THALES
Building a future we can all trust

Extreme Lasers & applications

Christophe SIMON-BOISSON

EPIC online technology meeting
28th October 2024

www.thalesgroup.com

Summary of Thales laser activity

A world leader in high-power solid-state laser systems

- Over **30 years of laser expertise**
- **World record 1 petawatt (PW) laser** with the BELLA system (USA) in 2012
  World record 10 PW with ELI-NP system (Romania) with one beam in 2019
- Laser solutions for **industrial processes** and new **medical applications**
- **World's only company** to send operational laser to Mars (with CNES and NASA) in 2011 and 2020
- Long-standing laser research partnership between Thales and Gérard Mourou, winner of 2018 **Nobel Prize in Physics**

Gérard Mourou
2018 Nobel Prize in Physics

HPLS 10 PW laser at ELI-NP - *« The most powerful laser in the world »*

System aiming to deliver two laser beams with three possibe peak power

2x10 PW, 1 tir/min
2x1 PW, 1 Hz
2x100 TW, 10 HZ

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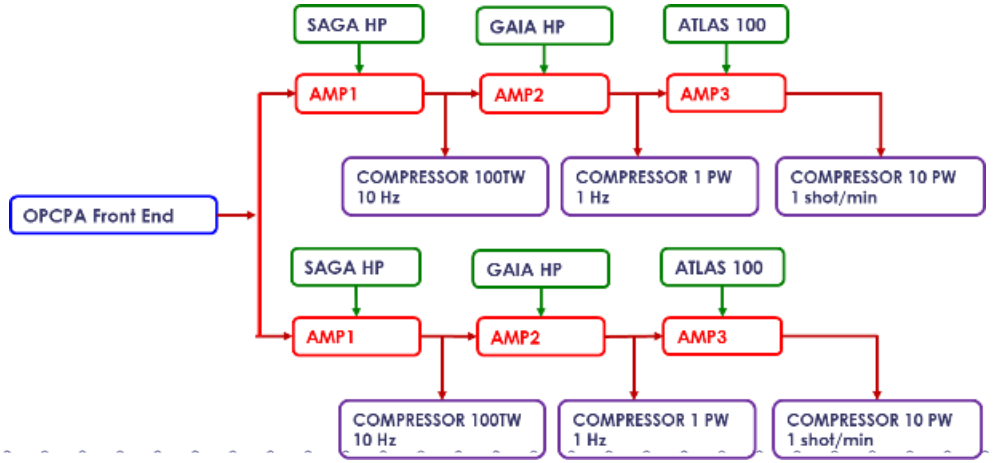
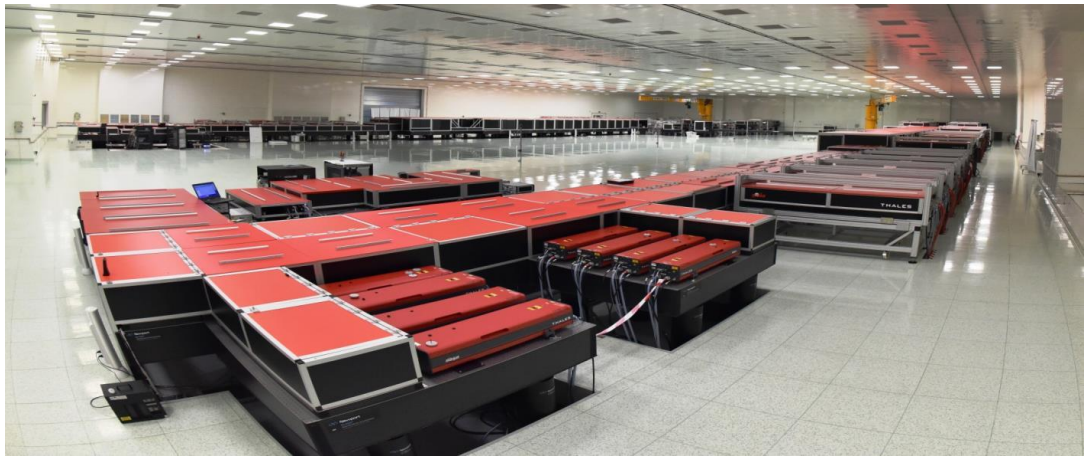
48 pump lasers

A dedicated clean room (ISO7)
2 400 m²

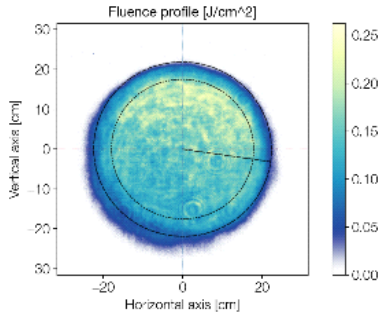


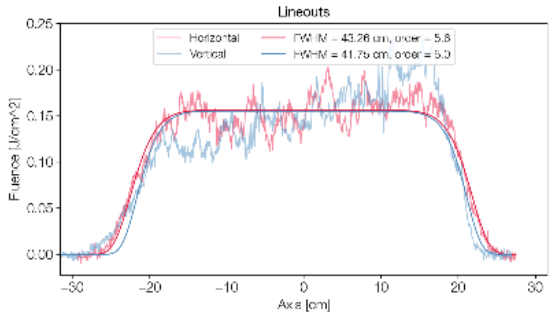


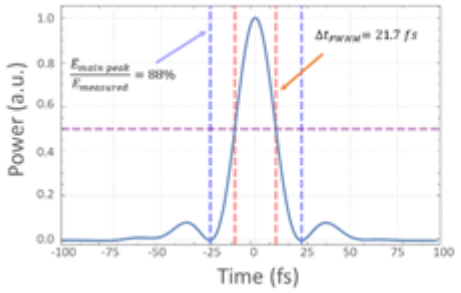
THALES - ELI ; the most powerful laser in the world (ecliptique.com)

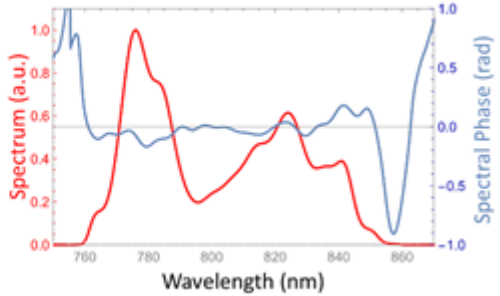
HPLS 10 PW laser at ELI-NP - *« The most powerful laser in the world »*

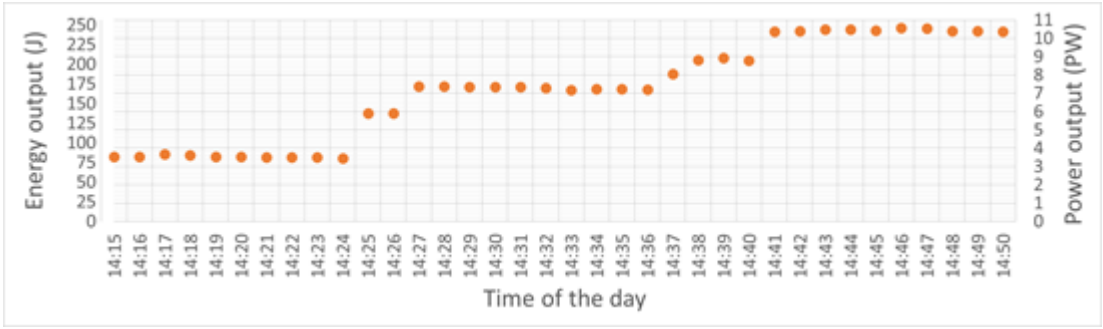
Retrieved peak power (from energy and duration measurements) = 10,2PW (in the main pulse)











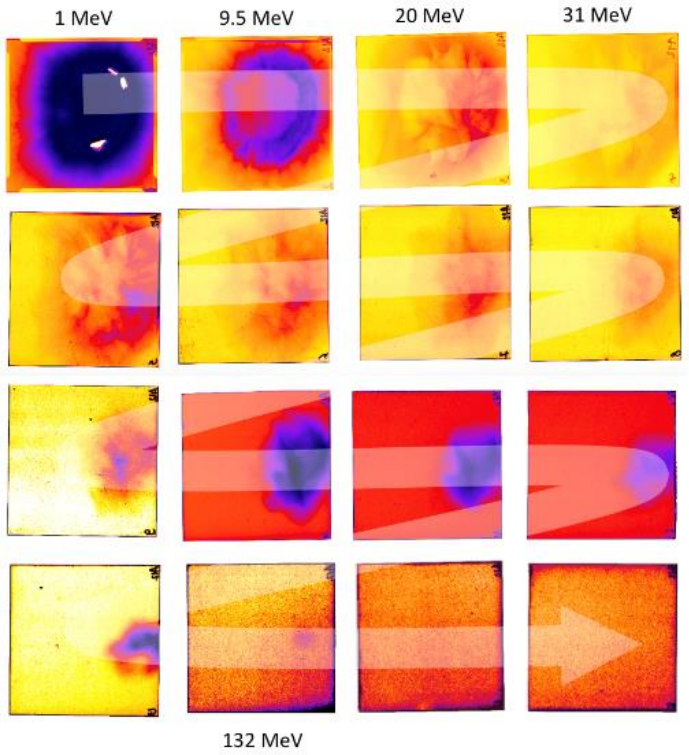
HPLS 10 PW laser at ELI-NP - *« The most powerful laser in the world »*

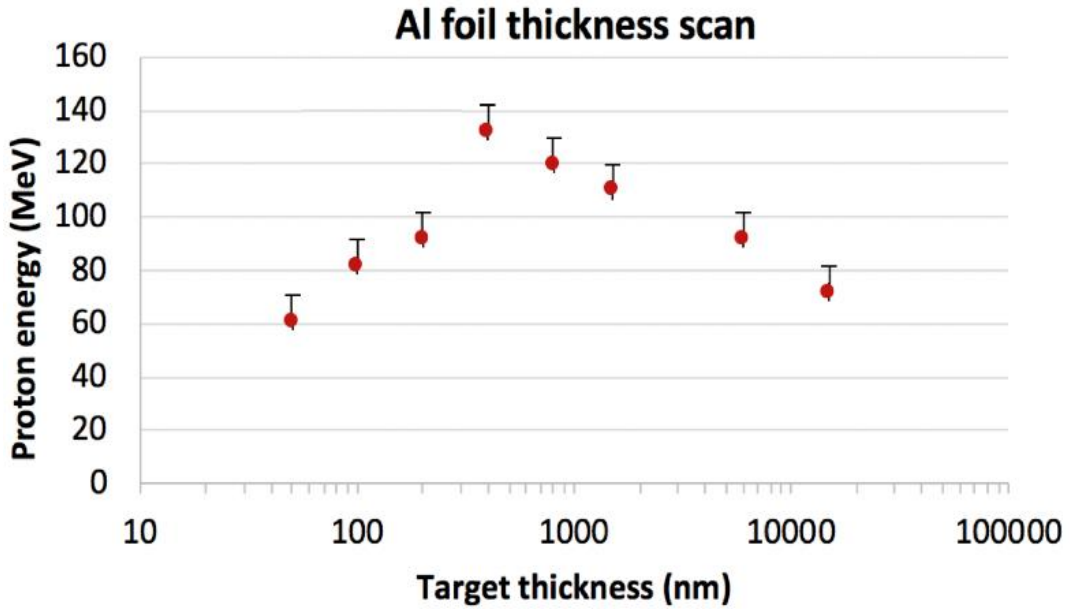
10 PW laser shots

High-power shots on thick Al foils (thickness scan) in June 2023

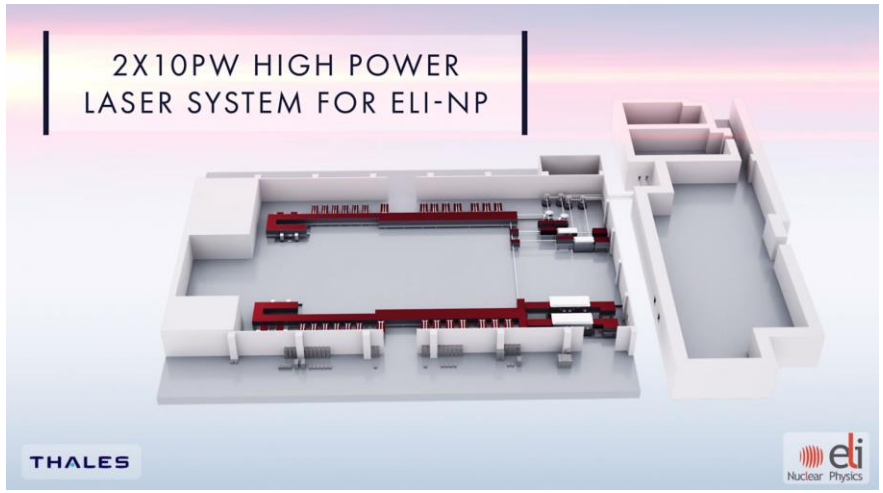
Radiochromic and CR39 stack detector

$I_L = 3.6 \times 10^{22}$ Wcm^{-2} on 400nm Al foil





HPLS 10 PW laser at ELI-NP - *« The most powerful laser in the world »* - Laser Fusion Experiments



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Experiments done early 2023 with PW beams at ELI-NP
(within ELI-NP/Marvel Fusion/Thales cooperation agreement)

Contrast enhancement at ELI-NP allowing for laser interaction with nanostructured fusion targets

A. Fazzini[1], V. Scutelnic[1], E. Schork[1], A.K. Schmidt[2], L.D. Geulig[2], P. Fischer[1], B. Gonzalez-Izquierdo[1], A.K. Härle[1], J. Hartmann[1], J.J. Jung[1], K. Kenney[1], D.E. Rivas[1], M. Speicher[1], M. Cernăianu[3], P. Ghenuche[3], L. Tudor[3], D. Sangwan[3], D. Doria[3], M. Schollmeier[1], S. Steinke[1], and G. Korn[1]

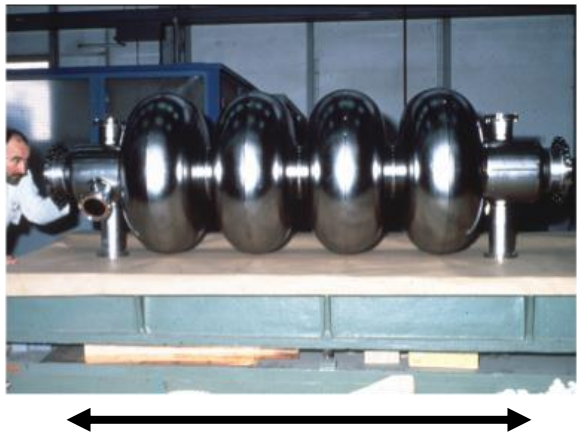
[1]Marvel Fusion GmbH, Theresienhöhe 12, 80339 Munich, Germany
[2]Ludwig-Maximilians-Universität München, Am Coulombwall 1, 85748, Garching, Germany
[3]Extreme Light Infrastructure (ELI-NP), 30 Reactorului Street, 077125 Magurele, Romania

Nanostructured targets are capable of efficient energy and power absorption of ultra-intense laser radiation, making them an attractive component of fuel mixes for laser-driven fusion [1]. High temporal laser contrast is essential to prevent early-stage target ionization, maximizing the laser-plasma energy deposition. In this context, a recent collaboration between Marvel Fusion, the Extreme Light Infrastructure – Nuclear Physics (ELI-NP) and Thales has been conducted to upgrade one of the most powerful lasers worldwide, based at the ELI-NP facility. A laser contrast enhancement in two orders of magnitude at a few tens of picoseconds before the peak of the pulse was measured after the upgrade process.

[The 3rd International Workshop on Proton-Boron Fusion (2-5 October 2023): Welcome · ELI ERIC Indico Page (eli-laser.eu)]

Example of application of CPA laser: laser plasma application

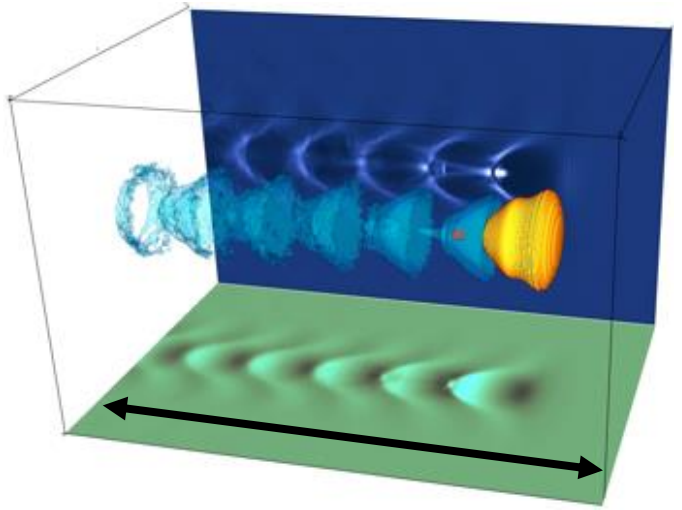
RF Cavity



1 m => 50 MeV Gain

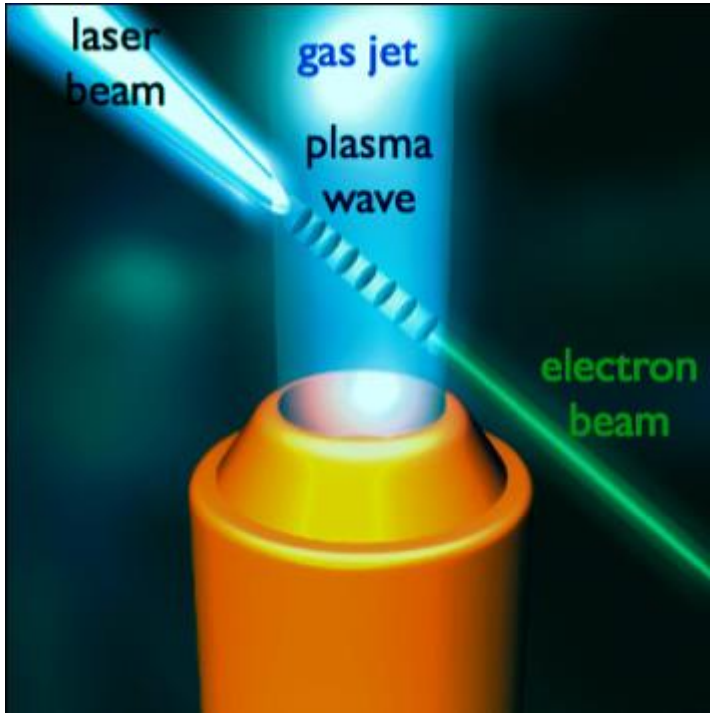
Electric field < 100 MV/m

Plasma Cavity



1mm => 100 MeV

Electric field > 100 GV/m



Courtesy of Victor Malka

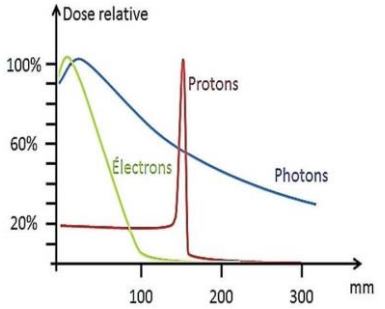
A. Pukhov & J. Meyer-ter-Vehn, Appl. Phys. B **74**, 355-361 (2002)

V. Malka *et al.*, Science **298**, 1596 (2002)

Increase the repetition rate of lasers: a need for industrial & medical applications

Rationale

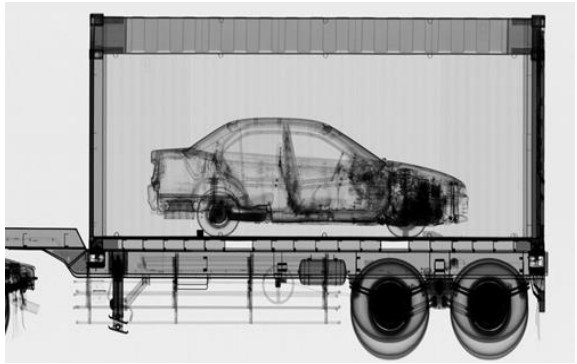
- **Titanium Sapphire is confirmed as the ideal technology for producing high-energy ultrashort pulses (< 30 fs)**
- **Development of 1J / 100 Hz laser system for scientific, industrial and medical applications**



Revolutionising the way we treat cancer - Ebeam4Therapy

MULTI SCAN 3D

Home - Multiscan3D (multiscan3d-h2020.eu)



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LAPLACE HC platform at LOA for electron acceleration (within Heracles joint research lab)

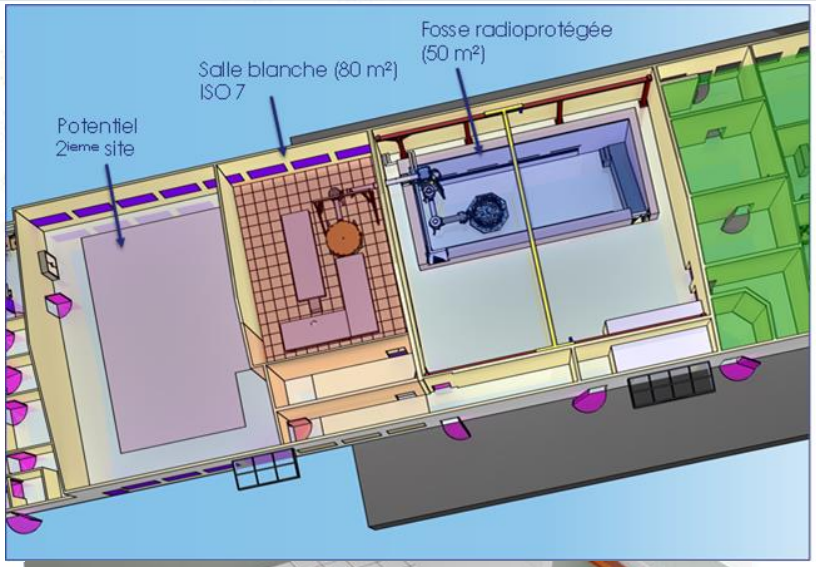
The LAPLACE Project

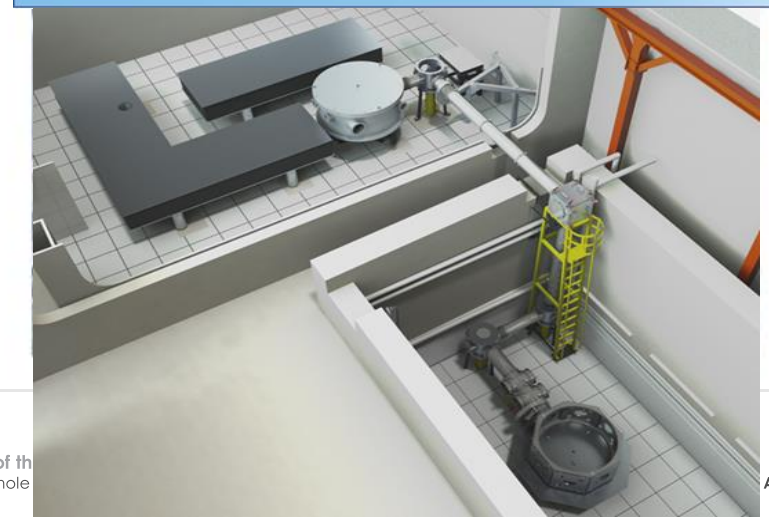
LAPLACE HC

- 80 m² clean room
- Laser 1 J @ 100 Hz
- 50 m² radioprotected area
- 2nd radioprotected area in option

Average power of ~ 100 W (vs 1 W now)

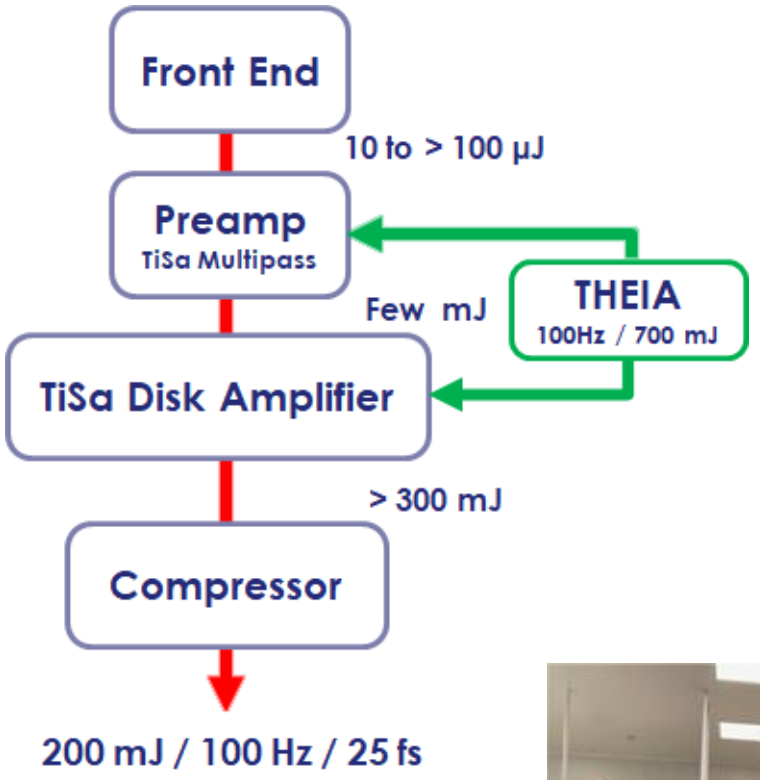
O. Chalus , WG2 Th. (THALES LAS)



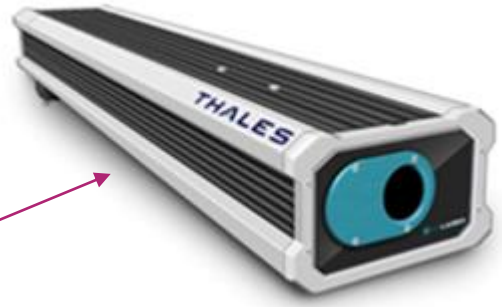


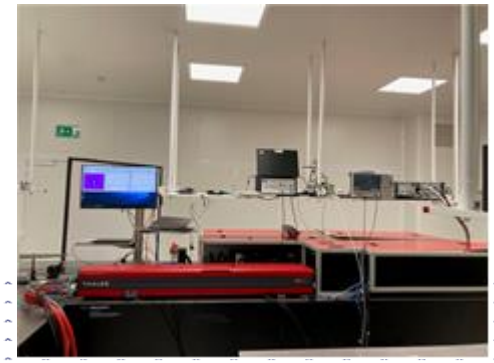
[LAPLACE – Laser Plasma Acceleration Center at LOA (laplace-loa.fr)]

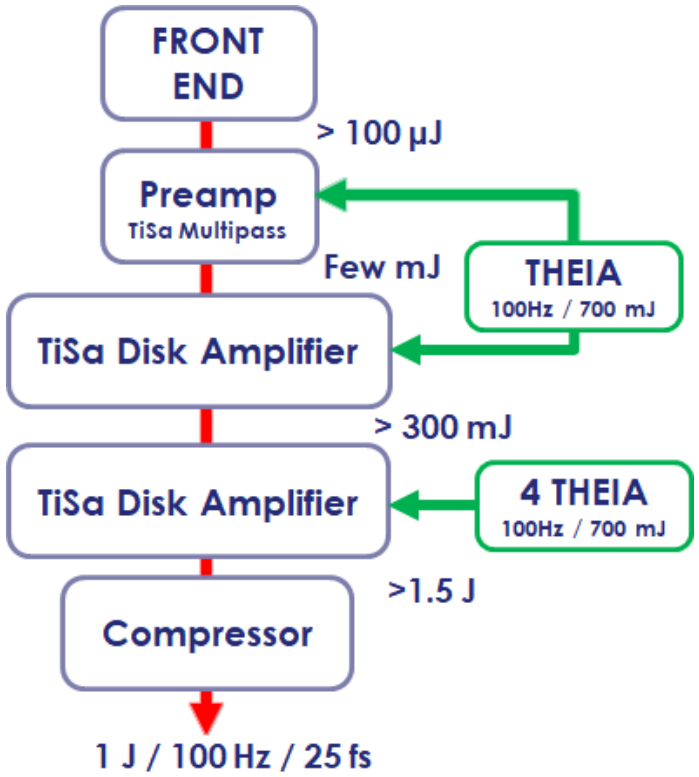
1 J @ 100 Hz Ti:Sa Laser Development



Online end of 2024

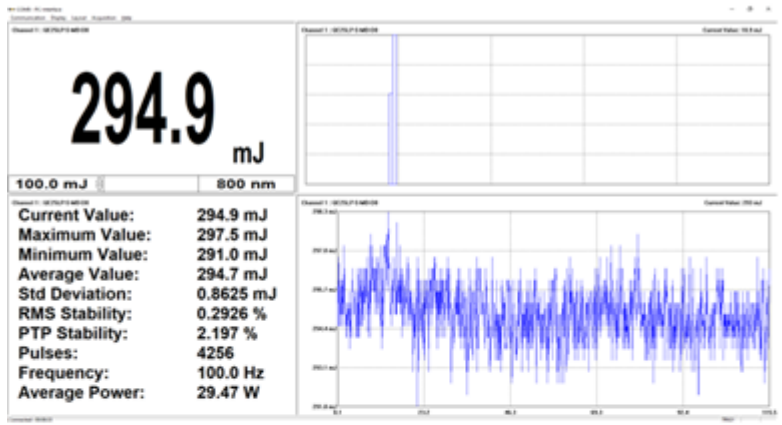






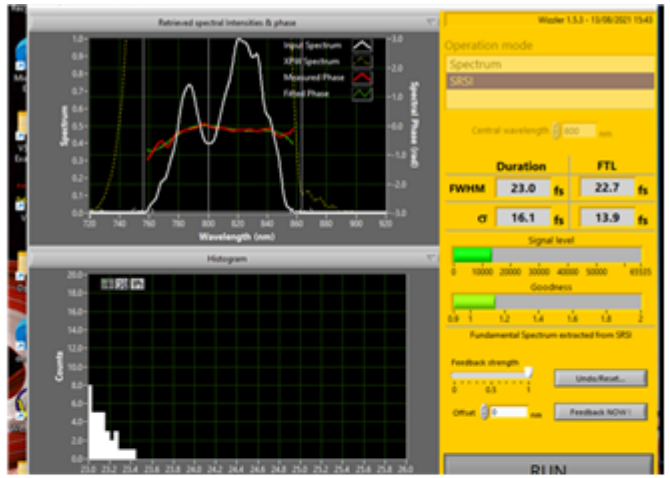
Online end of 2025

200 mJ – 100 Hz TiSa Laser results



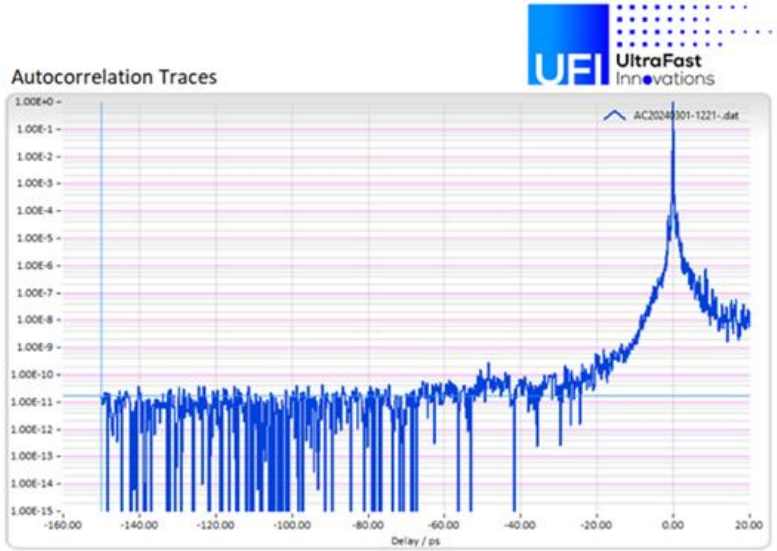
Energy after amplifier : 295 mJ

Energy stability : < 0.3 % rms



Pulse compressed
- full aperture
- attenuated energy (at air)

Pulse duration: 23 fs (1.01 FTL)
(from Wizzler measurements)



Contrast @ - 10 ps

Specification **< 1:10^6**
Test **1:3x10^8**

Thank you for your attention