



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 '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 TrackIsoWmu separately for signal and bkg. Is there a difference? How can one discriminate between signal and background?
- Plot the impact parameter variable 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

=== 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 : Weight