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# Jet Reconstruction in ATLAS

WARNING !! THIS PAGE IS OBSOLETE Please see [JetEtMiss](#)

## Introduction

Jets are initiated by quarks & gluons that spray(hadronise) in jet of hadrons. The hadrons interact with the detector and produce energy clusters. Algorithms/tools to identify jet clusters and calibrate its energy can be found in the JetRec package [in Athena](#).

The general structure of Athena algorithms and tools in JetRec is described in this talk [in the implementation](#) there is only one jet algorithm skeleton, which can be configured externally as a sequence of tools to implement a given jet finder strategy. This algorithm and most of the tools are designed such that they do not depend on any specific feature of the input data objects, thus allowing the use of exactly the same algorithm for different inputs. The only requirements to the input objects are that they implement the general four-vector and navigation interfaces.

## Who is doing what

### Jet Validation

### Jet clustering algorithms

Jets can be reconstructed from detector signals as well as generated particles. Following implementation of the jet clustering algorithms are available in JetRec.

- **Cone** - There are two flavors of cone algorithms implemented, one that requires seed (faster) and other that does not (slower, but theoretically more accurate). Both the cone algorithms pass through a split-merge tool to define non overlapping exclusive jets in the event. More details on jet algorithms can be found in the report from Fermilab workshop [in the report](#).
- **Kt** - Both FastKt and Kt algorithm [in the report](#) are implemented. Due to speed requirements normal input to Kt algorithms clusters made from preclustered projective towers. More details on the algorithm can be found here [in the report](#) and in the report above. Since 11.0.x the FastKt algorithm has become the default Kt algorithm and it does not use tower preclustering.

More details about all jet algorithms available in ATLAS and their parameters are given in [JetAlgorithms](#).

### Jet calibration algorithms

The jet clustering algorithms produce jets that are uncalibrated i.e, at electromagnetic(EM) scale. These jets are then calibrated to hadronic scale using different weighting schemes.

- **H1-style** - Weights are applied that depends on energy density in CaloCell. At present, this is the default calibration in JetRec. More details can be found in this note [in the report](#).
- **Pisa** - Weights are applied based on CaloCell energy and Jet energy. More details can be found in this note [in the report](#).
- **Sampling** - Weights are applied to EM (LAR) & HAD (Tile, HCAL, FCAL) layers of the calorimeter. More details can be found in (ref). The sampling weights can also be applied at

ParticleJet at AOD level (See 'Analysis with Jets' below).

Some studies on-going to compare calibration performance CalibrationPerformance.

The above approach describes a calibration scheme that is top-down jet->layer->cell. A bottoms-up approach that first calibrates the calorimeter cluster by discriminating em and hadronic cluster, and also identifying and correcting various losses separately is being pursued by the Hadronic calibration group. Their ongoing work on Jet Level corrections to be applied on the clusters calibrated to hadronic scale on calorimeter level is described here JetCalibrationForTopoClusters.

Monitoring performance of these calibration schemes and a general setup to derive weights can be found in JetCalib.

## Effect of Noise/PileUp in Jets

Different noise treatment schemes effect Jet clustering algorithm input and energy calibration. With large number of LAr readout channel, an efficient treatment of noise is important. The following approaches have been tried and are under study,

- JetTowerNoiseTool
- CaloTopoCluster
- A/symmetric cut on CaloCell to reject noise.

## Truth Jets

Two definitions of truth Jet have been studied so far.

- Particle-In-Cone: A jet is formed by taking all truth particles - with the exception of neutrinos, muons and non interacting particles - within a cone around reconstructed Jet.
- Nearest-Truth-Jet: Jet clustering algorithm is run on truth particles - with the exception of neutrinos, muons and non interacting particles - and nearest match to reco jet in eta-phi is found.

## ParticleJet - Jet Merger

For release 14.1.0, the two classes ParticleJet (found in rel 13 in AOD) and Jet (found in rel 13 in ESD) have been merged. Not all (member) functions from the ParticleJets could be moved transparently to the Jets, therefore some adjustments in the user analysis code might be necessary. This page describes the necessary modifications to the user code.

## Jets in Standard Reconstruction

Several jet collections are build during reconstruction, varying

- Input to jet finder : Calorimeter Tower, topological clusters or truth particles
- Jet Finder algorithm : Cone or Kt
- Main parameter of the jet finder

The collections are saved in ESD and AOD as JetCollection objects (in ESD) or ParticleJetContainer objects (in AOD).

A typical name (or key) for a JetCollection is 'Cone7H1TowerJets' and all names follow this pattern : (algorithm type)(main parameter)(calibration method)(input type)Jets.

More details on each aspects :

- **Algorithm type**
  - ◆ Cone : the seeded cone algorithm. Default parameters : Radius=0.4 or 0.7, Pt of seeds = 1 GeV, split/merge fraction=0.5
  - ◆ Kt : the inclusive kt algorithm (fast version), D parameter =0.4 or 0.6
- **Main parameter** : corresponds to Radius\*10 for cone algs or D\*10 for Kt algs.
- **Input type**
  - ◆ Towers : means calorimeter towers at EM scale
  - ◆ Topo : means topological clusters. If calibration type is H1, using clusters at EM scale. Else if calibration is LC, using calibrated TopoClusters
- **calibration method**
  - ◆ H1 : means the 'global' H1-style calibration is applied on jets after jet finding. The H1 calibration is specific for each type of jet finder and each value of the main parameter. For example, the set of corrections for Cone7H1TowerJets is different than for Cone7H1TopoJets and for Cone4H1TowerJets.
  - ◆ LC : means Local Calibration. It applies only to jets build from topo clusters. In this case the jet finder uses the local calibrated topoclusters (which include hadronic calibration, dead material correction and **after 13.0.1** out-of-cluster corrections).

**Currently only tower and topo jets with H1 calibration are written out in ESD and AOD.**

In AOD the ParticleJetContainer name are the same than in ESD except that 'Jets' is replaced by 'ParticleJets' You can find the full list of SG names for ESD and for AOD. **This are the new keys starting with release 13.0.1**, the correspondance to older keys is simply ('H1Tower' <-> 'Tower') and ('H1Topo' <-> 'Topo') there was no local calibrated jets before. Also note that with previous keys Cone algo with radius R=0.7 were labeled 'Cone' rather than 'Cone7'.

Examples: in order to retrieve from ESD cone 0.7 built from towers and H1 calibrated jets, the storegate key is:

- **ConeTowerJets** for ESD athena version < 13.0.1
- **ConeTowerParticleJets** for AOD athena version < 13.0.1
- **Cone7H1TowerJets** for ESD athena version >= 13.0.1
- **Cone7H1TowerParticleJets** for AOD athena version >= 13.0.1.

With configurable (newstyle) jobOptions these standard jets are configured by using the make\_StandardJetGette function (see JetConfigurableJobO).

## Analysis with Jets

- New configurable jobOptions are available for 13.0.0 and more. See documentation at JetConfigurableJobO
- Default jobOptions file for Jet reconstruction can be found in the share directory of JetRec package. Some general features of the default setup.
  - ◆ Since 12.0.4 default jet collections are: Cone DR=0.7, cone DR=0.4, Kt D=0.4, Kt D=0. Prior 12.0.4 default jet collections were: Cone DR=0.7, cone DR=0.4, Kt D=1.
  - ◆ Run on projective towers and truth particles. Since 12.0.4 also from topoclusters.
  - ◆ Since 12.0.4 (before 12.0.4): final cut on Jet Et>7 GeV (10 GeV) and default lcal < 5.0. When the cut is set at 7 GeV the minimum measureble Et should be 20 GeV.
  - ◆ Since 12.0.4 (before 12.0.4) default cone has a seed pt of 1 GeV (2 GeV). Split-merge algorithm is run with overlap fraction=50% to decide split or merge.
  - ◆ An initial cut of 10 MeV is applied on Kt input.
  - ◆ Input to tower jet clustering algorithm are first treated with JetTowerNoiseTool algorithm.
  - ◆ By Default all jets are calibrated with cell based H1-style weights.
- Other features

- ◆ In principle jet clustering and deciding the kinematics of the jet from its constituents (Recombination scheme) are two distinct steps. The default recombination scheme is four vector addition. Jet class provides mechanism to implement a different recombination scheme.
- ◆ Since Jets are navigable, the constituents of Jets can be accessed in a straight forward manner. An example of this is the JetClassifier class in the JetUtils package [↗](#), which returns energy in layers of the calorimeter (filled in JetSampling object in JetEvent package [↗](#)) for a given Jet. Other views of Jet constituents can be implemented in similar ways.
- Using CBNT Rootple
  - ◆ If you require in your joboption the production of the rootple you will get the CBNT rootple, description of rootple variables [↗](#). In Rome production the *VarTags* used for the variable in the rootple are for example: "C4Jets" for Cone algo with Dr=0.4; "CJets" for Cone algo with Dr=0.7; "C4McJets" for Cone algo with dr=0.4 applied to MC particles; "CMcJets" for Cone algo dr=0.7 applied to MC particles. In this way for example the jet Et variables for the 4 different collection will be jetEtC4Jets, jetEtCJets, jetEtC4McJets and jetEtCMcJets respectively.
- Using ESD
  - ◆ ESD's contain Jets clustered/calibrated. Cone(0.7), Cone(0.4) and Kt.
  - ◆ Since ESD's contains CaloCell, default jet reconstruction can be run on ESD's directly.
  - ◆ Most jet calibration studies are done on ESD's directly.
- Using AOD
  - ◆ AOD's contain ParticleJet objects, which are high level objects used for Physics analysis. The interface of this object can be found in ParticleEvent package [↗](#). Information on the ParticleJet content can be found here [↗](#).

## Re-running jet algorithms on ESD / AOD

This page describes how to re-run jet algorithms, possibly with different parameters on ESD and AOD and produce different output such as CBNT and new AODs.

## Jet substructure

One possible tool in jetrec is YSplitter. See YSplitterDocumentation for details.

## Analysis to check the status of hadronic energy scale and In-Situ Calibration

There are various studies planned to check the hadron energy scale. First studies are planned to be done checking E/p with single hadron tracks from tau decays and from pions in MB events. The energy range that is needed to be checked is evaluated looking at the jet fragmentation (first draft of document is here: [https://twiki.cern.ch/twiki/pub/AtlasArchive/JetS/JetFragDoc\\_23March2006.ps](https://twiki.cern.ch/twiki/pub/AtlasArchive/JetS/JetFragDoc_23March2006.ps) and a newer version using CSC Pythia and Herwig samples is attached to the jet8 wiki page here

The absolute jet energy scale is foreseen to be estimated/validated via In-situ calibration methods, using

- Pt Balance
- EtMiss Projection

in Z/gamma + jet events and the W -> jet jet decays from top events.

## Software Design & Code Organization

The basic design of the Jet reconstruction domain software is guided by the recommendations of the Reconstruction Taskforce [\(2003\)](#). The interpretation and implementation of those for the jet reconstruction software was discussed and decided at a dedicated workshop at Barcelona, Spain, in Summer 2003 (agenda [and summary](#)), thus superseding an earlier design developed at an earlier workshop at the University of Arizona, Tucson, Arizona, USA (summary) in Summer 2001.

### Design Guidelines

The guidelines for jet reconstruction domain code design and implementations are discussed in some detail on the Jet Event Data Model and the Jet Software Algorithms & Tools pages. In brief the software design features:

- a generic data class Jet [to represent jets from all possible sources](#):
  - ◆ calorimeter reconstruction objects like cells, clusters, towers, both in simulation and experiment;
  - ◆ tracks from simulation and experiment;
  - ◆ generated particles in simulation;
  - ◆ signal truth information like CalibrationHits in the calorimeters;
  - ◆ any (navigable) physics software object providing a four-vector...
- a sufficiently granular algorithm and tool structure which allows easy implementation and configuration of various jet finders without duplication of common code elements.

### Software Package Structure

The jet reconstruction domain software is in the process of being restructured for release 12.0.0. Presently the following documentation is available on the

- jet software packaging page for releases before 12.0.0, and
- jet software packaging page for release 12.0.0 and higher;

**Note that all new code in the 11.0.X development branch should be committed into the new package structure. This needs to be coordinated with the jet reconstruction domain software coordinator Ambreesh Gupta .**

### Official Athena Package to test Jet Calibrations on Truth and Reco-Level (JetPerformancePackage)

There is an official software package meant to be used to test the Jet energy scale on different samples (using a comparison between the the reconstructed jets and the MC truth jets). A description of the code can be found here [JetPerformancePackage](#).

### Jet Flavor Tagging

[Link to FlavourTagging](#)

### Jet Trigger

[Link to JetTriggerTable](#)

[Link to HighLevelTrigger](#)

## Links to Documents/Talks

Workshop on LHC jet algorithm - CERN July 06 [↗](#)

II Joint Workshop on hadron calibration - JetEtMiss and Hadron calibration groups [↗](#)

Jet EtMiss Tau status report [↗](#)

Joint Workshop on hadron calibration - JetEtMiss and Hadron calibration groups [↗](#)

Current Jet/EtMiss bi-weekly phone meeting agenda page [↗](#) and older page [↗](#)

Performance study and related documents [↗](#)

Rome Physics Workshop [↗](#)

Athens Physics Workshop [↗](#)

Lund Physics Workshop [↗](#)

## Links to talks at conferences

Jet Reconstruction in the ATLAS Calorimeters - Joint Meeting of Pacific Region Particle Physics Communities - Hawaii [↗](#)

Local Hadron Calibration in ATLAS - Calor06 - Chicago [↗](#)

Jet Reconstruction and Calibration with the ATLAS Calorimeter - Calor06 - Chicago [↗](#)

Jet measurements at CMS and ATLAS - HCP06 - Duke [↗](#)

ATLAS Jet Energy Measurements - HCP05 - Les Diablerests [↗](#)

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### Major updates:

-- Main.cavalli - 15 Jun 2005 -- AmbreeshGupta - 08 July 2005 -- Main.lochp - 16 Dec 2005

- ListOfJobsJet.txt: List of jobs
- ListOfJobsJet.txt: List of jobs

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This topic: AtlasArchive > JetS

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