Current status of the PEnELOPE project

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Helmholtz-Centre Dresden-Rossendorf

7th international HEC-DPSSL workshop
Lake Tahoe, September 11th – 14th 2012

Overview

DRACO – Ti:Sa 150 TW laser

- Proton acc. & Cell irradiation experiments

PENELOPE – diode-pumped high-energy laser

- Lab infrastructure
- Amplifier Design
- Pump Modules
- Laser Material
- Stretcher – Compressor
- Lasers

150 TW laser – DRACO

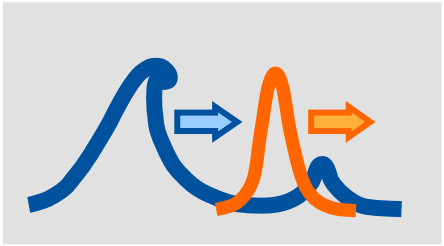
Electron acceleration

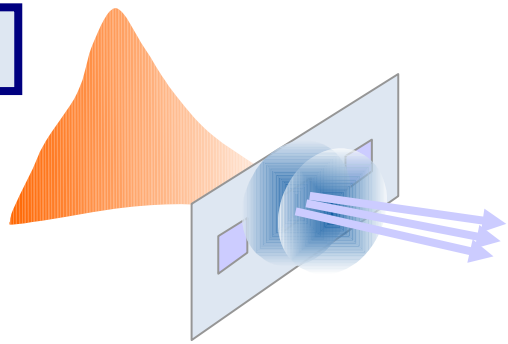
Thomson scattering

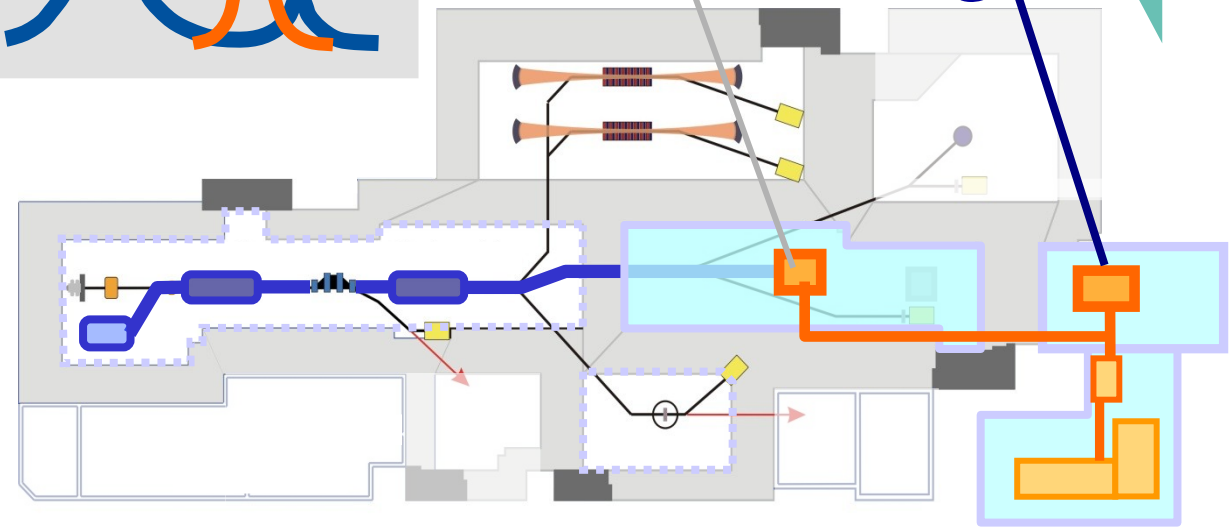
Ion acceleration

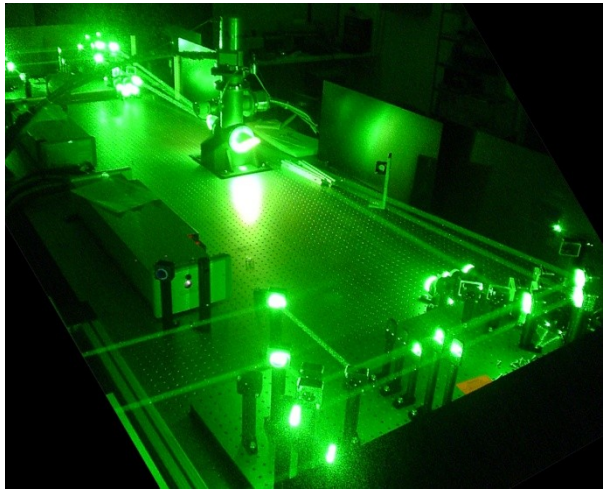
since 02/10

since 01/09



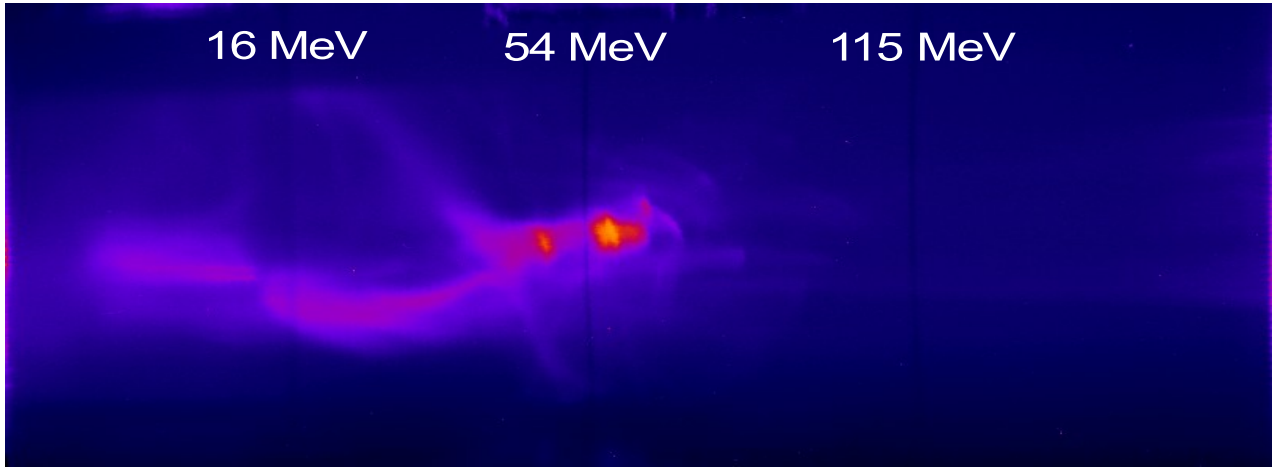


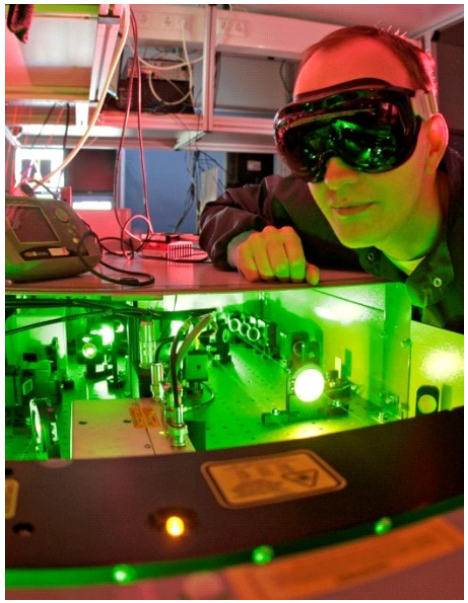


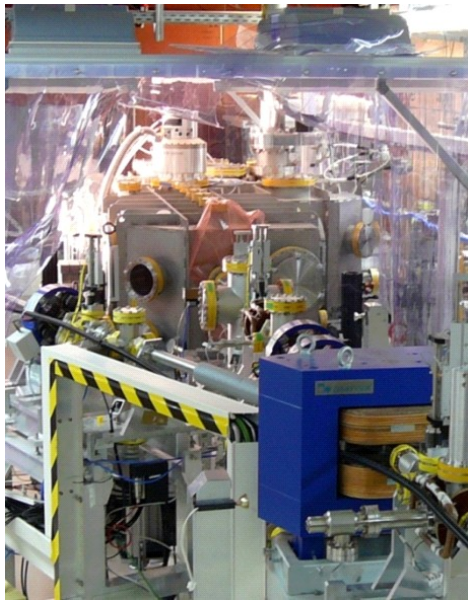


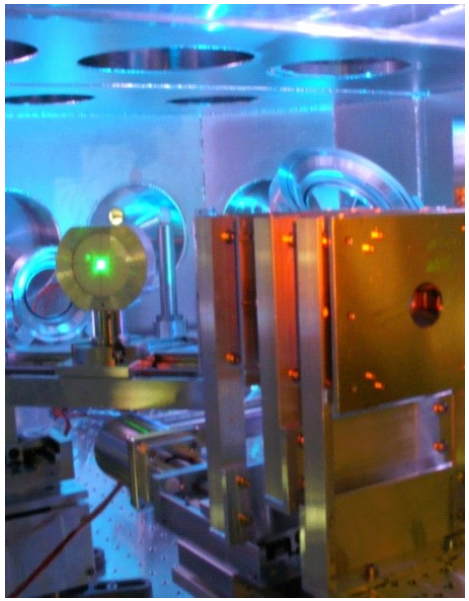
150 Terawatt
4 J / 25 fs
500TW-Upgrade planned

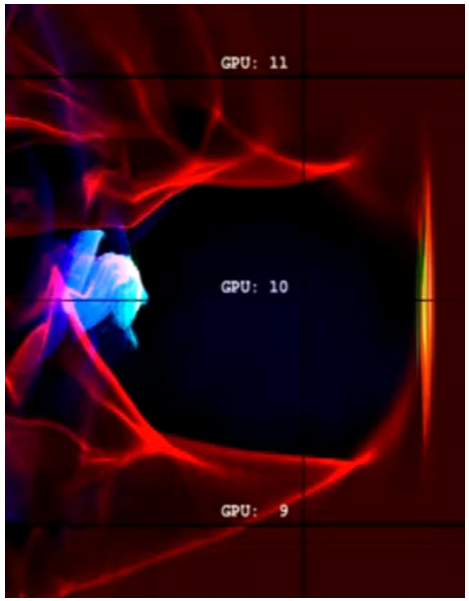
Electron acceleration with DRACO



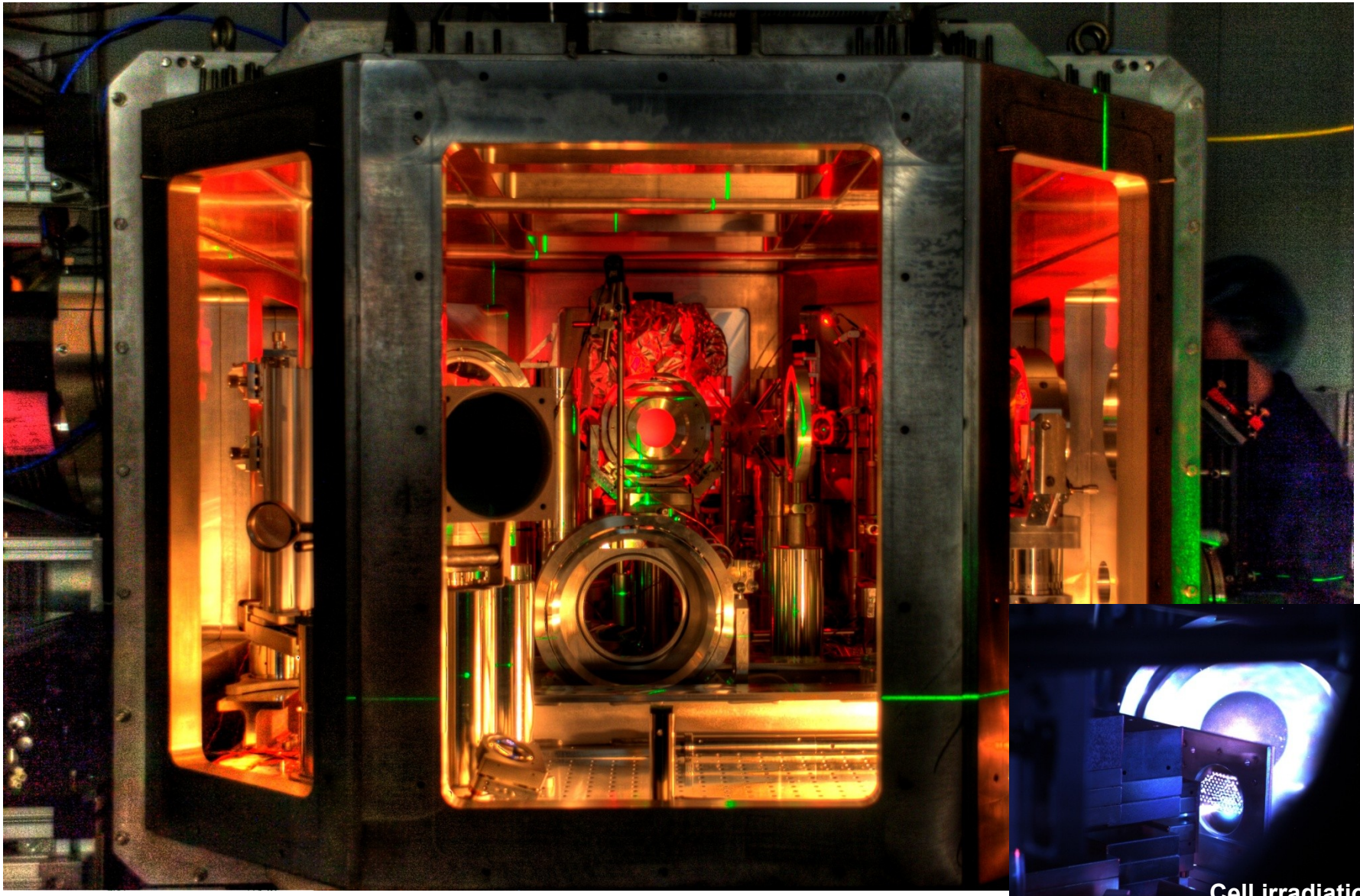


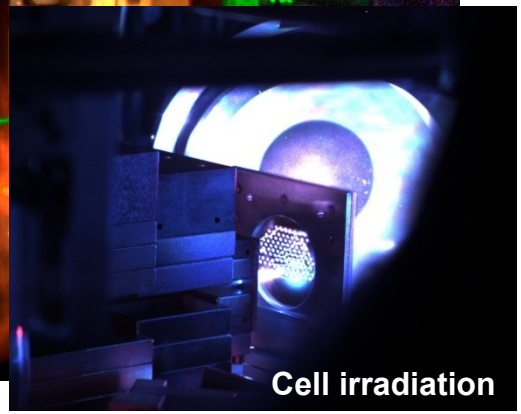




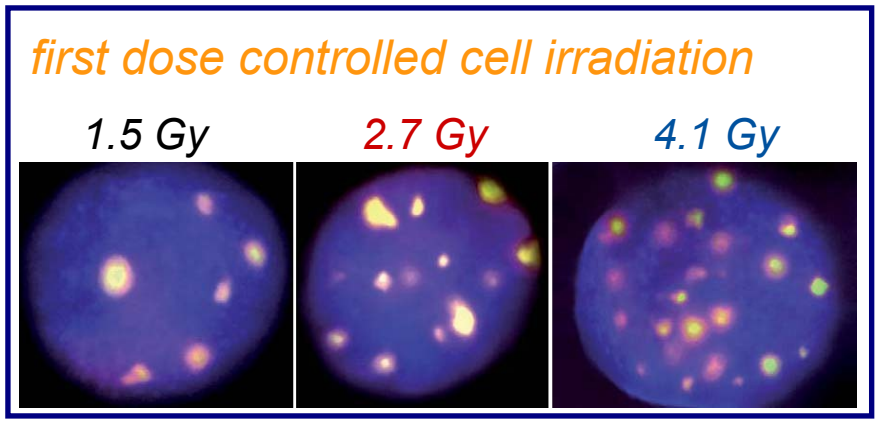


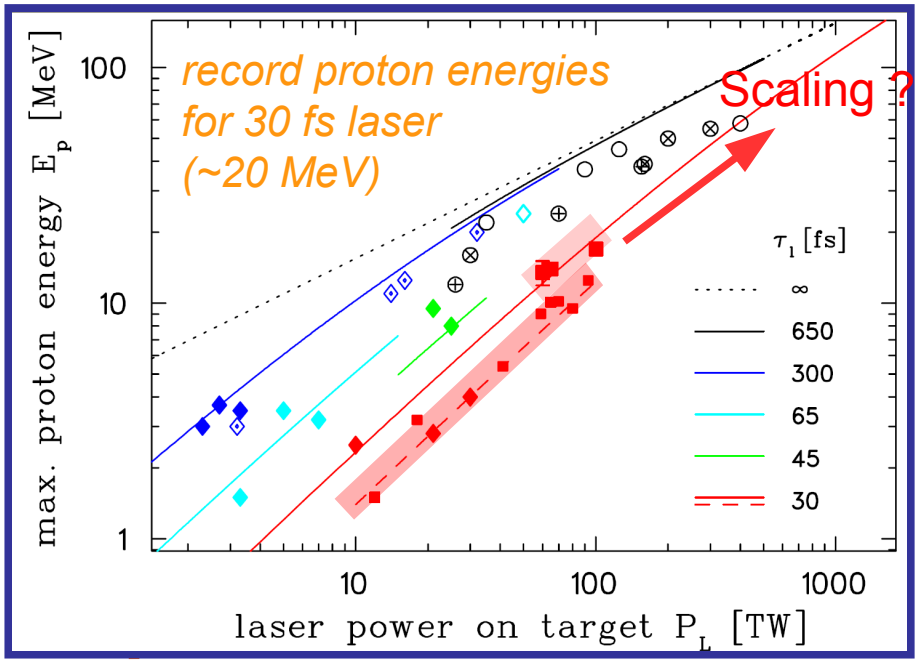
Ion acceleration with DRACO

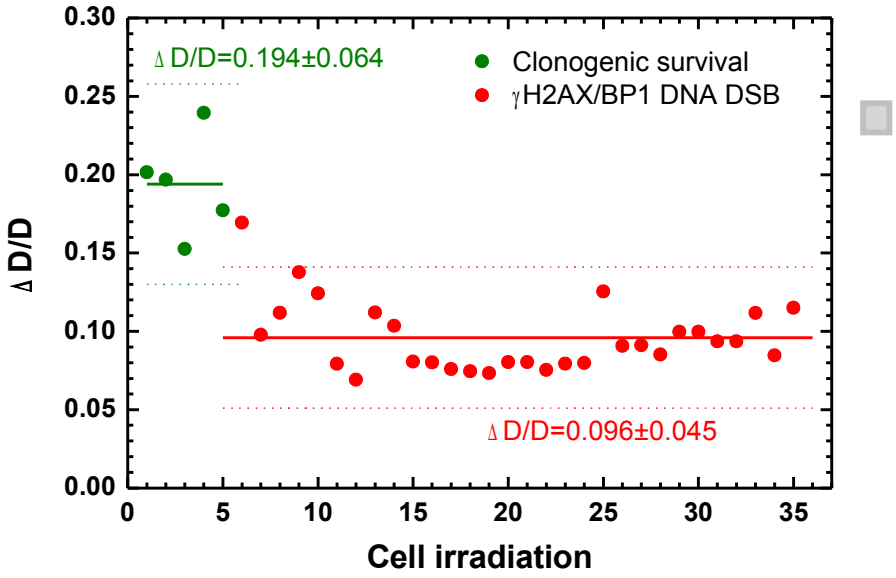


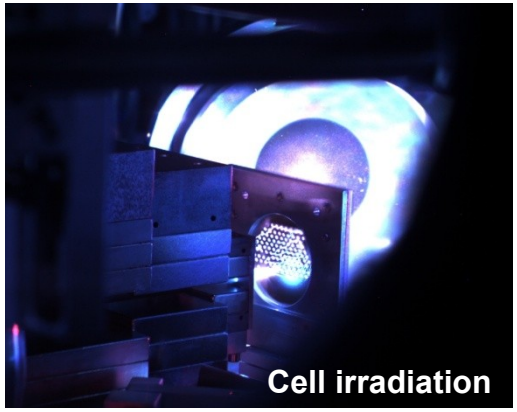


First cell irradiation experiments



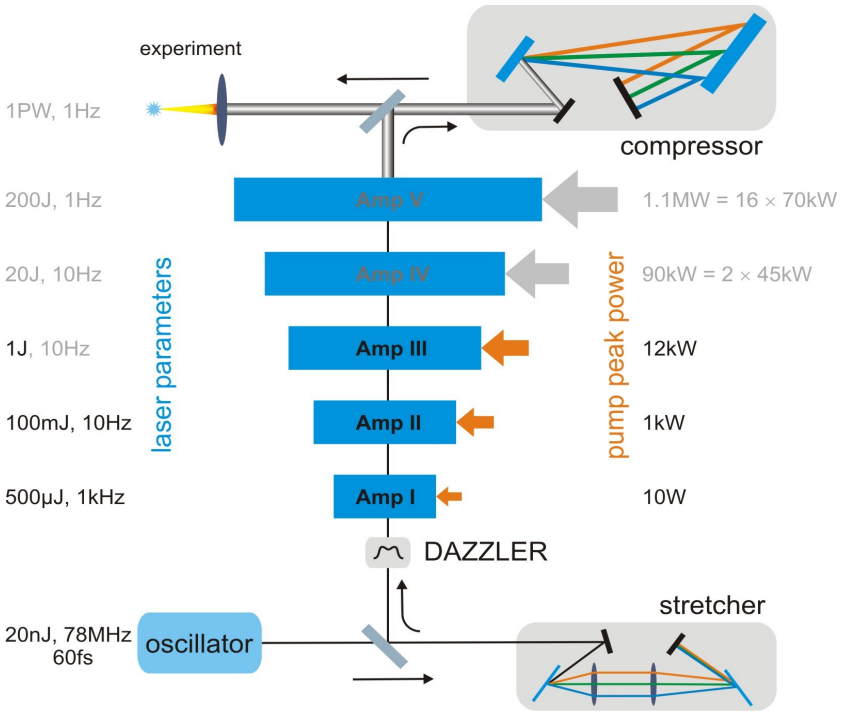




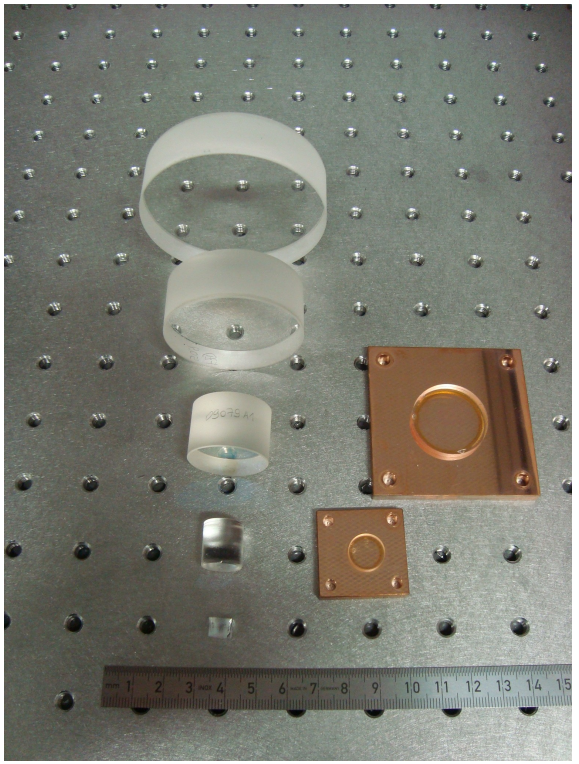


PEnELOPE

Petawatt, Energy-Efficient Laser for Optical Plasma Experiments

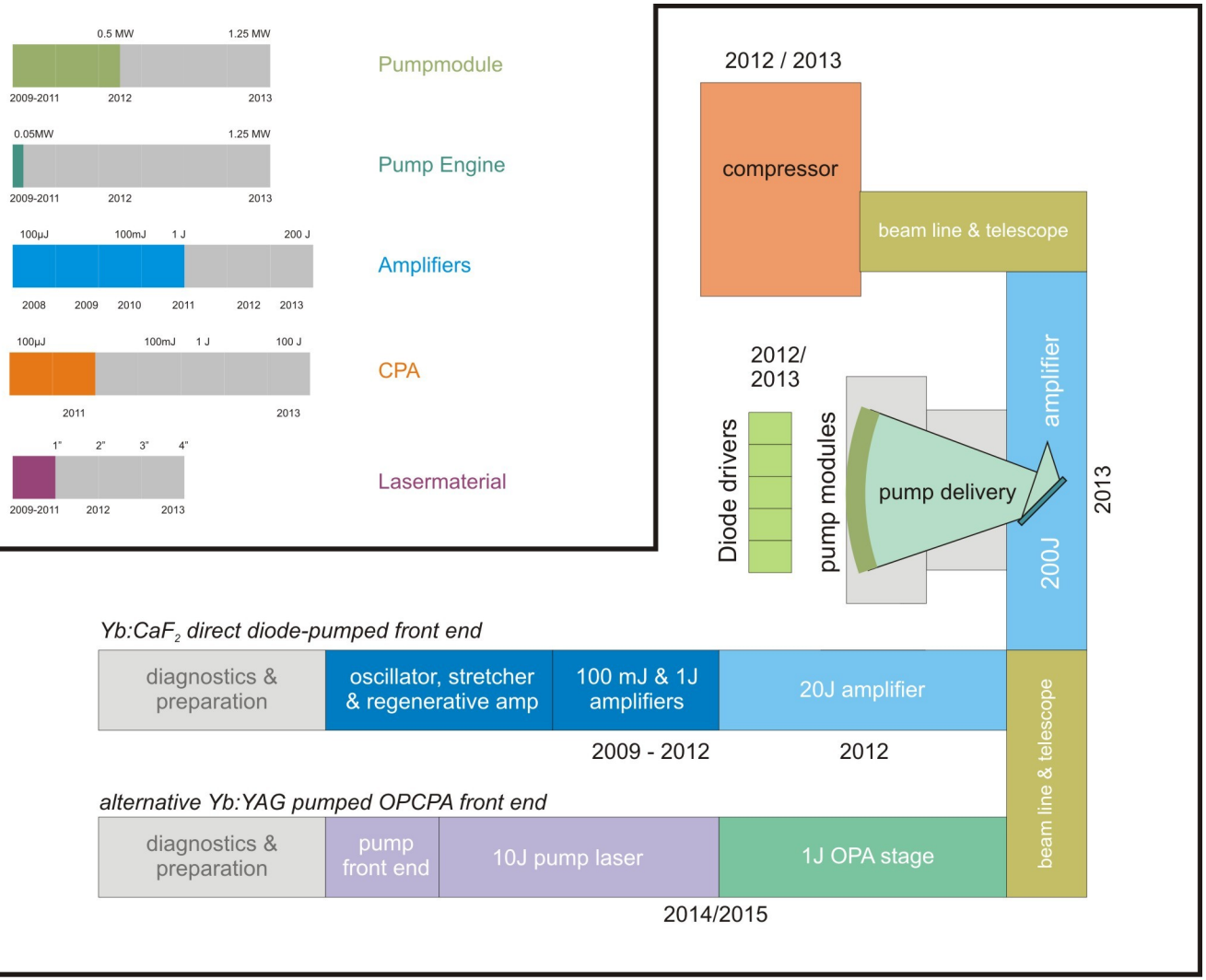


Laser-System



Gain medium: $Yb:CaF_2$

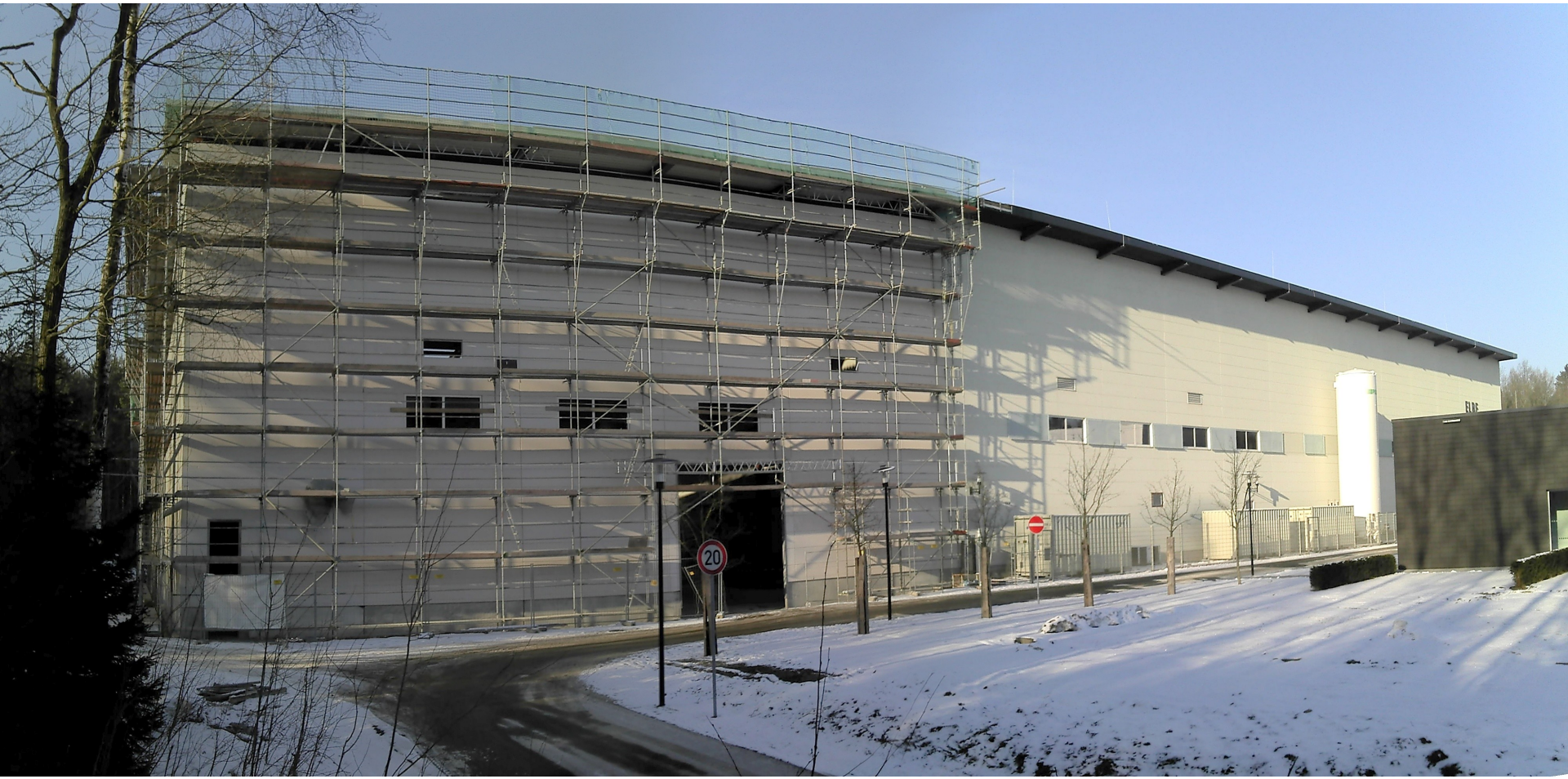
Lab infrastructure



Lab infrastructure

September 2010

Lab infrastructure



February 2011

Lab infrastructure

October 2011

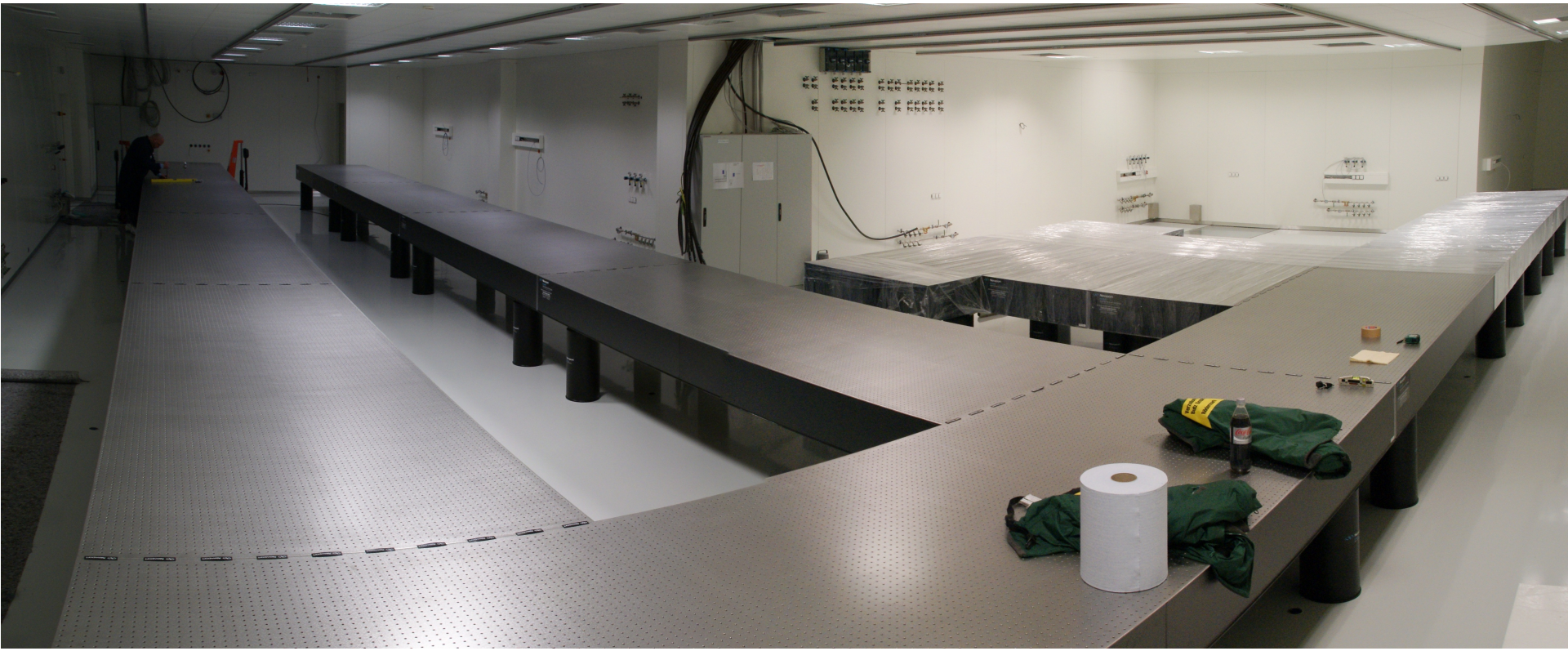
Lab infrastructure

November 2011

Lab infrastructure

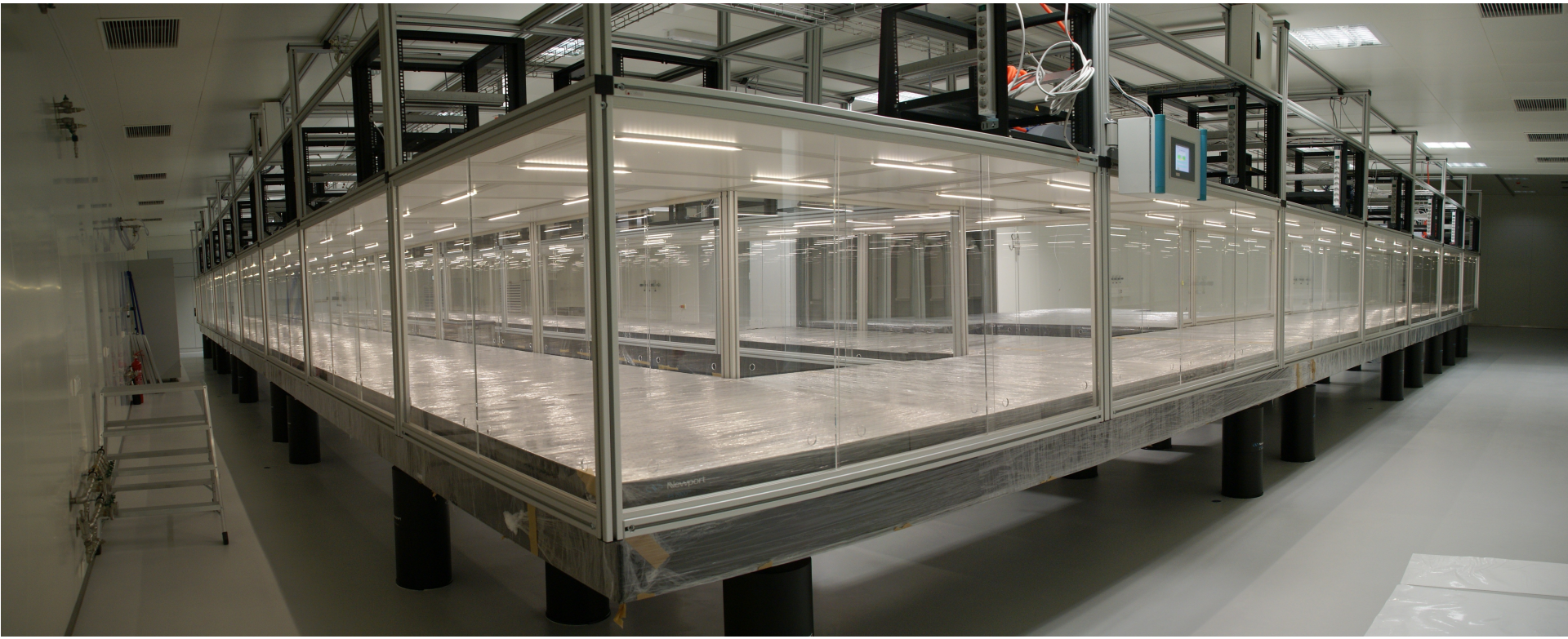
January 2012

Lab infrastructure



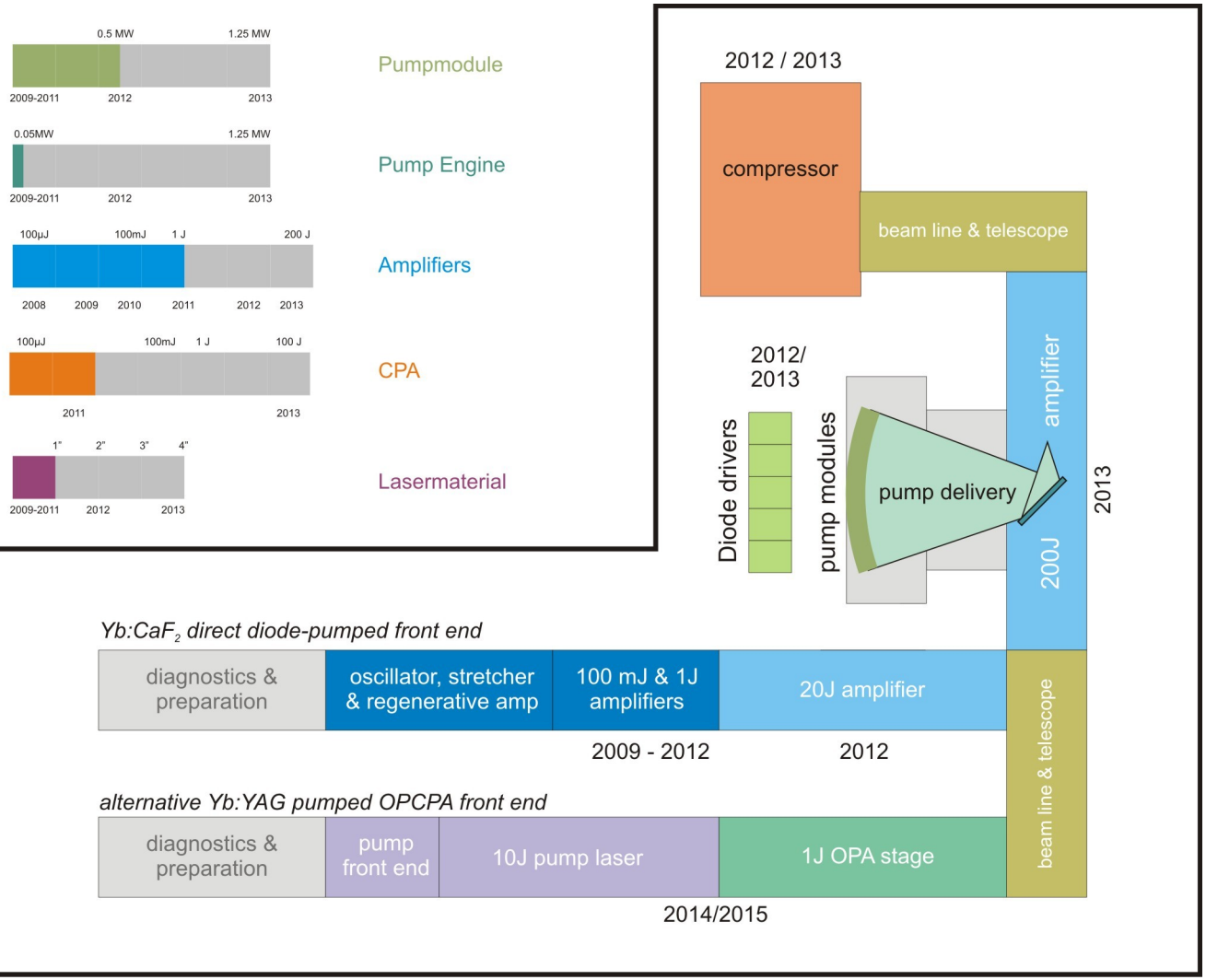
February 2012

Lab infrastructure

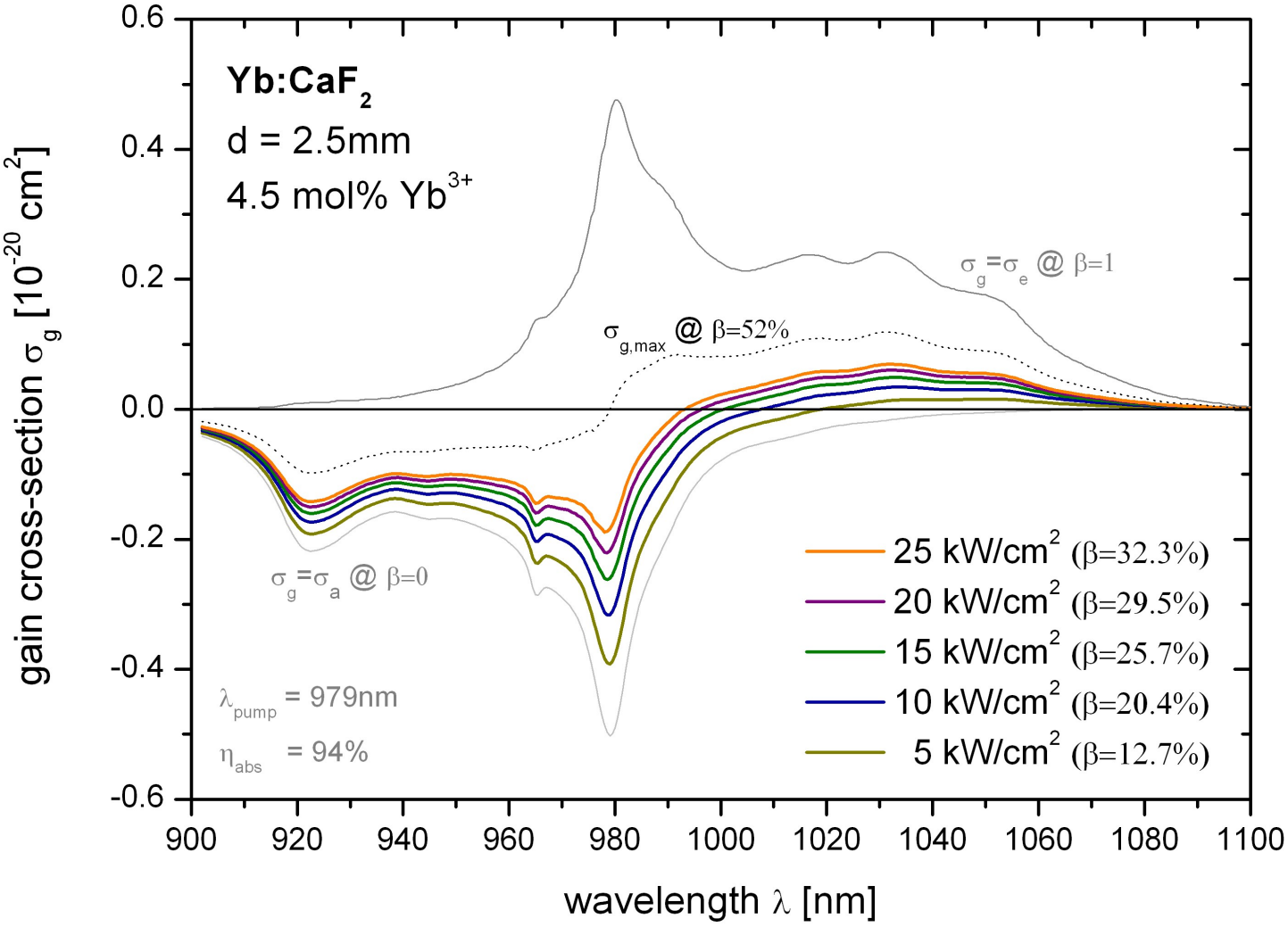


now.

Current status

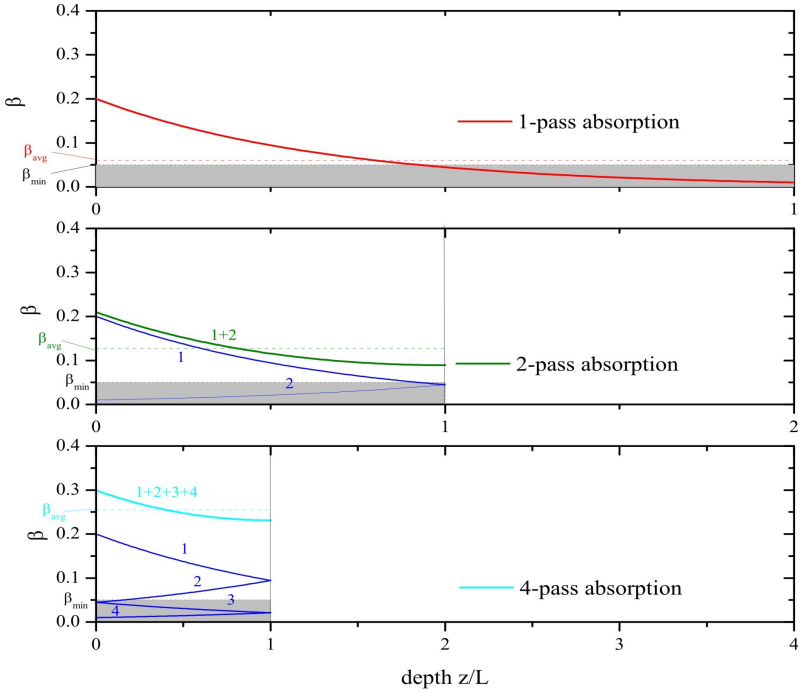


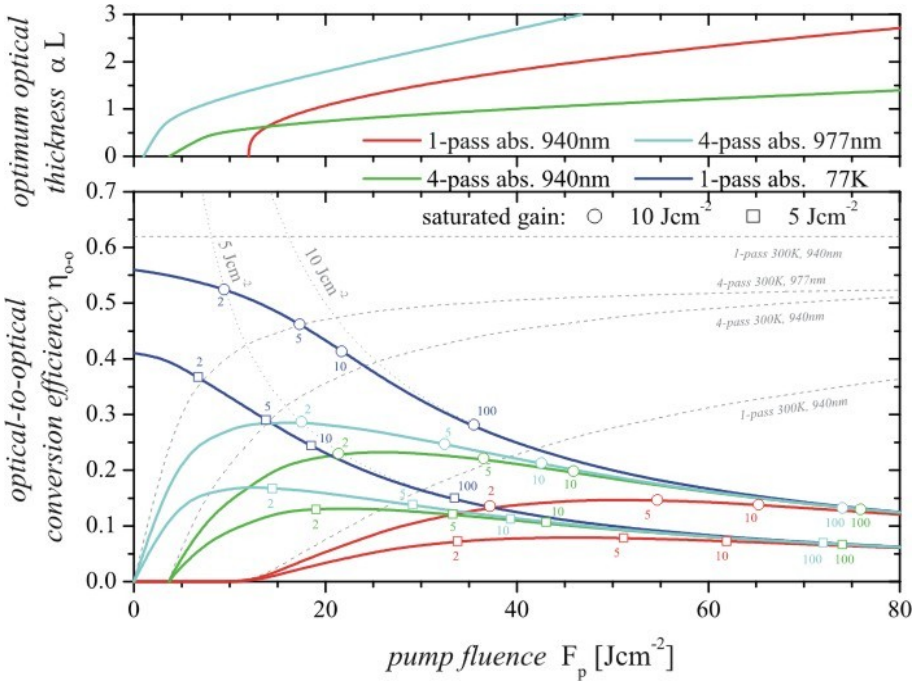
Penelope Amplifier - Design



Penelope Amplifier - Design

Multipass Pumping

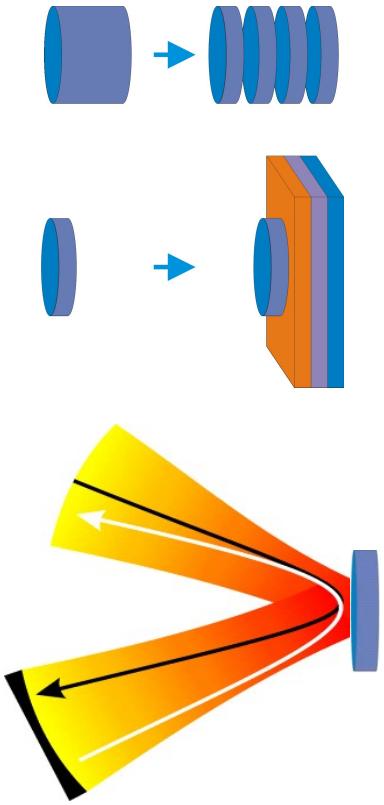




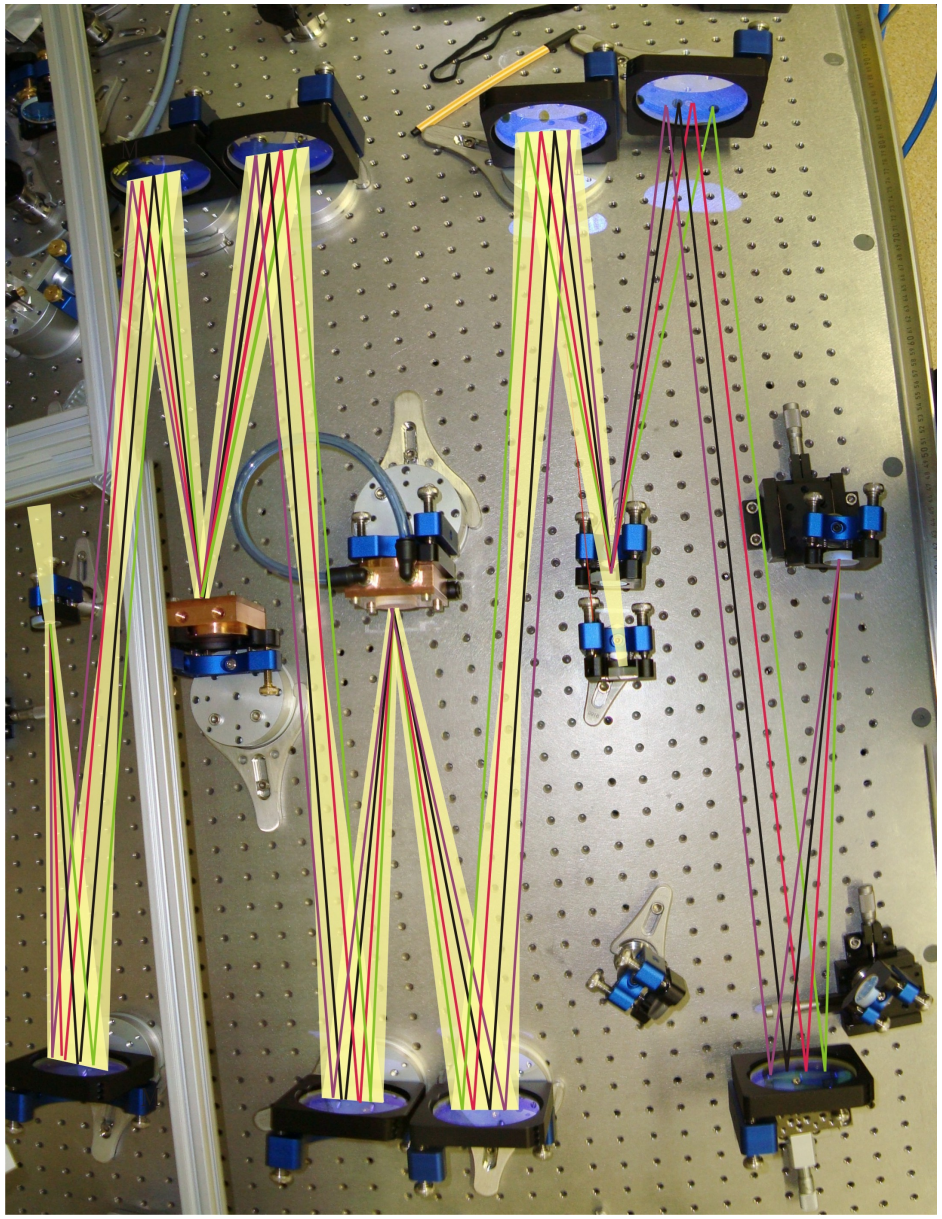
$$\beta_{min} = \sigma_a / (\sigma_a + \sigma_e)$$

$$\eta_{st} = \frac{h c N_{dop}}{\lambda_l I_p \tau_p} \int_0^L (\beta(z) - \beta_{min})\, dz$$

Penelope Amplifier - Design

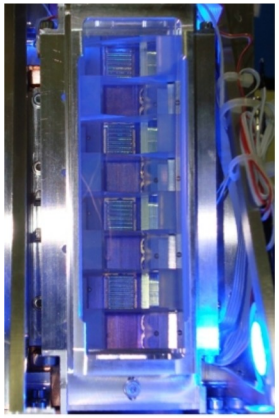


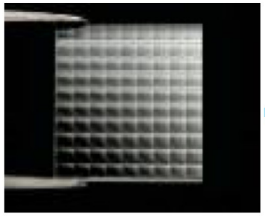
→ high brightness pumping
(i.e. 1MW / cm² / sr)

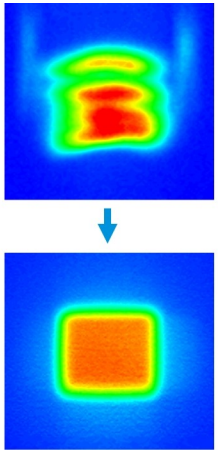


Pump modules

× 8







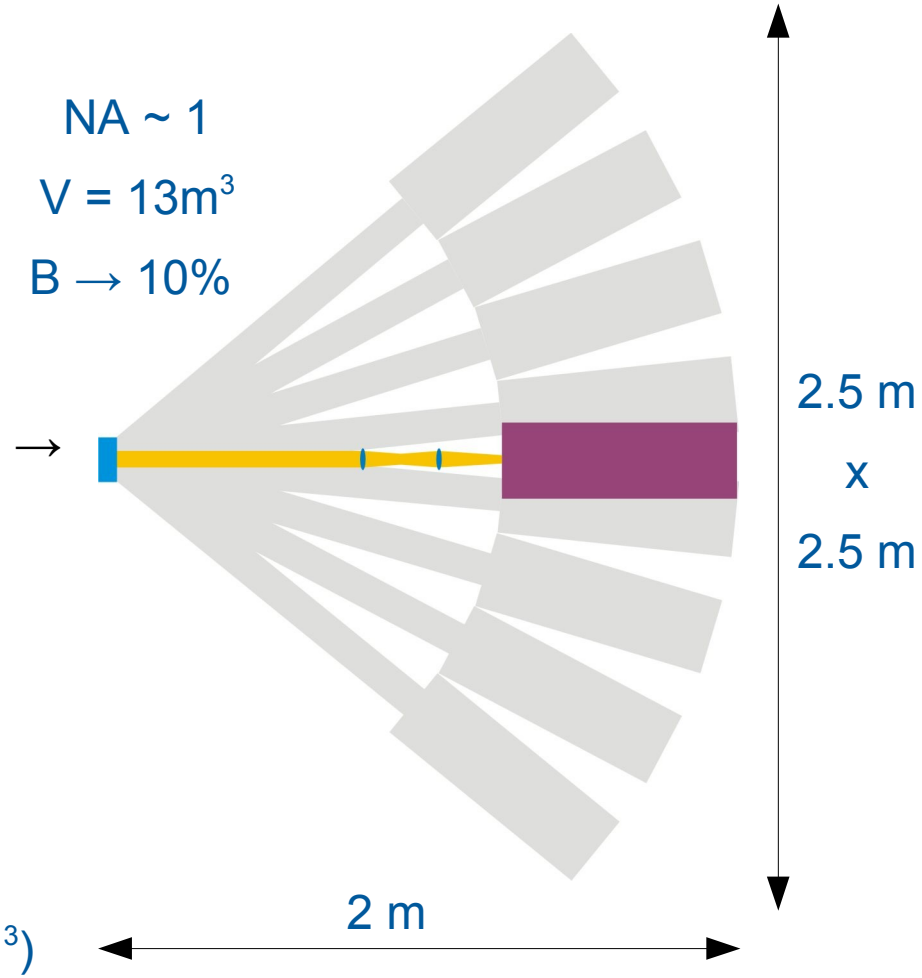
laser pump modules: ~20 kW

Pump modules

NA ~ 1

V = 13m^3

B → 10%

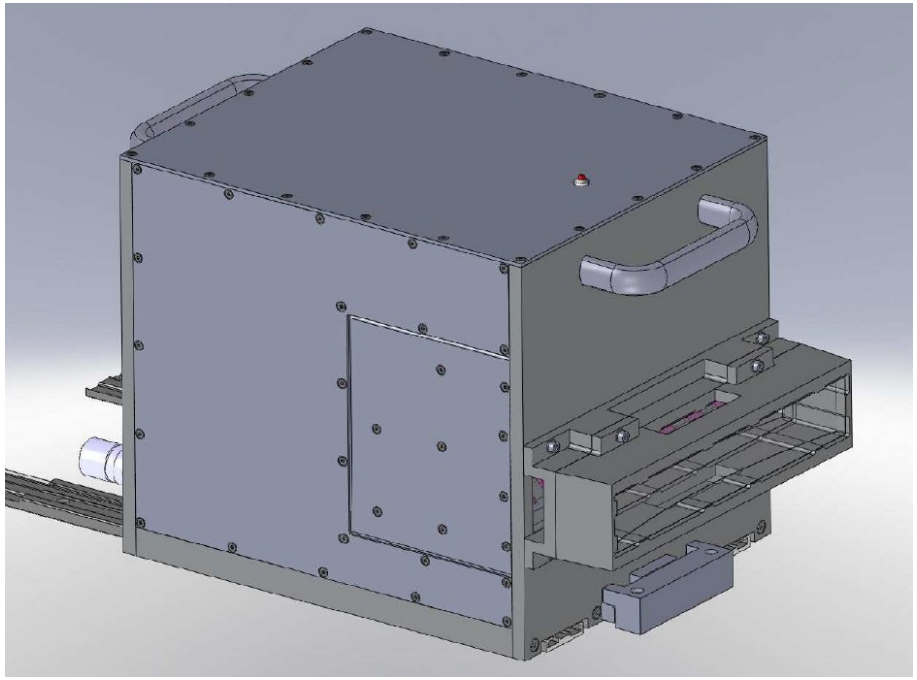


20kW / module : V = 21L

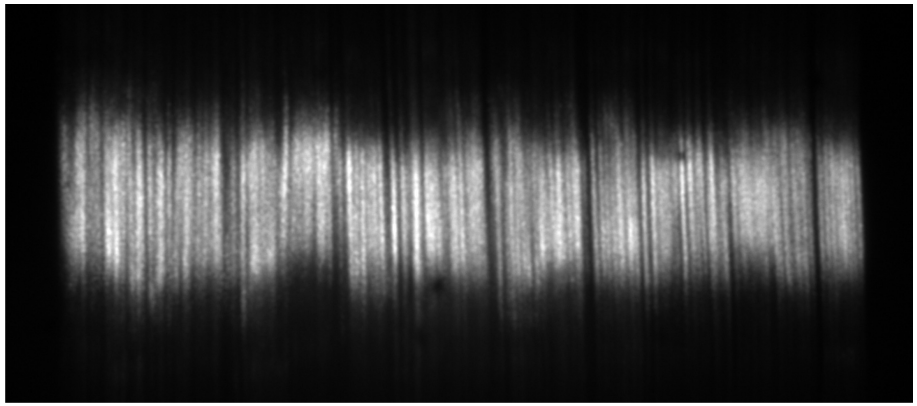
PEnELOPE : 1.3MW (1.3m^3)

Pump modules

PM80
- diode power: 76 kW
- output power: 70 kW @300A
- wavelength: 980 nm
- bandwidth: < 8nm

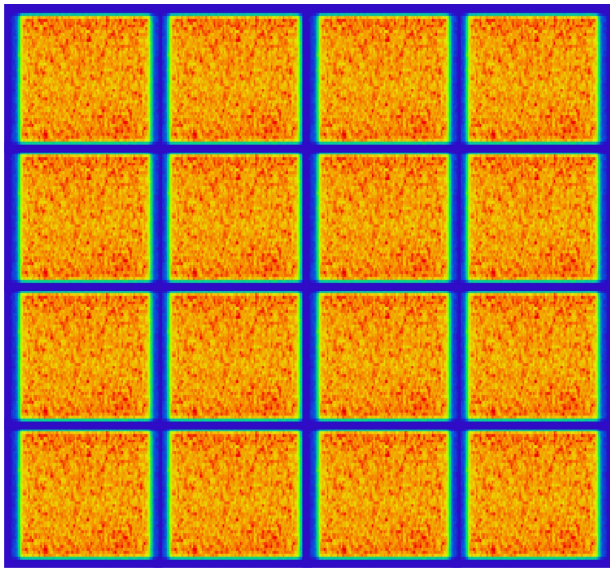


Near field pattern
Symmetric beam
Parameter product
of SA & FA:
200mrad × cm



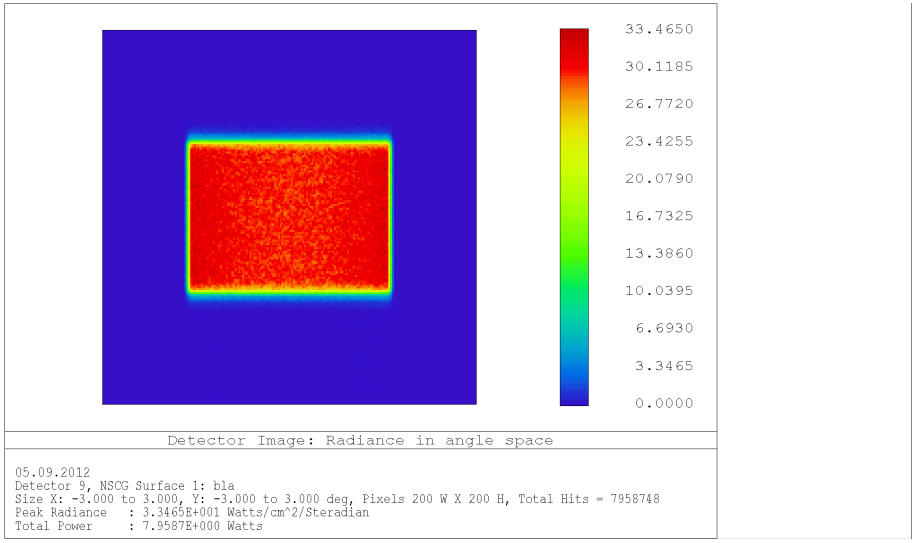
Pump modules

Near field stacking:
(simulation)
16 × 70 kW



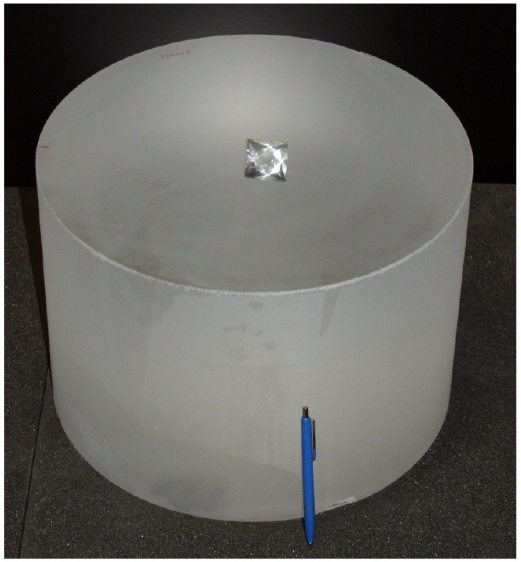
→ into hex / square lens homogenizer

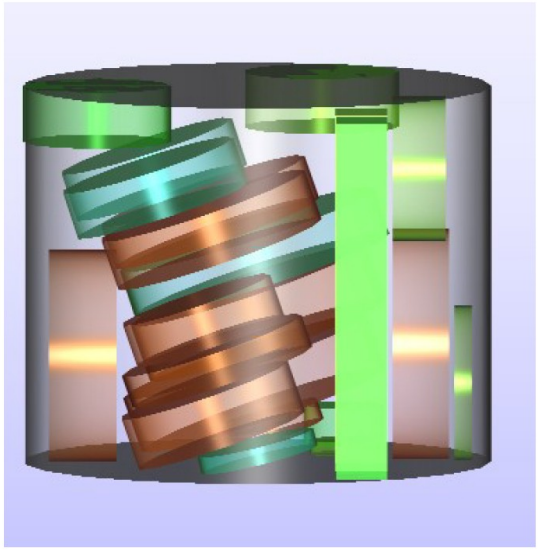
Far field:
(simulation)
16 × 70 kW



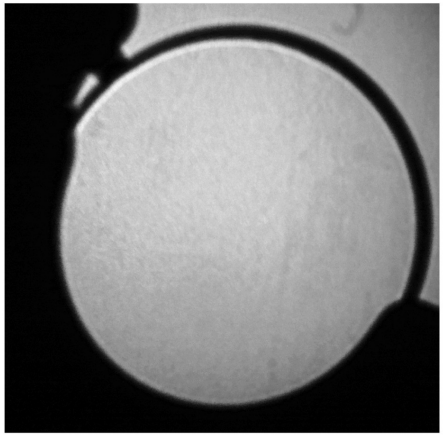
→ stacking in the image plane
(no angular multiplexing)

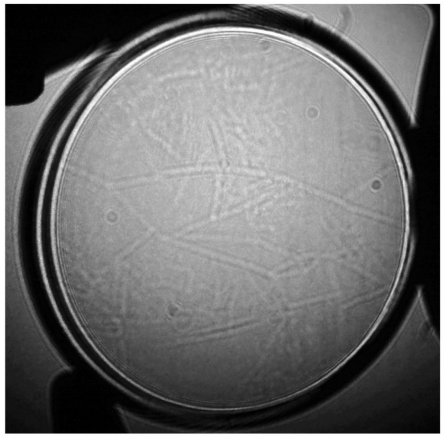
Laser Material





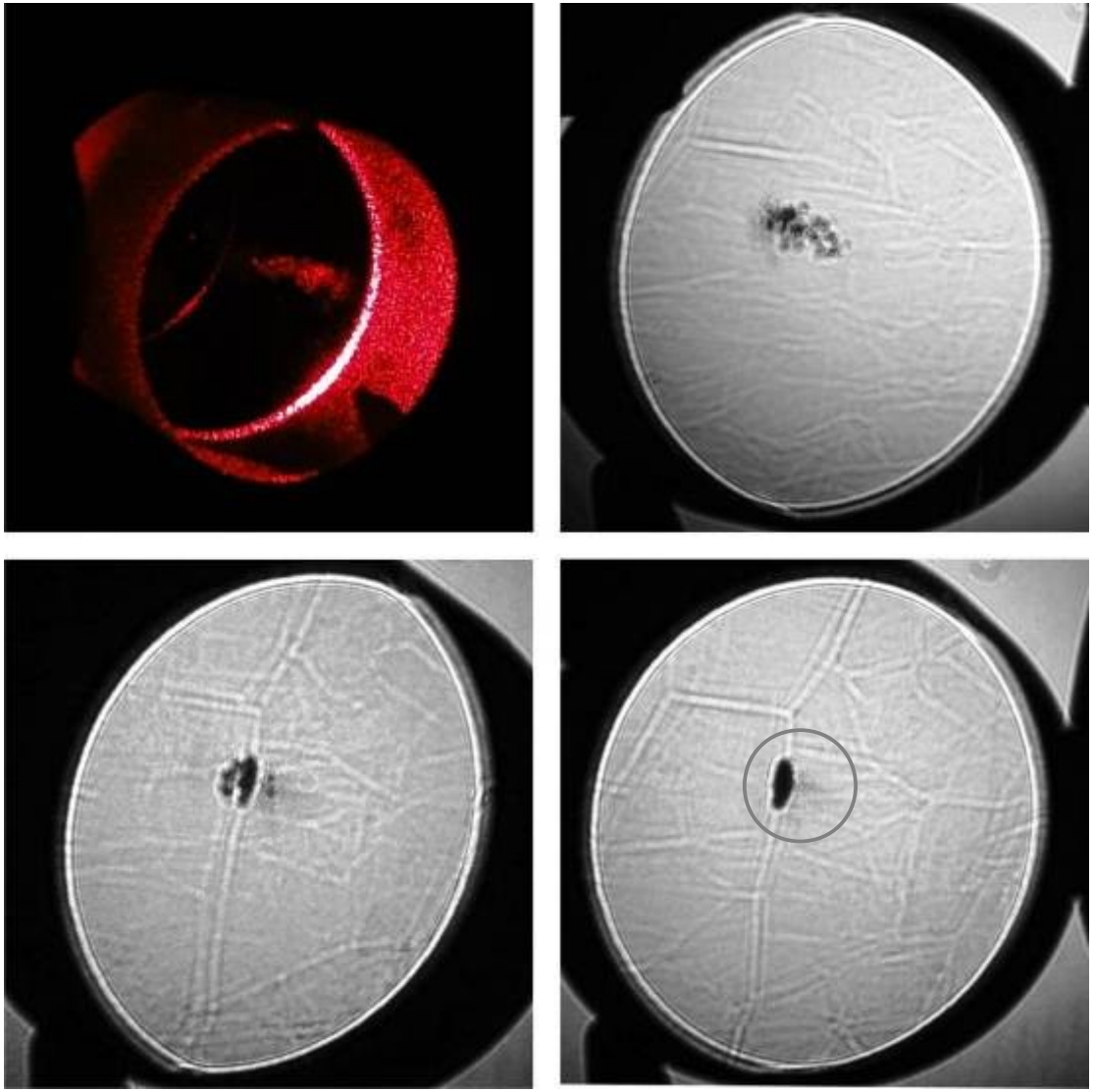
Hellma Materials
Yb:CaF_2
Ø = 38cm, d = 26cm,
M = 120kg





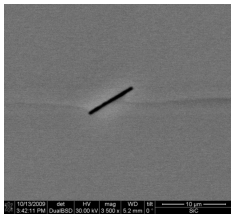
Kigre Yb:QX glass

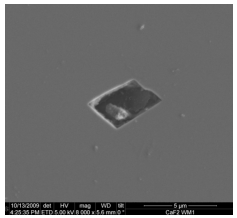
Laser Material

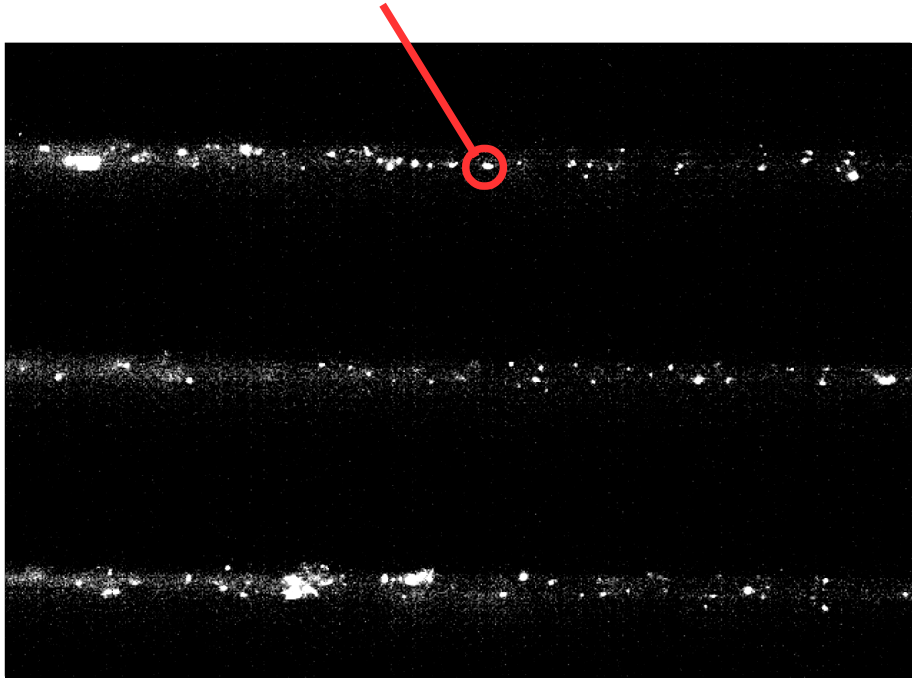


2mol% Yb, d=20mm, Ø=28mm

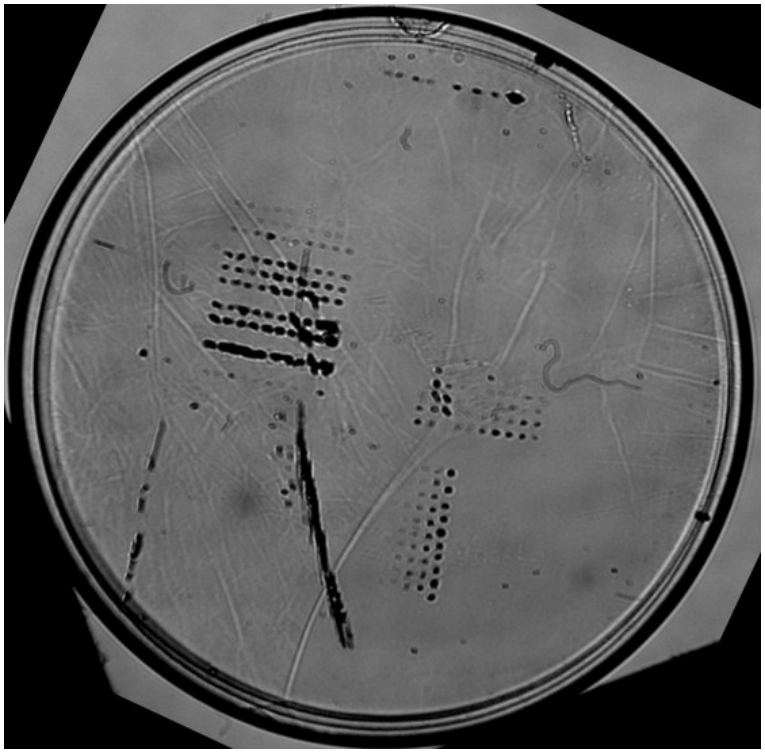
Laser Material





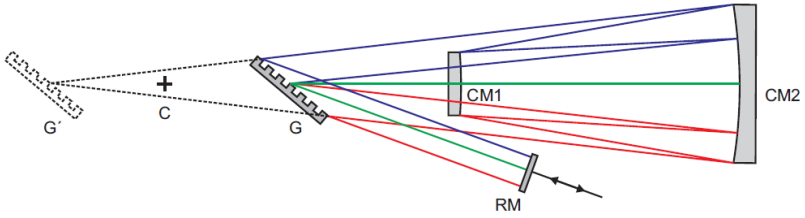


Damage inside matrix (multi-shot)
vs. damage on precipitates (single-shot)

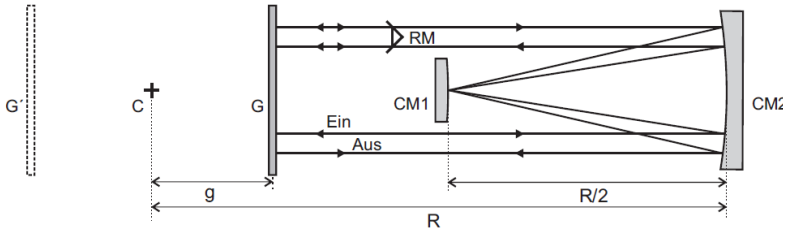


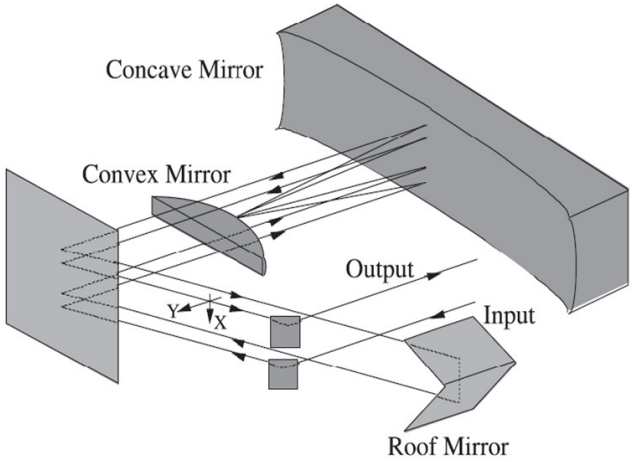
single shot: ~5Jcm^{-2}

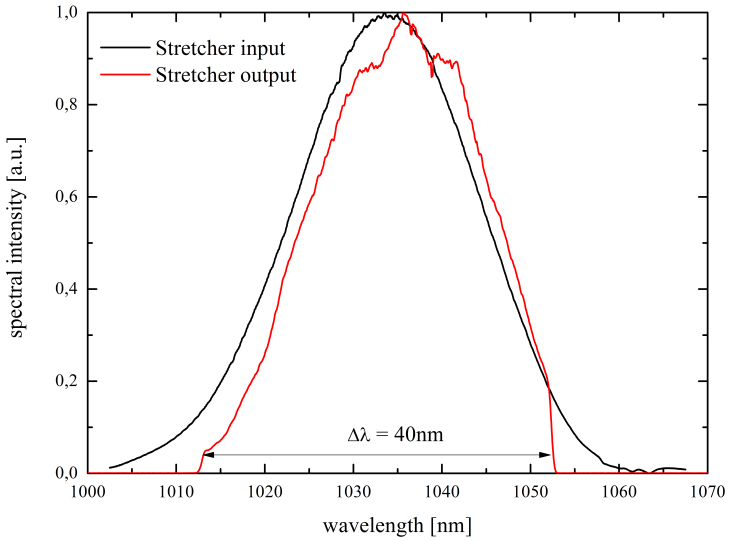
Stretcher – Compressor



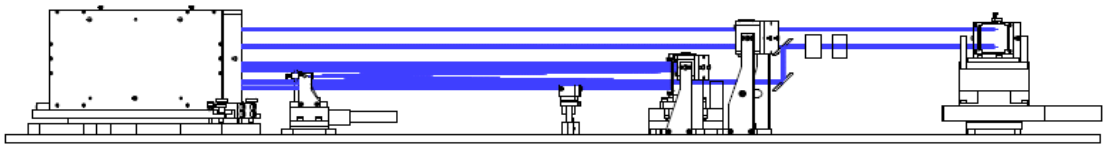
(a)

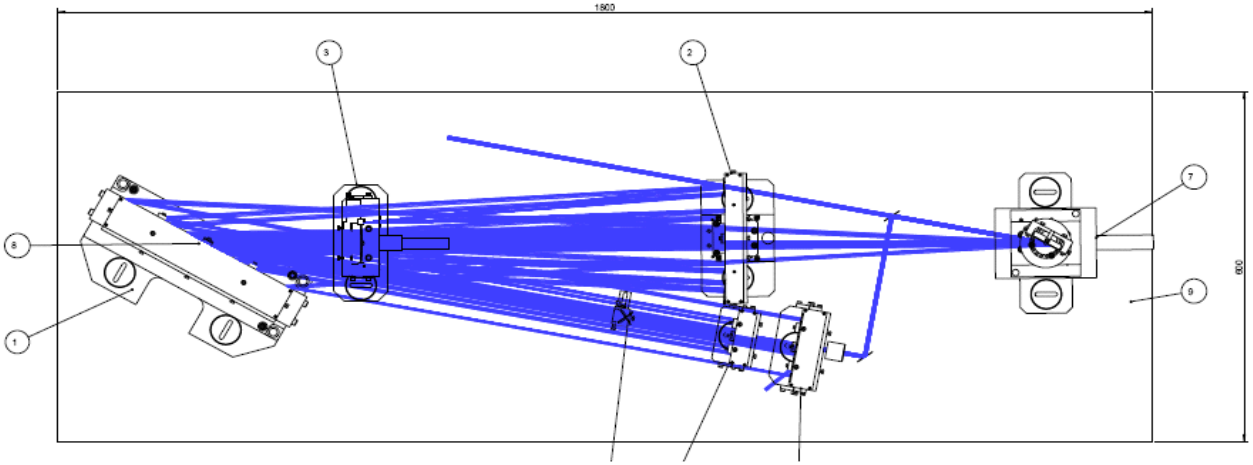






Stretcher – Compressor



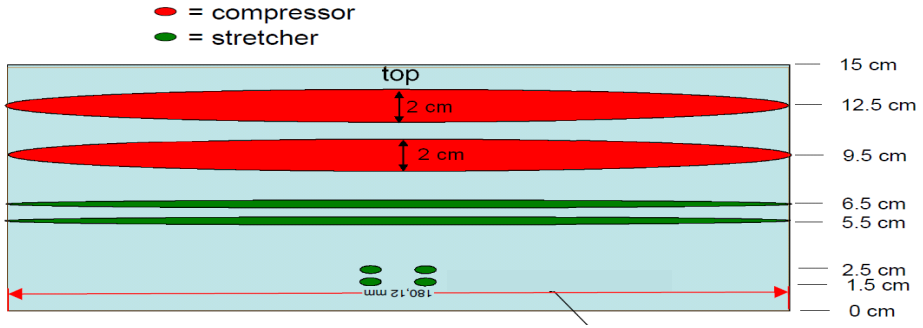


Small scale test setup

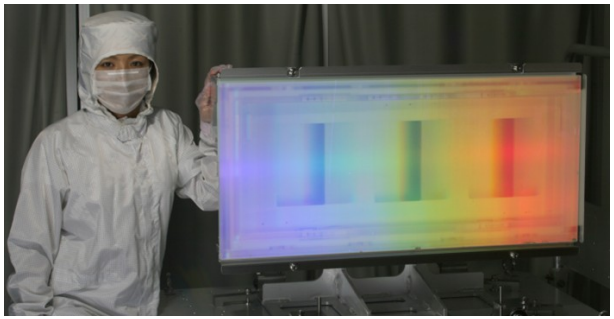
stretched pulse duration: ~2ns

hardcut bandwidth: 30nm

grating size: 35cm



Stretcher – Compressor

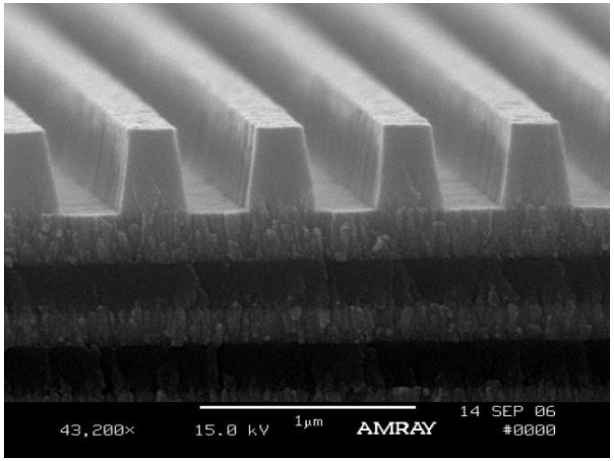


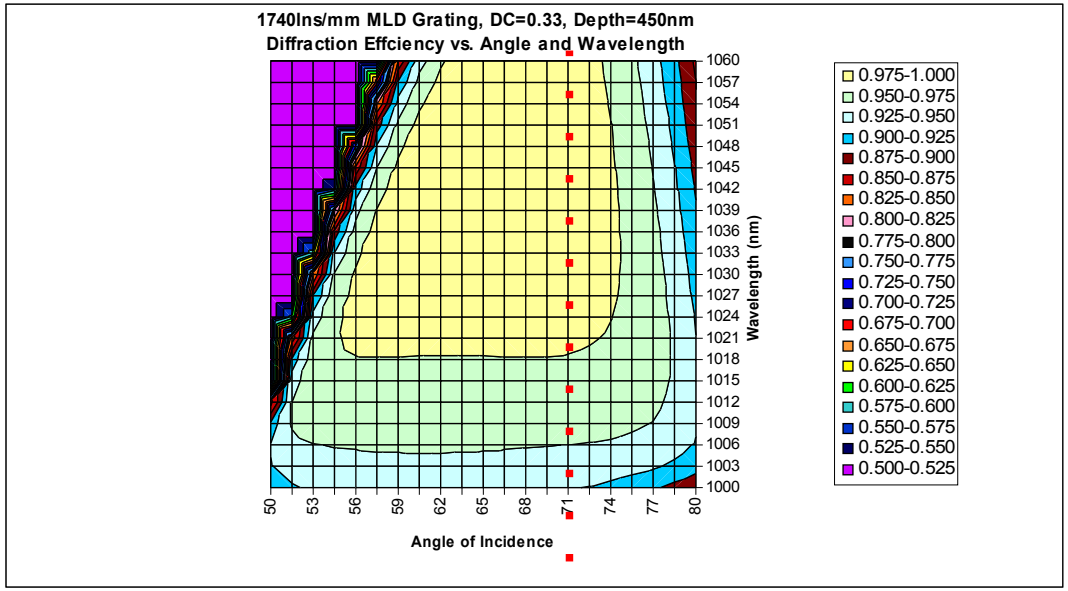
Plymouth dielectric grating

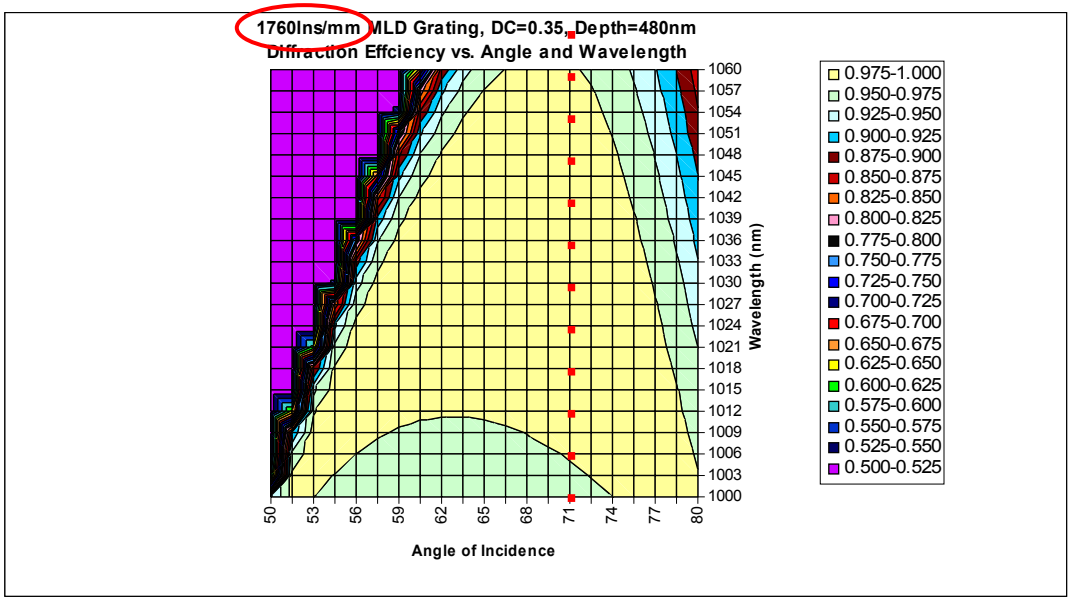
94 × 42 cm²

1760 lines/mm + 71°

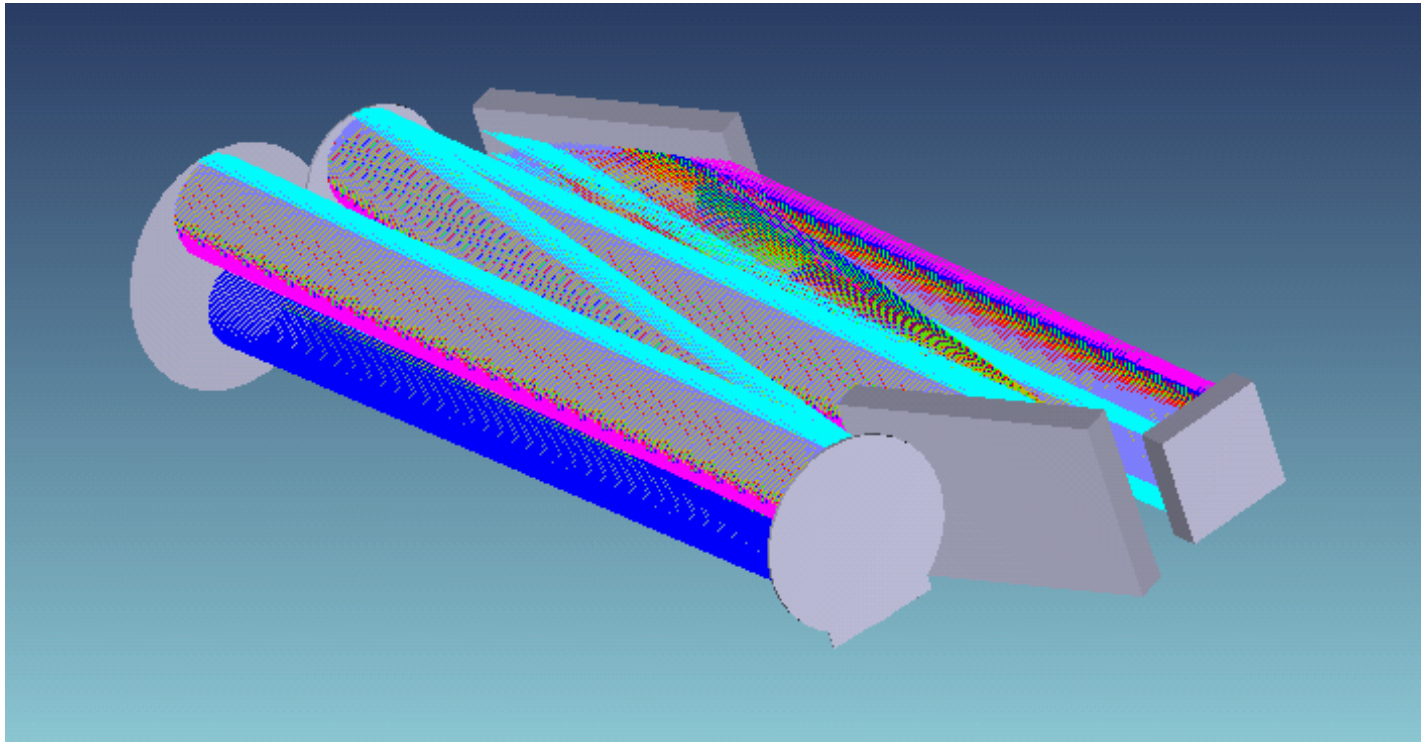
~0.5 J/cm²





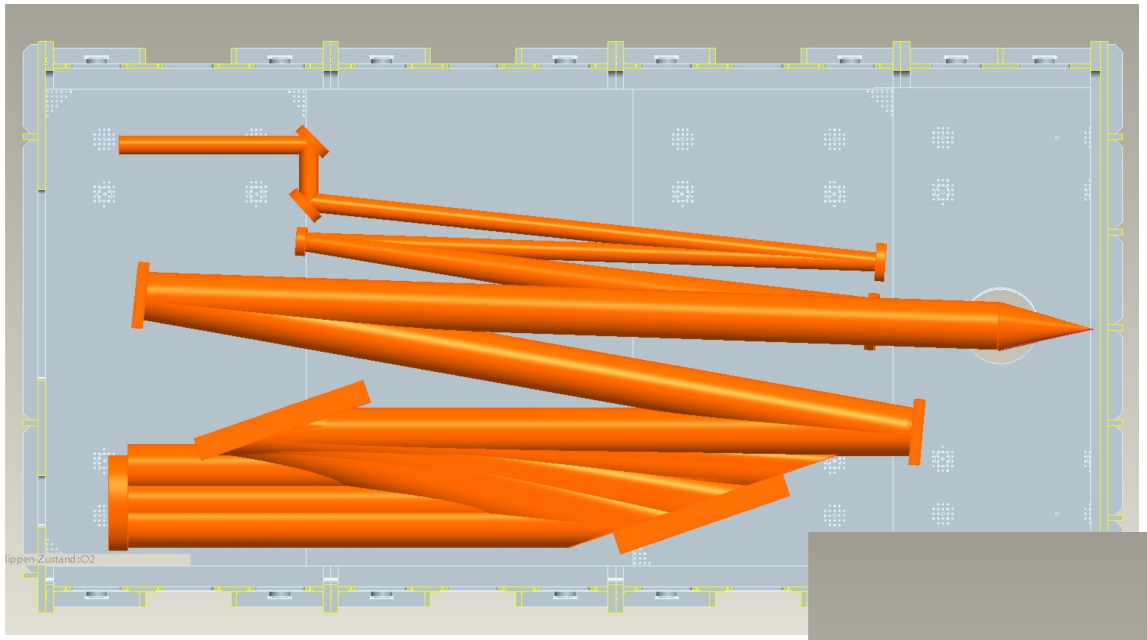


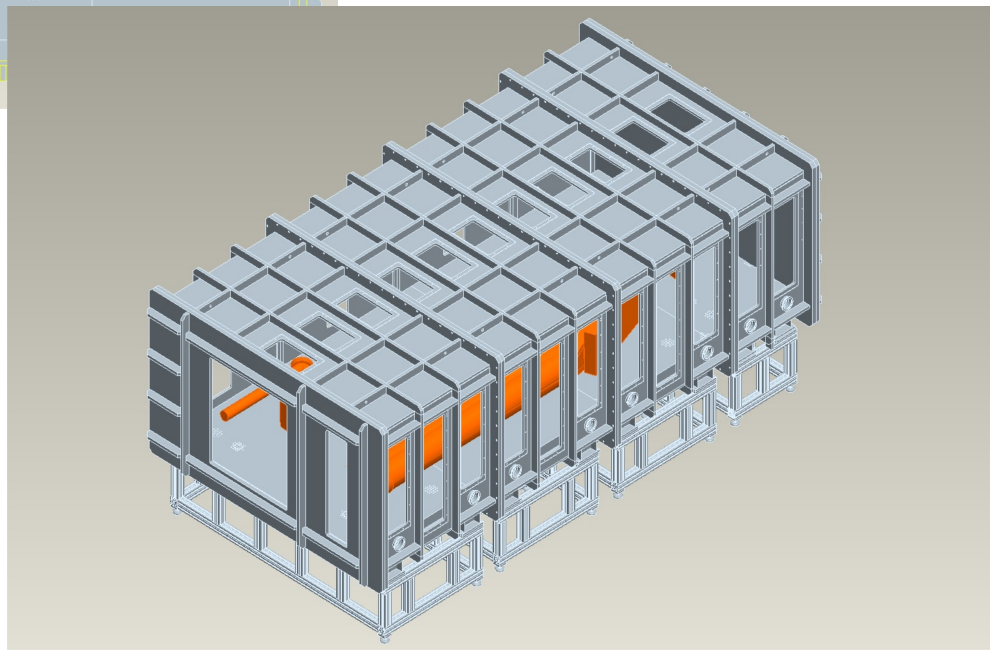
Stretcher – Compressor



Grating separation: 2.37m
Beam diameter: 30 cm

Stretcher – Compressor

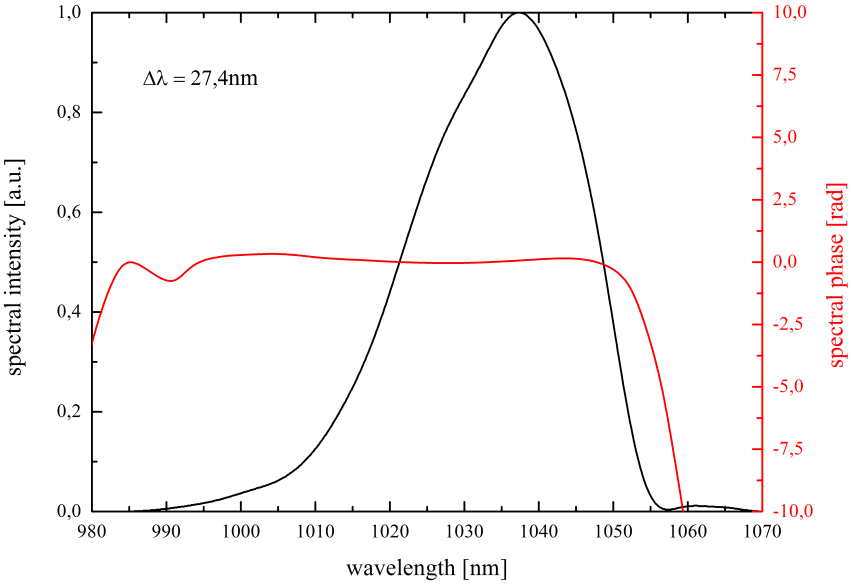


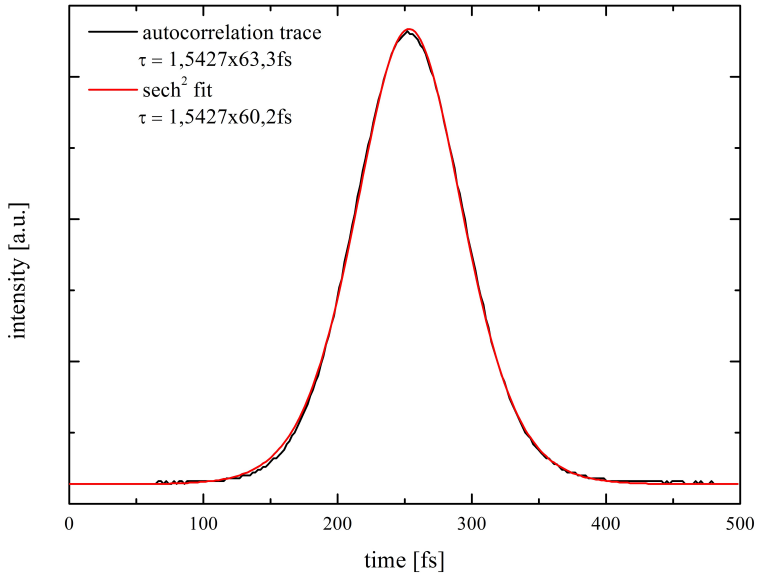


Dimensions: 6 × 3 × 1.5 m^3

Kerr lens mode-locked
Yb:KGW oscillator

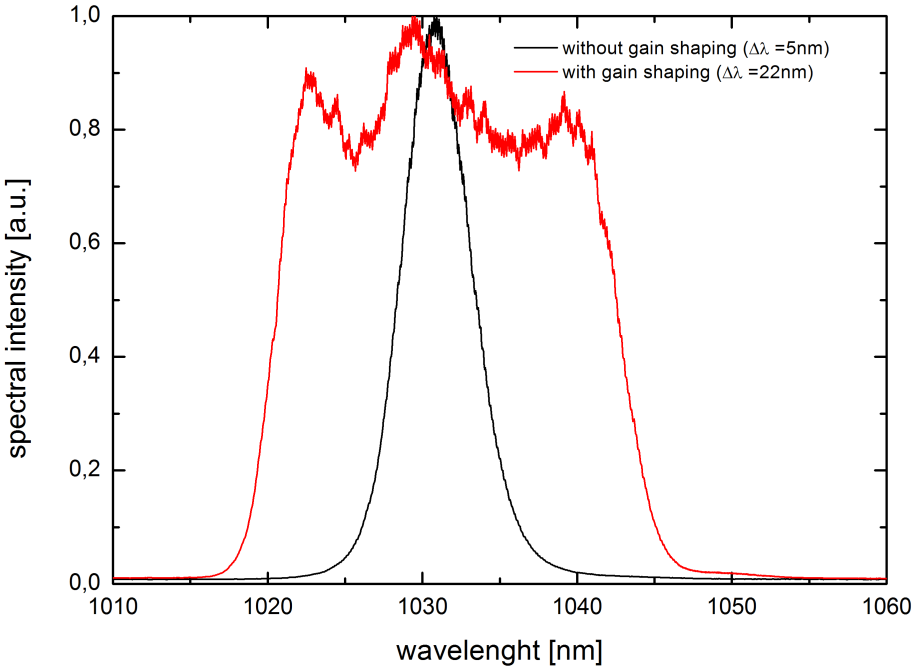
Repetition rate: 78 MHz
Output power: 1.5 W
Pulse duration: 64 fs

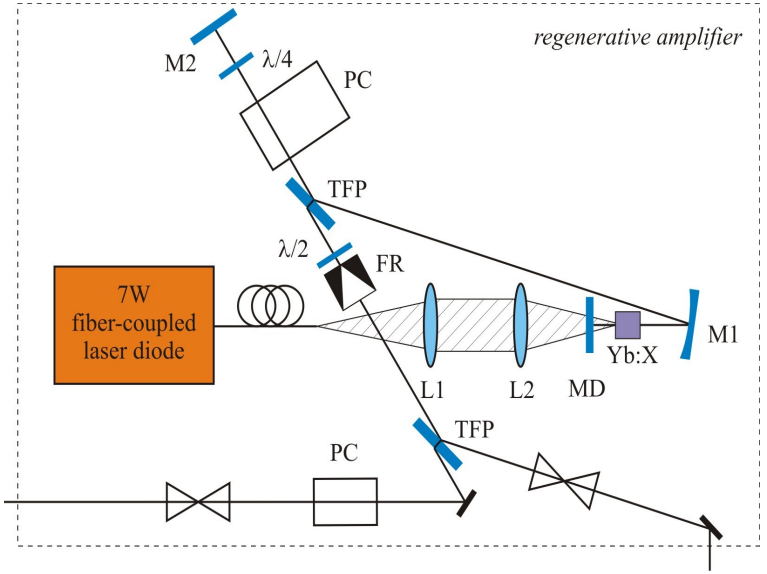




Regenerative amplifier

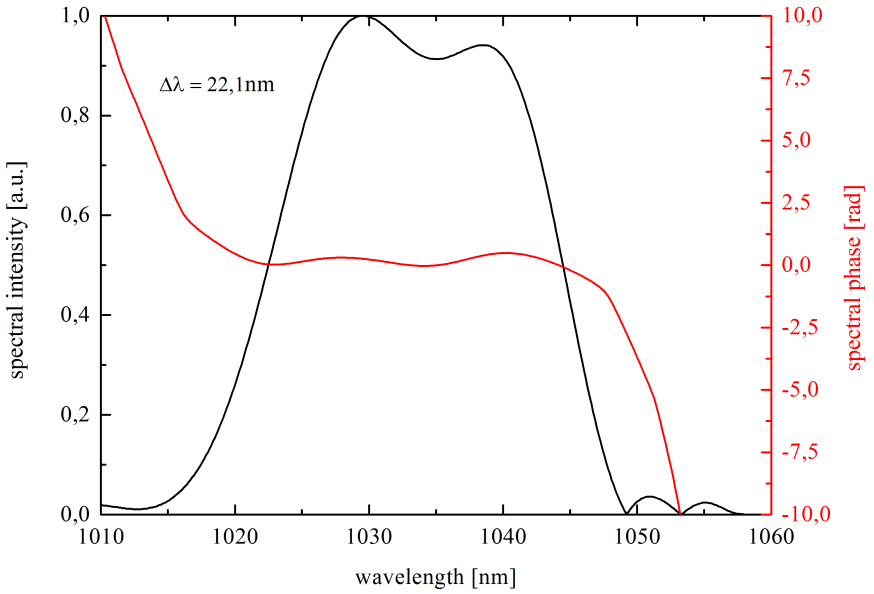
Bandwidth: 25 nm
Pulse energy: ~300µJ

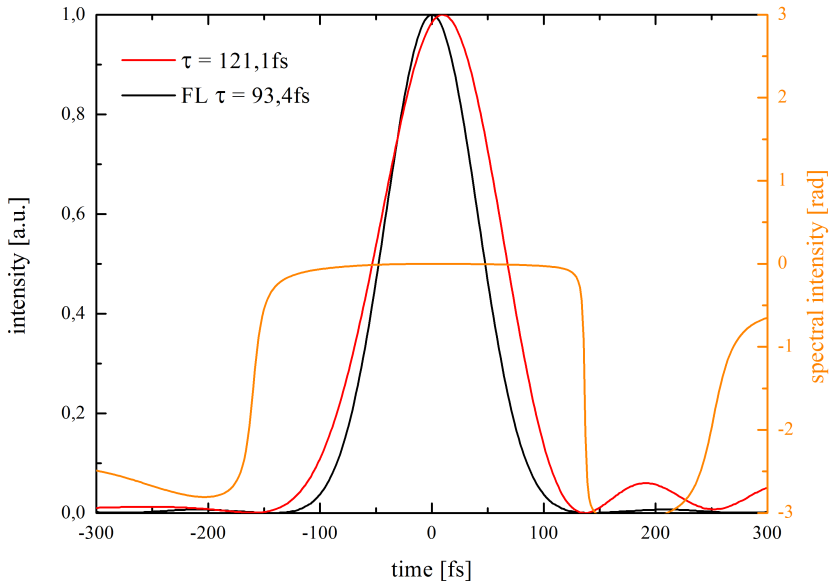




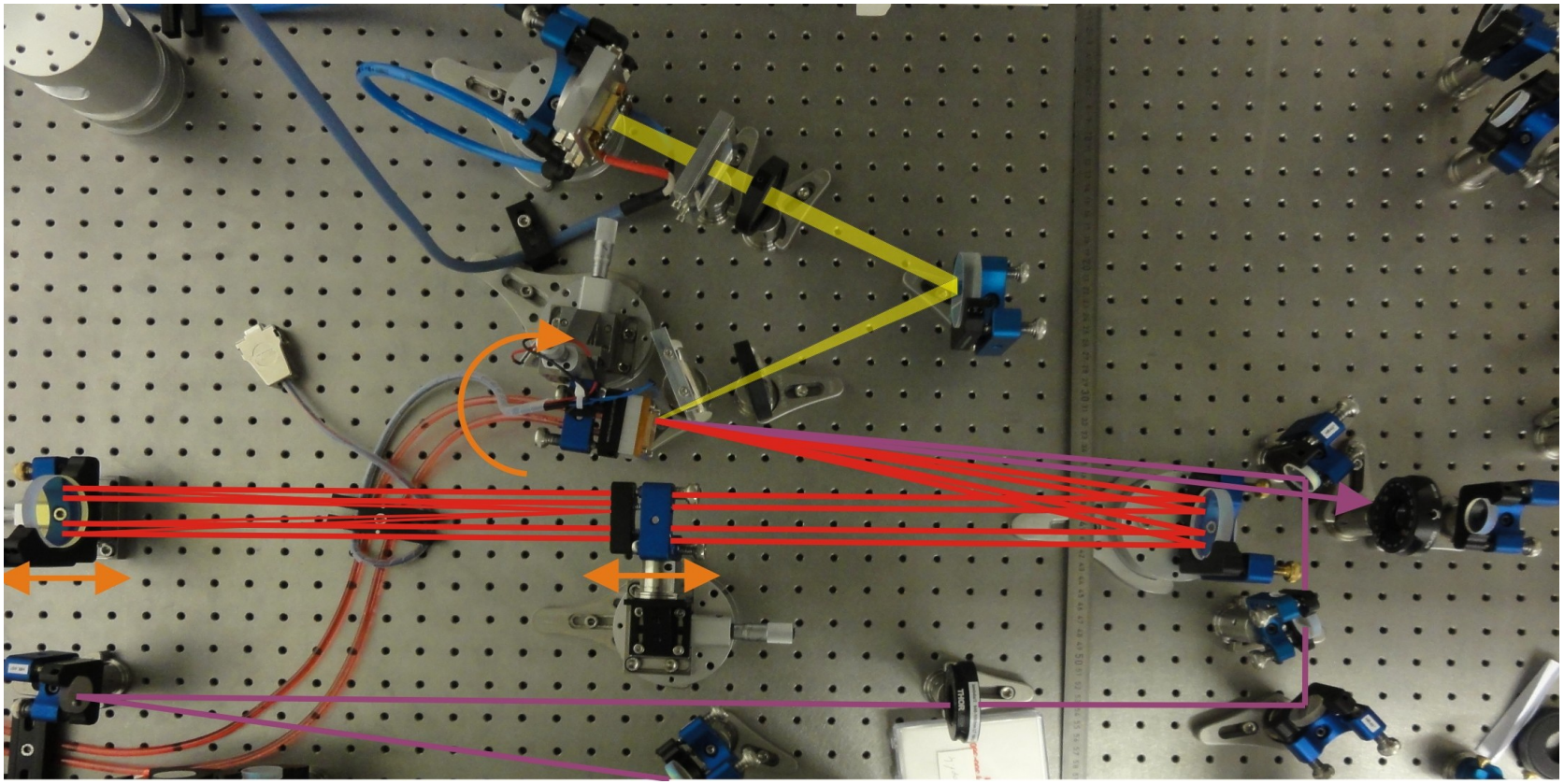
Regenerative amplifier

121 fs after compression



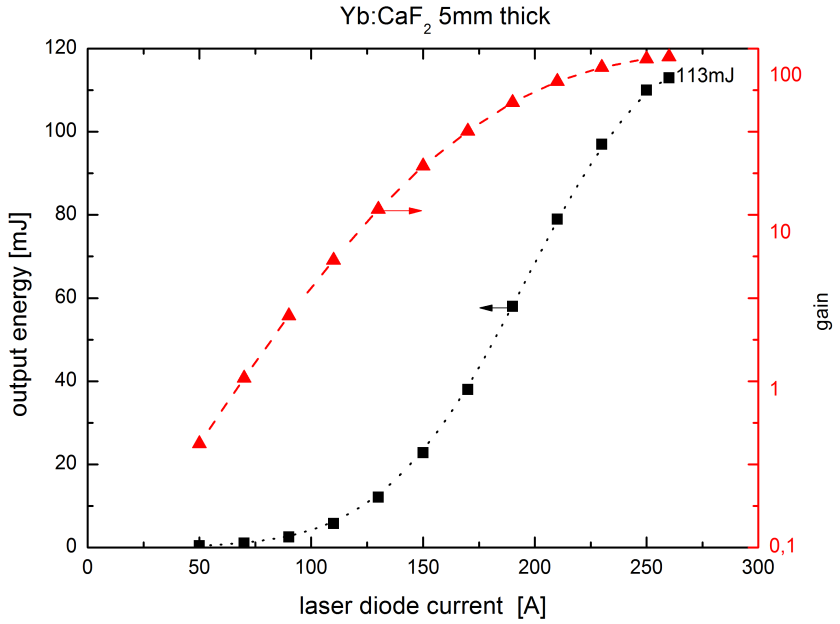


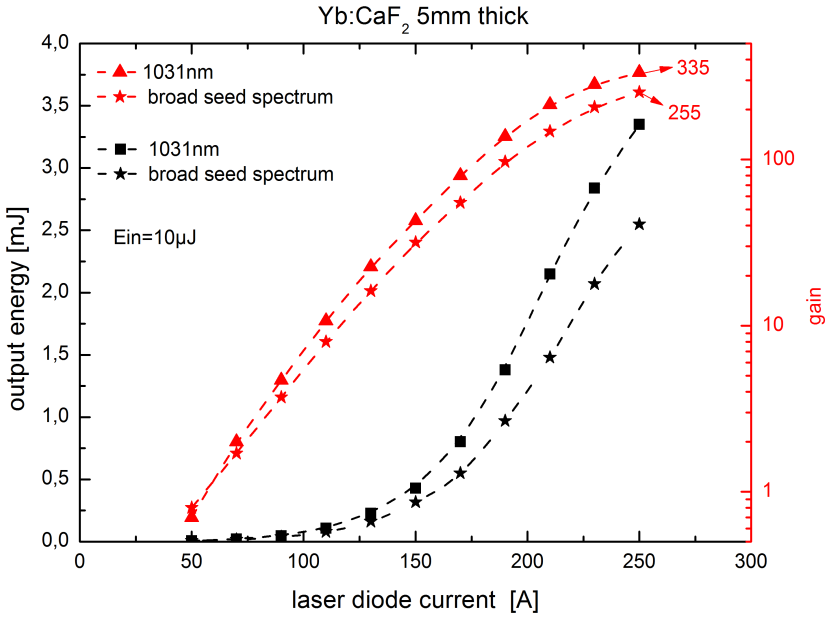
16-pass disk amplifier



16-pass disk amplifier

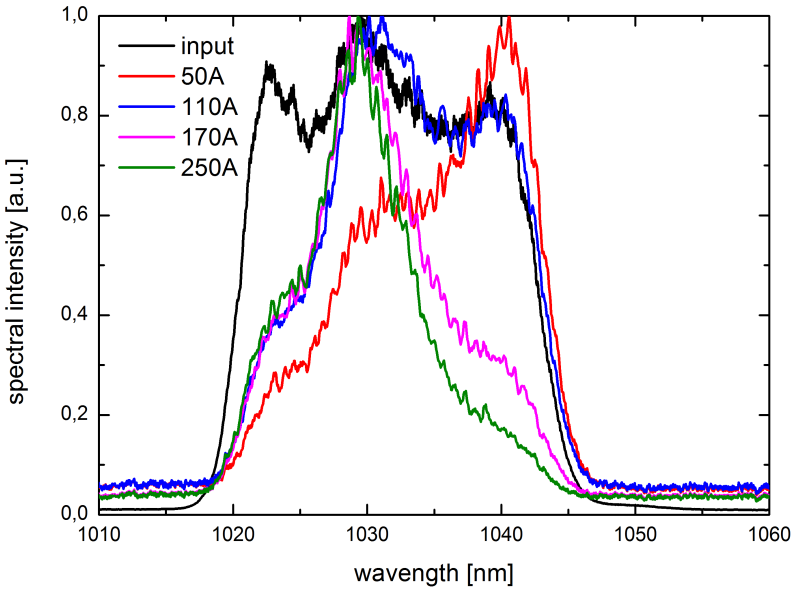
Pulse energy: 113mJ

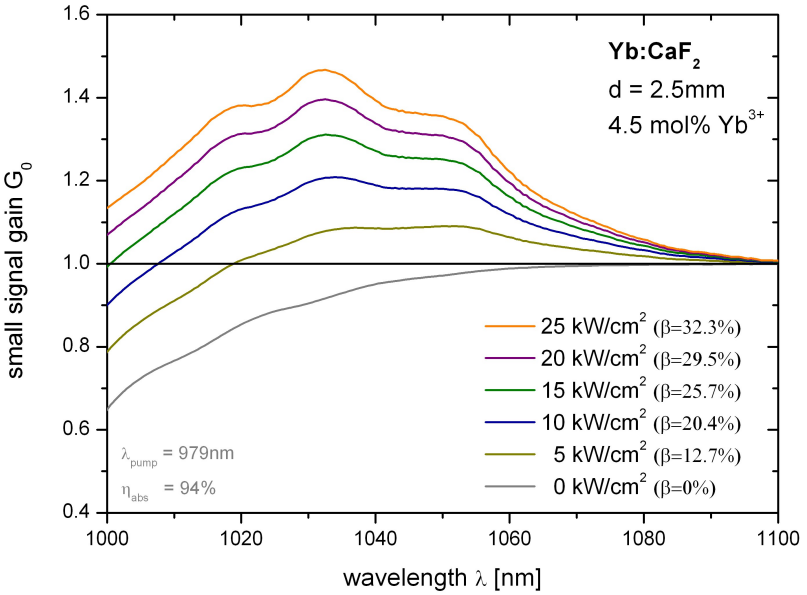




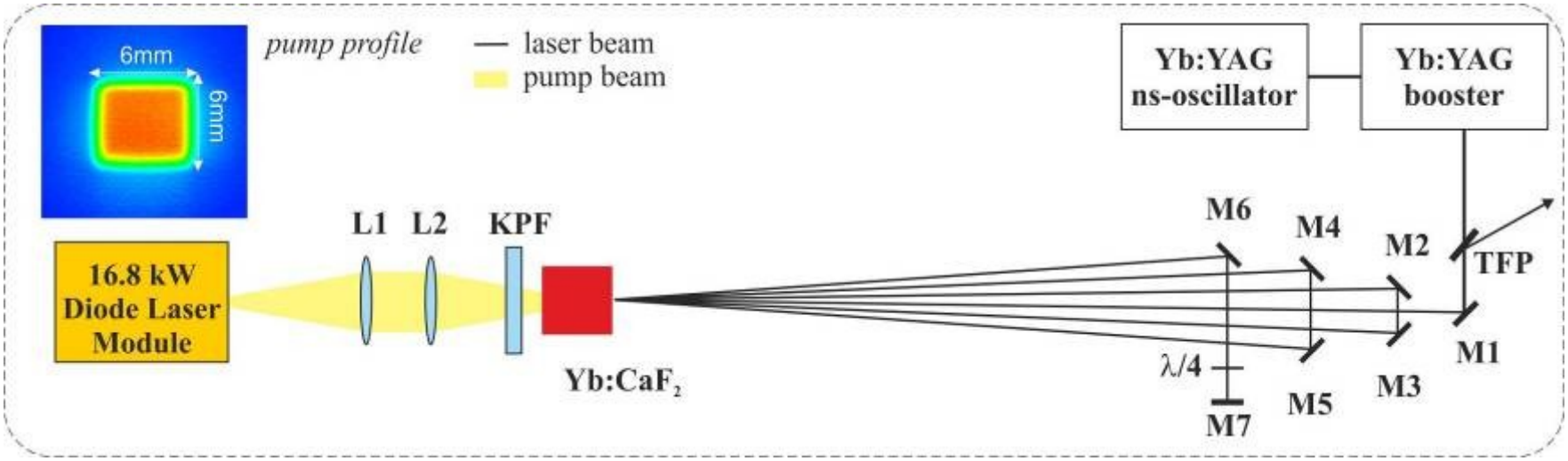
16-pass disk amplifier

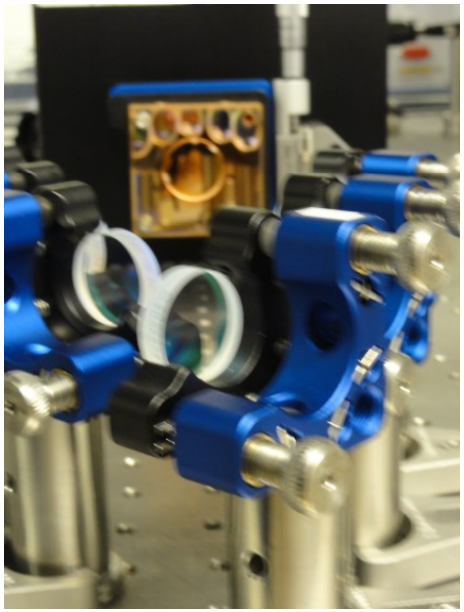
Gain narrowing

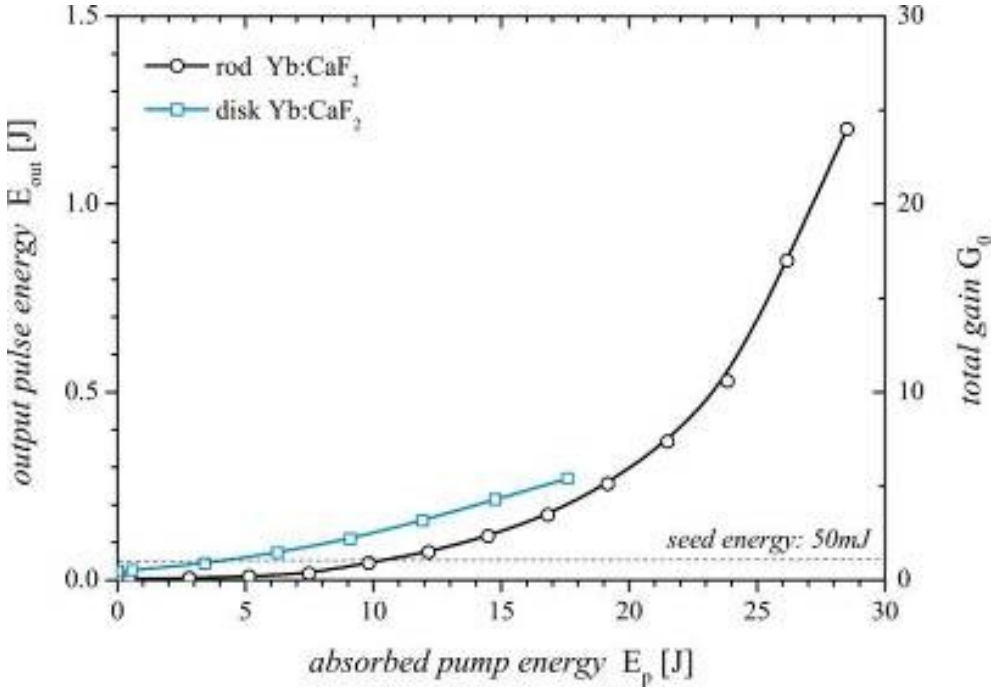




Lasers

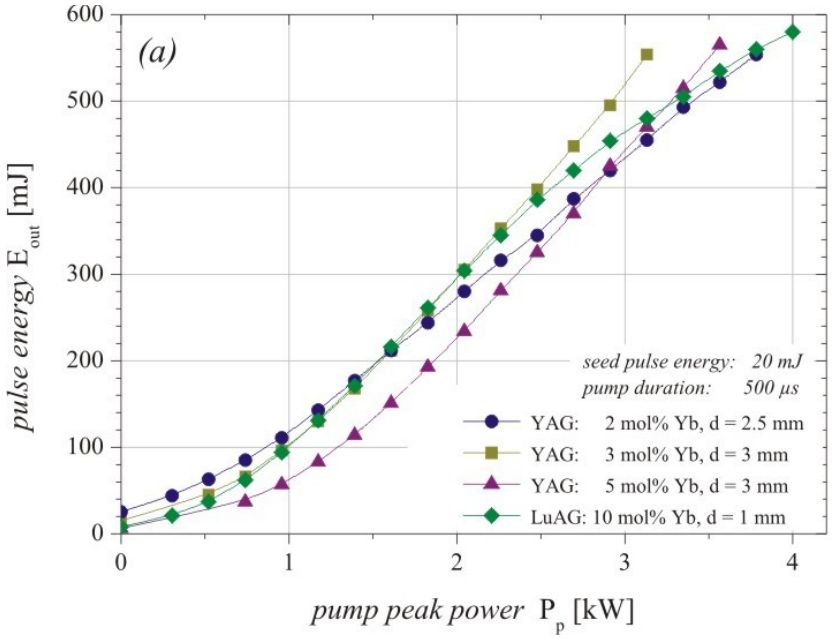

6mm
6mm
pump profile
laser beam
pump beam
Yb:YAG
ns-oscillator
Yb:YAG
booster
16.8 kW
Diode Laser
Module
L1
L2
KPF
Yb:CaF2
M6
M4
M2
TFP
M1
M3
M5
M7
λ/4

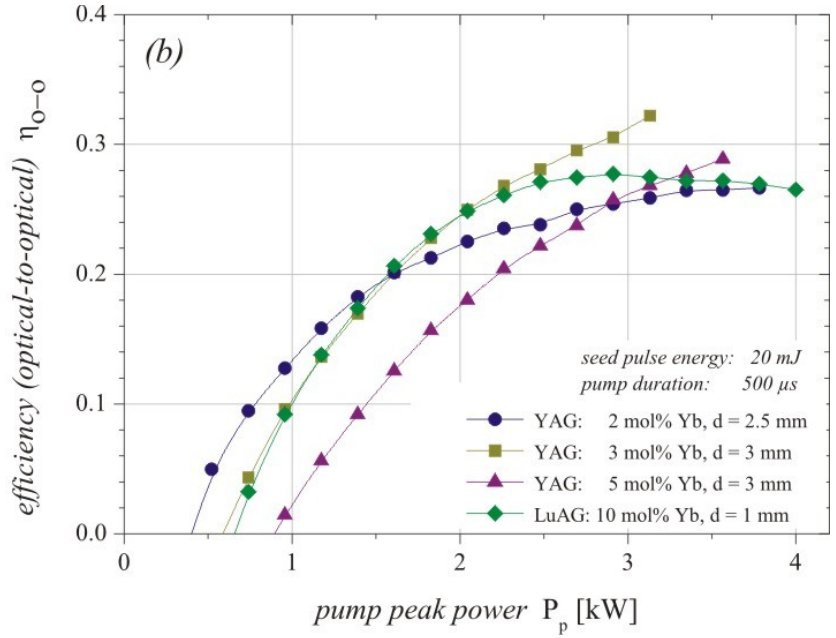



rod Yb:CaF2
disk Yb:CaF2
seed energy: 50mJ
output pulse energy Eout [J]
total gain G0
absorbed pump energy Ep [J]
0.0
0.5
1.0
1.5
0
5
10
15
20
25
30

Yb:YAG & Yb:LuAG amplifiers

(see Markus Loeser talk)





Thank you.