

Ultra-Intense Laser Interaction With Nanostructured Near-Critical Plasmas

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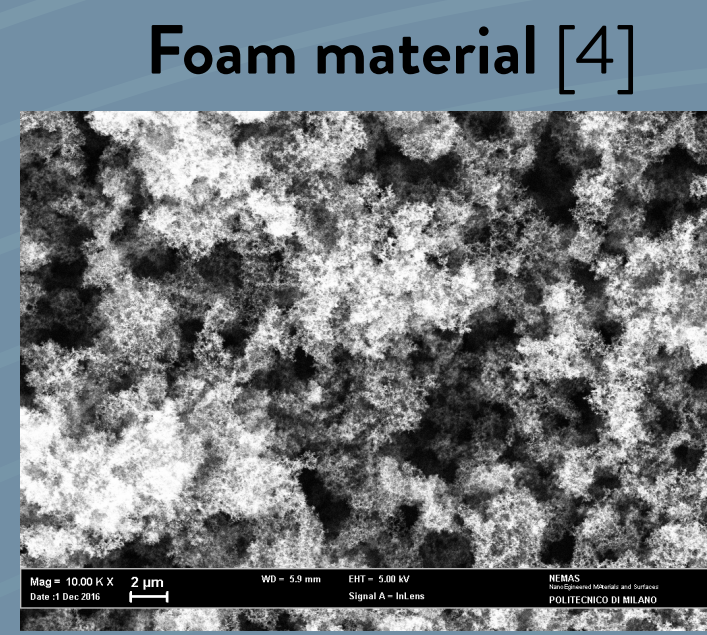


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INTRODUCTION

Near-critical plasmas from nanostructured materials

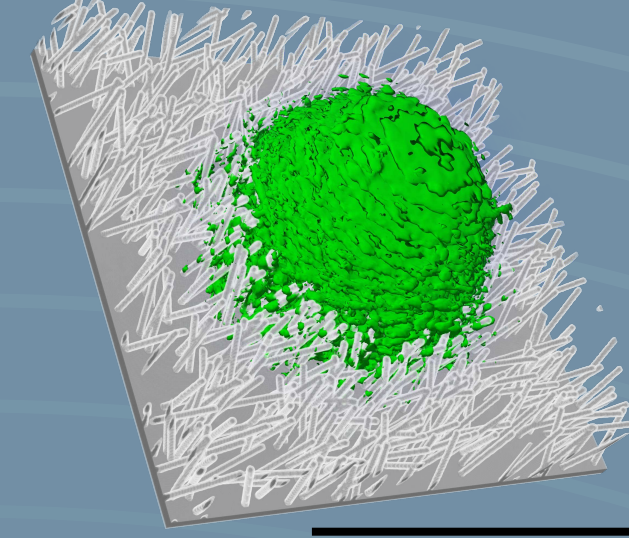
- Why? Near-critical plasmas are very interesting [1,2,3]
- But? Very challenging to produce...
- How so? n_c corresponds to few mg/cm^3 : intermediate density between typical gas-jets and solids
- One option? Irradiate an ultra-low density, solid material with a high-intensity laser pulse
- Issues? Ultra-low density, solid materials are nanostructured...
- So? The nanostructure may influence the interaction, since ultra-short dynamics and possibly high contrast



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CONCLUSIONS

Include the nanostructure for a complete physical picture



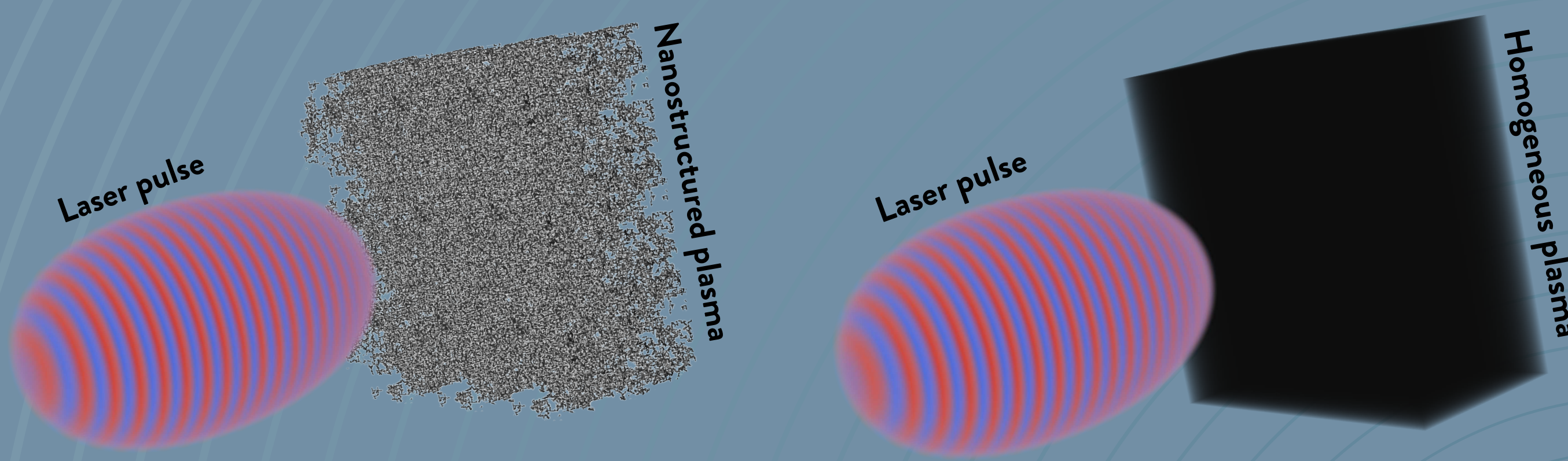
It is important to include a realistic description of the material nanostructure and morphology (if any) to get a complete understanding of the processes at play and to be able to perform "realistic" simulations.

Next... How can we use these materials? Can we exploit them for some applications?
See Luca Fedeli's poster!

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OPEN ISSUES

Does the nanostructure influence laser-plasma interaction?



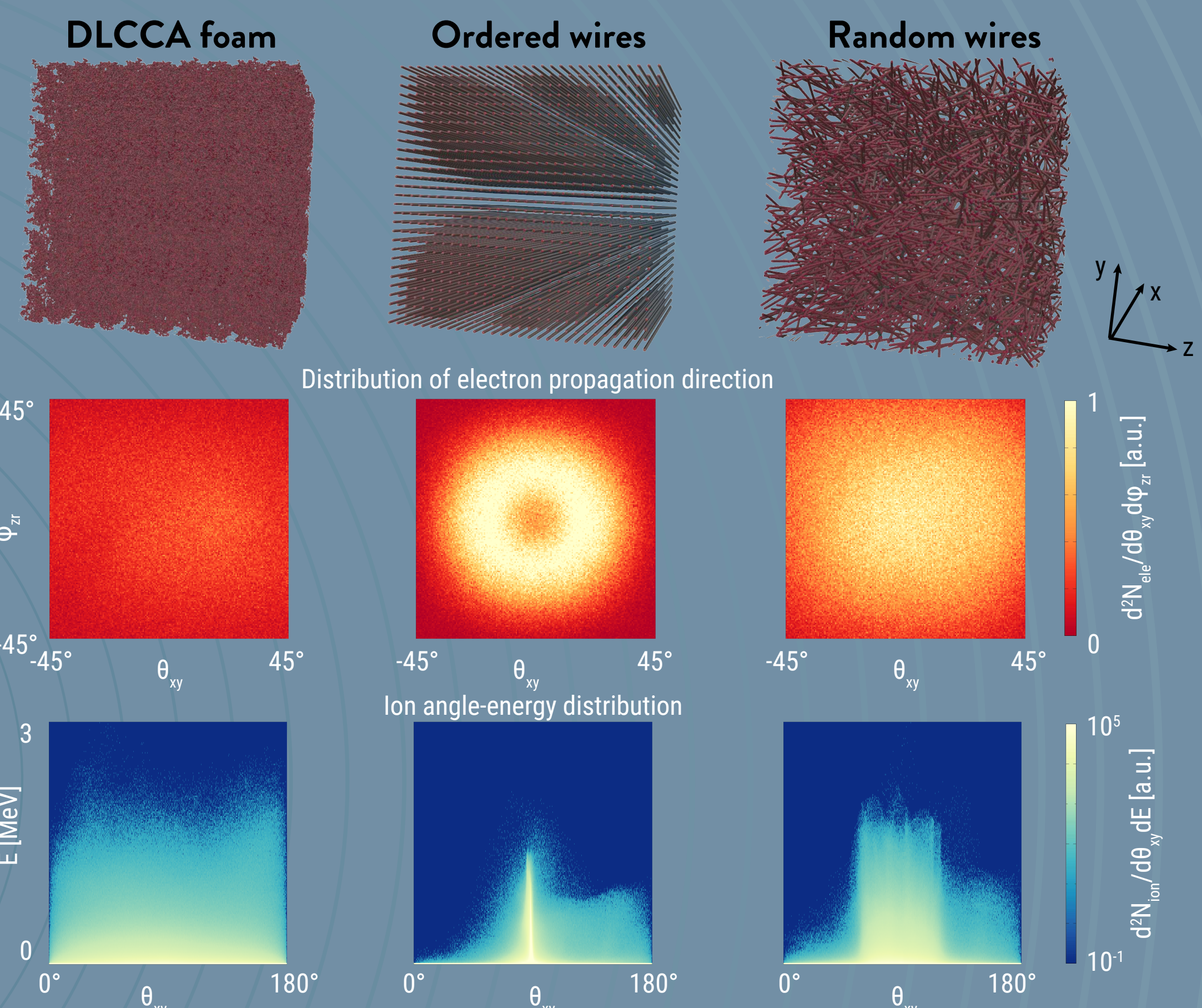
Numerical simulations! As a reference, a homogeneous plasma with same average density

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RESULTS 2

The morphology of the nanostructure also plays a role

- [6] The morphology:
- does not influence much laser energy absorption: all nanostructures lead to strong and similar absorptions and energy repartition among electrons and ions
 - strongly influences the angular and energy distributions of plasma populations



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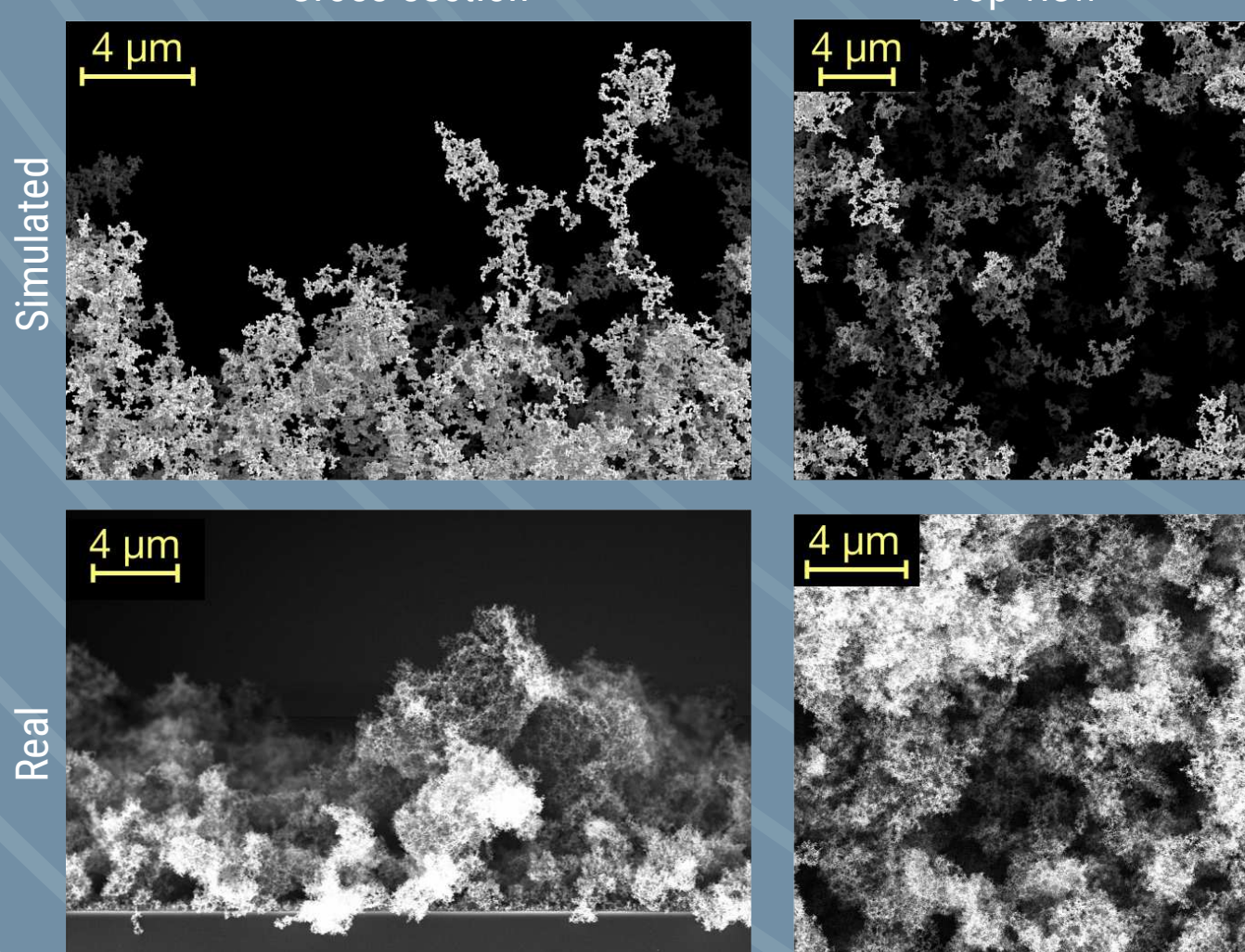
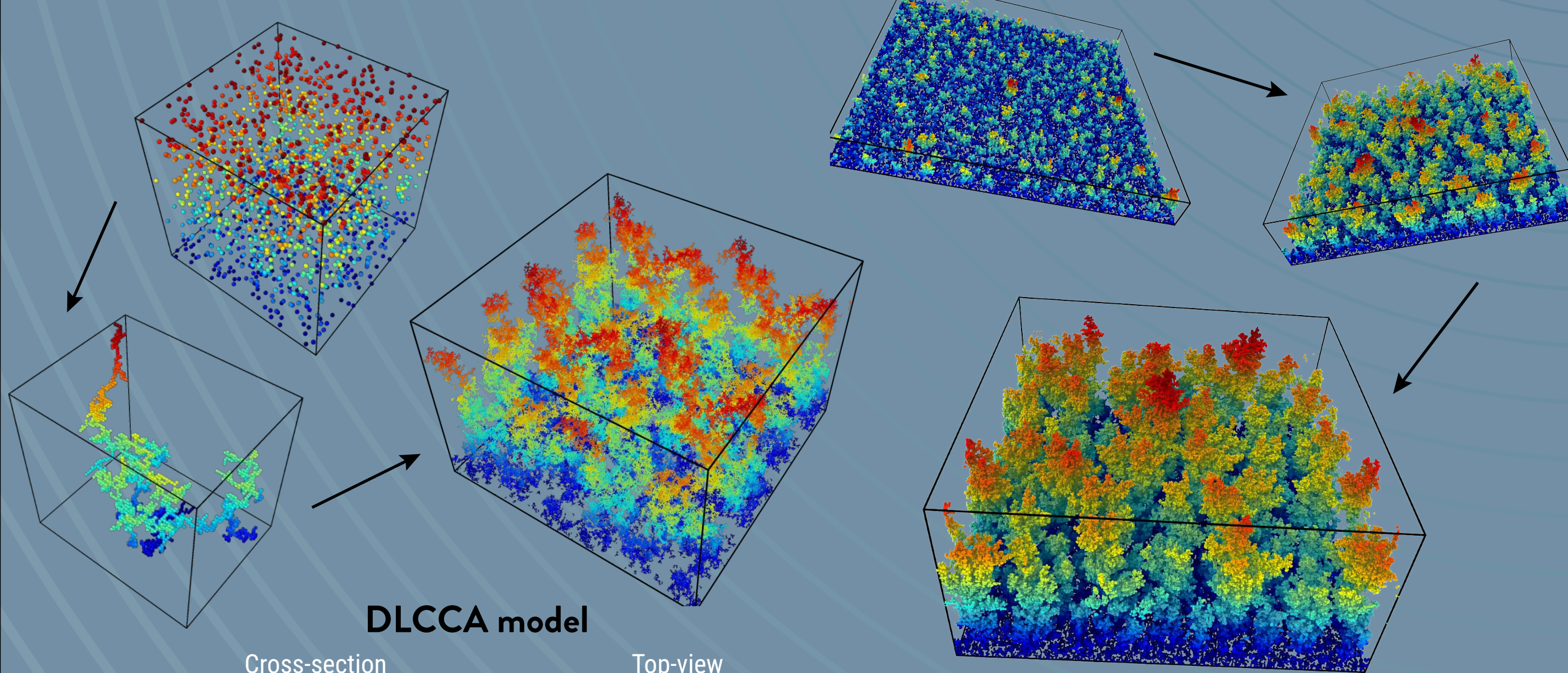
MODELS

Aggregation models to describe the nanostructure

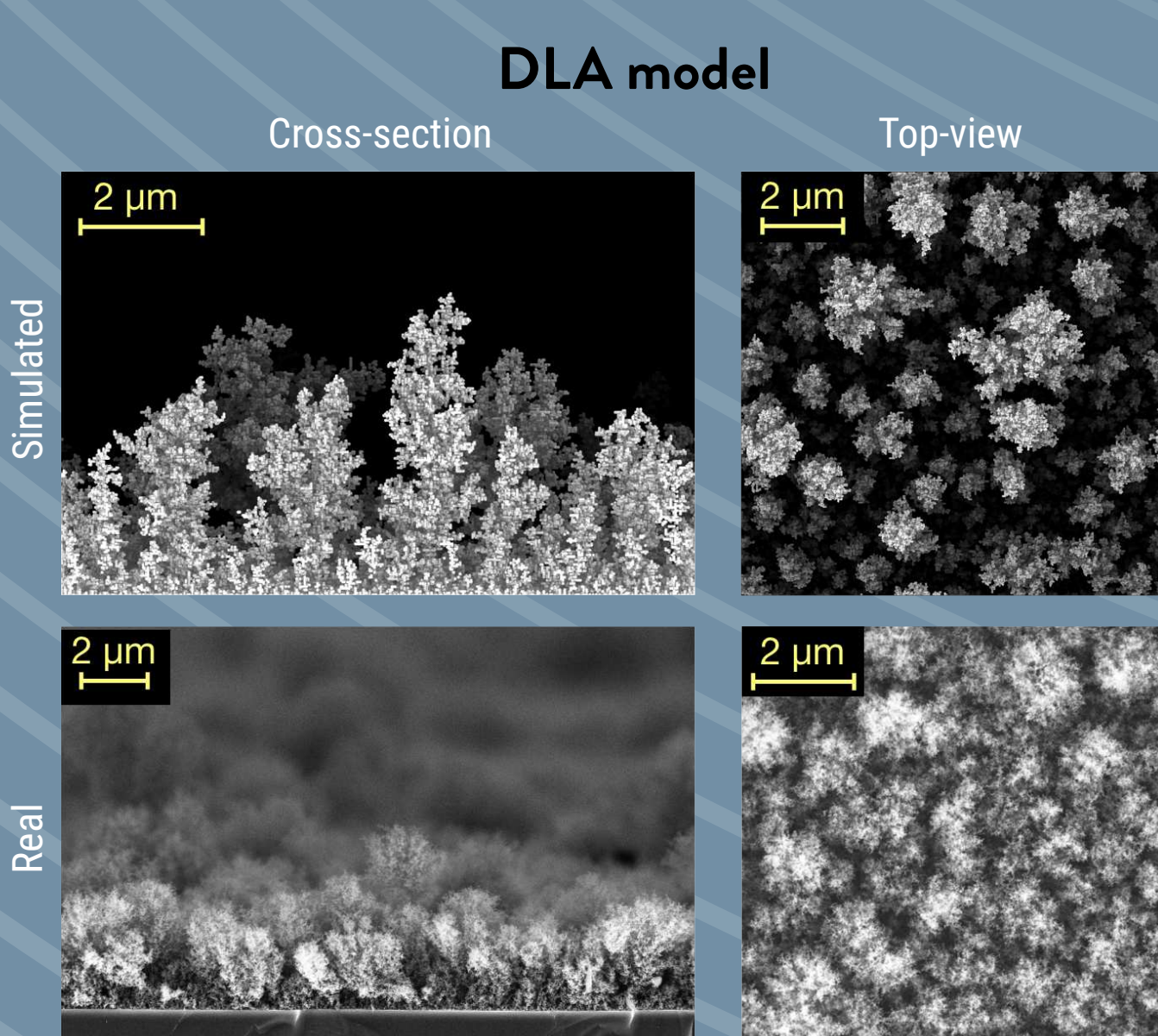
Diffusion-Limited Cluster-Cluster Aggregation (DLCCA) Diffusion-Limited Aggregation (DLA)

Nanoparticles in Brownian motion
Cluster assembly by irreversible sticking
Cluster deposition on a substrate

Nanoparticles in Brownian motion one at a time
Irreversible sticking to substrate or to other particle



Good description of foam materials produced by means of the Pulsed Laser Deposition technique [4]



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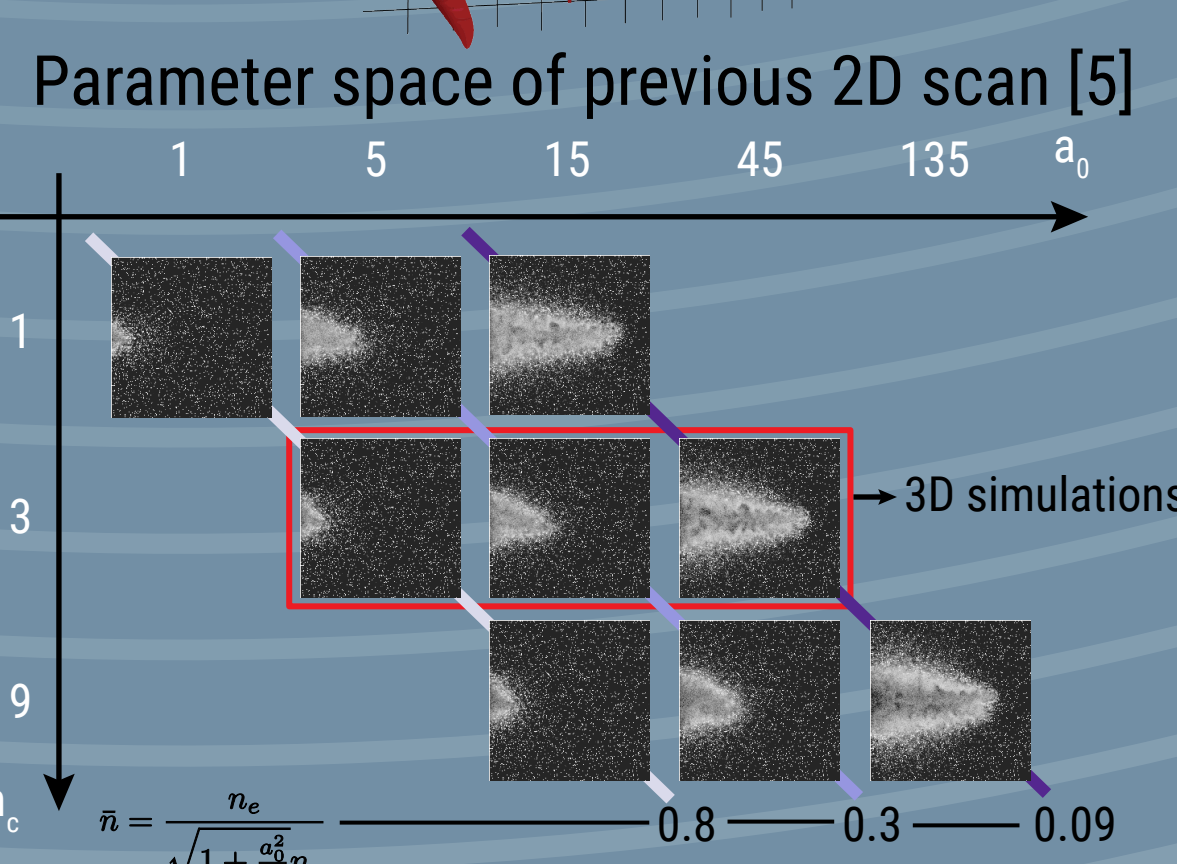
METHODS

3D Particle-In-Cell simulations

Laser pulse
30 fs
5 λ waist
 $a_0 = 5, 15, 45 (\sqrt{2})$
normal incidence
P-pol (C-pol)

Plasmas
40 $\lambda \times 30\lambda \times 30\lambda$
3 n_c on average
5% filling factor
0.05 λ sphere radius

Simulations
80 $\lambda \times 30\lambda \times 30\lambda$ box
50pp λ resolution

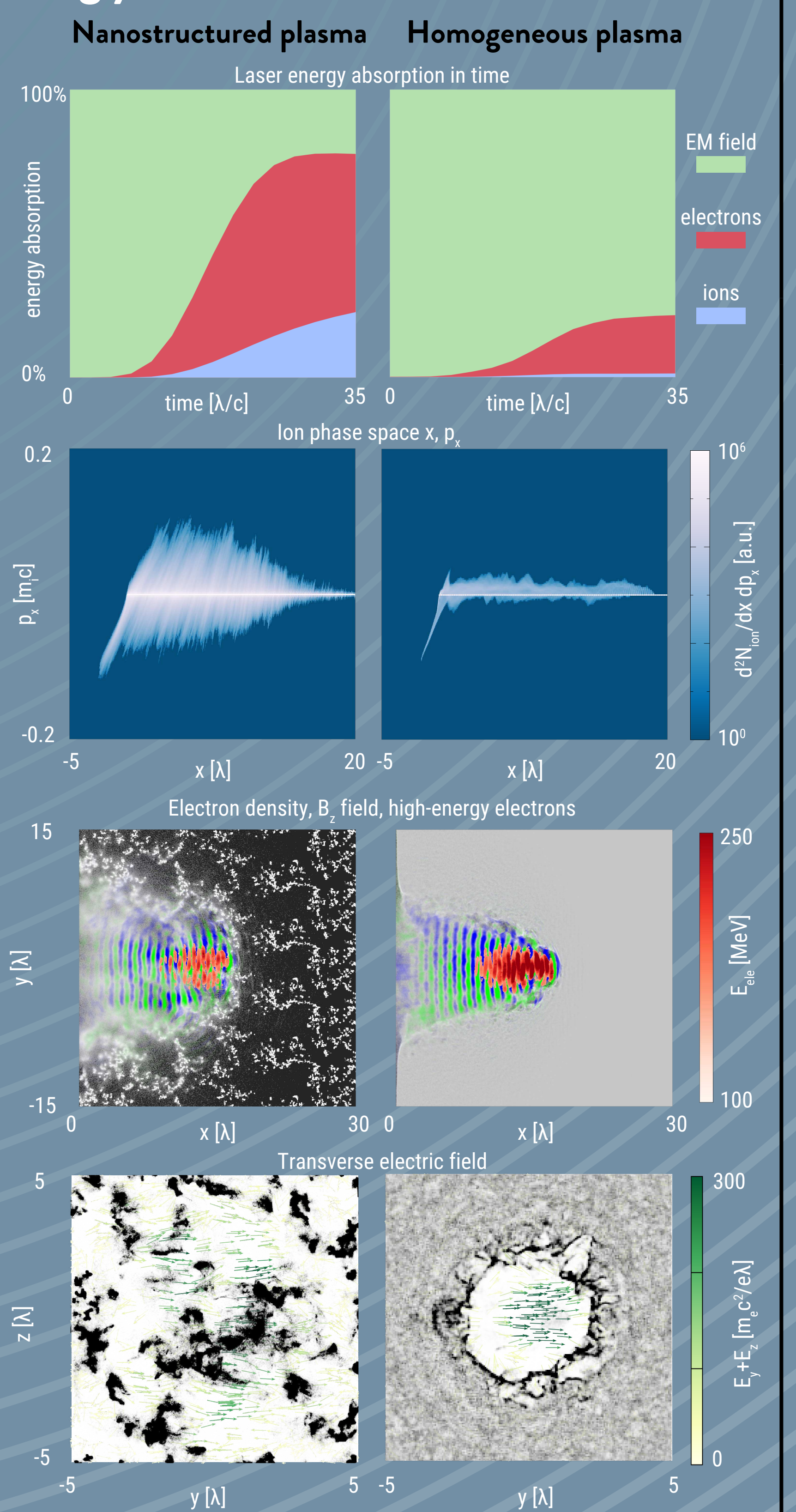


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RESULTS 1

The nanostructure strongly influences the interaction

- [6] The nanostructure:
- enhances electron energy absorption
 - enhances (a lot) ion energy absorption
 - makes ions experience explosions: that's why they get so much energy
 - reduces maximum electron energy
 - generates more medium-energy electrons
 - leads to "messier" EM fields
 - kills polarization dependence



REFERENCES

- [1] Passoni et al., Phys. Rev. Acc. Beams, 19.6 061301 (2016) Zani et al., Carbon, 56, 358-365 (2012) [4]
[2] Stark et al., Phys. Rev. Lett., 115, 025002 (2015) Fedeli et al., Eur. Phys. Journal D, 71.8, 202 (2017) [5]
[3] Grassi et al., Phys. Rev. E, 96:033204 (2017) Fedeli et al., Sci. Rep., 8:3834 (2018) [6]

CONTACTS

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ACKNOWLEDGMENTS

