# SKFlatAnalyzer User Guide

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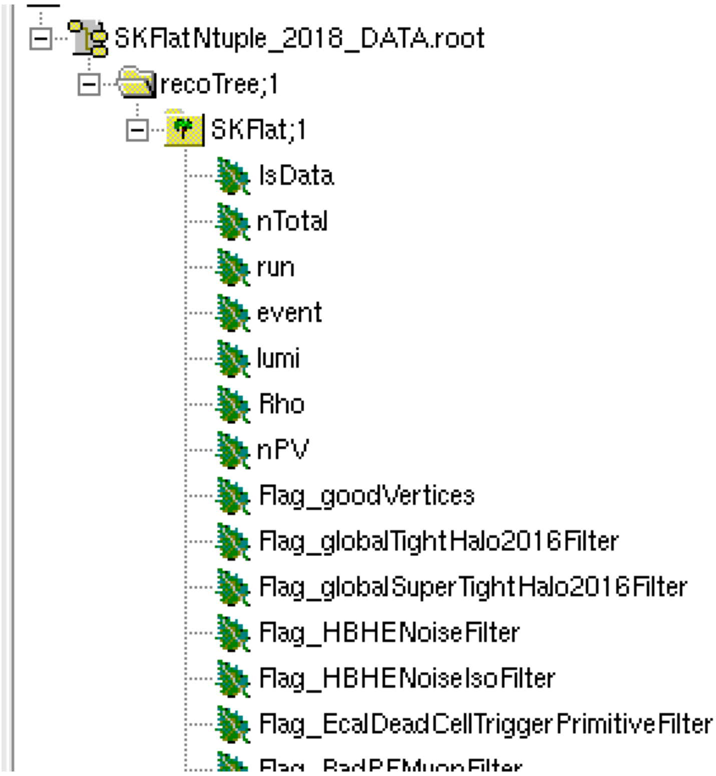
# Contents

# 1 Introduction

## 1.1 SKFlat

- A flat ntuple
- Use MiniAOD as an input
- GihHub link : https://github.com/CMSSNU/SKFlatMaker
- 

```
SKFlatNtuple_2018_DATA.root
  recoTree;1
    SKFlat;1
      IsData
      nTotal
      run
      event
      lumi
      Rho
      nPV
      Flag_goodVertices
      Flag_globalTightHalo2016Filter
      Flag_globalSuperTightHalo2016Filter
      Flag_HBHENoiseFilter
      Flag_HBHENoiseIsoFilter
      Flag_EcalDeadCellTriggerPrimitiveFilter
      Flag_BadPFMuonFilter
```

## 1.2 SKFlatAnalyzer

- ROOT6 based analyzer
- SNU (tamsa1), KISTI and KNU batch are supported by same submission commands (2019.01.22)
- Use SKFlat as an input
- Run over each event, and do the analysis!!
- Construct physics objects using branch elements:

```
Muon mu;
double rc = muon_roch_sf->at(i);
double rc_err = muon_roch_sf_up->at(i);
mu.SetMiniAODPt(muon_pt->at(i));
mu.SetPtEtaPhiM(muon_pt->at(i)*rc, muon_eta->at(i), muon_phi
    ->at(i), muon_mass->at(i));
```

- GitHub link : https://github.com/CMSSNU/SKFlatAnalyzer

# 2 Directories

## 2.1 DataFormats/

Physics objects

## 2.2 Analyzers/

Physics objects

## 2.3 include/

Header files

## 2.4 src/

Source files (define class, functions, ...)

## 2.5 data/$SKFlatV

Various data files including .root, .txt, ...
E.g., fake rates, scale factors,
Defined as an environment variable, $DATA_DIR

## 2.6 python/

Python scripts for job submission

## 2.7 script/

Any useful scripts

## 2.8 lib/

Compiled shared-libraries moved here

# 3 Structure

## 3.1 Analyzer inheritance

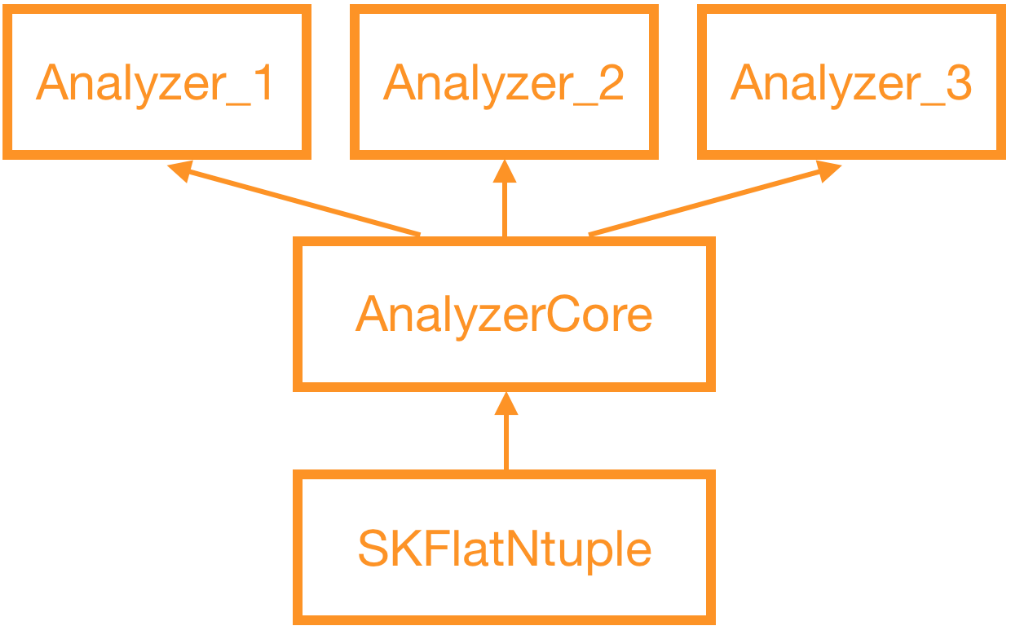


Figure 1: Diagram of analyzer inheritance.

### 3.2 Physics object inheritance

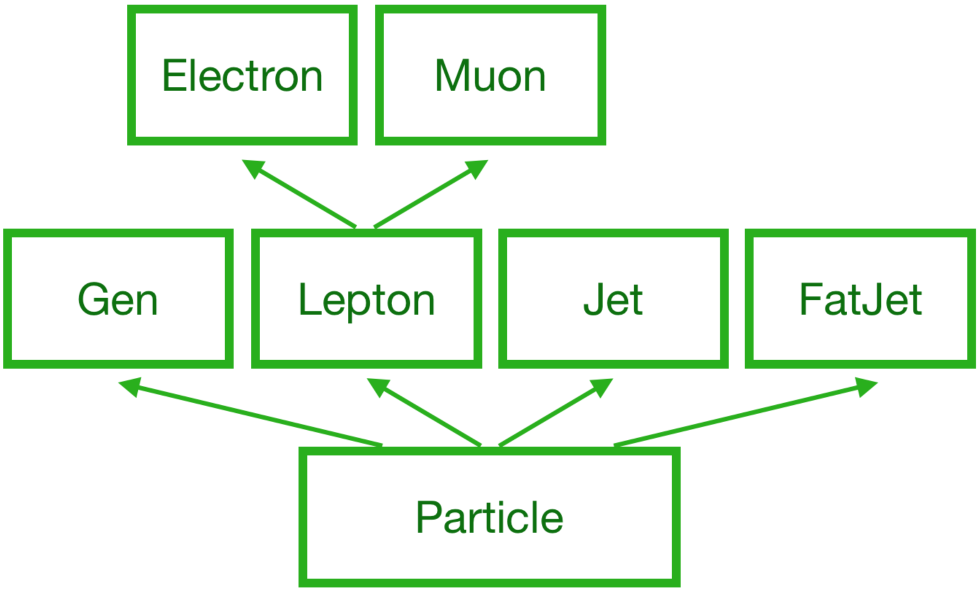


Figure 2: Diagram of physics object inheritance.

# 4 Analyzer class and submission command

*Every analyzer inherits AnalyzerCore*
*AnalyzerCore inherits SKFlatNtuple*

## 4.1 SKFlatNtuple

- Almost same as the output from TTree::MakeClass()
- SKFlatNtuple::Loop() loops over each event

## 4.2 AnalyzerCore

- Inherits SKFlatNtuple
- Includes header files of physics objects classes
- Physics analysis functions

```
std::vector<Muon> AnalyzerCore::GetAllMuons(); // return all
     muons
std::vector<Muon> AnalyzerCore::GetMuons(TString id, double
    ptmin, double fetamax); // return muons passing ID
    selection
std::vector<Muon> AnalyzerCore::SelectMuons(std::vector<Muon
    > muons, TString id, double ptmin, double fetamax); //
    Select muons passing id out of pre-collected muon
    collections
```

- Histogram related functions

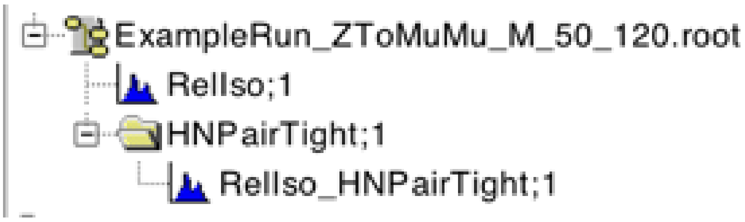
```
FillHist(TString histname, double value, double weight, int
    n_bin, double x_min, double x_max); // histogram is
    saved in the default directory of the output root file
JSFillHist(TString suffix, TString histname, double value,
    double weight, int n_bin, double x_min, double x_max);
    // histogram is saved in the directory named "suffix" of
     the output root file
```

- (Example)

```
  vector<Electron> electrons = GetElectrons(param.
    Electron_Tight_ID, 10., 2.5);
  for(unsigned int i=0; i<electrons.size(); i++){

    Electron el = electrons.at(i);
    FillHist("RelIso", el.RelIso(), 1, 100, 0., 1.);
    JSFillHist(param.Electron_Tight_ID, "RelIso_"+param.
   Electron_Tight_ID, el.RelIso(), 1, 100, 0., 1.);

  }
```



```
ExampleRun_ZToMuMu_M_50_120.root
    RelIso;1
    HNPairTight;1
        RelIso_HNPairTight;1
```

- Even if two histograms are in different directories, if their names are the same, we have warning message : “Warning in <TFile::Append>: Replacing existing TH1: RelIso (Potential memory leak).”
- So I recommend you to add directory name as a prefix/suffix of the histogram name :

  Instead of “RelIso” alone, use “RelIso_”+<Directory Name>

## 4.3 MyAnalyzer

- Inherits AnalyzeCore
- Run by the job macro

## 4.4 Job macro

- Macro will be created *automatically* by SKFlat.py command
- MyAnalyzer object is declared
- Input sample information ([DATA] DataStream / [MC] Sample name, input files, xsec, sumW) is set
- Output file path is set
- SKFlatNtuple::Init() is run : Initializing branch element variables
- AnalyzerCore::initializeAnalyzer() is run
  - This function is virtual, and can be redefined in ExampleRun

  - Anything you want to do before the event loop can be done here
  - Userflag is supported by python/SKFlat.py, by the option "−−userflags flag1,flag2,flag3"
  - The existence of a flag can be checked by using AnalyzerCore::HasFlag(TString flag)
- SKFlatNtuple::Loop() is run : loop over events
- AnalyzerCore::WriteHist() is run : write histograms in the output

## 4.5 SKFlat.py

Script for batch job submission

# 5 Macro run order

## 5.1 Example of a macro with comments inline

```
R__LOAD_LIBRARY(libPhysics.so)
R__LOAD_LIBRARY(libTree.so)
R__LOAD_LIBRARY(libHist.so)
R__LOAD_LIBRARY(./lib/libDataFormats.so)
R__LOAD_LIBRARY(./lib/libAnalyzers.so)

void run(){

  //==== Declaring an analyzer class immediately runs followings in orders;
  //==== 1) Constructor of SKFlatNtuple is called
  //==== 2) Constructor of AnalyzerCore is called
  //==== 3) Constructor of ExampleRun is called
  ExampleRun m;

  //==== SKFlat ntuple directory structure..
  m.SetTreeName("recoTree/SKFlat");

  //==== DATA or MC?
  m.IsDATA = true;
  //==== If DATA, PD name
  m.DataStream = "SingleMuon";
  //==== DATA year
  m.DataYear = 2016;
  //==== Files to be ran with this macro
  m.AddFile("SKFlatNtuple_2016_DATA_100.root");
  //==== output rootfile path
  m.SetOutfilePath("hists.root");
  //==== SKFlatNtuple::Init(), which does SetBranchAddress()
  m.Init();
  //==== AnalyzerCore::initializeAnalyzerTools Read histograms or initialize MCCorrection helpers or data-driven estimators
  m.initializeAnalyzerTools();
  //==== Any initialization just before running event loop. This is only ran once within a macro. For example, you should run AnalyzerCore::HasFlag() here. More example can be found HERE
  m.initializeAnalyzer();
  //==== Finally, run event loops
  m.Loop();

  //==== All events are ran. Now write histograms to the output rootfile
  m.WriteHist();
}
```

# 6 Migration from CATAnalyzer

Direct copy from CATAnalyzer codes to SKFlatAnalyzer won't work, but here are some tips.

- FillHist(histname, variable, weight, x_min, x_max, n_bin)

  → FillHist(histname, variable, weight, n_bin, x_min, x_max)

  : follow the order of arguments of TH1 in ROOT

# 7 Rules for developers

Some rules you should follow, if you want to make a pull request to the master branch.

## 7.1 File/Function/Variable names are important

Let's spend enough time for naming our new file/function/variable... Good naming makes programming efficient.

## 7.2 Equality operator between float or double

Guess what you would get from "root -l -b -q test.C" with below.

```
float GetFatJetSF(float tau21cut){

  if(tau21cut == 0.45){
    return 0.45;
  }
  if(tau21cut == 0.6){
    return 0.6;
  }
  else{
    return 1.;
  }

}

void test(){

  cout << "Value : " << GetFatJetSF(0.45) << endl;

}
```

Result is **Value : 1**. It works properly if you change **float GetFatJetSF(float tau21cut)** to **float GetFatJetSF(double tau21cut)**. However, it is NOT recommended to apply equality operator between floats. If you really need it, you can do $|A - B| < e$ with a very small $e$ (e.g., 0.001).

## 7.3 std::map is good, but be careful

We use a lot of std::map in the analyzer; rootfile for MCCorrection are saved as "std::map<TString, TH1D> histmap", and histogram can be accessed by "histmap[key]". But if you store so many histograms into the map, it spends so much time to obtain "histmap[mykey]", because it checks "mykey==key" for each keys. If you have saved thousands of fake-rate histograms into a map and run a fake estimation, it will take years... If you are applying muon scale factors, “map_hist_Muon[YOUR_ID]” is ran for each event and each muons. If you wrote too many IDs in ID/Muon/histmap.txt, you will waste your time looping over unnecessary keys. To save your time, you can add a “#” at the beginning of each lines in “ID/Muon/histmap.txt” (i.e., deactivating it) :

```
ID SF NUM_MediumID_DEN_genTracks RunAveraged_SF_ID.root NUM_MediumID_DEN_genTracks_eta_pt
↓
#ID SF NUM_MediumID_DEN_genTracks RunAveraged_SF_ID.root NUM_MediumID_DEN_genTracks_eta_pt
```

Then histogram for Medium ID will not be saved in the histmap.

## 7.4 When using random variables..

Some functions use random variables (e.g., smearing from a distribution). If you use default random seed, your results can be changed everytime you run the analyzer. Easiest way to avoid this issue is using a combination of RunNumber and EventNumber as a seed. E.g., seed = RunNumber $\times$ 1000000000 + EventNumber.