



Jet Muon Analysis



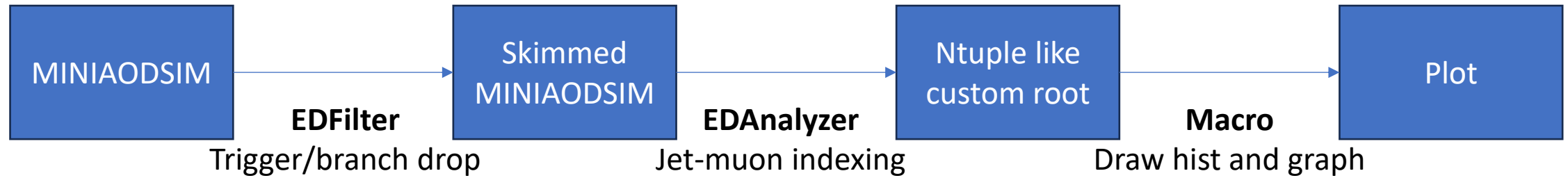
권 우 연

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



MC era : Run3Summer22

ttbar to semi leptonic : TTtoLNu2Q_TuneCP5_13p6TeV_powheg-pythia8

Trigger

HLT_IsoMu24 *or* HLT_Ele32_WPTight_Gsf

Event Selection

- Exact 1 Iso lepton (exact one prompt lepton)
 - Isolation criteria
 - electron : Electron mva_Isolated > 0.9 (Multivariate Analysis based isolation score)
 - muon : Tight PF Isolation ($Iso_{PF}^{Rel} < 0.15$, R=0.4)

Generator Object

- **genJet** : slimmedGenJets, reconstructed gen jet with anti-kt $R=0.4$
- **genMuon** : packedGenParticles, slimmed gen particle with $\text{pdgID} = \pm 13$ (muon)

Reconstructed Object

- **patJet** : slimmedJetsPuppi, ak4PFPuppiJets
- **muon** : packedPFCandidates, slimmed PFCandidates with $\text{pdgID} = \pm 13$ (muon)

Muon multiplicity in each Jet

total number of jets entries : 15,157,222

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

⇒ about 12,000 jets have muons more than two

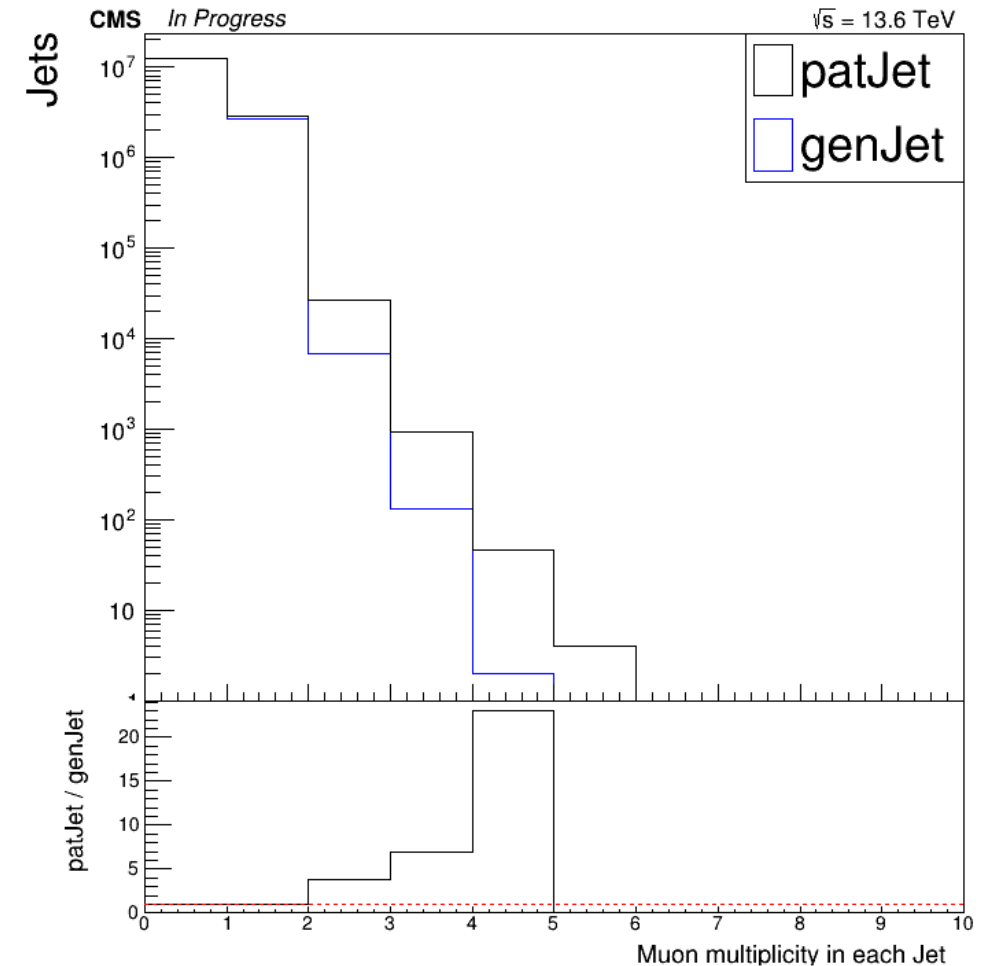
⇒ the ratio is less than 0.1%...

⇒ fake muons in Jet?

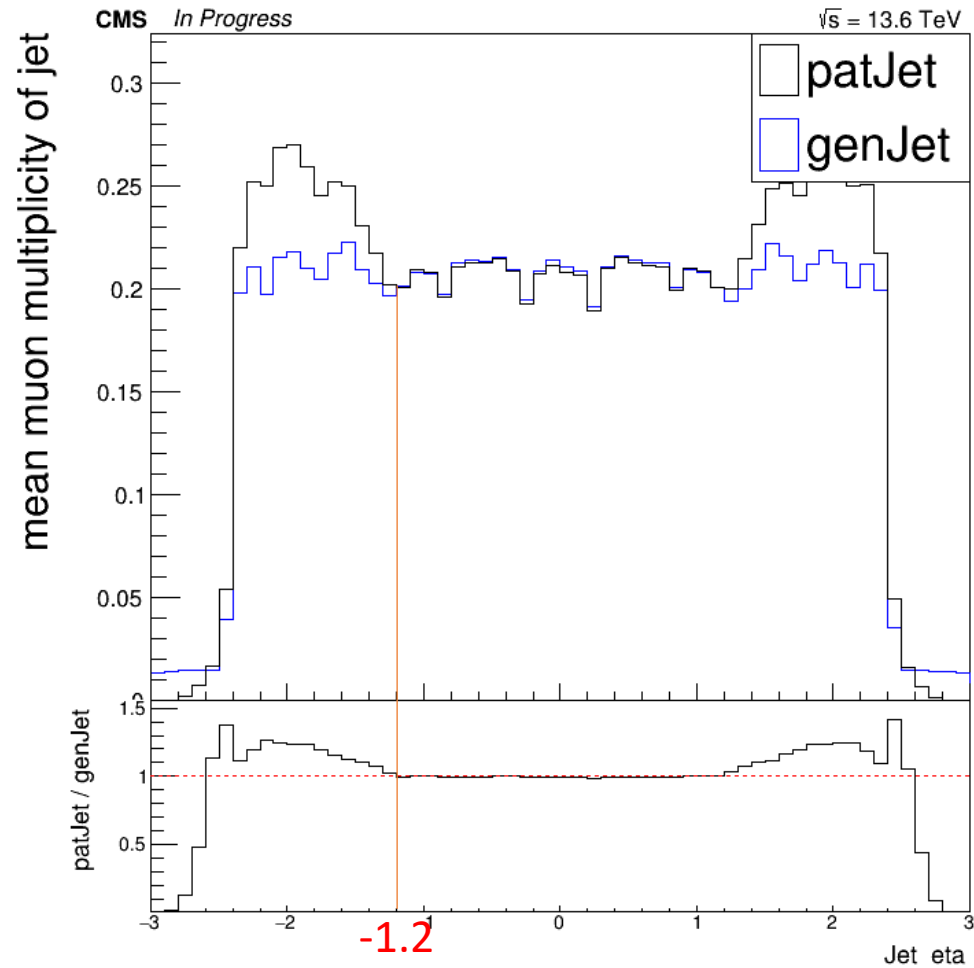
※ Jet matching applied with *genJet()* method

original number of genJets entries : 20,403,727

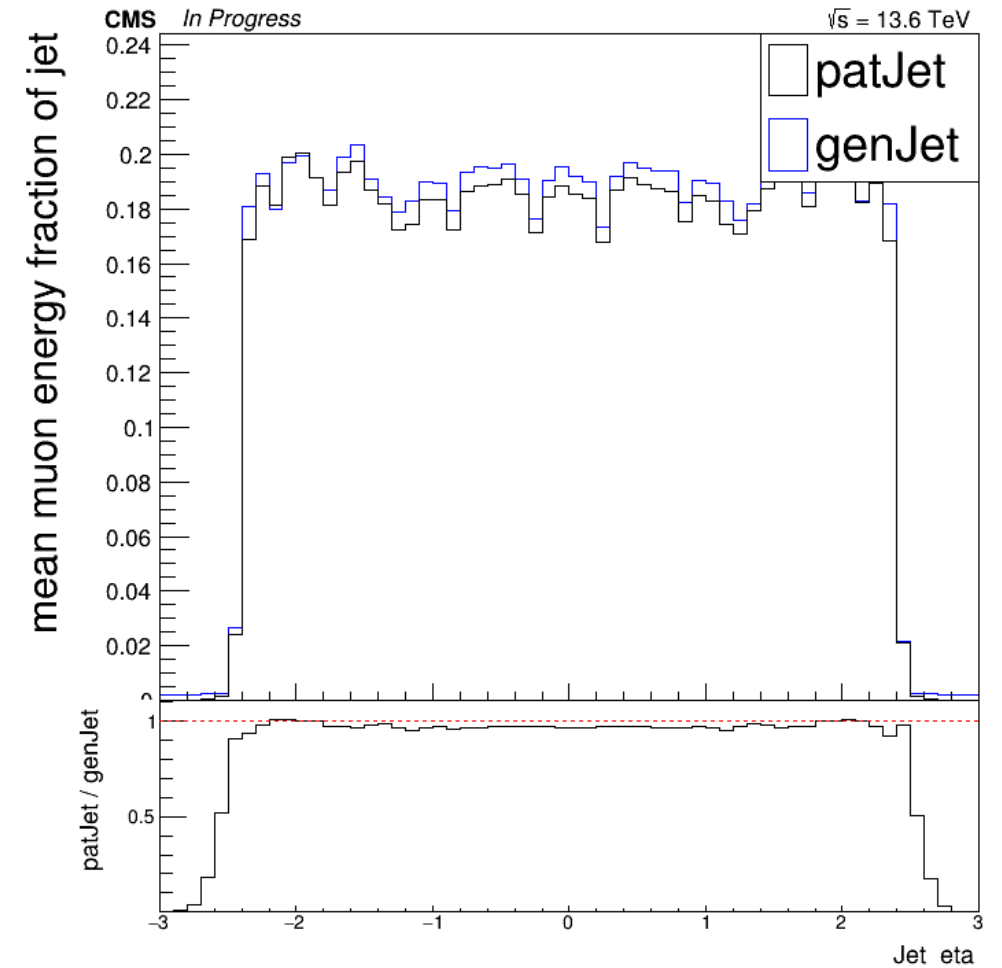
original number of patJets entries: 21,610,591



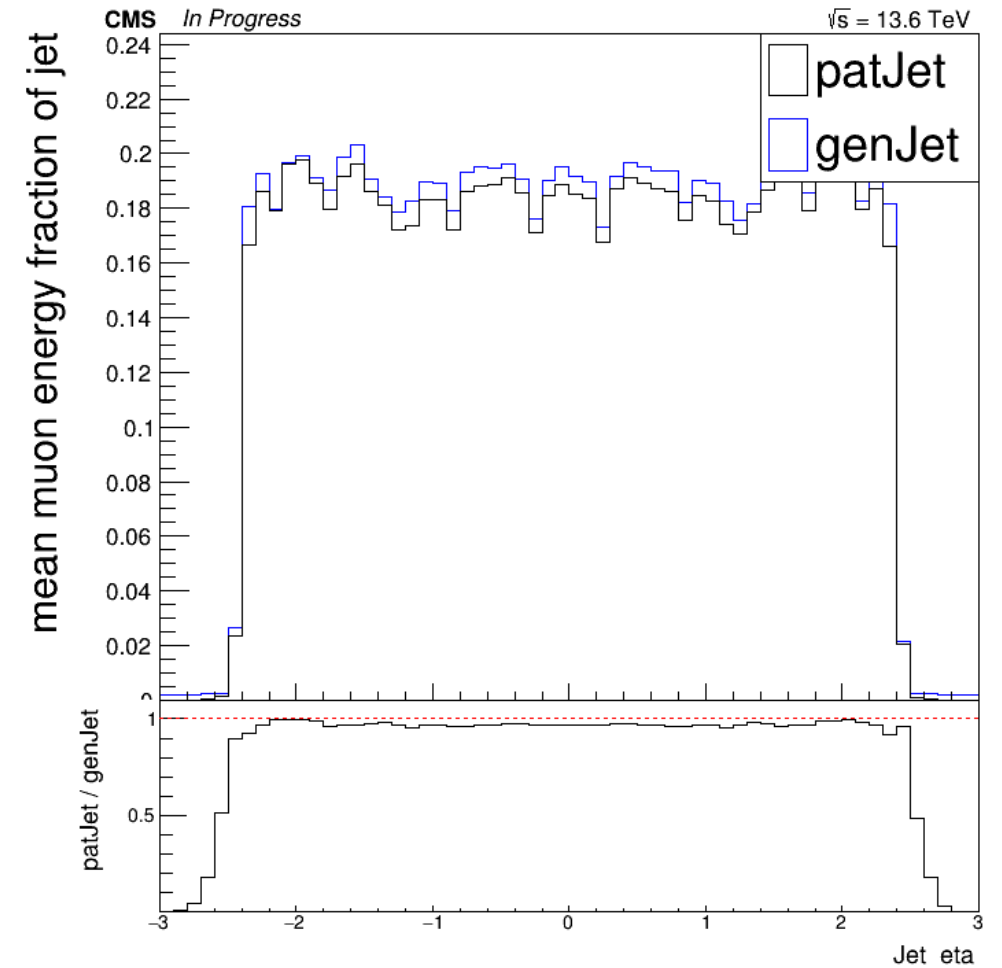
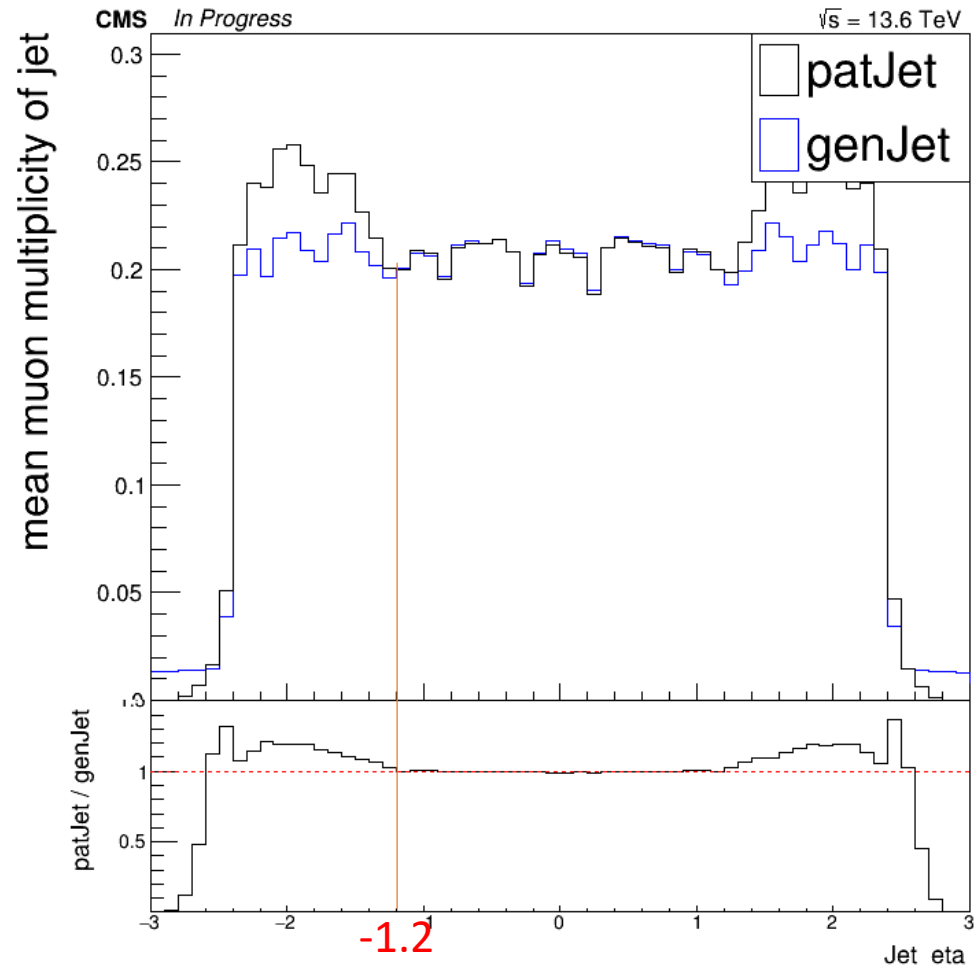
average muon multiplicity in jet



average muon energy fraction in one

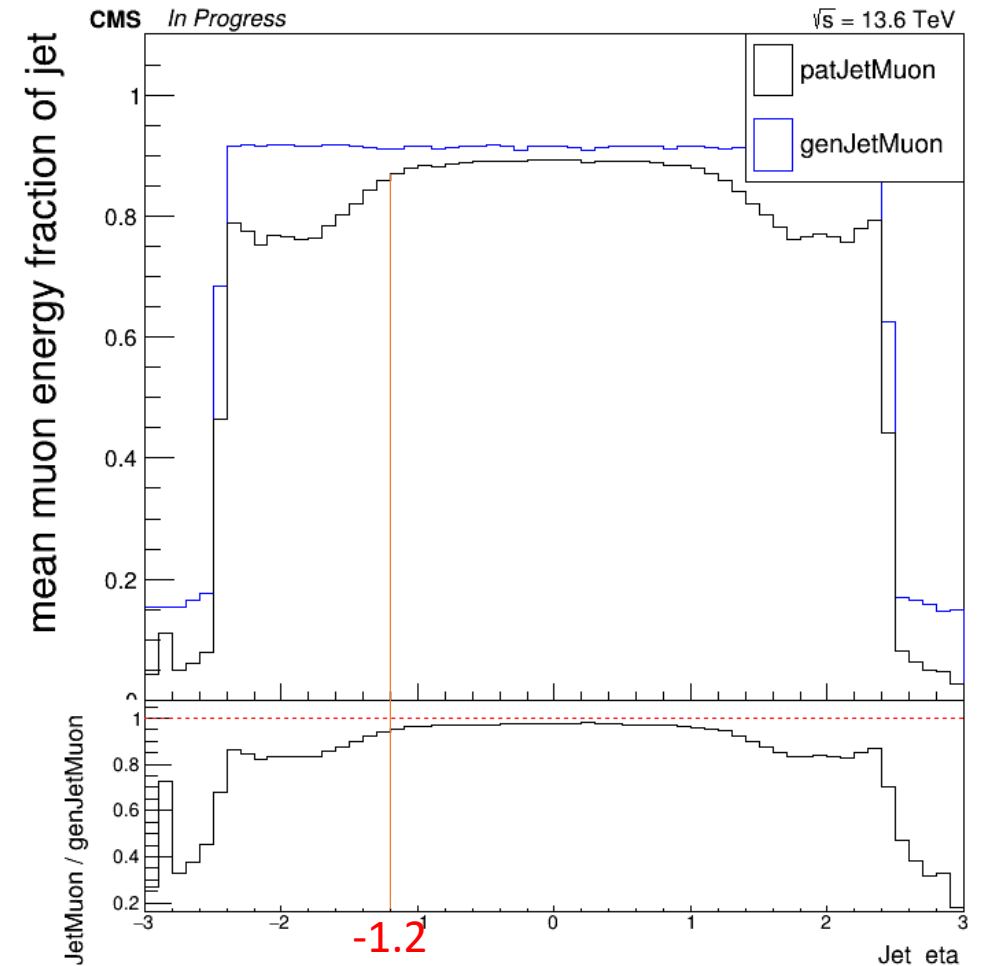
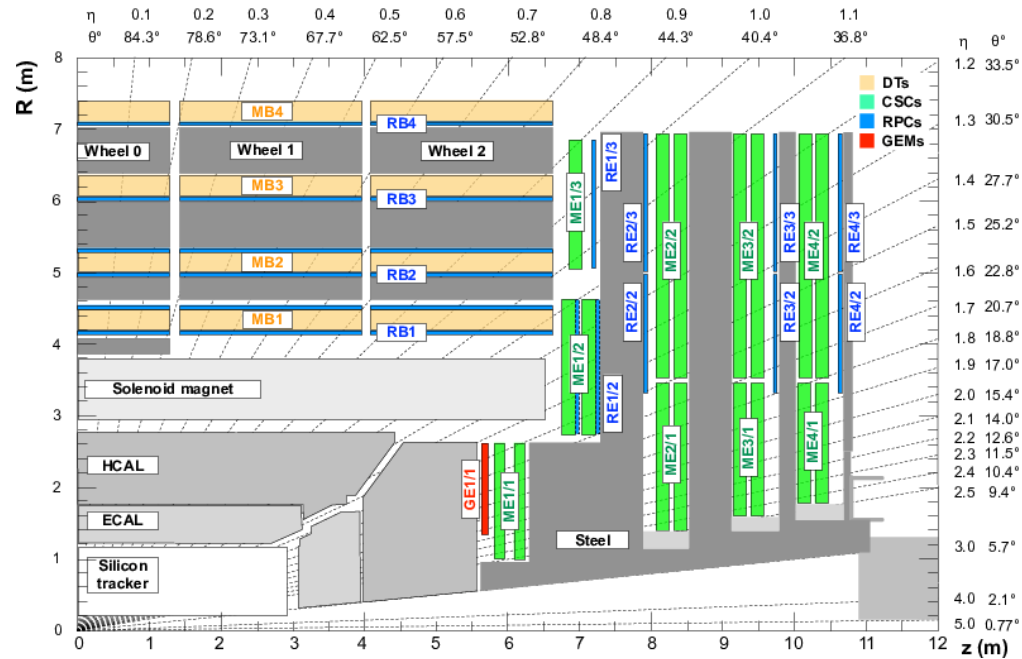


Object Selection : Jets which have 0 or 1 muon.

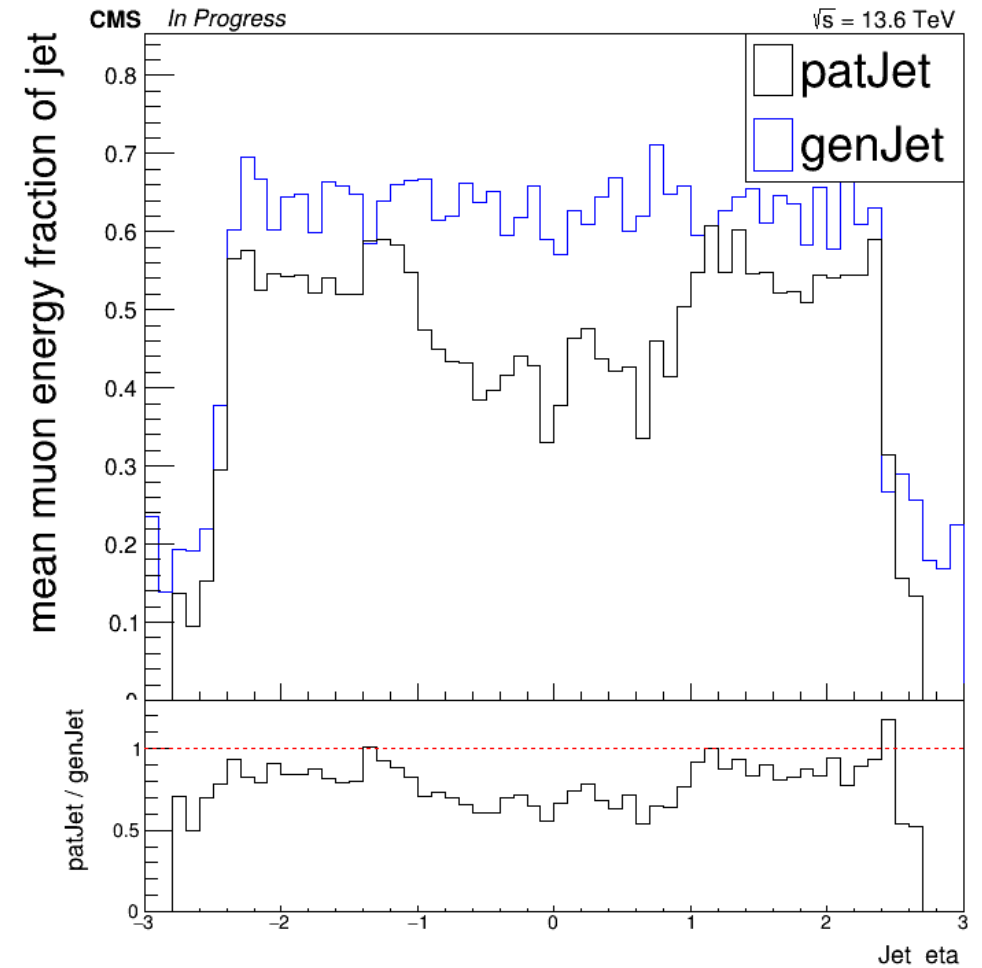
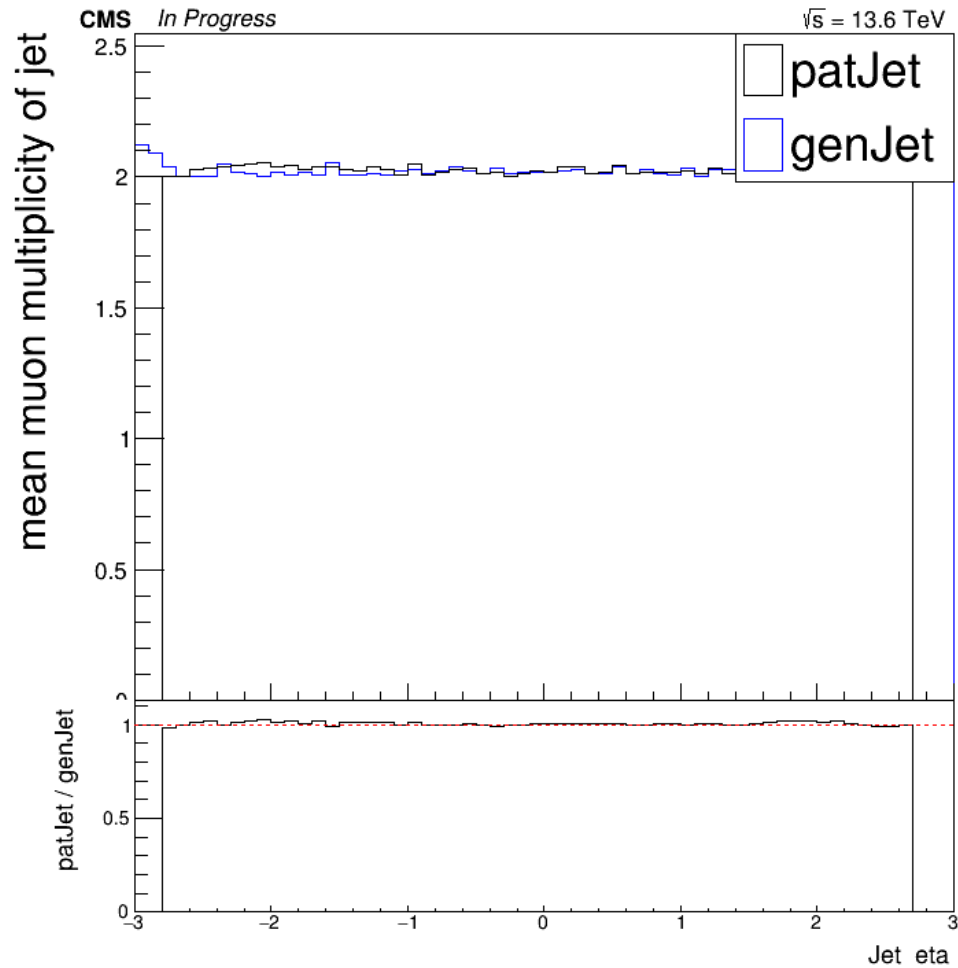


Object Selection : Jets which have 1 muon.

we can see that $|\eta| > 1.2$ region is weird



Object Selection : Jets which have 2 or more muon.



Muons pt in Jet

patJetMuon entries: 2805545

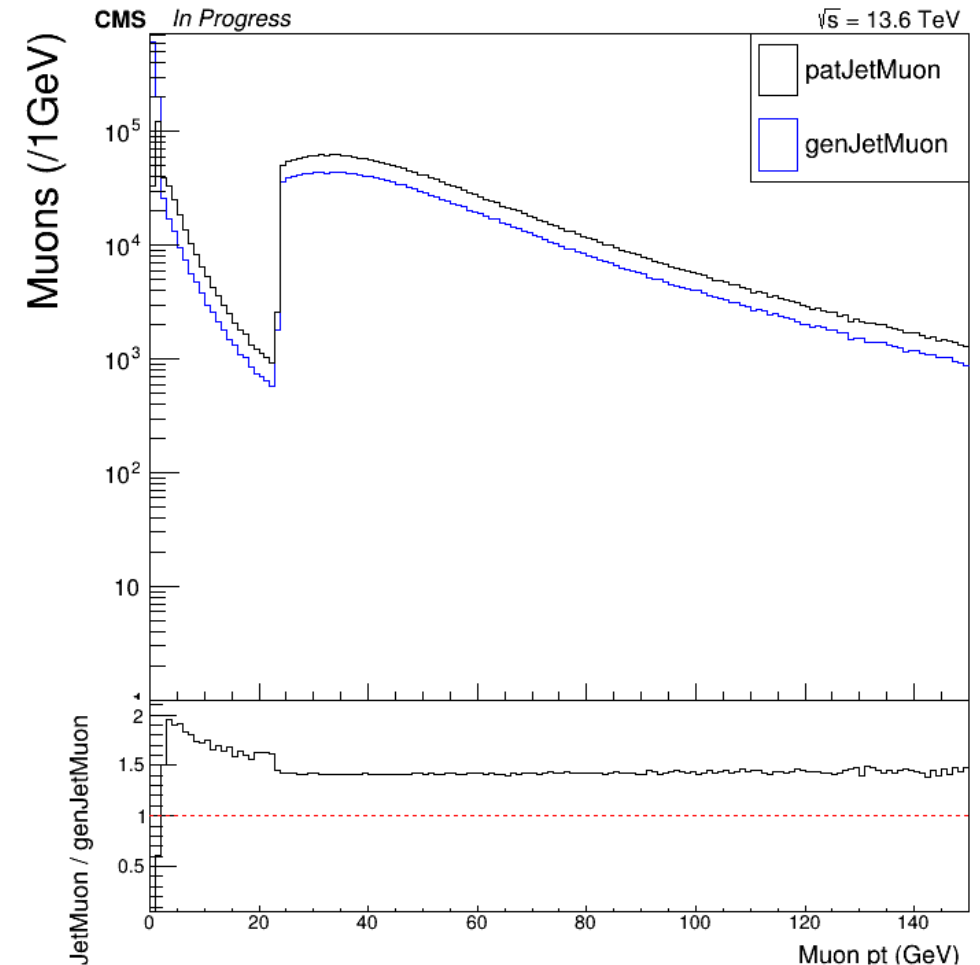
genJetMuon entries : 2658918

⇒ only muons in Jet (not prompt muon)

⇒ only mc matching for Jet applied

To do...

- why this difference occurs between pat and gen?
- leading, n-th leading case
- looking difference between eta regions



※ 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”

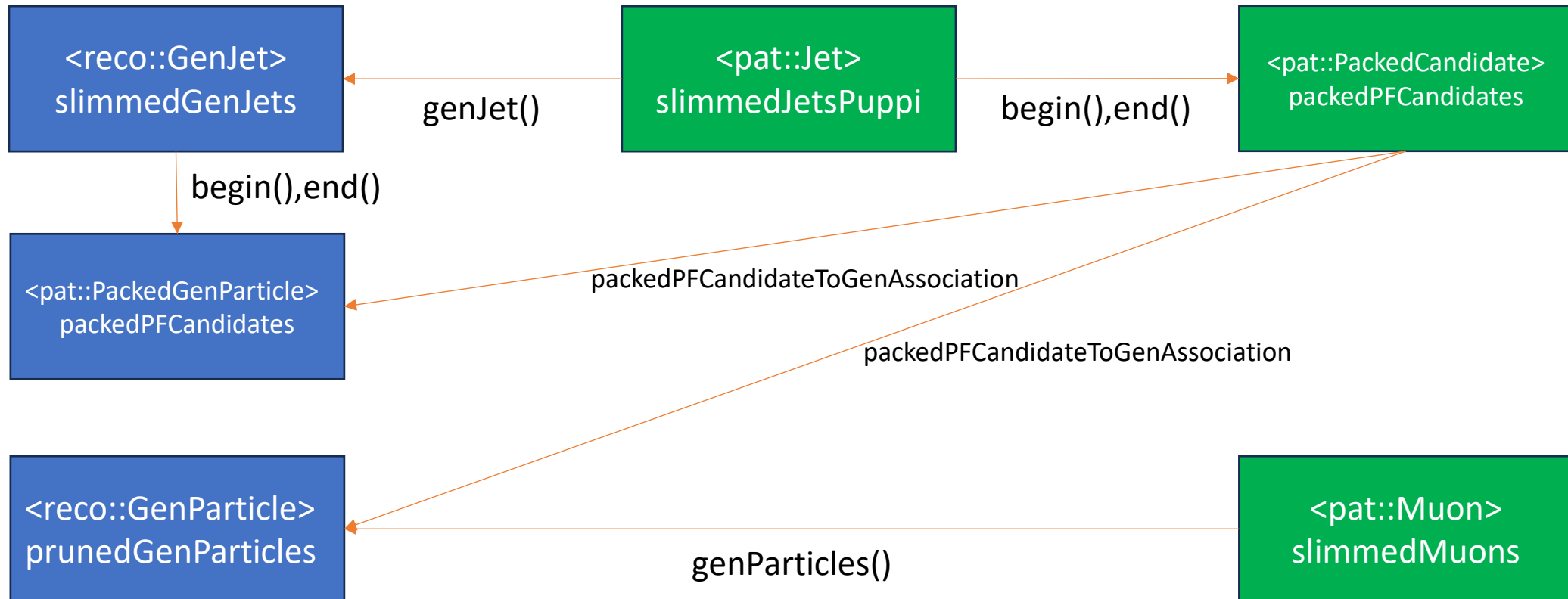
reco level object

pat::Jet "slimmedJetsPuppi" : ak4 PFJets Puppi

pat::Muon "slimmedMuons" : slimmed reco muon

pat::PackedCandidate "packedPFCandidates" : slimmed PFCandidates

miniAOD structure and its reference call methods



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.

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

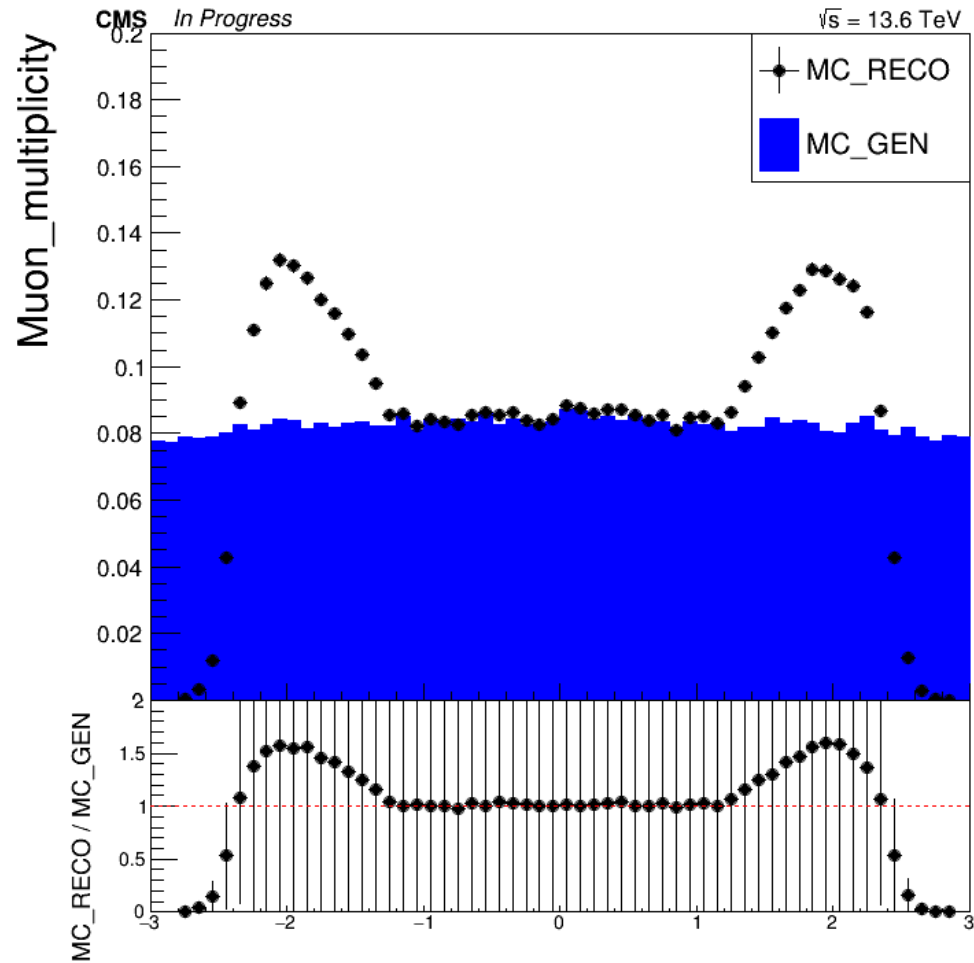
99 int muonMultiplicity() const { return muonMultiplicity_; }

▼ DataFormats/Scouting/interface/ScoutingPFJet.h

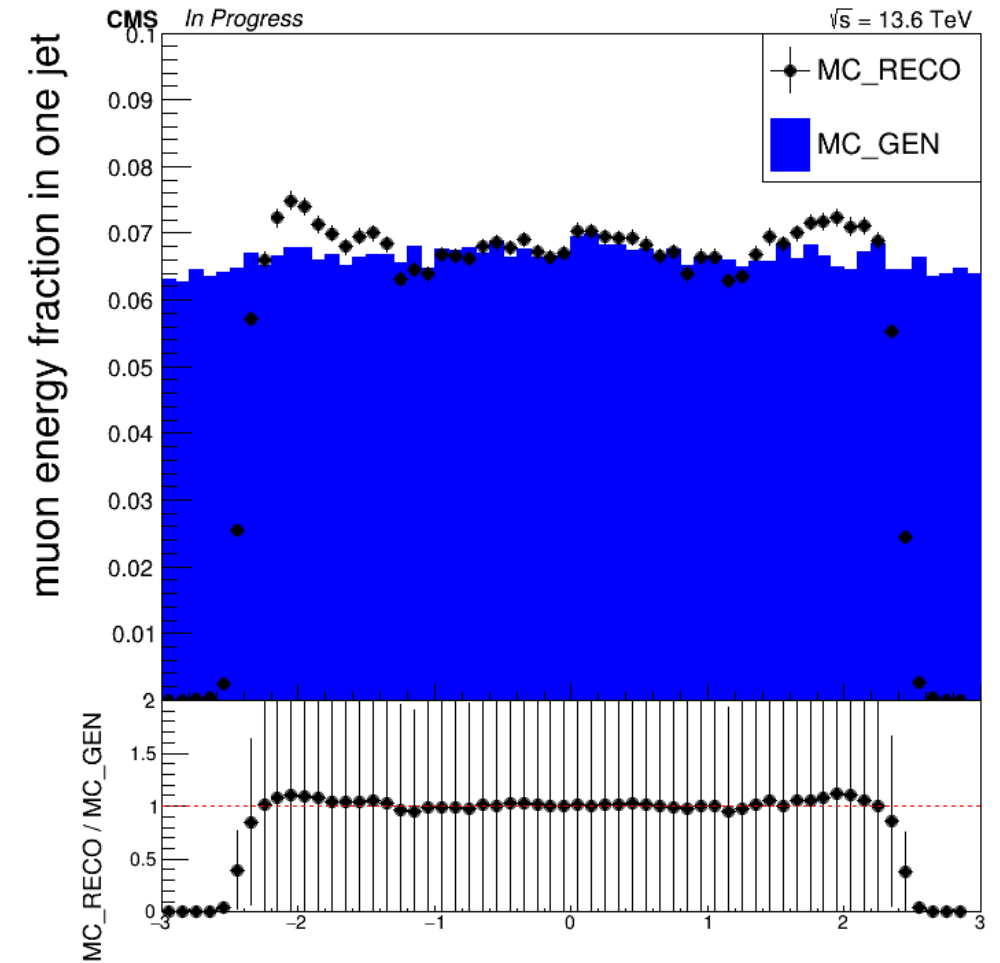
100 int muonMultiplicity() const { return muonMultiplicity_; }

Backup - Gen vs Reco (no any filter or trigger)

average muon multiplicity in jet



average muon energy fraction in one jet



htop status

htop data storage structure

/data1 : main data storage for Run2 NanoAOD and personal datasets. (But we use with Run3 also now...)

/NanoAOD/<version>/<data/mc>/<dataset>/...

suggestion

/data1 : Run2 + personal storage

/data2 : Run3 only (same structure with /data1)

I'll move Run3 data and mc to **/data2** this weekend. (Run2 files will not be touched)

+ Do we still need to set permission for data folders?

```
/data1/
├── common
│   ├── NanoAOD
│   ├── skimmed_NanoAOD
│   └── topNanoAOD
├── users
│   ├── dndus0107
│   ├── ecasilar
│   ├── fcarneva
│   ├── itseyes
│   ├── juhee5819
│   ├── ljw1015
│   ├── minerva1993
│   ├── sarakm0704
│   ├── stiger97
│   ├── tiyang
│   └── tjkim
```

```
/data1/common/NanoAOD/v9_UL/
├── data
│   ├── Run2016B
│   ├── Run2016C
│   ├── Run2016D
│   ├── Run2016E
│   ├── Run2016F
│   ├── Run2016G
│   ├── Run2016H
│   ├── Run2017B
│   ├── Run2017C
│   ├── Run2017D
│   ├── Run2017E
│   ├── Run2017F
│   ├── Run2018A
│   ├── Run2018B
│   └── Run2018C
```

```
├── mc
│   ├── Run3Summer22EENanoA0Dv12
│   ├── Run3Summer22NanoA0Dv12
│   ├── Run3Summer23BPixNanoA0Dv12
│   ├── Run3Summer23NanoA0Dv12
│   ├── RunIISummer20UL16NanoA0DAPV
│   ├── RunIISummer20UL16NanoA0Dv9
│   ├── RunIISummer20UL17NanoA0Dv9
│   └── RunIISummer20UL18NanoA0Dv9
```