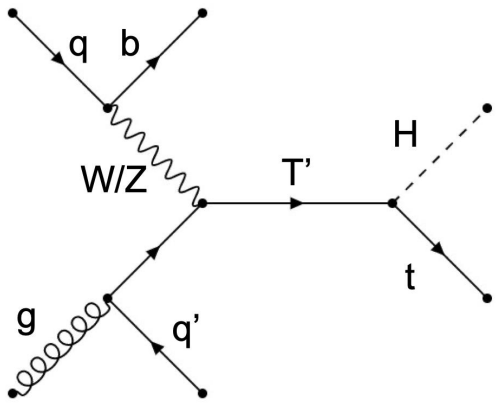
Cut Strategy

- **Basic cuts& triggers**
  - Triggers for dimuon channel: HLT_IsoMu24, HLT_Mu17_TrkIsoVVL_Mu8_TrkIsoVVL
  - For Muons
    - muon pair mass > 10 GeV
    - Two opposite sign muons
    - p_T > 20GeV, $|\eta|$ < 2.4
    - Tight Muon ID: Muon_tightId
    - Tight isolation: goodMuons_miniPFRelIso_all < 0.05
    - Significance cut: Muon_sip3d < 3
  - For jets
    - p_T > 30GeV, $|\eta|$ < 2.5
    - At least 3 tight ID jets, including 1 medium B jet
    - Remove overlapped jets
    - HT > 80 GeV
  - **Main cuts**
    - Cut0: μ pair mass < 60GeV
    - $Cut1$: μ pair p_T + top p_T > 350 GeV
    - Cut2: Minimal δR (μ, b jet from top) > 2
    - $Cut3$: δR (b jet from top, W from top) < 2.5



2 major update:
Add more DY MC samples
Add MC event weight

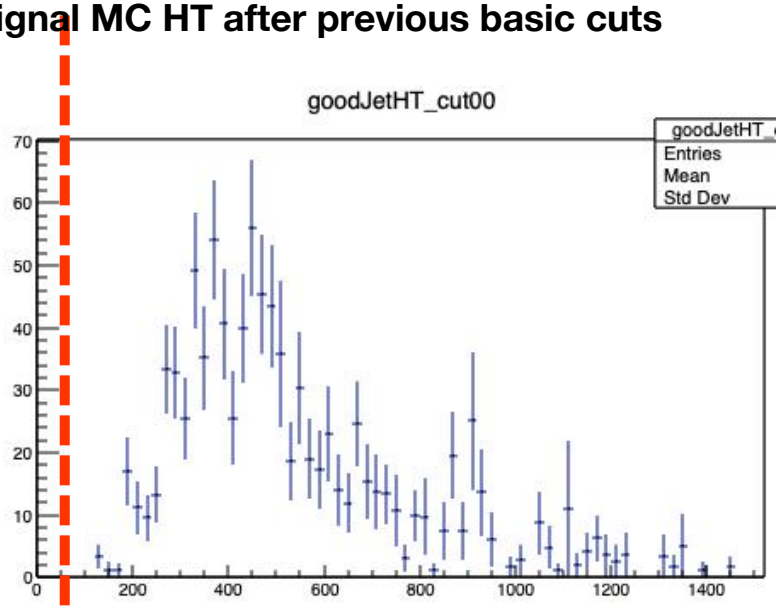
Add new MC samples to Solve DY Shortage Issue

New DY low samples (UL NanoAOD v9)	cross section pb
DYJetsToLL_M-4to50_HT-70to100_TuneCP5_13TeV-madgraphMLM-pythia8	314
DYJetsToLL_M-4to50_HT-600toInf_TuneCP5_13TeV-madgraphMLM-pythia8	1.216
DYJetsToLL_M-4to50_HT-400to600_TuneCP5_13TeV-madgraphMLM-pythia8	4.05
DYJetsToLL_M-4to50_HT-200to400_TuneCP5_13TeV-madgraphMLM-pythia8	42.27
DYJetsToLL_M-4to50_HT-100to200_TuneCP5_13TeV-madgraphMLM-pythia8	190.6

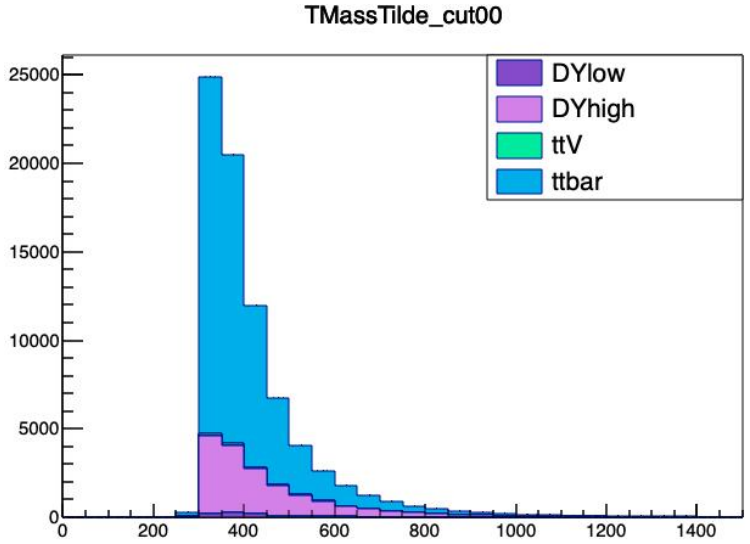
New DY high samples (UL NanoAOD v9)	cross section pb
DYJetsToLL_M-50_HT-70to100_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8	140.0
DYJetsToLL_M-50_HT-100to200_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8	139.2
DYJetsToLL_M-50_HT-200to400_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8	38.4
DYJetsToLL_M-50_HT-400to600_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8	5.174
DYJetsToLL_M-50_HT-600to800_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8	1.258
DYJetsToLL_M-50_HT-800to1200_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8	0.5598
DYJetsToLL_M-50_HT-1200to2500_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8	0.1305
DYJetsToLL_M-50_HT-2500toInf_TuneCP5_PSweights_13TeV-madgraphMLM-pythia8	0.002997

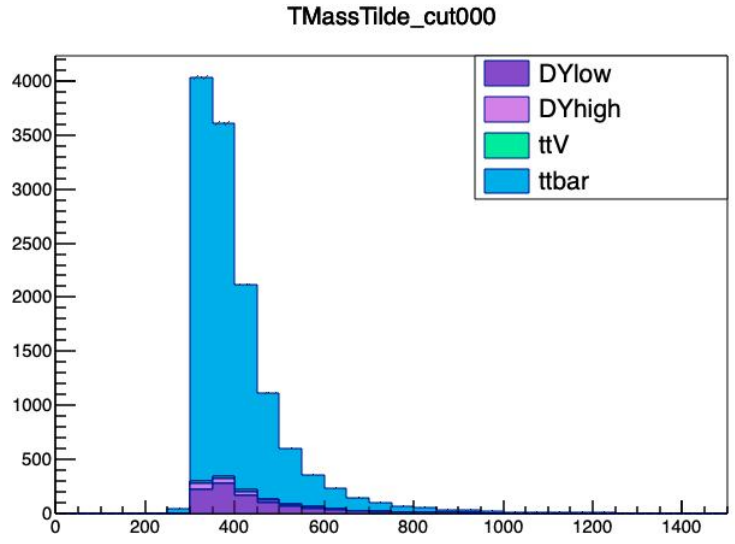
- **Those LO DY sample can cover all HT region (>70GeV) without overlap**
- **Add good jets HT > 80 GeV cut to basic cut**
  - **This cut has no influence to signal**

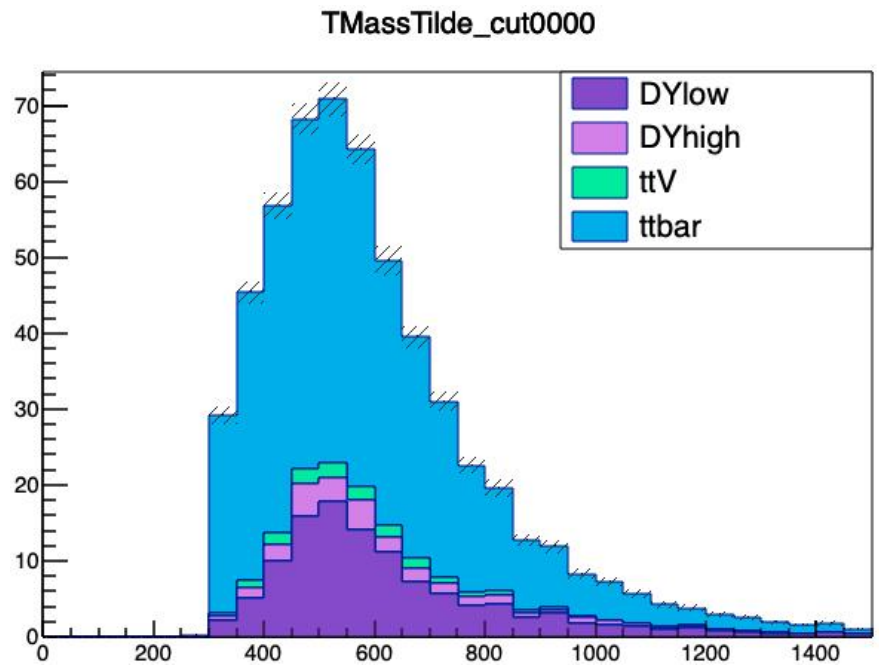
Signal MC HT after previous basic cuts

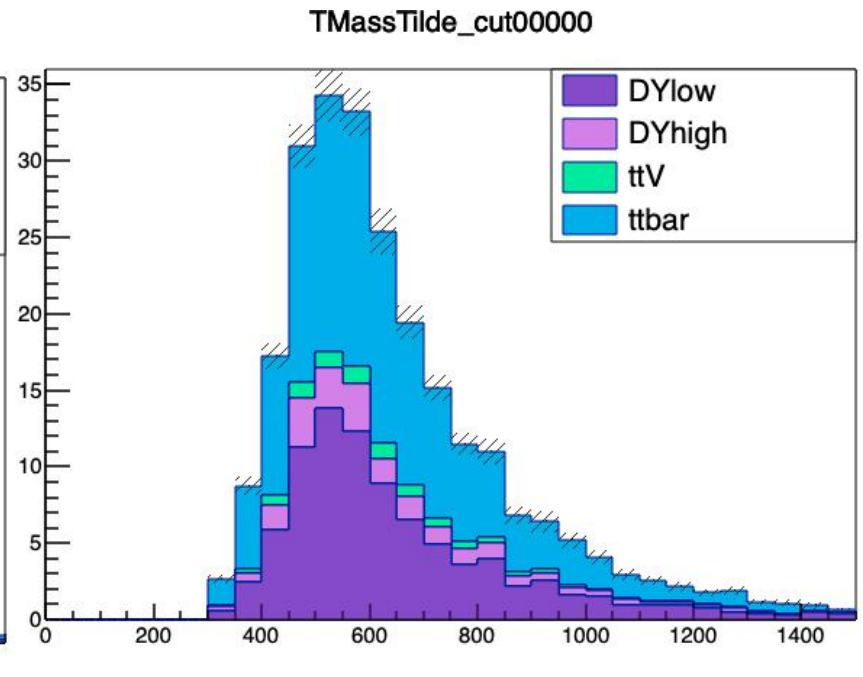


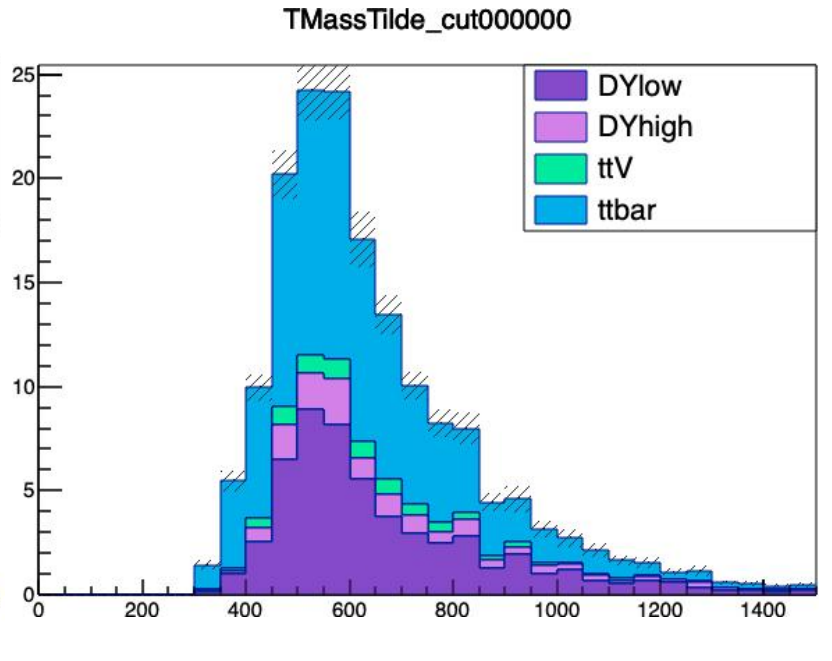
Main Variable: VLQ mass tilde











events weight for MC

- Weight(for 1 MCevent) = Weight(muon ID) $*$ Weight(muon iso) $*$ Weight(trigger) $*$ GEN weight $*$ Pileup weight $*$ Weight(b tag)
  - **All are added except trigger weight**
  - **Json files are from official POG webpage** https://gitlab.cern.ch/cms-nanoAOD/jsonpog-integration/-/tree/master

- Weight(muon ID/iso) = $\prod_{\mu i=\mu 1}^{\mu n} SF(p_{T(\mu i)}, |\eta(\mu i)|)$
  - **muon ID type in json file: NUM_TightID_DEN_genTracks**
  - **muon Iso type in json file: NUM_TightRelIso_DEN_TightIDandIPCut**

- GEN Weight = $\{^{\pm 1 \text{ for Madgraph NanoAODv9}}_{\text{Original values for powheg NanoAODv9}}$

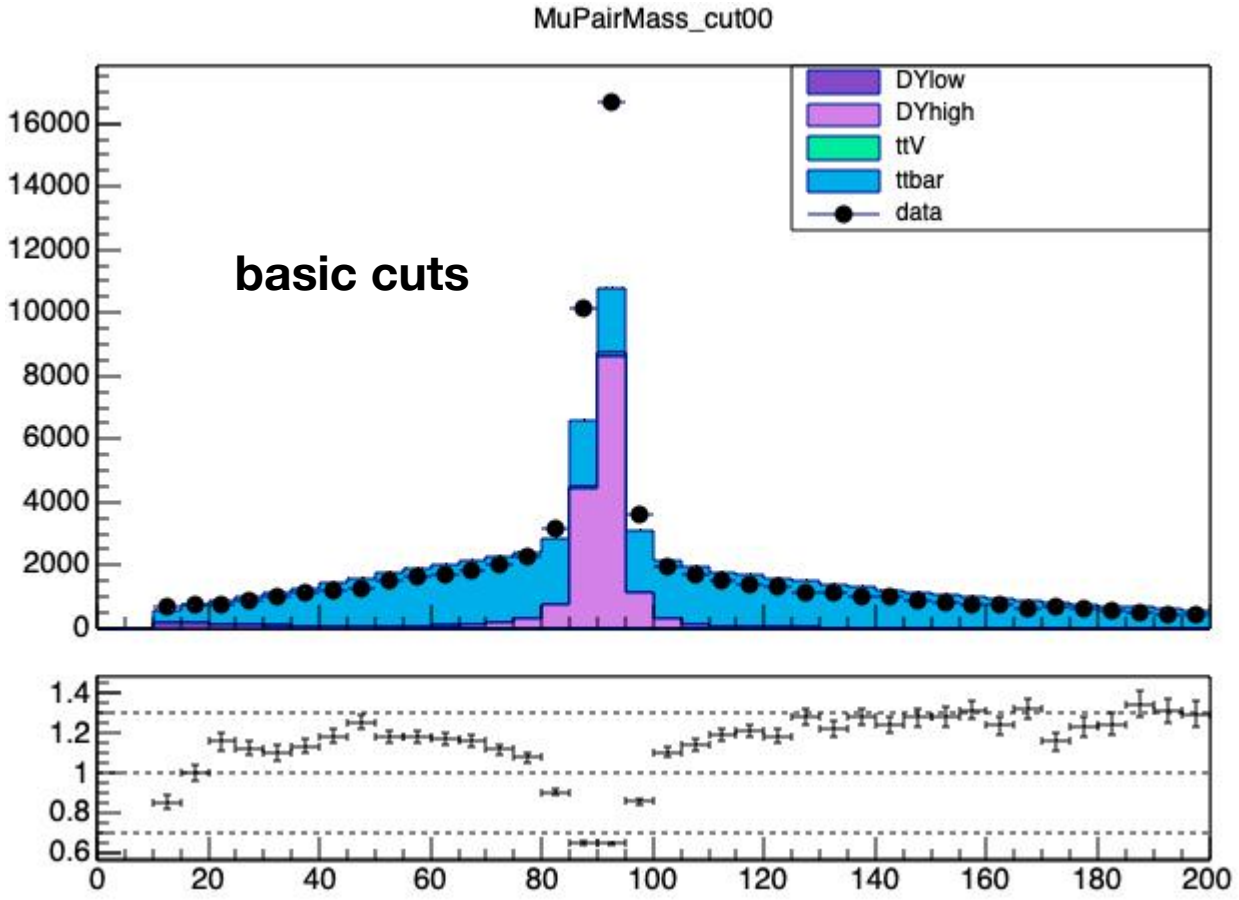
- **Pile-up weight is directly got from json file**
  - **tag: Collisions18_UltraLegacy_goldenJSON**

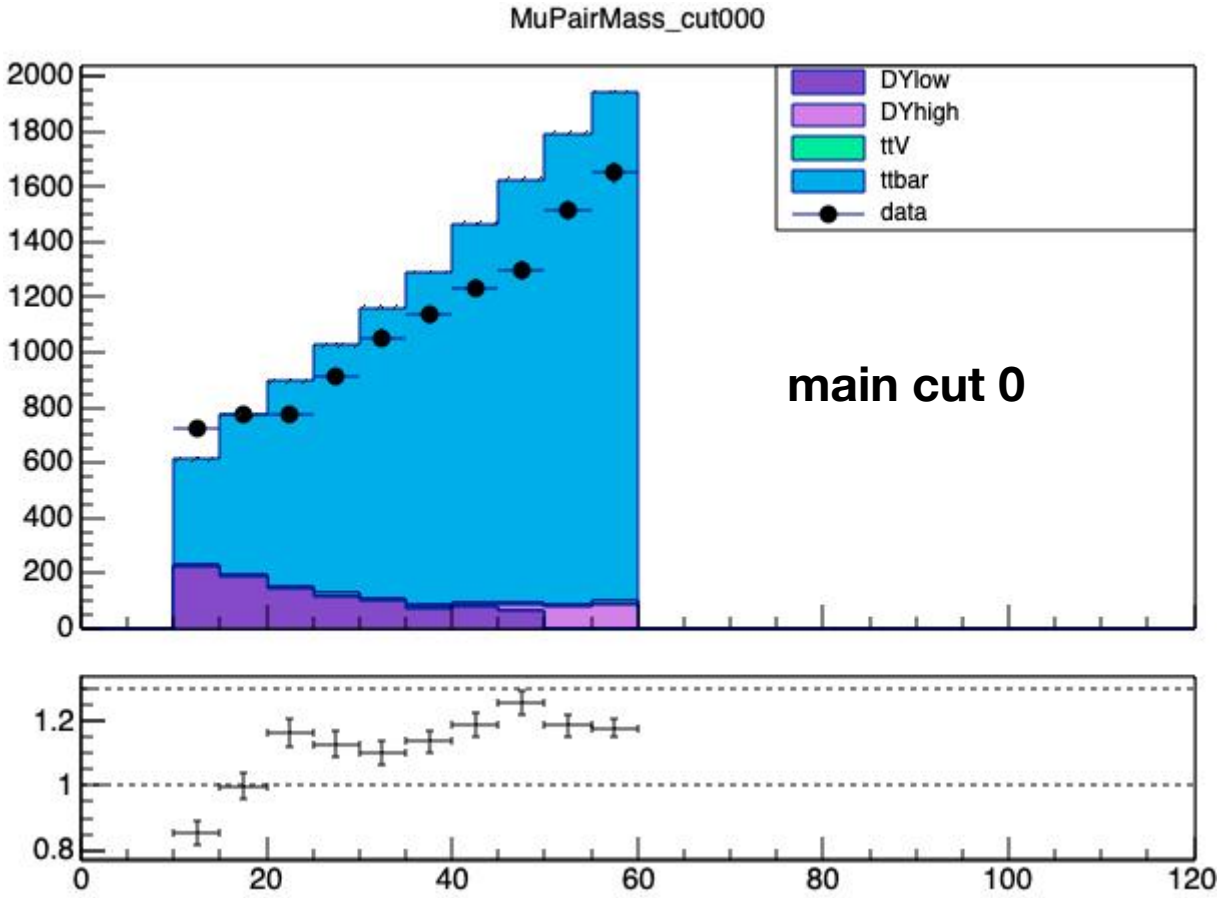
- Weight(b tag) = $\prod_{ji=j1}^{jn} SF(\text{medium } wp, \text{ hadron flavor, } p_{T(ji)}, |\eta(ji)|)$

  SF tag(jet)= $\{^{\text{deepJet\_mujets (hadron flavor } = 0)}_{\text{deepJet\_incl (hadron flavor } != 0)}$

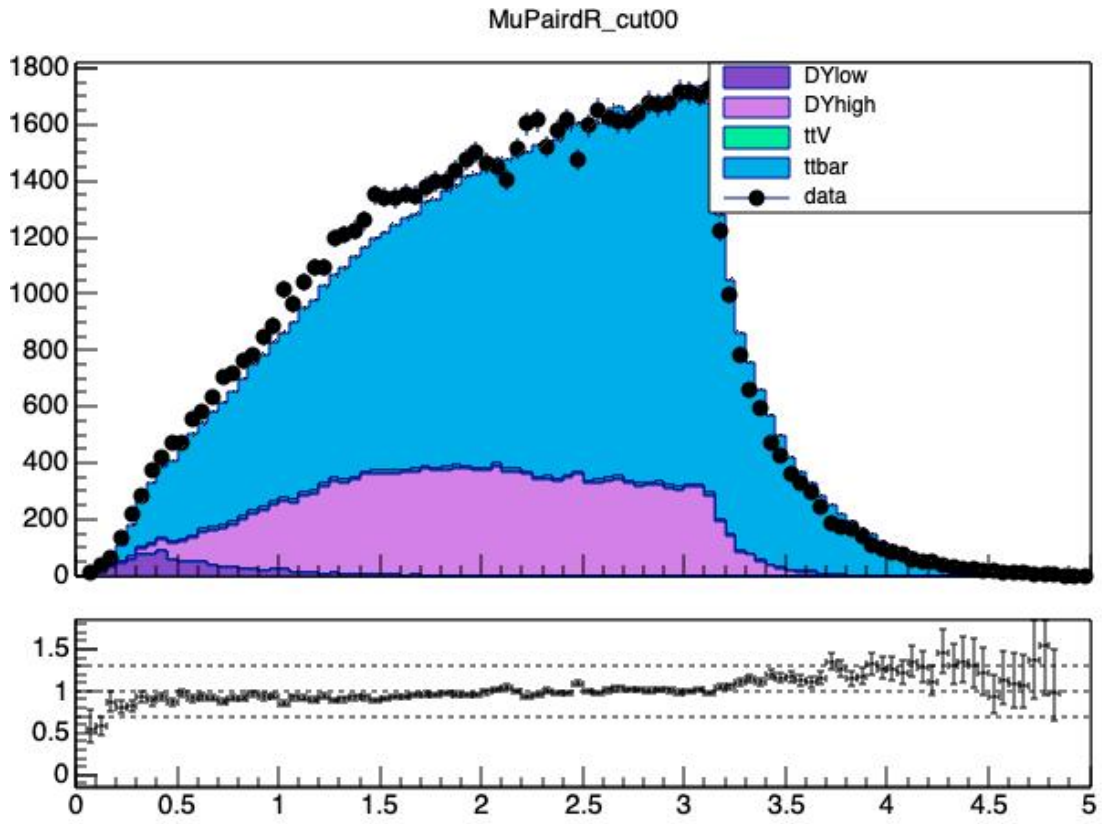
Mu Pair Mass

- **Low mu pair mass region ttbar is over estimated**
- **DY in high mass region is under estimated**





dR(mu+, mu-)


MuPairdR_cut00
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DYhigh
ttV
ttbar
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1800
1600
1400
1200
1000
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600
400
200
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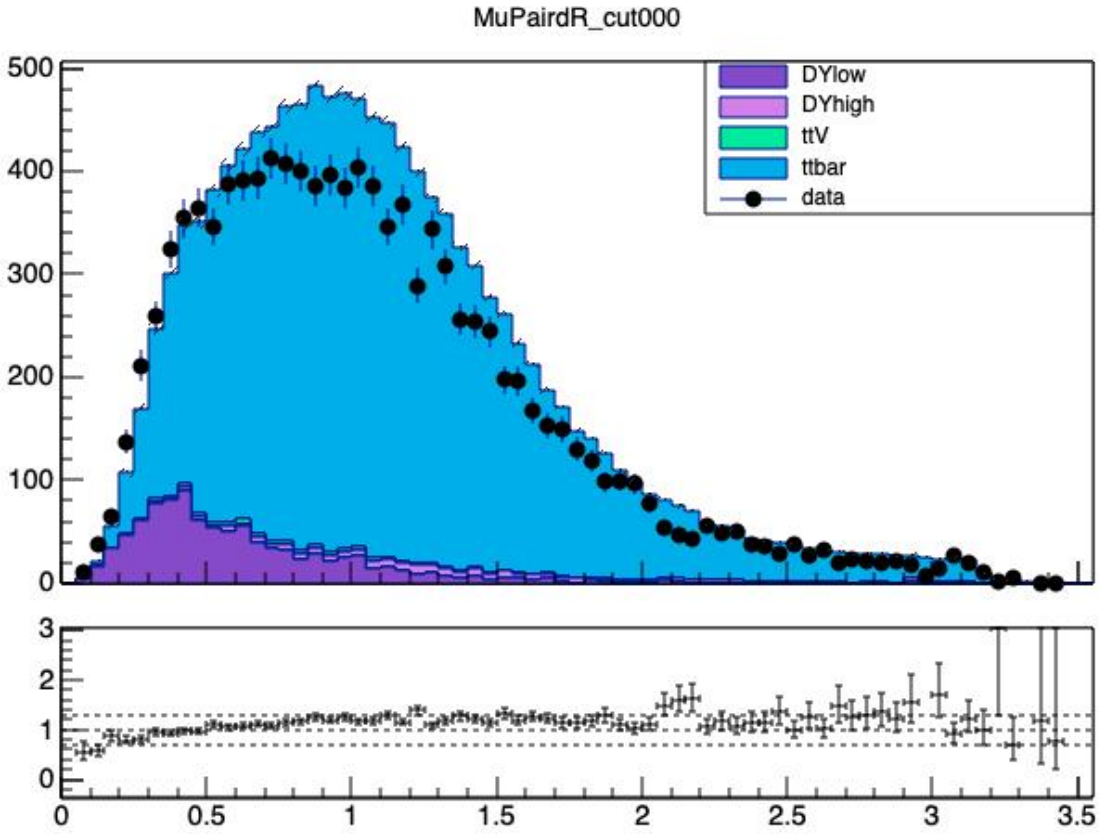
3
3.5
4
4.5
5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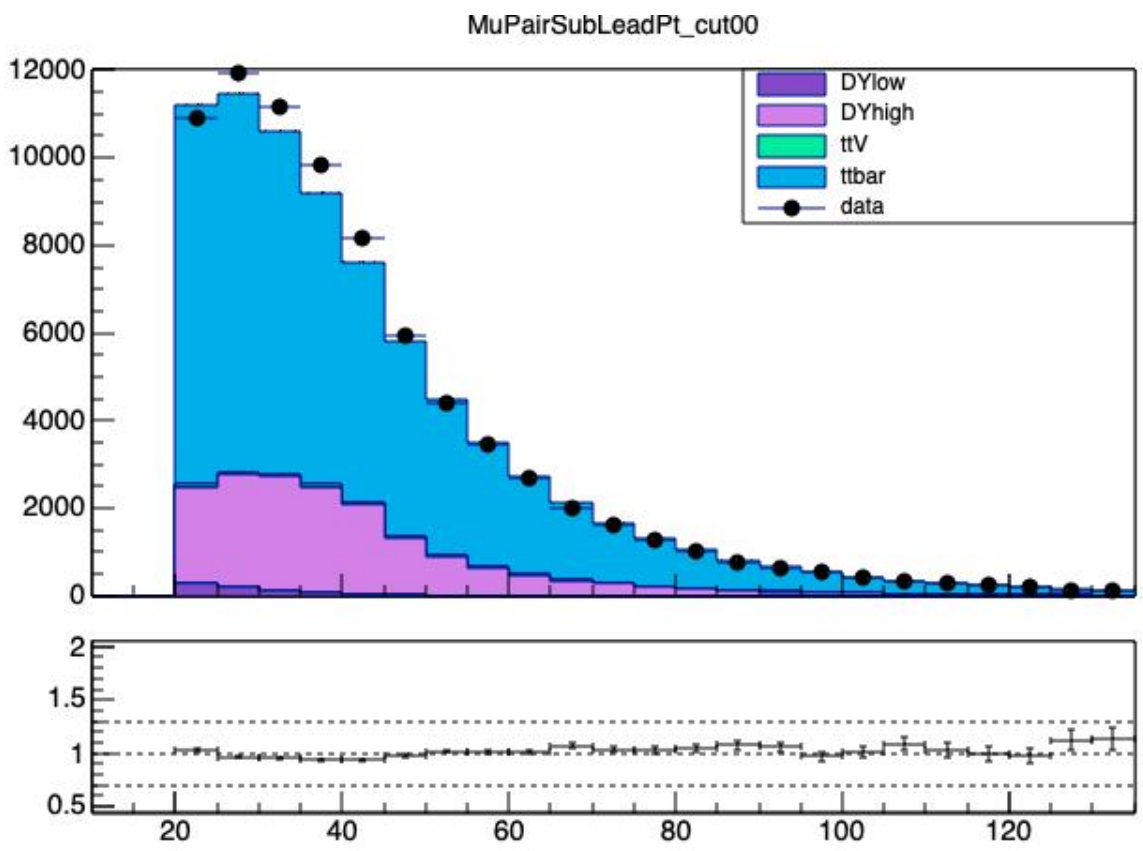
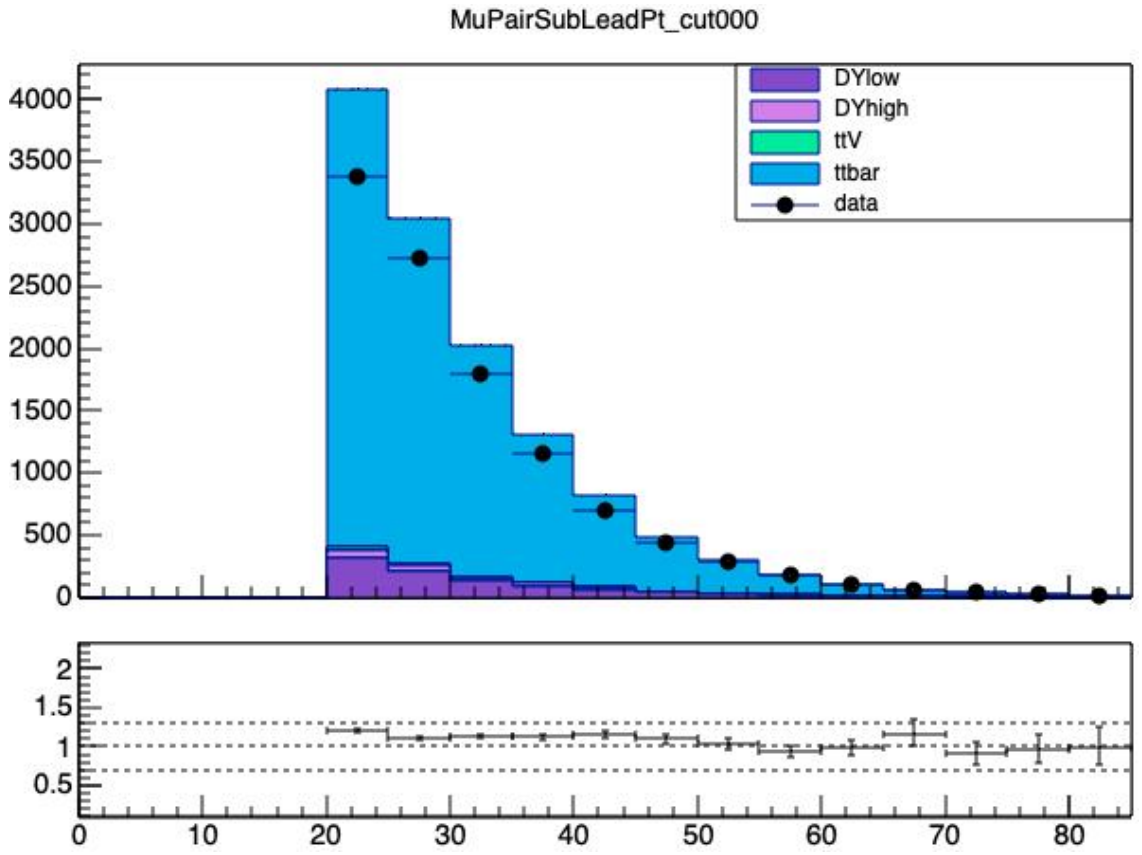
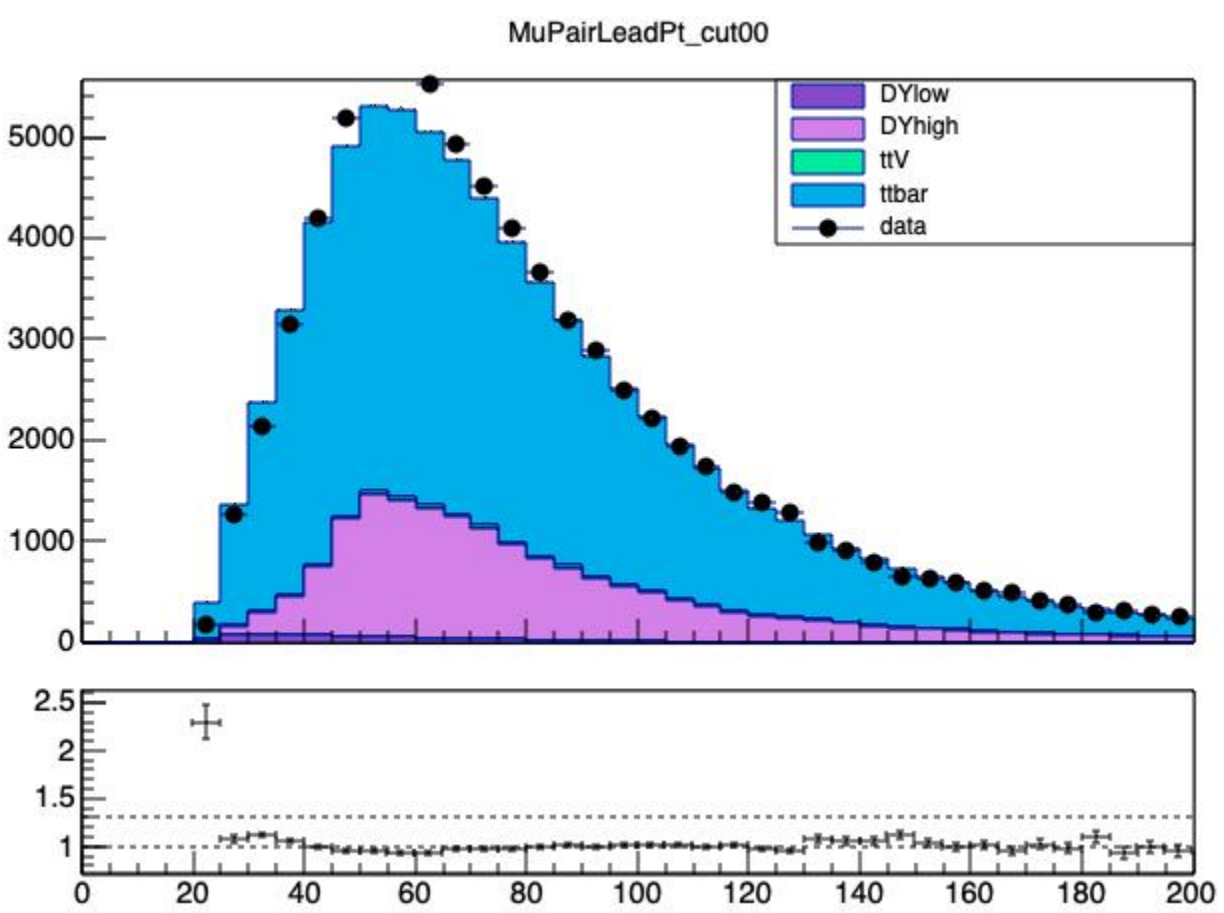
2
2.5
3
3.5

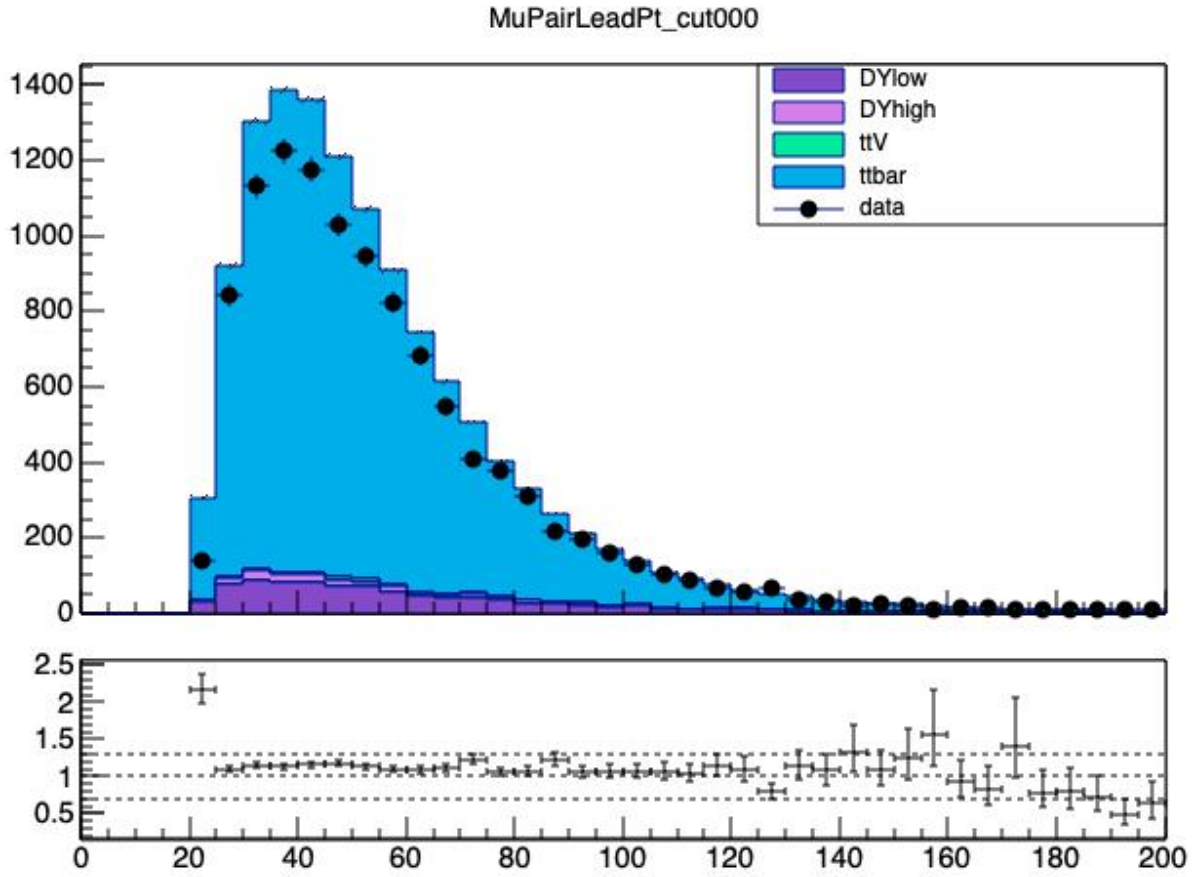
Subleading muon pt



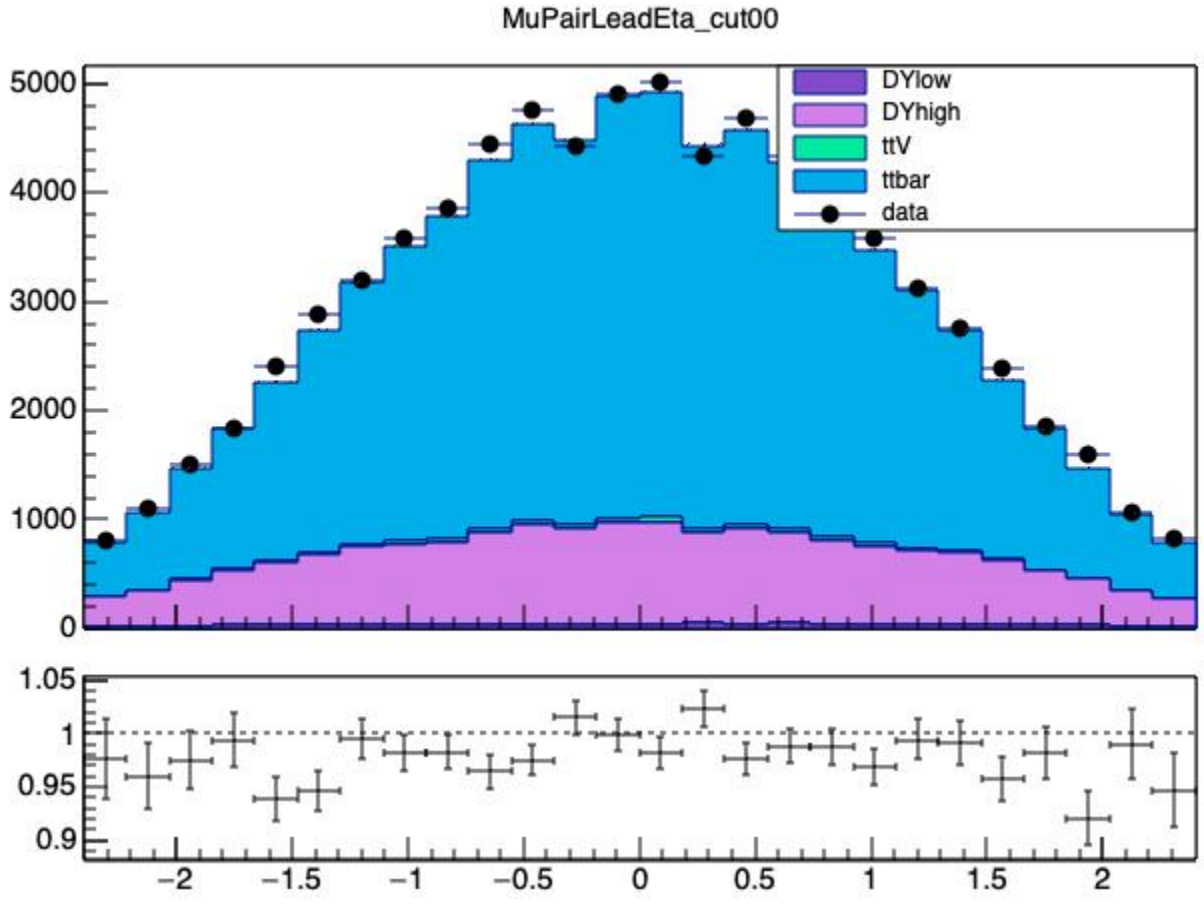


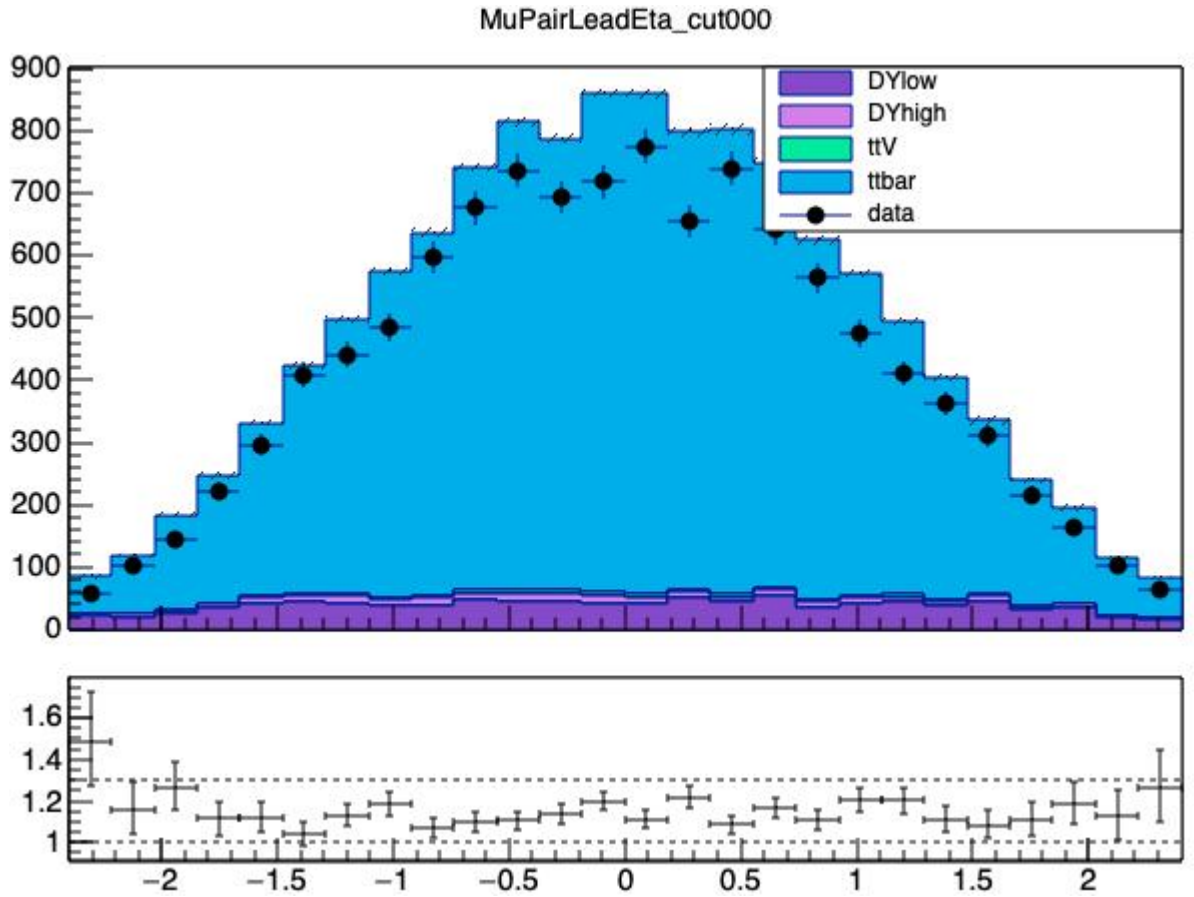
Leading muon pt





Leading muon eta





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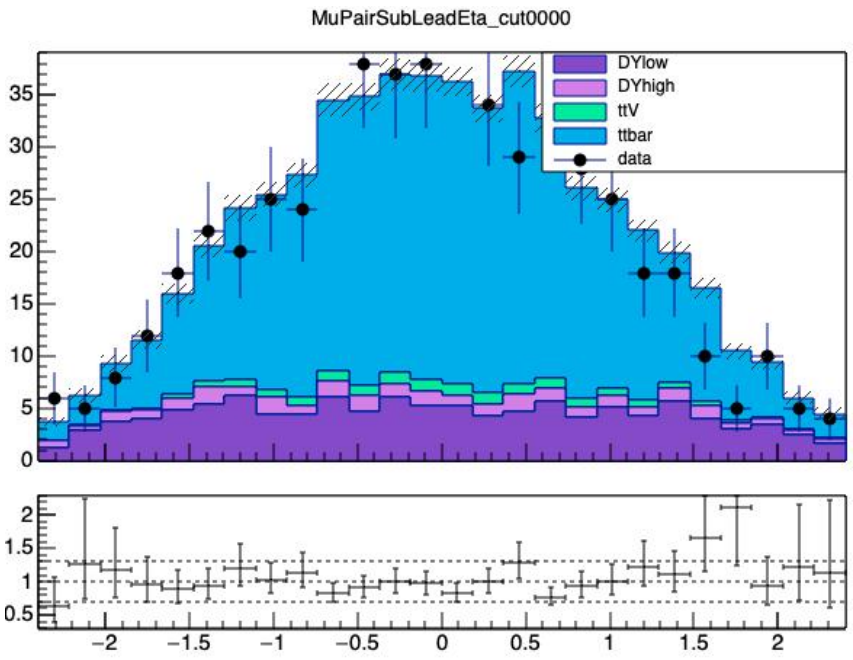
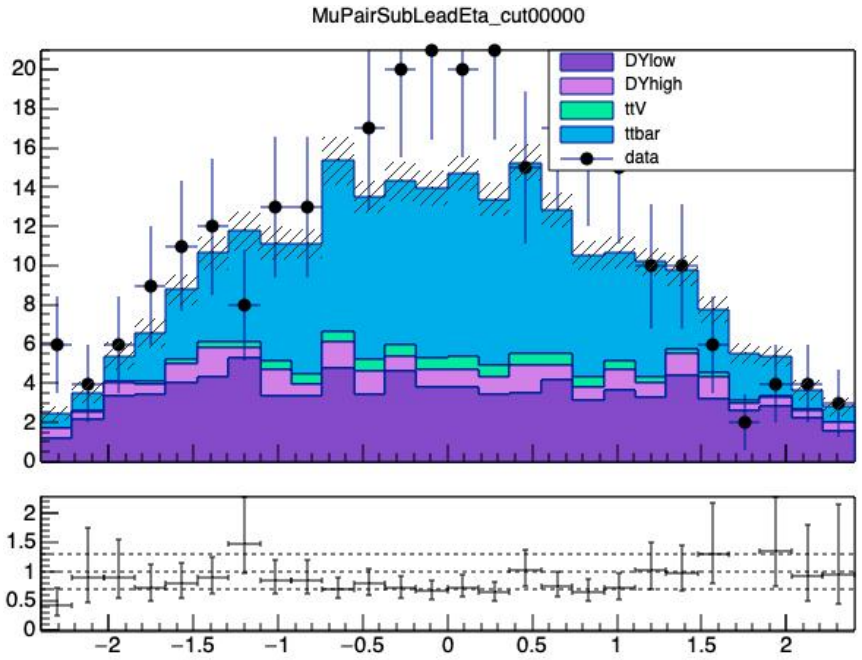
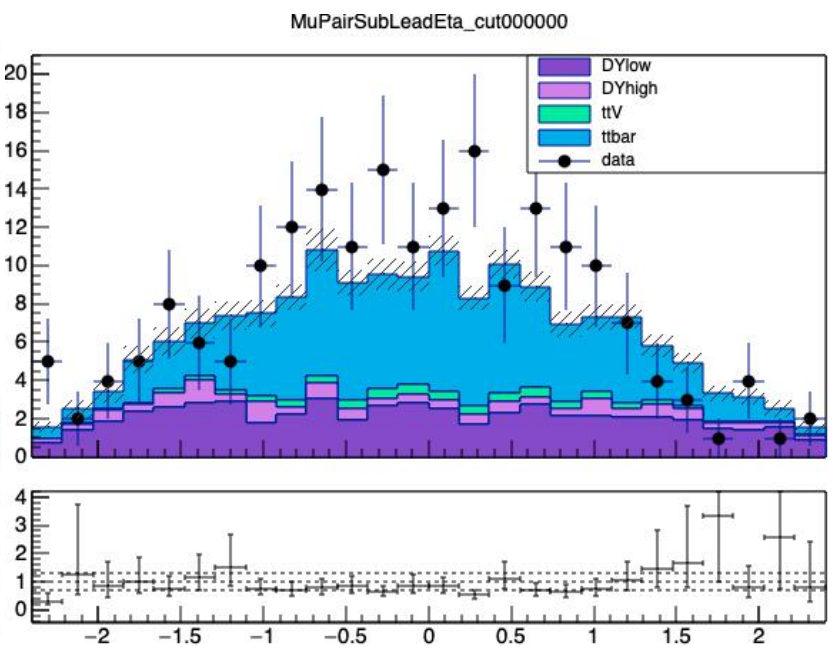
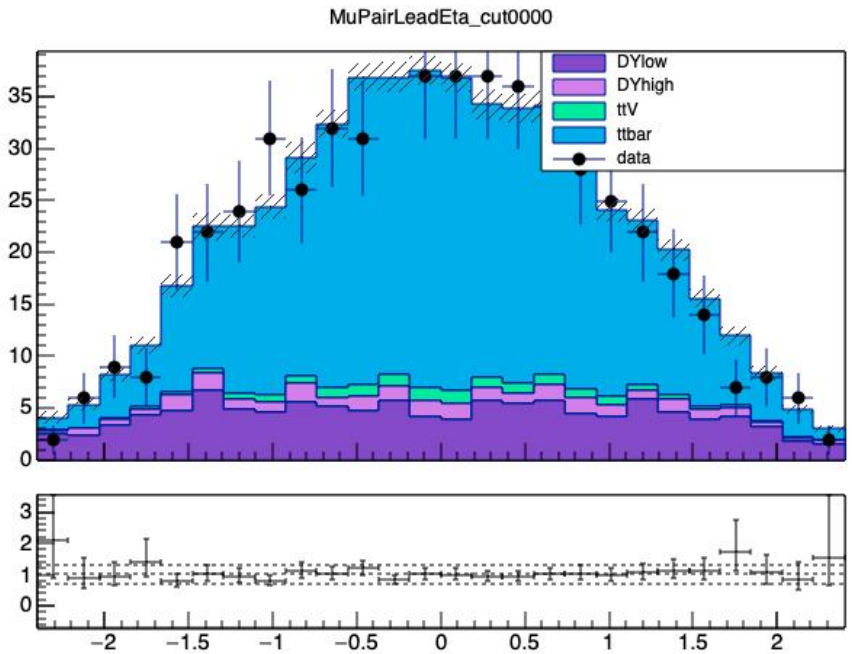
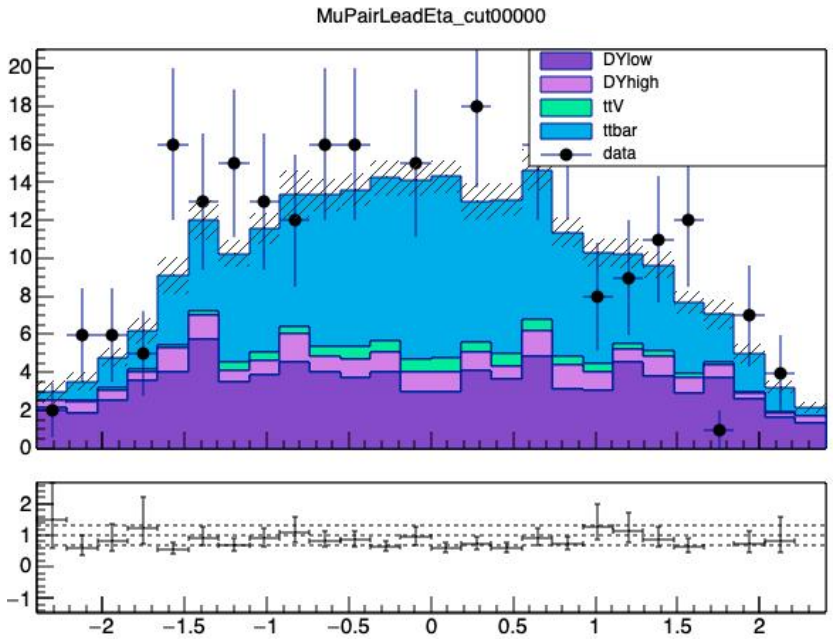


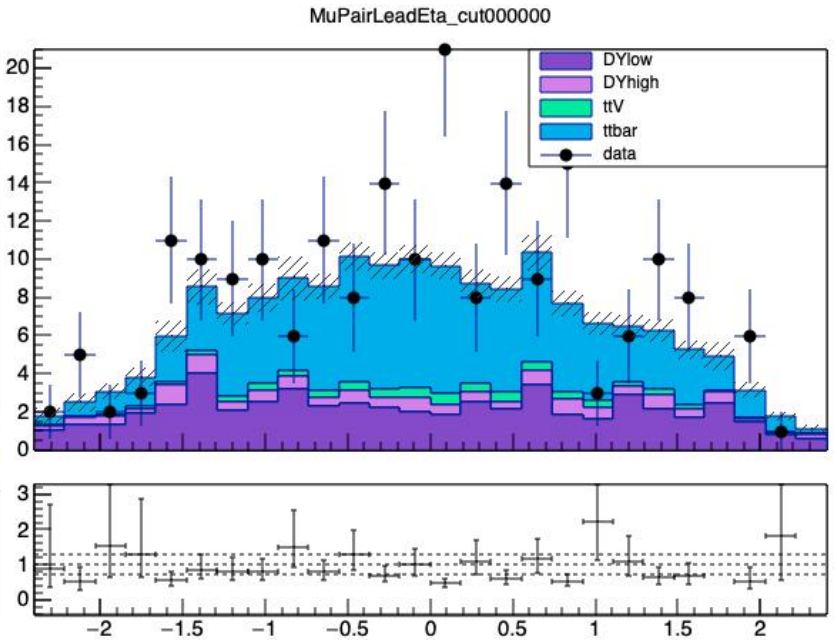




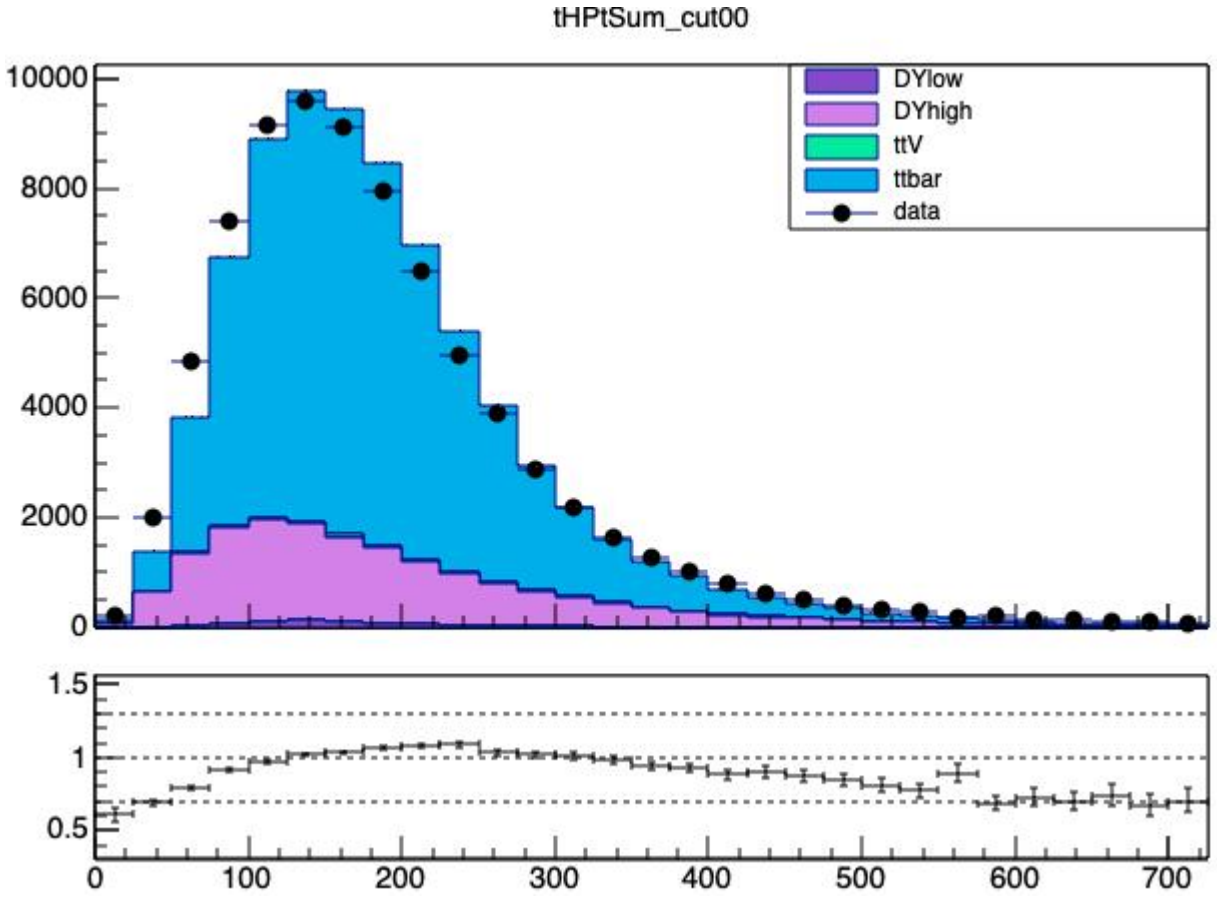
Leading muon eta

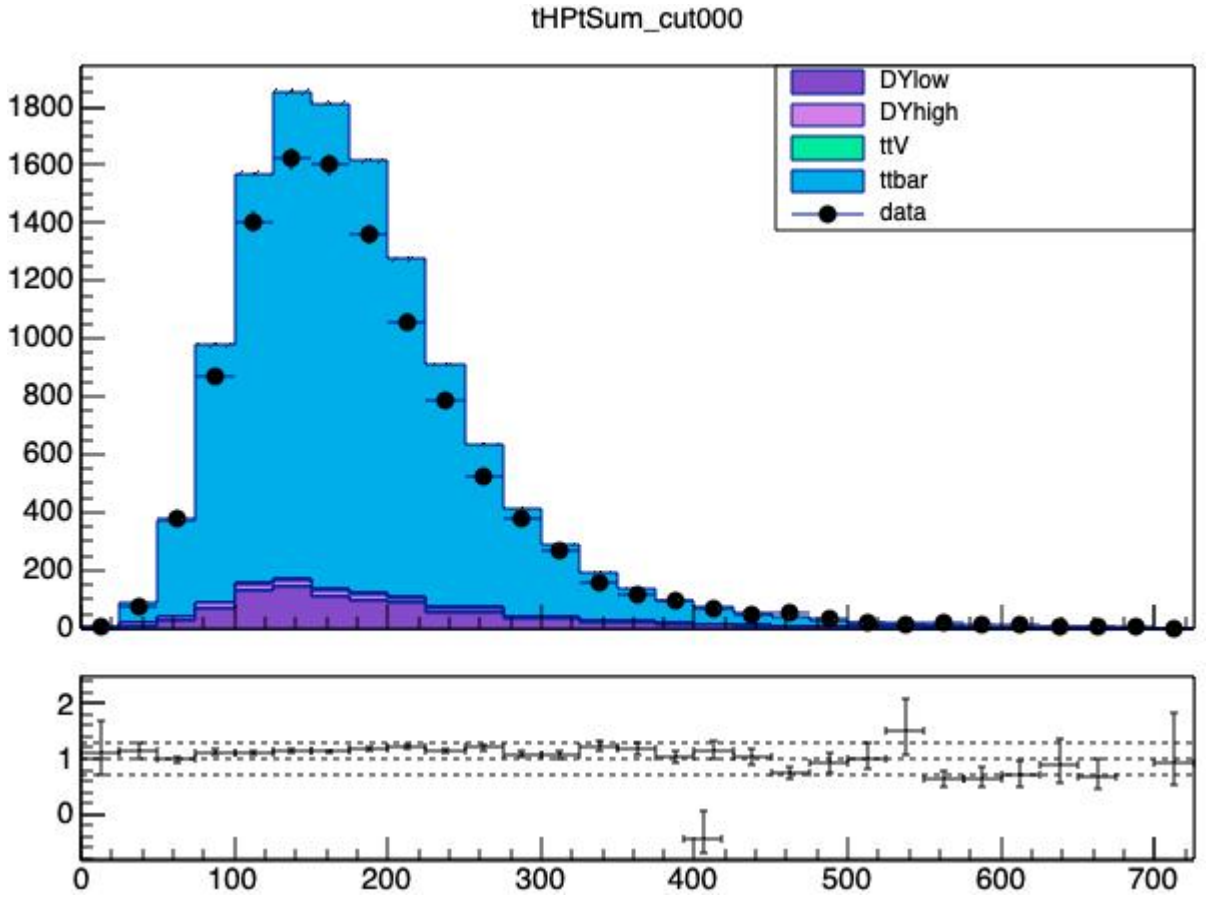




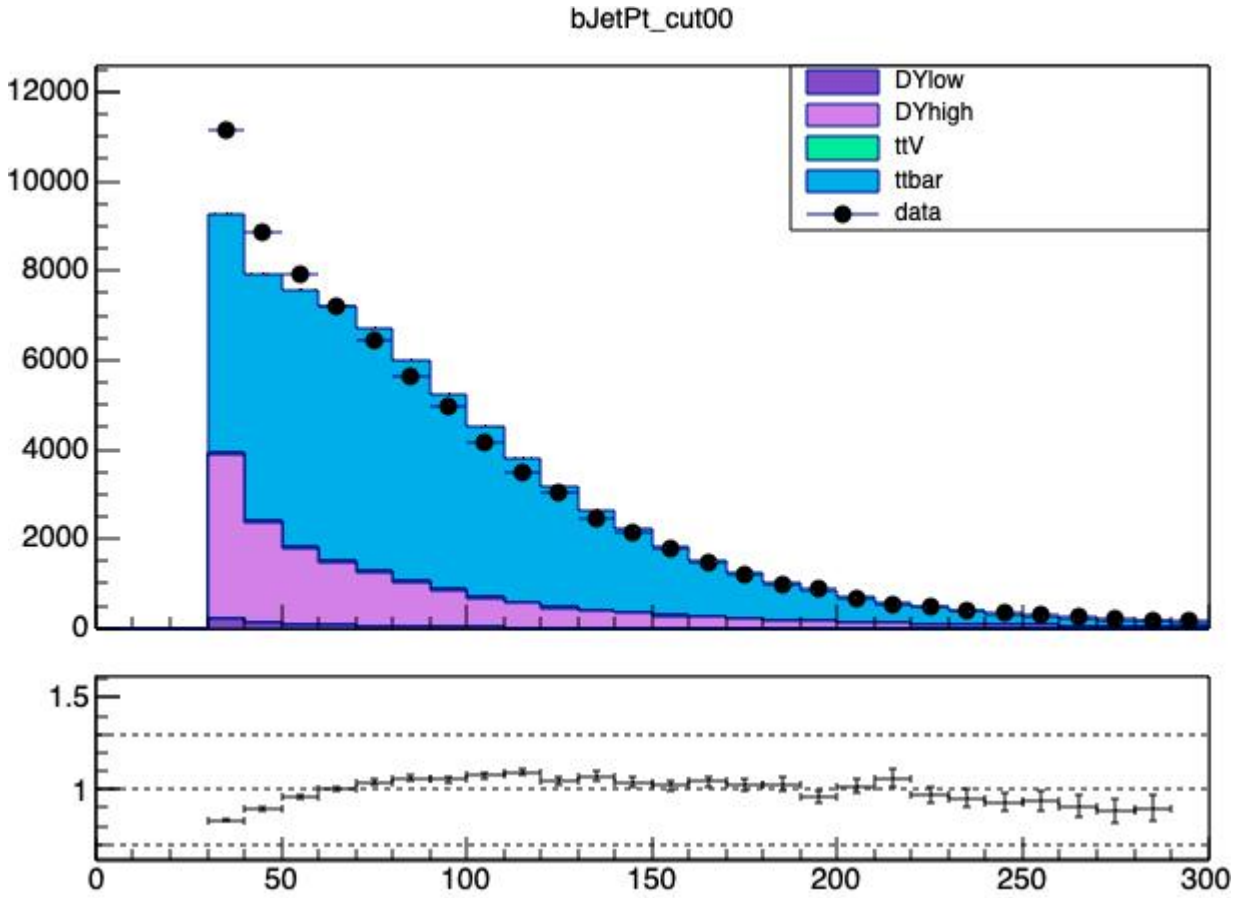


top pt + Higgs pt





b jet pt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DYhigh
ttV
ttbar
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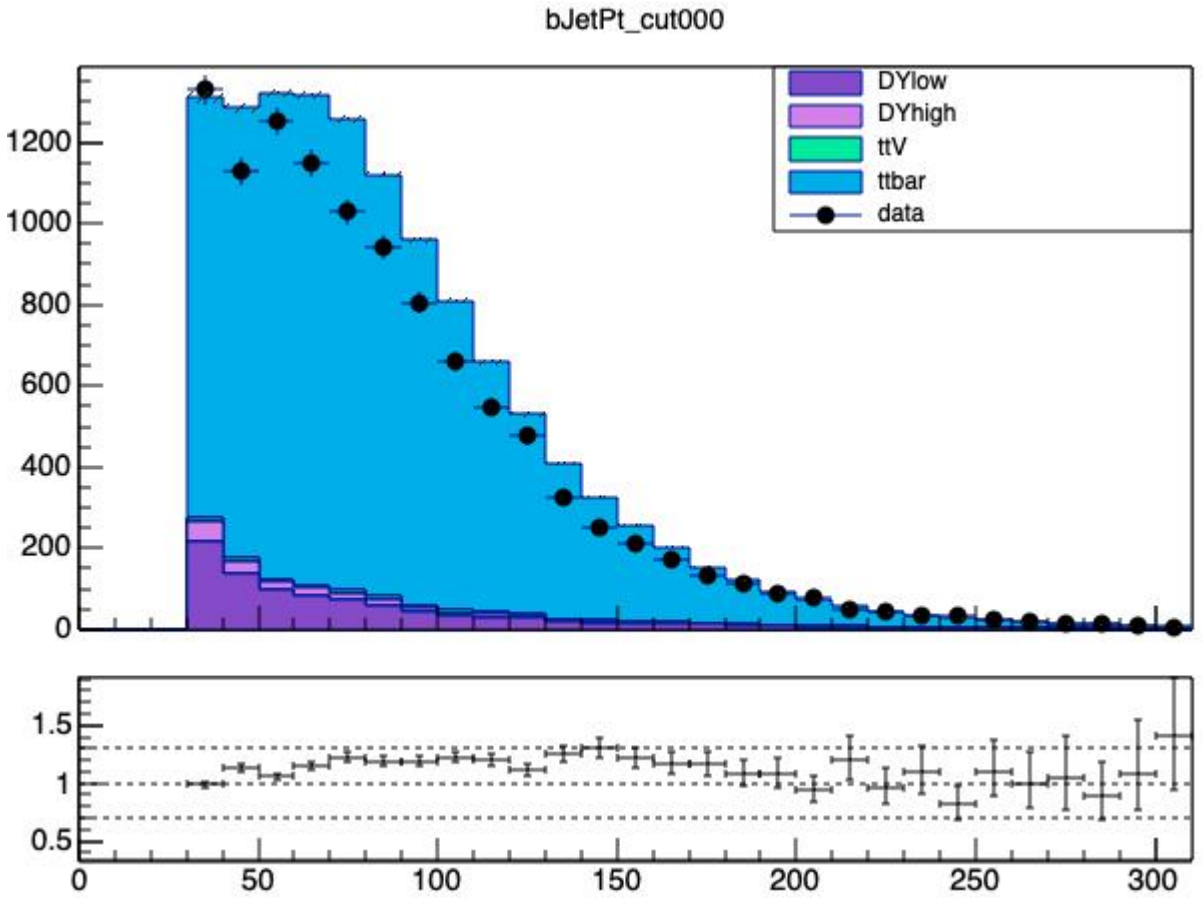
300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ttbar
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0
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100
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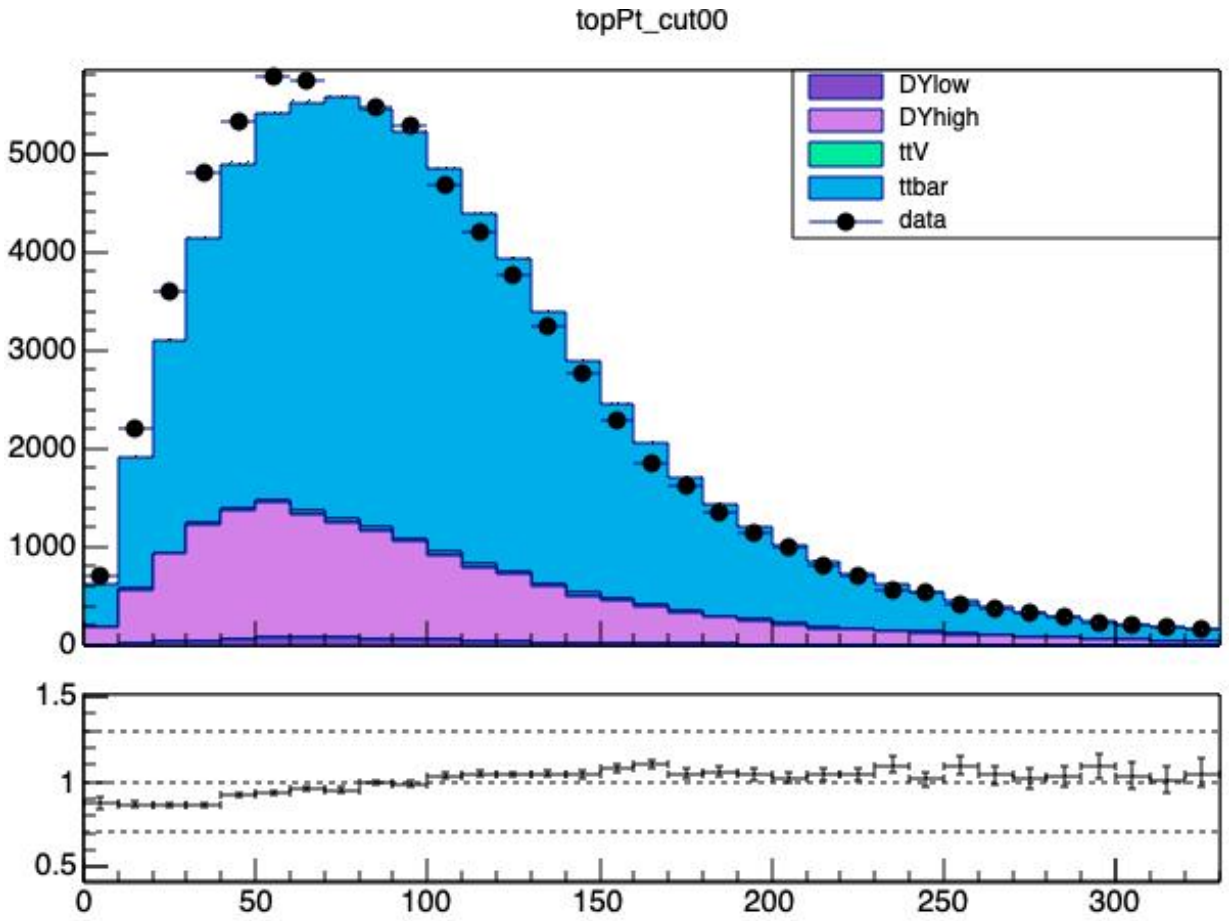
top pt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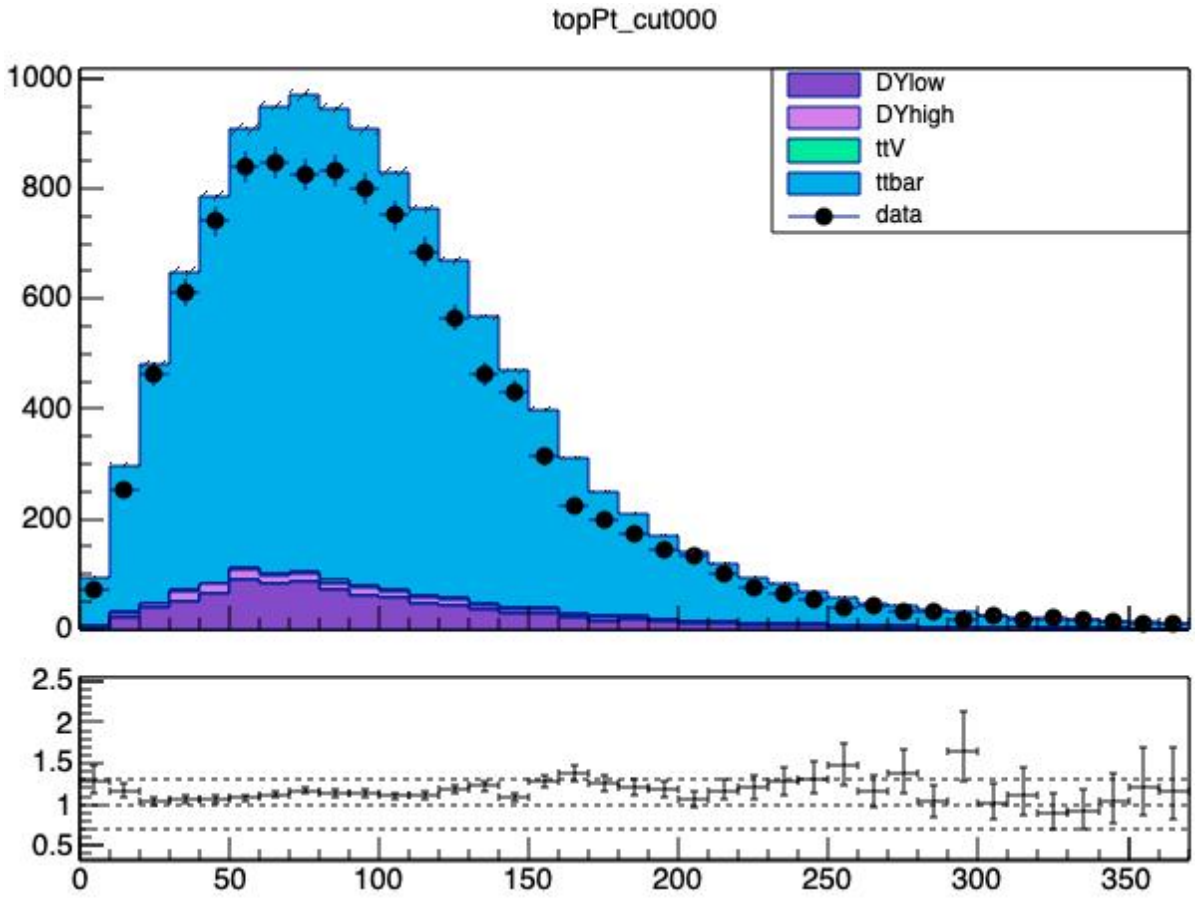
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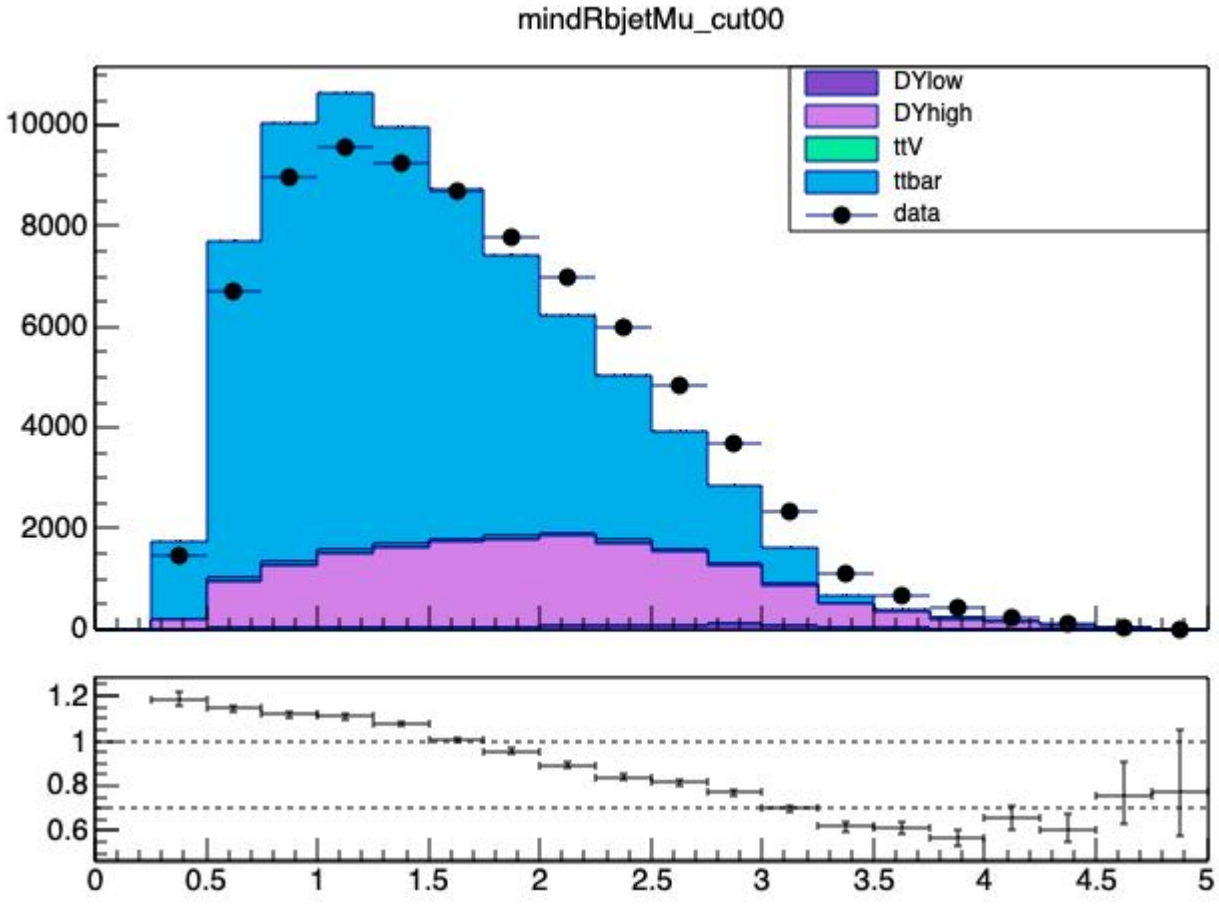
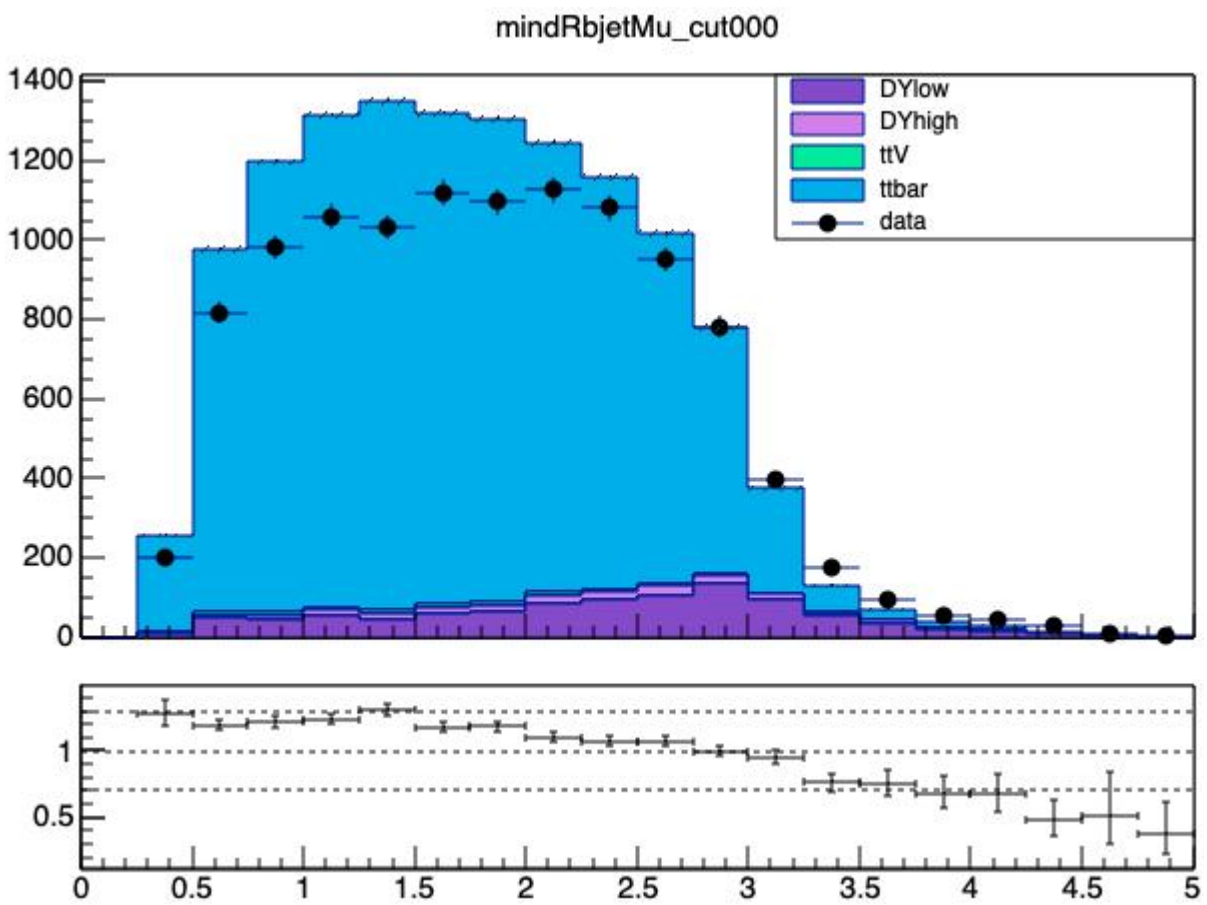
350

mindR(b jet, mu)





mindR(b jet, mu)