PHY213 - KT II
Exercise Sheet 4

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Prof. N. Serra

D. Lancierini
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Exercise 1: Decay width calculation

The partial decay width of the Z boson to a massless fermion is given by

$$\Gamma(\mathrm{Z} \to f\bar{f}) = \frac{1}{48\pi}\frac{g^2}{cos^2\theta_W} m_Z \left[c_V^2 + c_A^2\right] \tag{1}$$

where θ_W is the Weinberg angle, g is the weak coupling and $c_{V/A}$ are the vector/axial couplings of the fermion f. Equation 1 is the $m \to 0$ limit of

$$\Gamma(\mathrm{Z} \to f\bar{f}) = \frac{1}{48\pi}\frac{g^2}{cos^2\theta_W}\frac{1}{m_Z} \left[2m(c_V^2 - 2c_A^2) + m_Z^2(c_V^2 + c_A^2)\right] \tag{2}$$

Using Pythia8 internal parameters

a) Verify that when decaying into leptons the Z prefers to decay to neutrinos almost twice of the times

b) Calculate the total width of the Z in GeV

c) Express the lifetime of the Z in seconds

d) Calculate the partial decay width of the Z in each lepton and quark

Exercise 2: Pythia8 simulation

The partial width is closely connected to the branching fraction, in order to inspect this relation generate 10^5 $e^+e^- \to Z \to f\bar{f}$ events in Pythia8 after having set the energy of the beams to produce a Z boson at rest.

a) Loop inside each generated event to extract the final state particle identity and increase a counter for each identity

b) How many top quarks are generated? Why?

c) Compare the branching ratios with the results of the previous exercise