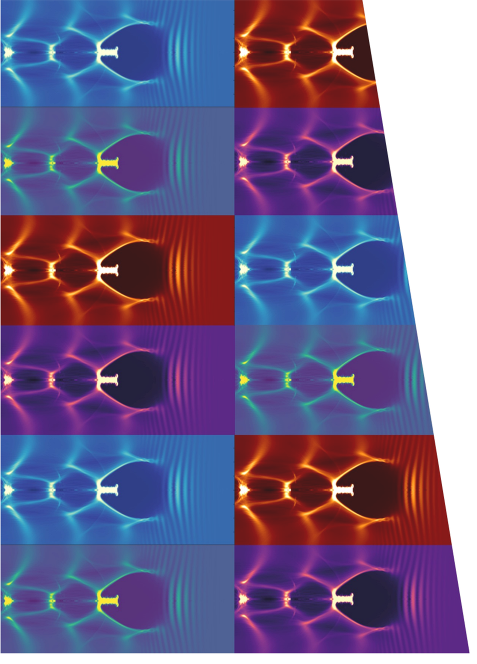

Breaking new ground: first electron acceleration with an industrial Yb:YAG laser at 2.5 kHz

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Industrial applications call for industrial lasers

Laser plasma accelerators working at **kHz repetition rate** [1, 2, 3, 4, 5] can be disruptive in a wide range of applications:

- Time resolved studies
- Imaging and medical treatment
- Industrial processing

Industrial lasers are turn-key systems which deliver milliJoule pulses and can be extremely useful for the goal:

- High repetition rate
- Reliability
- Stability

Yb:YAG lasers (1030 nm) can efficiently drive a plasma accelerator

From milliJoule, picosecond pulses to relativistic intesity with a 200 W laser

Post-compression techniques enable pulse compression beyond the initial transform limited duration [6]:

- Spectral broadening
- Dispersion compensation

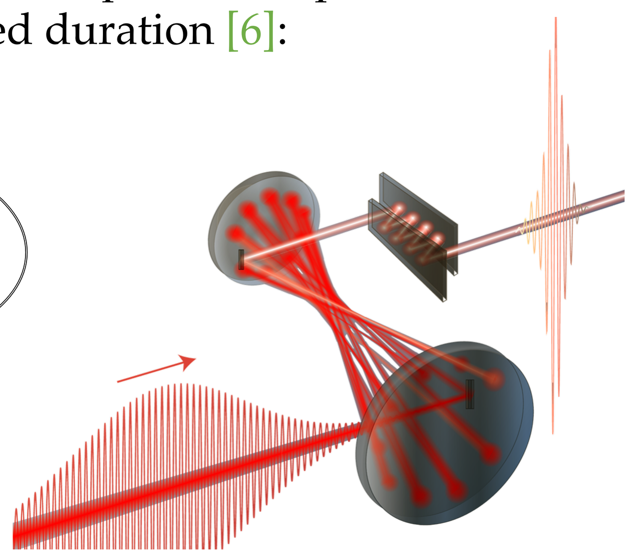


Fig 1: General scheme of a multi-pass cell (MPC) post-compression setup.

Combined with a **strong focusing**, they allow the intensity needed to drive the laser plasma interaction to be reached:

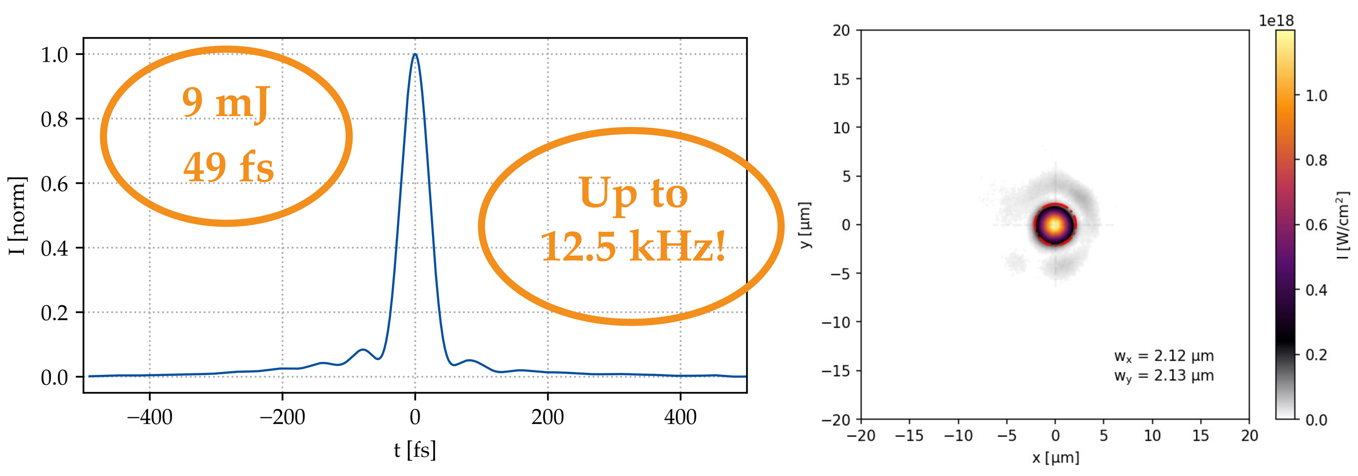
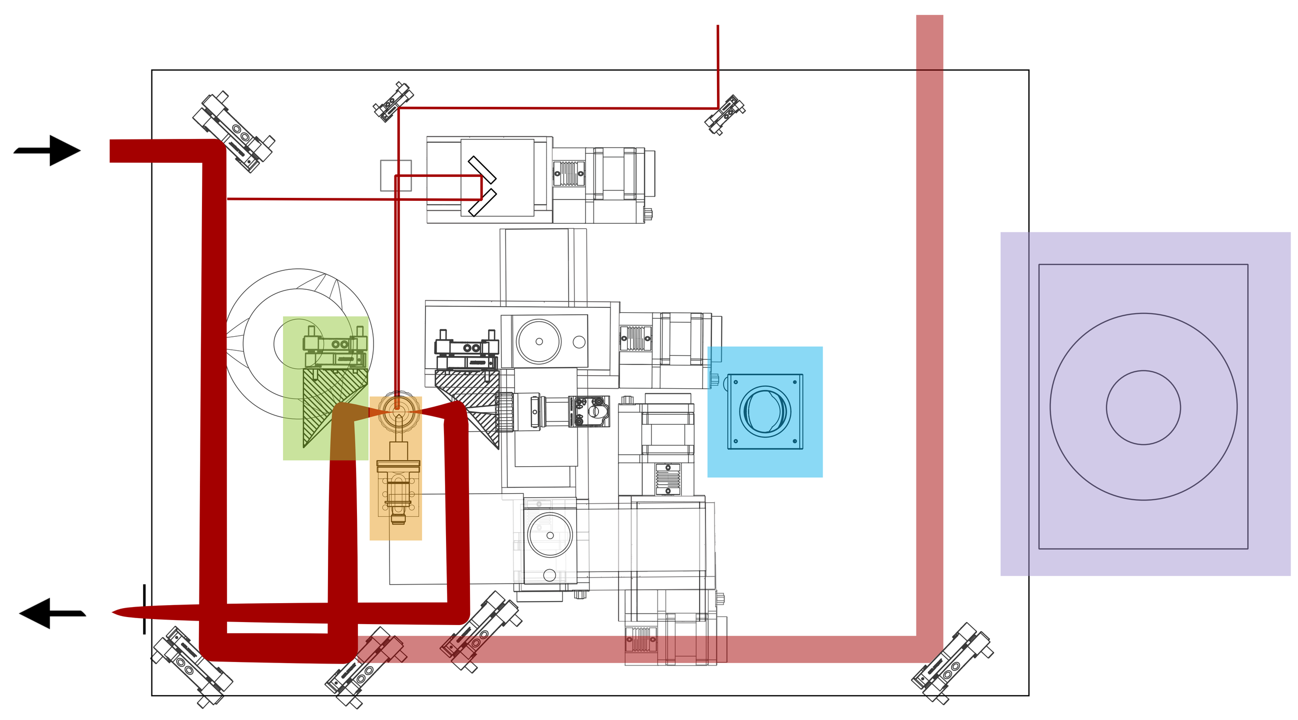


Fig 2: FROG retrieved pulse temporal profile at the interaction point (left) and corresponding laser spot size (right).



- Off-axis parabola
- Plasma source
- Electron profile screen
- Radiation detector

Fig 3: Scheme of the acceleration chamber, with the key components marked in different colours.

MilliJoule lasers require stable, micrometer-scale plasma sources

Supersonic de Laval nozzles enable long-term, high average power operation

Supersonic nozzles [7] are easy to manufacture, easy to operate and allow free optical access for plasma diagnostics.

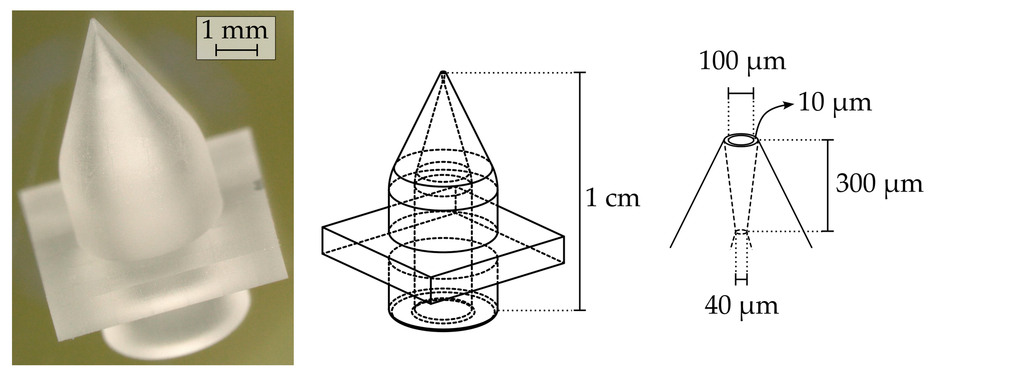


Fig 4: Selective laser etched supersonic nozzle, designed in-house and produced by LightFab.

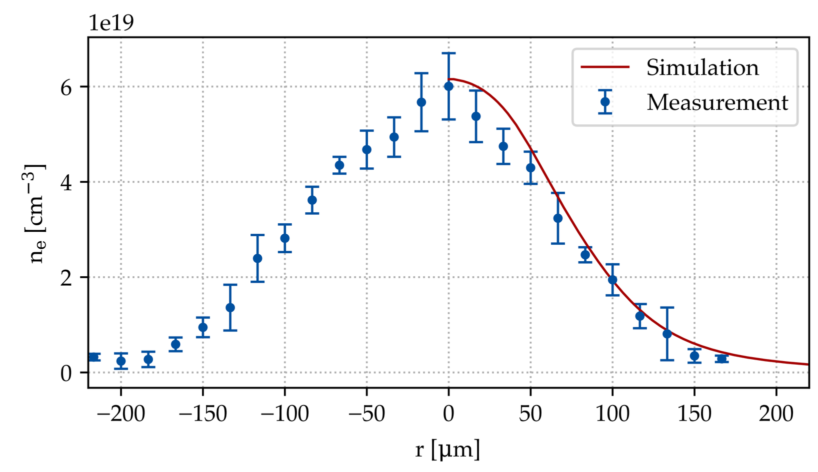


Fig 5: Typical plasma density profile, obtained 230 μm above the nozzle with 23 bar of backing pressure of N_2. The measured density (blue) is compared with the simulated one (red).

The first electron acceleration driven by an industrial Yb:YAG laser has been achieved!

Demonstrated a record repetition rate acceleration of 2.5 kHz

Clear electron signal has been measured on the electron profile screen and on the main radiation detector [8]. The signal could be optimised through: (1) plasma source backing pressure, (2) plasma source position, (3) laser compressor configuration. Results are still under analysis [9].

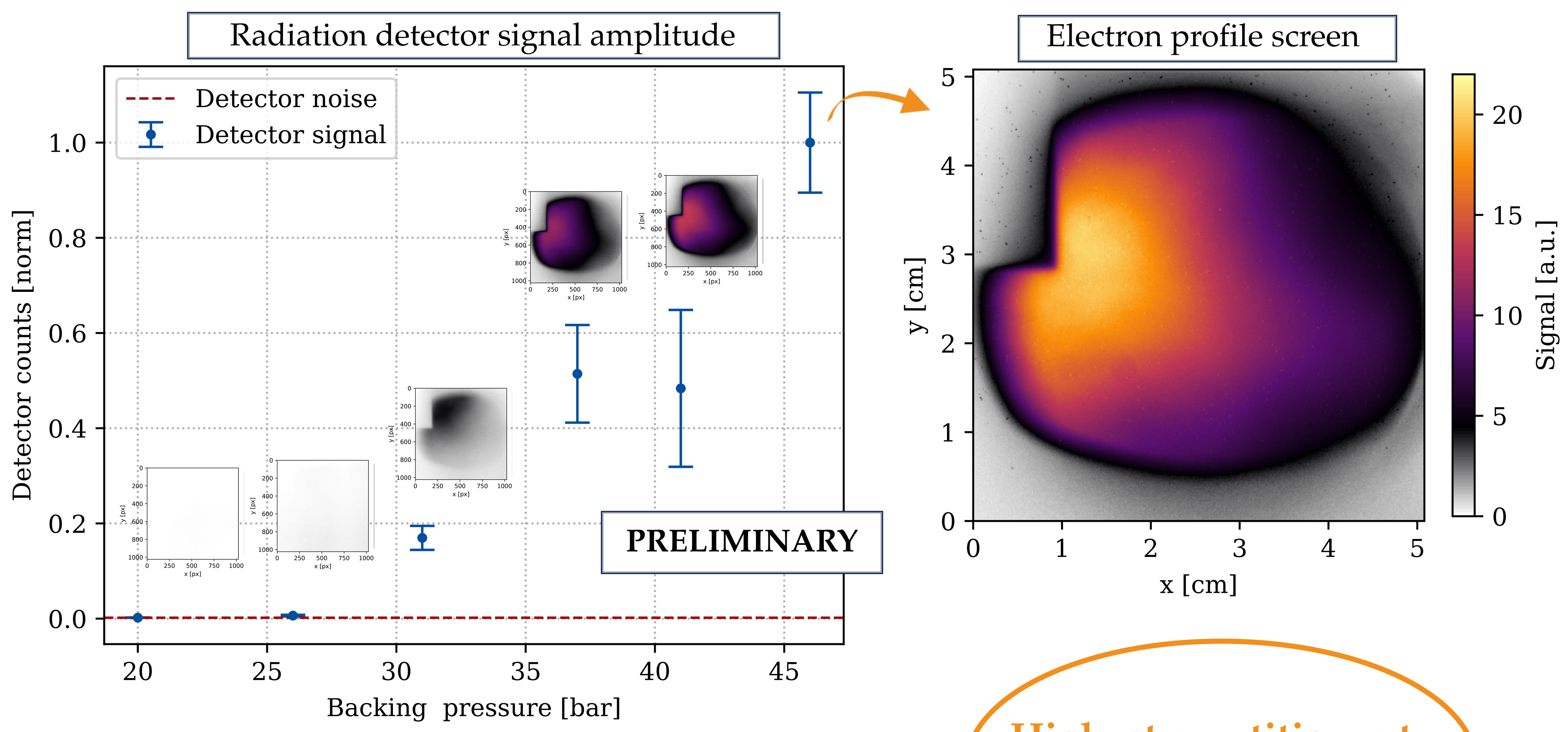


Fig 6: Radiation detector signal and electron profile screen images as a function of the nozzle backing pressure (nitrogen). The profiles shown are averaged over 20 images, each one integrating 12 laser shots [9].

Highest repetition rate registered to date!

Currently operating at 2.5 kHz, the system is designed to go **beyond 10 kHz!**

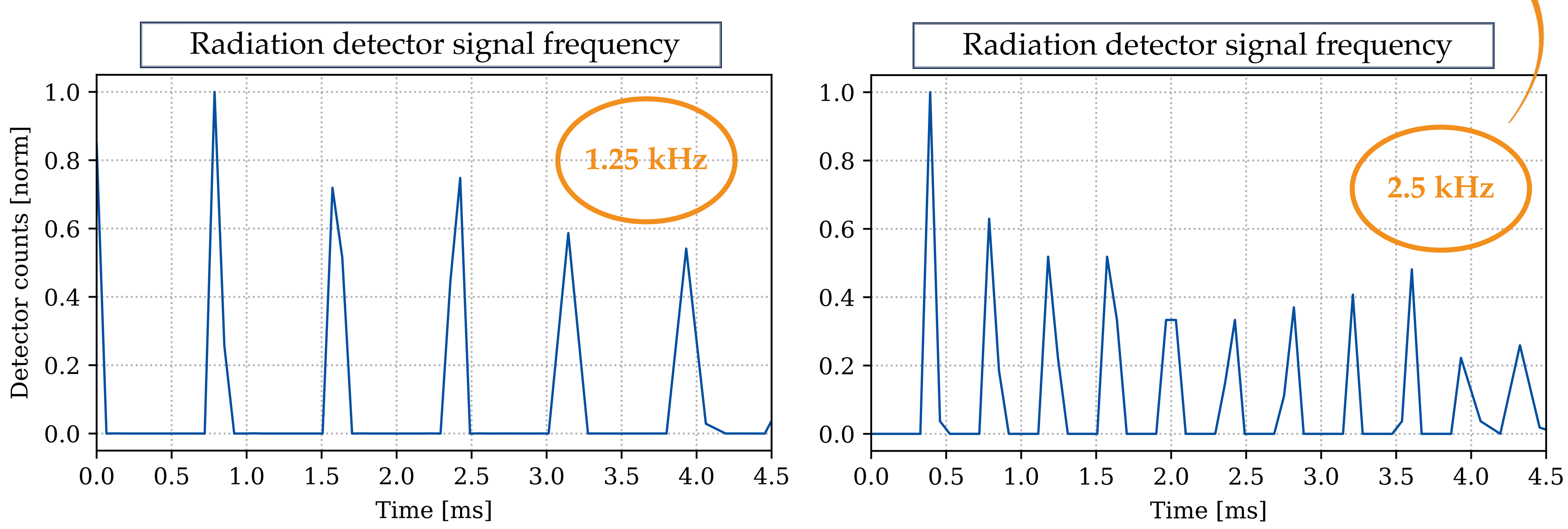


Fig 7: Radiation detector signal frequency, showing electron acceleration at 1.25 kHz (left) and at the record repetition rate of 2.5 kHz (right) [9].

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