Top Quark Physics At The CEPC

Physics Department, Mohammed V University, Rabat

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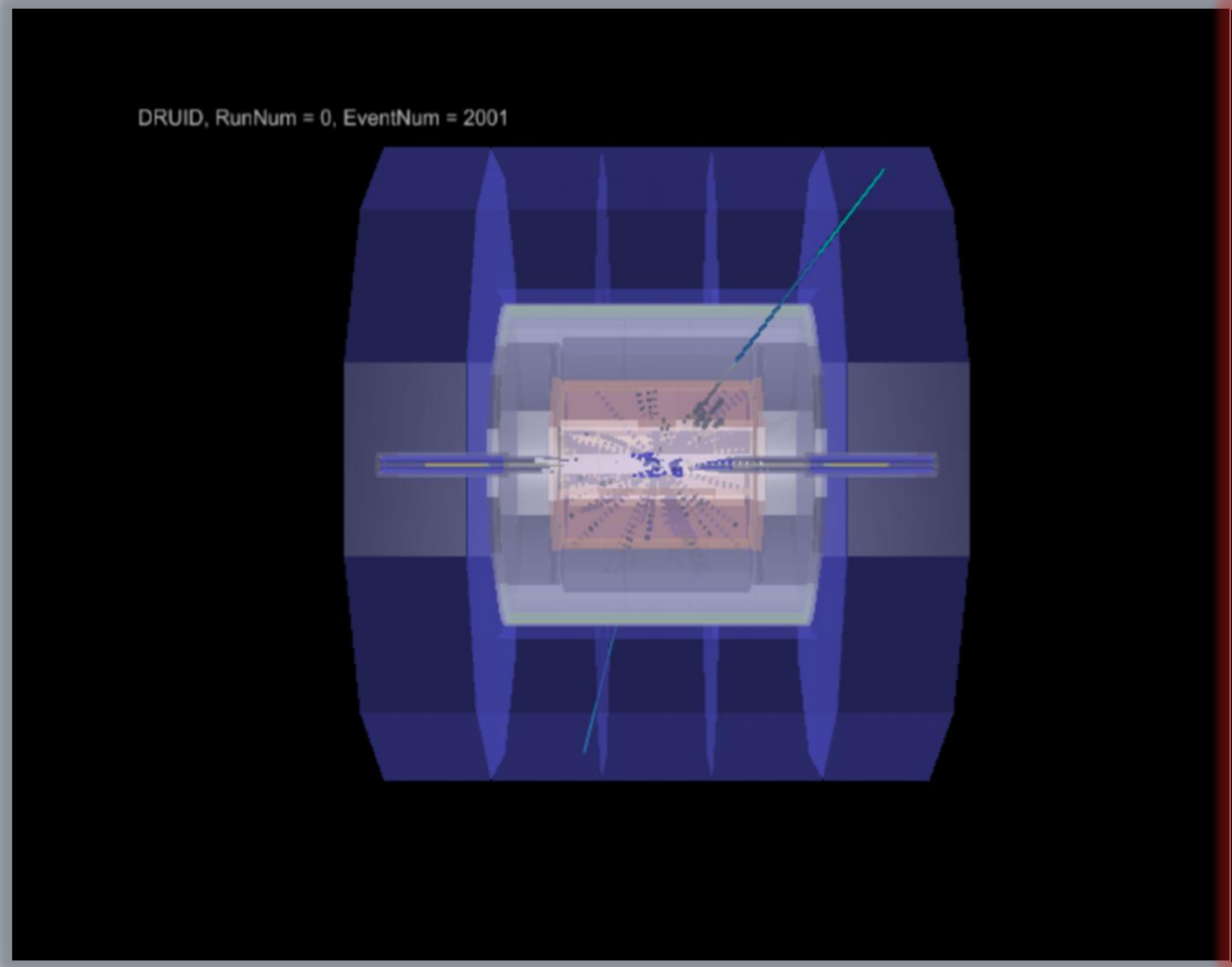
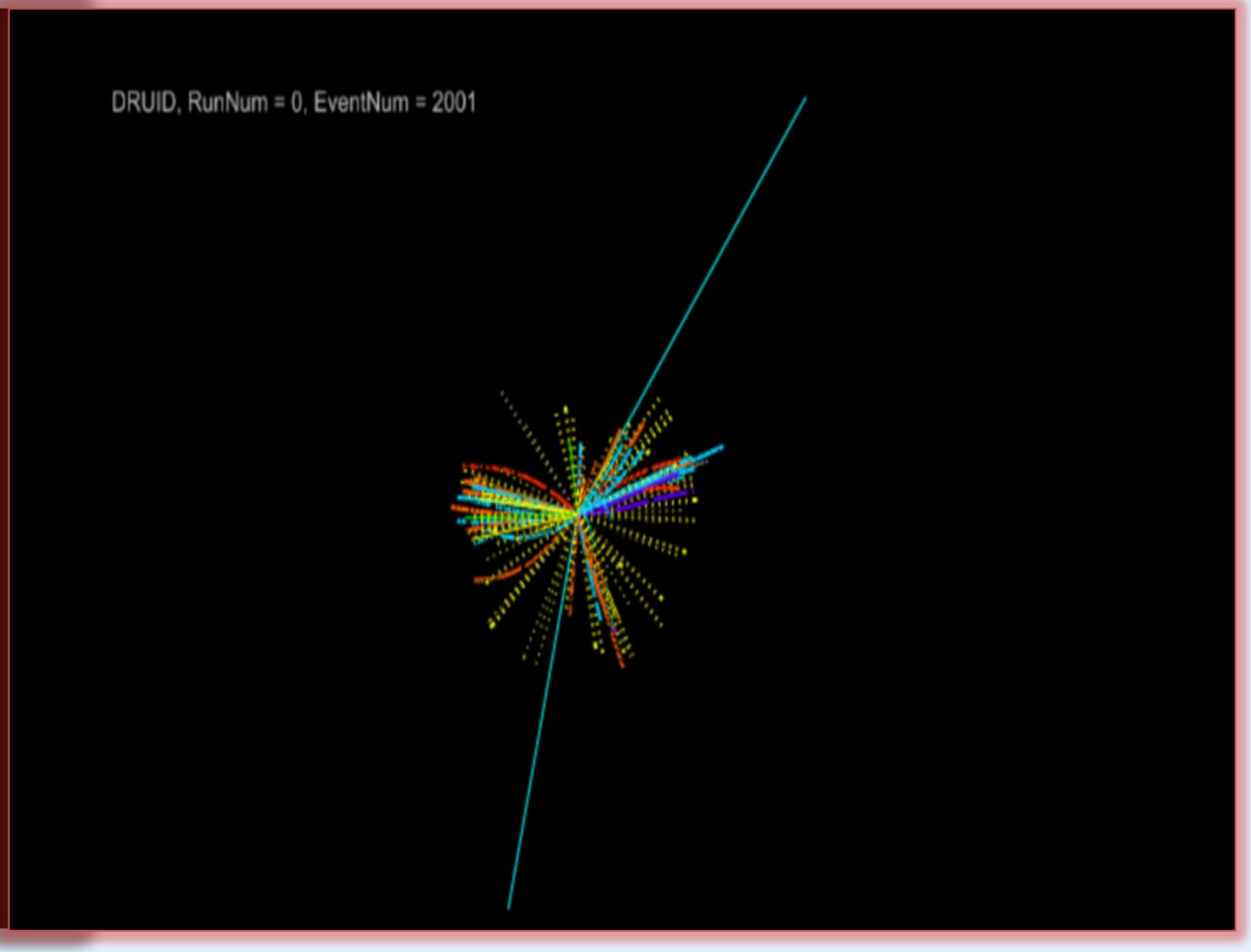
Mustapha Biyabi

Event Display

Events visualization in parallel To detector geometry :





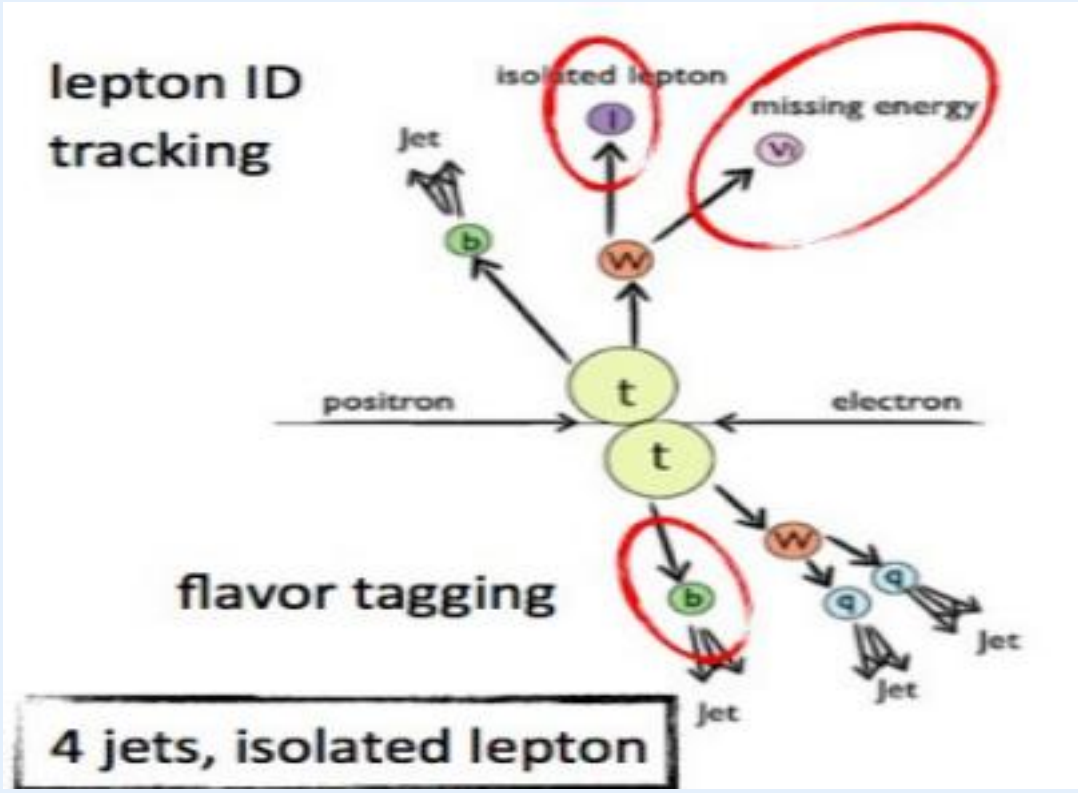
Goal

- **The *config file* for the semi leptonic channel :**

$$e^- e^+ \longrightarrow t\,\tilde{t},\ (t > w^+ b,\ w^+ > l^+ \nu l),\ (\tilde{t} > w^-\,\tilde{b},\ w^- > 2 \text{ quark jets})$$

- **The Data (Signal samples) :**

```
DETECTOR: CEPC_v4
COLLECTIONS: (see below)
//////////////////////////////////

-------------------------------------------------------------------------------
COLLECTION NAME                 COLLECTION TYPE          NUMBER OF ELEMENTS
===============================================================================
AncientPFOs                     ReconstructedParticle          141
ArborCharged                    Cluster                         36
ArborNeutral                    Cluster                        104
ArborPFOs                       ReconstructedParticle          141
CluAB_1st                       Cluster                        166
ClupatraTrackSegments           Track                           99
ClupatraTracks                  Track                           50
ClusterChargedCore              Cluster                         31
EHBushes                        Cluster                        255
ForwardTracks                   Track                           0
LSBranches                      Cluster                       1355
MCParticle                      MCParticle                    1755
MCParticlesSkimmed              MCParticle                     313
MarlinTrkTracks                 Track                           41
RecoMCTruthLink                 LCRelation                     140
SiTracks                        Track                           35
SubsetTracks                    Track                           35
-------------------------------------------------------------------------------
```



Marlin Processor

In order to use the data being generated/reconstructed To produce the root file, we need to :

- **Isolate leptons which we want using IsolatedLeptonFinderProcessor.**
- **Cluster all the remain PFOs into *4 jets* and tag their flavors using LcfiplusProcessor.**
- **Classify final state particles using FSClasserProcessor, i.e the final state particles typically include a combination of charged and neutral hadrons, photons, and leptons.**

⑩ **For this we need to use Marlin software whcih is a simple C ++ application framework for the analysis of LCIO data that provides a platform for the distributed development of new reconstruction algorithms.**

Marlin applications are entirely configured through xml steering files.

Steering File

- **The names of the processors which are to be executed are listed using the keyword processor :**

```
<?xml version="1.0" encoding="us-ascii"?>
<marlin xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespace
<execute>
  <processor name="RootFileProcessor" />
  <processor name="MyISOlatedLeptonFinderProcessor" />
  <processor name="VertexFinder" />
  <processor name="JetClusteringAndFlavorTag" />
  <processor name="FSClasserProcessor" />
</execute>
```

- After setting the input files, IsolatedLeptonFinderProcessor Collections :

```
<processor name="MyISOlatedLeptonFinderProcessor" type="LGISOlatedLeptonFinderProcessor">
   <!--Input collection of ReconstructedParticles-->
   <parameter name="InputCollection" type="string" lcioInType="ReconstructedParticle">ArborPFOs </parameter>
   <!--Output collection of isolated leptons-->
   <parameter name="OutputCollectionIsolatedLeptons" type="string" lcioOutType="ReconstructedParticle">Isoleps </parameter>
   <!--Copy of input collection but without the isolated leptons-->
   <parameter name="OutputCollectionWithoutIsolatedLepton" type="string" lcioOutType="ReconstructedParticle">RemainPFOs </parameter>
```

Steering File

For the Vertex Finder and its parameters ：

```
<processor name="VertexFinder" type="LcfiplusProcessor">

        <!-- run primary and secondary vertex finders -->
        <parameter name="Algorithms" type="StringVec"> PrimaryVertexFinder BuildUpVertex </parameter>
        <parameter name="ReadSubdetectorEnergies" type="int" value="1" /> <!-- true for ILD -->
        <parameter name="UpdateVertexRPDaughters" type="int" value="0" /> <!-- false for non-updative PandoraPFOs -->
        <parameter name="TrackHitOrdering" type="int" value="1" /> <!-- Track hit ordering: 0=ILD-LOI,SID-DBD, 1=ILD-DBD -->
        <parameter name="PrintEventNumber" type="int" value="0" /> <!-- 0 for not printing event number, n for printing every n events -->

        <!-- specify input collection names -->
        <parameter name="PFOCollection" type="string" value="RemainPFOs" />
        <parameter name="PrimaryVertexCollectionName" type="string" value="PrimaryVertex" />
        <parameter name="BuildUpVertexCollectionName" type="string" value="BuildUpVertex" />
        <parameter name="BuildUpVertex_V0VertexCollectionName" type="string" value="BuildUpVertex_V0" />
```

Define Jet Clustering&FlavorTag Processor and its Parameters ：

```
<processor name="JetClusteringAndFlavorTag" type="LcfiplusProcessor">

        <!-- run primary and secondary vertex finders -->
        <parameter name="Algorithms" type="StringVec"> JetClustering JetVertexRefiner FlavorTag ReadMVA</parameter>

        <!-- general parameters -->
        <parameter name="PFOCollection" type="string" value="RemainPFOs" /> <!-- input PFO collection -->
        <parameter name="UseMCP" type="int" value="0" /> <!-- MC info not used -->
        <parameter name="MCPCollection" type="string" value="" /> <!-- not used -->
        <parameter name="MCPFORelation" type="string" value="" /> <!-- not used -->
        <parameter name="ReadSubdetectorEnergies" type="int" value="1" /> <!-- true for ILD -->
        <parameter name="UpdateVertexRPDaughters" type="int" value="0" /> <!-- false for non-updative PandoraPFOs -->
        <parameter name="TrackHitOrdering" type="int" value="1" /> <!-- Track hit ordering: 0=ILD-LOI,SID-DBD, 1=ILD-DBD -->
```

Flavor Tagging

✓ ***For the tag flavour we specifie the Collections :***

```
<!-- FlavorTag parameters -->
        <parameter name="PrimaryVertexCollectionName" type="string" value="PrimaryVertex" />
        <parameter name="FlavorTag.JetCollectionName" type="string" value="RefinedJets" />
```

- The name of the book containing the BDT training information ("FlavorTag.BookName").
- The "FlavorTag.PIDAlgo" parameter specifies the type of flavor tagging algorithm to be used (LCFIPlus).

```
  <parameter name="FlavorTag.WeightsDirectory" type="string" value="/besfs5/groups/higgs/users/lig/analysis/LCFIplus/cepc_v4_20180509/lcfiweights/" />
  <parameter name="FlavorTag.WeightsPrefix" type="string" value="zpole_v00" />
  <parameter name="FlavorTag.BookName" type="string" value="bdt" />
  <parameter name="FlavorTag.PIDAlgo" type="string" value="lcfiplus" />
  <parameter name="FlavorTag.D0ProbFileName" type="string" value="/besfs5/groups/higgs/users/lig/analysis/LCFIplus/cepc_v4_20180509/data/vtxprob/d0prob_zpole.root" />
  <parameter name="FlavorTag.Z0ProbFileName" type="string" value="/besfs5/groups/higgs/users/lig/analysis/LCFIplus/cepc_v4_20180509/data/vtxprob/z0prob_zpole.root" />
```

- Specifies the name of the file containing the ***PDFs*** for impact parameters (d0)/z0), which are used to calculate the ***likelihood ratio*** for each flavor.

FSClasser_Processor

- Specify the input Collections :

```
<processor name="FSClasserProcessor" type="FSClasserProcessor">
<parameter name="InputMCParticlesCollection" type="string" lcioInType="MCParticle">       MCParticle      </parameter>
<parameter name="InputMCTruthLinkCollection" type="string" lcioInType="LCRelation">         RecoMCTruthLink  </parameter>
<parameter name="InputPandoraPFOsCollection" type="string" lcioOutType="ReconstructedParticle"> RemainPFOs </parameter>
<parameter name="InputIsoLepsCollection" type="string" lcioOutType="ReconstructedParticle">Isolep </parameter>
<parameter name="InputJetsCollection" type="string" lcioInType="ReconstructedParticle">       RefinedJets     </parameter>
<!-- -->
```

```
FSClasser.FS(N) = "(EXC/INC)(tag)(code2)_(code1)";
```

```
code1 = abcdefg
        a = number of gamma
        b = number of tau+
        c = number of tau-
        d = number of mu+
        e = number of mu-
        f = number of e+
        g = number of e-

code2 = h
        h = number of jets
```

- Specify the possible final states : ***«Exclusive» : we're not considering any undetected particles such as neutrinos that may be produced in the final state.***

```
<parameter name="FS144" type="string">  EXC4_0001000 </parameter>
<parameter name="FS145" type="string">  EXC4_0000010</parameter>
```

FSClasser Processor

Specify the Parameters :

```
  <parameter name="FastOrFull"        type="int"    > 1 </parameter>
  <parameter name="ShowMC"            type="int"    > 0 </parameter>
  <parameter name="Verbosity"         type="string"> 4         </parameter>
  <parameter name="Luxury"            type="string">  1        </parameter>
  <parameter name="DEBUG"             type="string">  0        </parameter>
  <parameter name="TagFlavor"         type="string">  1        </parameter>
  <parameter name="MatchMC"           type="string">  1        </parameter>
  <parameter name="kmfit"             type="string">  1        </parameter>
  <parameter name="EventShape"        type="int"    >  0       </parameter>
  <parameter name="LinearSphericity"  type="int"    >  1       </parameter>
  <parameter name="Kappa"             type="string">  1.0      </parameter>
  <parameter name="ECM"               type="string">  360.0    </parameter>
</processor>
```

- MC Events Comparaison to Reconstruted ones ! ("matchMc")

```
recon object is        11, mctruth is        22
recon object is      2112, mctruth is        22
recon object is      2112, mctruth is        22
recon object is      2112, mctruth is        22
recon object is     -2112, mctruth is        22
recon object is       130, mctruth is        22
recon object is       130, mctruth is        22
recon object is      2112, mctruth is        22
recon object is       130, mctruth is        22
[ VERBOSE "MyISOlatedLeptonFinderProcessor"] Lepton not from W+ boson decay.
neutral pandora=501
recon object is       130, mctruth is        22
recon object is       211, mctruth is        22
recon object is       130, mctruth is        22
recon object is      -211, mctruth is        22
recon object is      2112, mctruth is        22
```

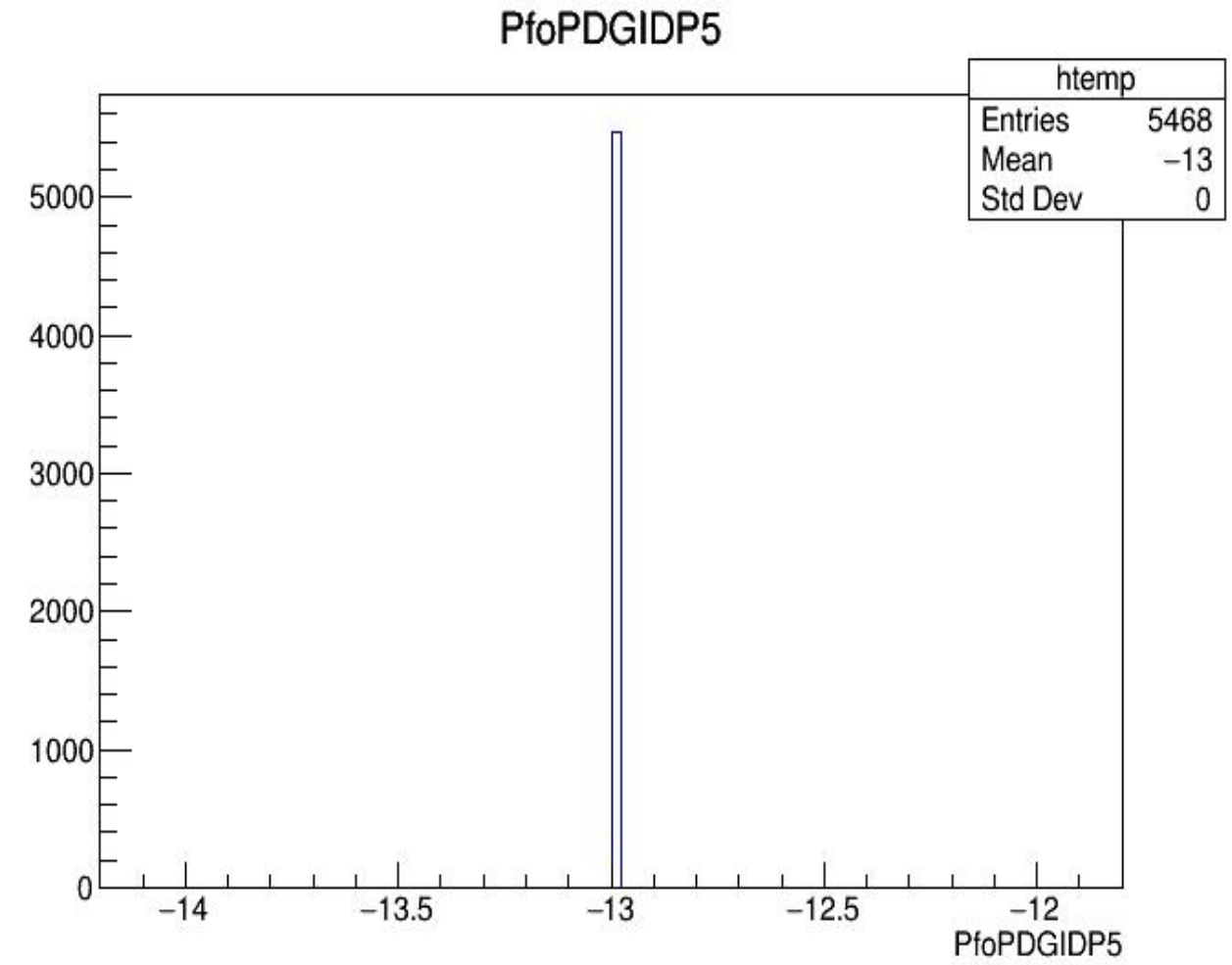
Results

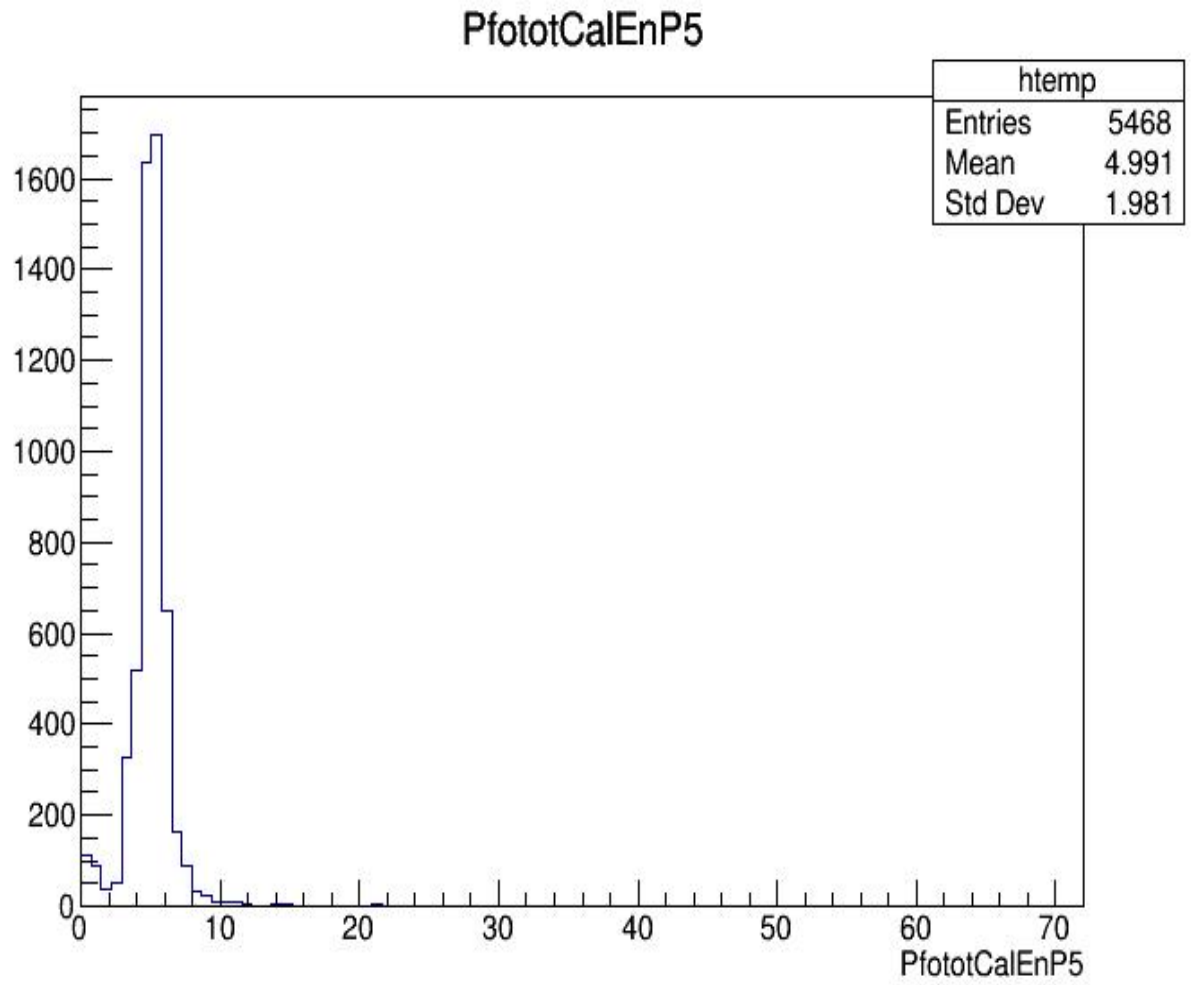
- Running the steering file with **Marlin** command Yields : Marlin ttbar_semileptonic.xml

```
[ VERBOSE "FSClasserProcessor"] Total events = 14000

               EXC4_0001000
  0)          Input Number of   Evts :       14000      100.00%
  1)          nChrg  protection  Cut :       14000      100.00%
  2)          nCombo uplimit protect :       14000      100.00%
  3)          nCombo greater than  0 :        5865       41.89%
  4)          Before  E and P    Cut :        6126      104.45%
  5)          Missing Energy     Cut :        6126      100.00%
  6)          Missing Momentum   Cut :        6126      100.00%
  7)          Missing Mass       Cut :        5468       89.26%
  8)          Raw   4-Momentum   Cut :        5468      100.00%
  9)          No  of Filling Entries :        5468      100.00%

               EXC4_0000010
  0)          Input Number of   Evts :       14000      100.00%
  1)          nChrg  protection  Cut :       14000      100.00%
  2)          nCombo uplimit protect :       14000      100.00%
  3)          nCombo greater than  0 :        4862       34.73%
  4)          Before  E and P    Cut :        5273      108.45%
  5)          Missing Energy     Cut :        5273      100.00%
  6)          Missing Momentum   Cut :        5273      100.00%
  7)          Missing Mass       Cut :        4814       91.30%
  8)          Raw   4-Momentum   Cut :        4814      100.00%
  9)          No  of Filling Entries :        4814      100.00%

        EXC4_0001000 fill number :      5468
        EXC4_0000010 fill number :      4814
```

Lepton Isolation

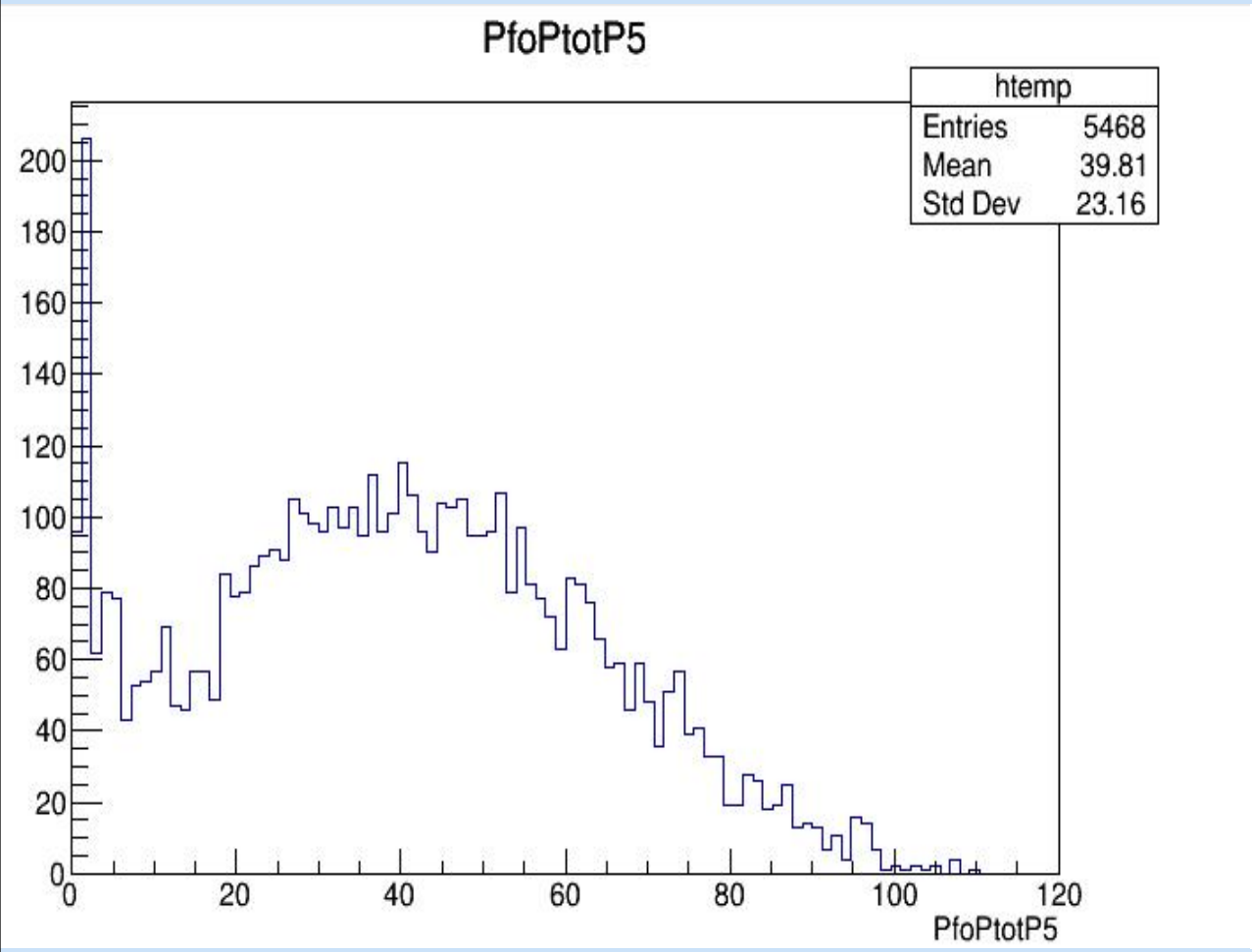
- The lepton selected was assumed to be decaying from the W boson :
- Since neutrinos are not directly reconstructed as separate particles !
- The tree associated to one ***muon and 4 jets*** being produced is **«ntEXC4_0001000» :**

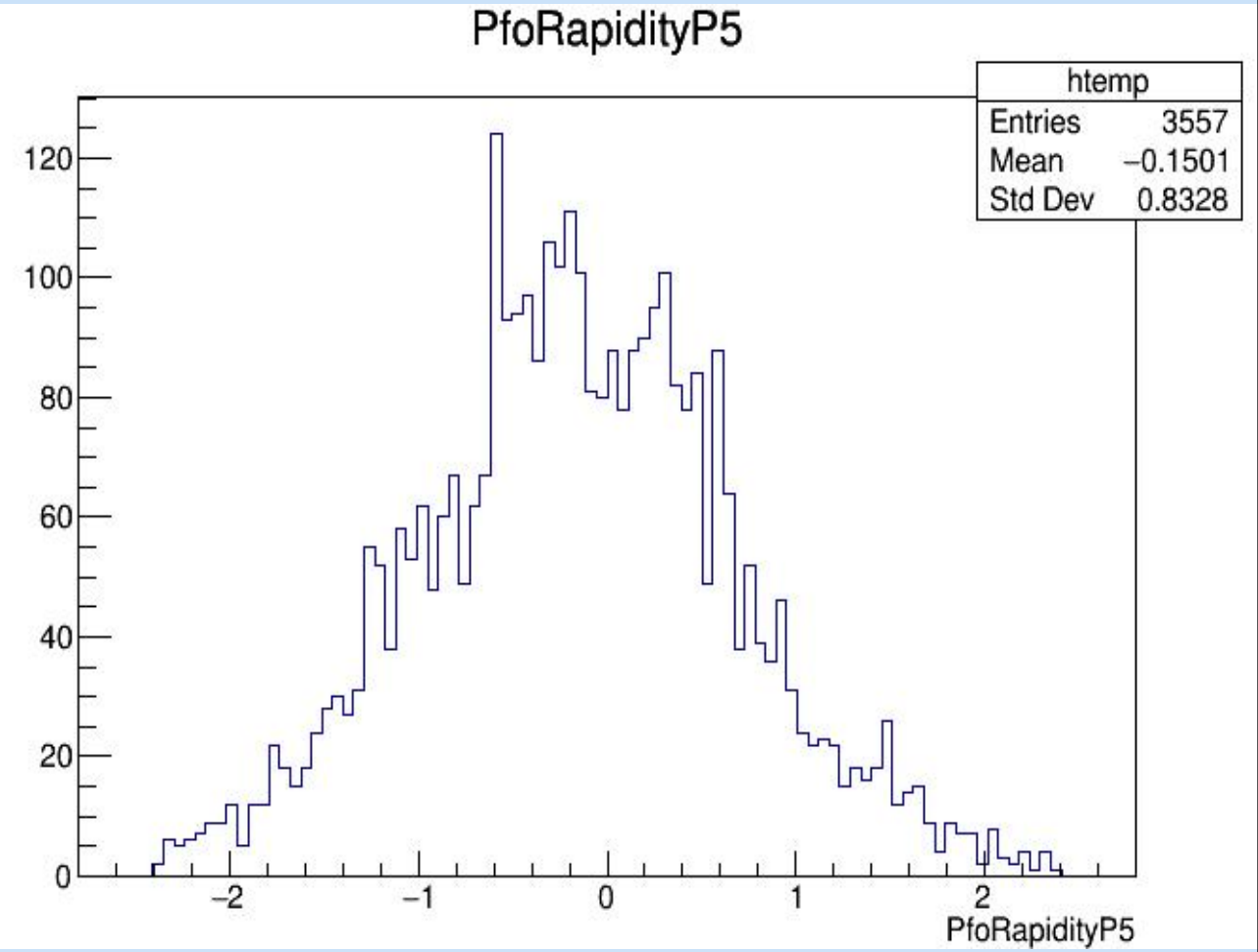




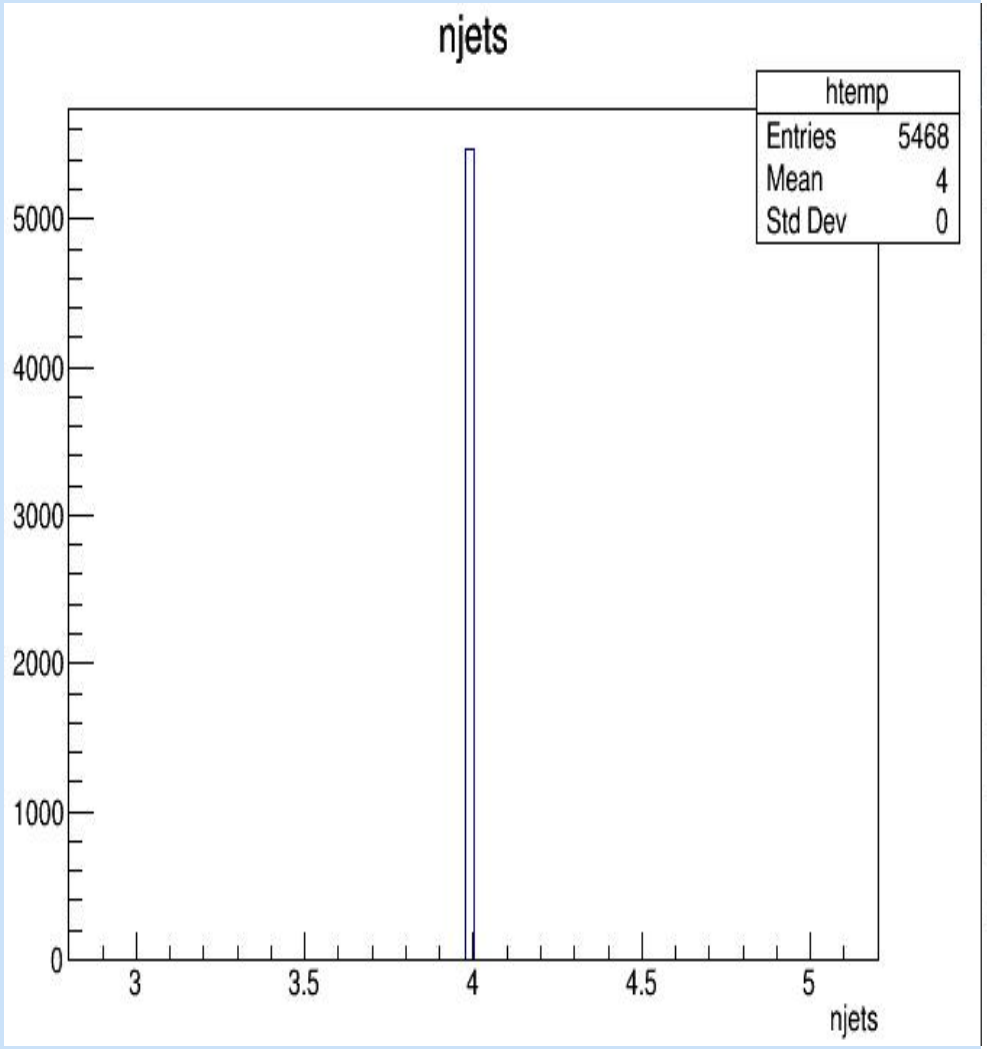
Lepton Isolation

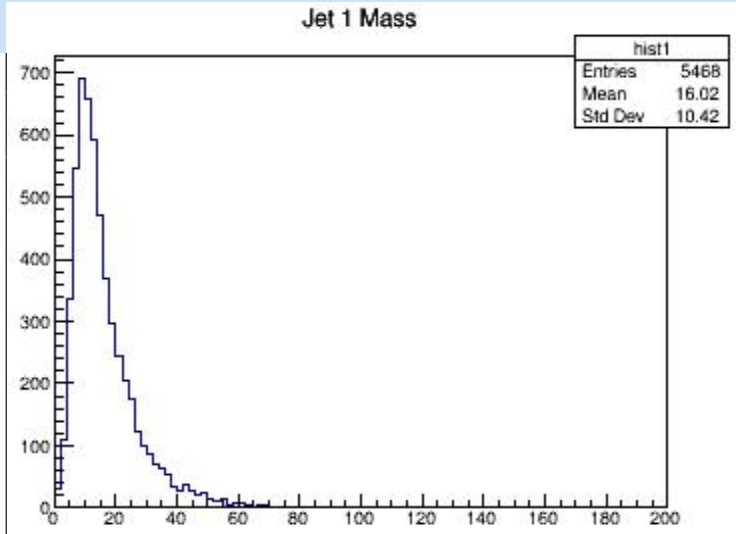
- The Total momentum distribution,
- The rapidity of a reconstructed particle : describes how far the particle is from the ***beam axis*** in the direction of its motion.

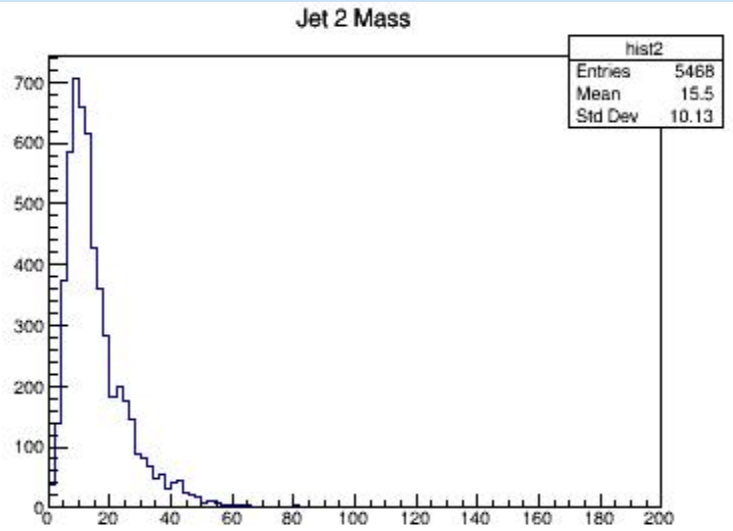


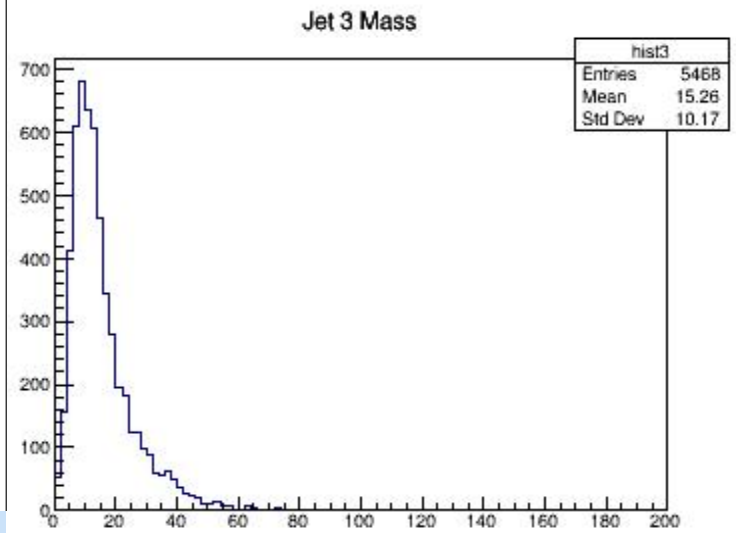


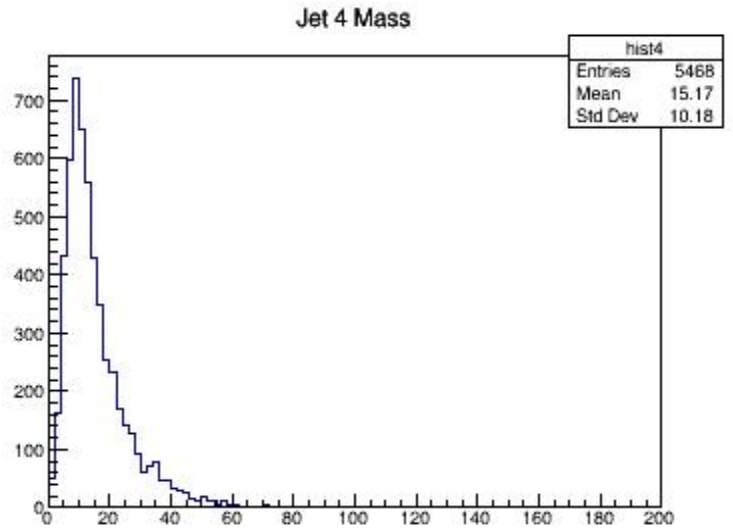
Number/Mass of Jets



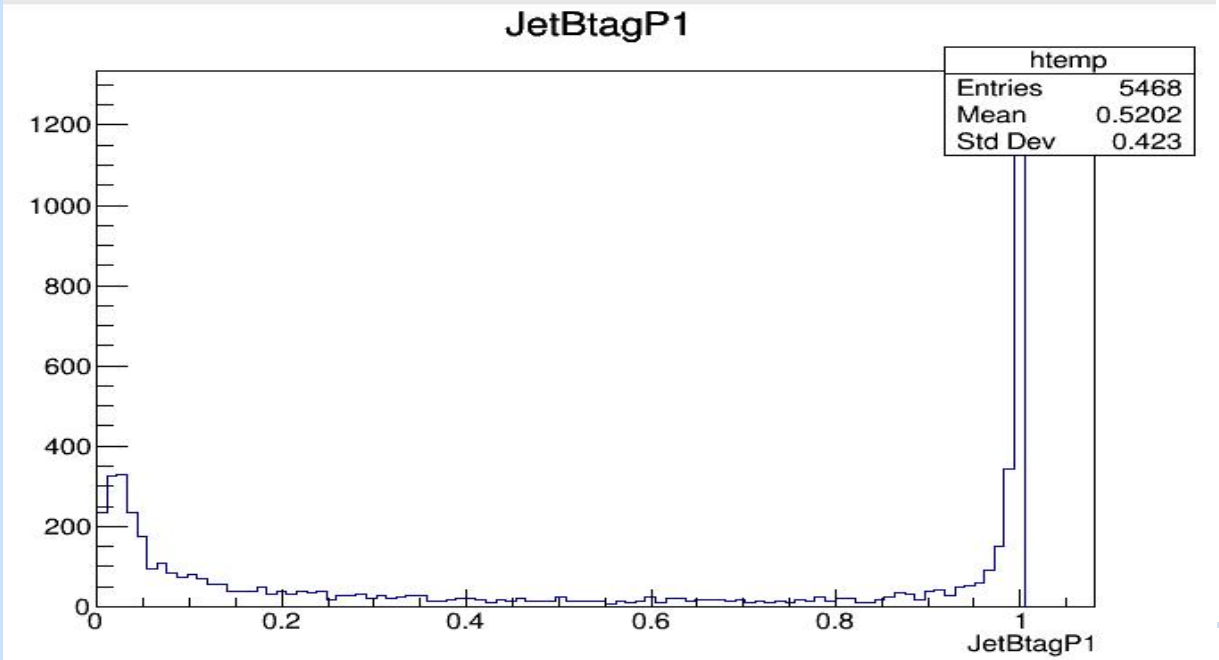


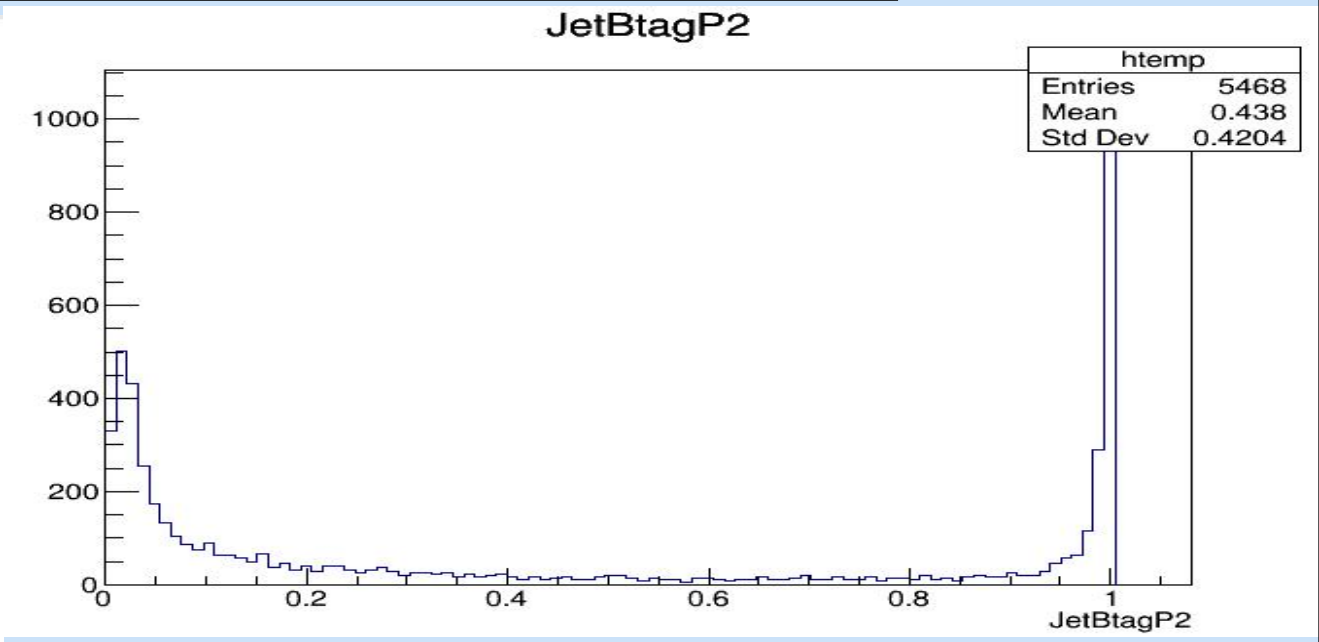


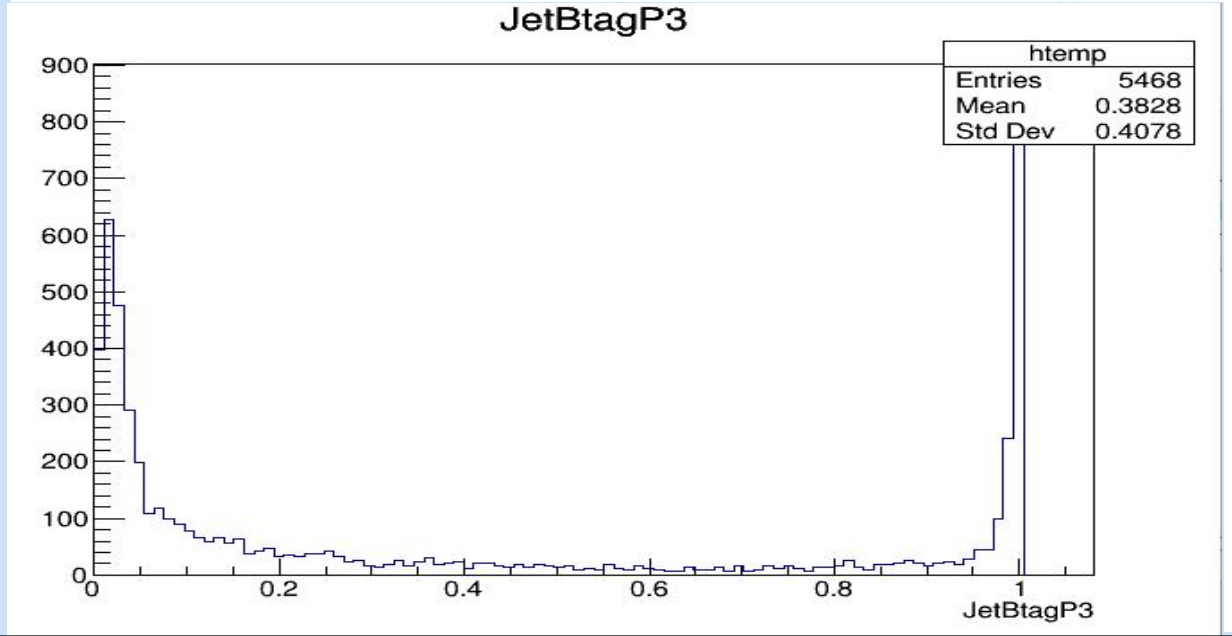


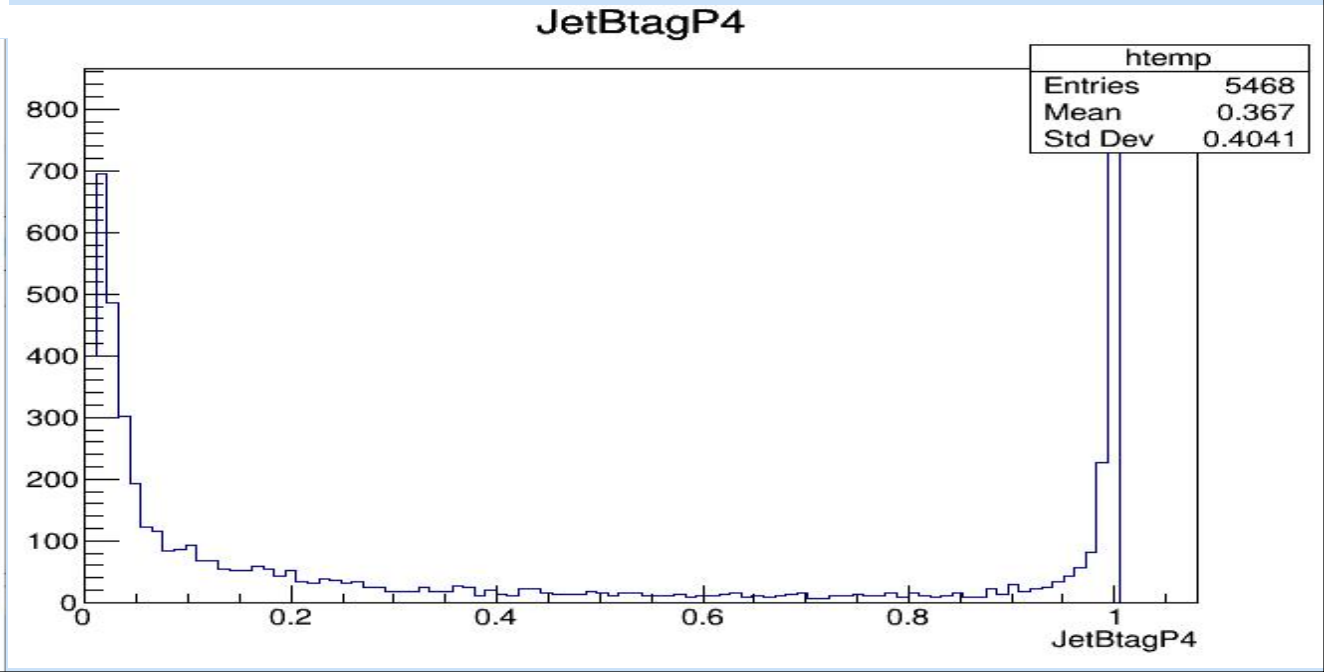


Jets B Tagging



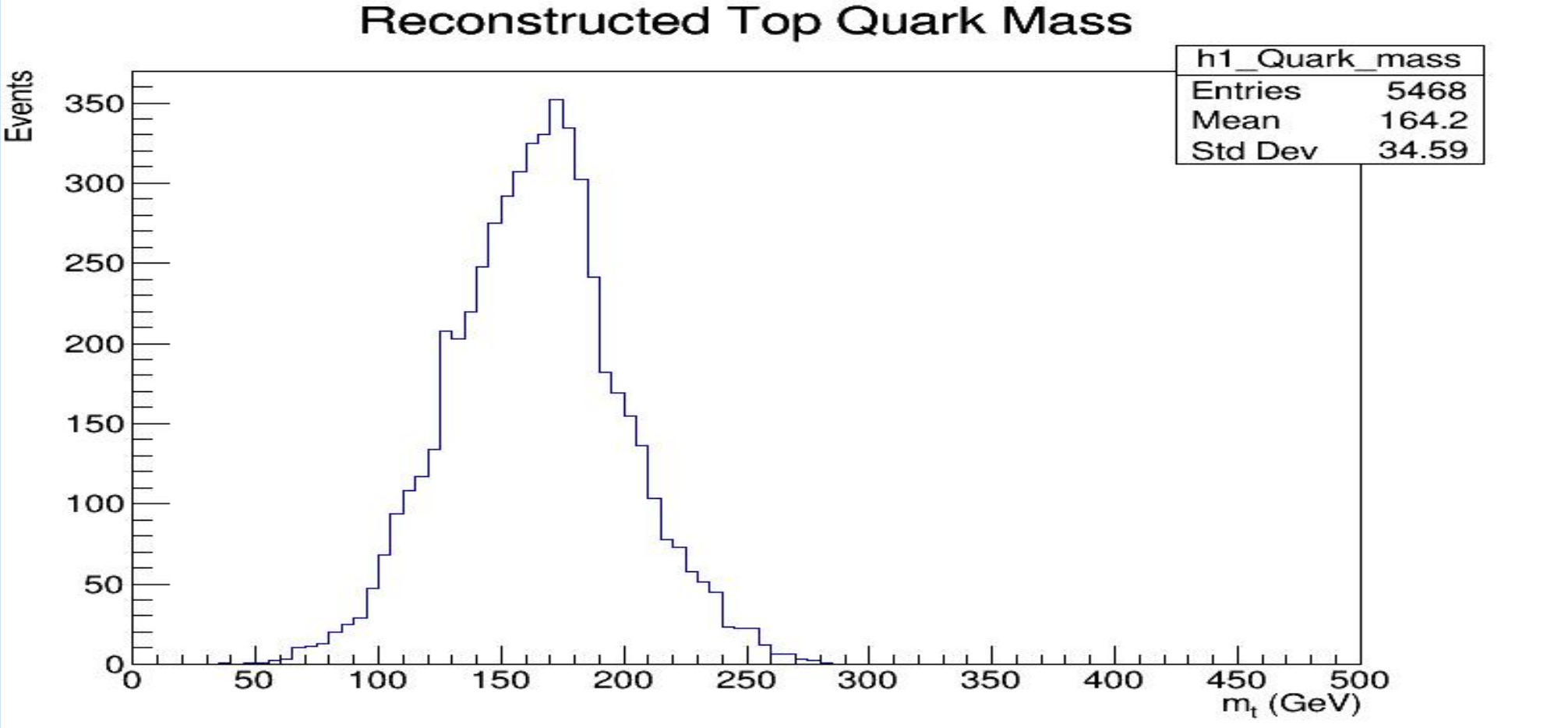






Top quark Mass

- The Reconstructed Top Quark Mass : check the Lepton isolation efficiency !



- The larger the sample size, the smaller the statistical uncertainty on the measurement !

Back Up Slides

Alternative Way

- ***The alternative way** is to remove all leptons in order for the jet clustering algorithms to work properly.*

- ***First, isolate all leptons and put them in one collection, and put all the remaining particles in another collection.***

- ***Then, produce two additional collections: one will contain the lepton with the highest momentum, and the other will contain all the remaining PFOs without the isolated lepton.***

- ***The reconstructed mass of top quark :***