# CP Violation in $B^{\pm} \to D^0 K^{\pm}$

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## Introduction

- In the Standard Model $b \to c\bar{u}s$ and $b \to \bar{c}us$ transitions have a relative CKM phase $\gamma$.

- Atwood, Dunietz & Soni : CP Violation enhanced for
  $B^- \to D^0 K^-$, $D^0 \to K^+\pi^-$
  $B^- \to \overline{D}^0 K^-$,$\overline{D}^0 \to K^+\pi^-$

- CP asymmetry

$$\frac{N(B^-) - N(B^+)}{N(B^-) + N(B^+)}$$

- Need 2 different decay modes of $D^0$ to extract $\gamma$

- Use $D^0 \to K^+K^-$ for 2nd mode

- No time dependence or tagging

## Description of method

Measure BRs for at least two distinct final states f1 and f2.

Define the following quantities :

$$a = Br(B^- \to K^- D^0)$$

$$b = Br(B^- \to K^- \overline{D}^0)$$

$$c(f1) = Br(D^0 \to f1)$$

$$c(\overline{f1}) = Br(D^0 \to \overline{f1})$$

$$d(f1) = Br(B^- \to K^- f1)$$

$$\overline{d}(f1) = Br(B^+ \to K^+ f1)$$

Assume that we can measure the quantities a, $c(f1)$, $c(f2)$, $c(\overline{f1})$, $c(\overline{f2})$ $d(f1)$, $d(f2)$, $\overline{d}(f1)$ and $\overline{d}(f2)$ but not b.

We can express $d(f1)$ in terms of a, b, $c(f1)$, $c(\overline{f1})$, the strong phase $\xi_1$ and the weak phase $\gamma$.

$$d(f1) = a * c(f1) + b * c(\overline{f1}) + 2\sqrt{a * b * c(f1) * c(\overline{f1})}\cos(\xi_1 + \gamma)$$

$$\overline{d}(f1) = a * c(f1) + b * c(\overline{f1}) + 2\sqrt{a * b * c(f1) * c(\overline{f1})}\cos(\xi_1 - \gamma)$$

$$d(f2) = a * c(f2) + b * c(\overline{f2}) + 2\sqrt{a * b * c(f2) * c(\overline{f2})}\cos(\xi_2 + \gamma)$$

$$\overline{d}(f2) = a * c(f2) + b * c(\overline{f2}) + 2\sqrt{a * b * c(f2) * c(\overline{f2})}\cos(\xi_2 - \gamma)$$

These four equations contain the 4 unknowns $\xi_1, \xi_2, b, \gamma$ which can be determined up to discrete ambiguities.

## Reconstruction Efficiency

- Reconstruction effic 2.6% $(K\pi)$, 2.2%$(KK)$
- Trigger effic $\sim$ 60% (2 tracks @$4\sigma$) both modes

| Decay Mode | $K^-(K^+\pi^-)$ | $K^-(K^+K^-)$ |
|---|---|---|
| Luminosity | $2 \times 10^{32}$ | |
| Running time | $10^7$ sec | |
| Integrated Luminosity | 2 fb$-1$ | |
| $\sigma_{b\bar{b}}$ | 100$\mu$b | |
| Number of $B^\pm$ | $1.5 \times 10^{11}$ | |
| Branching ratio | $1.7 \times 10^{-7}$ | $1.1 \times 10^{-6}$ |
| Reconstruction efficiency | .026 | .022 |
| Trigger efficiency | 0.6 | 0.6 |
| Number of reconstructed $B^\pm$ | 410 | 2500 |

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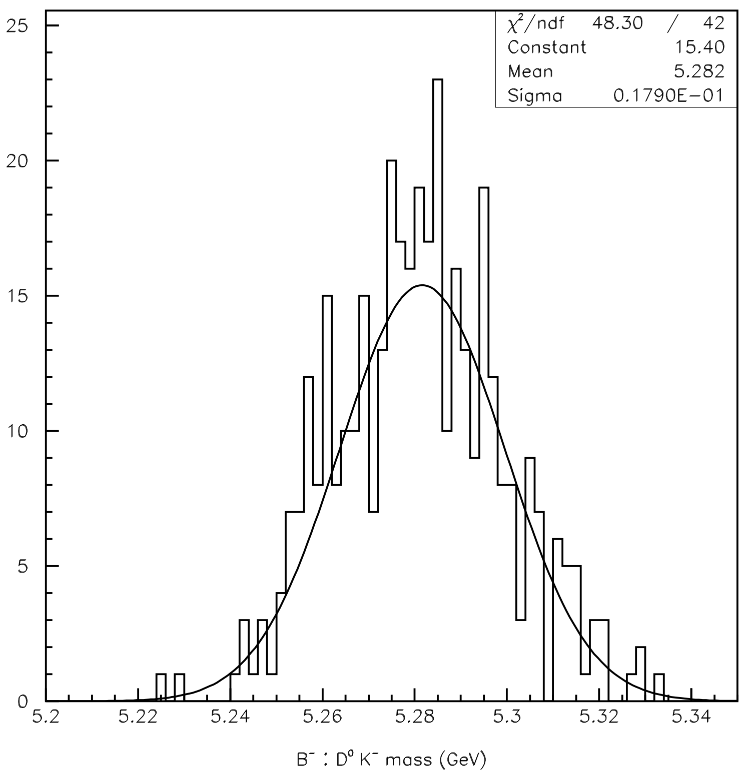

$\chi^2$/ndf 48.30 / 42
Constant 15.40
Mean 5.282
Sigma 0.1790E-01
25
20
15
10
5
0
5.2
5.22
5.24
5.26
5.28
5.3
5.32
5.34
$B^-$ : $D^0$ $K^-$ mass (GeV)

# Background from fake $D^0$s

- $D^0$ from generic $b\bar{b}$,$c\bar{c}$
- $S/B > 5$
- Only Background from real $D^0$s need be considered

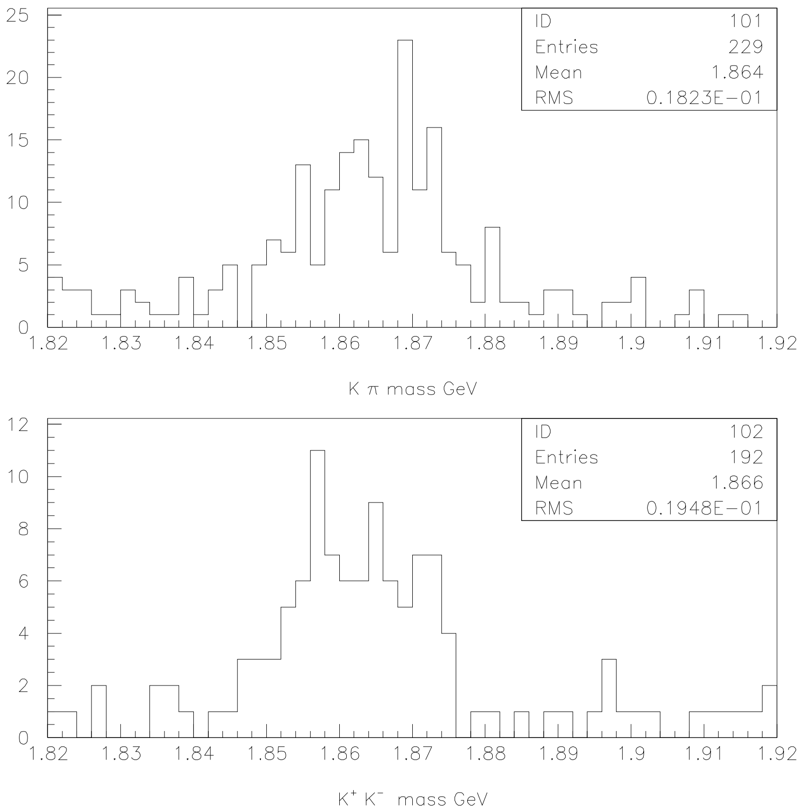


Figure 1: $D^0$ signal from generic $b\bar{b}$ events

## MisID BG: $B^- \to D^0\pi^- X$, $(D^0\pi^-,\ D^0\rho^-,\ D^{*0}\pi^-)$

- Assume particle MISID rate 2%
- $\dfrac{BR(B^-\to D^0\pi^-)}{BR(B^-\to D^0K^-)} = 20$
- $\dfrac{BR(B^-\to D^0\rho^-)}{BR(B^-\to D^0K^-)} = 50$
- $\dfrac{BR(B^-\to D^{*0}\pi^-)}{BR(B^-\to D^0K^-)} = 20$

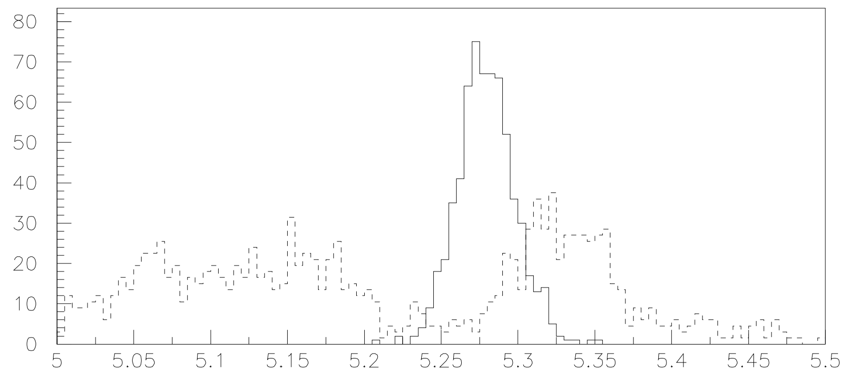


Figure 2: Signal (solid line) and background (dashed line) from $B^- \to \pi^- D^0$ and $B^- \to \pi^- D^0 X$ where the $\pi^-$ is misidentified as a $K^-$.

## $\boxed{\text{Combinatoric BG: } B \to \overline{D^0}X,\ BK^-X}$

- 1.6 million events generated $B \to \overline{D^0}X$, $\overline{D^0} \to K^+\pi^-$
- After all cuts 0 events in 5.0–5.5 GeV mass window, (1 event 5.5–6.0 GeV)
- Estimate S/B $> 1$

## Extracting $\gamma$ from Decay Rates

A mini Monte Carlo was done to estimate our ability to measure $\gamma$

- A set of values for the input parameters (b, $\gamma$, $\xi_1$, $\xi_2$) was chosen and the expected number of events in each channel was calculated.
- 1000 trials were done smearing the number of events in each channel by $\sqrt{N+B}$.
- For each trial values for b and $\gamma$ are calculated

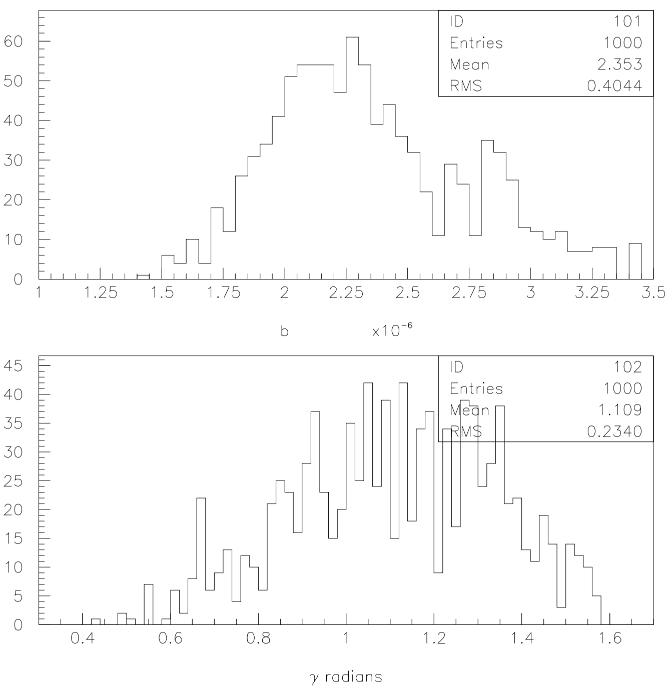


Figure 3: Results of Test: input $\gamma = 65^o$, (1.1 rad)

## Results

| | test 1 | test 2 | test 3 | test4 |
|---|---|---|---|---|
| b ($\times 10^{-6}$) | 2.2 | 2.2 | 2.2 | 2.2 |
| $\xi_1$ | $45^o$ | $0^o$ | $90^o$ | $70^o$ |
| $\xi_2$ | $30^o$ | $45^o$ | $10^o$ | $30^o$ |
| $\gamma$ | $65^o$ | $75^o$ | $85^o$ | $50^o$ |
| $\gamma$ fit | $(67 \pm 10)^o$ | $(75 \pm 7)^o$ | $(85.0 \pm 2.4)^o$ | $(50.0 \pm 3.2)^o$ |

## Conclusions

- We expect to reconstruct about 400 $B^{\pm} \to (K\pi)K^{\pm}$ and 2500 $B^{\pm} \to (KK)K^{\pm}$ per year at design luminosity of $2 \times 10^{32}$.
- The error on $\gamma$ depends mostly on $|\xi_1 - \xi_2|$.
  If $|\xi_1 - \xi_2| > 15^o$ we should be able to measure $\gamma$ to about $10^o$ or better in one year.