ATLAS cross-section measurement homework 2014

This homework will require you to use some minimal computing and plotting. The level of precision used when quoting results is not important. Pick something reasonable.

You are provided with three "data" files based on $Z \rightarrow ee$ events from proton collisions at $\sqrt{s}$=8TeV at the LHC corresponding to an **integrated luminosity of 0.0087fb^{-1}.**

1) **Zee_truth_MC.txt** provides you with the "truth" values of the energy E and momenta p of ALL electron (particle 1), positron (particle 2) pairs (in units of GeV):

File format: E1, px1, py1, pz1, E2, px2, py2, pz2

Of these "truth" events, only a subset falls within your **perfect** ATLAS detector giving you your second file:

2) **Zee_truth_fid_MC.txt** provides you with the "truth" values of the energy E and momenta p of all electron (particle 1), positron (particle 2) pairs (in units of GeV) falling within the acceptance of your detector (i.e. passing the requirements on the minimum p_T and the possible η range of your leptons, AKA your fiducial acceptance):

File format: E1, px1, py1, pz1, E2, px2, py2, pz2

Of these events, only a subset is actually reconstructed by your detector, and passes all your analysis requirements giving you your third file:

3) **Zee_reco_MC.txt** which provides you with the "reconstructed" (detector-level) values of the energy E and momenta p of the electron (particle 1) - positron (particle 2) pairs (in units of GeV):

File format: E1, px1, py1, pz1, E1, px2, py2, pz2

To do :

a) In the mass window 50-110GeV, plot the 2-lepton invariant mass for the truth events (file 1) and superpose the 2-lepton invariant mass for the truth events within your fiducial acceptance (file 2) and for the reconstructed events (file 3). You can assume that your leptons are massless. Use a coarse-enough binning that you can see a nice Z mass peak. Give an estimate (say to the nearest GeV) of the position of the peaks in the three distributions.

b) Calculate the number of *reconstructed events within a mass window ±10GeV around the world average of the Z-boson mass* (you need to figure out what that world average is!).

c) Using the *reconstructed events* in this mass window, calculate the detector-level cross section for $Z \rightarrow ee$ production ("σ(crudest)" from the lecture notes) in units of nb (i.e. 10^{-9} b). (You can assume that your data contains no background events).

d) Comparing the number of *reconstructed events* in this mass window to the number of *truth events falling in your fiducial acceptance* in this same mass window, calculate the correction factor **C** and hence give the fiducial cross section for $Z \rightarrow ee$ production ("σ(fid)" from the lecture notes) in units of nb.

e) Comparing the number of *reconstructed events* in this mass window to the number of *truth events over the full mass range/phase space* of truth, calculate the product of the correction and acceptance factors **CxA** and hence give the total cross section for $Z \rightarrow ee$ production ("σ(tot)" from the lecture notes) in units of nb.

f) Calculate the statistical uncertainty on "σ(crudest)" in units of nb (assume that all the statistical uncertainty comes from the statistics of your reconstructed events).