IL NUOVO CIMENTO Vol. 34 C, N. 6 Novembre-Dicembre 2011
DOI 10.1393/ncc/i2011-11035-4

Colloquia: IFAE 2011

# First ADS result with doubly Cabibbo suppressed $B^- \to D^0 K^-$ decays

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(ricevuto il 29 Luglio 2011; pubblicato online il 2 Novembre 2011)

**Summary.** — Measurements of branching fractions and $CP$ asymmetries of $B^- \to D^0 K^-$ modes allow a theoretically clean extraction of the CKM angle $\gamma$. The method proposed by Atwood, Dunietz and Soni makes use of doubly Cabibbo-suppressed decay modes, which produce large $CP$-violating effects. The CDF experiment reports the first measurement at a hadron collider of branching fractions and $CP$ asymmetries of both DCS $B \to D\pi/K$ signals. Using $5.0\,\text{fb}^{-1}$ of data we found a combined significance exceeding $5\sigma$ and we determined the physics parameters with accuracy comparable with $b$ factories.

PACS 13.25.Hw – Decays of bottom mesons.
PACS 11.30.Er – Charge conjugation, parity, time reversal, and other discrete symmetries.
PACS 14.40.Nd – Bottom mesons ($|B| > 0$).

## 1. – Introduction

The measurement of the Cabibbo-Kobayashi-Maskawa (CKM) matrix parameters is one of the fundamental test for the standard model consistency. In particular the phase $\gamma = arg(-V_{ud}V^*_{ub}/V_{cd}V^*_{cb})$ still suffers from large statistical uncertainties [1, 2], that can be improved through the large production of $B$ mesons of a hadron collider environment. The cleanest way to extract $\gamma$ makes use of tree level $B \to DK$ decays, for which very small theoretical uncertanties are predicted [3-5]. The interference of the favored $b \to c\bar{u}s$ transition of the $B^- \to D^0 K^-$ and the color-suppressed $b \to u\bar{c}s$ transition of the $B^- \to \overline{D}^0 K^-$ enhances the $CP$ violation effects from which $\gamma$ can be extracted.

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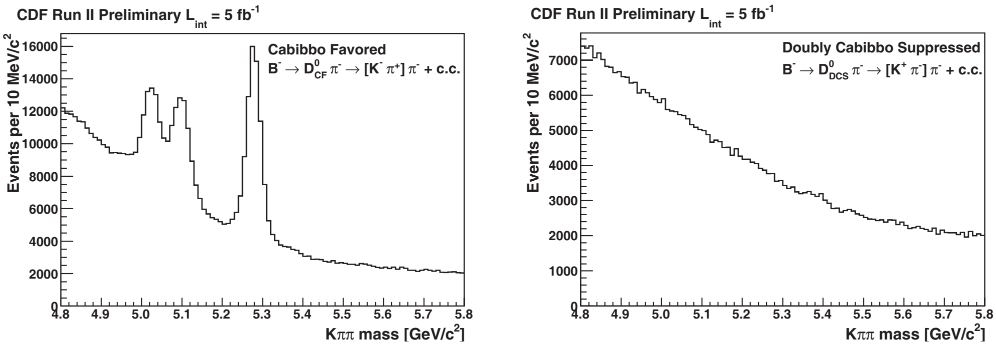


Fig. 1. – Invariant mass distributions of $B^- \to D^0\pi^-$ candidates, plus charge conjugate (c.c.), for each reconstructed decay mode, Cabibbo favored on the left and doubly Cabibbo suppressed on the right. The pion mass is assigned to the track from the $B$ decay.

## 2. – The Atwood-Dunietz-Soni method

In the Atwood-Dunietz-Soni (ADS) method [4], both $D^0$ and $\overline{D}^0$ decay into the $K^+\pi^-$ final state. The interfering amplitudes are of the same order of magnitude, so the expected asymmetry is large [4].

We measure the direct $CP$ asymmetry:

$$A_{ADS} = \frac{\mathcal{BR}(B^- \to [K^+\pi^-]_D K^-) - \mathcal{BR}(B^+ \to [K^-\pi^+]_D K^+)}{\mathcal{BR}(B^- \to [K^+\pi^-]_D K^-) + \mathcal{BR}(B^+ \to [K^-\pi^+]_D K^+)}$$

and the ratio between the doubly Cabibbo-suppressed (DCS) and the Cabibbo-favored (CF) branching ratios:

$$R_{ADS} = \frac{\mathcal{BR}(B^- \to [K^+\pi^-]_D K^-) + \mathcal{BR}(B^+ \to [K^-\pi^+]_D K^+)}{\mathcal{BR}(B^- \to [K^-\pi^+]_D K^-) + \mathcal{BR}(B^+ \to [K^+\pi^-]_D K^+)}\,.$$

They are sensitive to $\gamma$ through $A_{ADS} = \frac{2r_Br_D \sin\gamma \sin(\delta_B+\delta_D)}{r_D^2+r_B^2+2r_Dr_B\cos\gamma\cos(\delta_B+\delta_D)}$ and $R_{ADS} = r_D^2 + r_B^2 + 2r_Dr_B\cos\gamma\cos(\delta_B+\delta_D)$, where $r_B = |A(b\to u)/A(b\to c)|$, $\delta_B = arg[A(b\to u)/A(b\to c)]$ and $r_D$ and $\delta_D$ are the corresponding amplitude ratio and strong phase difference in the $D$ meson decay diagrams. We measure the corresponding quantities, $A_{ADS}$ and $R_{ADS}$, also for the $B^- \to D^0\pi^-$ mode, for which small asymmetries are expected [6].

The invariant mass distributions of CF and DCS modes, using a data sample of $5\,\mathrm{fb}^{-1}$ of data, with a nominal pion mass assignment to the track from the $B$ meson, are reported in fig. 1. A $B \to D^0\pi$ CF signal is visible at the correct mass of about $5.279\,\mathrm{GeV}/c^2$. Events from $B \to D^0K$ decays are expected to form a much smaller and wider peak, located about $50\,\mathrm{MeV}/c^2$ below the $B \to D^0\pi$ peak. The $B \to D^0\pi$ and $B \to D^0K$ DCS signals instead appear to be buried in the combinatorial background. For this reason, a crucial issue of this analysis is the suppression of the combinatorial background, obtained through a cut optimization focused on finding a signal for the $B \to D_{DCS}\pi$ mode. Since the $B \to D_{CF}\pi$ mode has the same topology of the DCS one, but more statistic, we did the optimization using the signal (S) and the background (B) directly from CF data,

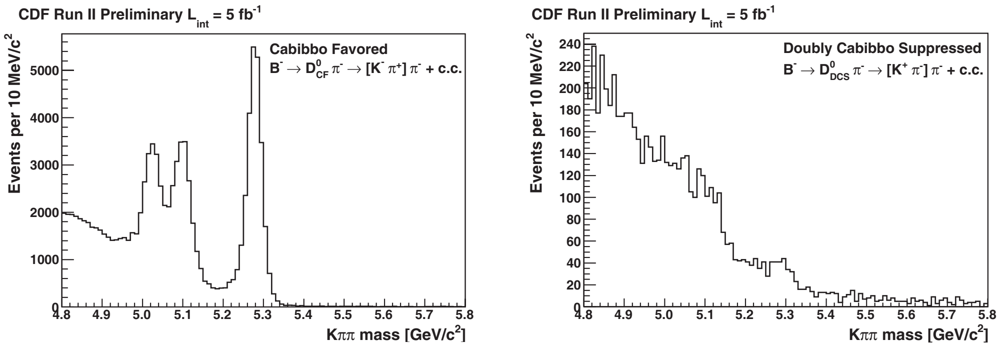


Fig. 2. – Invariant mass distributions of $B^- \to D^0\pi^-$ candidates, plus charge conjugate (c.c.), for each reconstructed decay mode, Cabibbo favored on the left and doubly Cabibbo suppressed on the right, after the cut optimization. The pion mass is assigned to the track from the $B$ decay.

choosing a set of kinematic and particle identification variables and maximizing the figure of merit $S/(1.5+\sqrt{B})$ [7]. All variables and threshold values applied are described in [8].

The resulting invariant mass distributions of CF and DCS modes are reported in fig. 2, where the combinatorial background is almost reduced to zero and an excess of events is now visible in the correct DCS signal mass window.

An unbinned maximum likelihood fit has been performed to separate the $B \to DK$ contributions from the $B \to D\pi$ signals and the combinatorial and physics backgrounds.

Preliminary results can be found in [8]. Results are in agreement with measurements by $b$ factory experiments and show competitive resolutions. Updating the analysis with $7\,\text{fb}^{-1}$ we find evidence of DCS $B \to DK$ and $B \to D\pi$ signals, with a kaon asymmetry different from zero at a level of about $2\sigma$.

## 3. – Conclusions

The preliminary results using the ADS method are competitive with previous measurements performed at $b$ factories. CDF, which has a global program to measure the $\gamma$ angle from tree-dominated processes, demonstrated the feasibility of these kind of measurements also at a hadron collider.

REFERENCES

[1] Bona M. *et al.* (The UTfit Collaboration), `http://www.utfit.org/`.
[2] Charles J. *et al.* (CKMfitter Group), *Eur. Phys. J. C*, **41** (2005) 1, arXiv:0406184 [hep-ex].
[3] Gronau M. and Wyler D., *Phys. Lett. B*, **265** (1991) 172.
[4] Atwood D., Dunietz I. and Soni A., *Phys. Rev. Lett.*, **78** (1997) 3257; Atwood D., Dunietz I. and Soni A., *Phys. Rev. D*, **63** (2001) 036005.
[5] Giri A., Grossman Y., Soffer A. and Zupan J., *Phys. Rev. D*, **68** (2003) 054018.
[6] Asner D. *et al.* (The Heavy Flavor Averaging Group), arXiv:1010.1589v1 [hep-ex].
[7] Punzi G., arXiv:physics/0308063v2 [physics.data-an].
[8] CDF Collaboration, CDF Public Note 10309.