



High mass DY differential cross-section measurement with full Run2 data: neutral and charged DY

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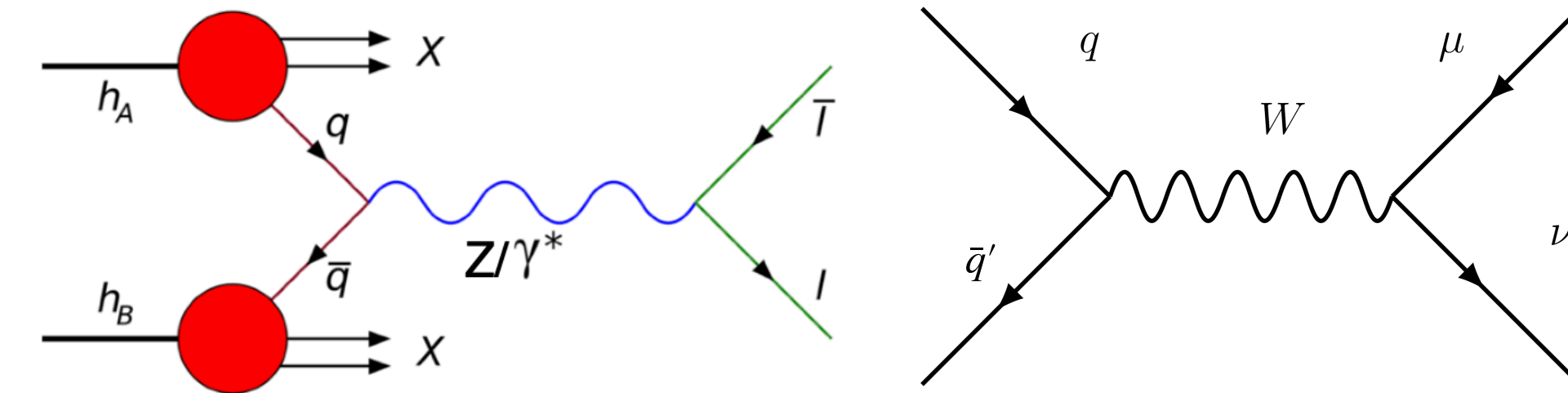
Nov 5, 2025

DY and TMD Workshop

Introduction

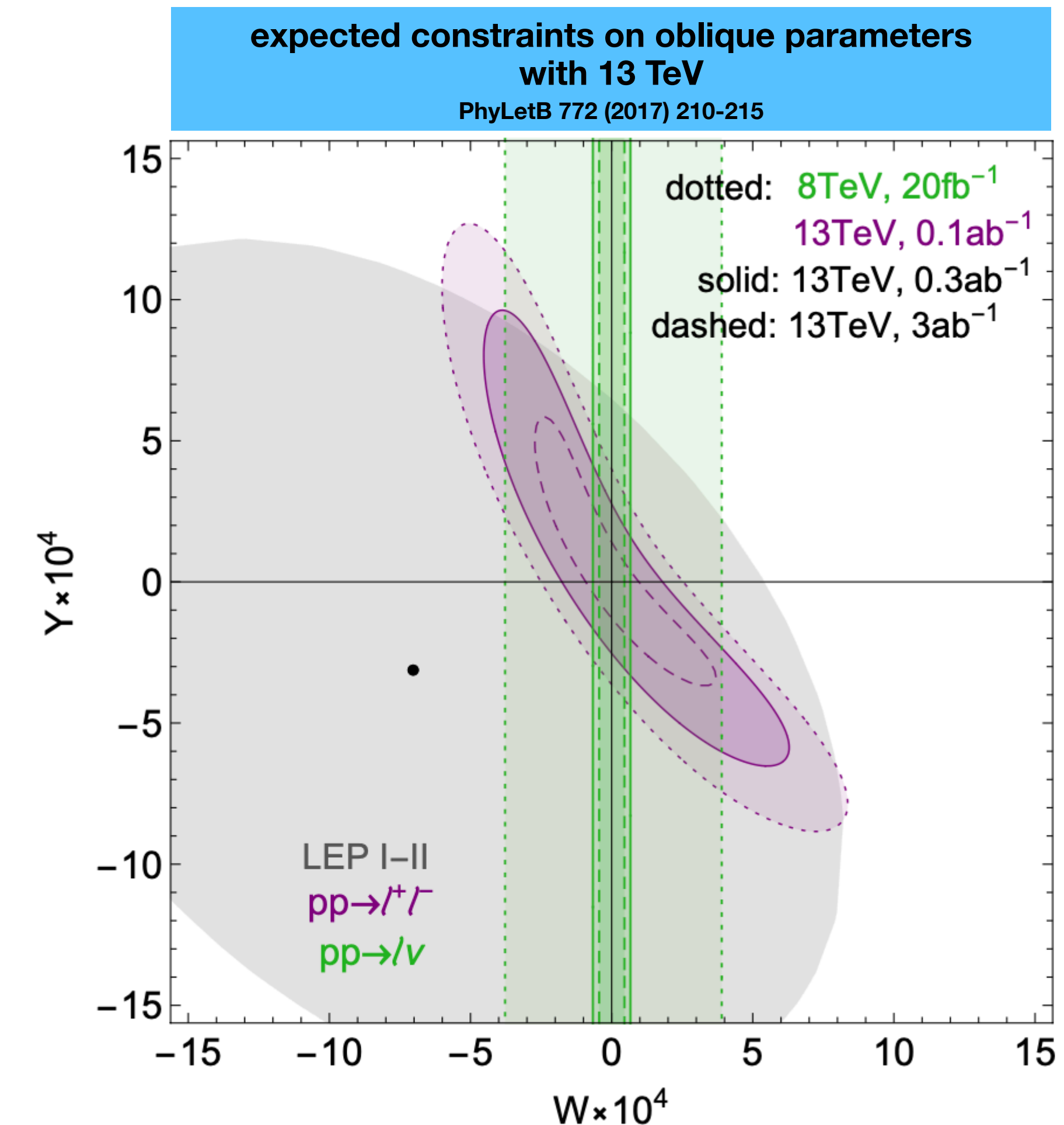
Charged and neutral Drell-Yan process

- Charged DY: process with lepton and neutrino pair produced via W exchange
- Neutral DY: process with 2 lepton final state produced via γ^*/Z exchange
- Previous reports @ SMP-V: [Jul 29 2025](#), [Feb 25 2025](#)



Motivation

- Providing tight constraints to theory
 - Tighter constraints on oblique parameter (W & Y) [\[1\]](#)
- Constraints PDFs on high- x regime
 - PDFs high- x regime is less constrained by existing data
 - Precision measurement on high mass tail provide **direct access to the high- x valence quark PDFs**
 - (Neutral DY only) With different jet multiplicity at high- x , different parton informations can be obtained
 - 0-jet:** quark and anti-quark, **1-jet:** gluon, **2-jets:** gluon, sea quarks
- Providing advantages to BSM physics searches
 - Indirect search for BSM by observing the differences with SM DY
 - Enhance the sensitivity to new physics
 - by reducing background uncertainties for BSM searches

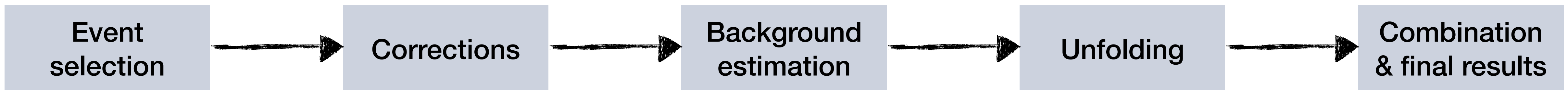


Analysis details

● Analysis goal

- **Measure DY differential cross section @ high mass ($M > 200$ GeV) with full Run2 data**
 - **Neutral DY:** measure $d\sigma/dm_{ll}$ w.r.t jet multiplicity (0 jet, 1 jet and more than 1 jet)
 - **Charged DY:** measure $d\sigma/dm_T$

● Analysis strategy (Both neutral and charged DY study with muon channel is on-going, **electron channel will be added**)



▸ High-pT single-muon trigger with

- high-pT muon ID
- tracker based isolation

▸ Data-driven method

- **Neutral:** emu method & SS
- **Charged:** ABCD

▸ High-pT dedicated corrections

- Efficiency scale factor
- Momentum scaling & smearing

▸ Considering two options

- conventional unfolding
- ML based unfolding
[Deep Dive: Unfolding on Jun 2024](#)

Neutral DY

Analysis contact: Kyuyeong Hwang (khwang@cern.ch)

Dataset and MC

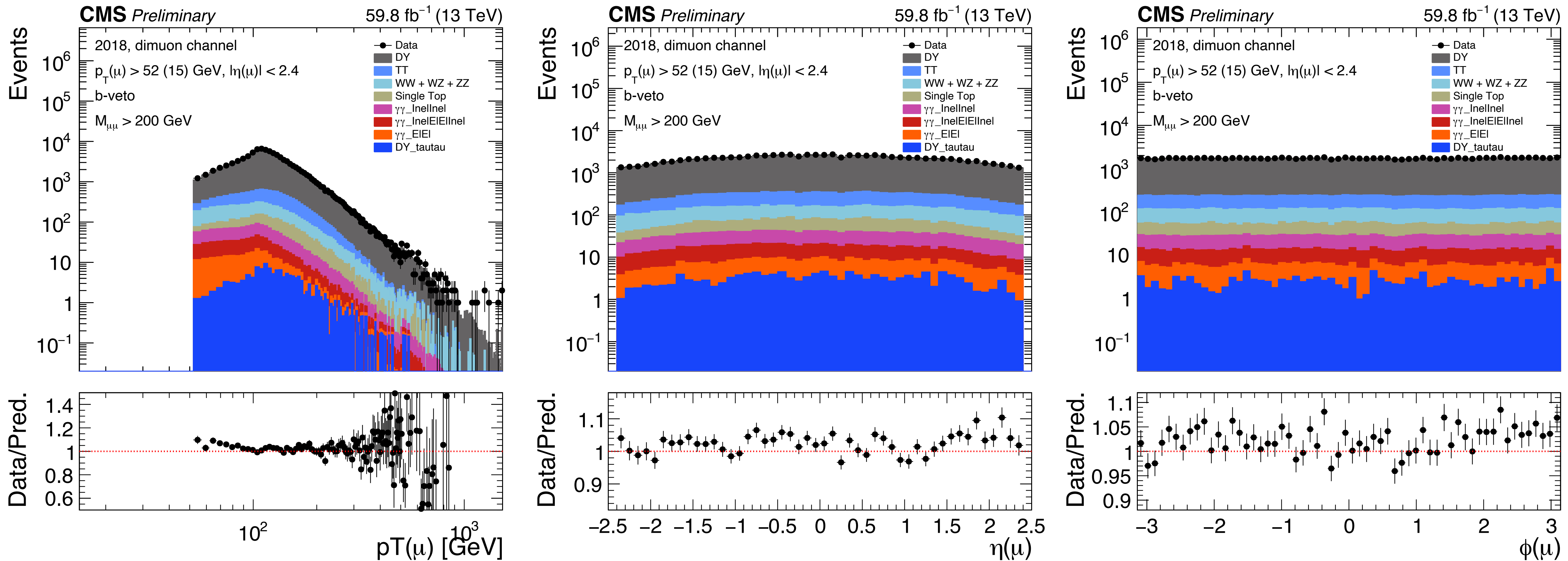
- 2018 (other eras on backup)
 - All used data and MC is based on NanoAODv9
 - Reference: **SMP-24-004 (previous presentation)**

2018	DAS name	QCD order
Data	/SingleMuon/Run2018A-UL2018_MiniAODv2_NanoAODv9-v2/NANOAOD /SingleMuon/Run2018B-UL2018_MiniAODv2_NanoAODv9-v2/NANOAOD /SingleMuon/Run2018C-UL2018_MiniAODv2_NanoAODv9-v2/NANOAOD /SingleMuon/Run2018D-UL2018_MiniAODv2_NanoAODv9-v1/NANOAOD	
DYJetsToMuMu	/DYJetsToMuMu_M-50_massWgtFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext1-v2/NANOAODSIM /DYJetsToMuMu_M-100to200_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-200to400_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-400to500_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-500to700_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-700to800_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-800to1000_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-1000to1500_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-1500to2000_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-2000toInf_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM	NNLO powhegMiNNLO +pythia8
DYJetsToTauTau	/DYJetsToTauTau_M-50_AtLeastOneEorMuDecay_massWgtFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM	NNLO powhegMiNNLO +pythia8
TTTo2L2Nu	/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM	NLO powheg +pythia8
Single Top	/ST_s-channel_4f_leptonDecays_TuneCP5_13TeV-amcatnlo-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM /ST_t-channel_top_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM /ST_t-channel_antitop_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM /ST_tW_top_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /ST_tW_antitop_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM	NLO powheg(or aMC@NLO) +pythia8
WZ	/WZ_TuneCP5_13TeV-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM	NLO pythia8
WW	/WWTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM	NLO powheg +pythia8
ZZ	/ZZ_TuneCP5_13TeV-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM	NLO pythia8

Data vs. MC: control plot @ high mass

2018, b-veto (other eras on backup)

Leading muon distribution

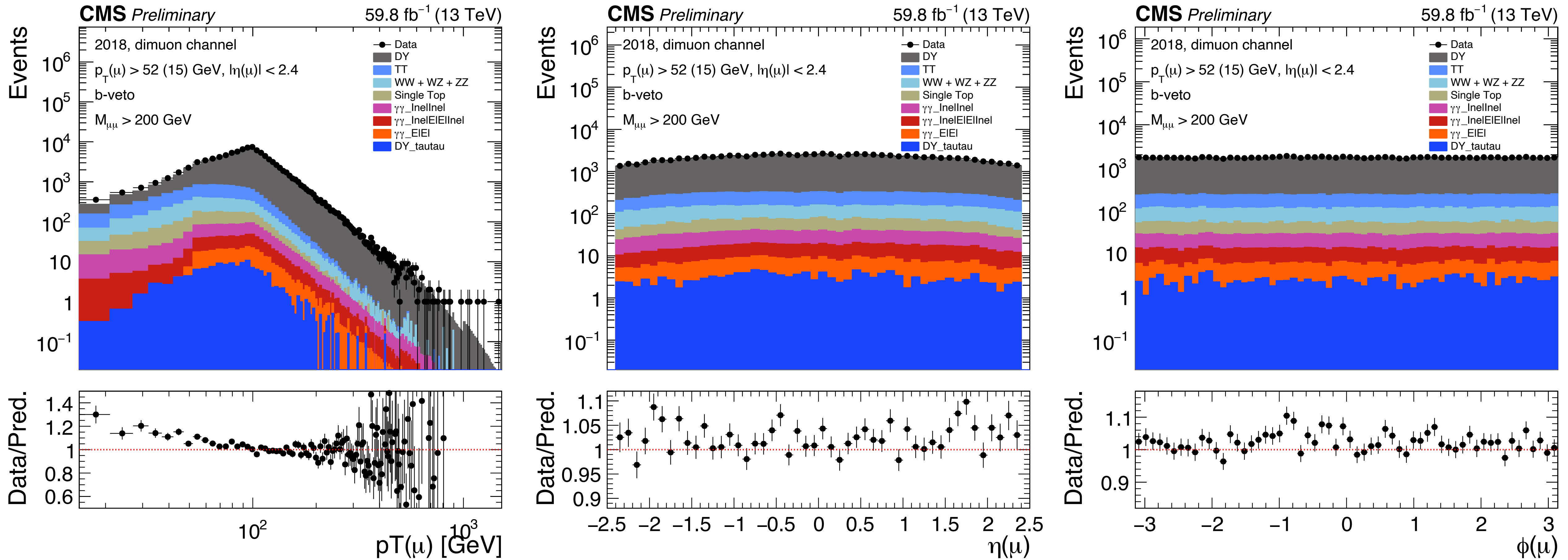


⌘ CAVEAT: results in this slide are inclusive in jets

Data vs. MC: control plot @ high mass

2018, b-veto (other eras on backup)

Sub-leading muon distribution

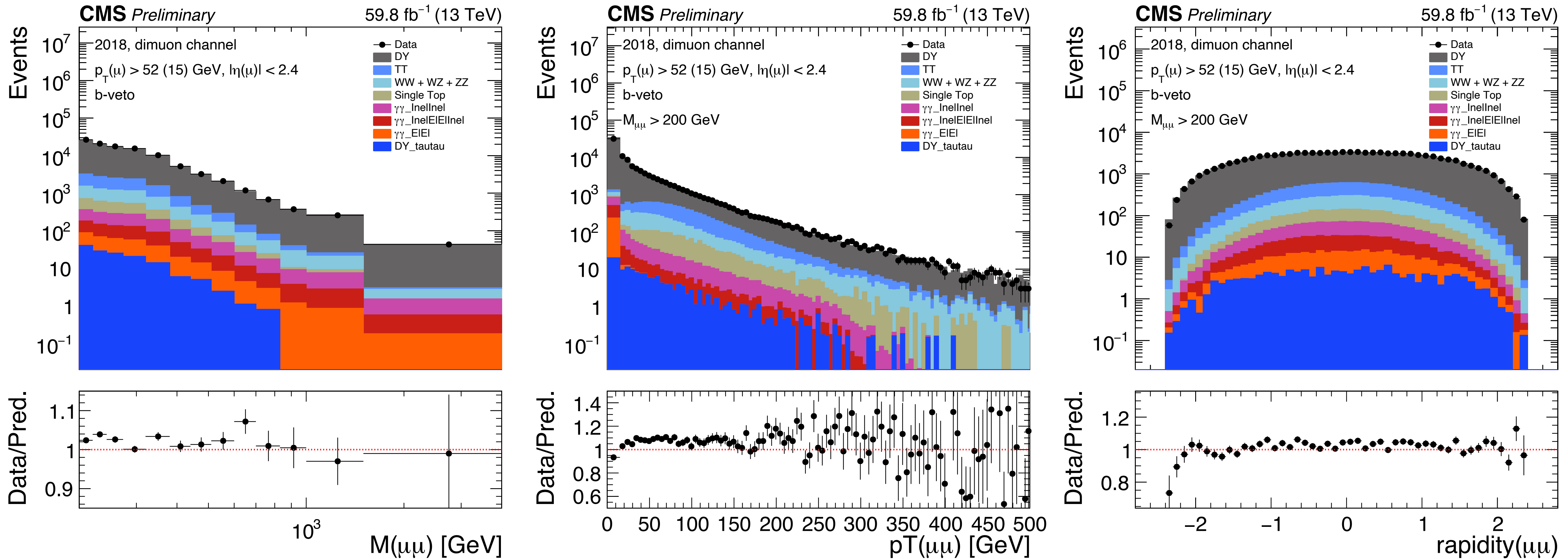


⌘ CAVEAT: results in this slide are inclusive in jets

Data vs. MC: control plot @ high mass

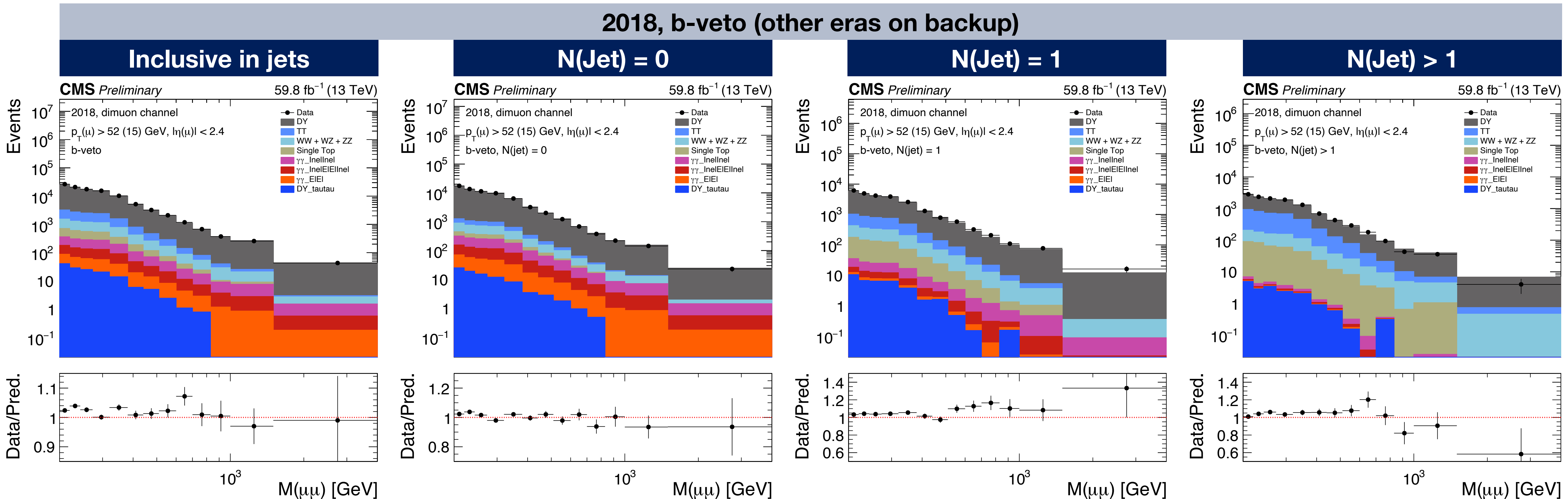
2018, b-veto (other eras on backup)

Di-muon distribution



⌘ CAVEAT: results in this slide are inclusive in jets

Data vs. MC: control plot @ high mass



Dimuon mass distributions w.r.t jet multiplicity

- ▶ have good agreement up to 1 TeV,
- ▶ From 1 to 4 TeV, data to MC ratio agreed within statistical uncertainty
- ▶ **CAVEAT: mass binning will be updated**

Next step

◎ Background estimation: data-driven method

- **Bkg with fixed branch ratio** like TTbar, single top (and possibly EW process, under consideration): **emu method, WIP**
 - emu to mumu conversion factor will be measured from MC, bkg will be estimated from the data
- **Fake background:** same-sign method
 - SS to OS conversion factor will be measured from MC, bkg will be estimated from the data

◎ Adding dielectron channel

- **At very early stage, study on event selection and corrections on-going**

Charged DY

Analysis contact: Sungwon Kim (sungwon.kim@cern.ch)

Current status

◎ Event selection and corrections are finalized

▸ Dataset & MC:

- Full Run2 single muon dataset
- $W \rightarrow l\nu$ (inclusive, HT binned and mass-binned) as signal MC and TTbar, single top, DY $\rightarrow$ tautau/ $\mu\mu$, EW process as background MC

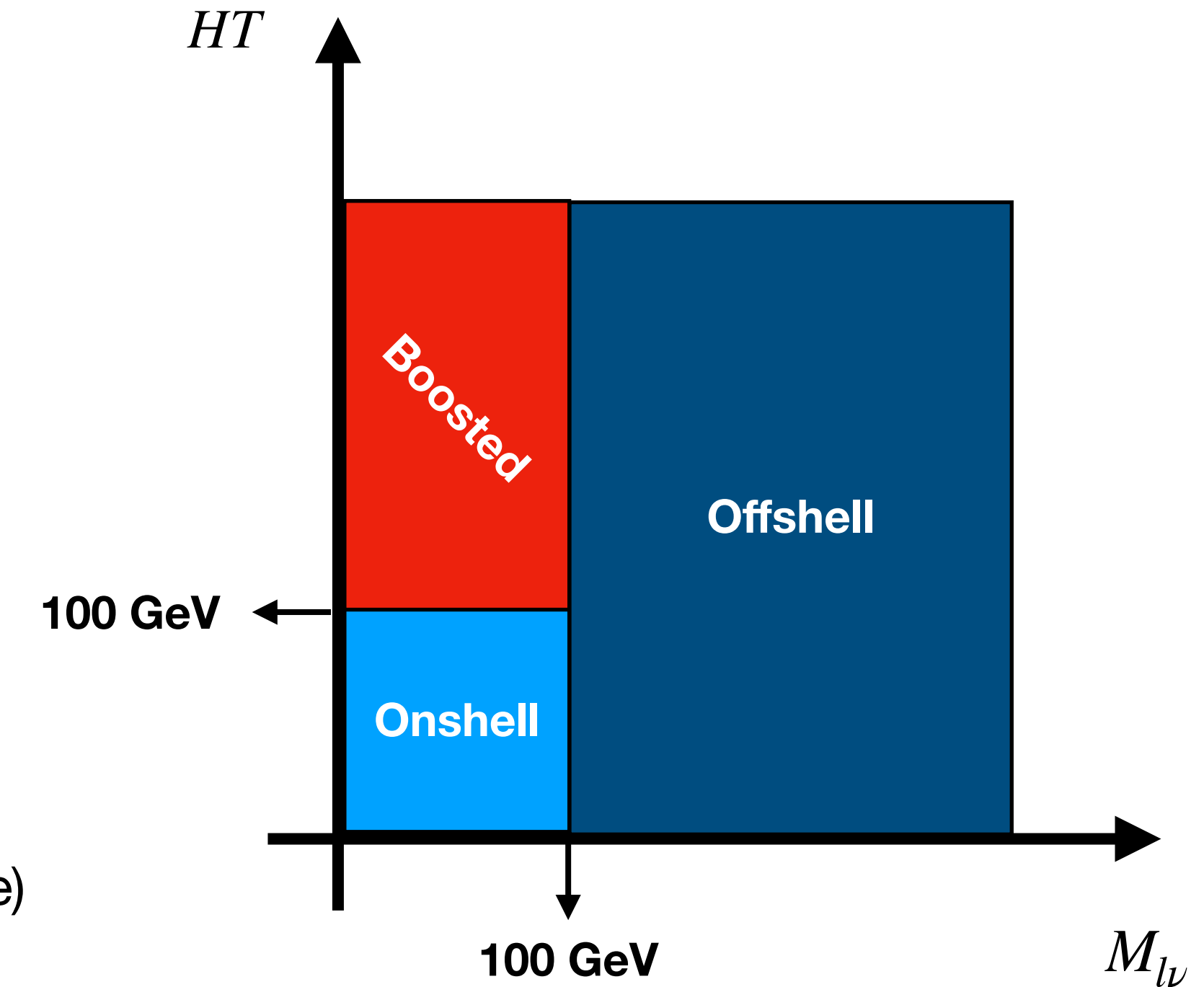
▸ Event selection:

- passing **non-isolated muon trigger**
- requiring **one muon** with **pT > 53 GeV** and passing **high-pT muon ID** and **tracker based isolation**
- **Second lepton veto** is applied with pT > 10 GeV and LooseID (see [backup](#) for details)
- Using PUPPI MET (see [backup](#) for details)

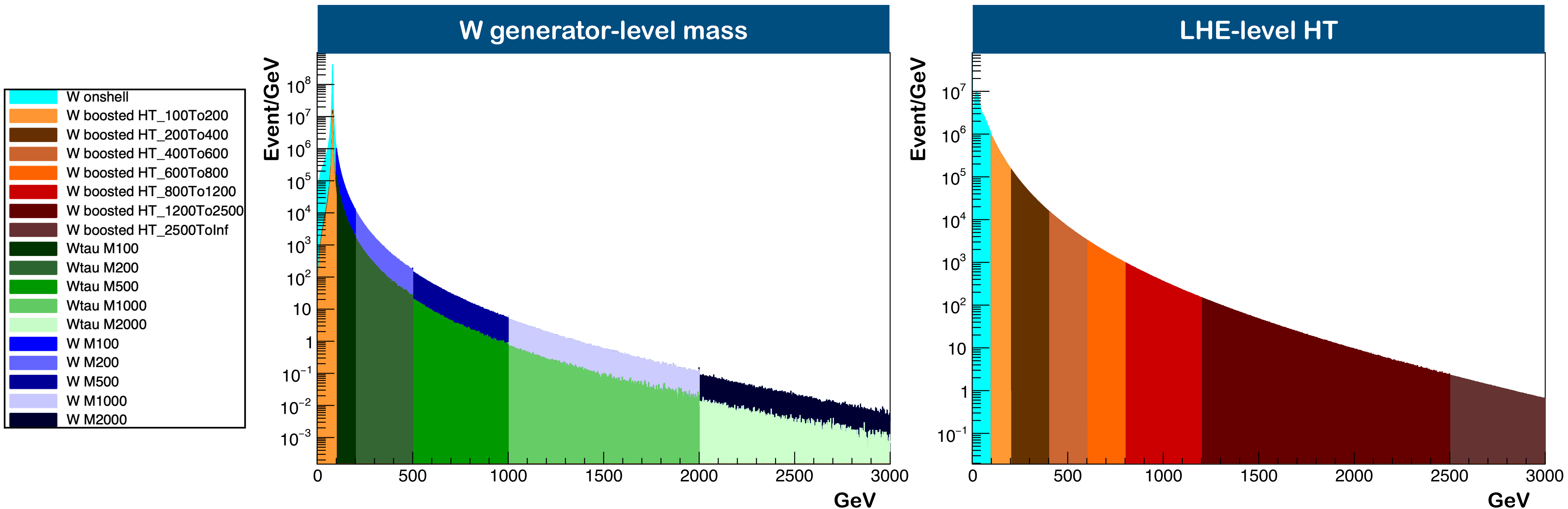
▸ Corrections: basic corrections are applied (L1 pre-firing weight, PU re-weighting and etc.)

- **High-pT muon dedicated corrections** are applied
 - Efficiency scale factors and muon momentum corrections

- Various W samples are merged to **fully cover the wide M_T range** with enough statistics
- Following study from **Run2 W' analysis** ([CADI](#), [JHEP](#))
- Procedure for merging W samples
 - Onshell sample merging
 - Select $M_{l\nu} < 100$ GeV events at generator-level
 - Using the LHE-level HT for event selection
 - $HT < 100$ GeV: **onshell inclusive sample**
 - $HT > 100$ GeV: **onshell boosted sample**
 - Offshell sample merging
 - Merge **high mass binned offshell samples**
 - Apply proper $M_{l\nu}$ cuts for smooth continuity in generator-level mass spectrum
(ex. M-100 + M-200: Select events with $100 \text{ GeV} < M_{l\nu} < 200 \text{ GeV}$ to patch with M-200 sample)
- Apply muon filtering
 - Select events with muon in final state for samples used in patching
- **Higher order cross section normalization**
 - **Both offshell and boosted W samples** are normalized to **NNLO QCD** and **NLO EWK** cross sections, provided by [W' group](#) and [dark matter group](#)



Sample	W mass cut	HT cut	Selected decay channel	k-factor
Onshell inclusive $W \rightarrow l\nu$	$M_{l\nu} < 100 \text{ GeV}$	$HT < 100 \text{ GeV}$	$W \rightarrow \mu\nu, W \rightarrow \tau\nu_\tau \rightarrow \mu\nu_\mu\nu_\tau\nu_\tau$	NNLO (QCD) + NLO (EWK)
Onshell HT-binned $W \rightarrow l\nu$ (divided in 7 samples)		$HT > 100 \text{ GeV}$		NNLO (QCD) + NLO (EWK)
Offshell M(W)-binned ($W \rightarrow \mu\nu$ or $W \rightarrow \tau\nu$, divided in 5 samples)	$M_{l\nu} > 100 \text{ GeV}$	Any HT		NNLO (QCD) + NLO (EWK)

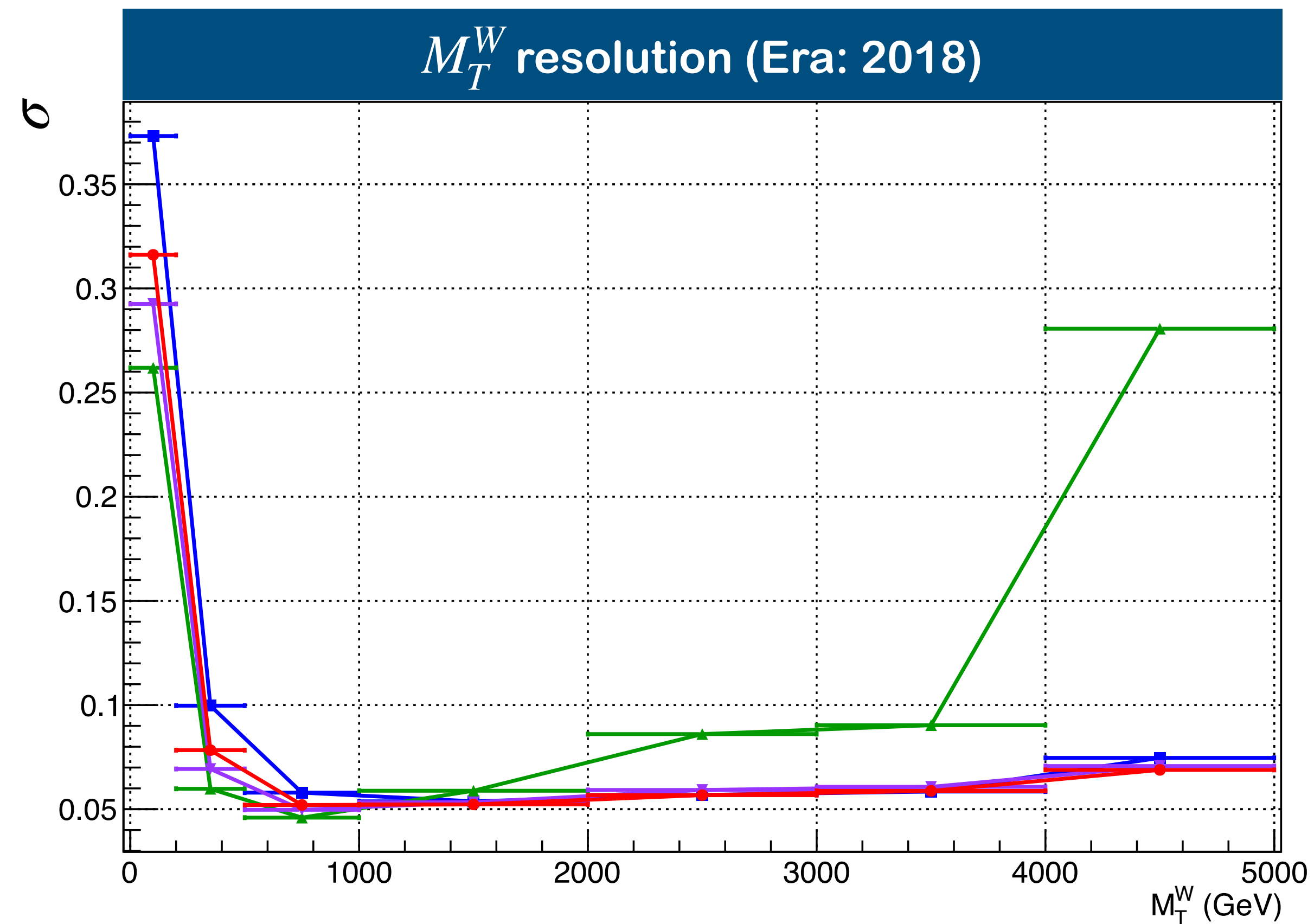
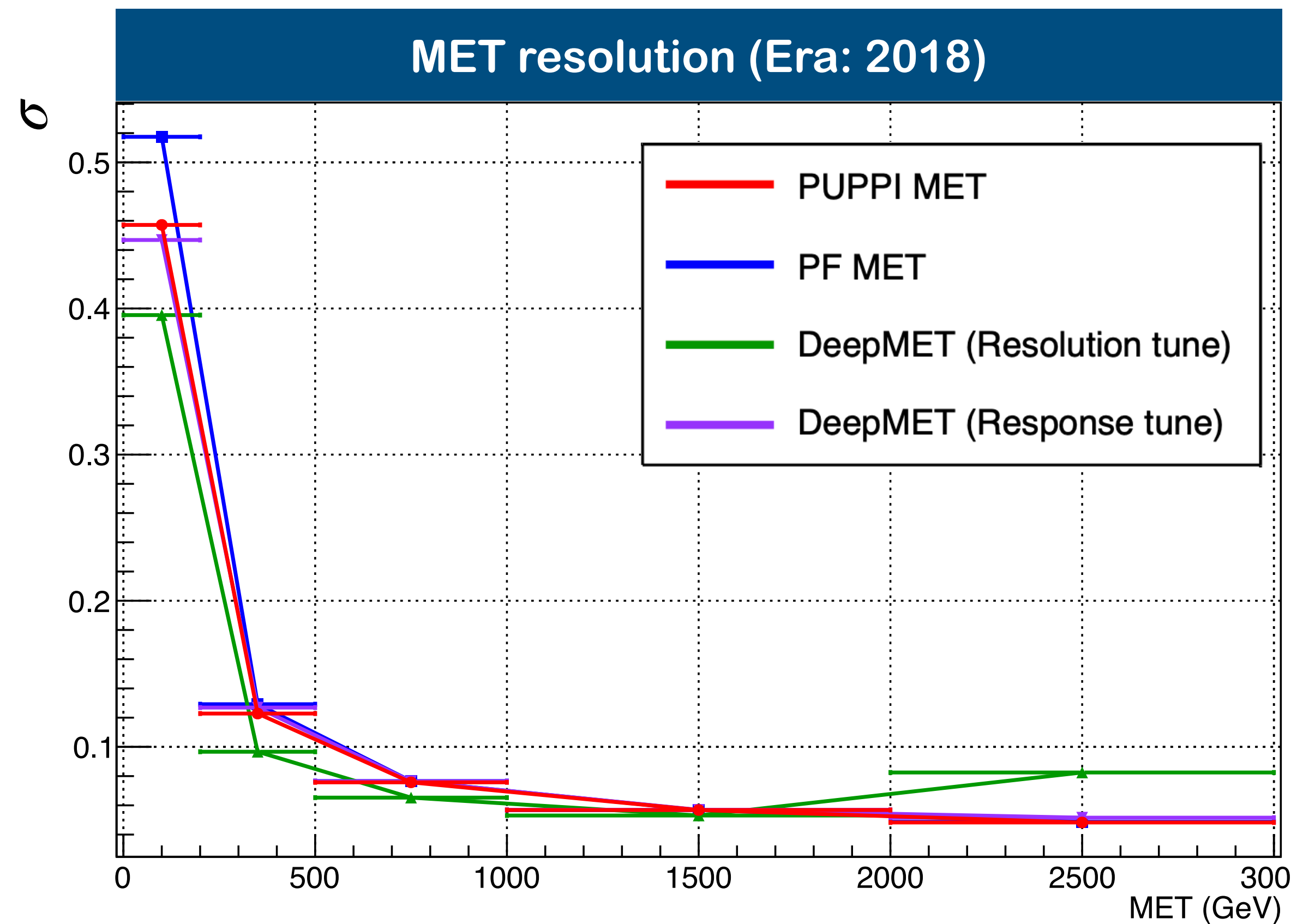


- **4 different samples smoothly patched** over generator level W mass distribution
 - Checked the smoothness by zooming in each patched area (with 1 GeV binning)
- Also checked the **LHE-level HT distribution** is also well patched after applying **k factor** to boosted W samples

Event, object selection and filter

	2016	2017	2018	List of Noise Filters
Trigger	Mu50 TkMu50	Mu50 TkMu100 OldMu100		Primary vertex filter
Muon requirement	Require single highPt muon			Beam halo filter
	High p_T Muon: TuneP $p_T > 53$ GeV && Global highPt ID && TkRelIso < 0.1 && highPurity && $ \eta < 2.4$			HBHE noise filter
Noise filter	No ecalBadCalibFilter	Use all recommended filter		HBHEIso noise filter
Loose lepton veto	Veto event with additional loose muon or electron			ECAL TP filter
	Loose Muon: TuneP $p_T > 10$ GeV && LooseID && $ \eta < 2.4$			Bad PF Muon filter
	Loose Electron: TuneP $p_T > 10$ GeV && LooseID && $ \eta < 2.5$ excluding ECAL gap			Bad PF Muon Dz filter
W MT	Require W transverse mass > 200 GeV			HF noisy hits filter
				ee badSC noise filter
				ECAL bad calibration filter update

MET and M_T^W resolution comparison between 4 MET algorithms

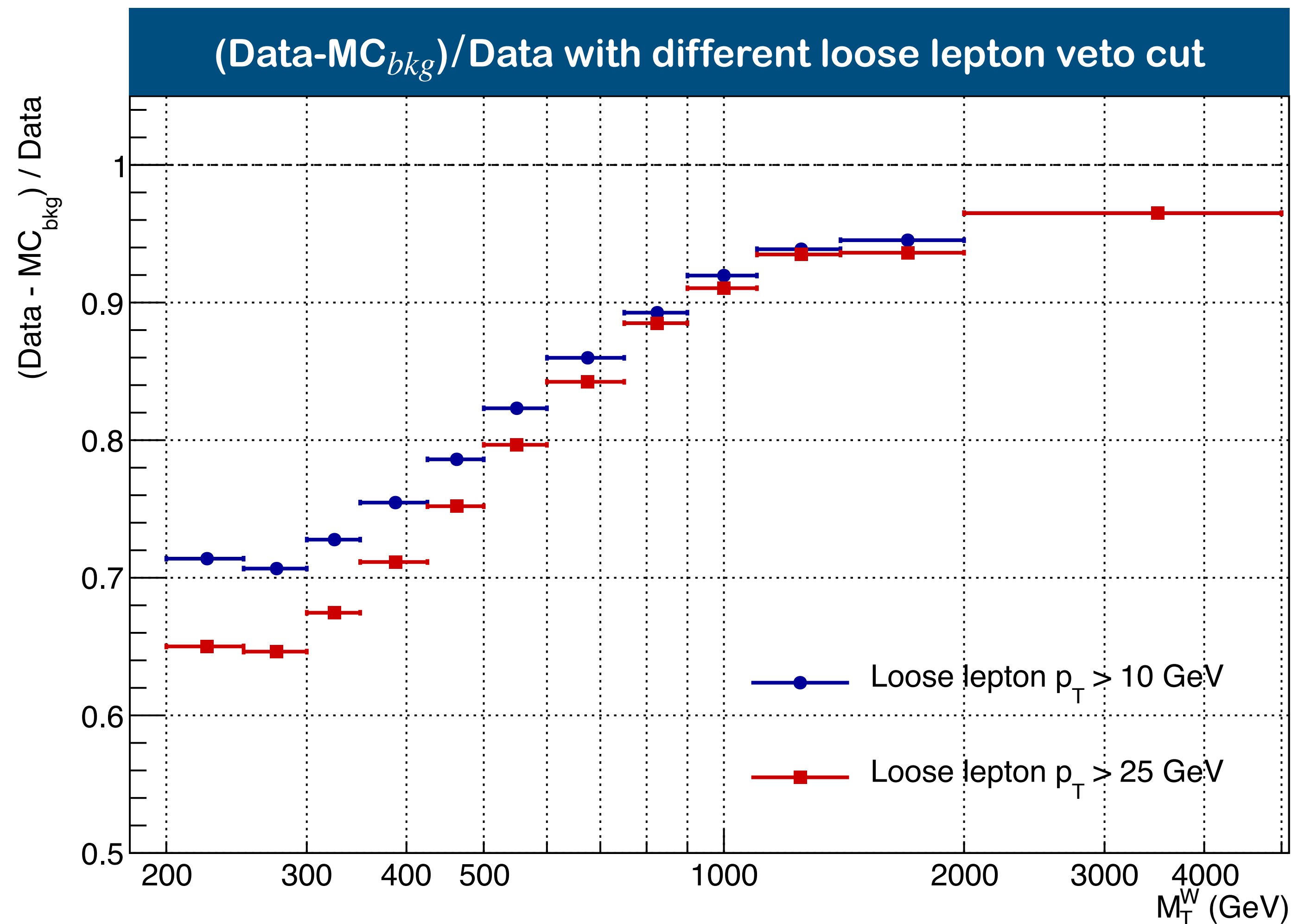


- Checked **sigma value of each MET type** as a function of MET (M_T^W) bins
- DeepMET(reso. tune) shows good resolution for MET up to 2 TeV, while **PUPPI MET shows best M_T^W resolution** for high M_T^W region (over 1 TeV)
- Since our main observable is M_T^W , decided to use **PUPPI MET**

2018

59.83 fb^{-1}

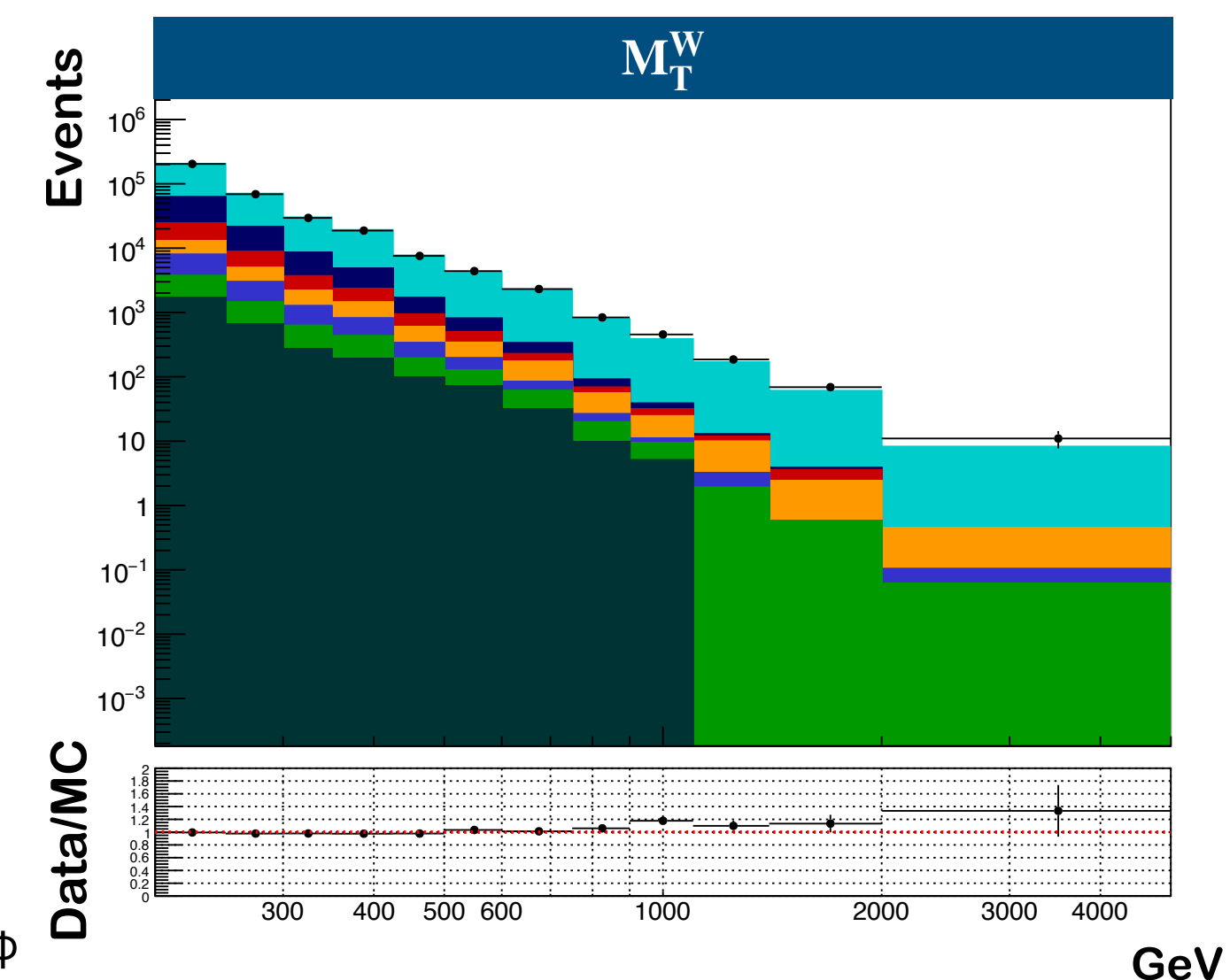
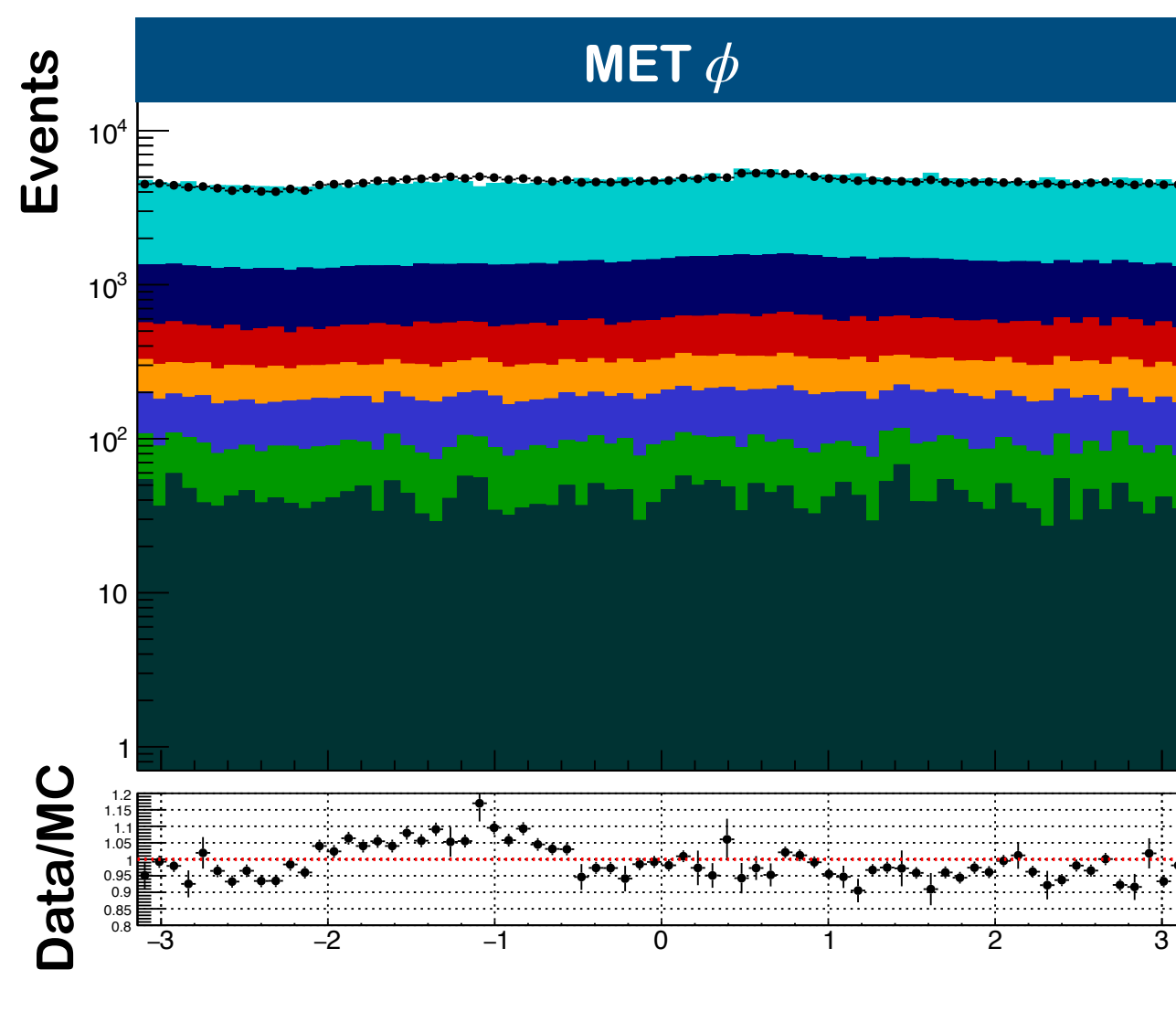
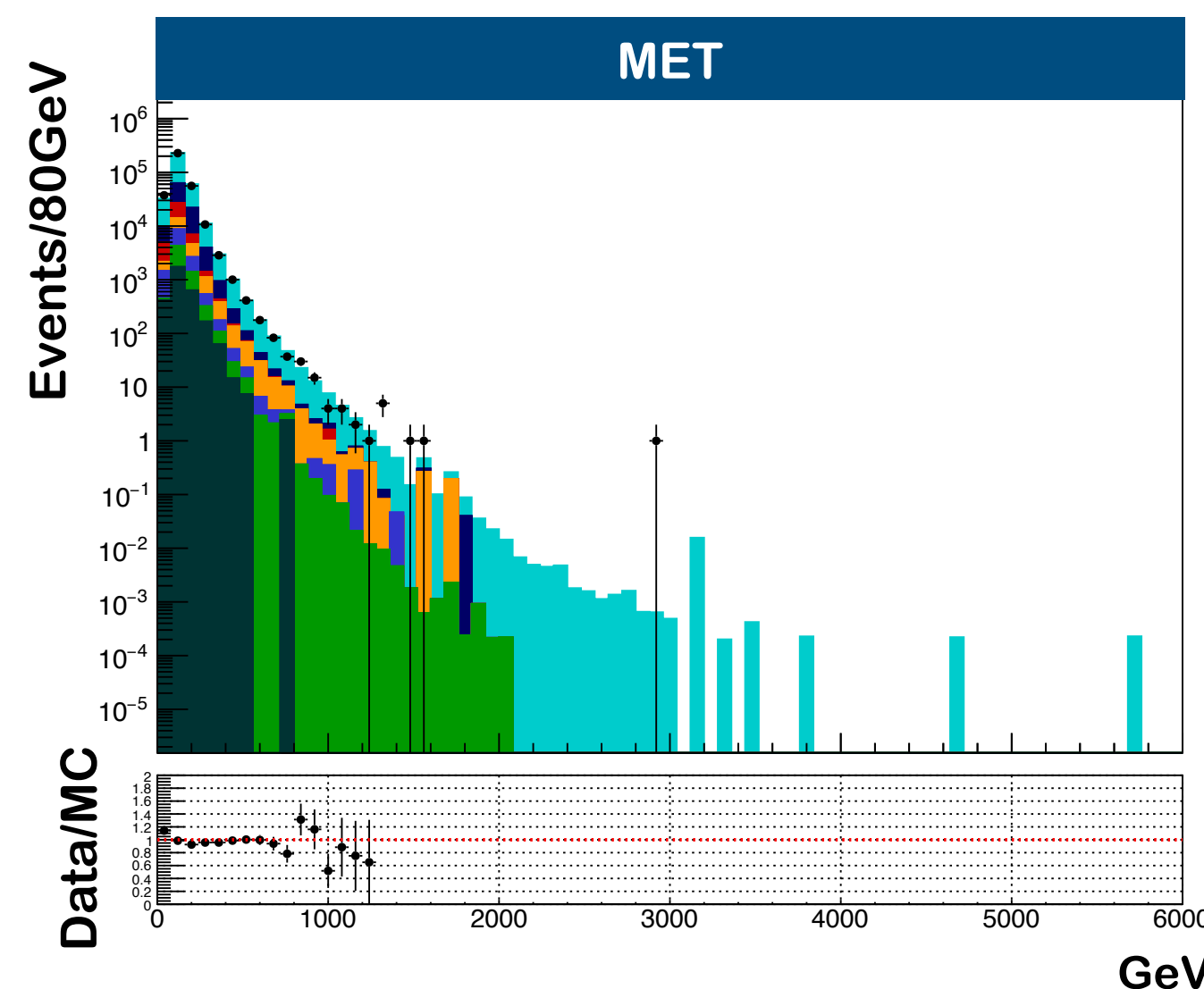
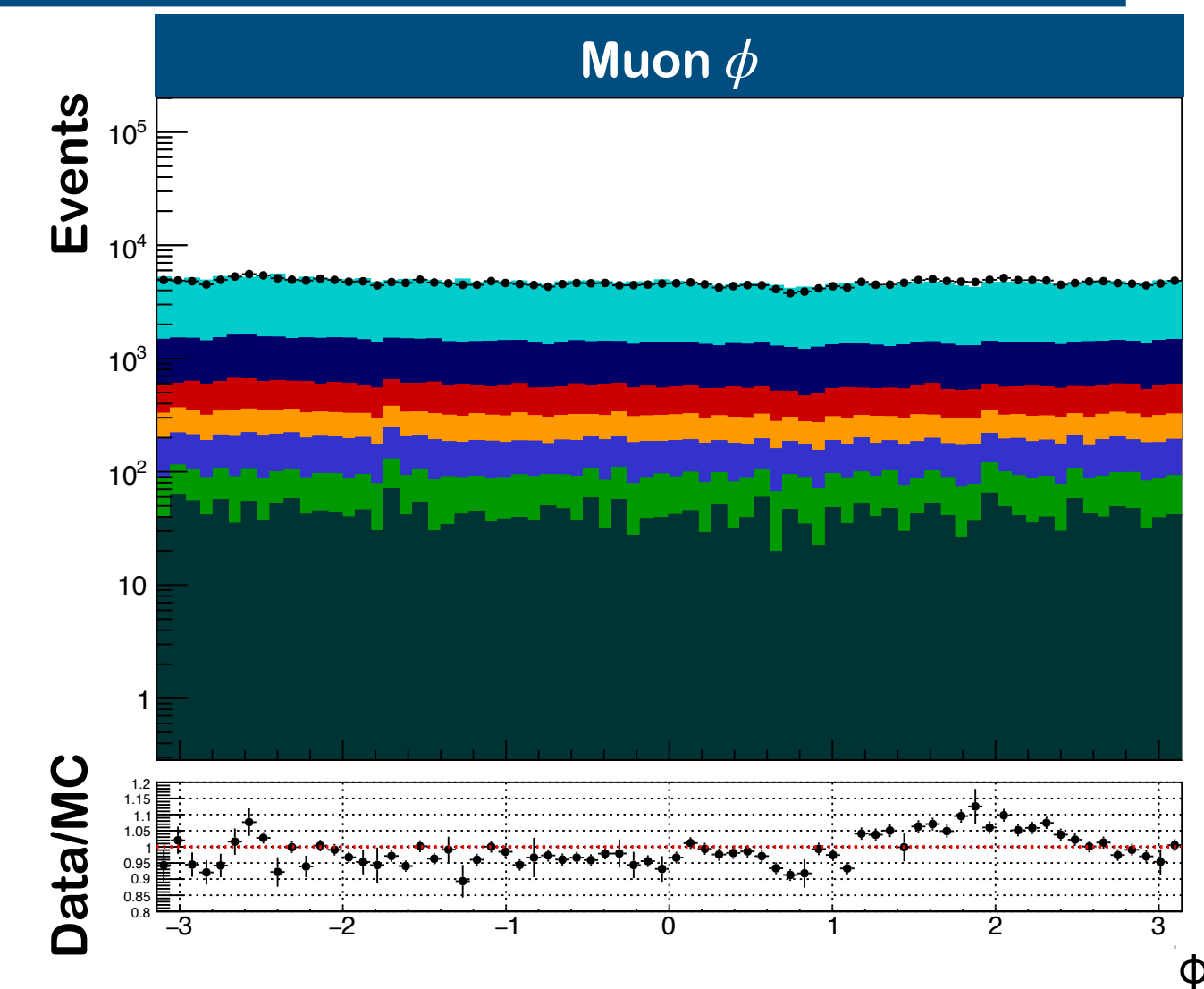
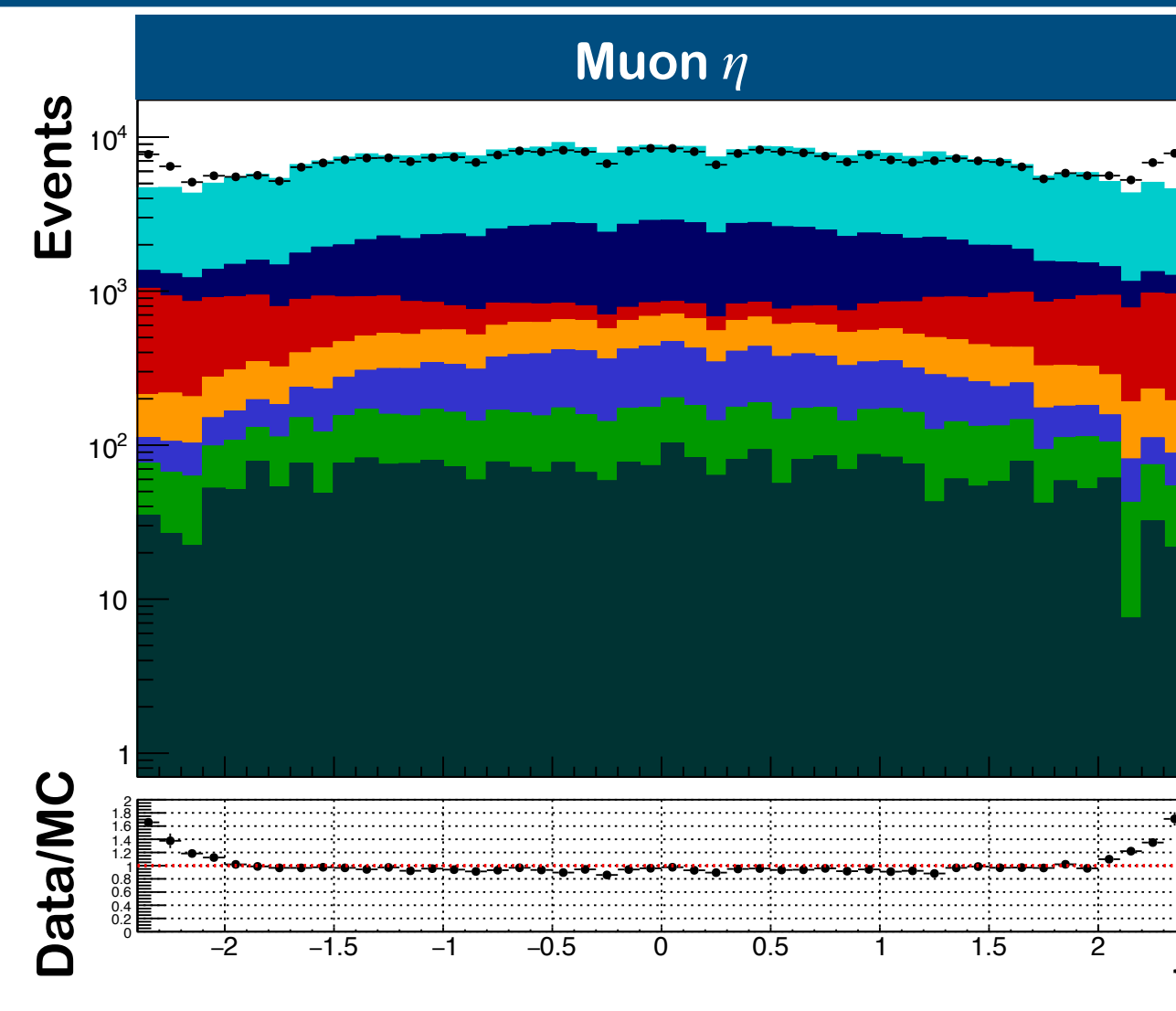
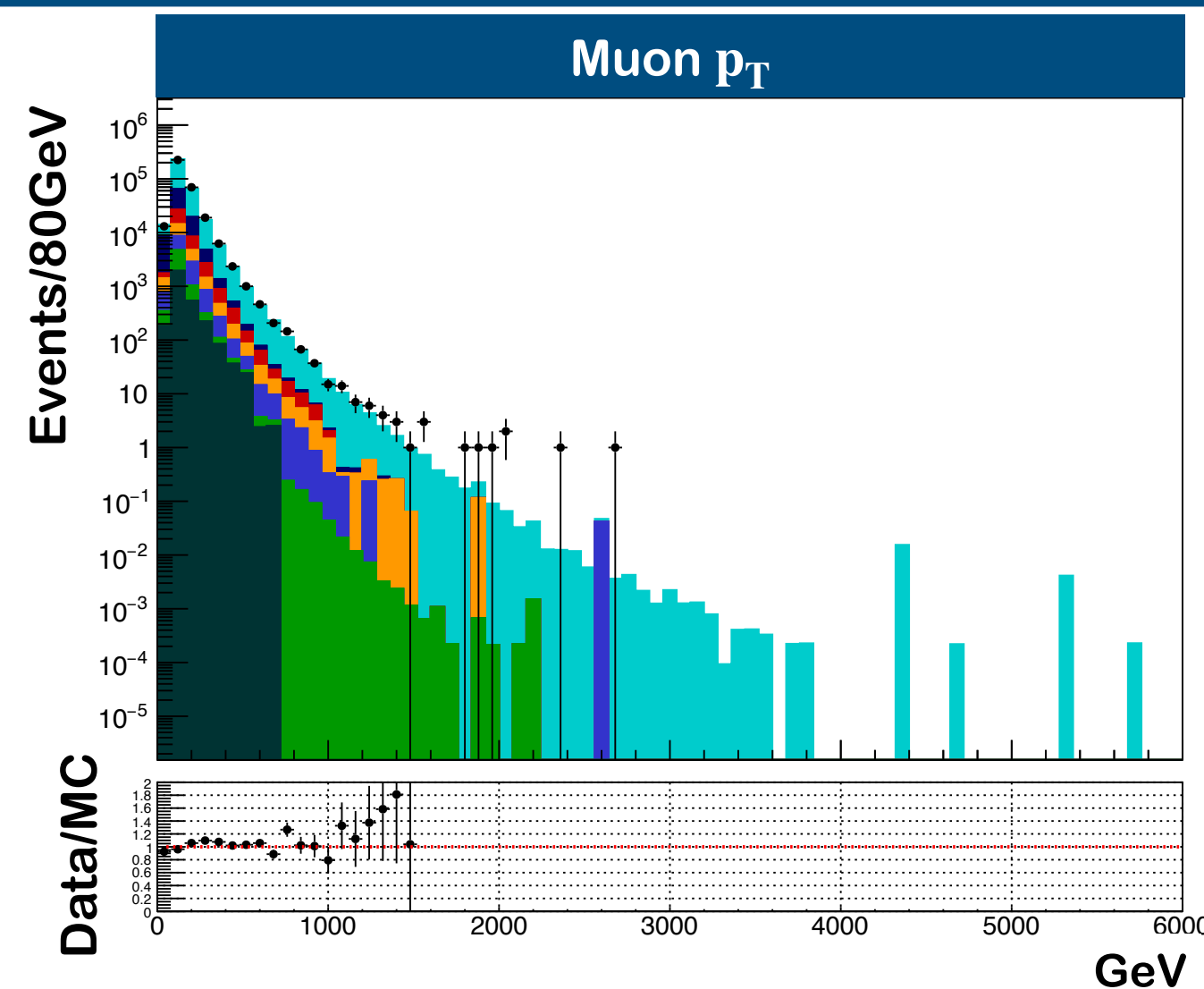
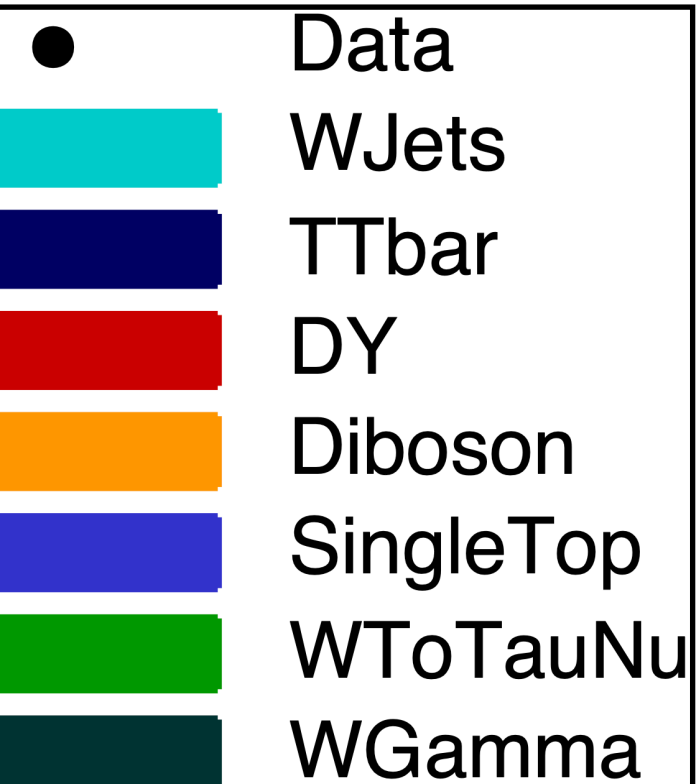
(Other eras at backup)



- Tried **lowering the loose lepton p_T cut to 10 GeV** to reduce the background
- Also checked the Signal/Data ratio: Even though updating the p_T threshold removes some data, it mostly comes from the background, and the **signal ratio increases for overall M_T^W range including high M_T^W region**
- Decided to update the loose lepton p_T threshold to 10 GeV

2018

59.83 fb^{-1}



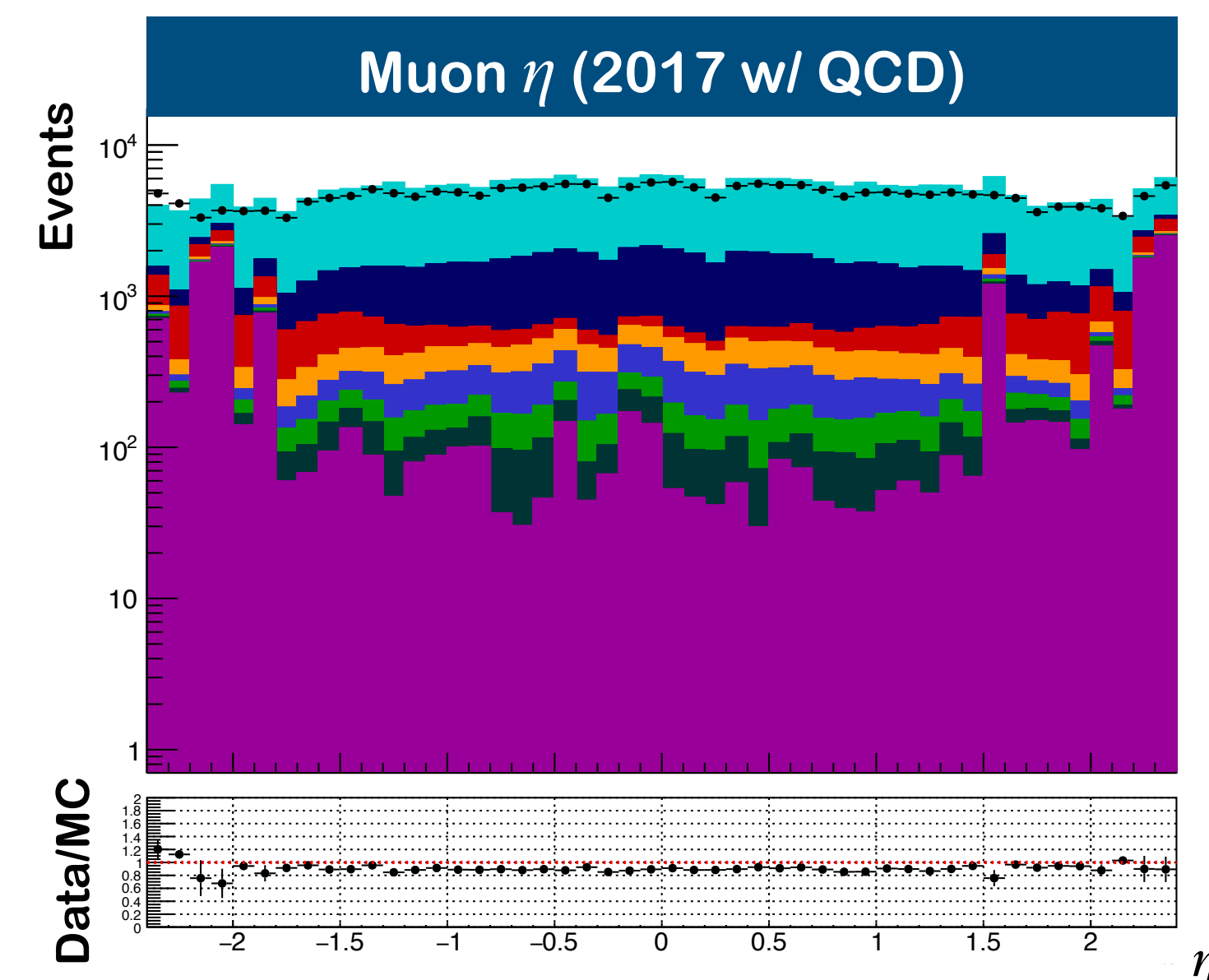
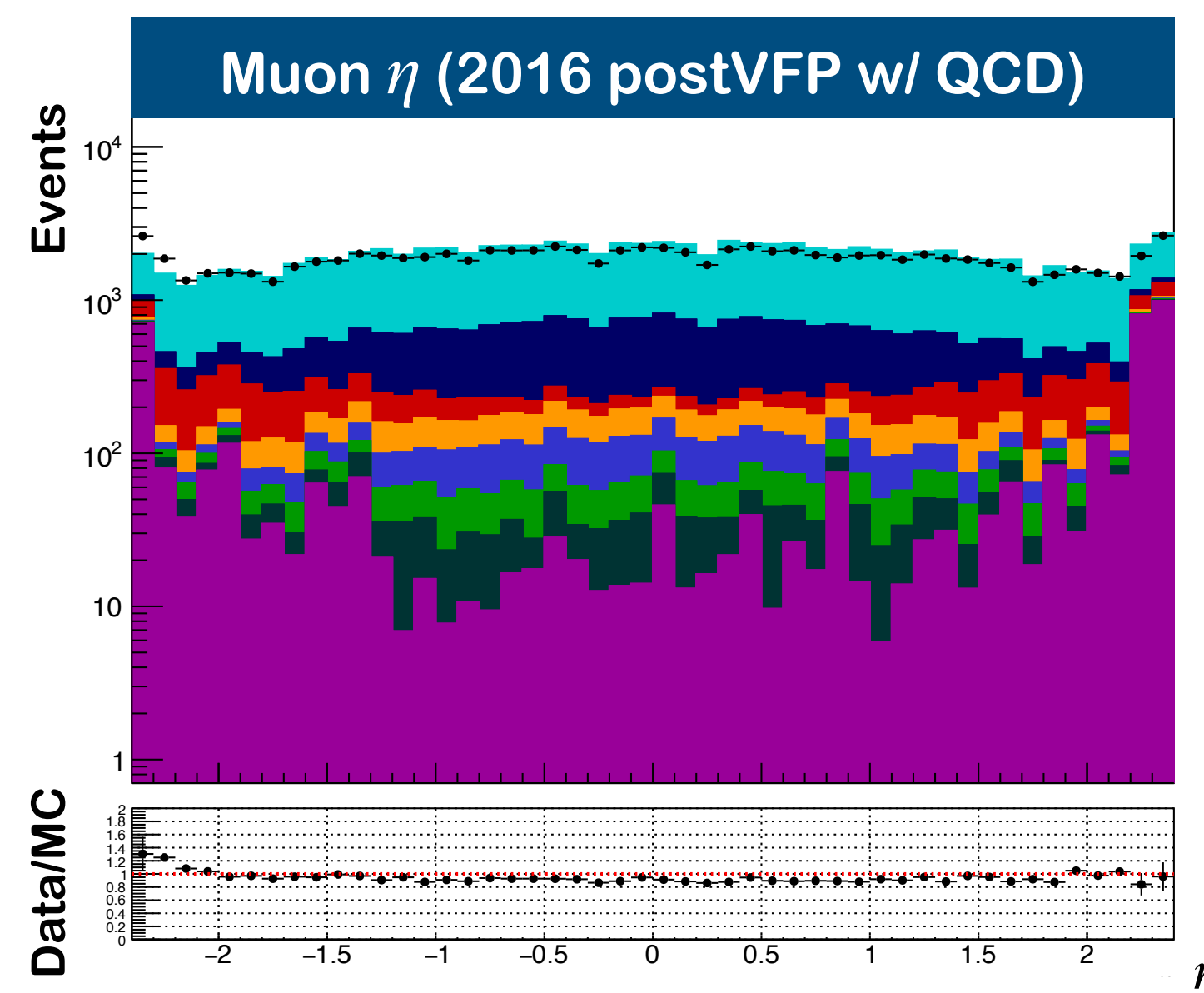
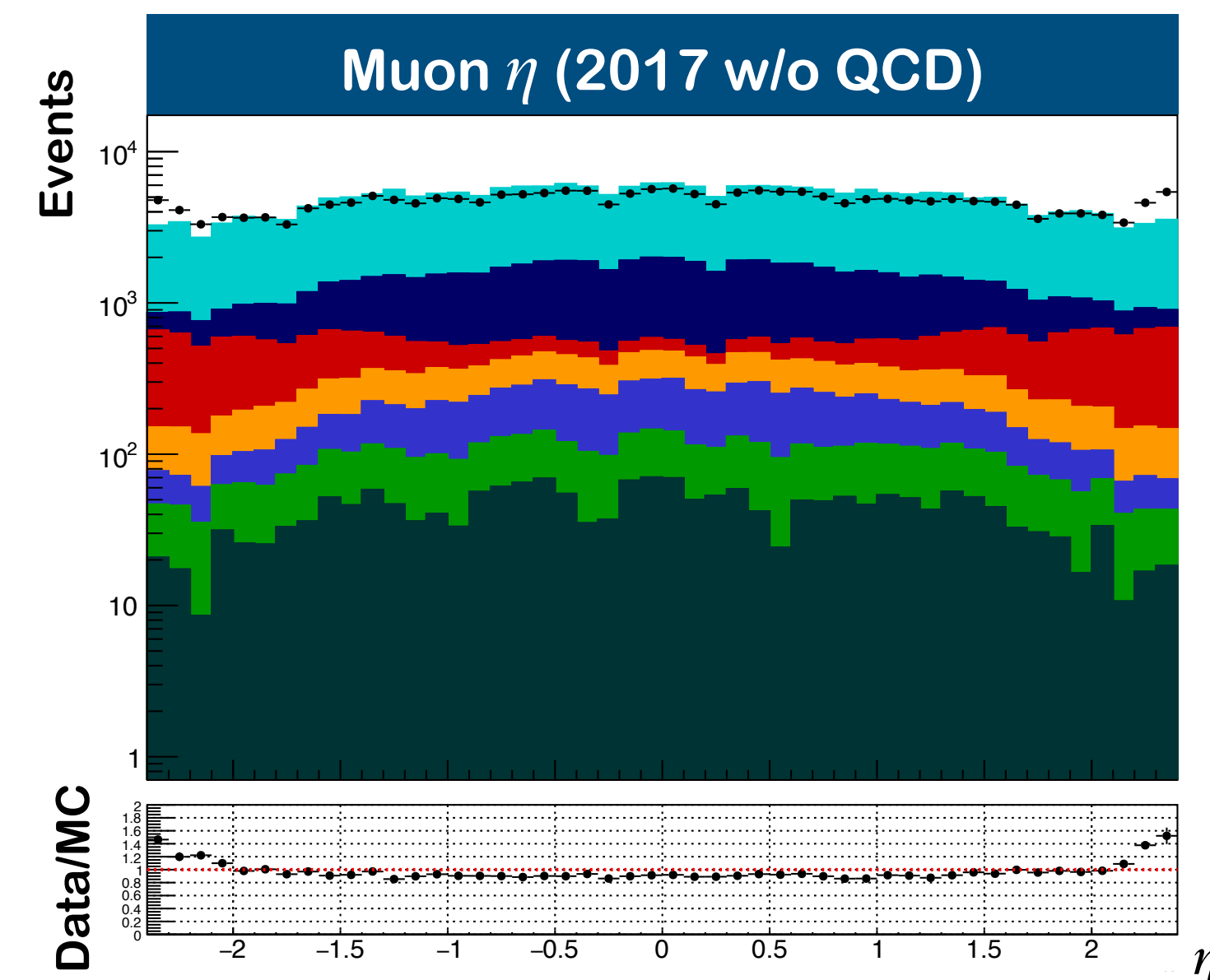
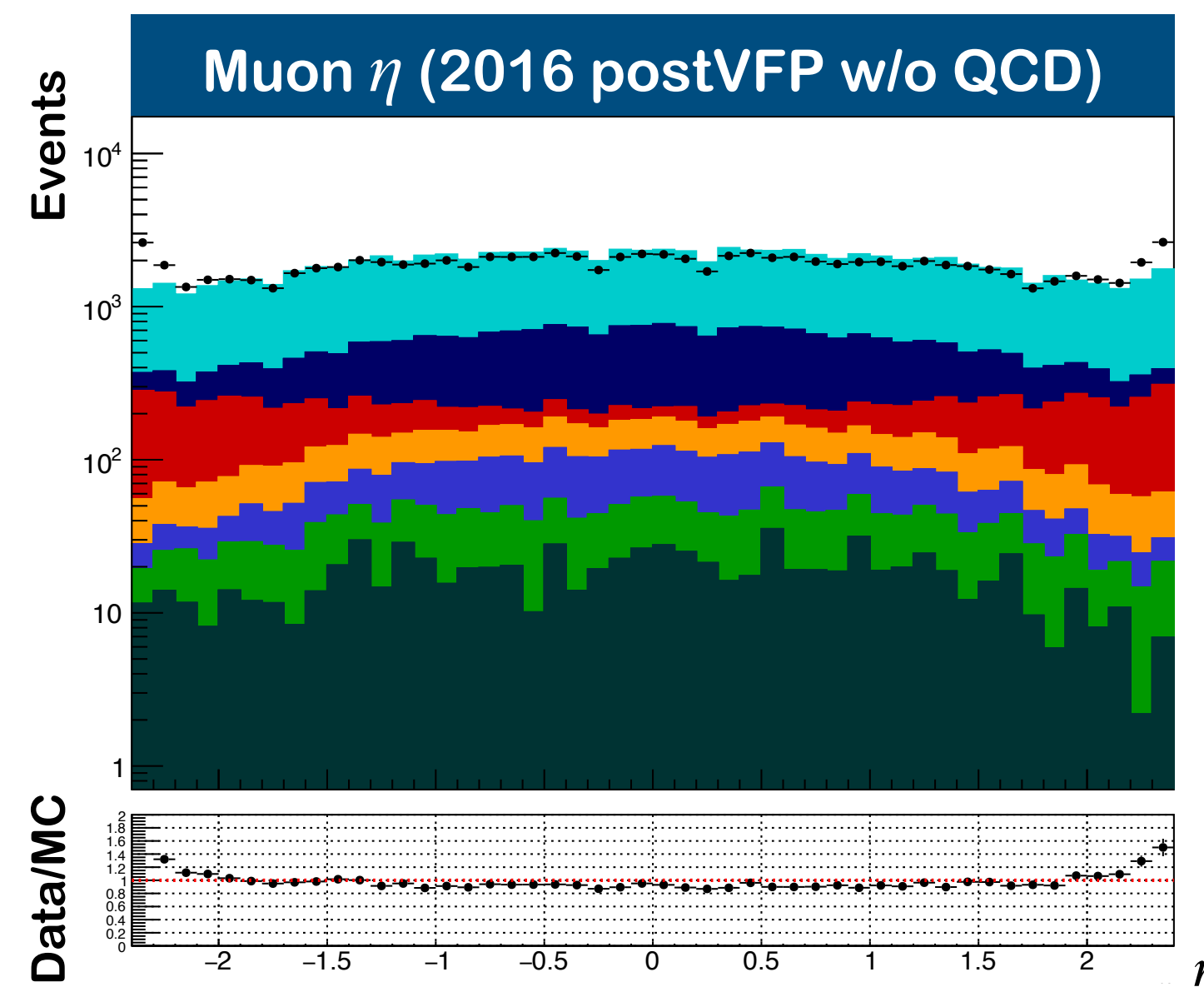
- Result for **2018 (59.83 fb^{-1})** with updated selection, correction and background MC samples
- Using same binning as ATLAS paper ([link](#)) for the M_T^W for now, will optimize further
- **QCD will be added** after study for better background modeling

Investigation on discrepancy @ forward region



► After adding QCD:

- **discrepancy has been reduced**
- Will be studied further based on conveners' comments & background estimation
 - **Feedback on forward region discrepancy**
 - **Isolation cross-check:**
Tracker-based iso vs. PF iso
 - **Trigger matching check:**
muon pT near HLT threshold
 - **Muon veto extension**
Vetoing second muon with $|\eta| < 2.5$
 - **Gen-flavour study**
GenPartFlav of high-eta muons in QCD MC



Summary & next steps

● Motivation

- **With great precision** on the DY process, **we expect:**
 - Providing indirect search for **BSM**, improving the sensitivity to **BSM** and constraints on **PDF** at high-x regime

● Analysis goal

- **Measuring the differential cross-section of DY process**
 - **Neutral DY:** $d\sigma/dm_{\ell\ell}$ w.r.t jet multiplicity
 - **Charged DY:** $d\sigma/dm_T$

● Current status and next step

- **Both analyses are finalizing the event selection and corrections**
- **Background estimation** with data-driven method is **working in progress**
- Dielectron channel for both analyses is in early stage

● Expected timeline: ~ 1 year for neutral DY, ~ 1.5 year for charged DY

Back up

Neutral DY

Data and MC: 2016preVFP

DAS name		
Data	/SingleMuon/Run2016B-ver1_HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD /SingleMuon/Run2016B-ver2_HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD /SingleMuon/Run2016C-HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD /SingleMuon/Run2016D-HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD /SingleMuon/Run2016E-HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD /SingleMuon/Run2016F-HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD	
DYJetsToMuMu	/DYJetsToMuMu_M-50_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM /DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM /DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext1-v2/NANOAODSIM /DYJetsToMuMu_M-100to200_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM /DYJetsToMuMu_M-200to400_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM /DYJetsToMuMu_M-400to500_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM /DYJetsToMuMu_M-500to700_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM /DYJetsToMuMu_M-700to800_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM /DYJetsToMuMu_M-800to1000_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM /DYJetsToMuMu_M-1000to1500_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM /DYJetsToMuMu_M-1500to2000_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM /DYJetsToMuMu_M-2000toInf_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM	NNLO powhegMiNNLO +pythia8
DYJetsToTauTau	/DYJetsToTauTau_M-50_AtLeastOneEorMuDecay_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM	NNLO powhegMiNNLO +pythia8
TTTo2L2Nu	/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM	NLO powheg +pythia8
Single Top	/ST_s-channel_4f_leptonDecays_TuneCP5_13TeV-amcatnlo-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM /ST_t-channel_top_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v3/NANOAODSIM /ST_t-channel_antitop_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v3/NANOAODSIM /ST_tW_top_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM /ST_tW_antitop_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM	NLO powheg(or aMC@NLO) +pythia8
WZ	/WWTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM	NLO pythia8
WW	/WWTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM	NLO powheg +pythia8
ZZ	/ZZ_TuneCP5_13TeV-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM	NLO pythia8

Data and MC: 2016postVFP

DAS name		
Data	/SingleMuon/Run2016F-UL2016_MiniAODv2_NanoAODv9-v1/NANOAOD /SingleMuon/Run2016G-UL2016_MiniAODv2_NanoAODv9-v1/NANOAOD /SingleMuon/Run2016H-UL2016_MiniAODv2_NanoAODv9-v1/NANOAOD	
DYJetsToMuMu	/DYJetsToMuMu_M-50_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM /DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM /DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17_ext1-v2/NANOAODSIM /DYJetsToMuMu_M-100to200_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM /DYJetsToMuMu_M-200to400_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM /DYJetsToMuMu_M-400to500_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM /DYJetsToMuMu_M-500to700_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM /DYJetsToMuMu_M-700to800_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM /DYJetsToMuMu_M-800to1000_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM /DYJetsToMuMu_M-1000to1500_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM /DYJetsToMuMu_M-1500to2000_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM /DYJetsToMuMu_M-2000toInf_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM	NNLO powhegMiNNLO +pythia8
DYJetsToTauTau	/DYJetsToTauTau_M-50_AtLeastOneEorMuDecay_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM	NNLO powhegMiNNLO +pythia8
TTTo2L2Nu	/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM	NLO powheg +pythia8
Single Top	/ST_s-channel_4f_leptonDecays_TuneCP5_13TeV-amcatnlo-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM /ST_t-channel_top_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v3/NANOAODSIM /ST_t-channel_antitop_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v3/NANOAODSIM /ST_tW_top_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM /ST_tW_antitop_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM	NLO powheg(or aMC@NLO) +pythia8
WZ	/WZ_TuneCP5_13TeV-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM	NLO pythia8
WW	/WWTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM	NLO powheg +pythia8
ZZ	/ZZ_TuneCP5_13TeV-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM	NLO pythia8

Data and MC: 2017

DAS name		
Data	/SingleMuon/Run2017B-UL2017_MiniAODv2_NanoAODv9-v1/NANOAOD /SingleMuon/Run2017C-UL2017_MiniAODv2_NanoAODv9-v1/NANOAOD /SingleMuon/Run2017D-UL2017_MiniAODv2_NanoAODv9-v1/NANOAOD /SingleMuon/Run2017E-UL2017_MiniAODv2_NanoAODv9-v1/NANOAOD /SingleMuon/Run2017F-UL2017_MiniAODv2_NanoAODv9-v1/NANOAOD	
DYJetsToMuMu	/DYJetsToMuMu_M-50_massWgtFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM /DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM /DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9_ext1-v2/NANOADSIM /DYJetsToMuMu_M-100to200_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM /DYJetsToMuMu_M-200to400_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM /DYJetsToMuMu_M-400to500_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM /DYJetsToMuMu_M-500to700_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM /DYJetsToMuMu_M-700to800_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM /DYJetsToMuMu_M-800to1000_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM /DYJetsToMuMu_M-1000to1500_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM /DYJetsToMuMu_M-1500to2000_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM /DYJetsToMuMu_M-2000toInf_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM	NNLO powhegMiNNLO +pythia8
DYJetsToTauTau	/DYJetsToTauTau_M-50_AtLeastOneEorMuDecay_massWgtFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM	NNLO powhegMiNNLO +pythia8
TTTo2L2Nu	/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v1/NANOADSIM	NLO powheg +pythia8
Single Top	/ST_s-channel_4f_leptonDecays_TuneCP5_13TeV-amcatnlo-pythia8/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v1/NANOADSIM /ST_t-channel_top_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v1/NANOADSIM /ST_t-channel_antitop_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v1/NANOADSIM /ST_tW_top_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM /ST_tW_antitop_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM	NLO powheg(or aMC@NLO) +pythia8
WZ	/WZ_TuneCP5_13TeV-pythia8/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v1/NANOADSIM	NLO pythia8
WW	/WWTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v2/NANOADSIM	NLO powheg +pythia8
ZZ	/ZZ_TuneCP5_13TeV-pythia8/RunIISummer20UL17NanoAODv9-106X_mc2017_realistic_v9-v1/NANOADSIM	NLO pythia8

Dataset and MC

◎ 2018 (other eras on backup)

- All used data and MC is based on NanoAODv9
- Reference: **SMP-24-004 (previous presentation)**

⌘ Photon induced process ($gg \rightarrow ll$) will be added later

2018	DAS name	QCD order
Data	/SingleMuon/Run2018A-UL2018_MiniAODv2_NanoAODv9-v2/NANOAOD /SingleMuon/Run2018B-UL2018_MiniAODv2_NanoAODv9-v2/NANOAOD /SingleMuon/Run2018C-UL2018_MiniAODv2_NanoAODv9-v2/NANOAOD /SingleMuon/Run2018D-UL2018_MiniAODv2_NanoAODv9-v1/NANOAOD	
DYJetsToMuMu	/DYJetsToMuMu_M-50_massWgtFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext1-v2/NANOAODSIM /DYJetsToMuMu_M-100to200_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-200to400_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-400to500_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-500to700_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-700to800_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-800to1000_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-1000to1500_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-1500to2000_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /DYJetsToMuMu_M-2000toInf_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM	NNLO powhegMiNNLO +pythia8
DYJetsToTauTau	/DYJetsToTauTau_M-50_AtLeastOneEorMuDecay_massWgtFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM	NNLO powhegMiNNLO +pythia8
TTTo2L2Nu	/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM	NLO powheg +pythia8
Single Top	/ST_s-channel_4f_leptonDecays_TuneCP5_13TeV-amcatnlo-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM /ST_t-channel_top_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM /ST_t-channel_antitop_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM /ST_tW_top_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM /ST_tW_antitop_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM	NLO powheg(or aMC@NLO) +pythia8
WZ	/WZ_TuneCP5_13TeV-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM	NLO pythia8
WW	/WWTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM	NLO powheg +pythia8
ZZ	/ZZ_TuneCP5_13TeV-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM	NLO pythia8

b-jet selection

Passing Jet selection

Passing b-tagging

DeepJet medium WP

Noise filter

Beam halo filter

Ee badSC noise filter (data only)

- ▶ **Jet pT threshold was studied to get reasonable statistics @ high jet multiplicity region (see [back up](#))**

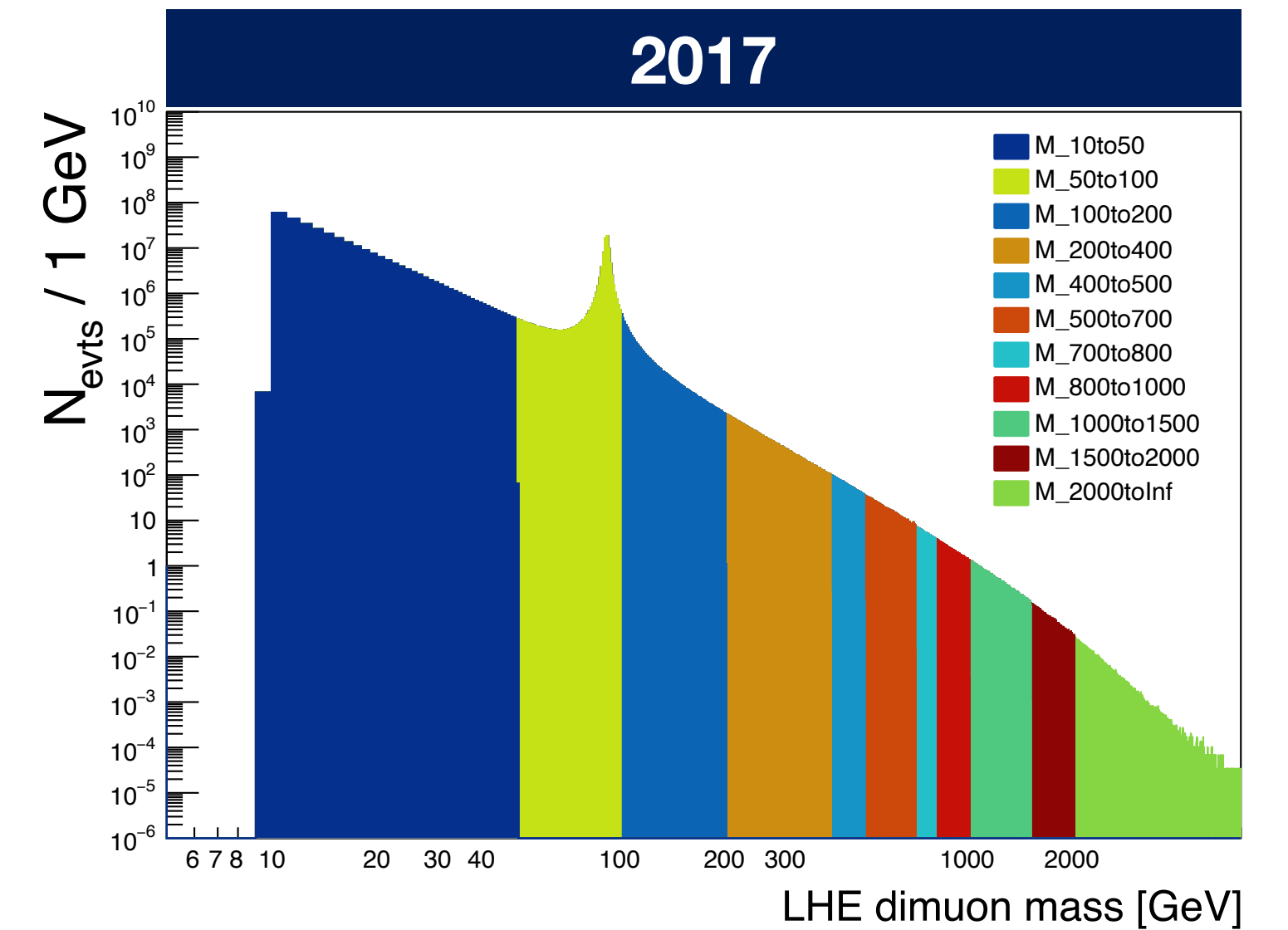
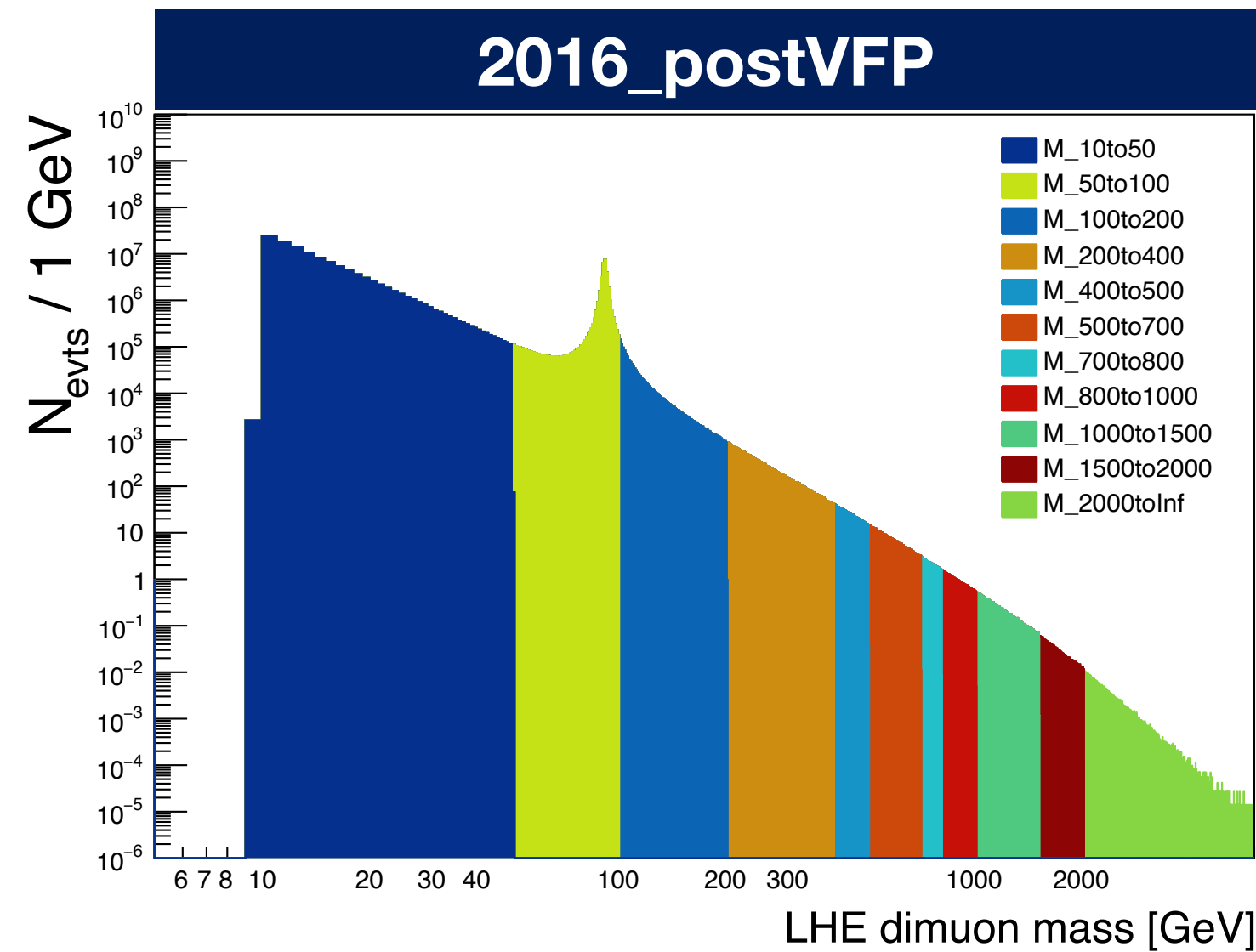
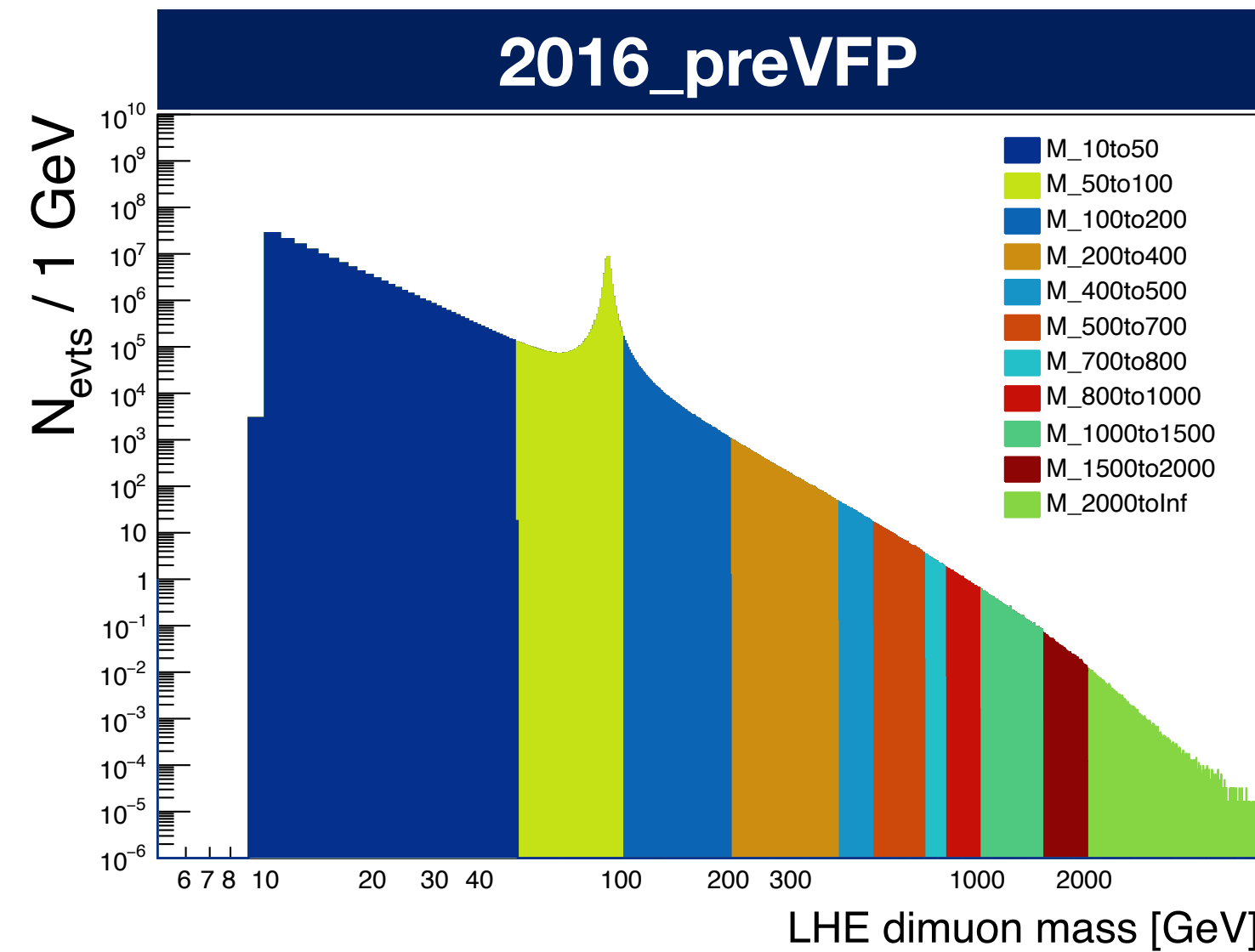
Corrections

● **Applied corrections: Recommended corrections from each POG are used**

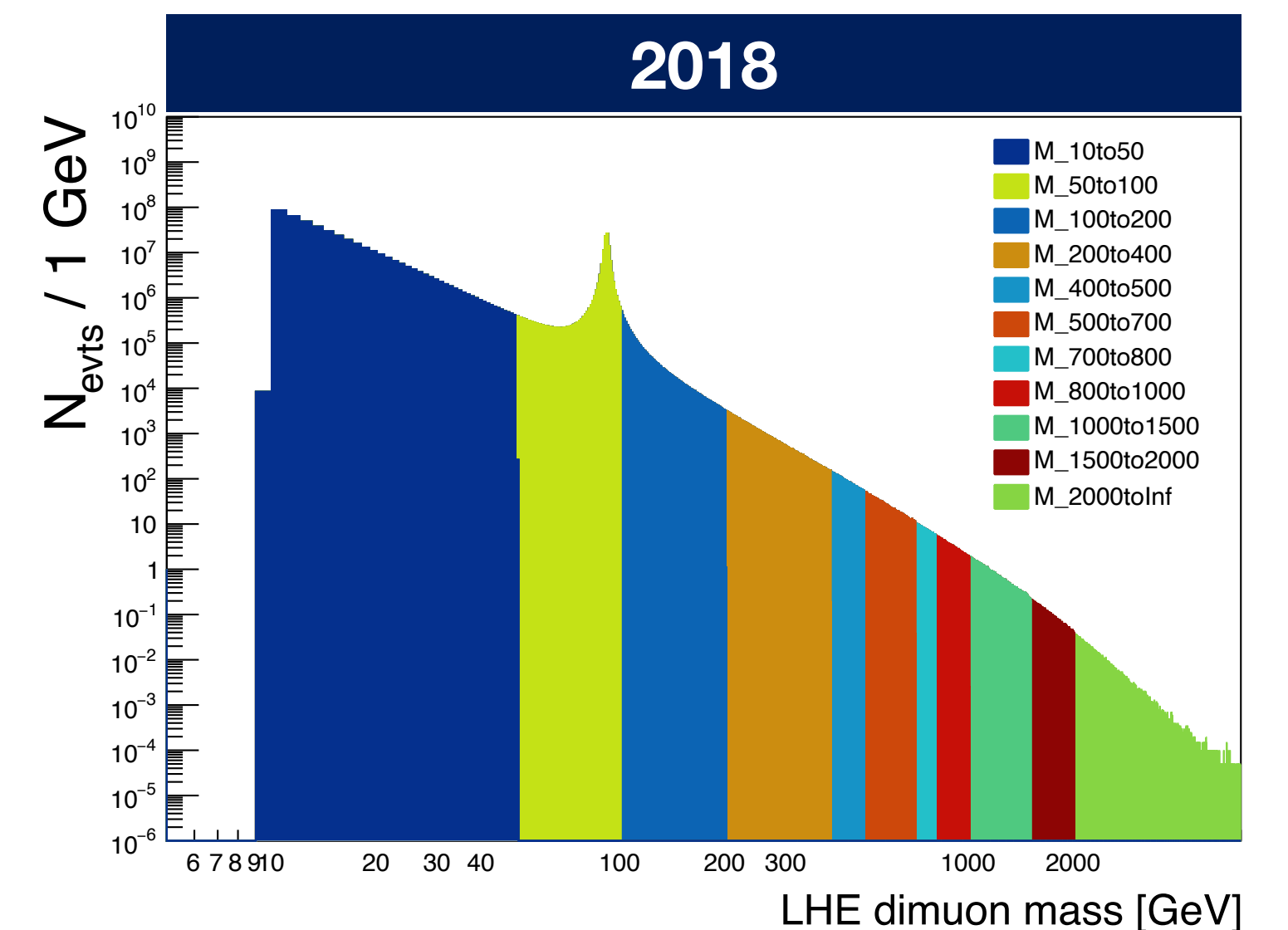
- ▶ PU reweighting: **Official LumiPOG values for PU** [LINK](#)
- ▶ L1 pre-firing: **Using the branch for the correction in the NanoAOD**
- ▶ Muon efficiency scale factor: **Official MuonPOG values for high pT muon** [LINK](#)
- ▶ Muon momentum scale correction and smearing: **Official MuonPOG high pT muon resolution smearing**
 - [2016](#), [2017](#), [2018](#)
- ▶ Jet PileUp ID efficiency scale factor: **Official JMEPOG value** [LINK](#)
- ▶ b-tagging efficiency scale factor: **Official BTV value** [LINK](#)

● **Recommended corrections from each POG are used**

Fetching mass-binned DY MCs



- ▶ ~O(10) events overlap at boundary observed
- ▶ We conclude it with round-off error from different variable types stored at MINIAOD and NANOAOB
 - MINIAOD: store as **double**
 - NANOAOB: store as **float**

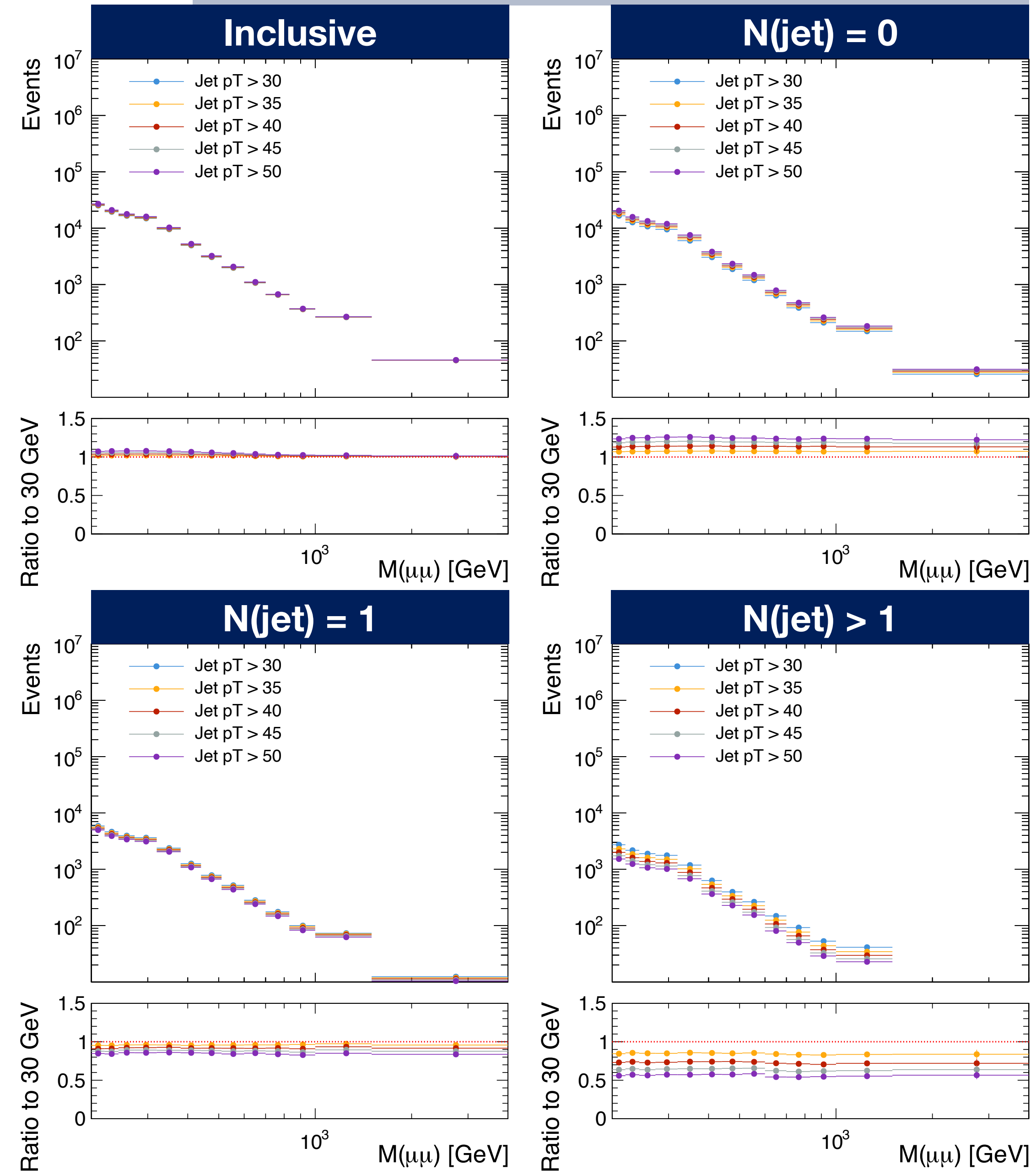


Study on the jet pT threshold

2018, DY MC (b-veto applied)

Effect of jet pT threshold

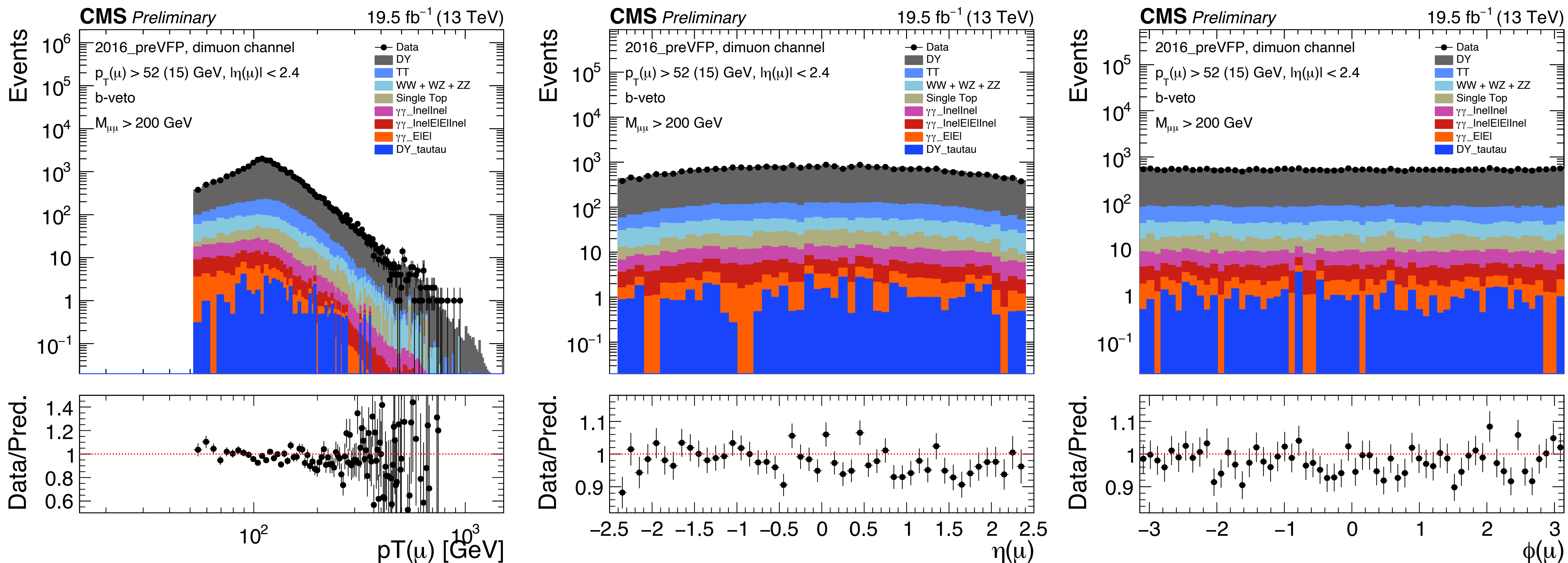
- ▶ Our observables are Drell-Yan differential cross section at high mass
 - With b-veto, with jet multiplicity
- ▶ Jet selection affects the event yields and also uncertainty since, PU identification and its SF should be applied to jet pT < 50 GeV
- ▶ Expected event yields with jet pT
 - Jet pT threshold $\uparrow$: event yields on **inclusive result** $\uparrow$, event yields with **high jet multiplicity** $\downarrow$
 - Jet pT threshold $\downarrow$: event yields on **inclusive result** $\downarrow$, event yields with **high jet multiplicity** $\uparrow$
- ▶ Investigation is done for the effect on event yields with different jet pT threshold with different jet multiplicity
- ▶ At jet pT > 50 GeV compared with jet pT > 30 GeV
 - has ~ 10% large events at inclusive in jets
 - has ~ 50% small events at N(Jet) > 1
- ▶ Since, with high jet pT threshold, we observe significant event loss at high jet multiplicity
 - We decide to use the lowest pT threshold, 30 GeV



Data vs. MC: control plot @ high mass

2016 preVFP, b-veto (other eras on backup)

Leading muon distribution

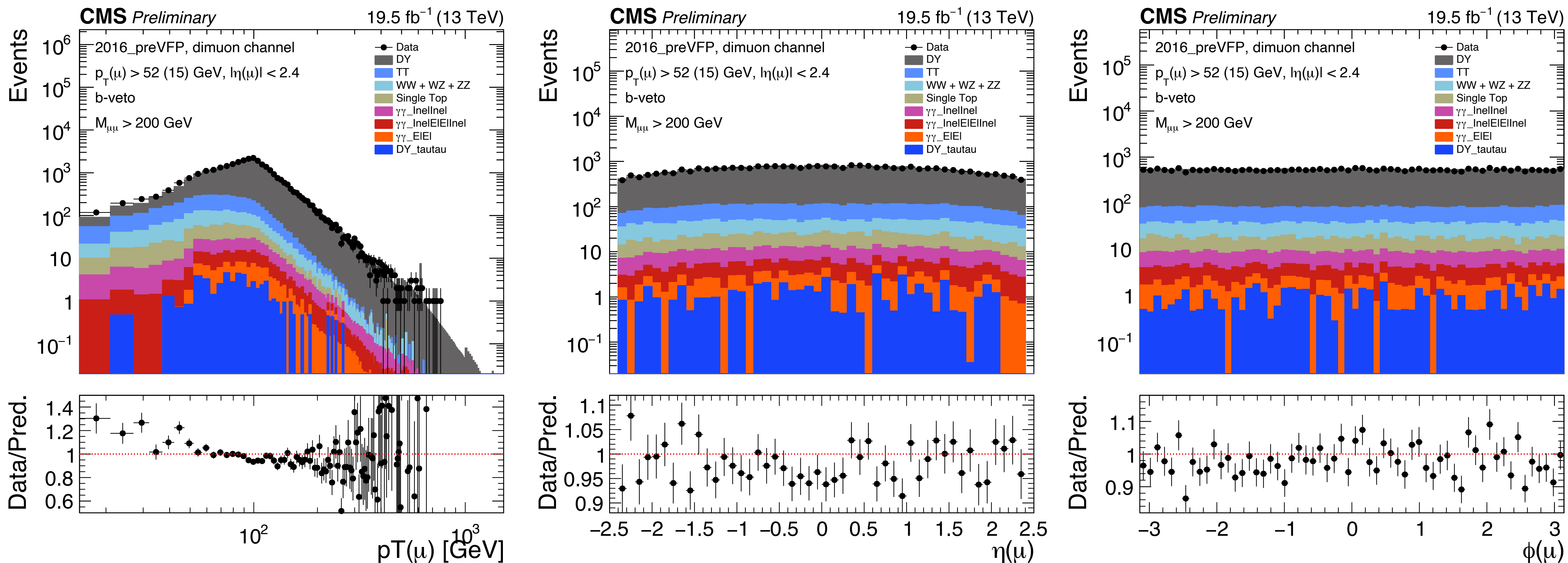


⌘ CAVEAT: results in this slide are inclusive in jets

Data vs. MC: control plot @ high mass

2016 preVFP, b-veto (other eras on backup)

Sub-leading muon distribution

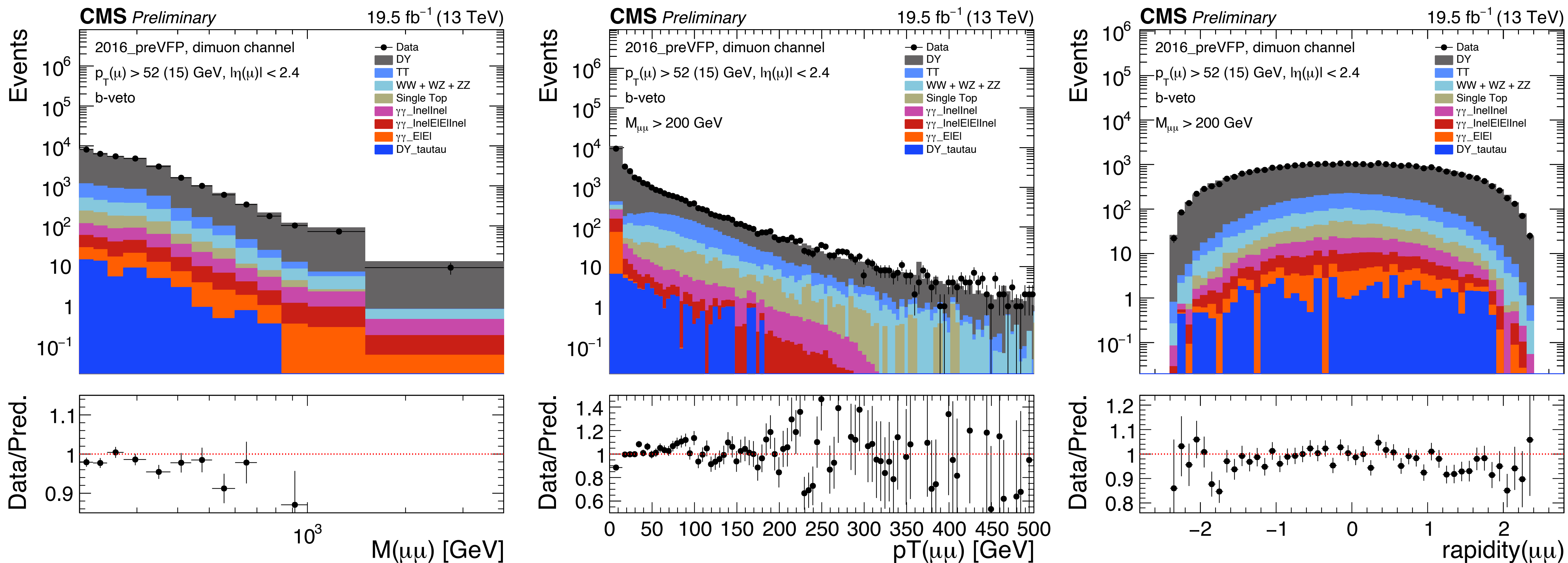


⌘ CAVEAT: results in this slide are inclusive in jets

Data vs. MC: control plot @ high mass

2016 preVFP, b-veto (other eras on backup)

Di-muon distribution

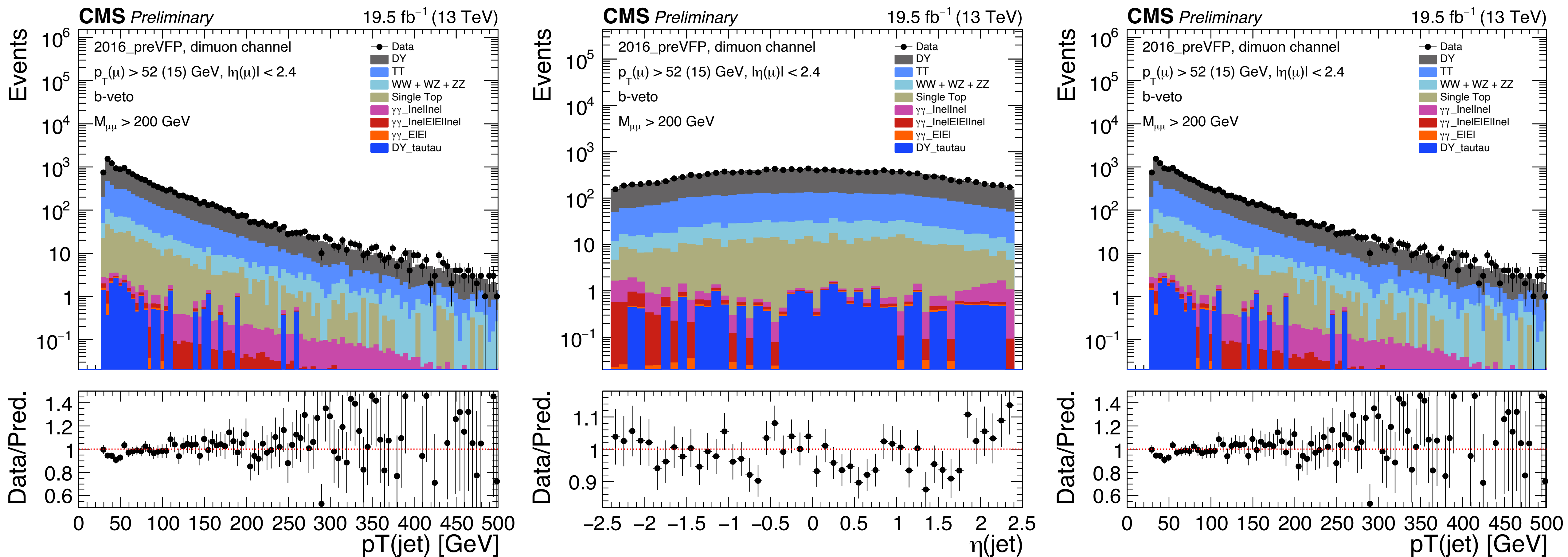


⌘ CAVEAT: results in this slide are inclusive in jets

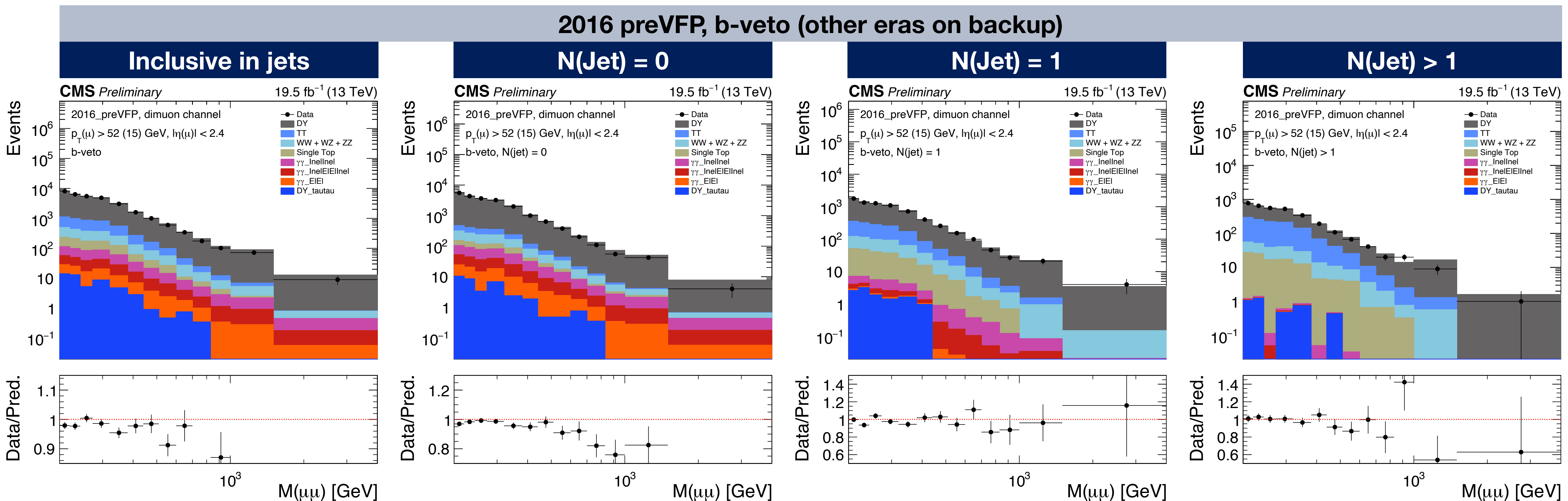
Data vs. MC: control plot @ high mass

2016 preVFP, b-veto (other eras on backup)

Jet distribution (inclusive in jets)



Data vs. MC: control plot @ high mass



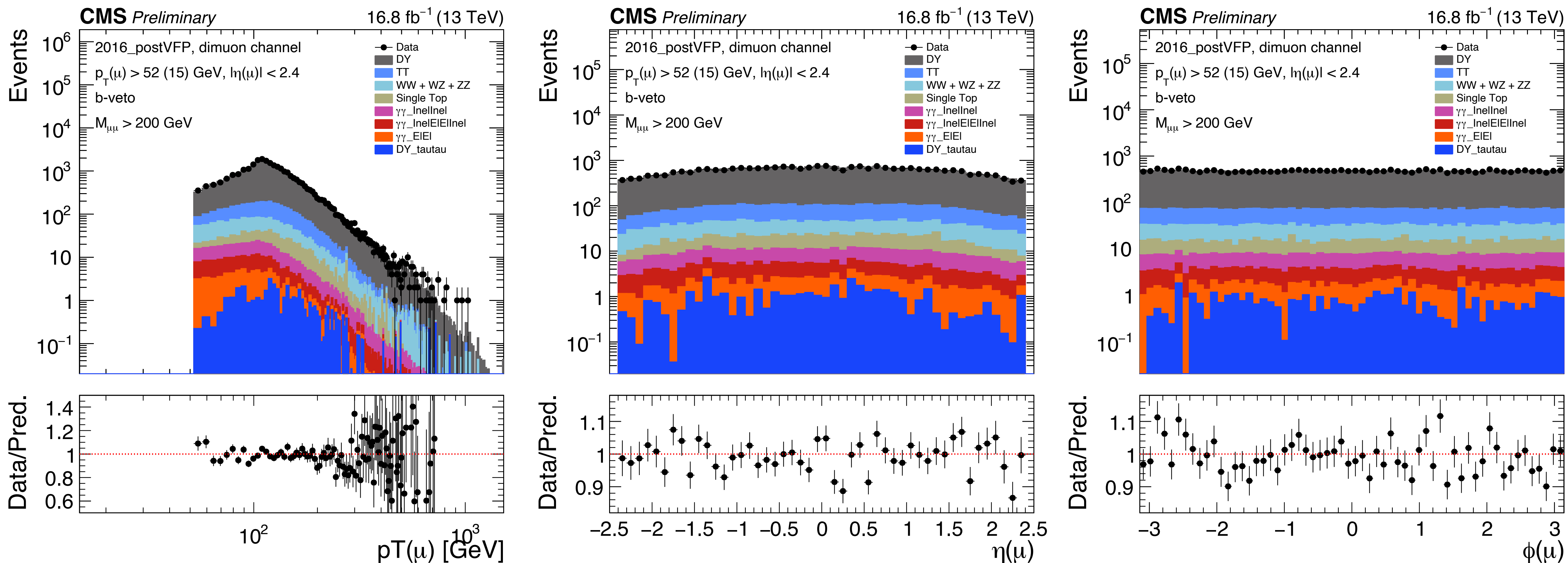
Dimuon mass distributions w.r.t jet multiplicity

- ▶ have good agreement up to 1 TeV,
- ▶ From 1 to 4 TeV, data to MC ratio agreed within statistical uncertainty
- ▶ **CAVEAT: mass binning will be updated**

Data vs. MC: control plot @ high mass

2016 postVFP, b-veto (other eras on backup)

Leading muon distribution

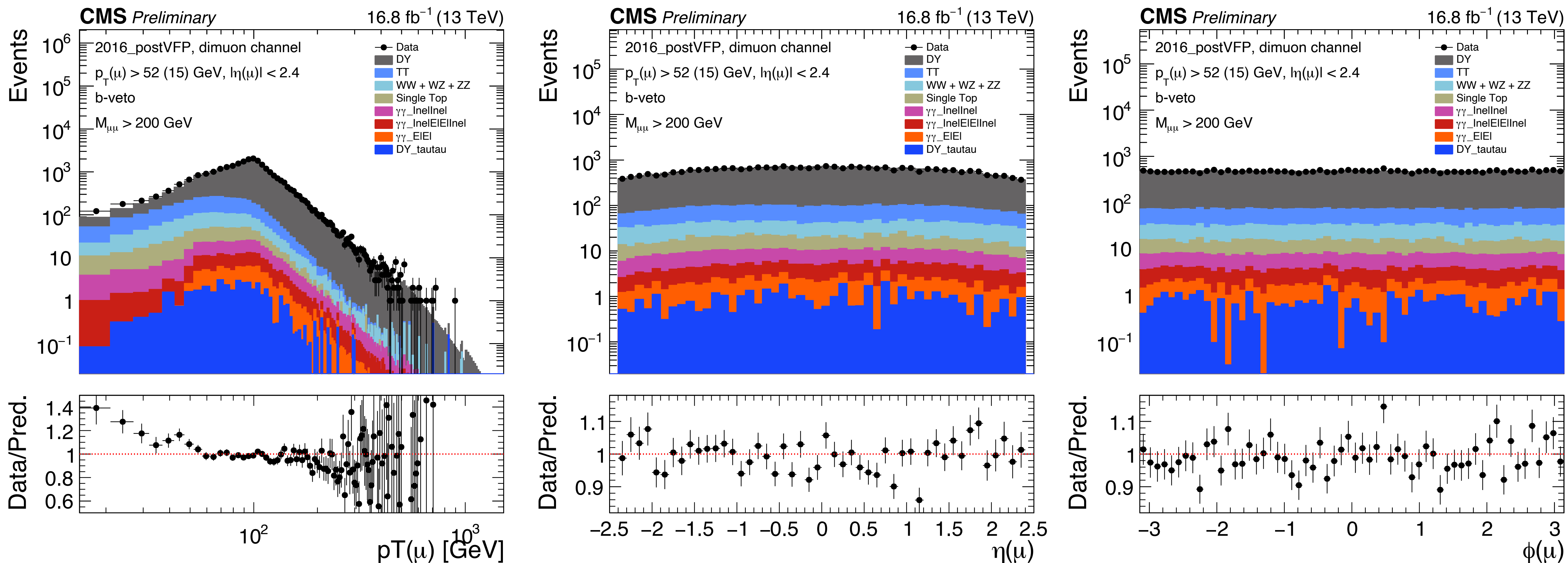


⌘ CAVEAT: results in this slide are inclusive in jets

Data vs. MC: control plot @ high mass

2016 postVFP, b-veto (other eras on backup)

Sub-leading muon distribution

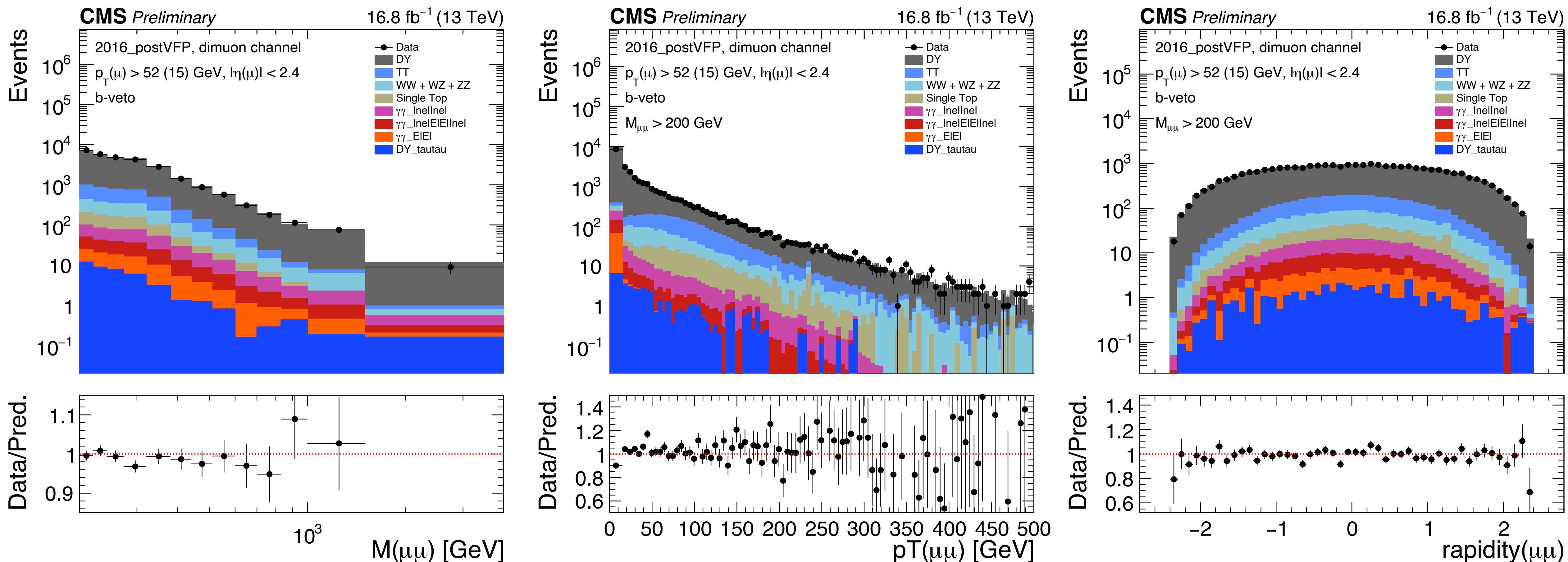


⌘ CAVEAT: results in this slide are inclusive in jets

Data vs. MC: control plot @ high mass

2016 postVFP, b-veto (other eras on backup)

Di-muon distribution

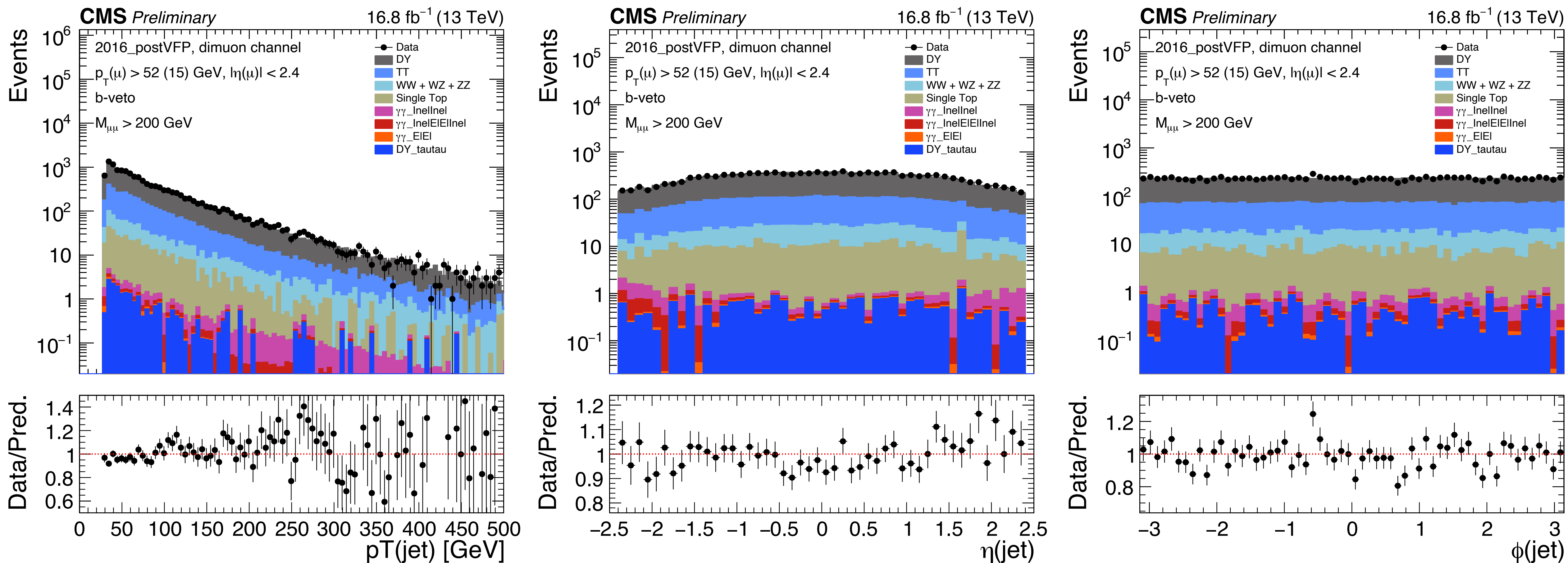


⌘ CAVEAT: results in this slide are inclusive in jets

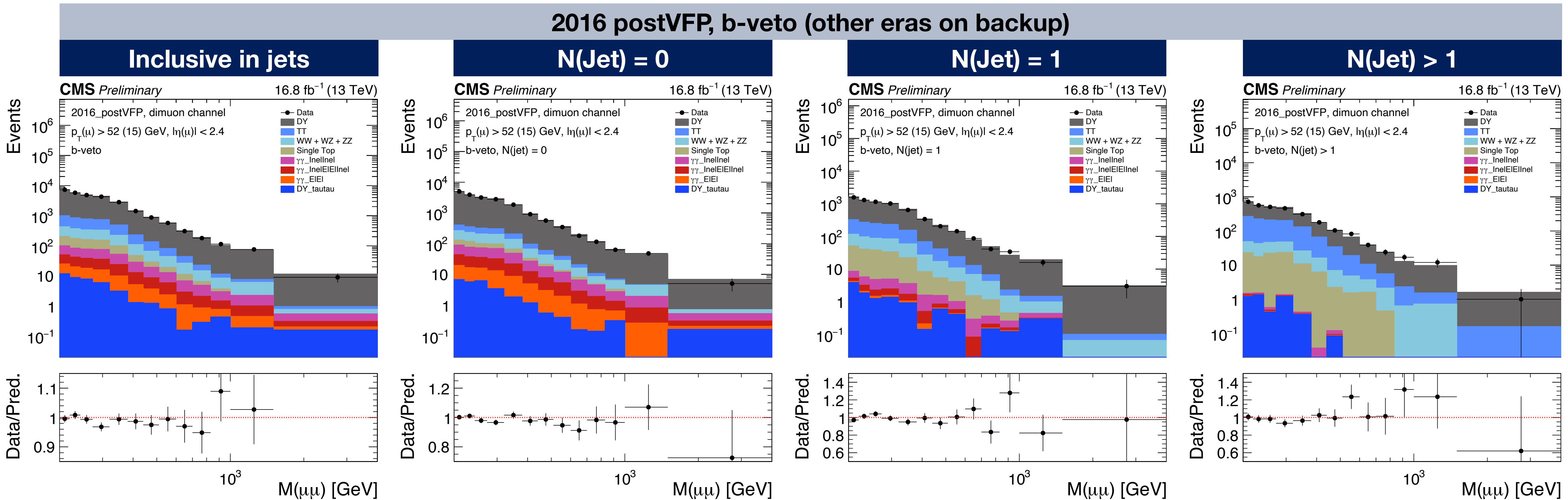
Data vs. MC: control plot @ high mass

2016 postVFP, b-veto (other eras on backup)

Jet distribution (inclusive in jets)



Data vs. MC: control plot @ high mass



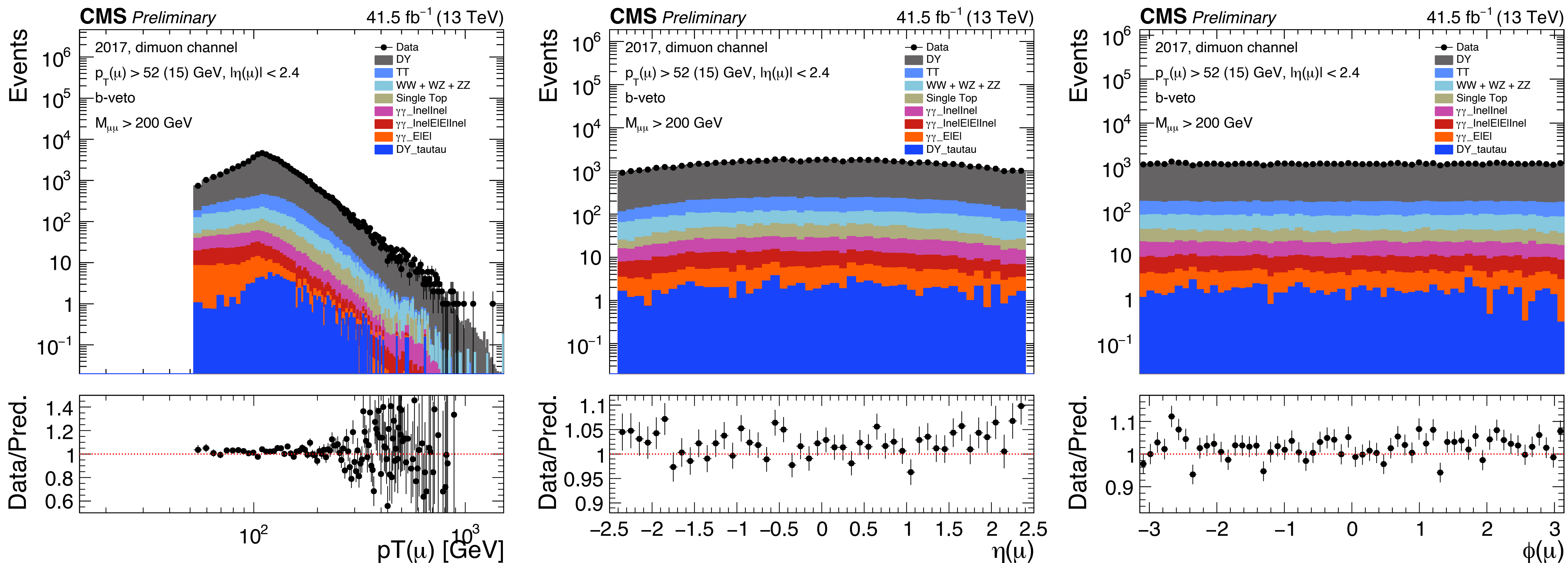
Dimuon mass distributions w.r.t jet multiplicity

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- ▶ **CAVEAT: mass binning will be updated**

Data vs. MC: control plot @ high mass

2017, b-veto (other eras on backup)

Leading muon distribution

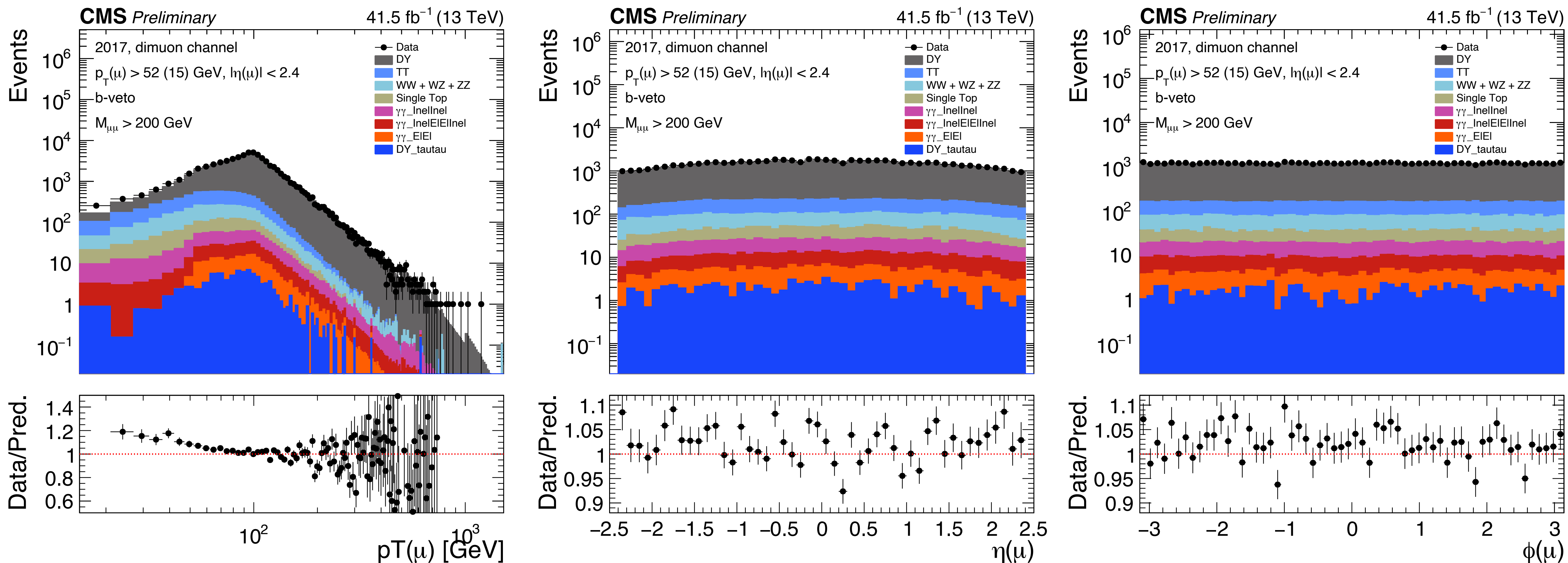


⌘ CAVEAT: results in this slide are inclusive in jets

Data vs. MC: control plot @ high mass

2017, b-veto (other eras on backup)

Sub-leading muon distribution

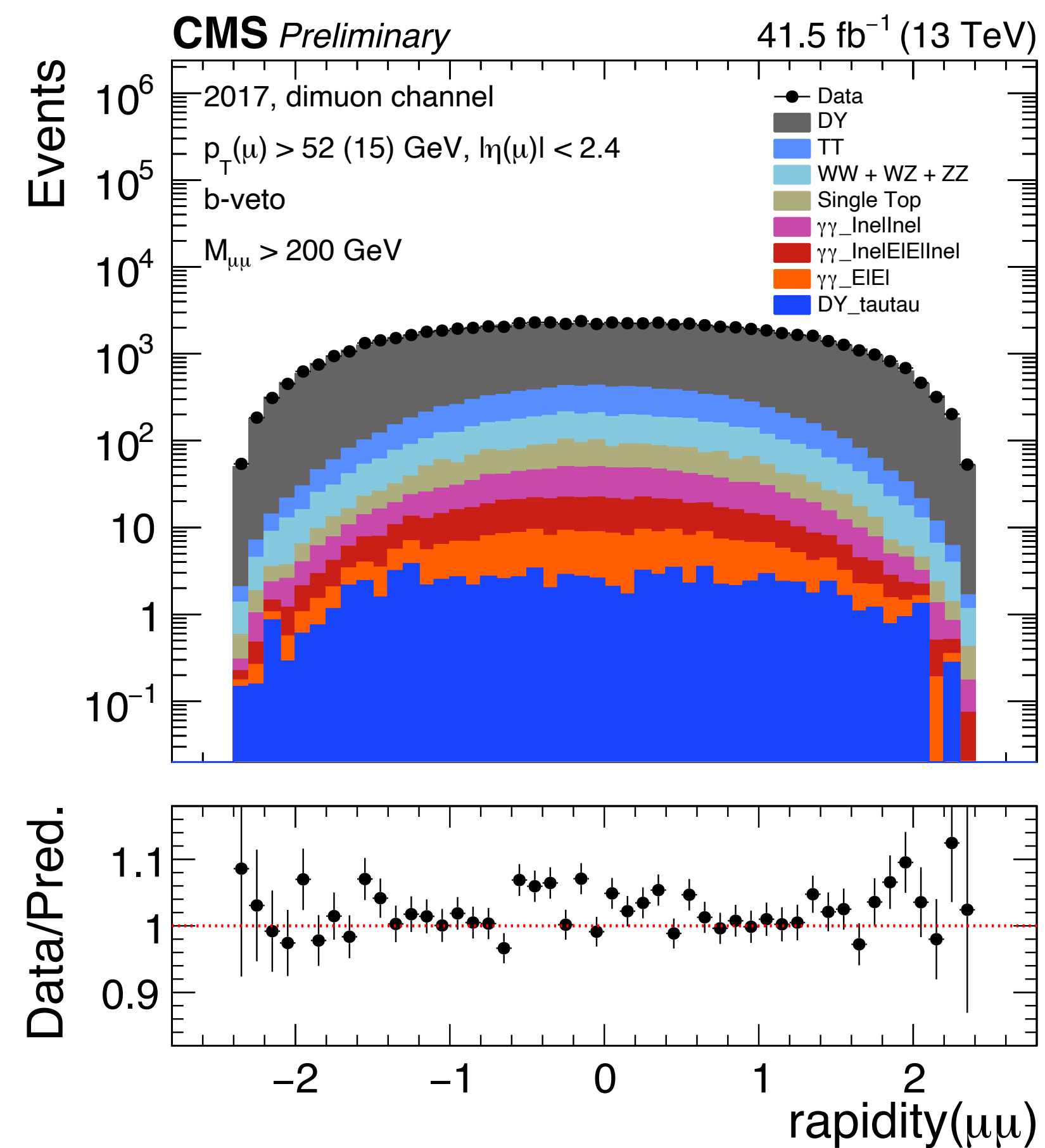
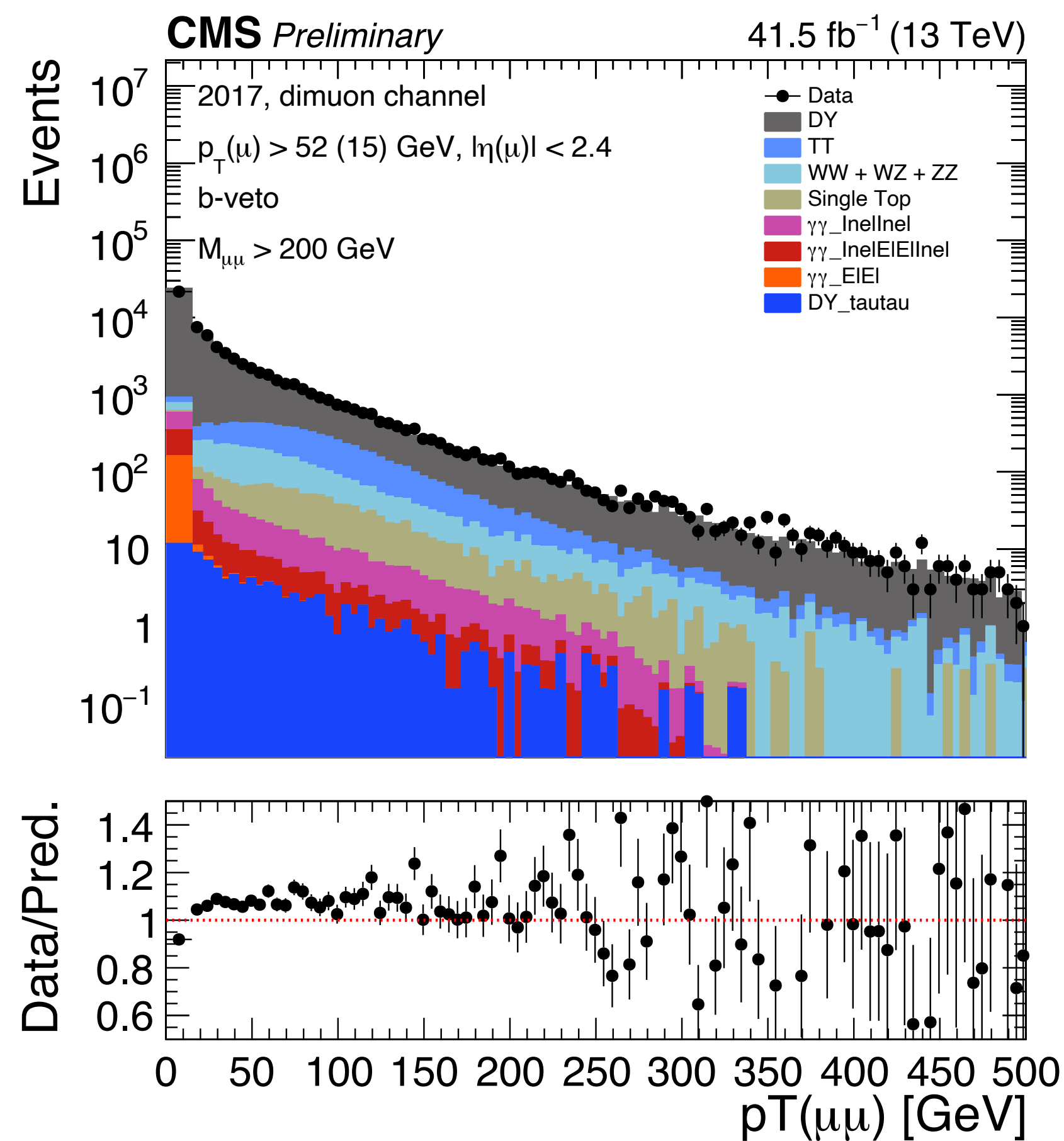
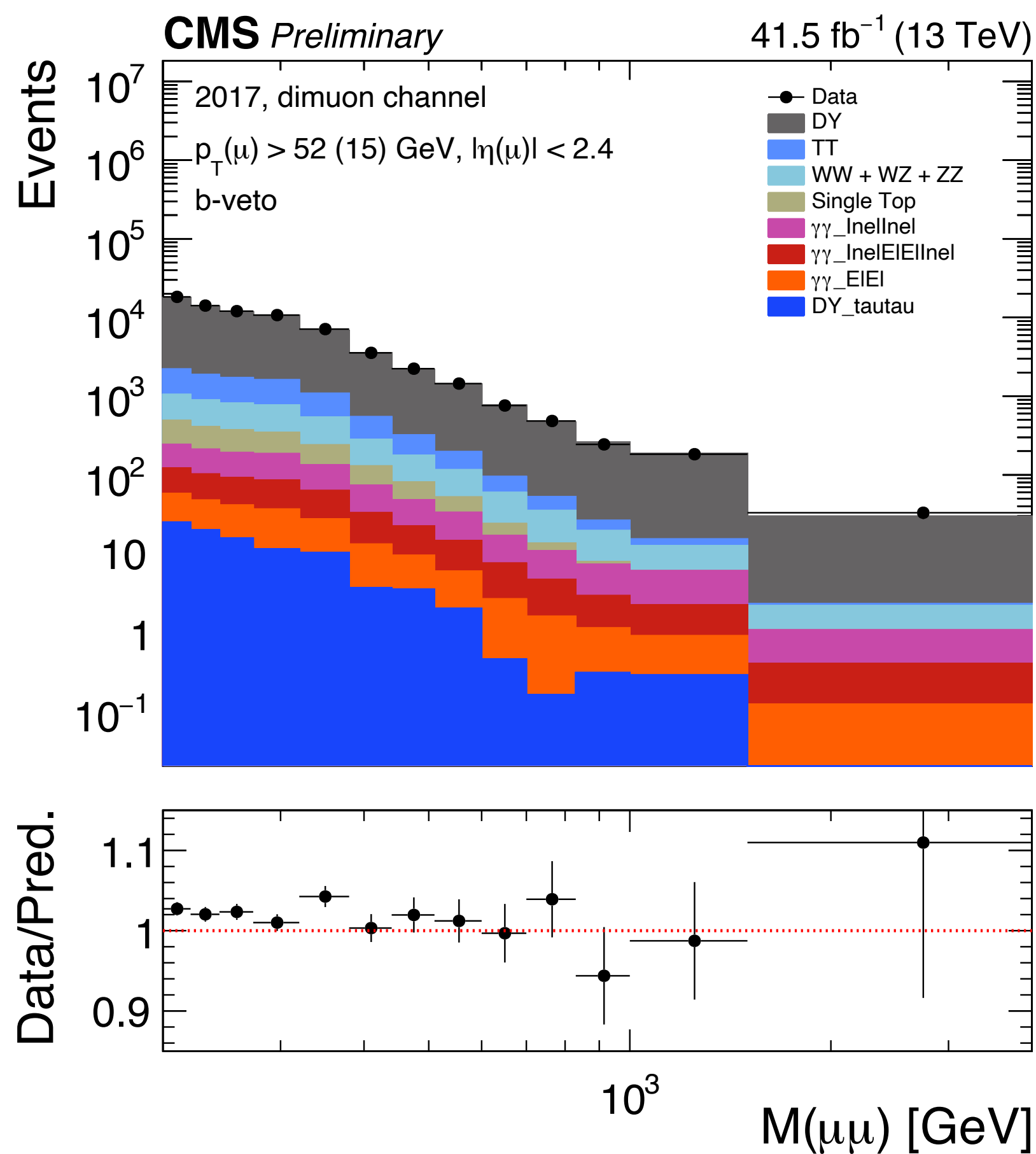


⌘ CAVEAT: results in this slide are inclusive in jets

Data vs. MC: control plot @ high mass

2017, b-veto (other eras on backup)

Di-muon distribution

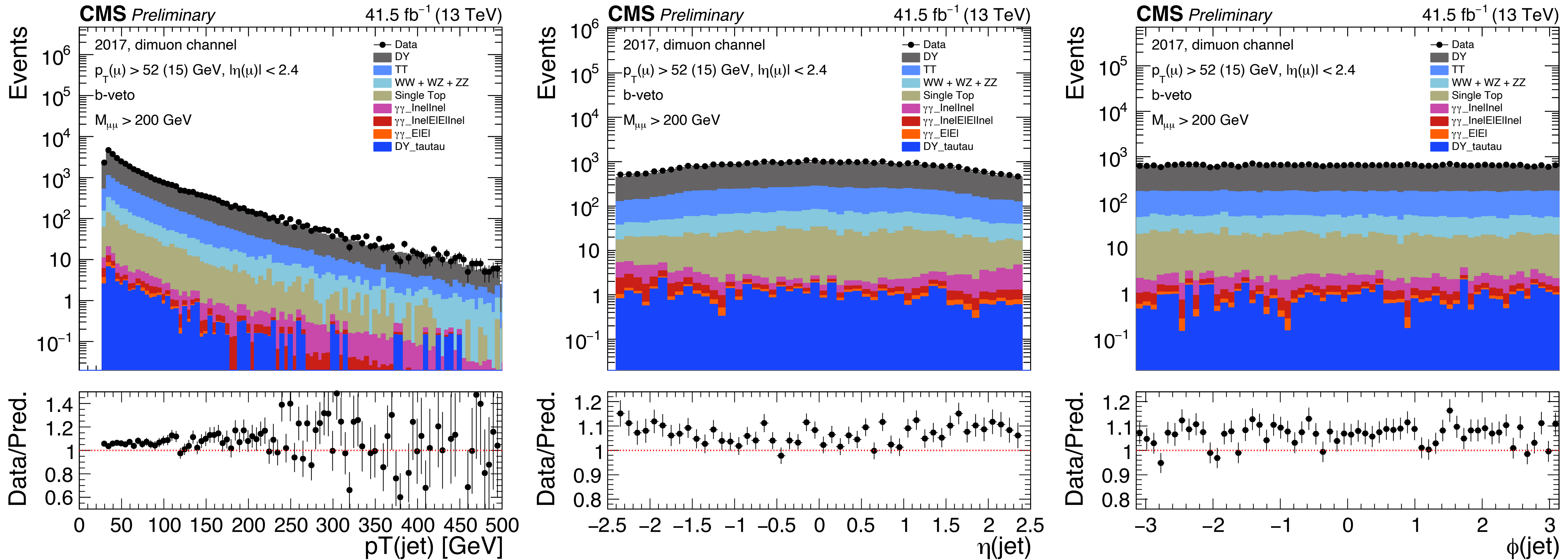


⌘ **CAVEAT:** results in this slide are inclusive in jets

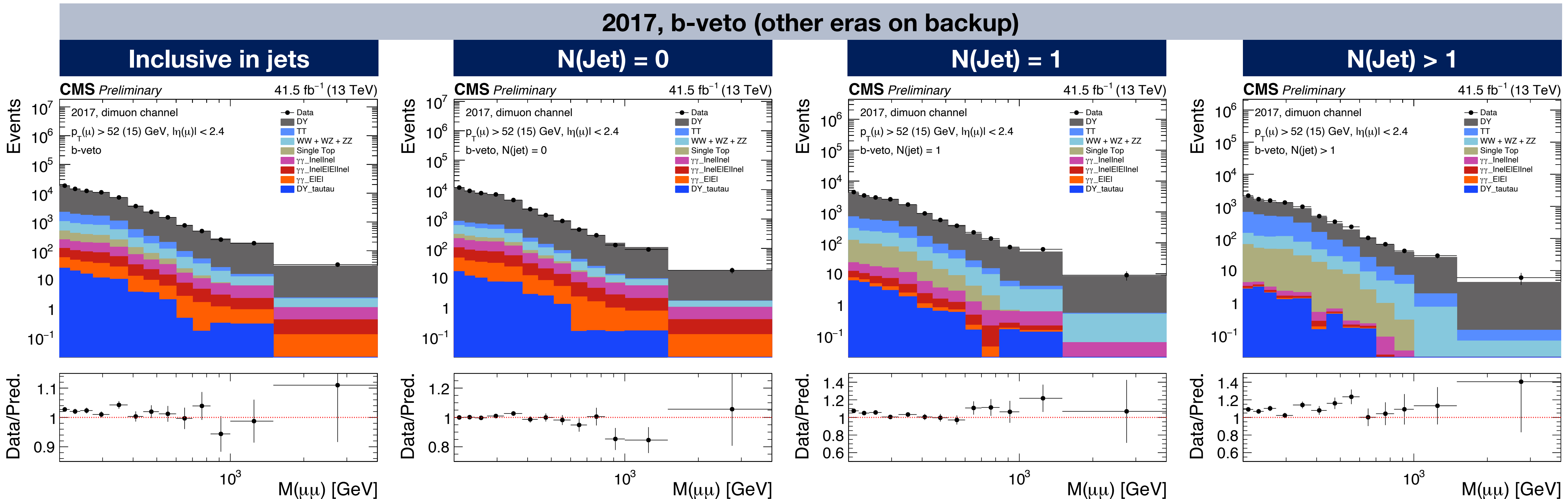
Data vs. MC: control plot @ high mass

2017, b-veto (other eras on backup)

Jet distribution (inclusive in jets)



Data vs. MC: control plot @ high mass



© Dimuon mass distributions w.r.t jet multiplicity

- ▶ have good agreement up to 1 TeV,
- ▶ From 1 to 4 TeV, data to MC ratio agreed within statistical uncertainty
- ▶ **CAVEAT: mass binning will be updated**

Charged DY

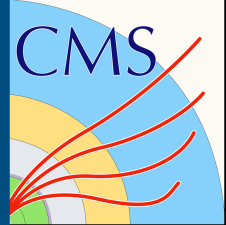
Type	Era	Sample name
Data	2016 preVFP	<u>/SingleMuon/Run2016B-ver1_HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD</u>
		<u>/SingleMuon/Run2016B-ver2_HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD</u>
		<u>/SingleMuon/Run2016C-HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD</u>
		<u>/SingleMuon/Run2016D-HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD</u>
		<u>/SingleMuon/Run2016E-HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD</u>
		<u>/SingleMuon/Run2016F-HIPM_UL2016_MiniAODv2_NanoAODv9-v2/NANOAOD</u>
	2016 postVFP	<u>/SingleMuon/Run2016F-UL2016_MiniAODv2_NanoAODv9-v1/NANOAOD</u>
		<u>/SingleMuon/Run2016G-UL2016_MiniAODv2_NanoAODv9-v1/NANOAOD</u>
		<u>/SingleMuon/Run2016H-UL2016_MiniAODv2_NanoAODv9-v1/NANOAOD</u>
	2017	<u>/SingleMuon/Run2017B-UL2017_MiniAODv2_NanoAODv9_GT36-v1/NANOAOD</u>
		<u>/SingleMuon/Run2017C-UL2017_MiniAODv2_NanoAODv9_GT36-v1/NANOAOD</u>
		<u>/SingleMuon/Run2017D-UL2017_MiniAODv2_NanoAODv9_GT36-v1/NANOAOD</u>
		<u>/SingleMuon/Run2017E-UL2017_MiniAODv2_NanoAODv9_GT36-v2/NANOAOD</u>
		<u>/SingleMuon/Run2017F-UL2017_MiniAODv2_NanoAODv9_GT36-v1/NANOAOD</u>
		<u>/SingleMuon/Run2017G-UL2017_MiniAODv2_NanoAODv9_GT36-v1/NANOAOD</u>
		<u>/SingleMuon/Run2017G-UL2017_MiniAODv2_NanoAODv9_GT36-v2/NANOAOD</u>
		<u>/SingleMuon/Run2017H-UL2017_MiniAODv2_NanoAODv9_GT36-v1/NANOAOD</u>
	2018	<u>/SingleMuon/Run2018A-UL2018_MiniAODv2_NanoAODv9_GT36-v1/NANOAOD</u>
		<u>/SingleMuon/Run2018B-UL2018_MiniAODv2_NanoAODv9_GT36-v1/NANOAOD</u>
		<u>/SingleMuon/Run2018C-UL2018_MiniAODv2_NanoAODv9_GT36-v1/NANOAOD</u>
		<u>/SingleMuon/Run2018D-UL2018_MiniAODv2_NanoAODv9_GT36-v1/NANOAOD</u>

Type	Era	Process	Sample name
MC (Sig)	2016 preVFP	Onshell inclusive WJetsToLNu	/WJetsToLNu_TuneCP5_13TeV-amcatnloFXFX-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM
		Boosted onshell WJetsTLNu	/WJetsToLNu_HT-100To200_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/WJetsToLNu_HT-100To200_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext1-v3/NANOAODSIM
			/WJetsToLNu_HT-200To400_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/WJetsToLNu_HT-200To400_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext1-v3/NANOAODSIM
			/WJetsToLNu_HT-400To600_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/WJetsToLNu_HT-400To600_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext1-v1/NANOAODSIM
			/WJetsToLNu_HT-400To600_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext2-v3/NANOAODSIM
			/WJetsToLNu_HT-600To800_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
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			/WJetsToLNu_HT-800To1200_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext1-v2/NANOAODSIM
			/WJetsToLNu_HT-800To1200_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext2-v3/NANOAODSIM
			/WJetsToLNu_HT-1200To2500_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/WJetsToLNu_HT-1200To2500_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext1-v2/NANOAODSIM
			/WJetsToLNu_HT-1200To2500_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext2-v3/NANOAODSIM
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			/WJetsToLNu_HT-2500ToInf_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext2-v3/NANOAODSIM
		Offshell WToMuNu	/WToMuNu_M-100_TuneCP5_13TeV-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/WToMuNu_M-200_TuneCP5_13TeV-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
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Type	Era	Process	Sample name
MC (Bkg)	2016 preVFP	Offshell WToTauNu	/WToTauNu_M-100_TuneCP5_13TeV-pythia8-tauola/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
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			/WToTauNu_M-500_TuneCP5_13TeV_pythia8-tauola/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM
			/WToTauNu_M-1000_TuneCP5_13TeV_pythia8-tauola/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM
			/WToTauNu_M-2000_TuneCP5_13TeV_pythia8-tauola/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM
		Single top	/ST_s-channel_4f_leptonDecays_TuneCP5_13TeV-amcatnlo-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/ST_t-channel_top_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/ST_t-channel_antitop_4f_InclusiveDecays_TuneCP5_13TeV-powheg-madspin-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/ST_tW_top_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/ST_tW_antitop_5f_inclusiveDecays_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
		TTbar	/TTTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/TTToSemiLeptonic_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
		WGamma	/WGToLNUg_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
		Diboson	/WWTo1L1Nu2Q_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
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			/WWTo2L2Nu_TuneCP5_13TeV-powheg-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/WZTo1L1Nu2Q_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/WZTo3LNU_TuneCP5_13TeV-amcatnloFXFX-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/WZTo2Q2Nu_4f_TuneCP5_13TeV-amcatnloFXFX-madspin-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v2/NANOAODSIM
			/WZTo1L3Nu_4f_TuneCP5_13TeV-amcatnloFXFX-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/ZZ_TuneCP5_13TeV-pythia8/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
		neutral DY	/DYJetsToMuMu_M-50_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANOAODSIM
			/DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11-v1/NANQAQDSIM
			/DYJetsToMuMu_M-10to50_H2ErratumFix_TuneCP5_13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODAPVv9-106X_mcRun2_asymptotic_preVFP_v11_ext1-v1/NANOAODSIM



Data/MC sample details



Type	Era	Process	Sample name
MC (Sig)	2016 postVFP	Onshell inclusive WJetsToLNu	/WJetsToLNu_TuneCP5_13TeV-amcatnloFXFX-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM
		Boosted onshell WJetsTLNu	/WJetsToLNu_HT-100To200_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM
			/WJetsToLNu_HT-100To200_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17_ext1-v3/NANOAODSIM
			/WJetsToLNu_HT-200To400_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM
			/WJetsToLNu_HT-200To400_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17_ext1-v3/NANOAODSIM
			/WJetsToLNu_HT-400To600_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM
			/WJetsToLNu_HT-400To600_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17_ext2-v3/NANOAODSIM
			/WJetsToLNu_HT-600To800_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM
			/WJetsToLNu_HT-600To800_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17_ext2-v3/NANOAODSIM
			/WJetsToLNu_HT-800To1200_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM
			/WJetsToLNu_HT-800To1200_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17_ext2-v3/NANOAODSIM
			/WJetsToLNu_HT-1200To2500_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM
			/WJetsToLNu_HT-1200To2500_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17_ext2-v3/NANOAODSIM
			/WJetsToLNu_HT-2500ToInf_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM
			/WJetsToLNu_HT-2500ToInf_TuneCP5_13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17_ext2-v3/NANOAODSIM
		Offshell WToMuNu	/WToMuNu_M-100_TuneCP5_13TeV-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM
			/WToMuNu_M-200_TuneCP5_13TeV-pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v1/NANOAODSIM
			/WToMuNu_M-200_TuneCP5_13TeV_pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM
			/WToMuNu_M-500_TuneCP5_13TeV_pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM
			/WToMuNu_M-1000_TuneCP5_13TeV_pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM
			/WToMuNu_M-2000_TuneCP5_13TeV_pythia8/RunIISummer20UL16NanoAODv9-106X_mcRun2_asymptotic_v17-v2/NANOAODSIM

Type	Era	Process	Sample name
MC (Bkg)	2016 postVFP	Offshell WToTauNu	/WToTauNu M-100 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/WToTauNu M-200 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/WToTauNu M-200 TuneCP5 13TeV pythia8-tauola/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v2/NANOAODSIM
			/WToTauNu M-500 TuneCP5 13TeV pythia8-tauola/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v2/NANOAODSIM
			/WToTauNu M-1000 TuneCP5 13TeV pythia8-tauola/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v2/NANOAODSIM
			/WToTauNu M-2000 TuneCP5 13TeV pythia8-tauola/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v2/NANOAODSIM
		Single top	/ST s-channel 4f leptonDecays TuneCP5 13TeV-amcatnlo-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/ST t-channel top 4f InclusiveDecays TuneCP5 13TeV-powheg-madspin-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/ST t-channel antitop 4f InclusiveDecays TuneCP5 13TeV-powheg-madspin-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/ST tW top 5f inclusiveDecays TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v2/NANOAODSIM
			/ST tW antitop 5f inclusiveDecays TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v2/NANOAODSIM
		TTbar	/TTTo2L2Nu TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/TTToSemiLeptonic TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
		WGamma	/WGToLNUg TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
		Diboson	/WWTo1L1Nu2Q 4f TuneCP5 13TeV-amcatnloFFFX-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/WWTo4Q 4f TuneCP5 13TeV-amcatnloFFFX-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/WWTo2L2Nu TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/WZTo1L1Nu2Q 4f TuneCP5 13TeV-amcatnloFFFX-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/WZTo3LNU TuneCP5 13TeV-amcatnloFFFX-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/WZTo2Q2Nu 4f TuneCP5 13TeV-amcatnloFFFX-madspin-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v2/NANOAODSIM
			/WZTo1L3Nu 4f TuneCP5 13TeV-amcatnloFFFX-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/ZZ TuneCP5 13TeV-pythia8/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
		neutral DY	/DYJetsToMuMu M-50 TuneCP5 13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/DYJetsToMuMu M-10to50 H2ErratumFix TuneCP5 13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17-v1/NANOAODSIM
			/DYJetsToMuMu M-10to50 H2ErratumFix TuneCP5 13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL16NanoAODv9-106X mcRun2 asymptotic v17_ext1-v1/NANOAODSIM

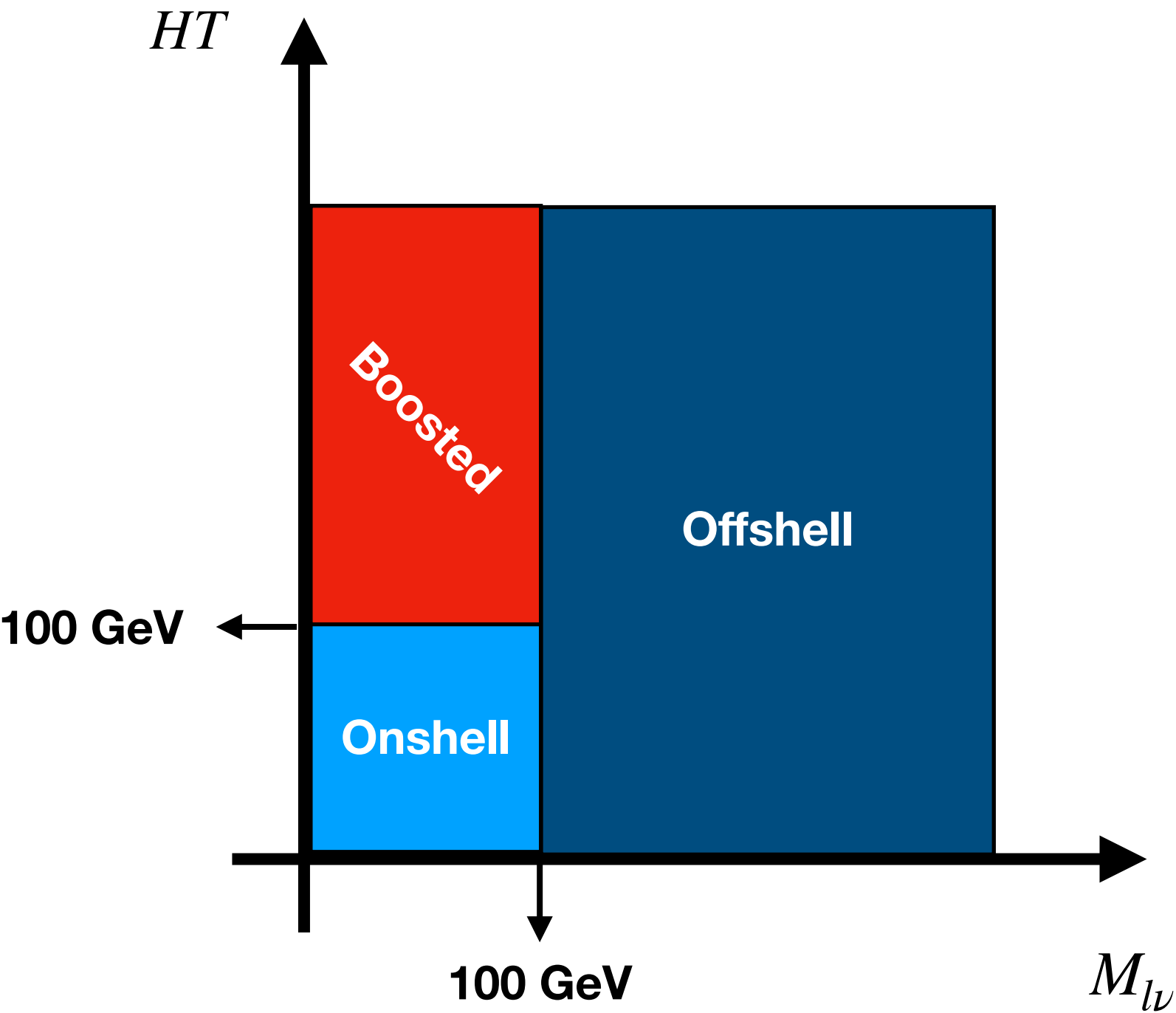
Type	Era	Process	Sample name
MC (Sig)	2017	Onshell inclusive WJetsToLNu	/WJetsToLNu TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v2/NANOAODSIM
		Boosted onshell WJetsTLNu	/WJetsToLNu HT-100To200 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WJetsToLNu HT-100To200 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext1-v3/NANOAODSIM
			/WJetsToLNu HT-200To400 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WJetsToLNu HT-200To400 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext1-v3/NANOAODSIM
			/WJetsToLNu HT-400To600 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WJetsToLNu HT-400To600 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext1-v2/NANOAODSIM
			/WJetsToLNu HT-400To600 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext2-v3/NANOAODSIM
			/WJetsToLNu HT-600To800 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WJetsToLNu HT-600To800 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext1-v2/NANOAODSIM
			/WJetsToLNu HT-600To800 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext2-v3/NANOAODSIM
			/WJetsToLNu HT-800To1200 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v3/NANOAODSIM
			/WJetsToLNu HT-800To1200 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext1-v2/NANOAODSIM
			/WJetsToLNu HT-800To1200 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext2-v3/NANOAODSIM
			/WJetsToLNu HT-1200To2500 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WJetsToLNu HT-1200To2500 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext1-v2/NANOAODSIM
			/WJetsToLNu HT-1200To2500 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext2-v3/NANOAODSIM
			/WJetsToLNu HT-2500ToInf TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v2/NANOAODSIM
			/WJetsToLNu HT-2500ToInf TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext1-v3/NANOAODSIM
			/WJetsToLNu HT-2500ToInf TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9_ext2-v3/NANOAODSIM
		Offshell WToMuNu	/WToMuNu M-100 TuneCP5 13TeV-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v2/NANOAODSIM
			/WToMuNu M-200 TuneCP5 13TeV-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WToMuNu M-500 TuneCP5 13TeV-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WToMuNu M-1000 TuneCP5 13TeV-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WToMuNu M-2000 TuneCP5 13TeV-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM

Type	Era	Process	Sample name
MC (Bkg)	2017	Offshell WToTauNu	/WToTauNu M-100 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v2/NANOAODSIM
			/WToTauNu M-200 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WToTauNu M-500 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WToTauNu M-1000 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WToTauNu M-2000 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
		Single top	/ST s-channel 4f leptonDecays TuneCP5 13TeV-amcatnlo-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/ST t-channel top 4f InclusiveDecays TuneCP5 13TeV-powheg-madspin-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/ST t-channel antitop 4f InclusiveDecays TuneCP5 13TeV-powheg-madspin-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/ST tW top 5f inclusiveDecays TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v2/NANOAODSIM
			/ST tW antitop 5f inclusiveDecays TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v2/NANOAODSIM
		TTbar	/TTTo2L2Nu TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/TTToSemiLeptonic TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
		WGamma	/WGToLNUg TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
		Diboson	/WWTo1L1Nu2Q 4f TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WWTo4Q 4f TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WWTo2L2Nu TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v2/NANOAODSIM
			/WZTo1L1Nu2Q 4f TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/WZTo3LNU TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v2/NANOAODSIM
			/WZTo2Q2Nu 4f TuneCP5 13TeV-amcatnloFXFX-madspin-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v2/NANOAODSIM
			/WZTo1L3Nu 4f TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/ZZ TuneCP5 13TeV-pythia8/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
		neutral DY	/DYJetsToMuMu M-50 massWgtFix TuneCP5 13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v2/NANOAODSIM
			/DYJetsToMuMu M-10to50 H2ErratumFix TuneCP5 13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9-v1/NANOAODSIM
			/DYJetsToMuMu M-10to50 H2ErratumFix TuneCP5 13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL17NanoAODv9-106X mc2017 realistic v9 ext1-v1/NANOAODSIM

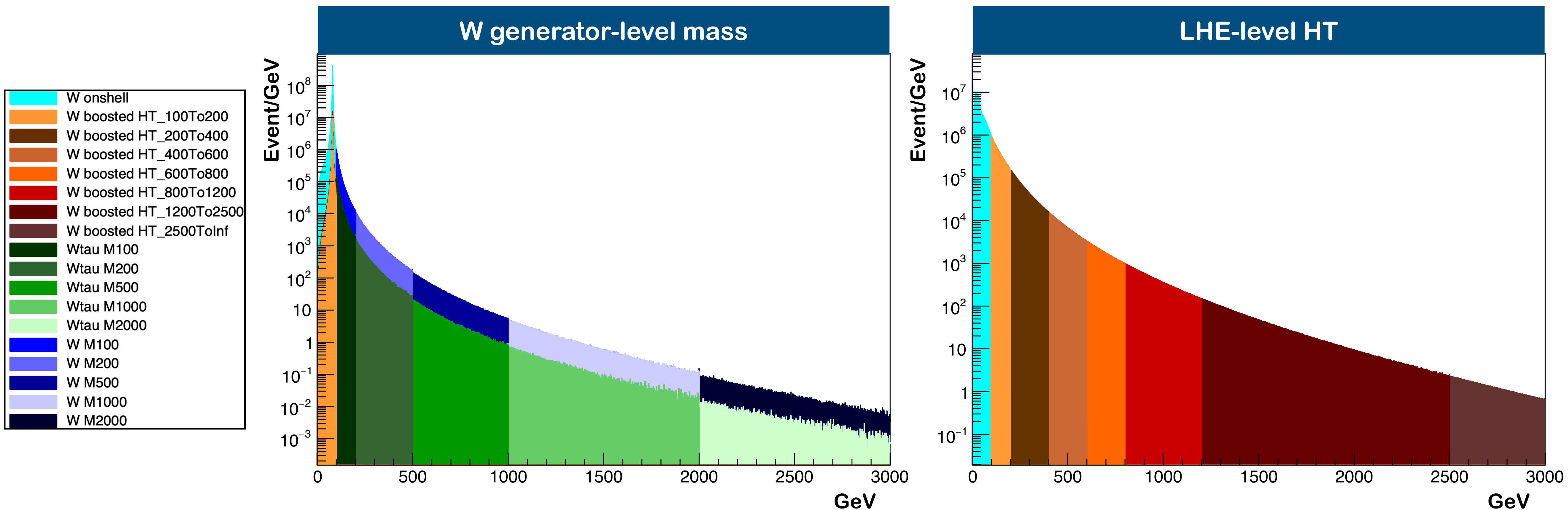
Type	Era	Process	Sample name
MC (Bkg)	2017	Offshell WToTauNu	/WToTauNu M-100 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v2/NANOADSIM
			/WToTauNu M-200 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
			/WToTauNu M-500 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
			/WToTauNu M-1000 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
			/WToTauNu M-2000 TuneCP5 13TeV-pythia8-tauola/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
		Single top	/ST s-channel 4f leptonDecays TuneCP5 13TeV-amcatnlo-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
			/ST t-channel top 4f InclusiveDecays TuneCP5 13TeV-powheg-madspin-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
			/ST t-channel antitop 4f InclusiveDecays TuneCP5 13TeV-powheg-madspin-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
			/ST tW top 5f inclusiveDecays TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v2/NANOADSIM
			/ST tW antitop 5f inclusiveDecays TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v2/NANOADSIM
		TTbar	/TTTo2L2Nu TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
			/TTToSemiLeptonic TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
		WGamma	/WGToLNUg TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
		Diboson	/WWTo1L1Nu2Q 4f TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
			/WWTo4Q 4f TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v2/NANOADSIM
			/WWTo2L2Nu TuneCP5 13TeV-powheg-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v2/NANOADSIM
			/WZTo1L1Nu2Q 4f TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
			/WZTo3LNU TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v2/NANOADSIM
			/WZTo2Q2Nu 4f TuneCP5 13TeV-amcatnloFXFX-madspin-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v3/NANOADSIM
			/WZTo1L3Nu 4f TuneCP5 13TeV-amcatnloFXFX-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
			/ZZ TuneCP5 13TeV-pythia8/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
		neutral DY	/DYJetsToMuMu M-50 massWgtFix TuneCP5 13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v2/NANOADSIM
			/DYJetsToMuMu M-10to50 H2ErratumFix TuneCP5 13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1-v1/NANOADSIM
			/DYJetsToMuMu M-10to50 H2ErratumFix TuneCP5 13TeV-powhegMiNNLO-pythia8-photos/RunIISummer20UL18NanoAODv9-106X upgrade2018 realistic v16 L1v1_ext1-v1/NANOADSIM

Type	Era	Process	Sample name
MC (Sig)	2018	Onshell inclusive WJetsToLNu	/WJetsToLNu TuneCP5 13TeV-amcatnloFFFX-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM
		Boosted onshell WJetsTLNu	/WJetsToLNu HT-100To200 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM
			/WJetsToLNu HT-100To200 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext1-v3/NANOAODSIM
			/WJetsToLNu HT-200To400 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM
			/WJetsToLNu HT-200To400 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext1-v3/NANOAODSIM
			/WJetsToLNu HT-400To600 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM
			/WJetsToLNu HT-400To600 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext1-v2/NANOAODSIM
			/WJetsToLNu HT-400To600 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext2-v3/NANOAODSIM
			/WJetsToLNu HT-600To800 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM
			/WJetsToLNu HT-600To800 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext1-v2/NANOAODSIM
			/WJetsToLNu HT-600To800 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext2-v3/NANOAODSIM
			/WJetsToLNu HT-800To1200 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM
			/WJetsToLNu HT-800To1200 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext1-v2/NANOAODSIM
			/WJetsToLNu HT-800To1200 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext2-v3/NANOAODSIM
			/WJetsToLNu HT-1200To2500 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM
			/WJetsToLNu HT-1200To2500 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext1-v2/NANOAODSIM
			/WJetsToLNu HT-1200To2500 TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext2-v3/NANOAODSIM
			/WJetsToLNu HT-2500ToInf TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM
			/WJetsToLNu HT-2500ToInf TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext1-v2/NANOAODSIM
			/WJetsToLNu HT-2500ToInf TuneCP5 13TeV-madgraphMLM-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1_ext2-v3/NANOAODSIM
		Offshell WToMuNu	/WToMuNu M-100 TuneCP5 13TeV-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v2/NANOAODSIM
			/WToMuNu M-200 TuneCP5 13TeV-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM
			/WToMuNu M-500 TuneCP5 13TeV-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM
			/WToMuNu M-1000 TuneCP5 13TeV-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM
			/WToMuNu M-2000 TuneCP5 13TeV-pythia8/RunIISummer20UL18NanoAODv9-106X_upgrade2018_realistic_v16_L1v1-v1/NANOAODSIM

- Various W samples are merged to **fully cover the wide M_T range** with enough statistics
- Following study from **Run2 W' analysis** ([CADI](#), [JHEP](#))
- Procedure for merging W samples
 - Onshell sample merging
 - Select $M_{l\nu} < 100$ GeV events at generator-level
 - Using the LHE-level HT for event selection
 - $HT < 100$ GeV: **onshell inclusive sample**
 - $HT > 100$ GeV: **onshell boosted sample**
 - Offshell sample merging
 - Merge **high mass binned offshell samples**
 - Apply proper $M_{l\nu}$ cuts for smooth continuity in generator-level mass spectrum
(ex. M-100 + M-200: Select events with $100 \text{ GeV} < M_{l\nu} < 200 \text{ GeV}$ to patch with M-200 sample)
- Apply muon filtering
 - Select events with muon in final state for samples used in patching
- **Higher order cross section normalization**
 - **Both offshell and boosted W samples** are normalized to **NNLO QCD** and **NLO EWK** cross sections, provided by [W' group](#) and [dark matter group](#)



Sample	W mass cut	HT cut	Selected decay channel	k-factor
Onshell inclusive $W \rightarrow l\nu$	$M_{l\nu} < 100 \text{ GeV}$	$HT < 100 \text{ GeV}$	$W \rightarrow \mu\nu, W \rightarrow \tau\nu_\tau \rightarrow \mu\nu_\mu\nu_\tau\nu_\tau$	NNLO (QCD) + NLO (EWK)
Onshell HT-binned $W \rightarrow l\nu$ (divided in 7 samples)		$HT > 100 \text{ GeV}$		NNLO (QCD) + NLO (EWK)
Offshell M(W)-binned ($W \rightarrow \mu\nu$ or $W \rightarrow \tau\nu$, divided in 5 samples)	$M_{l\nu} > 100 \text{ GeV}$	Any HT		NNLO (QCD) + NLO (EWK)

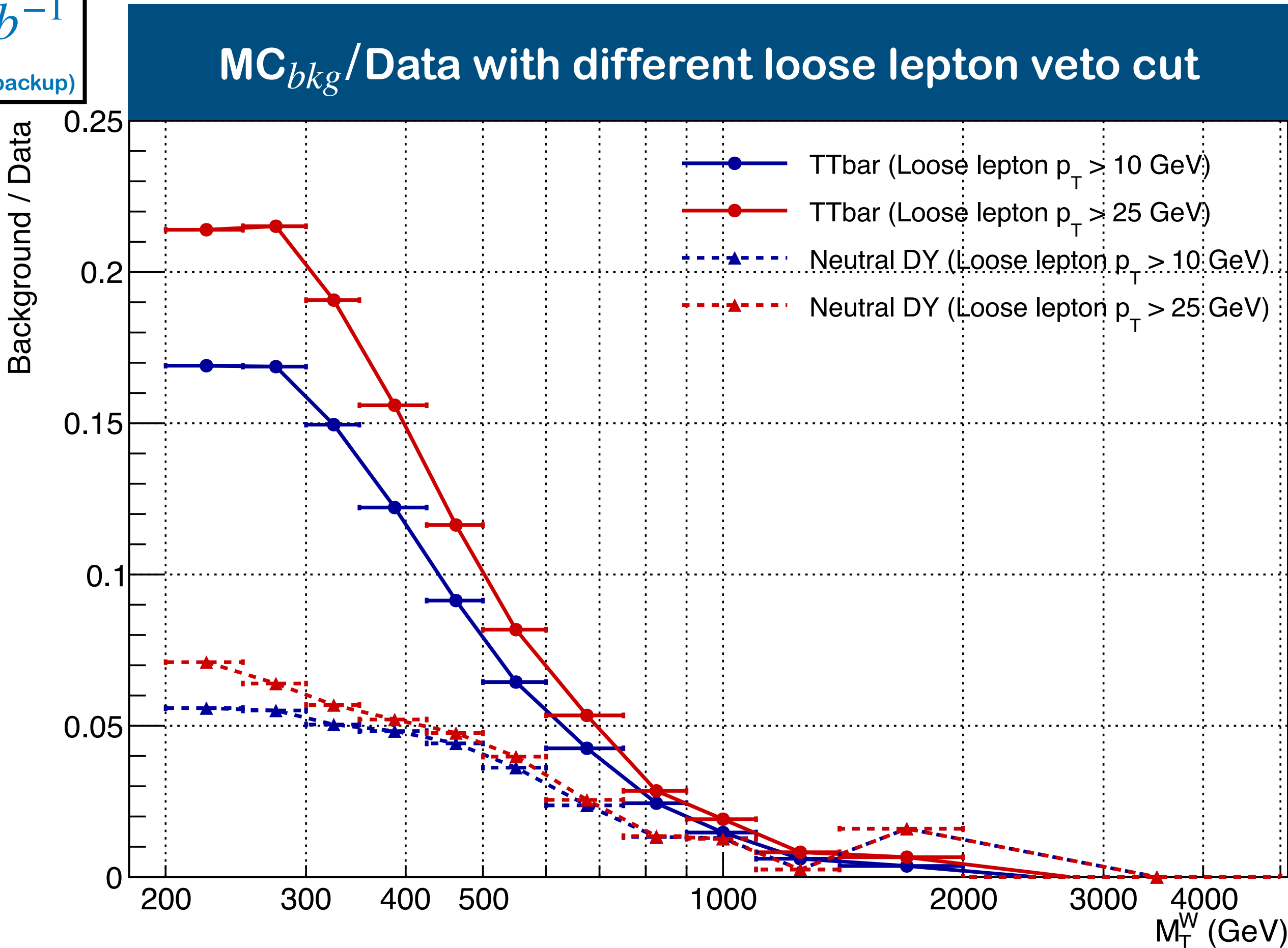


- **4 different samples smoothly patched** over generator level W mass distribution
 - Checked the smoothness by zooming in each patched area (with 1 GeV binning)
- Also checked the **LHE-level HT distribution** is also well patched after applying **k factor** to boosted W samples

2018

59.83 fb^{-1}

(Other eras at backup)



	Loose lepton $p_T > 25\text{GeV}$	Loose lepton $p_T > 10\text{GeV}$	Difference
Data	372340	337296	-35044
Background MC	125200.93	94146.27	-31054.66
TTbar	75770.62	53956.72	-21813.9
Neutral DY	24537.20	18155.12	-6382.08
Diboson	10480.45	9049.31	-1431.14
Single top	8686.46	6355.76	-2330.7
WToTauNu	3605.83	3588.73	-17.1
WGamma	3120.37	3050.62	-69.75

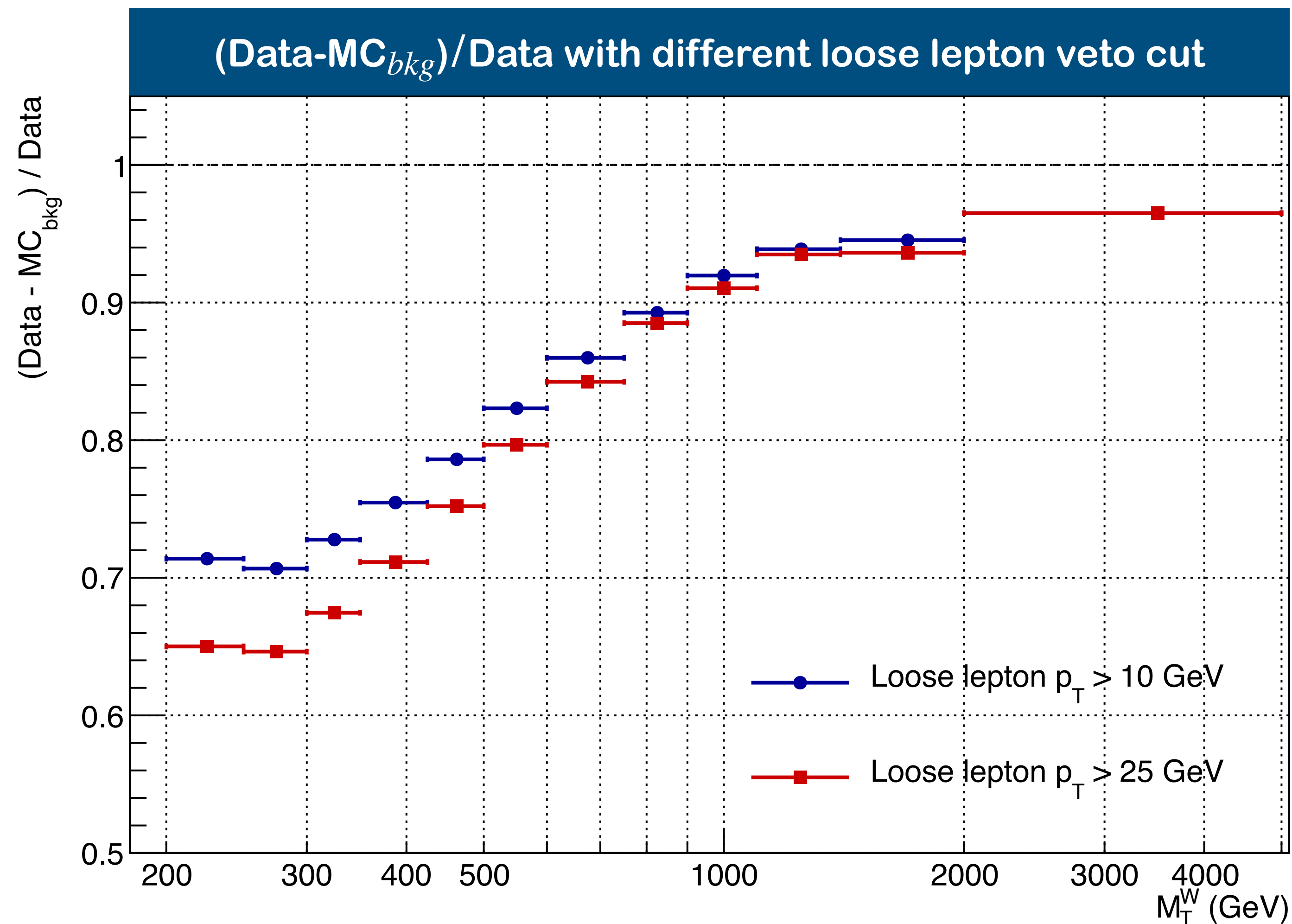
Total # of events for Data and background MCs

- Tried **lowering the loose lepton p_T cut to 10 GeV** to reduce the background
- Checked MC_{bkg}/Data **ratio of two main background processes** ($t\bar{t}$ and neutral DY) as a function of M_T^W
- Lowering the loose lepton p_T efficiently **reduced the backgrounds**

2018

59.83 fb^{-1}

(Other eras at backup)



- Tried **lowering the loose lepton p_T cut to 10 GeV** to reduce the background
- Also checked the Signal/Data ratio: Even though updating the p_T threshold removes some data, it mostly comes from the background, and the **signal ratio increases for overall M_T^W range including high M_T^W region**
- Decided to update the loose lepton p_T threshold to 10 GeV

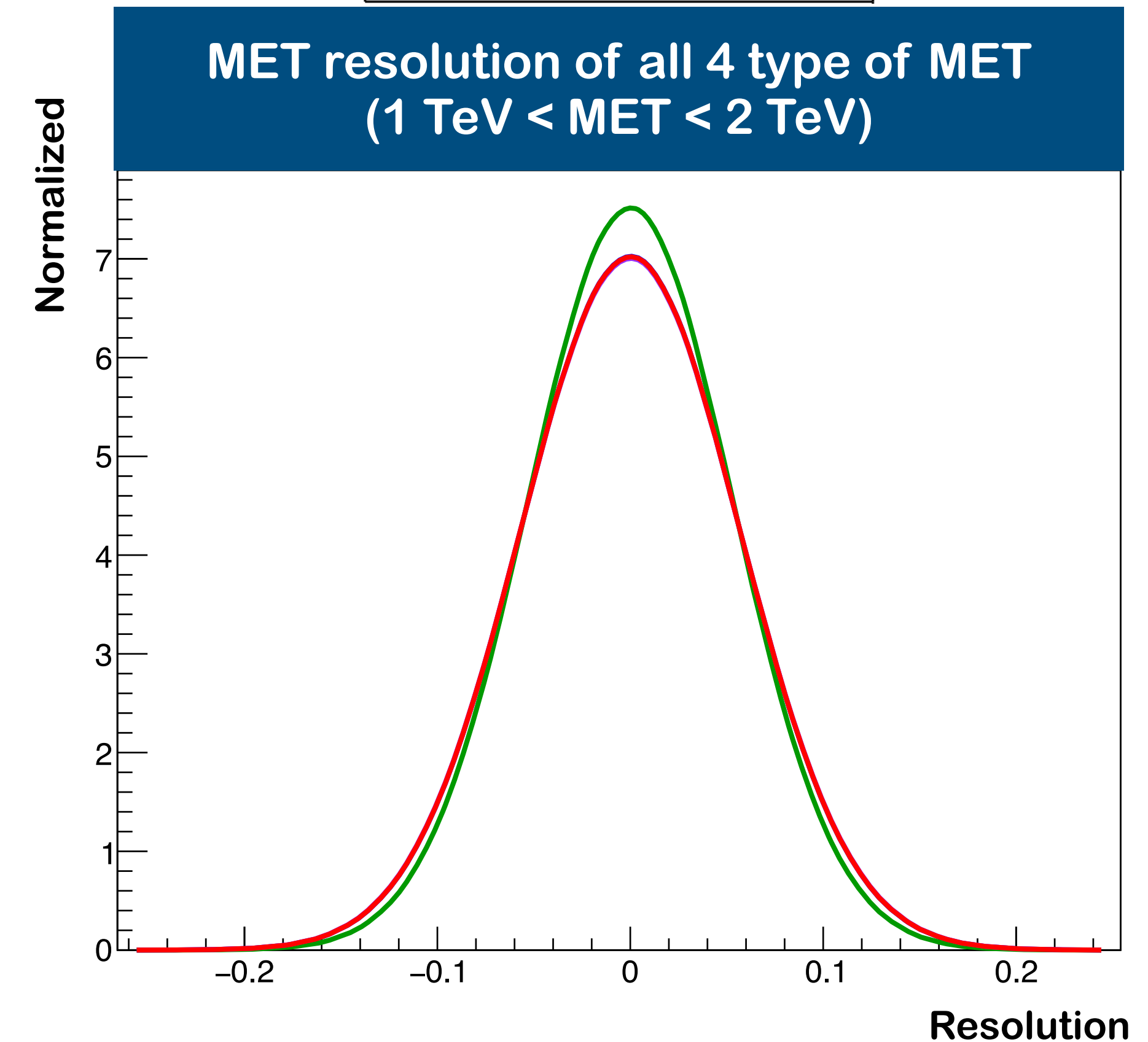
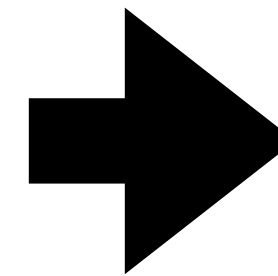
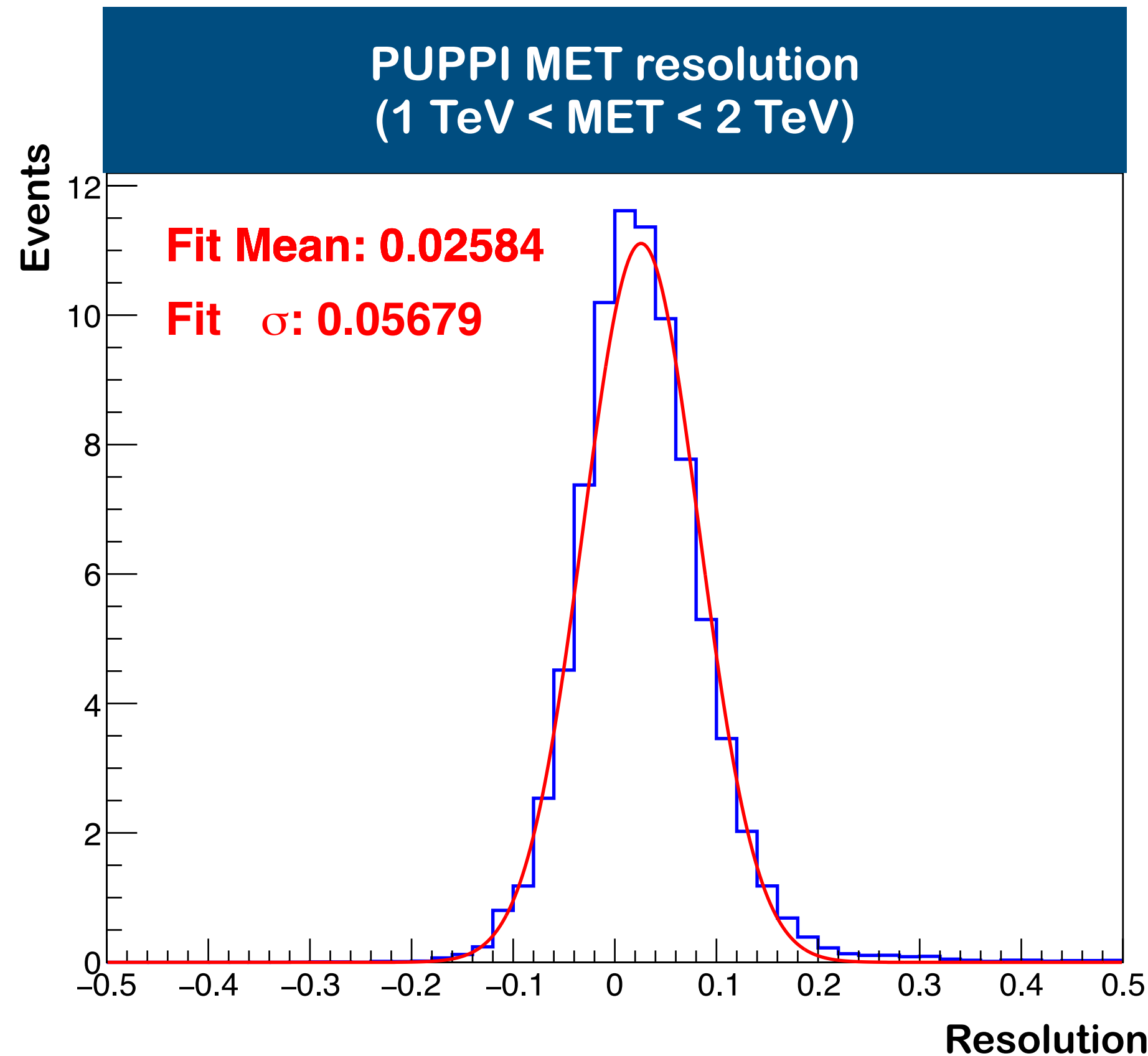
2018

$59.83 fb^{-1}$

(Other eras at backup)

$$\text{MET resolution} = \frac{\text{Reco-lv MET} - \text{Gen-lv MET}}{\text{Gen-lv MET}}$$

— PUPPI MET
— PF MET
— DeepMET (Resolution tune)
— DeepMET (Response tune)



- To decide which MET type to use, checked the **MET and M_T^W resolutions** for each MET type
- Compared the results using PF MET, PUPPI MET, DeepMET (resolution tune), DeepMET (response tune)
- Make histogram of MET (M_T^W) resolution, fit using Gauss, and normalize the fitting result to compare the result with other MET types

Evaluating MET resolution across various MET bins for 4 different MET algorithms

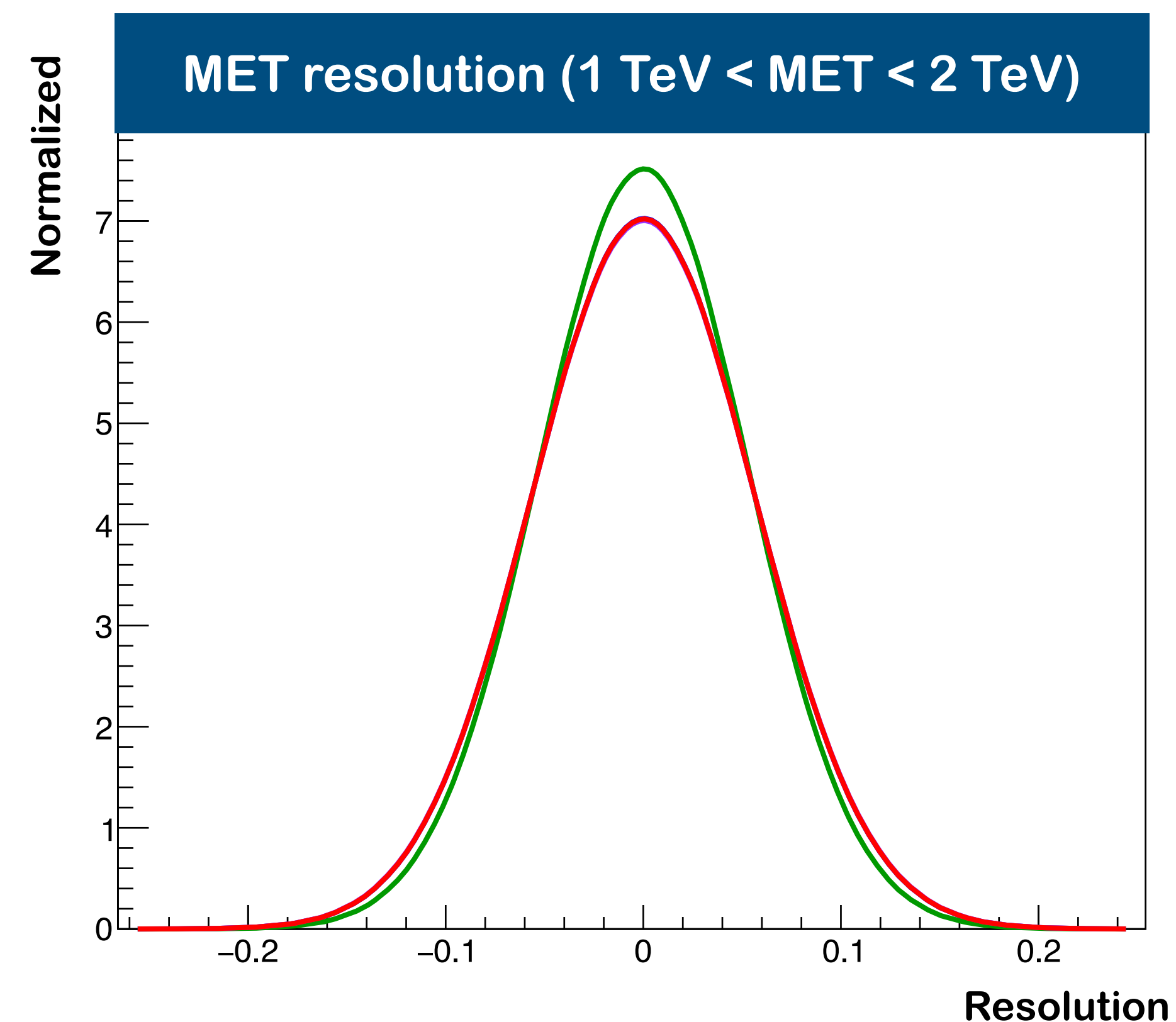
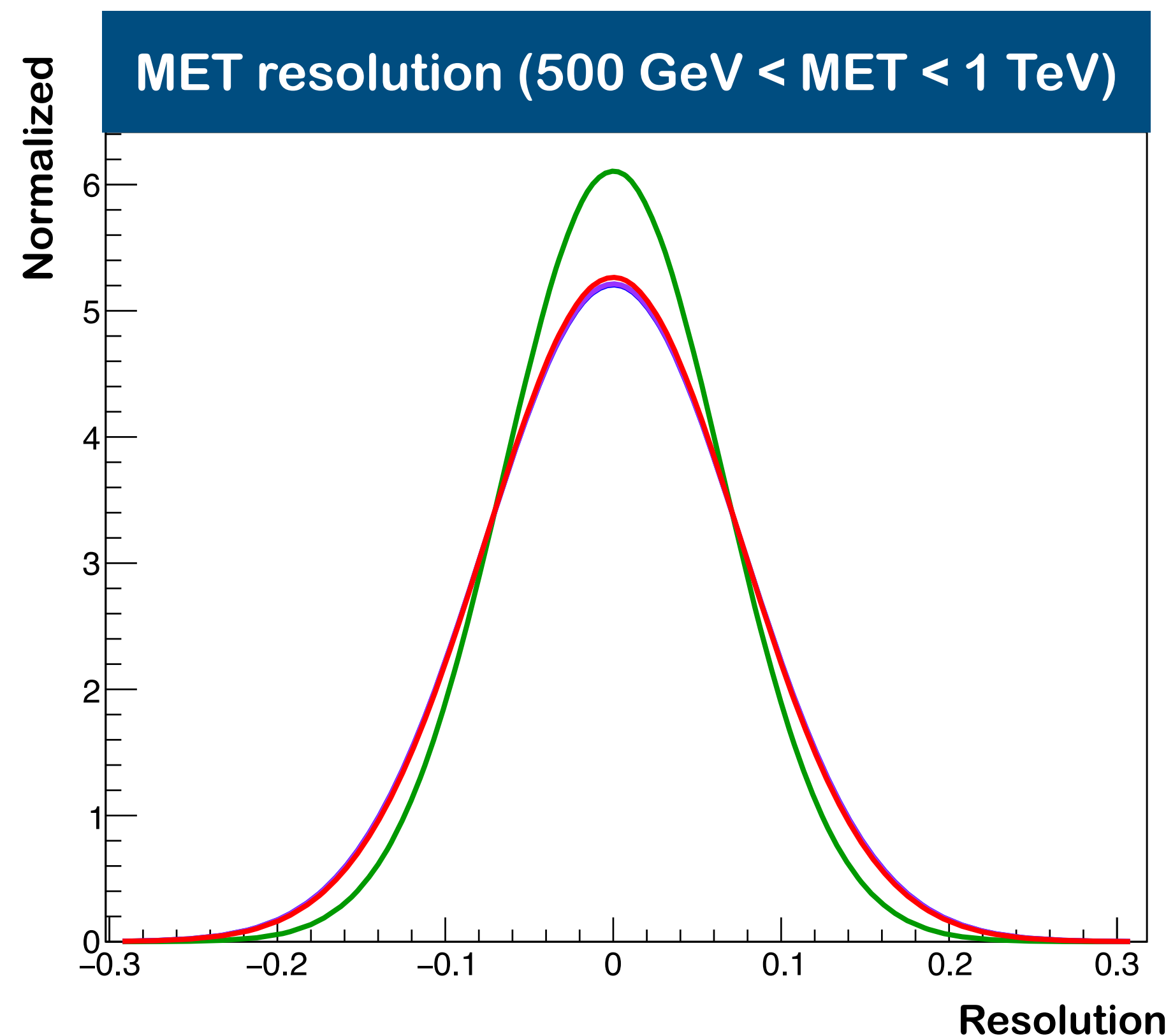
2018

59.83 fb^{-1}

(Other eras at backup)

- PUPPI MET
- PF MET
- DeepMET (Resolution tune)
- DeepMET (Response tune)

$$\text{MET resolution} = \frac{\text{Reco-lv MET} - \text{Gen-lv MET}}{\text{Gen-lv MET}}$$



- To decide which MET type to use, checked the **MET and M_T^W resolutions** for each MET type
- Compared the results using PF MET, PUPPI MET, DeepMET (resolution tune), DeepMET (response tune)
- For the **MET resolution**, **DeepMET (reso. tune)** showed best results

Evaluating M_T^W resolution across various M_T^W bins for 4 different MET algorithms

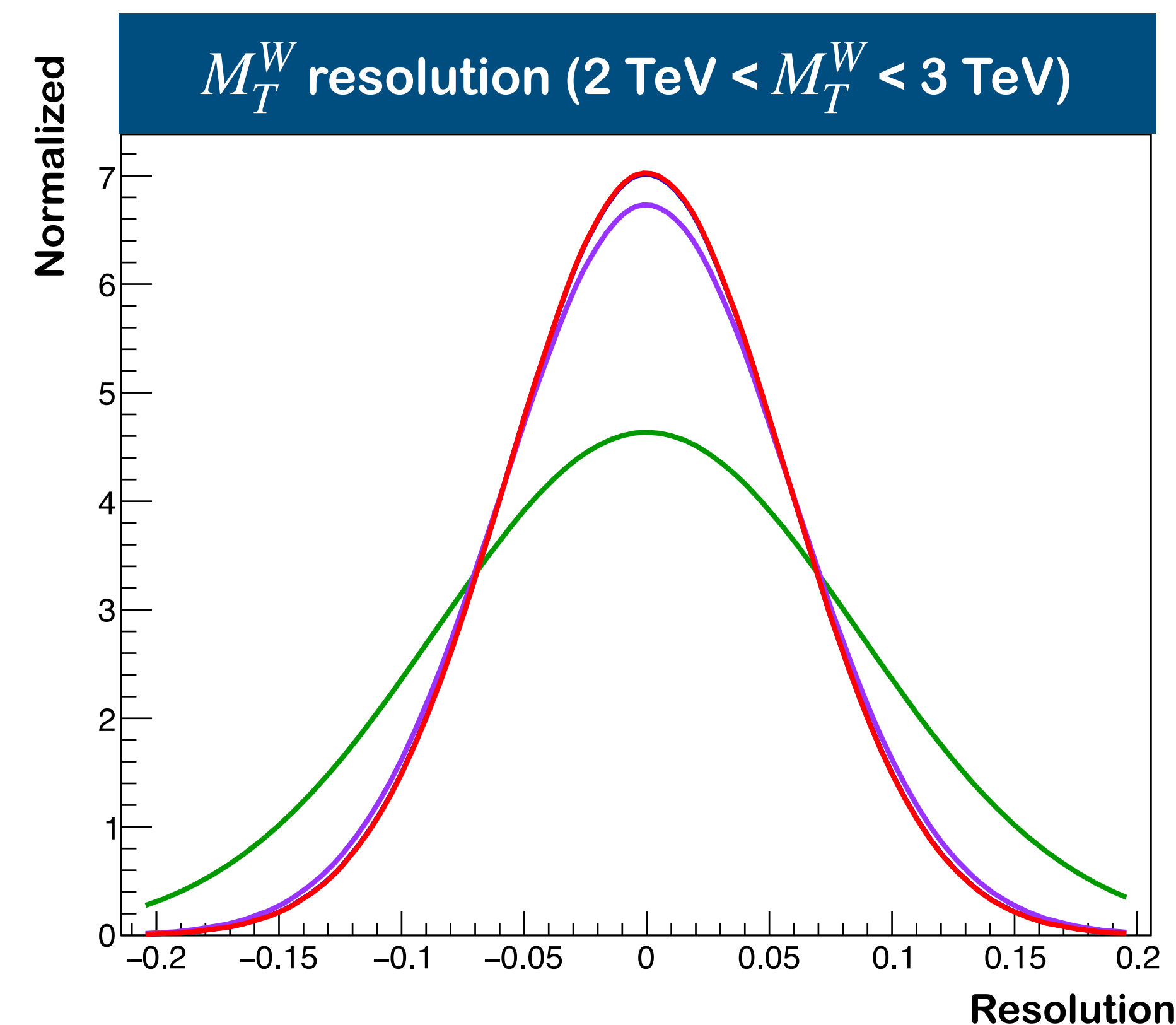
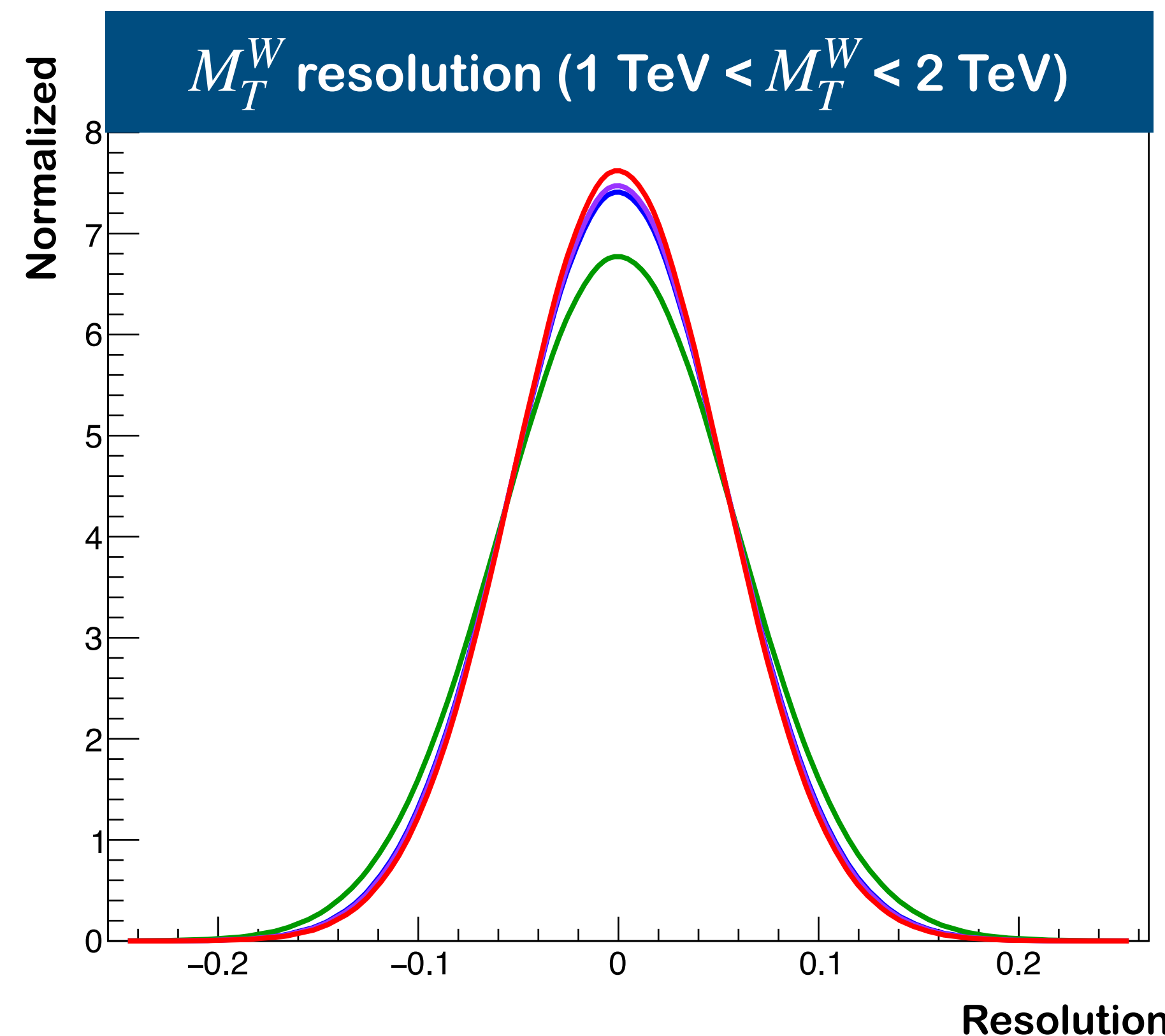
2018

59.83 fb^{-1}

(Other eras at backup)

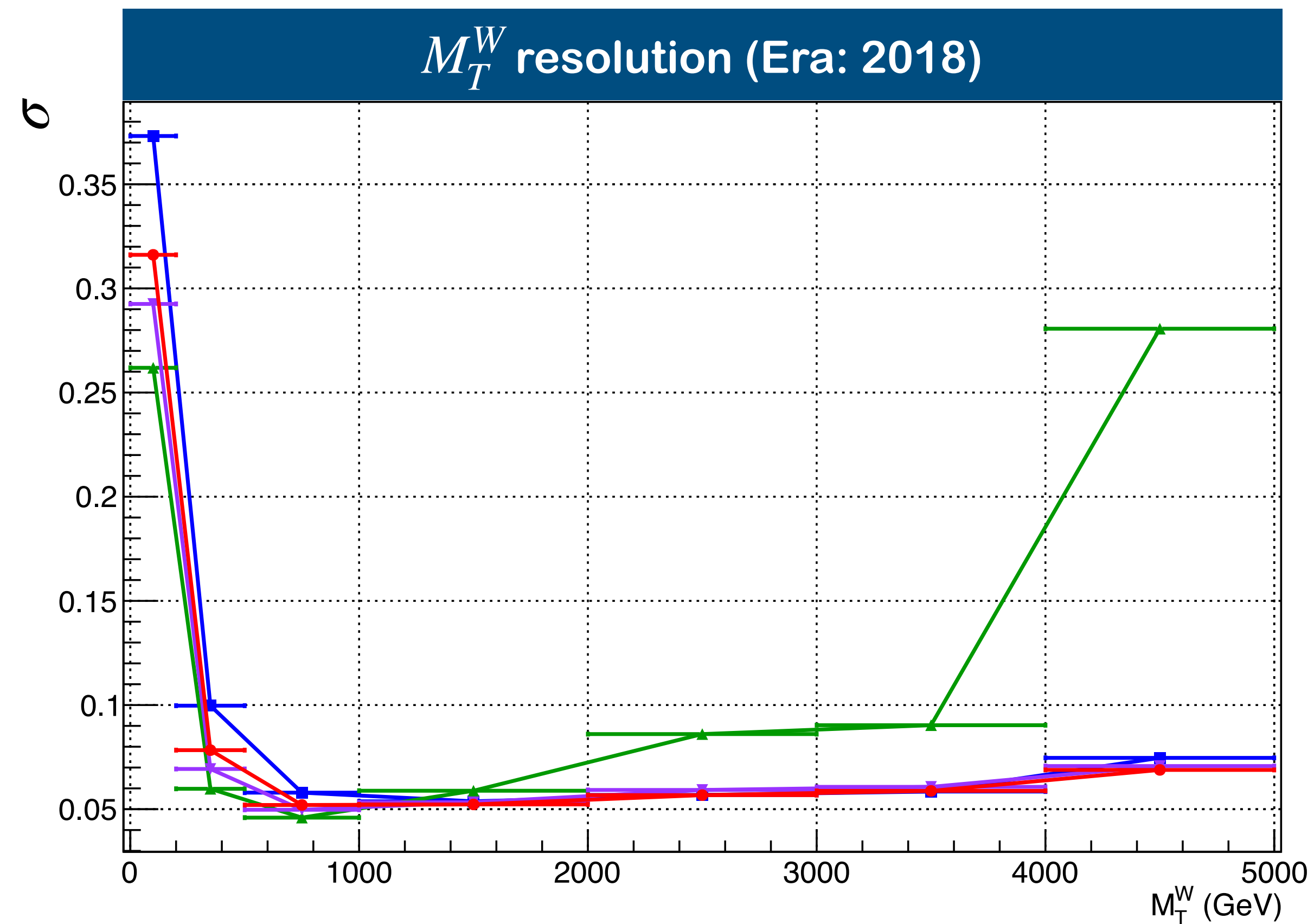
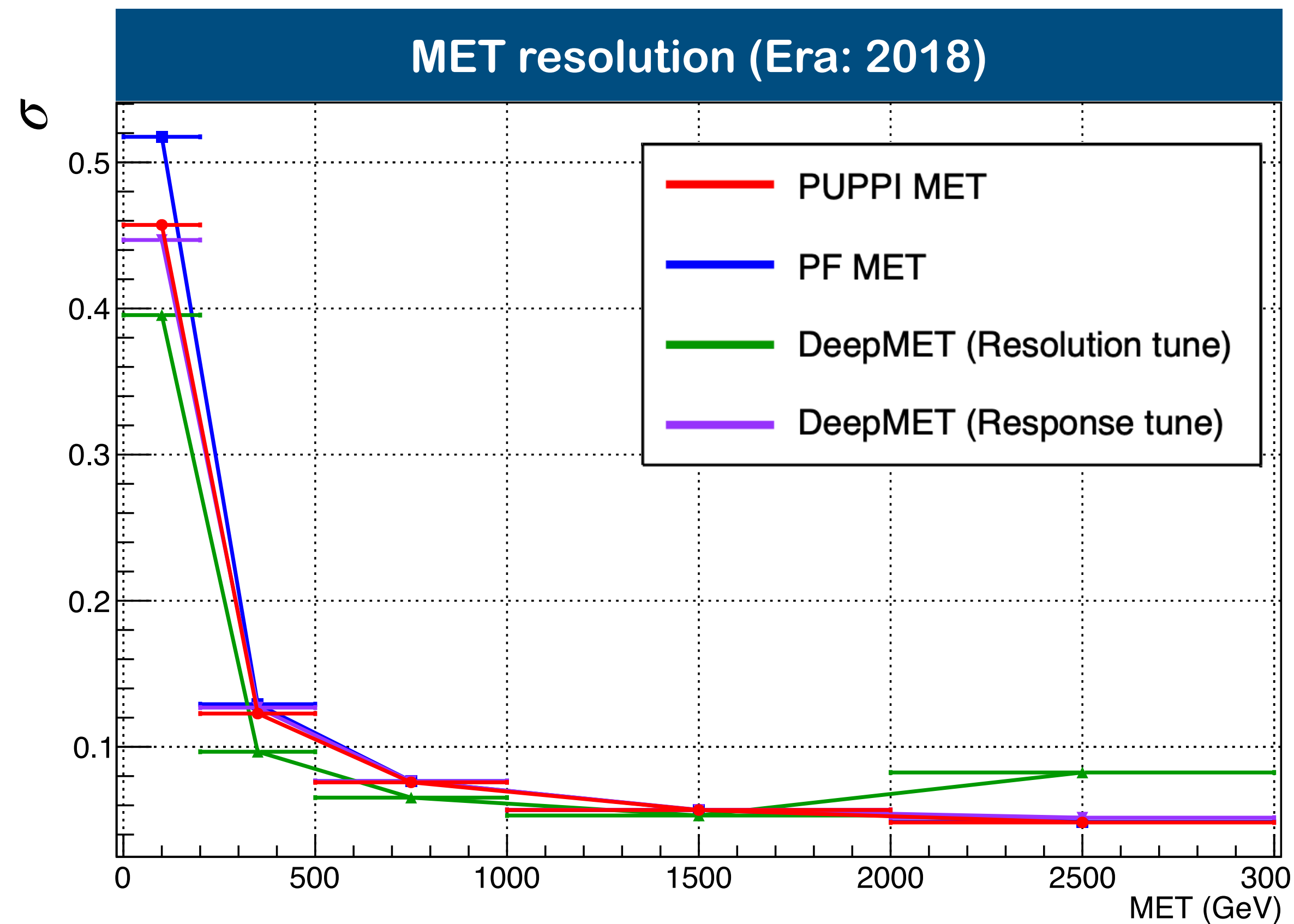
- PUPPI MET
- PF MET
- DeepMET (Resolution tune)
- DeepMET (Response tune)

$$M_T^W \text{ resolution} = \frac{\text{Reco-lv } M_T^W - \text{Gen-lv } M_T^W}{\text{Gen-lv } M_T^W}$$



- To decide which MET type to use, checked the **MET and M_T^W resolutions** for each MET type
- Compared the results using PF MET, PUPPI MET, DeepMET (resolution tune), DeepMET (response tune)
- For the M_T^W resolution, **PUPPI MET** showed best result

MET and M_T^W resolution comparison between 4 MET algorithms

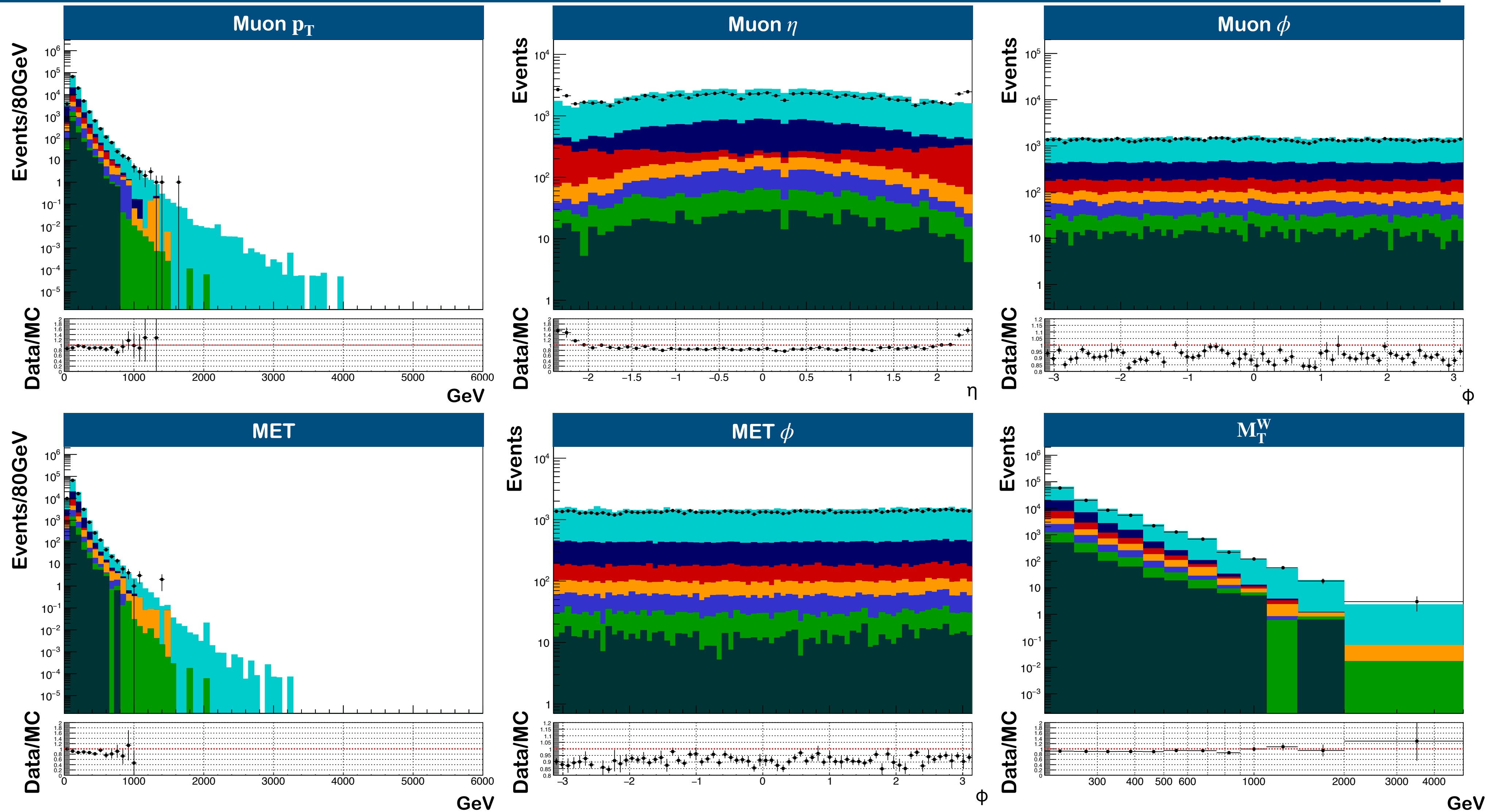
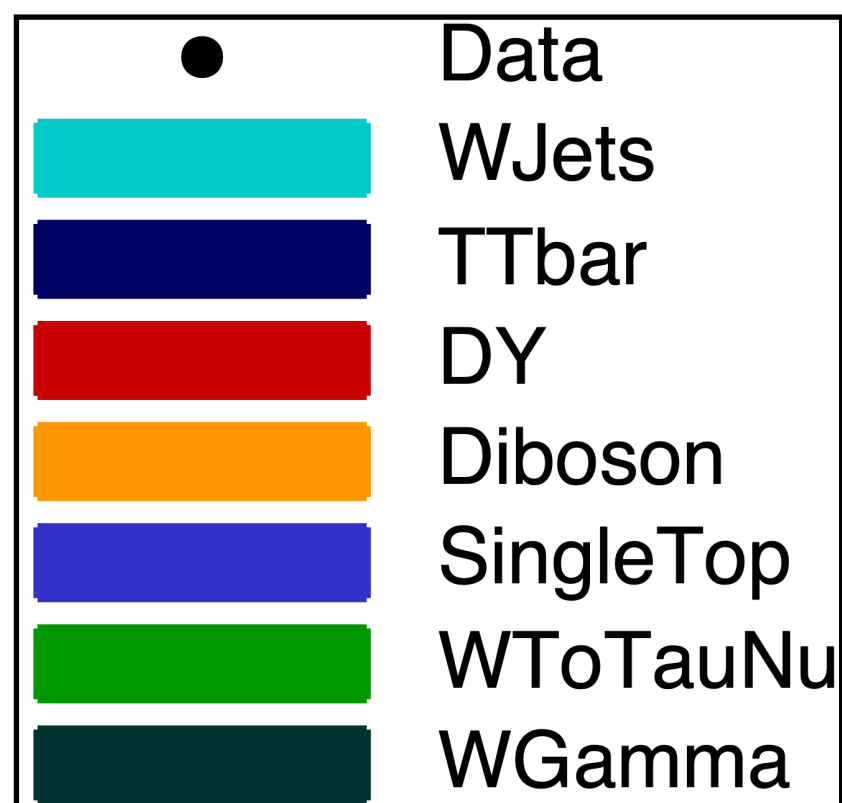


- Checked **sigma value of each MET type** as a function of MET (M_T^W) bins
- DeepMET(reso. tune) shows good resolution for MET up to 2 TeV, while **PUPPI MET shows best M_T^W resolution** for high M_T^W region (over 1 TeV)
- Since our main observable is M_T^W , decided to use **PUPPI MET**

Event, object selection and filter

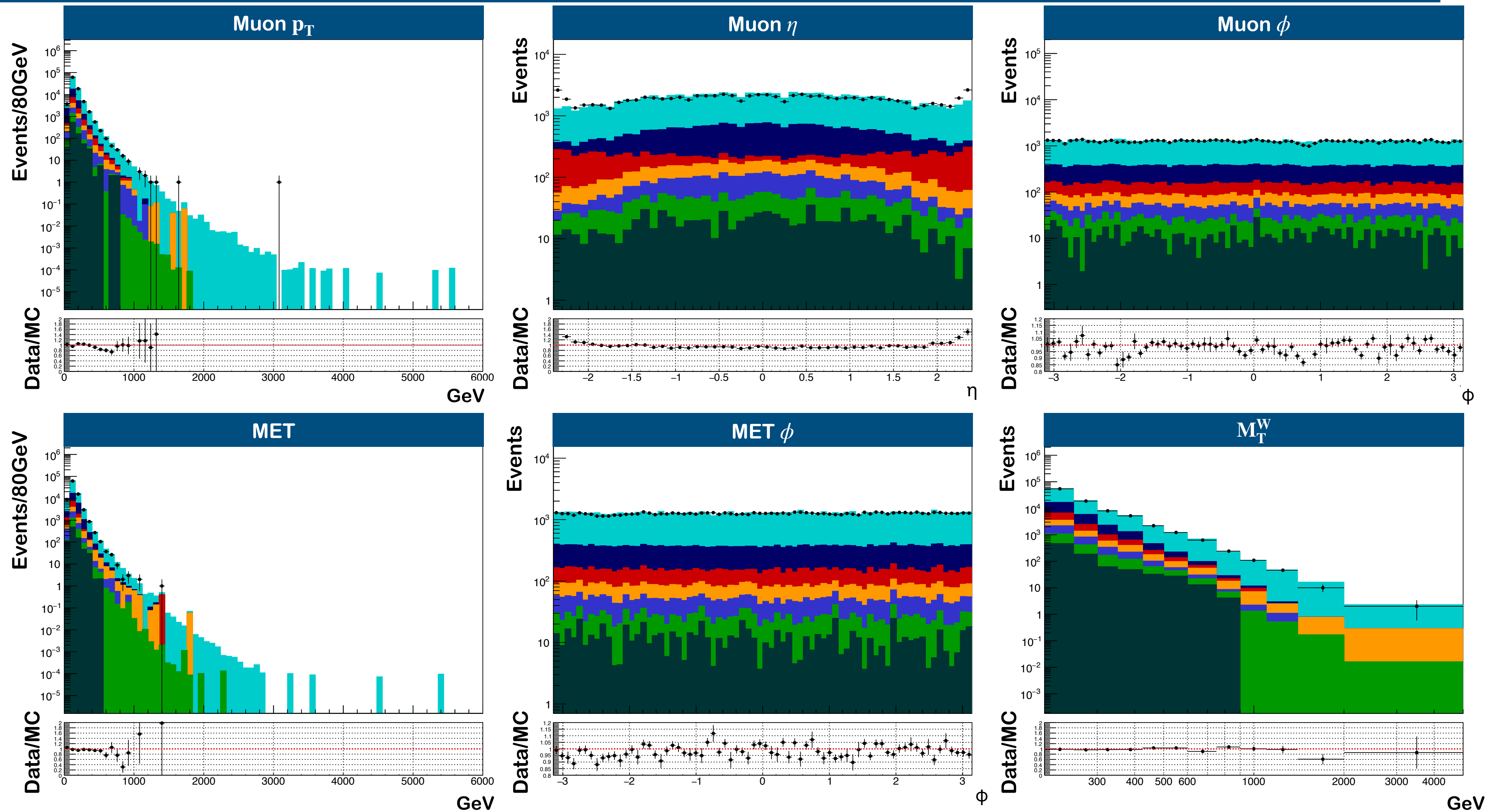
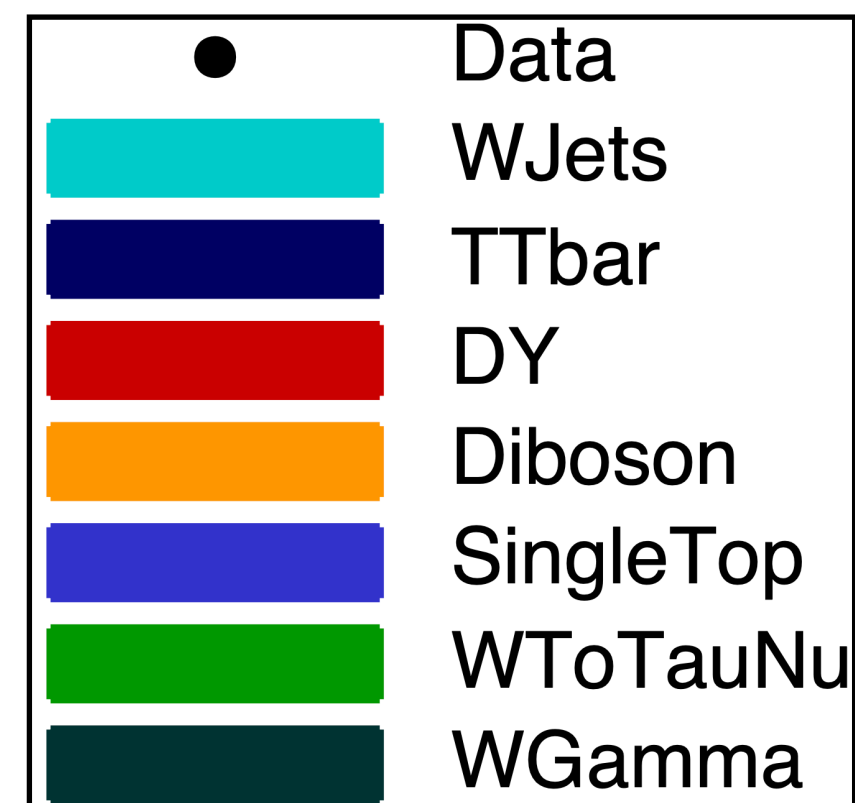
	2016	2017	2018	List of Noise Filters
Trigger	Mu50 TkMu50	Mu50 TkMu100 OldMu100		Primary vertex filter
Muon requirement	Require single highPt muon			Beam halo filter
	High p_T Muon: TuneP $p_T > 53 \text{ GeV}$ && Global highPt ID && TkRelIso < 0.1 && highPurity && $ \eta < 2.4$			HBHE noise filter
Noise filter	No ecalBadCalibFilter	Use all recommended filter		HBHEIso noise filter
Loose lepton veto	Veto event with additional loose muon or electron			ECAL TP filter
	Loose Muon: TuneP $p_T > 10 \text{ GeV}$ && LooseID && $ \eta < 2.4$			Bad PF Muon filter
	Loose Electron: TuneP $p_T > 10 \text{ GeV}$ && LooseID && $ \eta < 2.5$ excluding ECAL gap			Bad PF Muon Dz filter
W MT	Require W transverse mass > 200 GeV			HF noisy hits filter
				ee badSC noise filter
				ECAL bad calibration filter update

2016 preVFP
 19.5 fb^{-1}



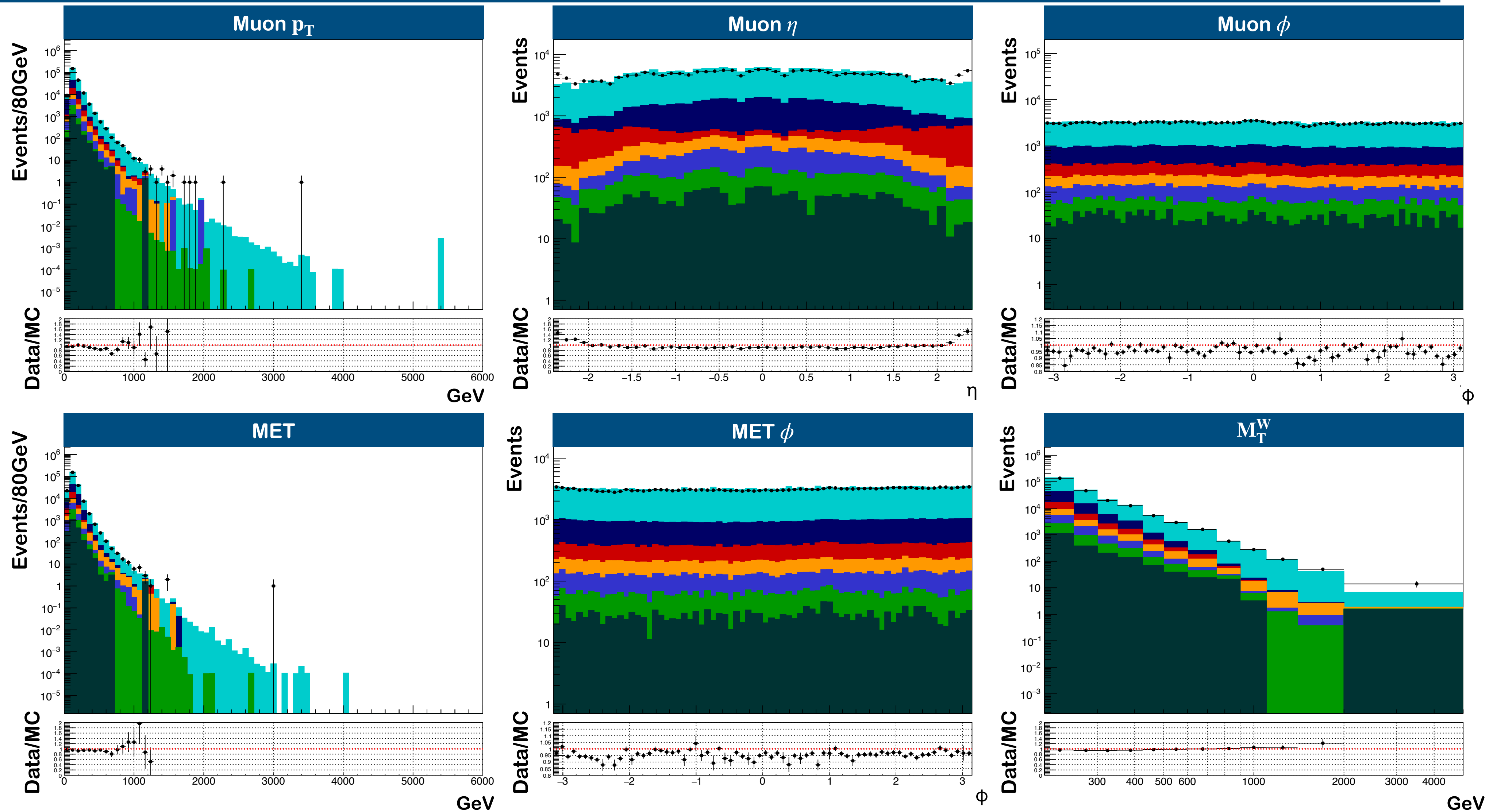
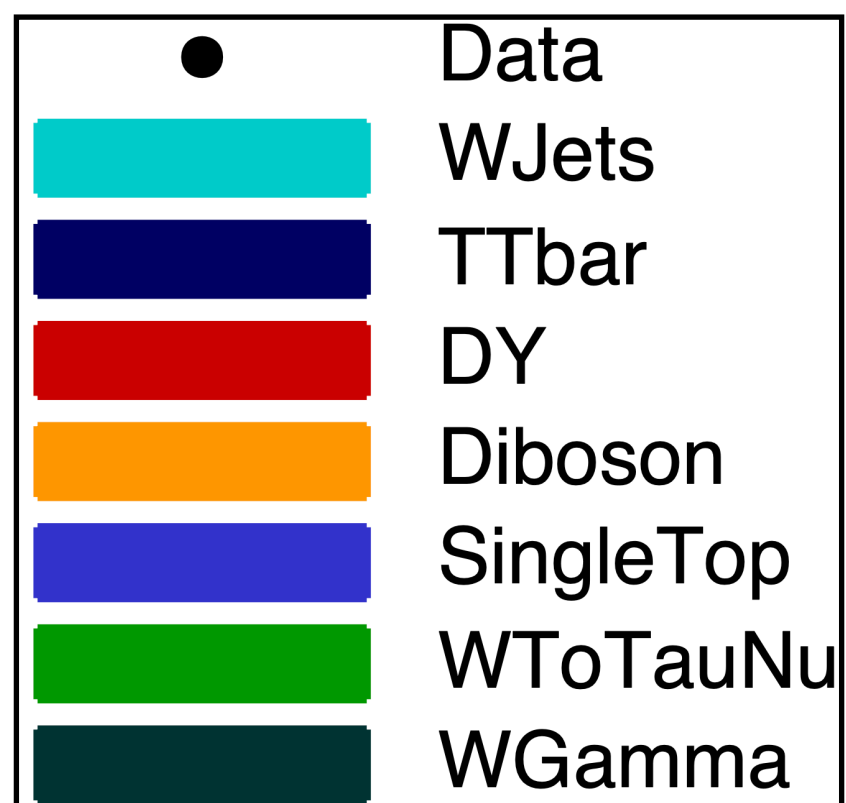
- Result for **2016 preVFP (19.5 fb^{-1})** with updated selection, correction and background MC samples
- Using same binning as ATLAS paper ([link](#)) for the M_T^W for now, will optimize further
- **QCD will be added** after study for better background modeling

2016 postVFP
 16.8 fb^{-1}



- Result for **2016 postVFP (16.8 fb^{-1})** with updated selection, correction and background MC samples
- Using same binning as ATLAS paper ([link](#)) for the M_T^W for now, will optimize further
- **QCD will be added** after study for better background modeling

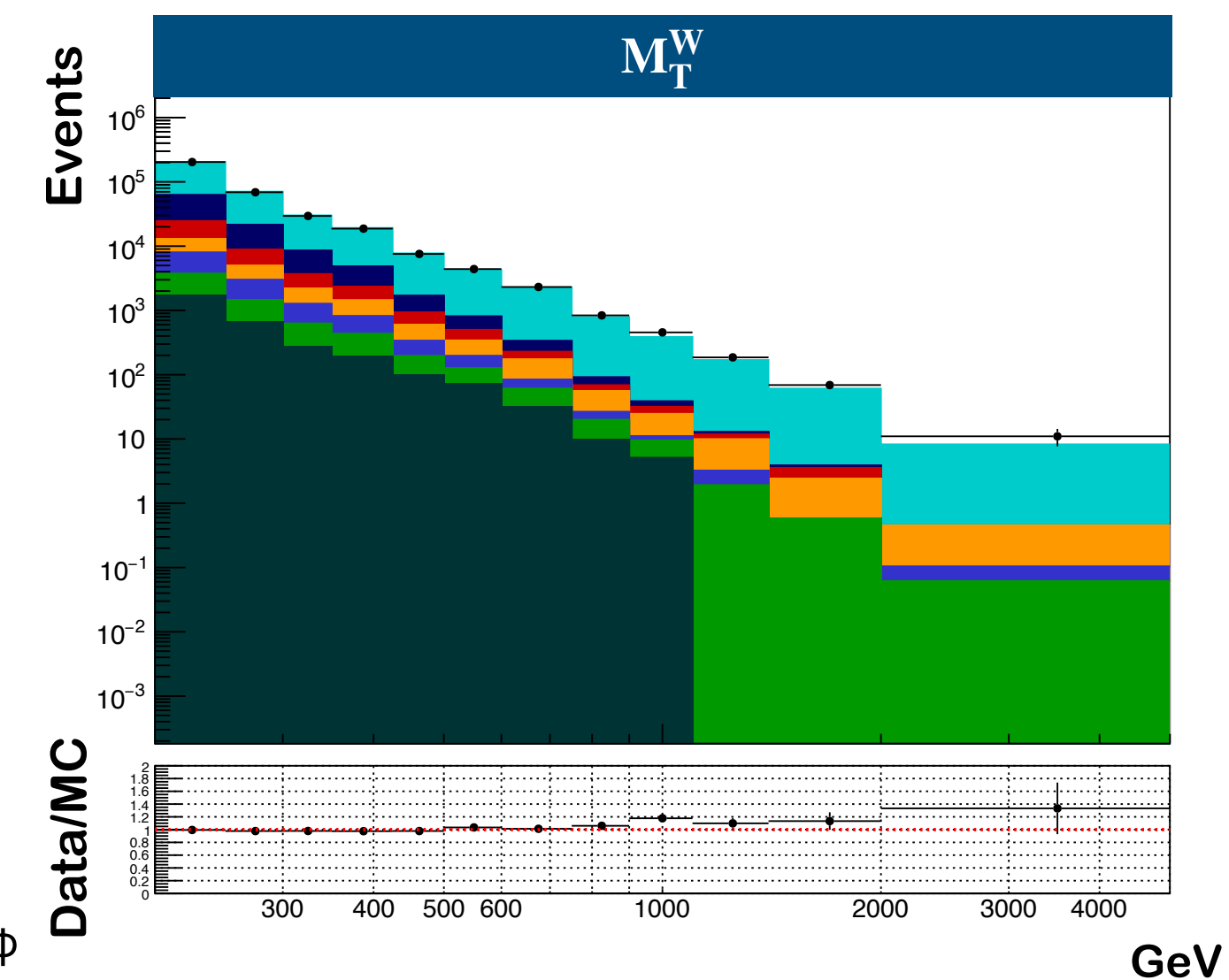
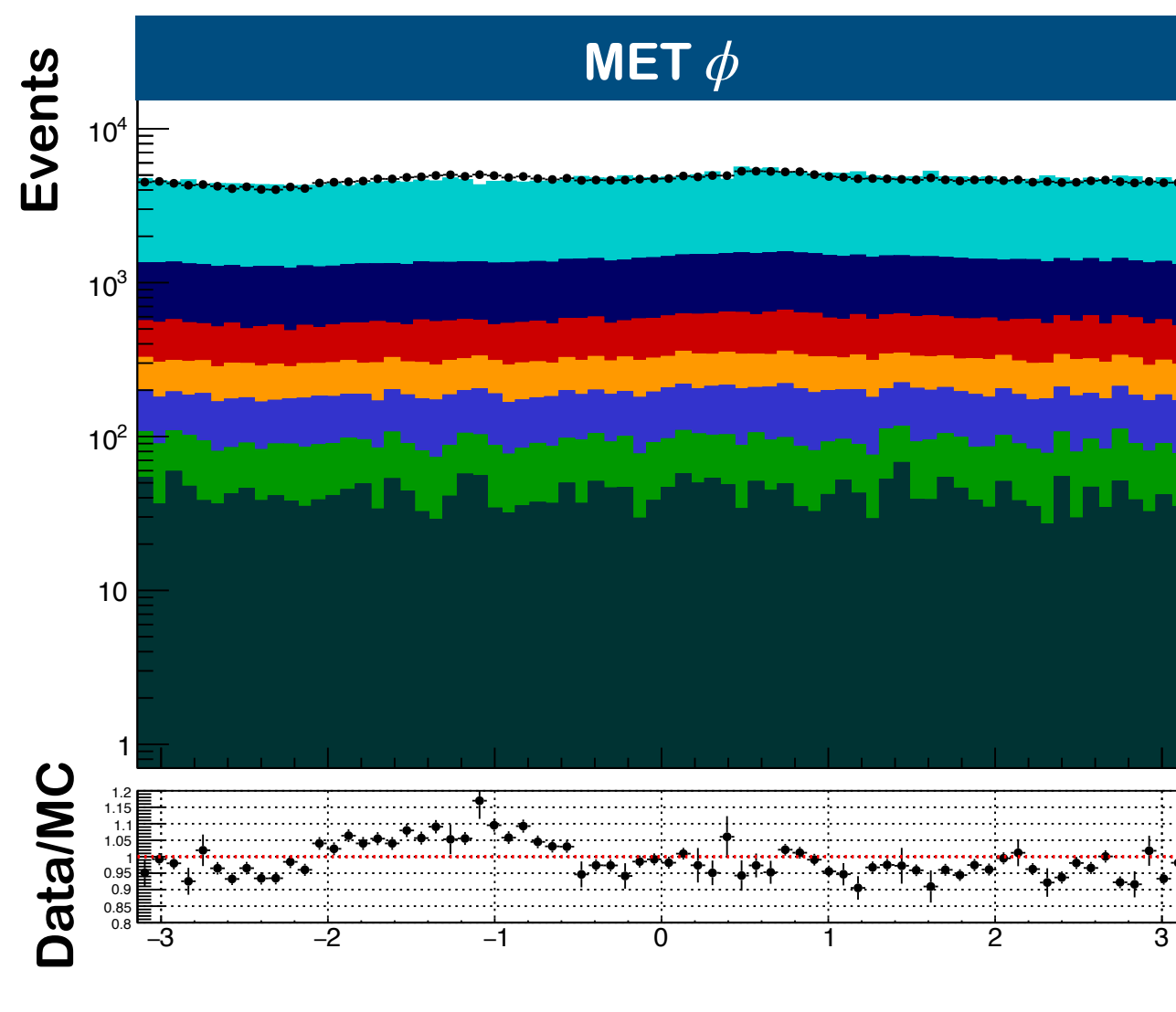
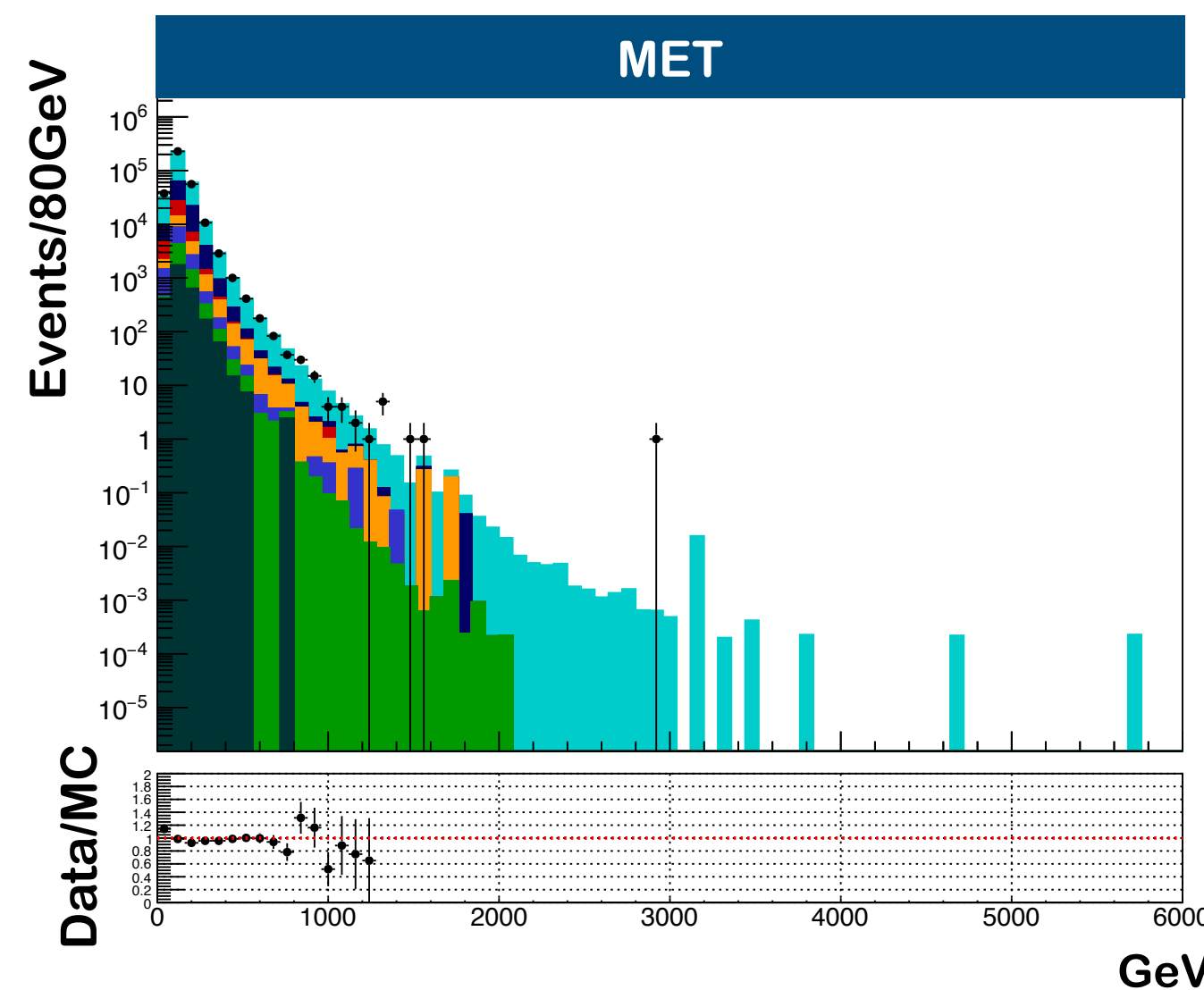
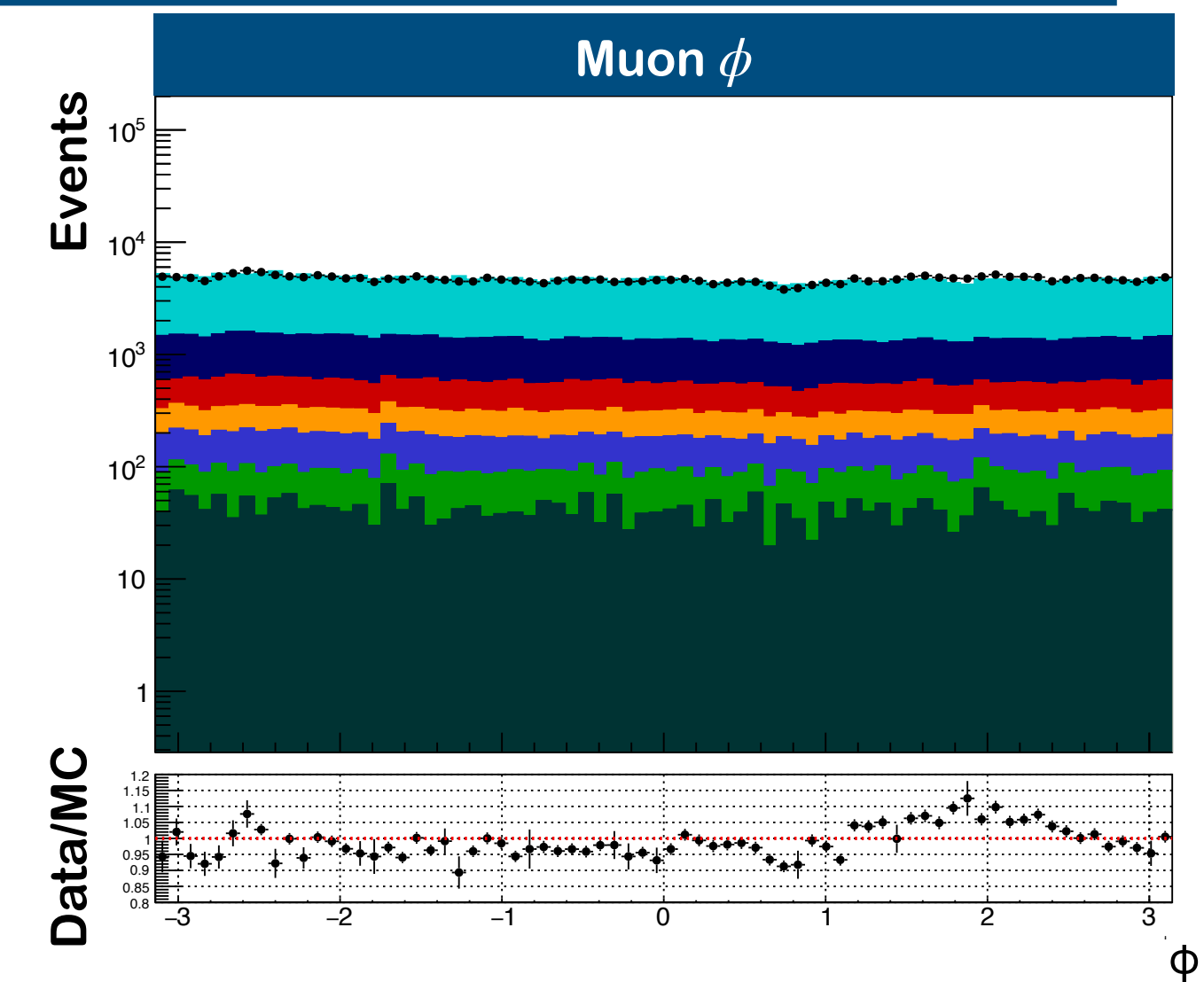
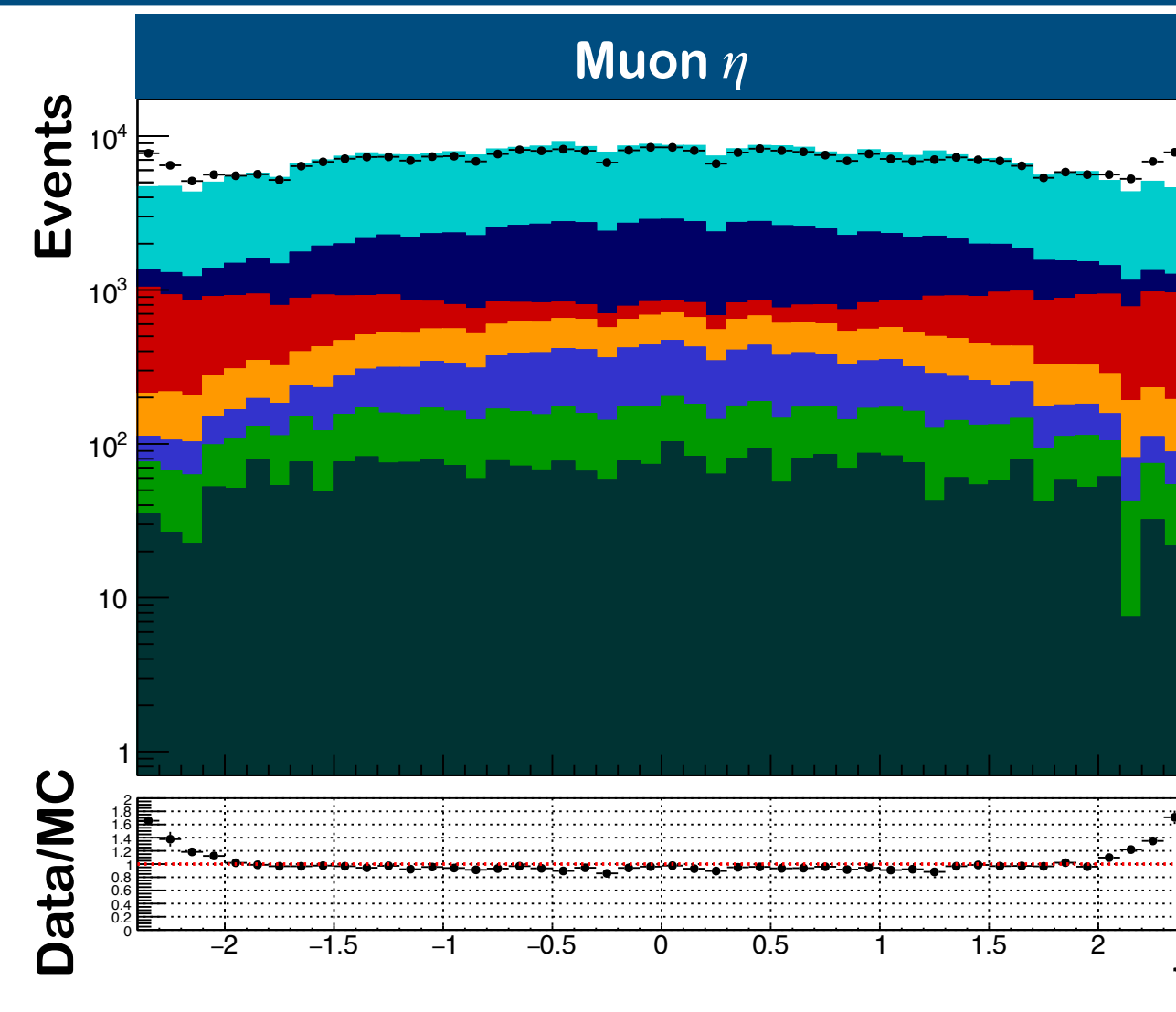
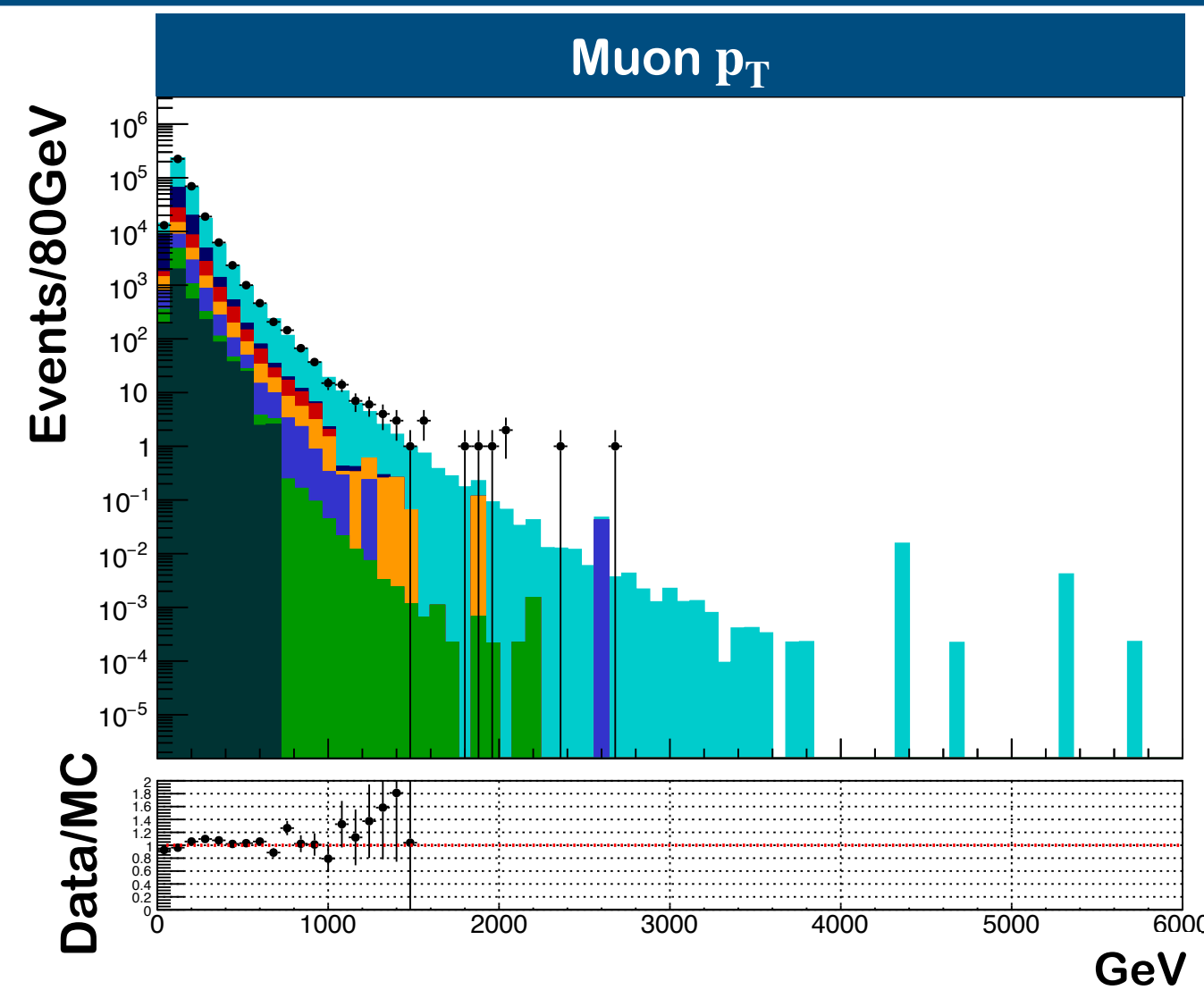
2017
 41.48 fb^{-1}



- Result for **2017 (41.48 fb^{-1})** with updated selection, correction and background MC samples
- Using same binning as ATLAS paper ([link](#)) for the M_T^W for now, will optimize further
- **QCD will be added** after study for better background modeling

2018

59.83 fb^{-1}



- Result for **2018 (59.83 fb^{-1})** with updated selection, correction and background MC samples
- Using same binning as ATLAS paper ([link](#)) for the M_T^W for now, will optimize further
- **QCD will be added** after study for better background modeling