

Estimation of the IBS effects in the Accumulator for mu2e.

Intrabeam scattering (IBS) plays a significant role in emittance growth for proton machines like Tevatron and the Accumulator. In the past, when operational regimes of the Accumulator assumed running for hours with large stacks (more than 100e10) of stochastically cooled antiprotons, special lattice ramps were engaged in order to mitigate those effects. In case of mu2e, IBS is not expected to be an issue because of very short beam life time and large emittance of the proton beam, even though the bunch density will be much higher.

A crude estimate has been made using IBS growth rates approximation in [1]. As the condition

$\frac{\Delta p_{\parallel}}{\gamma \mathcal{P}} \ll \theta_{x,y}$ is satisfied, we use

$$\Gamma_p = \frac{d(\sigma_p^2)}{dt} = \frac{e^4 \left\langle \frac{N}{\sigma_1 \sigma_2 \sigma_s} \frac{\Psi(0, \theta_1, \theta_2)}{\sqrt{\theta_1^2 + \theta_2^2}} L_c \right\rangle_s}{4\sqrt{2} m^2 c^3 \gamma^3 \beta^3}$$

Where σ_p is the rms momentum spread, $\sigma_1, \sigma_2, \theta_1, \theta_2$, are the rms transverse ellipse semi-axis and σ_s is the rms bunch length, L_c is the Coulomb logarithm and N_b is the number of particles per bunch. Ψ -function can be approximated as

$$\Psi(0, x, y) \approx 1 + \frac{\sqrt{2}}{\pi} \ln \left(\frac{x^2 + y^2}{2xy} \right) - .055 \left(\frac{x^2 - y^2}{x^2 + y^2} \right)^2$$

After averaging this growth rate over the Accumulator lattice, the transverse emittance growth rate is given as

$$\Gamma_x = \frac{d\varepsilon_x}{dt} = \Gamma_p \cdot \gamma \cdot \left\langle \frac{D_x^2 + (\beta_x D_x' + \alpha_x D_x)^2}{\beta_x} \right\rangle$$

For a single 2.5MHz bunch with 3e12 protons and normalized emittance 20 π mm mr and rms energy spread of 25MeV in the Accumulator, emittance growth rate yields

$$\Gamma_x = 3 \cdot 10^{-4} \pi \cdot mm \cdot mr \text{ in 1 second,}$$

which is by far negligible.

[1] Valeri Lebedev, "Single and Multiple Intrabeam Scattering in Hadron Colliders", 33rd ICFA Advanced Beam Dynamics Workshop on High Brightness Hadron Beams, October 18-22, 2004, Bensheim, Germany