Search for massless dark photons in resonant monophoton signatures from Higgs boson decays

Work in progress ...

Hassnae EL JARRARI

Mohammed V University in Rabat

Rabat group meeting

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Update

- Photon Truth matching
  1. Retrieve truth photons from egammaTruthParticles container based on their pdgId and status.
  2. Compute $\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2}$ between truth and reconstructed Photons.
  3. Plot ΔR and make a cut to proceed with events containing Photons coming from Higgs boson.
- Photon-MET deltaPhi: To check the correlation between the MET vector and the Photon.
- New Backgrounds were checked

Datasets

- Signal MC dataset for $ZH \rightarrow l^+l^- + \gamma + E_T^{miss}$ obtained from $ZH \rightarrow l^+l^- + \gamma\gamma$

  mc15_13TeV.345319.PowhegPythia8EvtGen_NNPDF30_AZNLO_ZH125J_Hyy_Zincl_MINLO.merge.DAOD_HIGG1D1.e5743_s2726_r7772_r7676_p3015

- Background MC dataset: $WW_\gamma \rightarrow l^+l^- + \gamma + E_T^{miss}$

  mc16_13TeV.366161.Sherpa_225_N30NNLO_WWy_leptonic.deriv.DAOD_HIGG1D2.e7090_s3126_r10724_p3703

Object Selection

1. Electrons: $p_T > 25$ GeV, $|\eta| < 2.47$, $\eta \notin [1.37, 1.52]$
   - Pass medium likelihood based identification working point
   - Pass the track and calorimeter-based isolation requirements such that the efficiency of the selection is 95% at 25GeV and 99% at 60 GeV.
2. Photons:$p_T > 25$ GeV, $|\eta| < 2.37$, $\eta \notin [1.37, 1.52]$
   - Pass tight identification working point
   - Pass the calorimeter-based isolation requirements such that the transverse energy deposited in a cone of size $= 0.4$ surrounding the energy deposition of the photon, $E_T^{0.4}$ must satisfy the relation: $E_T^{0.4} < 2.75 GeV + 0.22 E_T$
3. Muons: $p_T > 25$ GeV, $|\eta| < 2.7$, combined
   - Pass medium identification working point
   - Pass the same track and calorimeter isolation criteria that are applied to electrons
4. Jets: $p_T > 20$ GeV, antikt4EMTopo with R=0.4, calibrated.
5. Missing transverse momentum : MET_TST

Event selection

- $ZH- > \rightarrow l^+l^- + \gamma\gamma$
  1. 2 Photons, 2 leptons with opposite charges, 80 GeV $< m_{ll} <$ 110 GeV.
- $ZH \rightarrow l^+l^- + \gamma + E_T^{miss}$
  1. 2 Photons, 2 leptons with opposite charges, 80 GeV $< m_{ll} <$ 110 GeV.
  2. Randomly mark one of the two photons as invisible.
- $WW_\gamma \rightarrow l^+l^- + \gamma + E_T^{miss}$
  1. 1 Photons, 2 leptons with opposite charges, 80 GeV $< m_{ll} <$ 110 GeV.

Electrons pT in $ZH \rightarrow l^+l^- + \gamma + E_T^{miss}$

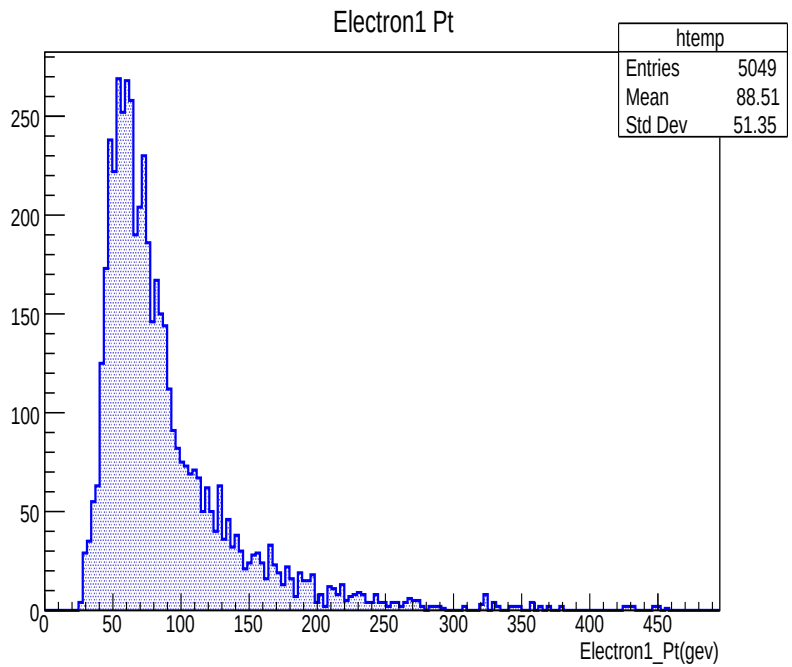


Figure:Electron1 pT

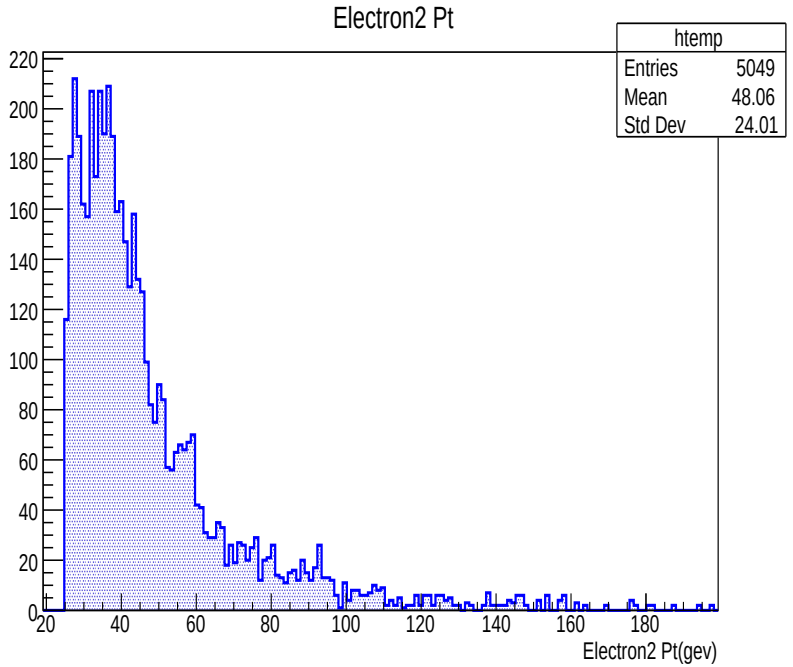


Figure:Electron2 pT

Muons pT in $ZH \rightarrow l^+l^- + \gamma + E_T^{miss}$

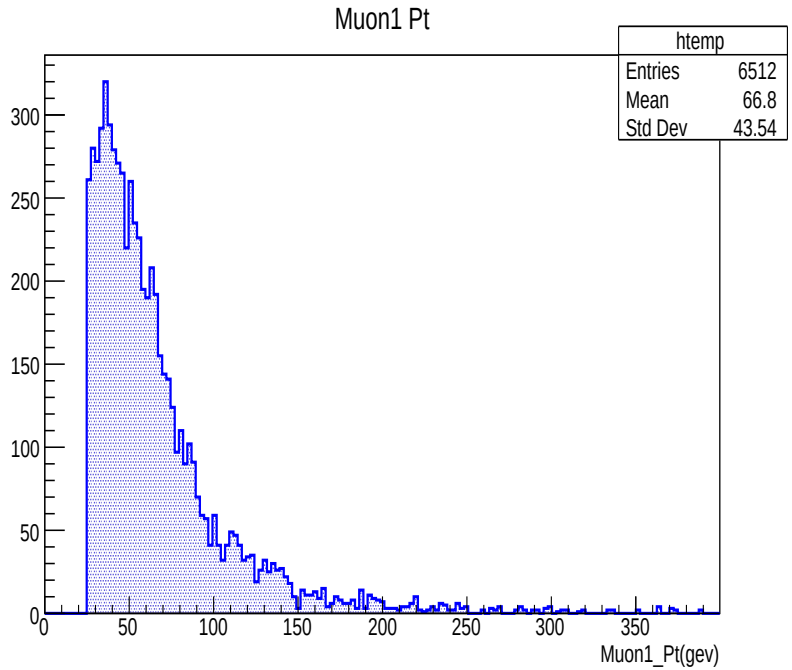


Figure:Muon1 pT

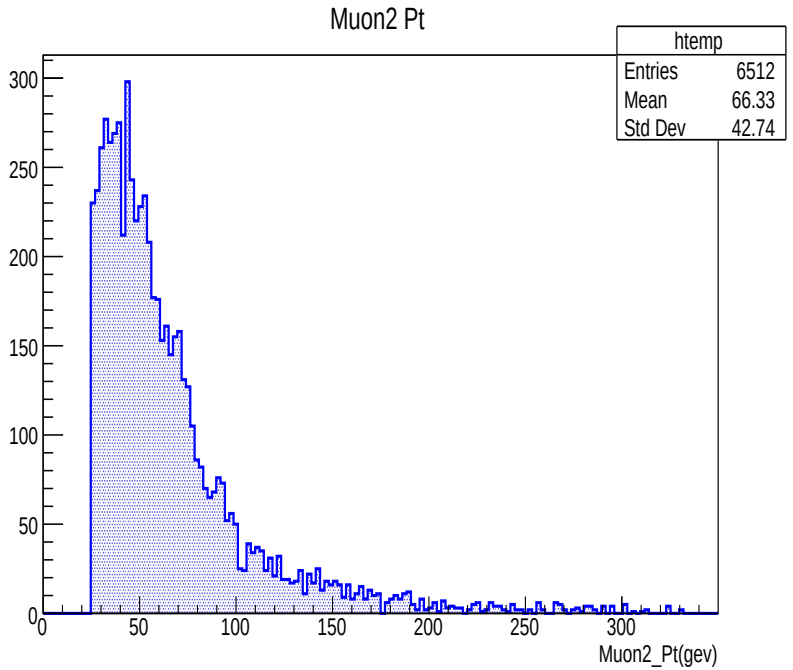
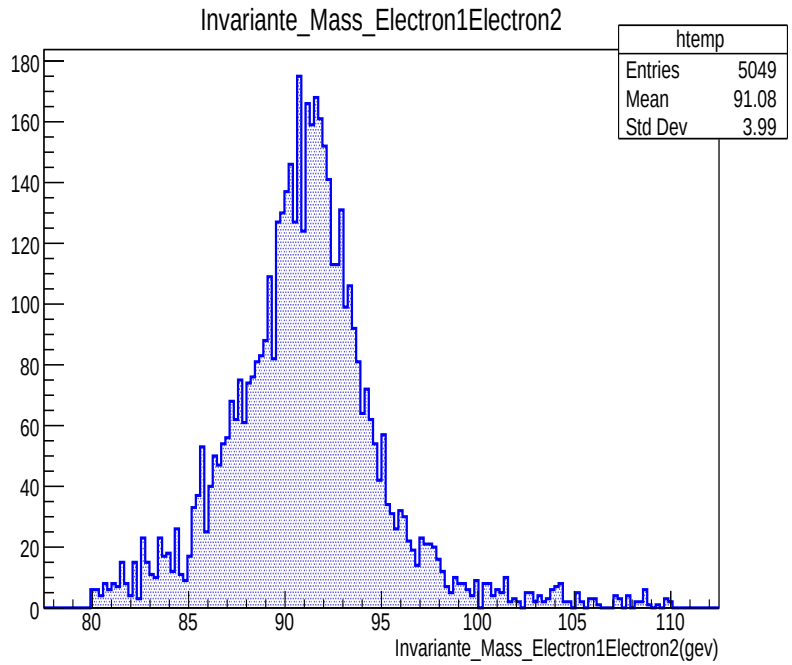
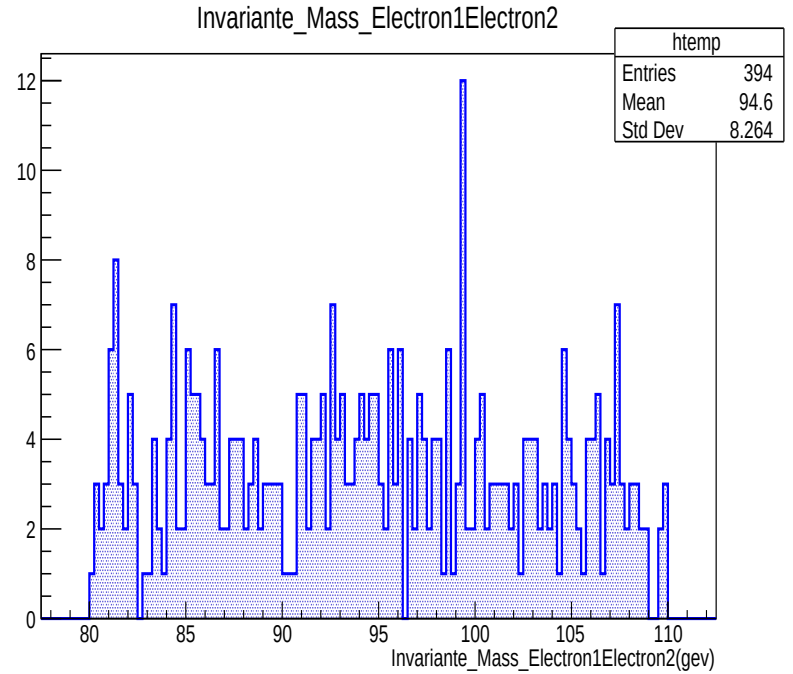


Figure:Muon2 pT

Invariant Mass electron1 electron2

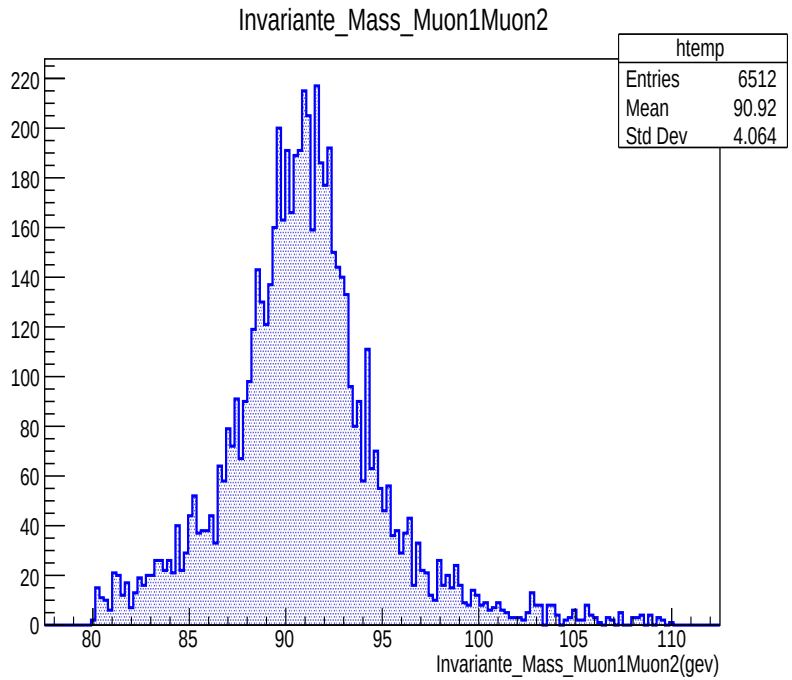


Invariant mass Electron1 Electron2 in $ZH \rightarrow l^+l^- + \gamma + E_T^{miss}$

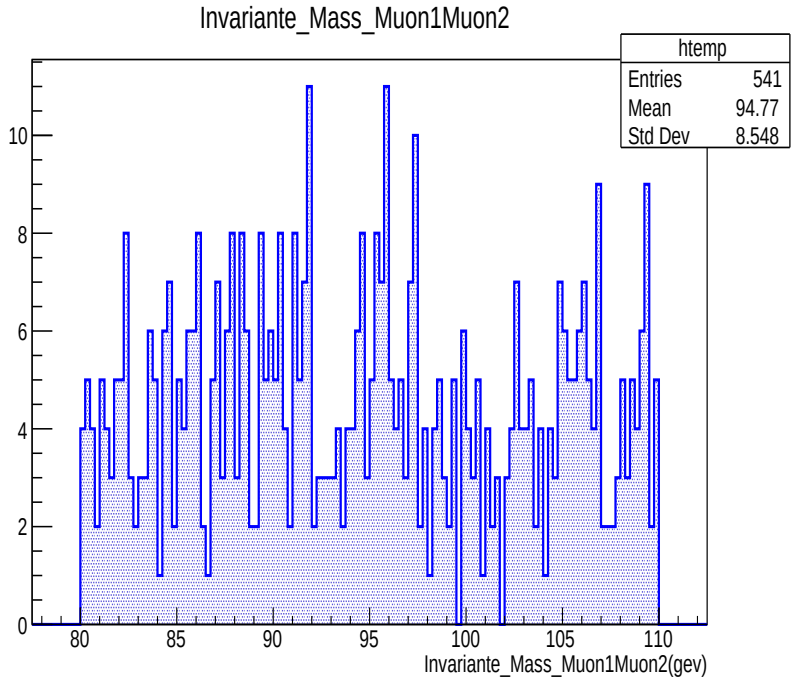


Invariant mass Electron1 Electron2 in WW_γ

Invariant Mass muon1 muon2

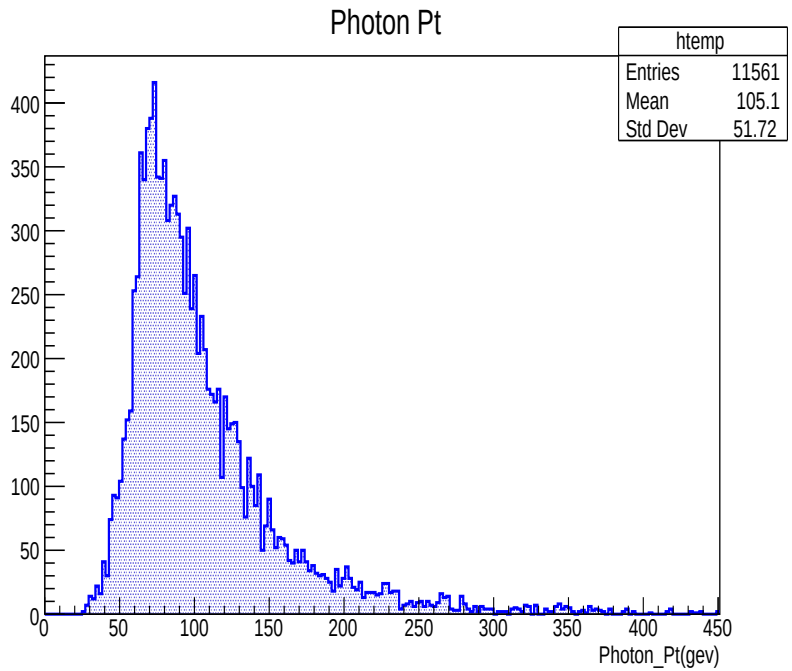


Invariant mass Muon1 Muon2 in $ZH \rightarrow l^+l^- + \gamma + E_T^{miss}$

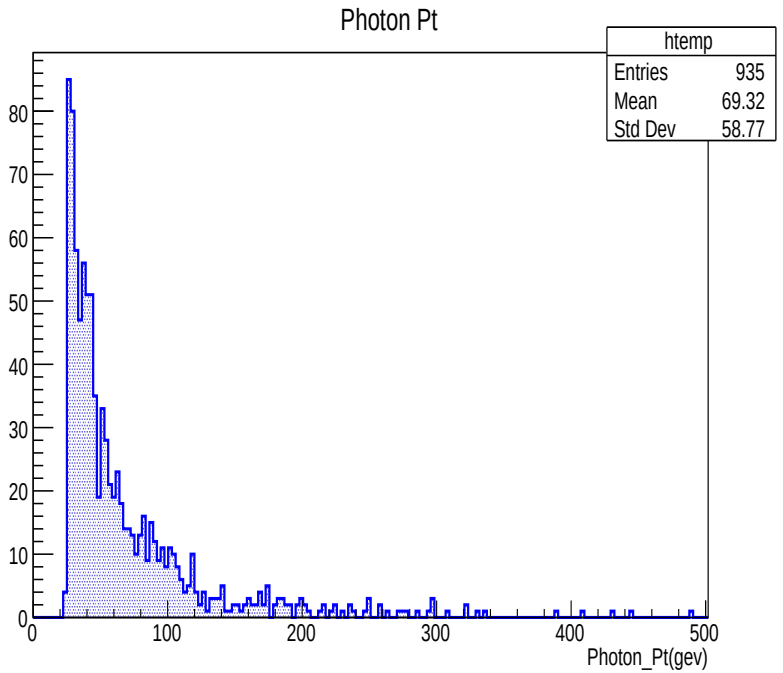


Invariant mass Muon1 Muon2 in WW_γ

Photons pT



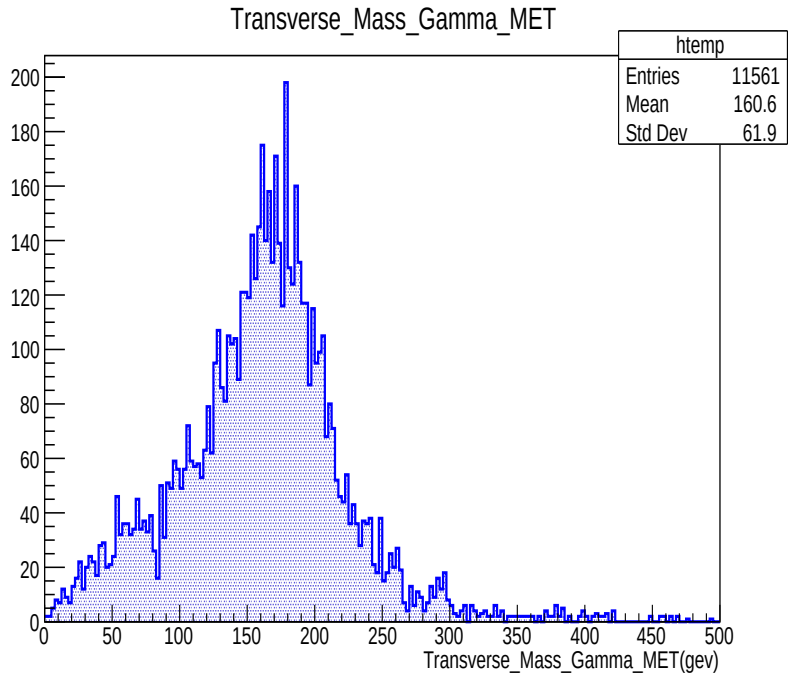
Photon pT in
$ZH \rightarrow l^+l^- + \gamma + E_T^{miss}$



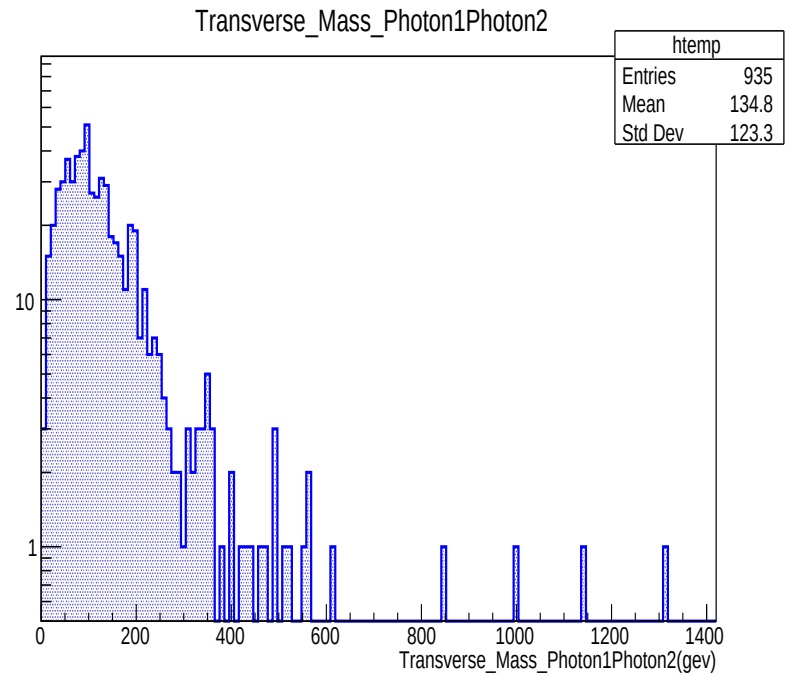
Photon pT in WW_γ

Transverse mass

$$M_T = \sqrt{2p_T^{\gamma} \not{E}_T (1 - \cos \Delta\phi)}$$

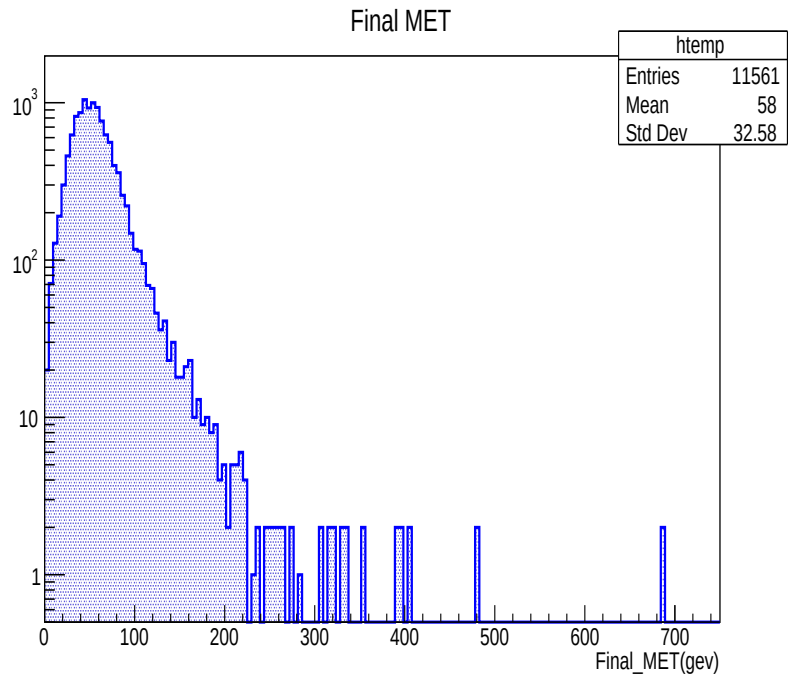


Transverse mass $\gamma + E_T^{miss}$ in $ZH \rightarrow l^+l^- + \gamma + E_T^{miss}$

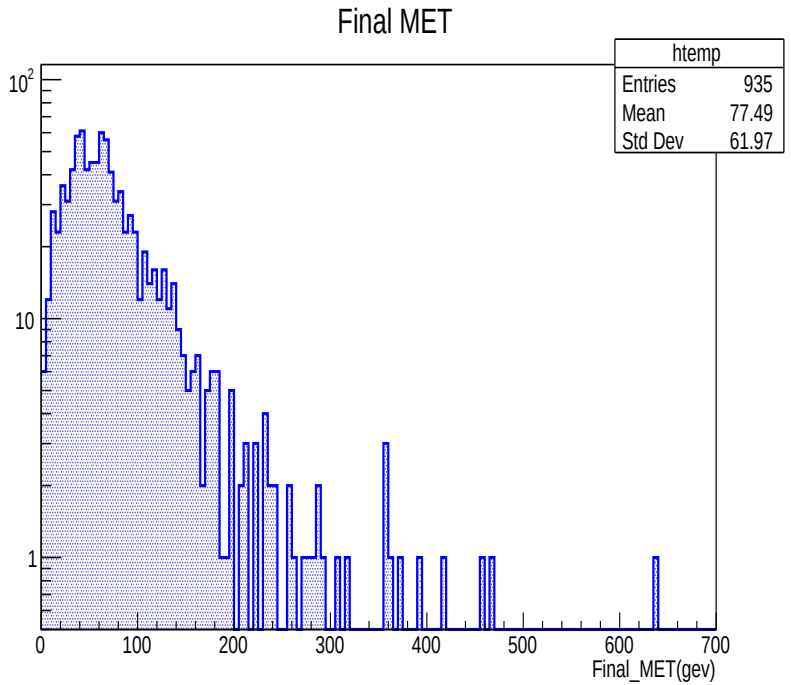


Transverse mass $\gamma + E_T^{miss}$ in WW_γ

Final MET



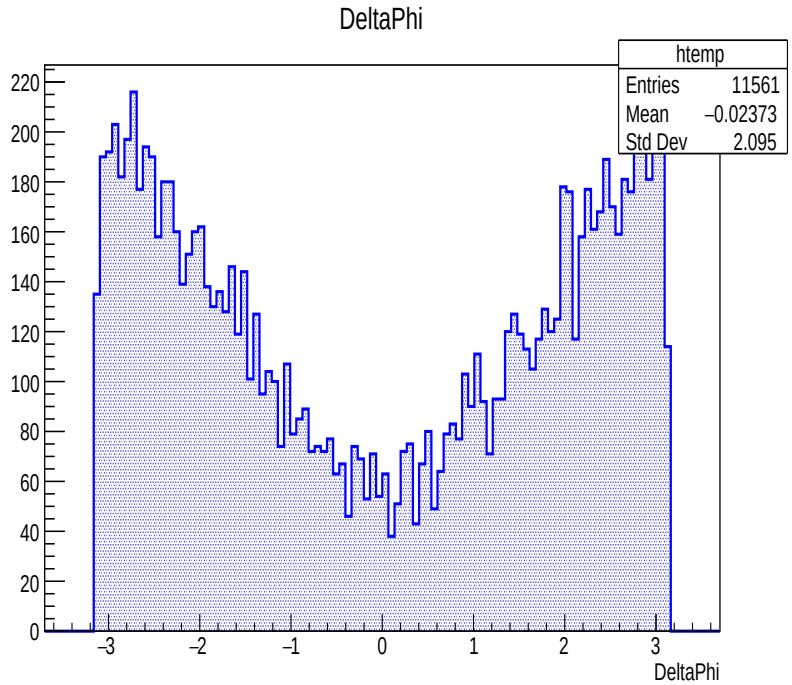
Final MET in
$ZH \rightarrow l^+l^- + \gamma + E_T^{miss}$



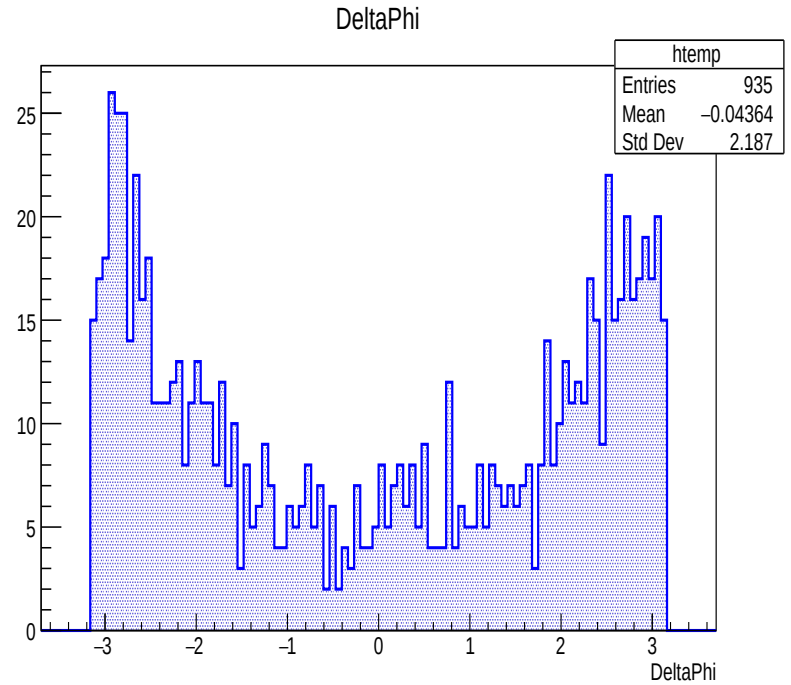
Final MET in WW_γ

deltaPhi: To check the correlation between the MET vector and the Photon.

deltaPhi should be large in the signal event as the photon and the darl photon are well separated and coming from the Higgs decay.



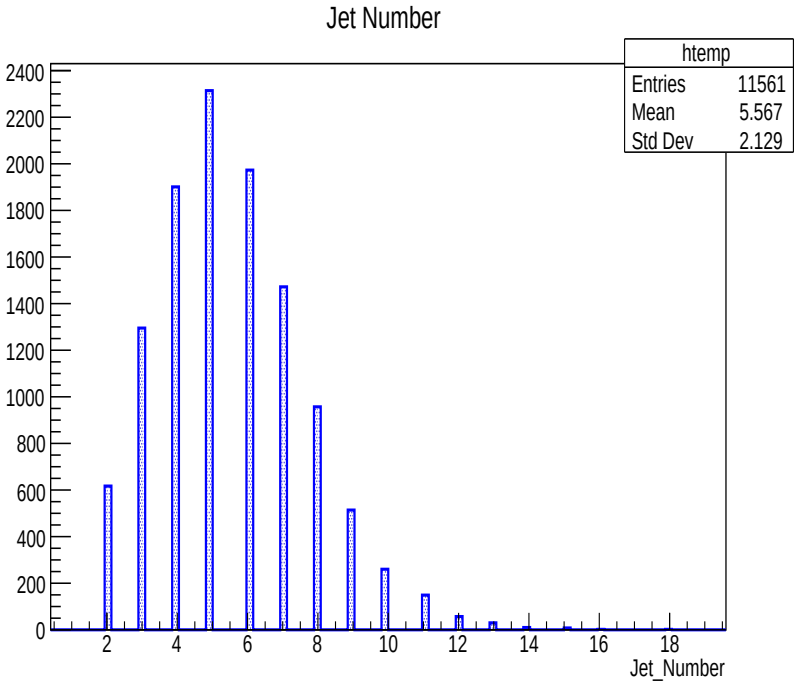
deltaPhi $\{Met, Gamma\}$ for ZH$\rightarrow$ $l^+l^- + \gamma + E_T^{miss}$



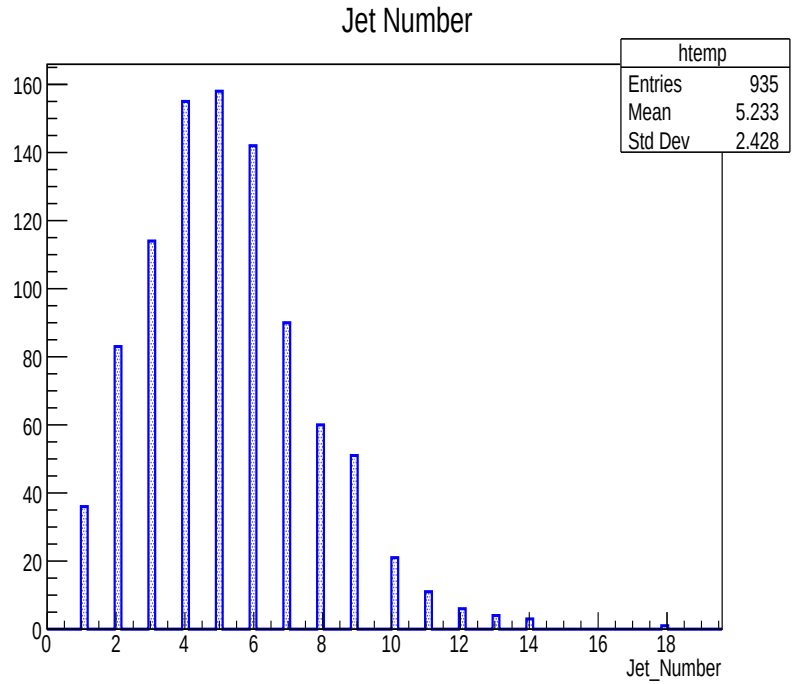
deltaPhi $\{Met, Gamma\}$ for WW$_\gamma$

Number of Jets(pT $>$ 20 GeV)

Jet Number for the ZH signal should be lower as it is purely an EW process(this will be confirmed while looking at Z + jet process)



Jet Number for
$ZH \rightarrow l^+l^- + \gamma + E_T^{miss}$



Jet Number for WW_γ

New Backgrounds

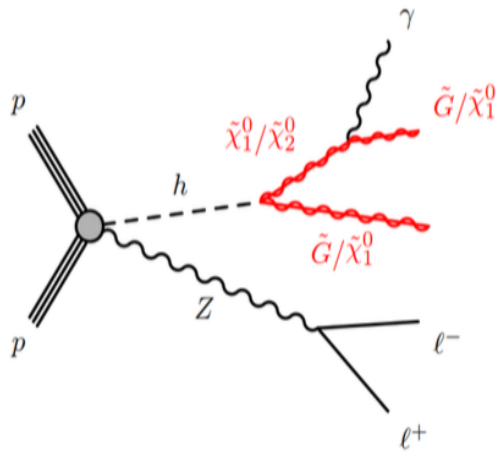
- For now the following background are being considered (signal $ZH \rightarrow l^+l^- + \gamma\gamma$:σ =760 fb)

process	σ	Comment
WWγ	86.8 fb	Available (HIGG1D2)
ZZγ	1.04 fb	DAOD needed
WZγ	11.8 fb	DAOD needed
Z+γ+jets(EW+QCD)	79.7 pb ($15 < p_T^{\gamma} < 140$ GeV))	Available (only TOPQ1 DAOD)

- A mix of mc15 and mc16 samples, produced with Sherpa 2.24 and 2.25
- Making requests for HIGG1D2 derivation for all samples
- Other backgrounds (dibosons, Z/W+jets, W_γ) will be investigated

Signal MC: From SUSY group

- A previous ATLAS analysis searching for H→χ_1^0 $\tilde{G}$, with similar final state: γ+E_T^{miss} (ATLAS-CONF-2018-019). But:
  - Different model and kinematics
  - Strongly Depend on χ_1^0 and $\tilde{G}$ masses
  - Not compatible with Higgs coupling to DM mediator or γ_D.



- We will use also this signal for a matter of comparison, with the following constraints: mχ_1^0 , m$\tilde{G}$ = 65 GeV for kinematic compatibility.
  - MC sample available but need derivation