Sustainable Laser Drivers for Next-Generation Accelerators

Symposium - Innovations for a Sustainable Tomorrow

10 July 2026

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A Laser Bright Future

SUMMARY

01 **Amplitude Laser Group**

02 **Increasing Ti:Sa drivers repetition rate**

03 **Post-Compression of High-Repetition Yb Lasers**

Amplitude

01

Amplitude Laser group

Amplitude at a glance

Founded in 2001
as innovative & visionary company

Expert manufacturer
in ultrafast laser technology

4500 +
lasers in the field

450 +
employees worldwide

3 000
M^2 of production area

10+ offices and production plants
around the world.

Technology landscape at Amplitude

High Energy – Nd

> up to 100s J, ns / ps

High Peak Power – Ti:Sa

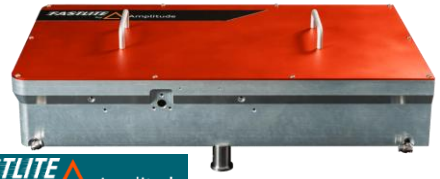
> up to 10s – 100 J, fs

High Power Ultrafast – Yb

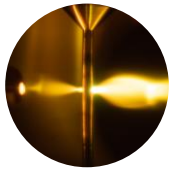
> Up to kW, up to J / MHz, fs - ps

Ultrashort tunable – OPCPA

> UV to MIR, µJ to mJ, few fs, CEP



TiSa / OPCPA for exploration

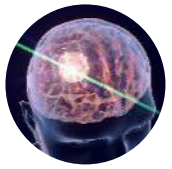


X-Ray Generation

Electron and Ion Acceleration

Diode-pumped Yb for exploitation

Medical Imaging



Laser therapy

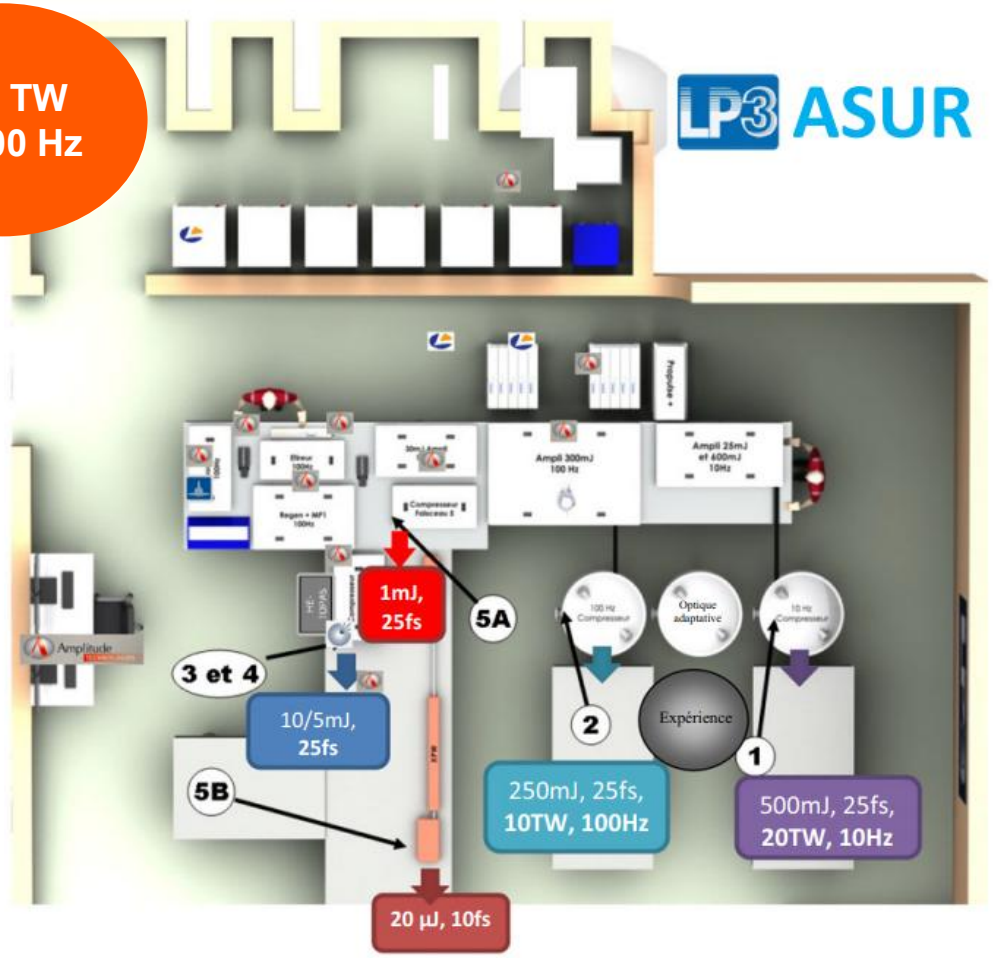
NDT

02

Increasing Ti:Sa drivers repetition rate

ASUR a multidisciplinary laser facility since 2013

>10 TW at 100 Hz



- Amplitude has a history of >20 years in building 100 Hz Ti:Sa
- ASUR operates with five beamlines powered by a PULSAR 100 Hz laser from Amplitude, delivering a unique 10 TW beamline at 100 Hz for advanced laser-matter interaction experiments
- ASUR mostly uses flashlamp pumps

Key Technologies

2013

> Pump lasers at 100 Hz
- Flashlamp pumping : Up to 1J 100Hz @532nm

> Thermal management of Ti:Sa Amplifiers
- Cryogenic cooling : 360mJ 100 Hz output

> Thermal management of gratings
- Passive cooling

> High contrast Seeder
- Based on XPW and Saturable absorber

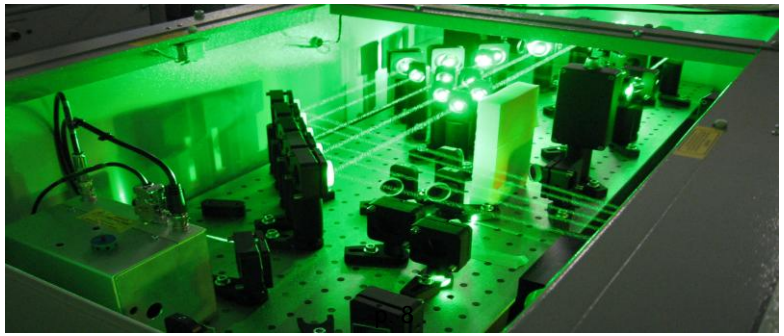
2026

> Pump lasers at >100 Hz
- Diode pumping : 1J up to 10J 100Hz

> Thermal management of Ti:Sa Amplifiers
- Cryocooling up to few J 100Hz
- Liquid cooling >1kW (10J 100Hz)

> Thermal management of gratings
- Active cooling / MLD gratings

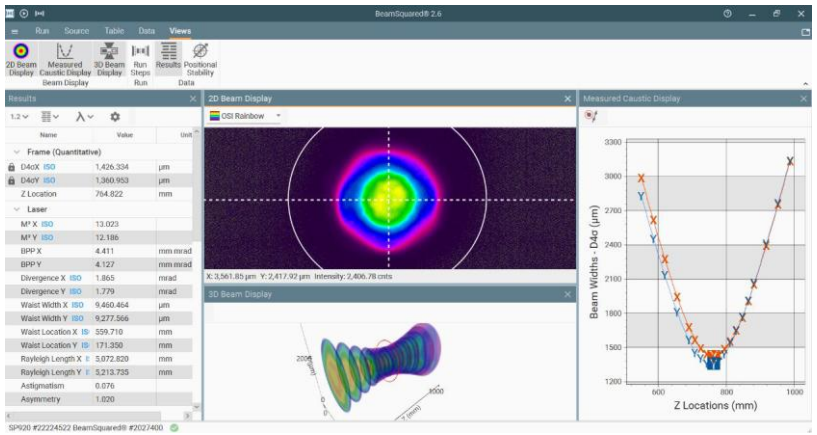
> High contrast Seeder
- Based on OPCPA

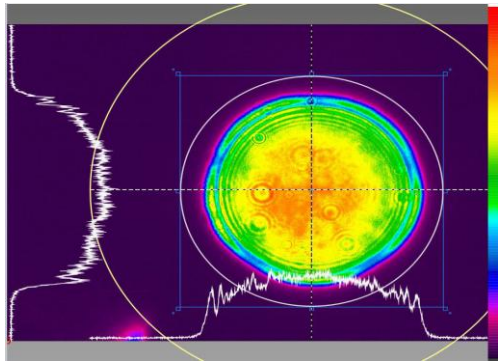


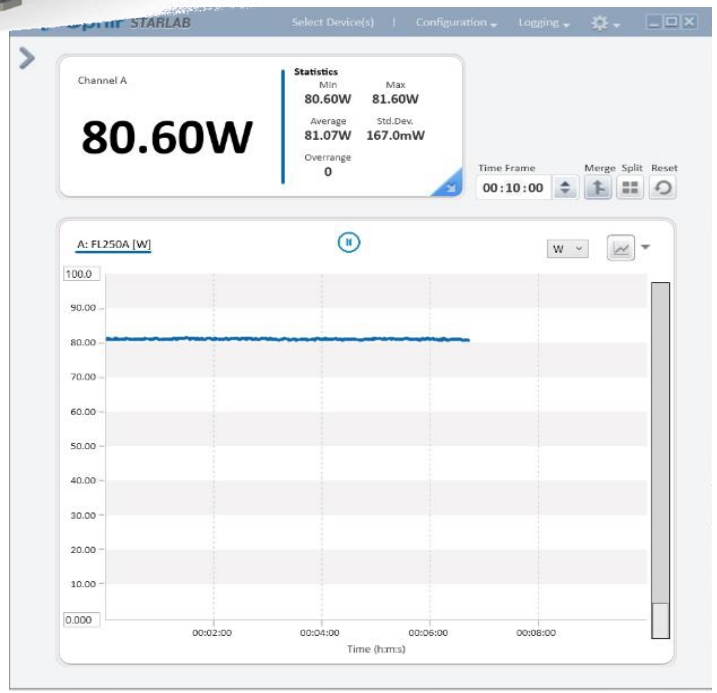
Amplitude

DPSS Pump Laser: Titan Century

- Newly developed 100-200 Hz pumping source
  - Diode-pumped
  - > 1.4 J in IR
  - > 0,8 J at 532 nm
  - Excellent beam properties







Towards 10J 100Hz pumps:
(First version, 4J, expected by Summer 2026)

→

Diode-pumped
6-14J in IR, 4 - 10J at 532 nm
100 to 200 Hz

Ti:Sa Cryogenic cooling

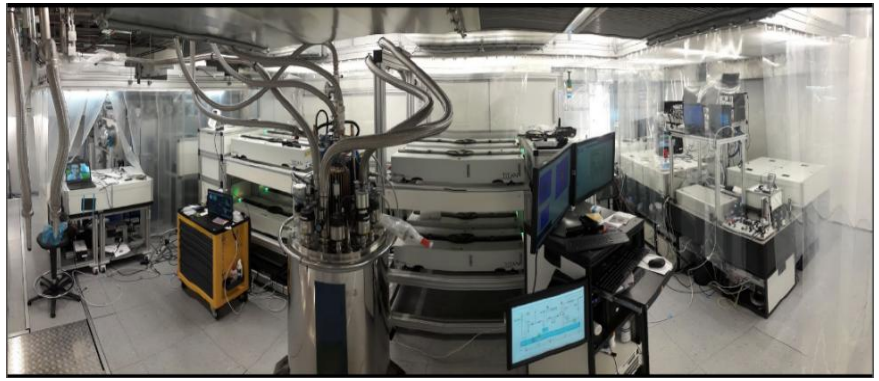
> Cryo temperatures : better conductivity, i.e. lower thermal lensing

> Compatible with multi-kW heat extraction

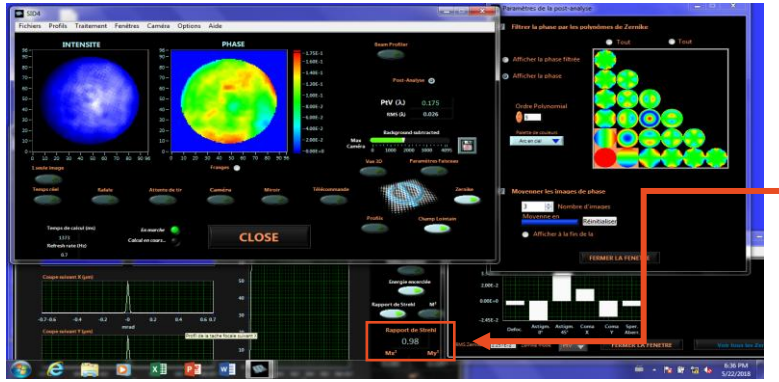
> Use twin architecture (patented solution)

> High beam quality and focus stability

> Already validated on HiBEF Relax laser @ XFEL (500TW@5Hz)



TWIN CryoCooler with two TiSa crystals



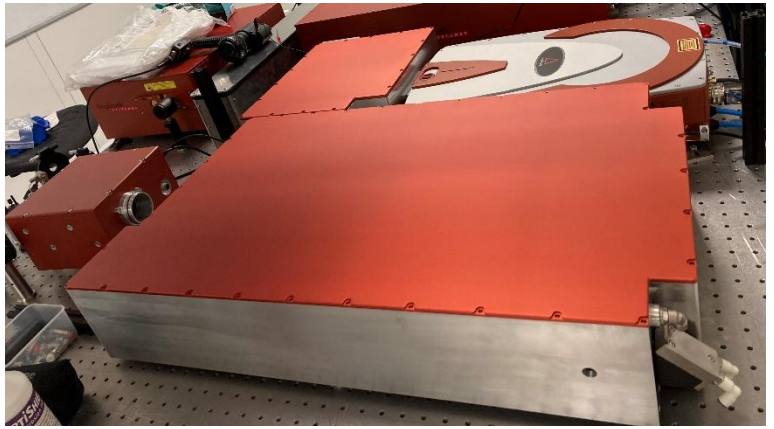
Strehl ratio
98%
With DM

High contrast OPCPA seeder

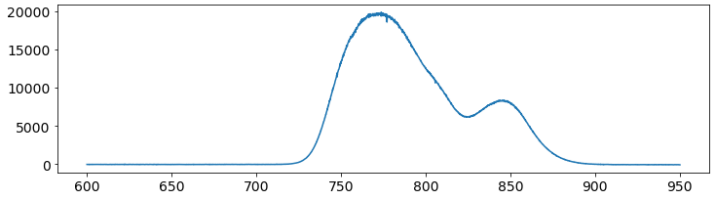
Based on Ytterbium industrial pump

µJ to mJ OPCPA developed for Petawatt TiSa lasers

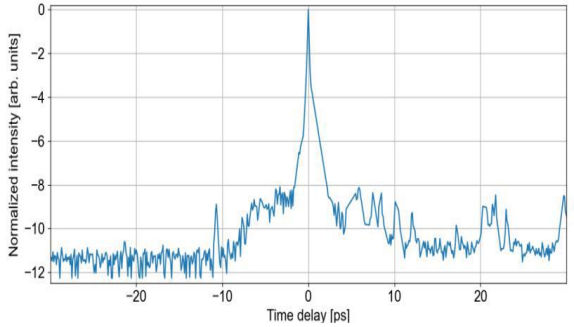
… ready for seeding Nd/Yb CPA lasers



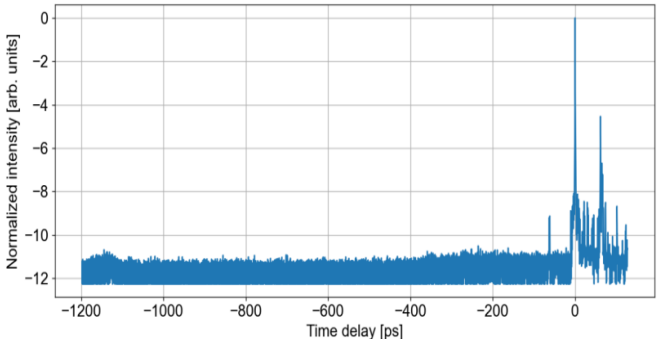
Seeder @800nm



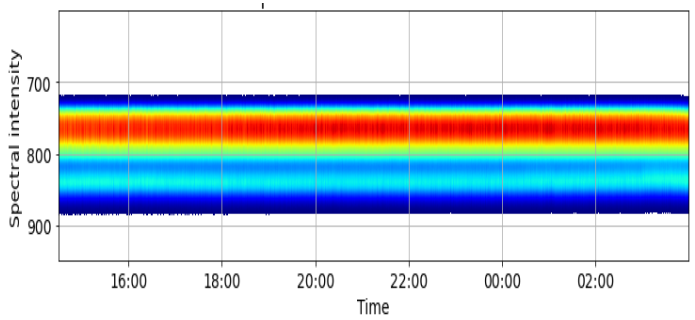
ps contrast



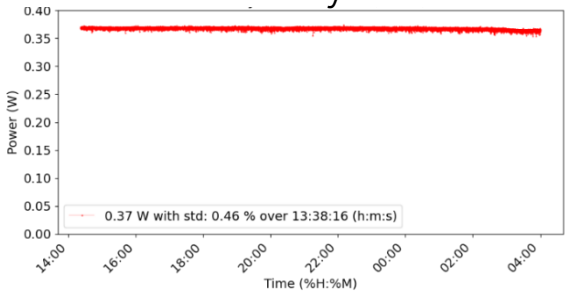
ns contrast



Spectral stability



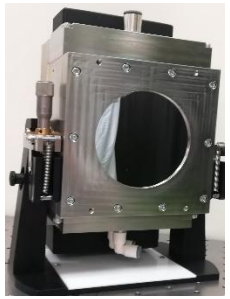
Power stability



Increasing rep rate: Amplitude roadmap

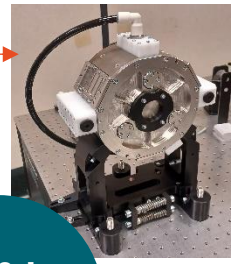
Liquid cooling of multidisks is a key enabling technology for high rep rate PW lasers

Flashlamp Pumped



50J 10Hz

Diode Pumped



>1J 100Hz

>10J 100Hz

2016 2019 2022 2025 2028 2031

750TW 10Hz

> 500TW 100Hz

Amplitude

03

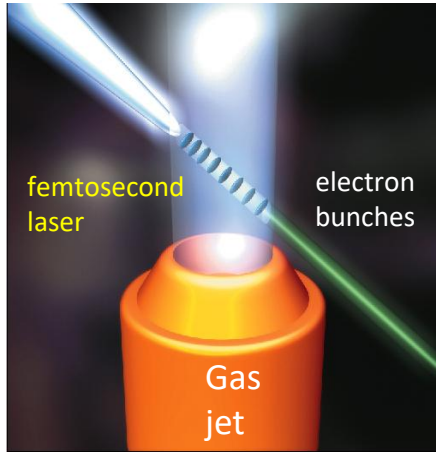
Post-Compression of High-Rep Yb Lasers

Motivation to use Yb

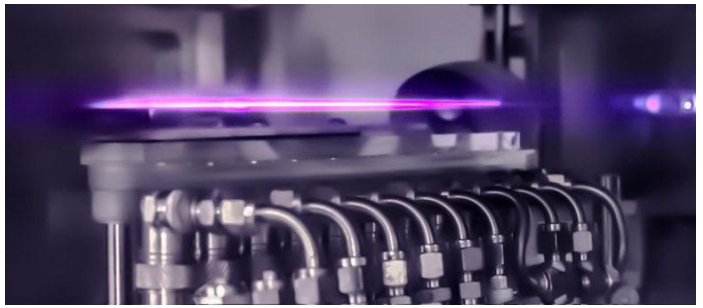
> Laser WakeField Acceleration : a revolution for compact electron acceleration

LWFA :

~100GV/m



LBNL : 30cm for 10GeV



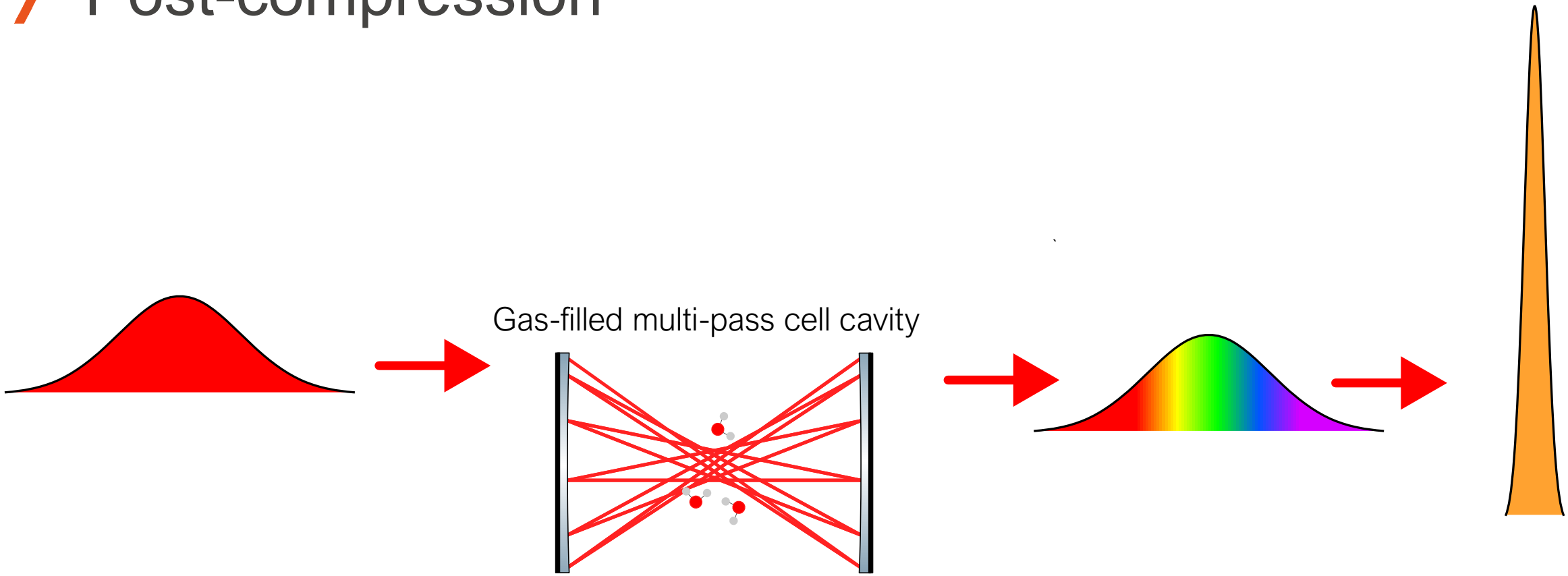
> Ti:Sa: high energy, low pulse duration, but low rep rate (10Hz)

> Yb: kHz rep rate, low pulse duration enabled by post compression

Ti:Sa, 10Hz

Yb, 1kHz-100kHz

Post-compression



Initial fs pulses

Self-phase modulation

Broad and chirped pulse

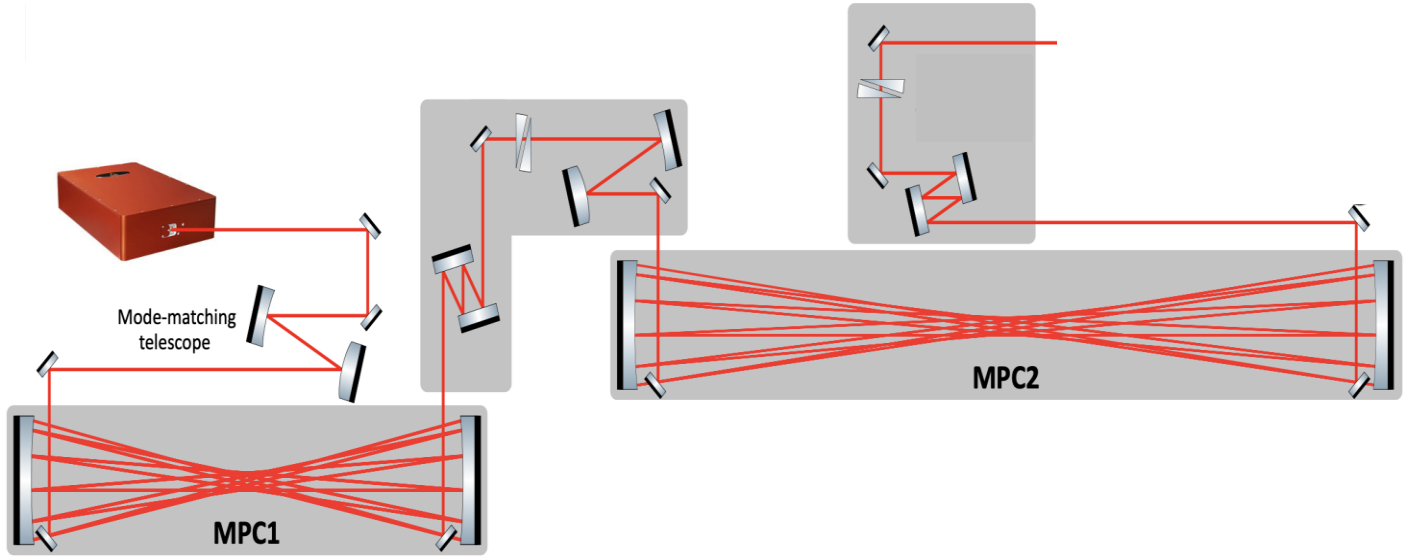
Recompression

Preparing the Yb driver for electrons

> Post-compress a Magma 25, 25mJ 1kHz sub-500fs, Yb laser by Amplitude to 10mJ sub-10fs for electron acceleration

> Compression factor of 50 is challenging in a single post-compression stage

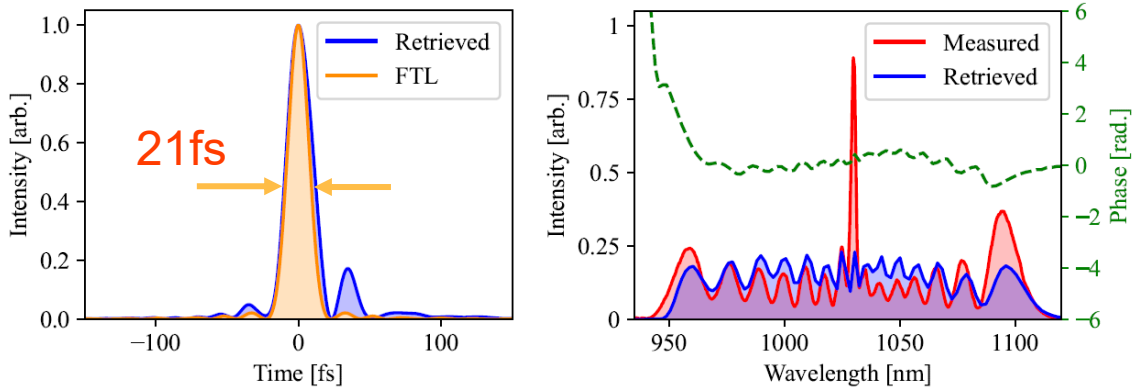
> Setup : Plan 2 Multipass Cells



Key results with MPC1

Laser used: Magma25 Yb laser :
~20mJ 350fs 1kHz

- 21fs compressed at full energy 16mJ (FTL17fs)
- High transmission : 88% (97% MPC, 91% compressor)
- Corresponding peak power : 0,6TW
- Argon filled MPC cavity, 26 passes



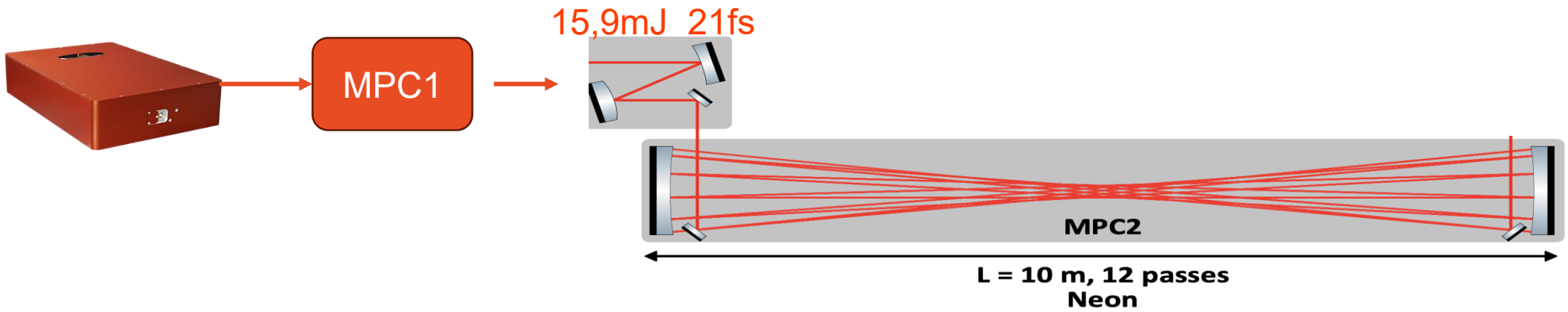
Measured with TipToe

Progress with MPC2

> Second cavity filled with Neon - 12 passes

> High transmission : 82%

> Spectrum supports 5fs pulse duration



Conclusion & Sustainability Impact

- Ti:Sa systems:
  - Demonstrated high peak power at increased repetition rate (→ 100 Hz)
  - Key enablers: OPCPA seeding, diode pumping, advanced thermal management

- Post-compression of Yb lasers:
  - Successful kHz operation with strong pulse compression
  - Achieved 0.6 TW (16 mJ, 21 fs)
  - Validates scalability toward sub-5 fs and multi-TW operation

- Why this is sustainable:
  - Diode-pumped architectures improve energy efficiency
  - Higher repetition rates increase scientific output per unit energy
  - Advanced thermal management extends system lifetime
  - High-repetition-rate Yb lasers support sustainable future accelerators
  - Compact accelerator concepts can reduce facility footprint and infrastructure requirements

A Laser Bright Future

Thank you!

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