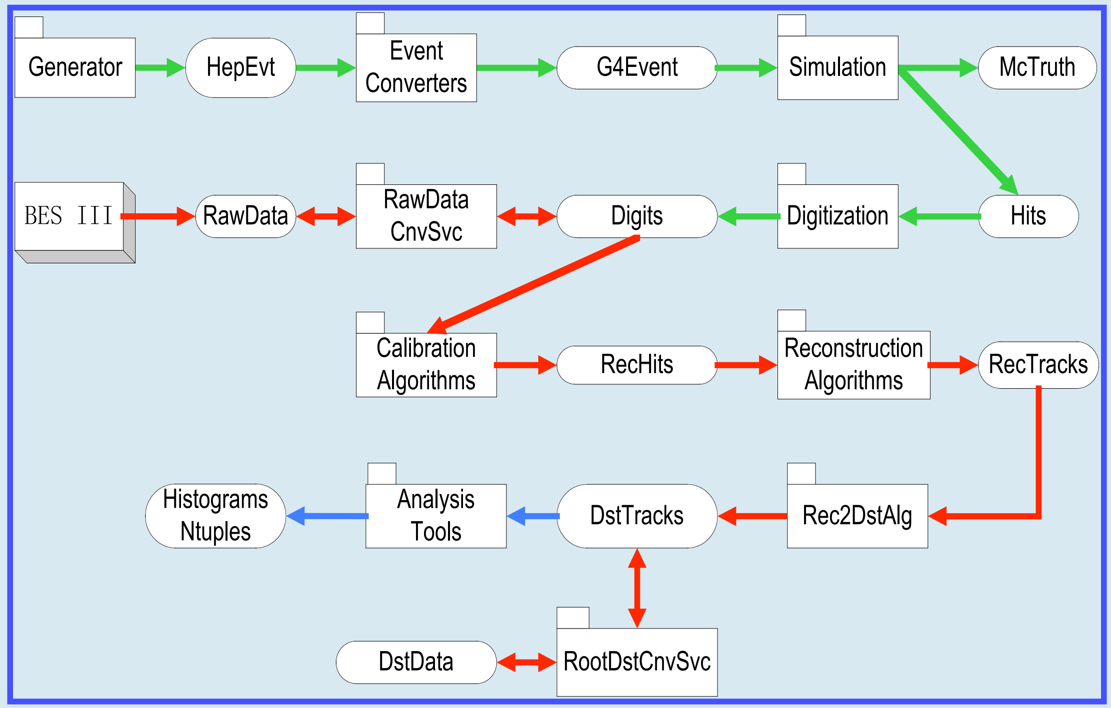
1000 * BESII DAQ system



Offline software

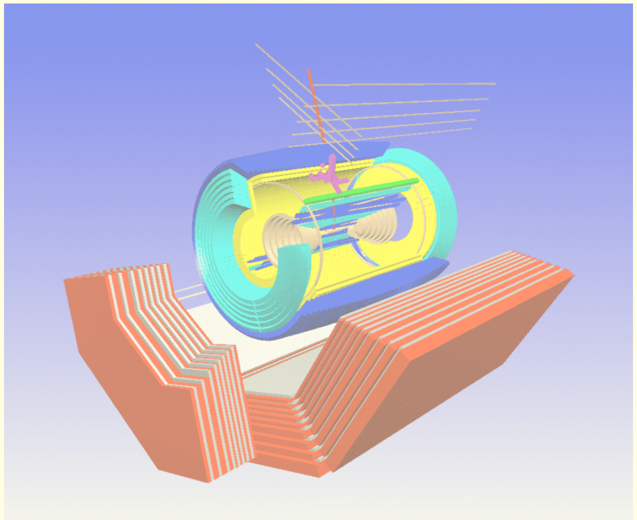
BOSS – BES Offline Software System
based on Gaudi.

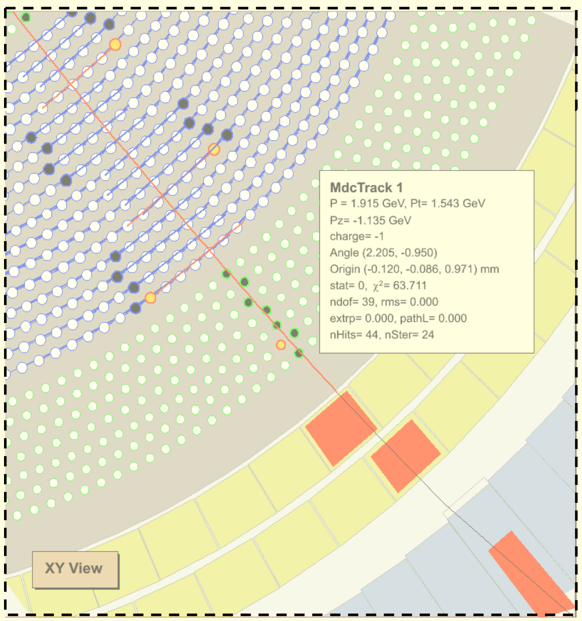


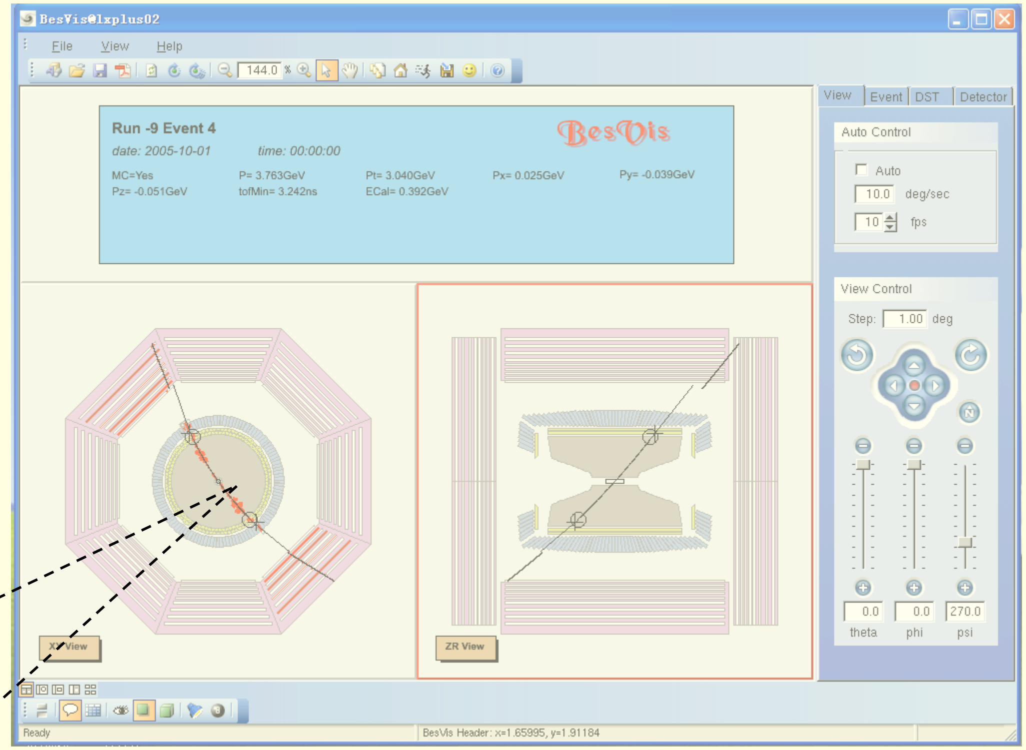


Tremendous amount accomplished so far.
Much more to do.

Event Display Tool: BesVis





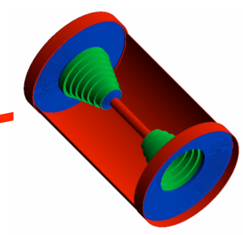


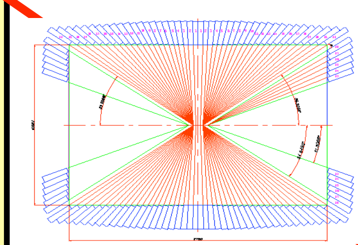
- Based on ROOT, OpenGL, X3D and XML
- Support both 2D and 3D view
- Operations and controls available through menu and toolbar items
- First version was released in December 2005.

SIMULATION – Based on Geant4

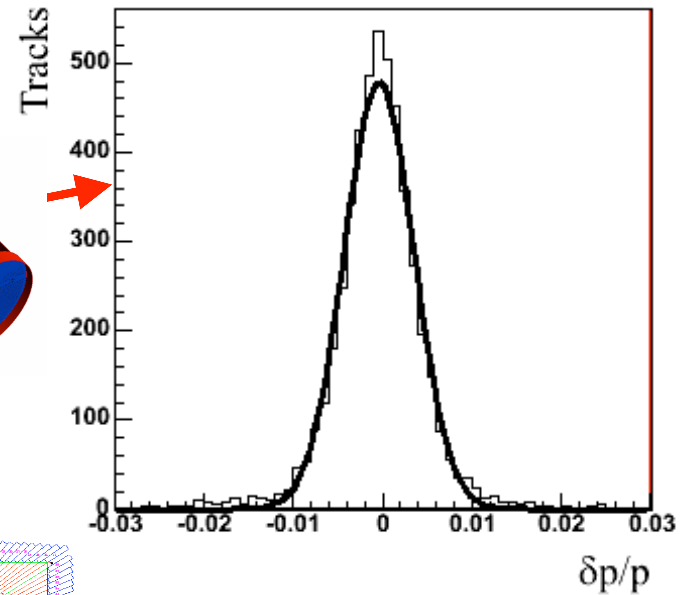
MDC tracking performance:

Sub-detector		Design	MC
MDC	σ_w (μm)	130	110
	σ_p/p	0.5%	0.4%
	$\sigma_{dE/dx}$	6-7%	6%
TOF	σ_t (ps)	90	85
EMC	σ_E/E	2.5%	2.2%
	σ_{xy}(mm)	6	4.8
MUC	$\epsilon(\mu_{ID})$	95%	96%
	$\epsilon(\pi\text{->}\mu)$	6%	6.2%

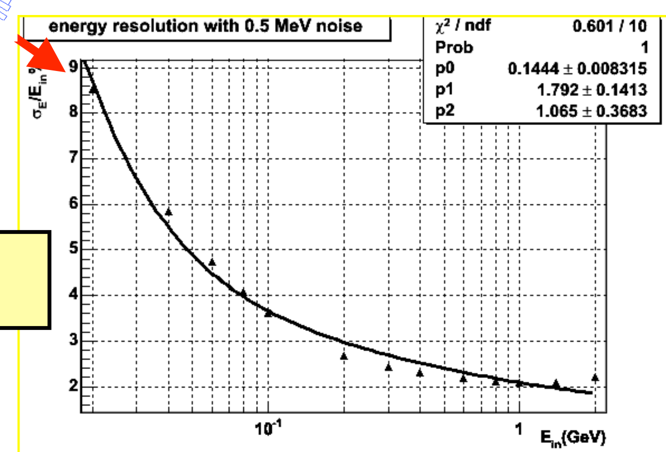




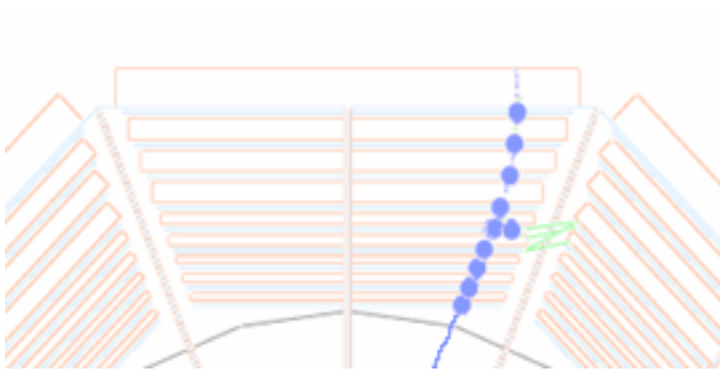
μ^- at p_t = 1GeV/c
Momentum resolution
σ = 0.4 MeV

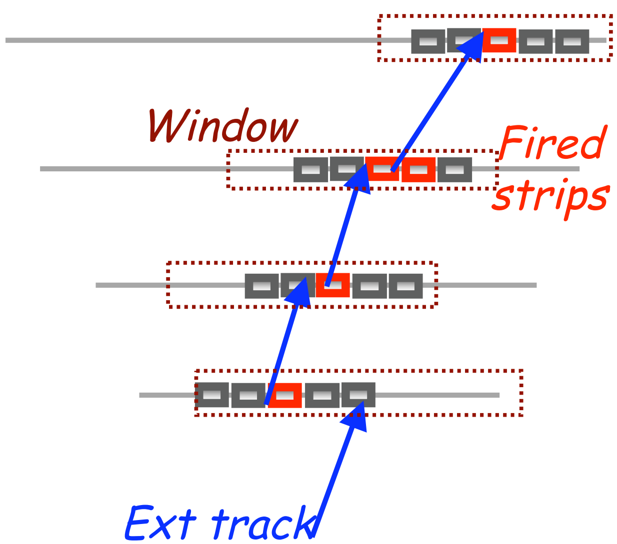


EMC (barrel) Energy Resolution -single γ

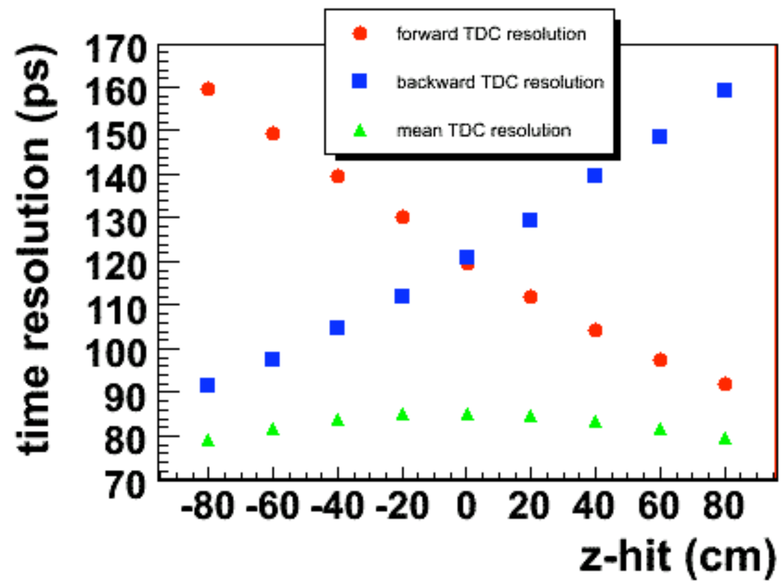


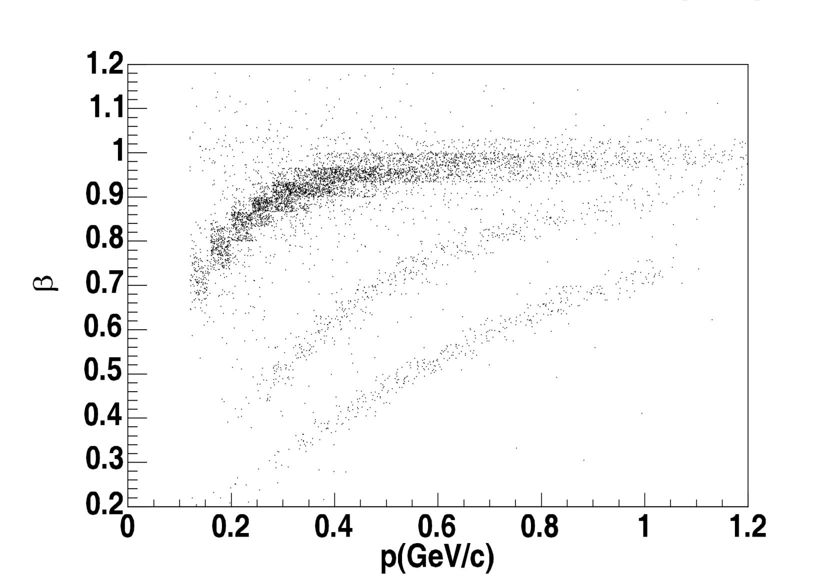
Muon Counter





TOF



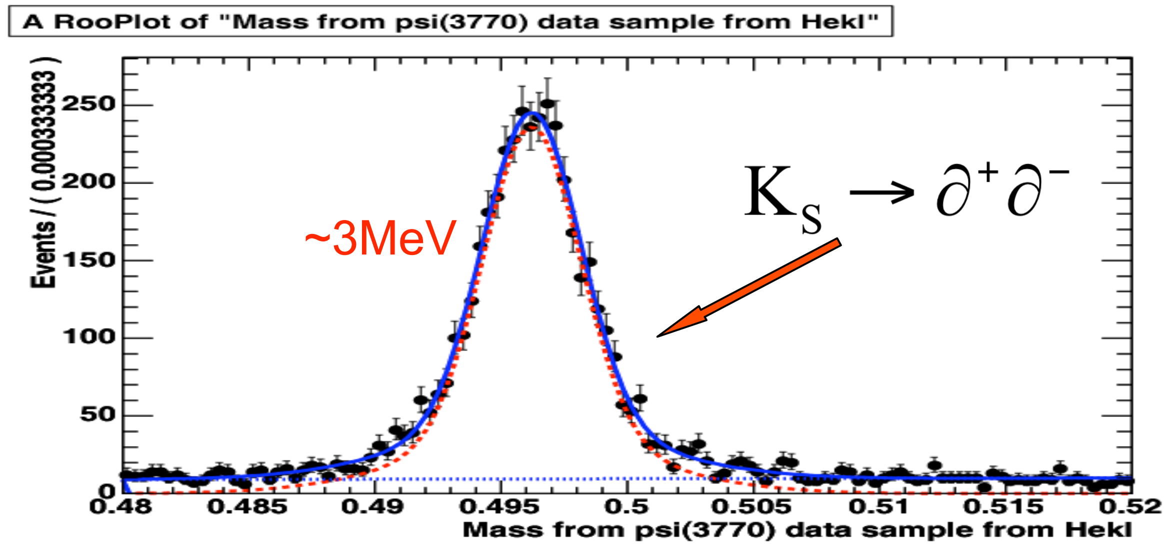


BESIII and CLEOc comparison

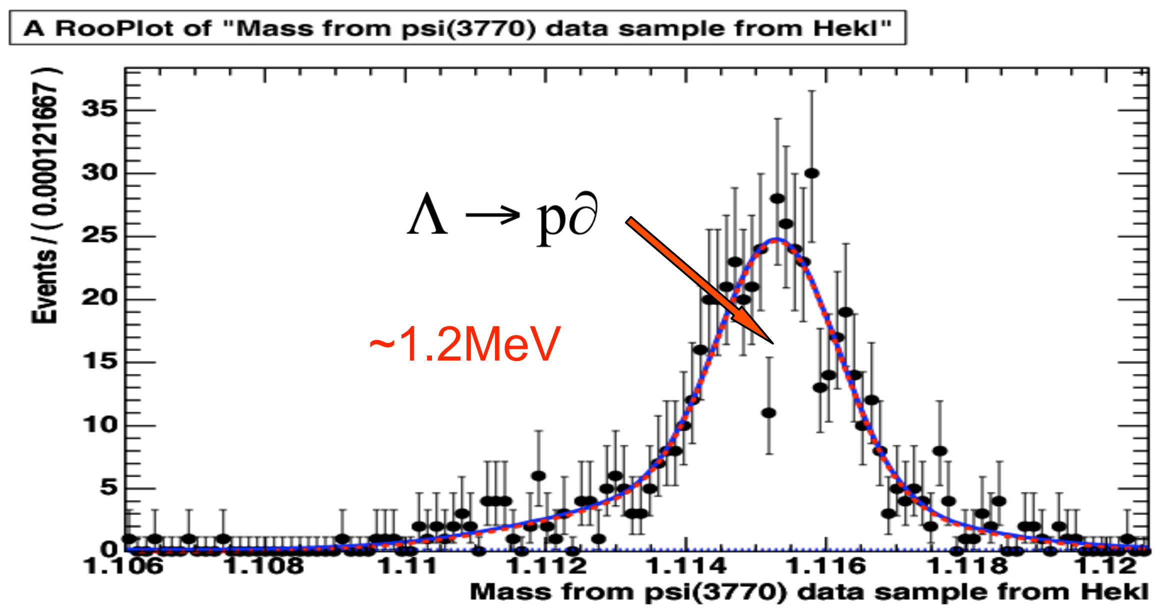
Detector	BES III	CLEOc
MDC	σ_{xy} (μm) = 130	90 μm
	$\Delta P/P$ ($^0/_0$) = 0.5 %(1 GeV)	0.5 %
	$\sigma_{dE/dx}$ ($^0/_0$) = 6 - 7 %	6%
EMC	$\Delta E/\sqrt{E}$($^0/_0$) = 2.5 %(1 GeV) σ_z(cm) = 0.5cm/$\sqrt{E}$	2.0% 0.3 cm /$\sqrt{E}$
TOF	σ_T(ps) = 100-110/layer Double layer	Rich
μ counter	9 layers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

Physics Simulations

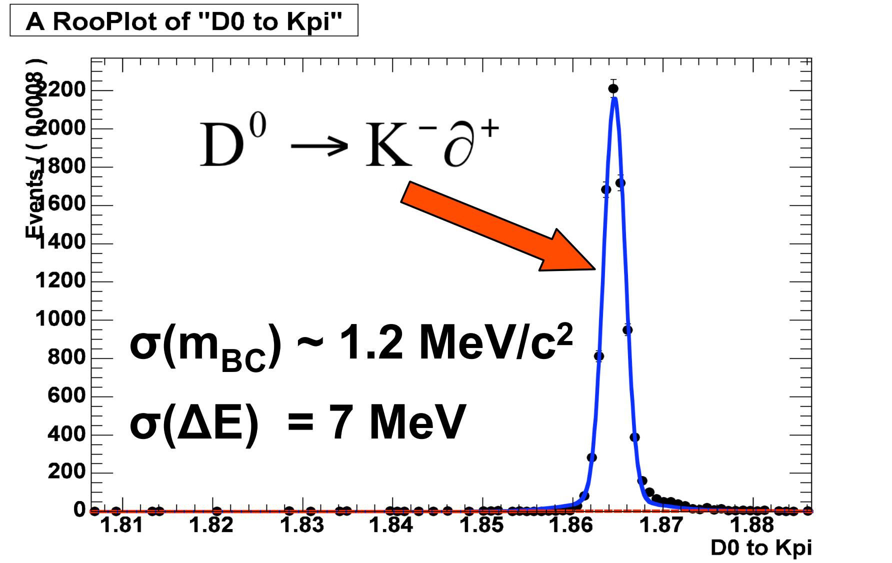
50, 000 ψ″ Inclusive event sample.

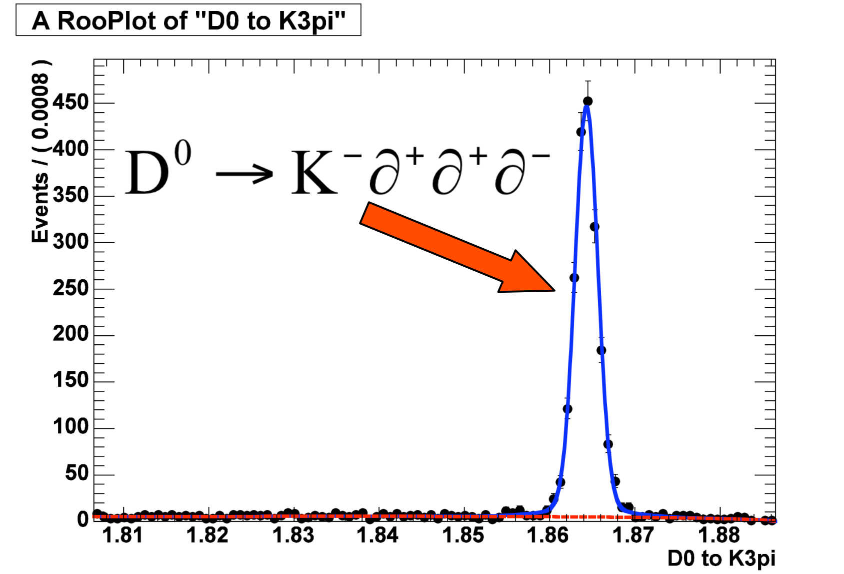


We can learn a lot from CLEOc experience

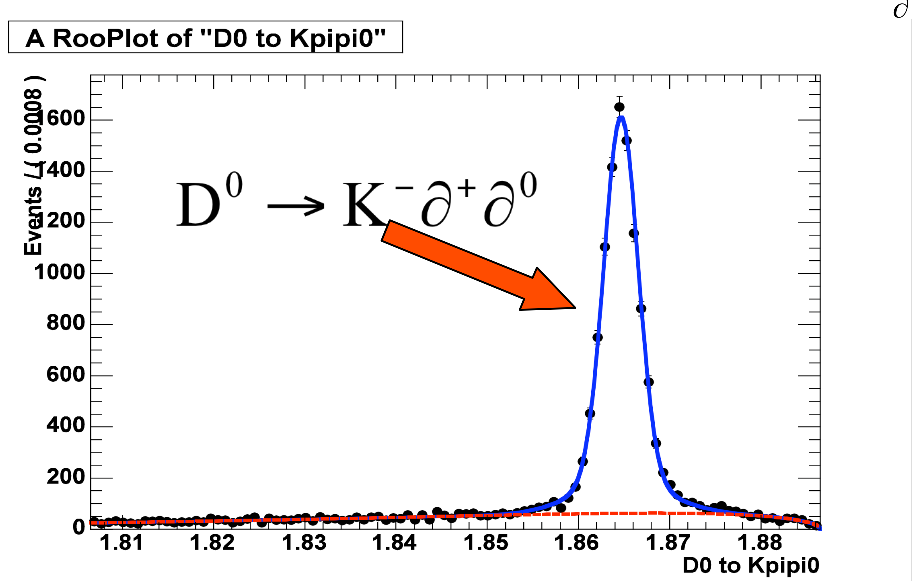


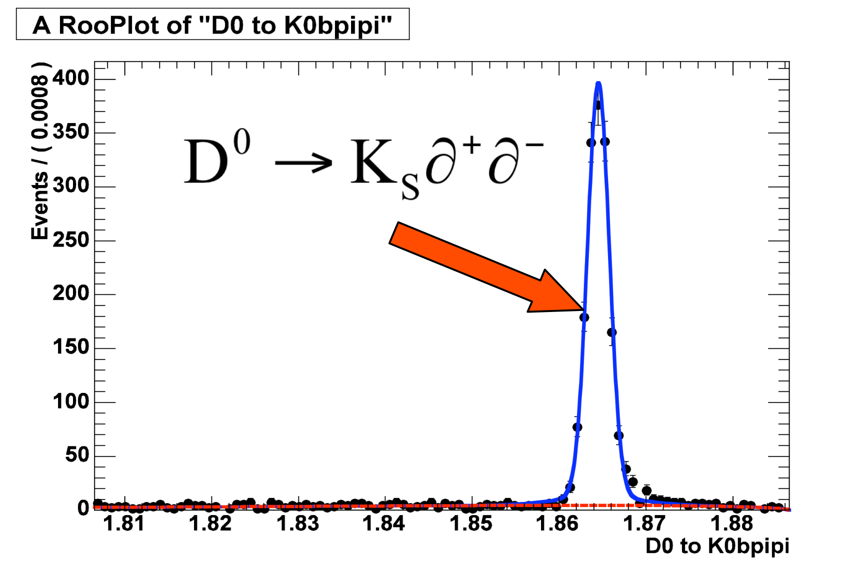
50, 000 ψ″ Inclusive event sample.





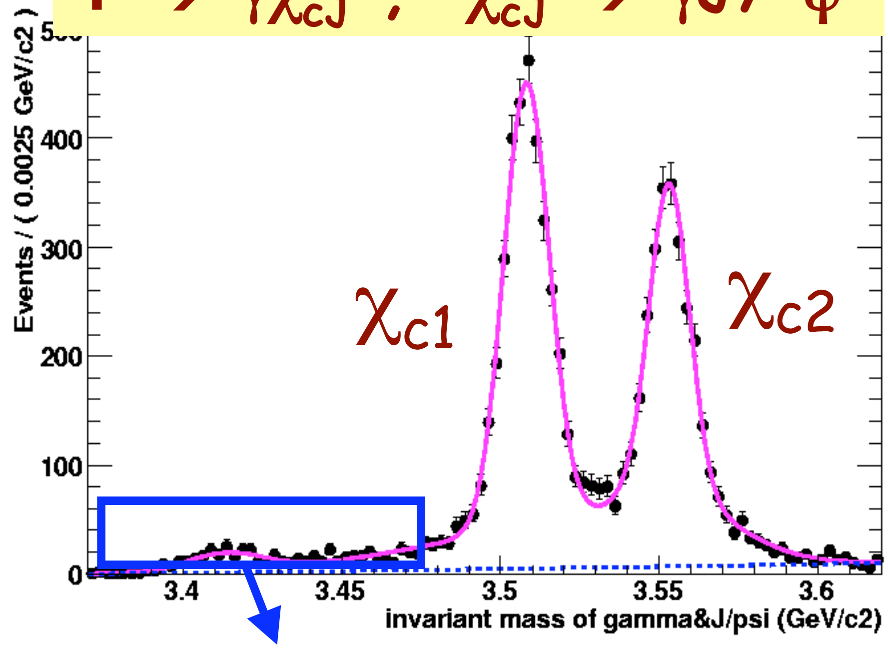
∂^+

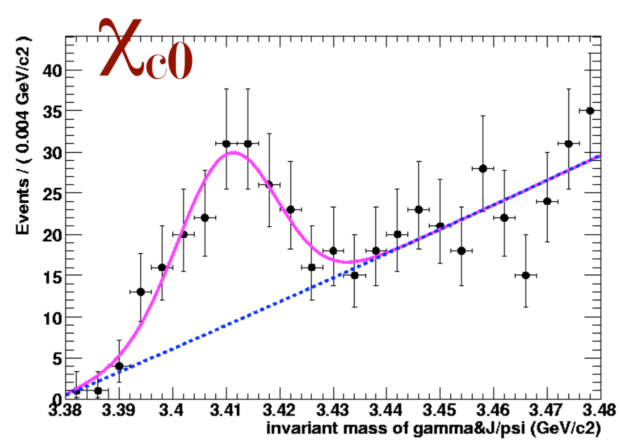




BESIII: *(8M , M.C.)*
$m(\chi_{c1})$ = 3.508GeV,
$m(\chi_{c2})$ = 3.553GeV;
$\sigma(\chi_{c1})$ = 8.1MeV,
$\sigma(\chi_{c2})$ = 9.4MeV.

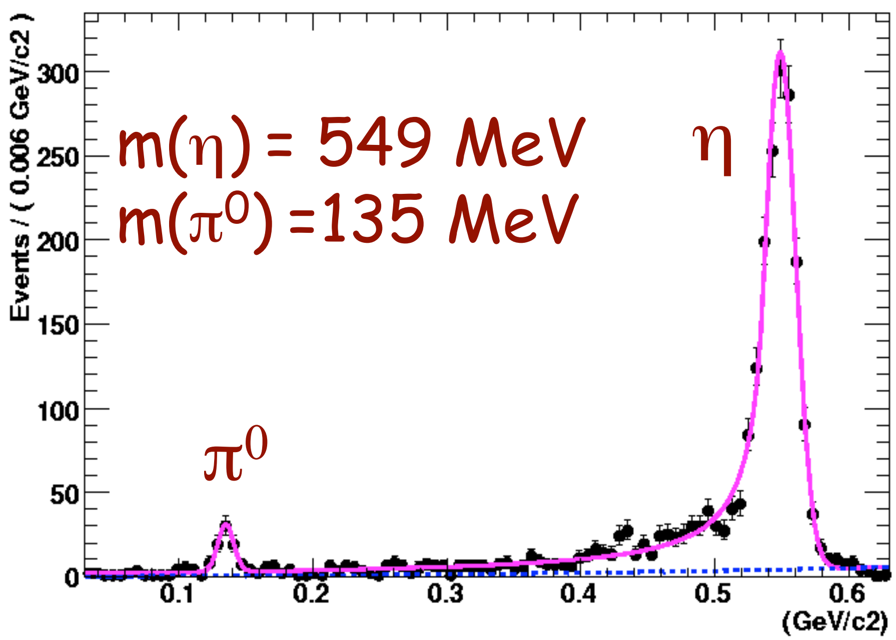
$\Psi' \rightarrow \gamma\chi_{cJ}$, $\chi_{cJ} \rightarrow \gamma J/\psi$





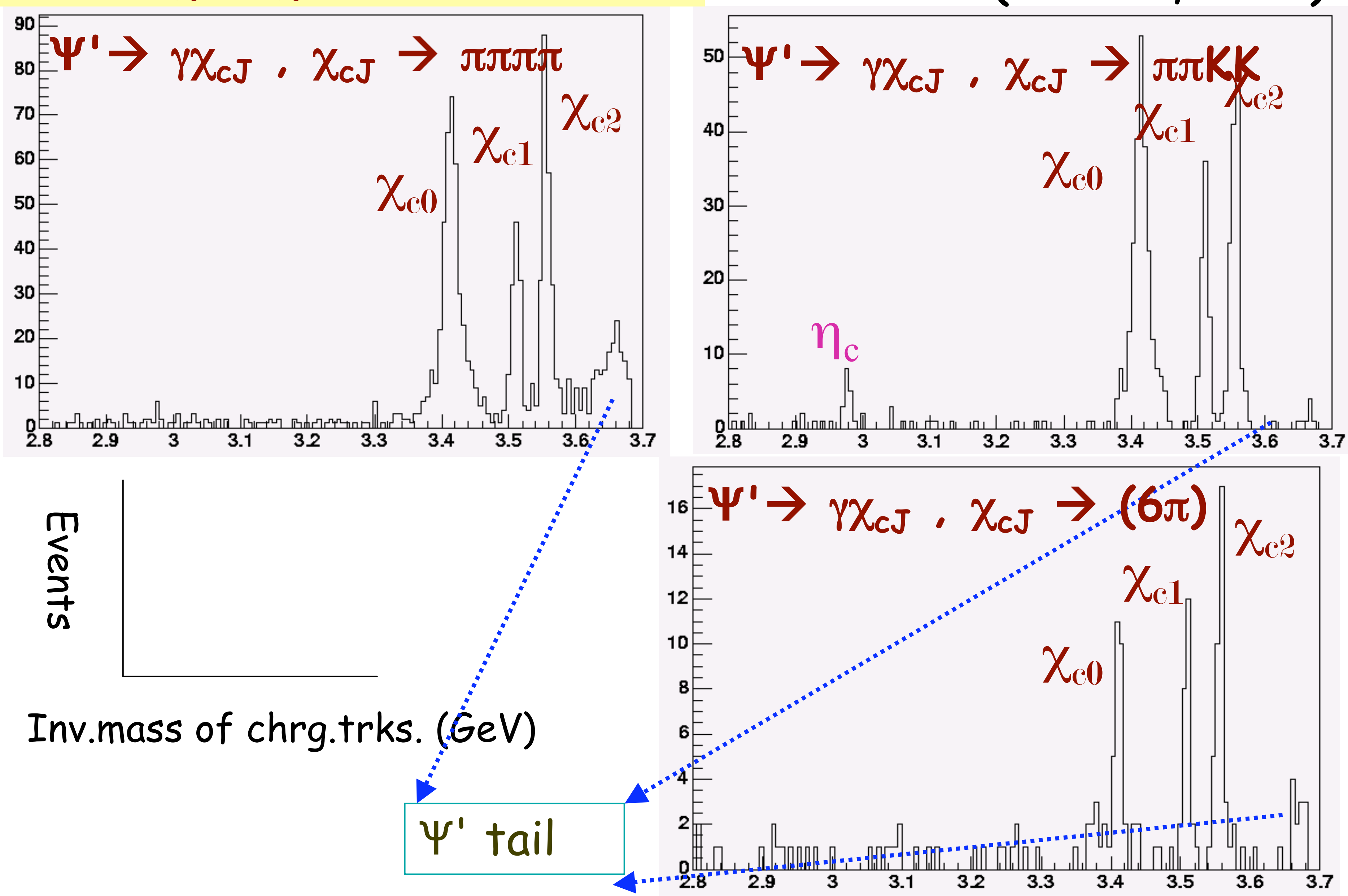
$m(\chi_{c-})$ =3.413GeV,
$\sigma(\chi_{c0})$ =9.0MeV.

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



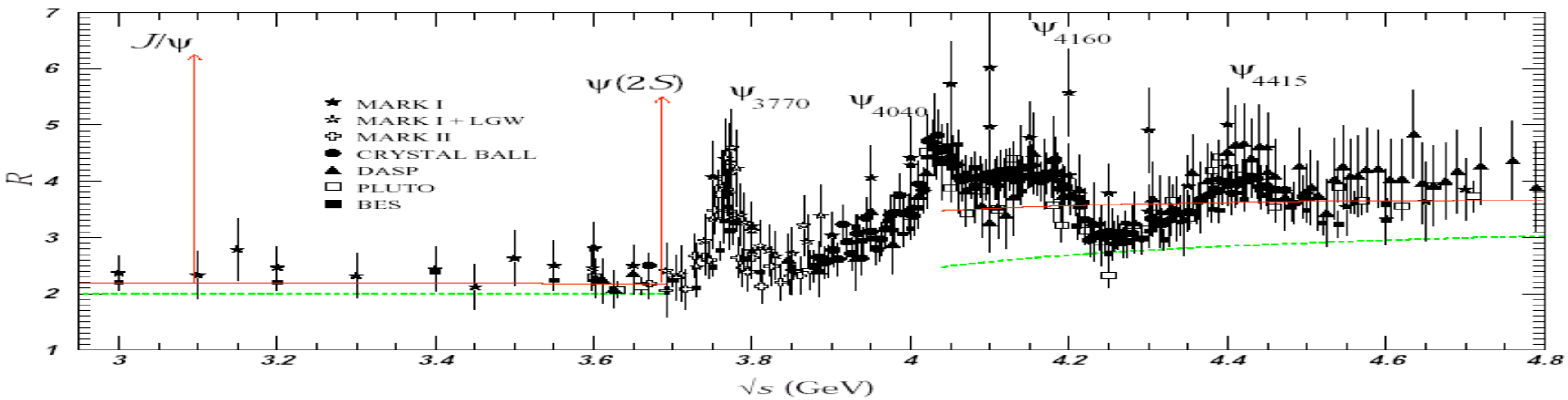
Ψ' → $\gamma\chi_{cJ}$, χ_{cJ} → multi-tracks

BESIII: (0.5 M , M.C.)



Physics Topics at BESIII

- Charmonium: J/ψ, $\psi(2S)$, $\eta_c(1S)$ in J/ψ decay, $\chi_{c\{0,1,2\}}$, $\eta_c(2S)$ and $h_c(^1P_1)$ in $\psi(2S)$ decay, $\psi(1D)$ and so on
- Exotics : hybrids, glueballs and other exotics in J/ψ and $\psi(2S)$ radiative decays;
- Baryons and excited baryons in J/ψ and $\psi(2S)$ hadronic decays;
- Mesons and mixing of quark and gluon in J/ψ and $\psi(2S)$ decays;



- Open charm factory :

Absolute BR measurements of D and Ds decays; 1-2%

Rare D decay; D^0-D^0bar mixing;CP violation;

f_{D+}, f_{Ds} , form factors in semi-leptonic D decays;

precise measurement of CKM (Vcd, Vcs);

CP violation and strong phase in D Dalitz Decays;

light spectroscopy in D^0 and D^+ Dalitz Decays.

- Electromagnetic form factors and QCD cross section;
- New Charmonium states above open charm threshold
- R values .; Should aim at 1% error, now MC → <2%.
- tau physics near the threshold.

Yearly Event Production

Average Lum: $\mathcal{L}$ = 0.5×Peak Lum.; data taking time: T = 10^7s/year

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

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

Resonance	Energy(GeV)	Peak Lum. ($10^{33}cm^{-2}s^{-1}$)	Physics Cross Section (nb)	Nevents/yr
J/ψ	3.097	0.6	3400	10×10^9
τ	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	**4.140**	**0.6**	**0.67**	**2.0×10^6**

Huge J/ψ and $\psi(2S)$ samples at BESIII

Below are a few examples of physics reach

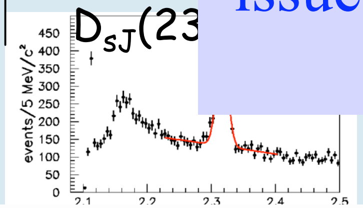
Hints for New Spectroscopy-Challenge QCD

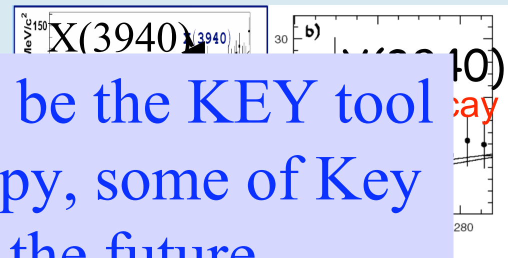
Courtesy of R. Faccini

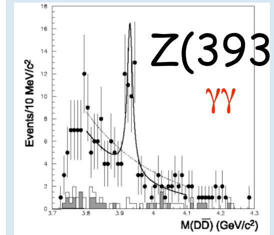
Belle

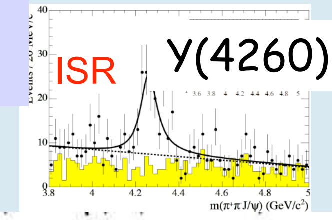
2003

BaBar









X(3872)

Δm_{π^0} gev/c²
Continuum

Partial Wave Analysis will be the KEY tool in the study of spectroscopy, some of Key issues should be solved in the future.

B

Glueball, hybrid or exotic search in J/ψ (10×10^9) @ BESIII

$J/\psi \rightarrow (\gamma, \omega, \rho, \phi) +$ { **f_0(600)**, **f_0(980)**, **f_0(1370)**, **f_0(1500)**, **f_0(1710)**, **f_0(1790)** }

and also Tensor candidates

and Many threshold enhancements

$J/\psi \rightarrow$ ppbar +X → probe excited and exotic baryon states

Scan of the resonances (3.7 ÷ 4.6 GeV)

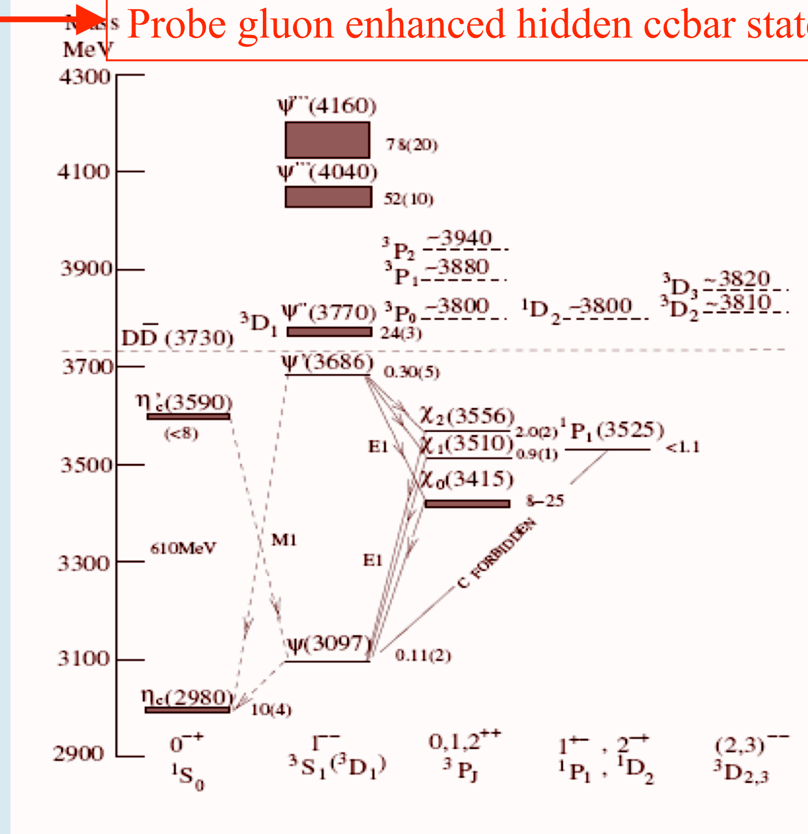
$\sigma(e^+e^- \to D\overline{D}^{(*)}), \sigma(e^+e^- \to D_S^+ D_S^{-(*)})$, → Test QCD @ 3.7 ÷ 4.6 GeV

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

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

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

→ Probe gluon enhanced hidden ccbar states



A detail plan to take data @ BESIII should be made based on the study of R&D in Physics book.

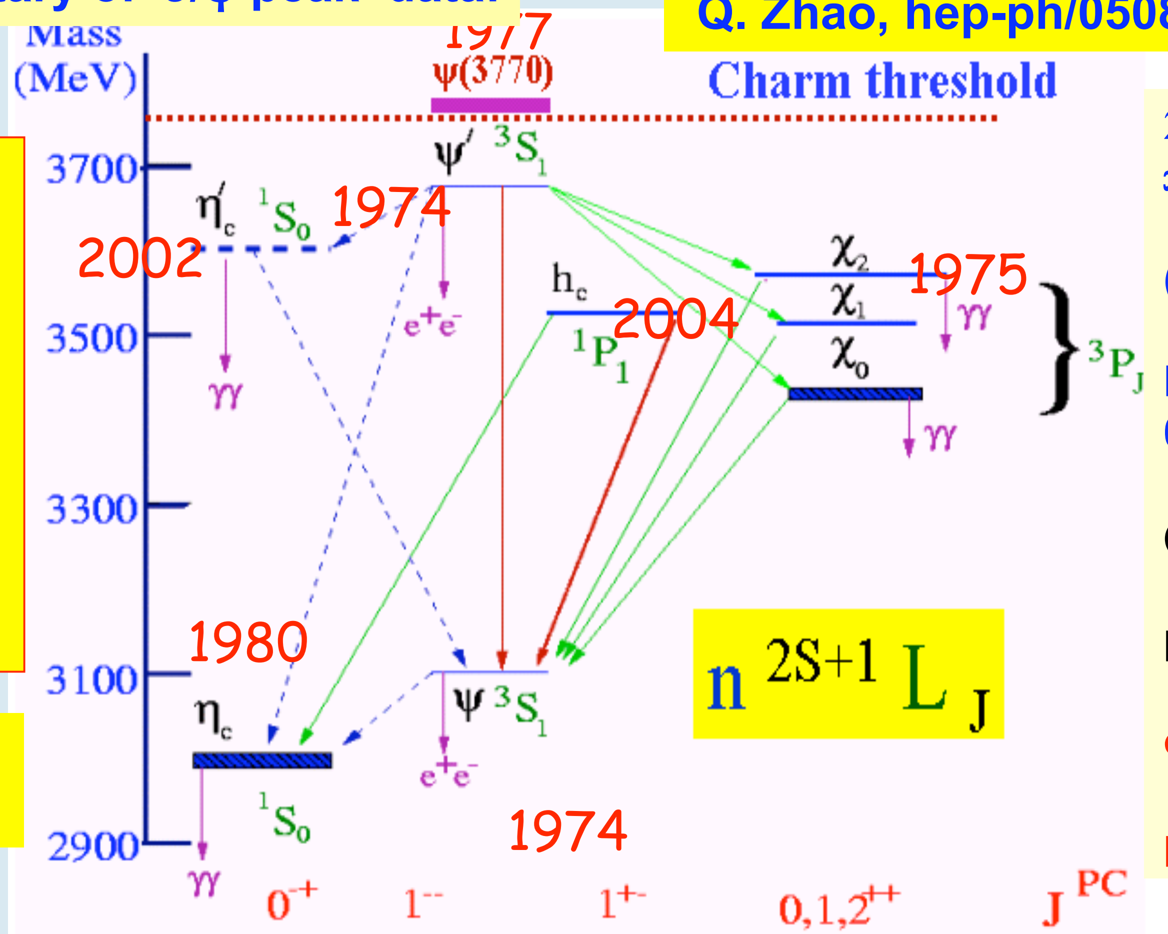
Charmonium below open charm @ BESIII ??

$\Psi(2S) \rightarrow \pi^+\pi^- J/\psi$ (31%) **really "pure" J/ψ sample a complementary of J/ψ peak data!**

$\chi_{c,0,1,2}$ sample useful to understand the decay dynamics of ccbar and light hadron with same J^{PC}!
Q. Zhao, hep-ph/0508086

η_c' in $\psi(2S)$ $\rightarrow \gamma K_S K\pi$
$\psi(2S) \rightarrow \gamma \pi^+\pi^-\eta_c$ with untagged gamma
M. Voloshin hep-ph/0206240
$B(\eta_c(2S) \rightarrow \pi^+\pi^- \eta_c) = 5\text{-}10\%$

Detail study of h_c at BESIII



2S – 1D mixing : "ρ π" puzzle
J. Rosner PRD 64 (094002) 2001
P. Wang et al PRD70(114014)2004
Non-DD decay of ψ(3770):
N. Achasov hep-ph/0505146
The production of D^0D^0, D^+D^-
M. Voloshin hep-ph/0402171

$\eta_c(1S)$ sample from $J/\psi \rightarrow \gamma\, \eta_c(1S)$ used to study the light spectrum

BES III Charm Mixing

Mixing: $\psi(3770) \to D\bar{D}$ (C = -1)

Coherence simplifies study DCSD interfere away so not a background

Unmixed: $D^0 \to K^-\pi^+$ $\quad \bar{D}^0 \to K^+\pi^-$

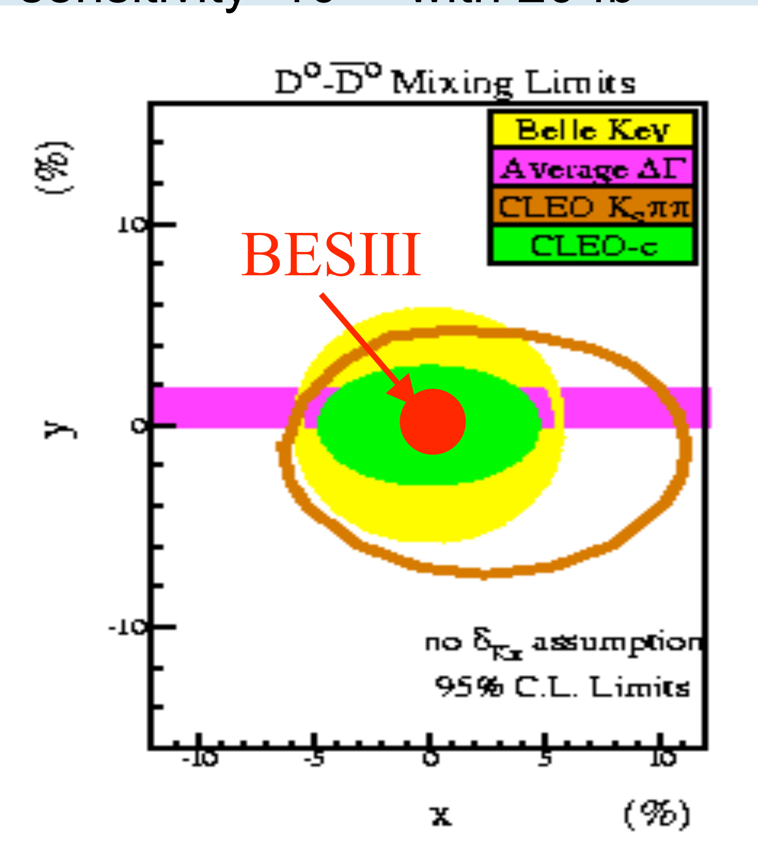
mixing: $D^0 \to K^-\pi^+$ $\quad D^0 \to \bar{D}^0 \to K^-\pi^+$

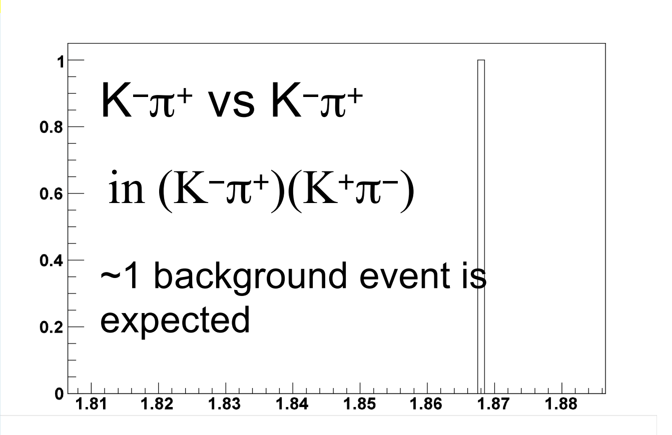
Can add lepton final states (Klv Klv)

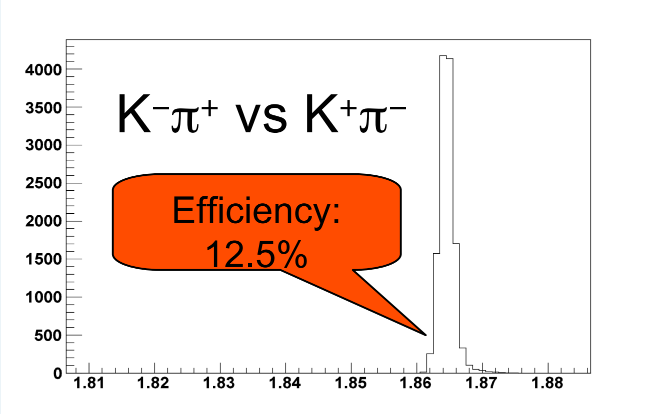
Sensitivity: current limit: 10^{-3}

$$\frac{\Gamma(D^0\bar{D}^0 \to (K^-\pi^+)(K^-\pi^+))}{\Gamma(D^0\bar{D}^0 \to (K^-\pi^+)(K^+\pi^-))} = \frac{x^2+y^2}{2}\,\frac{|p|^2}{|q|^2}\,\frac{B^2{}_{K^-\pi^+}}{B^2{}_{K^+\pi^-}}$$

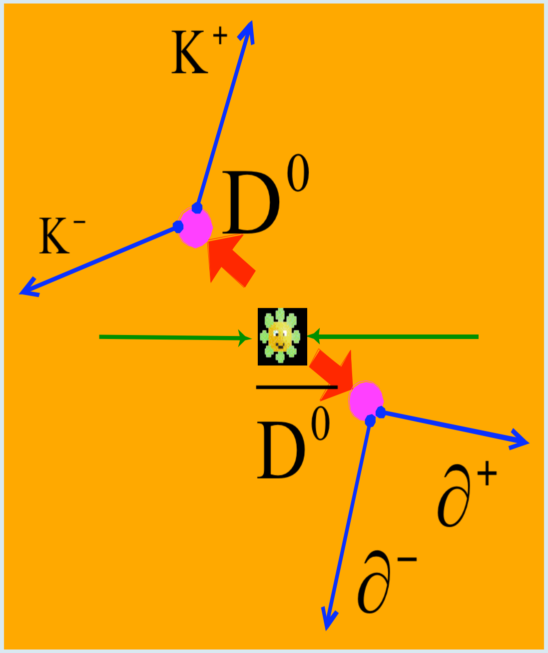
r_M sensitivity 10^{-4} with 20 fb^{-1}







Direct CP Violation at ψ(3770) at BESIII



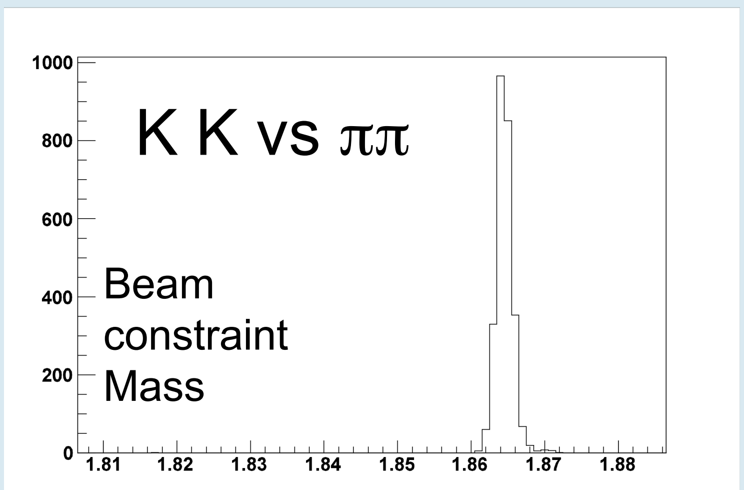
$$Acp \approx \frac{\mathrm{Im}\left[V_{cd}V_{ud}^{*}V_{cs}V_{us}^{*}\right]}{\lambda^{2}}\sin\delta_{PT}\frac{P}{T} \sim A^{2}\eta\lambda^{4}\sin\delta_{PT}\frac{P}{T} \leq 10^{-3}$$

- CP violating asymmetries can be measured by searching for events with two CP odd or two CP even final states ex:

p^+p^-, K^+K^-, $p^0\, p^0$, Ksp^0 ,

for the decay of $ø'' \longrightarrow f_1 f_2$

$$\mathrm{CP}(f_1 f_2) = \mathrm{CP}(f_1)\cdot\mathrm{CP}(f_2)\cdot(-1)^{\mathrm{L}} = -$$
$$\mathrm{CP}(ø'') = +$$



A_{CP} sensitivity 10^{-2} - 10^{-3}

Semileptonic decay and CKM Matrix at BESIII

$$\frac{d\Gamma(D\to P\ell\nu)}{dq^2}=\frac{|V_{cq}|^2 P_P^3}{24\pi^3}|f_+(q^2)|^2$$

To find V_{cs} & V_{cd} need form factor from theory at one fixed q^2 point.

$$f_+(q^2)=\frac{f_+(0)}{1-q^2/m_{pole}^2}$$

$$\frac{\Delta|V_{cq}|}{|V_{cq}|}=\sqrt{\left(\frac{\Delta B}{2B}\right)^2+\left(\frac{\Delta\tau_D}{2\tau_D}\right)^2+\left(\frac{\Delta FF}{2FF}\right)^2}$$

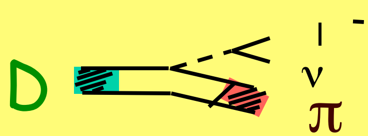
$$\frac{\Delta\tau_D}{\tau_D}\approx 0.6\% \qquad \frac{\Delta\tau_{D_s}}{\tau_{D_s}}\approx 1.0\%$$

Well measured

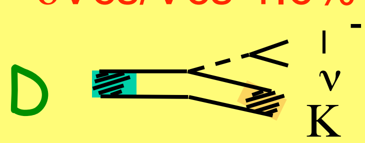
Form factor term come from theory (Lattice QCD).
Supposing $\Delta FF/FF$ ~3% , BESIII will get

BESIII:
Integrate Lumi.
$20fb^{-1}$ DDbar
MC simulation

δVcd/Vcd 1.7%



δVcs/Vcs 1.6%



Great contribution to CKM Unitarity

Quark models, HQET, Lattice & other methods have all been invoked to calculate form factor absolute normalizations. These calculations have been done mostly at $q^2=0$ or $q^2=q^2_{max}$. (i..e w=1, just like F in V_{cb} in $B\to D^* l\nu$)

Future

In US:

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

In China:

BESIII commissioning in summer 2007.

BESIII will be a unique facility.

BESIII Collaboration

First formal meeting held Jan. 10-12, 2006 at IHEP, Beijing.

Adopted Governance Rules, elected IB Chair and Spokespersons.

Institute of High Energy Physics
University of Science and Technology
Peking University
Tsinghua University
Shangdong University
Nankai University
Central China Normal University
University of Anhui
University of Zhejiang
University of Zhengzhou
Nanjing Normal University
Nanjing University
Shanxi University
Sichuan University
Henan Normal University

University of Hawaii
University of Washington
University of Tokyo
Joint Institute of Nuclear Research, Dubna
GSI
University of Bochum
University of Giessen

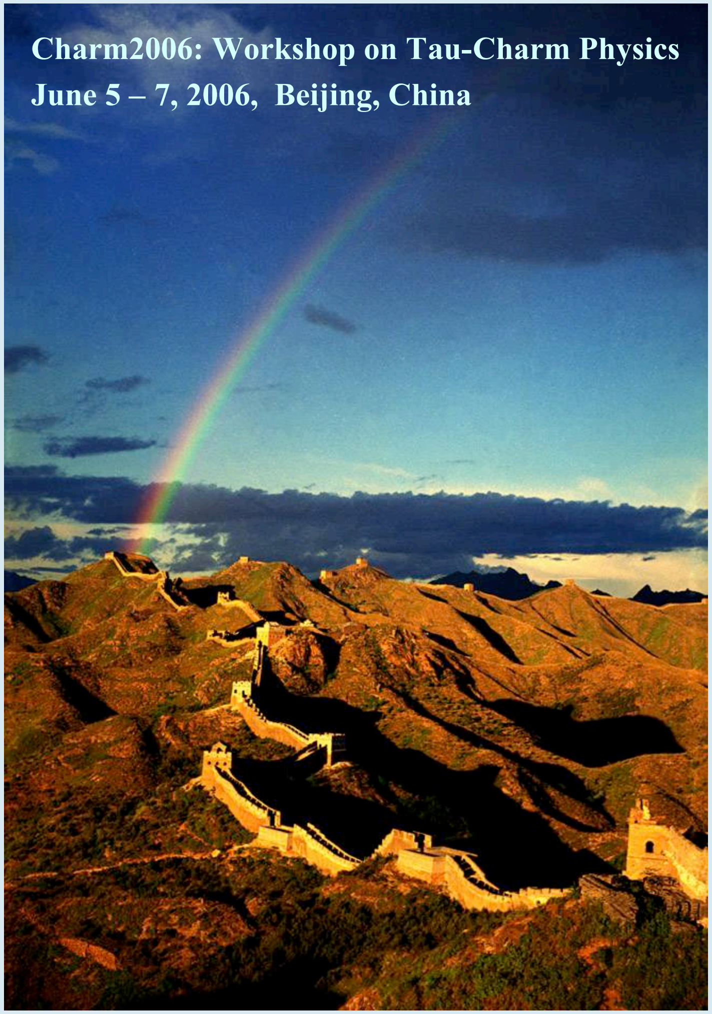
Need more here!

Physics preparation

- Write a yellow book on BESIII physics: a summary of theoretical and experimental tau-charm physics and the BESIII physics reach.

  http://bes.ihep.ac.cn/bes3/phy_book/book/book.html

- Workshops:
  - Charm 2006: International tau-Charm workshop Beijing June 5-7 2006
  - US-China workshop on HEP cooperation



Summary

- **BEPCII linac installation complete.**
- **Elements for collider complete; installation begins.**
- **BESIII hardware and software progressing rapidly, although still much to do.**
- **Machine/detector Commissioning expected in 2007.**
- **Rich physics after CLEO-c.**
- **More Collaborators welcomed!**

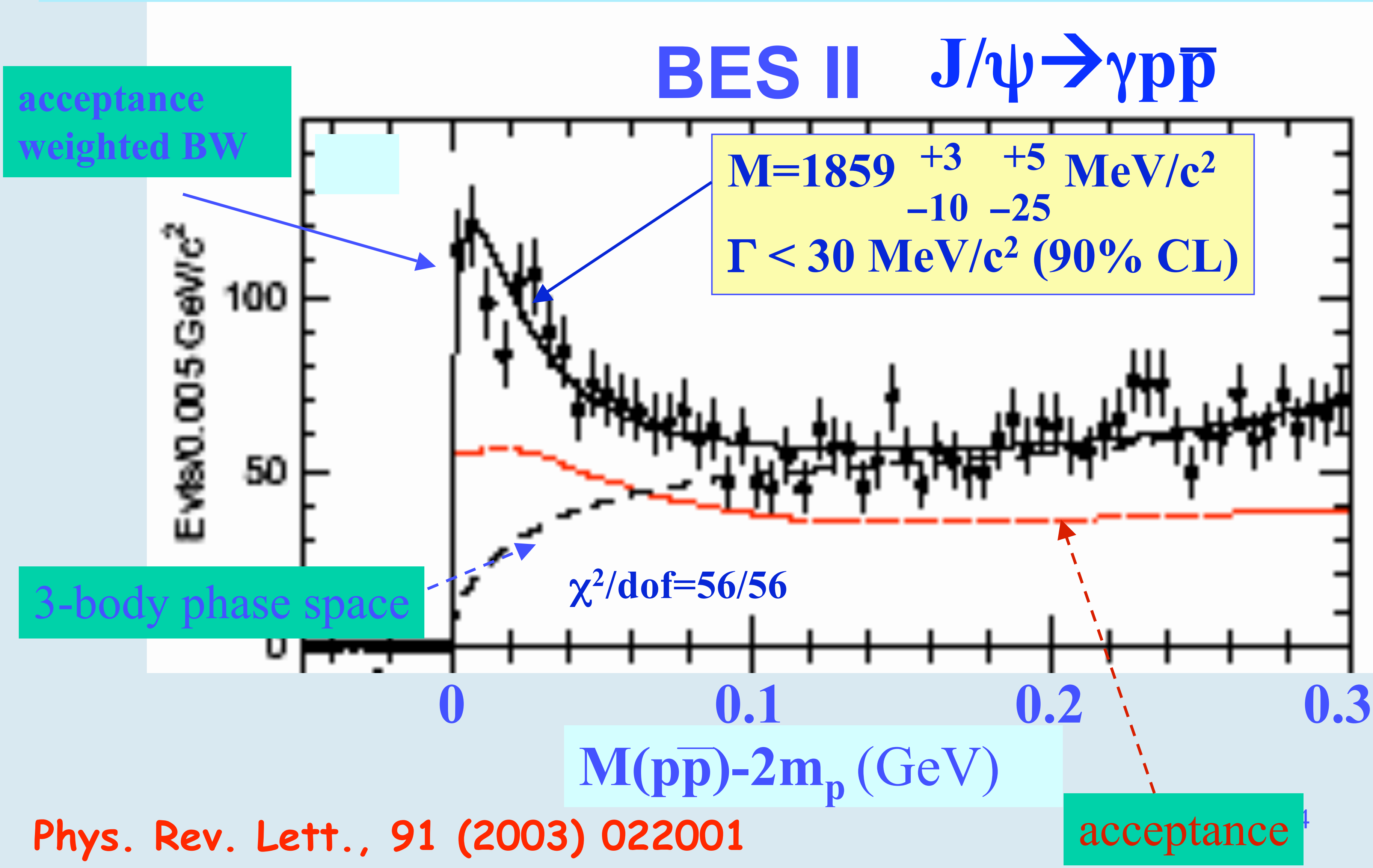
Thanks

谢谢

Challenge to BEPCII/BESIII

- Three super-conducting devices, sc cavity, sc quadrapole; detector sc magnet;
- Machine reaches design luminosity; detector can take data without too much backgrounds;
- For physics analyses, how to beat down the systematic errors of the measurements, and how to improve the partial wave analyses.

Observation of an anomalous enhancement near the threshold of $p\bar{p}$ mass spectrum at BES II



Phys. Rev. Lett., 91 (2003) 022001

$p\bar{p}$ bound state (baryonium)?

There is lots & lots of literature about this possibility

E. Fermi, C.N. Yang, Phys. Rev. 76, 1739 (1949)
…
I.S. Sharpiro, Phys. Rept. 35, 129 (1978)
C.B. Dover, M. Goldhaber, PRD 15, 1997 (1977)
…
A. Datta, P.J. O'Donnell, PLB 567, 273 (2003)]
M.L. Yan *et al.*, hep-ph/0405087

deute

attracti … ce?

Observations of this structure in other decay modes are desirable.

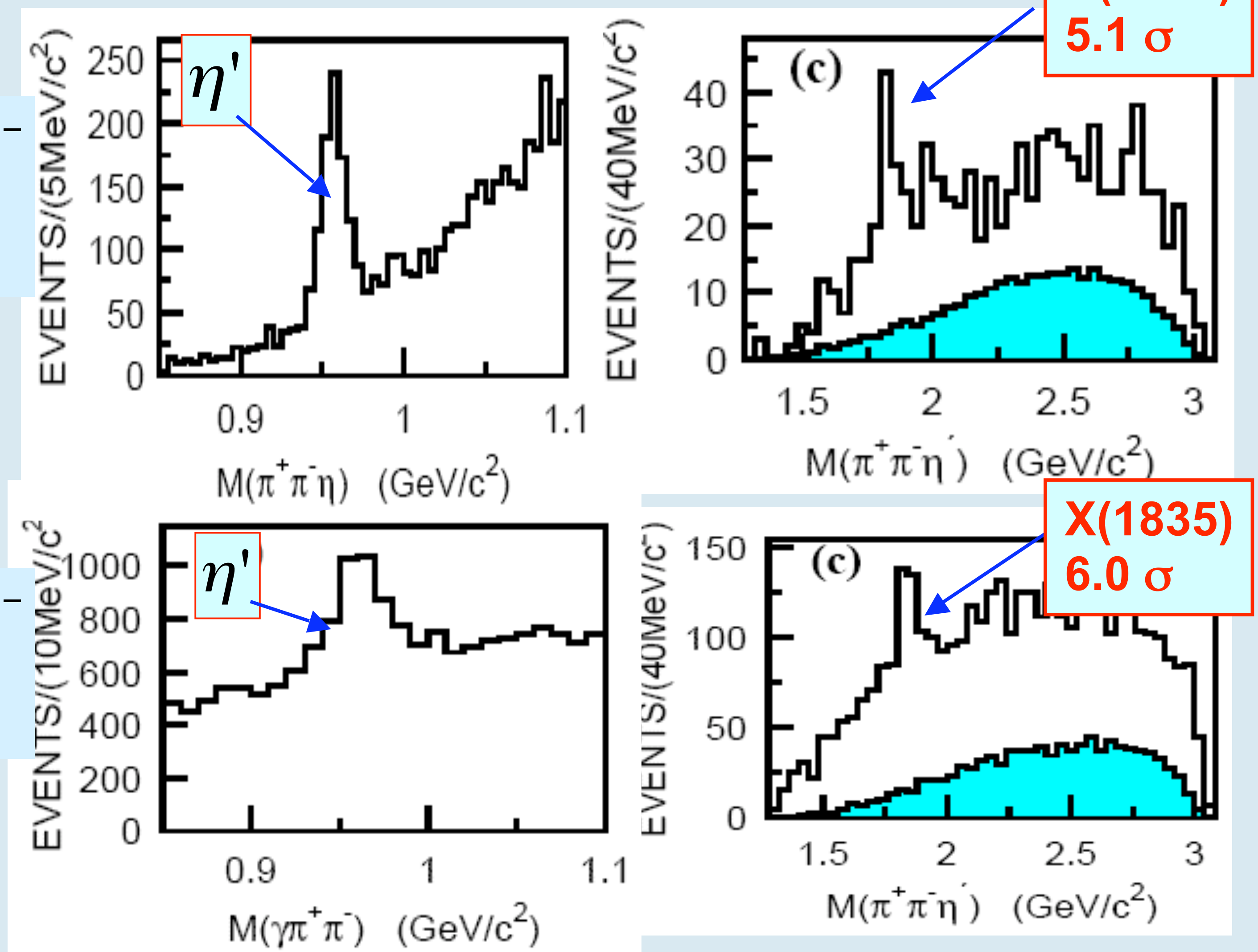
singlets with
$M_d = 2m_p - \varepsilon$

singlets with
$M_b = 2m_p - \delta$?

Observation of X(1835) in $J/\psi \to \gamma\pi^+\pi^-\eta'$

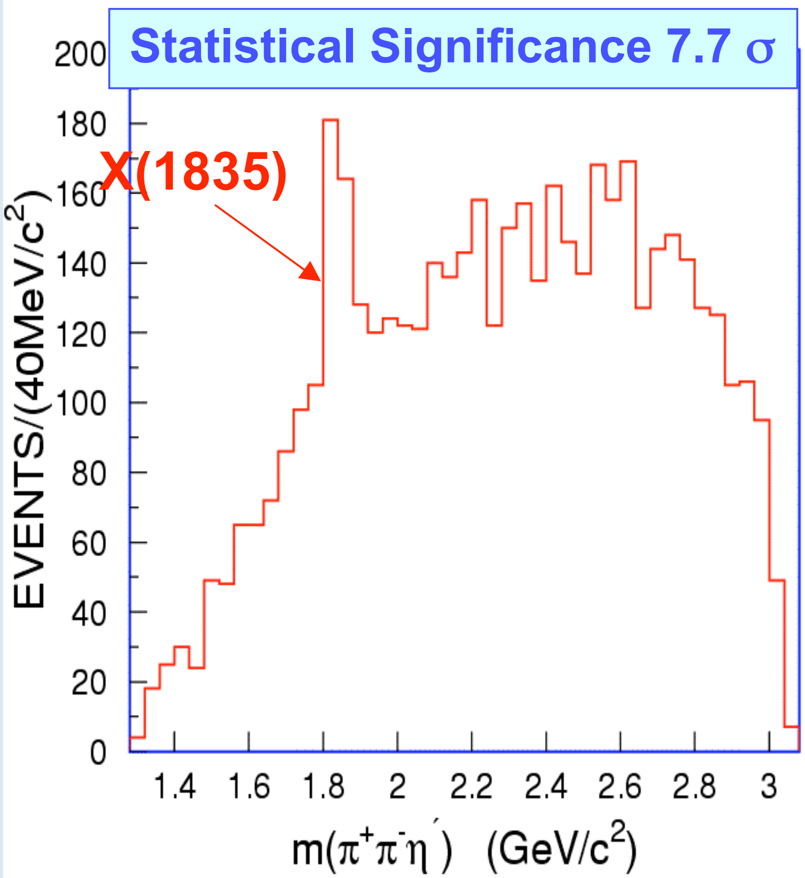
$$J/\psi \to \gamma\eta'\pi^+\pi^-$$
$$\eta' \to \eta\pi^+\pi^-$$

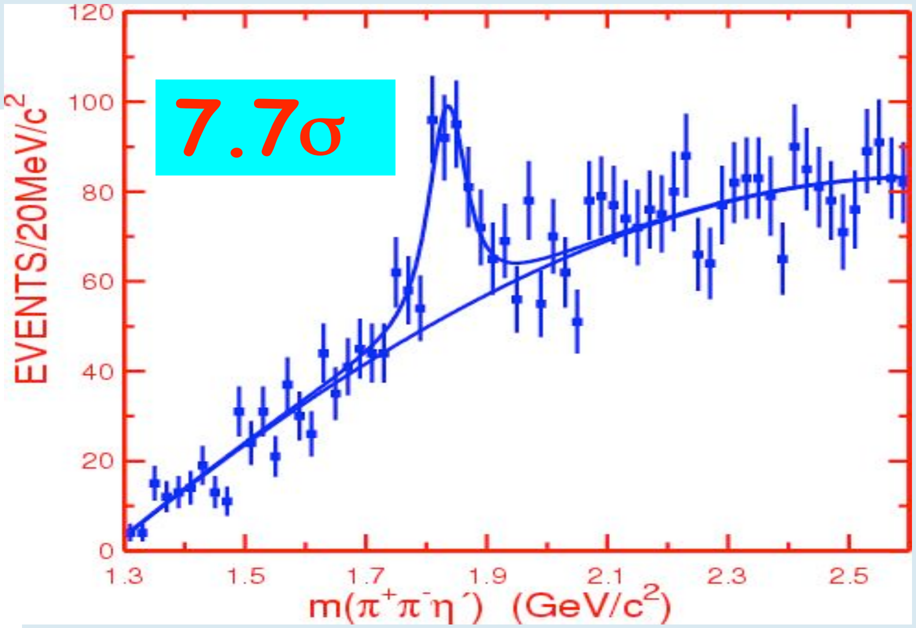
$$J/\psi \to \gamma\eta'\pi^+\pi^-$$
$$\eta' \to \gamma\rho$$



Combine two channels

$$J/\psi \to \gamma\, \pi^+\pi^-\eta'$$





$$N_{obs} = 264 \pm 54$$

$$M = 1833.7 \pm 6.1 \pm 2.7 \text{ MeV/c}^2$$

$$\Gamma = 67.7 \pm 20.3 \pm 7.7 \text{ MeV/c}^2$$

$$B(J/\psi \to \gamma X)B(X \to \pi^+\pi^-\eta') = (2.2 \pm 0.4 \pm 0.4) \times 10^{-4}$$

Phys. Rev. Lett., 95 (2005) 262001

X(1835) could be the same structure as X(1860) indicated by $p\bar{p}$ mass threshold enhancement

- X(1835) mass is consistent with the mass of the S-wave resonance X(1860) indicated by the $p\bar{p}$ mass threshold enhancement.

  Its width is 1.9σ higher than the upper limit of the width obtained from $p\bar{p}$ mass threshold enhancement.

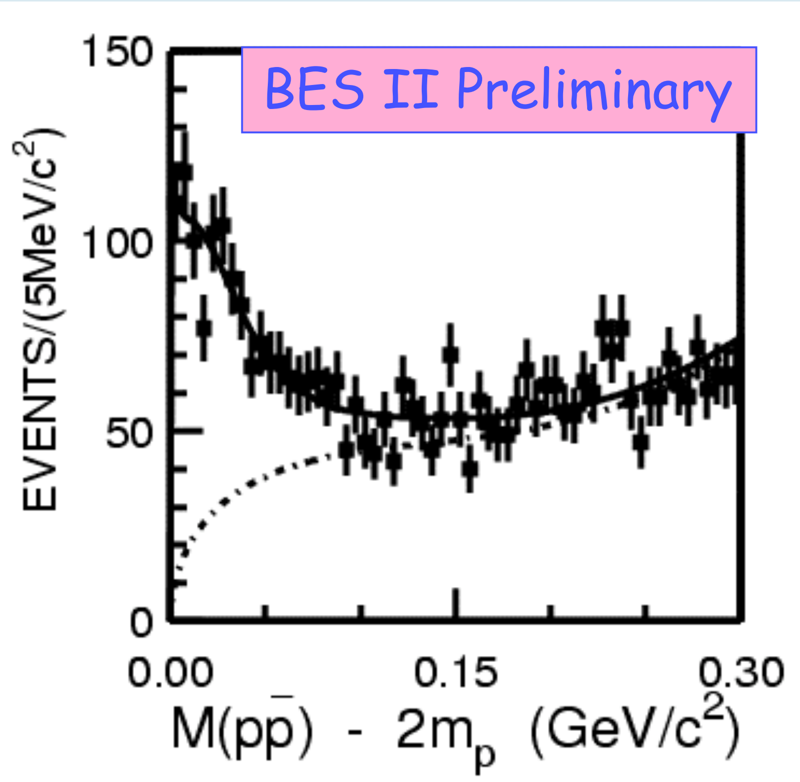
- On the other hand, if the FSI effect is included in the fit of the $p\bar{p}$ mass spectrum, the width of the resonance near $p\bar{p}$ mass threshold will become larger.

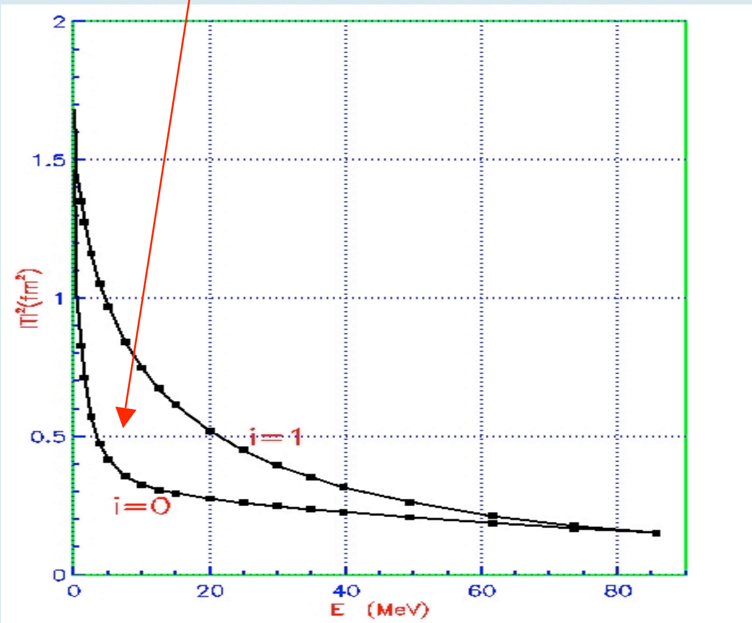
Fit to $J/\psi \rightarrow \gamma p\bar{p}$ including FSI

$M = 1830.6 \pm 6.7$ MeV

$\Gamma = 0 \pm 93$ MeV

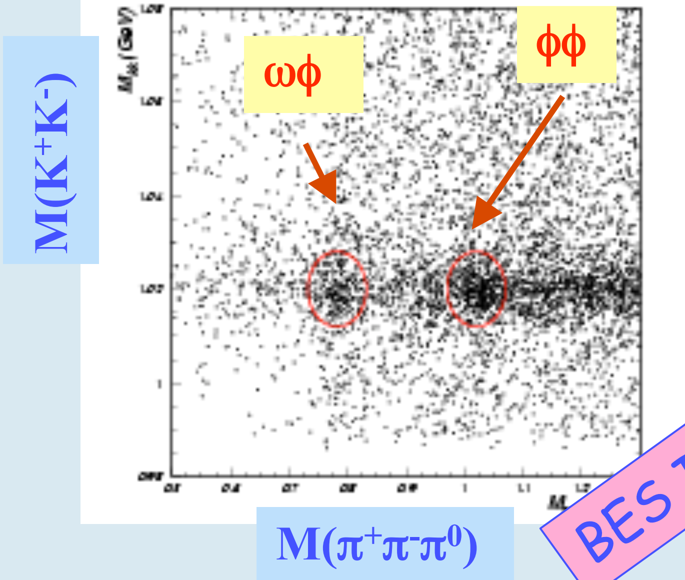
Include FSI curve from A.Sirbirtsev et al.(hep-ph/0411386) in the fit (I=0)

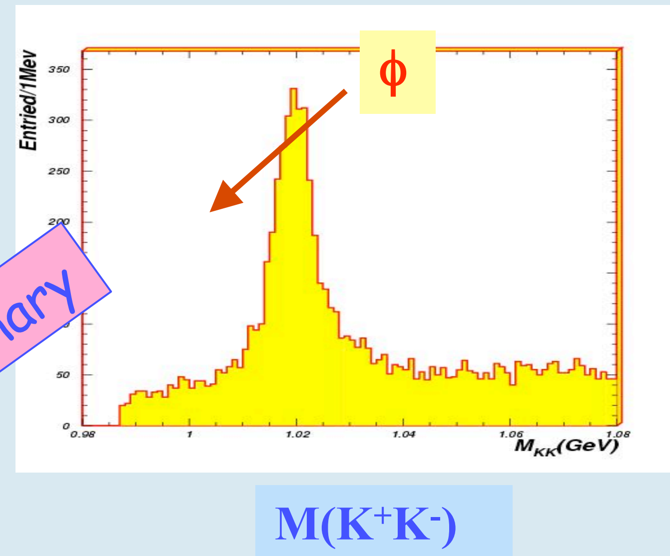




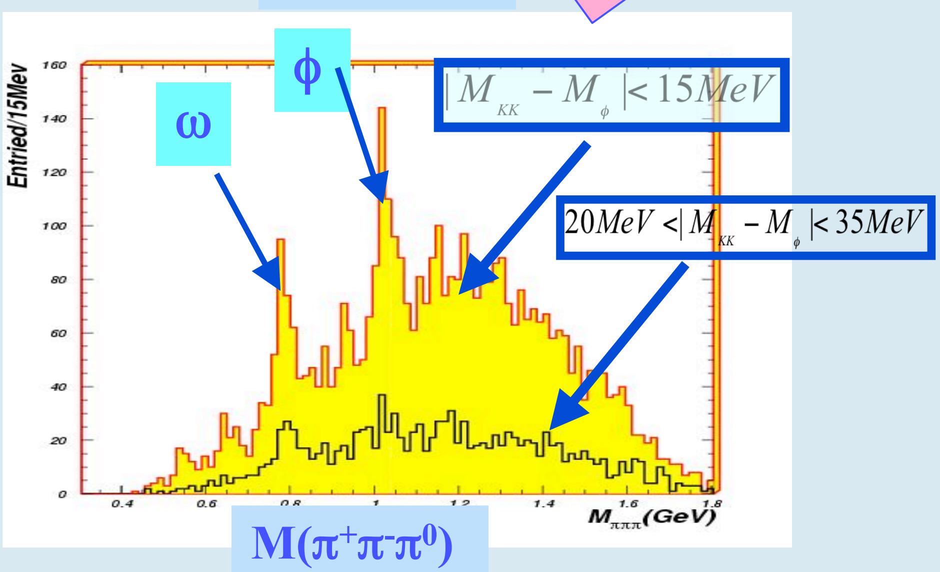
In good agreement with X(1835)

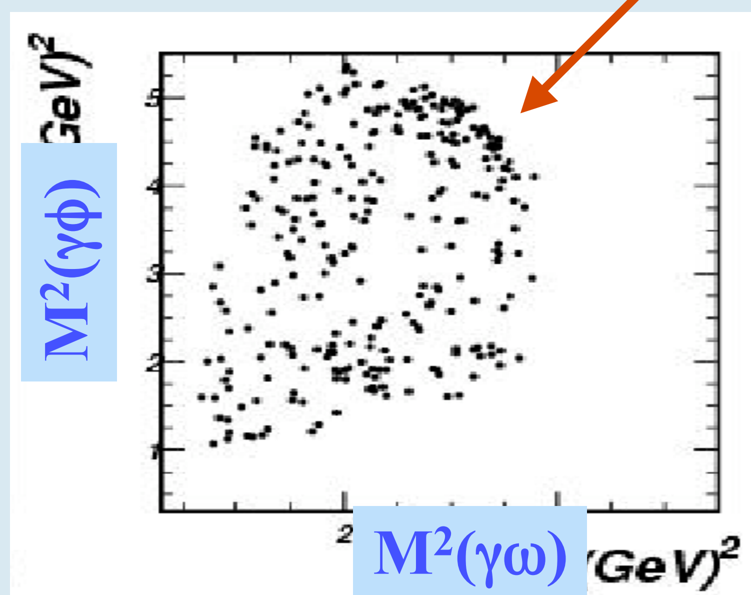
Observation of ωϕ threshold enhancement in $J/\psi \to \gamma\omega\phi$



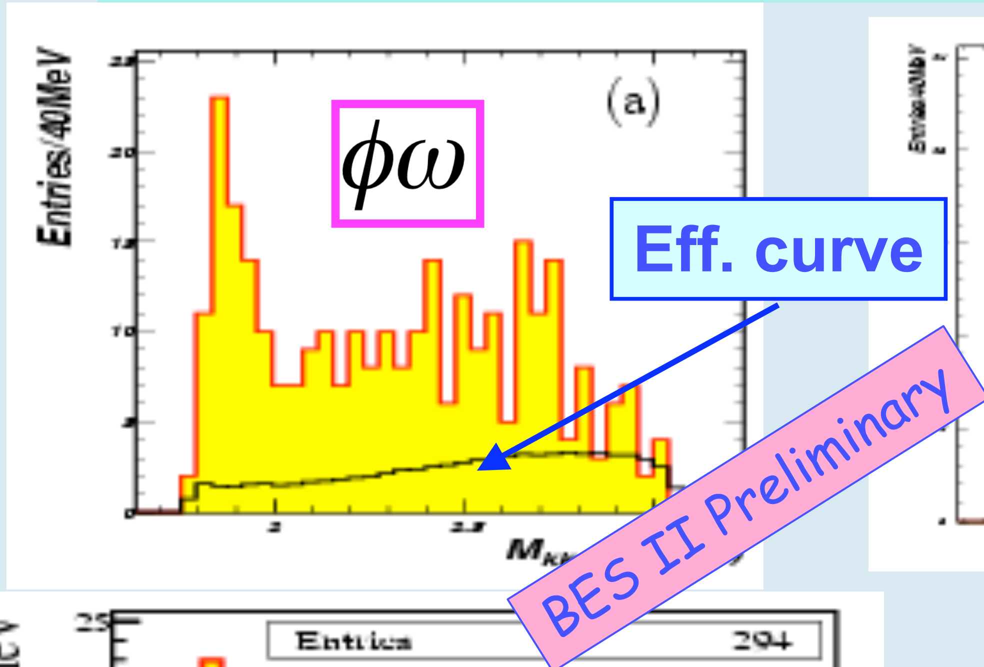


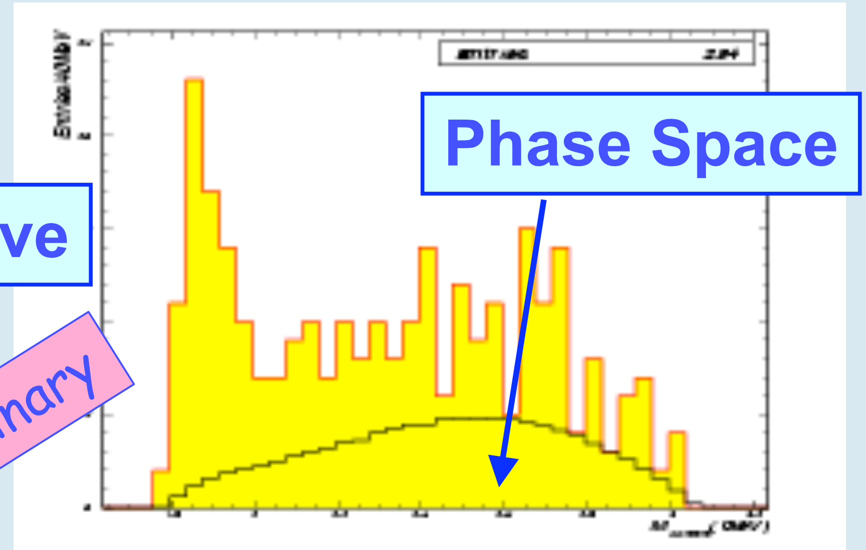
BES II Preliminary

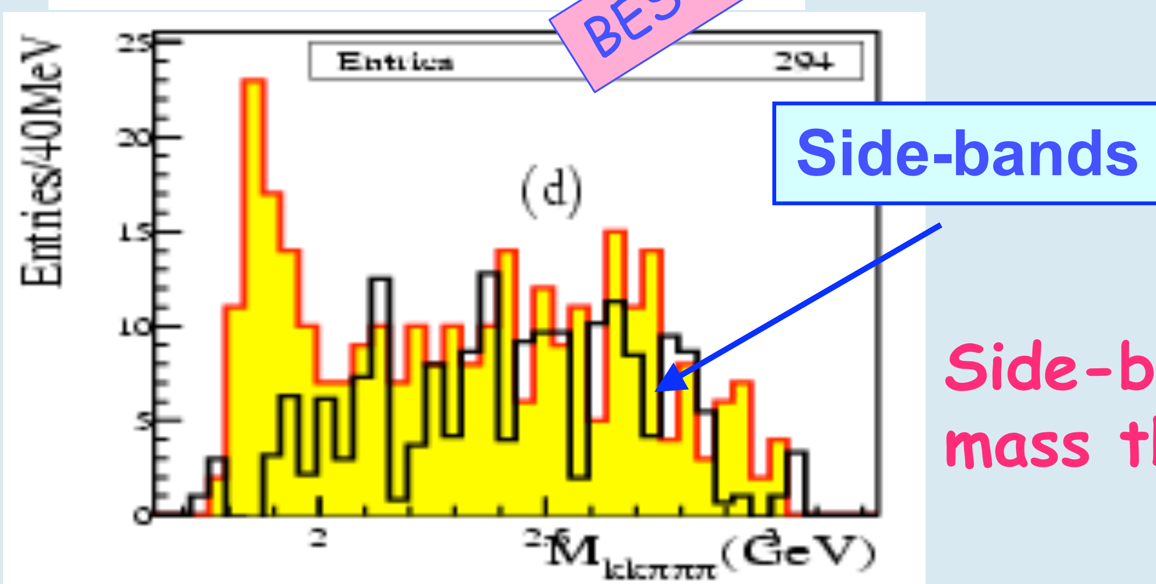




DOZI decay of J/ψ→γωϕ is observed, a clear threshold enhancement is observed







Side-bands do not have mass threshold enhancement!

BES II Preliminary

Partial Wave Analysis is performed.

0^{++} is favored over 0^{-+} and 2^{++}

$$M = 1812^{+19}_{-26} \pm 18 \text{ MeV/c}^2$$

$$\Gamma = 105 \pm 20 \pm 28 \text{ MeV/c}^2$$

$$Br(J/\psi \to \gamma X) \cdot Br(X \to \omega\phi) = (2.61 \pm 0.27 \pm 0.65) \times 10^{-4}$$

Submitted to Phys. Rev. Lett., hep-ex/0602031

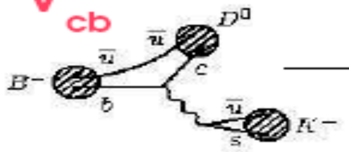
What is the nature of this structure?

hep-ph/0602172, hep-ph/0602190

Methods for extraction of γ at B factories

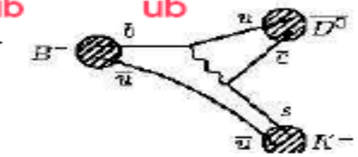
Giri-Grossman-Soffer-Zupan (GGSZ) PRD68, 054018(2003)

V_{cb}



Same final state
$B^- \to D(^*)K^-$
Interference

$V_{ub} = |V_{ub}| e^{-i\gamma}$



$A(B^- \to D^0 K^-) = A_B$

$A(B^- \to \overline{D}^0 K^-) = A_b r_B e^{+i(\delta_B^- \ \gamma)}$

$A(B^+ \to \overline{D}^0 K^+) = A_b r_B e^{+i(\delta_B^+ \ \gamma)}$

$r_B = |A(B^- \to \overline{D}^0 K^-) / A(B^- \to D^0 K^-)|$

$A(D^0 \to Ks\pi^-\pi^+) = A(s_{12}, s_{13})$

$A(D^0 \to Ks\pi^+\pi^-) = A(s_{13}, s_{12})$

$A(\overline{D}^0 \to Ks\pi^+\pi^-) = A(D^0 \to Ks\pi^-\pi^+)$

$s_{12} = m^2(Ks\pi^-)$ $s_{13} = m^2(Ks\pi^+)$

$$f_{B^-} = \left| f_D(s_{12}, s_{13}) \right| + r_B e^{-i\gamma + i\delta_B} \left| f_D(s_{13}, s_{12}) \right| e^{i(\delta(s_{12}, s_{13}) - \delta(s_{13}, s_{12}))}$$

Limited by uncertainty due to Dalitz plots

Model in D^0 decays currently 11^0

$\gamma = 68^{+14}_{-15} \pm 13 \pm 11$

$22 < \gamma < 113$ (@2σ)

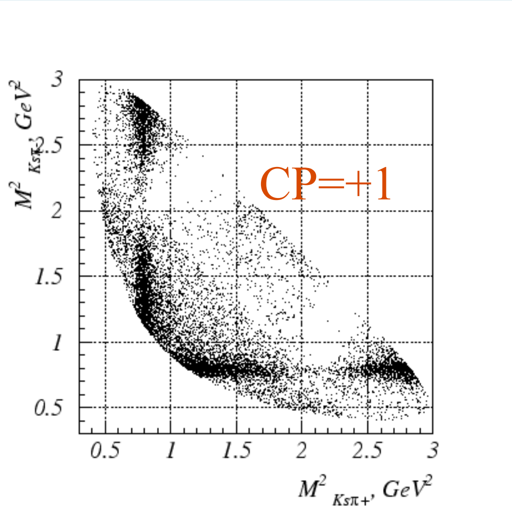
Belle hep-ex/0411049

This difference of phases can only be obtained in e+e- → $\psi(3770)$→DDbar, where the other (tag-side) D meson is reconstructed in CP eigenstate, such as K^+K^- or Ks π^0 and so on. → @BESIII

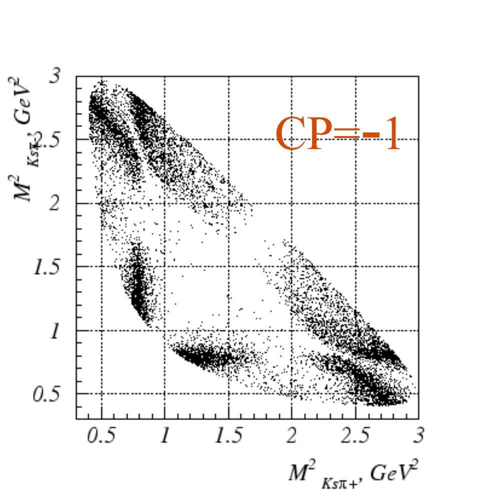
We need to do detail MC study and more theoretical input to the physics book

CP-tagged events at BESIII

CP properties of the D states produced in the Ψ (3770) are anticorrelated. If one D decaying as CP=+1 other state is "CP-tagged" as CP=-1



32,000 CP-tagged $K^+\pi^-$ decays are expected for one year run at CLEO-c (G.Burdman, I.Shipsey hep-ph/0310076) ???



Based on this number we can estimate:

10,000 $K_S\pi^+\pi^-$

7,500 $\pi^+\pi^-\pi^0$ at BESIII / 2 years 10^{-fb}

1,900 $K_SK^+K^-$

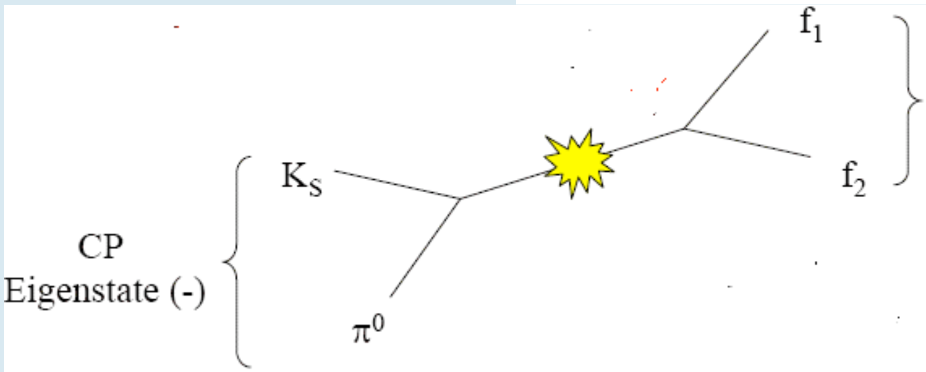
The $\delta(\cos(\delta_D))$ 2% → 1^0 – 2^0 for γ at B factories A.E. Bonder hep-ph/0510246

Measurement of Strong Phase

If CP violation in Charm is neglected: mass eigenstates = CP eigenstates

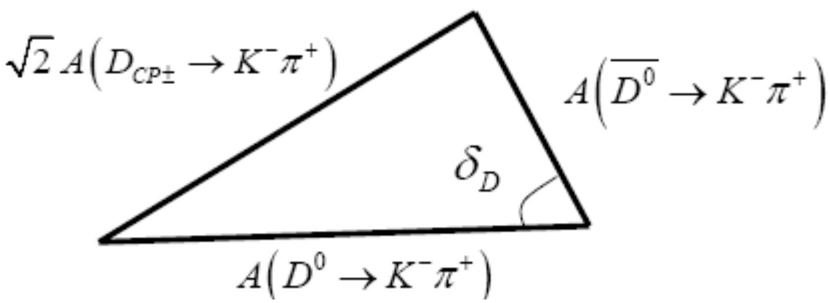
$$|D_{CP\pm}\rangle = \frac{1}{\sqrt{2}}\left[|D^0\rangle \pm |\overline{D^0}\rangle\right]$$

$$\sqrt{2}\,A(D_{CP\pm} \to K^-\pi^+) = A(D^0 \to K^-\pi^+) \pm A(\overline{D^0} \to K^-\pi^+)$$



Flavor mode

$$D_{CP(+)} \to f_1 f_2$$



In the limit of CP-invariance

$$A(D^0 \to K^+\pi^-) = A(\overline{D^0} \to K^-\pi^+)$$

$$\cos\delta_D = \frac{Br(D_{CP+} \to K^-\pi^+) - Br(D_{CP-} \to K^-\pi^+)}{2\sqrt{r_D}\,Br(D^0 \to K^-\pi^+)}$$

$\cos\delta_D$ ~ ±2% at BESIII