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LPC Hands-on Advanced Tutorials Session (HATS) on MET

Instructions for HATS on MET at FNAL LPC in March 2014

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Introduction

This topic includes instructions for LPC HATS on MET, which takes place in March 2014.

- https://indico.cern.ch/event/303854

Hands-on 1: Check out CMSSW and MET recipe

Computing Environment at FNAL LPC

This exercise uses the LPC Cluster **`cmslpc-sl5.fnal.gov`**. After logging into **`cmslpc-sl5.fnal.gov`**, you need to set up the CMS environment by sourcing one of two files depending on the shell that you are using. For bash users,

```
source /uscmst1/prod/sw/cms/shrc prod # for bash
```

For tcsh users,

```
source /uscmst1/prod/sw/cms/cshrc prod # for tcsh
```

More information about **`cmslpc-sl5.fnal.gov`** can be found at CMSPublic.WorkBookRemoteSiteSpecifics.

CMSSW Environment

You need to move to a directory in which you would like to practice this exercise.

```
mkdir -p ~/your/work/dir
cd ~/your/work/dir
```

Please replace **`~/your/work/dir`** with a path to the directory of your choice.

Then, you can check out a CMSSW release. This exercise uses CMSSW_5_3_15.

```
scramv1 project CMSSW CMSSW_5_3_15
```

Move down two directories and enter the CMSSW runtime environment:

```
cd CMSSW_5_3_15/src
cmsenv
```

MET Recipe

In order to work out this twiki, you need to check out several extra files from github repositories.

A git environment needs to be properly set up in order to be able to check out extra packages from github repositories. The instruction can be found at http://cms-sw.github.io/cmssw/faq.html.

Check out extra files with the following commands:

```
git cms-addpkg PhysicsTools/PatAlgos # PAT Recipe
git cms-merge-topic cms-analysis-tools:5_3_15-addCSCTightHaloFilter # PAT Recipe
git cms-merge-topic -u TaiSakuma:53X-met-140217-01
```

These commands are for **`CMSSW_5_3_15`**. The commands for other CMSSW versions are listed on

- SWGuideMETRecipe53X

Build

Now, you can build with the scram command:

```
scram build -j 9
```

More information about scram can be found at

- WorkBookScramV1Intro
- SWGuideScram

Exercise files

This exercise uses files in the branch **`hats_2014_mar_fnal`** at the github repo **`TaiSakuma/WorkBookMet`**:

- https://github.com/TaiSakuma/WorkBookMet/tree/hats_2014_mar_fnal

Clone this repo to your local directory.

```
git clone git@github.com:TaiSakuma/WorkBookMet
```

If the above command doesn't work, you can try instead

```
git clone git://github.com/TaiSakuma/WorkBookMet
```

Checkout the branch **`hats_2014_mar_fnal`** with the following commands.

```
cd WorkBookMet/
git checkout hats_2014_mar_fnal
cd ..
```

Hands-on 2: Explore datasets

Sample AOD files

This exercise uses two sample AOD files stored in an EOS at FNAL LPC:

```
255M  /eos/uscms/store/user/cmsdas/2014/MET/ZeroBias_Run2012C_22Jan2013-v1_AOD_numEvent1000.root
62M  /eos/uscms/store/user/cmsdas/2014/MET/MET120_Run2012C_22Jan2013-v1_AOD_numEvent201.root
41M  /eos/uscms/store/user/cmsdas/2014/MET/TTJets_AODSIM_532_numEvent100.root
```

The 1st file contains 1000 events which were triggered by **`HLT_ZeroBias_*`** in the run 200491 in Run2012C, which were certified (json), and which were stored in ***/MinimumBias/Run2012C-22Jan2013-v1/AOD*** (DAS).

The 2nd file contains 201 events which were triggered by **`HLT_MET120_*`** in the run 200491 in Run2012C, which were certified (json), and which were stored in ***/MET/Run2012C-22Jan2013-v1/AOD*** (DAS).

The 3rd file contains 100 MC simulated events from ***/TTJets_MassiveBinDECAY_TuneZ2star_8TeV-madgraph-tauola/Summer12_DR53X-PU_S10_START53_V7A-v1*** (DAS).

...

These are the commands used to create the 1st and 2nd files:

```
cmsrel CMSSW_5_3_15
cd CMSSW_5_3_15/src
cmsenv
git clone git@github.com:TaiSakuma/WorkBookMet
git checkout hats_2014_mar_fnal
cd ..
cmsRun WorkBookMet/copyPickMerge_cfg.py \
    inputFiles=/store/data/Run2012C/MinimumBias/AOD/22Jan2013-v1/20001/0434D6A7-FB73-E211-9655-00
    outputFile=ZeroBias_Run2012C_22Jan2013-v1_AOD.root \
    certFile=WorkBookMet/Cert_20140114_01_200491_JSON.txt \
    triggerConditions=HLT_ZeroBias_\* \
    maxEvents=2057  #
```

Exercises

The AOD sample files contain data collected in the run 200491.

- Find answers to the following questions by using CMS web services: CADI, iCMS, TWiki, DAS, WBM, PREP, DocDB, LXR, HLT Config Browser.
    - When were the data collected?
    - What was the HLT key used in the run?
    - Which versions of HLT_ZeroBias_* are HLT_MET120_* were used? (What were '*'s in the HLT paths in this run?)
    - What were the pre-scale columns for these HLT paths?
    - Which pre-scale column was actually used?
    - Which PDs are the data triggered by these HLT paths stored?
    - How do you locate the data?
    - Are the data currently stored at Fermilab?
- Find the same information by the command line?

Hands-on 3: Access to MET objects in AOD

Here, we will access to **`pfMet`**, particle-flow MET, which is the negative of the vector sum of pT of all reconstructed particle flow candidates in the event.

\[{\hspace{0.1ex}\not\mathrel{\hspace{-0.1ex}\vec{E}}}_\textrm{T}^\textrm{raw} = -\sum_{i\in \textrm{all}} \vec{p}_{\textrm{T}i} \]

We sometimes call it *raw pfMet* to distinguish from *corrected pfMet*, which we will produce later.

Note: In CMSSW_5_3_X, which was used to produce the sample files, **`pfMet`** is the negative of the vector sum of ET instead of pT. We switched from ET to pT at CMSSW_6_0_X.

We will use the python script:

- WorkBookMet/printMet_AOD.py

This script uses **`FWLite.Python`**, introduced at WorkBookFWLitePython.

We will use this script to access **`pfMet`** in the MC AOD sample file introduced above:

Execute the script:

```
./WorkBookMet/printMet_AOD.py --inputPath=/eos/uscms/store/user/cmsdas/2014/MET/ZeroBias_Run2012C
```

The script will print event contents as follows:

```
   run        lumi      event      met.pt      met.px      met.py     met.phi
200491         212  255053363       7.186      -1.839       6.946      104.83
200491         212  255247499      13.971      13.532       3.472       14.39
200491         212  255280539      32.086       9.459      30.660       72.85
200491         212  255343555      31.557      27.650      15.210       28.81
200491         212  255501891      23.574      19.861      12.700       32.60
200491         212  255649379       1.585       1.414      -0.716      -26.84
200491         212  255881363      18.739      13.624     -12.866      -43.36
200491         212  255988467      23.115      22.483       5.366       13.42
200491         212  256203515      13.184      -7.333     -10.956     -123.80
200491         212  256238275      27.825     -16.356     -22.511     -126.00
200491         212  256326827      31.791     -12.983     -29.019     -114.10
200491         212  256323987      20.441      19.904       4.654       13.16
200491         212  256351491      16.441      -2.489     -16.252      -98.71
200491         212  256352459      22.466     -19.864     -10.495     -152.15
200491         212  255259541      13.226      -7.177     -11.109     -122.87
200491         212  255304645      27.764      27.641      -2.611       -5.40
```

- **`run`**, **`lumi`**, **`event`** are the run number, the luminosity section, and the event id.
- **`met.pt`** is the magnitude of MET. MET is, in principle, a vector on the px-py plane. However, we often casually call its magnitude MET as well.
- **`met.px`**, **`met.py`** are the x and y components of MET respectively.
- **`met.phi`** is the azimuth of MET.

Exercises

- pfMet is not the only MET stored in AOD. Find what other METs are stored on SWGuideDataFormatRecoMET.

- Modify WorkBookMet/printMet_AOD.py and make histograms of met.px, met.py, and met.pt.
    - Why are they distributed in the way they are?
    - What are possible distribution functions?
    - Do met.px, met.py have Gaussian with the mean zero and the same variance? If so, what will be the distribution for met.pt?

To create a file in python

```
outFile = ROOT.TFile('filename.root', 'RECREATE')
```

To create a histogram in python

```
hist = ROOT.TH1D("hist_name", "hist_title", 80, -40, 40)
```

To fill a histogram

```
hist.Fill(value)
```

To save the histogram in the file and close the file

```
outFile.Write()
outFile.Close()
```

Hands-on 4: Apply MET filters

Large MET is caused not only by interesting physics processes in collisions such as production of invisible particles. In fact, large MET has more often uninteresting causes such as detector noise, *cosmic rays*, and *beam-halo* particles. MET with uninteresting causes is called *false* MET, *anomalous* MET, or *fake* MET. For an accurate reconstruction of MET, it is, therefore, not sufficient to reconstruct all visible particles produced in collisions.

We developed several algorithms to identify false MET. These algorithms, for example, use timing, pulse shape, and topology of signal. After the identified false MET is removed, the agreement of the MET spectrum with MC, in which causes of false MET are not explicitly simulated, will typically improve significantly.

Here, we will apply a set of MET filters. We will use the python configuration file:

- WorkBookMet/met_filters_cfg.py

In the configuration file, we use the Global Tag **`FT_R_53_V21::All`** at L25.

```
process.GlobalTag.globaltag = cms.string("FT_R_53_V21::All")
```

The Global Tag specifies a set of alignment and calibration constants stored in the database to be used in **`cmsRun`**. If you use the configuration file met_filters_cfg.py other than for this HATS, you might need to find the correct Global Tag at

- SWGuideFrontierConditions.

The MET group recommends a set of MET filters to be used for physics analyses. The recommendation is documented at

- MissingETOptionalFilters

Run the filters on a sample AOD file,

```
cmsRun WorkBookMet/met_filters_cfg.py inputFiles=file:/eos/uscms/store/user/cmsdas/2014/MET/MET12
```

Exercises

- The sample AOD file contains 201 events triggered by **`HLT_MET120_*`**.
    - How many events are rejected by which filters?
    - How many events are not rejected by any filter?

- Look at events with **`cmsShow`**.

```
cmsShow /eos/uscms/store/user/cmsdas/2014/MET/MET120_Run2012C_22Jan2013-v1_AOD_numEvent201.root
```

Hands-on 5: Apply MET corrections

MET objects accessed above are called *raw MET*. The raw MET is systematically different from true MET, i.e., the transverse momentum carried by invisible particles, for many reasons including the non-compensating nature of the calorimeters and detector misalignment. To make MET a better estimate of true MET, we will apply MET corrections with the python configuration file:

- WorkBookMet/corrMet_cfg.py

```
cmsRun ./WorkBookMet/corrMet_cfg.py inputFiles=file:/eos/uscms/store/user/cmsdas/2014/MET/TTJets_
```

This will produce a file **`corrMet.root`**, which contains various MET collections, each with different combinations of the MET corrections as summarized in the table.

module name	descriptions
pfMetT0rt	pfMET + Type-0RT
pfMetT0rtT1	pfMET + Type-0RT + Type-I
pfMetT0pc	pfMET + Type-0PC
pfMetT0pcT1	pfMET + Type-0PC + Type-I
pfMetT0rtTxy	pfMET + Type-0RT + xy-Shift
pfMetT0rtT1Txy	pfMET + Type-0RT + Type-I + xy-Shift
pfMetT0pcTxy	pfMET + Type-0PC + xy-Shift
pfMetT0pcT1Txy	pfMET + Type-0PC + Type-I + xy-Shift
pfMetT1	pfMET + Type-I
pfMetT1Txy	pfMET + Type-I + xy-Shift

The python script printMet_corrMet.py shows an exmple how to access to the corrected METs in **`corrMet.root`**.

```
./WorkBookMet/printMet_corrMet.py --inputPath=./corrMet.root
```

This will simply print the contents as follows.

```
   run        lumi      event              module      met.pt      met.px      met.py     met.phi
     1       34734   10417901               pfMet      36.837      18.857     -31.645      -59.21
     1       34734   10417901           pfMetT0rt      32.819       9.912     -31.286      -72.42
     1       34734   10417901         pfMetT0rtT1      37.309      -0.433     -37.307      -90.67
     1       34734   10417901           pfMetT0pc      32.296       9.728     -30.796      -72.47
     1       34734   10417901         pfMetT0pcT1      36.822      -0.618     -36.816      -90.96
     1       34734   10417901             pfMetT1      38.615       8.511     -37.665      -77.27
     1       34734   10417901        pfMetT0rtTxy      29.873      10.417     -27.998      -69.59
     1       34734   10417901      pfMetT0rtT1Txy      34.018       0.072     -34.018      -89.88
     1       34734   10417901        pfMetT0pcTxy      29.349      10.233     -27.508      -69.59
```

1	34734	10417901	pfMetT0pcT1Txy	33.528	-0.113	-33.528	-90.19
1	34734	10417901	pfMetT1Txy	35.539	9.016	-34.377	-75.30
1	34734	10417902	pfMet	19.955	-16.211	-11.636	-144.33
1	34734	10417902	pfMetT0rt	15.390	-9.634	-12.002	-128.76
1	34734	10417902	pfMetT0rtT1	12.675	-5.521	-11.410	-115.82
1	34734	10417902	pfMetT0pc	16.339	-13.267	-9.537	-144.29
1	34734	10417902	pfMetT0pcT1	12.799	-9.153	-8.945	-135.66
1	34734	10417902	pfMetT1	16.381	-12.098	-11.044	-137.61
1	34734	10417902	pfMetT0rtTxy	14.504	-9.535	-10.929	-131.10
1	34734	10417902	pfMetT0rtT1Txy	11.672	-5.421	-10.337	-117.68
1	34734	10417902	pfMetT0pcTxy	15.653	-13.167	-8.465	-147.27
1	34734	10417902	pfMetT0pcT1Txy	11.998	-9.054	-7.873	-138.99
1	34734	10417902	pfMetT1Txy	15.601	-11.998	-9.971	-140.2

Hands-on 6: Learn MET in pile-up interactions

Exercises

In the Exercises in Hands-on 3, we modified WorkBookMet/printMet_AOD.py and made histograms of met.px, met.py, and met.pt. Here we study how these distributions change with the number of the pile-up interactions.

- Modify WorkBookMet/printMet_AOD.py further and make the same histograms of met.px, met.py, and met.pt for each of the four different ranges of the number of the reconstructed vertices: [1, 9], [10, 19], [20, 26], and [27, ∞].

You can make **`handle`** for vertices as

```
handleVertex = Handle("std::vector<reco::Vertex>")
```

With this handle, the number of the reconstructed vertices can be obtained with the following piece of code:

```
event.getByLabel(("offlinePrimaryVertices", "", ""), handleVertex)
vertices = handleVertex.product()
nvtx = len(vertices)
```

-- TaiSakuma - 18 Mar 2014

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