FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG
NATURWISSENSCHAFTLICHE FAKULTÄT

Bundesministerium für Bildung und Forschung

GORDON AND BETTY MOORE FOUNDATION

Generation and characterization of attosecond micro-bunched electron pulse trains via dielectric laser acceleration

Norbert Schönenberger

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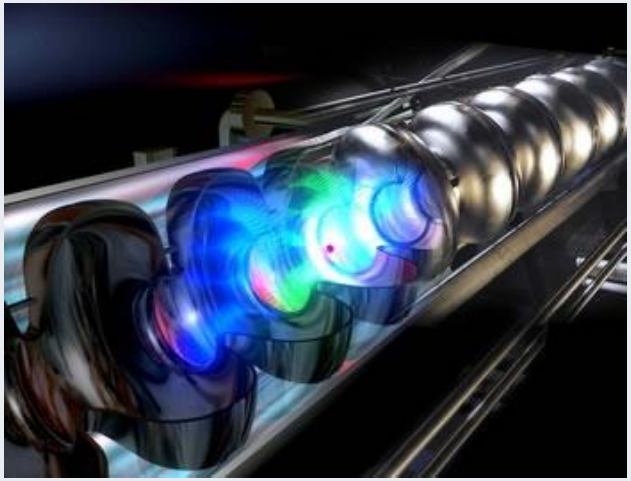
ACHIP

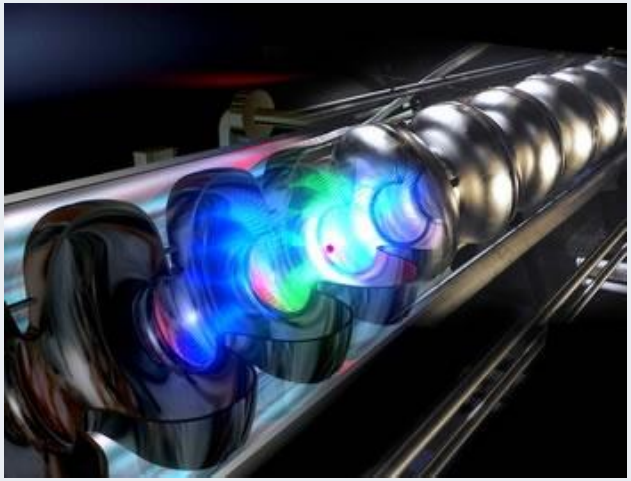
Particle accelerators: from RF to optical/photonic drive?



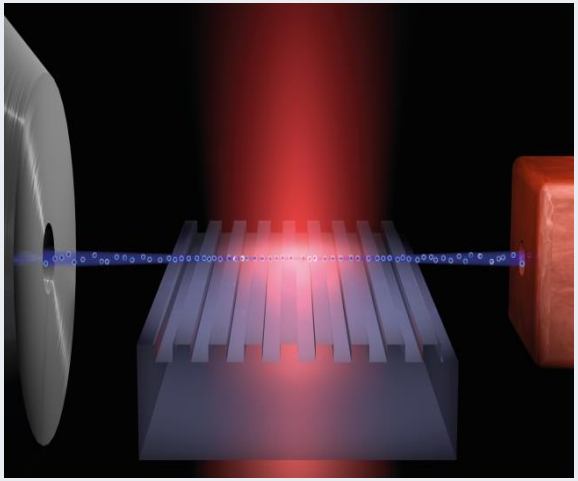
RF cavity (TESLA, DESY)

	Conventional linear accelerator (RF)
Based on	(Supercond.) RF cavities
Peak field limited by	**Surface breakdown: 200 MV/m**
Max. achievable gradients	**100 MeV/m**

Particle accelerators: from RF to optical/photonic drive?

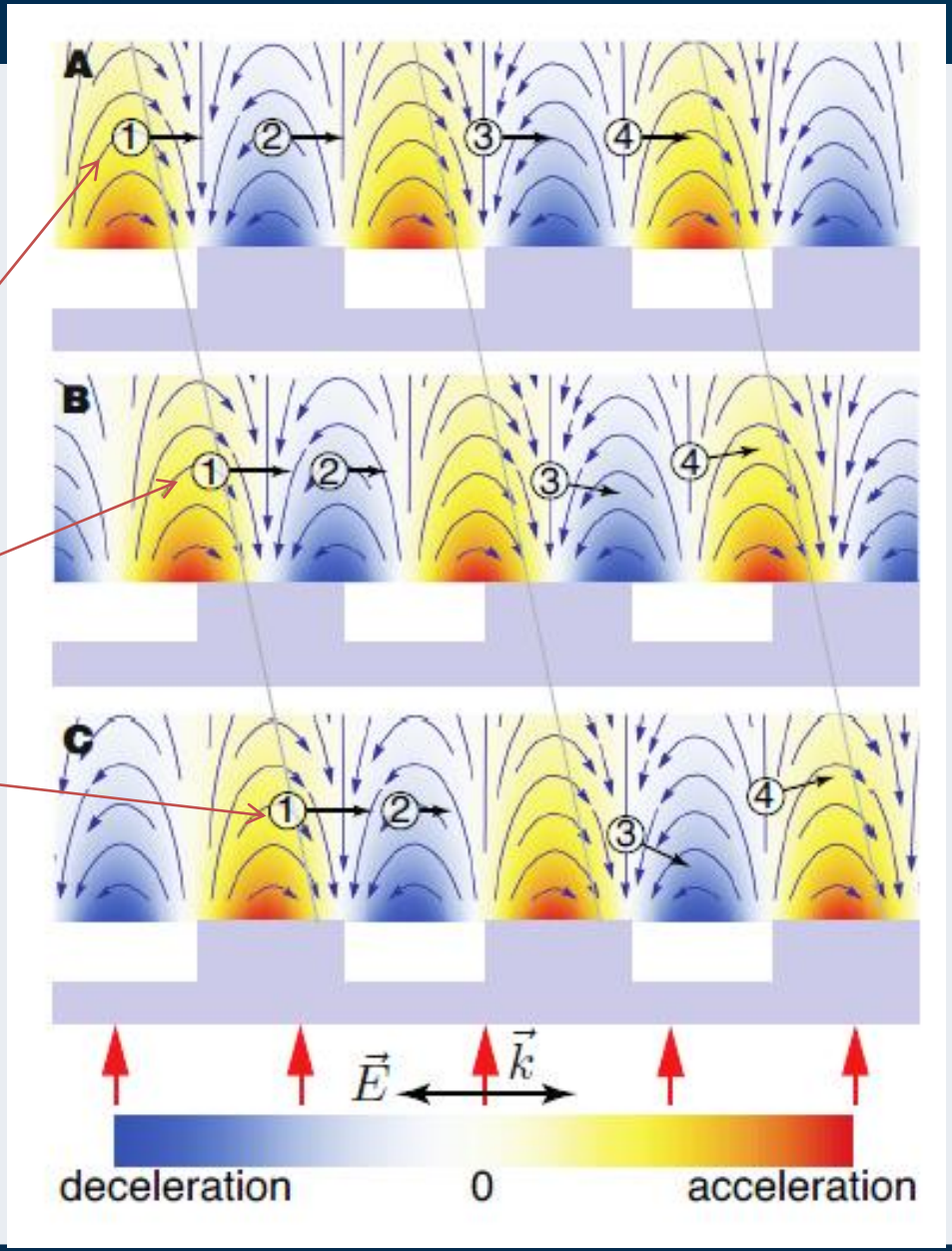


RF cavity (TESLA, DESY)



	Conventional linear accelerator (RF)	**Laser-based dielectric accelerator (optical)**
Based on	(Supercond.) RF cavities	Silicon nano structures
Peak field limited by	**Surface breakdown: 200 MV/m**	**Damage threshold: 30 GV/m**
Max. achievable gradients	**100 MeV/m**	**10 GeV/m**

Acceleration by phase-synchronous propagation



t = 0

t = π/2

t = π

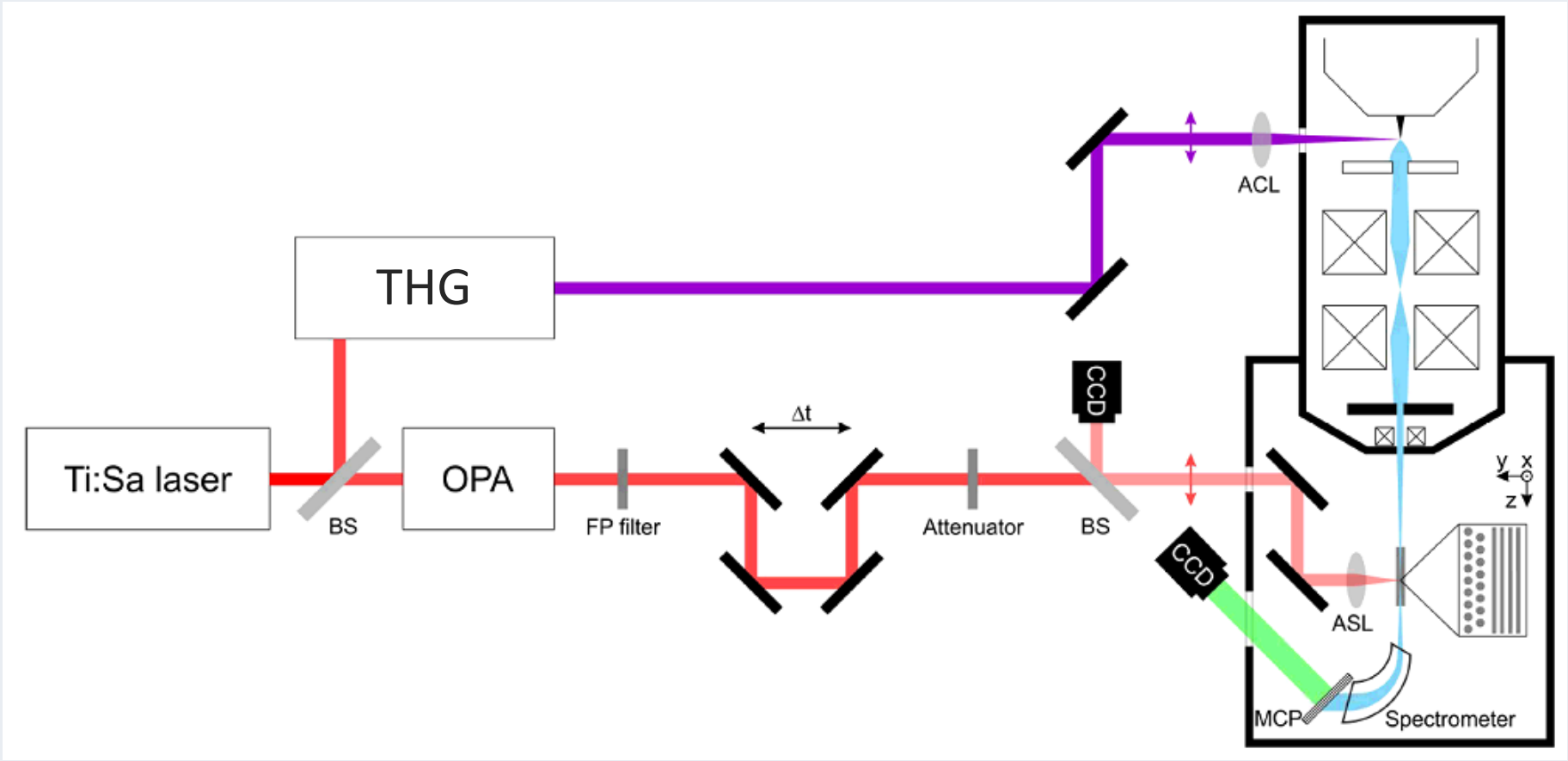
1 acceleration

2 deceleration

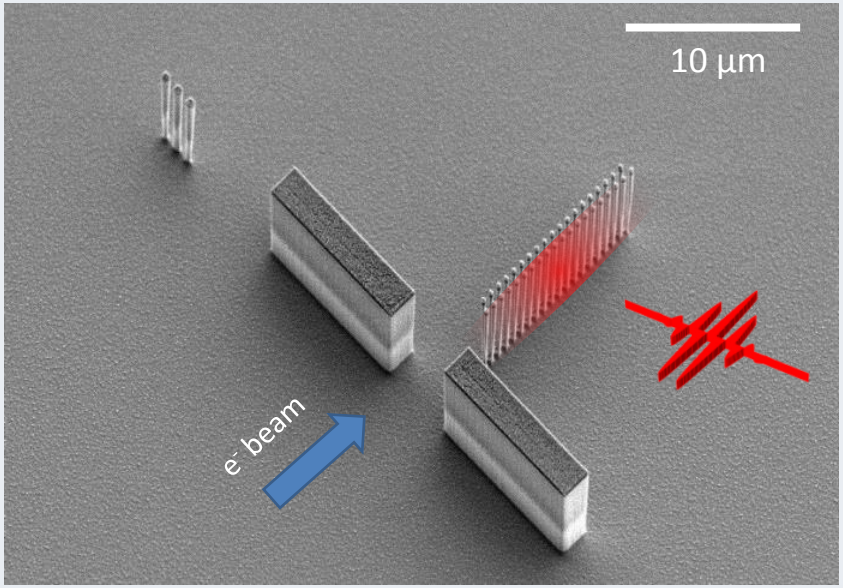
3 deflection

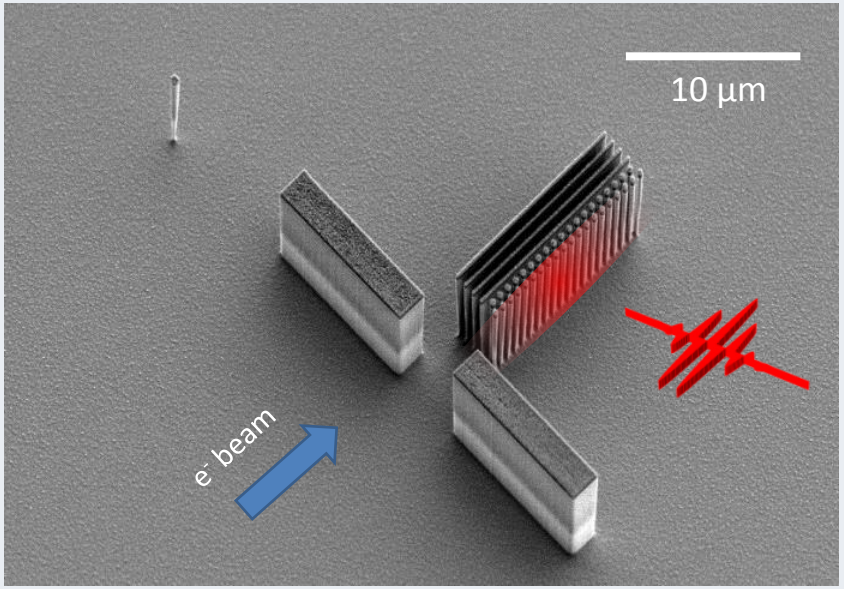
4 deflection

Setup


THG
Ti:Sa laser
BS
OPA
FP filter
Δt
Attenuator
BS
CCD
ACL
CCD
ASL
MCP
Spectrometer
y
x
z

Dielectric Laser Acceleration

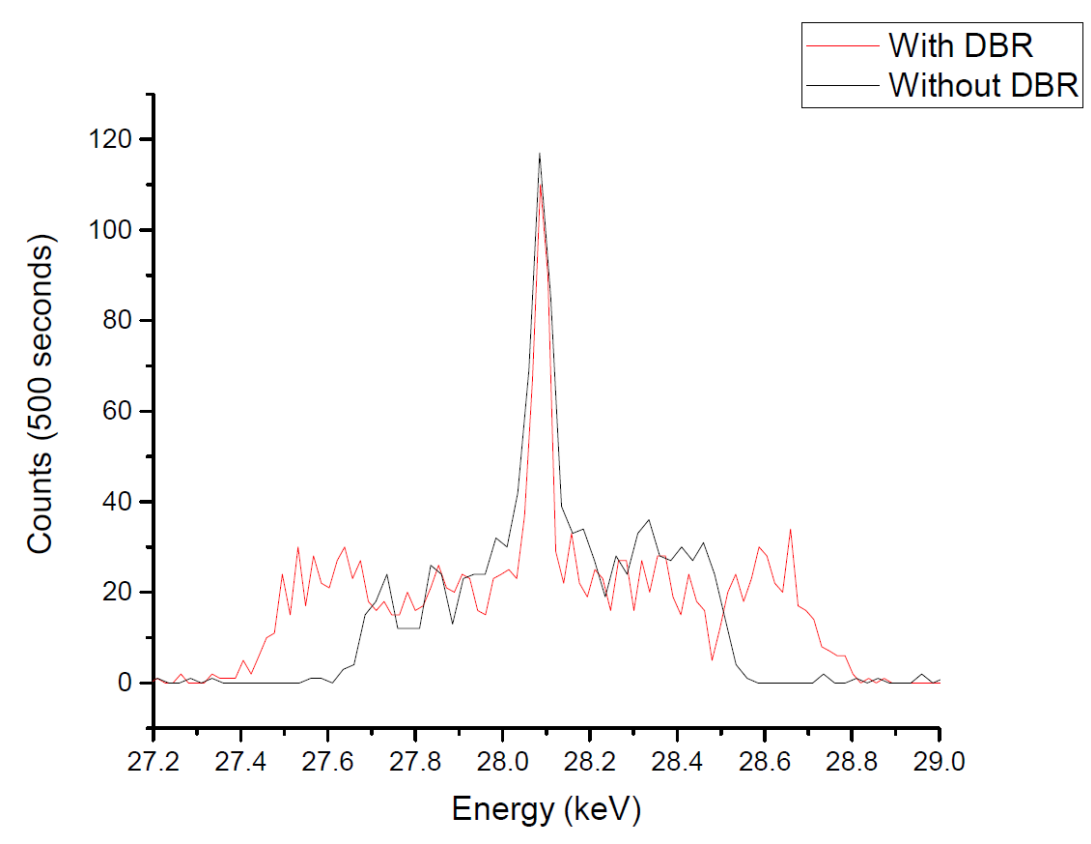




Incident field: 0.5 GV/m
Pulse duration: 650 fs

P. Yousefi et al., Optics Letters Vol. 44, Issue 6, pp. 1520-1523 (2019)

Dielectric Laser Acceleration



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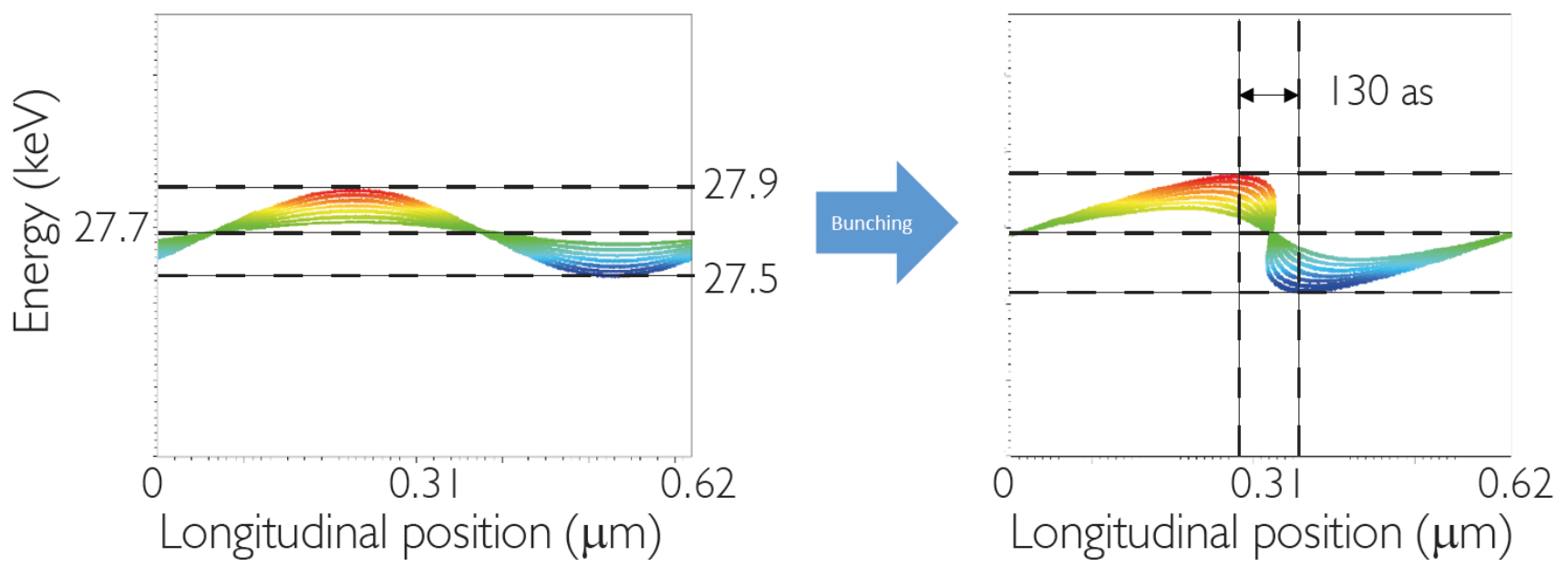
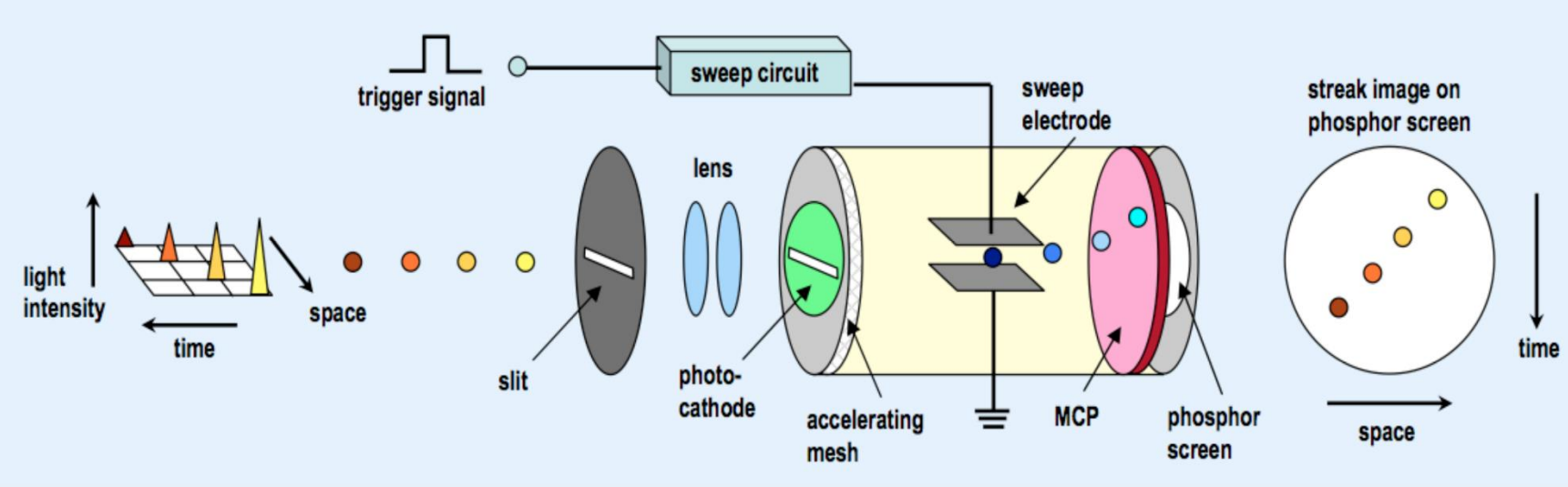
Dielectric Laser Acceleration: Dynamics

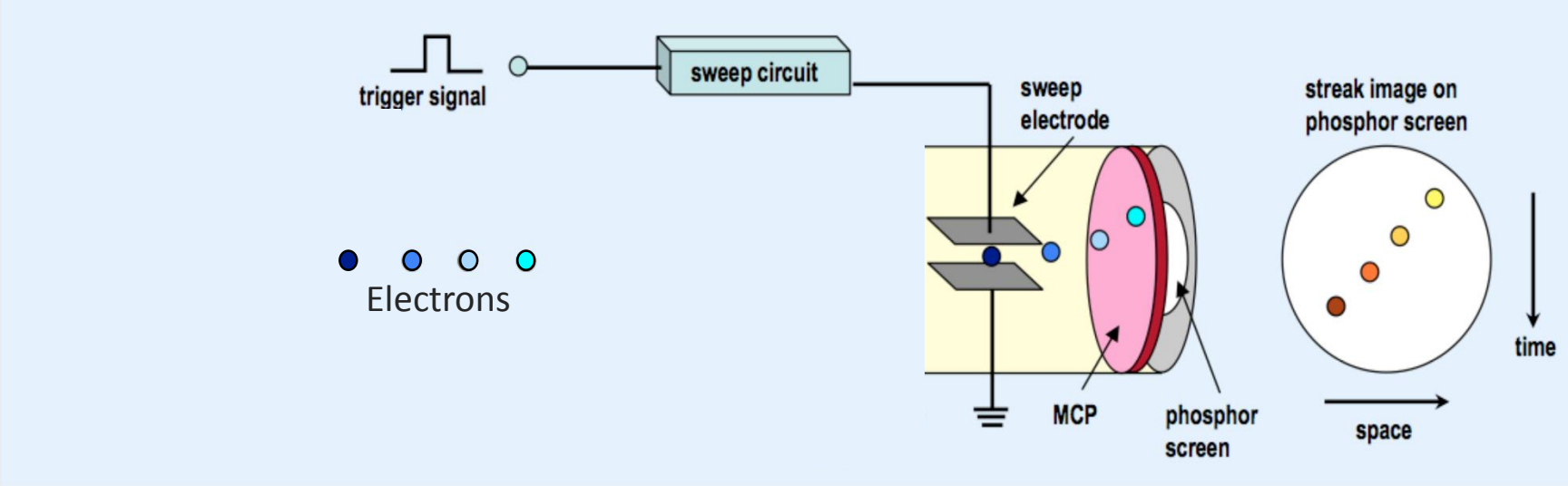


Streak camera



http://rasmus-ischebeck.de/media/Accelerator%20Physics/Drawings/PDFs/slides/Streak%20Camera.html

Streak camera



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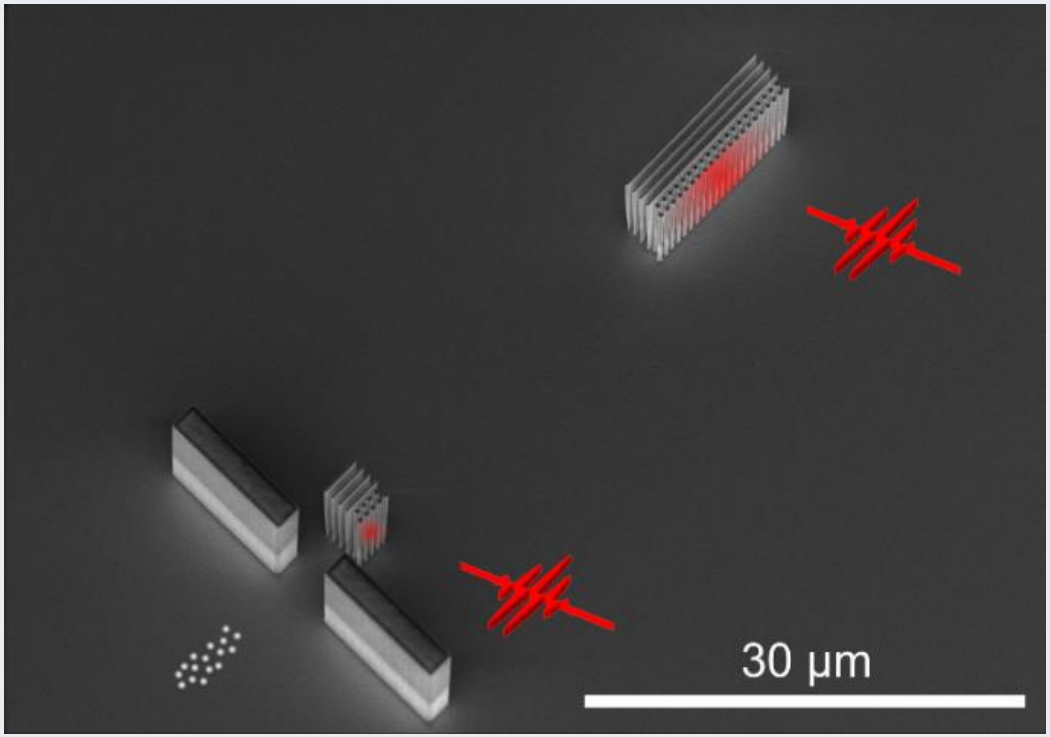

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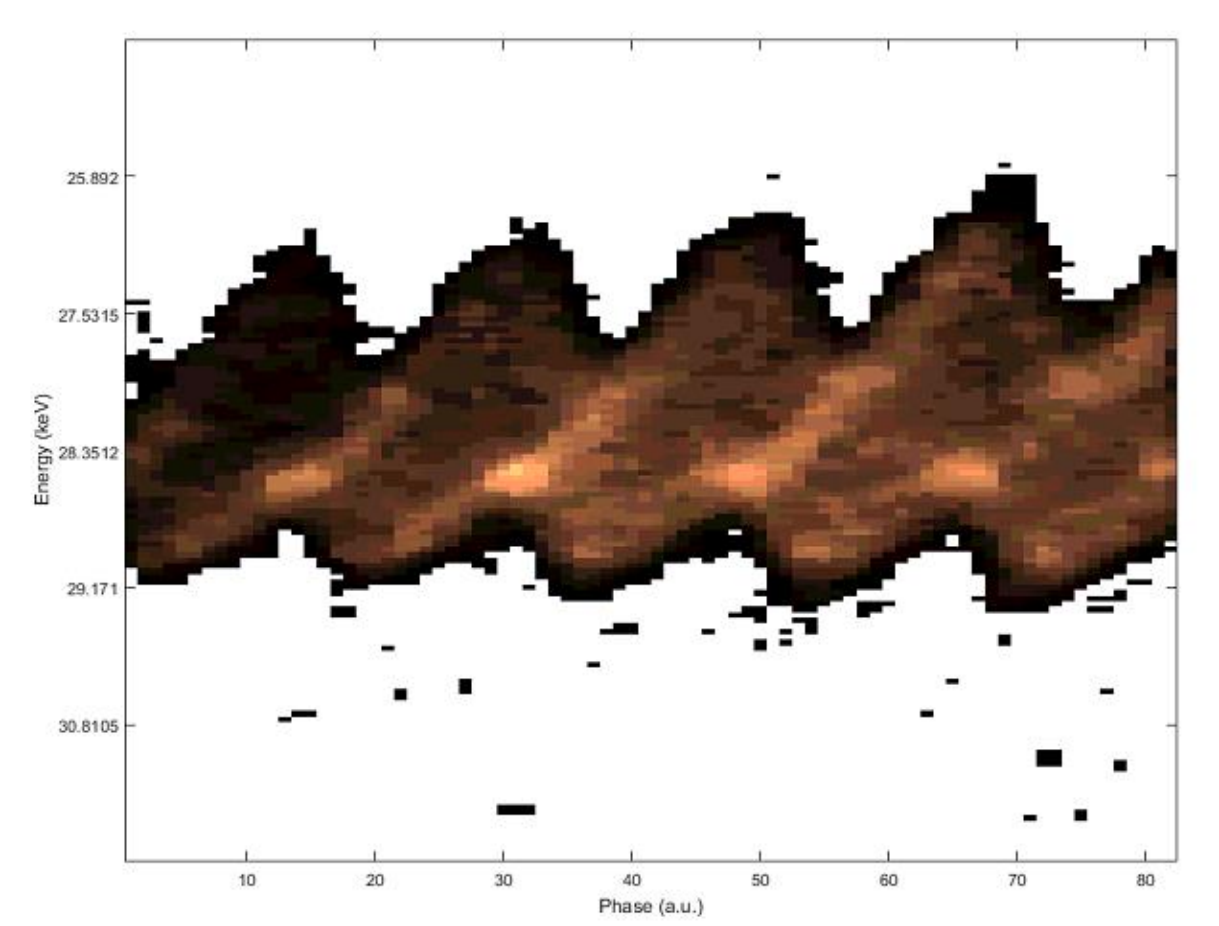

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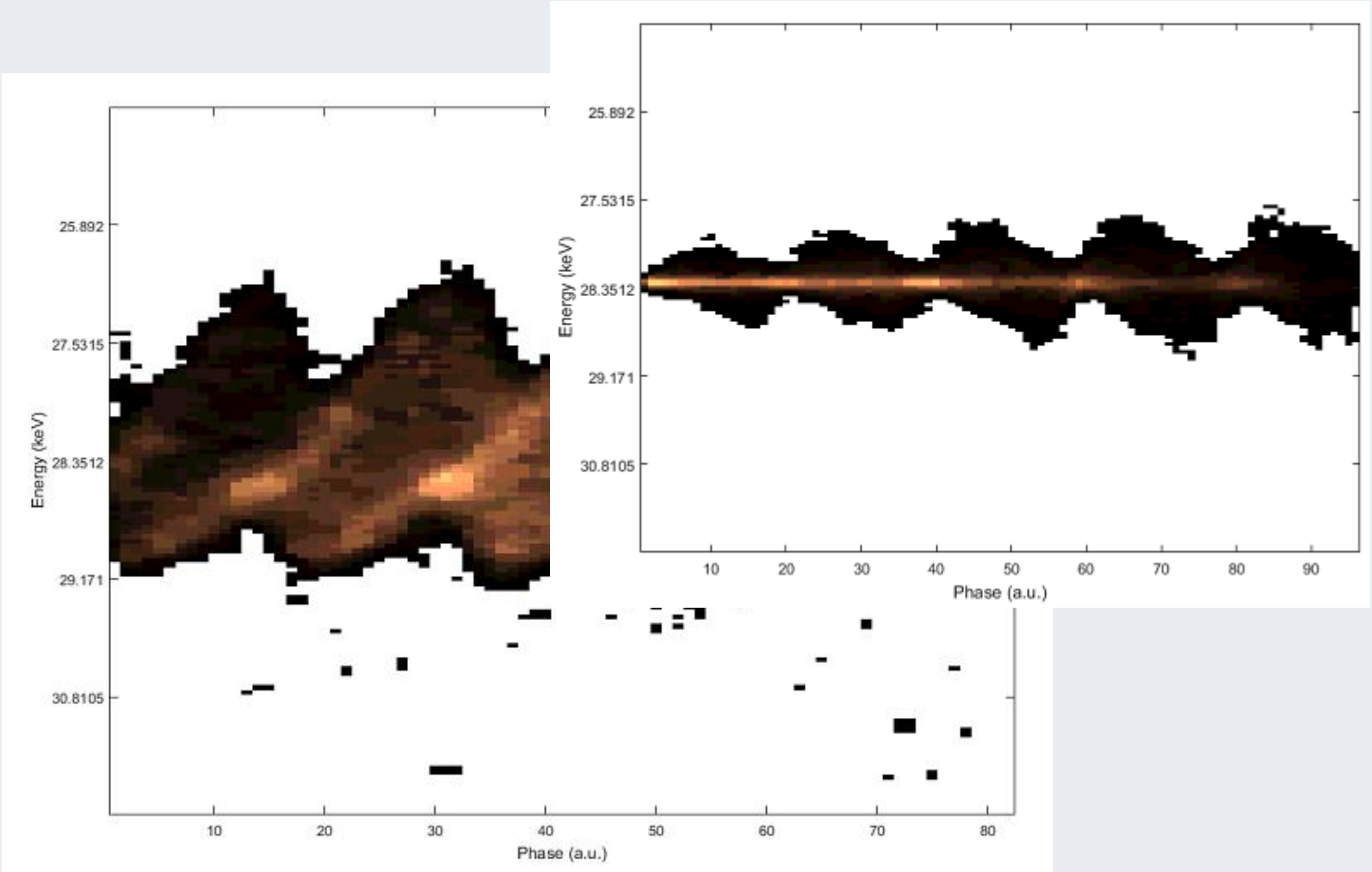

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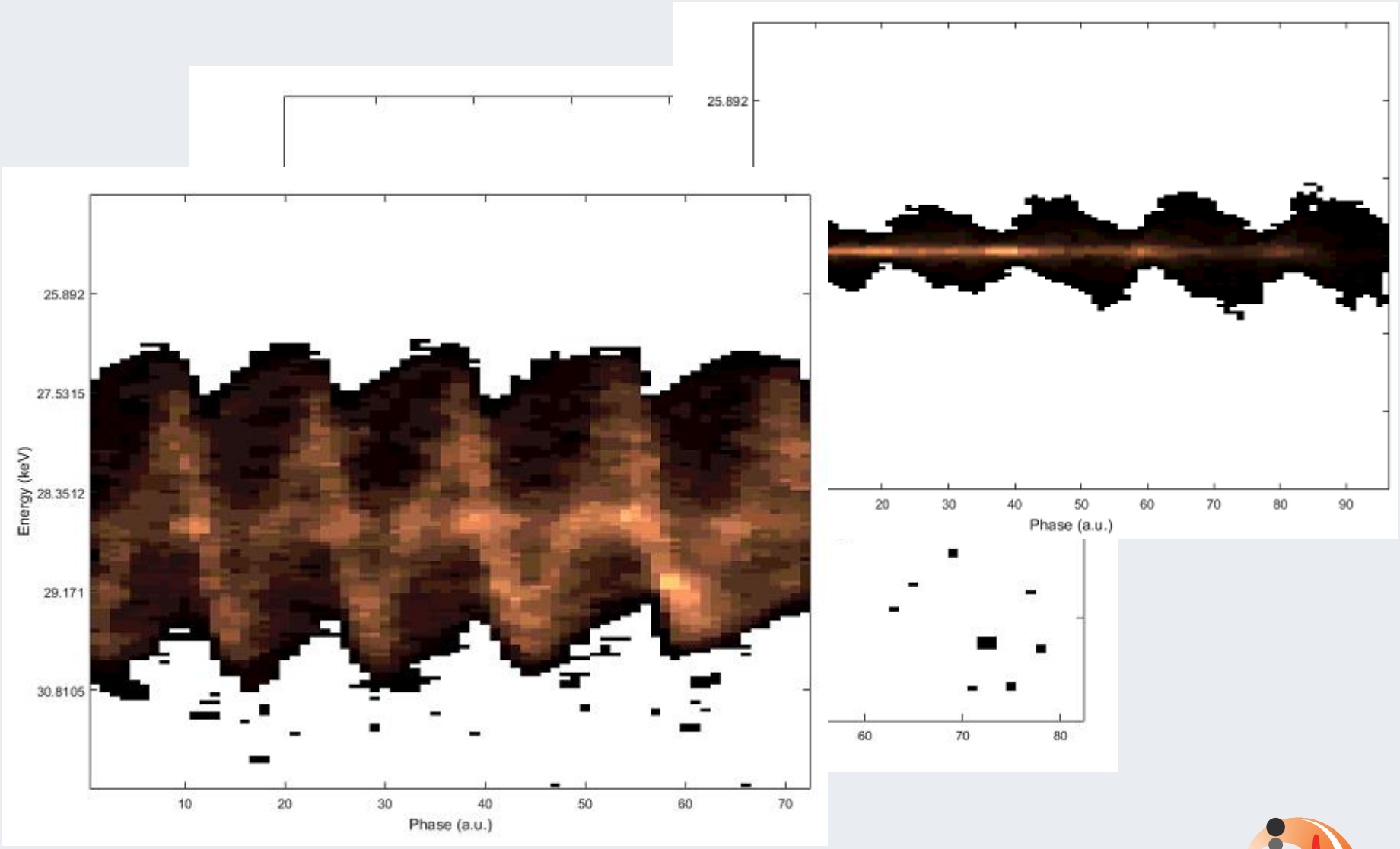

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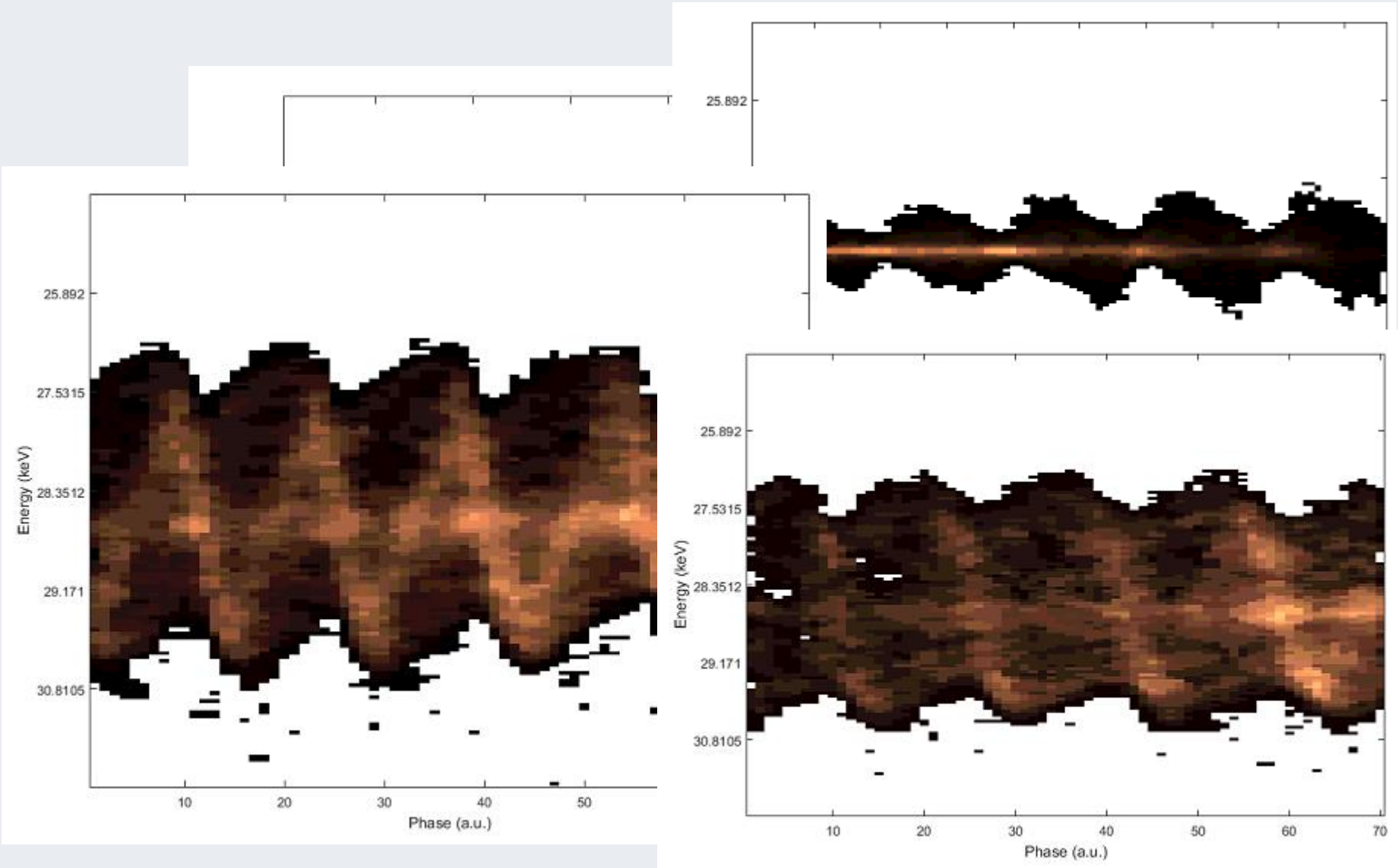
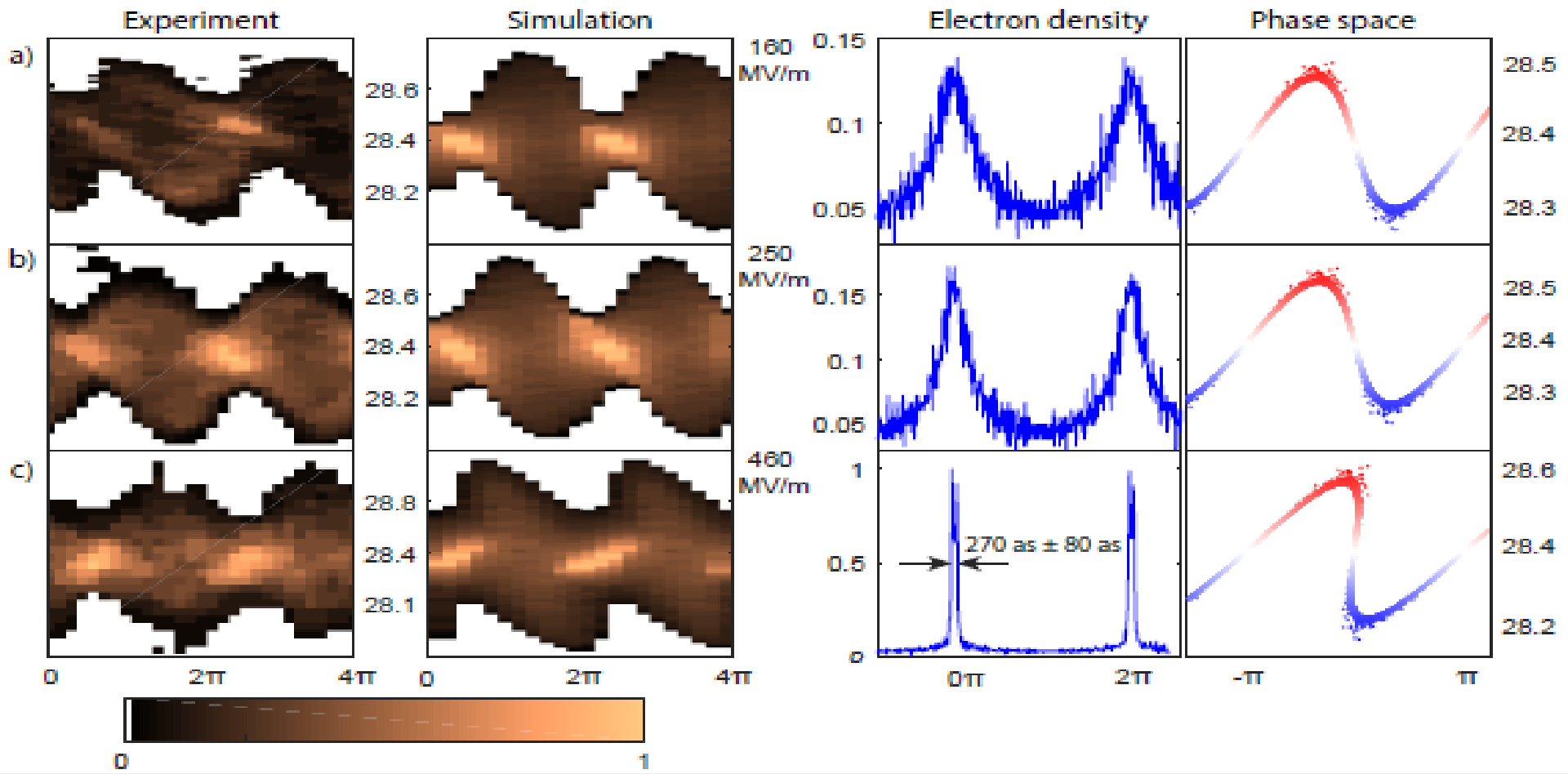
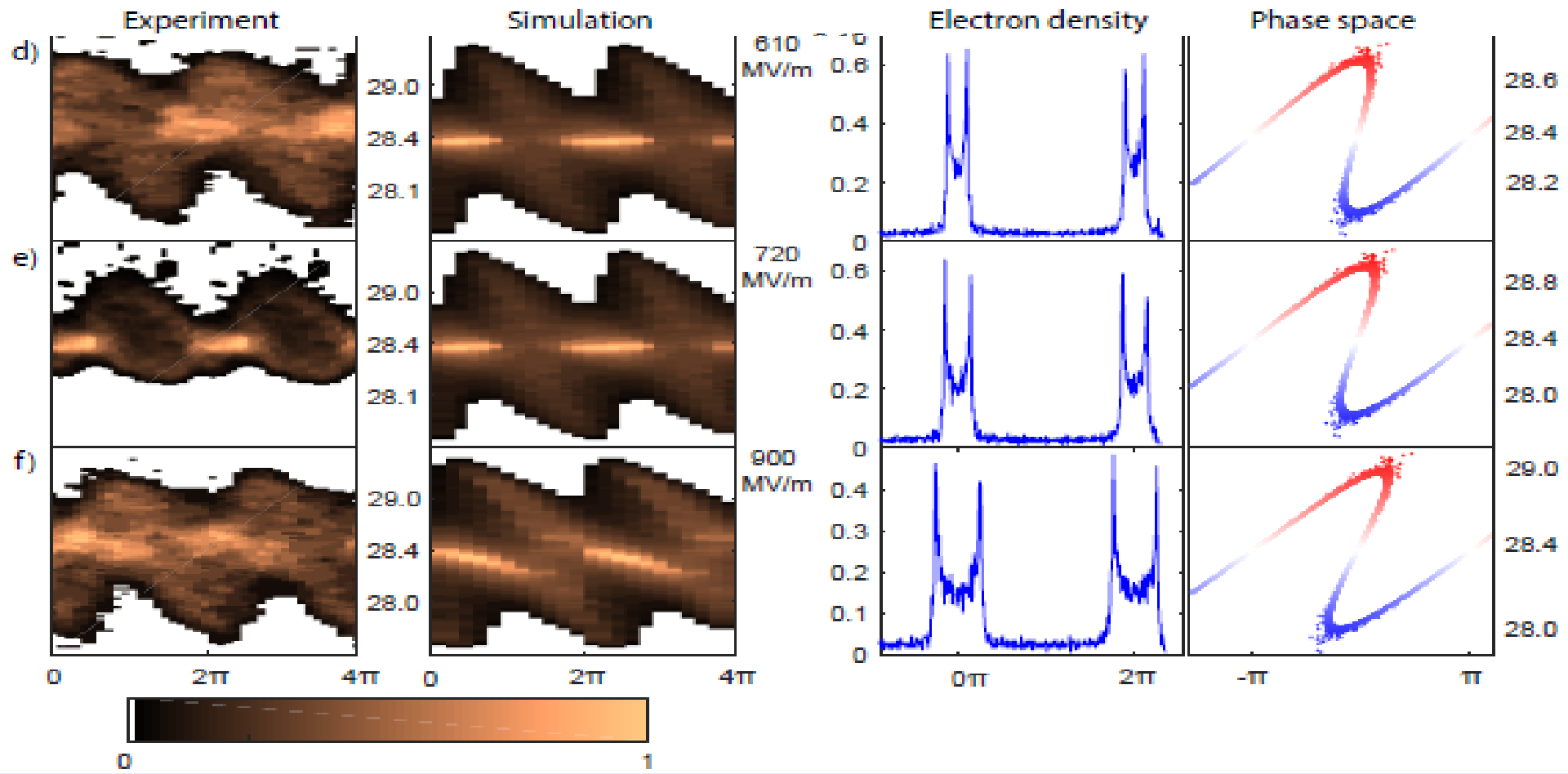


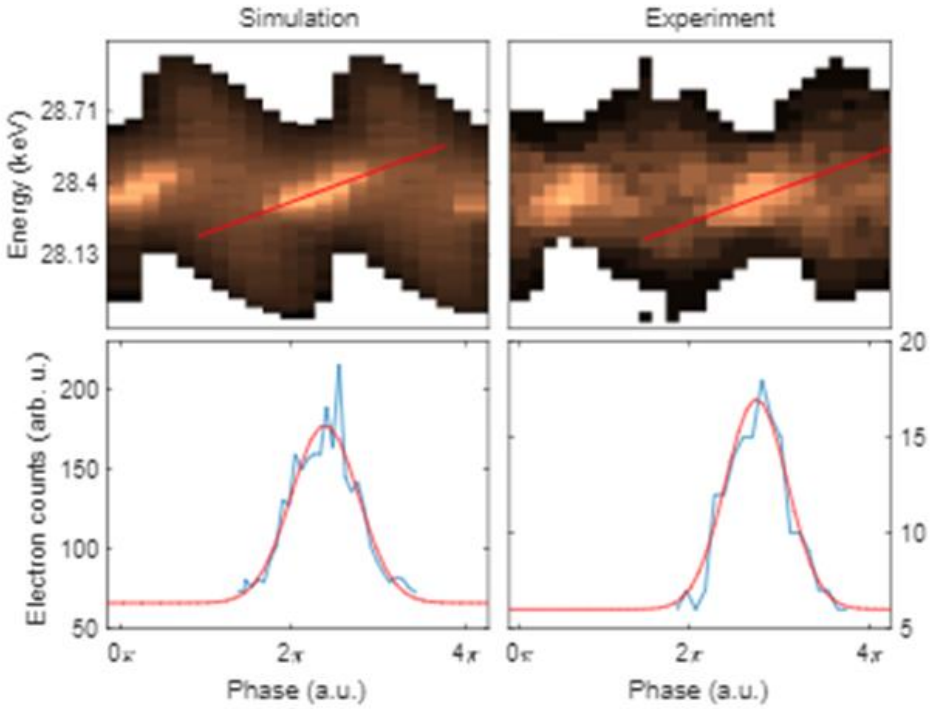
Dielectric Laser Acceleration: Bunching

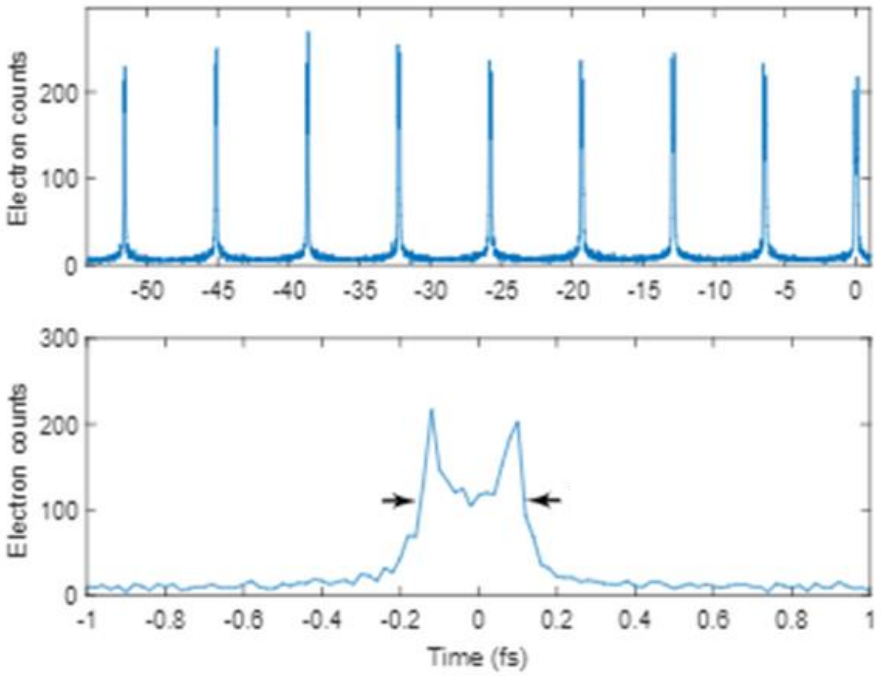


Dielectric Laser Acceleration: Bunching

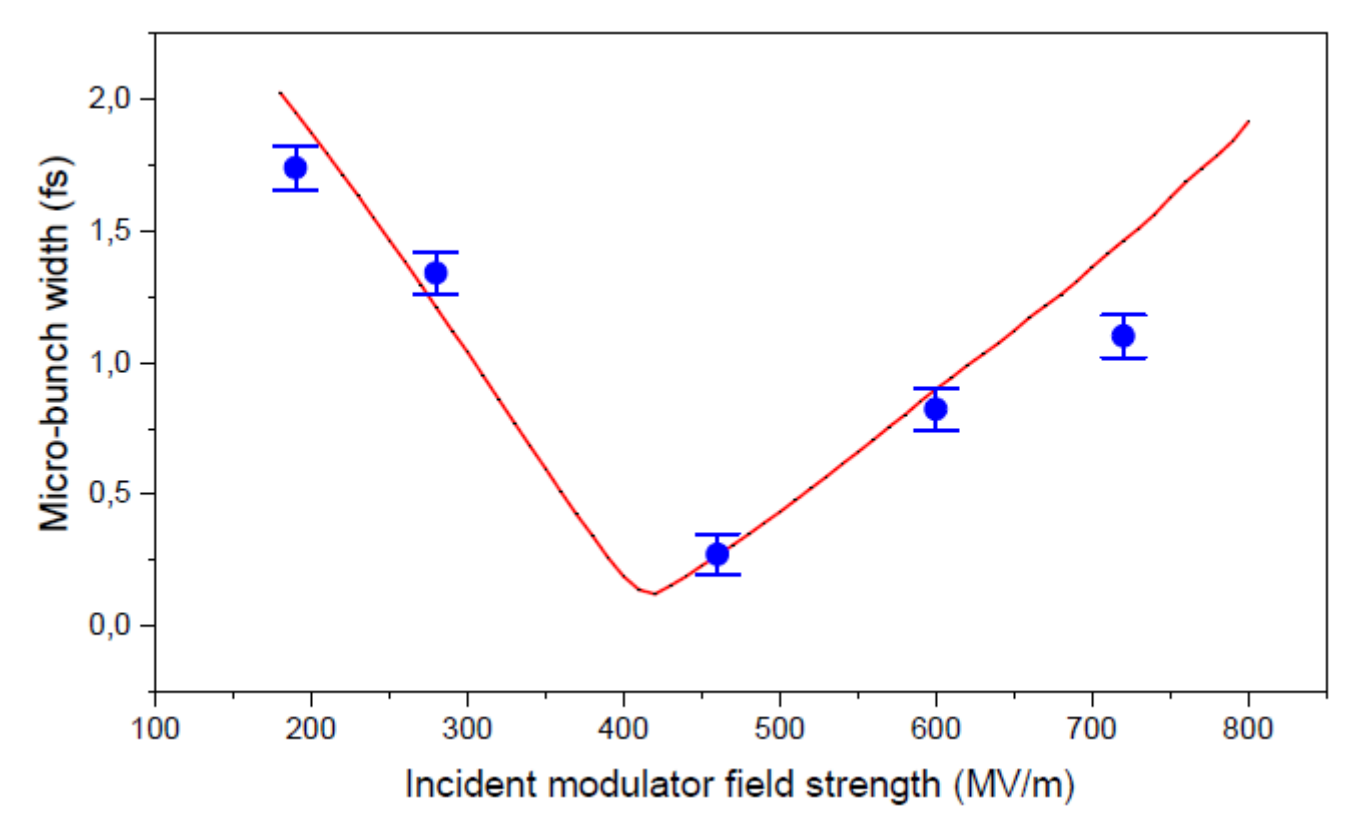


Shortest bunches





Bunching



Minimal bunch length achievable ~125 as

Submission currently in review

Net acceleration

Net acceleration

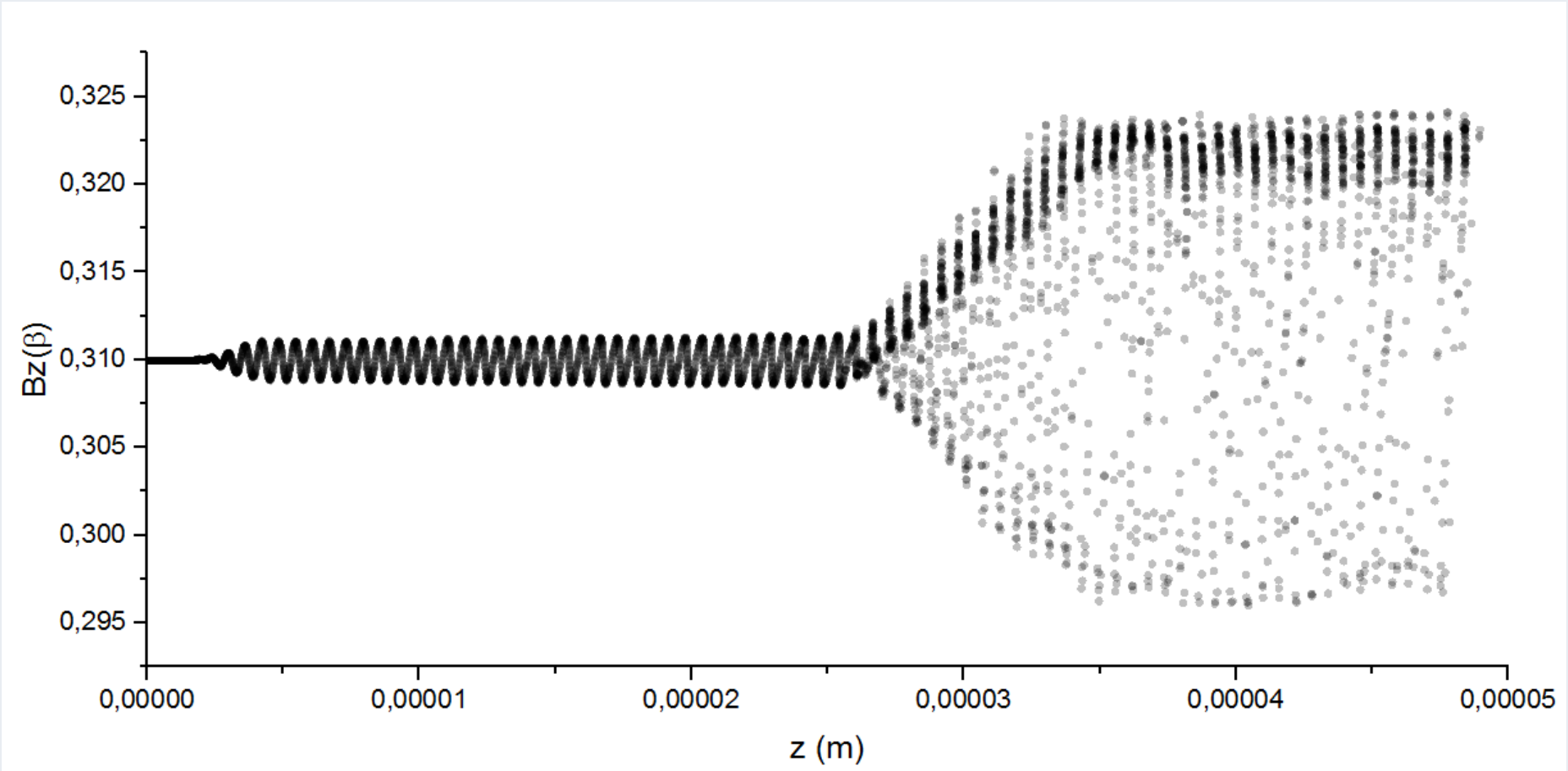
buncher

strong acceleration

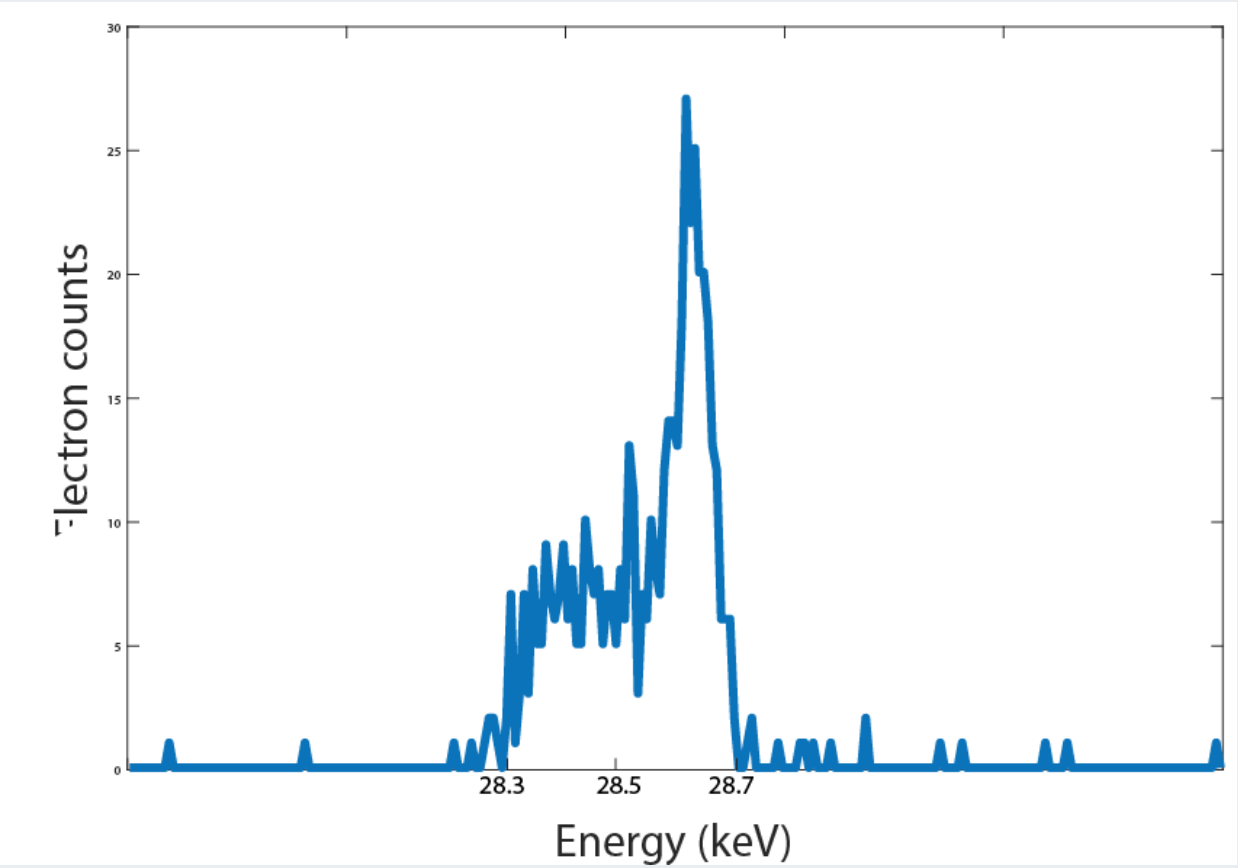
Net acceleration

buncher

strong acceleration

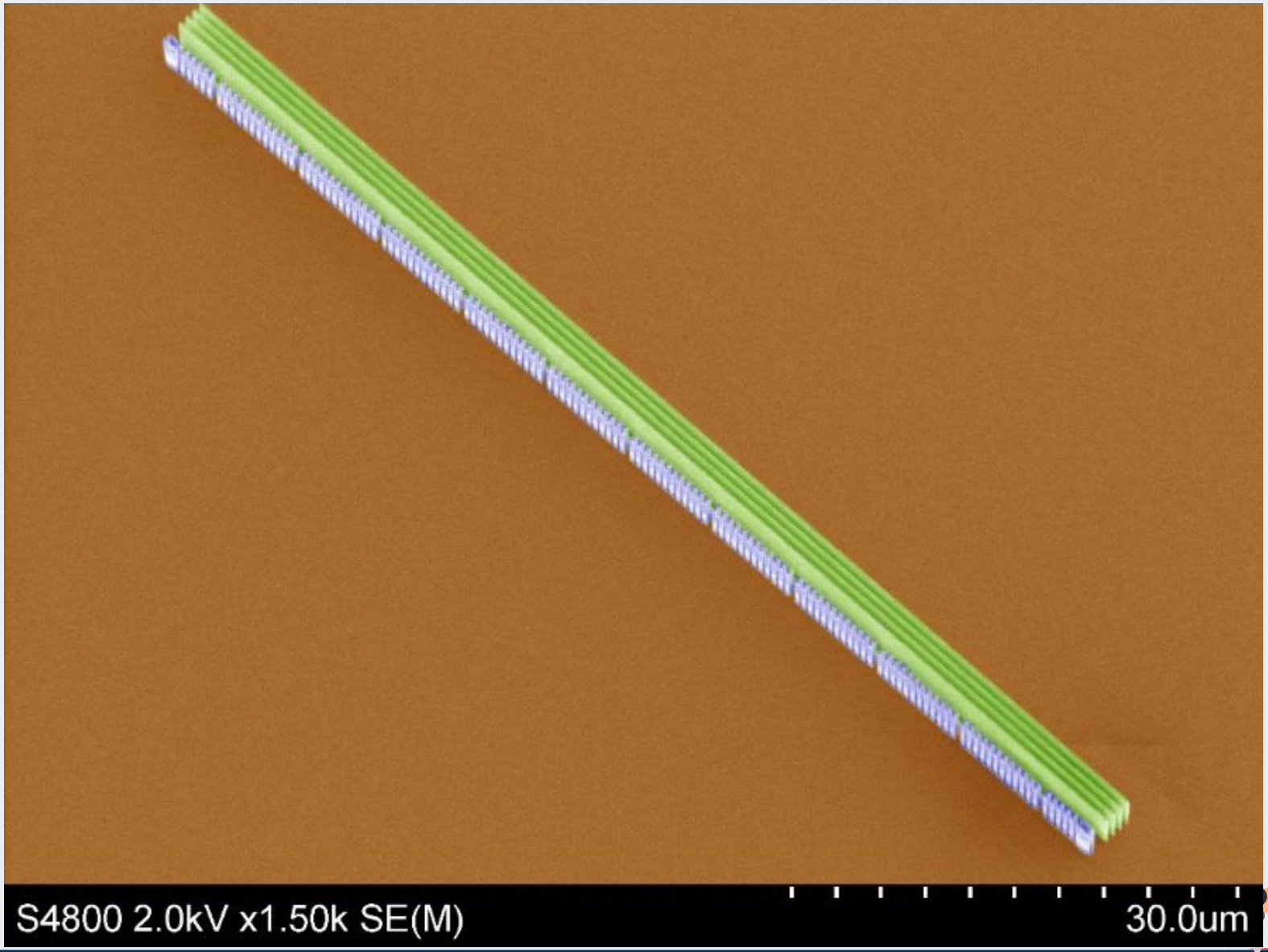


Measured net acceleration



- Relatively low energy gain due to large input energy spread into secon structure
- Inclusion of demodulator would greatly increase accepatance

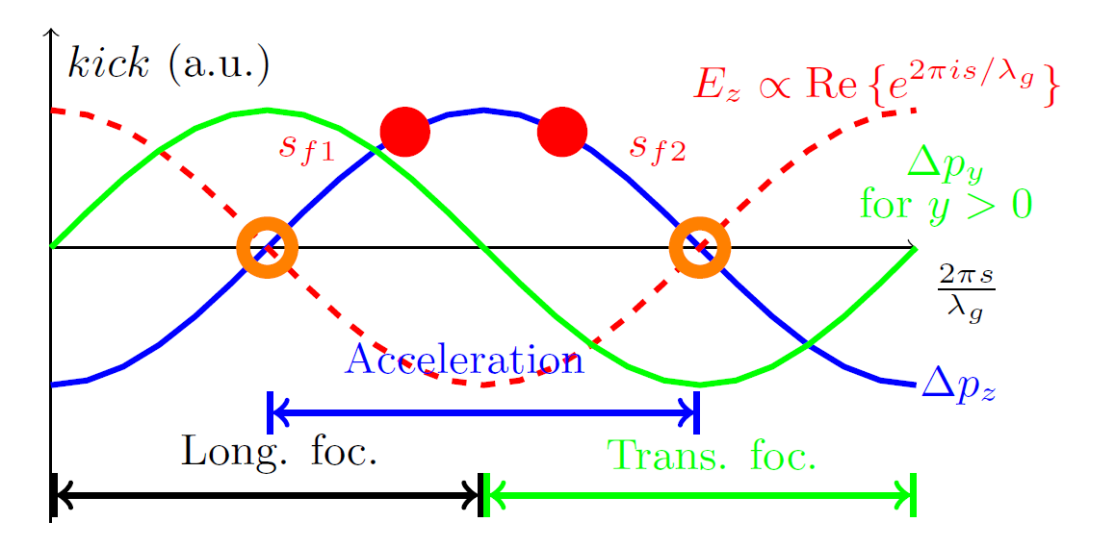
Phase-reset structure – towards a photonic LINAC



Keeping the beam together

Alternate between transverse focusing-longitudinal defocusing and transverse defocusing-longitudinal focusing

➡ ***net focusing***



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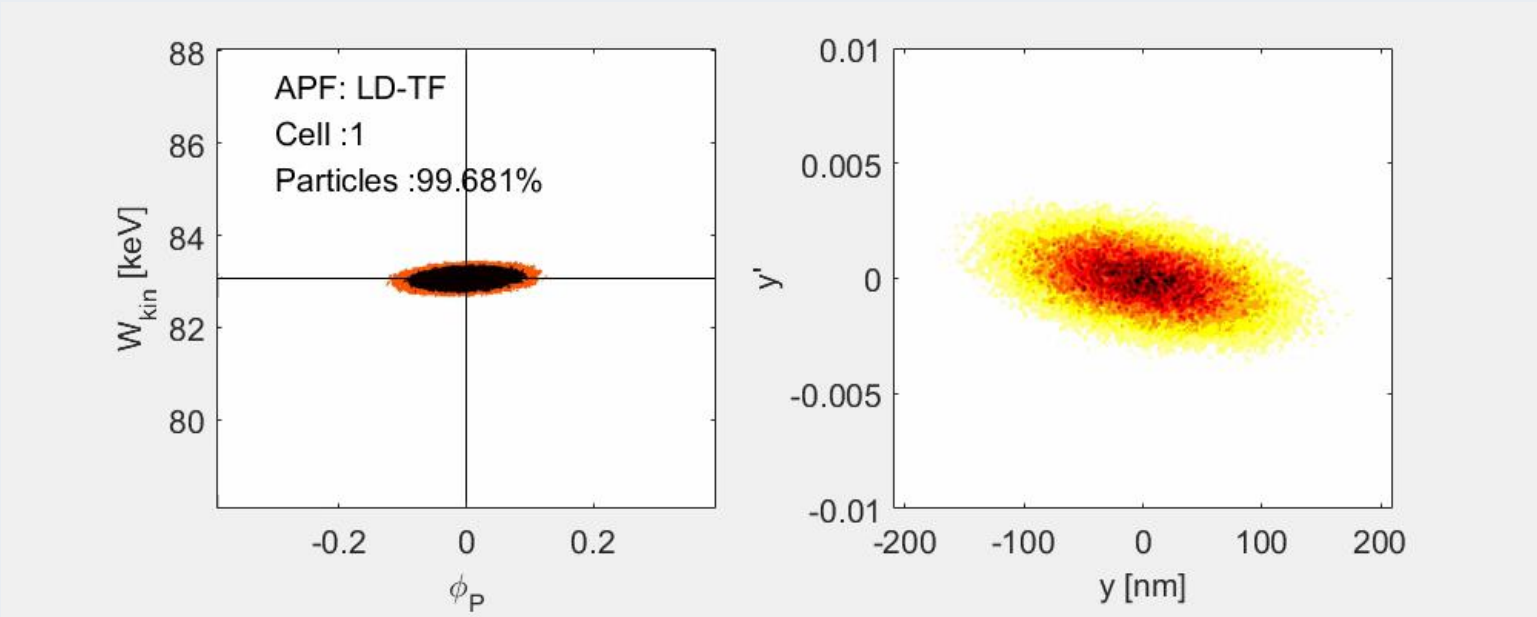

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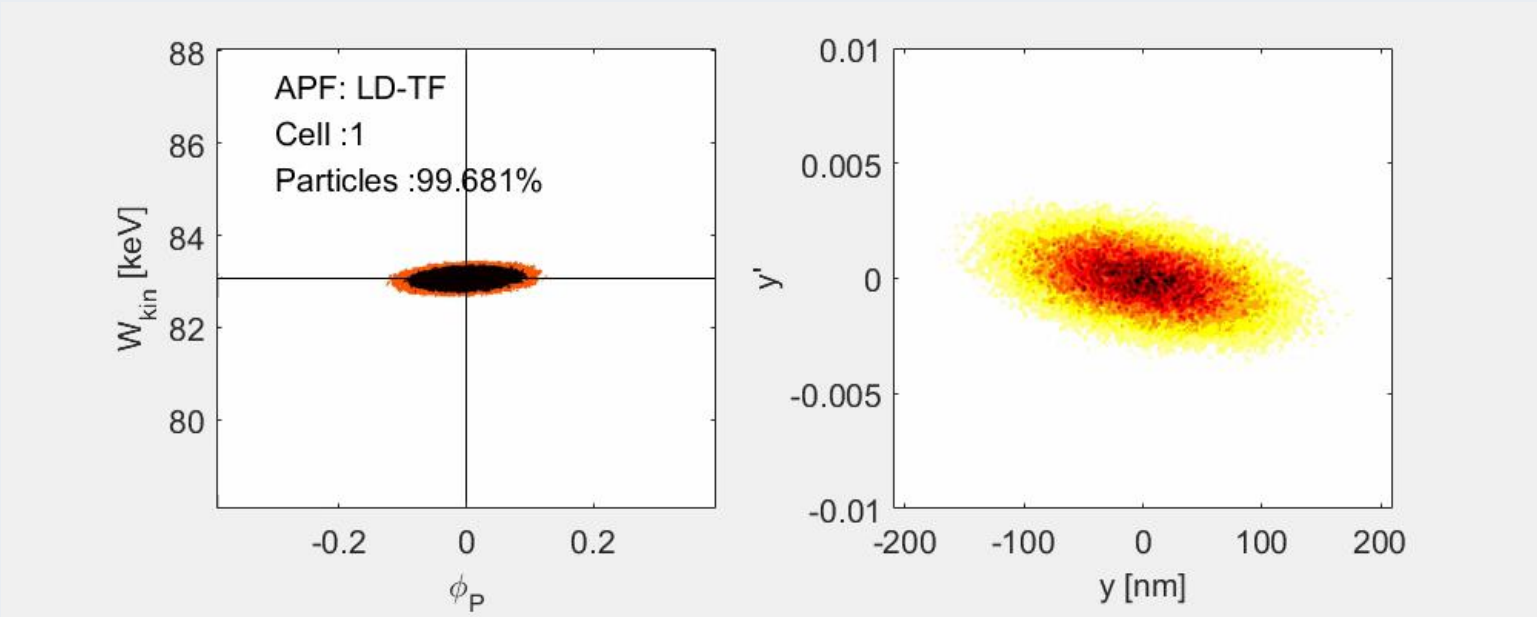

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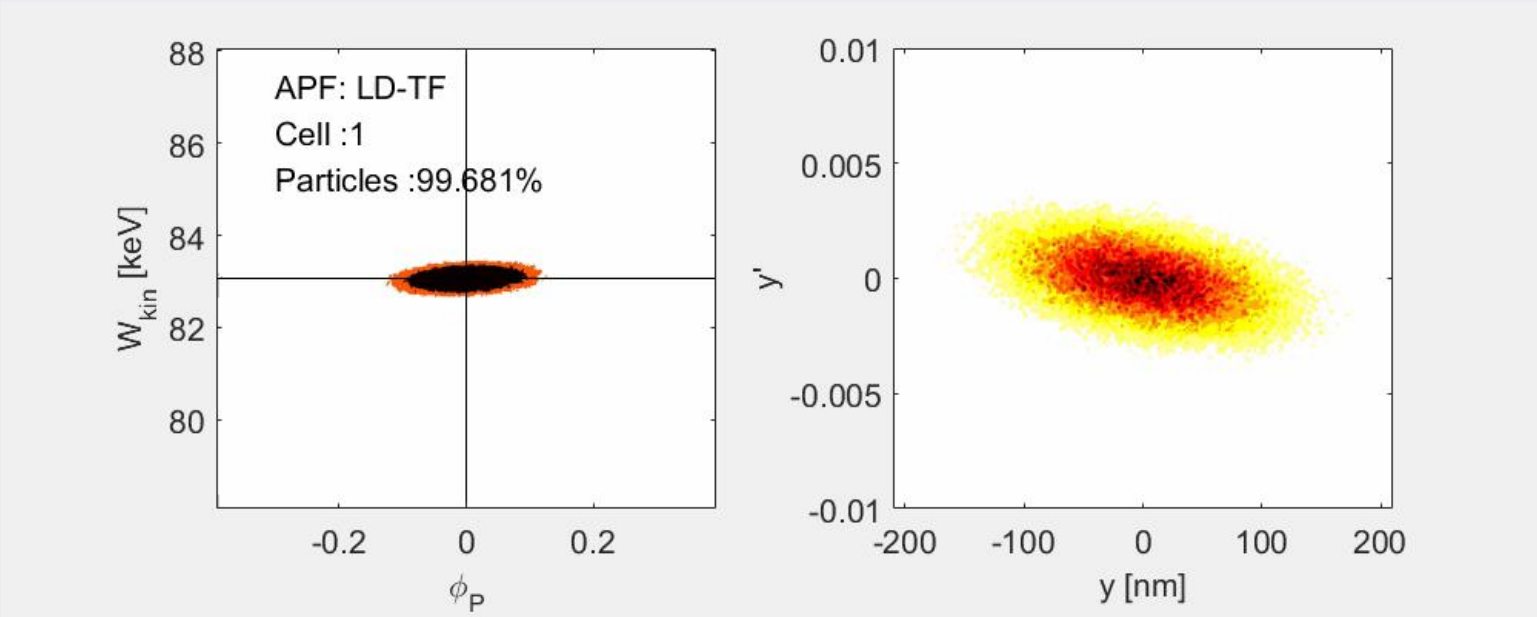

83 keV → >1 MeV:
56% transmission for 100pm,
93% for 25pm emittance

U. Niedermayer, T. Egenolf, O. Boine-Frankenheim, P. Hommelhoff, Phys. Rev. Lett. 121, 214801 (2018)

Thank you for your attention!