CSU NUPAC Tutorials
2019

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I’m borrowing a lot of the material from Harinder Bawa (CSU Fresno)
The Analysis Chain in High Energy Physics

1. Raw Data
2. Simulated Raw Data
3. Simulation
   - 4-Vectors
   - Monte Carlo Generator
4. Reconstruction
5. Reconstructed Data (DST)
6. High-Level Reconstruction
7. Condensed Data (ROOT Trees)
8. Analysis Code
9. Histograms, Plots
10. Journal Publication

Dr. Harinder Bawa, CSUNUPAC
The Framework Organization

The diagram depicts the organization of the framework, with directories and files listed under various categories such as `bin`, `lib`, `tutorials`, `test`, and `include`. Notable files include `root.c`, `rootutil.c`, `root.h`, `root.1`, `root-config`, `root-cipo`, `root-draw`, `root-gui`, `root-gx11.c`, and `root-x11`. The diagram also shows links to header files like `formula.c`, `functions.c`, `geometry.c`, `hxdraw.c`, `hxiostream.c`, `hxloaddb.c`, and `hxloaddb.c`.
Launching and Quiting ROOT

ROOT is prompt-based. Launch ROOT:

$ root

The ROOT Prompt will appear:

root [0] _

- root --l (without logo)
- root --b (without browser) *Used in running root remotely (using ssh)
- To quit root, simply type “.q”

It “speaks” C++:

root [0] gROOT->GetVersion();
(const char* 0x5ef7e8)"5.27/04"
ROOT: As a pocket calc.

Calculations:

```
root [0] sqrt(42)
(const double)6.48074069840786038e+00
root [1] double val = 0.17;
root [2] sin(val)
(const double)1.69182349066996029e-01
root [2] TMath::Erf(1.)
(Double_t)8.42700792949714783e-01
```

Uses C++ Interpreter CINT
User Interfaces
GUI (Graphical User Interface)
Basic Navigation by Clicking

- **Left Click**
  - select the object
  - drag the object
  - resize the object

- **Right Click**
  - context menu
  - class::name
  - methods

- **Middle Click**
  - activate canvas
  - freezes event status bar
Handling a root file

Download: http://zimmer.csufresno.edu/~hbawa/hsimple.root

TBrowser - the ROOT navigator

- You just need to know one command in order to start the ROOT file/spectra browser:

root [0] new TBrowser

Or you could do:
b1

```
TBrowser t;
TBrowse *tata = new TBrowser
```

Explanations tomorrow (Day 2)!
Opening a ROOT file

- In the **File** menu of TBrowser, select "Open…"
- Select a file in the dialogue box which appears:

![Dialogue box for opening a file]

1. Select the file

```
Look in: [Home]
```

- **root1**
- **qt**
- **include**
- **lib**
- **thumbnails**
- **screenshots_ROOT**
- **kaon**
- **K4files**
- **K4MetaDoc**
- **Programmes**

**File name:** [ROOT files (.root)]

[Open] [Cancel]
Opening a ROOT file

- In the **File** menu of TBrowser, select "Open…"
- Select a file in the dialogue box which appears:

![Image of Open dialogue box]

2. Click "Open"
Looking at ROOT file contents

- The file has been added to the list of open ROOT files - to see it, you have to display the list

1. Double click on ROOT Files
Looking at ROOT file contents

- Next click on the file to see its contents:

2. Click the file
Looking at ROOT file contents

• You see (if you choose the right options) a list of spectra with their titles

3. Choose option "detailed list"
Looking at ROOT file contents

- Icons represent the different types of spectra:
  - profile, 1-D histogram, 2-D histogram, N-tuple...
Plotting A Spectrum

- To plot a 1-D histogram, nothing could be simpler: double-click it!

1. Double-click histogram "hpix"
Discovering the canvas (TCanvas)

• A new window appears - the *canvas*
The Canvas objects

- This canvas contains many objects which we can manipulate:

  - Spectrum title
  - "Y" axis
  - Canvas
  - The histogram
  - "X" axis
  - Statistics box with name of histogram

File Edit View Options Inspect Classes Help

Entries 25000
Mean 0.0007145
RMS 0.9999

2/16/2017
Dr. Harinder Bawa, CSUNUPAC
What is this object?

To see the identity of every object the mouse passes over, activate the "Event Status" bar in the "View" menu:

The bar appears below the canvas:

- Mouse position in pixel units (0,0)=top left corner
- Position in "spectrum" units + bin contents & partial integral for spectra
- Object title
- Object name
What is the object?

- Or, you can "right-click" on an object and access its context menu:

Right-click on histogram "hp".
The objects (again)

- So we can identify the type (class) of every object used in the canvas:

  - Spectrum title (TPaveText)
  - "Y" axis (TAxis)
  - The canvas (TCanvas)
  - Histogram (TH1F)
  - Statistics box with name of histogram (TPaveStats)
  - "X" axis (TAxis)
  - Display frame (TFrame)
Manipulating objects

• Use the mouse to move and resize objects…

With the left button of the mouse you can reposition and redimension all objects in the canvas.
Activate the canvas editor

- To change colours, line widths, etc. we use the canvas editor

Activate the editor by selecting "Editor" in the "View" menu
Canvas editor

- The editor appears to the left of the canvas
- It displays/modifyes the characteristics of the last object selected with the mouse (careful!)

Name & type (class) of last-clicked object

E.g. Tick here to make all spectra scales on this canvas logarithmic
Canvas editor

- The editor appears to the left of the canvas
- It displays/modifyes the characteristics of the last object selected with the mouse (careful!)

Like this!

This is the px distribution
Changing look of the spectrum

- or "the art of clicking in the right place at the right time"

1. Check you have selected the right object
Changing look of the spectrum

- or "the art of clicking in the right place at the right time"…

2. Click the line-colour box to the palette
Changing look of the spectrum

- or "the art of clicking in the right place at the right time"…

3. Choose a fill style…
Changing look of the spectrum

- or "the art of clicking in the right place at the right time"…

4. ...and a colour in order to activate it
Changing look of the spectrum

or "the art of clicking in the right place at the right time"…

5. And why not change the title while we're at it?
Changing look of the spectrum

- or "the art of clicking in the right place at the right time"…

On the second tab you can change the binning...

...as well as the range of displayed axis values.
Handling the canvas*

*without smudging the artwork
Canvas manipulation

- If you want a new canvas:

**WARNING!**
Double-click on a spectrum and it will be drawn on the active canvas, replacing any previous content.
Canvas manipulation

- To wipe the canvas clean:

  Wipe only the active (sub-)pad...

  Wipe the WHOLE canvas (careful!)
Manipulating the canvas

- To refresh the canvas display:

Sometimes, the result of a modification is not visible straight away.

To force an update of all the objects on the canvas, option "Refresh" can help*

*(and reduce stress levels and anxiety...)*
Manipulating the canvas

• Some useful options:

In the "Options" menu of the canvas we also control whether or not to show:

- statistics boxes
- histogram title
- fit parameters
Manipulating the canvas

• Dividing the canvas to display several spectra at once:

Open the context menu of the canvas (right-click on the canvas)

Select "Divide"
Manipulating the canvas

- Dividing the canvas to display several spectra at once:

Fill in the form, e.g. to have 2x2 pads:

- Number of columns
- Number of rows
- Margins between pads
- Pad colour

And click "OK"
Manipulating the canvas

- Dividing the canvas to display several spectra at once:

Next, choose the pad where you want to display your spectrum (click with middle button)

WARNING! The first sub-pad is not automatically selected
Dividing Canvas

Right now: We are talking about GUI.

```c
root [1] c1 = new TCanvas("c1","Title",800,600);
root [2] c1->Divide(2,2);
root [3] c1->cd(1);
root [4] h1->Draw();
root [5] c1->cd(2);
root [6] h2->Draw();
root [7] c1->cd(3);
root [8] h1->SetLineColor(2)
root [9] h2->SetLineColor(4)
root [10] h1->Draw();
root [12] c1->cd(4);
root [13] h1->Fit("gaus");
```
Decorating a figure

Make pretty picture
Adding objects to the canvas

• Open the toolbar

Select "Toolbar" in the "View" menu
Adding objects to the canvas

• Open the toolbar

With the buttons we can draw all sorts of graphical objects on the canvas...
Adding objects to the canvas

- Open the toolbar

...arc/circle, line, arrow, diamond, ellipse, rectangle, ...
Adding objects to the canvas

- Open the toolbar

...polyline, "curly line", "curly arc", ...
Adding objects to the canvas

• Open the toolbar

...marker, closed contour
(graphical cut selection
- Day 4!)
Adding objects to the canvas

- Spectra within spectra within...

Why add a pad?

=> Easy way to have an 'insert' showing e.g. a zoom

Pad = mini-canvas inside a canvas (or a pad... etc. etc.)
Adding a pad

- Spectra within spectra within…

Draw the pad, then click on it with the middle button to make it active (yellow border)*

*(true for all pads/canvases)
Adding a pad

- Spectra within spectra within...

Then the next spectrum we display will be drawn in the active (yellow) pad*

*(this is always true, even with several windows)
Adding text

- To make the figure self-explanatory, add a legend...

Several choices are available for adding text, do you want just text ('L' button)* or text in a box?

*(it's 'L' for 'LaTeX')
Adding text

- …using LaTeX (well, almost)

Example of a 'TPaveLabel'

Raw text entered: 
-4#leq p_{x}#leq 4

To change font, size, colour of text, use the canvas editor
Modifying the statbox
Modifying the statbox

The Canvas in the Browser
- Setting the (7) statistics options
  – default = 1111

If I use: 111111 then
Range of Histogram

The diagram shows a histogram with the y-axis labeled as yStar. The histogram is centered around zero with peaks at both negative and positive values of yStar. The statistics for the histogram include:

- Entries: 500002
- Mean: 0.0007854
- RMS: 0.8715
Saving your figures

It'd be a pity to lose everything…
Saving a masterpiece

Before saving, we'll remove the yellow border of the active canvas - otherwise it'll be in the figure.

In the canvas' context menu select `SetBorderMode` change the value: "0" = no border.
Saving a masterpiece

- Open the menu "File", sub-menu "Save"

You can save an image of your figure in many popular formats (PS, PDF, GIF, JPG) with the name c1.xxx by default.*

*With "Save As..." you can even choose the name you want
Saving a masterpiece

- What if I want to change the figure later?

Two choices:
create some code ('c1.C')
or
save the objects ('c1.root')
Saving the objects??

- By choosing ".root" in menu "Save", a file 'c1.root' is created.
- In order to display the image later, you need to open this file, e.g. with the browser:

It seems the file only contains one object, c1. But double-click it and...
Saving the objects??

- By choosing ".root" in menu "Save", a file 'c1.root' is created.
- In order to display the image later, you open this file, e.g. with the browser:

...the figure is displayed.

In fact, a canvas is a sort of list of objects to display on the screen. The command "Draw" just adds an object to this list...
Create some code?

- By choosing "cl.C" in the menu, a file is created which contains all the (C++) instructions necessary to recreate our figure.

You can look at the result in any text editor...
Announcements

- Due to time change in the US, I won’t be able to hold the Tuesday sessions at 9am Pacific time for the next two weeks.
- The sessions will be prerecorded and uploaded before Tuesday 9am Pacific time.
- Thursday sessions will not be affected.