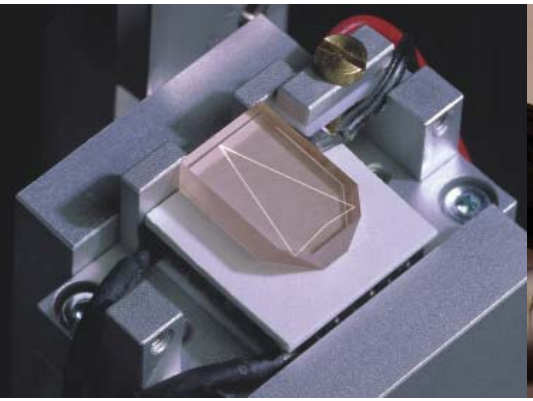
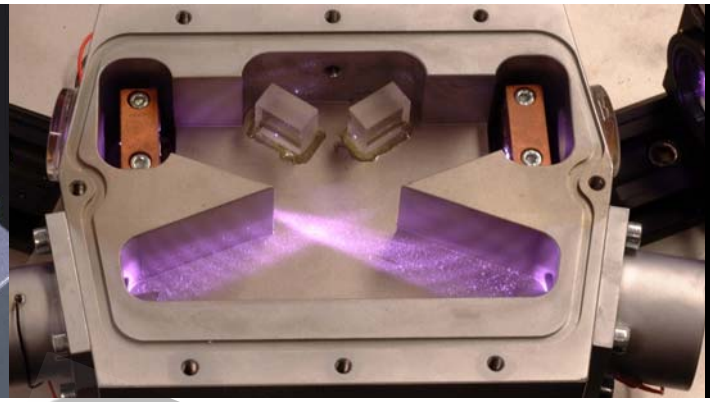
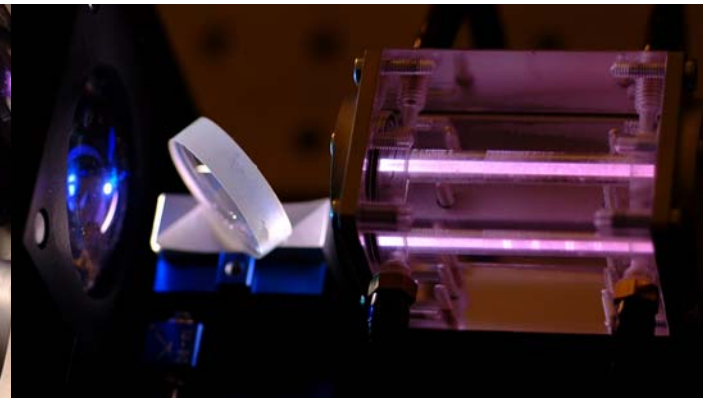




High Power Lasers for Future GW Detectors

Maik Frede

Laser Zentrum Hannover

GWADW
Elba 06

Lasers for GW Detectors

Single frequency operation

(kHz line width)

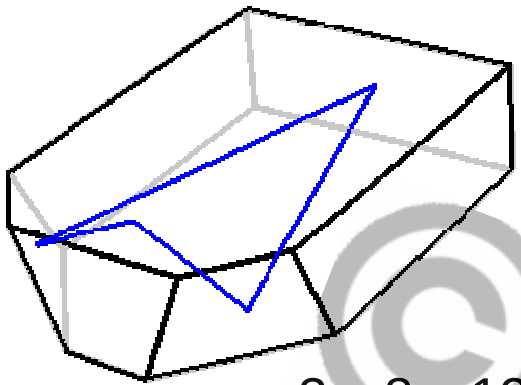
$TEM_{0,0}$ fundamental mode operation

Linearly polarized light

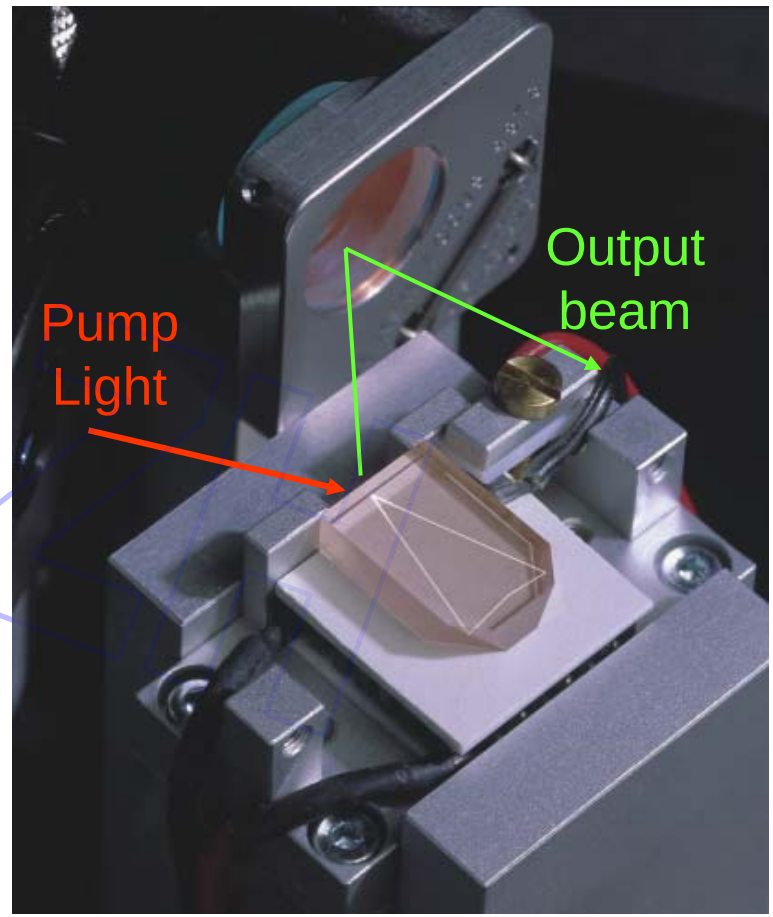
Low noise and high reliability

NPRO

NonPlanarRingOscillator



3 x 8 x 12 mm



- Output power: 0.5 - 2 W
- Beam quality ($M^2_{x,y}$): < 1.1
- Single frequency
- Line width: ~ kHz / 100ms

INNOLIGHT

Lasers for GW Detectors

Single frequency operation

(kHz line width)

$TEM_{0,0}$ fundamental mode operation

Linearly polarized light

Low noise and high reliability

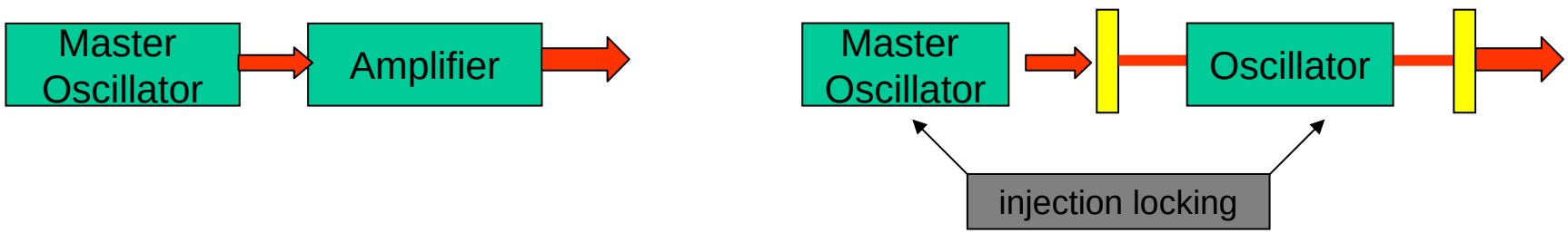
NPRO

+

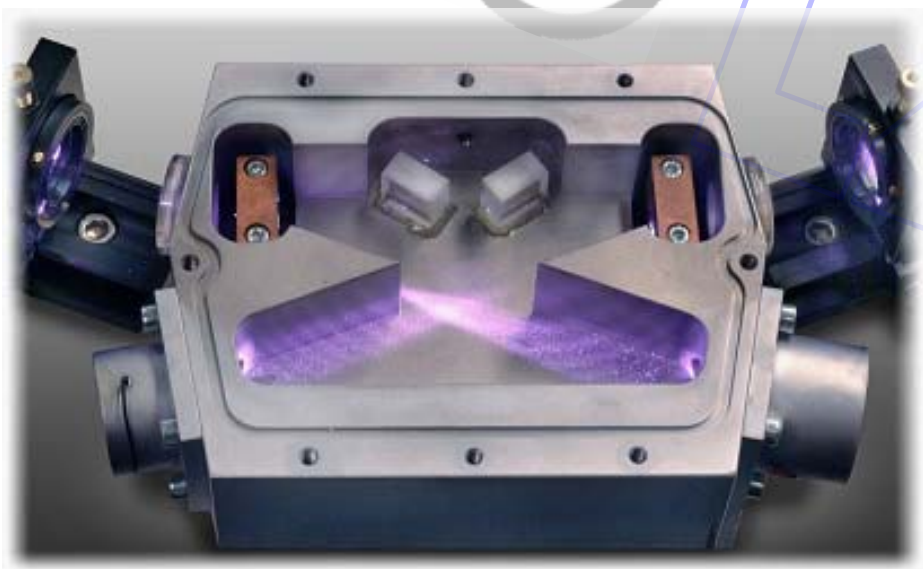
Output Power

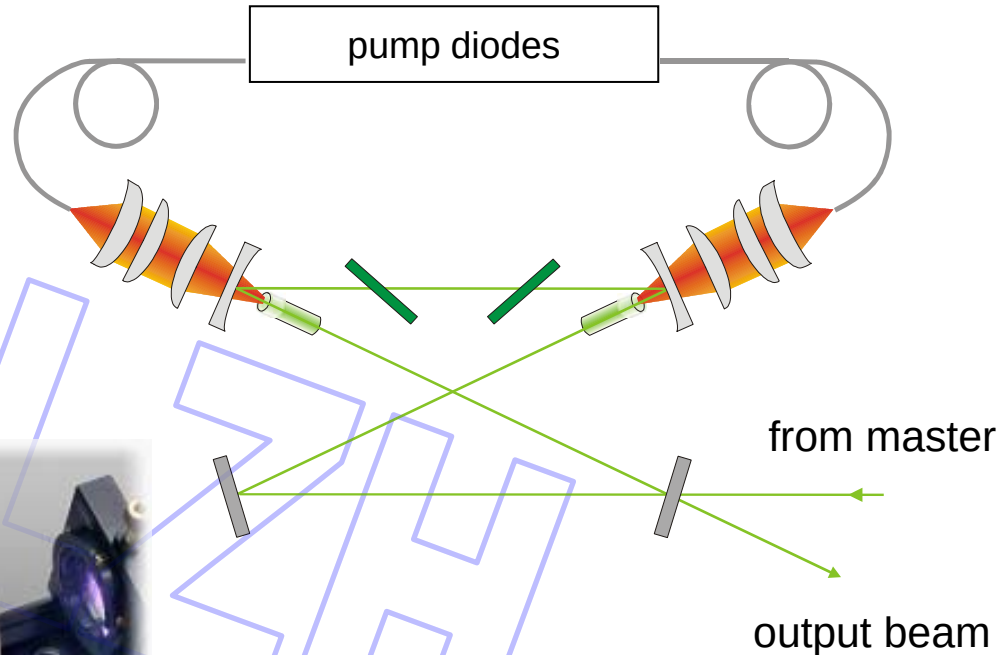
MOPA

Oscillator



Medium Power Oscillators





Medium Power Oscillators

GEO 600 Laser System

Laser Medium: Nd:YAG

Output power: 12 W

Beam quality ($M^2_{x,y}$): < 1.1

Opt-Opt. Efficiency: > 35%

Linearly polarized > 100:1

VIRGO Laser System

Laser Medium: Nd:YVO_4

Output power: 24 W

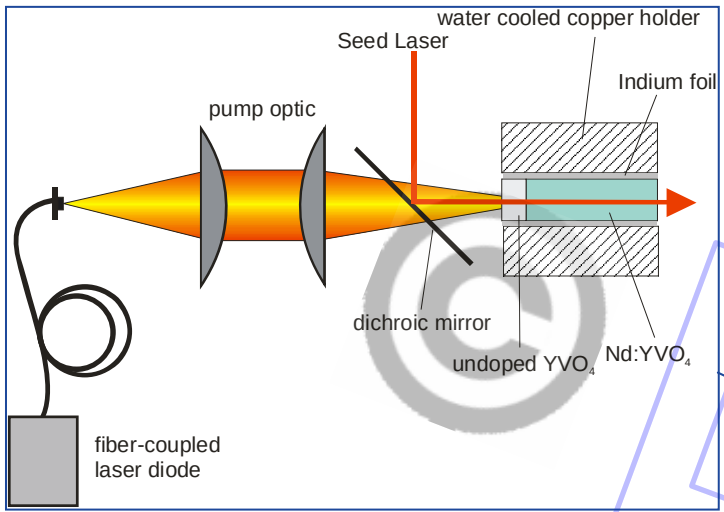
Beam quality ($M^2_{x,y}$): < 1.1

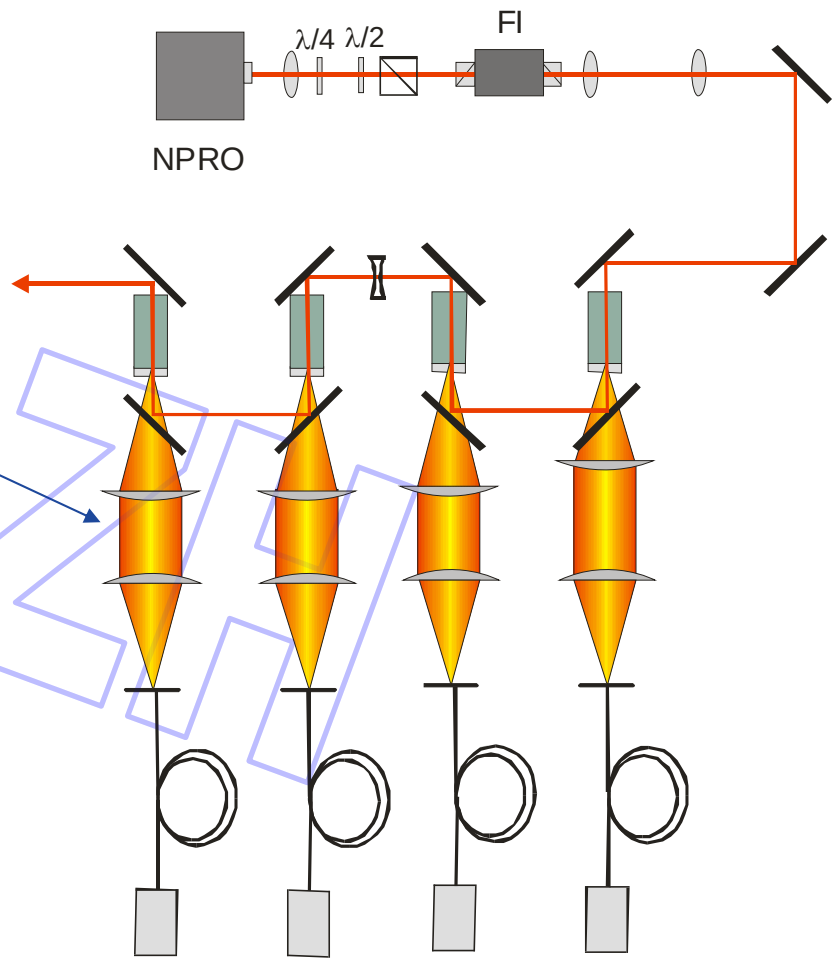
Opt-Opt. Efficiency: > 50%

Linearly polarized > 100:1

⇨ **continuously runtime > 2 years**

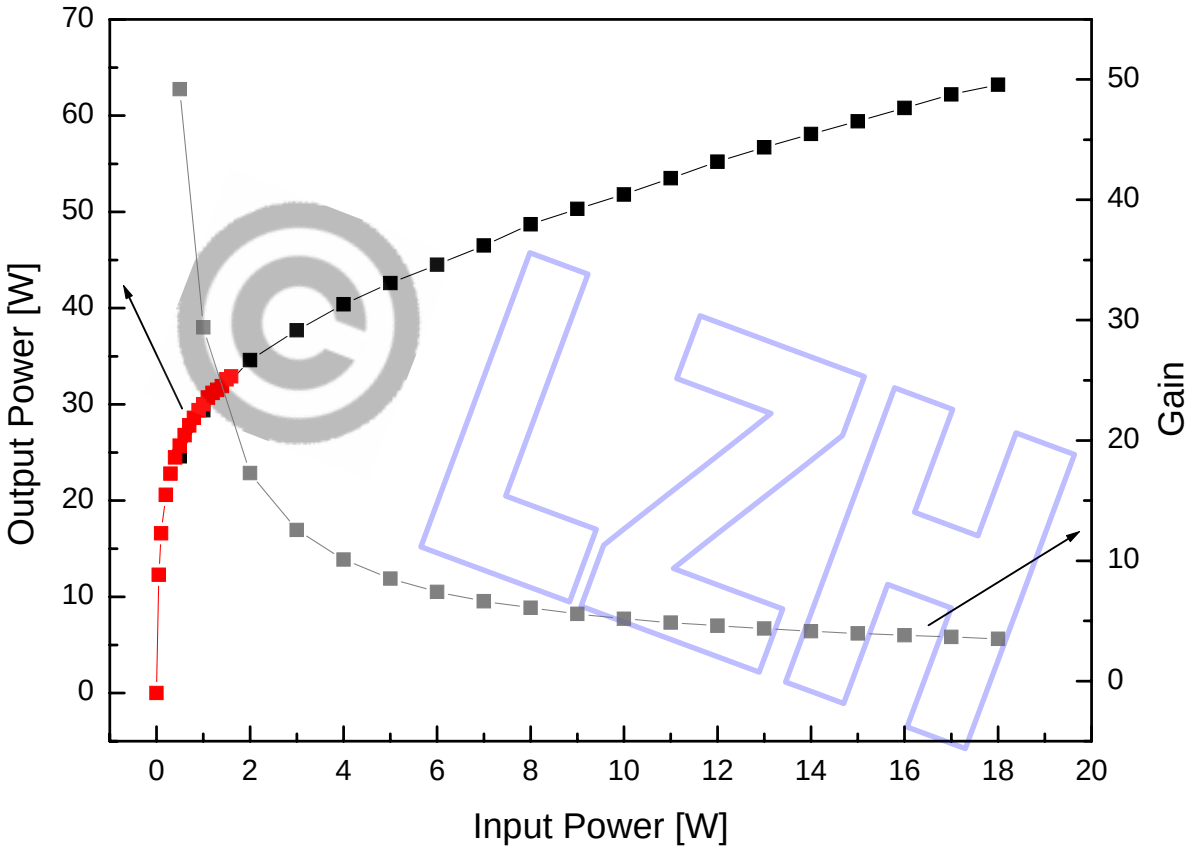
Medium Power Amplifier





- Master: 2 W NPRO
- Output power : 35 W
- M^2 : < 1,1

Medium Power Amplifier

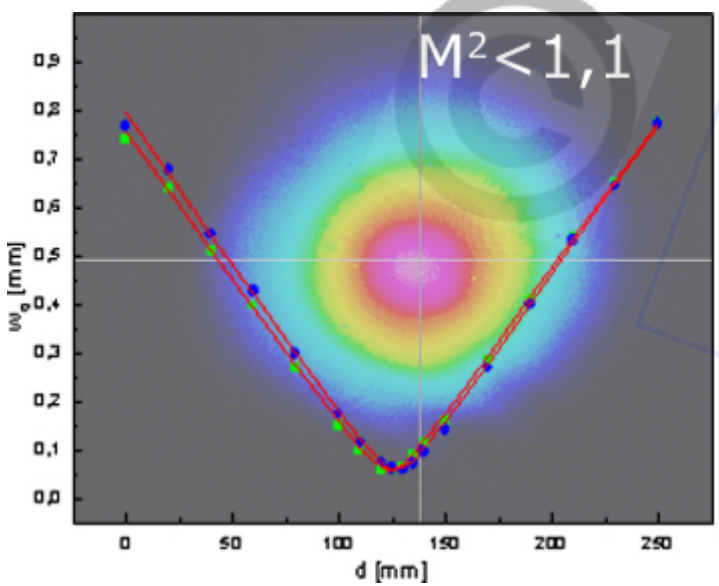


⇒ 35 W @ 2 W __ 52 W @ 10 W __ 64 W @ 18 W

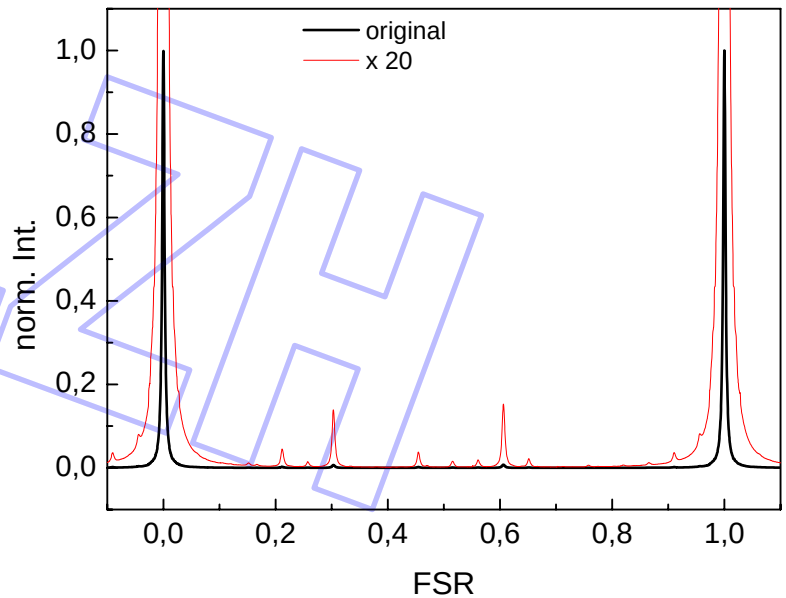
Medium Power Amplifier

Beam-Quality

CCD and M^2-masurement

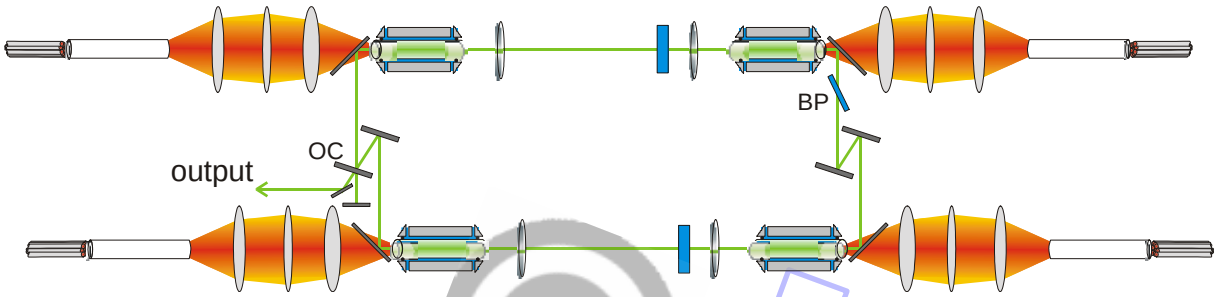


PMC- measurement

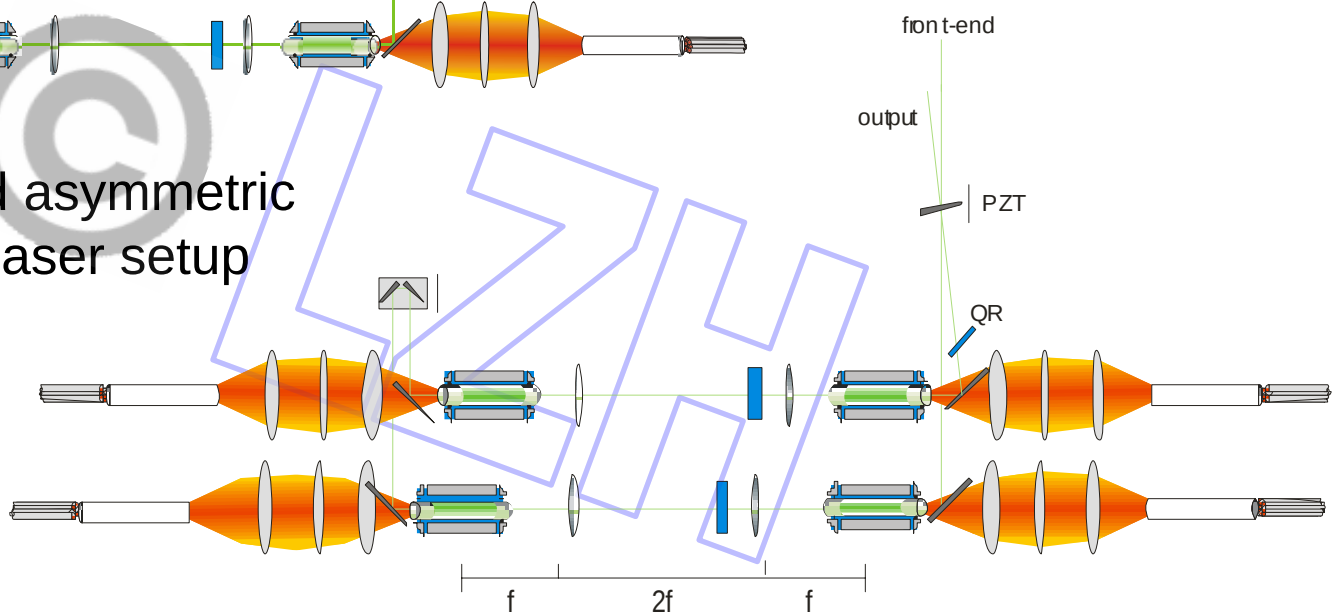


> 95% in $TEM_{0,0}$ (for NPRO input)

High Power Oscillators



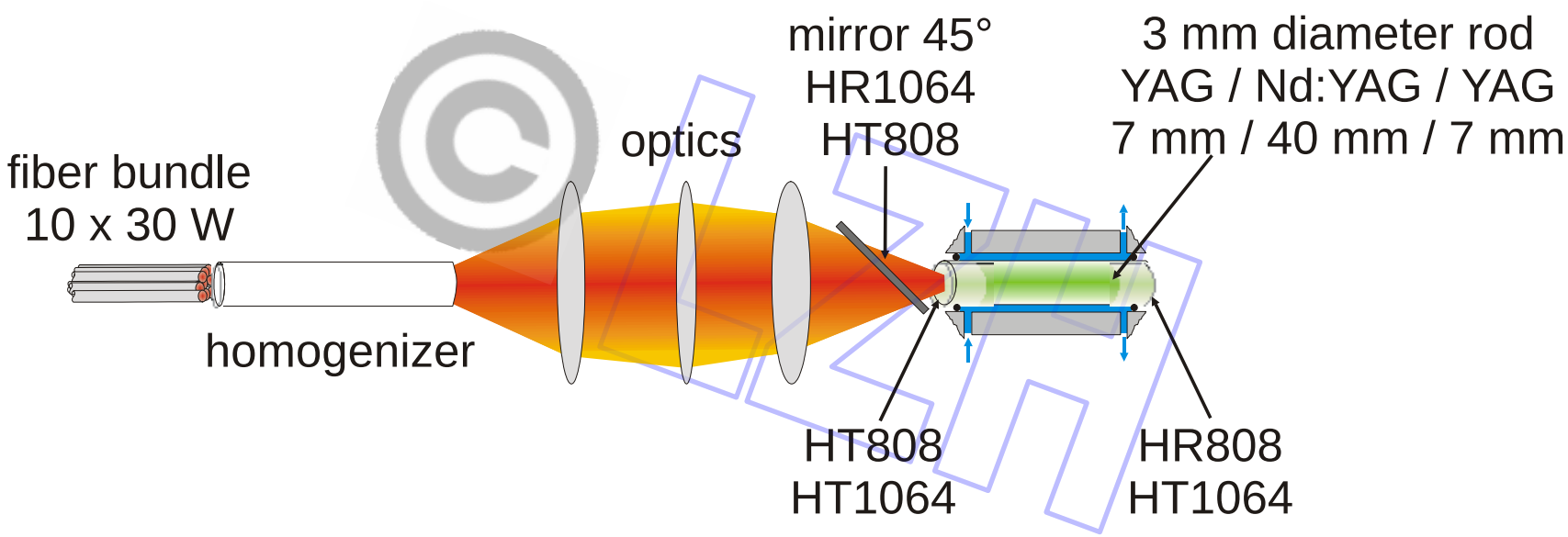
Symmetric and asymmetric high power laser setup



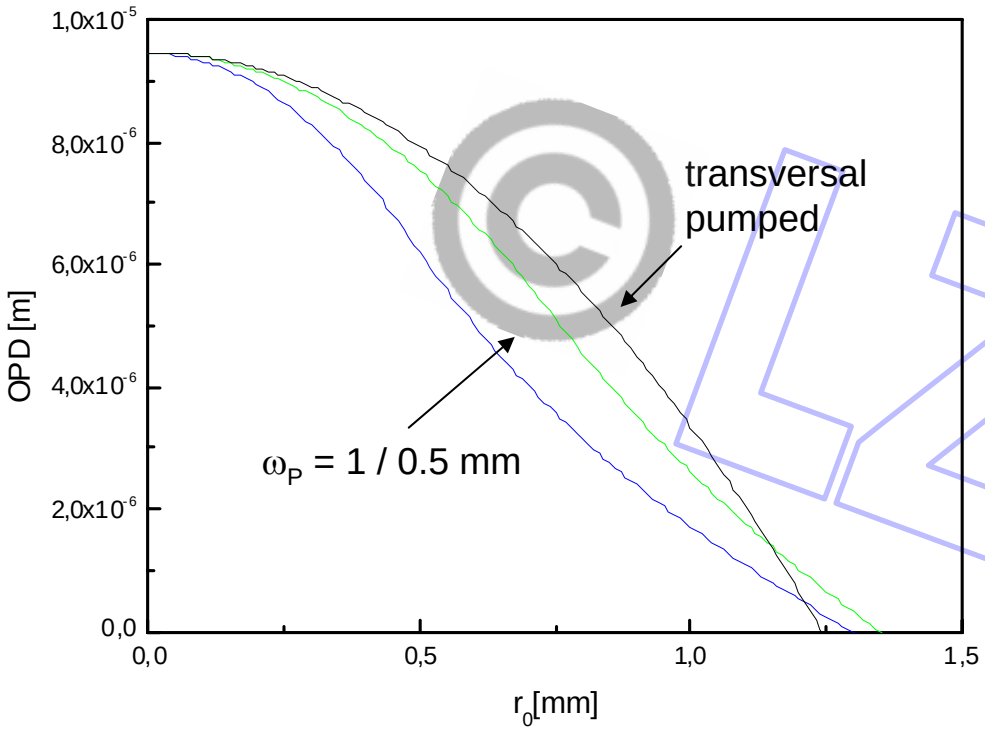
- Output powers: 180 - 200W
- Fundamental mode operation: $M^2 < 1.3$

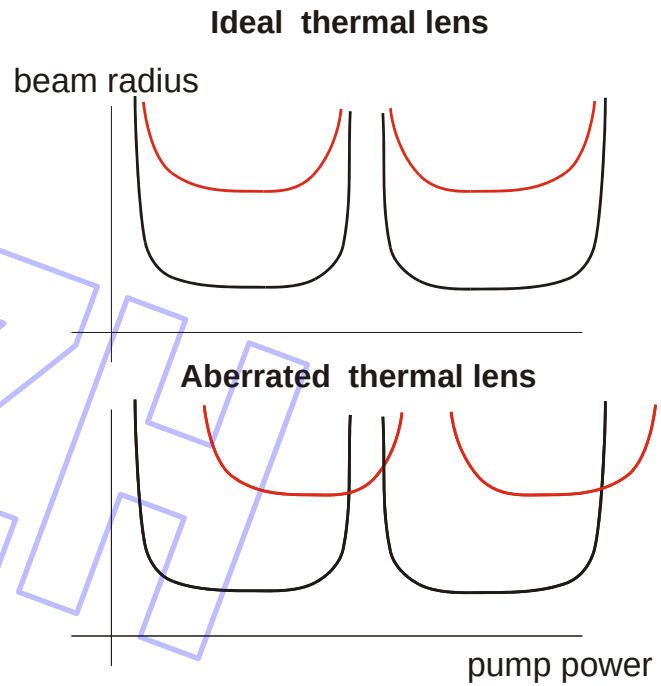
High Power Oscillator

End-Pumped Laser Head



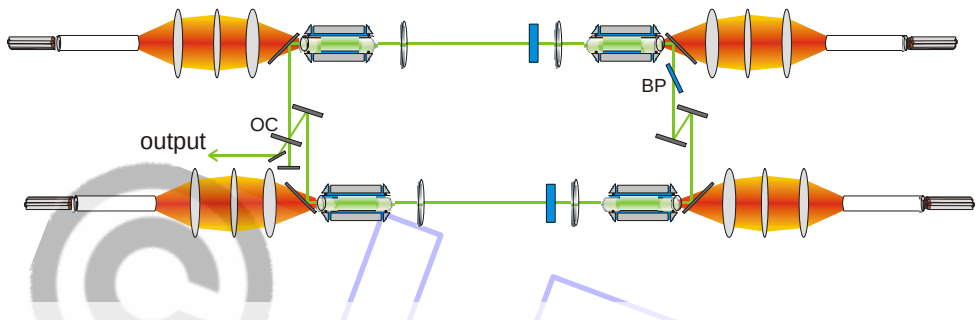
Thermal Lens in End-Pumped Rods

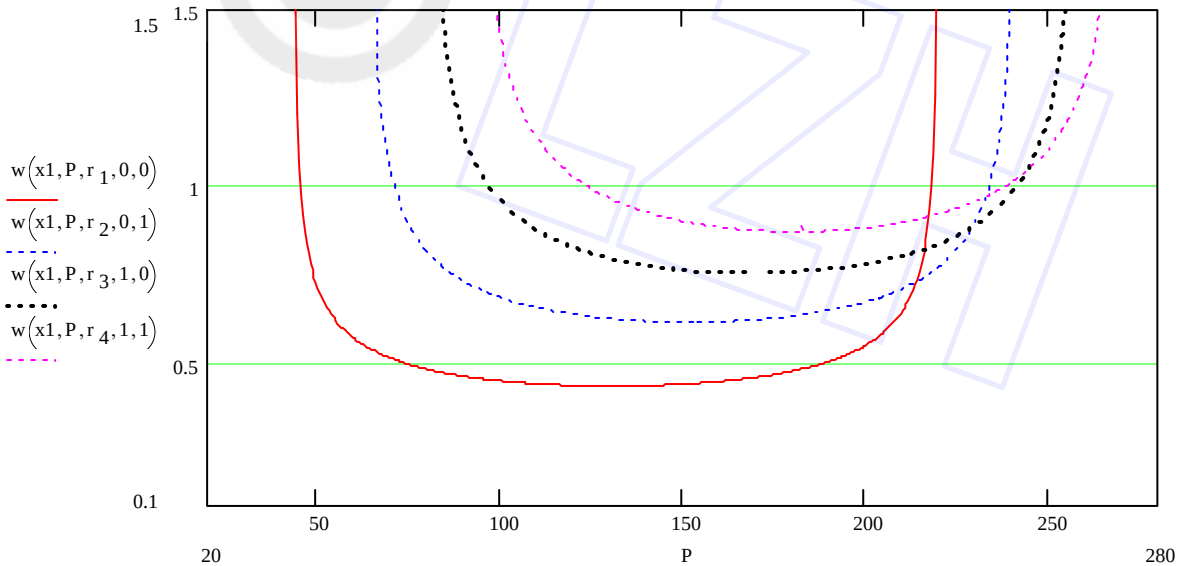




Mode Control

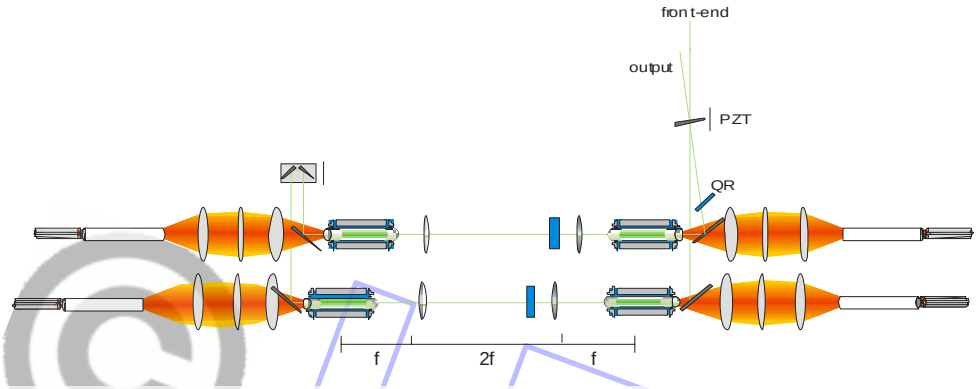
Symmetric Resonator Design

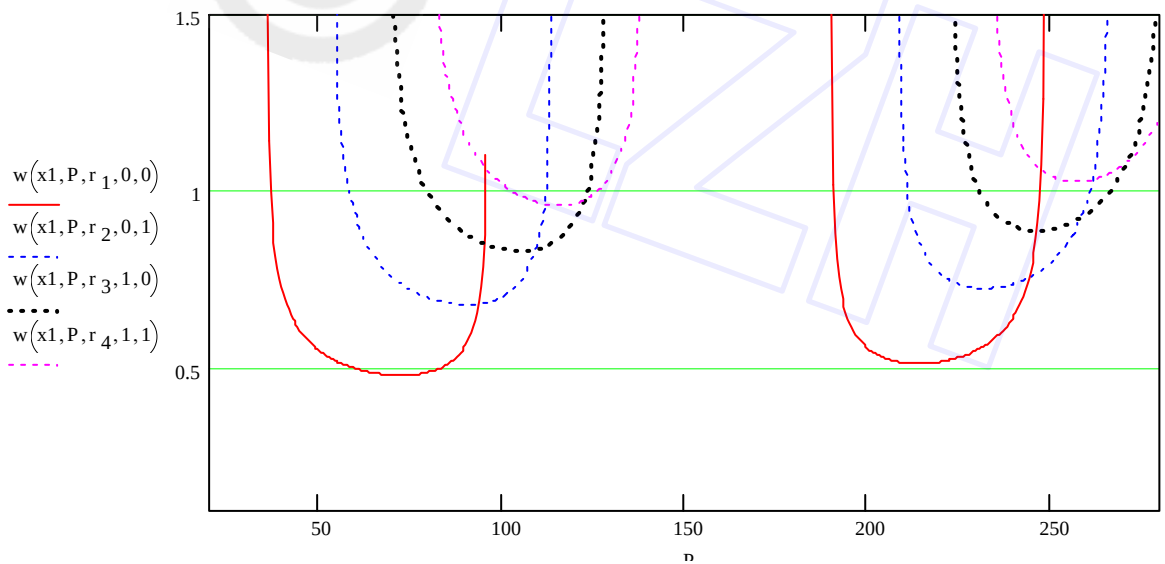




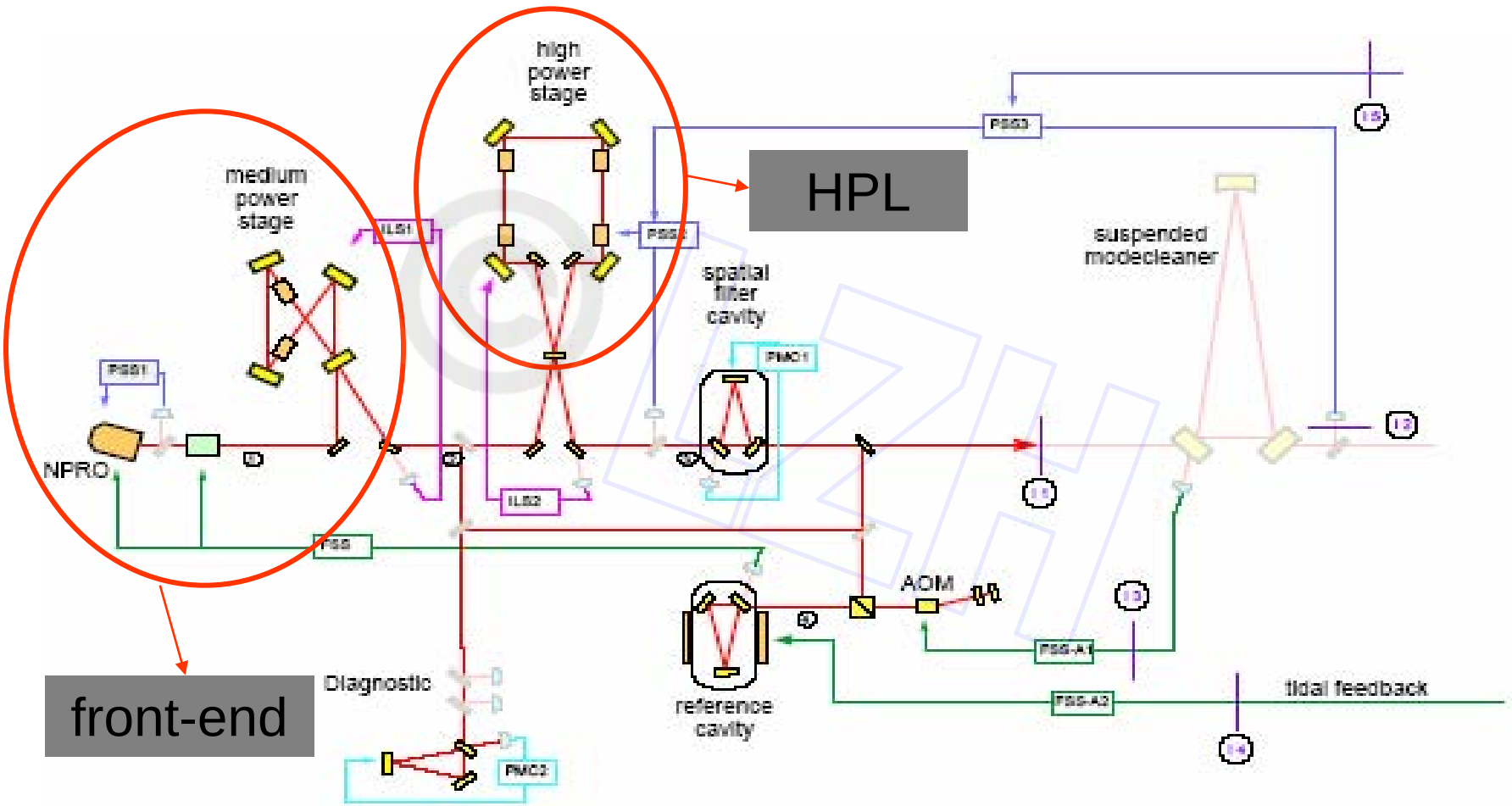
Mode Control

Asymmetric Resonator Design



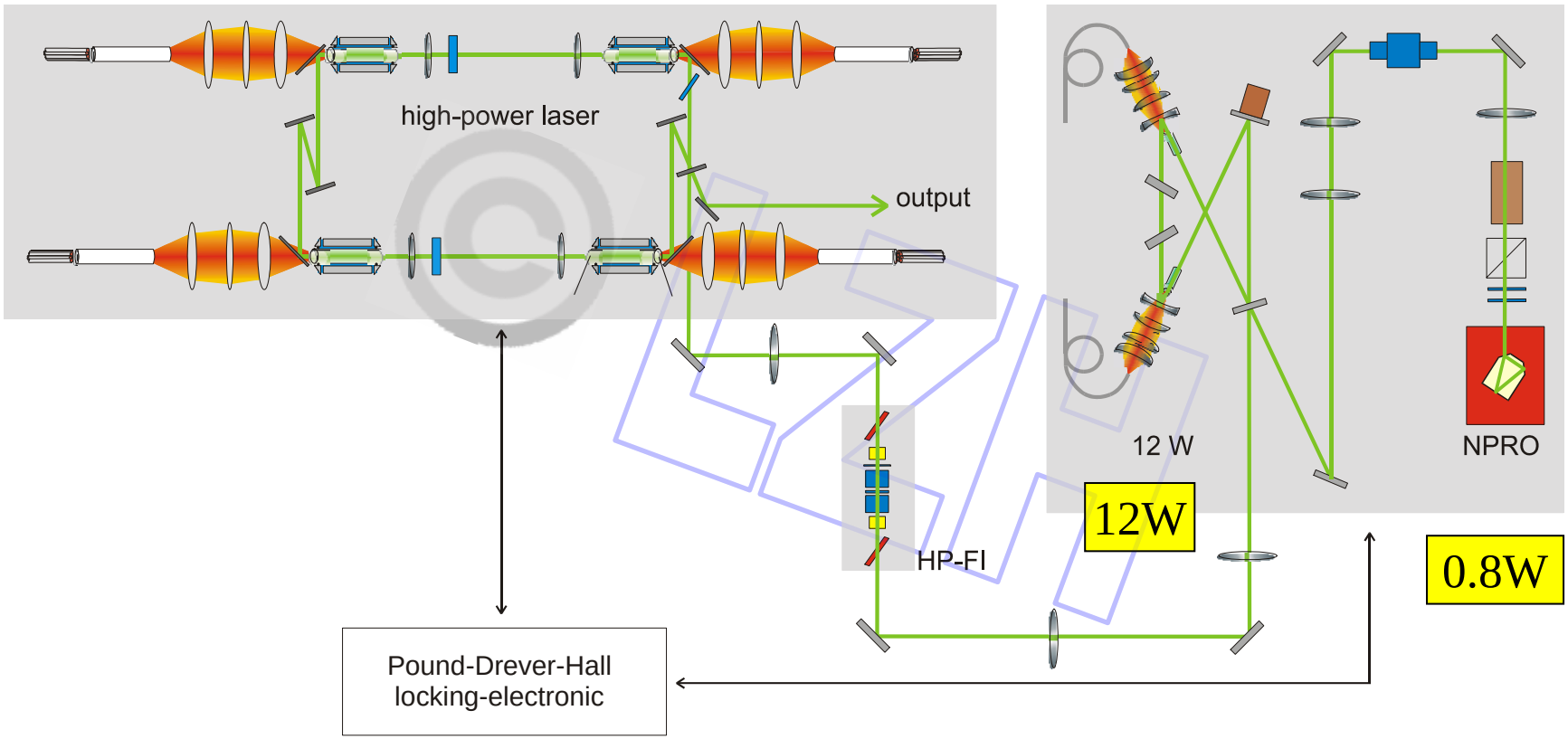


Advanced LIGO PSL



High Power Laser

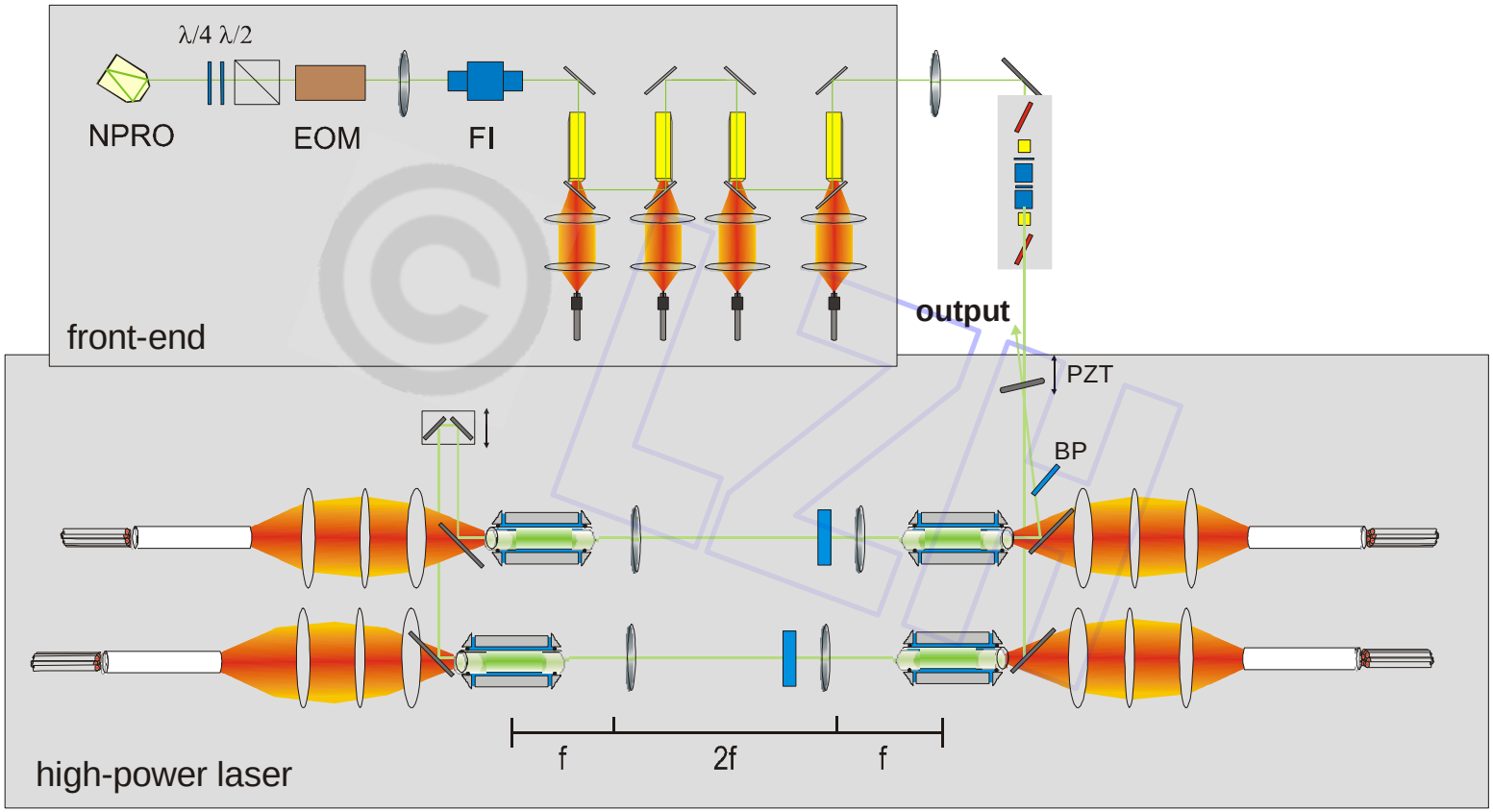
1st Approach



⇒ 195 W single-frequency output power demonstrated

High Power Laser

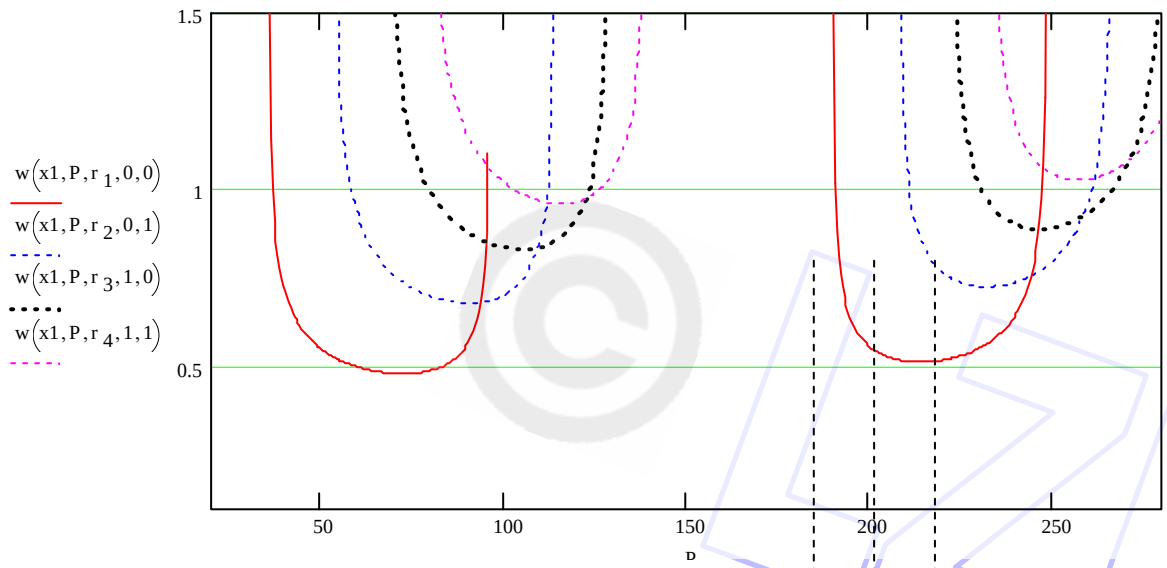
2nd Approach

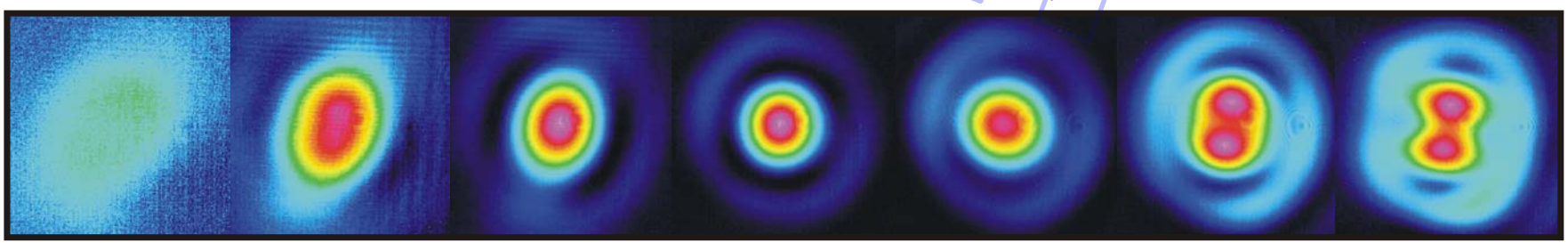


⇒ 190 W single-frequency output power demonstrated

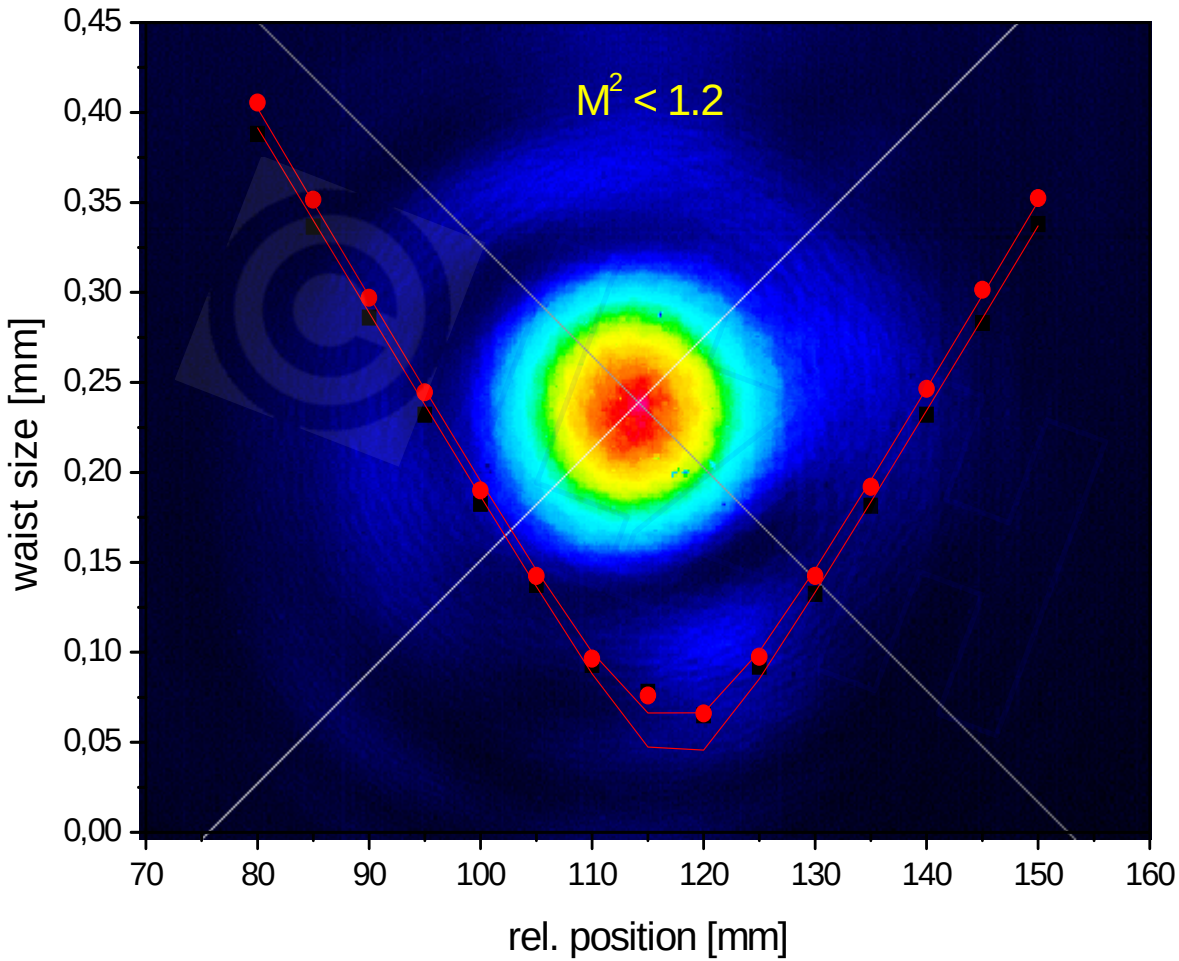
Optimized Mode Control

$TEM_{0,0}$ Operation

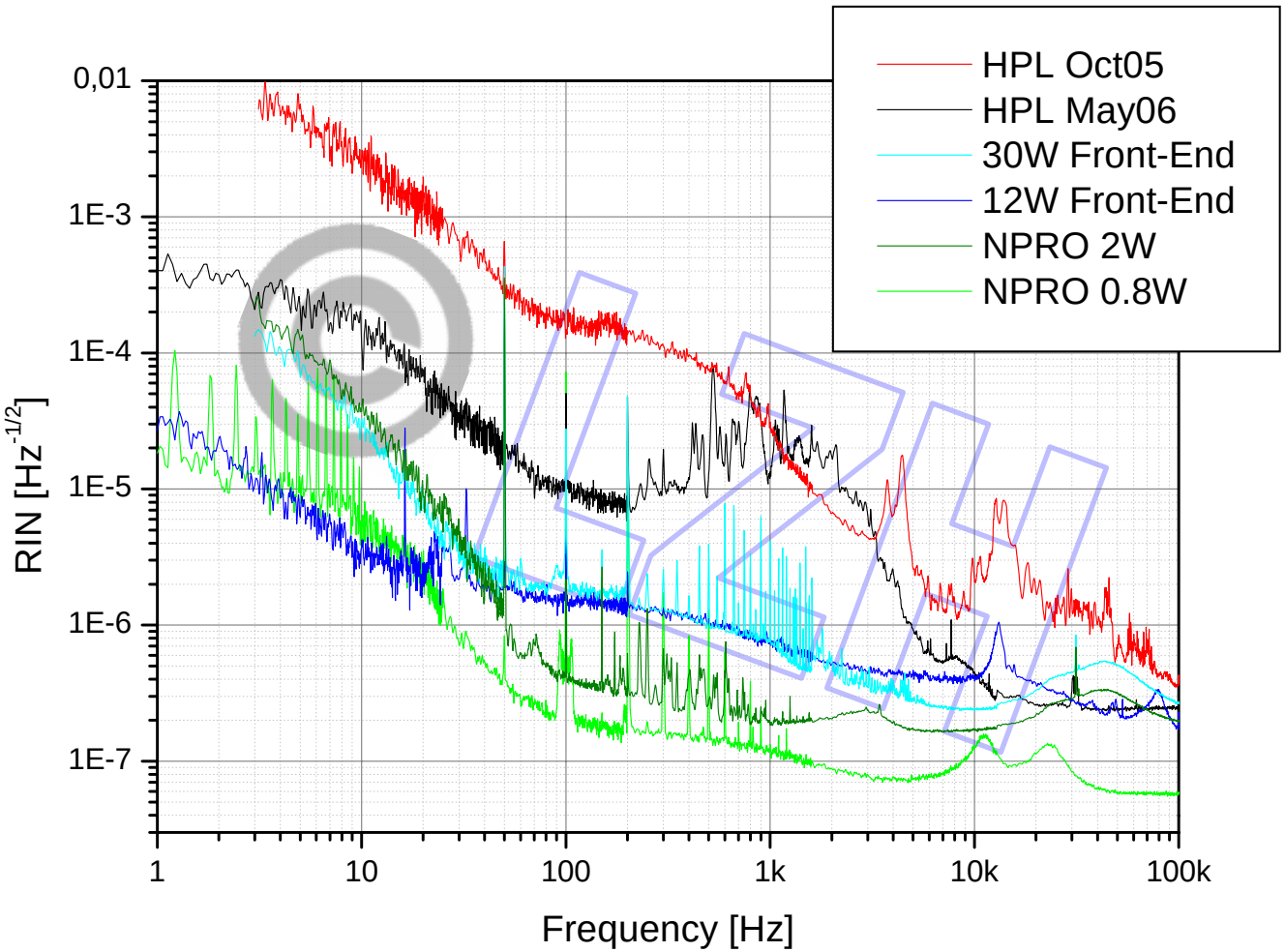




Beam Quality



Relative Intensity Noise



Summary

- 12 - 65 W medium power lasers
  - GEO / VIRGO and VIRGO+ / LIGO+
- ~ 190 W high power laser
  - Advanced LIGO
- Stable locking
- Beam quality $M^2 < 1.1$ to 1.3
- High reliability