Plasma Components

K. Cassou (CNRS/IJClab) on behalf of LOA (C. Thaury, J. Faure), LPGP (B. Cros)

Multi-scale gas jet target

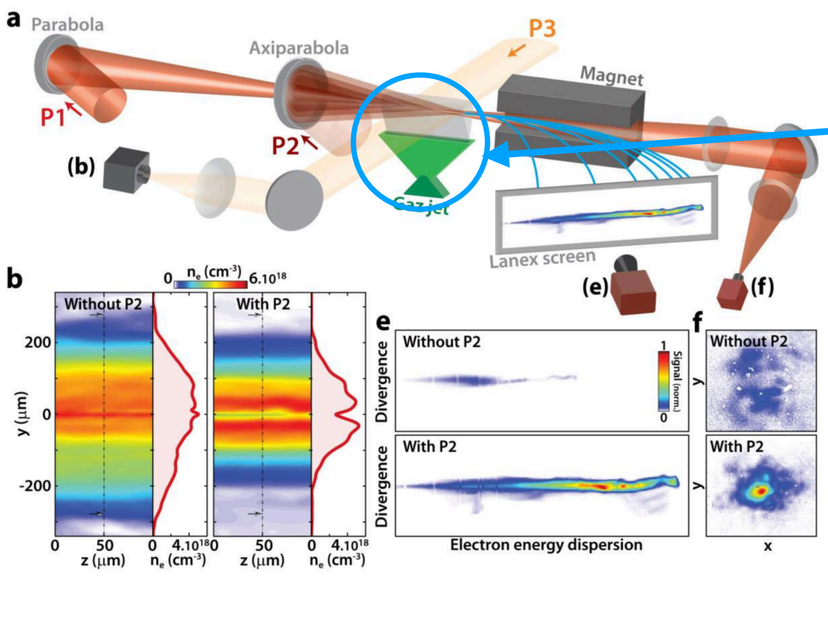
R&D objectives

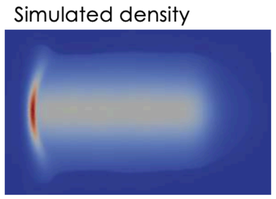
- Development of **multi-scale gas jet targets: from 100 µm to 10 cm**

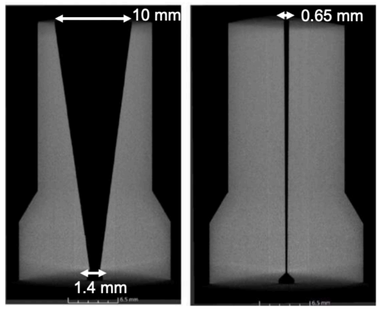
- Development of techniques for structuring plasma density (shocks, precursors, multi-jets, etc.)

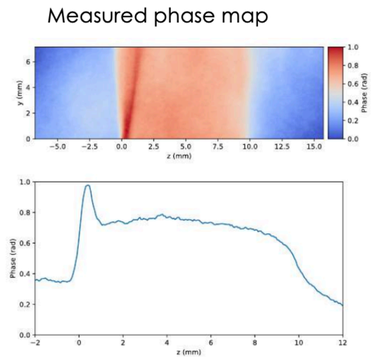
- Development of **jets for high rate** (continuous or pulsed flow, pumping issues) and high medium power (resistance to laser and plasma and plasma damage)

Long gas jet, >50 TW laser guiding

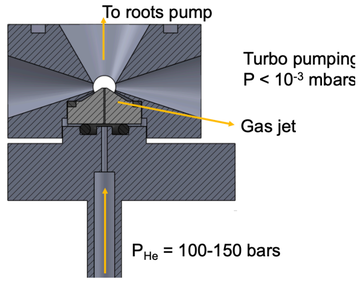




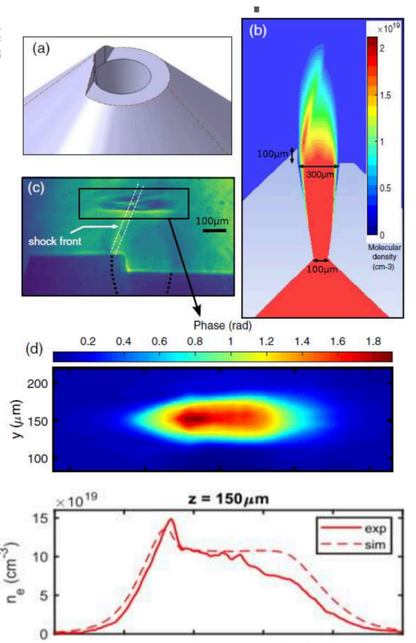




kHz high density micro gas jet



src: LOA, kHz LPA line



Oubrerie, K., Leblanc, A., Kononenko, O. *et al*. Controlled acceleration of GeV electron beams in an all-optical plasma waveguide. *Light Sci Appl* **11**, 180 (2022). https://doi.org/10.1038/s41377-022-00862-0

FLSE technique: V. Tomkus et al. Opt. Express **26,** 27965 (2018) L. Rovige et al., RSI **92**, 083302 (2021)

Multi-scale gas jet target

Available facilities

Currently: laser 80TW Salle Jaune and Apollon laser for centimetric gas jets. Laser Salle Noir for kHz and micro-jet developments

From 2024: the LAPLACE-HC platform for high speed / high medium power 100 Hz, 50W

Beam time :

substantial beam time as development is integrated with current activities

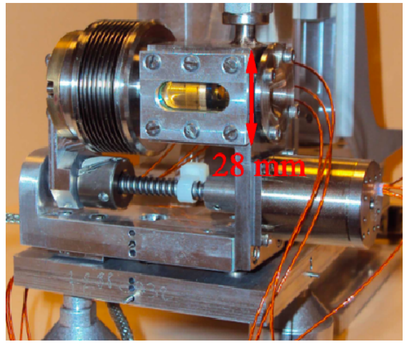
Resources :

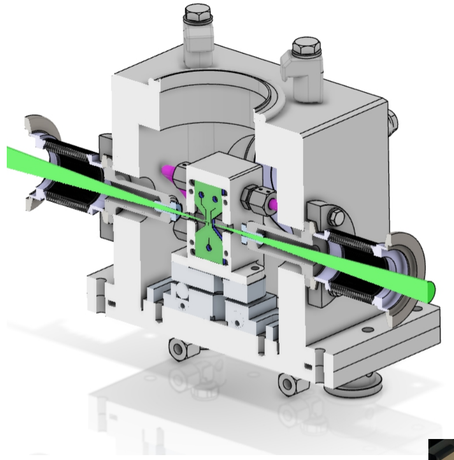
2 research teams ~10 FTE
Collaboration with LTS-FMS Center for physical sciences (Lt)

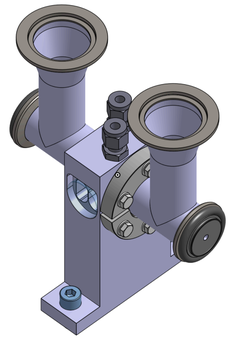
Funding :

IFAST MILPAT (very modest) and important regional public funding for **LAPLACE** project

Gas cell target development

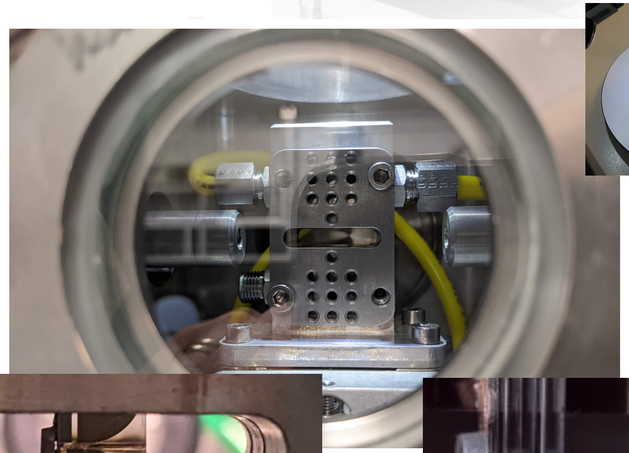


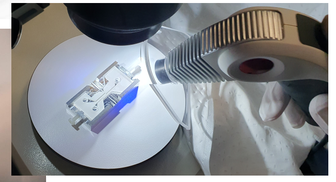


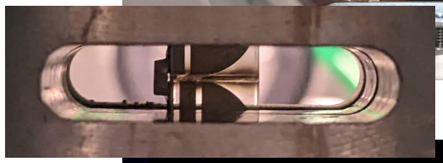


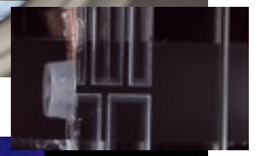
R&D objectives

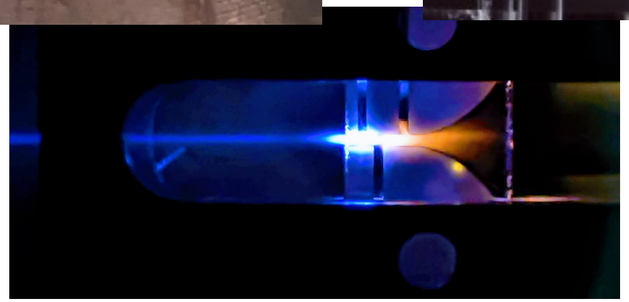
- Inline integrated target
- continuous gas flow operation
- Power dissipation
- Density out ramp control
- transverse optical access for diagnostic

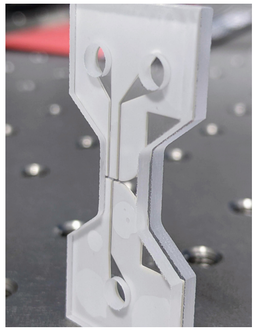


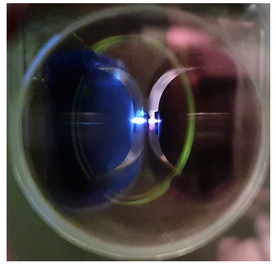


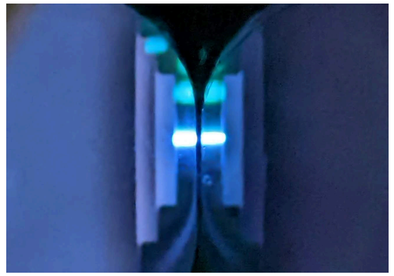












Gas cell type

- Channel type
- Gas slab type
- Variable length cell (ELISA LPGP)
- Waveguide structure (LPGP)

Gas cell target test bench & test facilities

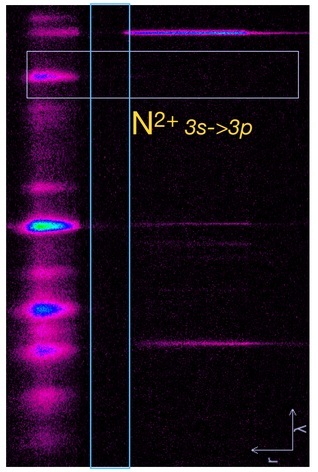
Currently : dedicated test bench for inline plasma target

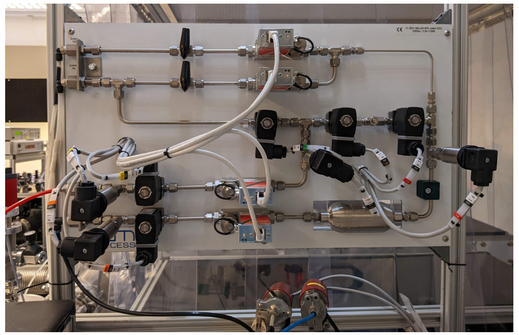
2.5 TW 10Hz, 50 fs laser with synchronized probe [- 50 ;+ 150 ps]

Plasma diags :

- density measurement (SID4-HR),
- visible spectroscopy (2D imaging spectrometer)
- target lifetime diagnostics / aperture imaging

+ national (LOA) and European collaboration in EuPRAXIA framework (LNF)

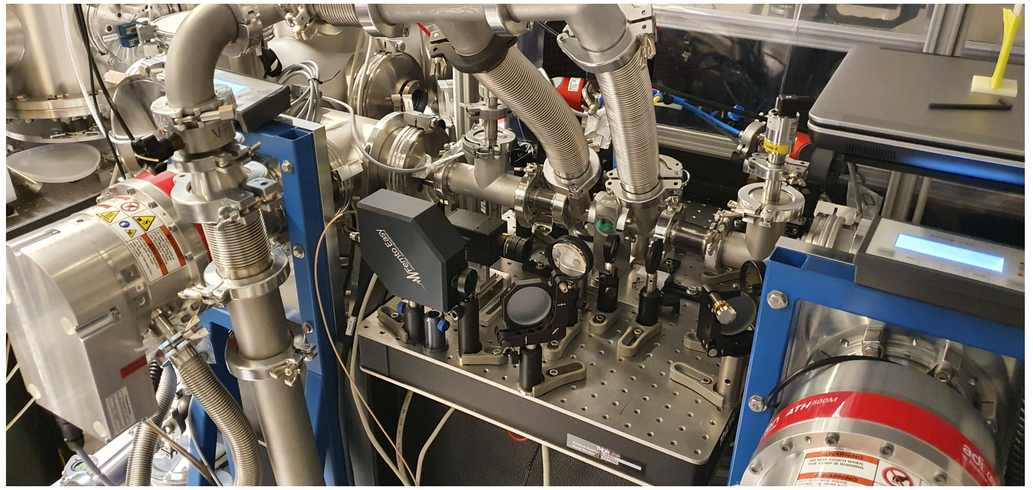




By 2024 : PALLAS test facility

50 TW 10Hz laser driver with advanced control inline target positionner

With complete characterization e- beamline (beam transport focusing, spectra, charge, position, …) emittance, collimation studies



Beam time : 22 weeks / year + extra on test bench

Resources : one team ~ 10 FTE

Funding : ANR-PACIFICS, IN2P3-PALLAS

Developing industrial collaboration for target manufacturing

Possible topic of joint work

- Reliable and accurate plasma density diagnostics with large dynamic 10^{15} - 10^{18} cm^{-3} . Currently stuck to 3-10% precision on electron density. Accurate measurement on pressure or flow (~ 0.2-0.5%)

- Development of common open source tools for plasma diags - reproducibility of phase map analysis

- Long plasma cell / jet (HOFI oriented)

- Integration of micro mechanic of ceramic, gas flow management and heat dissipation optimized components, shields

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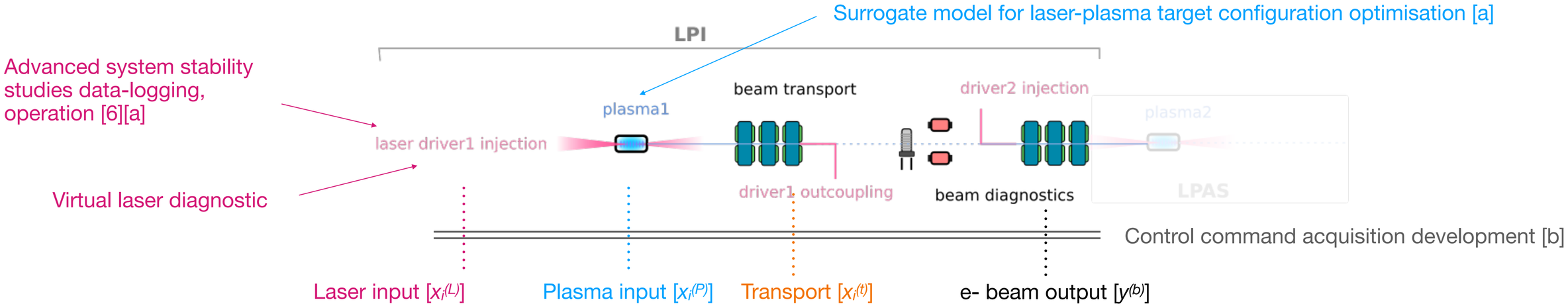
What kind of target for kHz/kW LPA ?

Control command and online optimisation of LPA

Application of **ML to laser-driven plasma accelerator** is growing, plenty of nice work reported since a few year [1,2,3,4,5…]

In the context of advanced accelerator high quality beam laser plasma injector R&D at IJClab (PALLAS project) : 10 Hz 200MeV LPI test facility to improve **quality and stability of e- beam generated by laser-plasma accelerator**.



[a] Starting with sub-system optimisation

Sub system stabilisation and optimisation :
- laser system data-logging
- laser - closed loop (HW) / auto compensation drift (BW)
- Virtual diag for STC (see afternoon slides)
- Tango DS development

[b] Data acquisition development [8]

Timestamped data in archived in HDB++ timeScaledB
Distributed control command (Tango Controls) ease deployment
Development of device server specific for LPA/LPI
Open data

[1] : A. Döpp et al. arXiv:2212.00026 [2] M. Kirchen et al., & S. Jalas 10.1103/PhysRevLett.126.174801 [3] M.Streeter et al. doi:10.1017/hpl.2022.47 [4] R. Shalloo et al. arXiv:2007.14340 [5] F. Irshad et al. arXiv:2303.15825 [6] Lin et al. doi;10.1017/hpl.2023.1 [7] P. Drobniak et al arXiv:2305.09264. [8] S. Feister arXiv:2306.01661

Control command and online optimisation of LPA

Possible joint work

Very long journey from demo experiment to full control and automated system….

Integration of « high level blackbox optimizer » for LPA

Work on training of model for laser control and stabilisation

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