Performance of Muons using Z boson events in Run3 at the CMS

권 우 연

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Motivation

- CMS collects Run3 data from 2022 to 2024 at $\sqrt{s} = 13.6$ TeV
- We need to understand about Run 3 data
- CMS is specialist in detecting muons. CMS offers various muon objects.
- To understand about muon data we verify muon performance with muon objects
- Z boson mass reconstruction with $Z \rightarrow \mu\mu$ process is a good indicator of muon performance

Muon objects

Global Muon

Reconstructed muon with tracker track information inner trackers and standalone tracks with hits

Tracker Muon

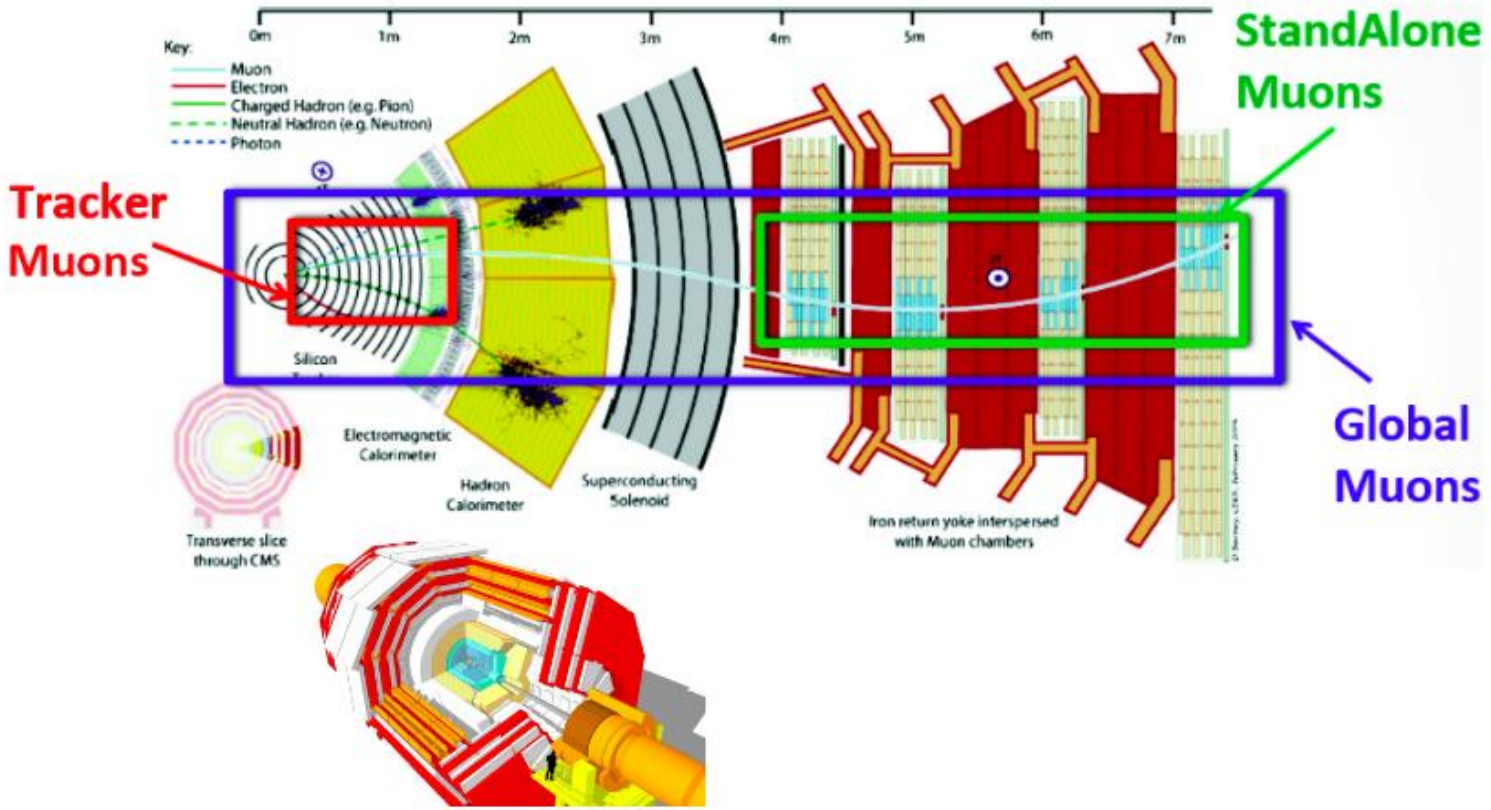
Reconstructed muon with tracker track

Stand Alone Muon

Reconstructed muon with tracks and hits information of muon detector in muon cha

PF Muon

Reconstructed Muon with Particle Flow(PF) Algorithm. This uses all information of detectors including calorimeter. generally used muon object in MINIAOD or NANOAOD data.



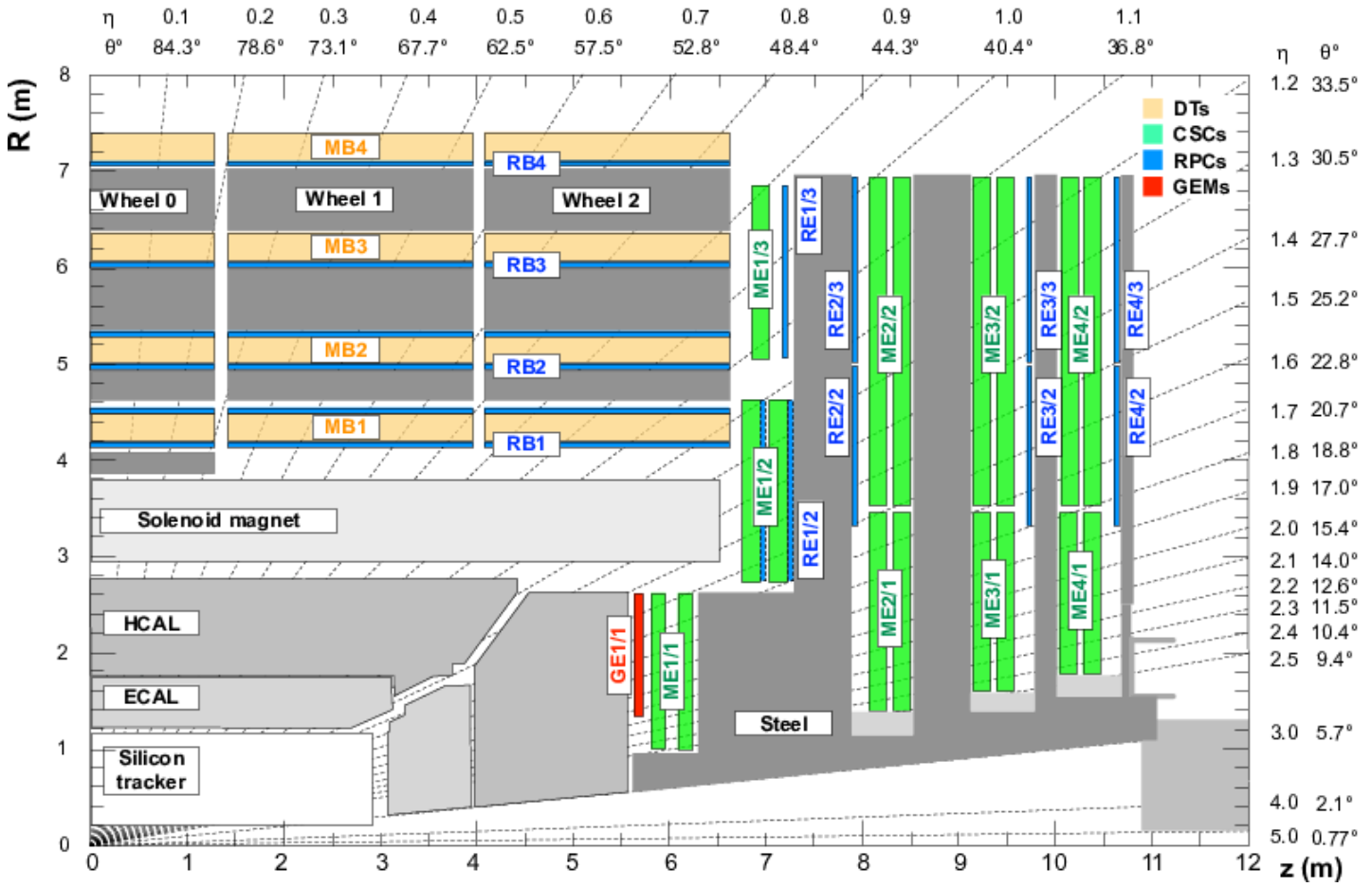
Muon objects

RPC Muon

Reconstructed Muon with Resistive Plate Chamber(RPC) information

GEM Muon

Reconstructed Muon with Gas Electron Multiplier(GEM) information



Datasets

DATA*

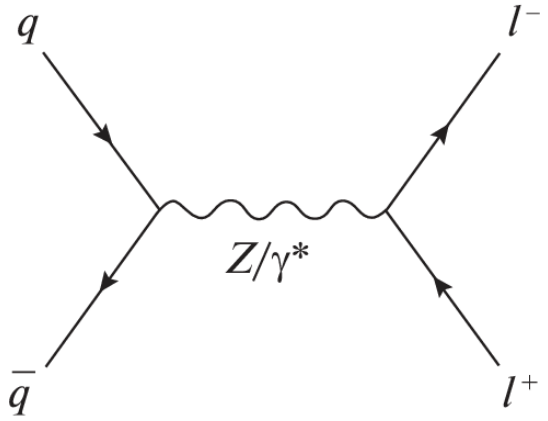
⇒ Total luminosity : **120.5741** fb^{-1}

Run2022(C~G) : 34.652 fb-1

Run2023(B~D) : 27.862 fb -1

Run2024(B~G) : 58.06 fb -1

*Luminosity value with Golden Json



MC Simulation

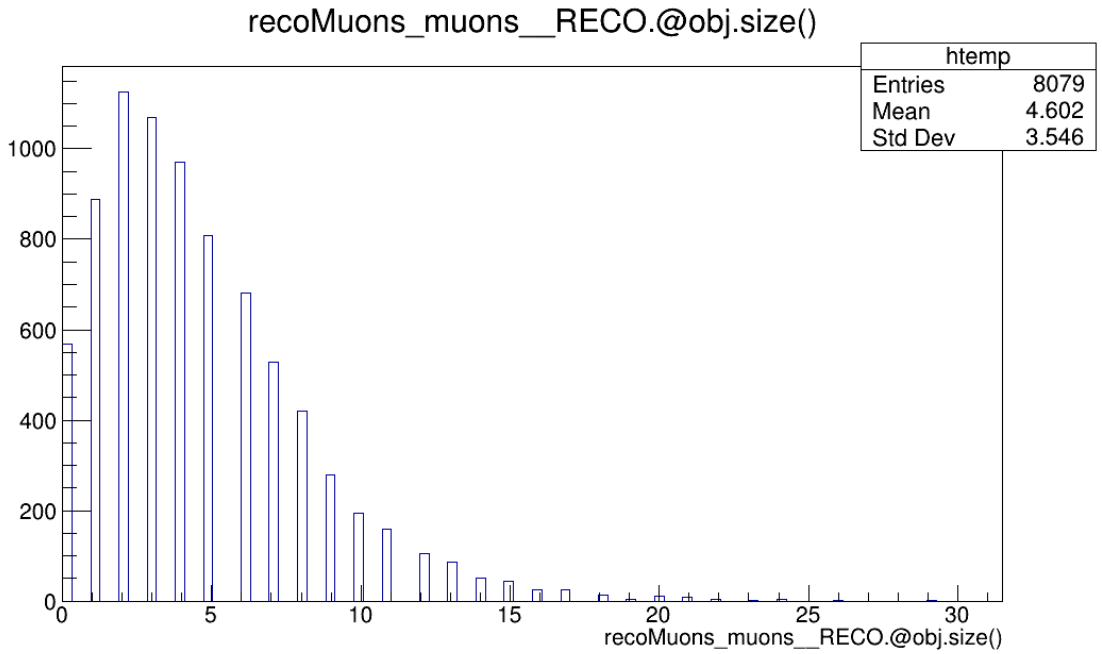
Drell-Yan to 2 leptons with invariant mass > 50 GeV at 13.6TeV

/DYJetsToLL_M-50_TuneCP5_13p6TeV-madgraphMLM-pythia8/Run3Summer22DRPremix-124X_mcRun3_2022_realistic_v12-v2/AODSIM

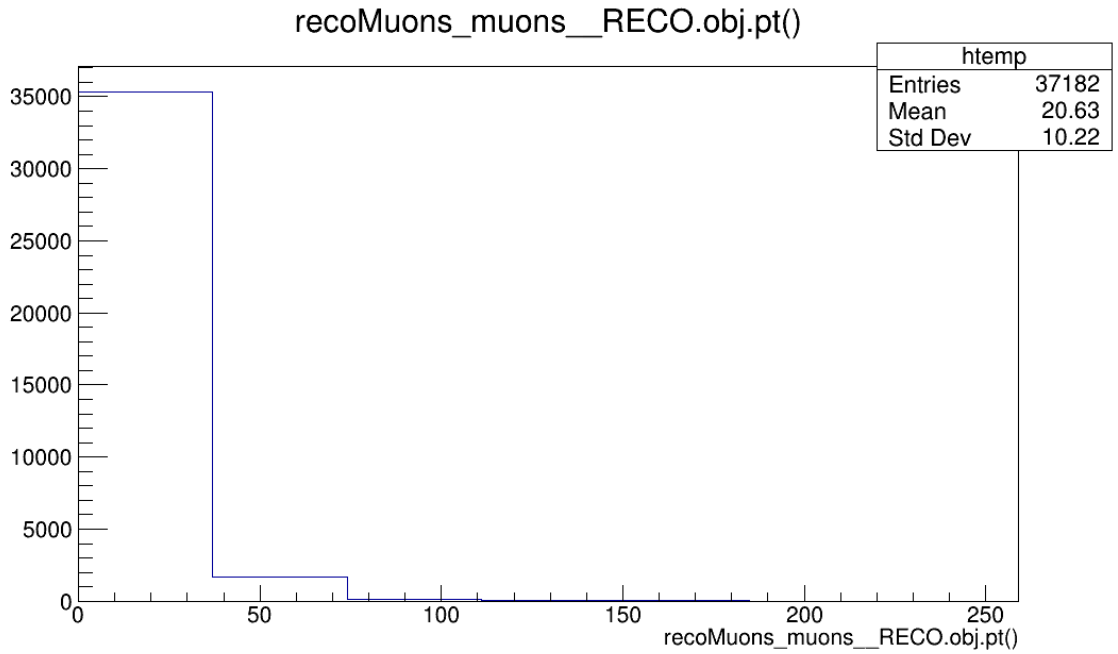
cross section : 6688.0 (equivalent lumi : 0.06817)

*see more information at backup slides

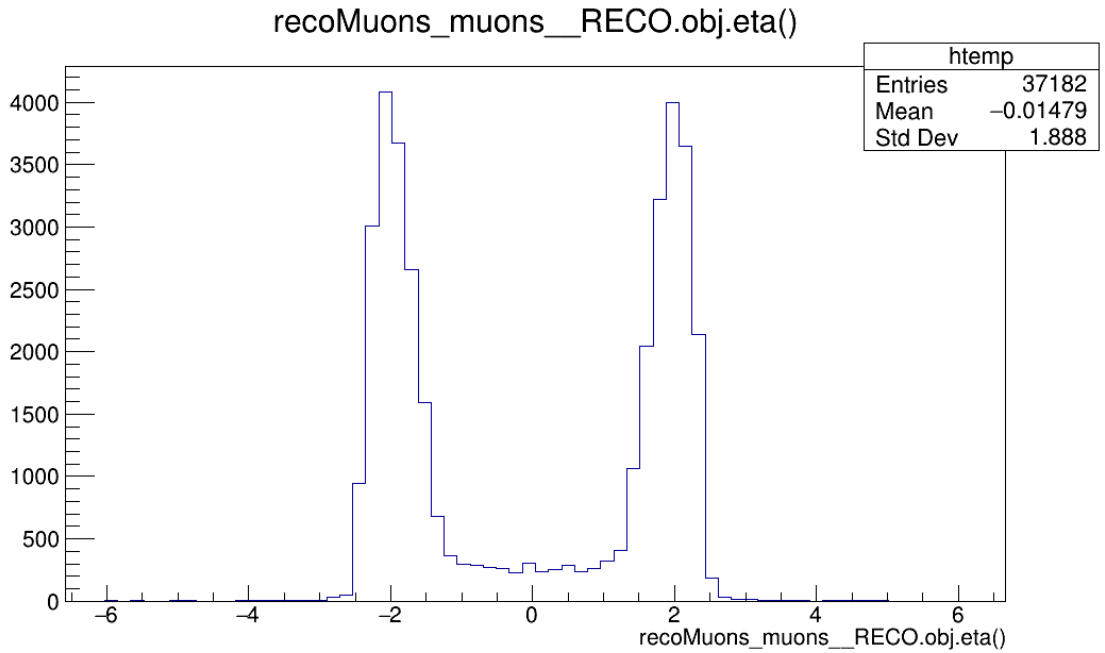
Reco MC / Data Info – muon multiplicity



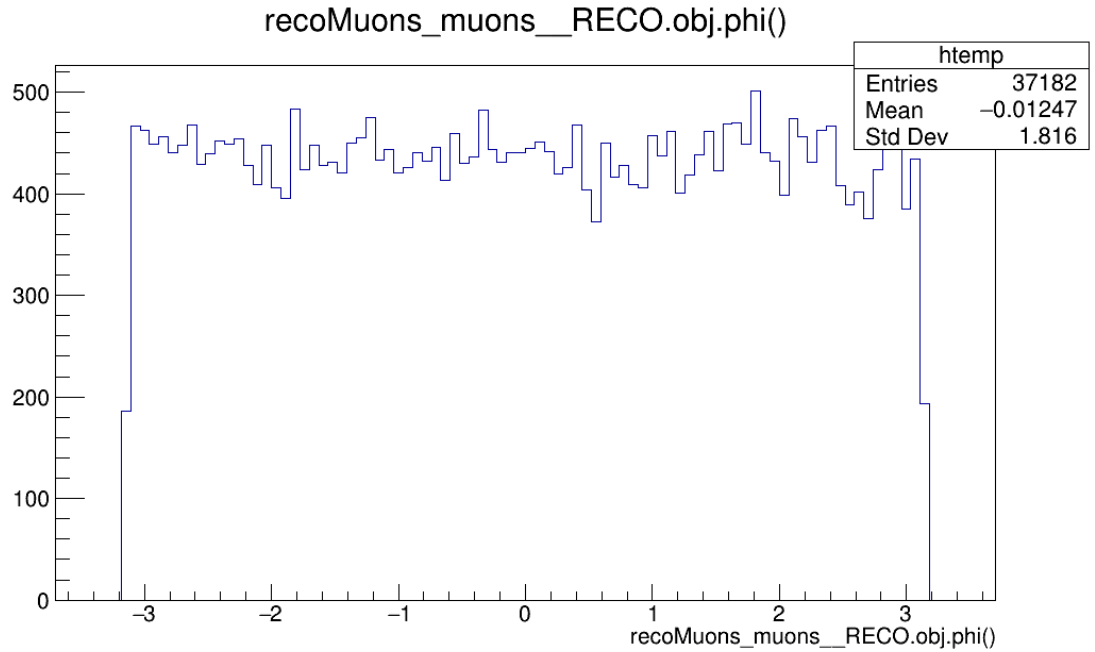
Reco MC / Data Info – muon pt



Reco MC / Data Info – muon eta



Reco MC / Data Info – muon phi



Reco MC / Data Info – muon Iso

Selection

HLT Trigger : HLT_IsoMu24_v

Muon selection

- $p_T > 24GeV \ + |\eta| < 2.4$
- Tight ID + Tight PF Isolation($Iso_{PF}^{Rel} < 0.15$, dR = 0.4)

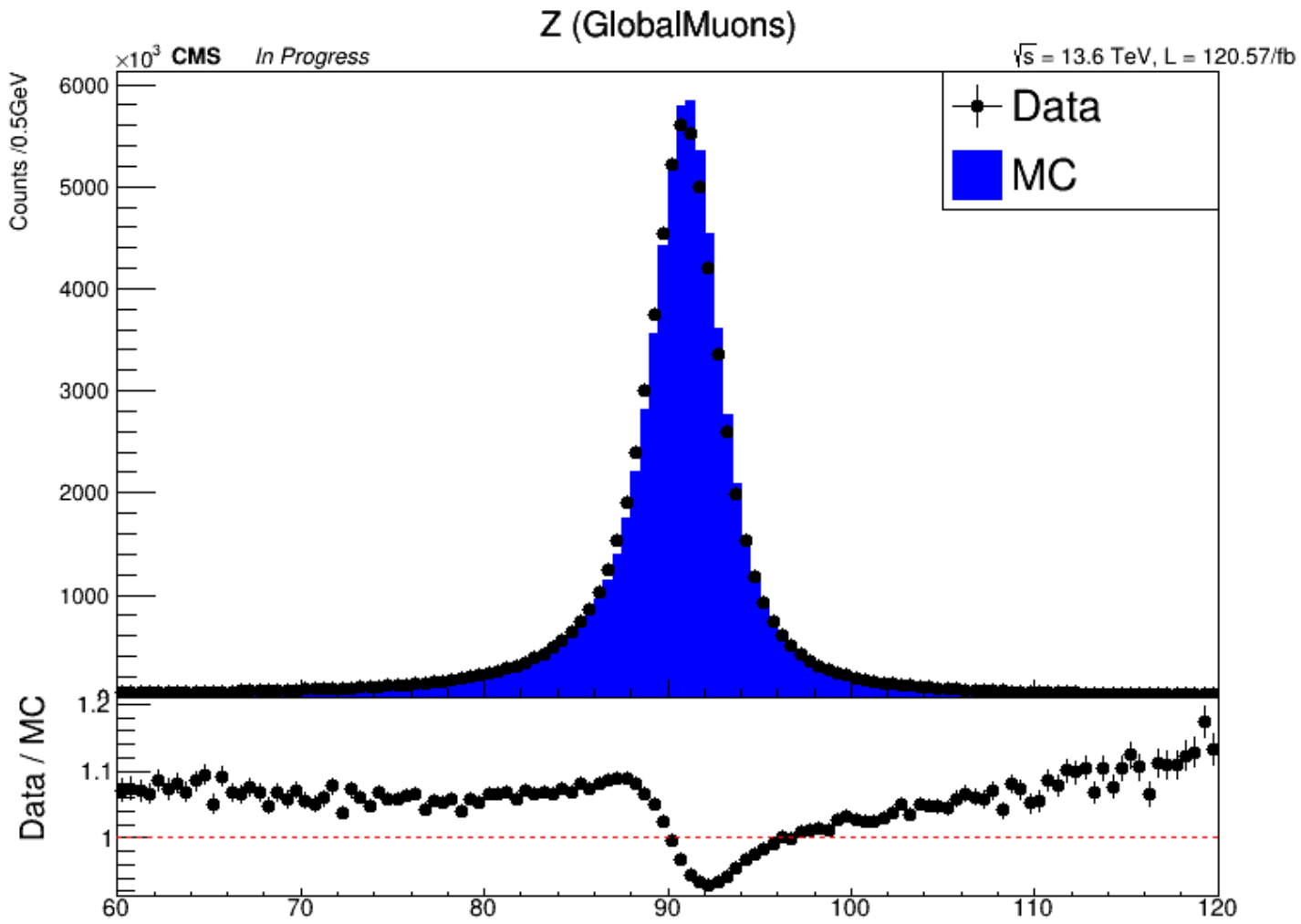
* $Iso_{PF}^{Rel} = [\sum_{\substack{charged \\ hadron}} p_T + max(0, \sum_{\substack{neutral \\ hadron}} E_T + \sum_{photon} E_T - 0.5 * \sum_{pileup} p_T)] / p_T^{\mu}$

Event selection

- select two muons with below condition
- $\left| dz_{\mu\mu} \right| < 0.5$
- opposite charge

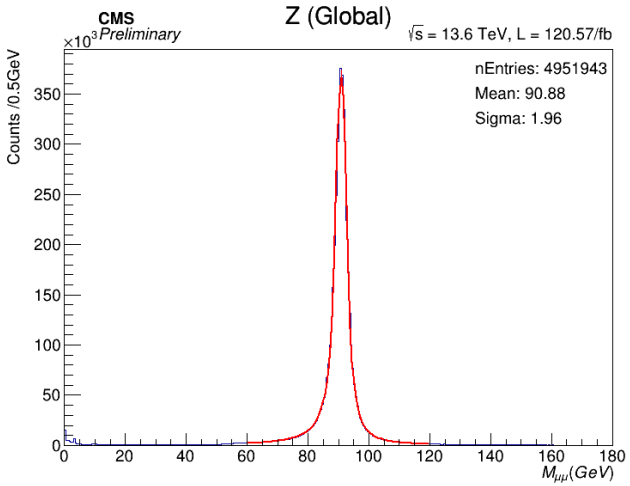
Z mass is reconstructed with a muon pair whose invariant mass is closest to 91.1876GeV

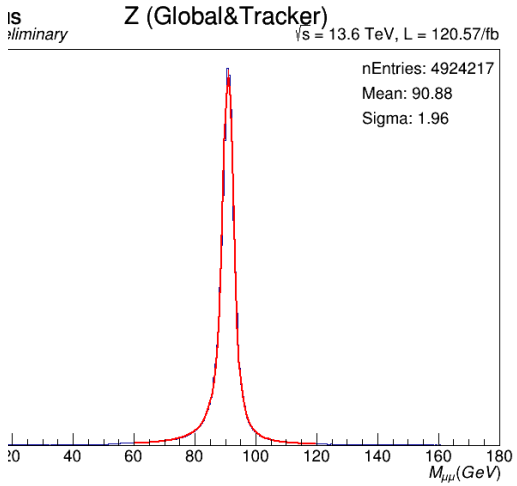
Result

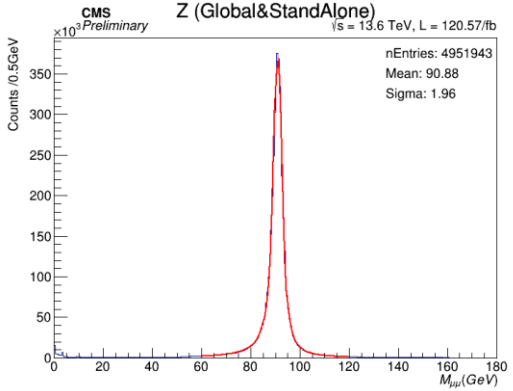

Z (GlobalMuons)
×10³ CMS In Progress
√s = 13.6 TeV, L = 120.57/fb
Data
MC
Counts /0.5GeV
6000
5000
4000
3000
2000
1000
Data / MC
1.2
1.1
1
60
70
80
90
100
110
120

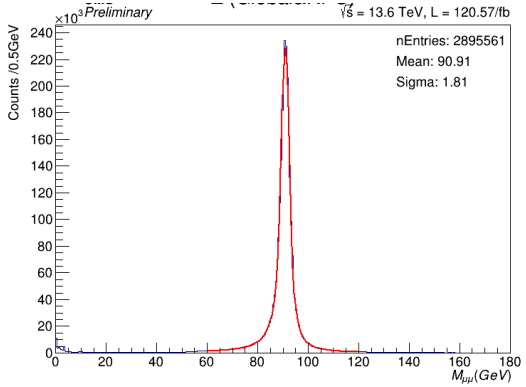
Back up

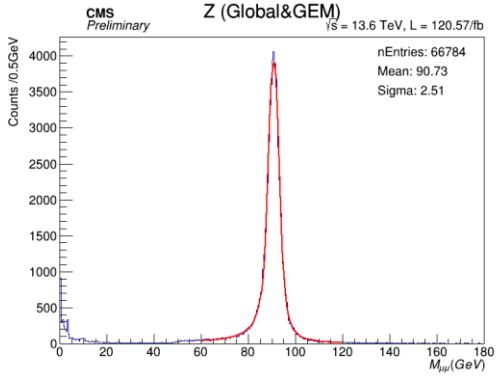
Z mass fitting

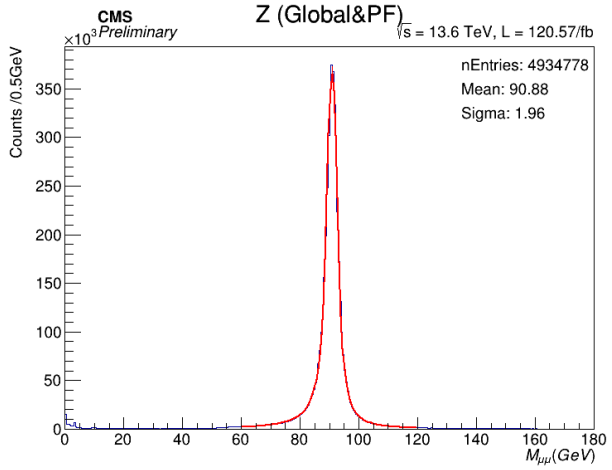






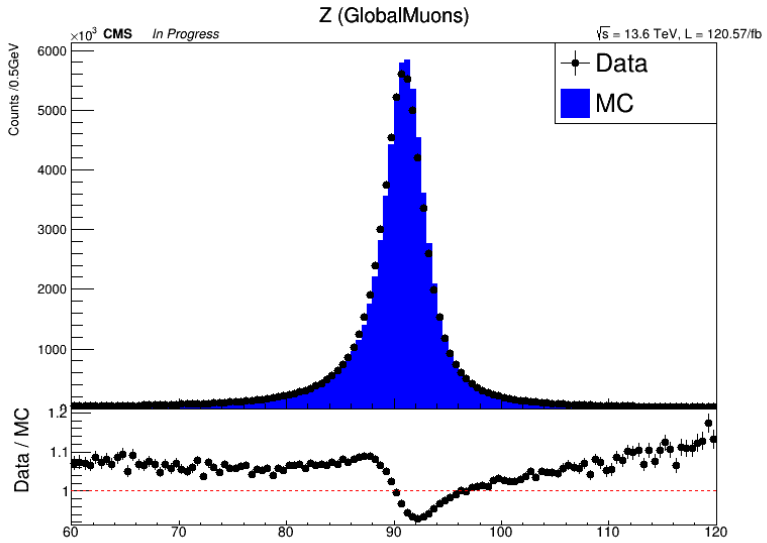


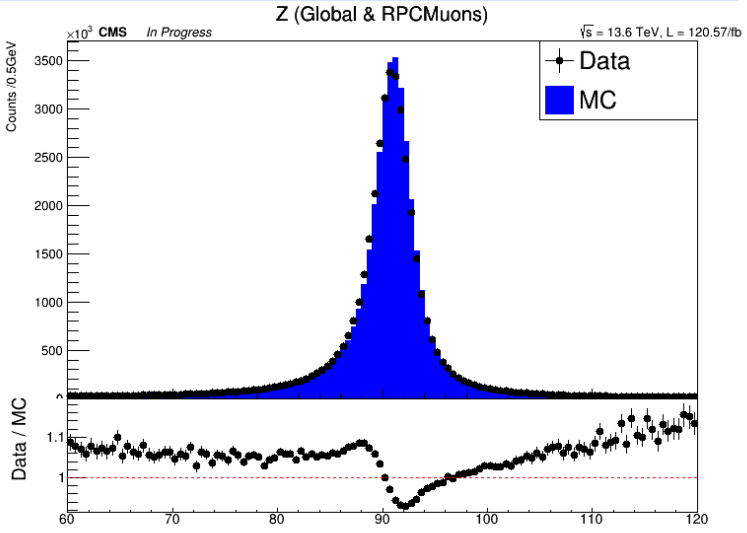


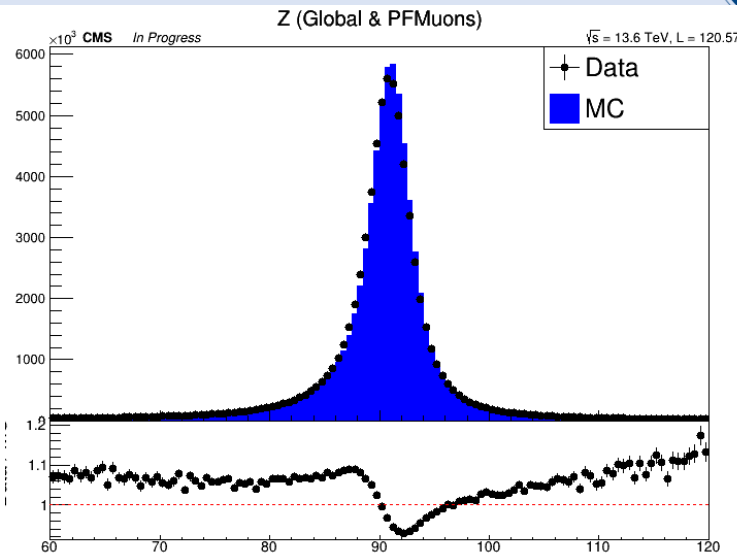


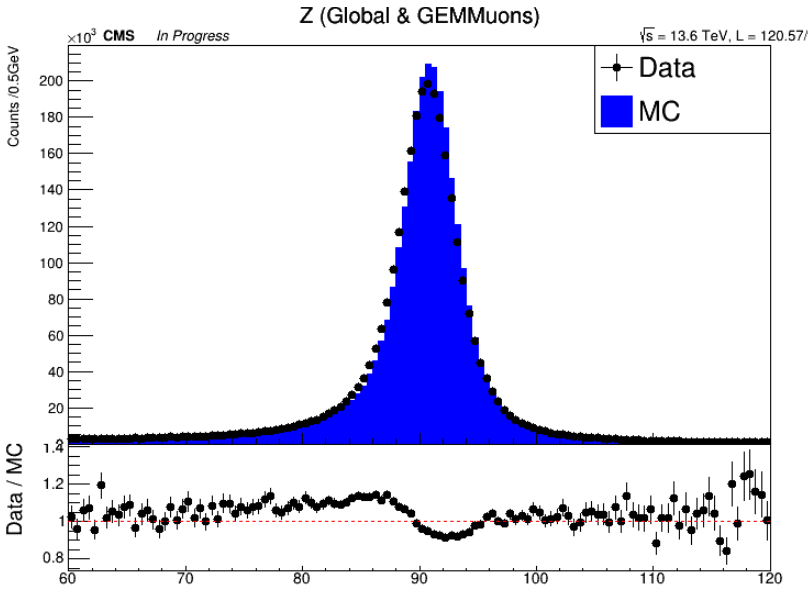
Data : /Muon/Run2022D-27Jun2023-v2/AOD, 13.6TeV, 3.0828 fb^{-1} , other data will be added soon

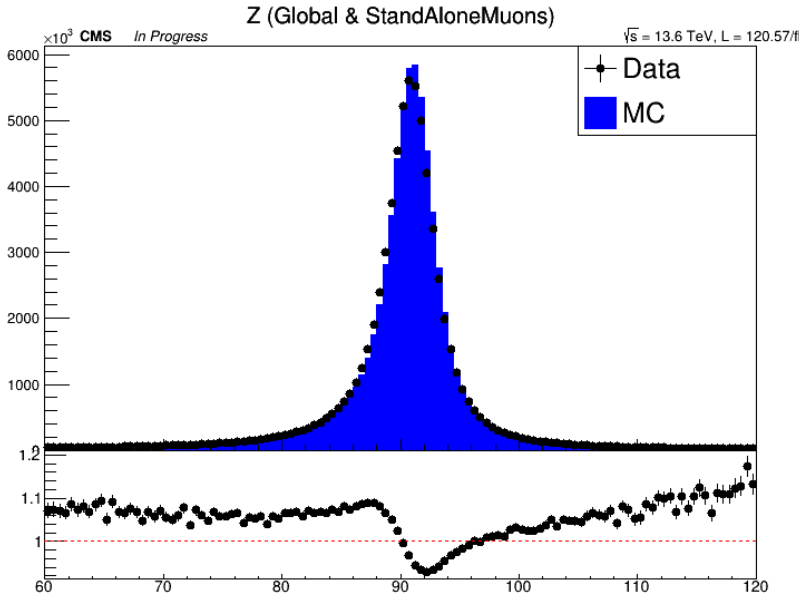
Data / MC

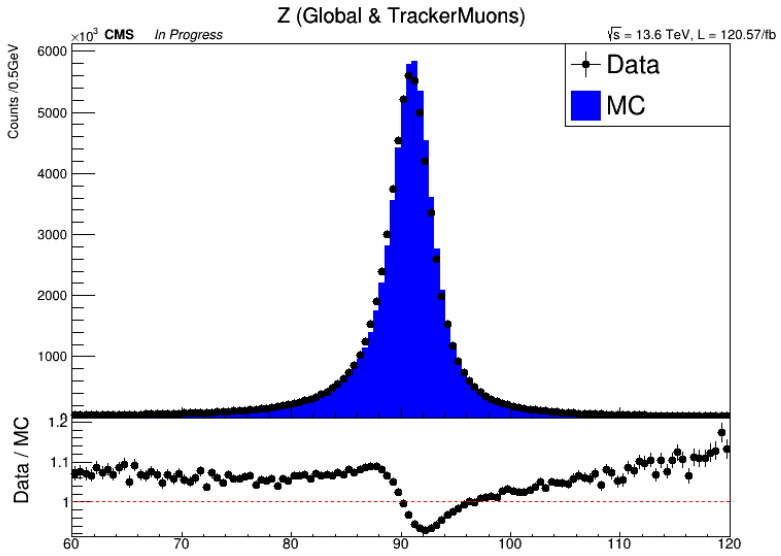

Z (GlobalMuons)
CMS In Progress
√s = 13.6 TeV, L = 120.57/fb
Data
MC
Counts /0.5GeV
Data / MC


Z (Global & RPCMuons)
CMS In Progress
√s = 13.6 TeV, L = 120.57/fb
Data
MC
Counts /0.5GeV
Data / MC


Z (Global & PFMuons)
CMS In Progress
√s = 13.6 TeV, L = 120.57/fb
Data
MC


Z (Global & GEMMuons)
CMS In Progress
√s = 13.6 TeV, L = 120.57/fb
Data
MC
Counts /0.5GeV
Data / MC


Z (Global & StandAloneMuons)
CMS In Progress
Data
MC


Z (Global & TrackerMuons)
CMS In Progress
√s = 13.6 TeV, L = 120.57/fb
Data
MC
Counts /0.5GeV
Data / MC

$dZ_{\mu\mu}$ histogram

Datasets

DATA(2022)	Delivered by LHC(fb^{-1})	Recorded by CMS(fb^{-1})	Golden JSON(fb^{-1})
/Muon/Run2022C-27Jun2023-v1/AOD	7.0067	6.3777	5.0104
/Muon/Run2022D-27Jun2023-v2/AOD	3.8044	3.3773	2.9700
/Muon/Run2022E-27Jun2023-v1/AOD	6.7495	6.2649	5.8070
/Muon/Run2022F-PromptReco-v1/AOD	20.1584	18.6049	17.7819
/Muon/Run2022G-PromptReco-v1/AOD	3.6185	3.2748	3.0828
total	41.3375	37.8996	**34.6521**

DATA(2023)	Delivered by LHC(fb^{-1})	Recorded by CMS(fb^{-1})	Golden JSON(fb^{-1})
/Muon*/Run2023B-PromptReco-v1/AOD	1.267	1.134	0.617
/Muon*/Run2023C-PromptReco-v4/AOD	20.064	18.466	17.794
/Muon*/Run2023D-PromptReco-v2/AOD	10.761	9.897	9.451
total	32.094	29.504	**27.862**

DATA(2024)	Delivered by LHC(fb^{-1})	Recorded by CMS(fb^{-1})	Golden JSON(fb^{-1})
/Muon*/Run2024B-PromptReco-v1/AOD	0.742	0.656	0.13
/Muon*/Run2024C-PromptReco-v1/AOD	7.95	7.434	7.238
/Muon*/Run2024D-PromptReco-v1/AOD	8.899	8.301	7.957
/Muon*/Run2024E-PromptReco-v2/AOD	12.899	11.92	11.319
/Muon*/Run2024F-PromptReco-v1/AOD	30.786	28.433	25.79
/Muon*/Run2024G-PromptReco-v1/AOD	5.988	5.484	5.477
total	66.29	61.42	**58.06**

$\sqrt{s} = 13.6\ TeV$

Total luminosity with Golden JSON : **120.5741 fb^{-1}**

lumimasks

Cert_Collisions2022_355100_362760_Golden.json

Cert_Collisions2023_366442_370790_Golden.json

Cert_Collisions2024_378981_385194_Golden.json

MC Simulation

/DYJetsToLL_M-50_TuneCP5_13p6TeV-madgraphMLM-pythia8/Run3Summer22DRPremix-124X_mcRun3_2022_realistic_v12-v2/AODSIM

cross section : 6688.0 (equivalent lumi : 0.06817)

Muon Tight ID