



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 μ .

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 (**pt1**) 'from the Z ', for signal ($\rightarrow$ Get "WZSignal") and from the background ($\rightarrow$ Get ("ttbar")). (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 two most energetic leptons). **Suggestion**: look at the slides: how to compute the invariant mass ? how to compute p_x , p_y and p_z from the variables of the ntuple: E , pt , η and ϕ ? how to compute the angle between two 'spatial' vectors (p_x , p_y and p_z) ?

- 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.

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 you may neglect this variable