Defending the Merit Factor in Neutrino Factories

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`http://keil.home.cern.ch/keil/MuMu/Doc/ANL-Aug02/meritF.pdf`

Merit Factor F

- Traditional definition of the merit factor F

$$M = \frac{\varepsilon_x^0}{\varepsilon_x^f} \frac{\varepsilon_y^0}{\varepsilon_y^f} \frac{\varepsilon_s^0}{\varepsilon_s^f} \exp\left(-\frac{s}{\beta\gamma c\tau_\mu}\right)$$

- M is product of the ratio of final over initial emittances in 3 directions, multiplied by losses caused by muon decay
- Along a cooling channel, M starts at $M = 0$ at $s = 0$, then rises, reaches a maximum and finally drops
- The drop occurs when the final emittances are so close to the equilibrium values that there is hardly any cooling, and decay losses dominate.

Palmer's Quality Parameter Q

- Palmer defines quality parameter Q

$$Q = \frac{\log\left(\frac{\varepsilon_6^f}{\varepsilon_6^i}\right)}{\log\left(\frac{N^f}{N^i}\right)}$$

- Numerator is logarithm of ratio of 6D emittances, denominator is logarithm of decay losses
- Palmer gives example of a cooling channel for a muon collider with $\varepsilon_6^f/\varepsilon_6^i = 10^{-6}$ and $N^f/N^i = 0.5$, and finds approximately $Q = 20$
- Cooling channel with $Q = 20$ is a nice cooling channel
- Not all cooling channels with $Q = 20$ suitable for muon collider
- Cooling channel for muon collider must have $M = 5 \cdot 10^5$

Trivial Quality Parameter Q

- In the approximation that the final emittances are large compared to their equilibrium values, the initial emittances are cooled exponentially with cooling length c

$$\varepsilon(s) = \varepsilon(0)\exp(-s/c)$$

- Substituting into the definition of Q shows that Q does not depend on s

$$Q = \frac{1/c_x + 1/c_y + 1/c_s}{1/\beta\gamma c\tau_\mu}$$

- Q is simply the ratio of the sum of the inverse cooling lengths and the inverse decay length
- Without the approximation $Q(0)$ is smaller than the above formula, and $Q(s) < Q(0)$