SYNCHROTRON RADIATION IN THE 20 TEV PROTON ACCELERATOR

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Because of their mass, protons radiate less than electrons of the same energy by a factor of about 10^{13}. The synchrotron radiation per turn by a proton E_r is given by

$$E_r = 7.8 \cdot 10^{-12} E^4/R$$

where the proton energy E is measured in TeV and the radius of curvature is in kilometers. For the 20 TeV proton synchrotron used as an example in the ICFA study at Fermilab, the radius of curvature is 10.5 km which leads to about 120 KeV of radiative energy per turn at 20 TeV. For a circulating beam of 10^{15} protons, this means a total energy radiation of 100 KW which is comparable to the normal heat losses at 4°K. The characteristic wave length is about 0.5μ, so there should be considerable visible light which should help with beam diagnostics. The coherent radiation, calculated by Shiff, is not important.

The damping of vertical betatron oscillations is given approximately by $E_r/2E$, which for this case implies that the vertical size of the beam will be reduced by half in about 24 hours. Although not significant during the acceleration period, such damping will limit the growth of a beam due to multiple scattering to a small size, depending of course on the pressure.