Using skimmed/reduced trees and nano-AODs in DQ analysis

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Motivation

- Typical DQ analysis involve measurements of quarkonia decaying in dilepton decay channels or low mass dileptons
  - Leptons represent a very small fraction of the tracks written in ESD/AODs in the central barrel
  - For quarkonia analyses, we only need tracks with relatively high pt (pt> 1GeV/c for J/psi)
  - Detector information needed in a specific analysis is usually much smaller then what is written in ESDs/AODs
- Producing data sets (“standard” or not) which contain JUST the needed information lead to (sometimes) huge reduction factors in data size and very fast processing

MUON analyses

- MUON analyses → special case because the datasets (ESD/AOD) are already relatively small
  - Most analyses use AliAOD.Muons.root

- There are a few examples of using skimmed trees
  - Low mass di-muons (Antonio Uras)
  - J/psi to di-muons (Roberta Arnaldi)
- Trees are produced in an analysis task on the grid
- Use LEGO trains or user analysis on AliAOD.Muons.root
- Reduction factor wrt AliAOD.Muons.root of ~2 (low mass dimuons) or ~20 (jpsi analyses)
  - The difference comes from the selection cuts (tipically much more open for low mass dimuons)

Example of tree structure (Roberta)

- Small skimmed tree
- Contents: event, track and di-muon information
- Selection: standard MUON cuts. No fine tuning needed at the time of tree making
- Example: run 265694 (p-Pb at 8.16 TeV)
  - AliAOD.root: 60 GB
  - AliAOD.Muons.root: 14 GB
  - Private tree: ~0.7 GB
- Full p-Pb and Pb-p analysis on a private laptop takes ~2h

```
fOutputTree = new TTree("pPbTree","Data Tree");
fOutputTree->Branch("FiredTriggerClasses",fTrigClass,"FiredTriggerClasses/C");
fOutputTree->Branch("inpmask",&finpmask,"inpmask/i"); //unsigned integer
fOutputTree->Branch("NMuons",&fNMuons,"NMuons/I");
fOutputTree->Branch("NContributors",&fNContributors,"NContributors/I");
fOutputTree->Branch("NTracklets",&fNTracklets,"NTracklets/I");
fOutputTree->Branch("Vertex",fVertex,"Vertex[3]/D");
fOutputTree->Branch("PercentV0M",&fPercentV0M,"PercentV0M/F");
fOutputTree->Branch("PercentCL0",&fPercentCL0,"PercentCL0/F");
fOutputTree->Branch("PercentCL1",&fPercentCL1,"PercentCL1/F");
fOutputTree->Branch("PercentV0A",&fPercentV0A,"PercentV0A/F");
fOutputTree->Branch("PercentV0C",&fPercentV0C,"PercentV0C/F");
fOutputTree->Branch("PercentZNA",&fPercentZNA,"PercentZNA/F");
fOutputTree->Branch("PercentZNC",&fPercentZNC,"PercentZNC/F");
fOutputTree->Branch("Pt",fPt,"Pt[NMuons]/D");
fOutputTree->Branch("E",fE,"E[NMuons]/D");
fOutputTree->Branch("Px",fPx,"Px[NMuons]/D");
fOutputTree->Branch("Py",fPy,"Py[NMuons]/D");
fOutputTree->Branch("Pz",fPz,"Pz[NMuons]/D");
fOutputTree->Branch("Y",fY,"Y[NMuons]/D");
fOutputTree->Branch("Eta",fEta,"Eta[NMuons]/D");
fOutputTree->Branch("MatchTrig",fMatchTrig,"MatchTrig[NMuons]/I");
fOutputTree->Branch("TrackChi2",fTrackChi2,"TrackChi2[NMuons]/D");
fOutputTree->Branch("MatchTrigChi2",fMatchTrigChi2,"MatchTrigChi2[NMuons]/D");
fOutputTree->Branch("DCA",fDCA,"DCA[NMuons]/D");
fOutputTree->Branch("Charge",fCharge,"Charge[NMuons]/I");
fOutputTree->Branch("RAtAbsEnd",fRAtAbsEnd,"RAtAbsEnd[NMuons]/D");
fOutputTree->Branch("NDimu",&fNDimu,"NDimu/I");
fOutputTree->Branch("DimuMu",fDimuMu,"DimuMu[NDimu][2]/I");
fOutputTree->Branch("DimuPt",fDimuPt,"DimuPt[NDimu]/D");
fOutputTree->Branch("DimuPx",fDimuPx,"DimuPx[NDimu]/D");
fOutputTree->Branch("DimuPy",fDimuPy,"DimuPy[NDimu]/D");
fOutputTree->Branch("DimuPz",fDimuPz,"DimuPz[NDimu]/D");
fOutputTree->Branch("DimuY",fDimuY,"DimuY[NDimu]/D");
fOutputTree->Branch("DimuMass",fDimuMass,"DimuMass[NDimu]/D");
fOutputTree->Branch("DimuCharge",fDimuCharge,"DimuCharge[NDimu]/I");
fOutputTree->Branch("DimuMatch",fDimuMatch,"DimuMatch[NDimu]/I");
```

Central barrel

- Both low mass dielectron and quarkonia analyses benefit from large rejection factors by filtering electrons
- A few approaches
  - Filtered AODs (aka nano-AODs)
  - Skimmed/reduced trees (a few implementations)
- Produced from either ESD, AOD or nano AODs using LEGO trains on the grid
- Need to be created 2-3 times during an analysis
- Typical data size reduction factors: 500-1000 relative to AOD size

Nano-AODs (used in both LMee and Jpsi2ee)

- Filtering task:
  - AliPhysics/PWGDQ/dielectron/core/AliAnalysisTaskDielectronFilter.cxx
- AddTask example (Pascal Dillenseger)
  - AliPhysics/PWGDQ/dielectron/macros/AddTask_pdill_JpsiFilter_PbPb.C
- Standard event selection (PhysicsSelection, -10<z<+10cm, etc)
- Track selection: electrons
- Not needed branches removed

Skimmed trees (S.Lehner)

- Trees tailored for specific analyses
- Tree structure:
  - PWGDQ/Lmee/AliAnalysisTaskMLTreeMaker
  - PWGDQ/dielectron/macrosLMEE/AddTaskMLTreeMaker.(
- Produced from nanoAODs, 2-3 times a year
- Contents: event and track selected information
  - Standard event selection
  - Track selection: electrons
- Example:
  - LHC15o_highIR, 40 million events
    - Size: 74 GB

```
fTree->Branch("centrality", &cent);
fTree->Branch("#tracks", &n);
fTree->Branch("pt", &pt);
fTree->Branch("eta", &eta);
fTree->Branch("phi", &phi);
fTree->Branch("charge", &charge);
fTree->Branch("RunNumber", &runn);
fTree->Branch("EsigTPC", &EsigTPC);
fTree->Branch("EsigITS", &EsigITS);
fTree->Branch("EsigTOF", &EsigTOF);
fTree->Branch("PsigTPC", &PsigTPC);
// fTree->Branch("NClustersITS", &NClustersITS);
fTree->Branch("NCrossedRowsTPC", &NCrossedRowsTPC);
fTree->Branch("NClustersTPC", &NClustersTPC);
fTree->Branch("RatioCrossedRowsFindableClusters", &RatioCrossedRowsFindableClusters);
fTree->Branch("HasSPDfirstHit", &HasSPDfirstHit);
fTree->Branch("NTPCSignal", &NTPCSignal);
```

```
fTree->Branch("DCAxy", &dcar);
fTree->Branch("DCAz", &dcaz);
fTree->Branch("vertx", &vertx);
fTree->Branch("verty", &verty);
fTree->Branch("vertz", &vertz);
fTree->Branch("nITS", &nITS);
fTree->Branch("nITSshared_frac", &nITSshared);
fTree->Branch("chi2ITS", &chi2ITS);
// fTree->Branch("chi2TPC", &chi2TPC);
fTree->Branch("chi2GlobalvsTPC", &chi2GlobalvsTPC);
fTree->Branch("chi2GlobalPerNDF", &chi2GlobalPerNDF);

if(hasMC) {
  fTree->Branch("Pdg", &pdg);
  fTree->Branch("Pdg_Mother", &pdgmother);
  fTree->Branch("Mother_label", &motherlabel);
  fTree->Branch("Label", &label);
  fTree->Branch("Has_Mother", &hasmother);
  fTree->Branch("IsEnh", &enh);
  fTree->Branch("MCpt", &MCpt);
  fTree->Branch("MCeta", &MCeta);
  fTree->Branch("MCphi", &MCphi);
  fTree->Branch("MCTrack_vertx", &MCvertx);
  fTree->Branch("MCTrack_verty", &MCverty);
  fTree->Branch("MCTrack_vertz", &MCvertz);
}
```

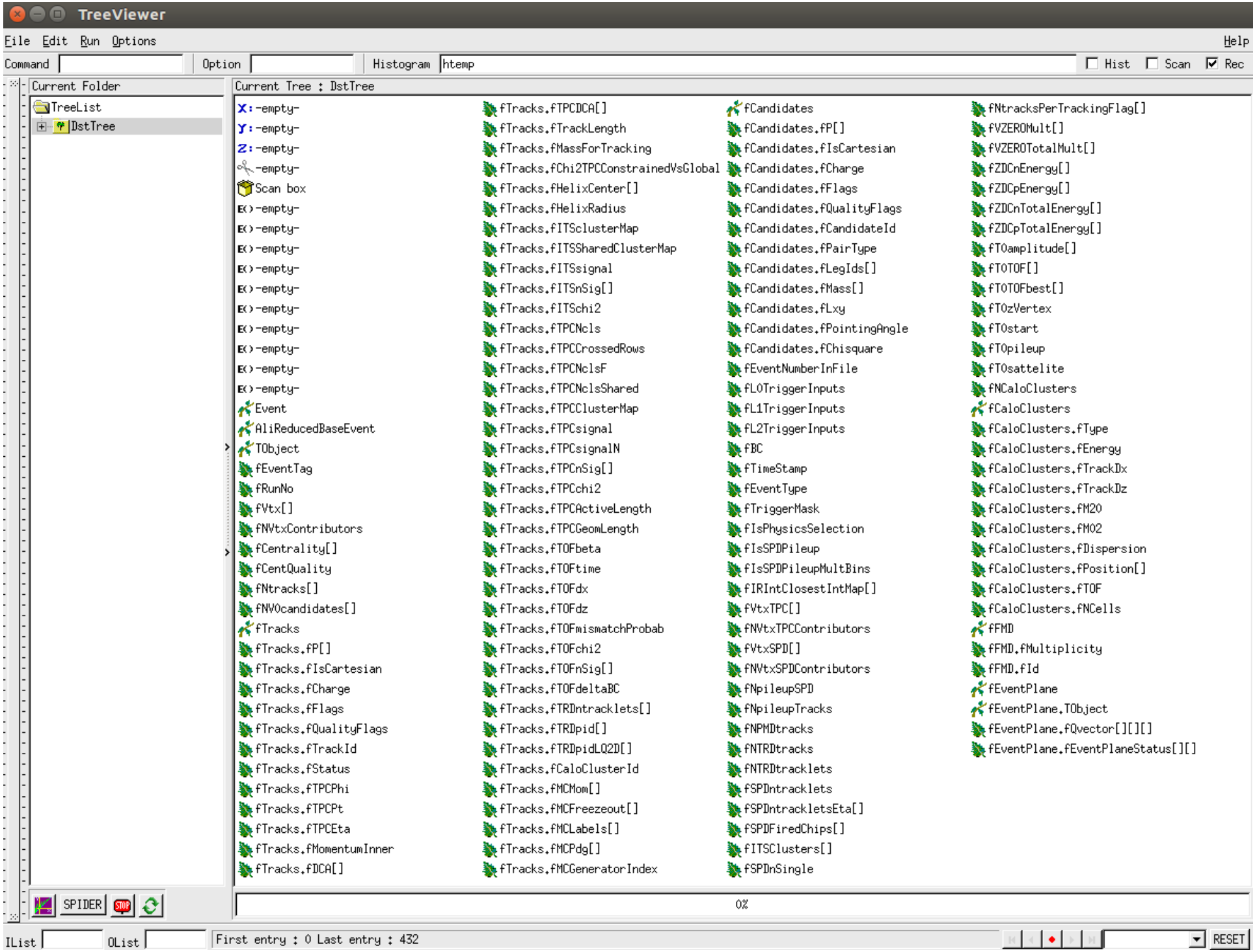
Skimmed trees (I.Arsene)
-used in both Jpsi2ee and LMee-

- See PWGDQ/reducedTree/
- Light framework producing trees from either ESDs or AODs
- Provides:
  - A tree maker analysis task based on an event type structure
  - Analysis tools
    - Data structures: event, track, pair, calo cluster, event plane
    - Cut classes
    - Variable manager and histogram manager
    - Event mixing handler
    - InputEventHandler

Creating the trees

- See PWGDQ/reducedTree/macros/AddTask_iarsene_dst.C
- Uses PWGDQ/reducedTree/AliAnalysisTaskReducedTreeMaker.h,.cxx
- Create objects which have an event-like structure (AliReducedEventInfo) containing:
  - Event wise information
  - List of selected tracks containing
    - Global properties (momentum, charge, quality flags)
    - Specific detector information (ITS, TPC, TOF, TRD, EMCAL/PHOS, MC)
  - List of selected pairs (e.g. V0's or user created candidate pairs)
  - List of calorimeter clusters (EMCAL and PHOS)
  - Detector information: ITS, VZERO, ZDC, TZERO, FMD
  - Event plane
- The current event structure allows for almost any type of analysis
- Flexible tuning of the filtering done in the AddTask by
  - Selection cuts (event, track or pair level)
  - Setting branches as inactive
- The tree maker can be run in either LEGO trains or user analysis
- The trees are typically created a few times (2-3 times) during the analysis

Event data members



Analyzing the reduced trees

- Trees prepared for dielectron analysis are usually very small so it is convenient to download them locally for analysis (on a local farm or even laptop)
- The reducedTree framework allows to run AliAnalysisTask trains on these trees → either locally or on the grid
- Additional filtering of the reduced trees is possible

- Several analyses run by different users; examples:
  - LMee analysis on LHC16l: ~1.0e+8 pp events, disk size 10 GB, AOD size ~5TB (Oton)
  - Jpsi2ee analysis on all LHC16d,e,g,h,i,j,k,l,o: 5.1e+8 MB and 2.5e+8 HM pp events: disk size ~500 GB (Steffen)
  - Jpsi2ee analysis on LHC15o_highIR and LHC15o_pidfix: ~1.0e+8 Pb-Pb events, disk size ~100 GB (Dennis)
  - Jpsi2ee analysis on LHC15n_pass3, ~1.15e+8 MB pp events, 15 GB (Tona)
  - Jpsi2ee analysis on LHC17n_pass1, ~1.4e+6 MB Xe-Xe events, 3.2 GB (Ionut)
  - General purpose trees on LHC10h and LHC11h, ~6.5e+7 kMB, kCentral and kSemiCentral Pb-Pb events, ~7 TB, AOD size ~70 TB (Ionut)

Summary

- Many examples of analyses using data structures from filtered AODs with a very large reduction in data size
  - A big part of the reduction comes from the particular analyses done in DQ
  - But large reduction factors can be obtained with trees even for analysis on hadrons (charged hadrons, identified particles, etc.)
- Tailoring the information to the needs of a specific analysis can bring large advantages: reduction in data size and smaller CPU needs
- Building a framework which allows the user or an analysis working group to easily filter their data would have a large impact