The Extreme Light Infrastructure

EPIC Online Technology Meeting

High repetition rate PW laser pulses in ALPS

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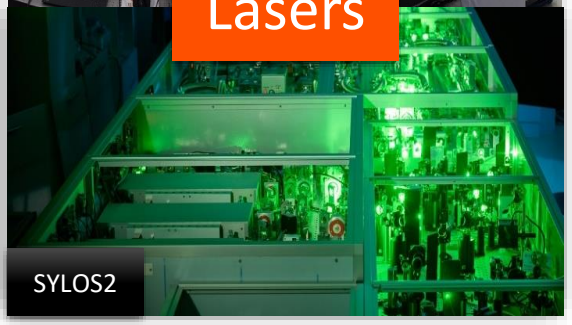
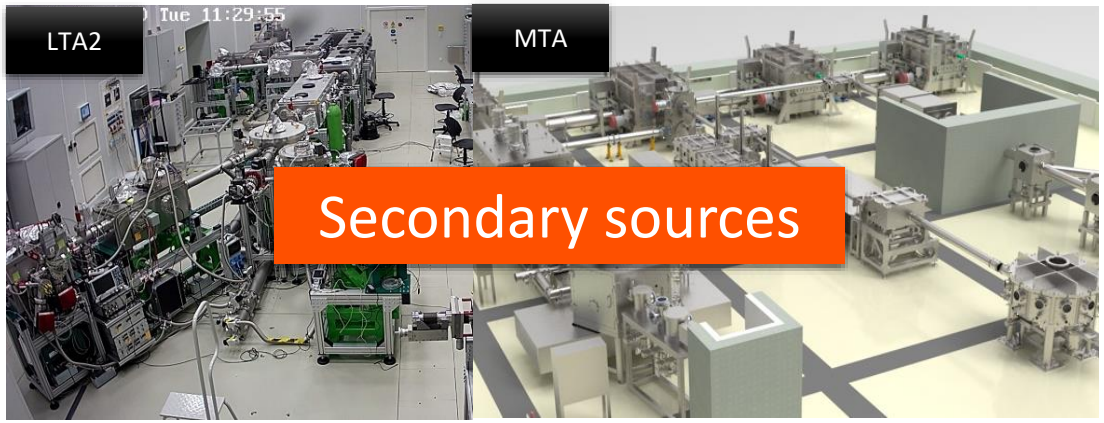
ALPS facility: portfolio

Lasers



End stations

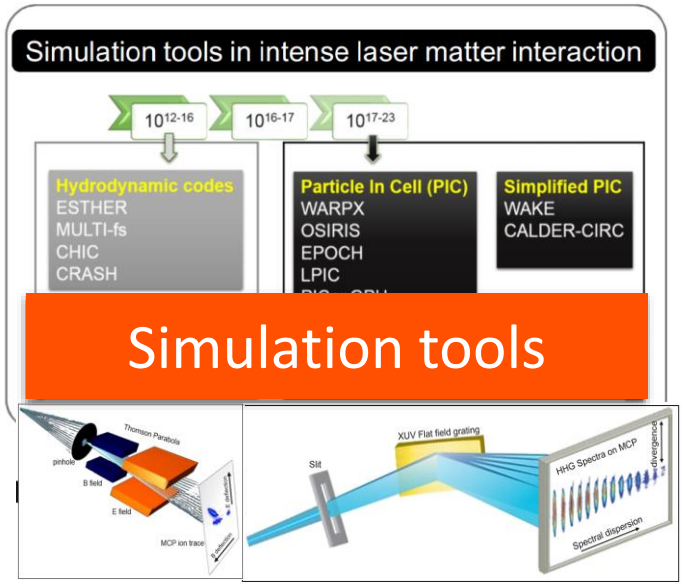


Secondary sources

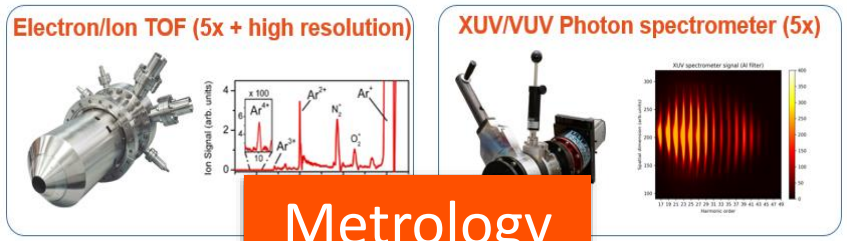
Applications

- Material science and recollision physics in generation medium
- Ultrafast semiconductor optoelectronics
- Ultrafast material change
- Plasma optics
- Laser accelerator physics
- Attosecond resolved plasma physics
- Attosecond collective phenomena
- Tomography and imaging
- Flash Radiobiology with e and high energy THz
- Strong field quantum optics
- Pump probe attosecond physics
- Nano-photonics
- The micro macro connection

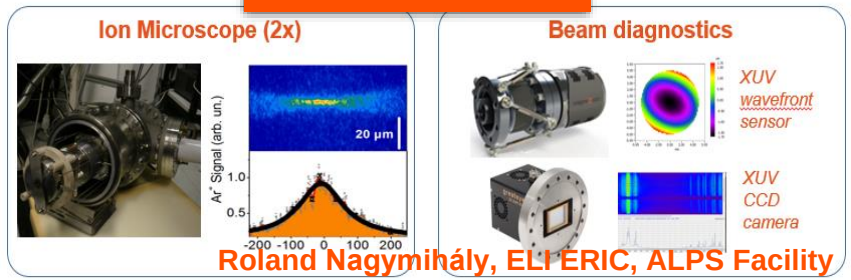
……In gas-solid-liquid-plasma and designed matter



Simulation tools



Metrology



Laser sources

	(*Target*) Specifications
HR1	100 kHz, 30 fs, 1.8 mJ 100 kHz, <7 fs, 1 mJ
HR2	*100 kHz, <6 fs, 5 mJ, CEP*
HR Alignment	10 kHz, 7 fs, 1 mJ
MIR	100 kHz, <42 fs, 130 μJ, CEP 100 kHz, <20 fs, 70 μJ, CEP
MIR-HE	*3.2um, 1 kHz, CEP, <50 fs, 20 mJ or <25fs, 10 mJ* *1.6um, 1 kHz, CEP, <100 fs, 12 mJ*
SYLOS 2	1 kHz, <7.5 fs, >30 mJ (flat top), >24 mJ (Gaussian), CEP
SYLOS 3	1 kHz, <8 fs, >120 mJ, CEP
SYLOS Alignment	10 Hz, <12 fs, >40 mJ
SYLOS Alignment 2	50 Hz, 12 fs, 40 mJ
HF PW	*10 Hz, <17 fs, 34 J* 2.5 Hz, 25 fs, 10 J
THz Pump	1 kHz, 100 fs, 4 mJ 50 Hz, <0.5 ps, 0.5 J, synch

user ready
in commissioning

Parameter spaces

100 kHz, 1 kHz, 10 Hz, single shot

850 nm, 1030 nm, 3.2 μm

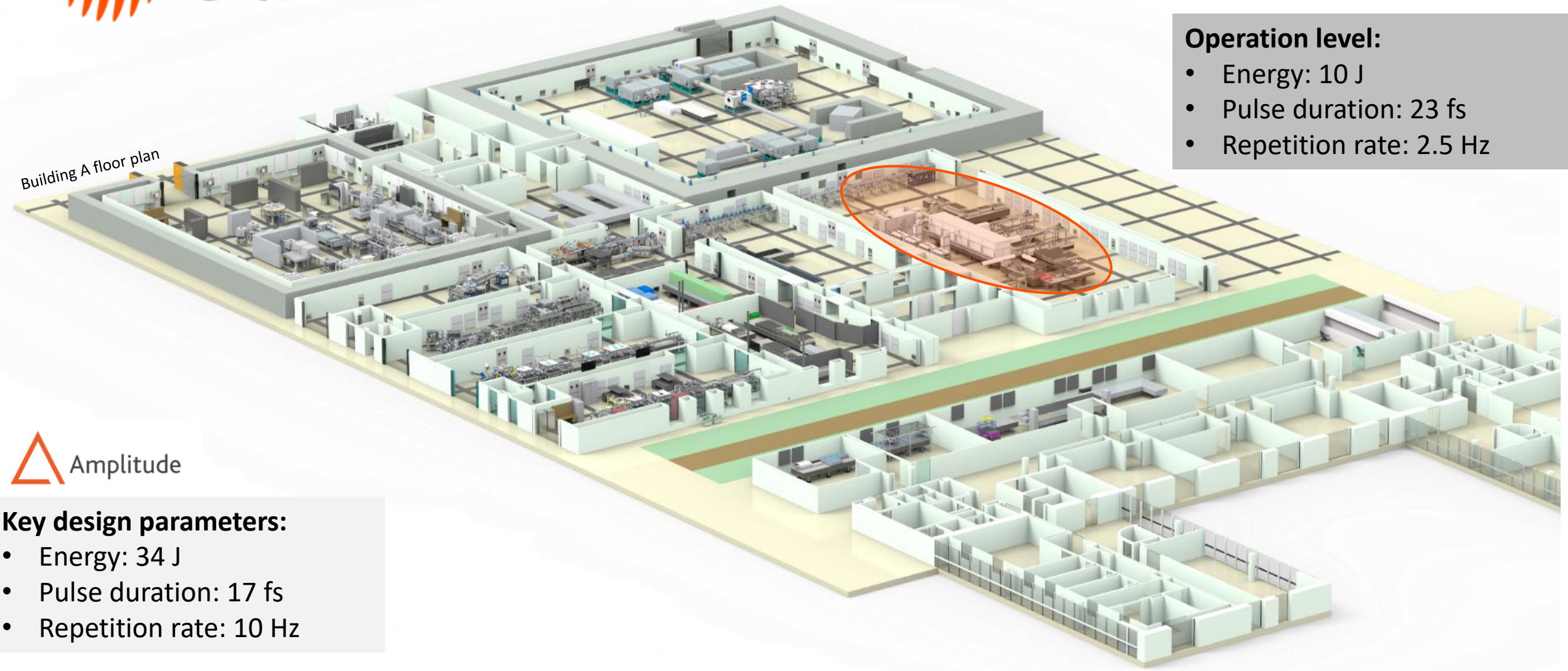
150 μJ, 1 mJ, 120 mJ, 10 J

most few cycles

many CEP-stable

HFPW laser

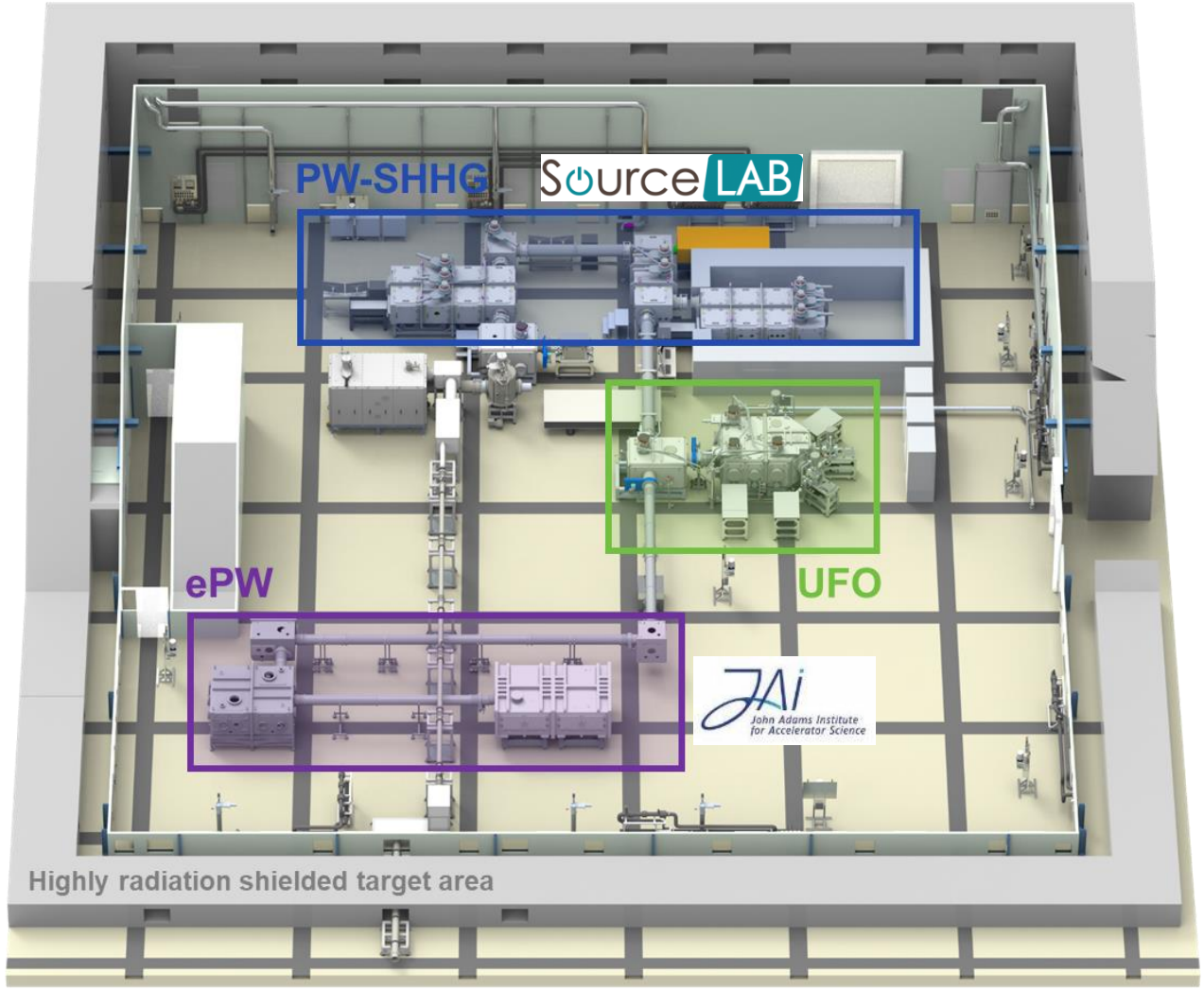
Operation level:
- Energy: 10 J
- Pulse duration: 23 fs
- Repetition rate: 2.5 Hz



Amplitude

Key design parameters:
- Energy: 34 J
- Pulse duration: 17 fs
- Repetition rate: 10 Hz

HFPW beamlines



Surface high harmonic beamline

- **Target:** mJ level attosecond XUV pulses
- **Status:** in commissioning, ion production already observed

Electron beamline

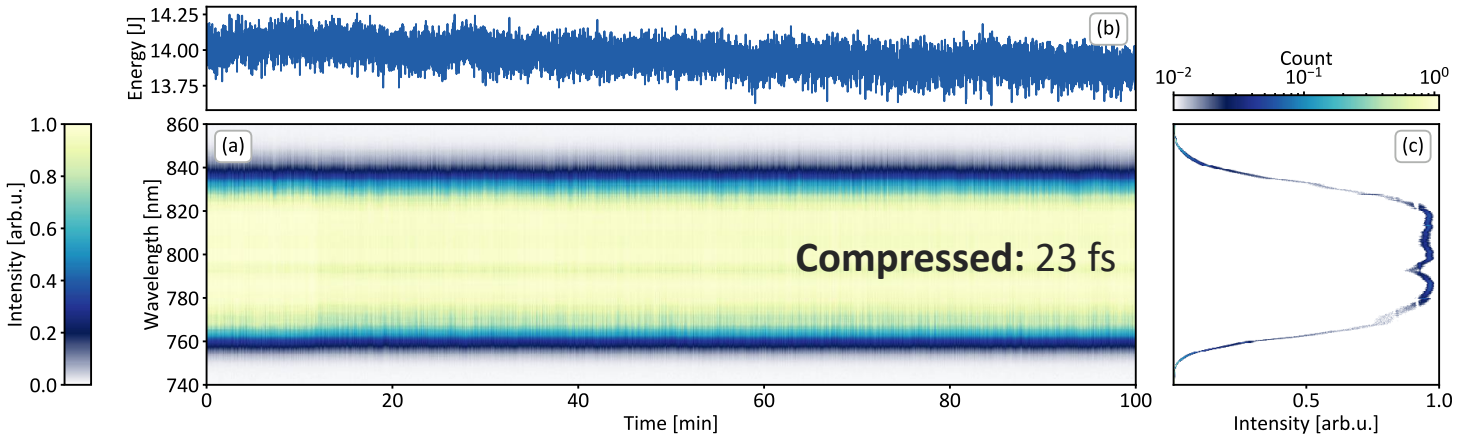
- **Target:** GeV electrons
- **Status:** in commissioning, diagnostics installed

UFO beamline

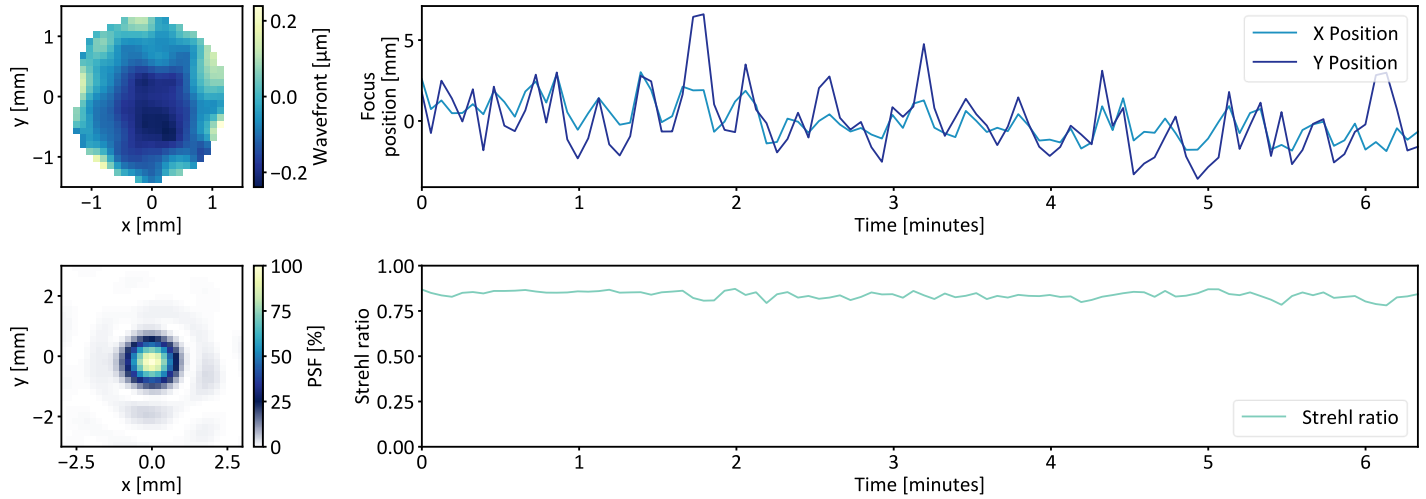
- **Target:** foil, gas, liquid targets with relativistic intensities, material studies, ultrafast probing
- **Status:** in commissioning, diagnostics installed

Laser performance

Energy and spectral stability



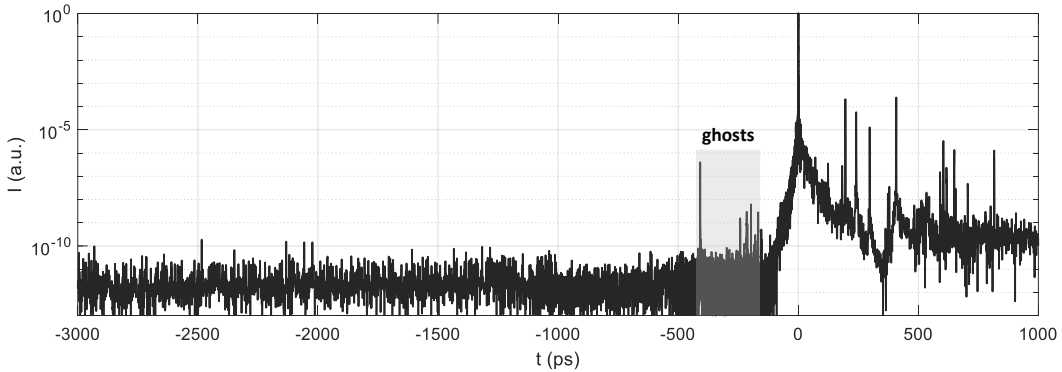
Wavefront stability



Unmatched rep-rated laser performance

- High stability
- Day-to-day reproducibility
- 10 Hz to single shots
- 8 h operation every weekday

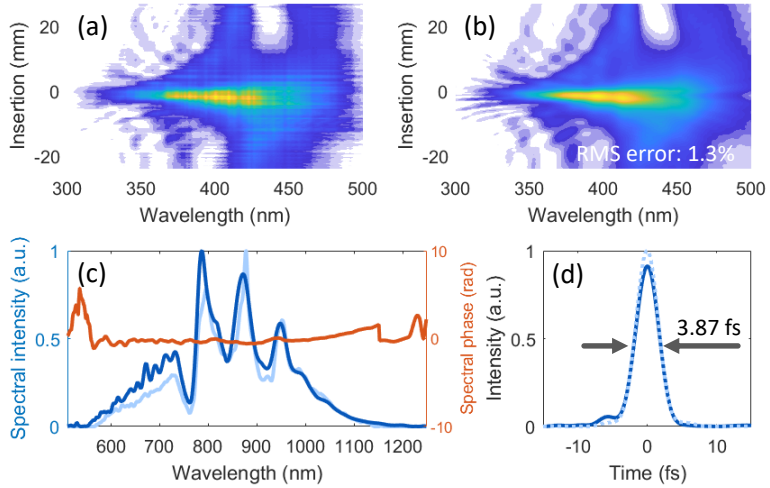
Temporal contrast (4 ns)



Internal R&D activities

Post-compression

- few mJ, 1-100 kHz (HR1, HR2)
- 10s of mJ, 1 kHz (SEA, SYLOS2)
- 100s of mJ, 10 Hz – 1 kHz (SYLOS3, HF)



SEA, 15 mJ, 10 Hz

Ultrabroadband 100 Hz Ti:Sa laser development

- Frontend: OPCPA (Pharos + Orpheus, Light Conversion)
- Ti:Sa amplifiers
- 1.3 mJ, <15 fs pulses demonstrated

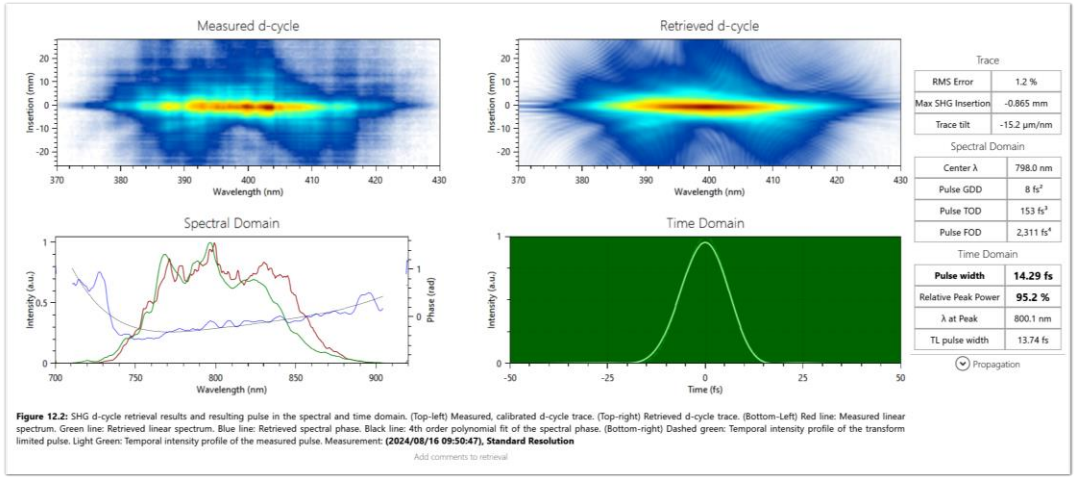


Figure 12.2: SHG d-cycle retrieval results and resulting pulse in the spectral and time domain. (Top-left) Measured, calibrated d-cycle trace. (Top-right) Retrieved d-cycle trace. (Bottom-Left) Red line: Measured linear spectrum. Green line: Retrieved linear spectrum. Blue line: Retrieved spectral phase. Black line: 4th order polynomial fit of the spectral phase. (Bottom-right) Dashed green: Temporal intensity profile of the transform limited pulse. Light Green: Temporal intensity profile of the measured pulse. Measurement: **(2024/08/16 09:50:47), Standard Resolution**

Collaborations in metrology

Diagnostics for temporal measurements

- Few-cycle sources → new diagnostics required
- New spectral ranges, single-cycle pulses
- Spatio-temporal diagnostics R&D

Diagnostics for temporal and ST measurements

- Extreme bandwidth sources → TIPTOE
- Spatio-temporal diagnostics → increased bandwidth

Diagnostics for spectral measurements

- Imaging spectrometers: large bandwidth
- New spectral range requirements pushed to SWIR

New few-to-single-cycle sources push the boundaries of existing metrology devices. New developments are driven by extreme sources!

What we need for operation

Pump lasers

- Flashlamps
- Capacitor banks
- D2O as coolant

Amplifiers

- High damage threshold dielectric mirrors up to 30 cm diameter with 730-870 nm bandwidth
- Ti:Sa repolishing, recoating

Compressor

- Diffraction gratings: gold coated
- RF plasma cleaning

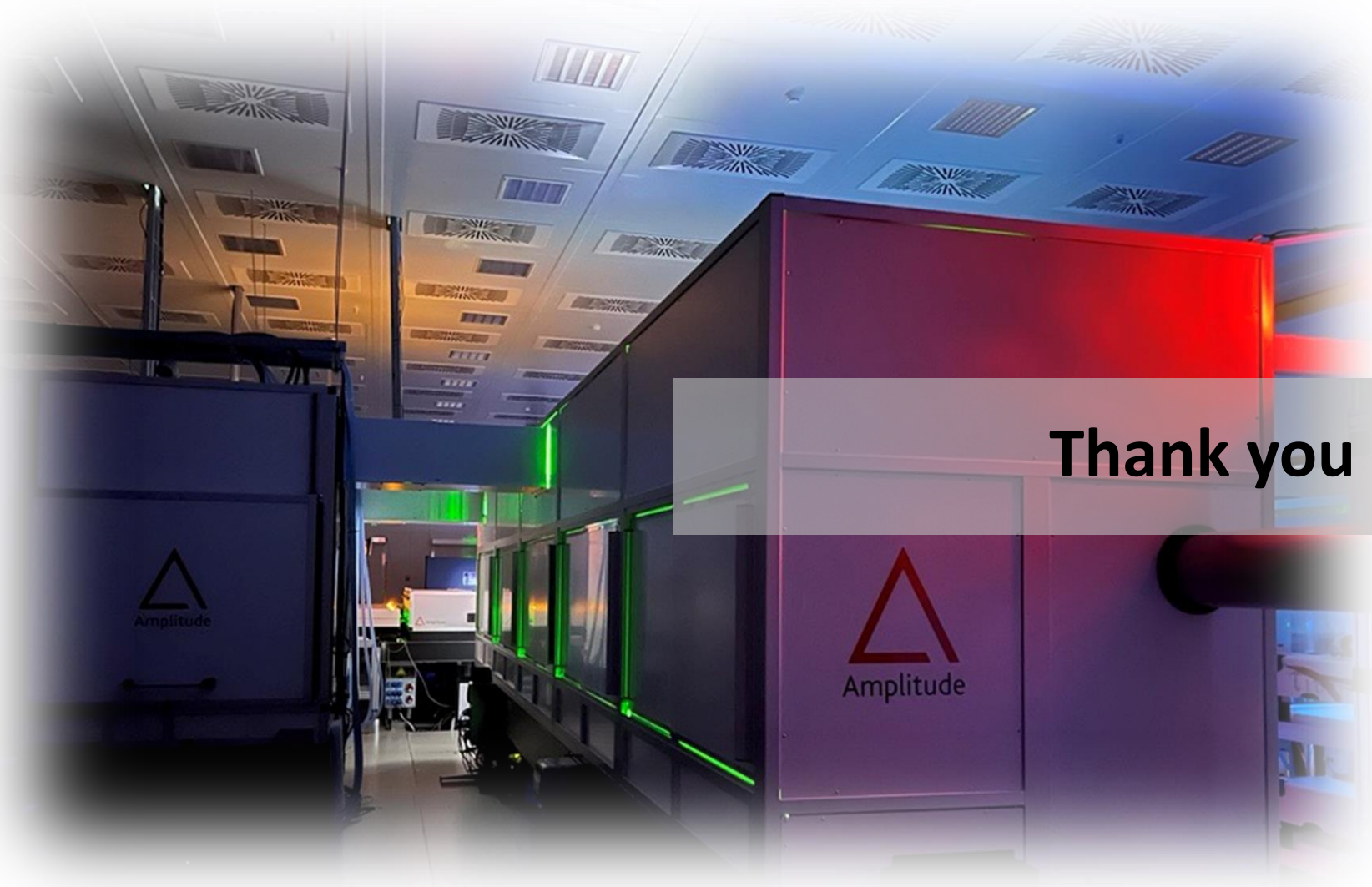
What we need for developing further

Pump lasers
- Improved cooling of laser heads
- Diode lasers?
- Improved beam quality

Targets
- High rep-rate gas/liquid jets
- Rotating/shifting solids
- Cooling?

Amplifiers
- Improved Ti:Sa quality for >4 cm diameter crystals
- Mirrors with increased bandwidth and LIDT

Compressor
- Diffraction gratings: multilayer dielectric?
- Grating cooling in vacuum for high repetition rates



Thank you for your kind attention!