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

Backgrond study and D^{**} FF re-weighting

Fitting Method

- Binned chi-square fitting

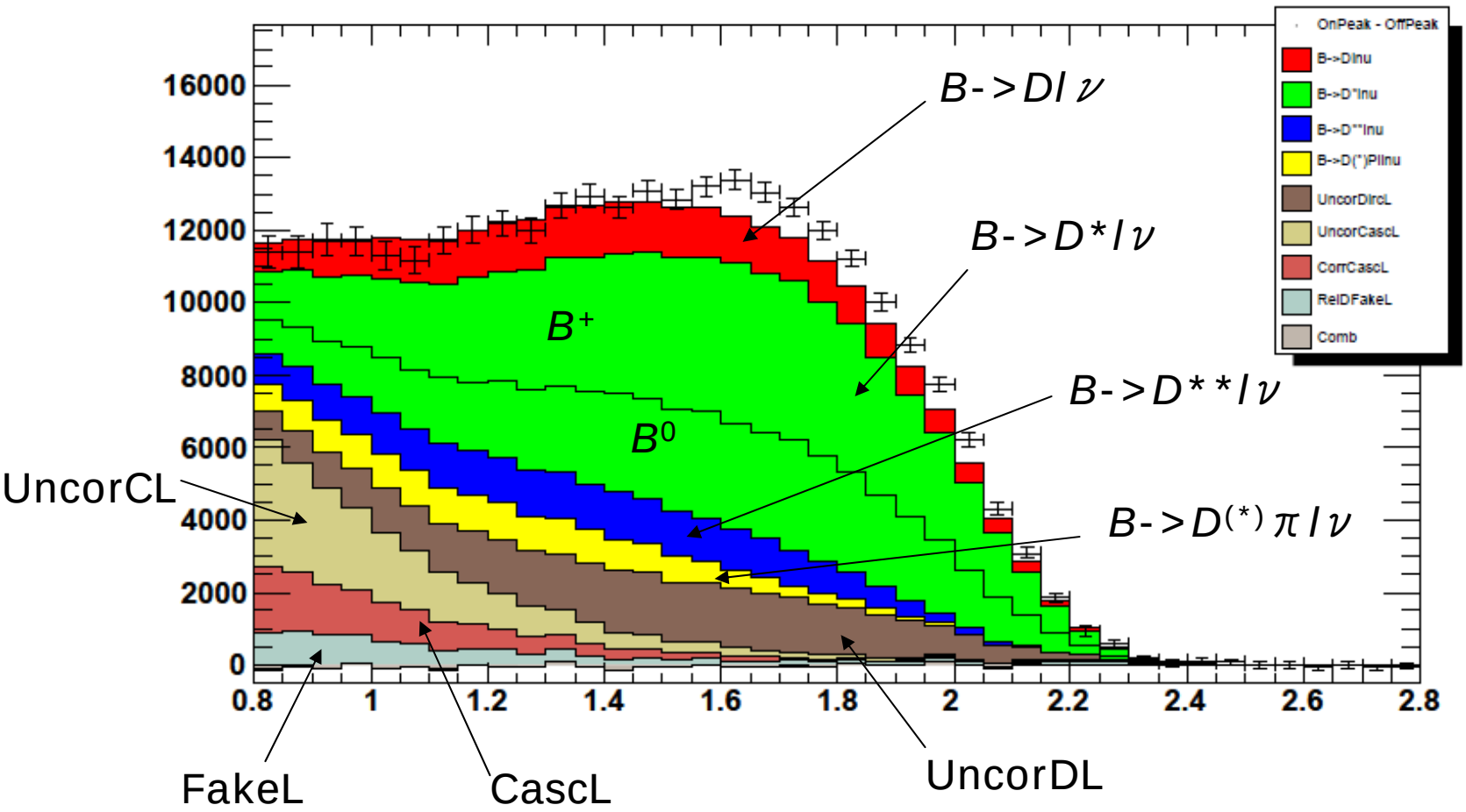
$$\chi^2 = \sum_{i=bin}^{D^0} \frac{\left(N_i^{\text{OnPeak data}} - N_i^{\text{OffPeak data}} - \sum C N_i^{B\bar{B}MC}\right)^2}{\left(\sigma_i^{\text{OnPeak data}}\right)^2 + \left(\sigma_i^{\text{OffPeak data}}\right)^2 + \sum \left(C\sigma_i^{B\bar{B}MC}\right)^2}$$

$$+ \sum_{i=bin}^{D^+} \frac{\left(N_i^{\text{OnPeak data}} - N_i^{\text{OffPeak data}} - \sum C N_i^{B\bar{B}MC}\right)^2}{\left(\sigma_i^{\text{OnPeak data}}\right)^2 + \left(\sigma_i^{\text{OffPeak data}}\right)^2 + \sum \left(C\sigma_i^{B\bar{B}MC}\right)^2}$$

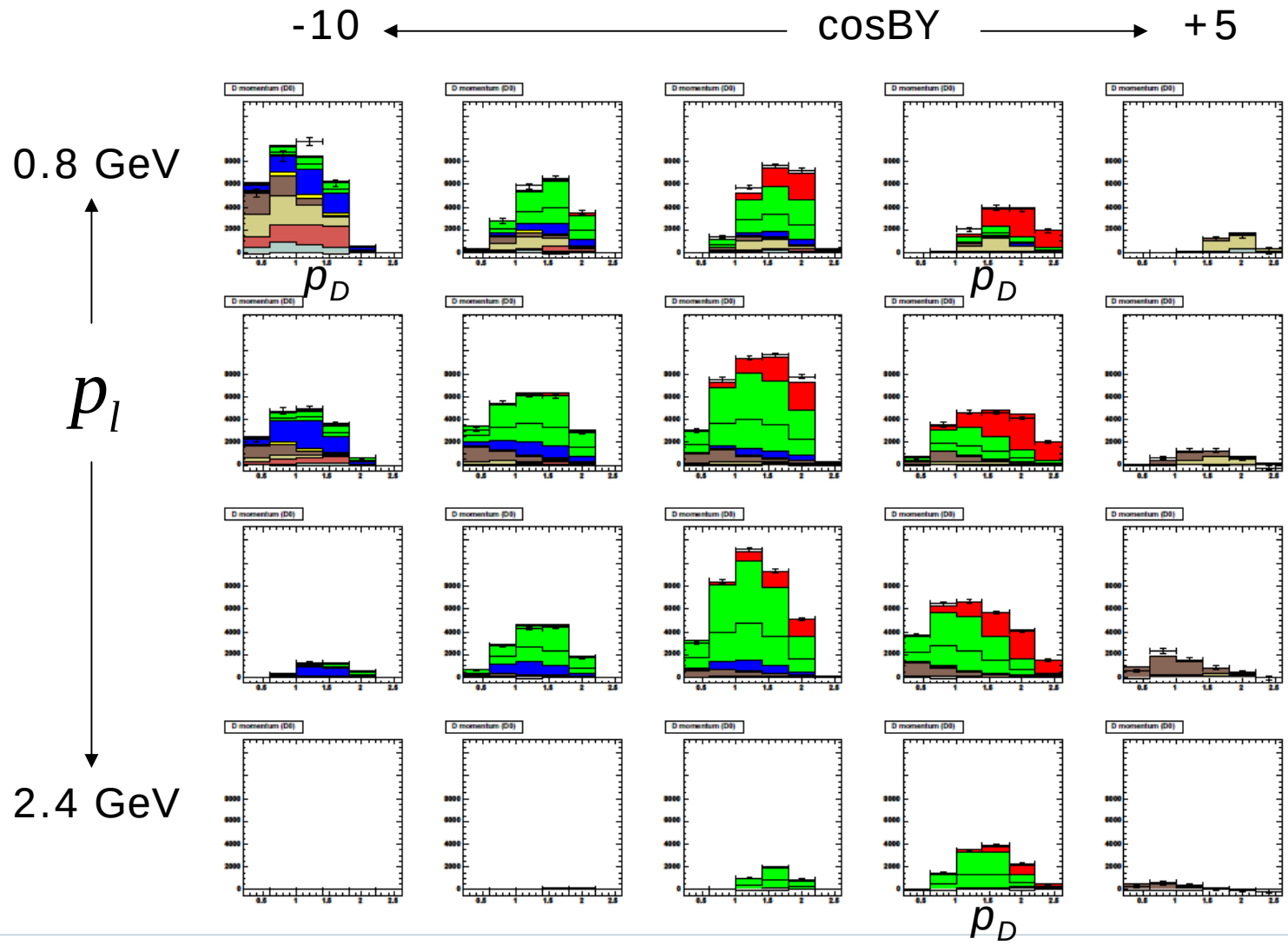
- $N_i^{B\bar{B}MC}$: expected number of candidates from $B\bar{B}$ MC.
- C : consists of branching fractions to be determined by the fit.
- BF or FF re-weighting is done to produce $N_i^{B\bar{B}MC}$.
- 4 major backgrounds after D mass sideband subtraction.

Lepton Momentum : P_l

(OnPeak – OffPeak) data vs B$\underline{\text{B}}$ MC



3D Binning : p_l, p_D, cosBY



Changes since last December

- Branching Fraction (BF) re-weighting for backgrounds was done.
- $B->D^{**}l\nu$ Form Factor (FF) re-weighting completed.
- Many changes and bug fixes in our fitting code.
  - Re-did event selection.
  - Changed binning.
  - D* FF slope fitting.
  - Changed the variables to be floated in the fit.
  - Need validation.

- will be presented today
- are not shown today, but will be ready soon.

Background Components

- UncorDL = Uncorrelated (= *D* and *l* from different *B*) and *l* directly from *B* :
  - $B \to D_{(s)}^{(*,**)} \overline{D}^{(*,**)} X$ decays : 80 % of B^+ and 40 % of B^0
  - $B^0 \overline{B}^0$ mixing : 50% of B^0
- UncorCL = Uncorrelated (= *D* and *l* from different *B*) and Cascade (=*l* not directly from *B*) :
  - Semileptonic *D* decays : 90 %
- CascL = Cascade (= *l* not directly from *B*) and correlated
  - $B \to D^{(*,**)} \overline{D}_{(s)}^{(*,**)} X$ decays + semileptonic *D* decays : 50 %
  - $B \to D \tau \nu$ decays : 45 %
- FakeL = Fake lepton (= misidentified *l*) :
  - π misidentified as μ : 90 %

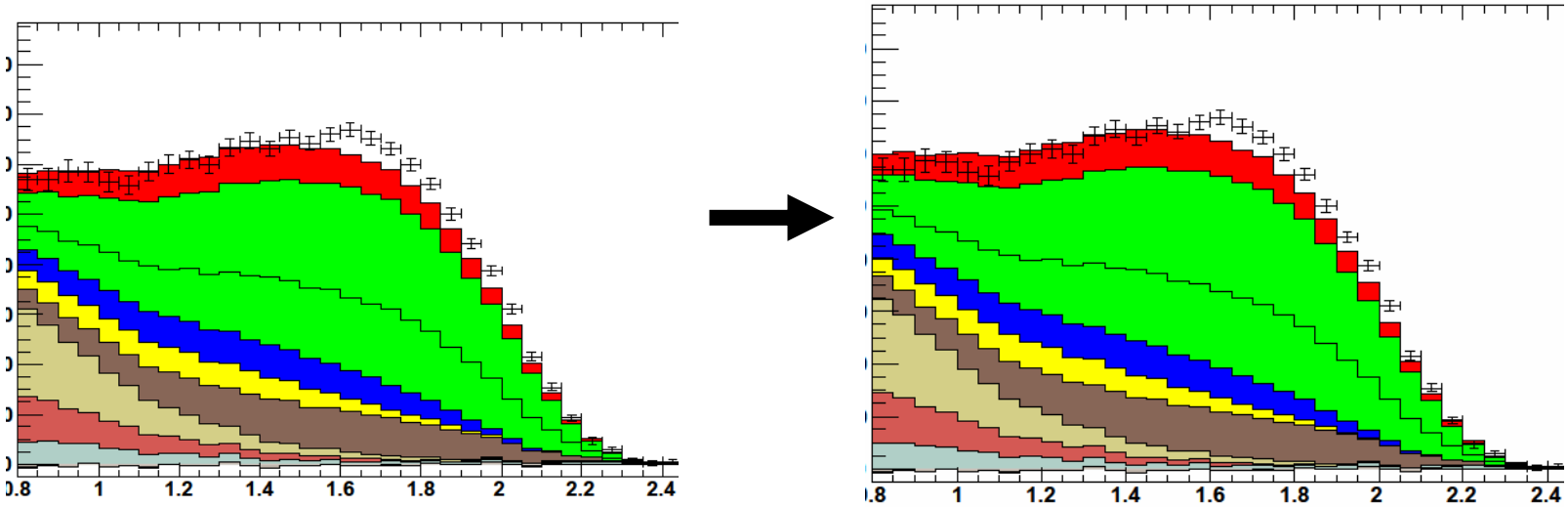
Background BF re-weighting

- Exclusive semileptonic D decay BF
  - For example
  - $D^+ \to K^* l \nu$: weight = 1.1625
  - $D^+ \to K l \nu$: weight = 1.3209
  - $D^0 \to \pi l \nu$: weight = 0.7297
- Inclusive $B \to D$ BF for cascade backgrounds
  - For example

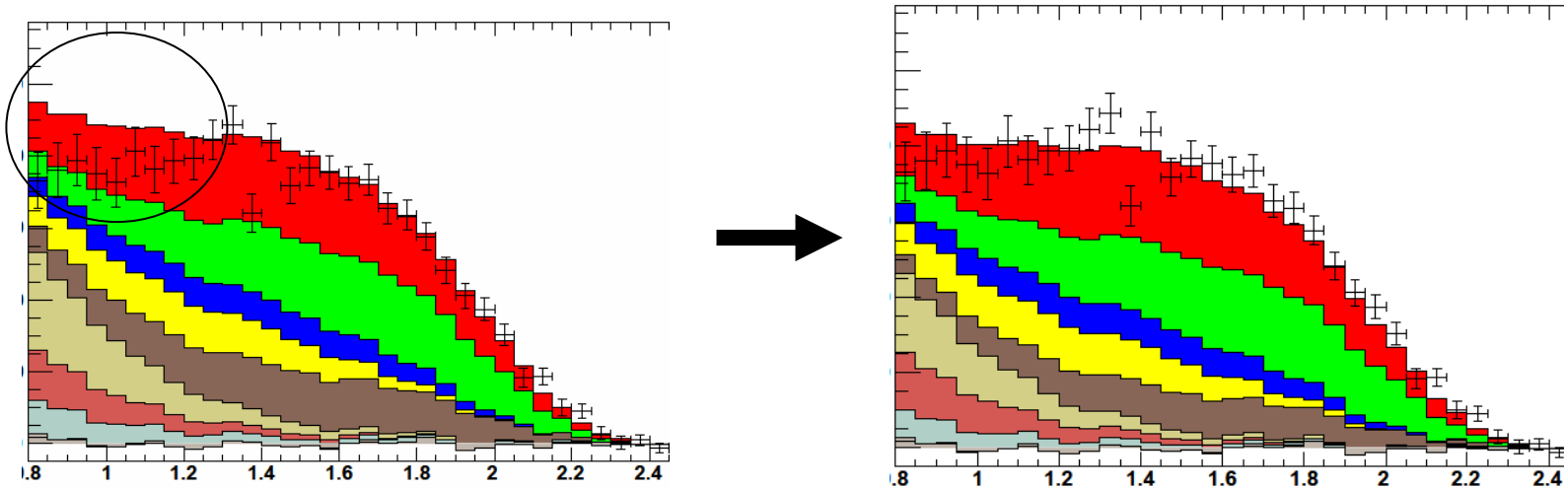
Mode	Weight
$B^- \to D^+$	0.7344
$B^+ \to D^+$	0.5835
$B^0 \to D^+$	0.8043
$\underline{B}^0 \to D^+$	0.5792

P_l : BF re-weighting

D^0



D^+



Form Factor Re-weighting

- $B \to D l \nu$: ISGW2 -> HQET

Slope

$$h_+(w) = h_+(1)[1 - \rho_D^2 (w-1)]$$

- $B \to D^* l \nu$: HQET
  - Babar measurement of R_1, R_2 and slope ρ^2.
- $B \to D^{**} l \nu$: ISGW2 -> HQET
  - Based on LLSW paper (Leibovich, Ligeti, Stewart and Wise, PRD57(1998)308, hep-ph/9705467)
- Normalization
  - Total decay rate should stay same

$$\Gamma = \int \frac{d\Gamma(\text{old FF})}{dw} dw = R_N \int \frac{d\Gamma(\text{new FF})}{dw} dw$$

  - R_N is the normalization factor

B->D**lν FF : LLSW model

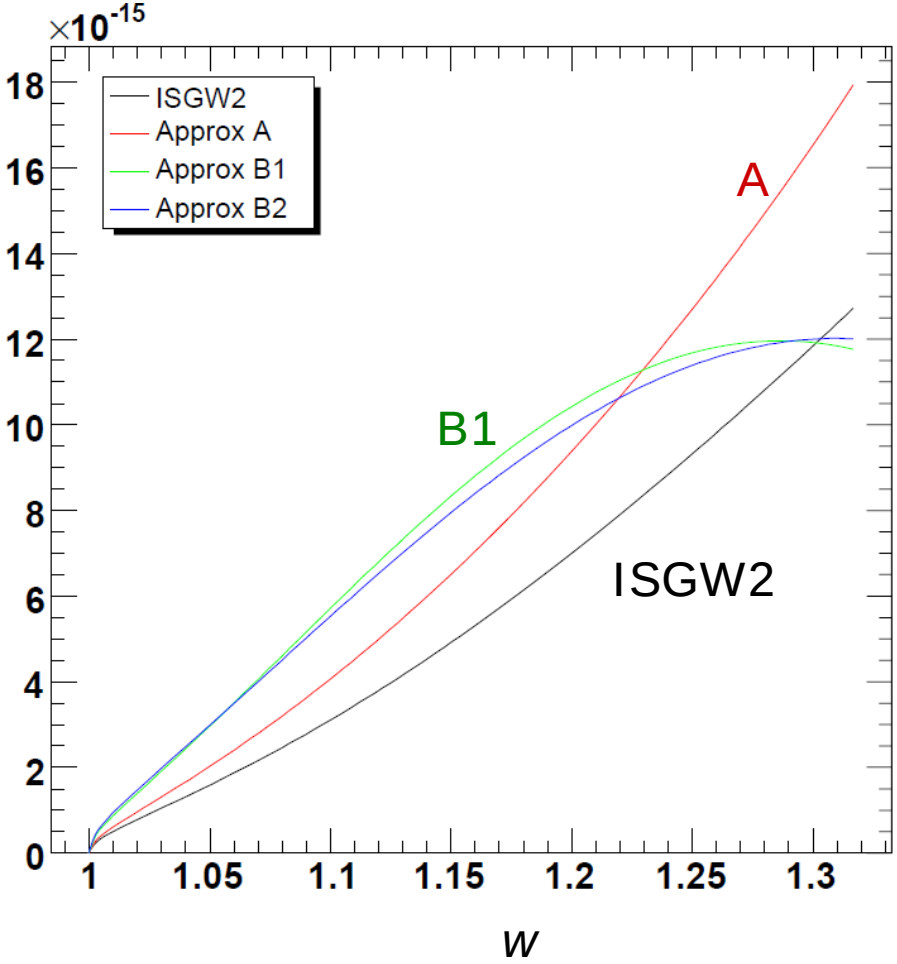
- HQET based model.
- Two approximations were employed:
  - Approximation A :
    - Expand the differential decay rates by (w-1).
    - Useful only near w = 1.
  - Approximation B :
    - Keep the known order of (Λ_{QCD}/m_Q) to FF
    - Keep full w dependence
- We use the Approximation B
  - Form factors are proportional to $\tau(w)$
  - $\tau(w) = \tau(1)\,[1 + \tau'(w-1)]$
  - $\tau(1) = 0.71$, $\tau' = -1.5$ are used.

Slope

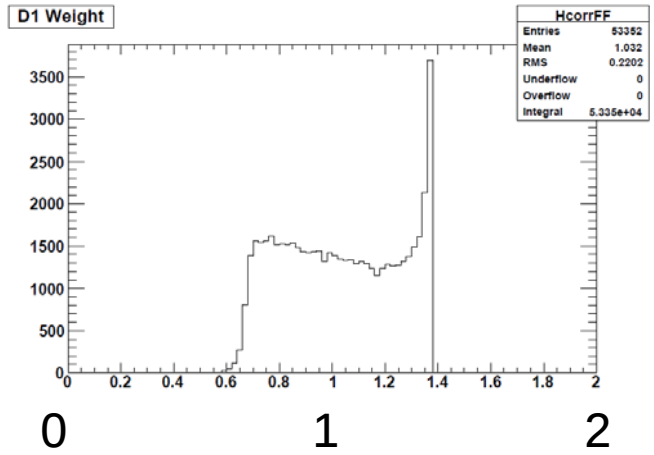
- We could reproduce the numbers in the paper with help of Zoltan Ligeti. Thanks!

D_1 dΓ/dw and Weights

dΓ/dw

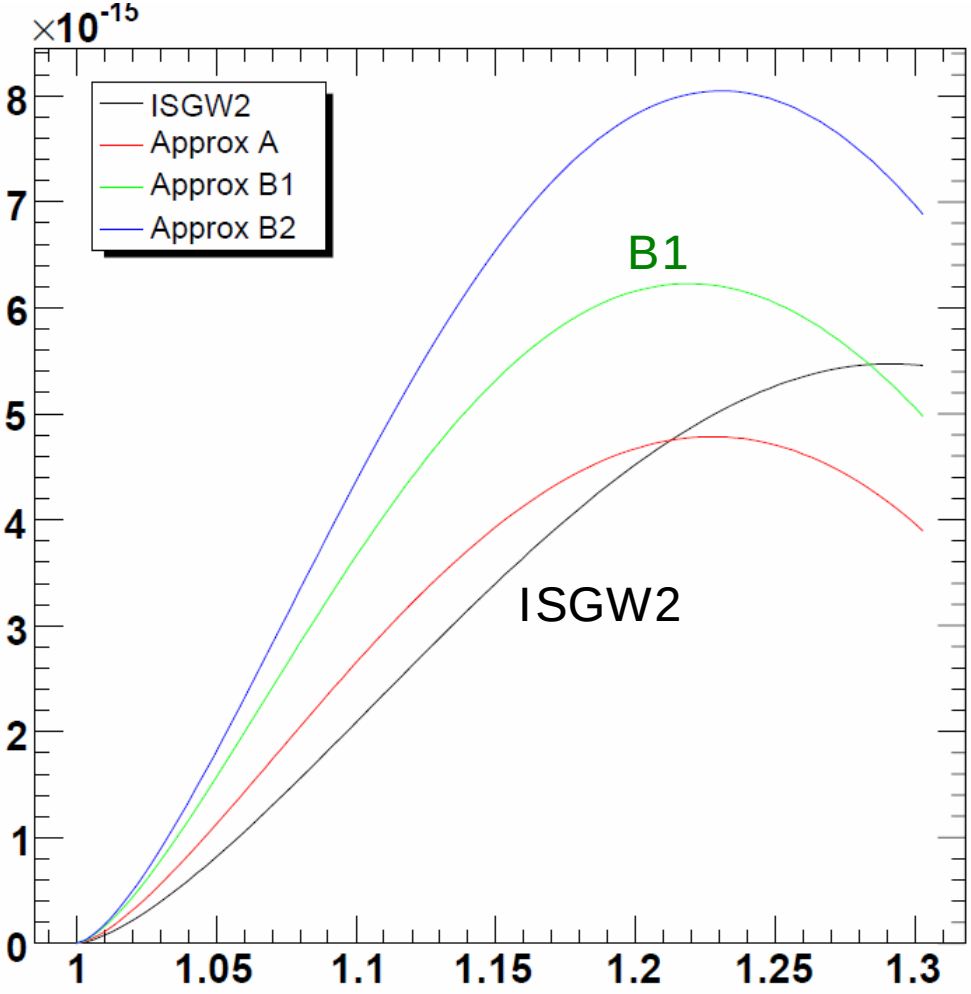


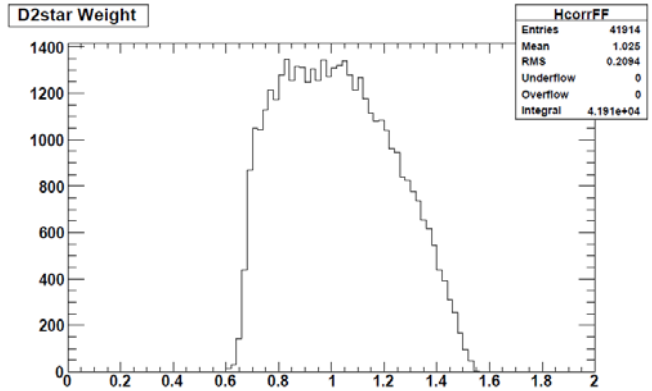
weights



R_N = 0.733

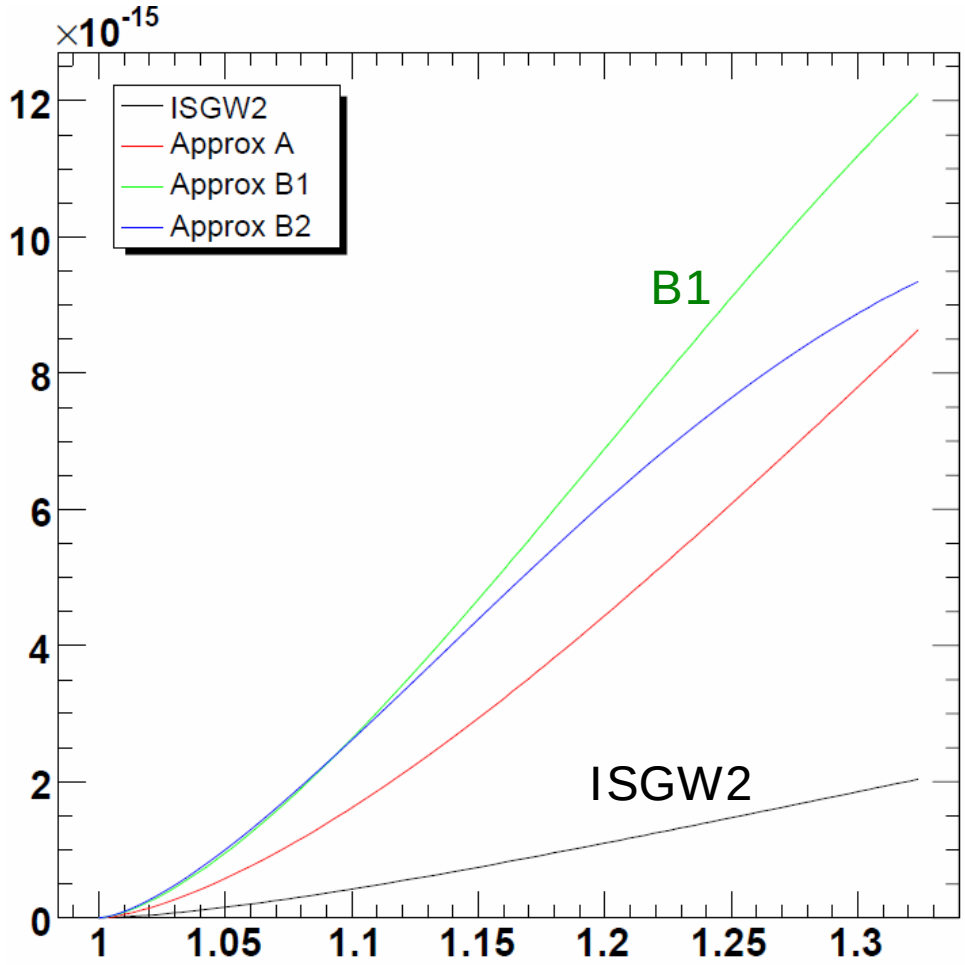
D_2^* dΓ/dw and Weights

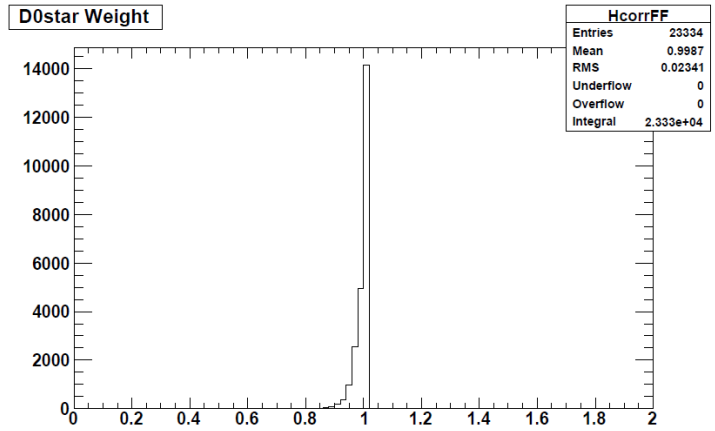




$R_N = 0.749$

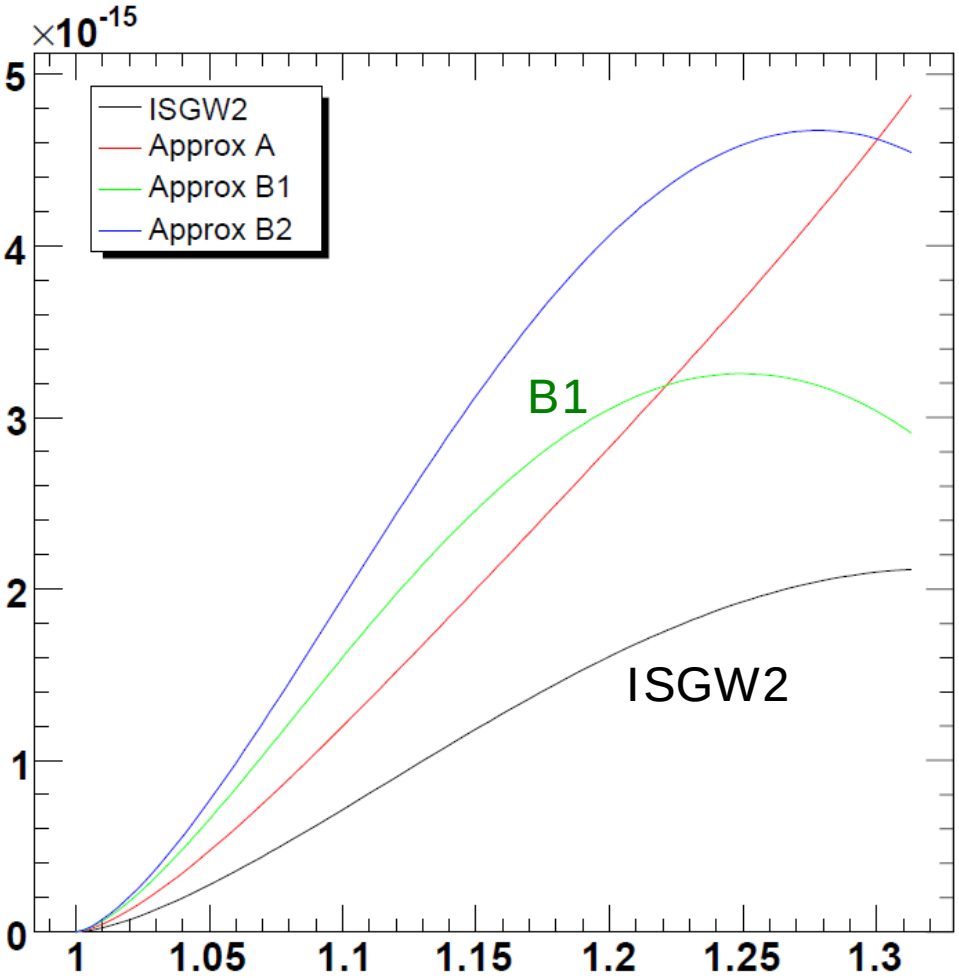
D_0* dΓ/dw and Weights

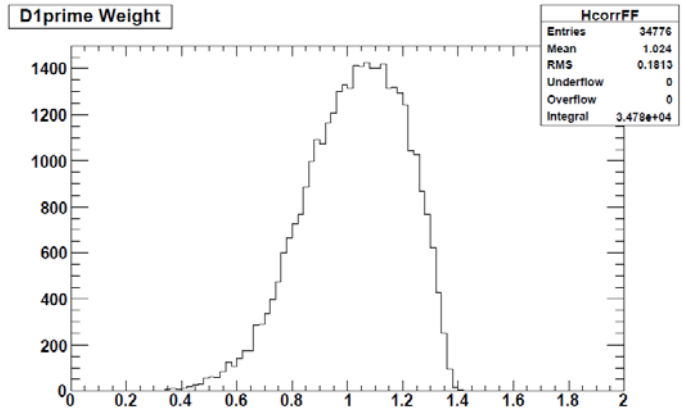




R_N = 0.162

D_1' dΓ/dw and Weights

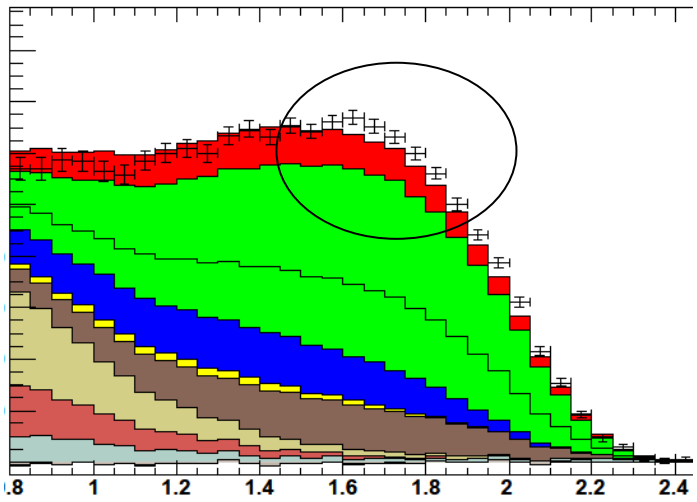


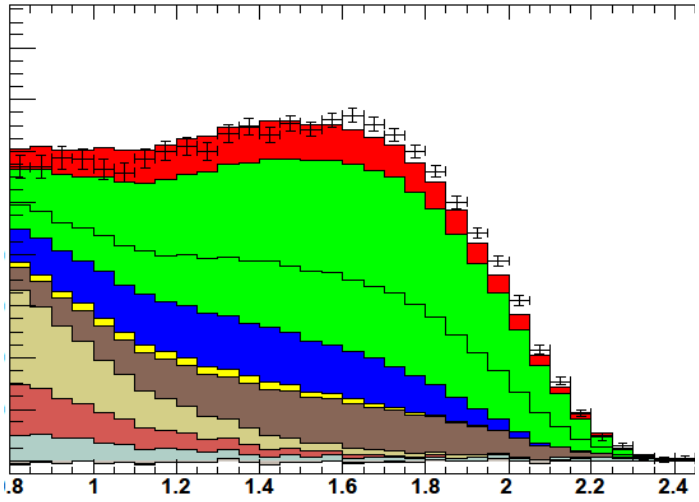


R_N = 0.549

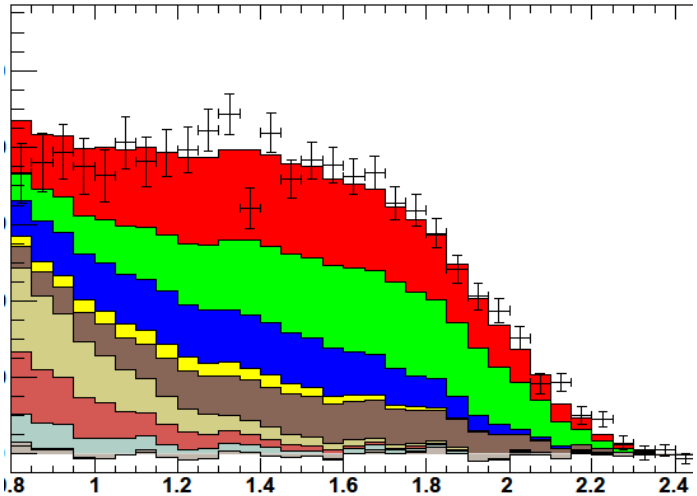
P_l : D^{**} FF re-weighting

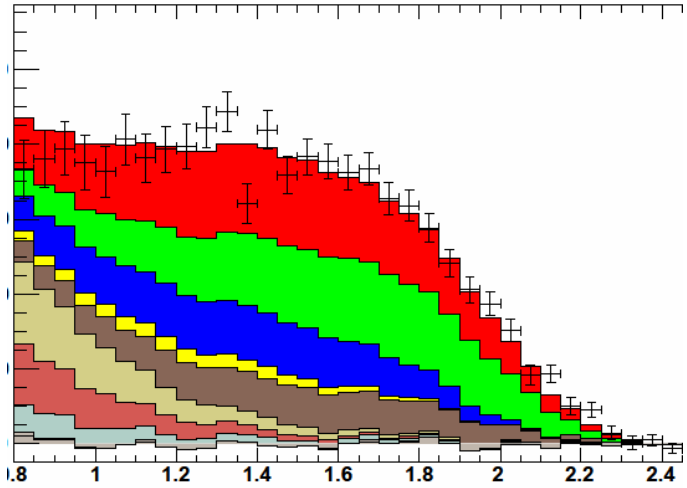
D^0





D^+



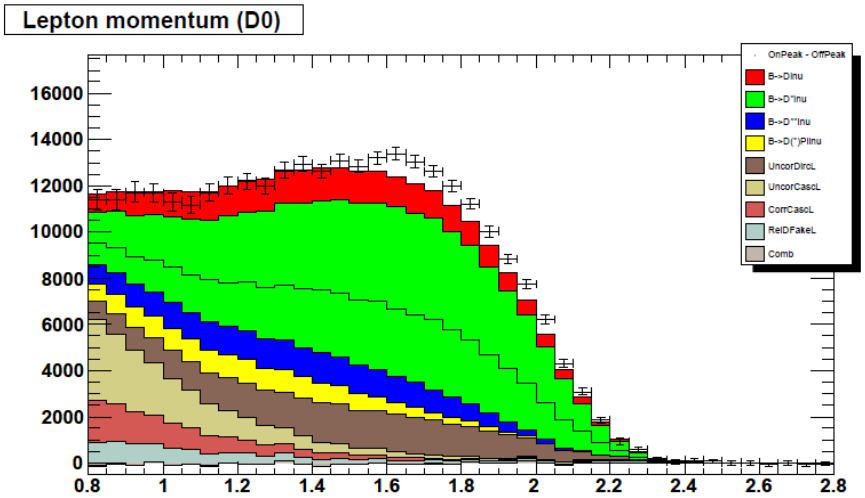


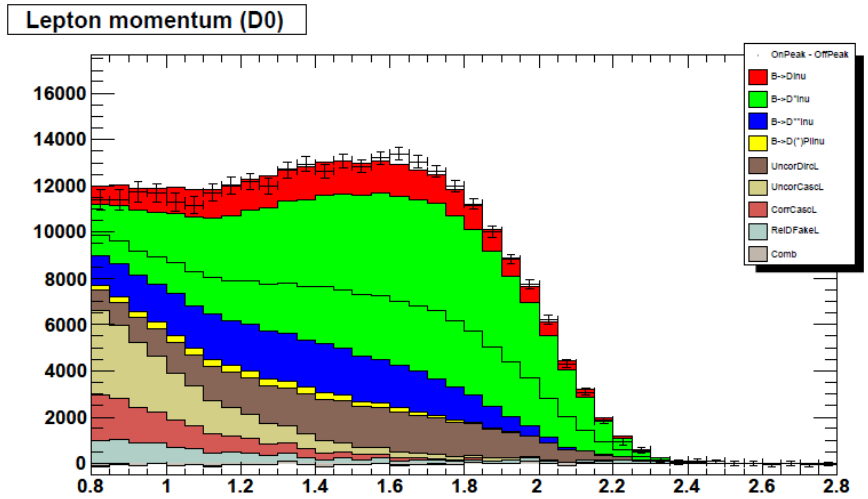
Effect is small.

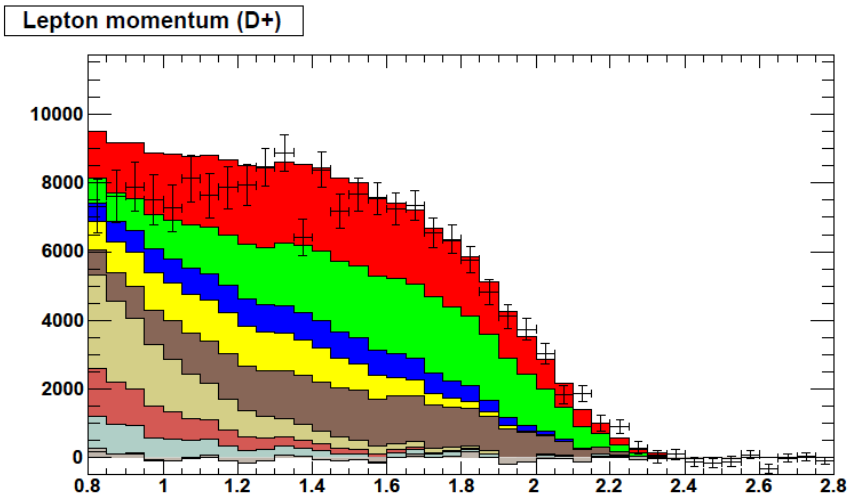
Summary

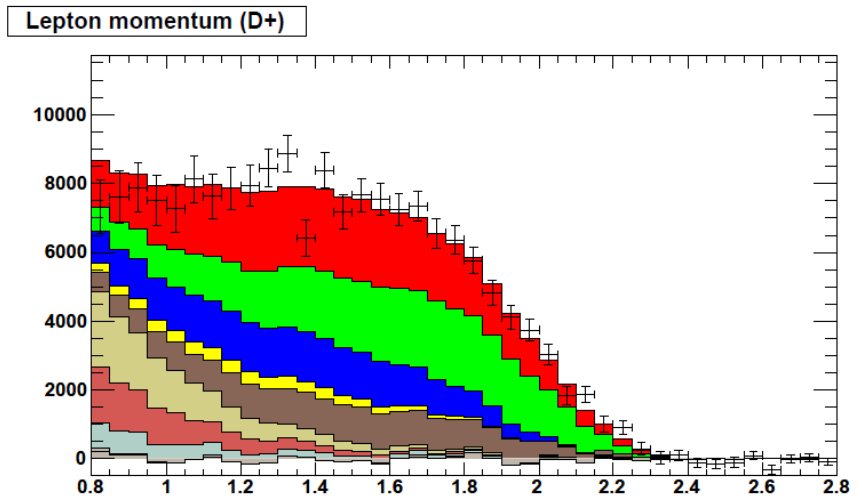
- Background BF re-weighting is done.
- $B->D^{**}l\nu$ FF re-weighting is done.
  - Effect is amall.
  - All D, D^* and D^{**} are now HQET models!
- Better agreement between MC and data
- Next steps (will be done soon)
  - Fit validation
  - Perform fitting
  - Systematic study
  - BAD1586 V2

Effect of All re-weighting, except *D*

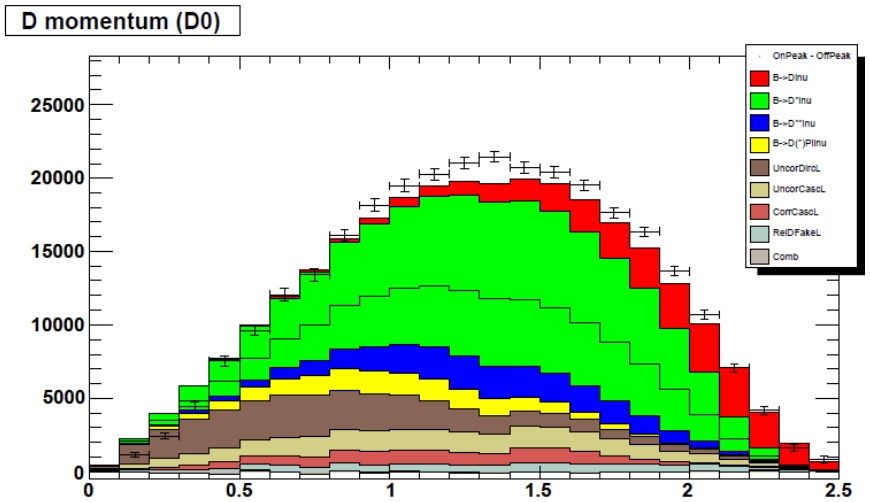


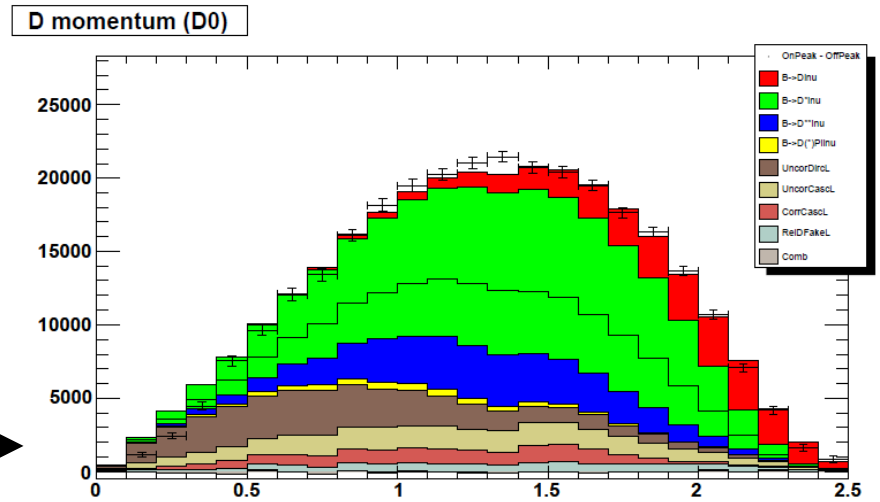


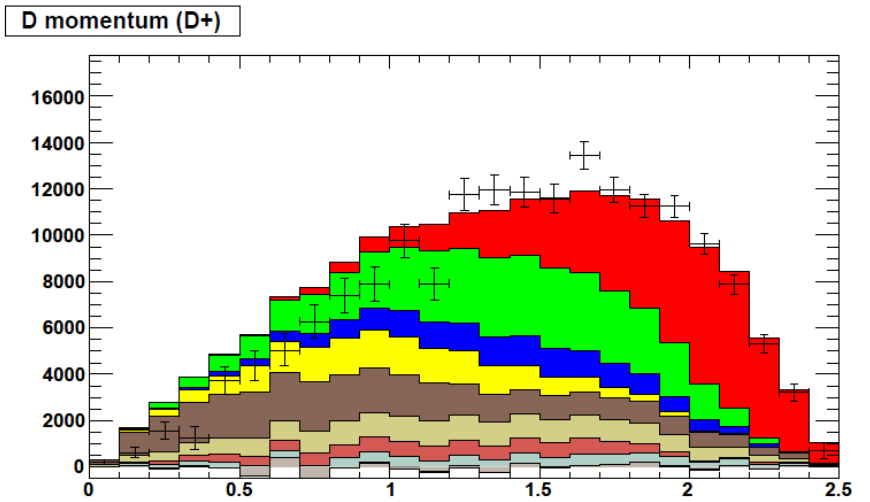


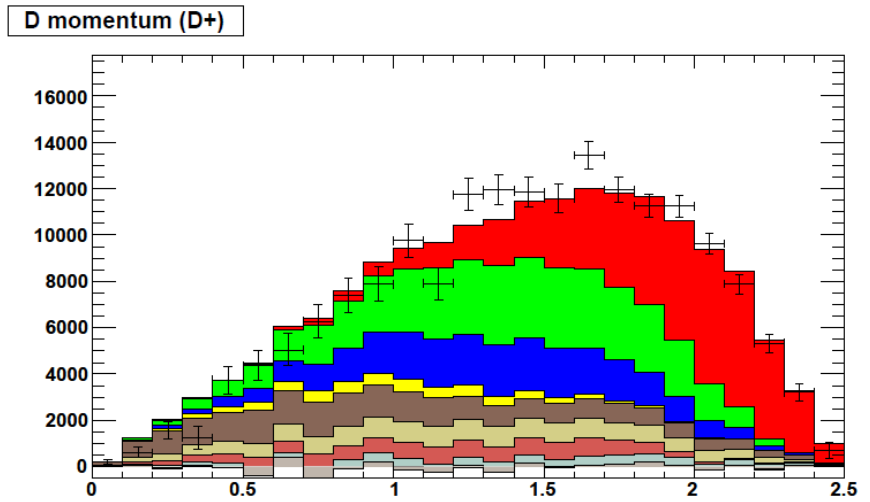


D Momentum

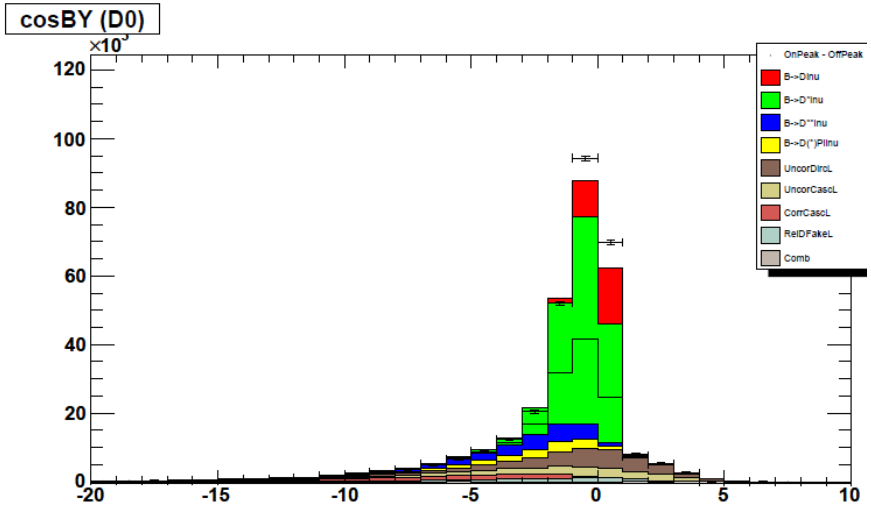

D momentum (D0)
OnPeak - OffPeak
B->Dlnu
B->D*lnu
B->D**lnu
B->D(*)Pilnu
UncorDirL
UncorCascL
CorrCascL
RelDFakeL
Comb
25000
20000
15000
10000
5000
0
0
0.5
1
1.5
2
2.5

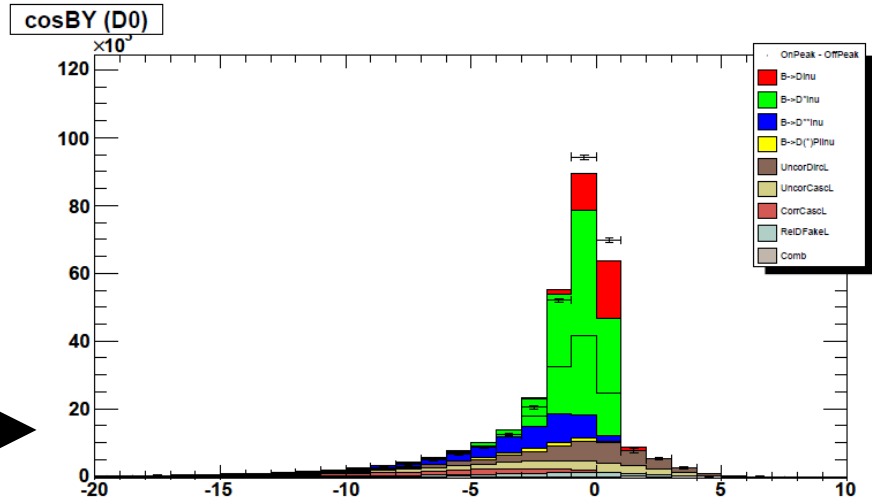

D momentum (D0)
OnPeak - OffPeak
B->Dlnu
B->D*lnu
B->D**lnu
B->D(*)Pilnu
UncorDirL
UncorCascL
CorrCascL
RelDFakeL
Comb
25000
20000
15000
10000
5000
0
0
0.5
1
1.5
2
2.5

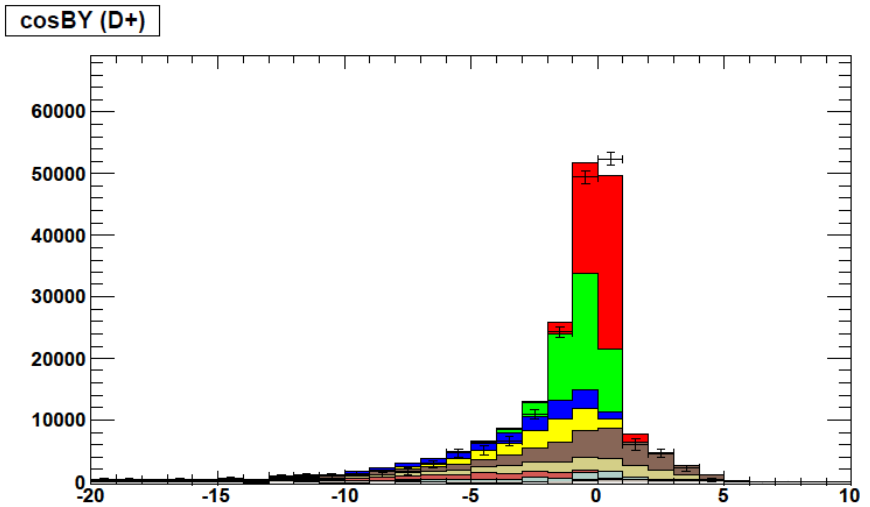

D momentum (D+)
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.5
1
1.5
2
2.5

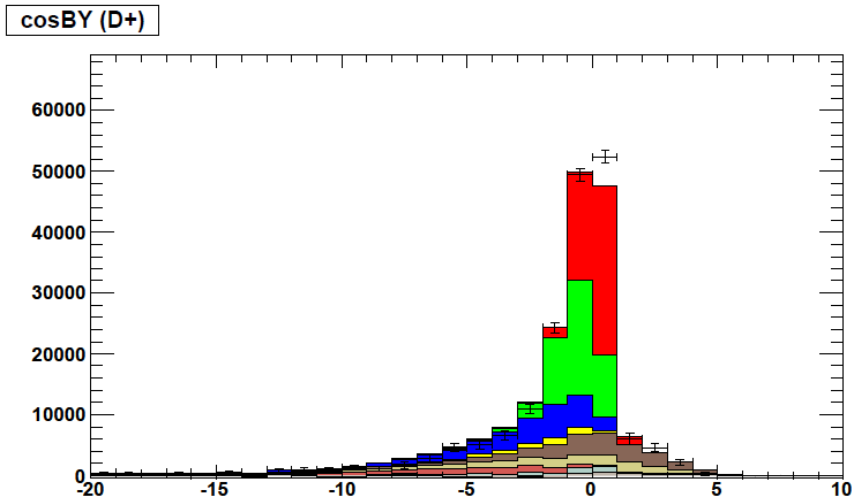

D momentum (D+)
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.5
1
1.5
2
2.5

cosBY


cosBY (D0)
×10³
120
100
80
60
40
20
0
-20
-15
-10
-5
0
5
10
OnPeak - OffPeak
B->Dlnu
B->D*lnu
B->D**lnu
B->D(*)Pilnu
UncorDirL
UncorCascL
CorrCascL
RelDFakeL
Comb


cosBY (D0)
×10³
120
100
80
60
40
20
0
-20
-15
-10
-5
0
5
10
OnPeak - OffPeak
B->Dlnu
B->D*lnu
B->D**lnu
B->D(*)Pilnu
UncorDirL
UncorCascL
CorrCascL
RelDFakeL
Comb


cosBY (D+)
60000
50000
40000
30000
20000
10000
0
-20
-15
-10
-5
0
5
10


cosBY (D+)
60000
50000
40000
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10000
0
-20
-15
-10
-5
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