Measurement of inclusive differential kinematic distributions for $|V_{cb}|$

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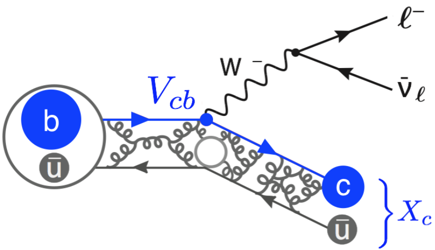
$|V_{cb}|$ from semi-leptonic decays



- $|V_{cb}| = \sqrt{\frac{\Delta\mathcal{B}}{\tau_B \Delta\Gamma}}$

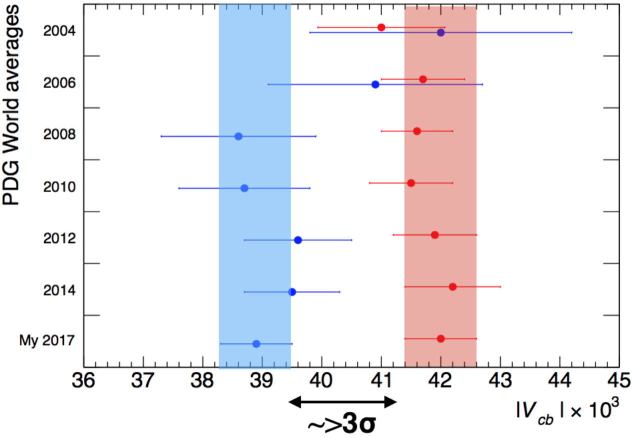
Exclusive V_{cb}

- $\bar{B} \to D l \bar{\nu}$
- Needs input from non-perturbative methods, e.g. lattice QCD.

Inclusive V_{cb}

- $\bar{B} \to X_c l \bar{\nu}$
- Total decay rate determined from the Heavy Quark Expansion (HQE).

Inclusive/Exclusive Puzzle



Exclusive

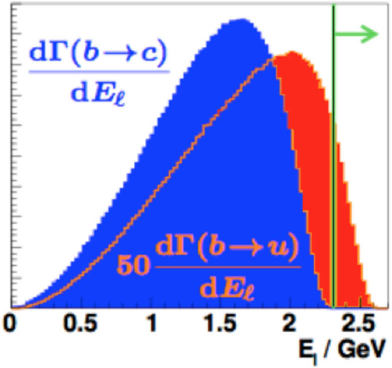
$\bar{B} \to D l \bar{\nu}$, $\bar{B} \to D^* l \bar{\nu}$

Inclusive

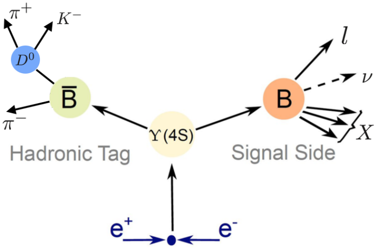
$\bar{B} \to X_c l \bar{\nu}$

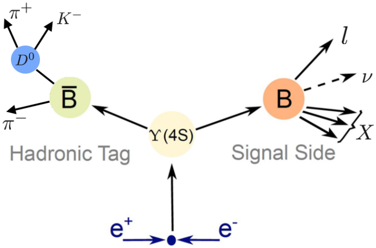
How can we help V_{ub}?

- Dominant background:
- $\mathcal{O}(100)$ times more abundant than $B \to X_u l \nu$ decays!
- Perfect to test and validate analysis strategies
- Improved MC modelling for background decays
- Affects the normalisation mode



Reconstruction

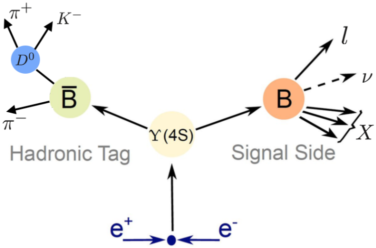




Signal lepton

One lepton with $p_l^B > 1$ GeV.

Reconstruction



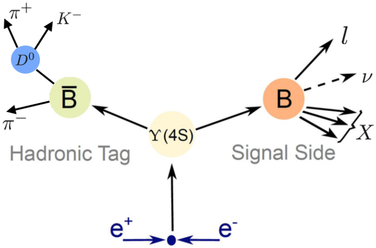
Signal lepton

One lepton with $p_l^B > 1$ GeV.

Missing mass^2

$$p_\nu^2 = (p_{\Upsilon(4s)} - p_{B_{tag}} - p_X - p_l^B)^2$$

Reconstruction



Signal lepton

One lepton with $p_l^B > 1$ GeV.

Missing mass^2

$p_\nu^2 = (p_{\Upsilon(4s)} - p_{B_{tag}} - p_X - p_l^B)^2$

Additional selection

- $M_{bc} > 5.24$ GeV
- log(NB) & log(ContNB)> -4
- Charge correlation cut

Upgrade both signal and background samples

Update the modelling of both the $b \to ul\nu$ signal and the $b \to cl\nu$ background to the very latest, state-of-the-art:

Signal

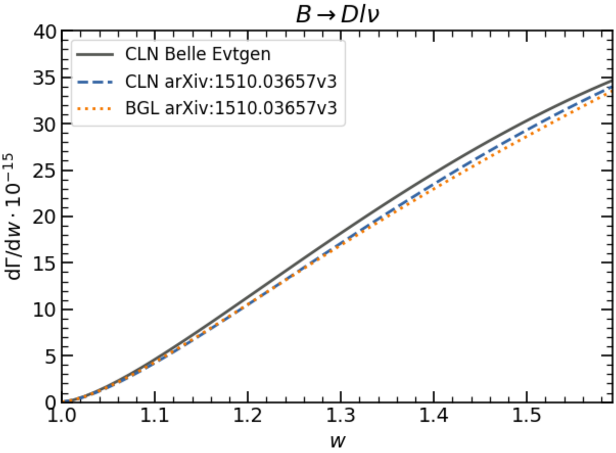
- Reweight $[D, D^*, D^{**}]$ to the latest form factors (BGL, LLSW)
  - Reweight in 1D for D and D^{**} and
  - reweight in 4D for D^* from EvtGen default.
  - Gap model for inclusive and sum over excl. difference, $[D^*\pi\pi, D^*\eta]$.

Background

- Reweight $[\pi, \rho, \omega]$ to latest form factors (BCL, SSE) and use new hybrid mixing
  - Reweight in 1D for π and ω and
  - reweight in 4D for ρ from EvtGen default.
  - Resonant & non-resonant hybrid model.

Exclusive $B \to Dl\nu$

- 1D reweighing in q^2 of $B \to Dl\nu$ FFs from EvtGen HQET2 (CLN) to BGL FFs



Exclusive $B \to D^{**} l\nu$

- Particle masses and widths for $B \to D^{**} l\nu$ used in Belle generic MC are outdated
- Use new Belle MC with updated values generated by M. Welsch, as shown in the table below
- The values in parenthesis are the original values used for the simulation of the official Belle MC
- Reweight using interpolated ratio of generator level variables histograms

	Charged		Neutral	
D^{**} Type	Mass in GeV	Width in GeV	Mass in GeV	Width in GeV
D_1	2.4230 (2.4270)	0.0200 (0.0280)	2.4223 (2.4222)	0.2040 (0.0189)
D_2^*	2.4601 (2.4590)	0.0370 (0.0250)	2.4611 (2.4589)	0.3090 (0.0230)
D_1'	2.4450 (2.4223)	0.2503 (0.4120)	2.4450 (2.4223)	0.2503 (0.4120)
D_0^*	2.4000 (2.3080)	0.1503 (0.2760)	2.4000 (2.3080)	0.1503 (0.2760)

Filling the Gap

New MC!

To fill the gap between the inclusive and exclusive measurement, additional MC samples were generated (again with the help of Max :)):

- $B \to D_1(\to D\pi\pi)l\nu$
  - This sample needs to be reweighted and added back with the rest of the D^{**} MC
- $B \to D^*\pi\pi l\nu$
- $B \to D^*\eta l\nu$
- The final cocktail seems insufficient and needs more work.

Putting everything together

$b \to ul\nu$

- Resonance & non-res. Hybrid Model (10 streams)

$b \to cl\nu$

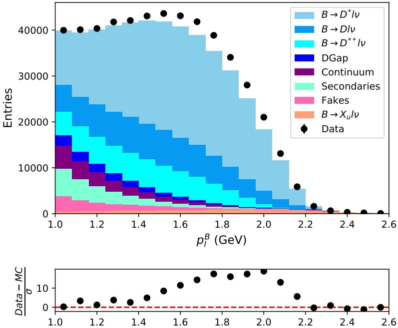
- Generic MC (with D^{**}'s and existing gap kicked out) (1 stream)
- New D^{**} (approximately 10 streams)
- Additional gap decay modes (2 streams)

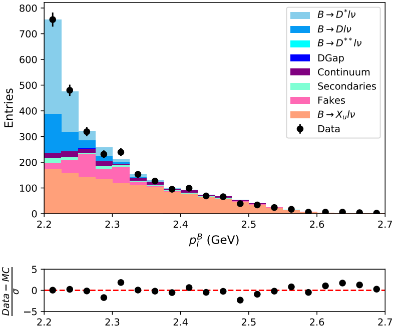
MC Correction weights

- Form factor weights
- PID corrections
- Tagging efficiency corrections
- Many, many more!

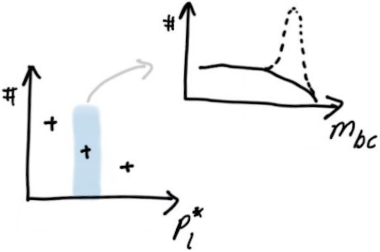
p_l distribution before fitting

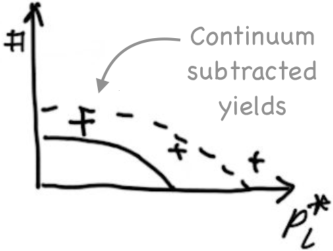
- Looking here at the normalisation mode: $B \to Xl\nu$





Background subtraction





- Subtraction of continuum background and badly reconstructed B-tags with m_{bc} fits.

- Subtraction of other backgrounds.

Signal extraction and other cool stuff

Now that we've sorted out the MC cocktail, we can investigate a bunch of potentially cool stuff:

Fit p_l to extract normalisation BF:

- Perform a likelihood binned fit with templates obtained from MC
- Plan to use the BF's of individual states as a constraint to the fit
- Plan to float the 2 broad D^{**} states, while keeping the narrow states fixed.

Investigate the MM^2 distribution. Can we fit this distribution in some way?

Try performing 2D fits in a similar manner as described above.