ROOT

Data Analysis Framework

Introduction to ROOT

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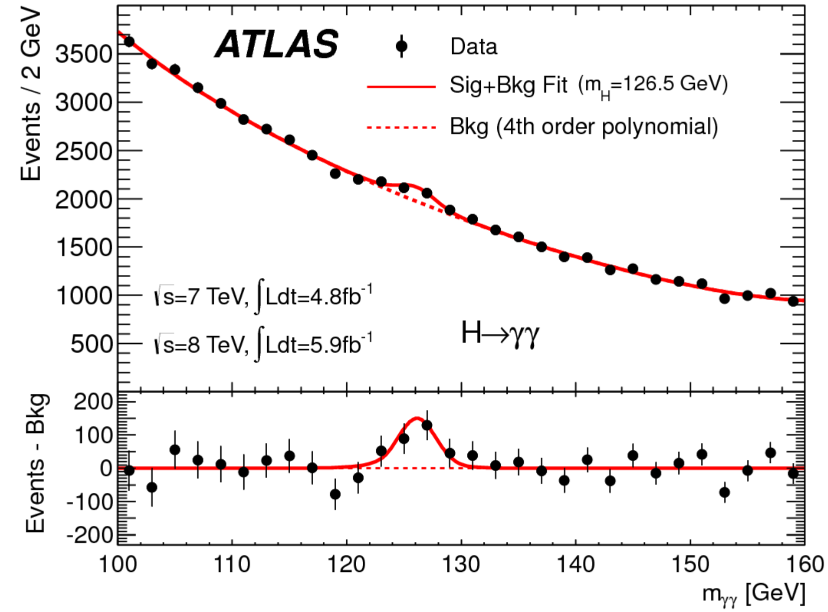
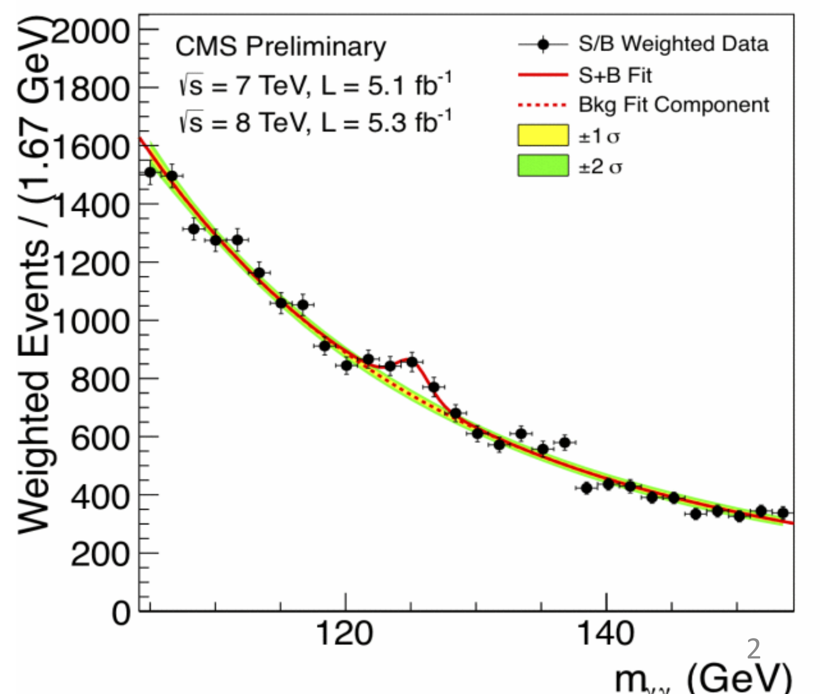
Physics 403
February 2, 2021

What is ROOT?

- **ROOT** is an object-oriented framework for large-scale data handling & analysis.
- It is originally developed for high energy physics experiments (still used by *most* particle physics experiments), but now also finds application in astronomy, data mining, etc.
- For example, the analysis and plots of recent Higgs Boson discovery are mostly done using ROOT.

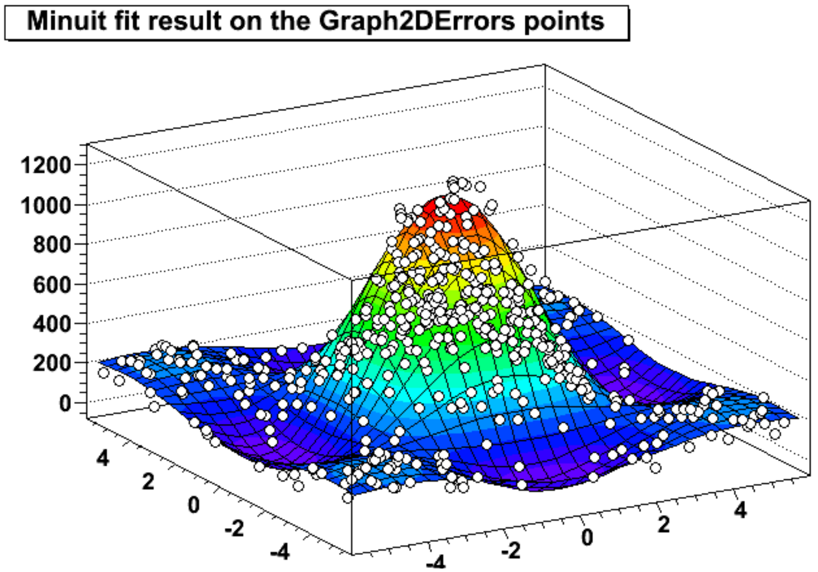


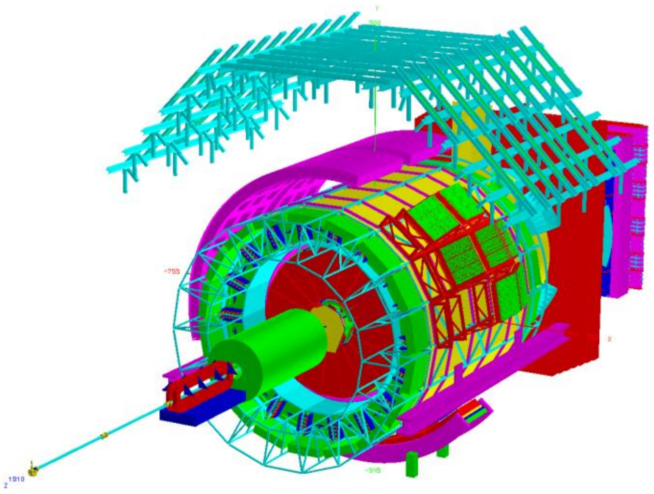
Higgs Boson Discovery



Why use ROOT?

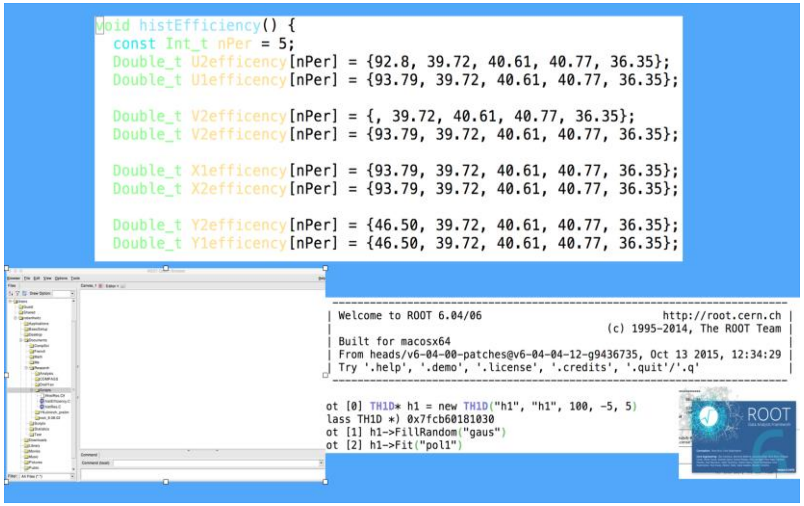
- ROOT can *efficiently* handle structured **large data sets** (PetaBytes ⚠).
- ROOT has **advanced statistical analysis algorithms** (multi-dimensional fitting, neural network, etc).
- ROOT has scientific **visualization tools** with 2D and 3D graphics; not as ‘pretty’ as e.g. Origin, but functional.
- ROOT is an **open-source** project. It is free, and available for **Windows**, **Mac**, and **Linux** machines.





ALICE Detector

Using ROOT



Three user interfaces:

- Graphic User Interface
- Command line
- Macros and scripts

We can use all of them to help us with the analysis; you will write your own (or modify existing) analysis scripts.

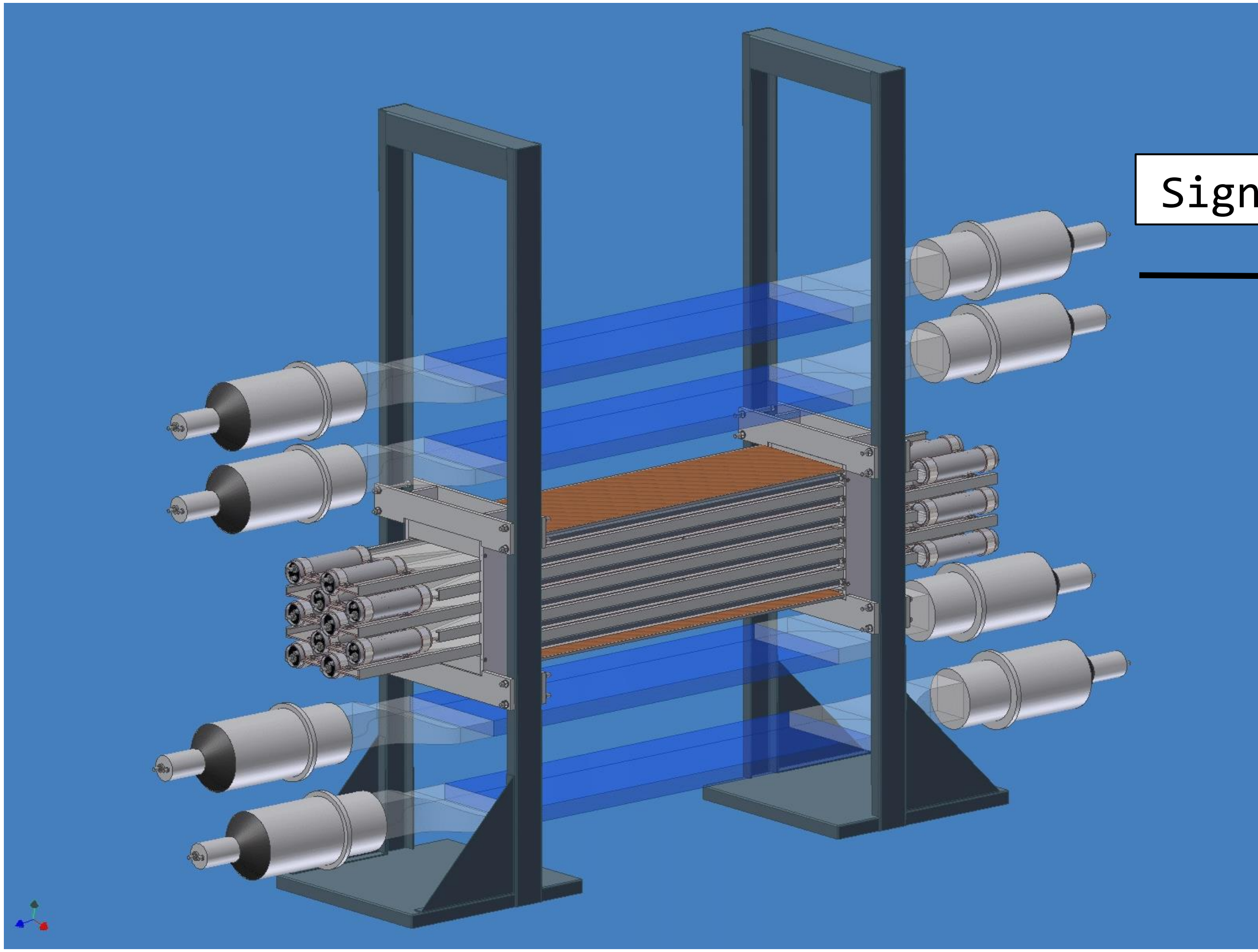
→ ROOT is installed on the LINUX machine in 5103

→ Can also use ROOT by remotely logging into the machine (ask TA).

→ Finally, you can install it on your own computer... There is an extremely helpful blog post by a physicist on medium.com that will take you through each step:

https://medium.com/@blake.leverington/installing-cern-root-under-windows-10-with-subsystem-for-linux-beta-75295defc6d4

Application: Muon Experiment



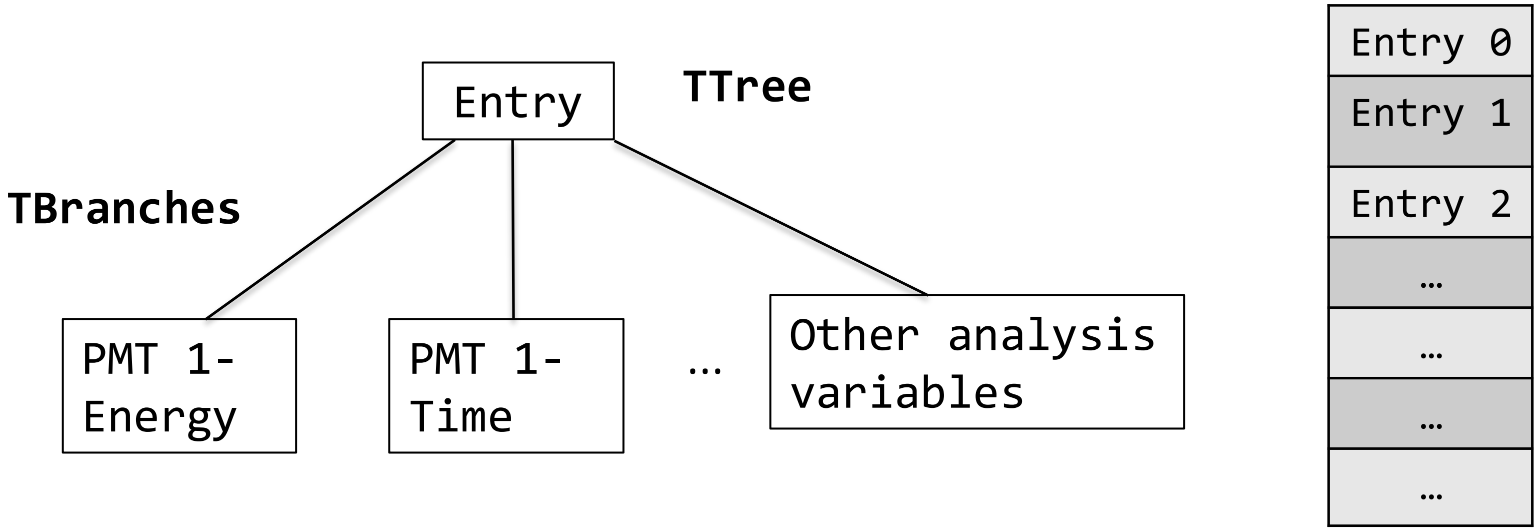
Signal-out

NIM Electronics

Computer: ROOT tree

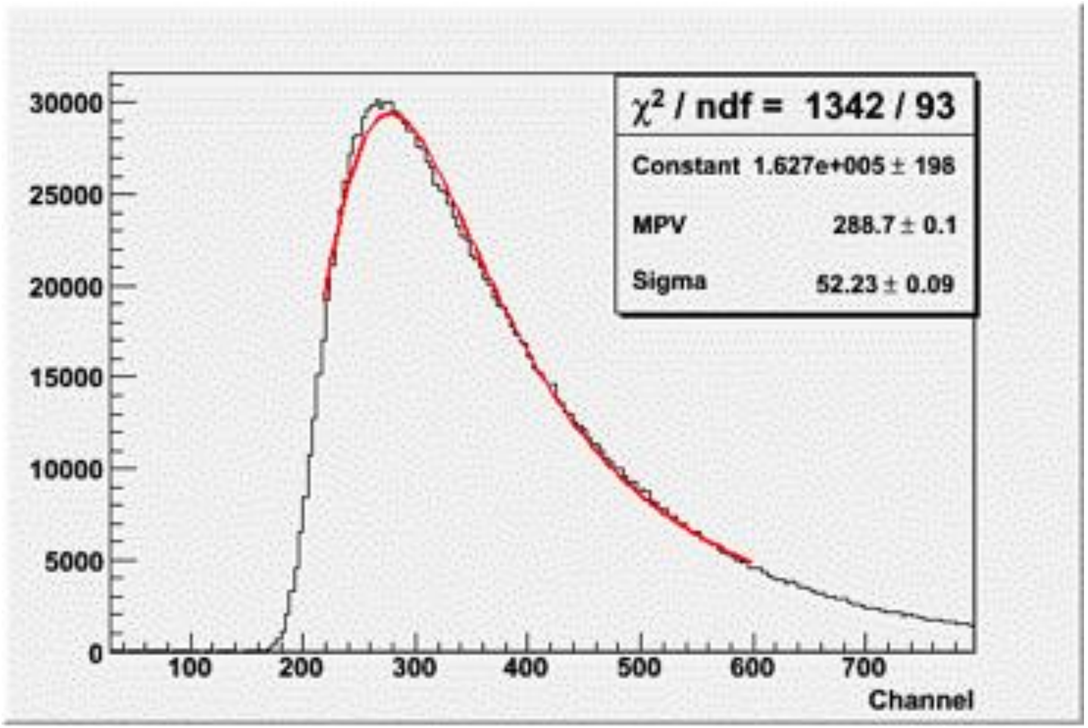
→ 16 PMT signals, w/both **energy** and **timing** information, are recorded by the data acquisition system (DAQ). An analyzer program converts the binary data into a ROOT tree.

Data Structure (TTree)



- TTree is one of the most commonly used structures in ROOT.
- One can store variables, arrays and any other C++ datatype in the tree ‘branches’
- If we store only floating number variables in the branches, this tree structure is also called a Tntuple
- Usually we “loop” over a TTree to obtain relevant information from each entry and make **plots**

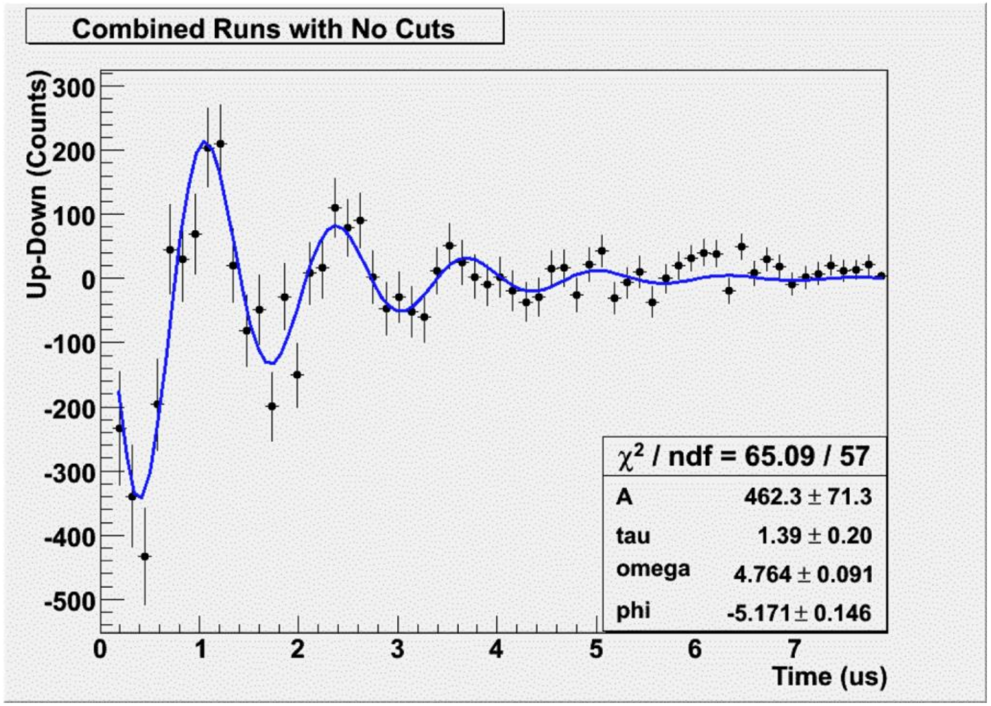
Histogram and Fitting



Histogram of a PMT energy signal

- From the ROOT tree, one can extract information recorded by each PMT & make histograms.
- You can then fit them with appropriate functions – **this will be a major task of most groups.**

Data Cuts and Analysis



Muon g-factor measurement

- Data analysis involves the selection of interesting events, called data cuts.
- You will also perform fitting and other analysis work to perform calibrations & extract important physics quantities.

Where to find more information?

- Users Guide and Reference Manuals are available at: http://root.cern.ch
- Online tutorials are very useful: http://root.cern.ch/root/html/tutorials/
- Sample scripts & datasets can also be found in the 403 drive & can be provided by TA
- Online forums, such as **roottalk**: http://root.cern.ch/phpBB3/, where you can ask help from the user community.