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 between experiments.
    - B0 -> D* lnu, B+ -> D* lnu disagreement.
  - Check "Inclusive BF = Sum of Exclusive BF" ?
- Determine B->Dlnu Form Factor (FF) slope
  - Current uncertainty ~ 30 %.

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) = h+(1) [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.

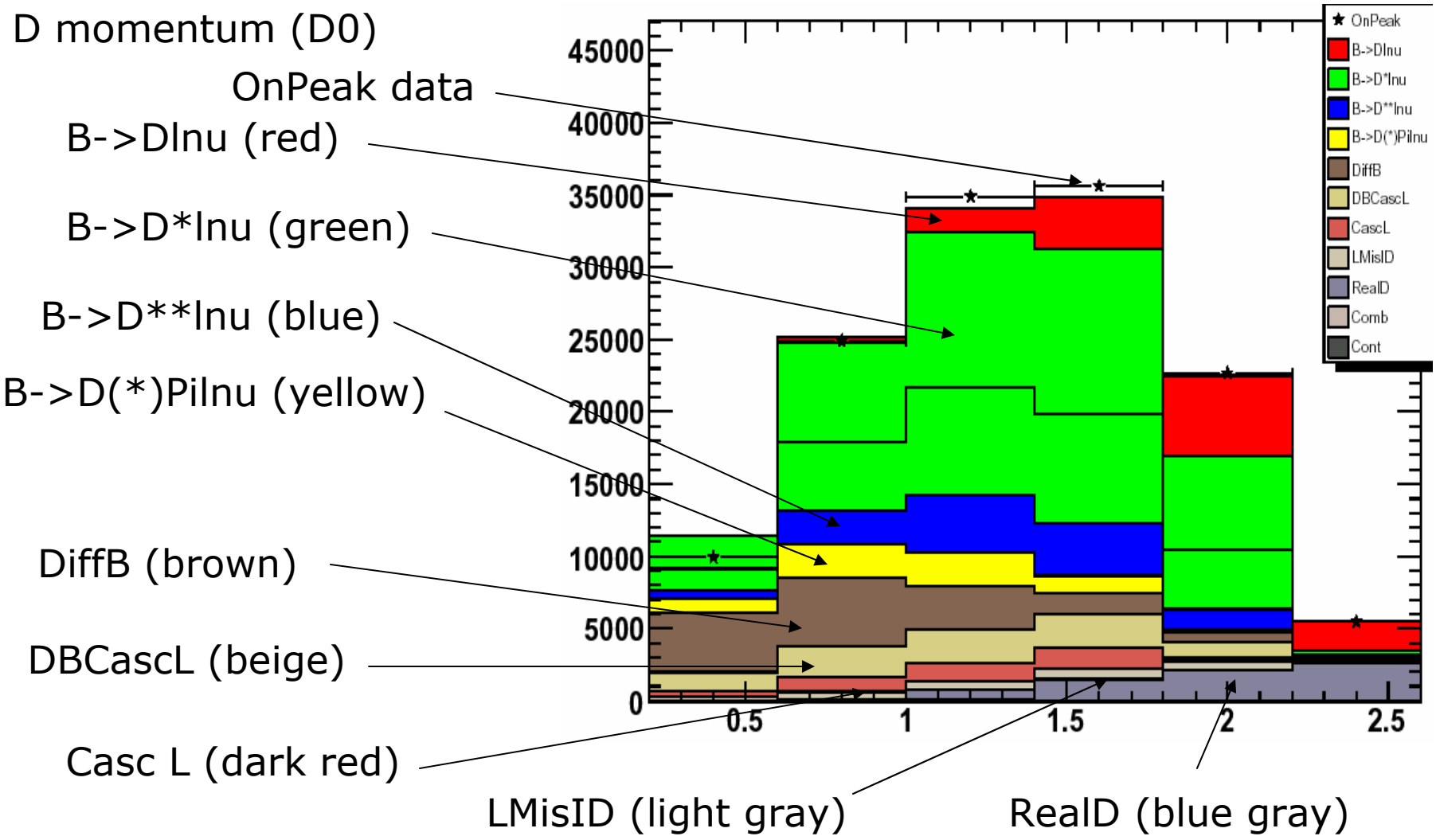
Event Selection

- BToDlnu skim
  - Select events including B->D/D*lnu candidates.
  - In practise, select Dl combinations.
- 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
  - $\cos\theta_{Dl-\mathrm{non}Dl} < 0.88$

Signal and background

- Signal
  - B -> D l nu
  - B -> D* l nu
  - B -> D** l nu
  - B -> D(*) Pi l nu (non-resonant)
- Background
  - DiffB = *D* and *l* come from different B. *l* come directly from B.
  - DBCascL = *D* and *l* come from different B. *l* come not directly from B (B -> D -> K l nu).
  - CascL = *D* and *l* come from same B. *l* does not come directly from B (B -> D -> K l nu).
  - LMisID = *l* miss identification.
  - RealD = ccbar events with real *D*.

After sideband subtraction



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 > 25" bins -> ~187 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.

Binned chi-square fitting

$$\chi^2 = \sum_i^{D^0} \frac{\left(N_i^{data} - \sum_j C_j N_{ij}^{MC} \right)^2}{\left(\sigma_i^{data}\right)^2 + \sum_j \left(C_j \sigma_{ij}^{MC}\right)^2} + \sum_i^{D^+} \frac{\left(N_i^{data} - \sum_j C_j N_{ij}^{MC} \right)^2}{\left(\sigma_i^{data}\right)^2 + \sum_j \left(C_j \sigma_{ij}^{MC}\right)^2}$$

- 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),
    c_+0 = MC modeling difference in D0 and D+
- Isospin symmetry is assumed for B->DlnuX decays (not for D*->D).
- Use TMINUIT to minimize chi-square.

Binned chi-square fitting

- Free parameters
  - Branching fractions
    - BF(B->Dlnu)
    - BF(B->D*lnu)
    - BF(Total B->D**lnu)
    - BF(Total B->D(*)Pilnu)
  - Background components
    - 5 components each for D0 and D+ = 10 parameters
  - Other constants
    - f_+0
    - c_+0
- Used constants
  - D** constants :
    D0*/D1= 0.88, D1'/D1 = 1.61, D2*/D1 = 0.77
  - D(*)Pi constants : Dpi/D*Pi = 0.66

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 : looks good
  - Number of bins = 179, number of parameters = 16, number of dof = 190 - 18 = 163

    Chi-square = 154
  - Fitted branching fractions are consistent with the values used in the MC
    - B->Dlnu :0.02073 +- 0.00089 (0.0210 in SP6)
    - B->D*lnu :0.0565 +- 0.0016 (0.0560 in SP6)
    - B->D**lnu :0.01557 +- 0.00099 (0.0150 in SP6)
    - B->D*Pilnu :0.0111 +- 0.0015 (0.0120 in SP6)

First results of fitting to Data

- Branching fractions
  - BF(B->Dlnu) = 0.0250 +- 0.0012 (4.8 %)
  - BF(B->D*lnu) = 0.0614 +- 0.0019 (3.2 %)
  - BF(B->D**lnu) = 0.0109 +- 0.0014 (13 %)
  - BF(B->D(*)Pilnu) = 0.0139 +- 0.0018 (13 %)
- Dlnu FF slope
  - rho^2 = 1.459 +- 0.053 (3.6 %)
- Float background components separately for D0 and D+
- Float f+0 and c_+0. Gaussian constraints on f+0 and c_D+0
- No significant correlation between variables.

B+/B0 -> D* lnu BF

- Relase isospin symmetry constarint on B+ -> D*lnu and B0 -> D* lnu
- Result
  - BF(B+ -> D*lnu) = 0.0585 +- 0.0037
  - BF(B0 -> D*lnu) = 0.0602 +- 0.0049
- Isospin symmetry holds!
  - Using B+/B0 lifetime ratio t_+0 = 1.071
  - (0.0602 +- 0.0049) * 1.071 = 0.0645 +- 0.0052

Problems of the fitting results

- #dof = #bins - #parameters = 187 – 17 = 170

  Chi-square = 307 : not really good.
- Some of fitted background components are far from 1.
  - LMisID(D0) = 0.175464 +- 0.224735
  - DiffB(D+) = 0.591759 +- 0.119507
  - DBCascL(D+) = 0.564115 +- 0.155397

Next steps

- Improve chi-square
  - Vary B->D*lnu FF parameters.
  - Re-weight D**lnu MC
  - Re-weight D(*)Pilnu (non-resonant) MC.
- Review constraints on D**lnu and D(*)Pilnu BFs in the fit.
- Review backgrounds.