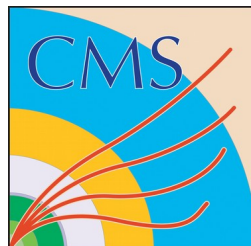




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IHEP Framework Tutorial

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2021-09-22





Scope of the code

Main goals

- Create a **generic**, highly **customisable** and easily **configurable** framework,
- Highly parallelisable to exploit Condor cluster.

Inputs

- Ntuples,
 - BSM TNT/BOOM trees,
 - nanoAOD,
- Cut and object definitions.

Action on trees

- Extract particles and apply all necessary/relevant corrections,
- Apply customisable selection requirements,
- Plot customisable histograms,
- Calculate systematic uncertainties.

Outputs

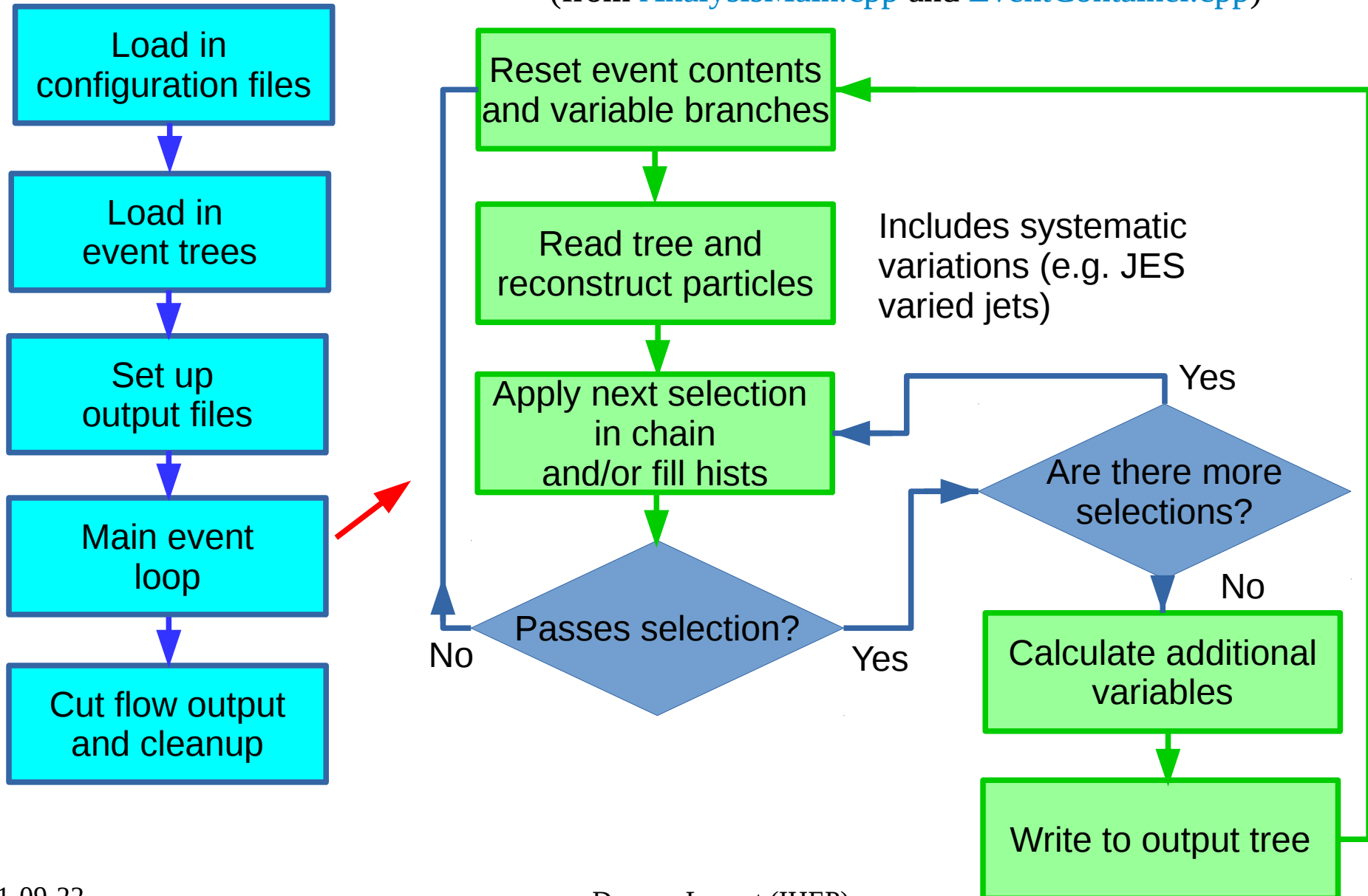
- Skimmed output tree (including additional variables),
- Histogram files.

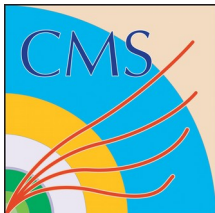


Flow of the code



Main event loop
(from [AnalysisMain.cpp](#) and [EventContainer.cpp](#))





Github frontpage



leggat / tWIHEPFramework

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Code

leggat Moving the fill branches command so that it doesn't break weighting 016678f 5 days ago 267 commits

SingleTopRootAnalysis	Merge pull request #4 from leggat/nonStableJESChanges	2 months ago
bin/Wt	Setting up skim version of the code	2 months ago
config	Updating git ignores to clean up repository	2 months ago
macros/wt-channel/LP/config	Updating git ignores to clean up repository	2 months ago
src	Moving the fill branches command so that it doesn't break weighting	5 days ago
tmva	Merge pull request #4 from leggat/nonStableJESChanges	2 months ago
utils	Merge pull request #4 from leggat/nonStableJESChanges	2 months ago
.gitignore	Updating git ignores to clean up repository	2 months ago
Makefile	Setting up skim version of the code	2 months ago
README.md	Updating documentation	5 years ago
SingleTop.Wt.LP.mm1+j.muonMSS...	added main config file	5 years ago
newTest.sh	Update the test file	2 months ago

About

tW code based on IHEP framework

Readme

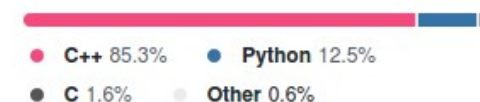
Releases

No releases published
[Create a new release](#)

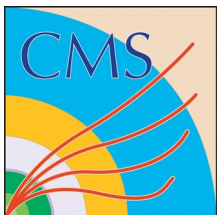
Packages

No packages published
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Languages



Framework front page: <https://github.com/leggat/tWIHEPFramework>



What's in each folder?

SingleTopRootAnalysis	→ Headers for all classes
bin/Wt	→ Analysis executables
config	→ Configuration files
macros/wt-channel/L...	→ Object and cut definitions
src	→ Source code for all classes
tmva	→ TMVA code
utils	→ Utilities
.gitignore	→ Git ignore file
Makefile	→ Make file
README.md	
SingleTop.Wt.LP.m...	
newTest.sh	→ Example to run Wt_generic.x

Key:
Main code
Configurations
Utility Codes







Utility codes are largely focused on tW, but I am currently working on providing generic examples



Main code sub-directories



Main code directories found in SingleTopRootAnalysis (headers) and src (source)

 Base	→ Classes that govern the central running of the code
 Cuts	→ Event selections
 Histogramming	→ Classes for the production of histograms
 Particles	→ Definition of particles
 Trees	→ Event tree (makeclass output)
 Vars	→ Additional variables to store in output tree



- Instructions assume use of lxslc7.ihep.ac.cn*

There should be a bunch of output finished by the following:

```
<CutFlowTable> GlobalCutFlow result:
-----
| Cut Name | exposed | pass | cut |
| count | yield | count | yield | | |
|---|---|---|---|---|---|
| TightMuon.Number.Min | 398904 | 24687.7 | 98059 | 6068.77 | Tight Muon : N >= 1 |
| TightMuon.Number.Max | 398904 | 24687.7 | 395218 | 24459.6 | Tight Muon : N <= 1 |
| TightMuon.Number.All | 398904 | 24687.7 | 94373 | 5840.64 | Tight Muon : 1 <= N <= 1 |
| TightElectron.Number.Min | 94373 | 5840.64 | 94373 | 5840.64 | Tight Electron : N >= 0 |
| TightElectron.Number.Max | 94373 | 5840.64 | 88852 | 5498.95 | Tight Electron : N <= 0 |
| TightElectron.Number.All | 94373 | 5840.64 | 88852 | 5498.95 | Tight Electron : 0 <= N <= 0 |
| Jet.Number.Min | 88852 | 5498.95 | 70265 | 4348.62 | Jet : N >= 2 |
| Jet.Number.Max | 88852 | 5498.95 | 83029 | 5138.58 | Jet : N <= 4 |
| Jet.Number.All | 88852 | 5498.95 | 64442 | 3988.25 | Jet : 2 <= N <= 4 |
-----

<CutListProcessor::PrintCutDetails> Total Efficiency: 3988.25/24687.7 = 0.161548

<AnalysisMain::Loop>
<AnalysisMain::Loop>
<AnalysisMain::Loop> -----
| Processing Summary |
|-----|
| # of events: 398904 |
| Real time: 251.6 s |
| Time per event: 0.0006308 s |
| Events/second: 1585 |
|-----|
<AnalysisMain::Loop>
<AnalysisMain::Loop>
<AnalysisMain::Loop> Closing histogram file: hists/nanoAODTest_histFile.root
<AnalysisMain::Loop> Write skim file: skims/nanoAODTest_skimFile.root
<AnalysisMain::Loop> Closing skim file: skims/nanoAODTest_skimFile.root
<driver> Finished Loop over events in chain
<driver> Writing histograms to file: hists/nanoAODTest_histFile.root
<driver> Deleting chains
<driver> Successful Completion.
```



Example executable



A bunch of pre-amble, but the important bit starts at l.225

Two main vectors to be customised:

Cut list `mystudy.AddCut()`

- Includes selection requirements and histogramming classes,
- Performed sequentially on each event until the event passes or fails a cut.

Additional variable list

`mystudy.AddVars()`

- Add additional variables to the output skim tree,
- Performed to all events that pass selection.

```
225 //////////////////////////////////////////////////
226 // Add Cuts and Histograms applicable to Fast and Full Analyses
227 //////////////////////////////////////////////////
228 // ***** Cuts and Histograms applied to all studies *****
229
230 mystudy.AddCut(new EventWeight(particlesObj,mystudy.GetTotalMCatNLOEvents(), mcStr, doPileup, dobWeight, useLeptonSFs, usebTagR
231
232 mystudy.AddCut(new HistogrammingMuon(particlesObj,"All")); // make the muon plots, hopefully.
233 mystudy.AddCut(new HistogrammingMuon(particlesObj,"Tight",useInvertedIsolation)); // make the muon plots, hopefully.
234 mystudy.AddCut(new HistogrammingMuon(particlesObj,"Veto")); // make the muon plots, hopefully.
235 mystudy.AddCut(new HistogrammingMuon(particlesObj,"UnIsolated")); // make the muon plots, hopefully.
236 mystudy.AddCut(new CutPrimaryVertex(particlesObj));
237 mystudy.AddCut(new CutTriggerSelection(particlesObj, whichtrig));
238
239 mystudy.AddCut(new HistogrammingMET(particlesObj));
240 //mystudy.AddCut(new CutElectronTighterPt(particlesObj, "Tight"));
241 mystudy.AddCut(new CutMuonN(particlesObj, leptonTypeToSelect)); //require that lepton to be isolated, central, high pt
242
243 mystudy.AddCut(new CutMuonN(particlesObj, "Veto")); //require that lepton to be isolated, central, high pt
244
245
246
247 mystudy.AddCut(new CutElectronN(particlesObj, leptonTypeToSelect)); //require that lepton to be isolated, central, high pt
248 mystudy.AddCut(new CutElectronN(particlesObj, "Veto")); //require that lepton to be isolated, central, high pt
249
250 mystudy.AddCut(new HistogrammingElectron(particlesObj,leptonTypeToSelect,useInvertedIsolation)); // make the muon plots, hopef
251 mystudy.AddCut(new HistogrammingElectron(particlesObj,"Veto")); // make the muon plots, hopefully.
252
253 mystudy.AddCut(new HistogrammingMET(particlesObj));
254 mystudy.AddCut(new HistogrammingMtW(particlesObj,useInvertedIsolation));
255
256 mystudy.AddCut(new HistogrammingMuon(particlesObj,leptonTypeToSelect)); // make the muon plots, hopefully.
257
258 //mystudy.AddCut(new CutMuonTighterPt(particlesObj, "Tight")); //require that new Pt cut for leading and subleading muon
259 //if (isemu){
260 // mystudy.AddCut(new CutEMuOverlap(particlesObj));
261 //}
262 //mystudy.AddCut(new CutJetPt1(particlesObj));
263 mystudy.AddCut(new CutJetN(particlesObj,nJets));
```

Link: https://github.com/leggat/tWIHEPFramework/blob/master/bin/Wt/Wt_generic.cpp



Example cut class

Each cut contains;

- BookHistogram()
 - Book histograms to fill when running cut
 - Also defines the value of the cut
- Apply()
 - Applies the cut to each event
 - Fill histograms
 - Returns true if pass, false if fail cut

Added into analysis executable

```
1  /*****
2   * CutMissingEt.hpp
3   *
4   * Cuts on Missing Et
5   *
6   * Derived from HistoCut which is in turn derived from BaseCut
7   *
8   * Public Member Functions of CutMissingEt class
9   *   CutMissingEt()                -- Parameterized Constructor
10  *   ~CutMissingEt()               -- Destructor
11  *   BookHistogram()               -- Book histograms
12  *   Apply()                       -- Apply cuts and fill histograms
13  *   GetCutName()                  -- Returns "CutMissingEt"
14  *
15  * Private Data Members of CutMissingEt
16  *   myTH1F* _hMissingEtBefore     -- Hist of MissingEt before cuts
17  *   myTH1F* _hMissingEtAfter     -- Hist of MissingEt after cuts
18  *   Int_t _missingEtMin;          -- Minimum Missing Et
19  *   Int_t _missingEtMin;          -- Minimum Missing Et
20  *
21  * History
22  *   15 Dec 2006 - Created by P. Ryan
23  *****/
```

```
236  mystudy.AddCut(new CutPrimaryVertex(particlesObj));
237  mystudy.AddCut(new CutTriggerSelection(particlesObj, whichtrig));
```

<https://github.com/leggat/tWIHEPFramework/blob/master/src/Cuts/Other/CutMissingEt.cpp>



Example histogram class



Histogram classes are treated as cuts but always return true

Added into executable in the cut flow list chain:

```
1  /*****
2  * HistogrammingMET.hpp
3  *
4  * Books and fills histograms
5  * Used for events passing cuts applied in other classes
6  *
7  * Derived from HistoCut which is in turn derived from BaseCut
8  *
9  * Public Member Functions of AnalysisMain class
10 *   HistogrammingMET()           -- Parameterized Constructor
11 *   ~HistogrammingMET()          -- Destructor
12 *   BookHistogram()              -- Book histograms
13 *   Apply()                      -- Fill histograms only (No Cuts)
14 *   GetCutName()                 -- Returns "HistogrammingMET"
15 *
16 * Private Data Members of this class
17 *   - histograms of MET
18 *
19 * History
20 *   14 Nov 2006 - Created by R. Schwienhorst for ATLAS
21 *   20 Nov 2006 - Modified by Bernard Pope
22 *   21 Mar 2007 - RS: Fill from event container, add sumET, mex, mey
23 *****/
```

```
271  mystudy.AddCut(new HistogrammingMET(particlesObj));
272  mystudy.AddCut(new HistogrammingMtW(particlesObj,useInvertedIsolation));
273  mystudy.AddCut(new HistogrammingJetAngular(particlesObj,useInvertedIsolation));
274  mystudy.AddCut(new HistogrammingJet(particlesObj));
275  mystudy.AddCut(new HistogrammingNPvtX(particlesObj));
```

Link: <https://github.com/leggat/tWIHEPFramework/blob/master/src/Histogramming/Recon/HistogrammingMET.cpp>



Example of additional variable class



Adds additional variables to the output tree

- Variables are defined in the constructor
 - float, int, vectors of floats and ints are currently supported types
- Filled in the FillBranches() method

Included in analysis executable in the additional variable chain:

```
289 mystudy.AddVars(new JESBDTVars());
290 mystudy.AddVars(new WeightVars(useIterFitbTag));
291 mystudy.AddVars(new ChannelFlag());
```

Additional variable definition

```
15 WeightVars::WeightVars(Bool_t useIterFit){
16     _floatVars["EventWeight"] = 0.;
17     _floatVars["bWeight"] = 0.;
18     _floatVars["puWeight"] = 0.;
19     _floatVars["lepSF"] = 0.;
20     _floatVars["trigSF"] = 0.;
```

Now the output tree contains additional branches named after these strings

Variable filling

```
39 void WeightVars::FillBranches(EventContainer * evtObj){
40
41     //Fill the nominal event weight variables
42     _floatVars["EventWeight"] = evtObj->GetOutputEventWeight();
43     _floatVars["bWeight"] = evtObj->GetEventbTagReshape();
44     _floatVars["puWeight"] = evtObj->GetEventPileupWeight();
45     _floatVars["lepSF"] = evtObj->GetEventLepSFWeight();
46     _floatVars["trigSF"] = evtObj->GetEventTrigSFWeight();
```

Link: <https://github.com/leggat/tWIHEPFramework/blob/master/src/Vars/WeightVars.cpp>



Running the code

Once we've written our main analysis and cut/histogram/variable classes we need to compile the code

- Most technical bit: edit Makefile to run over your specific code

Now we are ready to run the analysis:

```
bin/myAnalysis.x -config config/overall/myAnalysis.config -inlist config/files/myAnalysisFiles.list  
-skimfile skimFileOutput/mySkim.root -hfile histFileOutput/myHists.root [additional options]
```

Necessary parts of execution command:

- Analysis executable
- -config <config> – contains links to further configuration files
- -inlist <inlist> – a list of files to run over
- -skimfile <skimFile> – what to call the output skim tree (optional)
- -hfile <hfile> – histogram file destination (optional)
- Additional opts – Defined in analysis executable and AnalysisMain.cpp

Commands can also be run on Condor cluster

- Utility classes to help with this are available in the utils folder



Main Configuration File



Important information that the analysis needs

All configuration files are united into one common TEnv area accessible to the analysis code.

Each item is stored in a map locatable by its unique string identifier (e.g. Include.CutsFile)

The cut values to use in the analysis

Information of weights of MC samples

Physics objects definitions

Root file containing pt/eta dependent muon ID SF information

```
1 #####
2 #
3 # Configuration file for the single top analysis.
4 #
5 # Modifications:
6 #####
7 #
8 #
9 # Set the debug level: the higher, the more printout
10 DebugLevel: 10
11 #
12 # Mass set to MC value for this study.
13 # If we are optimizing for some top mass, set that mass here:
14 TopMass: 172.5
15 #
16 #
17 # Read in a file listing cuts we want to make (electron channel):
18 #Include.CutsFile: macros/wt-channel/LP/config/cuts/SingleTopCuts.Wt.DiElectron.onePlusJets.cuts
19 Include.CutsFile: macros/wt-channel/LP/config/cuts/SingleTopCuts.Wt.ElectronMuon.onePlusJets.cuts
20 #
21 #
22 # Read in a file listing the event weight:
23 Include.WeightsFile: config/weights/MCInformation.weights
24 #
25 #
26 # Read in a file listing the object ID definitions:
27 Include.ObjectIDFile: macros/wt-channel/LP/config/objects/SingleTopObjects.Wt.LP.noshift.config
28 #
29 # Output file with topological variables
30 Topology.SkimFile: topovars.root
31 #
32 #
33 # Events files
34 Include.MCTotEventNumberFile: config/weights/MCInformation.weights
35 #
36 #
37 # pile up vtx reweighting
38 #Include.pileUpReweightFile: config/weights/SingleTopWeights.PileUpReWeight.156.weights
39 #
40 #
41 #muonID SFs
42 Include.MuonIDSFsFile: config/weights/muon/MuonID_all.root
```

Example for tW analysis:

[https://github.com/leggat/tWIHEPFramework/blob/master/config/overall/SingleTop.Wt.](https://github.com/leggat/tWIHEPFramework/blob/master/config/overall/SingleTop.Wt.LP.mm1%2Bj.muonMSSmeardown.config)

[LP.mm1%2Bj.muonMSSmeardown.config](https://github.com/leggat/tWIHEPFramework/blob/master/config/overall/SingleTop.Wt.LP.mm1%2Bj.muonMSSmeardown.config)



Examples of cut and object definition files



- Cut definitions are read in by the cut classes
- Object definitions are read by the particle classes

```
#-----  
# Jets  
#-----  
ObjectID.Jet.MinPt: 30.0  
ObjectID.Jet.MaxEta: 2.4  
ObjectID.BJet.MaxEta: 2.4  
ObjectID.BJet.MinPt: 30.  
#ObjectID.BJet.BTagCut: 0.5426 #Loose CSVv2 WP  
ObjectID.BJet.BTagCut: 0.8484 #Medium CSVv2 WP  
#ObjectID.BJet.BTagCut: 0.9535 #Tight CSVv2 WP  
ObjectID.BJet.InverseTag: 0.6 # For QCD region possibly  
ObjectID.Jet.ElectronDeltaRMin: 0.3  
ObjectID.Jet.LepCleanR: 0.4  
  
#ObjectID.Jet.ElectronDeltaRMin: 0.2  
##ObjectID.Jet.ElectronDeltaRMin: 0.0  
  
ObjectID.Vertex.Ndof: 4.  
ObjectID.Vertex.Z: 24.  
ObjectID.Vertex.Dxy: 2.█
```

```
#####  
# SingleTopCuts.Wt.ElectronMuon.onePlusJets.cuts  
#  
#####  
  
# ##### Trigger Cuts #####  
# Trigger cuts implemented within the trigger cut classes (for now)  
  
##### Electron Cuts #####  
# Number of Electrons  
Cut.Electron.Tight.Number.Min: 0  
Cut.Electron.Tight.Number.Max: 0  
Cut.Electron.Tight.LeadingPt: 26  
Cut.Electron.Tight.SubLeadingPt: 20  
##### Veto Electron Cuts #####  
# Number of Electrons  
Cut.Electron.Veto.Number.Min: 0  
Cut.Electron.Veto.Number.Max: 0  
##### Muon Cuts #####  
# Number of Muons  
Cut.Muon.Tight.Number.Min: 1  
Cut.Muon.Tight.Number.Max: 1  
Cut.Muon.Tight.LeadingPt: 26  
Cut.Muon.Tight.SubLeadingPt: 20  
##### UnIsolated Muon Cuts #####  
# Number of Muons  
Cut.Muon.UnIsolated.Number.Min: 1  
Cut.Muon.UnIsolated.Number.Max: 1  
Cut.Muon.UnIsolated.LeadingPt: 26  
Cut.Muon.UnIsolated.SubLeadingPt: 20  
##### Veto Muon Cuts #####  
# Number of Veto Muons  
Cut.Muon.Veto.Number.Min: 1  
Cut.Muon.Veto.Number.Max: 1  
# ##### Jet Cuts #####  
# Jet multiplicity cuts  
Cut.Jet.Number.Min: 2  
Cut.Jet.Number.Max: 4  
Cut.Jet.Pt.1.Min: 30  
Cut.Jet.Pt.1.Max: 999
```

<https://github.com/leggat/tWIHEPFramework/blob/master/macros/wt-channel/LP/config/objects/SingleTopObjects.Wt.LP.noshift.config>

<https://github.com/leggat/tWIHEPFramework/blob/master/macros/wt-channel/LP/config/cuts/SingleTopCuts.Wt.ElectronMuon.onePlusJets.cuts>



File list and MC weighting



An example file list file:

```
Name: tw_top_nfh
Number: 500026 1
/publicfs/cms/data/TopQuark/cms13TeV/twLJetSamples/mc/updatedEleJets/ST_tw_top_5f_NoFullyHadronicDecays_13TeV-powheg_TuneCUETP8M1/crab_tw_top_NFHextlupdatedEleJets/180508_153925/0000/OutTree_5.root
/publicfs/cms/data/TopQuark/cms13TeV/twLJetSamples/mc/updatedEleJets/ST_tw_top_5f_NoFullyHadronicDecays_13TeV-powheg_TuneCUETP8M1/crab_tw_top_NFHextlupdatedEleJets/180508_153925/0000/OutTree_6.root
/publicfs/cms/data/TopQuark/cms13TeV/twLJetSamples/mc/updatedEleJets/ST_tw_top_5f_NoFullyHadronicDecays_13TeV-powheg_TuneCUETP8M1/crab_tw_top_NFHextlupdatedEleJets/180508_153925/0000/OutTree_12.root
/publicfs/cms/data/TopQuark/cms13TeV/twLJetSamples/mc/updatedEleJets/ST_tw_top_5f_NoFullyHadronicDecays_13TeV-powheg_TuneCUETP8M1/crab_tw_top_NFHextlupdatedEleJets/180508_153925/0000/OutTree_31.root
/publicfs/cms/data/TopQuark/cms13TeV/twLJetSamples/mc/updatedEleJets/ST_tw_top_5f_NoFullyHadronicDecays_13TeV-powheg_TuneCUETP8M1/crab_tw_top_NFHextlupdatedEleJets/180508_153925/0000/OutTree_7.root
/publicfs/cms/data/TopQuark/cms13TeV/twLJetSamples/mc/updatedEleJets/ST_tw_top_5f_NoFullyHadronicDecays_13TeV-powheg_TuneCUETP8M1/crab_tw_top_NFHextlupdatedEleJets/180508_153925/0000/OutTree_25.root
/publicfs/cms/data/TopQuark/cms13TeV/twLJetSamples/mc/updatedEleJets/ST_tw_top_5f_NoFullyHadronicDecays_13TeV-powheg_TuneCUETP8M1/crab_tw_top_NFHextlupdatedEleJets/180508_153925/0000/OutTree_20.root
/publicfs/cms/data/TopQuark/cms13TeV/twLJetSamples/mc/updatedEleJets/ST_tw_top_5f_NoFullyHadronicDecays_13TeV-powheg_TuneCUETP8M1/crab_tw_top_NFHextlupdatedEleJets/180508_153925/0000/OutTree_23.root
/publicfs/cms/data/TopQuark/cms13TeV/twLJetSamples/mc/updatedEleJets/ST_tw_top_5f_NoFullyHadronicDecays_13TeV-powheg_TuneCUETP8M1/crab_tw_top_NFHextlupdatedEleJets/180508_153925/0000/OutTree_29.root
```

'Number' corresponds to a specific number in the config/weights/MCInformation.weights file:

Weight.Source.Number: <cross section>
Events.Source.Number: <nEvents in sample>

Plausible that additional settings could be added into this file (i.e. different configuration for run years?) but not included as of now.

```
#500026 = not fully hadronic tw
Weight.Source.500026: 19.559
Events.Source.500026: 11345619

#500027 = not fully hadronic tw_antitop
Weight.Source.500027: 19.559
Events.Source.500027: 11408144

#500028 = w+0jets
Weight.Source.500028: 49670.0
Events.Source.500028: 98083988
```



Cut flow output



At completion the framework outputs a cut flow of the processed trees

- A cut class can be linked the cut flow using

```
GetCutFlowTable()->AddCutToFlow(cutName)
```

- And filled using:

```
GetCutFlowTable()->[Pass|Fail]Cut(cutName)
```

<CutFlowJetTable> GlobalCutFlow result:

Cut Name	0 jet	1 jet	2 jet	3 jet	4 jet	5 jet	6 jet	7 jet	8+jet	total
PV	25768	131334	259142	255591	146440	60764	21016	6409	2425	908889
MuonTrigger	7631	38972	69302	60413	30588	11769	3971	1132	398	224176
TightMuon.Number.Min	7388	36856	63229	51601	24027	8765	2840	791	255	195752
TightMuon.Number.Max	6515	35026	67179	59566	30298	11686	3952	1125	395	215742
TightMuon.Number.All	6272	32910	61106	50754	23737	8682	2821	784	252	187318
VetoMuon.Number.Min	6272	32910	61106	50754	23737	8682	2821	784	252	187318
VetoMuon.Number.Max	5218	26438	49180	39900	17709	6006	1884	495	145	146975
VetoMuon.Number.All	5218	26438	49180	39900	17709	6006	1884	495	145	146975
TightElectron.Number.Min	5218	26438	49180	39900	17709	6006	1884	495	145	146975
TightElectron.Number.Max	5042	25907	48927	39810	17682	6002	1883	495	145	145893
TightElectron.Number.All	5042	25907	48927	39810	17682	6002	1883	495	145	145893
VetoElectron.Number.Min	5042	25907	48927	39810	17682	6002	1883	495	145	145893
VetoElectron.Number.Max	4809	22908	40990	32616	13686	4395	1313	348	80	121145
VetoElectron.Number.All	4809	22908	40990	32616	13686	4395	1313	348	80	121145
Jet.Number.Min	0	1266	40990	32616	13686	4395	1313	348	80	94694
Jet.Number.Max	4809	22908	40990	32616	13686	488	5	0	0	115502
Jet.Number.All	0	1266	40990	32616	13686	488	5	0	0	89051

<CutFlowTable> GlobalCutFlow result:

Cut Name	exposed		pass		cut
	count	yield	count	yield	
PV	925904	56240.1	908889	55383.7	Primary Vertex Cut
MuonTrigger	908889	55383.7	224176	13516.1	Muon Trigger
TightMuon.Number.Min	224176	13516.1	195752	11769.5	Tight Muon : N >= 1
TightMuon.Number.Max	224176	13516.1	215742	13024.7	Tight Muon : N <= 1
TightMuon.Number.All	224176	13516.1	187318	11278.1	Tight Muon : 1 <= N <= 1
VetoMuon.Number.Min	187318	11278.1	187318	11278.1	Veto Muon : N >= 1
VetoMuon.Number.Max	187318	11278.1	146975	9003.72	Veto Muon : N <= 1
VetoMuon.Number.All	187318	11278.1	146975	9003.72	Veto Muon : 1 <= N <= 1
TightElectron.Number.Min	146975	9003.72	146975	9003.72	Tight Electron : N >= 0
TightElectron.Number.Max	146975	9003.72	145893	8944.91	Tight Electron : N <= 0
TightElectron.Number.All	146975	9003.72	145893	8944.91	Tight Electron : 0 <= N <= 0
VetoElectron.Number.Min	145893	8944.91	145893	8944.91	Veto Electron : N >= 0
VetoElectron.Number.Max	145893	8944.91	121145	7418.47	Veto Electron : N <= 0
VetoElectron.Number.All	145893	8944.91	121145	7418.47	Veto Electron : 0 <= N <= 0
Jet.Number.Min	121145	7418.47	94694	5779.79	Jet : N >= 2
Jet.Number.Max	121145	7418.47	115502	7076.55	Jet : N <= 4
Jet.Number.All	121145	7418.47	89051	5437.87	Jet : 2 <= N <= 4



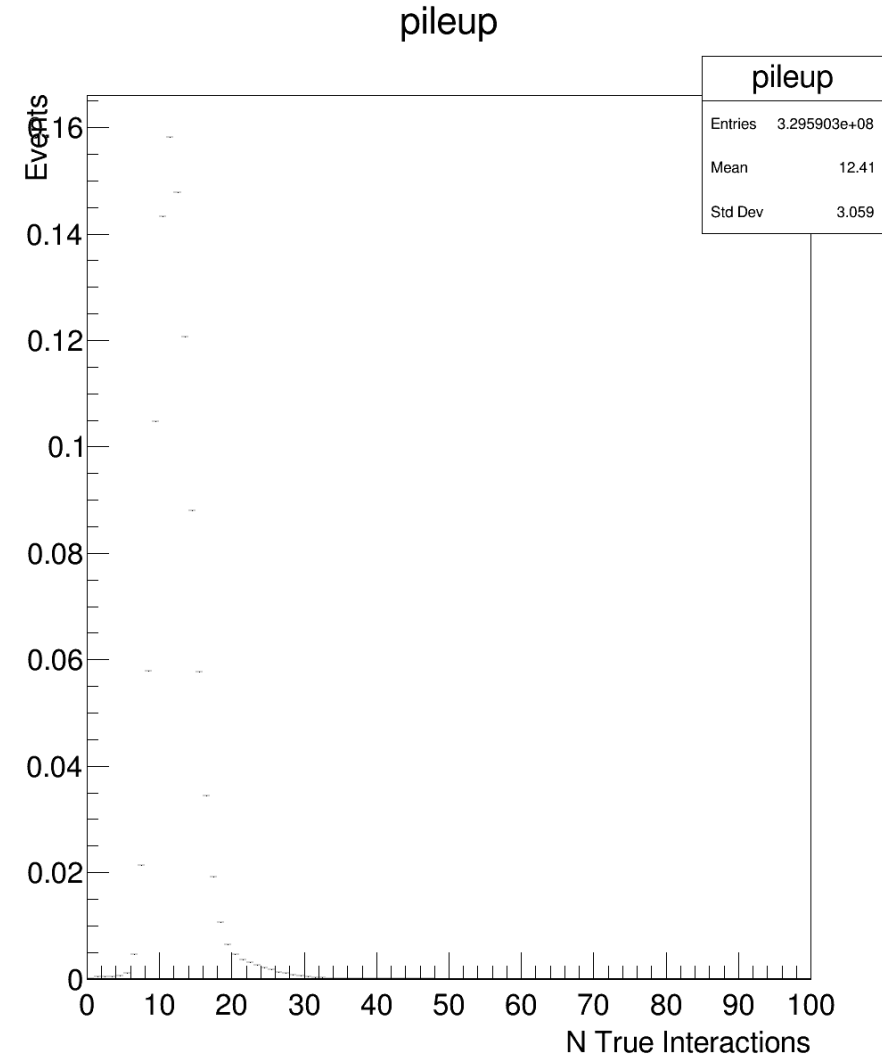
Pileup how to



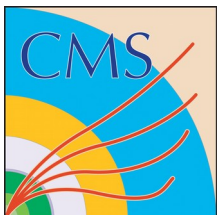
- Add command line option `-PileUpWgt` to executable command.
- Add lines to configuration file with data and MC PV distribution, and min bias up and down plots for systematic calculations,
 - Plot must be titled/named 'pileup' and be divided into integer bins

```
#pileup reweighting files
Include.dataPVFile: config/weights/dataPV.root
Include.mcPVFile: config/weights/mcPV80X.root
Include.minBiasUp: config/weights/minBiasUpPileupHistogram.root
Include.minBiasDown: config/weights/minBiasDownPileupHistogram.root
```

- See <https://twiki.cern.ch/twiki/bin/view/CMS/PileupJSONFileforData> for details on calculating PV distributions and syst variants



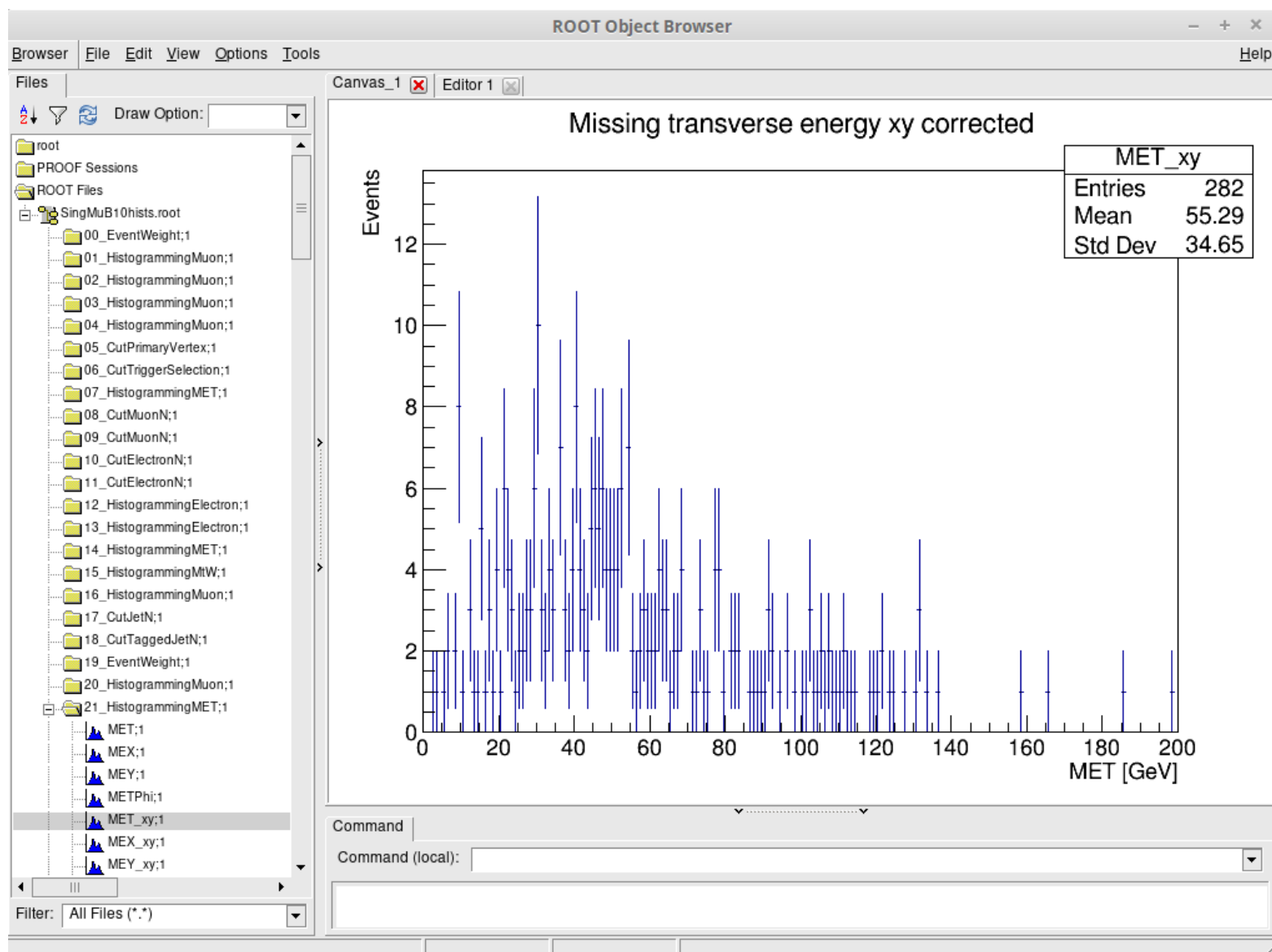
An example pileup distribution



Output histogram file



Example of
output histogram
file





Thoughts on developments



Developments in progress

- Provide native nanoAOD support,
- Continue to provide generic examples of utility codes,
- Improve documentation based on your suggestions?

Potential developments

- Generic histogramming class with basic configuration options (similar to additional variable classes).