Centrality Filters on miniAOD

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CMSSW and MB Samples

CMSSW_10_3_3_pre1

- MB dataset (6960 events)
  - AOD:
    - /eos/cms/store/group/phys_heavyions/mnguyen/miniAOD/FF6B819E-F476-8E43-A322-77A7BE3E36EB.root
  - miniAOD without centrality filters:
    - /afs/cern.ch/work/d/ddesouza/public/Cent_filter/reMiniAOD_DATA_PAT_withoutCentfilter.root (same as in HIN eos)
  - miniAOD with centrality filters:
    - /afs/cern.ch/work/d/ddesouza/public/Cent_filter/reMiniAOD_DATA_PAT_withCentfilter.root

Codes

Recipe to do AOD->miniAOD

- https://twiki.cern.ch/twiki/bin/view/CMS/HiReco2021#Recipe_to_produce_mini_AOD_from

Track control plots (packedPFCandidates)

- https://github.com/CesarBernardes/cmssw/blob/PFCandidateAnalyzer_CMSSW_11_1_X/PFCandAnalyzer.cc

Timing studies (from tracking)

- https://github.com/cmsHiTracking/TrackingCode/tree/CMSSW_10_2_0_pre5_trkAnalysis/HITrackingStudies/Timing

Example code to access the filters in miniAOD

- https://github.com/denerslemos/Centrality_Filters_in_miniAOD

Changes on miniAOD

First, need to update hfCoincFilter_cff.py for miniAOD

- From:
  - https://github.com/CmsHI/cmssw/blob/hiMiniAOD_103X/HeavyIonsAnalysis/Configuration/python/hfCoincFilter_cff.py
- To:
  - https://github.com/CmsHI/cmssw/blob/forest_CMSSW_10_3_1/HeavyIonsAnalysis/Configuration/python/hfCoincFilter_cff.py

Second, easy way to include the filter is using same MET schema, basically store the filters as “triggers”

- https://twiki.cern.ch/twiki/bin/view/CMSPublic/WorkBookMiniAOD2017#ETmiss_filters
- https://github.com/cms-sw/cmssw/blob/master/PhysicsTools/PatAlgos/python/slimming/MicroEventContent_cff.py#L73
- https://twiki.cern.ch/twiki/bin/viewauth/CMS/MissingETOptionalFiltersRun2

Incluing filters as “triggers” (I)

Can be included in reMiniAOD_DATA_PAT.py as

- hfCoincFilter_cff.py:

```
process.load('HeavyIonsAnalysis.Configuration.hfCoincFilter_cff')
```

- Than include the “cmsPath” for each filter (example for *hfCoincFilter2Th4)*:

```
process.Flag_hfCoincFilter2Th4 = cms.Path(process.hfCoincFilter2Th4)
```

  - There are in total 72 filters

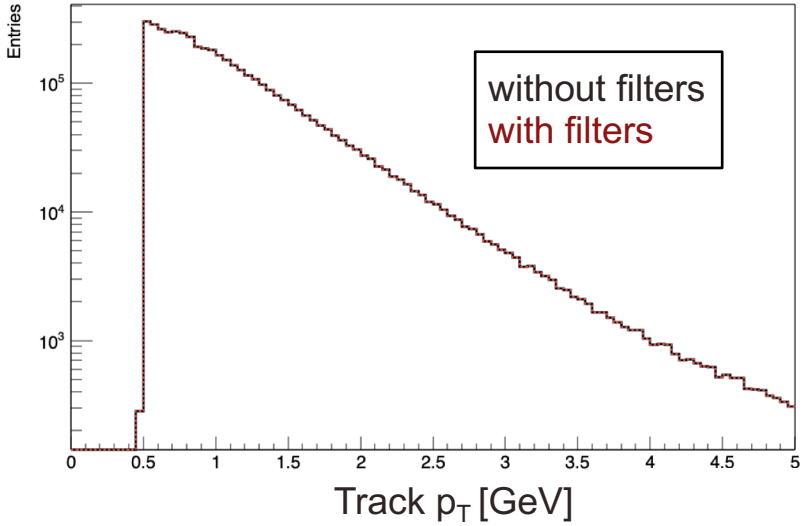
- Then include each path in the sequence

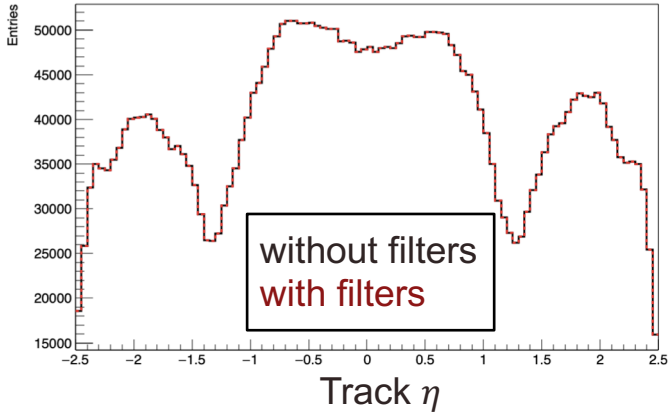
```
# Schedule definition
process.schedule = cms.Schedule(process.Flag_HBHENoiseFilter,process.Flag_HBHENoiseIsoFilter,process.Flag_CSCTightHaloFilter,process.Flag_CSCTightHaloTrkMuUnvetoFilter,process.Flag_CSCTightHalo2015Filter,
process.Flag_globalTightHalo2016Filter,process.Flag_globalSuperTightHalo2016Filter,process.Flag_HcalStripHaloFilter,process.Flag_hcalLaserEventFilter,process.Flag_EcalDeadCellTriggerPrimitiveFilter,proces
s.Flag_EcalDeadCellBoundaryEnergyFilter,process.Flag_ecalBadCalibFilter,process.Flag_goodVertices,process.Flag_eeBadScFilter,process.Flag_ecalLaserCorrFilter,process.Flag_trkPOGFilters,process.Flag_charge
dHadronTrackResolutionFilter,process.Flag_muonBadTrackFilter,process.Flag_BadChargedCandidateFilter,process.Flag_BadPFMuonFilter,process.Flag_BadChargedCandidateSummer16Filter,process.Flag_BadPFMuonSummer
16Filter,process.Flag_trkPOG_manystripclus53X,process.Flag_trkPOG_toomanystripclus53X,process.Flag_trkPOG_logErrorTooManyClusters,process.Flag_METFilters,process.Flag_towersAboveThreshold,process.Flag_tow
ersAboveThresholdTh2,process.Flag_towersAboveThresholdTh4,process.Flag_towersAboveThresholdTh5,process.Flag_hfPosTowers,process.Flag_hfNegTowers,process.Flag_hfPosTowersTh2,process.Flag_hfNegTowersTh2,pro
cess.Flag_hfPosTowersTh4,process.Flag_hfNegTowersTh4,process.Flag_hfPosTowersTh5,process.Flag_hfNegTowersTh5,process.Flag_hfPosFilter,process.Flag_hfNegFilter,process.Flag_hfPosFilterTh2,process.Flag_hfNe
gFilterTh2,process.Flag_hfPosFilterTh4,process.Flag_hfNegFilterTh4,process.Flag_hfPosFilterTh5,process.Flag_hfNegFilterTh5,process.Flag_hfCoincFilterTh2,process.Flag_hfCoincFilterTh3,process.Flag_hfCoincF
ilterTh4,process.Flag_hfCoincFilterTh5,process.Flag_hfPosFilter2,process.Flag_hfNegFilter2,process.Flag_hfPosFilter2Th2,process.Flag_hfNegFilter2Th2,process.Flag_hfPosFilter2Th4,process.Flag_hfNegFilter2T
h4,process.Flag_hfPosFilter2Th5,process.Flag_hfNegFilter2Th5,process.Flag_hfCoincFilter2Th2,process.Flag_hfCoincFilter2Th3,process.Flag_hfCoincFilter2Th4,process.Flag_hfCoincFilter2Th5,process.Flag_hfPosF
ilter3,process.Flag_hfNegFilter3,process.Flag_hfPosFilter3Th2,process.Flag_hfNegFilter3Th2,process.Flag_hfPosFilter3Th4,process.Flag_hfNegFilter3Th4,process.Flag_hfPosFilter3Th5,process.Flag_hfNegFilter3T
h5,process.Flag_hfCoincFilter3Th2,process.Flag_hfCoincFilter3Th3,process.Flag_hfCoincFilter3Th4,process.Flag_hfCoincFilter3Th5,process.Flag_hfPosFilter4,process.Flag_hfNegFilter4,process.Flag_hfPosFilter4
Th2,process.Flag_hfNegFilter4Th2,process.Flag_hfPosFilter4Th4,process.Flag_hfNegFilter4Th4,process.Flag_hfPosFilter4Th5,process.Flag_hfNegFilter4Th5,process.Flag_hfCoincFilter4Th2,process.Flag_hfCoincFilt
er4Th3,process.Flag_hfCoincFilter4Th4,process.Flag_hfCoincFilter4Th5,process.Flag_hfPosFilter5,process.Flag_hfNegFilter5,process.Flag_hfPosFilter5Th2,process.Flag_hfNegFilter5Th2,process.Flag_hfPosFilter5
Th4,process.Flag_hfNegFilter5Th4,process.Flag_hfPosFilter5Th5,process.Flag_hfNegFilter5Th5,process.Flag_hfCoincFilter5Th2,process.Flag_hfCoincFilter5Th3,process.Flag_hfCoincFilter5Th4,process.Flag_hfCoinc
Filter5Th5,process.endjob_step,process.MINIAODoutput_step)
```

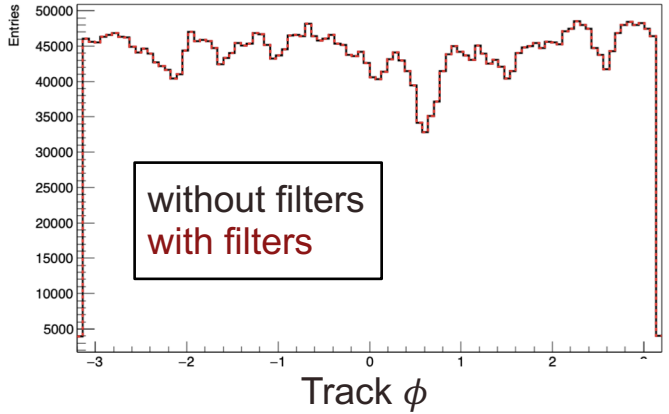
miniAOD with and without the filters

Using packedPFCandidates collection

No filter is applied, only implemented







No difference on track distributions

Checking filter in miniAOD

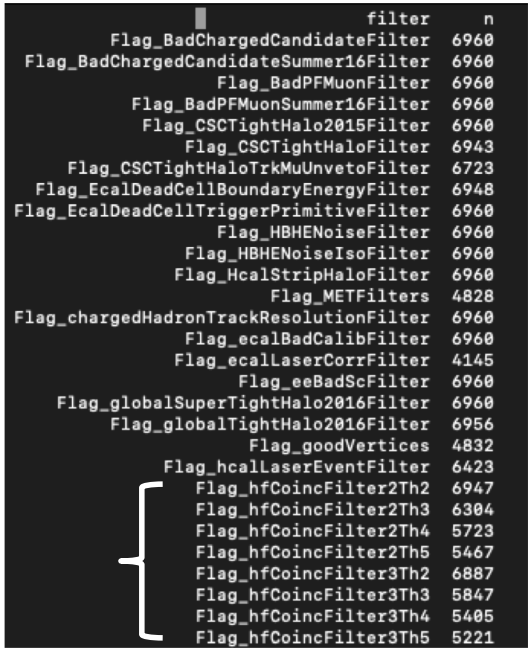
Is possible to check that using this code: [github]

No centrality filter

filter	n
Flag_BadChargedCandidateFilter	6960
Flag_BadChargedCandidateSummer16Filter	6960
Flag_BadPFMuonFilter	6960
Flag_BadPFMuonSummer16Filter	6960
Flag_CSCTightHalo2015Filter	6960
Flag_CSCTightHaloFilter	6943
Flag_CSCTightHaloTrkMuUnvetoFilter	6723
Flag_EcalDeadCellBoundaryEnergyFilter	6948
Flag_EcalDeadCellTriggerPrimitiveFilter	6960
Flag_HBHENoiseFilter	6960
Flag_HBHENoiseIsoFilter	6960
Flag_HcalStripHaloFilter	6960
Flag_METFilters	4828
Flag_chargedHadronTrackResolutionFilter	6960
Flag_ecalBadCalibFilter	6960
Flag_ecalLaserCorrFilter	4145
Flag_eeBadScFilter	6960
Flag_globalSuperTightHalo2016Filter	6960
Flag_globalTightHalo2016Filter	6956
Flag_goodVertices	4832
Flag_hcalLaserEventFilter	6423
Flag_muonBadTrackFilter	6960
Flag_trkPOGFilters	6960
Flag_trkPOG_logErrorTooManyClusters	6960
Flag_trkPOG_manystripclus53X	6960
Flag_trkPOG_toomanystripclus53X	6960

n: number of events passing the filter

With centrality filter



filter	n
Flag_BadChargedCandidateFilter	6960
Flag_BadChargedCandidateSummer16Filter	6960
Flag_BadPFMuonFilter	6960
Flag_BadPFMuonSummer16Filter	6960
Flag_CSCTightHalo2015Filter	6960
Flag_CSCTightHaloFilter	6943
Flag_CSCTightHaloTrkMuUnvetoFilter	6723
Flag_EcalDeadCellBoundaryEnergyFilter	6948
Flag_EcalDeadCellTriggerPrimitiveFilter	6960
Flag_HBHENoiseFilter	6960
Flag_HBHENoiseIsoFilter	6960
Flag_HcalStripHaloFilter	6960
Flag_METFilters	4828
Flag_chargedHadronTrackResolutionFilter	6960
Flag_ecalBadCalibFilter	6960
Flag_ecalLaserCorrFilter	4145
Flag_eeBadScFilter	6960
Flag_globalSuperTightHalo2016Filter	6960
Flag_globalTightHalo2016Filter	6956
Flag_goodVertices	4832
Flag_hcalLaserEventFilter	6423
Flag_hfCoincFilter2Th2	6947
Flag_hfCoincFilter2Th3	6304
Flag_hfCoincFilter2Th4	5723
Flag_hfCoincFilter2Th5	5467
Flag_hfCoincFilter3Th2	6887
Flag_hfCoincFilter3Th3	5847
Flag_hfCoincFilter3Th4	5405
Flag_hfCoincFilter3Th5	5221

...continue…

Incluing filters as “triggers”

Size

- Adding centrality filters, the file is 76201 bytes bigger for 6960 events
  - All the 72 filters are taking ~ 11 bytes per event

Timing

- Small time difference: without filter is 0.0134 s/ev and with filter: 0.0139 s

No differences using edmDumpEventContent

An example code, how to access/use this filters can be found on:

- https://github.com/denerslemos/Centrality_Filters_in_miniAOD/blob/master/DemoAnalyzer.cc

Cross-Check using *hfCoincFilter2Th4*

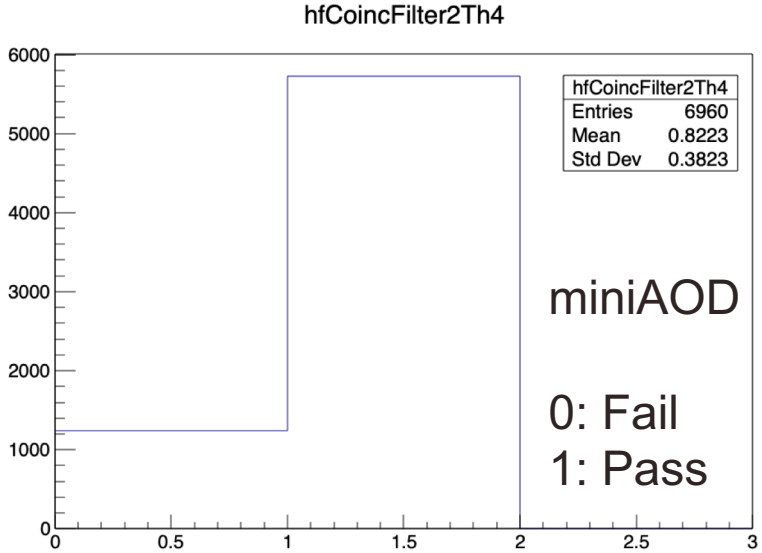
hfCoincFilter2Th4 is a default filter used for 2018 PbPb data

AOD (default centrality filter on cfg file)

```
TrigReport ---------- Event  Summary ------------
TrigReport Events total = 6960 passed = 5723 failed = 1237
```

miniAOD (using the example code)

```
Total of events: 6960
Pass: 5723
Fail: 1237
```

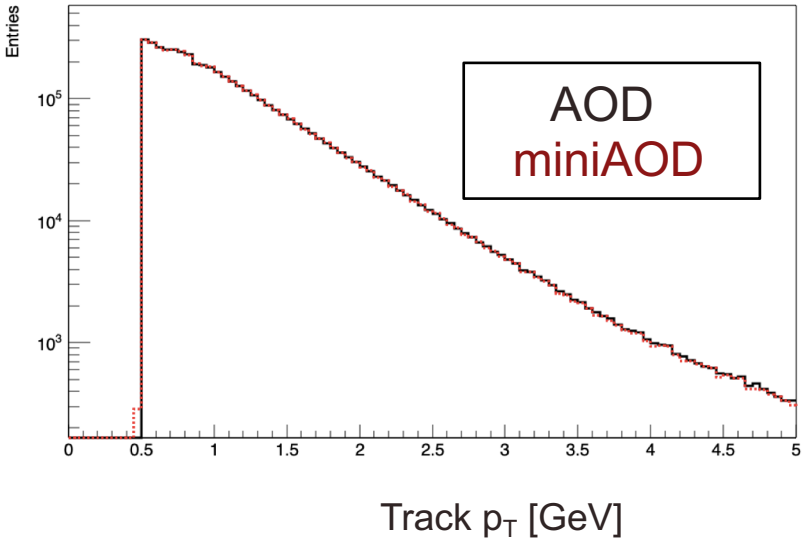


- Number of tracks removed by filter: 142 in both AOD and miniAOD
- A table with all hfCoincFilter checks can be found on backup slides.

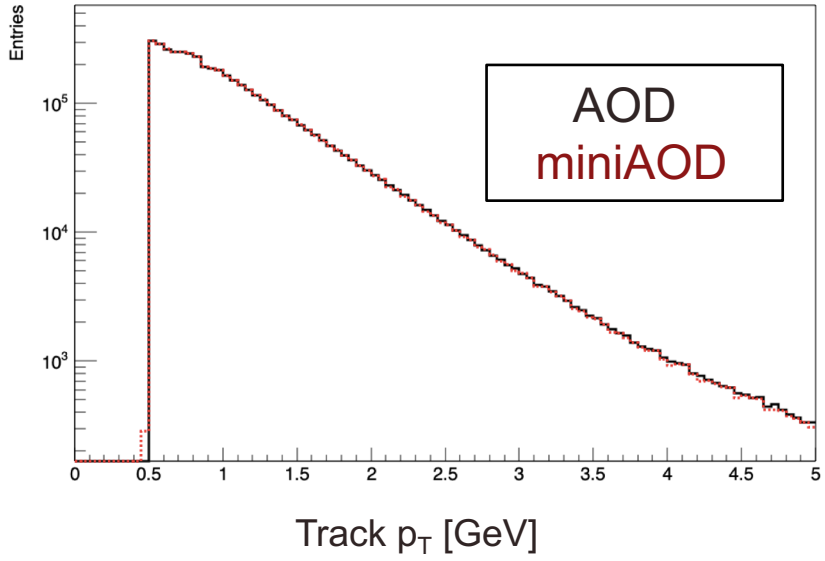
Comparison: AOD x miniAOD (p_T)

The results are similar, see Cesar's presentation: slides

No filters



phfCoincFilter2Th4 applied

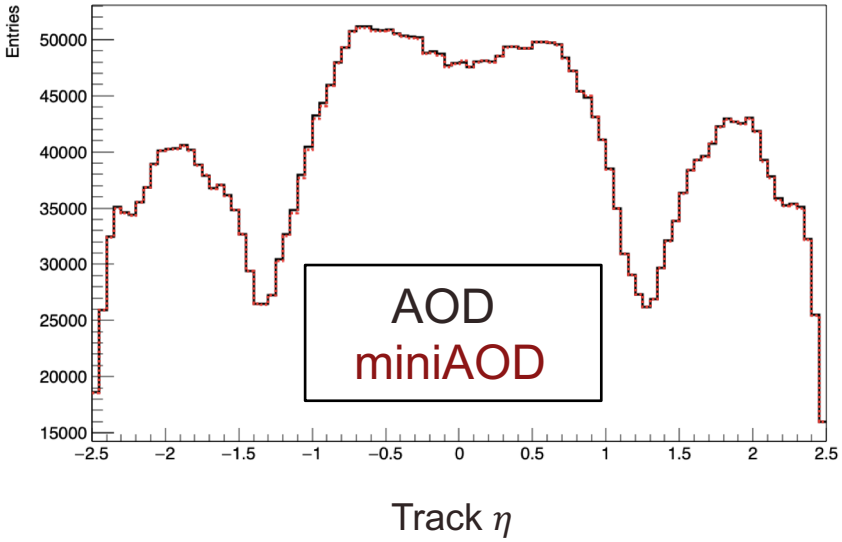


packedPFcandidate tracks are similar
to generalTracks with highPurity and p_T> 0.5 GeV

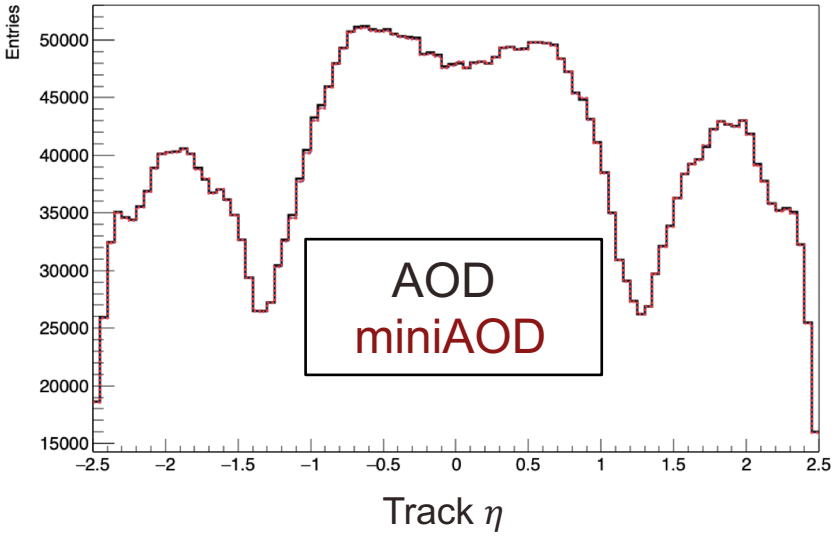
Comparison: AOD x miniAOD (η)

The results are similar, see Cesar's presentation: slides

No filters



phfCoincFilter2Th4 applied

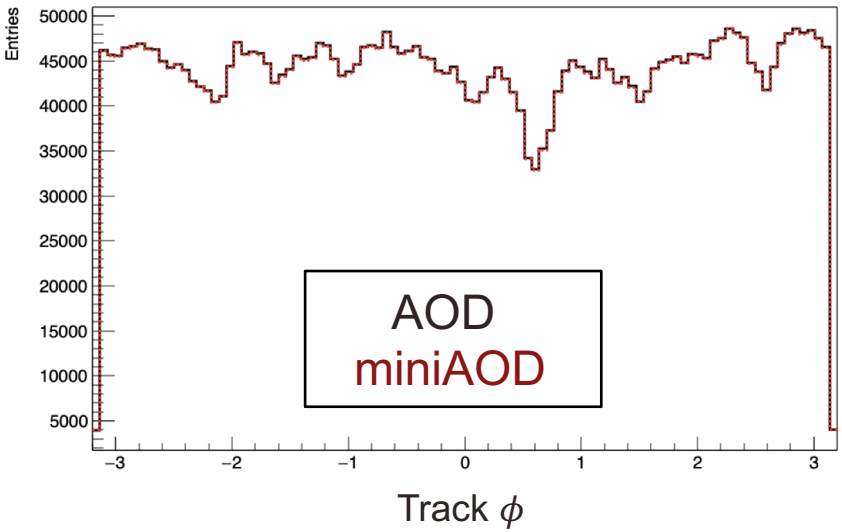


packedPFcandidate tracks are similar
to generalTracks with highPurity and p_T> 0.5 GeV

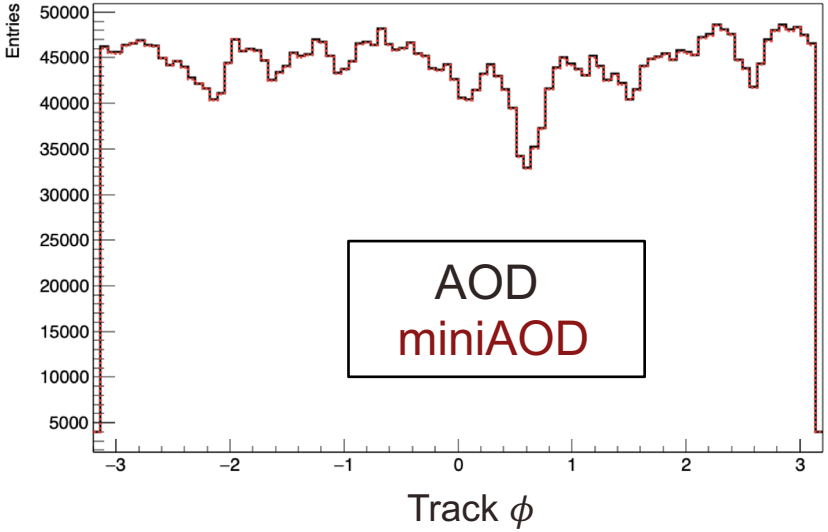
Comparison: AOD x miniAOD (ϕ)

The results are similar, see Cesar's presentation: slides

No filters



phfCoincFilter2Th4 applied



packedPFcandidate tracks are similar
to generalTracks with highPurity and p_T> 0.5 GeV

Summary

All the 72 centrality filters are implemented at miniAOD using the same schema as in MET filters

- For now using reMiniAOD_DATA_PAT.py, but if needed can be changed

Total size of the files with filters increases ~ 11 bytes per event

Timing basically does not change

The application of the filter in miniAOD remove exactly the same number of events and same number of tracks as in AOD

Looking in to the example code, is quite simple to apply the filters in a EDAnalyzer using the Boolean triggerBits->accept(i)

Backup

Cross-Check using *phfCoincFilter2Th4*

phfCoincFilter2Th4 is a default filter used for 2018 PbPb data

AOD

```
TrigReport ---------- Event  Summary ------------
TrigReport Events total = 6960 passed = 5723 failed = 1237

TrigReport ---------- Path   Summary ------------
TrigReport  Trig Bit#   Executed     Passed     Failed      Error Name
TrigReport     1    0       6960       5723       1237          0 p

TrigReport -------End-Path   Summary ------------
TrigReport  Trig Bit#   Executed     Passed     Failed      Error Name

TrigReport ---------- Modules in Path: p ------------
TrigReport  Trig Bit#    Visited     Passed     Failed      Error Name
TrigReport     1    0       6960       6960          0          0 towersAboveThresholdTh4
TrigReport     1    1       6960       6960          0          0 hfPosTowersTh4
TrigReport     1    2       6960       6960          0          0 hfNegTowersTh4
TrigReport     1    3       6960       6070        890          0 hfPosFilter2Th4
TrigReport     1    4       6070       5723        347          0 hfNegFilter2Th4
TrigReport     1    5       5723       5723          0          0 hiCentrality
TrigReport     1    6       5723       5723          0          0 centralityBin
TrigReport     1    7       5723       5723          0          0 demo

TrigReport ---------- Module Summary ------------
TrigReport    Visited   Executed     Passed     Failed      Error Name
TrigReport       6960       6960       6960          0          0 TriggerResults
TrigReport       5723       5723       5723          0          0 centralityBin
TrigReport       5723       5723       5723          0          0 demo
TrigReport       6070       6070       5723        347          0 hfNegFilter2Th4
TrigReport       6960       6960       6960          0          0 hfNegTowersTh4
TrigReport       6960       6960       6070        890          0 hfPosFilter2Th4
TrigReport       6960       6960       6960          0          0 hfPosTowersTh4
TrigReport       5723       5723       5723          0          0 hiCentrality
TrigReport       6960       6960       6960          0          0 p
TrigReport       6960       6960       6960          0          0 towersAboveThresholdTh4

TimeReport ---------- Event  Summary ---[sec]----
TimeReport       event loop CPU/event = 0.020097
TimeReport      event loop Real/event = 0.020308
TimeReport     sum Streams Real/event = 0.019750
TimeReport efficiency CPU/Real/thread = 0.989594
```

miniAOD

```
Total of events: 6960
Pass: 5723
Fail: 1237

TrigReport ---------- Event  Summary ------------
TrigReport Events total = 6960 passed = 6960 failed = 0

TrigReport ---------- Path   Summary ------------
TrigReport  Trig Bit#   Executed     Passed     Failed      Error Name
TrigReport     1    0       6960       6960          0          0 p

TrigReport -------End-Path   Summary ------------
TrigReport  Trig Bit#   Executed     Passed     Failed      Error Name

TrigReport ---------- Modules in Path: p ------------
TrigReport  Trig Bit#    Visited     Passed     Failed      Error Name
TrigReport     1    0       6960       6960          0          0 demo

TrigReport ---------- Module Summary ------------
TrigReport    Visited   Executed     Passed     Failed      Error Name
TrigReport       6960       6960       6960          0          0 TriggerResults
TrigReport       6960       6960       6960          0          0 demo
TrigReport       6960       6960       6960          0          0 p

TimeReport ---------- Event  Summary ---[sec]----
TimeReport       event loop CPU/event = 0.006402
TimeReport      event loop Real/event = 0.006419
TimeReport     sum Streams Real/event = 0.006233
TimeReport efficiency CPU/Real/thread = 0.997384
```

Filter	AOD	miniAOD
hfCoincFilter2Th2	Pass: 6947; Fail: 13;	Pass: 6947; Fail: 13;
hfCoincFilter2Th3	Pass: 6304; Fail: 656;	Pass: 6304; Fail: 656;
hfCoincFilter2Th4	Pass: 5723; Fail: 1237;	Pass: 5723; Fail: 1237;
hfCoincFilter2Th5	Pass: 5467; Fail: 1493;	Pass: 5467; Fail: 1493;
hfCoincFilter3Th2	Pass: 6887; Fail: 73;	Pass: 6887; Fail: 73;
hfCoincFilter3Th3	Pass: 5847; Fail: 1113;	Pass: 5847; Fail: 1113;
hfCoincFilter3Th4	Pass: 5405; Fail: 1555;	Pass: 5405; Fail: 1555;
hfCoincFilter3Th5	Pass: 5221; Fail: 1739;	Pass: 5221; Fail: 1739;
hfCoincFilter4Th2	Pass: 6772; Fail: 188;	Pass: 6772; Fail: 188;
hfCoincFilter4Th3	Pass: 5573; Fail: 1387;	Pass: 5573; Fail: 1387;
hfCoincFilter4Th4	Pass: 5255; Fail: 1735;	Pass: 5255; Fail: 1735;
hfCoincFilter4Th5	Pass: 5111; Fail: 1849;	Pass: 5111; Fail: 1849;
hfCoincFilter5Th2	Pass: 6596; Fail: 364;	Pass: 6596; Fail: 364;
hfCoincFilter5Th3	Pass: 5406; Fail: 1554;	Pass: 5406; Fail: 1554;
hfCoincFilter5Th4	Pass: 5164; Fail: 1796;	Pass: 5164; Fail: 1796;
hfCoincFilter5Th5	Pass: 5038; Fail: 1922;	Pass: 5038; Fail: 1922;