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

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Outline

- ✓ Introduction
- ✓ Soft Term : Track-Soft-Term methode
- ✓ Track Soft Term Selection
- ✓ Analysis Setup
- ✓ Objects and Event Selection
- ✓ Control plots
- ✓ Conclusion

Introduction

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 :**

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

■ **Two extremes approaches :**

■ **transverse vector sum of all objects :**

→Fully reconstruction par Muons, Electrons, Jets, Taus, photon ➡ Hard Term

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

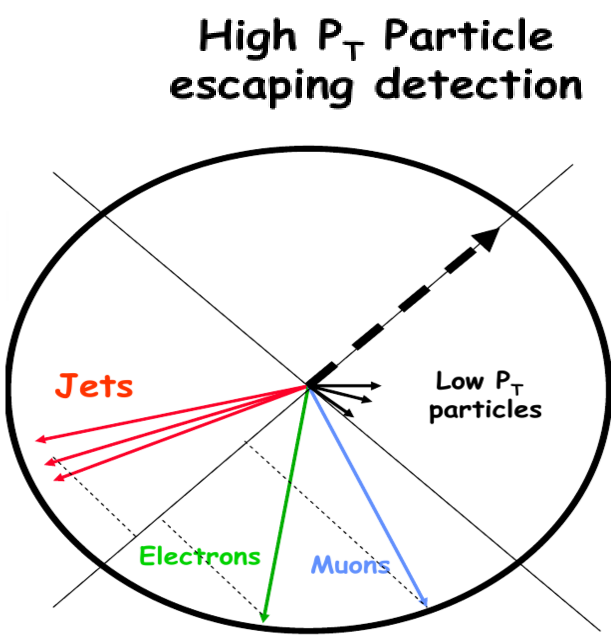
→Signals not used in reconstructed physics objects

➡ Soft Term :

◆ Calorimeter Soft Term (CST) →Reconstructed in the Calorimeter cells

◆Track Soft Term (TST) → Reconstructed in the ID

Focus in TST



Soft Term : Track-Soft-Term

Track Soft Term (TST) built with only from ID tracks satisfying the track selection but not matched to any reconstructed object physic.

- Neglects the cluster contribution → **very sensitive to pileup**
- Associate tracks to primary vertex
- Calculate MET based on primary vertex for soft term :

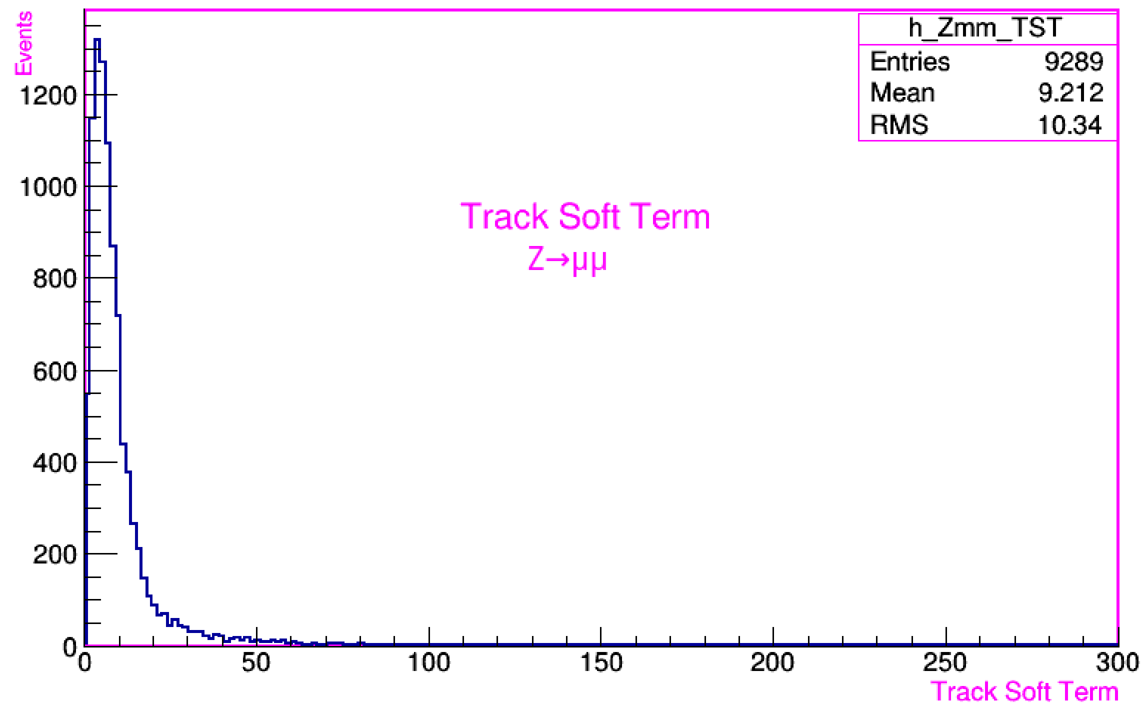
(1) - Better resolution

(2) - reject pileup contribution

(3) - No contribution of soft neutral particle

Track Selection for TST

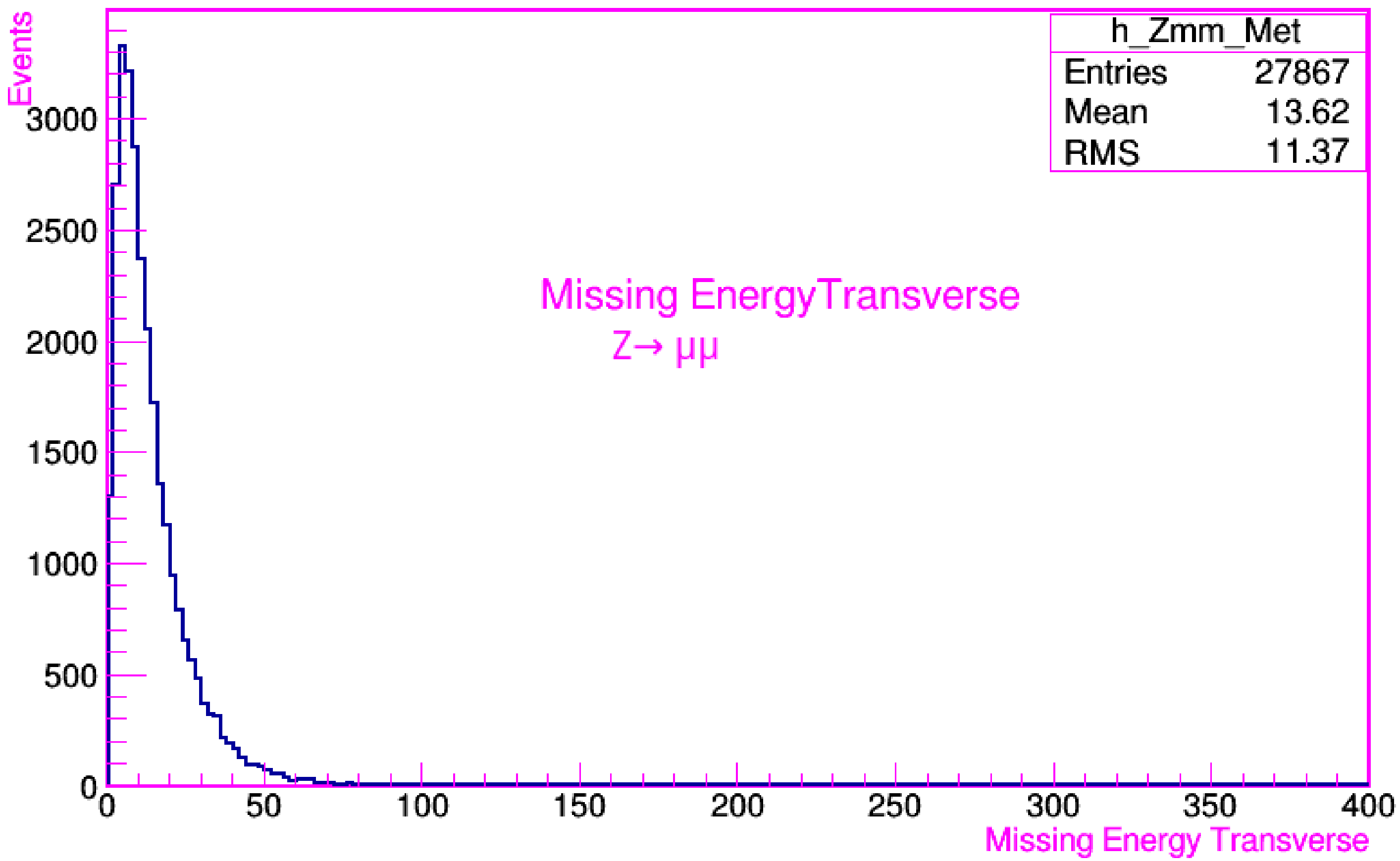
- ➔ Tracks are required to have :
- Track pT > 400 MeV
- Track |η| < 2.5
- Either (N(Si) ≥ 7 and N(shared Si) = 0) OR N(Si) ≥ 10
- N(shared module) ≤ 1
- N(pixel hole) = 0
- N(SCT hole) ≤ 2
- |d0| < 2 mm
- |z0sin(theta)| < 3 mm



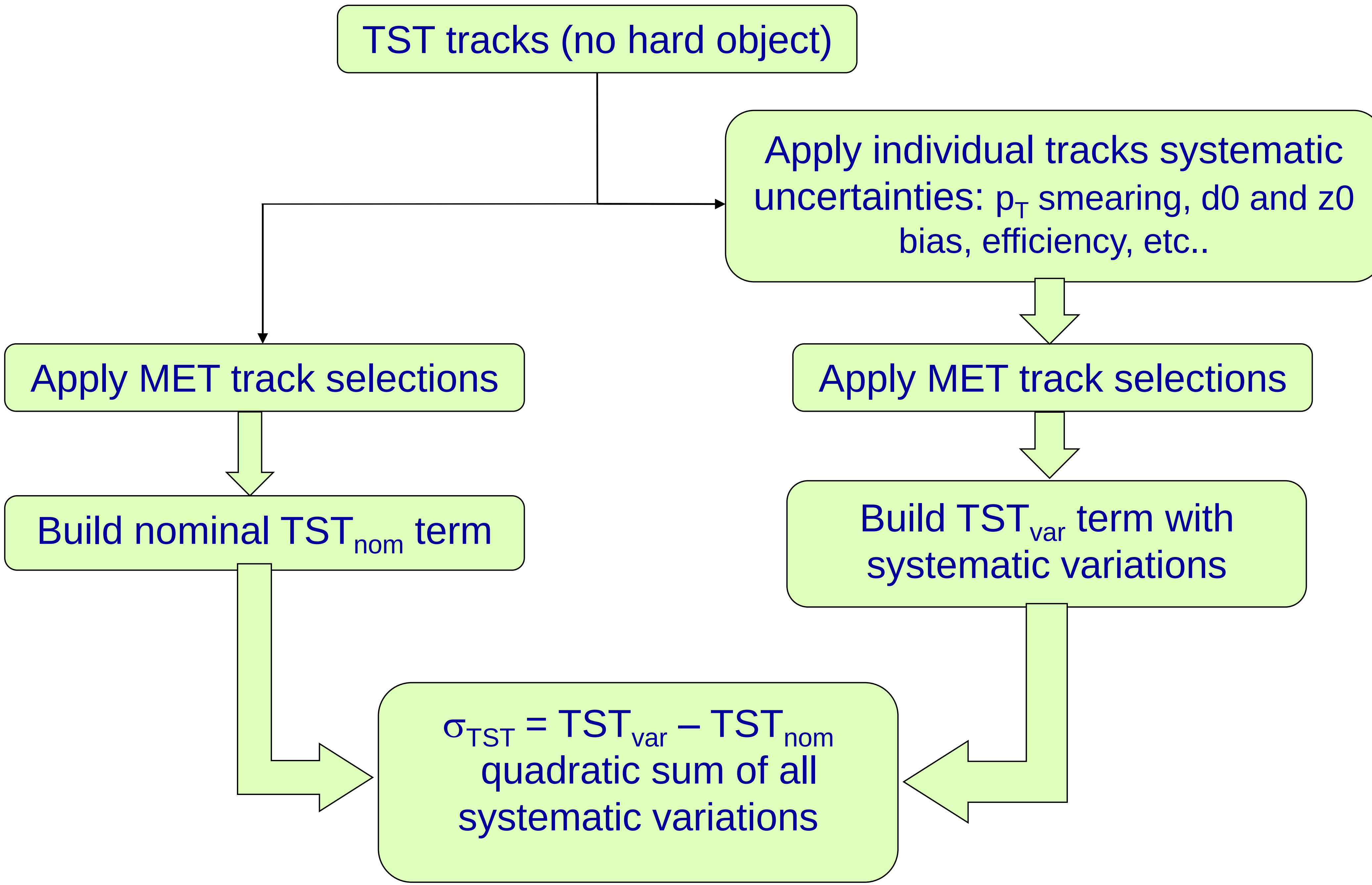
MET in Z→❍❍ +0jet

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

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



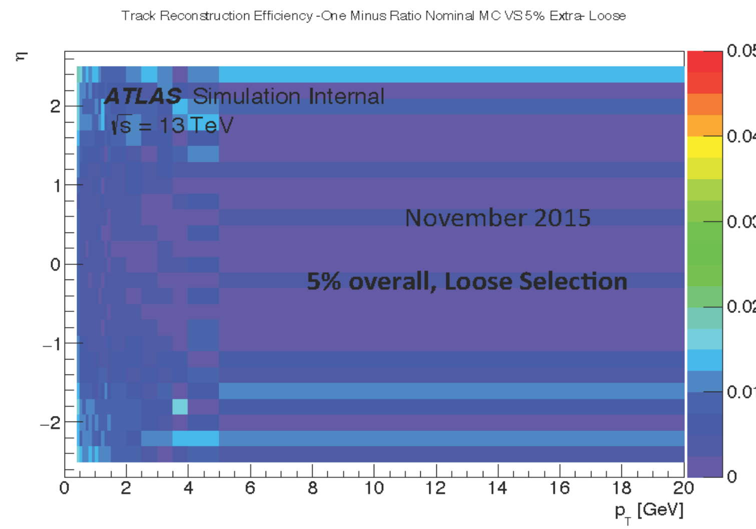
Framework for track-based systematic uncertainties

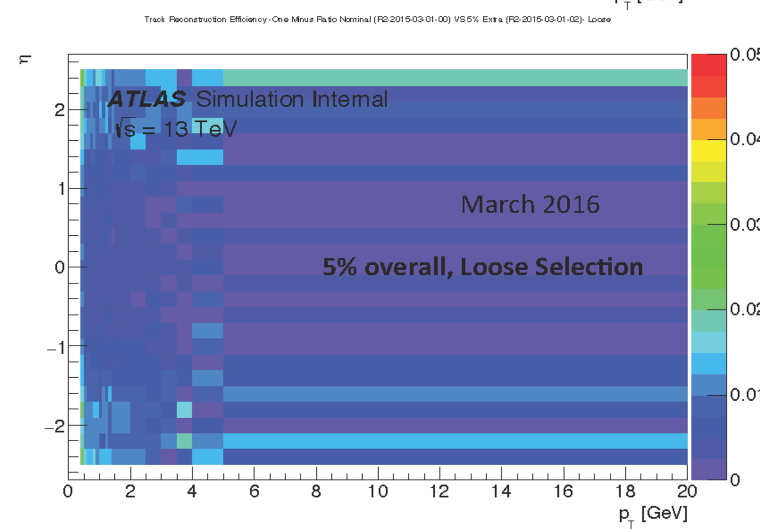


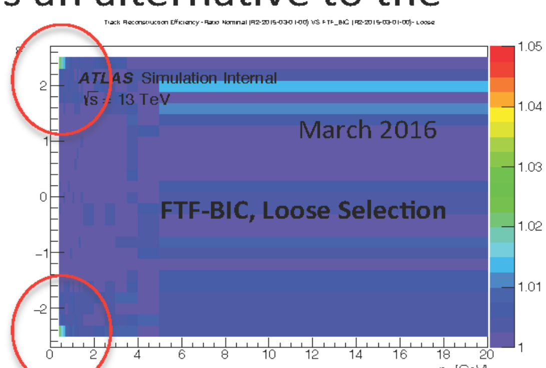
Systematic uncertainties on tracking: Efficiency

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

- Main source of systematic uncertainty on the tracking efficiency is the **material** in the Inner Detector → Considered **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

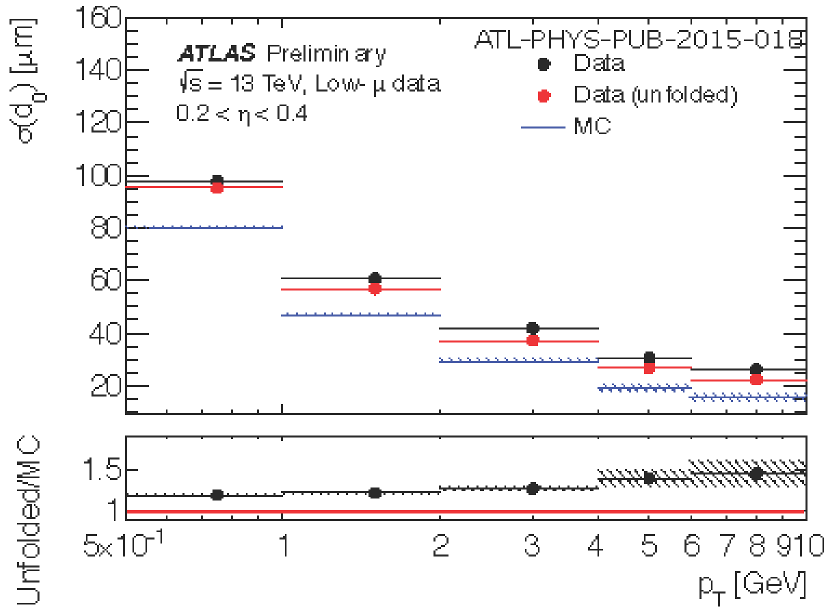






Systematic uncertainties on tracking: Vertexing

- 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)

Analysis Setup

Framework : AthenaAnalysisBase 2.4. 29, MC15 Sample : DAOD_JET3M

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

The major classes and packages that are important to analysis with MET in ATLAS and to access to MET objects are:

- **METUtilities package**
- met::METMaker
- met::METRebuilder

- **Track Tools**
- Sysetematic variation
- Track Selection Tool

Object and event selection

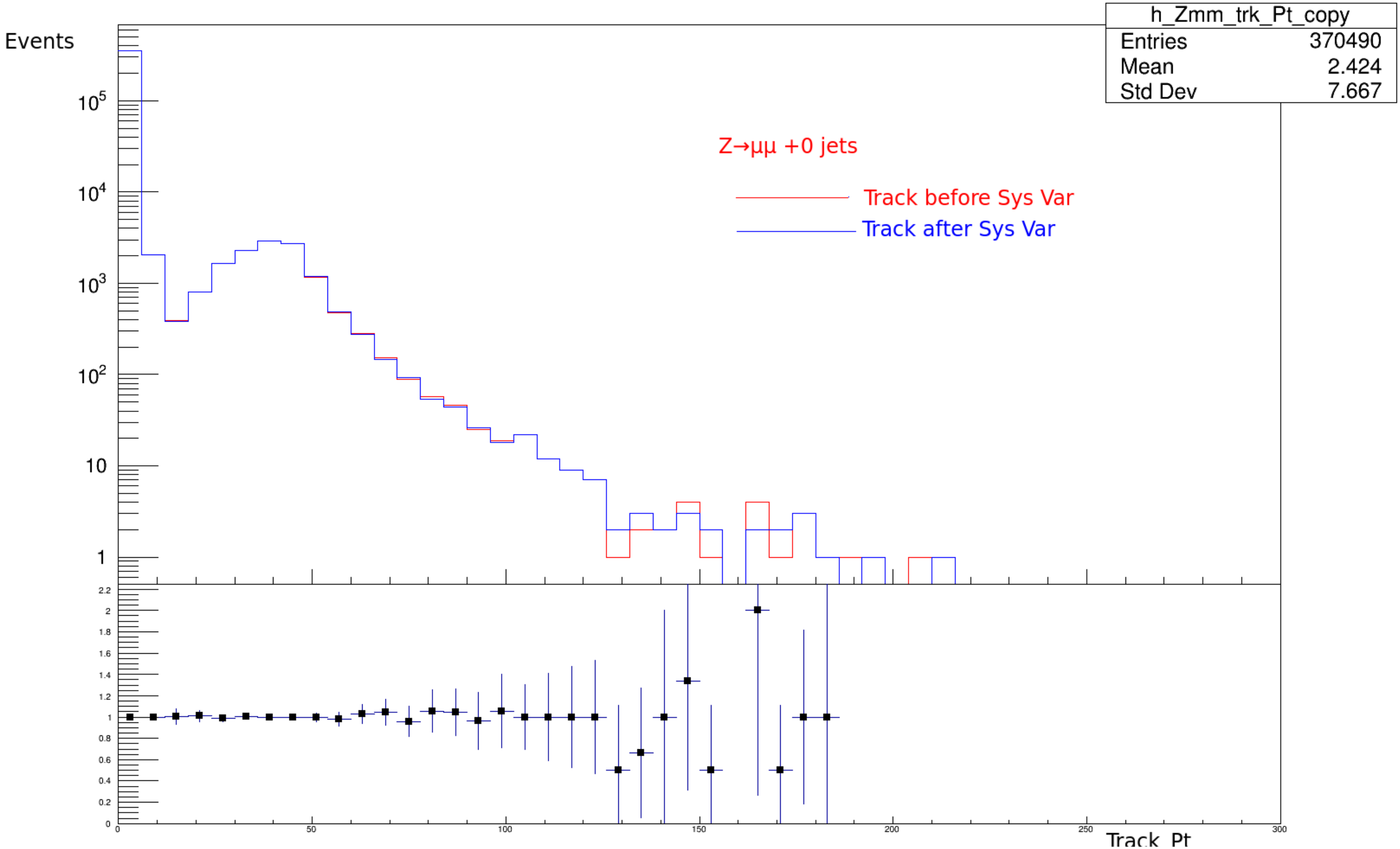
$E_{x(y)}^{miss,e}$, $E_{x(y)}^{miss,Photon}$, $E_{x(y)}^{miss,Tau}$
- Good isolated calo object
- Matched to track
- Pt>10GeV

$E_{x(y)}^{miss,Jets}$
- Topological clusters
- calibrated with LCW+JES
- Anti-kT (R=0.4)
- Pt > 25 GeV

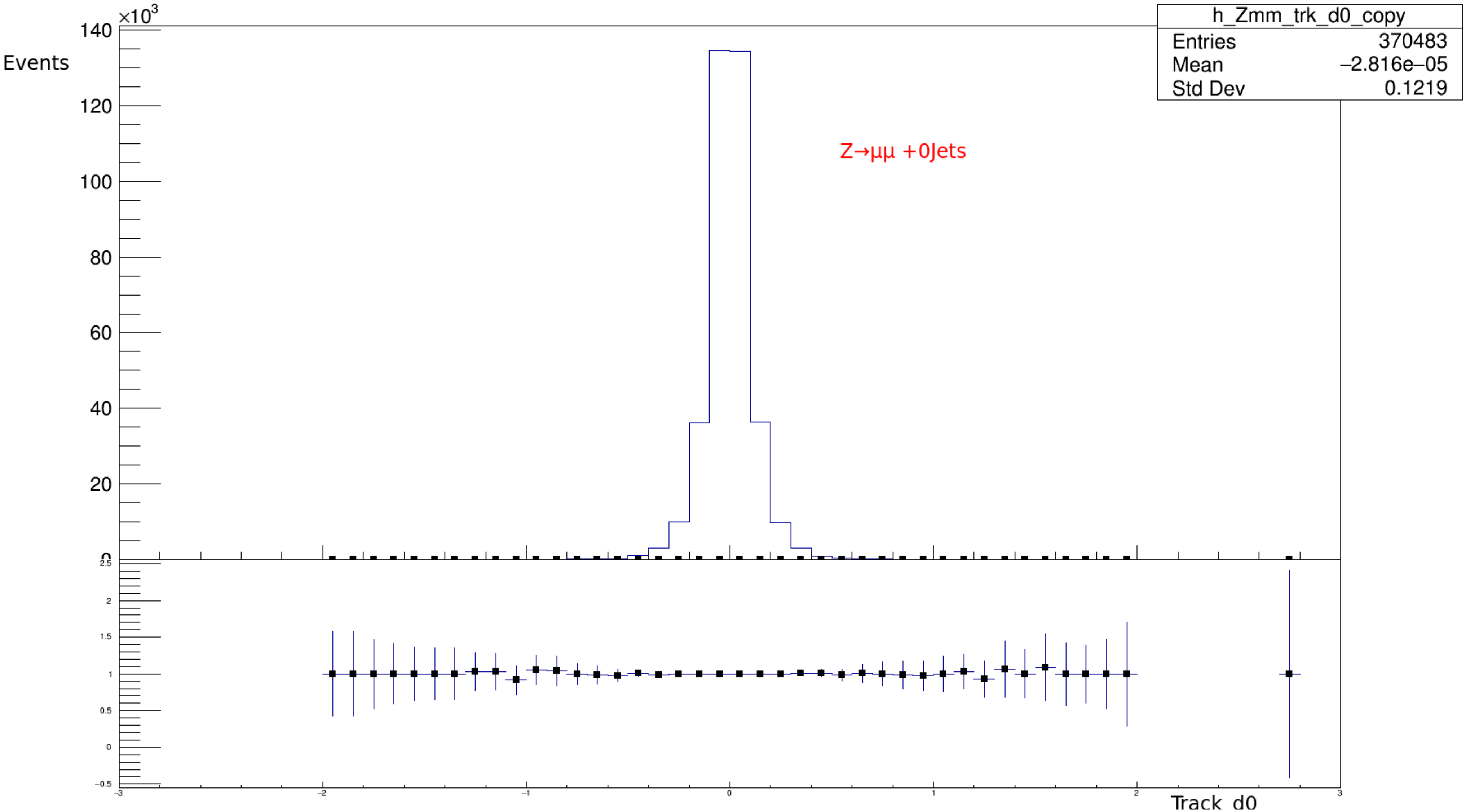
$E_{x(y)}^{miss,mu}$
- Segments in tracker and muon detector
- Pt > 25 GeV

Z→ll+0-Jets
- Presence of exactly two good muons and of opposite charge
- Pt(muon) > 25 GeV and $\eta_{muon}|$ < 2,5
- Z boson mass: 66 < mll< 116 GeV

Control Plot



Control Plots



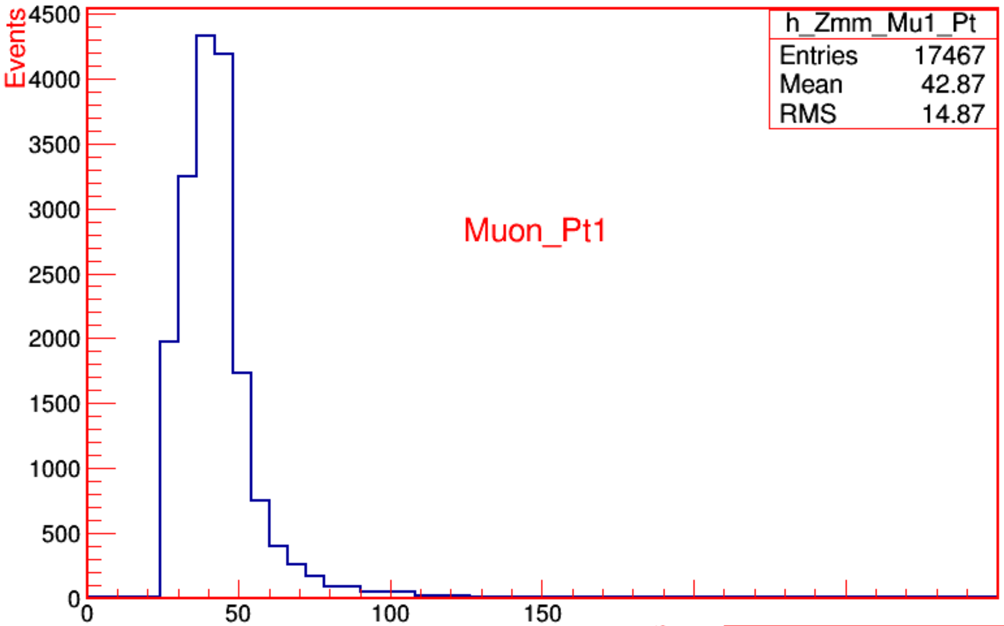
E_t^{Miss} is an important tool for many physics searches that are in progress at ATLAS.

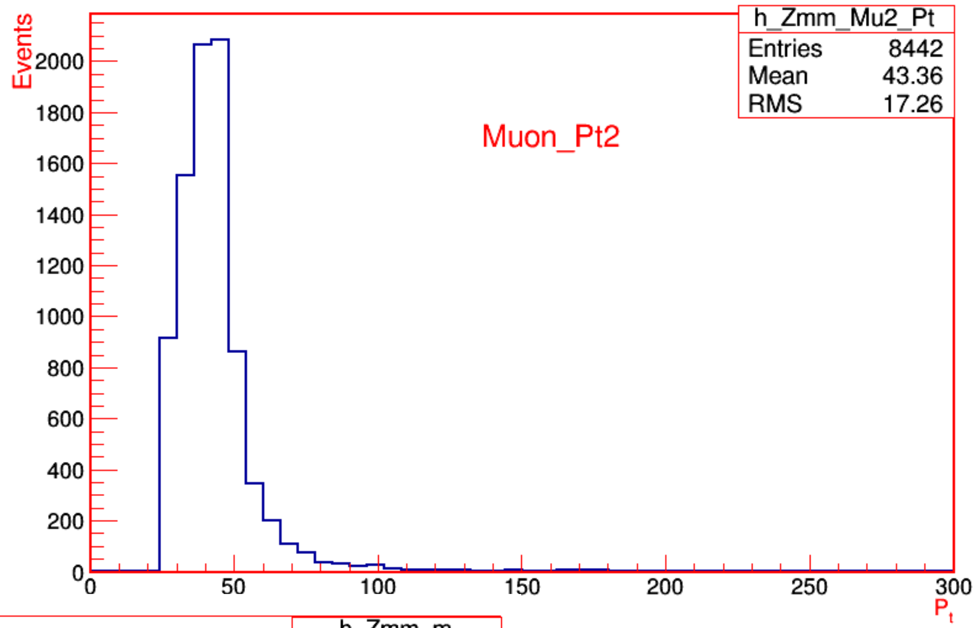
Most direct approach is to calculate tranverse vector sum of all particle detected.

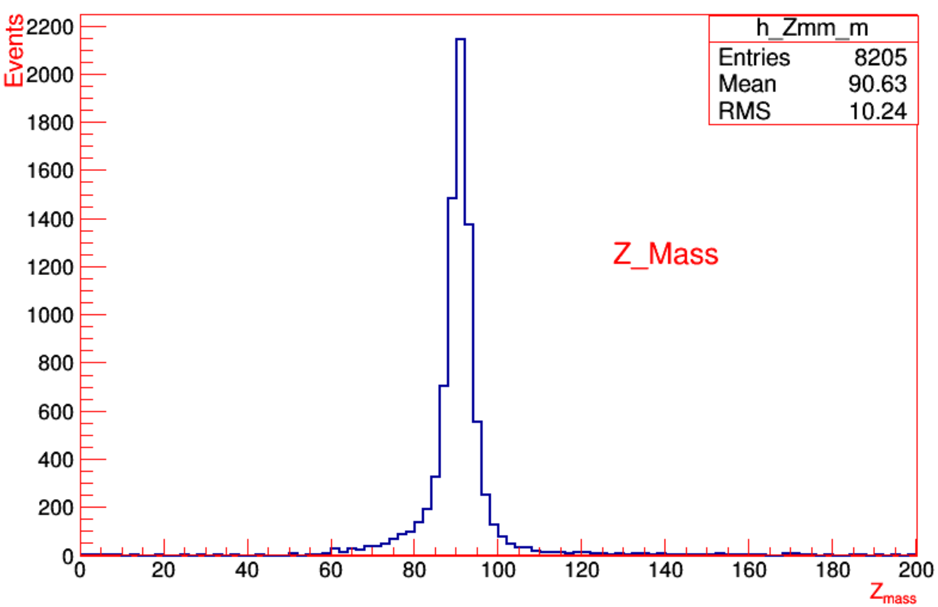
Many techniques using of tracks Soft Term provide for optimal performence .

THANKS   :)

Control Plots

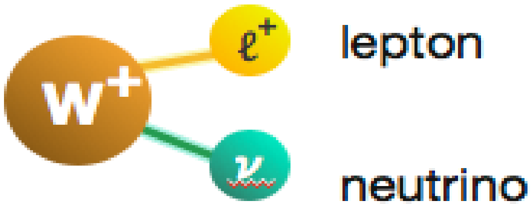






Standard Model (SM) Process

- **SM Process**
  - **W+jets :**
    - W→ lv, in Wish v electron or muon
    - W→ lτ, in Which τ decays hadronically



- **Z+jets :**
    - Z→ ll, in Which l electron or muon
  - **Single/Pair top production**

•$t\bar{t} \rightarrow W b \bar{W} \bar{b}$

  - **QCD multijet production**