7th International HEC-DPSSL Workshop
Lake Tahoe, September 14, 2012

LASTRONICS
DIODE LASER PUMP MODULES • PUMP ENGINES • DRIVERS

DIODE LASER PUMP ENGINES

Joachim Hein, Jörg Körner, Thomas Töpfer

LASTRONICS
1.1 What we do

LASTRONICS

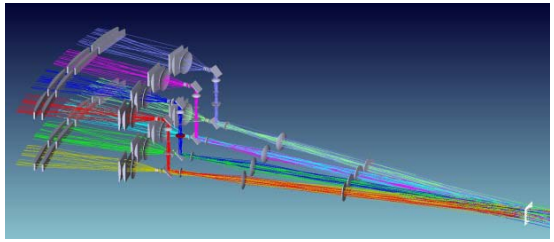
Laser Electronics

- MC controlled stabilized qcw current sources (<10%DC)
- Drive current up to 4 x 330 A
- Control Electronics ITL 9
- LabView Control Software

Diode Laser Pump Modules

- 2 to 80kW peak power
- square or rectangular shaped, round or hex shaped output beam
- wavelength 9xx nm, 808 nm
- spectral width FWHM <6 nm (1 ms), <8 nm (2.5 ms)

Pump Engines



- for Yb:CaF_2/YAG CPA systems and Ti:sapphire pump sources
- Scalable, modular system of diode laser pump modules
- Round or rectangular beam shape
- Includes PMs, beam delivery, drivers, chillers, and control

LASTRONICS
1.2 Who we are

Design, manufacturing and sale of opto-mechanical and opto-electronical systems, laser diode based optical pump engines and amplifiers, MC controlled electronics and devices

- 1998 LDD (300 .. 600 A, 5 V) for diode testing
- **2001 Töpfer & Hein GbR, Jena**
- 2002 MC controlled LDD 4300 (4x**200A**, 60V, **1%DC**) for POLARIS laser
- 2006 laser diode driver 4310 (4x**300A**, 60V, **2%DC**)
- **2009 Lastronics GmbH**
- 2009 diode based **Pump Modules** PM 2.4 and 19.2
- 2010 first **Pump Engine**
- 2011 pump modules PM48 and PM80
- 2012 ISO9001 and LDD1310 (**330A, 80V, 10%DC**)

LTX competencies

- 11 employees – thereof 6 engineers/physisists

  (optics, electronics, mechanics, assembly and testing)
- Solid-Works and Zemax for modelling of pump modules and beam delivery system
- MC programming for LDD and PM firmware
- LabView for pump engine control

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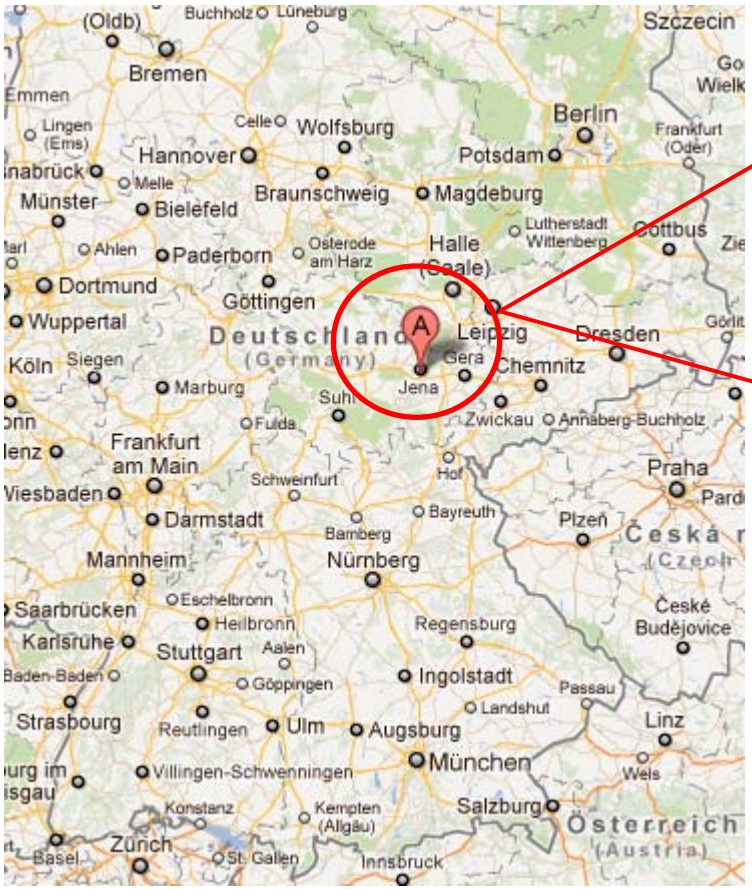
1.3 How to find us



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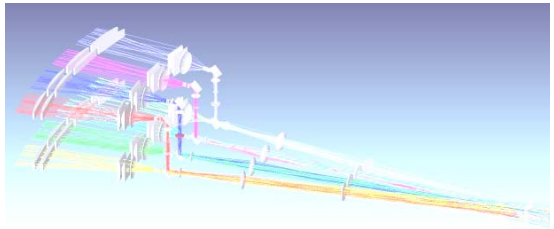
07745 Jena
Tel. +49 3641 508 590
Fax. +49 3641 508 591
www.lastronics.com

LASTRONICS
2.1 What we do

Laser Electronics	Diode Laser Pump Modules	Pump Engines
		
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Drive current up to 4 x 330 A	square or rectangular shaped, round or hex shaped output beam	Scalable, modular system of diode laser pump modules
Control Electronics ITL 9	wavelength 9xx nm, 808 nm	Round or rectangular beam shape
LabView Control Software	spectral width FWHM <6 nm (1 ms), <8 nm (2.5 ms)	Includes PMs, beam delivery, drivers, chillers, and control

Laser Electronics
2.2 Design criteria for LDD4311/4312

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Design considerations	Why	limits
high drive current	bring down EUR/W level of overall system	SA divergence fitting acceptance NA of beam delivery system
high compliance voltage high duty cycle	as many bars/stacks electrically in series as possible	Availability, size and cost of capacitors
rise/fall time	as short as possible without causing ringing	cable length and inductivity at very high current
energy stability and jitter	determines ultimate pulse to pulse stability of the amplifier	Processor clock
efficiency	overall power consumption of the system	extraction of energy of capacitors
total size and weight	has to be scalable to drive TW and PW class amplifiers	size of capacitors for energy storage

Laser Electronics
2.4 Pulsed Laser Diode Driver LDD4311/12

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Configuration

- drive current up to 4 x 330A,
- compliance voltage up to 80V,
- 2.5% DC (2.5ms, 10Hz operation)
- pulse stability 0.1% p-p
- jitter <0.1µs
- rise time 30µs (1m cable)
- bias current (up to 5A)
- remote control, trigger options
- 3 height units, 20kg
- 230VAC, 50Hz, 16A operation
- 89% efficiency (LDD to LD)

Laser Electronics
2.6 Pulse ripple LDD4312

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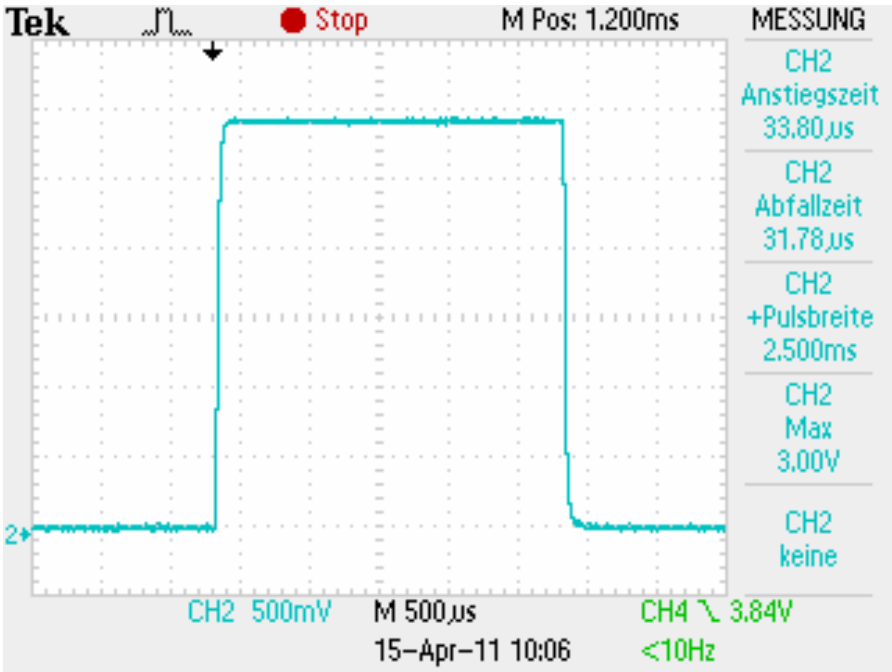
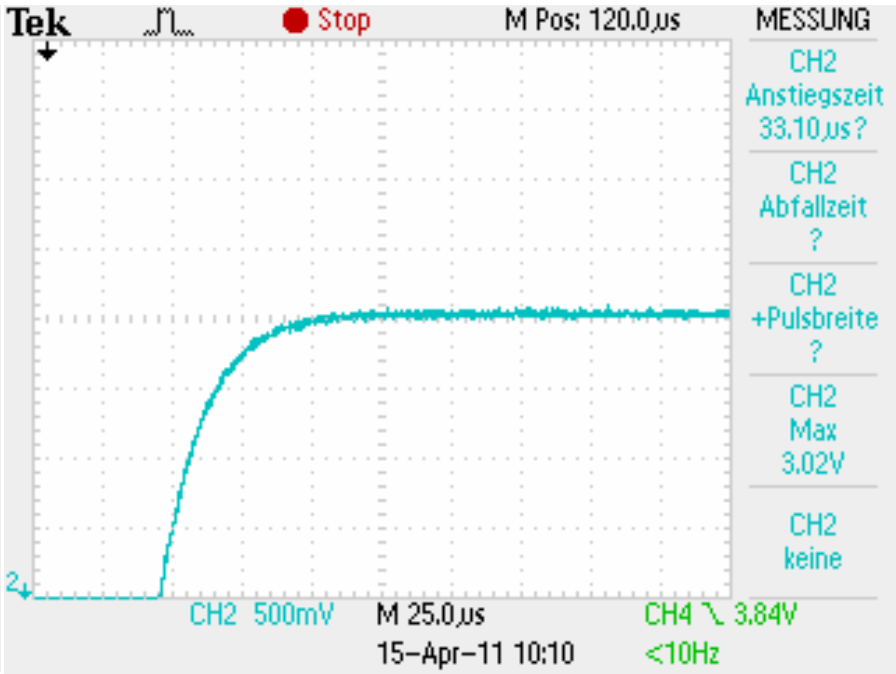
Pulse ripple	% rms	<0.1





Laser Electronics
2.7 Rise/fall time

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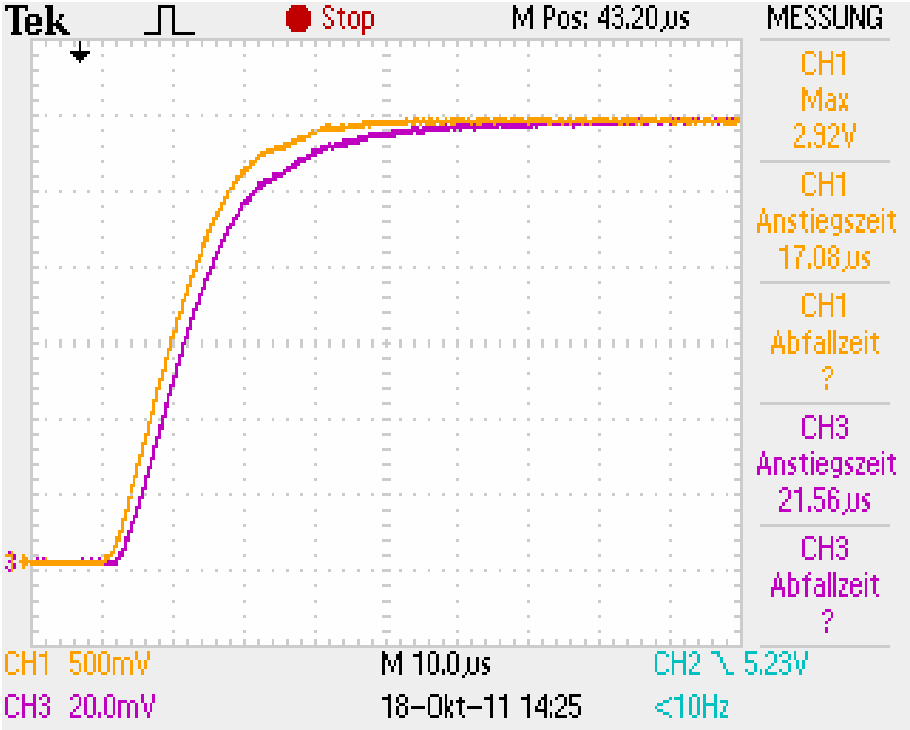

— electrical signal
— optical signal

Rise and fall time on a PM48 with 5 stacks electrically in series for 300A, 1.5ms, employing a 0.8m cable

0.8m cable	Rise time 10-90 (electrical/optical) [µs]	Fall time 10-90 (electrical/optical) [µs]
300A	17/18	18/13

Laser Electronics
2.8 High current pulses with LDD4312

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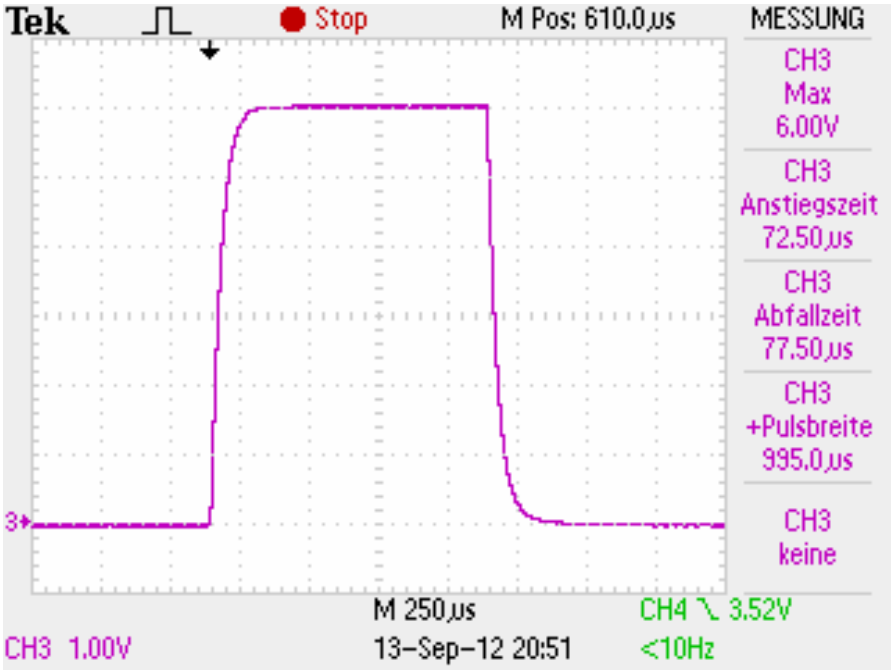
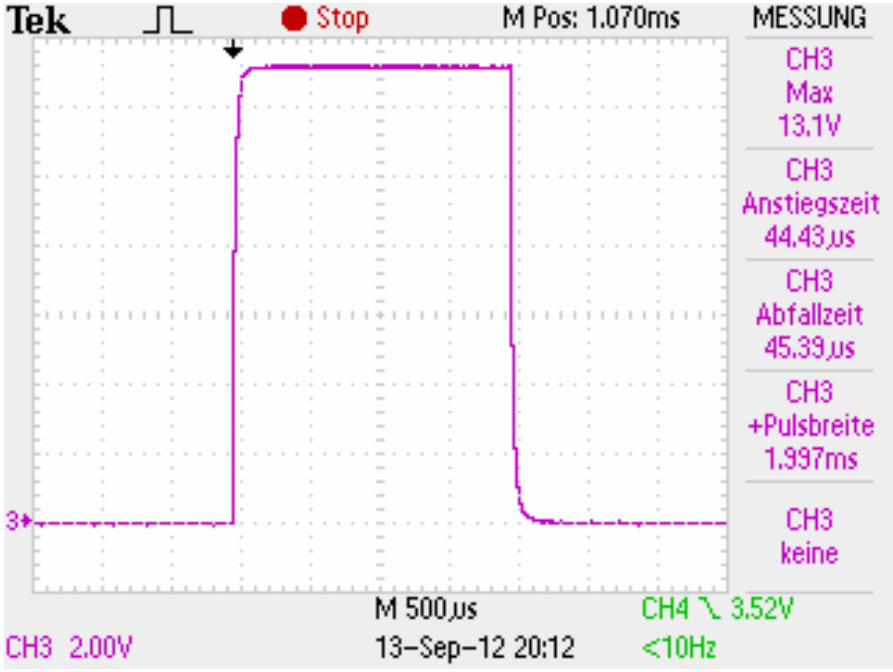
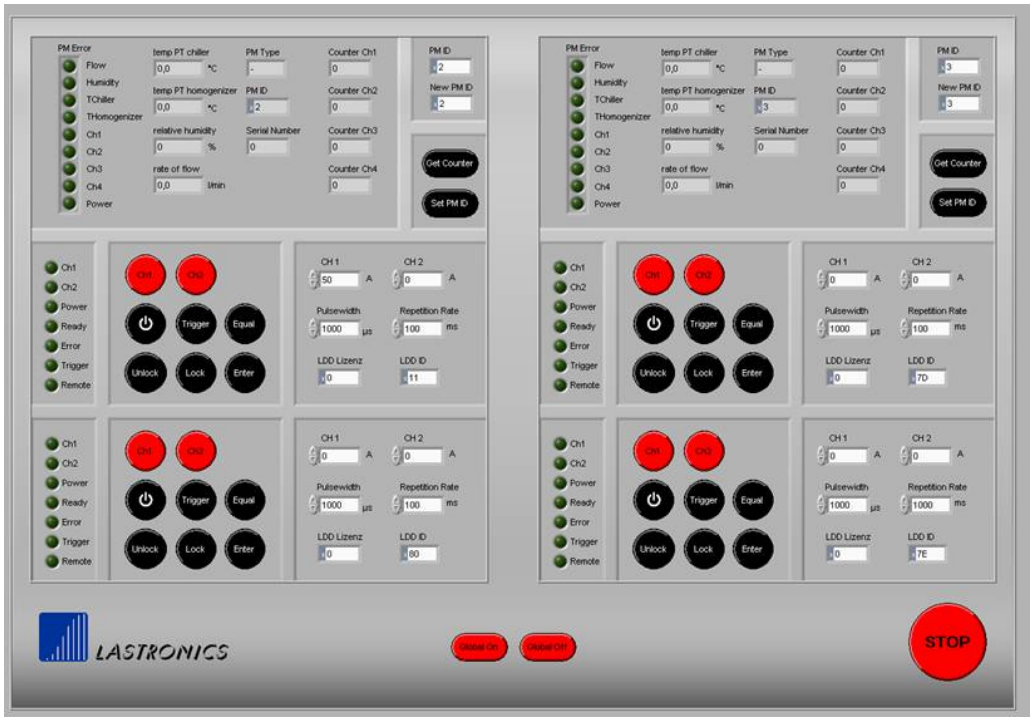


600 A on diode dummy load



1.3kA on resistor load

Laser Electronics
2.9 LabView Control Panel for LDD/PM



LabView Control

- LDD 43xx operation
- PM signal readout and control
- Control of intensity at target, pulse width FWHM, rep-rate
- Chiller signal readout and control

PUMP MODULES
3.1 What we do

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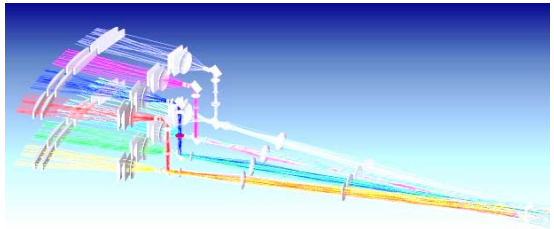
Laser Electronics	Diode Laser Pump Modules	Pump Engines
		
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Pump Modules for DPSSL
3.2 Design considerations

Considerations

- Cost EUR/W
- Total peak power
- Brightness
- Wavelength drift & spectral width
- Cooling requirements
- System reliability & lifetime
- Control and safety features

Pump Modules for DPSSL
3.3 Output power and lifetime of an individual stack

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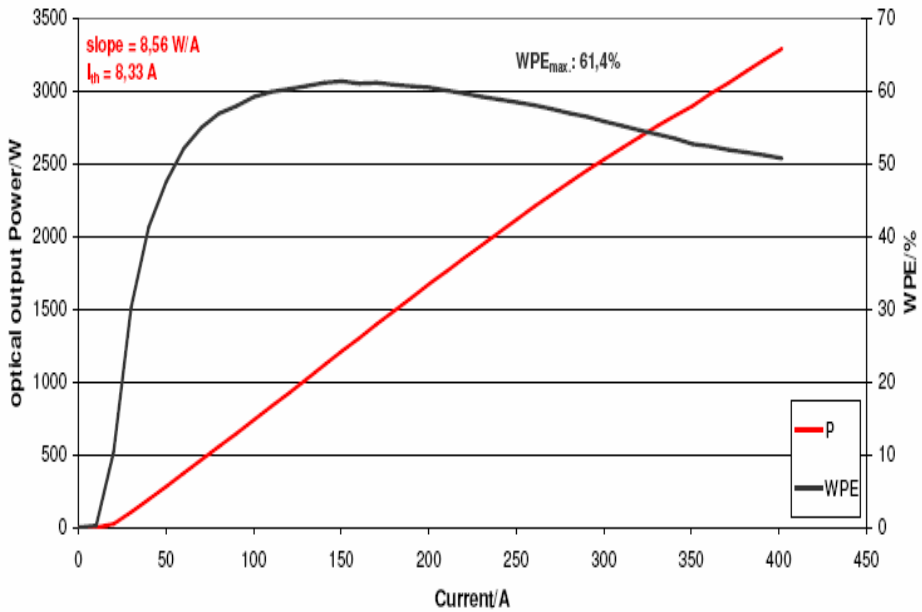
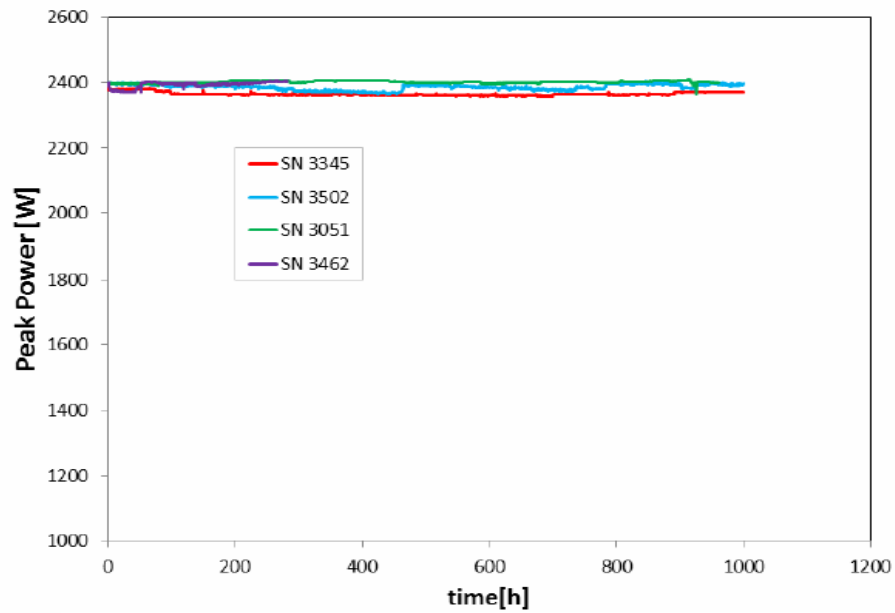
300 W/bar, 2.4kW/stack at 1ms, 10Hz, 20°C





DILAS

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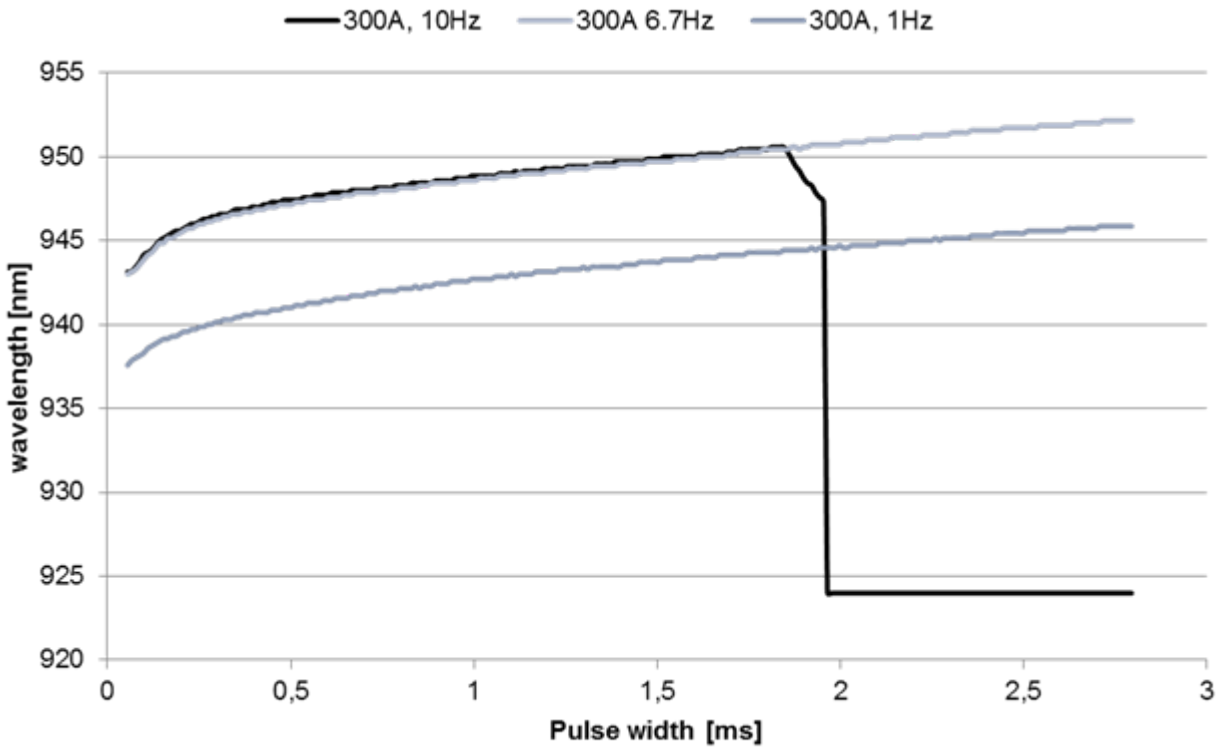
Impact of duty cycle on wavelength



Water temperature 20°C, driver LDD4310, rise time pulse (10-90) 100µs

How to kill a diode

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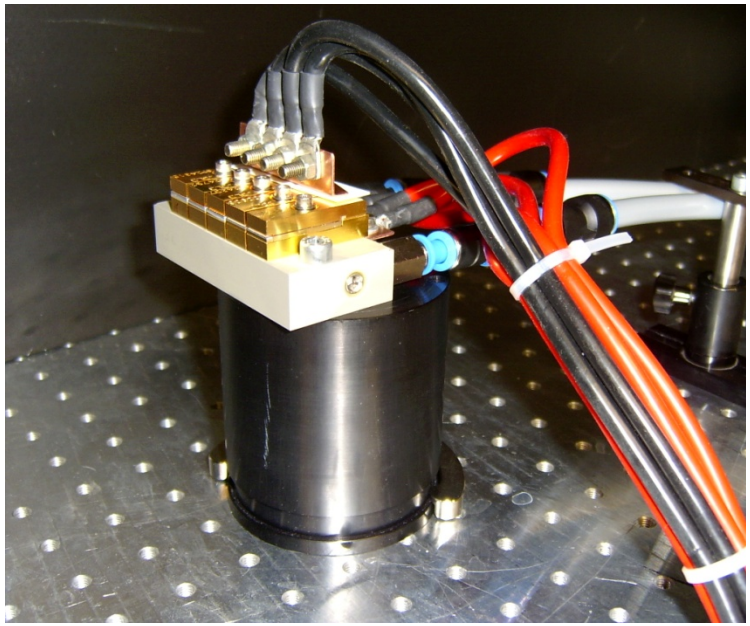
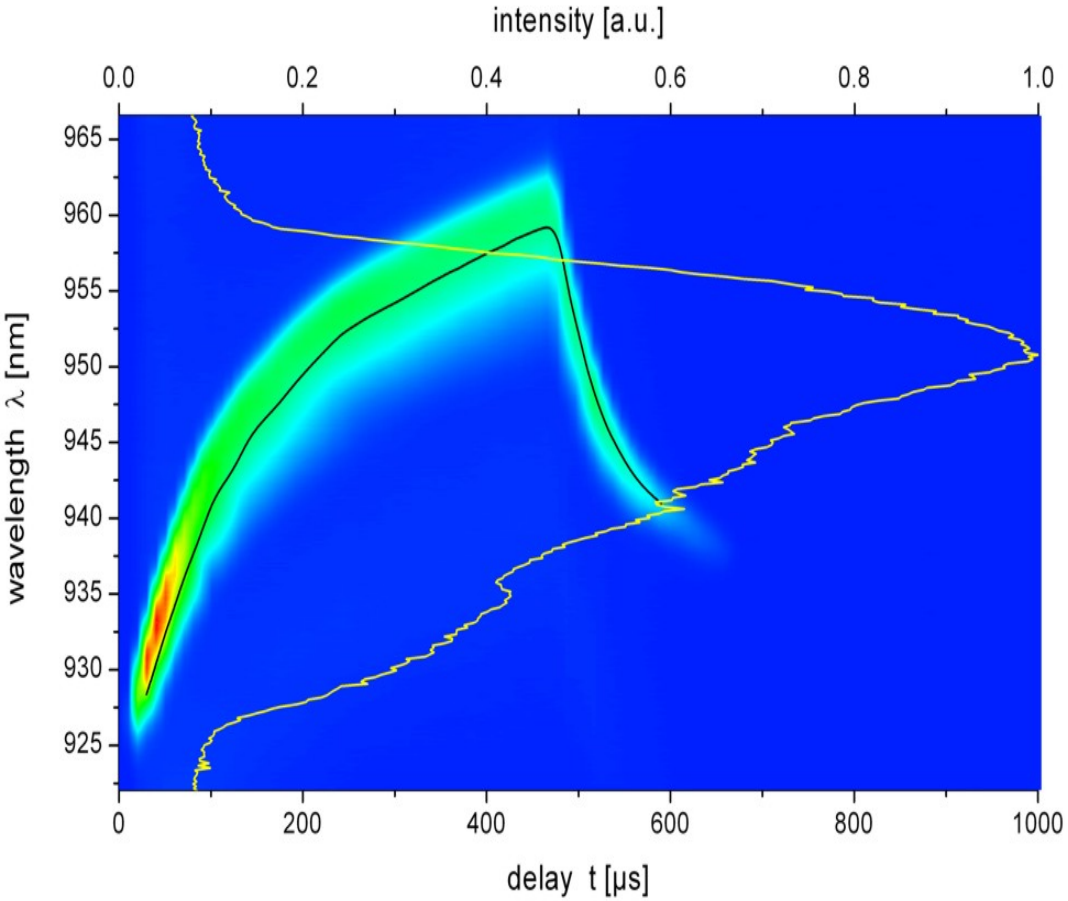
1.2 kA!





Pump Modules for DPSSL
3.5 Integrated Emission Spectrum

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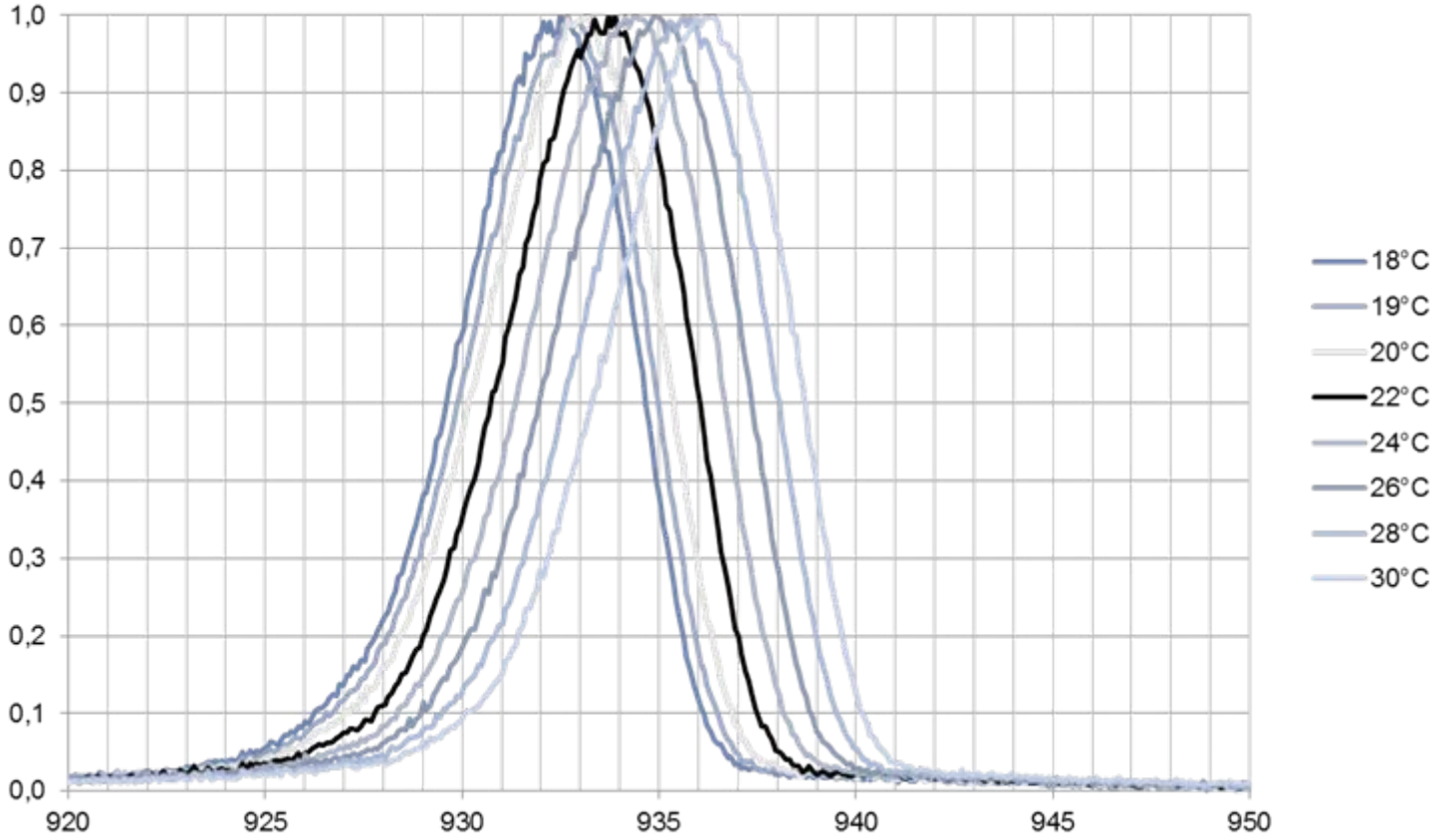
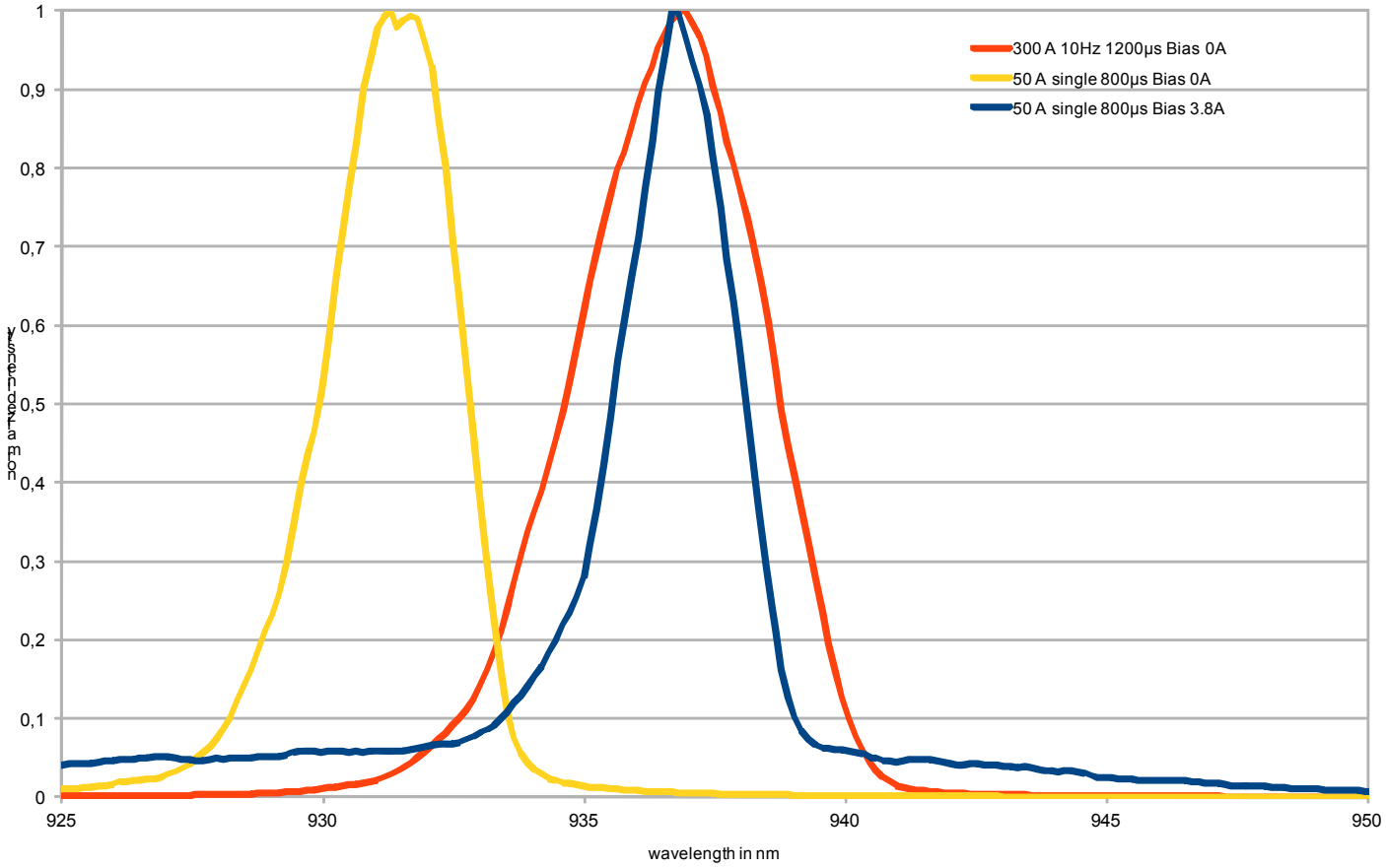
Center wavelength shift 0.32nm/K



DILAS 2x4 8bar stacks, PM19.2 heat sink, flow rate 10 ltr./min., 300A, 1ms, 10Hz

Pump Modules for DPSSL
3.6 Shift in wavelength



Pump Modules for DPSSL
3.7 Integrated emission spectrum - failure

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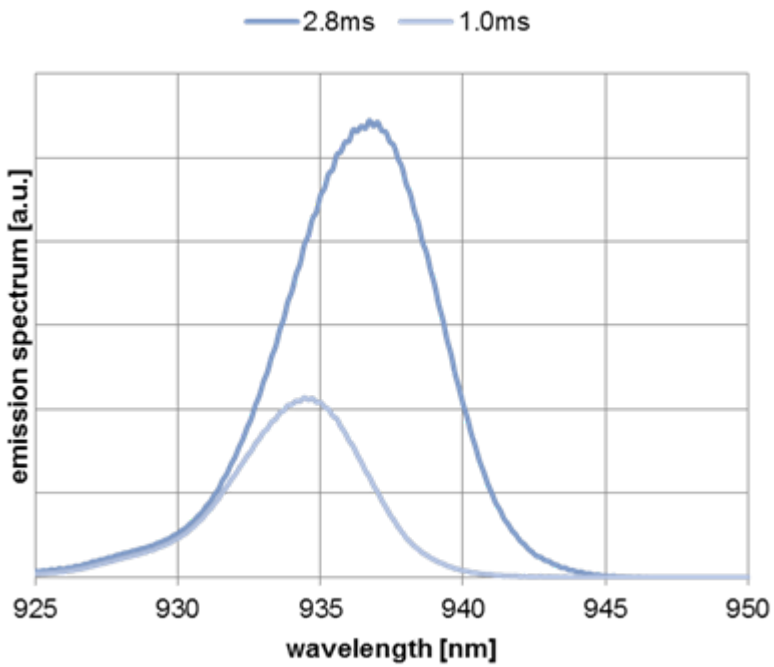
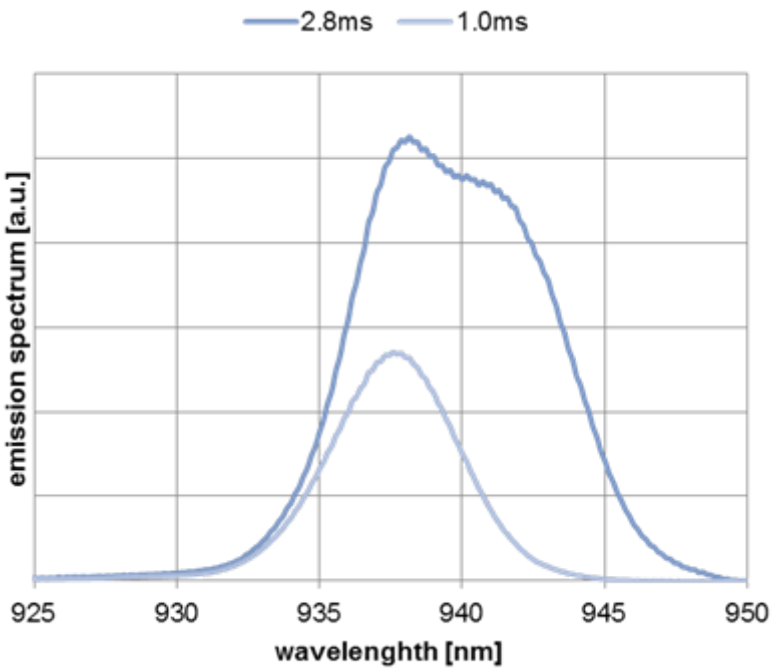
Integrated spectrum at 300A, 1Hz and 6.3 Hz

1.0ms – 5.1 nm FWHM, 2.8ms – 6.2nm FWHM



1.0ms – 5.2 nm FWHM, 2.8ms – 8.1nm FWHM



Y1, water temperature at 20°C, driver LDD4310 pulse rise time (10-90) 100µs, 50µs-2.8ms, 50 µs – 1.0 ms

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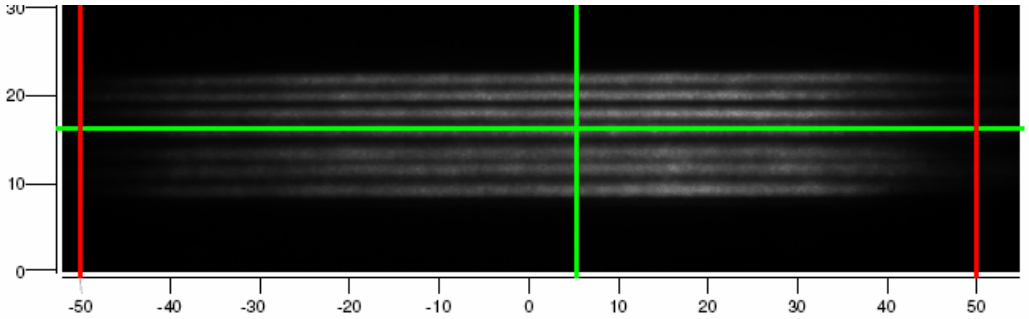
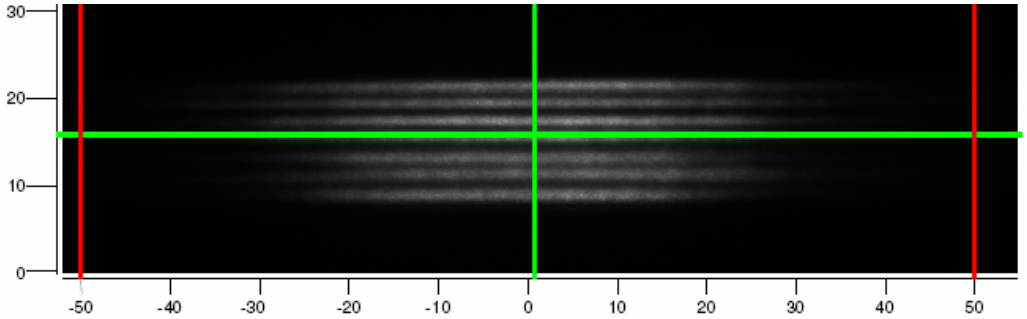
Significant increase in slow axis divergence

300 A, 2.8%DC



100 A, 2.8%DC



Normalized slow axis divergence

I DC	0.1%	1%	2.8%
300A	1.47	1.50	1.61
200A	1.26	1.26	1.32
100A	1	1	1

Screen at 0.5 m

Water temperature 24°C

Pump Modules for DPSSL
3.9 Overview

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PM19.2

- 8 8bar passively cooled LD stacks
- 939nm at max I, 2.5%DC
- **17 kW** qcw output
- 7x7 mm^2, 0.22 NA
- FWHM <6.0nm (max I, DC1.0%)
- 2.5% max DC (2.5ms, 10Hz)
- Tap water cooled (no DI water)
- Size: 750 mm (L) x 120 mm (W) x 130 mm (H)

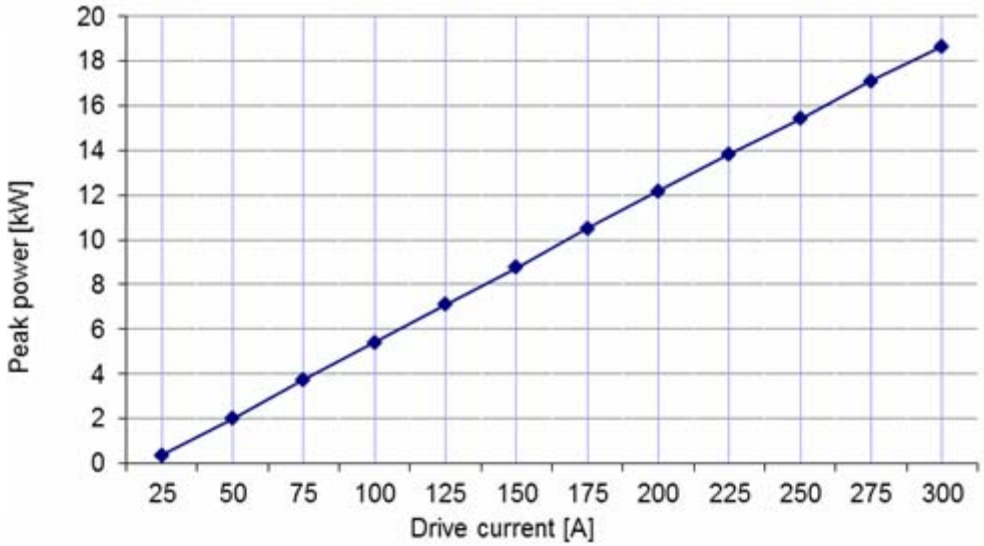
PM48

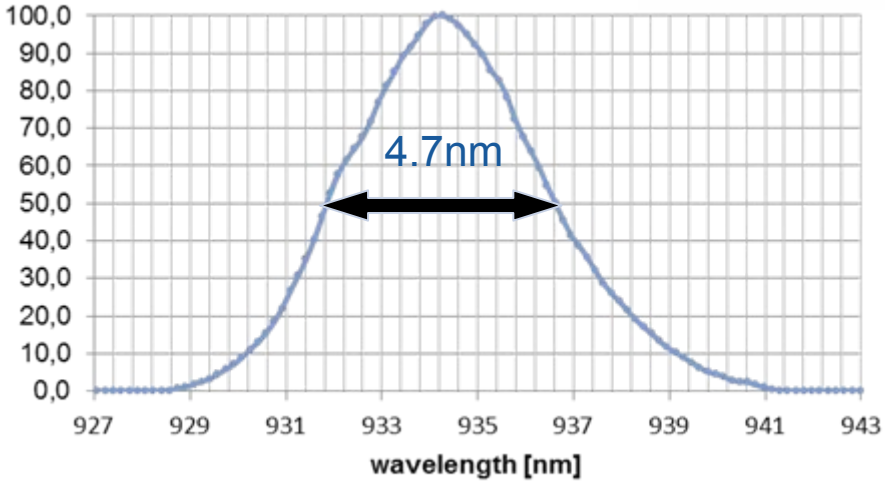
- 20 8bar passively cooled LD stacks
- 939nm at max I, 1%DC
- **40-42 kW** qcw output
- 20x20 mm^2, 0.14 NA
- FWHM <6.0nm (maxI, DC 1.0%)
- 1.25% max DC (1.25ms,10Hz)
- Water cooled (no DI water)
- Size: 850 mm (L) x 220 mm (W) x 230 mm (H)

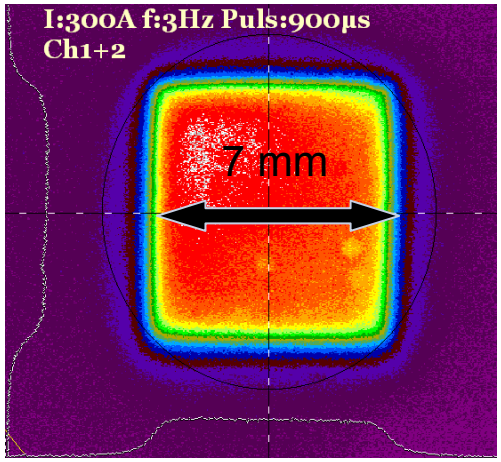
PM80

- 32 8bar passively cooled LD stacks
- 939 or 979nm at max I, 1%DC
- **75 kW** qcw output
- 70x70 mm^2, 0.06 NA (with BD)
- FWHM <6.0nm (maxI, DC 1.0%)
- 1.25% max DC (1.25ms,10Hz)
- Water cooled (no DI water)
- Size: 422 mm (L) x 265 mm (W) x 278 mm (H)

Pump Modules for DPSSL
3.10 Results for PM19.2





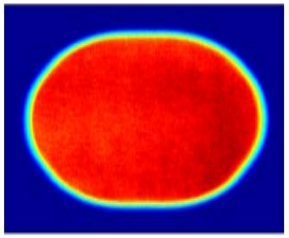


Water temperature 20°C, DC 1.0%, drive current 300A

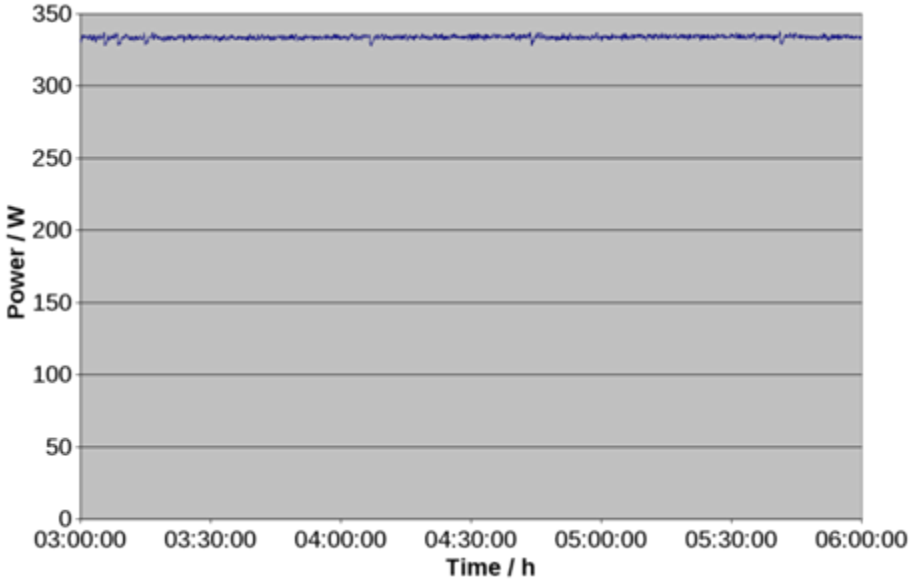
Spot size 7 x 7 mm^2

Pump Modules for DPSSL
3.11 Results for PM48 – elliptical beam shape

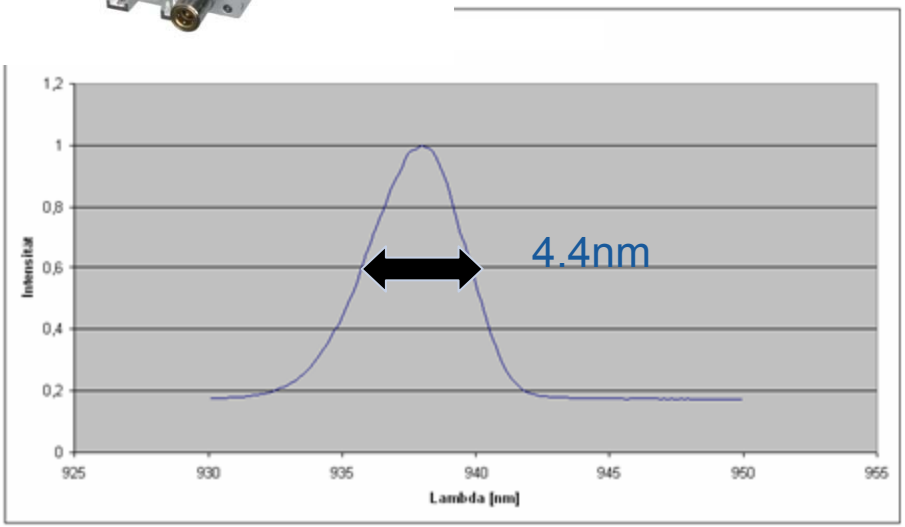
LASTRONICS



Beam size 21 mm x 27 mm



Water temperature 20°C, DC 1.0%, drive current 310A



Pump Modules for DPSSL
4.5 PM80

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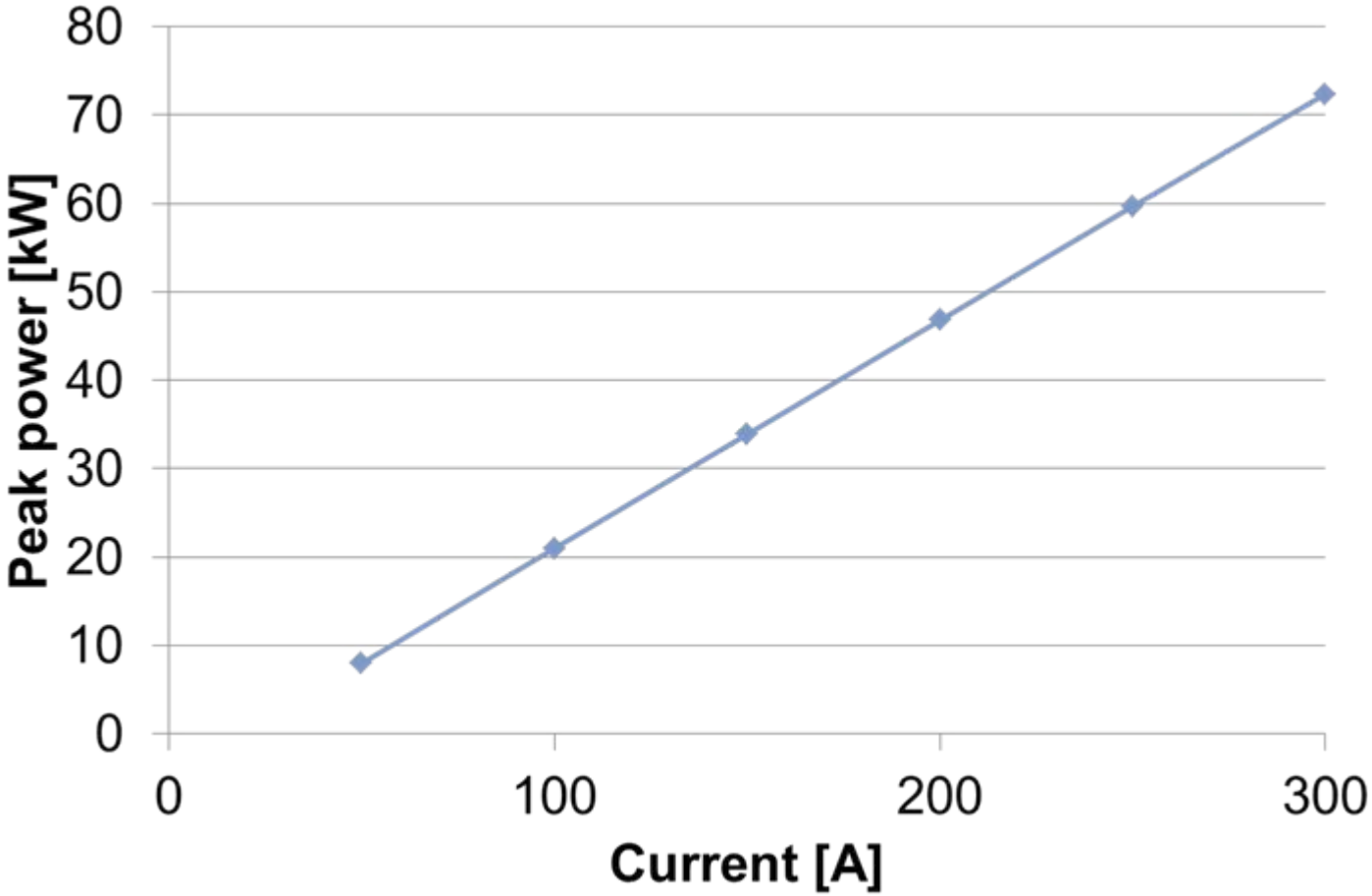
Specifications	
Number of passively cooled LD stacks	32 x 8 bars
Wavelength at max I, 1% DC	939 or 979nm
FWHM (max I, DC 1.0%)	<6.0nm
Qcw ouput power	**75 kW**
Max DC	1.25 % (1.25ms, 10Hz)
Brightness (with BD)	0.6 – 1.3 MW/cm²/sr
with polarisation coupling	0.8 – 2.1 MW/cm²/sr
Homogenized, symmetrical output using MLAs	
Polarized output	
Remote control	
Tap water cooled	
Size (L) x (W) x (H)	422 mm x 265 mm x 278 mm

Pump Modules for DPSSL
4.5 PM80



LASTRONICS
4.1 What we do

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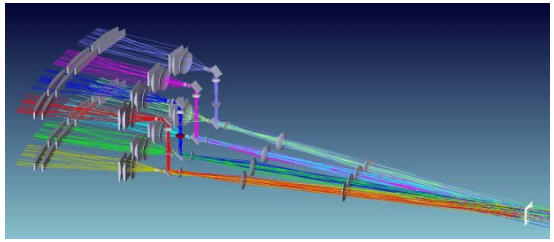
Laser Electronics	Diode Laser Pump Modules	Pump Engines
		
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Pump Engines for DPSSL
4.2 Design considerations

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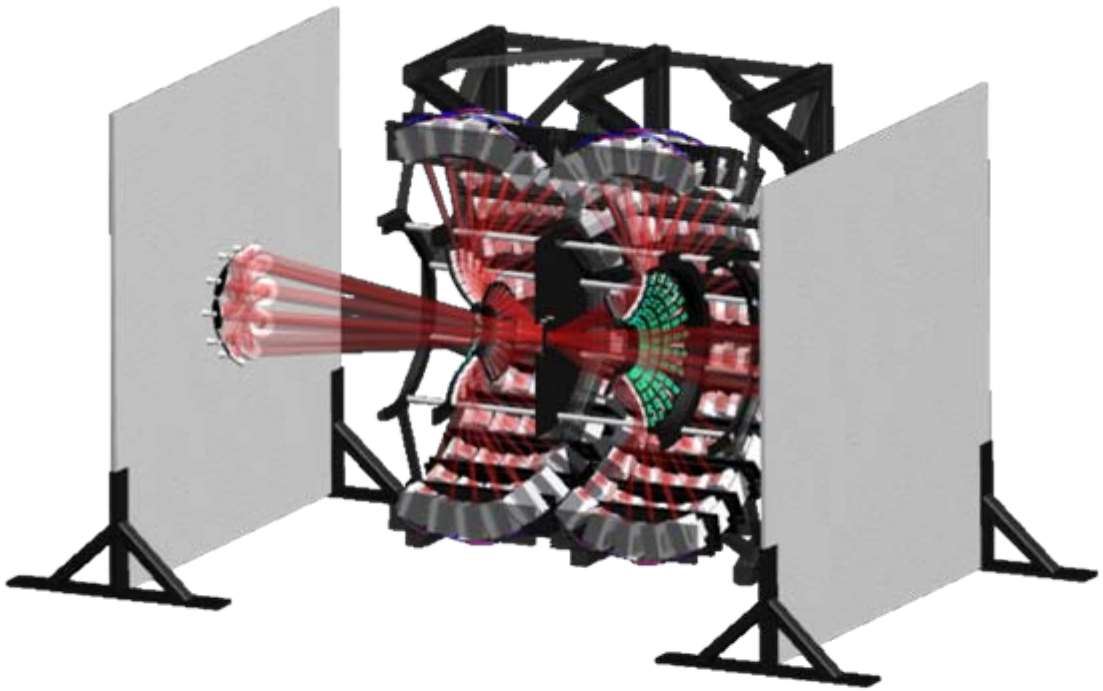

Considerations

- Cost EUR/W
- Total peak power
- Brightness
- Number of beams & combination
- System reliability
- Gshot lifetime

Pump Engines
4.3.1 Beam delivery system to target

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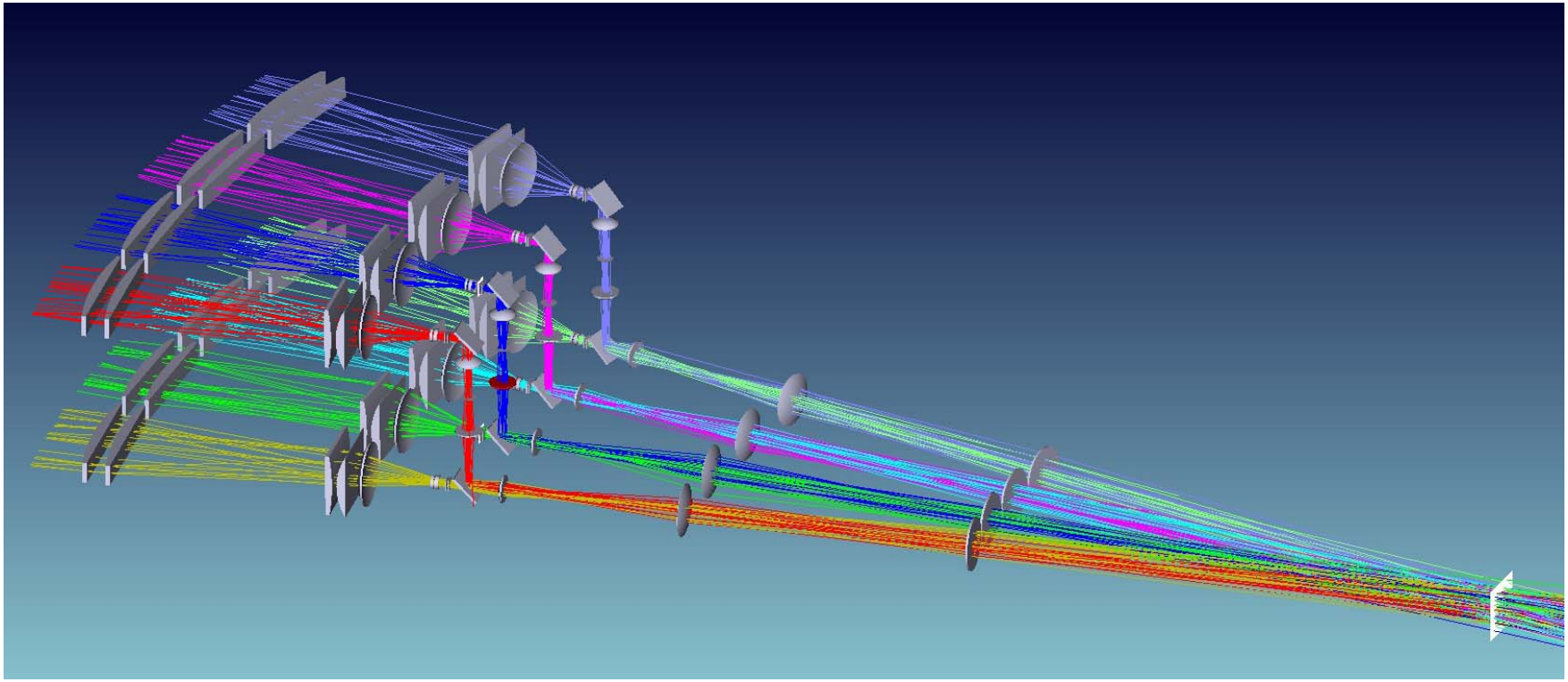
8 PM 80 pol coupled for 560 kW (to be extended to 1.000 kW) at target



Pump Engines
4.3.2 Beam delivery system to target

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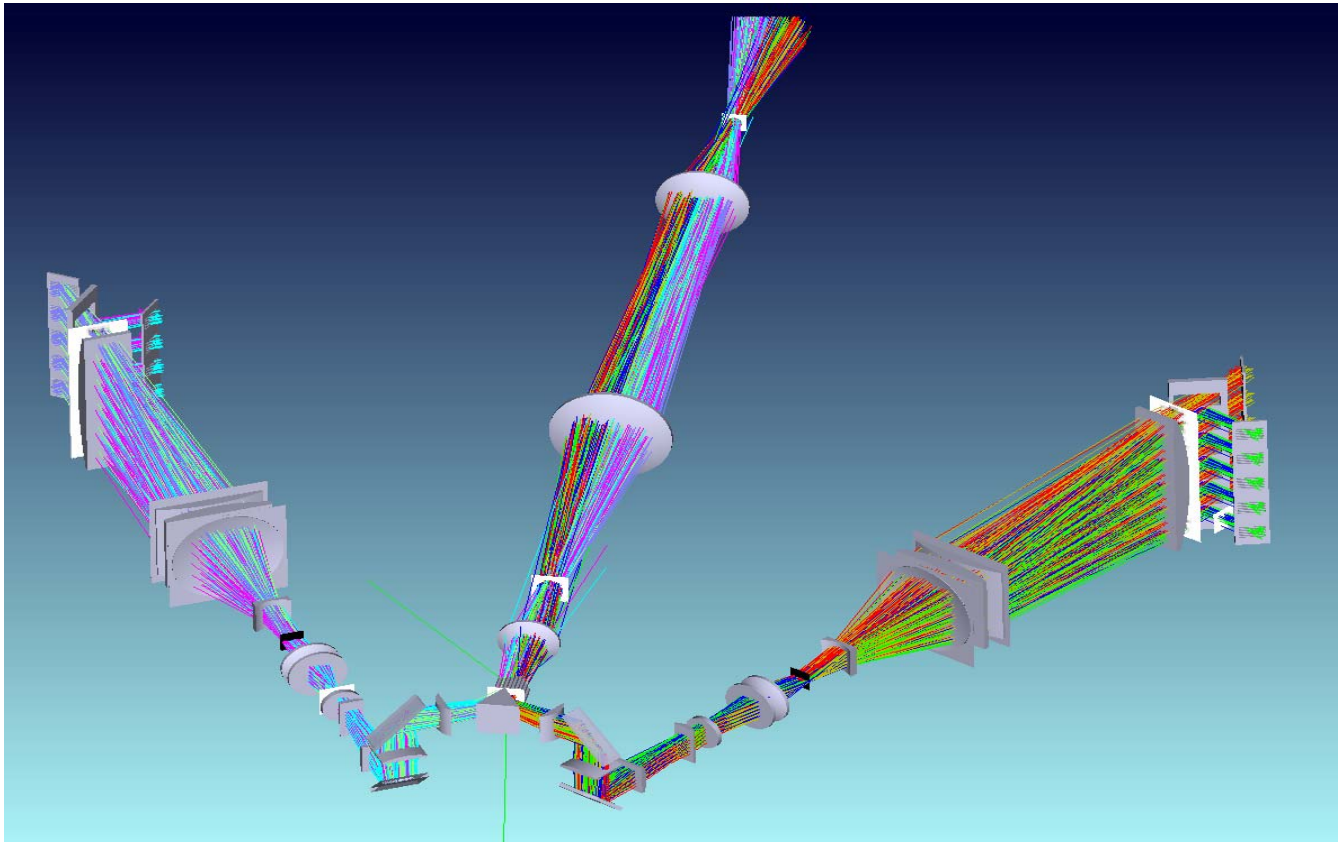
2 PM 48 polarized for 80kW at target with 1.3 MW/cm^2/sr



Pump Engines
4.3.3 Beam delivery system to target

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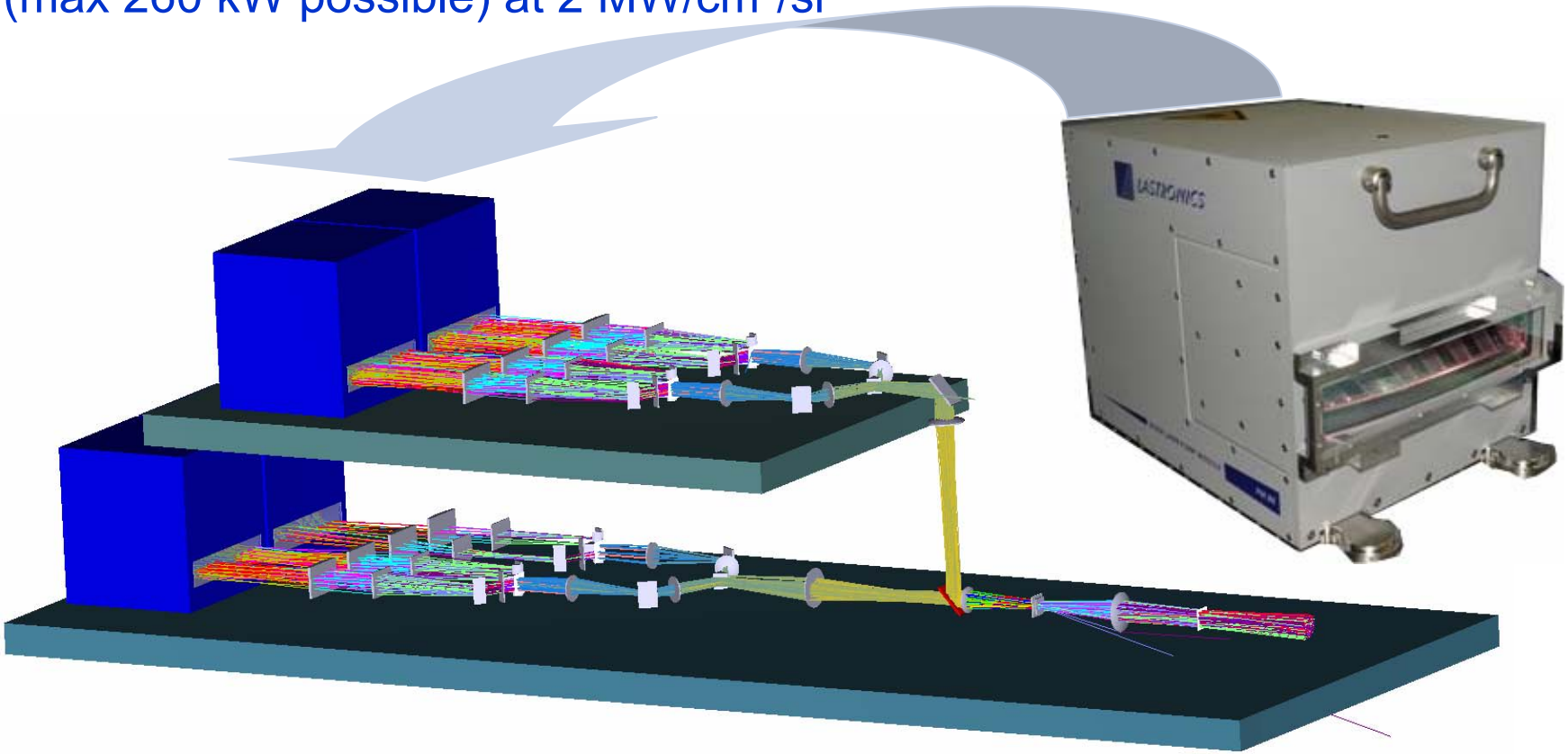
4 PM80 with polarisation coupling for 200 kW at target (max 260 kW possible) at 2 MW/cm^2/sr



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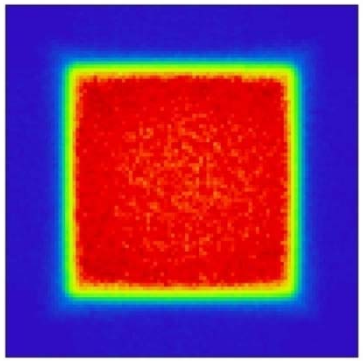
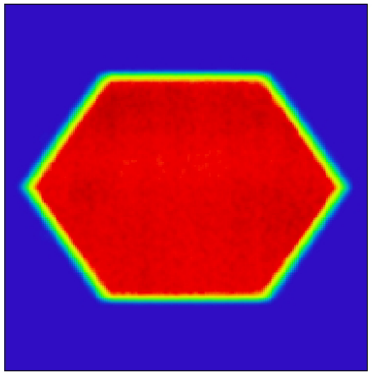
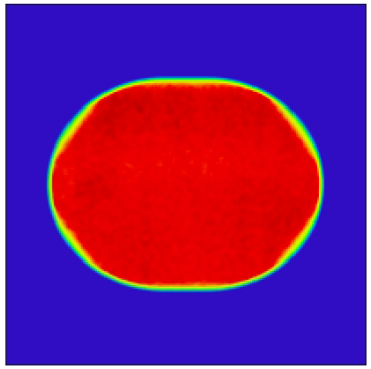
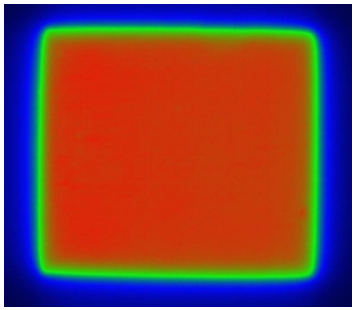
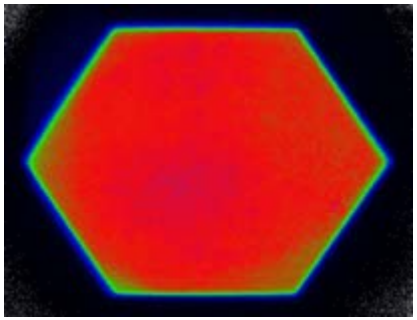
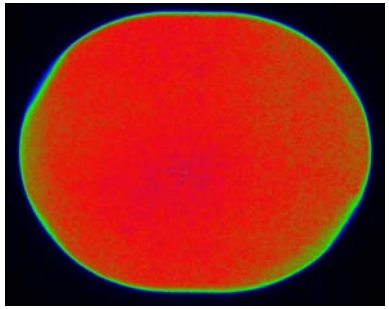
Homogenized foci with different shapes

Zemax Simulation

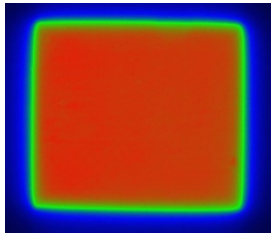




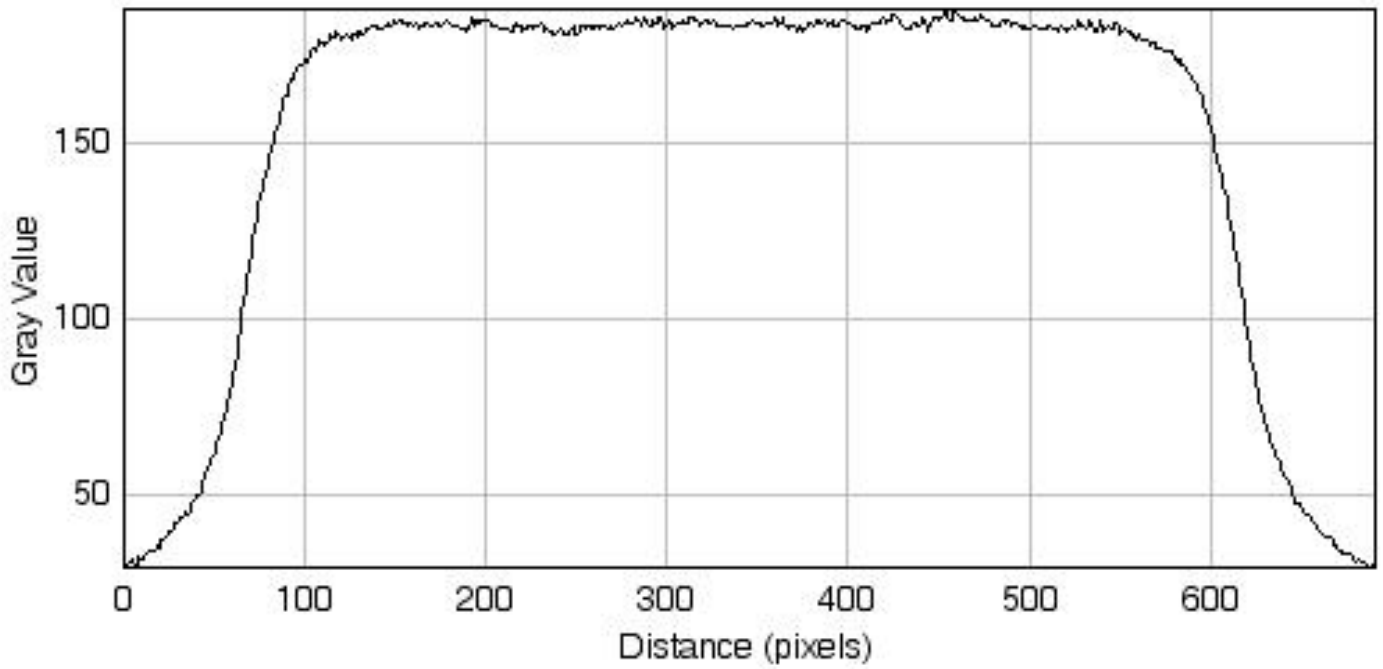
Measurement (PM 48)

Pump Engines
4.4.2 Homogenized focus (measurement)

LASTRONICS





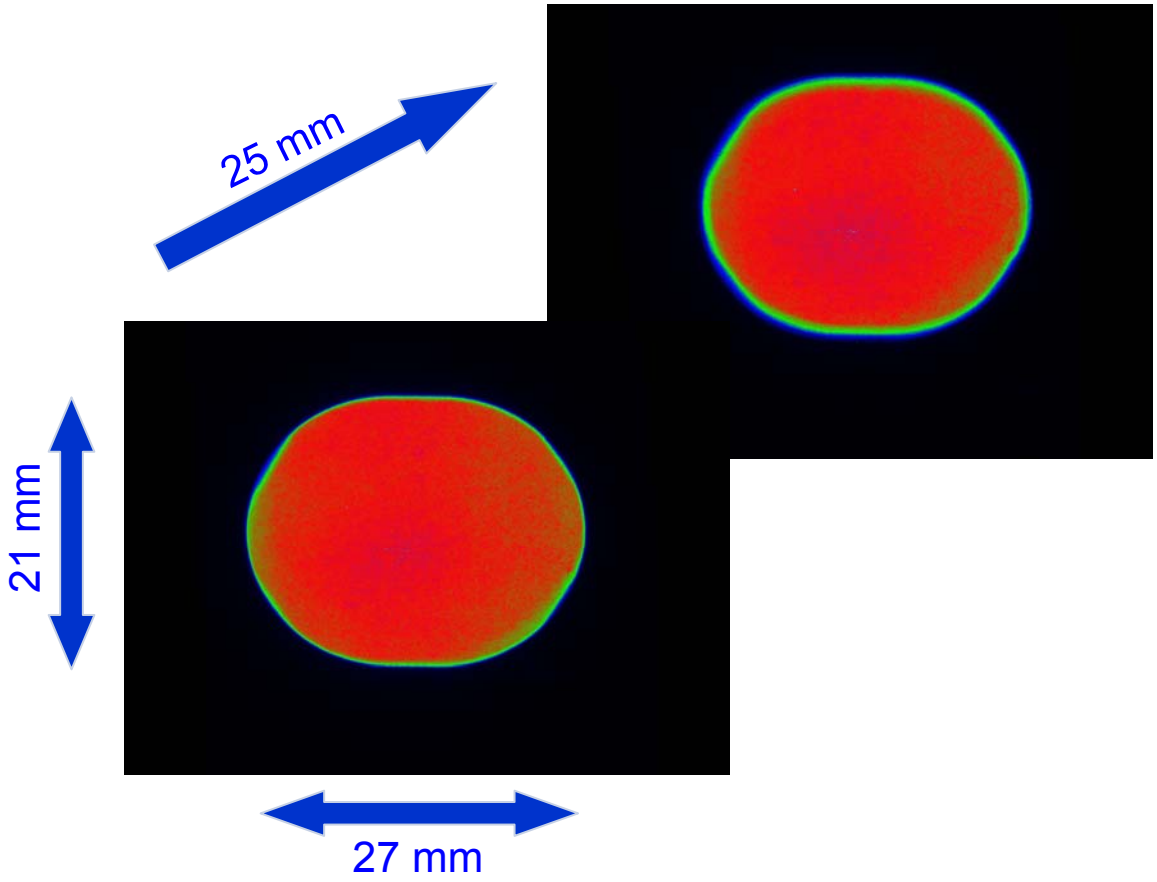
Cross section of a homogenized beam of a PM48 with 2 Flat TOP5

PV fluctuations are less than +/-2.5%

Pump Engines
4.4.3 Through focus measurement

LASTRONICS

PM 48



5.1 Summary

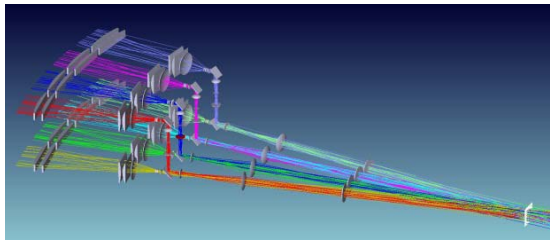
LASTRONICS

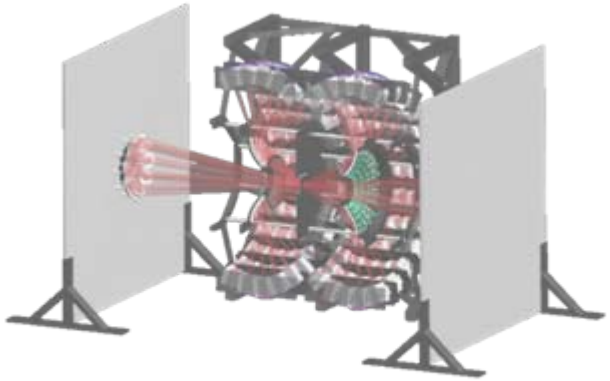
- LTX provides a family of several pump engines for low reprate (10Hz) CPA laser systems for the multi TW to PW range
- Current focus is on 9xxnm for Yb-doped materials
- Max single pump module peak power is 75kW (polarized)
- Max single beam line peak power past homogenizer is 0.5 .. 1.0 MW
- Target is to build entire diode laser driven amplifiers in the multi TW to PW range

1 **Pump Module**

2 **Pump Engines**

3 **TW/PW Amplifiers**
(incl. FE and compressor)



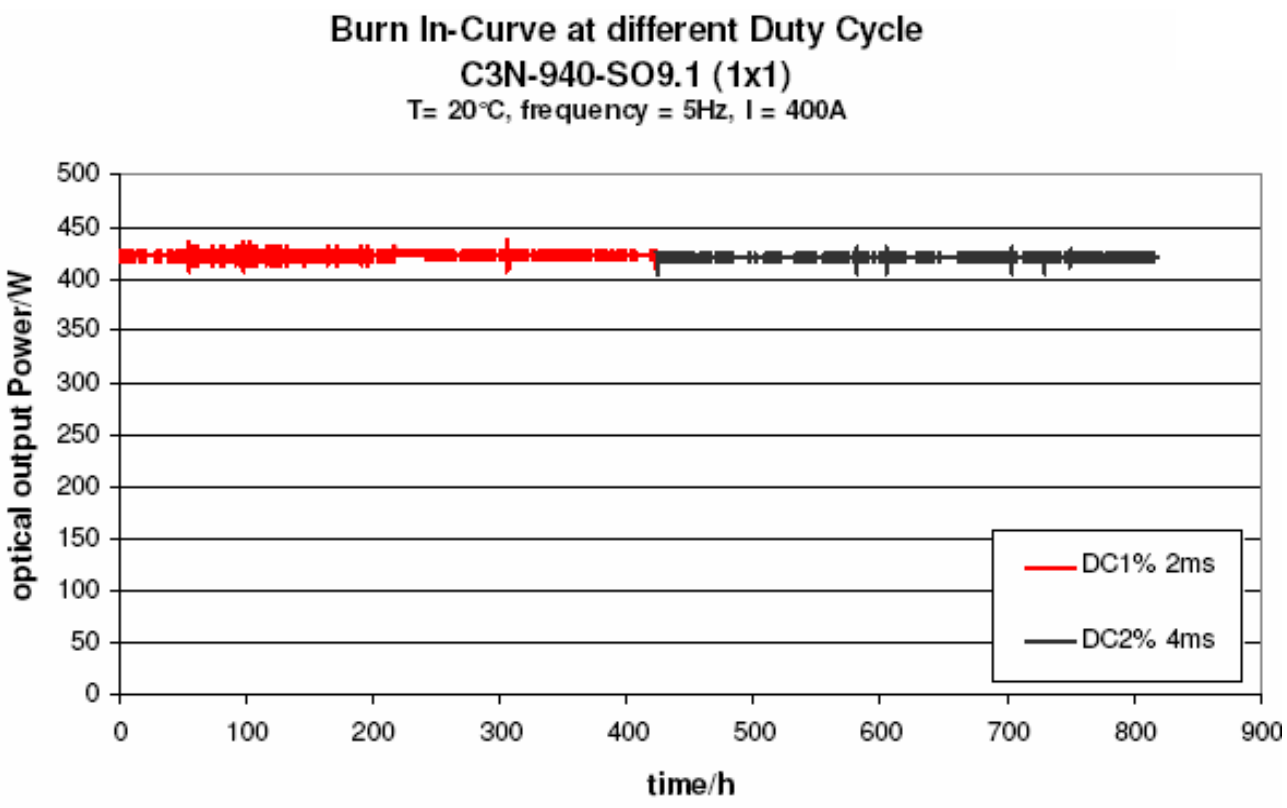


Thank you for your attention!

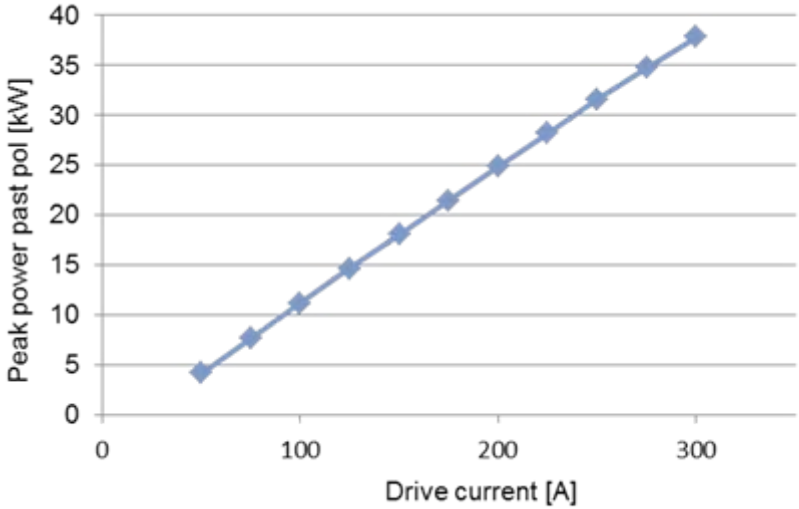
Pump Modules for DPSSL
A1 Lifetime test

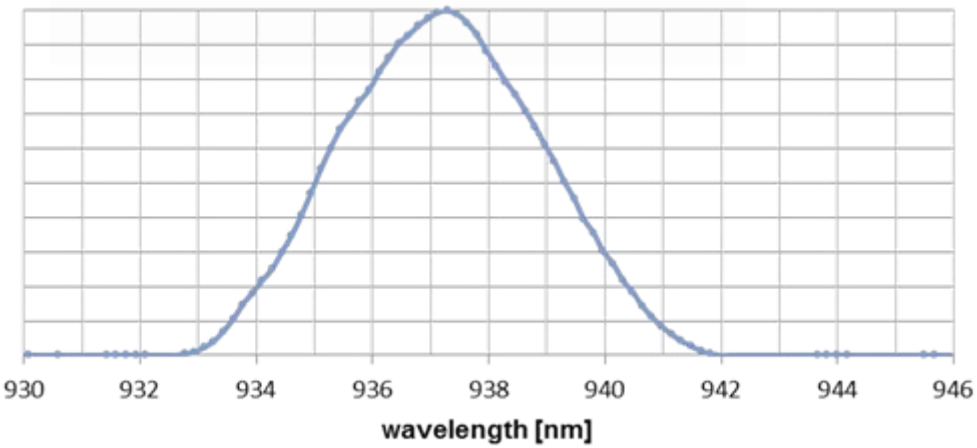
LASTRONICS

Target for lifetime: 2Gshot, test under way

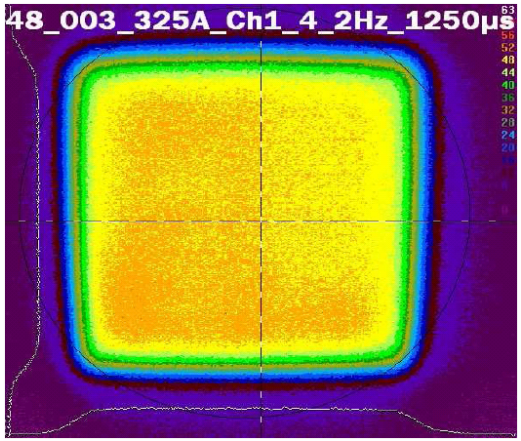


Pump Modules for DPSSL
4.4.2 PM48





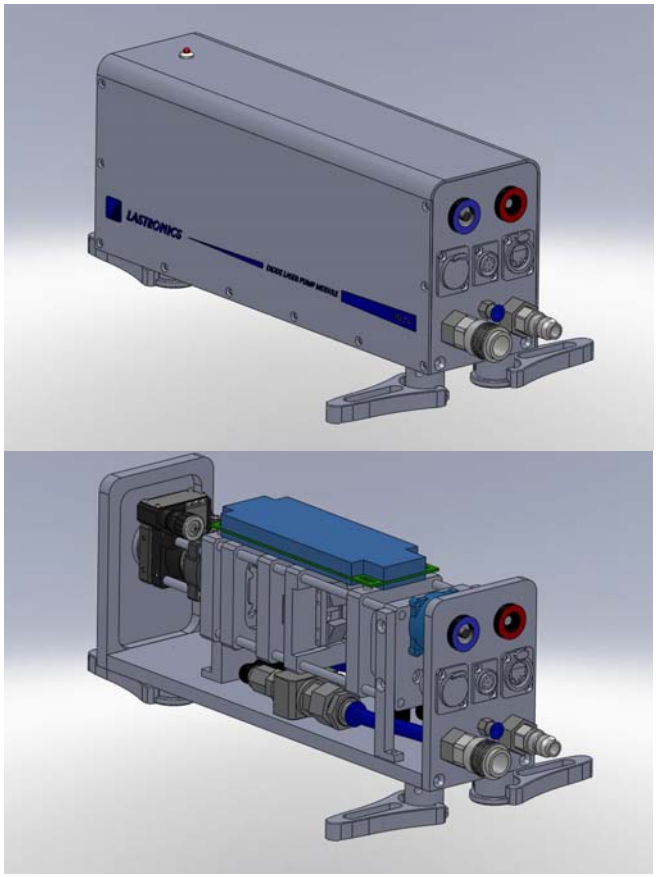
Water temperature 20°C, DC 1.0%, drive current 300A



Spot size 20 x 20 mm^2

Pump Modules for DPSSL
4.1 PM2.4

LASTRONICS



Specs

- Pump module with 1 8bar passively cooled LD stacks
- 939/981nm at max I, 1%DC
- **2.0 kW** qcw output
- 2.0 x.2.0 mm^2, 0.18NA
- FWHM <6.0nm (maxI, DC 1.0%)
- 2.5% max DC
- Homogenized, symmetrical output using MLAs
- Polarized output
- Remote control
- Tap water cooled (no DI water)
- Size: 350 mm (L) x 94 mm (W) x 130 mm (H)

Pump Modules for DPSSL
4.4 Specs of PM19.2

LASTRONICS

Specifications	
Number of passively cooled LD stacks	8 x 8 bars
Wavelength at max I, 2.5% DC	939nm
FWHM (max I, DC 1.0%)	<6.0nm
Qcw ouput power	**17 kW**
Max DC	2.5 % (2.5ms, 10Hz)
Homogenized, symmetrical output using MLAs	
Polarized output	
Remote control	
Tap water cooled	
Size (L) x (W) x (H)	750 mm x 120 mm x 130 mm

Pump Modules for DPSSL
4.4.1 PM48

LASTRONICS

Specifications	
Number of passively cooled LD stacks	20 x 8 bars
Wavelength at max I, 1% DC	939nm
FWHM (max I, DC 1.0%)	<6.0nm
Qcw ouput power	**40-42 kW**
Max DC	2.5 % (2.5ms, 10Hz)
Brightness	0.5 – 1.3 MW/cm²/sr
Image size at 15cm	22 x 22 mm², 0.06NA
Homogenized, symmetrical output using MLAs	
Polarized output	
Remote control	
Tap water cooled	
Size (L) x (W) x (H)	850 mm x 220 mm x 230 mm

Pump modules
3.13 Control and safety features

LASTRONICS

Pump Module Safety Issues

- passively cooled laser diode stacks
- water flow sensor
- several temperature sensors
- humidity sensor
- no cemented optical elements
- absorption free optical elements
- HR coating for laser wavelength
- energy sensor