PALS Research Infrastructure

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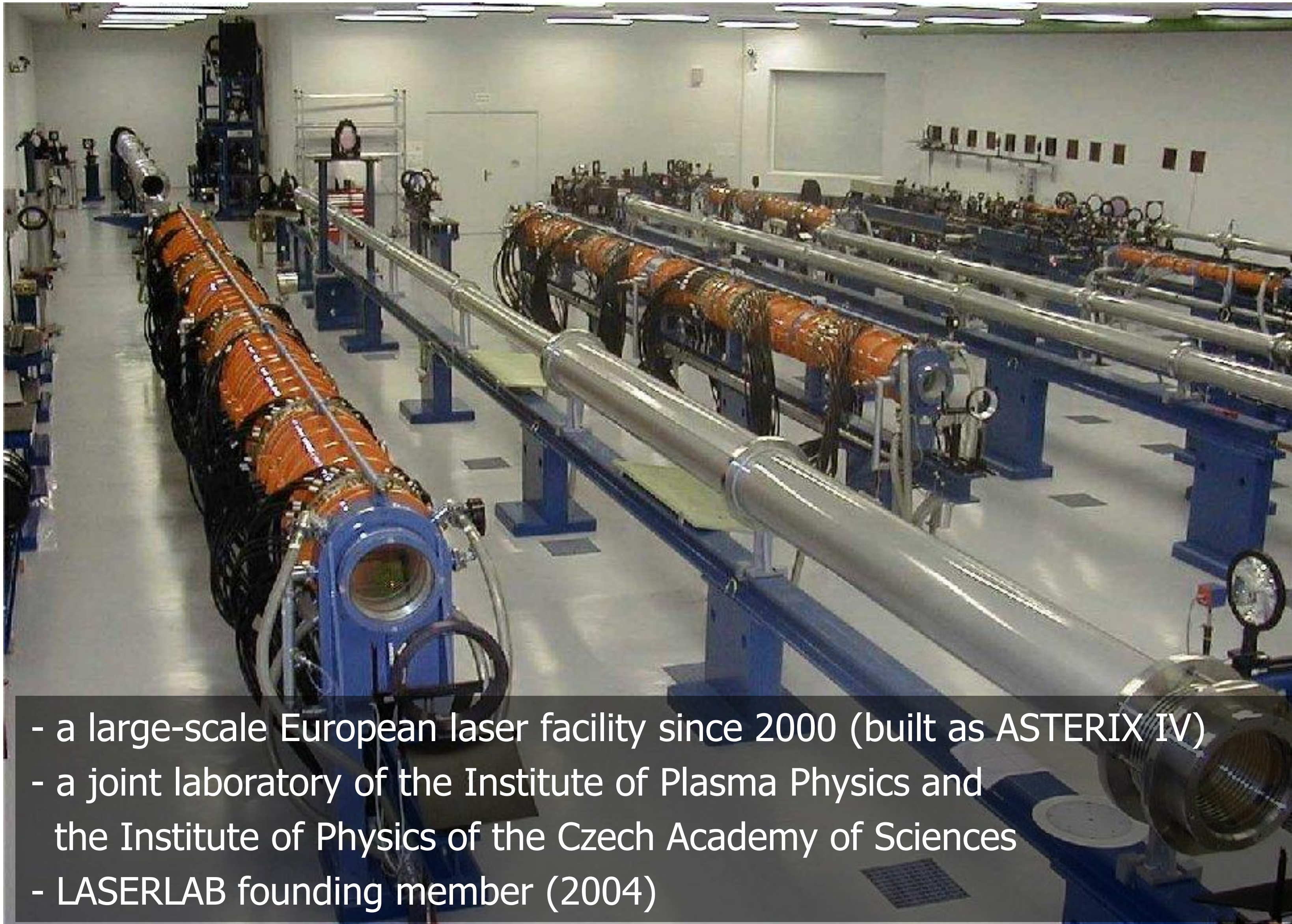
May 2016

PALS = Prague Asterix Laser System



- a large-scale European laser facility since 2000 (built as ASTERIX IV)
- a joint laboratory of the Institute of Plasma Physics and the Institute of Physics of the Czech Academy of Sciences
- LASERLAB founding member (2004)

PALS HISTORY

EU cooperation

- **Transfer of ASTERIX IV laser from MPQ 1998-1999**
  Initial investment 1 DM + the PALS laser hall
- **PALS Research Centre** - self-coordinated access project 5th FP 2000-2003
- **The first experiments of EU users: SEP 2000**
- **LASERLAB-EUROPE I** 2004-2008, 6th FP
- **LASERLAB-EUROPE II** 2009-2012, 7th FP
- **LASERLAB-EUROPE III** 2012-2015, 7th FP
- **LASERLAB-EUROPE IV** 2016-2019, Horizon 2020
- **EURATOM Keep-in Touch Activities on ICF**

Domestic support

Czech National Research Centres Programme of the Ministry of Schools, Youth and Sports

Consortium project by IP, IPP and CTU in Prague

- **Laser Plasma Research Centre** 2000-2004
- **Laser Plasma Centre** 2005-2011

Czech Roadmap of Research Infrastructures

- **PALS Research Infrastructure** 2011-2015, prolonged for a period of 2016-2019

Brief History of the Czech HP-Laser Research

Perun 1 (

Perun 2 (1990
SOFIA (2002

ASTERIX IV (199

PALS (2000 - 2016 ?)

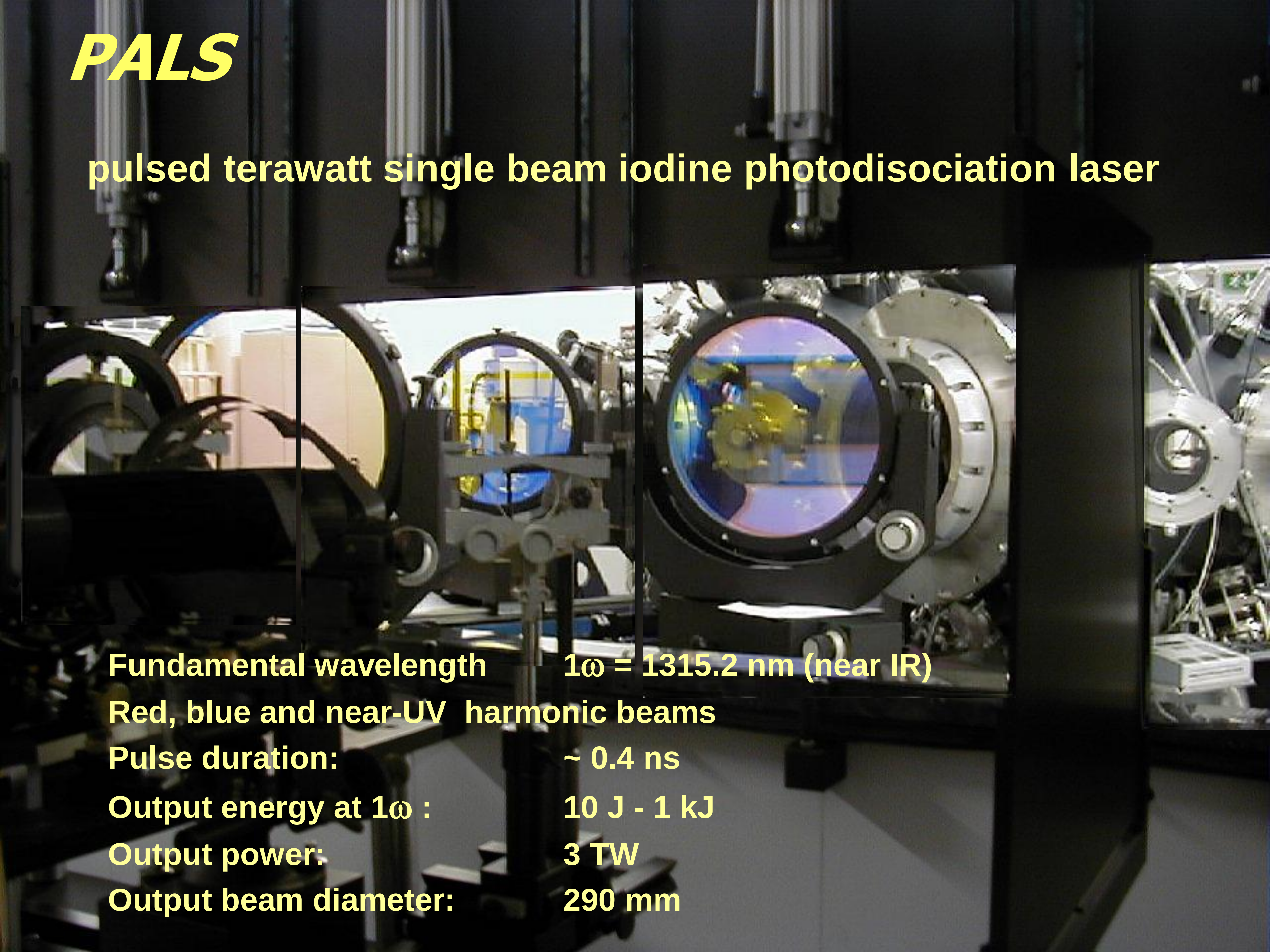
2016 - buildings are ready

LASERNET
(2000 - 2004)

LASERLAB 1 (2005 - 2008)

LASERLAB 2 (2009 - 2012)

HiPER-PP 2008-2014
ELI-PP 2008-2011
LASERLAB 3 (2012 - 2015)
LASERLAB 4 (2016 - 2019)



PALS

pulsed terawatt single beam iodine photodisociation laser

Fundamental wavelength	**1ω = 1315.2 nm (near IR)**
Red, blue and near-UV harmonic beams	
Pulse duration:	**~ 0.4 ns**
Output energy at 1ω :	**10 J - 1 kJ**
Output power:	**3 TW**
Output beam diameter:	**290 mm**

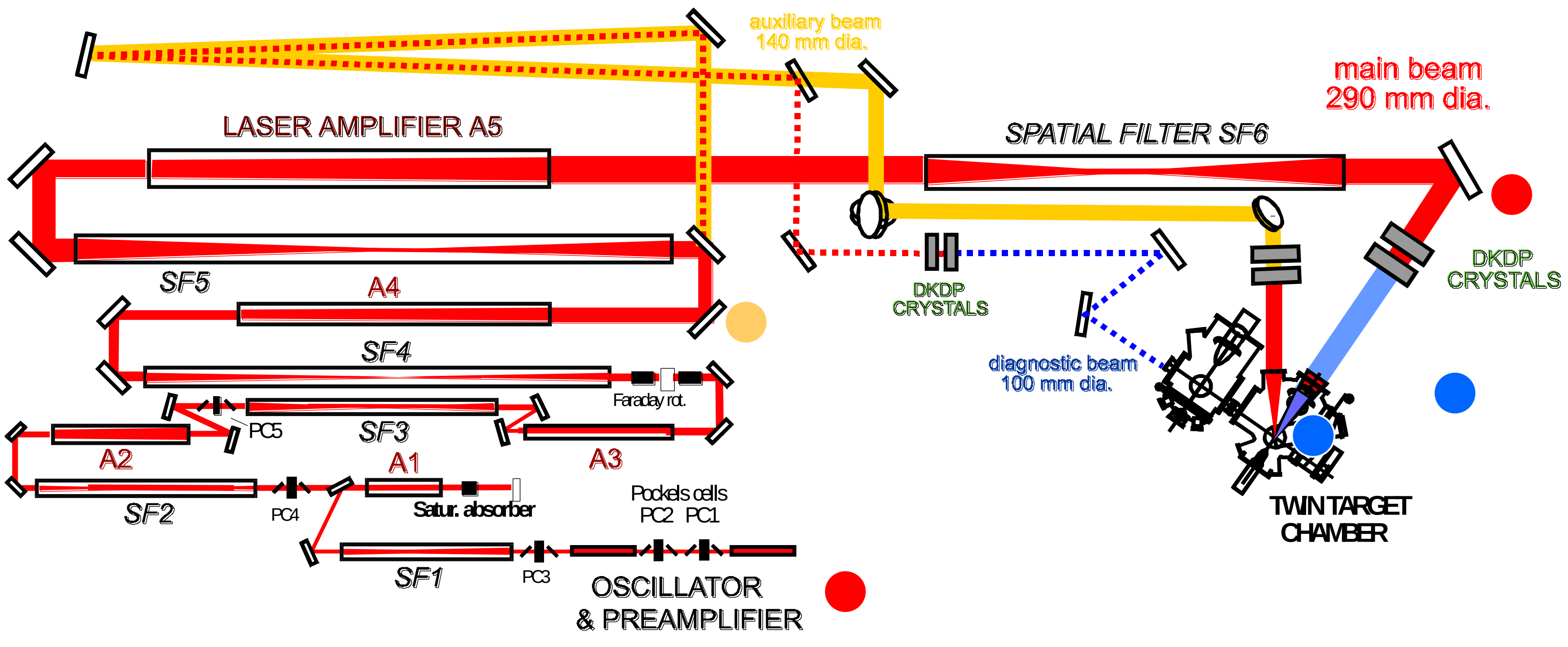
PALS specific features

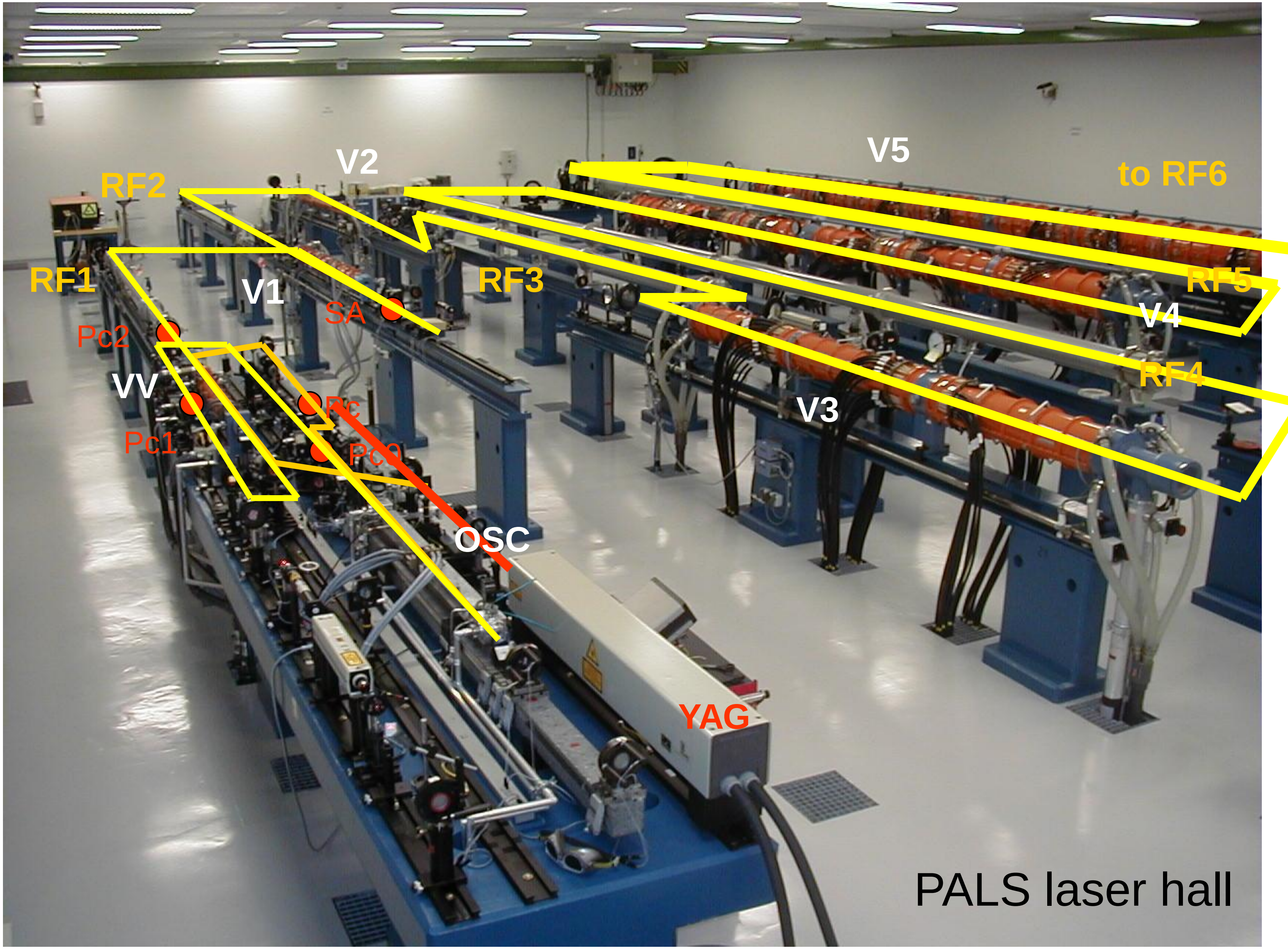
- *iodine gas laser, unique by its working wavelength 1.315 nm and very narrow laser line (line half-width ~ 10 GHz)*
- *one of a few lasers providing kJ in a single beam configuration*

  6 gas laser amplifiers + 6 spatial filters

  Main, auxiliary and diagnostic different-color beamlines

scheme of the kJ laser system

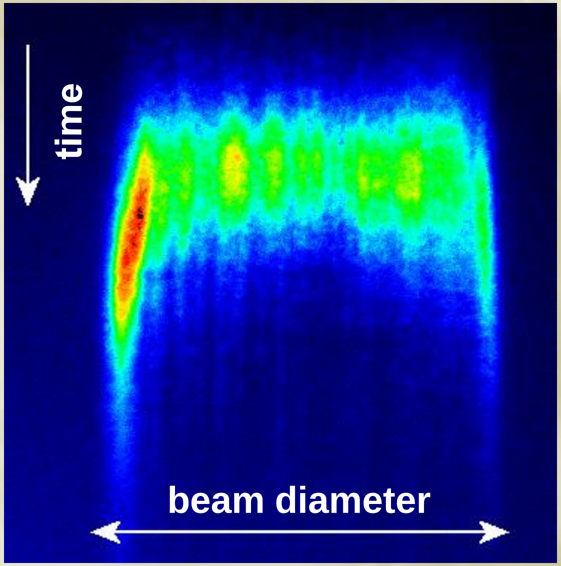




RF2
V2
V5
to RF6
RF1
V1
RF3
SA
RF5
V4
Pc2
VV
Pc
RF4
V3
Pc1
Pc0
OSC
YAG
PALS laser hall

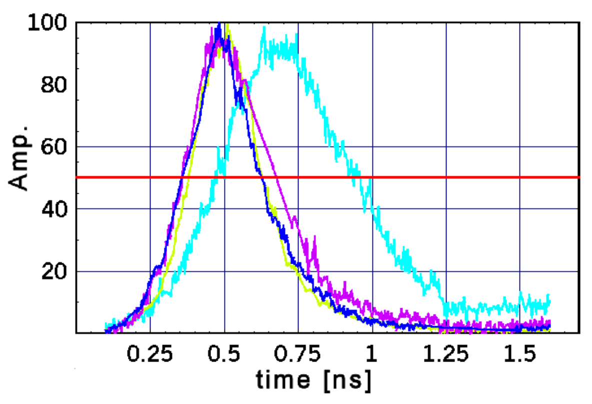
PALS output characteristics:

Pulse shape

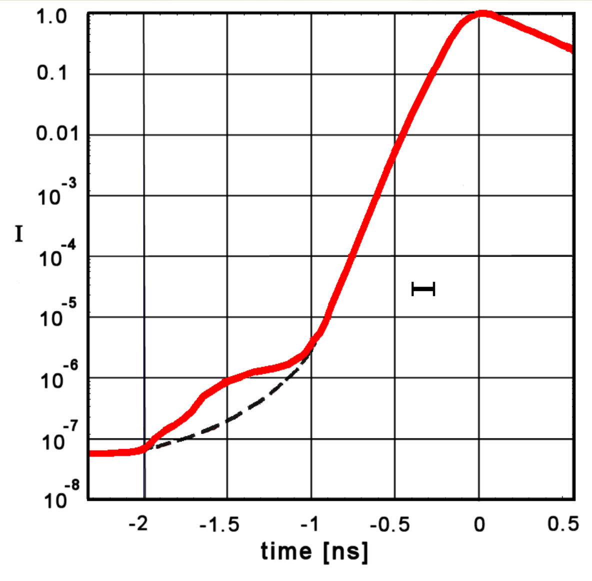


shot #39378
340 ps FWHM
604 J

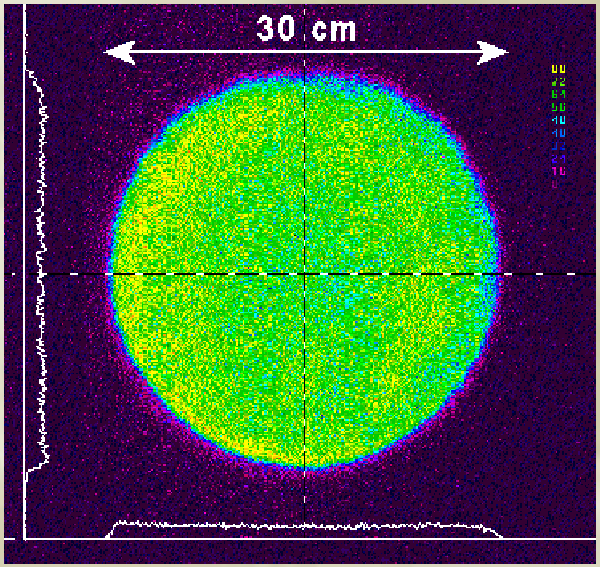
pulse width
250-490 ps
FWHM



Contrast
~ 10^7

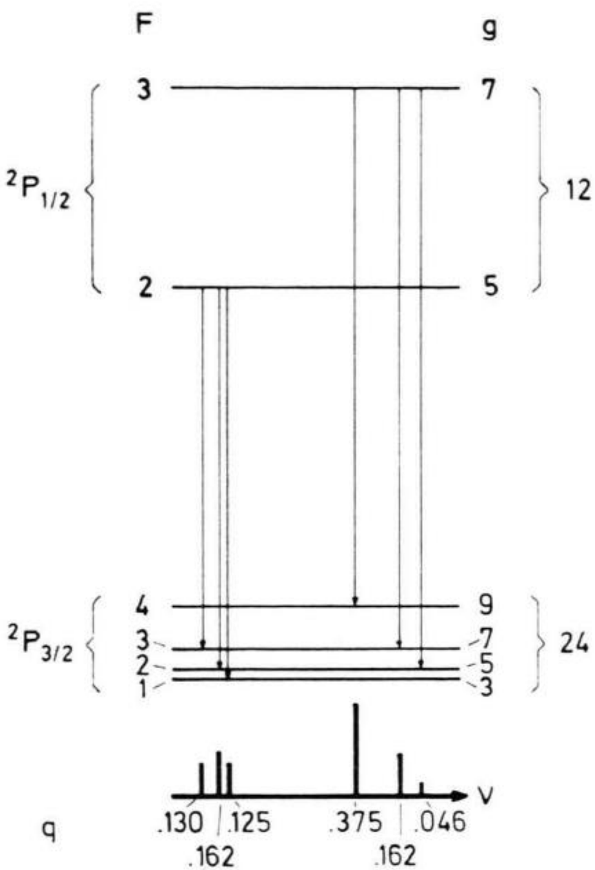


Flat intensity profile

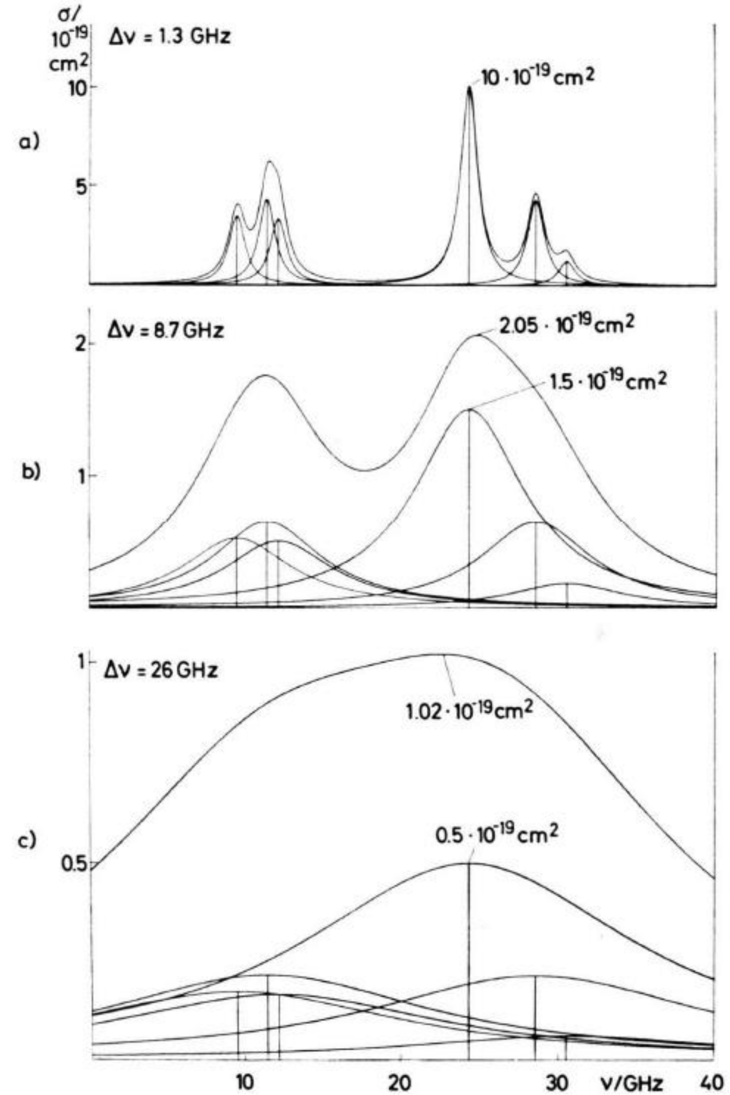


Focus diameter < 100 µm
Focused intensity > 10^{16} Wcm^{-2}

PALS output parameters: a bandwidth



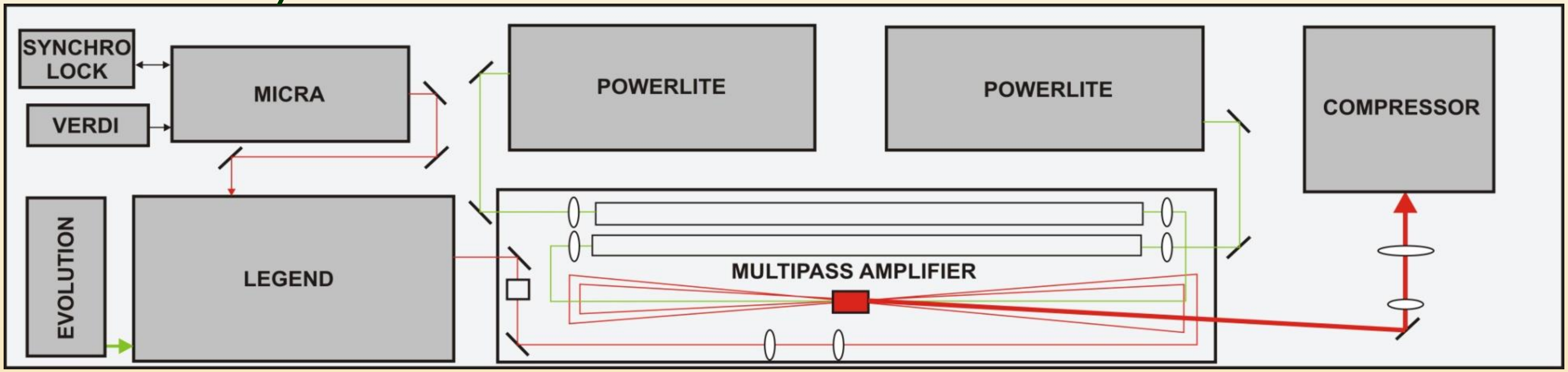
Hyperfine structure of laser transitions in atomic iodine



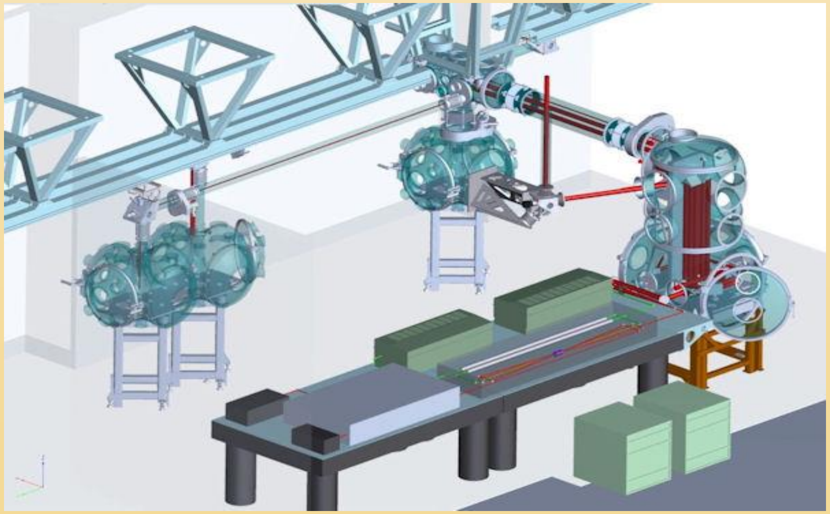
W. Fuß, K. Hohla: Z. Naturforsch. 31a, 569 (1976)

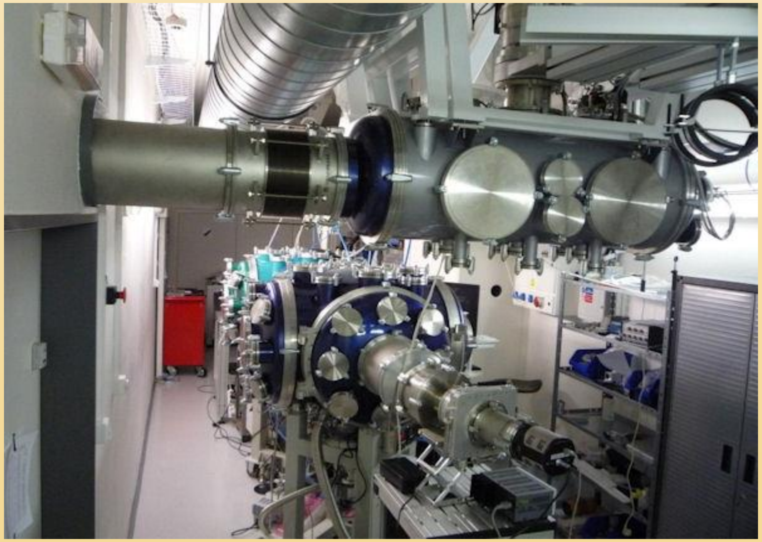
Ti:Sapphire laser chain at the PALS facility

25-TW 10 Hz Ti:Sa beamline 1.5 J / 45 fs fully operational since 2011 (dazzler will be installed in 2017)

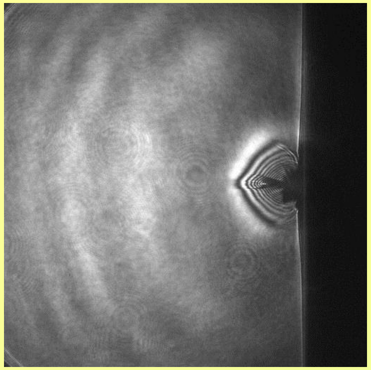


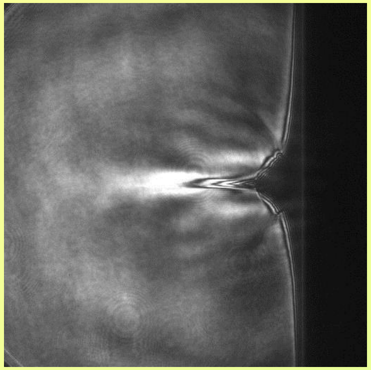
Beam distribution to Ti:Sa and PALS interaction bays

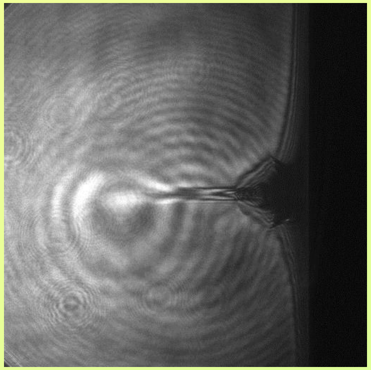


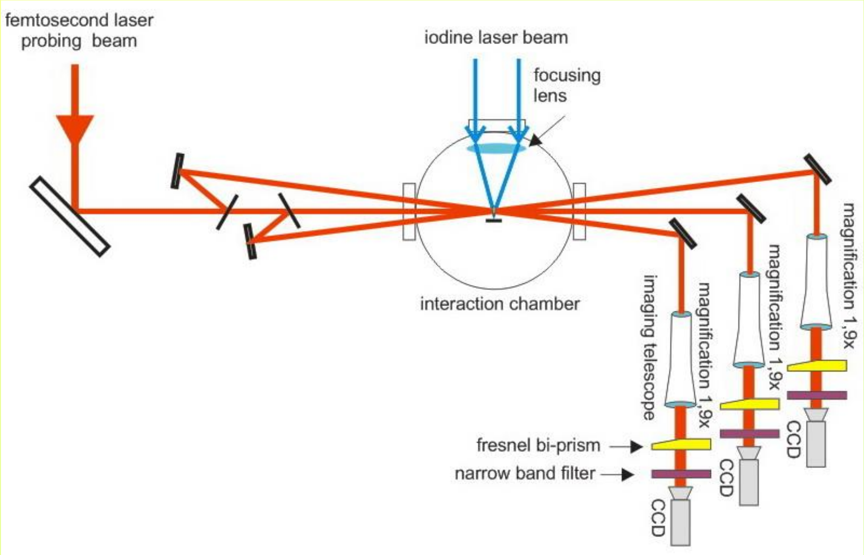


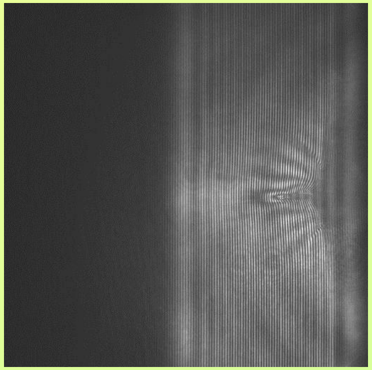
Three-frames interferometer with mutual delay of 300 ps

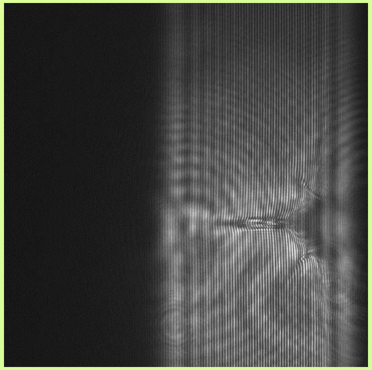


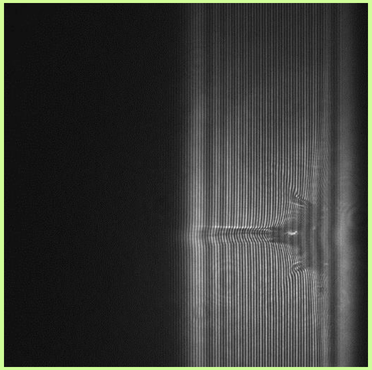












PALS target facilities

A system of two connected interaction chambers

An irradiance at the target > 10^{16} W/cm^2

Several different-colour laser beam lines

Both point and linear focusing optics available

Advanced ion, UV-Vis-NIR, XUV and x-ray diagnostics

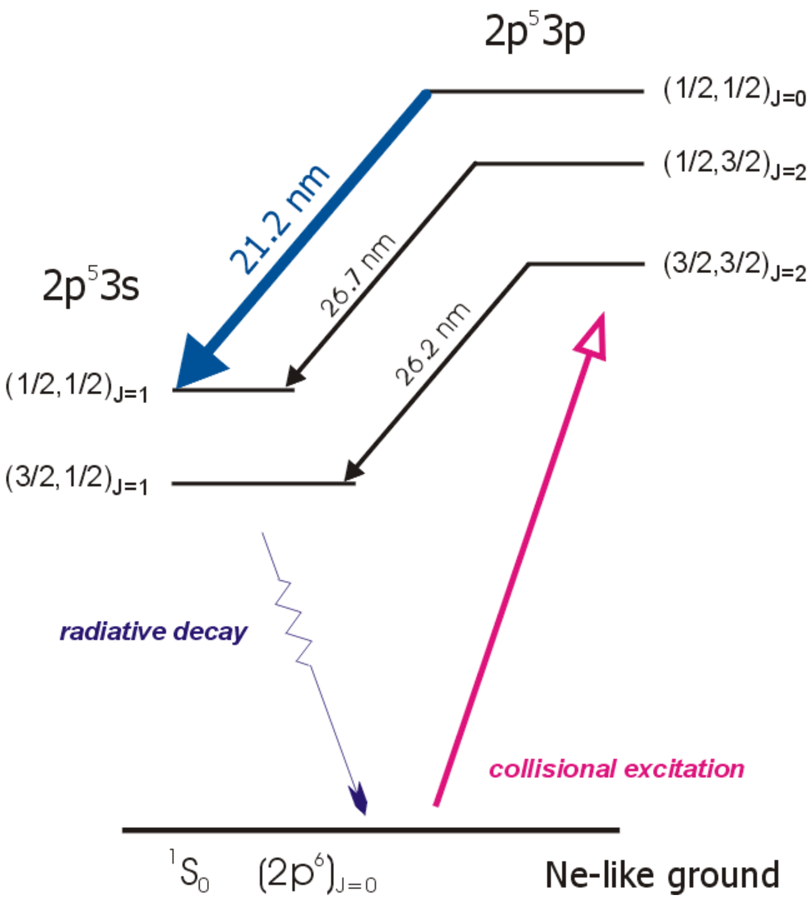
Several schemes for XUV laser experiments: both QSS and TG

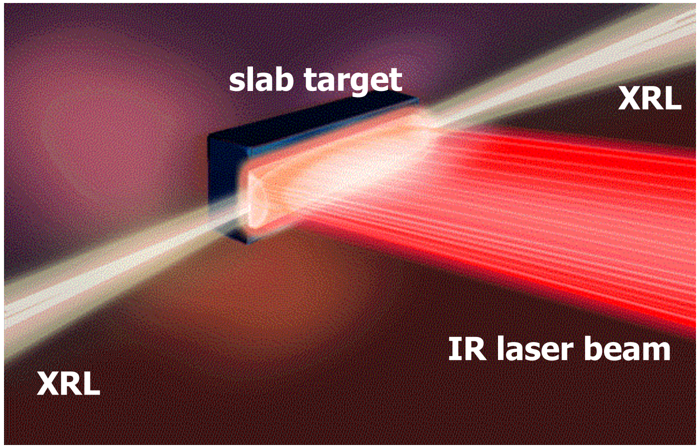
Single- and double-stream gas-puff targets

Equipment for shock wave studies

3-frame interferometer for fs probe beam

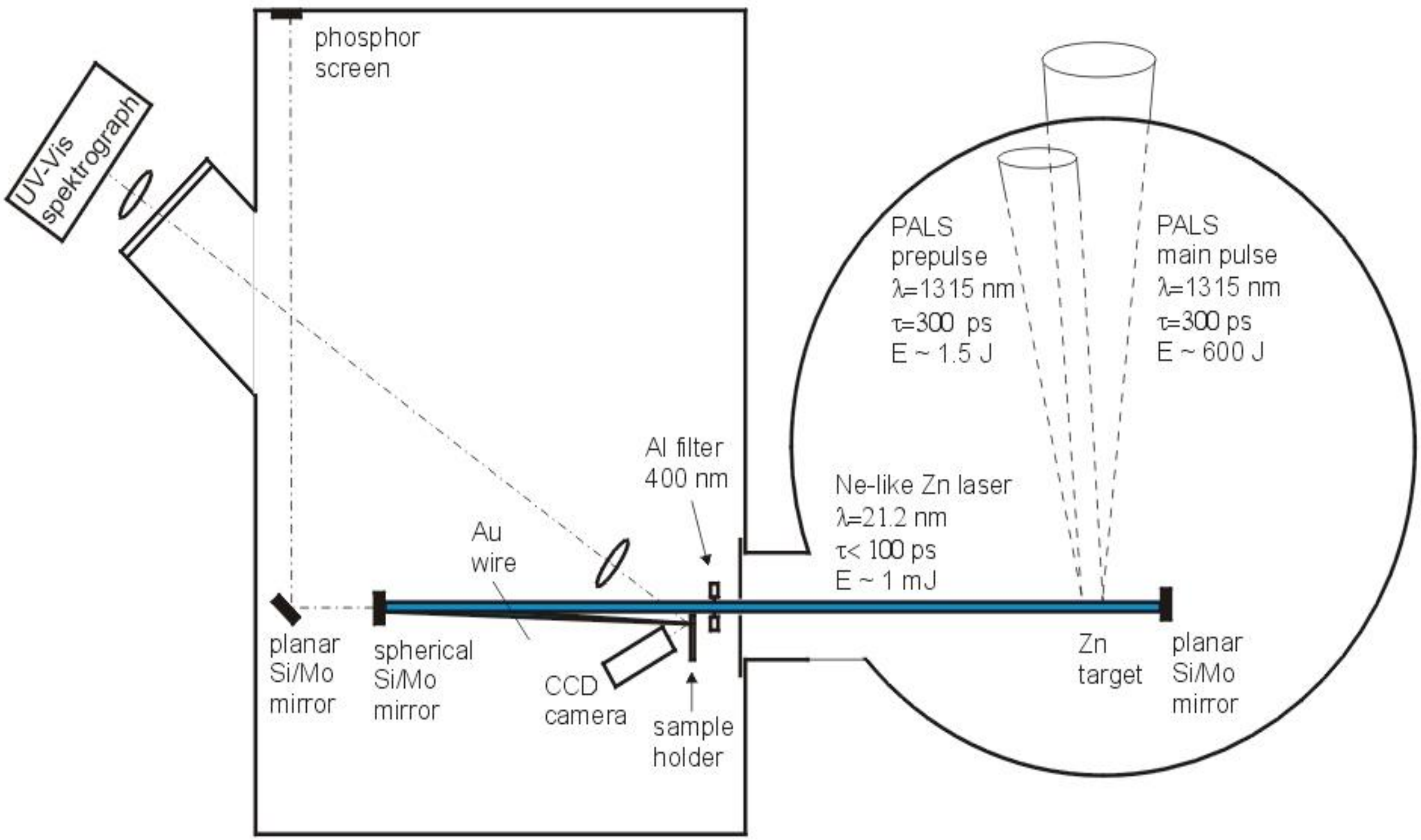
Neon-like zinc XRL driven by multi-100-ps NIR laser pulses

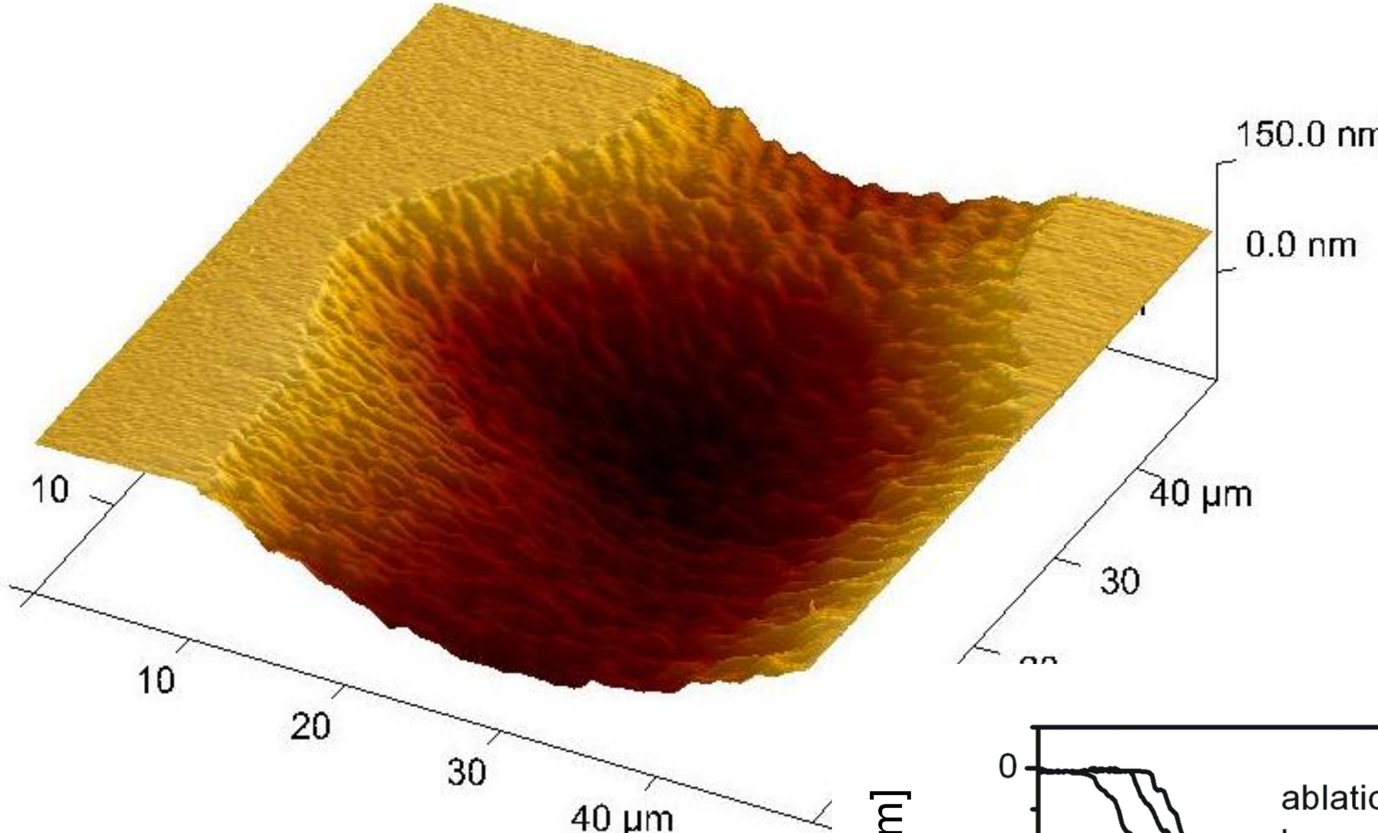




Active medium: a plasma column created from slab target by linearly focused NIR laser beam

focusing scheme of Ne-like Zn soft x-ray laser

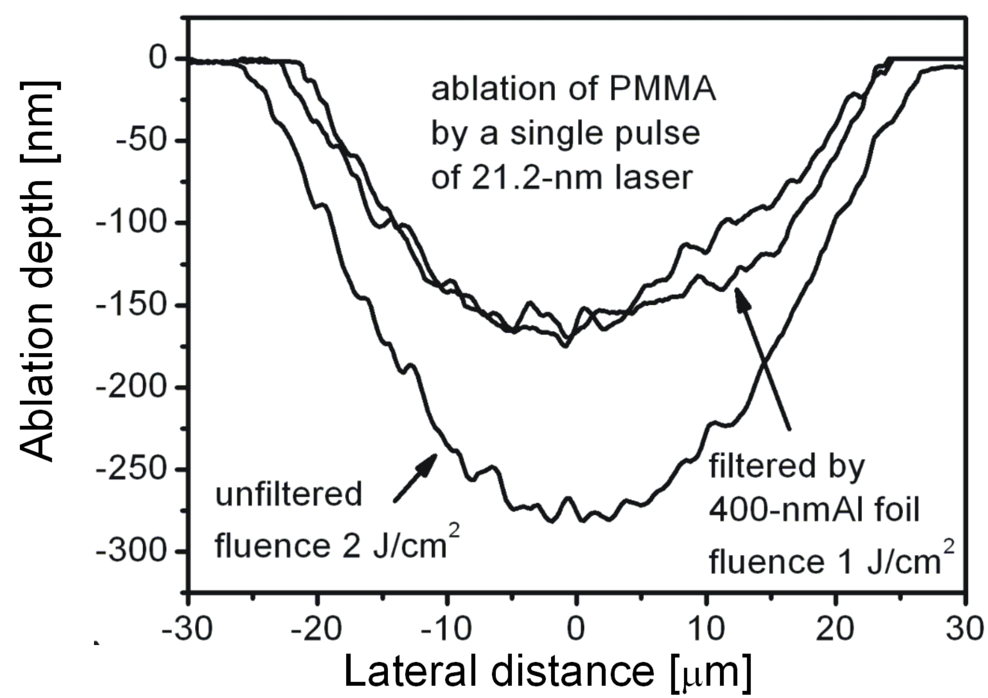


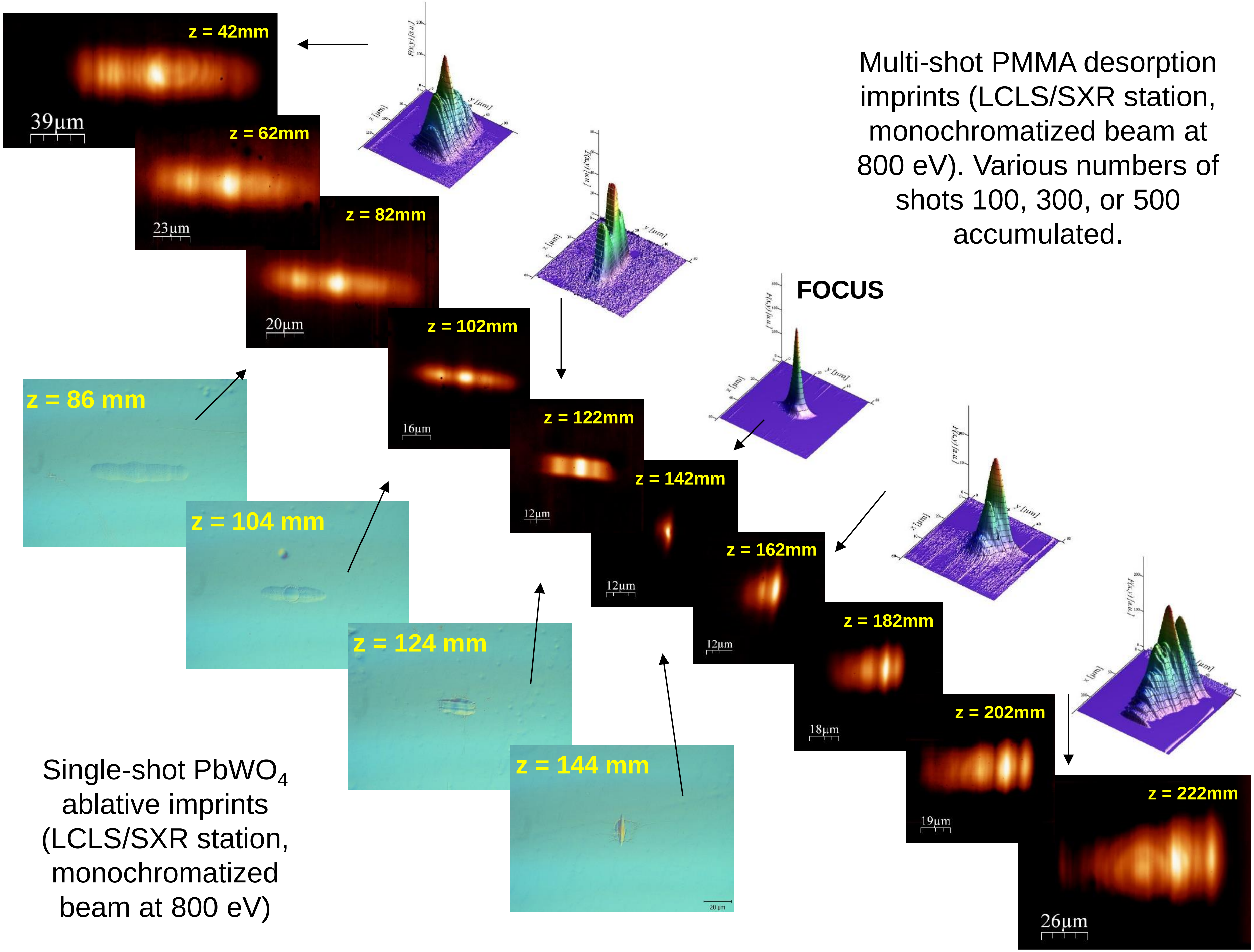


AFM image of crater ablated in PMMA by a focused beam of 21.2-nm laser radiation.

J. Microlith. Microfab. Microsyst. **4**, 033007 (2005)

Appl. Phys. Lett. **89**, 051501 (2006)



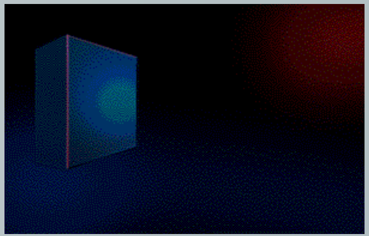


Multi-shot PMMA desorption imprints (LCLS/SXR station, monochromatized beam at 800 eV). Various numbers of shots 100, 300, or 500 accumulated.

Single-shot $PbWO_4$ ablative imprints (LCLS/SXR station, monochromatized beam at 800 eV)

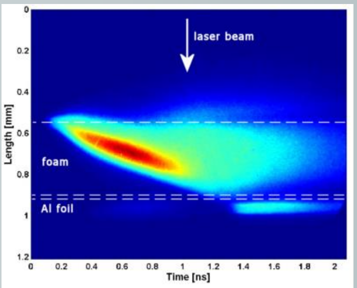
PALS Research Programme

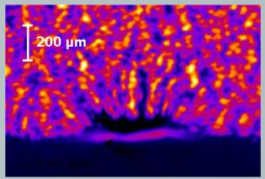
Interaction of short- and long-wavelength laser radiation with matter



ICF-relevant and ELI and HiPER-related target experiments

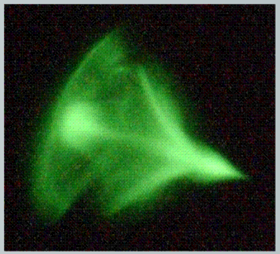
- Target ablation phenomena, WDM studies
- Generation and interaction of plasma jets
- Non-linear phenomena in laser-plasma interaction
- Plasma and macroparticle acceleration
- Shock wave studies

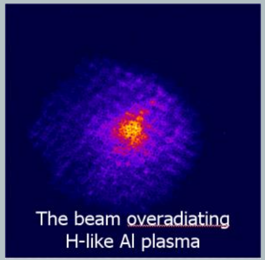




Laboratory astrophysical and cosmochemical experiments

- Simulation of protostellar jets and Herbig-Haro objects
- HDP opacity measurements and laser-plasma chemistry





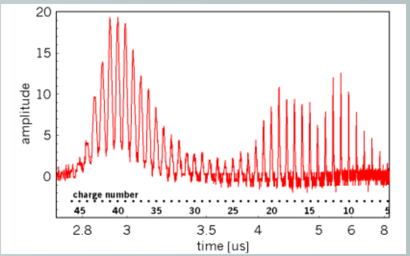
S&T applications of laser-produced plasmas

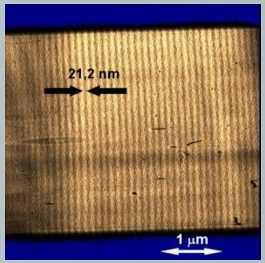
Development of laser ion sources

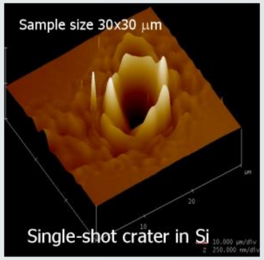
- Ion acceleration in laser-produced plasmas
- Ion implantation

Development of plasma XUV radiation sources

- Plasma-based XUV lasers and amplifiers, XUV interferometry
- HHG XUV radiation sources , XUV ablation and nanopatterning





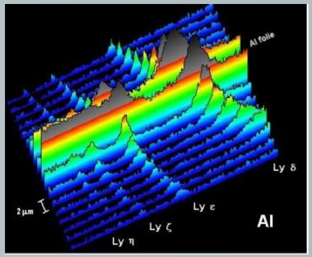


Advanced methods of plasma diagnostics

Creating and probing WDM by XUV lasers

XUV spectroscopy and imaging of hot plasmas

Ion charge/mass spectroscopy and radiation detection



HiLASE & ELI-Beamlines: present status

The mission of ELI Beamlines

1. Primary sources: maximizing peak and average power at ELI Beamlines and HiLASE, respectively

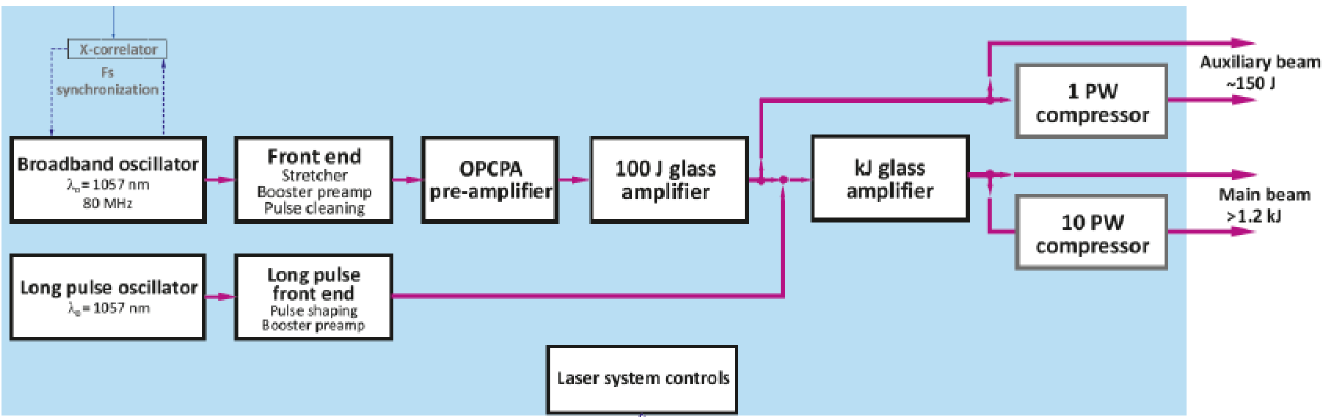
2. Development, optimization and applications of various secondary sources of energetic photons and charged particles

3. High-field physics experiments at an irradiance level of 10^{23}-10^{24} Wcm^{-2}

4. Development & testing new technologies for multi-PW laser systems

L4

- kJ beamline to generate 10 PW peak power
- 10 PW generation: mixed Nd:glass providing spectral bandwidth for direct pulse compression to <150 fs
- Nanosecond pulses with programmable temporal shape for sophisticated laser-plasma experiments
- PW auxiliary beam for plasma probing
- Future use as OPCPA driver for generation >10 PW power
- *Selection of supplier in progress*



L4 performance requirements

Parameter		Value
Main beam		
Energy		1.2 kJ in a single aperture
Peak power		10 PW
Auxiliary beam		
Energy		150 J in a single beam
Peak power		1 PW
Both beams		
CPA regime	Output pulse duration (FWHM)	$\leq$150 fs
Non-CPA regime	Output pulse duration	0.5 to 5 ns (adjustable)
	Time step of pulse temporal shaping	150 ps
Shot rate		1 per minute
Contrast (main pulse to pre-pulse/s power)		$1:10^{11}$
Shot-to-shot pulse energy RMS stability		<10%
Beam pointing stability		<10 µrad
Output beam quality: encircled energy in diffraction limited spot		60%
Energy in 2nd and 3rd harmonics		$\geq$800 J
Operation		Independent, externally synchronizable

thank you for your attention