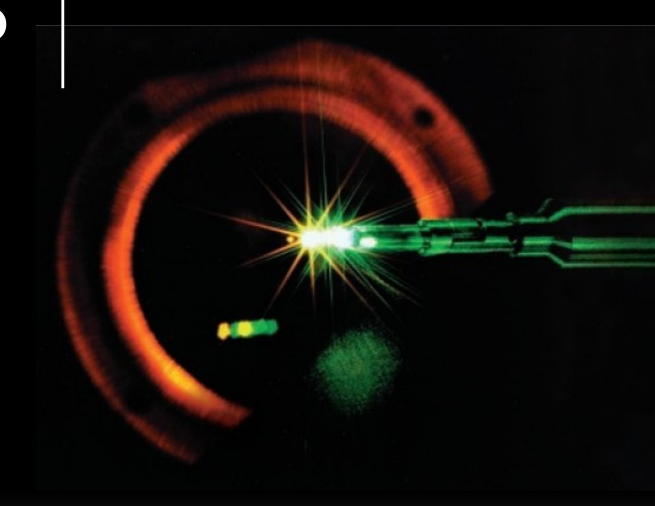
Carbon nanofoam targets for inertial confinement fusion experiments

POLITECNICO MILANO 1863

EPS 2024

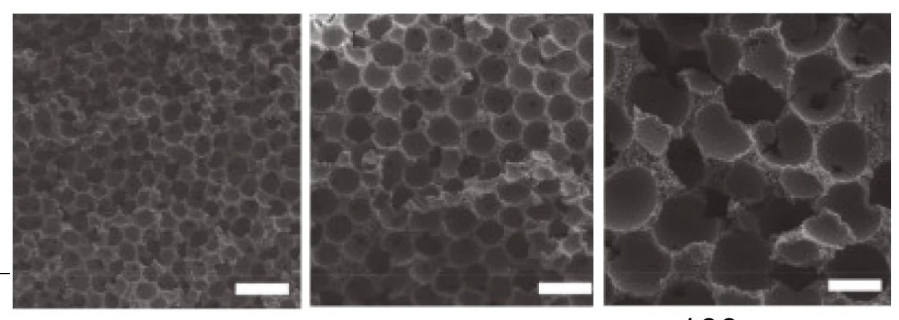
50th EPS Conference on Plasma Physics

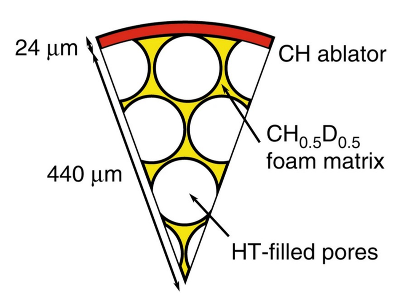
Salamanca– July 8-12, 2024



1 BACKGROUND

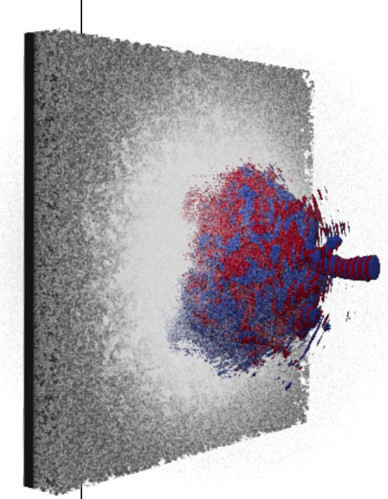
- Foams: porous materials ubiquitous in laser-matter interaction and Inertial Confinement Fusion (ICF).
- Applications: bright X-ray sources, equation of state studies, particles acceleration....
- Foams in ICF: smooth laser inhomogeneities, improve absorption, enhance ablation loading. [1,2]
- **Conventional foams**: plastic, voids and solids in the 10-100 μm range





MOTIVATIONS & GOALS 2

We propose a new class of materials for ICF:
Carbon nanofoams by Pulsed Laser Deposition

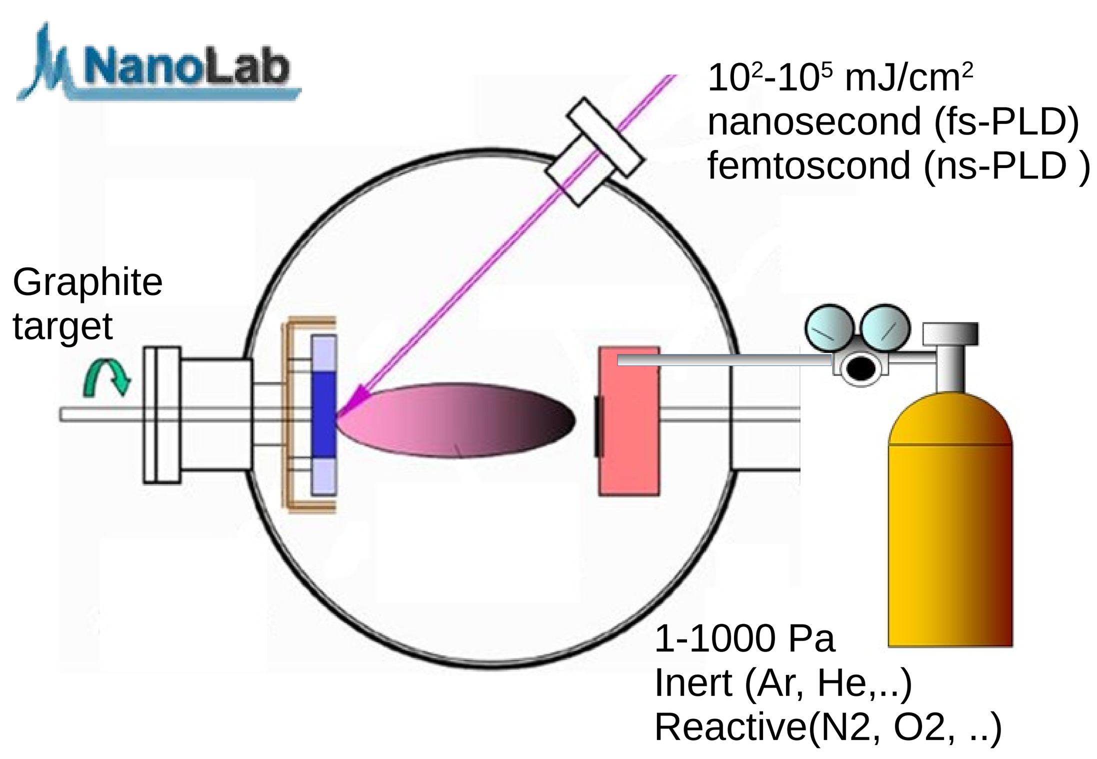


- Already explored for ultra-short (t<100 fs), ultra-intense ($I>10^{18}$ W/cm²) laser acceleration [3,4]
- Numerical study hints at benefits of mid-Z elements and nanostructured materials for ICF ablators [5].
- An experimental study in ICF-relevant conditions is required!

3 NANOFOAM PRODUCTION

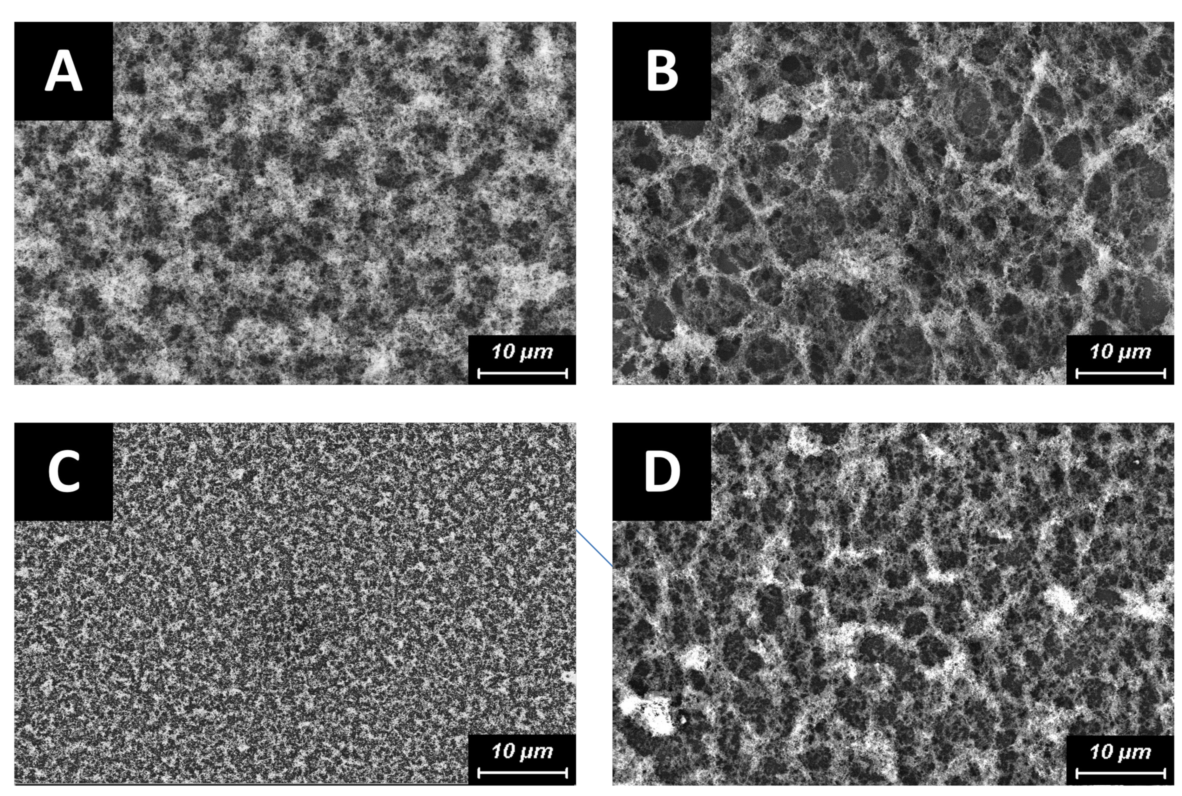
Nanofoams grown by **PLD** technique

NanoLab

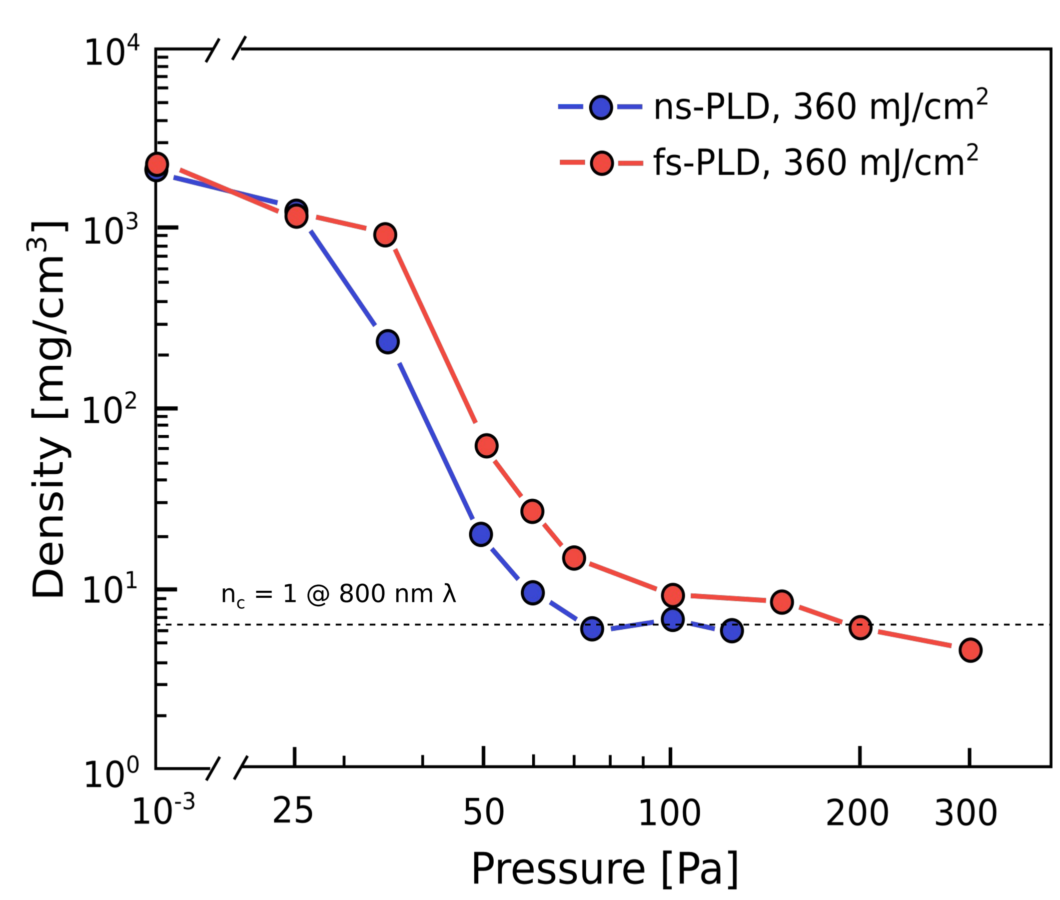


✓ Virtually any kind of substrate
✓ Versatility through process parameters [6]

Controlled **morphology** & nanostructure

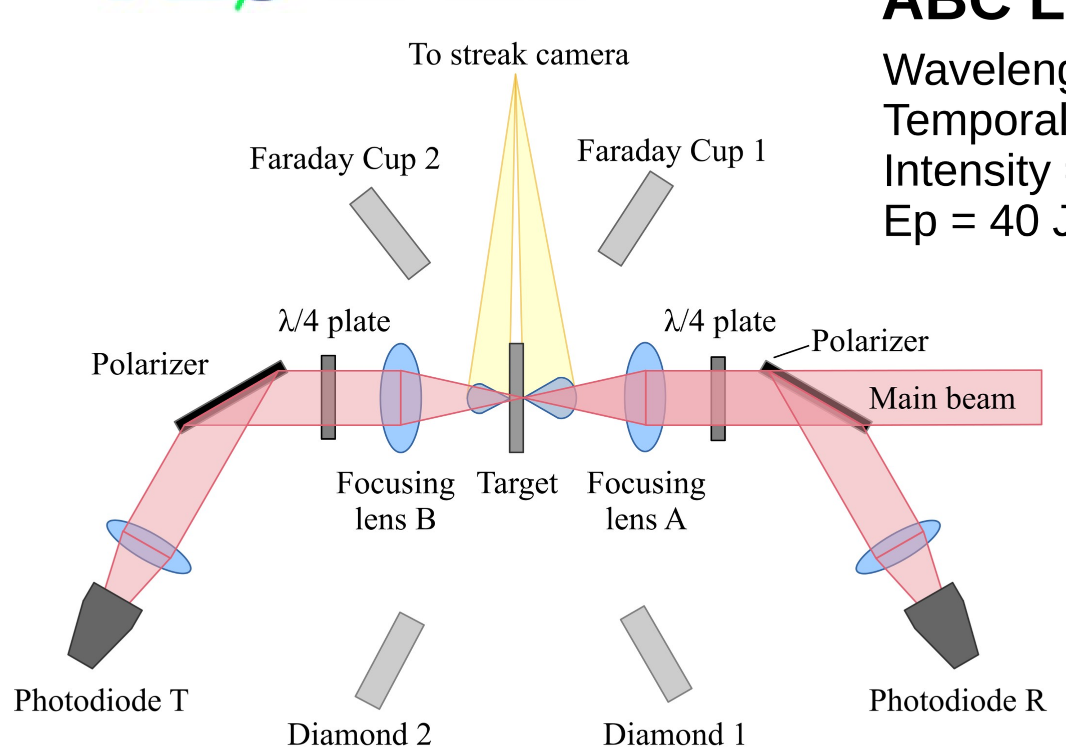


Tunable **density** (6 – 100 mg/cm²)



4 IRRADIATION EXPERIMENT @ ABC

ABC ENEA

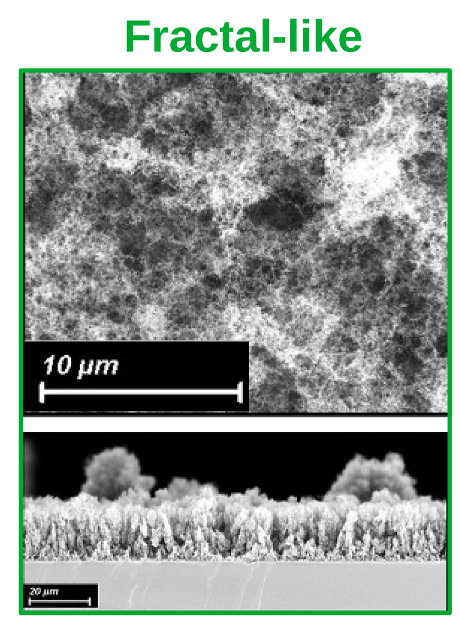


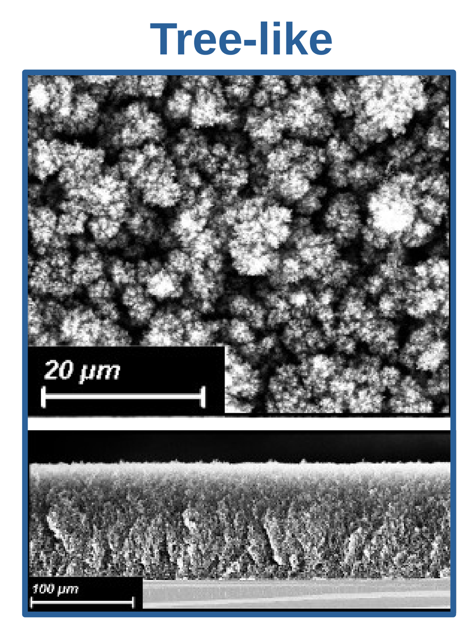
ABC Laser

Wavelength = 1054 nm
Temporal FWHM = 3 ns
Intensity = 10^{14} W/cm²
Ep = 40 J

Target configurations

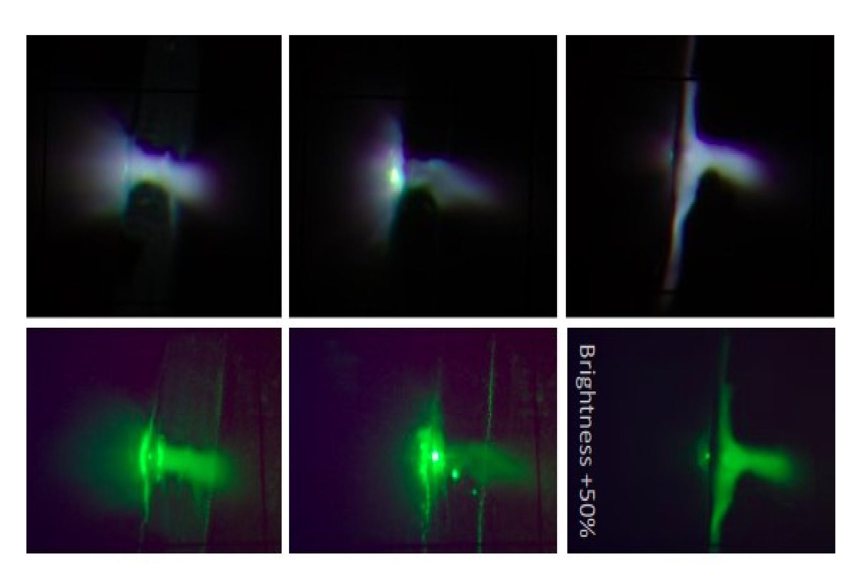
Substrates: 1.5 μm Al, thick Al disks
Nanofoam thickness: from 30 μm to 270 μm
fractal-like (6 mg/cm³) & **tree-like** (26 mg/cm³)



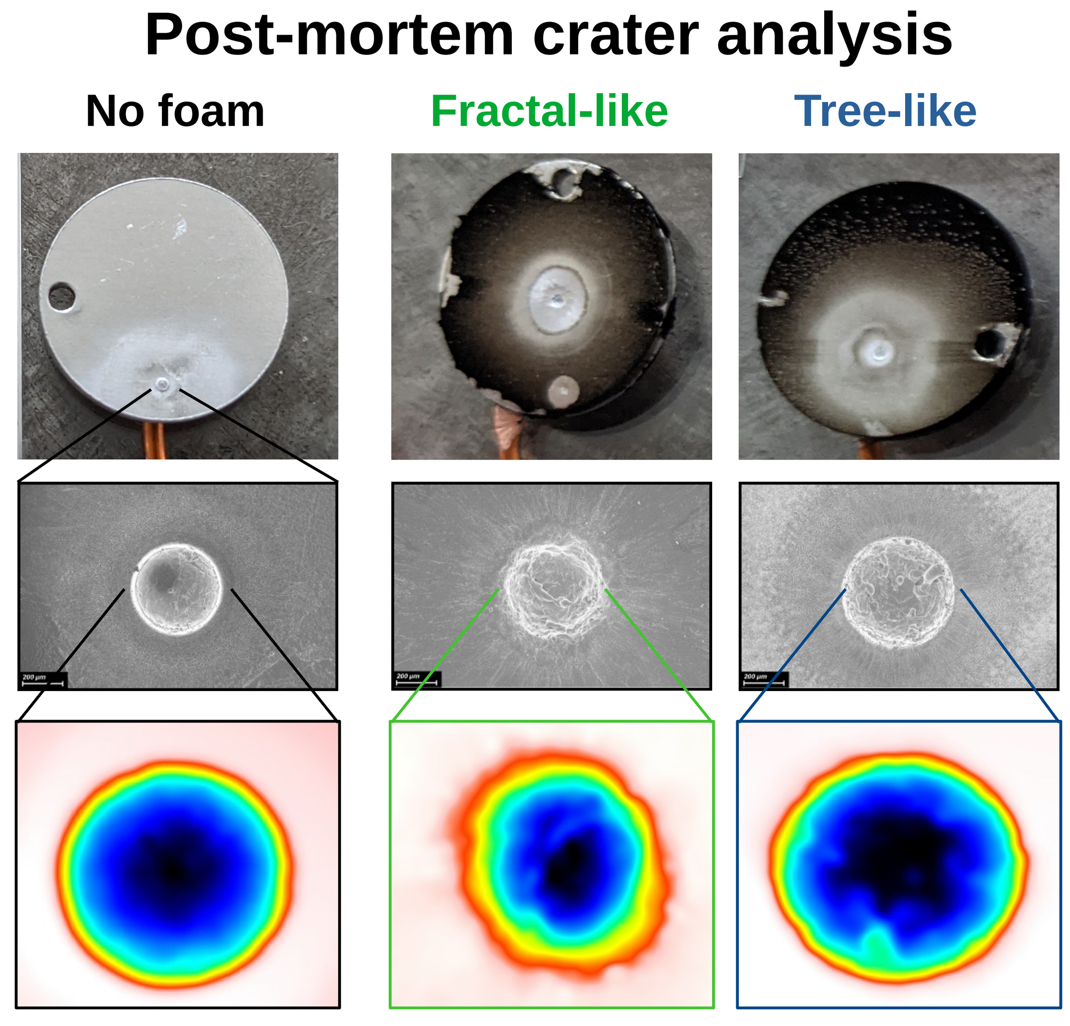


Diagnostic setup

Optical emission & streak camera
Interferometry & shadowgraphy
Particle & x-ray emission
Post-mortem crater analysis



Post-mortem crater analysis



5 CONCLUSIONS

- Carbon nanofoams potential as ICF ablators is confirmed
- Enhanced target loading and compression efficiency
- Future work: understand the role of nanofoam morphology (PIC+Hydro)
- Future work: optimize nanofoam properties for improved ICF performance.
- Future work: comparison with conventional plastic foams

6 REFERENCES

[1] M. Hohenberger et al., Physics of Plasmas, 27, (2020) 11270
[2] M. Lafon et al., Physics of Plasmas, 22, (2015) 032703
[3] I. Prencipe, et al. *New J. Phys.* 23.9 (2021): 093015.
[4] A. Maffini, et al. *EPJ tech. instrum.* 10.1 (2023): 15.
[5] A. Maffini, et al., *Laser and Particle Beams*, (2023) 1214430
[6] A. Maffini, et al. *Appl. Surf. Sci.* 599 (2022): 153859.