# Introduction to ROOT

Daniel R. MacLean
Physics 403
June 17th, 2020

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.
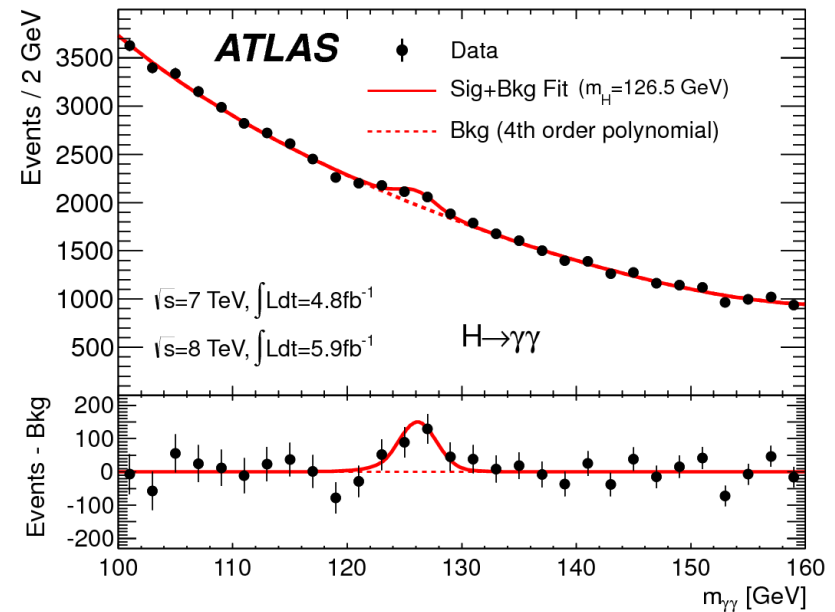

Higgs Boson Discovery
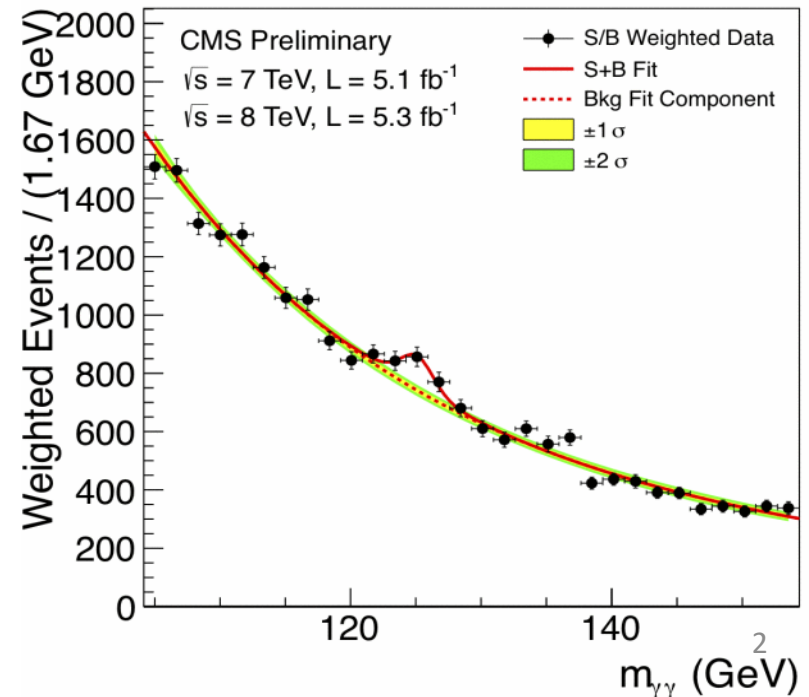
Why use ROOT?

➢ 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.

Minuit fit result on the Graph2DErrors points
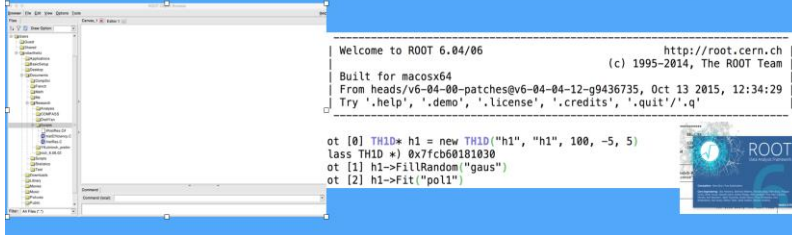
ALICE Detector

3
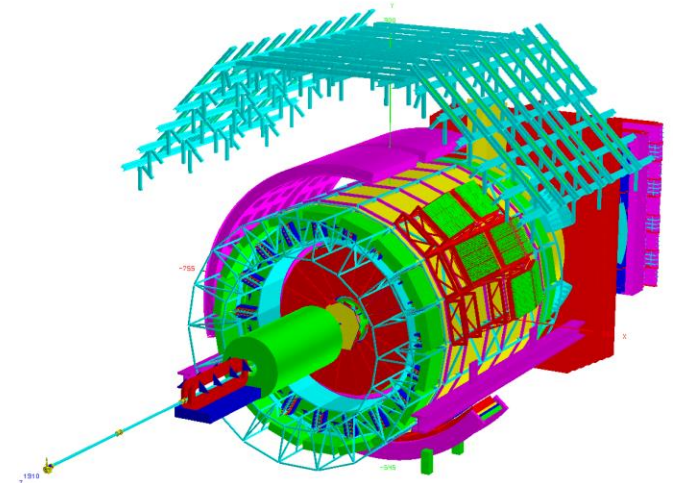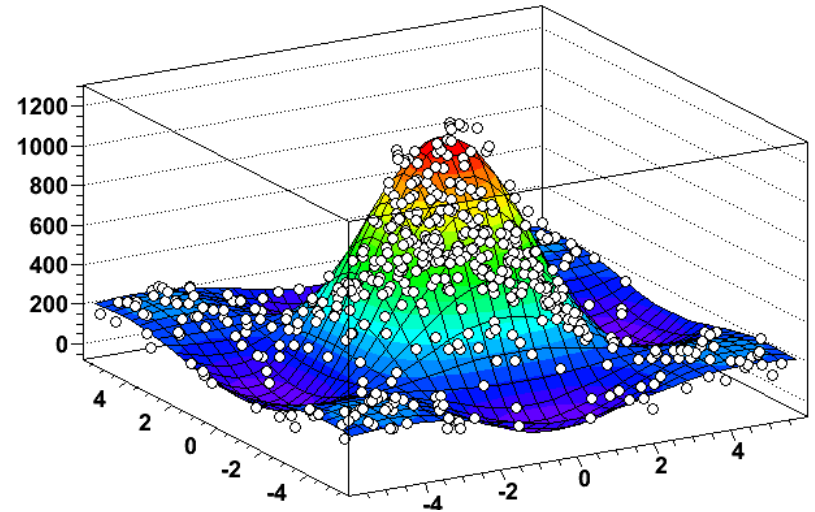
Using ROOT

Three user interfaces:
- ➢ Graphic User Interface
- ➢ Command line
- ➢ Macros and scripts

We will use all of them to help us with the analysis, you will write your own (or modify existing) analysis scripts.
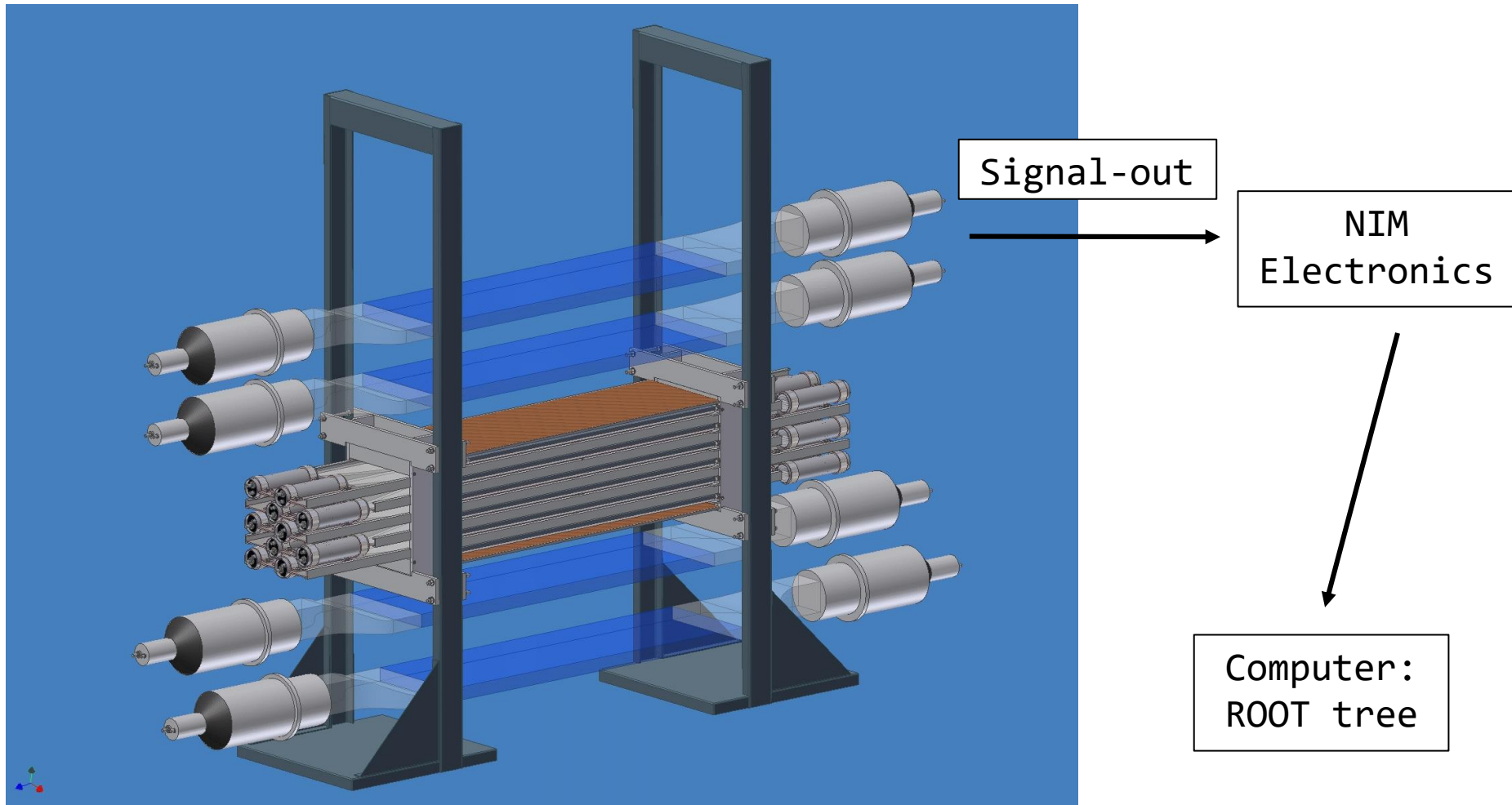
→ ROOT is installed on the LINUX machine in 5103 (not viable during remote-learning)

→ You can also do your work by remotely logging into the machine (ask Daniel).

→ Finally, you can install it on your own computer... There is an extremely useful 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)
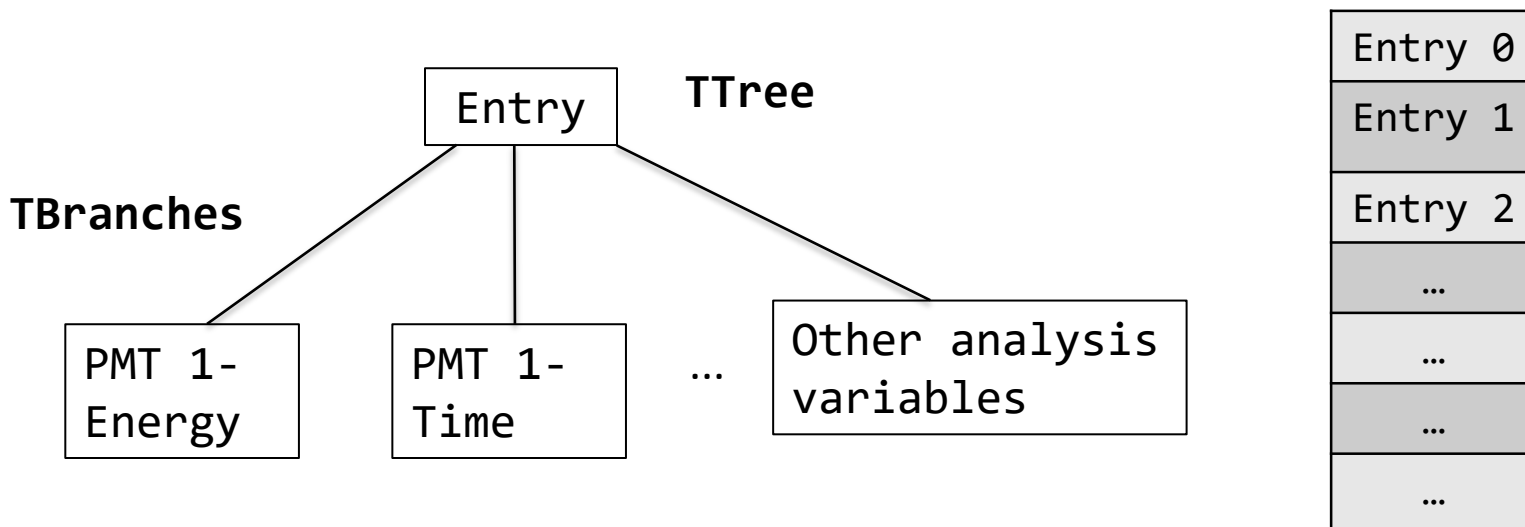
> TTree is one of the most commonly used structures in ROOT.

> 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**

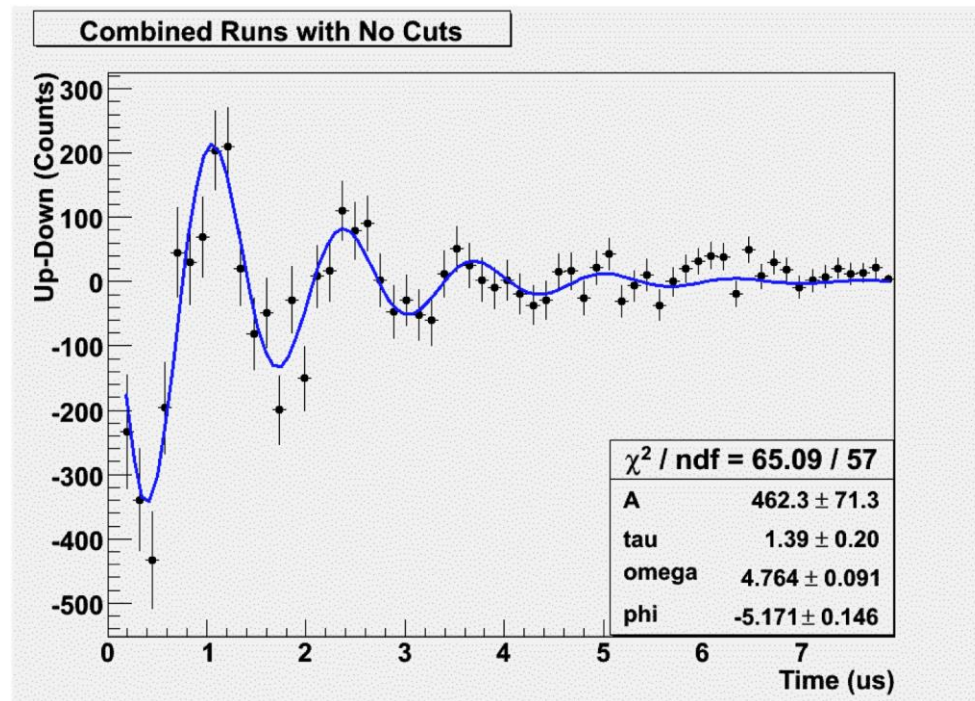# Histogram and Fitting
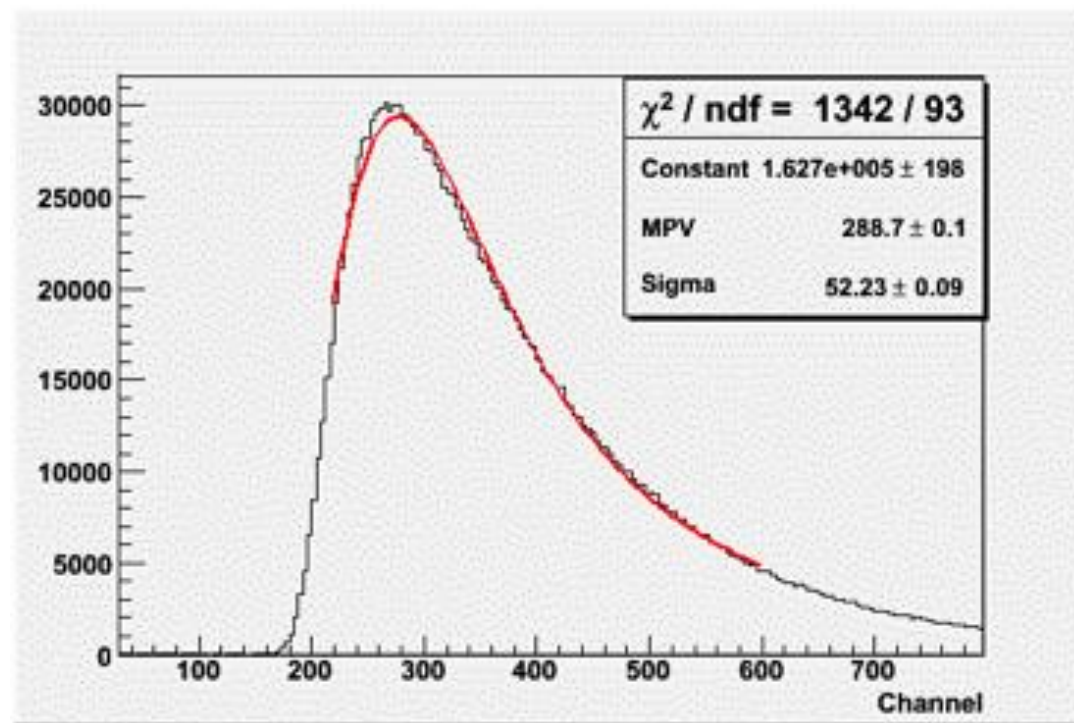
Histogram of a PMT energy signal

➤ 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 can also be found in MyRoot on the course portal (for plotting MCA spectrum, γ-γ coincidence experiments, etc)

➢ Online forums, such as roottalk: http://root.cern.ch/phpBB3/, where you can ask help from the user community.