Homework 488/688

Advanced Topics in Accelerator Physics (Hoffstaetter)

Due Date: Monday, 9/27/04 - 14:45 in 132 Rockefeller Hall

Exercise 1: A time of flight spectrometer takes all particles that come from a collision point regardless of their initial slopes x' and y' and transports them to a point in a detector plane. The time of flight should depend only on the energy, not on the initial position or the initial angle of the particles in the collision plane. Write the most general form that the transport matrix from the collision plane to the detector plane can have.

Exercise 2: If not the time of flight $\tau = (t_0 - t)\frac{E_0}{p_0}$ and the relative energy change $\delta = \frac{\Delta E}{E}$ had been chosen as phase space variables, but the deviation in path length Δl and the relative momentum deviation $\frac{\Delta p}{p}$, how would the transport matrix look like and how could it be computed from the transport matrix in exercise 1?

Exercise 3: A section of an accelerator or beamline is called achromatic to order n when the final positions and slopes x, y and x', y' do not depend on energy up to order n in a Taylor expansion in the initial phase space variables. Furthermore, a beamline is called time independent when the 6 dimensional transport map $\vec{M}(\vec{z}_0)$ does not depend on the initial time of flight τ_0 except by $\tau = \tau_0 + \Delta_\tau(x, x', y, y', \delta)$. Show that an achromatic and time independent beamline has a time of flight that does not depend on the initial positions and slopes to first order, i.e. $\Delta_\tau = \Delta_\tau(\delta) + O^2$.

Exercise 4: Show that the claim of exercise 3 is true to any order n, i.e. show that a beamline that is achromatic to order n and time independent has a time of flight that does not depend on the initial position and slope to order n and therefore $\Delta_\tau = \Delta_\tau(\delta) + O^{n+1}$. Why is this information very useful for the design of time of flight spectrometers?