$|V_{ub}|$ and $|V_{cb}|$ at LHCb via tagging

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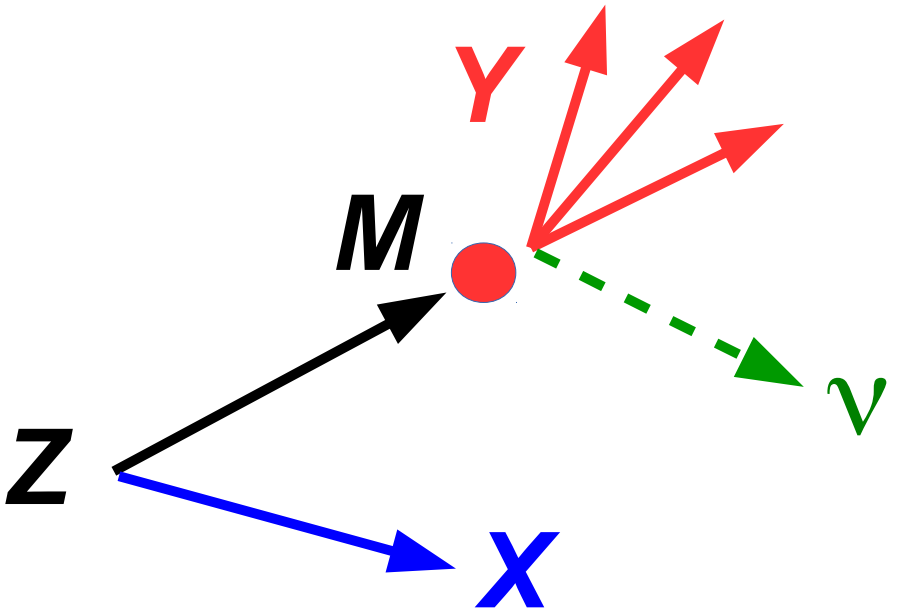
$|V_{ub}|/|V_{cb}|$ tensions

- The CKM elements $|V_{ub}|$ and $|V_{cb}|$ are critical inputs to closure test of the UT within the SM.
- Both show persistent tensions! Expected to be resolved after Belle II (flagship problem).
- Difficulty within LHCb – single missing neutrino can be reconstructed via vertexing, but with a two-fold ambiguity.
- IMO – lots of signal, but darned ambiguity means we can't pull it out.

Breaking the two-fold ambiguity via tagging

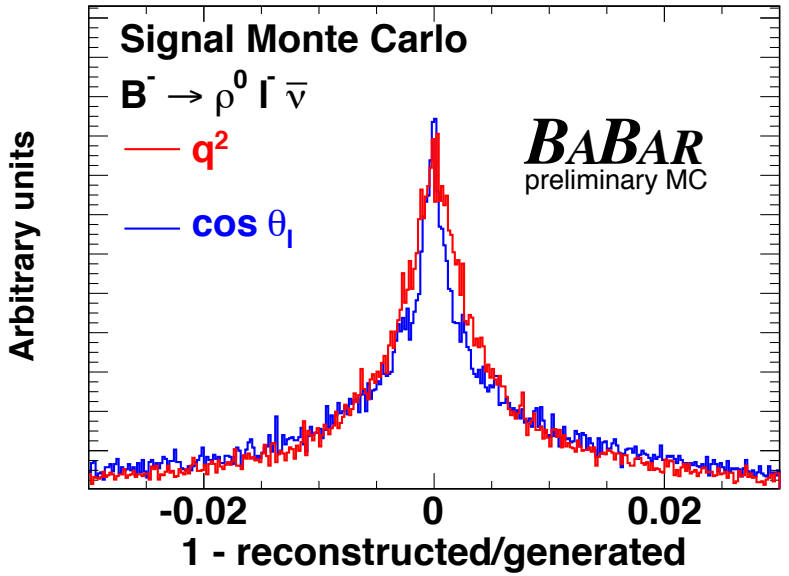


- $\{D^*, B^*_{s2}, \Sigma_b^{(*)}\} \to \{\pi, K\} M(\to Y(\nu))$
- Only one solution will peak at the $\{\Sigma_b^{(*)+}, B^*_{s2}, D^{*+}\}$ mass. Breaks the two-fold ambiguity.

Why we need a kinematic fitter to do this

- The missing neutrino 4-mom. comes from solving a quadratic equation. If $Det < 0$ (due to resolutions), no physical solutions.

- These cases can be nicely recovered by `TreeFitter` and mass-constraining the neutrino.
- Proven technique from *BABAR* tagged SL analyses. Percent-level resolutions after missing neutrino mass-constrained.

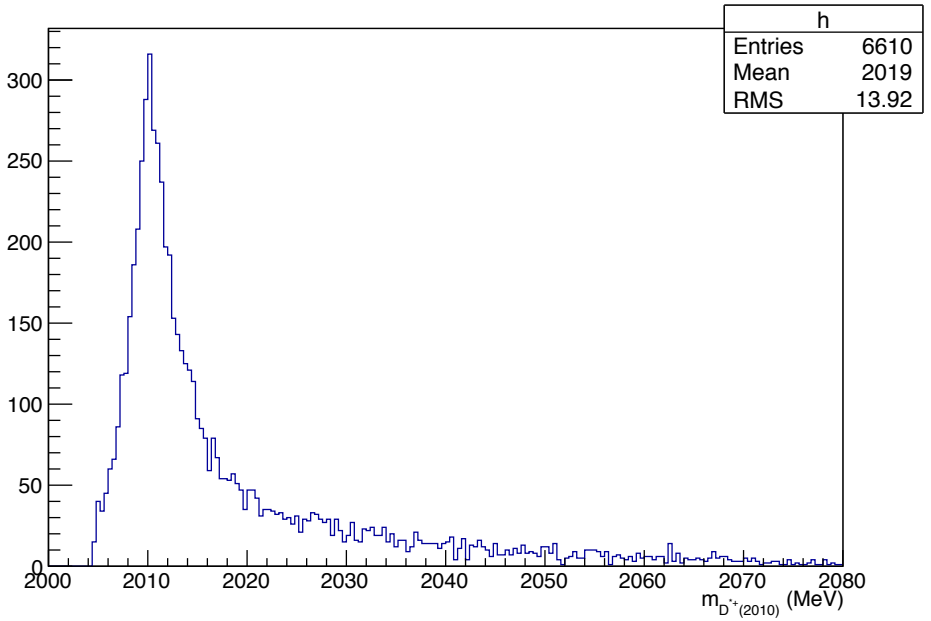


TupleToolDecayTreeFitterSL

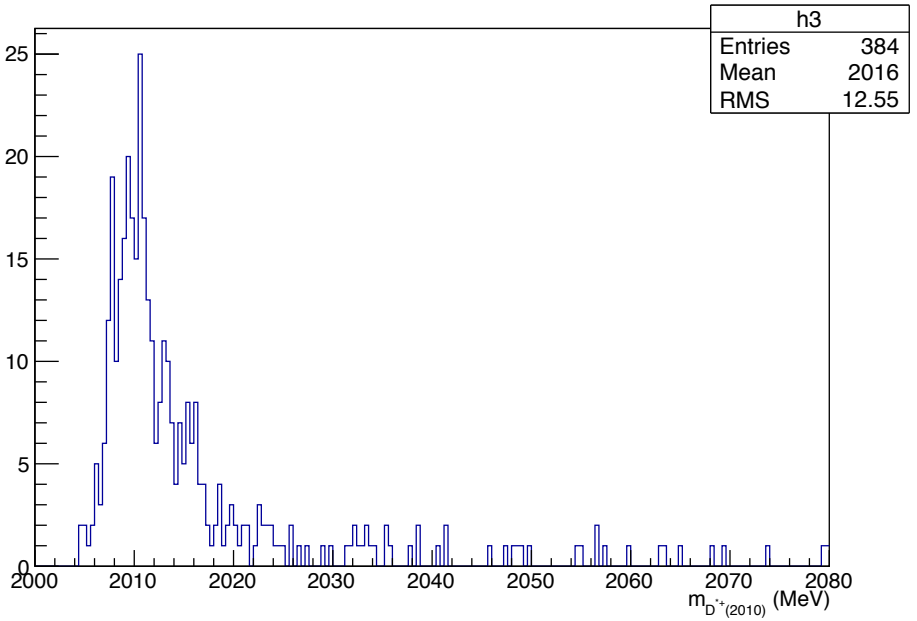
- TupleToolDecayTreeFitterSL: extention of existing the TupleToolDecayTreeFitter class to handle missing ν in SL decays
- Calculates both solutions of the ν 4-momentum and creates an instance of LHCb::Particle for this.
- Assigns only the PID, 4-momentum (no errors) and endVertex for the neutrino.
- Combines the ν and the Y using addToDaughters, creates a tree and does a TreeFit, with ν as mass-constrained.

Sanity check on $D^{*+} \to D^0(\to K^-\mu^+\nu)\pi^+$

Determinant > 0



Determinant < 0



- Discriminating (signal) variable will be the reconstructed Z mass.
- Preliminarily, it looks like the fitter can handle the det < 0 case. No cuts at this point.

Issues at this point

- Looping over all candidates + PVs/candidate + 2-fold ambiguity. High multiplicity.
- Expected χ^2-probability from the fit to provide the two BestB's (two-fold ambiguity still remains at this point).
- Works like a charm in *BABAR*. Not so in LHCb. Is it because of lack of constraints?
- My feeling is that it's a coding issue.

Coding issues

- Entire tree $B^*_{s2} \to B^+(\to \rho^0 \ell^- \overline{\nu}_\ell) K^-$ reconstructed from scratch.
- Tricky bit is adding the neutrino to the Y to form the B^+. Am I doing this correctly?
- What should `setReferencePoint`, `setMeasuredMassErr`, `setMomCovMatrix`, `setPosCovMatrix`, `setPosMomCovMatrix`, `addToDaughters`, `addToOutgoingParticles` be for both the neutrino and the B^+?