Outline

• BaBar Collaboration
• BaBar Mission
• Past & Present Achievements (FY02&FY03)
• What Next.......
## BaBar Collaboration Membership -- April 3, 2003

<table>
<thead>
<tr>
<th></th>
<th>Faculty</th>
<th>Grad Students</th>
<th>Post-docs</th>
<th>PhD Staff</th>
<th>Non-PhD Staff</th>
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</table>

36 PhD Thesis on BABAR results!!
The **BABAR Collaboration**

10 Countries
75 Institutions
579 Physicists

**Canada** [4/18]
- U of British Columbia
- McGill U
- U de Montréal
- U of Victoria

**China** [1/5]
- Inst. of High Energy Physics, Beijing

**France** [5/55]
- LAPP, Annecy
- LAL, Orsay
- LPNHE des Universités Paris VI et VII
- Ecole Polytechnique, Laboratoire Leprince-Ringuet
- CEA, DAPNIA, CE-Saclay

**Germany** [3/30]
- Ruhr U Bochum
- Technische U Dresden
- U Rostock

**Italy** [11/101]
- INFN, Bari
- INFN, Ferrara
- Lab. Nazionali di Frascati dell' INFN
- INFN, Genova &U
- INFN, Milano &U
- INFN, Napoli &U
- INFN, Padova &U
- INFN, Pisa &U &ScuolaNormaleSuperiore
- INFN, Roma &U "La Sapienza"
- INFN, Torino &U
- INFN, Trieste &U

**The Netherlands** [1/2]
- NIKHEF, Amsterdam

**Norway** [1/3]
- U of Bergen

**Russia** [1/9]
- Budker Institute, Novosibirsk

**United Kingdom** [10/66]
- U of Birmingham
- U of Bristol
- Brunel U
- U of Edinburgh
- U of Liverpool
- Imperial College
- Queen Mary, U of London
- U of London, Royal Holloway
- U of Manchester
- Rutherford Appleton Laboratory

April 3, 2003
Luminosity: Present and Future

So far in Run 3: On peak 19.03 fb\(^{-1}\)
Off peak 1.16 fb\(^{-1}\)

Summer 2002 and Winter 2003:
Run 1 + Run 2
On peak 83.9 fb\(^{-1}\)
Off peak 9.6 fb\(^{-1}\)
92 M BB pairs

Summer 2003:
Run 3
add 40 fb\(^{-1}\)

By end 2006:
500 fb\(^{-1}\)

By the end of the decade:
1\(^{\pm}\)2 fb\(^{-1}\)

B pair collected (Run 1+2+3) \(\approx 112\) Million
BaBar Physics Mission

New environment: high luminosity asymmetric collider

1) Search for CP violation in B mesons decays largely predicted by the Standard Model
2) Test extensively at this low energy scale the Standard Model by measuring precisely enough quantities to impose constraints on the Standard Model parameters

CP in b sector is FOUND!

TRY to open windows on new Physics beyond Standard Model
Rare B decays, Charm study, Tau rare decays
Flavour mixing and CP, T, CPT

Time dependence:
\[ dN \propto \exp(-|\Delta t|/\tau_B) \left( 1 \pm D \left( S \sin(\Delta m \Delta t) - C \cos(\Delta m \Delta t) \right) \right) \otimes R \]

\[ \lambda = \eta_{cp} \frac{q \overline{A}_{cp}}{p A_{cp}} \]

\[ S = \frac{2 \text{Im} \lambda}{1 + |\lambda|^2} \]

\[ C = \frac{1 - |\lambda|^2}{1 + |\lambda|^2} \]

D is the mis-tag dilution
R is the time resolution

\[ z = 2 \frac{\delta M - (i/2) \delta \Gamma}{\Delta m - (i/2) \Delta \Gamma} \]

\[ z \neq 0 \quad \text{CP & CPT violation} \]
Measurement of $\sin^2\beta = 0.741 \pm 0.067 \pm 0.034$

$\sin^2\beta = 0.755 \pm 0.074$ \hspace{1cm} $\sin^2\beta = 0.723 \pm 0.158$

PRL 89 (2002) 201802

Marcello A. Giorgi
Φ discovery in B sector

Osaka - 2002

Rome - 2001

Amsterdam - 2002
What else on $\sin 2\beta$

Measure $\sin 2\beta$ also in $\Phi K$ ($b\rightarrow sss$ pure penguin)

$B\rightarrow u, c, t$

$\bar{u}, \bar{d}$

$K^\pm$

$K_S$

$80$ Million $B$ pairs
(FY03) **Time dependent analysis**

Results:

\[
S_{\phi K^0_S} = -0.18 \pm 0.51 \text{(stat)} \pm 0.07 \text{(syst)}
\]

\[
C_{\phi K^0_S} = -0.80 \pm 0.38 \text{(stat)} \pm 0.12 \text{(syst)}
\]

Assuming C=0 (no direct CPV)

\[ S = \sin 2\beta = -0.26 \pm 0.51 \text{ stat.} \]

On control sample Charged K

expected S=0 Found S=0.26 \pm 0.27 \text{ stat.}
A simultaneous fit to tagged and untagged data gives:

\( \Delta m, \sin^2 \beta \) (consistent with previous analysis)

\( |A_{cp}/A_{cp}| \) (consistent with no direct CP violation (4.5%)

(Wrong tag with K due to DCS allowed. \( \Delta \Gamma/\Delta m, z, \lambda, |q/p| \) left free!)

\[
\text{sign}(\text{Re } \lambda_{CP}) \times \Delta \Gamma/\Gamma = -0.008 \pm 0.037 \pm 0.018 \ [ -0.084, +0.068 ]
\]

\[
|q/p| = 1.029 \pm 0.013 \pm 0.011 \ [ +1.001, +1.057 ]
\]

\[
(\text{Re } \lambda_{CP}/|\lambda_{CP}|) \times \text{Re } z = 0.014 \pm 0.035 \pm 0.034 \ [ -0.072, +0.101 ]
\]

\[
\text{Im } z = 0.038 \pm 0.029 \pm 0.025 \ [ -0.028, +0.104 ]
\]

90% CL
CP, T, CPT

From dileptons

\[ a_T = (0.5 \pm 1.2 \pm 1.4)\% \approx \frac{1 - |q/p|^4}{1 + |q/p|^4} \]
Towards $\sin 2\alpha_{\text{eff}}$: $S_{\pi\pi}$ and $C_{\pi\pi}$

(BaBar (Br/10^{-6}):

$B^0 \rightarrow \pi^+ \pi^- = 4.7 \pm 0.6 \pm 0.2$  \hspace{1cm} $B \rightarrow \pi^+ \pi^0 = 5.5 \pm 1.0 \pm 0.6$ \hspace{1cm} $B \rightarrow \pi^0 \pi^0 = \leq 3.6$

$\lambda_{\pi\pi} = e^{2i\alpha} \frac{1+|P/T|e^{i\delta} e^{i\gamma}}{1+|P/T|e^{i\delta} e^{-i\gamma}}$

$C_{\pi\pi} \propto \sin(\delta)$

$S_{\pi\pi} = \sqrt{1 - C_{\pi\pi}^2} \sin(2\alpha_{\text{eff}})$

$S_{\pi\pi} = 0.02 \pm 0.34(\text{stat}) \pm 0.05(\text{syst})$

$C_{\pi\pi} = -0.30 \pm 0.25(\text{stat}) \pm 0.04(\text{syst})$

4/9/03
SLAC-Annual Program Review
Measuring $\gamma$ with $B^+ \rightarrow D^0 K^+$

$$n_1 \equiv \frac{\Gamma(B^- \rightarrow D_1 K^-)}{\Gamma(B^- \rightarrow D_0 K^-)} = \frac{1 + r^2}{2} + r \cos(\Delta \delta - \gamma)$$

$$n_2 \equiv \frac{\Gamma(B^- \rightarrow D_2 K^-)}{\Gamma(B^- \rightarrow D_0 K^-)} = \frac{1 + r^2}{2} - r \cos(\Delta \delta - \gamma)$$

$$p_1 \equiv \frac{\Gamma(B^+ \rightarrow D_1 K^+)}{\Gamma(B^+ \rightarrow D_0 K^+)} = \frac{1 + r^2}{2} - r \cos(\gamma + \Delta \delta)$$

$$p_2 \equiv \frac{\Gamma(B^+ \rightarrow D_2 K^+)}{\Gamma(B^+ \rightarrow D_0 K^+)} = \frac{1 + r^2}{2} + r \cos(\gamma + \Delta \delta)$$

$$\Delta p_i = \Delta n_i = \alpha_i \sqrt{n_i} \frac{100 \text{ fb}^{-1}}{Ldt} \oplus 0.01$$

actual detector: $\alpha_i = 0.177$

“perfect” vertex detector: $\alpha_i = 0.133$ (no Bkg)

$$r \equiv \frac{A(B^- \rightarrow \bar{D}_0 K^-)}{A(B^- \rightarrow D_0 K^-)} = 0 \ (0.1)$$

$$n_1 \equiv \frac{\Gamma(B^- \rightarrow D_1 K^-)}{\Gamma(B^- \rightarrow D_0 K^-)} = 1.02 \pm 0.29 \pm 0.02$$

$$p_1 \equiv \frac{\Gamma(B^+ \rightarrow D_1 K^+)}{\Gamma(B^+ \rightarrow D_0 K^+)} = (0.72 \pm 0.26 \pm 0.02)$$
New results with full statistics 80/fb

\[ R_{CP} = \frac{\text{Br}(B^- \to D^0_{CP} K^-) + \text{Br}(B^+ \to D^0_{CP} K^+)}{\text{Br}(B^- \to D^0_{CP} \pi^-) + \text{Br}(B^+ \to D^0_{CP} \pi^+)} \]

- \( R_{CP}(KK) = (8.0 \pm 1.7 \pm 0.6)\% \)
- \( R_{CP}(\pi\pi) = (12.9 \pm 4.0^{+11}_{-13})\% \)

Combined \( R_{CP}(hh) = (8.8 \pm 1.6 \pm 0.5)\% \)

\[ A_{CP} = \frac{\text{Br}(B^- \to D^0_{CP} K^-) - \text{Br}(B^+ \to D^0_{CP} K^+)}{\text{Br}(B^- \to D^0_{CP} K^-) + \text{Br}(B^+ \to D^0_{CP} K^+)} \]

- \( A_{CP}(KK) = 0.25 \pm 0.20 \pm 0.07 \)
- \( A_{CP}(\pi\pi) = -0.44 \pm 0.34 \pm 0.06 \)

Combined \( A_{CP}(hh) = 0.06 \pm 0.17 \pm 0.06 \)

To complete the measurements odd CP eigenstates are needed as Ks \( \pi^0 \) and Cabibbo suppressed modes.
COMPUTING

Event Data Flow

HPSS

Skims

Objy

Ntuple

Root

Objy

SimProd

PrompReco

Oep

Production

Analysis
Computing Model Discussions (FY02)

* Current Model defined in 2000 (April review suggested an update)
* BaBar has 4 Tier-A sites (France, Italy, UK, US)
  - Looking at how to best exploit these distributed resources (BaBar GRID is one tool for this)
* Multiple analysis formats (now)
  - Objectivity, ROOT and Ntuples
  - Multi-step process
  - Problems found at any level need fixes propagated to other formats
* An ad hoc committee has evaluated the computing model with increased luminosity within a limited resource scenario (in both people and money)
Simulation Production (SP)

Since August 2001 (start of SP4) have gone from 7 sites to 25 (5 new in last 6 months)
First large experiment to utilise GEANT4 toolkit
Simulated 276 \( fb^{-1} \) BB and 75 \( fb^{-1} \) continuum
We adjusted the ratio of Bs to continuum to optimise analysis errors
Prompt Reconstruction

Now have two types of farms:
- Prompt Calibration (PC) process about 600pb$^{-1}$/day
- Event Reconstruction (ER) process about 150pb$^{-1}$/day

PC keeps pace with data taking:
- Accepts constant Hz of data should scale

Currently 2 ER farms:
- Add another shortly

New Computing Model (FY03)

BaBar will adopt ROOT Eventstore coupled with new analysis methodology.
BaBar should consider the complete phaseout of Objectivity.

Analysis and production testing milestones through September FY2003:
- Many areas should see improvements
- Current user job management is poor

Tools to manage running and bookkeeping out user output to be developed,
- Initial versions foreseen in FY2003.
FY2002 shutdown (DETECTOR)

Down period in summer 2002 motivated by the PEPII replacement of vacuum chamber and by a major intervention to improve the muon/Klong detection in the forward direction.

RPC newly built have been installed in the forward endcap together with new absorbers to improve the performance.
Down period Activity (DETECTOR)

- The main and programmed activities on the BABAR Detector:
  - the intervention on the IFR End Cap (muon/\(K_L\) detector).
  - The installation of new TDC in the Dirac.
  - The maintainance of SVT (possible because of the extraction from BABAR of Support Tube containing SVT, beam pipe and magnetic elements of interaction region)
SVT

SVT has been un-cabled, taken to the clean room, split in two halves and removed from the B1 magnets.

Once the SVT was exposed electrical tests and visual inspections were performed. We discovered the reason for some of the failures of the 9 non functioning readout sections, some modules fixed! Now only 4 out of 208 sections are not readable.

SVT so far tested for rad hardness up to 4 Mrad (OK!) rad tests are going on.

Partial SVT replacement of modules already built, tested and soon ready in Pisa and UCSB is considered by 2005.
New Forward EndCap from nov 2002

Terminology:
19 slots
and 15 RPC layers

Slot 18/19
5 brass layers
(slot 8,10,12,14,16)

Absorber Segmentation
7 layers 2 cm
1 layer 7 cm
2 layers 9 cm
2 layers 13 cm
2 layers 10 cm
total 85 cm
Barrel IFR Upgrade

The problem: dying RPCs.

REMEDIATION attempt made in 2002  NO  SUCCESS!

Can BABAR program survive without the IFR Barrel?

Decision taken in FY2003 to increase the thickness of the absorber and to replace the bakelyte RPC with a more robust detector (LST).
Physics Motivation for the IFR Barrel Replacement

• We have reviewed the long-term physics program in BaBar from the perspective of muon and $K_L$ identification in the IFR.

• The barrel IFR represents about half of our muon acceptance.

<table>
<thead>
<tr>
<th>Region</th>
<th>Lab frame polar angle (radians)</th>
<th>Fraction of CM coverage (with $\phi$ acceptance)</th>
<th>Frac. of IFR coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure barrel</td>
<td>$1 &lt; \theta_{lab} &lt; 2$</td>
<td>0.413 (0.380)</td>
<td>0.51</td>
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<tr>
<td>Barrel/endcap overlap</td>
<td>$0.7 &lt; \theta_{lab} &lt; 1$</td>
<td>0.185 (0.170)</td>
<td>0.23</td>
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<tr>
<td>Pure endcap</td>
<td>$0.3 &lt; \theta_{lab} &lt; 0.7$</td>
<td>0.215 (0.197)</td>
<td>0.26</td>
</tr>
<tr>
<td>Sum</td>
<td>$0.3 &lt; \theta_{lab} &lt; 2$</td>
<td>0.814 (0.748)</td>
<td>1.0</td>
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</table>
Physics Program for the IFR

- The IFR has been used in about 30 BaBar physics analyses.
  - Semileptonic decays (\(B \rightarrow Dl\nu\), \(B \rightarrow D^*l\nu\), \(\rho l\nu\), \(\pi l\nu\), \(X_u l\nu\), \(X_c l\nu\), ...)
  - Leptonic decays (\(B \rightarrow \tau \nu\), \(\mu\nu\), \(\mu^+\mu^-\), \(D_s \rightarrow \mu\nu\),...)
  - Electroweak penguins (\(B \rightarrow K^{\pm}\ell^-\), \(K^{\ast}\ell^+\ell^-\), \(X_s l^+l^-\))
  - Processes involving \(J/\psi\) or \(\psi(2S)\) (\(B \rightarrow J/\psi K_s\), new rare modes, e.g., evidence for \(J/\psi p^+\Lambda\).)
  - Lepton tagging (\(CP\), \(CPT\) studies, mixing, certain rare decays)
  - Reconstruction of \(B \rightarrow D^*l\nu\) on one side of the event
  - \(K_L\) identification (\(B \rightarrow J/\psi K_L\))

- We foresee many analyses involving muons for the long-term BaBar physics program. Now look at examples, focusing on need for statistics. (Different \(e/\mu\) systematics also important!)
$B \rightarrow Kl^+l^-, K^*l^+l^-, X_s l^+l^-$

Rare FCNC modes
- Sensitive to IFR performance ($2\mu$)
- $Kll$ observed ($4.4\sigma$)
- $K^*ll$ at $2.8\sigma$

ICHEP 2002: $82 \text{ fb}^{-1}$
Efficiency vs. time & effect of IFR barrel replacement

- **K(*)ee modes**: ε stable vs. run
- **K(*)μ+μ− modes**: ε low & falling with time
- **Lose 2/3 μ+μ− events w/o IFR barrel**

**Analysis efficiency: electron modes**

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<th>Efficiency</th>
<th>Run Period</th>
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<td>25</td>
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<tr>
<td>20</td>
<td>2000</td>
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<tr>
<td>15</td>
<td>2001</td>
</tr>
<tr>
<td>10</td>
<td>2002</td>
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</table>

**Analysis efficiency: muon modes**

<table>
<thead>
<tr>
<th>Efficiency</th>
<th>Run Period</th>
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<td>16</td>
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<tr>
<td>14</td>
<td>2000</td>
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<tr>
<td>12</td>
<td>2001</td>
</tr>
<tr>
<td>10</td>
<td>2002</td>
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</tbody>
</table>

**Significance in muon modes with and without Barrel IFR (500 fb-1)**

<table>
<thead>
<tr>
<th>Mode</th>
<th>S/sqrt(B) with Barrel IFR</th>
<th>S/sqrt(B) without Barrel IFR</th>
<th>S/sqrt(S+B) with Barrel IFR</th>
<th>S/sqrt(S+B) without Barrel IFR</th>
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</thead>
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<tr>
<td>K+mm</td>
<td>14.00</td>
<td>12.00</td>
<td>10.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Ksmm</td>
<td>12.00</td>
<td>10.00</td>
<td>8.00</td>
<td>6.00</td>
</tr>
<tr>
<td>K*0mm</td>
<td>10.00</td>
<td>8.00</td>
<td>6.00</td>
<td>4.00</td>
</tr>
<tr>
<td>K*+mm</td>
<td>8.00</td>
<td>6.00</td>
<td>4.00</td>
<td>2.00</td>
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Two paths to $|V_{ub}|$

- The uncertainty on $|V_{ub}|$ will soon limit tests of the unitarity triangle.
- Challenges:
  1. Small branching fractions, large $b \rightarrow c \ell \nu$ backgrounds
  2. Theoretical uncertainties associated with strong interaction effects
- Focus on experimental approaches with potential to reduce theoretical errors
  - Exclusive $B \rightarrow \pi \ell \nu$ at high $q^2$ with theory from lattice QCD; experiment uses “neutrino reconstruction”
  - Inclusive $B \rightarrow X_u \ell \nu$ with theory from heavy quark expansion; experiment uses fully reconstructed $B$ sample
  - Both methods need large event samples!
Replacing the IFR barrel gives us the opportunity to improve the absorber design. IFR barrel layer 19 cannot be replaced—we effectively lose 10 cm (0.6 $\lambda_{int}$) of absorber. (But this layer did not have full coverage.) Insert 5 brass detector/absorber layers (0.75 $\lambda_{int}$); Insert 5 brass detector/absorber configuration will emphasize muon detection more than original design, but will still preserve reasonable $K_L$ efficiency.

Plot based on depth cut only. $p$ rejection contribution: $\times 0.6$
The Barrel improvement is motivated.....

- Physics with muons is an essential part of BaBar’s long-term physics program.
- The barrel IFR provides about 50% of our muon acceptance.
  - The main effect of not replacing the barrel would be loss of statistics.
  - Muons are also valuable because they have very different systematics from electrons (Different detectors, radiation from electrons)
  - Modes with 2 leptons, such as $B \rightarrow K\pi\pi$, $B \rightarrow K^*\pi\pi$, and $B \rightarrow X_s\pi\pi$, would be severely affected without the barrel replacement.
- Physics with $K_L$’s will probably be less important than in the initial stage of BaBar, when $B \rightarrow J/\psi K_L$ was very important.
  - Can redesign the absorber to be more optimal for muon ID
  - Still retain significant $K_L$ capability
- With strong competition from Belle and soon from CDF, BaBar needs IFR Barrel replacement
IFR Barrel Upgrade (DETECTOR FY03 ....)

• Decision on technology made during Dec Collaboration Meeting.
• Project based on LST will be ready (WBS) by end of May 2003 and will be reviewed in June.
• Access for replacement of current RPCs is mechanically complex: significant engineering needed. Expect to upgrade in 2004 and 2005 to avoid an extremely long shutdown.
What next for Sin 2$\beta$

We can improve the expt. error on sin$2\beta$ with luminosity in time dependent asymmetry for channels as:

\[ b \rightarrow ccs \; O(\lambda^2) \text{ (golden as } J/\psi Ks) \] or \[ b \rightarrow ccd \; O(\lambda^3) \text{ (as } D(\ast)^\pm D(\ast'^-)) \],

where the leading term gives sin$2\beta$

\[ 0.5 \text{ ab}^{-1} \]
(>FY03) **What next for Sin 2β**

Pure penguin process $B \rightarrow \Phi k$

The present value with 80 /fb is:

$S = \sin 2\beta = -0.26 \pm 0.51 \text{ stat.}$

But also $B \rightarrow \eta k$ and $B \rightarrow K K K$

**How from $\alpha_{\text{eff}}$ to $\alpha$?**

ππ channel with isospin analysis?

ρπ with Dalitz plot analysis?

NEW PHYSICS?

New quanta in the loop?
In a full isospin analysis one can measure $\Phi$ and $\Phi'$ from $B$ and $B$ decays with a 4-fold ambiguity.

$$\cos \phi = \frac{\text{Br}(\pi^+\pi^-) + \frac{1}{2} \text{Br}(\pi^+\pi^-) - \text{Br}(\pi^0\pi^0)}{\sqrt{2\text{Br}(\pi^+\pi^-)\text{Br}(\pi^+\pi^0)}}$$

Fix: $\text{Br}(\pi^+\pi^-) = 4.7 \times 10^{-6}$, $\text{Br}(\pi^-\pi^0) = 4.1 \times 10^{-6}$ and assuming $\text{Br}(\pi^0\pi^0) \leq 1.0 \times 10^{-6}$
signal BR = 0.5e-6

\[ \sin 2\alpha_{\text{eff}} = -0.02 \pm 0.34 \pm 0.05 \]
with \( 2\alpha_{\text{eff}} = 2\alpha + 2\delta \)

**Grossman-Quinn bound:**
\[
\sin^2 \delta \leq \frac{Br(B^0 \rightarrow \pi^0\pi^0)}{Br(B^+ \rightarrow \pi^+\pi^0)}
\]

At present \( Br(B^0? \pi^0\pi^0) < 3.6 \times 10^{-6} \) (81 fb) \( \Rightarrow \delta = |\alpha_{\text{eff}} - \alpha| < 51^\circ \)

Best case with this method

\[ |\alpha_{\text{eff}} - \alpha| < 19^\circ \]
with 10 fb^{-1}

No significant gain with luminosity

SLAC-Annual Program Review
$\gamma$ from $B^+ \rightarrow D^0 K^+$

Fit: $\sin^2\gamma = 0.72 \pm 0.23$

$\Rightarrow \gamma = (59.9 \pm 10.2)^\circ$

Toy MC: results for $r=0.3$

Fit with $2ab^{-1}$ (perfect):

$\sin^2\gamma = 0.71 \pm 0.14$ ($\sin^2\gamma = 0.73 \pm 0.09$)

$\Rightarrow \gamma = (58.5 \pm 7.4)^\circ$ ($\gamma = (58.8 \pm 5.5)^\circ$)
Measuring $V_{ub}$

Measure $Br(b\rightarrow ul\nu)$ on the recoil of fully reconstructed $B$.

Close kinematics: $P^*_l$, $Q^2$ and $M_x$ available

Reco side

Before lepton selection: $>$3K events/fb$^{-1}$, S/B=0.5

After lepton selection: ~500 events/fb$^{-1}$, S/B=1.3

We are after the red part and one want to go as close as the D mass.
• $M_X$ spectrum depends on the Fermi motion of the $b$ quark in the $B$ meson

$$F(x) = N (1 - x)^{\alpha} x^{(1 + \alpha) x}$$
where $x = k_+/\bar{\Lambda}$ and $\bar{\Lambda} = m_B - m_b$

(see De Fazio, Neubert JHEP 9906:017,1999).

• The fraction of signal events removed by a cut on $M_X$ is then affected by a large uncertainty.

• $V_{ub}$ can be determined from:

$$|V_{ub}| = 0.00445 \left( \frac{B(\beta \rightarrow X_d \mu)}{0.002} \right)^{1/2} \times (1.0 \pm 0.02 + 0.030_{\text{pert}} \pm 0.035_{\text{stat}})$$

• $\sim 10\%$ theoretical uncertainty with a cut at $1.6 \text{ GeV}$

Assuming a $5\%$ theoretical error and a $5\%$ experimental systematic error, here are the projections of the error as a function of the luminosity.

The theoretical error of $10\%$ can be further reduced at the $5\%$ level using all information $P^*_l, Q^2$ and $M_X$.

N.B. this estimate neglects the fact that the full fledged theoretical extraction becomes feasible only with enough statistics.
# PEPII – “adiabatic” scenario

## Integrated Luminosity

<table>
<thead>
<tr>
<th>Year</th>
<th>Yearly Integrated Luminosity [fb⁻¹]</th>
<th>Cumulative Integrated Luminosity [fb⁻¹]</th>
<th>Peak Luminosity [10⁻³³]</th>
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<td>1999</td>
<td>3</td>
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<tr>
<td>2000</td>
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<td>106</td>
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<tr>
<td>2003</td>
<td>62.6</td>
<td>168,6</td>
<td>7.5</td>
</tr>
<tr>
<td>2004</td>
<td>66.1</td>
<td>234,7</td>
<td>10</td>
</tr>
<tr>
<td>2005</td>
<td>120.1</td>
<td>354.8</td>
<td>13</td>
</tr>
<tr>
<td>2006</td>
<td>151</td>
<td>505.8</td>
<td>16</td>
</tr>
<tr>
<td>2007</td>
<td>160.1</td>
<td>665.9</td>
<td>20</td>
</tr>
<tr>
<td>2008</td>
<td>217</td>
<td>882.9</td>
<td>22</td>
</tr>
<tr>
<td>2009</td>
<td>216</td>
<td>1098.9</td>
<td>25</td>
</tr>
</tbody>
</table>

## Peak Luminosity

- 2006: $1.6 \times 10^{34}$ fb⁻¹
- 2005: 5 ab⁻¹
Integrated luminosity vs physics

\[ \int L dt \left[ \frac{ab}{1} \right] \]

Continuous improvement

\[ \left| \frac{V_{ub}}{V_{cb}} \right| \quad \sin 2\beta \quad \sin 2\alpha \quad \gamma \]

\[ X_s l^+ l^- , K^* l^+ l^- \]

\[ \rho (\omega) \gamma \]

\[ X_s \nu \bar{\nu} , K^* \nu \bar{\nu} \]

\[ \tau \nu , \mu \nu \]

\[ \sin(2\beta + \gamma) \]

\[ \tau \rightarrow \mu \gamma \]

2002 \quad 2006 \quad \approx \quad 2009 \quad ? \text{BaBar}
Summary

**FY2002** - Precise measurement of $\sin^2\beta$, preliminary measurement of $\sin^2\alpha_{\text{eff}}$
- New IFR Endcap installed, SVT improved!
- Decision to move toward a new computing model, several Tier-A in operation (Lyon, Padova, Rutherford)

**FY2003** - Starts the implementation of the new computing model, Karlsruhe in operation.
- Decision taken to rebuild the IFR Barrel with a new technology (LST)
- Preliminary measurements of pure penguin processes for $\sin^2\theta$, preliminary measurements of $V_{ub}$, $B\to D K$, $B\to \rho \pi$. 
Summary

FUTURE - In 2005 install IFR Barrel and Spare modules of
SVT, to replace the heavily irradiated on horizontal plane.
New computing model based on Root files in operation in a
distributed system with 4 active Tier-A centers beside SLAC.
Approach the precision measurement with 0.5/ab of integrated
luminosity and towards more than 1.0/ab to explore possible
openings for new physics.
Study of CP asymmetries but also rare decays in b, c and tau
sectors.