# Examination



Using ROOT and c++ programming language to write codes to finish the following questions. Once you finished everything below, send your results including the following items:

- Your codes.
- Prepare a presentation show people your results and how did you get them, including the fitting plots.

## Experimental setup

Each of you will have a different ROOT file named "tree_group_xxx.root", where "xxx" is a number, different for each group.

In the root file, you will find three TTree objects:

- "tree_data": the Data tree, including both signal and background.
- "tree_mc_sig": the MC tree, stores only signal events.
- "tree_mc_bkg": the MC tree, stores only background events.

In each of the trees, you can find 2 branches:

- "ann": This is the Artificial Neural Network output variable for event selection (signal/background separation).
- "mass": This is the invariant mass of the signal particle you are going to measure.

Now, you are going to finish the following tasks:

## Task 1: event selection

Select the signal events by putting a cut on the Data tree, do the following:

- Find a cut an variable "ann" using the signal MC tree, so as you can keep 90% of your signal.
- Given the cut you find above, using the MC background tree, evaluate the corresponding background rejection rate, i.e. the "power" to reject the background (see our lecture note for the definition of the "power").
- Report the cut you find, and the "power" you get.

## Task 2: fit to the data

Fit to the data mass distribution, and extract the mass mean value ($\mu$) and the width ($\sigma$) using a composed function.

- Apply the cut you have found in Task 1 to the data tree on the "ann" variable, and draw the "mass" into a histogram. (Hint: if you cannot find the signal peak, remember to set more bins in your histogram, and narrow the range of your histogram to the place around the signal mass peak.)
- Define a composed function:
  $f(x) = k \cdot f_s(x) + (1 - k) \cdot f_b(x)$
  using Gaussian as your signal function and exponential function as your background function.
- Fit the composed function to the data mass histogram, to extract the mean value ($\mu$) and the width ($\sigma$) of the signal mass peak.
- Report the results, including the errors(uncertainties).

## Hints:

1. To read a ROOT tree:

```
TTree* tree = (TTree*)the_file->Get("tree");
```

2. To draw a variable "var" in a TTree "tree" directly to a histogram "hist":

```
TH1D* hist = new TH1D("hist", "hist", 100, 0, 100);
tree->Draw("var>>hist");
```

2. To draw a variable "var1" in a TTree "tree" directly to a histogram "hist", and with a selection cut on another variable "var2" with cut value (e.g. "var2 > 0.9"):

```
TH1D* hist = new TH1D("hist", "hist", 100, 0, 100);
tree->Draw("var1>>hist", "var2>0.9");
```