HiLASE: New lasers for industry and research

Antonio Lucianetti, Ph.D.
Research Program Leader
HiLASE Centre

CZ.1.05/2.1.00/01.0027

High average power, pulsed LASErs

hilase
Power of light

- Project of ***National Interest*** led by the Institute of Physics ASCR
- Financed by the Research and Development for Innovation Operational Program (ERDF)
- R&D Centre
- DPSSLs with breakthrough parameters
- Applications of DPSSL in high-tech industry
- Synergy with ELI Beamlines

VLÁDA ČESKÉ REPUBLIKY

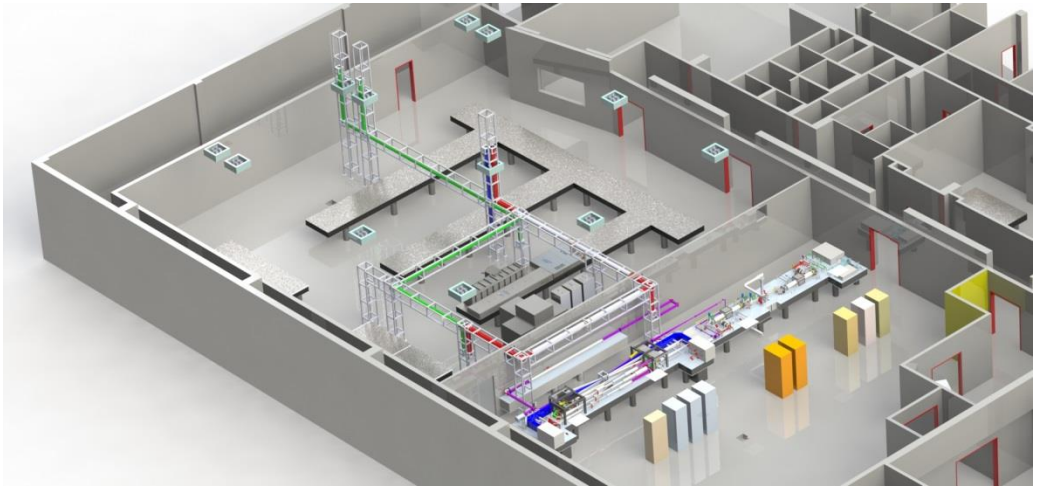
USNESENÍ

VLÁDY ČESKÉ REPUBLIKY
ze dne 23. listopadu 2009 č. 1442

k návrhu na podporu projektu HiLASE (High average-power pulsed LASErs) v kontextu strategie umístění projektu ELI (Extreme Light Infrastructure) na území České republiky

Vláda

I. **podporuje** projekt HiLASE (High average-power pulsed LASErs) jakožto projekt národního zájmu České republiky, zejména v kontextu strategie umístění projektu ELI (Extreme Light Infrastructure) na území České republiky a souvisejících mezinárodních závazků České republiky;



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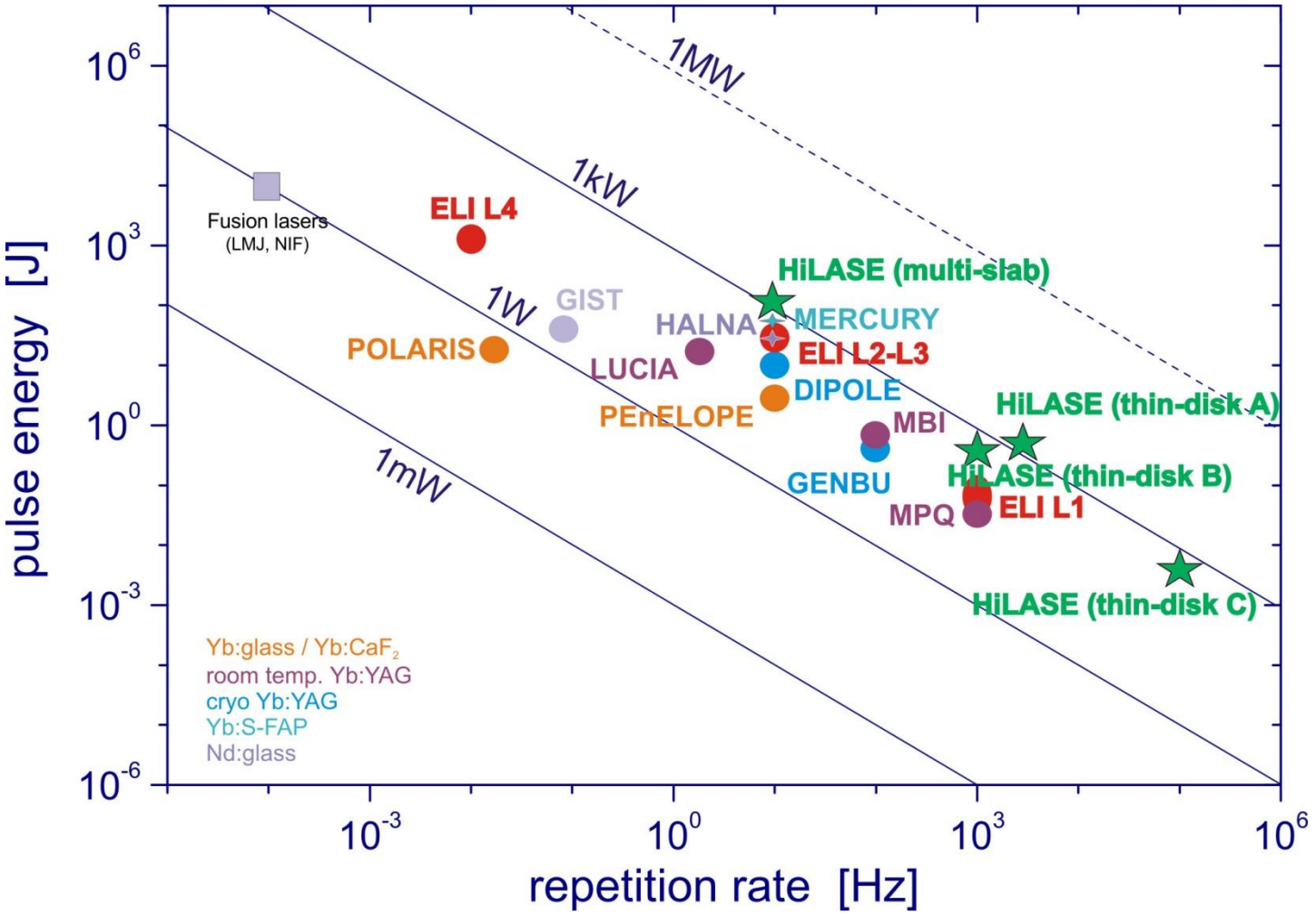
Aiming very high



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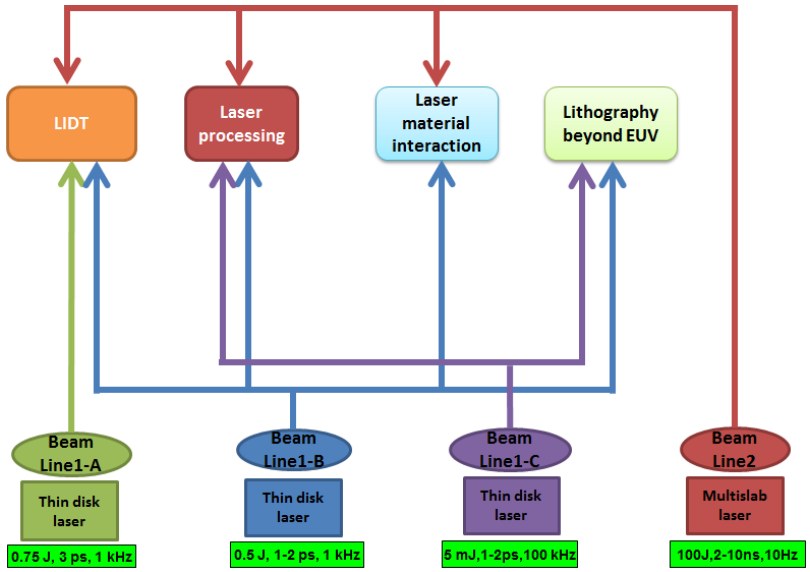
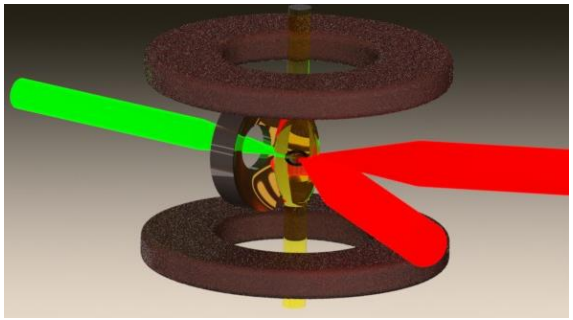
Lasers for real-world applications

- Laser induced damage threshold measurement of optical materials (LIDT)
- Laser shock peening (LSP)
- Compact EUV sources for lithography (EUVL)
- Precise cutting, drilling and welding of special materials for automotive and aerospace industry
- Technology of laser micromachining
- Laser surface cleaning and processing





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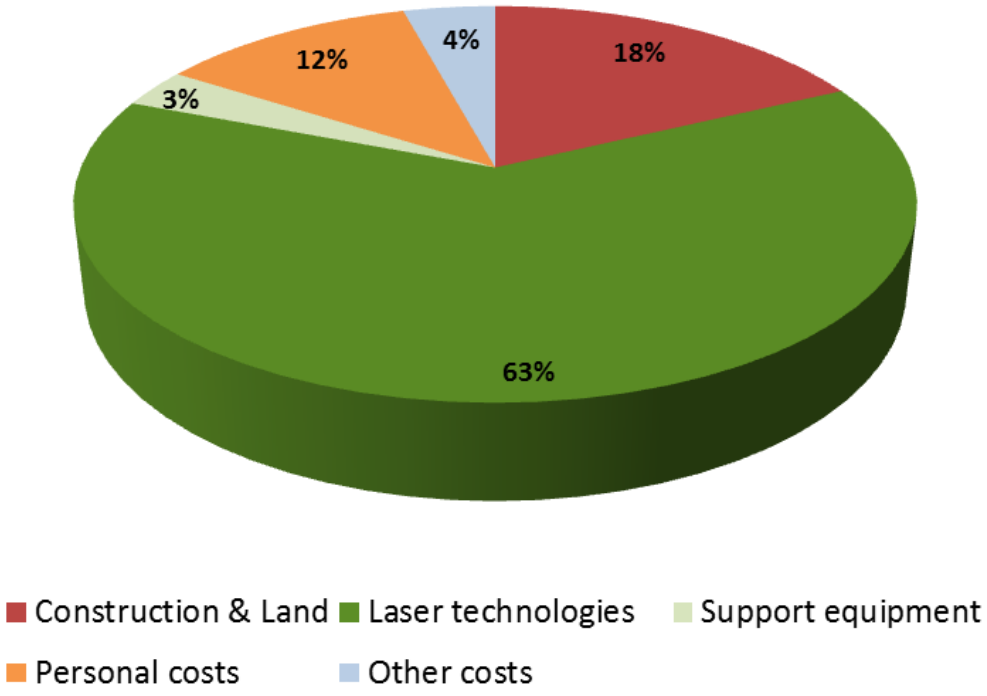
Budget



BUDGET CHAPTER	EUR Mio
Construction & Land	5,1
Laser technologies	17,9
Support equipment	0,9
Personal costs	3,3
Other costs	1,2
TOTAL COSTS	**28,4**

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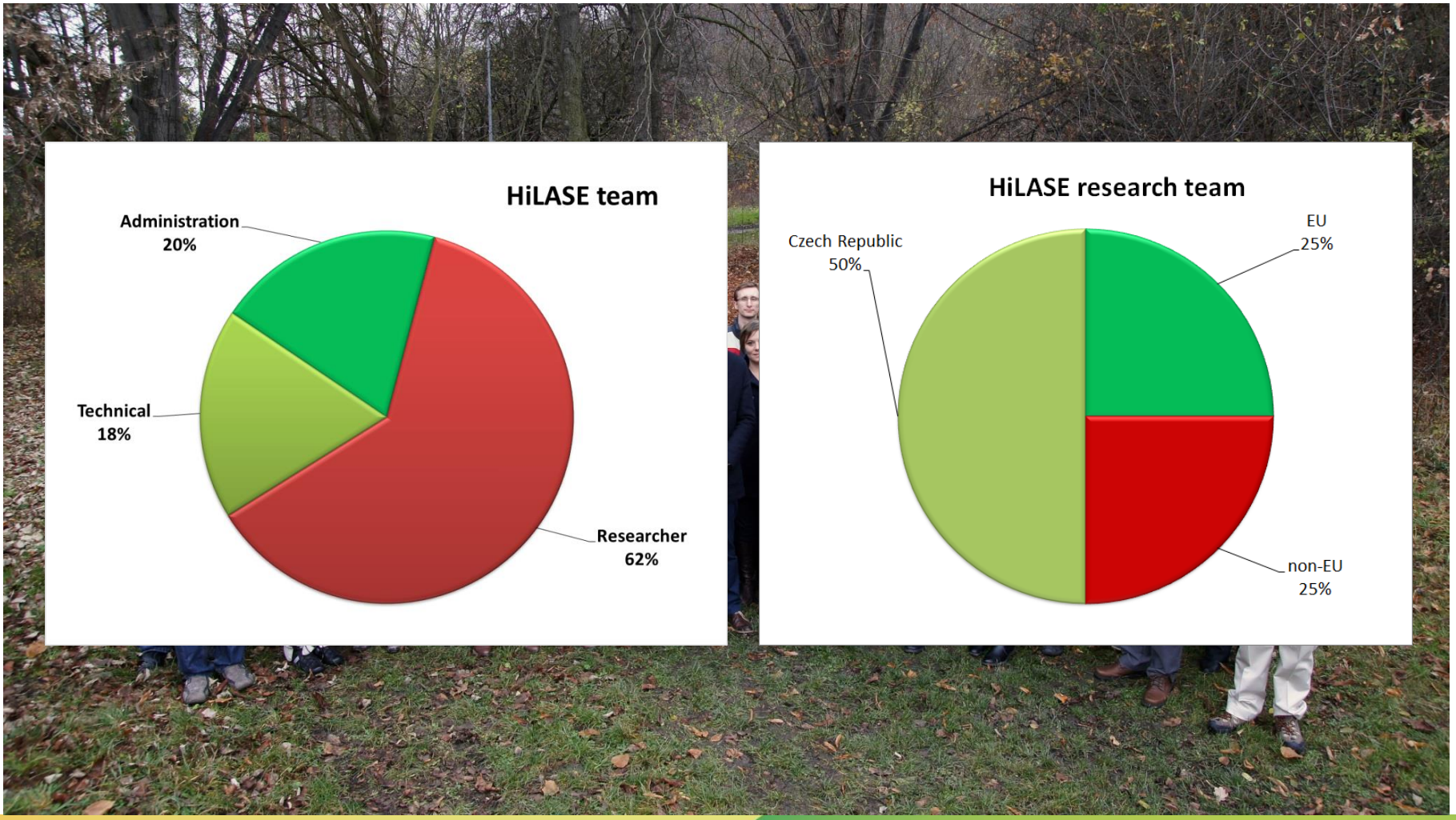
Crew complete: 70 heads / 60 FTE



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International collaboration

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WASEDA UNIVERSITY

POLITÉCNICA
"Ingeniamos el futuro"

Laser-
Laboratorium
Göttingen e.V.

CNR IFN
Istituto di Fotonica e Nanotecnologie

laboratoire d'optique appliquée

IOQ
Jena

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DEGLI STUDI
DI PARMA

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Time schedule: 11 months ahead

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09/2011
Decision on grant

10/2011
Start of procurement and in-house R&D of key laser systems, incl. construction

09/2012
Start of construction of new building

01-03/2013
Signing contracts for key laser systems

03-06/2014
End of construction, relocation from Prague to Dolní Břežany

01-08/2015
Installation and optimization of key laser systems

09/2015
Commissioning of HiLASE R&D Centre

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Development of multi-J, kW class thin-disk laser system (L1)

Prof. Akira Endo

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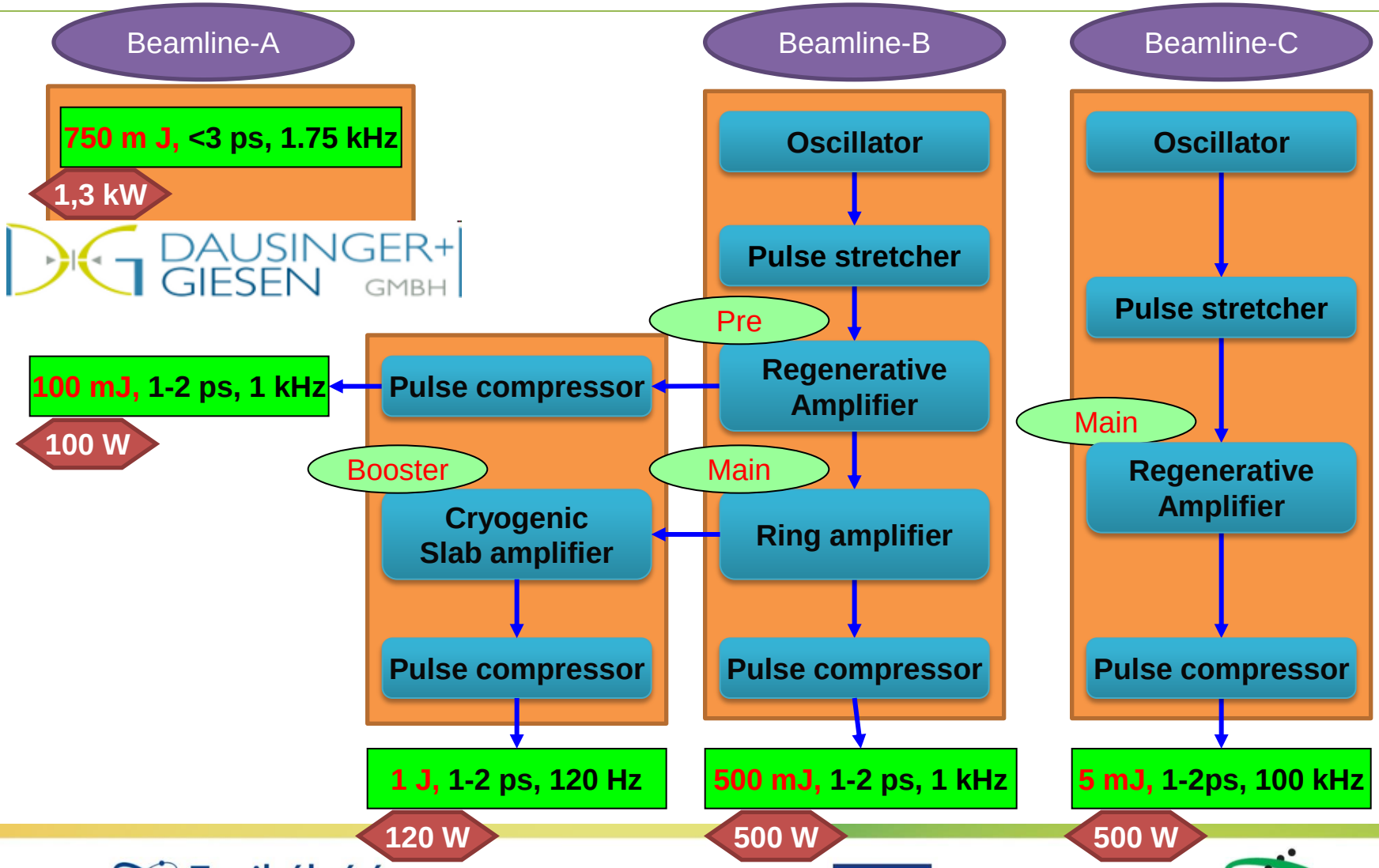
Concept of kW-class thin-disk DPSSL



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Applications of our thin-disk lasers

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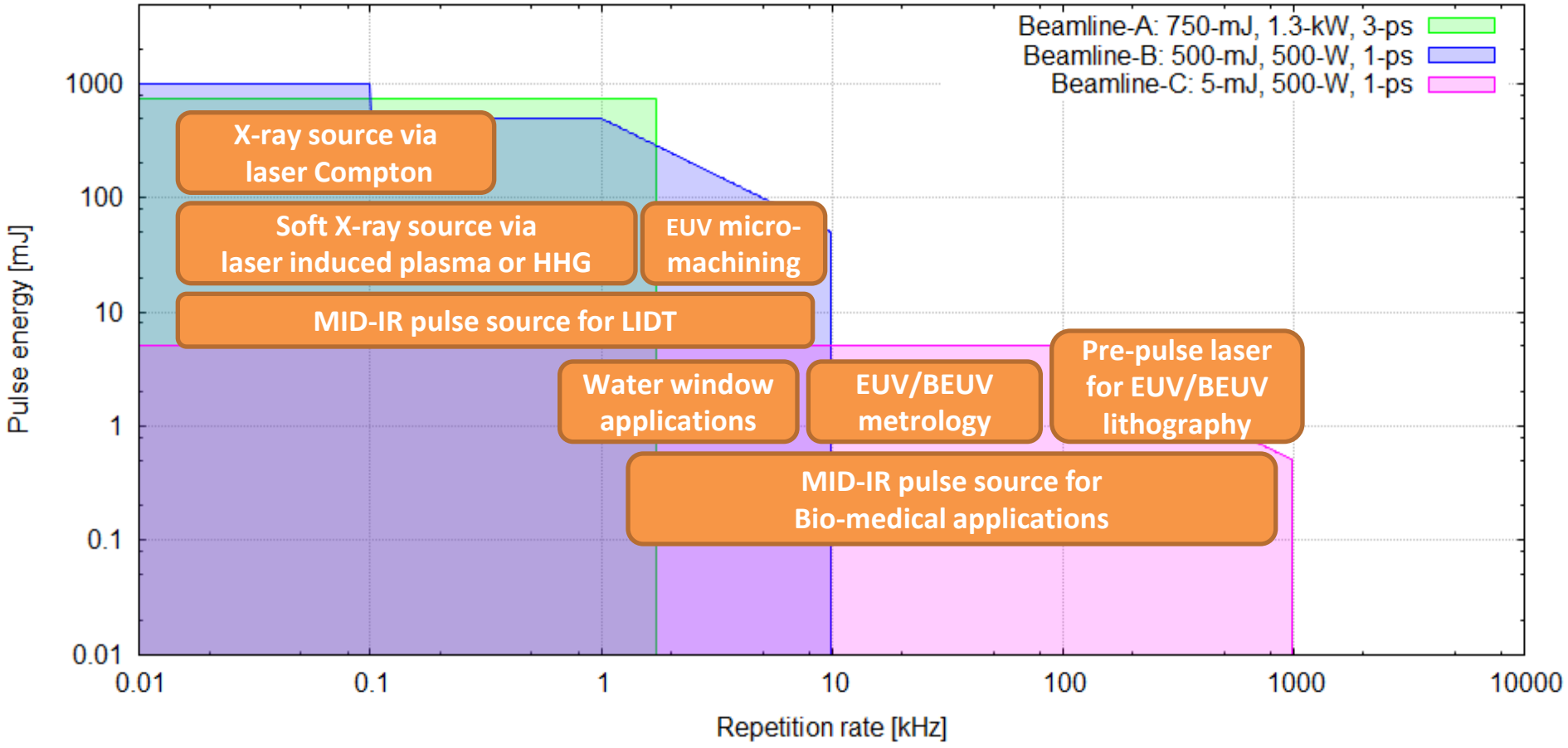

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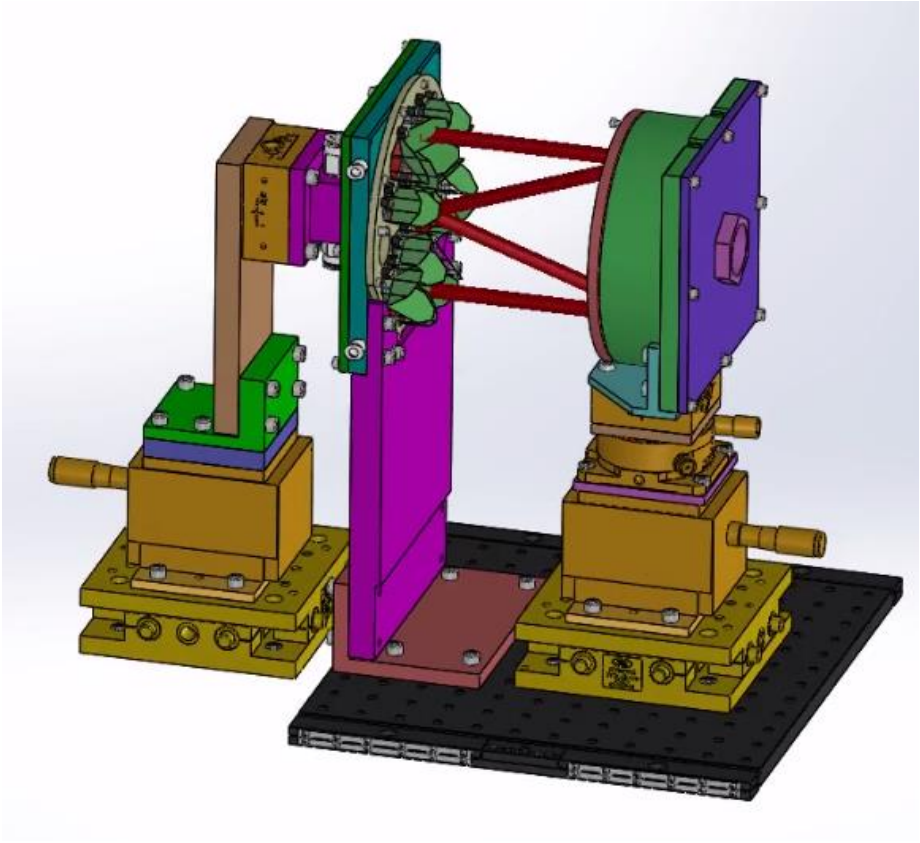
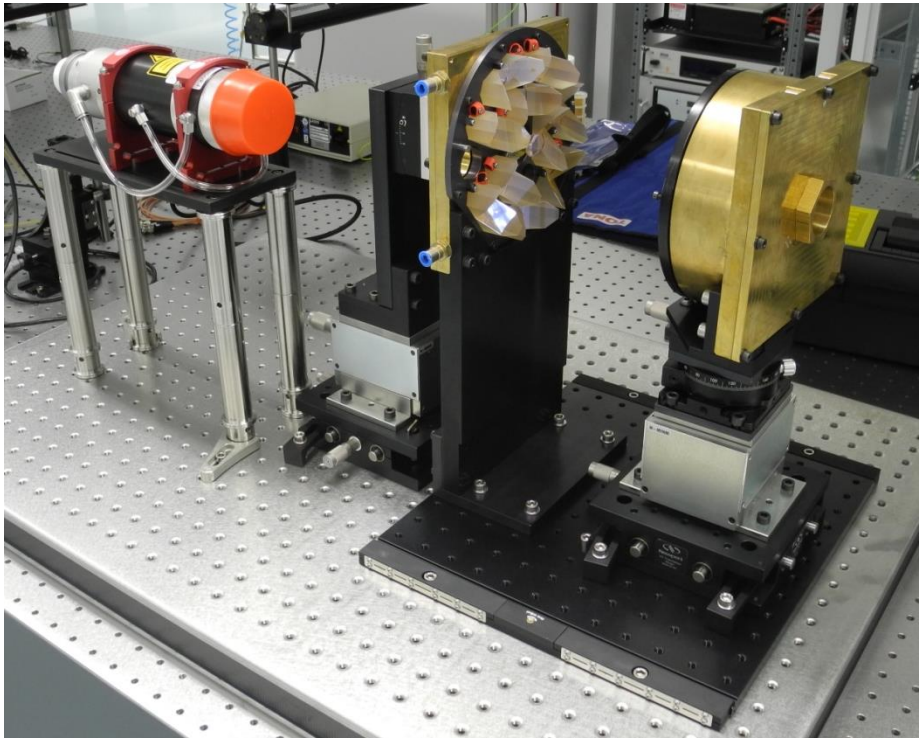
Thin-disk head for 5-kW pumping (home-made)





Thin-disk beamline C (100 kHz)

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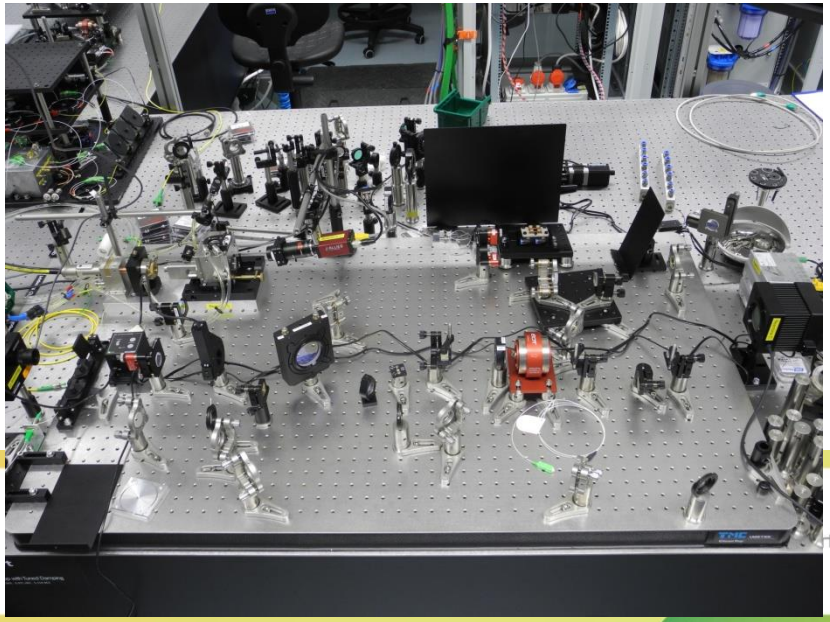
August 15, 2014 / Vol. 39, No. 16 / OPTICS LETTERS 4919

Suppression of nonlinear phonon relaxation in Yb:YAG thin disk via zero phonon line pumping

Martin Smrž,[1,*] Taisuke Miura,[1] Michal Chyla,[1,2] Siva Nagisetty,[1,2] Ondřej Novák,[1] Akira Endo,[1] and Tomáš Mocek[1]

[1]*HiLASE Centre, Institute of Physics ASCR, v.v.i., Za radnicí 828, 25241 Dolní Břežany, Czech Republic*

CW 969&940nm pump



- CVBGs designed for 2.2+-0.5nm bandwidth (FWHM)
- Aperture 8x8mm
- 180 ps/nm dispersion
- 88% diffraction efficiency
- Oscillator bandwidt approx. 20nm
- 78.5% pulse energy losses in stretcher
- Home-made oscillator is being developed
- Compressor (grating) efficiency 87 - 88% (measured)

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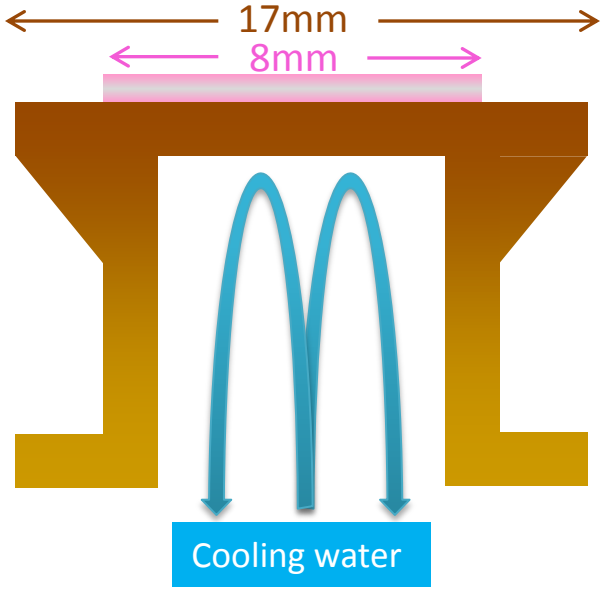
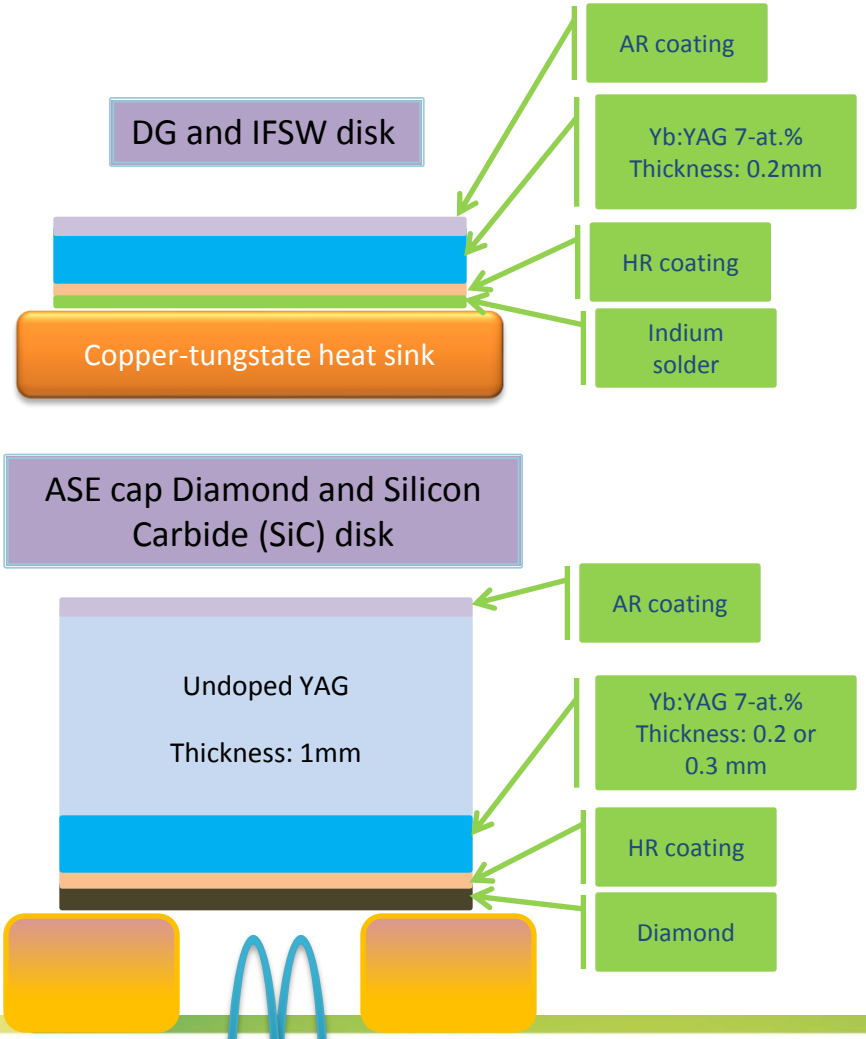
In-house thin-disk development





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Evaluation of Various Thin Disks (in CW Multimode Laser Cavity)

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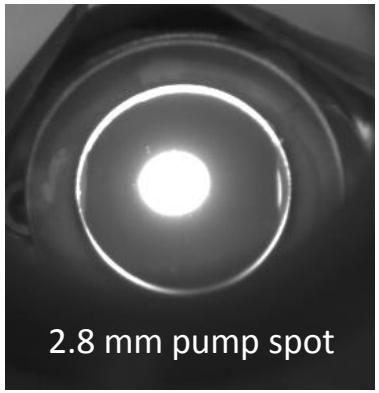
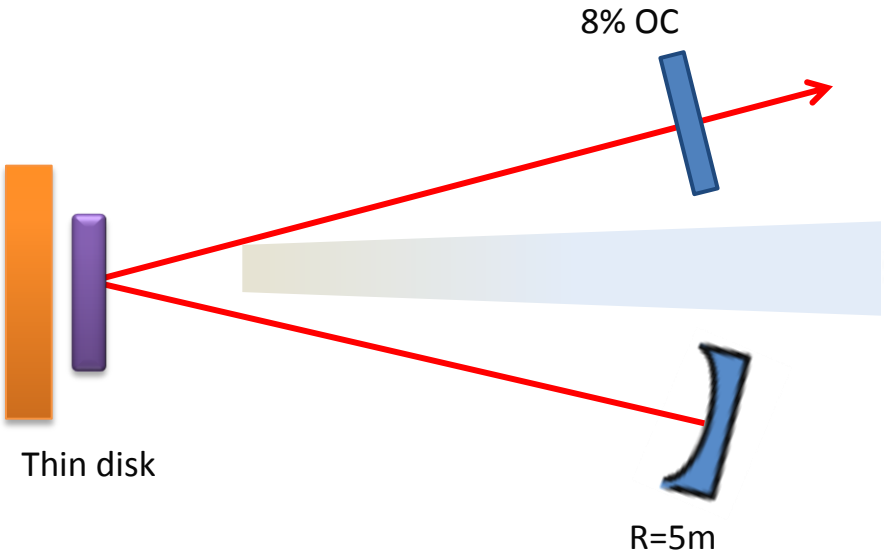
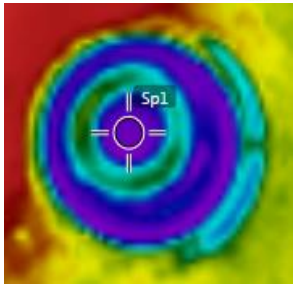
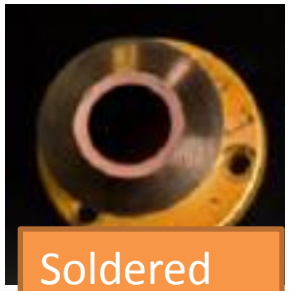


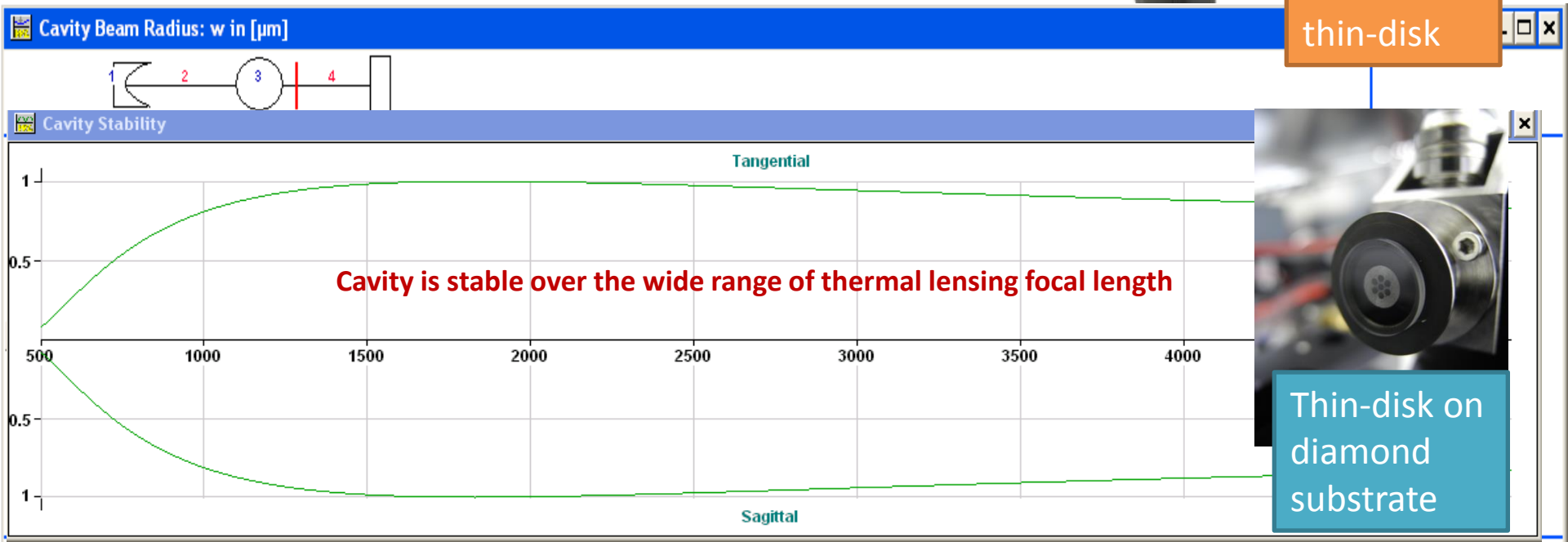


Thermal camera





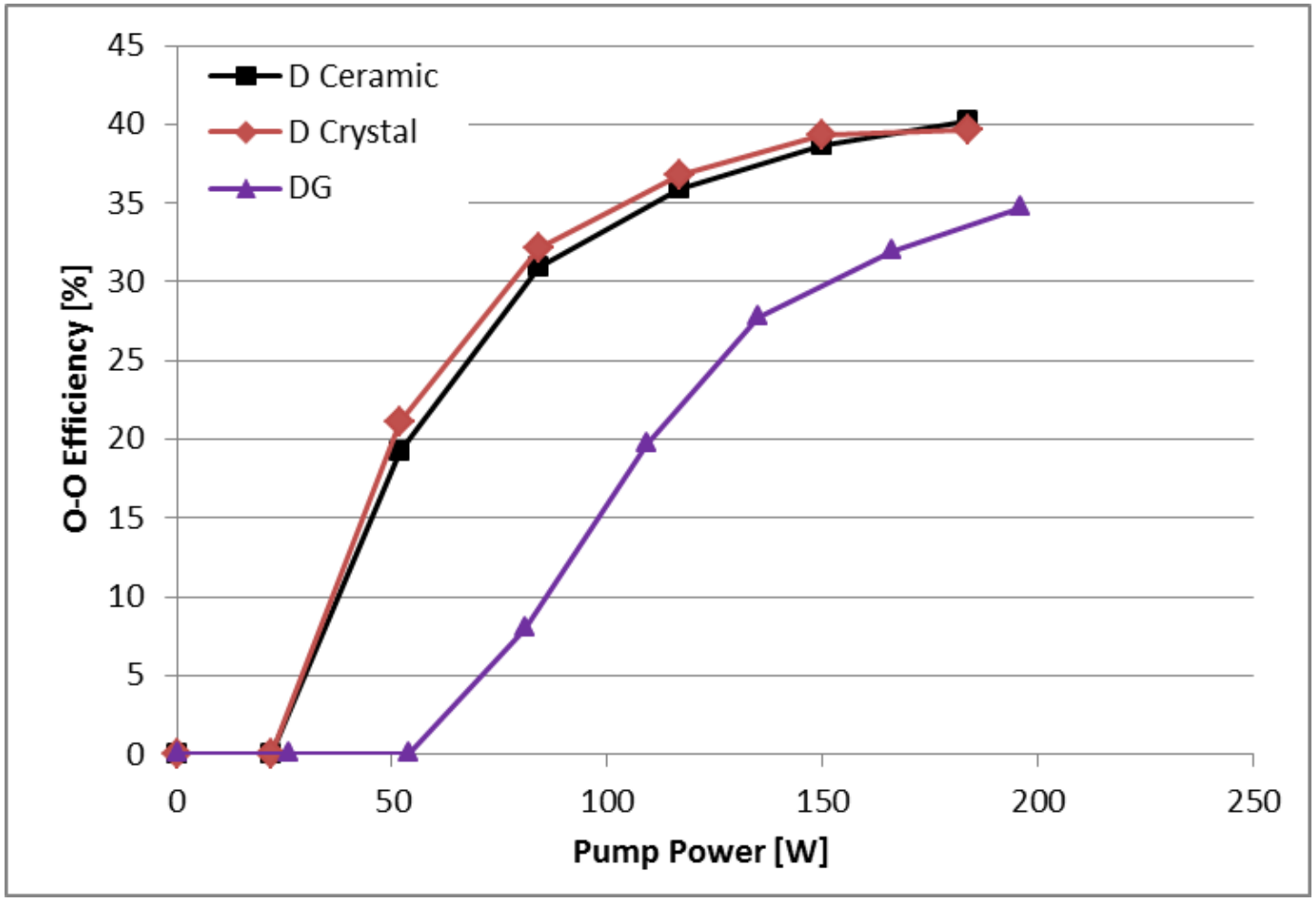
Soldered thin-disk



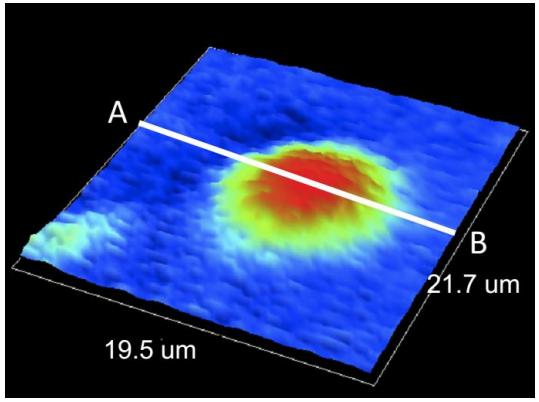
Cavity is stable over the wide range of thermal lensing focal length

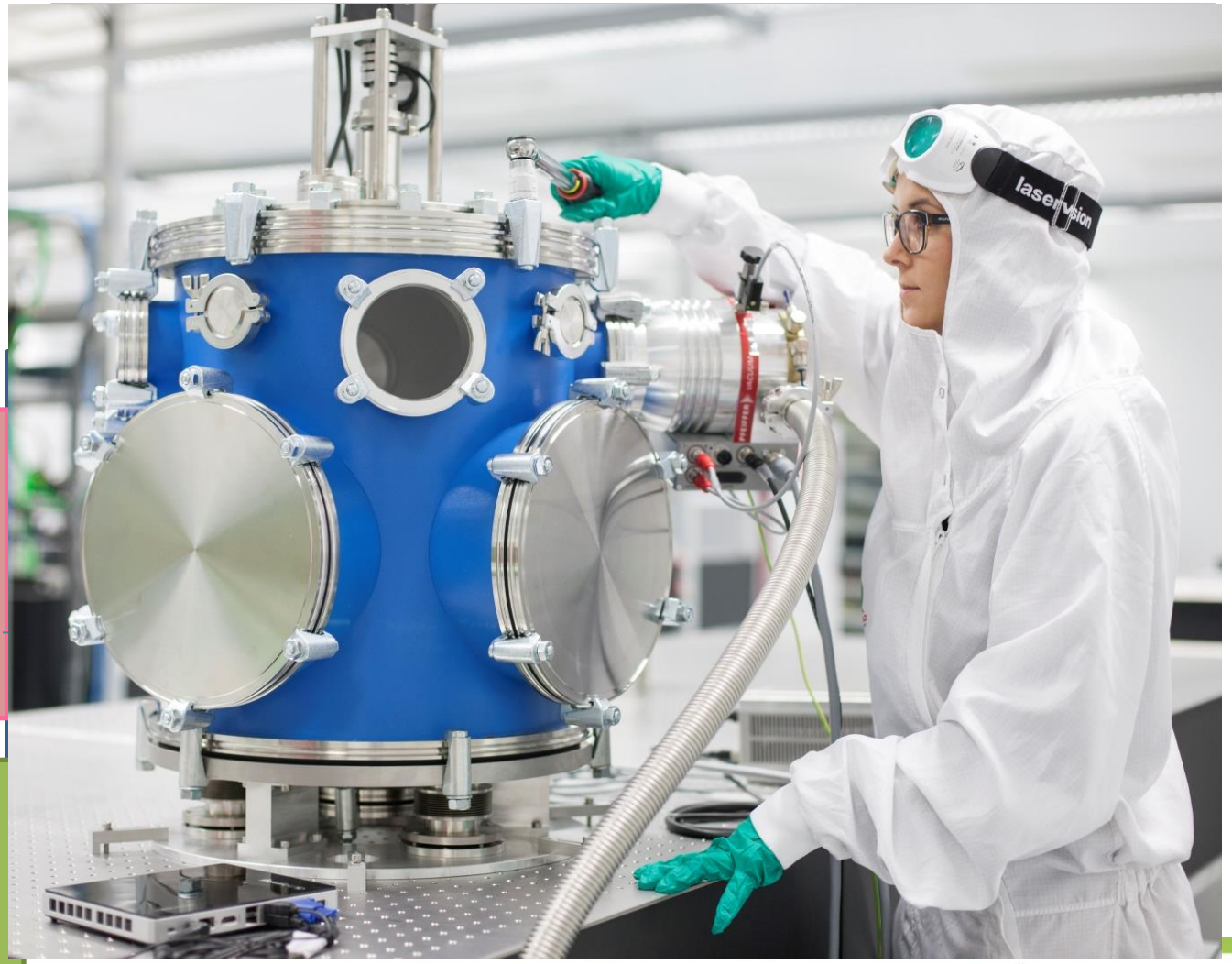
Thin-disk on diamond substrate

Optical-to-optical efficiency



Tin Rotational Target for EUV Metrology Source





Driving motor

Sn dot size: ϕ10 μm
Dot separation: 10 μm
Speed: 4000 rpm
Accuracy: +/- 1 rpm
Pointing stability: +/- 5 μm
Flatness: +/- 5 μm

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07/2014

08/2014

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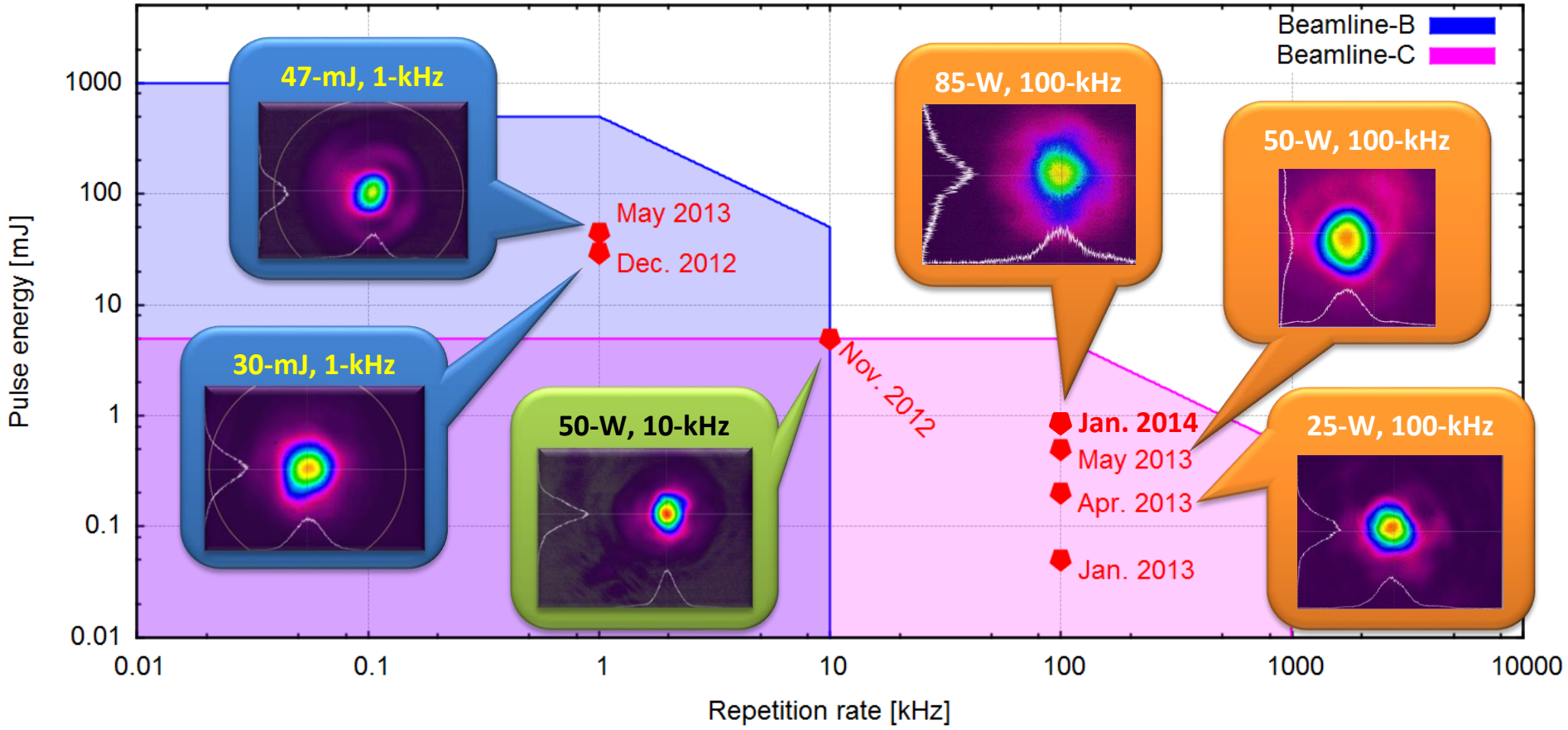
Status of in-house development



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Development of 100 J / 10 Hz cryogenically cooled multi-slab DPSSL system scalable to kJ level (L2)

Dr. Antonio Lucianetti

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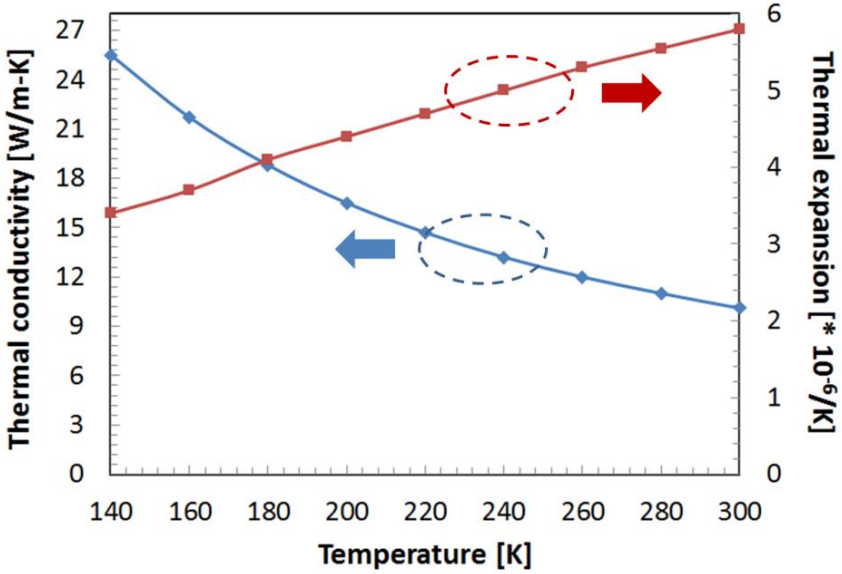
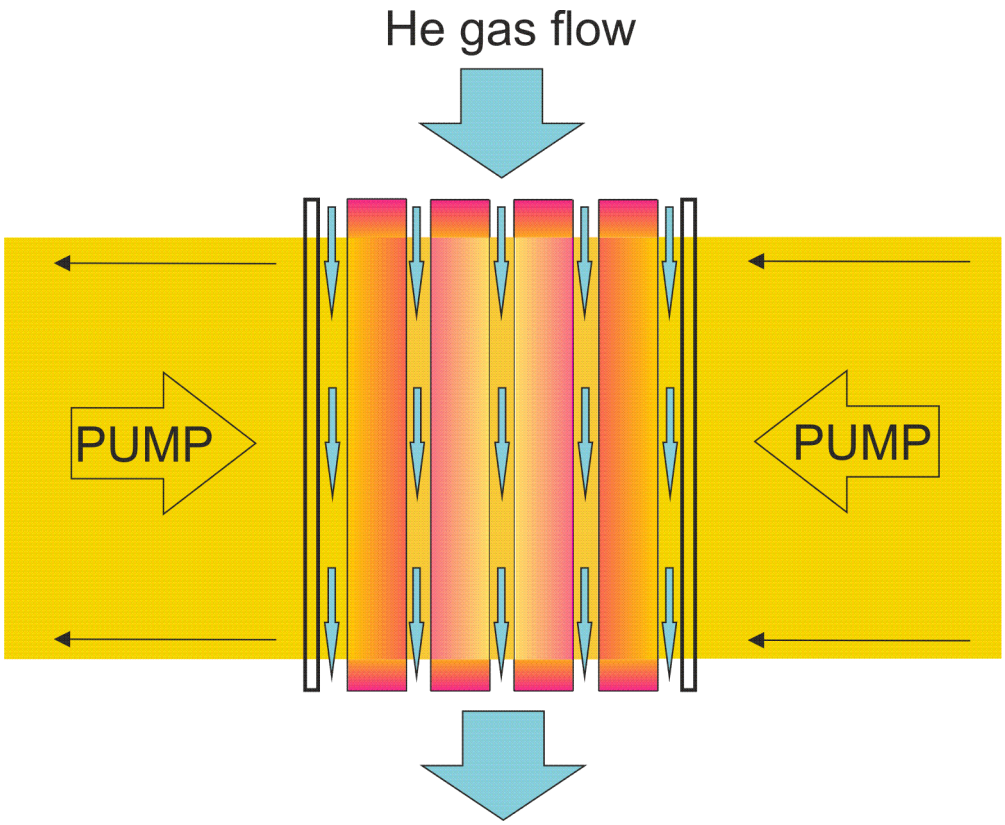
Concept of kW-class, multi-slab amplifier





DiPOLE

Science & Technology Facilities Council
Central Laser Facility

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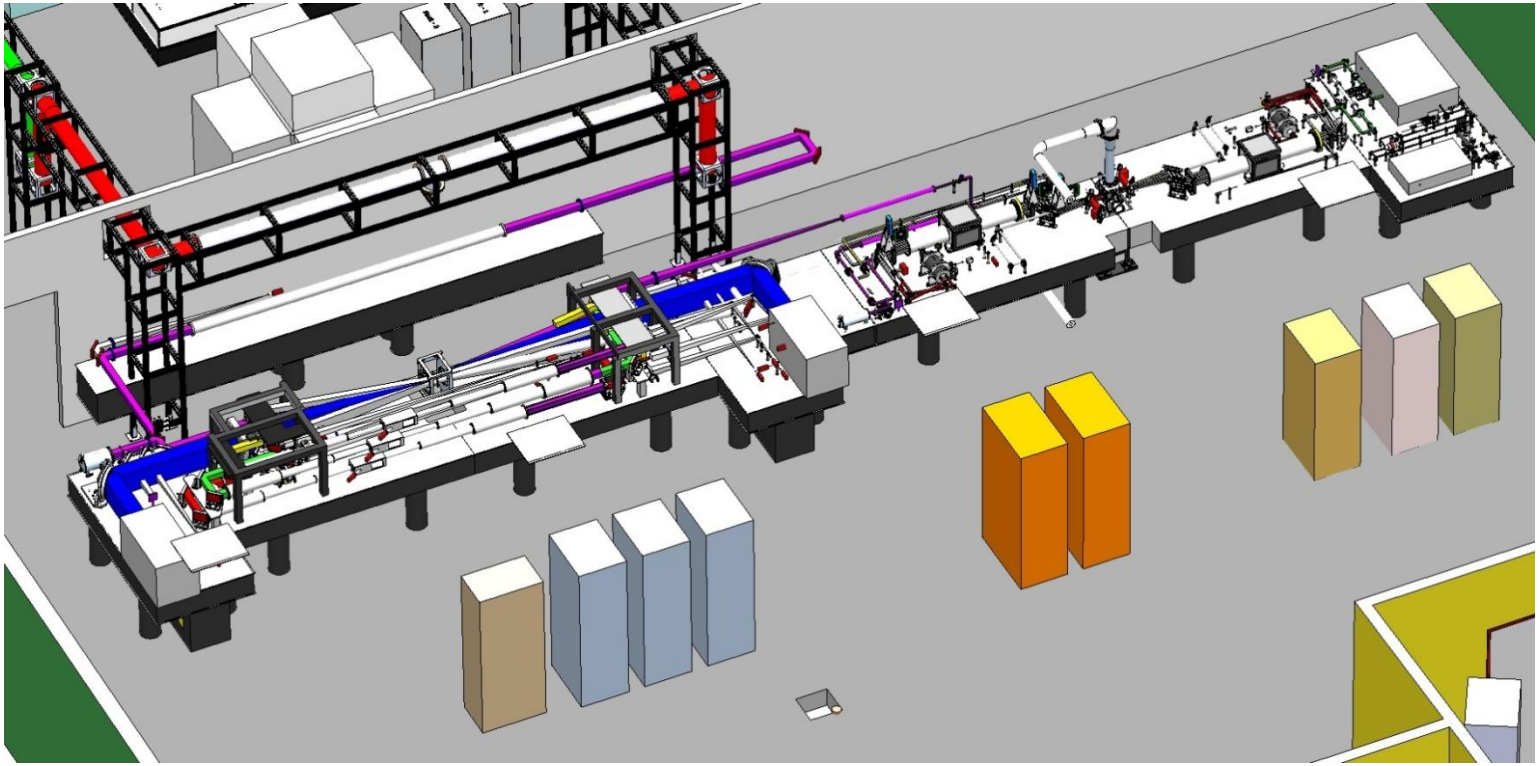
Strategic partnership with STFC/RAL

STFC Central Laser Facility



D1	✓
D2	✓
D3	✓
D4	✓
D5	✓
D6	✓
D7	
D8	
D9	
D10	
D11	
D12	
D13	

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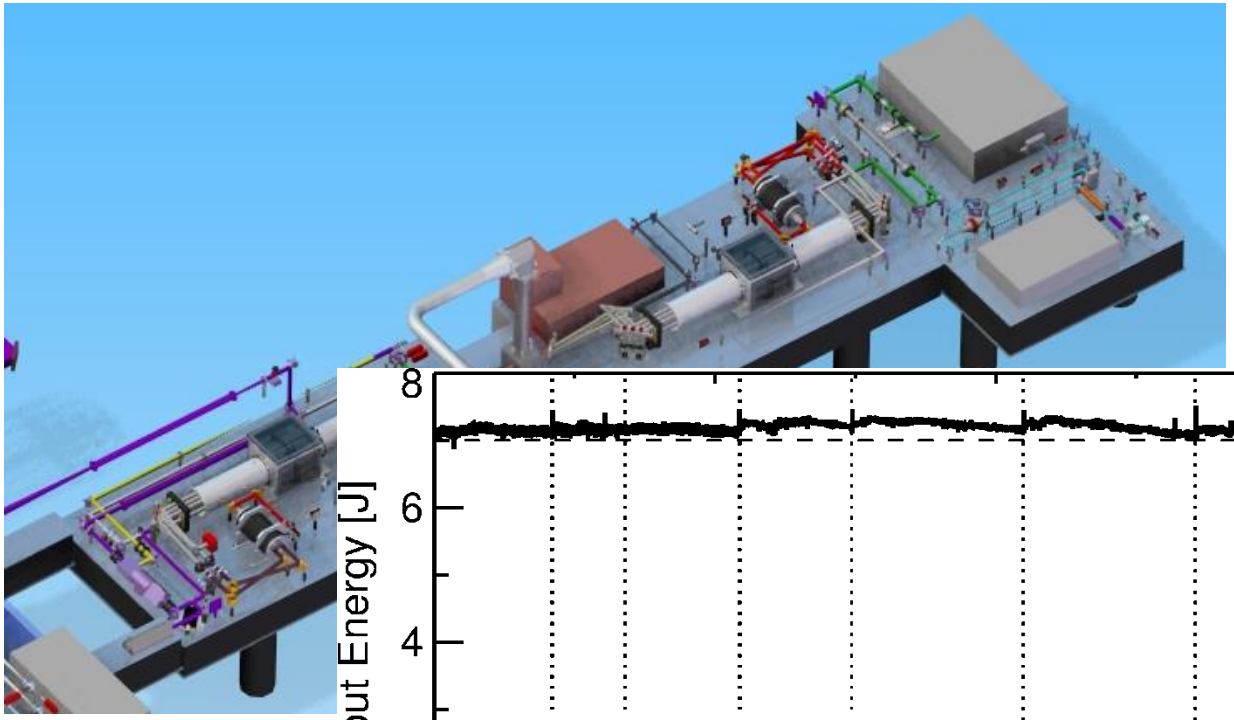
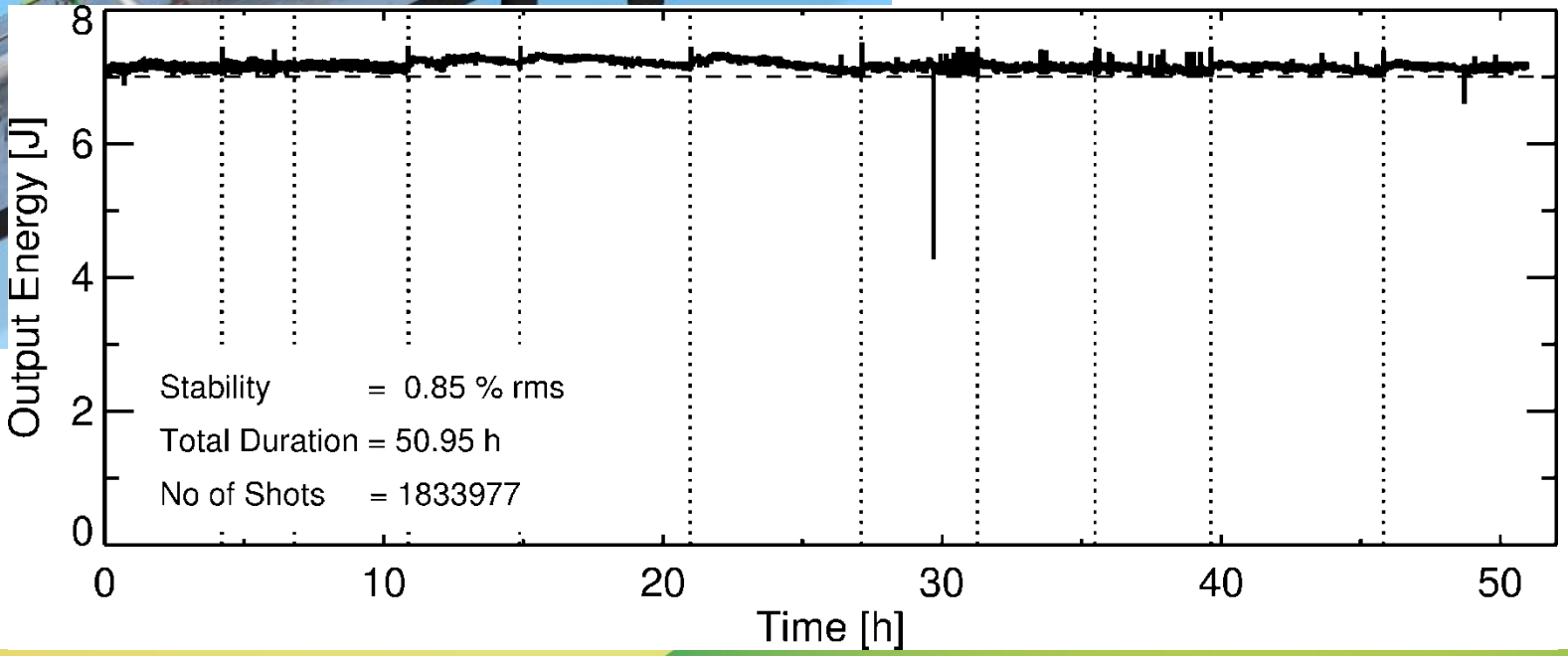
10 J / 10 Hz cryogenic pre-amplifier



Output energy	> 7 J
Average power	> 70 W
Wavelength	1030 nm
Cooling	He flow
Temperature	150-175 K



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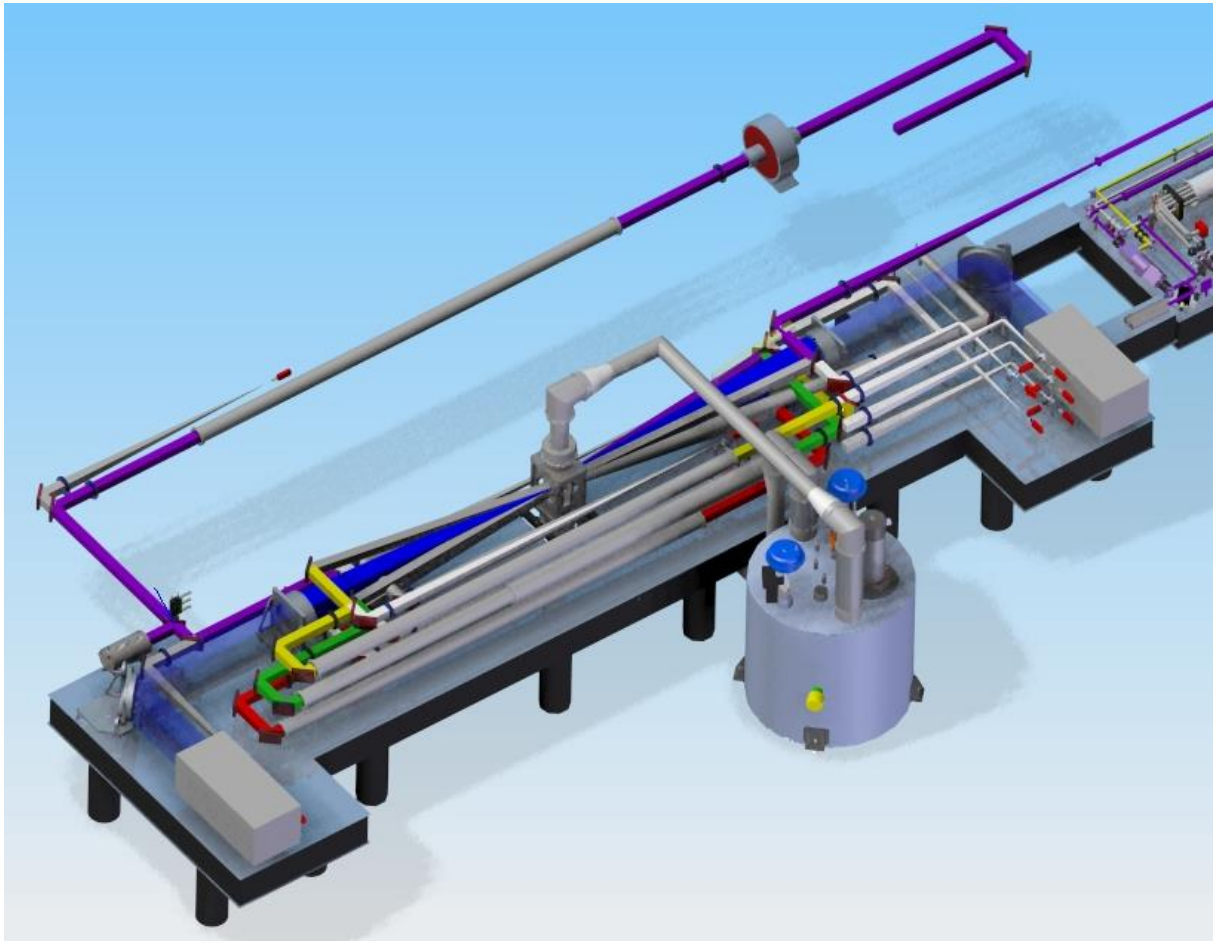
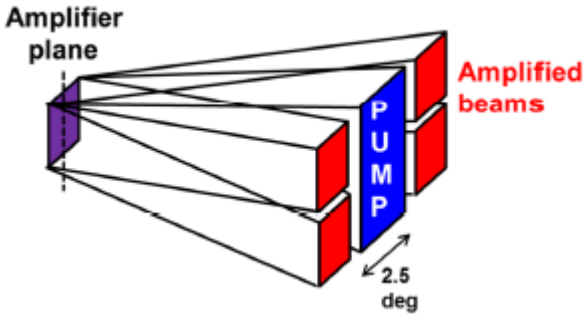
100 J / 10 Hz cryo power amplifier



Output energy	> 100 J
Average power	> 1 kW
Wavelength	1030 nm
Cooling	He flow
Temperature	150-175 K



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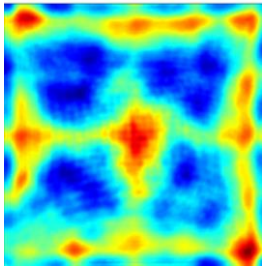
Complex 3D numerical modeling

1270 J. Opt. Soc. Am. B / Vol. 29, No. 6 / June 2012 Sawicka *et al.*

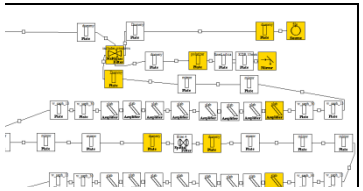
Modeling of amplified spontaneous emission, heat deposition, and energy extraction in cryogenically cooled multislab Yb^{3+}:YAG laser amplifier for the HiLASE Project

Magdalena Sawicka,[1,*] Martin Divoky,[1] Jakub Novak,[2] Antonio Lucianetti,[1] Bedrich Rus,[2] and Tomas Mocek[1]

[1]*HiLASE Project, Na Slovance 2, 18221 Prague, Czech Republic*



Wavefront correction



IEEE JOURNAL OF QUANTUM ELECTRONICS 1

Design and optimization of an adaptive optics system for a high-average-power multi-slab laser (HiLASE)

istortions and
ringence in a
Laser Amplifier

Sawicka, and Tomas Mocek

Jan Pilar,[1,3,*] Ondrej Slezak,[1] Pawel Sikocinski,[1,3] Martin Divoky,[1] Magdalena Sawicka,[1,3] Stefano Bonora,[1,2] Antonio Lucianetti,[1] Tomas Mocek,[1] and Helena Jelinkova[3]

[1]HiLASE project, Institute of Physics AS CR, Na Slovance 2, 18221 Prague, Czech Republic

Pump energy [J]

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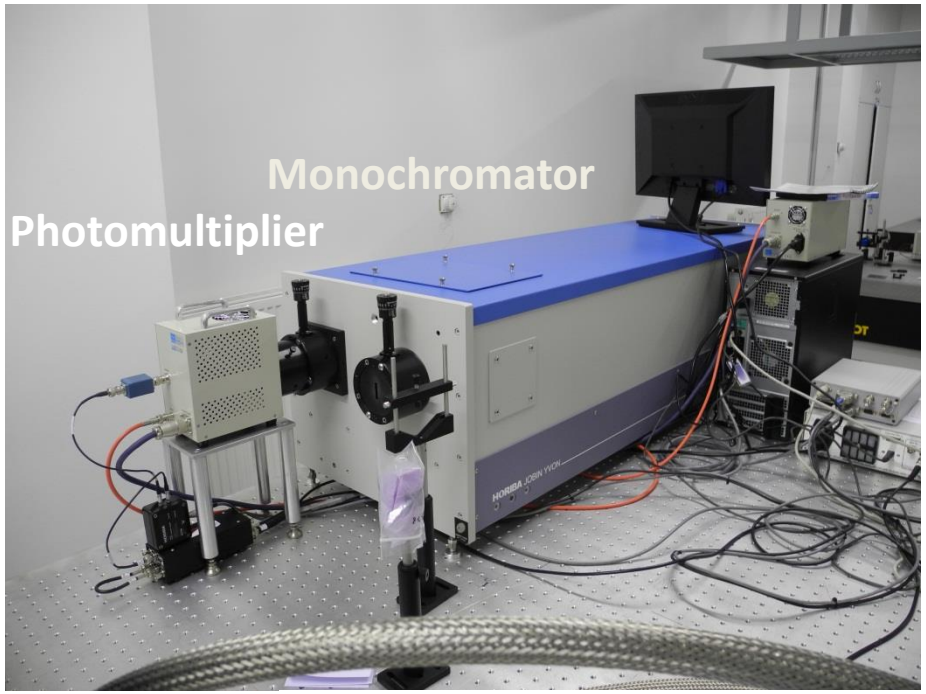
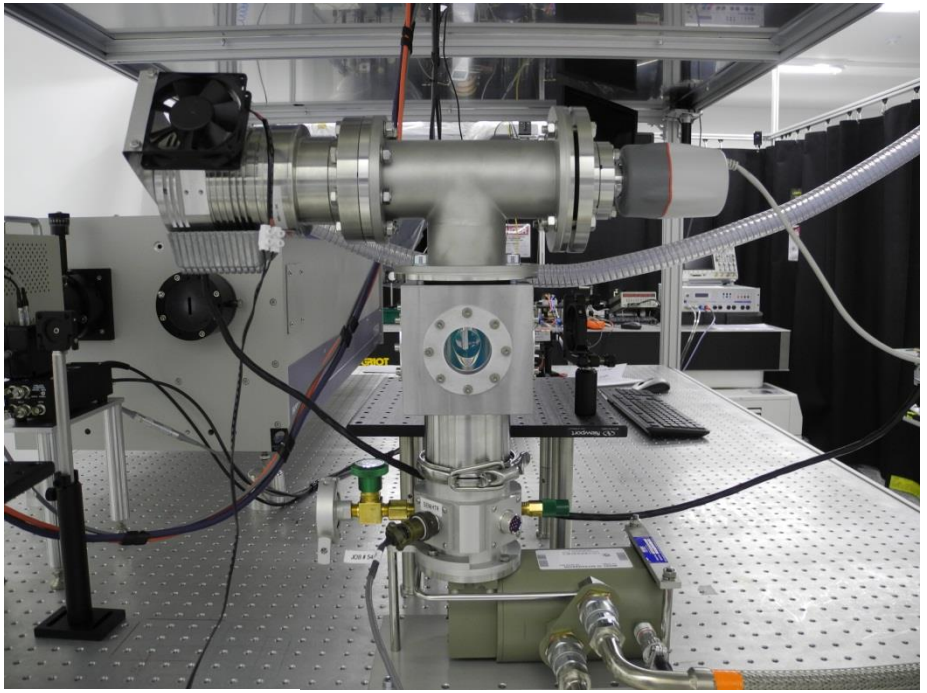
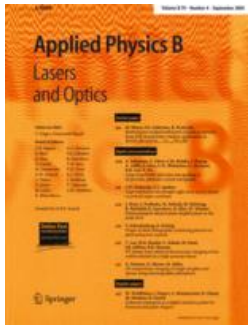
Spectroscopy at cryo temperatures







Appl. Phys. B
DOI 10.1007/s00340-013-5650-8

Applied Physics B
Lasers and Optics

Spectroscopic characterization of Yb^{3+}-doped laser materials at cryogenic temperatures

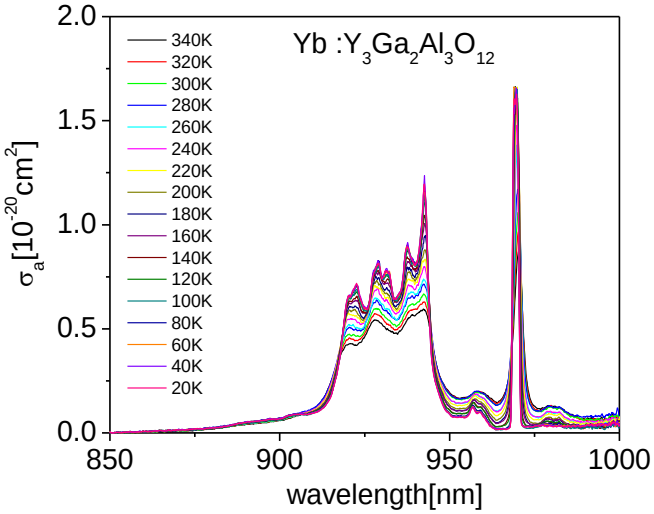
J. Körner · V. Jambunathan · J. Hein · R. Seifert · M. Loeser · M. Siebold · U. Schramm · P. Sikocinski · A. Lucianetti · T. Mocek · M. C. Kaluza

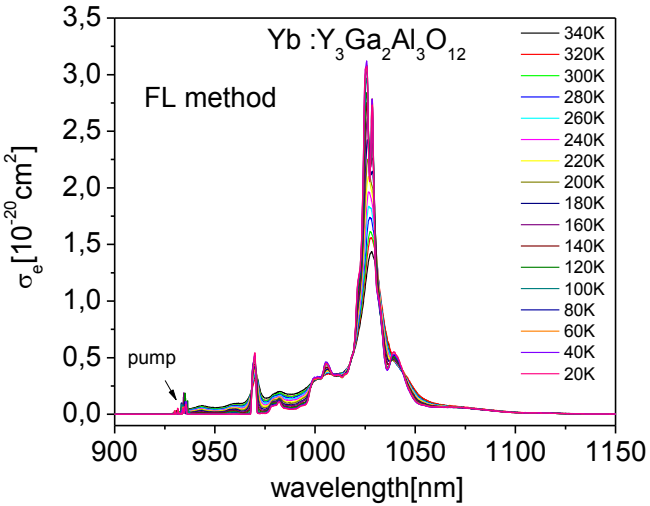
We are investigating various Yb-doped materials:

Yb-doped silicate glasses, Yb:YAP, Yb:LuAG, Yb:CaF_2,…

Cryo spectroscopy of Yb:YGAG ceramics

10at.%Yb:$Y_3Ga_2Al_3O_{12}$ with 2 mm in thickness and 18 mm in diameter ceramic





	Bandwidth [nm]			
Temperature [K]	Yb:YAG absorption @969nm	Yb:YGAG absorption @970nm	Yb:YAG emission @1030 nm	Yb:YGAG emission @1028 nm
300	2.46	2.60	8.13	9.68
200	1.12	2.03	2.42	7.94
160	0.82	1.91	1.86	7.45
100	0.58	1.74	1.34	7.14

for sub-ps pulses

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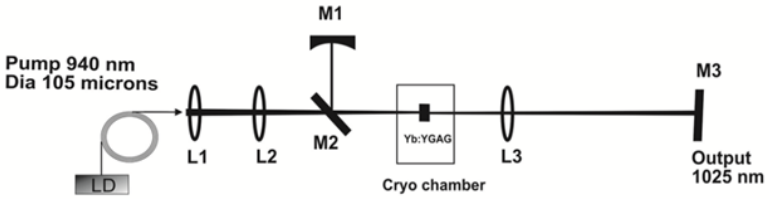
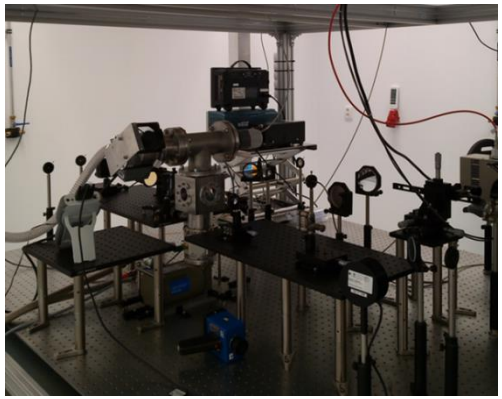
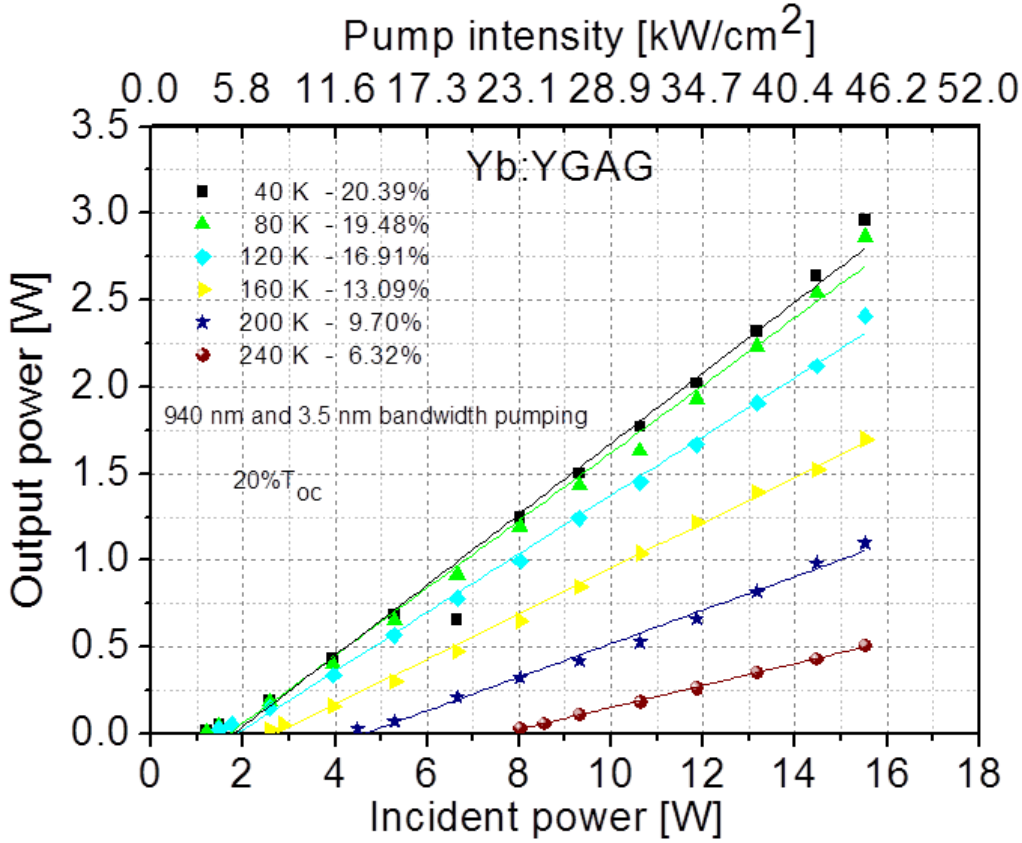
Preliminary laser cavity tests (CW)







Laser performance will be optimized by coating the Yb:YGAG ceramics sample with AR-coating. It is also planned to build the laser cavity for Q-switched operation.

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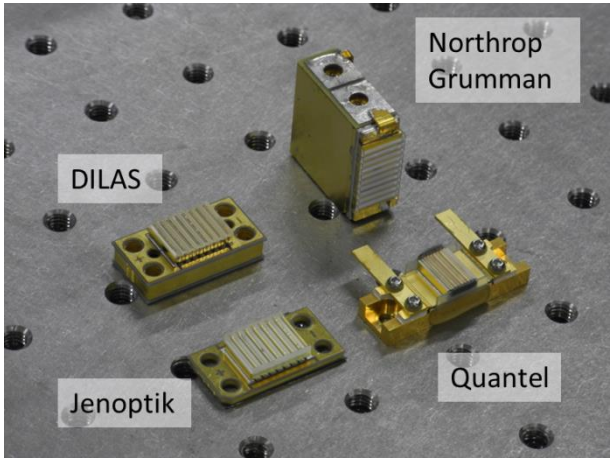
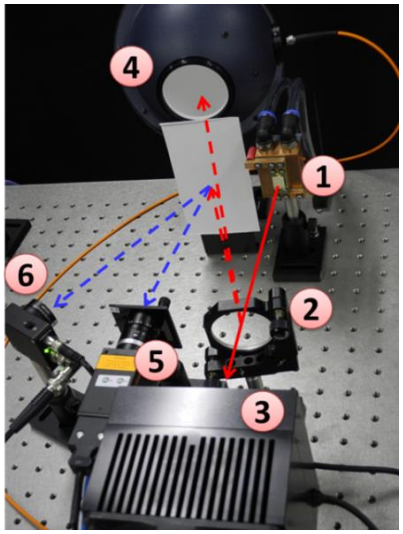
Diode stacks characterization



Parameters	QCW
Central wavelength	939 nm
Central wavelength tolerance	± 2nm
Spectral width (FWHM)	< 5-6 nm
Repetition rate (f)	10 Hz
Pulse duration (t)	0.8-1.2 ms
Output power per stack	> 2500 W



1) Diode stack

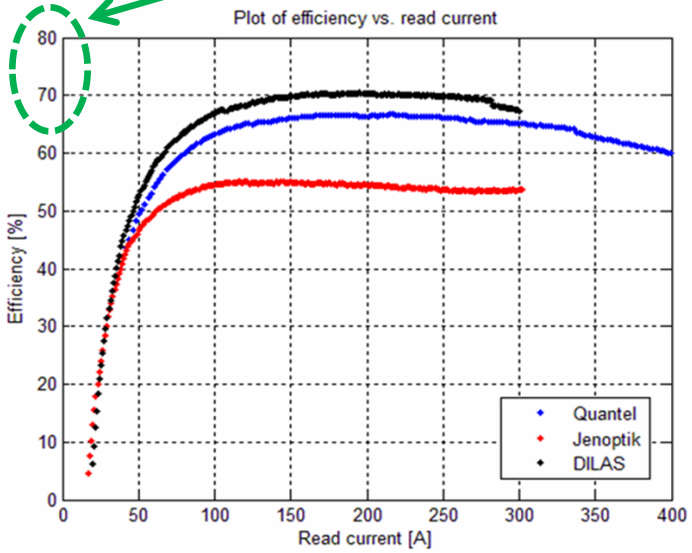
2) Wedge prism

3) Power meter

4) Integration sphere

5) CCD camera with nd filter

6) Fast photodiode with nd filter

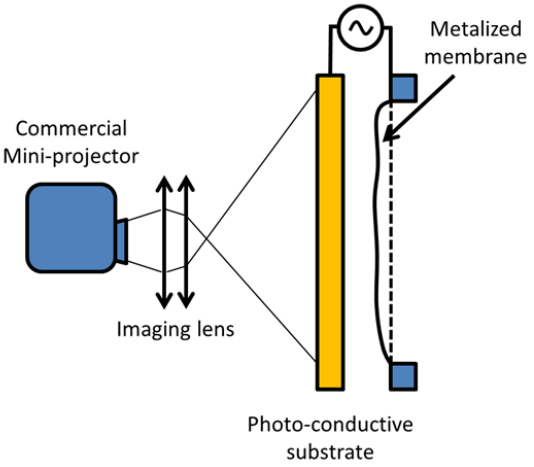


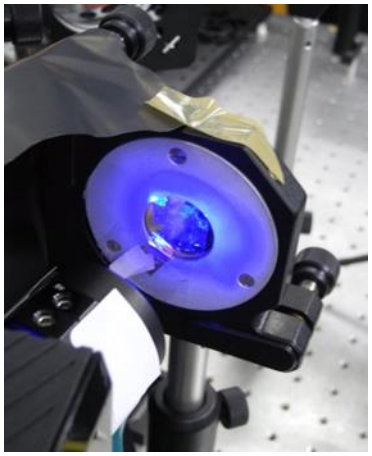
Workshop on AO for Industry and Medicine

AOIM

X International Workshop on Adaptive Optics
for Industry and Medicine
CNR-Institute of Photonics, Padova, Italy, 15-19 June 2015

- Photo-Controlled Deformable Mirror (PCDM)
- Arbitrary actuator array can be generated
- Ideal for benchmarking of numerical model





Development of high-tech industrial and scientific applications

Dr. Danijela Rostohar

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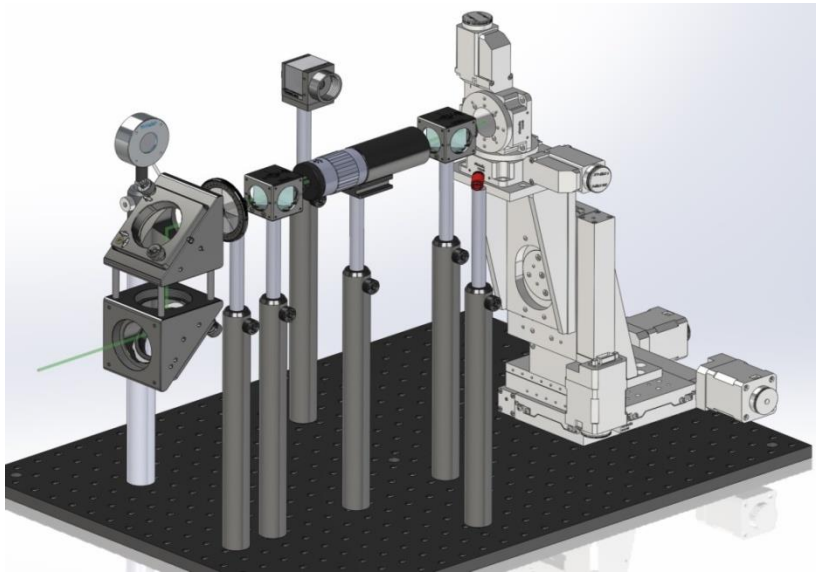
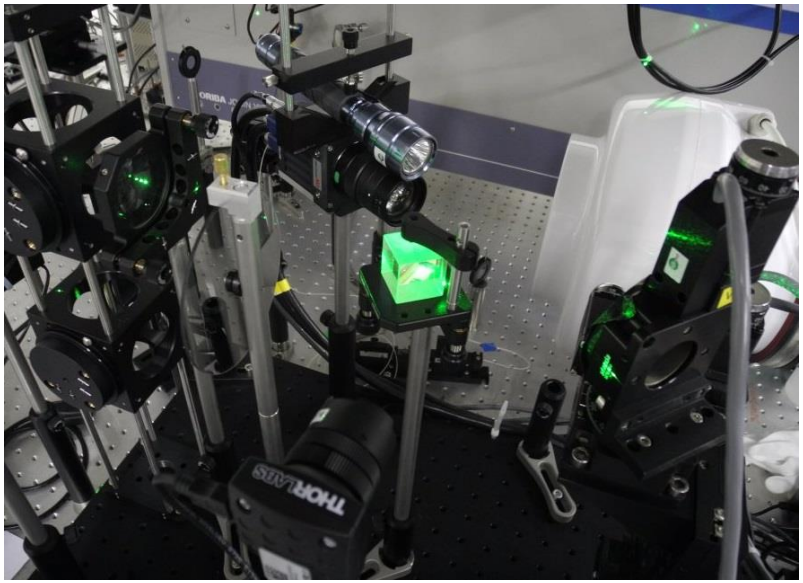
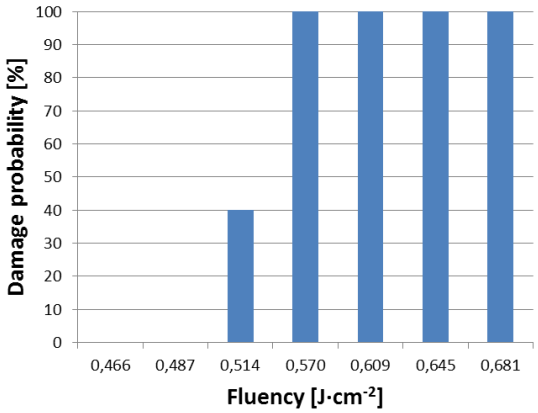
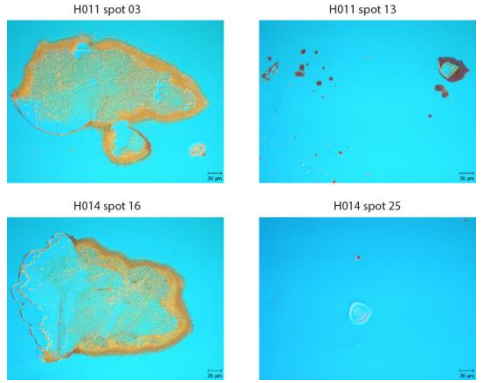
Laser Induced Damage Threshold (LIDT) station









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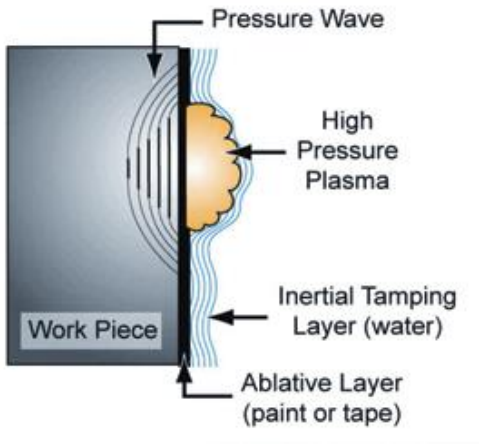
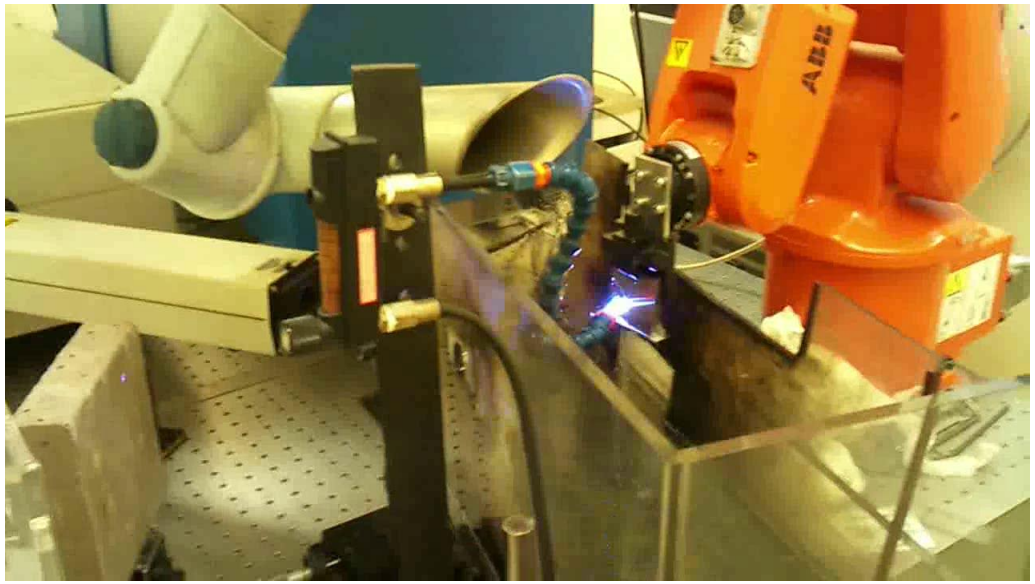
Laser Shock Peening (LSP) station

- Surface treatment process - improvement of the mechanical properties and fatigue performance of materials.





Laser Shock Peening in UPM laboratory (Spain)

- Use of a high intensity laser and suitable overlays to generate high pressure shock waves on the workpiece surface. An increase in fatigue strength is accomplished by the creation of large magnitudes of compressive residual stresses and increased surface hardness.
- Use of HiLASE 100 J laser and 3D robotic system.

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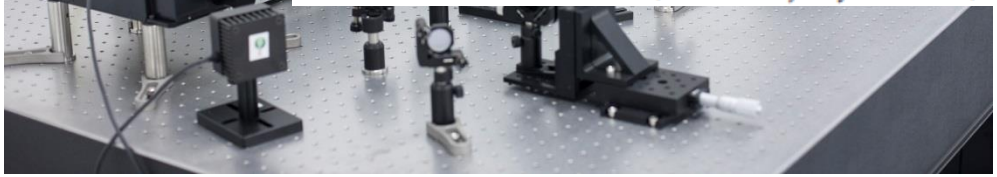
Laser µ-nano processing station

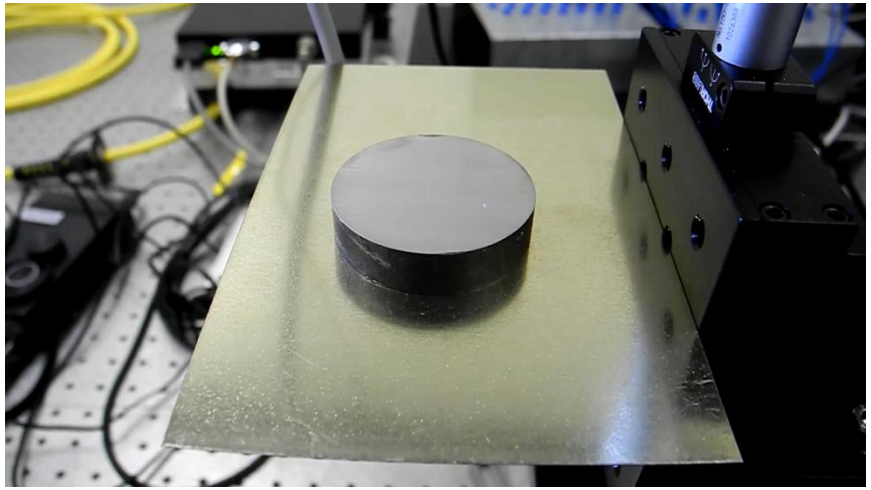
J. Opt. Soc. Am. B / Vol. 31, No. 11 / November 2014

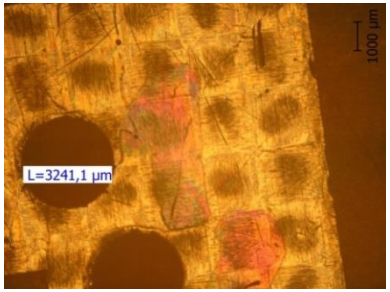
Pulsed laser modification of transparent dielectrics: what can be foreseen and predicted by numerical simulations?

Nadezhda M. Bulgakova,[1,2,*] Vladimir P. Zhukov,[3,4] Yuri P. Meshcheryakov,[5] Laura Gemini,[1,6] Jan Brajer,[1] Danijela Rostohar,[1] and Tomas Mocek[1]

[1]*HiLASE Centre, Institute of Physics ASCR, Za Radnicí 828, 25241 Dolní Břežany, Czech Republic*







Carbon Reinforced Plastics (CRFP), ITO thin films, …

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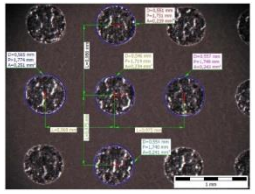
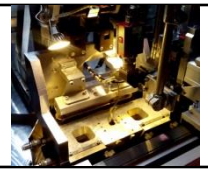
Contract Research for Industry

- Development and optimization of laser marking process parameters for hot-dip galvanized steel
- Experimental verification of appropriate type of laser

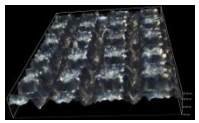


- Laser cutting of fabrics and textiles and development of new processes
- Training on laser safety and methods for optics cleaning

- Optimization of laser welding process for automotive industry – laser welding of copper alloys



- Development of laser engraving for special materials – plastics, ceramics



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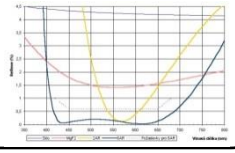
Contract Research for Industry

- Analysis of laser marking process – verification of depth and influence on the material structure

- Testing and development of a UV gas chromatograph
- Increase of accuracy and sensitivity of the device

- Testing of thin film coatings, used for optical components of high-power lasers



- Design of 3D laser heads models and system of their mounting to individual laser systems

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