Status of KEKB and BELLE

Oct. 5, 1999
ICFA Seminar at FNAL

M.Yamauchi
KEK

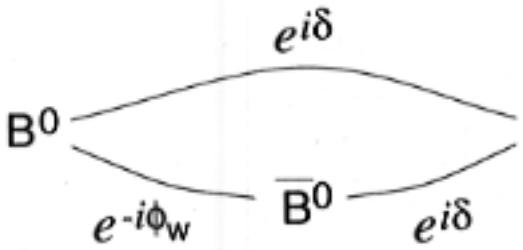
Outline

- Introduction
- KEKB - Commissioning status
- BELLE performance
- Summary and outlook

Introduction

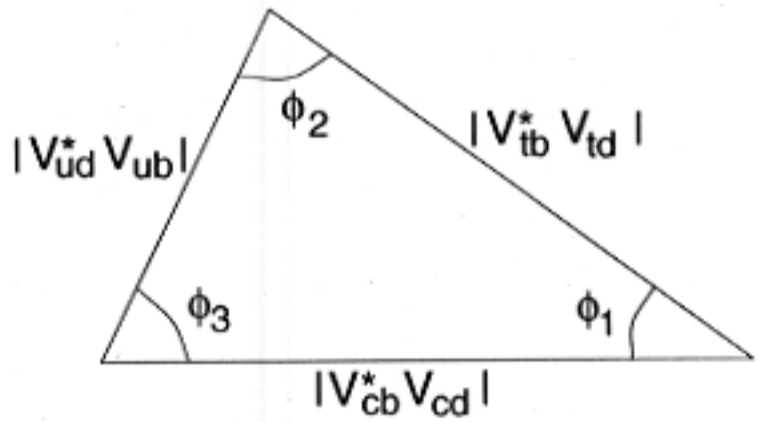
Purposes of KEKB

- **Discovery of CPV in B system (≈ 10 fb^{-1})**



$$A_{CP}(t) = \sin 2\phi_w \sin \Delta m\, t$$

- **Complete test of KM scheme (≈ 100 fb^{-1})**



- Measurements of various rare decays of *B*

  → New phenomena (?)

Brief chronology

1989 "B Physics Taskforce" formed

Jun. 1991 Conceptual design of machine and detector
Proposal submitted to Monbusho

Apr. 1994 Proposal approved.
Construction of the machine and detector began.

Oct. 1998 Completion of the detector construction

Dec. 1998 Machine commissioning without BELLE
rolled in.

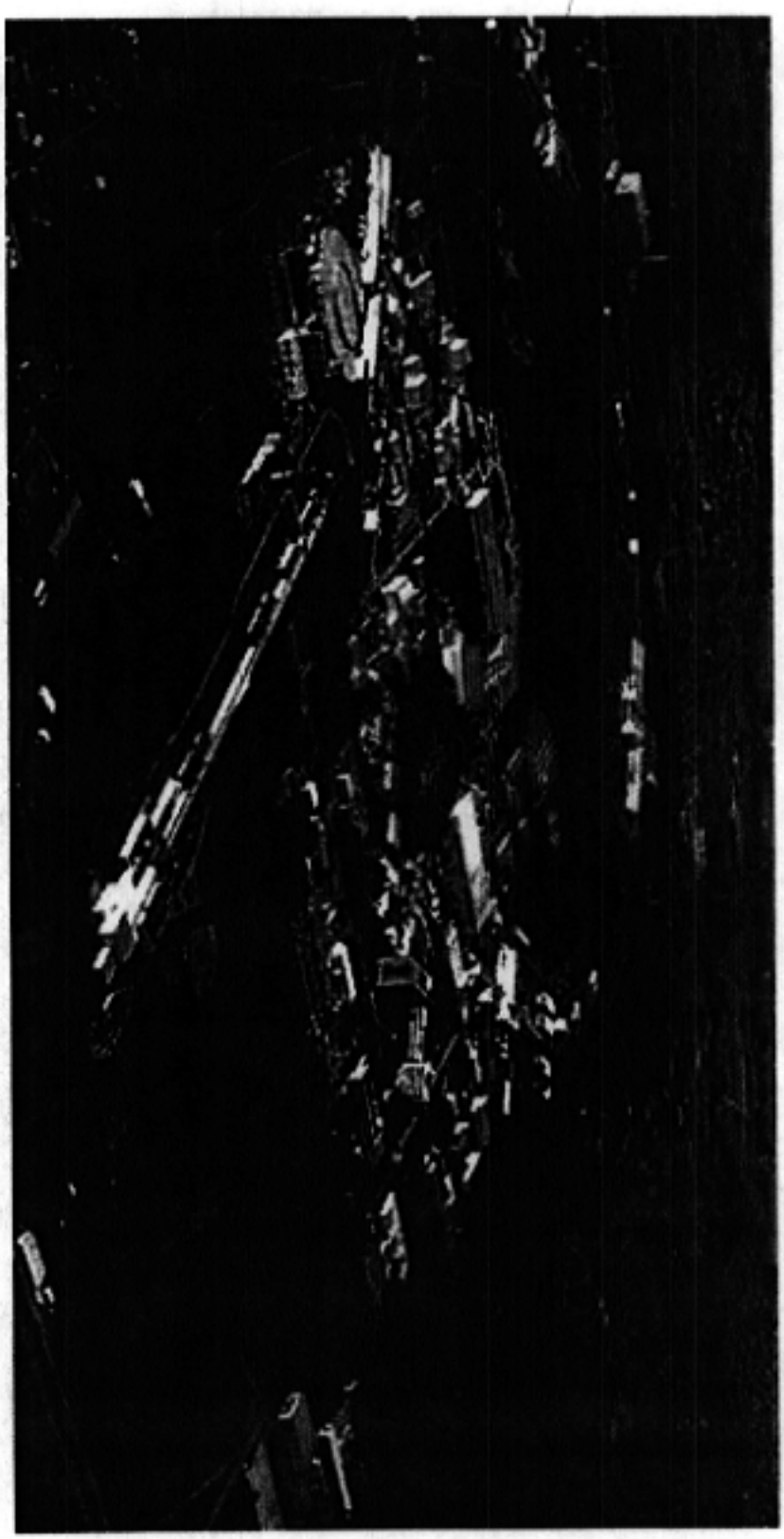
May 1999 Belle roll-in

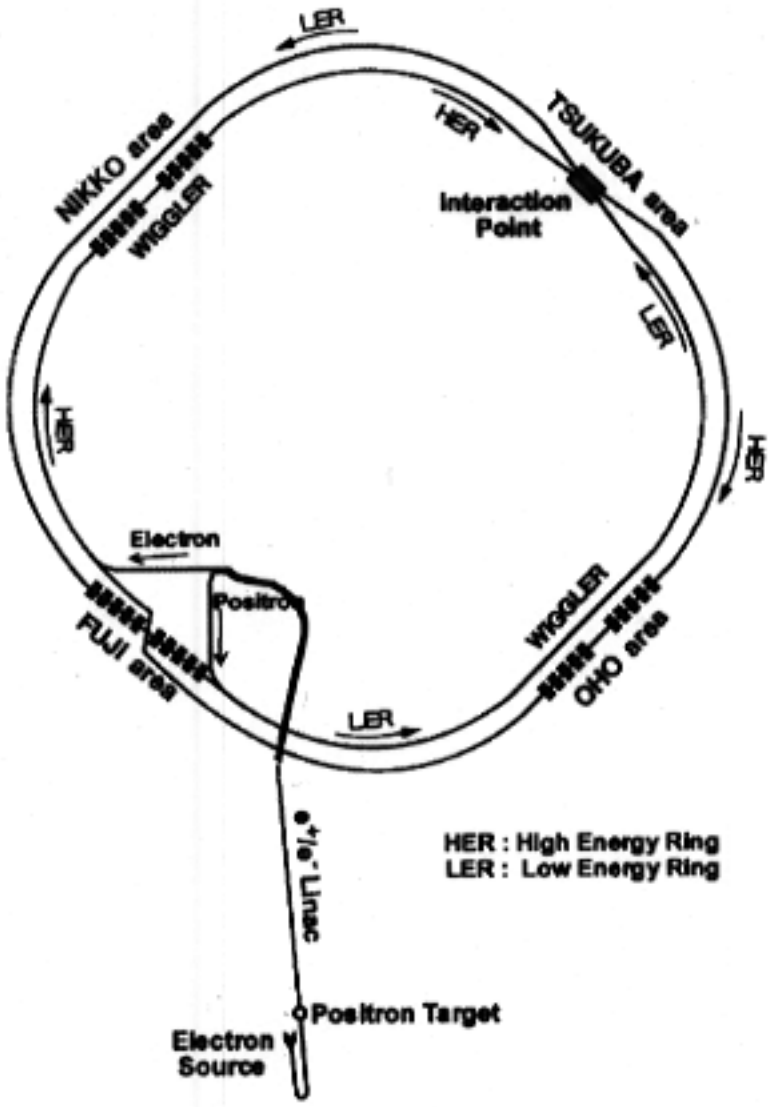
Jun. 1999 First collision observed.

Jul. 1 - Aug.4 Physics run, 25 pb^{-1} accumulated

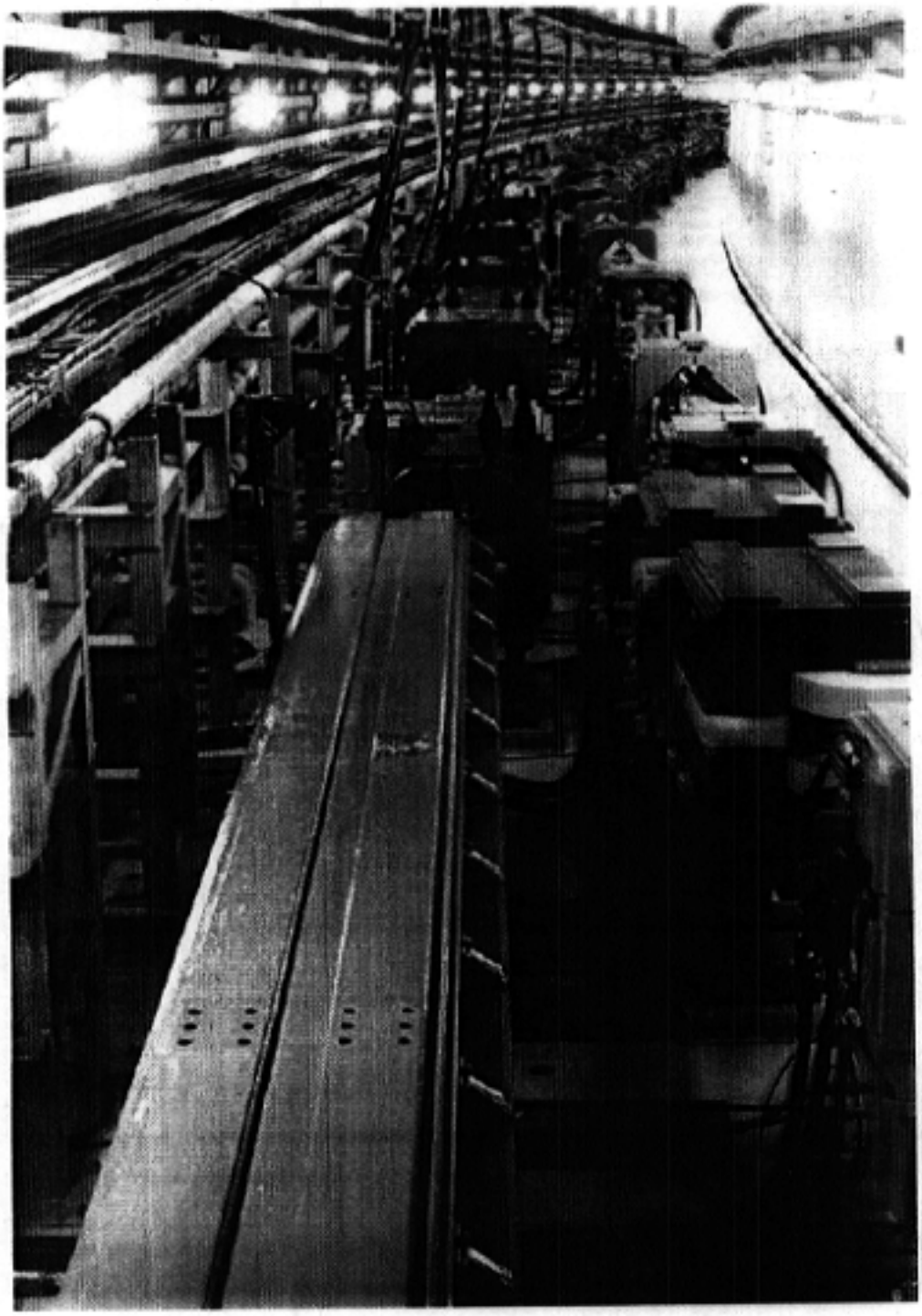
RF installation, LINAC upgrade, SVD replacement etc.

Oct.11, 99 Machine operation will be resumed.





Arrangement of two rings



Features of KEKB collider

- High luminosity double ring $e^+ e^-$ collider with asymmetric energies

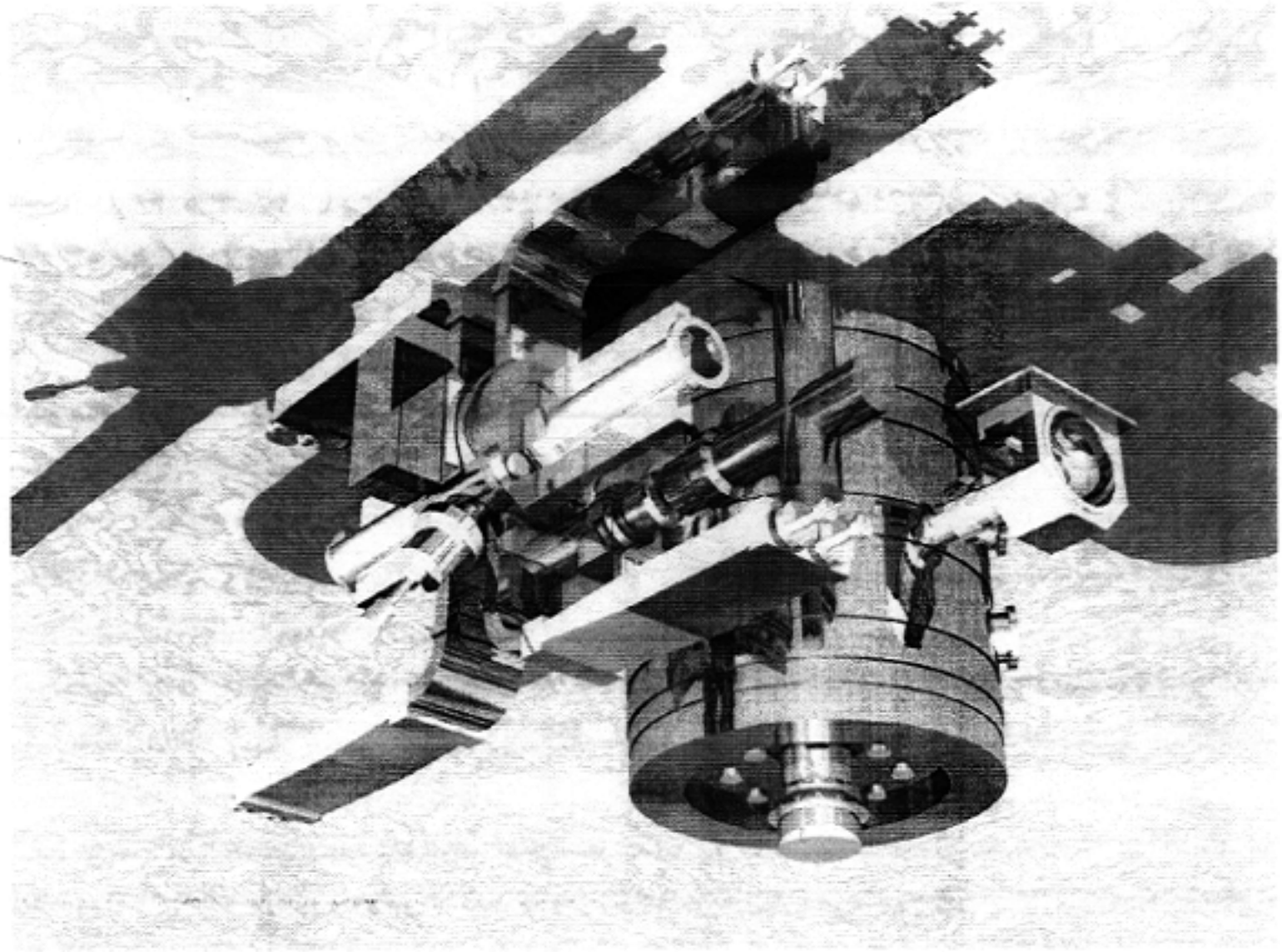
  Design luminosity = $1 \times 10^{34}/cm^2/sec$
  E (e^-) = 8 GeV and E (e^+) = 3.5 GeV

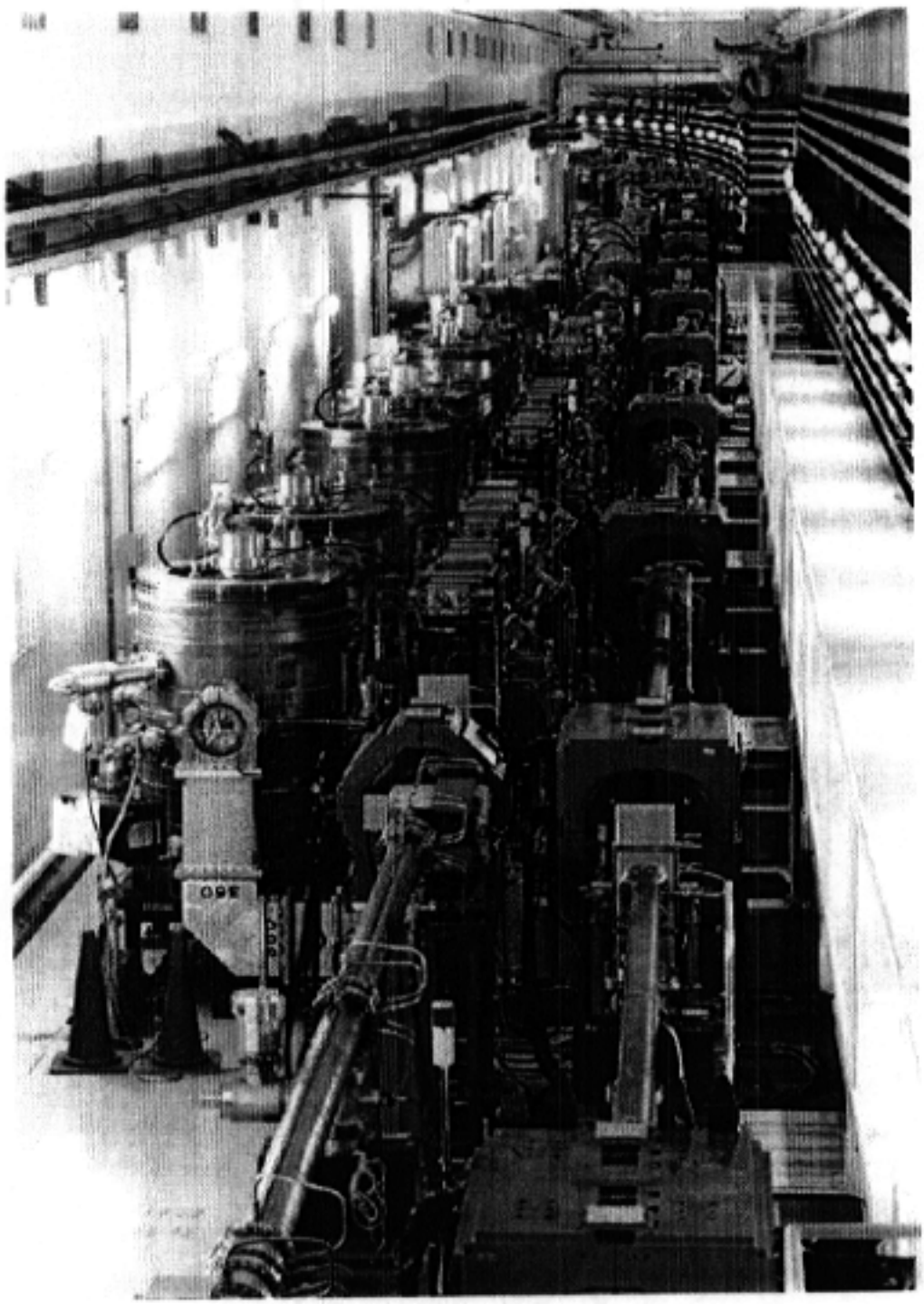
- Finite angle beam crossing, ±11 mrad
  R&D of crab cavity is in progress

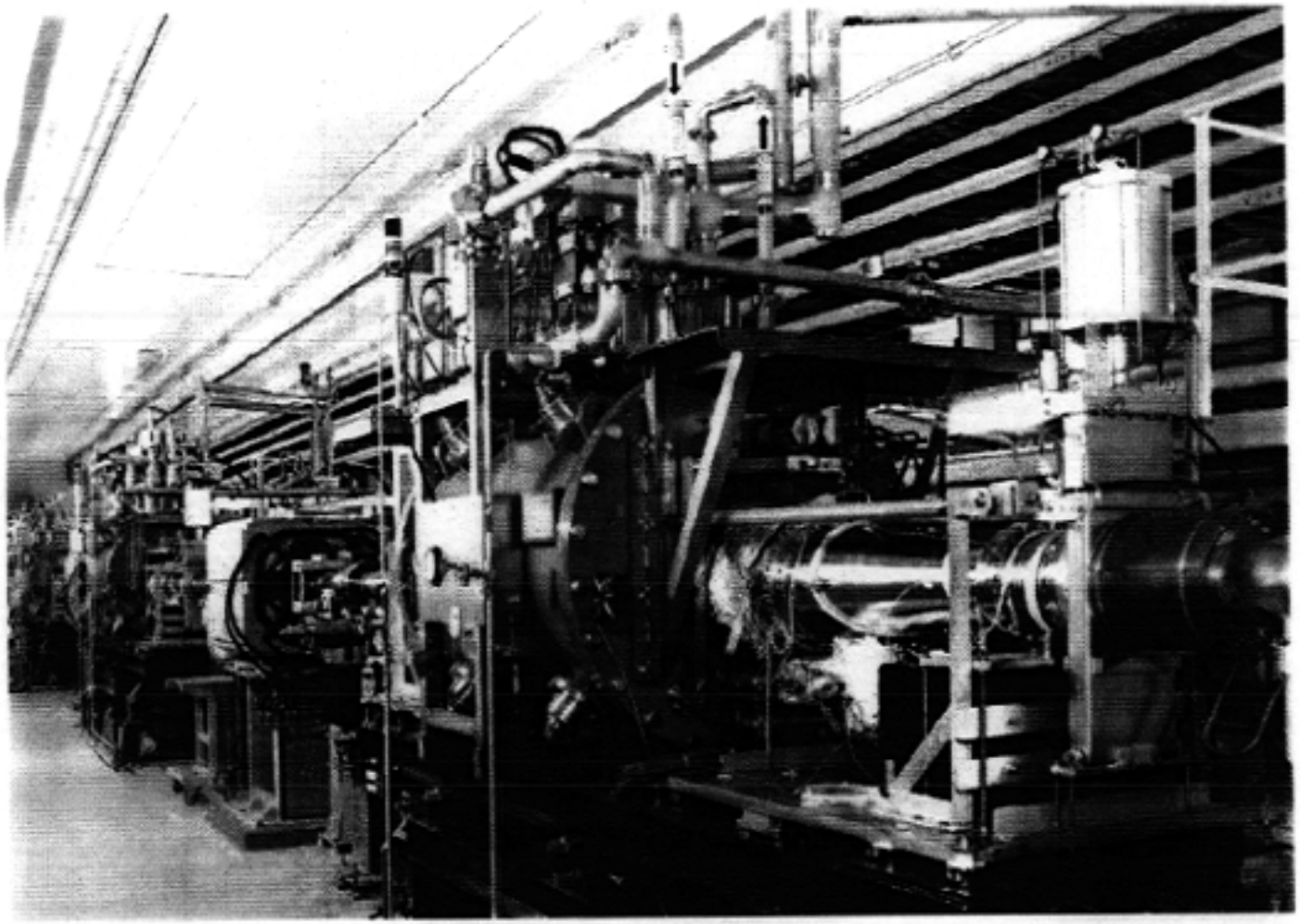
- Final focusing system with superconducting magnets

- ARES and superconducting RF cavities to avoid longitudinal instability

- Feedback system to avoid transverse instability







KEKB Performance

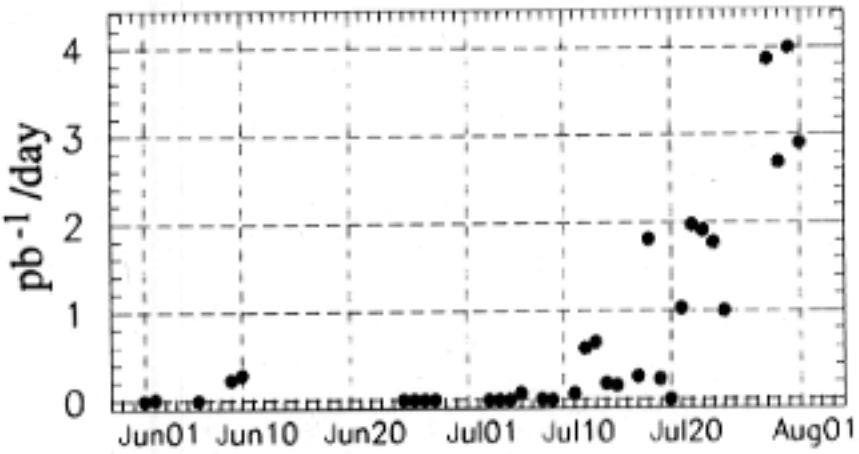
as of Aug.4, 1999

	LER	HER	
Beam current	293 (2600)	190 (1100)	mA
Number of bunches	1160 (5000)	1160 (5000)	
Bunch current	0.25 (0.52)	0.16 (0.22)	mA
Bunch spacing	1.8 (0.6)	1.8 (0.6)	m
Horizontal size at IP	190 (140)		μm
Vertical size at IP	3.9 (1.4)	3.3 (1.4)	μm
Emittance ratio	8.5 (1)	6.1 (1)	
$\beta x^* / \beta y^*$	100 / 1	100 / 1	cm
Beam life	100	300	min.
Luminosity (estimation)	4.0×10^{32}		$/cm^2/s$
Luminosity (BELLE)	2.9×10^{32}		$/cm^2/s$

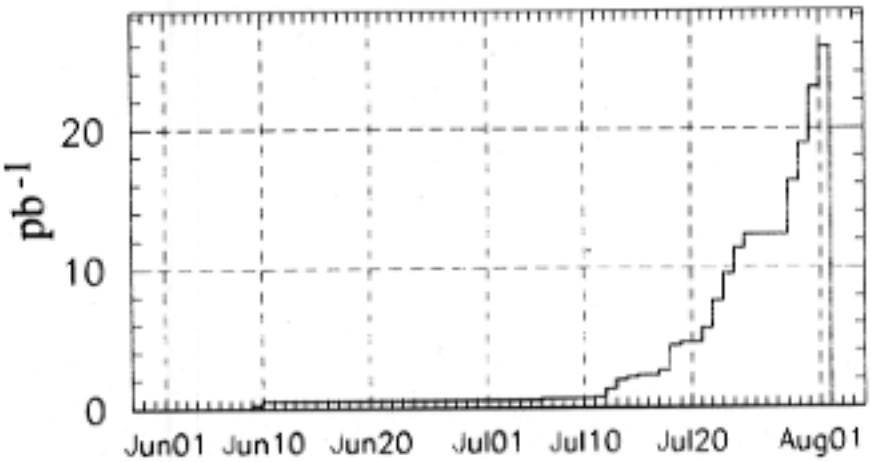
( ) : design values

Luminosity

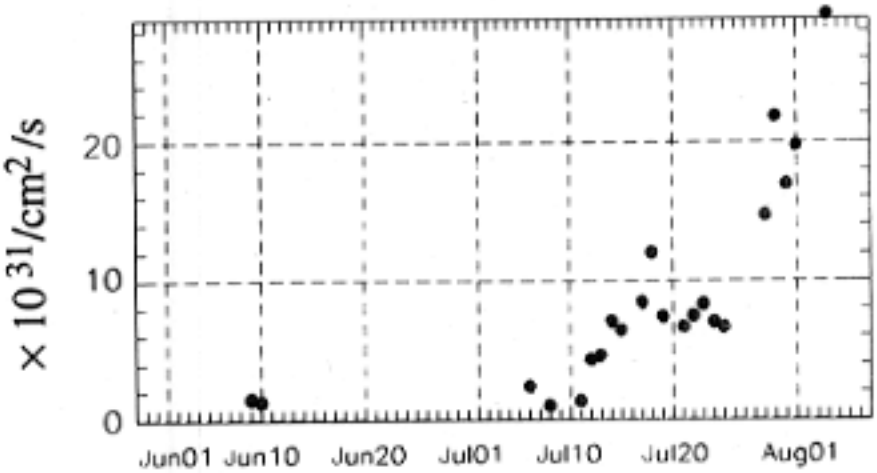
$\int L\,dt$ per day



Integrated luminosity



Highest lum. of the day



We observed "vertical blow-up" of the LER beam at $I_b > 200$ mA.

- This occurs with single-beam, i.e., without collision.
- This depends on x- and y-tunes, chromaticity and dispersions.

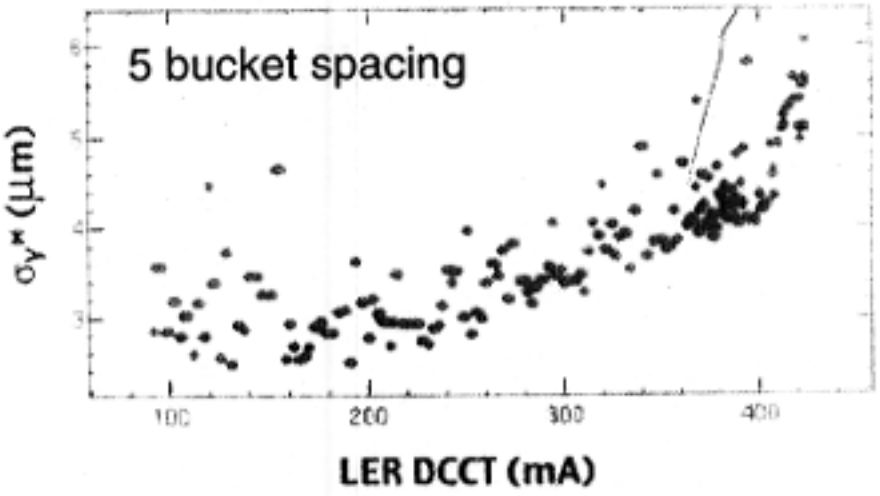
Hypotheses:

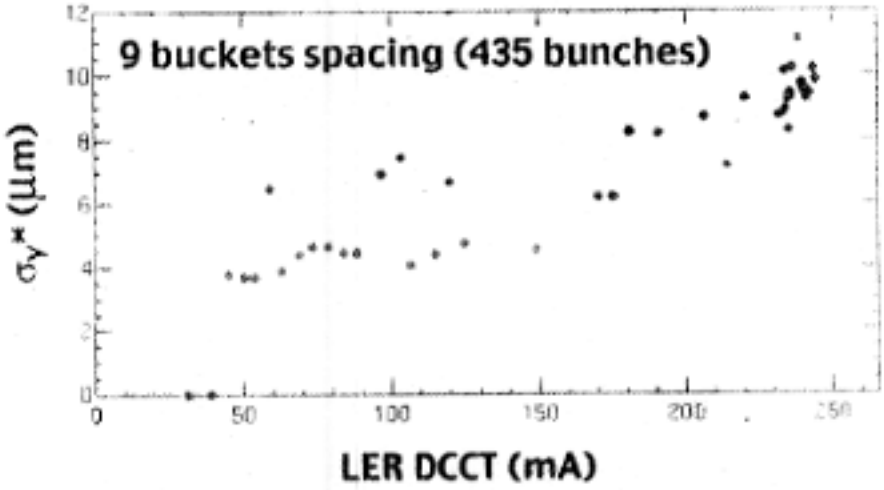
- Space charge of photo-electron cloud ?
- Trapped mode of the movable collimaters ?
- Related to multibunch bunch-lengthening ?

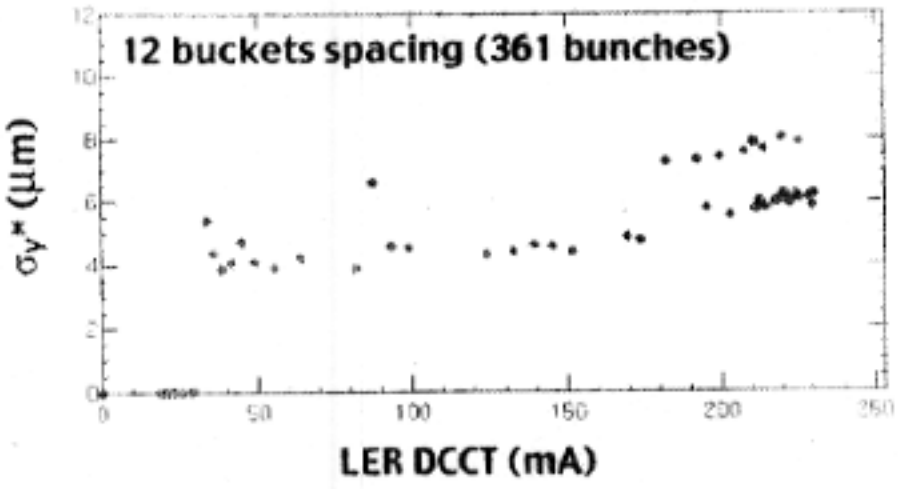
More studies will be made as soon as we resume the operation.

Possible solutions:

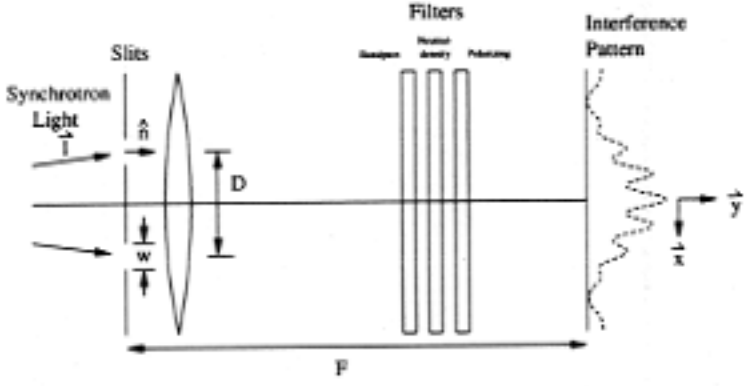
- Permanent magnet all around the arc
- Longer bunch spacing + higher bunch current + high emittance operation
- Large number of short trains
- Trapped mode damper/absorber at the collimaters


5 bucket spacing
σy* (μm)
100
200
300
400
LER DCCT (mA)


9 buckets spacing (435 bunches)
σy* (μm)
0
50
100
150
200
250
LER DCCT (mA)

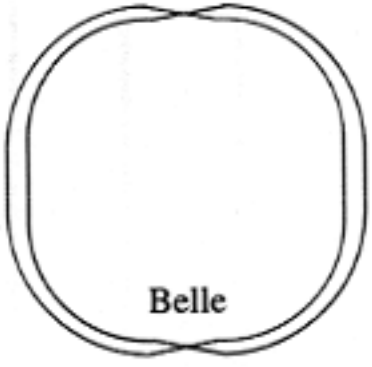

12 buckets spacing (361 bunches)
σy* (μm)
0
50
100
150
200
250
LER DCCT (mA)

SR Interferometry
Beam-Size Monitor



LER SR Monitor Source Bend

HER SR Monitor Source Bend



I.P.

$$y(x) = I_0 \left[\frac{\sin\left(\frac{2\pi}{\lambda} Fw\Phi x\right)}{\frac{2\pi}{\lambda} Fw\Phi x} \right]^2 \left(1 + \gamma \cos\left(\frac{2\pi}{\lambda} Dx\right)\right),$$

where :

λ = wavelength

$\Phi \propto \vec{I} \cdot \hat{n}$

γ = Visibility

Find Visibility

$$\sigma_{beam} = \frac{\lambda L}{\pi D M} \sqrt{\frac{1}{2} \ln \frac{1}{\gamma}},$$

where :

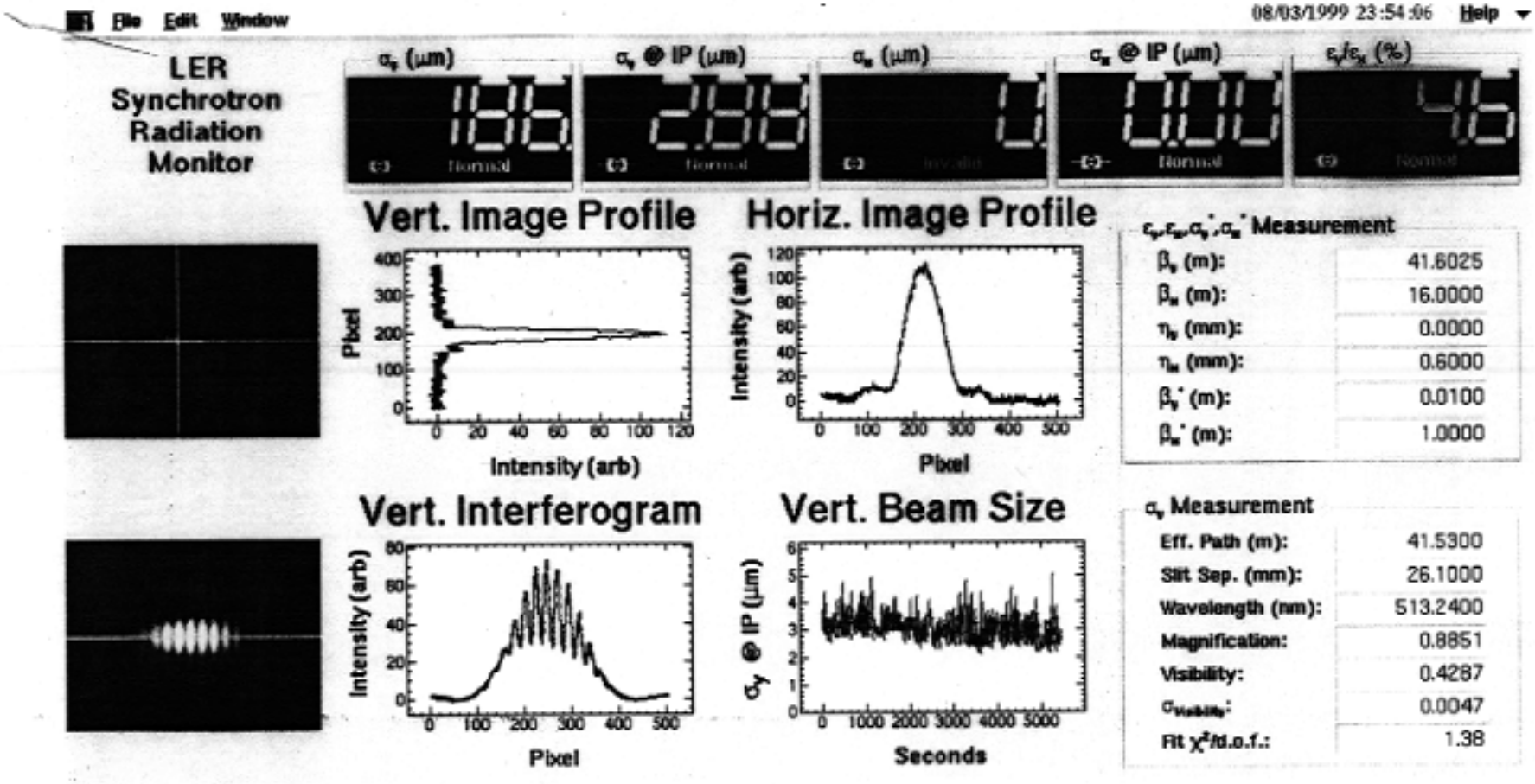
L = distance from source

M = magnification

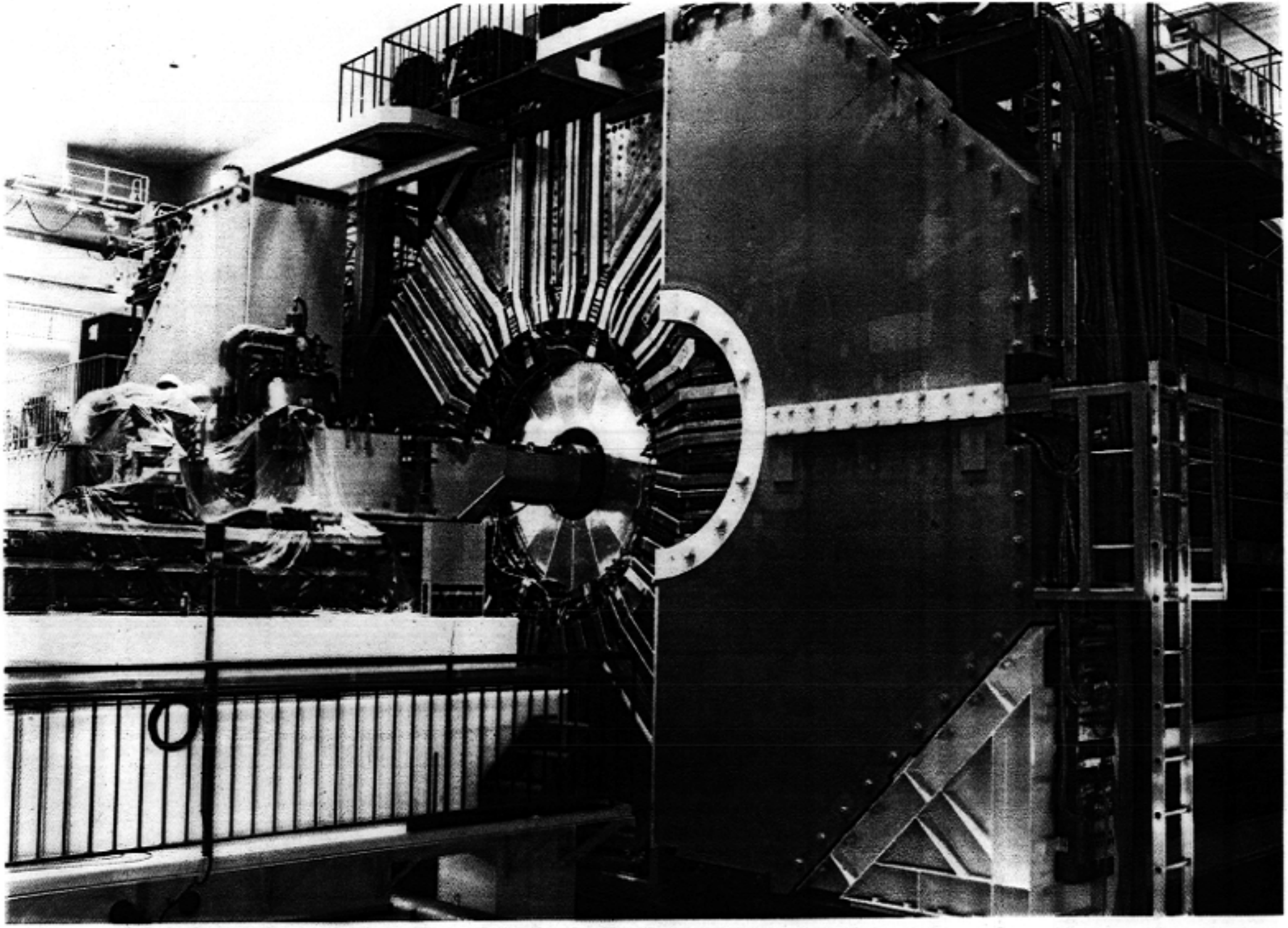
$$\sigma^* = \sigma(SRMon) \sqrt{\frac{\beta^*}{\beta(SRMon)}}$$

Translate to I.P.

SR Beam-Size Monitor
LER

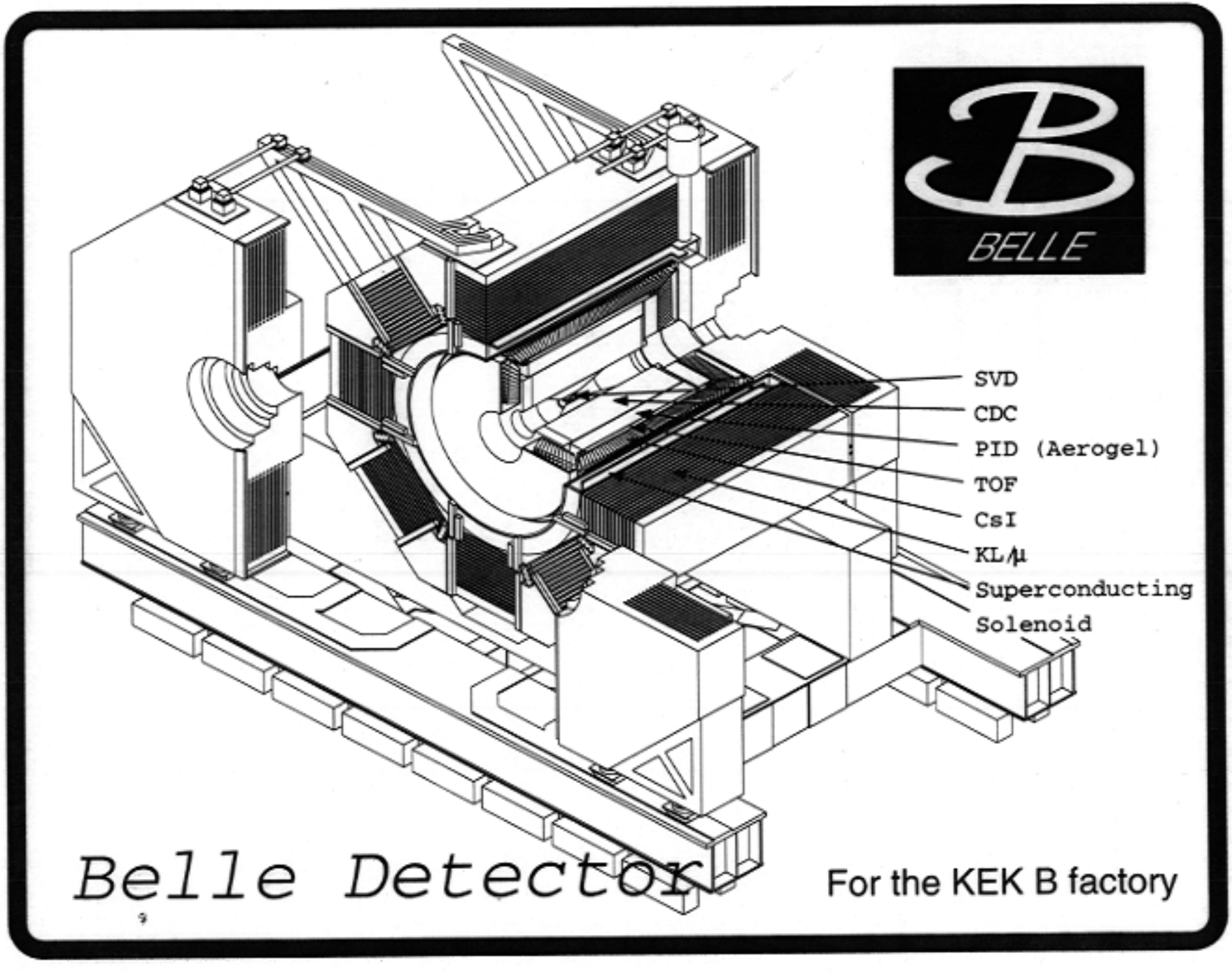


J. Flanagan / T. Mitsuhashi



BELLE Collaboration

Academia Sinica
Aomori University
Budker Institute of Nuclear Physics
Chiba University
Chuo University
University of Cincinati
Fukui University
Gyeongsang National University
University of Hawai
Hiroshima Institute of Technology
Hiroshima College of Maritime Tech.
Institute of High Energy Physics
Institute of Single Crystals
Joint Crystal Collaboration Group
Kanagawa University
KEK
Korea University
Krakow Institute of Nuclear Physics
Kyoto University
Mindanao State University
Nagasaki Institute of Applied Science
Nagoya University
Nara Woman's University
National Central University
National Kaoshing University
National Lien-Ho College of Tech. and Commerce
National Taiwan University
Niigata University
Nihon Dental College
Osaka University
Osaka City University
Princeton University
Saga University
Seoul National University
University of Science and Tech. of China
Sugiyama Woman's College
Toho University
Tohoku University
Tohoku-gakuin University
University of Tokyo
Tokyo Metropolitan University
Tokyo Institute of Technology
Tokyo University of Agriculure and Technology
Toyama National College of Maritime Technology
University of Tsukuba
Utkal Univesity
Virginia Polytechnic Institute and State University
Yonsei University

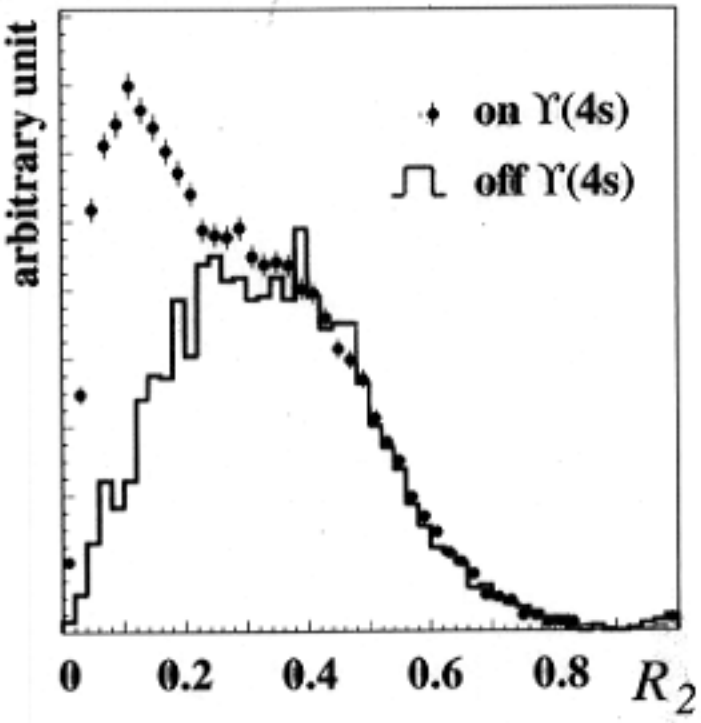

BELLE
SVD
CDC
PID (Aerogel)
TOF
CsI
KL/μ
Superconducting
Solenoid
Belle Detector
For the KEK B factory

Energy scan

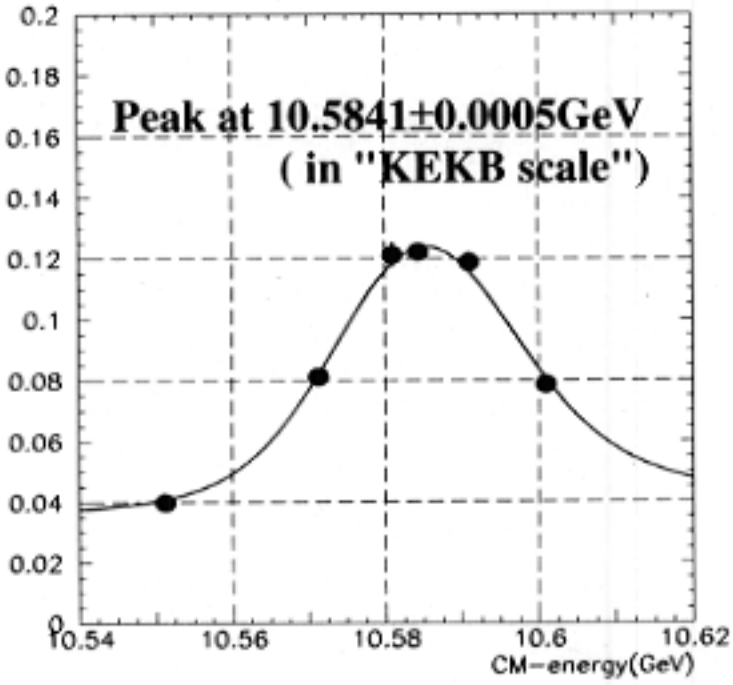
R_2 distribution

Fox-Wolfram moment ratio

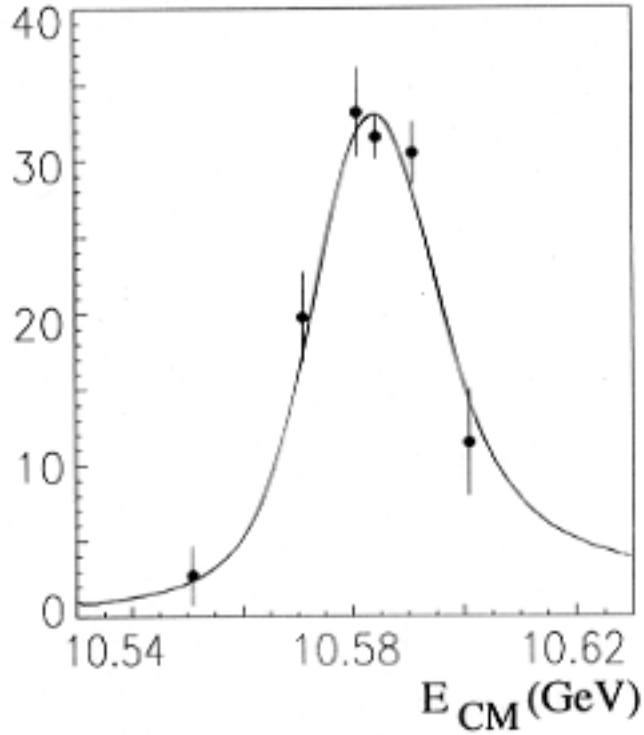
$$R_2 \equiv \frac{H_2}{H_0}$$



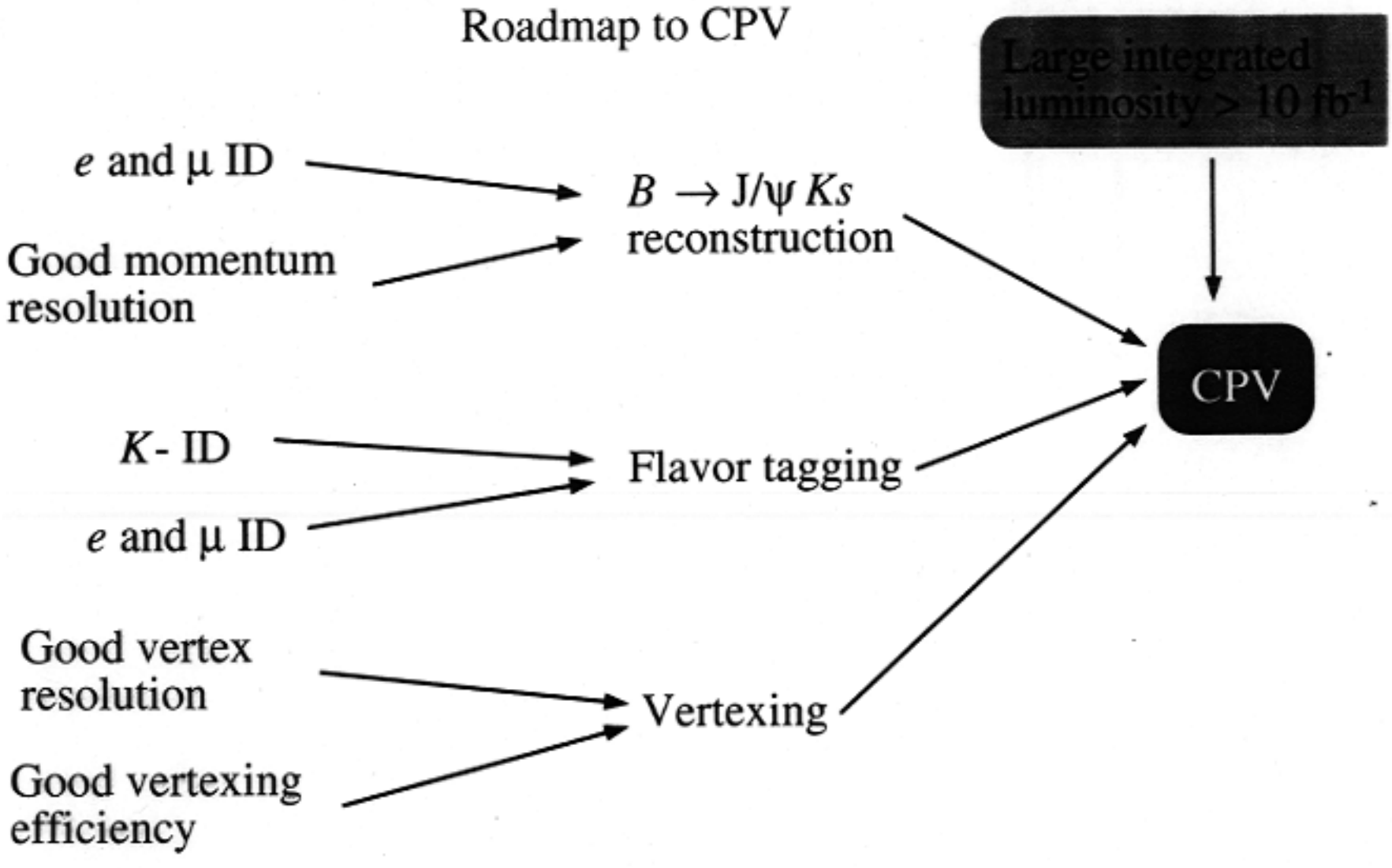
No. of events with $R_2 \leq 0.2$ / No. of Bhabha events



$B\bar{B}$ event rate from lepton spectrum



Probing CP violation in $B \to J/\psi\, Ks$

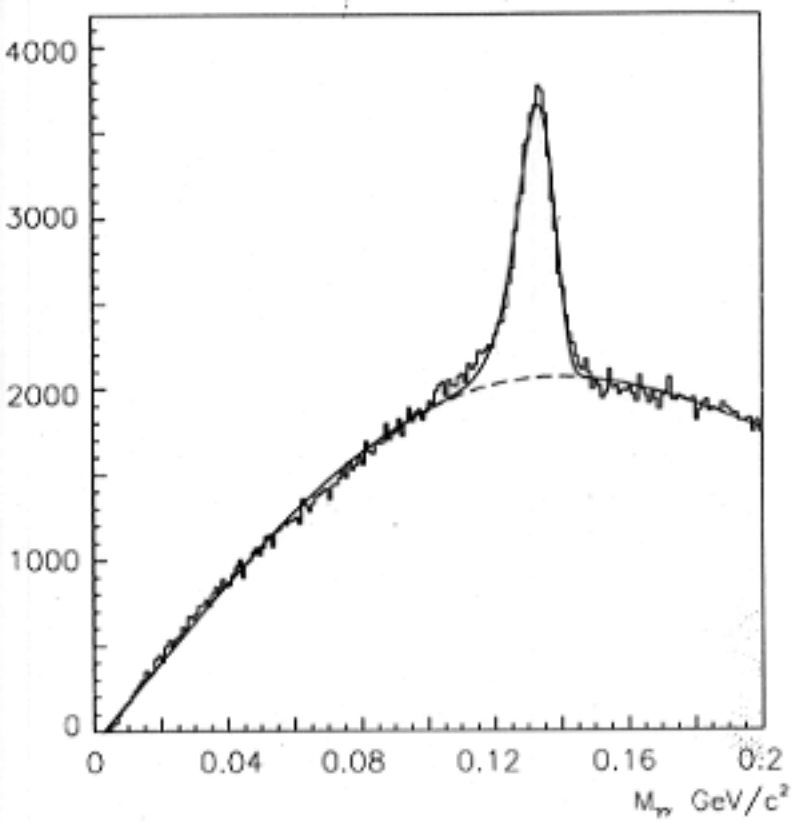


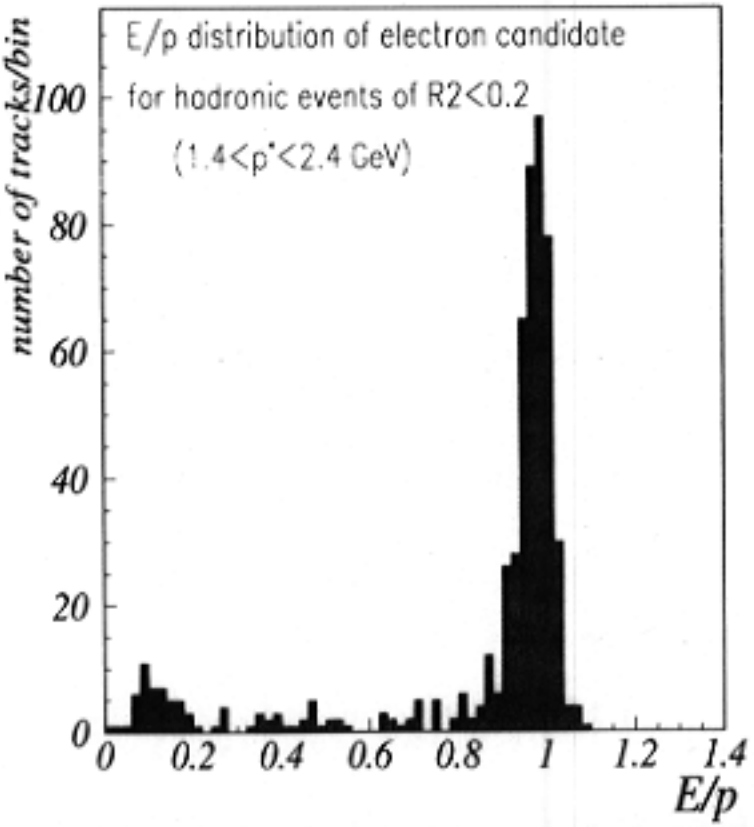
Performance of EM calorimeter

π^0 reconstruction

$E_\gamma \geq 50$MeV

$\sigma(m_{\pi^0}) = 5.6$ MeV





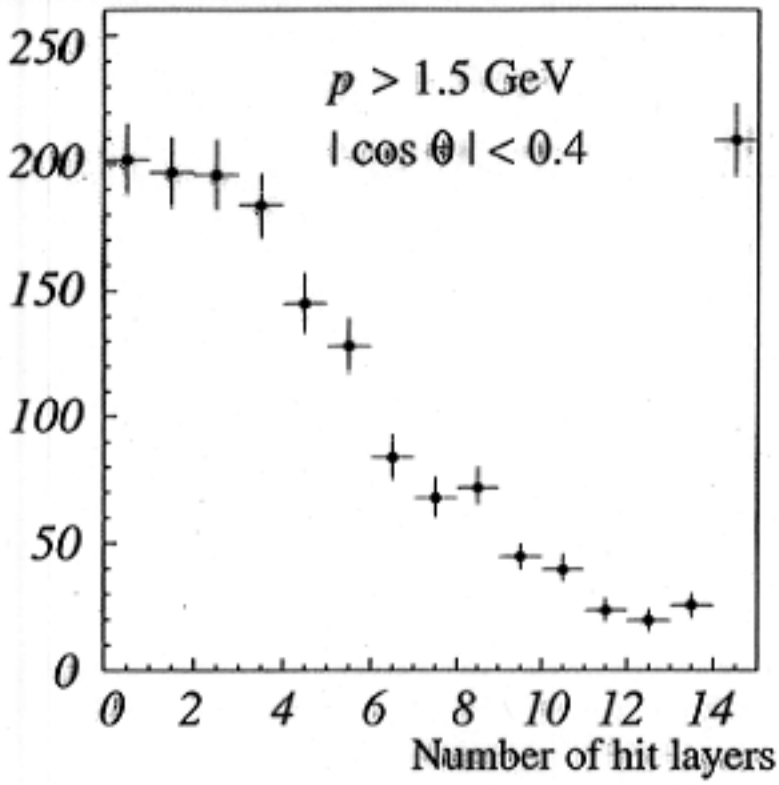
$e^\pm$ identification

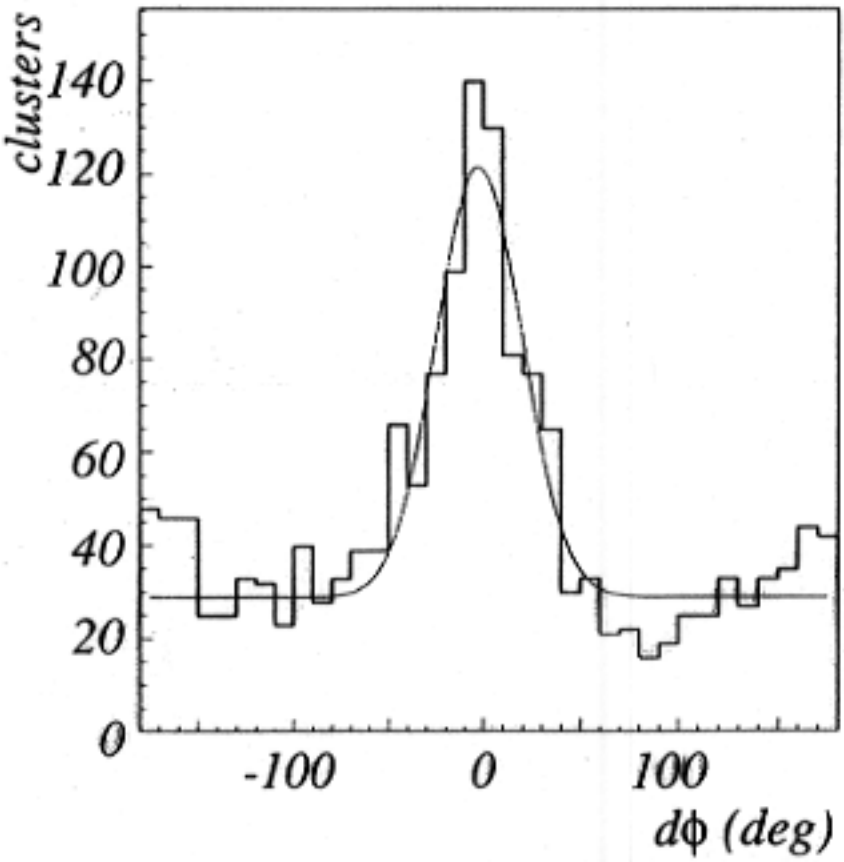
E/p distribution after
dE/dx and shower shape cuts

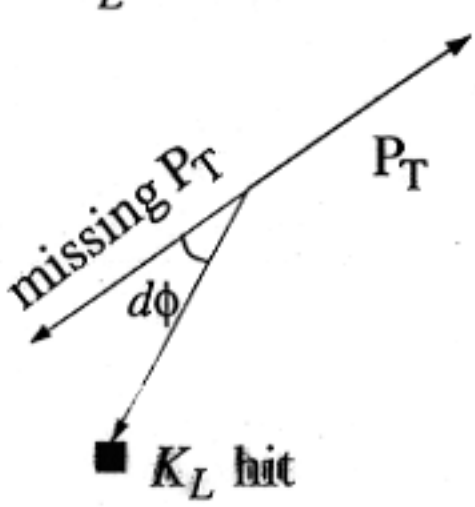
K_L and μ detector

μ± ID by KLM

Number of hit layers associated with a charged track





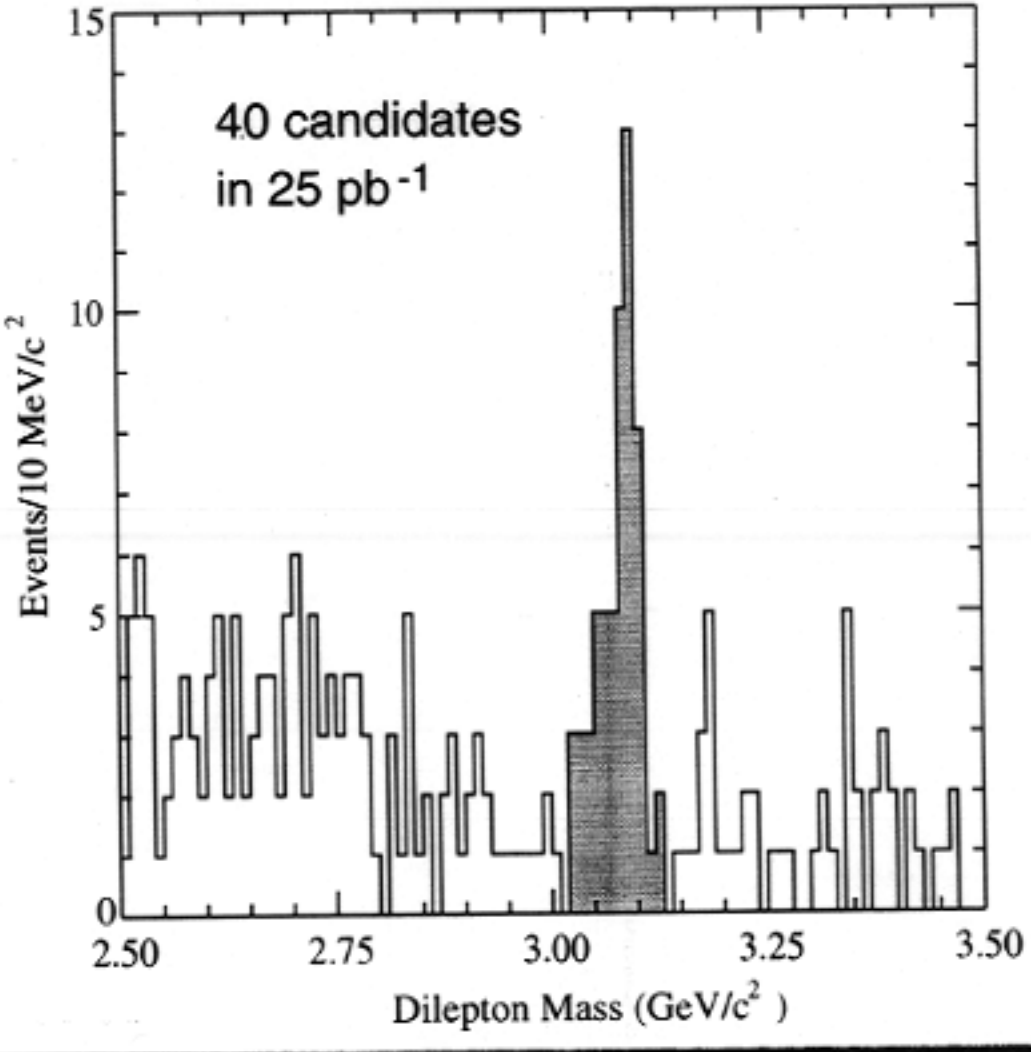


J/ψ reconstruction

$J/\psi \rightarrow \mu^+ \mu^-$
$\rightarrow e^+ e^-$

e-ID :
dE/dx
+ shower shape
+ E/p

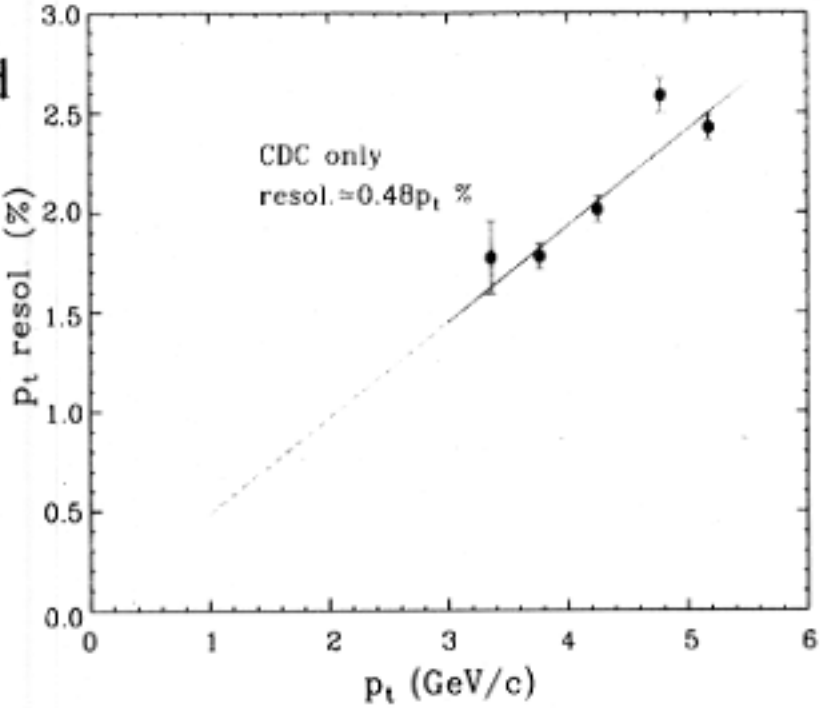
μ-ID:
13 hit layers in KLM



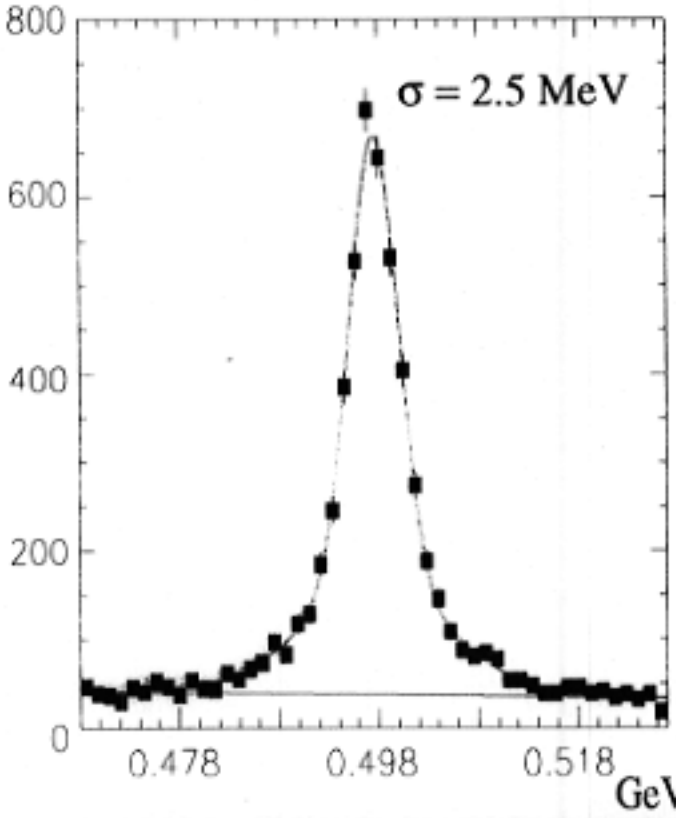
Tracking

P_T resolution measured by $\mu^+\mu^-$ events.

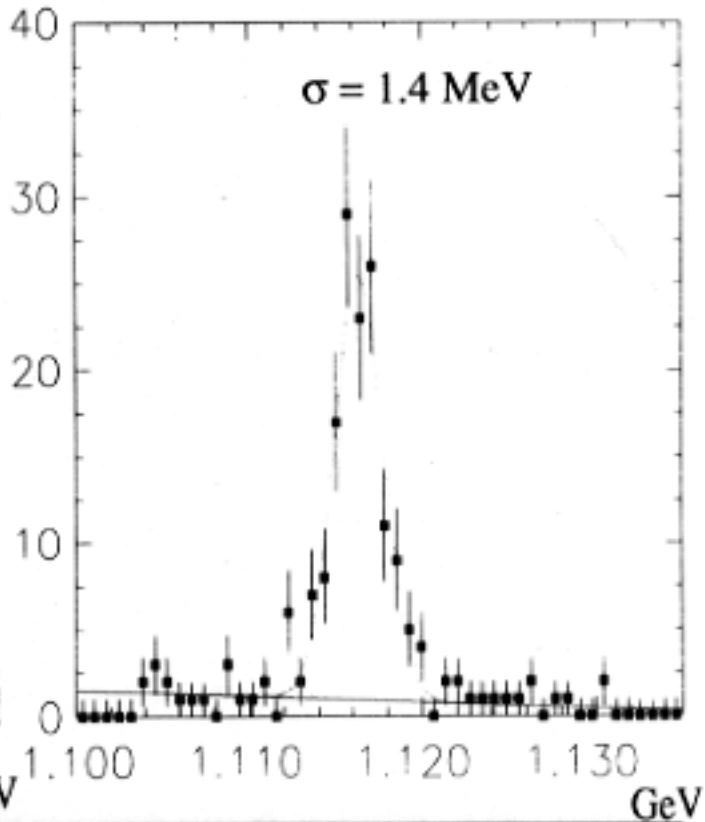
Spatial resolution per point = 160 μm



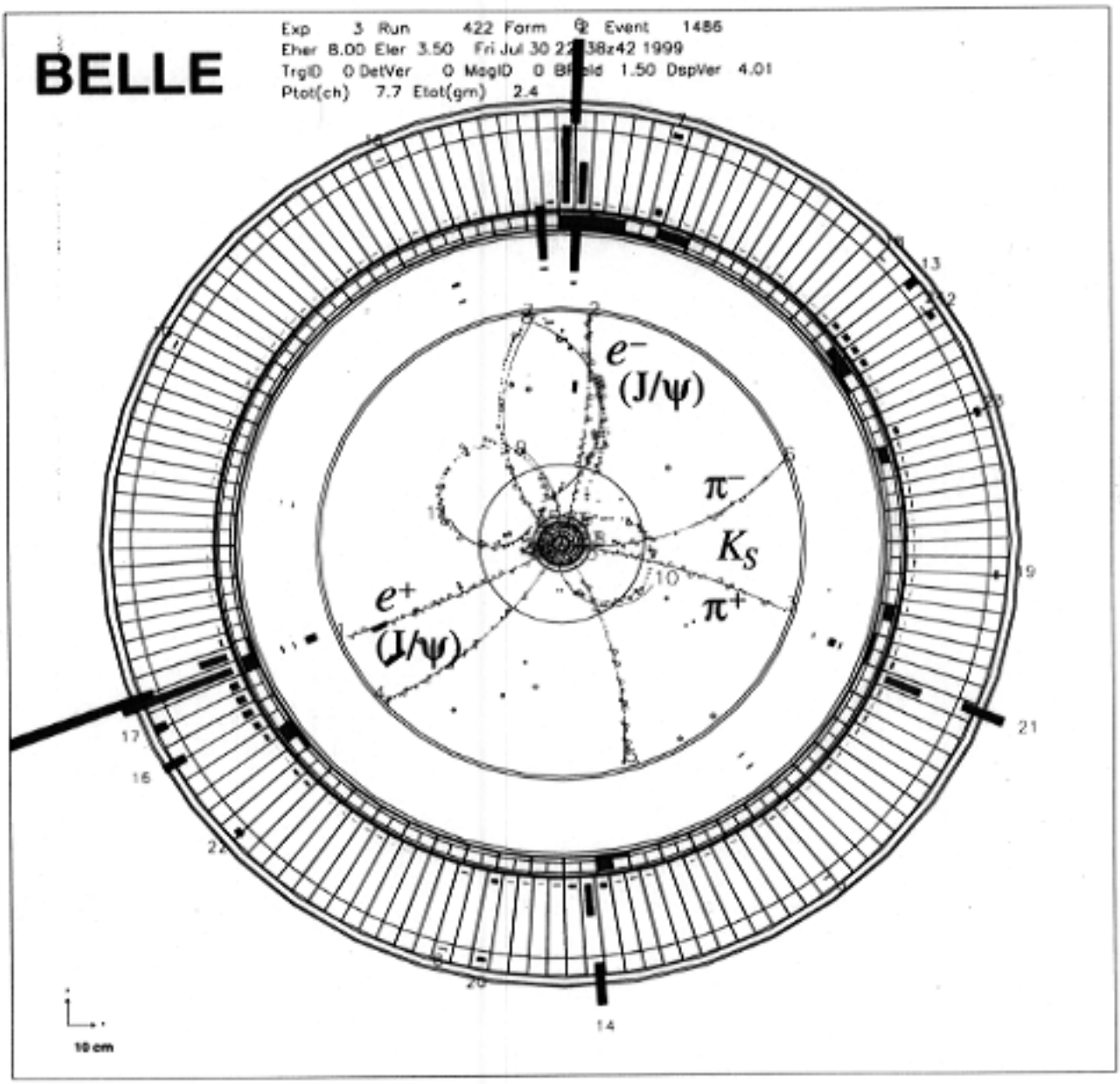
K_S reconstruction



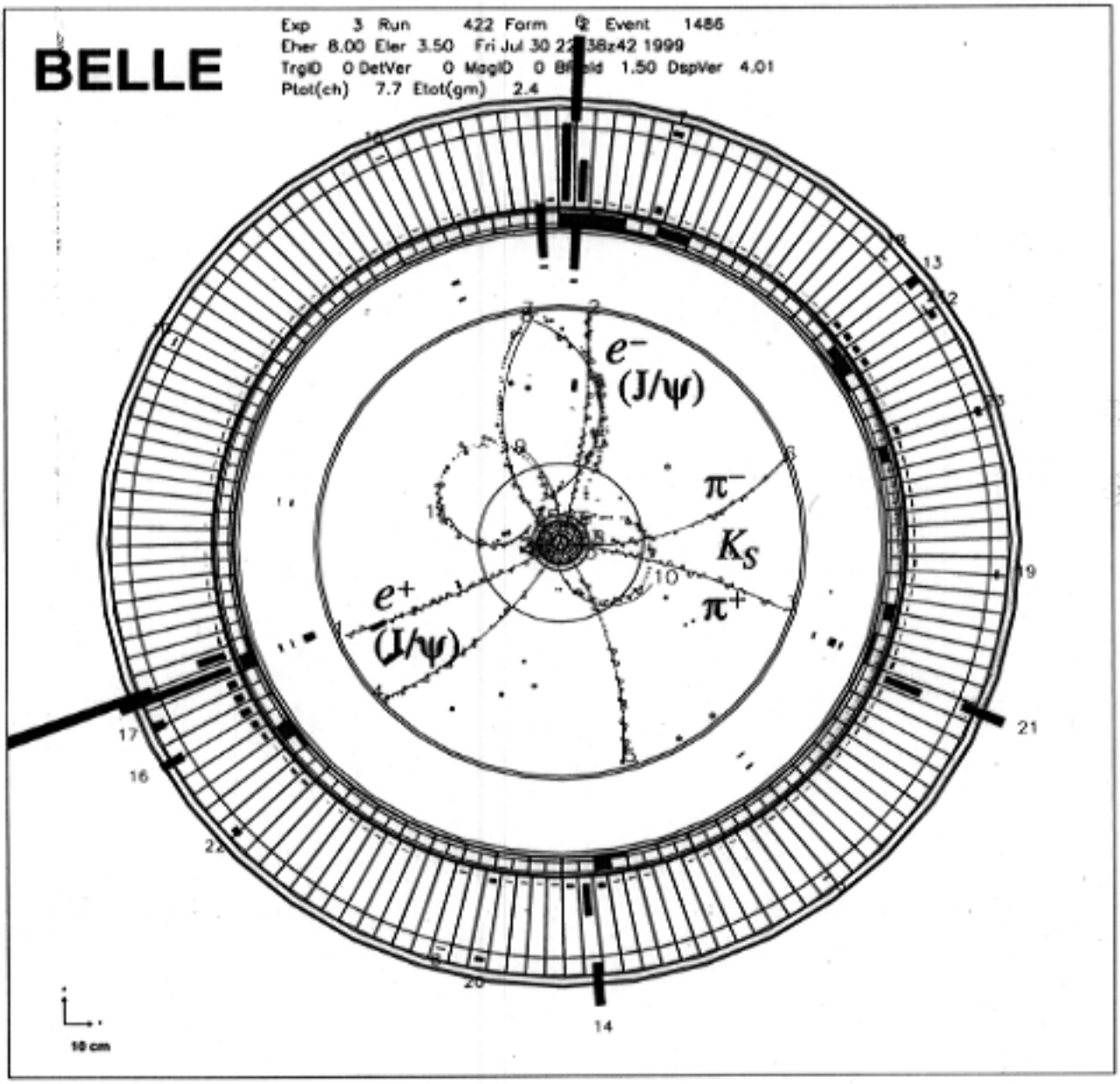
Λ reconstruction



$B^0 \rightarrow J/\psi\ Ks$ candidate



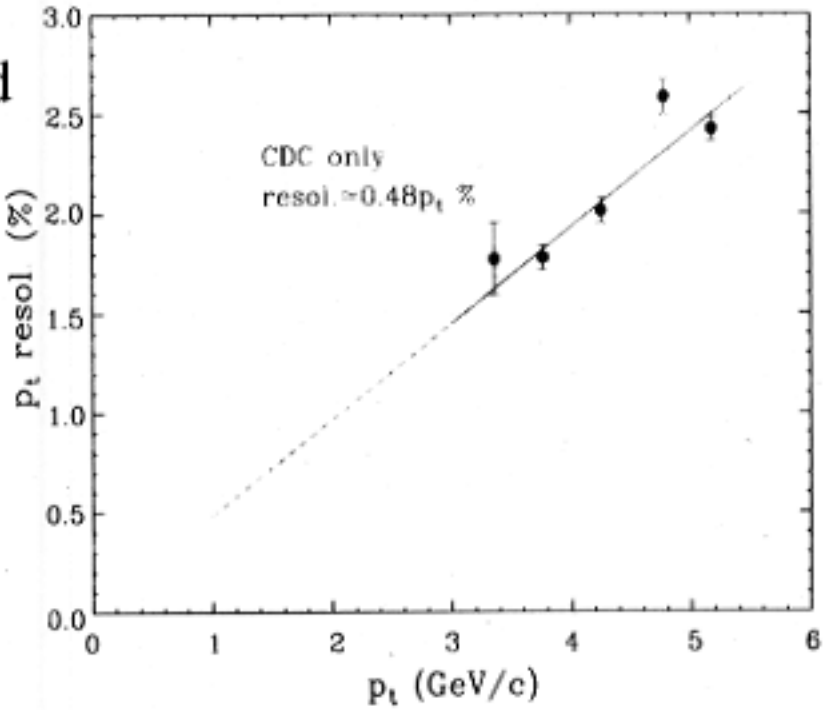
$B^0 \rightarrow J/\psi\ Ks$ candidate



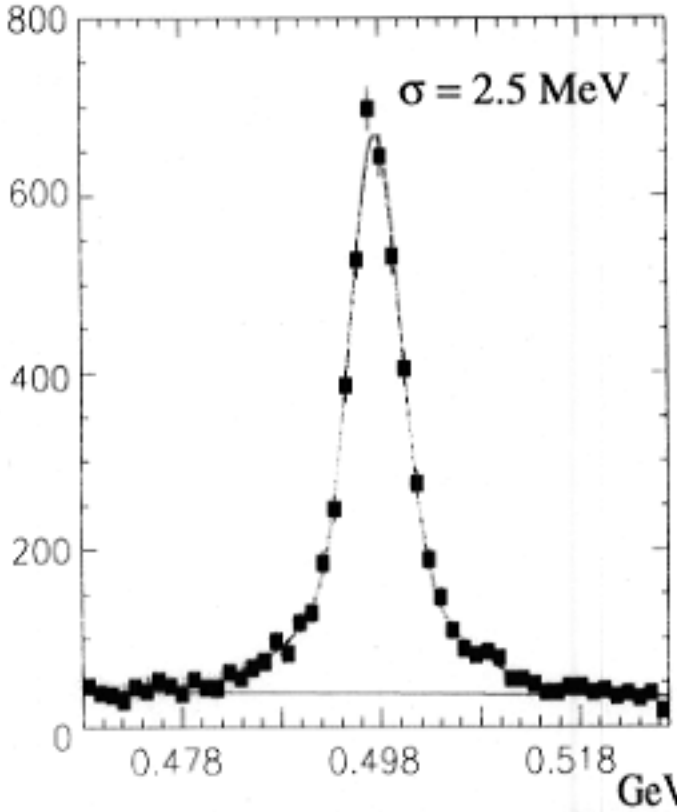
Tracking

P_T resolution measured by $\mu^+\mu^-$ events.

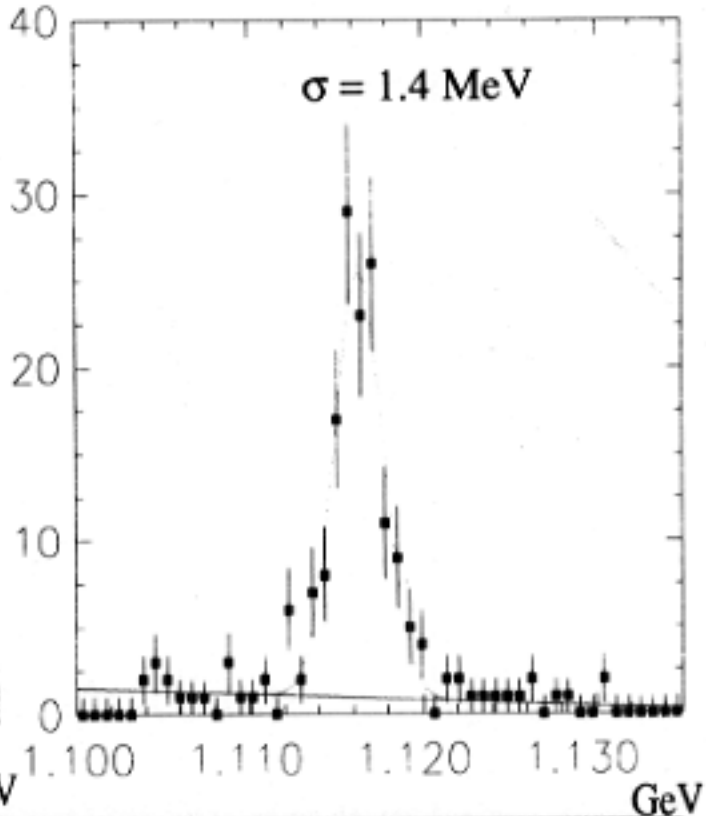
Spatial resolution per point = 160 μm



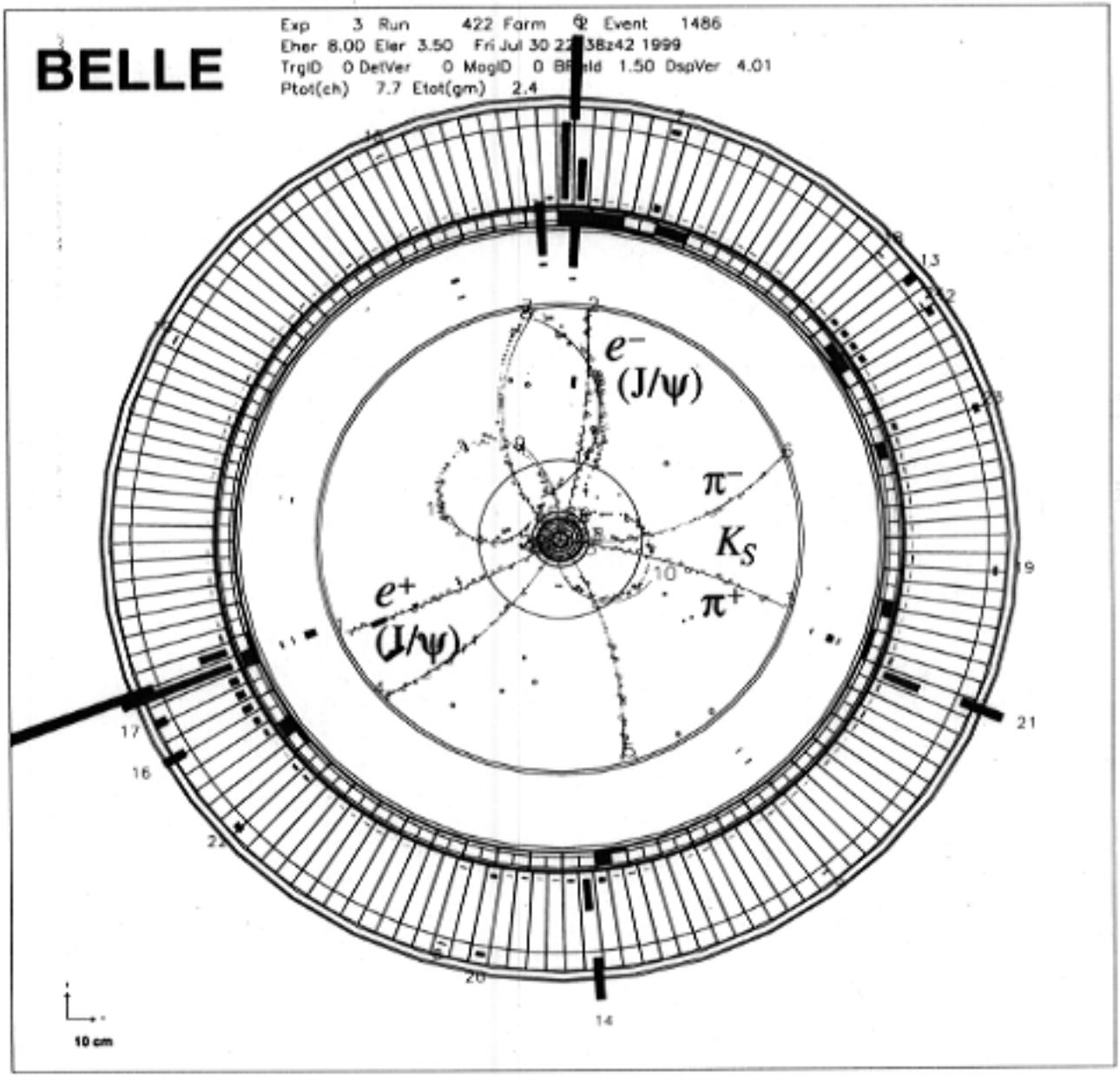
K_S reconstruction



Λ reconstruction

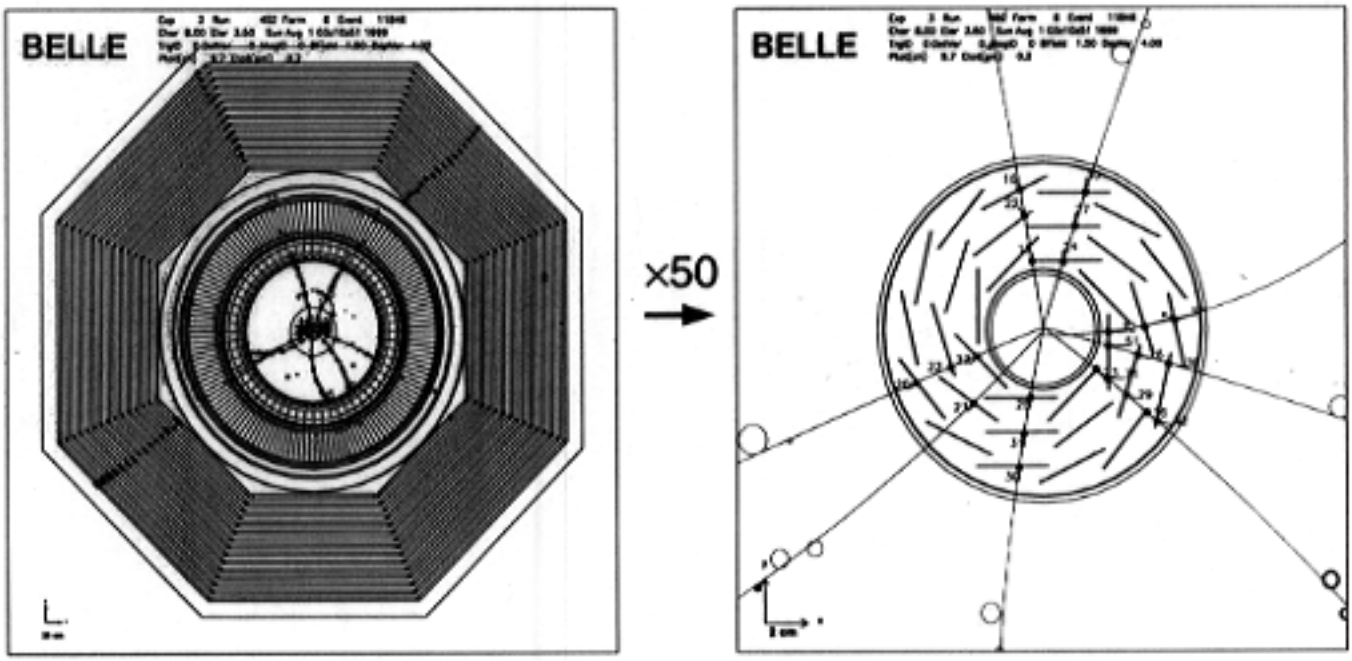


$B^0 \rightarrow J/\psi\ Ks$ candidate



Vertexing

$B^+ \to J/\psi\, K^+$ candidate



- Track matching efficiency
  $\cong$ 97% in hadronic events

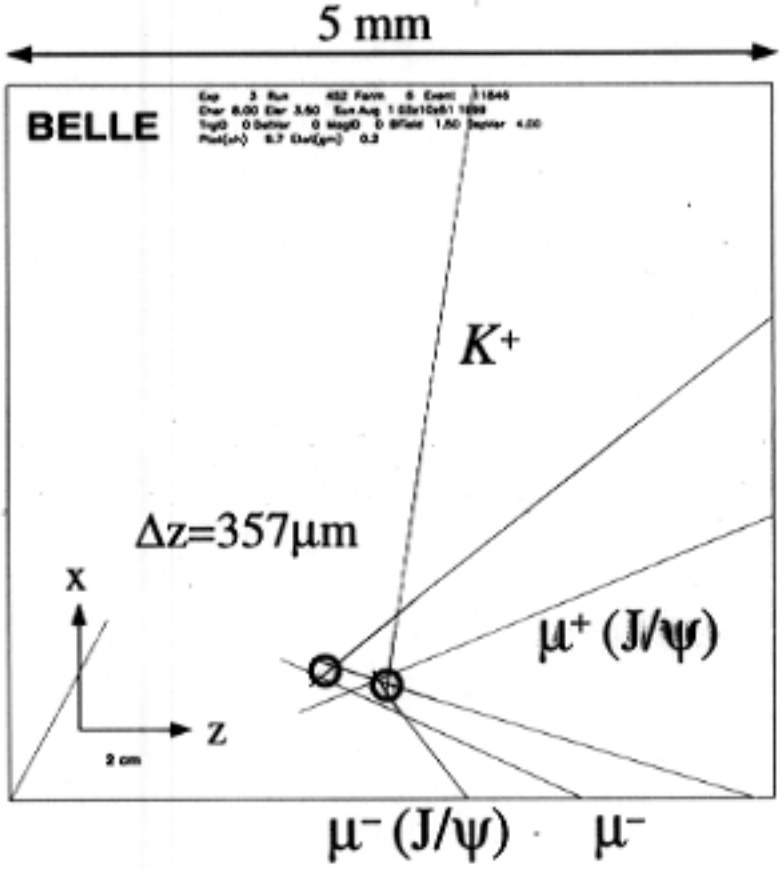
- Impact parameter resolution measured with Bhabha and cosmic ray events:

$$\sigma_{r\phi} \cong 33\ \mu\text{m}$$

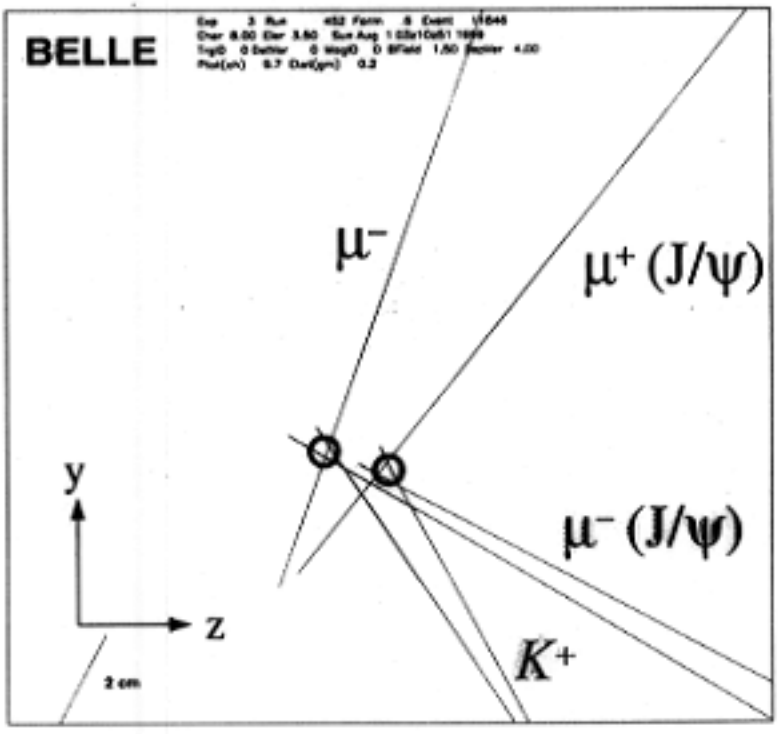
$$\sigma_z \cong 40\ \mu\text{m}$$

Vertexing

x-z view



y-z view



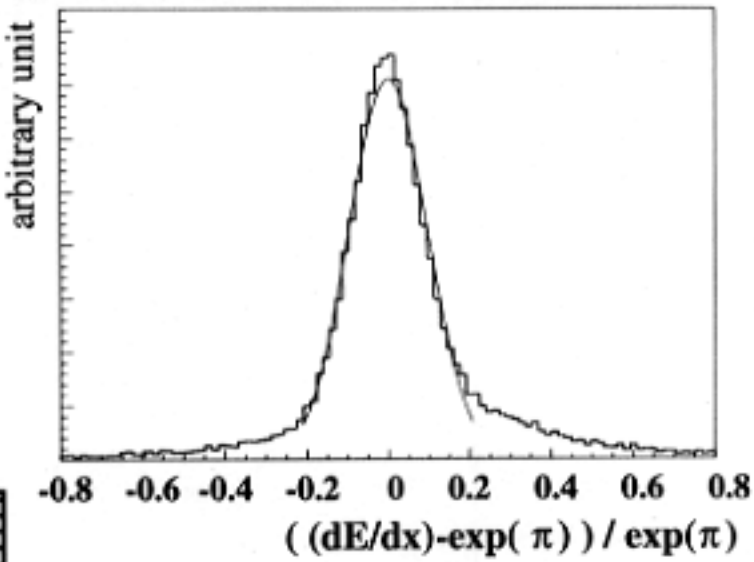
π/K separation

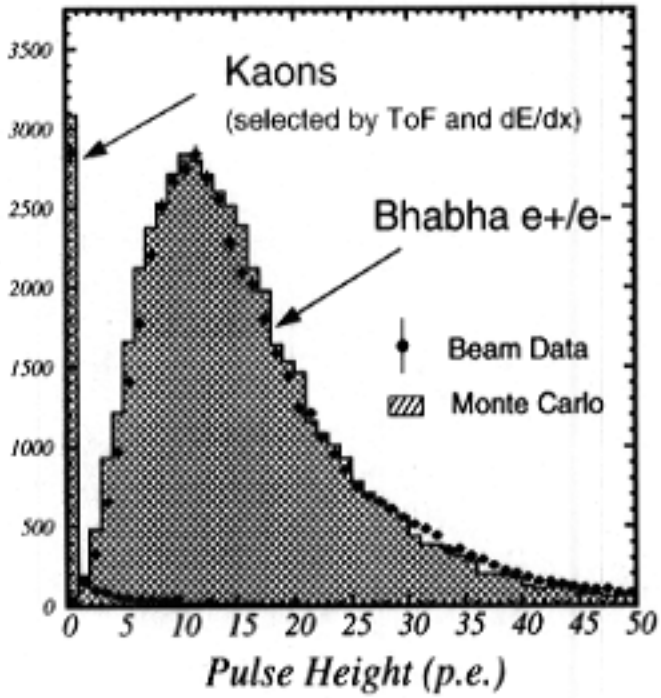
dE/dx meas. by CDC

80% truncated mean of 50 layers

$0.3 < P < 0.7$ GeV

$\sigma(dE/dx) = 6.8\ \%$





Aerogel Cherenkov counter

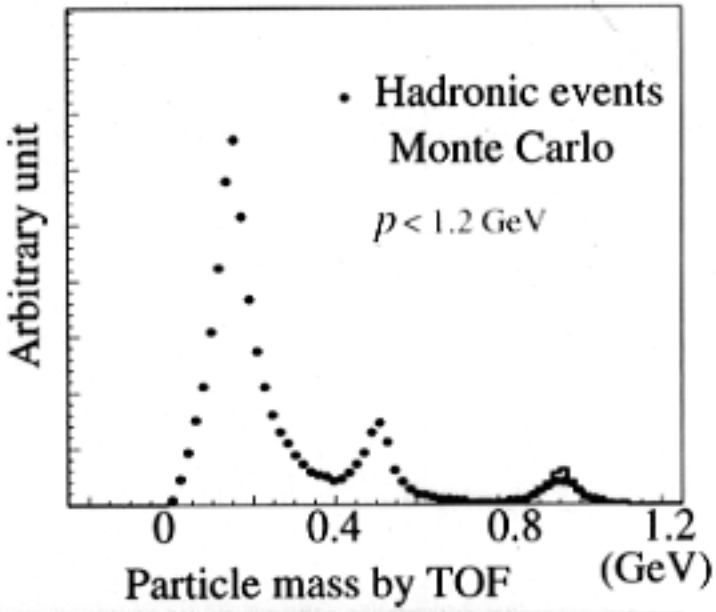
n=1.010 - 1.03 depending on θ

$N_{p.e.} = 20.0$ for $\beta=1$ part. (with n=1.015)

Time-of-flight measurement

$\sigma_{TOF} = 120$ psec

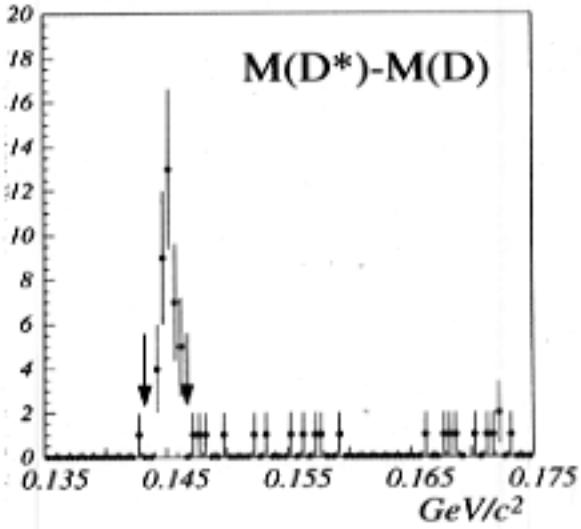
Track matching eff. $\cong 90\ \%$



Test of π/K separation

Test of KID w/ $D^{*+} \to D^0 \pi^+$

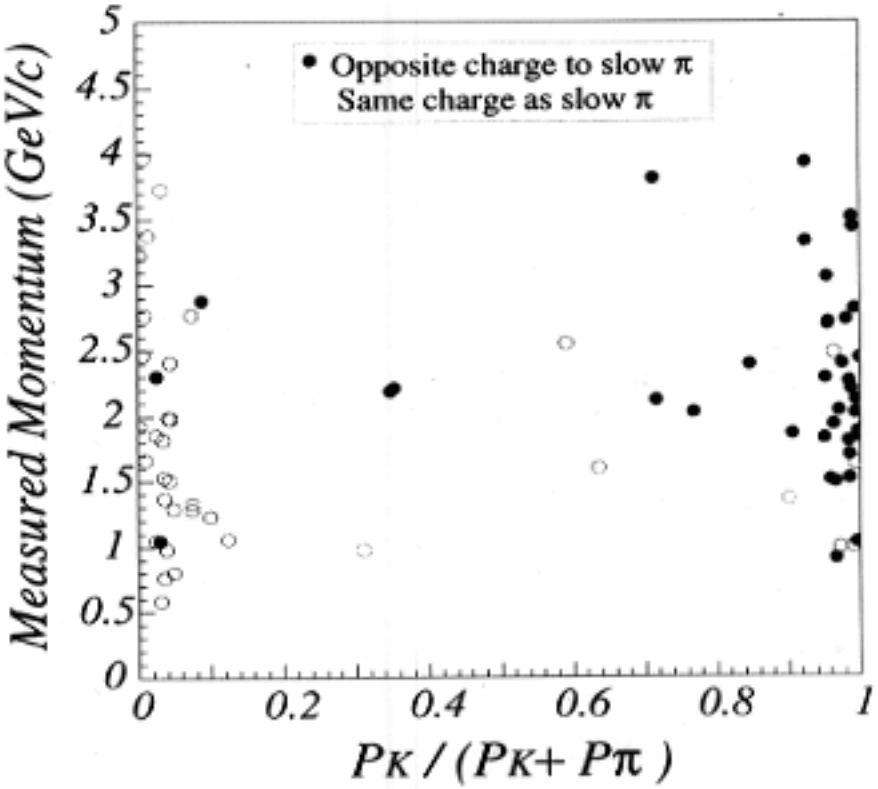
$\hookrightarrow K^- \pi^+$



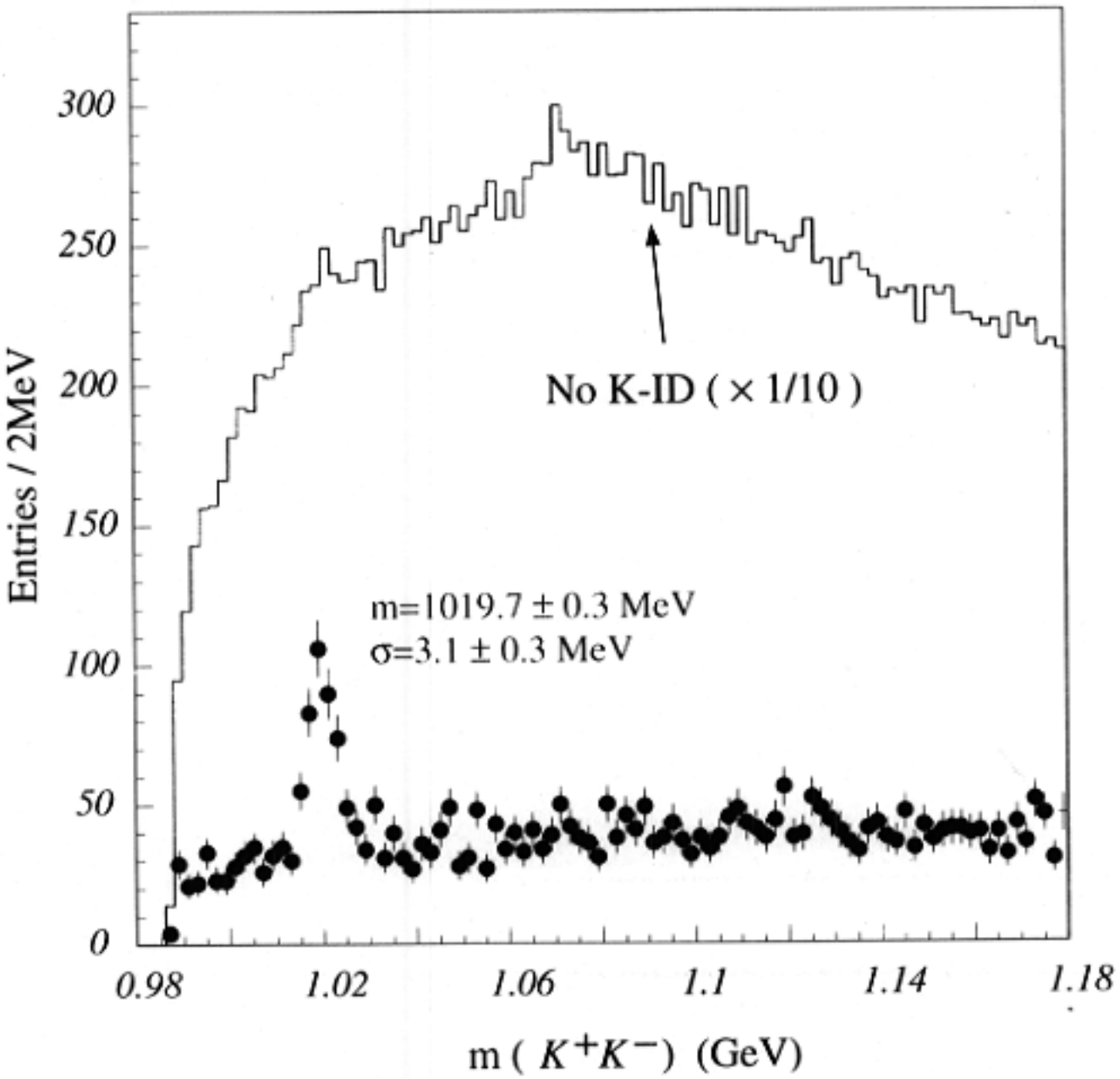
- $|M(D)-1.865| \leq 0.030$
- $P(D^*)/Eb(CM) > 0.5$
- $|\cos \theta k| \leq 0.8$

$\Rightarrow$ Estimated purity

~ 95%



$\phi \to K^+K^-$


300
250
200
150
100
50
0
Entries / 2MeV
No K-ID (× 1/10)
m=1019.7 ± 0.3 MeV
σ=3.1 ± 0.3 MeV
0.98
1.02
1.06
1.1
1.14
1.18
m (K^+K^-) (GeV)

Summary and outlook

- KEKB started it's operation.
  peak luminosity = $2.9 \times 10^{32}/cm^2/sec$
  $\int L\,dt = 25\ pb^{-1}$ in the first month of physics run

- Many improvements of the machine and the detector have been made in the summer shutdown.

- Beam blow-up problem at $I_b > 200mA$ (LER)
  $\rightarrow$ Many ideas to solve this problem but further studies necessary

- BELLE demonstrated good performance to measure CPV in $B\bar{B}$ system.
  - ♦ Vertexing
  - ♦ Lepton ID
  - ♦ π/K ID

Next target:
Accumulate O(10) fb^{-1} to see CPV by the summer 2000.