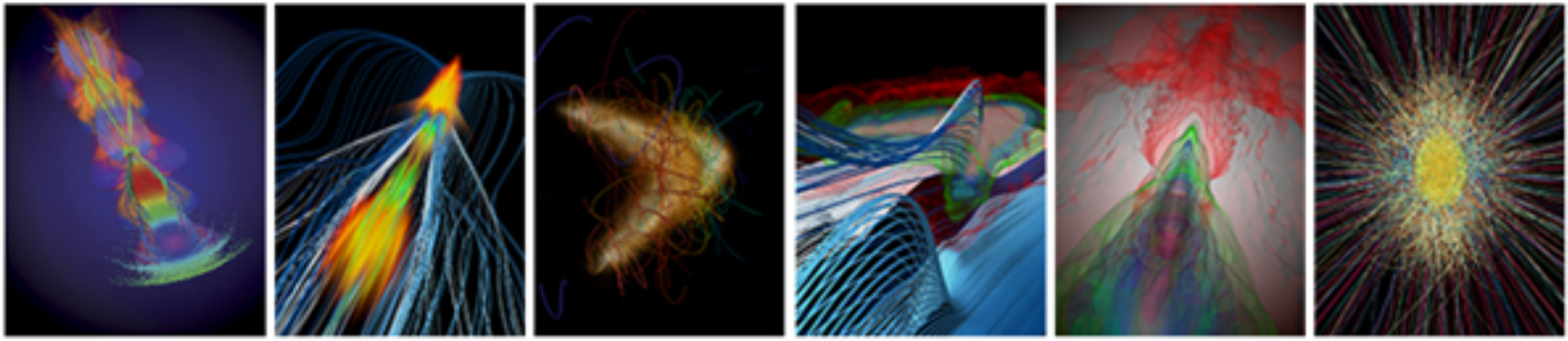

Discussion on Hosing Instability In the Blow-Out PWFA

Weiming An
University of California Los Angeles

anweiming@ucla.edu

With help from Xinlu Xu, Lance Hildebrand and Warren Mori

NSF

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

PICKSC

http://picksc.idre.ucla.edu

FACET·II

Facility for Advanced Accelerator Experimental Tests

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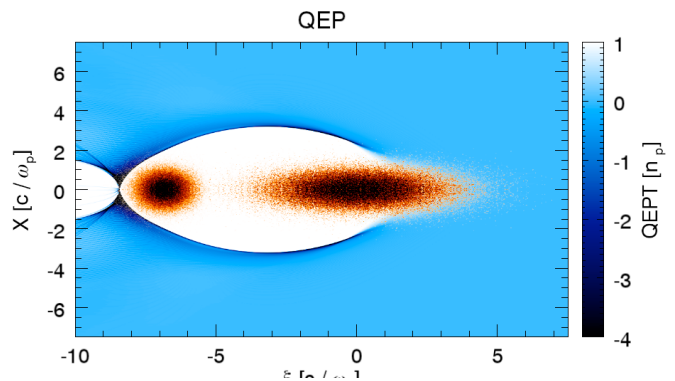
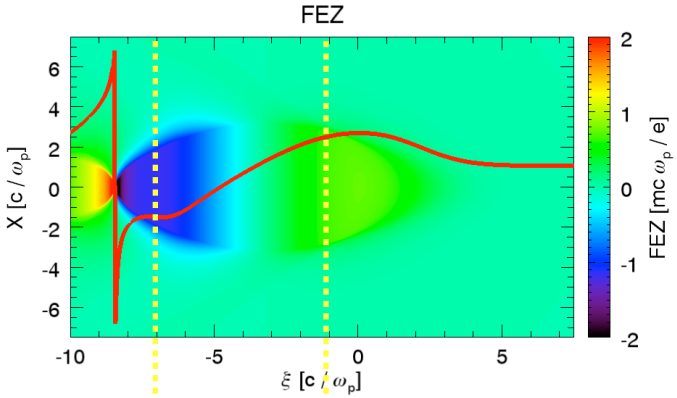
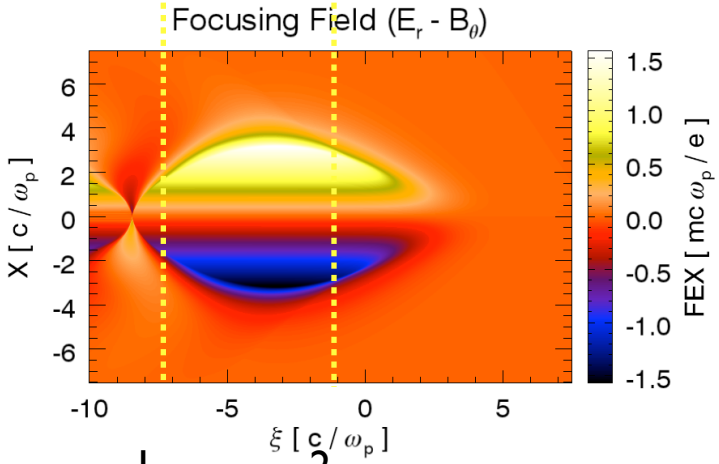
Nonlinear Plasma Wake Field

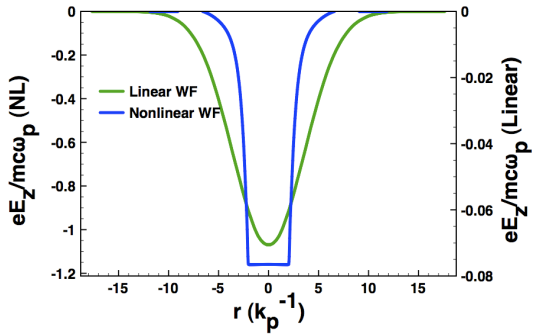




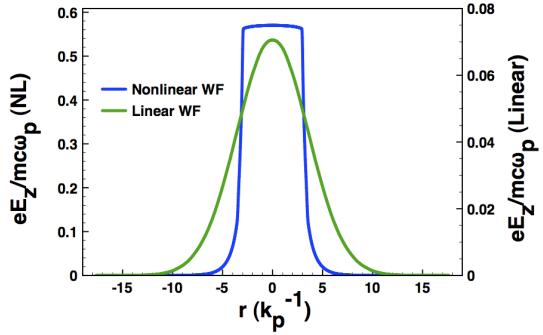


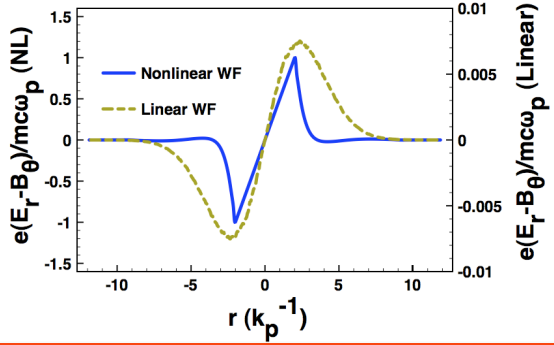
1 2

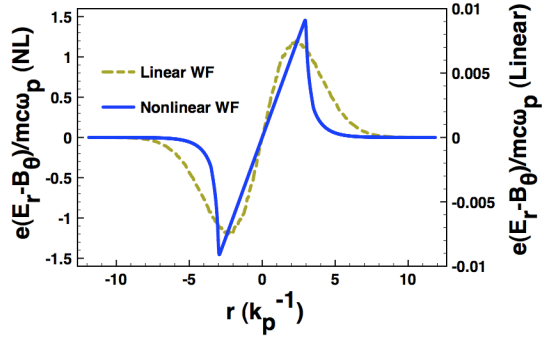
1



2







Superposition is Not Satsified for Strong Beam Load.

Zeroth order problem: Beam Loading

* M. Tzoufras et. al., PRL 101, 145002 (2008)

First order problem: Beam Hosing

2* C. Huang et. al., PRL 99, 255001 (2007)

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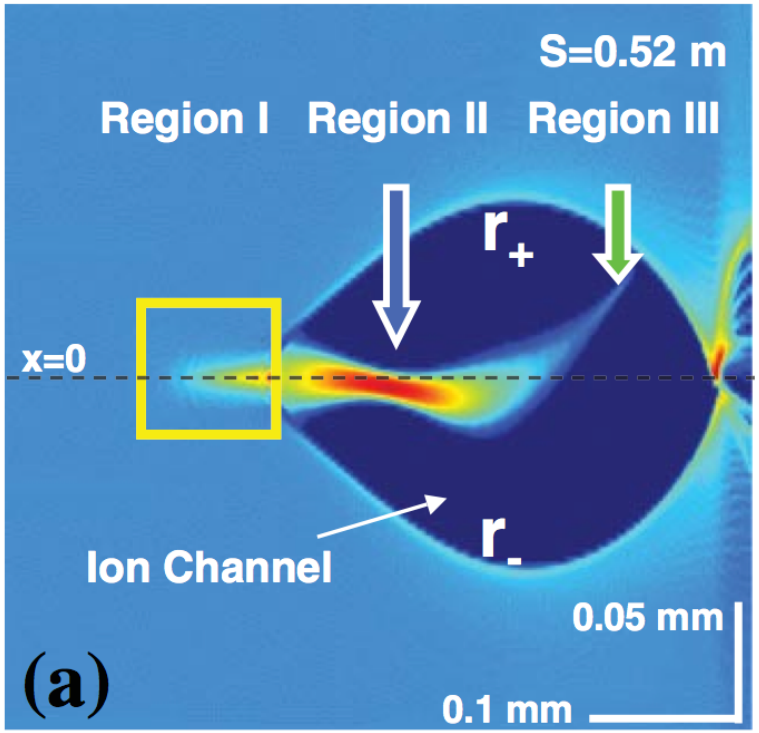
Hosing Instability in the Bubble



* C. Huang et. al., PRL 99, 255001 (2007)

$$\partial_s^2 x_b + k_\beta^2 x_b = k_\beta^2 x_c$$

$$x_c'' + c_r c_\psi \omega_0^2 x_c = c_r c_\psi \omega_0^2 x_b$$

Nonlinear Equation!

$$k_\beta = k_p/\sqrt{2\gamma},\ \omega_0 = k_p/\sqrt{2}$$

$$c_r \equiv n_b R_b^2/r_0^2$$

$$c_\psi \equiv 1/(1+\psi_0)$$

E-folding for the Growth Rate

$$1.3[c_r c_\psi (k_\beta s)(\omega_0 \xi)^2]^{1/3}$$

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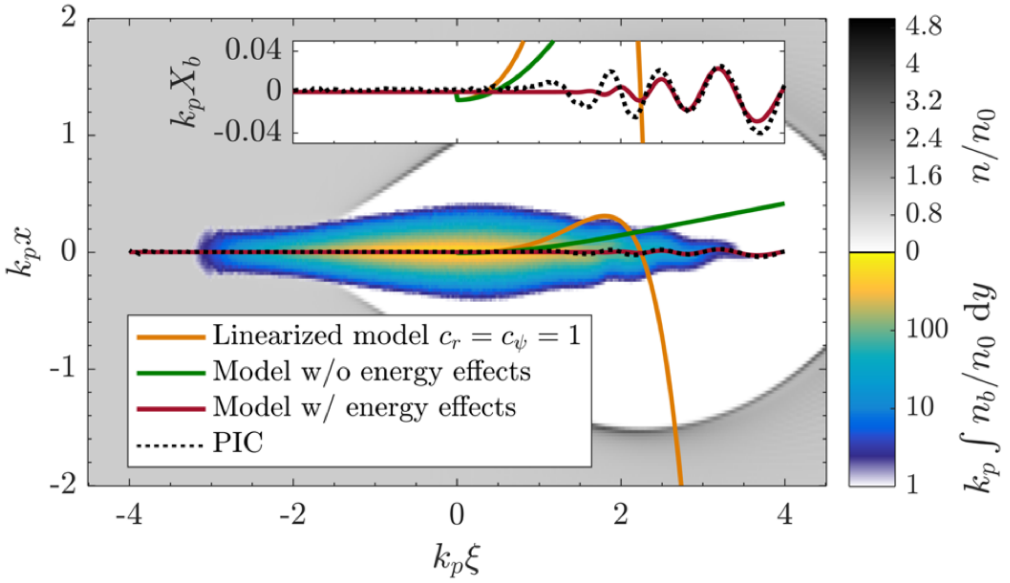
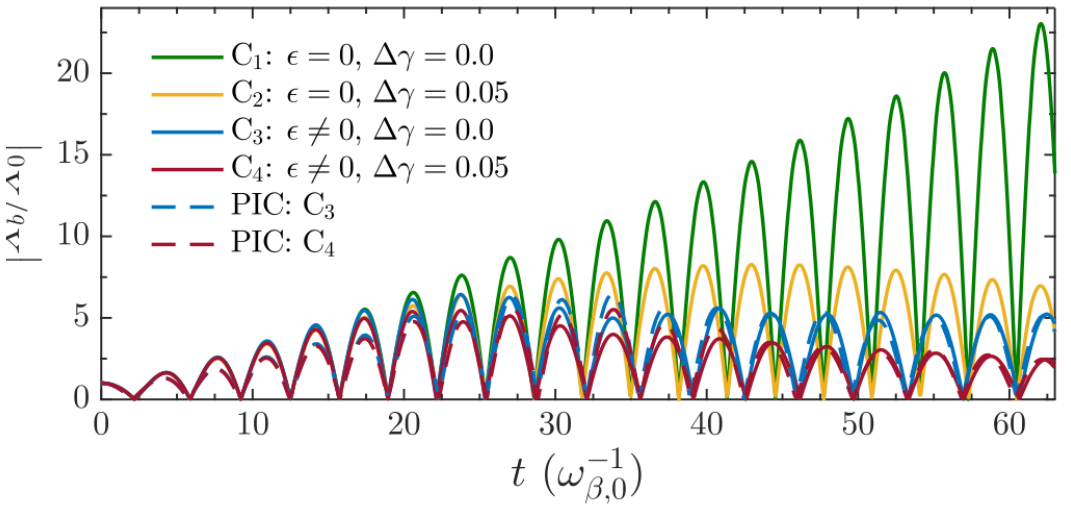
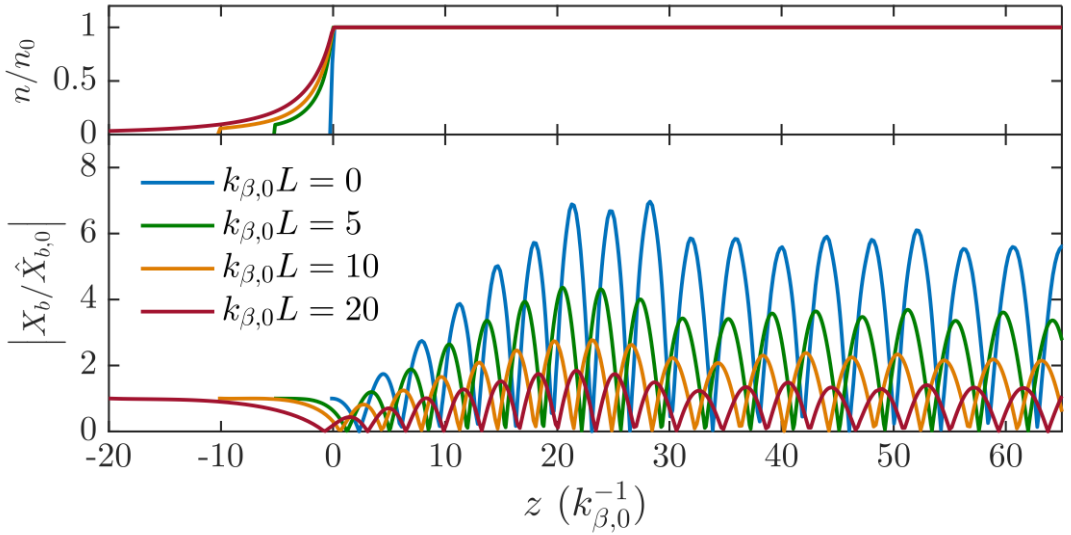
Mitigating Hosing Instability

BNS Damping | **Longitudinally correlated energy spread**



$$\frac{\partial^2 X_b}{\partial t^2} + \frac{\overline{\omega_\beta}^2}{\omega_{\beta,0}}(\epsilon + \kappa_1 \Delta\gamma^2)\frac{\partial X_b}{\partial t} + \overline{\omega_\beta}^2(1 + \kappa_2 \Delta\gamma^2)(X_b - X_c) = 0$$





* T. Mehrling et. al., PRL 118, 174801 (2017)

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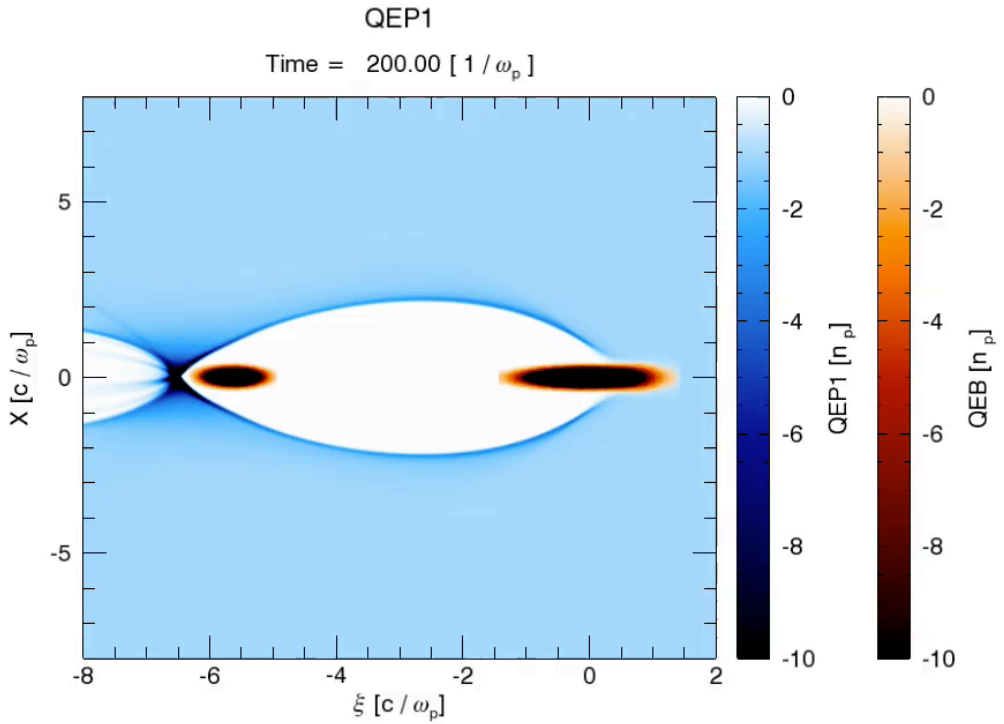
Mitigating Hosing Instability

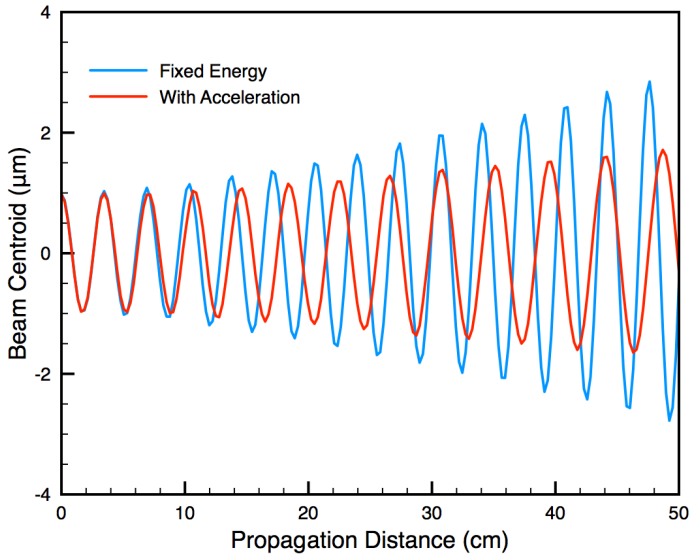
What about the trailing beam?

Drive Beam: E = 10 GeV, I_{peak}=15 kA
σ_r = 3.65 μm, σ_z = 12.77 μm ,
N =1.0 x 10^{10} (1.6 nC), ε_N = 50 μm

Trailing Beam: E = 10 GeV, I_{peak}=9 kA
σ_r = 3.65 μm, σ_z = 6.38 μm ,
N =4.33 x 10^{9} (0.69 nC), ε_N = 50 μm
(transversely offset by 1 μm)

Distance between two bunches: 150 μm
Plasma Density: 4.0 x 10^{16} cm^{-3}





Center Slice

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Mitigating Hosing Instability

What about the trailing beam?

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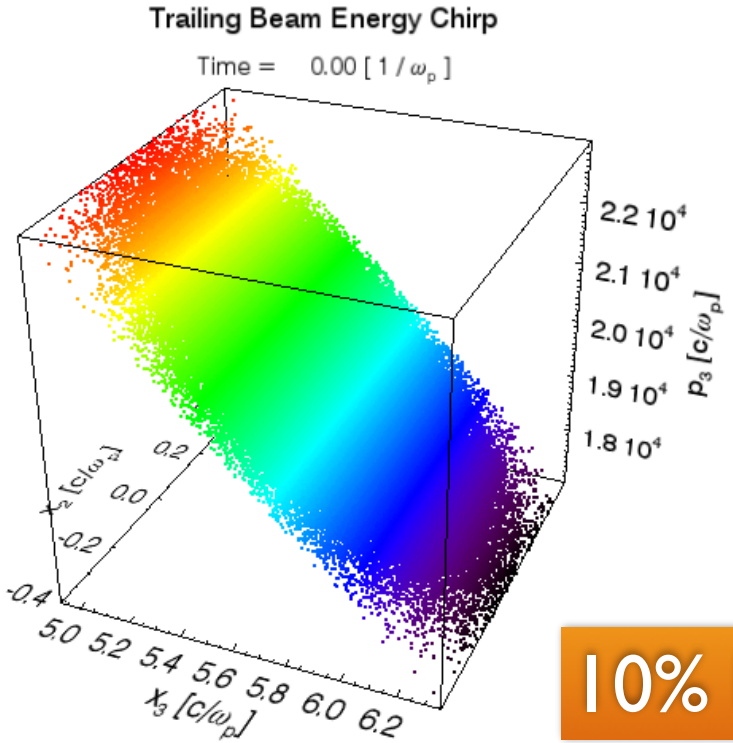

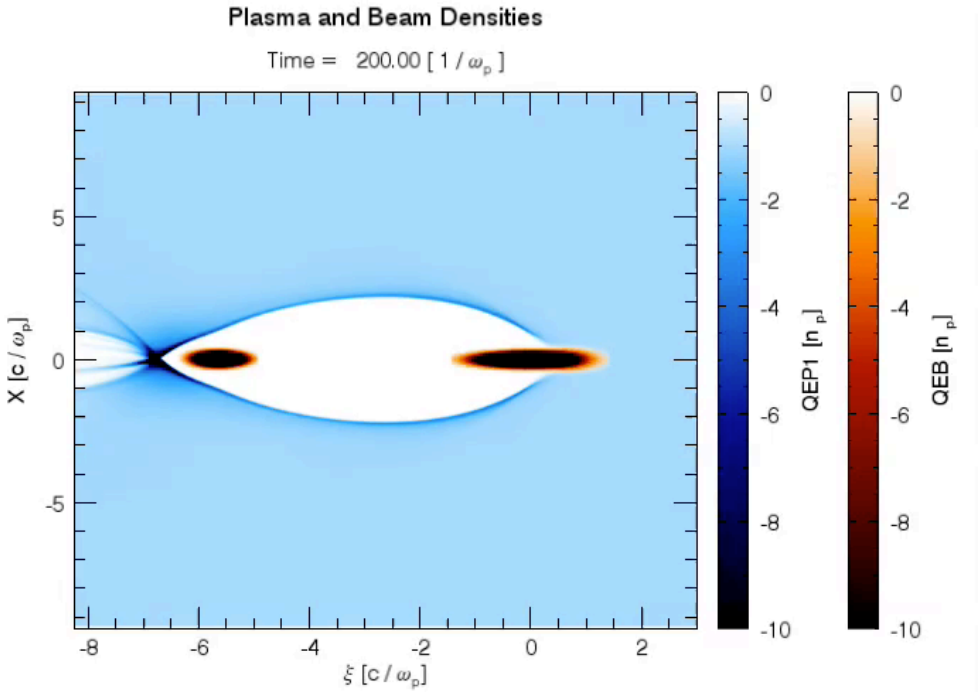

10% Energy Chirp

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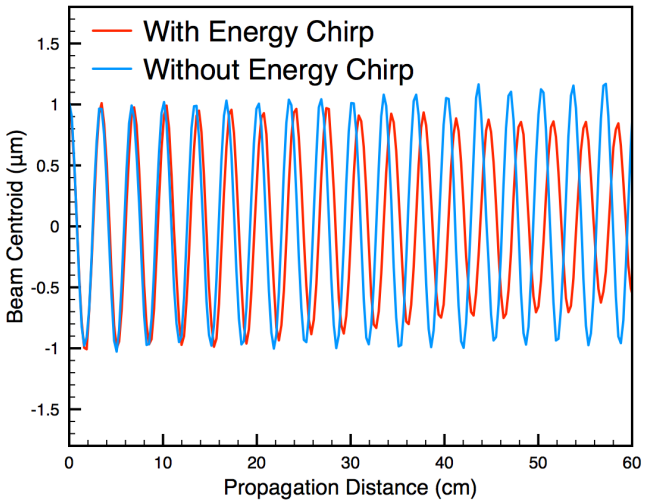
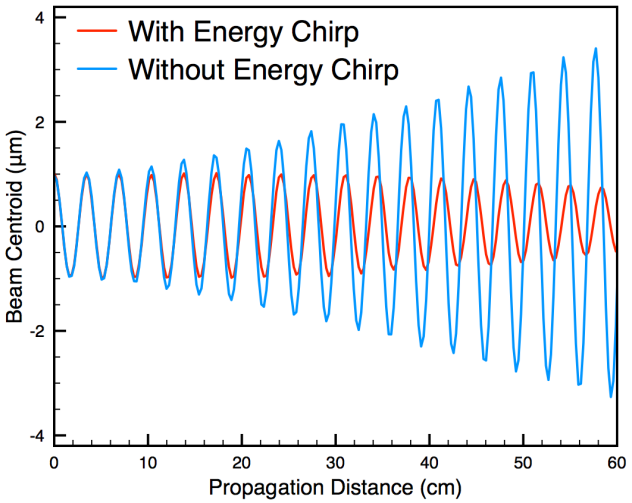
Mitigating Hosing Instability

Head



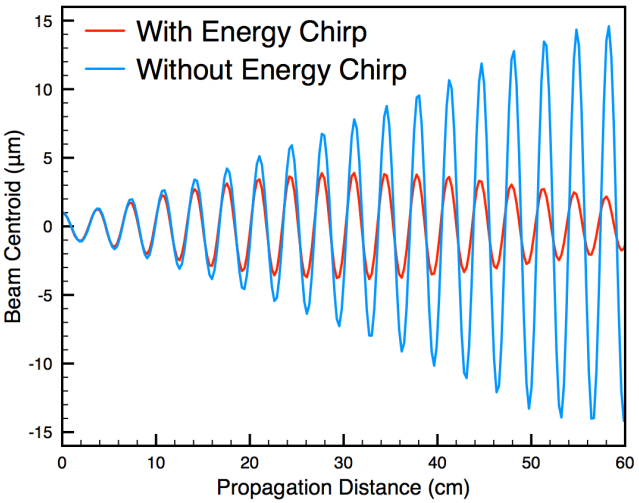
$\xi = -\sigma_z$

Center



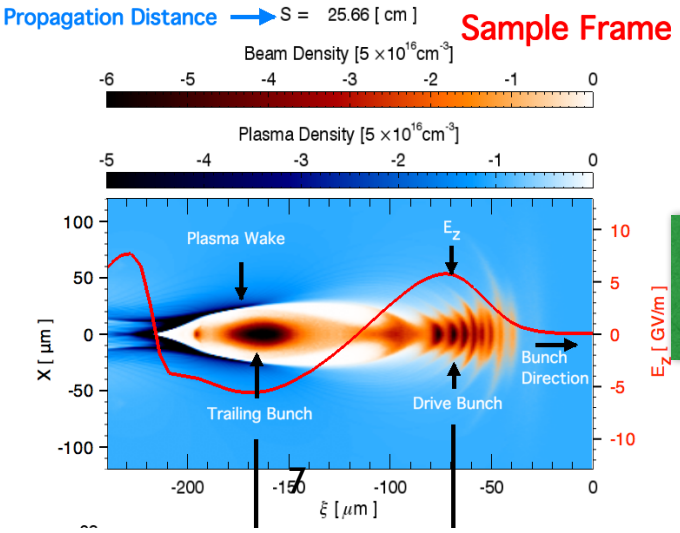
$\xi = 0$

Tail



$\xi = \sigma_z$

10% Energy Chirp



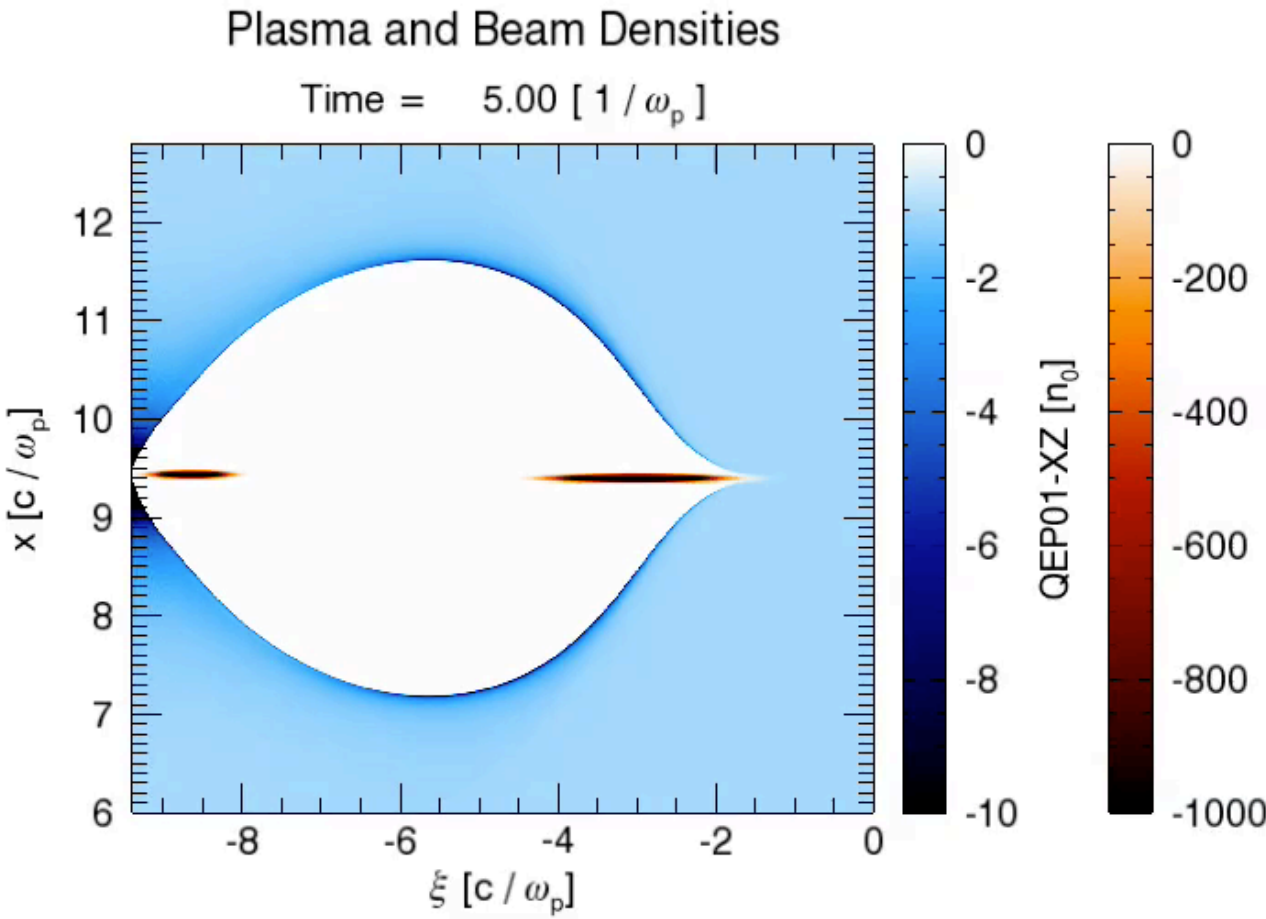
Overloading the Wake can compensate the chirp.

Killing the Hosing Instability

Drive Beam: E = 10 GeV, I_{peak}=15 kA
σ_r = 0.516 μm, σ_z = 12.77 μm ,
N =1.0 x 10^{10} (1.6 nC), ε_N = 1 μmrad

Trailing Beam: E = 10 GeV, I_{peak}=9 kA
σ_r = 0.516 μm, σ_z = 6.38 μm ,
N =4.33 x 10^{9} (0.69 nC), ε_N = 1 μmrad
(transversely offset by 1 μm)

Distance between two bunches:
150 μm
Plasma Density:
4.0 x 10^{16} cm^{-3} (Hydrogen)



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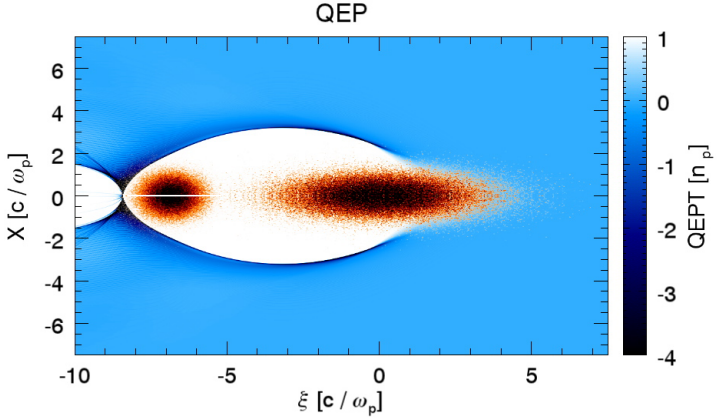
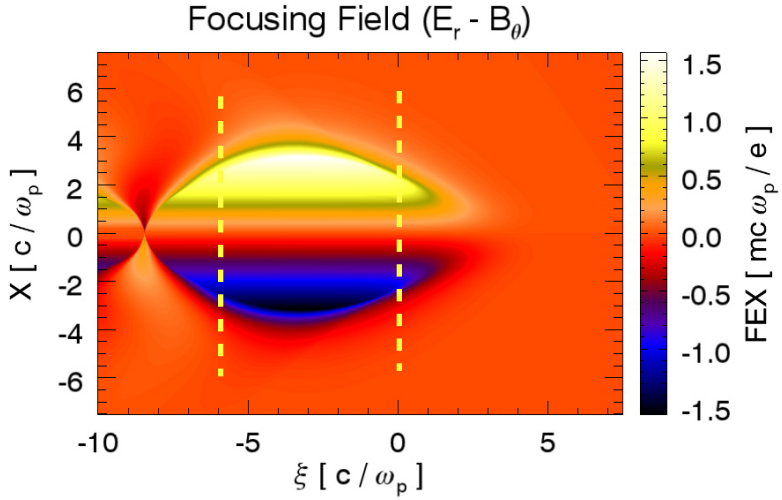
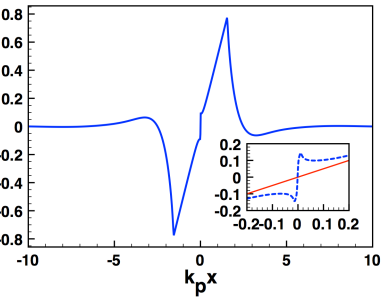
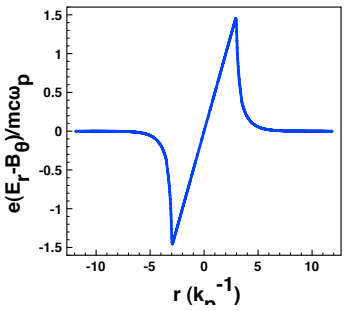
Killing the Hosing Instability

Blowout PWFA

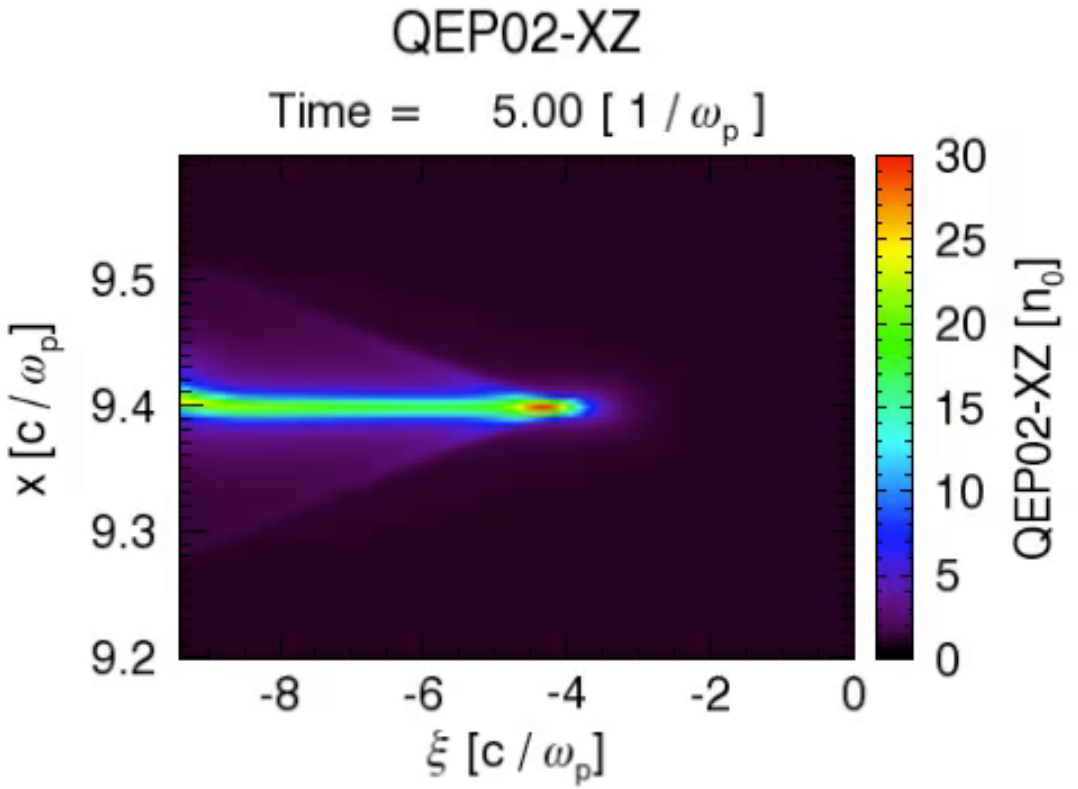








Plasma Ion Motion (Talk on Thursday)



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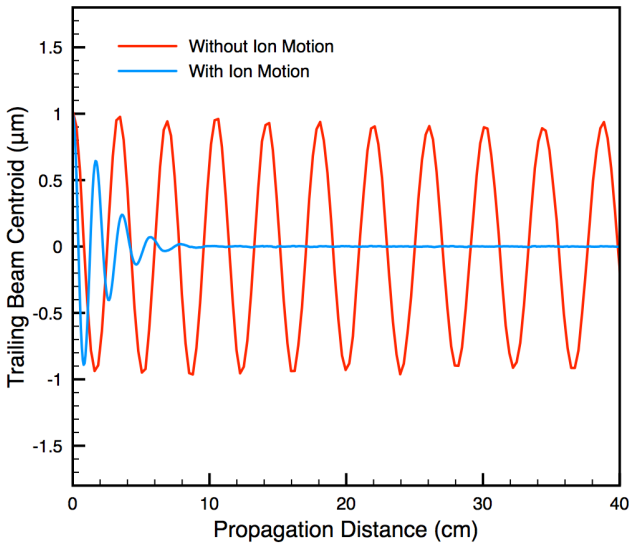
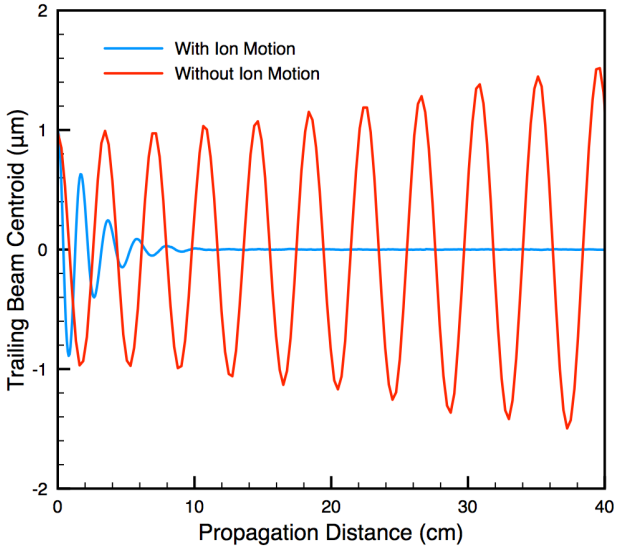
Killing the Hosing Instability

Head



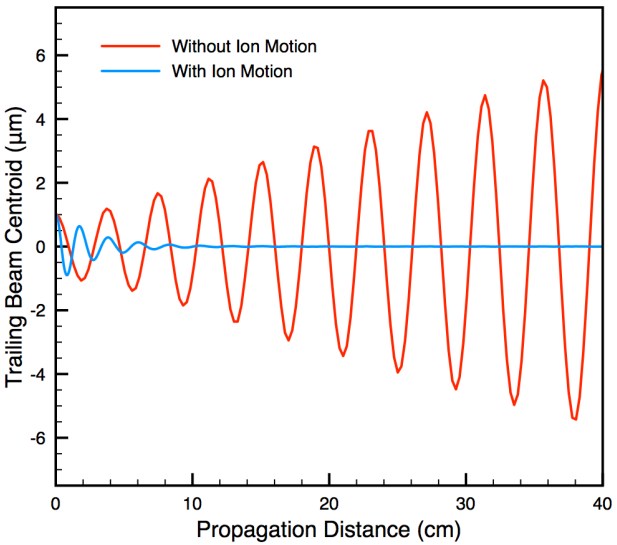
$\xi = -\sigma_z$

Center



$\xi = 0$

Tail



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