

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

Status Report

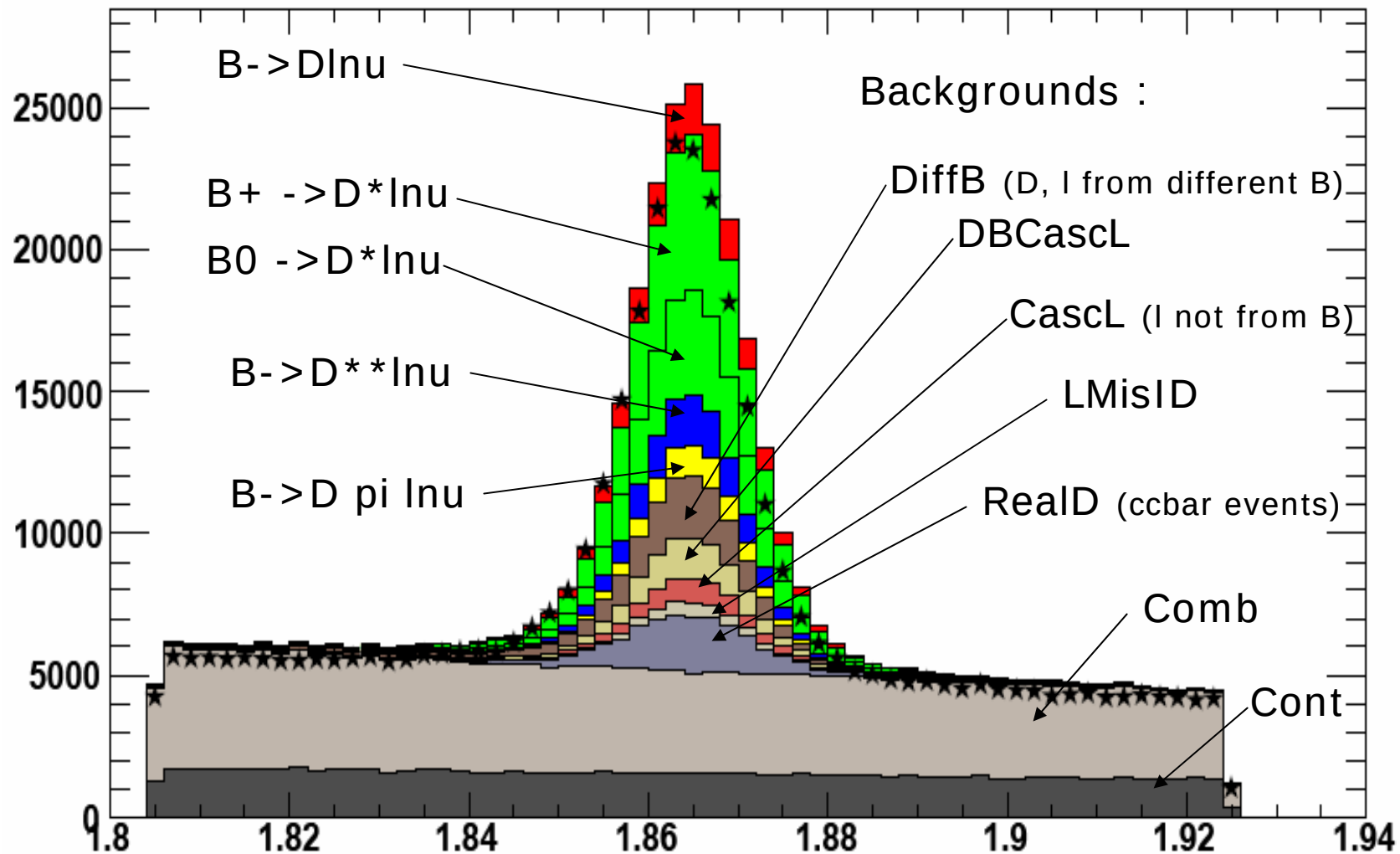
Motivation

- $B^0 \rightarrow D^* \ell \nu$ branching fraction problem.
 - Discrepancy between measurements :
 - BELLE(2002) $BF = 0.046 \pm 0.005$
 - BABAR(2005) $BF = 0.049 \pm 0.004$
 - CLEO(2003) $BF = 0.061 \pm 0.004$
 - Inclusive-Exclusive disagreement (PDG):
 - $BF(B^0 \rightarrow D \ell \nu) = 0.0213 \pm 0.0018$
 - $BF(B^0 \rightarrow D^* \ell \nu) = 0.0520 \pm 0.0024$
 - $BF(B^0 \rightarrow D^{**} / D_{pi} \ell \nu) = 0.0146 \pm 0.0028$
 - Sum $= 0.0879 \pm 0.0041$
 - $BF(B^0 \rightarrow X_c \ell \nu) = 0.1025 \pm 0.0060$
 - B^+ , B^0 disagreement (BELLE/BABAR):
 - $BF(B^0 \rightarrow D^* \ell \nu) = 0.047/0.049$
 - $BF(B^+ \rightarrow D^* \ell \nu) = 0.061/0.067$
- We use different approach.
 - Do not reconstruct D^* or D^{**} .
 - Use global fit. Use both D^0 and D^+ .
 - Can provide new measurements of BF.
- We can also measure $B \rightarrow D \ell \nu$ FF slope.
 - Uncertainty : 23 % $\rightarrow$ 10 %?

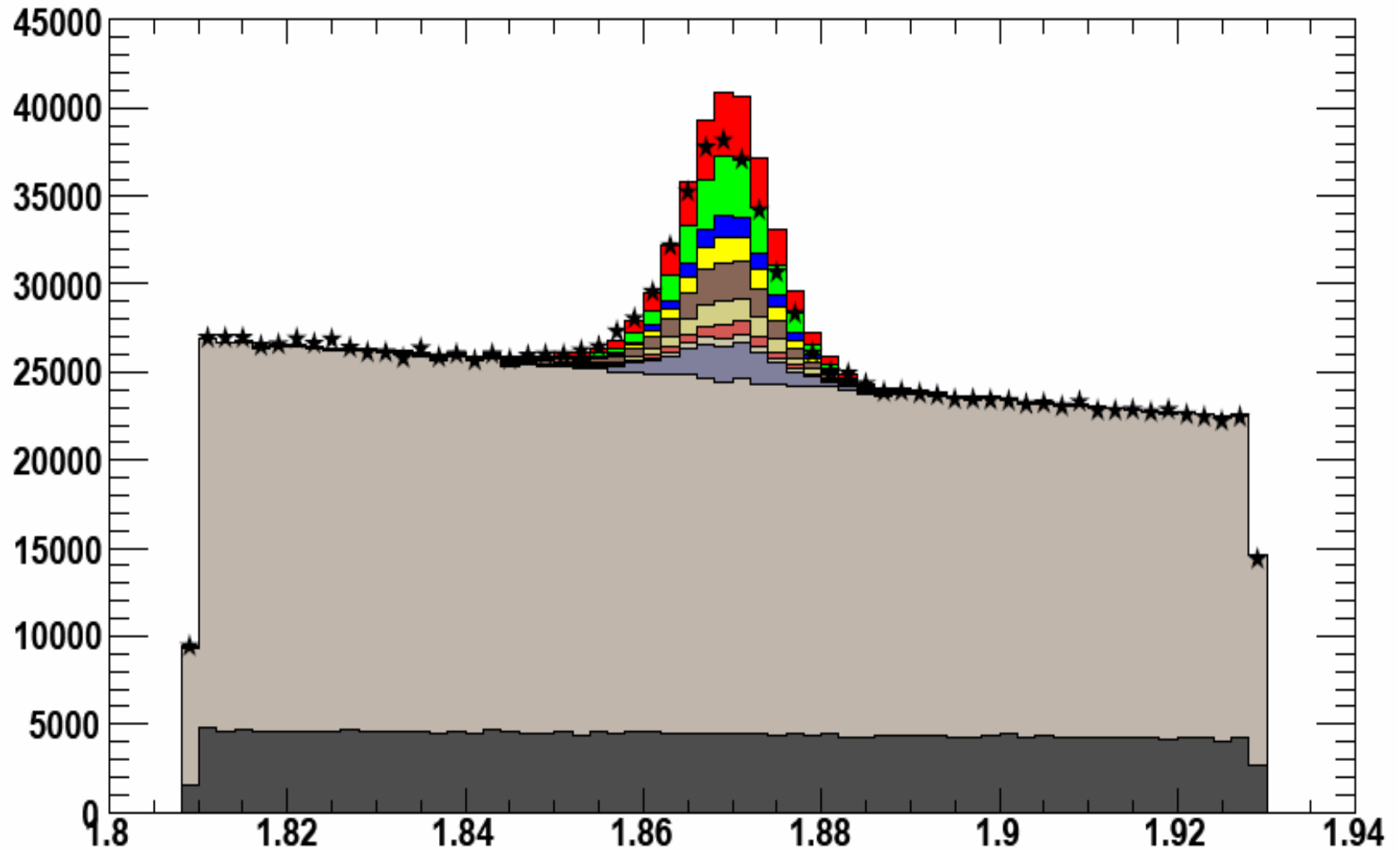
Outline of the analysis

- Dataset : Run1 – 4 (BToDInu R16b skims).
- Release : analysis-26 (16.1.5).
- Event selection :
 - BToDInu skim select events with DI candidates.
 - Radiative Bhabha veto.
 - Kaon selection : KLHNotPion.
 - Vertexing : both D and B vertex use $P > 0.01$.
 - Thrust cut : $|\cos(\text{DI-nonDI})| < 0.88$.
- Use Global Fit
 - 3-D binning.
 - Lepton momentum (4 bins)
 - D momentum (6 bins)
 - $\cos\text{BY}$ ($Y=\text{DI}$) (5 bins)
 - Reconstruct only D0 and D+.
 - All higher D states feed down to D0 or D+.
 - D mass sideband subtraction.

D0 mass plot



D+ mass plot



Fitting Method

- Binned chi-square fitting

$$\chi^2 = \sum_{i=bin}^{D^0} \frac{\left(N_i^{data} - \sum C N_i^{MC}\right)^2}{\left(\sigma_i^{data}\right)^2 + \sum \left(C \sigma_i^{MC}\right)^2}$$

- N_i^{MC} expected number of candidates from MC.
 - Form Factor re-weighted.
- C : consists of branching fractions.
- Four parameters to determine :
 - $BF(B \rightarrow D l \nu)$, $BF(B \rightarrow D^* l \nu)$, $BF(b \rightarrow D^{**} / D \pi l \nu)$.
 - $B \rightarrow D l \nu$ FF slope.
- Float background components.
- Normalize total branching fraction to inclusive value.
- Isospin symmetry for B and D^{**} decays.

Validation Fit

- Split Run3 MC into two halves. Use one half as a fake-data and fit the data with the other half.
- Result
 - Chi-square/n.d.f. = 170/175
 - $BR(B \rightarrow D l \nu) = 0.0207 \pm 0.0007$
 - $BR(B \rightarrow D^* l \nu) = 0.0561 \pm 0.0013$
 - $BR(B \rightarrow D^{**} / D_{pi} l \nu) = 0.0271 \pm 0.0013$
 - All consistent with SP5/SP6 values.

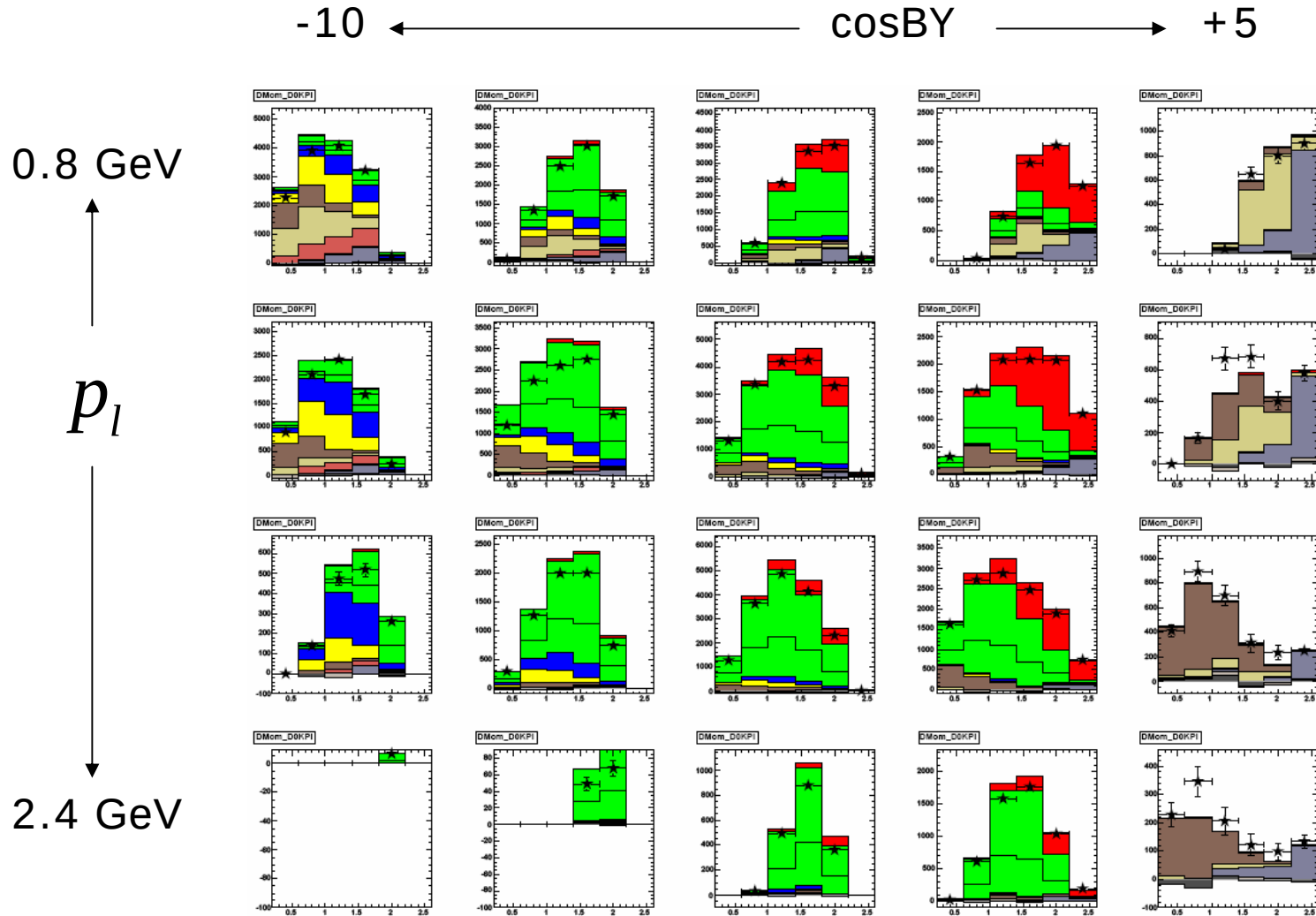
Fit to Data (Run3 only)

- Chi-square/n.d.f. = **313/178**
- Branching fractions
 - $B \rightarrow D \ln \nu = 0.0246 \pm 0.0009$ (3.7 %)
 - $B \rightarrow D^* \ln \nu = 0.0616 \pm 0.0016$ (2.6 %)
 - $B \rightarrow D^{**} / D_{\pi} \ln \nu = 0.0234 \pm 0.0014$ (6.0 %)
- Backgrounds
 - DiffB (D0) = 0.91 ± 0.05 , (D+) = **0.61 ± 0.11**
 - DBCascL (D0) = 1.04 ± 0.07 , (D+) = **0.67 ± 0.15**
 - CascL (D0) = 0.78 ± 0.13 , (D+) = 0.97 ± 0.30
 - LMisID (D0) = **0.12 ± 0.23** , (D+) = 0.86 ± 0.54
 - RealD (D0) = 0.94 ± 0.05 , (D+) = 1.18 ± 0.12
- $B \rightarrow D \ln \nu$ FF slope
 - Slope = 1.471 ± 0.058 (3.9 %)

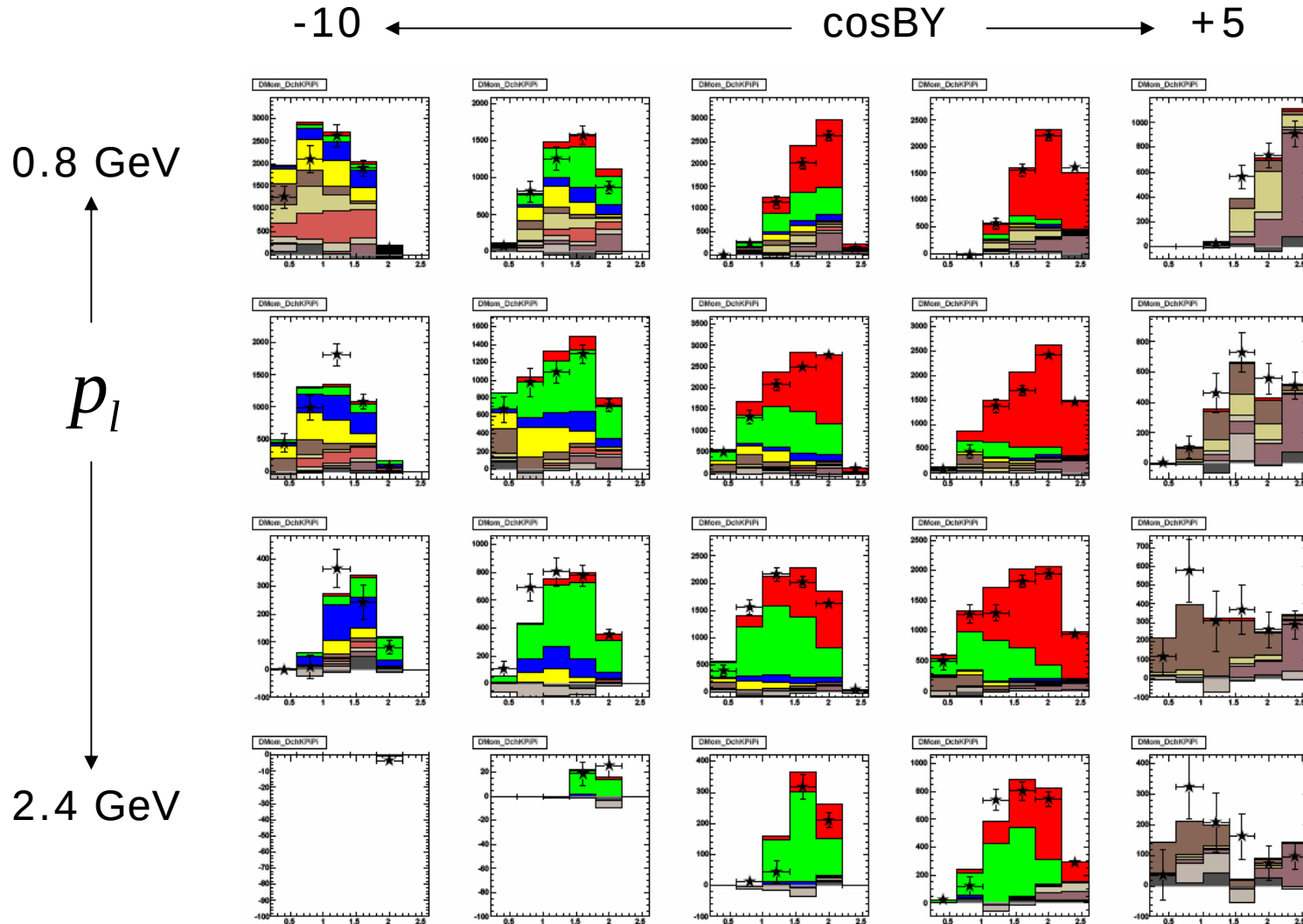
No Significant Correlation

	Slope	Dlnu	D*lnu	D**pi	LMis	DiffB	DBC
Slope		0.25	-0.22	0.05	-0.11	-0.02	-0.19
Dlnu	0.25		0.51	0.30	0.02	0.23	0.07
D*lnu	-0.22	0.51		0.01	0.04	0.20	0.19
D** / Dpi	0.05	0.30	0.01		-0.06	-0.05	0.01
LMis (D0)	-0.11	0.02	0.04	-0.06		0.01	0.08
DiffB (D+)	-0.02	0.23	0.20	-0.05	0.01		-0.24
DBCas (D+)	-0.19	0.07	0.19	0.01	0.08	-0.24	

Fitted Plots : D0 momentum



Fitted Plots : D+ momentum



Systematic Study

A. Effect of uncertainty on input numbers.

A1. $B \rightarrow D^* \ell \nu$ FF parameters

A2. Ratios between $B \rightarrow D^{**} \ell \nu$, $B \rightarrow D^{(*)} \ell \nu$ BFs

A3. Lifetimes, D , D^* and D^{**} branching fractions

B. Tracking efficiency and PID corrections.

C. Branching fraction normalization.

	$B(B \rightarrow D \ell \nu)$	$B(B \rightarrow D^{**} \ell \nu)$	Slope
A1	1.8 %	1.3 %	1.9 %
A2	1.4 %	2.8 %	0.9 %
A3	1.4 %	0.5 %	0.5 %
B	0.8 %	0.7 %	1.0 %
C	2 %	2 %	0 %

$B^0/B^+ \rightarrow D^* \ell \nu$

- Release isospin symmetry for $B \rightarrow D^* \ell \nu$
- Result is
 - $B(B^+ \rightarrow D \ell \nu) = 0.0252 \pm 0.0010$ (4.0 %)
 - $B(B^+ \rightarrow D^* \ell \nu) = 0.0606 \pm 0.0034$ (5.5 %)
 - $B(B^0 \rightarrow D^* \ell \nu) = 0.0587 \pm 0.0044$ (7.4 %)
 - $B(B^+ \rightarrow D^{*+} \ell \nu) = 0.0238 \pm 0.0014$ (6.1 %)
 - Slope = 1.465 ± 0.057 (3.9 %)
- Isospin symmetry holds !

Summary and To do list

- Possiblility to measure BF and FF slope with :
 - ~5 % uncertainty on BF
 - ~6 % uncertainty on Slope.
- Need to improve chi-square
 - Separate electron and muon.
 - Examine backgrounds
 - D0 : LMisID, D+ : DiffB (DBCascL)
 - B- $\rightarrow$ D** $\lnu$ FF re-weighting.
 - Non-resonant B- $\rightarrow$ Dp $\lnu$ FF re-weighting.
- BAD1586 V1 is ready.