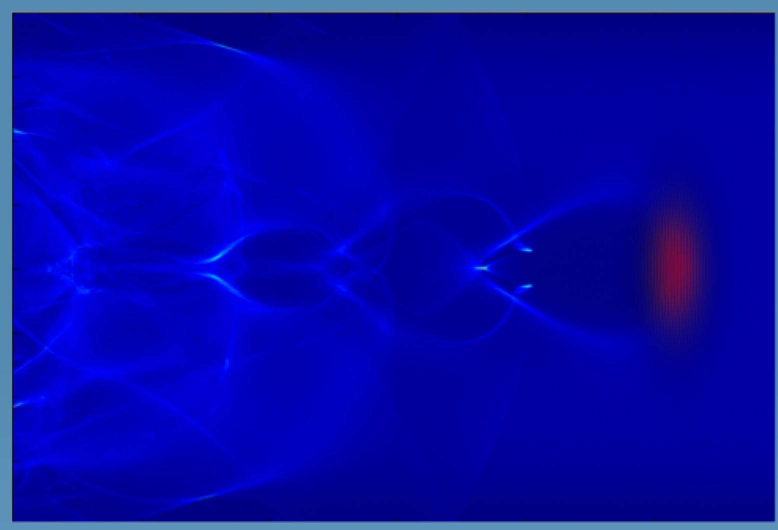
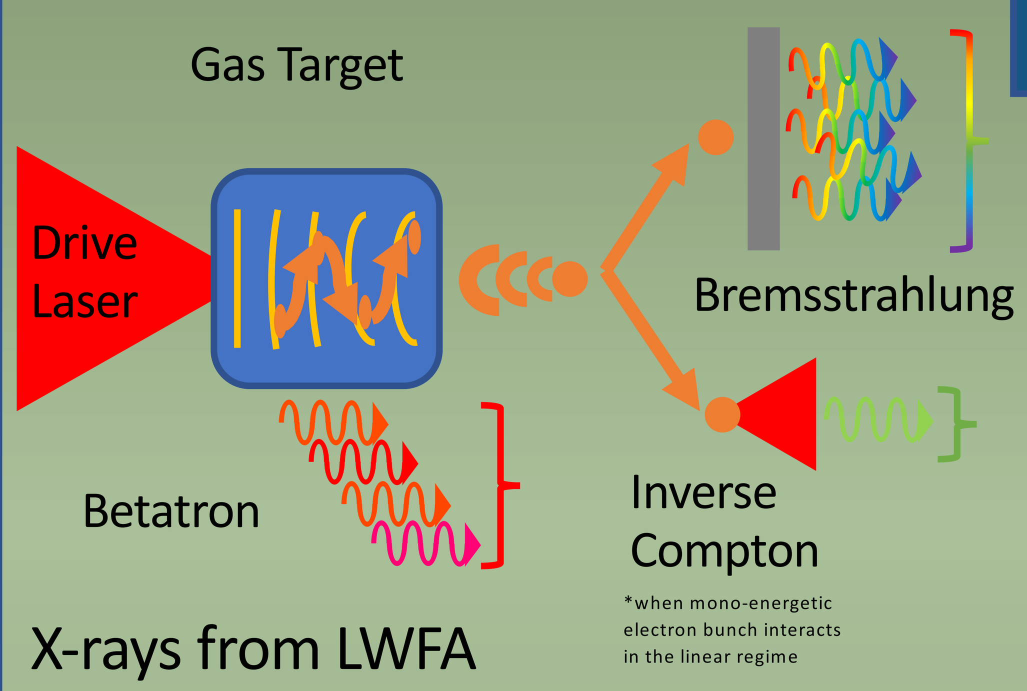
Integrated Simulations of wakefield-accelerated electrons using density-ramp injection for X-ray source generation

C. I. D. Underwood and Dr C. D. Murphy
York Plasma Institute, University of York





Motivation

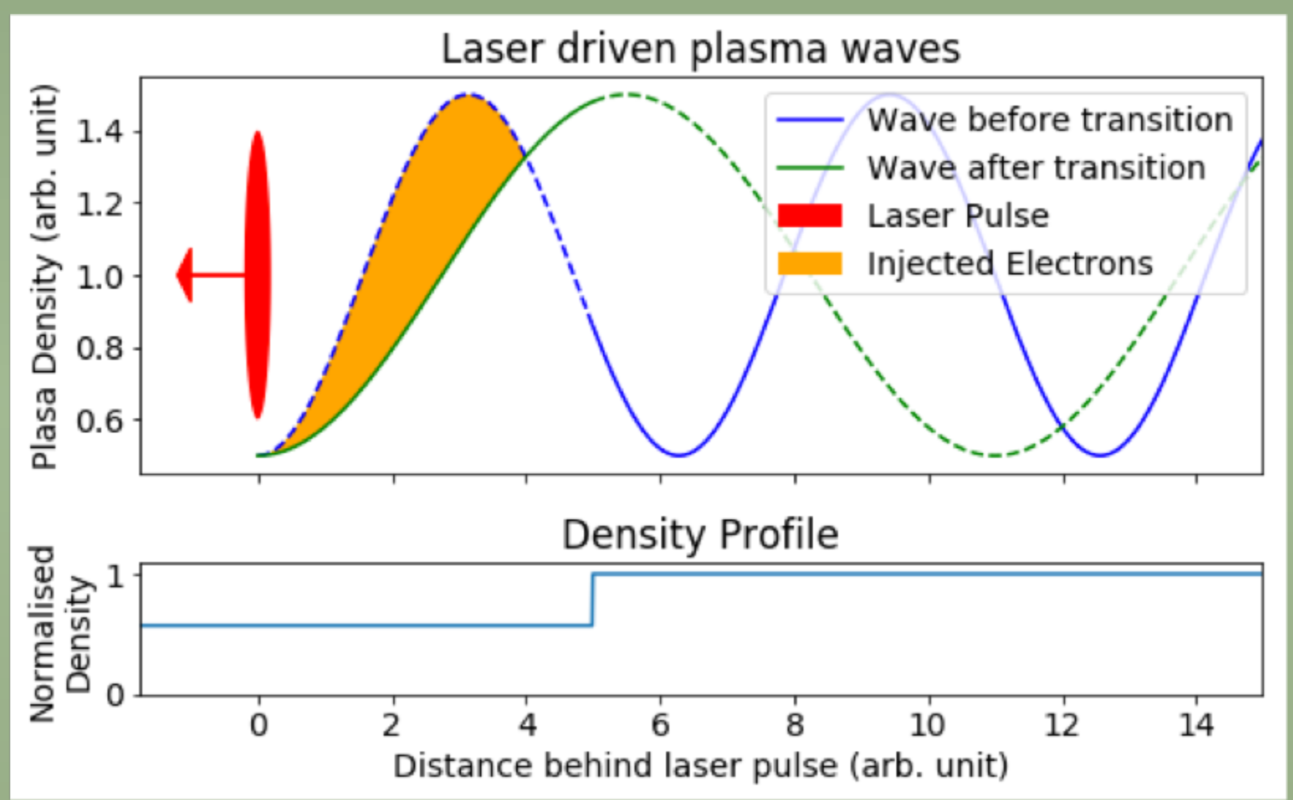
- Laser wakefield accelerators (LWFA) lead to more compact machines than conventional accelerators (LINAC), as accelerating fields in plasma are 3 orders of magnitude greater than LINAC technology [1].
- Creating a tunable LWFA electron source allows the creation of tunable quasi-mono chromatic X-ray sources via Compton scattering [2].
- A bremsstrahlung X-ray source from LWFA electrons can be simulated using Geant4 if the electron spectrum and convertor are known. Stabilising the electron beam through injection control allows the X-ray spectrum to be calculated before introducing the convertor.

Density Transition Injection

- The plasma wavelength is density dependent:

$$\lambda_p \propto \sqrt{\frac{1}{n_e}}$$

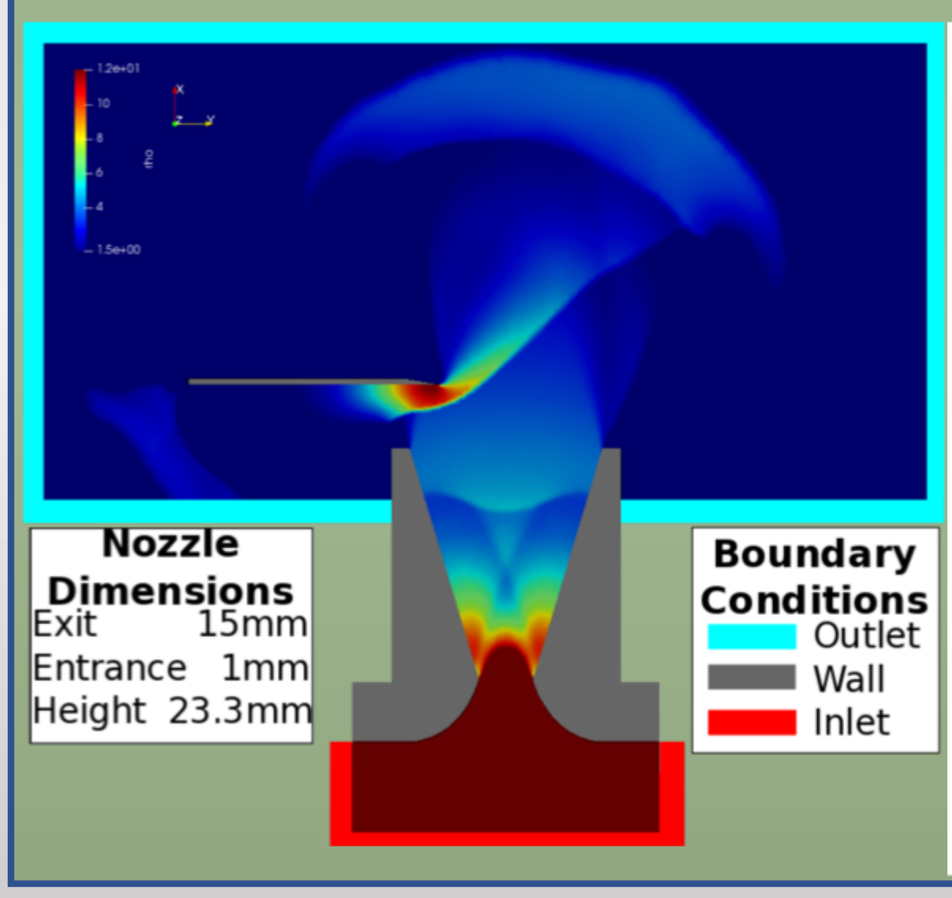
- The laser interaction creates plasma waves, with a wavelength corresponding to the density. Rapid density transition results in a quick transition in plasma wake lengths. This causes electrons that were oscillating in the high density regime to be out of phase with the low density wave [3].

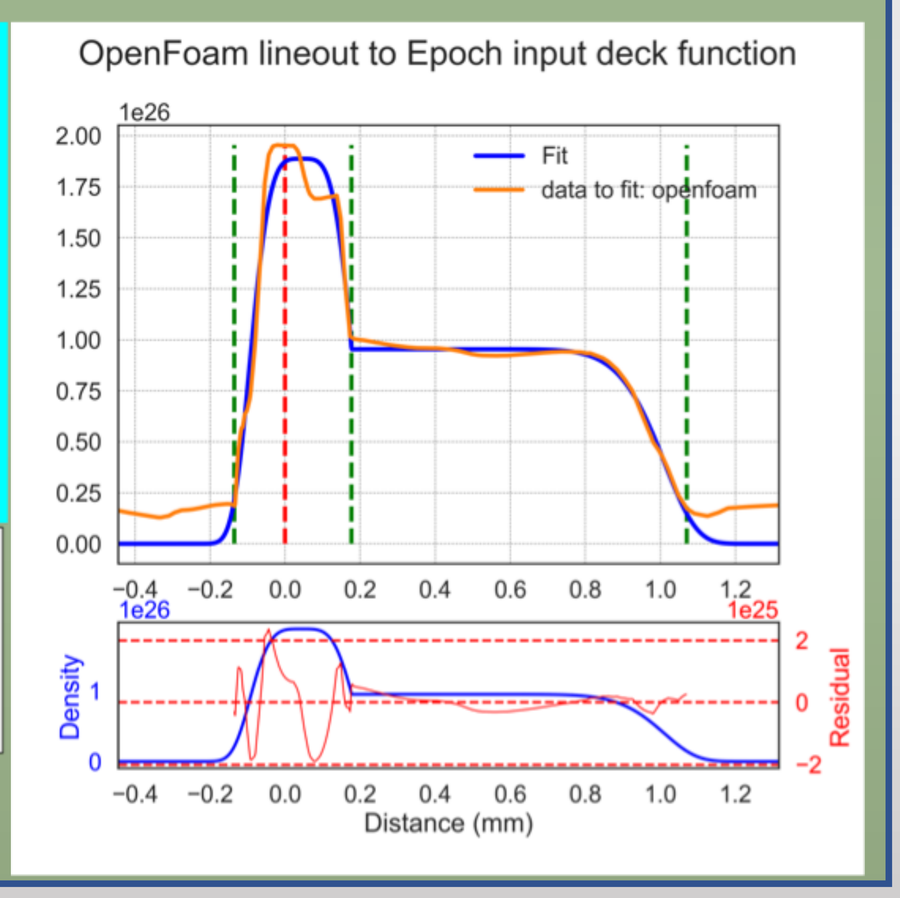


- Therefore these electrons are 'injected' and as this happens at a localized point they see the same accelerating field, leading to the creation of a quasi mono-energetic electron spectrum.

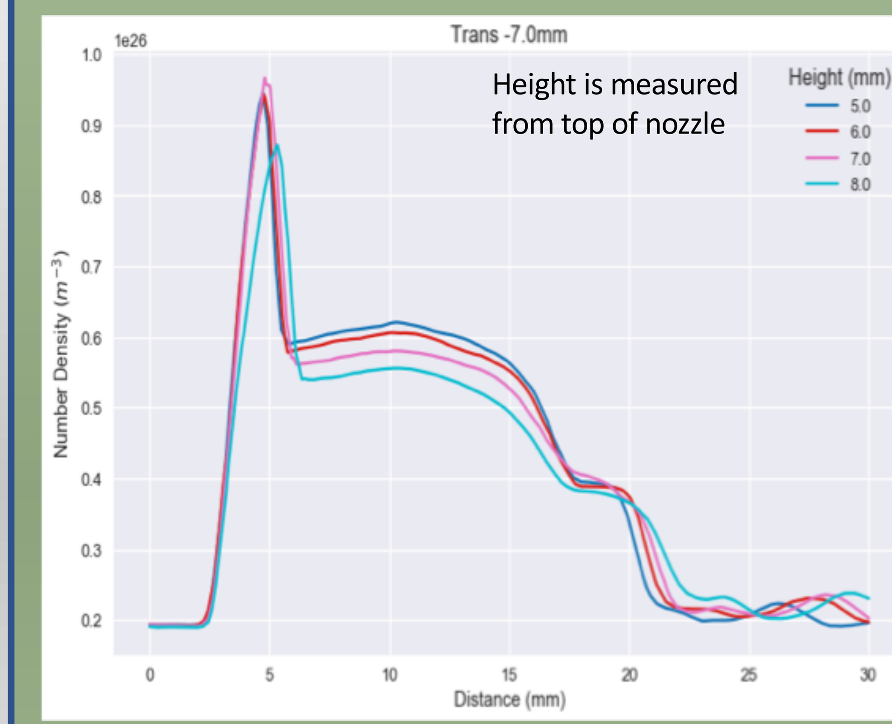
Hydrodynamics Simulation of Gas Jet Targets

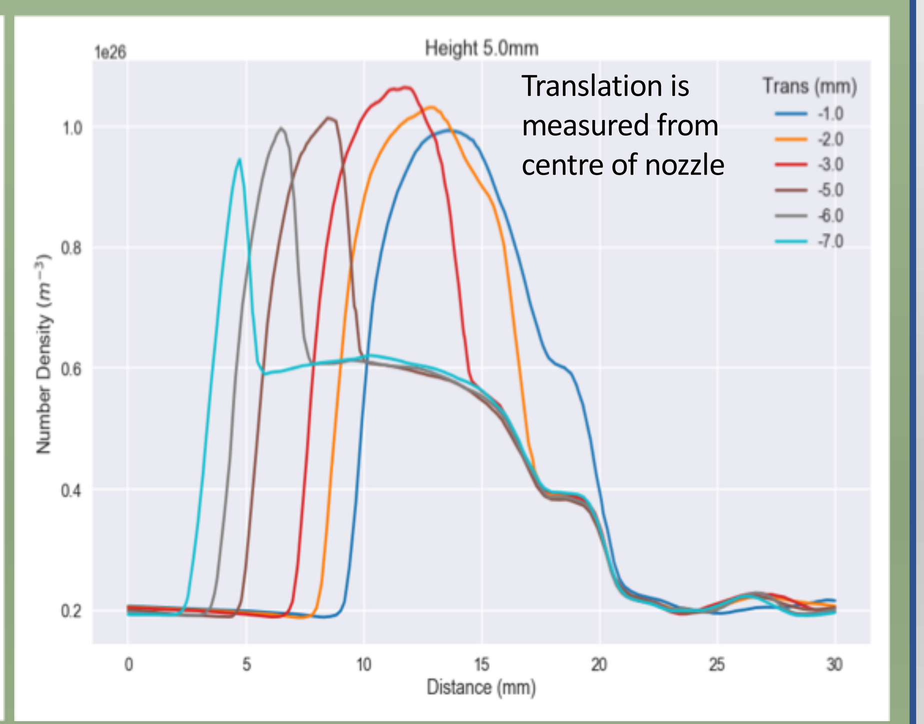
- Used open-source hydrodynamics code 'openFOAM' and its solver 'rhoCentralFoam'. Density based solvers work better at high (0.7<) Mach numbers [4].
- The simulation background pressure is higher than would be found experimentally to improve code stability. The effect of this will be investigated further.

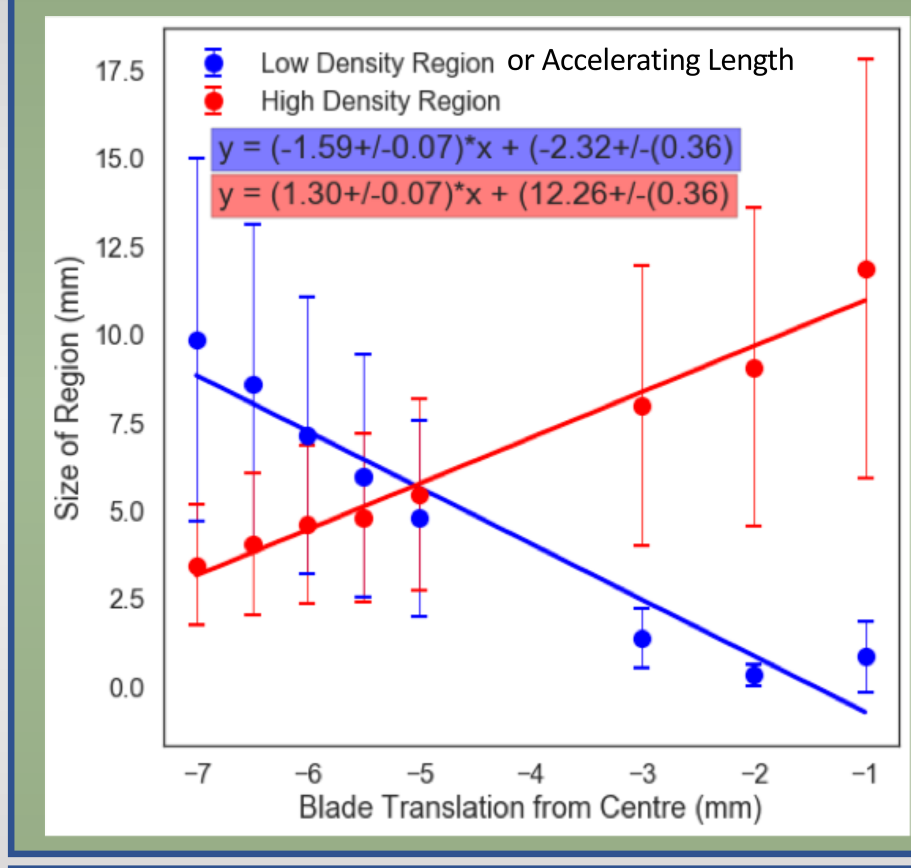




openFOAM Density Profiles



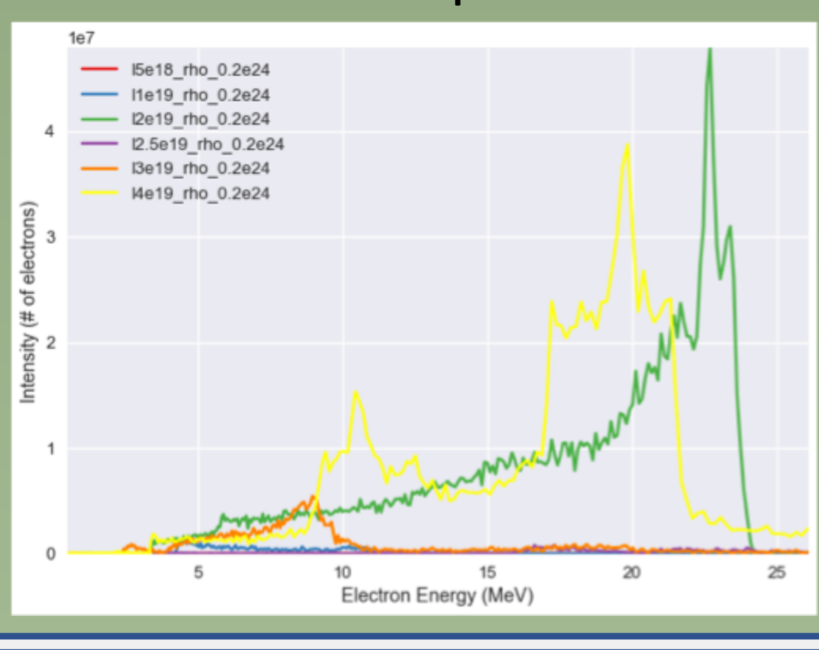


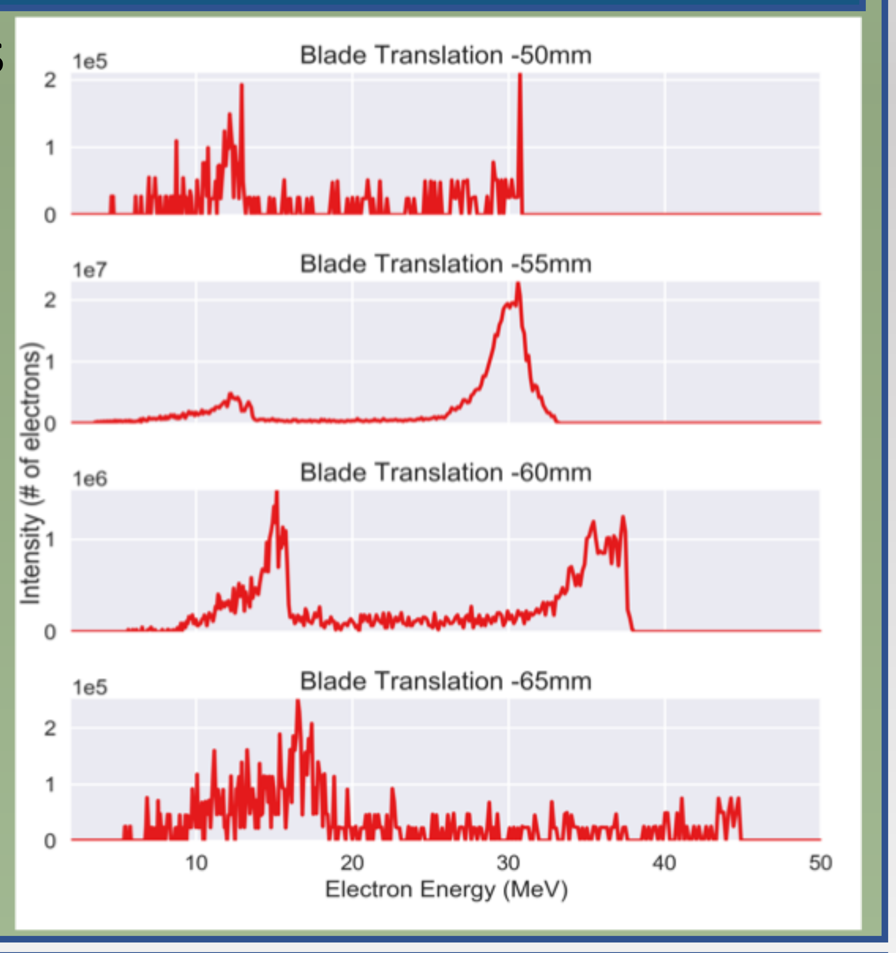


- Vertical translation of the blade has little effect on the density profile, horizontal translation greater one.
- A relation between position and accelerating region to initial has been found.
- Density profile can be altered to change the electron spectra.

Laser plasma (EPOCH) wakefield simulation

- Output of openFOAM is used as input.
- Intensity scan and profile scan have been completed.





Conclusions and Future Work

- Initial work shows signs of a tuneable spectrum. Convergence testing needs to be completed.
- Improve fitting of density profile for input into EPOCH.
- Investigate how shape of transition affects spectrum, and how to optimise the production of the electrons for specific applications.
- Test experimentally on Gemini in late 2018.

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