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Localised Ionisation Injection with Dual Stage Gas Cell

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Why dual stage gas cell?

- We need optimal beam loading in LPA’s to reduce the energy spread while preserving the particle acceleration.

- Single stage gas cells produce high charge and energy but the beam spread is large ~15% (kirchen et.al. PRL 126, 174801 (2021)).

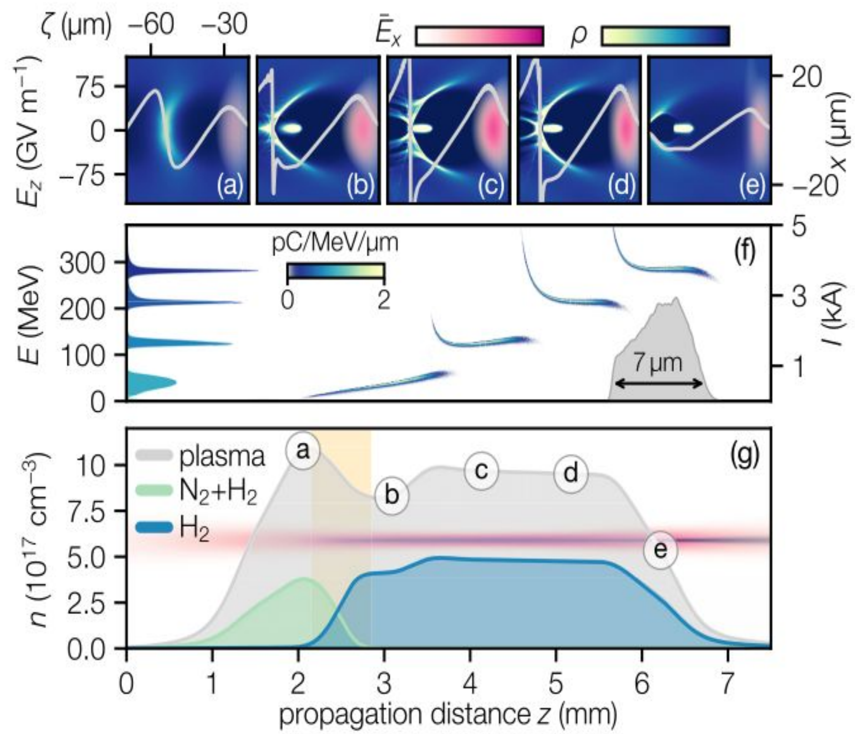
- Shock front injection using gas jet produces monoenergetic electron beams, but it’s not stable as gas cell.

- The idea: creating a density gradient inside the cell, to have more control on the injection process.

- Dual stage gas cell : 1st cell, injection process
  2nd cell, acceleration

Theory behind dual stage gas cell

- ❖ By tailoring the nonlinear plasma through the control of electron density and laser parameters , the control over wake phase velocity can be achieved which in turn facilitate the trapping of the electron bunch. [Gonsalves st. al, Nat. phys, vol 7, 2011.]
- ❖ At first density upramp (a), the wakefield evolution suppresses the trapping of Inner N electrons.
- ❖ At higher intensity,localised injection occurs at density downramp (a-b)
- ❖ At second density upramp, the tail of the injected electrons get truncated and the injected charge bunch is then accelerated through the H plateau.



PIC simulations and 2D snapshots of the working of the 2 stage LWFA process . [Kirchen et.al, PRL 126, 174801 (20219]

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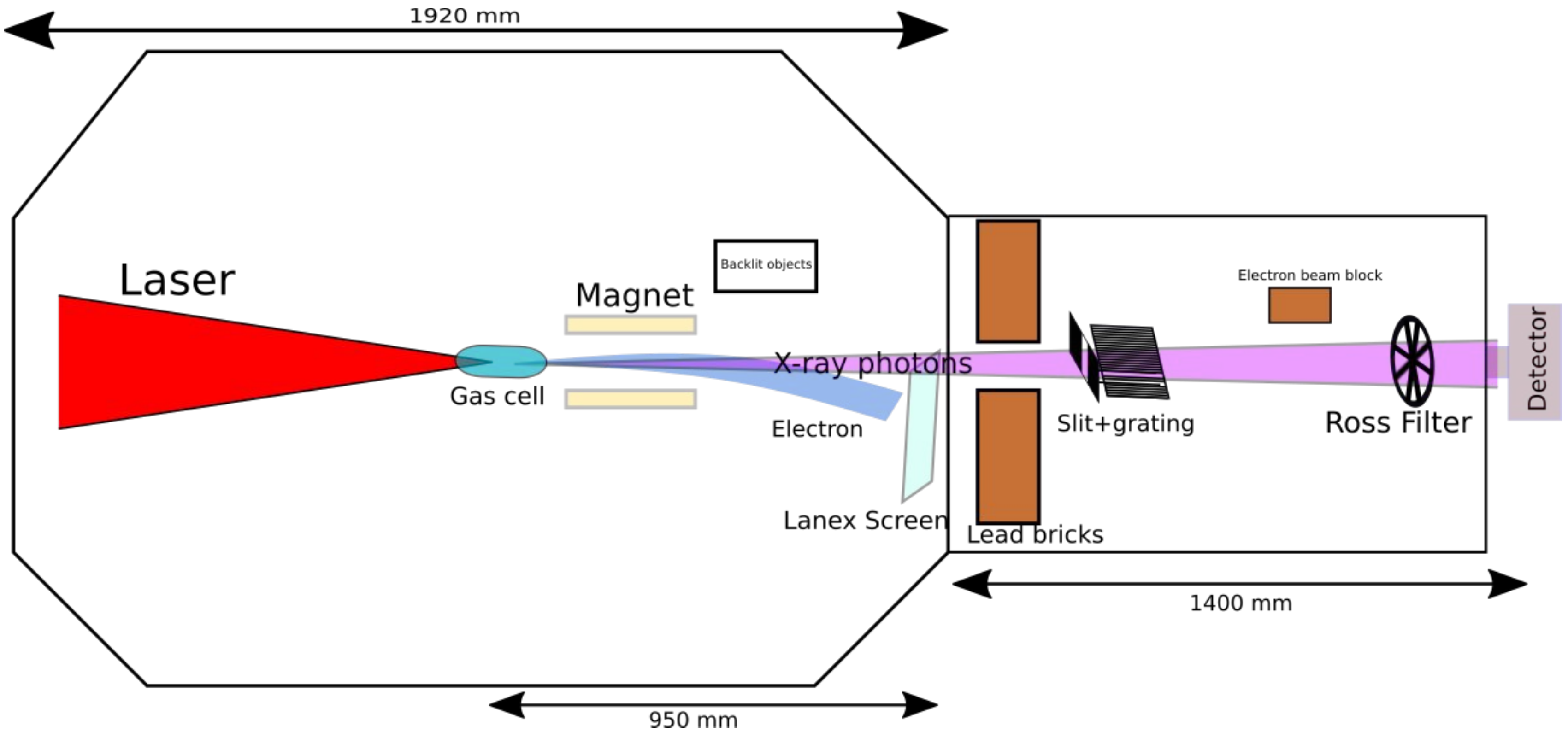
Experimental setup



- ❖ Focal spot ~25µm, 200 TW peak power focused on the gas cell.
- ❖ Electron spectrum on lanex screen and x-rays on Andor camera.
- ❖ Magnet, Gas cell, lanex: motorised.

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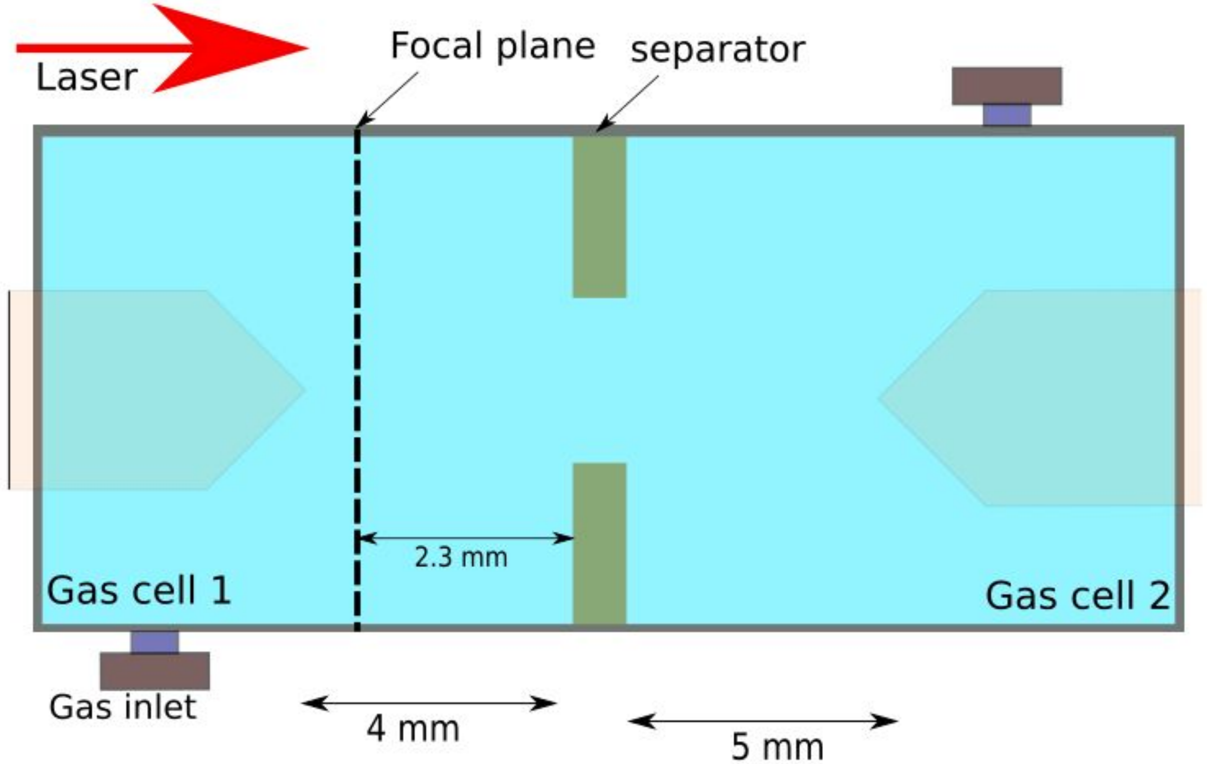
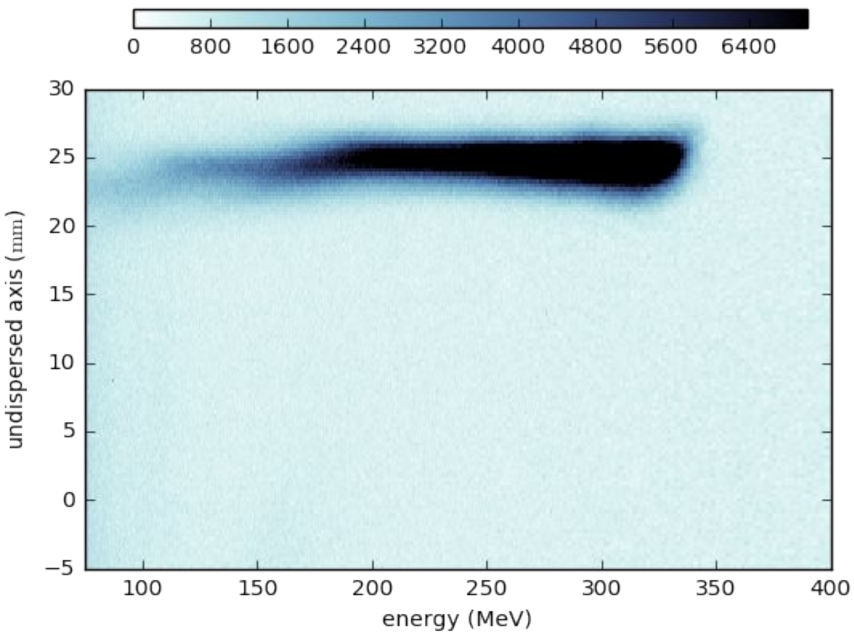
Dual stage Gas cell

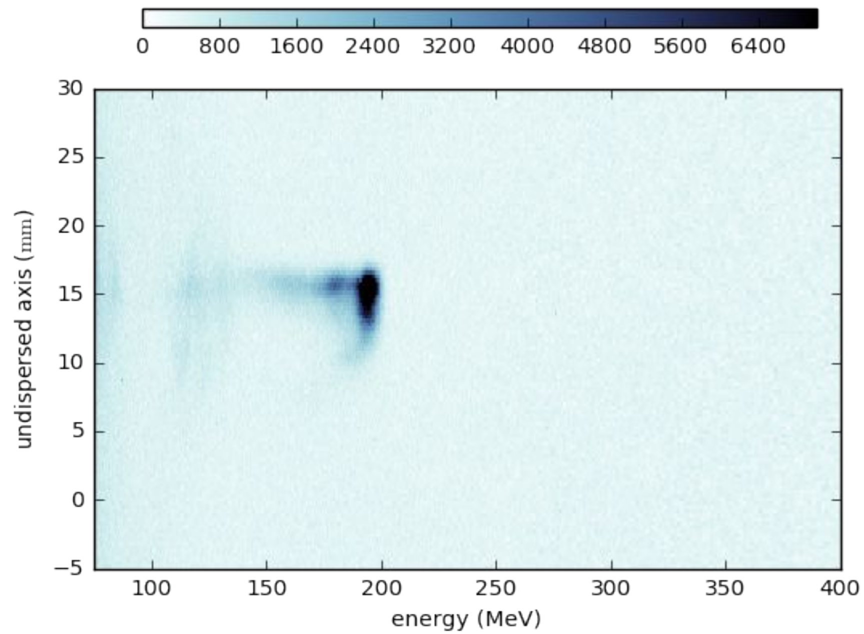


- Designed and developed by Dominik Hollatz, HIJ.
- The pressure in both chambers can be regulated separately.
- The acceleration length can be changed accordingly.

Preliminary results



Ionisation injection beam from the dual stage gas cell



Localised Ionisation injection beam from the dual stage gas cell

- ❖ Apart from pressure in both chambers, all other experimental parameters were kept constant for both these images.
- ❖ At higher pressure the ionisation injection becomes dominant, but at lower pressure, there's an evidence of localised ionisation injection leading to monoenergetic beam.
- ❖ These monoenergetic beams had 30-40% chance of occurrence and had ~5pC of charge.
- ❖ The tunability of huge parameter space to achieve such monoe electrons is quite a complicated process.

Conclusion

- We were successful in demonstrating the localised ionisation injection with our dual stage gas cell.

- Further data evaluation will help us to understand the correlation between multiple experimental parameters.

- The findings of this experimental campaign will boost the optimisation process of monoenergetic electrons from dual stage gas cell.

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Thanks

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