Estimate of incidence angle for RHIC losses

Typical beam diffusion rates are 1.e-3 (mm-mrad)^2/s at 1 mm-mrad (Fliller, RPAG004, PAC03) and beta functions are about 20 meters, 5 cm pipe

$$\Delta\varepsilon \approx T_{rev}B(J)/J = 1.3\times 10^{-14}\, m - rad$$

$$\hat{x}\Delta\hat{x} = \Delta\varepsilon\beta_L = R_{pipe}\Delta\hat{x}$$

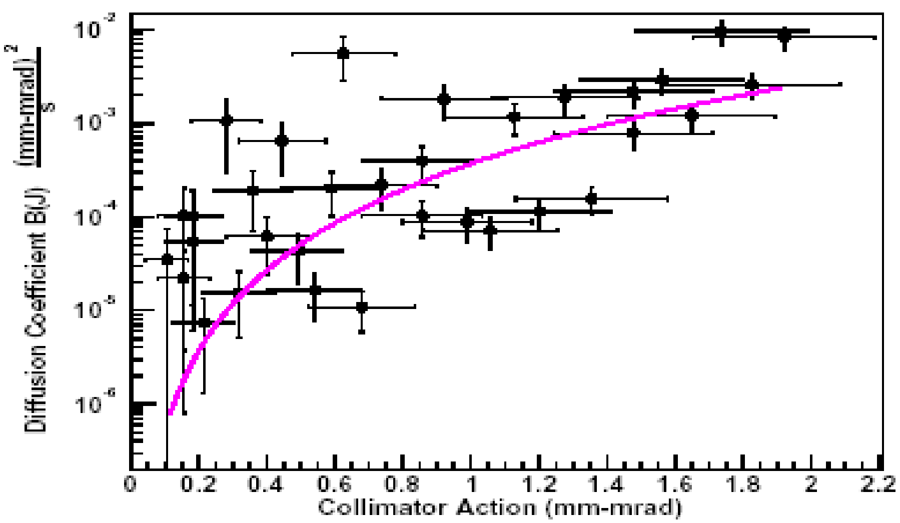

Figure 3: Reconstructed diffusion coefficient for Fill 02797. Note the vertical axis has a log scale.

So the increase in amplitude per turn is

$$\Delta\hat{x} \approx \beta_L\Delta\varepsilon / R_{pipe} \approx 6\times 10^{-12} m = 0.06 A^0$$

For comparison, during acceleration the charge in amplitude with energy for a particle near the wall is

$$\Delta\hat{x}_{acc} \approx 5\times 10^{-8} m$$

Impact angle estimate

Take a 1-D model with tune Q and emittance growth due to gas scattering.

$$x_n = A_n \cos(2\pi nQ) + B_n \sin(2\pi nQ)$$
$$A_{n+1} = A_n + a_n$$
$$B_{n+1} = B_n + b_n$$

Where a_n, b_n are uncorrelated random deviates.
The amplitudes A_n, B_n random walk and the particle eventually hits the aperture. Define the effective emittance increase $\Delta\varepsilon_e$ to be the difference between the machine acceptance and the particle's emittance when it strikes the wall. For a tune Q=N/M where N and M are integers $< \Delta\varepsilon_e > \leq M\Delta\varepsilon$ where the angular brackets denote average value. So, the effective emittance increase can be significantly larger than the emittance increase per turn. Better estimates are required here.

Glancing incidence

The incidence angle in a quad scales as

$$x_0' \approx \sqrt{\Delta\varepsilon_e / \beta}$$

where β is the beta function. Plots are Langevin simulations for 107 GeV/A Au on Cu. dE/dx = 0.7 GeV/A/cm. Mean free path (mfp) for inelastic nuclear collisions is a few cm so negligible probability of Bethe-Bloch stopping. Escape likely for small incidence angles.