

4D Beam Matching, Phase Smoothing, and Resonant Energy Exchange in a 1 Ampere Deuteron LINAC

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The 1A Space-Charge Challenge

At 1A, extreme space-charge forces destroy longitudinal bunching and create a massive transverse halo.

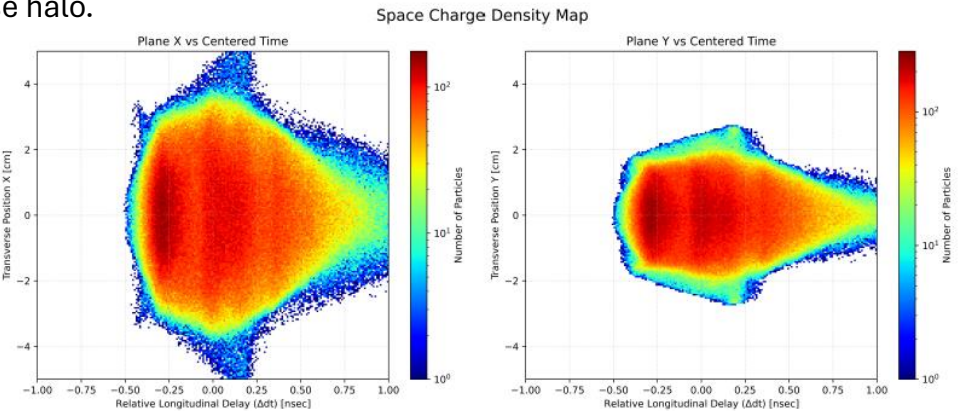


Figure : 2D Density map with the previous design. 0A lattice + $1/\beta^2\gamma^3$

The Solution : Phase Smoothing

Nelder-Mead 4D Twiss optimization coupled with a tailored parabolic RF phase profile $\phi_s(z)$

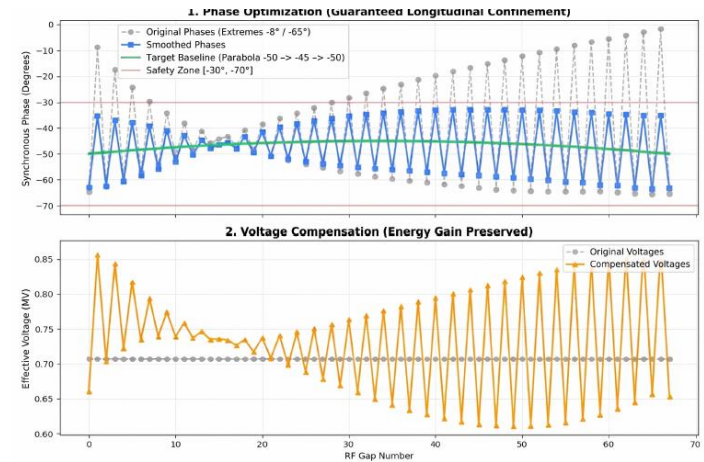


Figure : Graph of the phases and voltage profiles

Results : Halo Supression

Non-adiabatic transitions mitigated. Longitudinal bunching restored and halo safely confined

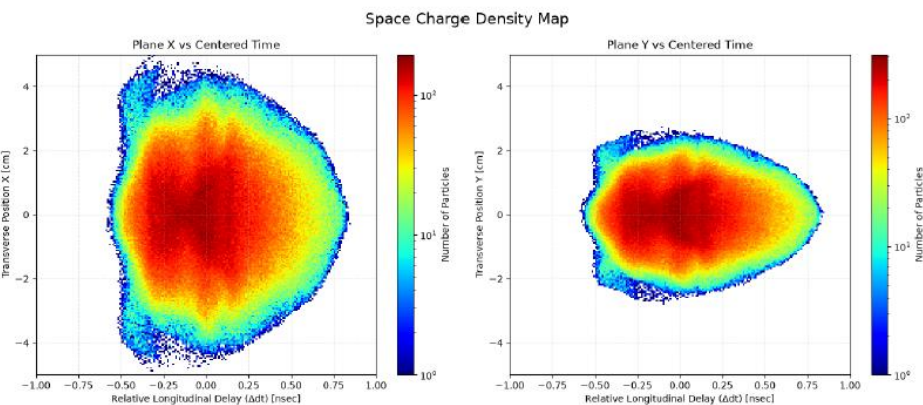


Figure : 2D Density map with the new design

Resonance Limits

Emittance exchange driven by structural resonances ($\sigma_t = \sigma_l$). Points towards future magnetic tapering and solenoid confinement.

Desiable tune evolution

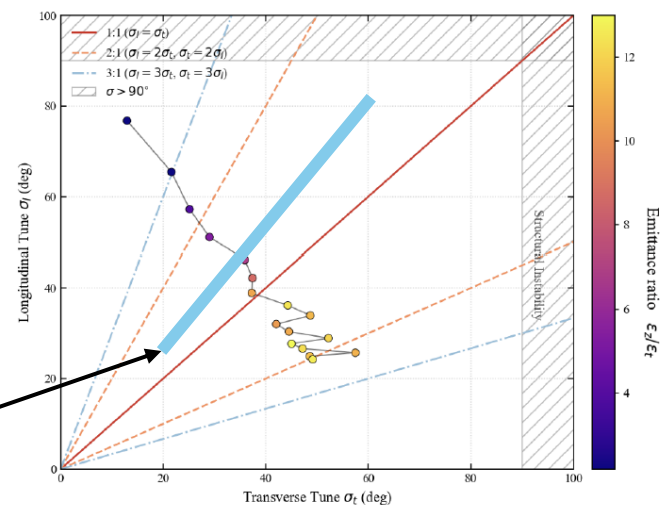


Figure : Tune stability diagram