Mixing and Time-Dependent CP Asymmetries in e^+e^- Annihilation

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Outline

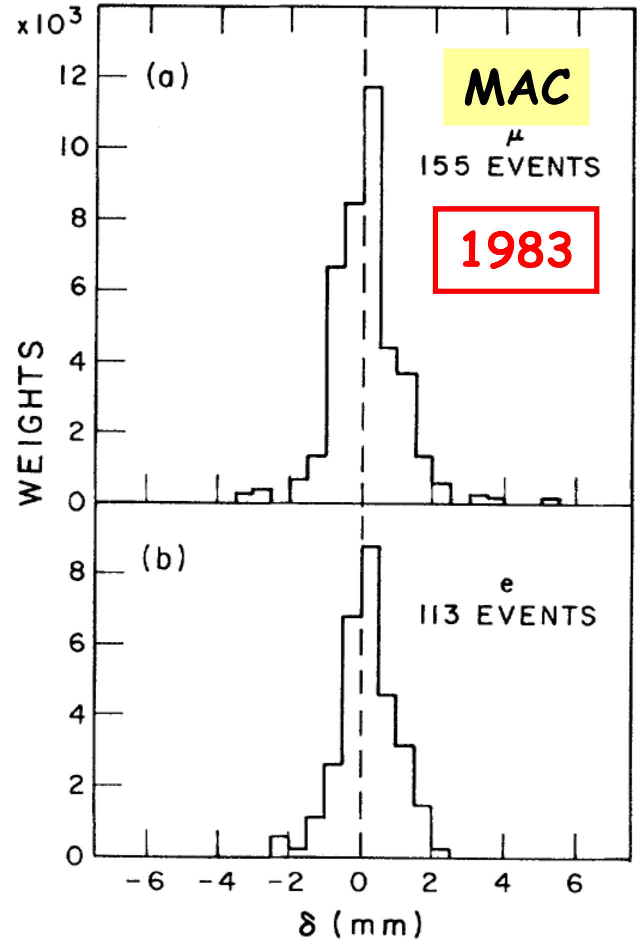
- *Lecture 1*
  - Requirements for time-dependent *CP* violation measurements and implementation at the asymmetric energy e^+e^- *B* Factories
  - $\Upsilon(4S)$ as a source and design of BABAR and Belle detectors
- *Lecture 2*
  - Reconstruction of *B* mesons
  - Determination of proper decay time differences and measurement of *B* lifetimes
  - Methods for tagging the state of the recoil *B* meson at time of its decay and measurement of the B^0 oscillation frequency
- **Lecture 3**
  - *CP* asymmetries in the golden charmonium modes
  - Measuring $\sin 2\beta$ in other channels
  - Asymmetries in 2-body neutral modes
  - Brief word on future prospects and plans

Lecture 1: Asymmetric Energy B Factories and Their Detectors

- Requirements for time-dependent asymmetry measurements at the $\Upsilon(4S)$
- Brief review of PEP-II and KEKB colliders
- Review of design and performance of BABAR and Belle detectors, with emphasis on vertexing and PID

Seeds of an Idea: B Lifetimes

- ***Isolate samples of high-p_T leptons (155 muons, 113 electrons) wrt thrust axis***
  - Measure impact parameter δ wrt interaction point
  - Signed by taking thrust axis of *b*-jet as the *B* hadron direction
- ***Lifetime implies V_{cb} small***
  - MAC: $(1.8\pm0.6 \pm0.4)$ ps
  - Mark II: $(1.2\pm0.4 \pm0.3)$ ps
- ***Integrated luminosity at 29 GeV:***
  - 109 (92) pb^{-1} ~ 3,500 $b\bar{b}$ pairs



MAC, PRL **51**, 1022 (1983)
MARK II, PRL **51**, 1316 (1983)

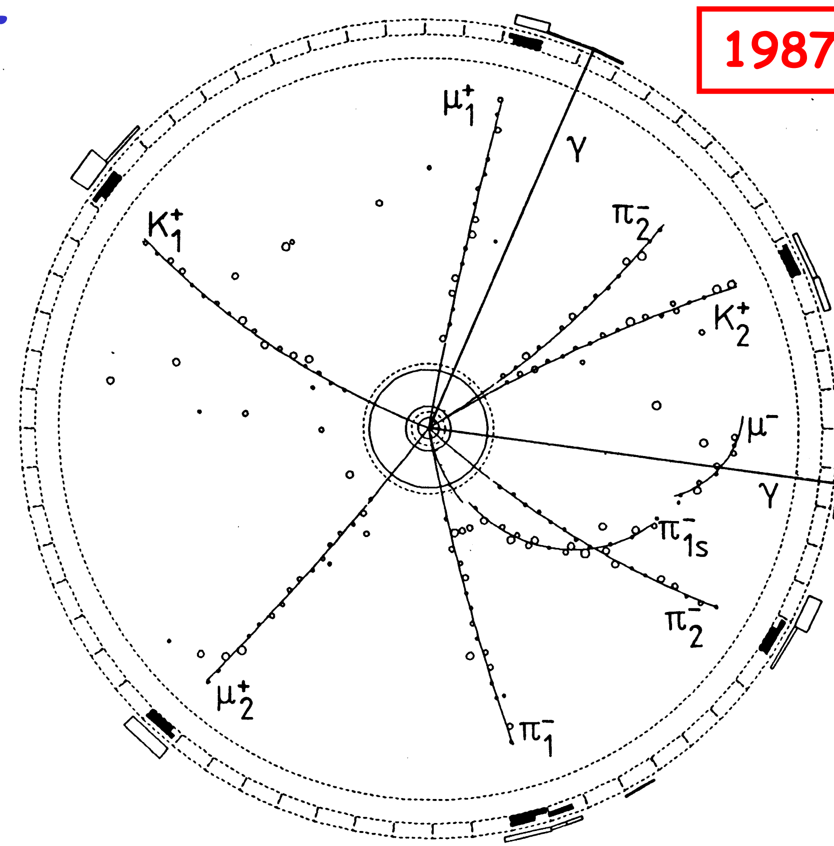
Seeds of an Idea: $B^0\bar{B}^0$ Oscillations

- ***Reconstructed $\Upsilon(4S)$ event***

$$\Upsilon(4S) \to B^0\bar{B}^0 \to B_1^0 B_2^0$$
$$B_1^0 \to D_1^{*-}\mu_1^+\nu_1,\ D_1^{*-} \to \bar{D}^0\pi_1^-$$
$$B_2^0 \to D_2^{*-}\mu_2^+\nu_2,\ D_1^{*-} \to D^-\pi^0$$

- ***Time-integrated 21% mixing rate***
  - 25 (270) like (opposite) sign dilepton events
  - 4.1 lepton-tagged semileptonic B decays
- ***Integrated $\Upsilon(4S)$ luminosity 1983-87:***
  - 103 pb^{-1} ~ 110,000 B pairs

1987

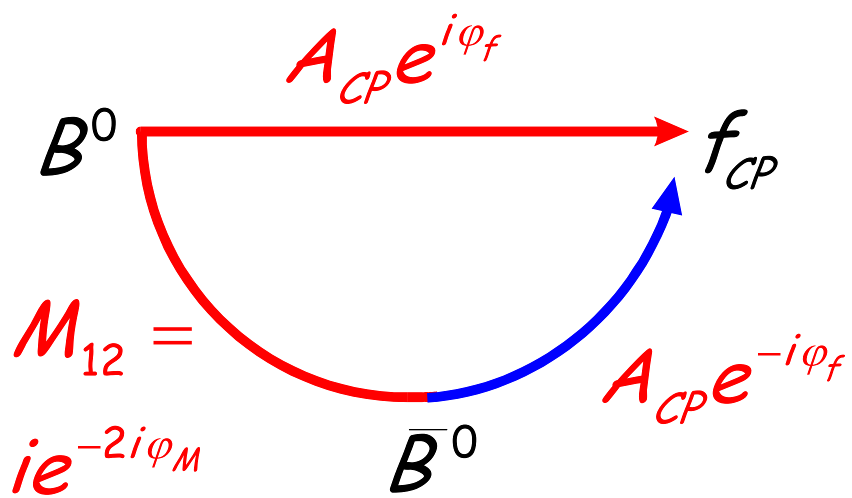


$$\chi_d = 0.17 \pm 0.05$$

ARGUS, PL B **192**, 245 (1987)

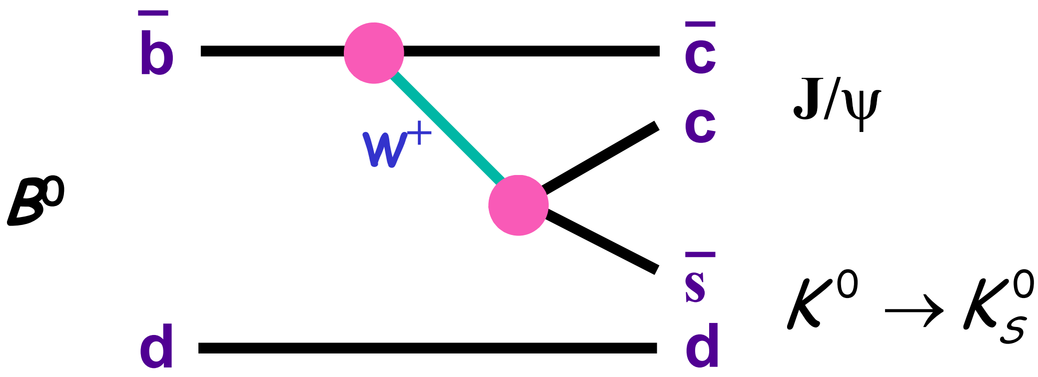
Expect CP Violation in the B System

- CPV through interference of decay amplitudes
- CPV through interference of mixing diagram
- CPV through interference between mixing and decay amplitudes



Directly related to CKM angles for single decay amplitude

Golden Channel: $B^0 \rightarrow J/\psi K^0_{S,L}$



***CP* Eigenstate:**
η_{CP} = -1

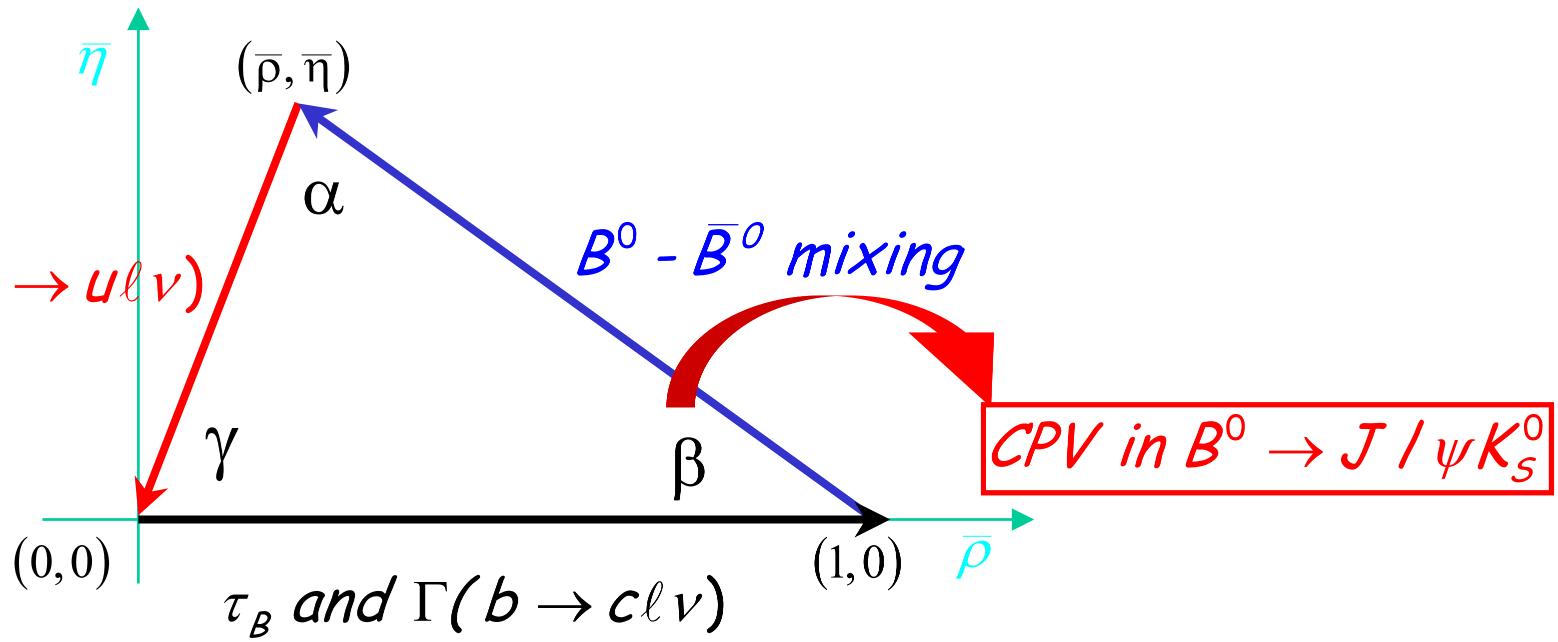
***CP* parameter**

$$\mathrm{Im}\,\lambda_{b\to c\bar{c}s} = \eta_{f_{CP}}\,\mathrm{Im}\left\{\frac{V_{cb}V_{cs}^*}{V_{cb}^*V_{cs}} \times \frac{V_{tb}V_{td}^*}{V_{tb}^*V_{td}} \times \frac{V_{cd}^*V_{cs}}{V_{cd}V_{cs}^*}\right\} = \eta_{f_{CP}}\,\mathrm{Im}\frac{V_{td}^*}{V_{td}} = \eta_{f_{CP}}\sin 2\beta$$

Quark subprocess | B^0 mixing | K^0 mixing

$$A_{f_{CP}}(t) = \frac{\Gamma(\bar{B}^0_{phys}(t) \to f_{CP}) - \Gamma(B^0_{phys}(t) \to f_{CP})}{\Gamma(\bar{B}^0_{phys}(t) \to f_{CP}) + \Gamma(B^0_{phys}(t) \to f_{CP})} = -\mathrm{Im}\,\lambda_{f_{CP}}\sin\Delta m_d t$$

CPV and Unitarity Constraints for CKM



$b \to c\bar{c}s$ channels

- Theoretically clean way to measure $\sin 2\beta$
- Clear experimental signatures
- Relatively large branching fractions

Sample Requirements: Snowmass Study 1988

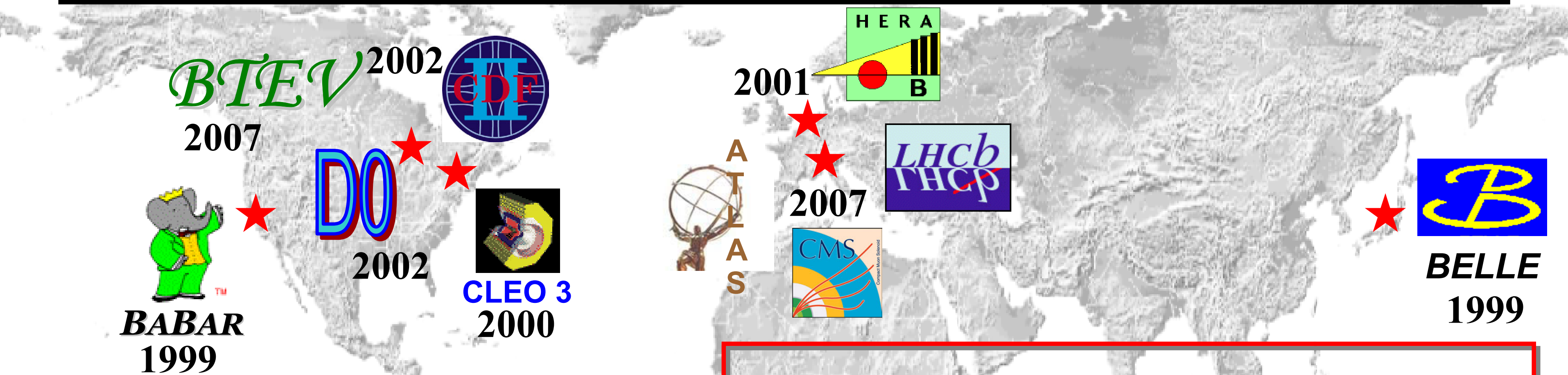
	Asymmetric $\Upsilon(4S)$ collider
$\sigma(bb)$ [nb]	1.2
B^0 fraction	0.43
Reconstruction efficiency	0.61
Tagging efficiency	0.48 (l, K)
Wrong-tag fraction	0.08
Dilution	0.61
Integrated Luminosity for 3σ measurement [$\times 10^{40}$ cm^{-2}] *	0.45-16

*** Assumes:**

- $\sin 2\beta$ in range from 0.05 to 0.3,
- $BF(B \to J/\psi K_S) = 5\times10^{-4}$
- $BF(J/\psi \to l^+l^-) = 0.14$,
- Luminosity in units of $\mathcal{L}_{peak}$ at full efficiency for 10^7 s

Conclude: Asymmetric energy e^+e^- collider has discovery capability at $\mathcal{L}_{peak} \sim 3\text{-}10\times10^{33}$ cm^{-2}s^{-1} in 2-5 years of running

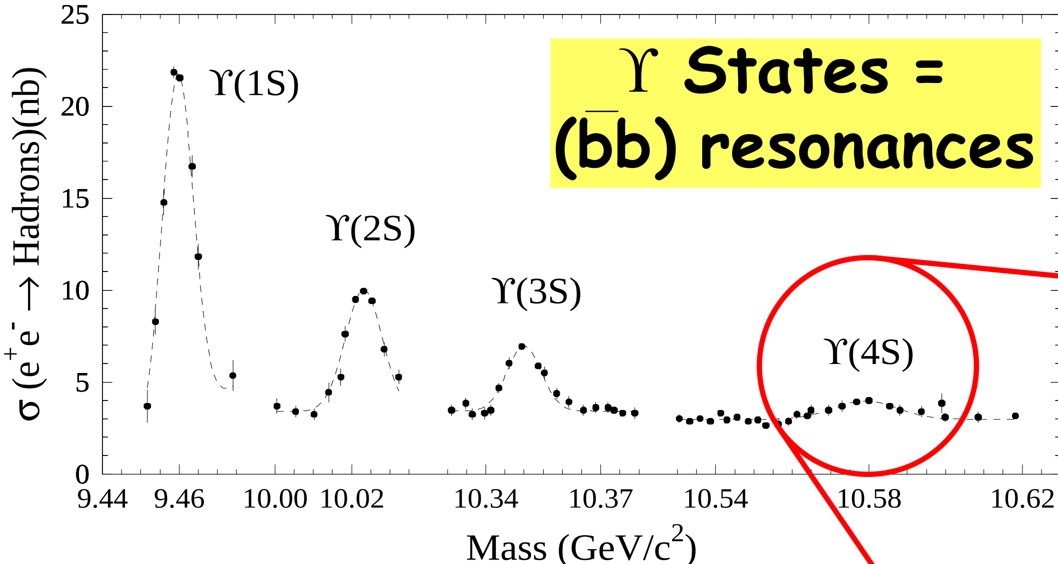
Genesis of Worldwide Effort

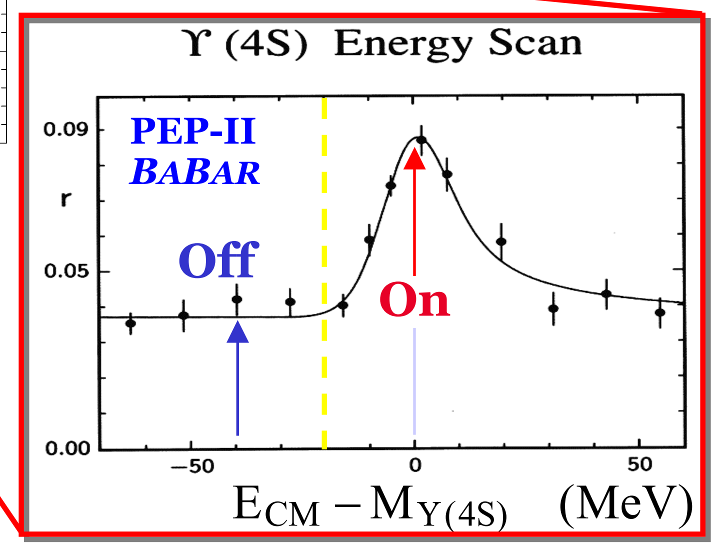


Primary Goal

Precision measurements of **charged weak interactions** as a test of the **CKM** sector of the Standard Model and a probe of the origin of the ***CP* violation**

Producing B Mesons





Cross Sections at Υ(4S):

$b\bar{b} \sim 1.1$ nb

$c\bar{c} \sim 1.3$ nb

$d\bar{d}, s\bar{s} \sim 0.3$ nb

$u\bar{u} \sim 1.4$ nb

$$e^+e^- \to \Upsilon(4S) \to B\bar{B}$$

$L = 1$ state

Time Evolution for Coherent Source

- ***L=1 $B^0\bar{B}^0$ system requires antisymmetric initial-state wave function in $\Upsilon(4S)$ frame:***

$$S(t_f,t_b) = 1/\sqrt{2}\Big[B^0_{phys}(t_f,\theta,\varphi)\bar{B}^0_{phys}(t_b,\pi-\theta,\varphi+\pi) - \bar{B}^0_{phys}(t_f,\theta,\varphi)B^0_{phys}(t_b,\pi-\theta,\varphi+\pi)\Big]\sin\theta$$

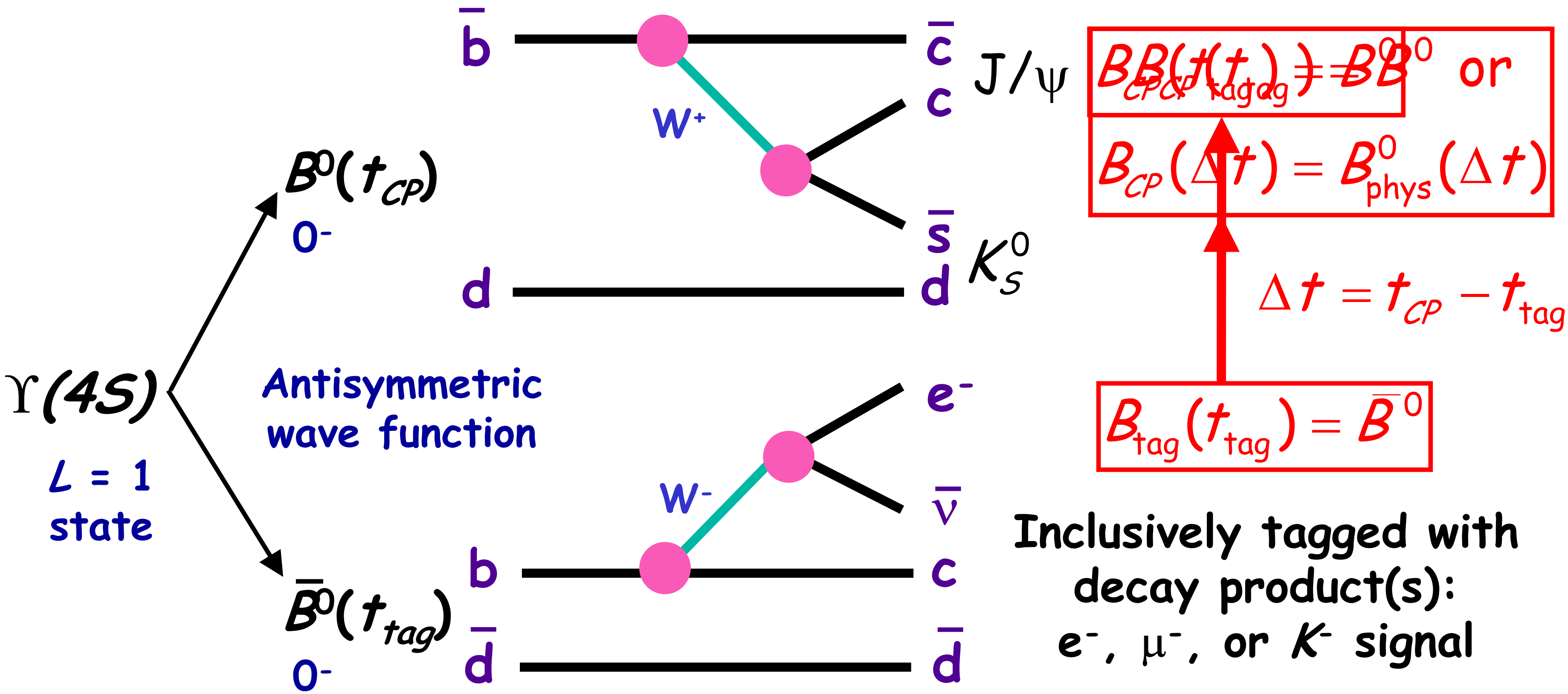
(θ,φ) are wrt e^- beam direction;

(f,b) are the forward (backward) going B meson,

with $(\theta_f < \pi/2)$ and $t_f = t_b$ until one B meson decays

- ***Consequently $B^0\bar{B}^0$ evolves coherently until one B mesons decays***
  - At any given time, until one of the *B* mesons decays, there is exactly one B^0 and one $\bar{B}^0$ including at time $\Delta t = t_{CP} - t_{tag} = 0$
  - *CP*/Mixing oscillation clock only starts ticking at the time of the first decay, relevant time parameter is Δt
  - Half of the time the *CP* eigenstate *B* decays first ($\Delta t < 0$)

Golden Channel Asymmetry on $\Upsilon(4S)$

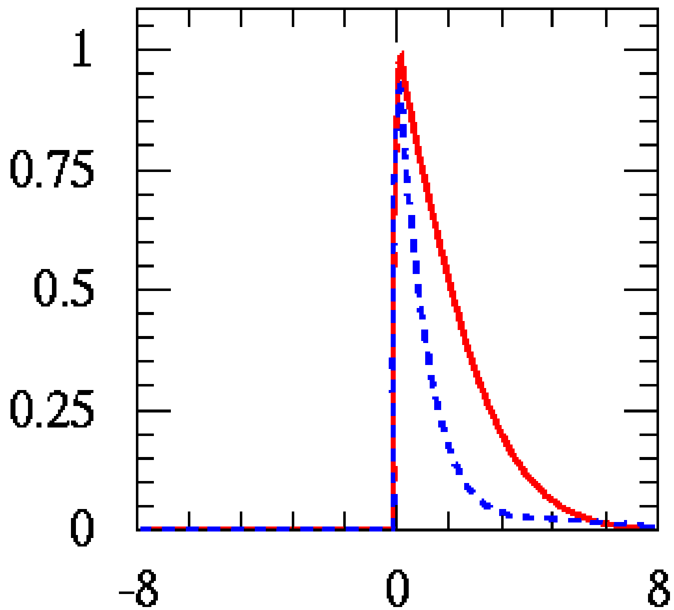


$$A_{f_{CP}}(\Delta t) = \frac{\Gamma(\bar{B}^0_{phys}(\Delta t) \to f_{CP}) - \Gamma(B^0_{phys}(\Delta t) \to f_{CP})}{\Gamma(\bar{B}^0_{phys}(\Delta t) \to f_{CP}) + \Gamma(B^0_{phys}(\Delta t) \to f_{CP})} = \sin 2\beta \sin \Delta m_d \Delta t$$

Neutral B Time Evolution

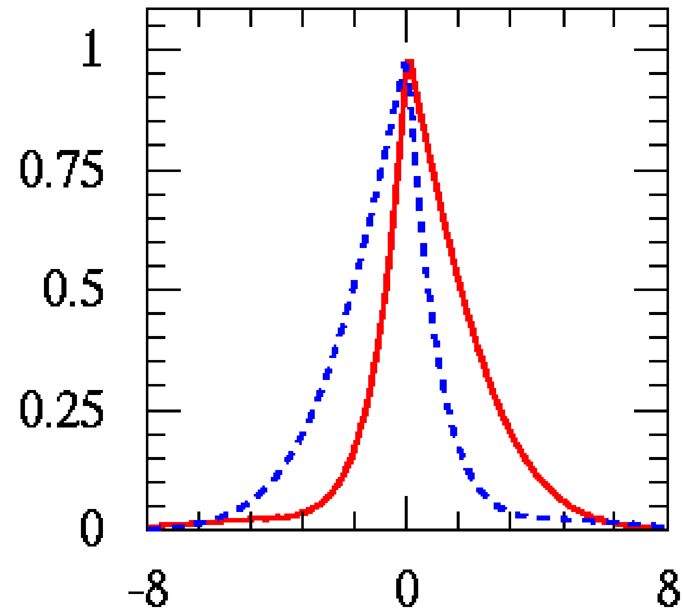
Evolution for $B^0(\bar{B}^0)$ state at $t_{CP}=0$

Incoherent



t [ps]

Coherent

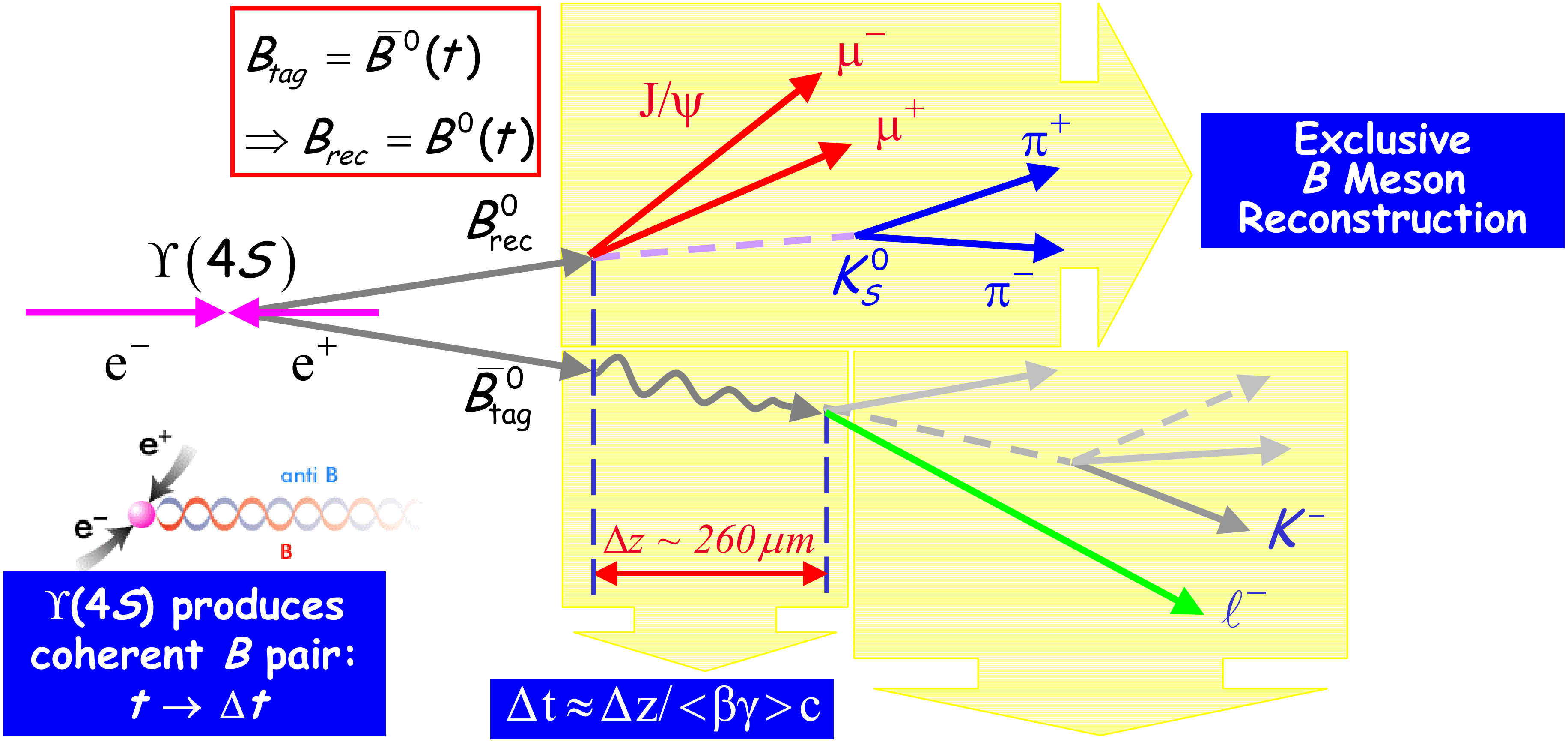


$\Delta t = t_{CP} - t_{tag}$ [ps]

For coherent source, integrated asymmetry is zero: must do a time-dependent analysis

$$\int_{-\infty}^{+\infty} F(\Delta t)\,d\Delta t = \int_{-\infty}^{+\infty} \bar{F}(\Delta t)\,d\Delta t$$

Experimental Technique for B Factories



Time-integrated asymmetries are zero

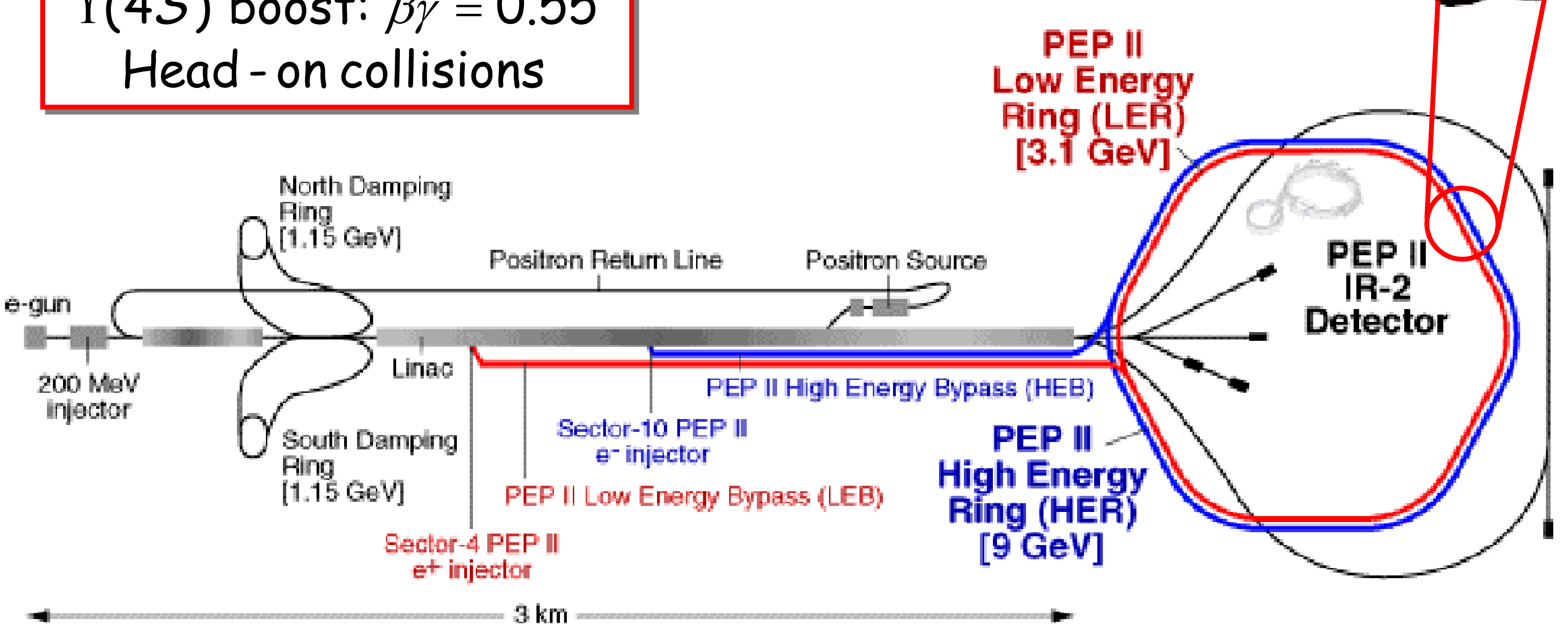
B-Flavor Tagging

$B^0_{rec} = B^0_{flav}$ (flavor eigenstates) → lifetime, mixing analyses

$B^0_{rec} = B^0_{CP}$ (CP eigenstates) → CP analysis

PEP-II Asymmetric B Factory

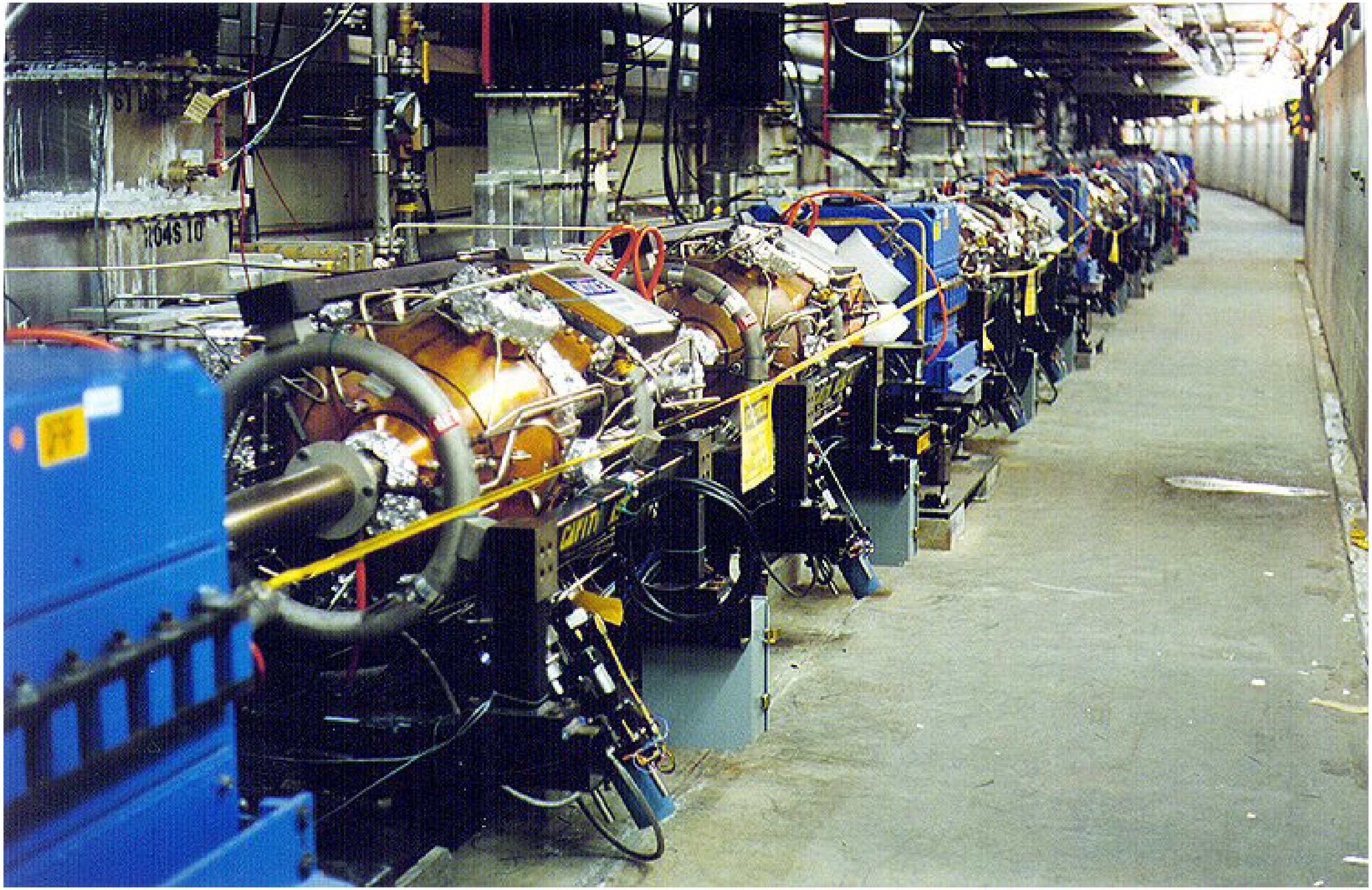
$9\ \text{GeV}\ e^- \times\ 3.1\ \text{GeV}\ e^+$
$\Upsilon(4S)$ boost: $\beta\gamma = 0.55$
Head-on collisions



Located in the 2.2 km PEP tunnel
at the Stanford Linear Accelerator Center

PEP-II Arc Section

PEP-II HER RF Cavities

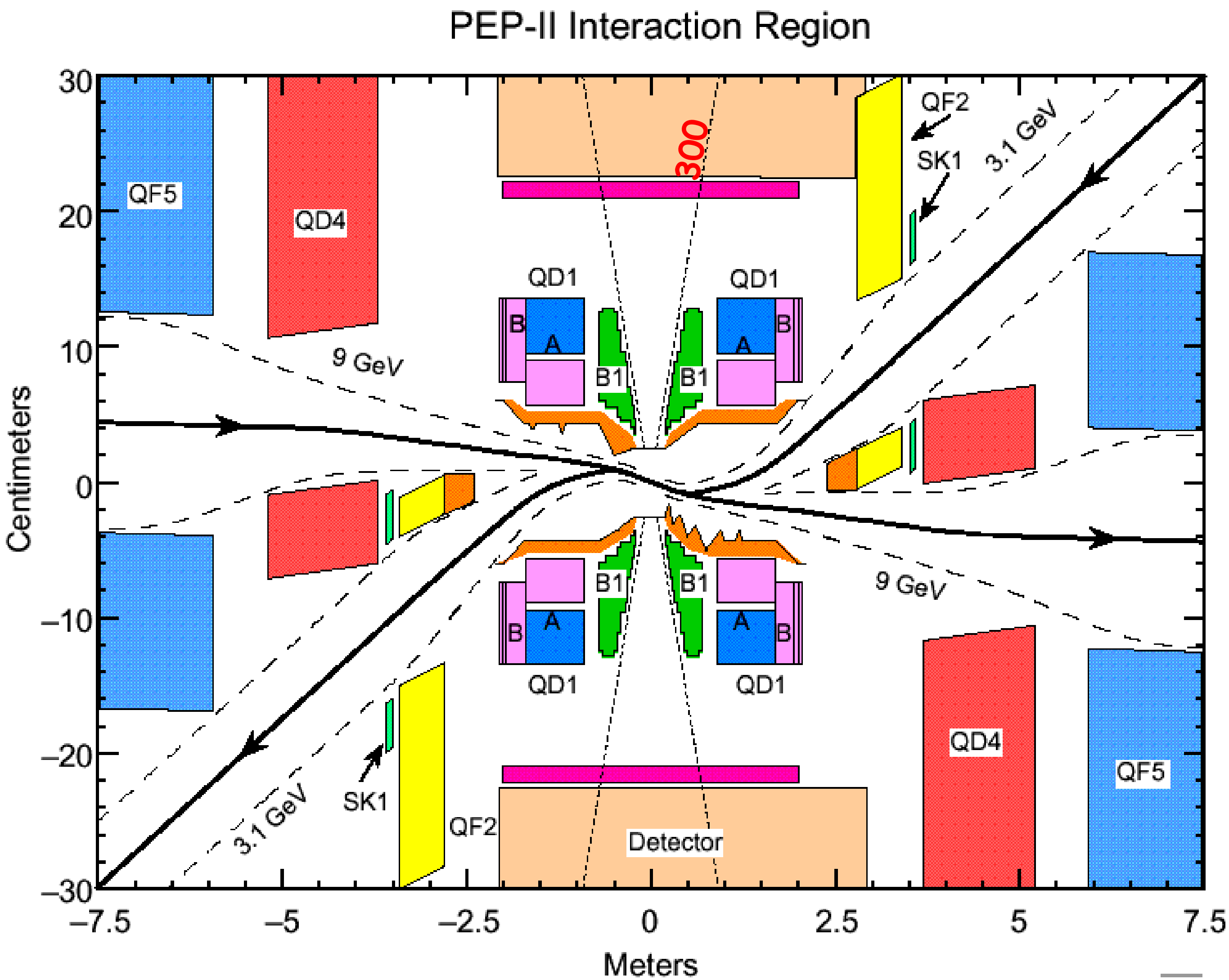


BR_049 HER Cavities Region 12 8-19-97

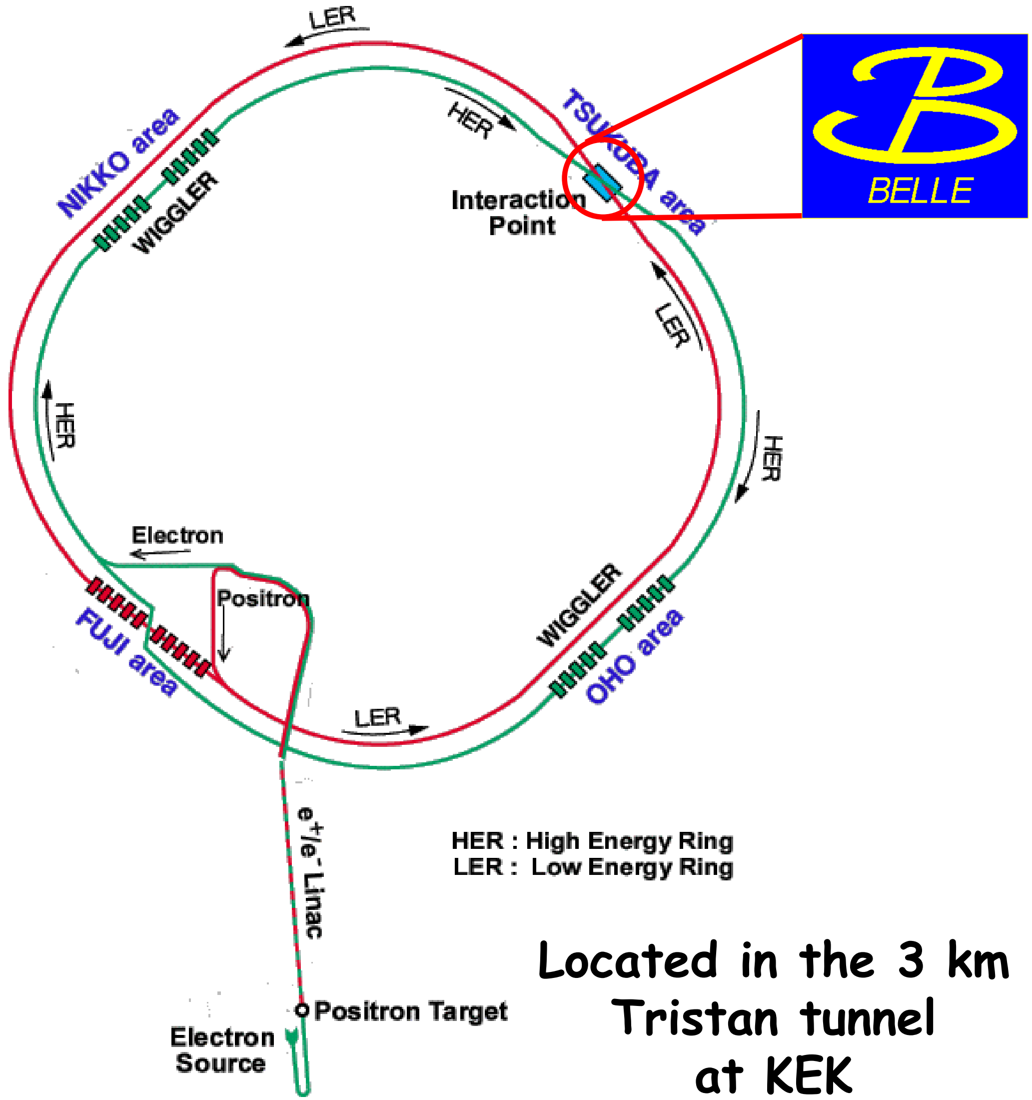
PEP-II Parameters

	Design		Achieved	
	e^-	e^+	e^-	e^+
Beam energies [GeV]	9	3.1		
Currents [A]	0.75	2.14	1.05	2.14
Number of bunches	1658		830	
Luminosity [$\times 10^{33}$ $cm^{-2}s^{-1}$]	3.0		4.6	
Bunch spacing [m]	1.26		2.52	
Bunch currents [mA]	0.45	1.29	1.28	2.20
Beam stored energy [kJ]	49	49	69	41
Beam power [GW]	6.7	6.7	9.4	5.6
Beam rf power [MW]	1.8	1.7	2.5	1.4

PEP-II Interaction Region



KEKB Storage Ring Layout



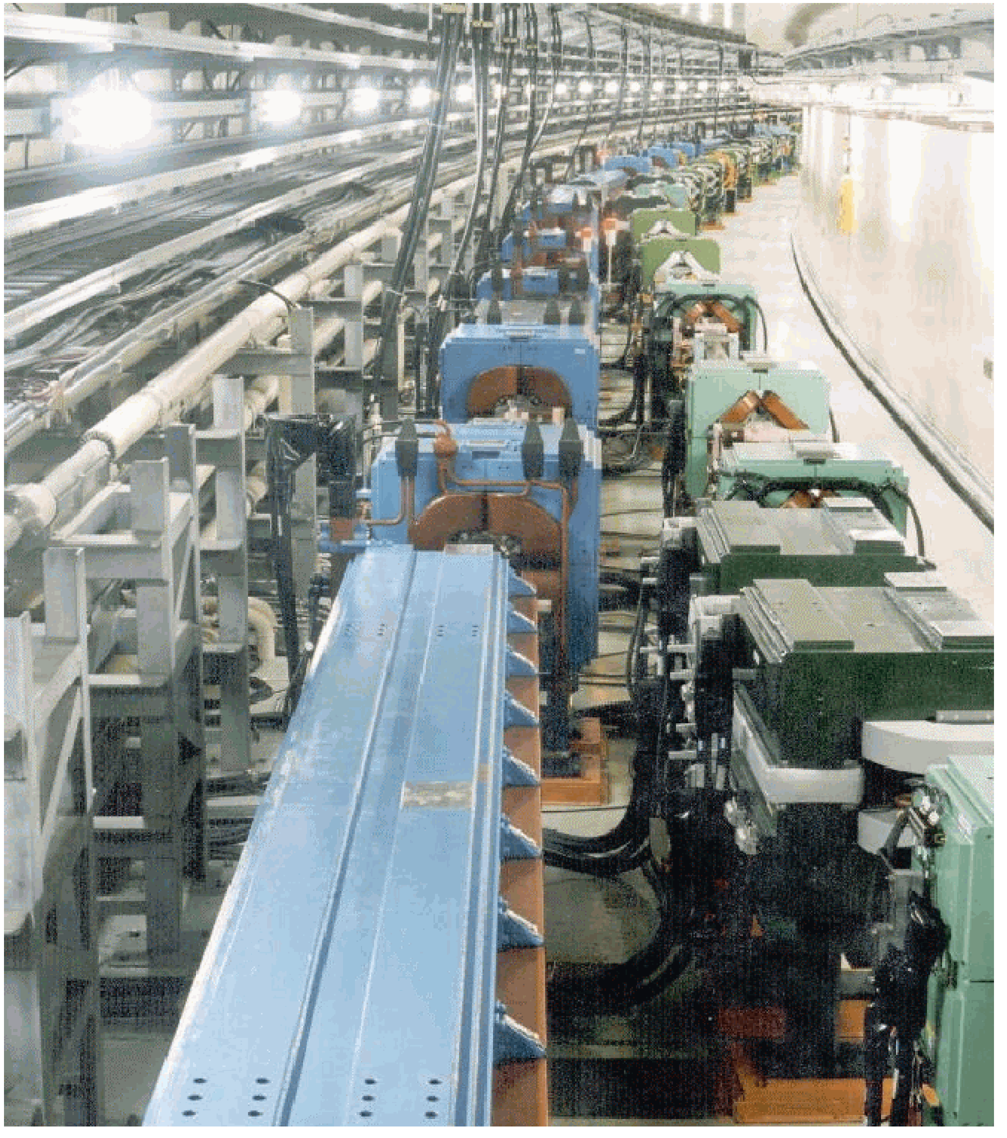
8 GeV e^- × 3.5 GeV e^+

$\Upsilon(4S)$ boost: $\beta\gamma = 0.425$

± 11 mrad crossing angle

Located in the 3 km Tristan tunnel at KEK

KEKB Arc Section

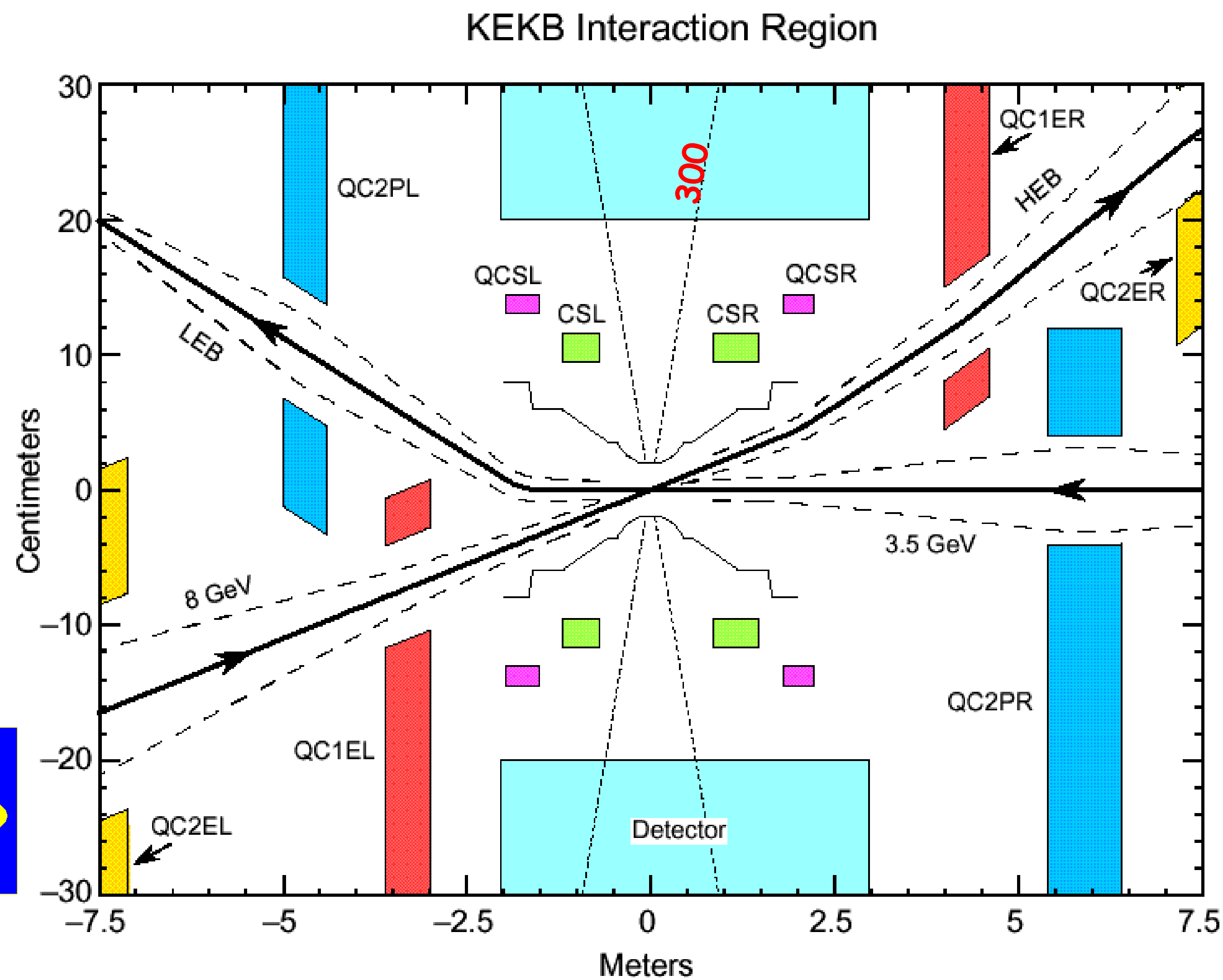


KEKB RF Section

KEKB Parameters

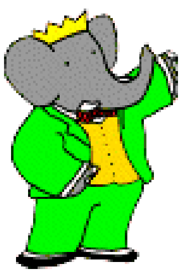
	Design		Achieved	
	e^-	e^+	e^-	e^+
Beam energies [GeV]	8	3.5		
Currents [A]	1.1	2.6	0.92	1.37
Number of bunches	5000		1223	
Luminosity [$\times 10^{33}$ $cm^{-2}s^{-1}$]	10.0		7.35	
Bunch spacing [m]	1.2		2.4	
Bunch currents [mA]	0.22	0.52	0.71	1.14
Beam stored energy [kJ]	90	92	73	49
Beam power [GW]	9	9	7	5
Beam rf power [MW]	4.0	4.5	3.2	2.4

KEKB Interaction Region



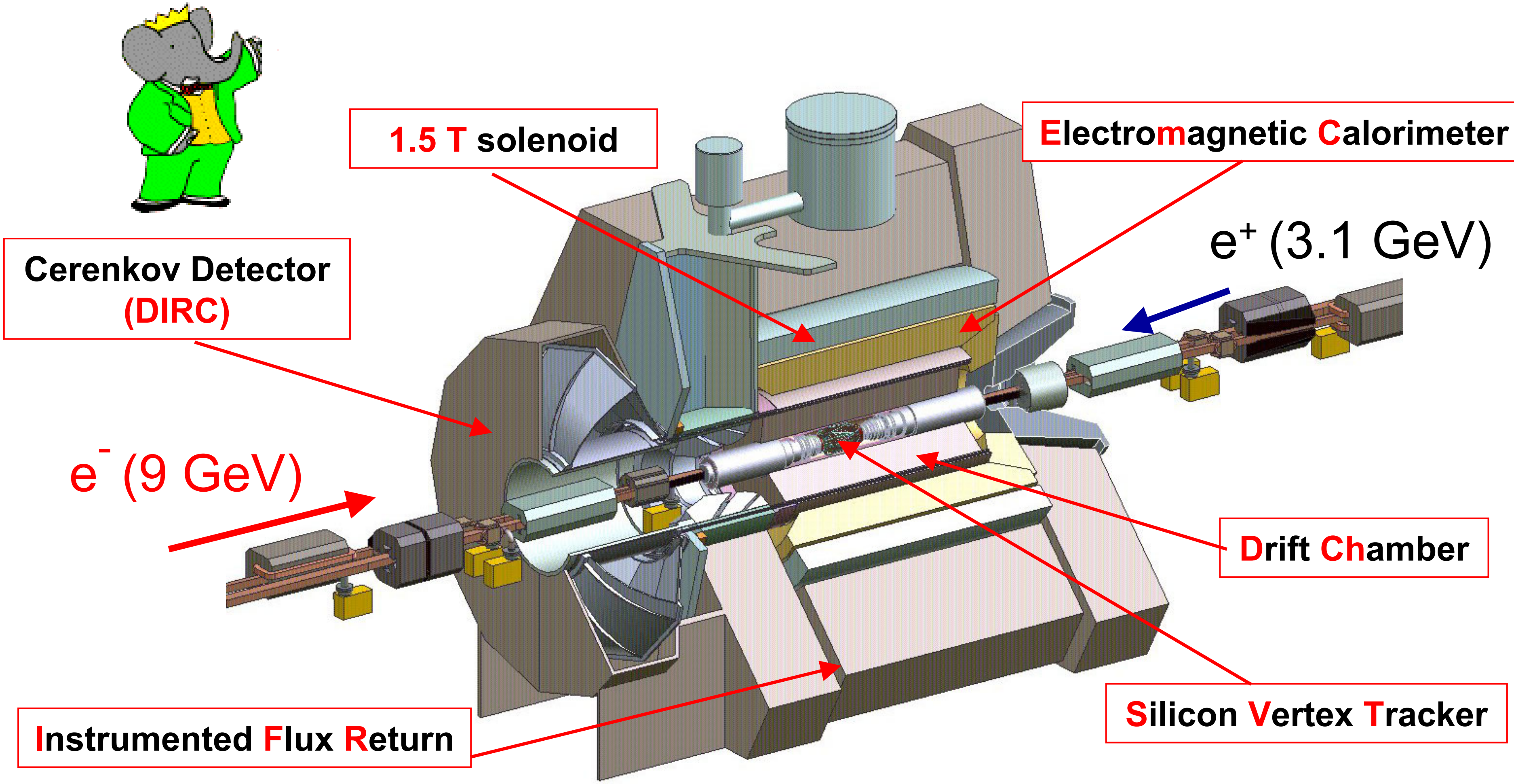
BABAR Collaboration

Gathering at SLAC, July 2002

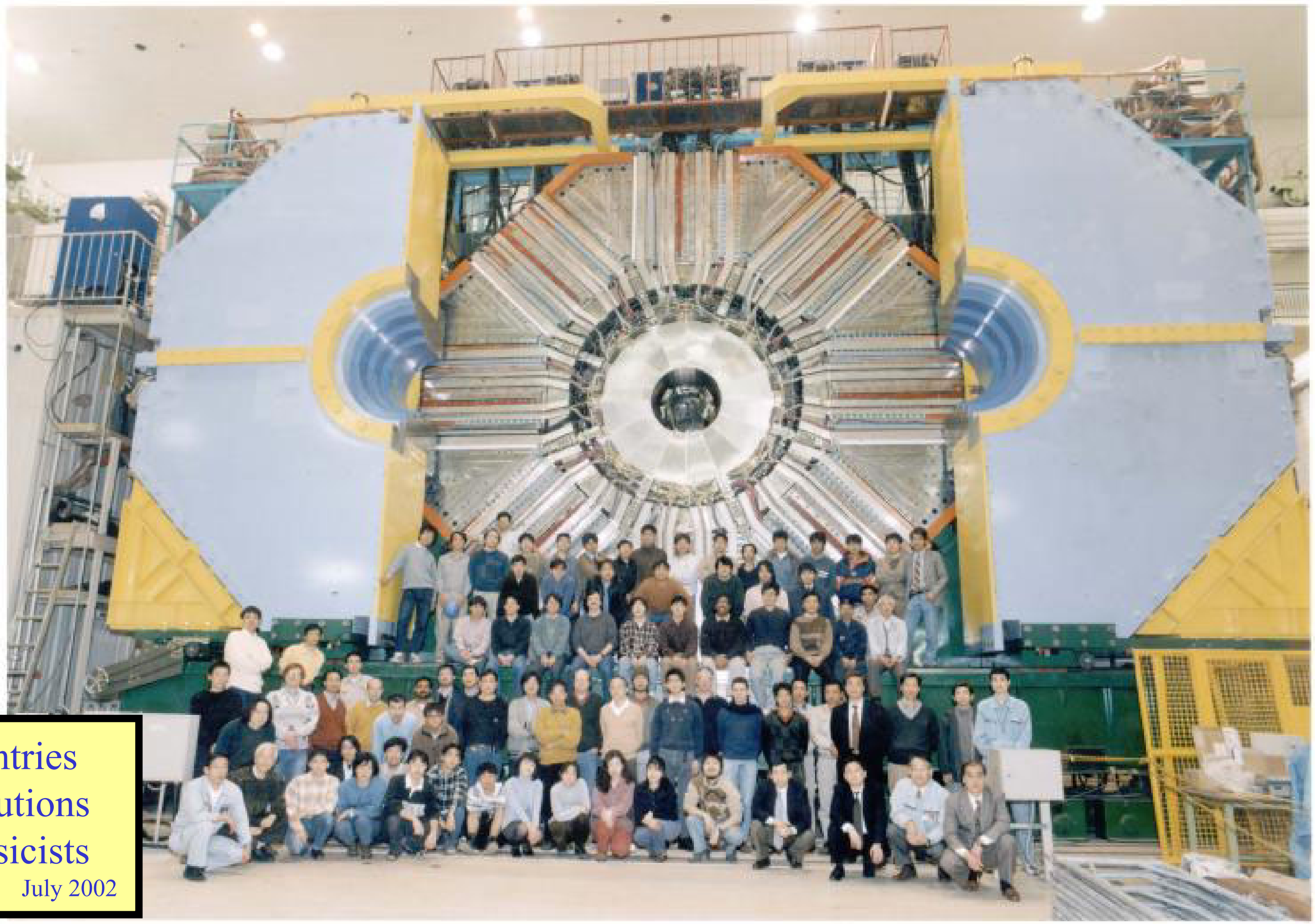


9 Countries
76 Institutions
550 Physicists
July 2002

BABAR Detector

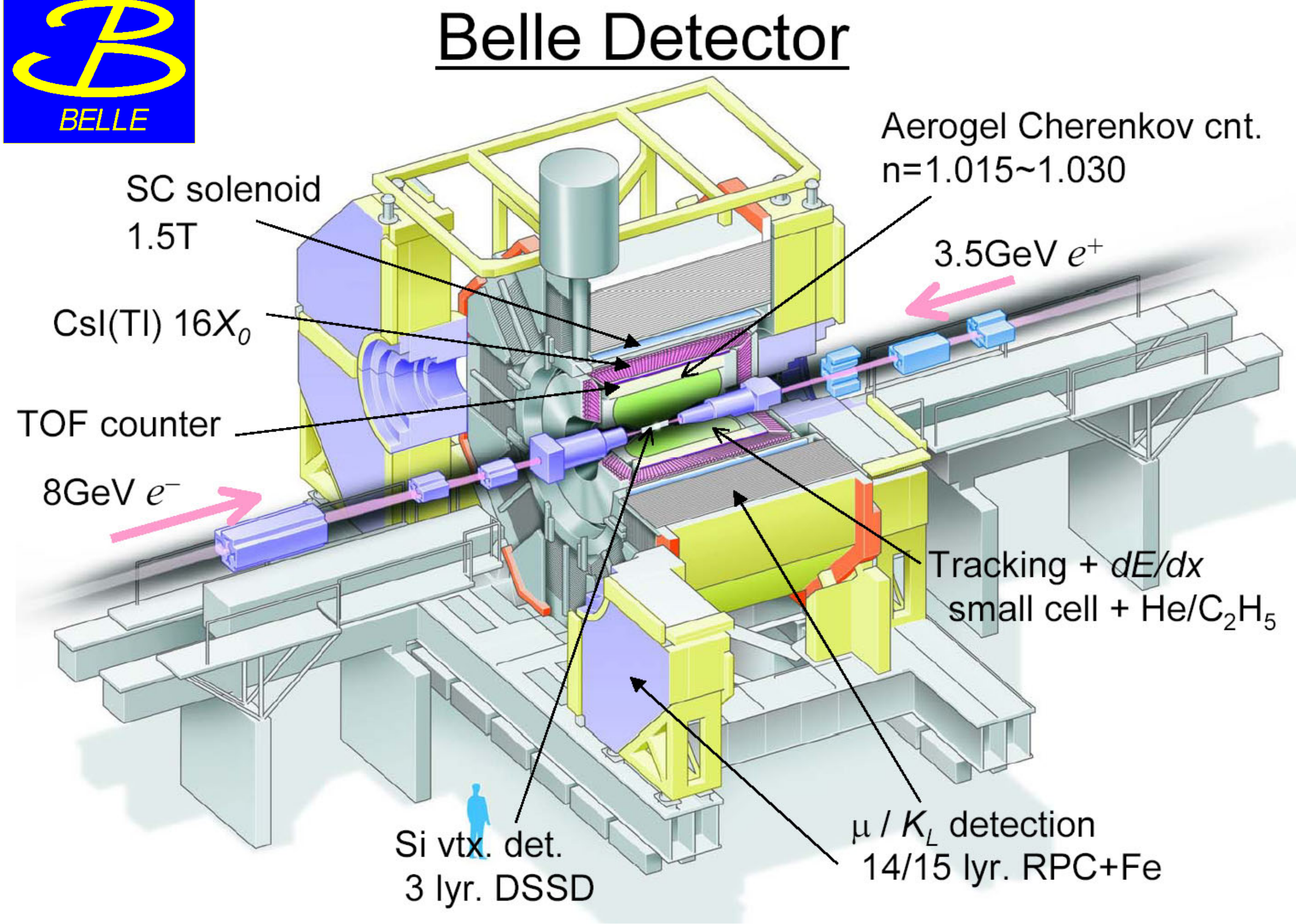


Belle Collaboration

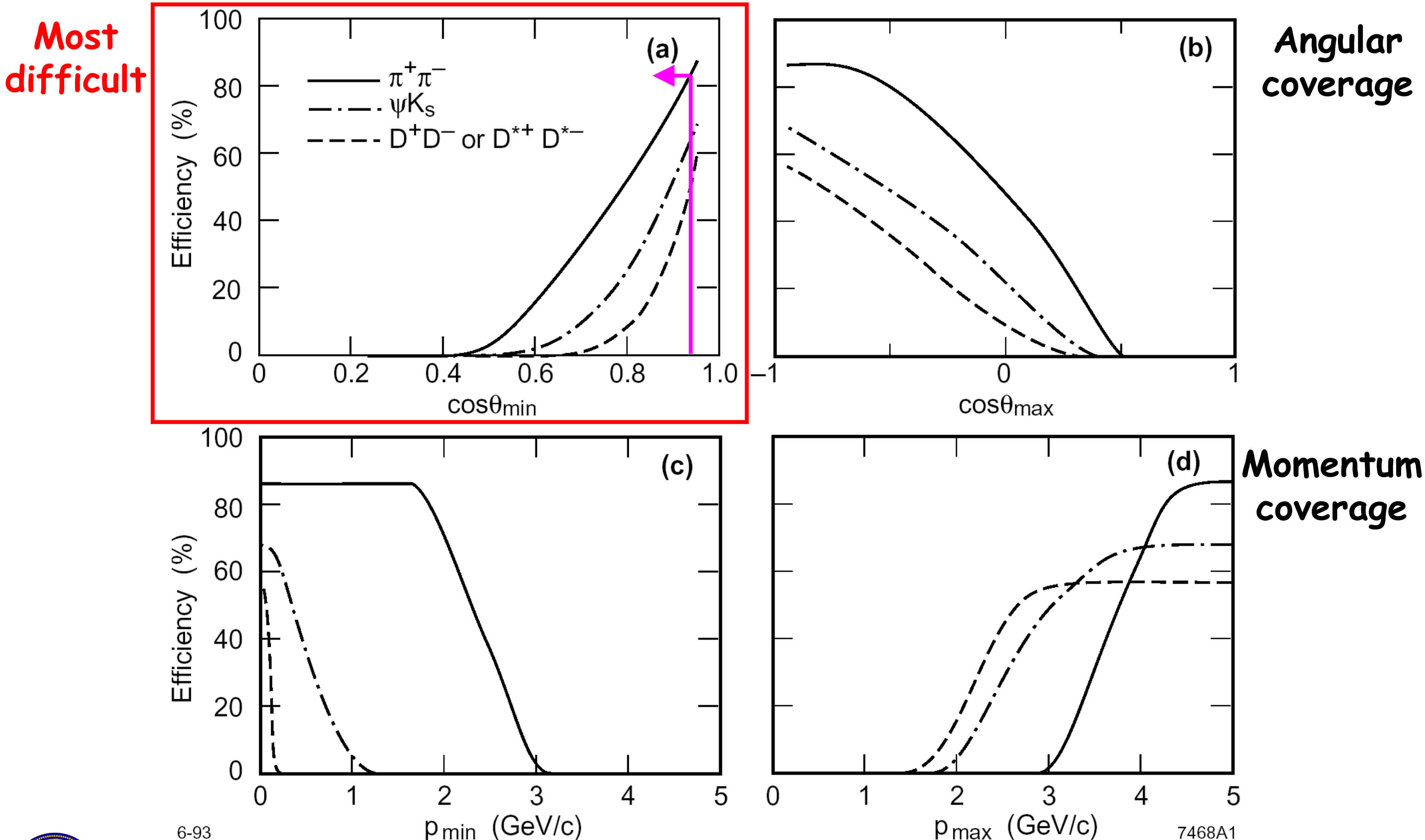


12 Countries
54 Institutions
285 Physicists
July 2002

Belle Detector

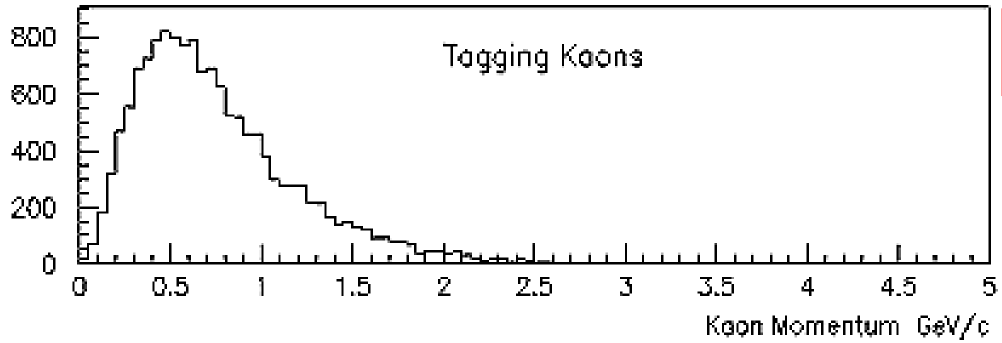


Requirements: Geometric Acceptance



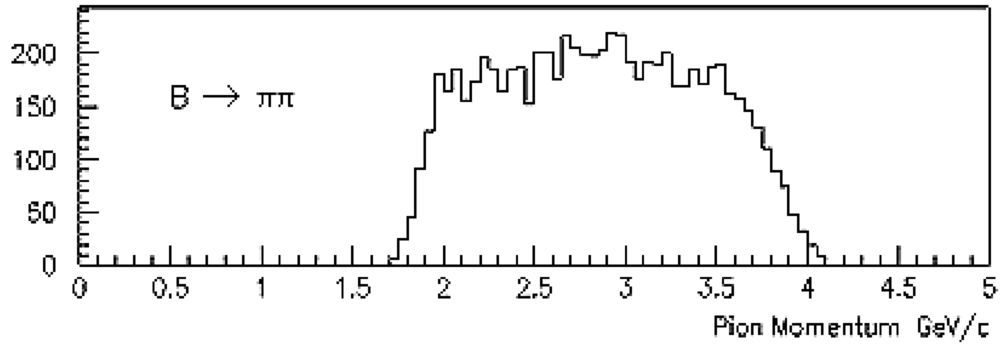
Requirements: Tracking and PID

Kaon spectra from Υ(4S) decays



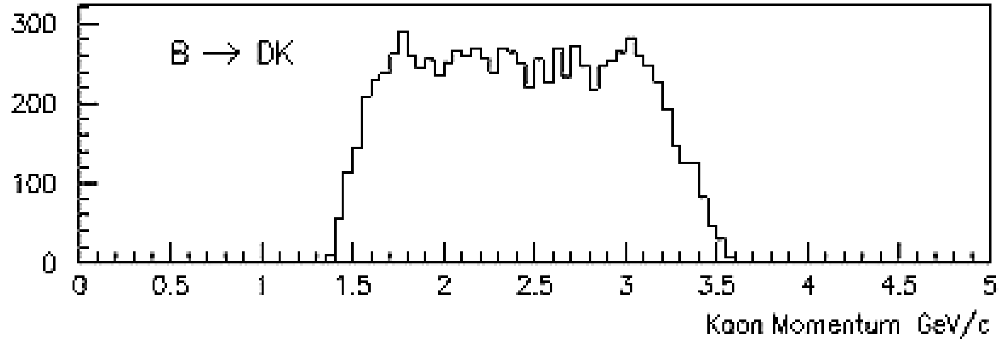
Tagging Kaons

Relatively soft, ms dominated for tracking



B → ππ

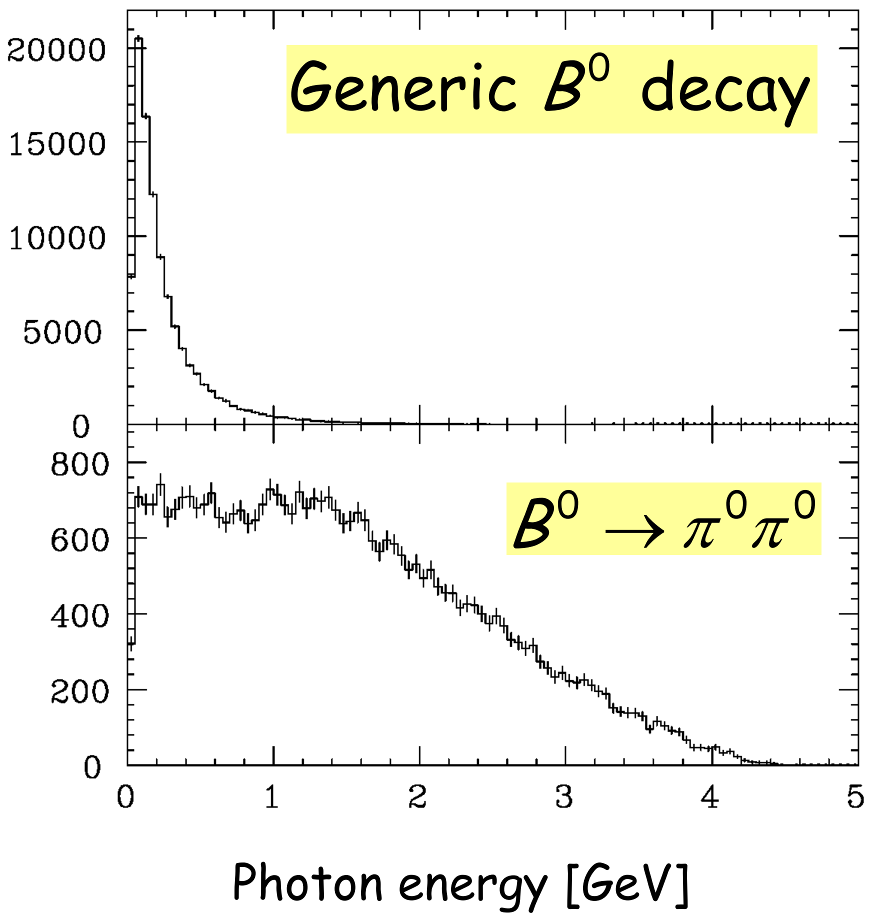
Requires dedicated PID

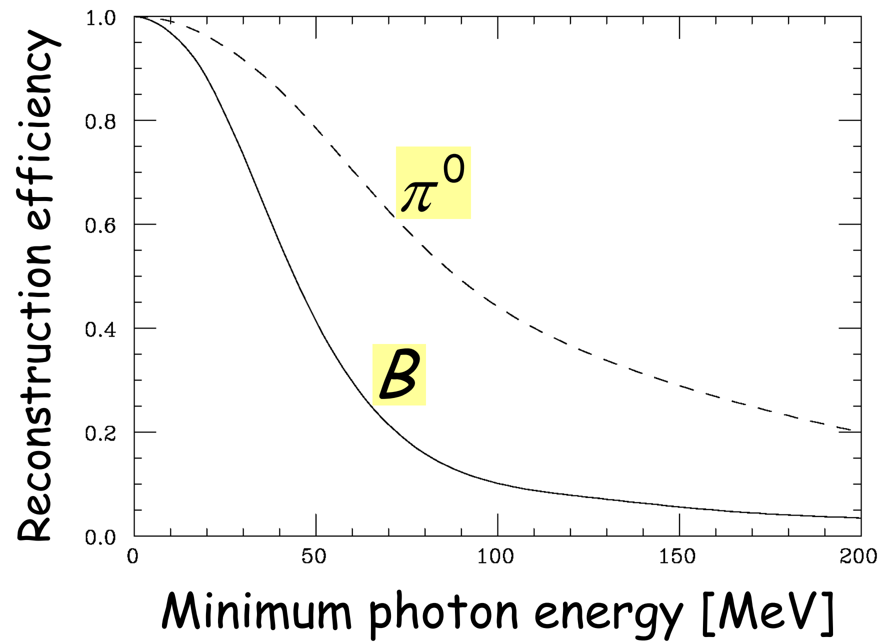


B → DK

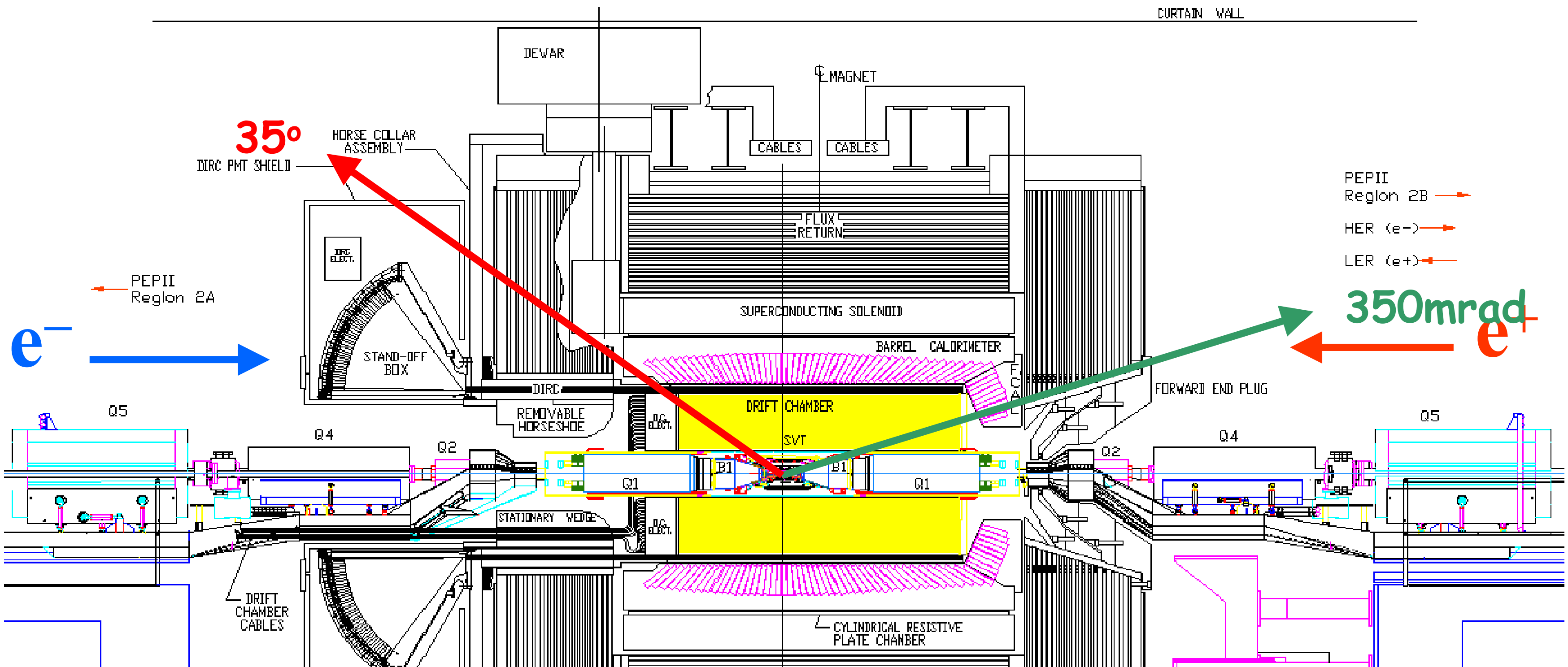
Requires dedicated PID

Requirements: Photons

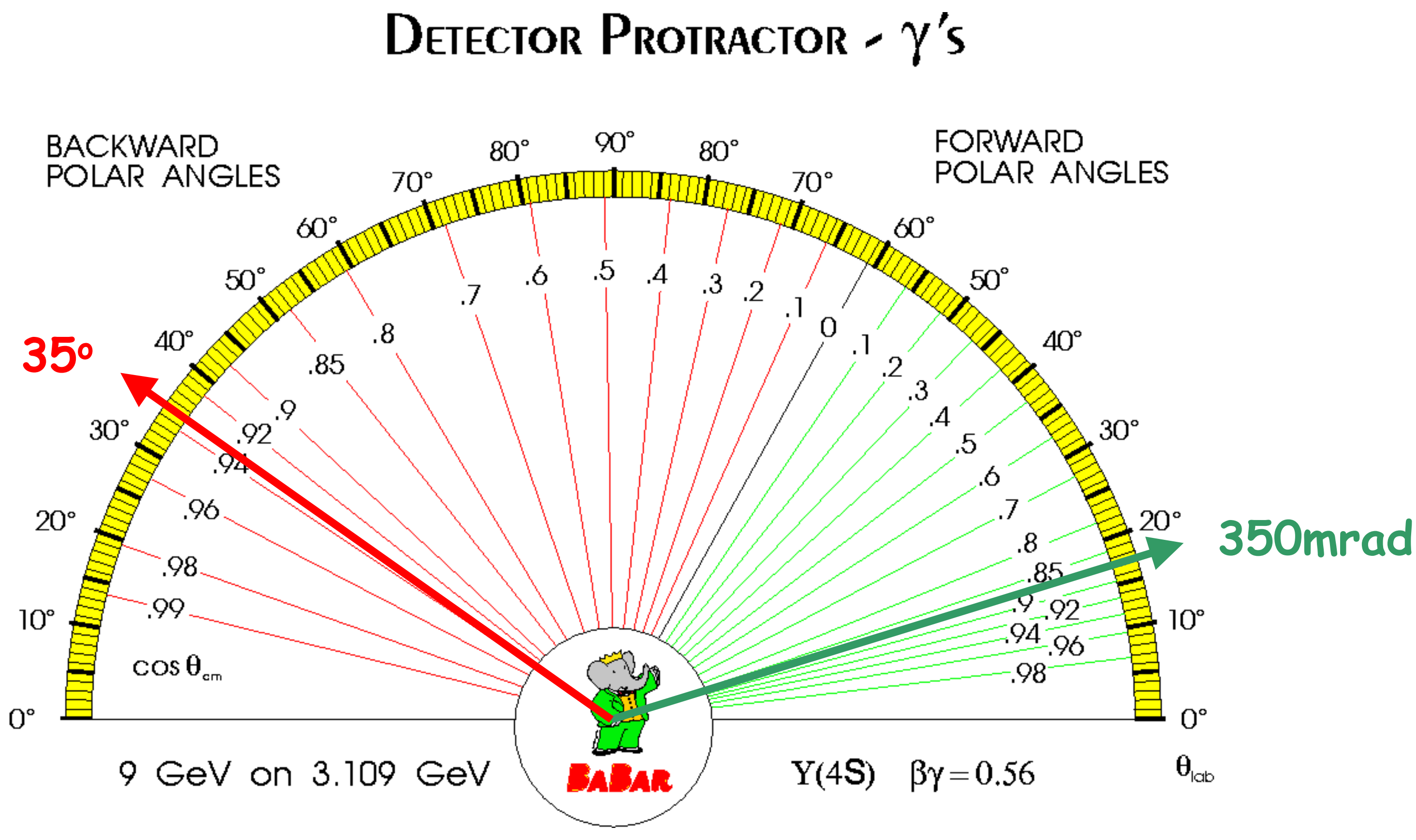




BABAR Detector



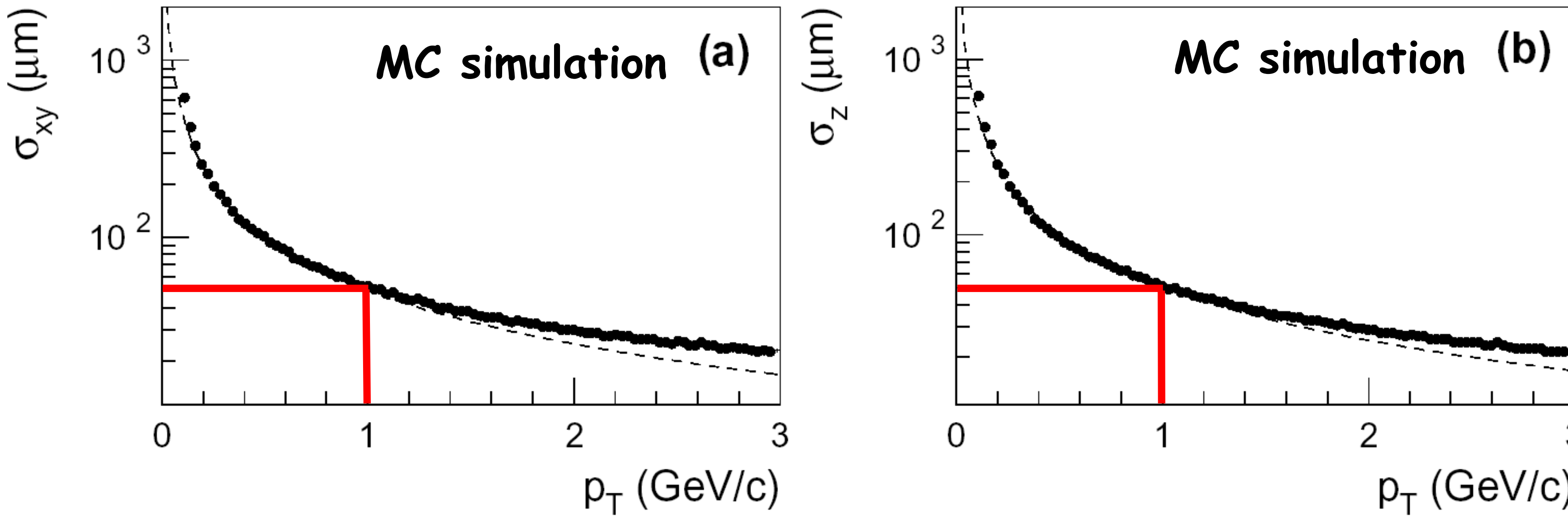
Impact of Boost



Vertex Detector Design

- ## *Requirements*
  - Transverse and longitudinal vertex resolution
    - Resolution on Δz must be small compared to oscillation distance
  - Polar and azimuthal angles at IP
  - [Stand-alone tracking and D^* detection]
  - High background tolerance and hence segmentation
  - Tolerance and longevity in high radiation environment
- ## *Constraints*
  - IP geometry sets acceptance (magnets occlude below 350mrad)
  - Shielding of SR backgrounds sets minimum radius
  - Cost sets outside radius
- ## *Implementation*
  - Double-sided AC-coupled silicon microstrip detectors
  - Custom radiation-hard readout chip

Vertex Resolution



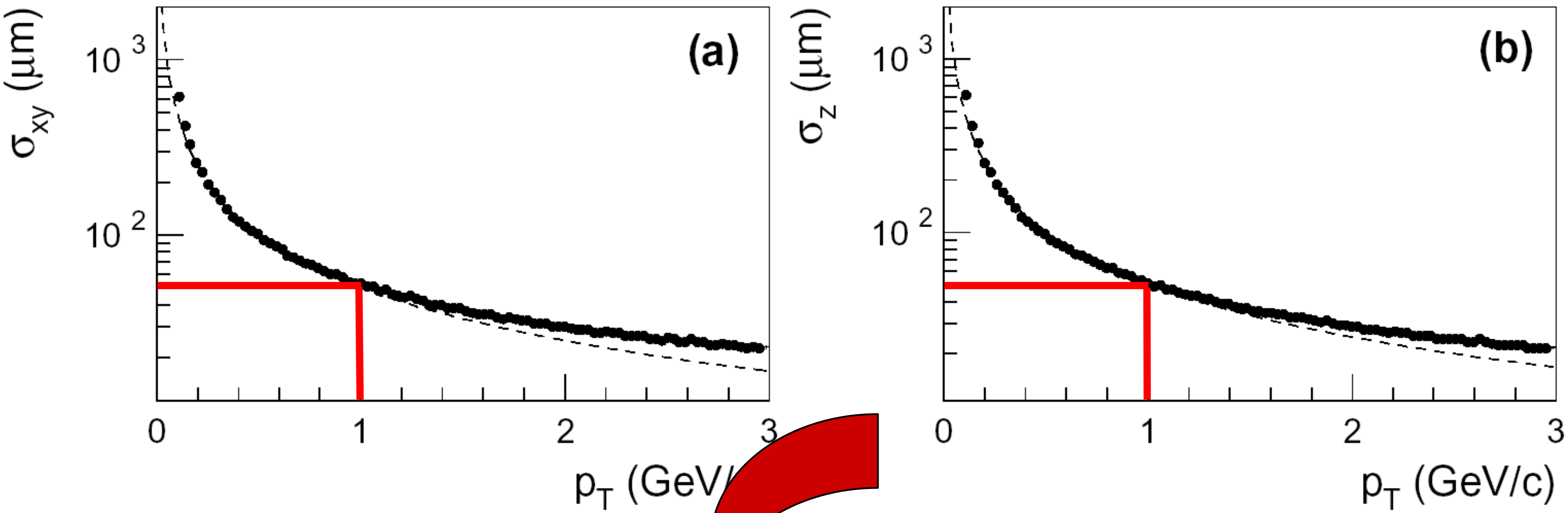
$$\sigma^2_{xy,z} = \sigma^2_{ms} + \sigma^2_{det}$$

$\sigma_{det} \sim 15\ \mu\text{m at } 90°$ ← Typical single point resolution for silicon microstrip detectors

$$\sigma_{ms} = \frac{0.014\, r\sqrt{X}}{\beta c p \sin^{5/2}\theta} \quad [p \text{ in GeV/c}]$$

$\sim 50\ \mu\text{m at 1 GeV/c}$ ← r_{BP} = 2.5cm, 1.13% X_0 in Be+H_2O

Vertex Resolution

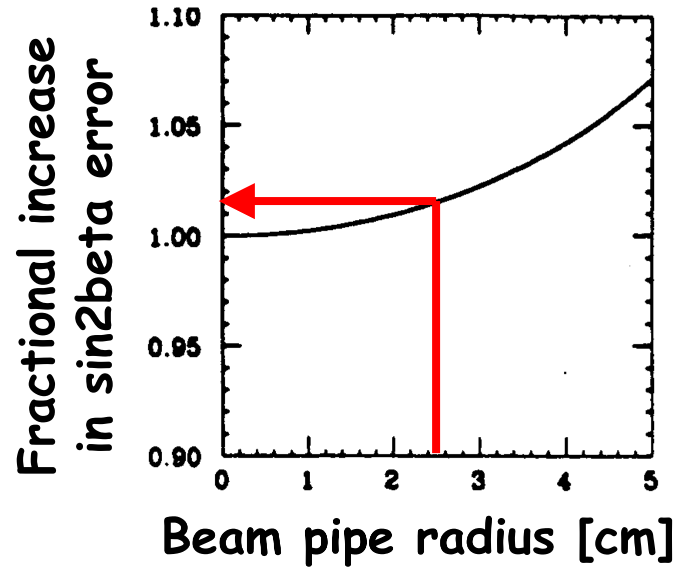


$$\sigma^2_{xy,z} = \sigma^2_{ms} + \sigma^2_{\det}$$

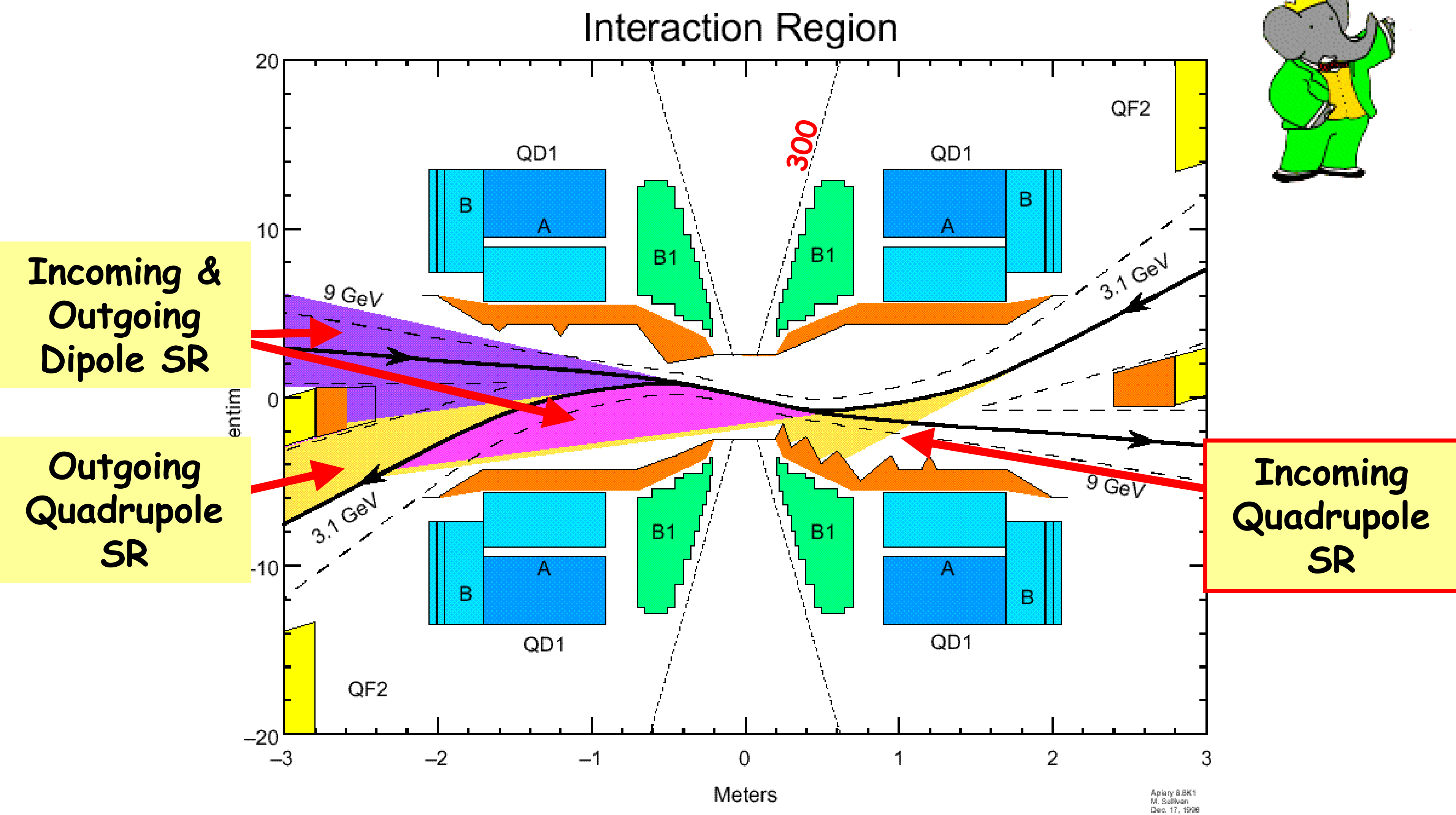
$\sigma_{\det} \sim 15\ \mu\text{m at } 90°$

$$\sigma_{ms} = \frac{0.014 r \sqrt{X}}{\beta c p \sin^{5/2}\theta} \quad [p \text{ in GeV}/c]$$

$\sim 50\ \mu\text{m at } 1\ \text{GeV}/c$

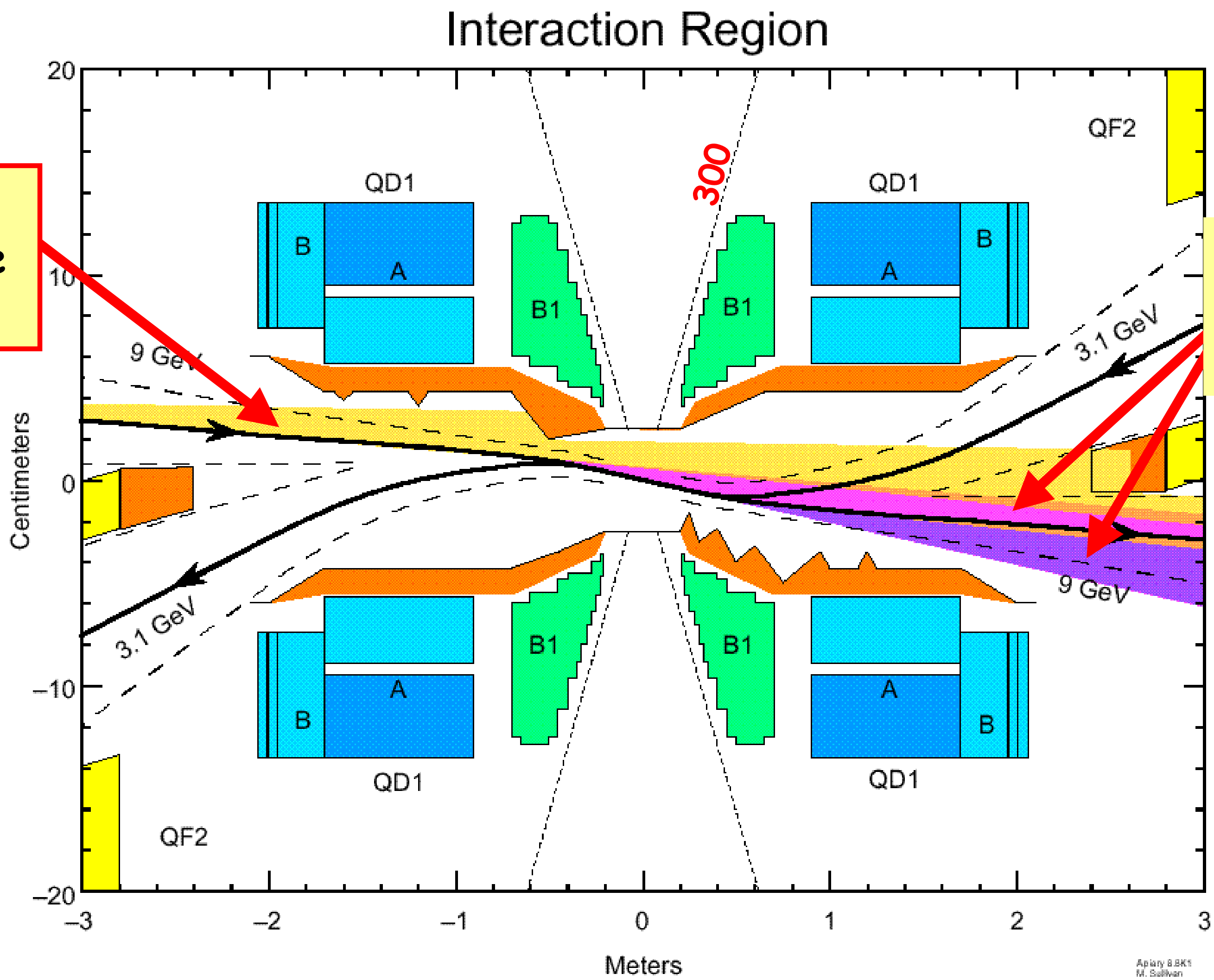


PEP-II IR SR fans: LER Beam



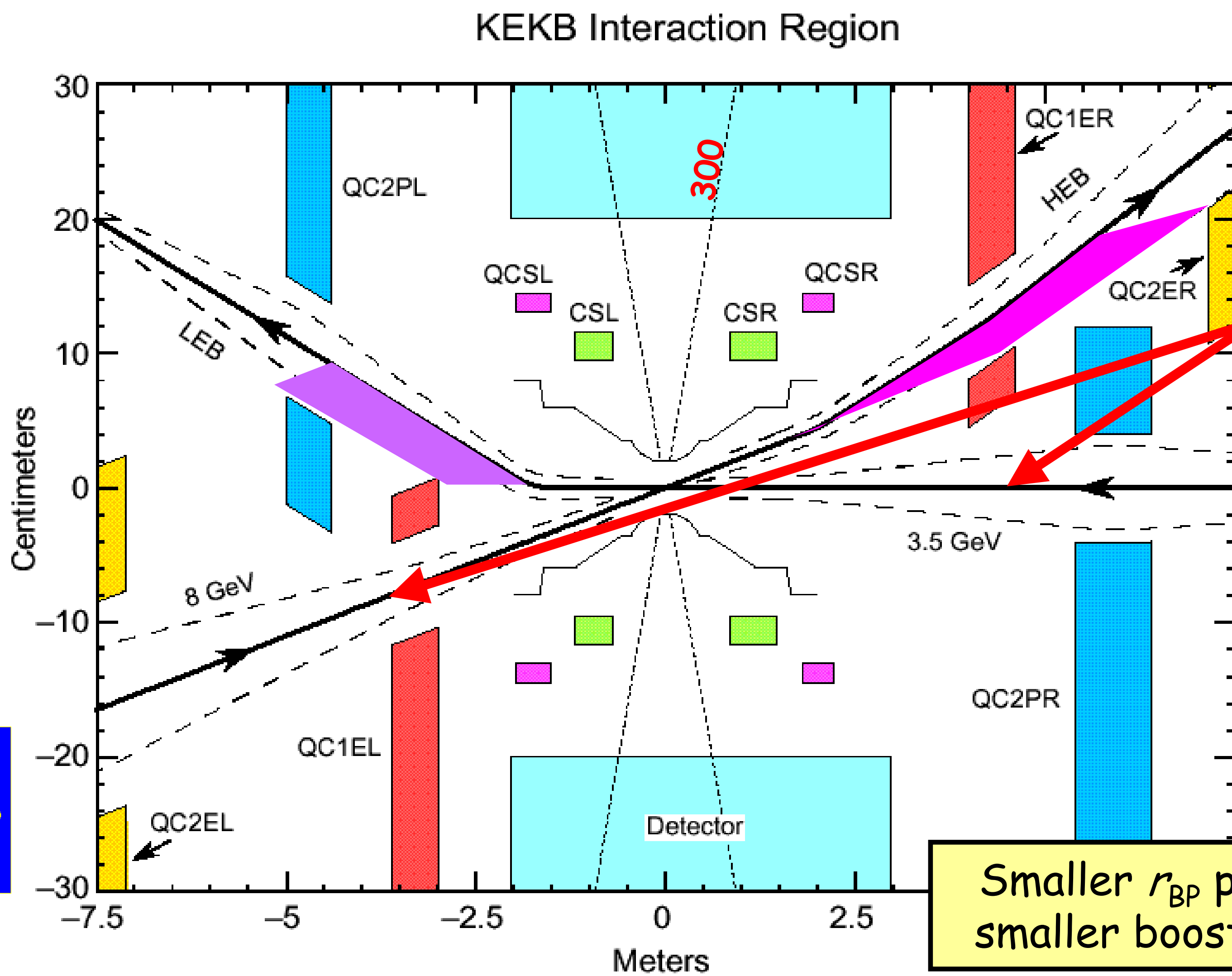
PEP-II IR SR fans: HER Beam

Incoming Quadrupole SR



Incoming & Outgoing Dipole SR

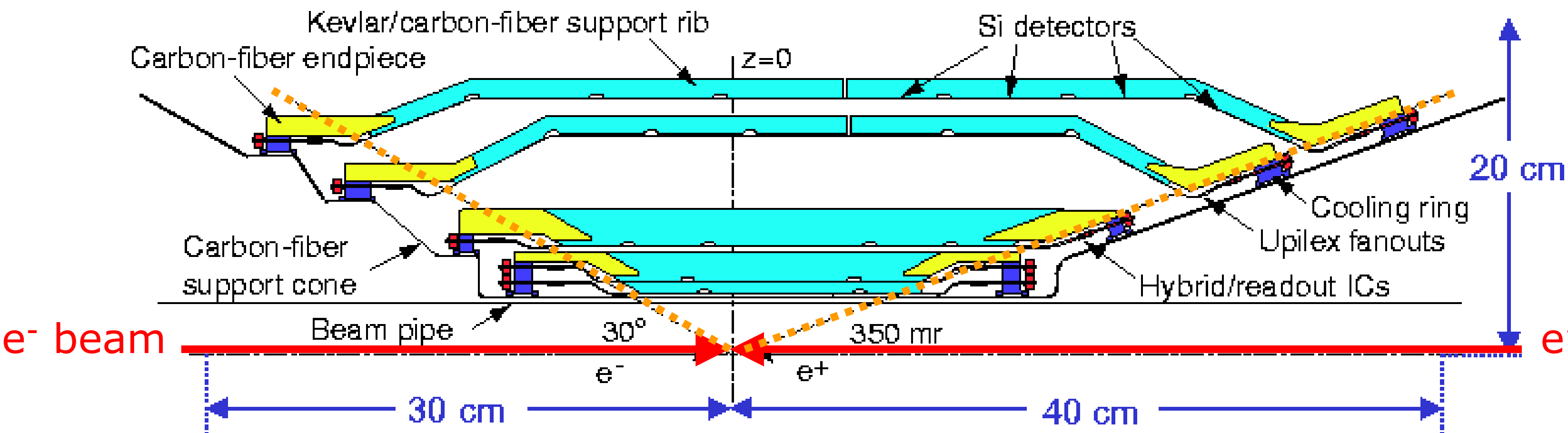
SR Fans in KEKB Design



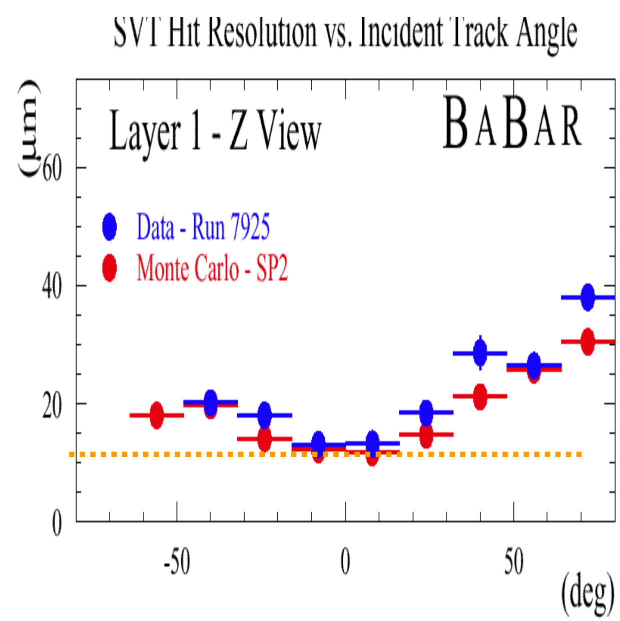
Incoming beams on axis: No SR

Smaller r_{BP} possible: smaller boost as well

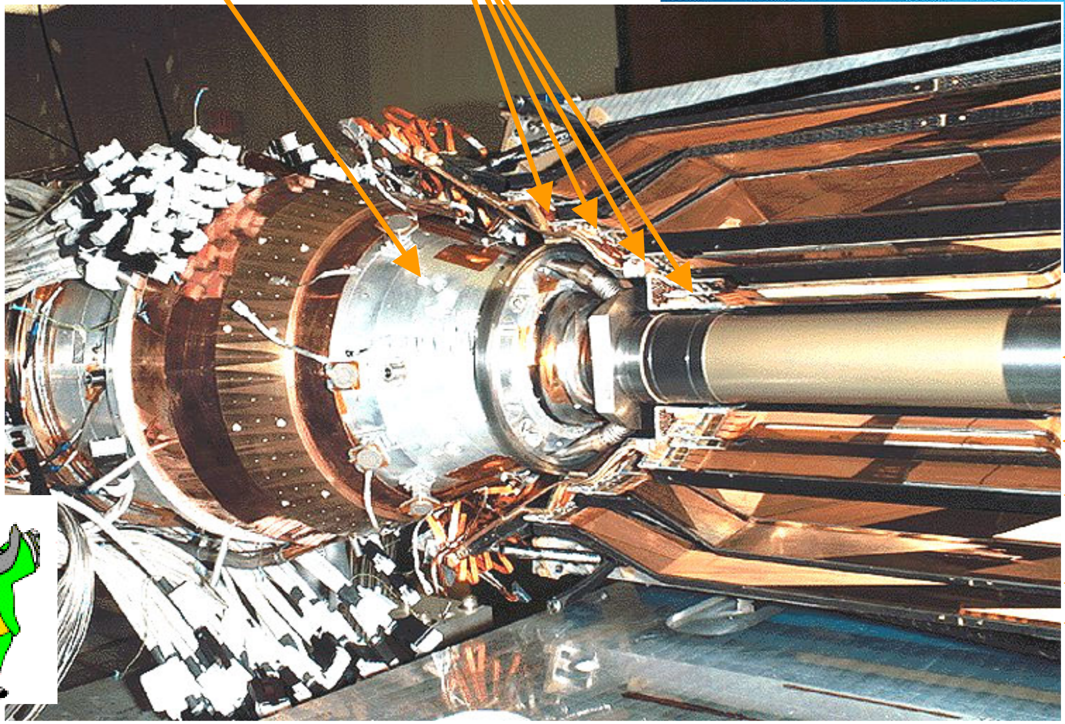
Silicon Vertex Detector at BABAR



- *5 Layer AC-coupled double-sided silicon detector*
- *Located in high radiation area*
  - Radiation hard readout electronics (4-5Mrad)
- *97% hit reconstruction efficiency*
- *Hit resolution ~15 μm at 90°*

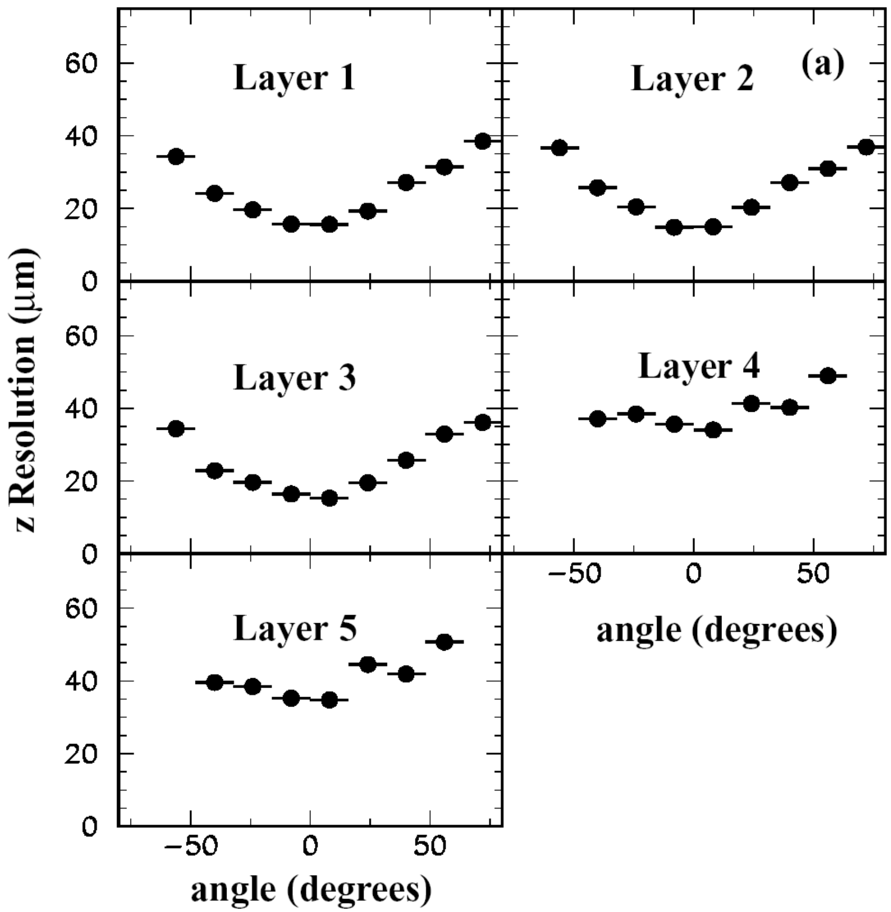


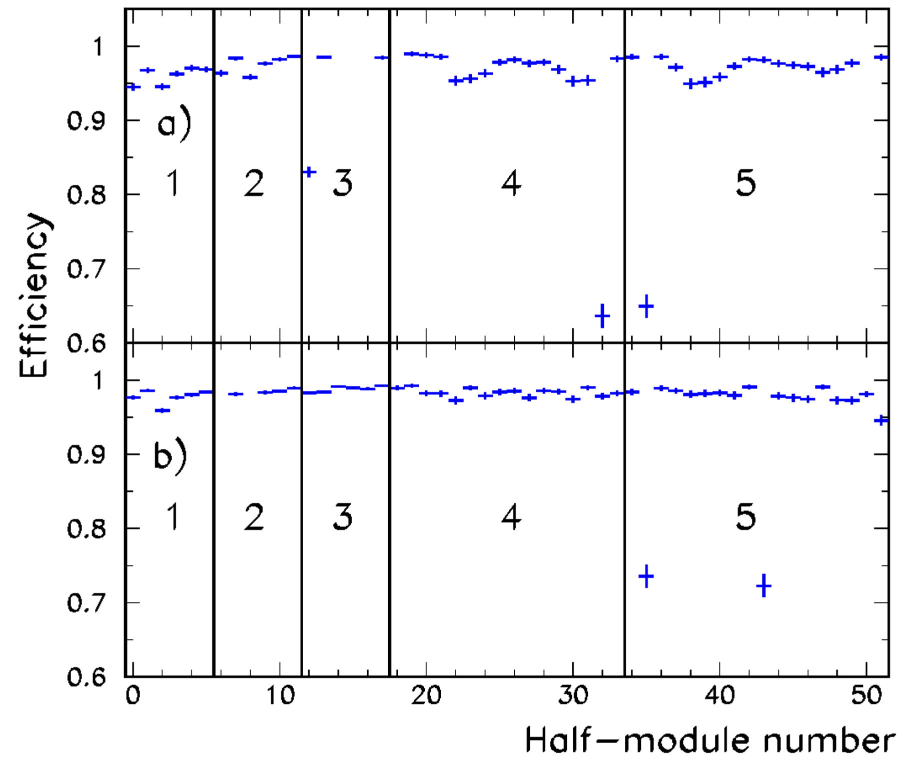
Completed SVT Detector

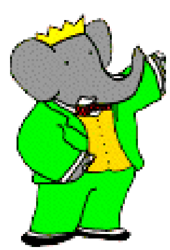


$r_{BP,IR}$ = 25 mm
2 x Be walls = 0.83+0.53 mm T
1.5 mm H_2O cooling gap

Resolutions and Efficiencies





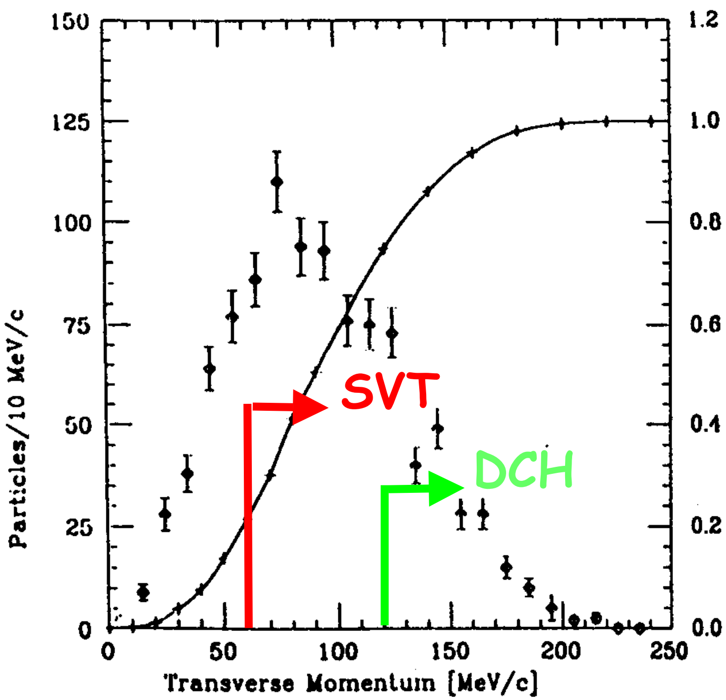


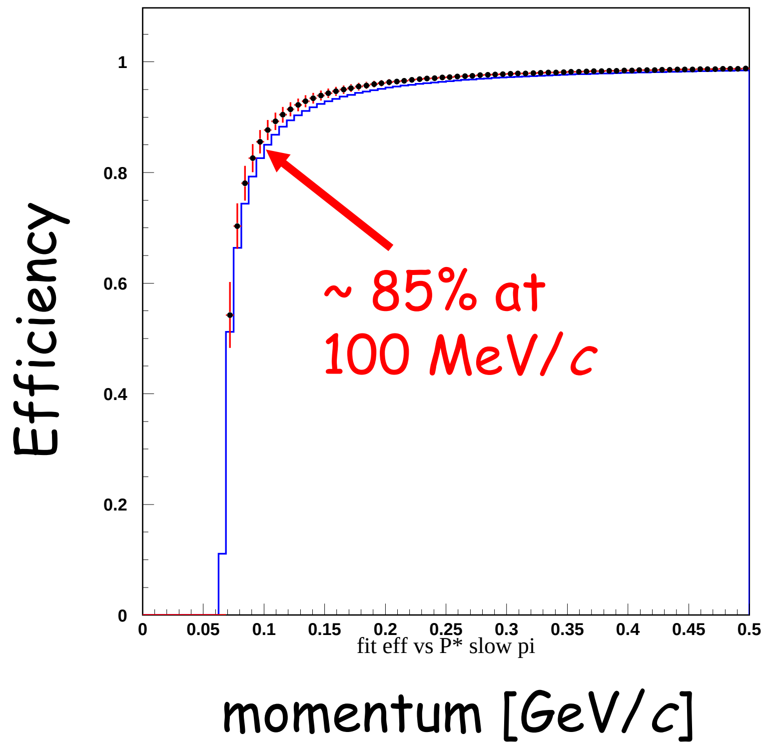
Requirements: Low p_t Tracking

Common to reconstruct $D^{*+} \rightarrow D^0\pi^+$ with very soft π^+

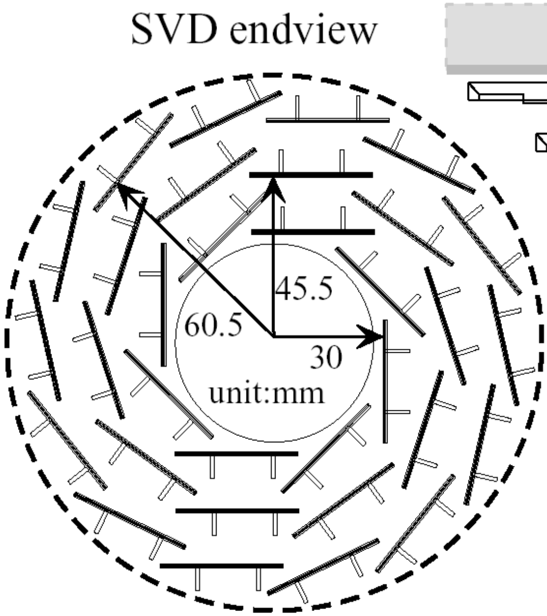
Advantage: *Excellent resolution for mass difference*

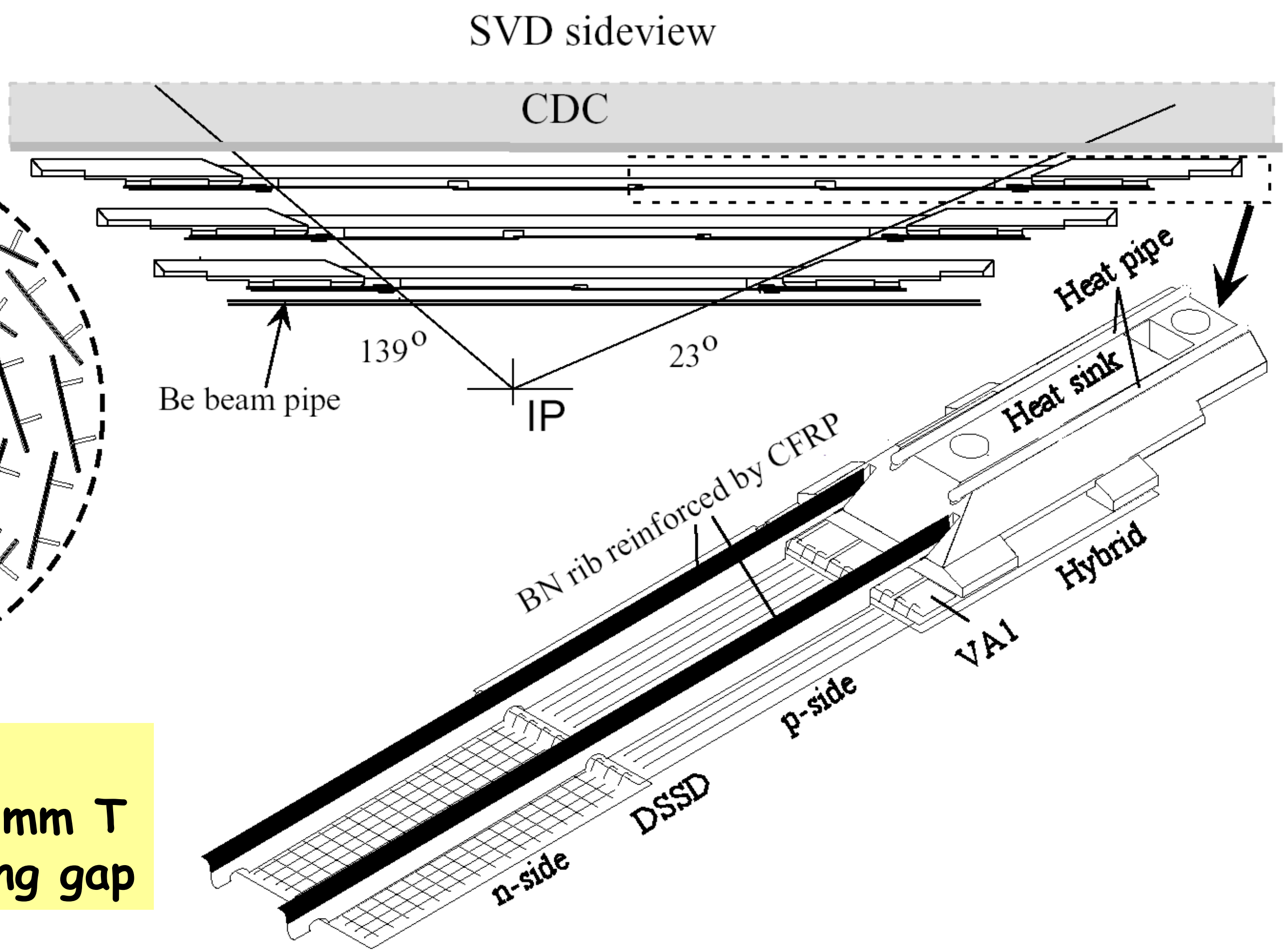
Disadvantage: *Small bending radius, difficult to track*





Silicon Vertex Detector at Belle





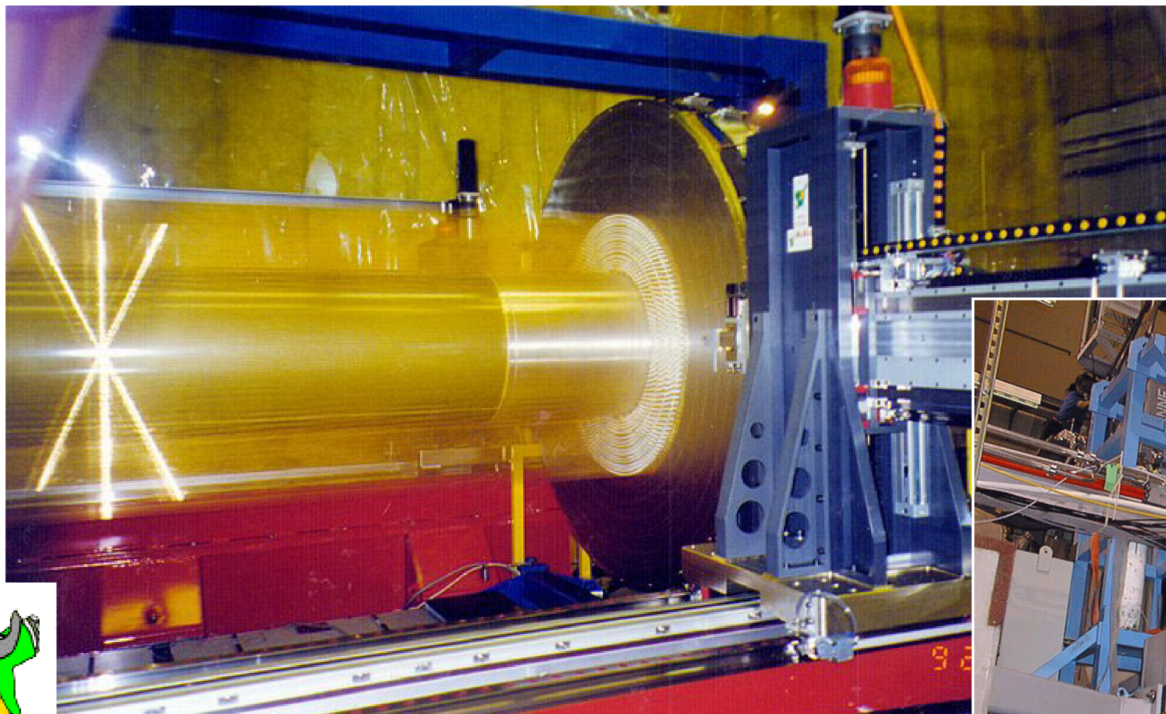
$r_{BP,IR}$ = 20 mm
2xBe walls = 2x0.5 mm T
2.5 mm Helium cooling gap

Drift Chamber Design

- **Requirements**
  - p_t measurement over maximum possible solid angle
  - 5 track parameters for secondary tracks
  - Track projections onto DIRC (angle) and EMC
  - dE/dx measurements for tagging (low momentum)
  - Fast L1 input to tracking trigger
- **Constraints**
  - Machine elements define angular acceptance
  - Outside radius balances cost (EMC) and p_t resolution $\sigma(p_t) \sim BR^2$
  - Minimize material in front of EMC, DIRC
- **Implementation**
  - Small-cell design for large number of tracks, low momentum
  - Aluminum field wires, helium-based gas to minimize multiple scattering contribution to resolution

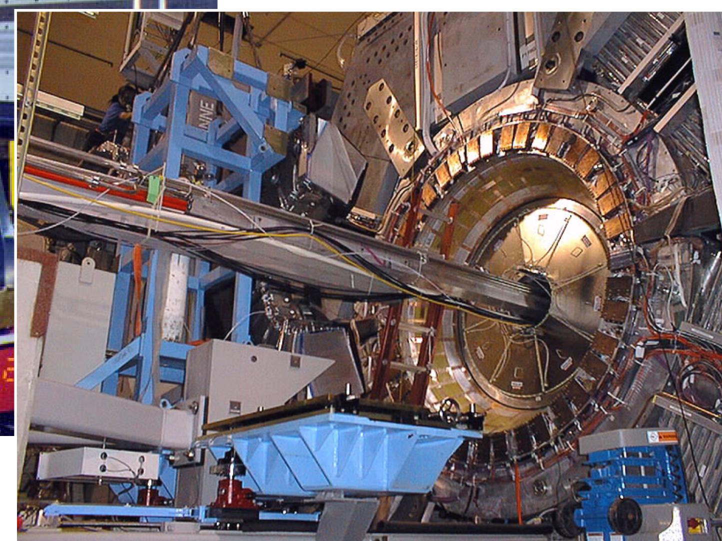
BABAR Drift Chamber

- 40 layers of wires (7104 cells) in 1.5 Tesla magnetic field
- Helium:Isobutane 80:20 gas, Al field wires, Beryllium inner wall, and all readout electronics mounted on rear endplate
- Particle identification from ionization loss (7% resolution)



$$\frac{\sigma(p_T)}{p_T} = 0.13\% \times p_T + 0.45\%$$

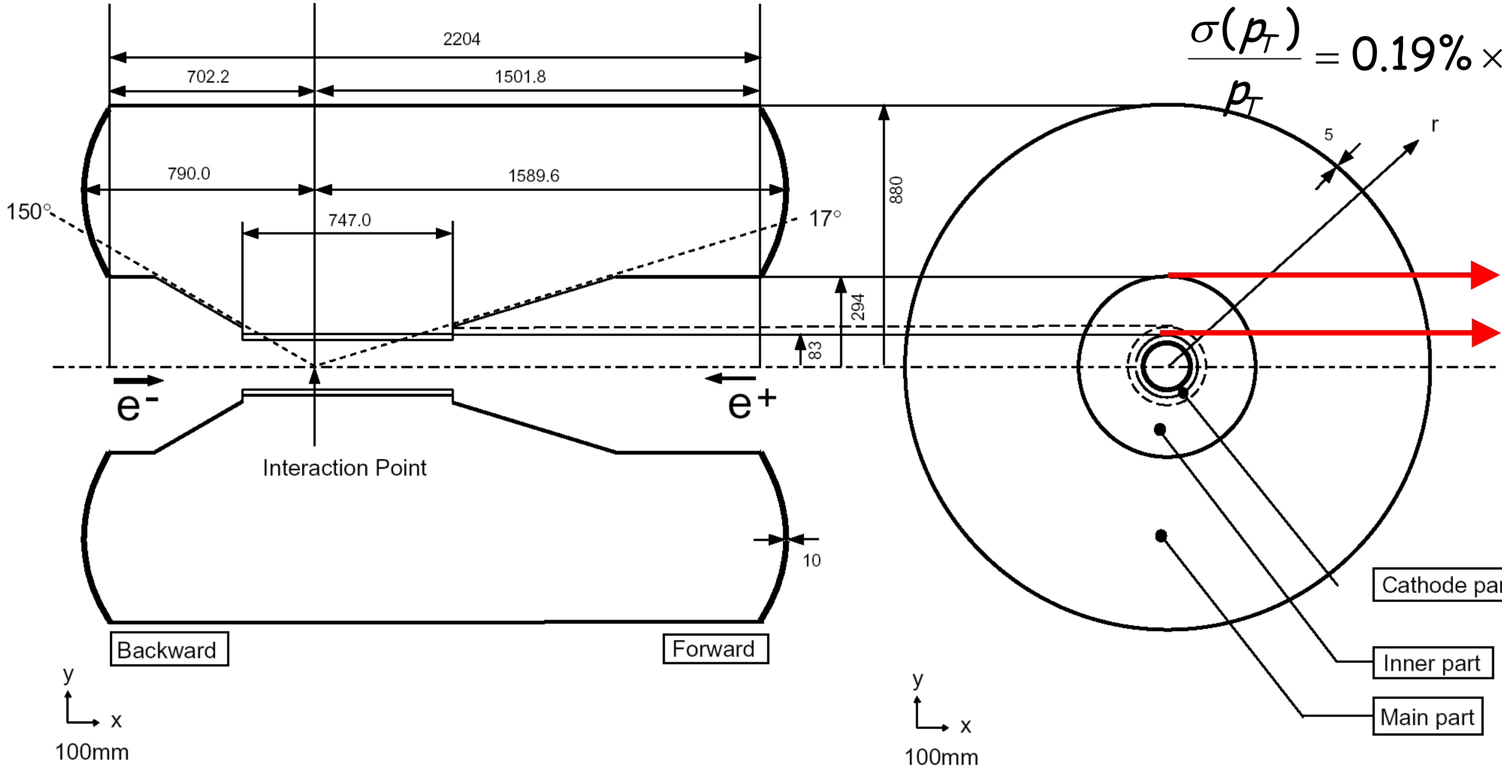
16 axial, 24 stereo layers



Belle Drift Chamber

- *50 layers of wires (8400 cells) in 1.5 Tesla magnetic field*
- *Helium:Ethane 50:50 gas, Al field wires, CF inner wall with cathodes, and preamp only on endplates*
- *Particle identification from ionization loss (5.6-7% resolution)*

$$\frac{\sigma(p_T)}{p_T} = 0.19\% \times p_T \oplus \frac{0.30\%}{\beta}$$

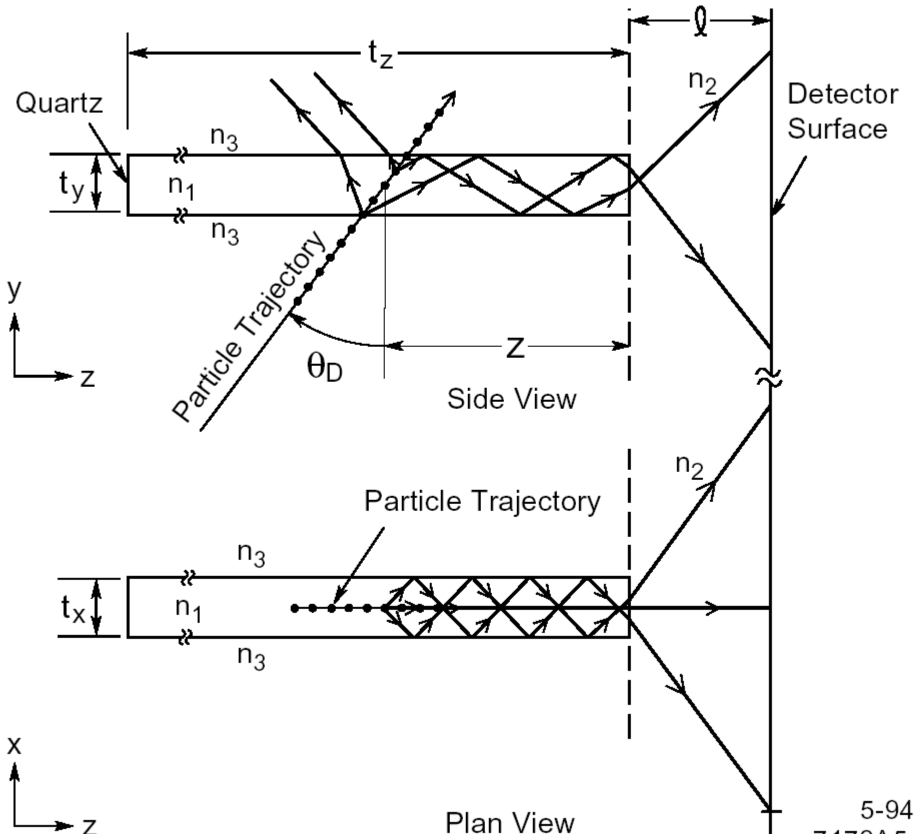


15 layers: 8.8-22.4 cm radius

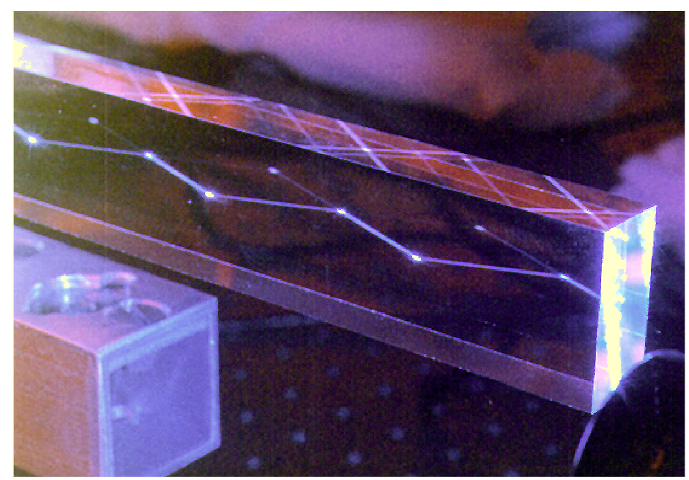
Hadron PID Detector Design

- ***PID Requirements***
  - In range 0.6-2 GeV/c for kaon tagging
  - Up to 4.4 GeV/c in forward direction for 2-body B decay modes
- ***Constraints***
  - Inside radius set by need to maximize tracking volume; outside by cost of calorimeter
  - Magnetic field limits photon detector choices in active volume
  - Minimal material degradation of calorimeter performance
- ***Implementation***
  - dE/dx covers part of kaon tag spectrum
  - For BABAR, novel ring-imaging Cherenkov detector (DIRC) based on quartz radiators and phototube imaging of rings
  - For Belle, time-of-flight (TOF) and threshold Cherenkov counters based on low-density materials and fine-mesh phototubes in active volume (ACC)

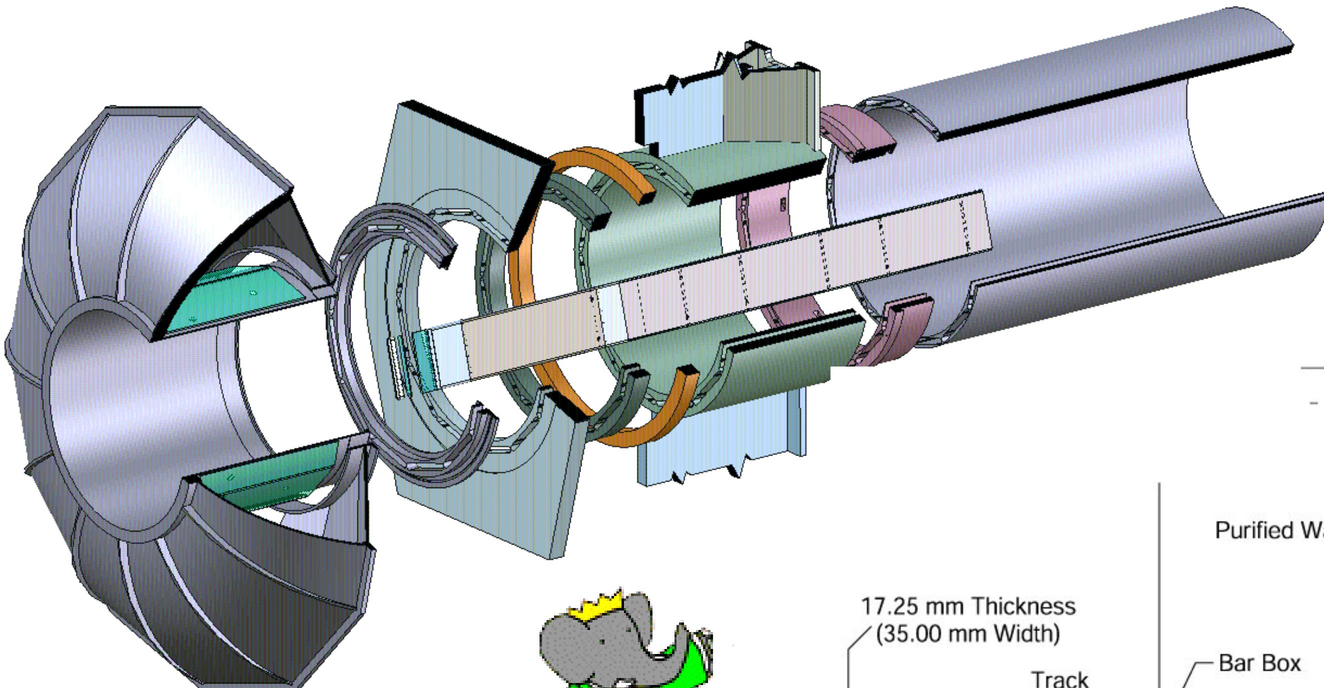
Principle of the DIRC

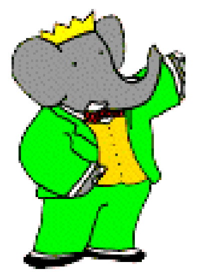


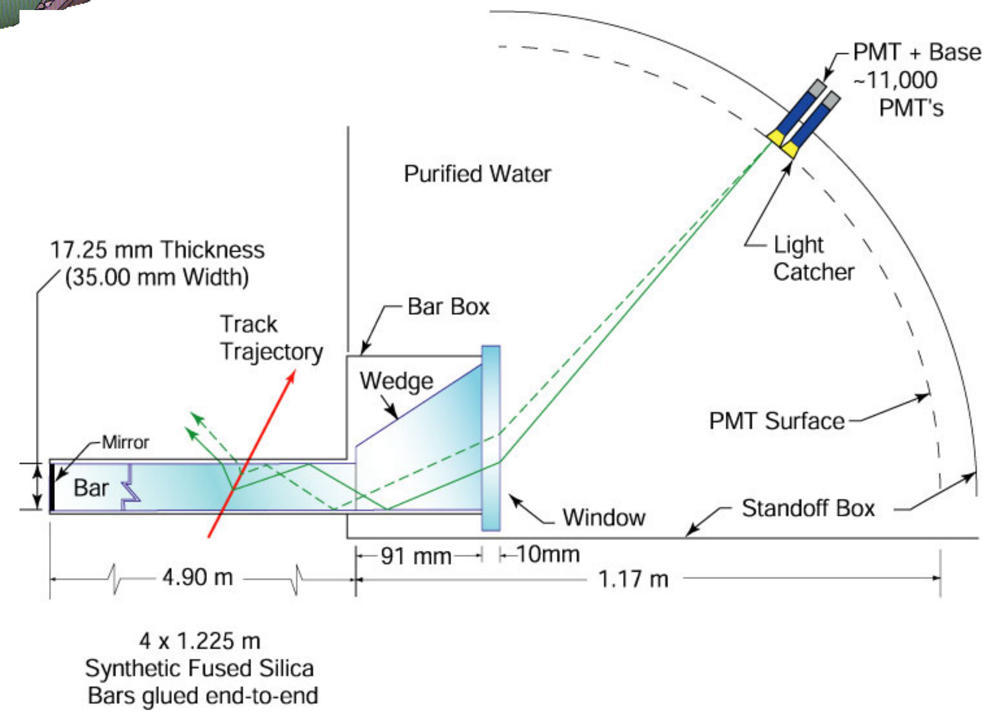
- UV Cherenkov light generated in quartz with characteristic $1/\beta$ opening angle
- Light transmitted length of bar by internal reflection, preserving angle information due to precision surfaces
- Rings projected in water-filled standoff box (best match to quartz index), where photons are detected with an array of 10K PMTs



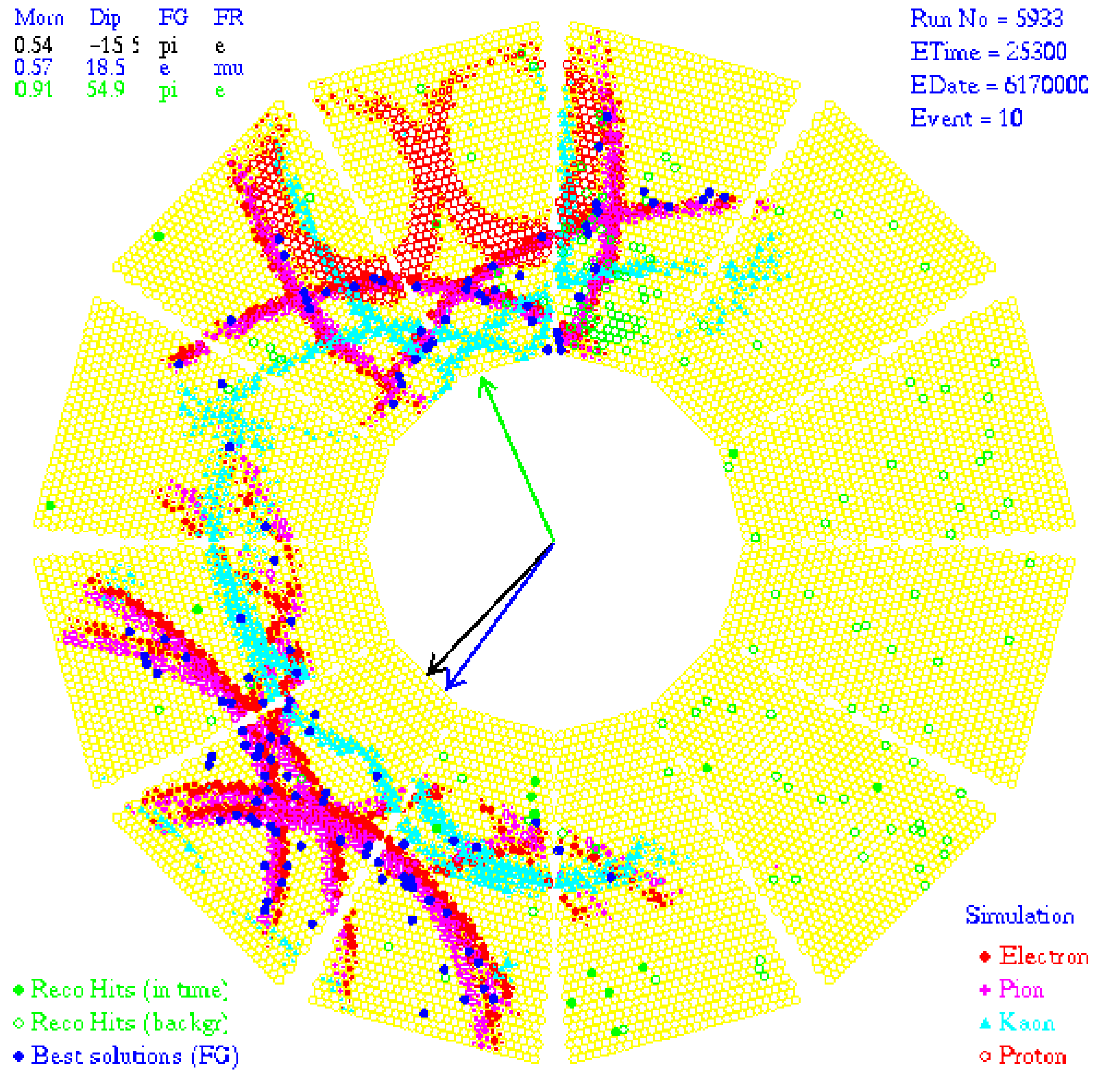
Elements of DIRC System

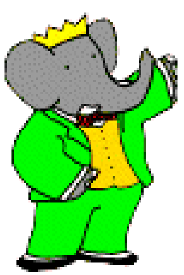




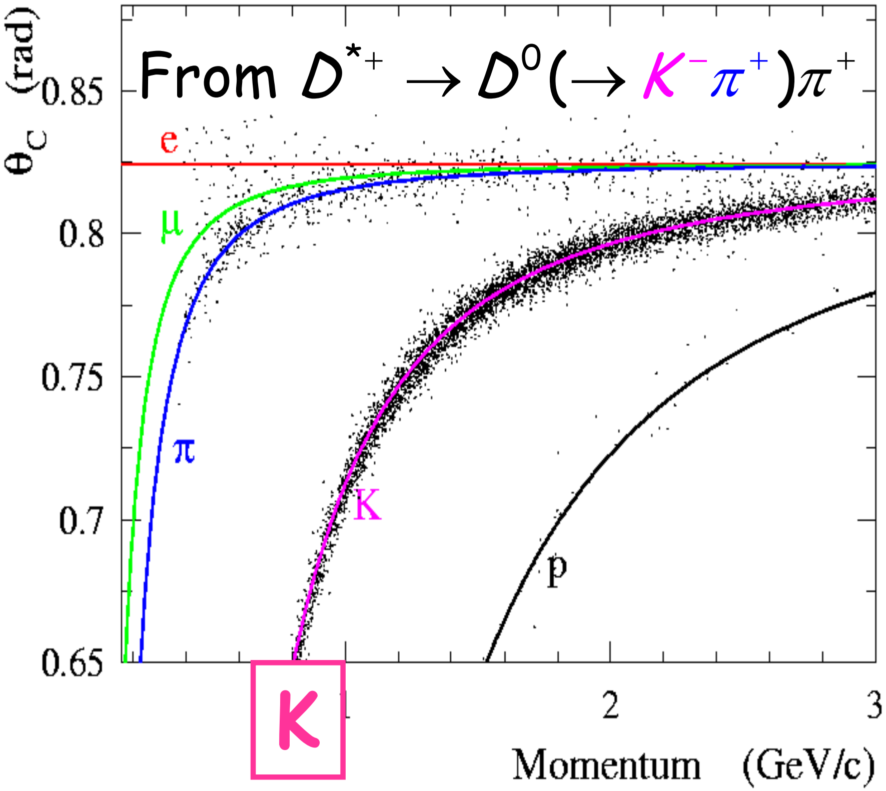


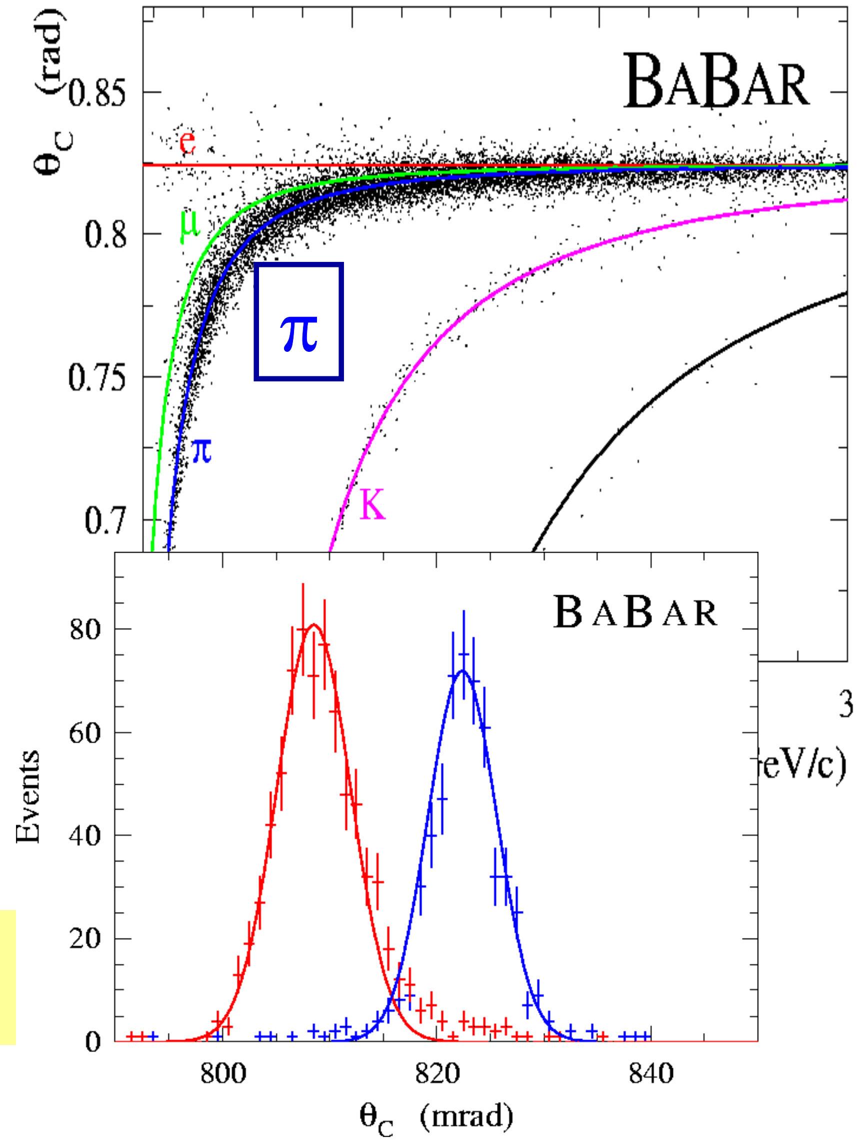
Comparing Hits with Cherenkov Signature





Control samples for π and K



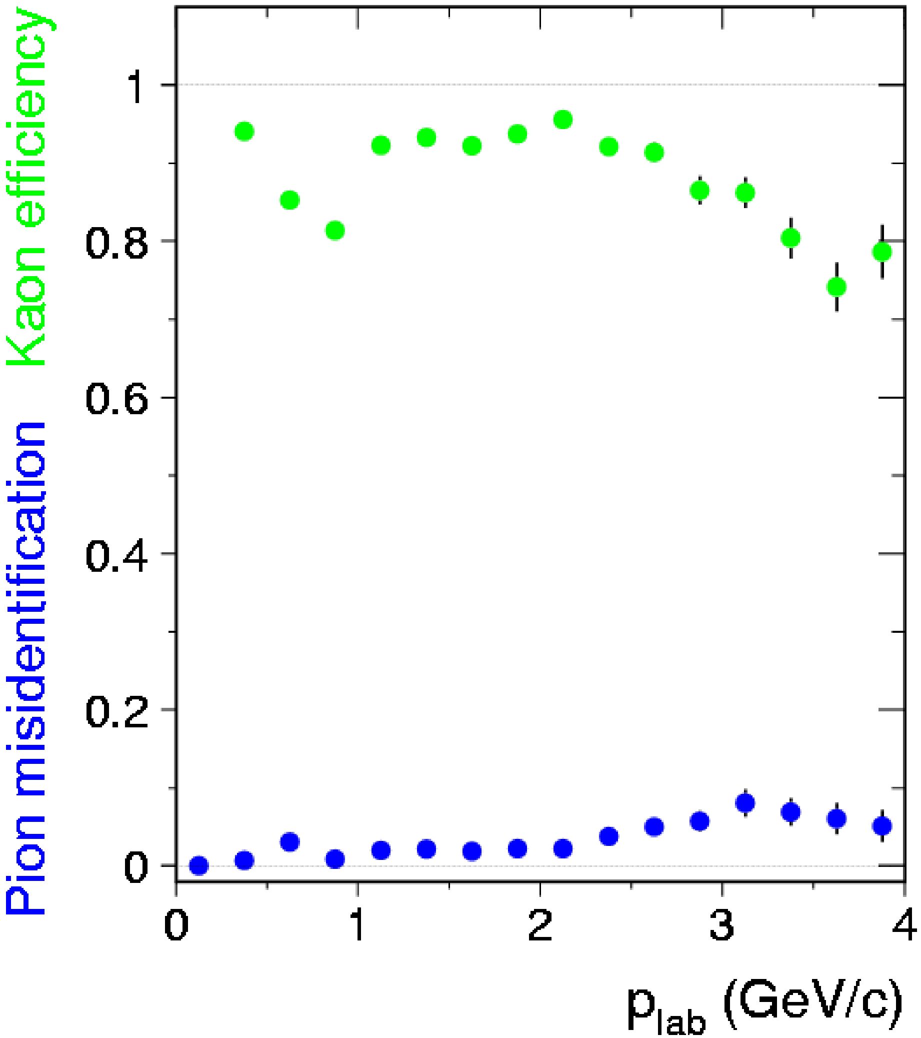


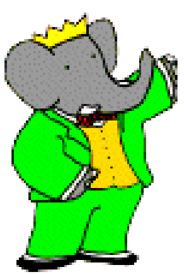
Projection for
2.5 < p < 3 GeV/c

Kaon ID at BABAR

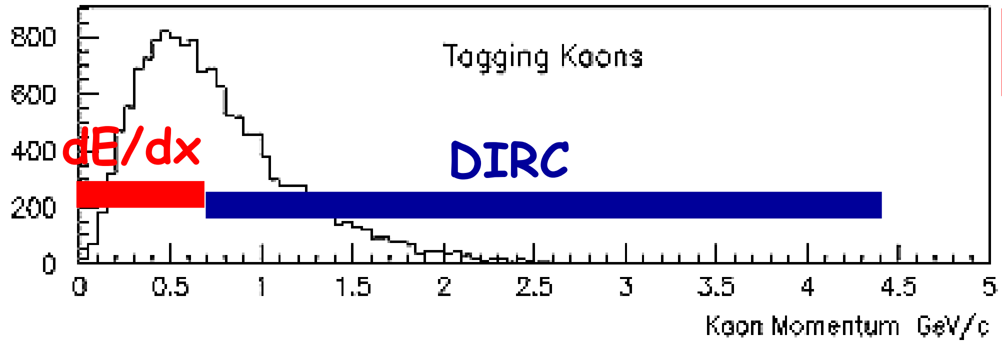
- NN based on likelihood ratios in DCH and SVT (dE/dx), and in DIRC (compare single hits with expected pattern of cherenkov light)
- > 3s K/p separation for 0.25 < p < 3.4 GeV/c

K eff = 85%, π misid = 5%

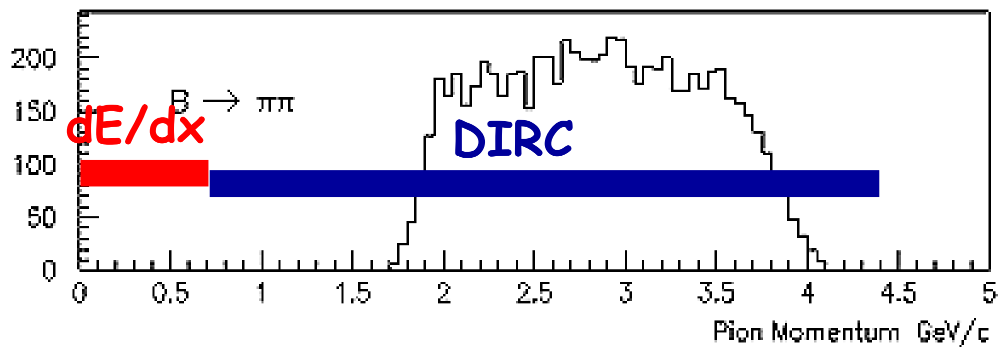




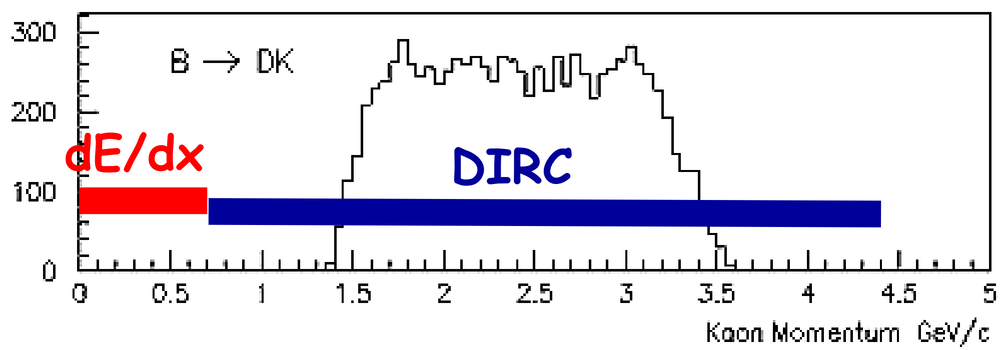
Kaon Spectra from $\Upsilon(4S)$ Decays



Tagging Kaons

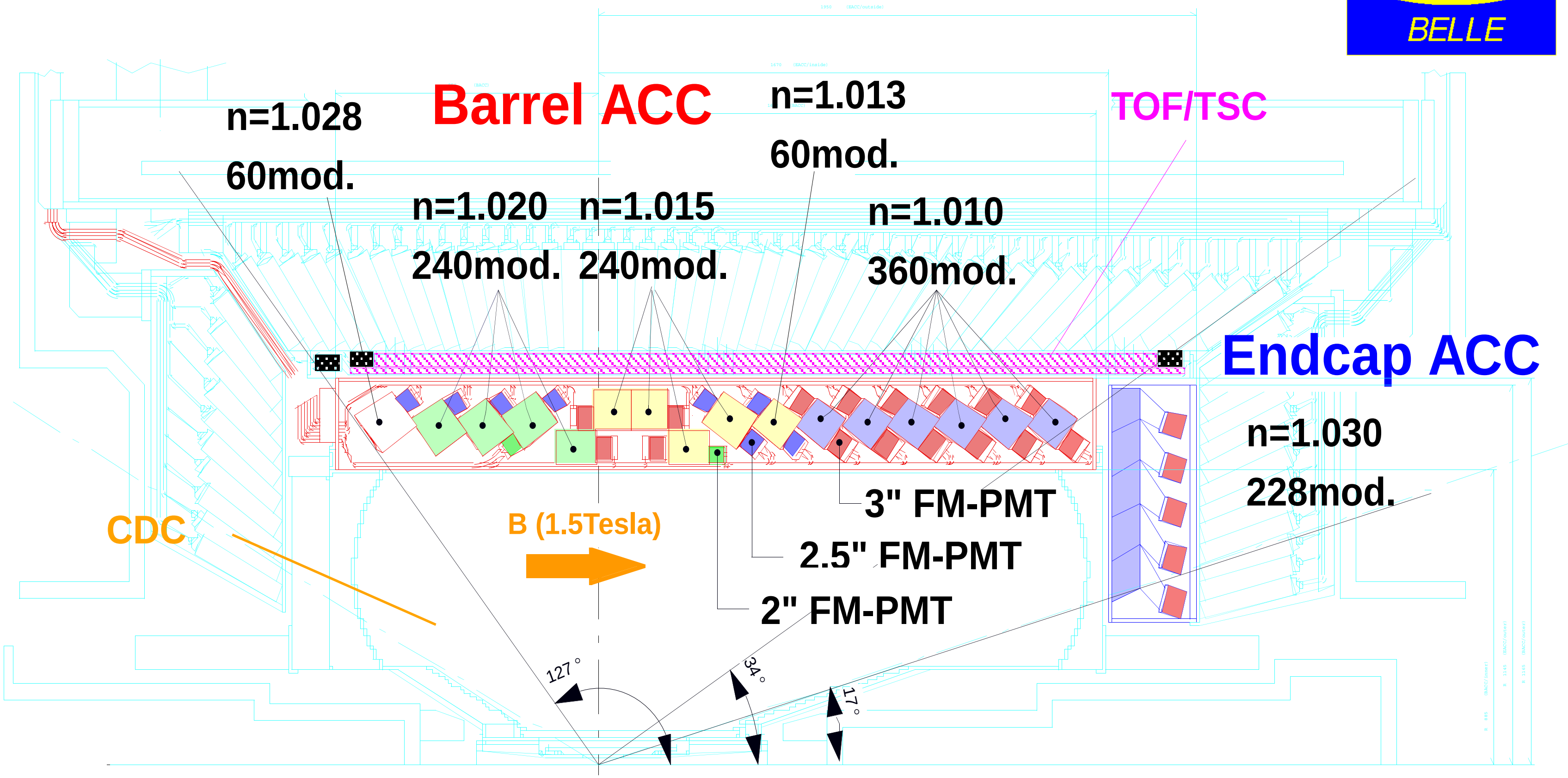


B → ππ



B → DK

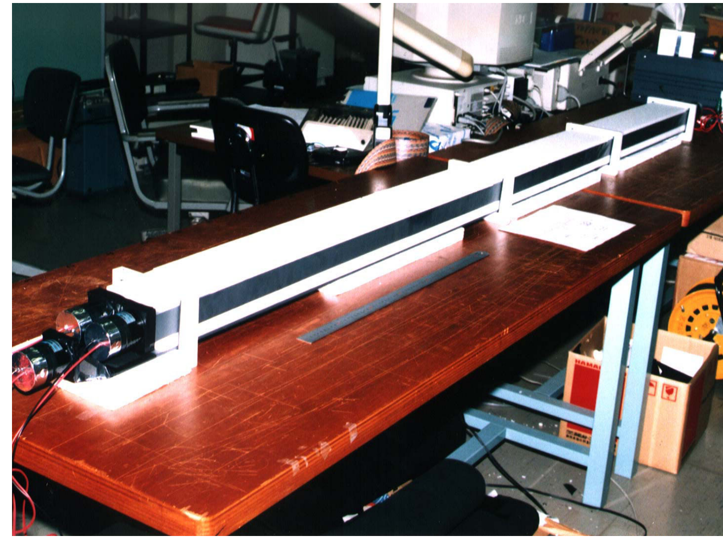
PID System at Belle

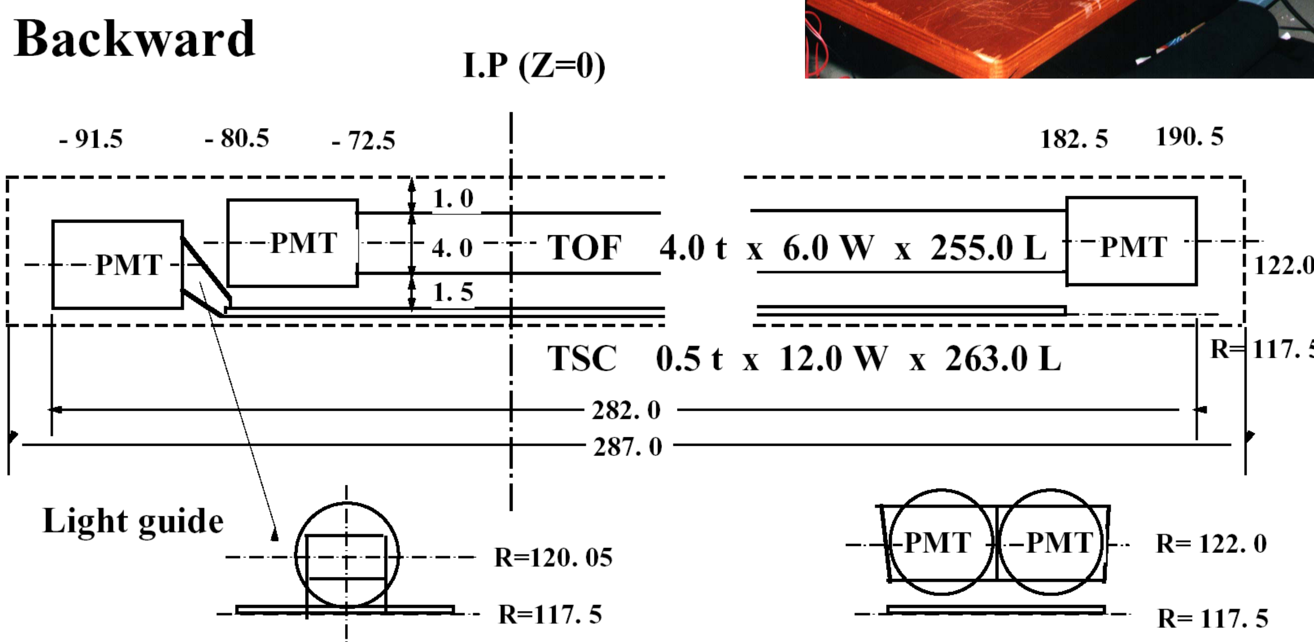


TOF and TSC Modules

- BC408 (4 x 6 x 255 cm T x W x L)
- TOF: Fine-mesh PMT's (both ends)
- TSC = Trigger Scintillator Counter (0.5 cm T): one FM-PMT
- 64 modules (128 TOF and 64 TSC)

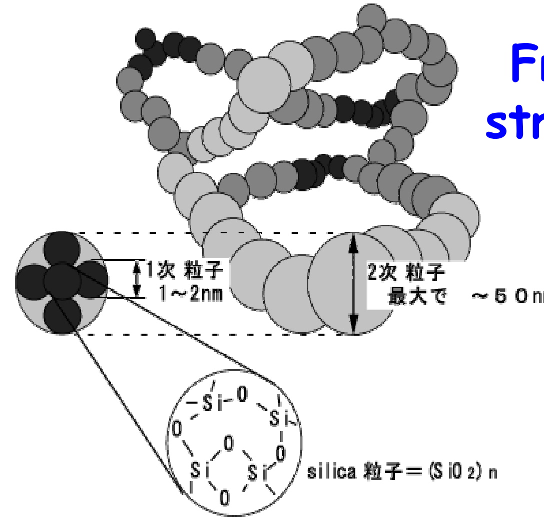
Achieves 80 ps timing resolution





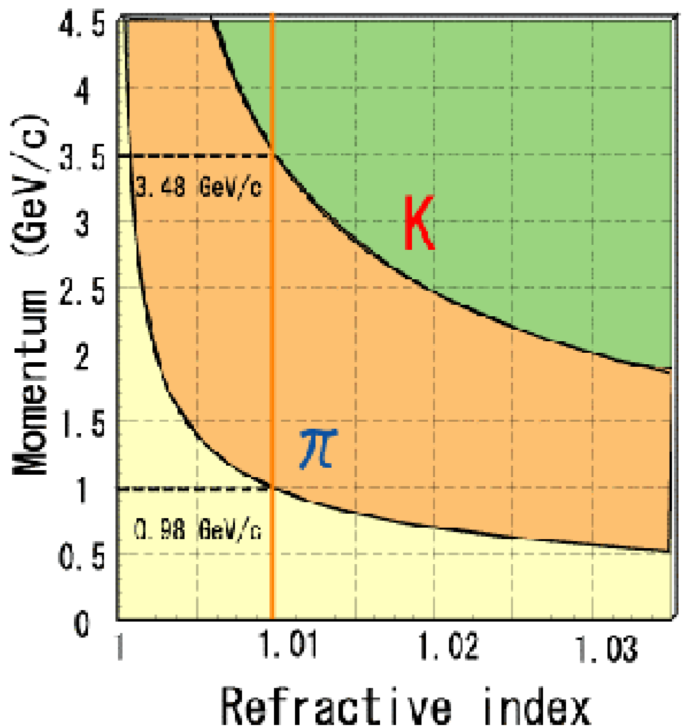
Aerogel Cherenkov Counters (ACC)

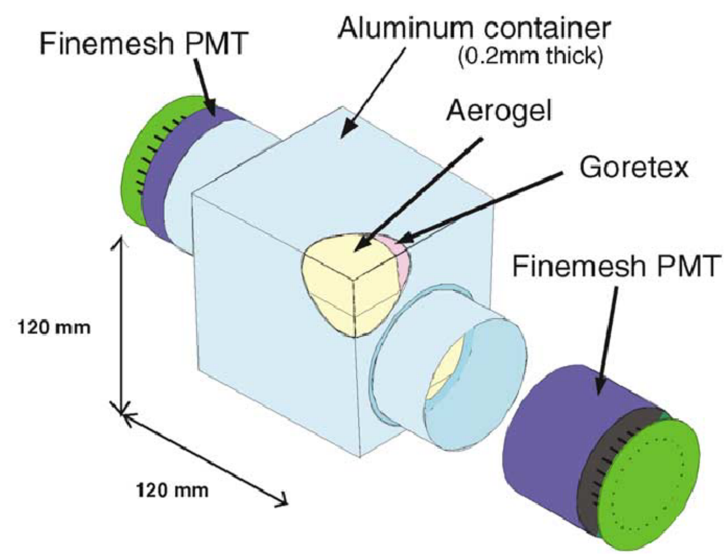
- Hydrophobic silica-aerogels
- n = 1.01~1.028 (barrel), 1.03 (endcap)
- 960 modules (barrel) ->1560 PMT's
- 228 modules (endcap) -> 228 PMT's



Fractal structure

Cherenkov light thresholds





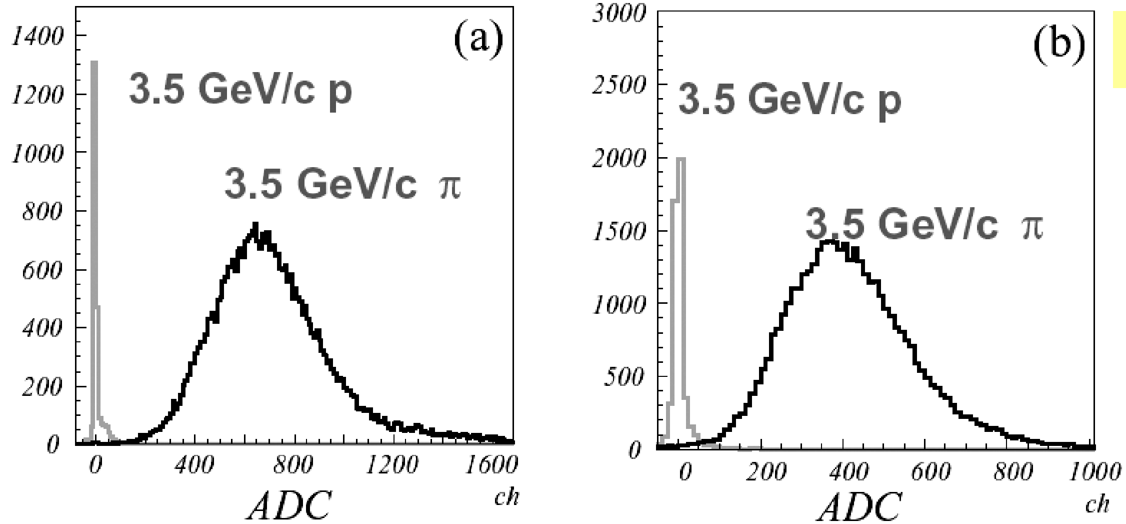
BELLE

Separation Capability of ACC

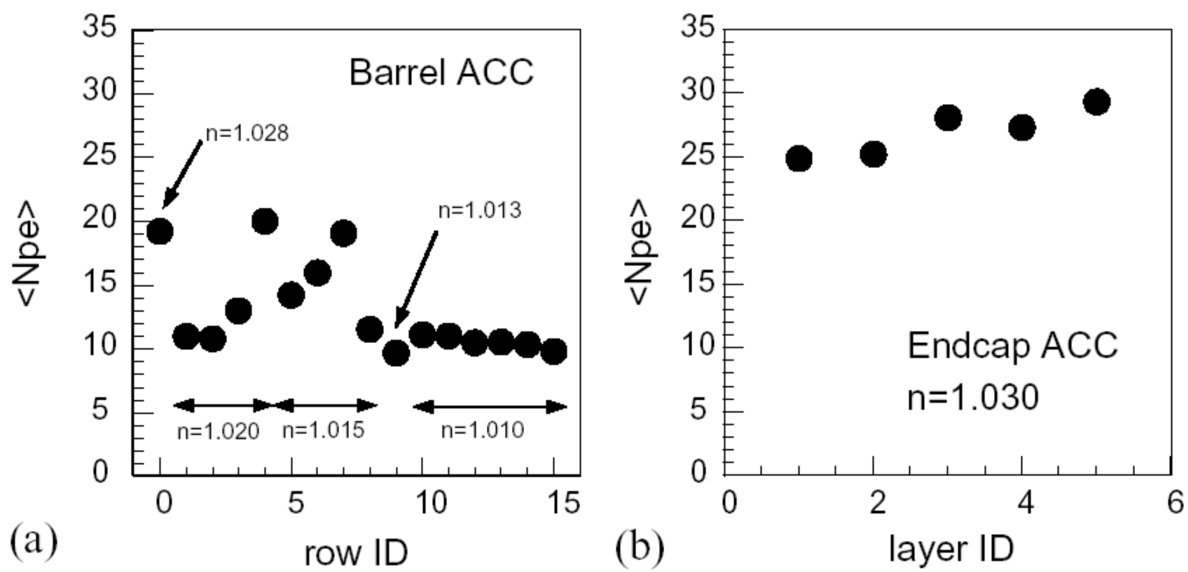
No field

1.5 Tesla

Test beam response to 3.5 GeV/c protons and pions



3σ separation for n = 1.015



Observed photoelectron yield across ACC modules

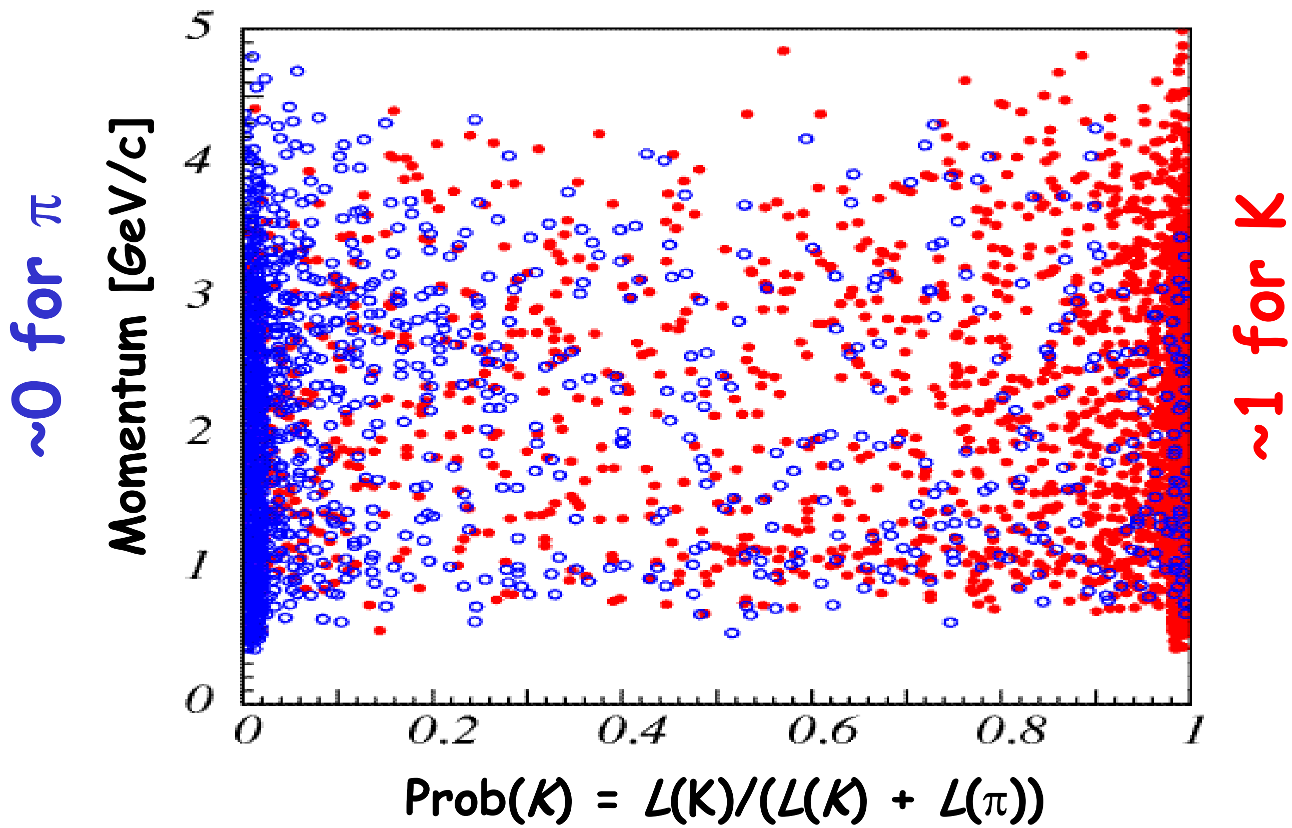
Measuring Kaon ID Performance

Use a kinematics selection to tag clean K, π sample

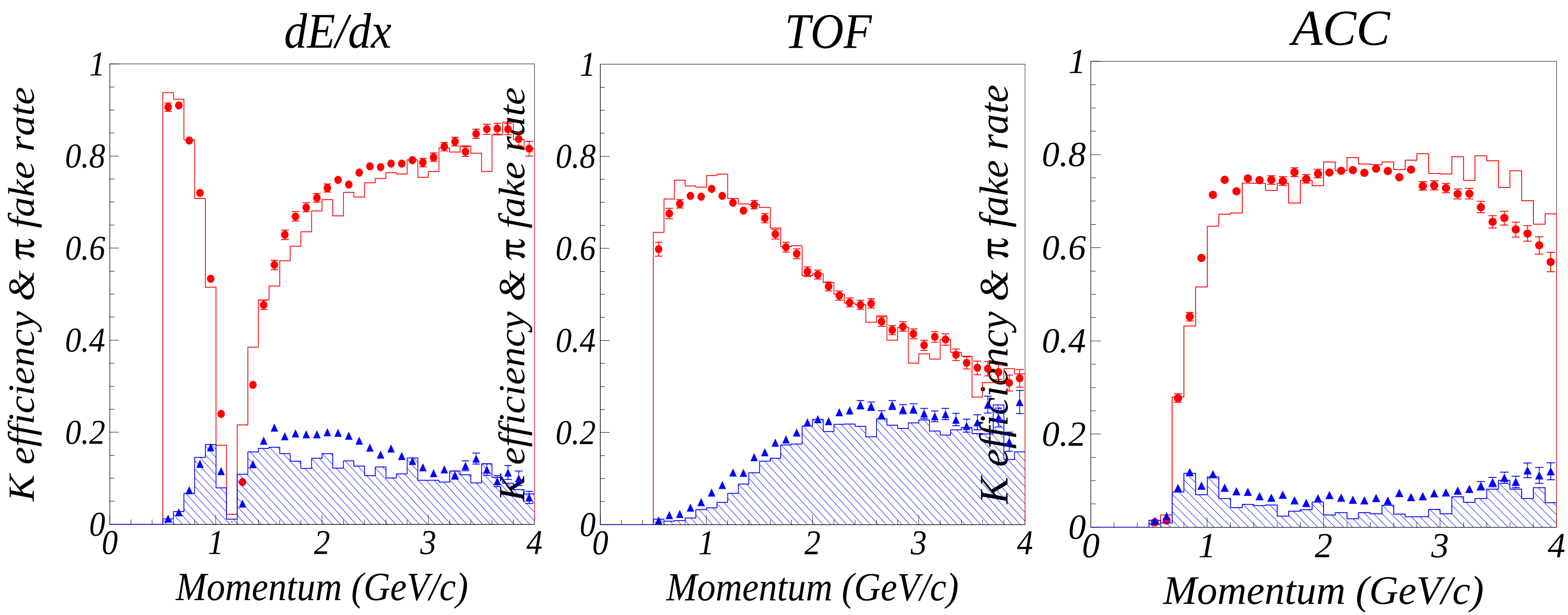
$$D^{*+} \to D^0(\to K^- \pi^+)\pi^+$$

BELLE

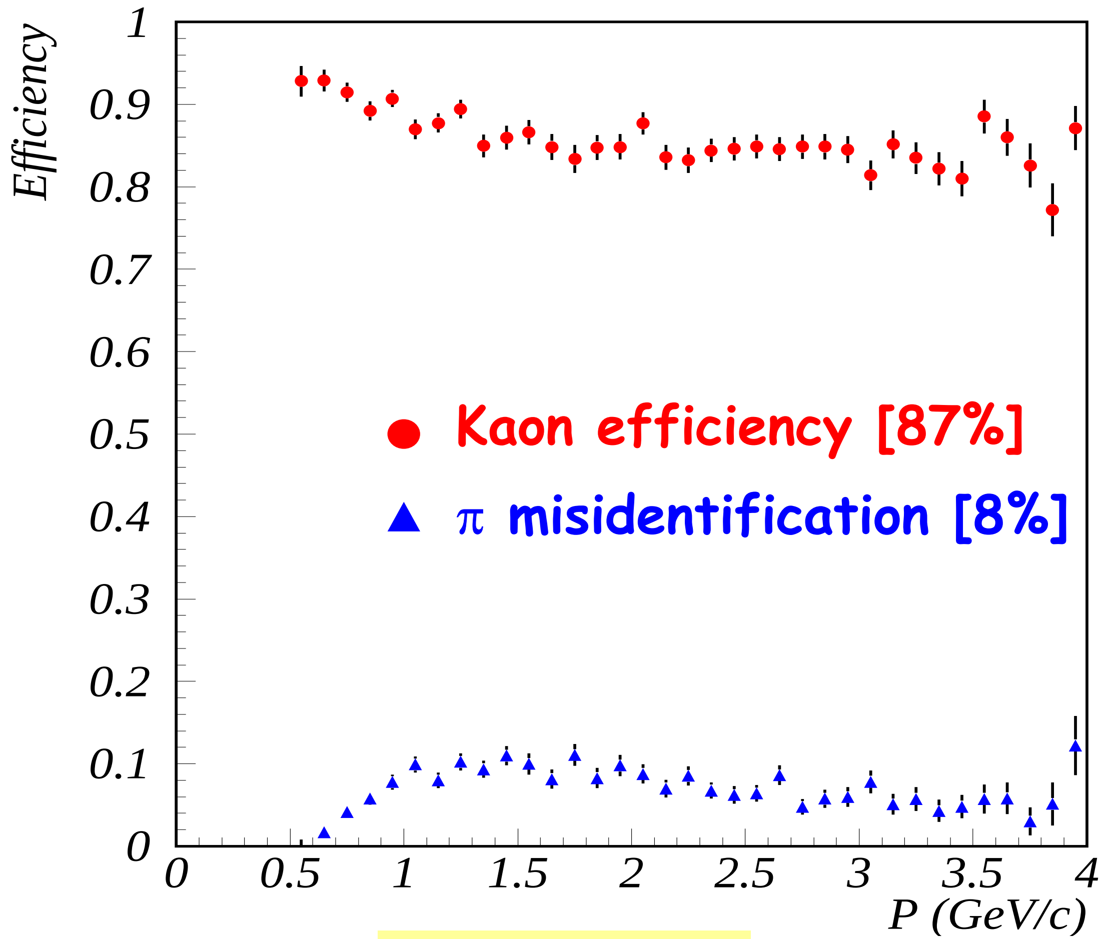
Compute kaon probability from K and π likelihoods obtained from dE/dx, TOF, and ACC



Components of Kaon ID Performance

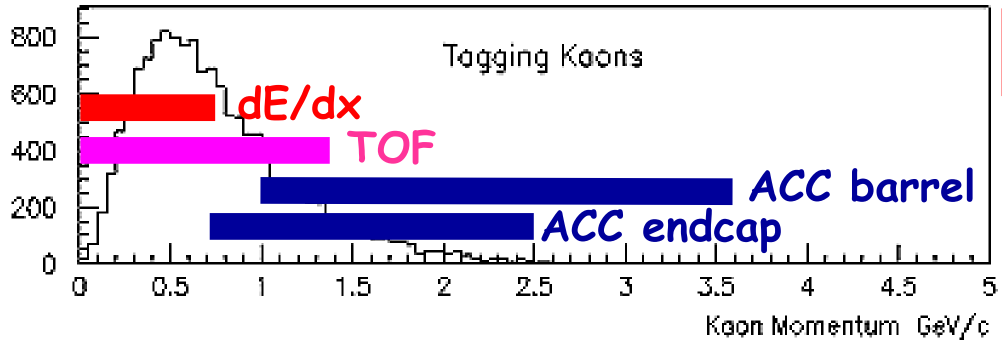


Combined Performance

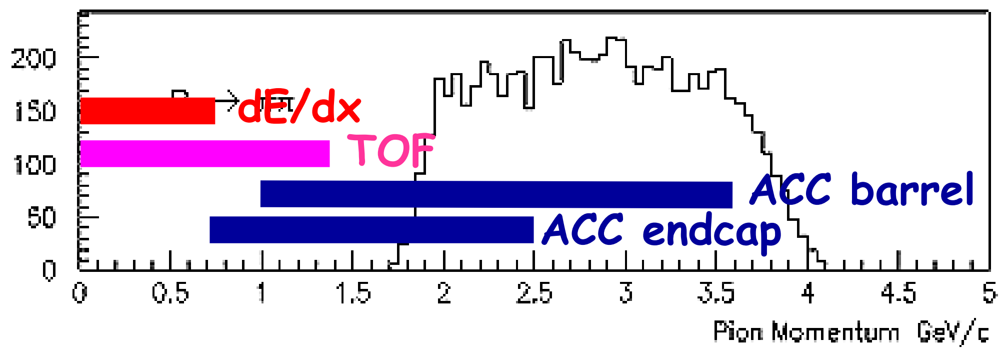


PID(K) > 0.6

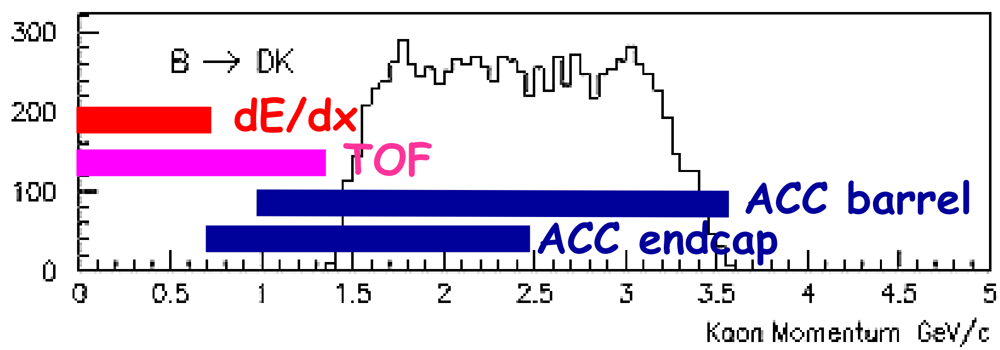
Kaon Spectra from $\Upsilon(4S)$ Decays



Tagging Kaons



B → ππ



B → DK

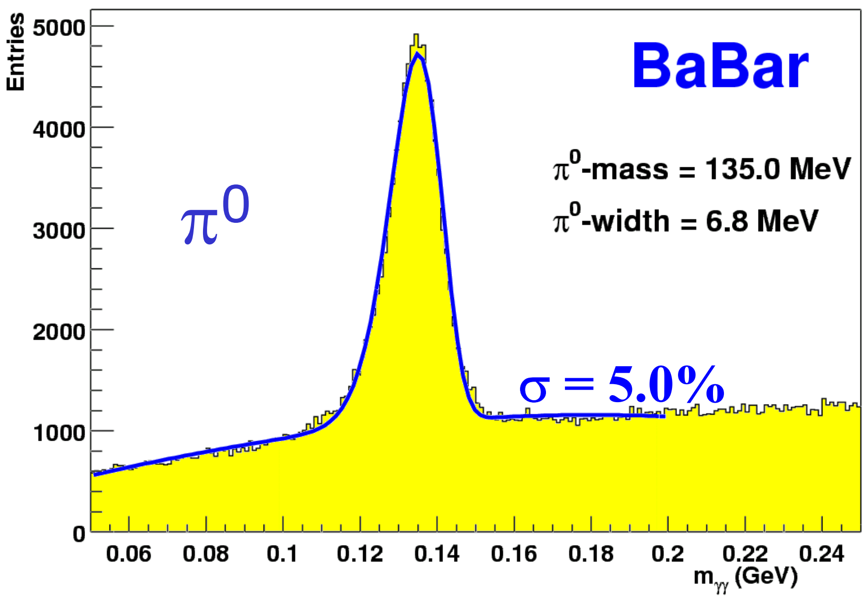
Calorimetry Design

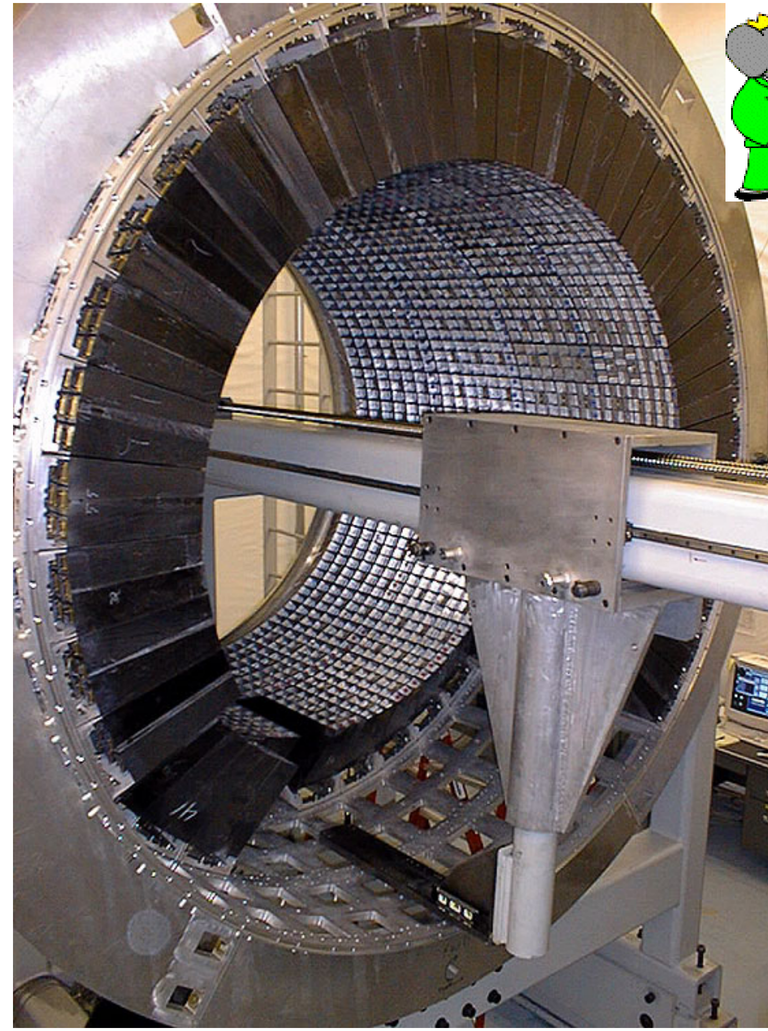
- ## *Requirements*
  - Best possible energy and position resolution
    - 11 photons per (4S) event; 50% below 200 MeV in energy
  - Acceptance down to lowest possible energies and over large solid angle
  - Electron identification down to low momentum
- ## *Constraints*
  - Cost of raw materials and growth of crystals
  - Operation inside magnetic field
  - Background sensitivity
- ## *Implementation*
  - Thallium-doped Cesium-Iodide crystals with 2 PID photodiodes per crystal for readout
  - Thin structural cage to minimize material between and in front of crystals

Electromagnetic Calorimeter at BABAR

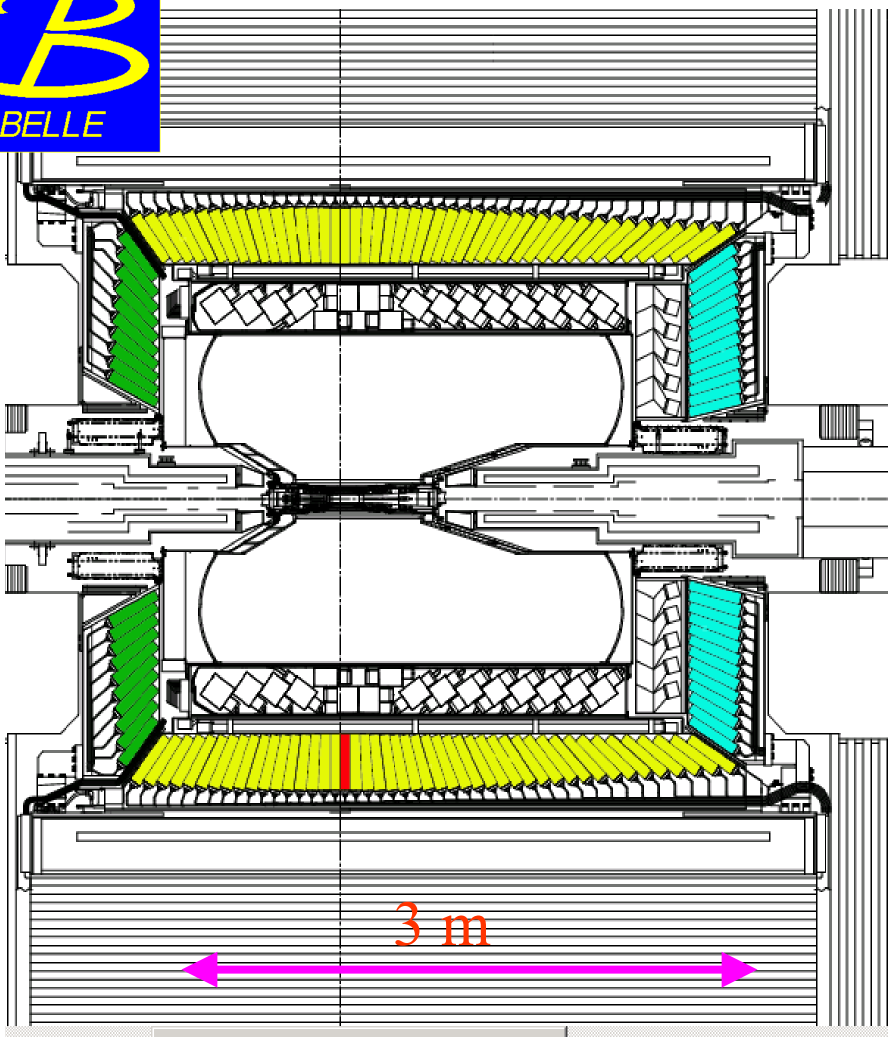
- *6580 CsI(Tl) crystals with photodiode readout*
- *About 18 X0, inside solenoid*

$$\frac{\sigma(E)}{E} = \frac{(2.32 \pm 0.03 \pm 0.3)\%}{\sqrt[4]{E}} \oplus (1.85 \pm 0.07 \pm 0.1)\%$$

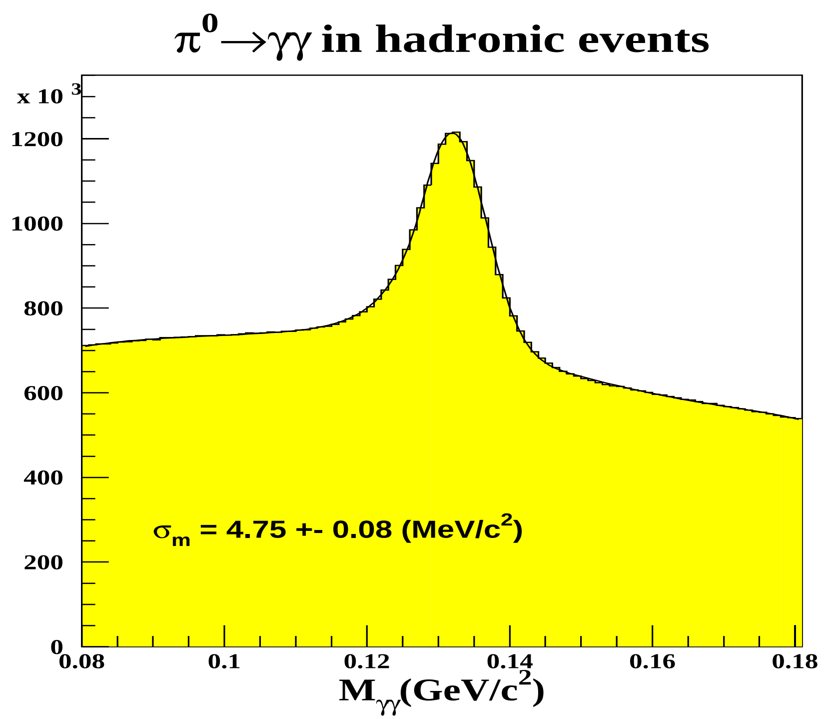




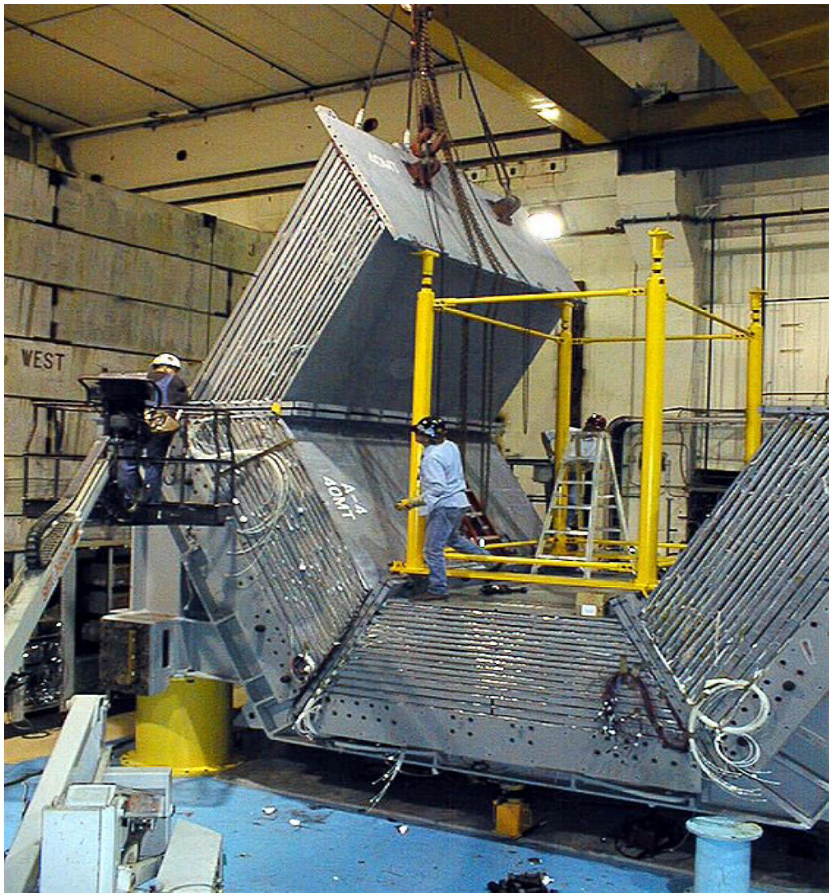
Electromagnetic Calorimeter at Belle



- 8736 CsI(Tl) crystals with photodiode readout
- About 16.2 X0, inside solenoid
- Coverage from 12 to 155°



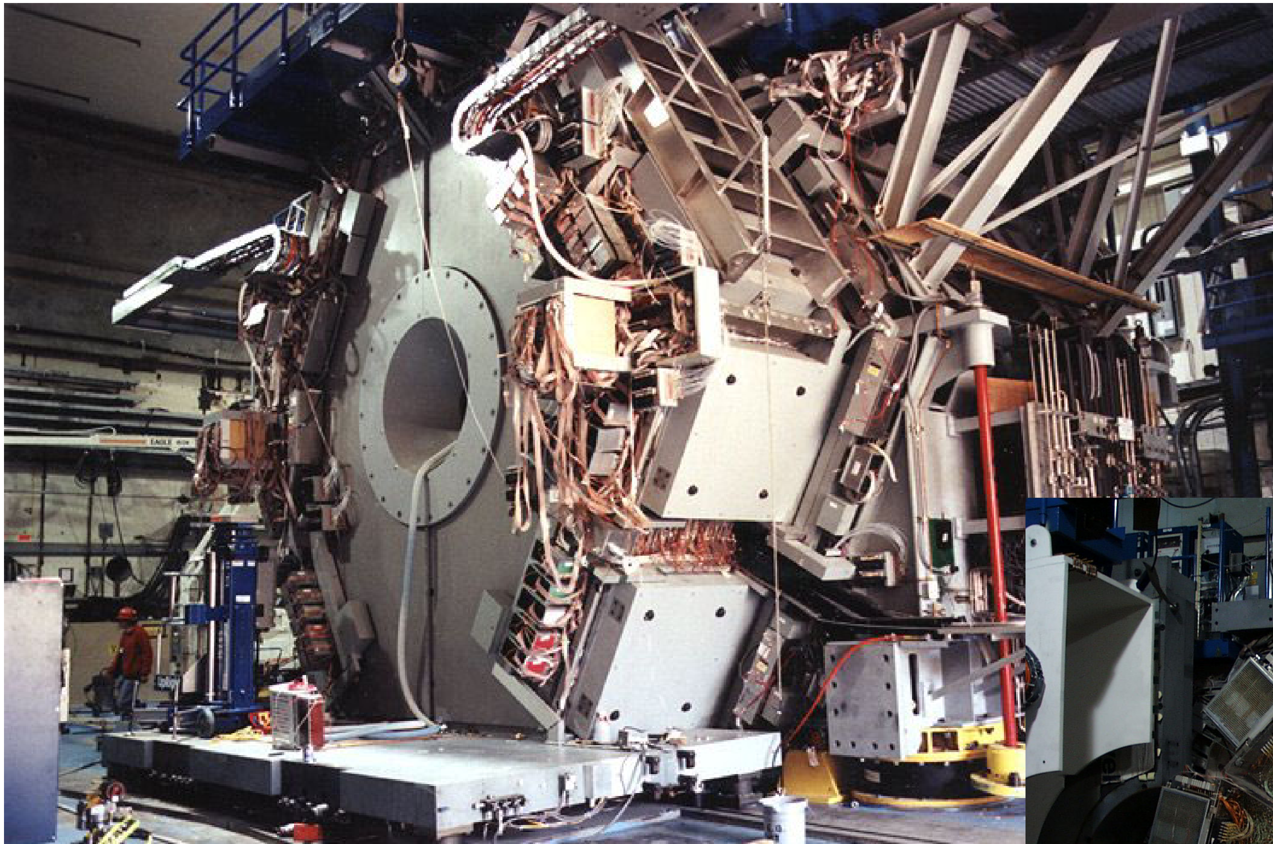
Instrumented Flux Return/KLM



Iron assembly with RPCs at BABAR

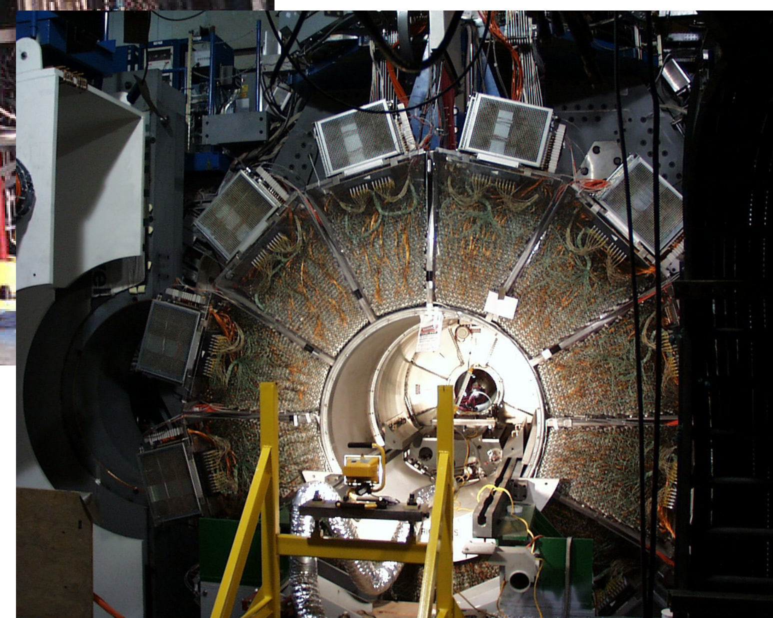
- ***Up to 21 layers of resistive-plate chambers (RPCs) between iron plates of flux return***
  - Muon identification > 800 MeV/c
  - Neutral Hadrons (K_L) detection; also with EMC/ECL
- ***Bakelite RPCs at BABAR***
  - Problems with QC, dark current, and stability
  - Forward endcap replacement this summer; barrel in 2005
- ***Glass RPCs at Belle***
  - Possible problems with neutrons in forward endcap
  - Probably problems at higher background rates

Completed Detectors



First collisions May, 1999

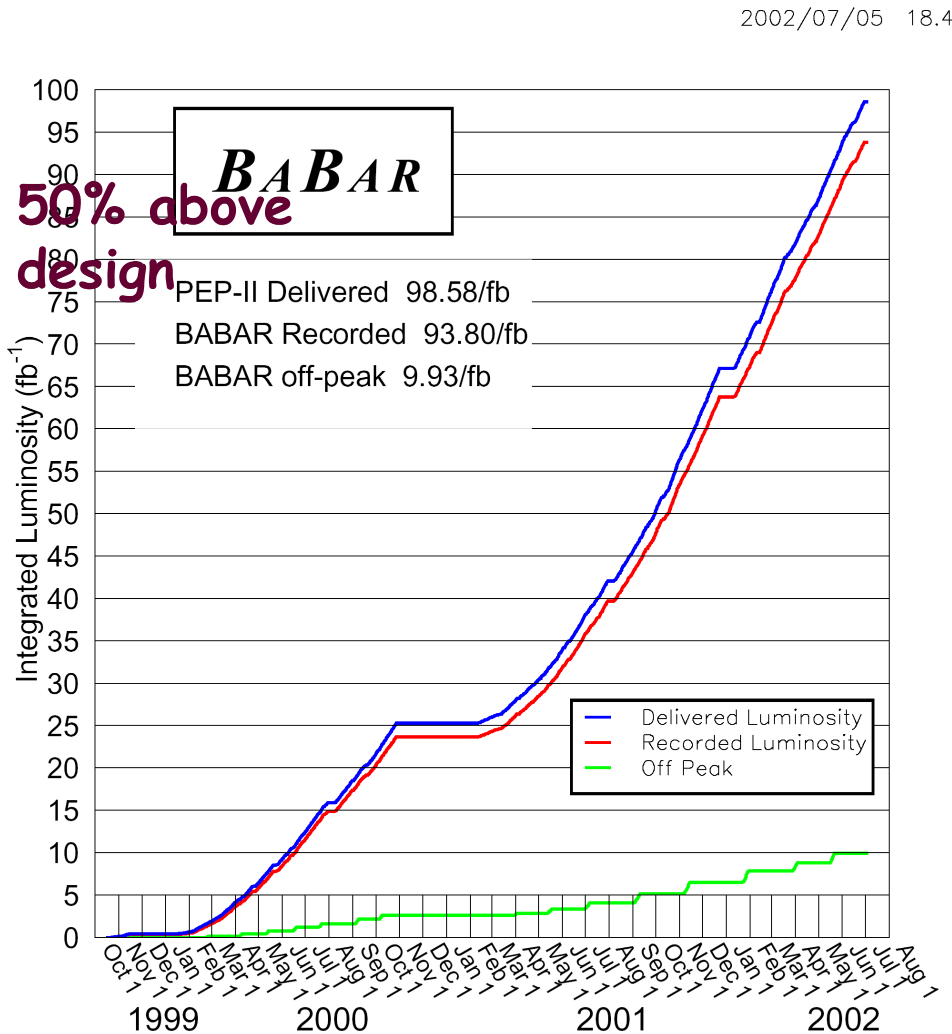
Completed Feb 1999
First collisions May, 1999



PEP-II Integrated Luminosity

PEP-II Records	
Peak luminosity	4.60×10^{33} $cm^{-2}\ s^{-1}$
Best shift	108.3 pb^{-1}
Best 24 hours	308.8 pb^{-1}
Best day	288.7 pb^{-1}
Best 7 days	1.865 fb^{-1}
Best week	1.836 fb^{-1}
Best month	6.66 fb^{-1}
BABAR logged	93.8 fb^{-1}

50% above design



(as of Jun 30, 2002)

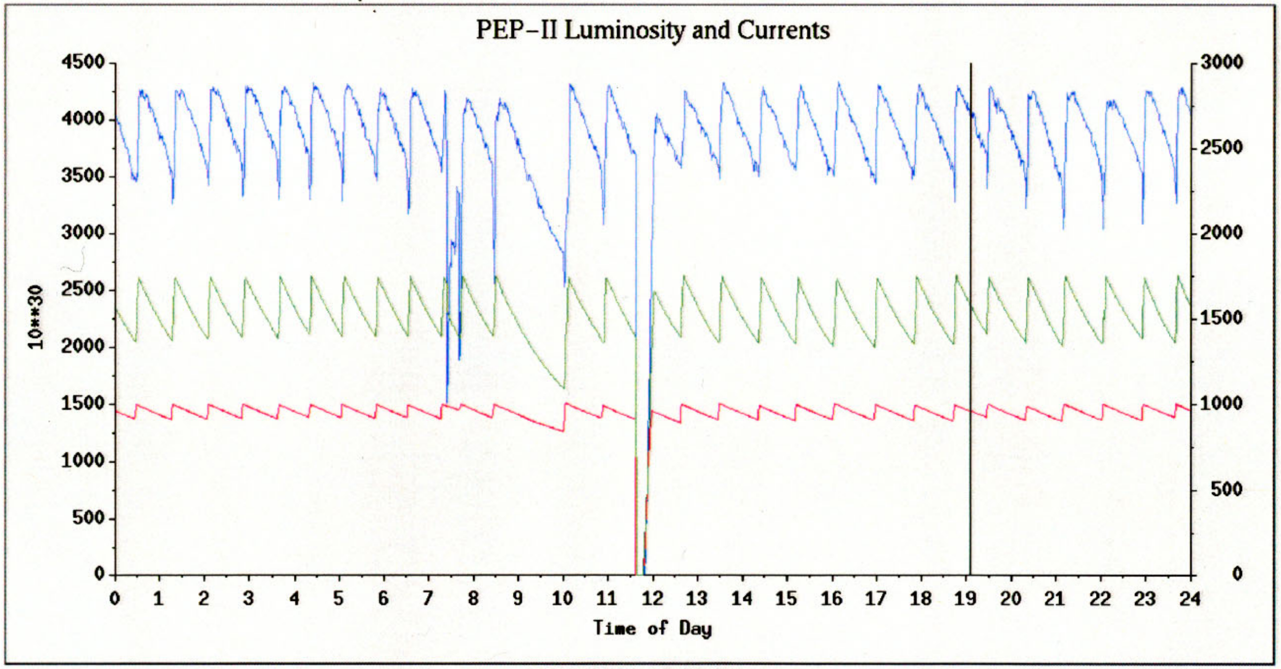
Typical "Very Good" Day at PEP-II

I HER	I LER	Luminosity	Spec Lum	E HER	E LER	E CM
955.33 mA	**1563.52** mA	**4023** 10^30	2.14 N*10**30 / mA**2	8992 MeV	3120 MeV	10594 MeV

N Buckets/HER Pattern: 796 by4_trains_of_23_off_by_2_her

N Buckets/LER Pattern: 796 by4_trains_of_23_off_by_2

Last Owl/Day/Swing/24 Hr:	105.0	97.6	106.2	308.8	Shift:	40.39	/pb
Peak Luminosities:	4339	4353	4395			4353	

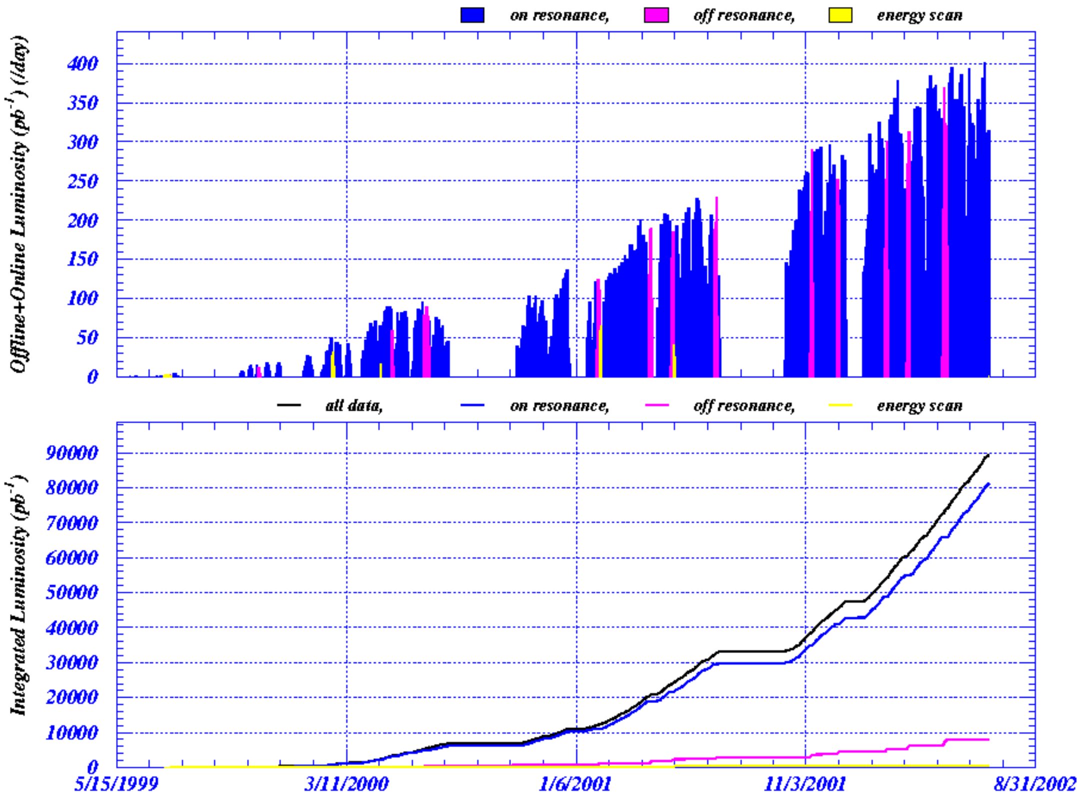


12/23/2001 19:07:38

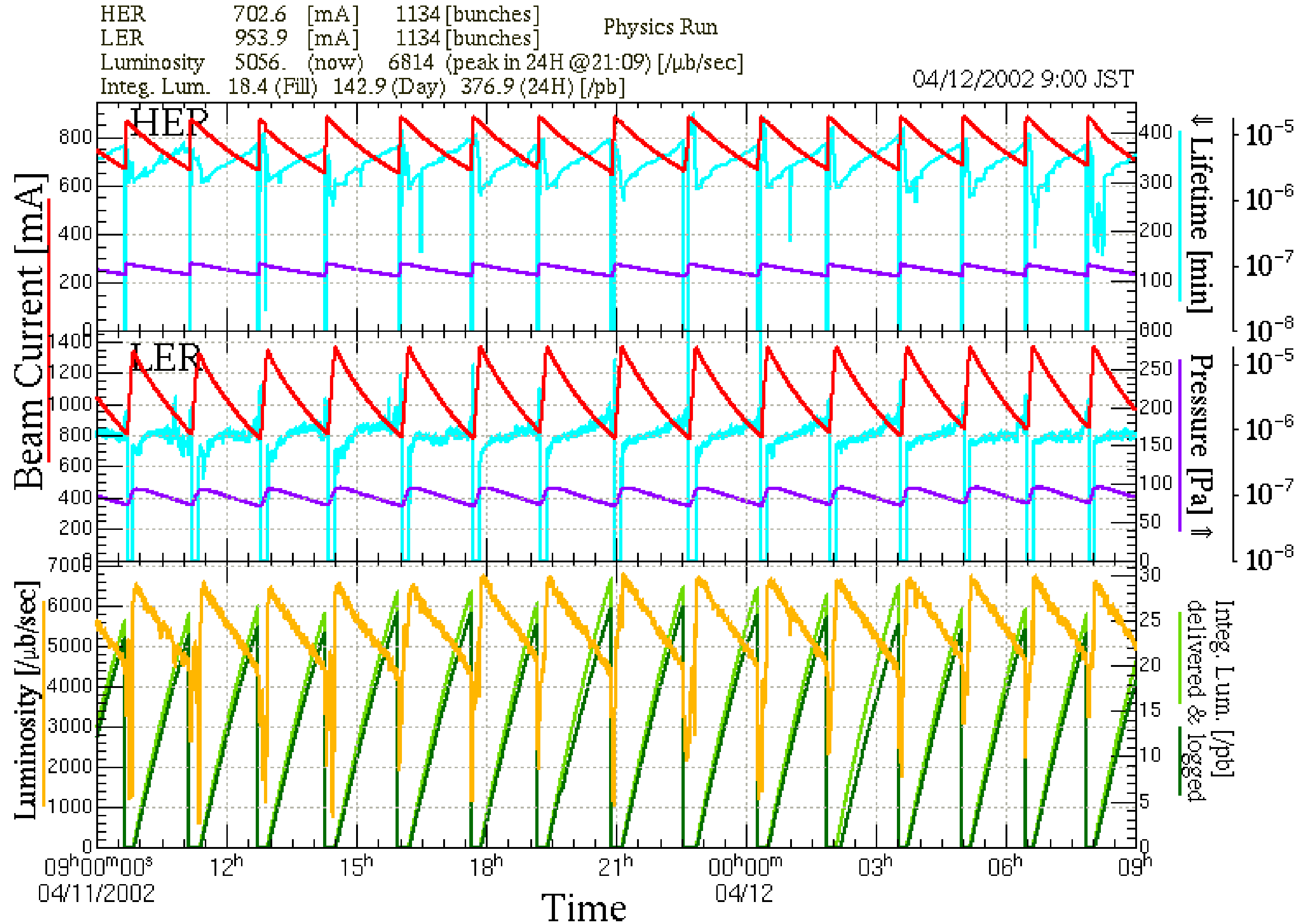
Current record for 24 hr integration

KEKB Integrated Luminosity

KEKB Records	
Peak luminosity	7.25×10^{33} $cm^{-2}\ s^{-1}$
Best shift	129.5 pb^{-1}
Best 24 hours	377.2 pb^{-1}
Best day	371.2 pb^{-1}
Best 7 days	2.207 fb^{-1}
Best month	7.25 fb^{-1}
Belle logged	89.6 fb^{-1}



Typical "Good Day" at KEKB



Nearly a new record for integration in a 24 hr period

Summary

- ***Dream of exploring CP violation has now been realized***
  - PEP-II/BABAR and KEKB/Belle operating with high efficiency and record luminosities
  - Detectors have been optimized for *CP* studies, with demonstrated capability for vertex separation measurement, tagging, and *B* meson reconstruction
  - Data samples are in hand: about 88 million $B\bar{B}$ pairs at BABAR, 85 million at Belle

Luminosity at PEP-II and KEK-B is the key factor in reaching samples that are capable of decisive CP asymmetry measurements

- ***Tomorrow:***
  - How to extract lifetimes, the B^0 oscillation frequency, and mixing-induced *CP* asymmetries from the time-dependent development of *B* mesons in these samples

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10. Belle Collab., A.Abashian et al., NIM A479, 117 (2002)