Matching

Livio (sorry Livio) has shown that the planned injection geometry will lead to significant emittance increase.

The matched beam radius depends on the emittance:

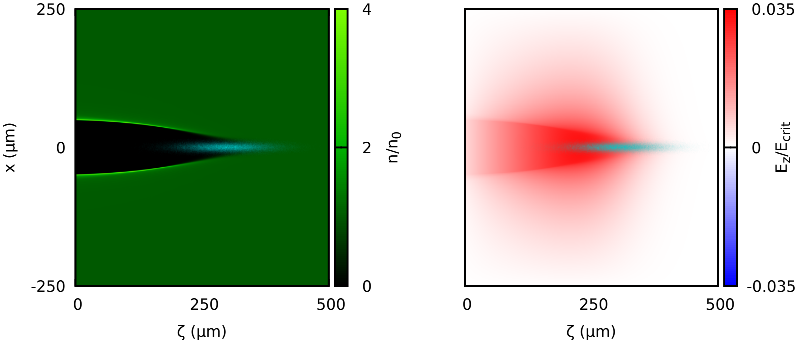
$$\sigma_x = \frac{\sqrt{2\gamma}c}{\omega_p}\sigma_{x'}, \tag{1}$$

$$= \left(\frac{2c^2\epsilon_x^{*2}}{\gamma\omega_p^2}\right)^{1/4}, \tag{2}$$

Unfortunately, the blowout depends on the witness density, and beam loading depends on witness current, so everything has to change.

Characterising the blowout

How can we characterise the blowout?



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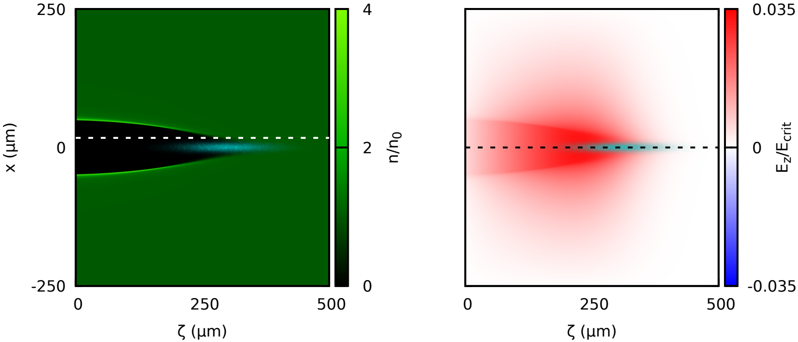
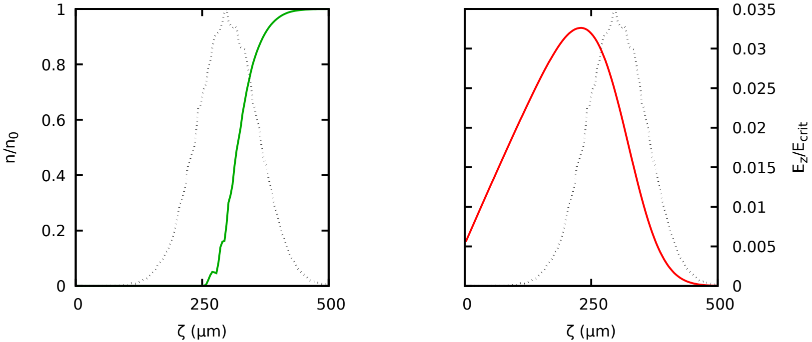


Consider plasma density at $3\sigma_r$ and electric field on axis

Characterising the blowout

How can we characterise the blowout?



For Veronica's paramters ($q = 100$ pC, $\sigma_z = 60\ \mu$m, $\epsilon^* = 2\ \mu$m)

- 17.5% of beam current sits inside a bubble of radius $\geq 3\sigma_r$
- Maximum decelerating field is 3.5% E_{crit}

(no driver, zero-time fields)

Scanning the paramter space

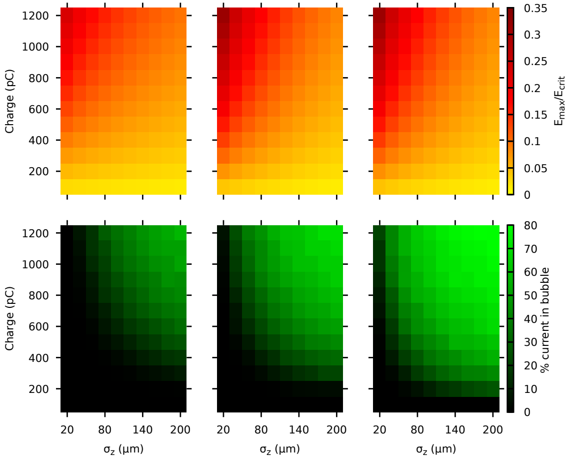
With these metrics, we can scan the paramter space.

I consider three cases:

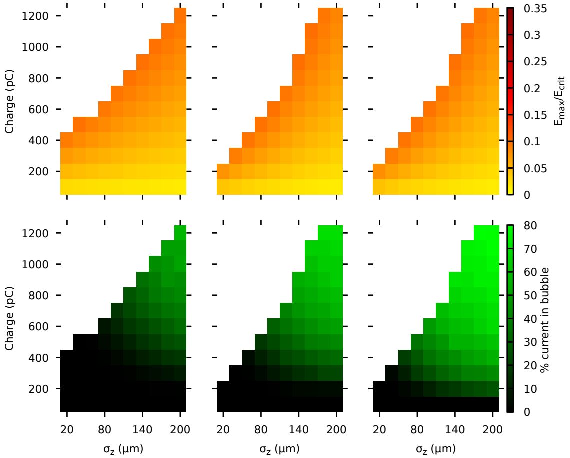
- low density, 100 μm foil ($\epsilon^* = 12$ μm)
- high density, 200 μm foil ($\epsilon^* = 12$ μm)
- high density, 100 μm foil ($\epsilon^* = 7$ μm)

(all numbers very approximate - taken from Livio's slides)

Scanning the paramter space

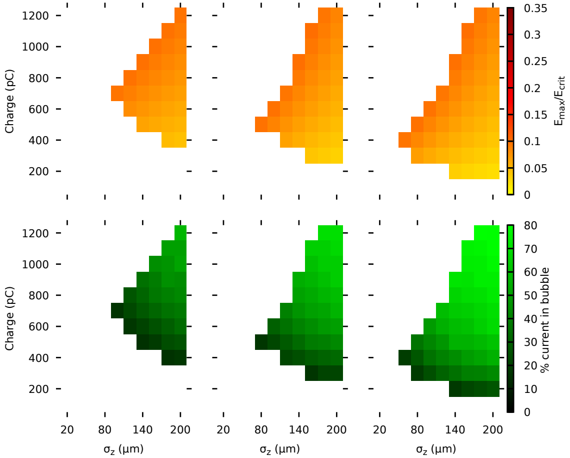


Scanning the paramter space



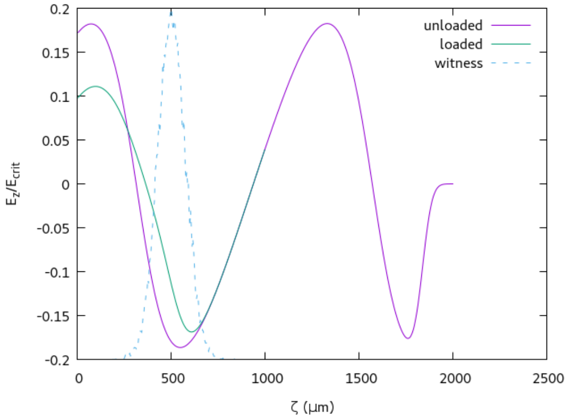
Driver wakefield $\sim 20\%\ E_{\mathrm{crit}}$, so can discount any witness which loads $> 10\%\ E_{\mathrm{crit}}$.

Scanning the paramter space



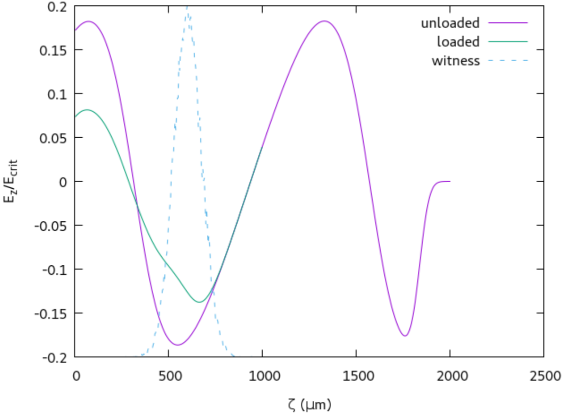
Can discount witness with $< 15\%$ of beam current sits inside a bubble of radius $\geq 3\sigma_r$.

Adjusting delay for beamloading



Basically just wiggle it around until the field is flat.
Nothing clever here, but nonlinearity requires simulations

Adjusting delay for beamloading



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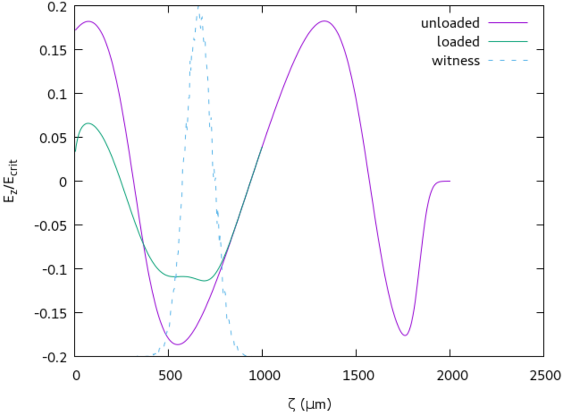

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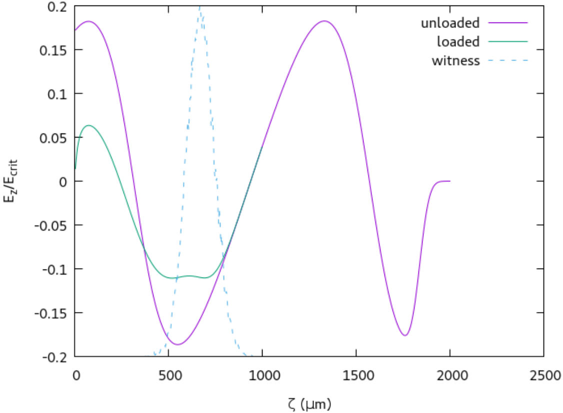

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Nothing clever here, but nonlinearity requires simulations

Conclusions

Rb vapor / beam dump increases emittance before injection
$\rightarrow$ Larger radius witness needed to match plasma focussing
$\rightarrow$ Larger charge needed to generate blowout
"Worse" beam requires higher charge

High currents can overload the wakefield
Witness wake $>$ driver wake $\rightarrow$ no acceleration
Can mitigate by using longer beam

Beamloading sets limits on parameter ranges
Everything is essentially more difficult for high emittance.