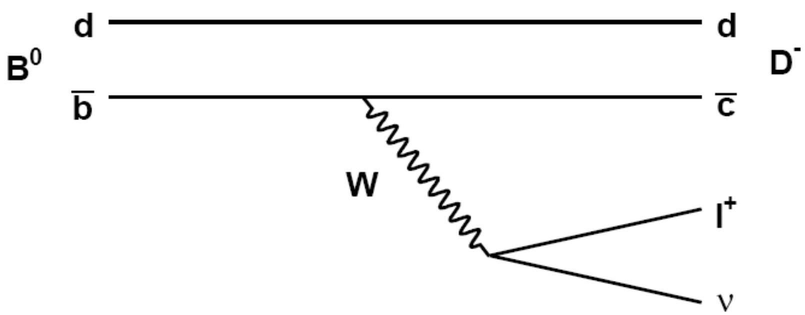
Global Fit for BF and FF in B->Dlnu decay

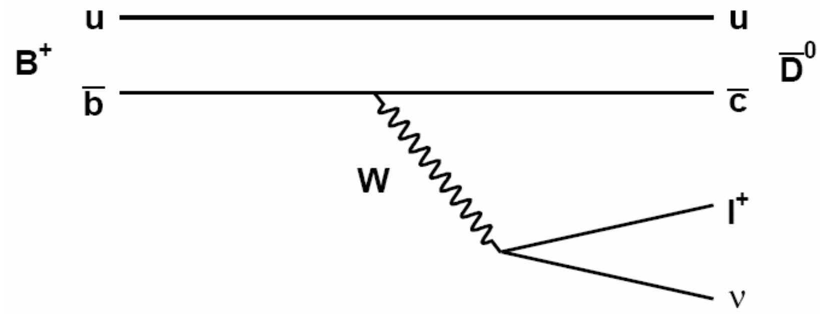
Fitting status

Motivation

- Determine B -> Dlnu and B->D*lnu Branching Fractions (BF)
  - Hoping to solve problems like
    - B0 -> D*- l nu BF disagreement
      - 0.0459 +- 0.0063 (BELLE 2002)
      - 0.0490 +- 0.0042 (Babar 2005)
      - 0.0590 +- 0.0072 (DELPHI 2004)
      - 0.0609 +- 0.0059 (CLEO2 2003)
    - Inclusive and exclusive discrepancy
      - Inclusive B0 -> Xc l nu : 0.105 +- 0.008 (PDG)
      - Exclusive B0 ->D- l nu : 0.0213 +- 0.0018
->D*- l nu : 0.0520 +- 0.0024
-> Others are small <0.01
- Determine B->Dlnu Form Factor (FF) slope
  - Current uncertainty ~ 30 %.

What is FF (Form Factor)?





- Quark level process is simple
  - Can be calculated with good precisions
- We need FF to include QCD effect in the B and D hadrons
  - QCD processes inside B or D hadron is non-perturbative
  - We push the non-perturbative effect into FF
  - Decay rate = (quark level process)*FF
- There are effective theories to deal with non-perturbative QCD
  - Quark models such as ISGW2 Model
  - HQET (Heavy Quark Effective Theory)
  - ChPT (Chiral Perturbation Theory), and more…

B->Dlnu decay FF and re-weighting

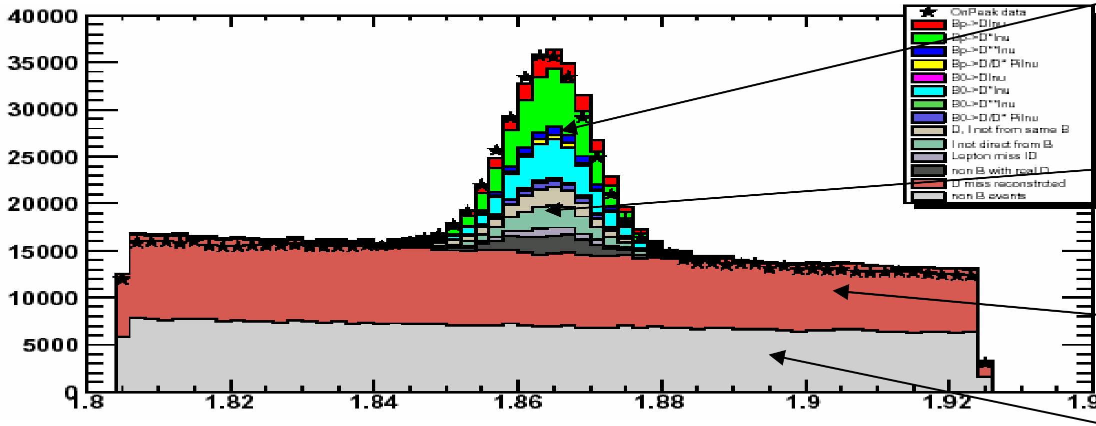
- In B->Dlnu decays, there is one FF:
  - h+(w) = R*f+(q^2)
    - W = (MB^2 + MD^2 – q^2)/(2MB*MD)
    - R=sqrt(MB*MD)/(MB + MD)
- ISGW2 Model and f+(q^2) is used in MC
- HQET
  - h+(w) = 1 – rho^2 (w -1)
  - rho^2 = FF slope
- Need to re-weight MC to change FF from ISGW2 to HQET
  - No need to generate new MC
  - We can just re-weight event by event (candidate by candidate) when making MC histograms.

Event Selection

- BToDlnu skim
  - Select events including B->D/D*lnu candidates.
- Bhabha veto
  - Reject radiative Bhabha events.
- Kaon selection
  - KMicroNotPion selector
- Vertexing (by TreeFitter)
  - D vertexing probab >0.01
  - B vertexing probab >0.01
- Trust cut
  - |cosDinonDl| < 0.88

D mass plot after selection

D0 mass (KPi mode)



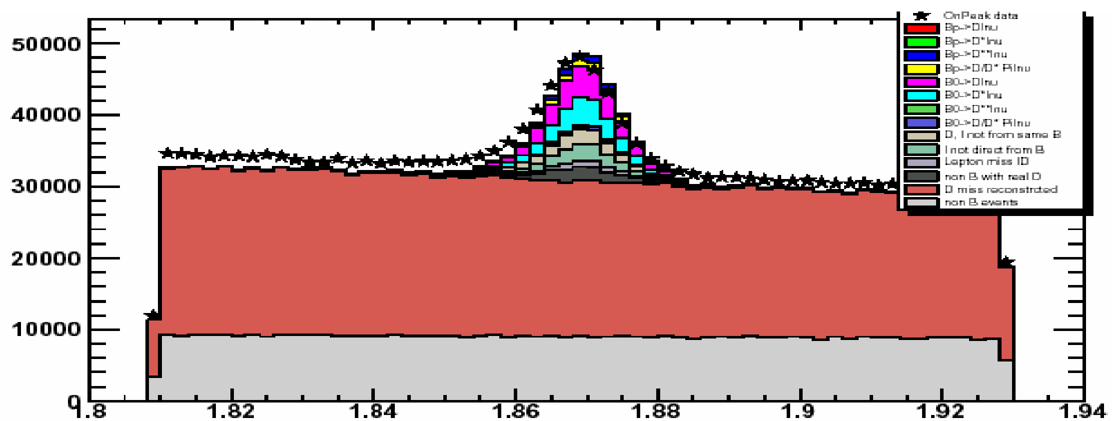
Signals

Peaking backgrounds from B and D

Continuum background from B

Continuum background from ccbar, uds and tau

D+ mass (KPiPi mode)



Do sideband subtraction to remove continuum background

After sideband subtraction

D momentum (D0)

OnPeak data

B->Dlnu (red)

B->D*lnu (green)

B->D**lnu (blue)

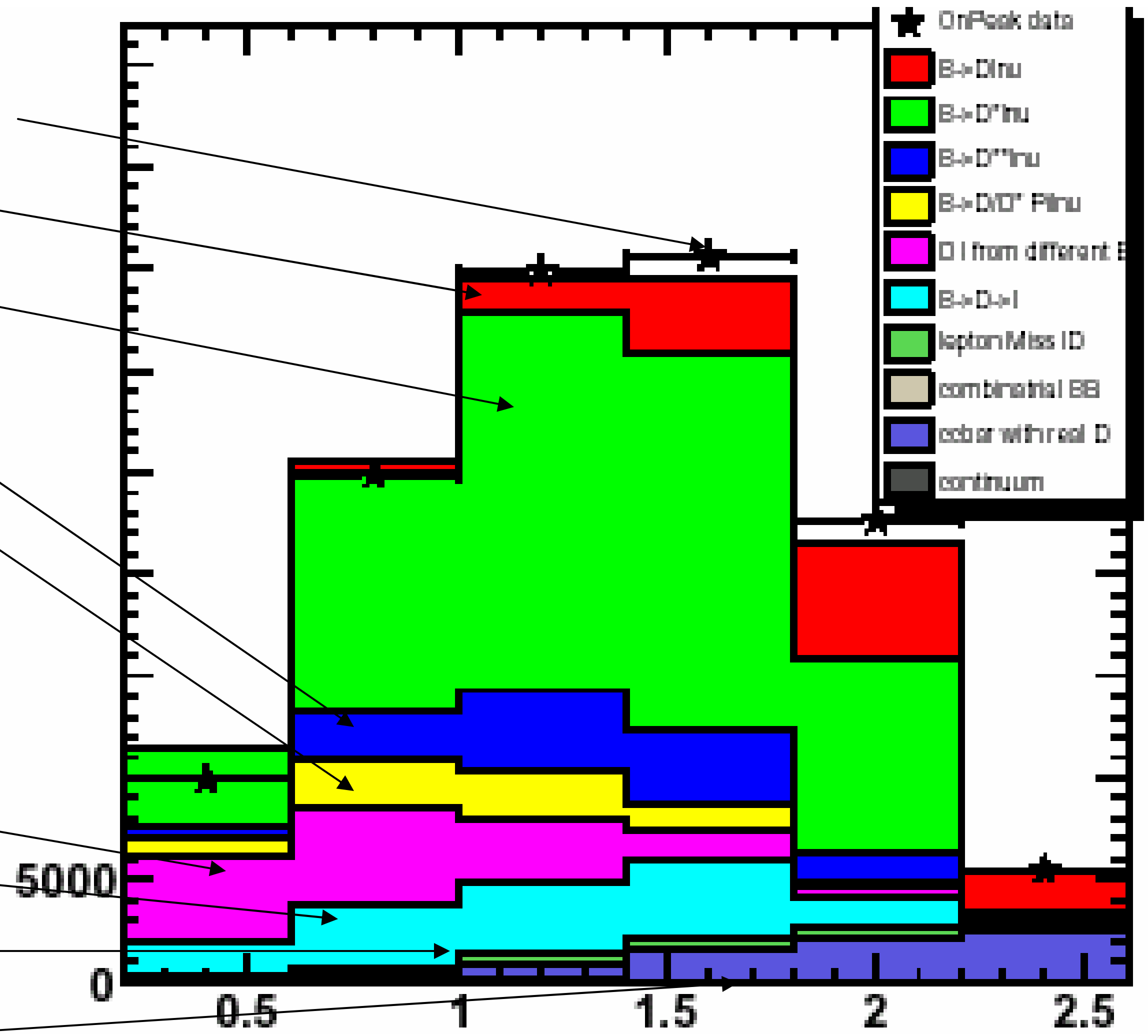
B->D/D*Pilnu (yellow)

Uncorr (magenta)

Casc L (light blue)

Fake L (dark green)

Cont D (purple)



What’s in the backgrounds?

- Uncorrelated background from BBbar
  - D and l came from different B
- Cascade lepton background from BBbar
  - Lepton did not come from B but came from D
- Lepton mis identification background from BBbar
  - Lepton was really a kaon, pi or proton
- Ccbar background with realD

Method of analysis

- Reconstruct only D0 l and D+ l candidates. All higher D state feeds down to D.
  - B->Dlnu
  - B->D*lnu, D*->DX
  - B->D**lnu, D** ->DX
  - B->D Pi lnu (non-resonant)
- Use clean modes D0->KPi and D+->KPiPi.
- Bin events in 3-D : D momentum, Lepton momentum and cosThetaB-Dl.
- Fit to B->Dlnu events.
  - Use MC histograms like PDF (Probability Density Functions)
  - Fit those PDFs to measured data.

Binning

- Lepton momentum bin (4bins):
  - 0.8, 1.2, 1.6, 2.0, 2.4 GeV
- D momentum bin (6 bins):
  - 0.2, 0.6, 1.0, 1.4, 1.8, 2.2, 2.6 GeV
- cosBY bin (5 bins):
  - -10, -2.5, -1.1, 0.0, 1.1, 5
- Total 120 * 2 (D+ and D0) = 240 bins
  - Use "#evt > 5" bins -> ~190 bins are used
- Run 3 data (30.6 fb-1)

  and MC (~100 fb-1 of BBbar and ~50 fb-1 of others)

  was used.

What is cosBY ?

- Y is Dl combination in this case
- cosBY = cosine of the angle between

  the direction of B

  and

  the direction of “D-l”

  in the Y(4S) rest frame
- -1 < cosBY < 1 is expected, but….

  This is not the case because of detector effects, miss-reconstructions, additional pion from higher D mass states or non-resonant DPilnu decays, etc.

  -> Can separate D**lnu, background etc.

Binned chi-square fitting

- Chi-sq = (N^{data} – sum of C*N^{MC})^2 / sigma^2
- Predicted number of events (N^{MC})
  - Tracking efficiency and PID corrected.
  - Luminosity normalised to data.
  - Form factor (FF) re-weighted.
- Coefficients (C) include
  - Branching fractions (BF)
  - Ratios like

    f_+0 = f_+-/f_00 (production rates ratio),

    t_0+ = t_00/t_+- (life time ratio),

    efficiency difference to reconstruct D+/D0 = c_D+0
- Isospin symmetry is assumed for B->DlnuX decays (not for D*->D).
- Use TMINUIT to minimize chi-square.

Validation of fitting

- Split Run3 MC into two halves.
- Use first half as a fake data.
- Fit this fake data by the second half of MC
- Results
  - Number of bins = 190, number of parameters = 18, number of dof = 190 - 18 = 172

    Chi-square = 170.0
  - Fitted branching fractions are consistent with the values used in the MC
    - B->Dlnu :0.02113 +- 0.00062 (0.0210 in SP5)
    - B->D*lnu :0.05564 +- 0.00086 (0.0560 in SP5)

First results of fitting to Data

- Branching fractions
  - BF(B->Dlnu) = 0.02542 +- 0.00079 (3.1 %)
  - BF(B->D*lnu) = 0.05625 +- 0.00114 (2.0 %)
  - Float all other branching fractions
- Dlnu FF slope
  - rho^2 = 1.473 +- 0.012 (0.8 %)
- Float background components separately fo D0 and D+
- Float f+0 and c_D+0. Gaussian constraints on f+0 and c_D+0
- No significant correlation between variables.

Fitted Plots (0)

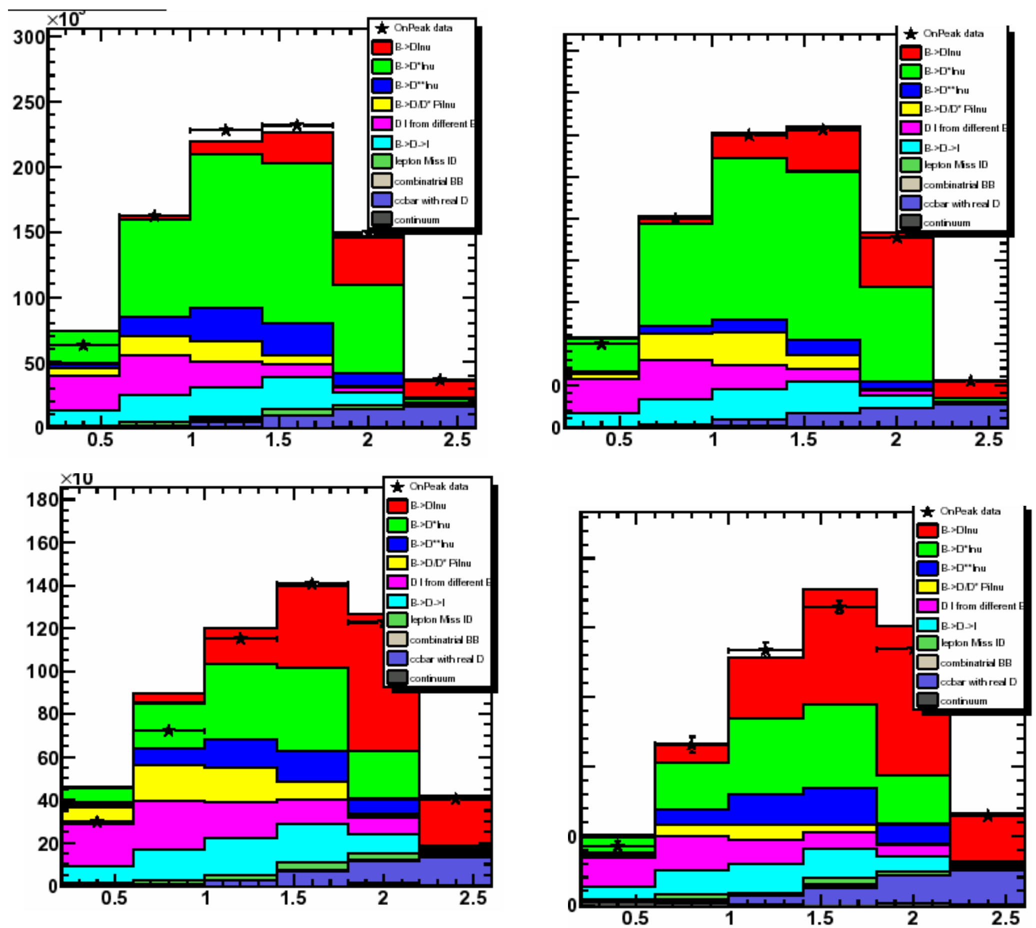
D momentum

Before fitting

After fitting

D0

D+

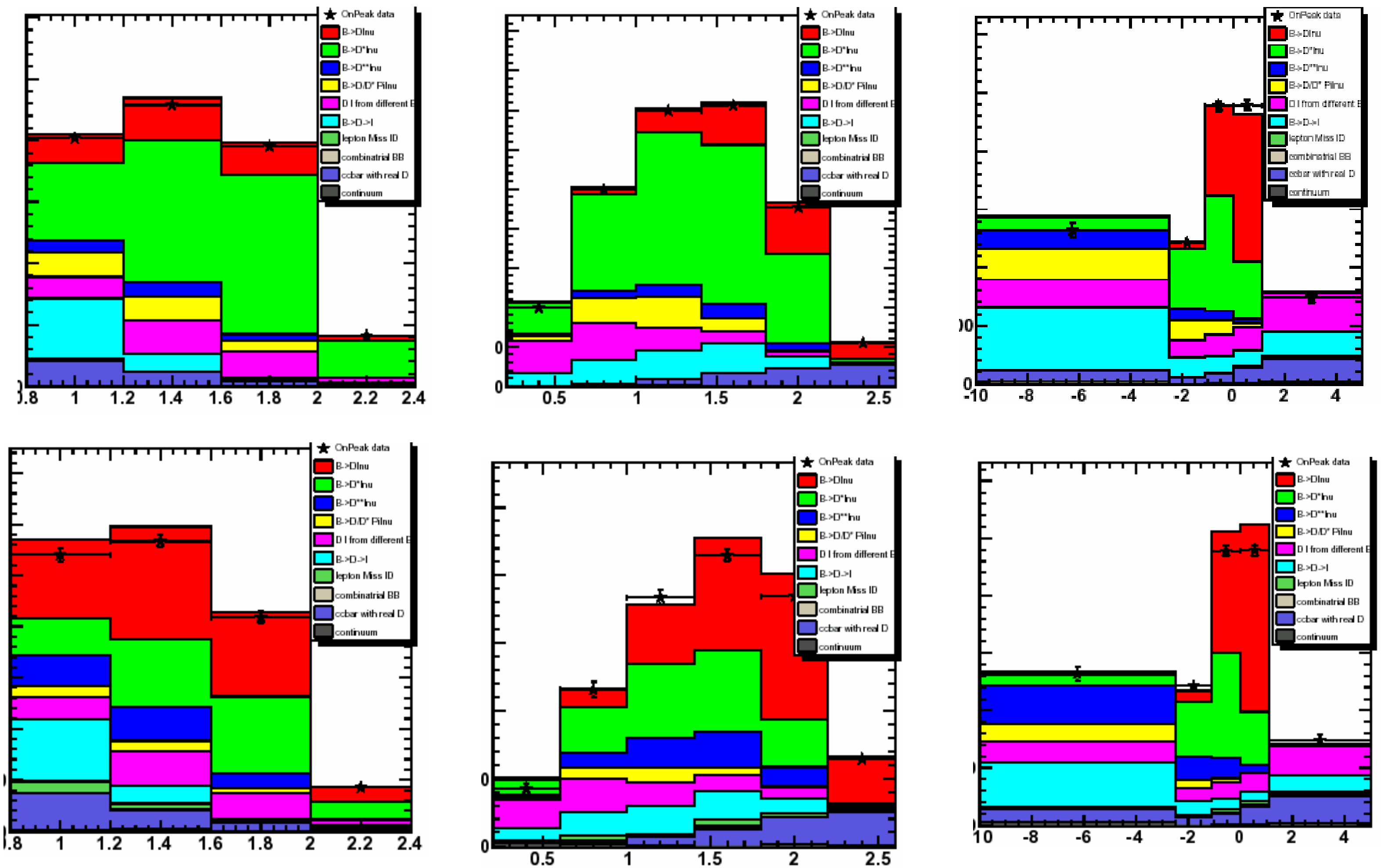


Fitted plots (1)

Lepton momentum | D momentum | cosBY

D0

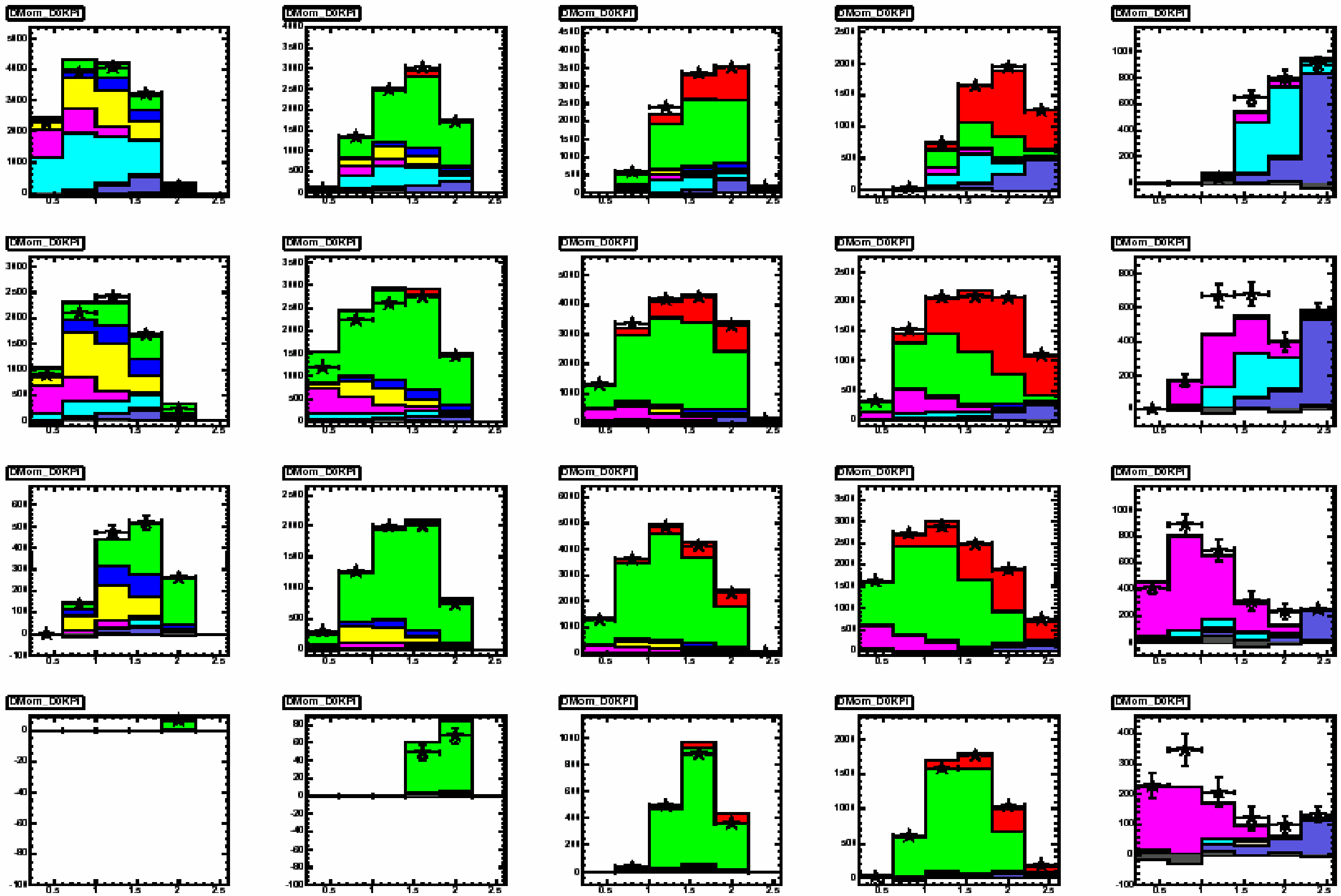
D+



Fitted Plots (2) – D0 momentum

neg ← cosBY → pos

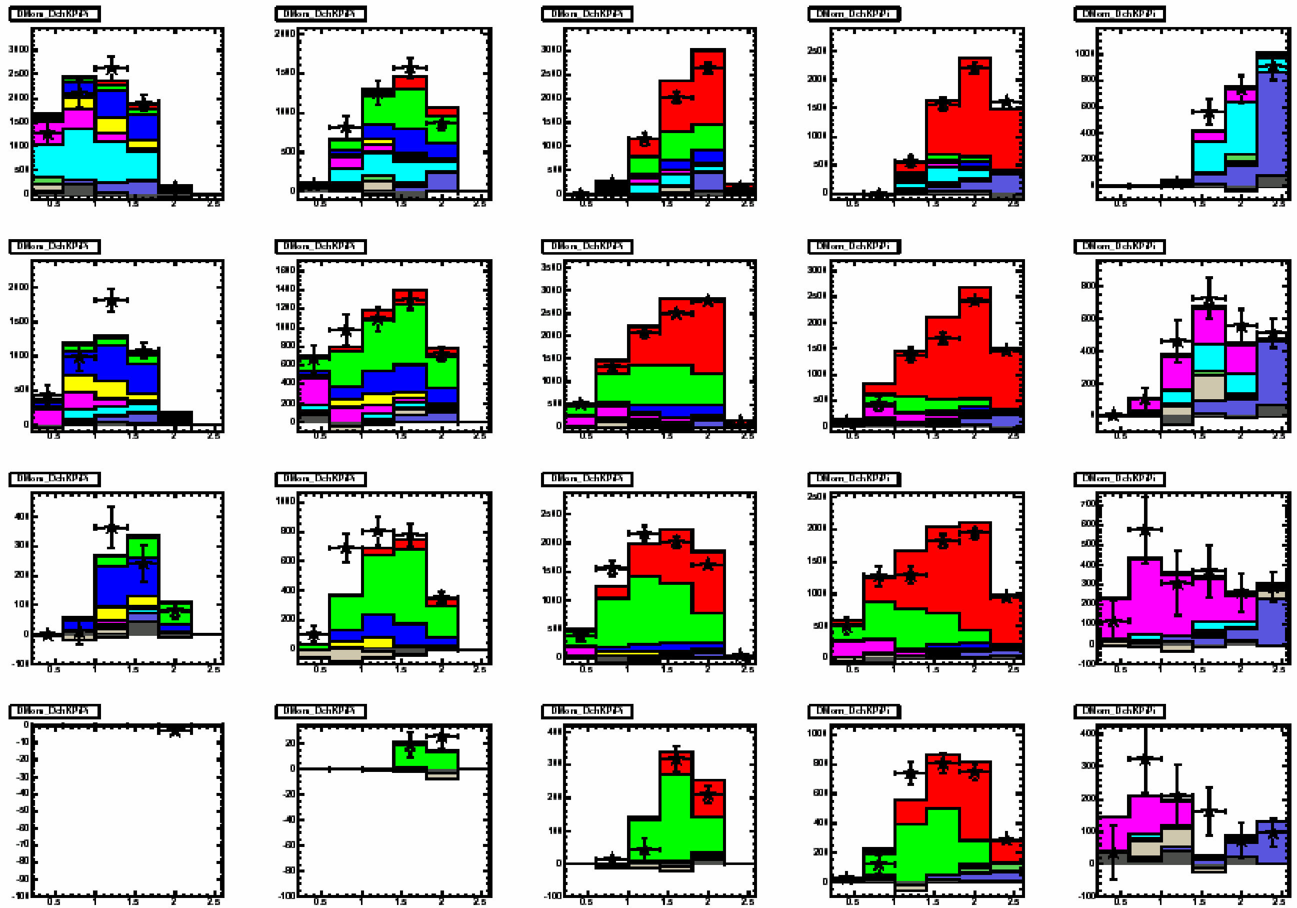
small ↑ Lep mom ↓ large



Fitted Plots (3) – D+ momentum

neg ← cosBY → pos

small ↑ Lep mom ↓ large



Next steps

- Vary B->D*lnu FF parameters.
- Re-weight D**lnu MC and DPilnu(non-resonant) MC.
- Apply constraints on D**lnu and D(*)Pilnu BFs in the fit.
- Systematic uncertainty.