Development of a track-based algorithm for MET TST systematic uncertainties

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Outline

- Overview on Missing Energy Transvers (MET)
- MET Track-Soft-Term
- Framework for track-based systematic uncertainties
- Systematic uncertainties on tracking
- Setup for track-based algorithm
- TST Track Selection
- Control plots
- Conclusion

Overview

- Missing Energy Transvers (MET) is essential for many physics studies at the LHC :

◆ **Model Standard :**

W boson, Z boson and top quark decay.

Higgs H→ WW and H->TauTau

◆ **Beyond the Standard Model :**

Supersymmetry with R-Party conservation

Extra dimensional models : Kaluza-Klein graviton/photon

◆ **Missing Transverse Energy at LHC:**

Energy imbalance measure in the transverse plane due to:

- Undetectable Particle (neutrinos)
- weakly-interacting (SUSY) Particle
- Susceptible to object mismeasurement/miscalibration

MET in ATLAS

- **Missing Transverse Energy based in 2D :**

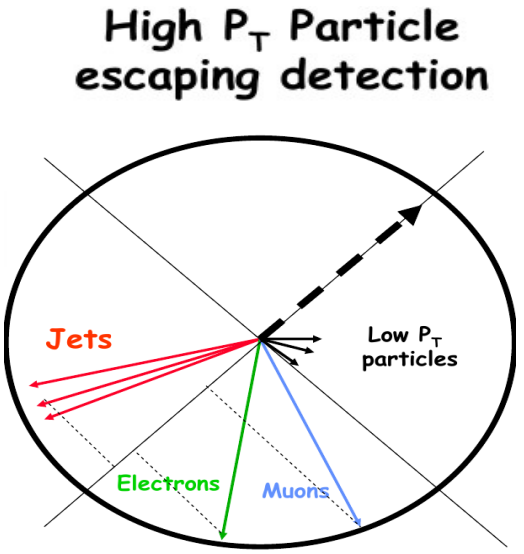
$$E_{x(y)}^{\text{miss}} = -\left(E_{x(y)}^{\text{jets}} + E_{x(y)}^{e} + E_{x(y)}^{\gamma} + E_{x(y)}^{\tau} + E_{x(y)}^{\mu} + E_{x(y)}^{\text{Soft Term}}\right)$$

- **MET reconstruction :**
- **transverse vector sum of all objects :**
  - → **Fully reconstruction par:**

    Muons, Electrons, Jets, Taus, photon ⇒ Hard Term

- **transverse vector sum of cluster or tracks :**

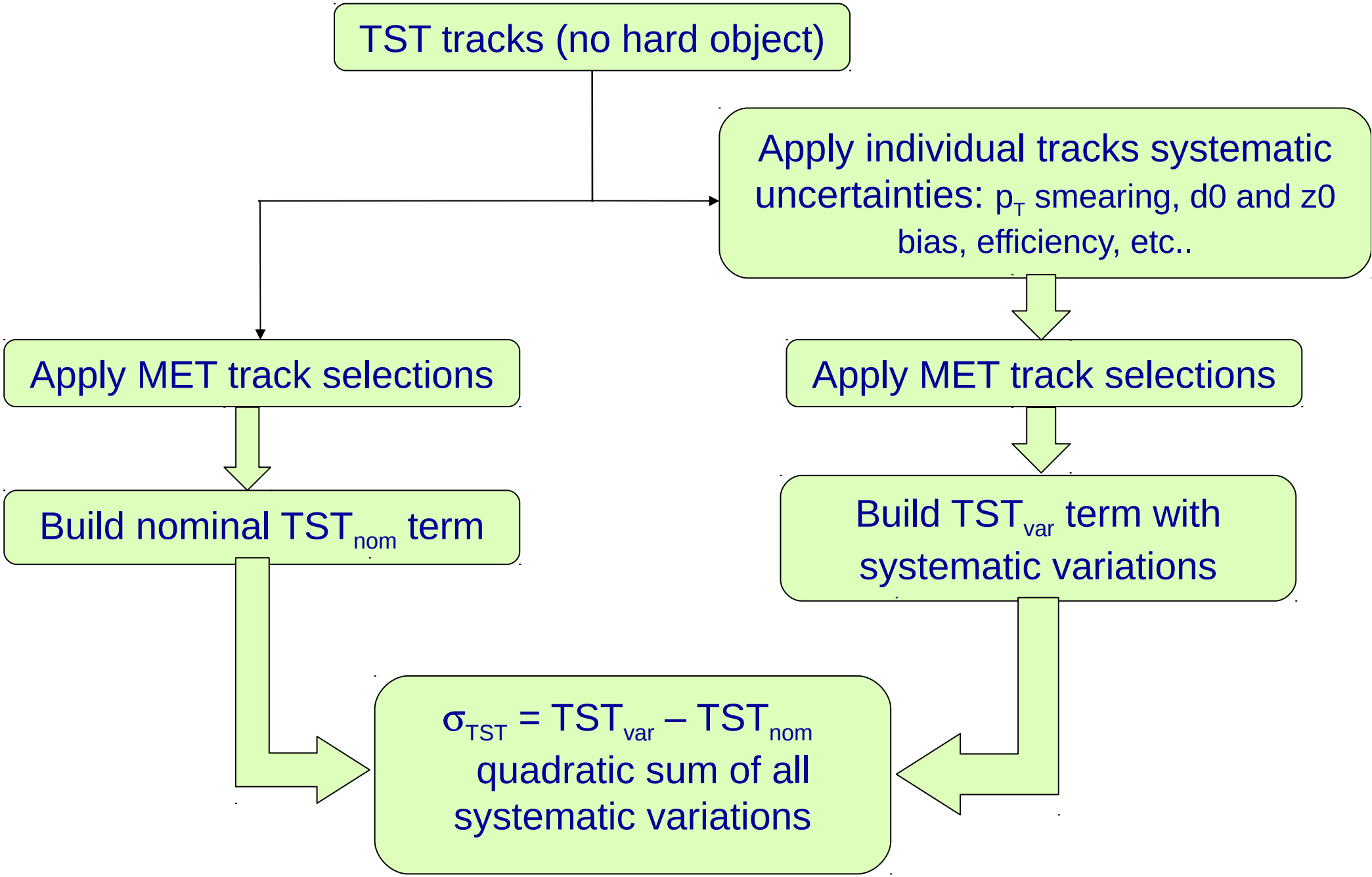
  Signals not used in reconstructed physics objects and are:



- **CST Calorimeter–based:** Calorimeter Soft Term (CST)
  - **Reconstructed in the Calorimeter cells**
- **TST track-based:**
  - Track Soft Term (TST) → Reconstructed in the ID

This talk will focus on TST

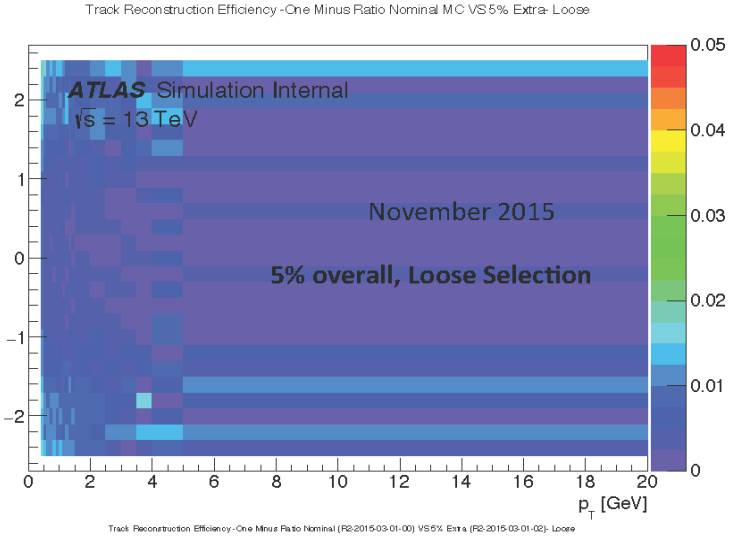
Framework for track-based systematic uncertainties



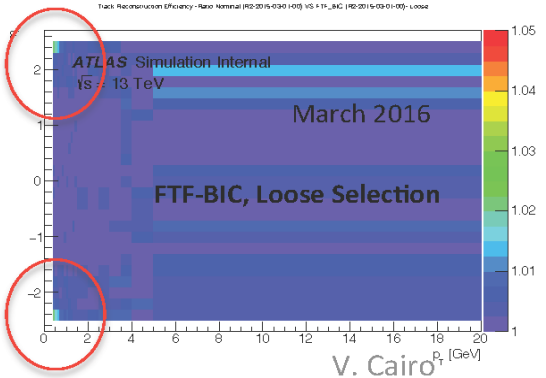
Systematic uncertainties on tracking: Efficiency

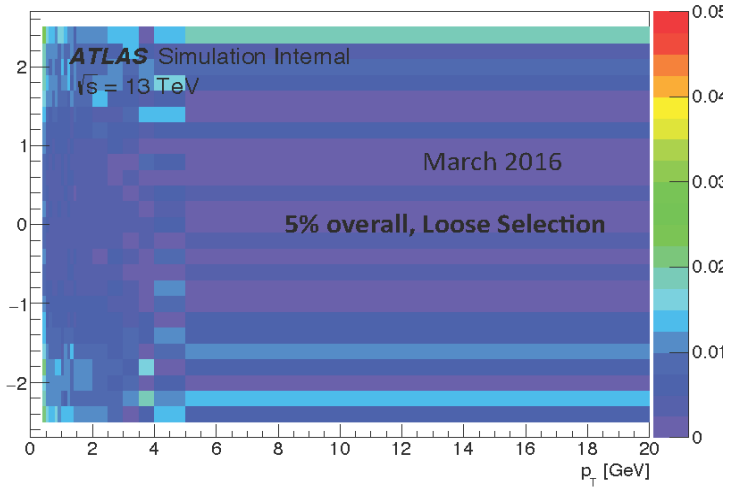
$$\mathrm{Sys}_{ExtraMaterial}(p_T,\eta) = \frac{\epsilon_{trk}^{default}(p_T,\eta)}{\epsilon_{trk}^{ExtraMaterial}(p_T,\eta)} - 1$$

- Main source of systematic uncertainty on the tracking efficiency is the **material** in the Inner Detector → Considered **$\mathrm{Sys}_{ExtraMaterial}$**:
  1. **5% extra material overall → November and March results are compatible!**
  2. **50% extra material PP0 → wrong geo tag in the pre-MC15c sample→ reco is being re-processed**
  3. **30% extra material IBL → wrong geo tag in the pre-MC15c sample→ reco is being re-processed**



- **NEW source of systematic uncertainty** being considered for updated recommendations:
  4. **FTF-BIC physics list** as an alternative to the baseline FTFP-BERT: impact on tracking in not negligible at very low p_T and high η, some extra check is needed

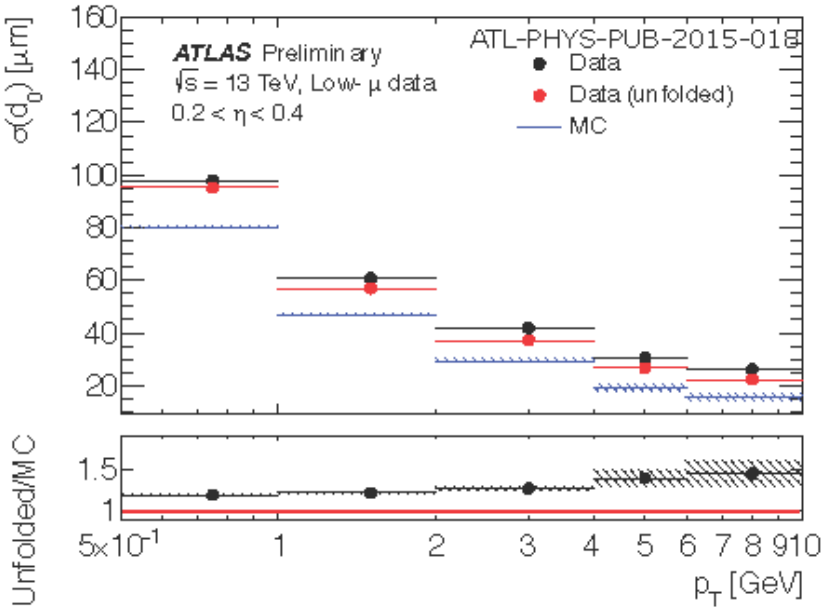




Systematic uncertainties on tracking: Vertexing

- Differences between data & MC are considered as the uncertainties
  - σ(data) > σ(MC):need to **smear the IP resolutions in MC**
- InDetTrackSmearingTool
  - Smear the IP in MC by: $\sqrt{\sigma(\text{data})^2 - \sigma(\text{MC})^2}$
  - Fit the resolutions by : $\sigma(d_0)_{\text{fixed }\theta} = \sqrt{E^2 + \frac{G^2}{p_T} + \frac{N^2}{p_T^2}}$.

    the uncertainties for higher pT are calculated with the fit functions
  - Usage:
    m_trackSmearingTool->correctedCopy(*track, newTrack)
    (see the InDetTrackSystematicsAlgs twiki)



Setup for track-based algorithm

Framework : AthenaAnalysisBase 2.4. 29

MC dataset: DAOD_JET3M

Event selection:

Events with $Z \rightarrow \mu\mu$ and 0-jets (pT>20GeV) are considered in this study for better estimation of tracking effects

Used all tracks with pT > 400MeV

Packages and classes that have been using are:

METUtilities package

- **met::METMaker**
- **met::METRebuilder**

Track Tools

Sysetematic variation

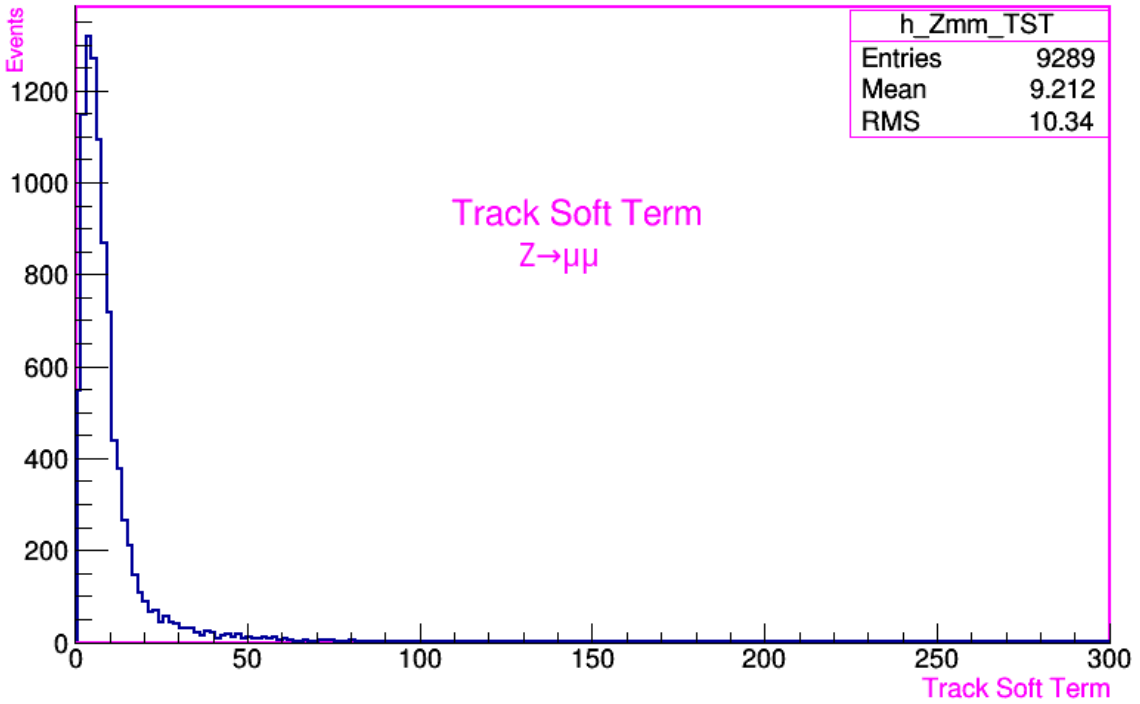
Track Selection Tool

TST Track Selection

➔ To check the TST variable the Z→muonmuon process has been used

➔ **To reconstruct the TST value, the tracks are required to have :**

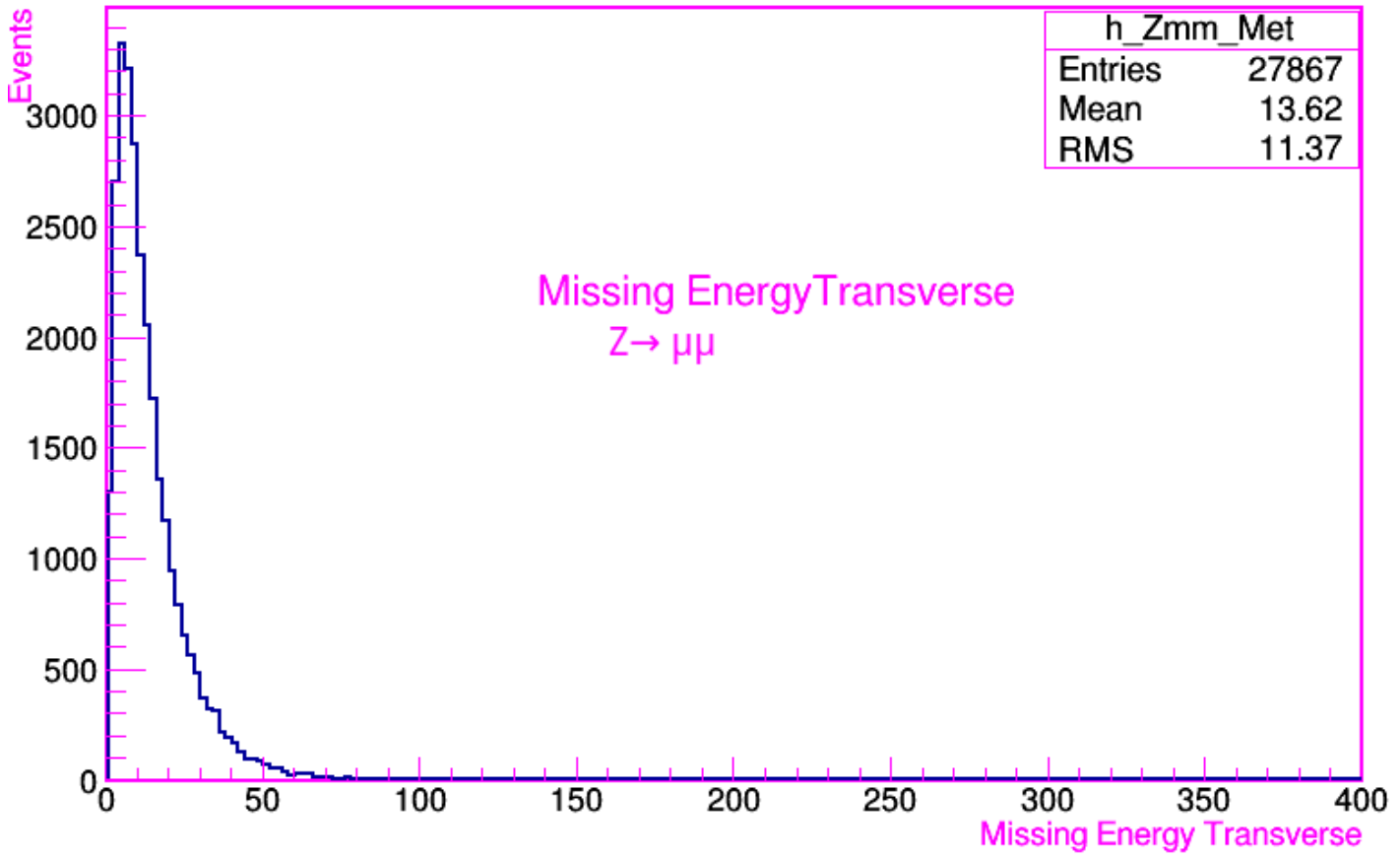
- **Track pT > 400 MeV**
- **Track |η| < 2.5**
- **Either (N(Si) ≥ 7 and N(shared Si) = 0) OR N(Si) ≥ 10**
- **N(shared module) ≤ 1**
- **N(pixel hole) = 0**
- **N(SCT hole) ≤ 2**
- **|d0| < 2 mm**
- **|z0sin(theta)| < 3 mm**



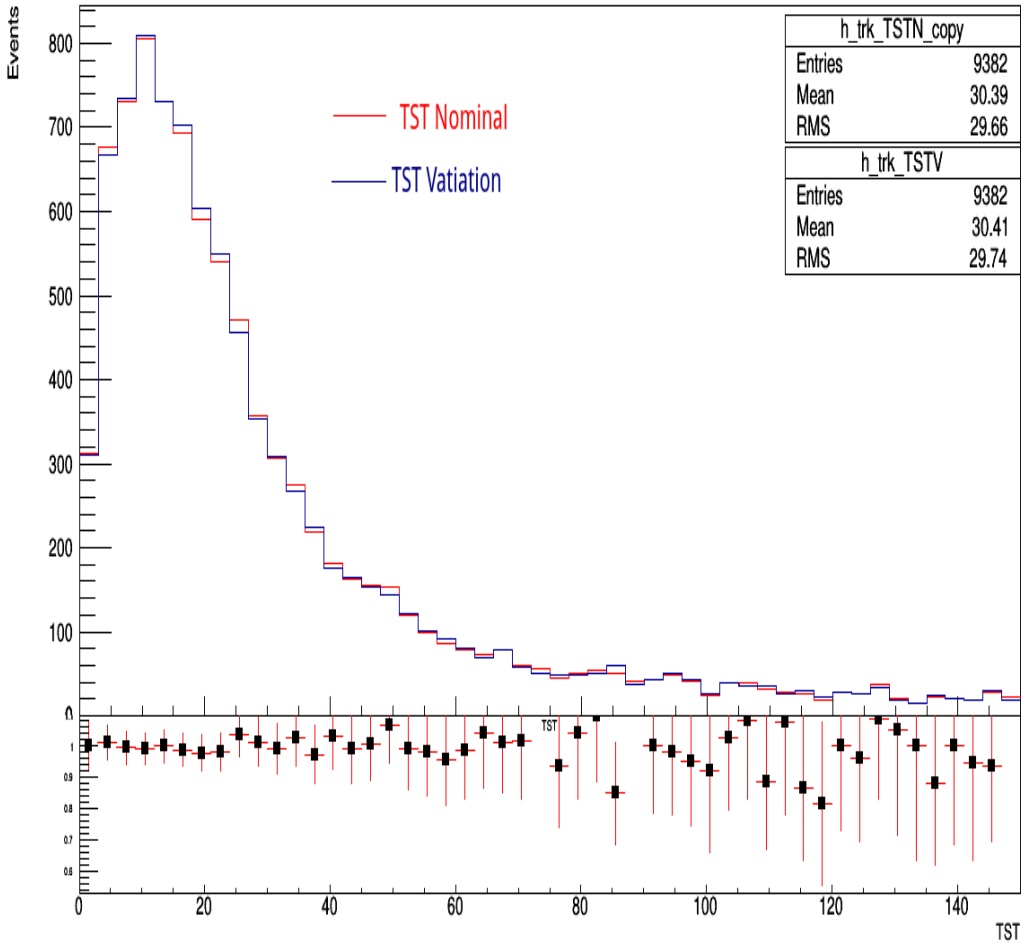
MET in Z→μμ +0jet

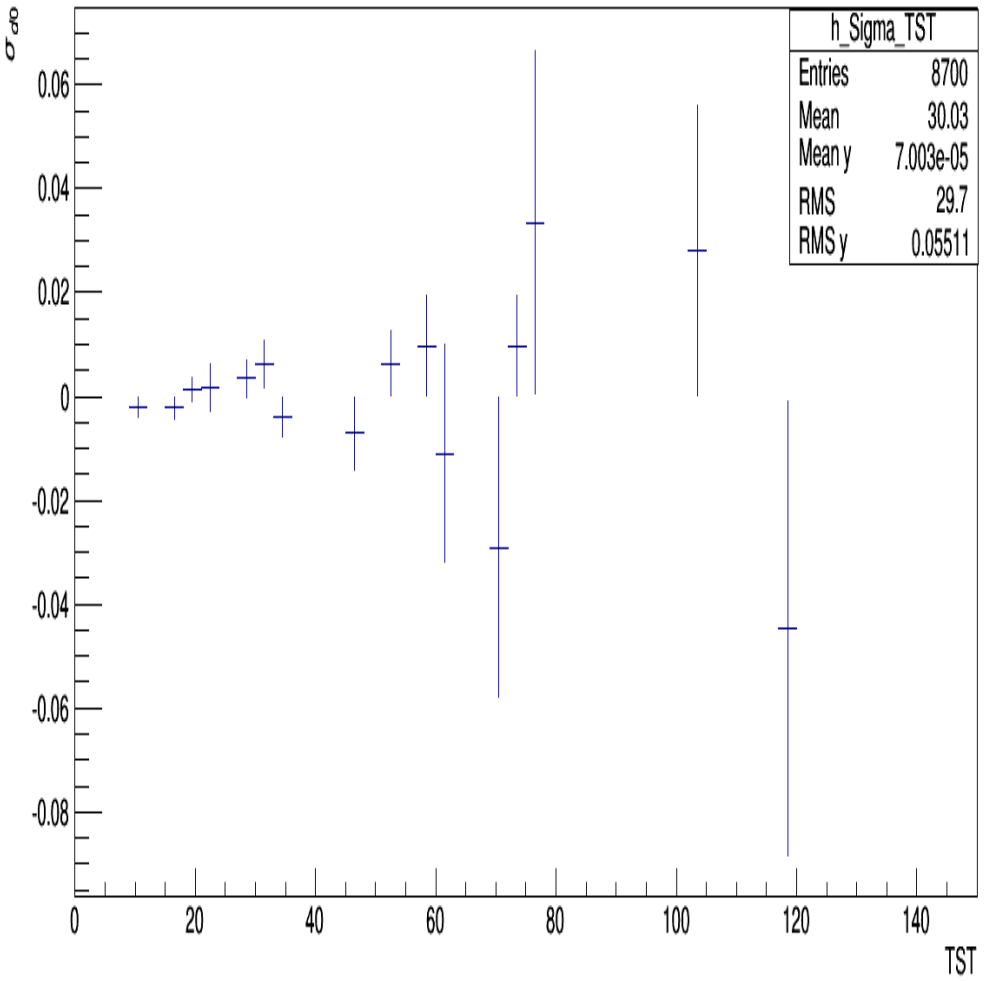
- The MET of an event is calculated as the sum of a number of components the x and y axis :

$$E_{x(y)}^{\text{miss}} = -\left(E_{x(y)}^{\text{jets}} + E_{x(y)}^{e} + E_{x(y)}^{\gamma} + E_{x(y)}^{\tau} + E_{x(y)}^{\mu} + E_{x(y)}^{\text{Soft Term}}\right)$$

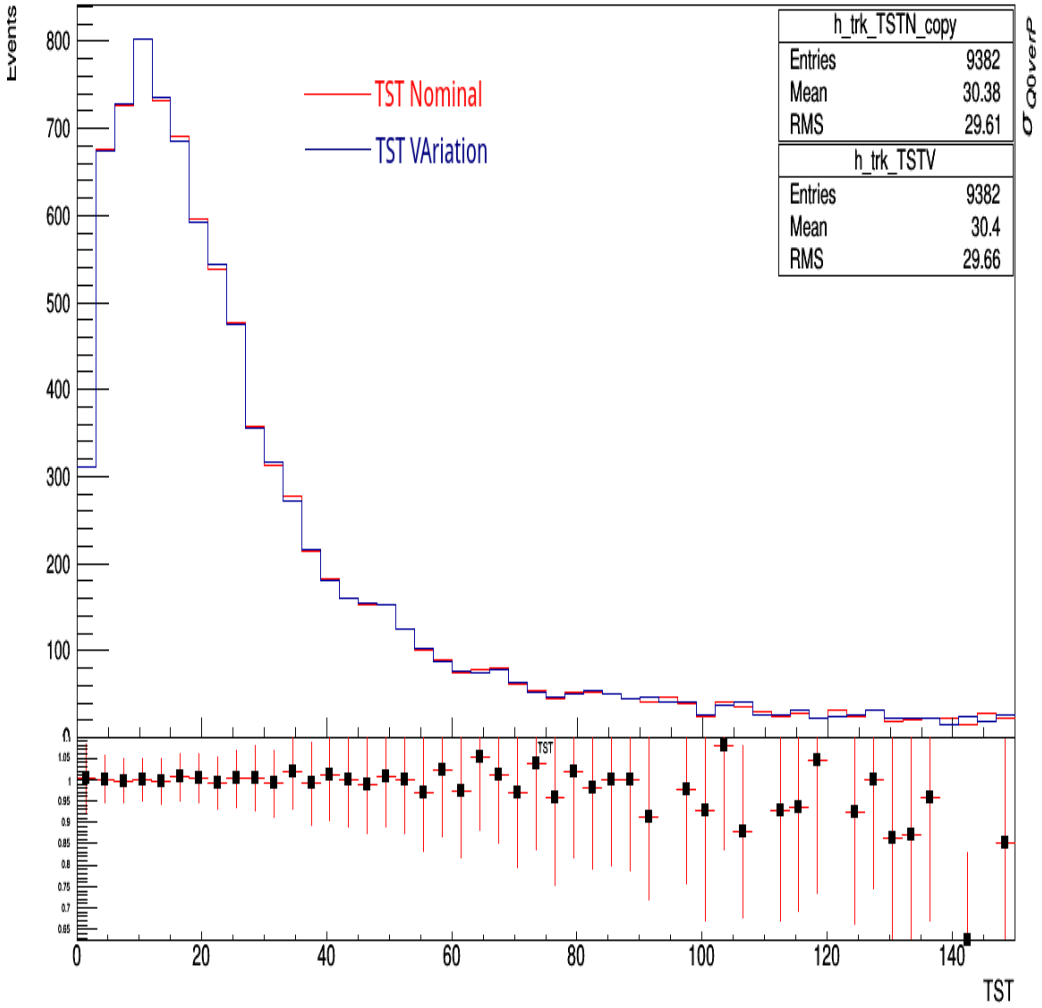


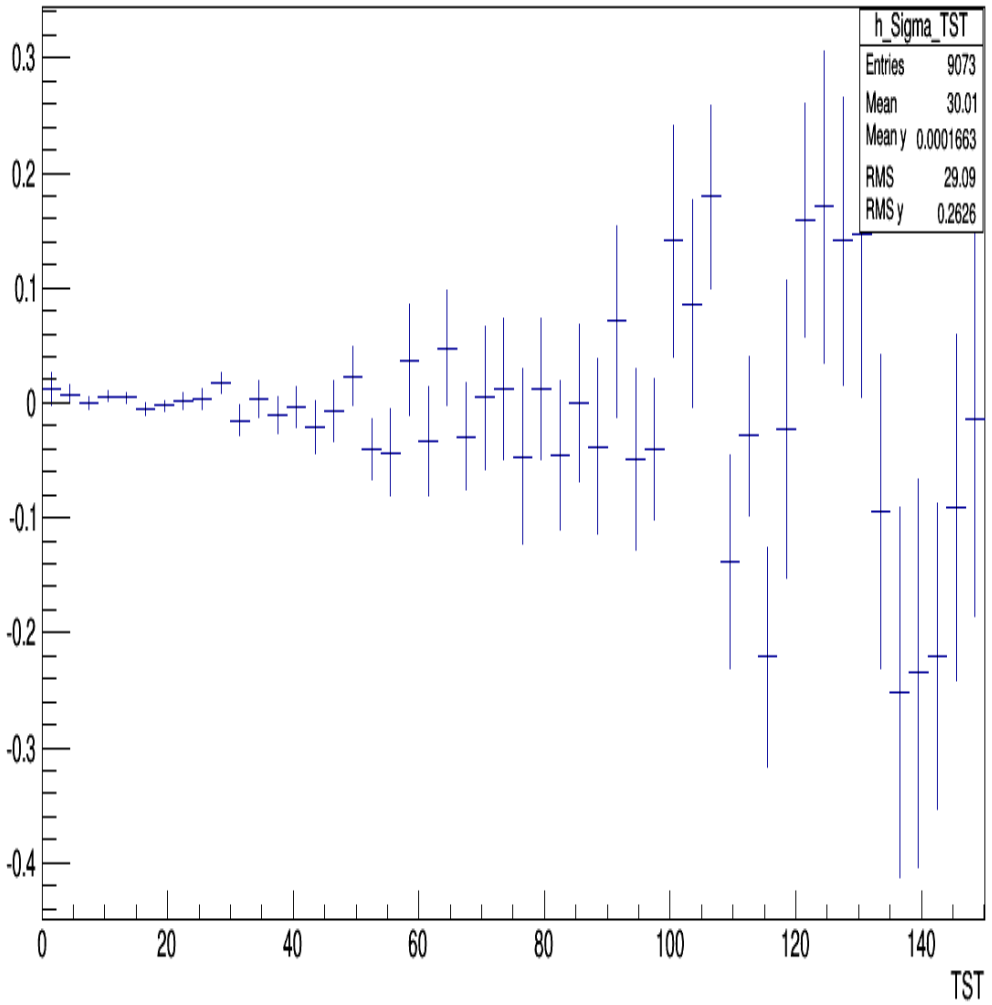
systematic uncertainties: d0 bias + MET Track Selection



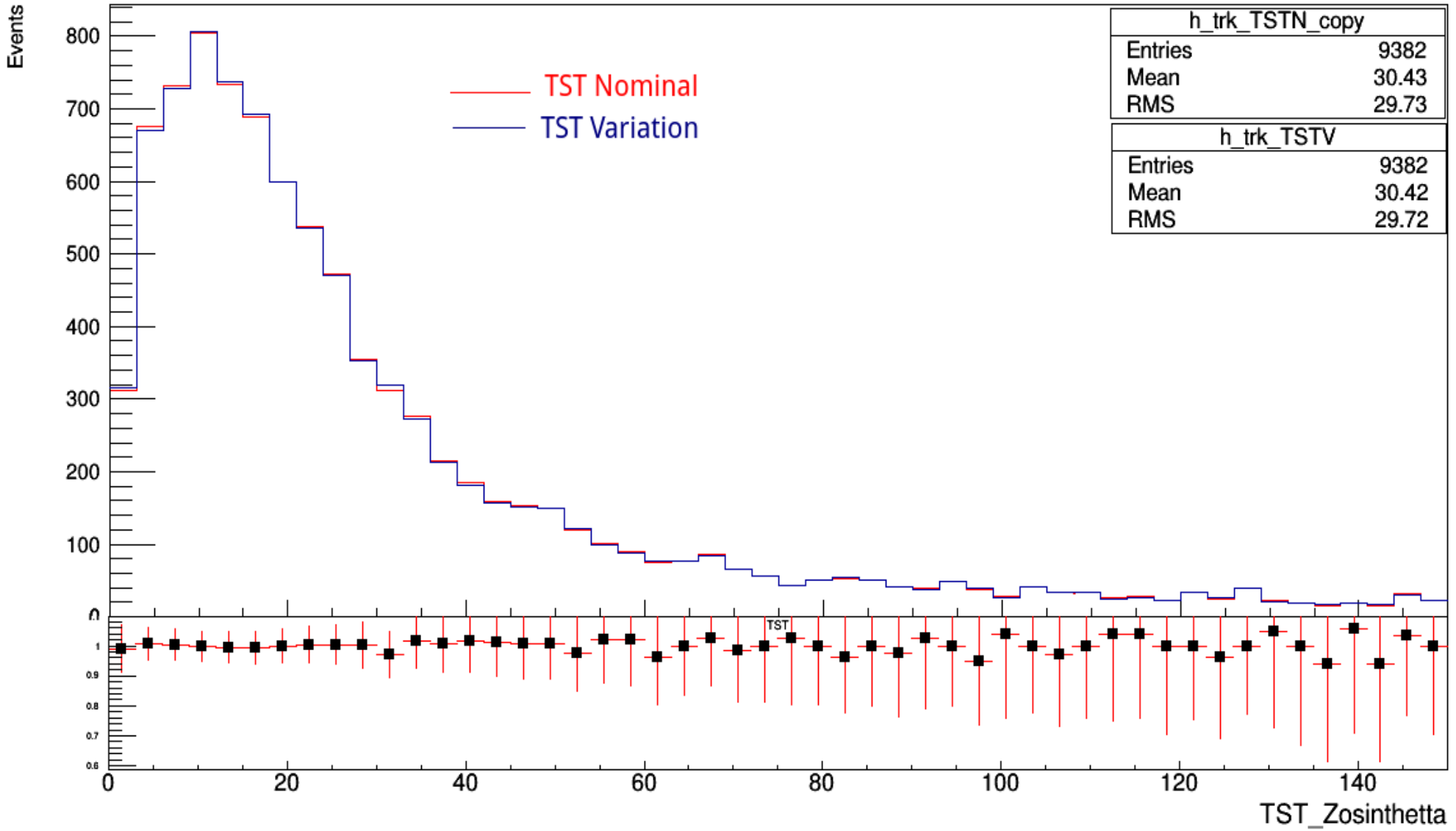


systematic uncertainties: Q0verP bias + MET Track Selection

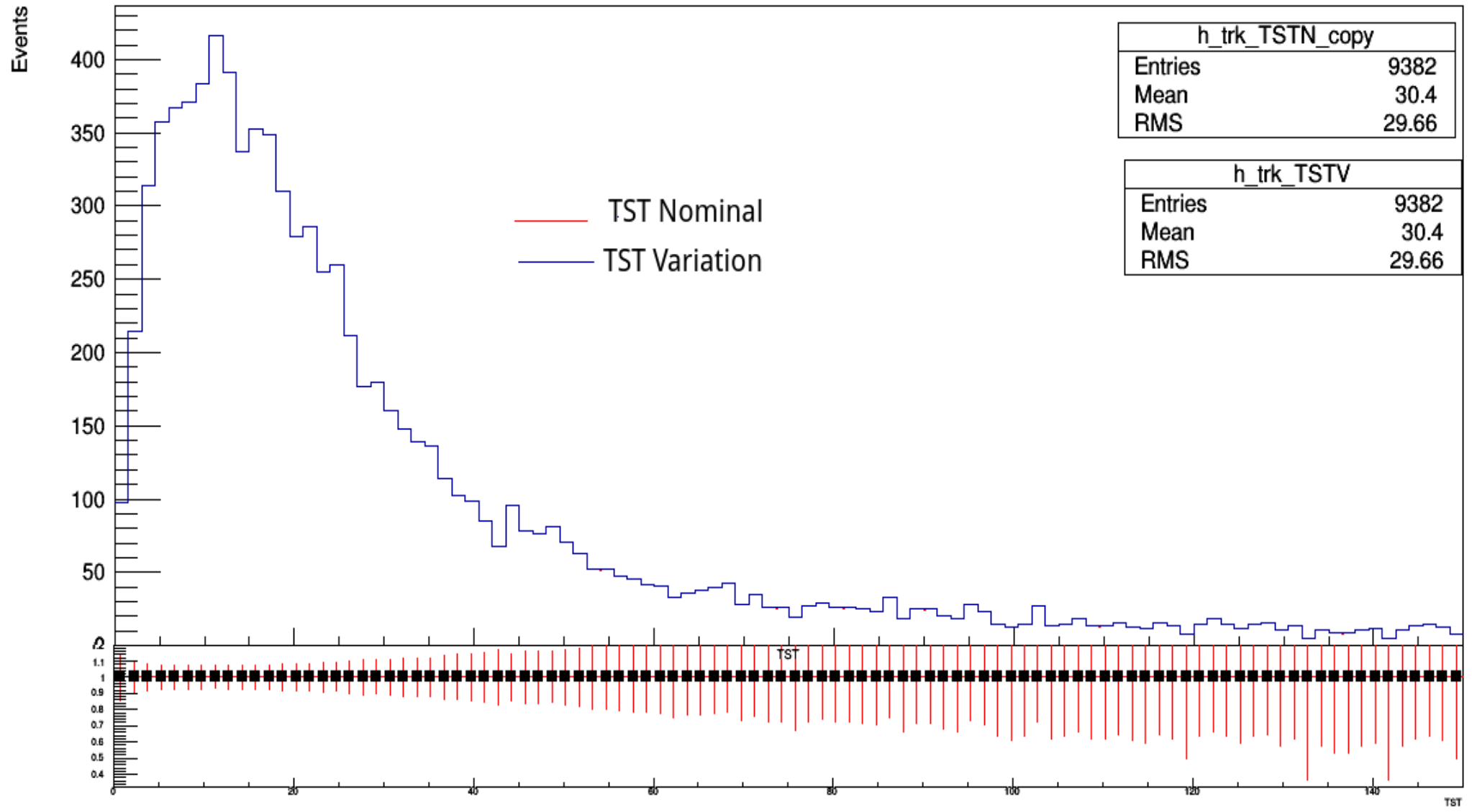




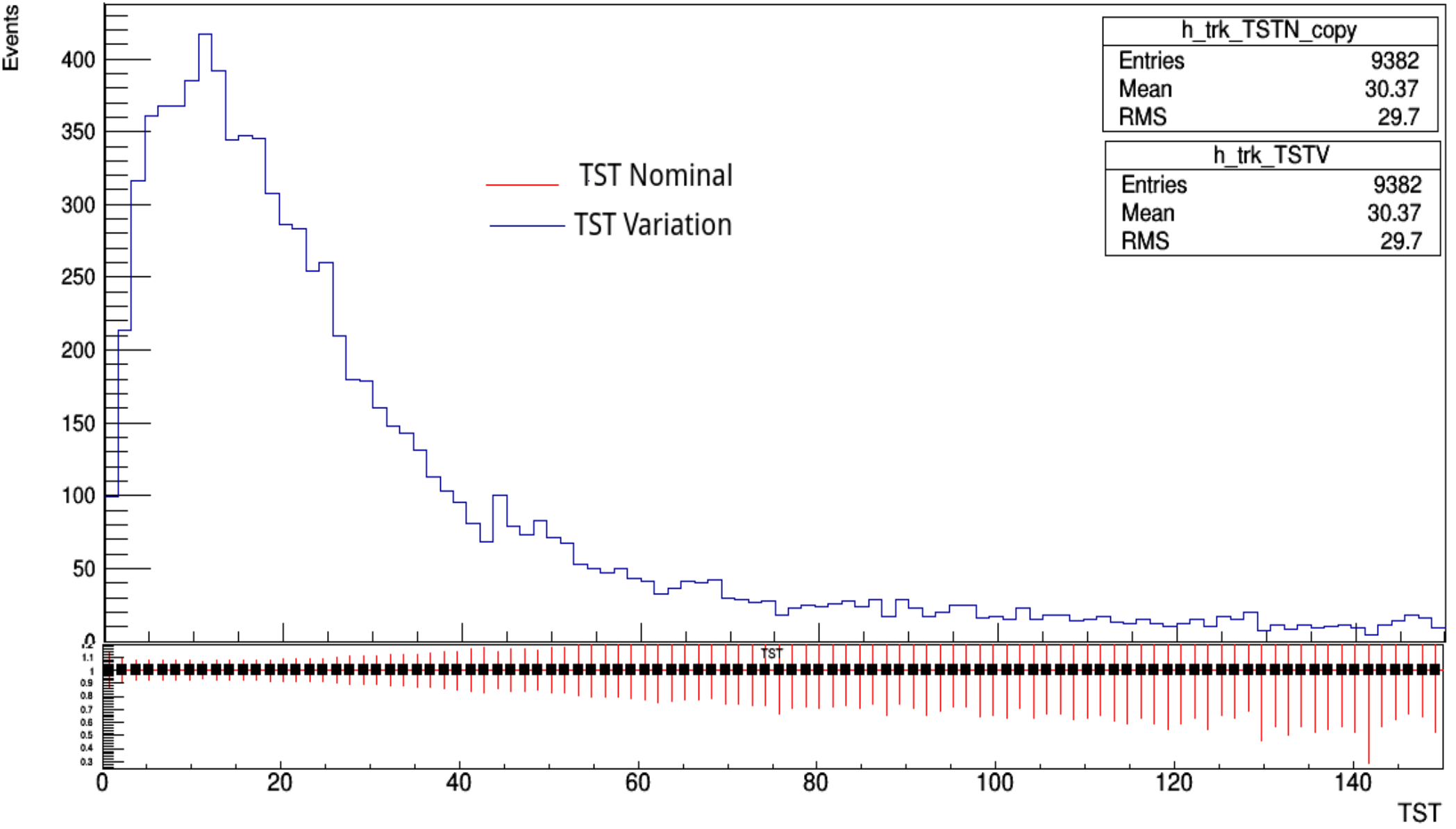
systematic uncertainties: Z0sintheta bias+ MET Track Selection



systematic uncertainties: Global efficiency+ MET Track Selection



systematic uncertainties: PHYModel efficiency+ MET Track Selection



Conclusions

- MET is an important tool for many physics searches
- **Track Soft Term is a critical ingredient in the MET calculation**
- **The current MET TST systematic uncertainties impact the value of the MET for several analyses.**
- **A new development of a track-based algorithm for MET TST systematic uncertainties is ongoing**
- **the plan is to move to Rel. 21 from now on in order to use this method for 2017 data.**