**Answer on Question #73097 Physics / Other**

In a circular accelerator a proton is accelerated to an energy of $E = 10^{12}$ eV, as measured in the laboratory frame. If the rest energy of the proton is $E_0 = 10^9$ eV, calculate

i) the speed of the proton as measured in the laboratory frame

ii) the force that must be applied by the magnets in the accelerator to keep the protons moving at this speed in a circle of radius $R = 1000$ m.

**Solution:**

**i)** The energy of the proton

$$E = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{E_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

Thus

$$v = c\sqrt{1-\left(\frac{E_0}{E}\right)^2}$$

$$v = c\sqrt{1-\left(\frac{10^9}{10^{12}}\right)^2} = 0.9999995c = 299999850 \text{ m/s}$$

**ii)** The Newton's second law states

$$ma = F$$

Centripetal acceleration

$$a = \frac{v^2}{R}$$

Thus

$$F = m\frac{v^2}{R}$$

$$F = 1.67 \times 10^{-27} \times \frac{299999850^2}{1000} = 1.5 \times 10^{-13} \text{ N}$$

**Answers:**

**i)** $0.9999995c = 299999850$ m/s

**ii)** $1.5 \times 10^{-13}$ N

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