

Uncertainty from b quark masses in Z pT spectrum

Status summary

AlphaS from Z pT analysis team, CMS

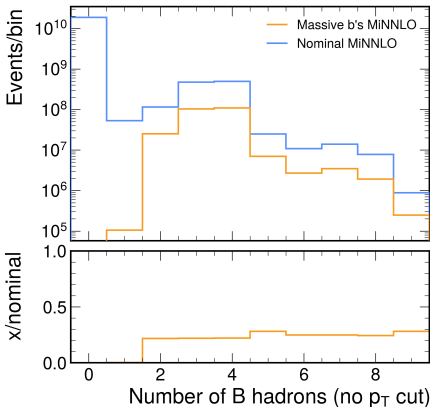
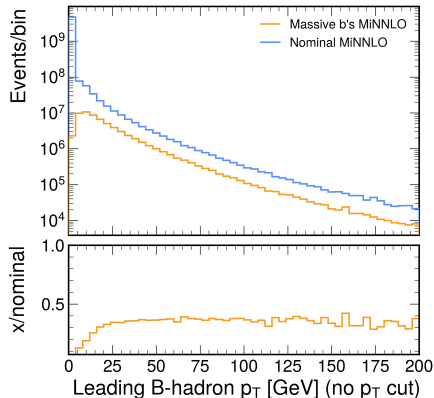
February 16, 2026

Overview: Samples, Goal, Methodology

- Samples:
 - nominal MiNNLO: massless b , 5FS
 - dedicated heavy b quark $Zb\bar{b}$ MiNNLO: massive b , 4FS. (From arXiv2404.08598.)
- Using $\sigma = 25.28\text{pb}$ from Table 1 in arXiv2404.08598, but unclear if that is inclusive $\ell = e, \mu$ or for each lepton flavor.
- Goal: build a b -mass uncertainty by replacing selected nominal MiNNLO events with an equivalent massive- b -quark MiNNLO component.
- Method: select events with at least one gen-level B hadron and build the corrected distribution as nominal MiNNLO (unselected) + massive- b MiNNLO (selected).

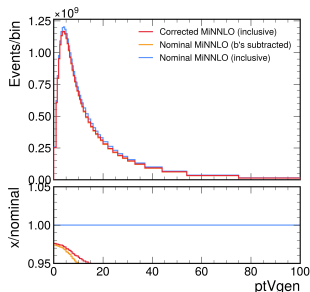
B-Hadron Diagnostics (No B-hadron p_T Cut)

- B hadrons are identified from GenPart using PDG-ID hadron-content logic (contains bottom flavor) with GenPart status 1 or 2.
- Shown without B-hadron p_T cuts: leading B-hadron p_T and B-hadron multiplicity.
- Exact implementation is shown in backup.



Swap Result and Definition

- Swap definition: select events with at least one such B hadron; corrected distribution is built as nominal MiNNLO (unselected) + massive- b MiNNLO (selected).

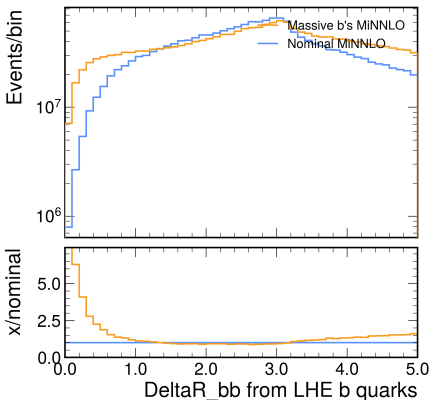
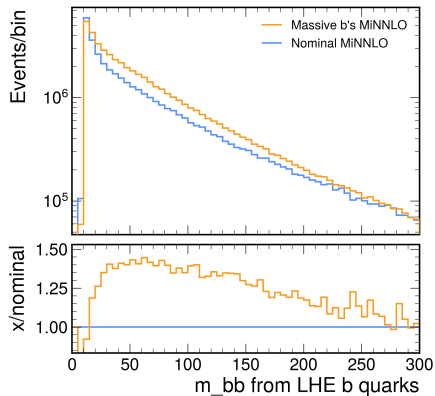


- Result: swapping gives a sizable normalization shift (not shape-only), so it is too aggressive as-is.

Backup

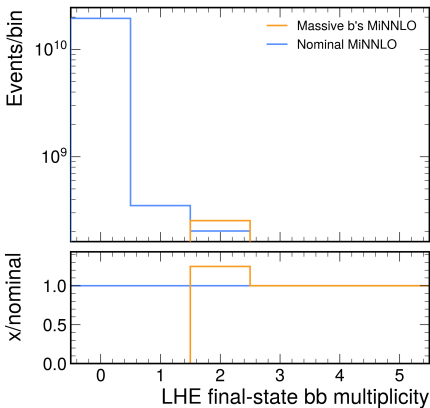
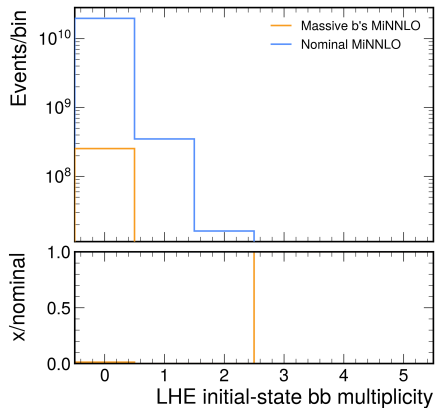
Backup: LHE $b\bar{b}$ Kinematics

- LHE b -quark observables built with $|\text{pdgId}| = 5$ and final-state status criteria in the histmaker.



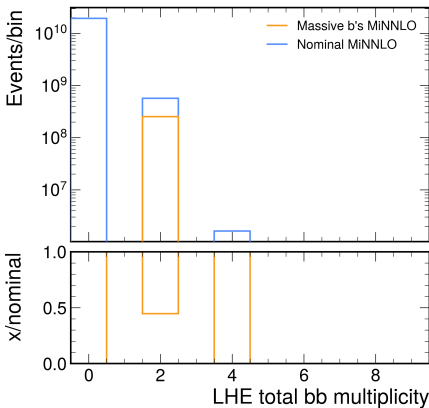
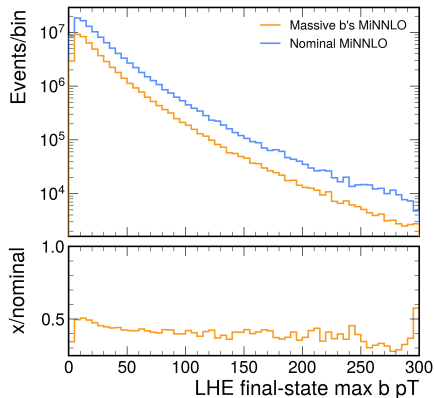
Backup: LHE Multiplicity (Initial vs Final)

- LHE multiplicities: number of b quarks in initial and final state.



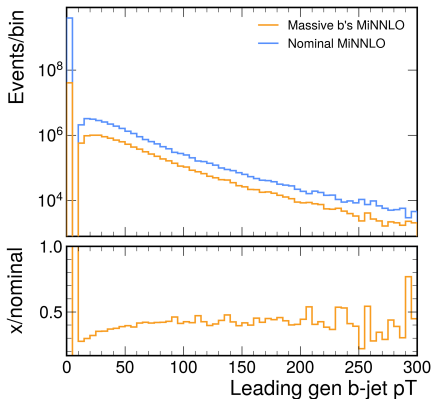
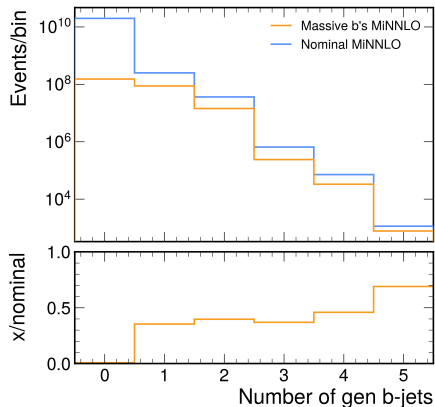
Backup: LHE Leading- b p_T and Total Multiplicity

- LHE leading- b observable: final-state maximum b -quark p_T .



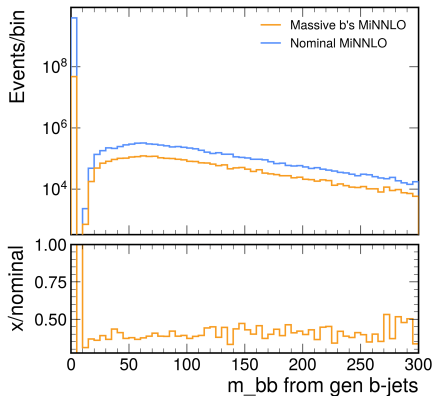
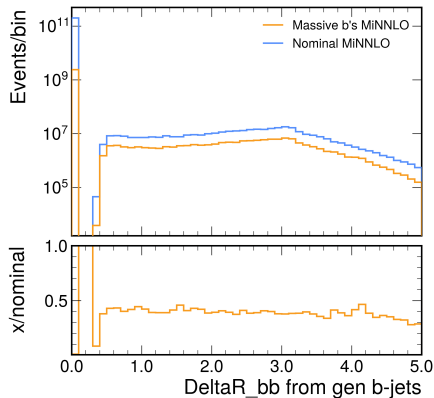
Backup: GenJet b -jet Observables

- Gen b -jet multiplicity is defined exactly as: count jets with `hadronFlavour = 5`, $p_T > 20 \text{ GeV}$, and $|\eta| < 2.5$.



Backup: GenJet ΔR_{bb} and m_{bb}

- Jet-level pair observables from gen b -jets (same jet definition: `hadronFlavour` = 5, $p_T > 20$ GeV, $|\eta| < 2.5$).



Backup: Exact B-hadron Selection Code

Implementation

```
// Source of truth: external library helper (ThePEG::PDT, from its
// Treat this external helper as authoritative for B-hadron ID
if (status[i] != 1 && status[i] != 2) continue;
const int apdg = std::abs(pdgId[i]);
if (!ThePEG::PDT::hasBottom(apdg)) continue;
idx.push_back((int)i);

// Histmaker usage
df = df.Define("bHadIdx", "wrem::finalStateBHadronIdx(GenPart_pdgId)");
df = df.Define("bHad_pt", "Take(GenPart_pt, bHadIdx)");
df = df.Define("nBhad", "static_cast<int>(bHad_pt.size())");
df = df.Define("bottom_sel", "(bHad_pt.size() >= 1)");
```

Backup: Unnormalized Swap with 4FS Scaled by 2

- Same unnormalized swap definition as main slide, but with an extra factor-2 scaling applied to the selected 4FS component before replacement.

