Muon Acceleration from 20 to 60 GeV for a Higgs Factory

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What is required to accelerate a μ^+ and a μ^- particle bunch from 20 to 60 GeV? A neutrino factory as outlined in the recent Brookhaven study provides 20 GeV muons which have enough energy to explore CP violation in the lepton sector. Further acceleration to 60 GeV may be enough to reach a low mass Higgs as suggested by theory and recent measurements at LEP.

To reduce the RF cost, consider twenty passes through a two GeV Linac and see if enough muons survive decay. A single continuos Linac with teardrop shaped arcs at each end is adopted. Muon decay losses are minimized; muons pass through shorter arcs when their gamma boost is low. To minimize magnet cost 45^0 turns are used with short straight sections to line up the arcs. For each teardrop, the length added to the curved sections by the two straight sections is $(4 - 2\sqrt{2})/2\pi = 18.6\%$.

Take a muon lifetime of 2.2×10^{-6} seconds, 1.8 Telsa dipoles, a 70% dipole packing fraction, and a 133 meter long 2 GeV Linac with 15 MV/meter. The total magnet bore length required is 7000 meters, 11% longer that the Fermilab Tevatron. Muon survival after twenty passes through the 2 GeV Linac is 95.5%. Squaring this percentage the luminosity is 91.8% of what it would be in a Higgs factory if there had been no decay loss in accelerating the muons from 20 to 60 GeV.

The magnet cell length may heve to be short to provide good acceptance for the muons in the arcs. An alternating gradient design where the magnet lamination change shape within a magnet avoids magnet ends and makes it easier to consider superconducting wire rather than copper. The magnets do have to be at full field constantly, so power consumption is an issue.

Finally note that in a dogbone geometry, muons can orbit clockwise in one end and counterclockwise in the other end, minimizing dispersion. This may help to preserve polarization. If muons are 100% polarized, the $\mu^+\mu^- \rightarrow$ Higgs cross section doubles (versus the case of zero polarization).

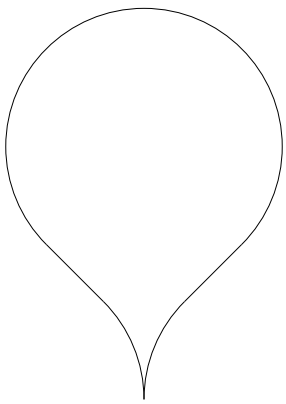

Figure 1: Sets of teardrop shaped magnet arcs each with 1.8 Tesla iron dipoles are used at each end of the 2 GeV Linac.