Update on BABAR Physics and Prospects

David B. MacFarlane
P5 Visit to SLAC
April 21, 2006
Pillars of BABAR physics program

- Highly constrained and redundant set of precision tests of weak interactions in the Standard Model
  - Full program of flavor physics/CP violation measurements will provide a legacy of fundamental constraints on future New Physics discoveries

- Searches for physics beyond the Standard Model in a well understood & characterized environment
  - Sensitivity to New Physics at LHC mass scales through rare decays and CP violation
  - Discovery potential from large data sample across a whole range of beauty, charm, tau, two-photon, ISR physics

Challenging measurements at the edge of sensitivity benefit enormously from operation of both PEP-II & KEK B Factories
Integrated data sample to date

Project Run 5 at 405 fb$^{-1}$ delivered
BABAR & Belle physics results

<table>
<thead>
<tr>
<th>Journal Papers</th>
<th>BABAR</th>
<th>Belle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total [Today]</td>
<td>204</td>
<td>167</td>
</tr>
</tbody>
</table>

+28 papers since last P-5 visit
Weak Interaction in Standard Model

Unitarity Triangle as a summary of Standard Model $b$ physics

Unitarity: $V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$

$V = \begin{pmatrix}
V_{ud} & V_{us} & V_{ub} \\
V_{cd} & V_{cs} & V_{cb} \\
V_{td} & V_{ts} & V_{tb}
\end{pmatrix} + \text{phases}$
Evolution of $\sin^2\beta$ measurements

- Present BABAR $0.722\pm0.040\pm0.023$
- Present Belle $0.652\pm0.039\pm0.020$

CDF
Aleph
BaBar
Belle

Present CKM fit

$*Belle\ 0.652\pm0.039\pm0.020$
Projected uncertainties on $\sin 2\beta$
Summary of constraints on $\alpha$

Mirror solutions disfavored

From combined $\pi\pi, \rho\pi, \rho\rho$ results:

$\alpha = \left[ 100^{+15}_{-9} \right]^{\circ}$

CKM indirect constraint fit: $\alpha = \left[ 97^{+5}_{-16} \right]^{\circ}$
Summary of constraints on $\gamma$

\[
\begin{align*}
    &\gamma = \left[62^{+35}_{-25}\right]^\circ \\
    &\gamma = \left[60^{+5}_{-4}\right]^\circ
\end{align*}
\]

Interference:

\[
b \rightarrow c \text{ with } b \rightarrow u
\]

Ratio $r_B$ of allowed to suppressed is critical

\[
\begin{align*}
    &B^+ \rightarrow D^{(*)0} \left[ \rightarrow D_{DCSD} \right] K^+ \\
    &B^+ \rightarrow D^{(*)0} \left[ \rightarrow D_{CP} \right] K^+
\end{align*}
\]

From combined analysis:

Indirect constraint:
New results for $B^0 \rightarrow D^{(*)0} K^{(*)0}$

Measure $r$ in self-tagging final state $D^0 K^{*0}$

$$r_B = \frac{A(B^0 \rightarrow \bar{D}^0 \bar{K}^{*0})}{A(B^0 \rightarrow D^0 K^{*0})}$$

No $V_{ub}$, $r_B$ less than expected!

$r_B < 0.40@90\%CL$
Projected uncertainty on $\gamma$

Based on original $\gamma$ modes, but we are still hunting for more!

$r_B = 0.1$

Projected sys error due to $D^0$ Dalitz plot
Global CKM fit: 2006

Includes CDF measurement of $\Delta m_s$
CPV in Penguin Modes

List of channels continues to expand...

\[ B^0 \rightarrow (\rho, \phi, \eta', f_0, \pi^0, \pi^0 \pi^0, K^+ K^-, K^0 S K^0 S) K^0 \]

\( \tau_B \) and \( \Gamma(b \rightarrow c \ell \nu) \)

Interference of suppressed \( b \rightarrow s \) Penguin decay with mixing
New: $\sin 2\beta_{\text{eff}}$ in $B \rightarrow \rho K_S$

Challenges:

- Overlap of $f_0(1280)$ and $\rho$, $B\bar{B}$ & non-resonant backgrounds
- Possible color-suppressed tree

Related New Results from BABAR:

- Update in $\omega K_S$
- Search for $B \rightarrow K_S K_SK_L$
- Many BF and $A_{CP}$ measurements in related modes control hadronic uncertainties in $b \rightarrow s$ penguins

First Measurement!
Summary of $\sin(2\beta)$ in Penguins

Representative theory estimates

Example from recent calculations (QCD factorization)
2-body: [Beneke; PL B620, 143 (2005)]
3-body: [Cheng,Chua,Soni; PRD72, 094003 (2005)]
Projected data sample growth

Integrated Luminosity [fb⁻¹]

- Double from 2004 to 2006
- Double again from 2006 to 2008

- L_peak = 9x10^{33}

- PEP-II: IR-2 vacuum, 2xrf stations, BPM work, feedback systems
- BABAR: LST installation

4-month down for LCLS, PEP-II & BABAR

April 21, 2006
Update on BABAR Physics and Prospects
Projected data sample growth

- Integrated Luminosity [fb⁻¹]
- L<sub>peak</sub> = 9x10<sup>33</sup>

- Jul-99 to Jul-08
- Sep 05 plan
- Feb 06 plan

- Data sample growth projections from July 1999 to July 2008.
How does this compare with KEKB?

Integrated Luminosity [fb⁻¹]

Jul-99  Jul-00  Jul-01  Jul-02  Jul-03  Jul-04  Jul-05  Jul-06  Jul-07  Jul-08

Sep 05 plan
Feb 06 plan
KEKB from Oide
KEKB no crab effect (30 fb⁻¹/month)
## Updated performance comparison

**Revised from 2005 results; conclusions unchanged from 2004 study**

<table>
<thead>
<tr>
<th>S Mode</th>
<th>Belle</th>
<th>BABAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S</td>
<td>stat err</td>
</tr>
<tr>
<td>phiK0</td>
<td>0.440</td>
<td>0.270</td>
</tr>
<tr>
<td>etapK0</td>
<td>0.620</td>
<td>0.120</td>
</tr>
<tr>
<td>KKK0</td>
<td>0.600</td>
<td>0.180</td>
</tr>
<tr>
<td>KSKKSKS</td>
<td>0.580</td>
<td>0.360</td>
</tr>
<tr>
<td>f0K0</td>
<td>0.470</td>
<td>0.360</td>
</tr>
<tr>
<td>pi0K0</td>
<td>0.220</td>
<td>0.470</td>
</tr>
<tr>
<td>ccbarK0</td>
<td>0.652</td>
<td>0.039</td>
</tr>
<tr>
<td>pipi</td>
<td>-0.670</td>
<td>0.160</td>
</tr>
<tr>
<td>rhopi S</td>
<td>-0.280</td>
<td>0.230</td>
</tr>
<tr>
<td>rhopi A+-</td>
<td>-0.020</td>
<td>0.160</td>
</tr>
<tr>
<td>rhopi A+</td>
<td>-0.530</td>
<td>0.290</td>
</tr>
<tr>
<td>rhoro</td>
<td>0.090</td>
<td>0.420</td>
</tr>
</tbody>
</table>

**Typically better errors for BABAR despite larger Belle dataset**

**Normalized performance ratio**

April 21, 2006

Update on BABAR Physics and Prospects
## BABAR CKM physics goals

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<tr>
<th>Physics</th>
<th>Impact</th>
<th>FY2006 450 fb(^{-1})</th>
<th>FY2007 650 fb(^{-1})</th>
<th>FY2008 1000 fb(^{-1})</th>
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<tr>
<td>Precision measurement of (\sin 2\beta)</td>
<td>Fundamental constant of the SM, whose precision is only limited by statistics</td>
<td></td>
<td></td>
<td>Improve error by factor of two to 2%</td>
</tr>
<tr>
<td>Precision measurement of (CP) asymmetry in (b \to s\bar{q}q) penguin modes</td>
<td>Primary approach to new physics in loop decays; (b \to s\bar{s}s) presently discrepant with SM predictions at 2.4(\sigma) level when averaged over all available modes</td>
<td></td>
<td>Potentially reach the 4-5(\sigma) level for average of all (b \to s\bar{s}s) modes</td>
<td>Could reach the 4-5(\sigma) level for individual theoretically-clean modes</td>
</tr>
<tr>
<td>Precision measurement of unitarity angle (\alpha)</td>
<td>Fundamental constraint on the UT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precision measurement of unitarity angle (\gamma)</td>
<td>Fundamental tree-level constraint on phases and amplitudes originating from any new physics beyond the SM</td>
<td></td>
<td>Pioneering measurements with 10-15(\degree) accuracy</td>
<td>Determine to 5-10(\degree) precision</td>
</tr>
<tr>
<td>Precision measurement of (\left</td>
<td>V_{ub}\right</td>
<td>) with inclusive &amp; exclusive semileptonic (B) meson decays</td>
<td>Fundamental tree-level constraint on amplitudes and phases originating from any new physics beyond the SM</td>
<td></td>
</tr>
</tbody>
</table>
Projections of $\sin2\beta$ from Penguin modes

Luminosity expectations:
- 2004 = 240 fb$^{-1}$
- 2008 = 1.0 ab$^{-1}$

Projections are statistical errors only; however systematic errors at few percent level

$\sigma(S) = 0.20$
**UT constraints in 2008**

- **now**
  - $\sigma(V_{ub}) = 8\%$

- **2008**
  - $\sigma(V_{ub}) = 6.5\%$

Assumption: no NP in trees [almost any NP model]

**Significant constraint on all New Physics models in LHC era**
Bounds on new physics

Introduce new physics in mixing diagram

\[
(\Delta M_{B_d}) = C_{B_d} (\Delta M_{B_d})^{SM}
\]

\[
A_{CP}(J / \psi K_S) = \sin 2(\beta + \phi_{B_d})
\]

Mass scale being probed for unit coupling:

\[ \Lambda(\text{now}) \sim 5 \text{ TeV} \]
\[ \Lambda(2008) \sim 10 \text{ TeV} \]
**New: \( T/CP/CPT \) Violation in \( B^0 \) mixing**

**Asymmetry in same-sign data:**
\[
A_{T/CP}(\Delta t) = \frac{N(\ell^+ \ell^+) - N(\ell^- \ell^-)}{N(\ell^+ \ell^+) + N(\ell^- \ell^-)} 
\approx 1 - \left| \frac{q}{p} \right|^4 
\approx 2\left(1 - \left| \frac{q}{p} \right| \right) 
\]

**Asymmetry in opposite-sign data:**
\[
A_{CP/CPT}(|\Delta t|) = \frac{N^{+-}(\Delta t > 0) - N^{-+}(\Delta t < 0)}{N^{+-}(\Delta t > 0) + N^{-+}(\Delta t < 0)} 
\approx \frac{\text{Re} \ z = (m_{B^0} - m_{\bar{B}^0})/\Delta m}{\text{Im} \ z = (\Gamma_{B^0} - \Gamma_{\bar{B}^0})/\Delta m} 
= \frac{2 \text{Re} \ z \sin(\Delta m \Delta t) - \text{Re} \ z \sinh(\frac{\Delta m \Delta t}{2})}{\cosh(\frac{\Delta m \Delta t}{2}) + \cos(\Delta m \Delta t)} 
\]

\[
|q/p| = 1.0008 \pm 0.0027(\text{stat}) \pm 0.0019(\text{syst}) 
\]

\[
\text{Im}(z) = 0.0139 \pm 0.0073(\text{stat}) \pm 0.0032(\text{syst}) 
\]

\[
\Delta \Gamma x \text{Re}(z) = -0.0071 \pm 0.0039(\text{stat}) \pm 0.0020(\text{syst}) 
\]

**Constraints on New Physics from \(|q/p|\)**

**Before:**

**After:**

**40% reduction in \( \sigma(q/p) \)**

**80% reduction in \( \sigma(\text{Im}(z)) \)**

**First Measurement!**

**April 21, 2006**

**Update on BABAR Physics and Prospects**
### BABAR rare decay physics goals

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<tr>
<td>Discovery of (B \to \tau\nu_\tau)</td>
<td>Provides a determination of (</td>
<td>V_{ub}</td>
<td>) and constrains Higgs sector in MSSM and NP in a parameter regime that is complementary to LHC</td>
<td>Limit</td>
</tr>
<tr>
<td>Precision determination of (b \to s\gamma) branching fraction, (CP) asymmetry, and photon energy spectrum</td>
<td>Loop diagram that provides unique insight into (B) meson structure and constrains Higgs sector in MSSM and NP in a parameter regime that is complementary to LHC</td>
<td>Ultimate precision on photon energy spectrum</td>
<td>Strong constraints from 5% error on BF; 1-2% error on (CP) asymmetry</td>
<td></td>
</tr>
<tr>
<td>Precision determination of (b \to s\ell^+\ell^-) branching fractions, (CP) and FB asymmetries</td>
<td>Contributions from Z-penguin and W-exchange loops that give additional constraints on MSSM and NP in a parameter regime that is complementary to LHC</td>
<td>Useful precision for constraints on NP</td>
<td>Strong constraint for NP from BF, (CP) and FB asymmetries</td>
<td></td>
</tr>
<tr>
<td>Discovery of (B \to \rho\gamma)</td>
<td>Provides a unique determination of CKM matrix elements (</td>
<td>V_{ud}</td>
<td>/</td>
<td>V_{ts}</td>
</tr>
</tbody>
</table>

*New Belle result*
Developments in $B \rightarrow \tau\nu$

Belle at FPCP (400 fb$^{-1}$)

$\sigma_{\text{Belle}} = \sigma_{\text{BaBar}} \times 0.7$

Under investigation, but likely recoverable

Example where Belle analysis is better than BABAR

Current analysis $\sigma_{\text{Belle}} = \sigma_{\text{BaBar}} \times 0.7$

Under investigation, but likely recoverable

SM prediction moved up $\sim 30\%$ due to $V_{ub}$, $B_s$ mixing

Winter '06

$\text{BR}(B \rightarrow \tau\nu)[10^{-4}]$

Probability density

$\sigma_{\text{BaBar}}$

$L(\text{fb}^{-1})$
New: angular analysis in $B \rightarrow K^{(*)}\ell\bar{\ell}$

$K^*$ polarization $F_L$

Low $q^2$ limit excludes SM at 98% CL (2.1σ)

$A_{FB} > 0.19$ (95% CL)

$A_{FB} (SM) = 0.03$

Forward-backward asymmetry $A_{FB}$ vs $q^2$

$K^*$ polarization consistent with Standard Model

Possible to exclude $C_7 = -C_7(SM)$ with 1 ab$^{-1}$

Wrong-sign $C_9C_{10}$ excluded at $>3\sigma$

$C_9C_{10} = -C_9C_{10}(SM)$

$A_{FB} > 0.19$ (95% CL) $A_{FB} (SM) = 0.03$
### BABAR Physics Goals

<table>
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<tr>
<th>Physics</th>
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<th>FY2007 650 fb⁻¹</th>
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</thead>
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<tr>
<td>Search for $D^0$-$\bar{D}^0$ mixing</td>
<td>Highly suppressed in the SM and therefore an ideal place to search for new physics in charm mixing diagram</td>
<td>Hint if 1% mixing amplitude</td>
<td></td>
<td>Discovery if 1% mixing amplitude</td>
</tr>
<tr>
<td>Search for lepton-flavor violation in ( \tau \rightarrow \mu \gamma ) or other tau decays</td>
<td>Expected to be significantly enhanced in many extensions of the SM accommodating neutrino mass, but extremely small in the SM itself</td>
<td></td>
<td></td>
<td>Limits reach 2x10⁻⁸ sensitivity</td>
</tr>
<tr>
<td>New discovery in heavy hadron spectroscopy</td>
<td>Improved understanding of QCD in non-perturbative regime</td>
<td>Discoveries possible anytime</td>
<td>Discoveries possible anytime</td>
<td>Discoveries possible anytime</td>
</tr>
</tbody>
</table>
New: search for D mixing in $K\pi\pi^0$

SM predicts small effect: $x, y < 10^{-5}$

Search for New Physics:
$CP$ violation in the $D$ system

Result consistent with no mixing @ 4.5%

$x \equiv \frac{2m_2 - m_1}{\Gamma_2 + \Gamma_1}$, $y \equiv \frac{\Gamma_2 - \Gamma_1}{\Gamma_2 + \Gamma_1}$

$R = \frac{\Gamma(D^0 \to K^+\pi^-\pi^0)}{\Gamma(D^0 \to K^-\pi^+\pi^0)}$

$= (0.214 \pm 0.008 \pm 0.008)\%$

Smaller DCS relative to $K\pi$

Allowing for $CP$ violation

April 21, 2006
Update on BABAR Physics and Prospects
Summary: Physics reach of BABAR

- **Goal for 2005-2006: double current data set**
  - Delay in Run 5 can be overcome by summer 2006 with extended running period, with substantial reduction in errors on CP violation asymmetries in rare decay modes
  - Error on average of Penguin modes should reach 0.06

- **Goal for 2007-2008: double again to ~1 ab⁻¹**
  - Individual Penguin modes with errors in range 0.06-0.12
  - Suite of fundamental Standard Model measurements with substantially improved levels of precision
    - Sensitivity to New Physics through rare decays, CP violation, & large data sample with a significant discovery potential
    - Full program of flavor physics/CP violation measurements provide fundamental constraints on future New Physics discoveries

- **Program will continue to be exciting and competitive through at least 2008**
Future opportunities in B physics

Terminating PEP-II/BABAR in 2008 is premature
- Many important physics goals are on the edge of sensitivity; a further doubling beyond 2008 would be feasible & welcome
- If there is new physics in Penguin modes then more data will almost certainly allow us to contribute to unraveling its nature
- Belle has shown that a $B_s^0$ program on the $\Upsilon(5S)$ is feasible; running on $\Upsilon(5S)$ would be important & complementary to LHCb

Ideas for Super B Factories are vigorously pursued
- Physics case based on sensitivity to new physics in beauty, charm and tau sectors
- Super KEKB is a mature proposal to upgrade KEKB to $4\times10^{35}$
- INFN is sponsoring a design study based on adopting linear collider ideas to a new very high luminosity facility ($1\times10^{36}$)

Interest in flavor physics at BABAR and beyond present B Factory programs remains strong
Backup Slides
The BABAR Collaboration
11 Countries
80 Institutions
623 Physicists

Stanford U
U of Tennessee
U of Texas at Austin
U of Texas at Dallas
Vanderbilt
U of Wisconsin
Yale

LPNHE des Universités Paris VI et VII
Ecole Polytechnique, Laboratoire Leprince-Ringuet
CEA, DAPNIA, CE-Saclay

Ruhr U Bochum
U Dortmund
Technische U Dresden
U Heidelberg
U Rostock

INFN, Bari
INFN, Ferrara
Lab. Nazionali di Frascati dell’ INFN
INFN, Genova & Univ
INFN, Milano & Univ
INFN, Napoli & Univ
INFN, Padova & Univ
INFN, Pisa & Univ & Scuola Normale Superiore

April 21, 2006 Update on BABAR Physics and Prospects 33
Evolution of $S_{\pi\pi}$ measurements

Gradual convergence of asymmetry measurement

Interpretation difficult due to large penguin amplitudes:

$$|\alpha - \alpha_{eff}| < 35^\circ$$

BABAR $-0.30 \pm 0.17 \pm 0.03$

Belle $-0.67 \pm 0.16 \pm 0.06$
Projected uncertainties on $\alpha$

New measurement of $\rho^+\rho^0$:

$B(B^\pm \rightarrow \rho^\pm \rho^0) = (17.2 \pm 2.5 \pm 2.8) \times 10^{-6}$

$f_L(B^\pm \rightarrow \rho^\pm \rho^0) = 0.96 \pm 0.04 \pm 0.05$

$A_{CP}(B^\pm \rightarrow \rho^\pm \rho^0) = 0.10 \pm 0.14 \pm 0.09$.

Projections depend on size of isospin corrections.
Exploring other $\gamma$ channels

Looking for $b \rightarrow u$ in $D_s^{(*)}a_0(2)$

No sign of $b \rightarrow u$ signal, $r_B$ smaller than expected!


hep-ex/0501105

No sign of $b \rightarrow u$ signal, $r_B$ smaller than expected!
UT from $\sin 2\beta$ & indirect constraints

Overconstrained: growing set of independent measurements are consistent with CKM picture

Now: looking for New Physics as correction to CKM

Paradigm change!
UT from CP violation measurements alone

New B Factory milestone: Comparable UT precision from CPV in B decays alone

Overconstrained: subsets of measurements can be used to test for new physics
Global CKM fit: 2008

95% contours

σ(V_{ub}) = 6.5%  σ(Δm_s) = 5%  σ(sin 2β) = 0.019  σ(α) = 8°  σ(γ) = 10°
Potential New Physics contributions

\( B^0 \rightarrow \phi K^0 \)

\( B^0 \rightarrow \eta' K^0 \)

New physics in loops?

SUSY contribution with new phases
Possible evolution of measurements

For each mode compare
\[ S_f \text{ with } S_f^{\text{exp}} = S(\chi_{c\bar{c}}) + \Delta S_f \]

Average: compare
\[ \frac{\sum \omega_f (S_f - S_f^{\text{exp}})}{\sum \omega_f} \text{ with } 0 \]

\[ \omega_f = \sigma_f^{\text{ex}} \oplus \sigma_f^{\text{th}} \]

Assume measurements will fluctuate around current world average central values
Snapshot II: Fall 2010?

Present SM uncertainty “1 sigma”

$B^0 \rightarrow XK_S^0$

- $\pi$
- $\eta$
- $\eta'$
- $\phi$
- $\omega$
- $\rho$

SM + various New Physics

NP in Z-Penguins

NP in gluonic-Penguins

NP in chromomagnetic operator

Projected errors

$S_{B \rightarrow XK_S^0}$

Buchalla, Hiller, Nir, Raz

hep-ph/0503151
**CPV in charmonium modes**

\[
\Gamma(b \to u \ell \nu)
\]

\[
(\rho, \eta)
\]

\[
\alpha = \phi_2
\]

\[
\beta = \phi_1
\]

\[
\gamma = \phi_3
\]

\[
\tau_B \text{ and } \Gamma(b \to c \ell \nu)
\]

**Interference of \( b \to c \) tree decay with mixing**

**CPV in \( B^0 \to J/\psi K^0_S \)**

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**April 21, 2006**

Update on BABAR Physics and Prospects
CPV in charmless modes

$$\Gamma(b \to u\ell\nu)$$

$$\gamma = \phi_3$$

$$\alpha = \phi_2$$

$$\beta = \phi_1$$

$$\tau_B$$ and $$\Gamma(b \to c\ell\nu)$$

Interference of suppressed $$b \to u$$ tree decay with mixing

CPV in $$B^0 \to \pi\pi, \rho\pi, \rho\rho, \ldots$$

$$B^0 - \bar{B}^0$$ mixing

3rd component: sizable Penguin diagram

$$\bar{B}^0$$

$$b \to W^+u, c, t, g$$

$$d \to \pi^-$$

$$d \to \pi^+$$

$$b \to W^+u, d \to \pi^-$$

$$d \to \pi^+$$

$$\bar{B}^0$$

$$b \to W^+d$$

$$d \to \pi^-$$

$$d \to \pi^+$$

$$\bar{B}^0$$

$$W^+ \bar{b}$$

$$W^- \bar{d}$$

$$\bar{B}^0$$

$$\tau_B$$ and $$\Gamma(b \to c\ell\nu)$$

Interference of suppressed $$b \to u$$ tree decay with mixing
Remarkably good progress on gamma!

Interference of color-allowed and color-suppressed tree decays

\[ \Gamma(b \rightarrow u \ell \nu) \]

\[ \alpha = \phi_2 \]

\[ \gamma = \phi_3 \]

\[ \beta = \phi_1 \]

\[ B^0 - B^0 \text{ mixing} \]

\[ \tau_B \text{ and } \Gamma(b \rightarrow c \ell \nu) \]

\[ \gamma : CPV \text{ in } B^0 \rightarrow D_{CP}K, D_{DCS}K, \ldots \]

Effect depends on ratio of two diagrams

\[ +D(D) \text{ decay to common final state } \]

\[ D_{CP}, D_{DCS}, D^0 \rightarrow K_s^0 \pi^+ \pi^- \]
BABAR publications since last P5 visit

1) A study of the $D_{sJ}^*(2317)^+$ and $D_{sJ}^*(2460)^+$ mesons in inclusive $c\bar{c}$bar production near $\sqrt{s} = 10.6$ GeV
2) Study of the decay $\bar{B}^0 \rightarrow D^{*+} \text{omega} \pi^-$
3) Observation of a Charmed Baryon Decaying to $D^0p$ at a Mass Near 2.94 GeV/c²
4) Measurements of $CP$-Violating Asymmetries and Branching Fractions in $B$ Decays to omega $K$ and omega $\pi$
5) Measurements of branching fractions, rate asymmetries, and angular distributions in the rare decays $B \rightarrow K l^+l^-$ and $B \rightarrow K^* l^+l^-$
6) Measurement of branching fractions and $CP$-violating charge asymmetries for $B$ meson decays to $D^{(*)}$ anti-$D^{(*)}$, and implications for the CKM angle gamma
7) Measurement of Branching Fractions in Radiative $B$ Decays to eta $K$ gamma and Search for $B$ Decays to eta' $K$ gamma
8) Search for $T$, $CP$ and $CPT$ Violation in $B^0$-anti-$B^0$ Mixing with Inclusive Dilepton Events
9) Search for the decay $\tau^- \rightarrow 3\pi^- 2\pi^+ 2\pi^0 \nu_{\tau}$
10) Search for the charmed pentaquark candidate $\Theta_c(3100)^0$ in $e^+e^-$ annihilations at $\sqrt{s}=10.58$ GeV
BABAR publications since last P5 visit

11) Observation of $B^0$ Meson Decay to $a_1^{+/-}(1260)$ $\pi^{+/-}$
12) Branching fraction limits for $B^0$ decays to eta' eta, eta' $\pi^0$ and eta $\pi^0$
13) Measurement of the $B^- \rightarrow D^0 K^{*-}$ branching fraction
14) Measurement of anti-$B^0 \rightarrow D^{(*)0}$ anti-$K^{(*)0}$ branching fractions
15) Measurement of time-dependent $CP$ asymmetries in $B^0 \rightarrow D^{(*)+/-}$ $\pi^{+/-}$ and $B^0 \rightarrow D^{+/-}$ rho$^{+/-}$ decays
16) Measurements of the branching fraction and time-dependent $CP$ asymmetries of $B^0 \rightarrow J/\psi \pi^0$ decays
17) The $e^+e^- \rightarrow 3(\pi^+\pi^-), 2(\pi^+\pi^-\pi^0)$ and $K^+K^-2(\pi^+\pi^-)$ cross sections at center-of-mass energies from production threshold to 4.5 GeV measured with initial-state radiation
18) Measurements of the $B \rightarrow D^*$ form factors using the decay anti-$B^0 \rightarrow D^{*-}e^{-}$ anti-$nue$
19) Measurement of $CP$ observables for the decays $B^{+/-} \rightarrow D^{0}_{CP} K^{+/-}$
20) Study of $e^+e^- \rightarrow p$ anti-$p$ using initial state radiation with BABAR
21) Determinations of $|V_{ub}|$ from Inclusive Semileptonic $B$ Decays with Reduced Model Dependence
22) Search for the rare decays $B^0 \to D_s^{(*)+} a_0^{(2)-}$
23) Search for rare quark-annihilation decays, $B^- \to D_s^{(*)-} \phi$
24) Measurements of Lambda$^+_c$ Branching Fractions of Cabibbo-Suppressed Decay Modes involving Lambda and Sigma$^0$
25) Measurement of the inclusive electron spectrum in charmless semileptonic B decays near the kinematic end point and determination of $|V_{ub}|$
26) Study of the X(3872) and Y(4260) in $B^0 \to J/\psi \pi^+ \pi^- K^0$ and $B^- \to J/\psi \pi^+ \pi^- K^-$ decays
27) Search for the decay $B^+ \to \tau^+ \nu_{\tau}$
28) Measurement of CP observables for the decays $B^{+/-} \to D^{0}_{CP} K^{*+/-}$