Towards improved control of laser-wakefield accelerators with multidimensional parameter scans

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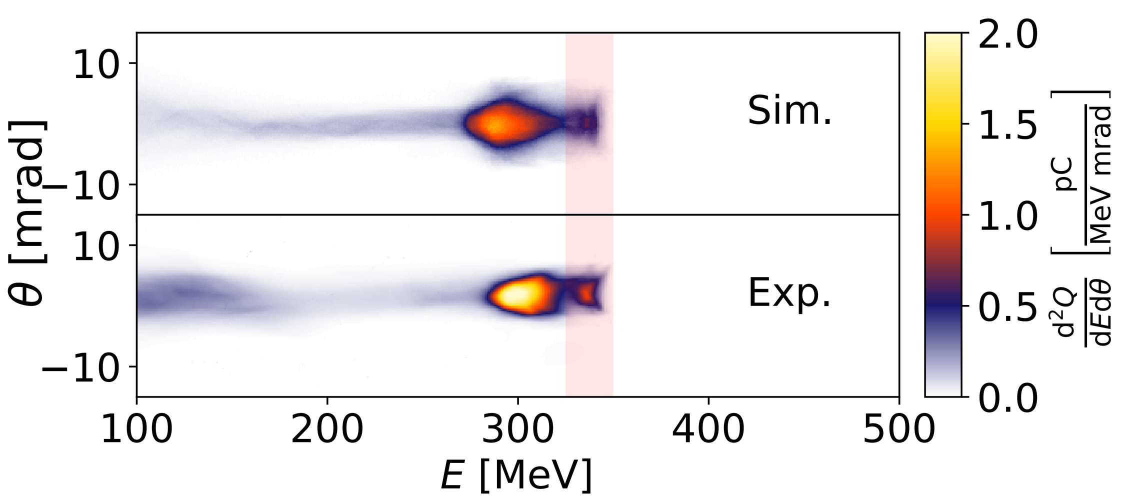
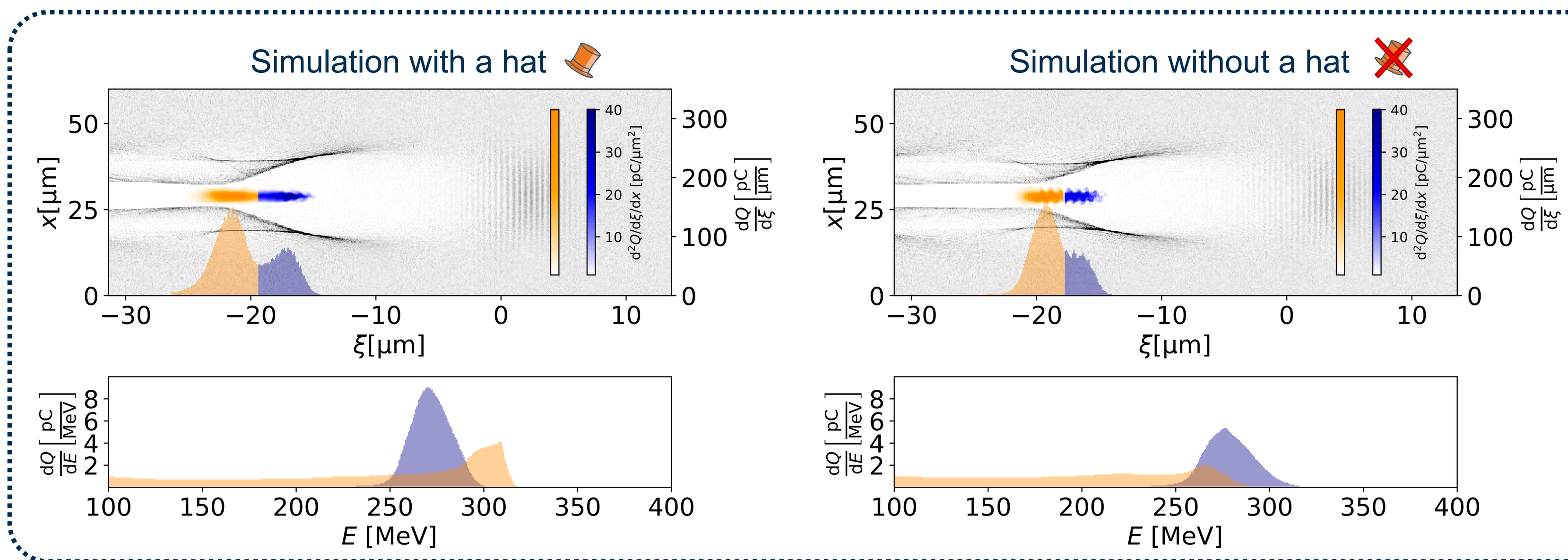
Experiments and simulations using self-truncated ionization injection (STII) in a laser wakefield accelerator (LWFA) showed an irregular charge distribution



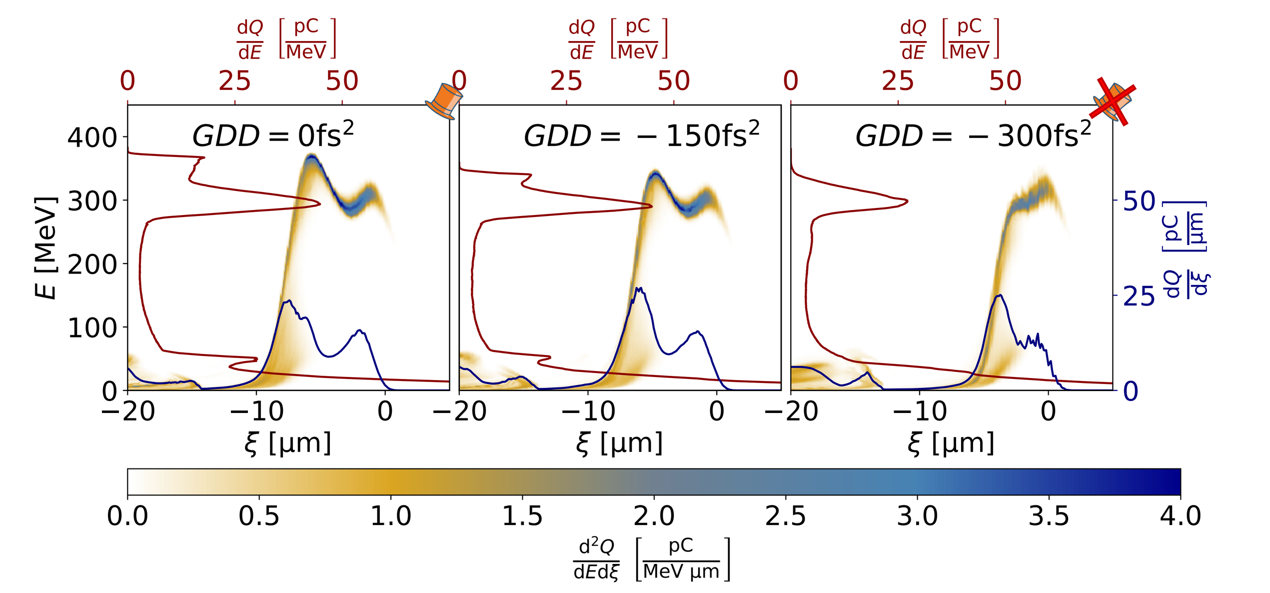
A characteristic, but for applications unfavorable feature in the electron spectra – **the hat**.

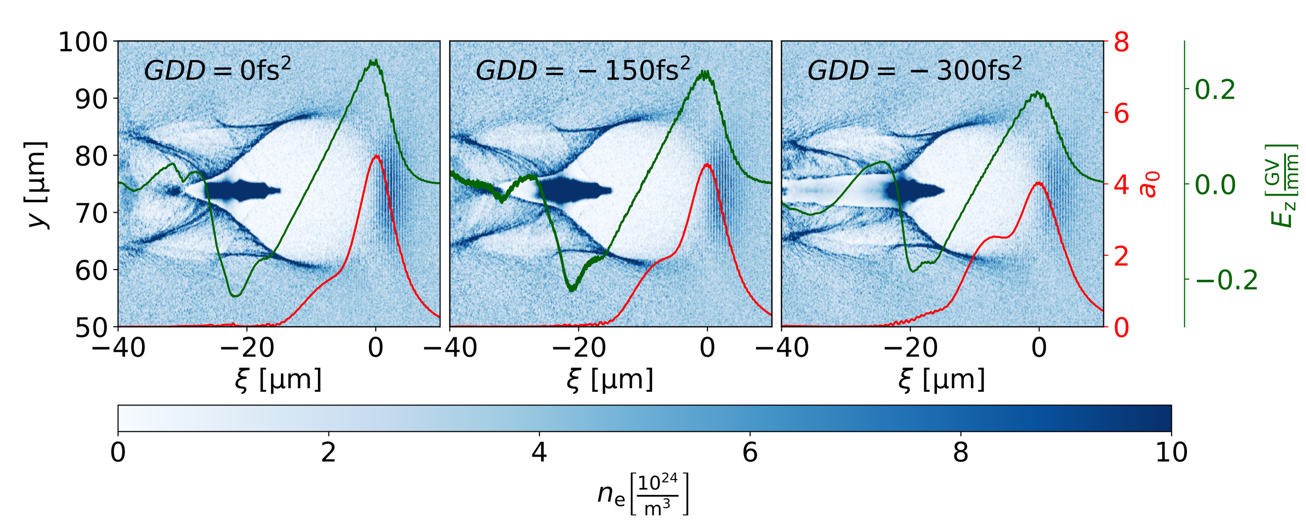


The hat feature corresponds to a double bunch charge distribution in the longitudinal direction, but not all simulations with such a distribution have the hat feature. This raises two questions:

- Where does the distribution originate?
- What distinguishes simulations with a hat feature from those without?

What distinguishes simulations with hat from simulations without?



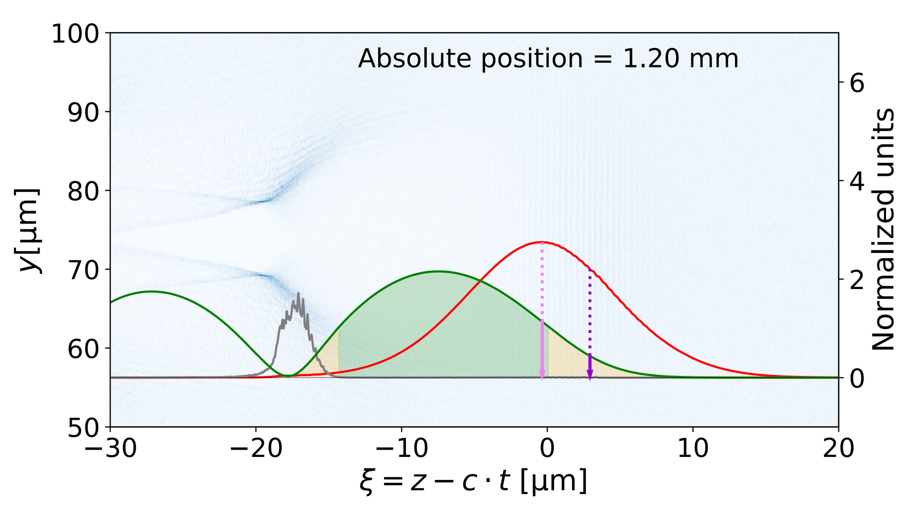


The hat occurs when the electron bunch closer towards the rear of the cavity experiences a strong accelerating field for a sufficiently long time. This can be prevented by a pre-mature breaking of the cavity, for example, due to weaker laser intensities.

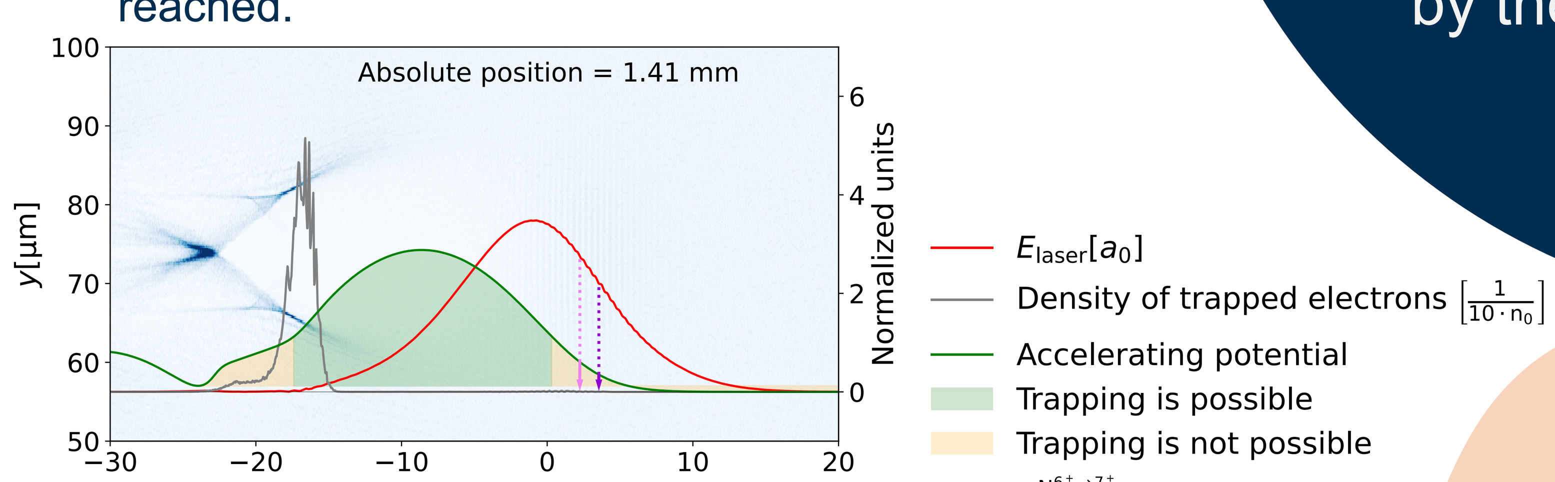
Where does the distribution originate?

In STII a doping gas is used, and one takes advantage of the higher ionization threshold of the inner shell electrons of the doping gas for trapping.

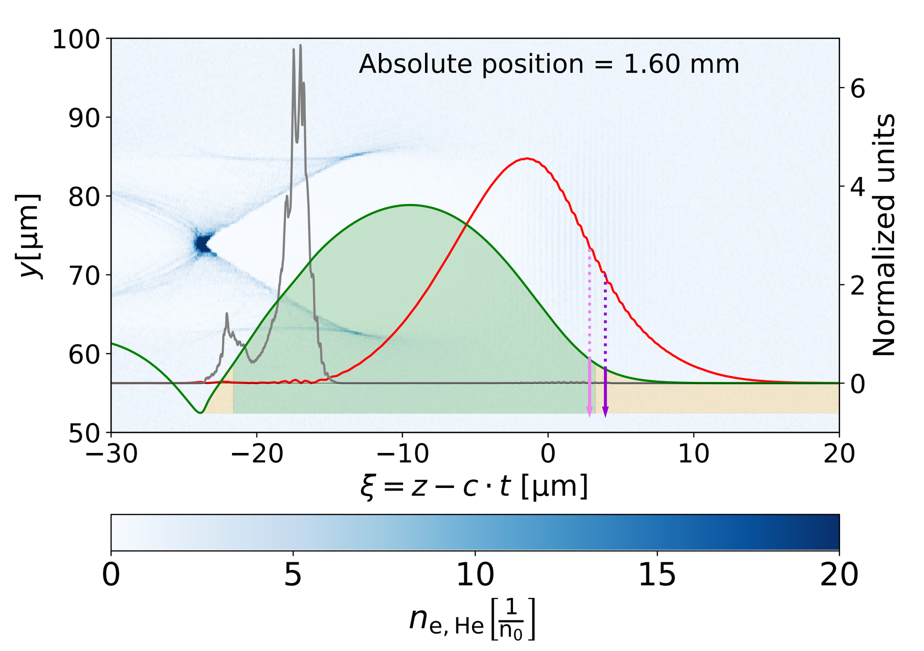
Trapping…



… occurs before the blowout regime is reached.



… is temporarily stopped due to the intensification of the laser and ionization closer to the front of the laser.



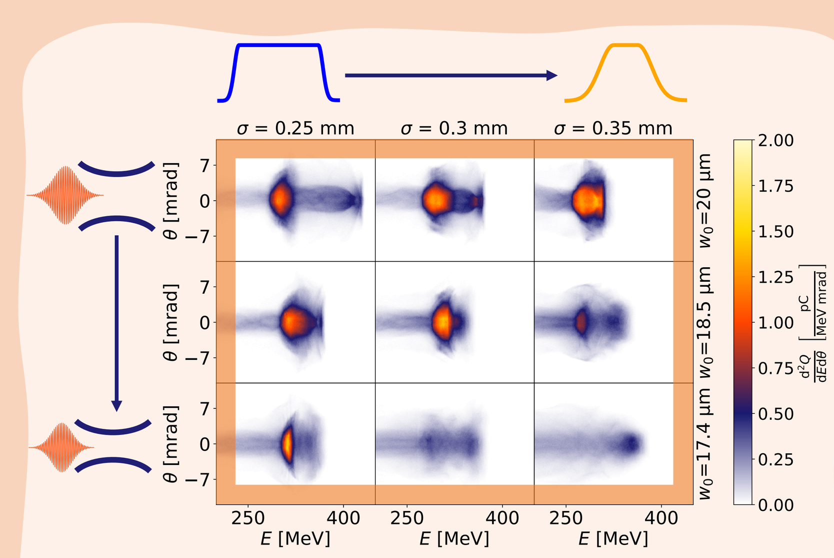
… reoccurs when the blowout regime is reached and the accelerating fields get stronger, making trapping possible to the front of the laser.

Powered by:

PIConGPU & Snakemake

Large scale, three-dimensional particle-in-cell simulations, automated by the python-based workflow engine Snakemake.

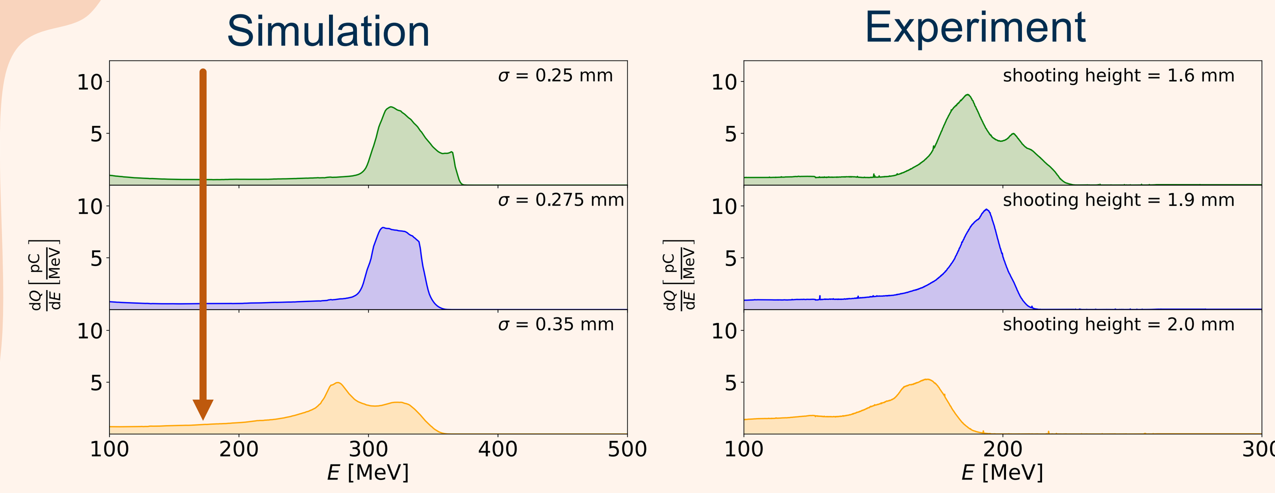
Impact of the **beam waist** & the **slope of up- and down ramp** of the plasma density



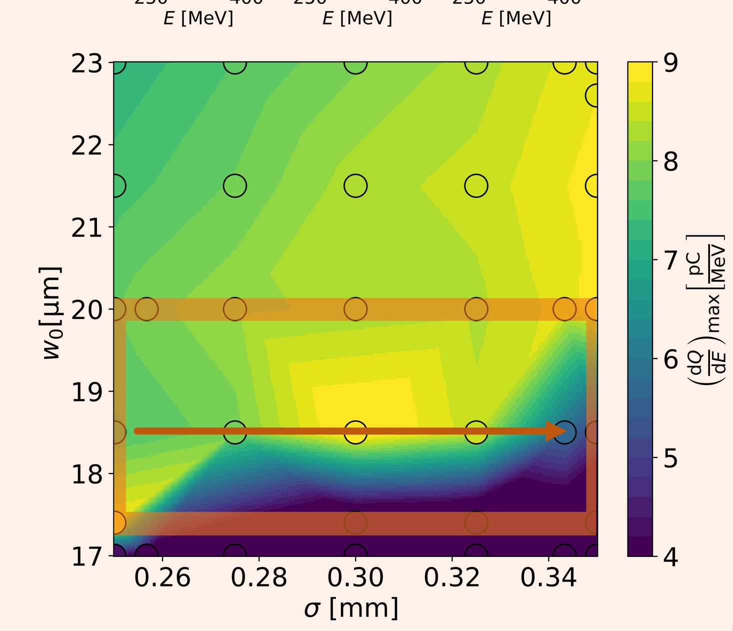
One possibility to get rid of the hat:

Adapt the beam waist of the laser to the plasma target!

Comparison to experiment



Results agree with experiments at @DRACO (HZDR)



Parameter scan searching the highest spectral charge density

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Institute of Radiation Physics · Laser Particle Acceleration

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