

# KAIO Accelerator

Boosting the broad dissemination of Laser-Plasma Accelerators



***R. Lopez-Martens***



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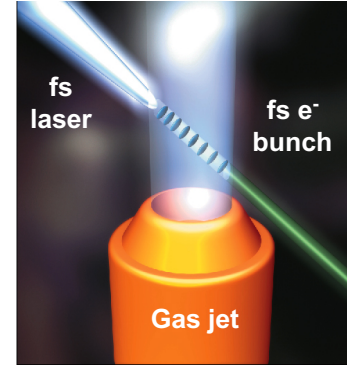
***F. Sylla***



***F. Canova***

# High repetition rate Laser-Plasma Accelerator (LPA)

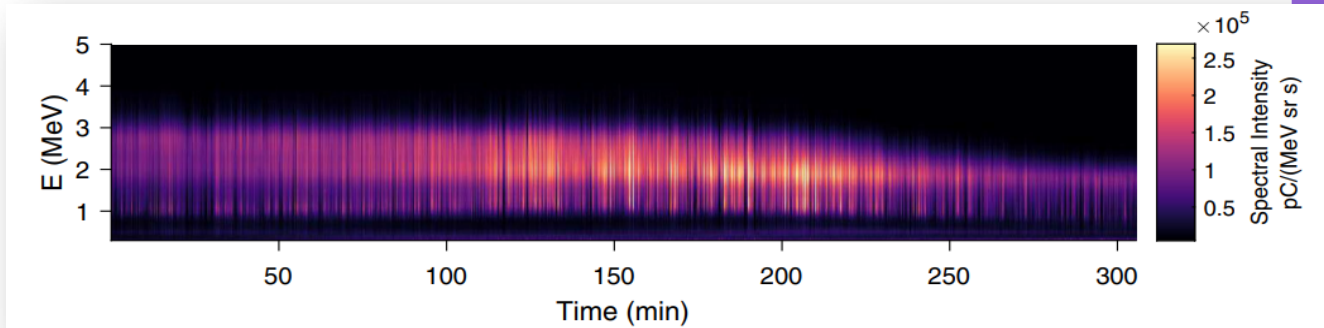
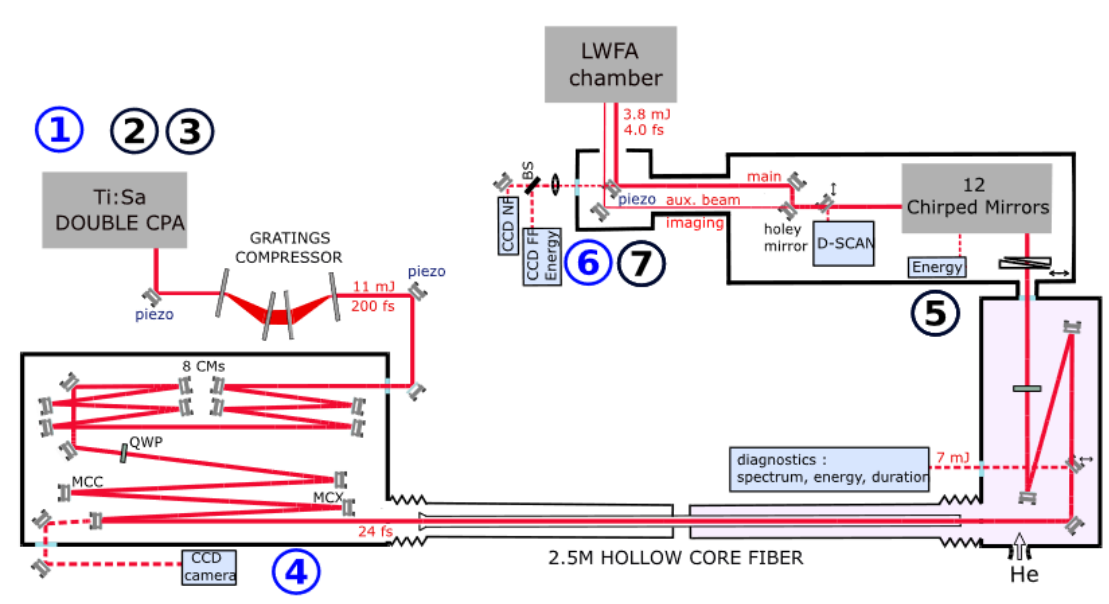
**Complex 30 fs laser + nonlinear pulse compression down to few-fs duration: 3 mJ, 4 fs on target**



**Resonant electron acceleration in a high-pressure μm gas jet target @ 1 kHz**

$$\text{Resonance condition: } \tau c \simeq \frac{\lambda_p}{2}$$

**Continuous LPA operation over 5 hours:**



**Scaling laws:**

$$E_L \propto \tau^3 \propto \lambda_p^3$$

$$\Delta E \propto \tau^2 \propto \lambda_p^2$$

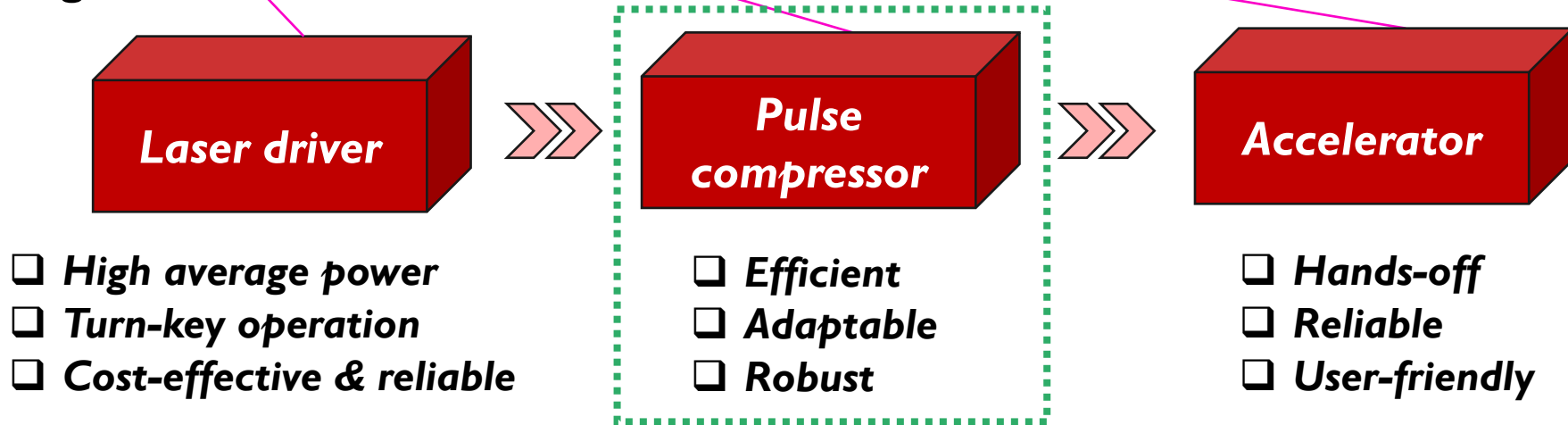
**Laser energy = 3 mJ  
Laser duration = 3 fs**

**→ 1 - 10 MeV electrons**

Guénot, D., et al. "Relativistic electron beams driven by kHz single-cycle light pulses" *Nature Photon* 11, 293–296 (2017)  
 Rovige, L., et al. "Demonstration of stable long-term operation of a kilohertz laser-plasma accelerator" *Phys. Rev. Accel. Beams* 23, 093401 (2020)  
 Beaurepaire, et al., "Electron acceleration in sub-relativistic wakefields driven by few-cycle laser pulses" *New Journal of Physics* 16, 023023 (2014)  
 Cavallone, M., et al., "Dosimetric characterisation and application to radiation biology of a kHz laser-driven electron beam" *Appl. Phys. B* 127, 57 (2021)



**Enabling technologies:**



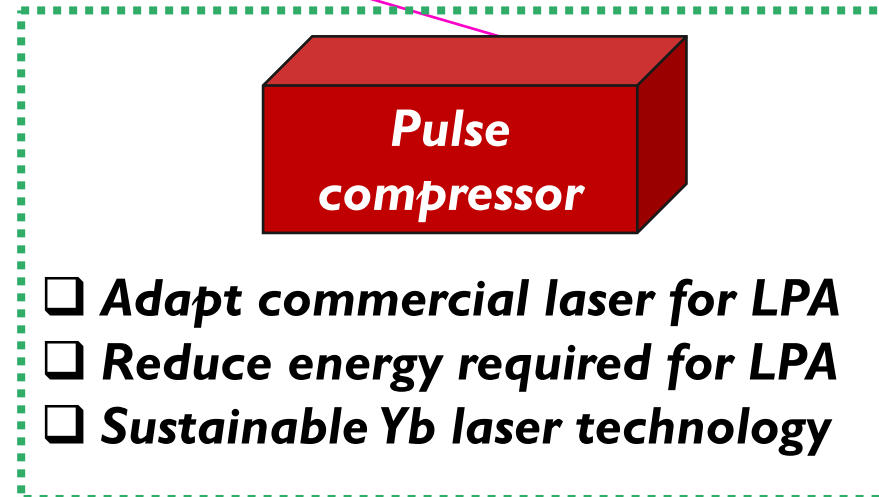
**Scope of KAIO-ACCELERATOR**



## Radiobiological testing



## Market study



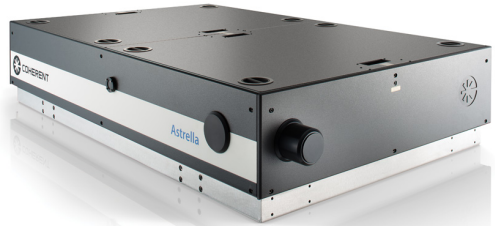
Scope of KAIO-ACCELERATOR



## Commercial lasers

- ✓ High rep rate
- ✓ mJ energies
- ✗ few fs duration

Ti:Sa based system (~30fs)



ASTRELLA from Coherent  
(1 kHz, 9 mJ, 30 fs)

Yb based system (~100fs-1ps)



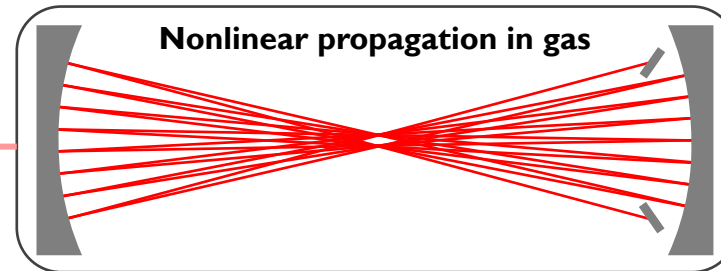
DIRA from Trumpf Scientific Lasers  
(3 kHz, 30mJ, 1 ps)



MAGMA from Amplitude Lasers  
(100 Hz, 25mJ, 500 fs)

## Pulse compression: Multi-pass cell (MPC)

- ✓ High rep rate
- ✓ Energy scalable
- ✓ Few-fs duration



**Few-fs, mJ-class MPC @ LOA**  
*Daniault et al., Optics Letters 46 (2021)*

## Technological benchmarking for KAIO-ACCELERATOR

## Commercial LPA (KAIO from SourceLAB)

- ✓ High rep rate
- ✓ MeV electrons
- ✓ Commercial product



Electron beams for applications

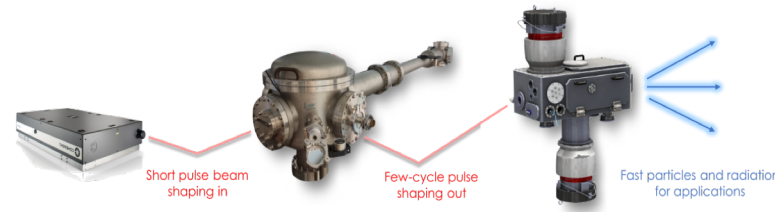


KAIO Specifications	
Pulse energy	2 – 500 mJ
Spectral bandwidth	500 – 1000 nm
Laser aperture	< 50 mm
Pulse duration	3 - 30 fs

# KAIO-ACCELERATOR: workplan

T0 + 6  
DLI: report

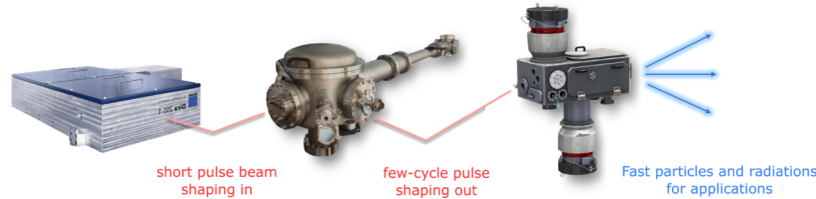
**WP 1**  
CNRS/LOA  
SourceLAB



- ASTRELLA system
- 7 mJ, 35 fs, 1 kHz
- MPC: 5 mJ, 5 fs, 1 kHz**
- 1<sup>st</sup> commercial LPA**

T0 + 12  
DLI: report

**WP 2**  
CNRS/LOA  
SourceLAB



- DIRA & MAGMA systems
- 10 mJ, 40 fs, 3 kHz
- MPC-NER: 5 mJ, 5 fs, 100 Hz - 3 kHz**
- 1<sup>st</sup> Yb-based commercial LPA**

T0 + 15  
DLI: report

**WP 3**  
CNR/INO  
CNRS/LOA  
SourceLAB

## Radiobiology tests (DNA single-strand breaking)

- Dosimetry of e-KAIO electron source
- Dose escalation study with e-KAIO
- Assess viability vs conventional electron source**



T0 + 24  
Final report

**WP 4**  
DF Consulting  
SourceLAB

## Managment, dissemination, exploitation

Q4 2024

# KAIO ACCELERATOR: resources and budget

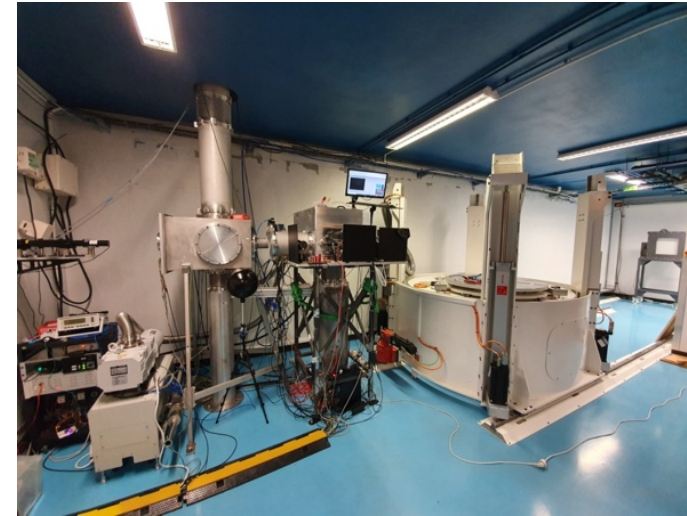
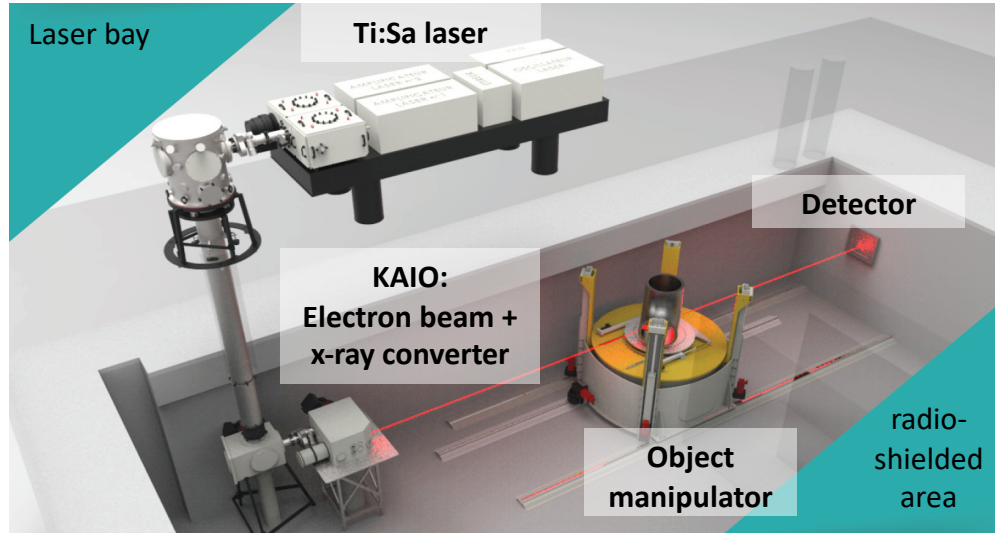
- **CNRS/LOA (Main beneficiary):** 2 researchers, 2 engineers, 2 PhD students
- **CNR/INO (Partner beneficiary):** 2 researchers, 1 postdoc, 1 PhD student
- **Sub-contracting:** DF Photonics Consulting
- **SourceLAB SAS:** e-KAIO, ASTRELLA and DIRA laser systems (*in kind*)

Project	WP1-10W	WP2-100W	WP3-Bio-tests	WP4-Mgt Diss	
Activity	RTD	RTD	RTD	DEM	Total
Man Months	6	6	5	3	20
Labour Cost	25 800	25 800	20 200	11 600	83 400
Travel	2 000	2 000	6 000	3 000	13 000
Equipment	-	-	-	-	-
Consumables	-	42 600	5 000	-	47 600
Other	-	-	-	-	-
Audit	-	-	-	-	-
sub total	2 000	44 600	11 000	3 000	60 600
overhead	6 950	17 600	7 800	3 650	36 000
Sub-Contract	-	-	-	20 000	20 000
Budget	34 750	88 000	39 000	38 250	200 000
Funding Requested	<b>34 750</b>	<b>88 000</b>	<b>39 000</b>	<b>38 250</b>	<b>200 000</b>

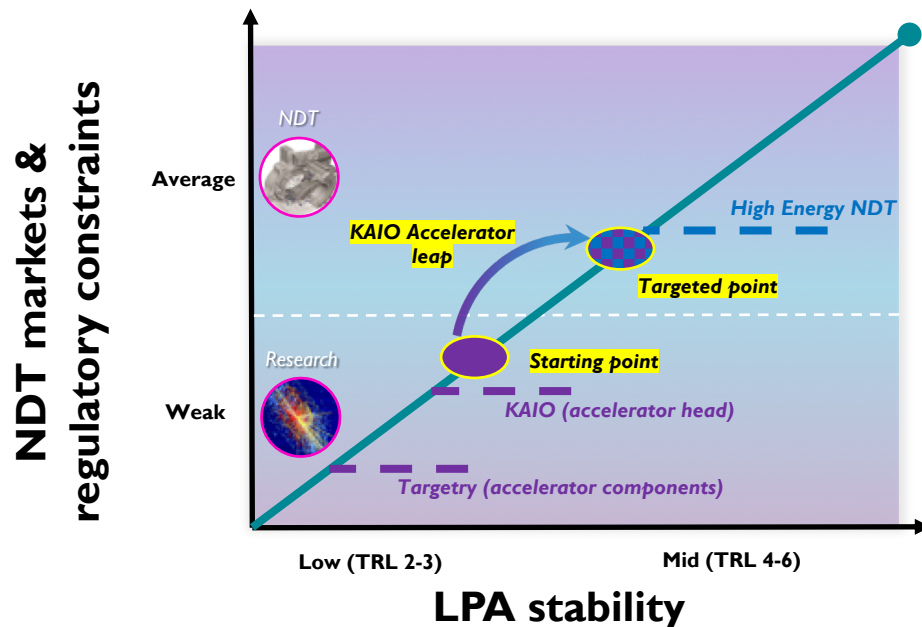
Partner No	Partner	Country	EC Budget	% Budget
1	CNRS/LOA	France	€180 000,00	€0,90
2	CNR/INO	ITALY	€20 000,00	€0,10
<b>Total</b>			<b>€200 000,00</b>	<b>€1,00</b>



# KAIO ACCELERATOR: development and impact



KAIO-based Non-Destructive Testing (NDT) platform with a 10 Hz Ti:Sa laser (SHERIL platform at LOA)



## Commercial LPA devices for science and industry

- ❑ Yb lasers: high wall-plug efficiency, reliable, high power
- ❑ KAIO module: integrated, adaptable, user-friendly
- reliable LPA beams for applications
- increased TRL to address NDT market
- few-10 to few-100 LPA devices/year



***Thank you for you attention !***

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[https://www.ino.cnr.it/?page\\_id=16599&p=a35](https://www.ino.cnr.it/?page_id=16599&p=a35)