



### COMPUTING EXERCISE

#### Study of the production of a pair of gauge bosons ( $W$ and $Z$ ) at the LHC

The data to analyse are organised into a '**Root n-tuple**' which we will provide to you. The Root n-tuple is a file containing information about the kinematics of "events", each resulting from a **proton-proton interaction**.

These events have three leptons (electrons or muons) and are of two kinds:

- 1) **SIGNAL EVENTS**: corresponding to  $pp \rightarrow W Z X$  with both bosons disintegrating leptonically ( $X$  stands for non identified generic particles ),
- 2) **BACKGROUND EVENTS**: top-antitop events  $pp \rightarrow t\bar{t}X$ .

We remind that the leptonic decays of the  $W$  and  $Z$  are:

$W \rightarrow \ell\nu$  and  $Z \rightarrow \ell^+\ell^-$  with  $\ell = e$  or  $\mu$ .

Since this ntuple is built from a MC file, the two kind of events appear in two separated 'trees' called here "WZSignal" and " $t\bar{t}$ ". For real data these events appear in the same tree and it is important to devise variables to distinguish between them.

The aim of the exercise is :

- 1) to look at some important variables,
- 2) to build the  $Z$  invariant mass from the decay leptons,
- 3) to learn how one can discriminate between the 'signal' and the 'background' (*we will provide an example of an analysis to guide you*)

#### Exercise:

- Open the Root file ( the name of the file is *Selected\_All\_EEM.root*)
- Access the 'branch' WZSignal and  $t\bar{t}$  (follow, as guide the macro *Macro.C*) The list of variables describing the event are given in the next page of this document.

- Plot the **transverse momentum** of the most energetic lepton 'from the  $Z$ ' for signal and background. (Note the average value and the shape of each distribution. Has this variable a good discriminating power?)

- Compute and plot the **invariant mass** of the Z for ALL events (using the decaying leptons)
  
- Plot the isolation variable called **TrackIsoWmu** separately for signal and bkg. Is there a difference? How can one discriminate between signal and background?
  
- Plot the impact parameter variable called **Trackd0cutWMu** for signal and bkg. Is there a difference? How can one discriminate between signal and background?
  
- Plot the Z invariant mass for ALL events requesting that the lepton from W has a small impact parameter and is isolated.
  
- Compare the Z invariant mass with the one in the signal tree (MZ).
  
- OPTIONAL: Fit the MZ distributions with a Breit-Wigner and extract the fraction of signal events in the total sample.

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List of Variables in the ntuple (Br 0,1,.. means "Branch 0, 1, ...")

== **IMPACT PARAMETER and ISOLATION of the lepton from W**

Br 0 :Trackd0cutWMu : Trackd0cutWMu

Br 1 :TrackIsoWmu : TrackIsoWmu

== **MISSING TRANSVERSE ENERGY**

Br 2 :MET : MET

=== **MASS of Z**

Br 3 :MZ : MZ

=== **MOST ENERGETIC LEPTON FROM THE Z**

Br 4 :pt1 : pt1

Br 5 :eta1 : eta1

Br 6 :phi1 : phi1

Br 7 :E1 : E1

=== **SECOND ENERGETIC LEPTON FROM THE Z**

Br 8 :pt2 : pt2

Br 9 :eta2 : eta2

Br 10 :phi2 : phi2

Br 11 :E2 : E2

==== **LEPTON FROM W**

Br 12 :pt3 : pt3

Br 13 :eta3 : eta3

Br 14 :phi3 : phi3

Br 15 :E3 : E3

Br 16 :Weight : Event Weight