Recent Results from BABAR

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the BABAR Collaboration

Outline

- CKM physics in the b-sector of the Standard Model
- The SLAC B-factory (PEPII and BABAR)
- Recent results
  - Mixing and Sin2β
  - Rare B-decay searches
- Future prospects

Quark mixing in the Standard Model

Quark electroweak doublets are composed of mass eigenstate mixtures given by a mixing matrix.

$$\begin{bmatrix} d \\ s \\ b \end{bmatrix}'_{EW} = \begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix}_{CKM} \times \begin{bmatrix} d \\ s \\ b \end{bmatrix}_{Mass}$$

The Wolfenstein parameterization suggests that B^0 couplings are a good place to look for new physics.

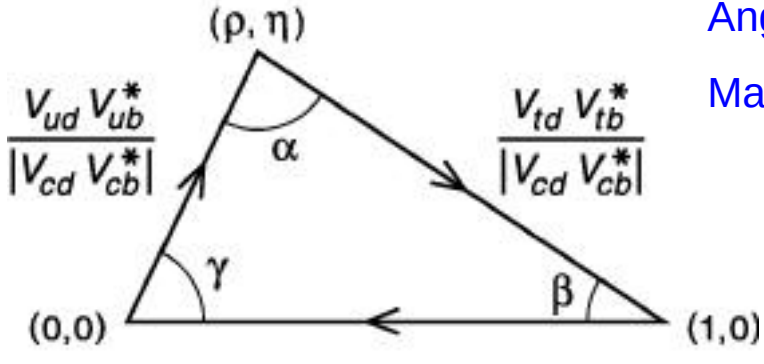
Small magnitude

Phase information

$$V = \begin{pmatrix} 1 - \frac{\lambda^2}{2} & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1 - \frac{\lambda^2}{2} & A\lambda^2 \\ A\lambda^3(1 - \rho - i\eta) & -A\lambda^2 & 1 \end{pmatrix} + \mathcal{O}(\lambda^4).$$

The Unitarity Triangle

The CKM unitarity condition can be shown graphically as a triangle.



Angles ~ phases

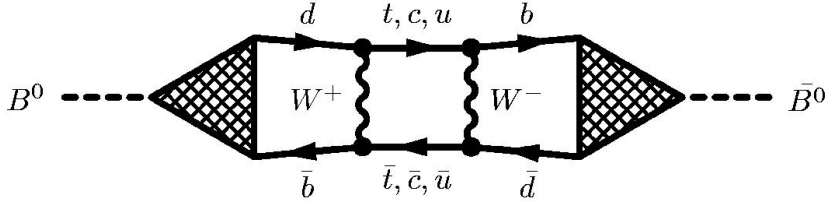
Magnitudes ~ rates

Non-zero triangle area (α,β, or γ != 0,π) implies CP violation

A ‘triangle’ which doesn’t close implies non-SM physics

$B^0 \overline{B}^0$ Mixing

$B^0 \overline{B}^0$ mixing can proceed through EW box diagrams

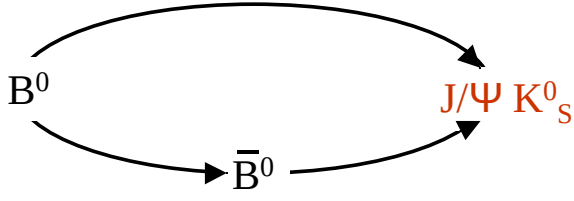


$$f_{\mathrm{Mixing},\pm}(\Delta t) = \frac{e^{-|\Delta t|/\tau_{B^0}}}{2\tau_{B^0}} \times \left[1 \pm \cos \Delta m_{B^0} \Delta t\right]$$

Δm_{B^0} is sensitive to $|V_{td} V_{tb}^*|$

CP Violation via Mixing Interference

Interference between mixed and unmixed B_0 decays to CP eigenstates induces a time and flavor-dependent rate



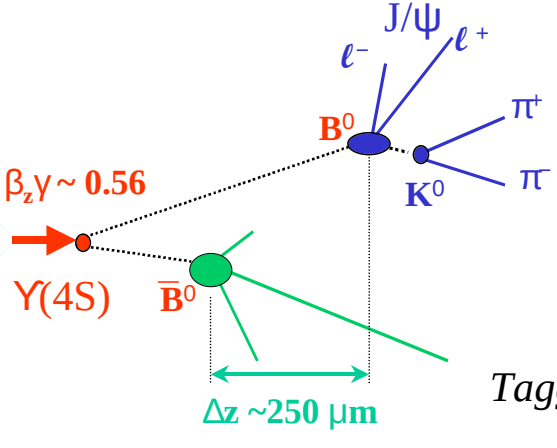
$$f_{CP,\pm}(\Delta t) = \frac{e^{-|\Delta t|/\tau_{B^0}}}{4\tau_{B^0}} \times [1 \pm \sin 2\beta \sin \Delta m_{B^0} \Delta t]$$

Flavor-specific rate vs time depends on sin2β

CP and Mixing at the Υ(4S)

Υ(4S) $B^0\overline{B}^0$ proceeds via coherent P-wave. Tagging the flavor of one B at decay determines the flavor of the other at that instant.

By boosting the Υ(4S) the decay time difference becomes observable.



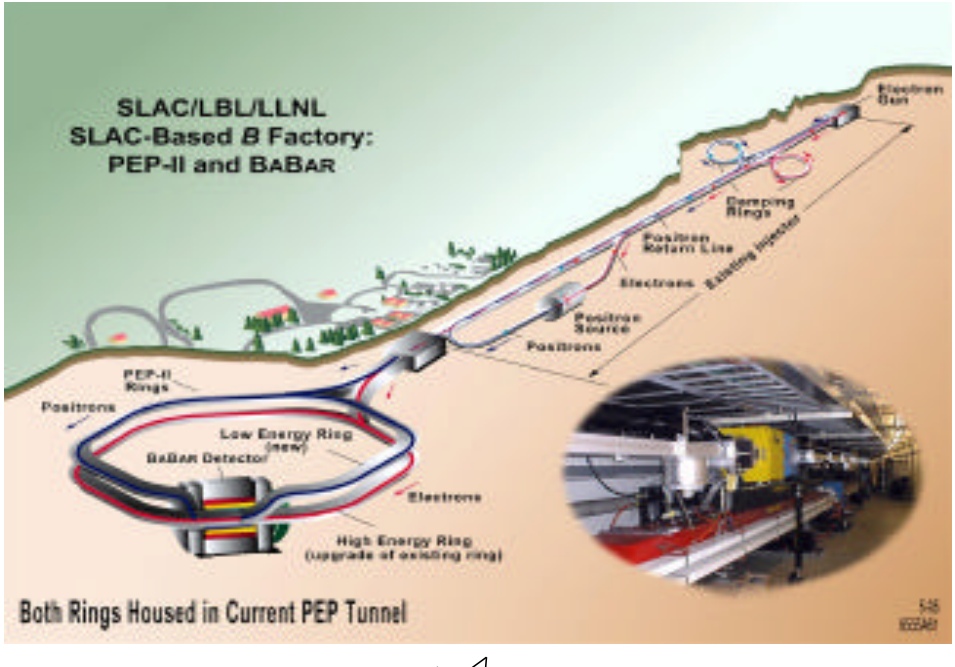
Reco side

Tagging side

A B-Factory Physics Program

- **Large luminosity**
  - **Significant samples in channels BR ~10^{-5}**
- **Boosted $\Upsilon(4S)$ system**
  - **Detectable time differences**
- **Powerful detector**
  - **Large acceptance**
  - **Particle Identification (e,π,μ,K, charged and neutral)**
- **'Early' physics (few ~10 fb^{-1})**
  - **sin2β from cp eigenstates (BR ~ few %)**
  - **B lifetimes, mixing, …**
  - **Detection of rare signals (B $\pi^+\pi^-$, …)**
- **'Mature' physics (few ~100 fb^{-1})**
  - **Measure angles α, γ**
  - **Measure ρ,η (?)**
  - **Surprises**

PEPII at SLAC



3.1 GeV e^+ → Υ(4S) ← 9 GeV e^-

The BABAR Collaboration

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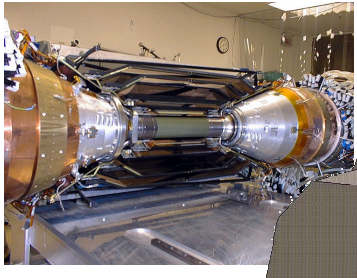
Princeton
SLAC
U of South Carolina
Stanford U
U of Tennessee
U of Texas at Dallas
Vanderbilt
U of Wisconsin
Yale

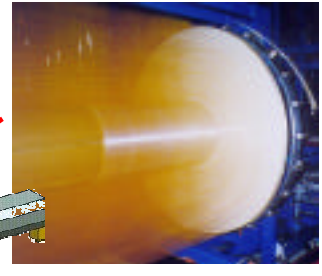
9 Countries, 72 Institutions, 554 Physicists

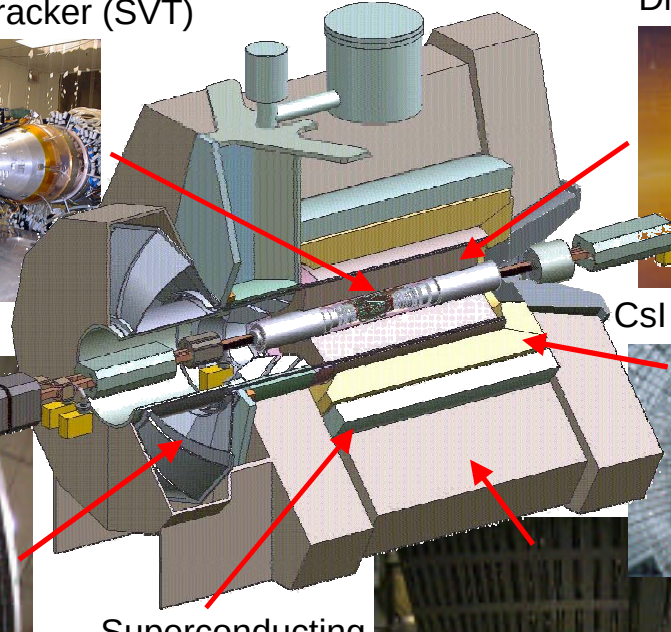
The BABAR Detector

Silicon Vertex Tracker (SVT)



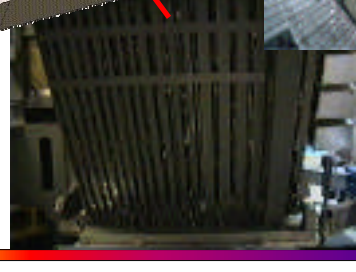
Drift Chamber (DCH)





CsI Calorimeter (EMC)

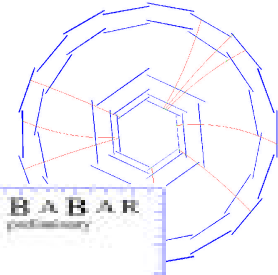
Superconducting Coil (1.5 Tesla)



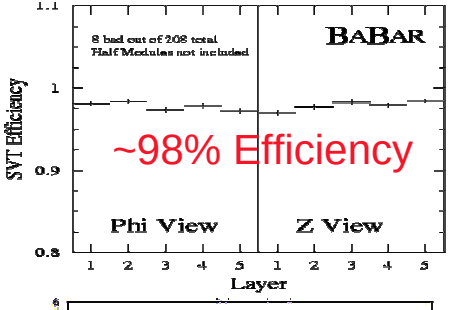
Instrumented Flux Return (IFR)

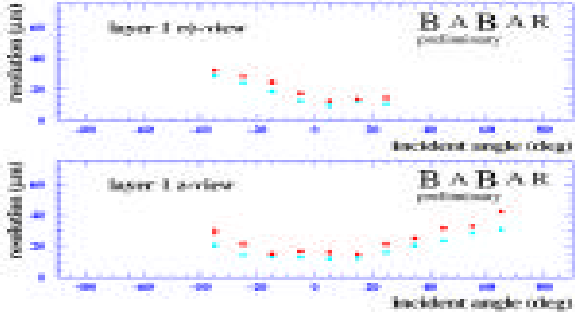
Cherenkov Detector (DIRC)

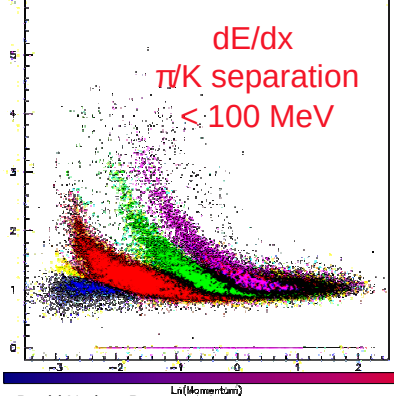
The SVT

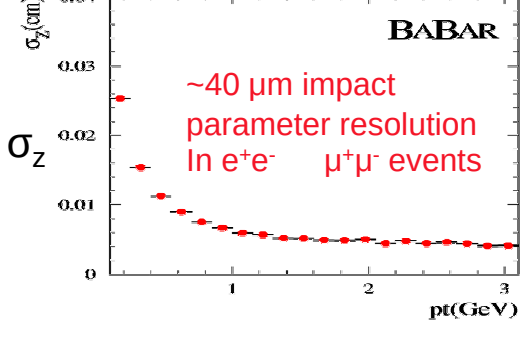


- **5 layers double-sided Si detectors**

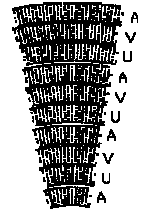


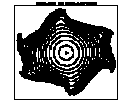




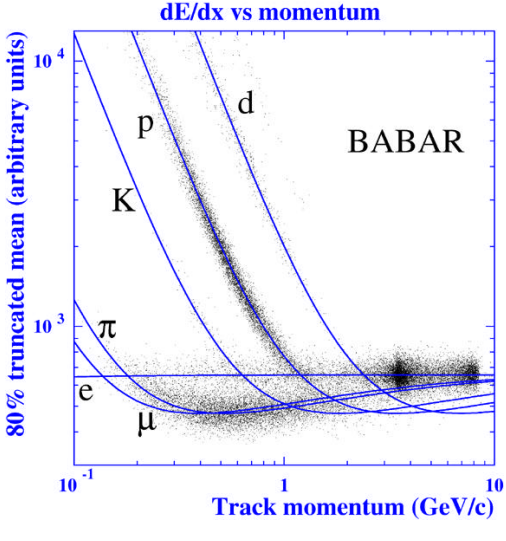


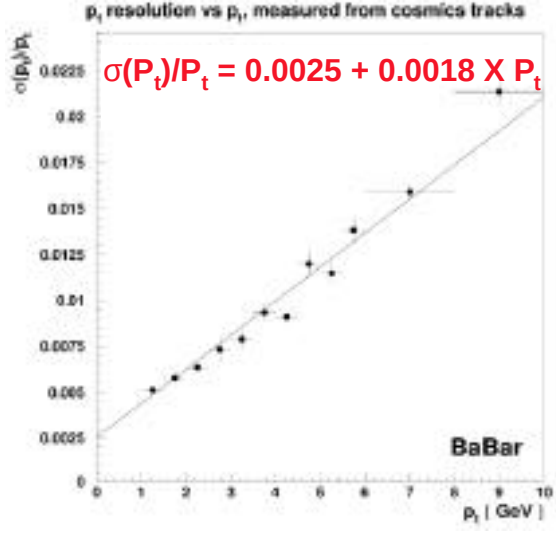
The DCH





- **16 Axial, 24 Stereo layers in He Isobutane**
  - **Average single-hit resolution ~125μm**

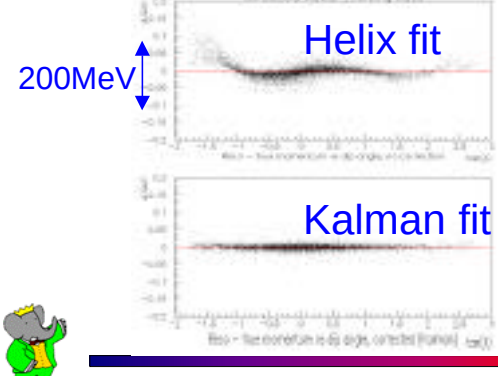




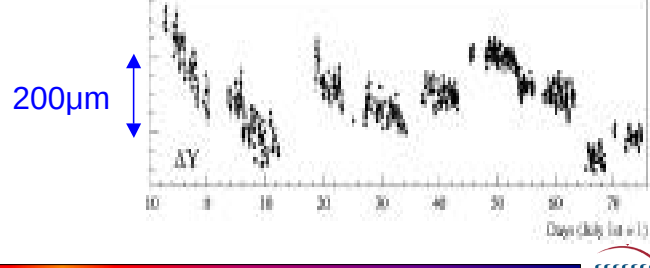
Tracking and Alignment

- **Road-based track finding**
  - **High-P tracks found in DCH, extrapolated in to SVT**
  - **Low-P tracks are found in SVT, extrapolated out to DCH**
- **All tracks are finalized with a Kalman filter fit**
  - **Multiple scattering, dE/dx, Bfield inhomogeneity,…**
- **SVT and DCH are aligned ~1/hour (automatically)**

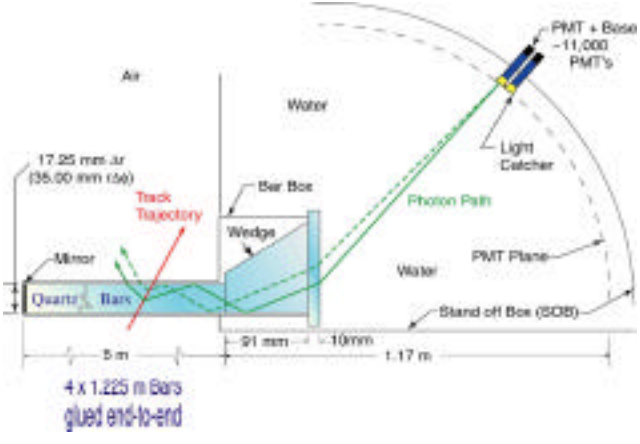
ΔP vs dip angle



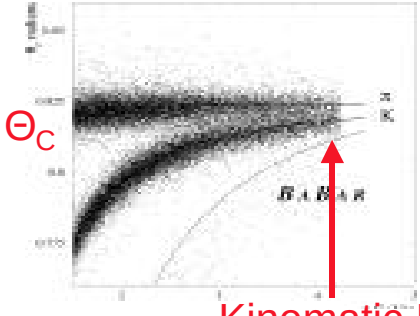
SVT vertical position WRT DCH

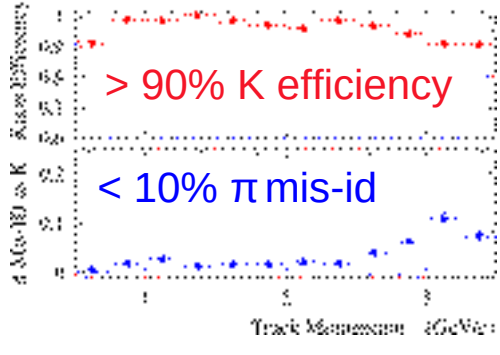


The DIRC



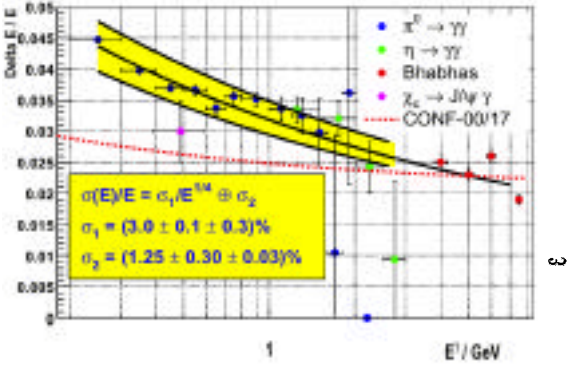
- **Detector of Internally Reflected Cherenkov (light) uses light trapped in radiator bars**
- **Light detected by an array of 11,000 PMT's**
- **π/K separation measured using D^{*+} $\pi_s D^0(K^-\pi^+)$**

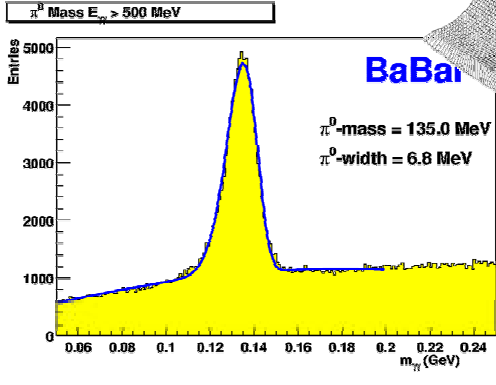


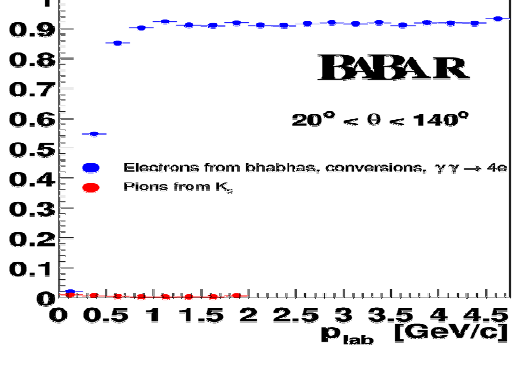


The EMC

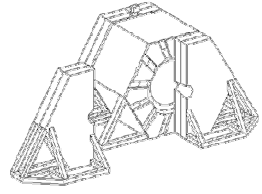
- ~6500 CsI crystals
  - ~18 X_0 each



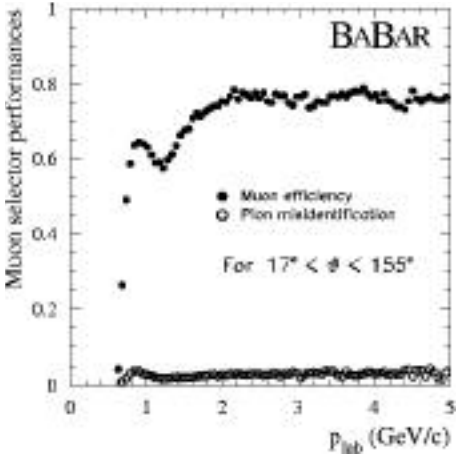


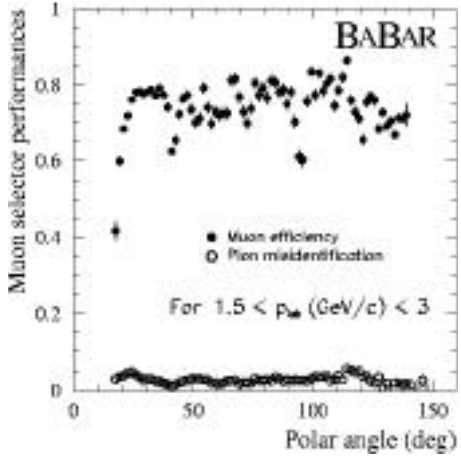


The IFR

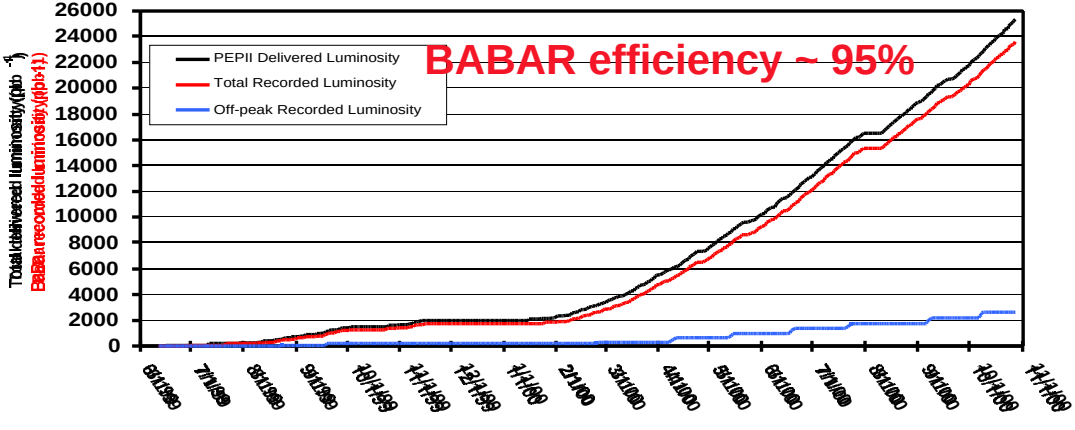


- ~65 cm Fe absorber
  - ~4 λ_I (together with EMC + coil)
- Max 21 layers RPC
  - Hit pattern readout



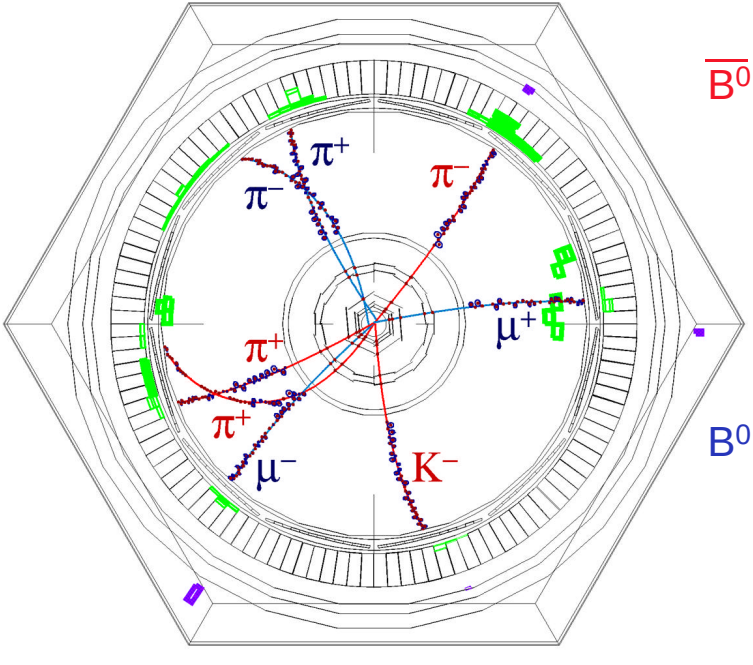


The (Current) BABAR Data Sample



- PEP II Peak luminosity 3.3X10^{33} cm^{-2}s^{-1}
  - design = 3.0X10^{33}
- ~21 fb^{-1} integrated on $\Upsilon(4S)$ peak
  - ~3 fb^{-1} below $\Upsilon(4S)$
- ~23M $B\overline{B}$ pairs detected in BABAR

A Fully-Reconstructed $\Upsilon(4S)$ $B^0\overline{B}^0$ Event



$\overline{B}^0$ $D^+\pi^-$

D^+ $D^0\pi^+$

D^0 $K^-\pi^+$

B^0 $\Psi(2s)K^0_s$

$\Psi(2s)$ $\mu^+\mu^-$

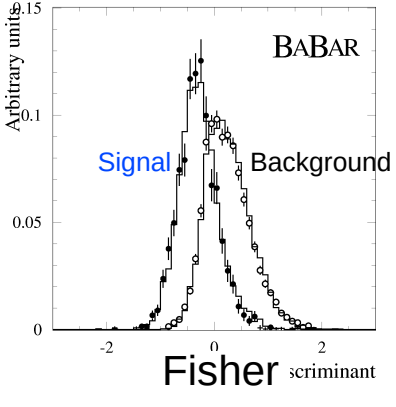
K^0_s $\pi^+\pi^-$

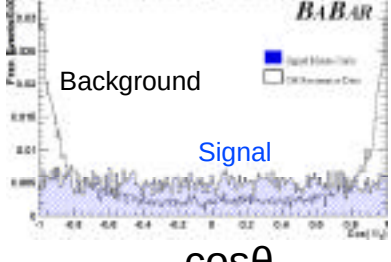
Mixing and sin2β Experimental Issues

- **Background suppression**
- **Signal extraction**
- **Flavor tagging**
- **Time resolution**
- **Time-dependent rate fitting**
  - **Use the data to constrain as much as possible**
  - **Fit simultaneously to signal and control samples**
- **‘Blind’ analysis**
  - **Central values are hidden until cuts/algorithms are ‘frozen’**
  - **Optimize on MC, data consistency**

Background Suppression at the Υ(4S)

- ~70% of $\Gamma(e^+e^- \rightarrow \text{hadrons})$ is non BB
  - Continuum events are 'jetty', B events are 'spherical'
- 'event shape' cuts
  - Fox-Wolfram moment
  - Fisher discriminant (CLEO)
    - measure energy in 9 co-axial cones
    - (optimized) weighted sum
- B-candidate angle wrt 'event'
  - B=flat distribution, continuum=peaked
  - 'event' = thrust axis or sphericity axis



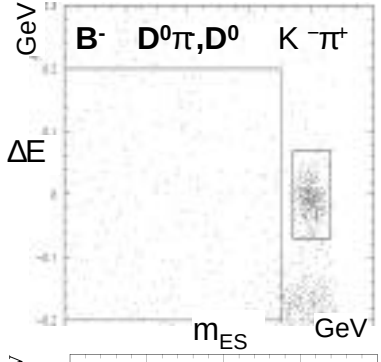


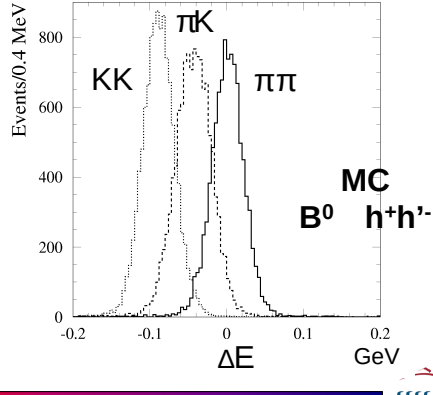
Kinematic Variables

- **Select B candidates using ΔE and m_{ES}**
  - **Essentially independent**
  - **Optimal resolution (using beam constraint)**
  - **Bkg from sidebands and/or off-peak**

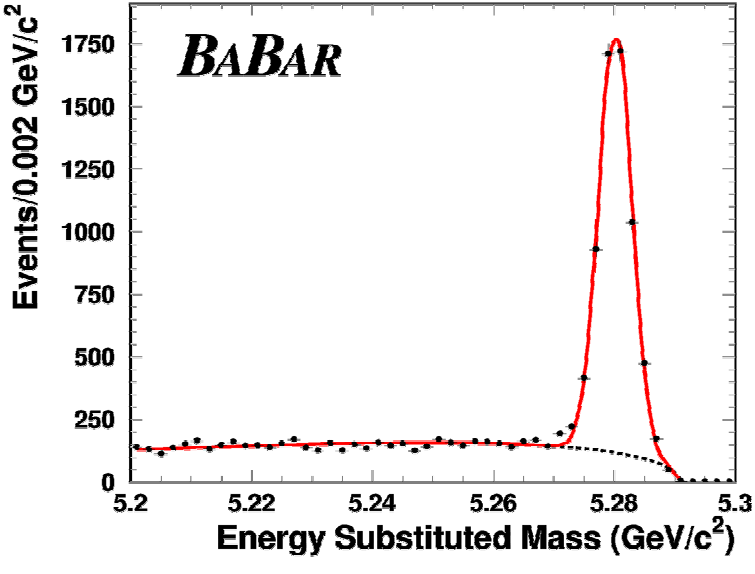
$$m_{ES} = \sqrt{E^2_{beam} - P^2_B}\Big|_{CM}$$

$$\Delta E = E_B - E_{beam}\Big|_{CM}$$





Hadronic (non-CP) B^0 Reconstruction



- B^0 $D^{(*)-}$ $(\pi,\rho,a_1)^+$
  - D^- $K^-\pi^+\pi^+, K^0\pi^-$
  - D^0 $K^-\pi^+$, $K^-\pi^+\pi^0$, $K^-\pi^+\pi^-\pi^+$, $K^0\pi^-\pi^+$
  - D^{*-} $D^0\pi^-$
- B^0 $J/\psi\ \overline{K}^{*0}$
  - $\overline{K}^{*0}$ $K^-\pi^+$

4637 Events above background (CP fit)

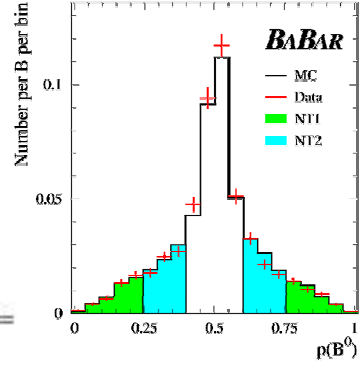
6368 Events above background (Δm_{B^0} fit)

~85% purity

Flavor Tagging

- **Tags are assigned hierarchically**
  - **High-P leptons from semi-leptonic decay (b → c W^-, W^- → e ν_e)**
  - **High-P Kaons From Cabibo-favored cascade (b → c → s)**
  - **Neural net**
    - Low-P leptons and kaons
    - soft pions
    - P-weighted average charge
- **Efficiency and mistag rates measured from fully-reconstructed hadronic B^0 decays**
  - **Parameters in sin2β, Δm_{B^0} Likelihood fits**
  - **Cross-checked with B^0 → $D^*\ell\nu$**

Tag Category	$\varepsilon(\%)$	$w(\%)$	$Q(\%)$
Lepton	10.9 ± 0.4	11.6 ± 2.0	6.4 ± 0.7
Kaon	36.5 ± 0.7	17.1 ± 1.3	15.8 ± 1.3
NT1	7.7 ± 0.4	21.2 ± 2.9	2.6 ± 0.5
NT2	13.7 ± 0.5	31.7 ± 2.6	1.8 ± 0.5
Total	68.9 ± 1.0		26.7 ± 1.6



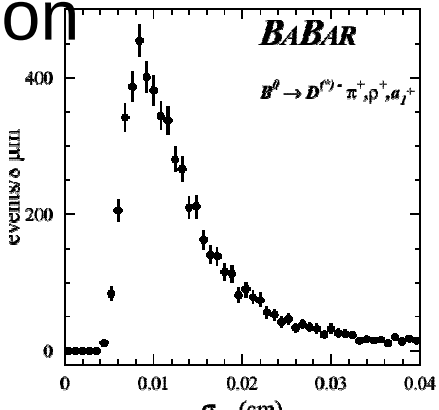
ε = efficiency

w = mistag rate

Q = ε (1-2w)²

Δt Resolution

- $\Delta t \approx \Delta z / \beta\gamma c$
  - $\Delta Z = Z1 - Z2$
  - **Z1 = signal vertex**
    - Charm pseudo-particle
    - resolution ~70 μm
  - **Z2 = vertex everything else**
    - Remove outlyers (charm, …)
    - resolution ~180 μm
- **Resolution modeled with 3 Gaussians**
  - **Core,Tail, and Outliers**
  - **σ scaled to vertex error estimate (core and tail)**
  - **Shifts from 0 allowed (charm vertex flight)**
- **Determined from data**



Parameter	Value
S_{Core}	1.1 ± 0.1
S_{Tail}	3.8 ± 0.9
f_{Tail} (%)	11 ± 5
f_{Outlier} (%)	0.8 ± 0.5
$\delta_{\text{Core,Lepton}}$ (ps)	0.08 ± 0.10
$\delta_{\text{Core,Kaon}}$ (ps)	0.21 ± 0.05
$\delta_{\text{Core,RT1}}$ (ps)	0.01 ± 0.10
$\delta_{\text{Core,RT2}}$ (ps)	-0.18 ± 0.09
δ_{Tail} (ps)	-0.46 ± 0.38

Time-dependent Rate Fits

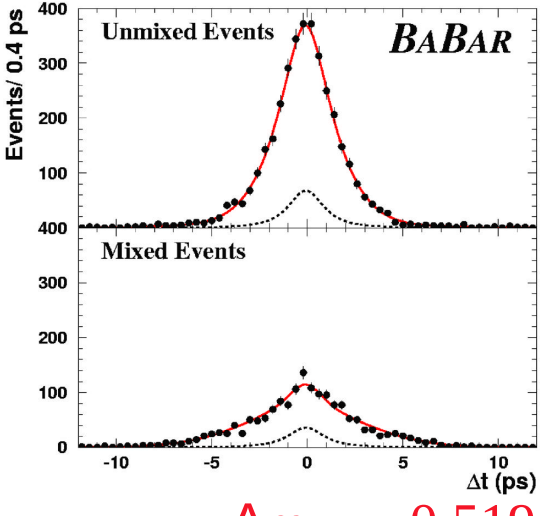
- **33-parameter maximum-likelihood fit**
  - **τ_{B^0} fixed to PDG 2000 value**
- **Separate rates by tag flavor (decay flavor, CP eigenvalue)**

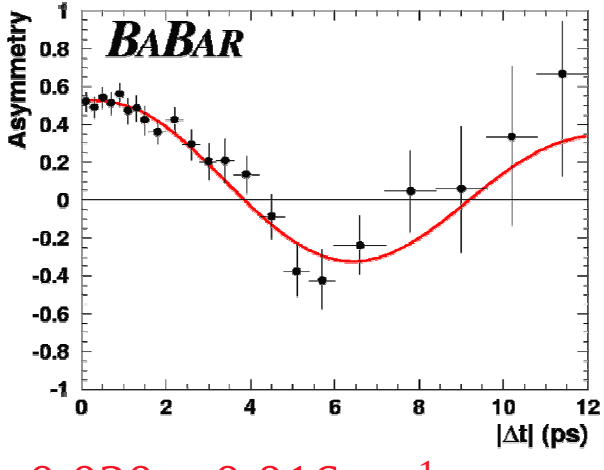
Effect	#params	Sensitive Sample	
sin2β	1	CP	Only in CP fit
ΔM_d	1	Hadronic	Only in mixing
Mistag + ΔMistag	4+4	Hadronic	
Δt resolution	9	Hadronic + CP	
Bkg. Mistag	8	Sidebands	
Bkg. Δt	6	Sidebands	
Bkg. Δt res.	3	Sidebands	

Biggest correlation with sin2b 7.6%

$B^0 \bar{B}^0$ Mixing Result (Preliminary)

$$A_{\text{mixing}} \equiv \frac{f(\text{unmixed}) - f(\text{mixed})}{f(\text{unmixed}) + f(\text{mixed})} = \cos(\Delta m_{B^0} \Delta t)$$





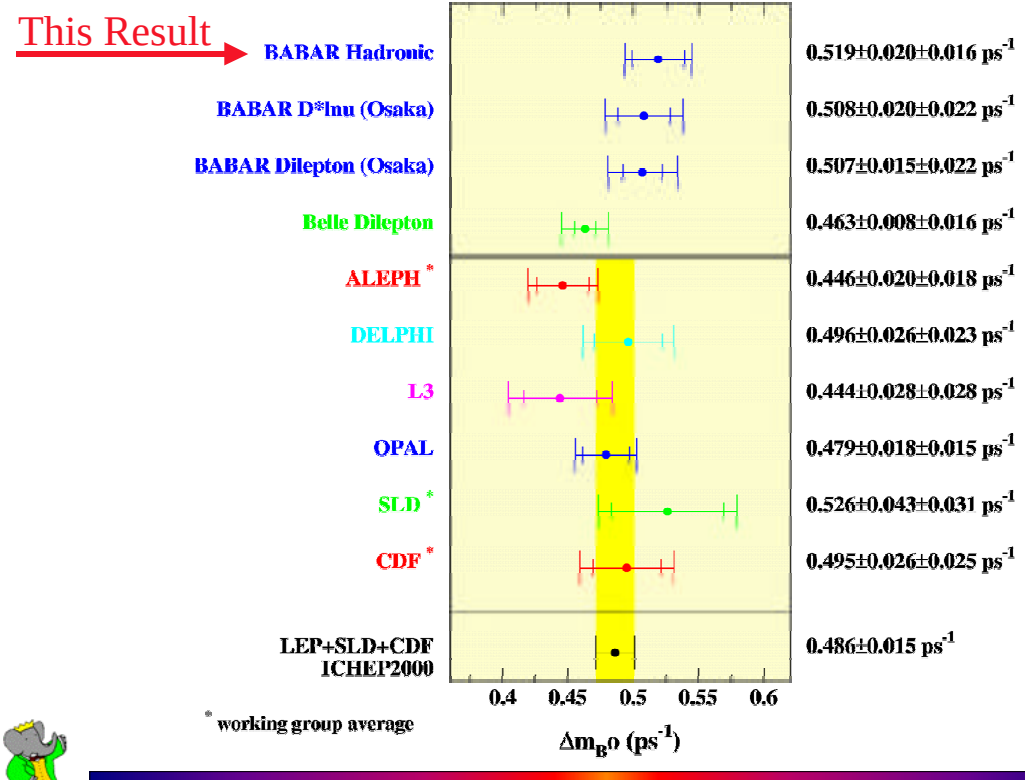
$$\Delta m_{B^0} = 0.519 \pm 0.020 \pm 0.016 \text{ ps}^{-1}$$

$B^0 \bar{B}^0$ Mixing Systematic Errors

- **No single source dominates**
- **Improvements expected for most sources**
  - **Better MC statistics and tuning**
  - **Better SVT alignment**
  - **Improved B^0 lifetime measurement**
    - Eventual simultaneous fit with Δm_{B^0}

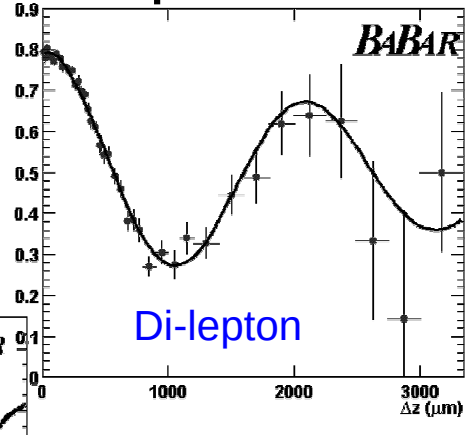
Source	Δm [$\hbar ps^{-1}$]
MC stats	0.004
MC correction	0.009
Δt outliers	0.002
Likelihood norm.	0.003
Background	0.005
B^0 lifetime	0.006
Z scale	<0.005
Z boost	0.005
SVT alignment	0.004
Beamspot	0.001
Total	**0.016**

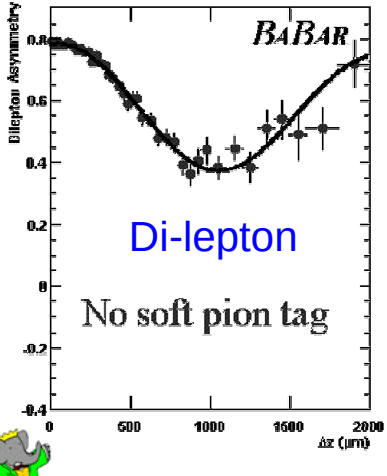
Comparison with Other Results

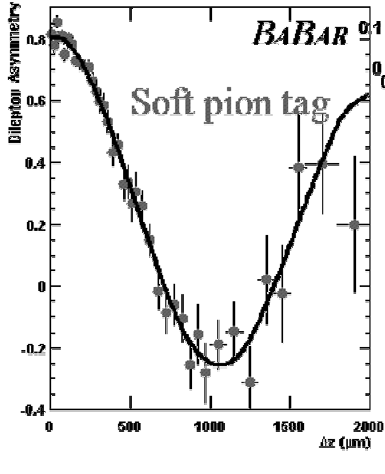


More Mixing Results In Preparation

- **Di-lepton analysis**
  - **Soft pion (D*) enrichment**
  - **Systematics dominated**
- **B^0 $D^*l\nu X$**
  - **Larger acceptance than exclusive**

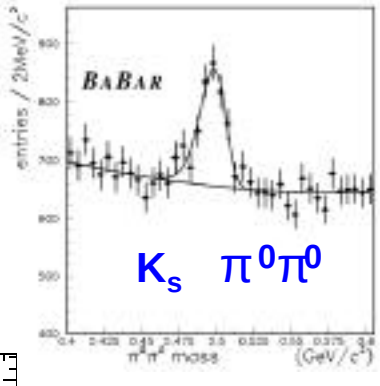


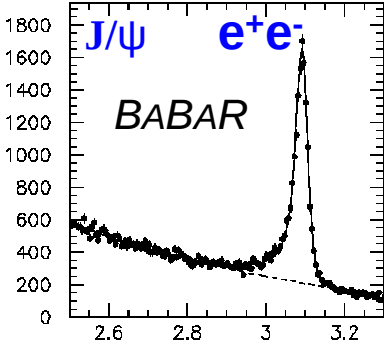


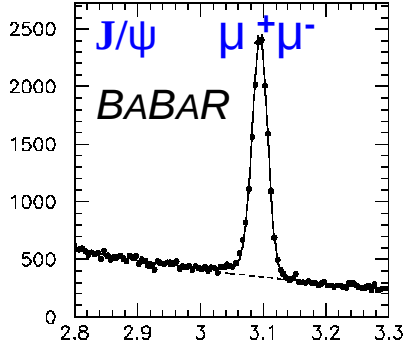


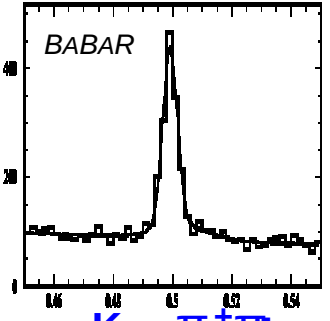
CP Sample Event Reconstruction

- **Select J/ψ $e^+e^-,\mu^+\mu^-$**
  - ψ' $e^+e^-,\mu^+\mu^-$, $\psi\pi^+\pi^-$
- **Reconstruct K_s $\pi^+\pi^-,\pi^0\pi^0$**
- **K_L are found in EMC and IFR**
  - **Cluster with no associated track**
  - **Inconsistent with π^0 or γ**



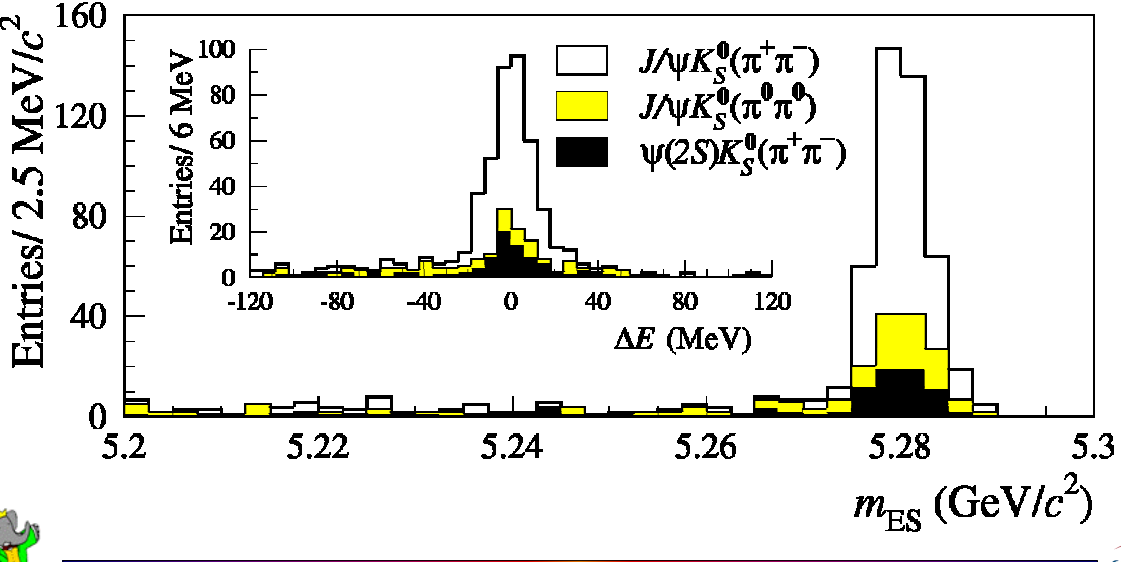






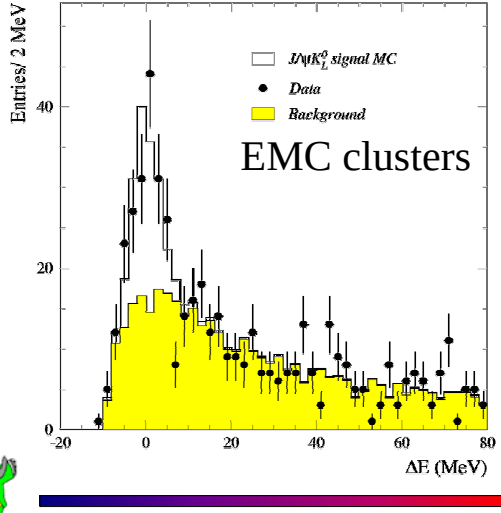
B^0 $J/\psi K_s$ and B^0 $\psi(2s) K_s$

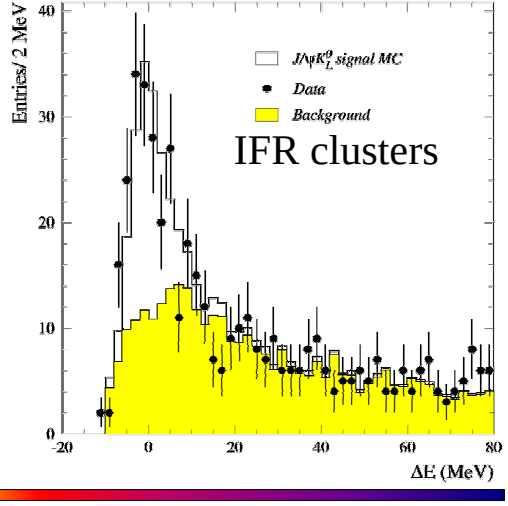
- **84% < Purity < 98%**
- **363 events above background (after tagging)**
- **Other charmonium modes (χ_c) still under study**



B^0 J/ψ K_L Reconstruction

- **B^0 mass used to determine K_l energy (no cut on m_{ES})**
- **40% < Purity < 50%**
  - **Background from B^0 $J/\psi X$**
- **182 events above background (after tagging)**

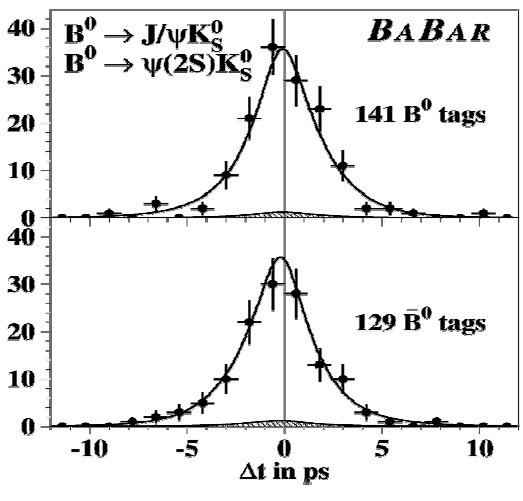


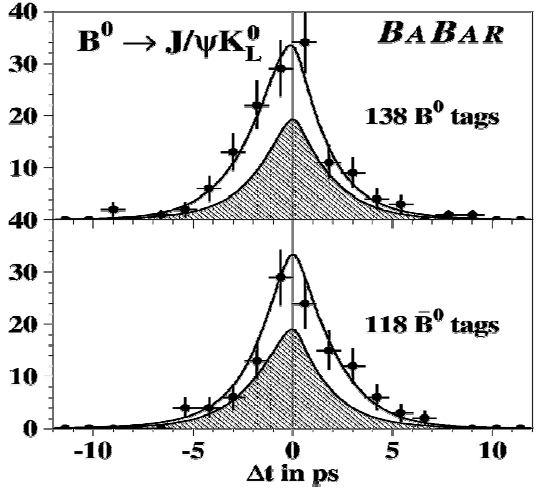


B^0 $J/\Psi K_L$ Sample Composition

	Fraction(%)	EMC	IFR
Inclusive J/Ψ MC	signal	40.3	50.7
	$J/\Psi K^{*0}(K_L\pi^0)$	9.1	9.9
	$J/\Psi K^{*+}(K_L\pi^+)$	14.4	16.9
	$J/\Psi K_s(\pi^0\pi^0)$	6.4	2.1
	Other- J/Ψ	29.8	20.4
J/Ψ sidebands	Non- J/Ψ	6.3	4.4

CP Rates by Mode and Tag





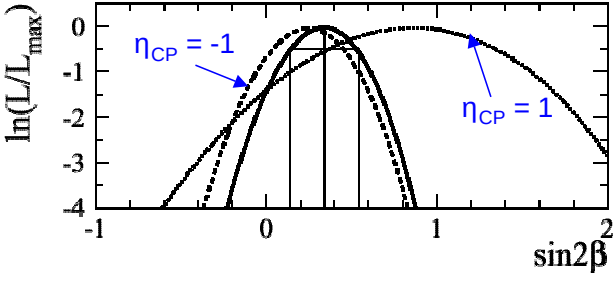
$$\sin(2\beta) = 0.34 \pm 0.20 \pm 0.05$$

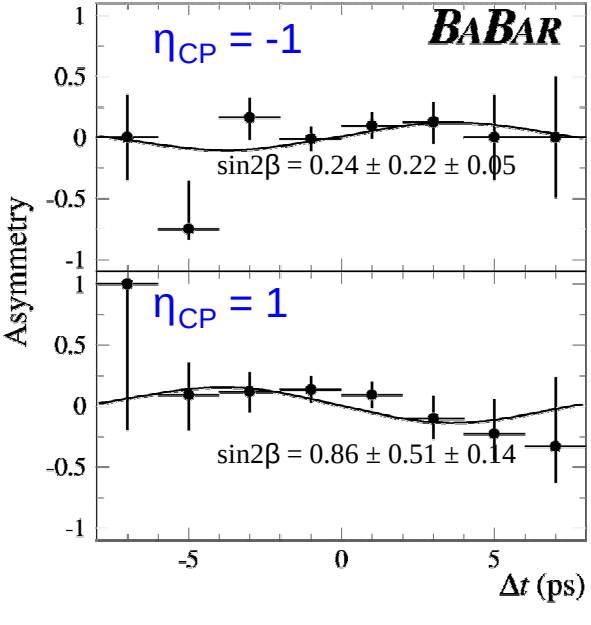
PRL Mar.19 2001 Vol. 86, Issue 12, pp. 2515-2522
PRD in preparation (draft)

CP Asymmetry

$$A_{CP} = \frac{f(tag = B^0) - f(tag = \overline{B^0})}{f(tag = B^0) + f(tag = \overline{B^0})}$$

$$= -\eta_{CP} \sin 2\beta \sin \Delta m_{B^0} \Delta t$$





Sin2β Systematic Errors

- **Most errors come from fit parameters (='statistical')**
  - **K_l^0 background is an exception**

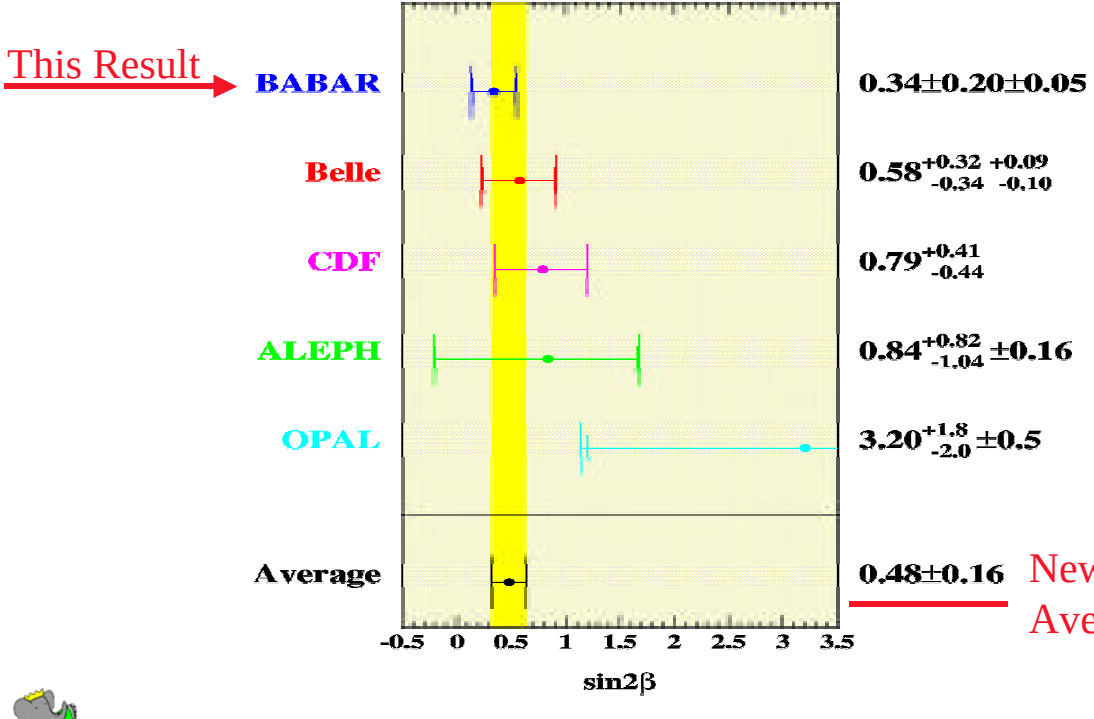
Systematic	$J/\psi K_S^0$,$\psi(2S)K_S^0$	$J/\psi K_L^0$	Full sample
Δt determination	0.04	0.04	0.04
$J/\psi K_S^0$, $\psi(2S)K_S^0$ back.	0.02	—	0.02
$J/\psi K_L^0$ back.	—	0.09	0.01
$J/\psi K_L^0$ Sig. fraction	—	0.10	0.01
τ_{B^0}	0.01	0.01	< 0.01
Δm_{B^0}	0.01	< 0.01	0.01
Other	0.01	0.01	0.01
Total	0.05	0.14	0.05

Sin2β Cross-Checks

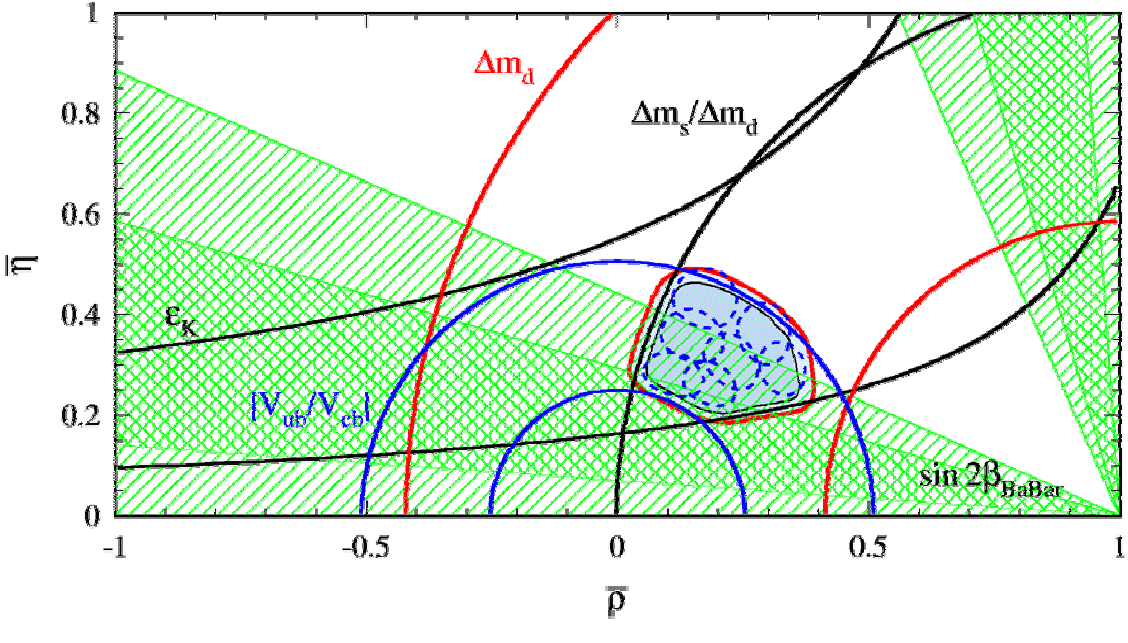
- **No significant differences are seen dividing sample by tagging mode, signal mode, decay mode, …**
- **No significant direct CP violation**
  - **Explicit term for CP amplitude gives value consistent with 1.0**
- **No CP asymmetry in fits to non-CP eigenstate samples**

MODE	APPARENT ASYMMETRY
$B^+ \to D^{(*)}\pi/\rho$	0.00 ± 0.05
$B^0 \to D^{(*)}\pi/\rho$	0.00 ± 0.06
$B^+ \to J/\Psi K^+$	0.06 ± 0.09
$B^0 \to J/\Psi K^{*0}\ (K^+\pi^-)$	0.28 ± 0.18

Comparison with Other Results



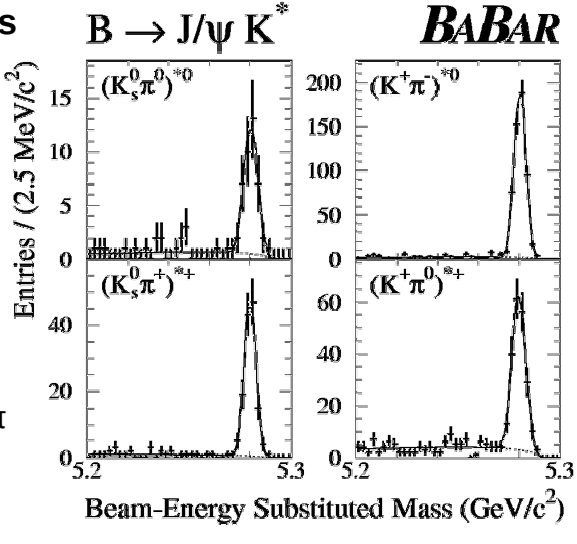
CKM Constraints



$V_{ub} \approx A\lambda^3(\rho - i\eta)$ (Wolfenstein parameterization)

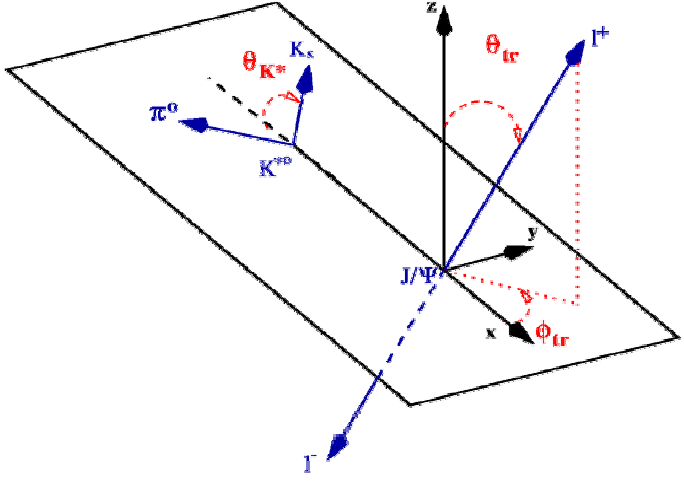
B^0 $J/\Psi K^*(K^* \quad K_s^0\pi^0)$

- **P VV decay (L=0,1, or 2)**
  - **Unknown CP decay amplitudes**
    - $A_0 = \sqrt{2}/3\ D - \sqrt{1}/3\ S$ (CP even)
    - $A_{||} = \sqrt{1}/3\ D + \sqrt{2}/3\ S$ (CP odd)
    - $A_{perp} = P$ (CP even)
  - **Amplitudes can be measured via angular analysis**
    - Measure CP 'dilution' from data
  - **Test of factorization**
    - Expect phase differences of 0, π
    - Recent CDF result shows (2σ) deviation
  - **Can use all K* modes in angular analysis**



Angular Analysis of B^0 $J/\Psi K^*$

- **K* defines the coordinates**
  - **Direction = x-axis**
  - **Kπ define x-y plane**
  - **Z axis defined implicitly**
- **Three observable angles**
  - **θ_{K^*} = K angle WRT K***
  - **θ_{tr} = J/Ψ polar angle**
  - **φ_{tr} = J/Ψ azimuthal angle**

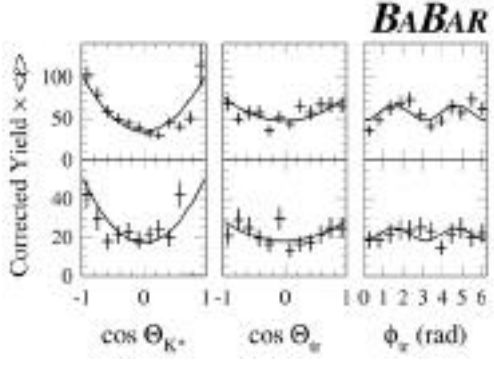


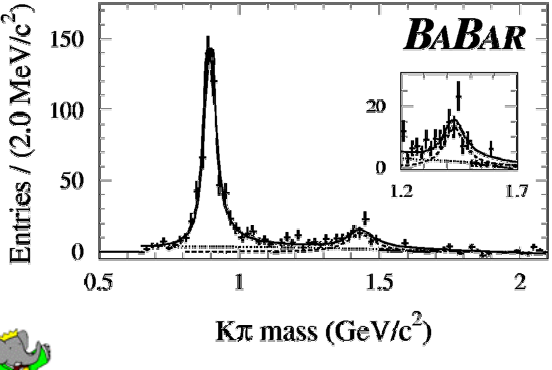
Experimental Concerns

- **Detector angular acceptance is not uniform**
  - **MC correction**
- **Contamination from B $J/\Psi K^*$ with fake or poorly reconstructed π^0**
  - **~10% correction**
  - **Couples angular analysis with amplitudes (cross-feed)**
- **4 (6) parameter fit**
  - **2 (3) magnitudes, 2 (3) phases**
  - **Sign of (some) phases depends on decay mode**
    - +1 for B^+ and B^0, -1 for B^- and $\overline{B}^0$
  - **Only 4 are 'real'**
    - Overall phase drops out
    - Total rate is 'known'
  - **Use Maximum likelihood method**

B^0 $J/\Psi K^*$ Results

- **Systematic errors dominated by (unknown) K*(1430) contamination**
  - **Will measure in future**
- **CP Dilution = 0.68±.1**
  - **Useful mode for sin2β**
- **$\Phi_{||}$ ~3σ from π**

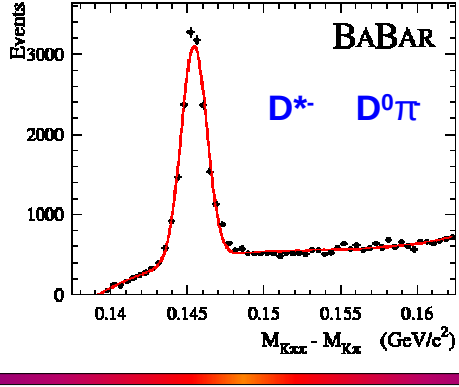




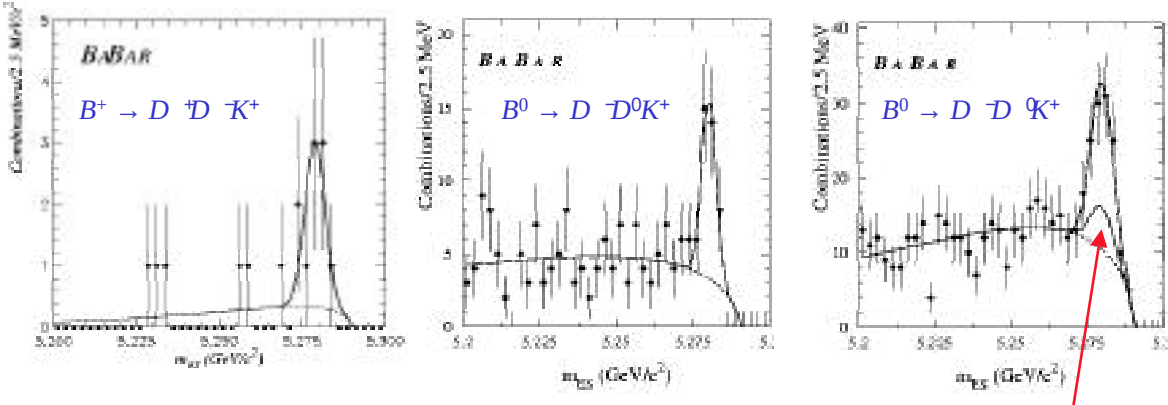
Quantity	Value
$\|A_0\|^2$	0.597±0.028±0.008
$\|A_\perp\|^2$	0.160±0.032±0.036
$\|A_{\|\|}\|^2$	0.243±0.034±0.033
$\phi_\perp = arg(A_\perp/A_0)$	-0.17±0.16±0.06
$\phi_{\|\|} = arg(A_{\|\|}/A_0)$	2.50±0.20±0.07

Double Charm Decays

- $B \rightarrow D^{(*)}\bar{D}^{(*)}(K)$
- $b \rightarrow c c \bar{s}$ transition without charmonium
  - A large rate could help resolve $B \rightarrow D_s/B \rightarrow l\nu$ discrepancy
- CP eigenstates can be used to measure angle β
  - $B^0 \rightarrow D^{(*)+}D^{(*)-}K_S$ sensitive to $\cos 2\beta$
  - $B^0 \rightarrow D^{+}D^{-}$ can be combined with other $\sin 2\beta$ modes
    - Requires angular analysis like $B^0 \rightarrow J/\Psi K^*$



$B \to D^{(*)}D^{(*)}K$



◎ $B^+ \to D^{(*)}\bar{D}^{(*)}K^+$: $N_{signal} = 8.2 \pm 3.5$ events

$Br(B^+ \to D^{(*)}\bar{D}^{(*)}K^+) = (0.34 \pm 0.16 \pm 0.09)\%$

◎ $B^0 \to D^{(*)}\bar{D}^0K^+$: $N_{signal} = 29.6 \pm 7.2$ events

$Br(B^0 \to D^{(*)}\bar{D}^0K^+) = (0.28 \pm 0.07 \pm 0.05)\%$

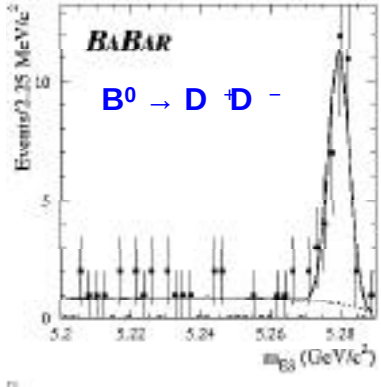
◎ $B^0 \to D^{(*)}\bar{D}^{(*)0}K^+$: $N_{signal} = 80.2 \pm 15.3$ events

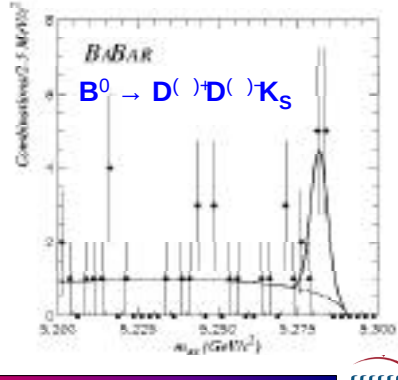
$Br(B^0 \to D^{(*)}\bar{D}^{(*)0}K^+) = (0.68 \pm 0.17 \pm 0.17)\%$

Bkg. From $B^+ \to D^{(*)}\bar{D}^{(*)}K^+$

$B^0 \to D^+ D^-, B^0 \to D^{(*)+} D^{(*)-} K_S$

- **$B^0 \to D^+ D^-$**
  - **Nsignal = 31.8 ± 6 Events**
  - **NBkg = 6.2 Events**
    - Estimated from sideband in ΔE and M_{ES}
  - **Br($B^0 \to D^+ D^-$) = (8.0 ± 1.6 ± 1.2) × 10^{-4}**
- **$B^0 \to D^{(*)+} D^{(*)-} K_S$**
  - **NSignal = 10.1 ± 3.7 Events**
  - **NBkg. = 3.4**
  - **Prob. of bkg fluctuation: 1.4 × 10^{-5}**



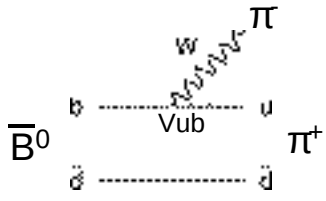


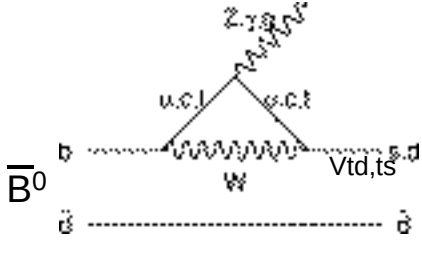
We will start using these modes for measuring β in 2001

Charmless B decays

- **B^0** $\pi^+\pi^-$
  - **Angle α (?)**
- **Penguins**
  - **B^0** $K^+\pi^-$, K^+K^-
  - **B^0** $K^*\gamma$
  - **B^0** φK_s^0
  - **B^-** φK^{*-}
  - **B^-** φK^-
  - **B^-** $\varphi\pi^-$
  - **Search for direct CP violation**

First Observation





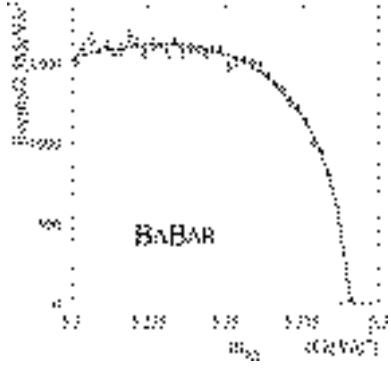
B^0 $h^+h'^-$ Analysis

- **Select events based on event shape, mass, …**
  - **26404 candidate events, $\varepsilon_{\pi\pi MC} \approx 0.45$**
- **Maximum likelihood fit to observables**
- **Parameters**
  - **$N_{\pi\pi}$ number of B^0 $\pi^+\pi^-$**
  - **$N_{K\pi}$ number of B^0 $K^+\pi^-$**
  - **N_{KK} number of B^0 K^+K^-**
  - **$A_{K\pi}$ asymm. in B^0 $K^+\pi^-$**
  - **$N_{b\pi\pi}$ background $\pi\pi$**
  - **$N_{bK\pi}$ background $K\pi$**
  - **N_{bKK} background KK**
  - **$A_{bK\pi}$ asymm in bkg. $K\pi$**
- **Observables**
  - **m_{ES}**
  - **ΔE**
  - **Fisher output**
  - **Cherenkov angles for positive + negative tracks**

Determination of PDF's

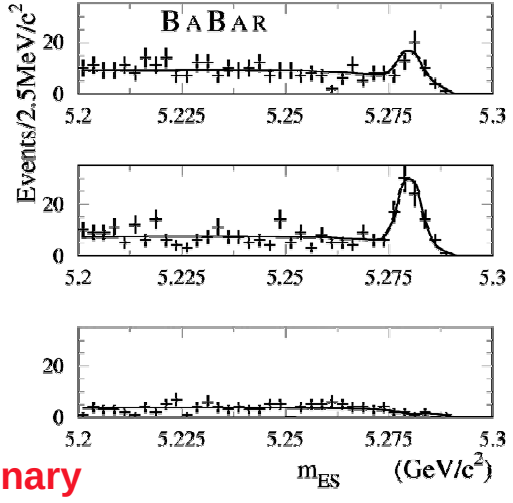
- **m_{ES}**
  - **Signal σ measured from B^- $D^0\pi$ (D^0 $K^-\pi^+$)**
  - **Background from ΔE sideband**
    - checked with offpeak data and MC
- **ΔE**
  - **Signal σ estimated from tracking resolution**
  - **Background from ΔE sideband**
- **Fisher**
  - **Signal from MC, cross-check using B^- $D^0\pi$**
  - **Background from m_{ES} sideband**
- **θ_c**
  - **π,K shapes taken from D^{*+} $\pi^+D^0(D^0$ $K^-\pi^+$)**

ΔE sideband



B^0 $h^+h'^-$ Fit Result

- **Systematic errors were estimated by varying PDFs Within statistical errors and data-MC differences**
- **Cross-checked with a "cut and count" analysis (gives a compatible result)**



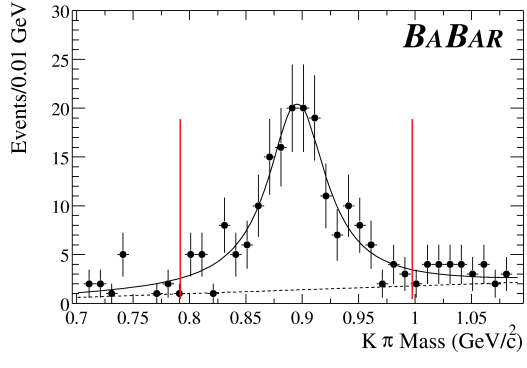
BaBar Preliminary

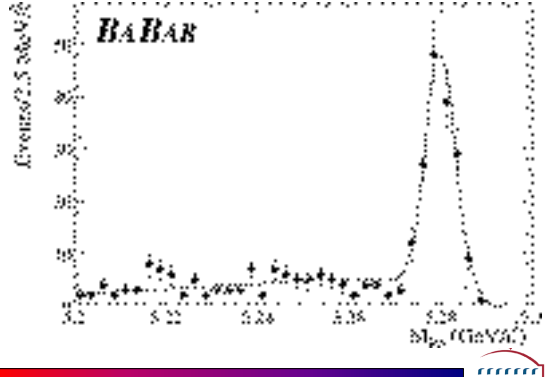
Decay Mode	$N_{signal} \pm \sigma_{stat} \pm \sigma_{syst}$	BR BaBar $(\times 10^{-6})$	BR CLEO $(\times 10^{-6})$
$\pi^+\pi^-$	$41 \pm 10 \pm 7$	$4.1 \pm 1.0 \pm 0.7$	$4.3 \pm ^{1.6}_{1.4} \pm 0.5$
$K^+\pi^-$	$169 \pm 17 ^{+12}_{-17}$	$16.7 \pm 1.6 ^{+1.2}_{-1.7}$	$17.2 ^{+2.5}_{-2.4} \pm 1.2$
K^+K^-	$8.2 ^{+7.8}_{-6.1} \pm 3.3$	< 2.5 (90% CL)	< 1.9 (90 % CL)

$B^0 \quad K^{*0}\gamma$

- **Photon candidate selection**
  - **High-energy EMC cluster**
  - **inconsistent with π^0 or e**
- **K* candidate selection**
  - **PID on K* daughters**
  - **Helicity cut on K^+**
  - **Mass cut**
- **Fit M_{ES} distribution**
  - **Signal as free gaussian**
  - **Background shape from off-peak data**

139.2 ± 13.1 events





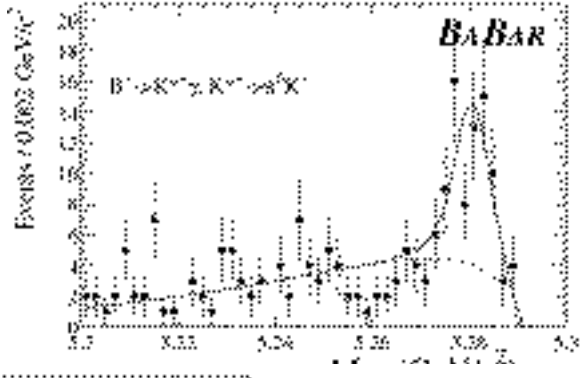
$B^0 \to K^{*0}\gamma$ BR and Asymmetry

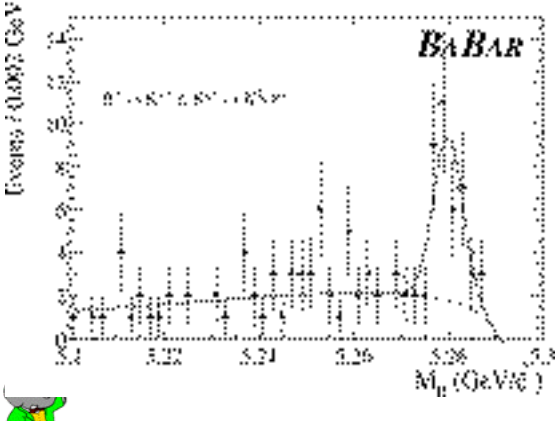
- **Efficiency calculated in Monte Carlo**
  - $\varepsilon = 0.209 \pm 0.013_{syst}$
- **Syst. errors dominated by efficiency corrections**
  - **Will improve with statistics, better detector modeling**
- $$A_{cp} = \frac{N(\overline{B}^0 \to K^{*0}\gamma) - N(B^0 \to K^{*0}\gamma)}{N(\overline{B}^0 \to K^{*0}\gamma) + N(B^0 \to K^{*0}\gamma)}$$
  - **Efficiency corrections drop out**

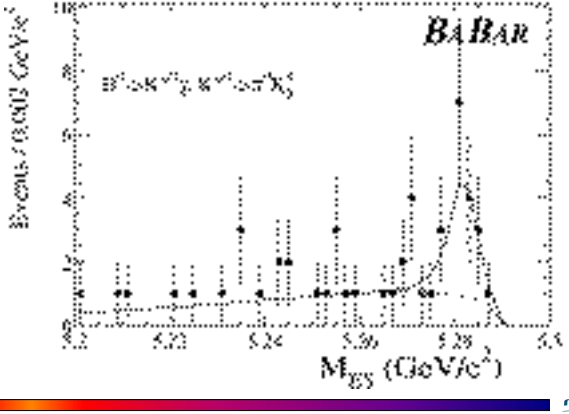
$$BR(B^0 \to K^{*0}\gamma) = (4.39 \pm 0.41 \pm 0.27)X10^{-5}$$

$$A_{cp} = -0.035 \pm 0.094 \pm 0.022$$

Other B K ν Modes Observed

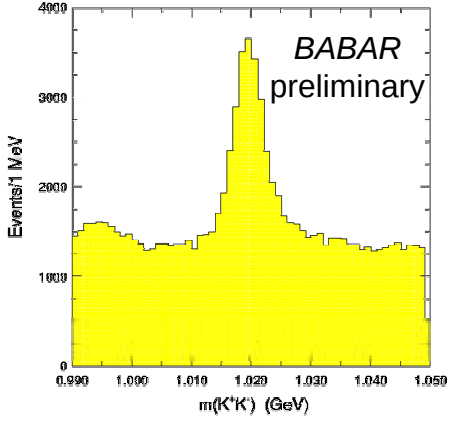






B^0 φX Searches

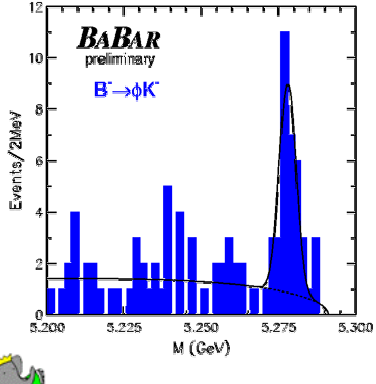
- **Event selection based on event shape, m_{ES}, ΔE, …**
- **φ selection**
  - **K Cherenkov angle Θ_c**
  - **Angle WRT event (thrust)**
    - Background peaks at $0, \pi$
- **Maximum Likelihood fit**
- **PDFs as in B^0 $h^+h'^-$ plus:**
  - **φ mass**
  - **Helicity**
    - Signal $\cos^2(\Theta_H)$
    - Bkg. From φ sidebands

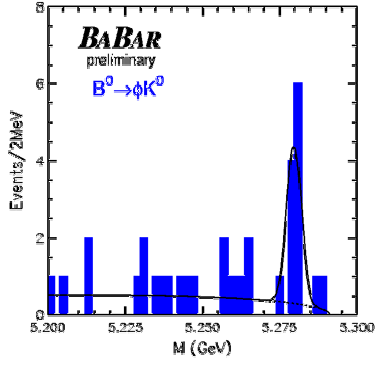


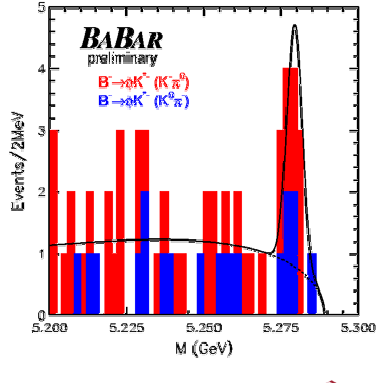
Results (Preliminary)

- **Systematic errors small compared to statistical**

Mode	Signal	Signific.	BR $\times 10^{-6}$
ϕK^-	$31.4^{+6.7}_{-5.9}$	10.5σ	$7.7^{+1.6}_{-1.4}$
ϕK^0	$10.8^{+4.1}_{-3.3}$	6.4σ	$8.1^{+3.1}_{-2.5}$
ϕK^{*-}	$7.0^{+4.3}_{-3.4}/4.5^{+2.7}_{-2.0}$	4.5σ	$9.6^{+4.1}_{-3.3}$
$\phi \pi^-$	$0.9^{+2.1}_{-0.9}$	0.6σ	< 1.3







Other Charmless B Results

Based on Summer 2000 data sample (7.7 fb-1).
Preliminary results, to be updated soon!

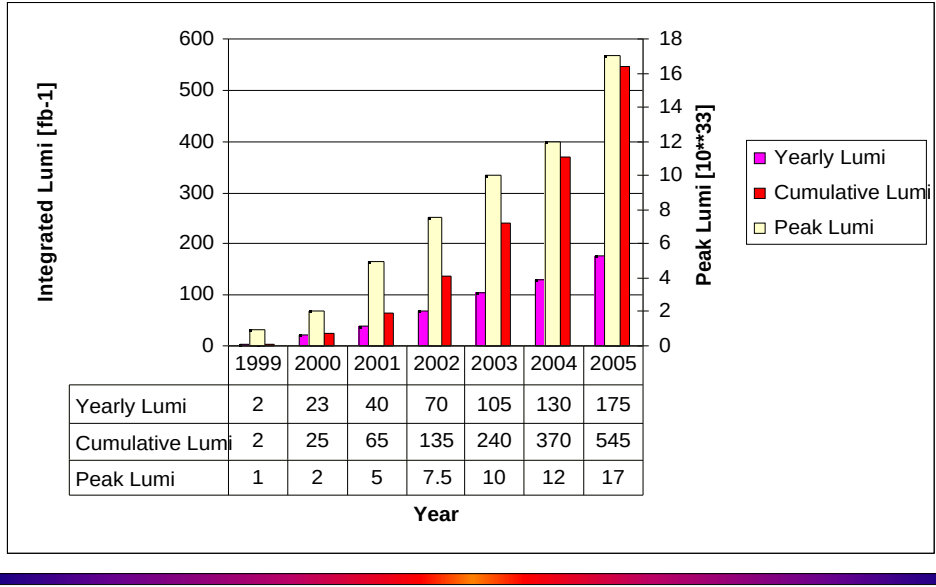
Decay Mode	BR BaBar ($\times 10^{-6}$)	Method
$K^{*0}\pi^+$	< 28 (90% CL)	cut & count
$\rho^0 K^+$	< 29 (90% CL)	cut & count
$K^+\pi^-\pi^+$	< 54 (90% CL)	cut & count
$\rho^0\pi^+$	< 39 (90% CL)	cut & count
$\pi^+\pi^-\pi^+$	< 22 (90% CL)	cut & count
$\rho^+\pi^0$	$49 \pm 13^{+6}_{-5}$	cut & count
ωh^+	< 24 (90% CL)	cut & count
ωK^0	< 14 (90% CL)	cut & count
$\eta' K^+$	$62 \pm 18 \pm 8$	cut & count
$\eta' K^0$	< 112 (90% CL)	cut & count

Conclusions

- **BaBar has recorded 23M BB decays in 1999-2000**
- **Most precise single measurement of sin2β**
  - **PRL submitted, PRD in preparation**
  - **Additional modes are being prepared**
- **Searches for direct CP, angles α+γ have begun**
  - **Accumulating statistics (and techniques)**
  - **First Observations of some B decay modes**
- **BaBar is running again since February 1**
  - **Low intial luminosity (new beamtune)**

PEPII Luminosity Projections

- We expect 30fb^{-1} more data by Aug2001
- **$\delta \sin 2\beta \sim 0.15$**
- **Lots more rare modes and precision to come**



	1999	2000	2001	2002	2003	2004	2005
Yearly Lumi	2	23	40	70	105	130	175
Cumulative Lumi	2	25	65	135	240	370	545
Peak Lumi	1	2	5	7.5	10	12	17