Jet Muon Analysis

권 우 연

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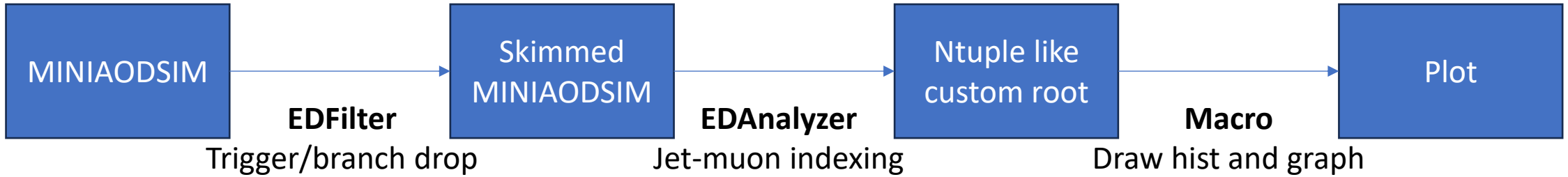
Workflow

Purpose : Looking into the PFjet and the muons inside it. Comparing with gen level info.



Object Definition

Generator Object

- **genJet** : slimmedGenJets, reconstructed gen jet with anti-kt R=0.4
- **genMuon** : packedGenParticles, slimmed gen particle with pdgID = ±13 (muon)

Reconstructed Object

- **patJet** : slimmedJetsPuppi, ak4PFPuppiJets
- **muon** : packedPFCandidates, slimmed PFCandidates with pdgID = ±13 (muon)

MC Samples

MC era : Run3Summer22

ttbar to semi leptonic : TTtoLNu2Q_TuneCP5_13p6TeV_powheg-pythia8

Event Selection

- Exact 1 prompt lepton
  - prompt lepton criteria
    - PAT electron
      - pt > 30 GeV
      - mva electron ID tight (egmGsfElectronIDs:mvaEleID-RunIIIWinter22-iso-V1-wp90)
      - mva_Isolated > 0.9 (Multivariate Analysis based isolation score)
    - PAT muon
      - pt > 24GeV
      - muon Tight ID (Cut based ID Tight)
      - Tight PF Isolation ($Iso_{PF}^{Rel} < 0.15$, R=0.4)

ttbar to SL jet distribution

patJet ID

For AK4 PUPPI jets				
PF Jet ID	abs(η) <= 2.6	2.6 < abs(η) <= 2.7	2.7 < abs(η) <= 3.0	3.0 < abs(η) <= 5.0
Neutral Hadron Fraction	< 0.99	< 0.90	< 0.99	-
Neutral EM Fraction	< 0.99	< 0.99	-	< 0.4
Number of Constituents	> 1	-	-	-
Muon Fraction	< 0.80 (for LepVeto)	< 0.80 (for LepVeto)	-	-
Charged Hadron Fraction	> 0.01	-	-	-
Charged Multiplicity	> 0	-	-	-
Charged EM Fraction	< 0.80 (for LepVeto)	< 0.80 (for LepVeto)	-	-
Number of Neutral Particles	-	-	-	> =2

Jet group recommendation ID cuts. They warned that it can cause bias with LepVeto. The jet ID can also be applied without the vetoing on leptons to avoid possible biases.

Jet Selection

- $p_t > 20\ GeV\ \&\&\ |\eta| \leq 5.0$

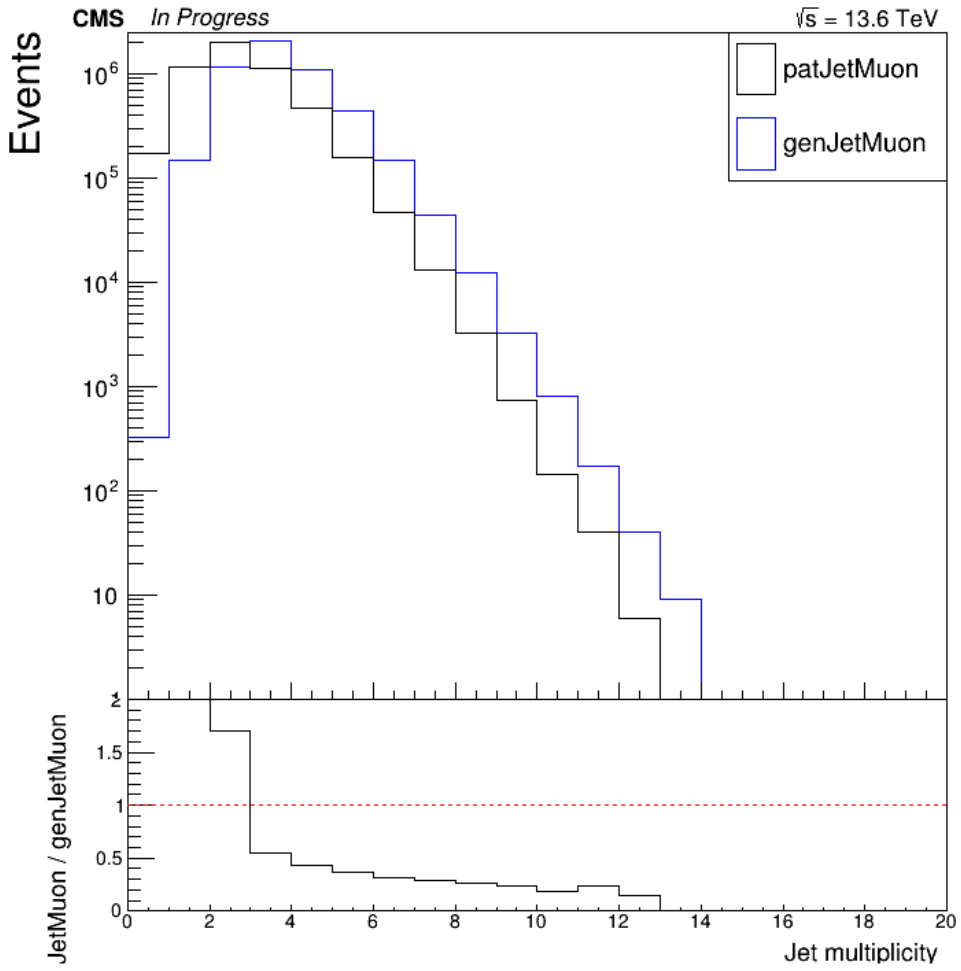
ttbar to SL jet distribution

Jet Multiplicity

total number of events : 5,126,611

patJet ID : LepVeto

There is shift for the jet multiplicity…

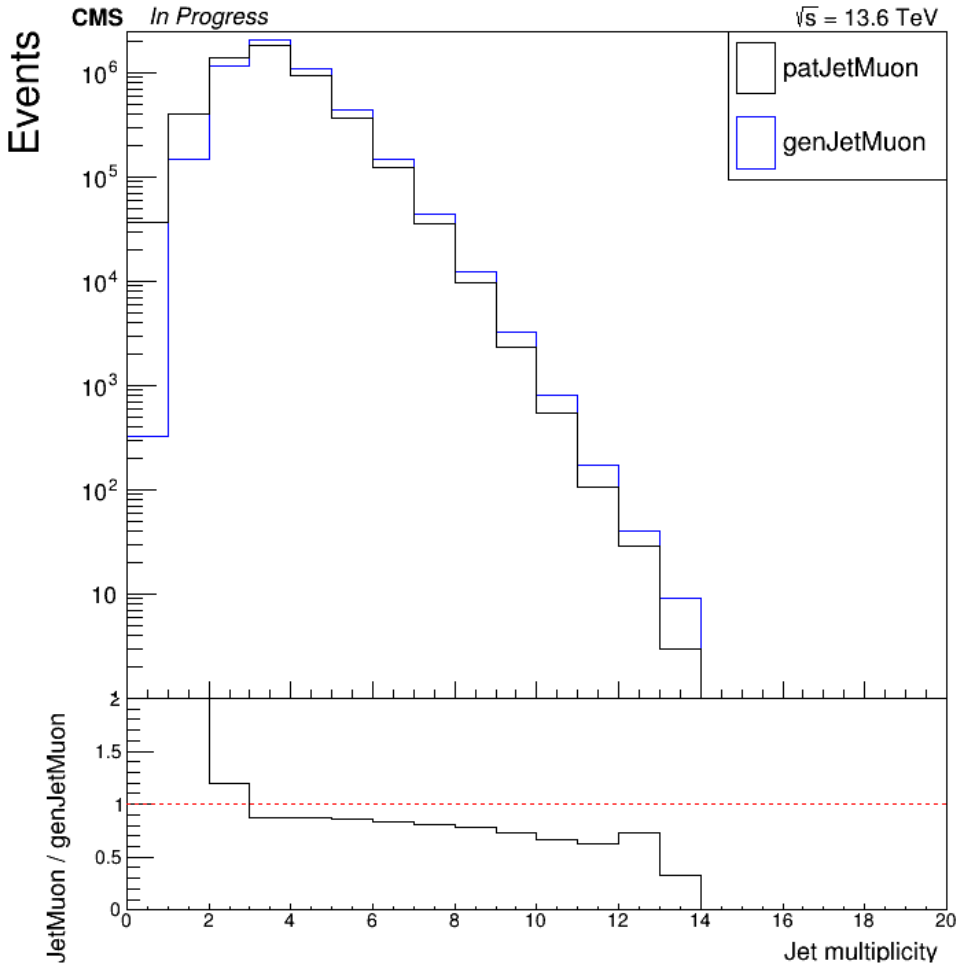


ttbar to SL jet distribution

Jet Multiplicity

total number of events : 5,126,611

patJet ID : No LepVeto



ttbar to SL muon distribution in Jets

Muon multiplicity in each Jet(LepVeto Jet)

Total number of patJets : 11,579,834

Total number of genJets : 16,594,196

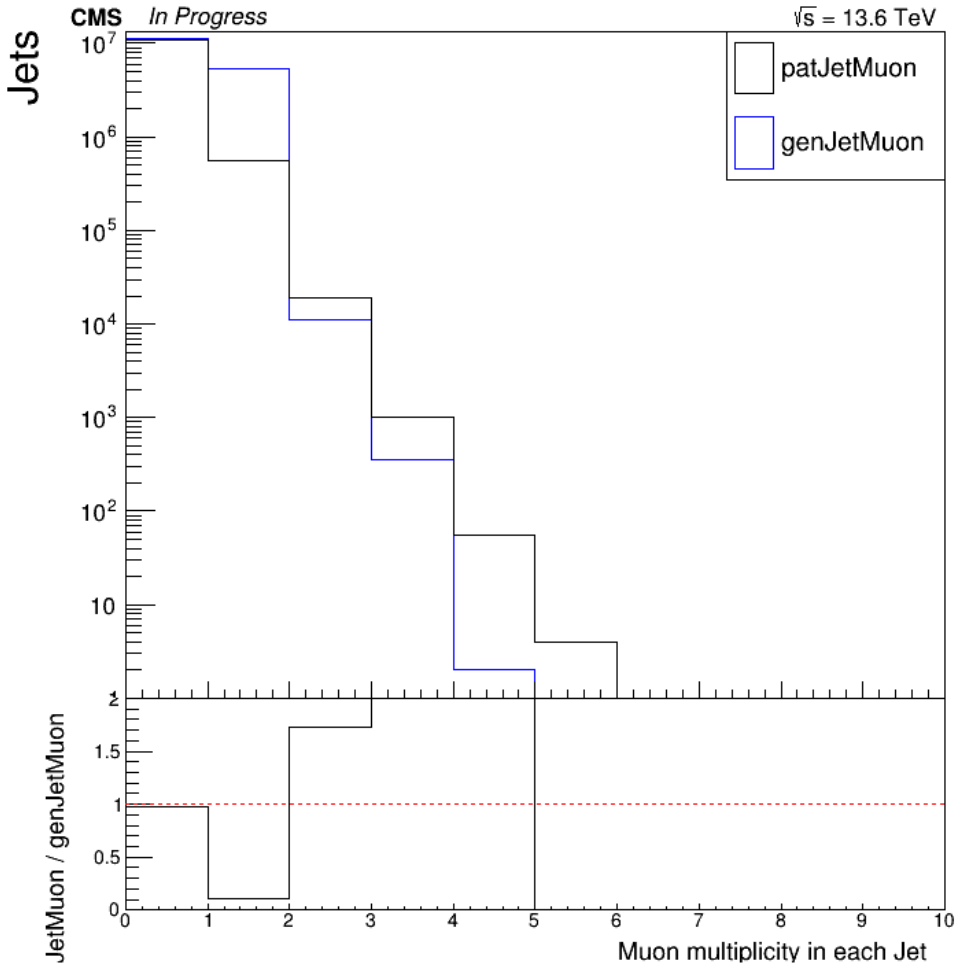
⇒ Count with *muonMultiplicity()* method (PF)

⇒ about 12,000 jets have muons more than two

⇒ the ratio is less than 0.1%...

⇒ fake muons in Jet?

※ Jet matching applied with *genJet()* method



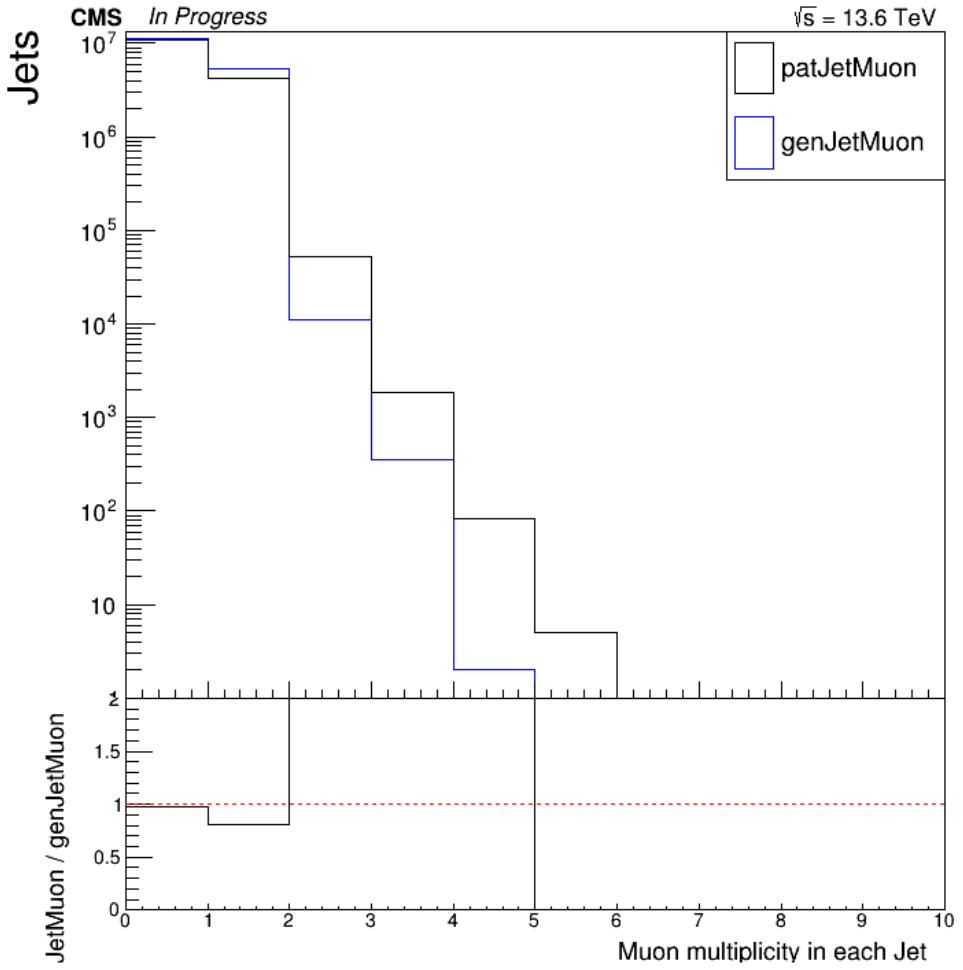
ttbar to SL muon distribution in Jets

Muon multiplicity in each Jet (no LepVeto Jet)

Total number of patJets : 15,344,389

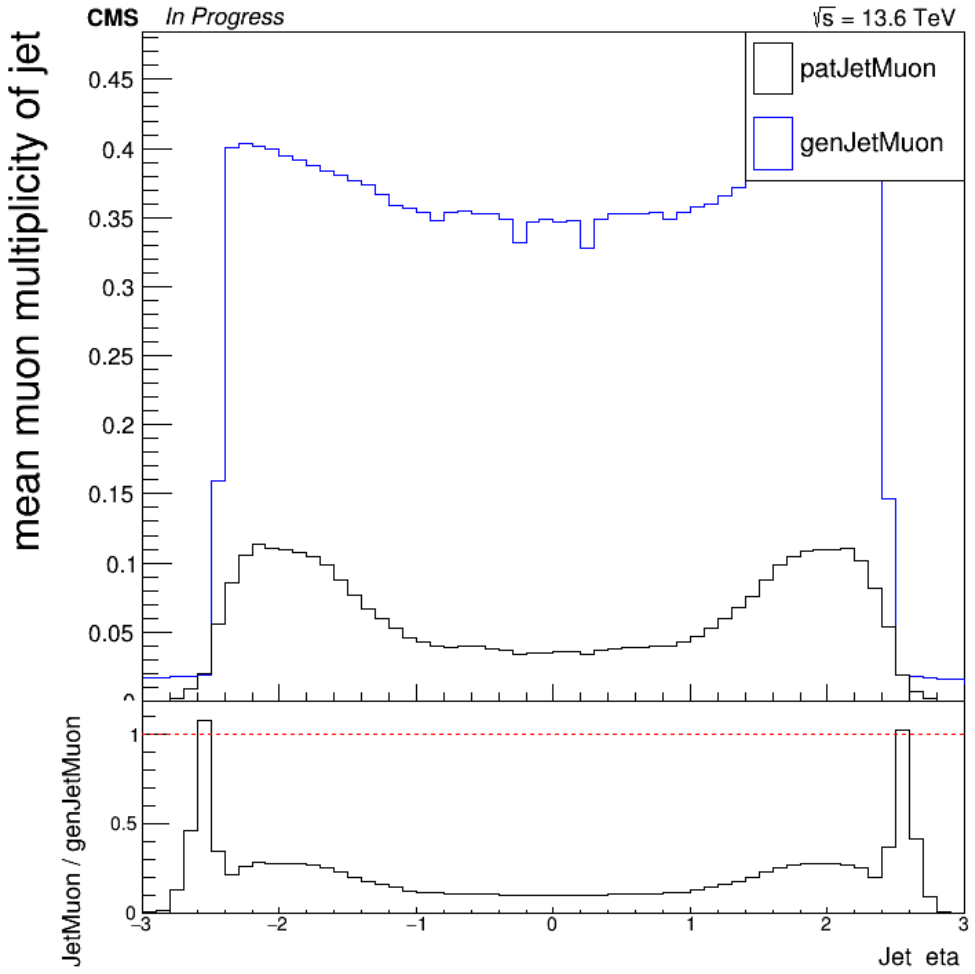
Total number of genJets : 16,594,196

=> more jets are survived. but fakes too.

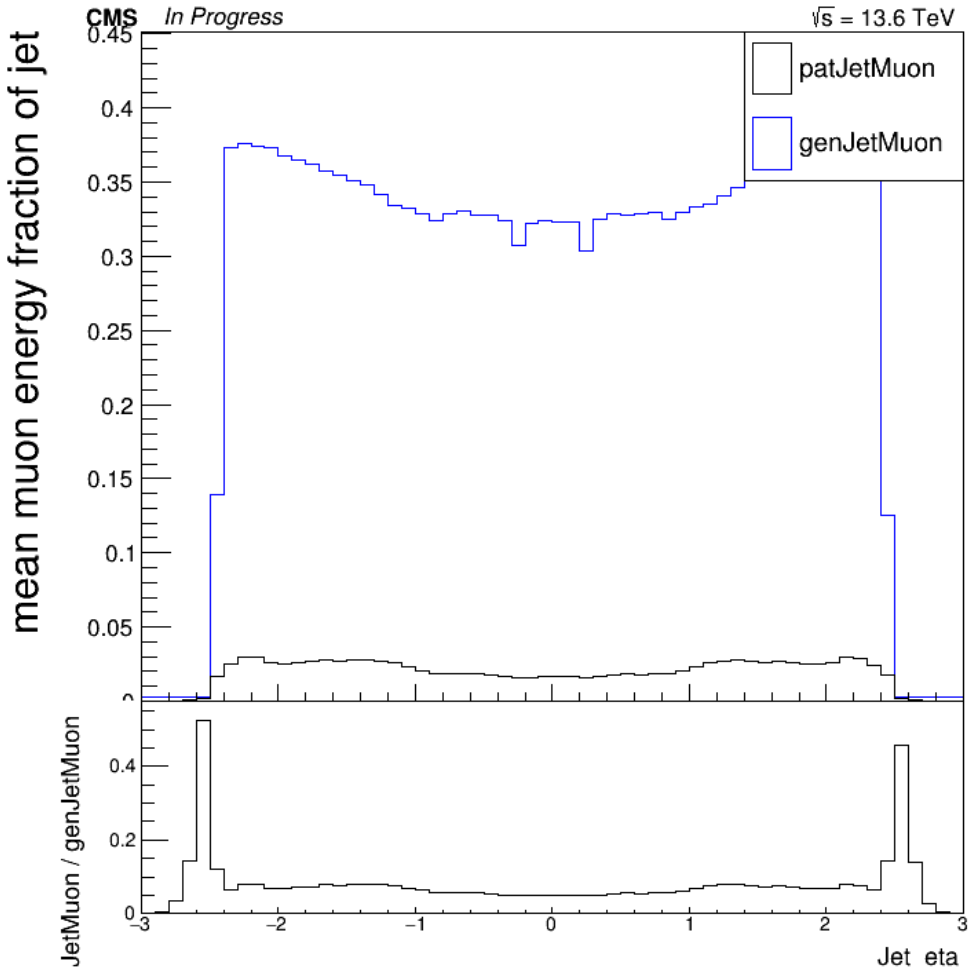


ttbar to SL muon distribution in Jets (LepVeto)

average muon multiplicity in jet

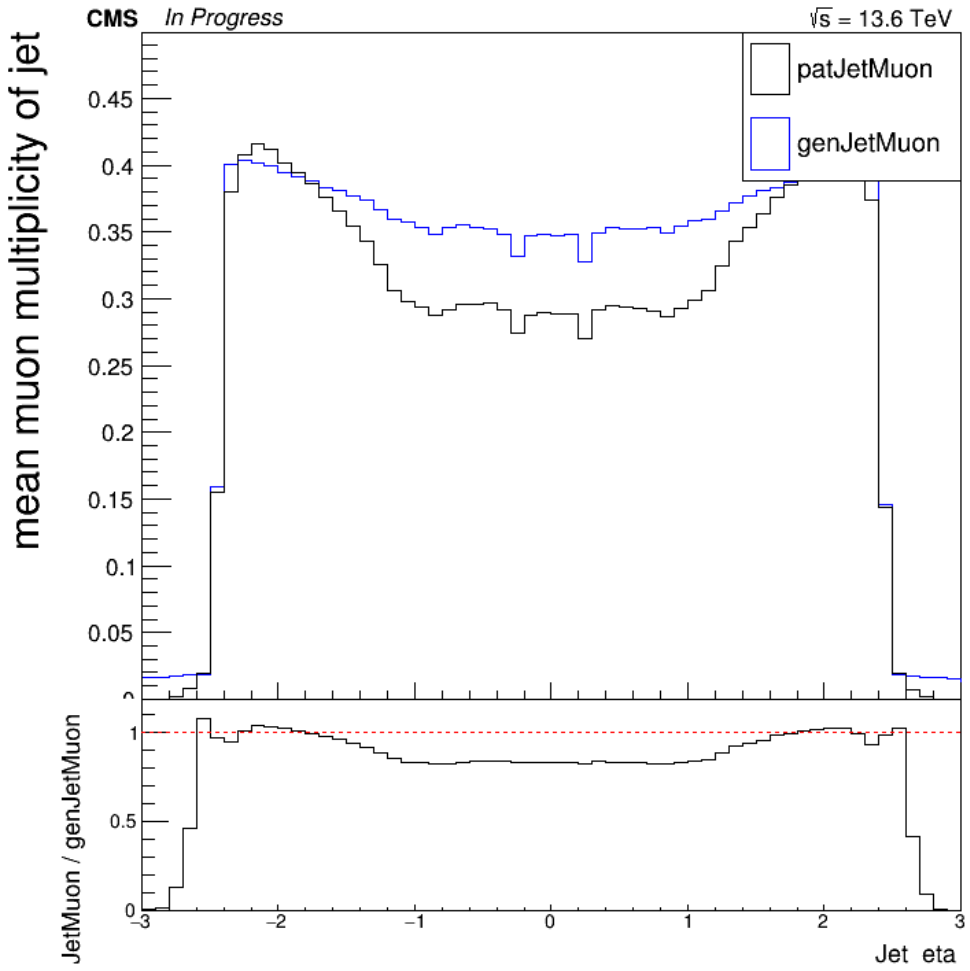


average muon energy fraction in one jet

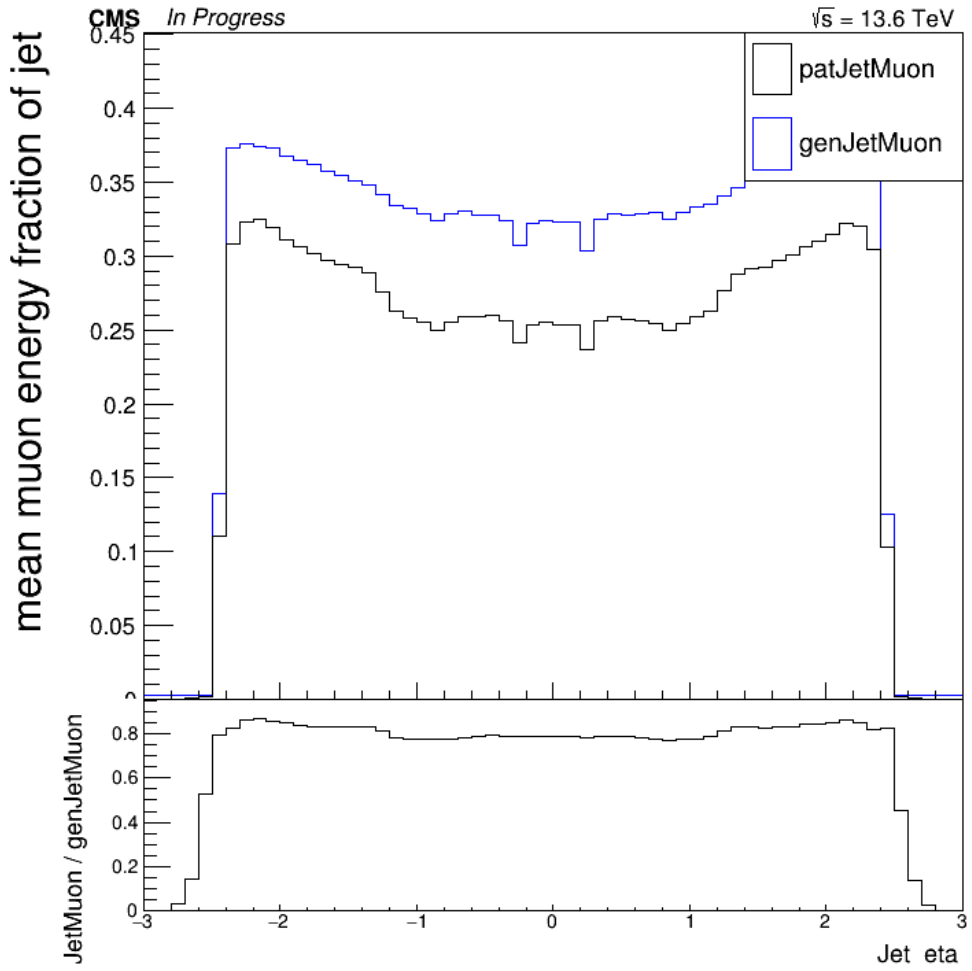


ttbar to SL muon distribution in Jets (no LepVeto)

average muon multiplicity in jet

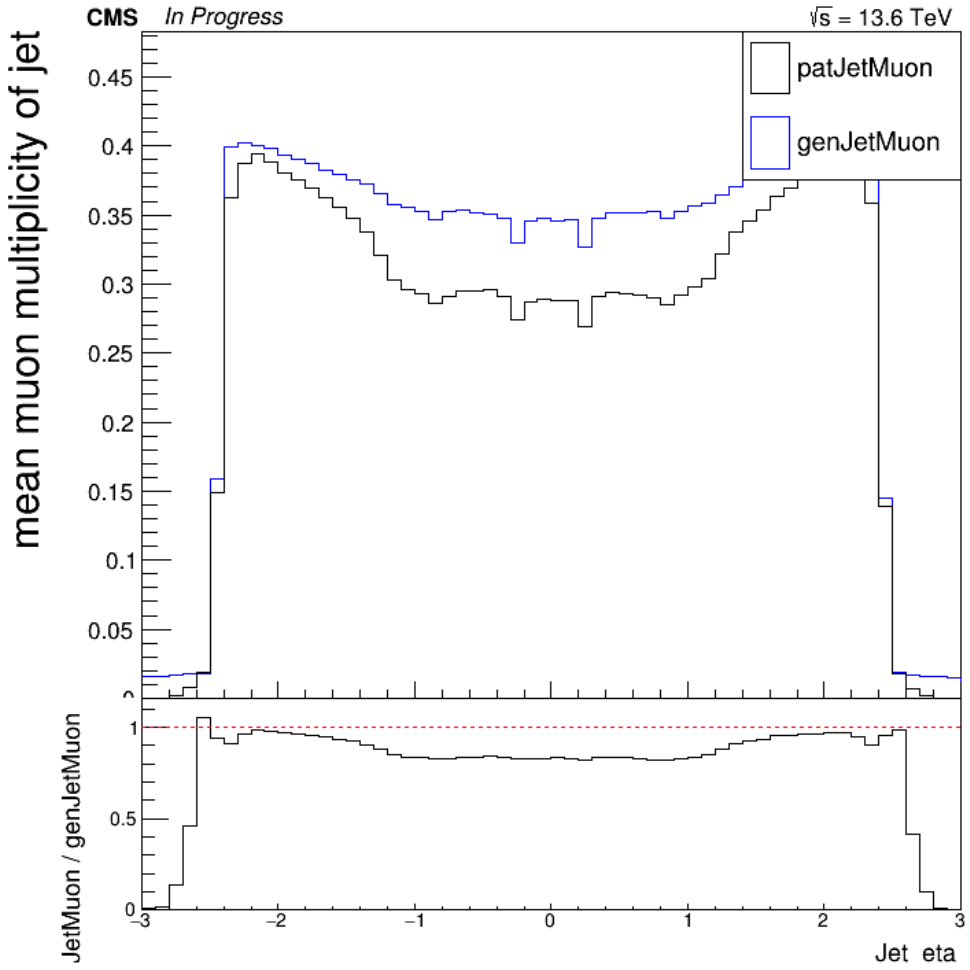


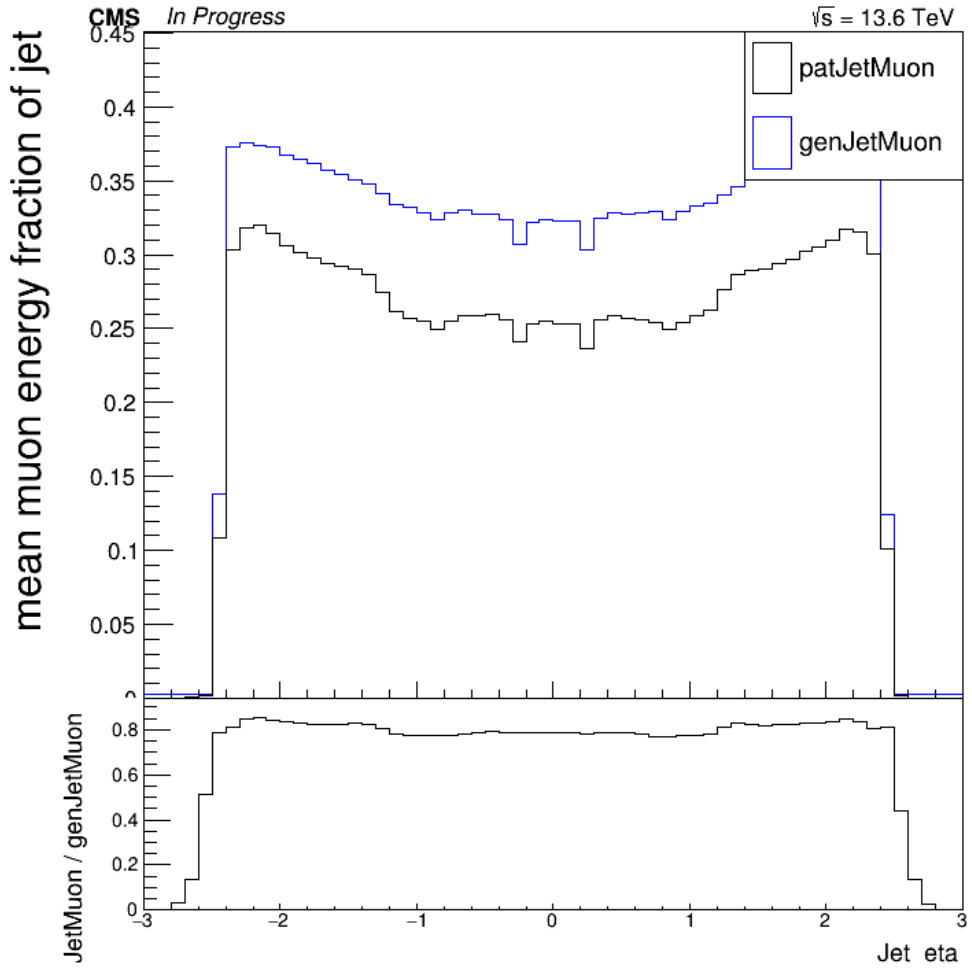
average muon energy fraction in one jet



ttbar to SL muon distribution in Jets (no LepVeto)

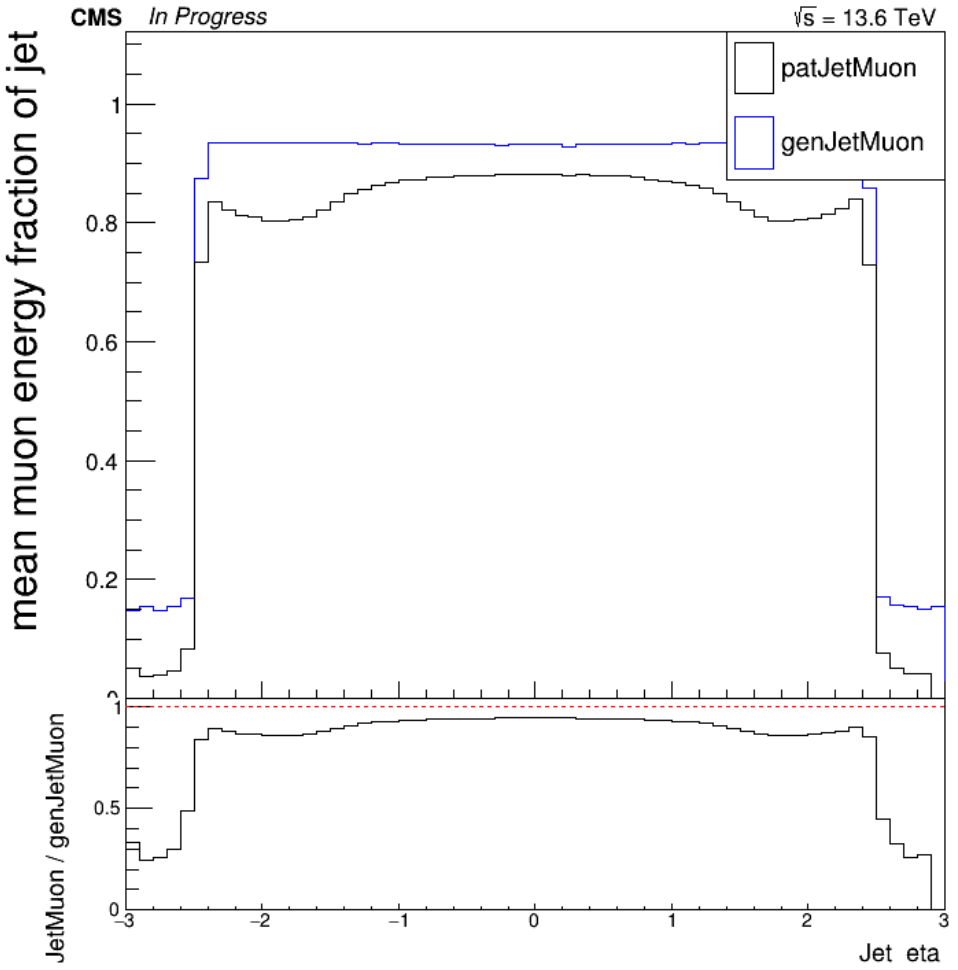
Object Selection : Jets which have 0 or 1 muon.





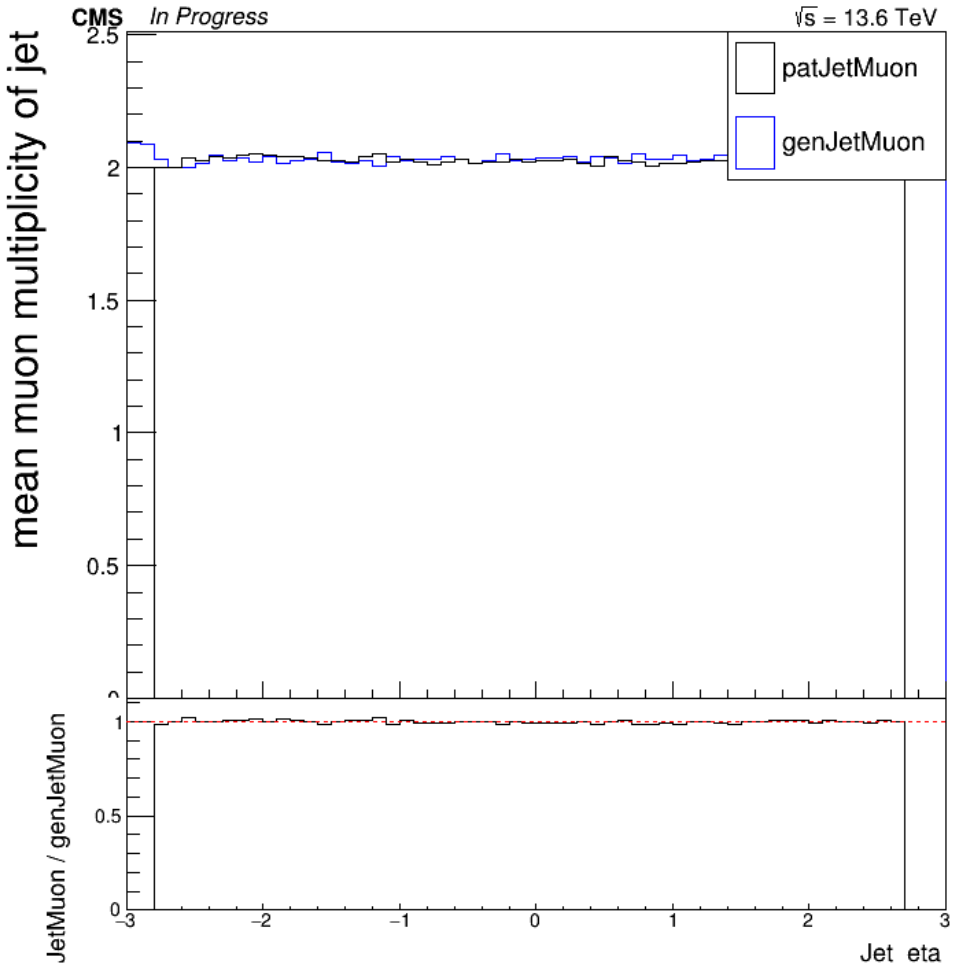
ttbar to SL muon distribution in Jets (no LepVeto)

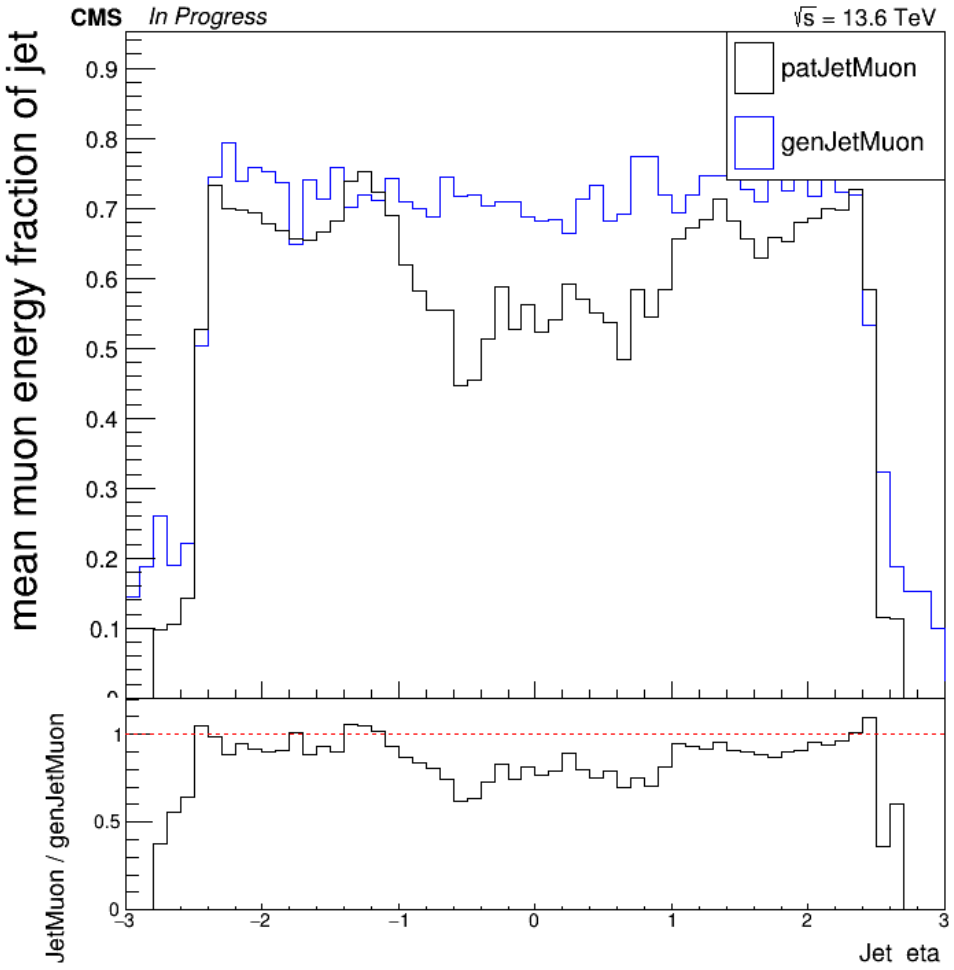
Object Selection : Jets which have 1 muon.



ttbar to SL muon distribution in Jets (no LepVeto)

Object Selection : Jets which have more than 2 muons.



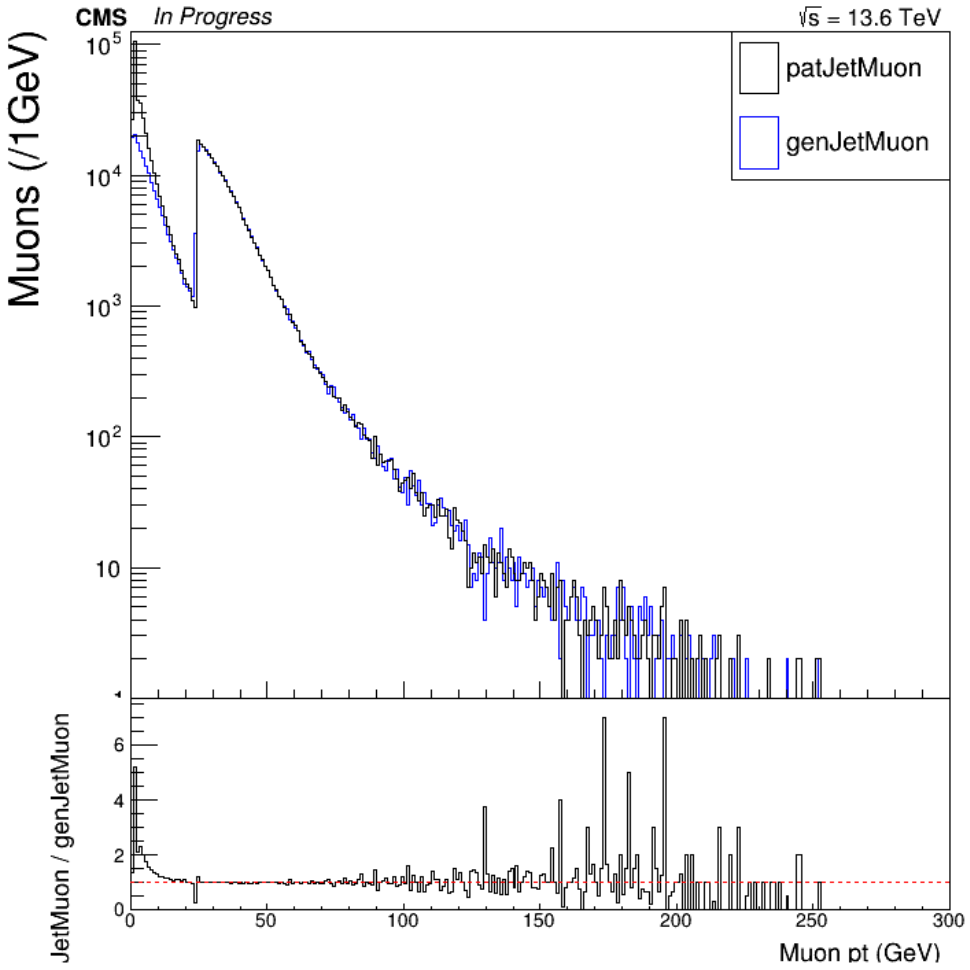


ttbar to SL muon distribution in Jets (LepVeto)

Leading Muons pt in Jet

patJetMuon entries: 581,560

genJetMuon entries : 406,618

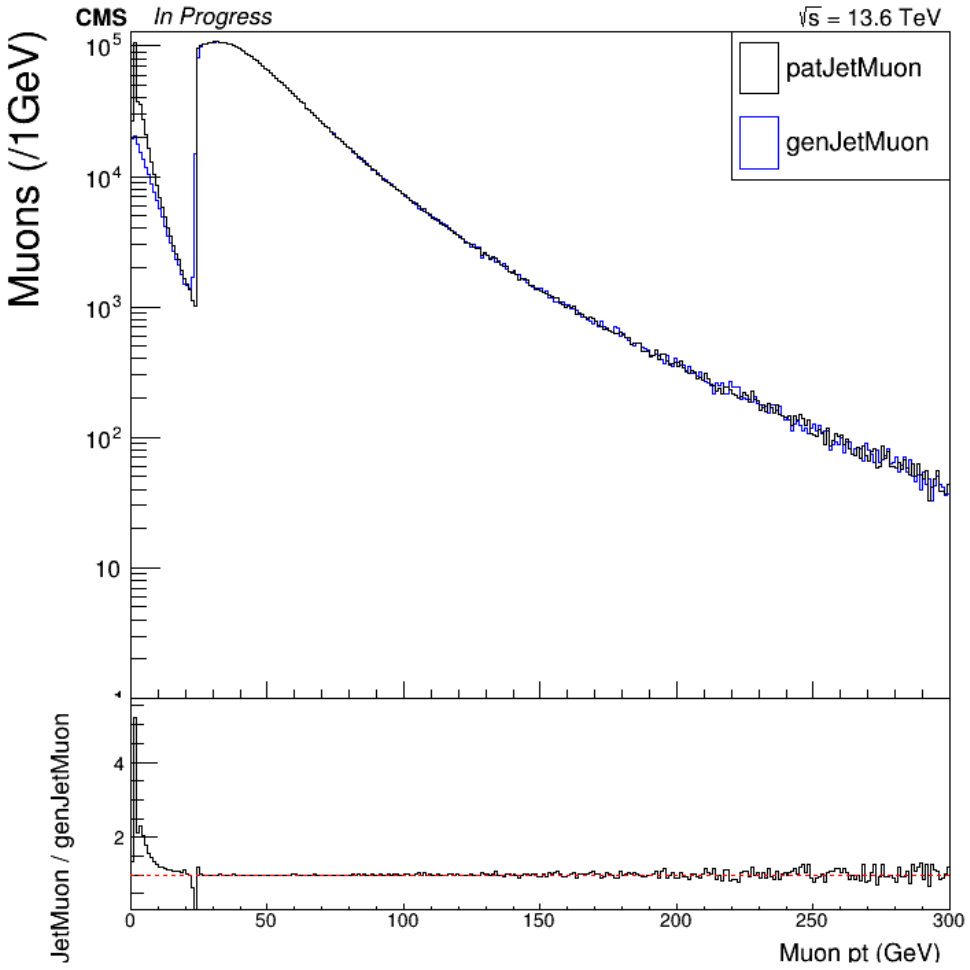


ttbar to SL muon distribution in Jets (no LepVeto)

Leading Muons pt in Jet

patJetMuon entries: 4,331,313

genJetMuon entries : 4,155,875

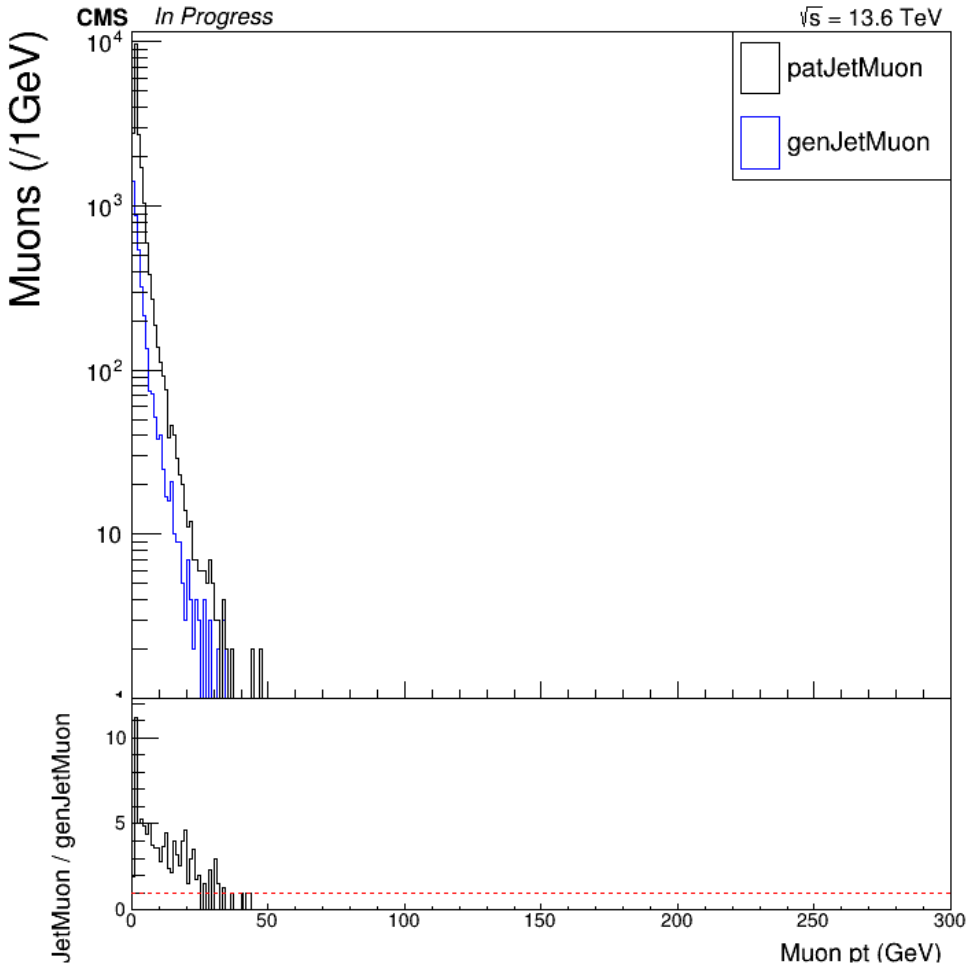


ttbar to SL muon distribution in Jets (LepVeto)

2nd Leading Muons pt in Jet

patJetMuon entries: 20139

genJetMuon entries : 3934

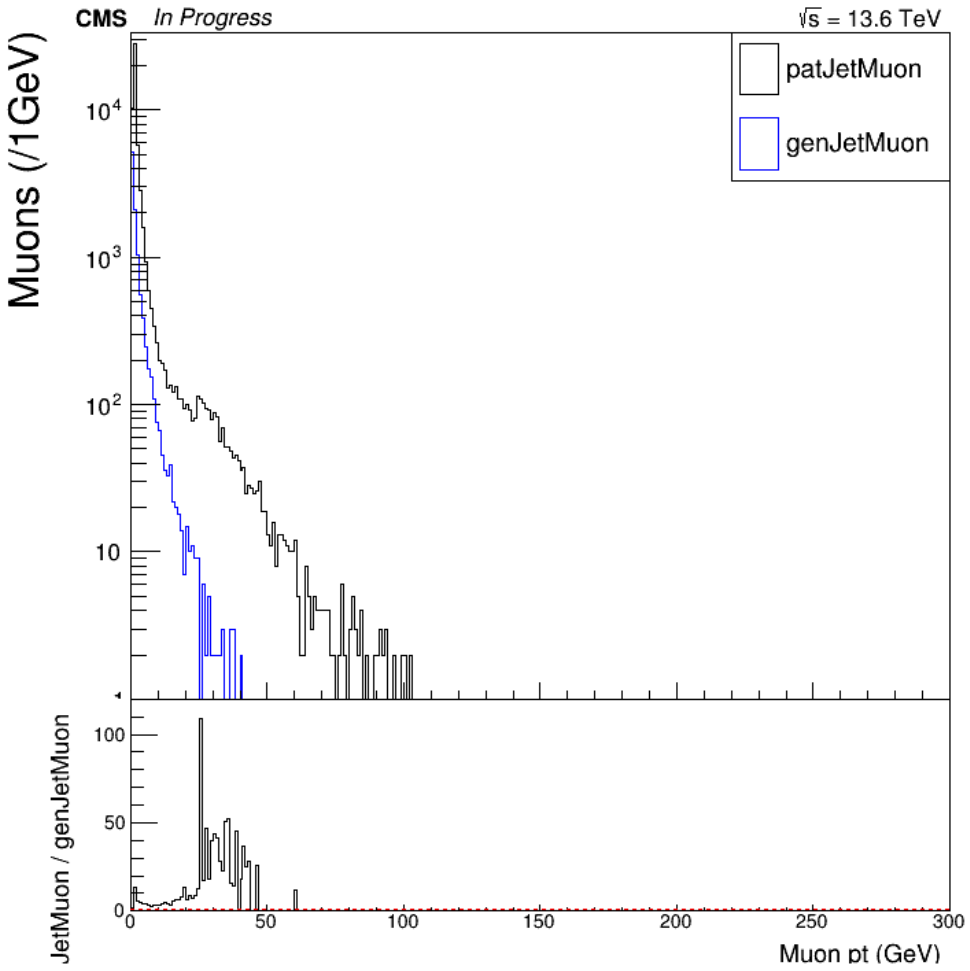


ttbar to SL muon distribution in Jets (no LepVeto)

2nd Leading Muons pt in Jet

patJetMuon entries: 54605

genJetMuon entries : 10385



Backup - Object Definition

※ Object definition in miniAODSIM

(Type “module” : description)

gen level object

reco::GenJet "slimmedGenJets" : reconstructed gen jet with anti-kt R=0.4

reco::GenParticle "prunedGenParticles" : slimmed gen particle

pat::PackedGenParticle "packedGenParticles" : more slimmed gen particle than “prunedGenParticles”

reco level object

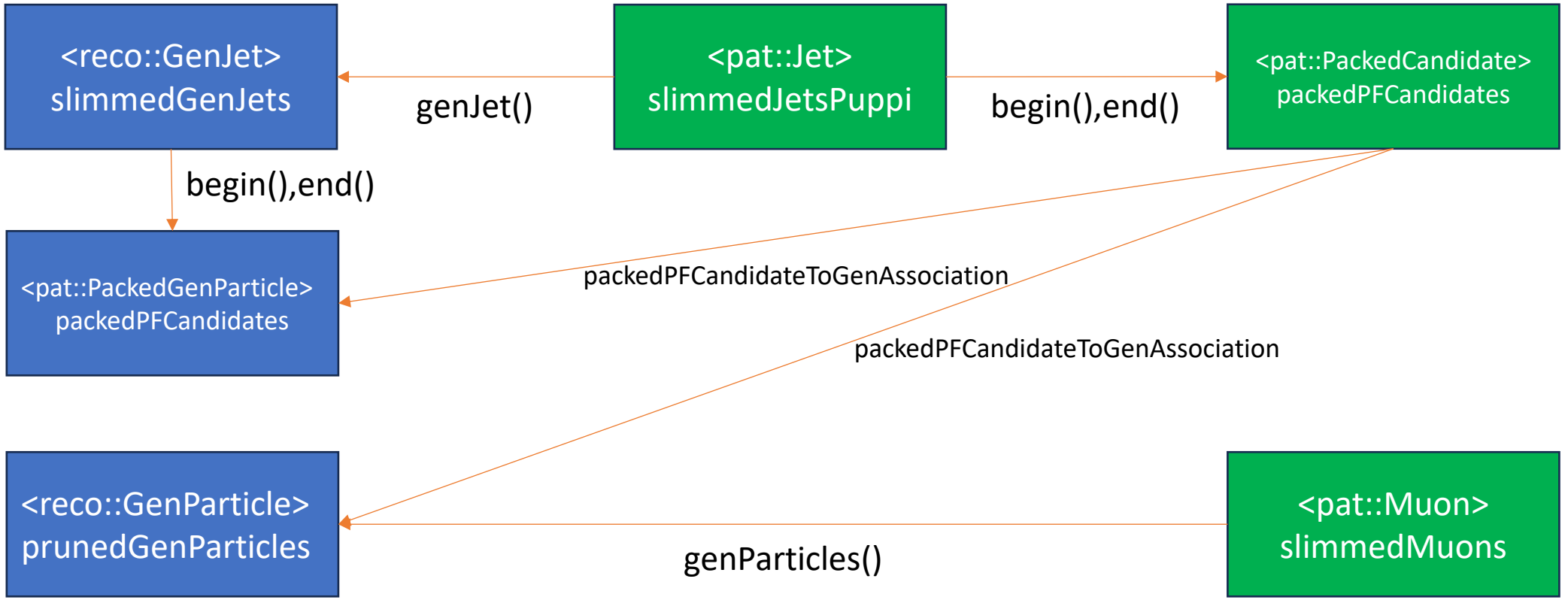
pat::Jet "slimmedJetsPuppi" : ak4 PFJets Puppi

pat::Muon "slimmedMuons" : slimmed reco muon

pat::PackedCandidate "packedPFCandidates" : slimmed PFCandidates

Backup – miniAOD structure

miniAOD structure and its reference call methods



Backup - Jet

NanoAOD also use ak4PFPuppiJets

```
*.....................................................................*
*Br  248 :nJet      :                                                  *
*        | Int_t slimmedJetsPuppi, i.e. ak4 PFJets Puppi with JECs applied, after basic selection (pt > 15)*
*Entries :      728 : Total  Size=       3550 bytes  File Size  =        598 *
*Baskets :        1 : Basket Size=      32000 bytes  Compression=   4.99     *
*.....................................................................*
*Br  249 :Jet_jetId : UChar_t Jet ID flag:                              *
*        |  bit2 is tight, bit3 is tightLepVeto                        *
*Entries :      728 : Total  Size=       6644 bytes  File Size  =       1239 *
*Baskets :        1 : Basket Size=      32000 bytes  Compression=   4.87     *
*.....................................................................*
*Br  250 :Jet_nConstituents : UChar_t Number of particles in the jet    *
*Entries :      728 : Total  Size=       6658 bytes  File Size  =       2455 *
*Baskets :        1 : Basket Size=      32000 bytes  Compression=   2.46     *
*                                                                     *
```

TWiki > CMS Web > JetMET > JetMETAlgorithmsReconstruction > JetID > JetID13p6TeV (2025-02-10, AnnaBenecke)

Jet Identification for the 13.6 TeV data

Contacts: M.Kotsarini, N.Saoulidou, E.Tziaferi

In the following tables, the JetID criteria for AK4PUPPI and AK4CHS jets are listed.

Please note: For AK8 jets, the corresponding (CHS or PUPPI) AK4 jet ID should be used.

Backup - muonMultiplicity

Definition

of PFCandidate muon in PFJet

In Gen case also use PF-like definition.

```
namespace reco {
  class PFJet : public Jet {
  public:
    typedef reco::PFCandidatePtr ConstituentTypePtr;
    typedef reco::PFCandidateFwdPtr ConstituentTypeFwdPtr;

    struct Specific {
      Specific()
          : mChargedHadronEnergy(0),
            mNeutralHadronEnergy(0),
            mPhotonEnergy(0),
            mElectronEnergy(0),
            mMuonEnergy(0),
            mHFHadronEnergy(0),
            mHFEMEnergy(0),

            mChargedHadronMultiplicity(0),
            mNeutralHadronMultiplicity(0),
            mPhotonMultiplicity(0),
            mElectronMultiplicity(0),
            mMuonMultiplicity(0),
        // PF-like definitions
        switch (std::abs(candidate->pdgId())) {
          case 11:  //electron
            genJetSpecific->m_ChargedEmEnergy += e;
            ++(genJetSpecific->m_ChargedEmMultiplicity);
            break;
          case 13:  // muon
            genJetSpecific->m_MuonEnergy += e;
            ++(genJetSpecific->m_MuonMultiplicity);
            break;
```

function

muonMultiplicity

Definitions Search

DataFormats/JetReco/interface/GenJet.h

```
104 int muonMultiplicity() const { return m_specific.m_MuonMultipl
```

DataFormats/JetReco/interface/JPTJet.h

```
100 int muonMultiplicity() const {
```

DataFormats/JetReco/interface/PFJet.h

```
132 int muonMultiplicity() const { return m_specific.mMuonMultipli
```

DataFormats/PatCandidates/interface/Jet.h

```
385 int muonMultiplicity() const;
```

DataFormats/Scouting/interface/Run3ScoutingPFJet.h

```
99 int muonMultiplicity() const { return muonMultiplicity_; }
```

DataFormats/Scouting/interface/ScoutingPFJet.h

```
100 int muonMultiplicity() const { return muonMultiplicity_; }
```