HEAVY IONS PHYSICS AND OPERATIONS OF ELECTROMAGNETIC CALORIMETER

ANALYSIS OF THE MASS SPECTRUM OF THE PRODUCTION OF TWO MUONS IN THE COLLISION OF HEAVY IONS, AND OBTAINING THE STANDARD CANDLES

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PROJECT AND OBJECTIVES

The objective of this project is the understanding of quark-gluon plasma (QGP) and his influence in the production of particle in heavy ions collisions. To understand these Properties, we intend to analyze the spectrum of mass in the production of pairs of muons by recreating their invariant mass and the standard candles, and compare to the proton collisions.

We will analyze the DATA provided by CERN in the Open Data portal. So far, we have four images to work with, but we only analyzed two of them because the others were recently released.

The images we are working with are from 2010, 2011, 2013 and 2015, but the 2013 and 2015 were recently released, so we haven't done much testing on them yet. In this presentation, we will focus on the 2010 and 2011 releases and show some of the problems we encountered and how we overcome them.

2010 IMAGE 3_9_2 AND PROBLEMS

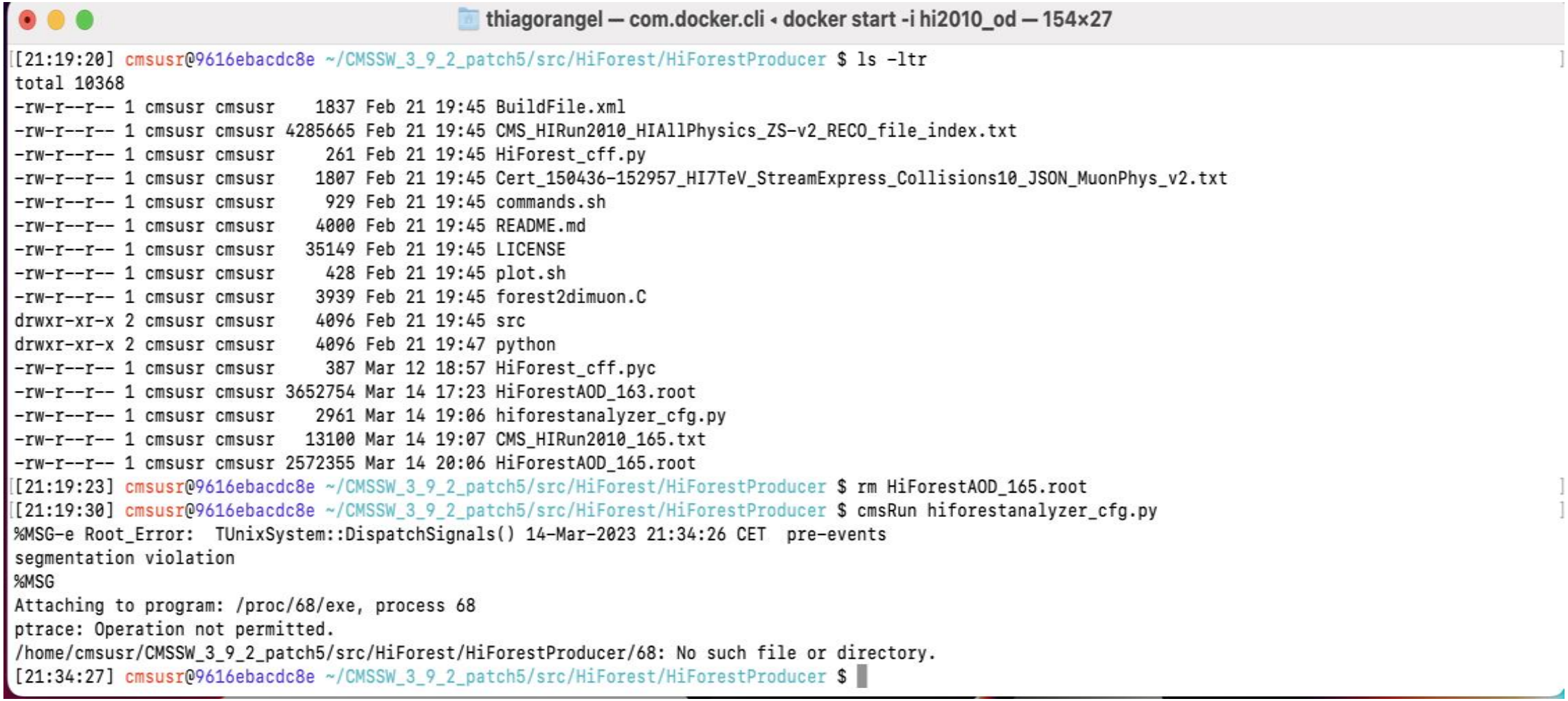
In the 2010 and 2011 images, we encountered some problems with download and setting up The container, but we were able to resolve all the issues.

The problem we are currently facing is the generation of the root files for 2010, which will be used to construct the plots. We haven't been able to completed the plots due to the reccuring erros that seem unavoidable. Since we have 32,372 input files, the problems are quite frequent.

Furthermore, we can't perform direct analysis with all of the files due to erros. Therefore, we must separate the original file into smaller batches and change the input files names each time during the analysis, which has resulted in significant loss of time.

2010 ERROS ON MAC

These erros are really recurrent on the Mac (ventura 13.2.1)



2010 ERROS ON MAC

thiagorangel — com.docker.cli ◂ docker start -i hi2010_od — 149×28

```
HLT_HIMinBiasPixel_SingleTrack   Trigger path status: WasRun=1 Accept=1 Error =0
HLT_HIMinBiasPixel_SingleTrack
Muons before selection: 3
Begin processing the 36516th record. Run 152766, Event 149111, LumiSection 24 at 15-Mar-2023 17:39:06.436 CET
HLT_HIMinBiasHfOrBSC     Trigger path status: WasRun=1 Accept=1 Error =0
HLT_HIMinBiasHfOrBSC
HLT_HIMinBiasPixel_SingleTrack   Trigger path status: WasRun=1 Accept=1 Error =0
HLT_HIMinBiasPixel_SingleTrack
Muons before selection: 0
15-Mar-2023 17:39:06 CET  Closed file root://eospublic.cern.ch//eos/opendata/cms/hidata/HIRun2010/HIAllPhysics/RECO/ZS-v2/0016/386ECF2A-8642-E011-8F8
C-0030487CD190.root
15-Mar-2023 17:39:06 CET  Initiating request to open file root://eospublic.cern.ch//eos/opendata/cms/hidata/HIRun2010/HIAllPhysics/RECO/ZS-v2/0016/38
ECB540-2641-E011-8B3D-003048F24610.root
230315 17:39:07 001 crypto_X509CreateProxy: EEC certificate cannot be opened (file: /home/cmsusr/.globus/usercert.pem)
15-Mar-2023 17:39:10 CET  Successfully opened file root://eospublic.cern.ch//eos/opendata/cms/hidata/HIRun2010/HIAllPhysics/RECO/ZS-v2/0016/38ECB540-
2641-E011-8B3D-003048F24610.root
*** glibc detected *** cmsRun: malloc(): smallbin double linked list corrupted: 0x00000000059f8920 ***
======= Backtrace: =========
/lib64/libc.so.6[0x7fe28a1a1a3b]
/lib64/libc.so.6(__libc_malloc+0x6e)[0x7fe28a1a2dfe]
/opt/cms/slc5_amd64_gcc434/external/gcc/4.3.4/lib64/libstdc++.so.6(_Znwm+0x1d)[0x7fe28aa0098d]
cmsRun(_ZNSt6vectorISsSaISsEE13_M_insert_auxEN9__gnu_cxx17__normal_iteratorIPSsS1_EERKSs+0xd6)[0x410166]
/opt/cms/slc5_amd64_gcc434/cms/cmssw-patch/CMSSW_3_9_2_patch5/lib/slc5_amd64_gcc434/libFWCoreParameterSet.so(_ZN3edm5splitISt20back_insert_iteratorIS
t6vectorISsSaISsEEEEEbT_RKSsccc+0x16f)[0x7fe28d95d55f]
/opt/cms/slc5_amd64_gcc434/cms/cmssw-patch/CMSSW_3_9_2_patch5/lib/slc5_amd64_gcc434/libFWCoreParameterSet.so(_ZN3edm12ParameterSet10fromStringERKSs+0
x5d)[0x7fe28d957fcd]
/opt/cms/slc5_amd64_gcc434/cms/cmssw-patch/CMSSW_3_9_2_patch5/lib/slc5_amd64_gcc434/libFWCoreParameterSet.so(_ZN3edm12ParameterSetC1ERKSs+0xb7)[0x7fe
28d959837]
```

2010 ERROS ON LINUX

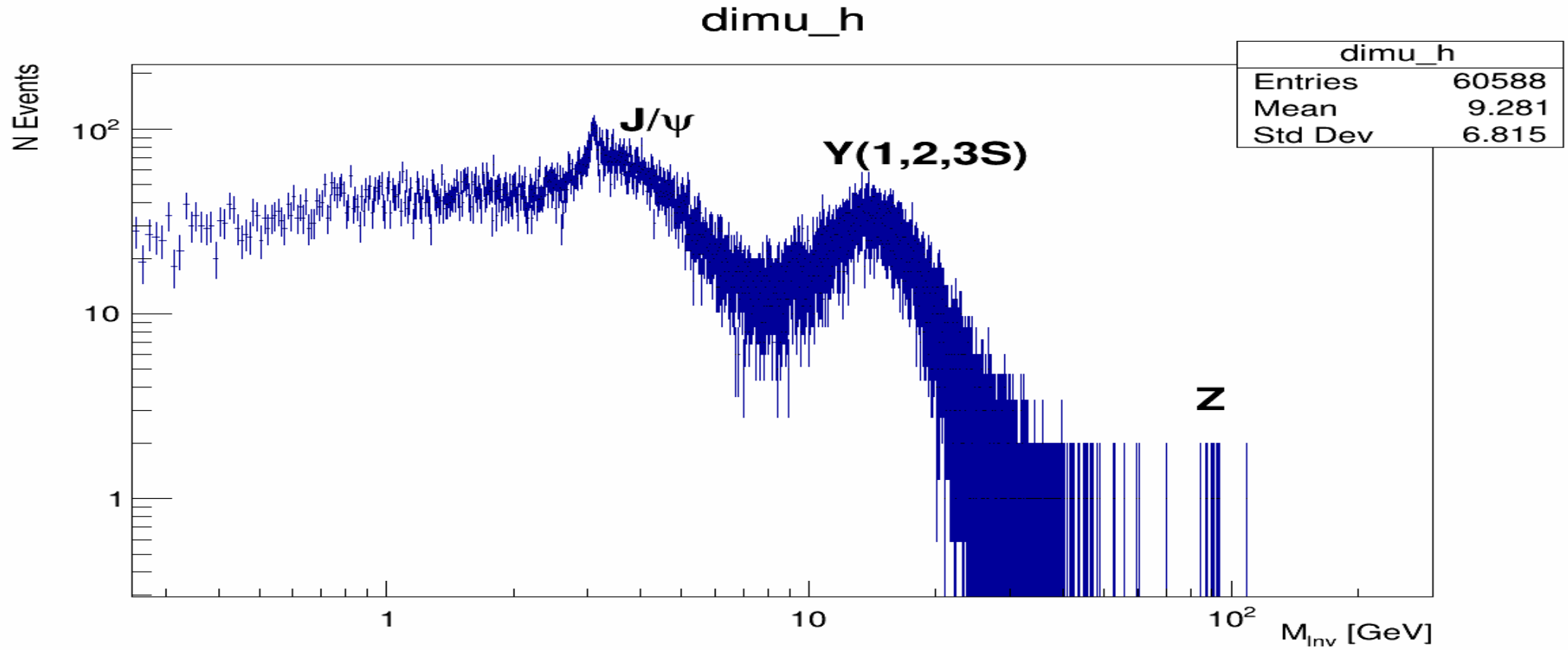
```
HLT_HIMinBiasZDC_Calo
Muons before selection: 0
15-Mar-2023 19:55:20 CET  Closed file root://eospublic.cern.ch//eos/opendata/cms/hidata/HIRun2010/HIAllPhysics/RECO/ZS-v2/0016/BCEEB388-3F42-E
011-9A57-003048FEB8CE.root
15-Mar-2023 19:55:20 CET  Initiating request to open file root://eospublic.cern.ch//eos/opendata/cms/hidata/HIRun2010/HIAllPhysics/RECO/ZS-v2/
0016/BE1B8486-C843-E011-8FAF-003048CF6D02.root
15-Mar-2023 19:55:23 CET  Successfully opened file root://eospublic.cern.ch//eos/opendata/cms/hidata/HIRun2010/HIAllPhysics/RECO/ZS-v2/0016/BE
1B8486-C843-E011-8FAF-003048CF6D02.root
15-Mar-2023 19:55:29 CET  Closed file root://eospublic.cern.ch//eos/opendata/cms/hidata/HIRun2010/HIAllPhysics/RECO/ZS-v2/0016/BE1B8486-C843-E
011-8FAF-003048CF6D02.root
15-Mar-2023 19:55:29 CET  Initiating request to open file root://eospublic.cern.ch//eos/opendata/cms/hidata/HIRun2010/HIAllPhysics/RECO/ZS-v2/
0016/BE23436A-3842-E011-88A5-003048F02D34.root
%MSG-s CMSException:  AfterModEndRun 15-Mar-2023 19:55:49 CET PostEndRun
cms::Exception caught in cmsRun
---- FileOpenError BEGIN
---- FatalRootError BEGIN
Fatal Root Error: @SUB=TXNetFile::CreateXClient
open attempt failed on root://eospublic.cern.ch//eos/opendata/cms/hidata/HIRun2010/HIAllPhysics/RECO/ZS-v2/0016/BE23436A-3842-E011-88A5-003048
F02D34.root
---- FatalRootError END

RootInputFileSequence::initFile(): Input file root://eospublic.cern.ch//eos/opendata/cms/hidata/HIRun2010/HIAllPhysics/RECO/ZS-v2/0016/BE23436
A-3842-E011-88A5-003048F02D34.root was not found or could not be opened.
cms::Exception caught in EventProcessor and rethrown
---- FileOpenError END


%MSG

=============================================

MessageLogger Summary

 type     category         sev    module        subroutine        count    total
 ---- -------------------- -- ---------------- ----------------  -----    -----
    1 CMSException          -s AfterModEndRun                       1        1
```

2010 ERROS ON LINUX

```
md64_gcc434/libFWCorePluginManager.so
7f89d8d72000-7f89d8dad000 rwxp 00000000 00:57 15368654                   /cvmfs/cms.cern.ch/slc5_amd64_gcc434/cms/cmssw/CMSSW_3_9_2/lib/slc5_a
md64_gcc434/libFWCoreMessageLogger.so
7f89d8dad000-7f89d8ef6000 rwxp 00000000 00:57 15368588                   /cvmfs/cms.cern.ch/slc5_amd64_gcc434/cms/cmssw/CMSSW_3_9_2/lib/slc5_a
md64_gcc434/libDataFormatsProvenance.so
7f89d8ef6000-7f89d8efb000 rwxp 00000000 00:00 0
7f89d8efb000-7f89d8fca000 rwxp 00000000 00:57 15360025                   /cvmfs/cms.cern.ch/slc5_amd64_gcc434/cms/cmssw-patch/CMSSW_3_9_2_patc
h5/lib/slc5_amd64_gcc434/libFWCoreParameterSet.so
7f89d8fca000-7f89d9095000 rwxp 00000000 00:57 15368541                   /cvmfs/cms.cern.ch/slc5_amd64_gcc434/cms/cmssw/CMSSW_3_9_2/lib/slc5_a
md64_gcc434/libDataFormatsCommon.so
7f89d9095000-7f89d9098000 rwxp 00000000 00:00 0
7f89d9098000-7f89d9127000 rwxp 00000000 00:57 15368659                   /cvmfs/cms.cern.ch/slc5_amd64_gcc434/cms/cmssw/CMSSW_3_9_2/lib/slc5_a
md64_gcc434/libFWCorePythonParameterSet.so
7f89d9127000-7f89d913c000 rwxp 00000000 00:57 15368648                   /cvmfs/cms.cern.ch/slc5_amd64_gcc434/cms/cmssw/CMSSW_3_9_2/lib/slc5_a
md64_gcc434/libFWCoreCommon.so
7f89d913c000-7f89d915b000 rwxp 00000000 00:57 15368661                   /cvmfs/cms.cern.ch/slc5_amd64_gcc434/cms/cmssw/CMSSW_3_9_2/lib/slc5_a
md64_gcc434/libFWCoreServiceRegistry.so
7f89d915b000-7f89d9178000 r-xp 00000000 00:57 15229905                   /lib64/ld-2.5.so
7f89d9178000-7f89d917b000 rwxp 00000000 00:57 15734570                   /cvmfs/cms.cern.ch/slc5_amd64_gcc434/external/boost/1.42.0-cms/lib/li
bboost_system.so.1.42.0
7f89d917b000-7f89d917e000 rw-p 00000000 00:00 0
7f89d917e000-7f89d9180000 rwxp 00000000 00:57 15360026                   /cvmfs/cms.cern.ch/slc5_amd64_gcc434/cms/cmssw-patch/CMSSW_3_9_2_patc
h5/lib/slc5_amd64_gcc434/libFWCoreVersion.so
7f89d9180000-7f89d9184000 rw-p 00000000 00:00 0
7f89d9184000-7f89d9373000 rwxp 00000000 00:57 15368650                   /cvmfs/cms.cern.ch/slc5_amd64_gcc434/cms/cmssw/CMSSW_3_9_2/lib/slc5_a
md64_gcc434/libFWCoreFramework.so
7f89d9373000-7f89d9374000 rwxp 00000000 00:00 0
7f89d9374000-7f89d9377000 rw-p 00000000 00:00 0
7f89d9377000-7f89d9378000 r--p 0001c000 00:57 15229905                   /lib64/ld-2.5.so
7f89d9378000-7f89d9379000 rw-p 0001d000 00:57 15229905                   /lib64/ld-2.5.so
7ffebb345000-7ffebb37d000 rwxp 00000000 00:00 0                          [stack]
7ffebb37d000-7ffebb383000 rw-p 00000000 00:00 0
7ffebb3ed000-7ffebb3f1000 r--p 00000000 00:00 0                          [vvar]
7ffebb3f1000-7ffebb3f3000 r-xp 00000000 00:00 0                          [vdso]
ffffffffff600000-ffffffffff601000 --xp 00000000 00:00 0                  [vsyscall]
Aborted (core dumped)
[02:58:34] cmsusr@8e8fbbff77f7 /code/CMSSW_3_9_2_patch5/src/HiForest/HiForestProducer $
[02:58:34] cmsusr@8e8fbbff77f7 /code/CMSSW_3_9_2_patch5/src/HiForest/HiForestProducer $
```

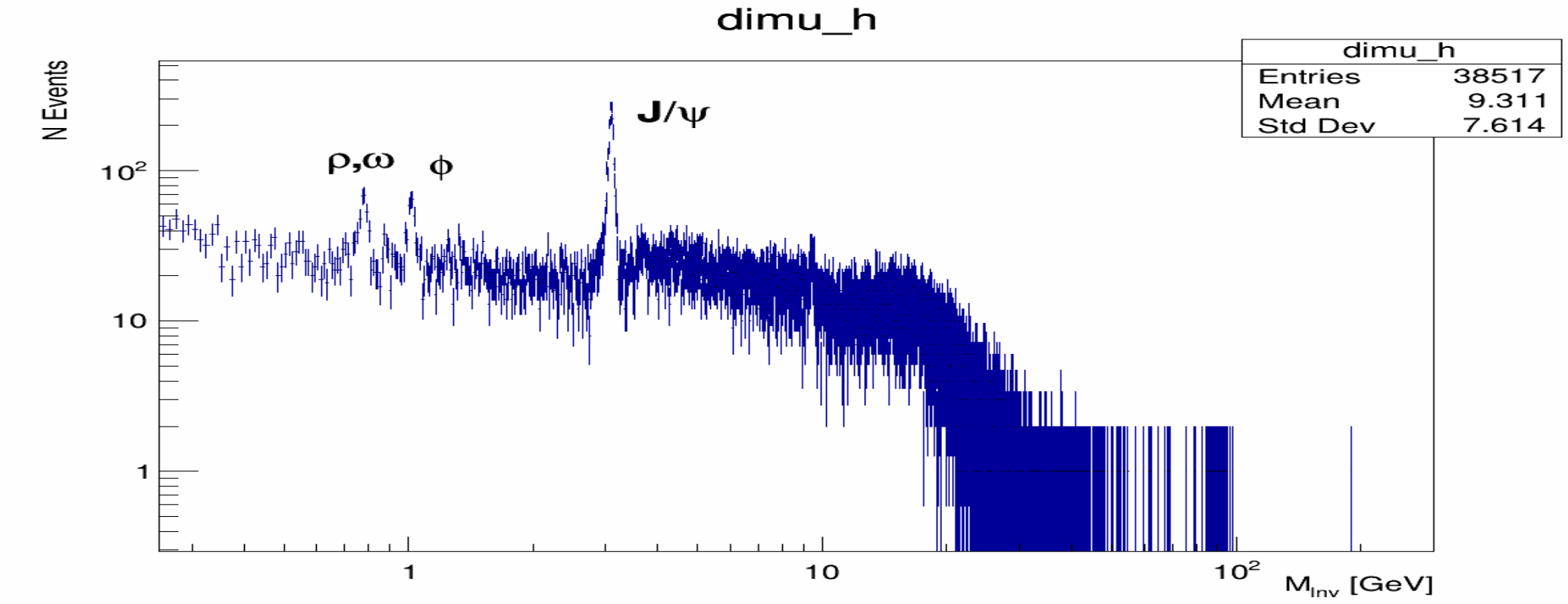
2010 PLOT AND RESULTS

Despite the problems we were able to produce some root files and so on this histogram and for now is what we have for 2010



2011 PLOT AND RESULTS

The problems we have with 2010 are the same of 2011 the unique diference is that the 2011 has only 1102 input files and for that we were able finish the analysis and the Plot is:



2013 IMAGE 5_3_20 AND TEST

In this new images we only look for the directories and if the script were running. In this image we have all the directories (FWCore, GeneratorInterface, HeavyIonsAnalysis, RecoJets) and we had no problem running the "runForest_pPb_DATA_53_X.py" except that the output has this strange message:

2013 IMAGE 5_3_20 AND TEST

```
     2 Parameter rho not us -w JetCorrFactorsPr                                  1           1
     3 Parameter rho not us -w JetCorrFactorsPr                                  1           1
     4 Parameter rho not us -w JetCorrFactorsPr                                  1           1
     5 Parameter rho not us -w JetCorrFactorsPr                                  1           1
     6 Parameter rho not us -w JetCorrFactorsPr                                  1           1
     7 Parameter rho not us -w JetCorrFactorsPr                                  1           1
     8 Parameter rho not us -w JetCorrFactorsPr                                  1           1
     9 Parameter rho not us -w JetCorrFactorsPr                                  1           1
    10 Parameter rho not us -w JetCorrFactorsPr                                  1           1
    11 Parameter rho not us -w JetCorrFactorsPr                                  1           1
    12 Parameter rho not us -w JetCorrFactorsPr                                  1           1
    13 fileAction               -s file_close                                    1           1
    14 fileAction               -s file_open                                     2           2

 type     category     Examples: run/evt          run/evt           run/evt
 ---- -------------------- ---------------- ---------------- ----------------
     1 Parameter rho not used pre-events
     2 Parameter rho not used pre-events
     3 Parameter rho not used pre-events
     4 Parameter rho not used pre-events
     5 Parameter rho not used pre-events
     6 Parameter rho not used pre-events
     7 Parameter rho not used pre-events
     8 Parameter rho not used pre-events
     9 Parameter rho not used pre-events
    10 Parameter rho not used pre-events
    11 Parameter rho not used pre-events
    12 Parameter rho not used pre-events
    13 fileAction              PostEndRun
    14 fileAction              pre-events        pre-events

Severity     # Occurrences    Total Occurrences
--------     -------------    -----------------
Warning                 12                   12
System                   3                    3
[21:16:18] cmsusr@696bccefdc14 HeavyIonsAnalysis/JetAnalysis/test $
```

2015 IMAGE 7_5_8 AND TEST

In this image we don't have the FWcore directory, but all the others are present and we also had no problem running the "runForest_pp_DATA_75X.py" except that there is a output called HIPhotonIsolation that should not exist in the proton-proton collision.

2015 IMAGE 7_5_8 AND TEST

```
Exception Message:
Principal::getByToken: Found zero products matching all criteria
Looking for type: edm::ValueMap<reco::HIPhotonIsolation>
Looking for module label: photonIsolationHIProducerpp
Looking for productInstanceName:

   Additional Info:
      [a] If you wish to continue processing events after a ProductNotFound exception,
add "SkipEvent = cms.untracked.vstring('ProductNotFound')" to the "options" PSet in the configuration.

----- End Fatal Exception -------------------------------------------------
15-Mar-2023 21:21:19 CET  Closed file root://eospublic.cern.ch//eos/opendata/cms/Run2015E/MinimumBias1/AOD/PromptReco-v1/000/261/395/00000/96A
E7BB7-308E-E511-A5DC-02163E012148.root

========================================

MessageLogger Summary

 type     category         sev    module        subroutine        count    total
 ---- -------------------- -- ---------------  ----------------  -----    -----
    1 OpenHLT              -w HLTBitAnalyzer:h                      1        1
    2 XrdAdaptor           -w file_open                             1        1
    3 Fatal Exception      -s PostProcessPath                       1        1
    4 fileAction           -s file_close                            1        1
    5 fileAction           -s file_open                             2        2

 type    category    Examples: run/evt        run/evt          run/evt
 ---- -------------------- --------------- ---------------- ---------------
    1 OpenHLT              261395/1386360
    2 XrdAdaptor           pre-events
    3 Fatal Exception      261395/1386360
    4 fileAction           PostEndRun
    5 fileAction           pre-events       pre-events

Severity    # Occurrences   Total Occurrences
--------    -------------   -----------------
```

CONCLUSION

Despite the normal occurrence of the erros, we are making progress and aiming to analyse all the root files for the 2010 image. We are also searching

for new input files to improve statistics and visualization of the standard candles for both cases.

I'm awaiting updates on how to proceed with the new images from 2013 and 2015, and i hope to see the plots for these new images.

If everything works out, and we complete these analysis, we will likely create plots of transversal momentum, energy and other characteristics of photons in heavy ion collisions.