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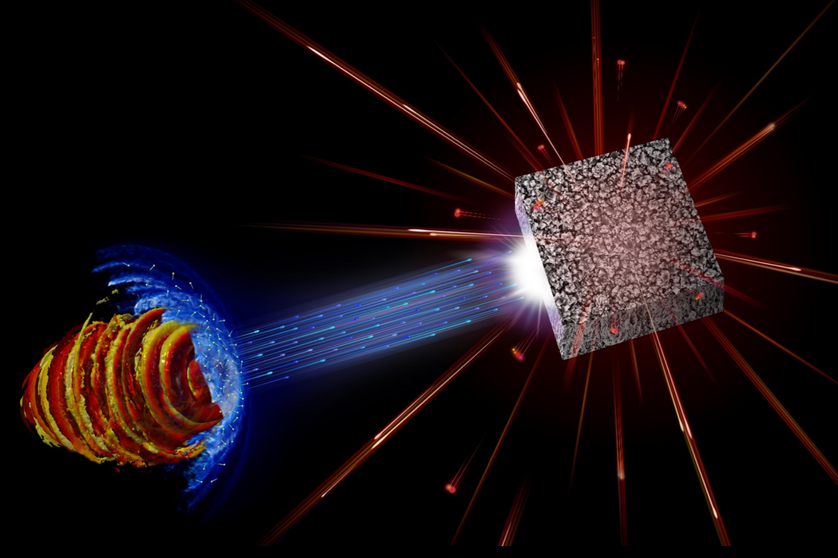
Target production for particle acceleration from laser interaction with near-critical nanostructured plasmas

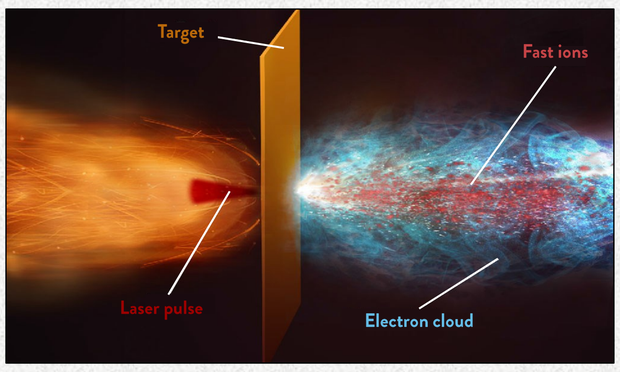
F. Mirani, A. Maffini, A. Galbiati, F. Gatti, K. Ambrogioni, M. S. Galli de Magistris, D. Orecchia, D. Vavassori, D. Dellasega, V. Russo, M. Zavelani-Rossi and M. Passoni

Department of Energy, Politecnico di Milano, Milan, Italy



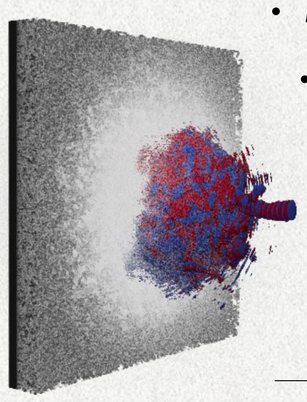
1 BACKGROUND

- **Plasma** generation via the interaction of an **ultrashort** (10s fs) **super intense laser** pulse (10^{18} – 10^{22} W/cm^2) **with a micrometric solid foil**. → **Acceleration** of high-energy (**1-10s MeV**) **e-** and **ions** [1].
- Double-Layer Targets (**DLT**) of **substrate + low-density nanostructured** layer [2].
  → **control** and **enhance** the **energy and number** of particles [3].
- Potentially **compact** and **flexible** sources. → Appealing for **applications** in **materials characterization** like Particle Induced X-ray Emission (**PIXE**) technique [4-6].

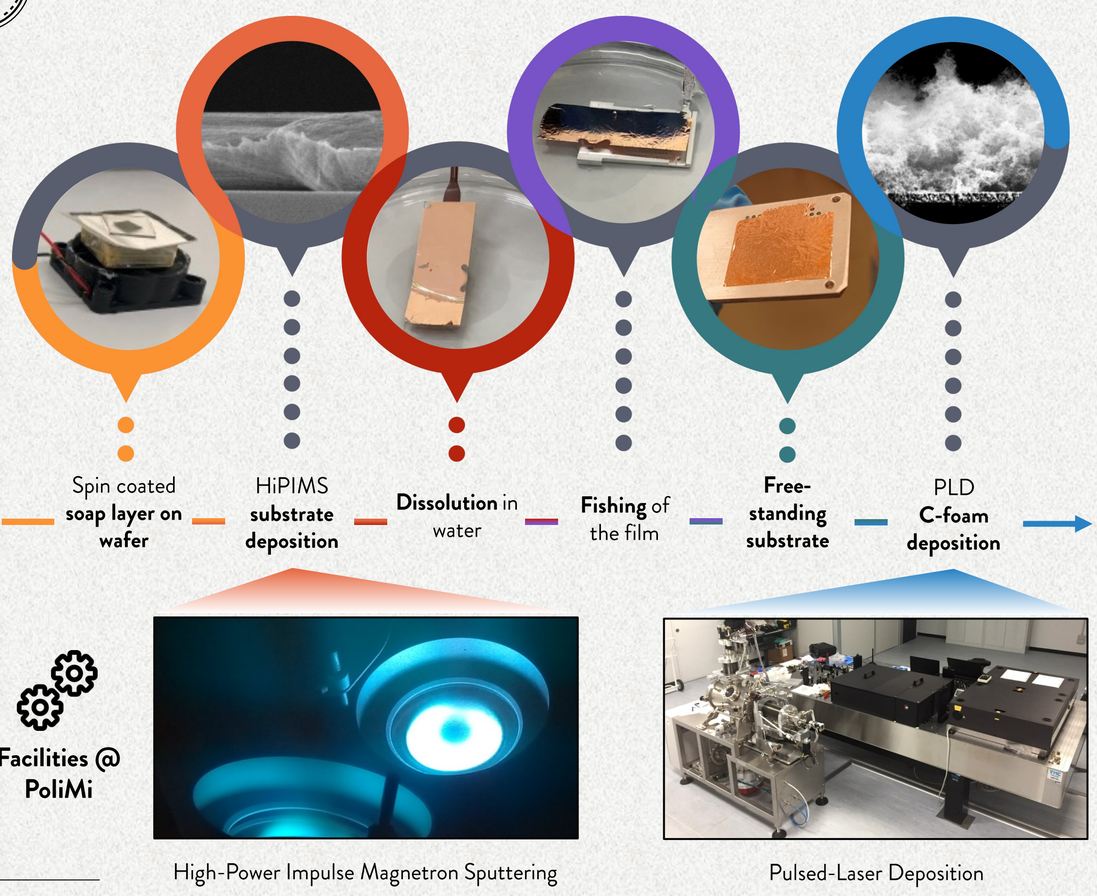


2 MOTIVATIONS & GOALS

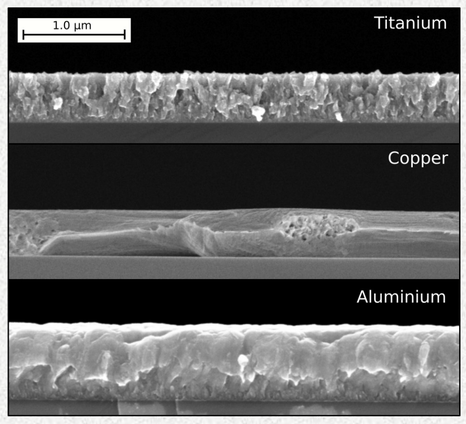
- Applications require **high stability** and **flexibility** of the exploited **radiation source.**
- Particle properties can be tuned **controlling** of the **laser-plasma interaction** process.
  - **Mitigate** the **laser requirements** acting on the target.
    - Development of a **procedure to engine DLTs** (substrate and carbon foam layer) with Magnetron Sputtering and Pulsed Laser-Deposition.
      - Assess the **applicability** of optimized **DLTs and 10s TW** commercial **lasers** for **environment monitoring** with **laser-driven PIXE** with Particle-in-Cell and Monte Carlo.

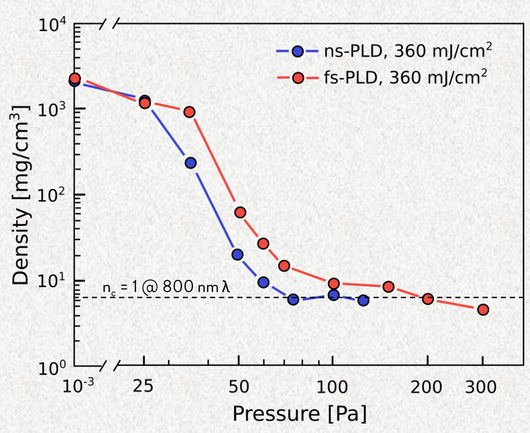


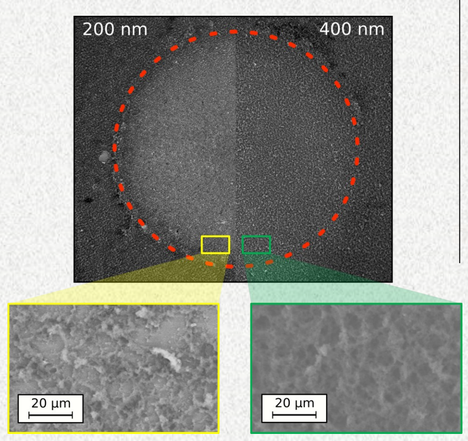
3 TARGET PRODUCTION



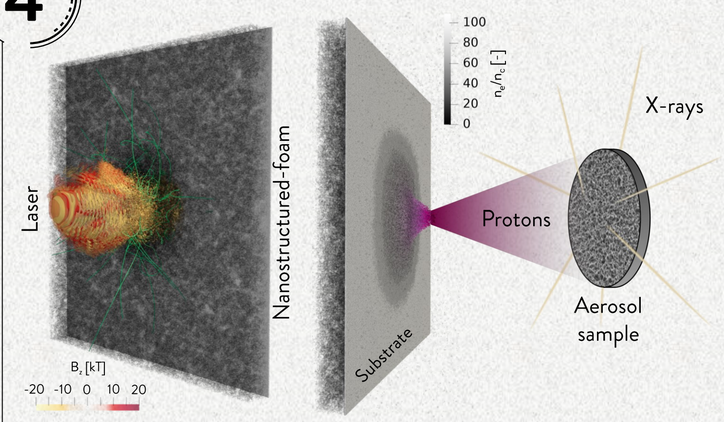
- Development of the **DLT preparation procedure** [7].
- Exploiting HiPIMS, bulk **substrates of different materials** (Ti, Al, Cu) are produced.
- Substrate thickness range between **50 nm to ~ 2 µm** with relative uncertainty < 5 % over several cm^2 area.
- **Control the C-foam thickness and density** (from bulk to critical plasma density) acting on PLD parameters [2].
- **Reduction of the C-foam deposition** rate for **thin substrates** (i.e. ≈ 300 nm) → **vibration of the film** during deposition → detachment of the aggregates.



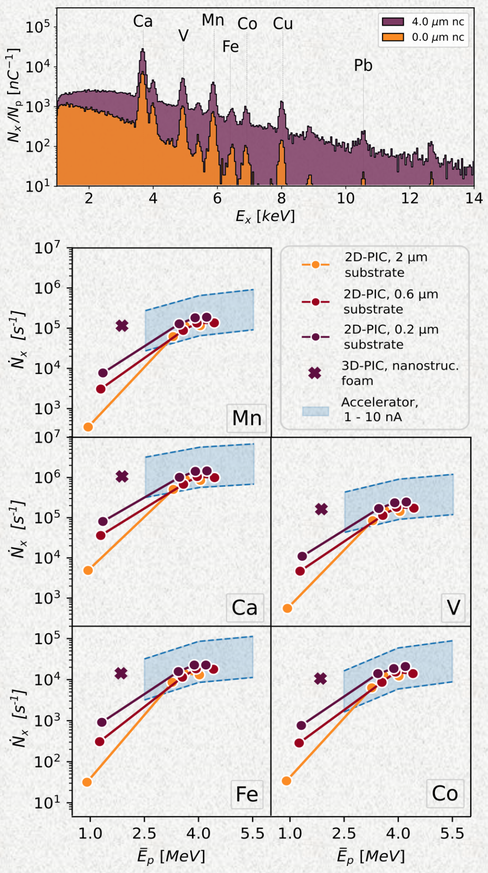




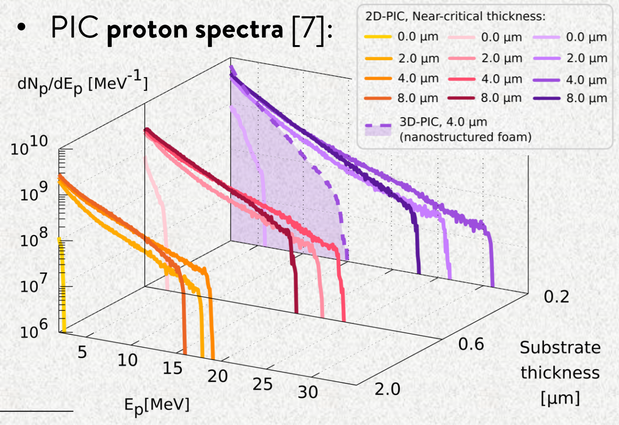
4 PIXE WITH LASER-GENERATED PLASMA



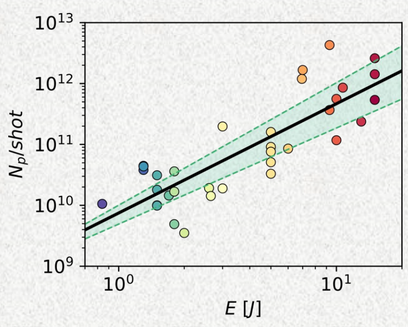
- 2D and 3D **PIC** WarpX simulations at **fixed laser parameters** (30 fs, 2.8 FWHM focal spot, 2.2 × 10^{20} W/cm^2). → Compact **20 TW system**.
- **Scan** over **DLT substrate** (0.1 – 2 µm) and **low-density layer thicknesses** (0 – 8 µm), fixed critical density. → **Control** the **proton maximum energy** from a few up to 10s MeV.
- Both homogeneous and **nanostructured plasma** (DLCCA aggregation model). → Effect of nanostructure: ↓ **max energy**, ↑ **laser absorption**.
- Proton spectra provided as input to GEANT4 **Monte Carlo simulations.** → **Estimate X-ray production** during laser-driven PIXE of aerosol samples.



- PIC **proton spectra** [7]:



- **Proton number** from expim. [8]:



- **1 – 3 orders of magnitude more characteristic X-rays** with DLTs compared with single-layer.
- Perform simulations also with **monoenergetic protons** and **comparison with laser-driven** source.
- **Same X-ray emission with DLT**-based laser-driven source **and** obtained with conventional TANDEM **accelerators.**

For further details, see the talk by Marta Galbiati

5 CONCLUSIONS

- **Fully optimized DLTs** can be produced **combining HiPIMS** and **PLD** techniques.
- **Control** DLT **thickness** & **density** → **tune plasma properties** and accelerated particle energy and number (**nanostructure plays a crucial role**).
- **20 TW** laser and **DLTs** allow performing **laser-driven PIXE of soil samples** with same performances of conventional accelerators.

6 REFERENCES

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7 ACKNOLEDGEMENT & CONTACTS

ERC-2022-PoC No. 101069171 PANTANI

CINECA

NanoLab

www.ensure.polimi.it

francesco.mirani@polimi.it