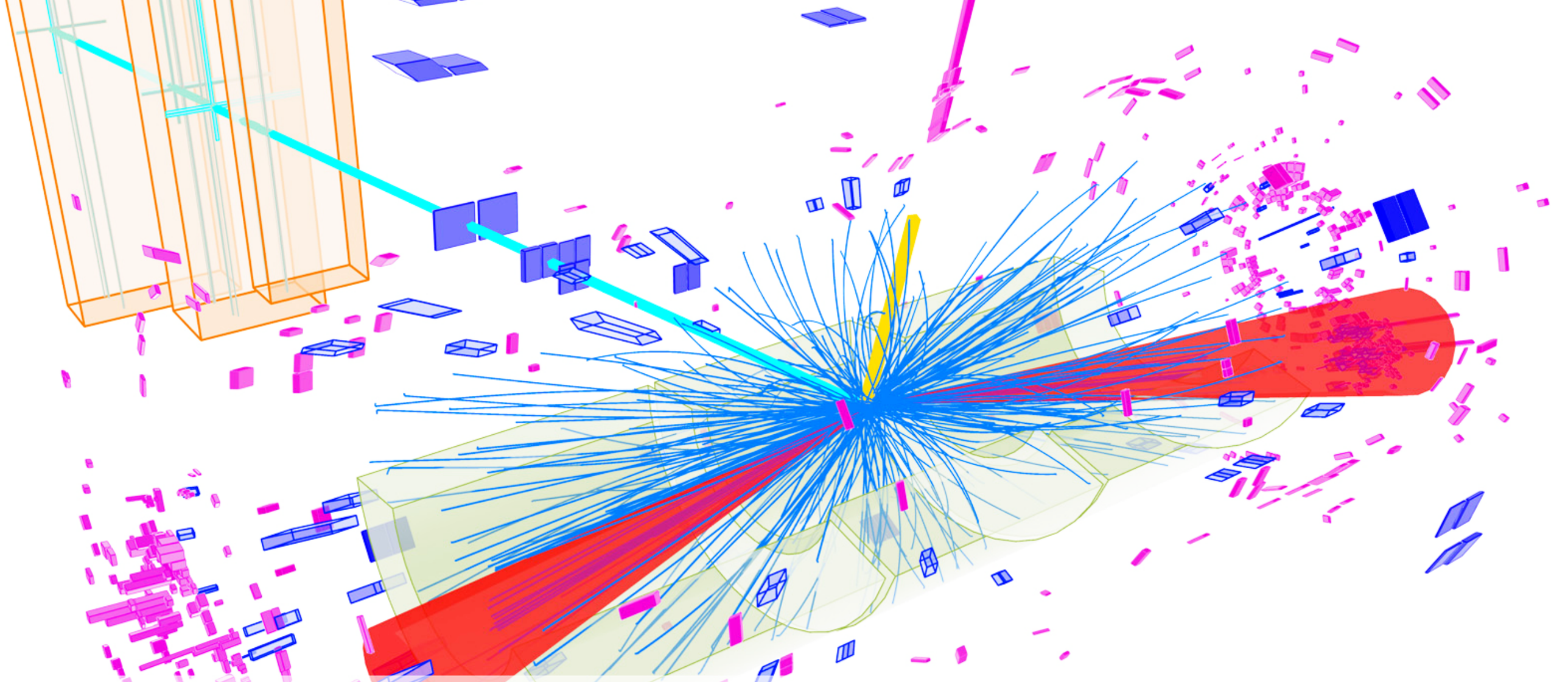

FIRST LOOK AT JET-BASED MISSING MOMENTUM

MC Detector and Physics Simulation meeting - 13th October 2020

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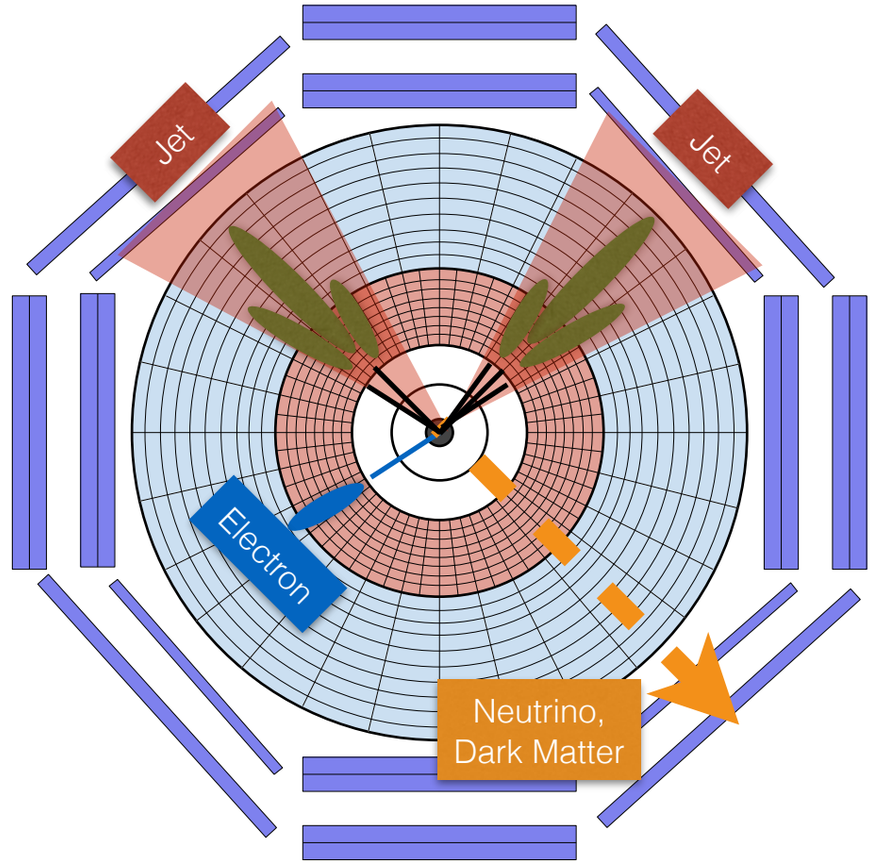
INTRODUCTION

- Missing Momentum (MM): extremely important quantity to observe invisible particles.
- In ATLAS: total subtraction of reconstructed particle momenta (i.e. jets, electrons, muons, etc.).
- Generally, this quantity is **very dependent on jet and calorimeter performance.**
- **At LHC, we generally look at the transverse component of the MM.**
- At lepton colliders we could in principle use the total missing momentum.
- Next slides: few studies of MM reconstruction using the full Muon Collider simulation framework (with CLIC detector).



$$0 = \sum_{\text{visible particles}} \vec{p}_i + \sum_{\text{invisible particles}} \vec{p}_i$$

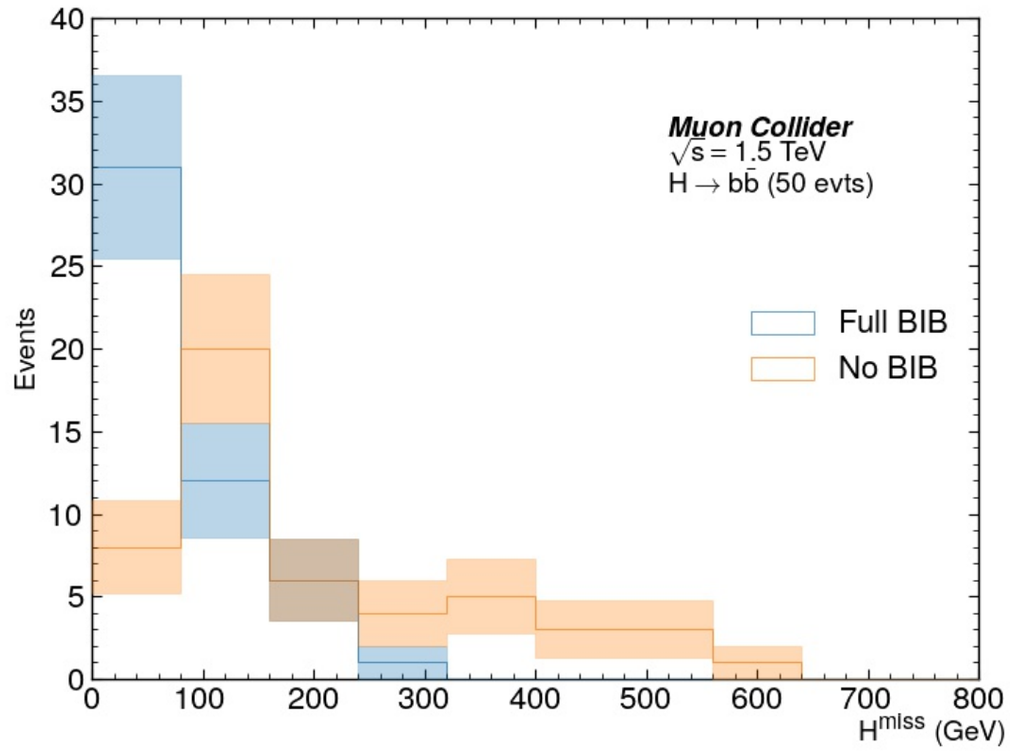
$$\vec{p}^{\,\text{miss}} = - \sum_{\text{visible particles}} \vec{p}_i$$

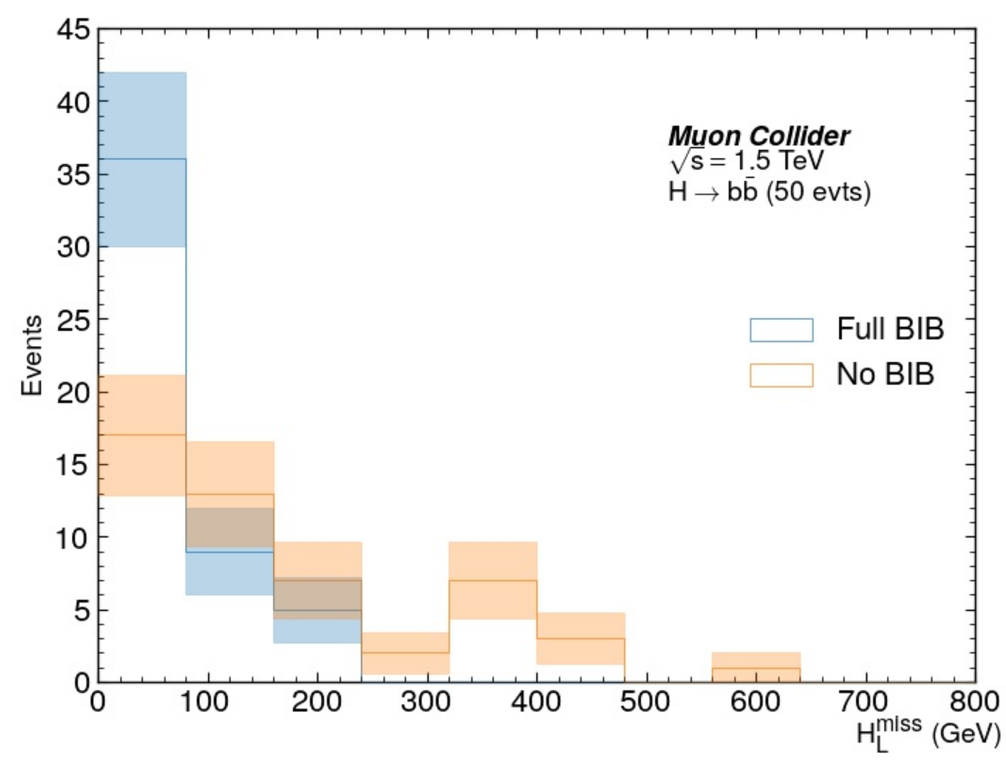
RECONSTRUCTING THE MISSING MOMENTUM

- Started from samples simulated by Lorenzo (more details here).
- 50 H->bb events available at 1.5 TeV (VBF $\nu\nu H$ production important here) with two configurations:
  1. **No BIB** applied.
  2. **Full BIB** with **calorimeter time selection** ($|t| < 25$ ns) and **energy digit selection** ($E > \overline{E}^{\mathrm{BIB}} + 2\sigma^{\mathrm{BIB}}$) + **correction** ($E^{\mathrm{corr}} = E - \overline{E}^{\mathrm{BIB}}$).
- Defined very simple $\vec{H}^{\mathrm{miss}}$ distribution:

$$\vec{H}^{\mathrm{miss}} = -\sum_{i \in \mathrm{jets}} \vec{p}_i$$

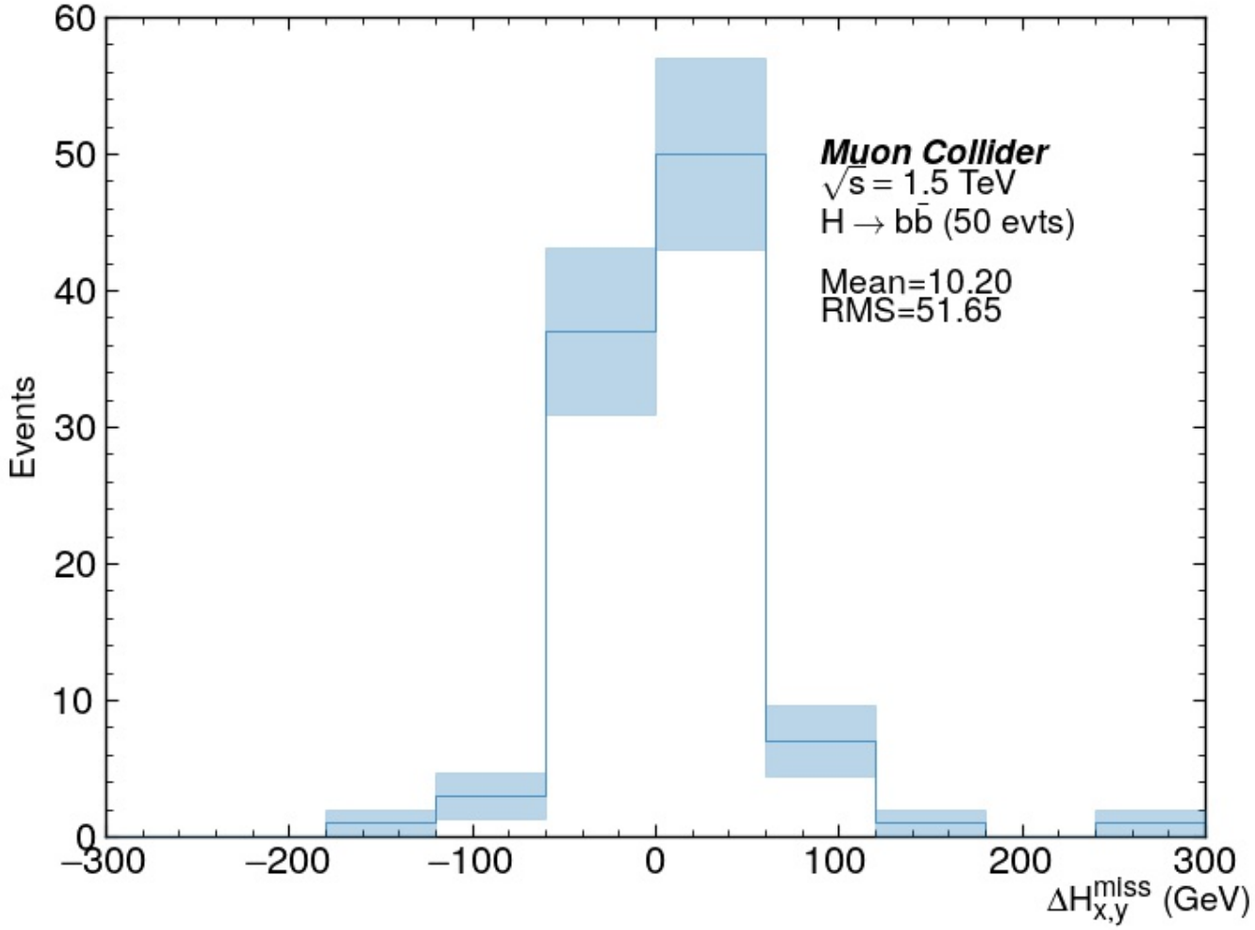
- **BIB seems to reduce the magnitude of this quantity.** Most of the effect due to the longitudinal part of $\vec{H}^{\mathrm{miss}}$.

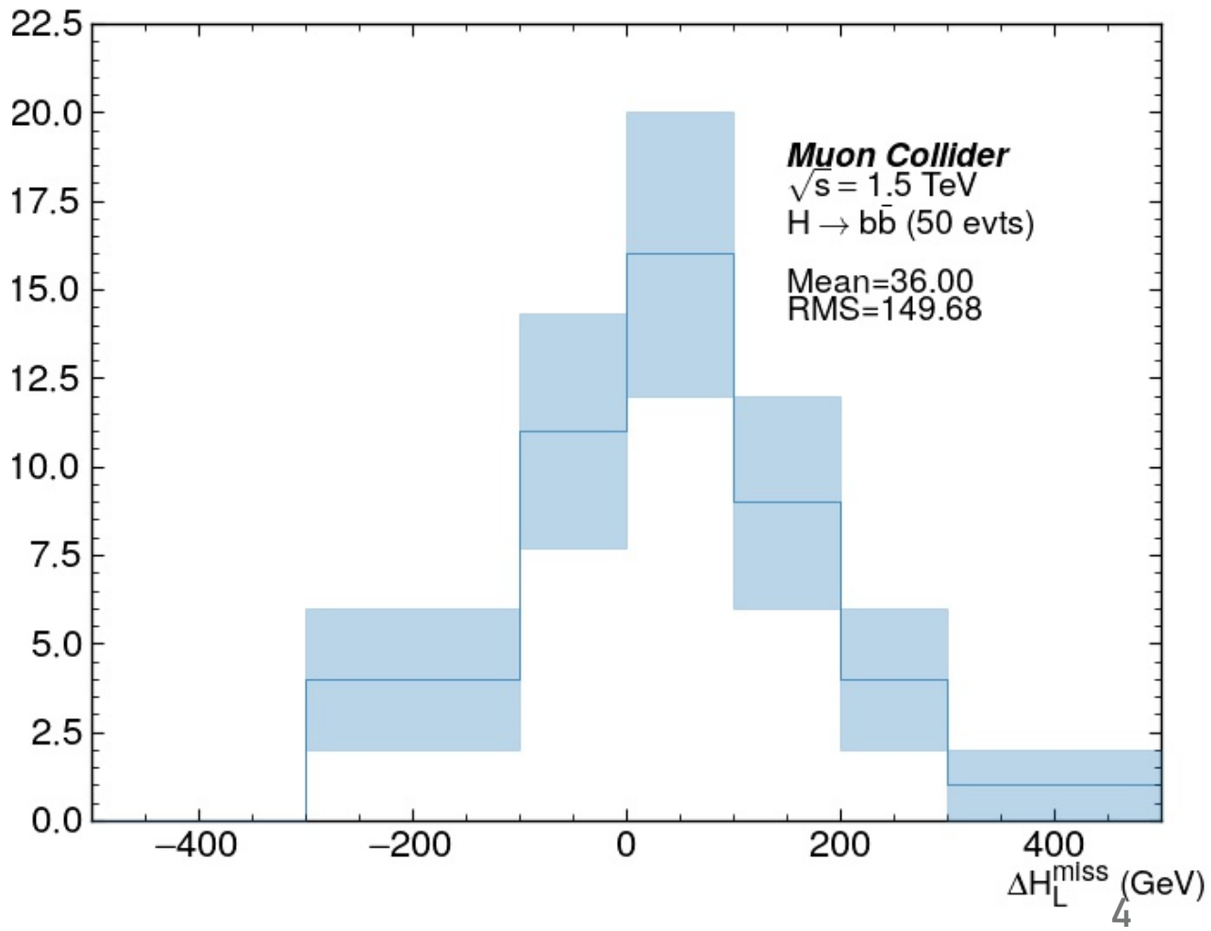




BIB EFFECTS ON DIFFERENT PLANES

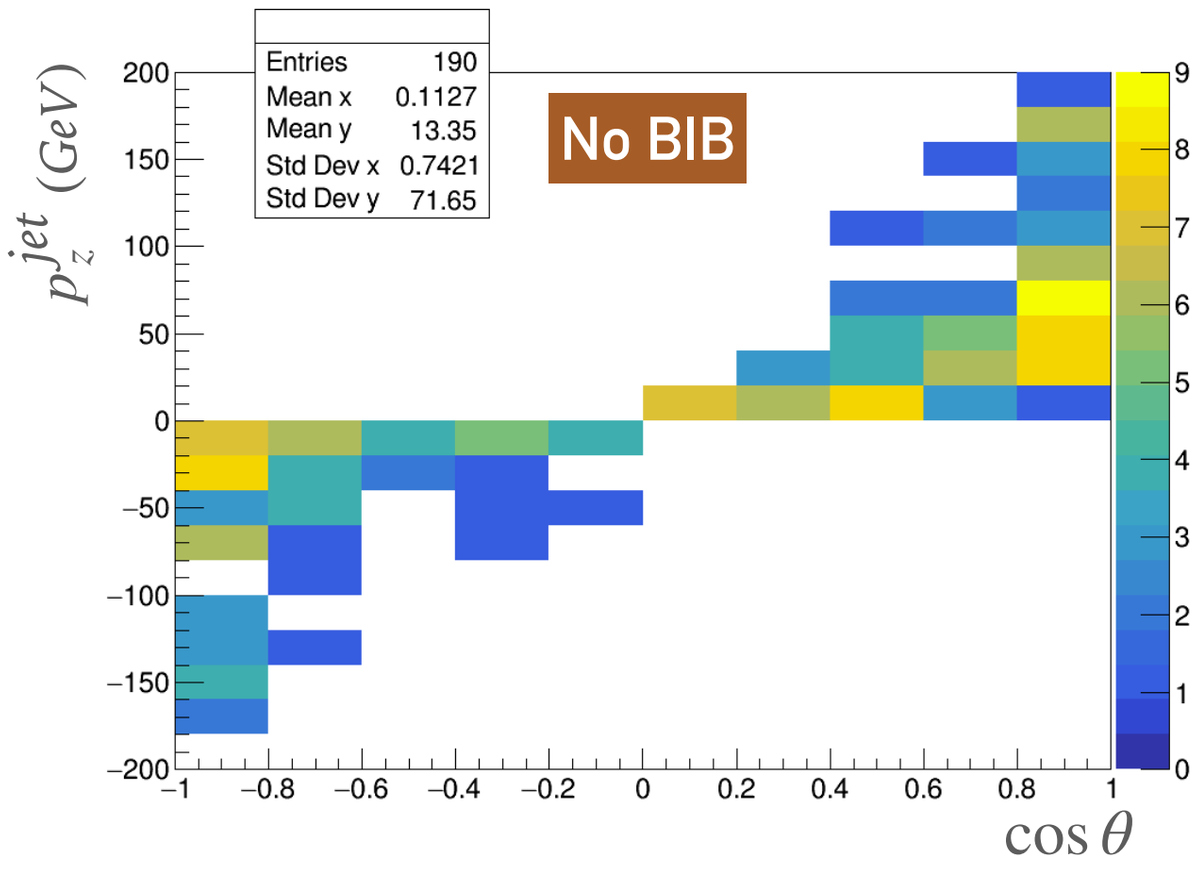
- Tried to look at BIB effect on different detector planes by computing $\Delta H_i^{\text{miss}} = H_i^{\text{miss}}(\text{BIB}) - H_i^{\text{miss}}(\text{no BIB})$ for each event.
- Suppressed BIB brings 50 GeV worse "resolution" on the transverse plane and 150 GeV on the longitudinal plane.
- Why longitudinal is worse?

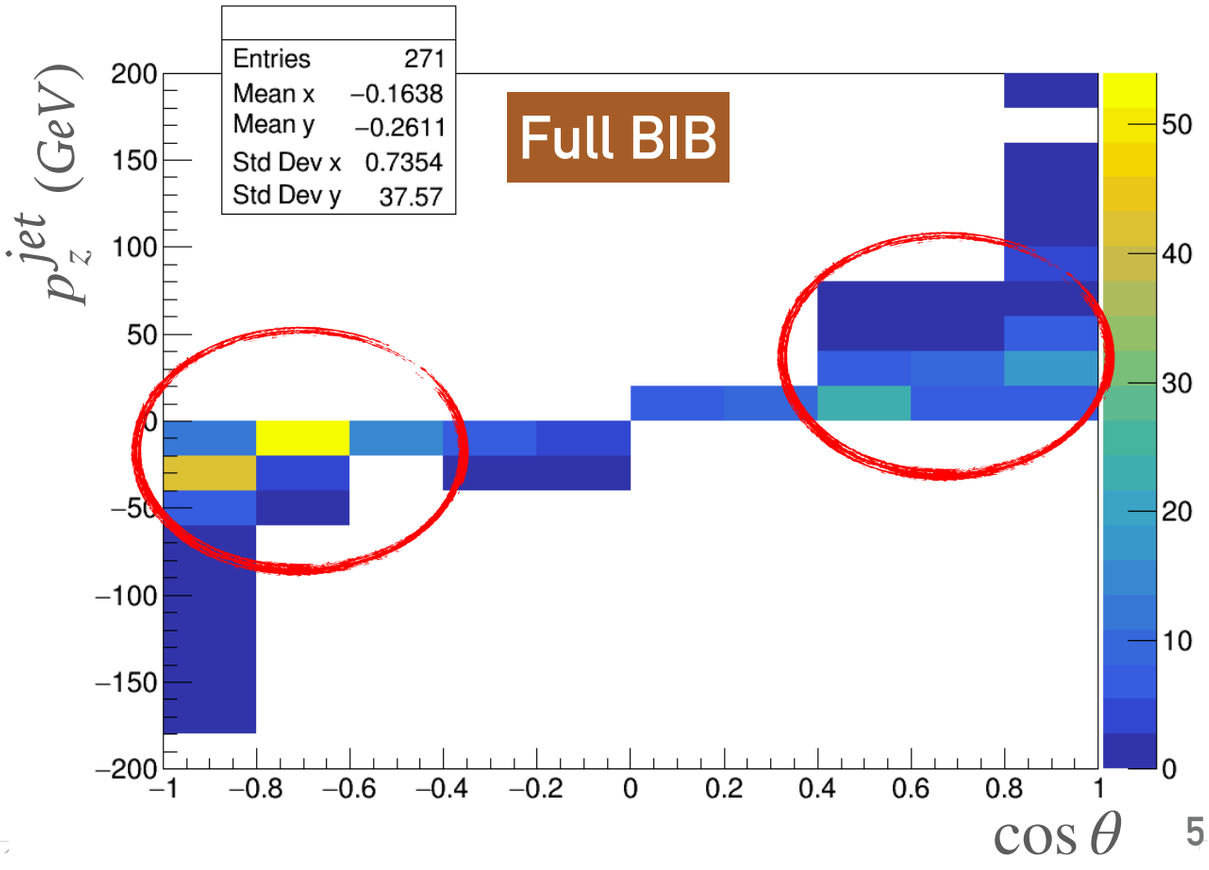




WHY LONGITUDINAL IS SO BAD?

- Because we have much more jets in the forward part of the detector (where a lot of $H \to b\bar{b}$ signal is).
- Probably expected since the BIB comes from the beams and the impact should be in forward part of the detector (i.e. closer to the beams).
- **Shall we look at the transverse Missing Momentum (MM)** in the end as for LHC experiments due to BIB effects?
- My personal opinion: a good tracker coverage and excellent timing resolution in the forward calorimeter might help to improve jet and MM measurement in the longitudinal plane.
  - This could be important for VBF topologies like $\mu\mu \to \nu\nu H$.



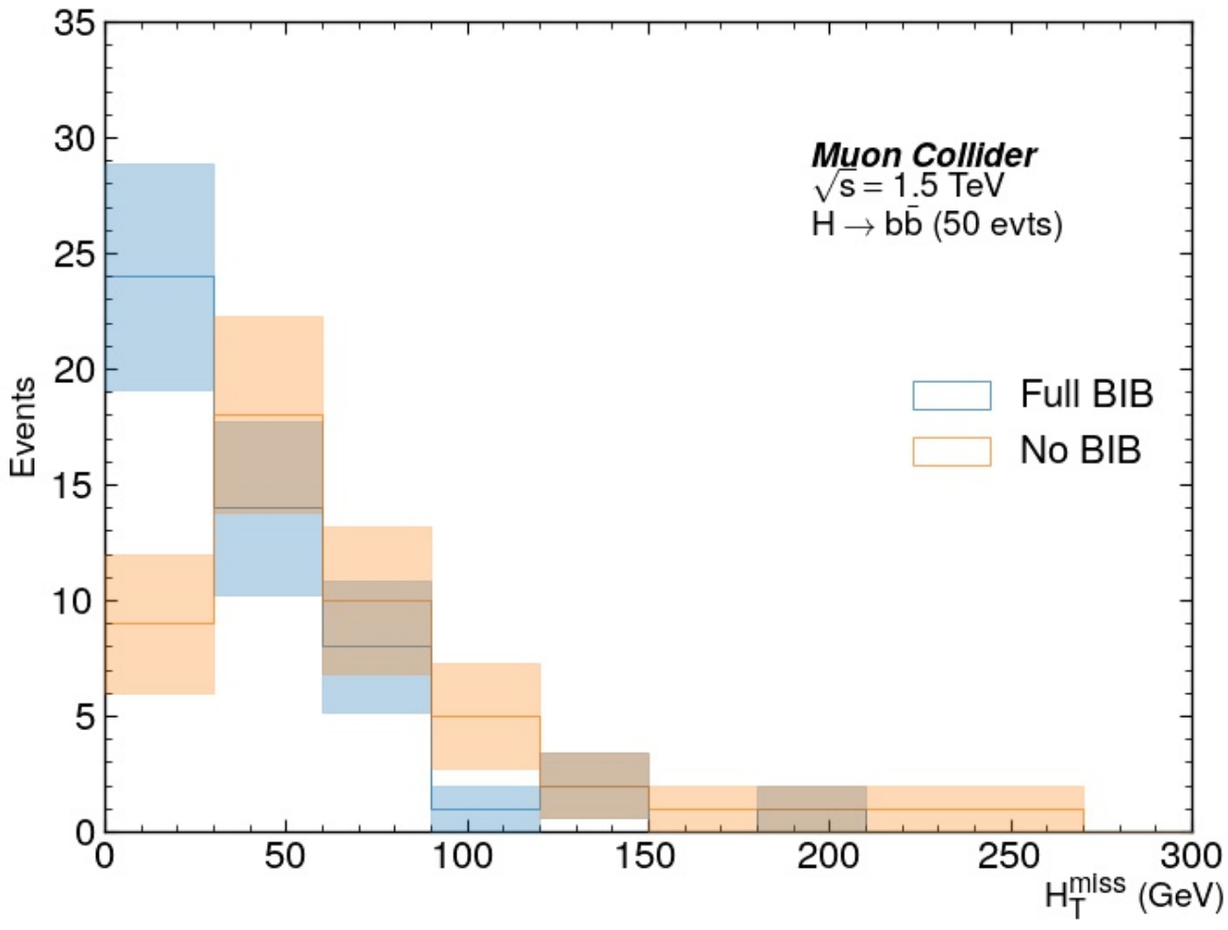


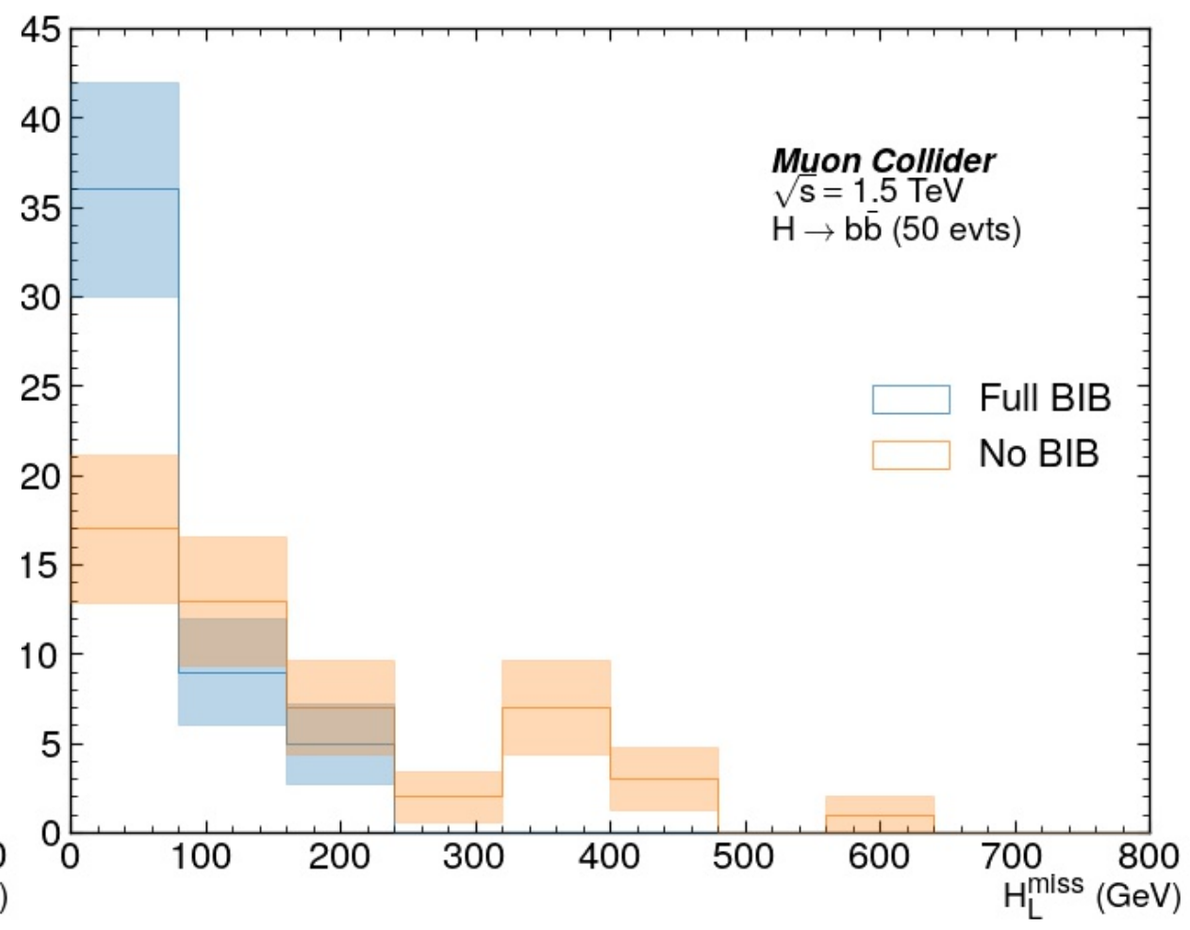
CONCLUSION AND THOUGHTS

- Looked at a very basic jet-based missing momentum reconstruction in 50 H->bb events at 1.5 TeV.
  - Certainly not the ideal signature (e.g. semi-leptonic decays of b-hadrons leaves invisible particles in the final state).
- **It seems that the BIB affects more the longitudinal part of $H^{\mathbf{miss}}$** due to the high calorimeter and jet activity in the forward region.
  - Might we end up looking at the transverse Missing Momentum like LHC experiments?
- What we could possibly do better:
  - Look at performance with **calorimeter noise mitigation techniques** (e.g. Soft Killer explored now by Davide Zuliani).
  - Simulate more clear signatures for MET performance (e.g. $Z \rightarrow \mu\mu$).
  - Include **tracking for jet ID or building in the forward region.** The BIB is mostly neutral and jets are made of charged particles at 66%.
  - More BIB events if possible.
- Any feedback/suggestion? :)

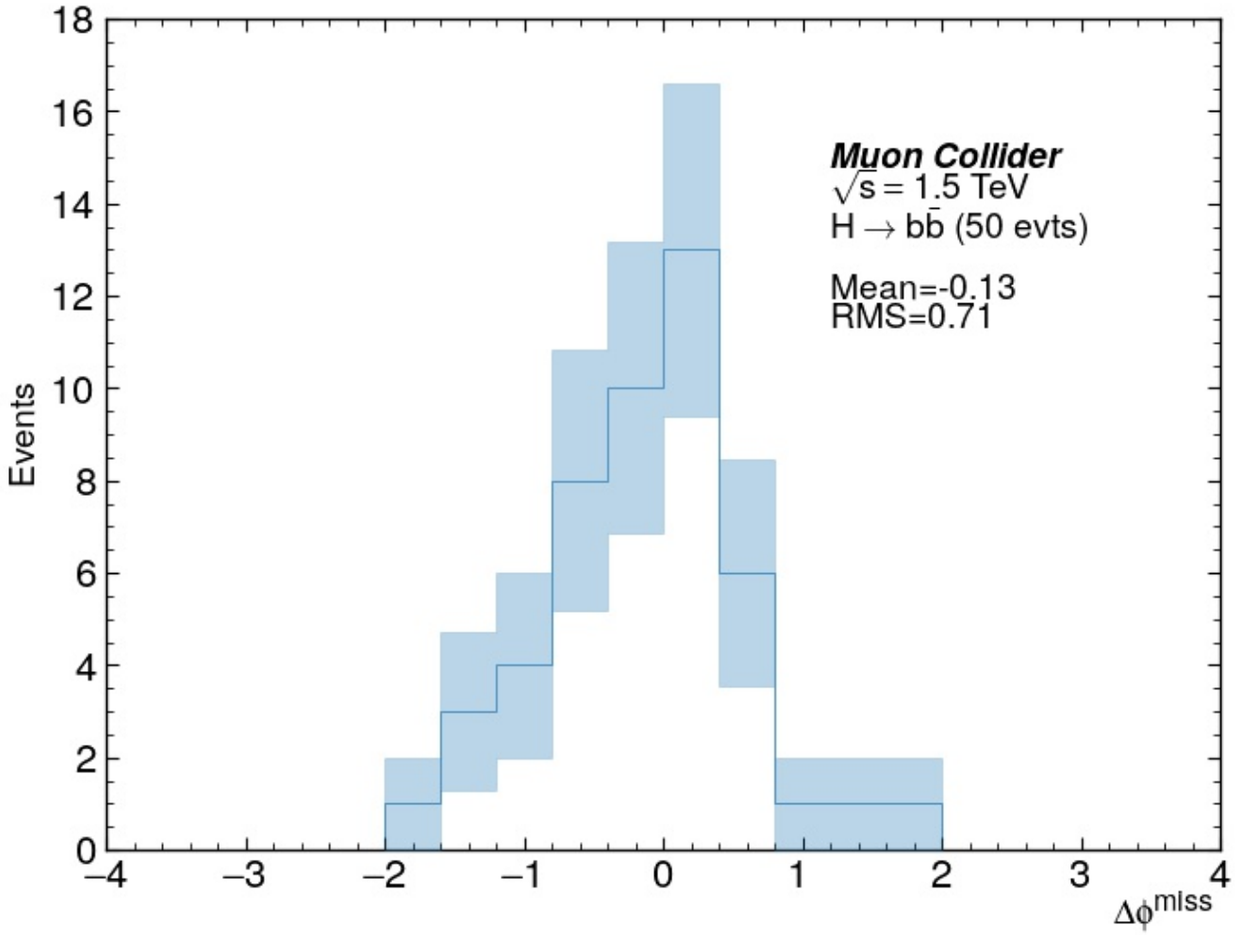
BACKUP

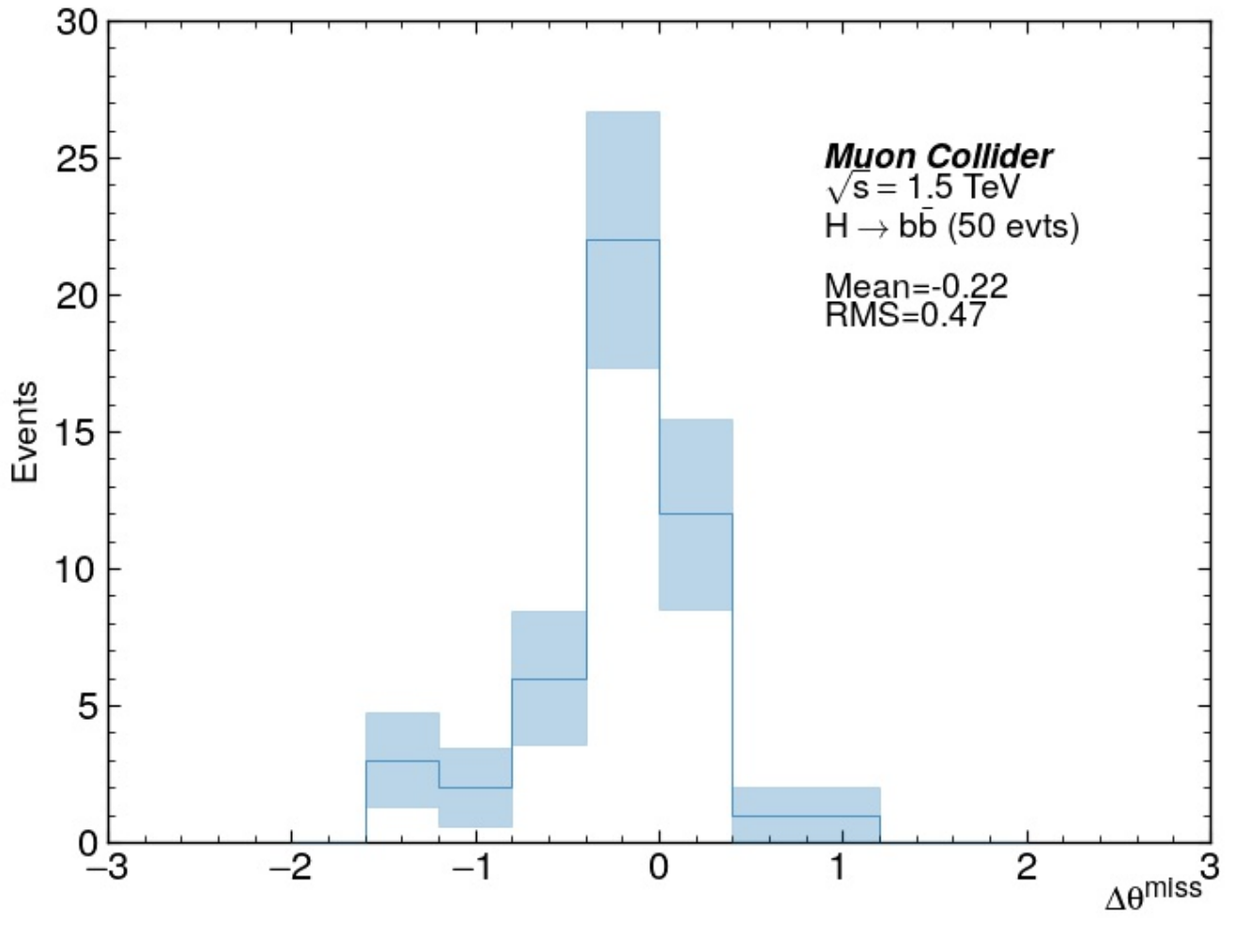
TRANSVERSE AND LONGITUDINAL MISSING MOMENTUM





BIB EFFECTS ON MISSING MOMENTUM ANGLES





MET RESOLUTION IN ATLAS