TopRecoObjTwikiModel

- General information (GRLs, event cleaning...)
- Trigger
- Electrons
  - Change log
  - Impact parameter selection
  - Likelihood identification selection
  - Isolation selection
  - Electron Charge ID Selection
  - Trigger selection
  - Efficiency correction
  - Energy scale and resolution
  - Loose electron
  - Systematics
  - Others news
- Photons
  - Change log
  - Cut-based identification selection
  - Isolation selection
  - Additional corrections
  - Trigger selection
  - Efficiency correction
  - Energy scale and resolution
- Muons
  - Change log
  - Impact parameter selection
  - Identification selection
  - Isolation selection
  - Trigger selection
  - Efficiency correction
  - Energy scale and smearing
  - Soft Muons
  - Useful links
- Fake lepton estimation (electrons and muons)
- Jets
  - Small-R Jets
    - Change log
    - Calibrations in AT
    - Systematic Uncertainty Models
    - JVT and fJVT
    - Analysis Specific Optimisations
      - Calculating Quark/Gluon Fractions
      - BadBatmanCleaning
      - R=0.4 Jet Mass Scale (JMS) Calibrations
  - *b*-Tagging
    - Changelog
      - Latest Recommendations
        - Recommended high-level taggers
      - Calibration
      - Redefinition of MC/MC SFs names
      - AnalysisTop specific Informations
        - Variable Radius Track jet Overlap Removal
- MET
  - Change log
  - Usage and TST systematics
  - JVT and fJVT flags
- Boosted Objects
  - Change log
  - Large-R jets
    - Available large-R jet collections
    - Inputs
    - JES and JMS calibration
    - Uncertainties
  - Boosted jets tagging
    - Tagging scale factors
  - Reclustered jets
- Taus
  - Change log
  - General selection:
  - TauJetIDWP
  - Electron Veto

↓ Scale Factors
↓ Overlap Removal

This page presents descriptions and links on the "physics side" for objects used in AnalysisTop, e.g. giving overviews on the Working Points that are available, on the calibrations, links to CP group pages with important info and so. For technical details on the settings available for the config file in AnalysisTop and basic usage please refer to the start guide. Details on changes between different releases are available on this page. If you are looking for latex references of these physical objects for your note/paper, please refer to this twiki

General information (GRLs, event cleaning...)

- Informations on how to set the GRL and pile-up reweigthing (PRW) are here

Trigger

Introduction how usage of triggers inside AnalysisTop can be found in the Top xAOD Start Guide. For some obejcts, some details about the trigger are given below:

- electrons
- photons
- muons

Electrons

This is the documentation of the electrons in AnalysisTop. It includes trigger, impact parameter selection, likelihood identification selection, isolation selection, charge ID selection, efficiency correlations, energy scale correction and smearing.

The current recommendation is based on the *Consolidated rel21" (Fall 2018), implemented peice by piece from AnalysisBase,21.2.40 to AnalysisBase,21.2.64. The recommendation for energy scale and resolution is updated since AnalysisBase,21.2.74.

Change log

Liaison	Description	Time	Link to MR (if available)	Included since release:
Yichen Li	More details	10.06.2020	None	None
Baptiste Ravina	More details	07.12.2019	None	None
Yichen Li	A first try to gather up-to-date information for electron	06.12.2019	None	None

Impact parameter selection

Impact parameter selection means selection on the d0 and z0 of the electron track, for which the definitions can be found at here and the following selections are applied.

- $|d_0^{BL}$ significance $| < 5$
- $|\Delta z_0^{BL} \sin\theta| < 0.5$ mm
- to be noted, in Run-2, the d0 reference point is changed from the hard-scattering vertex, or the primary vertex, to the beam spot.
- more infos about these recommendations can be found here.

Implementation in AnalysisTop:

- search for "passTTVACuts" function in the ElectronLikelihoodMC15 class
- cannot be configured by user

Likelihood identification selection

V13 tune of the likelihood based electron identification is in use for the current recommendation. There are several working points here provided by the egamma group:

- **Loose + B layer**, **Medium**, and **Tight** for central electron (calibrated)
  - there is also a **VeryLoose** WP, but not calibrated
- **Loose**, **Medium**, and **Tight** for forward electron (not calibrated)
- to be noted, the ID selection is applied on uncalibrated electron but the SFs to correct the ID efficiency are to be applied on calibrated electron
- for a comparison of some of these working points as a function of mu, pT, and eta, see fig 16 and 17 of this link.

Implementation in AnalysisTop:

- the 4 calibrated working points for central electron can be configured by user in the cut file with keyword **ElectronID" or "ElectronIDLoose**, with 4 allowed values **LooseAndBLayerLH**, **LooseLH**, **MediumLH**, **TightLH**
- for central electron, the ID flags stored in the derivatoin are used to perform ID selection.
  - search for the "passSelectionNoIsolation" function in the ElectronLikelihoodMC15 class to see how the selection is done in AnalysisTop.
  - search "ElectronPassLH" in EGammaCommon to see how the calculation of these flags is done in DAOD.
  - currently, the **20170828** configuration of the ID selection is used to make the flags
- the 3 calibrated working points for forward electron can be configured by user in the cut file with keyword **FwdElectronID" or "FwdElectronIDLoose**, with 3 allowed values **Loose**, **Medium**, **Tight**

Currently, forward electron is not calibrated and experimental ONLY. Please don't use it for physical results!

Isolation selection

4 track/calo based isolation WPs are provided in the current recommendation, all with calibration:

- **Gradient**, **FCLoose**, **FCTight** and **FCHighPtCaloOnly**
- the calibration files for the above WPs can be found here
- for more information here.
- the definitions of isolation variables are optimized, e.g. to reduce pileup dependency, see here.

- the **Gradient** WP was removed from the list of isolation WPs for full Run2 precision measurement

New isolation WPs are available (but not calibrated yet):

- WPs that could become the new benchmark
  - **HighPtCaloOnly**, **Loose**, **Tight**, **TightTrackOnly**, since AnalysisBase 21.2.91
  - **TightTrackOnly_FixedRad**, since AnalysisBase 21.2.101
  - need derivation release >=21.2.60.0/p3830
- Prompt lepton tagger (PLV) score based isolation WPs, since AnalysisBase 21.2.98:
  - **PLVLoose** and **PLVTight**
  - for more information here.
- PFlow isolation WPs are also available
  - **PflowTight**, **PflowLoose**
  - reported to be under-performing:

Implementation in AnalysisTop:

- isolation tools are initialized centrally in the TopIsolationCPTools class
- then these tools are used to decorate isolation flags to the electron object in the EgammaObjectCollectionMaker class
- using a CustomEventSaver, it is possible to retrieve all isolation decorations (not just the one used to select electrons) by looking up **AnalysisTop_Isol_XXX**.
- lastly, these flags are used in the IsolationTools class to make isolation selection
- for which isolation WP to use, it can be configured by user via cut file using keyword **ElectronIsolation** or **ElectronIsolationLoose**

Electron Charge ID Selection

A loose WP is provided to use the ElectronChargeFlipTaggerTool to select electrons whose charge is corrected identified and to suppress electrons with incorrectly reconstructed charge.

- the performance (efficiency and rejection factor) can be found here Benchmark_performance
- the tagger has to be applied on top of offline LH ID and isolation operating points. Currently, a limited set of ID + Iso combinations is supported by CP group, which can be found from the above link
  - MediumLH + FCTight, MediumLH + Gradient, TightLH + FCTight, TightLH + Gradient
- the WP is calibrated. Efficiency corrections and inefficiency SFs are available here
- the tagger is fully implemented (with calibration) since 21.2.73

Implementation in AnalysisTop:

- no selection is made. Instead AnalysisTop just stores the decision of the tagger and BDT value to the output ntuple (**el_ECIDSResult** and **el_ECIDS** respectively)
  - the decoration of the decision is done in the "passSelectionNoIsolation" function in the ElectronLikelihoodMC15 class
- the tagger can be turned on/off by user via cut file with the option **UseElectronChargeIDSelection**
  - when turned off, the value of the decision is defaulted to "pass"

Trigger selection

A list of possible electron triggers can be found here: 2015, 2016, 2017, and 2018. But only a limited set of the electron triggers are supported with efficiency correction scale factors, which can be found here.

Implementation in AnalysisTop:

- Trigger decision selector
- Trigger matching selector
- what trigger to use and whether to do trigger matching can be configured by user via cut file. More details can be found in Top xAOD Start Guide

Efficiency correction

Efficiency corrections are applied to the reconstruction, identification, isolation selection, charge misidentification selection and trigger selection of the electrons.

- for the moment, the Consolidated Recommendation for Rel21 (Fall 2018) is used, available since AnalysisBase 21.2.49 / 21.2.50 (ChargeMisID) / 21.2.56 (trigger).
- for more information here.

Inefficiency SFs are available. But they are experimental and not recommended for physics results

- inefficiency SF for charge misidentification selection is implemented in AnalysisTop, while others not yet (please open a JIRA ticket if your analysis would like to request this feature).
- more information here.

Implementation in AnalysisTop:

- ElectronScaleFactorCalculator
- cannot be configured by user

Energy scale and resolution

The current recommendation was released in 21.2.74, with the "es2018_R21_v0" configuration

- spring update (May 2019). More information here

A small bug to the wtots1 uncertainty

- bug reported here and fixed here MR32280
- effect up to few 10**-4 "spurious" systematics in the endcap (much less in the barrel)
- fixied in analysis release >= 21.2.119

Implementation in AnalysisTop:

- the calibration and smearing tool is initialized in TopEgammaCPTools.cxx
- the configuration of the tool is half hard-coded (which recommendation to use) and half user-configurable (the correlation model for systematics)

- the tool is applied to electron and forward electron in EgammaObjectCollectionMaker.cxx

Loose electron

Configuration keywords with **Loose** as appendix are used to define a second type of electron, usually with looser selection than the nominal electron. A separate "Loose" tree will be filled using the loose electrons, in addition to the nominal tree, when the event level flag **DoLoose** is on.

Systematics

The uncertainty model for the efficiency corrections is described here

Others news

The forward electron SFs are buggy for the moment. Waiting for further announcement from Egamma group.

Photons

This is the documentation of the photon selection in AnalysisTop. It includes trigger, identification selection, isolation selection, efficiency correlations, energy scale correction and smearing, and other corrections.

The current recommendation is based on the *Consolidated rel21" (Fall 2018), implemented peice by piece from AnalysisBase,21.2.40 to AnalysisBase,21.2.64. The recommendation for energy scale and resolution is updated since AnalysisBase,21.2.74.

Change log

Liaison	Description	Time	Link to MR (if available)	Included since release:
Yichen Li	More details	11.06.2020	None	None
Baptiste Ravina	First description of photons	28.01.2020	None	None

Cut-based identification selection

Instead of a likelihood-based selection for electron, a series of rectangular cuts are applied on shower shape variables to identify photons:

- !two ID working points are available: **Loose** and **Tight**
- please note that the Tight WP refers to a pT-dependent menu in the current recommendation, which requires p-tag >= p3627. It used to be pT-independent for older derivations! See figures 18-22 of this link.

Implementation in AnalysisTop:

- similarly to electrons

Isolation selection

3 calo-based isolation WPs are provided with calibration:

- **FixedCutTight**, **FixedCutLoose** and **FixedCutTightCaloOnly**
- FixedCutLoose should not be used for low pT photons (pT<25 GeV)
- PU-robust WPs will be used in the next release
- for more information see here.

Energy leakage correction is available since AnalysisBase 21.2.49:

- a data driven shift is applied to MC isolation variable
- more details here

Improved energy leakage correction is available since AnalysisBase 21.2.85 and made available/default in AnalysisBase 21.2.107

- three corrections: super cluster based core correction, improved pileup correction, improved pileup correction on MC
- need derivation release >= 21.2.71.0/p3947

New experimental WPs are available:

- **TightCaloOnly**, **Loose**, **Tight**, since AnalysisBase 21.2.91 and require derivation release >= 21.2.66.0/p3883

Implementation in AnalysisTop:

- isolation tools are initialized centrally in the TopIsolationCPTools class
- then these tools are used to decorate isolation flags to the photon object in the EgammaObjectCollectionMaker class
- using a CustomEventSaver, it is possible to retrieve all isolation decorations (not just the one used to select photons) by looking up **AnalysisTop_Isol_XXX**.
- lastly, these flags are used in the IsolationTools class to make isolation selection
- can be configured by user via cut file
- AFII isolation SFs were buggy and fixed in AnalysisBase 21.2.124. In the same release, photon SF starts to include the photon isolation SF

Additional corrections

In Run2 differences have been observed between data and fullsim MC in the distributions of the shower shape variables used by the photon identification algorithm, particularly those related to the lateral shower development. Data-MC shifts (a.k.a. **fudge factors**) are computed as the difference between the means of a given variable in data and MC. These are applied automatically by AnalysisTop. See more details here

Trigger selection

A list of possible photon triggers can be found here: 2015, 2016, 2017, and 2018. But only a limited set of the photon triggers are supported with efficiency correction scale factors, which can be found here.

Implementation in AnalysisTop:

- Trigger decision selector
- Trigger matching selector
- what trigger to use and whether do trigger matching can be configured by user via cut file

Efficiency correction

Efficiency corrections are applied to the reconstruction, identification, isolation and trigger selection of the photons. For the moment, the Consolidated Recommendation for Rel21 (Fall 2018) is used, available since AnalysisBase 21.2.49 / 21.2.56 (trigger). For more information here

Implementation in AnalysisTop:

- PhotonScaleFactorCalculator
- cannot be configured by user

Energy scale and resolution

Same as electron

Muons

This is the documentation of the muon selections in AnalysisTop. It includes the impact parameter selection, identification selection, isolation selection, triggers, efficiency correction, energy scale correction and smearing, soft muons and useful links.

The latest recommendation is available in AnalysisBase 21.2.124

Change log

Liaison	Description	Time	Link to MR (if available)	Included since release:
Yichen Li	Improve texts and layout	11.06.2020	None	None
Martinelli Luca	Bug fix PLV	19.05.2020	MR link	21.2.123
Martinelli Luca	New Options for WPs	05.05.2020	MR links 1-2	21.2.121/122
Martinelli Luca	Two new smearing options	10.04.2020	MR link	21.2.118
Martinelli Luca	New Iso WPs in AT	02.04.2020	MR link	21.2.116
Martinelli Luca	Bug fix for LowPt WP	23.03.2020	MR link	21.2.115
Martinelli Luca	New MCP Rec.	05.03.2020	MR link	21.2.112
Martinelli Luca	New Iso WP	27.02.2020	MR link	21.2.111 (not yet in AnalysisTop)
Martinelli Luca	HighPt WP update	25.02.2020	MR link	21.2.100
Martinelli Luca	Added info for Muons	22.12.2019	None	None
Martinelli Luca	Removed deprecated Iso WPs	09.09.2019	MR link	21.2.90
Martinelli Luca	Past R21 MCP Rec.	20.02.2019	MR link	21.2.79
Martinelli Luca	Past MCP Rec.	< 2019	twiki	None

Impact parameter selection

Impact parameter selection means selection on the d_0 and z_0 of the muon track, for which the definitions can be found at here and the following selections are applied:

- $|d_0^{BL}$ significance $| < 3$;
- $|\Delta z_0^{BL} \sin\theta| < 0.5$ mm;
- to be noted, in Run-2, the d_0 reference point is changed from the hard-scattering vertex, or the primary vertex, to the beam spot;
- more infos about these recommendations can be found here.

Implementation in AnalysisTop21:

- search for "passTTVACuts" function in the MuonMC15 class;
- cuts cannot be configured by user but TTVA can be removed setting to 'false' the flag **applyTTVACut** in the cut file.

Identification selection

Five working points (see here) are provided by the MCP group:

- **Loose**, **Medium**, **Tight**, **LowPt**, **HighPt**
- any analysis selecting a non-negligible fraction of muons with p_T >300 GeV should use the **HighPt** selection or explicit approval from the MCP conveners will be required (MCP guidelines here).
- for LowPt, there is an option **UseMVALowPt** to turn on MVA for low-p_T muons and it is optimized to improve efficiency and hadron rejection
- for HighPt, there is a recommended option **Use2stationMuonsHighPt** to allow the muons reconstruction using 2-station with missing inner MS station for $|\eta|<1.3$.
- all WPs are calibrated, with May 2020 precision recommendation here, available since AnalysisBase 21.2.123

There is also an event level muon selection: **isBadMuon**

- muons that are flagged as "bad" tend to have a significantly worst momentum resolution than those which pass the veto. In some analyses they can have a non-

negligible impact and the recommendation is to veto the event when such a muon is found.
- more info on the BadMuonVeto are here.

Implementation in AnalysisTop21:
- search for the "m_muonSelectionTool" in MuonMC15 class, where predefined flags calculated in DAOD stage are read;
- 'MuonQuality' can be configured by user via cut file: **Medium**, **Loose**, **Tight**, **LowPt**, **HighPt**;
- a second collection of events with a different 'MuonQuality' ('MuonQualityLoose') can be configured by setting 'DoTight' and 'DoLoose' to activate the loose and tight trees with Data, MC, Both, False;
- to use 'UseMVALowPt' option, you have to set 'True' the **MuonUseMVALowPt** option (**MuonUseMVALowPtLoose** for the loose tree)
  - available with AnalysisBase 21.2.122 and derivation release >= 21.2.96/p4164
  - default to false
- to use 'Use2stationMuonsHighPt' option, you have to set 'True' the **MuonUse2stationHighPt** option (**MuonUse2stationHighPtLoose** for the loose tree)
  - available with AnalysisBase 21.2.122
  - default to true, recommended by MCP
- to use the 'isBadMuon' method in AnalysisTop21, add the selector **NOBADMUON** into the AnalysisTop21 cut file;
- **BUG HAS BEEN FOUND** using LowPt WP for standard muons and a different one for the 'Loose' muons or using a different WP for standard muons and LowPt for 'Loose' muons. The obtained isolation SFs for the 'Loose' muons are NOT correct! This is fixed in the 21.2.115 release of AnalysisTop.

Isolation selection

Until AnalysisBase 21.2.115, the suggested isolation WPs are the following (1 dimensional as a function of the p_T).
- **FCLoose_FixedRad**, **FCTight_FixedRad**, **FCTightTrackOnly_FixedRad**, **FixedCutPflowTight**, **FixedCutPflowLoose**;
- **FCTight**, **FCLoose**, **FCTightTrackOnly**;

In the latest round of recommendation, the following new generation of muon isolation WPs are supported and calibrated
- most recommended and cover most use case: **PflowTight_VarRad**, **PflowTight_FixedRad**, **PflowLoose_VarRad**, **PflowLoose_FixedRad**;
- track only WPs: **HighPtTrackOnly**, **TightTrackOnly_VarRad**, **TightTrackOnly_FixedRad**.
- PLV WPs and conventional track+calo WPs are maintained for analyses with special needs: **PLVTight**, **PLVLoose**, **Tight_VarRad**, **Tight_FixedRad**, **Loose_VarRad**, **Loose_FixedRad**.
  - **LowPtPLV** WP is available since AnalysisBase 21.2.123
- these WPs are available since AnalysisBase 21.2.116 (bugfix in 21.2.123)
- new 2D calibration as function of pT and dR(jet,muon) is released in AnalysisBase 21.2.111. 2D SF only available since AnalysisBase 21.2.123, with derivation release >= 21.2.94/p4143, otherwise 1D SF will be used.

Experimental Improved PLV WP is available since AnalysisBase 21.2.123 and with derivation >= 21.2.96/p4164

Additional notes:
- for more information see here;
- studies about efficiency and fake rejection on simulation are reported in this presentation.
- lepton triggers include isolation (more infos here);
- When _FixedRad in the name:
  - Wider cone is used for track isolation above 50 GeV compared with _VarRad WP.
  - So this WP has a better bkg rejection above 50 GeV, but is not suitable for very boosted & busy environment.
- The definition of lepton PLV isolation WPs can be found here.

Implementation in AnalysisTop21:
- isolation tools are initialized centrally in the TopIsolationCPTools class;
- these tools are used to decorate isolation flags to the muon object in the MuonObjectCollectionMaker class;
- using a CustomEventSaver, it is possible to retrieve all isolation decorations by looking up **AnalysisTop _Isol_XXX** (XXX is the name of the Isolation WP);
- these flags are used in the IsolationTools class to make isolation selection;
- if the flag is -1, this means that the isolation WPs is not available with your derivation; please use a more recent derivation or change the isolation WP;
- 'MuonIsolation' can be configured by user via cut file;
- a second collection of events with a different 'MuonIsolation' ('MuonIsolationLoose') can be configured by setting 'DoTight' and 'DoLoose' to activate the loose and tight trees with Data, MC, Both, False.

Trigger selection

A list of recommended muon triggers can be found at this links:
- single-muon;
- multi-muons.

A full list of supported muon triggers can be found here.

Implementation in AnalysisTop21:
- Trigger decision selector;
- Trigger matching selector;
- what trigger to use and whether do trigger matching can be configured by user via cut file.

Efficiency correction

Efficiency corrections are applied to the trigger, reconstruction, identification, isolation selection, bad muon veto selection and TTVA selection of the muons. The Recommendation for Rel21 (2020) is used, available since AnalysisBase 21.2.112. For more information here.

Implementation in AnalysisTop:
- MuonScaleFactorCalculator;
- the default "200513_Precision_r21" calibration is used, available since AnalysisBase 21.2.123
- cannot be configured by user.

Energy scale and smearing

A new recommendation was released in AnalysisBase 21.2.112:

- first muon momentum calibrations fully based on R21
- new **do2StationsHighPt** allows to obtain special corrections for good muons reconstructed with two high pt stations. This option is recommended by the MCP group and it is to be used with HighPt WP
- new option **doExtraSmearing** allows to perform special resolution corrections for Medium muons not passing the HighPt selection criteria. To be used by analyses willing to check their sensitivity to momentum resolution effects at large muon momenta. Be careful: The extra smearing it provides is NOT a supported calibration! More information on when to use this feature can be found here.

Implementation in AnalysisTop:

- to use 'do2StationsHighPt' option (false by default), you have to set 'True' the **MuonDoSmearing2stationHighPt** option; this option is 'True' by default for the HighPt WP [since 21.2.122];
- to use 'doExtraSmearing' option (false by default), you have to set 'True' the **MuonDoExtraSmearingHighPt** option [since 21.2.122];

Soft Muons

A second set of muons with a different standard muon selection can be saved in AnalysisTop21 (available since AnalysisTop 21.2.96, bug fixed with AnalysisTop 21.2.101) setting 'True' the option **UseSoftMuons** in the cut file. These muons can be used to match them with jets to identify, for example, b→μ decays.

- **Identification**: this WPs are available for 'SoftMuonQuality': 'LowPt', 'Loose', 'Medium', 'Tight';
- **p_T cut**: can be configured by user via but file with the option 'SoftMuonPt' (can be as low as 4 GeV);
- **|η| cut**: can be configured by user via but file with the option 'SoftMuonEta';
- isolation and TTVA: **no isolation and TTVA cuts** are applied to these muons;
- **ΔR with jet**: can be configured by user via but file with the option 'SoftMuonDRJet' (can be set to 999 if no selection has to be applied here);
- **number of soft muons**: can be configured by user via cut file with the selector 'SOFTMU_N 4000 >= 1';
- the soft muon '4-vector', 'd_0', '$d_0$sig', 'z_0*sin(θ)', 'truth origin', 'truth type', 'isPrompt' are saved;
- reco SFs are saved for each soft muons;
- the option 'UseMVALowPt' is available also for the soft muons; you have to set 'True' the **SoftMuonUseMVALowPt** option in the config file to use it.

More infos are in this jira and in the TopxAODStartGuideR21.

Useful links

The latest article on muon reconstruction performance of the ATLAS detector can be found here. The list of all MCP publications can be found here.

Fake lepton estimation (electrons and muons)

The latest recommendation for fake lepton (electron and muon) estimations is to use the new tools provided by the Isolation and Fake Forum (IFF). More details about the supported methods, the tools and how to use them in the Top Group can be found here.

Jets

This is the documentation of the small-R jet selection in AnalysisTop (large-R jets are covered within the boosted objects section). It includes information on JES, JER, JMS, and JVT calibrations, associated nuisance parameters, b-tagging treatment, and some potential analysis-specific optimisations.

Small-R Jets

Change log

Liaison	Description	Time	Link to MR (if available)	Included since release:
Jonathan Jamieson	Add Jet Info	18.02.2020	None	None
Jonathan Jamieson	Add fJVT settings info	23.07.2020	MR	21.2.127

The Jet/MET group currently has consolidated jet energy scale (JES) and jet energy resolution (JER) calibrations with associated systematic uncertainties for both R=0.4 EMTopo and Particle Flow (EMPFlow) jet collections. More info can be found at these links for the current state of R21 jet calibrations, and systematic uncertainties. **The current recommendation for R21 analyses is to use calibrated R=0.4 EMPFlow jets.**

The latest jet energy scale corrections have been evaluated using di-jet, γ+jet, Z+jet, and multi-jet events, whilst the jet energy resolution is probed using di-jet events and the noise term evaluated from zero bias events. More information on the full calibration chains and uncertainty procedures can be found in these nice overviews for JES, JER, and some specifics for PFlow jets

Calibrations in AT

Generally AT should take care of matching up the correct calibrations and uncertainties for Data, FullSim, and AFII samples, as well as dealing with various uncertainty correlations provided the correct jet collection is defined. The available Small-R jet collections are:

Collection name	Short name	Inputs	Jet algorithm	Calibration Chain MC(Data)	Available since release	Notes
AntiKt4EMTopoJets _BTagging201810	EMTopo jets	EMTopo clusters	Anti-kt with R=0.4	JetArea +Residual+EtaJES+GSC+Smear(Insitu)	21.2.71	Recommended EMTopo collection
AntiKt4EMPFlowJets _BTagging201810	PFlow jets	Particle-Flow Objects	Anti-kt with R=0.4	JetArea +Residual+EtaJES+GSC+Smear(Insitu)	21.2.71	*b*-Tagging trained on EMTopo jets
AntiKt4EMPFlowJets _BTagging201903	PFlow jets	Particle-Flow Objects	Anti-kt with R=0.4	JetArea +Residual+EtaJES+GSC+Smear(Insitu)	21.2.71	*b*-Tagging trained on PFlow jets, Recommended PFlow collection

This is the new naming scheme introduced from release 21.2.72, for derivations with Ptag < P3954 the old naming scheme should be used for the collection by dropping the _BTaggingXXXXXX label

Systematic Uncertainty Models

JES and JER uncertainties are provided in several different schemes of varying precision. This allows uncertainty treatment to be tailored to an analysis based on how sensitive the physics is to JES and JER effects, and whether combinations are planned with other analyses/experiments. The supported schemes are outlined below

AnalysisTop Flag	Possible Values	Number of NPs	Valid for Combinations	Notes	Latest Recommendations available since release	Default	JER smearing
JetUncertainties _NPModel	AllNuisanceParameters	~100 Nuisance Parameters	Yes	Designed for most precise jet-dependent measurements	21.2.87	Yes	-
	CategoryReduction	~30 Nuisance Parameters	Yes (especially with CMS)	Designed for measurements that are jet-dependent and plan to perform combinations	21.2.87	No	-
	GlobalReduction	~20 Nuisance Parameters	No	Designed for individual analyses that don't intend to perform combinations	21.2.87	No	-
	StrongReduction	6 or 7 Nuisance Parameters	No	Designed for analyses that are not sensitive to JES correlations (Must show that this is the case!)	21.2.87	No	-
JetJERSmearingModel	All(_PseudoData)	34 Nuisance Parameters	Yes	Designed for most precise jet-dependent measurements	21.2.87	No	Smears both (pseudo-)data and MC (keeps anti-correlations in-tact)
	Full(_PseudoData)	13 Nuisance Parameters	Yes	Designed for measurements that are not sensitive to JER correlations	21.2.87	No	Smears both (pseudo-)data and MC (keeps anti-correlations in tact)
	Simple	8 Nuisance Parameters	Yes	Designed for most precise jet-dependent measurements	21.2.87	No	Only smears MC, loses anti-correlation information

A note on using the JES StrongReduction scheme: Within this scheme there are 4 different sets of possible NPs, initially using this option will produce trees for all 4 of these scenarios. It is then up to the analyser to compared these and show there is no sensitivity to correlations in your given selection. Once this has been shown, only the first scenario needs to be used for simplicity by setting: JetUncertainties _NPModel SR_Scenario1

A note on extra AFII uncertainties: the JER DataVsMC uncertainty treatment for Geant4 and AFII samples are different and thus should be treated separately. For certain schemes an extra JES nuisance parameter for AFII samples should also be expected, "ATLAS_JES_RelativeNonClosure_MC16_AFII" This is related to a non-closure of the absolute JES calibration in the forward regions of the AFII simulation and is not seen in G4 samples.

JVT and fJVT

The latest release 21 recommendations for JVT and fJVT are available for the R=0.4 EMTopo, and EMPFlow jet collections, with working points and scale-factors outlined here, and a more detailed description of the calibration process given here.

As of release 21.2.74 it's possible to set the JVT cut working point in AnalysisTop, the options are shown below, by default these are set to 'medium' for EMTopo and 'Tight' for PFlow

Jet Collection	Working Point	JVT cut	Average Efficiency
EMTopo	Loose	0.11	97%
	Medium	0.59	92%
	Tight	0.91	85%
EMPFlow	Medium	0.2	97%
	Tight	0.5	96%

Regardless of WP only a single nuisance parameter is derived from the MC scale-factor correction for JVT

As of release AnalysisTop 21.2.127 (June 2020) it is possible to specify the fJVT WP for forward jets, |eta| > 2.5. It is by default set to "None" which does not run any fJVT tools but can be set to either Tight (recommended) or Medium to match the Tight/Loose working points defined below, which are equivalent for EMTopo and PFlow jets.

AT option	Working Point	η range	pT range	fJVT cut
Tight	Tight	2.5 < abs(η) < 4.5	20 < pT < 60	fJVT < 0.5
Medium	Loose	2.5 < abs(η) < 4.5	20 < pT < 60	fJVT < 0.4

Similarly using either WP option (not None) results in a single nuisance parameter for fJVT derived from data/MC hard-scatter scale-factors

IMPORTANT: The fJVT calculation for PFlow jets needs to be done at derivation level, this functionality was added in derivation release 21.2.97.0 so the use of forward JVT with PFlow jets in an earlier derivation release is not possible

Additionally it's possible to use the fJVT decision within the METmaker to improve the final MET resolution using the boolean option *ForwardJVTinMETCalculation*. As this option can be used for analyses with a central-only jet selection this can be set independently of the fJVTWP option, in which case the Tight WP will be used, and SFs will **NOT** be applied.

More information on using the different fJVT options can be found here

Analysis Specific Optimisations

Calculating Quark/Gluon Fractions

For analyses with large JES uncertainties it is possible to reduce some JES components by specifying the correct quark/gluon fraction of jets in each event, by default a 50/50 fraction is assumed. Settings for this are built into AnalysisTop though it requires all events to be run twice, once to build the Q/G fraction maps, then a second time to apply these. More detailed instructions and explanation of this process can be found at the two twiki links here and here

BadBatmanCleaning

For full run-2 analyses utilising a jet selection with pT2.6, or those expected to be affected by fake MET an additional jet cleaning tool is available to remove events in 2015/16 data which have a high number of problematic forward jets. This flag however comes with same caveats, namely:

- It should **NOT** be used on 2017/18 data, or on any MC as this is a Data only effect.
- The cleaning tool vetos entire events and thus MC luminosity must be scaled appropriately, this will also affect the luminosity uncertainty.
- The effect on 2015 Data is expected to be negligible, whilst ~1.66% of 2016 Data events are expected to be lost.
- 2016 luminosity numbers should be scaled by 1.66% of events as a result, and an additional 1.1% luminosity uncertainty added in quadrature

More information on the effect and recommendations can be found in these slides.

R=0.4 Jet Mass Scale (JMS) Calibrations

To allow for better mass precision in highly boosted events, or selections using re-clustered jets, an additional, dedicated, JMS calibration is made available for both R=0.4 EMTopo and PFlow jet collections.

This can be accessed by changing the JetCalibSequence from GSC to JMS, as of release ?

b-Tagging

Changelog

Liaison	Description	Time	Link to MR (if available)	Included since release:
Manuel Guth	Adding latest b-tagging information			

Latest Recommendations

More details on the latest recommended taggers can be found on this FTAG-Twiki.

The most recent CDI file is **2020-21-13TeV-MC16-CDI-2020-03-11_v3.root** which can be found also here.

Since ptag `p3954`, flavour tagging is only applied in **"time-stamped" jet collections**.

NOTE: in this CDI there are no Sherpa 2.2.8 MC-MC SFs available (Herwig 7.1.3 SFs only available for 201903 EMPFlow)

Recommended high-level taggers

Only the DL1 family taggers are support in the future and have been retrained for PFlow and Variable Radius track jets.

The corresponding performances are available on the ATLAS public results twiki for PFlow and Variable Radius track jets.

Time Stamp	Support Jet Collections	Supported Taggers	Recommended Tagger	Supported WP	Calibration Status
201810	AntiKt4EMTopoJets	DL1, MV2c10	DL1	Fixed Cut (Accumulative and pseudo-continuous)	Copied from July 2019 release
	AntiKt4EMPFlowJets				
	AntiKtVR30Rmax4Rmin02TrackJets				
201903	AntiKt4EMPFlowJets	DL1r, DL1	DL1r	Fixed Cut (Accumulative and pseudo-continuous)	Calibrated using full Run2 data.
	AntiKtVR30Rmax4Rmin02TrackJets	DL1r, DL1	DL1r		Not calibrated yet.

DL1:
- Machine learning based high-level tagger

DL1r:
- same inputs as DL1 with additional RNNIP variables

DL1rmu:
- DL1r plus SMT input

Calibration

The calibrations are described in more detail on this Twiki

The following taggers are calibrated for the 60%, 70%, 77%, 85% and pseudo-continuous working points:
- DL1r
  - AntiKt4EMPFlowJets_BTagging201903
- DL1
  - AntiKt4EMPFlowJets_BTagging201903
  - AntiKt4EMPFlowJets_BTagging201810
  - AntiKtVR30Rmax4Rmin02TrackJets_BTagging201810
  - AntiKt4EMTopoJets_BTagging201810
- MV2
  - !AntiKt4EMPFlowJets_BTagging201810
  - !AntiKtVR30Rmax4Rmin02TrackJets_BTagging201810
  - !AntiKt4EMTopo_BTagging201810

Redefinition of MC/MC SFs names

Since AnalysisTop (AnalysisBase) 21.2.107 it is possible to redefine the names of the shower generators in the TopDataPreparation file. This is needed if you want to use old version of AnalysisTop (which doesnt know about the new generators) but you want to run on the new generators.

In AnalysisTop config file you can do:

```
RedefineMCMCMap sherpa228:pythia8,herwigpp713:pythia8
```

this will consider all `sherpa228` and `herwigpp713` as `pythia8` and will not apply any MC/MC SFs (as pythia8 is the default)

AnalysisTop specific Informations

For the AntiKt4EMPFlowJets_BTagging201903 jet collection it is recommended to use AnalysisBase version >=21.2.112
The time stamped AntiKtVR30Rmax4Rmin02TrackJets collection is supported from AnalysisBase version 21.2.113 onwards.

From this CDI (2020-21-13TeV-MC16-CDI-2020-03-11_v3.root) on, AT will only work with calibrated + experimental taggers, the following will break:
- AntiKt4EMTopo_BTagging201810 jet collection with DL1r and DL1rmu (AntiKt4EMTopo is only available with BTagging201810)
- AntiKt4EMPFlow_BTagging201903 jet collection with MV2
- AntiKtVR30Rmax4Rmin02TrackJets_BTagging201903 jet collections with MV2
- AntiKt4EMPFlow_BTagging201810 jet collection with DL1r & DL1rmu
- AntiKtVR30Rmax4Rmin02TrackJets_BTagging201810 jet collection with DL1r & DL1rmu

Variable Radius Track jet Overlap Removal

If using btagging with VRTrack jets it is necessary to apply the overlap removal as described in this Twiki.

In order to do that with AT you need to add "TRACKJETCLEAN" to your selection which will decorate the track jets with the "passDRcut" variable. This variable indicates if the overlap criterion passed or failed and you need to apply a cut on it to remove the events with overlapping jets.

MET

This is the documentation of Missing Transverse Energy (MET) in AnalysisTop. It includes information on the latest MET recommendations, systematic uncertainties, and the process if applying JVT/fJVT to jets used in MET calculations.

Change log

Liaison	Description	Time	Link to MR (if available)	Included since release:
Jonathan Jamieson	Added MET info	18.02.2020	None	None
Jonathan Jamieson	Added updated TST recommendation info	23.07.2020	MR	21.2.132

Usage and TST systematics

The MET calculation for each event uses information from high pT objects present in the event. Thus these objects should be sensibly defined, whether or not they are required for the current analysis. Not using sensible definitions or omitting object collections will result in a change to the final MET calculation and associated uncertainties, so be warned.

MET calculations in AnalysisTop use all hard objects in the event combined with an additional Track-based Soft Term (TST), which combines information from ID tracks and calorimeter deposits to quantify soft radiation within each event. This is the recommended process, and currently building MET from only tracking or only calorimeter information is not supported by AT.

For TST MET several **MC-only** uncertainties are derived, these are evaluated in Z+jets events and result in 3 nuisance parameters (4 trees), one double-sided uncertainty for TST scale and 2 one-sided uncertainties for resolution (1 perpendicular and 1 parallel). More information on the systematics derivation here.

Precision full run 2 TST systematic recommendations released in July 2020 no longer have separate calibrations for AFII samples for either EMTopo or PFlow. If these are required or if older recommendations are desired alongside a newer release (>21.2.131) it is possible using the following config option to revert to the older pre-recommendations which include a separate AFII config file, though only for EMTopo jets

```
AdvancedUsage_METUncertaintiesConfigDir METUtilities/data17_13TeV/prerec_Jan16/
```

Full R21 recommendations for MET treatment can be found here, and an intro to MET reconstruction can be found here

JVT and fJVT flags

It's possible to apply JVT or fJVT cuts to the jets passed to the METmaker in order to reduce the impact of pileup on the final MET calculation. These are enabled in AT by the following flags:

Flag Name	Options	(f)JVT cut
JVTinMETCalculation	True (default)	Matches JVT WP
	False	No JVT cut applied
fJVTinMETCalculation	False (default)	Does nothing on forward jets
	True	cuts forward jets (pT<60GeV, 2.5<abs(η)<4.5) based on fJVT WP defined in config, or Tight fJVT WP if not defined by user

Boosted Objects

This is the documentation of the boosted object in AnalysisTop. It includes available large-R jets definitions, boosted jets tagging and reclustered jets description

Change log

Liaison	Description	Time	Link to MR (if available)	Included since release:
Petr Jačka	Adding description of boosted objects	06.01.2019	None	None

Large-R jets

Available large-R jet collections

Collection name	Short name	Inputs	Jet alghorithm	Pileup removal	Available since release	Link to MR
AntiKt10LCTopoTrimmedPtFrac5SmallR20	LCTopo jets	LCTopo clusters	Anti-kt with R=1.0	Trimming with R=0.2 and f=0.05	21.2.20	merge request
AntiKt10TrackCaloClusterTrimmedPtFrac5SmallR20	TCC jets	TrackCalo clusters	Anti-kt with R=1.0	Trimming with R=0.2 and f=0.05	21.2.92	merge request

Inputs

Locally calibrated topological (LCTopo) clusters are used as inputs for AntiKt10LCTopoTrimmedPtFrac5SmallR20 jet collection. The calibration is performed using LC weighting which accounts for EM vs hadronic differences, out-of-cluster depositions and dead material. They are used for large-R jets only since they provide worse JER for R=0.4 jets (w.r.t. EMTopo or PFlow).

TrackCalo clusters are developed to provide better performance at high pt where topological clusters do not work well. At high pt, inner detector angular resolution is better at high pt while energy resolution is still better in calorimeter. **TrackCalo clusters** combine information from tracker and calorimeter to provide the best performance in boosted topology.

More details about jet inputs can be found in summary talk or JetEtMiss twiki pages (JetDefinitionsAndMCCalibration).

JES and JMS calibration

LCTopo jets: The MC-based JES and JMS calibration and the in situ JES calibration are provided for LCTopo jets. The in situ JMS will be released very soon. Three different mass definitions are provided - Calorimeter mass, Track-assisted mass, and Combined mass. The calorimeter mass uses information from the calorimeter only. The track-assisted mass (m_{TA}) is defined using $m_{TA} = m_{track} * (p_{T,calo} / p_{T,track})$, where track index corresponds to four-momenta calculated from charged particles tracks and $p_{T,calo}$ is calculated from calorimeter. Track-assisted mass performs slightly better at high pt while calo mass performs better at low pt. Combined mass is a weighted average of the calorimeter and the track-assisted mass. Weights are chosen to provide the best performance over the whole spectrum. The current recommendation is to use combined mass.

However, all three mass definitions are supported.

TCC jets: The simplistic MC-based JES and JMS calibrations are provided for TCC jets. In situ calibrations are not available. Mass is calculated from TrackCalo clusters (TCC mass). No new updates are expected for TCC jets since they will be replaced by new large-R jet collection in future (UFO jets).

More details about calibrations can be found in ApplyJetCalibrationR21 twiki page.

Uncertainties

LCTopo jets:

Uncertainties are described in detail in JetUncertaintiesRel21Summer2019LargeR. Three schemes are provided: AllNuissanceParameters, CategoryReduction, and GlobalReduction. The AllNuissanceParameters scheme is for analyses which requires the best possible precision. CategoryReduction and GlobalReduction schemes are for analyses with typical precision of results. The GlobalReduction can't be used in combinations with other measurements.

Uncertainties are provided for both MC-based and in situ calibrations. However, JMS and JMR uncertainties are outdated and they will be updated soon. JER uncertainties are not provided by uncertainties tools yet. The current recommendation is to use 2% relative gaussian random smearing. The next recommendations will provide also JER shifts for large-R jets.

Some sources of uncertainties are correlated with small-R jets. Analyses using both jet types should select consistent uncertainties scheme for both jet types.

TCC jets:

Uncertainties are described in detail in JetUncertaintiesRel21Summer2019TCC. They are derived using Rtrk method. Since the in situ calibration is not provided, the uncertainties are larger than for LCTopo jets. Resolution uncertainties are not provided by JetEtMiss group.

Boosted jets tagging

CP groups provide taggers to tag large-R jets as originating from hadronically decaying boosted object (top quark, W, Z bosons). Detailed description of available taggers can be found in BoostedJetTaggingRecommendationFullRun2. AnalysisTop supports all taggers described on this twiki. Taggers are initialized in TopBoostedTaggingCPTools. It is possible to run with multiple taggers as it is described in TopxAODStartGuideR21.

Top taggers:

Top taggers are provided for LCTopo jets only. Two truth labeling definitions are available: Inclusive top and Contained top.

- Inclusive top: Signal jets are required to be matched to a truth top quark
- Contained top: Inclusive top definition + matching to the truth trimmed jet with mass above 140 GeV and with at least one b-hadron ghost-associated to the matched truth jet Top taggers are deep neural networks with jet substructure variables used as inputs. 50% and 80% tagging working points are provided for both truth labeling definitions. **W/Z taggers**: W/Z taggers are provided for LCTopo and TCC jets. Their description can be found in BoostedJetTaggingRecommendationFullRun2.

Tagging scale factors

Scale factors are derived using in situ techniques and they scale MC to data. So far, the scale factors are available for 2 variables W/Z taggers for TCC jets only. Tagging scale factors for top-taggers and other W/Z taggers are being finalized.

Reclustered jets

Large-R jets clustered from small-R jets are called reclustered jets (RC jets). Analyses using reclustered jets can take calibrations and uncertainties from small-R jets which are well understood and which are provided sooner than for standard large-R jet collections.

AnalysisTop supports RC jets substructure variables calculation from small-R jet constituents or ghost-tracks.

Taus

This is the documentation of tau jets in AT. It includes the Jet ID and Electron Veto. These properties are set using two instances of the TauSelectionTool (one for loose and one for nominal taus). These and other recommended Tools are implemented in TopTauCPTools. The recommendations and a list of systematics can be found at TauRecommendations

Change log

Liaison	Description	Time	Link to MR (if available)	Included since release:
Tanja Holm	Adding Tau info	20.01.2020	None	None
Tanja Holm	new scalefactors available	19.03.2020	link	21.2.113
Tanja Holm	bugfix scalefactors	25.03.2020	link	21.2.114

General selection:

The tau selections can be either configured using separate options or using TauJetConfigFiles, a guideline to create these can be found here.

- **pT** : default 25000, configurable as **TauPt** (>20000)
- **|η|**: < 2.5 (excluding 1.37 < |η| < 1.52)
- **nTracks**: 1 or 3

TauJetIDWP

AnalysisTop supports two JetID discriminants: **BDT** or **RNN**, the discriminant based on RNN has a better background rejection and is thus recommended. It is available with the suffix "RNN".

Electron Veto

- **TauEleBDTWP**: Suppression of electrons faking TauJets using a BDT. An old (prefix Old) and a retuned working point are available, the retuned WP is the recommended electron veto algorithm
- **TauEleOLR**: OLR of electrons based on a LLH method, can be set True or False

Scale Factors

The latest scalefactors have the tag **2019-summer**. They have been latest updated in AnalysisBase 21.2.113.

Overlap Removal

ASG overlap removal tool is used to perform object overlap removal in AnalysisTop.

Two instances of the tool are defined, one for Tight lepton and the other for loose lepton.

The configuration of the instances in AnalysisTop can be found in TopOverlapRemovalCPTools.cxx. The ASG tool will decorate aux data of name "overlaps" to each object that it considers as an overlapped object. (Maybe put a summary of the exact configuration of the tool here)

The application of the instances in AnalysisTop can be found in OverlapRemovalASG.cxx, where the decorated flag "overlaps" is used to select a vector of object indices passing overlap removal, for each object type.

Some more documentation is available on gitlab in this repository. The overlap removal depends on which objects you have configured to be used in your analysis. However, assuming you use **everything** the following would be an appropriate description if you are using the **recommended** setup. If you use anything different, please check the file linked above to see how your overlap removal may differ. In addition, if you make explicit changes yourself, you will need to adjust this description accordingly This is our standard procedure since ICHEP2016:

```
Any electron found with a track overlapping with any other electron is removed.
Any calorimeter muon found to share a track with an electron is removed.
Any electron found to share a track with a muon is removed.
Any jet found within a delta-R of 0.2 of an electron is removed.
Any electron subsequently found within delta-R of of 0.4 of a jet is removed.
Any jet with less than 3 tracks associated to it found within delta-R of 0.2 of a muon is removed.
Any jet with less than 3 tracks associated to it which has a muon inner-detector track ghost-associated to it, is removed.
Any muon subsequently found within delta-R of 0.4 of a jet is removed.
Any tau found within a delta-R of 0.2 of a \texttt{LooseLH} electron is removed.
Any tau found within a delta-R of 0.2 of any type of muon with $p_T$ greater than 2 GeV is removed, while noting that if the tau $p_T$ is greated than 50 GeV, it wil
Any jet found within a delta-R of 0.2 of a tau is removed.
Any photon found within a delta-R of 0.4 of an electron or a muon is removed.
Any jet found within delta-R of 0.4 of a photon is removed.
Any large-R jet found within delta-R of 1.0 of an electron is removed.
Any jet found within a delta-R of 1.0 of a large-R jet is removed.
```

Major updates:
-- YichenLi - 2019-10-16

Responsible: YichenLi

Topic revision: r73 - 2020-07-24 - JonathanJamieson