



Charmless B decays at CDF

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Abstract. We report on the charmless B decays measurements performed on 180 pb^{-1} of data collected with the CDF II detector at the Fermilab TeVatron collider. This paper will describe: the first observation of the decay mode $B_s \rightarrow K^+K^-$ and the measurement of the direct CP asymmetry in the $(\bar{B}_d^0) \rightarrow K^\pm\pi^\mp$ decay; the first evidence of the decay mode $B_s \rightarrow \phi\phi$ and the branching ratio and CP asymmetry for the $B^\pm \rightarrow \phi K^\pm$ decay.

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1 Introduction

The Fermilab TeVatron collider is currently the only machine able to produce all species of b hadrons: both the B_d and the B_s mesons and all the b-baryons. The CDF II detector [1], thanks to its Silicon Vertex Trigger (SVT) is the only detector able to trigger on vertexes with two displaced tracks. This unique combination makes it possible to study several B decays and opens new windows in the understanding of the flavor dynamics of the SM. The principal characteristics of the detector used in the presented analysis, are related to the tracking and trigger systems. The tracks are reconstructed using the silicon detector and the central drift chamber. For the muons is also required the identification in the muons chambers. The online resolution of $35 \mu\text{m}$ on the impact parameter and the fast readout electronics are the key factors to allow the online pattern recognition of the SVT. The particle identification of the CDF II detector is based, for tracks with momenta above $2 \text{ GeV}/c$ as required for the SVT, on the specific ionization (dE/dx) measured in the volume of the drift chamber.

2 $B_{d/s}^0 \rightarrow h^\pm h^\mp$

The long term goal of this analysis is to measure the time-dependent CP asymmetries in the flavor tagged samples $B_d \rightarrow \pi^+\pi^-$ and $B_s \rightarrow K^+K^-$. A strategy to measure the angles β and γ , based on these decays has been proposed by Fleisher [2].

The invariant mass spectrum of the two tracks sample is shown in Fig. 1. The clear peak in the distribu-

tion corresponds to the following decays: $B_d \rightarrow K^+\pi^-$, $B_s \rightarrow K^+K^-$, $B_d \rightarrow \pi^+\pi^-$, $B_s \rightarrow K^-\pi^+$.

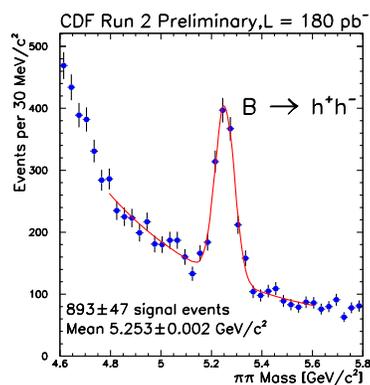


Fig. 1. Invariant mass for the $B_{d/s}^0 \rightarrow h^\pm h^\mp$ candidates.

The first steps performed on this sample are to disentangle the four signal contributions, to get to the relative branching ratios and then to measure the CP asymmetry for the $(\bar{B}_d^0) \rightarrow K^\pm\pi^\mp$. An analysis of the signals lifetime is ongoing and further in the future the flavor tagging will be added to tackle the time-dependent CP asymmetries. To separate the four channels it is possible to take advantage of their (little) difference in the kinematics and use the particle identification on the tracks couples to separate kaons from pions. Since none of the two is powerful enough to allow an event by event separation, the signals are analyzed through a maximum likelihood fit. The $B_{d/s}^0 \rightarrow h^\pm h^\mp$ modes are two body decays of the (spin 0) B meson. Kinematically the channels differ only for the B_d/B_s and kaon / pion mass difference. This tiny dif-

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ference translates into an unbalance in the momenta of the boosted decay products. The tracks in CDF II are all reconstructed in the π mass hypothesis. Thus, to fully exploit this kinematics difference a new variable α has been defined as $(1-p1/p2) \cdot q1$, where $p1(p2)$ is the modulus of the lower(higher) momentum of the track. In this way the $B_d \rightarrow \pi^+\pi^-$ will not show any dependence on α while the other channels, where one or both tracks have been reconstructed with the wrong mass assignment, will exhibit a distinctive dependence [3]. This allows to separate the $B_d \rightarrow K^+\pi^-$ and $B_s \rightarrow K^-\pi^+$ decays from the others, but not the $B_d \rightarrow \pi^+\pi^-$ and $B_s \rightarrow K^+K^-$ decays that have an identical α dependence. To distinguish the latter the dE/dx information has been included in the fit. With the actual data set it is possible for the first time to measure the $B_s \rightarrow K^+K^-$ branching ratio relative to $B_d \rightarrow K^+\pi^-$:

$$\frac{f_d BR(B_s \rightarrow K^+K^-)}{f_s BR(B_d \rightarrow K^+\pi^-)} = 0.50 \pm 0.08(stat.) \pm 0.07(syst.)$$

where f_s, f_d are the world averaged fragmentation fractions. Moreover it is possible to measure the direct CP asymmetry in the $(\bar{B}_d) \rightarrow K^\pm\pi^\mp$ decay:

$$\begin{aligned} A_{CP} &= \frac{N(\bar{B}_d \rightarrow K^-\pi^+) - N(B_d \rightarrow K^+\pi^-)}{N(\bar{B}_d \rightarrow K^-\pi^+) + N(B_d \rightarrow K^+\pi^-)} = \\ &= -0.04 \pm 0.08(stat.) \pm 0.01(syst.) \end{aligned}$$

3 $B_s \rightarrow VV$ decays

The peculiarity of $B_s \rightarrow VV$ decays resides in the presence of both CP-even and CP-odd components in the decay amplitudes, possibly leading to both the observation of CP violation and the measurement of the $\Delta\Gamma_s$. Recent measurements on decays mediated by $b \rightarrow s\bar{s}s$ amplitude show discrepancies with respect to the SM predictions [4], placing in the spotlight the presented decays: $B_s \rightarrow \phi\phi$ and $B^\pm \rightarrow \phi K^\pm$ ($\phi \rightarrow K^\pm K^\mp$) [5].

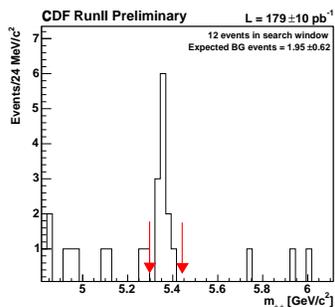


Fig. 2. Invariant mass for the $\phi\phi$ candidates

3.1 $B_s \rightarrow \phi\phi$

A blind analysis has been performed for the search of the $B_s \rightarrow \phi\phi$ decay. The selection cuts are optimized for pairs of tracks whose invariant mass is in a window around the ϕ mass. The two main sources of background are expected to be the combinatorial, studied on data using the sidebands, and the cross-feed of the $B_d \rightarrow \phi K^{0*}$ where the pion from the K^{0*} decay is misreconstructed as a kaon, studied with MC. As shown in Fig. 2 after the cuts optimization 12 events have been found in the signal region with an expected background of 1.95 ± 0.63 , corresponding to a 4.8σ significance.

A sample of $B_s \rightarrow J/\psi\phi$ is then used as normalization to extract the relative branching ratio as reported in table 1.

3.2 $B^\pm \rightarrow \phi K^\pm$

The analysis of the signal yield and CP asymmetry defined as

$$A_{CP} = \frac{N(B^- \rightarrow \phi K^-) - N(B^+ \rightarrow \phi K^+)}{N(B^- \rightarrow \phi K^-) + N(B^+ \rightarrow \phi K^+)}$$

on the $B^\pm \rightarrow \phi K^\pm$ ($\phi \rightarrow K^+K^-$) sample have been performed through an extended maximum likelihood fit in the following variables: the three kaons invariant mass, the invariant mass of the ϕ candidate, the ϕ helicity and the kaon dE/dx . A combination of MC and sideband data have been used to model the signal and the different background components. A sample of $B^+ \rightarrow J/\psi K^+$ is then used as normalization to extract the relative branching ratio. The results of the analysis are reported in table 1.

4 Conclusion

All the presented analysis are already being updated with a better tracking and better dE/dx calibrations. At the time of the conference already twice the integrated luminosity is available for analysis, leading to more precise measurement and bringing to the CDF II reach new B_s decay modes such as $B_s \rightarrow K^{0*}\bar{K}^{0*}$ and $B_s \rightarrow \phi\rho$.

Table 1. Preliminary CDF II results for $B^+ \rightarrow \phi K^+ B_s \rightarrow \phi\phi$

	$B^+ \rightarrow \phi K^+$	$B_s \rightarrow \phi\phi$
Yield	$47.0 \pm 8.4 \pm 1.4$	$7.3 \pm 2.8 \pm 0.4$
$BR \cdot 10^5$	$0.76 \pm 0.13 \pm 0.06$	$1.4 \pm 0.6 \pm 0.6$
A_{CP}	-0.07 ± 0.17	$^{+0.03}_{-0.02}$

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