Estágio de Verão CMS-HF

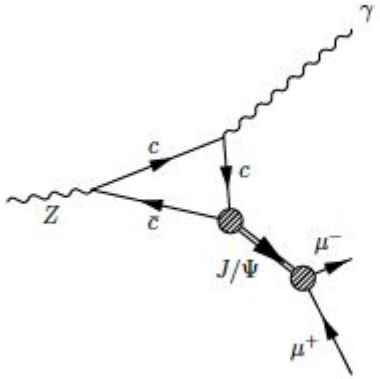
$H/Z \rightarrow Quarkonia + \gamma$

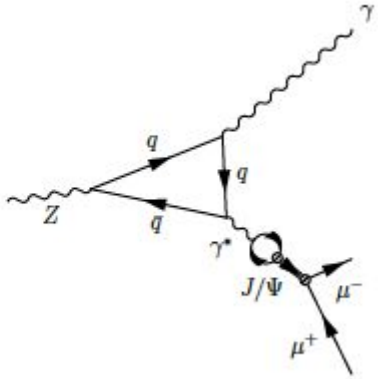
Miguel Afonso

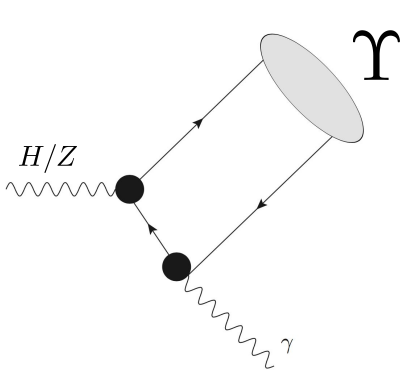
Coordenadora: Eliza Melo

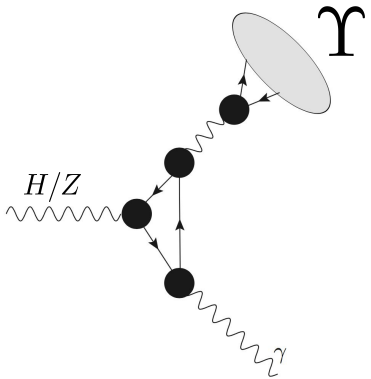
Physics Goals

- **H/Z SM rare decay channel.**
- Alternative probe for H/Z qqbar coupling.
- Sensitivity to Beyond SM.
- There are two channels,one for the Higgs and one for the Z
- Z is a Benchmark for the Higgs analogous process.
- References:
  - https://arxiv.org/abs/1709.09320v4
  - https://arxiv.org/abs/1710.09872v3





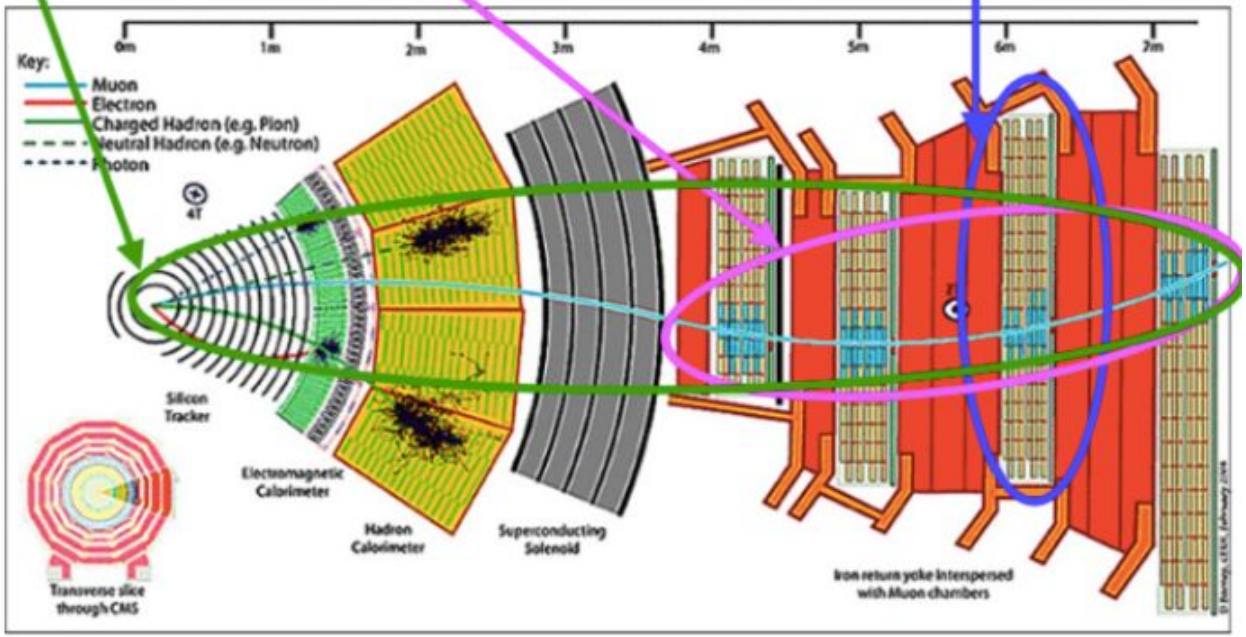


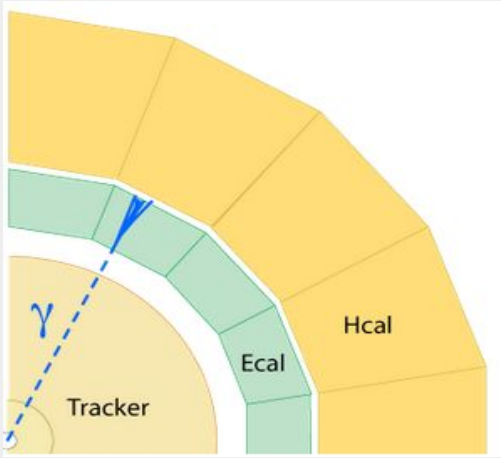


(3) Muons are reconstructed by combining information from the tracker and muon systems. So-called global and tracker muons are reconstructed in this way.

(2) Muon tracks (standalone muons) are reconstructed by combining hits and segments from different stations.

(1) Hits and segments are reconstructed within each chamber.





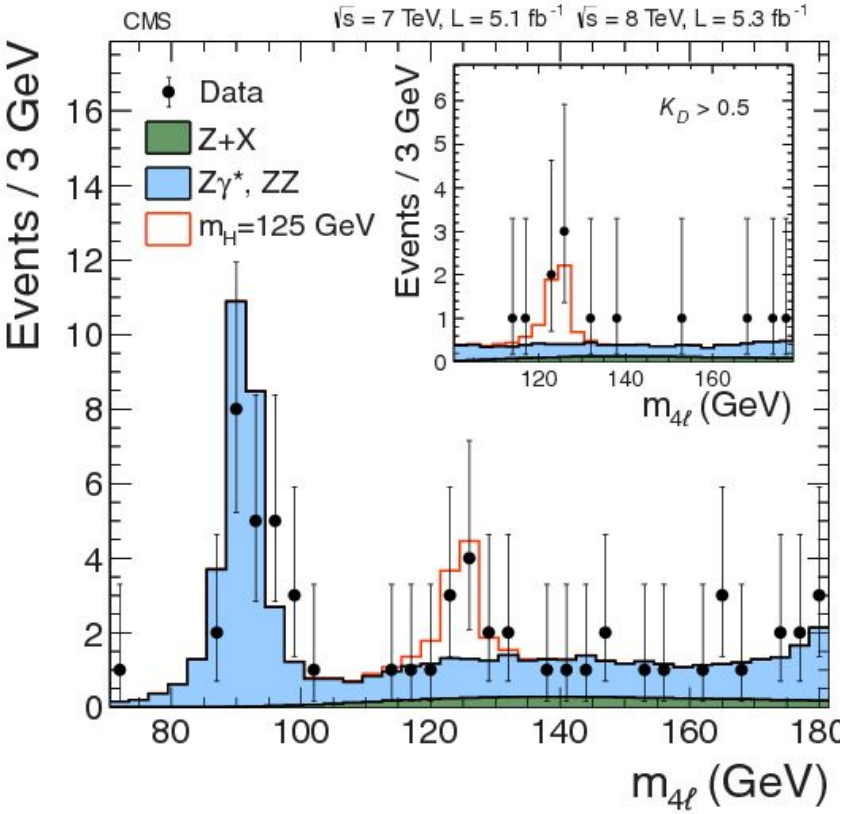
Photon objects are created based on depositions of energy within the ECAL. Each SuperCluster (deposits of energy in the Ecal that are clusters of BasicClusters) is potentially a Photon candidate.

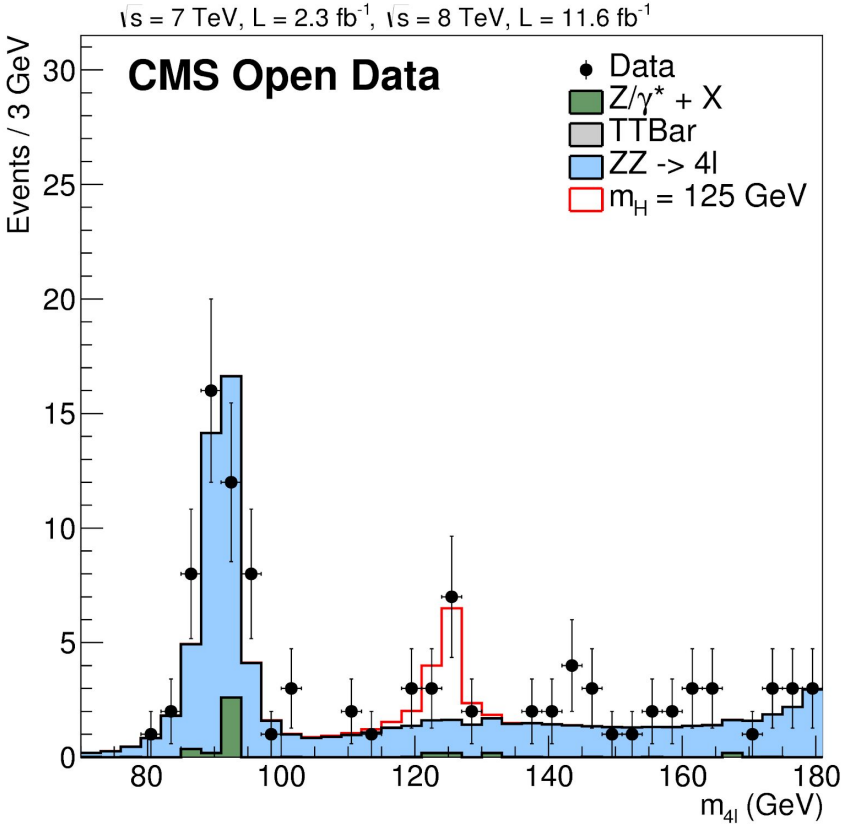
H ⇨ ZZ ⇨ 4l

-This study uses CMS open data

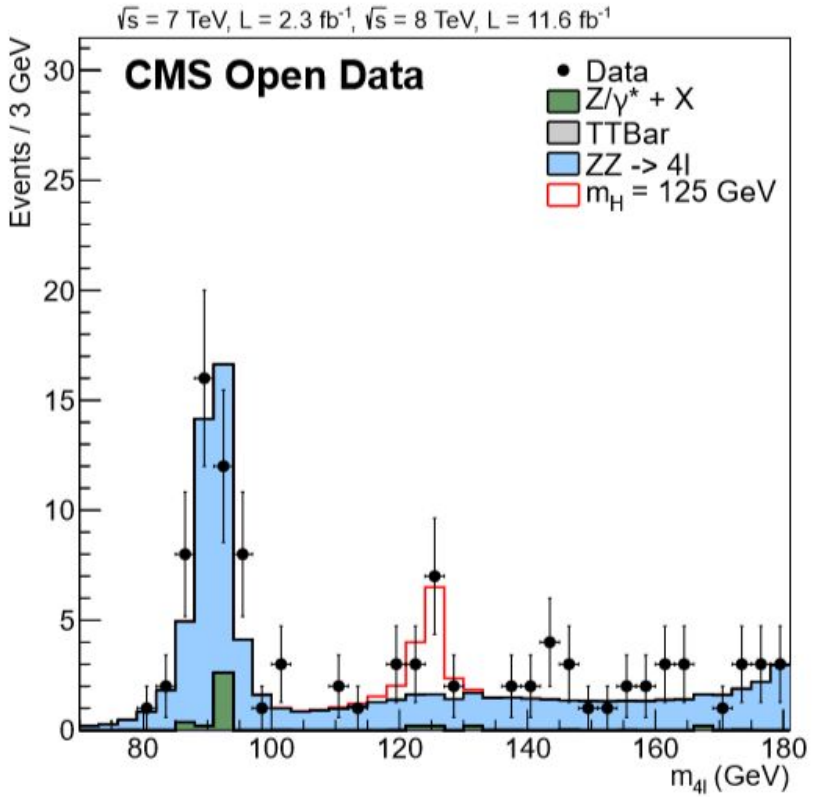
-it was reproduced at the start of the project to get acquainted with the cms framework

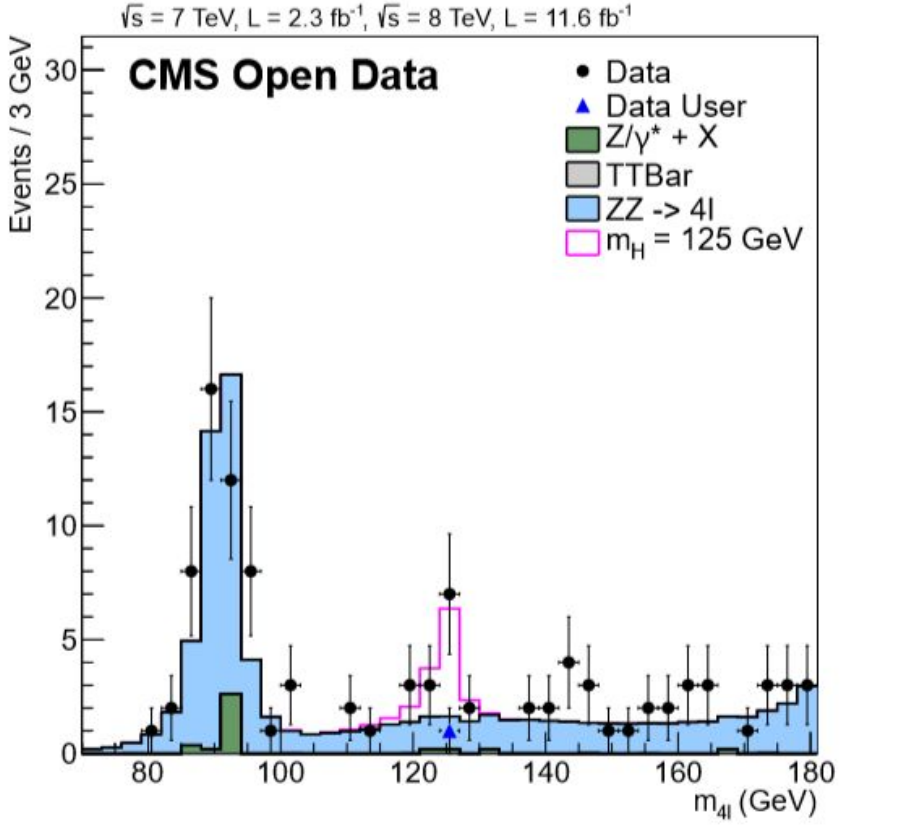
H⇨ZZ⇨4l


CMS
√s = 7 TeV, L = 5.1 fb-1 √s = 8 TeV, L = 5.3 fb-1
Data
Z+X
Zγ*, ZZ
mH=125 GeV
Events / 3 GeV
m4ℓ (GeV)
KD > 0.5


√s = 7 TeV, L = 2.3 fb-1, √s = 8 TeV, L = 11.6 fb-1
CMS Open Data
Data
Z/γ* + X
TTBar
ZZ -> 4l
mH = 125 GeV
Events / 3 GeV
m4l (GeV)

H ⇨ ZZ ⇨ 4l


√s = 7 TeV, L = 2.3 fb-1, √s = 8 TeV, L = 11.6 fb-1
CMS Open Data
Data
Z/γ* + X
TTBar
ZZ -> 4l
mH = 125 GeV
Events / 3 GeV
m4l (GeV)


√s = 7 TeV, L = 2.3 fb-1, √s = 8 TeV, L = 11.6 fb-1
CMS Open Data
Data
Data User
Z/γ* + X
TTBar
ZZ -> 4l
mH = 125 GeV
Events / 3 GeV
m4l (GeV)

MC Samples – Z Channel

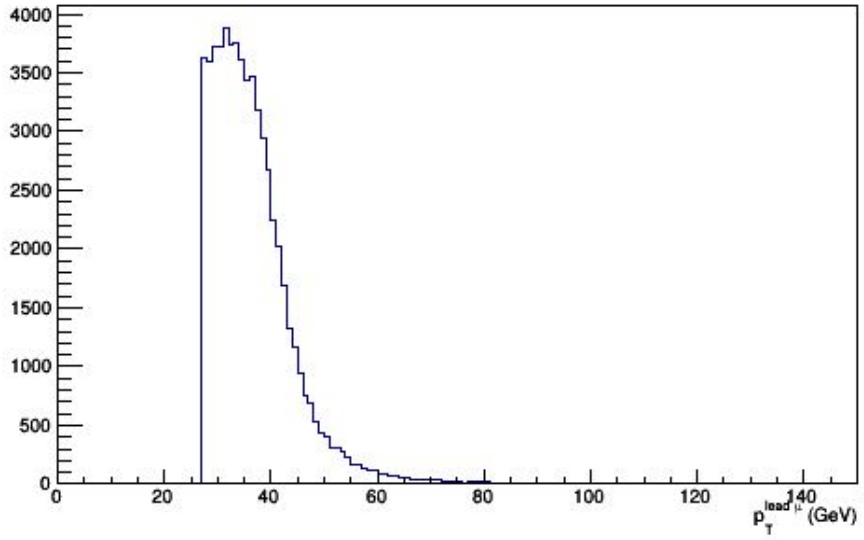
- **Z Signal MC:** Z Mass > 50 GeV applied at generator level.
    - /**ZToJpsiGamma**-TuneCUETP8M1_13TeV-**pythia8**/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v2/MINIAODSIM (70K Events)
    - /**ZToUpsilon1SGamma**-TuneCUETP8M1_13TeV-**pythia8**/RunIISummer16MiniAODv2-PUMoriond17_80X_mcRun2_asymptotic_2016_TrancheIV_v6-v2/MINIAODSIM (70K Events)
- **Background samples**:
    - **Peaking background:** pp → Z → μμγ$_{FSR}$ - Produced with MADGRAPH and showered with Pythia8.
      /ZGTo2MuG_MMuMu-2To15_*/RunIISummer16*-PUMoriond17_80X_*_TrancheIV*/MINIAODSIM (196K Events)

Event Selection

I	A	Trigger: `Muon with pT>17 GeV and photon with E>30 GeV`
	B	p_T(lead muon) > 27 GeV; p_T(trail muon) > 4 GeV
	C	Photon MVA ID (90% WP); $E_T(\gamma)$ >33 GeV; $\lvert\eta_{SC}\rvert$ < 2.5, excluding ECAL Barrel-Endcap intersection;
		2.8 GeV < μμ Mass < 3.2 GeV [Z ➔ Jpsi + γ] or 8.5 GeV < μμ Mass < 11 GeV [Z ➔ Upsilon + γ]

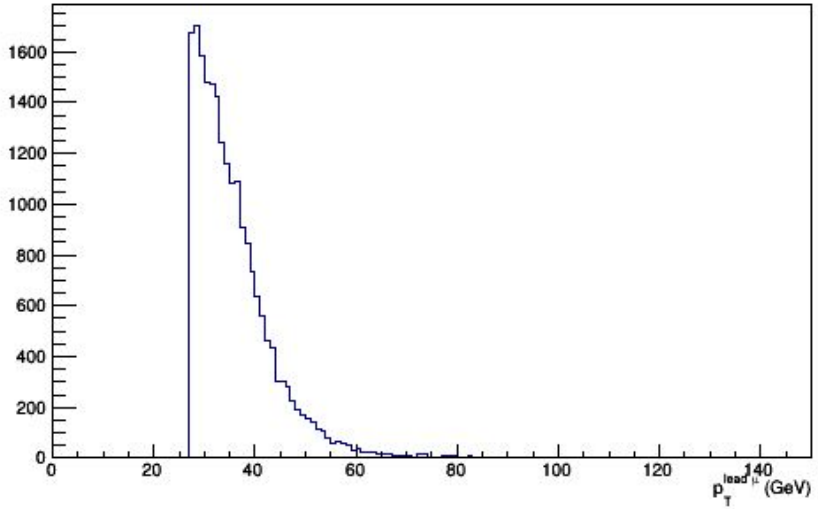
Control plots using Monte Carlo sample of Z⇨J/ψ +photon

Transverse momentum (pt) of the leading muon

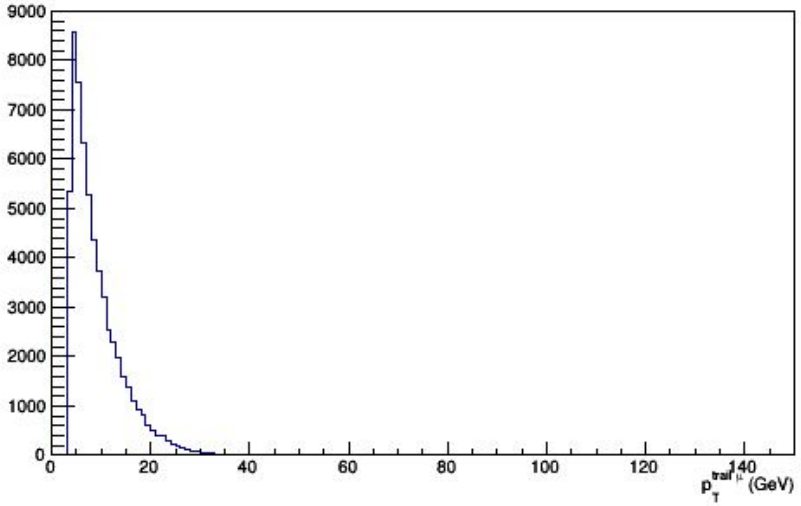


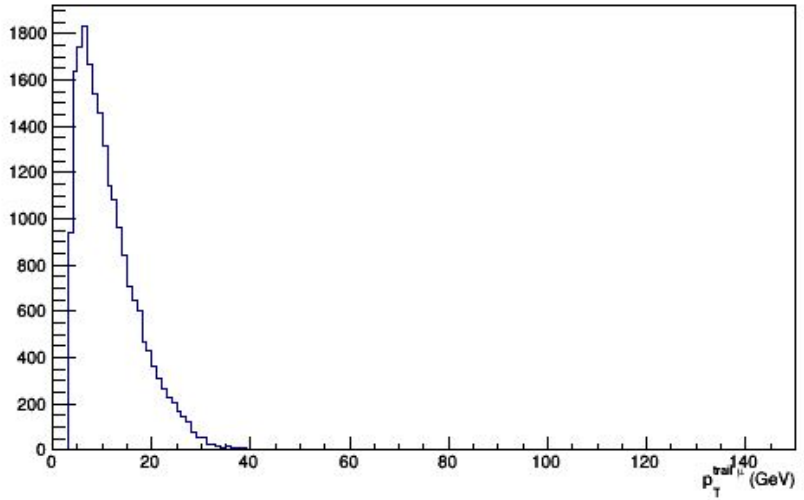
background

signal

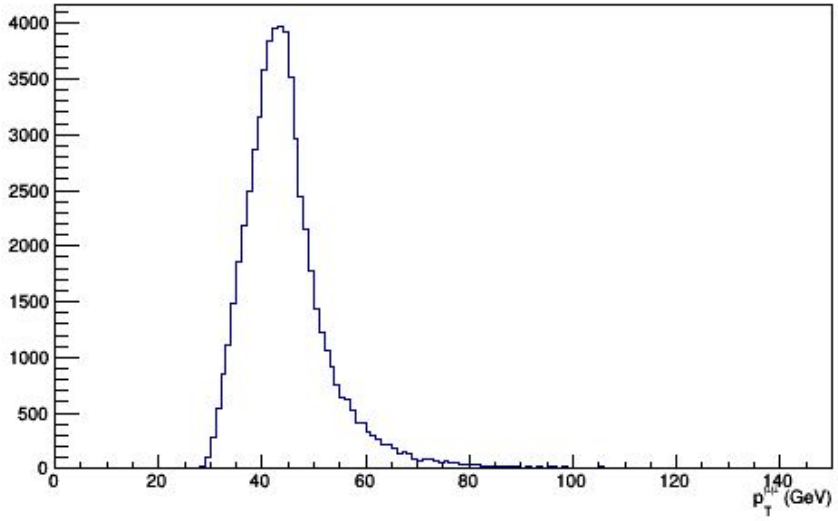


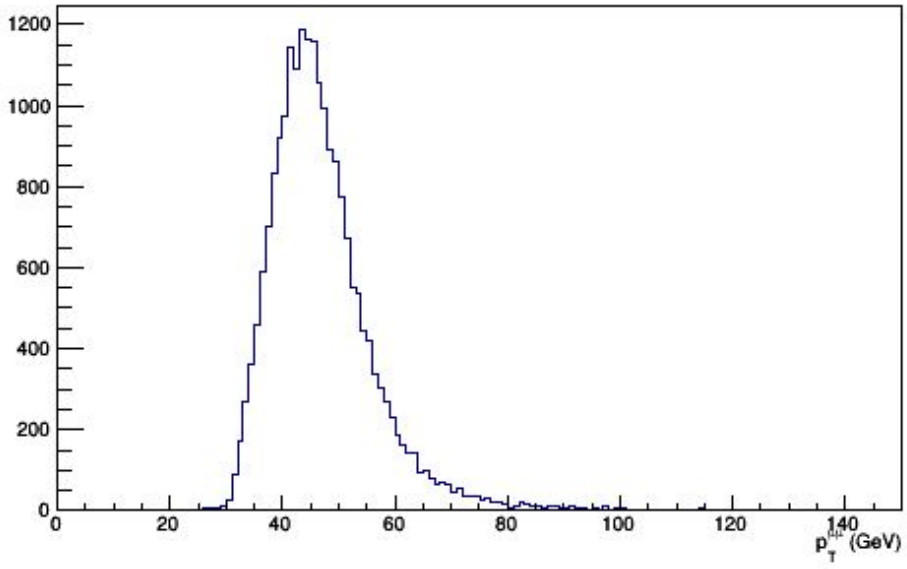
transverse momentum (pt) of the Trailing Muon



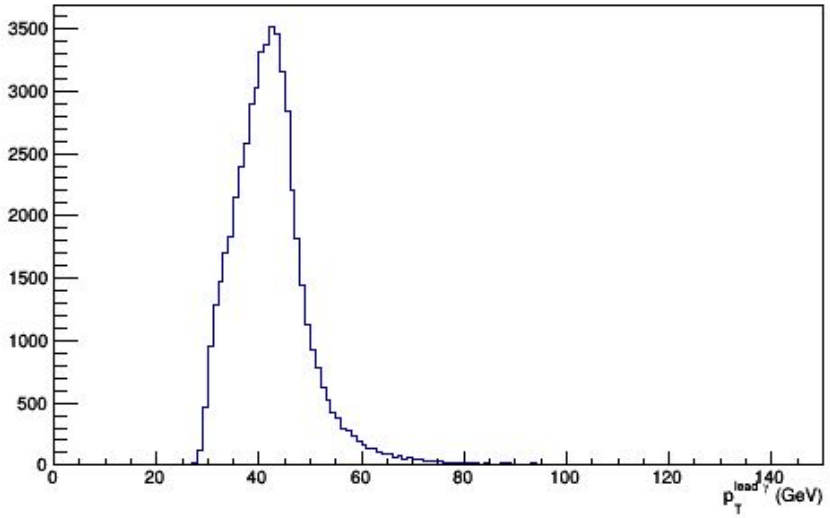


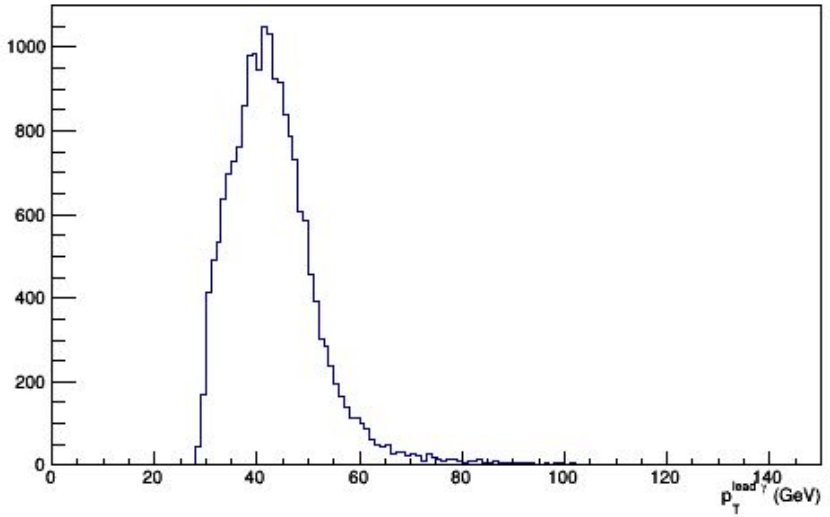
transverse momentum of Di Muon (pT(\mu\mu))



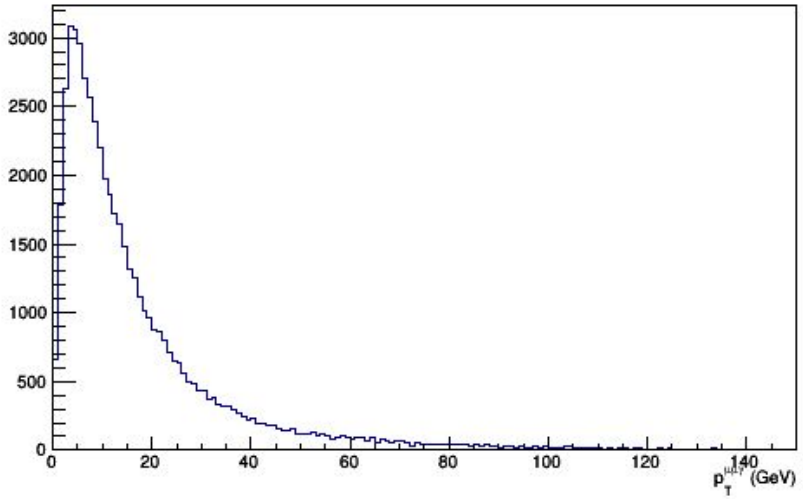


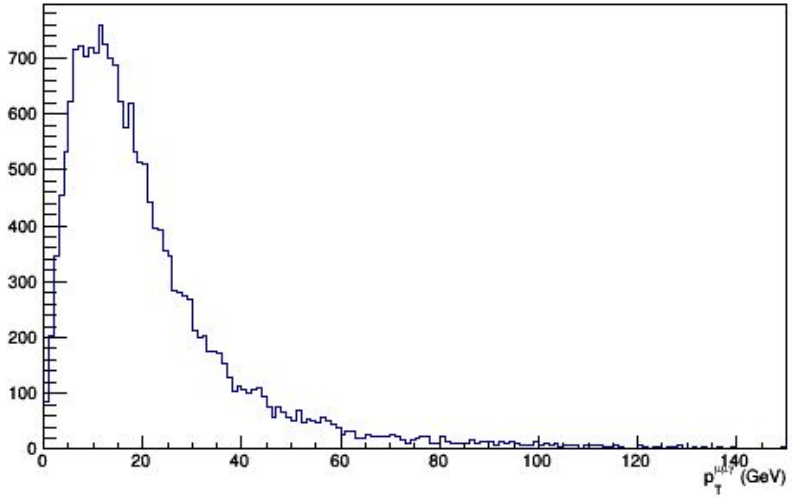
transverse Momentum of the photon



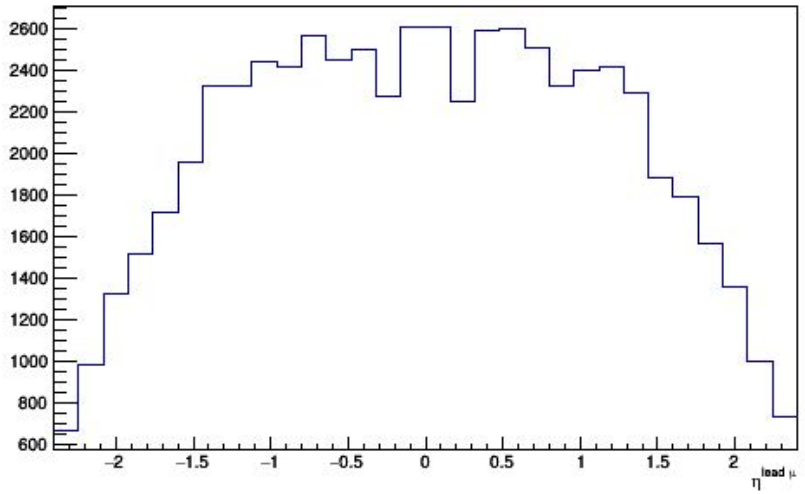


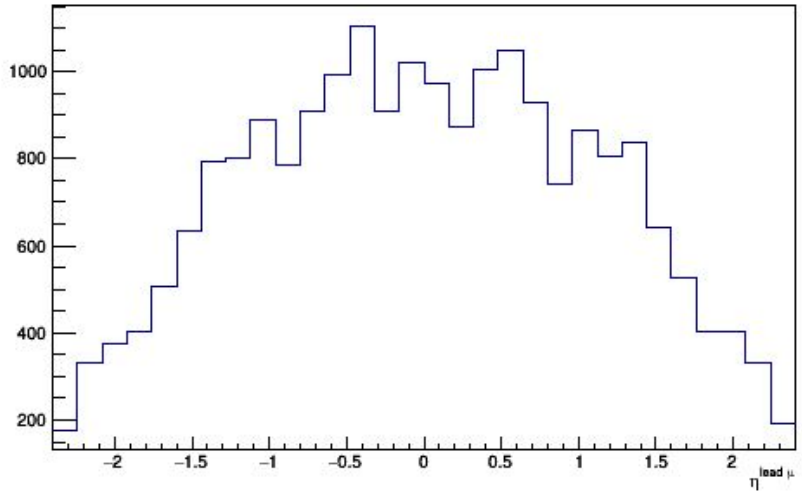
transverse momentum of DiMuon Photon



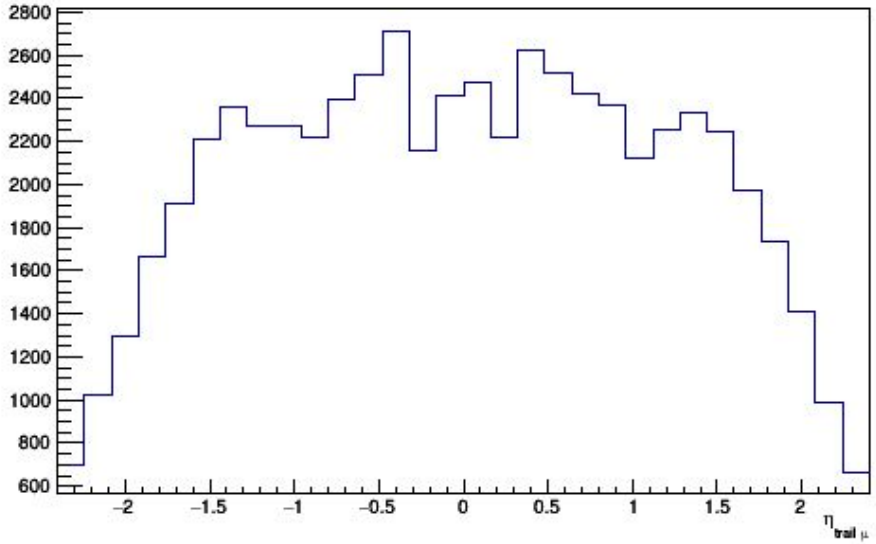


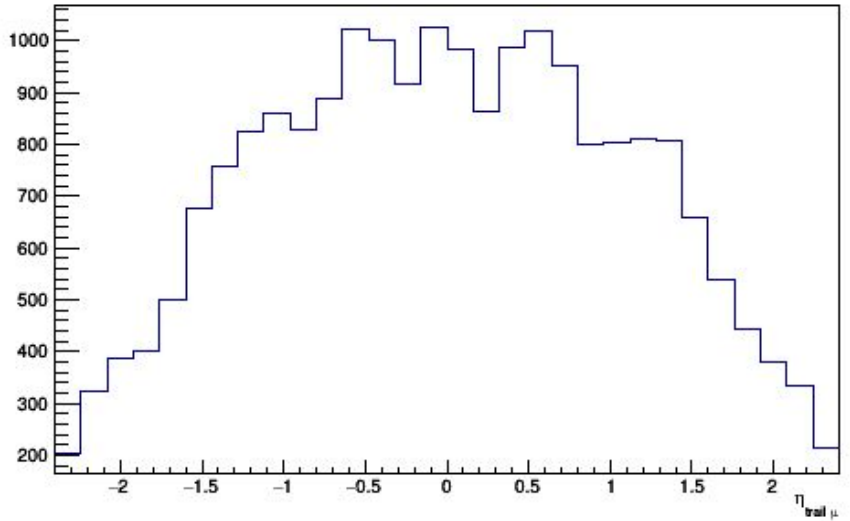
pseudorapidity of the leading muon



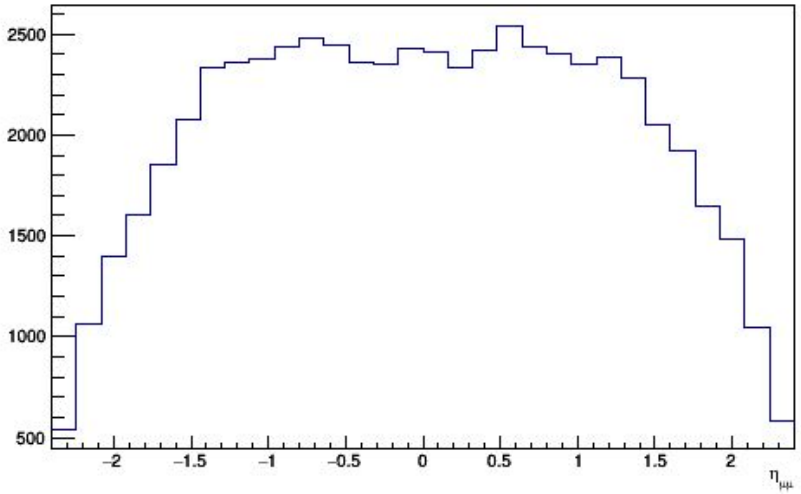


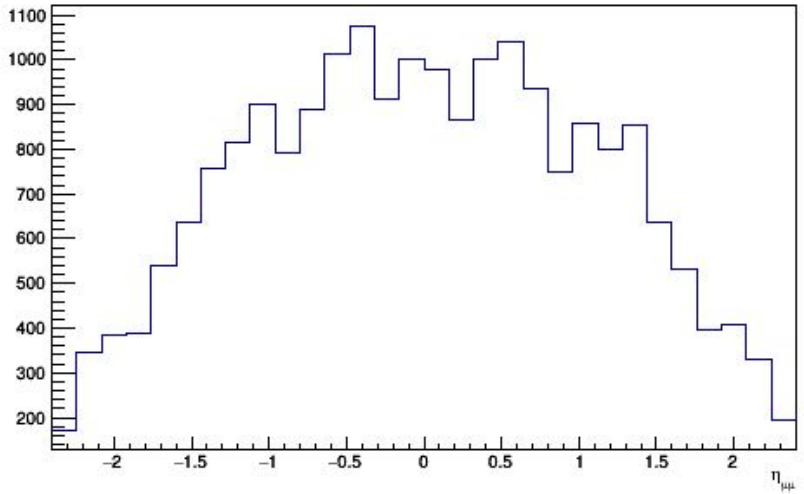
Pseudorapidity of the trailing muon



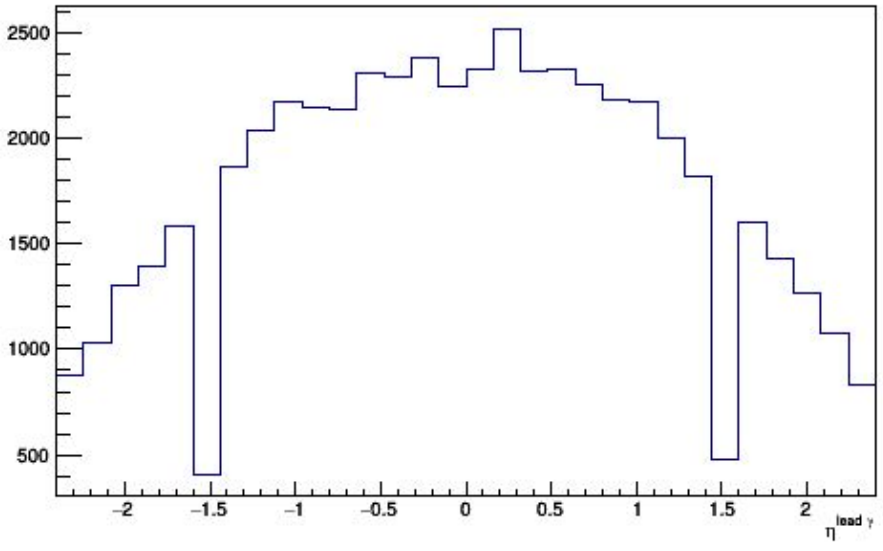


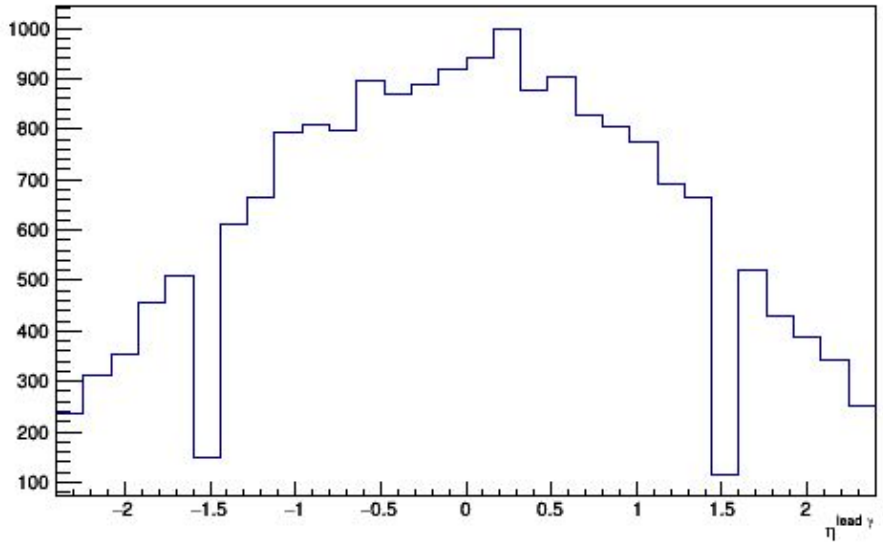
Pseudorapidity of the DiMuon



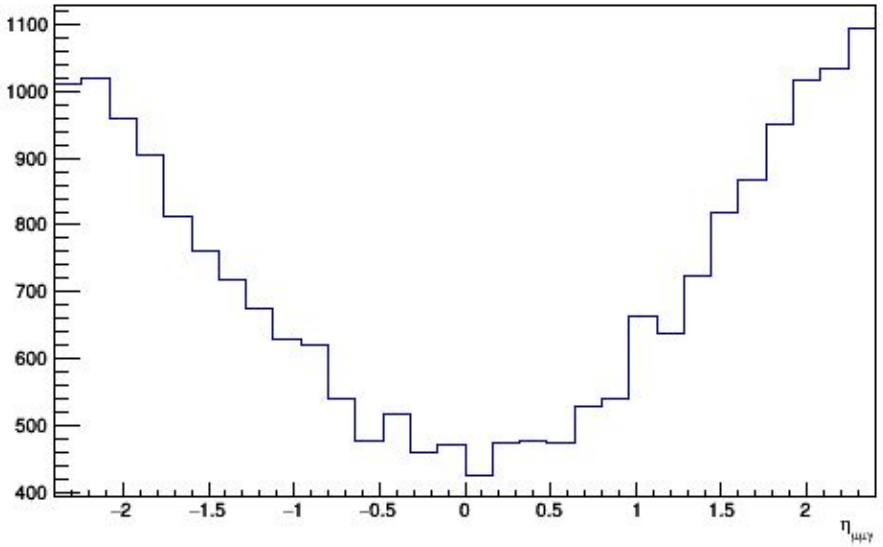


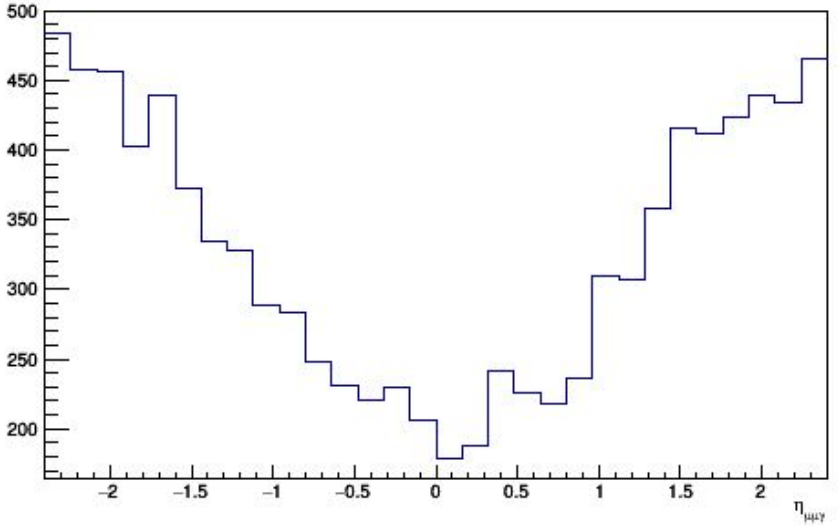
Pseudorapidity of the photon



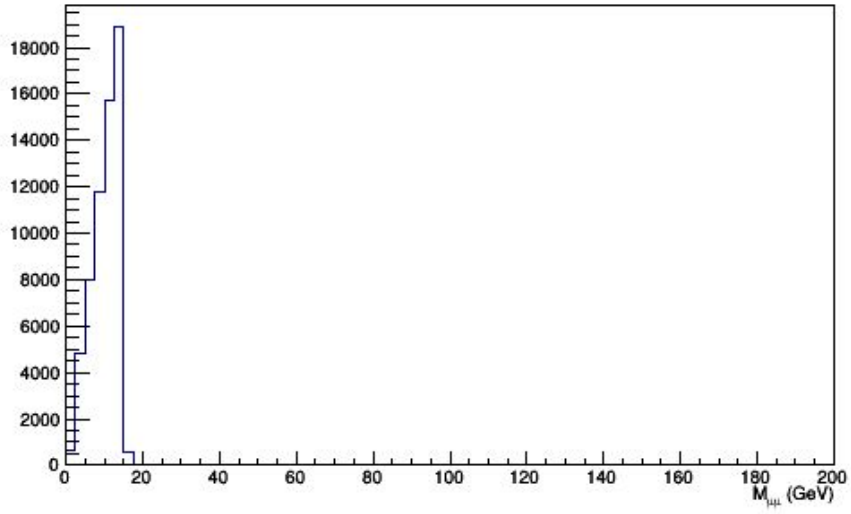


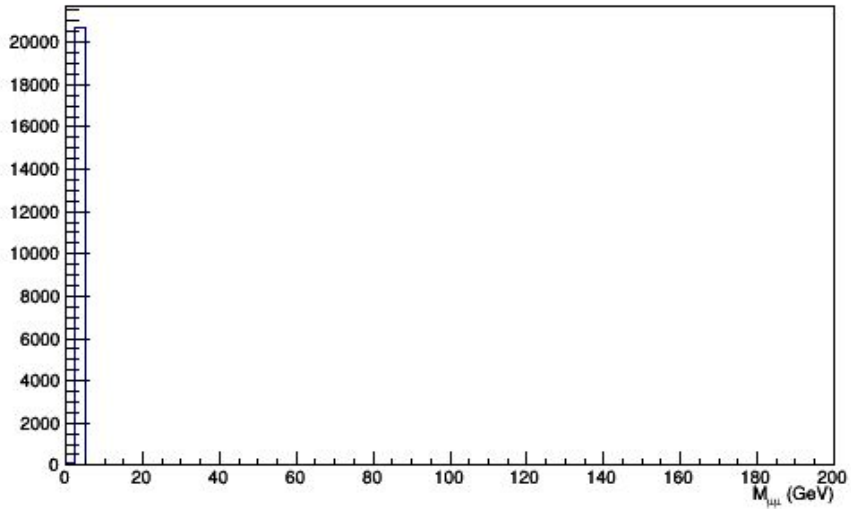
Pseudorapidity DiMuon Photon



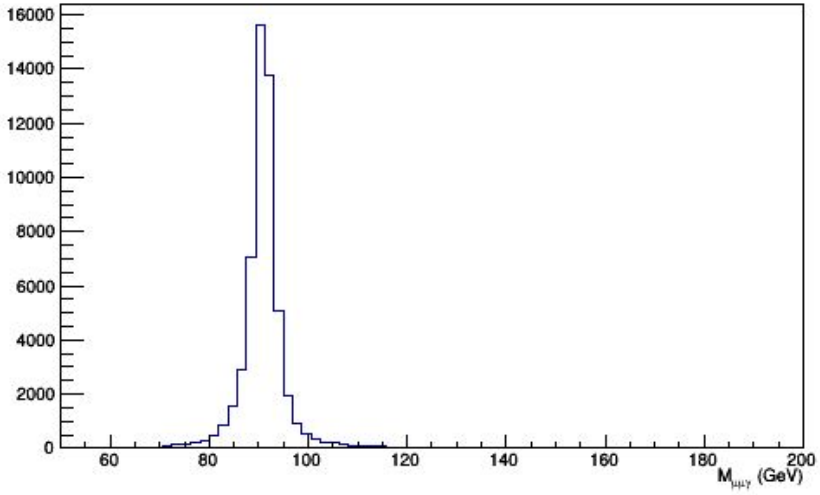


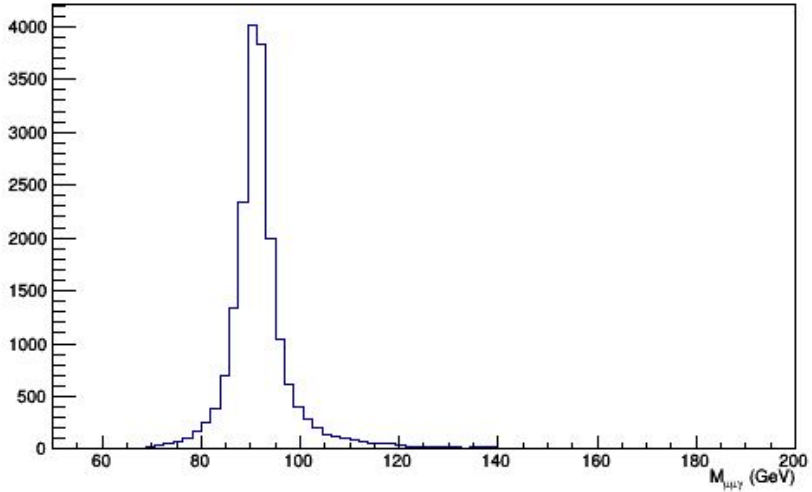
Mass of the DiMuon



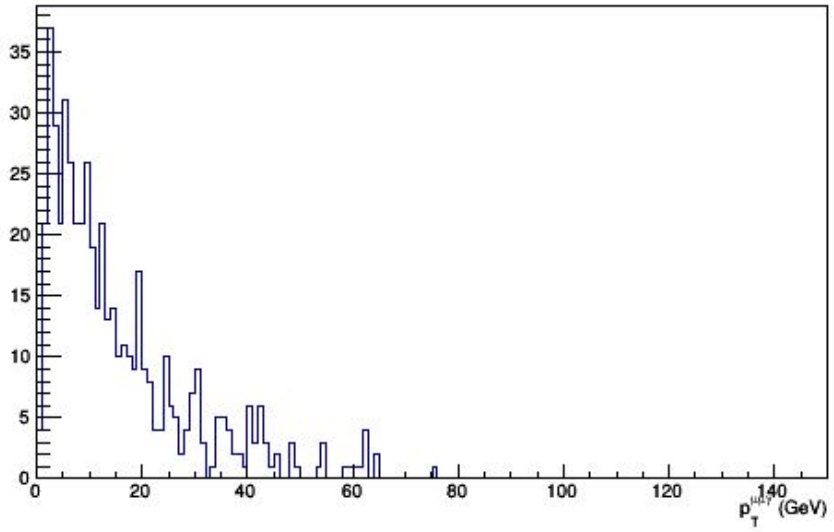


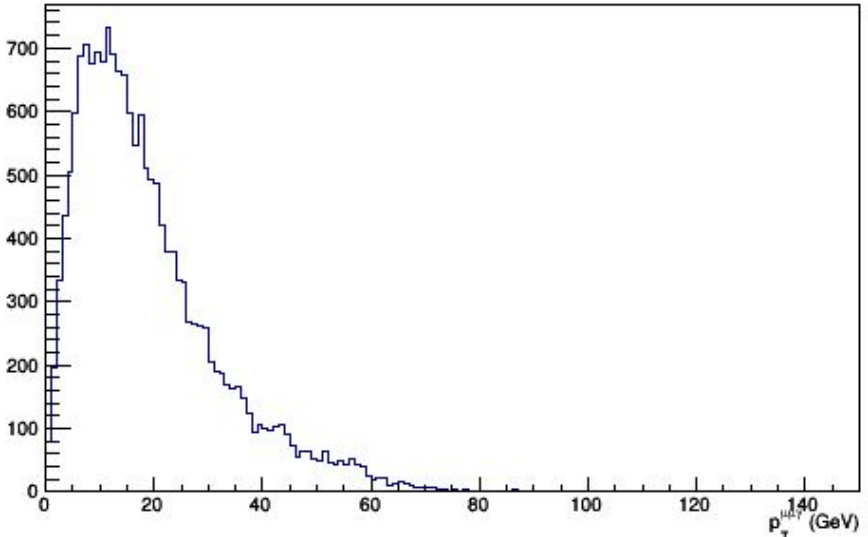
Mass of the DiMuon Photon



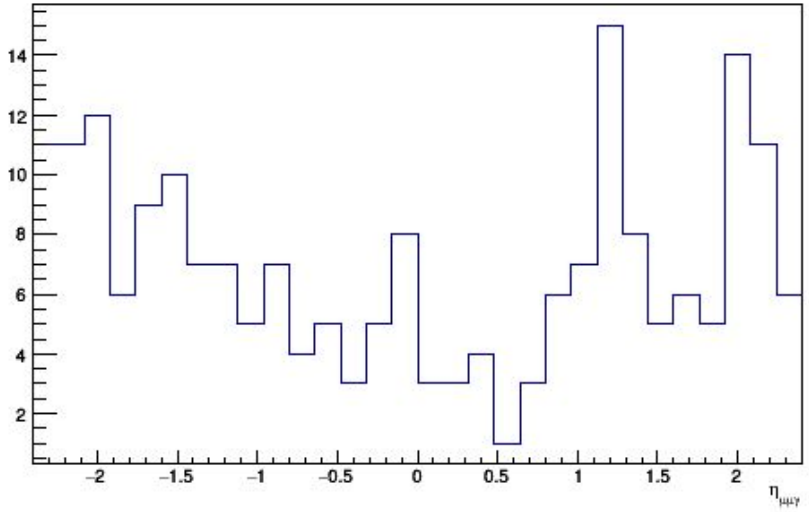


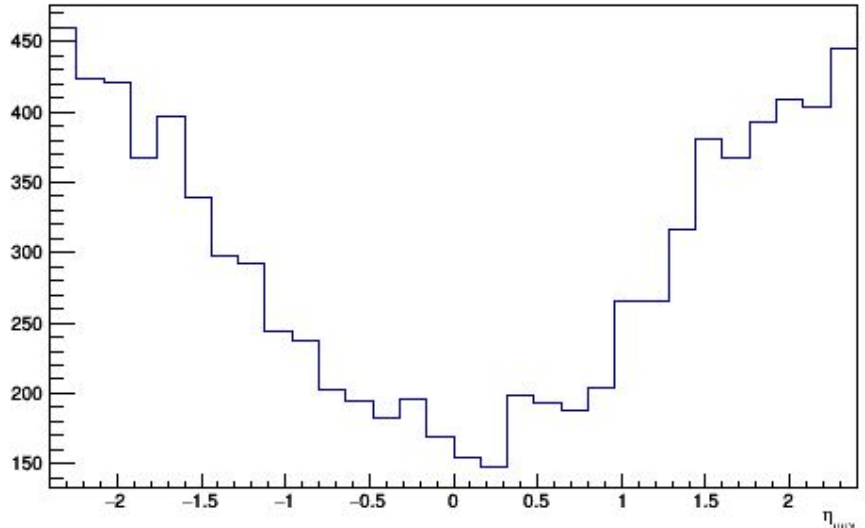
Z->J/ψ +photon
transverse momentum of Meson Photon



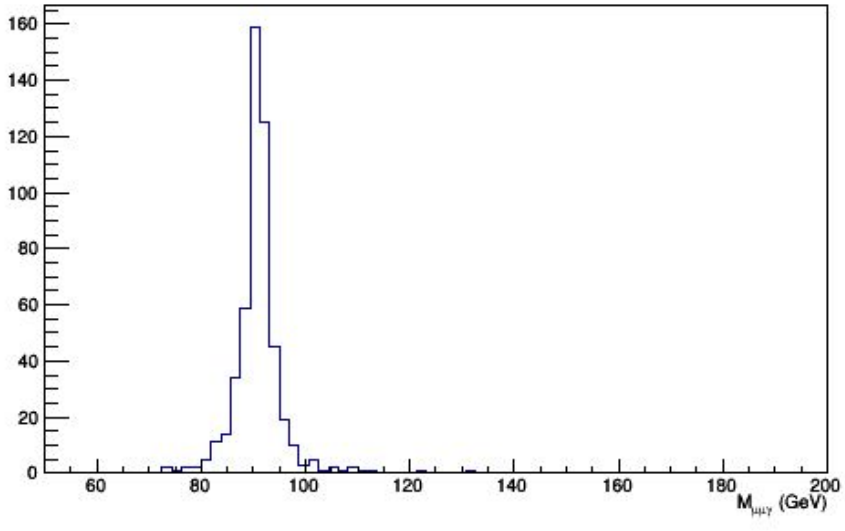


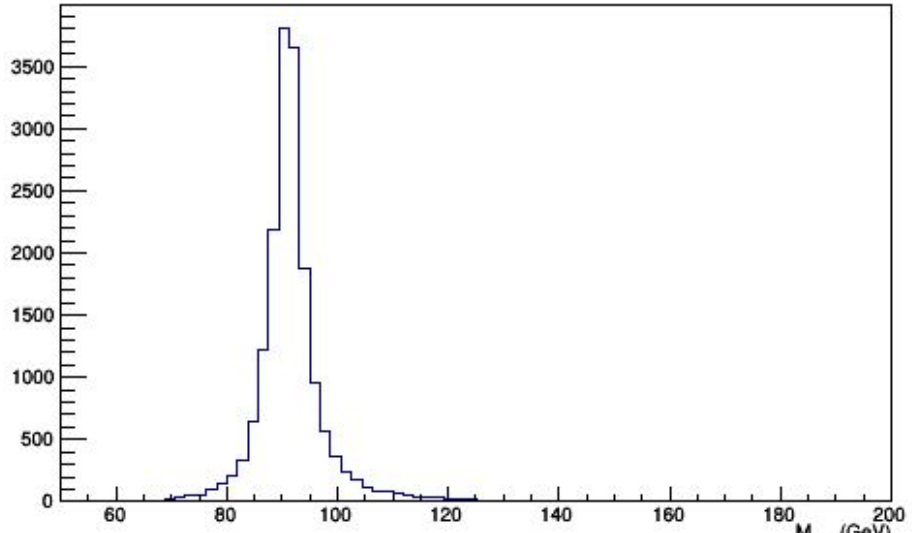
Z->J/ψ +photon
pseudorapidity of the Meson Photon





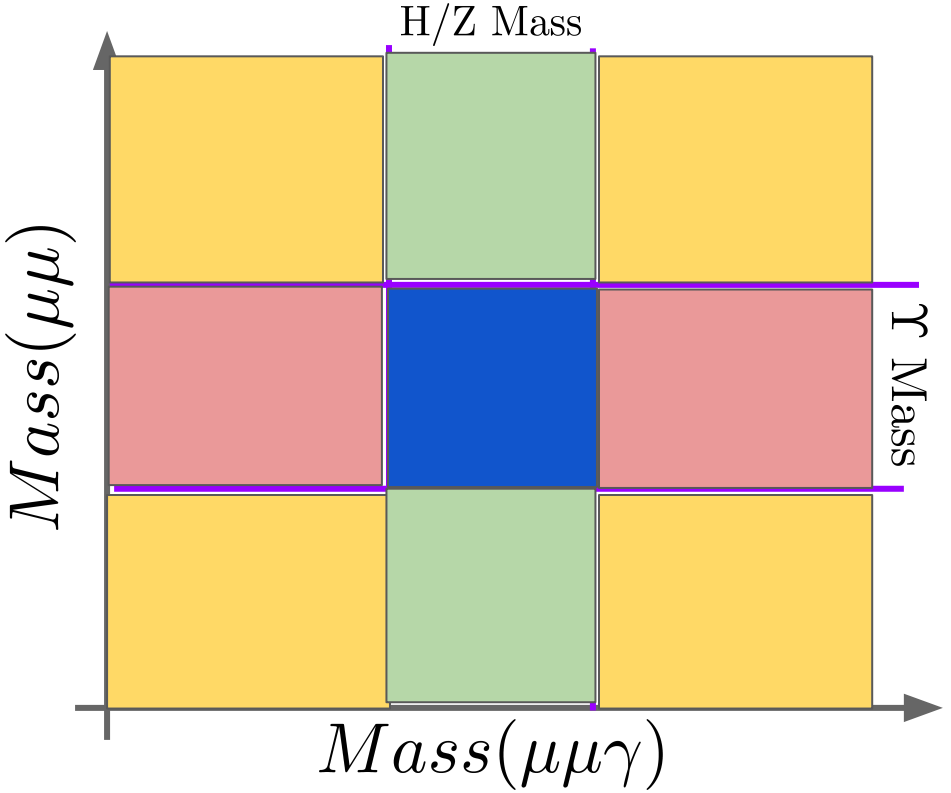
Z->J/ψ +photon
Mass of the meson photon



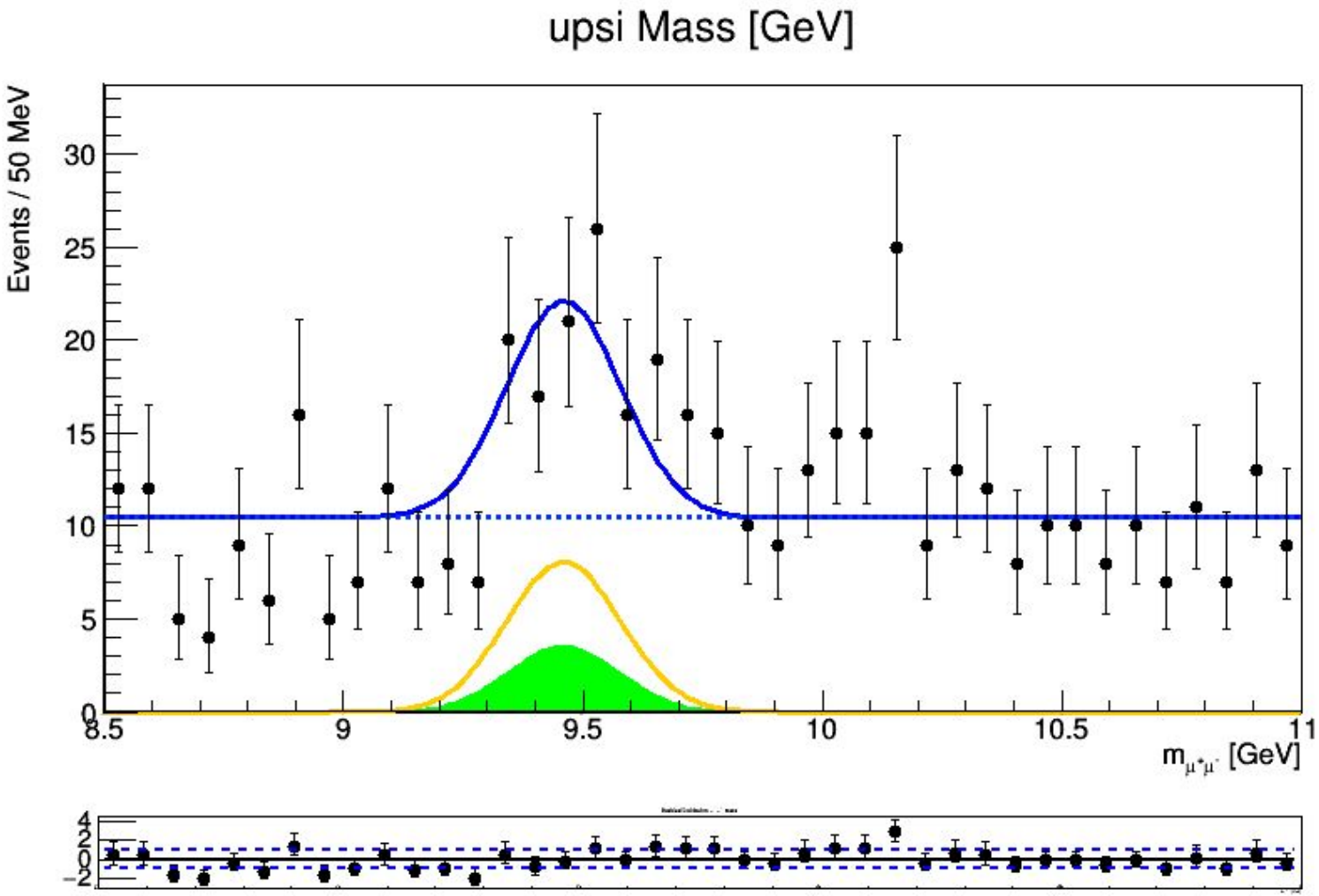


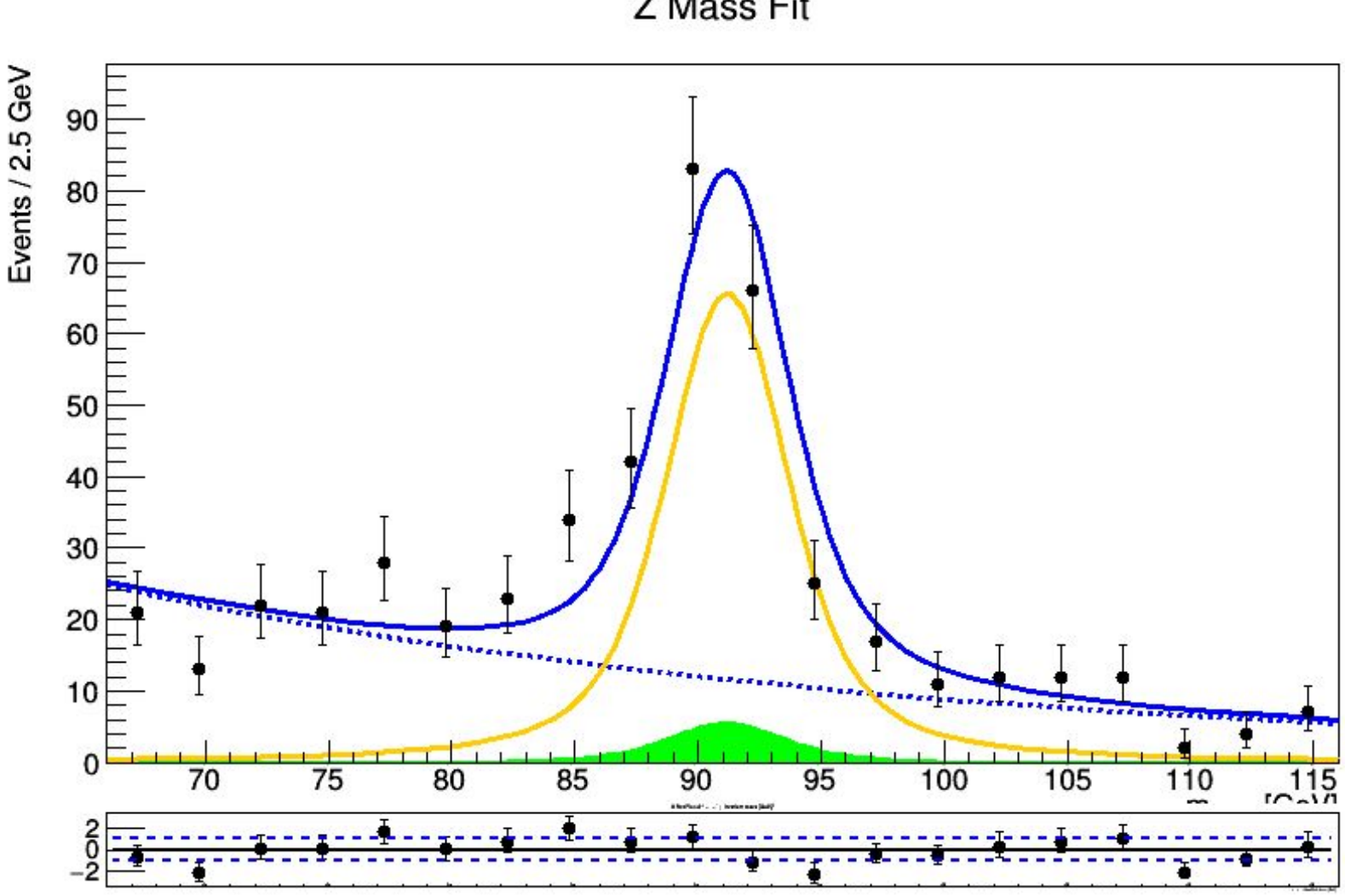
Fit 2D using 2016 data collected by CMS at 13 TeV

Yields components	VALUE	ERROR
Upsi background - Z background yield	2.181e+02	2.604e+01
Upsi background - Z signal yield	2.001e+02	2.518e+01
Upsi signal - Z background yield	3.851e+01	1.282e+01
Upsi signal - Z signal yield	1.723e+01	1.065e+01
resolution_sigma (Z)	1.700e+00	6.749e-01
sigma (Z)	3.257e+00	8.923e-01
sigma_m (upsi)	1.195e-01	2.848e-02



- Fit model:2D unbinned extended maximum likelihood fit
- Z signal: single Gaussian
- Y(1S) signal:single Gaussian
- Z and Y(1S) background:exponential


upsi Mass [GeV]
Events / 50 MeV
30
25
20
15
10
5
0
8.5
9
9.5
10
10.5
11
$m_{\mu^+\mu^-}$ [GeV]
4
2
0
−2


Z Mass Fit
Events / 2.5 GeV
0
10
20
30
40
50
60
70
80
90
70
75
80
85
90
95
100
105
110
115
2
0
−2

Summary

-explored the very rare decays of the higgs and Z bosons into a quarkonium and a photon

-studied the kinematic caracteristics of the final state particles using simulation for signal and backgroung process

-performed a 2D unbinned fit of the mass of the dimuon+photon using simulated data

-Current amount of LHC data not yet sufficient to detect SM signals…

-however,physics beyond the SM could cause an enhancement!

-sensitive analysis to be carried out during the high luminosity phase at LHC (HL-LHC