Longitudinal Physics

January 29, 2013

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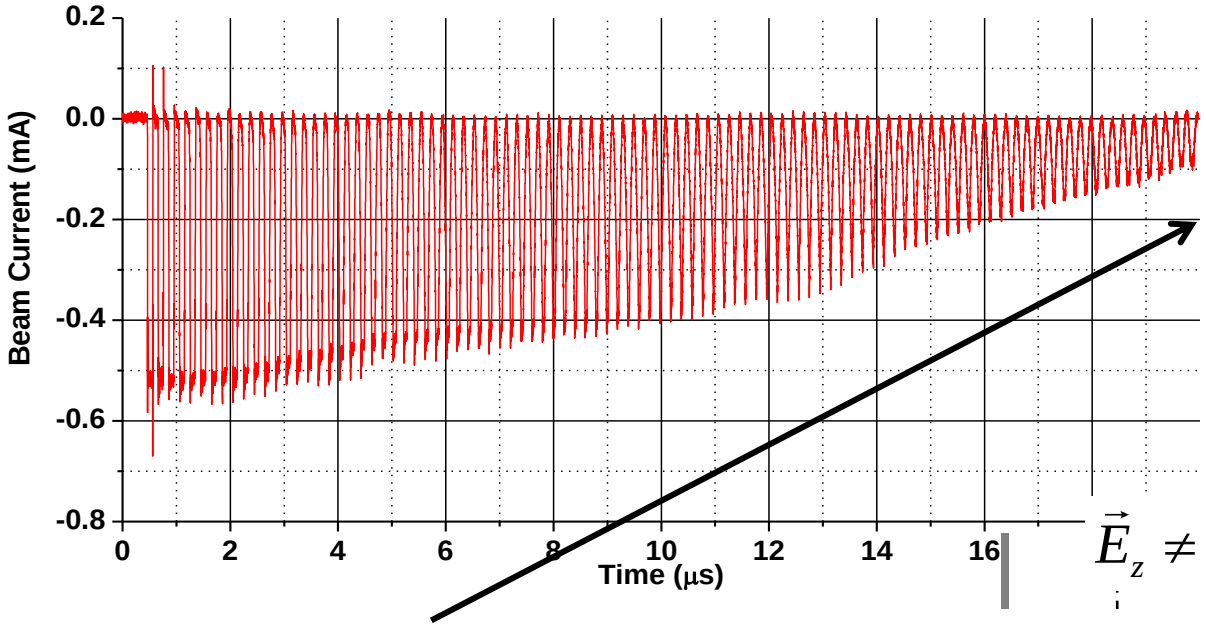
Longitudinal Space-Charge in a Ring



~100 turns

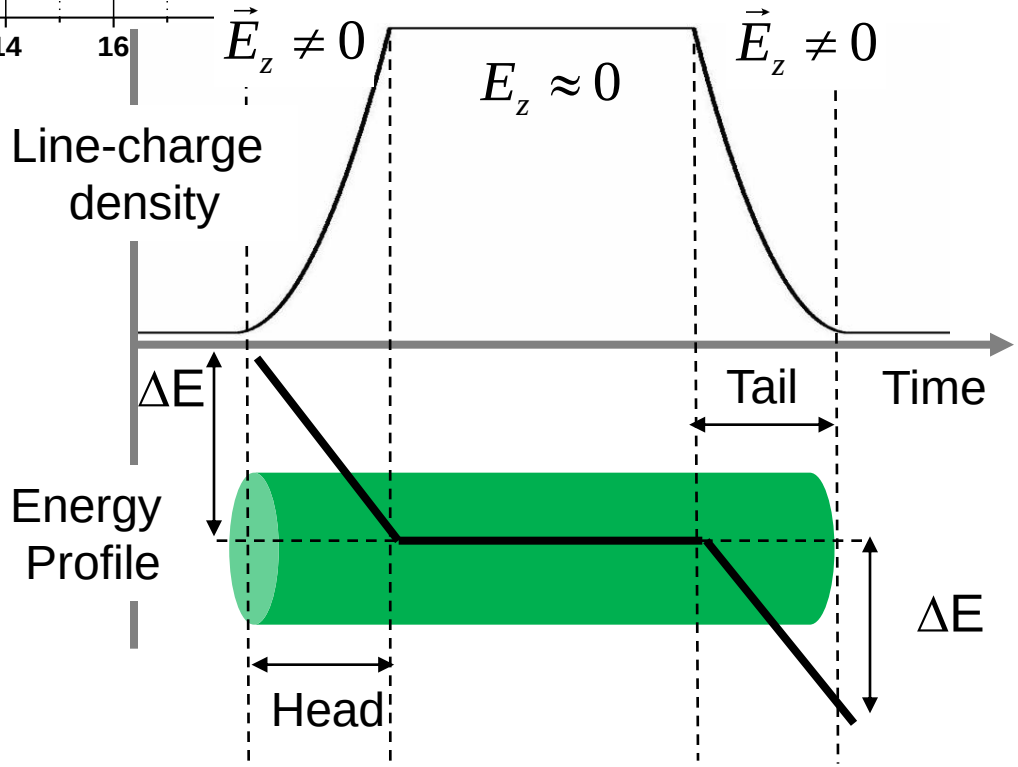
0.6 mA beam

$\eta = 0.5$

Initially injected 100 ns long bunch elongates as the beam propagates over multiple turns.

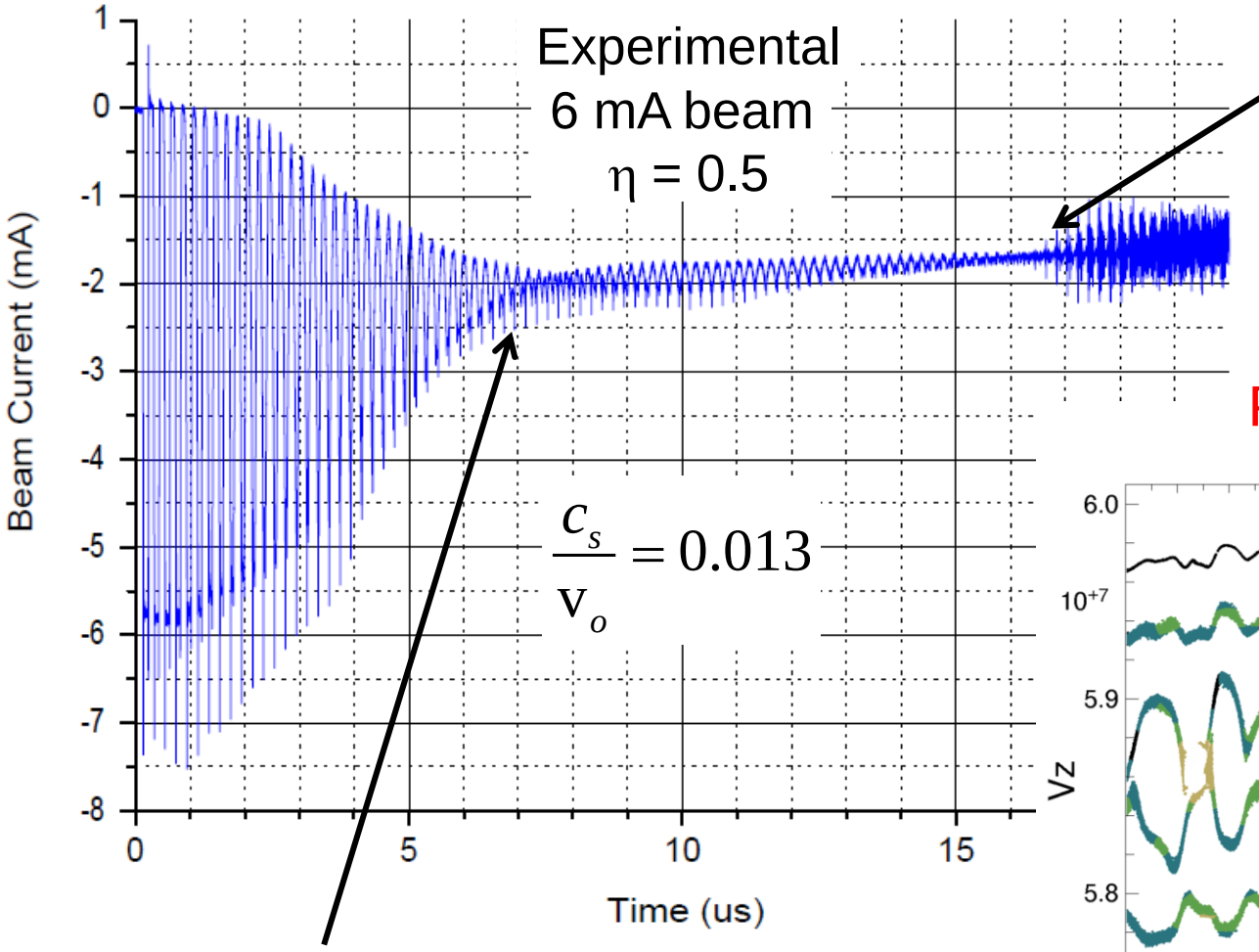
Changes in line-charge density induce axial electric fields at the edges of the beam

$$E_z \propto -\frac{d\lambda}{dz}$$

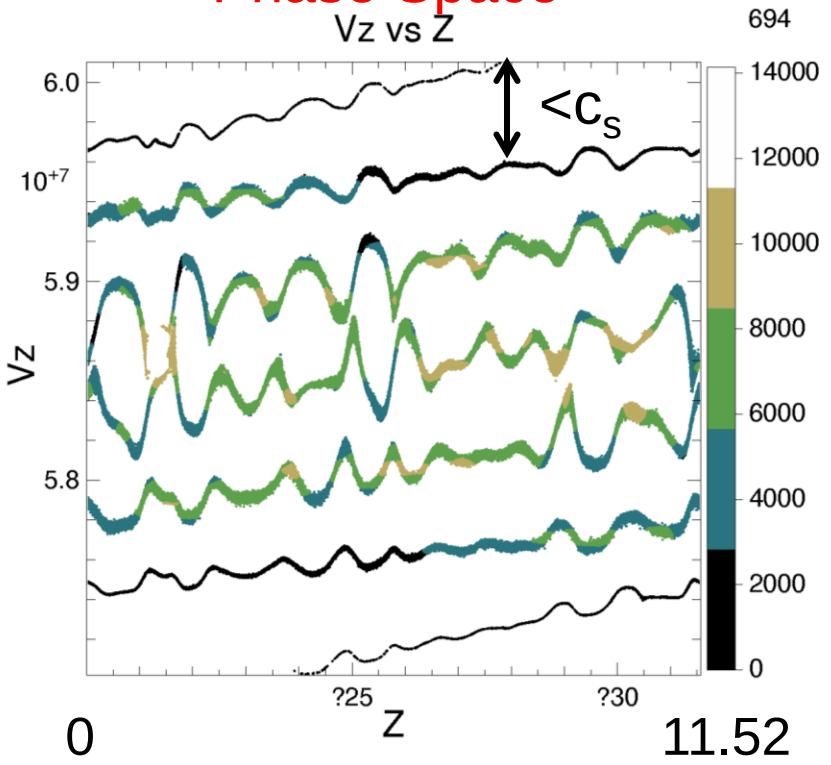


Observation of a Multi-stream instability

No longitudinal focusing – Beam expands and wraps around ring



Phase Space

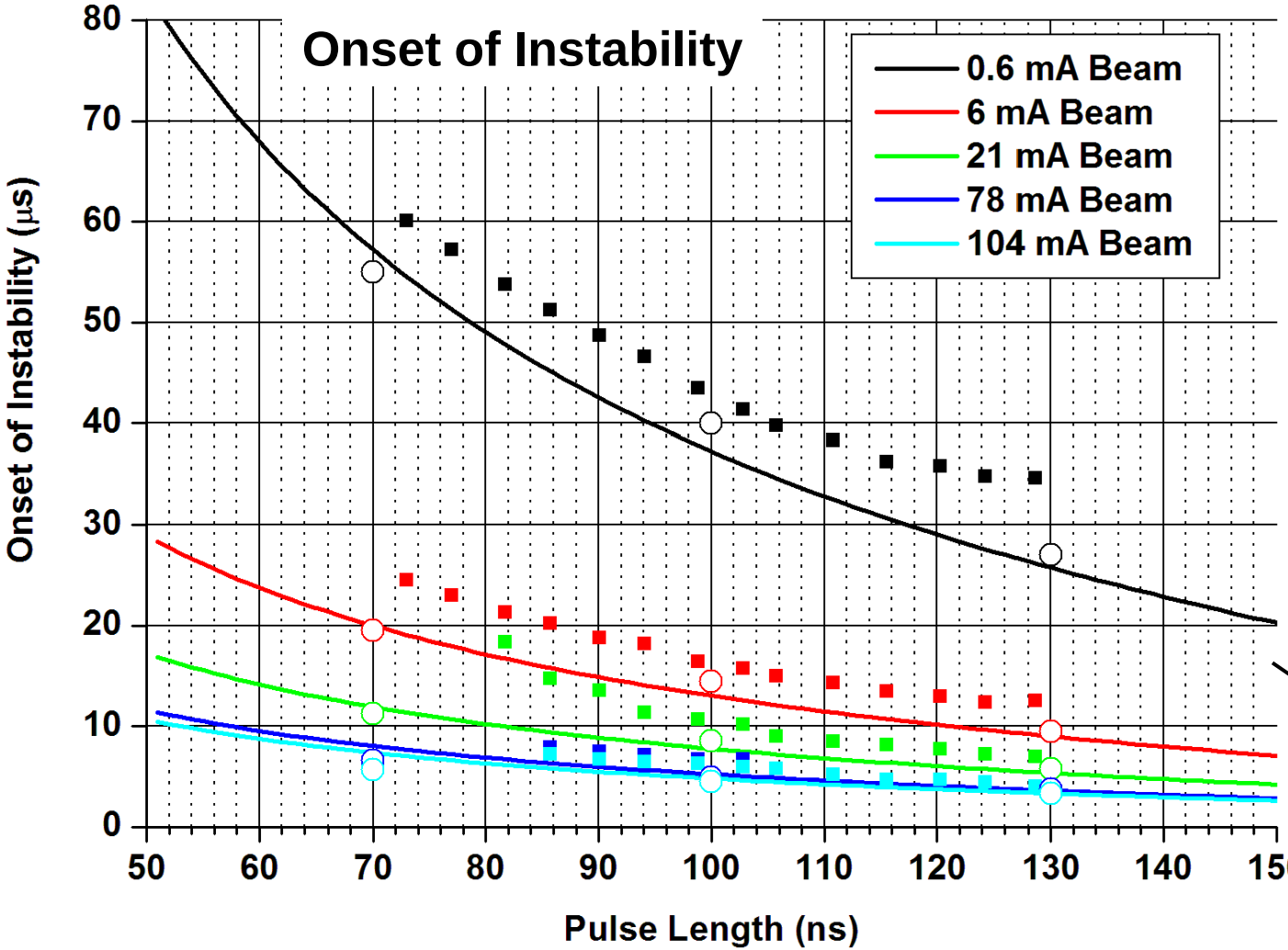


B.L. Beaudoin, R.A. Kishek, I. Haber, T.W. Koeth, submitted (2012).

Comparison between Theory, Simulation and Experiment

$$t_{onset} = \frac{C}{4c_s}\left(\frac{2}{\eta} - \eta\right)$$

η = fill factor
= injected pulse length / ring lap-time



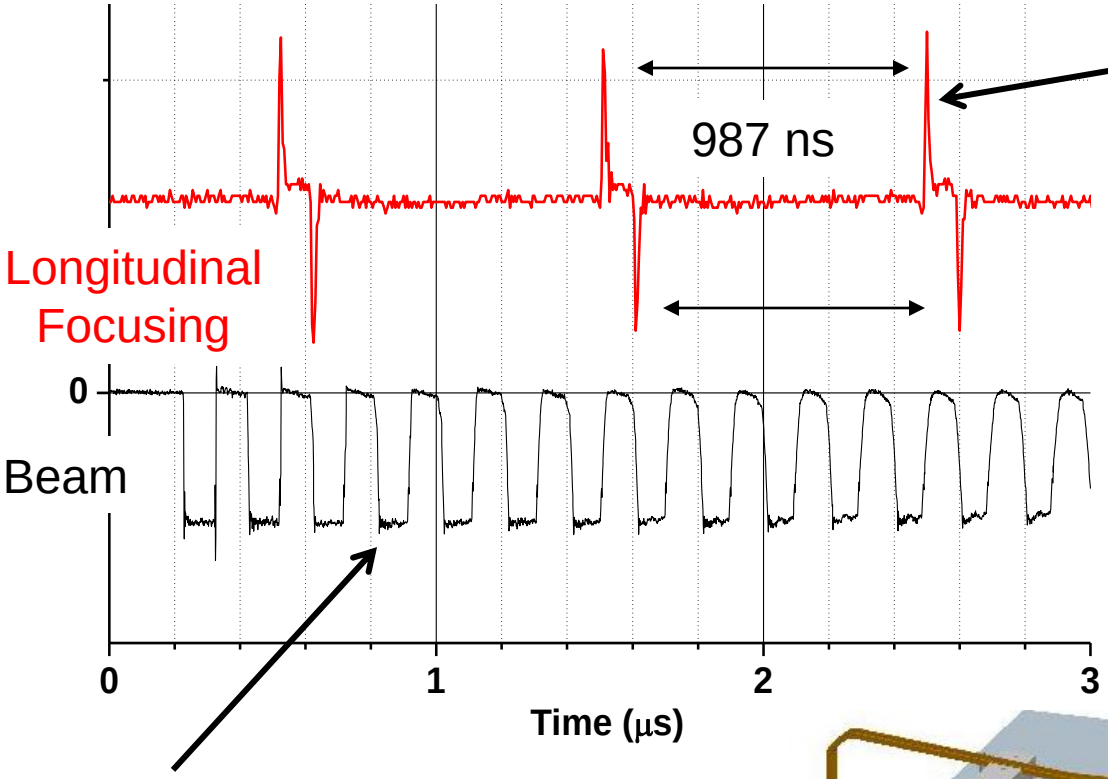
$$c_s = \left(\frac{qg\Lambda_0}{4\pi\varepsilon_0\gamma_0^5 m}\right)^{1/2}$$

■ Experiment

○ Simulation (WARP)

Theory

Periodically Applied Non-Linear Containment Fields

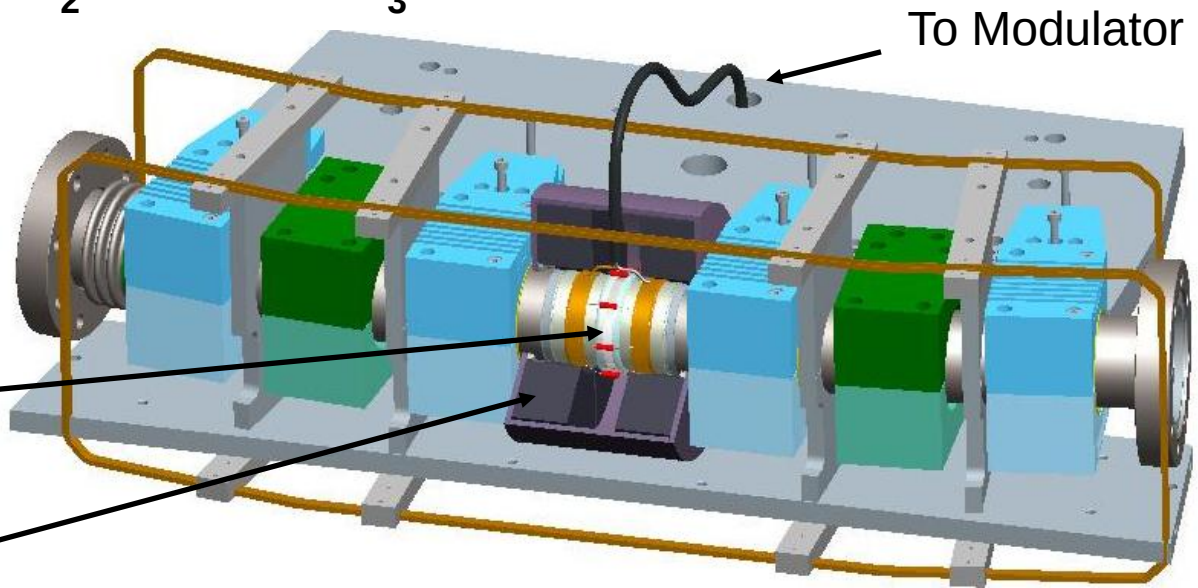


FWHM ~ 8.8 ns

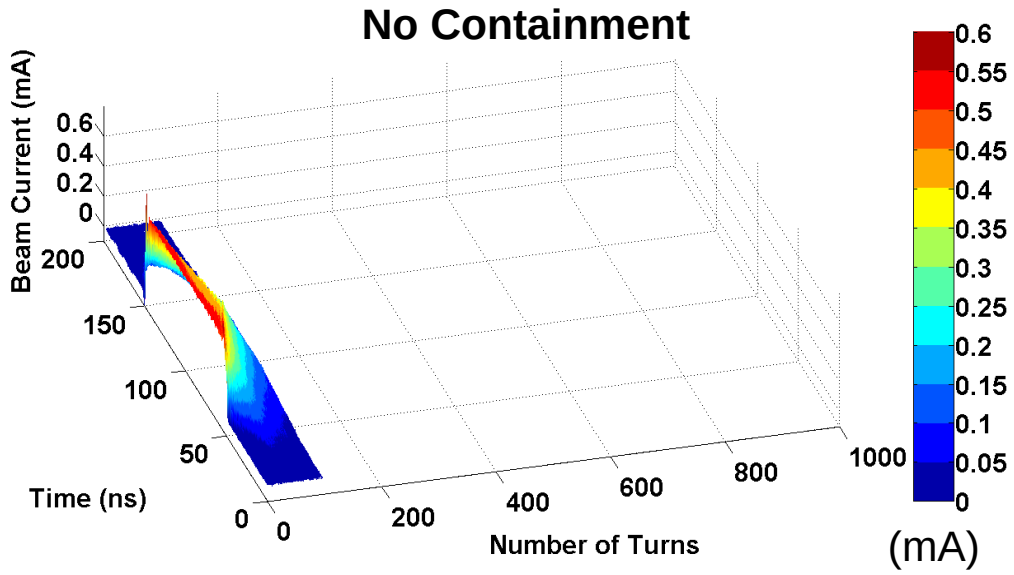
Induction cavity allows us to apply voltage waveforms with high harmonic content

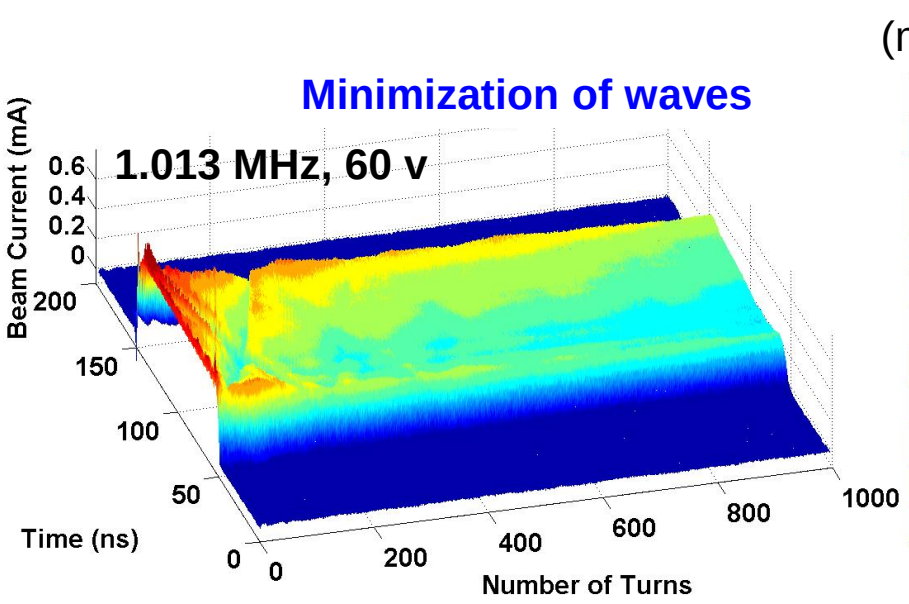
Revolution frequency of 5.066 MHz

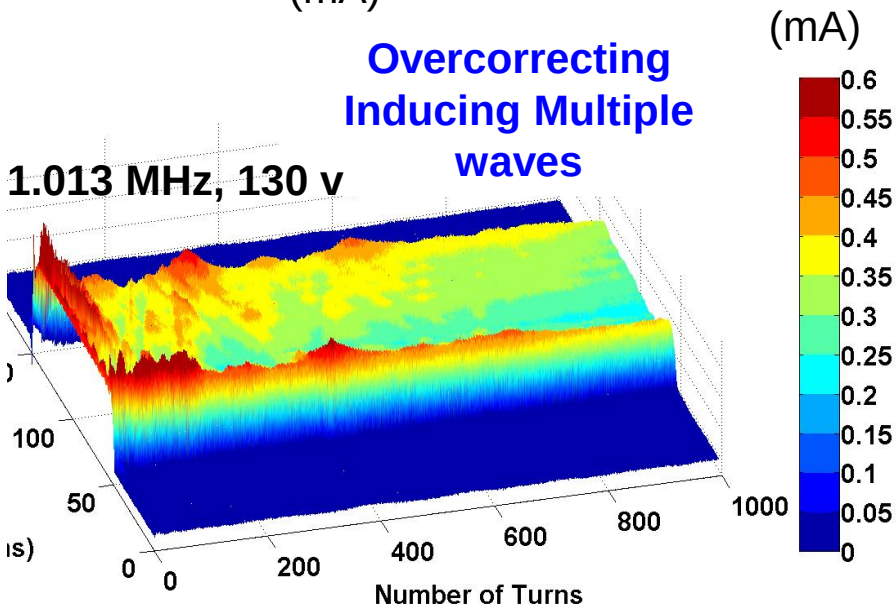
Induction Cavity



Containment of Long Bunches







-B. Beaudoin, I. Haber, R.A. Kishek, S. Bernal, T. Koeth, D. Sutter, P.G. O'Shea, and M. Reiser, Physics of Plasma, 18, 013104 (2011).