

# Uncertainty from $b$ quark masses in Z pT spectrum

## Status summary

AlphaS from Z pT analysis team, CMS

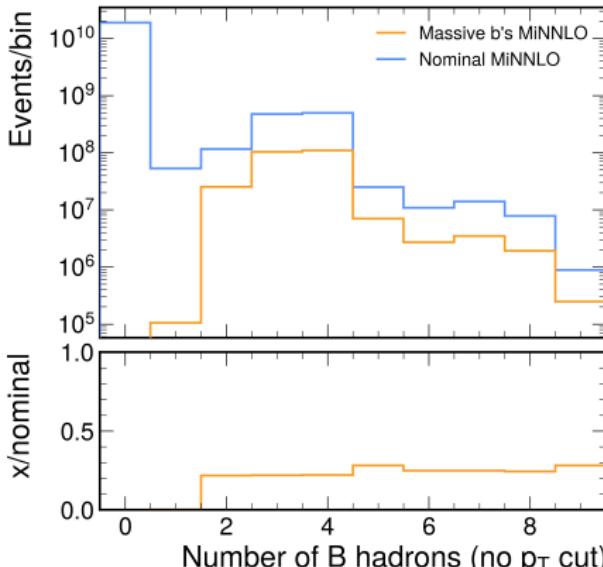
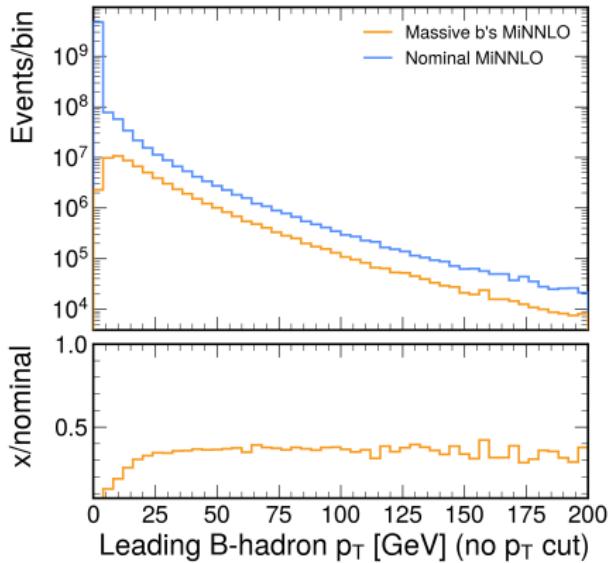
February 16, 2026

# Overview: Samples, Goal, Methodology

- Samples:
  - nominal MiNNLO: massless  $b$ , 5FS
  - dedicated heavy  $b$  quark  $Z b\bar{b}$  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).

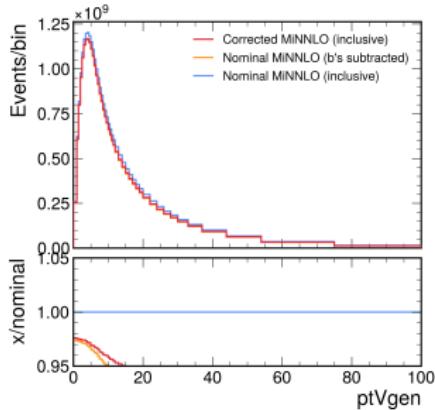
# B-Hadron Diagnostics (No B-hadron $p_T$ Cut)

- 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).

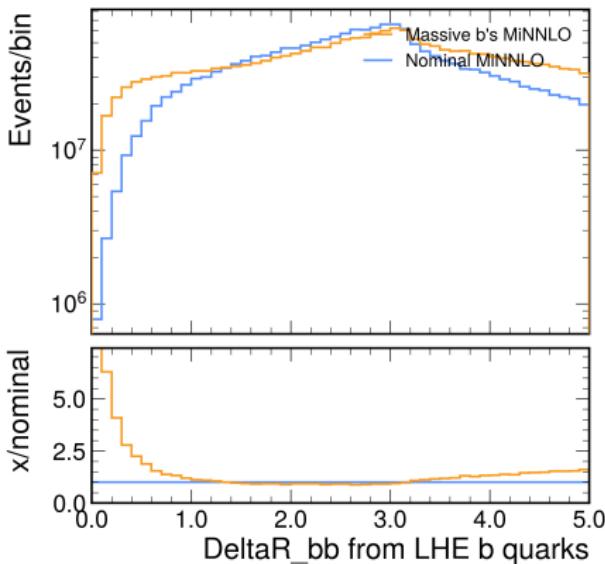
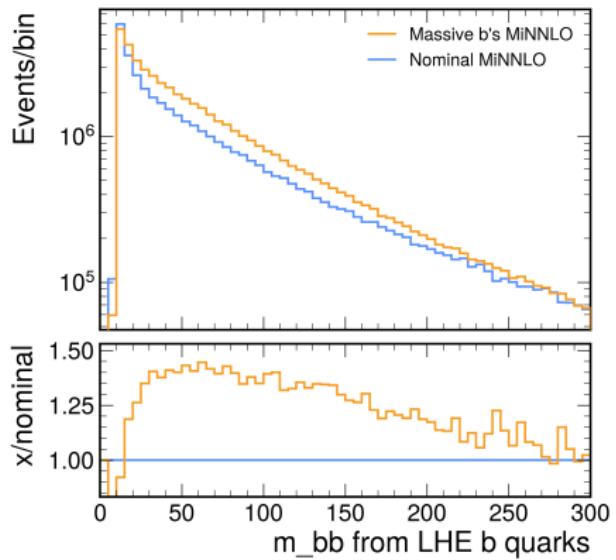


- Result: swapping gives a sizable normalization shift (not shape-only), so it is too aggressive as-is.

# Backup

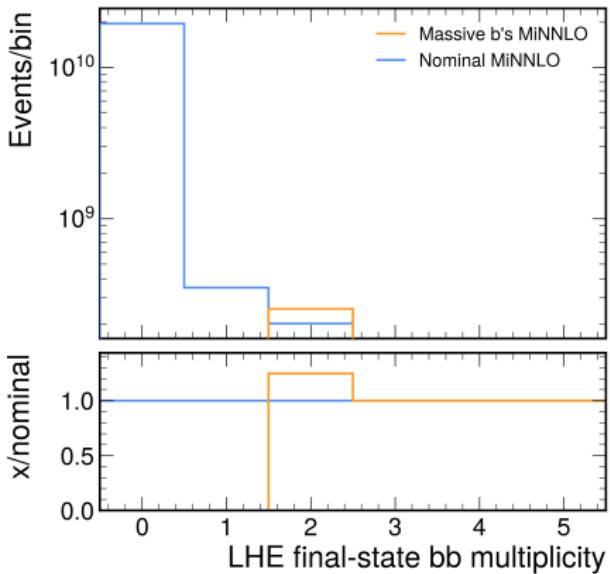
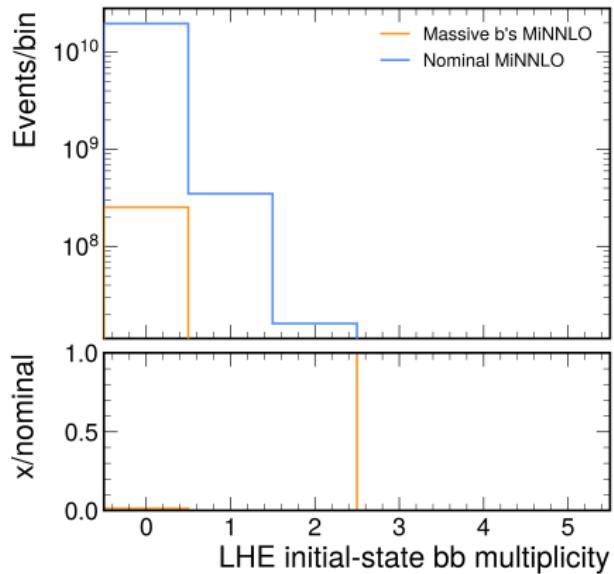
# Backup: LHE $b\bar{b}$ Kinematics

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



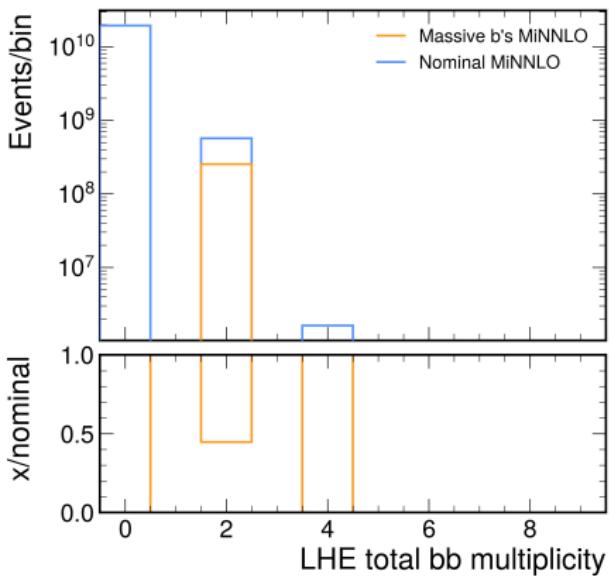
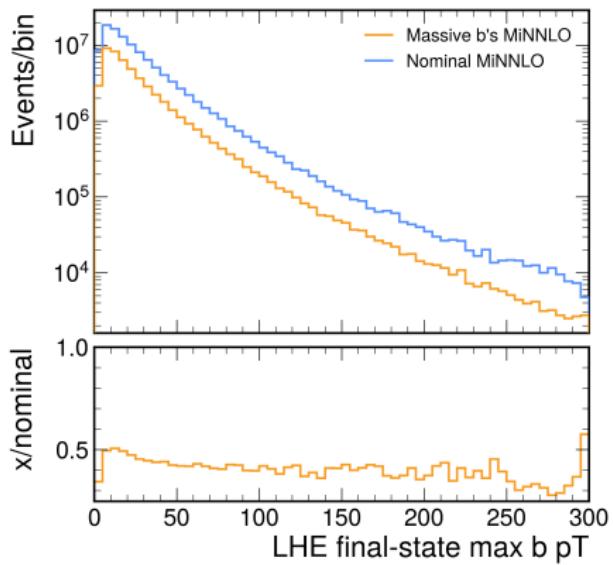
# Backup: LHE Multiplicity (Initial vs Final)

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



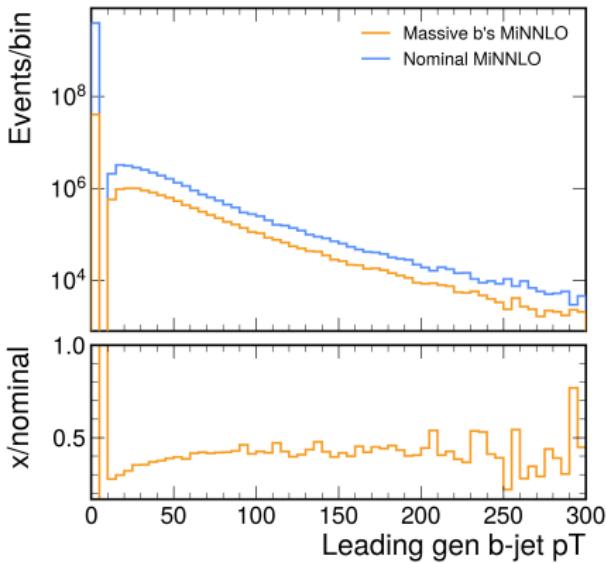
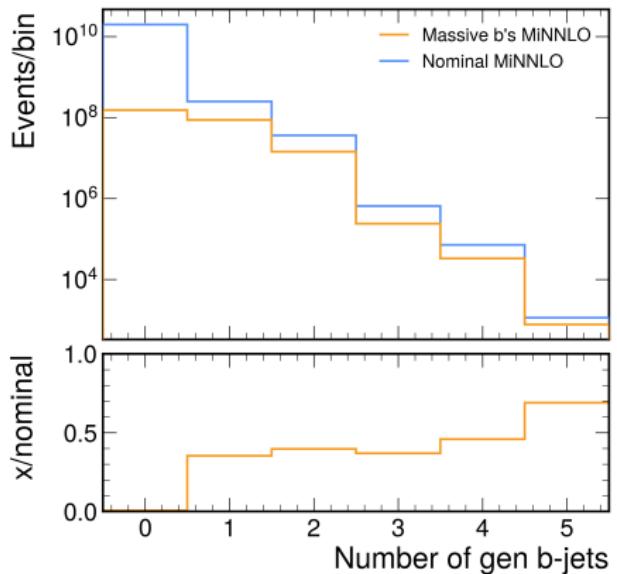
# Backup: LHE Leading- $b$ $p_T$ and Total Multiplicity

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



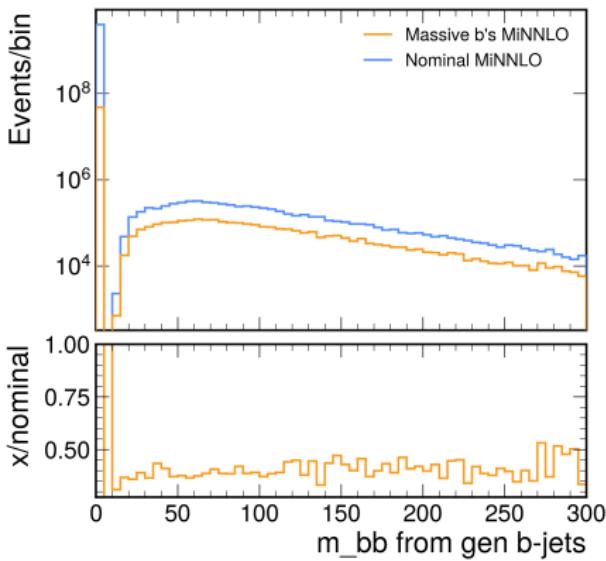
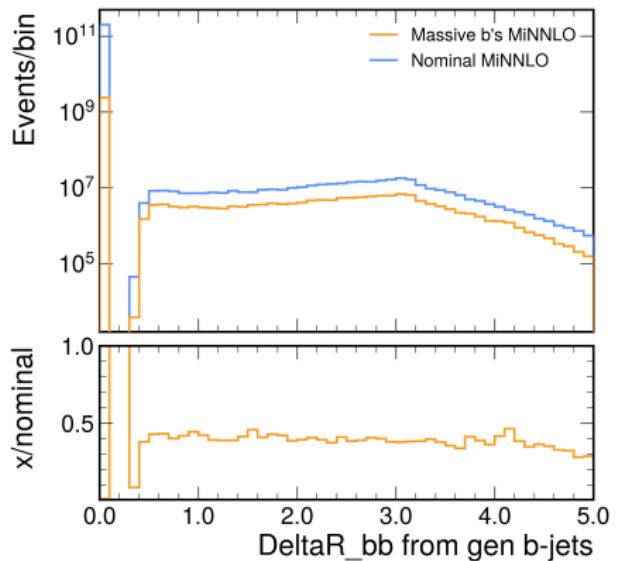
# Backup: GenJet $b$ -jet Observables

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



# Backup: GenJet $\Delta R_{bb}$ and $m_{bb}$

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



# 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.

