

# ROOT advanced tutorial

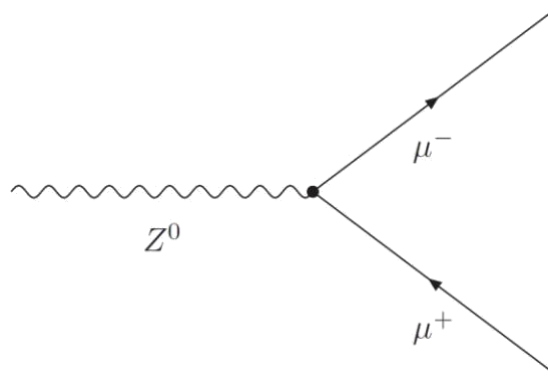
## Introduction

The purpose of this tutorial is to write a ROOT macro that receives a ROOT file with all the particles of an event and returns another ROOT file with only the Z boson that will be reconstructed. Then, you can write yet another ROOT macro to read the file you created, plot the Z boson mass peak and fit it to estimate the Z boson mass

This tutorial should be run inside the LIP machines which you can access by typing `ssh -XY USERNAME@pauli.ncg.ingrid.pt`. There you should have direct access to the data files that will be needed. Before starting you need to setup ROOT: `module load gcc63/root/6.24.06`.

## Reconstruct the Z boson

- Once inside the LIP machines, access the input file in folder `/home/share/` and name `zjet_unrec.root`. Alternatively, download the input file with this command:  
`wget "https://indico.lip.pt/event/1226/contributions/4222/attachments/3500/5443/zjet_unrec.root"`
- Create a new file (with whatever name you want) with a function with the same name as the file (so that you can run it as a standard ROOT macro)
- Declare the file object that we are going use to access our input file.
- Declare the tree object as in previous tutorials
- Declare a histogram object ([TH1 class reference](#)), with the limits, number of bins, and title you think best for the Z mass
- Declare the variables that we will use to access the particles of each event, saved in the tree (as done in the first ROOT tutorial)
- Link these variables to the tree with the [SetBranchAddress](#) function
- Loop over the entries in tree with a for loop, for example (to get the number of entries in the tree: `t->GetEntries()` and to get the values of entry `i` loaded on the linked variables make `t->GetEntry(i)`)
- Loop over the particles in each event
- The Z boson in this Monte Carlo "data" was forced to decay for two muons
- You must therefore find the muons in the particle list. Tip: The ids of the different particles used can be found [here](#)
- When you find the muons (there should be exactly two per event), calculate their invariant mass and fill a histogram with it



- Verify that the spectrum makes sense and then save the events that pass your selection in a new tree, in a new file. You can choose what variables you want to save but as a starting point the four vector (momentum plus energy) and the mass should be enough.
- To do this you should declare a file, more or less in the same place where you had declared the input one and the same for the tree
- You must declare new output variables (i.e. px, etc.) and link them to the new tree with the Branch function ([TBranch class reference](#))
- Every time an event passes you should fill the output variables with the values you want to save and then use `t->Fill()`, in order to save them to your output tree
- You have now created your own data file with a TTree that has information about a Z boson reconstructed from a pair of muons!

## Analyze the Z boson mass peak

- Write a new ROOT macro that opens your data file.
- Draw the Z boson mass peak and fit it using a Gaussian function. The fitted value of the Gaussian's mean should approximately correspond to the Z boson measured mass. How good is the agreement? (Compare, for example, with the value [here](#))
- In this case, because we are not taking into account detector resolution effects, the Z boson mass peak should be better described by a Breit-Wigner function. This function is not predefined in ROOT, therefore you need to define it yourself ([Fitting histograms reference](#), [check](#) section 7.2). Once you have defined your own TF1 function you can use it to fit the mass peak as before. Does your estimation the Z boson mass gets closer to the measured value? What about the goodness of fit, is it improved?