

Global Fit for Branching Fractions and Form Factor Slope of $B \rightarrow D^{(*)} \ell \nu$ Decays

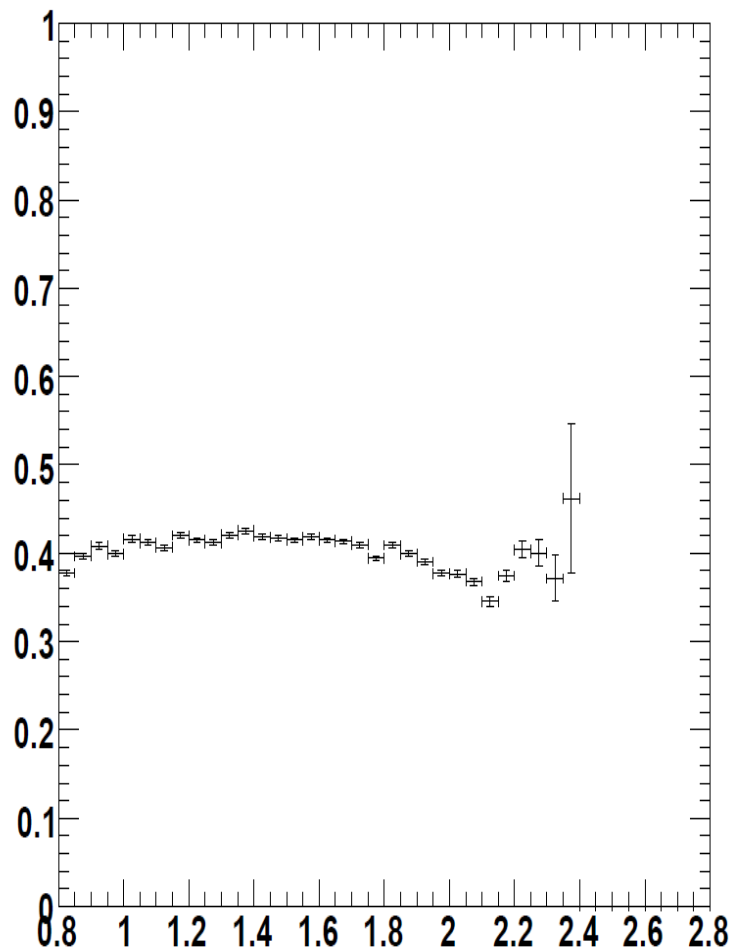
- Effect of $D \pi \pi \ell \nu$

Effect of $B \rightarrow D^{(*)} \pi \pi / \nu$ - method

- We generate 4 different types of decays :
 - $B \rightarrow X / \nu$, $B \rightarrow X^* / \nu$, $B \rightarrow Y / \nu$, $B \rightarrow Y^* / \nu$
 - X and Y are pseudo-scalar and X^* and Y^* are vector particles.
This affects lepton spectrum.
 - X and X^*
 - Mass = 2.61 GeV (just above $D^* \pi \pi$ threshold)
 - Width = 300 MeV, Decays to $D^{(*)} \pi \pi$
 - Y and Y^*
 - Mass = 2.87 GeV (just above $D^* \rho$ threshold)
 - Width = 100 MeV, Decays to $D^{(*)} \rho (\pi \pi)$
 - 3-body decay (X, X^*) and 2-body decay (Y, Y^*) affects D momentum spectrum.
- The numbers shown are for sum of the 4 modes in the case where each mode has the same BF.
- We use 3D efficiency matrix to convert generated histograms to reconstructed one.

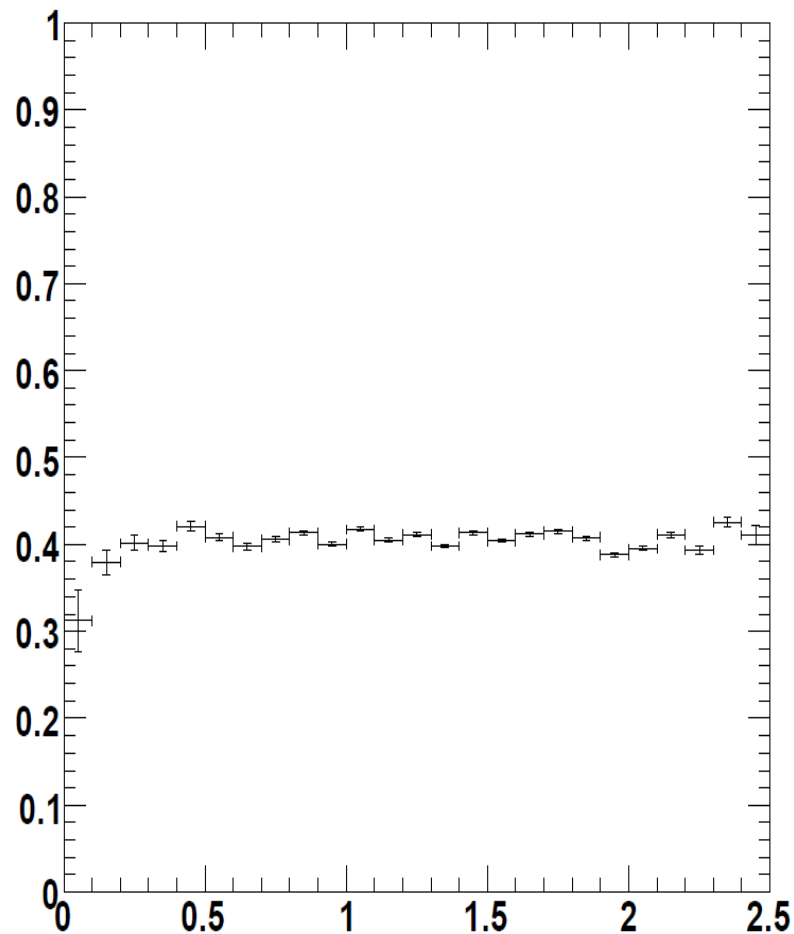
3D Efficiency matrix - projections

Lepton momentum



D momentum

BpBm -> D0



3D Efficiency matrix – all bins

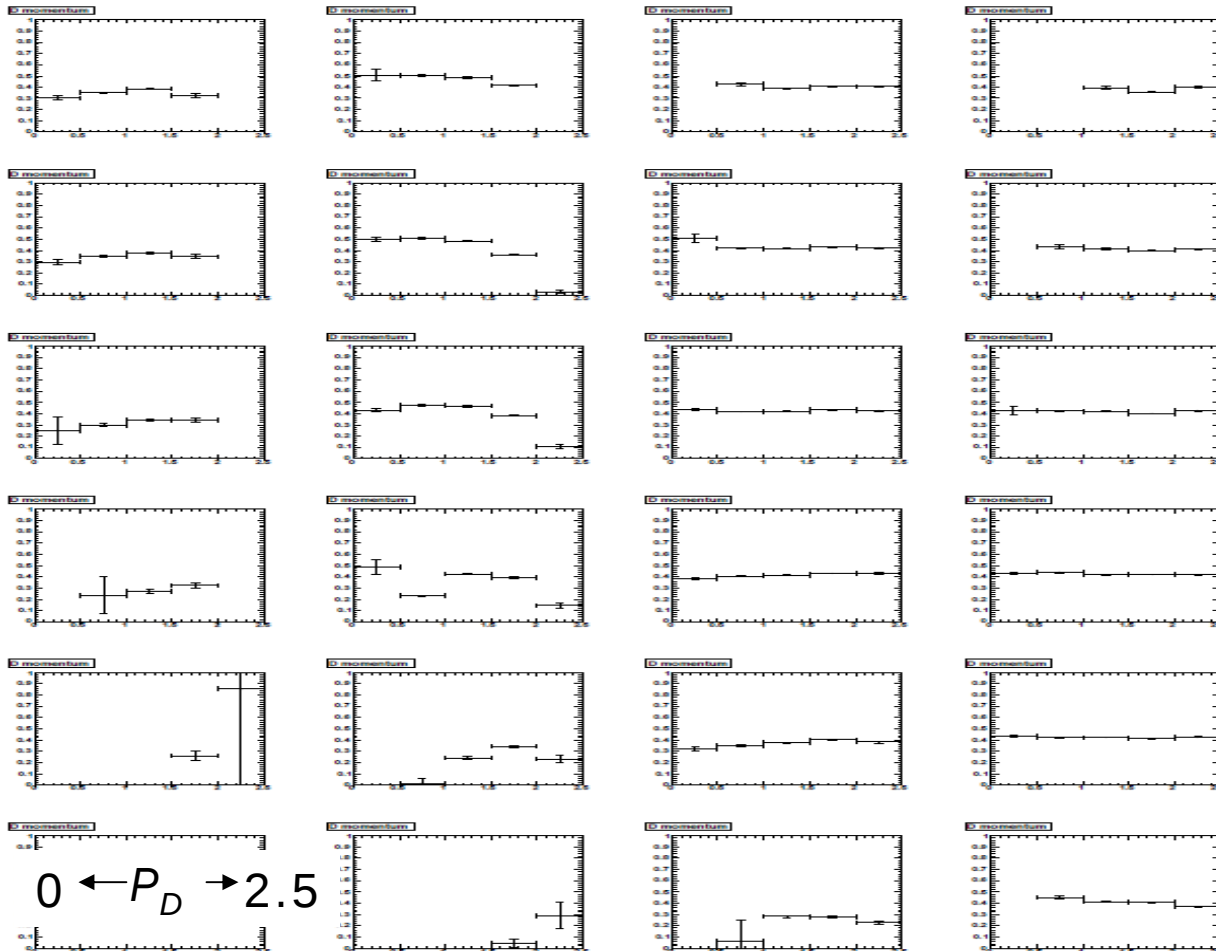
BpBm -> D0

-20 ← cosBY → +2

0.8 GeV

P_{lep}

2.3 GeV



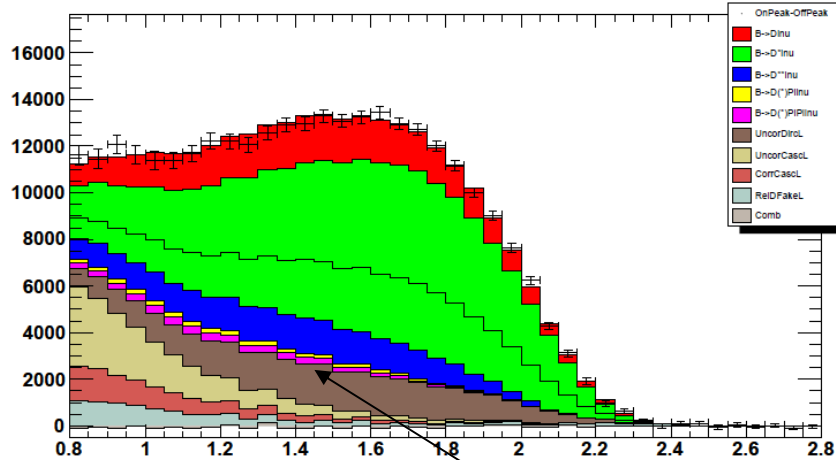
Effect of $B \rightarrow D^{(*)} \pi \pi / \nu$ - fit result

Parameters	Fit results	Nominal fit
ρ_D^2	1.331 ± 0.068	1.346 ± 0.067
ρ^2	1.373 ± 0.075	1.353 ± 0.076
R_1	1.418 ± 0.075	1.405 ± 0.109
R_2	0.632 ± 0.107	0.668 ± 0.099
$\mathcal{B}(B^+ \rightarrow \bar{D}^0 \ell^+ \nu)$	0.02511 ± 0.00063	0.02525 ± 0.00063
$\mathcal{B}(B^+ \rightarrow \bar{D}^{*0} \ell^+ \nu)$	0.05434 ± 0.00099	0.05291 ± 0.00083
$\mathcal{BT}(B^+ \rightarrow \bar{D}^{**0} / (D\pi)^0 \ell^+ \nu)$	0.01693 ± 0.00136	0.01961 ± 0.00090
$\mathcal{BT}(B^+ \rightarrow \bar{D}^{(*)} \pi \pi \ell^+ \nu)$	0.00487 ± 0.00189	n/a
f_{+0}	1.061 ± 0.030	1.080 ± 0.030
$C_{U_{ncor}DL}^{D^0}$	0.932 ± 0.052	0.968 ± 0.050
$C_{U_{ncor}CL}^{D^0}$	0.874 ± 0.063	0.859 ± 0.064
$C_{CascL}^{D^0}$	0.671 ± 0.098	0.762 ± 0.092
$C_{U_{ncor}DL}^{D^+}$	1.053 ± 0.126	1.092 ± 0.126
$C_{U_{ncor}CL}^{D^+}$	0.838 ± 0.135	0.815 ± 0.136
$C_{CascL}^{D^+}$	1.168 ± 0.234	1.377 ± 0.222
χ^2/ndof (P-value)	234/217 (0.20)	240/217 (0.13)
B^+ BF sum	0.1013 ± 0.0026	0.0978 ± 0.0014

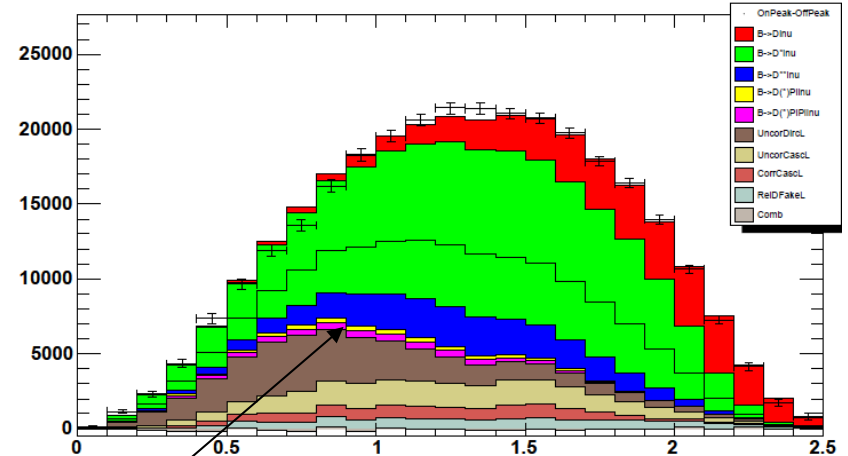
$B \rightarrow D \pi \pi / \nu$ eats
 $B \rightarrow D^{**}/D^{(*)} \pi / \nu$
 and
 Cascade background

Effect of $B \rightarrow D \pi \pi / \nu$ (plots 1)

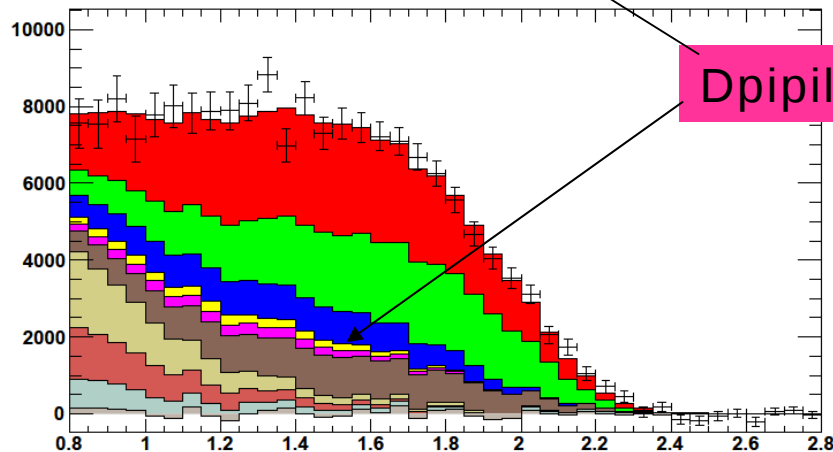
Lepton momentum (D0)



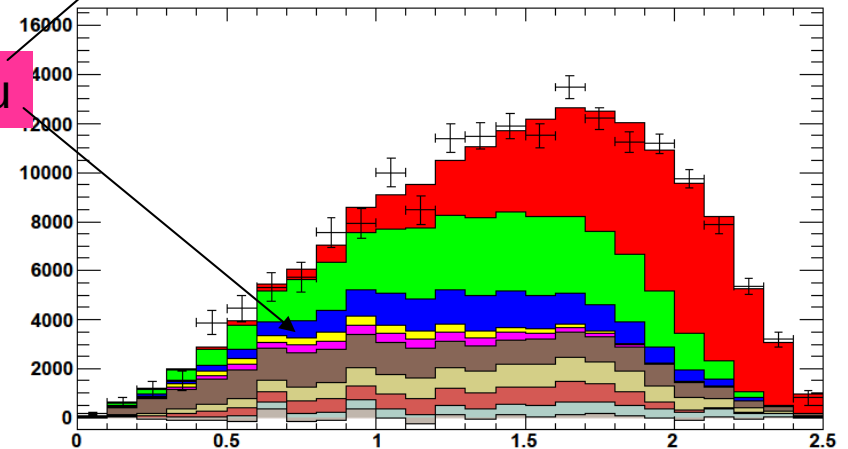
D momentum (D0)



Lepton momentum (D+)

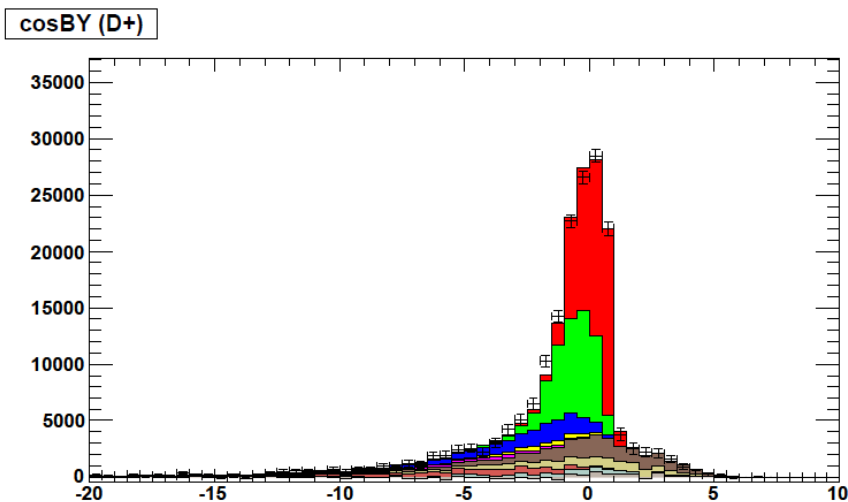
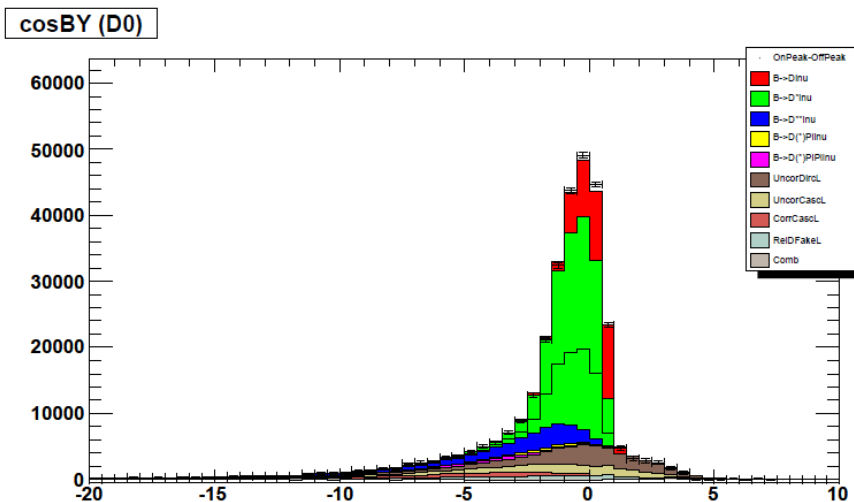


D momentum (D+)



Dpipilnu

Effect of $B \rightarrow D \pi \pi / \nu$ (plots 2)



Summed BF (%)

	BAD1889	Our result (stat err only) Nominal / Dpipi included
$\text{BF}(B^{+-} \rightarrow D \ell \nu)$	2.33 ± 0.13	2.53 ± 0.06 / 2.51 ± 0.06
$\text{BF}(B^{+-} \rightarrow D^* \ell \nu)$	5.83 ± 0.34	5.29 ± 0.08 / 5.43 ± 0.10
$\text{BF}(B^{+-} \rightarrow D \pi \ell \nu)$ $\text{BF}(B^{+-} \rightarrow D^* \pi \ell \nu)$ $\text{BF}(B^{+-} \rightarrow D^{(*)} \pi^0 \ell \nu)$	0.42 ± 0.07 0.59 ± 0.06 $0.505 ?$	1.96 ± 0.09 / 1.69 ± 0.14
Sum	9.675 ± 0.38	9.78 ± 0.13 / 9.63 ± 0.18
$\text{BF}(B^{+-} \rightarrow D \pi \pi \ell \nu)$		/ 0.49 ± 0.19
Sum		/ 10.12 ± 0.26

Effect of $B \rightarrow D^{(*)} \pi \pi / \nu$ - comparison

Use one decay mode only for comparison. No big difference. $D_1 \rightarrow D^{(*)} \pi \pi$

Parameters	Xc	Xc*	Yc	Yc*	D_1
ρ_D^2	1.315 ± 0.071	1.338 ± 0.068	1.330 ± 0.069	1.342 ± 0.067	1.341 ± 0.068
ρ^2	1.392 ± 0.077	1.370 ± 0.076	1.368 ± 0.075	1.360 ± 0.075	1.368 ± 0.079
R_1	1.447 ± 0.113	1.421 ± 0.110	1.416 ± 0.108	1.403 ± 0.108	1.412 ± 0.111
R_2	0.608 ± 0.104	0.628 ± 0.102	0.639 ± 0.099	0.657 ± 0.098	0.645 ± 0.104
$\mathcal{B}(B^+ \rightarrow \bar{D}^0 \ell^+ \nu)$	0.02505 ± 0.00064	0.02517 ± 0.00063	0.02508 ± 0.00064	0.02519 ± 0.00063	0.02524 ± 0.00063
$\mathcal{B}(B^+ \rightarrow \bar{D}^{*0} \ell^+ \nu)$	0.05452 ± 0.00101	0.05444 ± 0.00104	0.05396 ± 0.00092	0.05366 ± 0.00093	0.05332 ± 0.00096
$\mathcal{B}\mathcal{T}(B^+ \rightarrow \bar{D}^{**}/D \pi \ell^+ \nu)$	0.01611 ± 0.00158	0.01595 ± 0.00178	0.01818 ± 0.00107	0.01844 ± 0.00111	0.01838 ± 0.00172
$\mathcal{B}\mathcal{T}(B^+ \rightarrow \bar{D}^{(*)} \pi \pi \ell^+ \nu)$	0.00614 ± 0.00229	0.00497 ± 0.00210	0.00409 ± 0.00165	0.00215 ± 0.00120	0.00138 ± 0.00165
f_{+0}	1.058 ± 0.030	1.061 ± 0.030	1.064 ± 0.030	1.070 ± 0.030	1.076 ± 0.030
$C_{UncorDL}^{D^0}$	0.957 ± 0.051	0.930 ± 0.053	0.945 ± 0.051	0.938 ± 0.053	0.966 ± 0.051
$C_{UncorCL}^{D^0}$	0.887 ± 0.064	0.860 ± 0.064	0.881 ± 0.064	0.863 ± 0.064	0.856 ± 0.064
$C_{CascL}^{D^0}$	0.617 ± 0.107	0.769 ± 0.092	0.607 ± 0.111	0.730 ± 0.094	0.779 ± 0.094
$C_{UncorDL}^{D^+}$	1.077 ± 0.125	1.045 ± 0.126	1.066 ± 0.126	1.063 ± 0.126	1.089 ± 0.126
$C_{UncorCL}^{D^+}$	0.850 ± 0.135	0.832 ± 0.135	0.838 ± 0.135	0.823 ± 0.135	0.820 ± 0.136
$C_{CascL}^{D^+}$	1.057 ± 0.249	1.309 ± 0.222	1.091 ± 0.248	1.299 ± 0.225	1.373 ± 0.221
χ^2/ndof (P-value)	234/217 (0.21)	235/217 (0.19)	235/217 (0.19)	238/217 (0.16)	240/216 (0.13)
B^+ BF sum	0.1018 ± 0.0030	0.1005 ± 0.0030	0.1013 ± 0.0026	0.0994 ± 0.0020	0.0983 ± 0.0026

Effect of $B \rightarrow D^{(*)} \pi \pi / \nu$ – Fix to 1.0%

Parameters	Fit results	Nominal fit
ρ_D^2	1.315 ± 0.070	1.346 ± 0.067
ρ^2	1.395 ± 0.074	1.353 ± 0.076
R_1	1.434 ± 0.108	1.405 ± 0.109
R_2	0.594 ± 0.100	0.668 ± 0.099
$\mathcal{B}(B^+ \rightarrow \bar{D}^0 \ell^+ \nu)$	0.02511 ± 0.00063	0.02497 ± 0.00063
$\mathcal{B}(B^+ \rightarrow \bar{D}^{*0} \ell^+ \nu)$	0.05434 ± 0.00099	0.05583 ± 0.00082
$\mathcal{BT}(B^+ \rightarrow \bar{D}^{*0} / (D\pi)^0 \ell^+ \nu)$	0.01409 ± 0.00090	0.01961 ± 0.00090
$\mathcal{BT}(B^+ \rightarrow \bar{D}^{(*)} \pi \pi \ell^+ \nu)$	0.01 (Fixed)	n/a
f_{+0}	1.043 ± 0.030	1.080 ± 0.030
$C_{UncorDL}^{D^0}$	0.895 ± 0.050	0.968 ± 0.050
$C_{UncorCL}^{D^0}$	0.888 ± 0.064	0.859 ± 0.064
$C_{CascL}^{D^0}$	0.577 ± 0.092	0.762 ± 0.092
$C_{UncorDL}^{D^+}$	1.014 ± 0.125	1.092 ± 0.126
$C_{UncorCL}^{D^+}$	0.861 ± 0.134	0.815 ± 0.136
$C_{CascL}^{D^+}$	0.954 ± 0.219	1.377 ± 0.222
χ^2/ndof (P-value)	264/219 (0.02)	240/217 (0.13)
B^+ BF sum	0.1049 ± 0.0014	0.0978 ± 0.0014

Fix $D\pi\pi$ BF to 1.0 %

Not a good χ^2

Comparison by fixing to 1.0%

Not a good χ^2 except for Xc.

Parameters	Xc	Xc*	Yc	Yc*	D_1
ρ_D^2	1.295 ± 0.071	1.328 ± 0.069	1.307 ± 0.071	1.328 ± 0.069	1.307 ± 0.069
ρ^2	1.416 ± 0.074	1.389 ± 0.076	1.390 ± 0.074	1.386 ± 0.073	1.467 ± 0.076
R_1	1.473 ± 0.113	1.437 ± 0.111	1.431 ± 0.107	1.398 ± 0.103	1.462 ± 0.111
R_2	0.571 ± 0.103	0.586 ± 0.102	0.599 ± 0.099	0.618 ± 0.096	0.493 ± 0.107
$\mathcal{B}(B^+ \rightarrow \bar{D}^0 \ell^+ \nu)$	0.02492 ± 0.00063	0.02509 ± 0.00063	0.02486 ± 0.00063	0.02503 ± 0.00063	0.02523 ± 0.00062
$\mathcal{B}(B^+ \rightarrow \bar{D}^{*0} \ell^+ \nu)$	0.05557 ± 0.00082	0.05606 ± 0.00082	0.05539 ± 0.00082	0.05629 ± 0.00082	0.05579 ± 0.00080
$\mathcal{BT}(B^+ \rightarrow \bar{D}^{**} / D \pi \ell^+ \nu)$	0.01384 ± 0.00090	0.01208 ± 0.00090	0.01617 ± 0.00090	0.01425 ± 0.00090	0.01069 ± 0.00088
$\mathcal{BT}(B^+ \rightarrow \bar{D}^{(*)} \pi \pi \ell^+ \nu)$	0.01 (Fixed)	0.01 (Fixed)	0.01 (Fixed)	0.01 (Fixed)	0.01 (Fixed)
f_{+0}	1.044 ± 0.029	1.041 ± 0.028	1.045 ± 0.029	1.040 ± 0.028	1.056 ± 0.027
$C_{UncorDL}^{D^0}$	0.950 ± 0.051	0.887 ± 0.051	0.914 ± 0.050	0.833 ± 0.050	0.958 ± 0.037
$C_{UncorCL}^{D^0}$	0.904 ± 0.063	0.860 ± 0.063	0.913 ± 0.064	0.875 ± 0.064	0.834 ± 0.063
$C_{CascL}^{D^0}$	0.523 ± 0.092	0.782 ± 0.092	0.390 ± 0.092	0.616 ± 0.092	0.892 ± 0.093
$C_{UncorDL}^{D^+}$	1.064 ± 0.125	0.995 ± 0.125	1.033 ± 0.125	0.960 ± 0.124	1.075 ± 0.123
$C_{UncorCL}^{D^+}$	0.874 ± 0.134	0.860 ± 0.134	0.869 ± 0.134	0.854 ± 0.134	0.853 ± 0.130
$C_{CascL}^{D^+}$	0.835 ± 0.219	1.229 ± 0.220	0.710 ± 0.219	1.035 ± 0.219	1.344 ± 0.216
χ^2/ndof (P-value)	237/218 (0.18)	281/220 (0.003)	264/219 (0.02)	344/220 (6.0×10^{-8})	268/217 (0.01)
B^+ BF sum	0.1043 ± 0.0014	0.1032 ± 0.0014	0.1064 ± 0.0014	0.1056 ± 0.0014	0.1017 ± 0.0014