

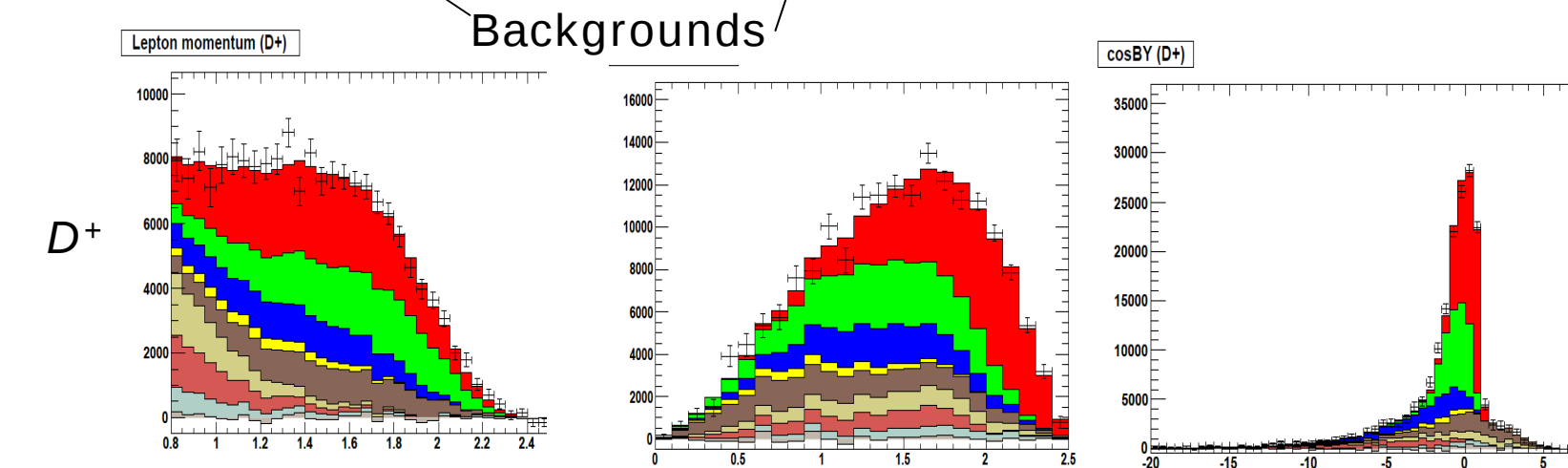
Global Fit for Branching Fractions and Form Factor Slope of $B \rightarrow D^{(*)} \ell \bar{\nu}$ Decays

- Full Run1-4 results
- New background reduction method
- New fit with new binning

Method

- Reconstruct only D^0l and D^+l
- Using 3-D fit by Lepton momentum, D momentum and $\cos\Theta_{BY}$.
- Fit for
 - $B \rightarrow D l \nu$ BF and FF slope
 - $B \rightarrow D^* l \nu$ BF and FF parameters (slope, R_1 and R_2)
 - $Y(4S) \rightarrow B^+ B^- / B^0 \underline{B}^0$ ratio (f_{+0})
- Isospin constraint on $B \rightarrow D^{(*, **)} (\pi) l \nu$ decays

Category	Percentage
Not at all	10%
Slightly	20%
Moderately	30%
Very much	40%



Many improvements

- Inclusive $B \rightarrow D$ BF correction improvement.
- Correlated – uncorrelated selection bug fix.
- Separate $B\bar{B}$ mixing from Uncorrelated background.
- Separate $B \rightarrow D \tau \nu$ from Cascade background.
- Improved calculation of $\cos\theta_{BY}$.
- Run by Run beam energy re-weighting.

Full Run1-4Fit Result

Parameters	f_{+0} floated	f_{+0} fixed
ρ_D^2	1.239 ± 0.042 (3.3 %)	1.225 ± 0.042 (3.4 %)
ρ^2	1.316 ± 0.038 (2.9 %)	1.311 ± 0.039 (2.9 %)
R_1	1.408 ± 0.055 (3.9 %)	1.402 ± 0.055 (3.9 %)
R_2	0.764 ± 0.048 (6.3 %)	0.763 ± 0.049 (6.4 %)
$\mathcal{B}(B^+ \rightarrow \bar{D}^0 \ell^+ \nu)$	0.02383 ± 0.00033 (1.4 %)	0.02360 ± 0.00029 (1.2 %)
$\mathcal{B}(B^+ \rightarrow \bar{D}^{*0} \ell^+ \nu)$	0.05246 ± 0.00045 (0.87 %)	0.05284 ± 0.00037 (0.70 %)
$\mathcal{BT}(B^+ \rightarrow \bar{D}^{**0} / (D\pi)^0 \ell^+ \nu)$	0.02039 ± 0.00043 (2.1 %)	0.02025 ± 0.00043 (2.1 %)
f_{+0}	1.060 ± 0.016 (1.5 %)	1.037 (Fixed)
$C_{UncorDL}^{D^0}$	0.763 ± 0.034 (4.4 %)	0.762 ± 0.034 (4.5 %)
$C_{UncorCL}^{D^0}$	0.830 ± 0.035 (4.2 %)	0.838 ± 0.035 (4.2 %)
$C_{CascL}^{D^0}$	0.950 ± 0.081 (8.5 %)	0.952 ± 0.051 (8.5 %)
$C_{UncorDL}^{D^+}$	0.802 ± 0.105 (13.1 %)	0.786 ± 0.111 (14.1 %)
$C_{UncorCL}^{D^+}$	0.756 ± 0.072 (9.6 %)	0.740 ± 0.071 (9.7 %)
$C_{CascL}^{D^+}$	0.939 ± 0.130 (13.8 %)	0.928 ± 0.148 (16.0 %)
χ^2/ndof (P-value)	407/223 (5.0×10^{-14})	409/224 (4.2×10^{-14})

Run2 results
1.354

0.680

0.02522

0.05156

Closer to 1

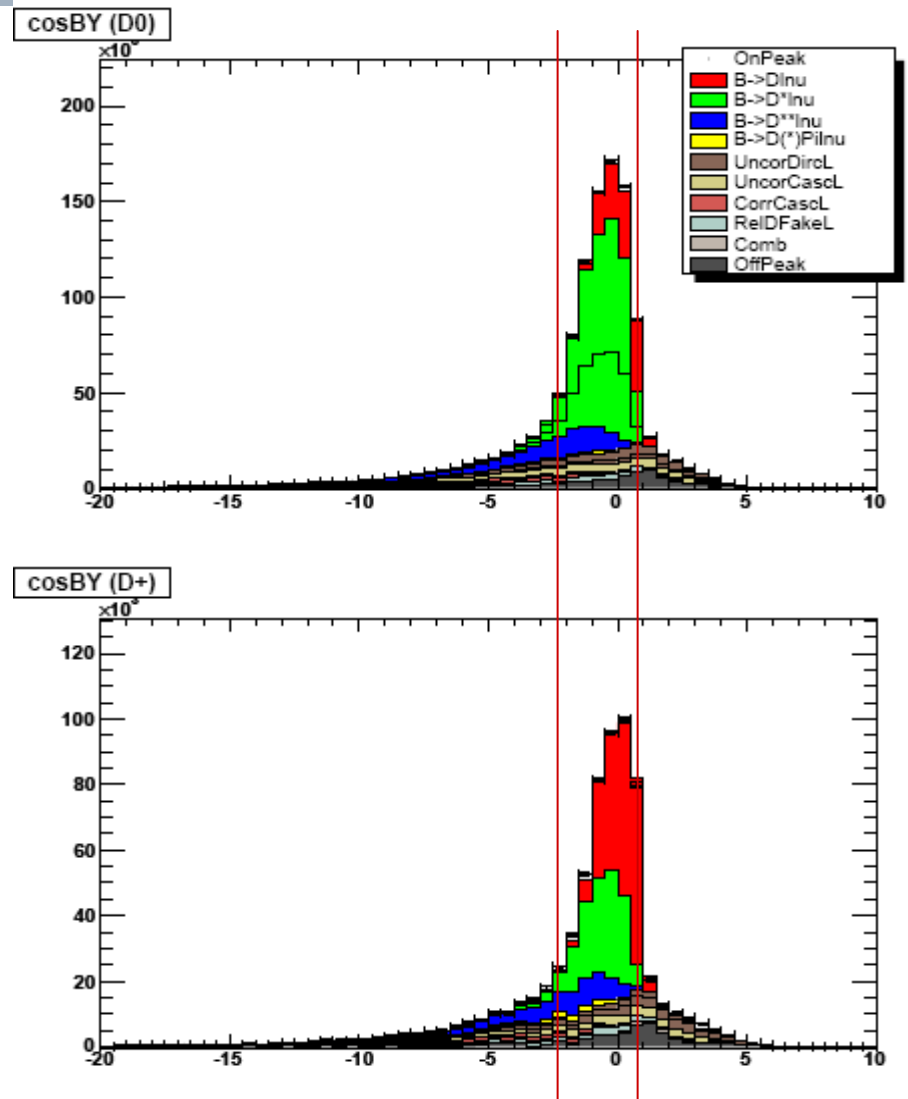
- Very poor χ^2 (and P-value)

Background modeling problem

- We tried to improve background modeling.
 - Many BF are replaced by newer values.
 - D momentum dependent inclusive $B \rightarrow D$ BF correction.
- We tried to improve $B \rightarrow D^{**} l \nu$ model.
 - ISGW2 $\rightarrow$ HQET inspired LLSW model
- But, still not well modeled.
- It is not possible to further improve their modeling.
- Thus, we decided to remove backgrounds.
 - Remove as much background as possible.
 - But, keep as much kinematic region as possible.

Background reduction (1)

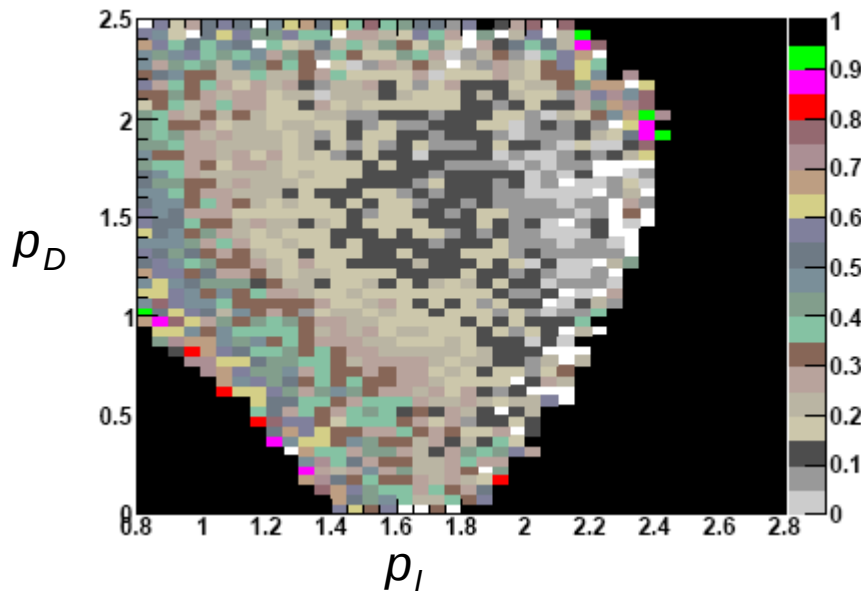
- Cuts on cosBY
 - $-2 < \cos\text{BY} < 1$



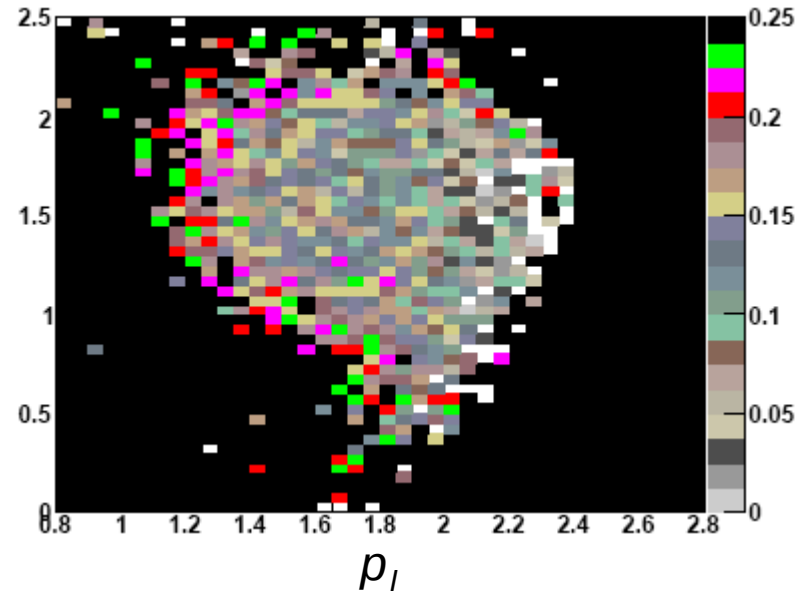
Background reduction (2)

- Lepton momentum and D momentum cuts.
- Background ratio plot in $p_l - p_D$ plane.

Full range



Background < 25 %



- We select the region : background < 25 %

New binning

- Lepton momentum – 9 bins (GeV)
1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.35
- D momentum – 7 bins (GeV)
0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0, 2.45
- $\cos\text{BY}$ – 3 bins
-2, -1, 0, 1

New fit result

Parameters	f_{+0} floated	f_{+0} fixed
ρ_D^2	1.164 ± 0.042 (3.6 %)	1.166 ± 0.039 (3.4 %)
ρ^2	1.278 ± 0.044 (3.5 %)	1.278 ± 0.044 (3.5 %)
R_1	1.402 ± 0.065 (4.6 %)	1.403 ± 0.064 (4.6 %)
R_2	0.752 ± 0.055 (7.3 %)	0.753 ± 0.055 (7.3 %)
$\mathcal{B}(B^+ \rightarrow \bar{D}^0 \ell^+ \nu)$	0.02328 ± 0.00031 (1.3 %)	0.02331 ± 0.00025 (1.1 %)
$\mathcal{B}(B^+ \rightarrow \bar{D}^{*0} \ell^+ \nu)$	0.05443 ± 0.00073 (1.4 %)	0.05437 ± 0.00052 (0.96 %)
$\mathcal{BT}(B^+ \rightarrow \bar{D}^{*0}/(D\pi)^0 \ell^+ \nu)$	0.01630 ± 0.00111 (6.8 %)	0.01637 ± 0.00097 (5.9 %)
f_{+0}	1.035 ± 0.017 (1.6 %)	1.037 (Fixed)
χ^2/ndof (P-value)	379/350 (0.135)	379/351 (0.143)

Background coefficients are all fixed.

Correlation

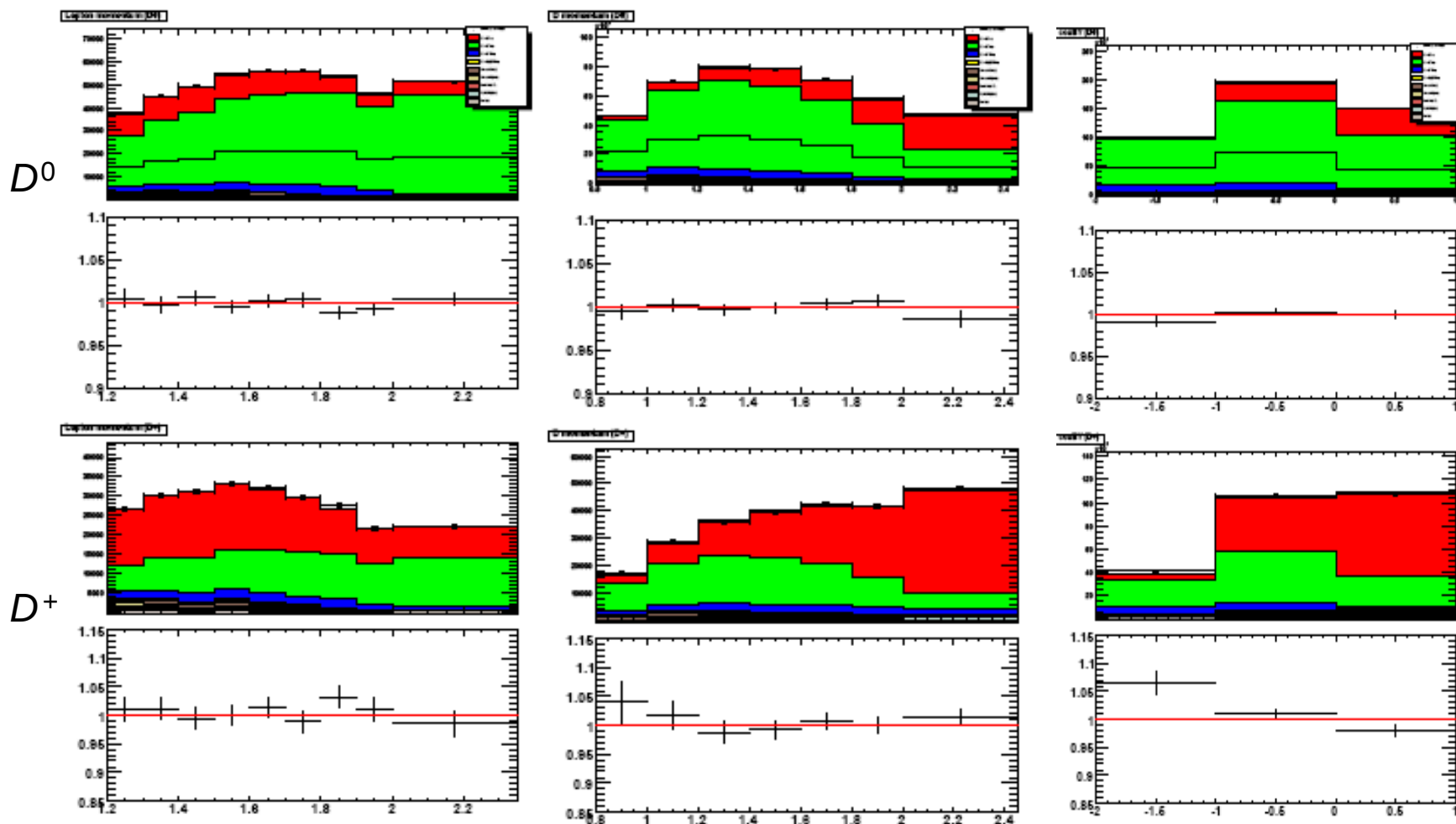
	ρ_D^2	ρ^2	R_1	R_2	$\mathcal{B}(D\ell\nu)$	$\mathcal{B}(D^*\ell\nu)$	$\mathcal{B}(\text{Oter})$	f_{+0}
ρ_D^2	1							
ρ^2	-0.229	1						
R_1	+0.027	+0.837	1					
R_2	+0.134	-0.912	-0.901	1				
$\mathcal{B}(D\ell\nu)$	+0.411	+0.181	+0.332	-0.094	1			
$\mathcal{B}(D^*\ell\nu)$	-0.514	+0.326	+0.042	-0.355	-0.605	1		
$\mathcal{B}(\text{Oter})$	+0.322	-0.362	-0.190	+0.354	+0.296	-0.813	1	
f_{+0}	+0.349	+0.016	+0.161	+0.044	+0.576	-0.695	+0.486	1

Projection plots after fitting

Lepton momentm

D momentum

cosBY



Summed BF (%)

	BAD1889	Our result (stat err only)
$\text{BF}(B^{+-} \rightarrow D \ell \nu)$	2.33 ± 0.13	2.33 ± 0.03
$\text{BF}(B^{+-} \rightarrow D^* \ell \nu)$	5.83 ± 0.34	5.44 ± 0.05
$\text{BF}(B^{+-} \rightarrow D \pi \ell \nu)$ $\text{BF}(B^{+-} \rightarrow D^* \pi \ell \nu)$ $\text{BF}(B^{+-} \rightarrow D^{(*)} \pi^0 \ell \nu)$	0.42 ± 0.07 0.59 ± 0.06 0.51	1.64 ± 0.10
Sum	9.68 ± 0.38	9.41 ± 0.12

Good agreement

D^* FF parameters

	Previous Babar results	Our results (stat error only)
Slope	1.179 ± 0.056 1.16 ± 0.10	1.278 ± 0.044
R1	1.417 ± 0.075	1.402 ± 0.065
R2	0.836 ± 0.043	0.752 ± 0.055
F(1)Vcb ($\times 10^{-2}$)	34.68 ± 1.19 35.9 ± 1.5	36.1 ± 0.3

Need to understand the difference.
Waiting for systematic uncertainties.

To do list

- If this new method is acceptable, then...
- Validation of new fit method
 - Fit with splitted MC vs MC
 - Toy fit (first look is OK)
- Fits for cross check
 - Electron vs muon
 - Run1-3 vs Run4
- Systematic study