# MCTruthClassifier

Not yet Certified as ATLAS Documentation



## Introduction

MCTruthClassifier is an athena tool to classify the truth particles according with their origin. Based on the truth particle classification the tool provides classification of Inner Detector and combined muon tracks, egamma electrons (including forward electrons), egamma photons and jets. The tool works with AOD or ESD formats.

## Truth particles classification

To classify truth particles the tool defines their origin and provide simple classification based on this. The following attributes are designated to each truth particle after classification:

- the particle type
- the particle origin
- the particle outcome process (or the particle final state).

The tool can be used to classify electrons, muons, taus and photons. Hadrons have their type classified as B-C-S-Light mesons or barions but no origin or outcome is provided. Neutrinos and nuclear fragments (pdgid > $10^8$) are not classified. For these particles the tool just inform the user that the truth particle is hadron of a particular type, neutrino or nuclear fragment, but origin and outcome process are not defined. The particles with barcode >$10^6$ classified as none primary. All other particles classified as generator particles. The electrons, muons, taus and photons subdivided into three main categories:

- Isolated (or prompt) - it is signal particle, for example electrons from Z boson decay Z->ee,
- None Isolated - which originated from decay of the charmed or b-flavored mesons and baryons (as exception decay of J/ψ included)
- Background - all the rest including bb and cc mesons decays

If the classification algorithm is failed or there is no original vertex, the particle is classified as Unknown (electron, muon, tau or photon). Here is an example how to use the tool for truth particles classification.

```
 using namespace MCTruthPartClassifier;

 // define output tool variable
 std::pair<ParticleType,ParticleOrigin> res;
 ParticleDef partDef;

 for ( pitr  = genEvent->particles_begin(); pitr  != genEvent->particles_end(); ++pitr){
   const HepMC::GenParticle* thePart = (*pitr);

  // call truth particle classification
  res=m_truthClassifier->particleTruthClassifier(thePart);

  ParticleType   iTypeOfPart  = res.first;
  ParticleOrigin iPartOrig       = res.second;

  // define truth particle final state
  ParticleOutCome iPartOutCome = m_truthClassifier->getParticleOutCome();

  // just to print results
  std::cout<<" pdg  "<<thePart->pdg_id()<<" particle  type        "<<partDef.sParticleType[iTypeOfPart]
                                       <<"  particle origin      "<<partDef.sParticleOrigin[iPartOrig]
                                       <<"  particle outcome "<<partDef.sParticleOutCome[iPartOutCome]<<std::endl;

  // additional useful methods  provided by tool

  // to get pointer to the mother
  HepMC::GenParticle* theMother = m_truthClassifier->getMother();
  //  to get mother pdg id
  int motherPDG = m_truthClassifier->getMotherPDG();
  // to get mother barcode
  int motherBarcode = m_truthClassifier->getMotherBarcode();


}   // end cycle for pitr
```

In case of τ lepton additional method return to the user all particle in decay chain of τ lepton (excluding photons conversions):

```
std::vector<const HepMC::GenParticle*>*  decayTauPart=m_truthClassifier->getTauFinalState();
```

## ID track classification

The ID track classification is based on element link between track and truth track which provided by athena. From the truth track the pointer to the truth particle can be defined. The method getGenPart(trkPntr) used to find truth particle associated with the track. In additional the tool checks ΔR cone between the track and truth particle. For TRT only tracks, when η not measured the tool check Δφ. The TRT only tracks defined as a tracks with the number of silicon (Pixel and SCT) hits less than 3 (default value which can be changed inside user jobOptions file or by the method setNumOfSiHitsCut(NumOfSiHits) either one time in initializing or just inside the looping over all track). In case if ΔR<0.2 (or Δφ<0.2 for TRT only tracks) the track classified as Unknown and origin set to Undefined. The default values of the cone ΔR<0.2 (or Δφ<0.2) can be changed inside user jobOptions file or by methods setdeltaRMatchCut(m_deltaRMatch) and setdeltaPhiMatchCut(deltaPhi). The method getProbTrktoTruth() return to the user the probability of the track association with the truth particle.

Here is an example how to use the tool for ID track classification.

```
using namespace MCTruthPartClassifier;

std::pair<unsigned int, unsigned int> res;
 ParticleDef partDef;

// loop over all tracks....
for (; trackItr != trackItrE; ++trackItr) {
  const Rec::TrackParticle* trkPtr = (*trackItr);

 // call the track particle classification
 res=m_truthClassifier->particleTruthClassifier(trkPtr);

 unsigned int iTypeOfPart = res.first;
 unsigned int iPartOrig   = res.second;

 // define track  particle final state
 ParticleOutCome iPartOutCome = m_truthClassifier->getParticleOutCome();

 // to get pointer  to the truth particle associated with the track
   const HepMC::GenParticle* thePart = m_truthClassifier->getGenPart();

// The overloaded method getGenPart(trkPtr) can be used to get  pointer
//  to the truth particle without calling of classification by the method particleTruthClassifier(trkPtr)

// just to print results
 std::cout<<" pdg  "<<thePart->pdg_id()<<" particle  type       "<<partDef.sParticleType[iTypeOfPart]
                                       <<"  particle origin      "<<partDef.sParticleOrigin[iPartOrig]
                                       <<"  particle outcome "<<partDef.sParticleOutCome[iPartOutCome]<<std::endl;


// additional useful methods  provided by tool
 // to get pointer to the mother
 HepMC::GenParticle* theMother = m_truthClassifier->getMother();
//  to get mother pdg id
 int motherPDG = m_truthClassifier->getMotherPDG();
 // to get mother barcode
 int motherBarcode = m_truthClassifier->getMotherBarcode();

 // these methods return to the user parameters which define the quality of the track association with the truth particle
  int  NumOfSiHits    =  m_truthClassifier->getNumOfSiHits();
   if(NumOfSiHits <3) {
    // TRT only tracks
     double dPhimatch  =  m_truthClassifier->getdeltaPhiMatch();
   else
     double dRmatch    = m_truthClassifier->getdeltaRMatch();

   // probability of  the track association with the truth particle
   m_truthClassifier->getProbTrktoTruth();

 }  // end cycle for  trkItr
```

To get additional information about background electrons which originated from the photon conversion the method checkOrigOfBkgElec(const HepMC::GenParticle* thePart) can be used. The method define the mother of the converted photon and in the case that the mother is a background electron which originated from converted photon too it make a loop over all that process. As example look into Z->ee decay. Initial electron from Z boson decay can produce the brem photon which will converted into the pair of electrons. One from these electrons also can produce the brem photon which will converted into the pair of electrons and etc. The method checkOrigOfBkgElec will loop over all that process to classify initial electron, muon or photon.

```
 if(iTypeOfPart==BkgElectron&& iPartOrig==PhotonConv){
   std::pair<unsigned int, unsigned int> partbkg= m_truthClassifier->checkOrigOfBkgElec(thePart);
    ParticleType   iType  = partbkg.first;
    ParticleOrigin iOrig  =   partbkg.second;
     HepMC::GenParticle* theMother = m_truthClassifier->getMother();

   std::cout<<" Mother pdg        "<<theMother->pdg_id()
                 <<" particle  type     "<<partDef.sParticleType[iType]
                 <<"  particle origin   "<<partDef.sParticleOrigin[iOrig]<<std::endl;
```

# Egamma electrons classification

The tool can be used for egamma electron classification both author AuthorElectron/AuthorSofte and AuthorFrwd. In case of the egamma electron author AuthorElectron/AuthorSofte there is a track matched by egamma algorithm to the egamma electron and classification based on the available track information (see section ID track classification). In case of forward electron there is no track associated to the egamma electron. Therefore the tool extrapolate truth particles (charged with $p_T$ > 1 GeV and all neutral) into the calorimeter using standard athena tool ExtrapolateToCalo. The match is done using as a reference position the barycentre of the cluster in the EM middle layer. All truth particles are extrapolated to this layer and the choice of the best match is defined as following

- within a cone ΔR<0.15 (tunable by the job options) the leading (with highest $p_T$) is preferred for classification of reconstructed egamma forward electron;

Here is an example how to run the tool for egamma electron classification.

```
using namespace MCTruthPartClassifier;

std::pair<unsigned int, unsigned int> res;
ParticleDef partDef;

 for (; elecItr != elecItrE; ++elecItr) {
  const Analysis::Electron* elec= (*elecItr);

  res=m_truthClassifier->particleTruthClassifier(elec);

  unsigned int iTypeOfPart = res.first;
  unsigned int iPartOrig   = res.second;

   std::cout<<" egamma elec  type "<< partDef.sParticleType[iTypeOfPart]
                <<"   origin  "<<partDef.sParticleOrigin[iPartOrig]<<std::endl;


 // to get pointer  to the truth particle associated with the reconstructed electron
    const HepMC::GenParticle* thePart = m_truthClassifier->getGenPart();
   // to get pointer to the mother of the  truth particle associated with the reconstructed electron
  HepMC::GenParticle* theMother = m_truthClassifier->getMother();


  if(!(elec->author()&egammaParameters:: AuthorFrwd))  continue;
  // additionally only for forward electrons only .....

  // get pointers to all  particles matched to egamma forward electron
   std::vector<const HepMC::GenParticle*> PhtPartPtr= m_truthClassifier->getEGPartPntr();
   //  get  dR  cone values for all particles matched to egamma forward electron
  std::vector<float> PhtPartdR= m_truthClassifier->getEGPartdR();
   // get  types and origin  or all particles  matched to  egamma forward electron
   std::vector<std::pair<ParticleType,ParticleOrigin> > PhtPart= m_truthClassifier->getEGPartClas();

   // loop over all particles matched to egamma forward electron
   for(int i=0; i< (int) PhtPartPtr.size(); i++){
    const HepMC::GenParticle* thePhtPart=PhtPartPtr[i];

    std::cout<<"part pdg   "<<PhtPartPtr[i]->pdg_id()<<"   dR  "<<PhtPartdR[i]
                <<"  part type  "<<partDef.sParticleType[PhtPart[i].first]
               <<"  part origin  "<<partDef.sParticleOrigin[PhtPart[i].second]<<std::endl;
    }
}
```

# Egamma photons classification

To classify egamma photon the tool extrapolate truth particles (charged with $p_T$ > 1 GeV and all neutral) into the calorimeter using standard athena tool ExtrapolateToCalo. On the first step the tool is looping over all truth stable particles (status code equal 1) with barcode less than 200000, excluding neutrino. It means that G4 particles (which are borne in the detector during the simulation) are not included. The match is done using as a reference position the barycentre of the cluster in the EM middle layer. All truth particles are extrapolated to this layer and the choice of the best match is defined as follows:

- within a narrow elliptical cone (default value Δη×Δφ=0.025 ×0.050, tunable in the job option file) the photon with highest $p_T$ (leading photon) is preferred for classification of reconstructed egamma photon;
- if no matched photons inside the narrow cone the leading particle (neutral or charged) used for classification;
- If no match in the narrow cone found, a wider circular cone of radius 0.1 (tunable) is used, and the particle closest in angle is taken for classification.

If the first step is failed leaving the reconstructed photon candidate unmatched, then Geant4 particles are used excluding those which decay or interact in the detector, i.e thePart->end_vertex() =0. It is done to avoid double counting of the particles matched into the egamma photon. By default this options is switched off. User to add matching of G4 particles should use the following line in the job option MCTruthClassifierDev.inclG4part=True (see section Job options configuration)

The tool provide to the user access to all particles matched to the egamma photon (see example below).

Here is an example how to run the tool for egamma photon classification.

```
using namespace MCTruthPartClassifier;

std::pair<unsigned int, unsigned int> res;
ParticleDef partDef;

 const CaloCluster* clus;


 for (; photItr != photItrE; ++photItr) {
   const Analysis::Photon* phot= (*photItr);

  // call egamma photon classification
   res=m_truthClassifier->particleTruthClassifier(phot);
   unsigned int iTypeOfPart = res.first;
   unsigned int iPartOrig      = res.second;

    // to print results of egamma photon classification
   std::cout<<" photon type      "<< partDef.sParticleType[iTypeOfPart]
                 <<"  photon origin  "<<partDef.sParticleOrigin[iPartOrig]<<std::endl;

  // to get pointer  to the truth particle associated with the reconstructed photon
    const HepMC::GenParticle* thePart = m_truthClassifier->getGenPart();
   // to get pointer to the mother of the  truth particle associated with the reconstructed photon
  HepMC::GenParticle* theMother = m_truthClassifier->getMother();

  // get pointers to all  particles matched to egamma photon
   std::vector<const HepMC::GenParticle*> PhtPartPtr= m_truthClassifier->getEGPartPntr();
   //  get  dR  cone values for all particles matched to egamma photon
  std::vector<float> PhtPartdR= m_truthClassifier->getEGPartdR();
   // get  types and origin  or all particles  matched to egamma  photon
   std::vector<std::pair<ParticleType,ParticleOrigin> > PhtPart= m_truthClassifier->getEGPartClas();

   // loop over all particles matched to egamma  photon
   for(int i=0; i< (int) PhtPartPtr.size(); i++){
    const HepMC::GenParticle* thePhtPart=PhtPartPtr[i];

    std::cout<<"part pdg   "<<PhtPartPtr[i]->pdg_id()<<"   dR  "<<PhtPartdR[i]
                <<"  part type  "<<partDef.sParticleType[PhtPart[i].first]
               <<"  part origin  "<<partDef.sParticleOrigin[PhtPart[i].second]<<std::endl;
    }

   //  to check reconstructed conversion
   // get vector contains pointers  to tracks from reconstructed conversion
   std::vector<const Rec::TrackParticle*>    cnvPhtTrkPtr=m_truthClassifier->getCnvPhotTrkPtr();
   if(cnvPhtTrkPtr.size()==0)  continue;  // if no reconstructed conversion

    // get vector contains pointers  to truth particles associated with  tracks from reconstructed conversion
    std::vector<const HepMC::GenParticle*> cnvPhtTrPart=m_truthClassifier->getCnvPhotTrkToTruthPart();
    // get vector contains types of the truth particles associated with  tracks from reconstructed conversion
    std::vector<ParticleType> cnvPhtPartType=m_truthClassifier->getCnvPhotPartType();
     // get vector contains origin of the truth particles associated with  tracks from reconstructed conversion
    std::vector<ParticleOrigin> cnvPhtPartOrig=m_truthClassifier->getCnvPhotPartOrig();

    // loop over all particles associated with  reconstructed conversion tracks
    for(int itrk=0;itrk<(int) cnvPhtTrkPtr.size();itrk++) {
        unsigned int iCnvType = cnvPhtPartType[itrk];
        unsigned int iCnvOrig   = cnvPhtPartOrig[itrk];
        int iCnvPDG=0;
        if(!cnvPhtTrPart[itrk]) iCnvPDG=cnvPhtTrPart[itrk]->pdg_id();
        std::cout<<" part type   "<< partDef.sParticleType[iCnvType]
                    <<"  part origin  "<<partDef.sParticleOrigin[iCnvOrig]
                    <<"   pdg  "<< iCnvPDG<<std::endl;
   }

 }
```

## Muons classification

The muon track classification is based on common ID-Muon tracking software. Here is an example how to run the tool for muons classification.

```
 using namespace MCTruthPartClassifier;

 std::pair<unsigned int, unsigned int> res;
 ParticleDef partDef;

 for (; muonItr != muonItrE; ++muonItr) {

  const Analysis::Muon* mu =  (*muonItr);

  res=m_truthClassifier->particleTruthClassifier(mu);
  iTypeOfPart  =  res.first;
  iPartOrig       = res.second;

  // to print results of muon classification

   std::cout<<"  part type  "<<partDef.sParticleType[iTypeOfPart]
             <<"  part origin  "<<partDef.sParticleOrigin[iPartOrig]<<std::endl;

 // see other available  methods  in the section - ID track  classification

}
```

## Jets classification

The tool can be used to classify a jet into four different cathegories (BJet, CJet, LJet of Unknown) based on the flavor of the hadrons matched to it. Particles after parton showering and ISR/FSR are matched to the jet and, based on the flavor of these associated hadrons, the jet type is BJet if there is a b-flavored hadron, CJet if there is a c-flavored hadron (but no b-hadron is found), LJet if there is a light-flavored hadron (but no b/c-hadron is found) or Unknown. The hadron classification follows that of the PDG MC numbering scheme.

The user can choose between two different matching schemes:

- ΔR matching: all particles within a cone of user-defined-radius are matched to a jet;
- ghost-association: particles are matched to a jet based on the "Catchment area of jets" (http://arxiv.org/abs/0802.1188). The jet reconstruction algorithm is re-run but adding truth particles with infinitesimal energy. After this, an unambiguous association of particles to a jet is performed based on an improved definition of the jet area. This procedure is done through the package JetMomentTools and requires only a few configuration lines in a job options file.

The tool also provides a classification of the origin of a jet. By looking into the mothers of the associated particles a record of all particles involved in the hadronization process and the particles before showering is used to determine the physics process giving rise to a particular jet. The processes considered are decays of W, Z, top, Higgs, HiggsMSSM, Heavy bosons, SUSY particles and QCD (or nondefined in the case of, for example, jets with no particles associated).

Here is an example how to run the tool for jet classification within an algorithm.

```
using namespace MCTruthPartClassifier;

std::pair<ParticleType,ParticleOrigin>    res;
ParticleDef partDef;

JetCollection::const_iterator jetItr  = m_jetColl->begin(), jetItrE = m_jetColl->end(); // m_jetColl is a user selected JetCollection conta
for (; jetItr != jetItrE; ++jetItr) {
  const Jet* thisjet = (*jetItr);

  res = m_truthClassifier->particleTruthClassifier(thisjet,true); // for DR matching
  //res = m_truthClassifier->particleTruthClassifier(thisjet,false); // for ghost-matching

  ParticleType   iTypeOfPart  = res.first;
  ParticleOrigin iPartOrig       = res.second;

  // print classification results for this jet
  printf("\tjet type:  %s\tjet origin:  %s\n", partDef.sParticleType[iTypeOfPart].c_str(),partDef.sParticleOrigin[iPartOrig].c_str());
} // end loop over jets
```

## Job options configuration

The job options which can be used to configure the tool is listed here.

```
#--------------------------------------------------------------------------------------------
# to configure ATLAS extrapolation tool ExtrapolateToCalo
#--------------------------------------------------------------------------------------------
DetDescrVersion = 'ATLAS-GEO-02-01-00'
include( "RecExCommon/AllDet_detDescr.py" )

import MCTruthClassifier.MCTruthClassifierBase
from  MCTruthClassifier.MCTruthClassifierConf import MCTruthClassifier
ToolSvc += MCTruthClassifier()

#-----------------------------------------------------------------------------------------
# to change  default name  ("GEN_AOD")  of  GenParticle container
# in case of running of ESD files
#--------------------------------------------------------------------------------------------
MCTruthClassifier.McEventCollection="TruthEvent"

#--------------------------------------------------------------------------------------------
# to change default names (listed below) of the containers
#--------------------------------------------------------------------------------------------
MCTruthClassifier.ElectronContainerName  = "ElectronAODCollection"
MCTruthClassifier.photonContainerName    = "PhotonAODCollection"
MCTruthClassifier.egDetailAODContainer   = "egDetailAOD"
MCTruthClassifier.MuonContainer               = "StacoMuonCollection"

#--------------------------------------------------------------------------------------------
# to change default cut values  (listed below)  of  track quality matching
# to the truth  particle
#--------------------------------------------------------------------------------------------
MCTruthClassifier.deltaRMatchCut   = 0.2
MCTruthClassifier.deltaPhiMatchCut = 0.2
MCTruthClassifier.NumOfSiHitsCut     = 3

#--------------------------------------------------------------------------------------------
# to change default (listed below)  values of egamma photon  matching to truth particle
#--------------------------------------------------------------------------------------------
# to include additional looping over G4 particle need to set True
MCTruthClassifier.inclG4part=False

# definition of cone size to match particles to the egamma photon
MCTruthClassifier.phtdRtoTrCut= 0.1

# definition of the narrow elliptical cone size  which used for the classification
MCTruthClassifier.phtClasConePhi = 0.05
MCTruthClassifier.phtClasConeEta=0.025

# to change default cut values of p<sub>T</sub> for the particles extrapolated to the Calo
MCTruthClassifier.pTChargePartCut = 1.0
MCTruthClassifier.pTNeutralPartCut=0.

#--------------------------------------------------------------------------------------------
# to change default (listed below)  values of forward electrons matching to truth particle
#--------------------------------------------------------------------------------------------
# definition of cone size to match particles to the egamma photon
MCTruthClassifier.fwrdEledRtoTrCut  = 0.15

#--------------------------------------------------------------------------------------------
# to configure jets
#--------------------------------------------------------------------------------------------
# definition of cone size to DR-match particles to the jet
MCTruthClassifier.jetPartDRMatch = 0.4

# to configure ghost association and select the particles and jets containers
# setup an associator tool and create an algorithm applying this tool
from JetMomentTools.GhostAssociation import addGhostAssociation, setupGhostAssociator
mytool = setupGhostAssociator( "TruthAssoc", "","SpclMC")
myAlg = addGhostAssociation("AntiKt4LCTopoJets", ghostAssoc=[mytool])
```

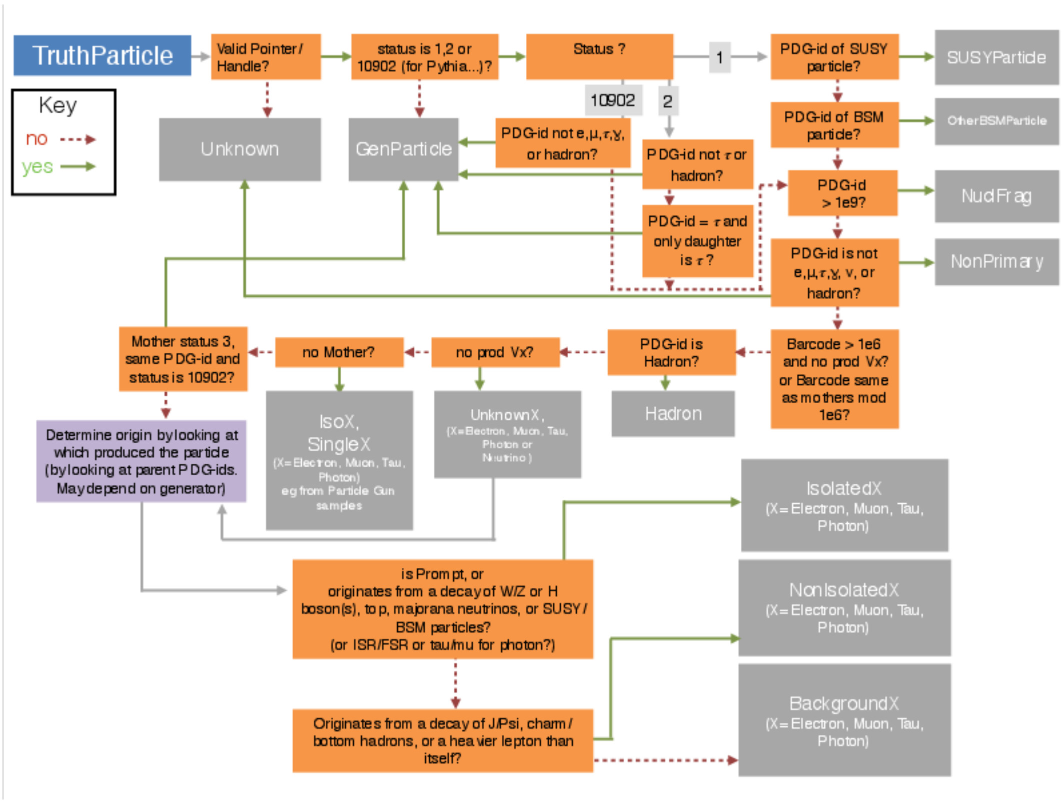
## Classification scheme

You can find the equivalent integer coding (used e.g in D3PDs and as decorations in dxAODs) in: MCTruthClassifierDefs.h

| Type | Origin | Comments |
|---|---|---|
| Unknown | Non defined | |
| Unknown e,μ,τ and γ | Non defined | algorithm to define origin fail or there is no particle production vertex |
| Isolated e,μ,τ | single e,μ,τ | primary e,μ,τ in single e,μ,τ data set |
| | W, Z and Higgs | W->eν Z->ll, H->4l |
| | t quark | t->W->lν |
| | SUSY | SUSY particles decay into e,μ and τ |
| | W,Z and Higgs MSSM | decay of gauge bosons and Higgs bosons with pdg from 32 to 37 into electrons |
| | $c\bar{c}$ and $b\bar{b}$ mesons | direct or prompt production of $c\bar{c}$ and $b\bar{b}$ mesons with decay into e and μ |
| | LQ | decays of leptoquarks |
| | $\nu_e^R$,$\nu_\mu^R$ and $\nu_\tau^R$ | decays of Majorana neutrinos |
| | $W_R$ | decays of left-right symmetric model W boson |
| Non Isolated e,μ, τ | Bottom meson | |
| | Bottom baryon | |
| | Charmed meson | |
| | Bottom baryon | |
| | Charmed baryon | |
| | J/ψ | decays into e or μ only |
| | τ decay | τ->eν or τ->μν excluding when τ originated from gauge bosons or t quark |
| | μ decay | μ->eν excluding when μ originated from gauge bosons or t quark |
| | Quark weak decays | it is for Herwig generator only, which allows direct quark decays b->c+e |
| Backg. Electron | | photons conversion, Dalitz decay, decay of light meson and etc |
| Backg. Muon | | |
| Backg. Tau | | |
| Isolated γ | single photon | primary photons in single photon data set |
| | prompt photon | |
| Non Isolated Photon | | |
| Backg. Photon | Undressed photon | Attempt at distinguishing ISR/FSR special case in SUSY and Exotics decays |
| Hadrons | Bottom meson | |
| | Bottom baryon | |
| | Charm meson | |
| | Charm baryon | |
| | Strange meson | |
| | Strange baryon | |
| | Light meson | |
| | Light baryon | |
| Nuclear fragments | Non defined | particles with pdgid > $10^8$ |
| Neutrinos | Non defined | |
| Non primary particles | Non defined | particles with barcode > $10^6$ |
| Generator particles | Non defined | |
| BJet, CJet, LJet | W, Z, H, top | hadronic decays (the W/Z does not come from a top or H) |
| | W,Z and Higgs MSSM | decay of gauge bosons and Higgs bosons with pdg from 32 to 37 into hadrons |
| | SUSY | SUSY particles hadronic decays |
| | LQ | leptoquarks decays |

| Type | Out Come Process | Comments |
|---|---|---|

See below a flowchart which gives a visual overview of the classification scheme:




Or in higher resolution PDF: https://twiki.cern.ch/twiki/pub/AtlasProtected/MCTruthClassifier/MCTruthClassifier_Diagram.pdf

## Examples

**Major updates**:
-- AnastopoulosChristos - 2009-08-27

Responsible: OlegFedin
Last reviewed by: **Never reviewed**

- MCTruthClassifier_Diagram.pdf: Flowchart Describing Classification scheme

| I | Attachment | History | Action | Size | Date | Who | Comment |
|---|---|---|---|---|---|---|---|
| | MCTruthClassifier_Diagram.pdf | r1 | manage | 64.7 K | 2018-11-30 - 17:02 | LouieDartmoorCorpe | Flowchart Describing Classification scheme |
| | MCTruthClassifier_Diagram.png | r1 | manage | 22.6 K | 2018-11-30 - 17:06 | LouieDartmoorCorpe | |

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