Missing Transverse Momentum (Ptmiss) in PbPb collusions with CMS detector at LHC

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Outlook

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- CMS
- Ptmiss
- Ptmiss in Z->mumu
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    - Z Event selection
    - Particle Flow and constituent subtracted .
    - Ptmiss
- Ptmiss in W->munu
    - Dataset
    - W Event selection
    - MT
- Summary and Outlook

Introduction

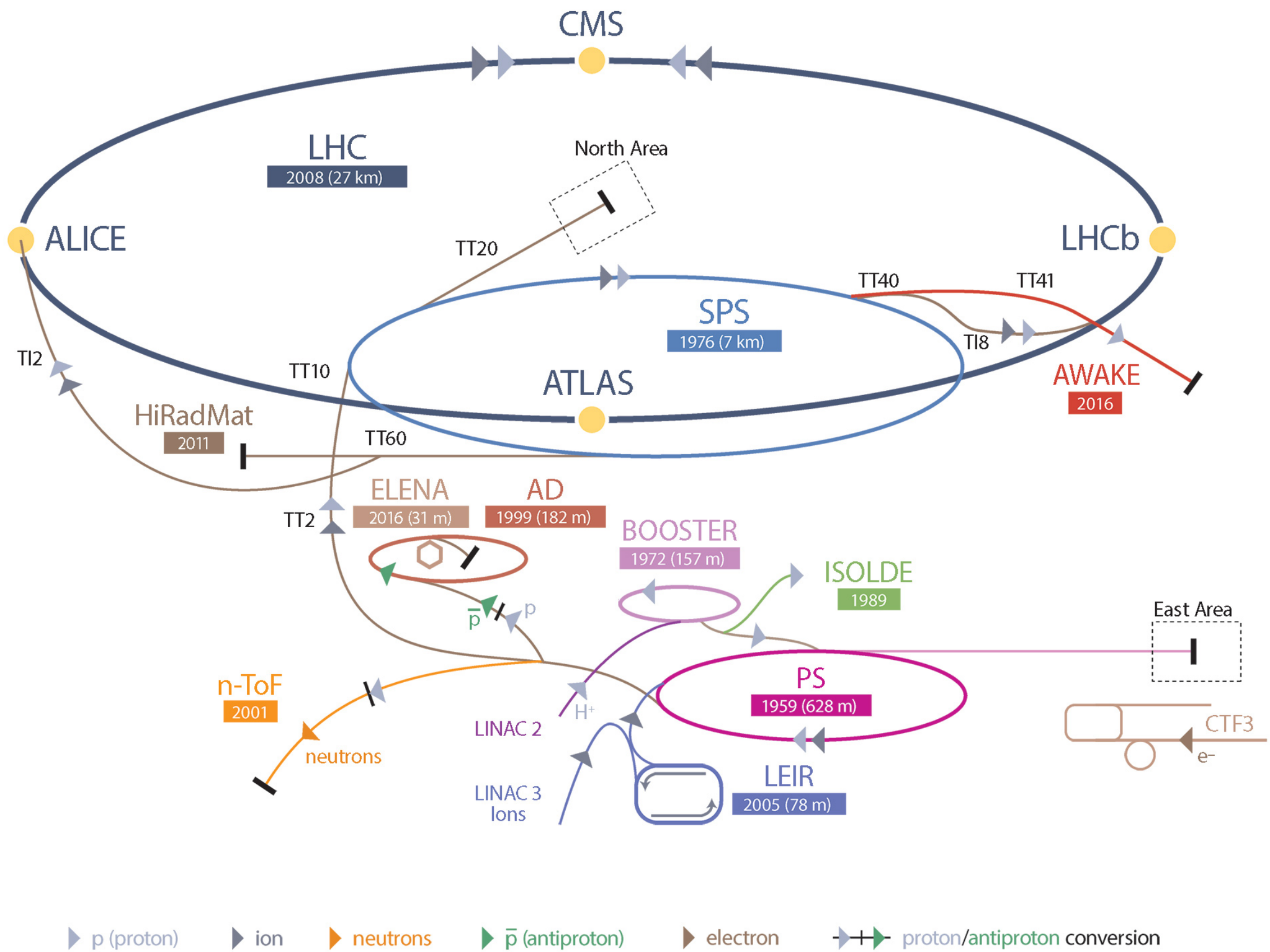
- At LHC a significant, unmeasured amount of energy is escaped in z direction.

- The initial and final momentum is zero in transverse direction, so the imbalance energy in transverse direction signals presence of weakly or non-interaction particle such as neutrino. → **Ptmiss**

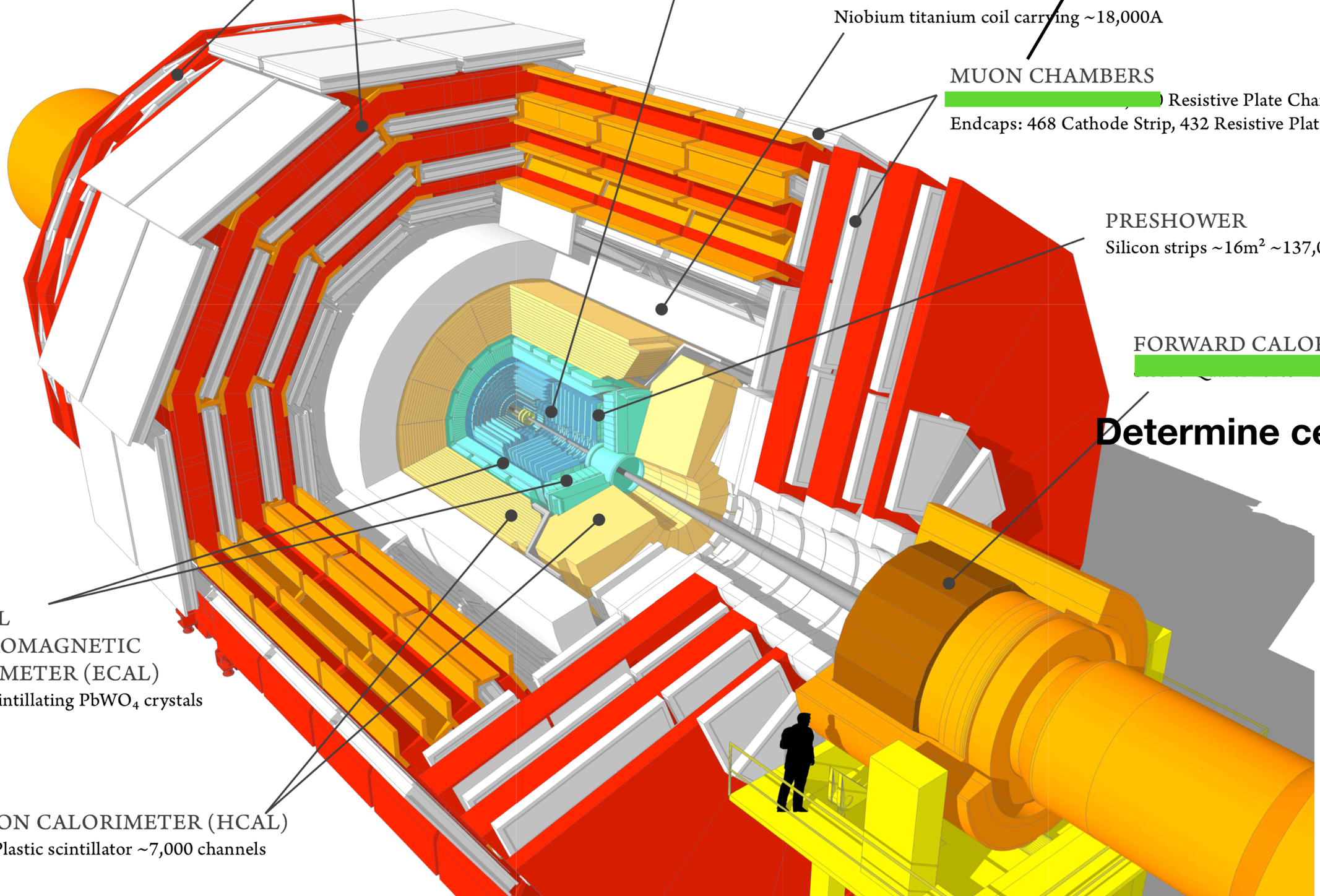
The main purpose of my project is the calculation of Ptmiss in PbPb collisions with an identified Z boson or W boson.

LHC

CERN's Accelerator Complex



CMS

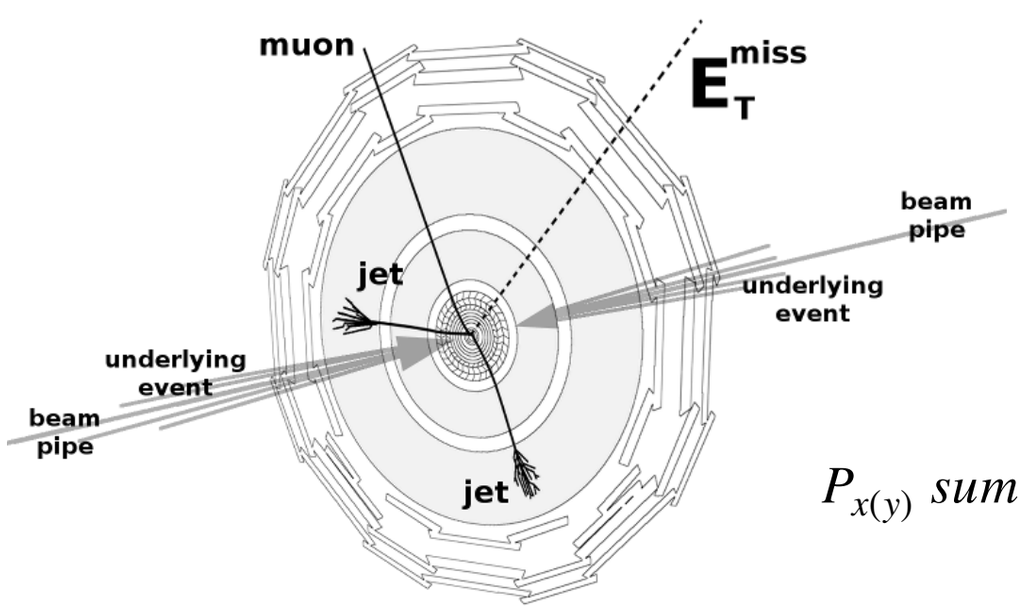

CMS DETECTOR
Total weight : 14,000 tonnes
Overall diameter : 15.0 m
Overall length : 28.7 m
Magnetic field : 3.8 T
STEEL RETURN YOKE
12,500 tonnes
SILICON TRACKERS
~66M channels
Microstrips (80x180 μm) ~200m² ~9.6M channels
reconstruct muons
SUPERCONDUCTING SOLENOID
Niobium titanium coil carrying ~18,000A
MUON CHAMBERS
Resistive Plate Chambers
Endcaps: 468 Cathode Strip, 432 Resistive Plate Chambers
PRESHOWER
Silicon strips ~16m² ~137,000 channels
FORWARD CALORIMETER
Determine centrality
CRYSTAL ELECTROMAGNETIC CALORIMETER (ECAL)
~76,000 scintillating PbWO4 crystals
HADRON CALORIMETER (HCAL)
Brass + Plastic scintillator ~7,000 channels

Ptmiss

Ptmiss correspondes to the transverse momentum that is carried by weakly interacting particles.

Ptmiss can be defined as the imbalance in the transverse momentum of all particles that interact with the detector.

Ptmiss is the negative of the vectorial sum of the transverse momenta of all PF particles.



$$Ptmiss = \sqrt{P_{xMiss}^2 + P_{yMiss}^2}$$

$$\overrightarrow{P_{x(y)Miss}} = -\sum \overrightarrow{Pt_{x(y)}}$$

$P_{x(y)}$ *sum of transverse momuntum of all PF particles in* $x(y)$ *direction*.

Ptmiss in Z->mumu

Data and simulation samples

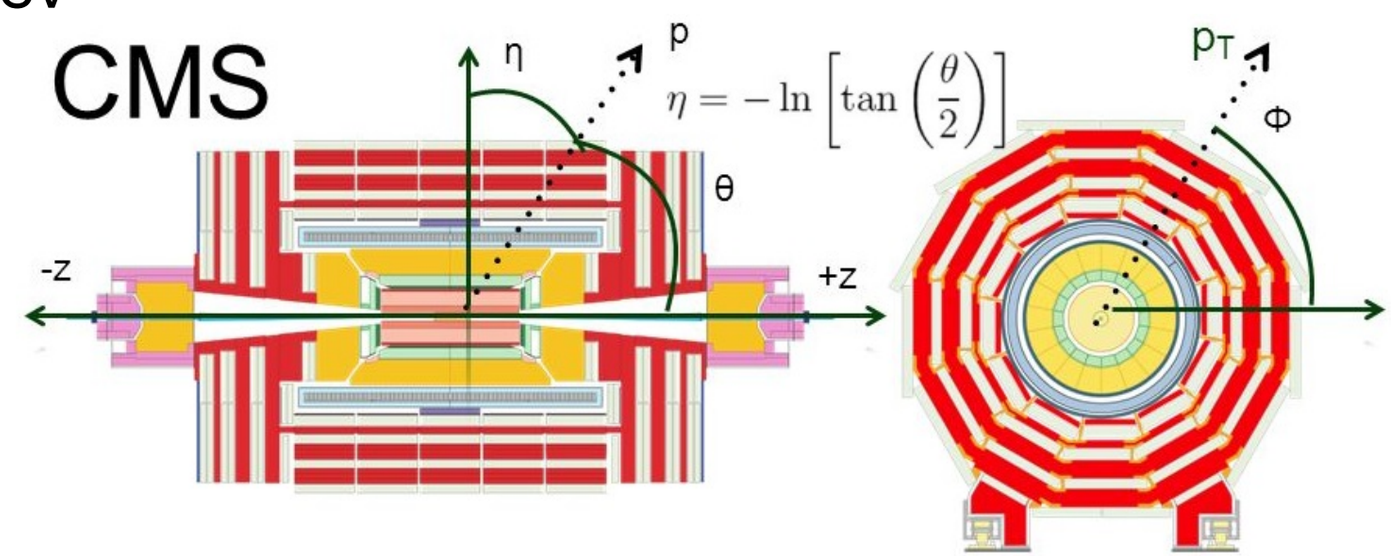
The performance of missing transverse energy is presented using $\sqrt{S_{NN}} = 5.02Tev$ PbPb collision data collected with CMS detector in 2015, corresponding to an integrated luminosity of 400 μb^{-1}. Also, Ptmiss is studied for the first time in this dataset.

Simulated Standard Model background sample is produced using Pyquen (based on Pythia).

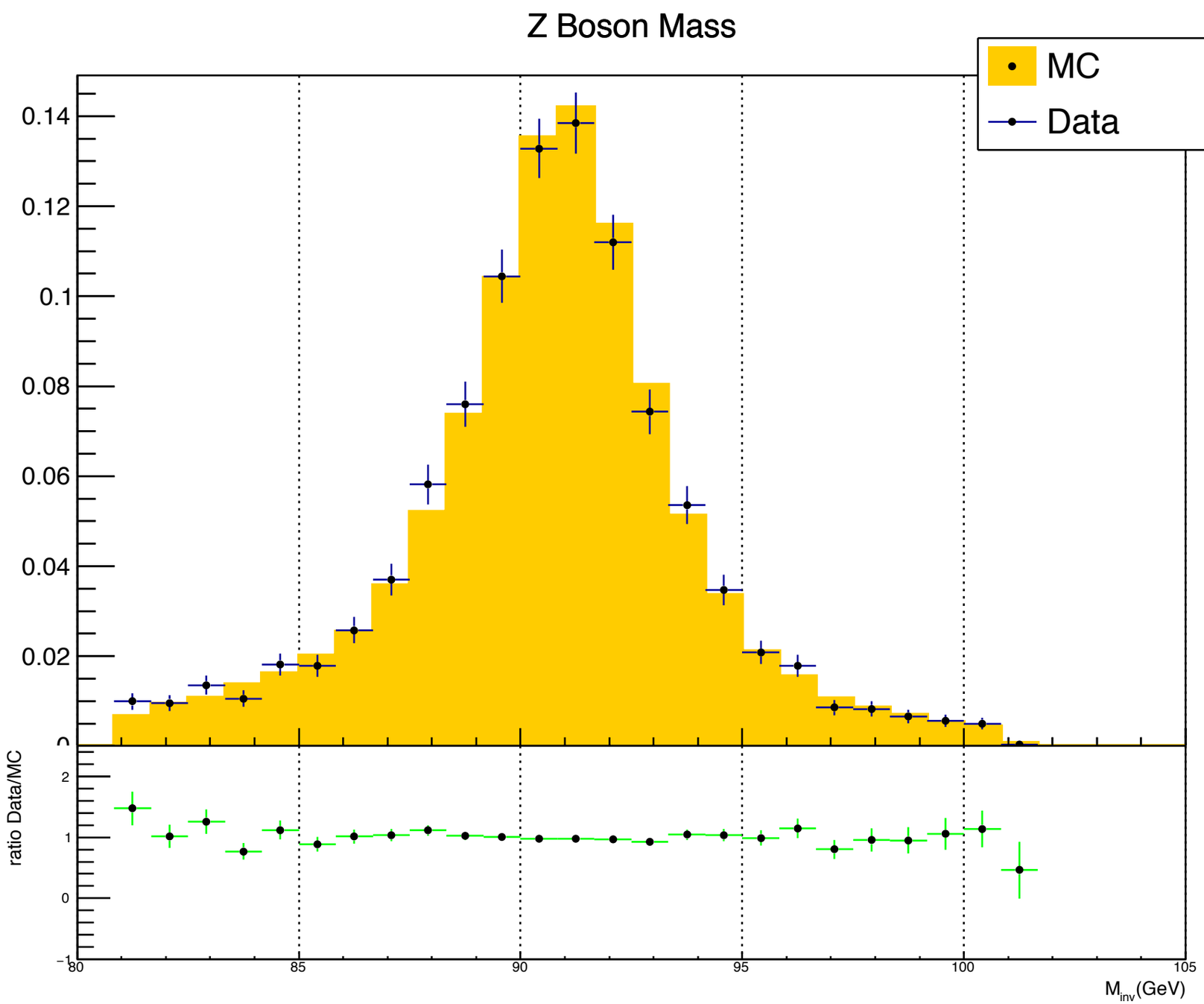
Z event selection

Exactly 2 muons , |η(μ)| < 2.4 $81Gev < M(\mu\mu) < 100Gev$

$p_T(\mu)$ > 25 Gev

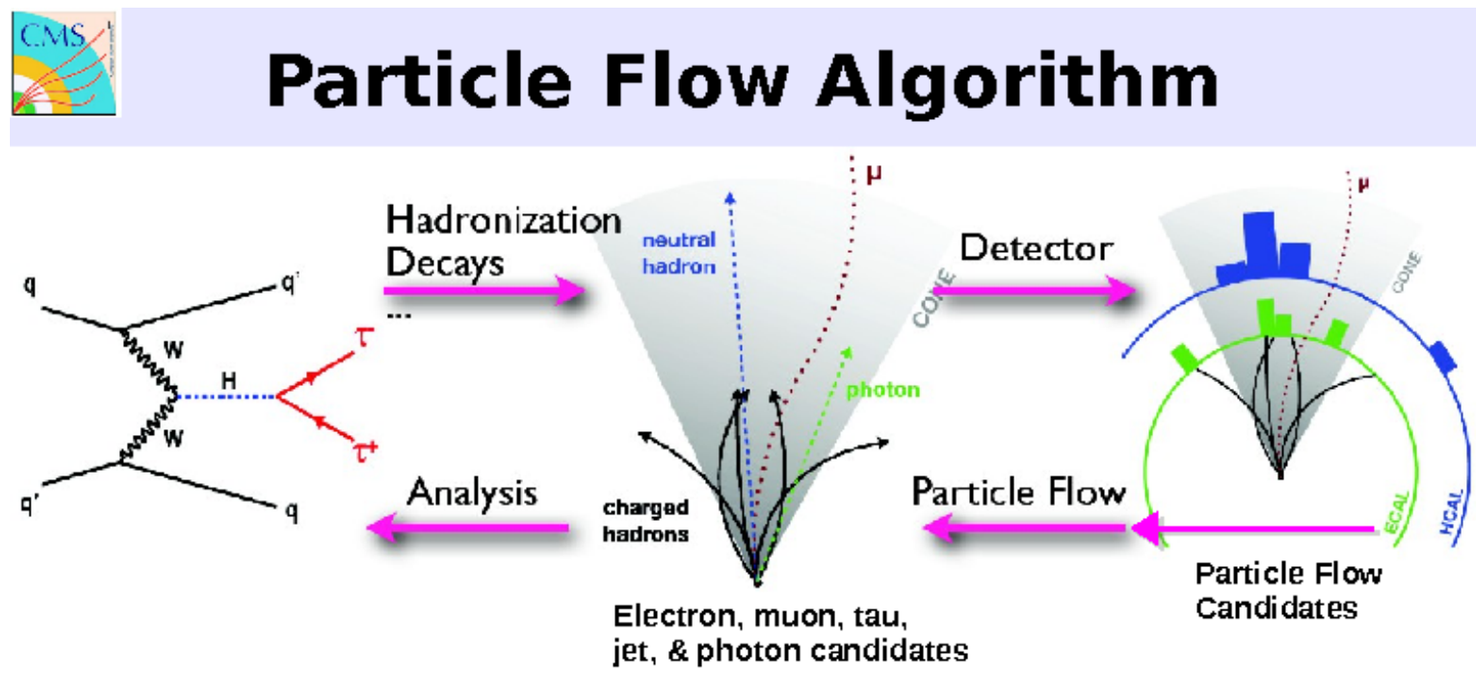


Invariant mass



Particle Flow and constituent subtracted

Particle Flow (PF)



Constituent Subtraction (CS)

- A method used to subtract the average underlying event background particle-by-particle.

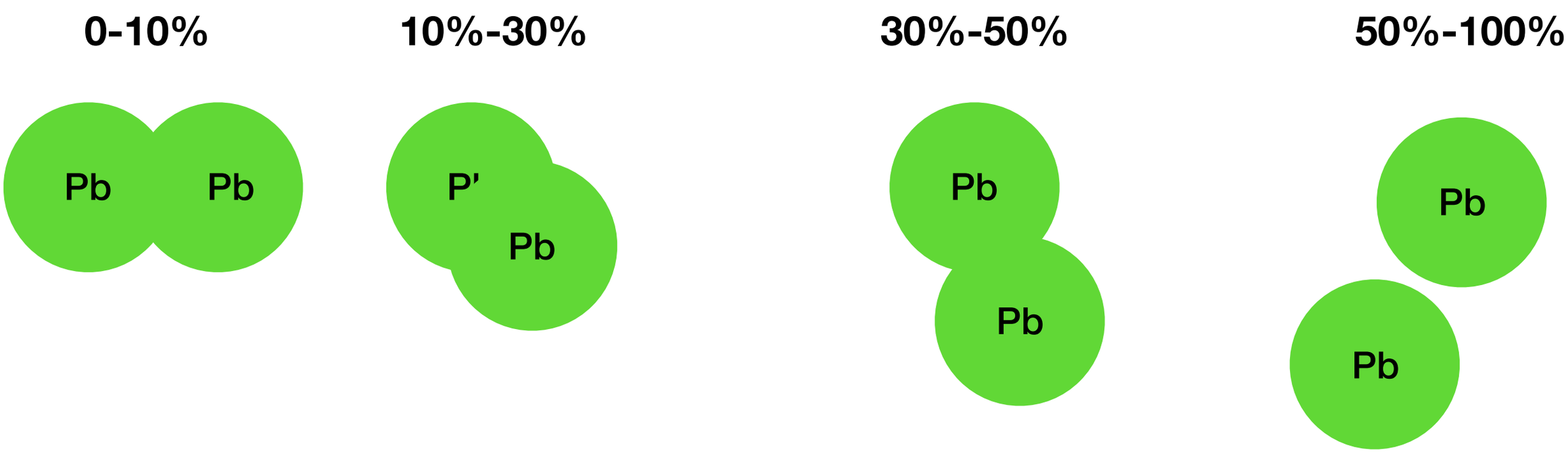
Ptmiss

Ptmiss Selection

- Using PF particles (with or without CS)
- ID { 1, 2, 3, 4, 5 }
- Centrality {0-10%, 10%-30%, 30%-50%, 50%-100%}

Centrality : quantity reflecting the impact parameter of the colliding nuclei, using the percentage of the total cross section, which is evaluated using the sum of the total energy deposited in both forward hadron calorimeters.

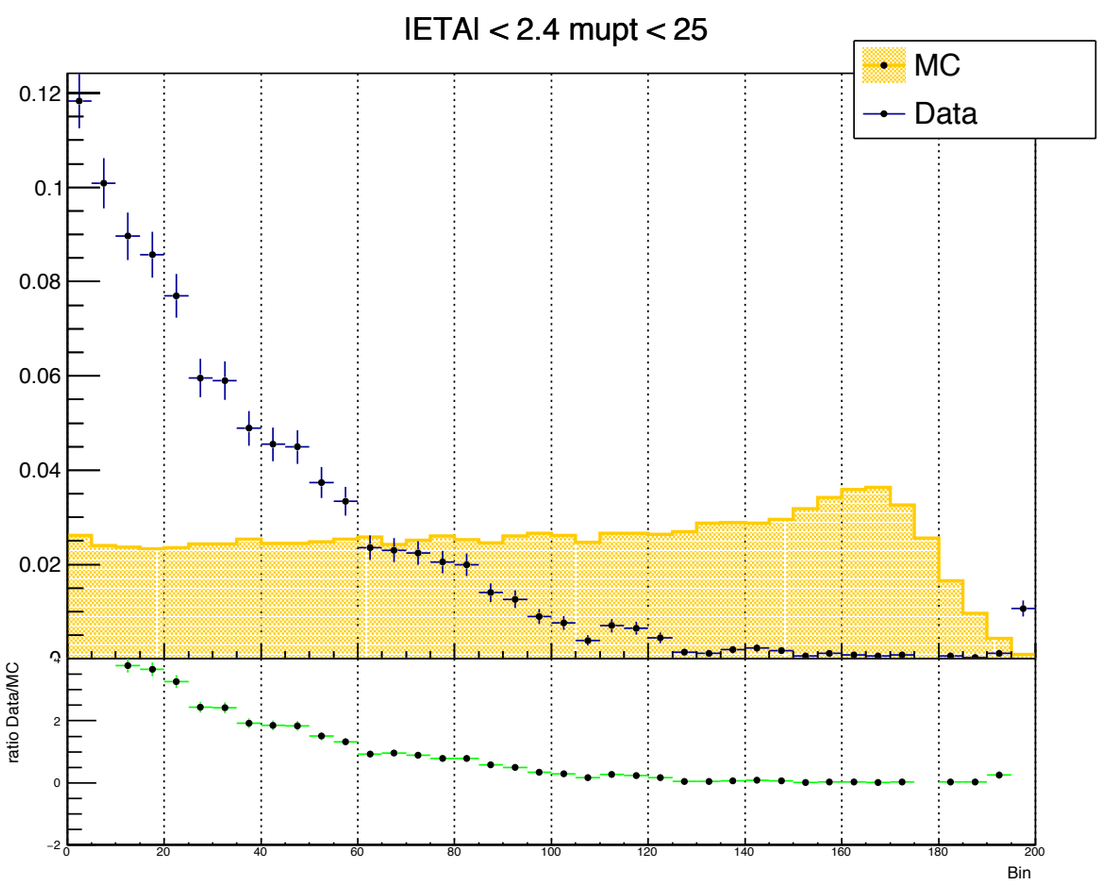
ID	Particle
1	charge hadron
2	electron
3	mu
4	gamma
5	neutral hadron

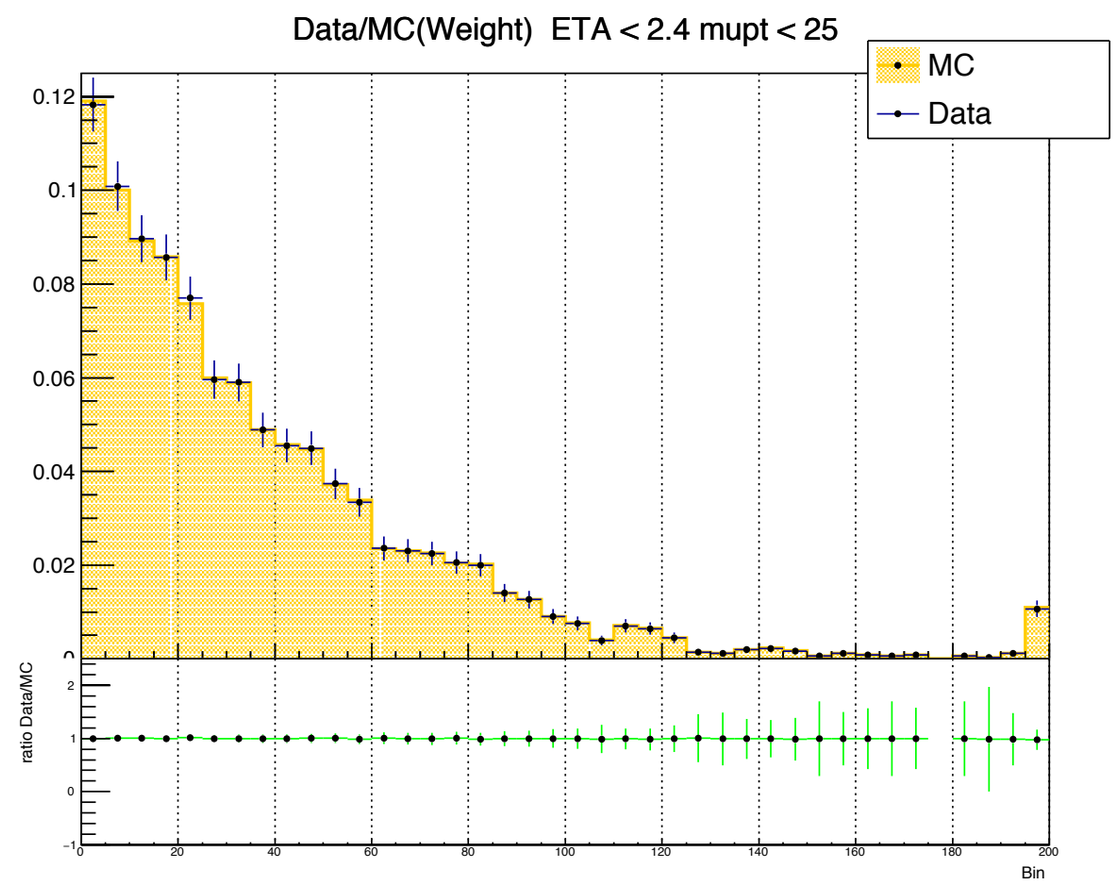


Centrality reweighing

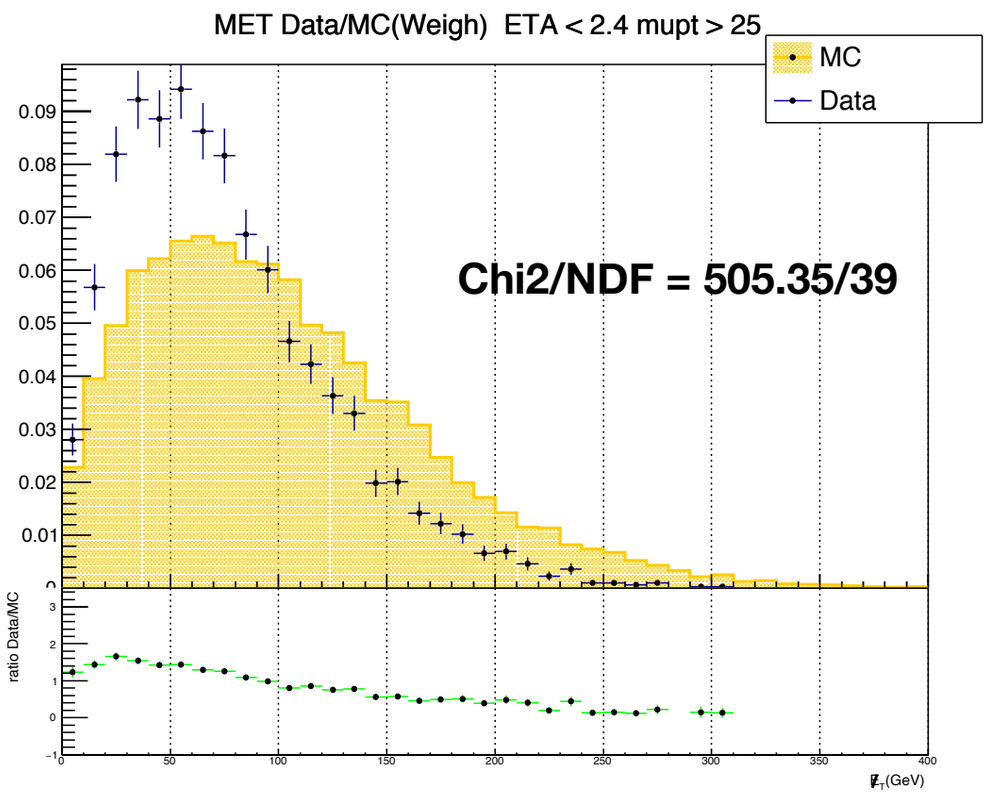
The MC sample is reweighted to match the data distribution before using MC sample for any corrections :

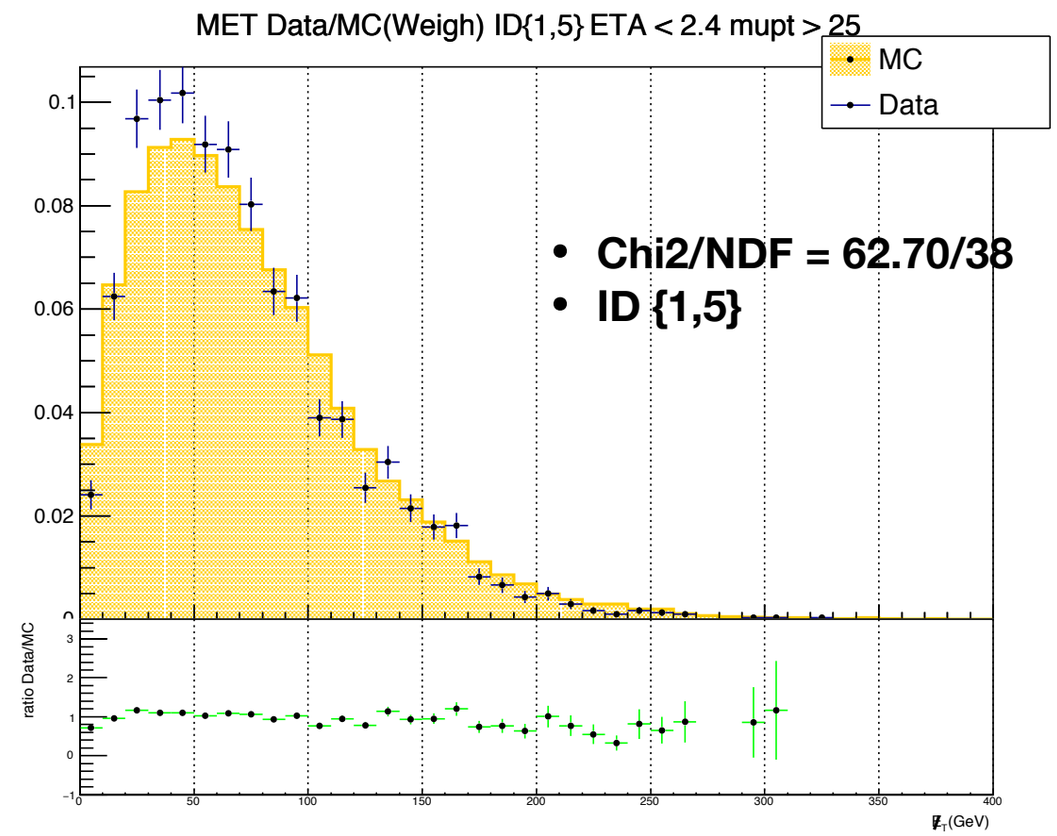
$$Centrality\ reweighing = \frac{Centrality\ bin(data)}{Centrality\ bin(MC)}$$

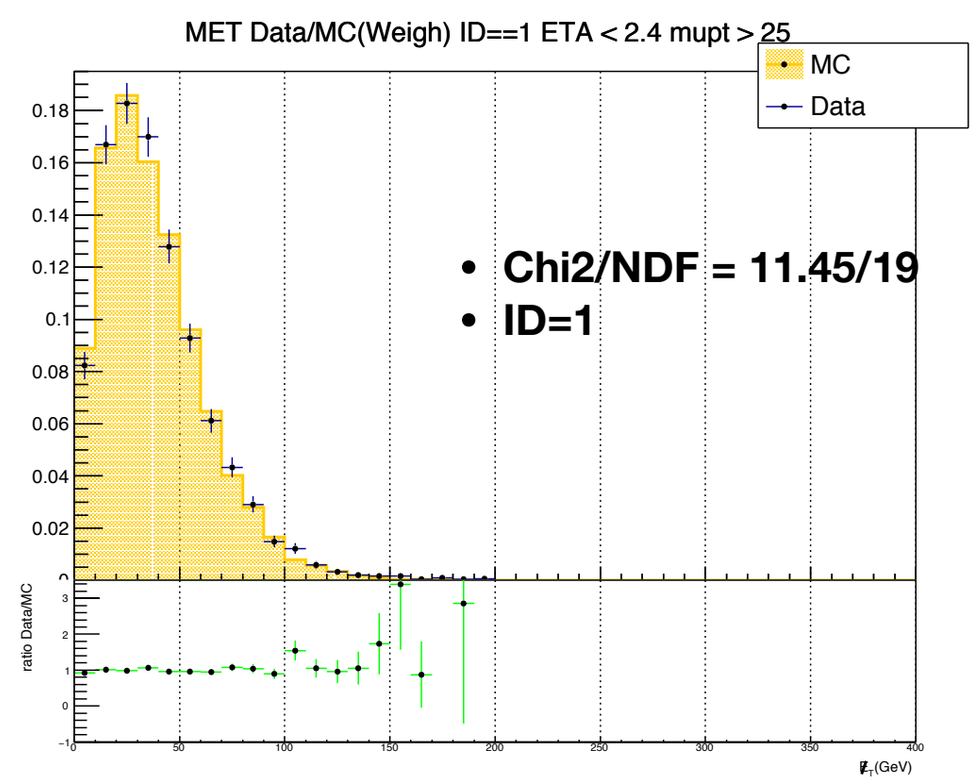




|η(μ)| < 2.4 p_T(μ) > 25Gev PF

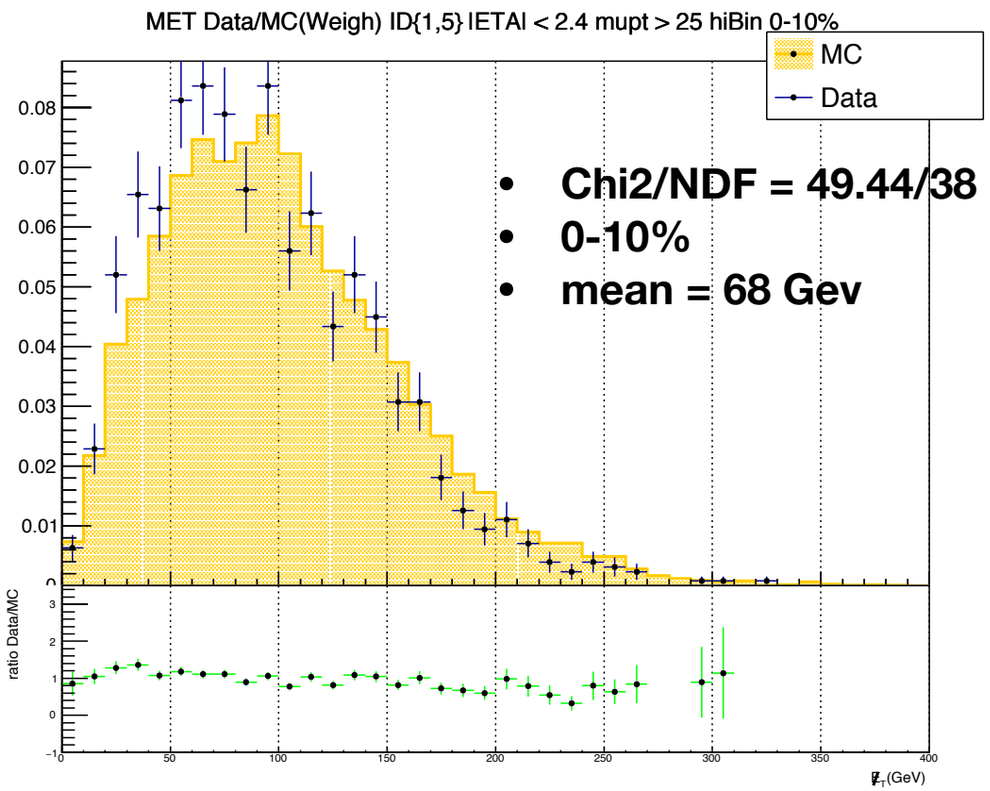


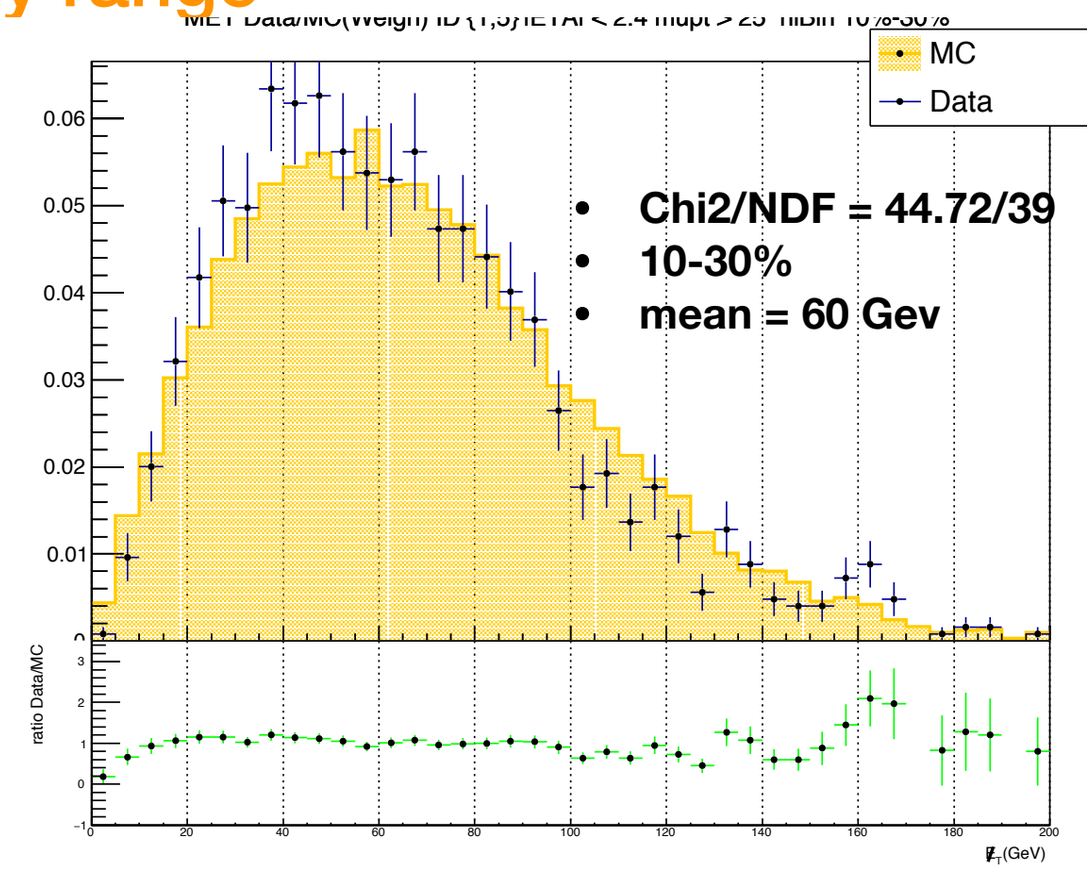


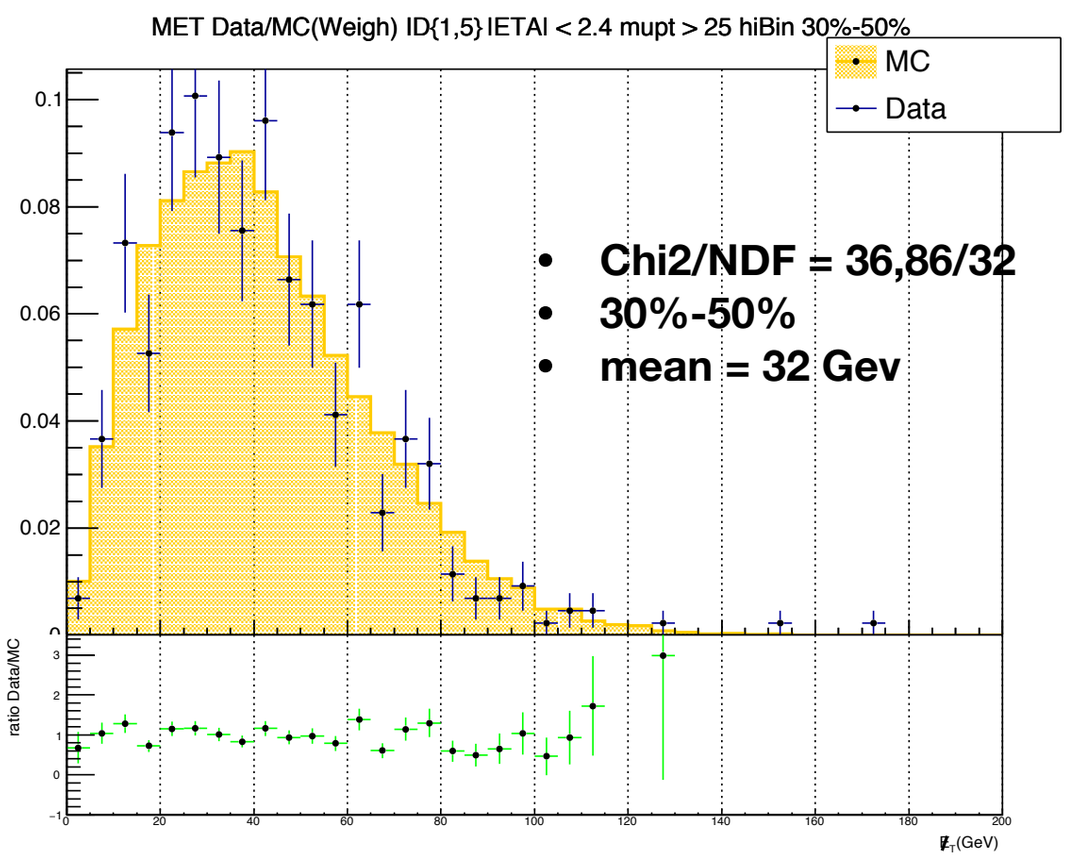


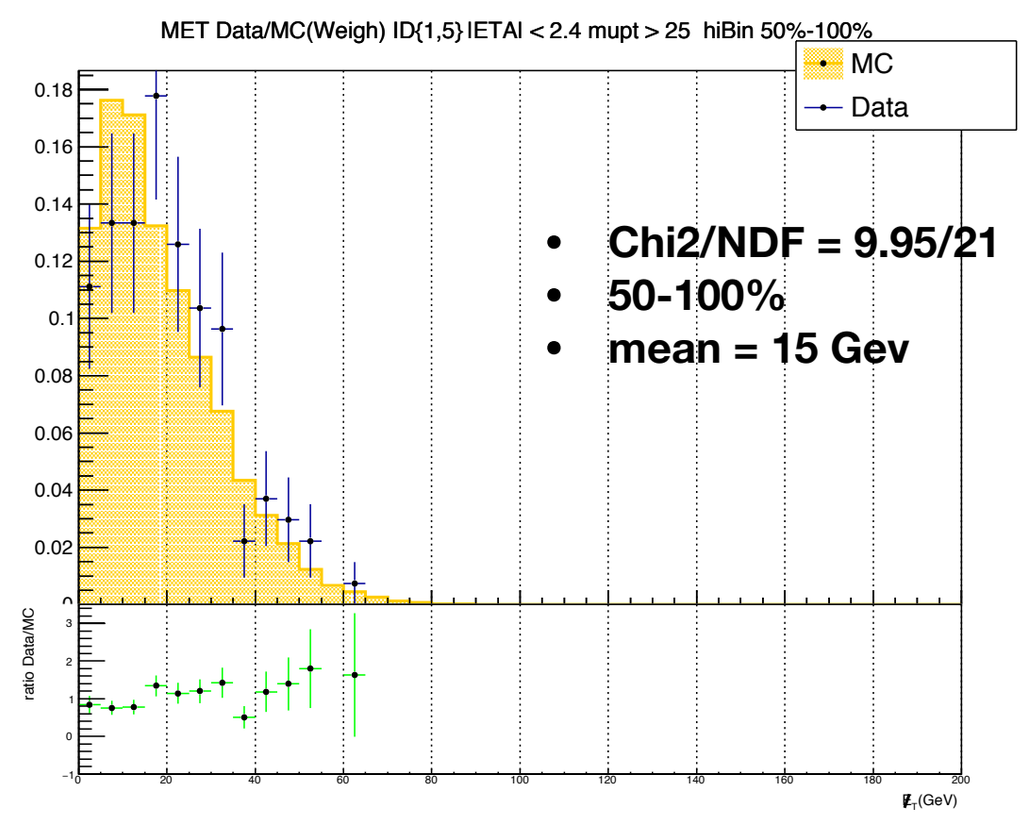
Ptmiss not well modelled in simulation, restricting to 1<=PFid<=5 improves modelling

|η(μ)| < 2.4 $p_T(\mu)$ > 25Gev PF ID {1,5} PF Ptmiss for different Centrality range

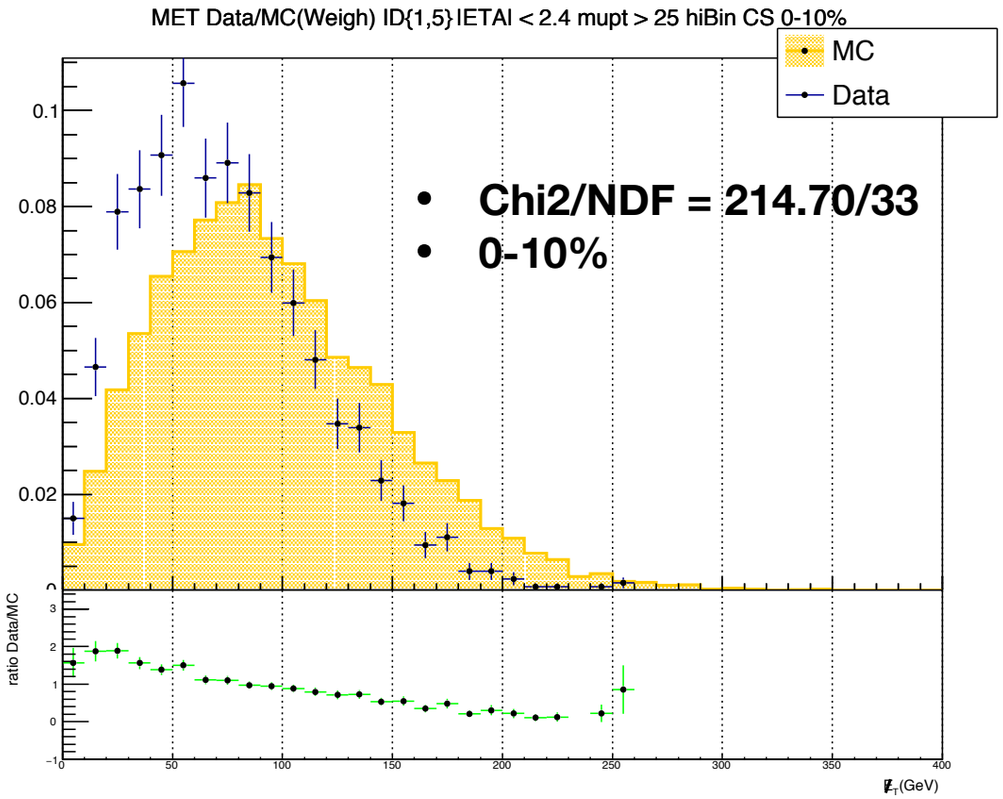


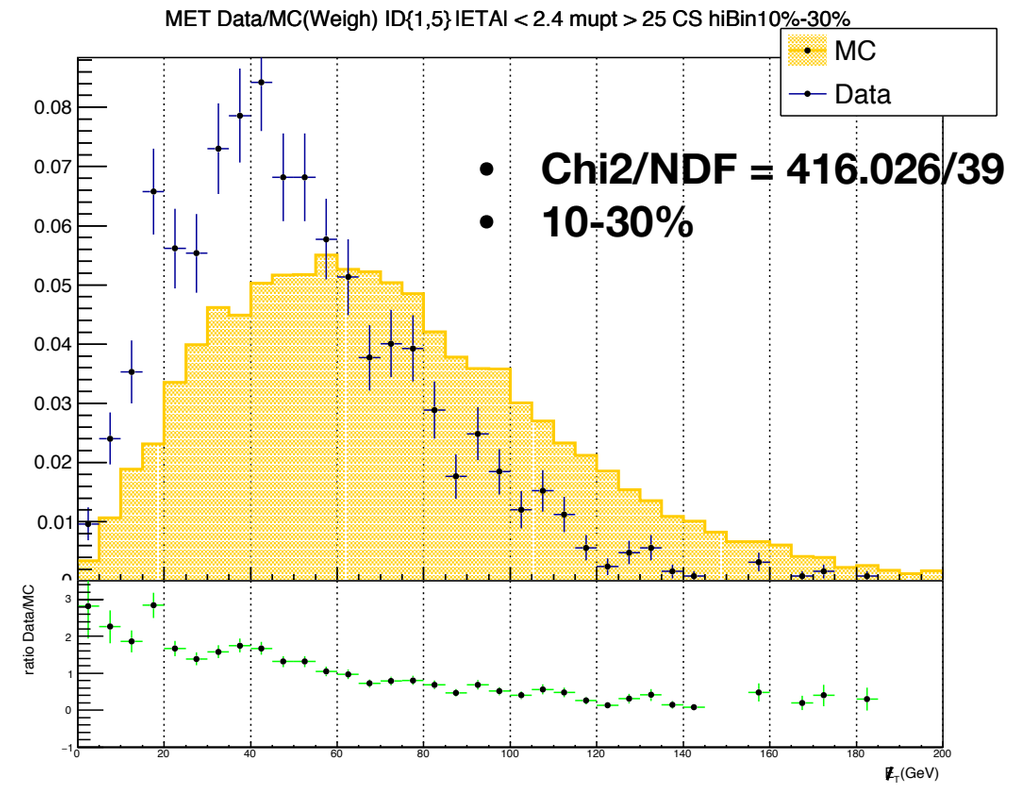


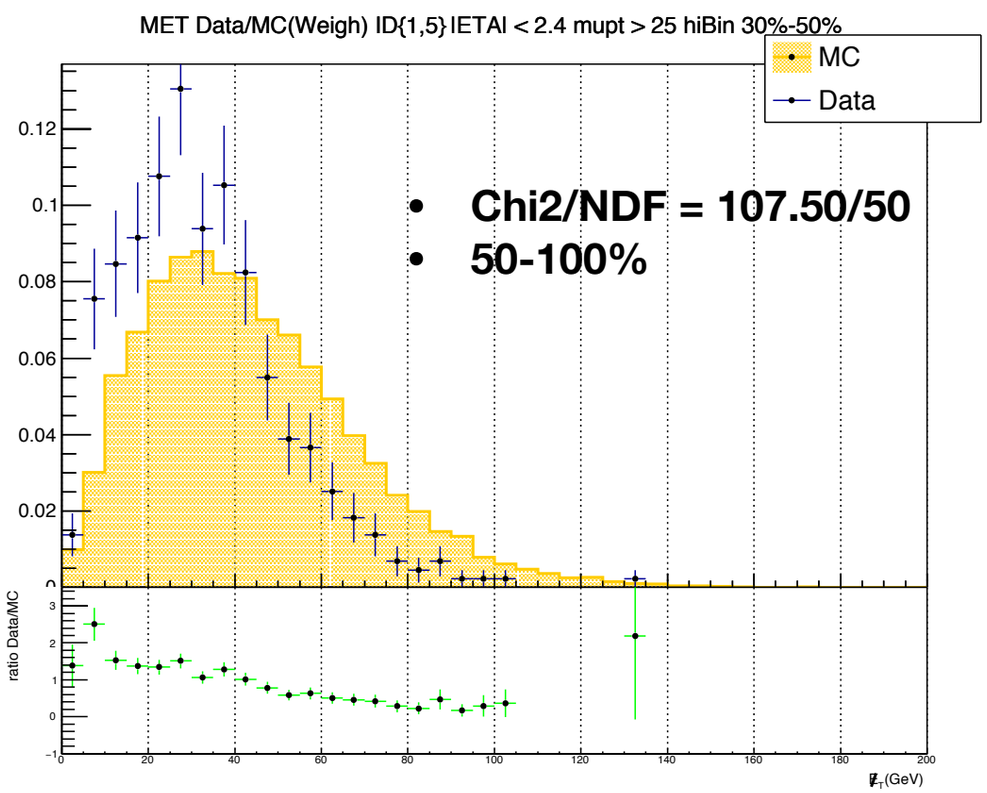


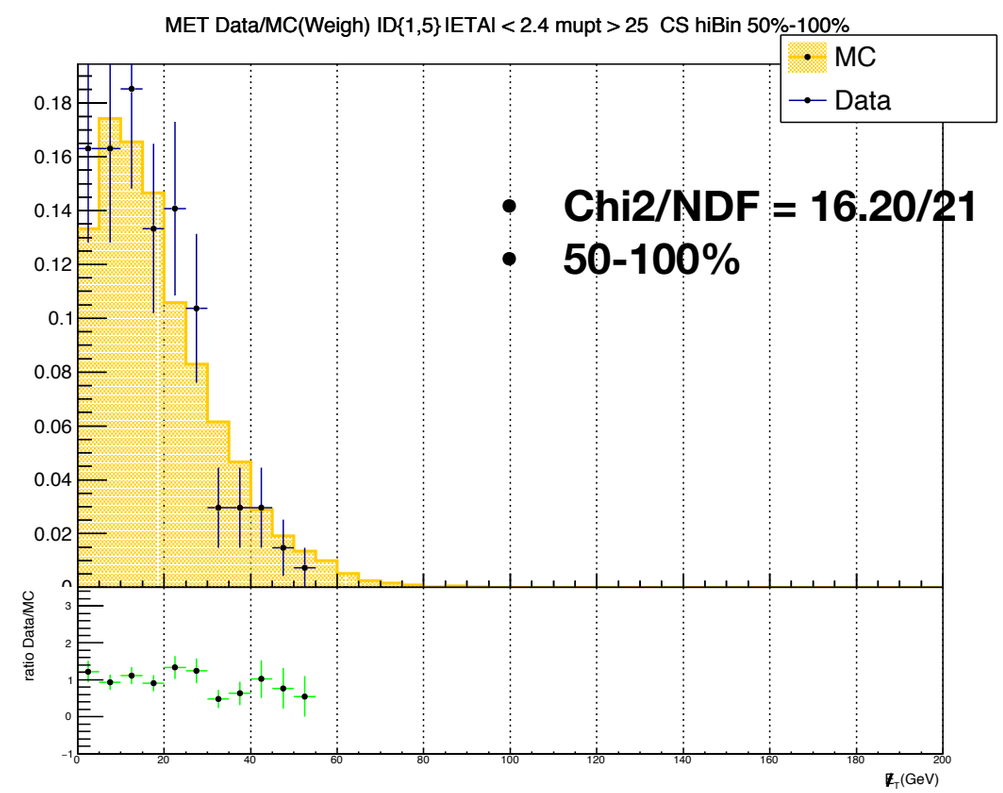


|η(μ)| < 2.4 $p_T(\mu)$ > 25Gev PF ID {1,5} CS Ptmiss for different Centrality range









Ptmiss in W->μν

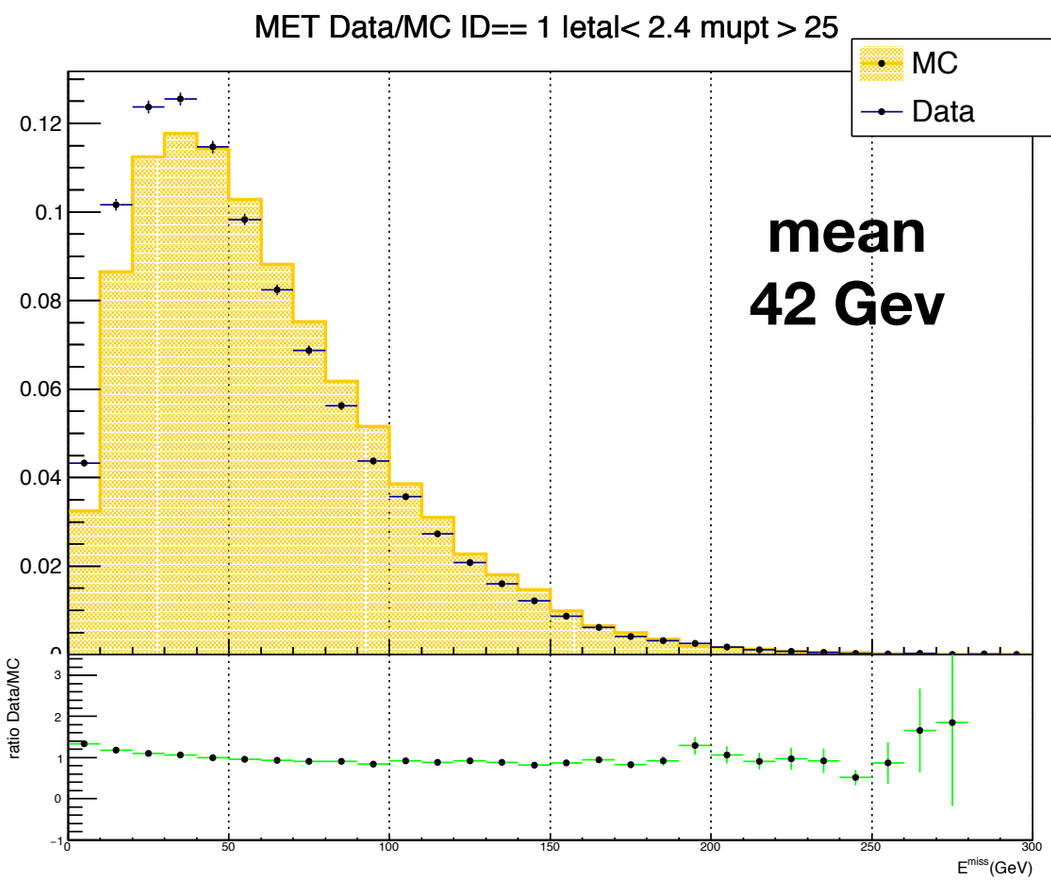
Transverse mass :

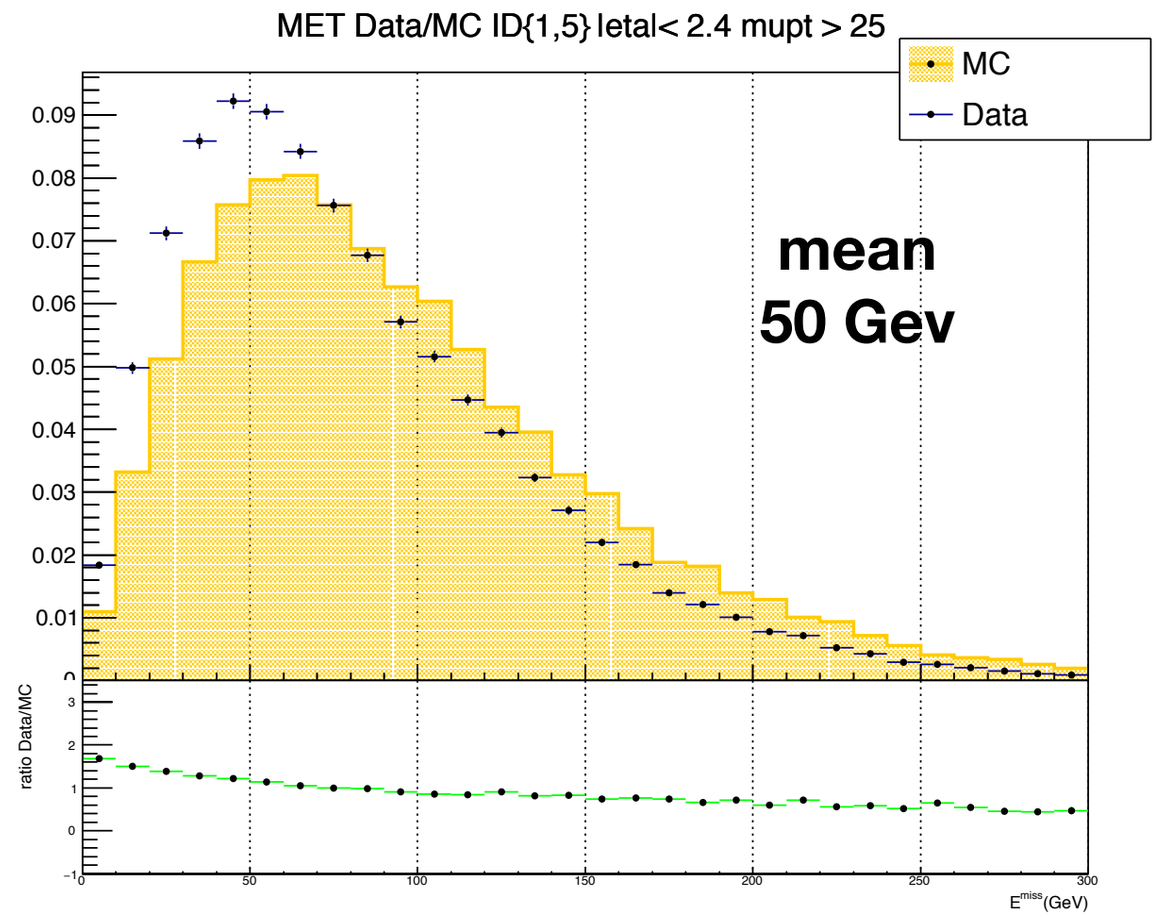
used when one particle can not be detected directly but is only indicated by missing transverse momentum and energy

$$MT = \sqrt{2 * Pt_{miss} * muPt * (1 - cos(\Delta\varphi)}$$

Where : $\Delta\varphi$ is the angle in the transverse plane between the lepton and the direction of the missing transverse energy.

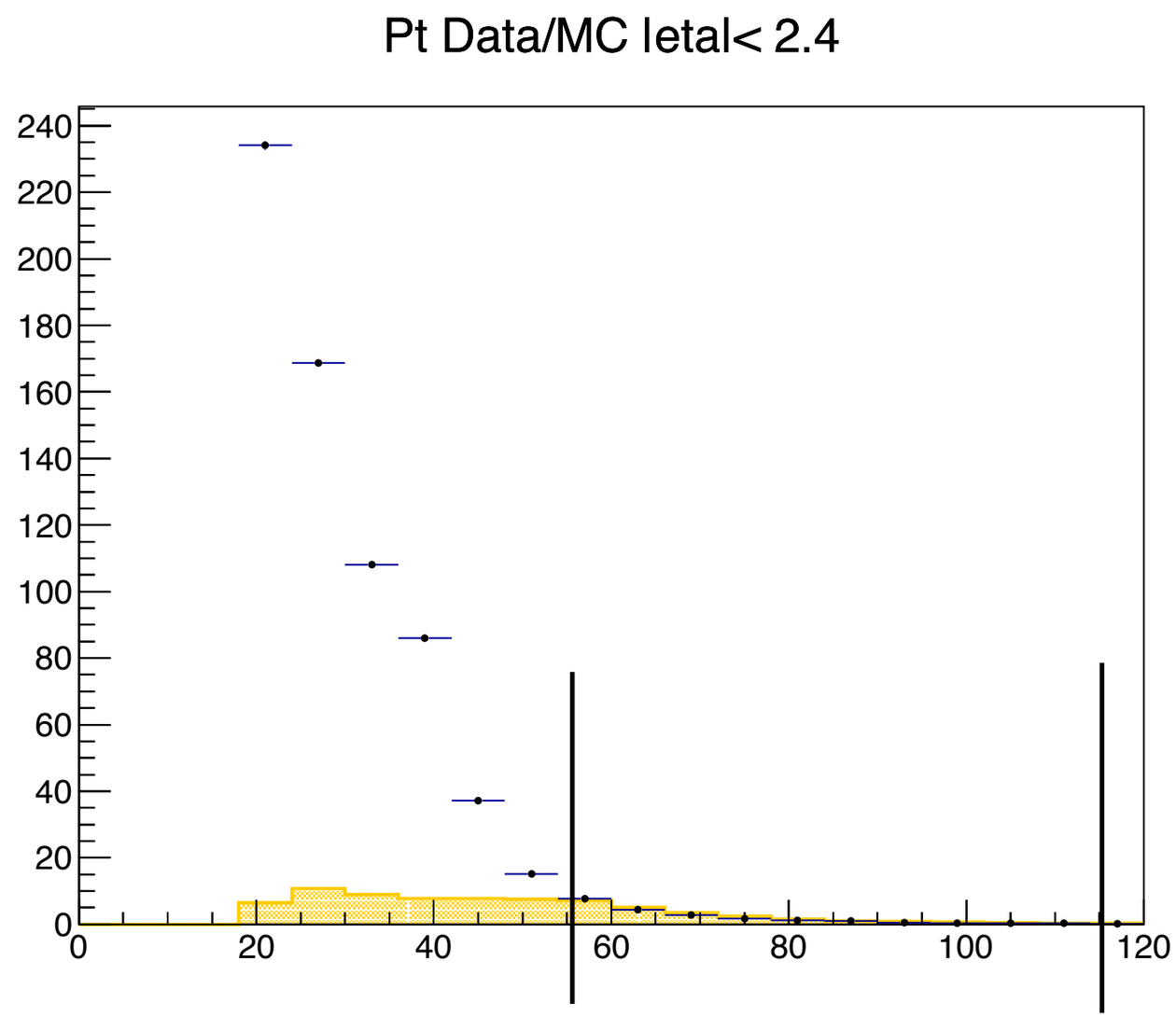
Ptmiss


MET Data/MC ID== 1 letal< 2.4 mupt > 25
MC
Data
mean
42 Gev
ratio Data/MC
E^miss(GeV)

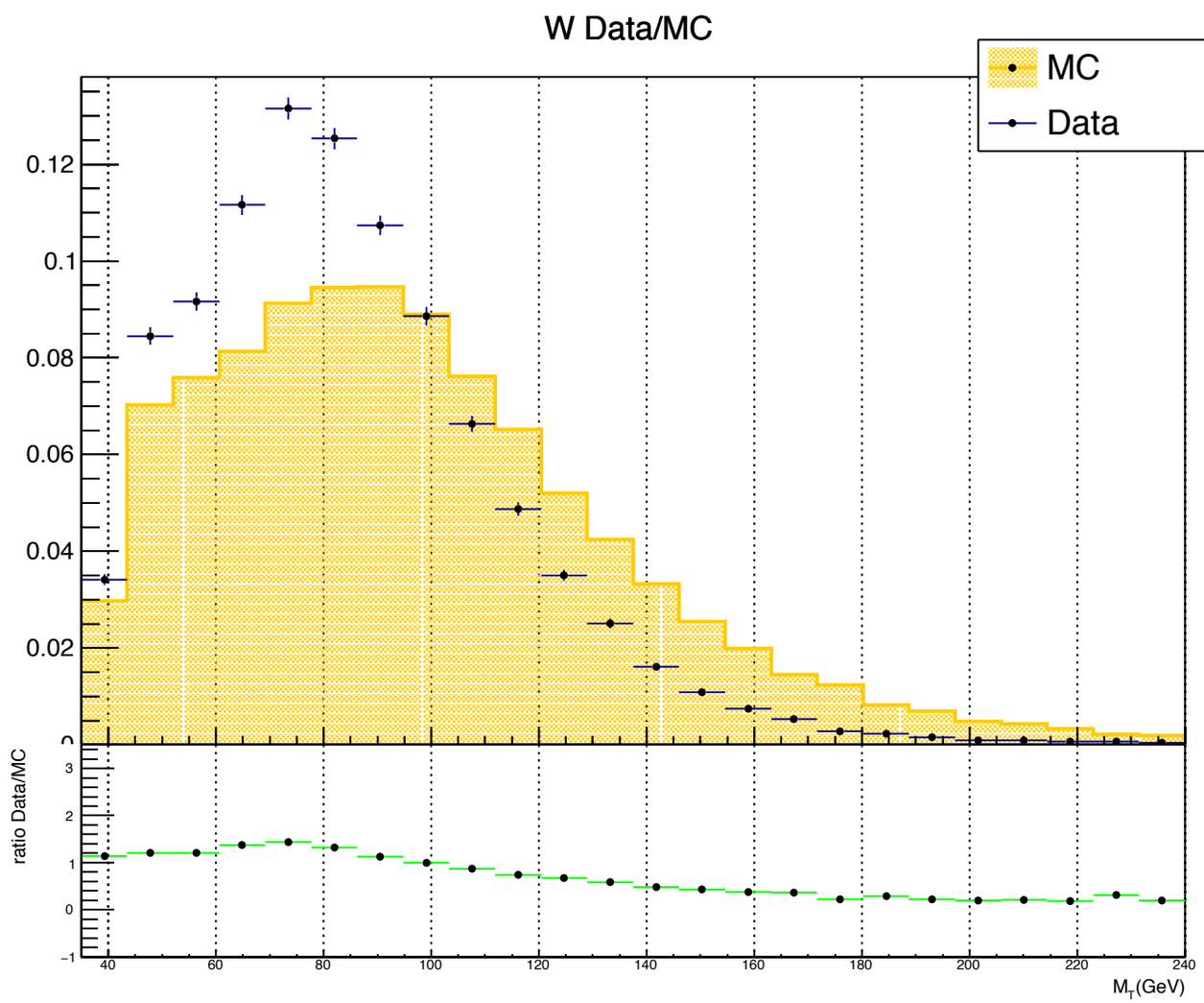

MET Data/MC ID{1,5} letal< 2.4 mupt > 25
MC
Data
mean
50 Gev
ratio Data/MC
E^miss(GeV)

Event Selection

- $p_T(\mu) > 25$ Gev
- $|\eta(\mu)| < 2.4$
- Ptmiss > 60 Gev
- MT > 40 Gev



MT



- bad agreement.
- likely presence of background

Summary and outlook

Summary

- Z boson Experimentally well understood and easy to reconstruct with low background

- Calculating ptmiss is a big challenge in PbPb and its value is the key to study W boson production, but also top quark production and physics beyond the standard model

- Ptmiss resolution depends on centrality.

- Non-zero ptmiss values arise from the presence of a neutrino in the event (W boson decays), but also from the resolution of the detector (Z boson decays)

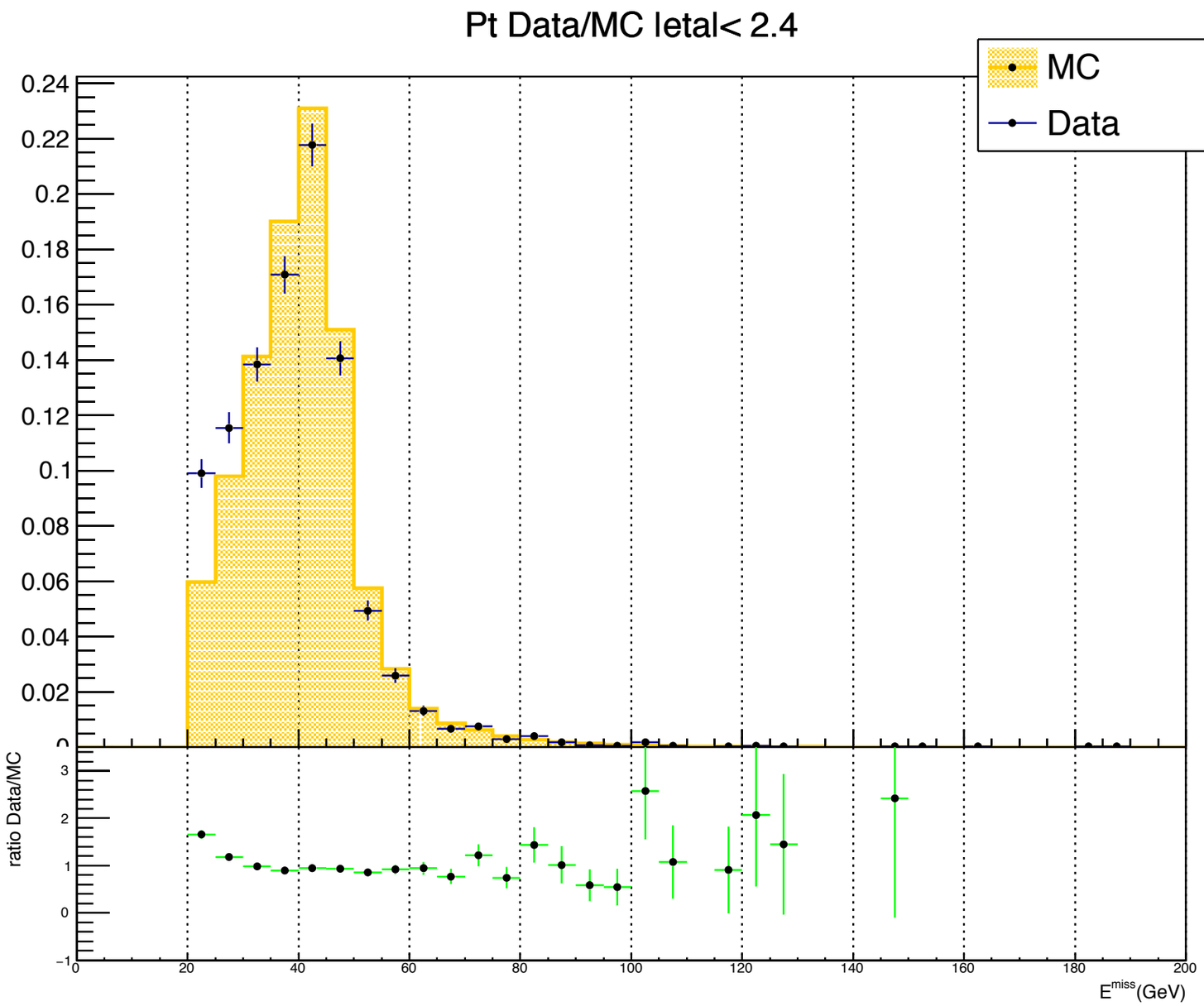
- Outlook

  - Study W boson in more details.

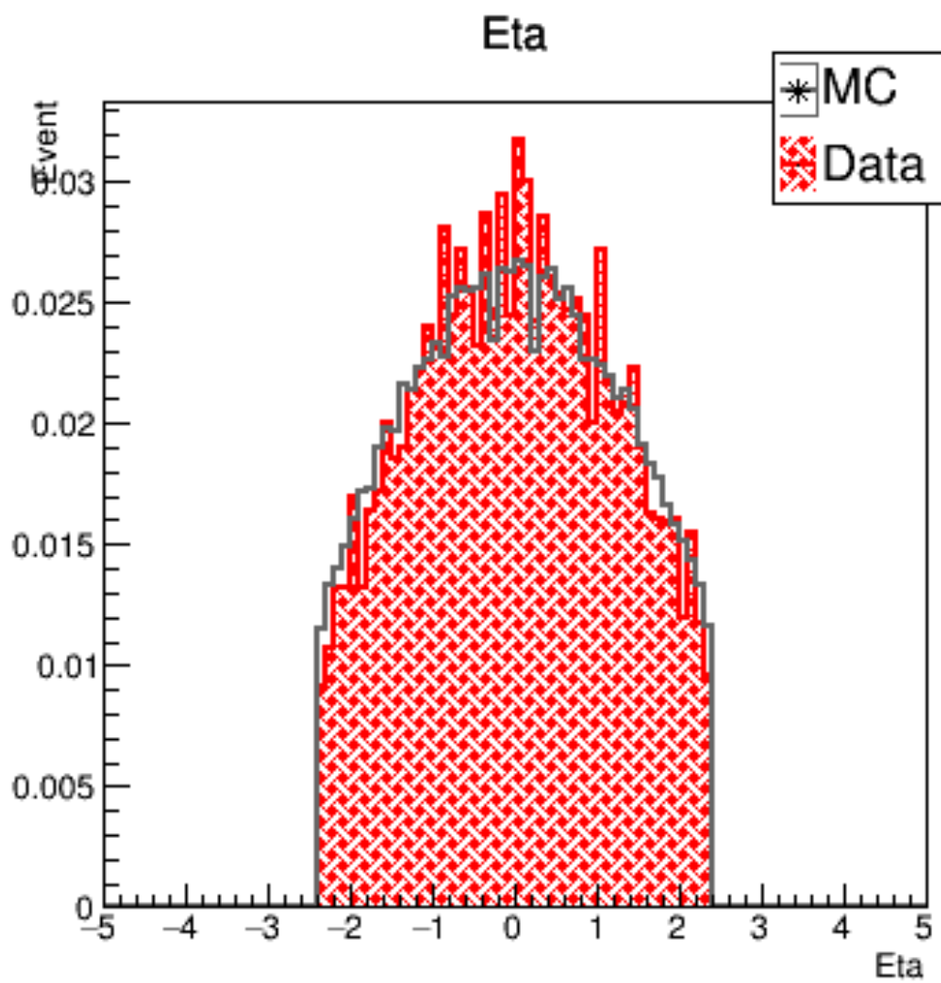
Thank You !

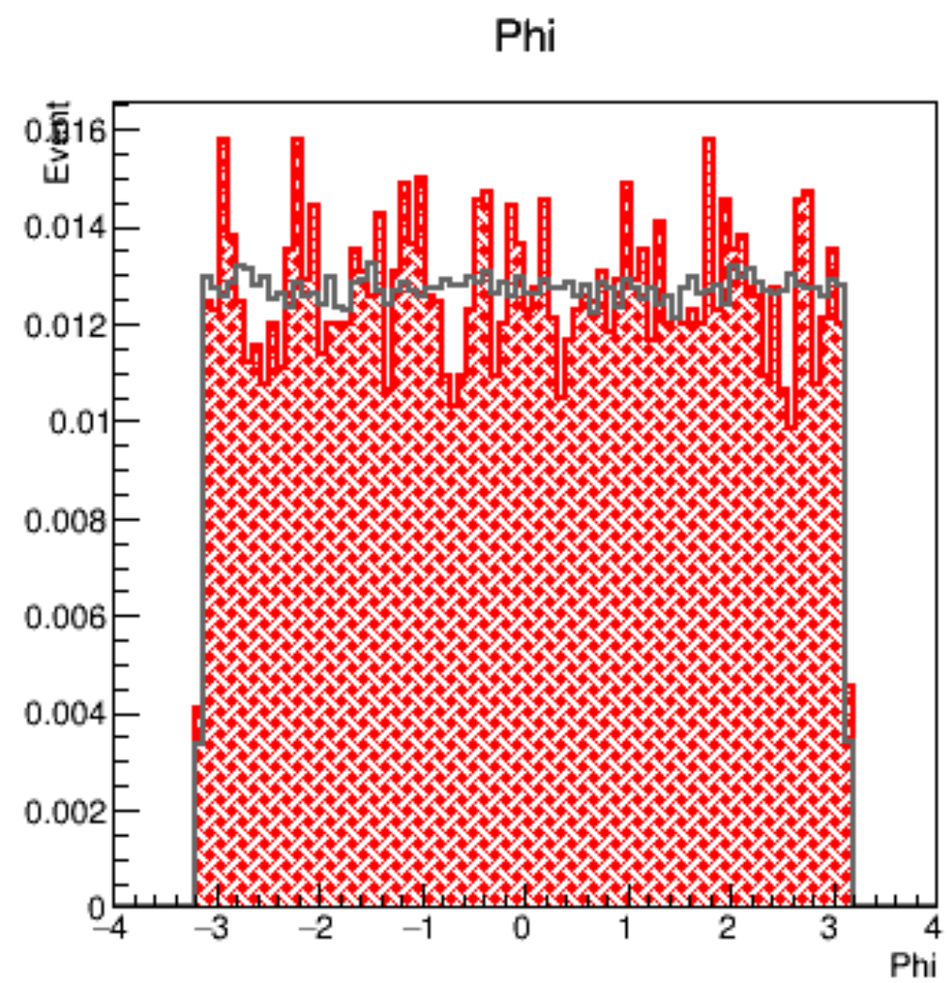
back up

For one single muon

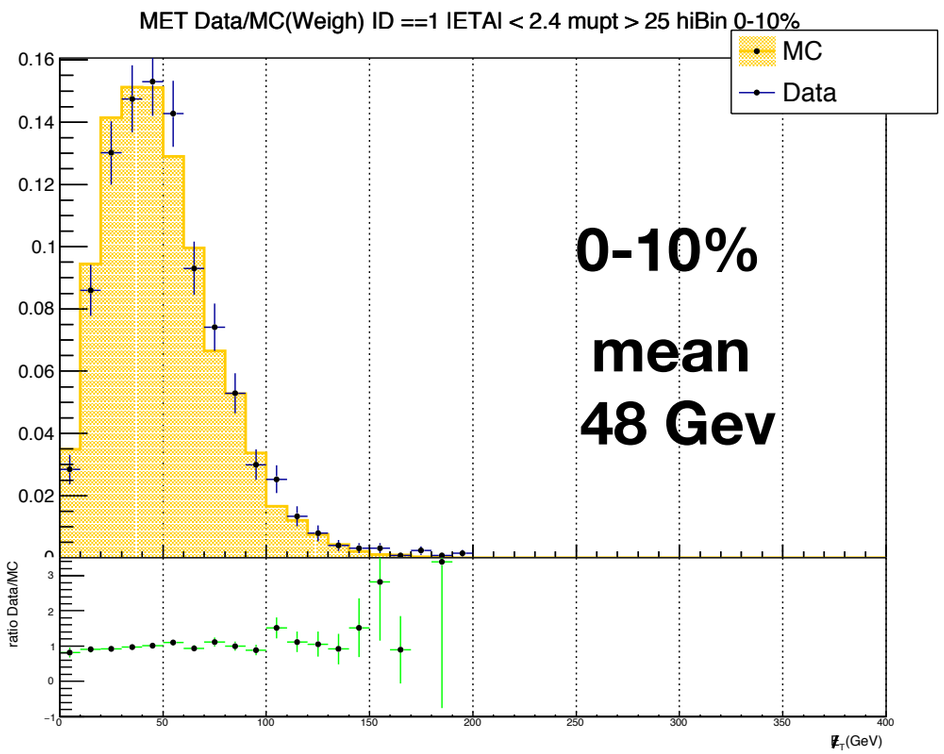


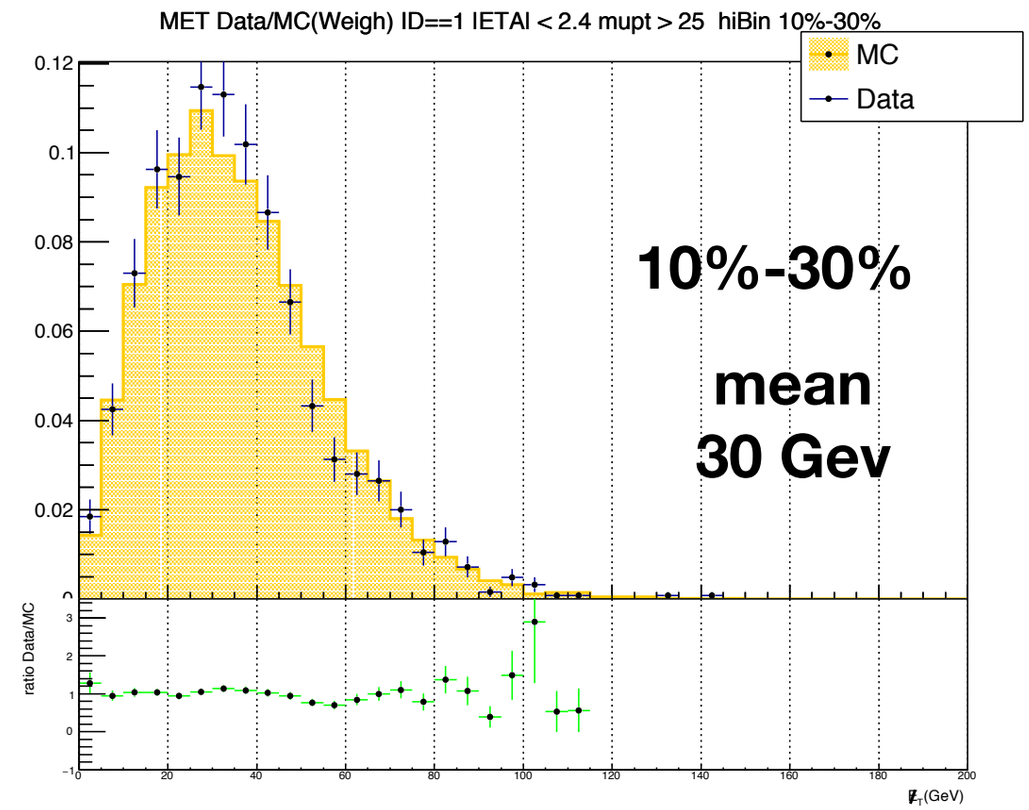
For one single muon

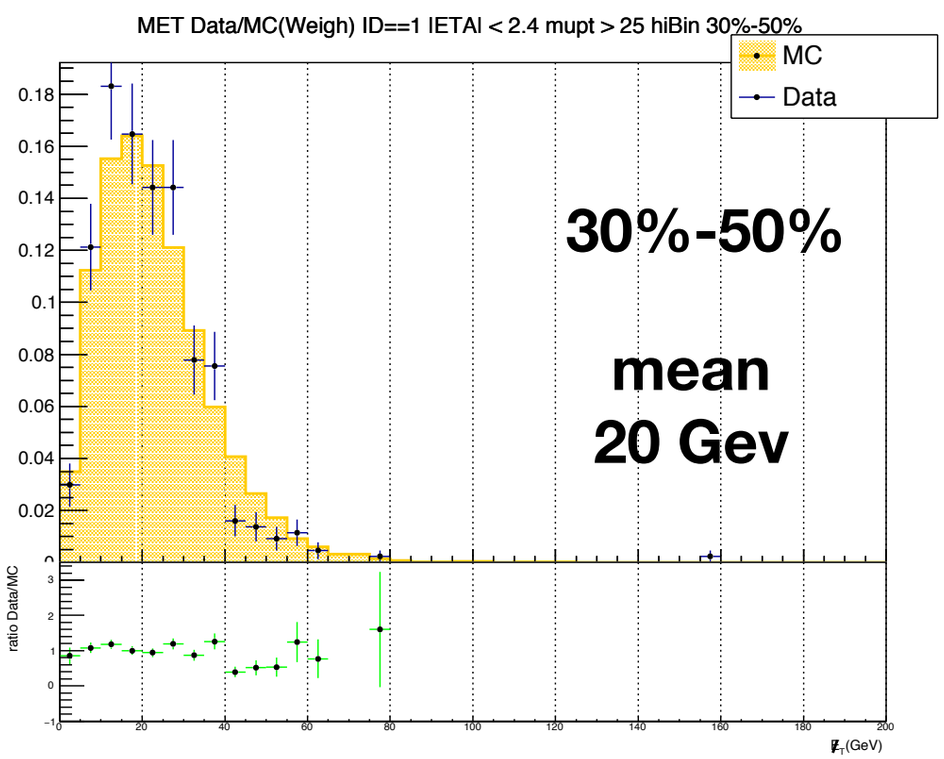


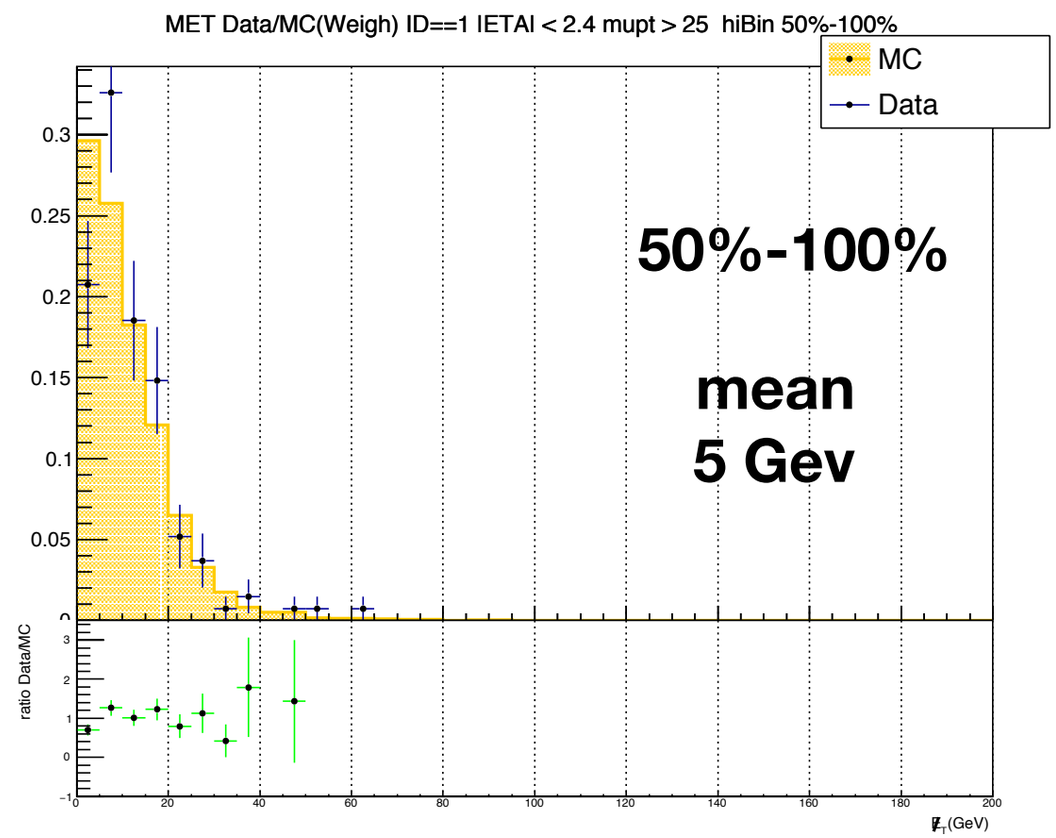


|η(μ)| < 2.4 p_T(μ) > 25Gev ID==1 PF Ptmiss

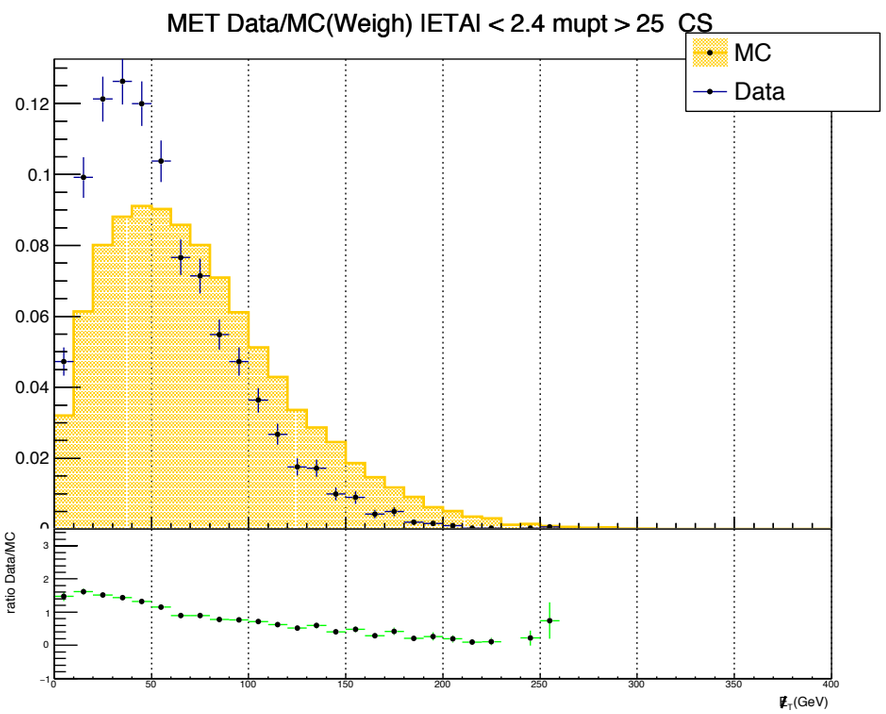


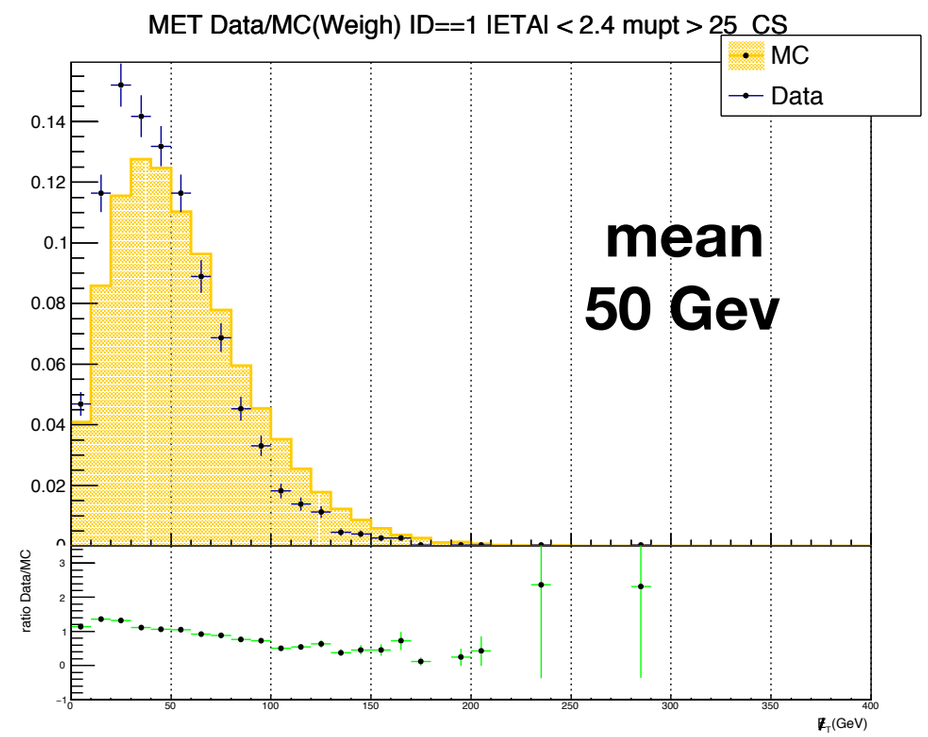


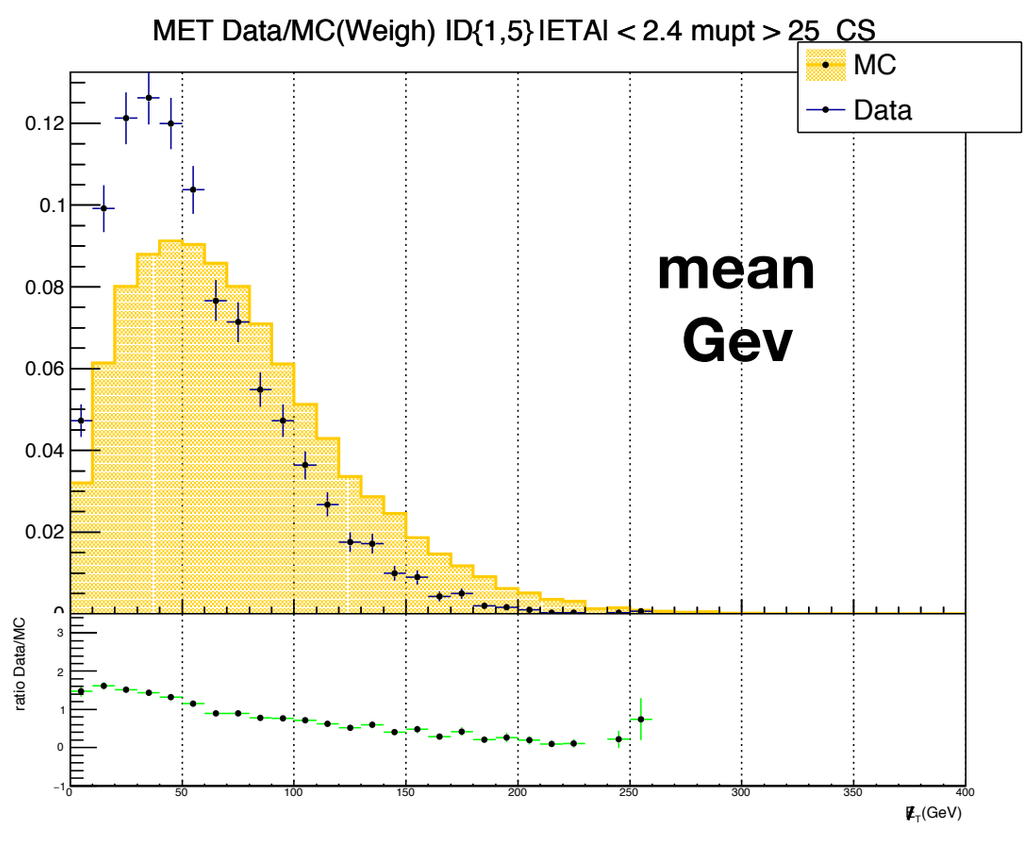




|Eta| < 2.4 mupt > 25 CS







|Eta| < 2.4 mupt > 25 ID==1 CS