2. **B)** In a proton-antiproton collider *b* quarks are produced in the process:

$$\bar{p}p \rightarrow \bar{b}b + X,$$

where *X* denotes additional particles and the proton anti-proton centre of mass energy is 1.8 TeV. The bottom quarks hadronize, and, for the case of interest here, one becomes a B_d^0 and "oscillates" into a B_d^0 meson. The mass of the B_d^0 is 5.3 GeV and it has an average momentum of 10 GeV/c and a lifetime of 1.58 ps. It is desired to measure the rate of oscillation of the B_d^0 experimentally.

i) The B_d^0 mass is 5.3 GeV, and it has an average momentum of 10 GeV/c and a lifetime of 1.58 ps. How far does it travel? **{4}**

ii) The B_d^0 meson can "oscillate" into a B_d^0 meson. Draw a Feynman diagram for this process indicating the CKM couplings and masses and hence the Standard Model parameters to which this measurement gives one access. **{4}**

iii) Describe the component of the ALEPH or CDF detector used to measure this decay distance. Assuming that the B_d^0 meson oscillates once in its lifetime, what resolution must that detector have to measure the oscillation? **{4}**

iv) The bottom quark that did not hadronize into a B_d^0 meson is used to tag the flavour of the bottom quark that did hadronize into a B_d^0. Sketch how this tagging is used to distinguish a B_d^0 which has oscillated from one which has not oscillated. **{5}**

v) Describe with the aid of a graph what quantity or quantities are used in this tagging process to measure the oscillation frequency. **{3}**

vi) If a B_s^0 meson were formed instead of a B_d^0 meson, indicate the difference in the Feynman diagram describing the B_s^0 oscillations and the demands on detector resolution. **{4}**