The BaBar experiment

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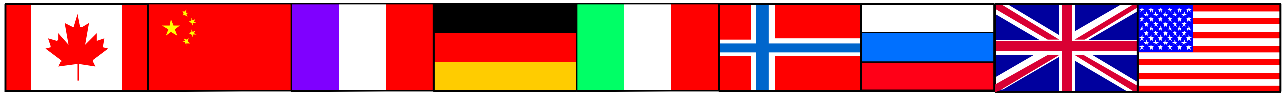
Outline of the talk

- Introduction (CPV et al…)
- PEPII & BaBar Detector
- Operation
- Discovery of ~~CP~~ and sin 2 β
- Towards α
- Rare b decays
- Future prospects

In the parallel sessions of this Conference there will be a more detailed treatment of:

Sin2α	David Kirkby
D*D* study	Justin Albert
Direct CP and rad. Penguins	Henry Band



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UC, Santa Cruz
U of Cincinnati
U of Colorado
Colorado State
Florida A&M
Harvard
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Iowa State U
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U of Louisville
U of Maryland
U of Massachusetts, Amherst
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The *BABAR* Collaboration

9 Countries
74 Institutions
527 Physicists

Canada [4/15]

U of British Columbia
McGill U
U de Montréal
U of Victoria

China [1/5]

Inst. of High Energy Physics, Beijing

France [5/52]

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LAL Orsay
LPNHE des Universités Paris 6/7
Ecole Polytechnique
CEA, DAPNIA, CE-Saclay

Germany [3/24]

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Ruhr U Bochum
Technische U Dresden

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Russia [1/8]

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United Kingdom [10/65]

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Royal Holloway, University of London
U of Manchester
Rutherford Appleton Laboratory

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3 ways for CP violation

a) Violation in the mixing (the eigenstates of Mass matrix are not eigenstates of CP) .Neutral states are involved [K^0,B^0, D^0(?),…]

$$H=\begin{pmatrix}\sum_f |\langle f|T|x_0\rangle|^2 & \sum_f \langle f|T|x_0\rangle\langle f|T|\bar{x}_0\rangle \\ \sum_f \langle f|T|x_0\rangle\,\langle f|T|\bar{x}_0\rangle^* & \sum_f |\langle f|T|\bar{x}_0\rangle|^2\end{pmatrix} \equiv \begin{pmatrix} M_{11}-i\frac{\Gamma_{11}}{2} & M_{12}-i\frac{\Gamma_{12}}{2} \\ M_{21}-i\frac{\Gamma_{21}}{2} & M_{22}-i\frac{\Gamma_{22}}{2}\end{pmatrix}$$

$$|x_\pm\rangle = \frac{1}{\sqrt{|p|^2+|q|^2}}\left(p|x_0\rangle \pm q|\bar{x}_0\rangle\right) \qquad p=\sqrt{H_{12}} \qquad q=\sqrt{H_{21}}$$

Then if $\left|p/q\right| \neq 1$ ⇒ ~~CP~~

For example using dilepton events

$$A_{CP,T} = \frac{N(l^+l^+)-N(l^-l^-)}{N(l^+l^+)+N(l^-l^-)} \approx \frac{1-|q/p|^4}{1+|q/p|^4}$$

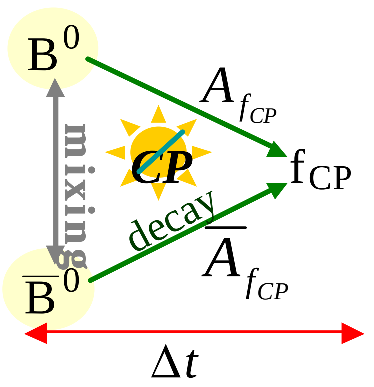
As in K sector $\varepsilon_B=(p-q)/(p+q)$ $\quad\varepsilon \sim O(10^{-3})$

3 ways for CP violation

b)Direct violation in decay, when the probability of the state $|i\rangle$ going into a final state $|f\rangle$ is different from the probability that the CP conjugate state $|\bar{i}\rangle$ goes into the CP conjugate state $|\bar{f}\rangle$ (Charged & neutral states are involved)

$$\left|\frac{A(|i\rangle \Rightarrow |f\rangle)}{\overline{A}(|\bar{i}\rangle \Rightarrow |\bar{f}\rangle)}\right| \neq 1$$

c)In the interference between mixing and decay amplitudes (only neutral states involved)



At least 2 amplitudes involved in the process are needed for ~~*CP*~~

~~CP~~ in the Standard Model

CP is explained in S.M. by the presence of a phase among the 4 parameters of the flavour mixing matrix CKM

$$\mathbf{V} = \begin{pmatrix} \mathbf{V_{ud}} & \mathbf{V_{us}} & \mathbf{V_{ub}} \\ \mathbf{V_{cd}} & \mathbf{V_{cs}} & \mathbf{V_{cb}} \\ \mathbf{V_{td}} & \mathbf{V_{ts}} & \mathbf{V_{tb}} \end{pmatrix} = \begin{pmatrix} \mathbf{1} - \frac{\mathbf{1}}{\mathbf{2}}\lambda^2 & \lambda & \mathbf{A}\lambda^3(\rho - \mathbf{i}\eta) \\ -\lambda & \mathbf{1} - \frac{\mathbf{1}}{\mathbf{2}}\lambda^2 & \mathbf{A}\lambda^2 \\ \mathbf{A}\lambda^3(\mathbf{1} - \rho - \mathbf{i}\eta) & -\mathbf{A}\lambda^2 & \mathbf{1} \end{pmatrix} + \mathbf{O}(\lambda^4)$$

In the above parametrization ,where λ is $\sin\theta_c$, η is the parameter contributing to ~~CP~~

Representing unitarity relations as Unitarity Triangles

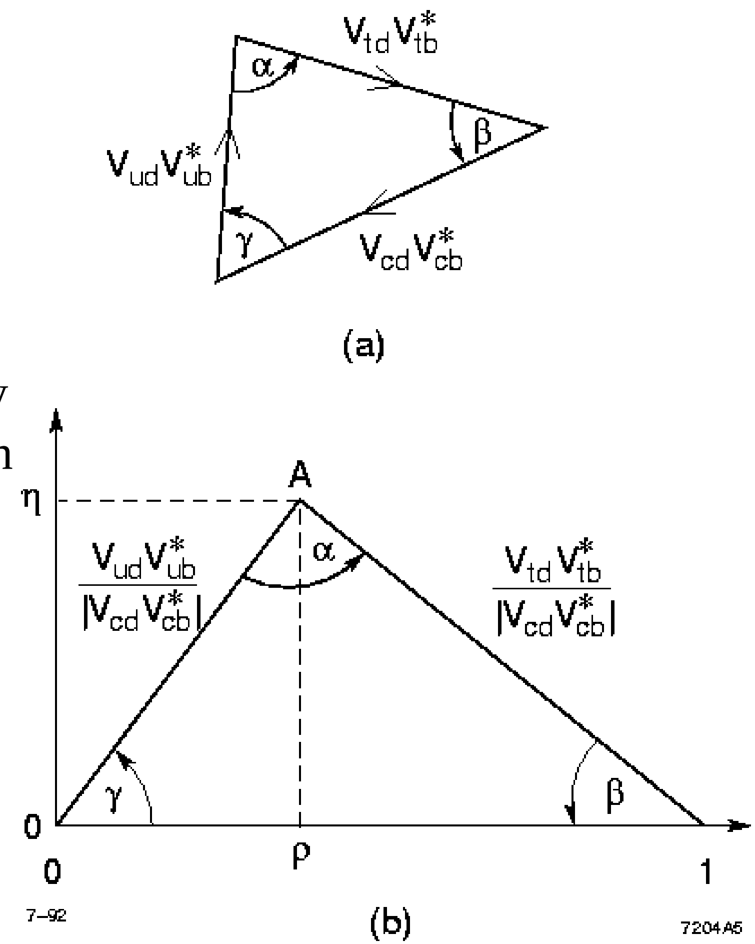
The unitarity condition of CKM matrix **$VV^{+}=V^{+}V=1$** gives 6 relations between the matrix elements as :

$$\mathbf{V_{ud}V^*_{ub} + V_{cd}V^*_{cb} + V_{td}V^*_{tb} = 0}$$

(in this relation the 3 terms have the same order of magnitude $\sim O(\lambda^3)$ and it can be graphically represented in a complex plane as a triangle with sides of comparable length. Other relations have terms of different order of magnitudes. E.g.:

$$\mathbf{\underline{V_{us}V^*_{ub}} + \underline{V_{cs}V^*_{cb}} + \underline{V_{ts}V^*_{tb}} = 0}$$

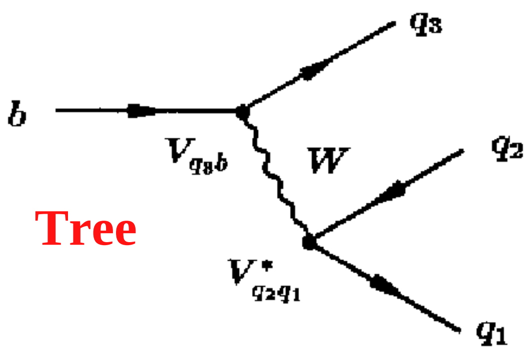
$O(\lambda^4)$ $O(\lambda^2)$ $O(\lambda^2)$



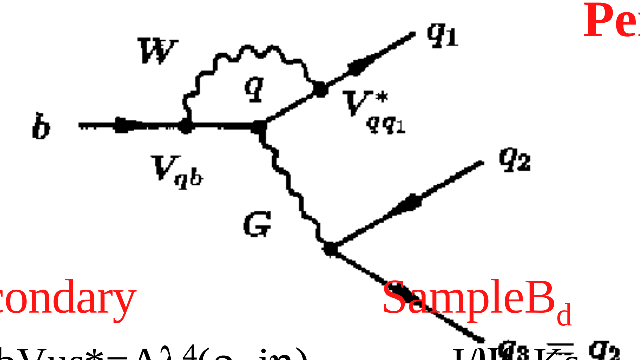
Overconstrain a,b,g and the 4 parameters of CKM r,h, A,l

Decaying amplitudes in SM

Tree



Penguin



Quarks	Leading Term	Secondary	Sample B_d	Angle
ccs	Vcb Vcs* $=A\lambda^2$ T+P(c-t)	VubVus*$=A\lambda^4(\rho-i\eta)$ P(u-t)	J/Ψ Ks	β
sss	VcbVcs*$= A\lambda^2$ P(c-t)	VubVus*$=A\lambda^4(\rho-i\eta)$ P(u-t)	Φ Ks	β
ccd	Vcb Vcd* $=A\lambda^2$ T+P(c-u)	Vtb Vtd* $=-A\lambda^3(1-\rho+i\eta)$ P(t-u)	D^+D^-	β(LT)
uud/ddd	VubVud*$=A\lambda^3(\rho-i\eta)$ T+P(u-c)	Vtb Vtd* $=-A\lambda^3(1-\rho+i\eta)$ P(t-c)	$\pi\pi,\rho\pi,a_1\pi$	α(LT)

Time-dependent CP asymmetry

CP violation results from interference between decays with and without mixing

$$A_{f_{CP}}(t)=\frac{\Gamma\left(\overline{B}^0_{phys}(t)\to f_{CP}\right)-\Gamma\left(B^0_{phys}(t)\to f_{CP}\right)}{\Gamma\left(B^0_{phys}(t)\to f_{CP}\right)+\Gamma\left(\overline{B}^0_{phys}(t)\to f_{CP}\right)}$$

$$=-C_{f_{CP}}\cos\left(\Delta m_d t\right)+S_{f_{CP}}\sin\left(\Delta m_d t\right)$$

Where

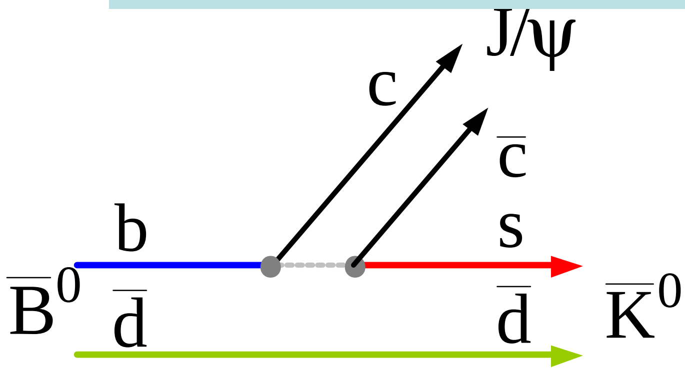
$$C_{f_{CP}}=\frac{1-|\lambda_{f_{CP}}|^2}{1+|\lambda_{f_{CP}}|^2} \quad \text{and} \quad S_{f_{CP}}=\frac{2\,\mathrm{Im}\,\lambda_{f_{CP}}}{1+|\lambda_{f_{CP}}|^2}$$

$$\lambda_{f_{CP}}=\eta_{f_{CP}}\frac{q}{p}\frac{\overline{A_{f_{CP}}}}{A_{f_{CP}}}=\left|\lambda_{f_{CP}}\right|\eta_{f_{CP}}e^{-2i\phi_{CP}}$$

η is the CP eigenvalue of the final state

$$|\lambda_{f_{CP}}|\neq 1 \Rightarrow \mathrm{Prob}(\overline{B}^0_{phys}(t)\to f_{CP})\neq \mathrm{Prob}(B^0_{phys}(t)\to f_{CP})$$ ➡ direct ~~CP~~

Golden CP modes



CHARMONIUM b→cc s

$\overline{B}^0 \to J/\psi\ \overline{K}^0$

$B^0 \to J/\psi\ K^0$

K⁰ mixing

$B^0_{CP=-1} \to J/y\, K^0_S$

$B^0_{CP=+1} \to J/y\, K^0_L$

Single weak phase = no direct ~~CP~~

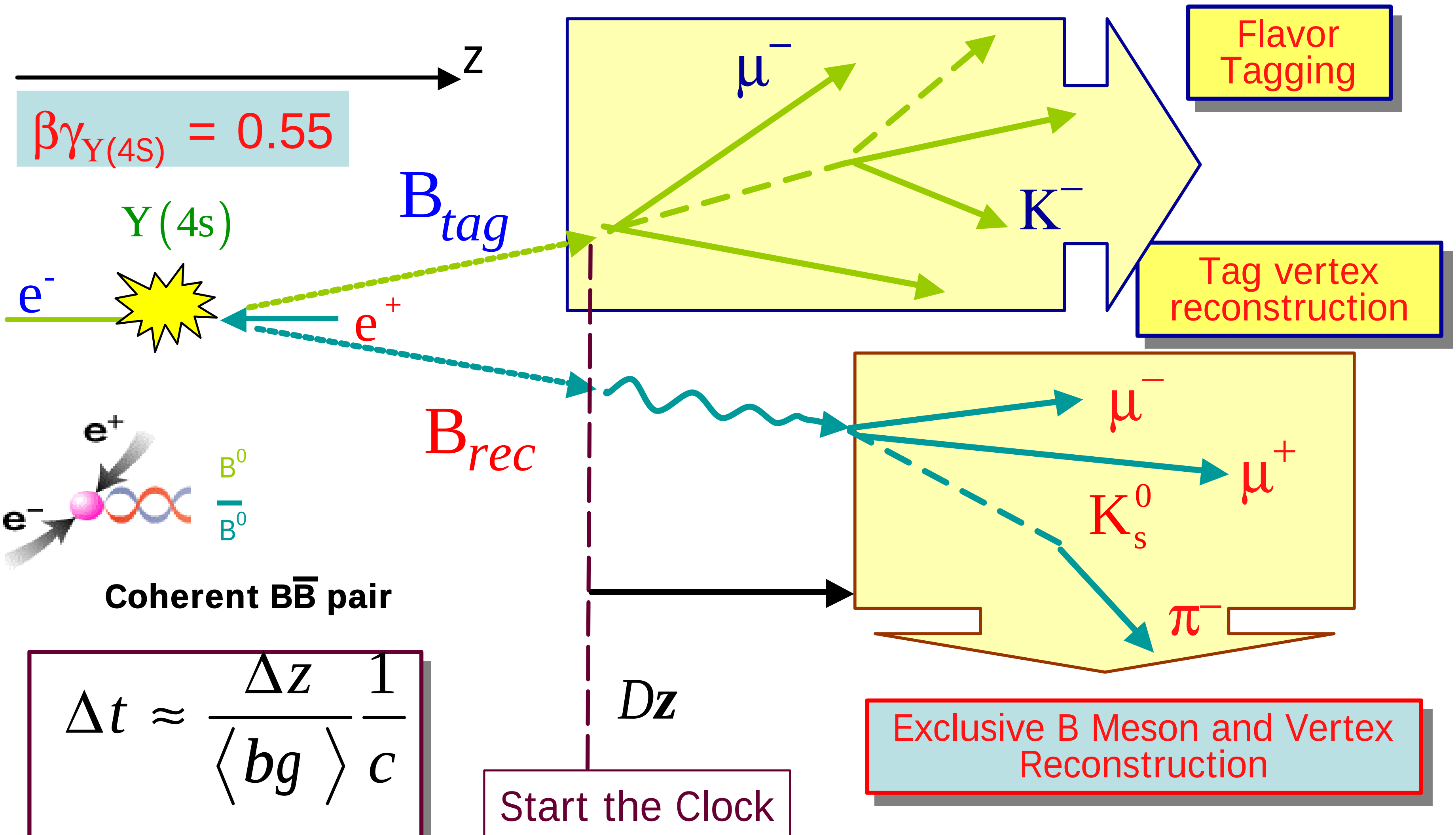
$\Rightarrow \left| l_{J/y\ K^0_{S,L}} \right| = 1$

$$A_{J/yK^0_{S,L}}(t) = -h_{J/yK^0_{S,L}} \sin 2b \sin(\Delta m_d t)$$

η_{CP} = -1 (+1) for J/ψ $K^0_{S(L)}$

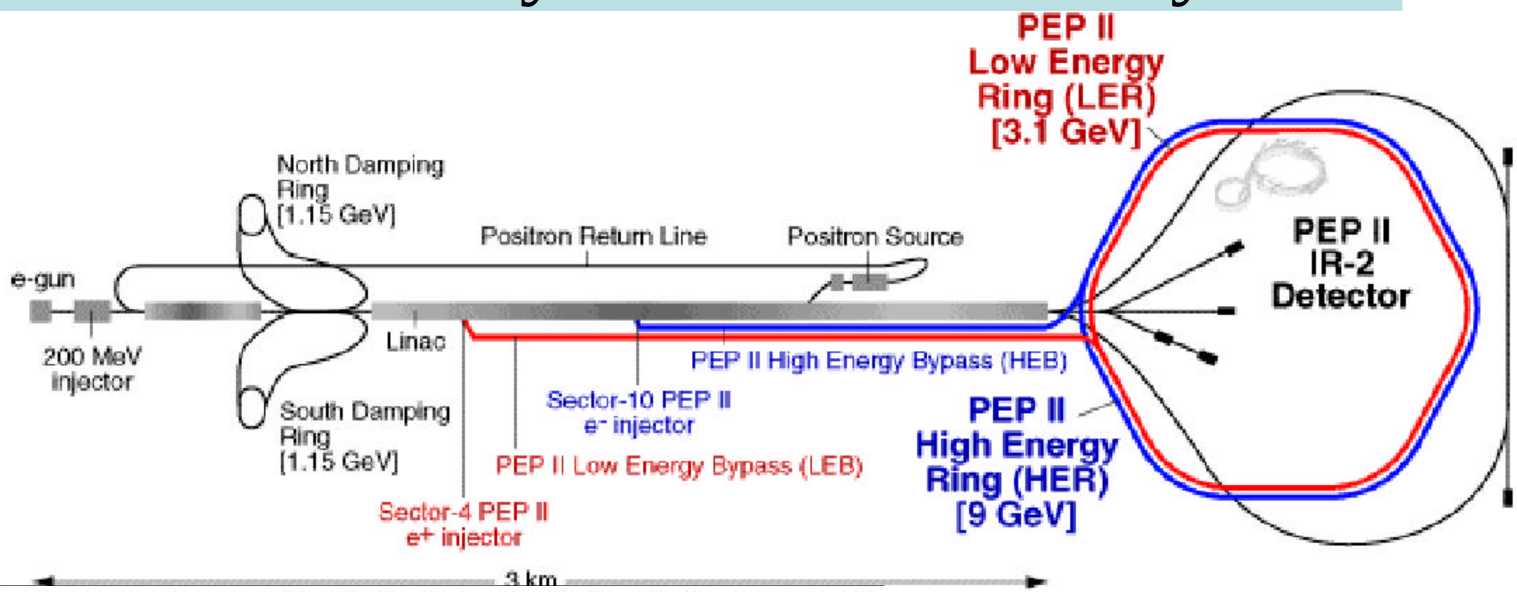
- Theoretically it is a clean way to measure sin2b
- Clear experimental signature
- Relatively large branching fraction

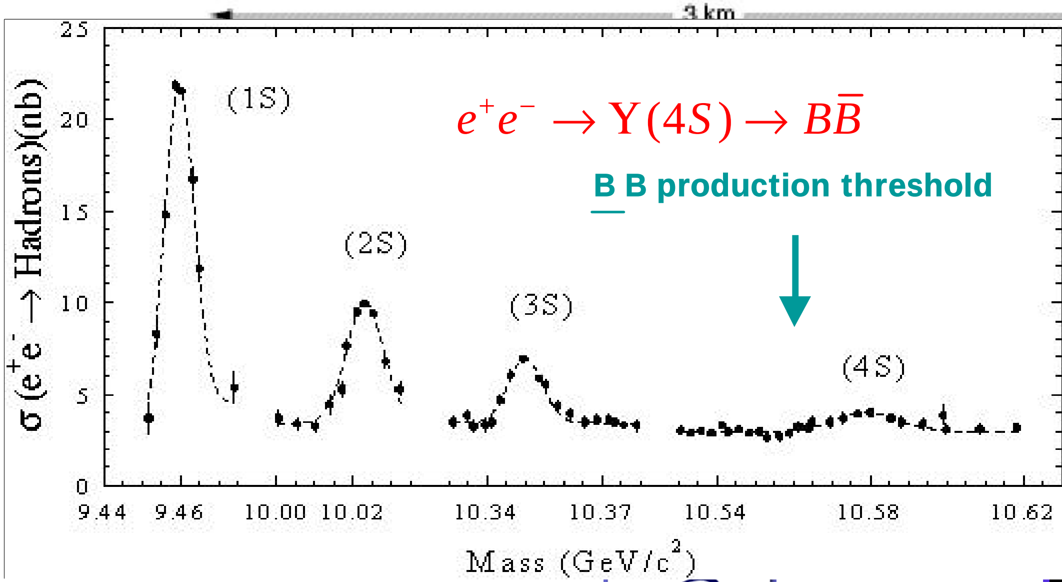
Principle of measurement



$$\Delta t \approx \frac{\Delta z}{\langle bg \rangle} \frac{1}{c}$$

PEP-II Asymmetric B-Factory



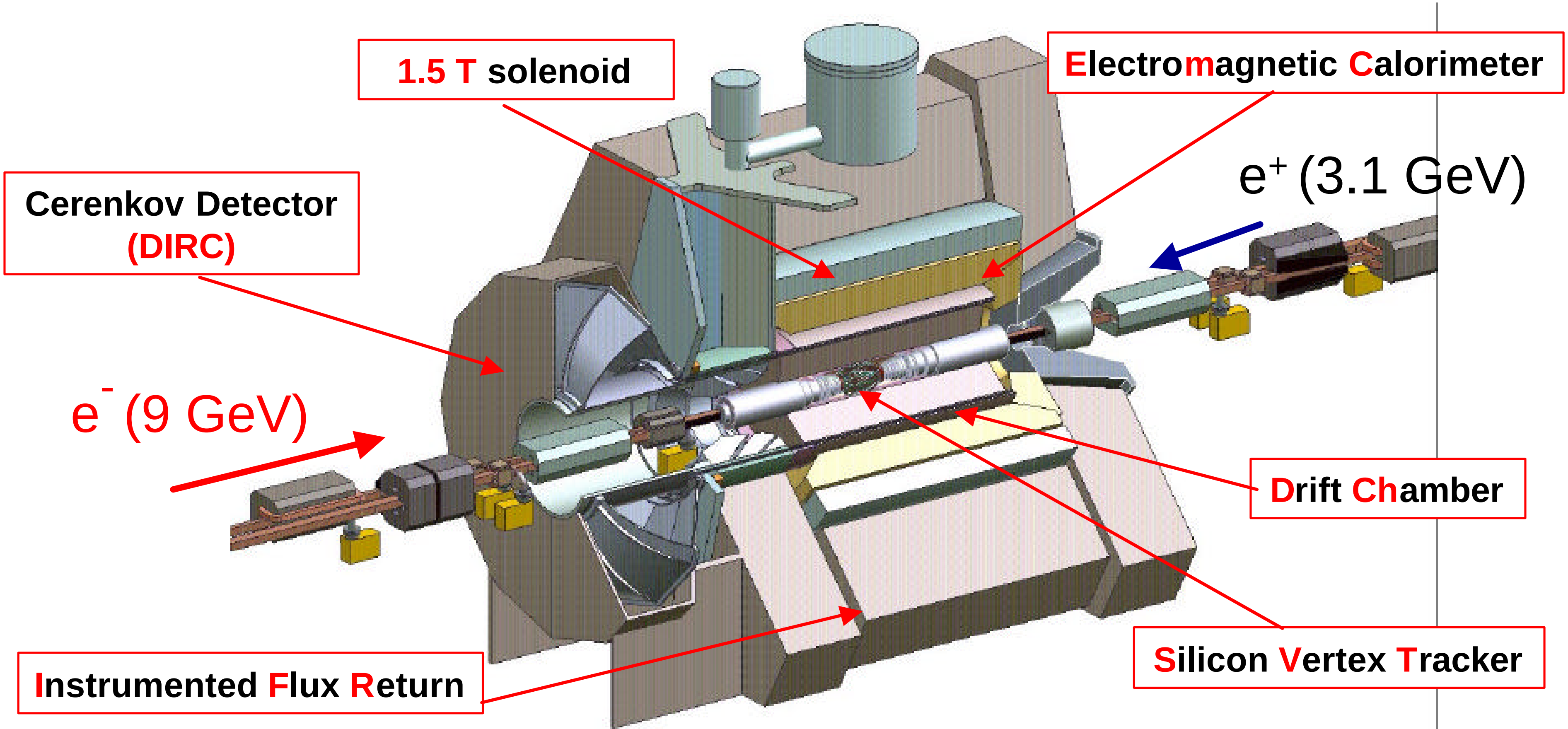


9 GeV e^- on 3.1 GeV e^+

Υ(4s) boost in lab frame

$\beta\gamma = 0.55$

The BaBar Detector



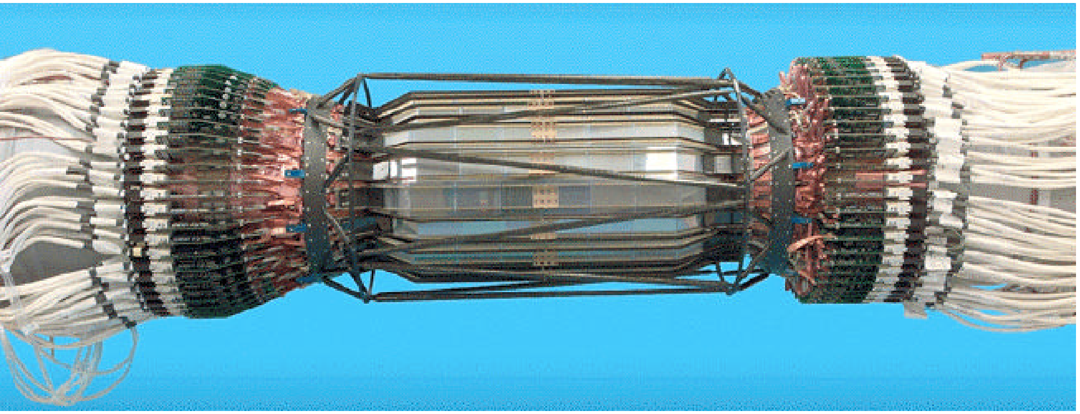
SVT: 97% efficiency, 15 μm z hit resolution (inner layers, perp. tracks)

SVT+DCH: $\sigma(p_T)/p_T = 0.13\ \%$ ´ p_T + 0.45 %

DIRC: K-π separation 4.2 σ @ 3.0 GeV/c → 2.5 σ @ 4.0 GeV/c

EMC: $\sigma_E/E = 2.3\ \% \cdot E^{-1/4}$ Å 1.9 %

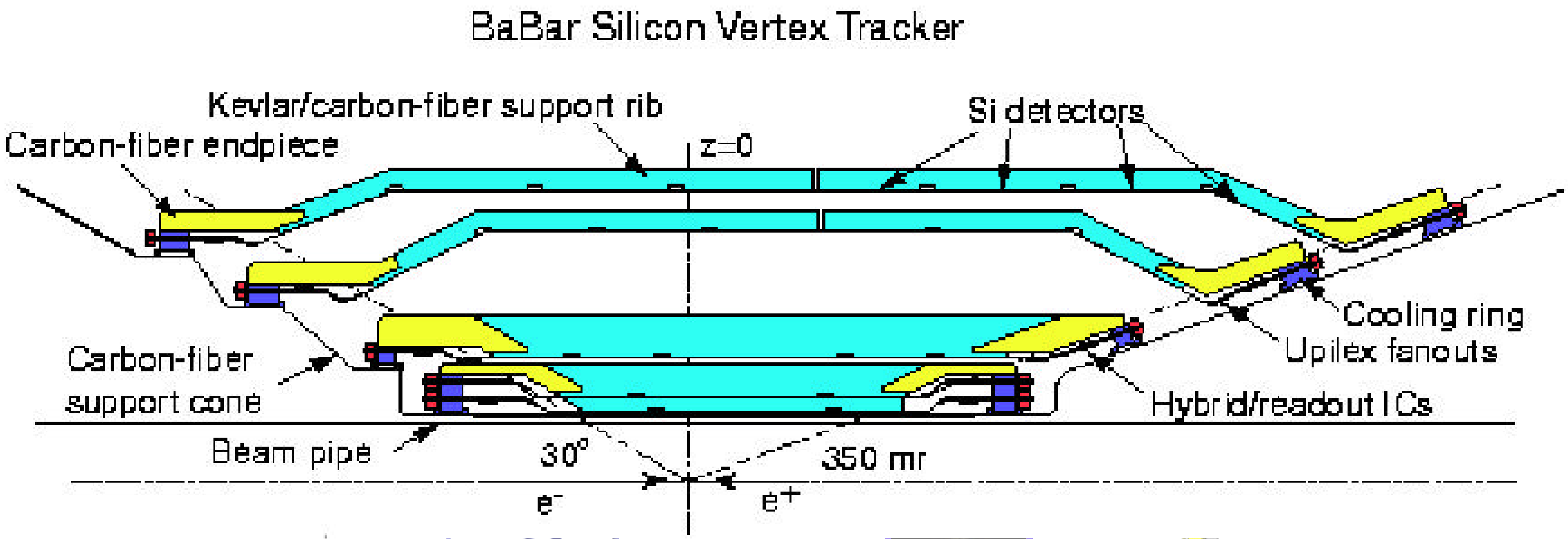
Silicon Vertex Tracker



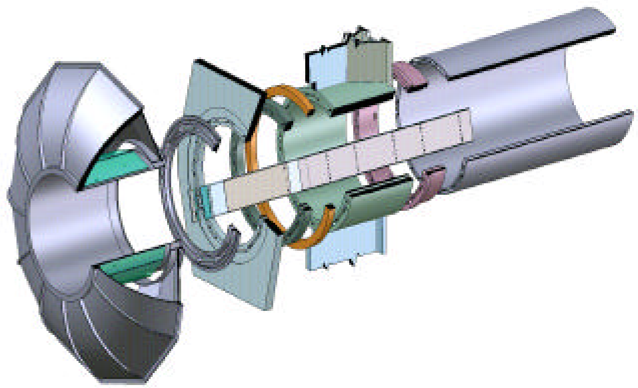
- Measure the track parameters just outside the beam pipe.
- dE/dx measurement for PID.
- 5 layers of double sided silicon strips

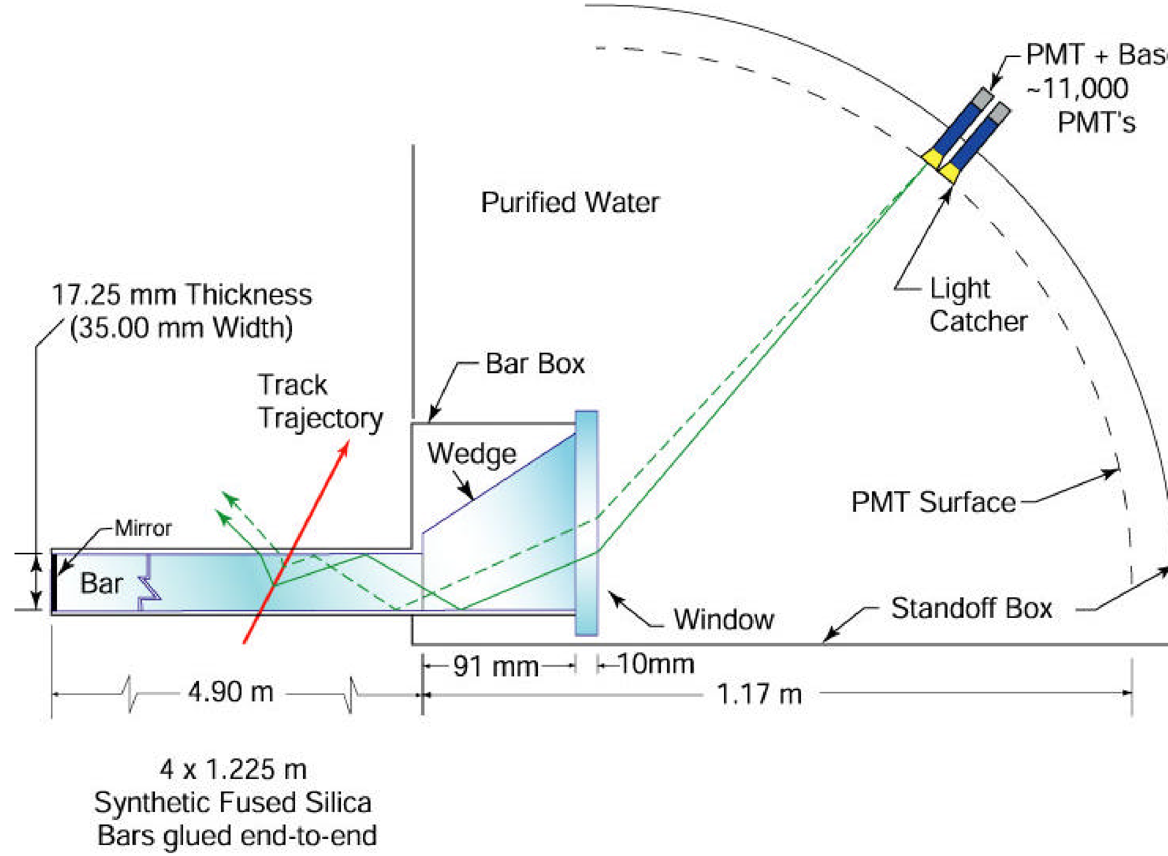
Single hit resolutions in the inner layers $\sigma d_0 \approx$ 55 µm, $\sigma z_0 \approx$ 65 µm

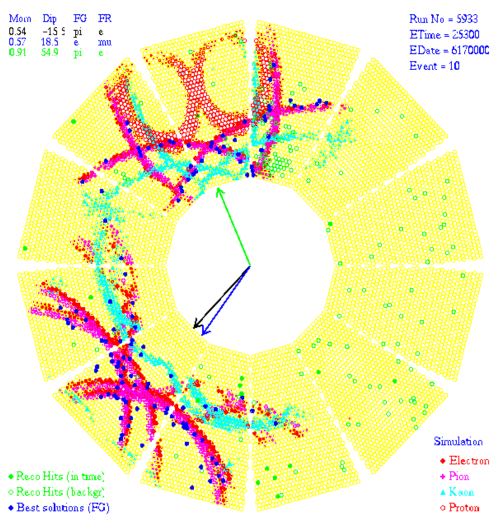
Soft π from the $D^* \to D\,\pi_s$ decays extends below p_T< 150 MeV/c



Detector of Internally Reflected Cherenkov light







K/π discrimination

144 fused silica bars (1.7 cm thick)

Cherenkov light transported by internal reflection

11000 PMTs,

25-50 p.e./particle

10 mrad single photon resolution

ElectroMagnetic Calorimeter

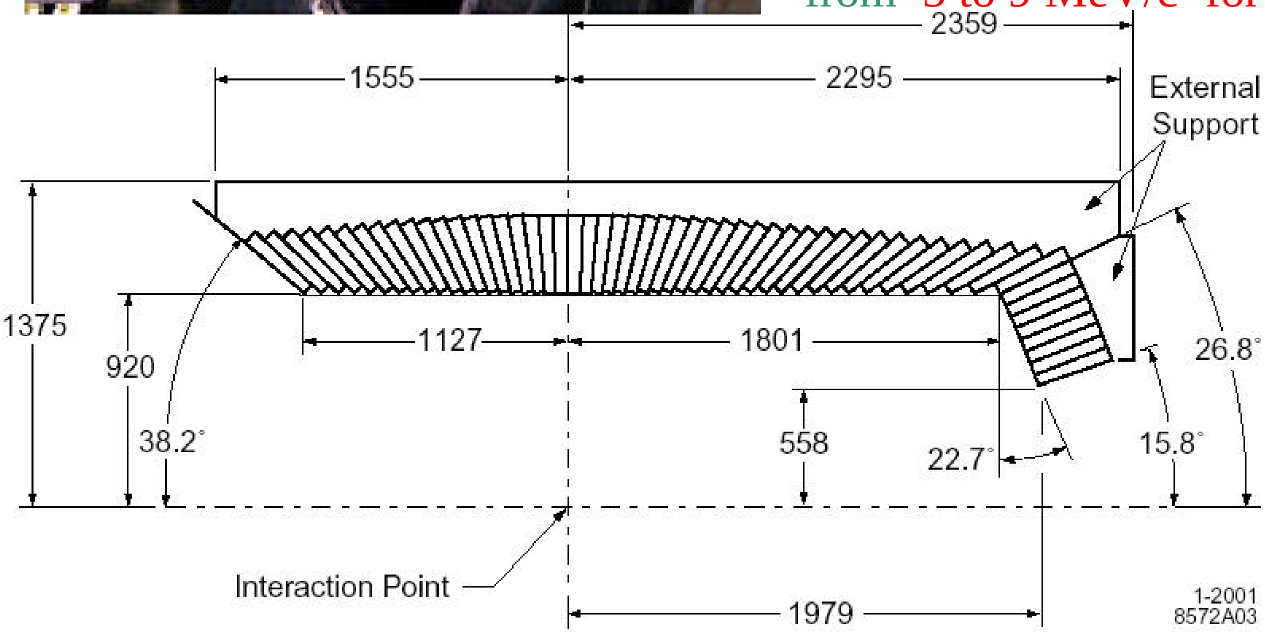
6580 CsI(TI) crystals

Barrel 48 rings in θ, 120 crystals per ring

Forward Endcap 8 rings in θ, 80/100/120 crystals per ring

Angular coverage: 126° in θ, 360° in ϕ.

π^0 reconstructed from $\pi_0 \to \gamma\gamma$, mass width varying from 5 to 9 MeV/c^2 for $0.2 < E_\pi < 4.8$ GeV



Electron i.d. efficiency up to 90% misidentification probability at the level of

1 × 10-3.

Instrumented Flux Return

Number of active elements

- 342 barrel RPC
- 432 endcap RPC
- 32 cylindrical inner RPC

Total surface covered

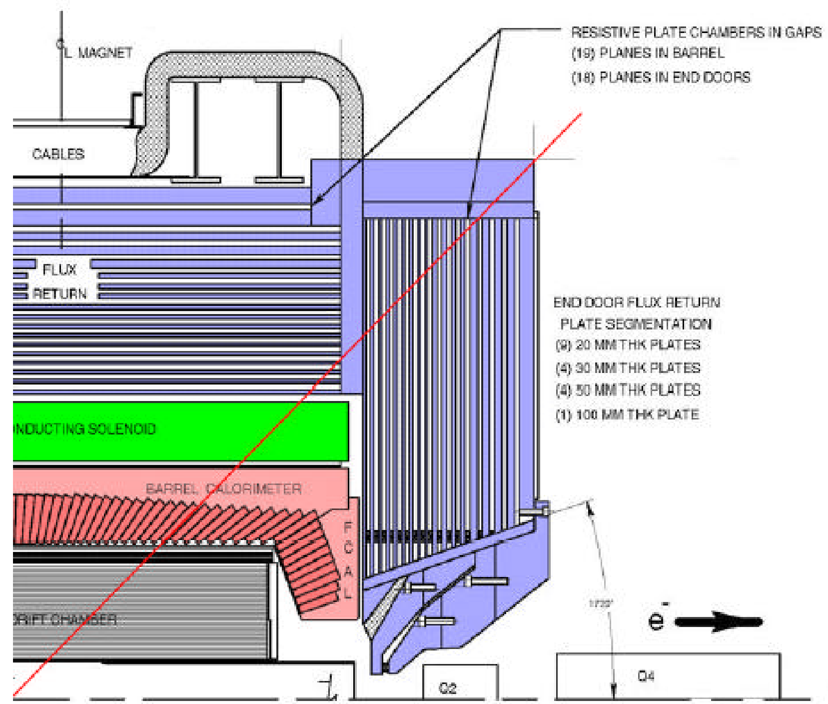
- 2000 m^2

Gas mixture

- Argon 60.5%
- Freon 35%
- Isobutane 4.5%

Electronics

- 50000 channels



Muon identification efficiency for tight criteria ε ≈ 65% for a misidentification at the level of 2%

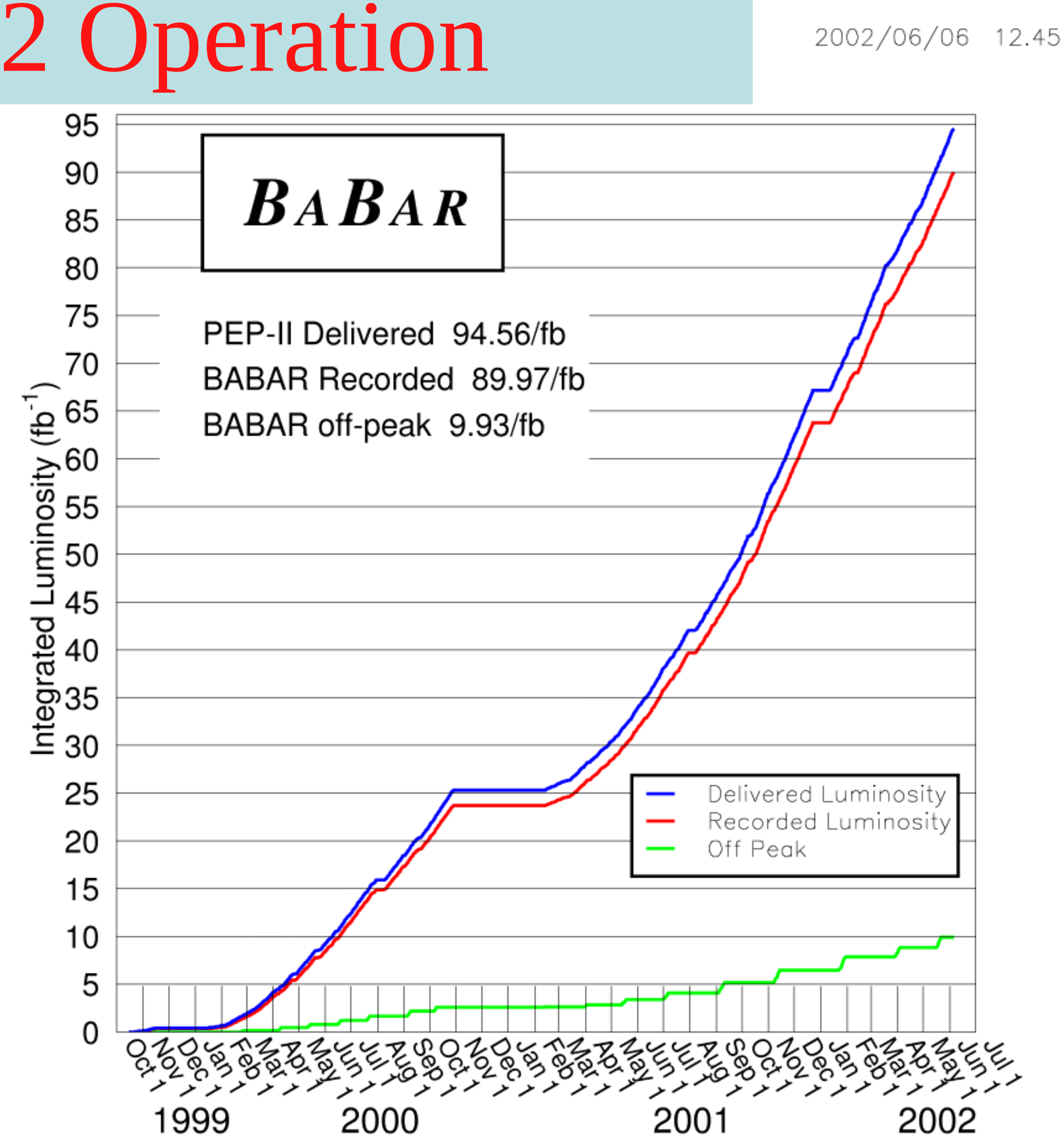
Neutral hadrons (namely KL) are detected after their interaction with iron.Only direction is measured

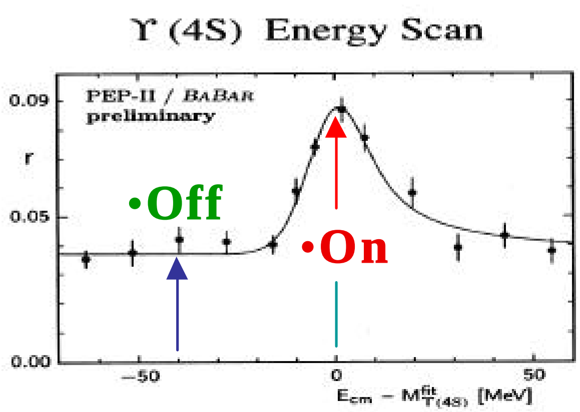
2000 – 2002 Operation

> 95 fb-1 recorded by June 30

(~10^8 B events)

(~12% off peak)

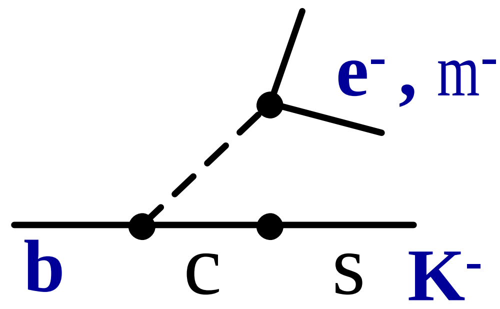




Sin2β measurement on a total 56/fb collected on peak

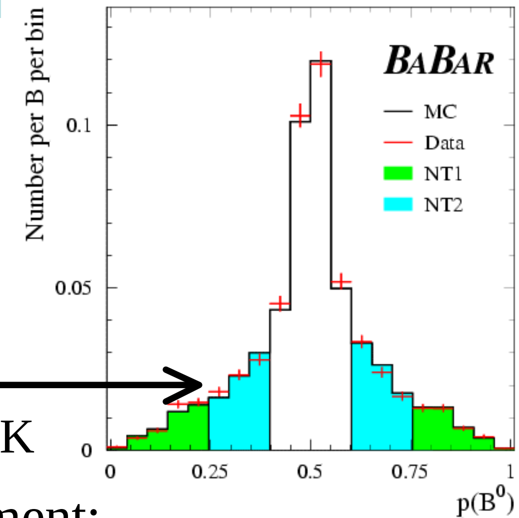
(~62 million B Bbar pairs)

Flavor Tagging



Hierarchical tagging categories:

- Lepton – charge of lepton
- Kaon – net charge of kaon
- NT1 } exploit information from momentum spectrum
- NT2 } of charged particles, soft π from D*, unidentified l and K



Large B_{flav} sample provide tagging performance measurement:

Tagging category	Efficiency ε (%)	Mistag fraction w (%)	$B^0/\overline{B}^0$ diff. Δw (%)	$Q = \varepsilon(1-2w)^2$ (%)
Lepton	11.1 ± 0.2	**8.6 ± 0.9**	0.6 ± 1.5	7.6 ± 0.4
Kaon	**34.7 ± 0.4**	18.1 ± 0.7	-0.9 ± 1.1	14.1 ± 0.6
NT1	7.7 ± 0.2	22.0 ± 1.5	1.4 ± 2.3	2.4 ± 0.3
NT2	14.0 ± 0.3	37.3 ± 1.3	-4.7 ± 1.9	0.9 ± 0.2
ALL	67.5 ±0.5			**25.1 ± 0.8**

$\sigma(\sin 2\beta) \propto 1/\sqrt{Q}$

Fully Reconstruction of B Decays

Two kinematical variables are used in BaBar analyses to select B mesons :

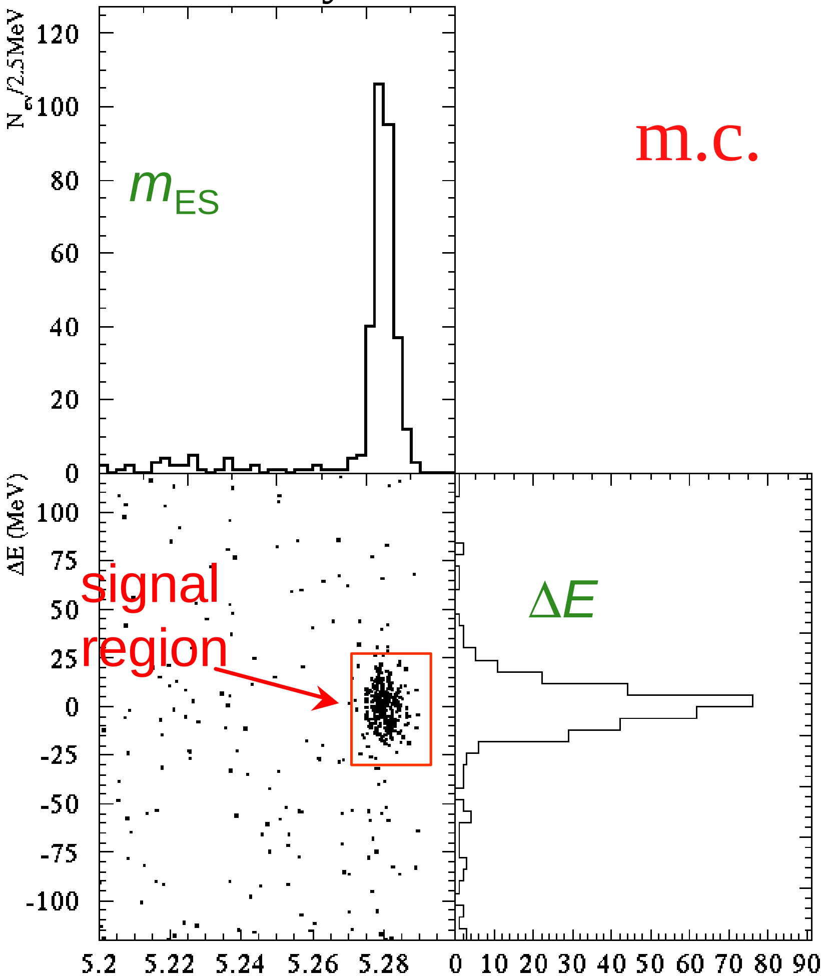
Energy substituted mass

$$m_{ES} = \sqrt{s/4 - p_B^{*2}}$$

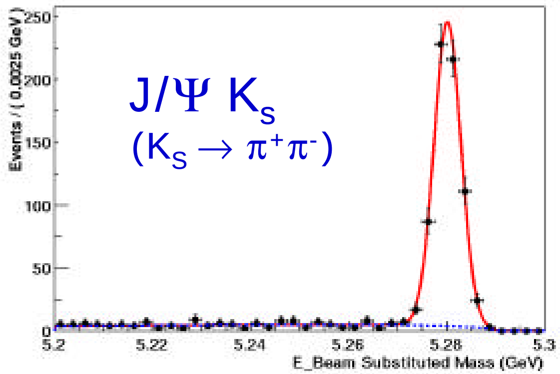
the resolution on m_{ES} is 2.6 MeV/c^2 and mainly depends on the E_{beam} uncertainty

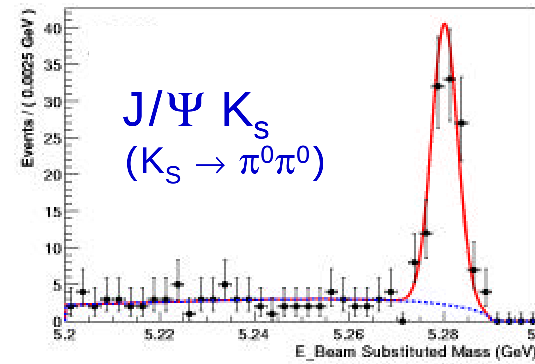
$$\Delta E = E_B^* - \sqrt{s}/2$$

ΔE depends on the decay channel(masses of products..), its resolution mainly on tracking

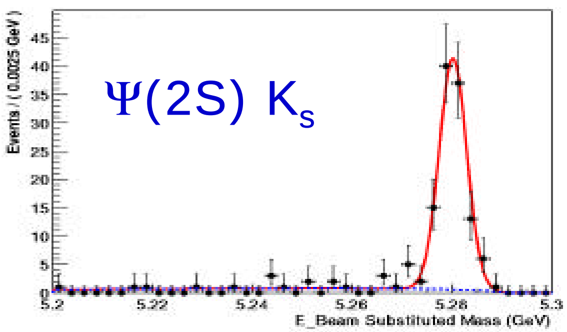


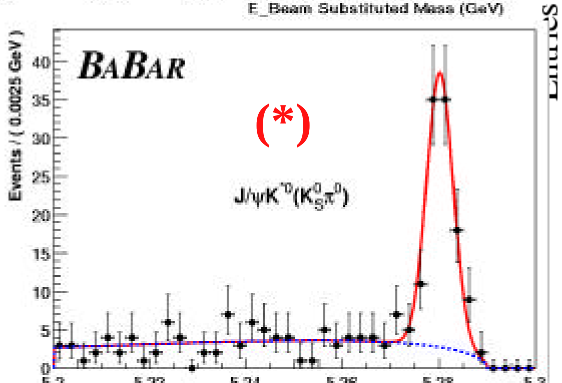
The fully Reconstructed CP(sin2b) Sample



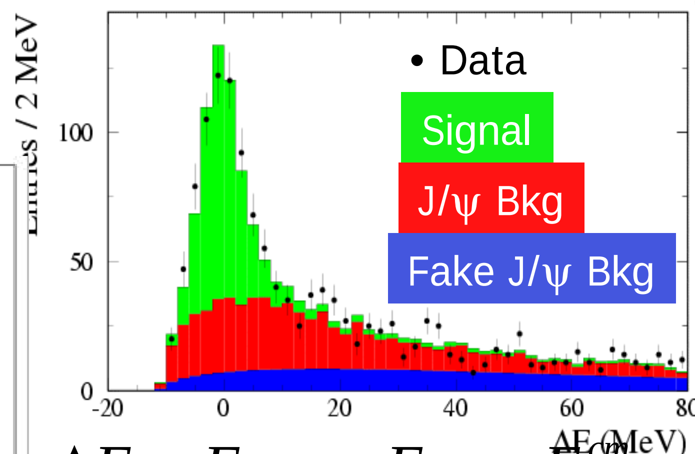


Mode	N_{tagged}	Purity
(cc)K_s	995	94%
J/Y K_L	742	57%
J/Y K^{*0}	113	83%
All CP	1850	79%

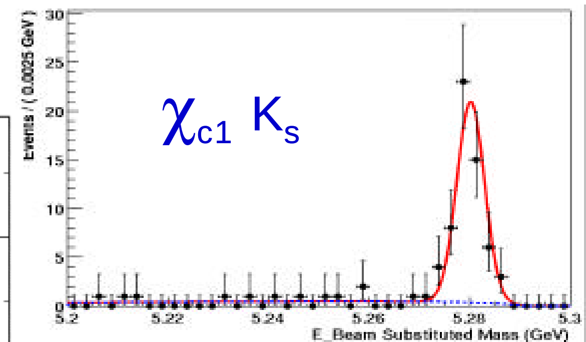




$m_{ES} = \sqrt{(E_{beam}^{cm})^2 - (p_B^{cm})^2}$



$$\Delta E = E_{J/y} + E_{K_L} - E_{beam}^{cm}$$



(*)angular analysis to take into account Cp=1 and CP=-1 eigenstates

sin2β Likelihood Fit

- **Unbinned** maximum likelihood fit to Δt distribution.
- Background is determined from m_{ES} fit (flat) or MC (peaking)
- B_{flav} sample → mistag rates and Δt resolution both for signal and for background
- Total of 34 parameters

CP PDF

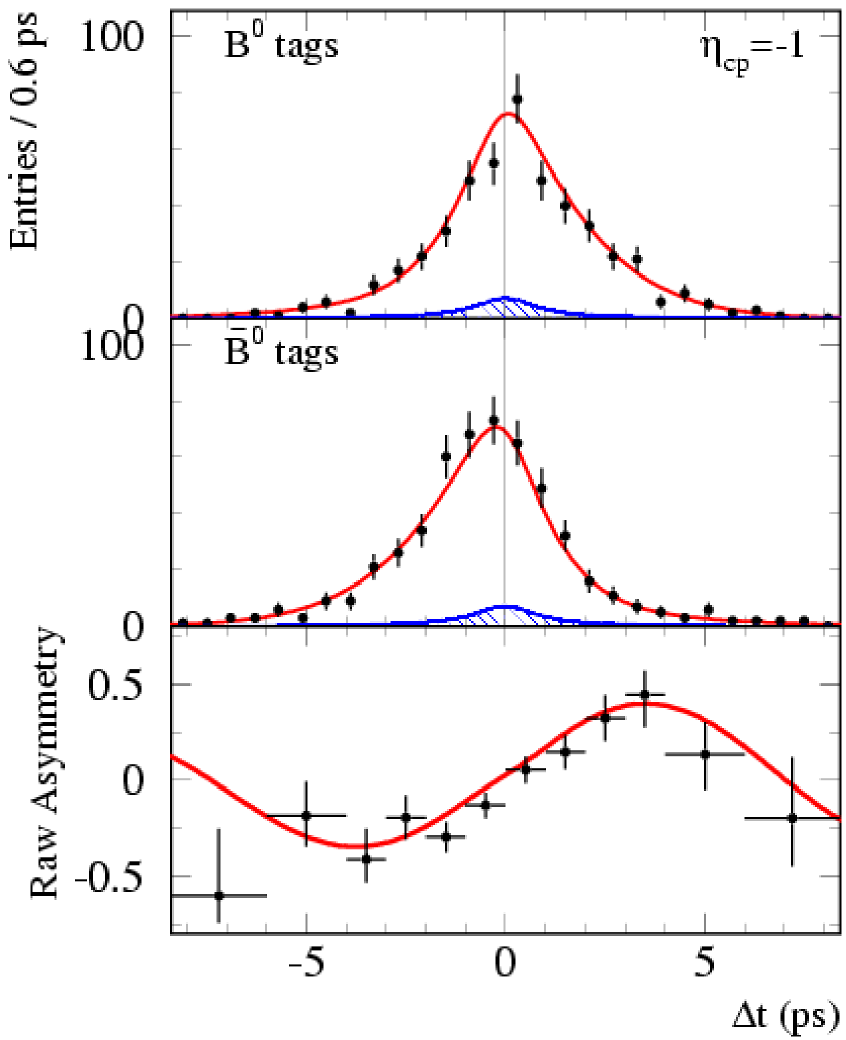
$$f_{CP,\pm}(\Delta t) = \left\{ \left| \frac{e^{-|\Delta t|/t_{B_d}}}{4t_{B_d}} \times \left(1 \pm h_f \sin 2b (1-2w) \sin(\Delta m_d \Delta t)\right) \right| \right\} \otimes R$$

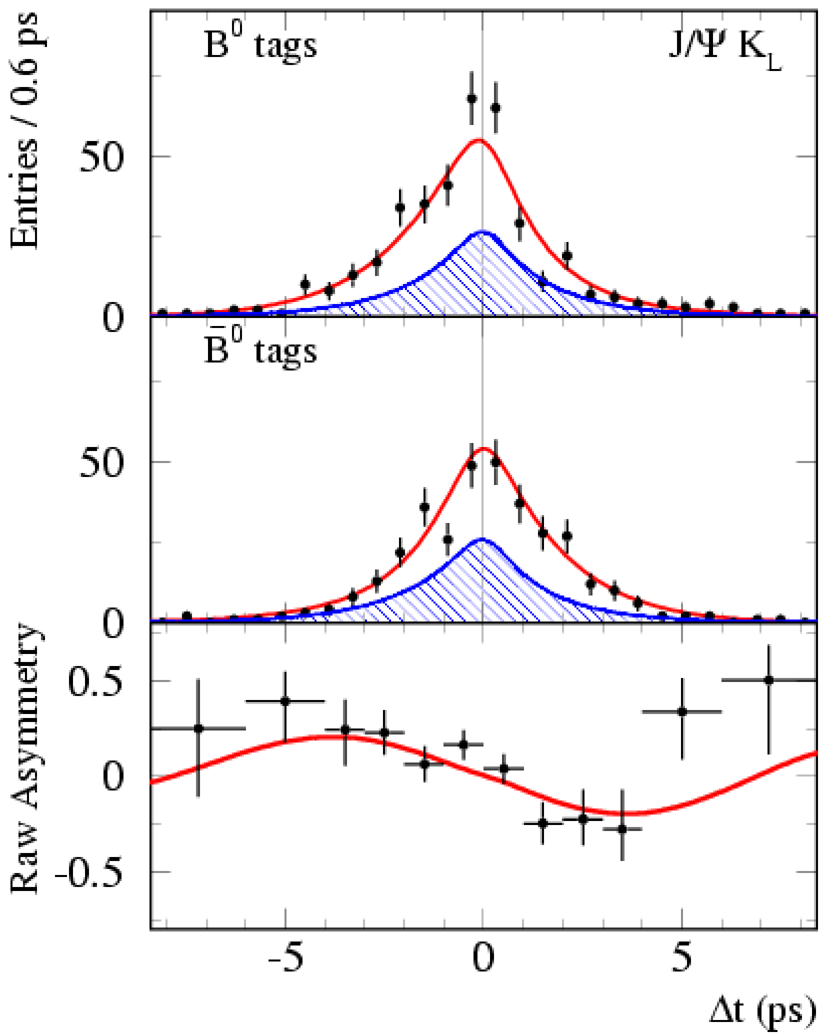
Mixing PDF

$$f_{mixing,\pm(\Delta t)} = \left\{ \frac{e^{-|\Delta t|/t_{B_d}}}{4t_{B_d}} \times \left[1 \pm (1-2w)\cos(\Delta m_d \Delta t)\right] \right\} \otimes R$$

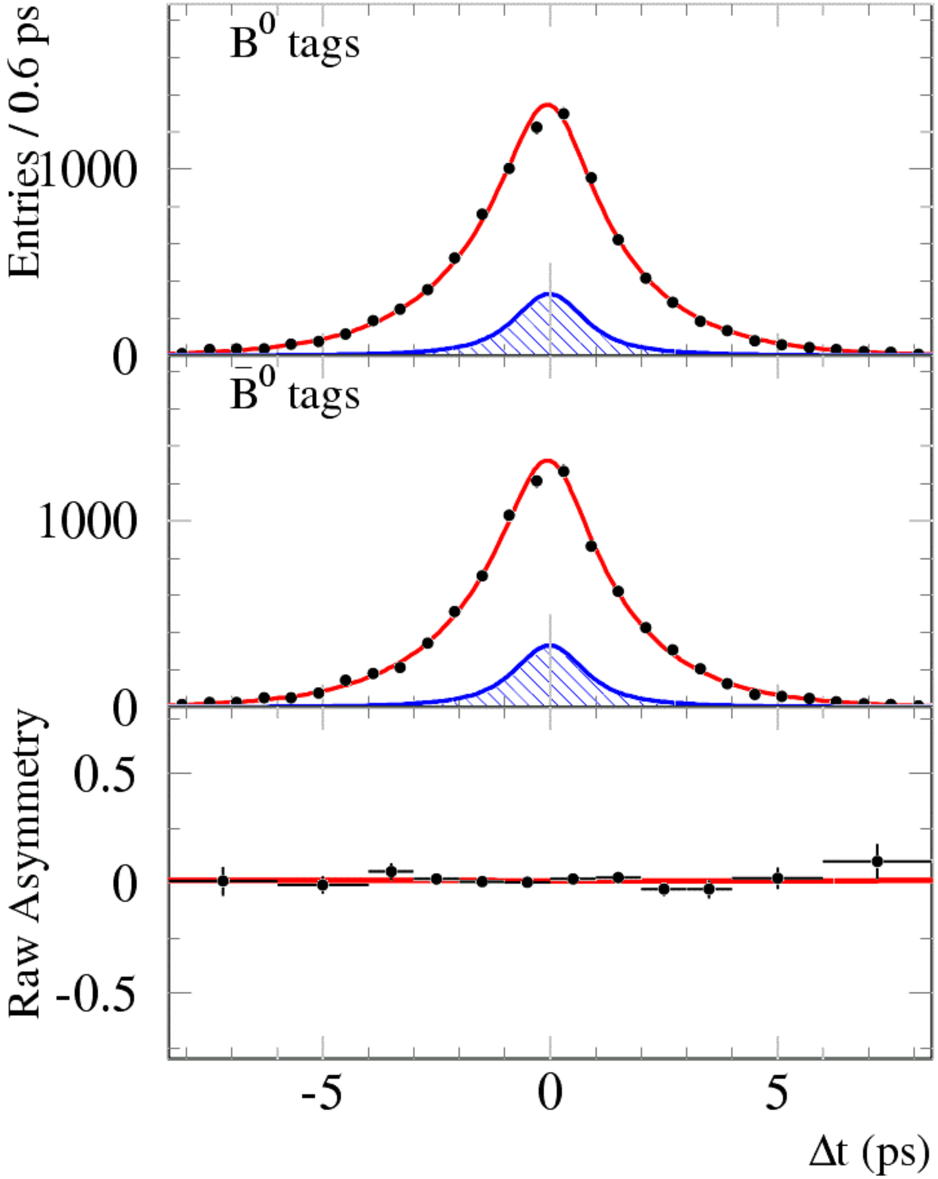
$\tau_B = 1.548$ ps
$\Delta m_d = 0.472$ ps^{-1}
fixed

CP asymmetries





Test in B Flavor Sample

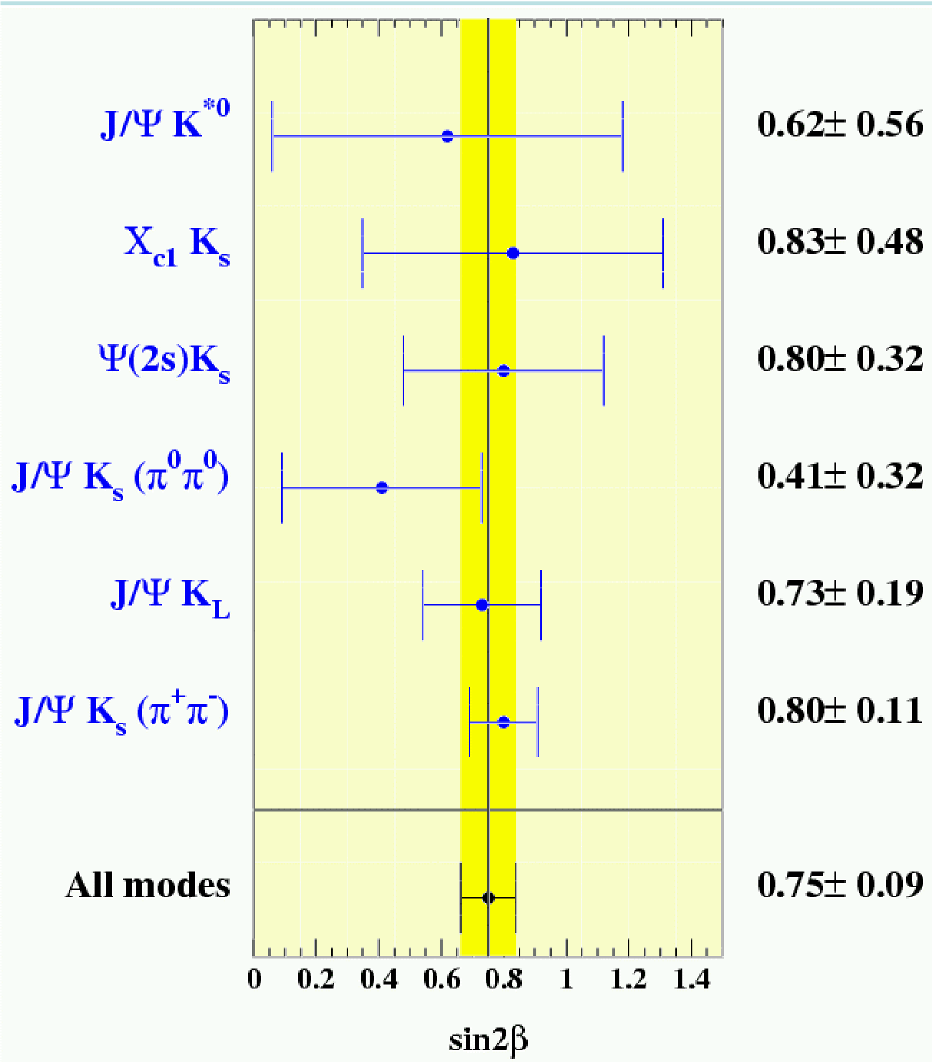


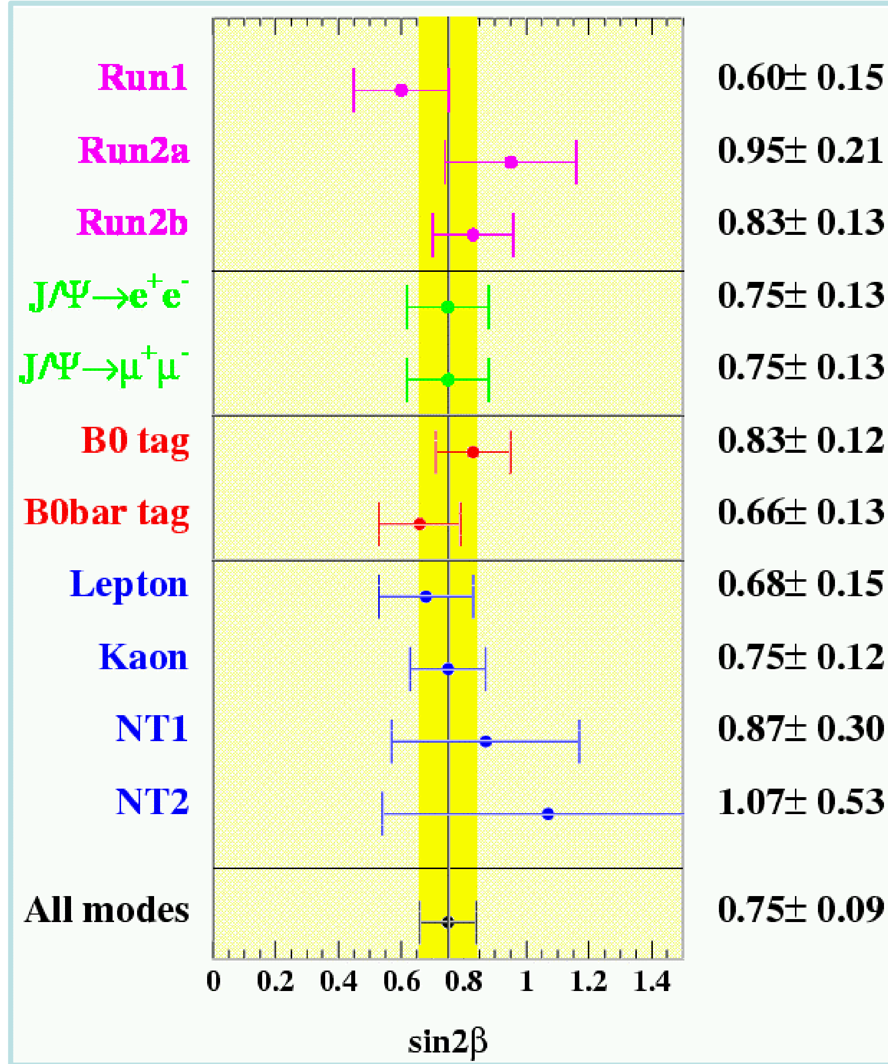
B flavor sample as control sample for CP analysis

Sample	Apparent “sin2b”
$B^0 \rightarrow D^{(*)-}$ p$^+$, r$^+$, a_1^+	-0.01 ± 0.03
$B^0 \rightarrow$ J/Y $K^{*0}(K^+$p$^-)$	0.00 ± 0.09
$B^- \rightarrow D^{(*)0}$ p$^-$	-0.01 ± 0.03
$B^- \rightarrow$ J/y ,c_c K^-	-0.05 ± 0.08

sin2β fit results

Sin2β = 0.75 ± 0.09 (stat) ± 0.04 (syst)





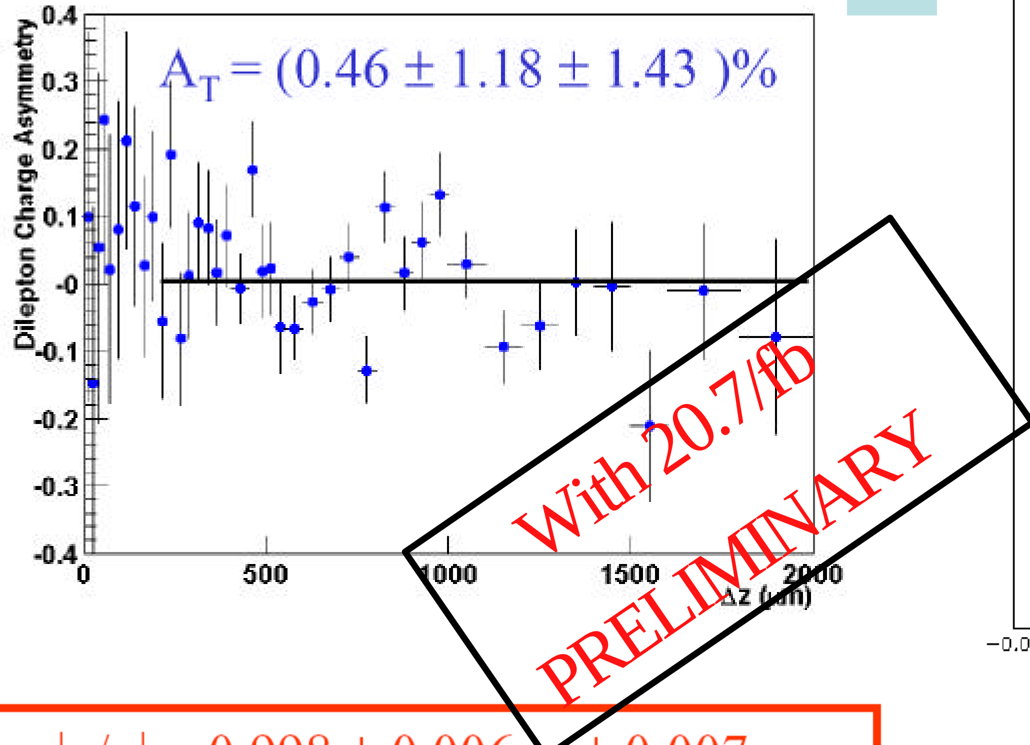
Direct CP violation ?

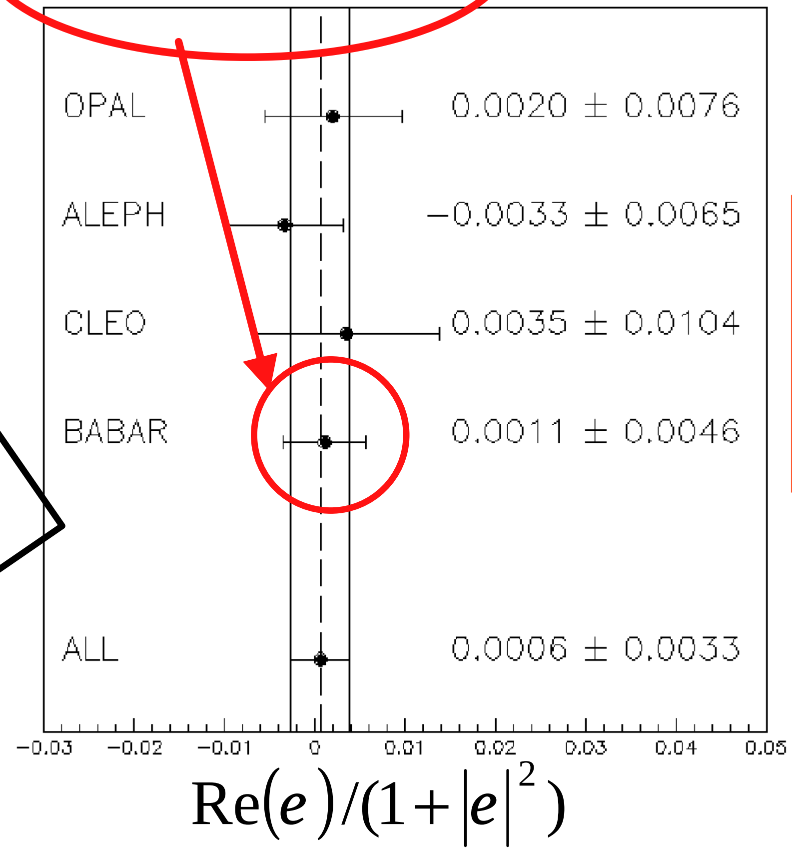
Allowing for direct CP violations in the fit:

$|\lambda| = 0.93 \pm 0.06\,(stat) \pm 0.02\,(syst)$

0.0011±0.0046

CP in mixing with dilepton events





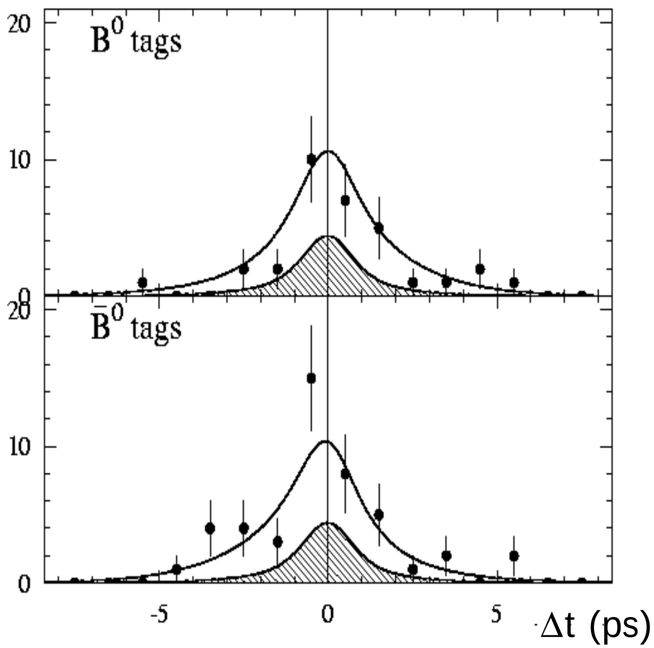
$|q/p| = 0.998 \pm 0.006_{stat} \pm 0.007_{sys}$

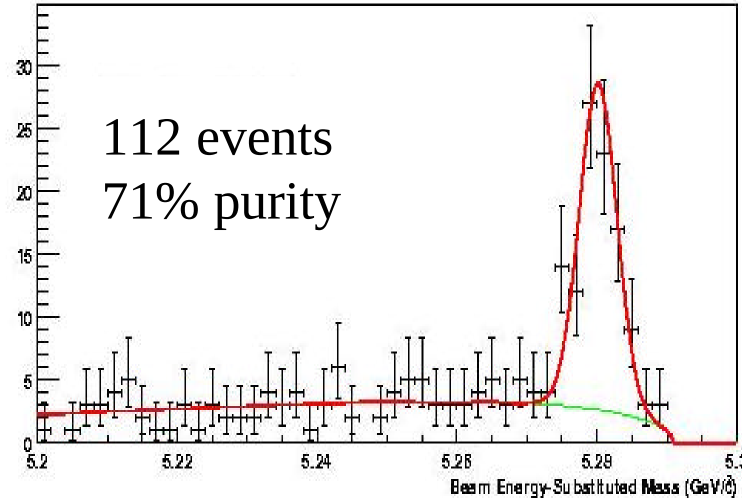
And a new Charmonium mode

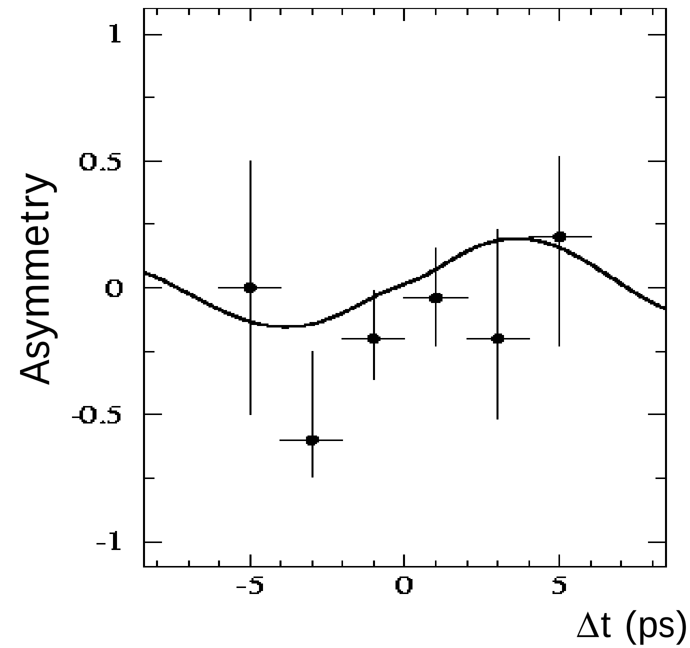
$B^0 \to \eta_c K_s$

$h_c \to K_s K^{\pm}\pi^{+}, K^{+}K^{-}\pi^{0}$

$\sin 2\beta = 0.43 \pm 0.46 \pm 0.08$





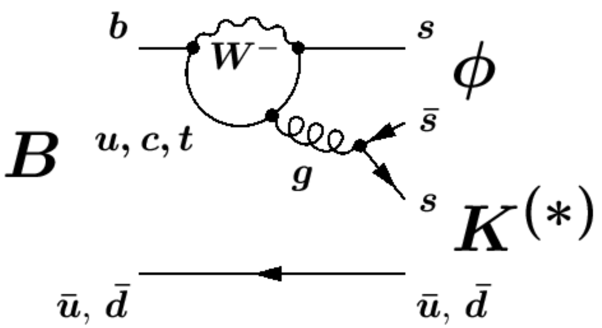


$B^0 \to D^{+*}D^{-*}$ see the talk of Justin Albert in the parallel session!

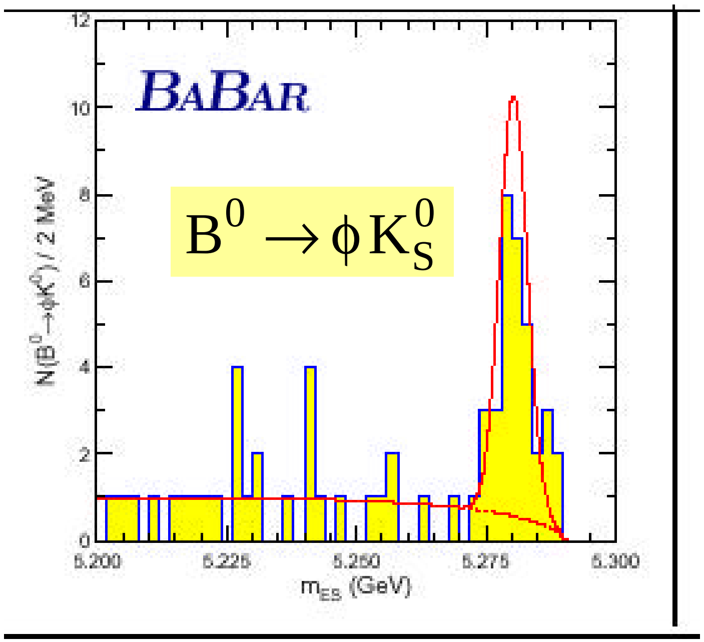
Next in the line: sin2b in pure penguin decays

Pure Penguin Decay:

40 +/- 8 event in 57 fb-1



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



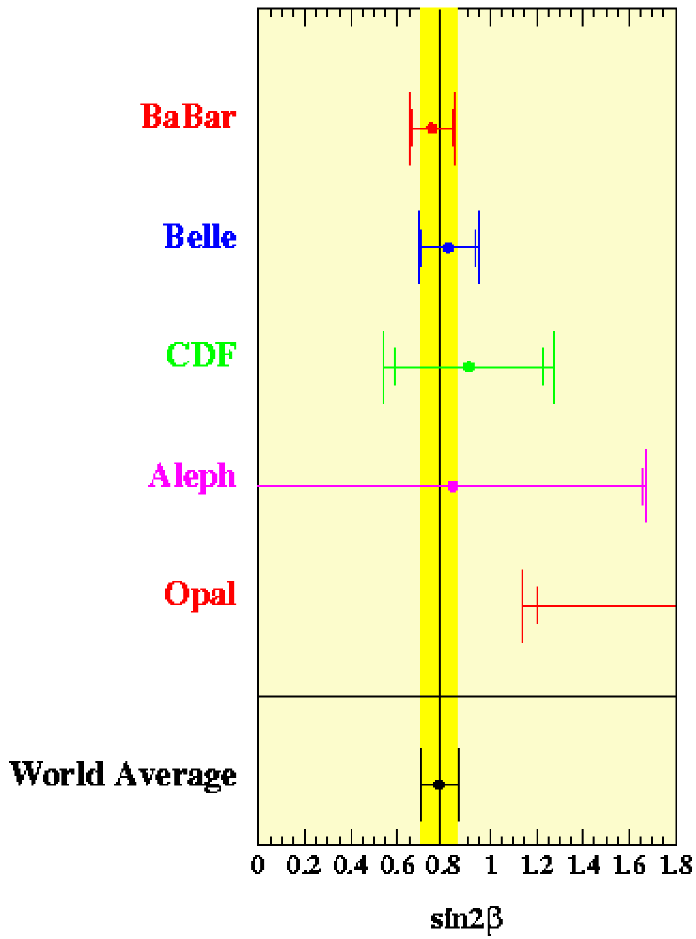
In SM: it gives an independent measurement of sin2b !!

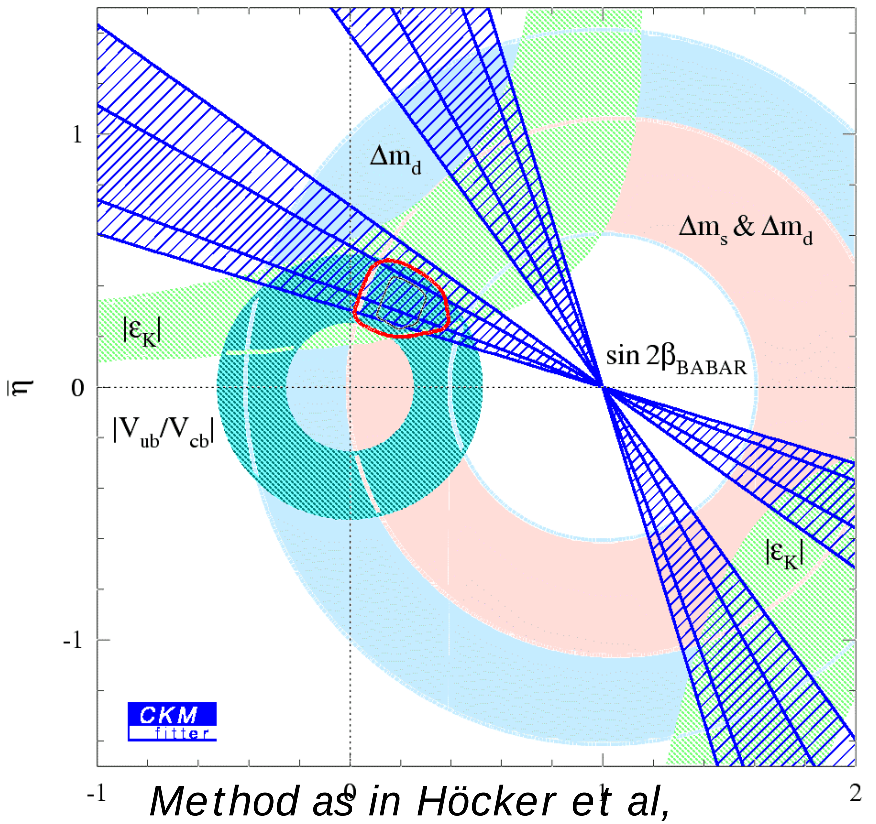
Deviations imply new physics beyond S.M

New BaBar Results based on 57 fb-1

- $\mathcal{B}(B^{\pm} \to \varphi K^{\pm}) = (9.2 \pm 1.0 \pm 0.8) \times 10^{-6}$
- $\mathcal{B}(B^{\pm} \to \varphi \pi^{\pm}) < 0.56 \times 10^{-6}$ (90% CL)
- $\mathcal{B}(B^{0} \to \varphi K^{0}) = (8.7^{+1.7}_{-1.5} \pm 0.9) \times 10^{-6}$

The Standard Model is resisting the attacks





Method as in Höcker et al, Eur.Phys.J.C21:225-259,2001 (also other recent global CKM matrix analyses)

Measuring a and g is an harder task
CP violation in Hadronic non-Charm B decays

From b→uud/uus/ddd

where **T** (CKM suppressed with $|V_{ub}/V_{cb}|^2 \approx 0.006$) **& P** amplitudes contribute to (LT) and (ST) at the same CKM order O(λ^3)

B→p+p-, **B→K+**p-, K+K-

B→p0p0, p+p0. K**0K0, ..**

B→r p, ppp, K*p,Kpp, KKp

B→fK(*), hK(*), h'**K(*),**

B→ wK(*), wp, **….**

3 amplitudes may mutually interfere **Mixing**, **Tree** and **Penguin**

If T only → Φ_{CP} (the phase of λ_{cp}) is $-2(\beta+\gamma)$ → measure 2α.

If P only → the phase Φ_{CP} is null

If both → directely, can only measure α_{eff}.

BUT:Small BR ~O(10^{-5}-10^{-6}). High udsc background.No easy signature for the searched modes. Particle ID (π/K separation) is necessary. Tagging and vertexing (Δt measurement) are needed

Look for asymmetries

Time dependent in CP eigenstates: B→p^+p^-

The rates for B^0 (B^0bar) tag are:

$$f_{\pm}(\Delta t) = \frac{e^{(-|\Delta t|/t)}}{4t}[1 \pm S_f \sin(\Delta m_d \Delta t) \mp C_f \cos(\Delta m_d \Delta t)]$$

$$S_f = \frac{2\,\mathrm{Im}(\lambda)}{1+|\lambda|^2}$$

$$C_f = \frac{1-|\lambda|^2}{1+|\lambda|^2}$$

Measure S_f, and C_f S_f=sin(2a+d)=sin2a [1+O(P/T)]

Some theory constraint (?) : 0.18<|P/T|<0.4

Isospin analysis could allow disentangling a(weak) and d(strong) phases

Time independent : B→Kp

$$A_{Kp} \equiv \frac{Br(B^0 \to K^- p^+) - Br(\overline{B}^0 \to K^+ p^-)}{Br(\overline{B^0} \to K^- p^+) + Br(B^0 \to K^+ p^-)} \sim \left|\tfrac{P}{T}\right| \sin(g)\sin(d)$$

Analysis strategy

2 Phase Analysis

Direct CP

extract branching fractions for ππ, Kπ and KK and also the Kπ decay CP asymmetry $A_{K\pi}$

- Maximum likelihood fit to kinematic/event shape quantities
- ★ Do not require tag or vertex measurement
- ★ Separate fit reduces systematic error

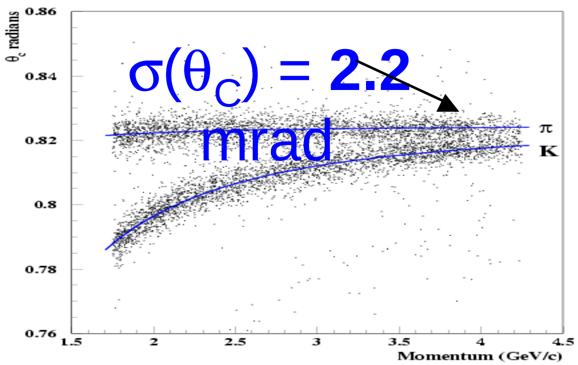
Indirect CP

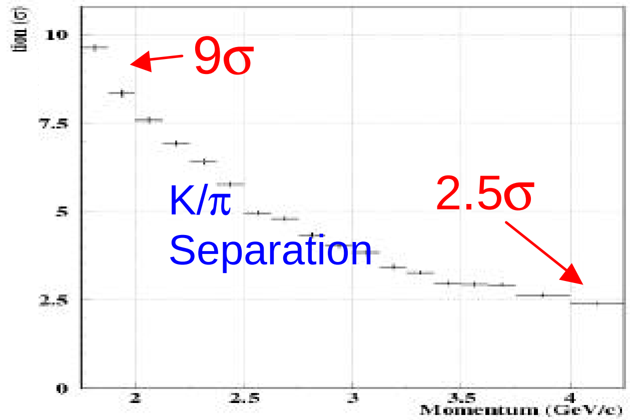
extract ππ CP asymmetry $\sin 2\alpha_{eff}$

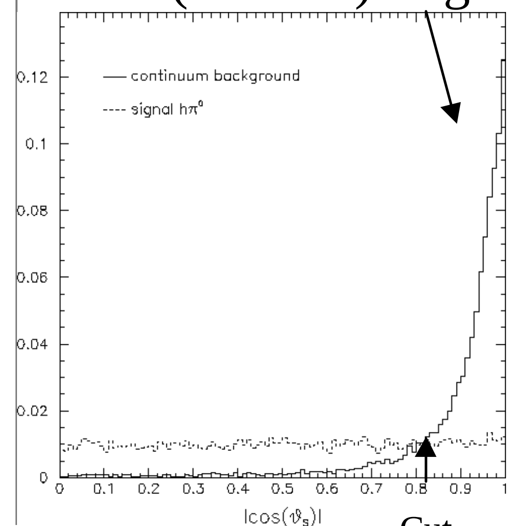
- Fix branching fractions and $A_{K\pi}$ to above results
- ★ Requires tag to determine if B^0 or $\bar{B}^0$
- ★ Requires vertex information for time dependent fit

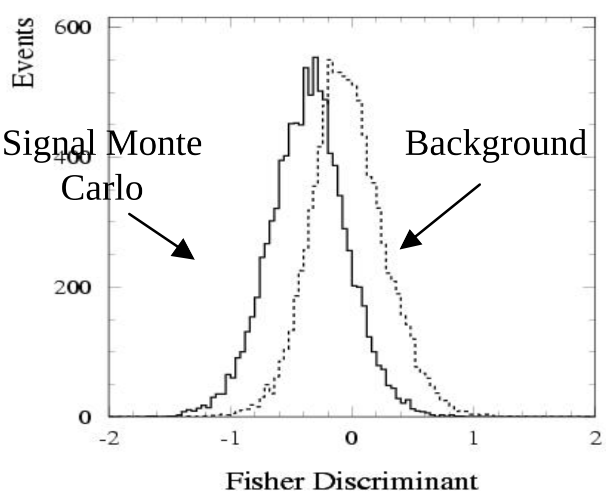
Event identification

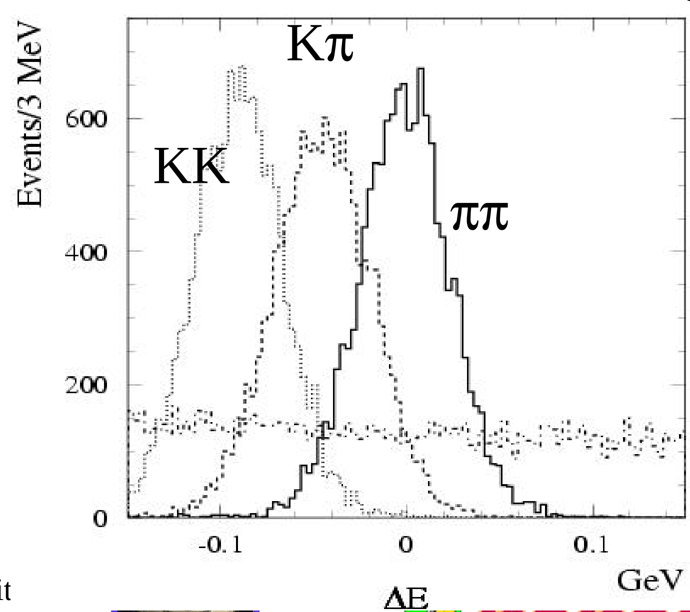
θ_C distribution from data (D* control sample)-Cut on angle between candidate and sphericity(other tracks)-CLEO Fischer. Energy flow in 9 cones (for now). Signal on MC, bkg from fit.











Branching fraction maximum likelihood fit and **results**

5 input variables for event identification; assume independent (uncorrelated) PDFs :

m_{ES} F ΔE θ_C^+ θ_C^-

Signal/Bkg discrimination (m_{ES}, F, ΔE)   Different signal modes discrimination (ΔE, θ_C^+, θ_C^-)

8 fit parameters: four for signal, four for background

$N(\pi^+\pi^-)$ $N(K^+\pi^-)$ $N(\pi^+K^-)$ $N(K^+K^-)$

Fit directly N(Kp) and $A_{K\pi}$: **$N(K^+p^-) = N(Kp)\,(1-A_{Kp})/2$ $N(p^+K^-) = N(Kp)\,(1+A_{Kp})/2$**

Mode	Yield (events)	Branching Fraction (10^{-6})	Kπ Asymmetry, $A_{K\pi}$
$B^0 \to p^+p^-$	124^{+16+7}_{-15-9}	$5.4 \pm 0.7 \pm 0.4$	
$B^0 \to K^+p^-$	$403 \pm 24 \pm 15$	$17.8 \pm 1.1 \pm 0.8$	$-0.05 \pm 0.06 \pm 0.01$
$B^0 \to K^+K^-$	< 15.6 (90% C.L.)	< 1.1 (90% C.L.)	

No significant direct CP violation seen in $B^0 \to K^+\pi^-$

90% C.L. $-0.14 < A_{K\pi} < 0.05$

Main systematic uncertainties:

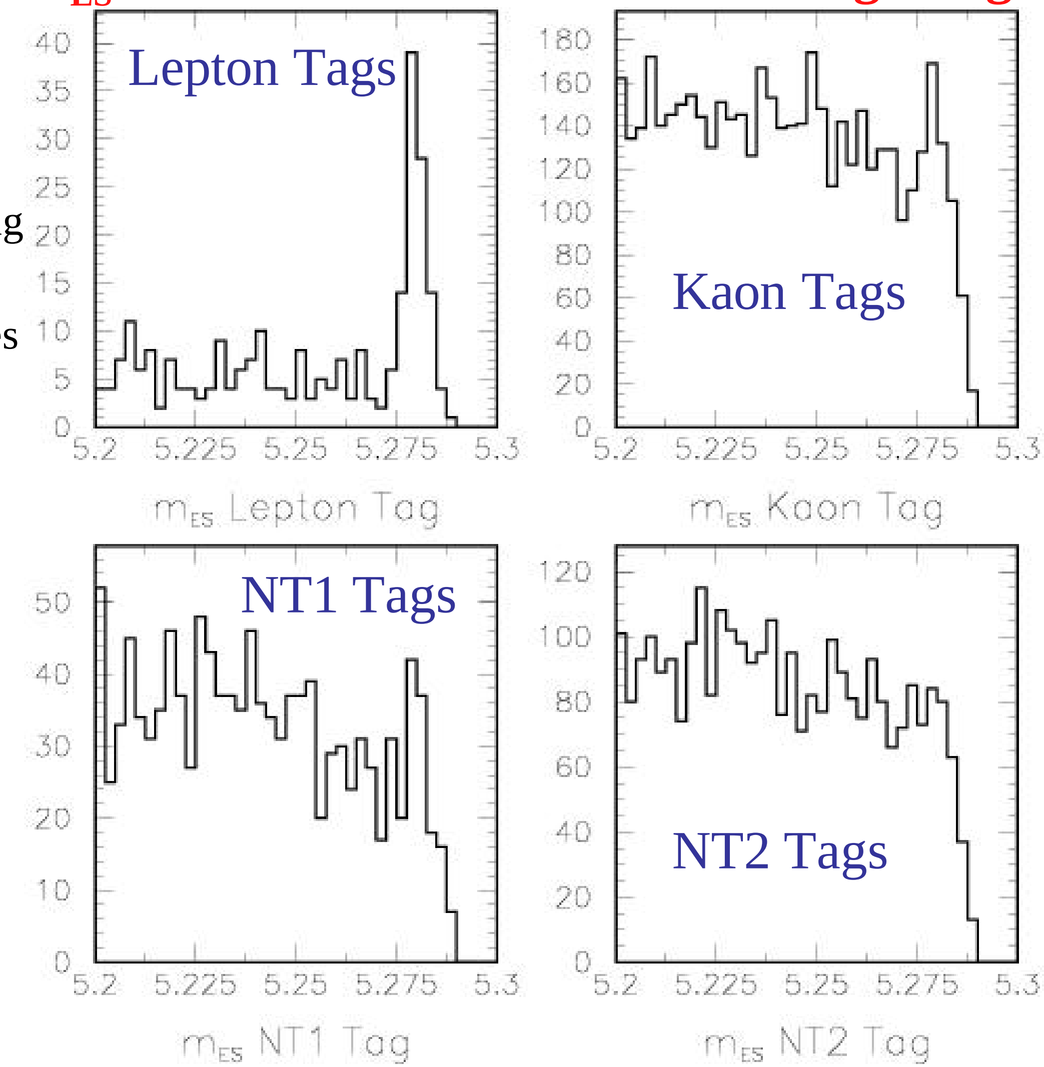
Branching fractions – uncertainty in shape of θ_C PDF

Asymmetry - possible charge bias in track and θ_C reconstruction

Indirect CPV Tagged CP sample

m_{ES} distributions for the different tag categories

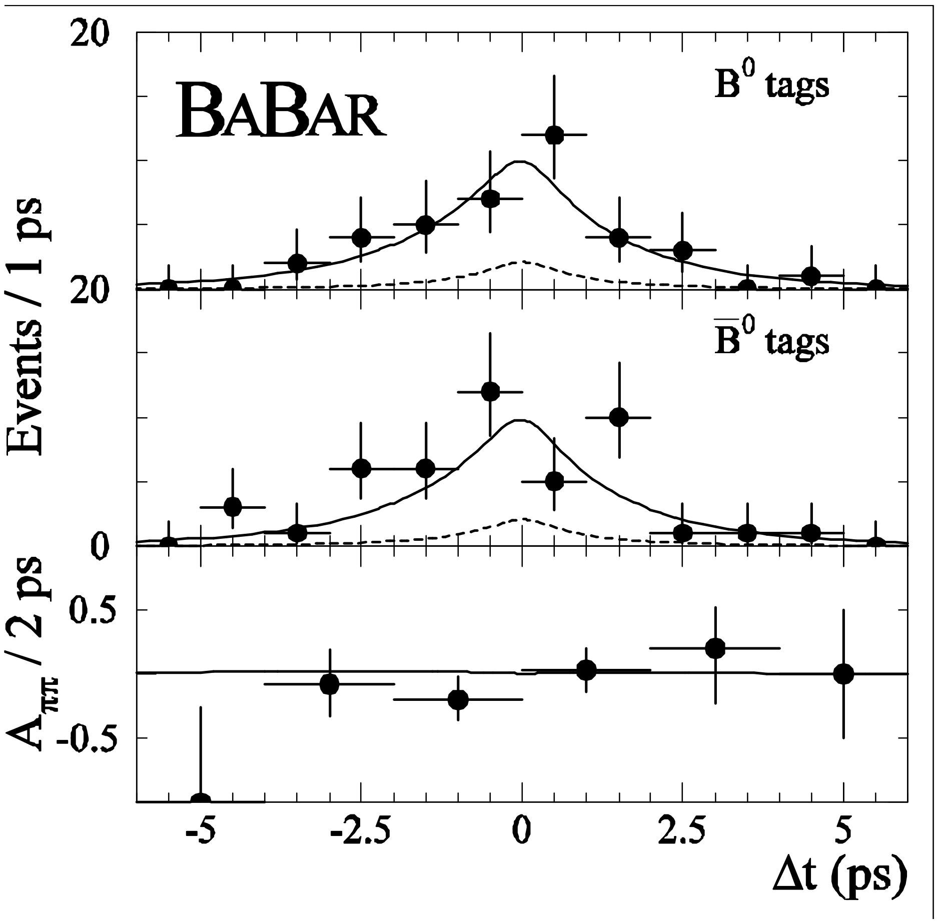
- Tagging efficiency is very different for signal and bkg
  - Strong bkg suppression in categories with the lowest mistag prob (Lepton/Kaon)
  - Separate bkg tagging efficiencies for different species (ππ, Kπ, KK)
- The Bkg shape in m_{ES} varies across categories (untagged events (~33%)retained in the fit to obtain Bkg shapes)
  - Assume separate shapes in the CP fit
- All bkg tagging parameters are determined together with CP asymmetries



CP Asymmetry Results

- **Global ML fit using:**
  - **m_{ES}, DE, F, q_c, and Dt**

Fit projection in sample of pp-selected events



$$S_{pp} = -0.01 \pm 0.37 \pm 0.07$$

$$C_{pp} = -0.02 \pm 0.29 \pm 0.07$$

$$A_{Kp} = -0.05 \pm 0.06 \pm 0.01$$

Validation of Tagging, Vertexing, and ML Fit

"Toy" studies of simulated experiments parameters unbiased

Errors and Likelihood values consistent with expcted

Kp decays are self-tagging

T = tag charge

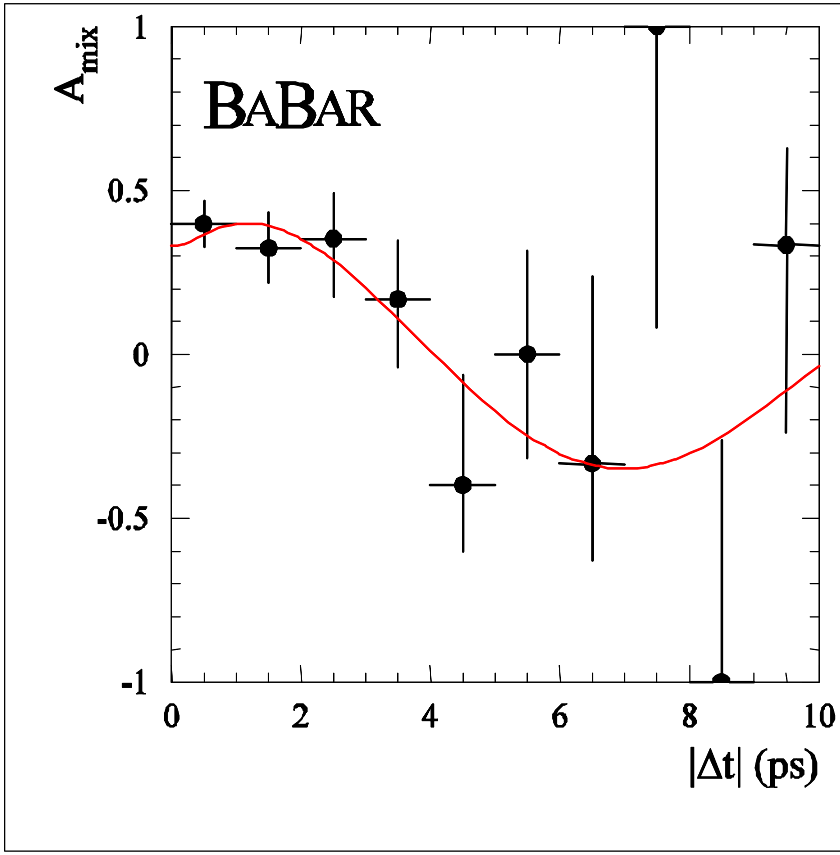
Q = kaon charge

$$f^{Kp}_{T,Q}(\Delta t) \approx \frac{e^{-|\Delta t|/t}}{4t}\left[1 - TQ(1-2w)\cos(\Delta m_d \Delta t)\right]$$

Float t and Δm_d in same sample used to extract CP asymmetries:

$$t = (1.66 \pm 0.09)\,\text{ps}$$

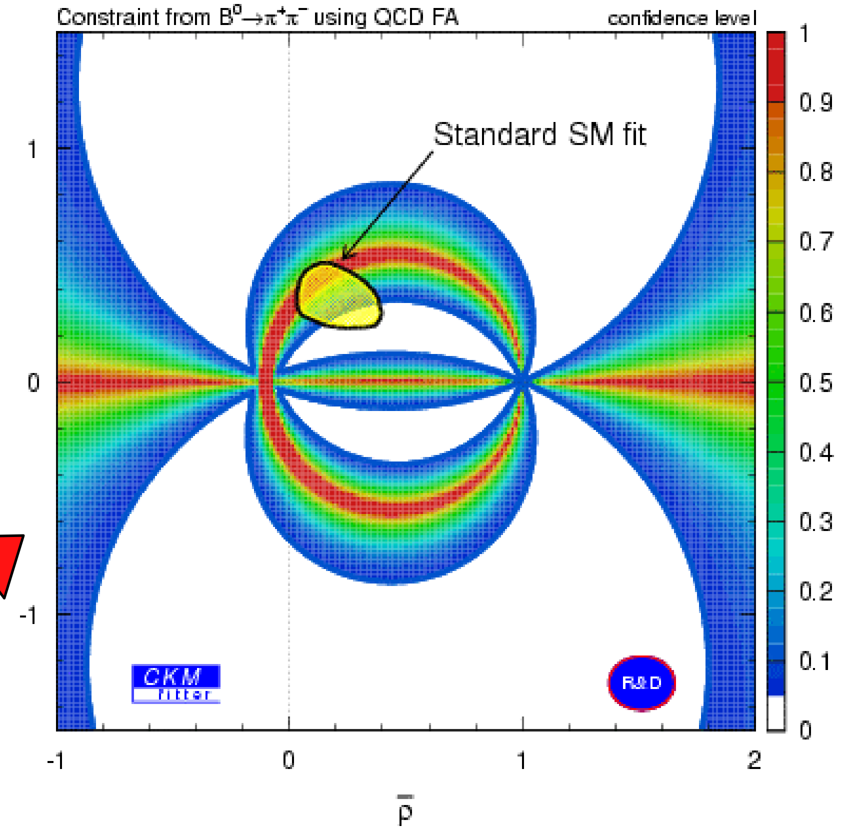
$$\Delta m_d = (0.517 \pm 0.062)\,\text{ps}^{-1}$$



Fit projection in sample of Kp-selected events

Result consistent with SM

Constraints assuming QCD FA



$$S_{pp} = -0.01 \pm 0.37 \pm 0.07$$

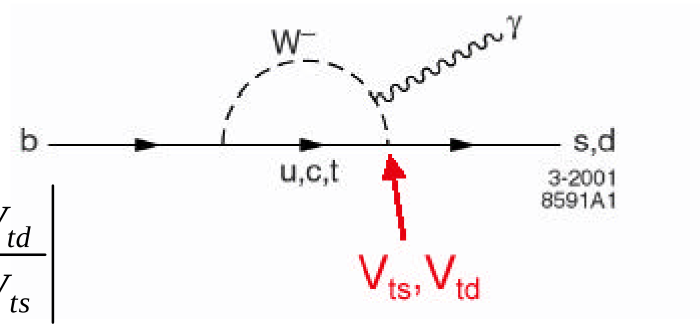
$$C_{pp} = -0.02 \pm 0.29 \pm 0.07$$

$$A_{Kp} = -0.05 \pm 0.06 \pm 0.01$$

If BBNS

EW Radiative Penguin Decays One window to new physics

EW loops sensitive to physics beyond the SM



SM prediction:

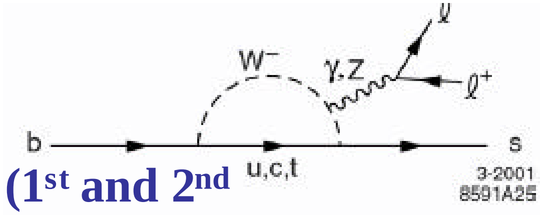
B(B→Xs g)=(3.29 +/- 0.33)**x10^{-4}**

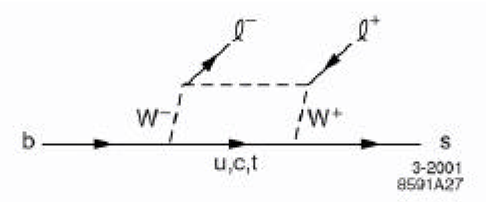
B(B→Kl$^+$ l$^-$) ~(0.5) x10^{-6}

B(B→K*l$^+$ l$^-$) ~(2) x10^{-6}

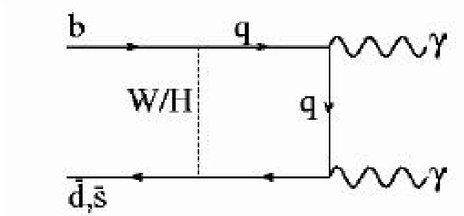
B(B→gg)=(0.1 - 2)**x10^{-8}**

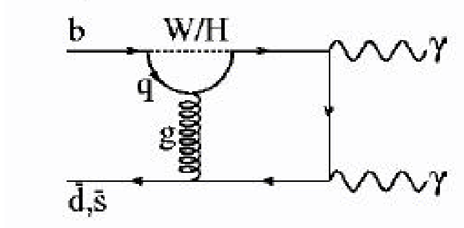
$$\frac{B(B \to ??)}{B(B \to K^{*}?)} \approx \left|\frac{V_{td}}{V_{ts}}\right|$$





Measurement of photon spectrum (1st and 2nd moments) allows for calibration of HQET (b Fermi motion, ……)





Exclusive modes sensitive to ratios of CKM elements

Similar analysis issues to hadronic charmless decays

- ★ **Large continuum Bkg and BB Bkg**
- ★ **Dependent on resolution of EM calorimeter**

Search for B→Kl⁺ l⁻ and B→K*l⁺ l⁻ Recent update with 57 fb-1

Reconstruct:

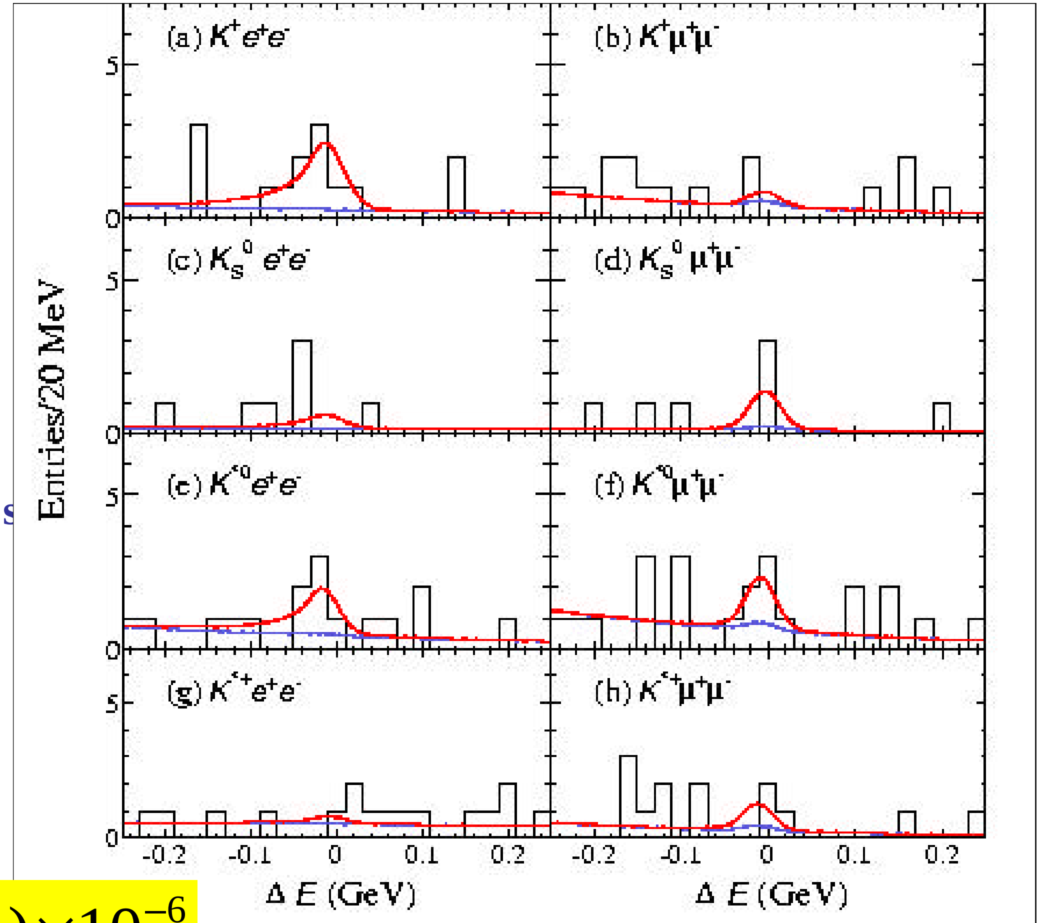
- $B \to K^+ l^+ l^-$ and $B \to K_s l^+ l^-$
- $B \to K^{*+} l^+ l^-$, $K^{*+} \to K_s p^+$
- $B \to K^{*0} l^+ l^-$, $K^{*0} \to K^- p^+$

Suppress continuum and BB(bar) Bkg

and semileptonic decays

Suppress peaking Bkg from

B→J/y K(*), y(2s)K(*), Dp (mis-identified p's



Previous limit:

$B(B \to K l^+ l^-) < 0.5 \times 10^{-6}$

$B(B \to K^* l^+ l^-) < 2.9 \times 10^{-6}$

New Results

$$B(B \to K\ell^+\ell^-) = (0.84^{+0.30+0.10}_{-0.24-0.18}) \times 10^{-6}$$

$$B(B \to K^*\ell^+\ell^-) = (1.89^{+0.84}_{-0.72} \pm 0.31) \times 10^{-6}$$

Preliminary

Mode	Signal yield	Eff. bkgd	ε (%)	$(\Delta\mathcal{B}/\mathcal{B})_\varepsilon$ (%)	$(\Delta\mathcal{B})_{fit}$ (10^{-6})	$\mathcal{B}$ (10^{-6})
$B^+ \to K^+ e^+ e^-$	$9.6^{+4.6}_{-3.3}$	1.9	17.1	± 6.8	$^{+0.11}_{-0.23}$	$0.91^{+0.42+0.13}_{-0.32-0.24}$
$B^+ \to K^+ \mu^+ \mu^-$	$0.8^{+2.5}_{-1.3}$	1.2	9.9	± 6.8	± 0.10	$0.13^{+0.37}_{-0.23} \pm 0.10$
$B^0 \to K^0 e^+ e^-$	$1.8^{+2.8}_{-1.3}$	1.1	18.1	± 8.0	± 0.35	$0.47^{+0.69}_{-0.39} \pm 0.35$
$B^0 \to K^0 \mu^+ \mu^-$	$2.9^{+2.7}_{-1.5}$	0.4	10.3	± 7.8	± 0.22	$1.34^{+1.16}_{-0.78} \pm 0.25$
$B^0 \to K^{*0} e^+ e^-$	$7.3^{+4.7}_{-3.5}$	3.4	10.2	± 7.7	± 0.48	$1.66^{+1.08}_{-0.83} \pm 0.50$
$B^0 \to K^{*0} \mu^+ \mu^-$	$4.6^{+4.2}_{-2.9}$	2.3	6.6	± 9.3	± 0.39	$1.68^{+1.57}_{-1.09} \pm 0.42$
$B^+ \to K^{*+} e^+ e^-$	$1.5^{+4.0}_{-2.0}$	4.9	9.8	± 9.7	$^{+1.04}_{-1.06}$	$1.07^{+2.86+1.04}_{-1.51-1.06}$
$B^+ \to K^{*+} \mu^+ \mu^-$	$2.8^{+3.5}_{-2.0}$	1.5	5.4	± 11.1	± 1.82	$3.68^{+4.39}_{-2.88} \pm 1.86$

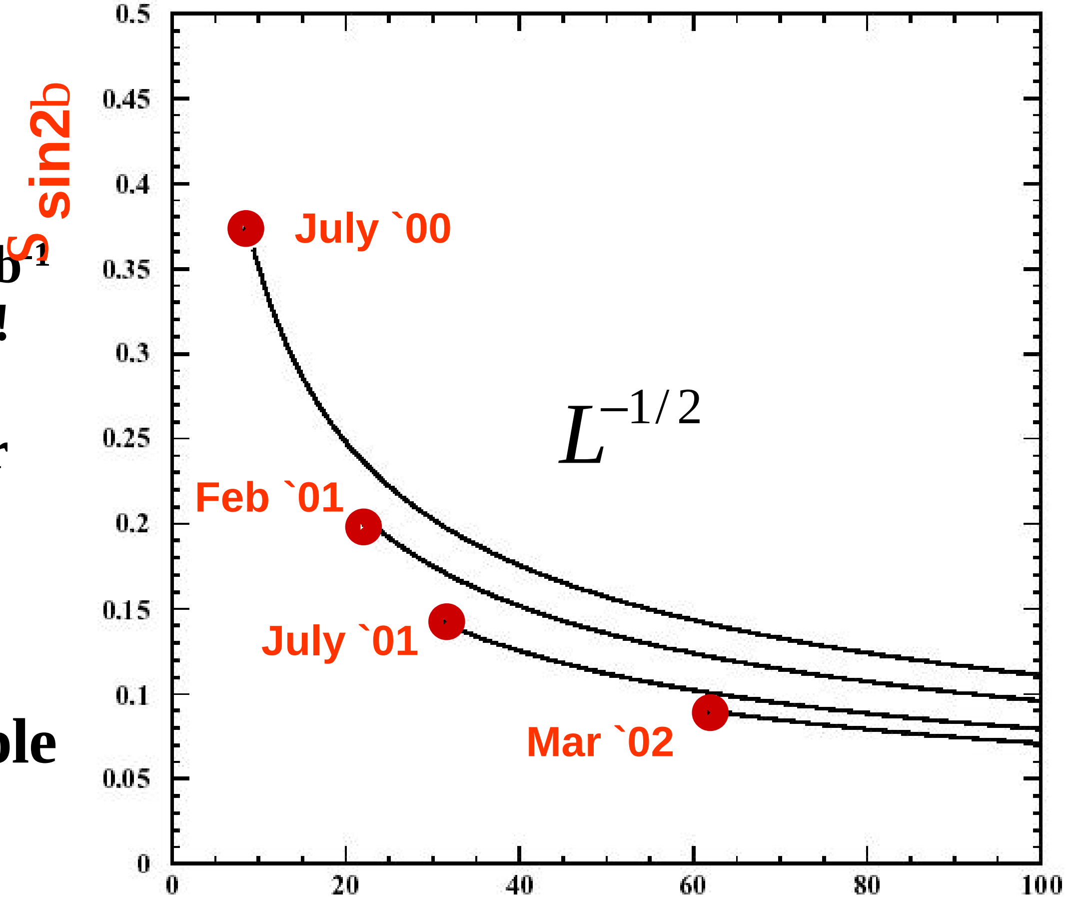
Towards the Future

Analysis is continuously improving

Alignment and tools, (tracking, vertexing, PID, etc.)

It is equivalent to increase the luminosity !

- **~ 30% more *CP* events/ fb^{-1} in 2001 data than 2000!!!**
- **~ 10% over all efficiency improvement from better alignment**



- **Purity of *J/y* K_L sample improved by 20%**
- **More modes in *CP* sample**
  - ***B* ® *J/y K****
  - ***B* ® c_c K_S**

PEP-II improving luminosity

Luminosity equation:

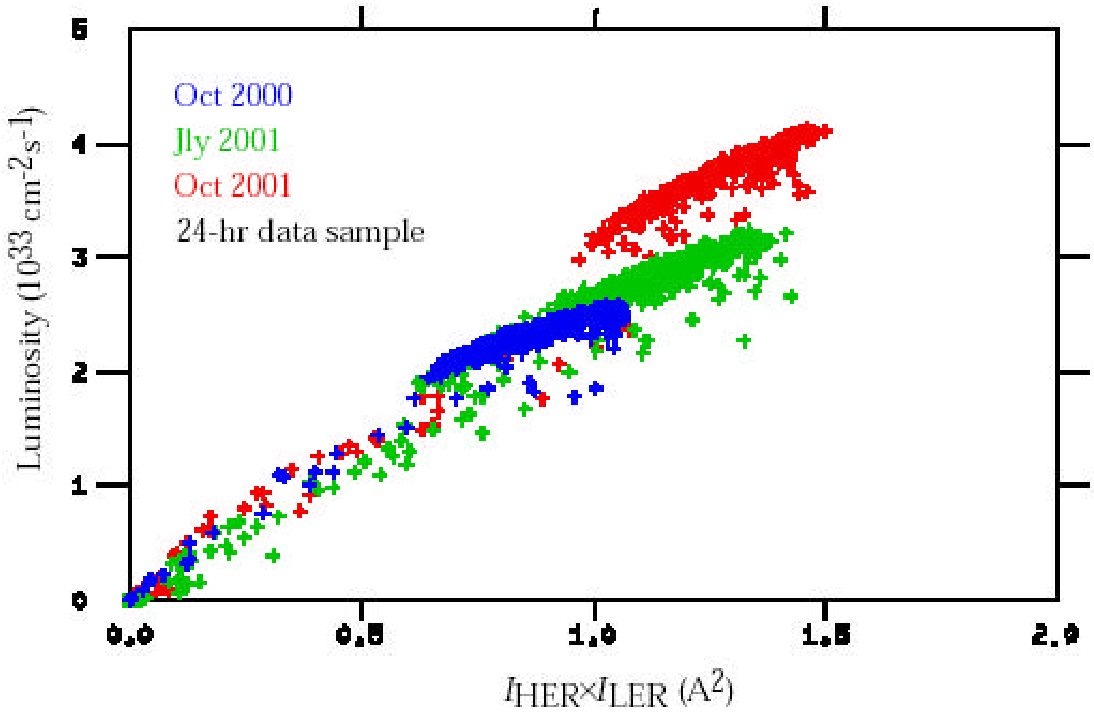
$$L = \frac{I_+ I_-}{n_b \cdot f_{rev} \cdot q^2 \cdot 2\pi \sqrt{\Sigma_x^2 \cdot \Sigma_y^2}}$$

=> raise beam currents *I*

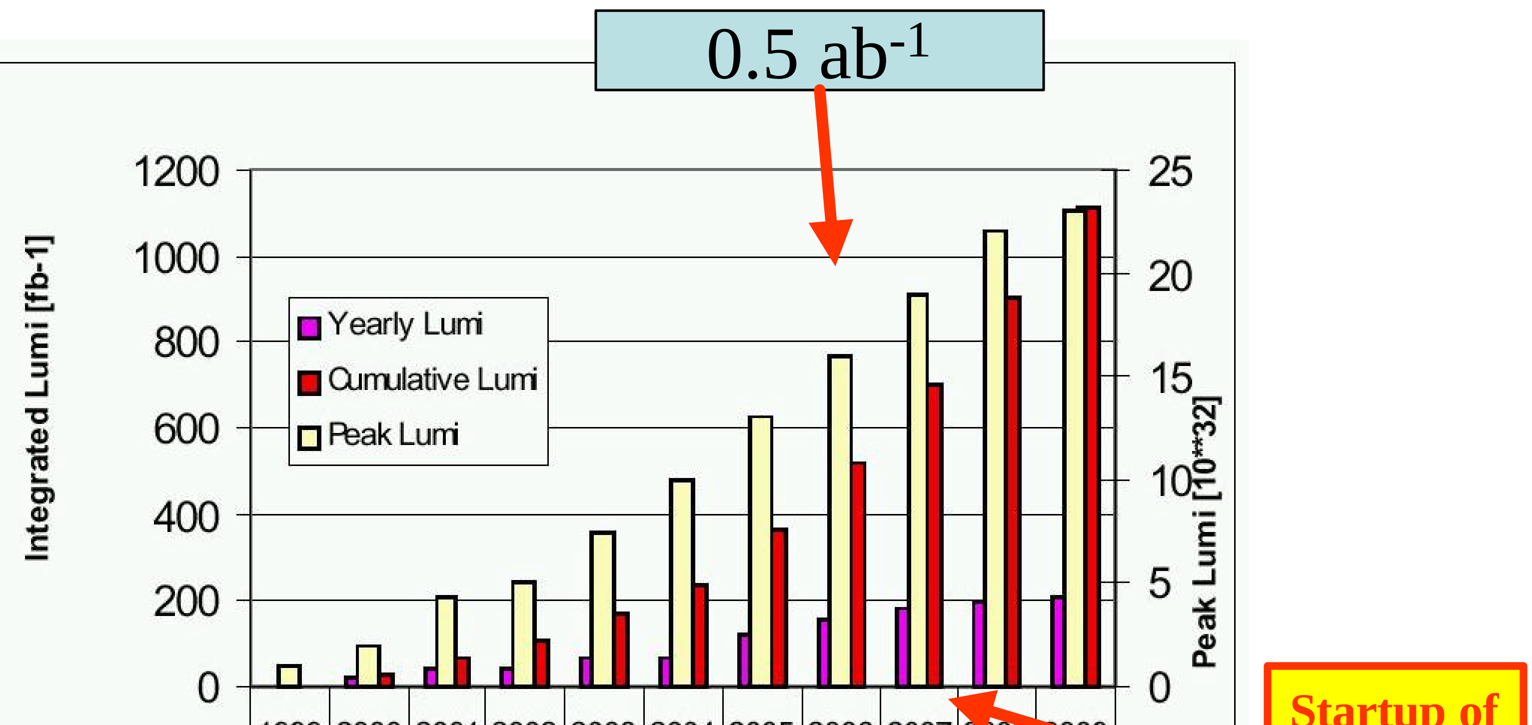
=> lower beam sizes Σ
... emittances, β^*

=> keep number of bunches n_b small

... until beam-beam limit reached



Luminosity profile "adiabatic scenario"



Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Yearly Lumi	3	23	41	39	64.6	68.2	124	156	185	199	212
Cumulative Lumi	3	26	67	106	171	239	363	519	704	903	1115
Peak Lumi	1	2	4.4	5	7.5	10	13	16	19	22	23

From J.Seeman 10/26/2001

Improve the experimental setup

A new IR with crossing angle would enable the increase of **L**

Higher currents, more bunches, lower β*, smaller background rates.

Internal studies within the collaboration to examine detector improvements that could go with the evolution of the machine.