Progress on the Flat Beam PWFA experiment at AWA

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Introduction

Particle beams with asymmetric transverse emittances and profiles can be used to drive asymmetric plasma wakefields Here, we create a formalism for the asymmetric plasma structures created by the beam and show that the focusing forces that are transversely asymmetric. We utilize the ellipticity of the plasma ion cavity to model the beam evolution of the flat beam driver in a plasma capillary (developed at UCLA), in preparation for the flat beam PWFA experiment at AWA

Flat beam plasma wakefield

- A flat beam driver creates an elliptical blowout
- Beam (right) has an aspect ratio of 10 and having a beam density (n_b) of 15
- Wake potential and wakefields:

$$\psi = -\frac{x^2 b_p^2 + y^2 a_p^2 - p_p^4}{2d_p^2} - \frac{\Delta_s p_p^2}{2d_p^4}\left[(x^2 - y^2)c_p^2 - a_p^4 - b_p^4\right]$$

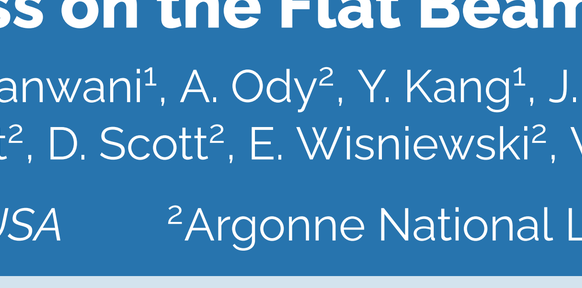
$$W_x = x\left[\frac{b_p^2}{d_p^2} + \Delta_s \frac{p_p^2 c_p^2}{d_p^4}\right] W_y = y\left[\frac{a_p^2}{d_p^2} - \Delta_s \frac{p_p^2 c_p^2}{d_p^4}\right],$$

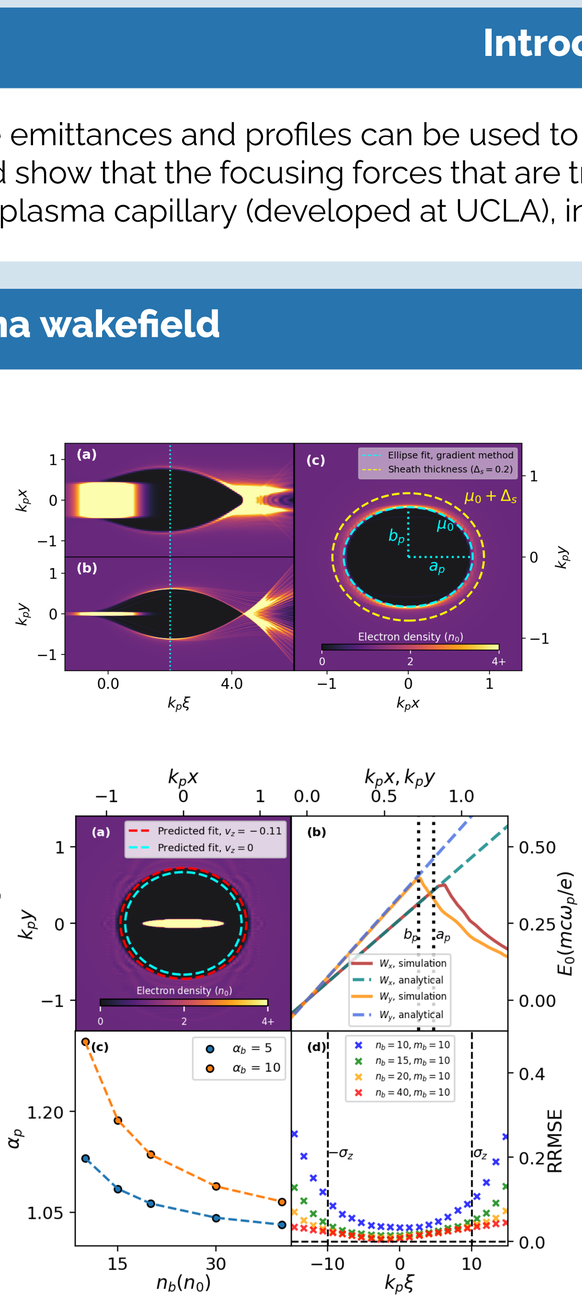
$$W_z = E_{z,p} = \frac{\partial \psi}{\partial \xi} = \left[A(x^2 - y^2) + B\right]$$

- The boundaries can be calculated in the long beam limit ($k_p \sigma_z > 1$)
- New matching conditions

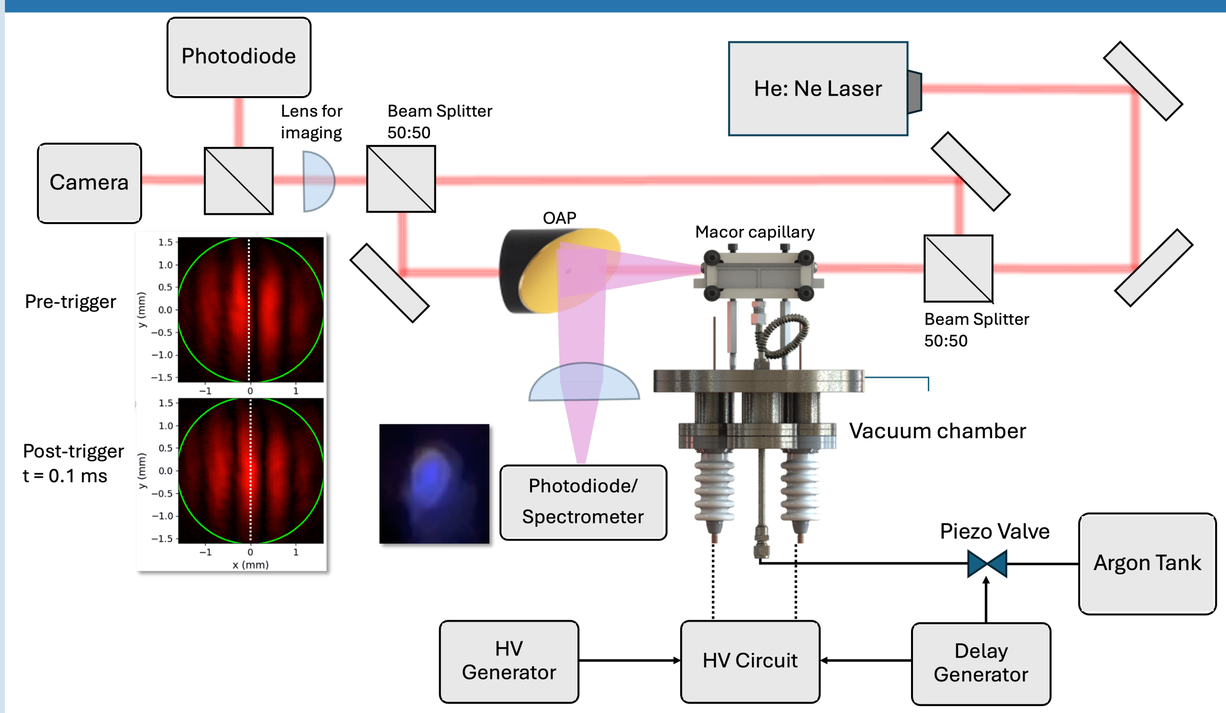
$$\beta_r = \sqrt{2\gamma} k_p^{-1}$$

$$\beta_x,\ \beta_y = \sqrt{(1+\alpha_p^2)\gamma} k_p^{-1},\ \sqrt{\frac{(1+\alpha_p^2)\gamma}{\alpha_p^2}} k_p^{-1}$$

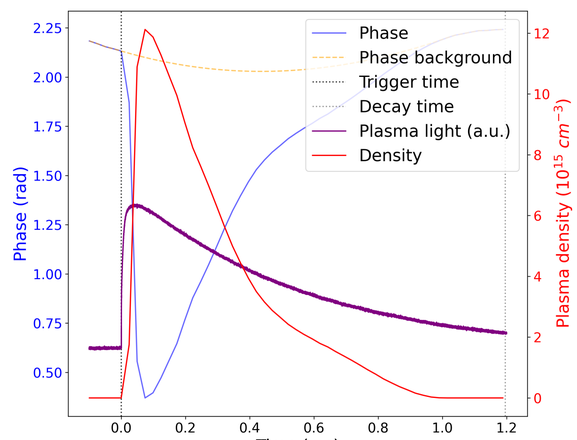




Capillary Plasma source



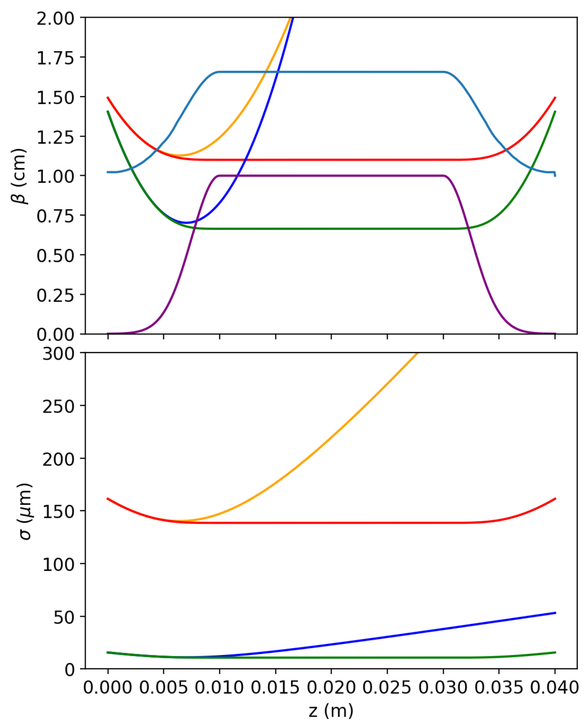
- Macor capillary: 4 mm diameter x $[4, 8]$ cm length
- 10 kV, 100 A ($1\ \mu$s) peak current
- Argon gas, Backing pressure: 100 psi, Valve window : 5 ms window
- Peak density increases with voltage
- Mach Zehnder based HeNe interferometer

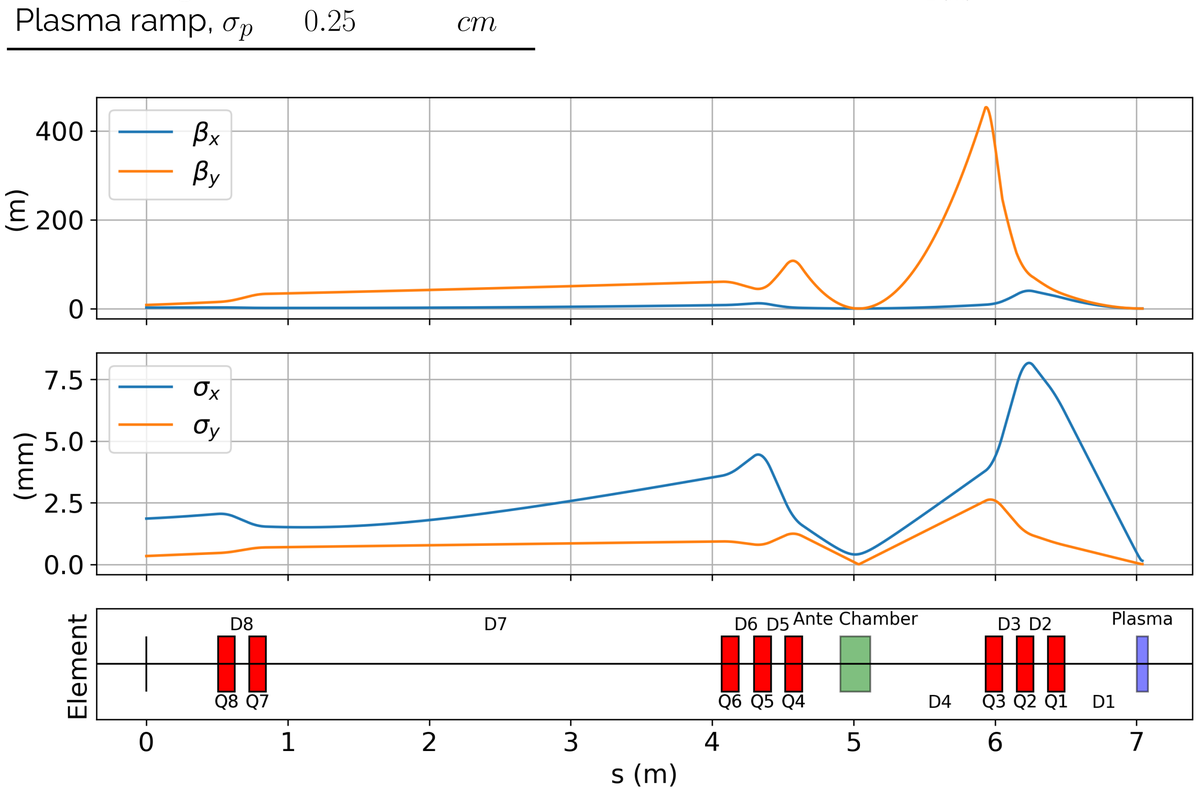


Matching conditions

- The long beam model can be used to get the vacuum-plasma transport
- The matched beam, mismatched beam envelope and drift evolution are shown on the right
- Required beta functions for given emittance and plasma density: β_x, β_y: 11 mm, 6.6 mm
- AWA beam parameters and expected operating plasma density:

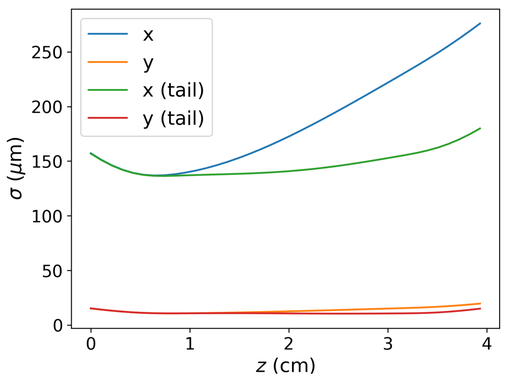
Parameter	Value	Unit
Charge, Q	2	nC
Energy, E_b	58	MeV
$\epsilon_{n,x}$, $\epsilon_{n,y}$	200, 2	$\mu m\ rad$
Plasma density, n_0	1×10^{14}	cm^{-3}
Plasma length, L	4	cm
Plasma ramp, σ_p	0.25	cm



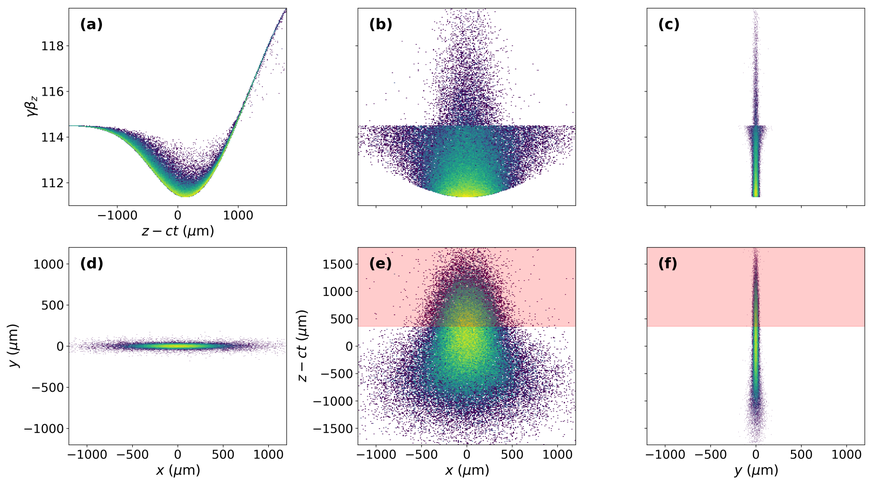


Diagnostics and observables

- PIC simulations were performed to study matched beam plasma interaction
- PWFA induced energy spread will be measured with transverse deflecting cavity and a dipole spectrometer
- Longitudinally dependent focusing - OTR foil at capillary exity with two downstream screens for emittance and angle measurements



- (a)$\xi - p_z$, (b)$x - p_z$, (c)$y - p_z$, (d)$x - y$, (e)$x - \xi$, (f)$y - \xi$
- Quadratic dependence of the longitudinal wake
- Asymmetric focusing and propagation



Acknowledgement and References

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