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Title: Sensitivity of Beam Parameters to a Station C Solenoid Scan on Axis II

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Sensitivity of Beam Parameters to a Station C Solenoid Scan on Axis II

Magnet scans are a standard technique for determining beam parameters in accelerators. Beam parameters are inferred from spot size measurements using a model of the beam optics. The sensitivity of the measured beam spot size to the beam parameters is investigated for typical DARHT Axis II beam energies and currents. In a typical S4 solenoid scan, the downstream transport is tuned to achieve a round beam at Station C with an envelope radius of about 1.5 cm with a very small divergence with S4 off. The typical beam energy and current are 16.0 MeV and 1.625 kA.

Sensitivity to Emittance

An initial envelope radius and angle of 1.25 cm and 0.0 mrad is assumed and the beam size at Station C is determined as a function of emittance and S4 current. The results are shown in Figure 1 for normalized emittances between 250 and 1500 π(mm-mrad). Figure 1 shows that the beam size is very sensitive to the emittance as the beam is converging and when the beam is focused on Station C. When the beam is focused upstream of Station C, there is essentially no correlation between beam size and emittance.

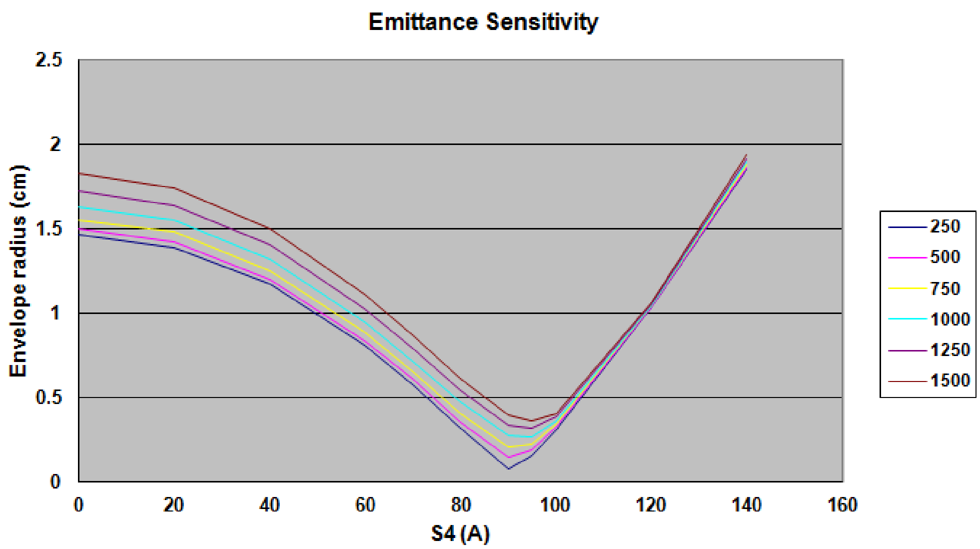

Figure 1: Sensitivity of the beam size at Station C as a function of S4 current for different normalized emittances.

Sensitivity to Initial Envelope Radius

Figure 2 shows a similar calculation in which the emittance and envelope angle are fixed at values of 1000 π(mm-mrad) and 0.0 mrad respectively and the initial envelope radius is varied. The initial envelope radius is varied from 0.8 to 1.4 cm. In this case, the envelope radius at Station C is very dependent on other factors especially space charge forces as the beam is converging and not well correlated with the initial envelope radius. The diverging beam, however is very strongly correlated with the initial envelope radius especially at the larger S4 currents.

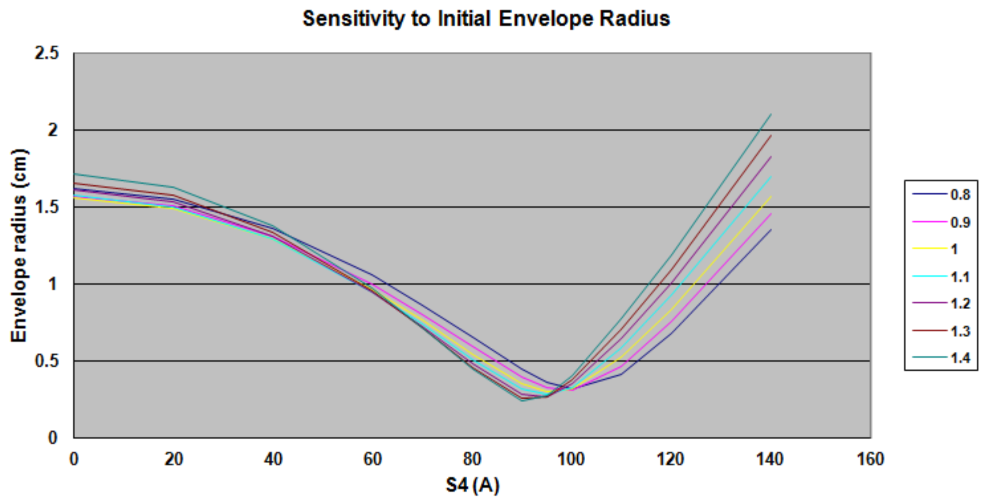

Figure 2: Sensitivity of the beam size at Station C as a function of S4 current for different initial beam envelope radii.

Sensitivity to Initial Envelope Angle

Figure 3 shows a similar calculation in which the emittance and envelope radius are fixed at values of 1000 π(mm-mrad) and 1.25 cm respectively and the initial envelope angle is varied. The initial envelope angle is varied from -2 to 2 mrad. Figure 3 shows that the beam size is strongly dependent on the initial envelope angle for both low and high values of the S4 current. There is essentially no sensitivity to the initial envelope angle when the beam is focused at Station C.

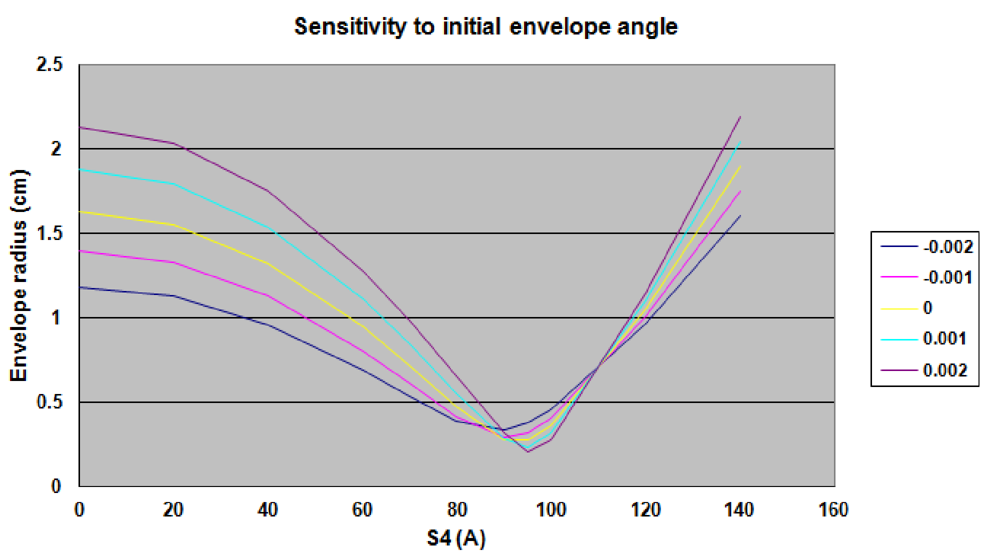

Figure 3: Sensitivity of the beam size at Station C as a function of S4 current for different initial beam envelope angle.

Discussion

Figures 1-3 show the sensitivity of the bean size at Station C to the emittance, initial radius and initial angle respectively. To better understand the relative sensitivity of the beam size to the emittance, initial radius and initial angle, linear regressions were performed for each parameter as a function of the S4 setting. The results are shown in Figure 4. The measured slope was scaled to have a maximum value of 1 in order to present the relative sensitivities in a single plot. Figure 4 clearly shows the beam size at the minimum of the S4 scan is most sensitive to emittance and relatively insensitive to initial radius and angle as expected. The beam emittance is also very sensitive to the beam size of the converging beam and becomes insensitive to the beam size of the diverging beam. Measurements of the beam size of the diverging beam provide the greatest sensitivity to the initial beam radius and to a lesser extent the initial beam angle. The converging beam size is initially very sensitive to the emittance and initial angle at low S4 currents. As the S4 current is increased the sensitivity to the emittance remains strong while the sensitivity to the initial angle diminishes.

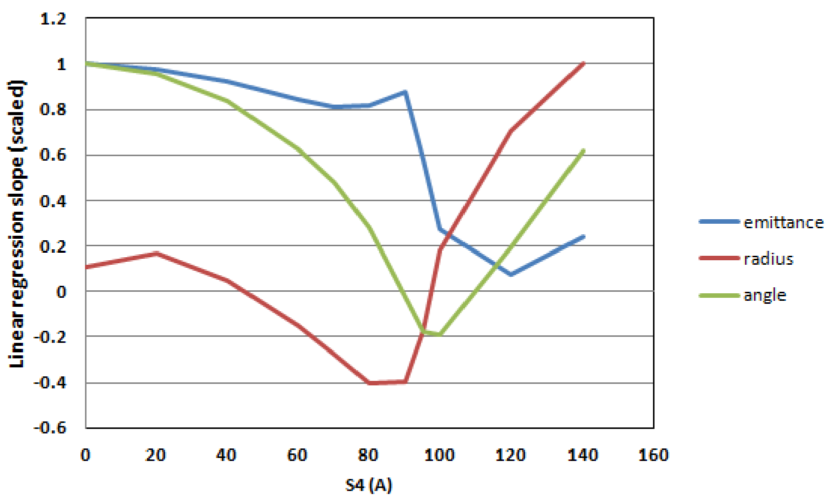

Figure 4: Scaled slope of a linear fit to the beam size at Station C for the beam parameters as a function of S4 setting.