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Chapter 1

Example Analysis

This chapter is an example of a typical physics analysis. Large data files are chained together and analyzed using the `TSelector` class.

1.1 Explanation

This script uses four large data sets from the H1 collaboration at DESY Hamburg. One can access these data sets (277 Mbytes) from the ROOT web site at: <ftp://root.cern.ch/root/h1analysis/>

The physics plots generated by this example cannot be produced using smaller data sets.

There are several ways to analyze data stored in a ROOT Tree

- Using `TTree::Draw`:
- This is very convenient and efficient for small tasks. A `TTree::Draw` call produces one histogram at the time. The histogram is automatically generated. The selection expression may be specified in the command line.
- Using the `TTreeView`:
- This is a graphical interface to `TTree::Draw` with the same functionality.
- Using the code generated by `TTree::MakeClass`:
- In this case, the user creates an instance of the analysis class. They have the control over the event loop and can generate an unlimited number of histograms.
- Using the code generated by `TTree::MakeSelector`: Like for the code generated by `TTree::MakeClass`, the user can do complex analysis. However, they cannot control the event loop. The event loop is controlled by `TTree::Process` called by the user. This solution is illustrated by the code below. The advantage of this method is that it can be run in a parallel environment using PROOF (the Parallel Root Facility).

A chain of four files (originally converted from PAW ntuples) is used to illustrate the various ways to loop on ROOT data sets. Each contains a ROOT Tree named “h42”. The class definition in `h1analysis.h` has been generated automatically by the ROOT utility `TTree::MakeSelector` using one of the files with:

```
h42->MakeSelector("h1analysis");
```

This produces two files: `h1analysis.h` and `h1analysis.C`. A skeleton of `h1analysis.C` file is made for you to customize. The `h1analysis` class is derived from the ROOT class `TSelector`. The following members functions of `h1analysis` (i.e. `TSelector`) are called by the `TTree::Process` method.

- `Begin`: This function is called every time a loop over the tree starts. This is a convenient place to create your histograms.
- `Notify()`: This function is called at the first entry of a new tree in a chain.
- `ProcessCut`: This function is called at the beginning of each entry to return a flag true if the entry must be analyzed.

- **ProcessFill**: This function is called in the entry loop for all entries accepted by **Select**.
- **Terminate**: This function is called at the end of a loop on a **TTree**. This is a convenient place to draw and fit your histograms.

To use this program, try the following session.

First, turn the timer on to show the real and CPU time per command.

```
root[] gROOT->Time();
```

Step A: create a **TChain** with the four H1 data files. The chain can be created by executed this short script **h1chain.C** below. **\$H1** is a system symbol pointing to the H1 data directory.

```
{
  TChain chain("h42");
  chain.Add("$H1/dstarmb.root");
  //21330730 bytes, 21920 events
  chain.Add("$H1/dstarp1a.root");
  //71464503 bytes, 73243 events
  chain.Add("$H1/dstarp1b.root");
  //83827959 bytes, 85597 events
  chain.Add("$H1/dstarp2.root");
  //100675234 bytes, 103053 events
}
```

Run the above script from the command line:

```
root[] .x h1chain.C
```

Step B: Now we have a directory containing the four data files. Since a **TChain** is a descendent of **TTree** we can call **TChain::Process** to loop on all events in the chain. The parameter to the **TChain::Process** method is the name of the file containing the created **TSelector** class (**h1analysis.C**).

```
root[] chain.Process("h1analysis.C")
```

Step C: Same as step B, but in addition fill the event list with selected entries. The event list is saved to a file "**elist.root**" by the **TSelector::Terminate** method. To see the list of selected events, you can do **elist->Print("all")**. The selection function has selected 7525 events out of the 283813 events in the chain of files. (2.65 per cent)

```
root[] chain.Process("h1analysis.C","fillList")
```

Step D: Process only entries in the event list. The event list is read from the file in **elist.root** generated by step C.

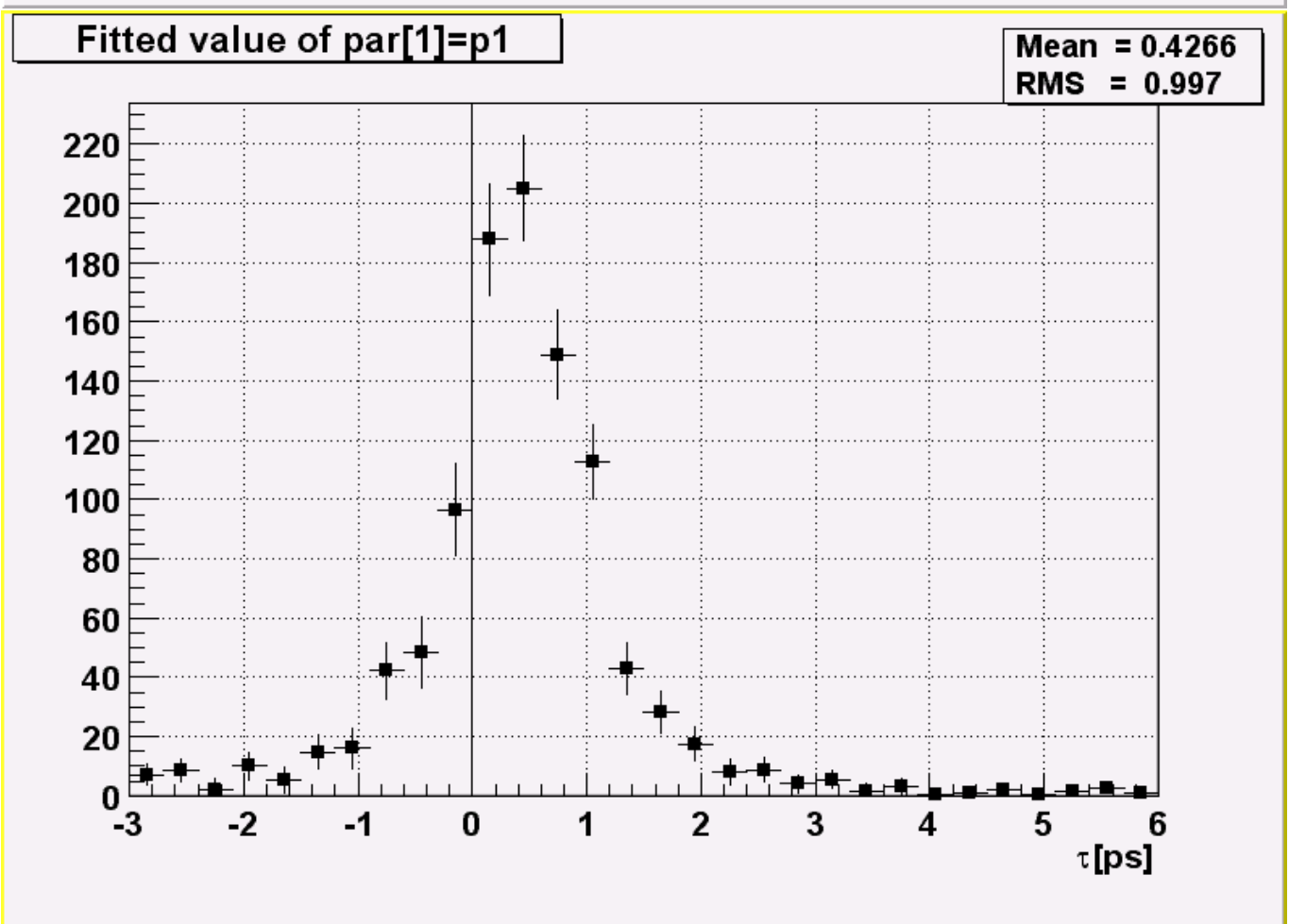
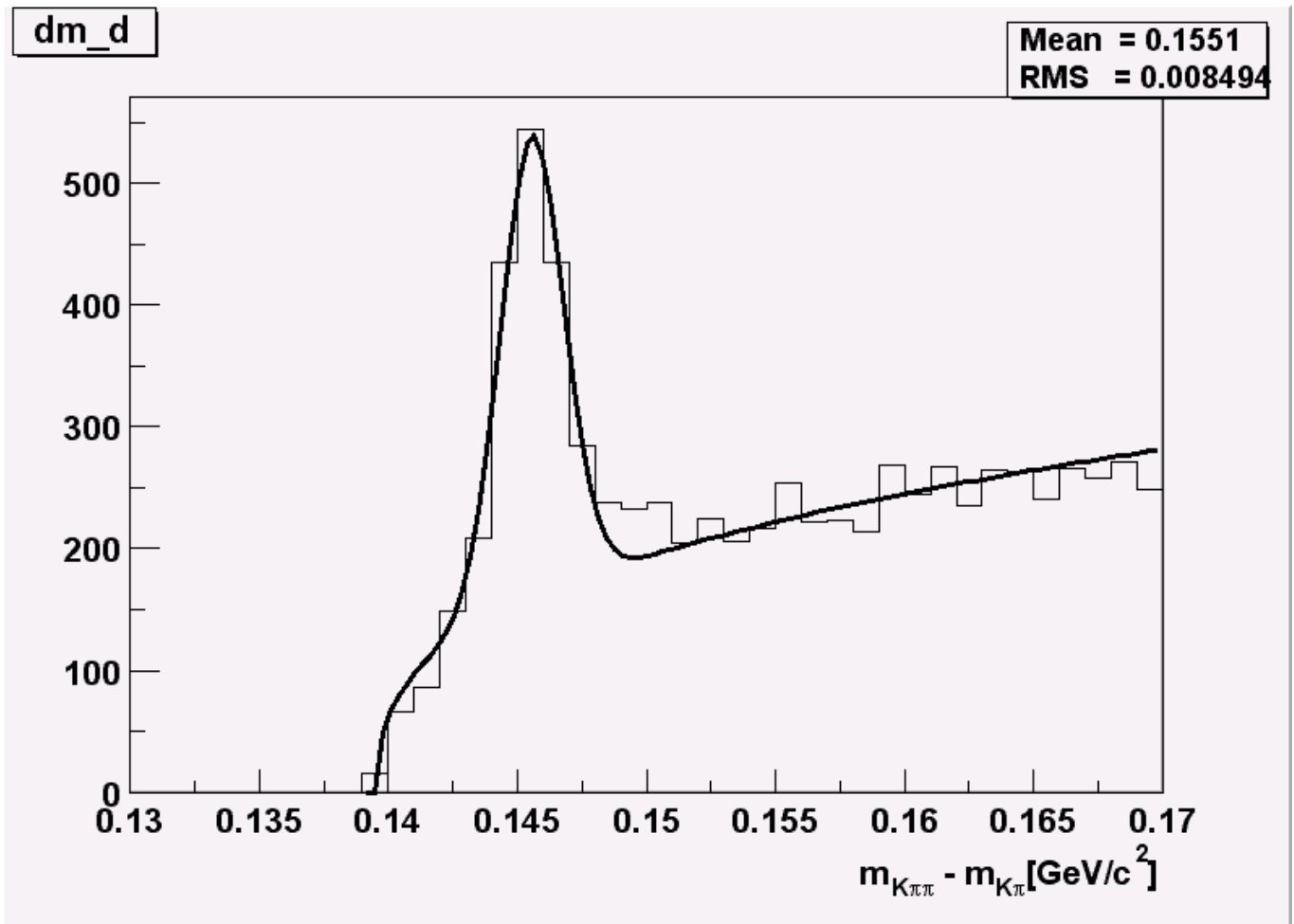
```
root[] chain.Process("h1analysis.C","useList")
```

Step E: The above steps have been executed with the interpreter. You can repeat the steps B, C, and D using **ACLiC** by replacing "**h1analysis.C**" by "**h1analysis.C+**" or "**h1analysis.C++**".

Step F: If you want to see the differences between the interpreter speed and **ACLiC** speed start a new session, create the chain as in step 1, then execute

```
root[] chain.Process("h1analysis.C+","useList")
```

The commands executed with the four different methods B, C, D and E produce two canvases shown below:



1.2 Script

This is the `h1analysis.C` file that was generated by `TTree::MakeSelector` and then modified to perform the analysis.

```

#include "h1analysis.h"
#include "TH2.h"
#include "TF1.h"
#include "TStyle.h"
#include "TCanvas.h"
#include "TLine.h"
#include "TEventList.h"

const Double_t dxbin = (0.17-0.13)/40; // Bin-width
const Double_t sigma = 0.0012;
TEventList *elist = 0;
Bool_t useList, fillList;
TH1F *hdmd;
TH2F *h2;

//-----
Double_t fdm5(Double_t *xx, Double_t *par)
{
    Double_t x = xx[0];
    if (x <= 0.13957) return 0;
    Double_t xp3 = (x-par[3])*(x-par[3]);
    Double_t res = dxbin*(par[0]*TMath::Power(x-0.13957,par[1])
    + par[2]/2.5066/par[4]*TMath::Exp(-xp3/2/par[4]/par[4]));
    return res;
}

//-----
Double_t fdm2(Double_t *xx, Double_t *par)
{
    Double_t x = xx[0];
    if (x <= 0.13957) return 0;
    Double_t xp3 = (x-0.1454)*(x-0.1454);
    Double_t res = dxbin*(par[0]*TMath::Power(x-0.13957,0.25)
    + par[1]/2.5066/sigma*TMath::Exp(-xp3/2/sigma/sigma));
    return res;
}

//-----
void h1analysis::Begin(TTree *tree)
{
    // function called before starting the event loop
    // -it performs some cleanup
    // -it creates histograms
    // -it sets some initialization for the event list

    //initialize the Tree branch addresses
    Init(tree);

    //print the option specified in the Process function
    TString option = GetOption();
    printf("Starting h1analysis with process option: %sn",option.Data());

    //Some cleanup in case this function had already been executed
    //Delete any previously generated histograms or functions
    gDirectory->Delete("hdmd");
    gDirectory->Delete("h2*");
    delete gROOT->GetFunction("f5");
    delete gROOT->GetFunction("f2");
}

```

```

//create histograms
hdmd = new TH1F("hdmd","dm_d",40,0.13,0.17);
h2   = new TH2F("h2","ptD0 vs dm_d",30,0.135,0.165,30,-3,6);

//process cases with event list
fillList = kFALSE;
useList  = kFALSE;
fChain->SetEventList(0);
delete gDirectory->GetList()->FindObject("elist");

// case when one creates/fills the event list
if (option.Contains("fillList")) {
    fillList = kTRUE;
    elist = new TEventList("elist","selection from Cut",5000);
}
// case when one uses the event list generated in a previous call
if (option.Contains("useList")) {
    useList = kTRUE;
    TFile f("elist.root");
    elist = (TEventList*)f.Get("elist");
    if (elist) elist->SetDirectory(0);
    //otherwise the file destructor will delete elist
    fChain->SetEventList(elist);
}
}
//-----
Bool_t h1analysis::ProcessCut(Int_t entry)
{ // Selection function to select D* and D0.

    //in case one event list is given in input,
    //the selection has already been done.
    if (useList) return kTRUE;
    // Read only the necessary branches to select entries.
    // return as soon as a bad entry is detected
    b_md0_d->GetEntry(entry);
    if (TMath::Abs(md0_d-1.8646) >= 0.04) return kFALSE;
    b_ptds_d->GetEntry(entry);
    if (ptds_d <= 2.5) return kFALSE;
    b_etads_d->GetEntry(entry);
    if (TMath::Abs(etads_d) >= 1.5) return kFALSE;
    b_ik->GetEntry(entry); ik--;
    //original ik used f77 convention starting at 1
    b_ipi->GetEntry(entry);
    ipi--;
    b_ntracks->GetEntry(entry);
    b_nhitrp->GetEntry(entry);
    if (nhitrp[ik]*nhitrp[ipi] <= 1) return kFALSE;
    b_rend->GetEntry(entry);
    b_rstart->GetEntry(entry);
    if (rend[ik]-rstart[ik] <= 22) return kFALSE;
    if (rend[ipi]-rstart[ipi] <= 22) return kFALSE;
    b_nlhk->GetEntry(entry);
    if (nlhk[ik] <= 0.1) return kFALSE;
    b_nlhpi->GetEntry(entry);
    if (nlhpi[ipi] <= 0.1) return kFALSE;
    b_ipis->GetEntry(entry);
    ipis--;
    if (nlhpi[ipis] <= 0.1) return kFALSE;
    b_njets->GetEntry(entry);
    if (njets < 1) return kFALSE;

    // if option fillList, fill the event list
    if (fillList) elist->Enter(fChain->GetChainEntryNumber(entry));
}

```

```

    return kTRUE;
}

//-----
void h1analysis::ProcessFill(Int_t entry)
{ // Function called for selected entries only

    // read branches not processed in ProcessCut
    b_dm_d->GetEntry(entry);
    //read branch holding dm_d
    b_rpd0_t->GetEntry(entry);
    //read branch holding rpd0_t
    b_ptd0_d->GetEntry(entry);
    //read branch holding ptd0_d           //continued...
    //fill some histograms
    hdmd->Fill(dm_d);
    h2->Fill(dm_d,rpd0_t/0.029979*1.8646/ptd0_d);
}

//-----
void h1analysis::Terminate()
{ // Function called at the end of the event loop

    //create the canvas for the h1analysis fit
    gStyle->SetOptFit();
    TCanvas *c1 = new TCanvas("c1","h1analysis analysis",10,10,800,600);
    c1->SetBottomMargin(0.15);
    hdmd->GetXaxis()->SetTitle("m_{K#pi#pi}-m_{K#pi}[GeV/c^{2}]");
    hdmd->GetXaxis()->SetTitleOffset(1.4);

    //fit histogram hdmd with function f5 using
    //the loglikelihood option
    TF1 *f5 = new TF1("f5",fdm5,0.139,0.17,5);
    f5->SetParameters(1000000,.25,2000,.1454,.001);
    hdmd->Fit("f5","lr");

    //create the canvas for tau d0
    gStyle->SetOptFit(0);
    gStyle->SetOptStat(1100);
    TCanvas *c2 = new TCanvas("c2","tauD0",100,100,800,600);
    c2->SetGrid();
    c2->SetBottomMargin(0.15);

    // Project slices of 2-d histogram h2 along X ,
    // then fit each slice with function f2 and make a
    // histogram for each fit parameter.
    // Note that the generated histograms are added
    // to the list of objects in the current directory.

    TF1 *f2 = new TF1("f2",fdm2,0.139,0.17,2);
    f2->SetParameters(10000,10);
    h2->FitSlicesX(f2,0,0,1,"qln");
    TH1D *h2_1 = (TH1D*)gDirectory->Get("h2_1");
    h2_1->GetXaxis()->SetTitle("#tau[ps]");
    h2_1->SetMarkerStyle(21);
    h2_1->Draw();
    c2->Update();
    TLine *line = new TLine(0,0,0,c2->GetUymax());
    line->Draw();

    // save the event list to a Root file if one was produced
    if (fillList) {

```



```
    TFile efile("elist.root","recreate");
    elist->Write();
  }
}
```