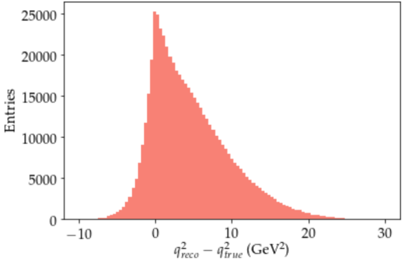
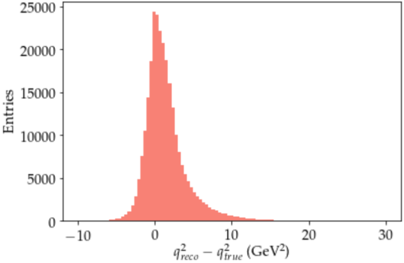
q^2 resolution

The $|E_{miss} - p_{miss}| < 0.5$ GeV selection requirement greatly improves the resolution:



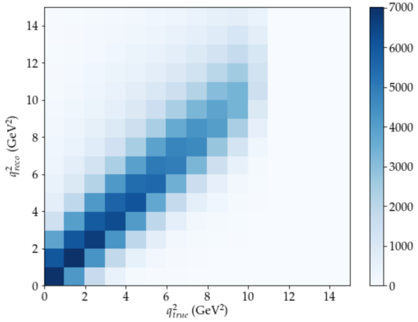
Resolution before cut



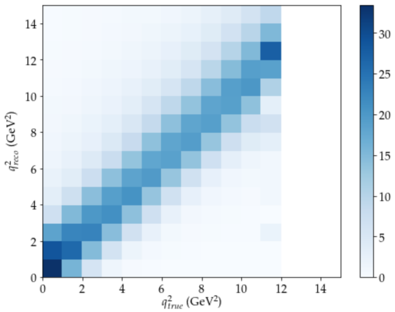
Resolution after cut

Me: the resolution looks so much better now!
Christoph: still looks really bad.
Me: oh. :-(

Migration matrix



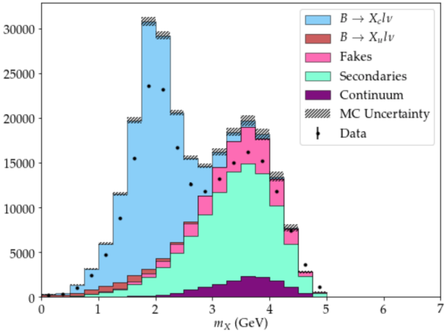
Before normalizing



Normalized to percentage

Secondary correction

Use a secondary enriched region to estimate a secondary shape correction function:

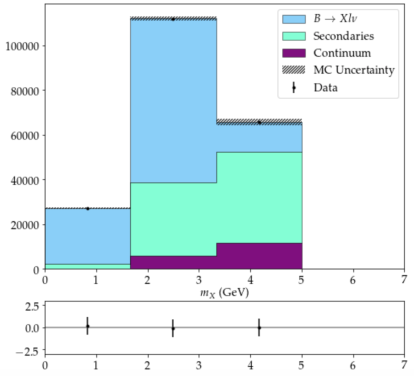


Secondary selection

- $m_{bc} > 5.27$ GeV
- $\log(\text{NB}) > -4$
- $\log(\text{contNB}) > -4$
- $p_e > 0.3$
- $p_\mu > 0.6$
- $Q_{tag} \times Q_{lep} > 0$
- $|E_{miss} - p_{miss}| < 0.5$

Secondary correction

Use a secondary enriched region to estimate a secondary shape correction function:

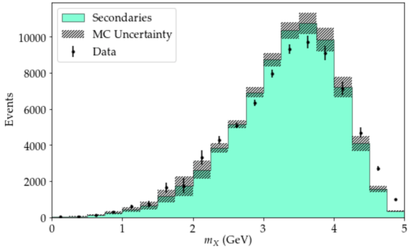


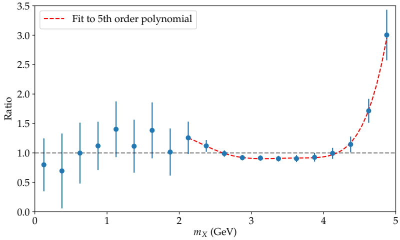
- Fit m_X in coarse bins to determine $B \to Xl\nu$ component
- Use these normalizations to subtract the m_X distribution in fine bins
- Derive a correction function from the secondary versus subtracted shape

Christoph: why are you doing something so complicated?

Secondary correction

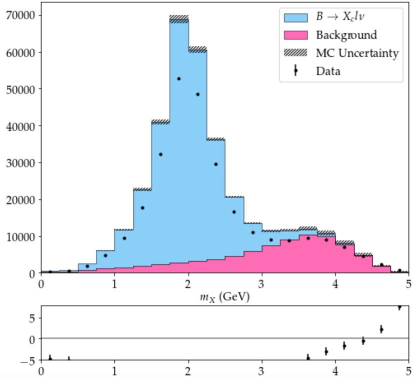
Use a secondary enriched region to estimate a secondary shape correction function:



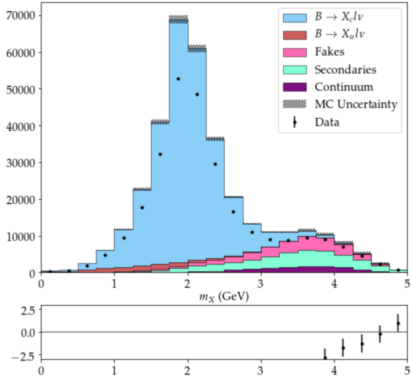


- Derive a correction function from the ratio between the secondary shape and subtracted data.

Corrected m_X distribution



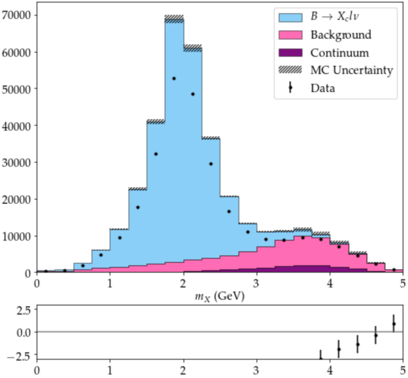
Before



After

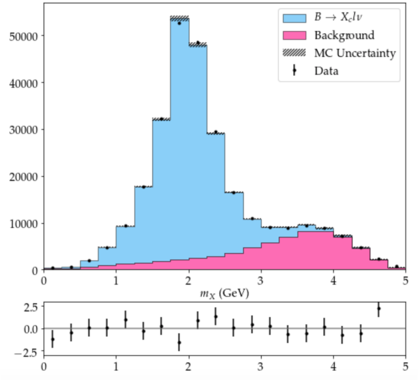
Fit with corrected m_X distribution

Estimate background component from a three component template fit to m_X

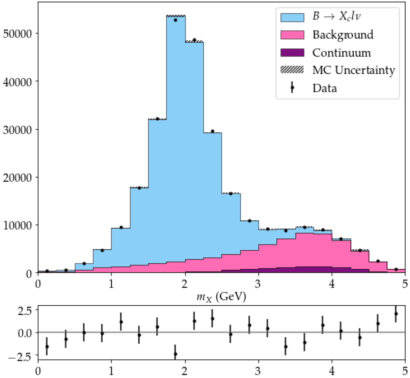


- Templates constained to $X_c l \nu$ BF errors (PDG 2020)
- All MC correction errors included as nuisance parameters
- 100% uncertainty assigned to the Gap modes
- Continuum constrained to off-resonance expectation

Fit results

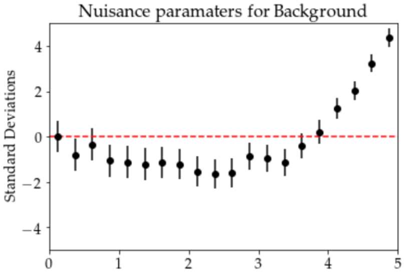


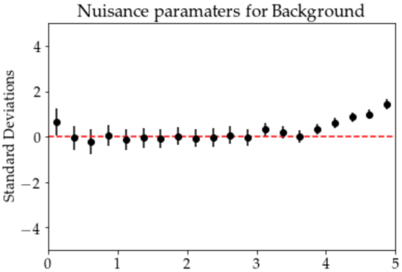
Old



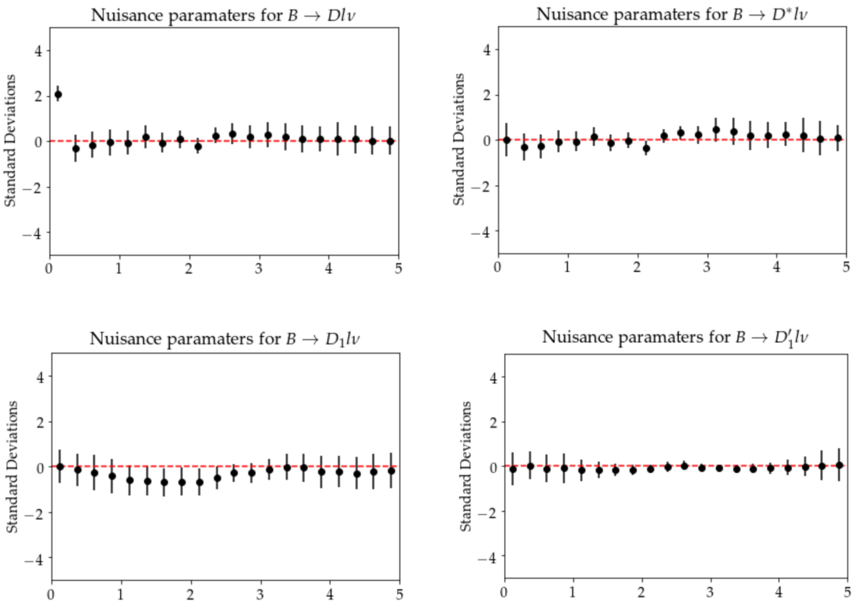
New

Nuisance parameters

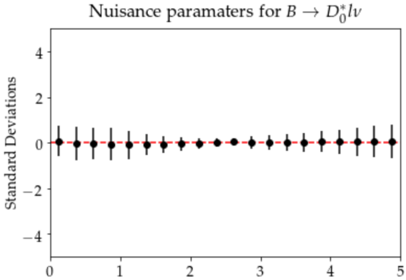


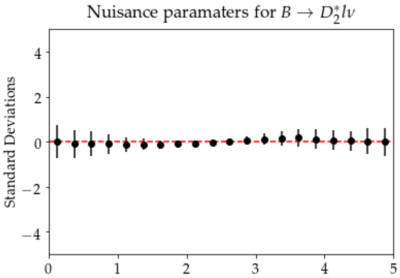


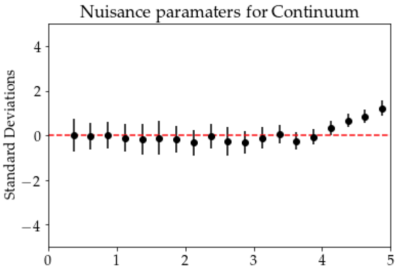
Nuisance parameters



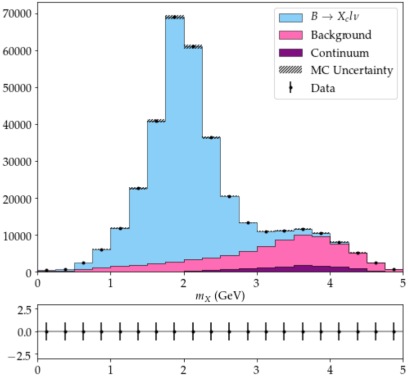
Nuisance parameters

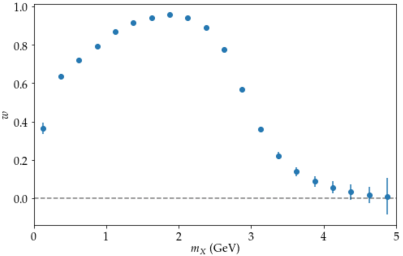






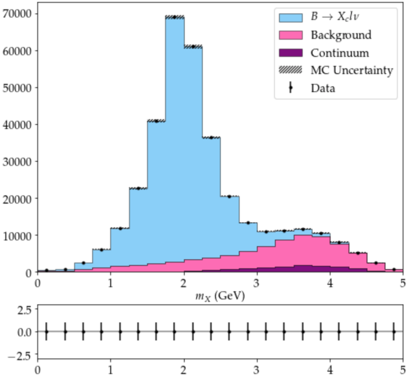
Calculate $w(m_X) = 1 - N_{bkg}/N_{tot}$ for each bin (only with MC for now):

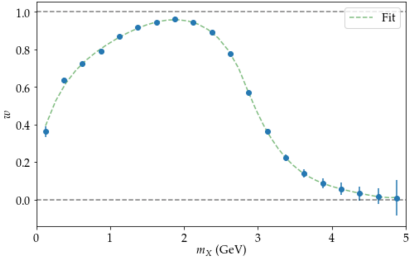




Calculating w_i

Calculate $w(m_X) = 1 - N_{bkg}/N_{tot}$ for each bin (only with MC for now):

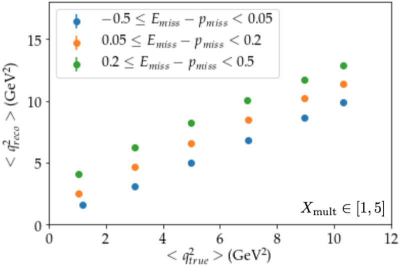


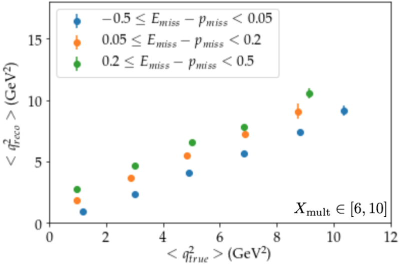


- Here, I fitted 2 polynomials over different ranges

Calibration

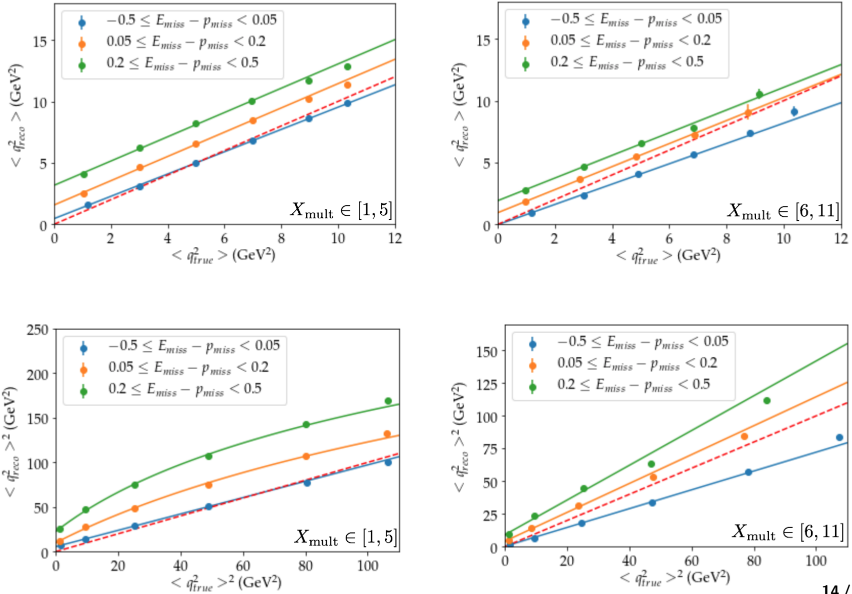
- Determine $\langle q^2_{,\mathrm{reco}} \rangle$ and $\langle q^2_{,\mathrm{true}} \rangle$ in bins of $q^2_{,\mathrm{true}}$
- We see a linear behaviour between $\langle q^2_{,\mathrm{reco}} \rangle$ and $\langle q^2_{,\mathrm{true}} \rangle$
- Fit in bins of X_{mult} and $E_{miss} - p_{miss}$
  - Three bins in $E_{miss} - p_{miss}$: [-0.5, 0.05, 0.2, 0.5] GeV
  - Two bins in X_{mult}: [1, 5] and [6, 10]
- Calculate $q^2_{,\mathrm{calib}} = (q^2_{,\mathrm{reco}} - c)/m$





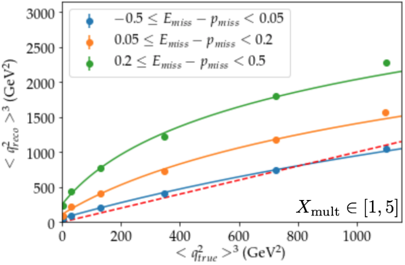
Fit to extract the calibration

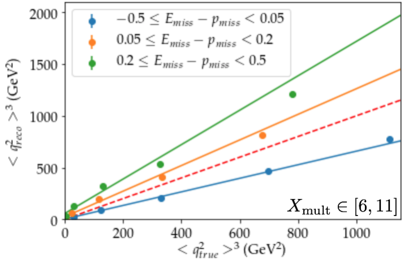
Fit linear curves to each of the scatter plots:

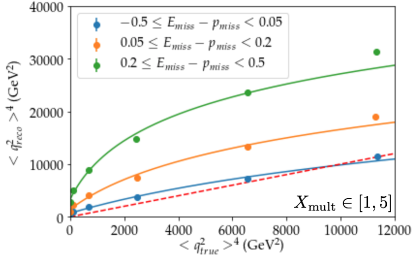


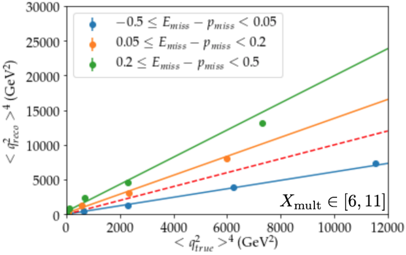
Fit to extract the calibration

Fit linear curves to each of the scatter plots:









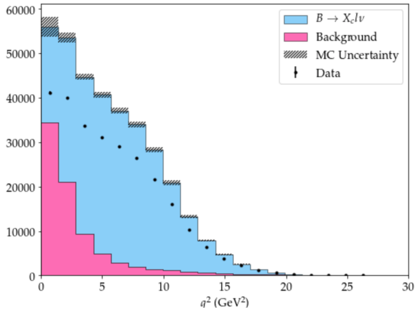
Old next steps

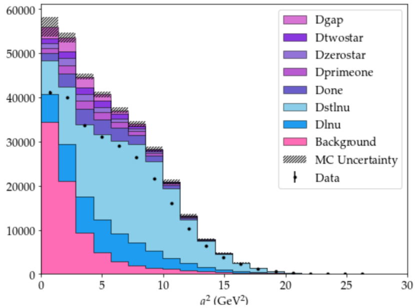
- Finish deriving the correction function for the secondaries (check!)
- Redo the m_X fit with the shape correction factors from the secondary enriched sample (check!)
- Determine the event-wise signal probability as a function of m_X (check!)
- Study and refine the calibration steps a bit more (check!)
- Investigate the additional bias correction, $\mathcal{C}_{\text{calib}}$ (Working on it!)
- Bonus Round: Get MC closure (Almost done!)

Next steps, questions, discussion points

- Finish getting MC closure
- Investigate the additional bias correction, $\mathcal{C}_{\text{calib}}$
- Propagate uncertainties through all the analysis steps
- Decide the width that we will use to present the final results
- Write my Belle Note (/thesis) when I'm bored (FYI: already started)

q^2 distribution after selection and corrections





How to calculate moments

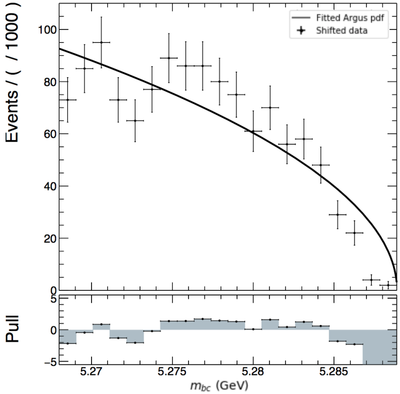
Moments calculated as a weighted mean:

$$\langle q^2 \rangle_n = \frac{\sum w_i(q^2)(q^2_{\mathrm{calib},i})^n}{\sum_i w_i(q^2)} \times \mathcal{C}_{\mathrm{calib}}$$

- $w_i(q^2)$: Event-wise signal probability as a function of q^2
- $q^2_{\mathrm{calib},i}$: Calibrated q^2_{reco}
- $\mathcal{C}_{\mathrm{calib}}$: Additional bias correction

Continuum correction

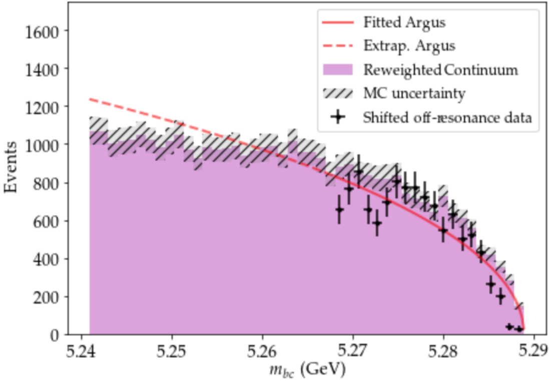
Use off-resonance data to derive a correction factor for Continuum MC



- Apply nominal selection cuts
- Shift data to end point of the distribution
- Fit Argus function to data points
- Extrapolate to full m_{bc} range

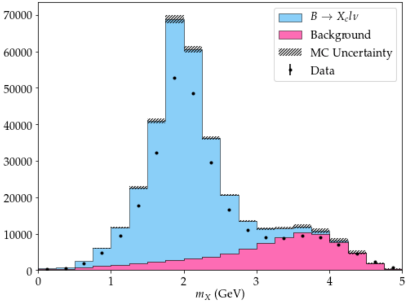
Continuum correction

Weight the number of MC to the number of expected events from the fit result:



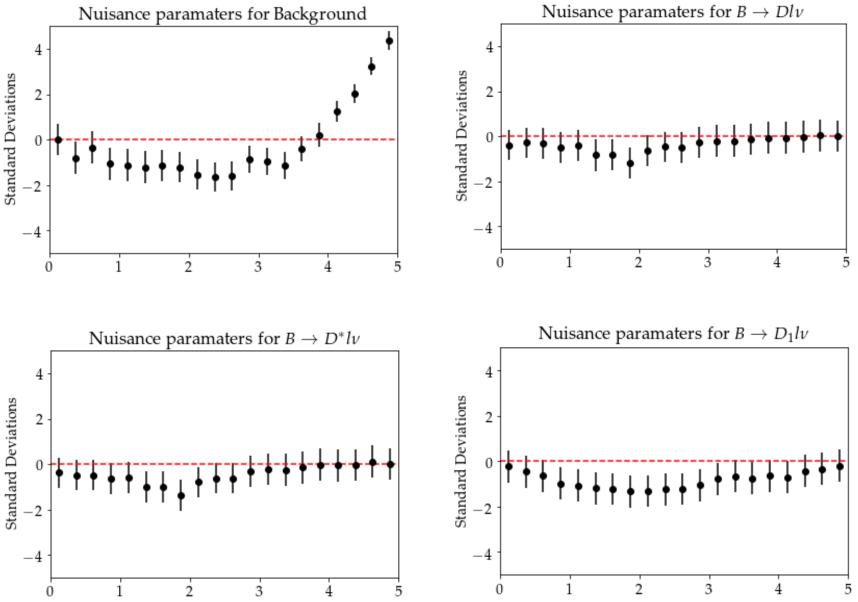
Old background subtraction

Estimate background component from a two component template fit to m_X

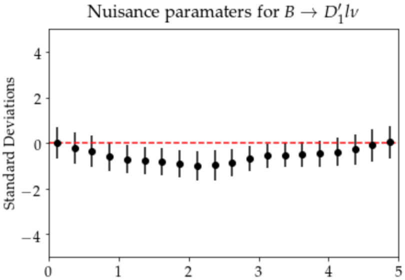


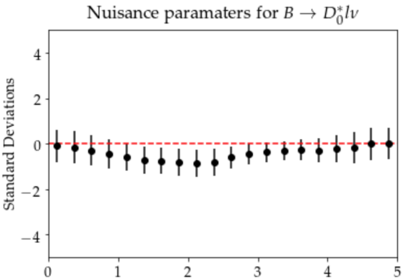
- Templates constained to $X_c l \nu$ BF errors (PDG 2020)
- All MC correction errors included as nuisance parameters
- Tracking error
- 100% uncertainty assigned to the Gap modes

Old nuisance parameters



Old nuisance parameters





Old nuisance parameters