Ntuple analysis framework

Data and simulated AOD samples are processed through D3PDMaker (standard ATLAS tool) to produce ntuples (till now it was done by Saclay group) which are brought back in /home/gpfs/manip/mnt/atlas/data_NTUP/ (Saclay group's task also).
A framework to read, select and analyze the ntuples was developed and is described here together with the ntuple content.

Contacts : Maarten Boonekamp, Nicolas Morange, Nathalie Besson

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How to get the code

The code is on svn :

- Environment variable definition :
  export SVNGRP svn+ssh://XXX@svn.cern.ch/reps/atlasgrp (XXX= login au CERN)

- Getting the last version of the code :

svn co $SVNGRP/Institutes/Saclay/AnalysisWZ/trunk AnalysisWZ

- Creating makefile :
  source setup.sh

- Compilation :
  make

General description

Basic directories:

- Selection/ : contains the basic classes (including the ntuples header files),
- Parameters/ : contains the "master" text used by the analysis codes, handling the input/ouputs and the event pre-selection,
- Cuts/ (pre-selection cuts, one by physics object), LumiBlocks/ (list of "good" lumiblocks), Branches/ (list of ntuple branches the user wants to activate), Data/ (list of samples the user wants to run on),
- Utils/ : analysis tools,
- GoodRunLists/ : package handling the good run list,
- MTools/ (and config.mk, gen.mk, Makefile, dictgen.mk) : compilation files,
- Scripts/ useful scripts (to generate an analysis skeleton or a sample list)
- bin/ and lib/, automatically generated, contain the library and the executables.

Analysis directories:

- Each analysis is in a special file called MyAnalysis/ (the default in svn provides as examples CutFlow and MinBias).
- The routine which will give the executable is called runMyAnalysis.C, after compiling the executable is runMyAnalysis and is in the directory bin/.
- The main loop is called MyAnalysis.C. It contains:
  - a first part which deals with pre-selection of the events monitored by the text files. The "master" file is in Parameters/ and is called myanalysis.par. Inside are called sub-files defining
    - the physics object selections (described in the directory Cuts/),
    - the samples the user wants to run on, in a list which is in the directory Data/,
    - the interesting lumiblocks in a list which is in the directory LumiBlocks/,
    - the ntuple branches to activate in a list which is in the directory Branches/,
    - output files: the ntuple containing the selected objects and the file necessary to compute the luminosity which corresponds to the analyzed sample. They will be produced in the directory bin/.
  - A second part dedicated to the analysis itself which has to be modified by the user.

Tutorial π^0

The exercize: from scratch, analyze the 900 GeV 2009 data and draw a gamma-gamma invariant mass peak.

- Get the code: see How to get the code.

- Create the analysis skeleton:
  - in the directory Scripts/,
  - launch NewAnalysis.sh MyAnalysis,
  - the directory MyAnalysis is created. It contains MyAnalysis.C, MyAnalysis.h, runMyAnalysis.C and module.mk,
  - the file myanalysis.par is created in Parameters/,
  - the file MyAnalysisCuts.txt is created in Cuts/,
  - the empty file MyAnalysis.branches is created in Branches/.

- Definition of the samples to run on:
  - in the directory Scripts/,
  - launch the command line

listCreator.sh "user10*data09_900GeV*MinBias*" myDataList.list
(this file is put in Data/. It contains the list of all the rootuples in /home/gpfs/manip/mnt/atlas/data_NTUP/ which name contains user10 & 900GeV & MinBias).

- Definition of the analysis cuts:
  - in the directory Parameters/,
  - edit the file myanalysis.par,
  - in this example we only deal with the emclusters objects hence we only need one cut text file (one file per object):

```
CutType1  STRING   EMCluster
CutName1  STRING   myEMClusters
CutFile1  STRING   ../Cuts/EMClusterCuts.txt
```

  The identifiers in the lines of the type CutType [i] are: Electron, Muon, Photon, Track, Cluster, EMCluster, None. The identifiers in the lines of the type CutName[i] can be chosen by the user.

  - The user has to define the input/outputs (which are not automatically generated by NewAnalysis.sh)

OutFile	STRING	contains the selected objects
OutFlag	INT	write (1) or not (0) the selected objects
NtupleList	STRING	myDataList.list (in Data/)
OutLBFile	STRING	output containing the good and read lumiblocks
InGoodLBFile	STRING	list of good lumiblocks (here ../LumiBlocks/FinalGoodRun900GeV.xml)
BranchesList	STRING	../Branches/MyAnalysis.branches

  - The user has to define the cuts he/she wants to apply to the emclusters by changing the file Cuts/EMClusterCuts.txt. Here we want EMclusters with a p_t > 300 MeV (beware of the units) and in the barrel region of the calorimeter.

```
myEMClusters @ emcl_pt>300        # $p_T > 300$ MeV
myEMClusters @ abs(emcl_eta)<2.5 # $|\eta| < 2.5$
```

  The variables used here are the ones defined in the header file of D3PDNtuple.

  - At last, the user has to define the cuts on the event by changing the file Cuts/MonAnalyseCuts.txt. Here we want only that there are at least 2 of the previously selected objects:

```
Event @ nselEMClustersEvt >= 2       # $N_{cl}$ >= 2
```

  The variables used here are the ones defined in the header file of OutputNtuple but those from D3PDNtuple can be used as well (example: cut on missing E_T to select the event).

- Definition of the analysis:
  - in the directory MyAnalysis/,
  - edit MyAnalysis.C,
  - add #include "TH1F.h"
  - under the line

    // declare histograms

    declare the histogram

    TH1F pi0mass("pi0mass", "pi0mass",100,0.,1000.);
  - for each event the routine selectEvent() of AnalysisNtuple is called and it:
    - verifies that the lumiblock is good,
    - pre-selects the objects,
    - selects the event.

Caution: the variables of D3PDNtuple are accessible with ntple-> because they are stored in vectors of pointers (e.g. ntple->emcl_E_EMB1->at(i)), the variables of OutputNtuple are accessible with output-> because they are stored in vectors (e.g. output->vselEMClusters[i]).

- Under the line

  ```
  // further analysis...
  ```

  loop over the selected emclusters:

  ```
  TLorentzVector pi0;
  int nsel = output->nselEMClustersEvt;
  for(int i=0; i<nsel; i++) {
    for(int j=i+1; j<nsel; j++) {
      pi0 = output->vselEMClusters[i] + output->vselEMClusters[j];
      if( pi0.Pt()>900. )
       {
       pi0mass.Fill( pi0.M() );
       }
     }
  }
  ```

- Under the line

  ```
  // write histos
  ```

  save the histogram

  ```
  TFile fhist("fhist.root","RECREATE");
  pi0mass.Write();
  fhist.Close();
  ```

- To compile: go in the root directory (AnalysisWZ), do make.

- Go in the directory bin/ and launch runMyAnalysis. The invariant mass histogram is stored in fhist.root in bin/ together with the other output file and the list of processed lumiblocks.

Detailed description

Cuts handling

The pre-selection cuts are handled by the classes located in the directory Selection/. There is a special class per object (ElectronSelector, MuonSelector, PhotonSelector, TrackSelector, ClusterSelector, EMClusterSelector), each of these classes inheriting from the class Selector.

Important remark:
As it is (what you get from svn) the classes ElectronSelector, MuonSelector and PhotonSelector allow to apply 2 different selections (for instance a very well reconstructed electron and second one more loose). The inside logic of the variables (for instance the sequence of IsEM identifications which are inclusive and not exclusive) forces the user to arrange the selections from the most stringent to the loosest. The classes TrackSelector, ClusterSelector, EMClusterSelector allow only one selection.

Example : two electron selection

In the file Parameters/myanalysis.par :

```
CutType1     STRING       Electron   (no choice)
CutName1     STRING       Elec1
CutFile1     STRING       ../Cuts/ElectronCuts.txt

CutType2     STRING       Electron   (no choice)
CutName2     STRING       Elec2
CutFile2     STRING       ../Cuts/ElectronCuts.txt
```

In the file Cuts/ElectronCuts.txt :

```
Elec1 @ el_tight!=0                  # el_tight \neq 0
Elec1 @ (el_isEM&ElectronTight)==0  # idem
Elec1 @ el_pt>25000.                 # $p_T > 25$ GeV
Elec1 @ abs(el_eta)<2.5              # $|\eta|<2.5$

Elec2 @ el_pt>5000.                  # $p_T > 5$ GeV
Elec2 @ abs(el_eta)<2.5              # $|\eta|<2.5$
Elec2 @ (el_isEM&ElectronMedium)==0 # el medium
```

As you can see cut number 1 is more stringent than cut number 2. Cuts of the type `el_isEM&ElectronTight` and `el_isEM&ElectronMedium` compare bit by bit the ntuple variable el_isEM and the variables which are defined in EGPID.h (every const unsigned int of this file can be used, not only the various definitions of loose, medium and tight, which allows the user to play with isolation, calorimeter layers, shower shape … i.e. to define his/her own "tight", "medium"…).

Important remark: in the .par file, the cuts lines must begin with CutType, CutName and CutFile followed by an integer and the integers must be in increasing order without hole between them starting with 1. To make the edition of these .par files easier, we introduced the type None. Then the corresponding CutType, CutName and CutFile are not taken into account.

Example :

```
CutType1        STRING        Electron
CutName1        STRING        Elec1
CutFile1        STRING        ../Cuts/ElectronCuts.txt

CutType2        STRING        None
CutName2        STRING        Elec2
CutFile2        STRING        ../Cuts/ElectronCuts.txt

CutType3        STRING        Photon
CutName3        STRING        Phot1
CutFile3        STRING        ../Cuts/PhotonCuts.txt
```

Event selection implementation in the file MyAnalysisCuts.txt:

```
Event @ nselElecEvt >= 2        # at least one selected electron passing cut1 || cut2
Event @ nselElec1Evt>= 1        # including at least one passing cut1
```

Handling of I/O time

By default, during an analysis, the user has access to

- D3PDNtuple :
  - the variables which are specifically used in the cuts (blablaCuts.txt files)
  - the "global" variables (evt number, run number, lumiblock)
  - the kinematic variables corresponding to the objects on which a preselection is applied (p_t, η, φ, d_0, z_0, mass)
- OutputNtuple :
  - all the variables associated to selected objects (a 4-vector, d_0, z_0 and an index giving the position of the object in the corresponding vector of D3PDNtuple. Example, in D3PDNtuple electron i is selected first, it will be electron 0 in the OutputNtuple and its index will give i.

This default filling of OutputNtuple minimizes the I/O time (all ntuple branches are disabled then the interesting branches are activated). If the user needs other D3PDNtuple variables in its analysis, he/she has to specify their names in a file of the directory Branches/.

Example :

```
el_truth_E
```

```
el_truth_pt
el_truth_phi
cl_E_em
cl_E_had
```

or

`emcl*` //all the ntuple branches beginning with emcl will be activated

or

`*` //all the ntuple branches will be activated.

User defined parameters

The user can define his/her own "datacard" foolowing the model of the parameter files (handled by the class Utils/loadPar).

Tutorial : change the name of the output histogram root file, pass the histogram boundaries

- Create a file user.par in Parameters/.
- Include a line of the type Identifier Type Value. The identifier is the name by which the user has access to the value in the remainder of the code, the type can be: INT (integer), FLOAT (float), DOUBLE (double), STRING (string),
- VINT (integer vector), VFLOAT (float vector), VDOUBLE (double vector), VSTRING (string vector). In these cases (vectors) the values must be separated by comas. Examples:
```
MyOutputName       STRING      hist.root
MyHistoBounds      VDOUBLE     0.,1000.
```
- In the analysis code MyAnalysis.C, instanciate the corresponding object of type loadPar:
```
loadPar* lp = new loadPar("user.par");
```
- Use the content of user.par :
```
string op = lp->getStringParam("MyOutputName");
vector<double> bounds = lp->getDoubleParamVec("MyHistoBounds");
```

Content of the D3PDNtuple

Global event variables

`RunNumber`	Run number
`EventNumber`	Event number
`timestamp`	Time stamp in seconds = UNIX time or POSIX (since midnight on the 01/01/1970)
`timestamp_ns`	Time stamp offset in ns
`lbn`	LumiBlock number
`bcid`	Bunch Crossing Identity
`detmask0`	bit field indicating which TTC zones have been built into the event, one bit per zone, 32 bit unsigned
`detmask1`	Same (other part of detmask)

Electron block variables

See https://twiki.cern.ch/twiki/bin/view/AtlasProtected/EgammaAOD (the ntuple variables are not all describded and sometimes the names are different but there are a lot of detailed information.)
See also
https://svnweb.cern.ch/trac/atlasoff/browser/PhysicsAnalysis/D3PDMaker/D3PDMakerConfig/trunk/doc/egamma-variables for description given by Scott.

Pay attention to the fact that electrons (egamma and softe) are built from 3x7 clusters in the barrel, 3x5 in the end-caps.For the photons, the size is 3x5 in the barrel for unconverted photons, 3x7 for the converted ones and 5x5 in the end-caps. Forward electrons are built from topoclusters.

el_n	Number of electron objects

Kinematics

el_E	Energy
el_Et	Transverse energy
el_pt	Transverse momentum
el_m	Mass (0.)
el_eta	Pseudo rapidity
el_phi	Azimuth angle
el_px	Momentum along x
el_py	Momentum along y
el_pz	Momentum along z
el_charge	Charge

Identification

See for instance
https://twiki.cern.ch/twiki/bin/view/AtlasProtected/ElectronReconstruction#Definition_of_the_author
https://twiki.cern.ch/twiki/bin/view/AtlasProtected/ElectronReconstruction#PID_variables

el_author	unknown=0, Standard=1 || 3, track-based=2 || 3, Forward =8
el_isEM	Bitted word for identification
el_loose	>0 if loose
el_medium	>0 if medium
el_mediumIso	>0 if medium plus isolation
el_tight	>0 if tight
el_tightIso	>0 if tight plus isolation

MC Truth

el_truth_E	True energy
el_truth_pt	True transverse momentum
el_truth_eta	True pseudo rapidity
el_truth_phi	True azimuth angle
el_truth_type	True PDG type
el_truth_status	Status MC status=1 pfinal particle, status=3 intermediate particle (documentary)
el_truth_barcode	index
el_truth_mothertype	True mother PDG type
el_truth_motherbarcode	Mother index
el_truth_hasHardBrem	True if electron has emitted a true “hard” brem
el_truth_matched	True is electron is matched to the truth

Different EM calo layers

Unless otherwise stated, the energy are uncalibrated.
For the strip variables, two consecutive cells in φ are merged.

el_Ethad	ET leakage into had calo
el_Ethad1	Et leakage into 1st sampling of had calo
el_f1	E_1(tot)/E(cluster)

el_f1core	E_1(3× 1)/E(cluster)
el_Emins1	Energy of strip with min between first and second max
el_fside	strips [E(±3) - E(±1)]/E(±1)
el_Emax2	2^{nd} maximum in strips
el_ws3	3-strip shower width
el_wstot	shower width in cluster size (max of 40 strips)
el_deltaEs	diff btn 2^{nd} max and 1^{st} min in strips
el_deltaEmax2	E of 2^{nd} max in 1^{st} sampling
el_E233	uncorrected energy in 3x3 cells in EM sampling 2
el_E237	uncorrected energy in 3x7 cells in EM sampling 2
el_E277	uncorrected energy in 7x7 cells in EM sampling 2
el_weta2	3x5 window lateral width (variance in η of the cluster weighted by the energy) $\omega_{\eta\,2} = \sqrt{}\,(\sum E_i \times \eta^2)/(\sum E_i)$ -$((\sum E_i \times \eta)/(\sum E_i))^2$
el_f3	fraction of energy found in EM Sampling 3 E_3/E(cluster)
el_f3core	E_3(3× 3)/E(cluster)
el_rphiallcalo	ratio of energy in 3x3 over 3x7 cells
el_reta	Ratio in η of cell E in 3 × 7 versus 7 × 7 cells in S2
el_rphi	Ratio in φ of cell E in 3 × 3 versus 3 × 7 cells in S2
el_Es0	Calo energy in presampler
el_etas0	η of cluster in presampler
el_phis0	φ of cluster in presampler
el_Es1	Calo energy in sampling 1
el_etas1	η of cluster in sampling 1
el_phis1	φ of cluster in sampling 1
el_Es2	Calo energy in sampling 2
el_etas2	η of cluster in sampling 2
el_phis2	φ of cluster in sampling 2
el_Es3	Calo energy in sampling 3
el_etas3	η of cluster in sampling 3
el_phis3	φ of cluster in sampling 3

Isolation

el_Etcone45	Energy in cone of 0.45 (-E(5x7) in EM)
el_Etcone20	Energy in cone of 0.20 (-E(5x7) in EM)
el_Etcone30	Energy in cone of 0.30 (-E(5x7) in EM)
el_Etcone40	Energy in cone of 0.40 (-E(5x7) in EM)
el_EtringnoisedR03sig2	E_T in a ring : $(0.1<\Delta R<0.3)$ with E > 2σ above noise
el_EtringnoisedR03sig3	E_T in a ring : $(0.1<\Delta R<0.3)$ with energy > 3σ above noise
el_EtringnoisedR03sig4	E_T in a ring : $(0.1<\Delta R<0.3)$ with energy > 4σ above noise

Discriminants

Results of likelihood computations for the electron/pion discrimination.

el_isolationlikelihoodjets	
el_isolationlikelihoodhqelectrons	
el_electronweight	Standard likelihood weight for electrons
el_electronbgweight	Standard likelihood weight for background
el_softeweight	Likelihood for soft electrons (for electrons in jets, b-tagging)
el_softebgweight	Likelihood for soft electrons (for electrons in jets, b-tagging)
el_neuralnet	
el_Hmatrix	
el_Hmatrix5	
el_adaboost	

el_softeneuralnet	

Pointing

el_pos7	Track/shower distance in units of distance between the strips
el_zvertex	pointing z at vertex reconstructed from the cluster (pointing done with a fit over the barycenters of the different layers of the shower)
el_errz	associated error on zvertex
el_etap	pointing η reconstructed from the cluster (first and second sampling)
el_depth	depth of the shower (position in R for the Barrel and z for the EndCap of the barycenter of the shower)

Bremstrahlung

Electron is fitted again with a brem hypothesis. L'électron est refitté avec une hypothèse de brem.

el_breminvpt	$1/p_T$ estimate according to EMBremFit
el_bremradius	estimated brem radius (mm) [x-y plane]
el_bremx	EMBremfitted track impact in 2^{nd} sampling - cluster distance (mm) : $\Delta\varphi$(EMBremfitted track impact in 2^{nd} sampling,cluster)*bremClusterRadius
el_bremclusterradius	cluster radius (mm) [x-y plane]
el_breminvpterr	error associated to $1/p_T$
el_bremtrackauthor	Track Author enum as Defined in Track/Track.h
el_hasbrem	The Number of brems identified by the track fitter
el_bremdeltaqoverp	$\Delta 1/p$ btn the fit and the fit without brem
el_bremmaterialtraversed	Amount of Material seen by the particle according to the track fitter (in X_0)

Track match

Track associated to the electron (no calo/tracker fit).
See details in https://twiki.cern.ch/twiki/bin/view/AtlasProtected/ElectronReconstruction#Trackmatching

el_etacorrmag	η of track extrapolated to first sampling
el_deltaeta1	$\Delta\eta$ of track extrapolated to calo S1 and cluster(S1)
el_deltaeta2	$\Delta\eta$ of track extrapolated to calo S2 and cluster(S2)
el_deltaphi2	$\Delta\varphi$ of track extrapolated to calo S2 and cluster(S2)

EMTrackFit variables

el_refittedtrackqoverp	$1/p_T$ estimate according to Track Refit
el_refittedtrackd0	transverse impact parameter (distance of closest approach) after Track Refit
el_refittedtrackz0	the z value at the point of closest approach after Track Refit
el_refittedtracktheta	θ of the track after EMTrackFit
el_refittedtrackphi	φ of the momentum at the point of closest approach after Track Refit
el_refittedtrackcovd0	covariance matrix item (d_0,d_0)
el_refittedtrackcovz0	covariance matrix item (z_0,z_0)
el_refittedtrackcovphi	covariance matrix item (φ,φ)
el_refittedtrackcovtheta	covariance matrix item (θ,θ)
el_refittedtrackcovqoverp	covariance matrix item (q/P,q/P)
el_refittedtrackcovd0z0	covariance matrix item (d_0,z_0)
el_refittedtrackcovz0phi	covariance matrix item (z_0,φ)
el_refittedtrackcovz0theta	covariance matrix item (z_0,θ)
el_refittedtrackcovz0qoverp	covariance matrix item $(z_0,q/p)$
el_refittedtrackcovd0phi	covariance matrix item (d_0,φ)

el_refittedtrackcovd0theta	covariance matrix item (d_0,θ)
el_refittedtrackcovd0qoverp	covariance matrix item (d_0,q/p)
el_refittedtrackcovphitheta	covariance matrix item (φ,θ)
el_refittedtrackcovphiqoverp	covariance matrix item (φ,q/P)
el_refittedtrackcovthetaqoverp	covariance matrix item (θ,q/P)

Cluster kinematics

el_cl_pt	cluster p_T
el_cl_eta	cluster η
el_cl_phi	cluster φ

Forward electron

Variables (moments) of the EMtopo clusters

el_firstEdens	energy density (moment for forward electron)
el_cellmaxfrac	tot clust E in cell with max E (moment for forward electron)
el_longitudinal	relative longitudinal moment (moment for forward electron)
el_secondlambda	second lambda (moment for forward electron)
el_lateral	relative lateral moment (moment for forward electron)
el_secondR	second R (moment for forward electron)
el_centerlambda	centre lambda (moment for forward electron)

Track

Track associated to the electron (no calo/tracker fit)

el_hastrack	Yes or no
el_trackd0	transverse impact parameter (distance of closest approach)
el_trackz0	the z value at the point of closest approach
el_tracktheta	θ of the track fit
el_trackphi	azimuth angle of the momentum at the point of closest approach
el_trackqoverp	1/p of track
el_trackpt	p_T of track
el_tracketa	η of the track
el_trackcovd0	Covariance matrix item (d_0,d_0)
el_trackcovz0	Covariance matrix item (z_0,z_0)
el_trackcovtheta	Covariance matrix item (θ,θ)
el_trackcovphi	Covariance matrix item (φ,φ)
el_trackcovqoverp	Covariance matrix item (q/P,q/P)
el_trackcovd0z0	Covariance matrix item (d_0,z_0)
el_trackcovd0phi	Covariance matrix item (d_0,φ)
el_trackcovd0theta	Covariance matrix item (d_0,θ)
el_trackcovd0qoverp	Covariance matrix item (d_0,q/P)
el_trackcovz0phi	Covariance matrix item (z_0, φ)
el_trackcovz0theta	Covariance matrix item (z_0,θ)
el_trackcovz0qoverp	Covariance matrix item (z_0,q/P)
el_trackcovphitheta	Covariance matrix item (φ,θ)
el_trackcovphiqoverp	Covariance matrix item (φ,q/P)
el_trackcovthetaqoverp	Covariance matrix item (θ,q/P)
el_trackfitchi2	χ^2 of track fit
el_trackfitndof	Number of degrees of freedom of track fit
el_nBLHits	Number of hits in B-layer
el_nPixHits	Number of hits in pixels
el_nSCTHits	Number of hits in SCT
el_nTRTHits	Number of hits in TRT

el_nTRTHighTHits	Number of high threshold hits in TRT
el_nBLSharedHits	Number of hits in B-layer shared with other track(s)
el_nPixSharedHits	Number of hits in pixels shared with other track(s)
el_nSCTSharedHits	Number of hits in SCT shared with other track(s)
el_nPixHoles	Number of holes in Pixel segment
el_nSCTHoles	Number of holes in SCT segment
el_nTRTOutliers	Number of hits in TRT which are on the road of the track but too far to enter the fit
el_nTRTHighTOutliers	Number of high threshold hits in TRT which are on the road of the track but too far to enter the fit
el_nSiHits	Number of hits in pixels + Number of hits in SCT
el_TRTHighTHitsRatio	Number of high threshold hits in TRT / Number of hits in TRT

Vertex

Event primary vertex variables.

el_vertx	X of vertex
el_verty	Y of vertex
el_vertz	Z of vertex

Jet

Reconstructed and true variables of the jet closest to the electron.

el_jet_dr	ΔR (reconstructed jet, reconstructed electron)
el_jet_E	Jet energy
el_jet_pt	Jet p_T
el_jet_m	Jet mass
el_jet_eta	Jet η
el_jet_phi	Jet φ
el_jet_truth_dr	ΔR (true jet, reconstructed electron)
el_jet_truth_E	True jet energy
el_jet_truth_pt	True jet p_T
el_jet_truth_m	True jet mass
el_jet_truth_eta	True jet η
el_jet_truth_phi	True jet φ
el_jet_truth_matched	Flag of matching of the rec. electron with a true jet
el_jet_matched	Flag of matching of the rec. electron with a rec. jet

Trigger

The variables beginning with el_EF, el_L2 et el_L1 are the same as in the previous blocks but as reconstructed by the triggers.

Photon block variables

Same as for the electron block except the ones given below. Pay attention to the fact that the photons are reconstructed from 3x5 clusters, hence the variables ph_topoXXX associating a photon with a topocluster.

ph_isRecovered	One of the authors (taken out of the electron container)
ph_convFlag	Conversion flag
ph_isConv	Flag (what's the diff. with the previous one?)
ph_truth_deltaRRecPhoton	ΔR (truth,rec)
ph_E132	?
ph_E1152	?
ph_convanglematch	true if conv is matched within an angle of 0.05 to cluster
ph_convtrackmatch	true if conv is matched to the track associated to cluster
ph_hasconv	Yes or no

ph_convvtxx	Conversion vertex position in x
ph_convvtxy	Conversion vertex position in y
ph_convvtxz	Conversion vertex position in z
ph_Rconv	Conversion radius
ph_zconv	Conversion z (?)
ph_convvtxchi2	Conversion vertex χ^2
ph_pt1conv	p_T of conversion track 1
ph_convtrk1nBLHits	Number of B-layer hits of conversion track 1
ph_convtrk1nPixHits	Number of Pixel hits of conversion track 1
ph_convtrk1nSCTHits	Number of SCT hits of conversion track 1
ph_convtrk1nTRTHits	Number of TRT hits of conversion track 1
ph_pt2conv	p_T of conversion track 2
ph_convtrk2nBLHits	Number of B-layer hits of conversion track 2
ph_convtrk2nPixHits	Number of Pixel hits of conversion track 2
ph_convtrk2nSCTHits	Number of SCT hits of conversion track 2
ph_convtrk2nTRTHits	Number of TRT hits of conversion track 2
ph_ptconv	p_z of conversion tracks 1+2
ph_pzconv	p_z of conversion tracks 1+2
ph_truth_isConv	flag
ph_truth_isBrem	flag
ph_truth_isFromHardProc	flag
ph_truth_isPhotonFromHardProc	flag
ph_truth_Rconv	True conversion radius
ph_truth_zconv	True conversion z
ph_topoEtcone20	Energy in cone of 0.20
ph_topoEtcone40	Energy in cone of 0.40
ph_topoEtcone60	Energy in cone of 0.60
ph_topodr	ΔR entre le 3x5 et le topo associé (?)
ph_topopt	p_T du topo cluster associé
ph_topoeta	η du topo cluster associé
ph_topophi	φ du topo cluster associé
ph_topomatched	flag
ph_topoEMdr	ΔR btn the 3x5 cluster and the associated topo EM (?)
ph_topoEMpt	p_T of associated EM topo cluster
ph_topoEMeta	η of associated EM topo cluster
ph_topoEMphi	φ of associated EM topo cluster
ph_topoEMmatched	flag

Muon block variables

See:
http://alxr.usatlas.bnl.gov/lxr/source/atlas/Tracking/TrkEvent/TrkTrackSummary/TrkTrackSummary/TrackSummary.h
and
http://alxr.usatlas.bnl.gov/lxr/source/atlas/Reconstruction/MuonIdentification/muonEvent/muonEvent/MuonParamDefs.h

mu_n	Number of muon type objects

Kinematics

mu_E	energy
mu_pt	p_T
mu_m	Mass
mu_eta	η
mu_phi	φ
mu_px	p_x

mu_py	p_y
mu_pz	p_z
mu_charge	charge

Algorithms

mu_allauthor	?
mu_author	unknown=0, highPt=1, lowPt=2

Isolation

mu_etcone20	E_t in a 0.2 cone
mu_etcone30	E_t in a 0.3 cone
mu_etcone40	E_t in a 0.4 cone
mu_nucone20	Number of tracks in a 0.2 cone
mu_nucone30	Number of tracks in a 0.3 cone
mu_nucone40	Number of tracks in a 0.4 cone
mu_ptcone20	Σp_T of the tracks in a 0.2 cone
mu_ptcone30	Σp_T of the tracks in a 0.3 cone
mu_ptcone40	Σp_T of the tracks in a 0.4 cone

Energy loss in the calo

mu_energyLossPar	Energy loss in the calo (parametrization?)
mu_energyLossMeas	Energy loss in the calo (measurement?)

Quality

mu_bestMatch	For a combined muon, identifies if the combination ID-MS is the best one
mu_isStandAloneMuon	MS (MuonBoy) alone
mu_isCombinedMuon	MS + ID (Staco)
mu_isLowPtReconstructedMuon	Mutag

Track pattern

mu_nBLHits	Number of B-layer hits
mu_nPixHits	Number of Pixel hits
mu_nSCTHits	Number of SCT hits
mu_nTRTHits	Number of TRT hits
mu_nTRTHighTHits	Number of high threshold TRT hits
mu_nBLSharedHits	Number of B-layer hits shared with another track
mu_nPixSharedHits	Number of Pixel hits shared with another track
mu_nPixHoles	Number of holes in the Pixel segment
mu_nSCTSharedHits	Number of SCT hits shared with another track
mu_nSCTHoles	Number of holes in the SCT segment
mu_nTRTOutliers	Number of TRT hits inside the road but to far away to enter the fit
mu_nTRTHighTOutliers	Number of high threshold TRT hits inside the road but to far away to enter the fit
mu_nMDTHits	Number of MDT hits
mu_nMDTHoles	Number of MDT holes
mu_nCSCEtaHits	Number of CSC η hits
mu_nCSCEtaHoles	Number of CSC η holes
mu_nCSCPhiHits	Number of CSC φ hits
mu_nCSCPhiHoles	Number of CSC φ holes
mu_nRPCEtaHits	Number of RPC η hits
mu_nRPCEtaHoles	Number of RPC η holes
mu_nRPCPhiHits	Number of RPC φ hits

mu_nRPCPhiHoles	Number of RPC φ holes
mu_nTGCEtaHits	Number of TGC η hits
mu_nTGCEtaHoles	Number of TGC η holes
mu_nTGCPhiHits	Number of TGC φ hits
mu_nTGCPhiHoles	Number of TGC φ holes
mu_nGangedPixels	Number of pixel with an ambiguity
mu_nOutliersOnTrack	Number of measurements flagged has out of road in the TSOS (Track State On Surface)

Track parameters

mu_trackd0	Impact parameter d_0
mu_trackz0	Impact parameter z_0
mu_tracktheta	Track θ
mu_trackphi	Track φ
mu_trackqoverp	Track q/p
mu_trackcovd0	Covariance matrix element(d_0,d_0)
mu_trackcovz0	Covariance matrix element(z_0,z_0)
mu_trackcovtheta	Covariance matrix element(θ,θ)
mu_trackcovphi	Covariance matrix element(φ,φ)
mu_trackcovqoverp	Covariance matrix element(q/p,q/p)
mu_trackcovd0z0	Covariance matrix element(d_0,z_0)
mu_trackcovd0phi	Covariance matrix element(d_0, φ)
mu_trackcovd0theta	Covariance matrix element(d_0,θ)
mu_trackcovd0qoverp	Covariance matrix element(d_0, q/p)
mu_trackcovz0phi	Covariance matrix element(z_0, φ)
mu_trackcovz0theta	Covariance matrix element(z_0,θ)
mu_trackcovz0qoverp	Covariance matrix element(z_0, q/p)
mu_trackcovphitheta	Covariance matrix element(φ,θ)
mu_trackcovphiqoverp	Covariance matrix element(φ,q/p)
mu_trackcovthetaqoverp	Covariance matrix element(θ,q/p)
mu_trackfitchi2	Track fit χ^2
mu_trackfitndof	Track fit number of degrees of freedom
mu_hastrack	Matching flag
mu_matchchi2	Matching χ^2
mu_matchndof	Matching number of degrees of freedom

Jet block variables

jet_n	Number of jet type objects
jet_E	energy
jet_pt	p_T
jet_m	mass
jet_eta	η
jet_phi	φ
jet_emfrac	EM energy fraction

Missing transverse energy variables

MET_etx	E_T(x)
MET_ety	E_T(y)
MET_sumet	Σ scalar of p_T (of topoclusters? Depends on container)
MET_et	E_T
MET_phi	φ

Cluster block variables

Calo topoclusters (420).

cl_n	Number of objects
cl_E	energy
cl_pt	p_T
cl_m	mass
cl_eta	η
cl_phi	φ
cl_E_em	EM energy
cl_E_had	Had. energy
cl_firstEdens	moment
cl_cellmaxfrac	moment
cl_longitudinal	moment
cl_secondlambda	moment
cl_lateral	moment
cl_secondR	moment
cl_centerlambda	moment
cl_deltaTheta	Difference in θ btn the pointing and the shower axis
cl_deltaPhi	Difference in φ btn the pointing and the shower axis
cl_time	Cluster timing with respect to the MHC clock

EM cluster variables

EM part of topo clusters of type 430.

emcl_n	Number of EMcluster objects
emcl_E	energy
emcl_pt	p_T
emcl_m	Mass
emcl_eta	η
emcl_phi	φ
emcl_E_em	EM energy
emcl_E_had	Had. Energy (0.)
emcl_firstEdens	moment
emcl_cellmaxfrac	moment
emcl_longitudinal	moment
emcl_secondlambda	moment
emcl_lateral	moment
emcl_secondR	moment
emcl_centerlambda	moment
emcl_deltaTheta	Difference in θ btn the pointing and the shower axis
emcl_deltaPhi	Difference in φ btn the pointing and the shower axis
emcl_time	Cluster timing with respect to the MHC clock
emcl_E_PreSamplerB	Energy in presampler barrel (PB MC !!!!!!!!!!!!!!!!!!)
emcl_E_EMB1	Energy in S1 barrel (PB MC !!!!!!!!!!!!!!!!!!)
emcl_E_EMB2	Energy in S2 barrel (PB MC !!!!!!!!!!!!!!!!!!)
emcl_E_EMB3	Energy in S3 barrel (PB MC !!!!!!!!!!!!!!!!!!)
emcl_E_PreSamplerE	Energy in le presampler Endcap (PB MC !!!!!!!!!!!!!!!!!!)
emcl_E_EME1	Energy in S1 Endcap (PB MC !!!!!!!!!!!!!!!!!!)
emcl_E_EME2	Energy in S2 Endcap (PB MC !!!!!!!!!!!!!!!!!!)
emcl_E_EME3	Energy in S3 Endcap (PB MC !!!!!!!!!!!!!!!!!!)
emcl_E_HEC0	0.
emcl_E_HEC1	0.

emcl_E_HEC2	0.
emcl_E_HEC3	0.
emcl_E_TileBar0	0.
emcl_E_TileBar1	0.
emcl_E_TileBar2	0.
emcl_E_TileGap1	0.
emcl_E_TileGap2	0.
emcl_E_TileGap3	0.
emcl_E_TileExt0	0.
emcl_E_TileExt1	0.
emcl_E_TileExt2	0.
emcl_E_FCAL0	0.
emcl_E_FCAL1	0.
emcl_E_FCAL2	0.

Track block variables

trk_n	Number of track objects
trk_d0	Impact parameter d_0
trk_z0	Impact parameter z_0
trk_theta	Track θ
trk_phi	Track φ
trk_qoverp	Track q/p
trk_pt	Track p_T
trk_eta	Track η
trk_covd0	Covariance matrix item (d_0,d_0)
trk_covz0	Covariance matrix item (z_0,z_0)
trk_covtheta	Covariance matrix item (θ,θ)
trk_covphi	Covariance matrix item (φ,φ)
trk_covqoverp	Covariance matrix item (q/p,q/p)
trk_covd0z0	Covariance matrix item (d_0,z_0)
trk_covd0phi	Covariance matrix item (d_0,φ)
trk_covd0theta	Covariance matrix item (d_0,θ)
trk_covd0qoverp	Covariance matrix item $(d_0,q/p)$
trk_covz0phi	Covariance matrix item (z_0,φ)
trk_covz0theta	Covariance matrix item (z_0,θ)
trk_covz0qoverp	Covariance matrix item $(z_0,q/p)$
trk_covphitheta	Covariance matrix item (φ,θ)
trk_covphiqoverp	Covariance matrix item $(\varphi,q/p)$
trk_covthetaqoverp	Covariance matrix item $(\theta,q/p)$
trk_chi2	Track fit χ^2
trk_ndof	Track fit number of degrees of freedom
trk_nBLHits	Number of B-layer hits
trk_nPixHits	Number of Pixel hits
trk_nSCTHits	Number of SCT hits
trk_nTRTHits	Number of TRT hits
trk_nTRTHighTHits	Number of TRT high threshold hits

Tau block variables

See
https://twiki.cern.ch/twiki/bin/view/AtlasProtected/TauEDM#The_EDM_content
https://twiki.cern.ch/twiki/bin/view/AtlasProtected/TauD3PDMaker

tau_n	Number of tau objects

Kinematics

tau_E	Energy
tau_pt	P_T
tau_m	mass
tau_eta	η
tau_phi	φ

Identification

tau_BDTEleScore	Boosted Decision Tree score for electron rejection
tau_BDTJetScore	Boosted Decision Tree score for Jet rejection
tau_discCut	acceptance flag for cut analysis (used by tau1p3p)
tau_discCutTMVA	acceptance flag for cuts optimized with TMVA (used by tau1p3p)
tau_discLL	discriminant value for LL analysis (used by tau1p3p)
tau_discNN	discriminant value for NN analysis (used by tau1p3p)
tau_efficLL	discriminant value for flat acceptance LL analysis (not used currently)
tau_efficNN	discriminant value for flat acceptance NN (used by tau1p3p)
tau_likelihood	discriminant value for default LL analysis
tau_tauJetNeuralNetwork	discriminant value for NN analysis (used by tauRec)
tau_tauENeuralNetwork	discriminant value for NN electron-tau separation (used by tauRec)
tau_tauElTauLikelihood	discriminant value for default electron-tau separation likelihood
tau_electronVetoLoose	cut-based tau/electron id - loose
tau_electronVetoMedium	cut-based tau/electron id - medium
tau_electronVetoTight	cut-based tau/electron id - tight
tau_muonVeto	cut-based tau/muon id
tau_tauCutLoose	cut-based tau/jet id - loose
tau_tauCutMedium	cut-based tau/jet id - medium
tau_tauCutTight	cut-based tau/jet id - tight
tau_tauCutSafeLoose	safe cut-based tau/jet id - loose
tau_tauCutSafeMedium	safe cut-based tau/jet id - medium
tau_tauCutSafeTight	safe cut-based tau/jet id - tight
tau_tauCutSafeCaloLoose	safe calorimeter cut-based tau/jet id - loose
tau_tauCutSafeCaloMedium	safe calorimeter cut-based tau/jet id - medium
tau_tauCutSafeCaloTight	safe calorimeter cut-based tau/jet id - tight
tau_tauLlhLoose	likelihood based tau/jet id - loose
tau_tauLlhMedium	likelihood based tau/jet id - medium
tau_tauLlhTight	likelihood based tau/jet id - tight

TauJet

tau_author	tau_author=1: Calo-seeded candidate but not track-seeded tau_author=2: Track-seeded candidate but not calo-seeded tau_author=3: Seeded by both calo and track
tau_ROIword	ROI Word - added for trigger purposes
tau_nProng	
tau_nProngLoose	

Détails for taus reconstructed from track+calo

tau_etOverPtLeadTrk	Ratio of E_T of TauCandidate to p_T of leading track.
tau_ipZ0SinThetaSigLeadTrk	Significance of $z_0 \sin(\theta)$
tau_leadTrkPt	p_T of leading loose track - for Trigger
tau_nLooseTrk	Loose tracks
tau_nLooseConvTrk	Loose Conversion tracks
tau_ipSigLeadTrk	Impact parameter significance of leading track
tau_ipSigLeadLooseTrk	Impact parameter significance of leading loose track
tau_etOverPtLeadLooseTrk	Ratio of E_T of TauCandidate to p_T of leading loose track

tau_leadLooseTrkPt	p_T of leading loose track - for Trigger
tau_chrgLooseTrk	Charge of loose tracks
tau_massTrkSys	Invariant mass of the tracks system
tau_trkWidth2	Width of tracks momenta
tau_trFlightPathSig	Transverse flight path significance for τ with at least 2 associated tracks
tau_etEflow	E_T from energy flow
tau_mEflow	Mass from E flow
tau_nPi0	

tau_ele_E237E277	
tau_ele_PresamplerFraction	
tau_ele_ECALFirstFraction	

Détails for taus reconstructed from calo

tau_seedCalo_EMRadius	Uncalibrated Et weighted radius in the Presampler + EM1 + EM2 within $\Delta R < 0.4$
tau_seedCalo_hadRadius	Uncalibrated hadron calorimeter weighted radius
tau_seedCalo_etEMAtEMScale	Uncalibrated Sum of Cell E_T in the Presampler + EM1 + EM2 within $\Delta R < 0.4$
tau_seedCalo_etHadAtEMScale	Uncalibrated Sum of Cell E_T in the Presampler + EM1 + EM2 within $\Delta R < 0.4$
tau_seedCalo_isolFrac	Ratio of the uncalibrated E_T of cells within $0.1<\Delta R<0.2$ and cells within $0<\Delta R<0.4$
tau_seedCalo_centFrac	Centrality fraction ($E_T(\Delta r<0.1)/E_T(\Delta r<0.4)$ for all calos
tau_seedCalo_stripWidth2	Uncalibrated transverse energy weighted width in the strip layer within $\Delta R < 0.4$
tau_seedCalo_nStrip	Number of Strip cells within $\Delta R < 0.4$, with energy above specified threshold
tau_seedCalo_etEMCalib	Calibrated EM E_T
tau_seedCalo_etHadCalib	Calibrated hadronic E_T
tau_seedCalo_eta	η of TauJet calculated from calorimeter
tau_seedCalo_phi	φ of TauJet calculated from calorimeter
tau_seedCalo_nIsolLooseTrk	Number of isolated tracks.
tau_seedCalo_trkAvgDist	
tau_seedCalo_trkRmsDist	

Détails for taus reconstructed from tracks

tau_seedTrk_EMRadius	EM radius
tau_seedTrk_isolFrac	Isolation fraction
tau_seedTrk_etChrgHadOverSumTrkPt	charged hadronic E_T over sum of p_T of all tracks
tau_seedTrk_isolFracWide	Ratio of E_T in $0.2 < \Delta R < 0.4$ to total E_T at EM scale
tau_seedTrk_etHadAtEMScale	Hadronic E_T at EM scale
tau_seedTrk_etEMAtEMScale	EM E_T at EM scale
tau_seedTrk_etEMCL	E_T of cells classified as "pure electromagnetic" seeded by egamma or topo cluster
tau_seedTrk_etChrgEM	E_T of EM cells (at EM scale) classified as "charged electromagnetic" collected in narrow window around qualified track
tau_seedTrk_etNeuEM	E_T of EM cells (at EM scale), within "core" cone around tau1P3P axis after subtraction of EMCL and Chrg cells
tau_seedTrk_etResNeuEM	Correction term for Eflow calculations
tau_seedTrk_hadLeakEt	hadronic leakage in E_T summed over cells
tau_seedTrk_sumEMCellEtOverLeadTrkPt	Ratio of ΣE_T of LAr Cells to the p_T of leading track
tau_seedTrk_secMaxStripEt	Secondary maximum

tau_seedTrk_stripWidth2	Strip width squared.
tau_seedTrk_nStrip	
tau_seedTrk_etChrgHad	Charged E_T in narrow window around track(s) in hadronic calorimeter
tau_seedTrk_nOtherCoreTrk	Associated, "not good" quality tracks in core region.
tau_seedTrk_nIsolTrk	
tau_seedTrk_etIsolEM	E_T in EM calo (at EM Scale) in $0.2 < \Delta R < 0.4$
tau_seedTrk_etIsolHad	E_T in HAD calo (at EM Scale) in $0.2 < \Delta R < 0.4$

MBTS block (MinBias Trigger Scintillator)

mb_n	Number of hits in scintillators
mb_counter	?
mb_e	
mb_time	
mb_quality	
mb_eta	
mb_phi	

Primary vertex block

vxp_n	Number of primary vertices
vxp_vertx	x
vxp_verty	y
vxp_vertz	z
vxp_chi2	Fit χ^2
vxp_ndof	Number of degrees of freedom
vxp_errx	σ_x
vxp_erry	σ_y
vxp_errz	σ_z

MC truth block

mc_n	Nomber of objects
mc_pt	p_T
mc_m	mass
mc_eta	η
mc_phi	φ
mc_status	Status MC status=1 final particle, status=3 documentary particle
mc_barcode	index
mc_parents	Vector of parents index
mc_children	Vector of children index
mc_pdgId	PDG identification number
mc_charge	charge

Trigger block

The variables are Booleans which say if a trigger was passed or not (EF Event filter, highest trigger level, L1, level 1, L2 level 2).

EF_2e5_medium	At least 2 medium electrons with p_T>= 5GeV
EF_e10_medium	At least 1 medium electron with p_T>=10 GeV
EF_e20_loose	At least 1 loose electron with p_T>=20 GeV
EF_em105_passHLT	At least 1 EM cluster with p_T >= 105 GeV and HLT is in passthrough mode
EF_g20_loose	At least 1 loose photon with p_T>=20 GeV
L1_EM3	At least 1 EM cluster with p_T>=3 GeV
L1_EM7	At least 1 EM cluster with p_T>=7 GeV

L1_EM13	At least 1 EM cluster with13 GeV de p_T >=13 GeV
L1_EM13I	At least 1 isolated EM cluster with p_T >=13 GeV
L1_EM18	At least 1 EM cluster with p_T>=18 GeV
L1_EM18I	At least 1 isolated EM cluster with p_T >=18 GeV
L1_EM23I	At least 1 isolated EM cluster with p_T >= 23 GeV
L1_EM100	At least 1 EM cluster with p_T >=100 GeV
L2_2e5_medium	At least 2 medium electrons with p_T>=5 GeV
L2_e10_medium	At least 1 medium electron with p_T>=10 GeV
L2_e20_loose	At least 1 loose electron with p_T>=20 GeV
L2_em105_passHLT	At least 1 EM cluster with p_T >=105 GeV and HLT is in passthrough mode
L2_g20_loose	At least 1 loose photon with p_T>=20 GeV