

# **The KEK B-Factory Status and Prospects**

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- ◆ **Introduction**
- ◆ **KEKB Accelerator Status**
- ◆ **BELLE Status**
- ◆ **Summary**

## **References:**

**For KEBB Accelerator**

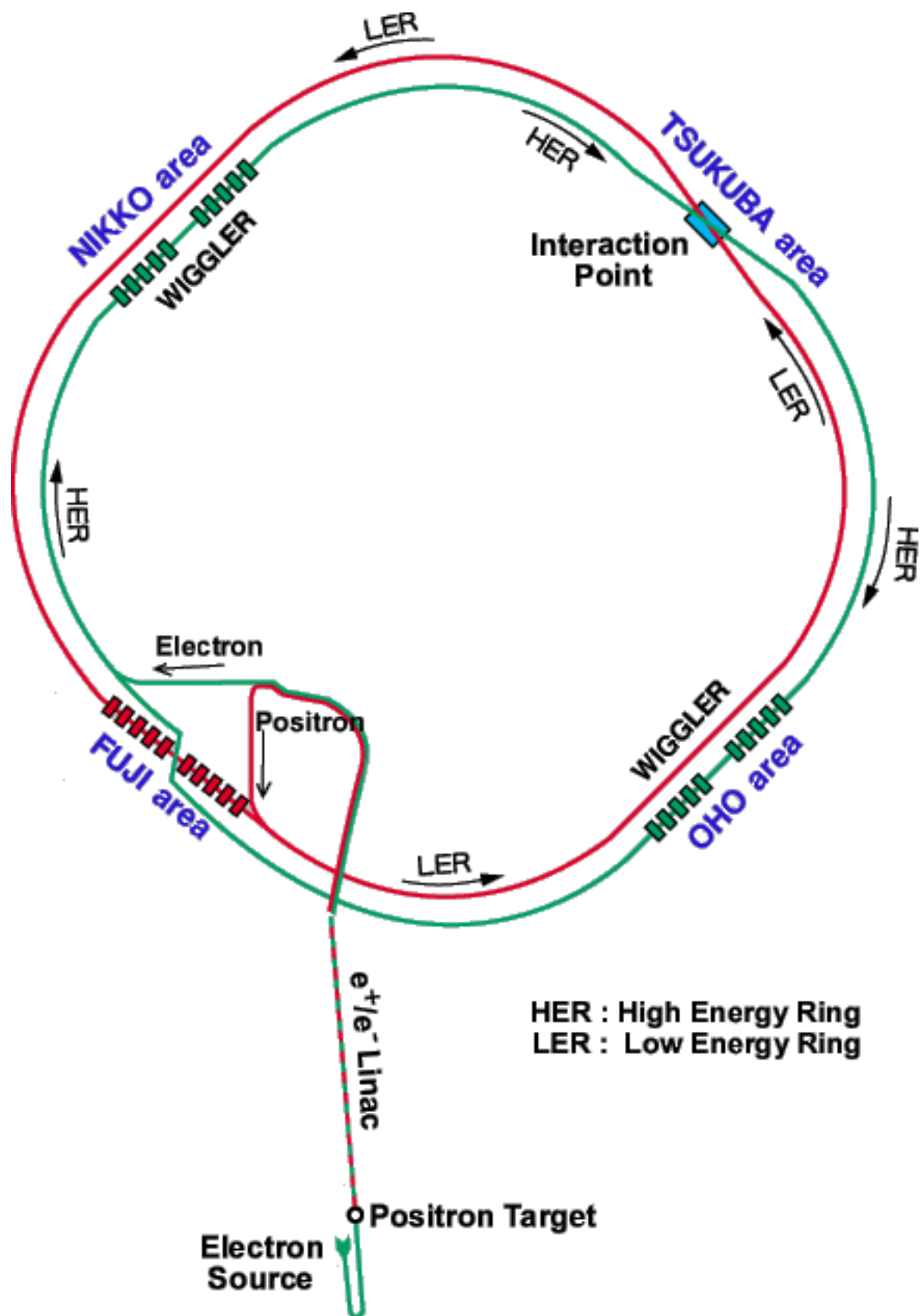
**KEK Report 95 -7**

**KEK Preprint 99 -8**

**For KEBB Detector and Experiment**

**KEK Proceeding1 95 -1**

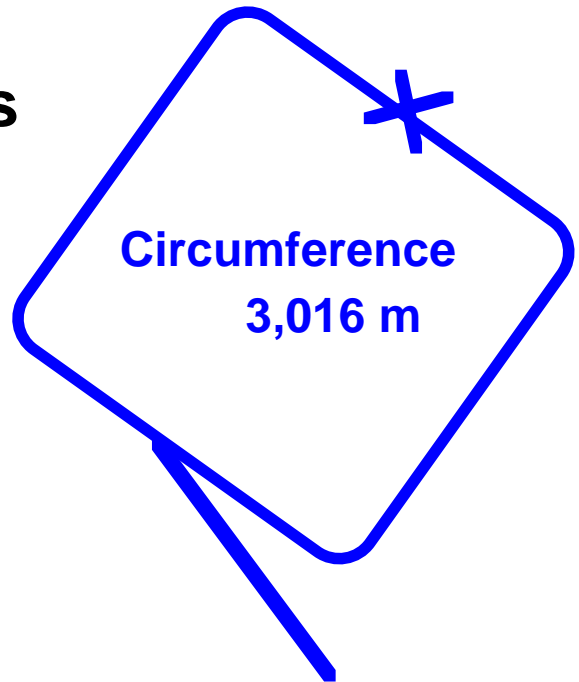
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# KEK B-Factory

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**Two Storage Synchrotrons  
built in TRISTAN Tunnel**



**Electron Ring : 8 GeV**

**Positron Ring : 3.5 GeV**

**Luminosity Goal :  $1 \times 10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$**

**to Produce more than  $10^8$   $B\bar{B}$  pairs/year**

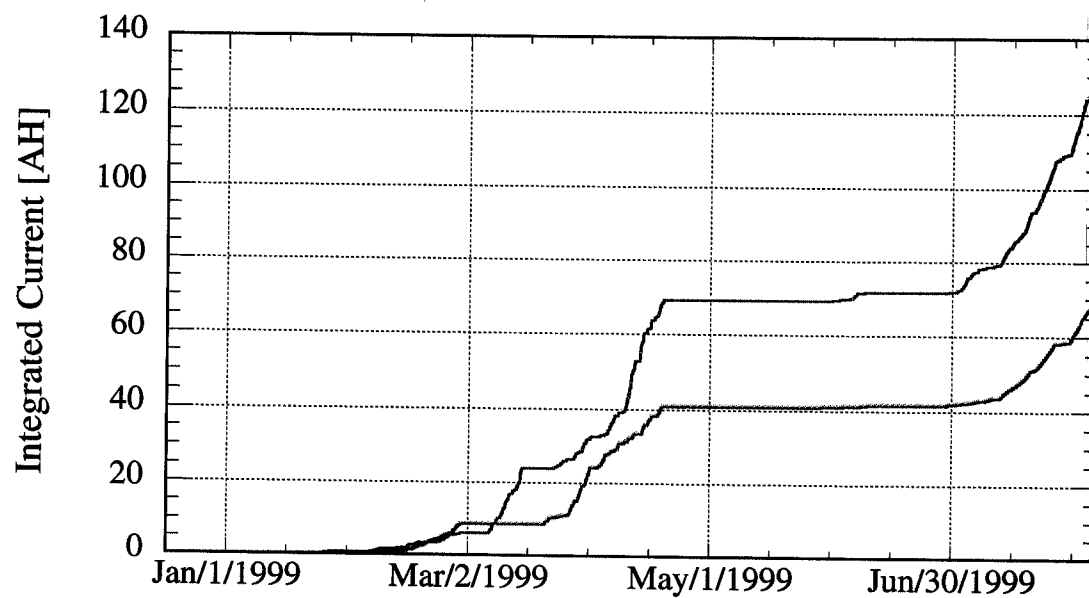
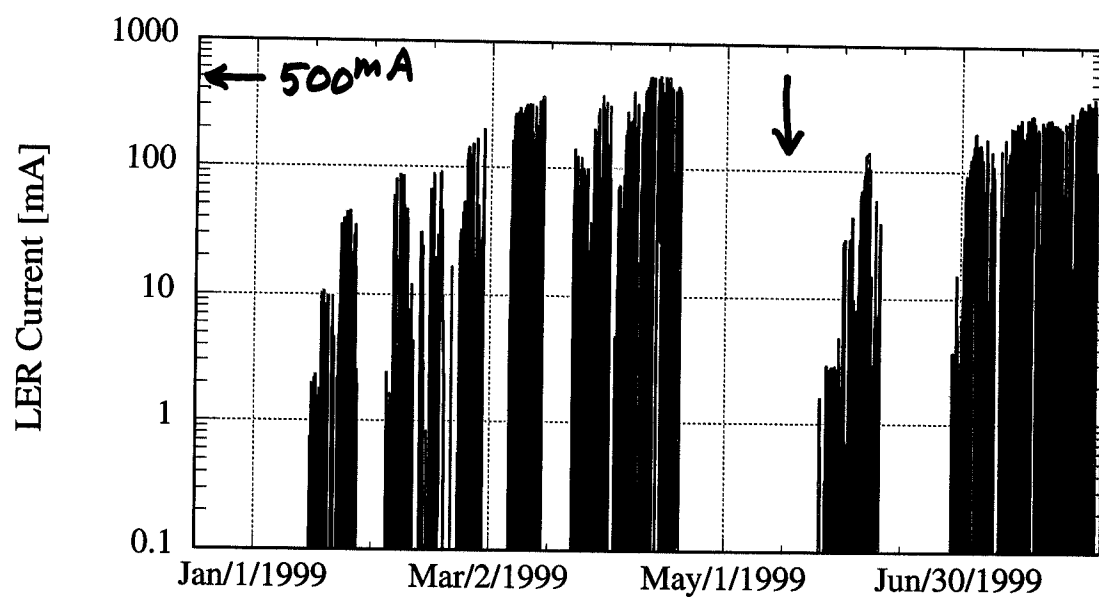
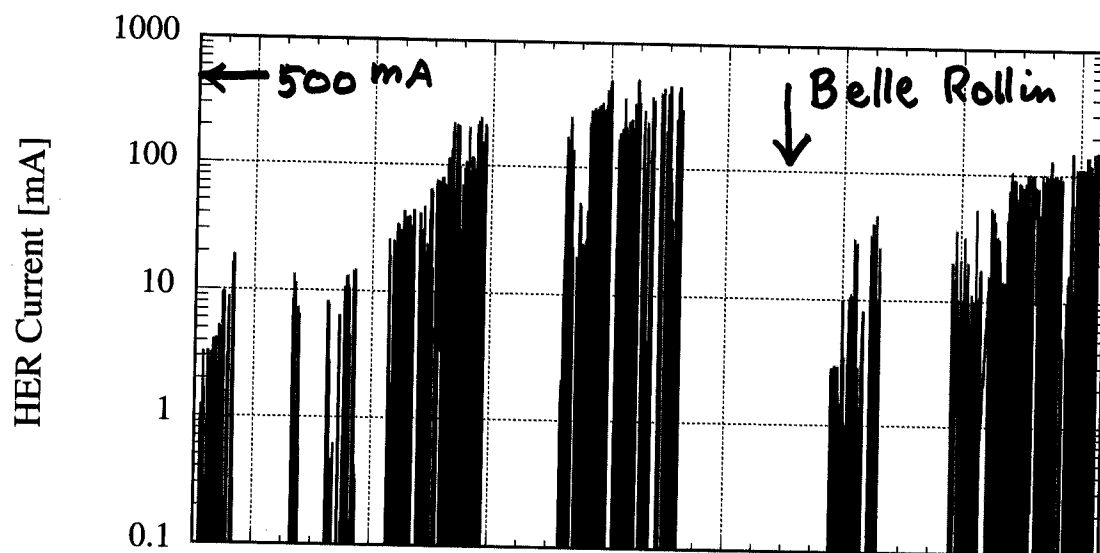
**Construction started in April 1994  
and completed in December 1998**

**Accelerator Commissioning Started in Dec.  
1998 without BELLE and from June 1999 with  
BELLE.**

# Accelerator Design

- ◆ Max. # of Bunches w. Small Bunch Current
- ◆ Finite Angle Beam Crossing
- ◆ Bunch-by-Bunch Feedback
- ◆ HOM Damping RF Cavities
- ◆ Many Wiggler Magnets for LER
- ◆ Supercond. IR Quads and Comp. Solenoid
- ◆ Good Vacuum
- ◆ LINAC Upgrade for Direct Beam Injection

	LER	HER
Number of Bunches	5,000	
Beam Currents	2.6 A	1.1 A
Crossing Angle	22 mrad	
Tune Shifts ( $\xi_x / \xi_y$ )	0.039 / 0.052	
Beta Function ( $\beta_x / \beta_y$ )	33 cm / 1 cm	
Emittance ( $\varepsilon_x / \varepsilon_y$ )	18 nm / 0.36 nm	
Bunch Size ( $\sigma_x / \sigma_y$ )	150 $\mu\text{m}$ / 1.9 $\mu\text{m}$	
Bunch Length ( $\sigma_z$ )	4 mm	
Betatron Tune ( $\nu_x / \nu_y$ )	45.52/46.08	47.52/43.08
Damping Time	21.6 ms	22.5 ms



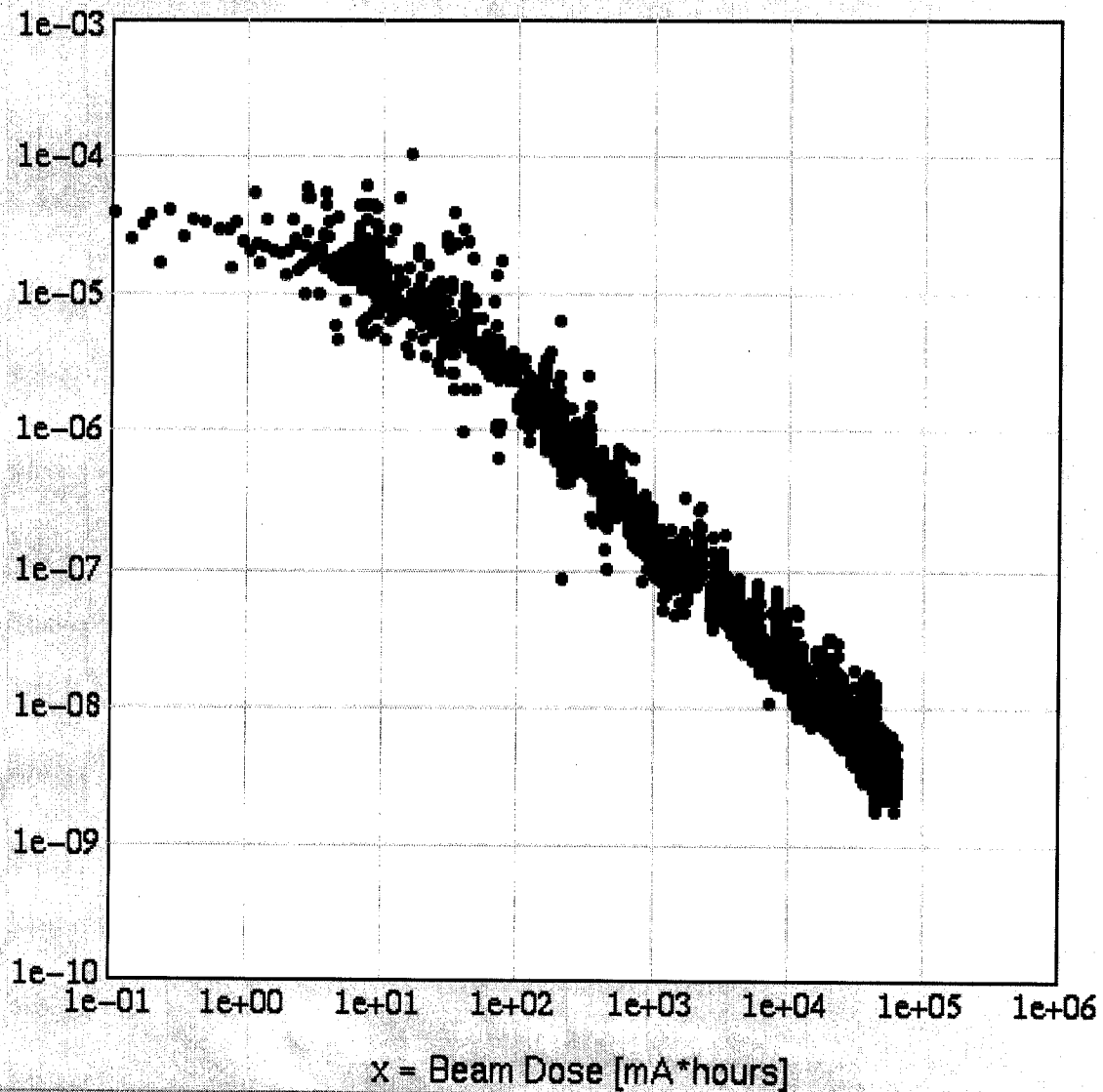
# HER

Date=07/30/1999 13:44:11

Beam Dose= 6.502e+04 [mA\*h]

Photon Dose= 7.022e+23 [photo/m]

$y = dP/dI(D03) [Pa/mA]$



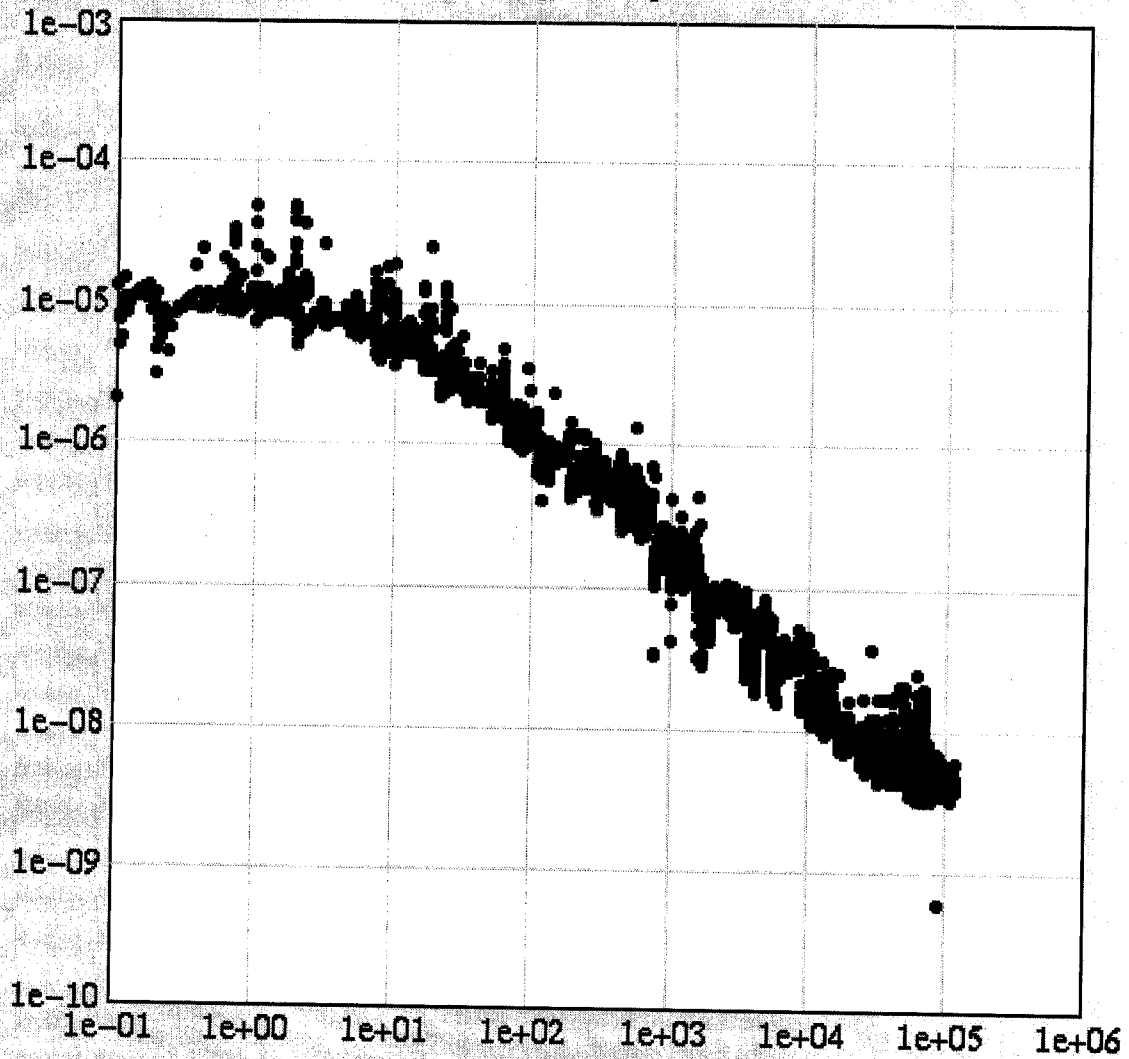
# LER

Date=07/30/1999 13:44:11

Beam Dose= 1.164e+05 [mA\*h]

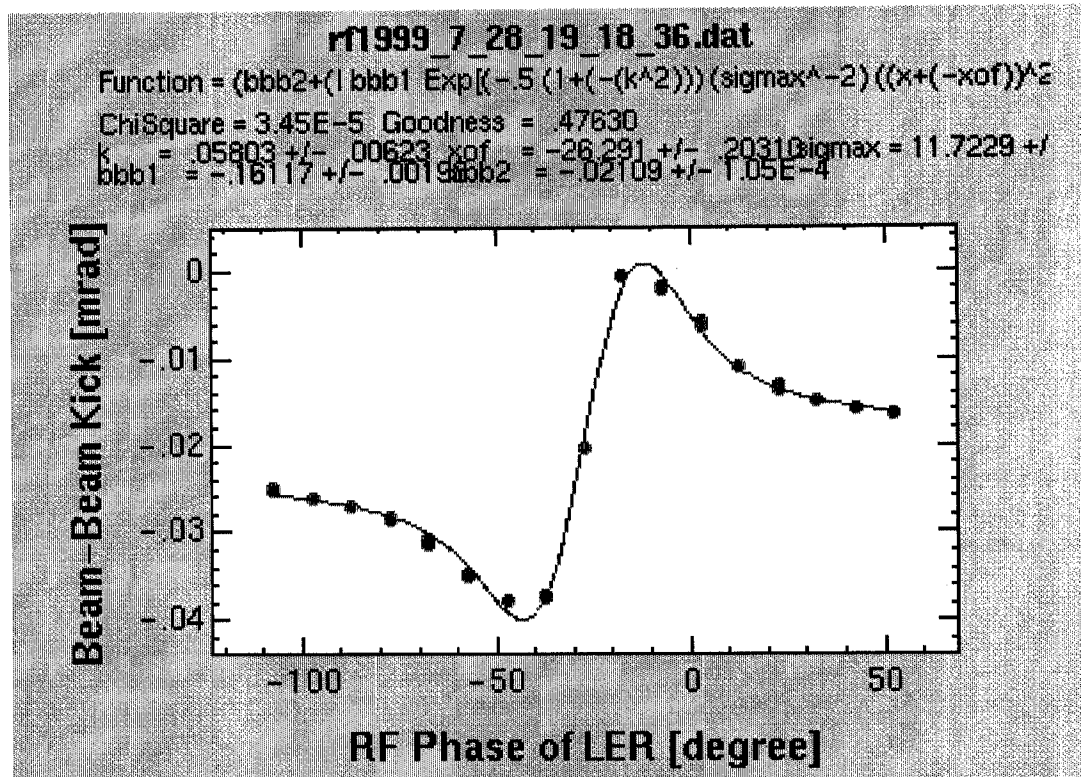
Photon Dose= 5.643e+23 [photo/m]

$y = dP/dI(D03)$  [Pa/mA]

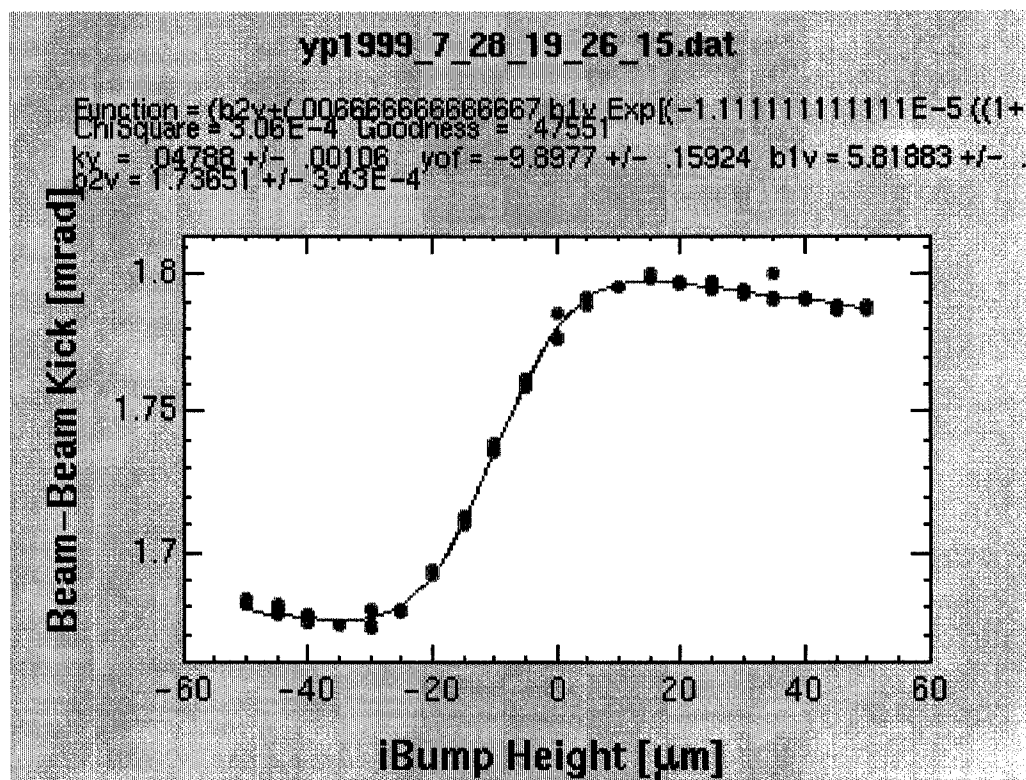


$x = \text{Beam Dose [mA*hours]}$

## Horizontal Scan

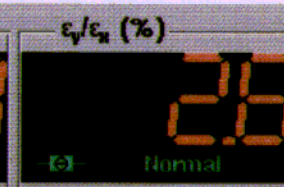
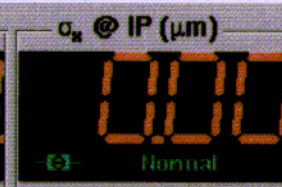
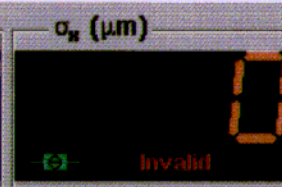


## Vertical Scan

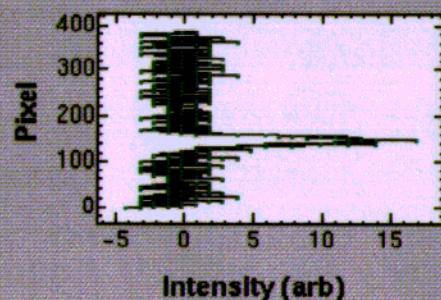




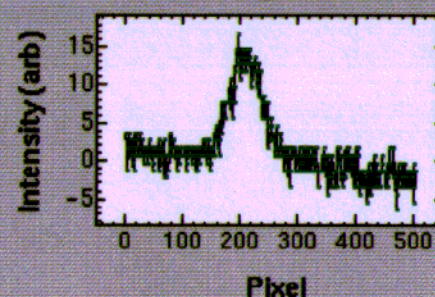
# LER Synchrotron Radiation Monitor



Vert. Image Profile



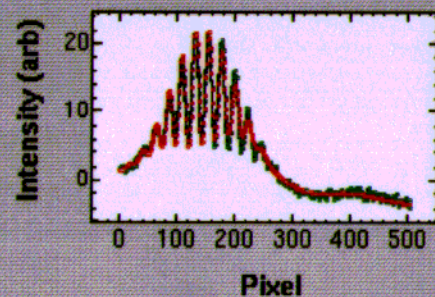
Horiz. Image Profile



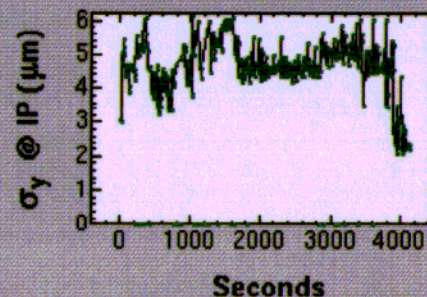
$\epsilon_y, \epsilon_x, \sigma_y^*, \sigma_x^*$  Measurement

$\beta_y$ (m):	41.6025
$\beta_x$ (m):	16.0000
$\eta_y$ (mm):	0.0000
$\eta_x$ (mm):	0.6000
$\beta_y^*$ (m):	0.0100
$\beta_x^*$ (m):	1.0000

Vert. Interferogram



Vert. Beam Size

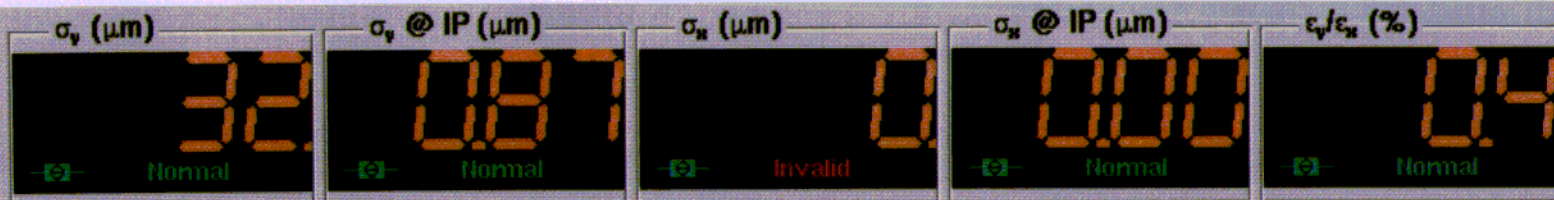


$\sigma_y$  Measurement

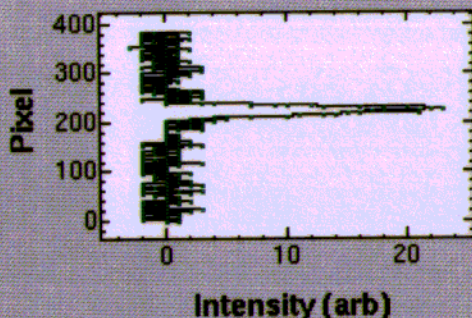
Eff. Path (m):	41.5300
Slit Sep. (mm):	26.1000
Wavelength (nm):	513.2400
Magnification:	0.8851
Visibility:	0.6205
$\sigma_{\text{visibility}}$ :	0.0226
Ft $\chi^2/\text{d.o.f.}$ :	0.26



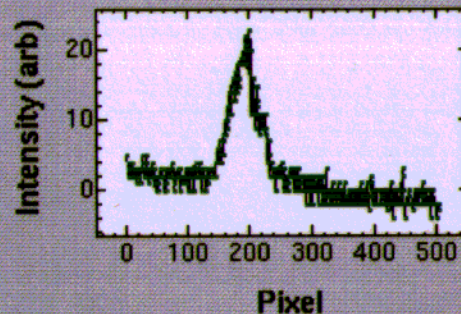
# HER Synchrotron Radiation Monitor



## Vert. Image Profile



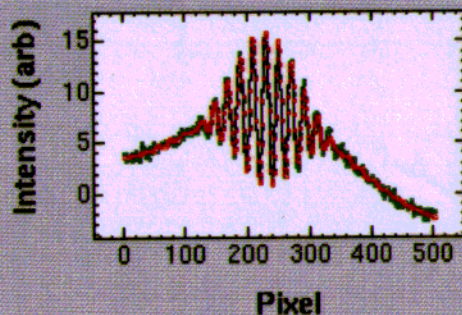
## Horiz. Image Profile



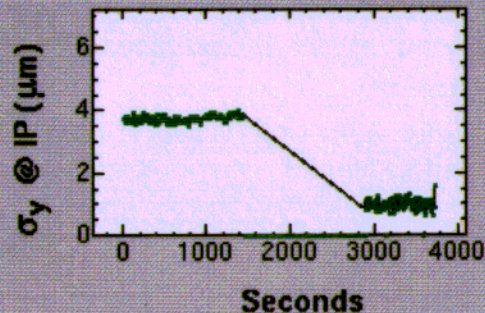
## $\epsilon_y, \epsilon_x, \sigma_y, \sigma_x$ Measurement

$\beta_y$ (m):	13.6900
$\beta_x$ (m):	25.0000
$\eta_y$ (mm):	0.0000
$\eta_x$ (mm):	4.7000
$\beta_y^*$ (m):	0.0100
$\beta_x^*$ (m):	1.0000

## Vert. Interferogram



## Vert. Beam Size



## $\sigma_y$ Measurement

Eff. Path (m):	37.6000
Slit Sep. (mm):	34.2000
Wavelength (nm):	513.1900
Magnification:	0.9180
Visibility:	0.9465
$\sigma_{\text{visibility}}$ :	0.0184
Fit $\chi^2/\text{d.o.f.}$ :	0.55

## $\sigma_x$ Measurement

Eff. Path (m):	37.6000
Slit Sep. (mm):	16.5000
Wavelength (nm):	500.0000
Magnification:	0.8000
Visibility:	0.0000
$\sigma_{\text{visibility}}$ :	0.0000
Fit $\chi^2/\text{d.o.f.}$ :	0.00



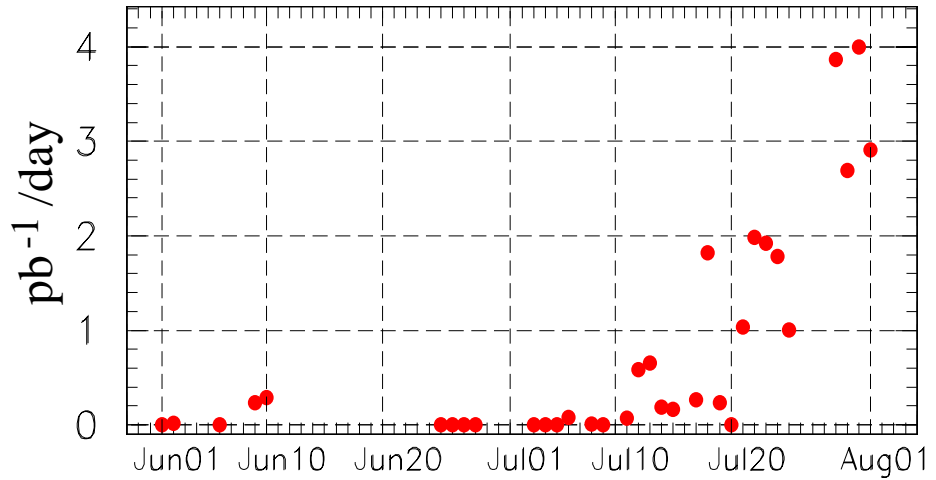
# KEKB Accelerator Status

With BELLE (Aug 4, 99)

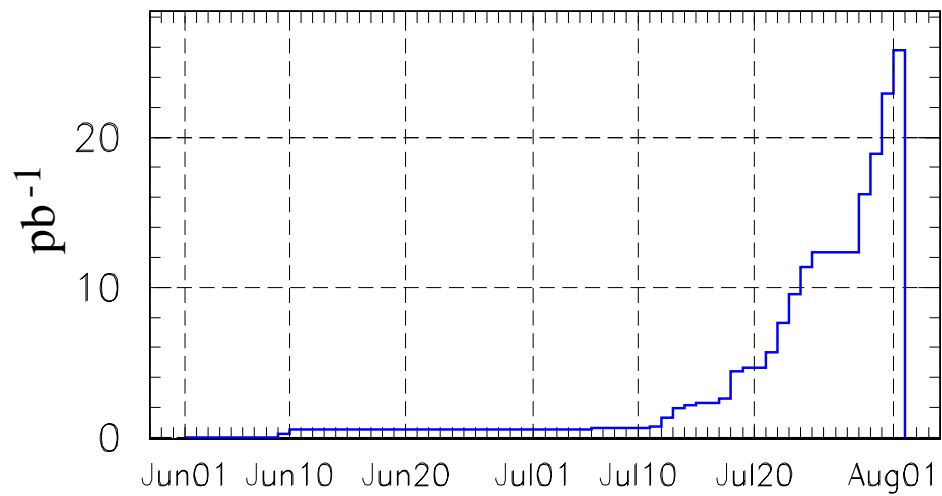
	LER	HER
Best Average Luminosity	$2.5 \times 10^{32} \text{ cm}^{-2} \text{ sec}^{-1}$	
Number of Bunches	1160 (32 - 40 - 3)	
Beam Current	293 mA	190 mA
Averaged Bunch Current	0.253 mA	0.164 mA
$\sigma_x^*$	140 $\mu\text{m}$	140 $\mu\text{m}$
$\sigma_y^*$	3.92 $\mu\text{m}$	3.26 $\mu\text{m}$
Beam Life Time	~ 100 min	~ 300 min
$\beta_x^*$	1 m	1 m
$\beta_y^*$	0.01 m	0.01 m
$\xi_x^*$	0.034	0.023
$\xi_y^*$	0.014	0.008

- ◆ **Finite Angle X-ing Scheme is OK! (?)**
- ◆ RF cavities, Feed-back system, Vac. system, etc, are functioning as designed.
- ◆ Top-Off of Beams is OK.

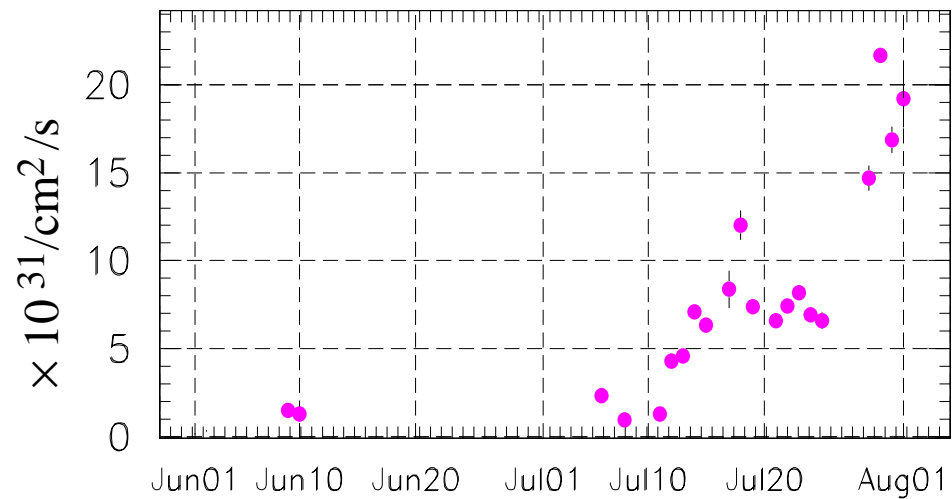
$\int L dt$  per day



Integrated luminosity



Highest lum.  
of the day



# Can KEKB provide $10^{34}$ ?

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We are learning rapidly the machine behavior and the delivered luminosity is improving accordingly.

We have not encountered so far any serious problems that would require us to modify the Accelerator Design drastically such as the choice of "Finite angle X-ing" Scheme. So we believe that we can get to the "Design  $L$ ." soon.

To gain 40 times improvement in  $L$ , we have to

- ◆ Squeeze Beam Size,
- ◆ Suppress Beam Blow-up at Collision,
- ◆ Store more Bunches.

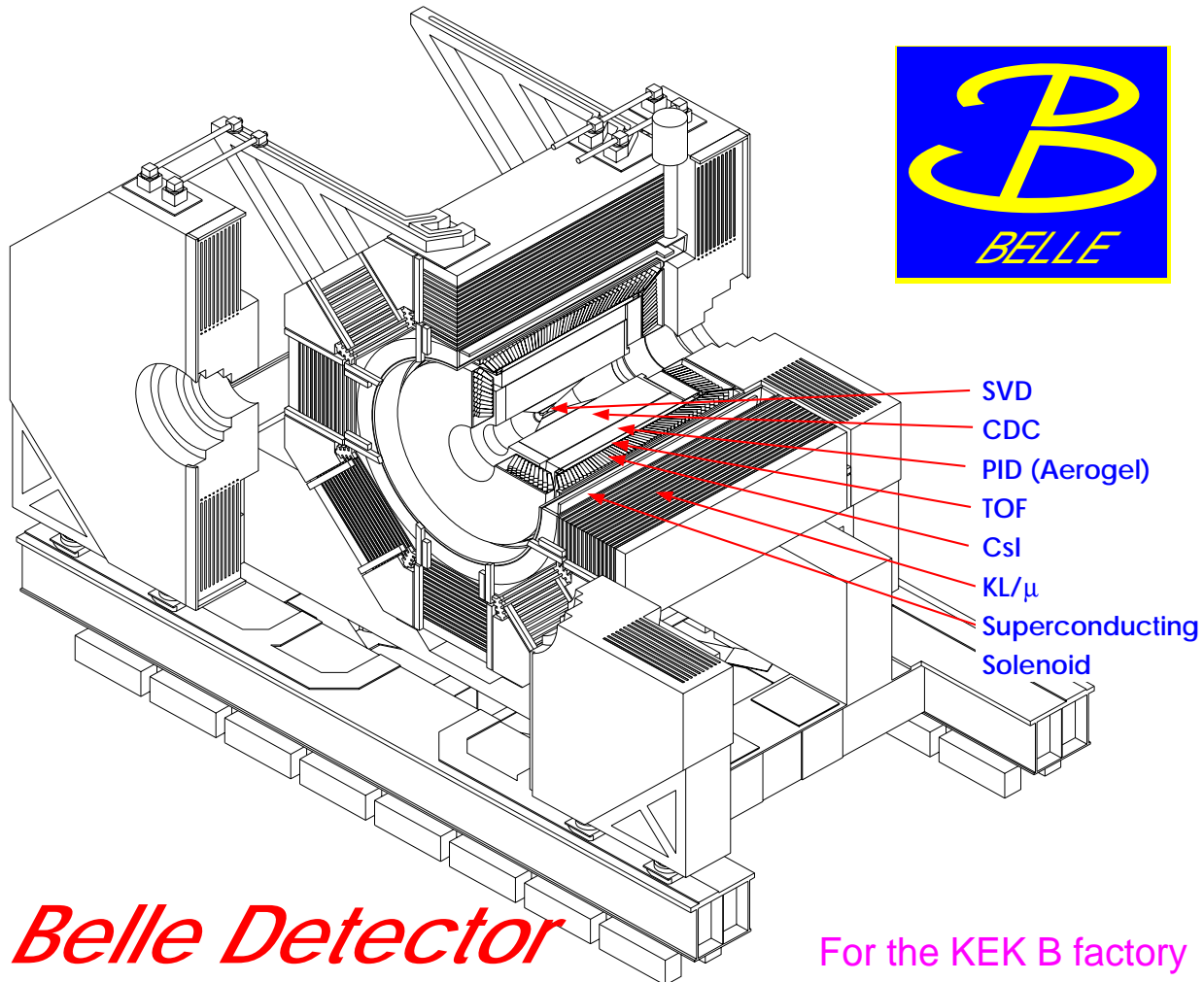
Plan : "Step by Step" Improvement

- ◆ Search for better tunes,
  - ◆ Reduce x-y coupling,
  - ◆ Search for "Missing" Impedance,
  - ◆ Adjustment of Tilt/Vert. X-ing Angle,
  - ◆ Better tuning of Feedback System,
  - ◆ Use of Crab Cavities.
-



# BELLE Detector

High precision magnetic spectrometer



SVD: Three layers of DSSD

Readout chip : VA1 ( **not rad hard** )

KID : ACC + dE/dx + TOF

(We are making **SVD1.1**, **SVD1.5** (semi R.-hard),  
and **SVD2** (R.-hard) to replace SVD, if needed. )

# BELLE Collaboration

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**51 Institutions from :**  
**Australia, China, India, Korea, Japan,**  
**Philippines, Poland, Russia, Taiwan, Ukraine,**  
**and USA**

**Academia Sinica,  
Budker Inst. of Nucl. Phys.,  
Chuo University,  
Fukui University,  
University of Hawaii,  
Inst. of High Energy Phys.,  
Inst. of T. & E. Phys.,  
Kanagawa University,  
Korea University,  
Kyoto University,  
Mindanao State University,  
Nagoya University,  
Nat'l Central University,  
Nat'l Lien Ho C. T. C.,  
Nihon Dental College,  
Osaka University,  
Princeton University,  
SankyunKwan University,  
Seoul Nat'l University,  
University of Sydney,  
Tohoku University,  
University of Tokyo,  
Tokyo Inst. of Tech.,  
Toyama N. C. M. T.,  
Utkal University,  
Yonsei University**

**Aomori University,  
Chiba University,  
Univ. of Cincinnati,  
GyeongSang Nat'l Univ.,  
ICRR, U. Tokyo  
Institute of Single Crystal,  
J. Crystal Collab. Group,  
KEK,  
Krakow Inst. of Nucl. Phys.,  
Melbourne University,  
Nagasaki Inst. of A. S.,  
Nara Women's University,  
Nat'l Kaoshin Normal Univ.,  
Nat'l Taiwan University,  
Niigata University,  
Osaka City University,  
Saga University,  
U. of S. T. of China,  
Sugiyama J-gaukin Univ.,  
Toho University,  
Tohoku-Gakuin University,  
Tokyo Metropolitan Univ.,  
Tokyo U. of Agr. & Tech.,  
University of Tsukuba,  
Virginia Polytechnic Inst.,**

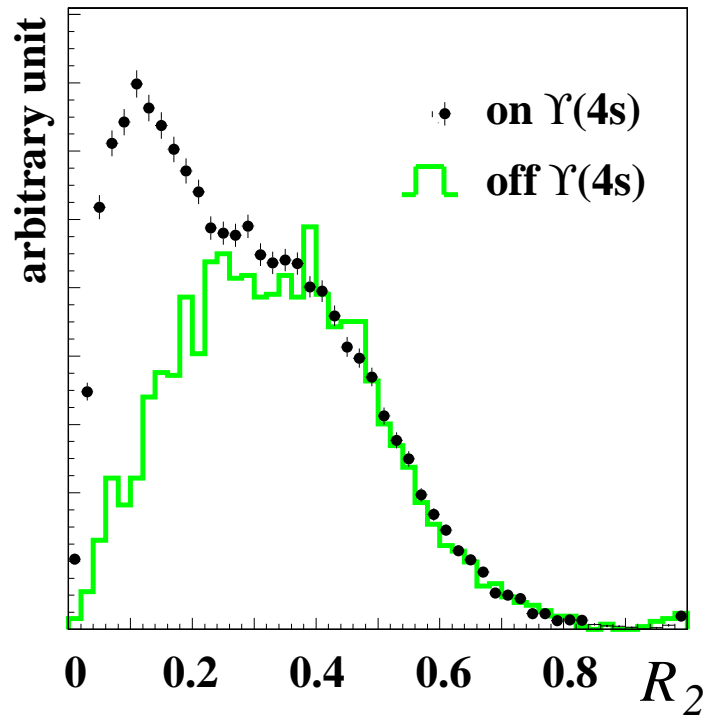




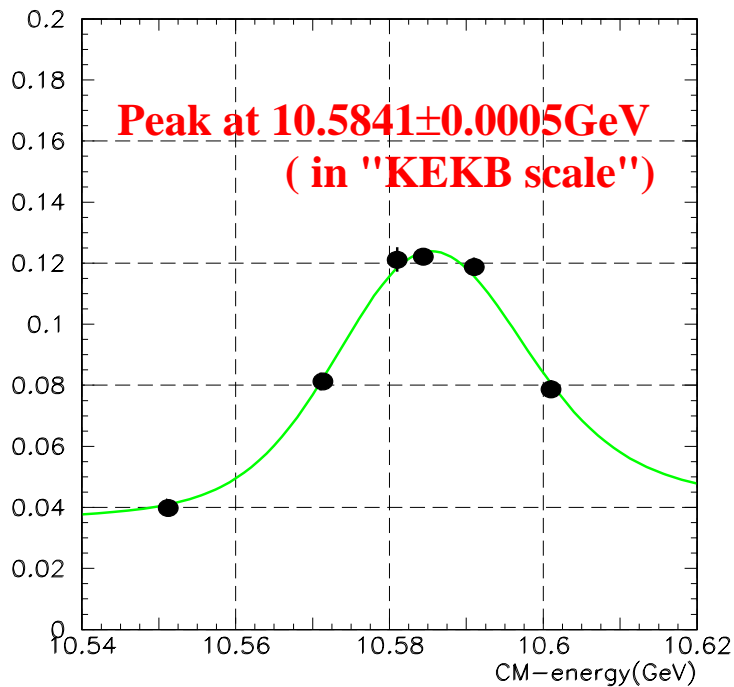
## $R_2$ distribution

Fox-Wolfram moment ratio

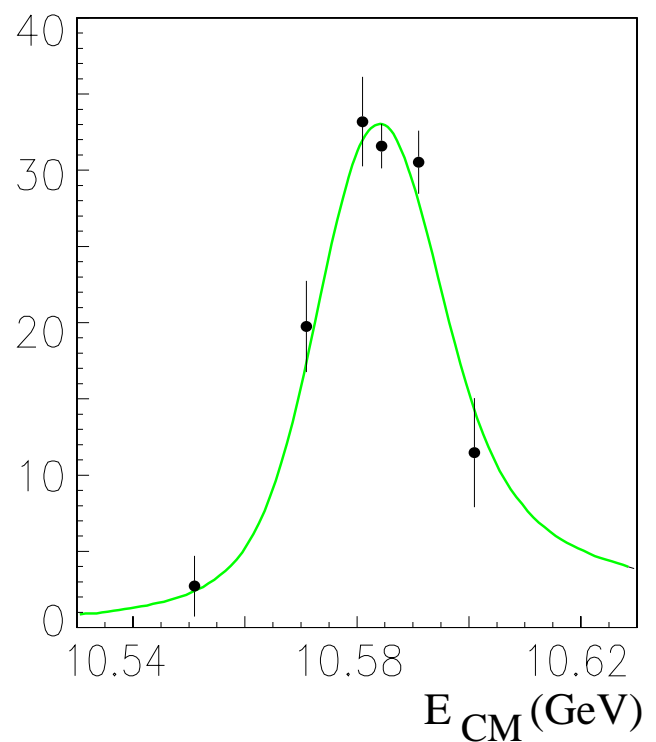
$$R_2 \equiv \frac{H_2}{H_0}$$



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

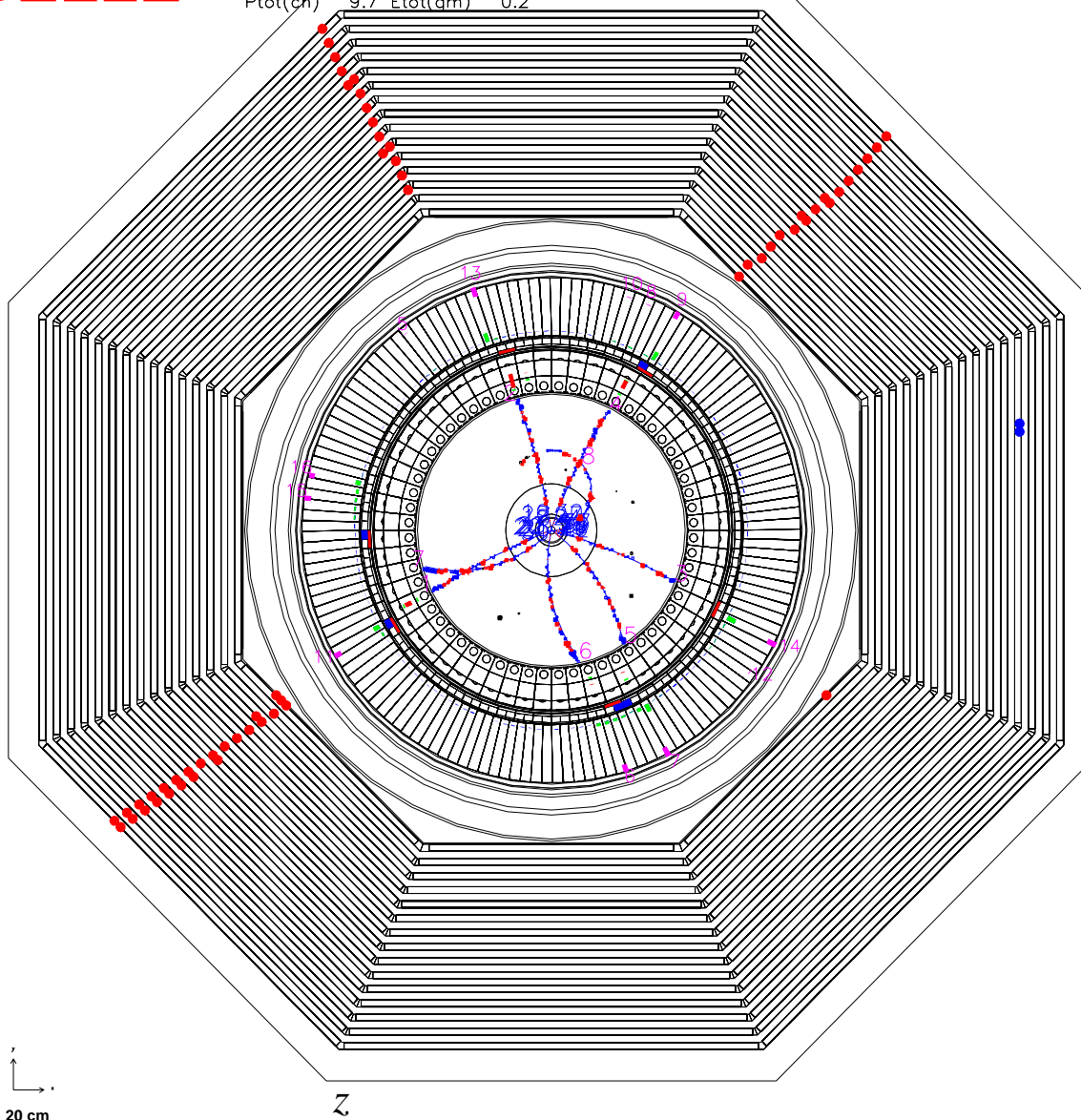


$B\bar{B}$  event rate  
from lepton spectrum (%)



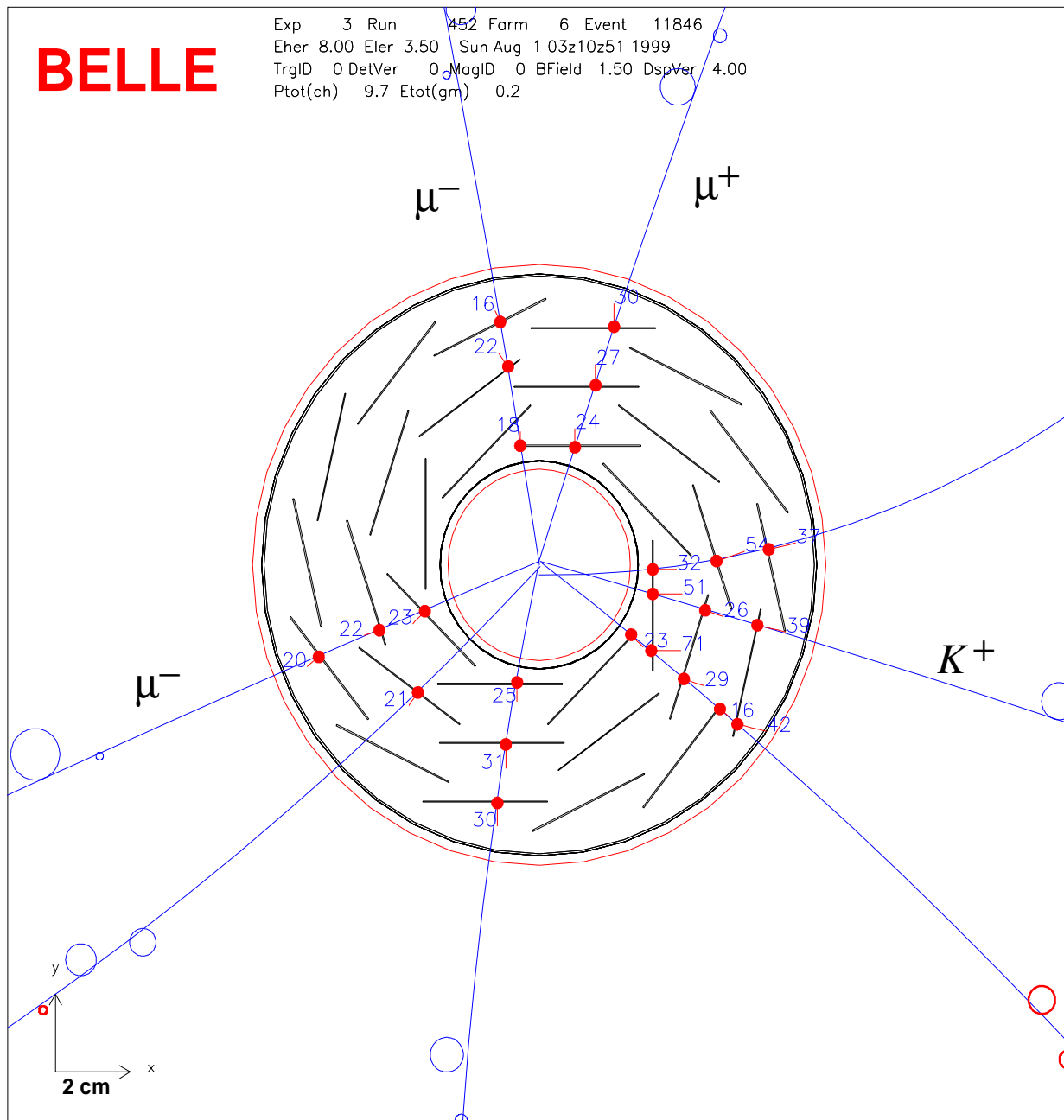
**BELLE**

Exp 3 Run 452 Farm 6 Event 11846  
 Eher 8.00 Eler 3.50 Sun Aug 1 03z10z51 1999  
 TrglD 0 DetVer 0 MagID 0 BField 1.50 DspVer 4.00  
 Ptot(ch) 9.7 Etot(qm) 0.2

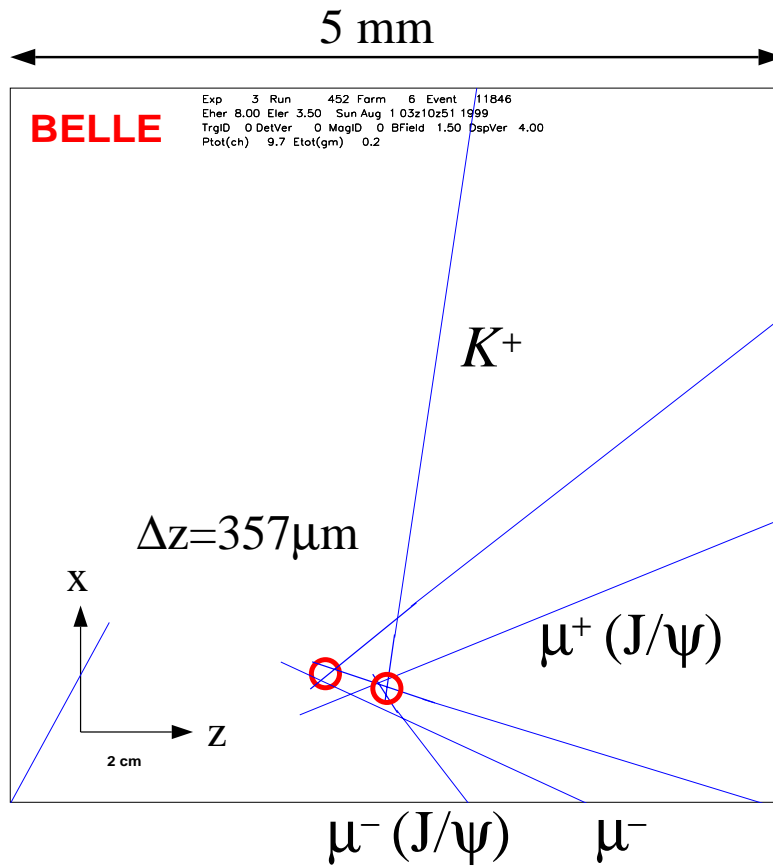




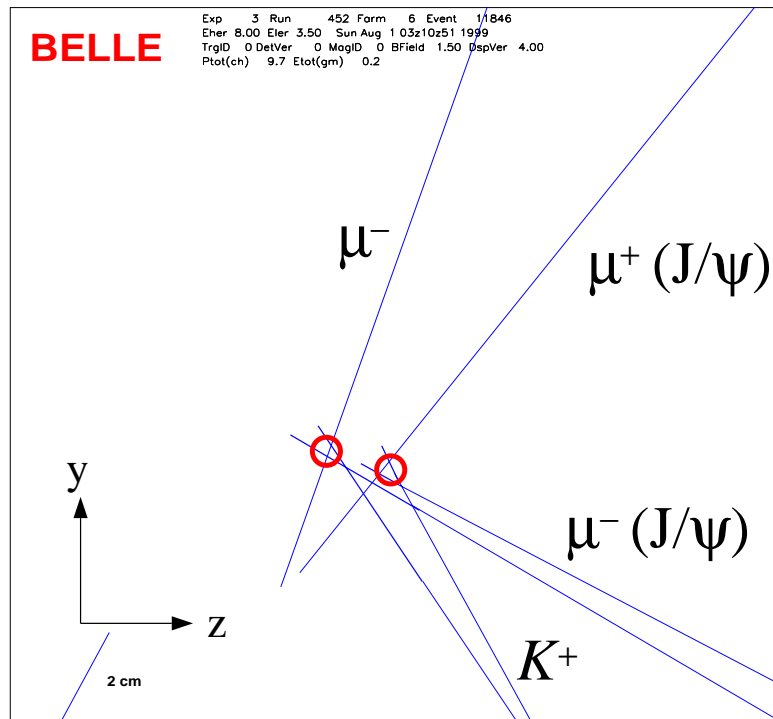
# $B^+ \rightarrow J/\psi K^+$ candidate - zoom



x-z view



y-z view

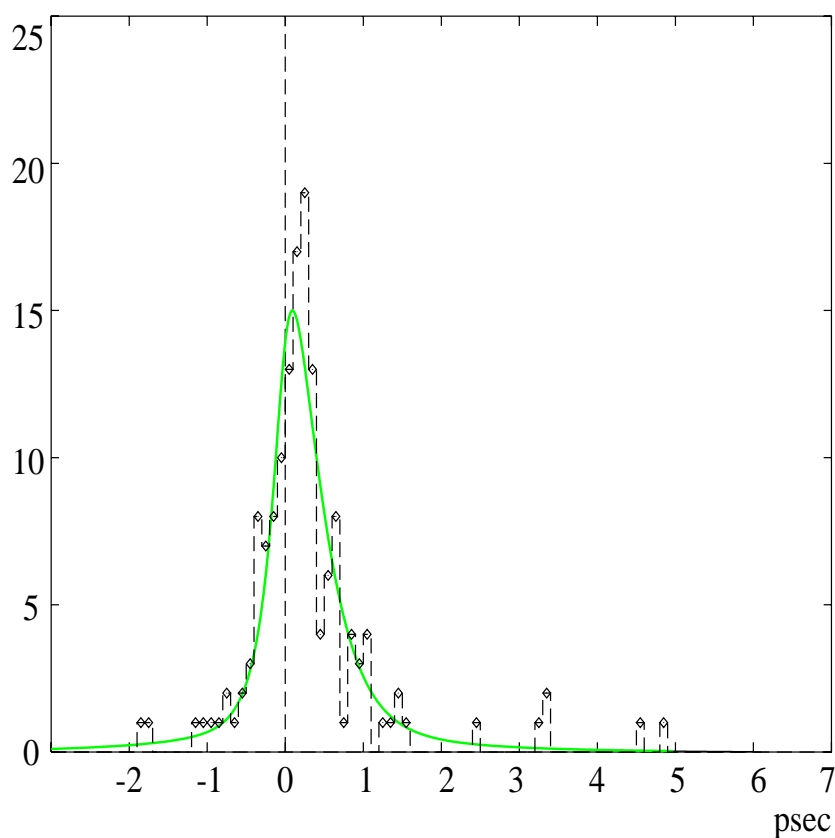
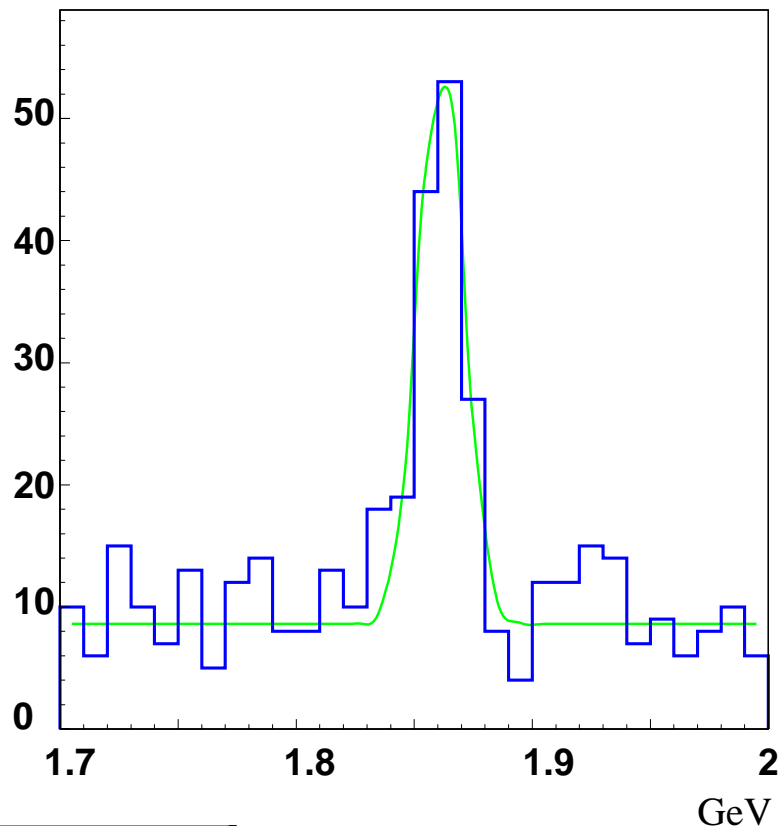


## $D^0$ reconstruction

$D^0 \rightarrow K^- \pi^+$  (and cc)

$\text{prob}(K) > 0.6$

$P(D^0) \geq 2.2 \text{ GeV}$



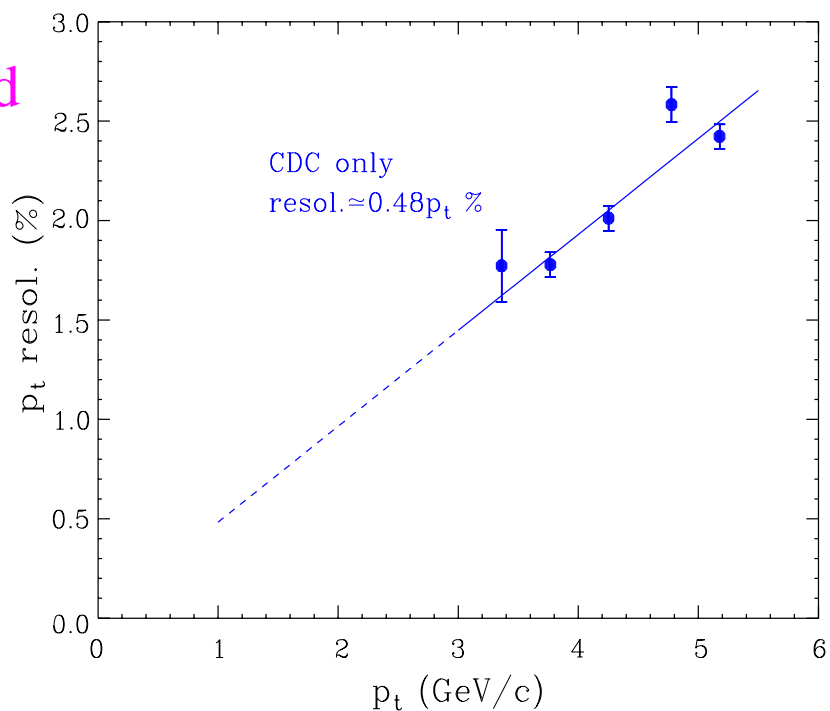
## $D^0$ life time

**Preliminary result**

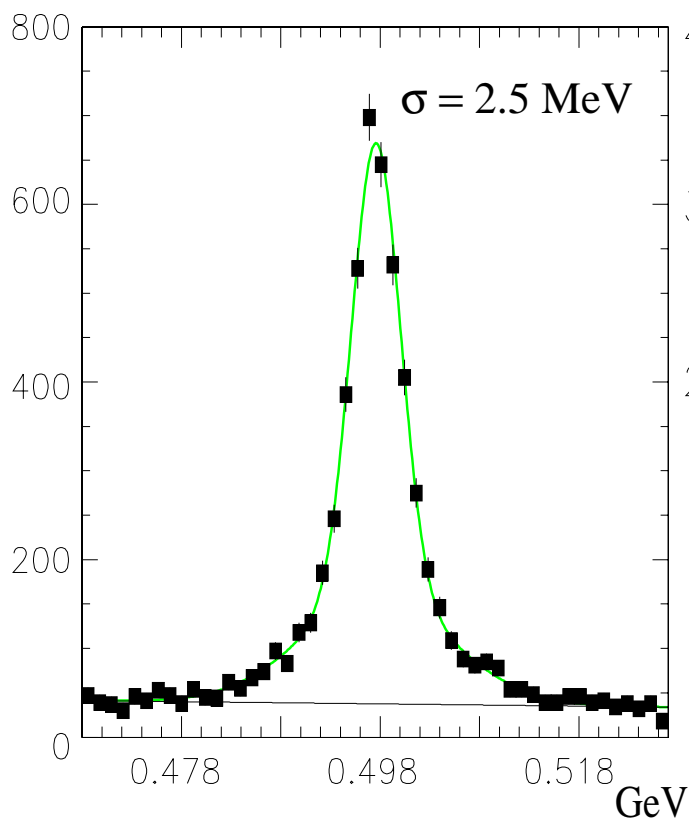
$\tau(D^0) = 0.33 \pm 0.05 \text{ ps}$   
(PDG98:  $0.415 \pm 0.004 \text{ ps}$ )

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

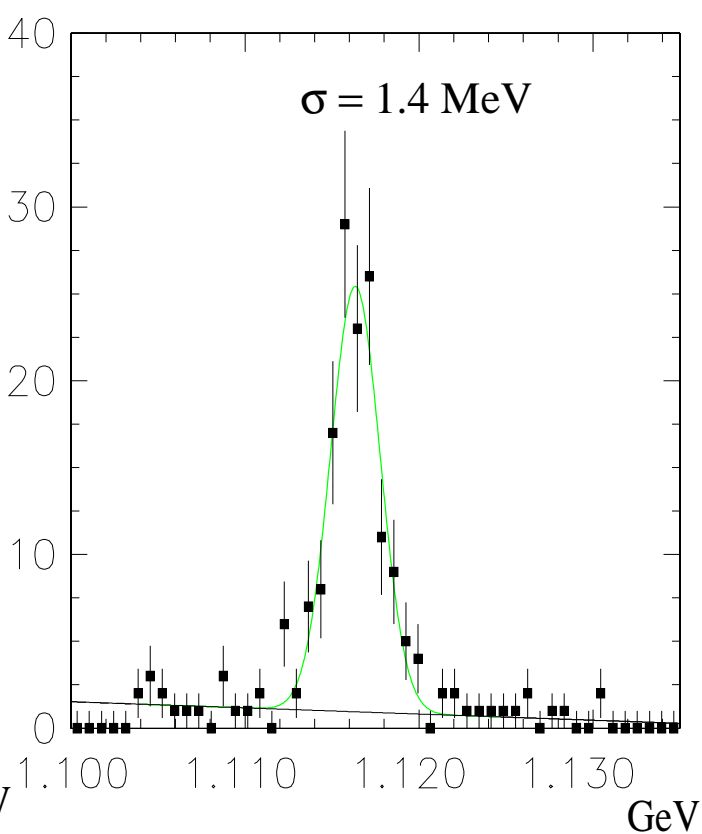
Spatial resolution  
per point =  $160\ \mu\text{m}$



$K_S$  reconstruction



$\Lambda$  reconstruction

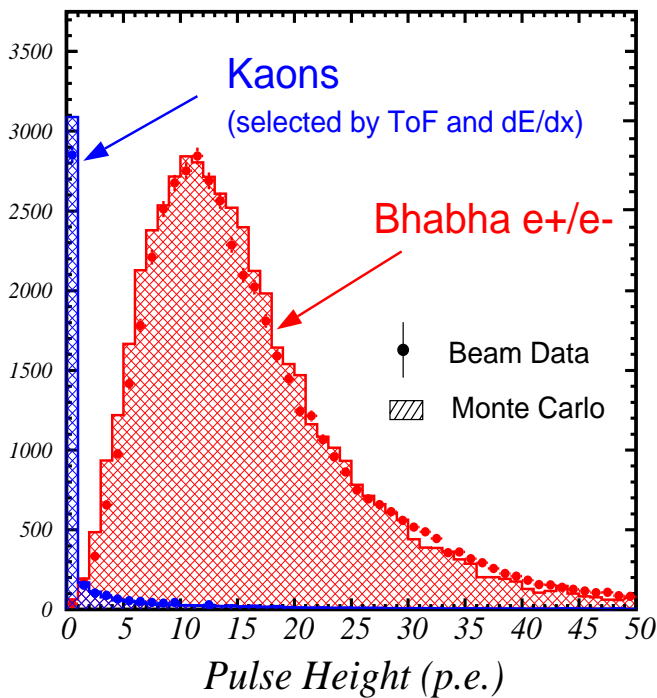


## dE/dx meas. by CDC

80% truncated mean  
of 50 layers

$0.3 < P < 0.7$  GeV

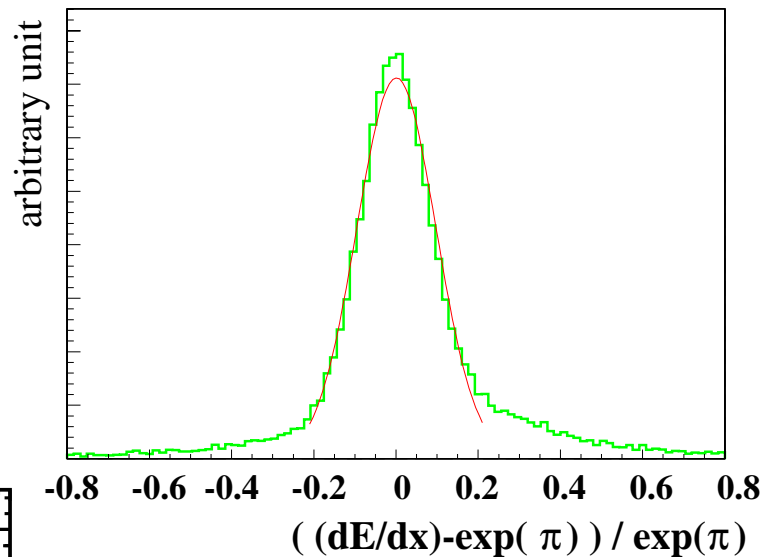
$\sigma(dE/dx) = 6.8 \%$



## Time-of-flight measurement

$\sigma_{TOF} = 120$  psec

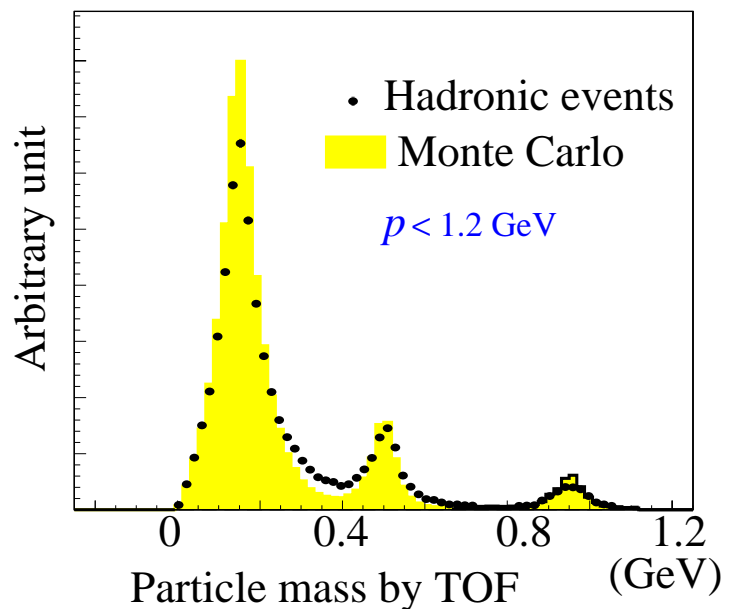
Track matching eff.  
 $\cong 90 \%$



## Aerogel Cherenkov counter

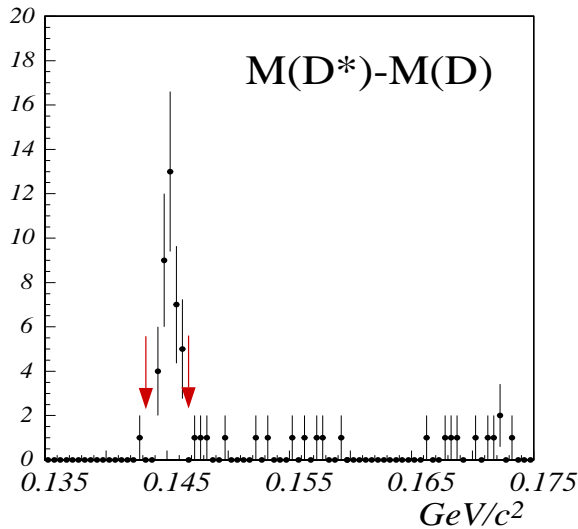
$n=1.010 - 1.03$  depending  
on  $\theta$

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



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

$\rightarrow K^- \pi^+$

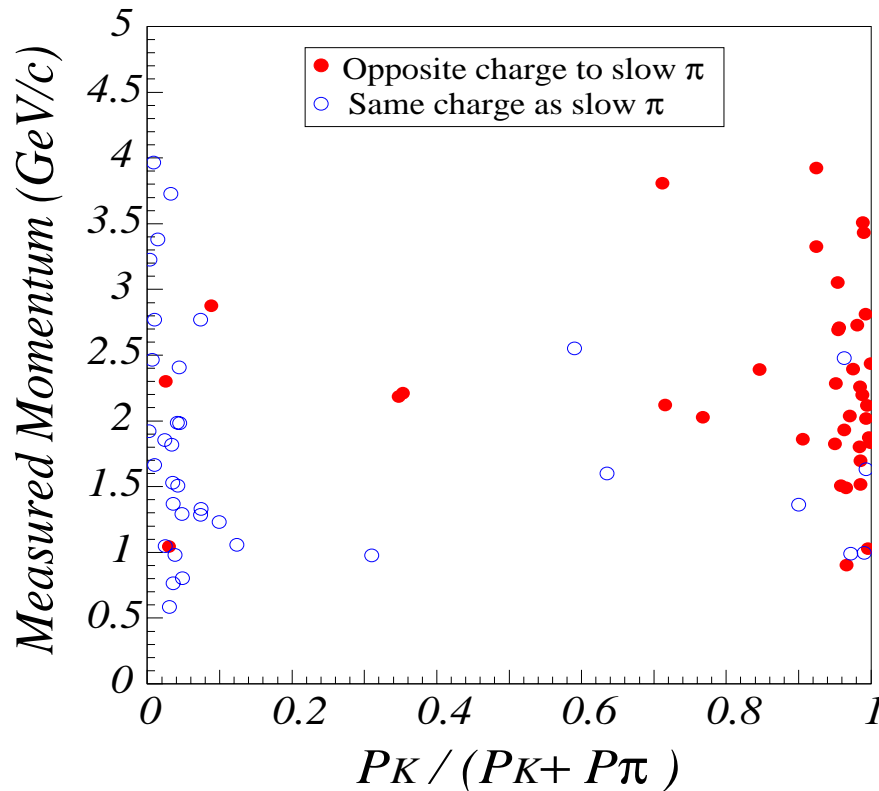


- $|M(D) - 1.865| \leq 0.030$

- $P(D^*)/E_b(\text{CM}) > 0.5$

- $|\cos \theta_k| \leq 0.8$

$\Rightarrow$  Estimated purity  
 $\sim 95\%$

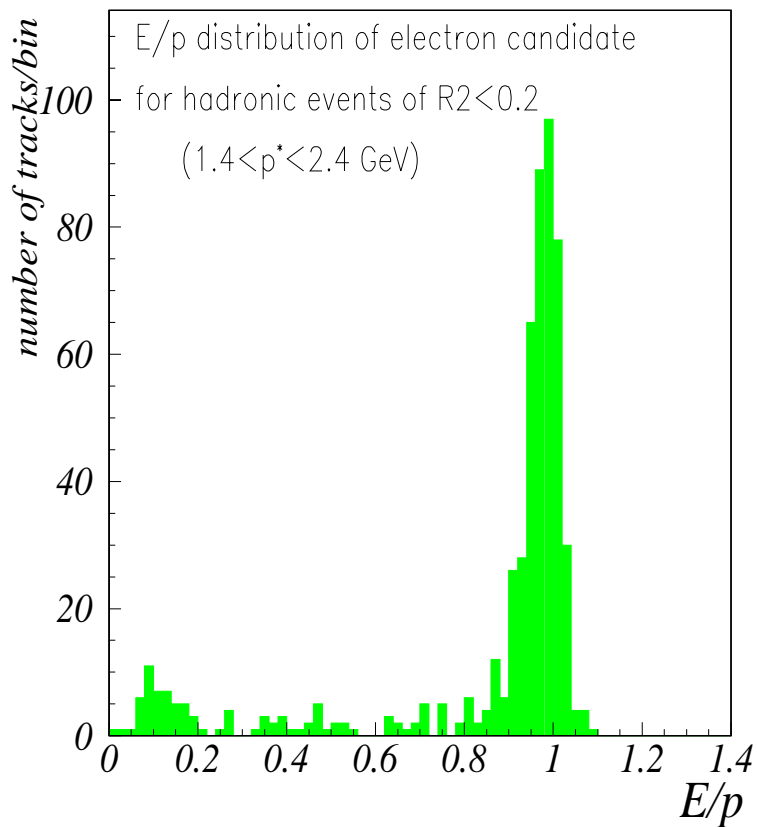
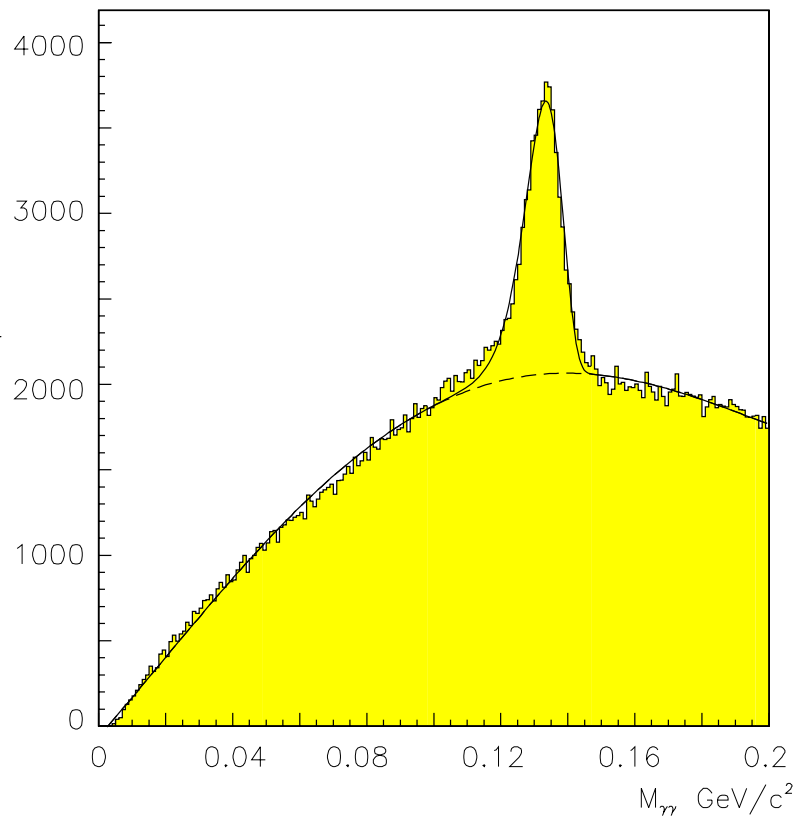




## $\pi^0$ reconstruction

$$E_\gamma \geq 50 \text{ MeV}$$

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



## $e^\pm$ identification

## Electron ID

Track-cluster match

+

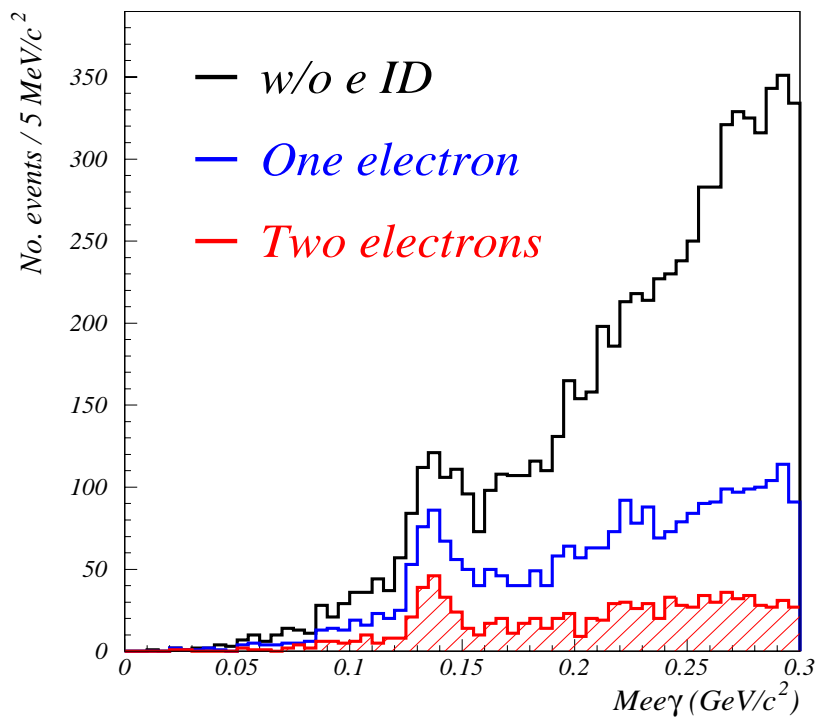
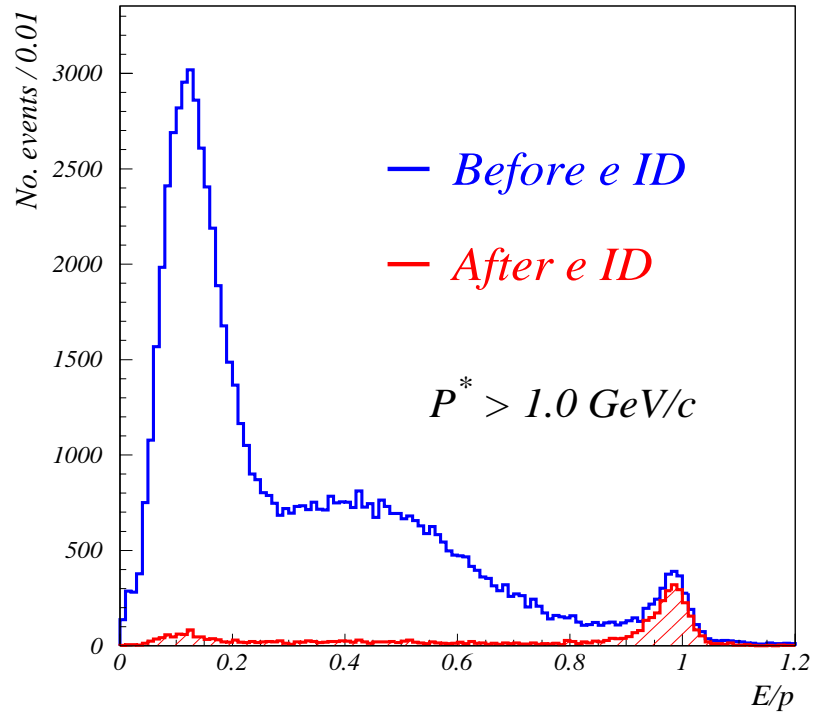
$dE/dx = \text{electron}$

+

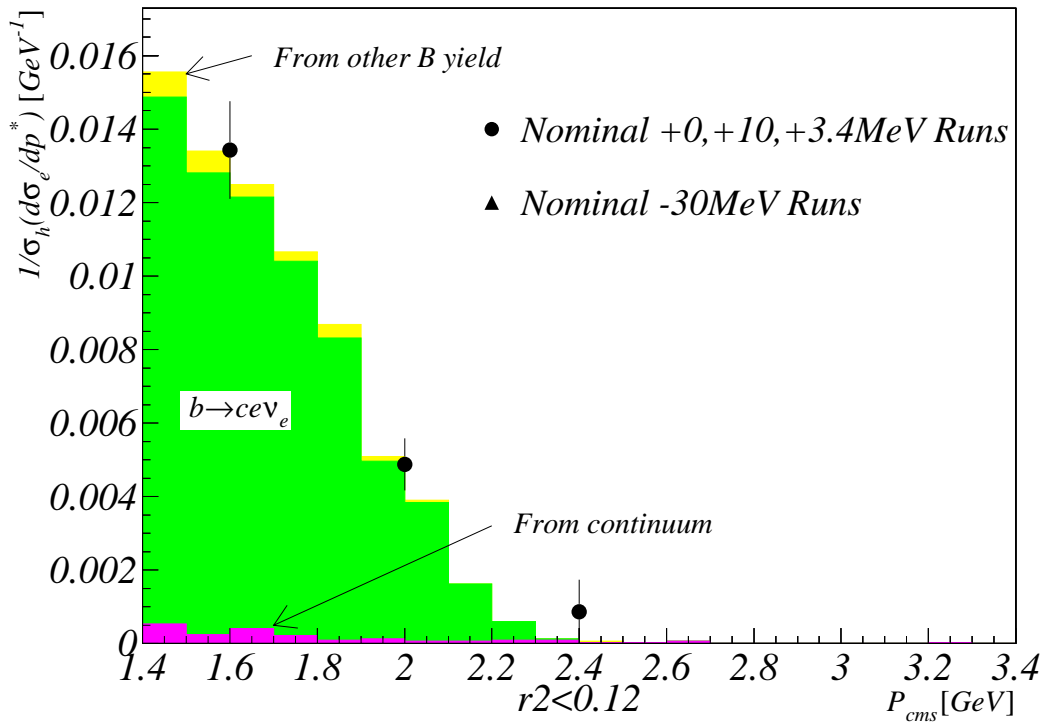
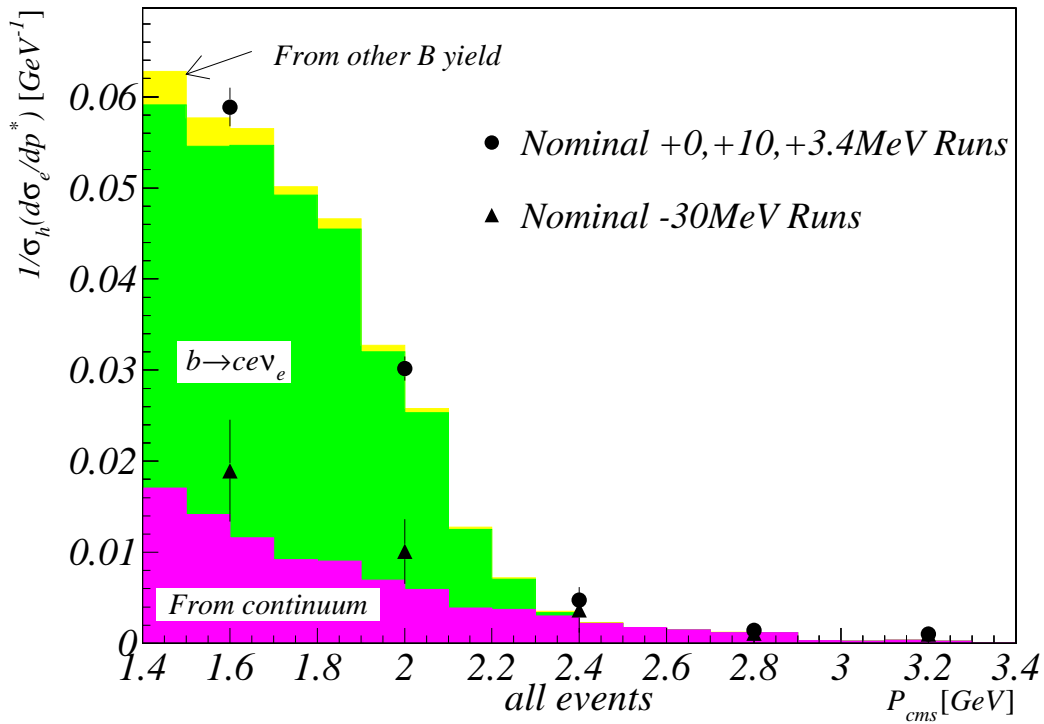
Shower shape cut

+

$E/p$  cut

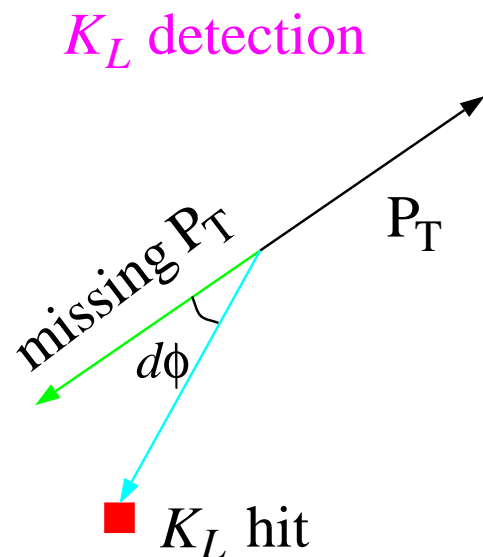
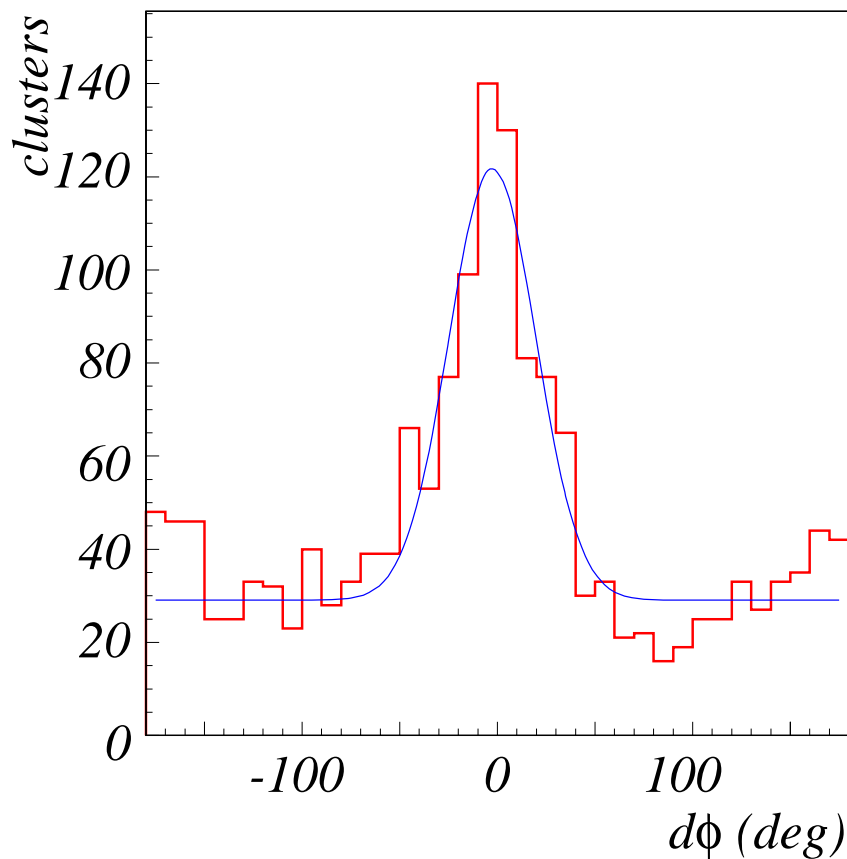
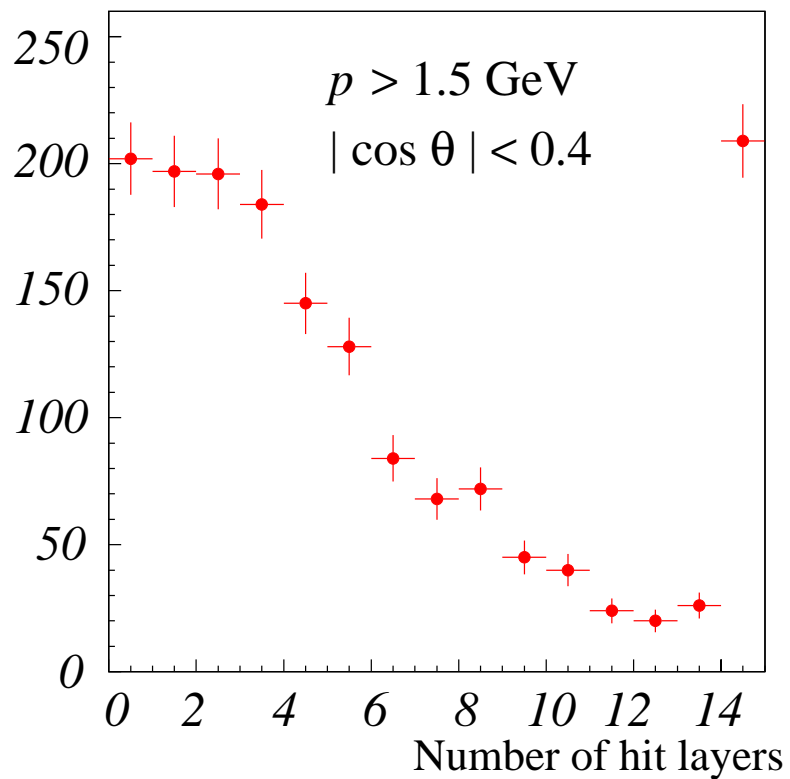


Reconstruction of  
 $\pi^0 \rightarrow e^+ e^- \gamma$



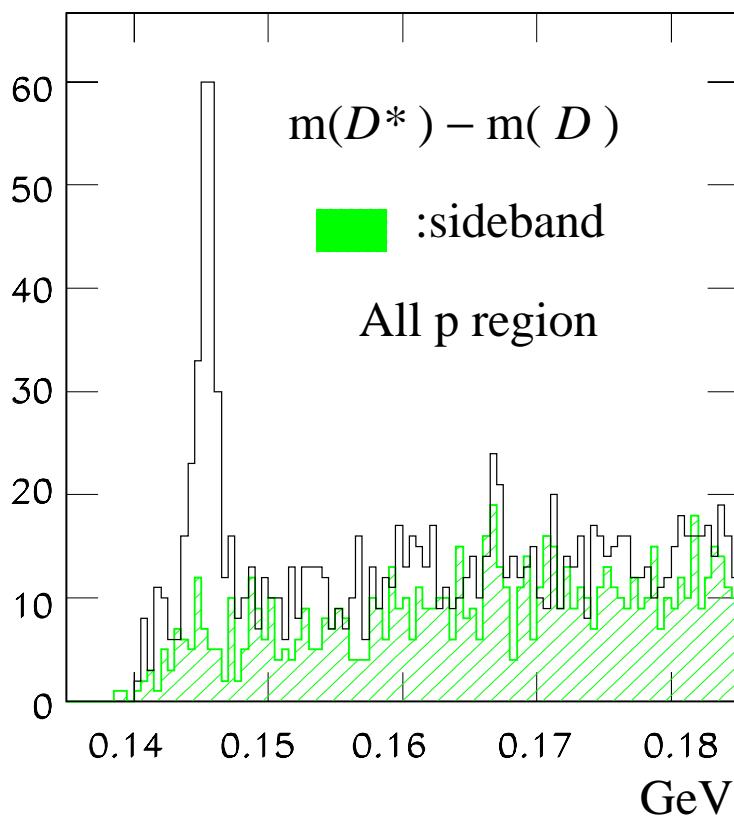
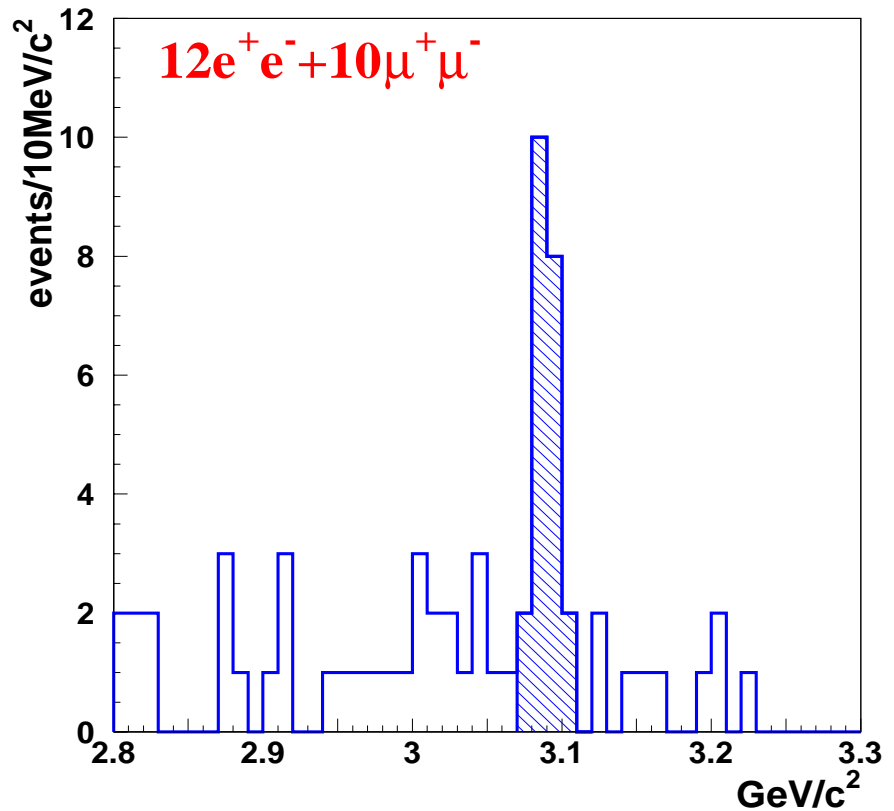
## $\mu^\pm$ ID by KLM

Number of hit layers  
associated with a charged  
track



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

One tight lepton cut  
+ one loose cut

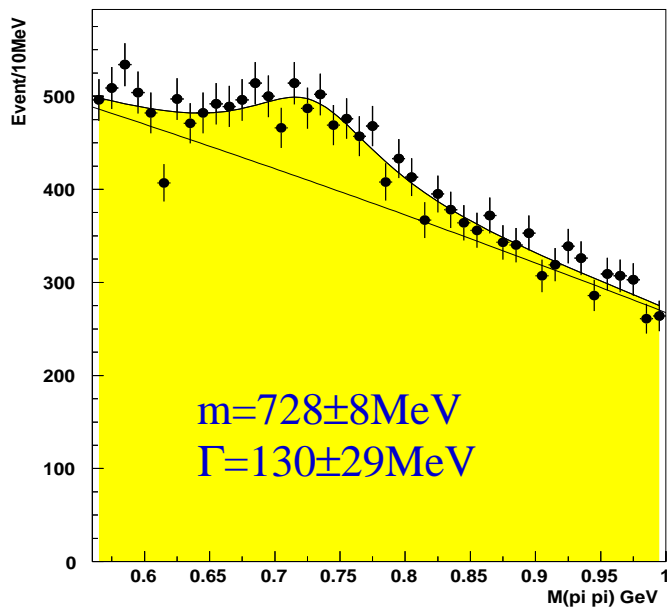


$D^{*\pm} \rightarrow \pi^\pm D^0$

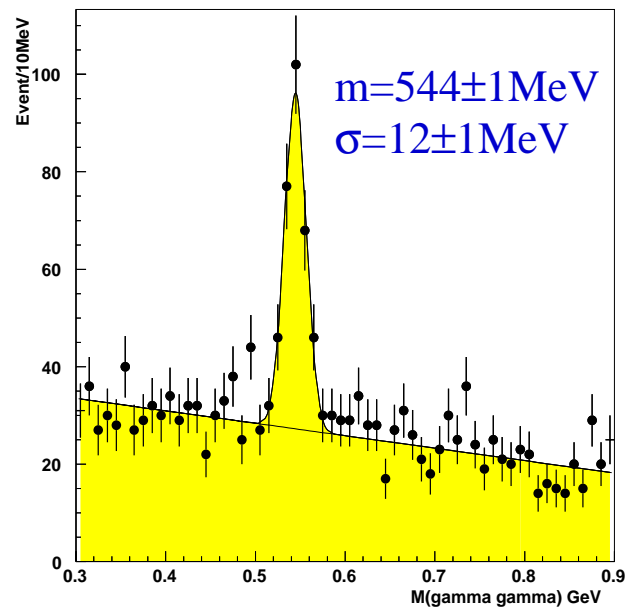
$\downarrow$   
 $K\pi, K\pi\pi$

$|m(D) - m(D; \text{PDG})|$   
 $< 30 \text{ MeV}$

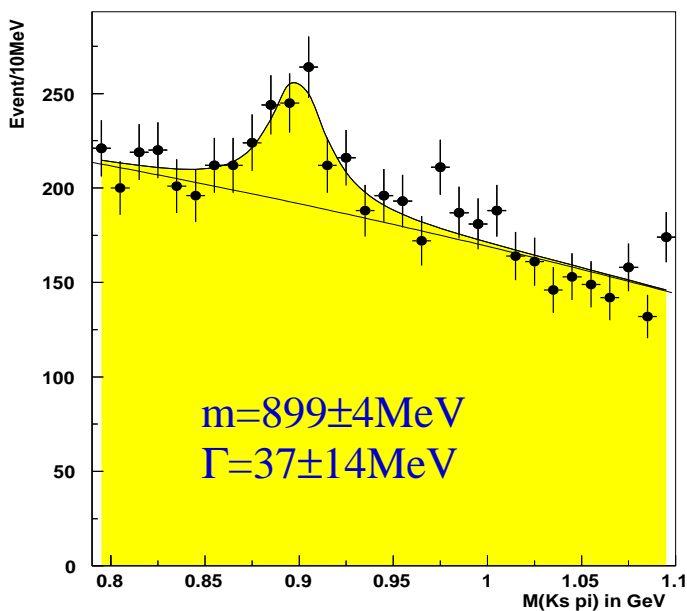
$$\rho^0 \rightarrow \pi^+ \pi^-$$



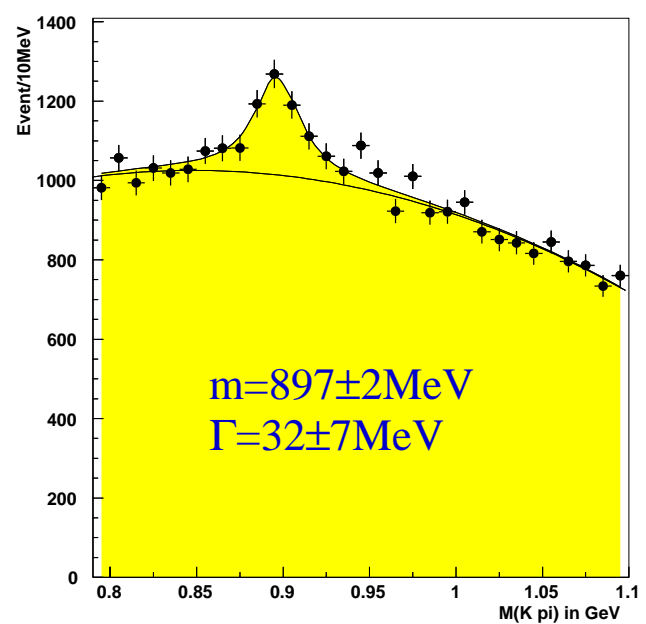
$$\eta \rightarrow \gamma \gamma$$



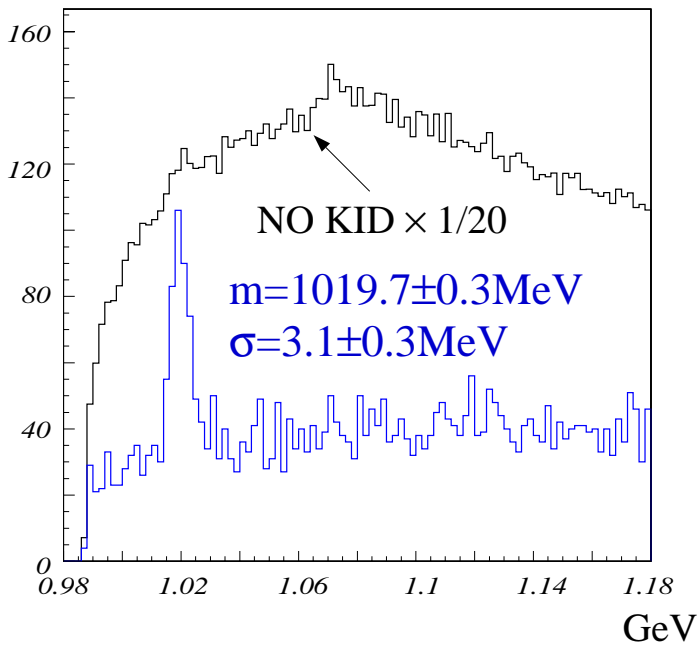
$$K^{*\pm} \rightarrow K_s \pi^\pm$$



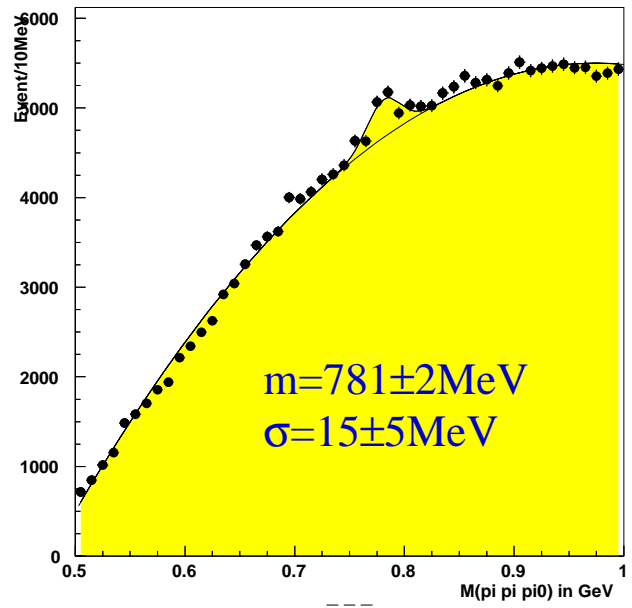
$$K^{*0} \rightarrow K^+ \pi^-$$



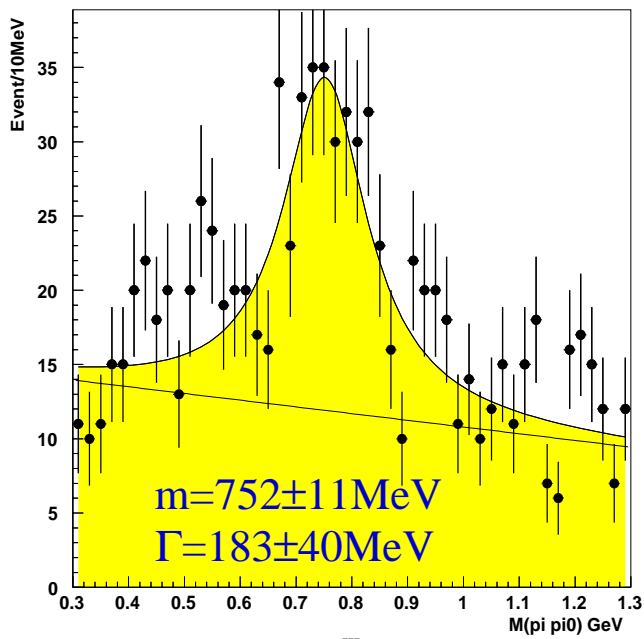
$$\phi \rightarrow K^+ K^-$$



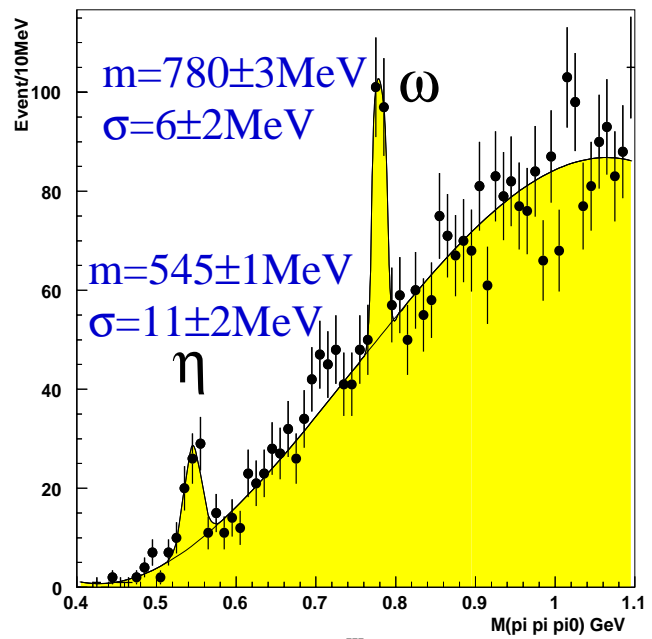
$$\omega \rightarrow \pi^+ \pi^- \pi^0$$



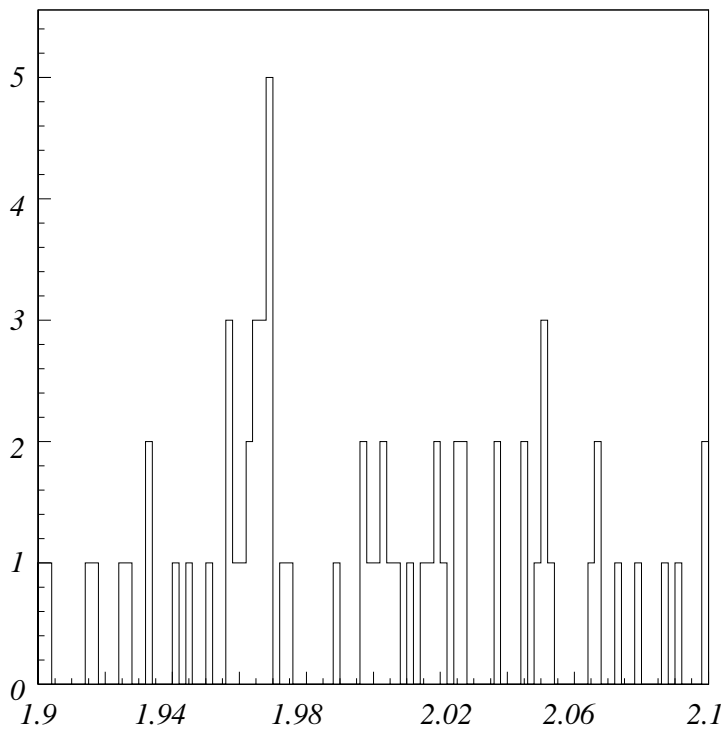
$$\rho^\pm \rightarrow \pi^\pm \pi^0 \quad p > 2.5 \text{ GeV}$$



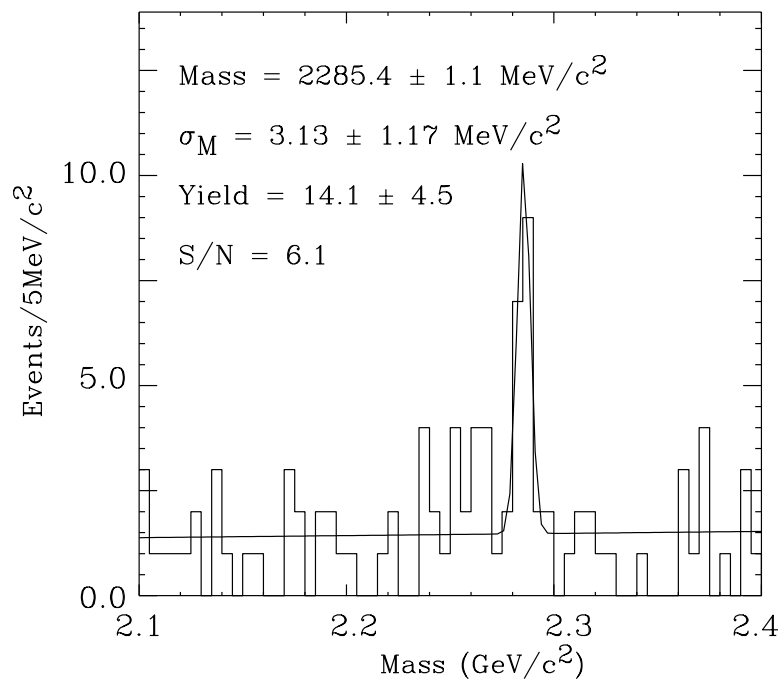
$$m(\pi^+ \pi^- \pi^0) \quad p > 1.5 \text{ GeV}$$



$$D_s^\pm \rightarrow K^+ K^- \pi^\pm, K_s K^\pm$$

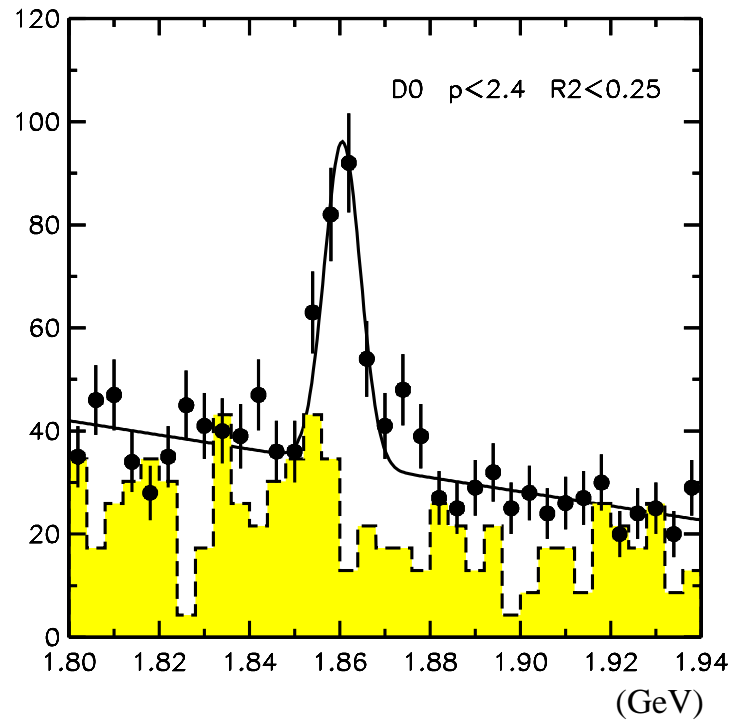


$$\Lambda_c \rightarrow p K \pi$$

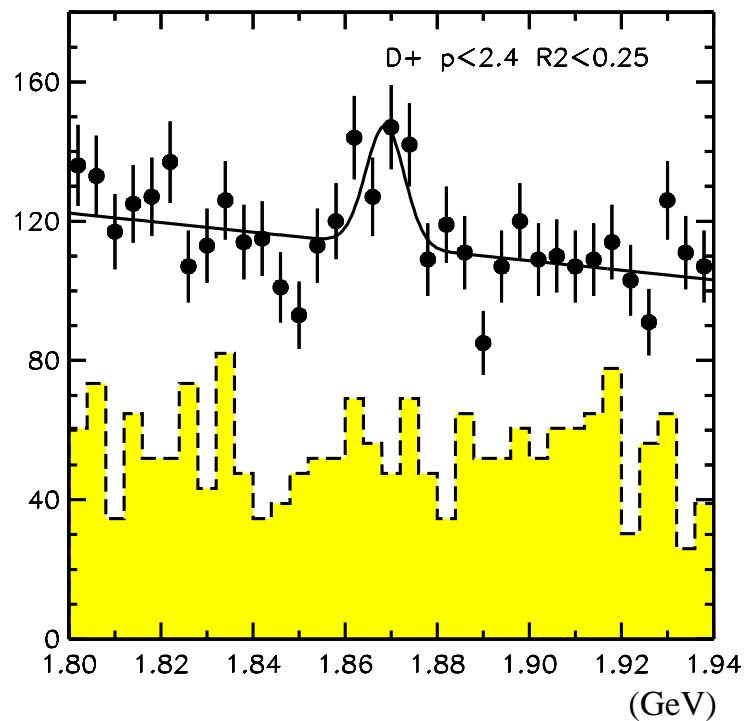




$D^0 \rightarrow K^- \pi^+$   
on / off  $\Upsilon(4s)$



$D^+ \rightarrow K^- \pi^+ \pi^+$   
on / off  $\Upsilon(4s)$



Preliminary results

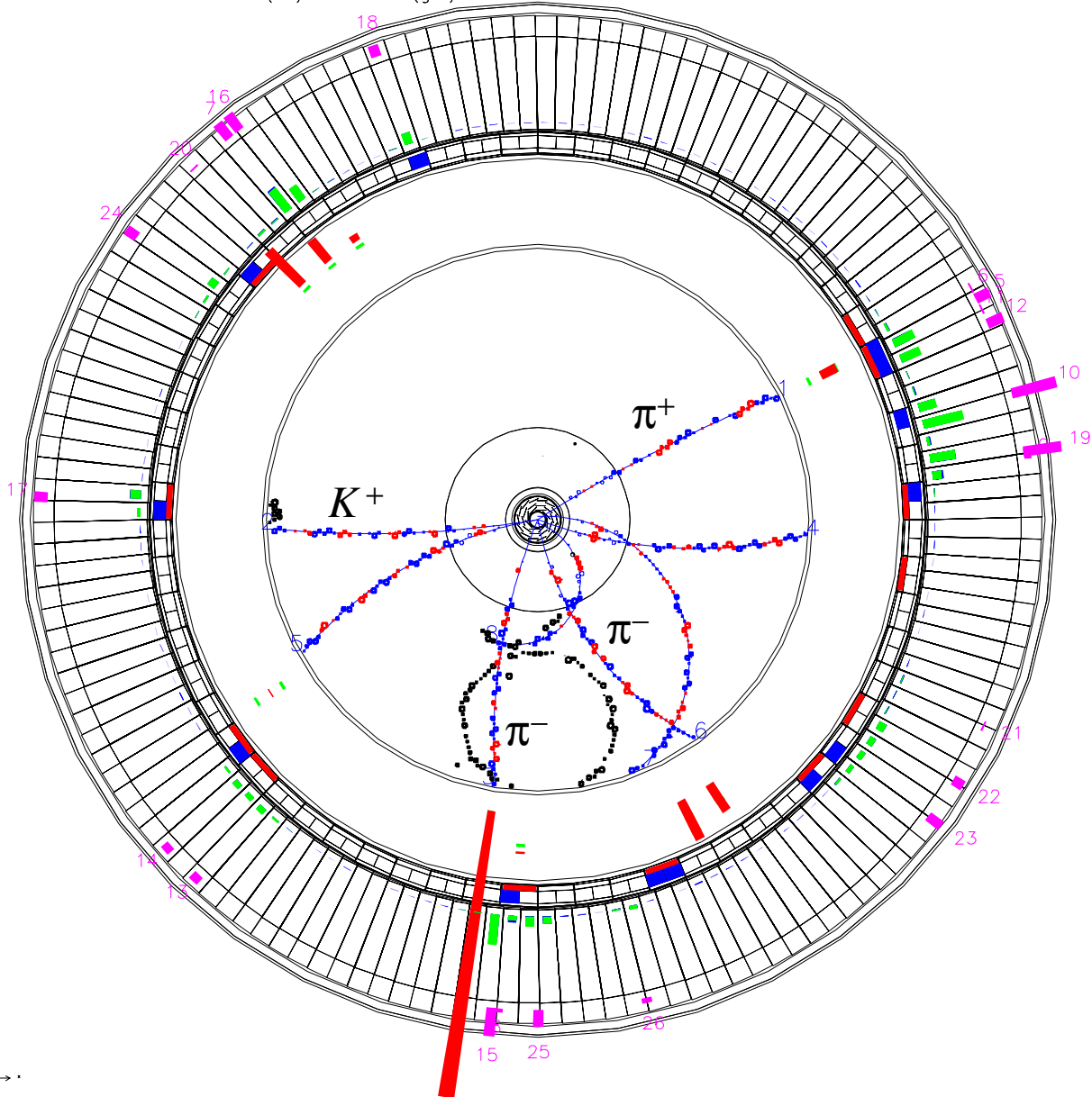
$$\text{BR}(B \rightarrow D^0 X) = 61.3 \pm 11.7\% \text{ (PDG98: } 63.1 \pm 2.9\%)$$

$$\text{BR}(B \rightarrow D^- X) = 19.4 \pm 9.8\% \text{ (PDG98: } 24.1 \pm 1.9\%)$$

$$B^0 \rightarrow D^- \pi^+, D^- \rightarrow K^+ \pi^- \pi^-$$

**BELLE**

Exp 3 Run 238 Farm 5 Event 1876  
 Eher 8.01 Eler 3.50 Sun Jul 18 20z33z07 1999  
 TrgID 0 DetVer 0 MagID 0 BField 1.50 DspVer 4.00  
 Ptot(ch) 7.3 Etot(gm) 2.8



# Summary and Prospects

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KEKB Accelerator and Detector have been commissioned successfully.

Luminosity measured by BELLE reached  $3 \times 10^{32}$ .

Data Analysis is in good shape.

However, we have to **improve the luminosity by a factor of 30** and have a better understanding of beam backgrounds.

## Summer Break

- ◆ Replace SVD.
- ◆ Add more Radiation Shield.
- ◆ Install 8 RF Cavities.
- ◆ Install Beam Dumps.
- ◆ Replace Beam Pipes at IR.

We will resume Accelerator Operation in October and will run for 10 months.

This will enable us to accumulate enough Data to be able to say something on CPV in B-meson decays by next Summer.

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