Romania and High Power Lasers
Towards Extreme Light Infrastructure in Romania

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The Extreme Light Infrastructure
European Project

Contents

- GiWALAS laser facility
- TEWALAS laser facility
- CETAL project
- Extreme Light Infrastructure project

CLARK MXR Laser – CPA 2101 (2006)

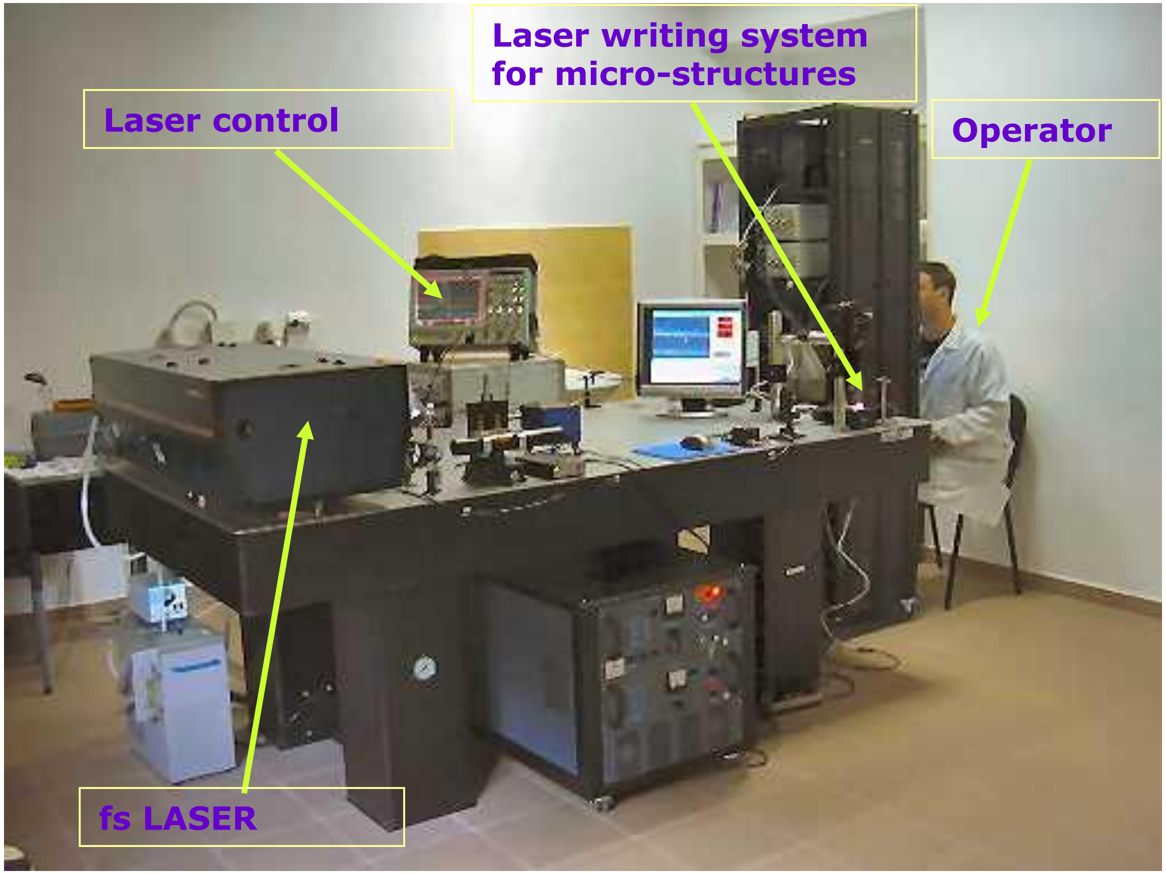
Er:glass fiber oscillator, frequency doubled

- Laser wavelength: 1550 nm → 775nm
- Pulse duration ~200fsec
- Repetition rate: 35MHz
- Pulse energy ~43 pJ
- Average power ~1.5mW

Ti:sapphire regenerative amplifier

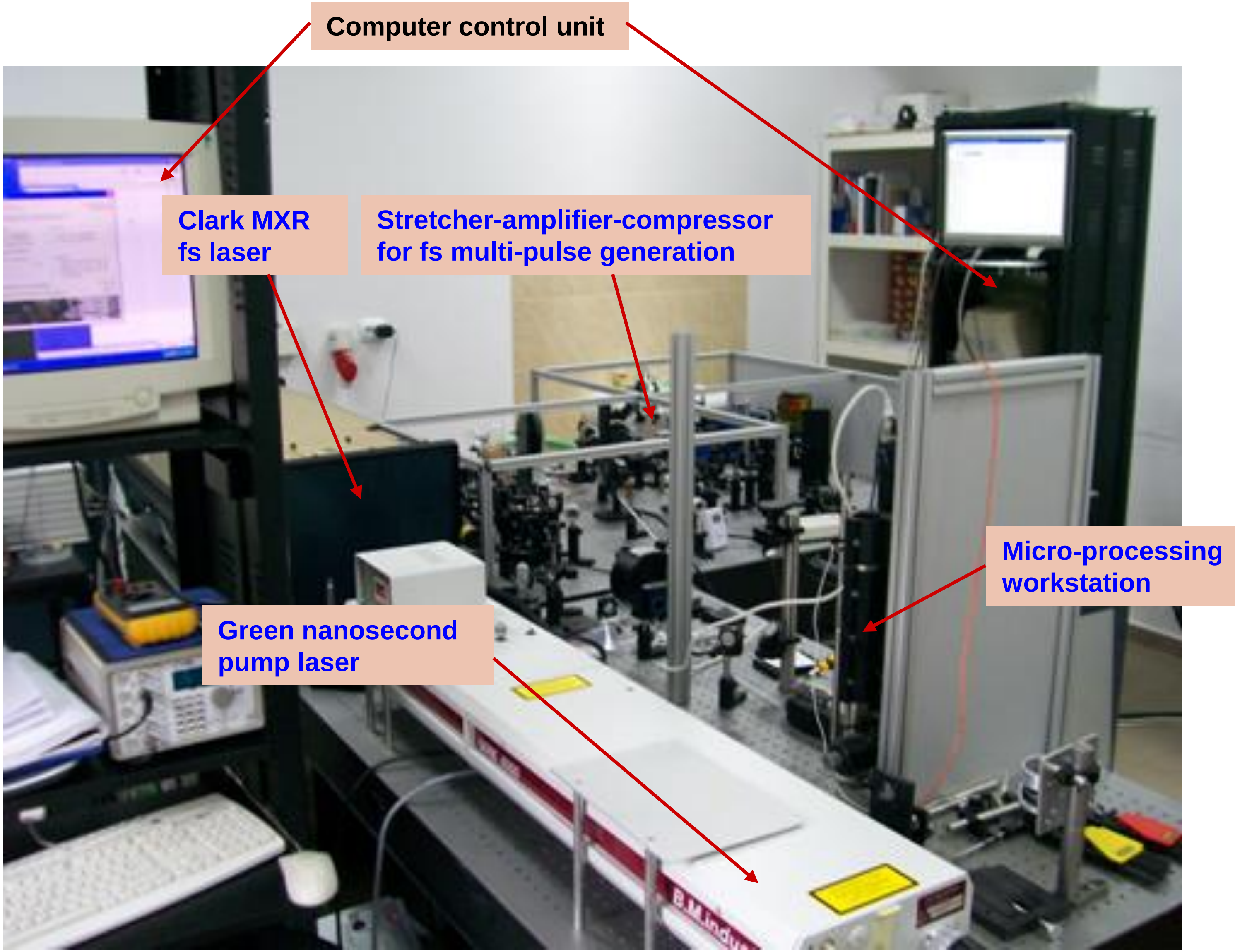
- Laser wavelength 775nm
- Pulse duration ~ 200 fsec
- Repetition rate 2kHz
- Maximum pulse energy ~ 700 μJ
- Average power ~ 1.4W

Femtosecond Laser and the Experimental Set-up for Micro-nanotechnologies (2007)



Laser wavelength, 775 nm; E_{pulse}= 0.7 mJ; t_p < 200 fs; f_{rep}= 2 kHz

GIWALAS Experimental Room (2010)



eli extreme light infrastructure

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TEWALAS Specifications

Laser specifications	Measured value
Central wavelength	808 nm
Spectral bandwidth	> 65 nm
Pulse energy before compressor	≤ 600 mJ
Pulse energy after compressor	≤ 450 mJ
Compressed pulse duration	25 ± 2 fs
Repetition rate	10 Hz
Pulse energy stabilization (RMS)	1.85%
Nanosecond pre-pulses contrast	8×10^{-8}
ASE contrast @1 ps	2×10^{-5}

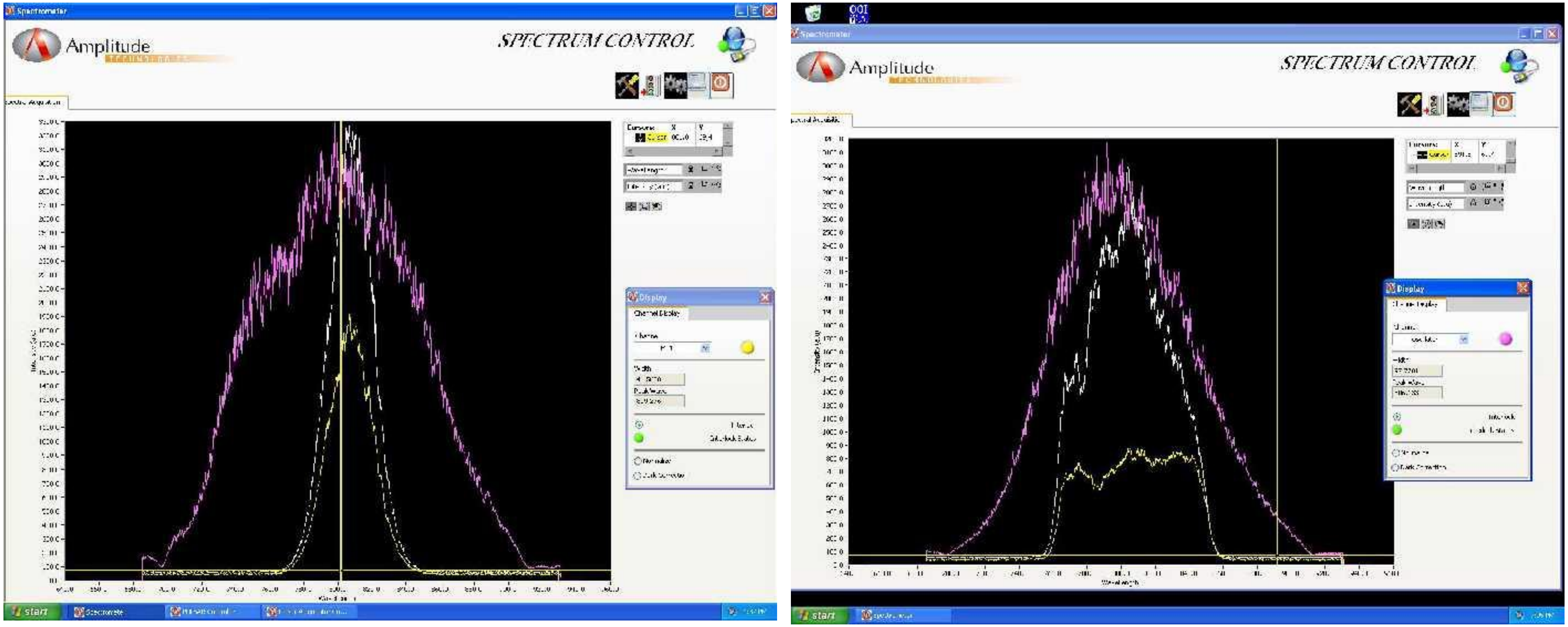
Critical Features of High Power Femtosecond Pulsed Lasers

- **Pulse duration** (spectral bandwidth, phase corrections)

- **Intensity contrast** (ASE, picosecond-nanosecond pre-pulses)

- **Available focused intensity - Strehl ratio** (high beam quality pump lasers, wavefront corrections with deformable mirrors)

Pulse spectrum narrowing during Ti:Sa amplification – TEWALAS

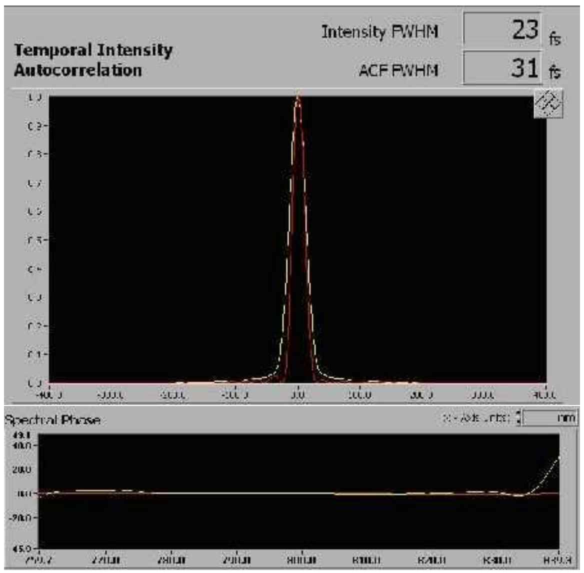


TEWALAS laser spectra: (a) without active Mazzler; (b) optimized by Mazzler. Mauve line – FEMTOLASERS oscillator (100 nm bandwidth); yellow line – after the first multi-pass amplifier, bandwidths - (a) 40 nm, (b) 75 nm; white line - after the second multi-pass amplifier- bandwidths (a) 35 nm, (b

Correction of Spectral Phase Dispersion Using Acousto-Optical Programmable Dispersion Filter

Temporal distortion of the amplified re-compressed pulse is produced by:

- **dispersion and phase distortions introduced by the laser amplifier system**
- **spectral gain narrowing in Ti:sapphire amplifiers**

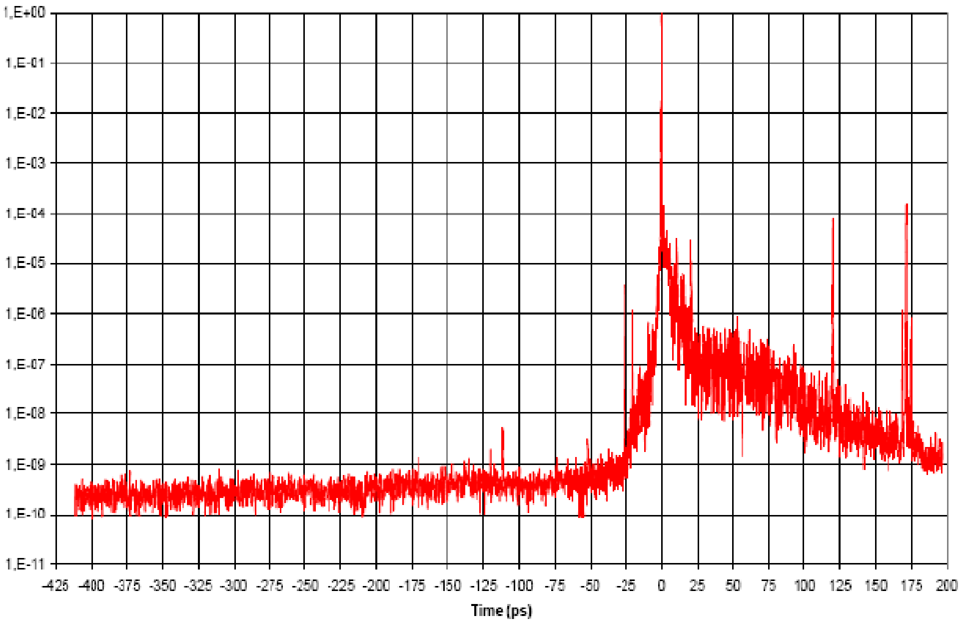


(a)

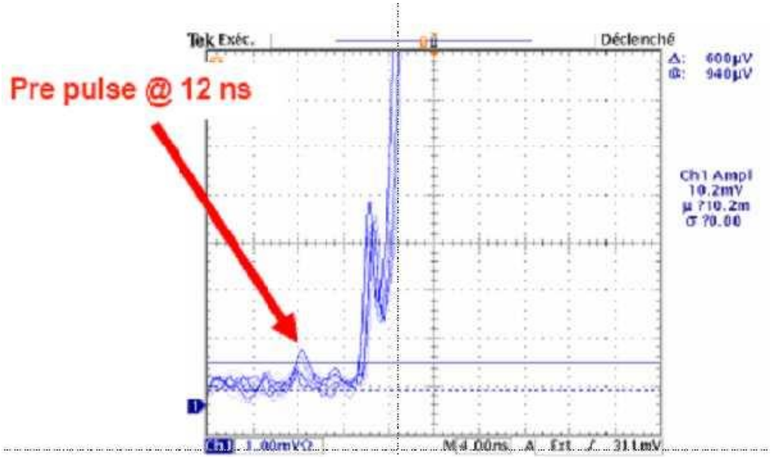
(b)

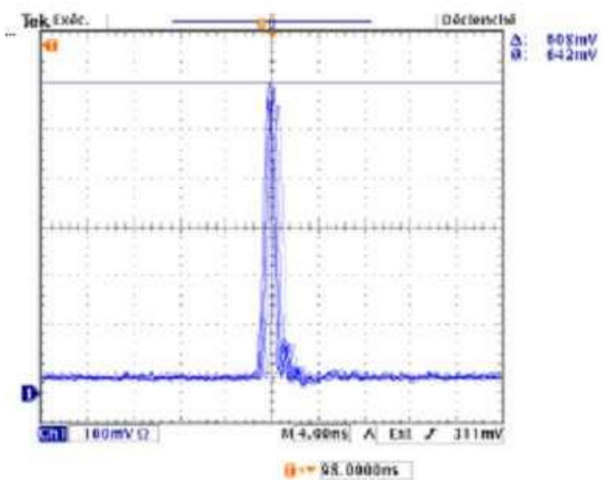
TEWALAS: Pulse duration measurements using SPIDER (a) with Dazzler phase correction; (b) without phase correction. All cases: with spectrum correction by Mazzler

Amplified spontaneous emission (ASE) and nanosecond intensity contrast



ASE contrast measured with a 3-rd order auto-correlator (SEQUOIA)





Nanosecond contrast

Measured intensity contrast:

ASE < 10^{-9}

Nanosecond @ 600mJ: 8×10^{-8}

Femtosecond Laser Studies and Experiments

Micro/nano-technologies (low energy, high repetition rate):

-Thin films micro-processing by femtosecond laser ablation

- Nano-processing in intensified laser field

- Direct laser writing of micro/nanostructures by two-photon photopolymerization

- Two-Photon Excited Spectroscopy

R&D based on femtosecond lasers (high energy):

- Multiple pulses generation in stretcher-compressor femtosecond laser systems

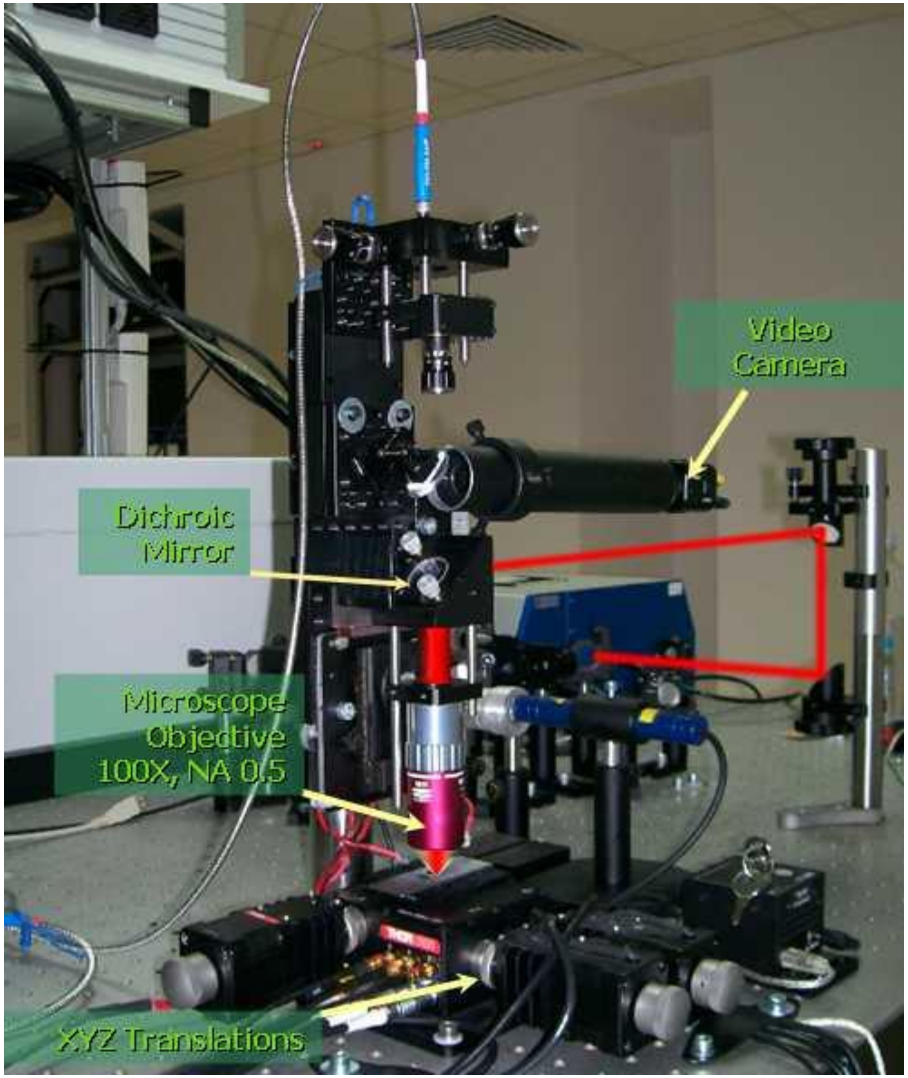
- Simulations and experiments of coherent beam combination

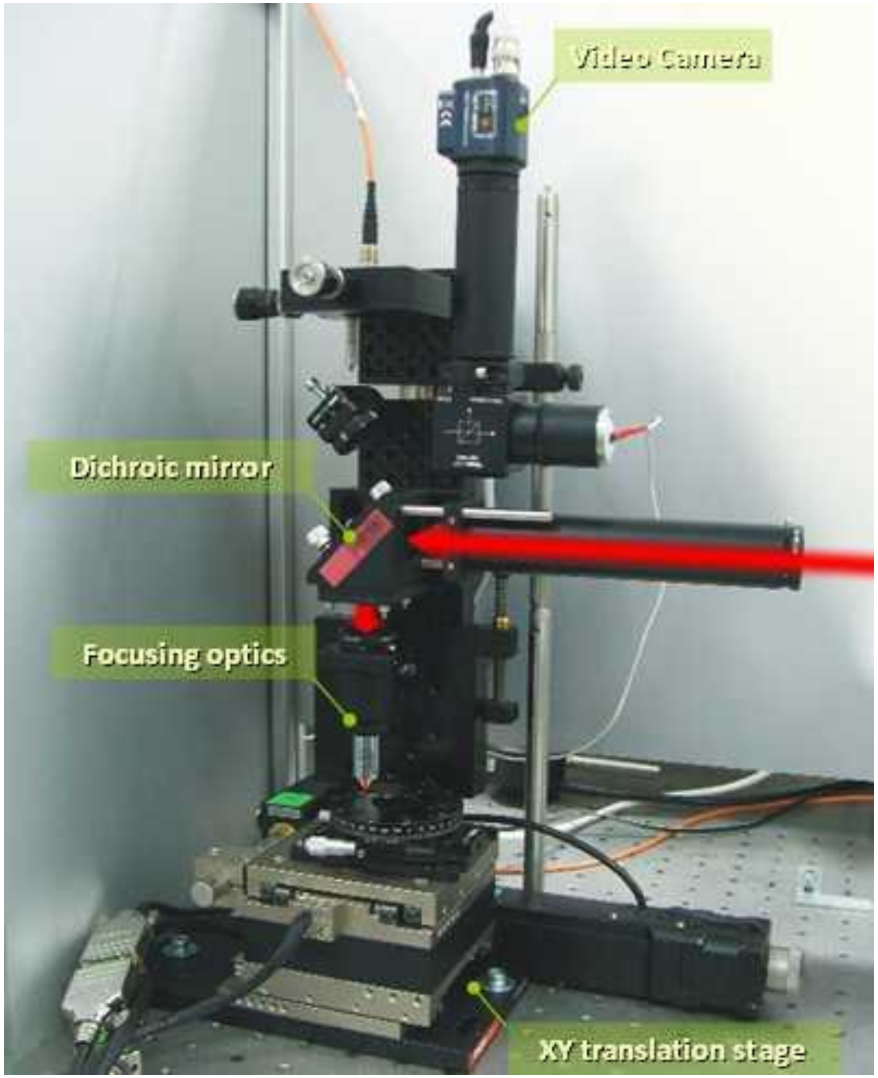
- Non-linear propagation of focused ultrashort pulses in air

- Theoretical studies of high intensity laser field – matter interaction

Direct Laser Writing (DLW) Workstations

Microscope for 3D lithography and laser spectroscopy





Physics of Extreme Light at INFLPR - Prospects

Next (possible) studies based on existing femtosecond lasers:

- Coherent combination of ultra-short pulses using interferometric methods
- X-ray generation using ultra-short laser pulses
- Collinear pump–probe experiments
- THz radiation generation
- Plasma mirror studies
- Study of absorption and density gradients in laser-produced plasmas
- Diagnosis and characterization of laser beams and optical components for nanosecond & femtosecond high energy lasers
- Large bandwidth OPCPA (OPCPA at critical wavelength degeneracy)

Prospects of High Power fs Lasers at INFLPR

2005 2009 2010 2012 2015

CPA 2101 CLARK MXR, USA
(0.7 mJ, 2 kHz, 4 GW/200 fs)

TEWALAS
AMPL. TECH., FRANCE
(400 mJ, 10 Hz,
15 TW/25 fs)

CETAL
(30 J, 0.1-1 Hz, 1 PW/30 fs)

ELI – NP
(2 x 250 J, 1 pulse/min, 2 x 10 PW/25 fs)

High power femtosecond laser projects:

- **1-PW (CETAL project, 2010-2013)**
- **10-PW (Extreme Light Infrastructure, Romanian Pillar for Nuclear Physics – ELI-RO-NP, 2010-2015)**

ELI-NP building

Possible solutions for a 10-PW laser

A) OPCPA based laser system (910-nm central wavelength):
Front-End → very broad-band signal radiation at 910-nm central wavelength generated by chirp-compensated collinear OPA.
High power OPCPA in large aperture DKDP crystals

B1) Hybrid laser system at ~ 800 nm central wavelength:

- **Front-End based on OPCPA in nonlinear crystals (BBO, LBO)**
- **High energy amplification in Ti:sapphire crystals**

or

B2) Ti:sapphire amplifiers at ~ 800 nm central wavelength :

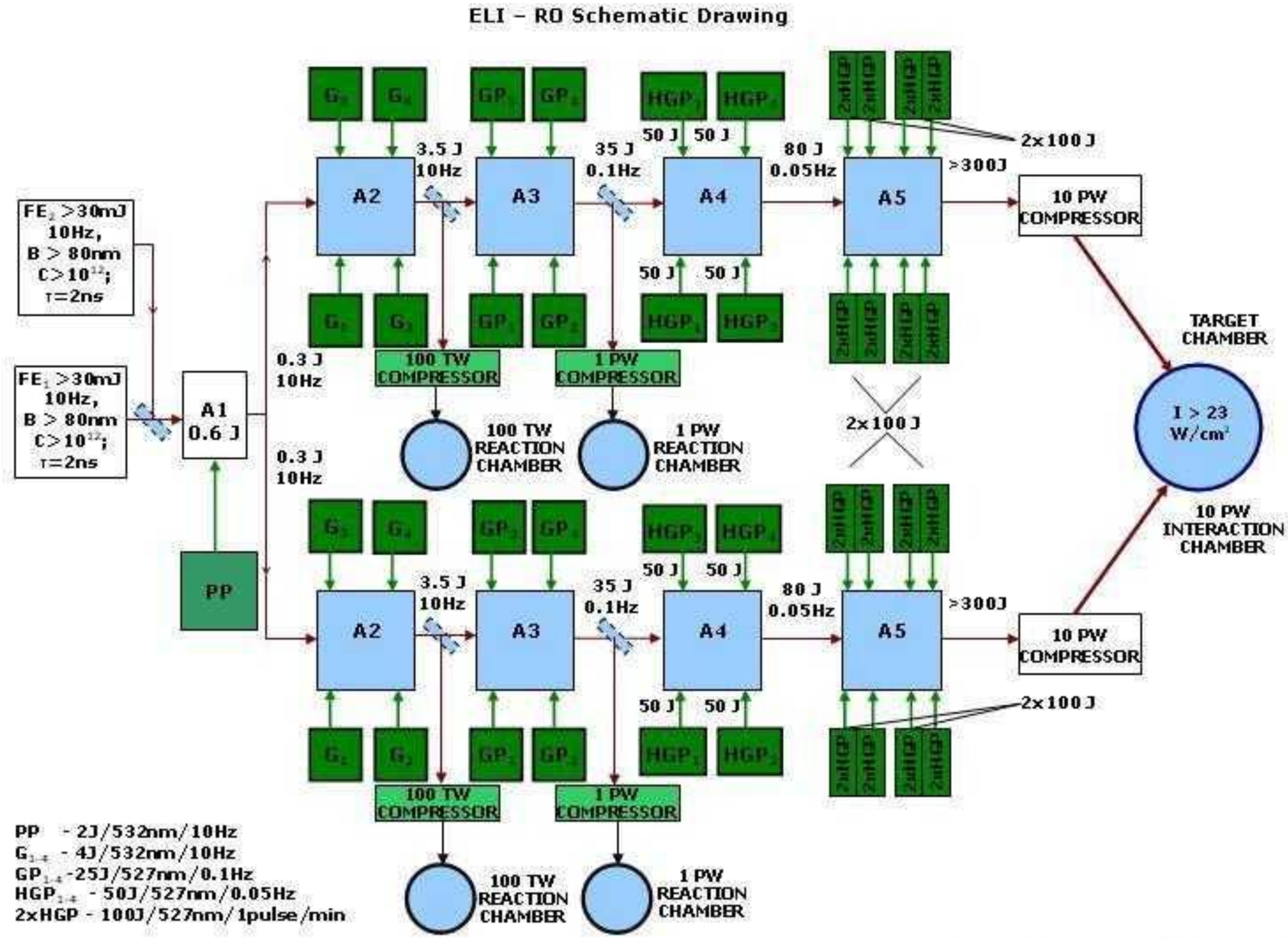
- **Front-End based on Ti:sapphire amplification**
- **High energy amplification in Ti:sapphire crystals**

Basic solution for ELI-RO-NP laser

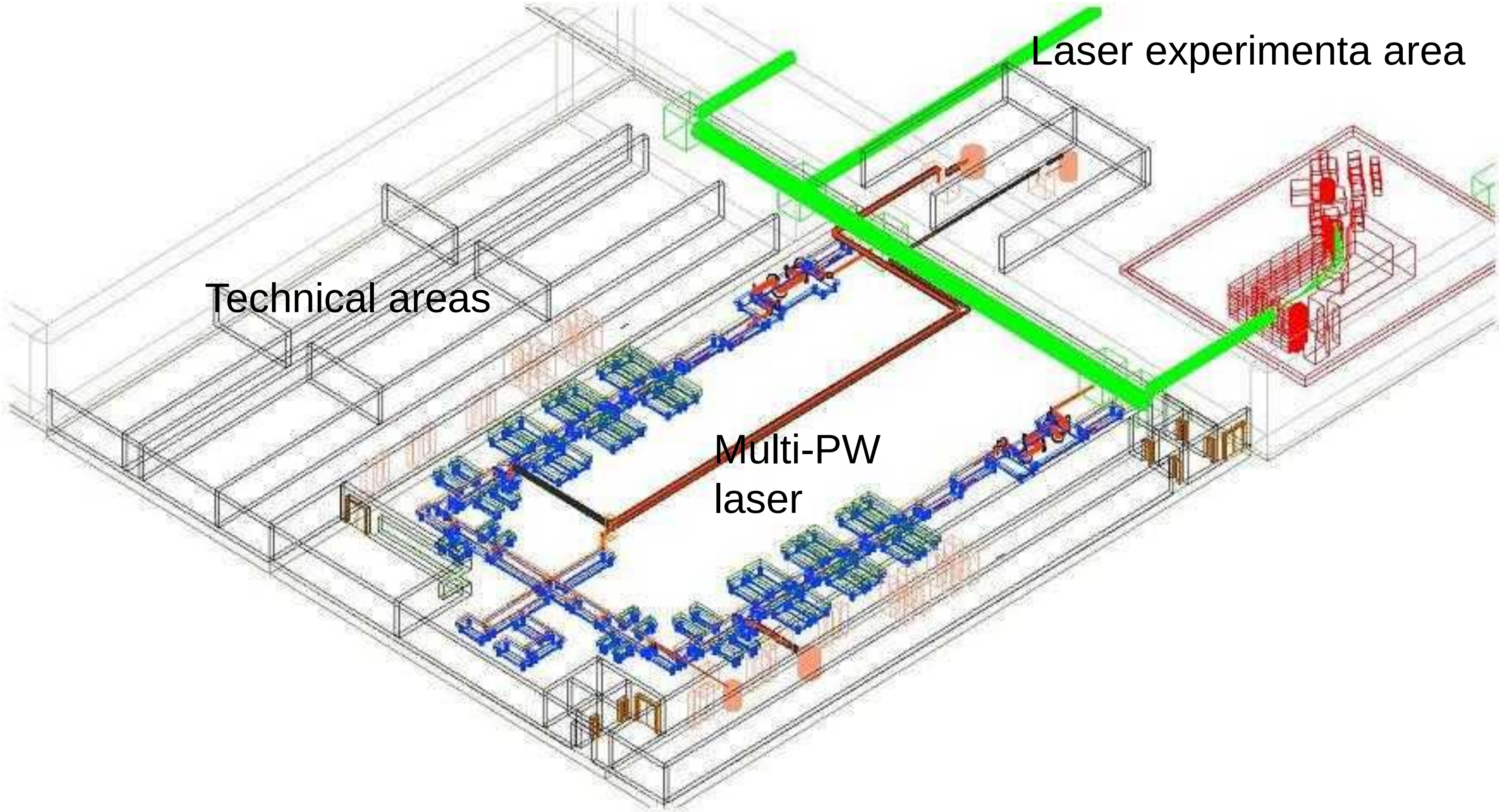
C) Hybrid laser system with Front-End based on OPCPA in BBO crystals and high energy amplification in mixed silicate/phosphate Nd-doped glasses near 1 μm wavelength

Alternative solution for ELI-RO-NP laser

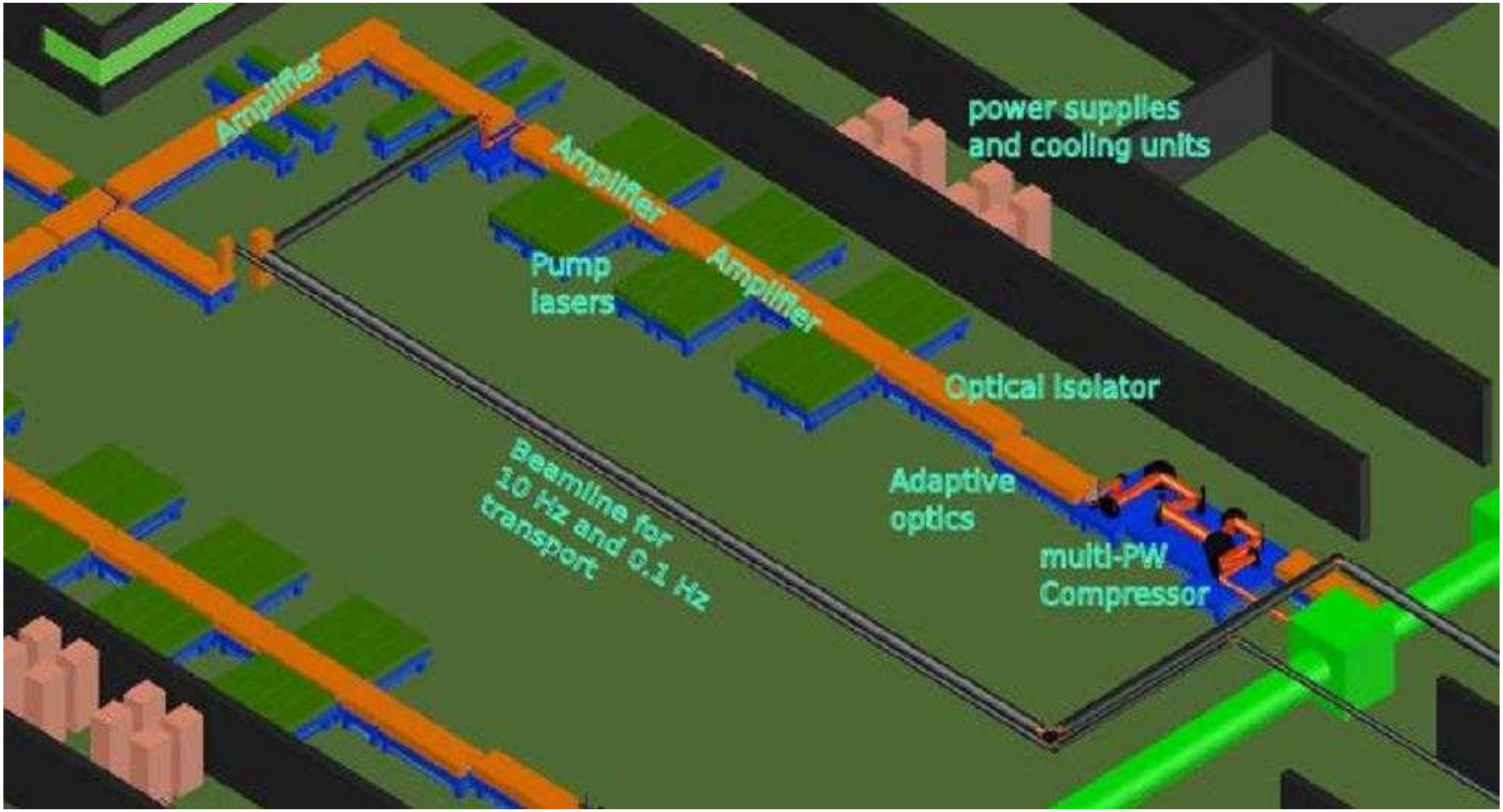
Laser Architecture



Overview of ELI-NP
Multi-PW Laser



Overview of ELI-NP laser arm



Overview

- GIWALAS facility - productive
- TEWALAS facility - fully comissioned + productive
- CETAL PW laser system on the track
- Extreme Light Infrastructure feasibility study reviewed

Thank You for attention!