Using Pulsed Lens to Compensate Tilt

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We have mentioned the possibility of using a pulsed lens upstream of the neutralizing plasma channel to compensate the energy tilt (dP/P) of the 2-kA, 19-MeV, 30 mm-mrad (un-normalized) Ne+ beam at the HEDP workshop. In this report, the needed pulsed magnetic field and the beam envelope and its final spot size are discussed. Figure 1 shows the magnetic tune for a simple beamline configuration. A constant solenoid field is used in this model to match the beam into the plasma channel. Base on the needed field strength, ~77 T, a solenoid may not the best choice to focus a space charge dominated ion beam. However, using a solenoidal matching lens allows the beam remains round regardless of the energy tilt and the setting of the pulsed lens. A single loop 8-cm radius and 1-cm wide coil placed inside the matching solenoid so that it can either focus or defocus the beam depending on the polarity of the driving current. Roughly the fast coil needs to provide 2 - 3 Tesla of magnetic field change during the beam time in order to get the same beam spot at the target plan for dP/P = ± 5%. For a 20 – 30 ns long beam pulse, dB/dt is about 1 kG/ns, which would be too large for a simple single-loop coil. Ten times of this fast coil field is also plotted in Fig. 1. LLNL's ETA-II target experiment's final focus lens' magnetic profile is used here for the final focus lens although LLNL's lens can only provide several kilogauss of magnetic fields. Two target plan locations (z_f = 20 cm and z_f = 30 cm) are studied.

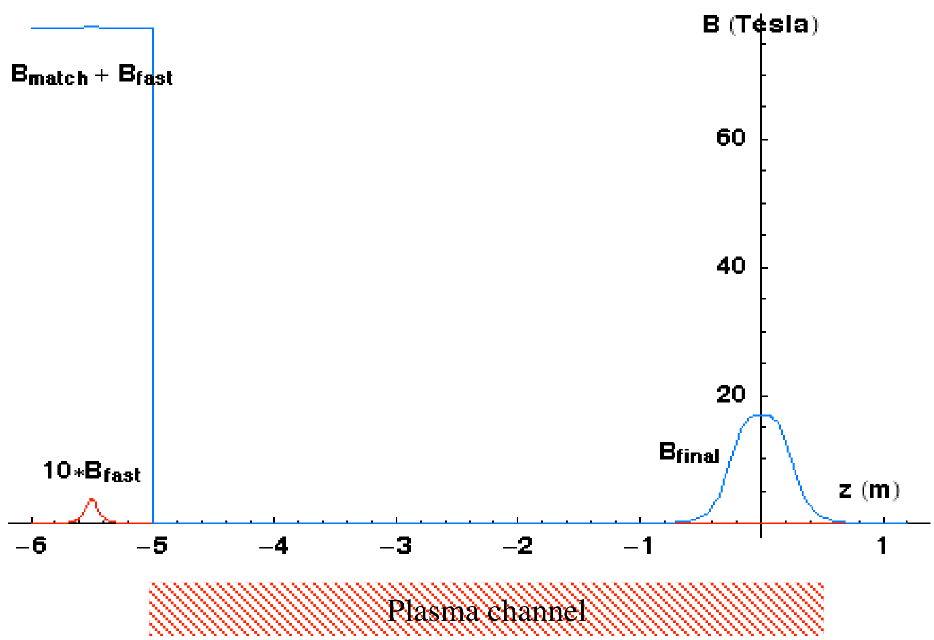

Fig. 1 The magnetic tune used in the envelope calcuations

Figure 2 and 3 show the beam envelopes and compensated beam spots for dP/P = ± 5%, ± 2.5%, and 0 when the target plan is 30 cm downstream from the center of the final focus lens. The beam envelope parameters (radius and slope) are identical at the starting point, z = -6 m. Although the beam envelopes are quite different, the variation of the final spots is less than ± 1.5%. The corresponding fast coil's fields are given in Fig. 4.

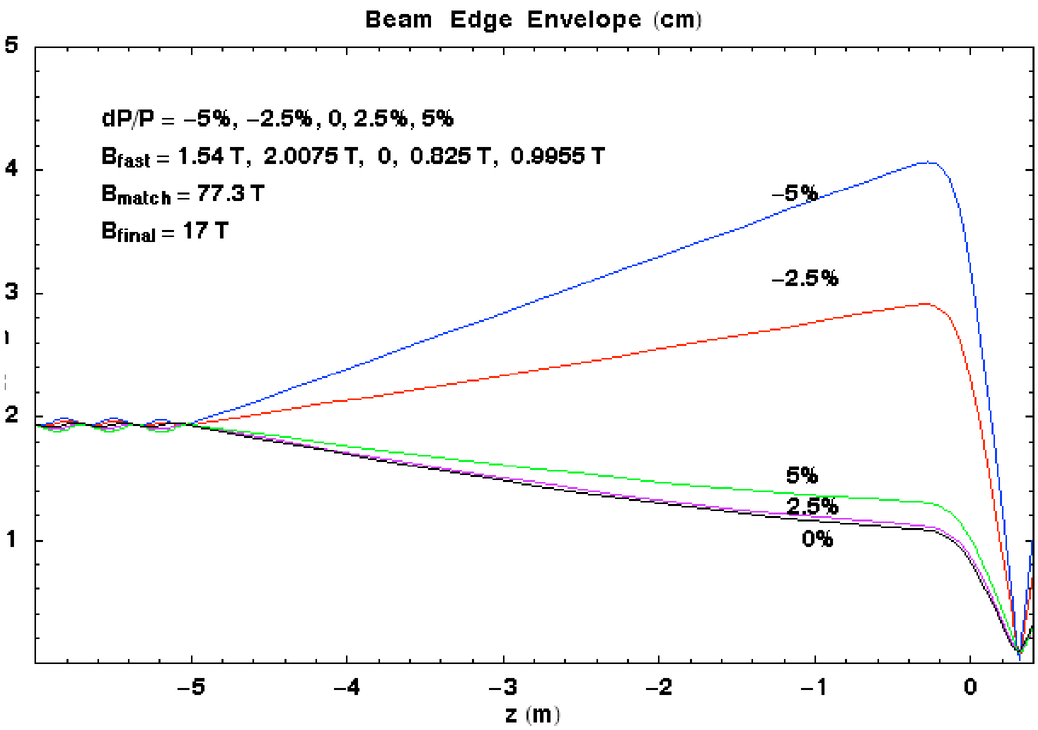

Fig. 2 Beam envelopes for the 2-kA, 19-MeV, 30 mm-mrad (un-normalized) Ne+ beam with various fast coil fields to compensate for final spot size variation introduced by energy tilt. The location of the focal point is at 30 cm.

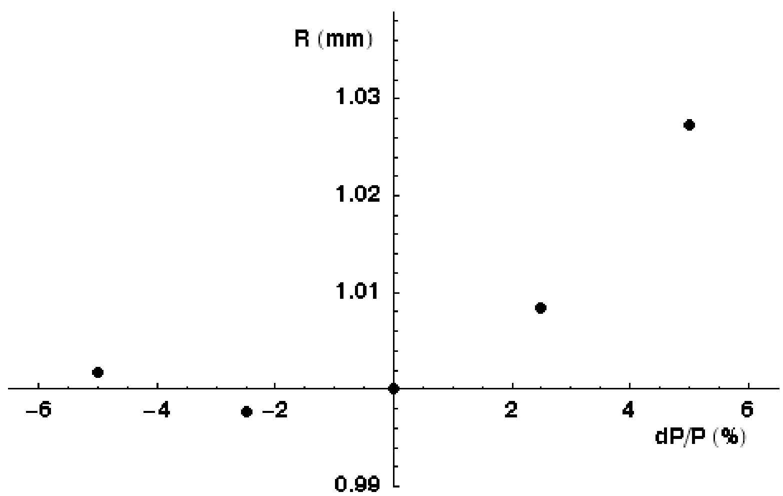

Fig. 3 Final beam radius at the focal point (z = 30 cm) as a function of energy tilt. The corresponding fast coil setting is given is Fig. 4.

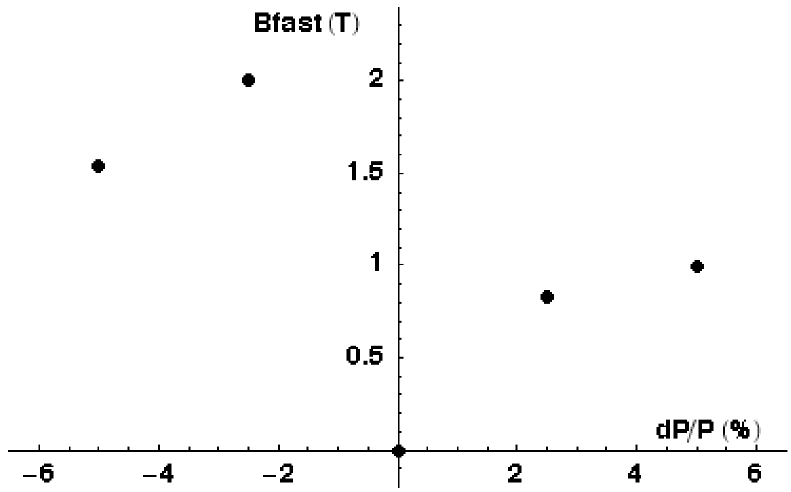

Fig. 4 The fast coil's magnetic fields used to maintain final spot size variation.

Figures 5, 6 and 7 show the beam envelope, spot size and the needed pulsed magnetic field when the focal point is located at z = 20 cm. These results are similar to the previous case.

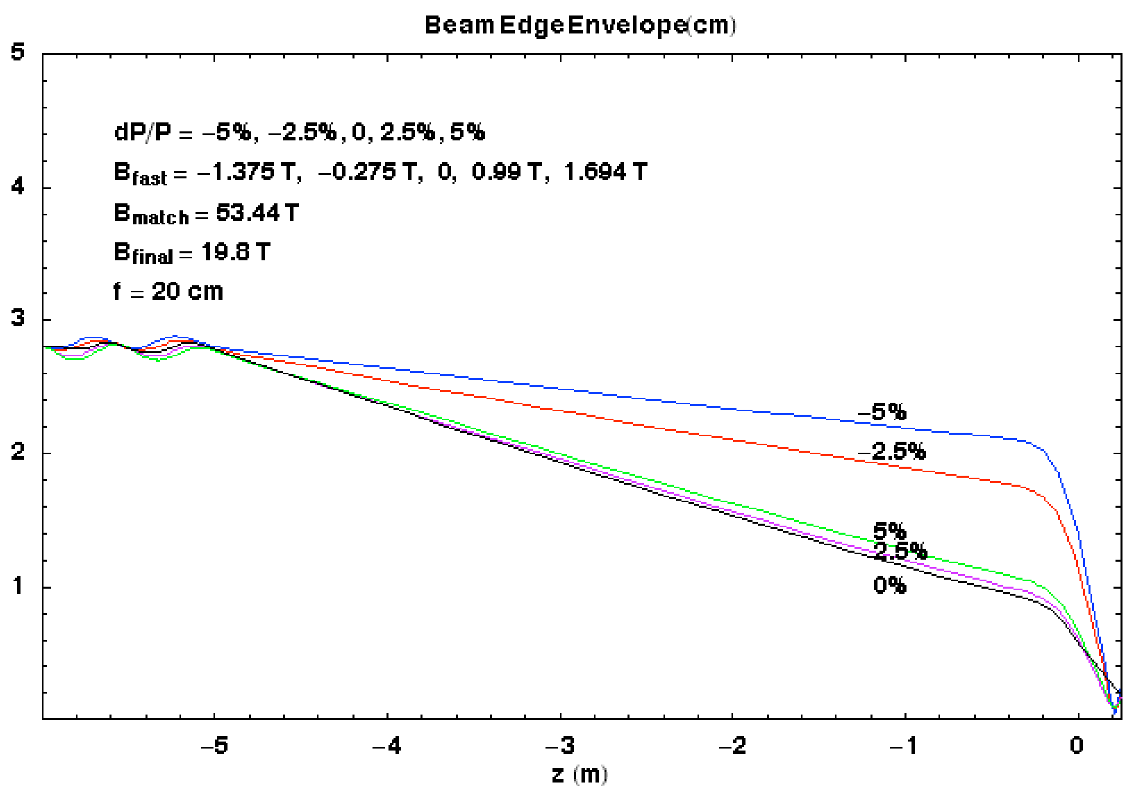

Fig. 5 Beam envelopes for the 2-kA, 19-MeV, 30 mm-mrad (un-normalized) Ne+ beam with various fast coil fields to compensate for final spot size variation introduced by energy tilt. The location of the focal point is at 20 cm.

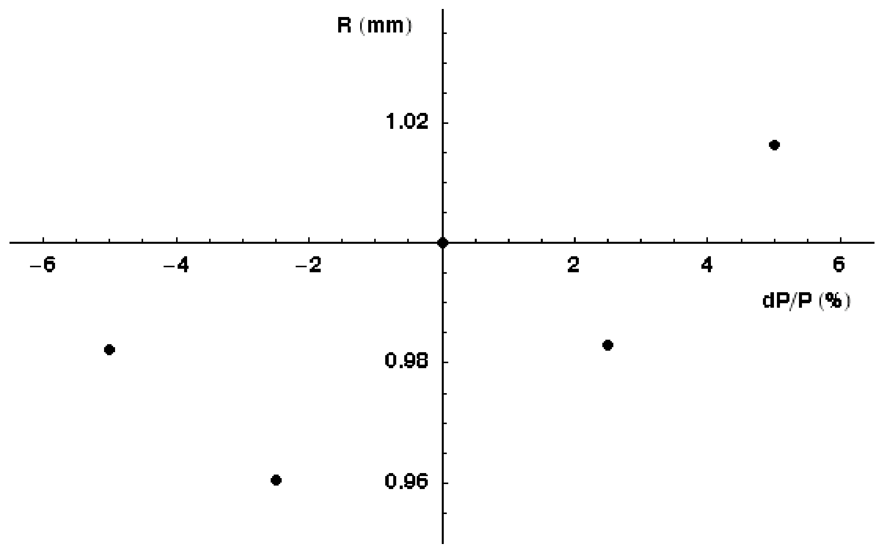

Fig. 6 Final beam radius at the focal point (z = 20 cm) as a function of energy tilt. The corresponding fast coil setting is given is Fig. 7.

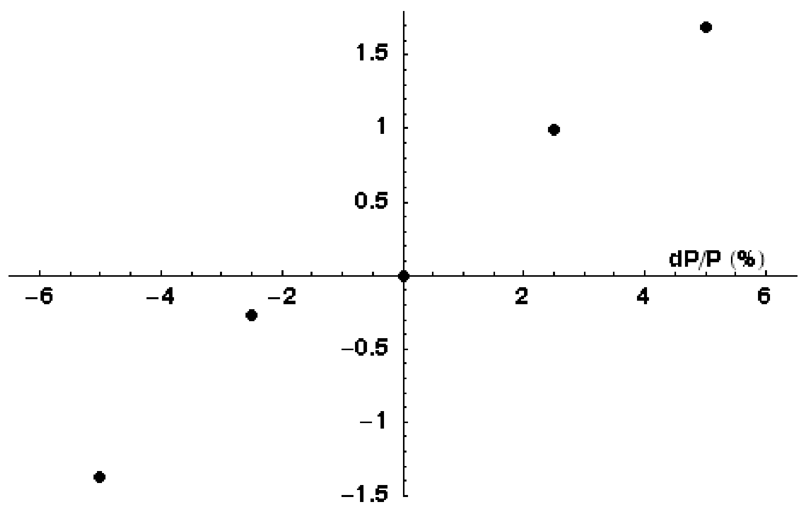

Fig. 7 The fast coil's magnetic fields used to maintain final spot size variation. (f = 20 cm)