CDF note 7176

First Run II Measurement of B^0 Oscillations Using a Combination of Flavor Taggers in Semileptonic B Decays

The CDF Collaboration
URL http://www-cdf.fnal.gov
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We present a measurement of the B^0 mixing parameter Δm_d in the partially reconstructed $B \to \ell D^{(*)}$ sample at the CDF experiment. Three final states are reconstructed with an integrated luminosity of about 245 pb^{-1}, which corresponds to a sample of over 115k B mesons. The initial b flavor is determined by a combination of three taggers: Same Side Pion Tagging, Opposite Side Muon Tagging and Jet Charge Tagging. We find $\Delta m_d = (0.536 \pm 0.037\ (stat.) \pm 0.009\ (s.c.) \pm 0.015\ (syst.))ps^{-1}$. The first error is statistical, the second one comes from the sample composition, and the third one contains the rest of the systematic uncertainties.

Preliminary Results for Summer 2004 Conferences

I. INTRODUCTION

In this note we present a measurement of the B^0 mixing parameter Δm_d using a $B \to \ell D^{(*)}$ sample obtained from the lepton+SVT trigger at the CDF experiment. The initial b flavor is determined by a combination of three taggers: Same Side Pion Tagging (SST), Opposite Side Muon Tagging (SMT) and Jet Charge Tagging (JQT). All those flavor taggers have been already well developed, and we will just point to the respective references, rather than providing extensive explanations of those taggers.

An unbinned likelihood fitter will be used in the future to combine all available Same Side and Opposite Side Taggers to perform $B_{d(s)}$ mixing measurements with semileptonic and fully reconstructed B decays. In the meanwhile, before performing an unbinned likelihood fit, we want to check the behavior of the Opposite Side Taggers (OST) in high statistics channels, e.g. Semileptonic B decays, using a binned likelihood fitting framework.

This analysis is the natural step after performing the same measurement using only the Same Side Tagging. Therefore, all the tools, the selection of the sample, the Monte Carlo simulation, the sample composition issues, the fake lepton contribution, the physics backgrounds and the fitter used are common to both measurements [1].

The CDF detector is described in detail in [2].

II. FLAVOR TAGGING ALGORITHMS

There are currently several algorithms for determining the production flavor of B mesons, being a very important part in any $B_{d(s)}$ mixing measurement. In this analysis we use all possible flavor taggers, which have already been blessed inside the CDF collaboration so far: SST, SMT and JQT. SST, SMT and JQT algorithms are explained in References [1, 3]. Both SMT and JQT divide the sample in several bins of p_T^{rel} [4] and Q_{jet} [5] respectively, in order to get a better performance. Our binned likelihood fit, in comparison with a unbinned likelihood fit, does not allow to split the sample in further bins due to a lack of statistics. Then, we do not split the sample in more bins in the SMT case, and $|Q_{jet}|$ must be greater than 0.2 for a candidate to be considered as tagged in the JQT case.

It is clear that in order to obtain the best possible measurement of a physics quantity like $\Delta m_{d(s)}$ one should make use of all the available flavor taggers. We need a single tagging decision per candidate, therefore we have to agree on which tag decision to assign to multiply tagged B candidates.

We use two Opposite Side Taggers. In addition JQT is divided in two categories: candidates with and without a secondary vertex in the tagging jet, which we will call "SecVtx" and "High P_T" tagged candidates respectively. SMT has higher dilution than JQT and JQT-SecVtx has lower efficiency, but higher dilution than JQT-High P_t jet; hence the Opposite Side Taggers are applied using the following order of priority:

- SMT;
- if there is not SMT decision, JQT-SecVtx is applied;
- if there is neither SMT nor JQT-SecVtx decisions, JQT-High P_t jet is applied.

So, we have already implemented a simple algorithm to split the Opposite Side tagged candidates in three independent samples, and having only one OST decision for each candidate. Nevertheless, each candidate might also be tagged using SST. Therefore there are four possible cases:

- candidates are tagged only with SST (one sample);
- candidates are tagged only with OST (three samples, one for each Opposite Side tagging algorithm);
- candidates are tagged with both SST and OST, and the tagging decisions agree (three samples);
- candidates are tagged with both SST and OST, and the tagging decisions disagree (three samples).

Therefore, we must divide the original single sample in ten subsamples.

Finally, we must compute the dilution for each subsample. In the first two cases, when there is only either SST or OST decision, clearly one assigns four different dilutions to be fitted. If we have doubly tagged candidates, we assume that there are not correlations between taggers, which is in principle true in the case of an Opposite Side Tagger versus a Same Side Tagger. The dilution for doubly tagged candidates for which SST and OST algorithms agree is given by:

$$D_{agreement} = \frac{D_{SST}+D_{OST}}{1+D_{SST}*D_{OST}}.$$

Similarly, the dilution for doubly tagged candidates for which SST and OST algorithms disagree is given by:

$$D_{disagreement} = \frac{|D_{SST}-D_{OST}|}{1-D_{SST}*D_{OST}}.$$

To perform the analysis it does not matter if one chooses either $D_{SST} - D_{OST}$ or $D_{OST} - D_{SST}$. Nevertheless we choose the tagger with higher expected dilution. This means we choose SMT or JQT-SecVtx when they are combined with SST; and SST when it is combined with JQT-High P_t.

III. TAGGED FLAVOR ASYMMETRY

With the B sample, tagging algorithms and sample composition in hand we can tag the events and form the flavor asymmetry, which we can fit to extract Δm_d. A few things must be modified with respect to the fit used in Reference [1].

To handle the observed asymmetries we split the B^0 and B^+ decays into those with and without a $\pi^{\pm}_{**}$, and define $\mathcal{F}_k^{0,+,**}$ as the fraction of decay signature k in which a $\pi^{\pm}_{**}$ was produced. Only a fraction ξ of $\pi^{\pm}_{**}$ tracks is selected as tags, and we split the B^0 components into $\mathcal{F}_k^0 - \xi\mathcal{F}_k^{0,**}$ and $\xi\mathcal{F}_k^{0,**}$, and similarly for B^+ mesons. Then, the prediction for the measured asymmetry is given by:

$$\begin{aligned}\overline{\mathcal{A}}_{k[0]} &= \{\mathcal{F}_k^0 - \xi\mathcal{F}_k^{0,**}\}\mathcal{A}^0 + \xi\mathcal{F}_k^{0,**}\{\mathcal{A}^{0,**}\} \\ &+ \{\mathcal{F}_k^+ - \xi\mathcal{F}_k^{+,**}\}\{-\mathcal{A}^+\} + \xi\mathcal{F}_k^{+,**}\{\mathcal{A}^{+,**}\} \\ &+ \mathcal{F}_k^{Bck}\overline{\mathcal{A}}_k^{Bck},\end{aligned} \tag{1}$$

being $\mathcal{A}^0$, $\mathcal{A}^{0,**}$, $\mathcal{A}^+$ and $\mathcal{A}^{+,**}$ the expected asymmetries, in which the dilution terms computed in Section II are involved. $\mathcal{F}_k^{Bck}$ and $\mathcal{A}_k^{Bck}$ is the fraction and the asymmetry factor corresponding to physics backgrounds respectively.

All relevant effects for a mixing measurement using SST and OST are contained in Equation (1); it describes the observed asymmetry $\overline{\mathcal{A}}_{k[0]}$ given the true asymmetries $\mathcal{A}^{0,+}$, the $\pi^{\pm}_{**}$ tagging probability ξ, the sample composition fractions $\mathcal{F}$ and the backgrounds.

IV. FLAVOR ASYMMETRY FIT

We form a χ^2 function to simultaneously fit Δm_d and the five dilutions over all ct-bins of all decay signatures by comparing the predictions $\overline{\mathcal{A}}_k(ct_k)$ calculated via Eq. (1) against the measured asymmetries $\mathcal{A}_k^{(meas)}(ct_k)$, where ct_k is used for $\mathcal{A}_k^{(meas)}$ since we were restricted to the direct chain ct_k when binning the data. The $\overline{\mathcal{A}}_k(ct_k)$ asymmetry depends not only upon the parameters Δm_d and dilutions, which are of direct interest, but also on τ_0, τ_+/τ_0, f^{**}, P_V, $\epsilon(\pi_*)$, and ξ_{norm} through the $\mathcal{F}^{0,+}$ fraction. This is explained in detail in [1].

The χ^2 function is minimized over ten ct bins for all three decay signatures and ten tagged subsamples simultaneously, letting the unknown parameters float freely, and the known inputs to vary within their errors. The asymmetry on data and fit results are shown in Figures 1 to 10, and listed in Table I.

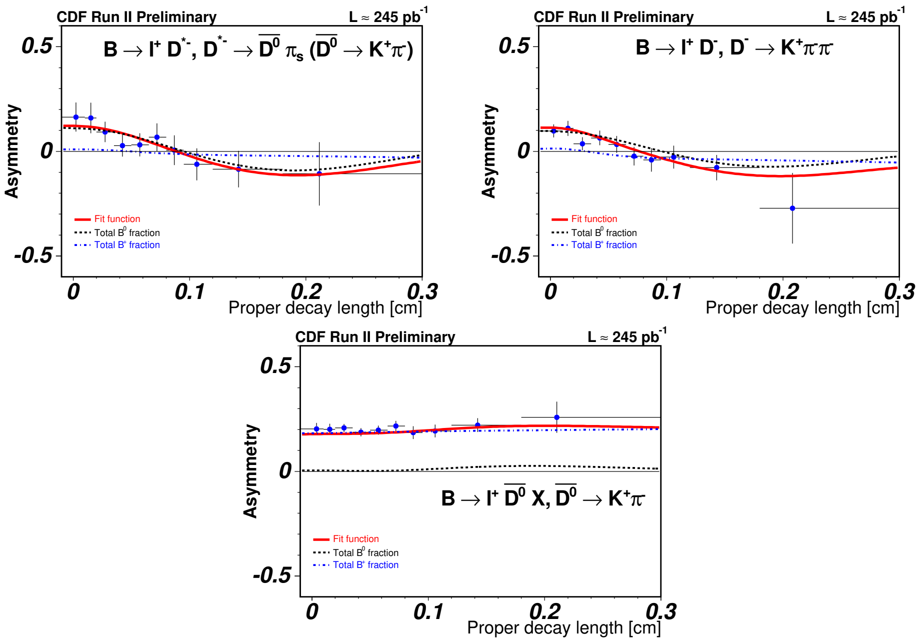

FIG. 1: Plots of the measured asymmetries with the fit results superimposed when candidates are tagged only with SST. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

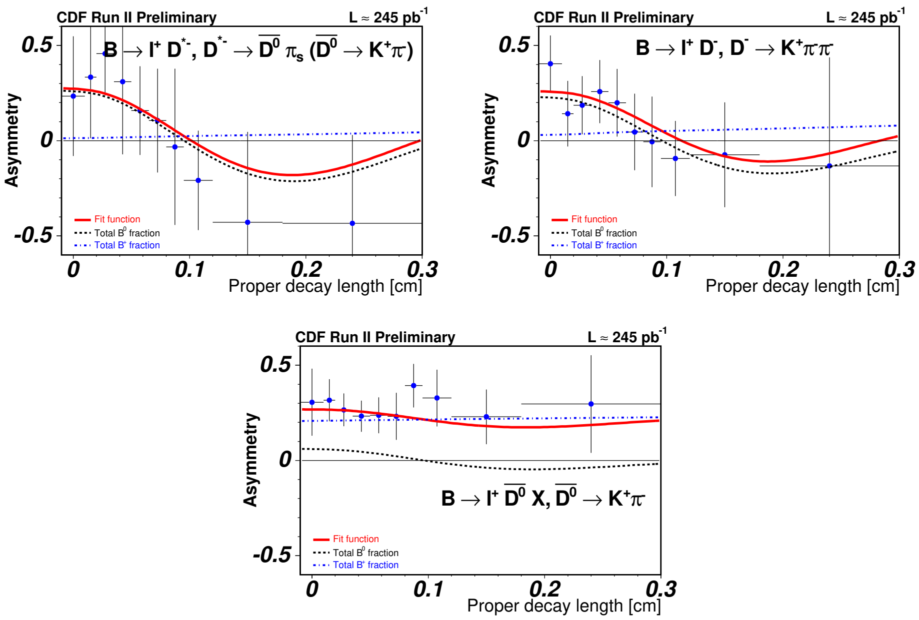

FIG. 2: Plots of the measured asymmetries with the fit results superimposed when candidates are tagged only with SMT. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

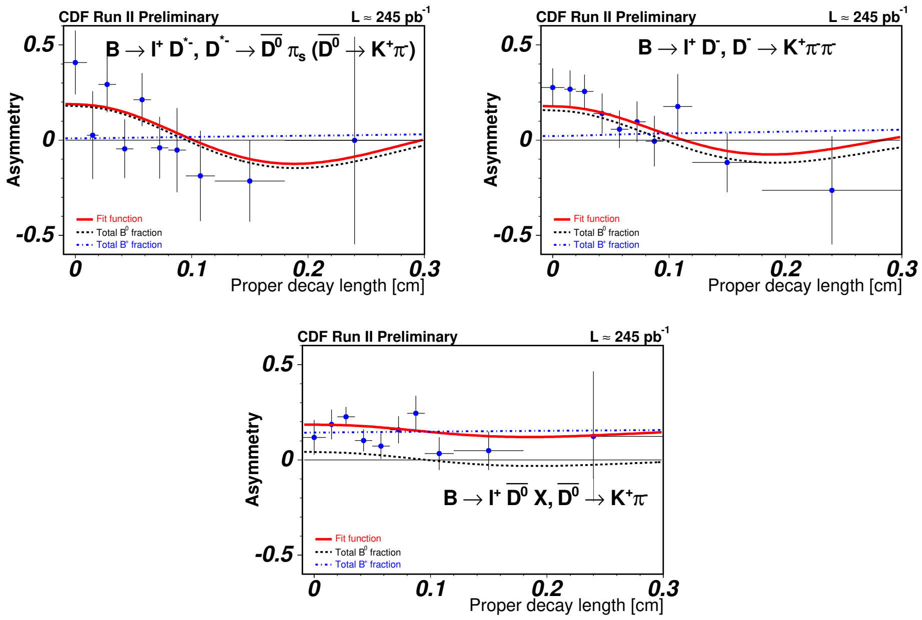

FIG. 3: Plots of the measured asymmetries with the fit results superimposed when candidates are tagged only with JQT-SecVtx. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

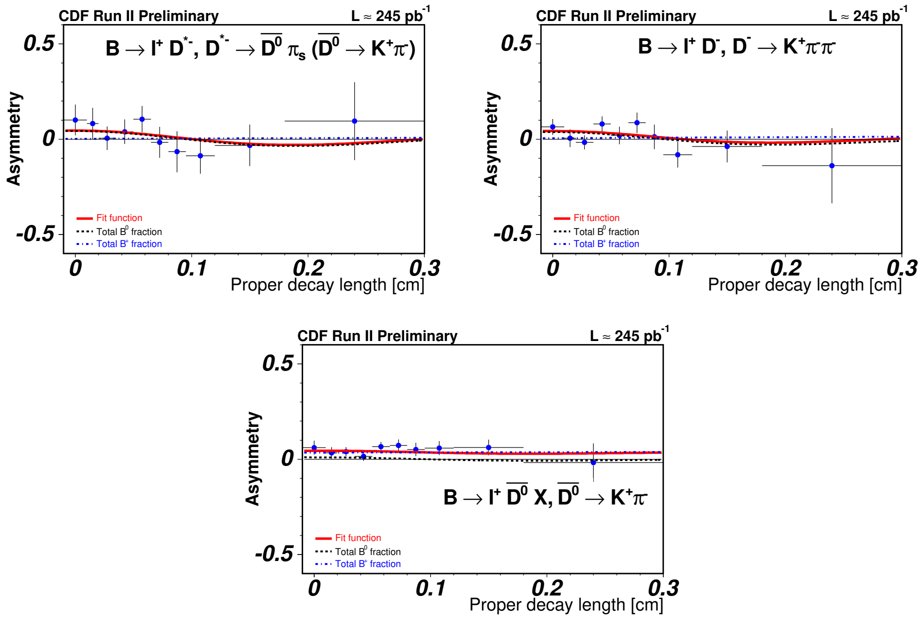

FIG. 4: Plots of the measured asymmetries with the fit results superimposed when candidates are tagged only with JQT–High P_t. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

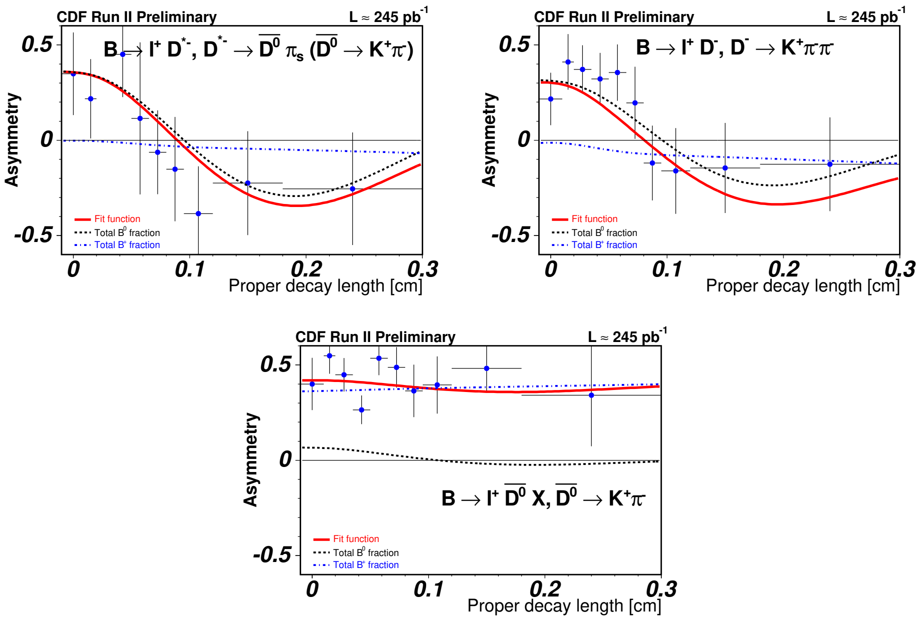

FIG. 5: Plots of the measured asymmetries with the fit results superimposed when candidates are tagged with both SST and SMT, and the tagging decisions agree. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

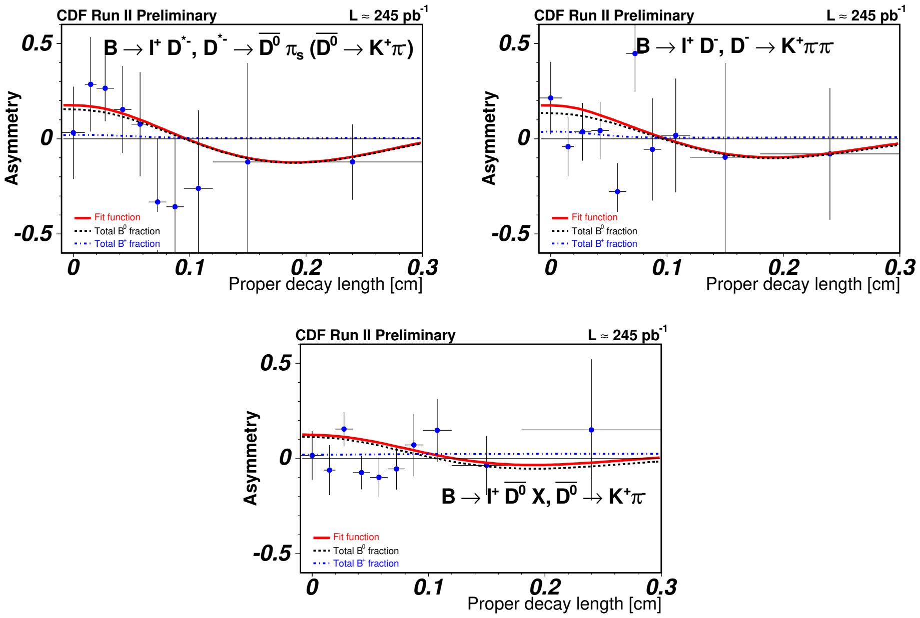

FIG. 6: Plots of the measured asymmetries with the fit results superimposed when candidates are tagged with both SST and SMT, and the tagging decisions disagree. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

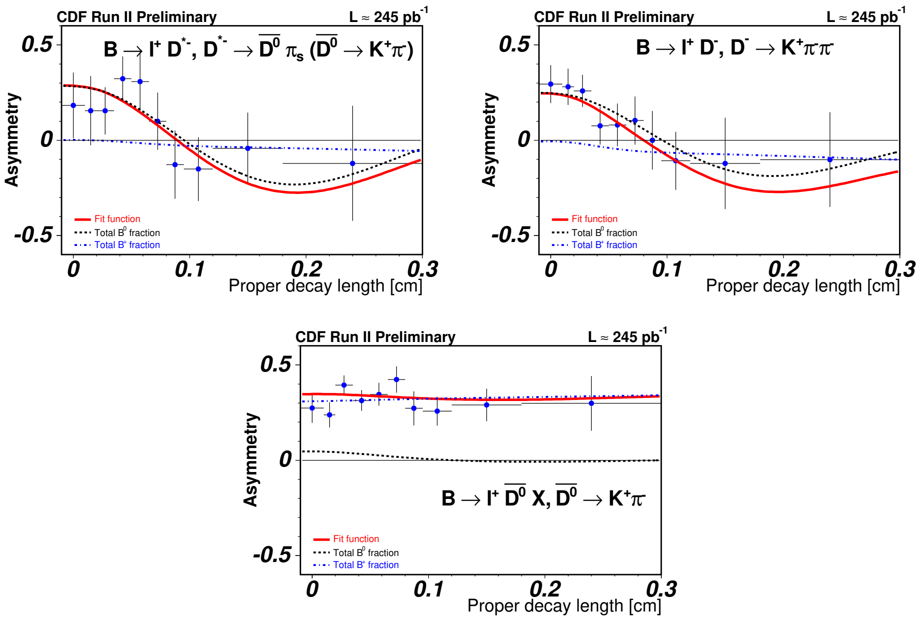

FIG. 7: Plots of the measured asymmetries with the fit results superimposed when candidates are tagged with both SST and JQT-SecVtx, and the tagging decisions agree. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

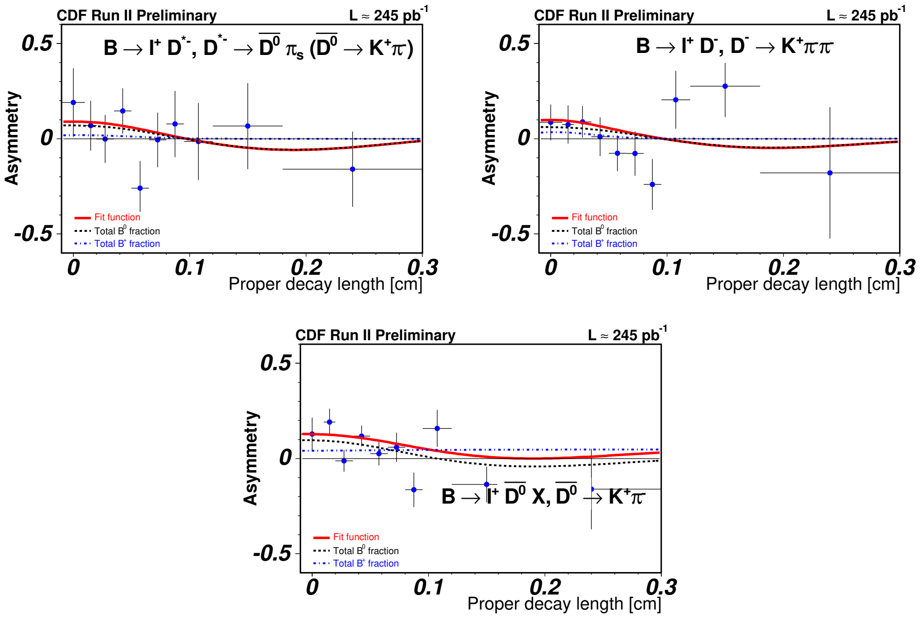

FIG. 8: Plots of the measured asymmetries with the fit results superimposed when candidates are tagged with both SST and JQT-SecVtx, and the tagging decisions disagree. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

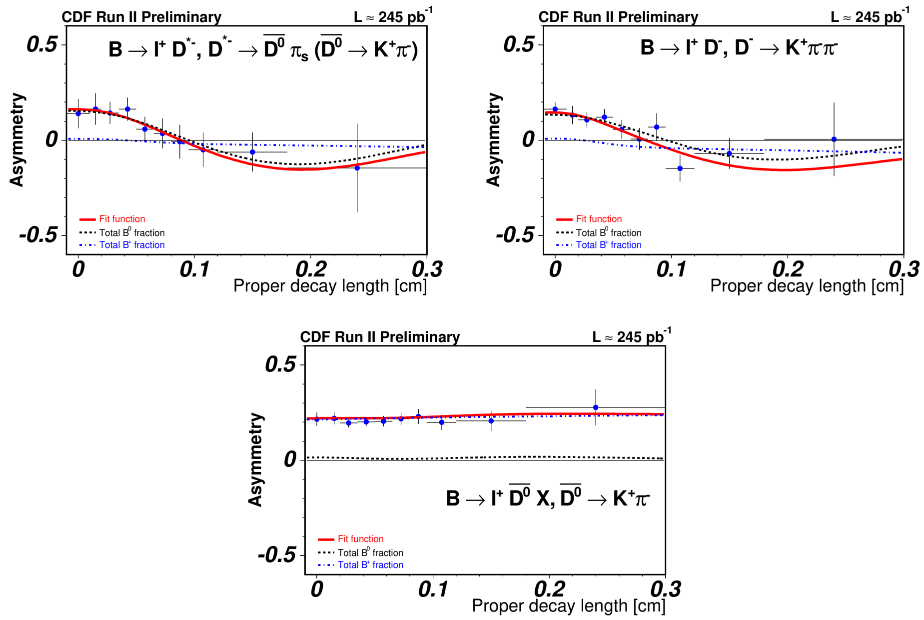

FIG. 9: Plots of the measured asymmetries with the fit results superimposed when candidates are tagged with both SST and JQT-High P_t, and the tagging decisions agree. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

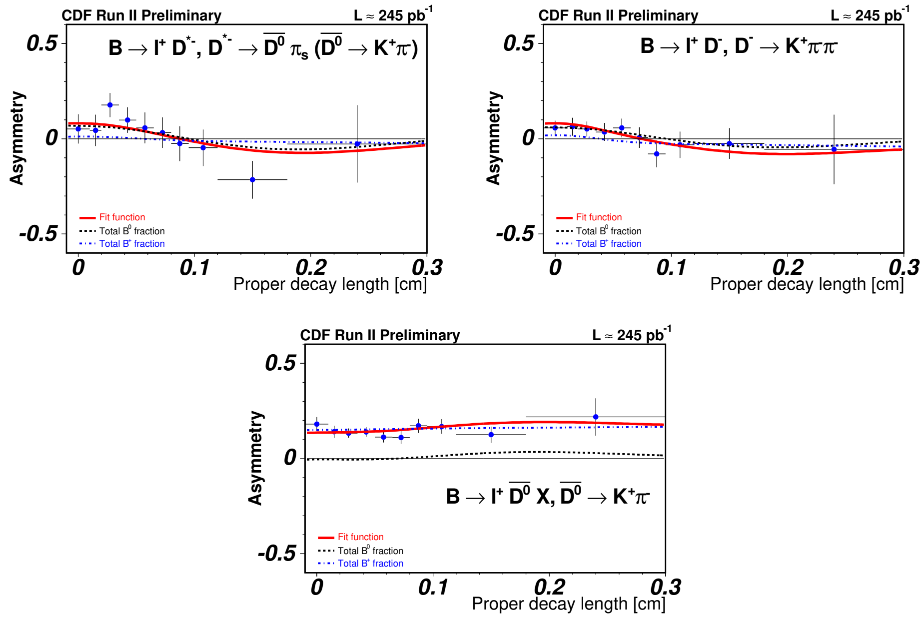

FIG. 10: Plots of the measured asymmetries with the fit results superimposed when candidates are tagged with both SST and JQT-High P_t, and the tagging decisions disagree. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

Parameter Name	Init. Value	Constraint Error	Final Value
Δm_d			0.5364 ± 0.0382
D_0			0.1245 ± 0.0146
D_+			0.2607 ± 0.0099
D_{smt}			0.2913 ± 0.0226
D_{jqtsvx}			0.2011 ± 0.0157
D_{highpt}			0.0485 ± 0.0065
R_f	2.1800	0.1400	2.1319 ± 0.1414
f^{**}	0.3100	0.0500	0.2609 ± 0.0341
P_V			0.3963 ± 0.1721
$\epsilon(\pi_*)$			0.5227 ± 0.0323
ξ_{norm}			1.3716 ± 0.2554
τ_0	0.0461	0.0004	0.0461 ± 0.0004
τ_+/τ_0	1.0860	0.0170	1.0829 ± 0.0168

TABLE I: Results of the full χ^2 fit along with the initial values. Parameters which are constrained in the χ^2 fit to their initial value also have an "error" by which they are constrained.

The Δm_d value is in good agreement with the PDG, but of course with poorer precision, $\Delta m_d = 0.532 \pm 0.038\ ps^{-1}$. The SST dilutions are $(12.5 \pm 1.5)\%$ and $(26.1 \pm 1.0)\%$ for the neutral and charged mesons respectively, while the OST dilutions are $(29.1 \pm 2.3)\%$ for SMT, $(20.1 \pm 1.6)\%$ for JQT-SecVtx and $(4.9 \pm 0.7)\%$ for JQT-High P_T. We get a value of $\epsilon(\pi_*) = (52.3 \pm 3.2)\%$, which agrees well with the expected value from Monte Carlo, 55%. In addition the normalization factor ξ_{norm} is close to one, which means the Monte Carlo describes rather well the data. The efficiencies, dilutions and ϵD^2 for each tagger, together with the combined Opposite Side Tagging performance, are shown in Table II.

Channel	$\epsilon(\%)$	$D(\%)$	$\epsilon D^2(\%)$
D_{SST} (B^+)	67.3 ± 0.10	26.41 ± 1.03	4.69 ± 0.37
D_{SST} (B^0)	67.3 ± 0.10	12.45 ± 1.46	1.04 ± 0.24
SMT	3.70 ± 0.07	29.13 ± 2.26	0.32 ± 0.05
JQT-SecVtx	9.31 ± 0.11	20.11 ± 1.57	0.38 ± 0.06
JQT-High P_t	47.96 ± 0.19	4.85 ± 0.65	0.11 ± 0.03
OST	60.97 ± 0.23	—	0.81 ± 0.08

TABLE II: Efficiencies, dilutions and ϵD^2 for each tagger. The last row shows the combined Opposite Side Tagging performance. The combination of the statistical and sample composition uncertainty is also quoted.

We have also performed the fit using only the Opposite Side Taggers. The results are listed in Table III. The asymmetry on data and fit results are shown in Figures 11 to 13.

The combined tagging performance in our sample can be computed by taking into account the dilution values obtained from the fit, the different 10 subsamples and the formulas given in Section II. The efficiencies, dilutions and ϵD^2 for each channel for B^0 decays are shown in Table IV. The combined ϵD^2 is $(1.820 \pm 0.114$ (stat.+s.c.))%.

V. SYSTEMATICS UNCERTAINTIES

Separation of systematic and statistical errors in the B^0 mixing measurement is performed for semileptonic B decays using the method explained in Reference [1]. This method takes into account the full correlations in the separation. In case the information contained in the data and the constraints are orthogonal a simple quadratic subtraction of the full fit and the fit repeated with fixed constraint

Parameter Name	Init. Value	Constraint Error	Final Value
Δm_d			0.5927 $\pm$ 0.0534
D_{smt}			0.2806 $\pm$ 0.0230
D_{jqtsvx}			0.1943 $\pm$ 0.0141
D_{highpt}			0.0618 $\pm$ 0.0063
R_f	2.1800	0.1400	2.1498 $\pm$ 0.1409
f^{**}	0.3100	0.0500	0.3026 $\pm$ 0.0335
P_V			0.3435 $\pm$ 0.1624
$\epsilon(\pi_*)$			0.5360 $\pm$ 0.0362
τ_0	0.0461	0.0004	0.0461 $\pm$ 0.0004
τ_+/τ_0	1.0860	0.0170	1.0849 $\pm$ 0.0168

TABLE III: Results of the χ^2 fit when only the Opposite Side Taggers are used.

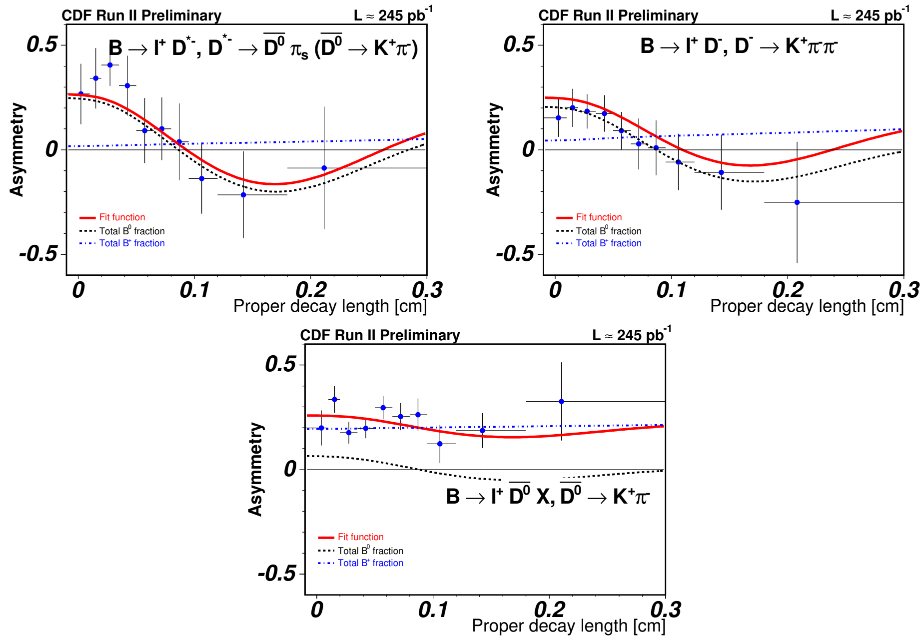

FIG. 11: Plots of the measured asymmetries with the fit results superimposed for the SMT, when only the Opposite Side Taggers are used. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

values will give identical results. For the case at hand the data do contain some information about the sample composition and therefore we apply the full procedure.

The systematic and statistical covariance matrices are here represented as the uncertainties and their correlations in Tables V and VI. The sample composition error gives rise to the largest systematic uncertainty.

Other systematic uncertainties on the extracted dilutions and oscillation frequency derive from several sources, and they were explained in detail Reference [1].

Systematic uncertainties from all sources are listed in Table VII. One of the biggest contributions comes from the uncertainties on the sample composition parameters. Nevertheless that contribution has been reduced a lot with respect to [1] due to the introduction of the Opposite Side Taggers, where there is not $\pi^{\pm}_{**}$ pollution, and it is possible to improve the sample composition knowledge.

The combined systematic uncertainty is still smaller than the statistical error in the case of Δm_d,

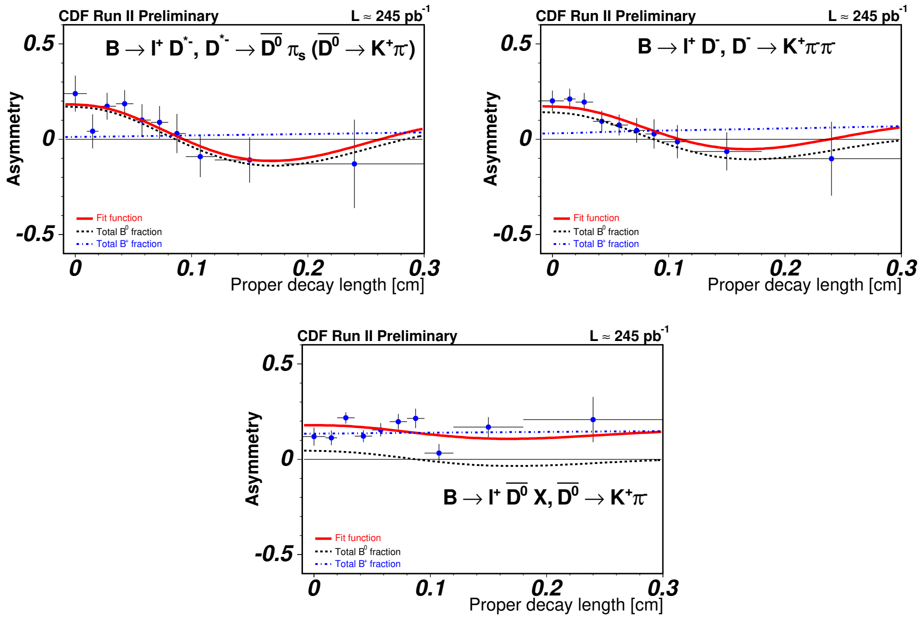

FIG. 12: Plots of the measured asymmetries with the fit results superimposed for the JQTSecVtx, when only the Opposite Side Taggers are used. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

Channel	$\epsilon(\%)$	$D(\%)$	$\epsilon D^2(\%)$
Only SST	25.89 ± 0.17	12.45 ± 1.46	0.401 ± 0.028
Only SMT	1.17 ± 0.04	29.13 ± 2.26	0.099 ± 0.016
SST and SMT (agree)	1.34 ± 0.04	40.12 ± 2.42	0.216 ± 0.027
SST and SMT (disagree)	1.22 ± 0.04	17.31 ± 2.79	0.037 ± 0.012
Only JQT-SecVtx	2.73 ± 0.06	20.11 ± 1.57	0.110 ± 0.017
SST and JQT-SecVtx (agree)	3.38 ± 0.07	31.76 ± 1.99	0.341 ± 0.043
SST and JQT-SecVtx (disagree)	3.19 ± 0.07	7.86 ± 2.19	0.020 ± 0.010
Only JQT-High P_t	16.13 ± 0.14	4.85 ± 0.65	0.038 ± 0.010
SST and JQT-High P_t (agree)	15.70 ± 0.14	17.20 ± 1.57	0.464 ± 0.084
SST and JQT-High P_t (disagree)	16.08 ± 0.14	7.65 ± 1.61	0.094 ± 0.040
Total	86.86 ± 0.33	—	1.820 ± 0.114

TABLE IV: Efficiencies, D and ϵD^2 for each channel for B^0 decays. The combination of the statistical and sample composition uncertainty is also quoted.

and both contributions are comparable in the case of the dilution measurements.

In addition we have also computed the systematic uncertainties for the analysis when only the Opposite Side Taggers are used. Systematic uncertainties from all sources are listed in Table VIII.

VI. SUMMARY

We have reconstructed $B \to \ell D^{(*)}$ candidates from almost 245 pb^{-1} of Run II data, and flavor tagged the events with the combination of three flavor taggers. We observe the time-dependent flavor

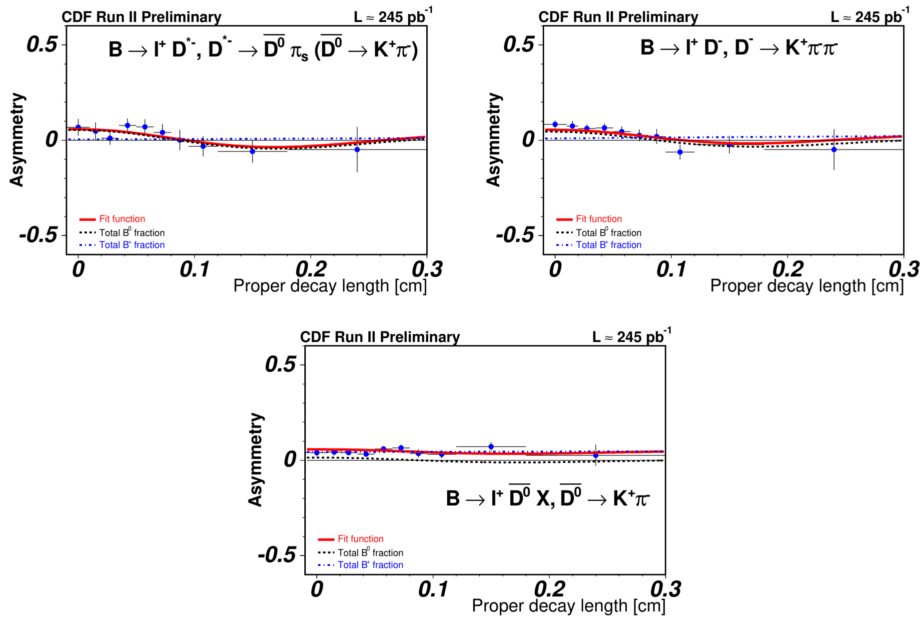

FIG. 13: Plots of the measured asymmetries with the fit results superimposed for the JQT-High P_t, when only the Opposite Side Taggers are used. The separate contributions of B^0 (black color) and B^+ (blue color) decays to each signature are also shown.

σ	Δm_d	D_0	D_+	D_{jqtsvx}	D_{smt}	R_f	f^{**}	P_V	ϵ	ξ	τ_0	τ_+/τ_0	D_{jqtpt}
0.00915	1.00	-0.99	-0.78	-0.89	-0.43	-0.00	-0.99	-0.81	-0.22	0.99	-0.04	-0.06	-0.77
0.00415	-0.99	1.00	0.77	0.90	0.43	-0.11	1.00	0.75	0.25	-1.00	0.01	-0.05	0.79
0.00355	-0.78	0.77	1.00	0.97	0.89	0.42	0.80	0.93	-0.41	-0.75	0.01	-0.42	0.98
0.00216	-0.89	0.90	0.97	1.00	0.78	0.19	0.91	0.88	-0.18	-0.88	0.01	-0.38	0.98
0.00083	-0.43	0.43	0.89	0.78	1.00	0.57	0.46	0.76	-0.75	-0.39	0.02	-0.68	0.88
0.14284	-0.00	-0.11	0.42	0.19	0.57	1.00	-0.06	0.57	-0.82	0.12	-0.00	-0.01	0.26
0.02329	-0.99	1.00	0.80	0.91	0.46	-0.06	1.00	0.79	0.21	-1.00	0.01	-0.05	0.81
0.01843	-0.81	0.75	0.93	0.88	0.76	0.57	0.79	1.00	-0.35	-0.74	-0.01	-0.08	0.84
0.00898	-0.22	0.25	-0.41	-0.18	-0.75	-0.82	0.21	-0.35	1.00	-0.28	0.01	0.55	-0.35
0.09946	0.99	-1.00	-0.75	-0.88	-0.39	0.12	-1.00	-0.74	-0.28	1.00	-0.01	0.00	-0.77
0.00036	-0.04	0.01	0.01	0.01	0.02	-0.00	0.01	-0.01	0.01	-0.01	1.00	0.00	0.03
0.01661	-0.06	-0.05	-0.42	-0.38	-0.68	-0.01	-0.05	-0.08	0.55	0.00	0.00	1.00	-0.54
0.00022	-0.77	0.79	0.98	0.98	0.88	0.26	0.81	0.84	-0.35	-0.77	0.03	-0.54	1.00

TABLE V: Systematic uncertainties, first column, and the corresponding correlations.

oscillation for the B^0, and measure the oscillation frequency to be

$$\Delta m_d = (0.536 \pm 0.037\ (stat.) \pm 0.009\ (s.c.) \pm 0.015\ (syst.))ps^{-1},$$

and the tagging dilutions are

$$\begin{aligned}
D_{SST}\ (B^0) &= (12.5 \pm 1.4\ (stat.) \pm 1.0\ (syst.))\%, \\
D_{SST}\ (B^+) &= (26.1 \pm 0.9\ (stat.) \pm 1.0\ (syst.))\%, \\
D_{SMT} &= (29.1 \pm 2.3\ (stat.) \pm 1.3\ (syst.))\%, \\
D_{JQT-SecVtx} &= (20.1 \pm 1.6\ (stat.) \pm 2.6\ (syst.))\%, \\
D_{JQT-High\ P_T} &= (4.9 \pm 0.7\ (stat.) \pm 0.5\ (syst.))\%.
\end{aligned}$$

σ	Δm_d	D_0	D_+	D_{jqtsvx}	D_{smt}	R_f	f^{**}	P_V	ϵ	ξ	τ_0	τ_+/τ_0	D_{jqtpt}
0.03709	1.00	-0.09	-0.27	0.05	0.13	0.00	-0.26	0.06	-0.06	0.28	-0.00	-0.03	0.06
0.01400	-0.09	1.00	0.29	0.14	0.02	0.00	0.32	-0.34	0.27	-0.59	-0.00	0.03	-0.00
0.00924	-0.27	0.29	1.00	0.09	0.03	0.00	0.33	0.26	-0.33	-0.25	0.00	0.02	0.03
0.01555	0.05	0.14	0.09	1.00	0.02	0.00	0.14	-0.00	-0.03	-0.12	0.00	0.01	0.01
0.02258	0.13	0.02	0.03	0.02	1.00	0.00	0.02	0.03	-0.04	-0.01	0.00	-0.00	0.01
0.00000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02491	-0.26	0.32	0.33	0.14	0.02	0.00	1.00	0.10	0.06	-0.45	-0.00	0.10	0.03
0.17111	0.06	-0.34	0.26	-0.00	0.03	0.00	0.10	1.00	-0.61	0.48	-0.00	0.01	0.05
0.03103	-0.06	0.27	-0.33	-0.03	-0.04	0.00	0.06	-0.61	1.00	-0.39	0.00	0.02	-0.04
0.23524	0.28	-0.59	-0.25	-0.12	-0.01	0.00	-0.45	0.48	-0.39	1.00	-0.00	-0.05	0.03
0.00018	-0.00	-0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	0.00	-0.00	1.00	-0.01	0.00
0.00255	-0.03	0.03	0.02	0.01	-0.00	0.00	0.10	0.01	0.02	-0.05	-0.01	1.00	0.00
0.00650	0.06	-0.00	0.03	0.01	0.01	0.00	0.03	0.05	-0.04	0.03	0.00	0.00	1.00

TABLE VI: Statistical uncertainties, first column, and the corresponding correlations.

Therefore, the tagging effectiveness are

$$\begin{aligned}
\epsilon_{SST} D^2_{SST}\ (B^0) &= (1.04 \pm 0.15\ (stat.) \pm 0.17\ (syst.))\%, \\
\epsilon_{SST} D^2_{SST}\ (B^+) &= (4.69 \pm 0.49\ (stat.) \pm 0.36\ (syst.))\%, \\
\epsilon_{SMT} D^2_{SMT} &= (0.32 \pm 0.05\ (stat.) \pm 0.03\ (syst.))\%, \\
\epsilon_{JQT-SecVtx} D^2_{JQT-SecVtx} &= (0.38 \pm 0.06\ (stat.) \pm 0.08\ (syst.))\%, \\
\epsilon_{JQT-High\ P_T} D^2_{JQT-High\ P_T} &= (0.11 \pm 0.06\ (stat.) \pm 0.05\ (syst.))\%.
\end{aligned}$$

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Error Source	Δm_d (ps^{-1})	D_0 (%)	D_+ (%)	D_{jqtsvx} (%)	D_{smt} (%)	D_{jqtpt} (%)
Statistical	0.0371	1.40	0.92	1.56	2.26	0.65
Sample composition	0.0092	0.42	0.36	0.22	0.08	0.02
b-quark model	0.0048	0.22	0.43	1.30	0.89	0.35
B decay model	0.0076	0.31	0.12	0.57	0.71	0.23
L_{xy} resolution	0.0023	0.01	0.01	0.01	0.02	0.01
$R^{*/**}$ measurements	0.0031	0.15	0.21	0.34	0.26	0.17
$\xi_{MC}(ct)$ shape	0.0041	0.26	0.22	0.01	0.02	0.02
Fitting mass	0.0034	0.13	0.10	0.34	0.26	0.04
$B \to DX$ background	0.0027	0.33	0.72	0.11	0.22	0.13
$c\bar{c}$ gluon splitting	0.0084	0.71	0.13	1.34	0.43	0.09
B Lifetime	0.0041	0.04	0.06	0.03	0.05	0.01
Total, except stat. and s.c.	0.0148	0.93	0.92	2.01	1.28	0.48
Total, except stat.	0.0174	1.02	0.99	2.03	1.29	0.49
Total	0.0410	1.73	1.35	2.55	2.60	0.81

TABLE VII: Table of statistical and systematic uncertainties for the full analysis.

ropean Community's Human Potential Programme under contract HPRN-CT-20002, Probe for New Physics.

[1] G. Bauer *et al.*, *Measurement of B0 Oscillations Using Same-Side Tagging in Semileptonic B Decays*, CDF7081.
[2] F. Abe, et al., Nucl. Instrum. Methods Phys. Res. A **271**, 387 (1988); D. Amidei, et al., Nucl. Instum. Methods Phys. Res. A **350**, 73 (1994); F. Abe, et al., Phys. Rev. D **52**, 4784 (1995); P. Azzi, et al., Nucl. Instrum. Methods Phys. Res. A **360**, 137 (1995); The CDFII Detector Technical Design Report, Fermilab-Pub-96/390-E.
[3] CDF public web pages.
[4] p_T^{rel} is the momentum component of the tagging candidate transverse to the combined momentum of the B meson plus the track momentum
[5] Q_{jet} is a weighted average of the charge of the jet; the proper definition can be found in [3].

Error Source	Δm_d (ps^{-1})	D_{jqtsvx} (%)	D_{smt} (%)	D_{jqtpt} (%)
Statistical	0.0530	1.40	2.29	0.63
Sample composition	0.0066	0.13	0.18	0.04
b-quark model	0.0042	0.93	0.68	0.20
B decay model	0.0065	0.30	0.69	0.17
L_{xy} resolution	0.0027	0.01	0.02	0.01
$R^{*/**}$ measurements	0.0019	0.12	0.15	0.09
Fitting mass	0.0039	0.41	0.24	0.11
$B \to DX$ background	0.0011	0.09	0.20	0.10
$c\bar{c}$ gluon splitting	0.0075	1.30	0.49	0.15
B Lifetime	0.0080	0.01	0.01	0.01
Total, except stat. and s.c.	0.0144	1.68	1.14	0.35
Total, except stat.	0.0158	1.69	1.15	0.36
Total	0.0553	2.19	2.56	0.72

TABLE VIII: Table of statistical and systematic uncertainties for the Opposite Side Tagging analysis.