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PIConGPU

HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

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

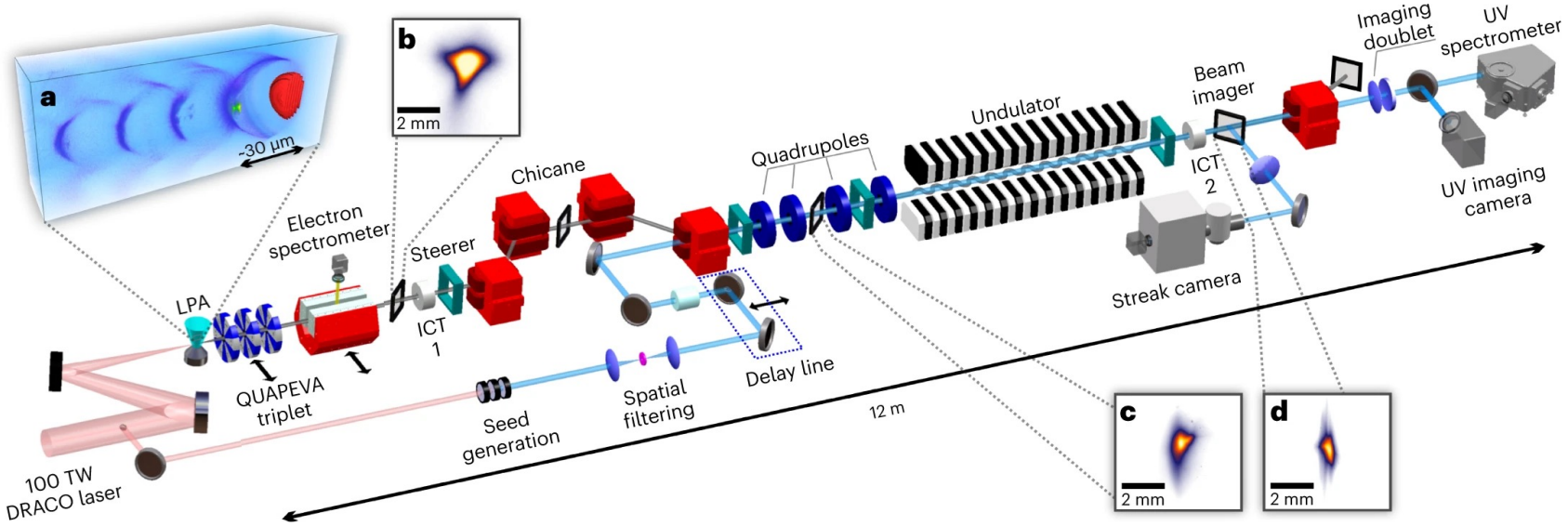
Jessica Tiebel[1,2], Richard Pausch[1], Michael Bussmann[1,3], Finn-Ole Carstens[1,2], Alexander Debus[1], Arie Irman[1], Susanne Schöbel[1], Klaus Steiniger[1,3], René Widera[1], Ulrich Schramm[1,2]

[1]Helmholtz-Zentrum Dresden – Rossendorf, [2]Technische Universität Dresden, [3]CASUS, Görlitz

Institute of Radiation Physics · Laser Particle Acceleration · Jessica Tiebel · j.tiebel@hzdr.de · www.hzdr.de

Operating a Free Electron Laser with a Laser Driven Electron Beam

M Labat, et al. *Nat. Photon,* 2022.



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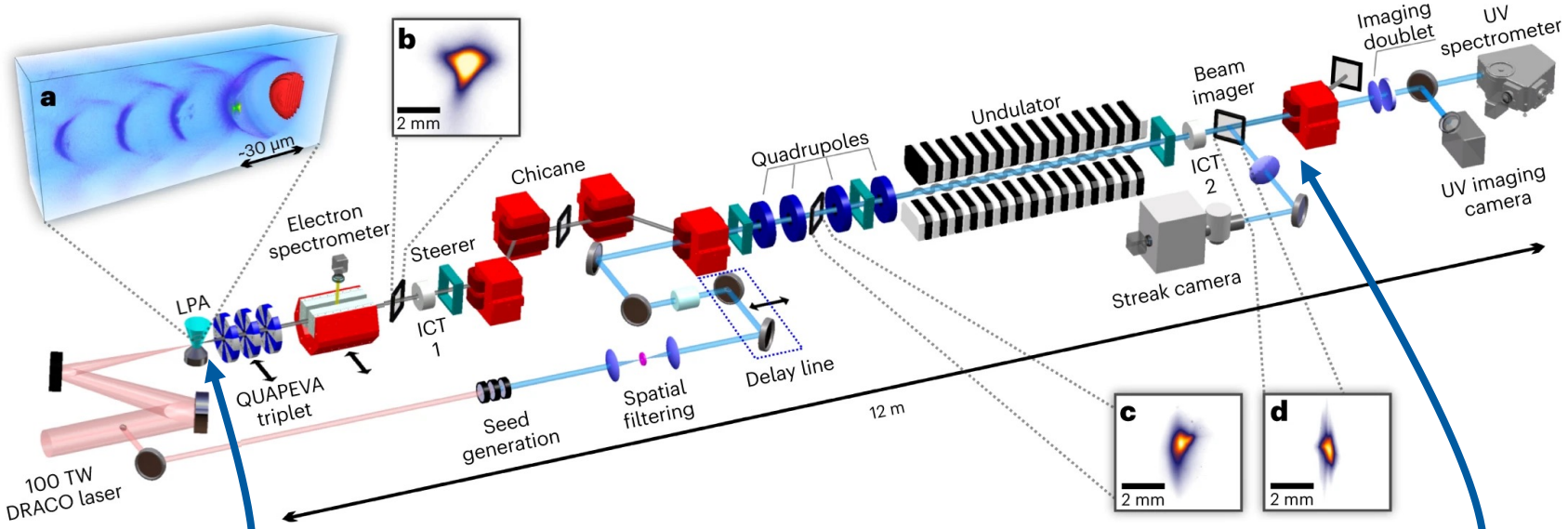

How can we efficiently tune this part?

To reach best and most stable results here?

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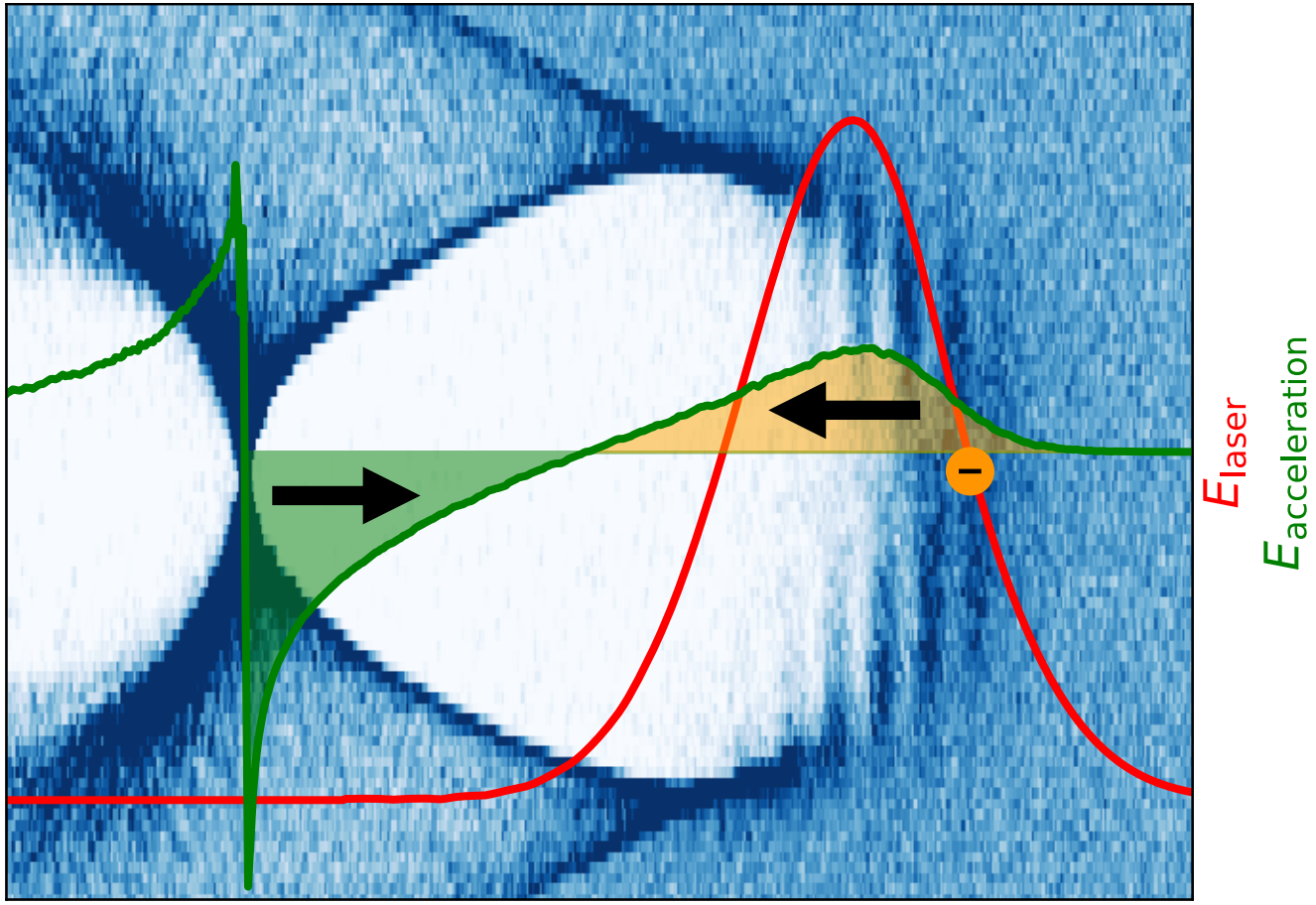
Self-Truncated Ionization Injection (STII)

Trapping Conditions and Electron Beam Parameters



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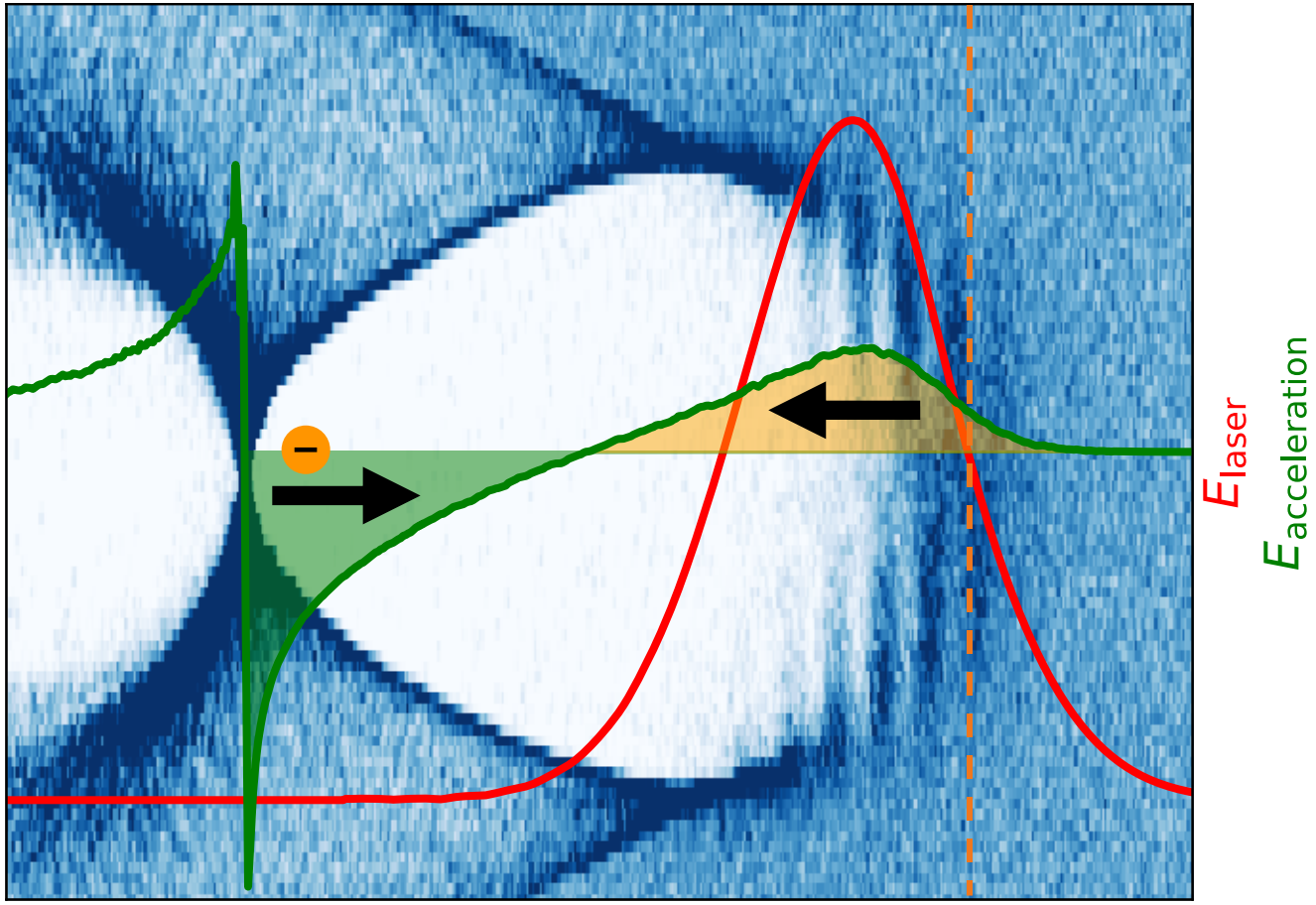

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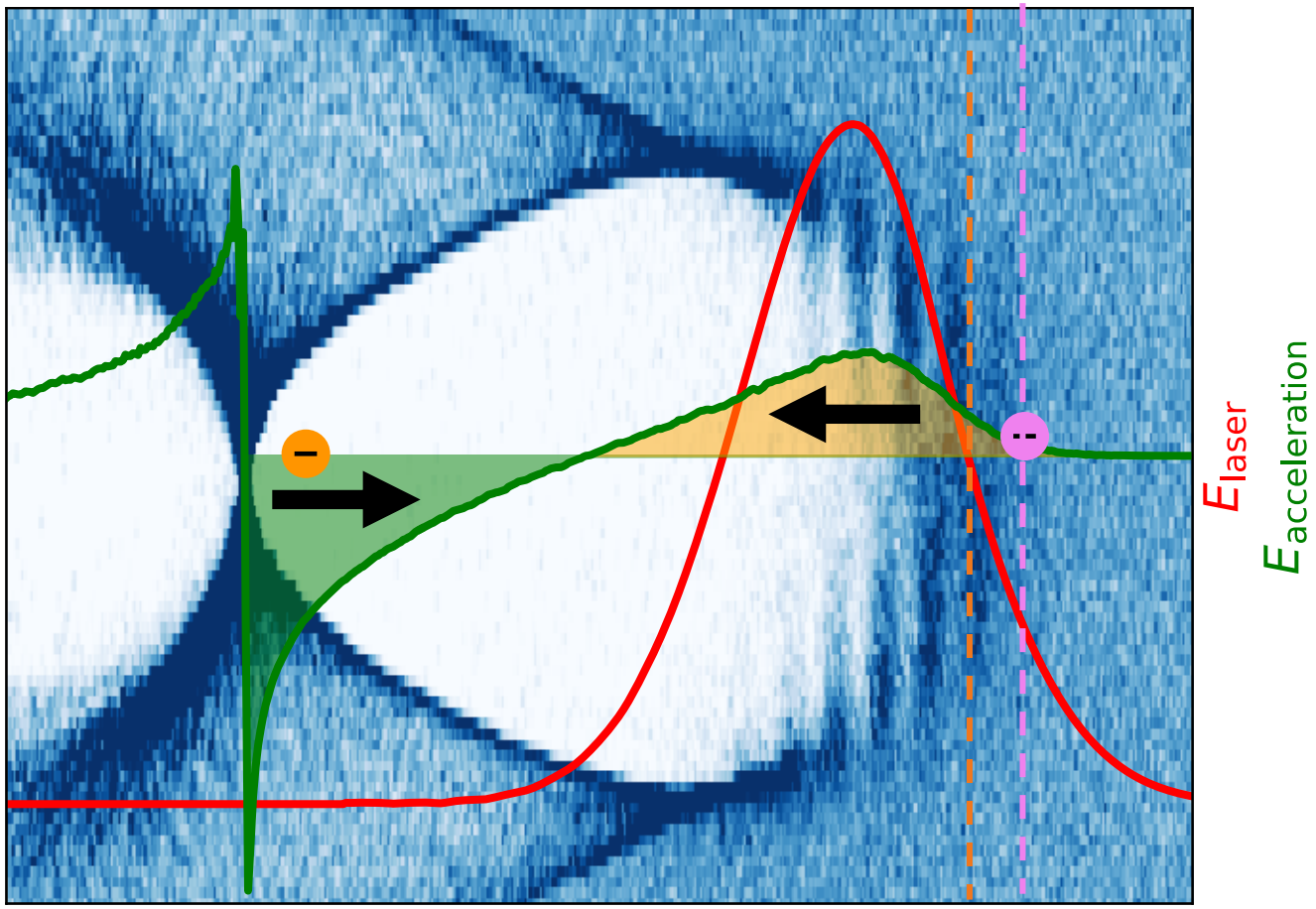

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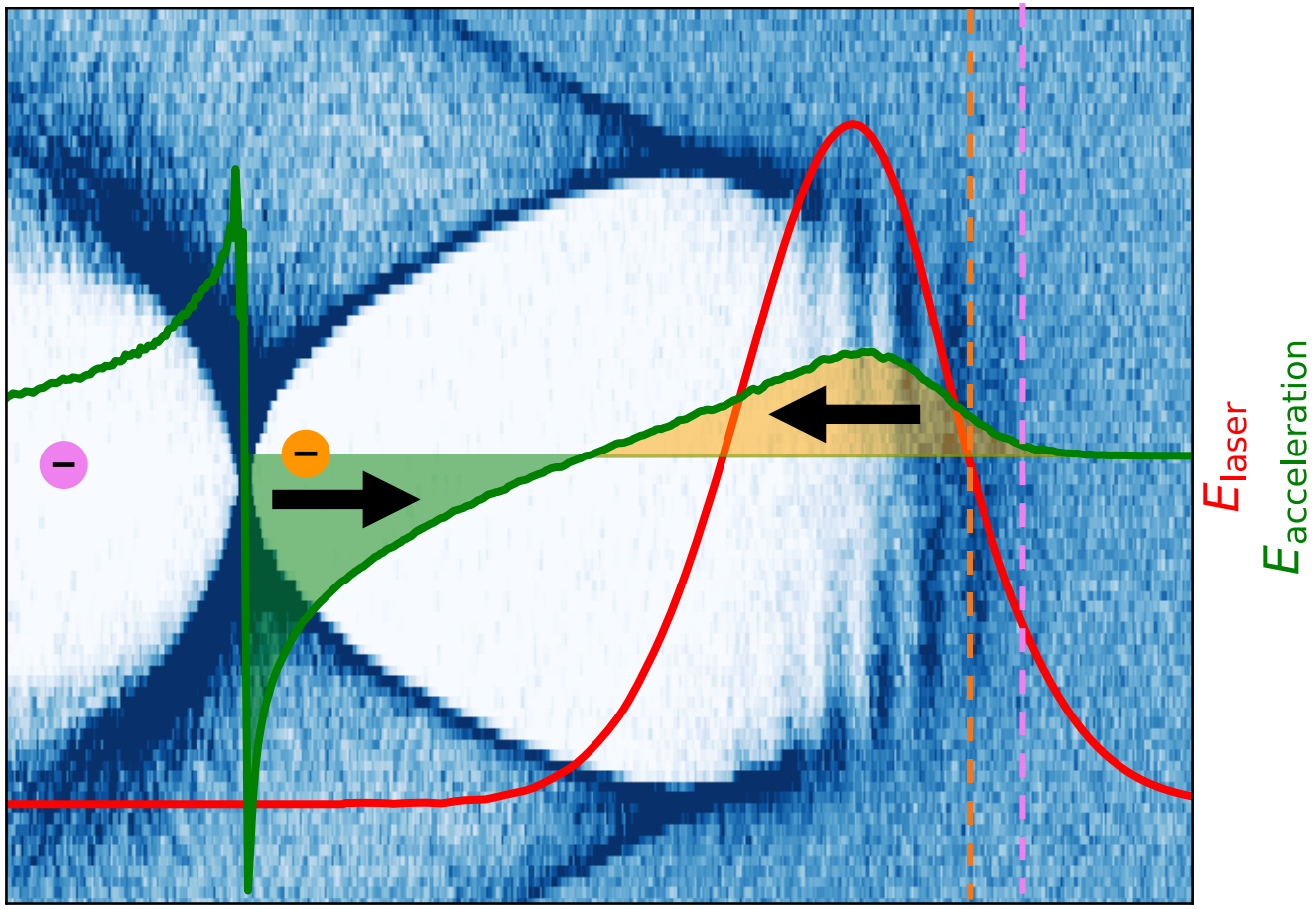

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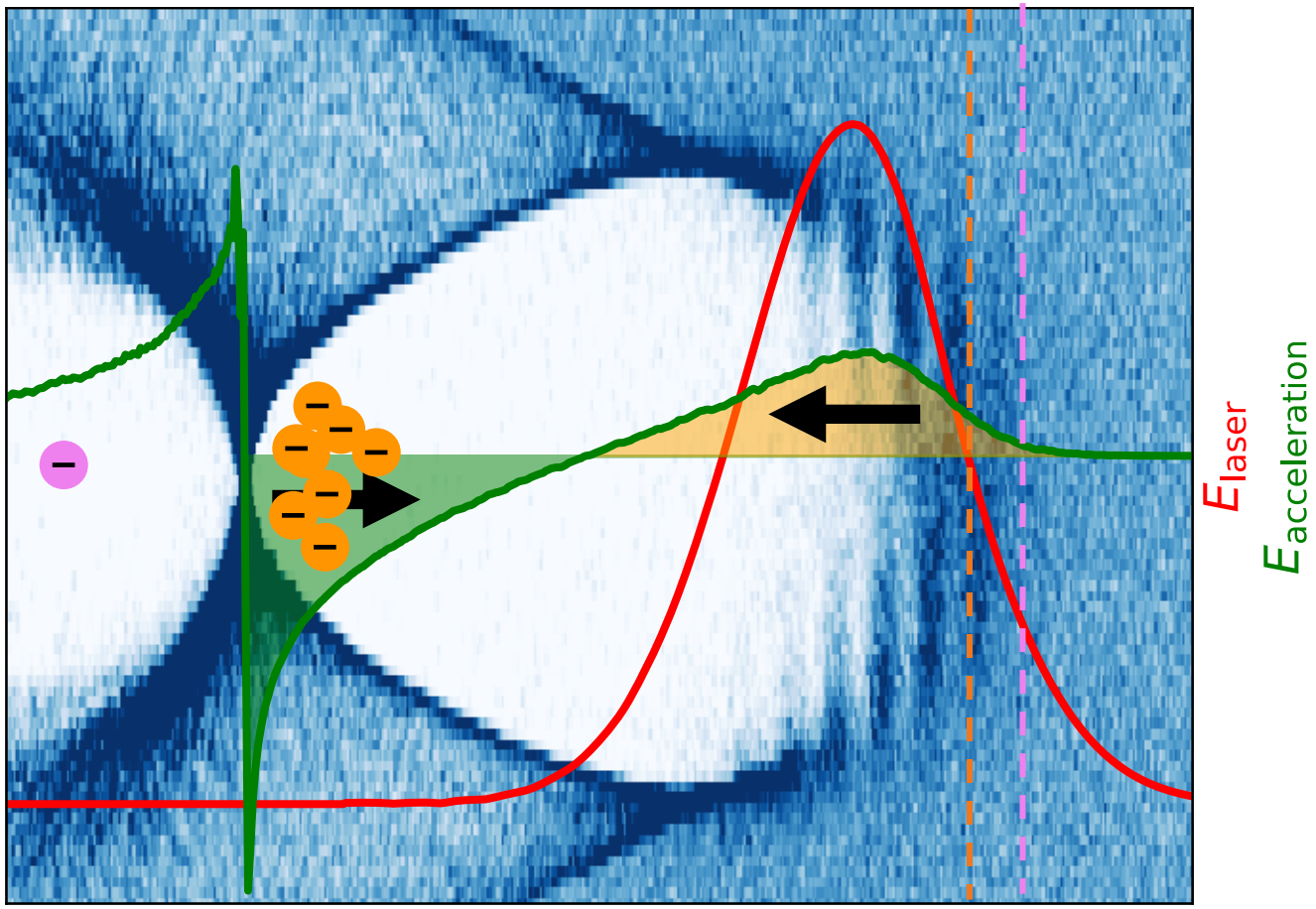

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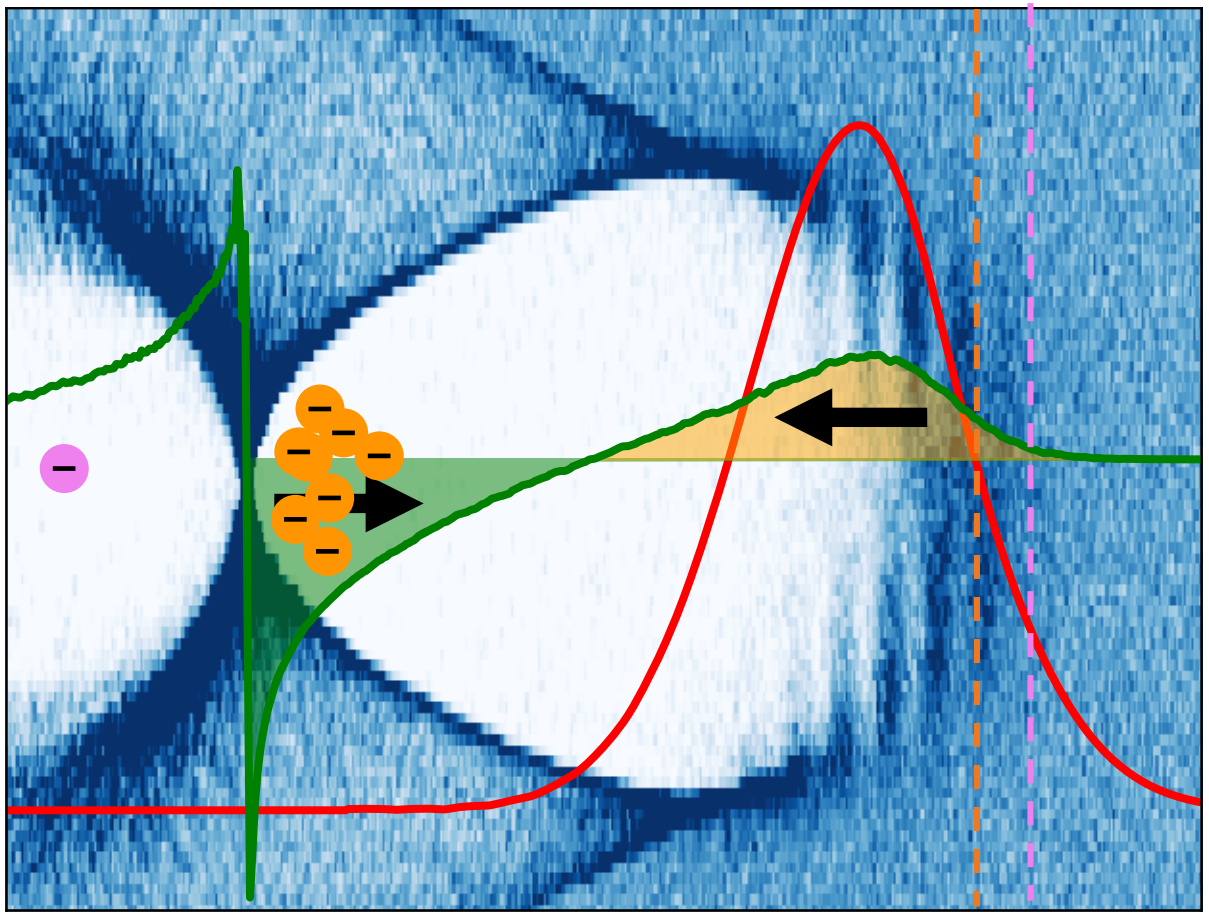

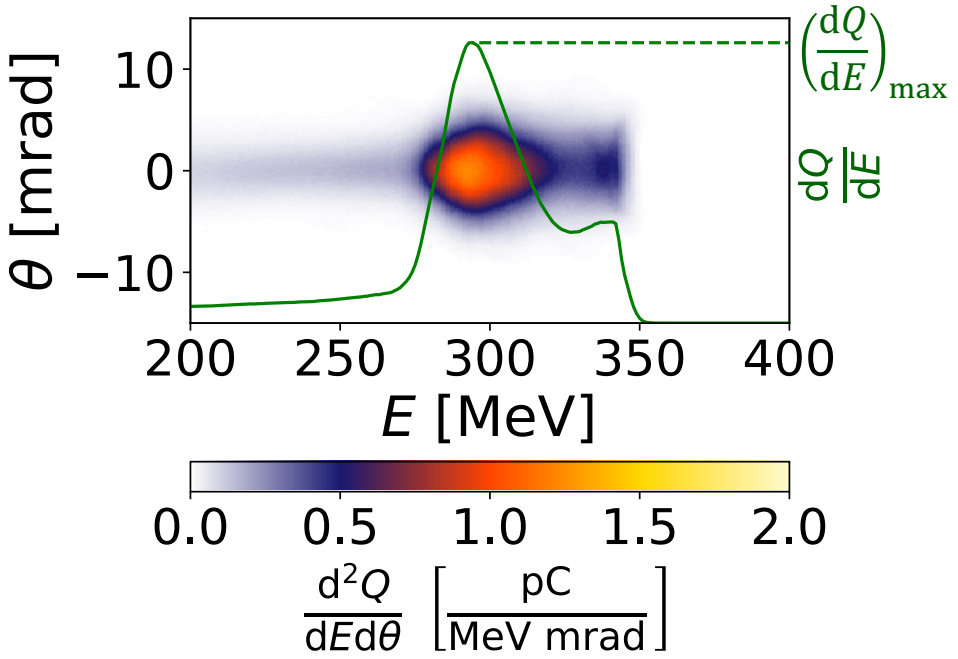

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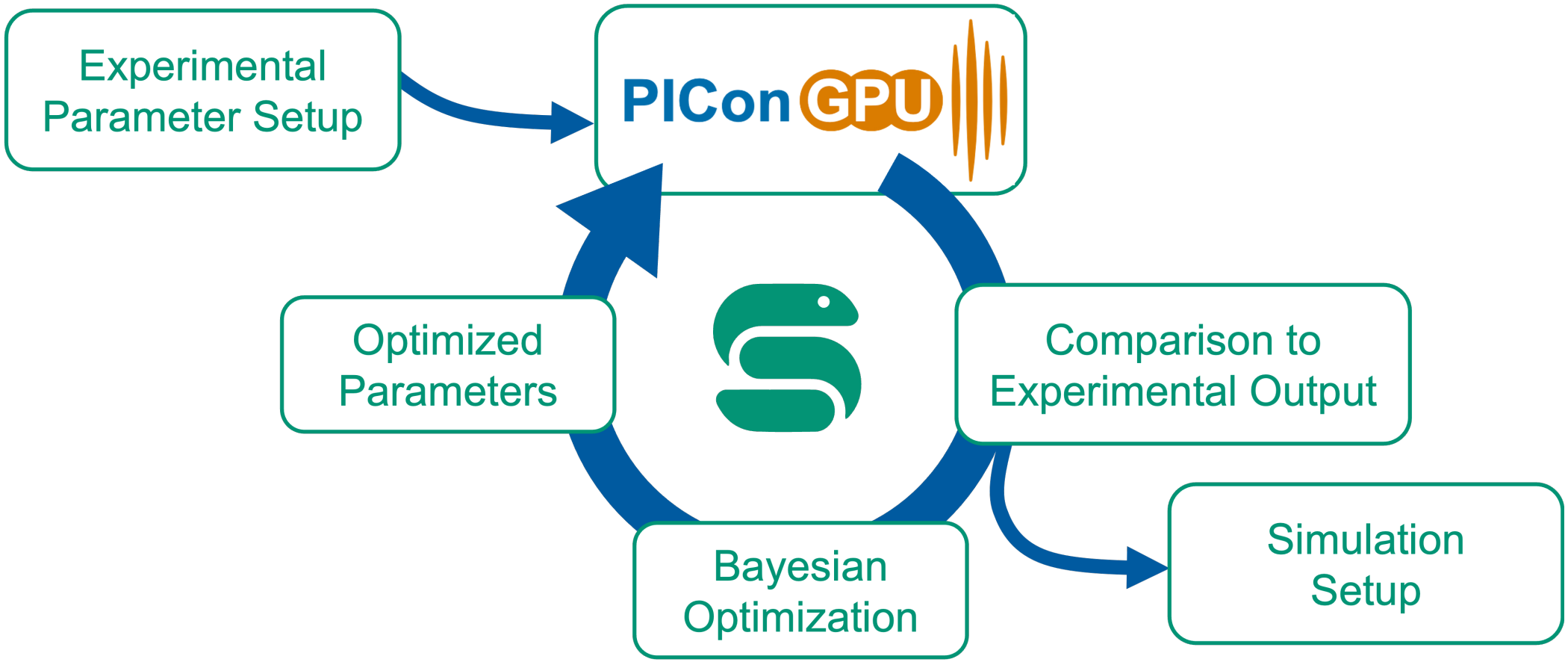
Modeling Experiments

With Snakemake and Bayesian Optimization



Finn-Ole Carstens will share additional details about PIConGPU later in this session.

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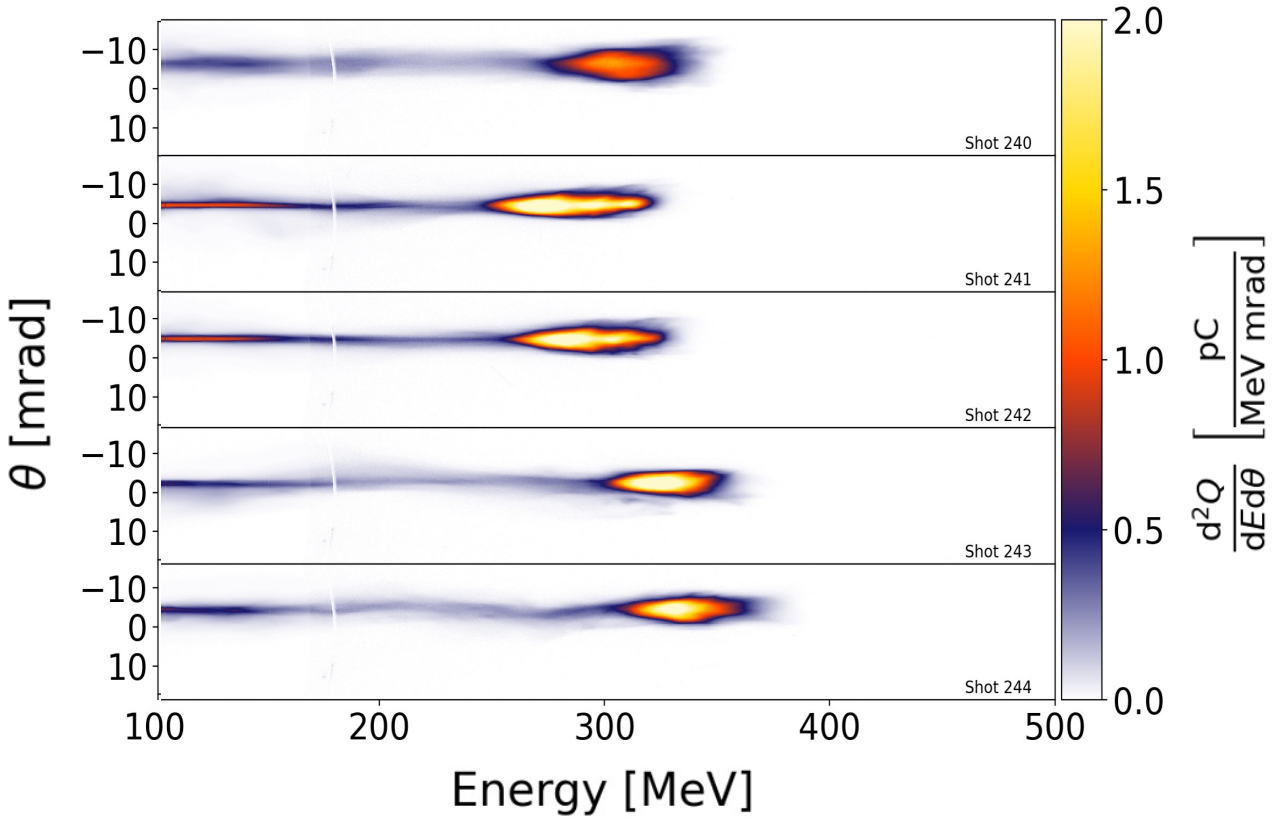
Modeling Experiments

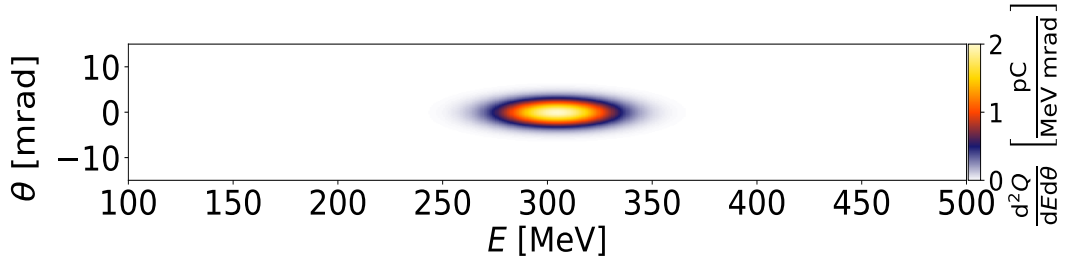
With Snakemake and Bayesian Optimization

Experiment

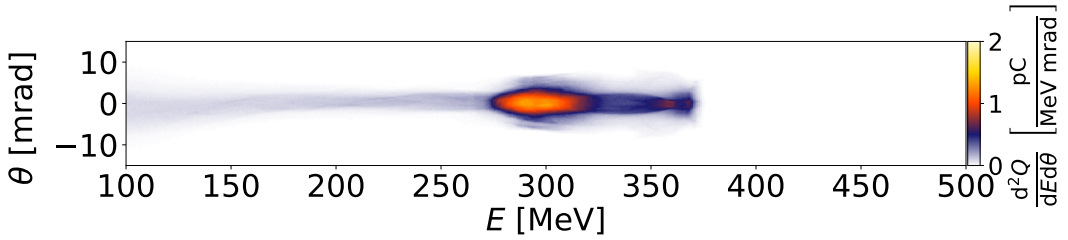


Simulation

Simplification acts as target spectrum



Best fitting simulation



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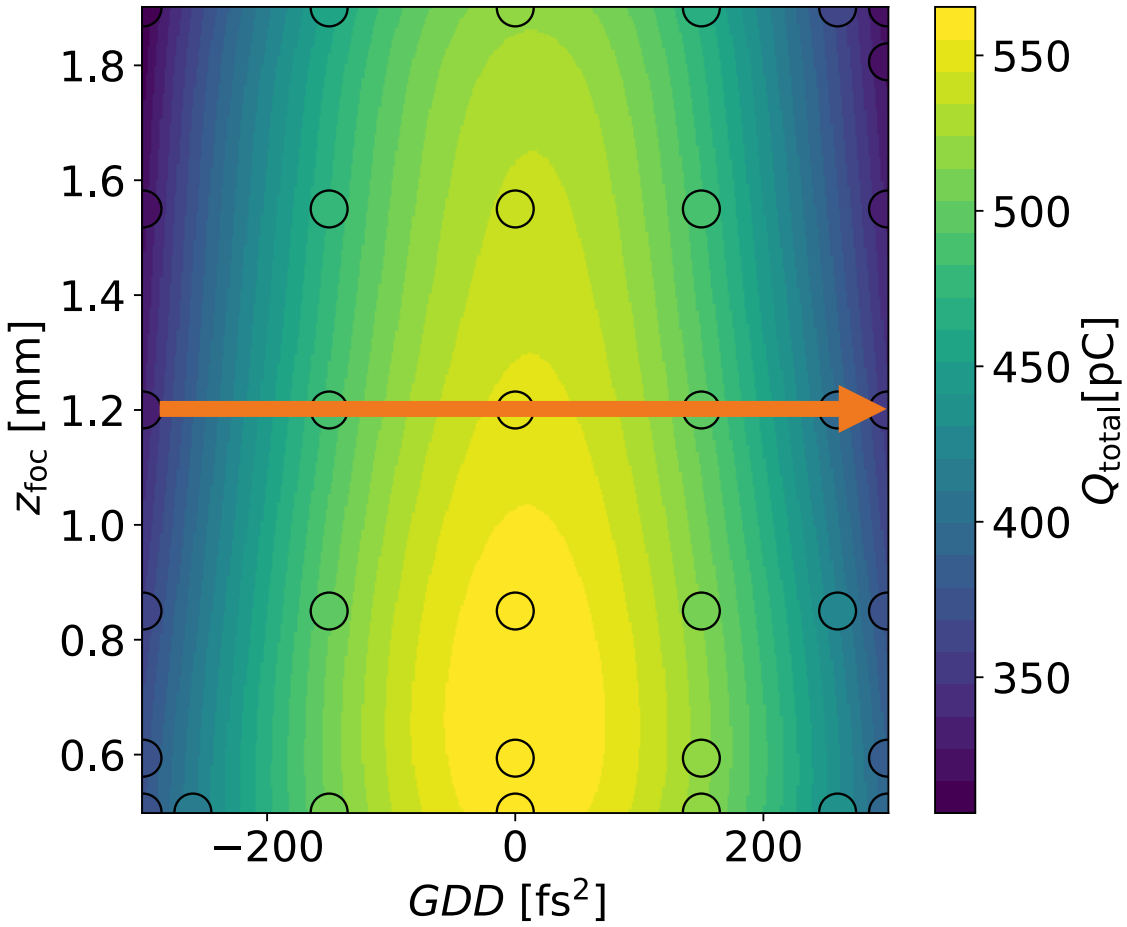
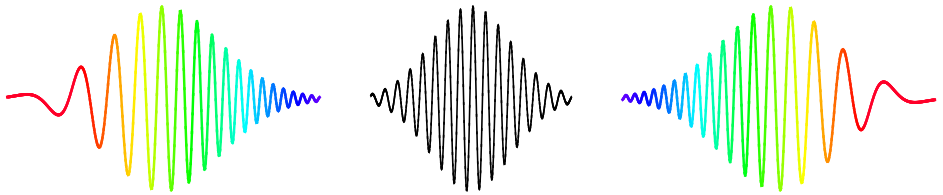
Beam Charge Depending on GDD and Focus Position





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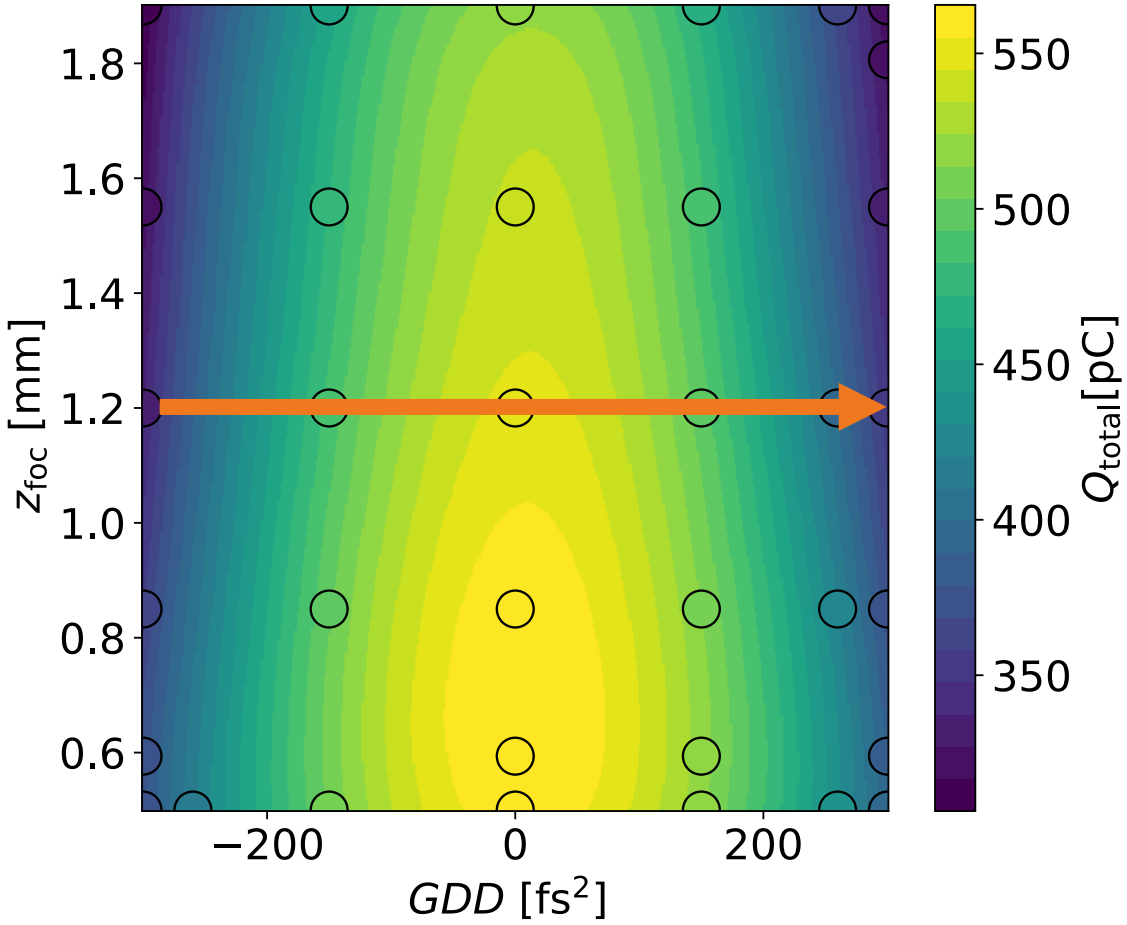

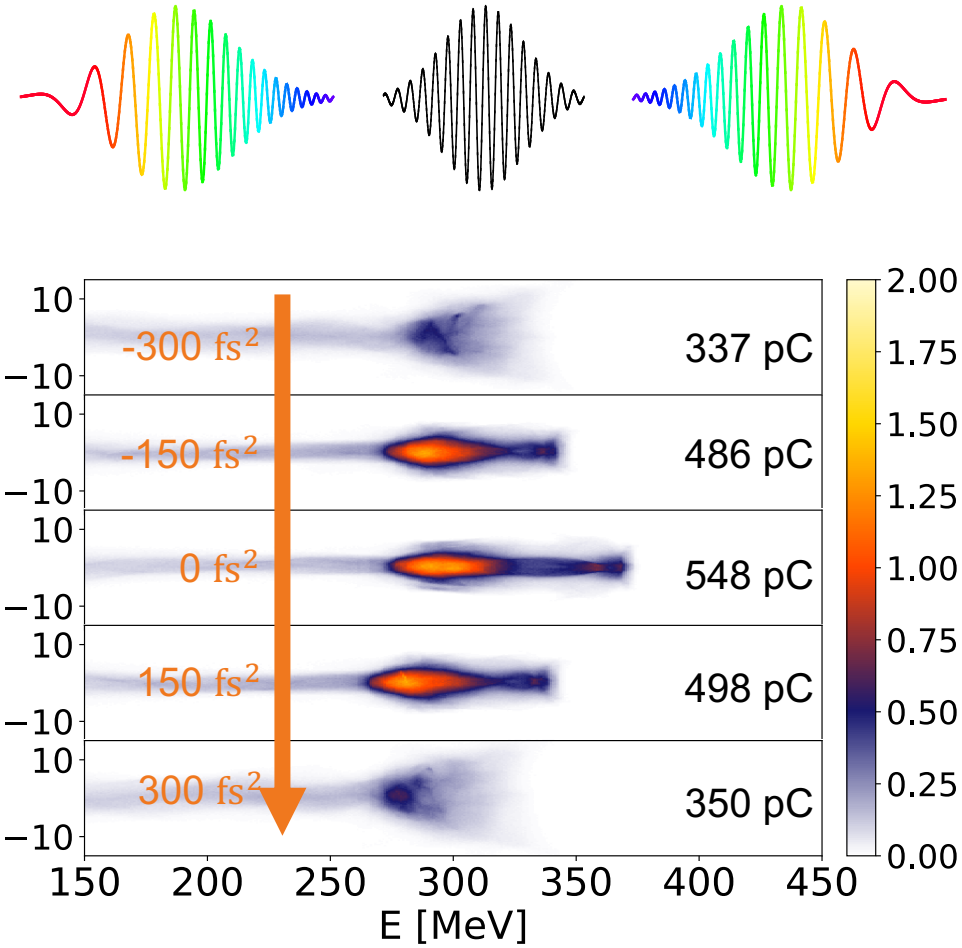

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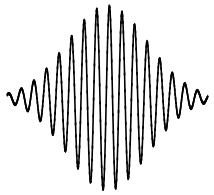
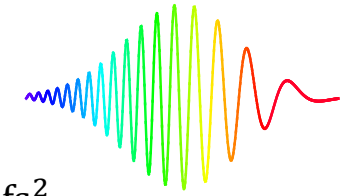
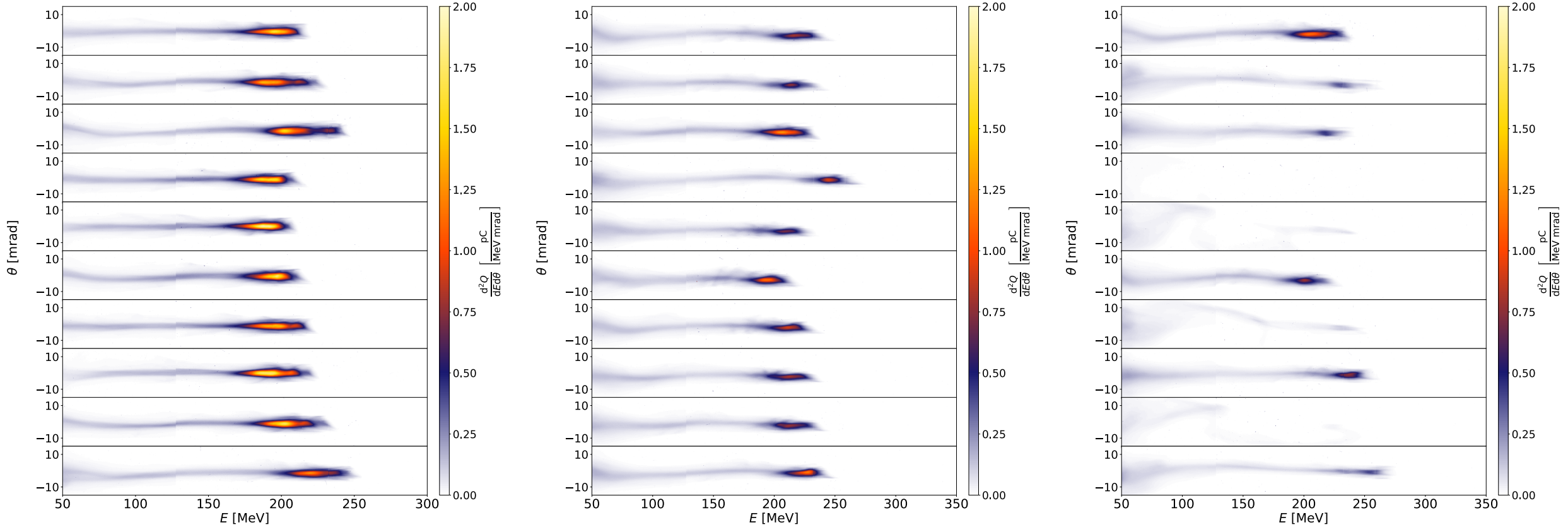




$GDD = 0\ fs^2$ $GDD = 200\ fs^2$ $GDD = 300\ fs^2$



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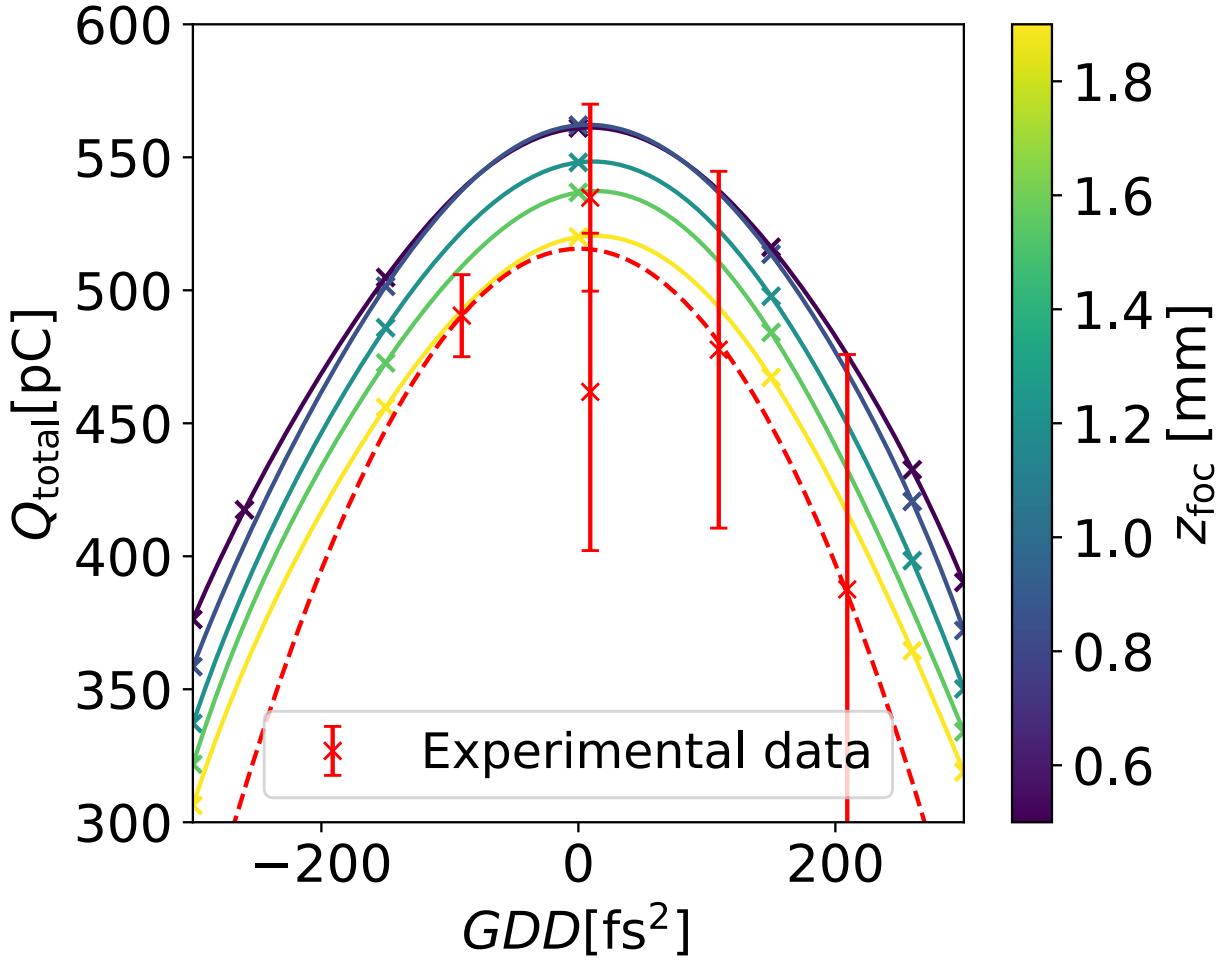
Beam Charge Depending on GDD and Focus Position

Comparison of Experiment and Simulation



Reproduction of experimental setup.

This allows us to investigate various physical properties.

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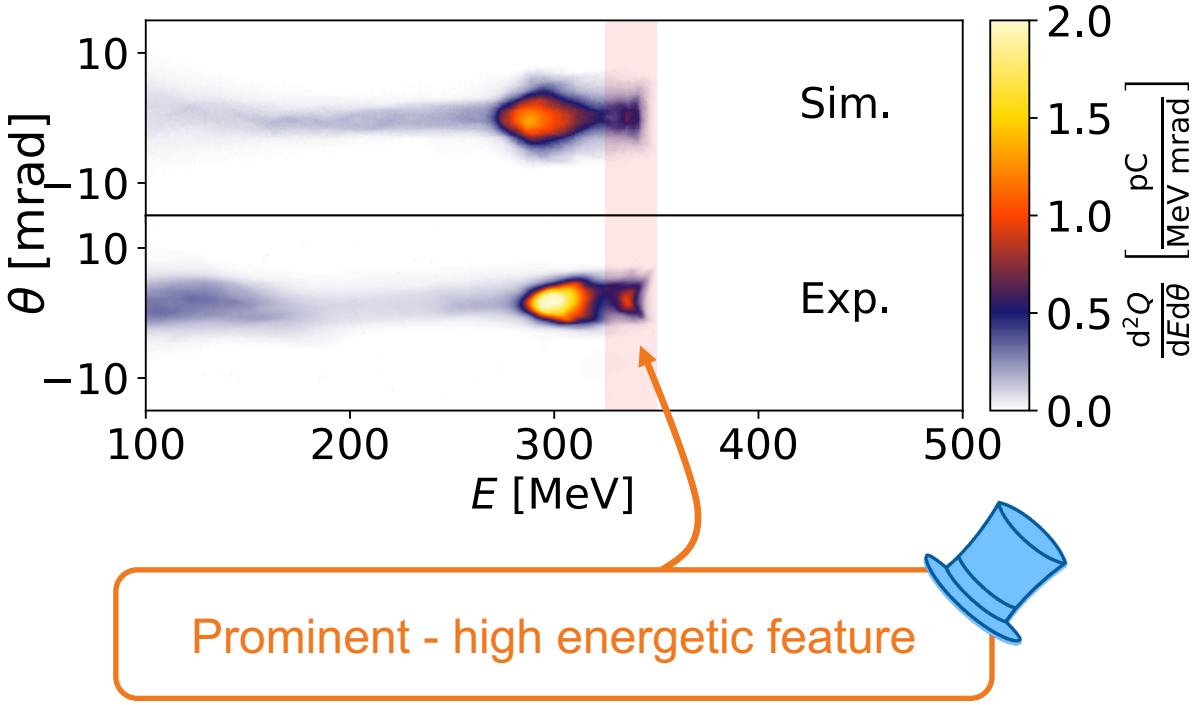
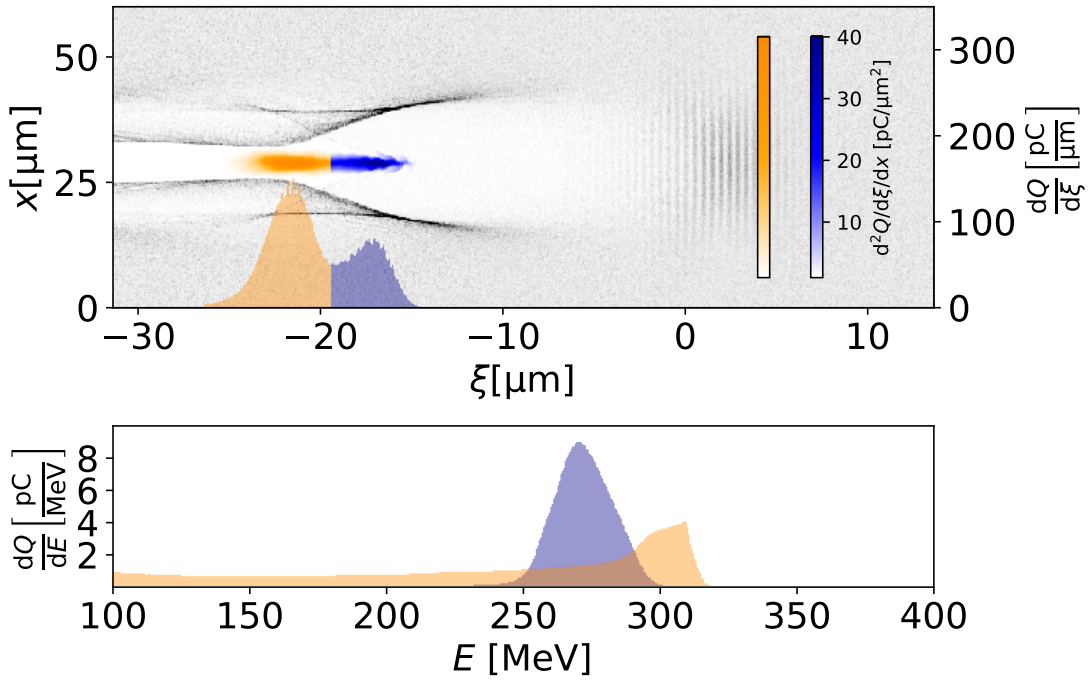
Prominent Feature of the Electron Spectra – High Energy Spread

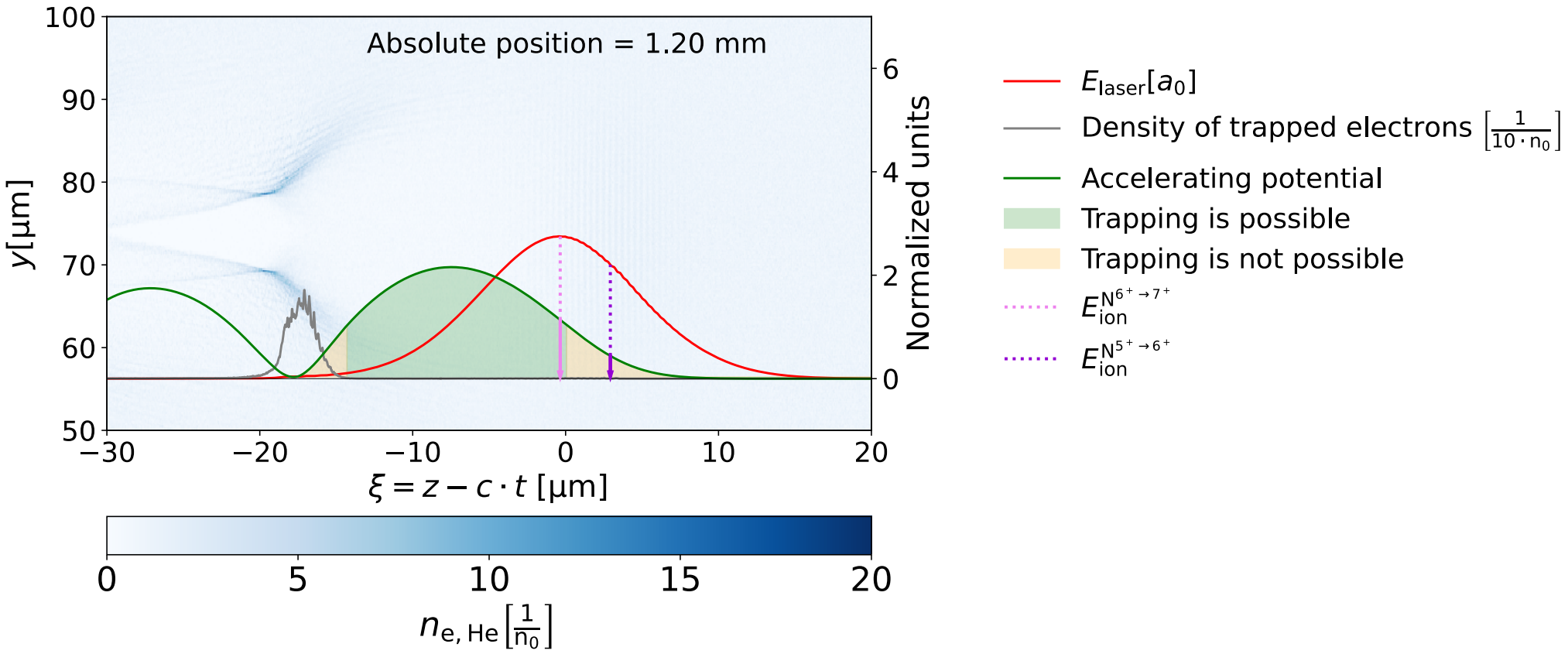
Explaining the High Energy Spread





Prominent Feature of the Electron Spectra – High Energy Spread

Origin of the Double Bunch Spatial Charge Distribution



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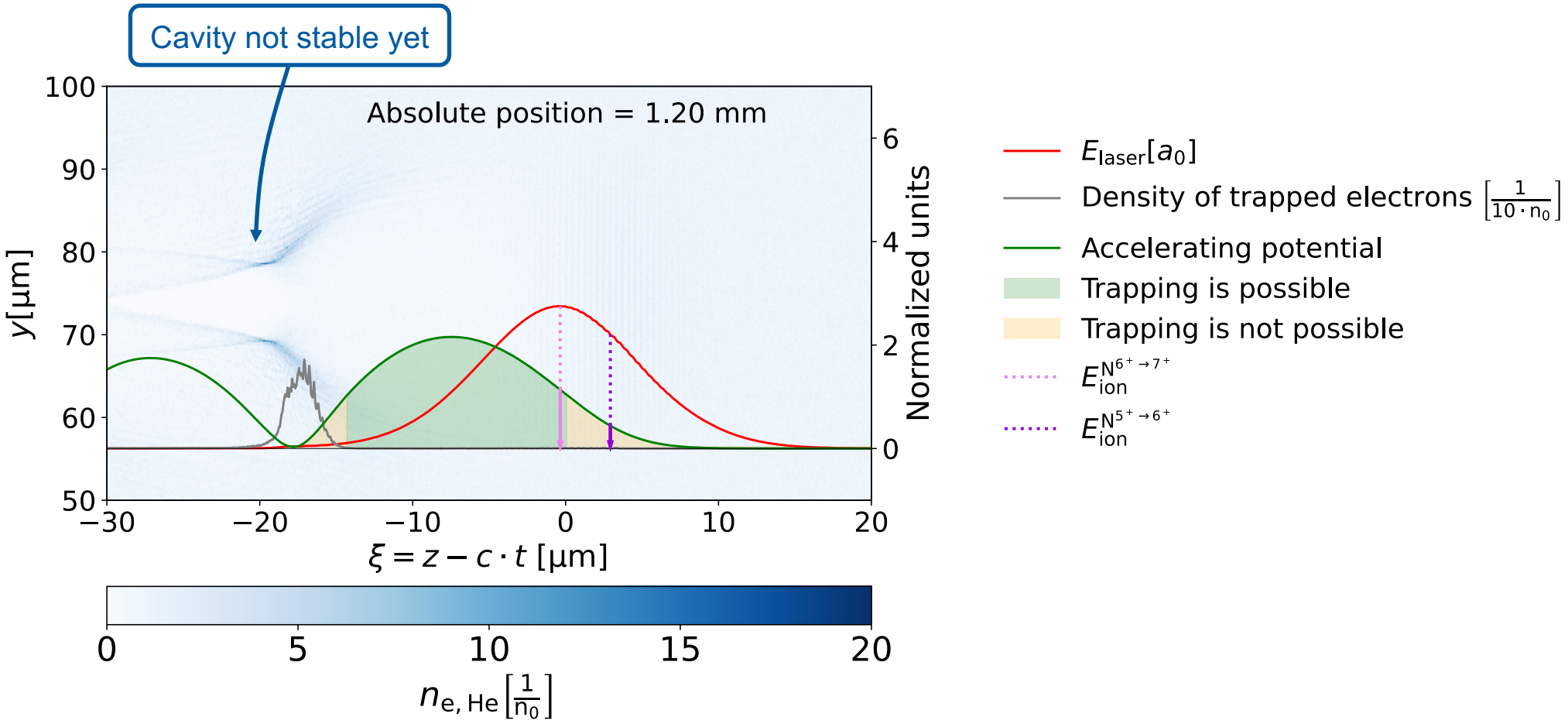

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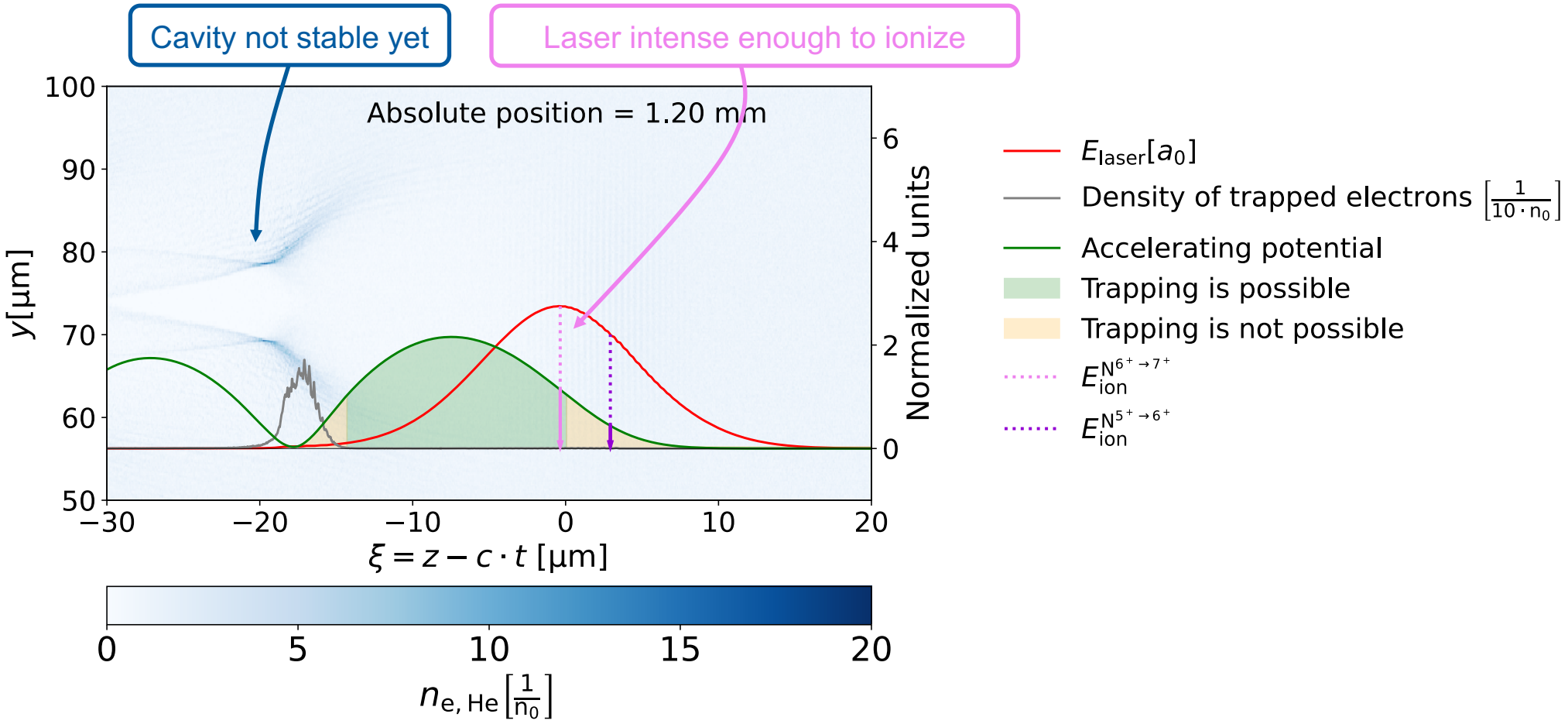

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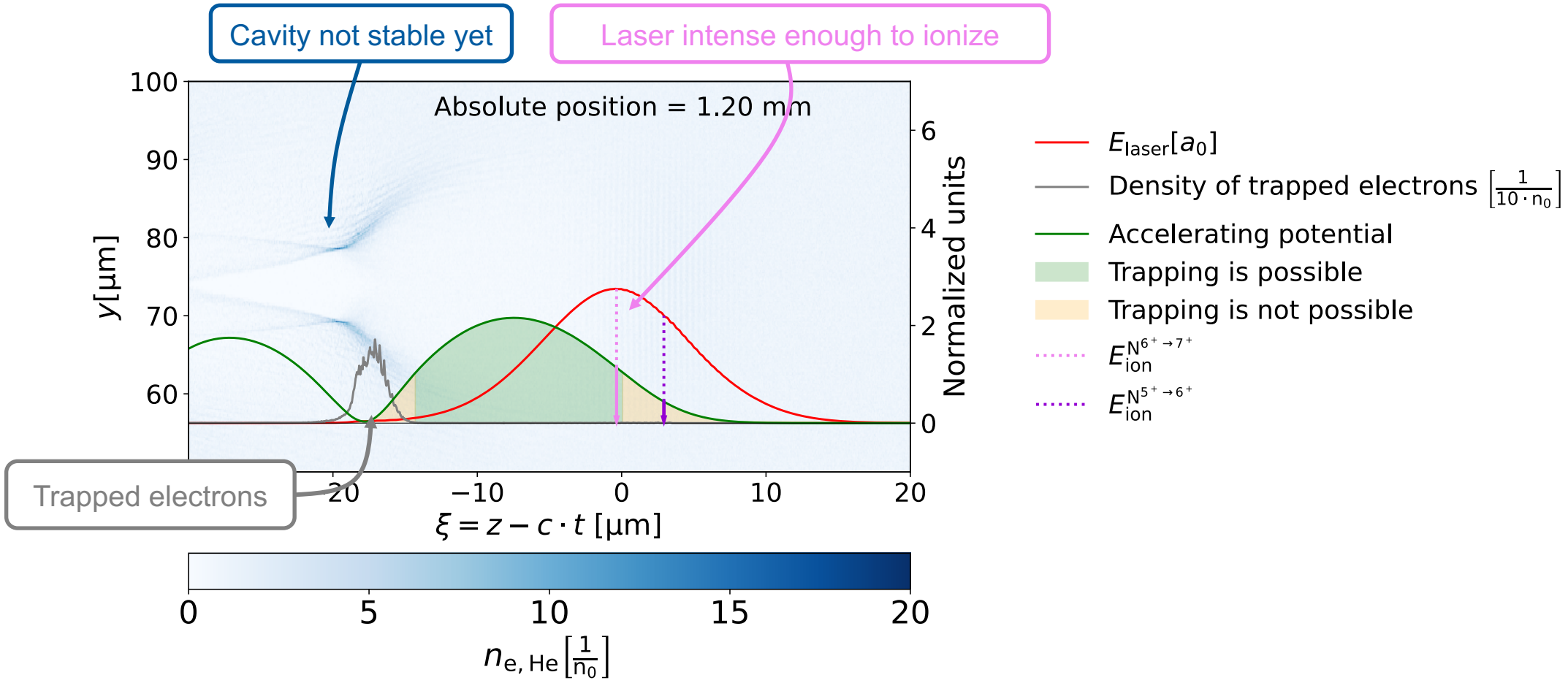

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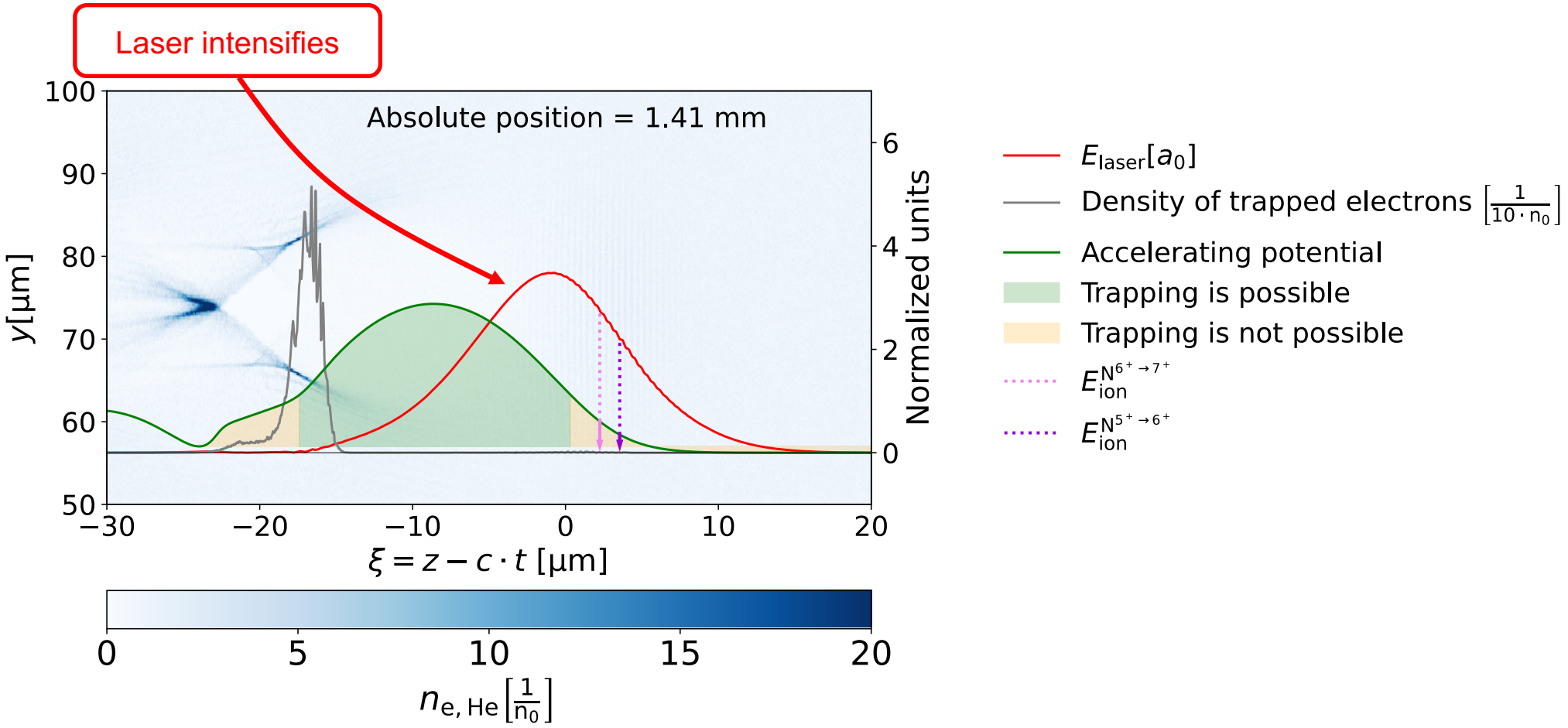

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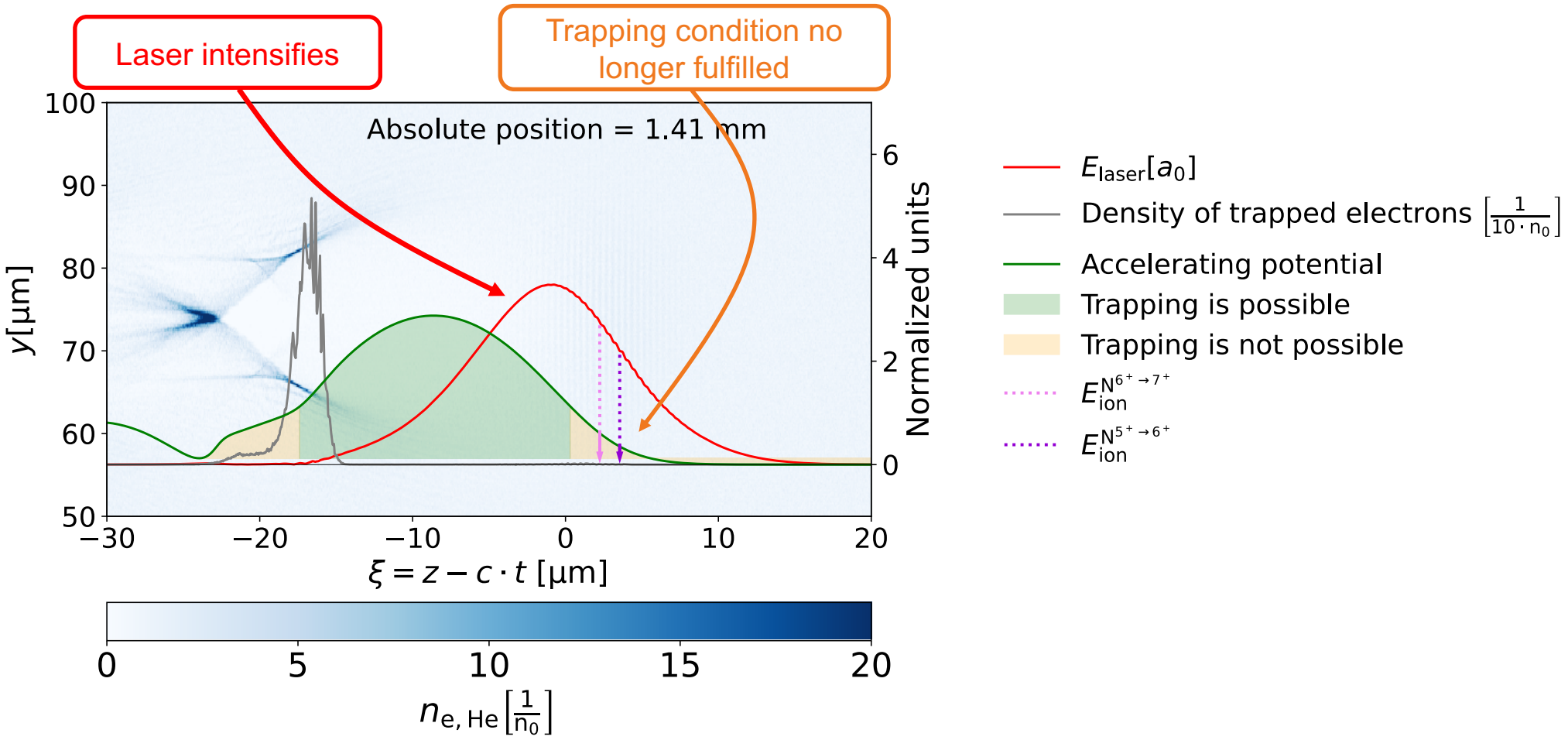

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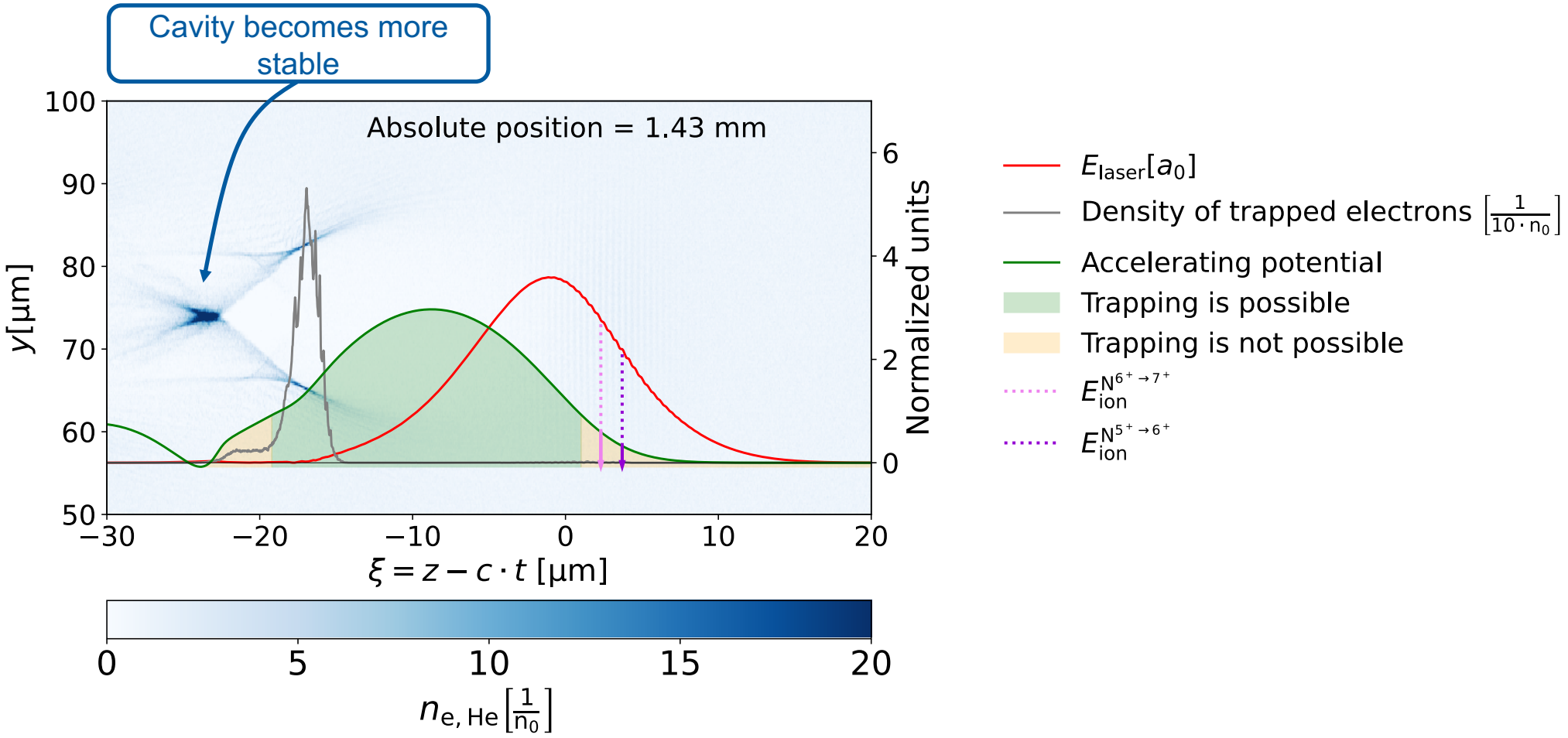

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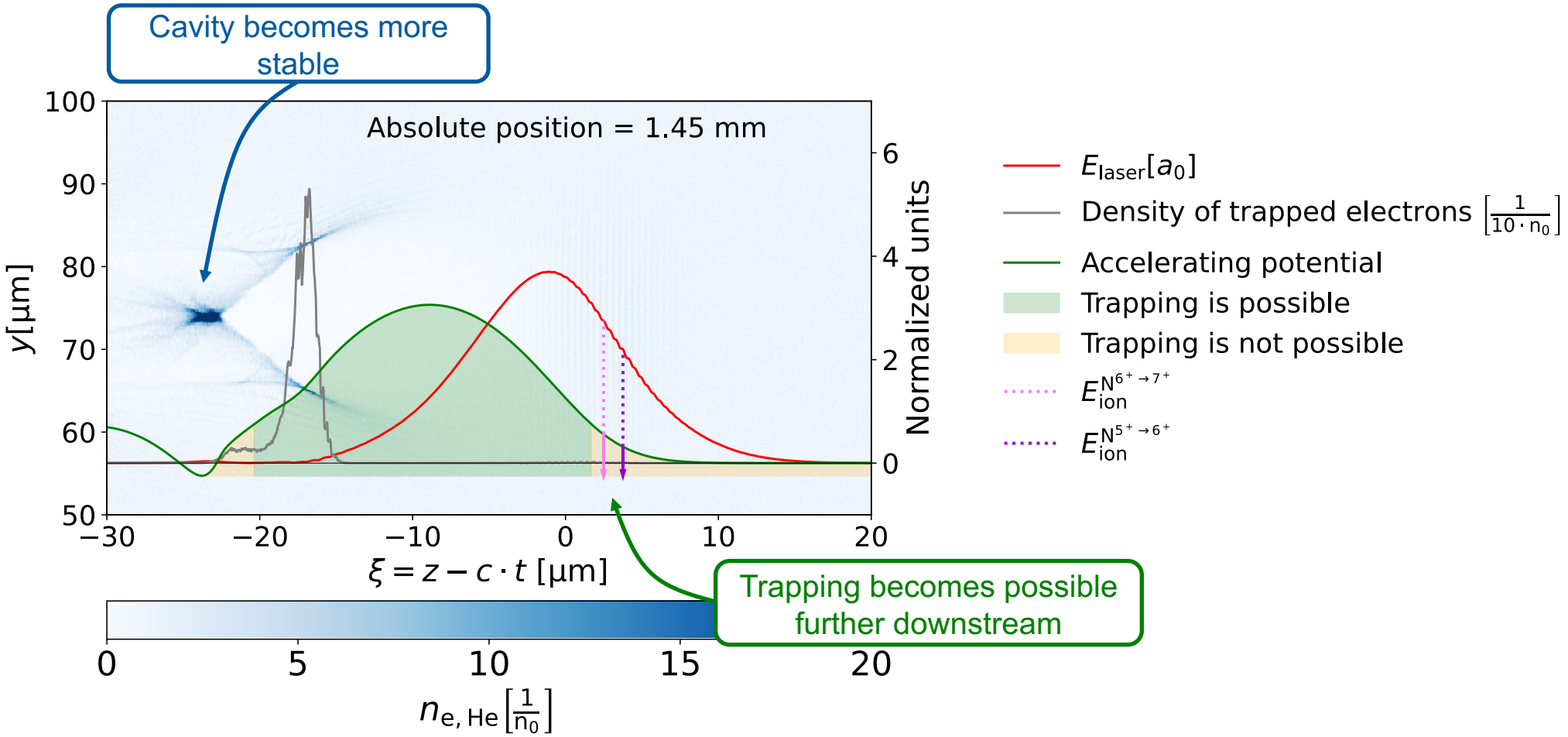

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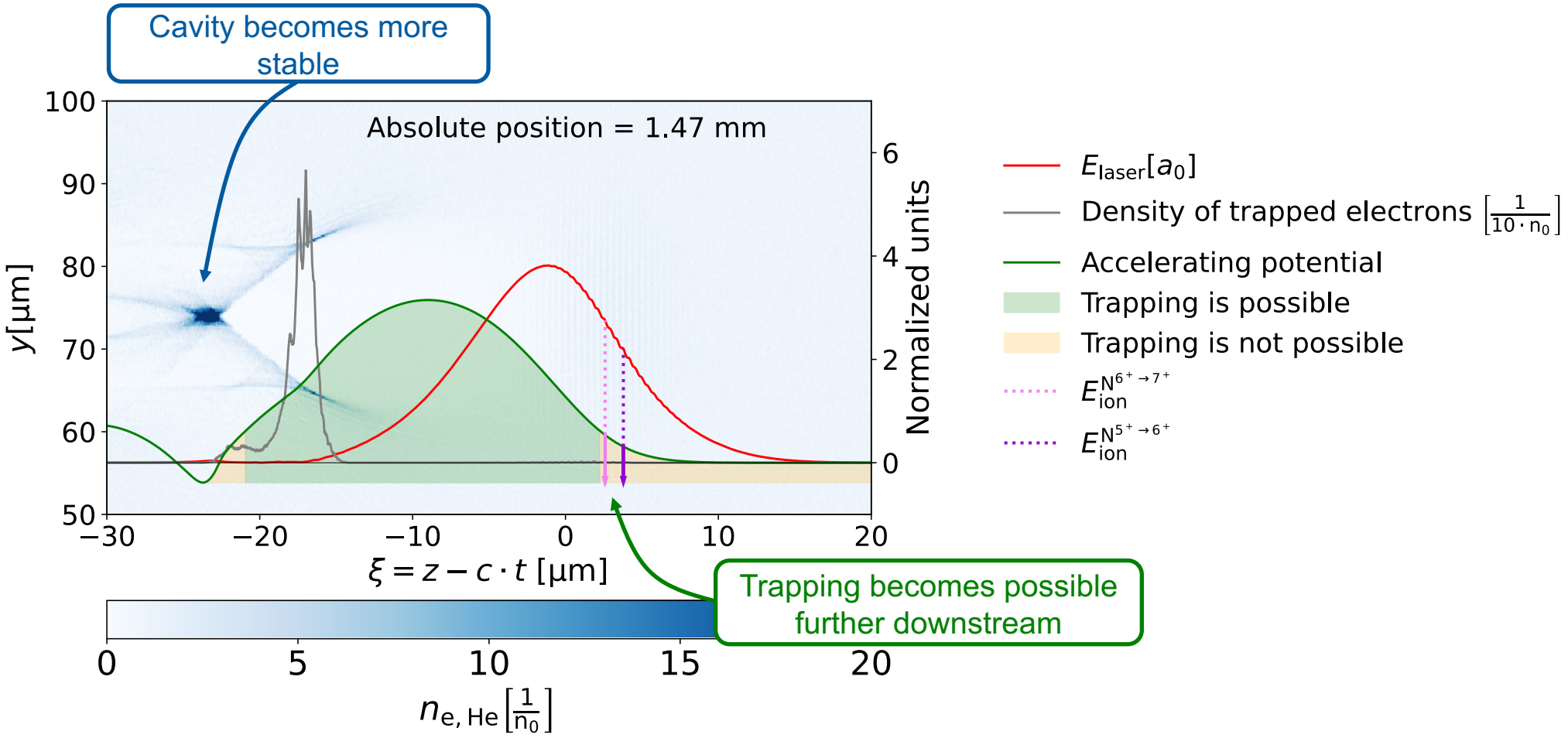

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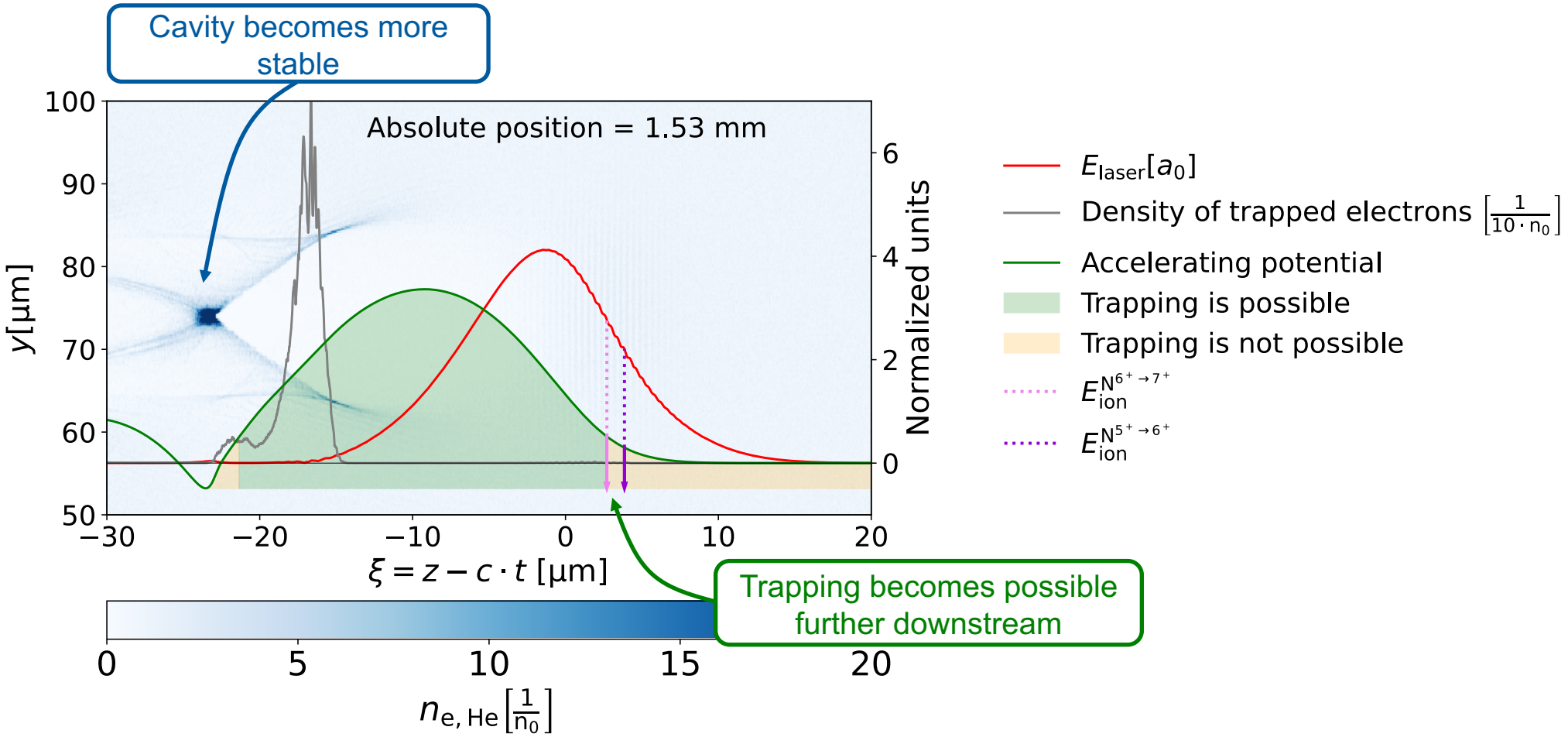

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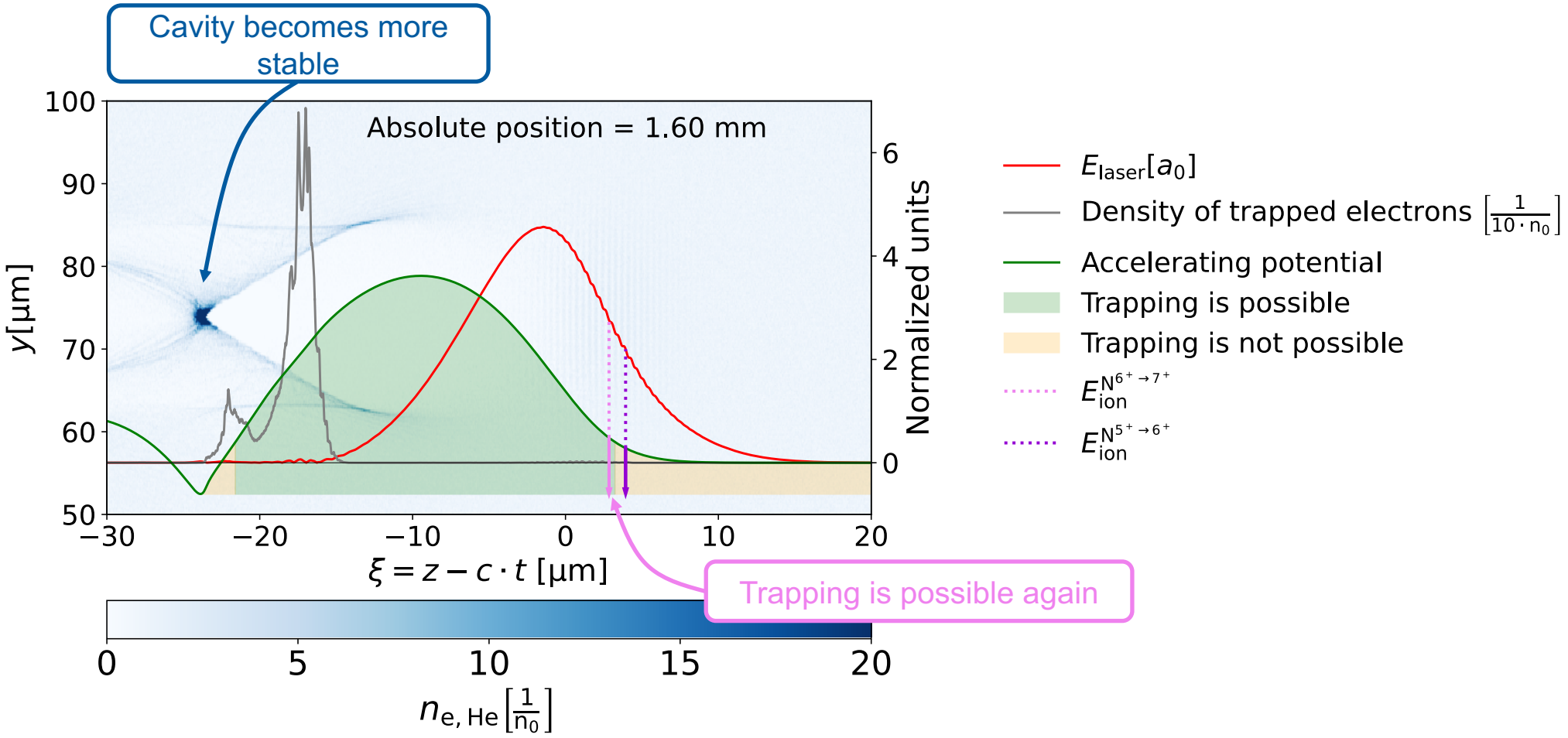

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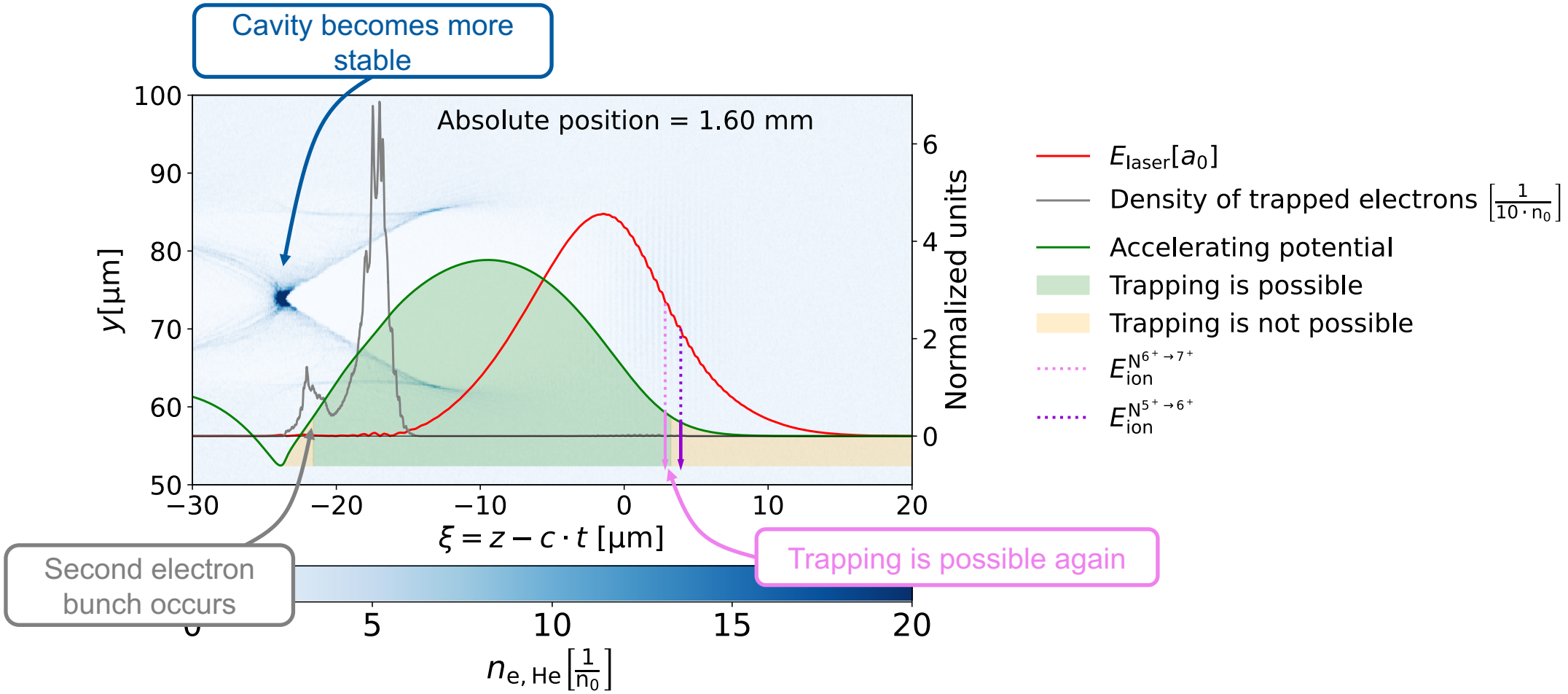

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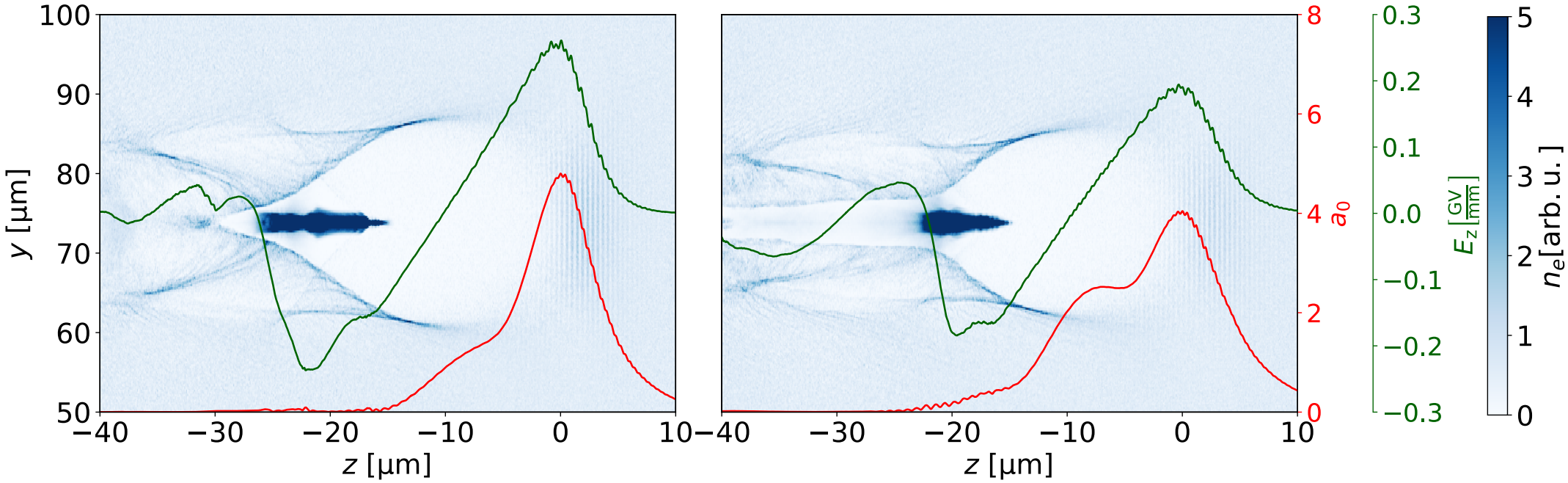
Prominent Feature of the Electron Spectra – High Energy Spread

Stability and Strength of the Accelerating Field

GDD = 0 fs^2
Electron bunch **with hat**

GDD = 300 fs^2
Electron bunch **without hat**



Second bunch experiences accelerating field

Cavity breaking
Less accelerating field for second bunch

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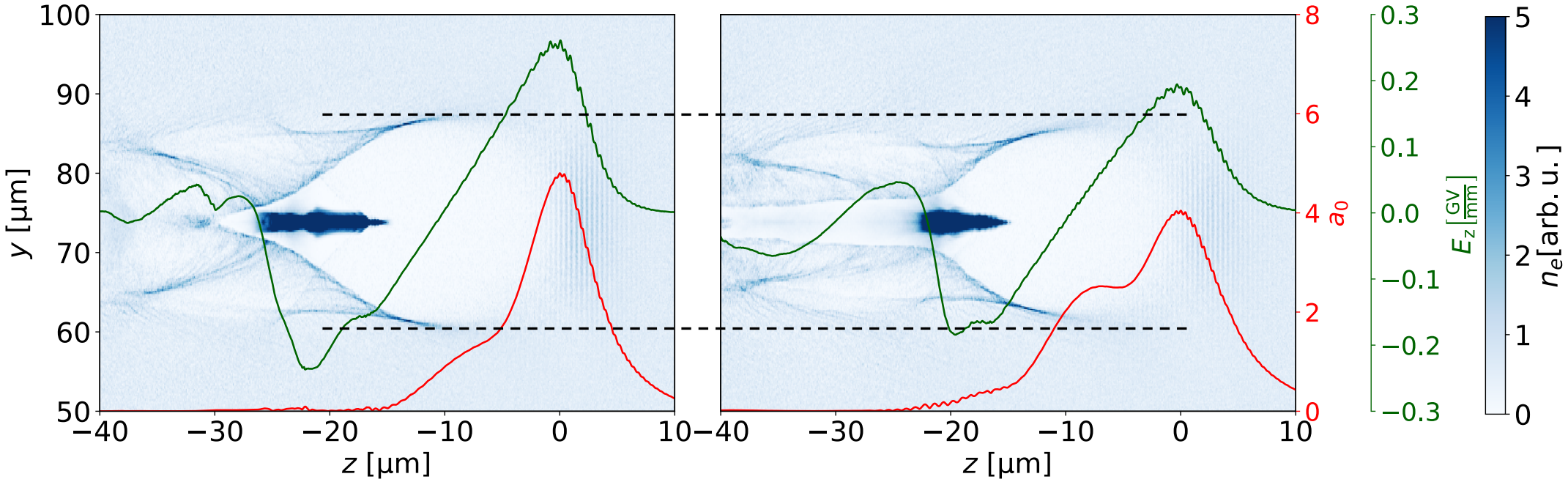

Second bunch experiences accelerating field

Cavity breaking
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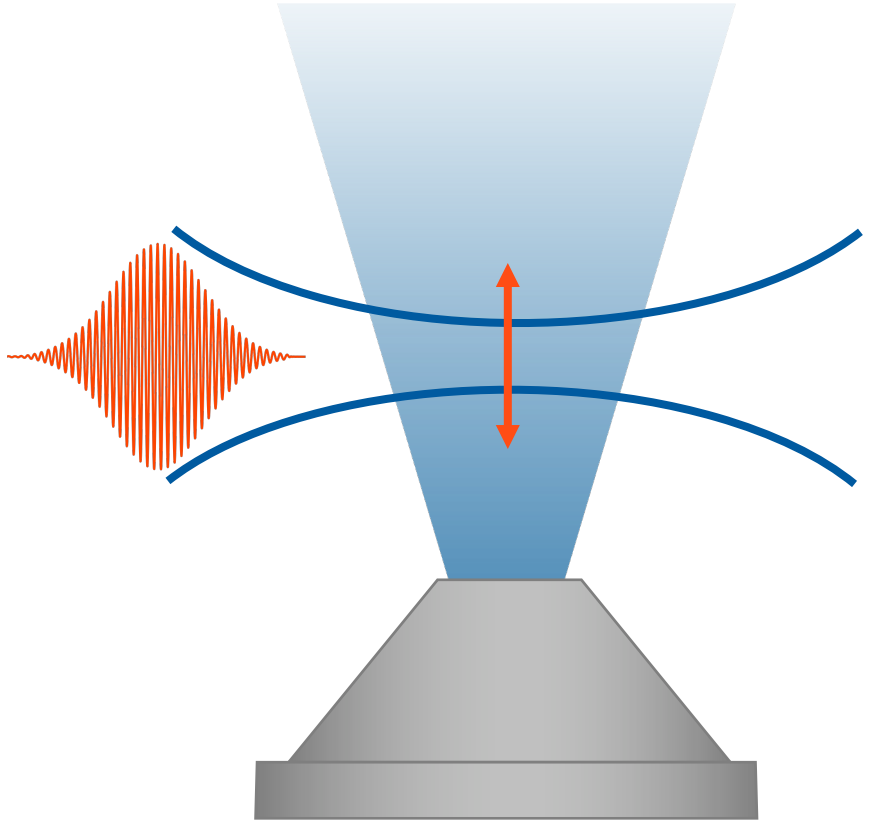
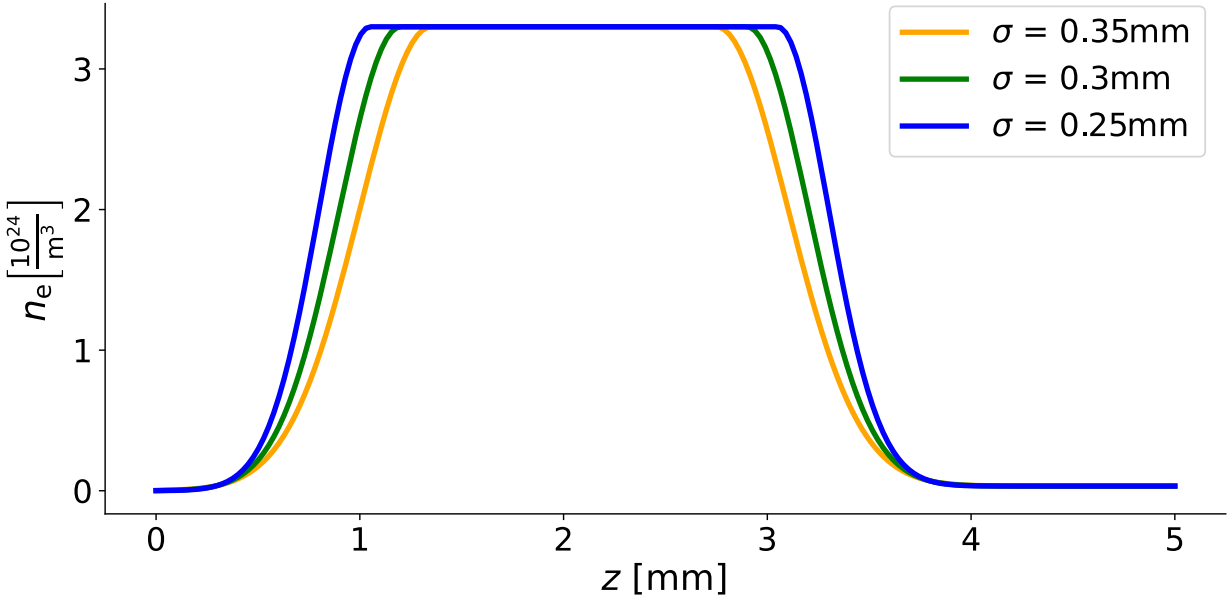
Beam Stability Depending on Plasma Slope and Beam Waist

Experiment



Simulation



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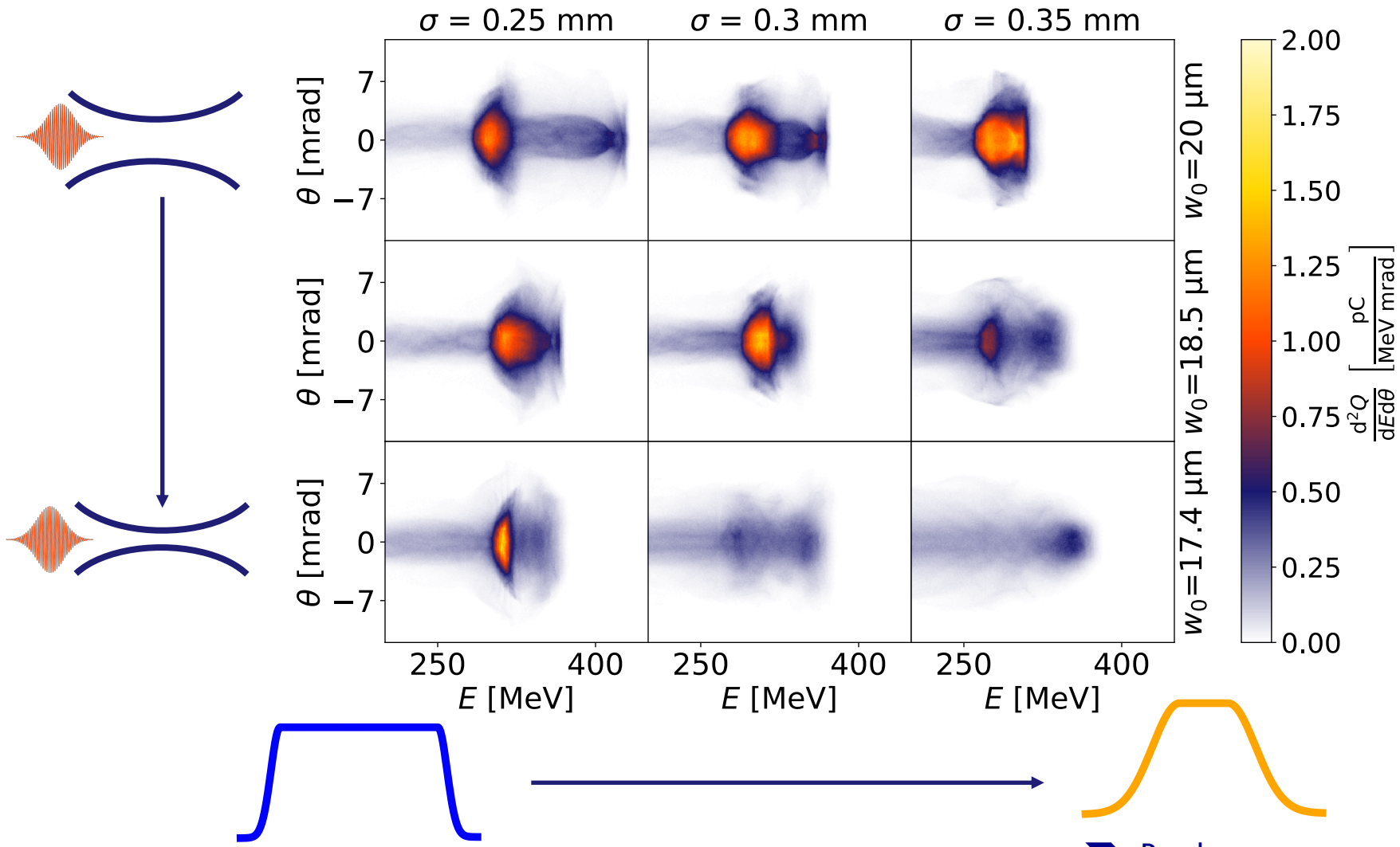

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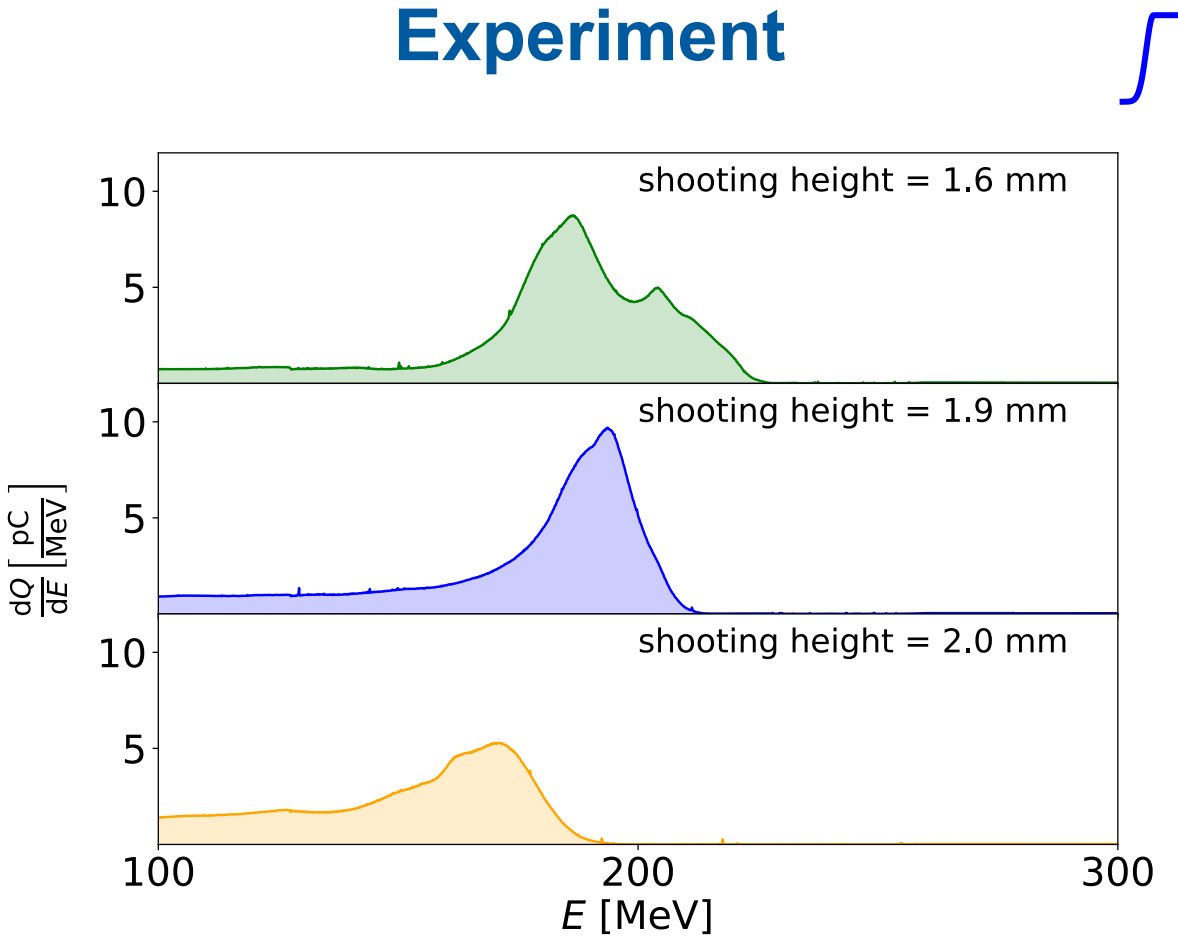
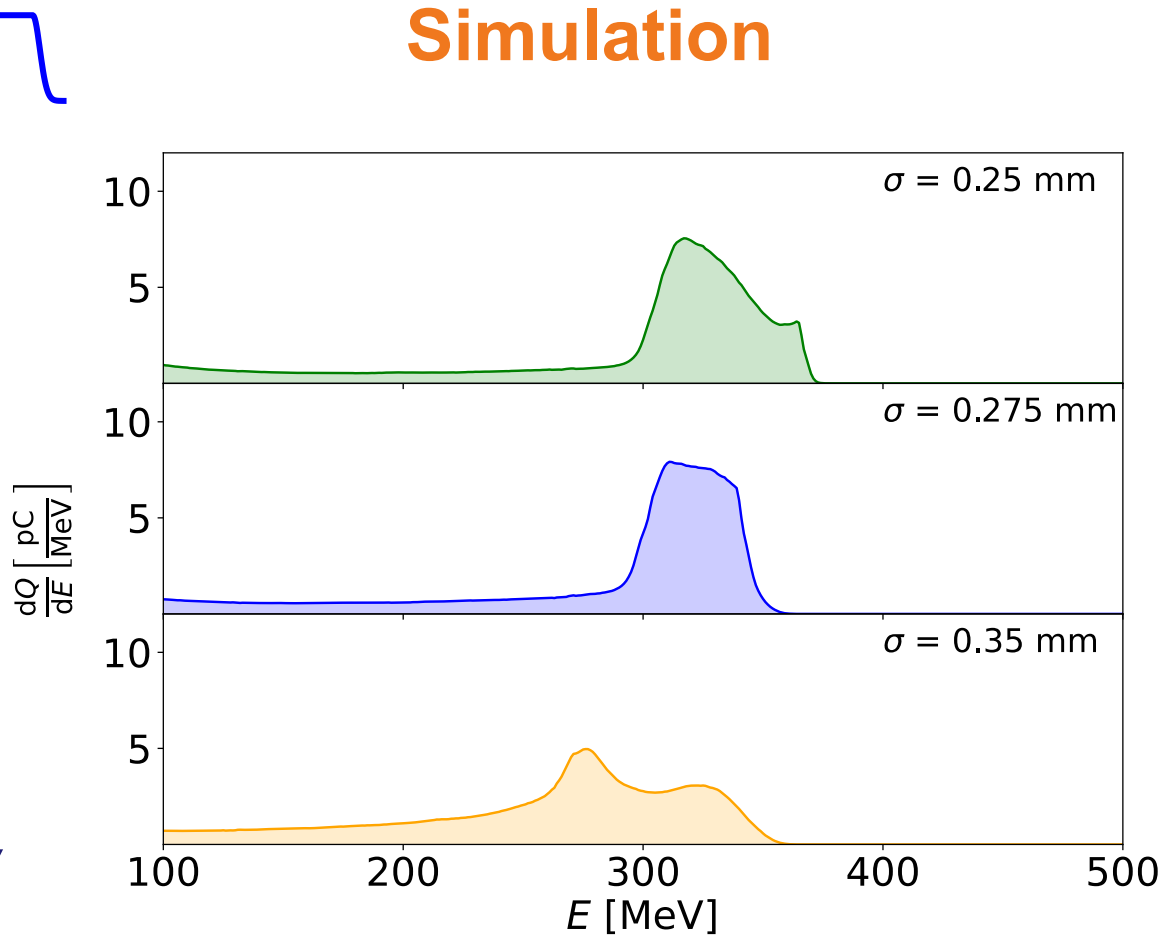


Simulation



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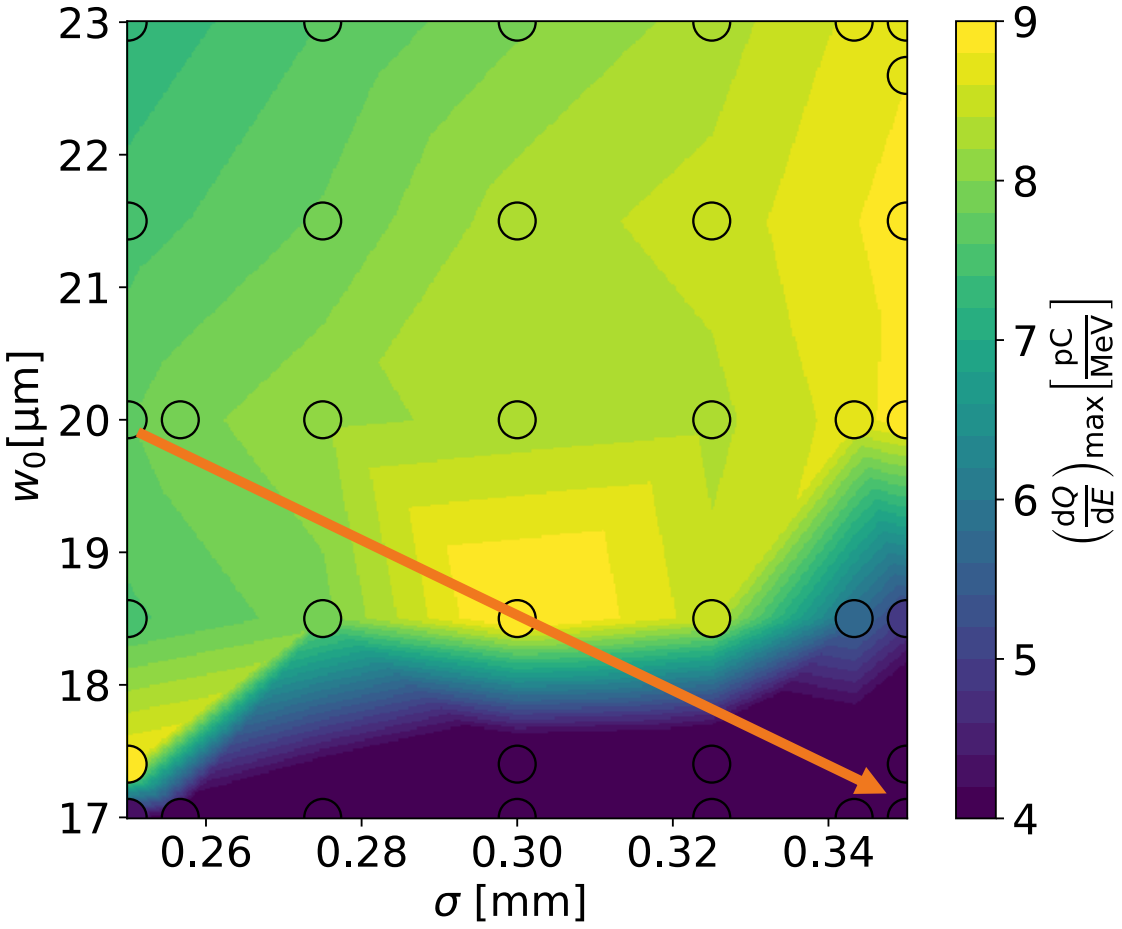

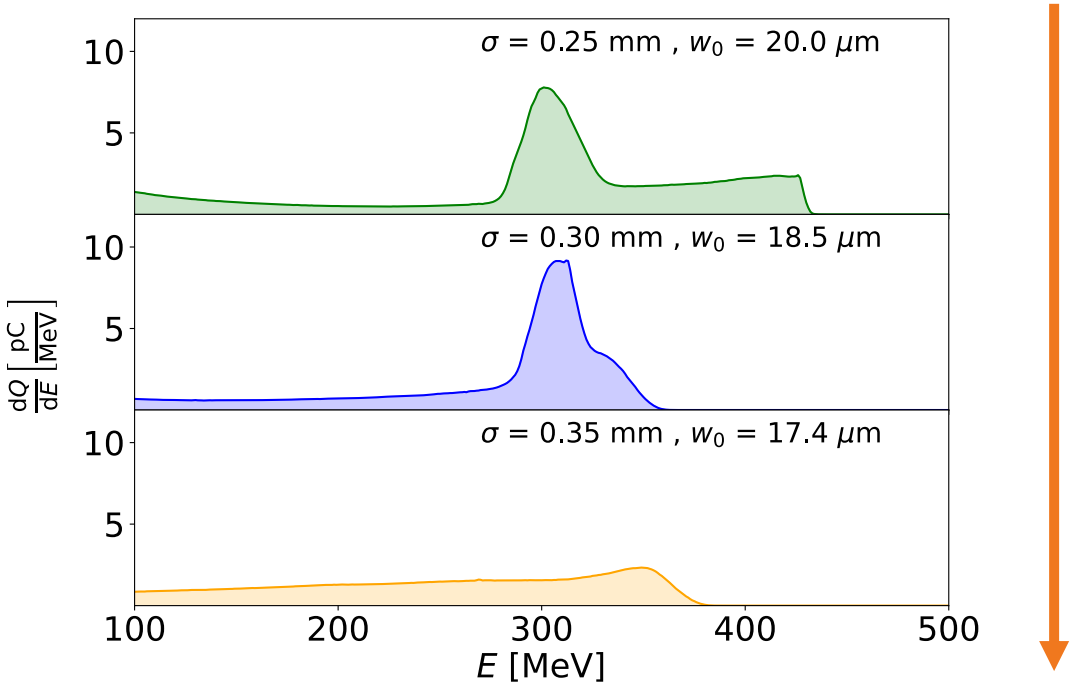

Both the beam waist and the shot height influence the beam quality, the energy distribution and the peak charge depending on each other.

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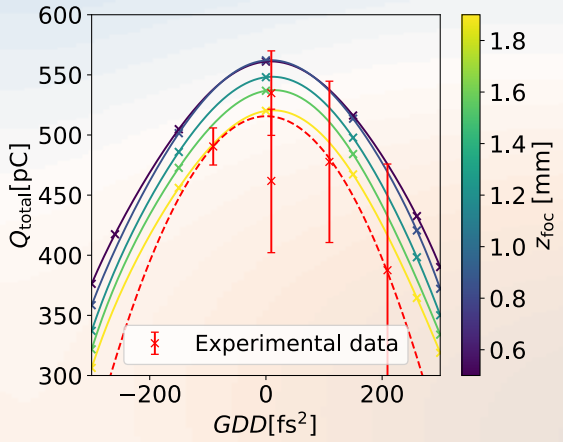
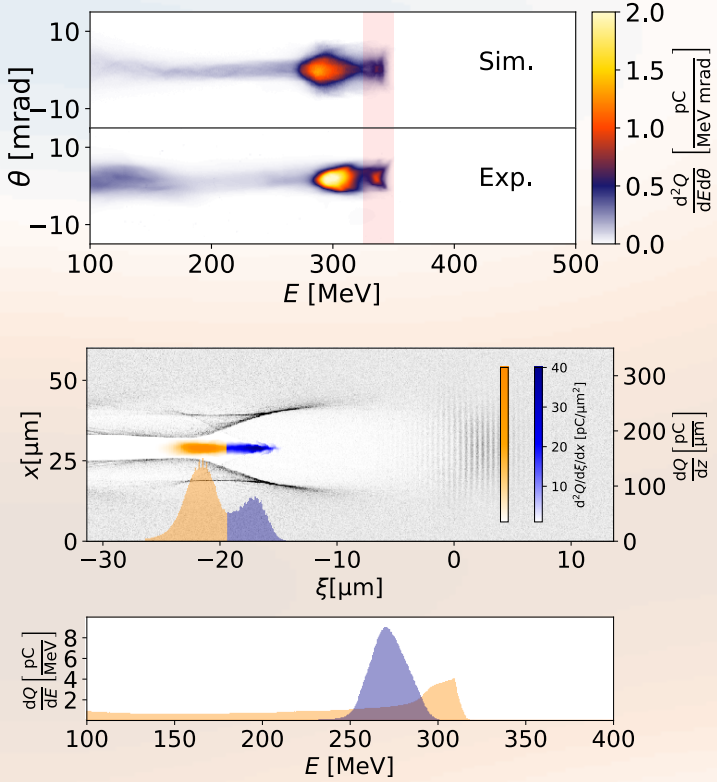
Summary

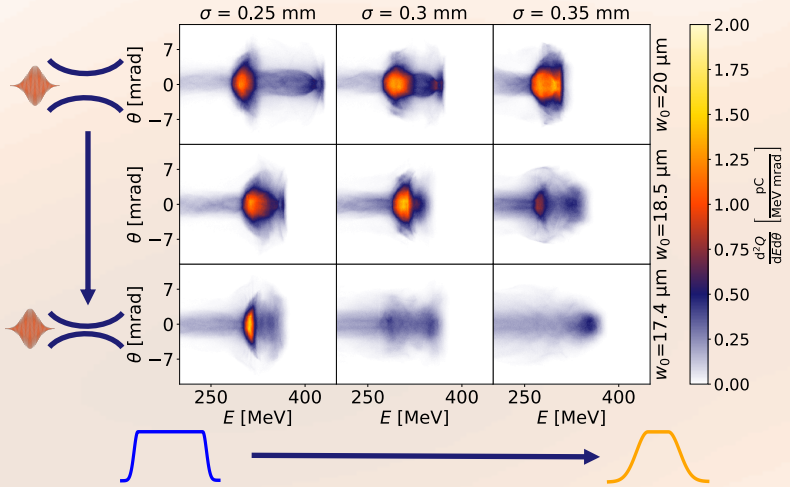
Reproduced experimental behavior



Described injection pattern of STII



Provide mappings to tune LWFA electron bunches



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