Status of Laser Zentrum Hannover Laser Program

Maik Frede

Ralf Wilhelm, Martina Brendel, Renê Gau, Frank Seifert, Ivo Zawischa, Carsten Fallnich,

Laser Zentrum Hannover

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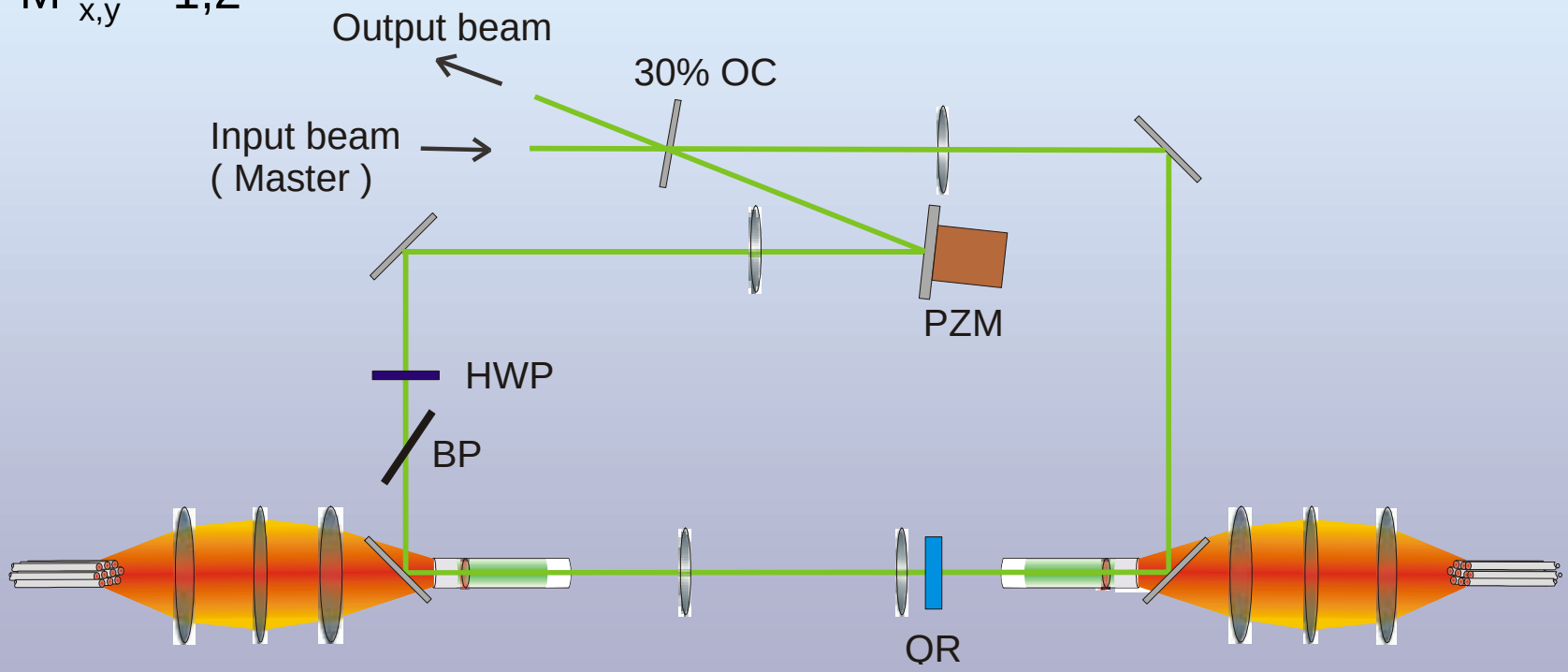
LSC Meeting-Livingston

LIGO - G030091-00-Z

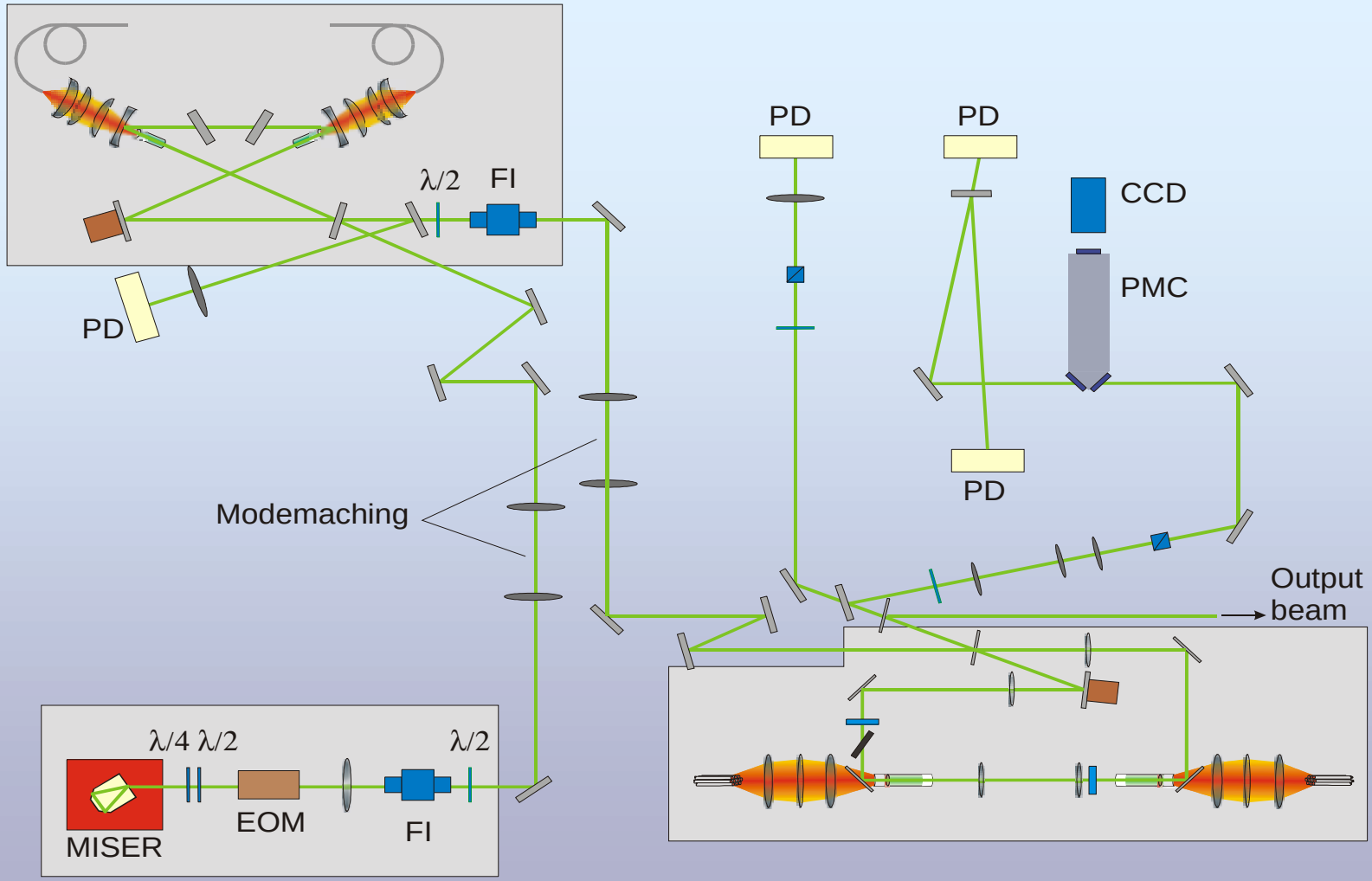
High Power Slave

- 87 W output power
- linear polarized
- single transverse mode
- $M^2_{x,y} \sim 1,2$



High Power Locking Scheme

Setup

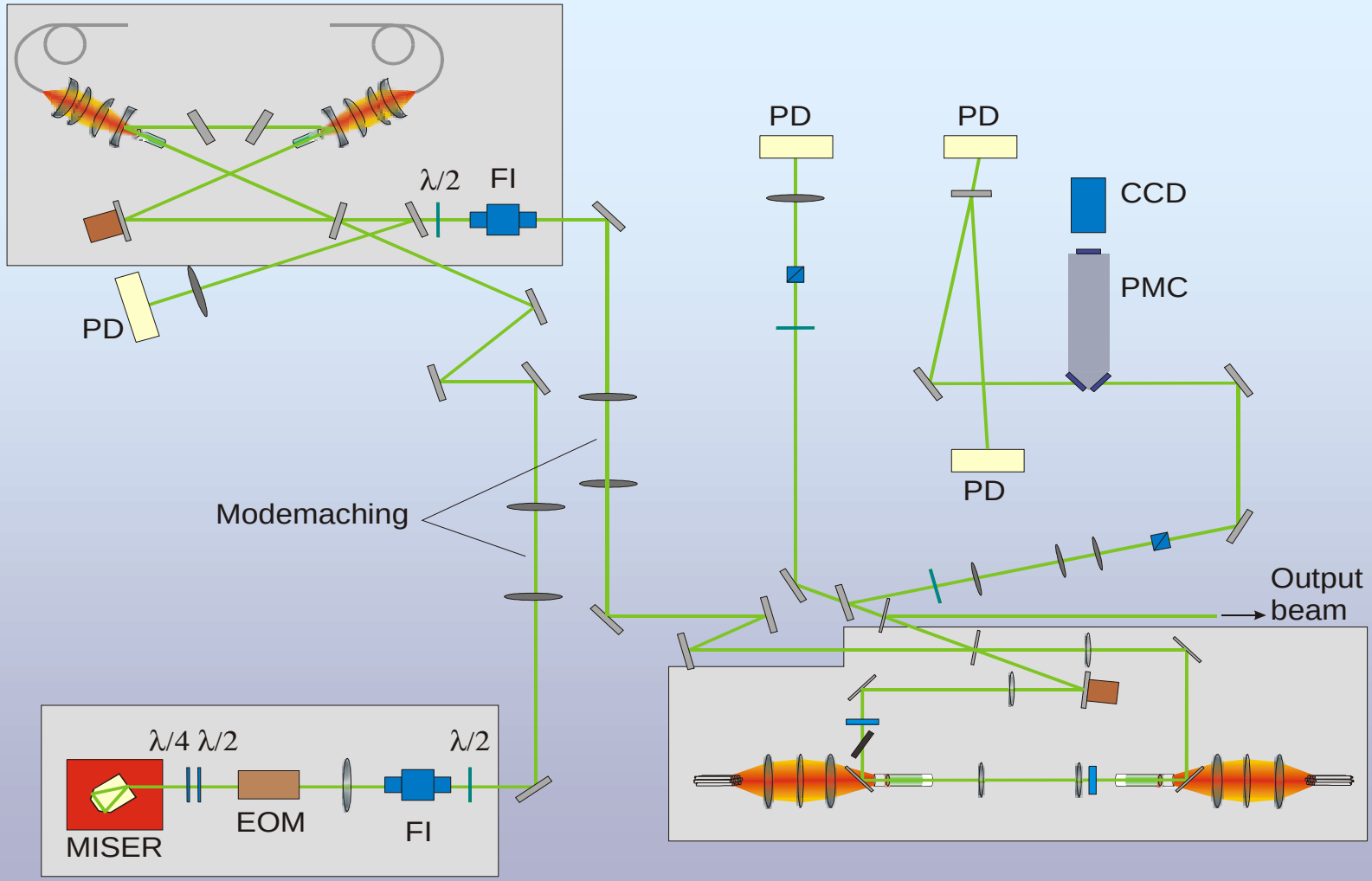


High Power Locking Scheme
Master

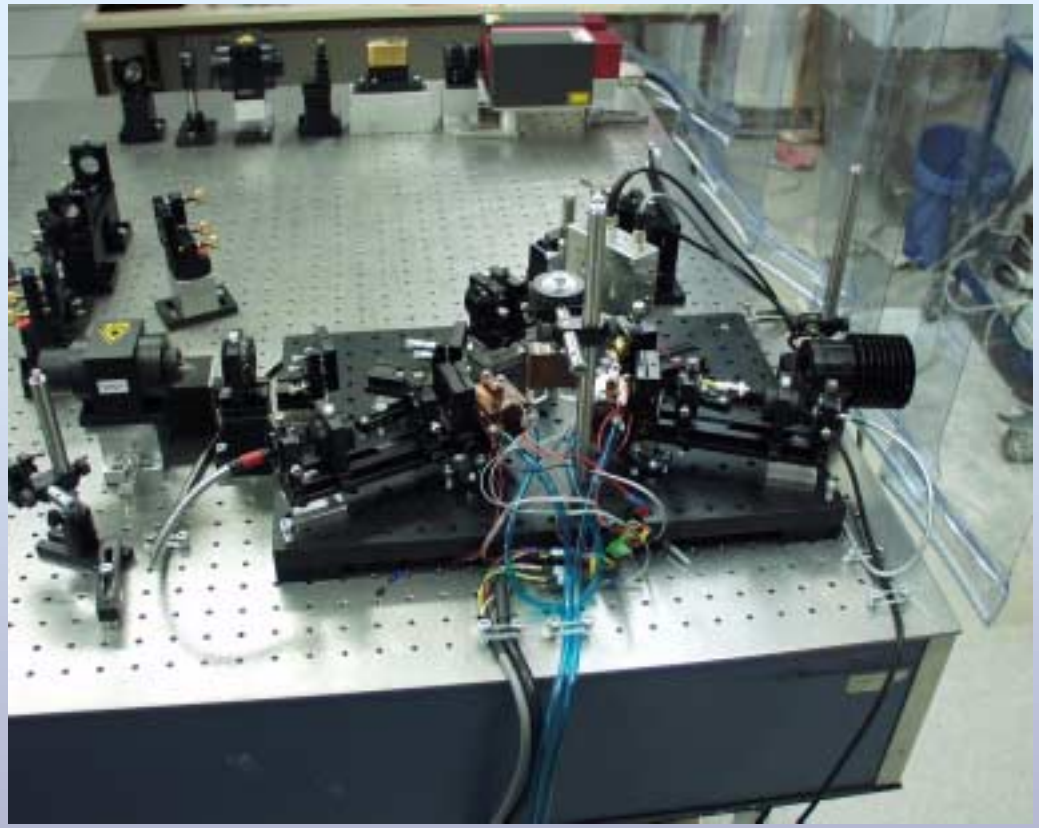
- 2W Miser
  Mephisto 2000 Innolight
- EOM: *New Focus*
  @ 29,02 MHz
- Isolator: *Gsänger*

High Power Locking Scheme

Setup



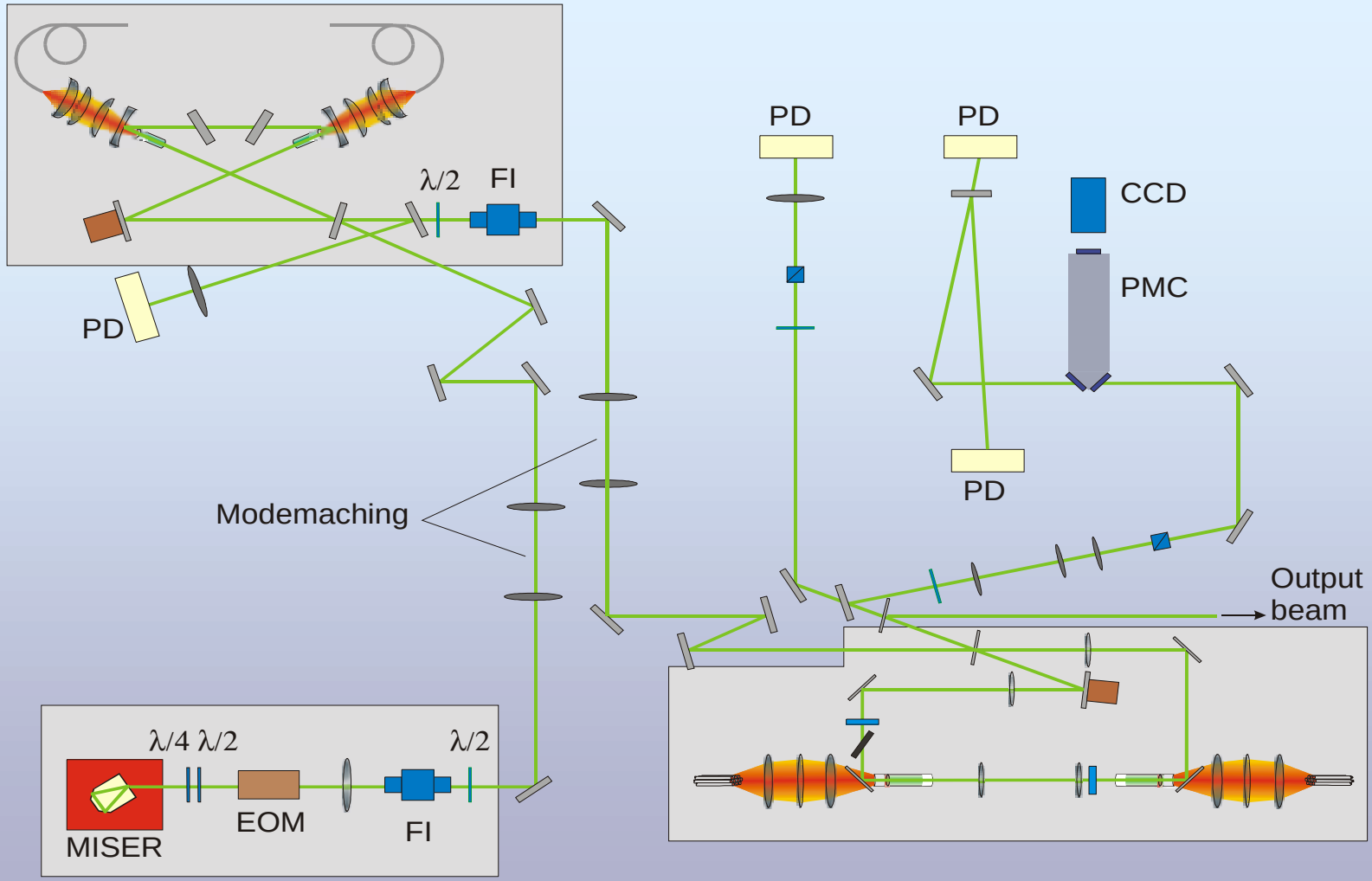
High Power Locking Scheme
Medium Stage



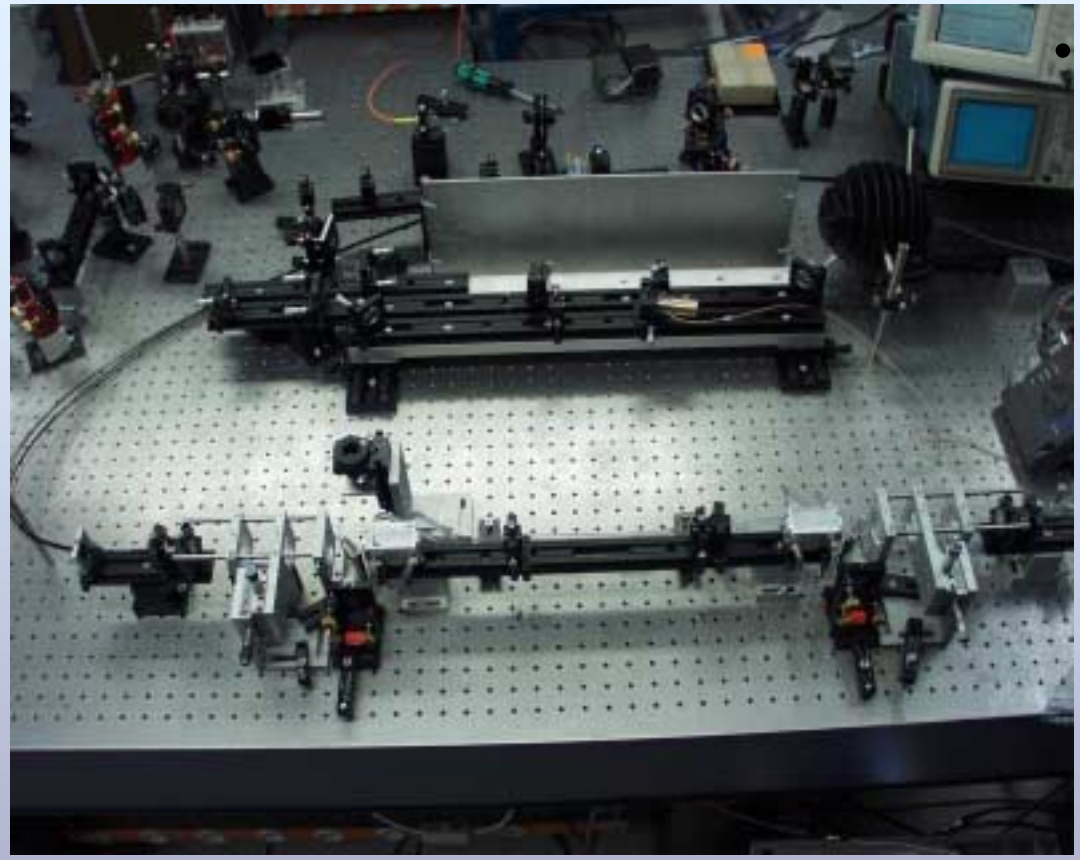
- 12 W med. power stage based on GEO 600 laser design
  η_{opt} ~ 30 %
- Isolator: *Gsänger high power design*

High Power Locking Scheme

Setup



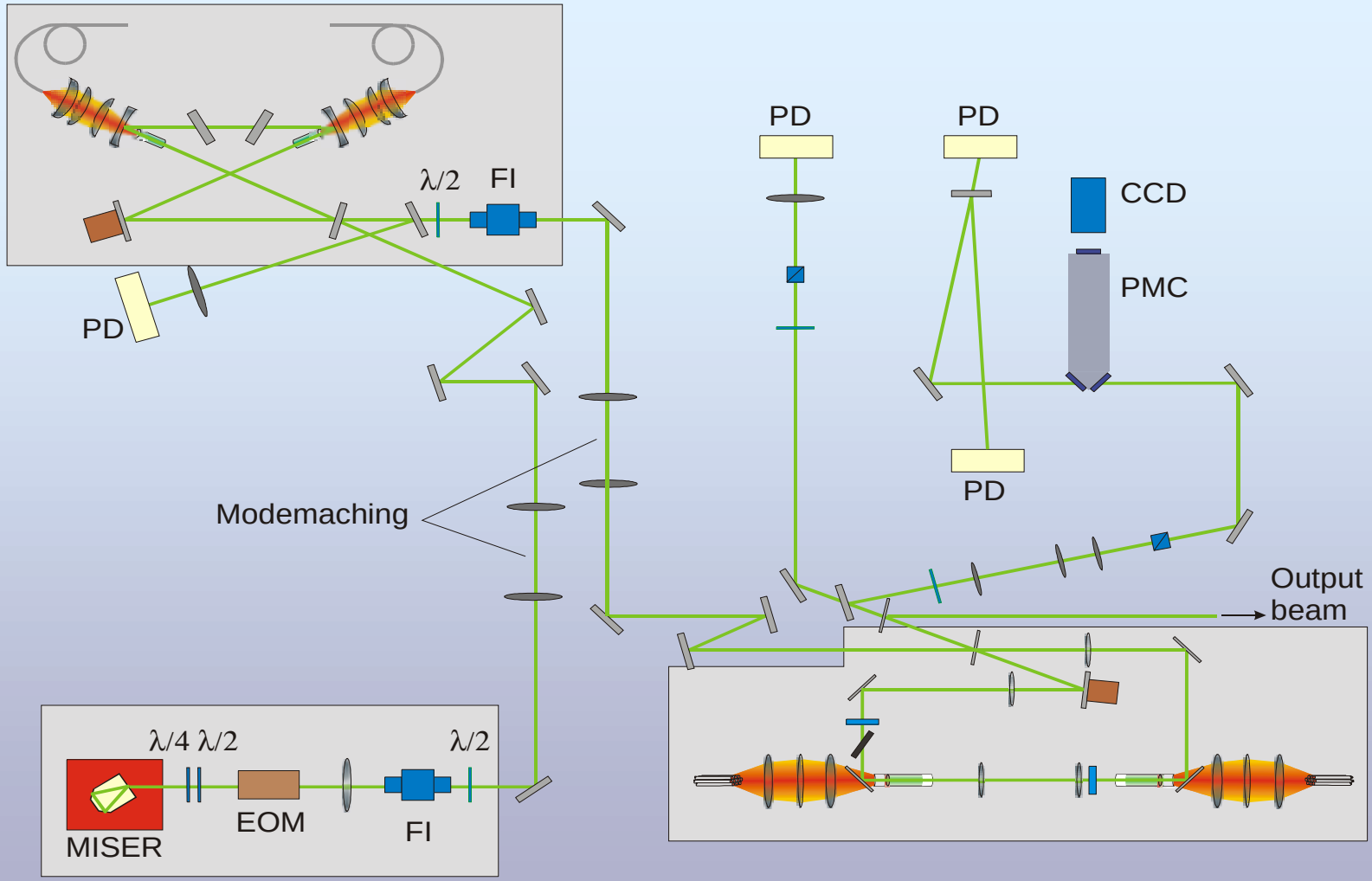
High Power Locking Scheme
High Power Slave



- 87 W high power slave
single transverse mode
$M^2 \sim 1,2$
$\eta_{opt} \sim 23\ \%$

High Power Locking Scheme

Setup



Results

First high power injection locked laser system

87 W linear polarized, single frequency,
single transverse mode
(total power of all systems ~ 101 W)

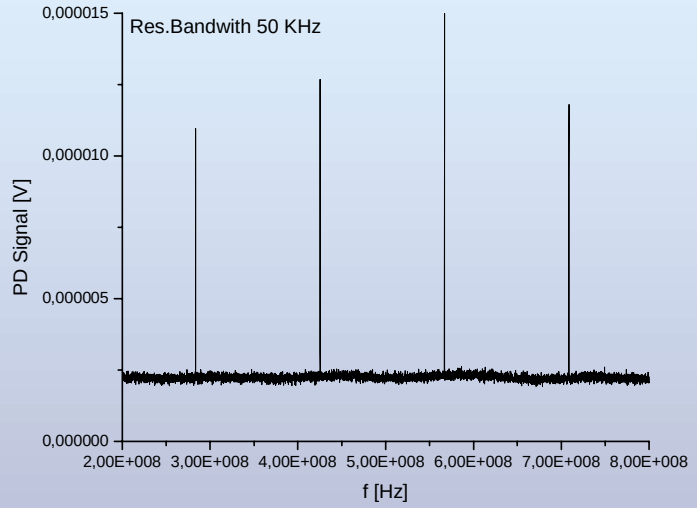
total optical efficiency 22%

locking direct to 2 W master possible
single frequency output power ~ 70 W

Beam Characterization

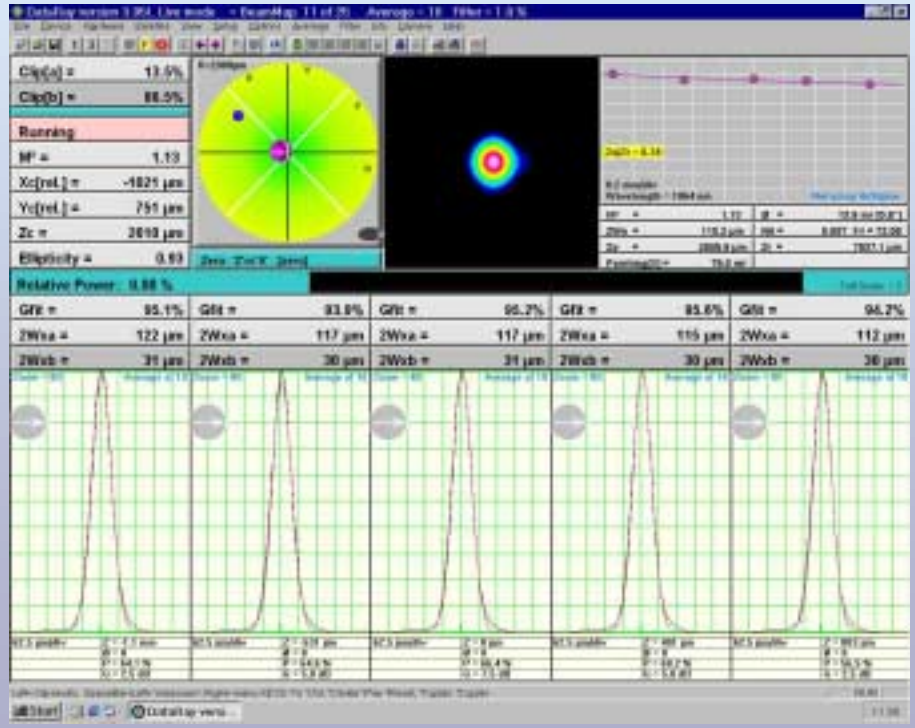
Beat signals of free running slave

⇒ no higher order modes detect

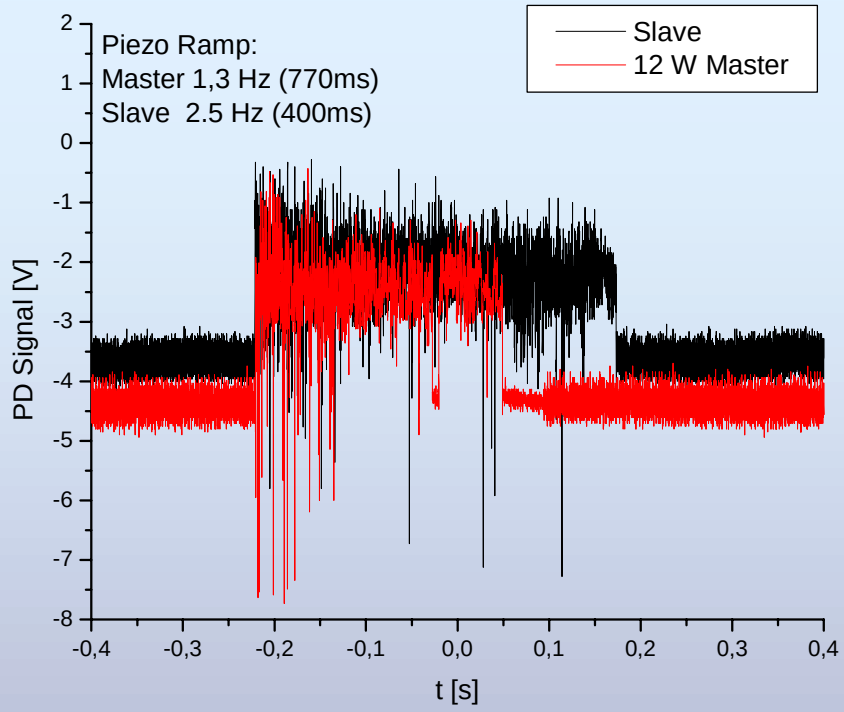


Beam profile of locked system

⇒ M^2~1.1 , less elliptical beam



Relock Time



relock time < 500 ms

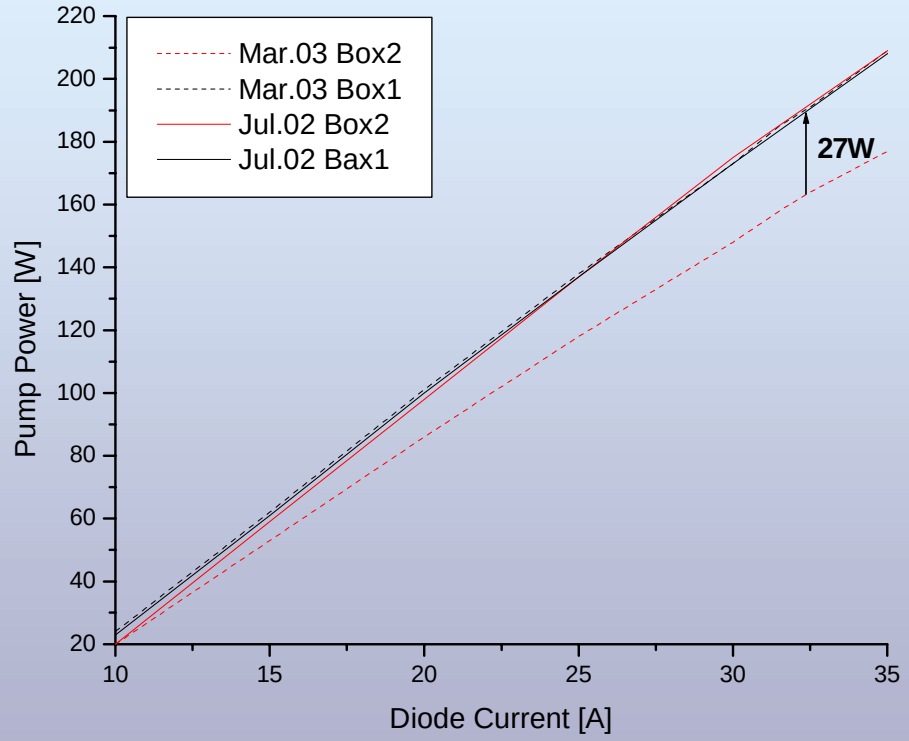
faster relock possible depending on piezo ramp

Decrease of Pump Power

During measurements slave laser power drops down to 70 W

⇒ pump power difference
~ 15 % pump power drop
on one diode box

⇒ higher Birefringence
⇒ higher beam distortion



System Optimization

To get full injection locked power following things has to be optimized:

- Modemaching in the high power slave
  (FI with compensated thermal lens)

- Outputcoupler of high power slave

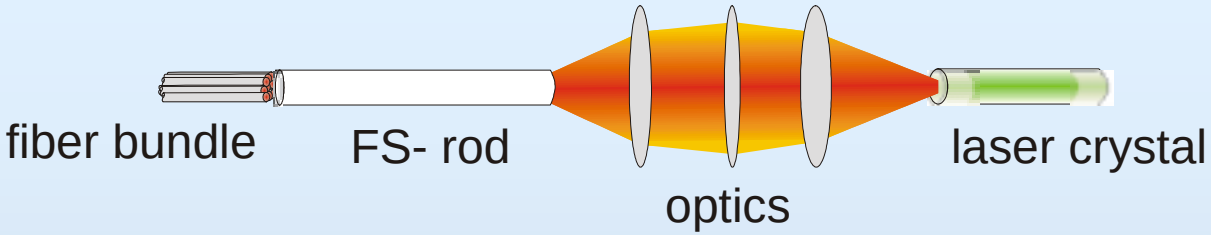
- optimize gain overlap of different Lasers

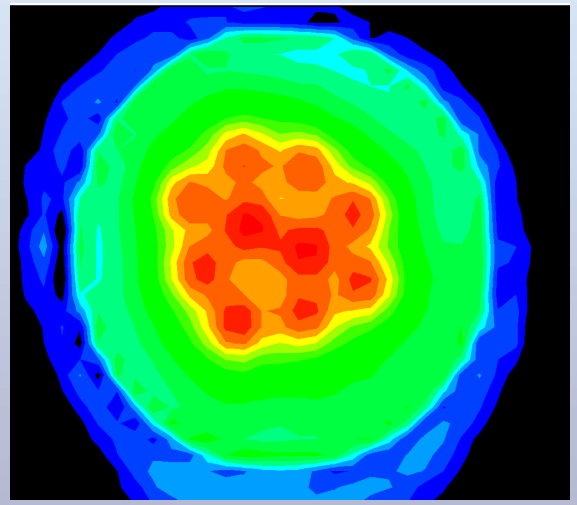
- implement pumplight optimization

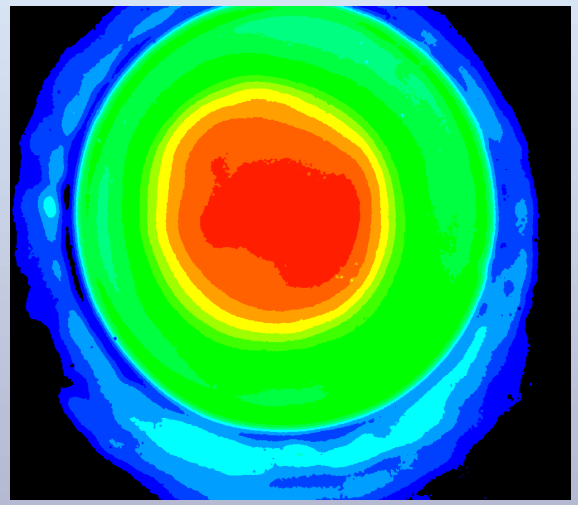
Pump Light Optimization

- Implementing diode power readout to control total pump power
- Implementing pump light homogenization
- Construct new pump light and laser crystal basement
- $\Rightarrow$ fixed,stable and reliable pump light distribution

Pump Light Homogenization

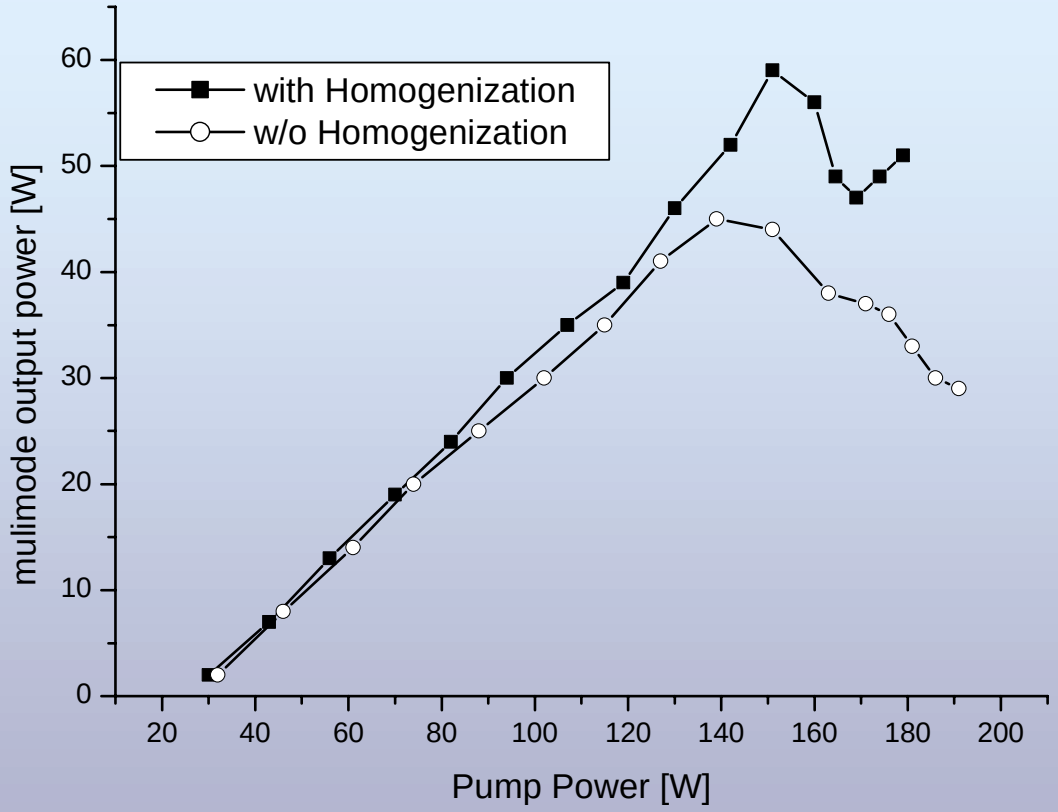


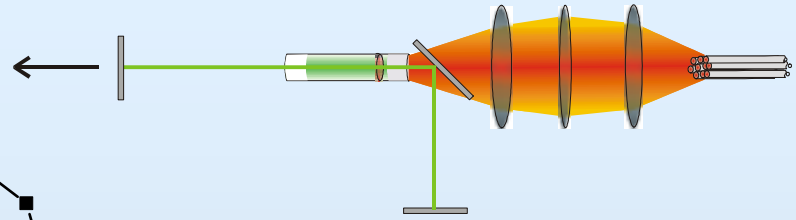




fluorescence w/o homogenization

Pump Light Homogenization

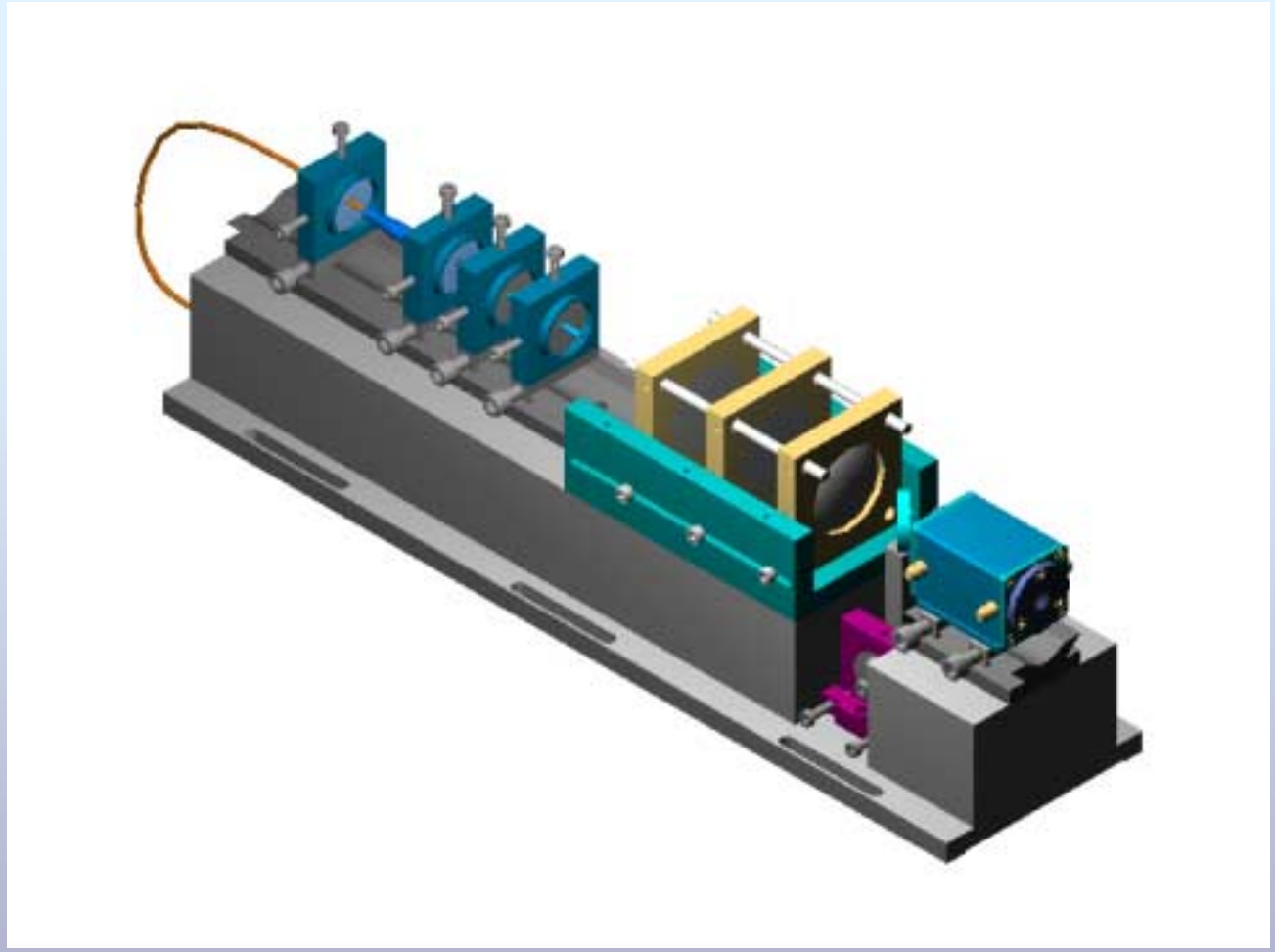




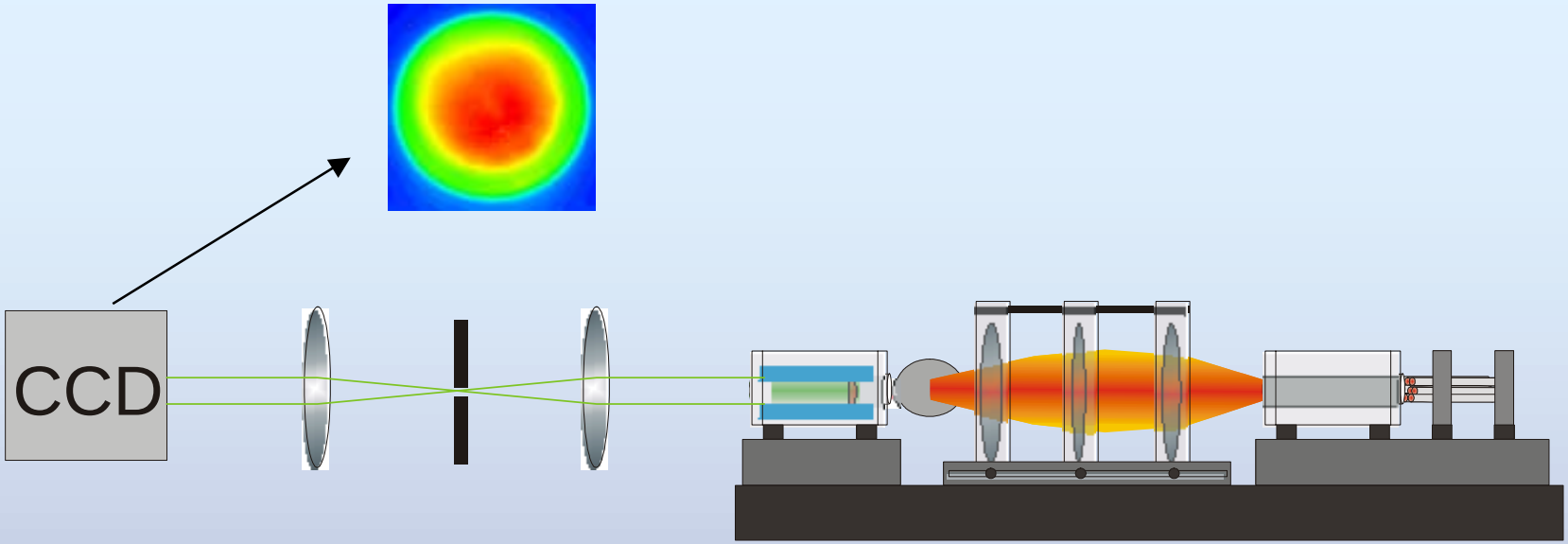
⇒ 30 % more output power with homogenization

⇒ better gain overlap and less distortion for low order modes

1 st Head Design

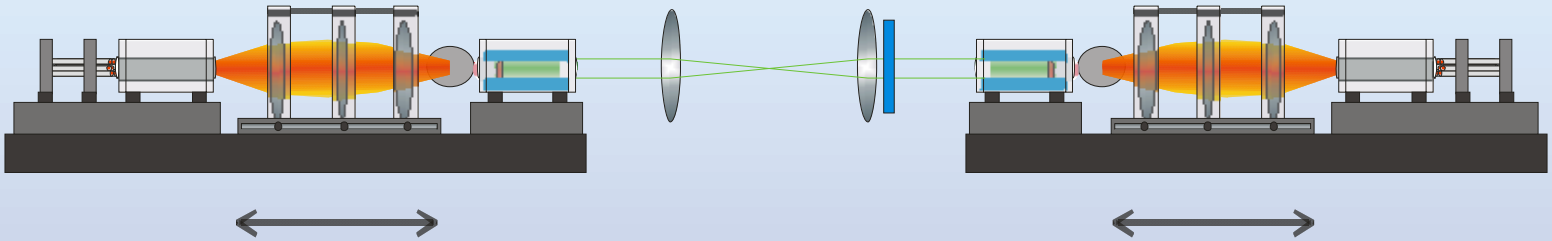


Optimization of Pump Light Distribution



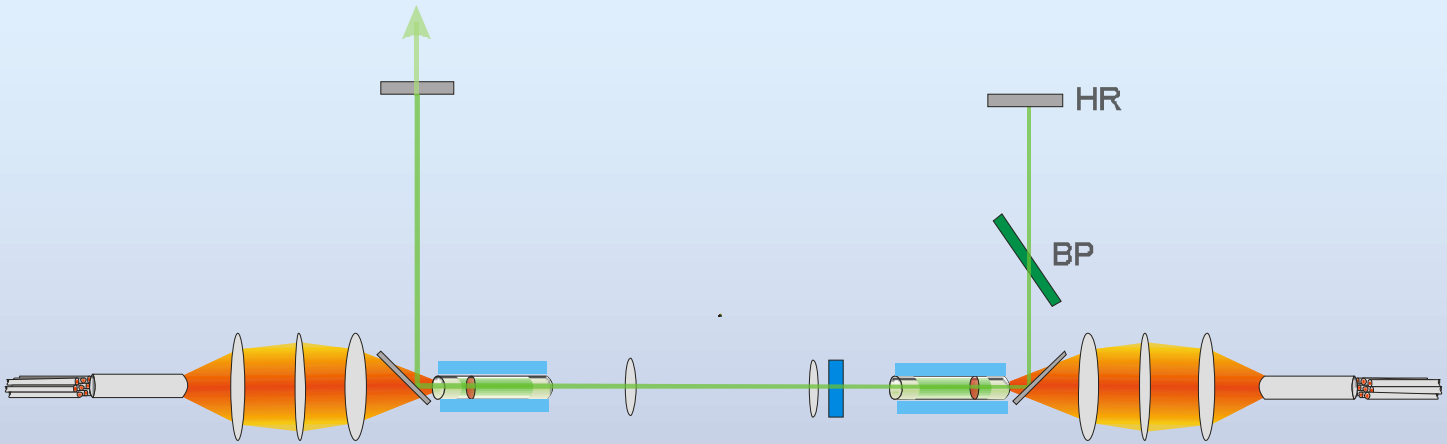
- alignment of homogenous and centered pump light profile
- pump power calibration for PD-readout

Birefringence compensation



Find working point with less birefringence

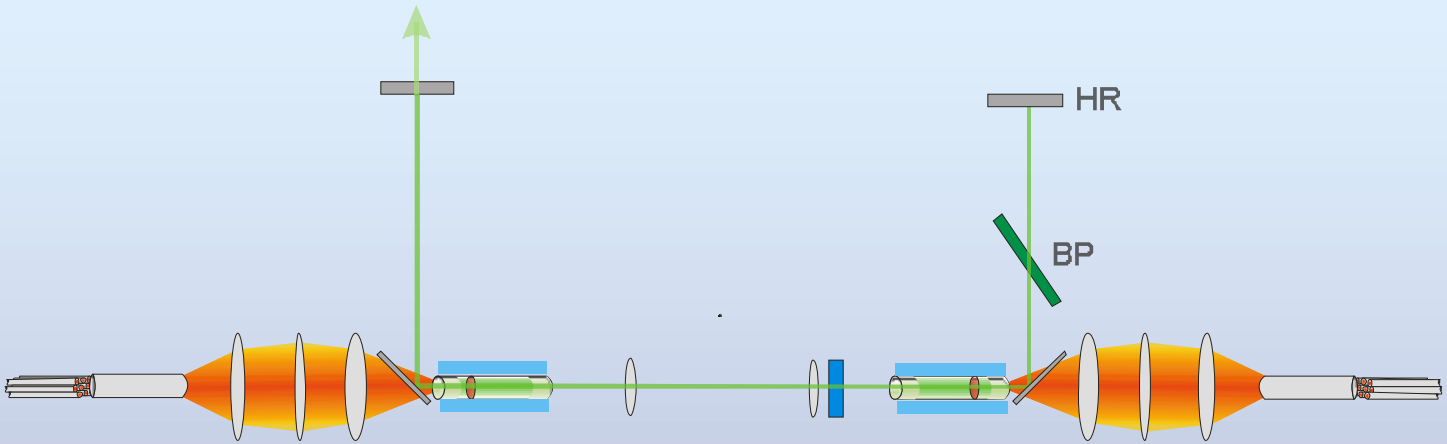
Optimize Resonator



- Test different laser rods 4,5 mm
- Test different pump spot sizes

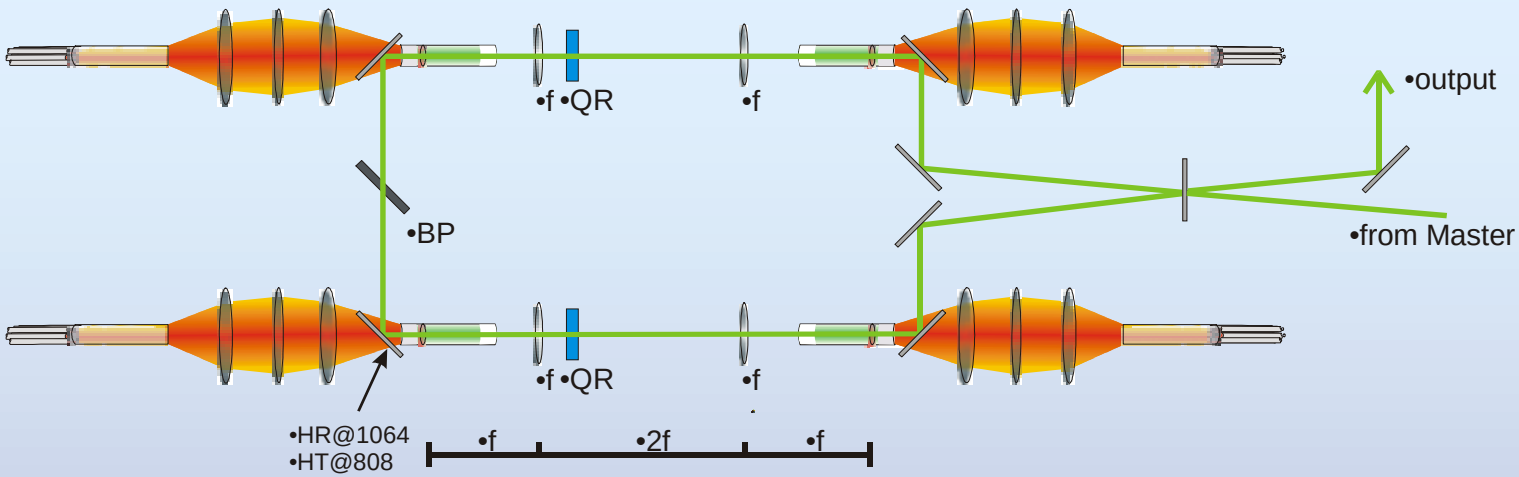
$\Rightarrow$ find best laser design before doubling the system

Advanced Ligo Laser 1st. Step



- Optimized laser head with respect to beam quality and output power
- up to now 100 W of output power in single transverse mode are demonstrated

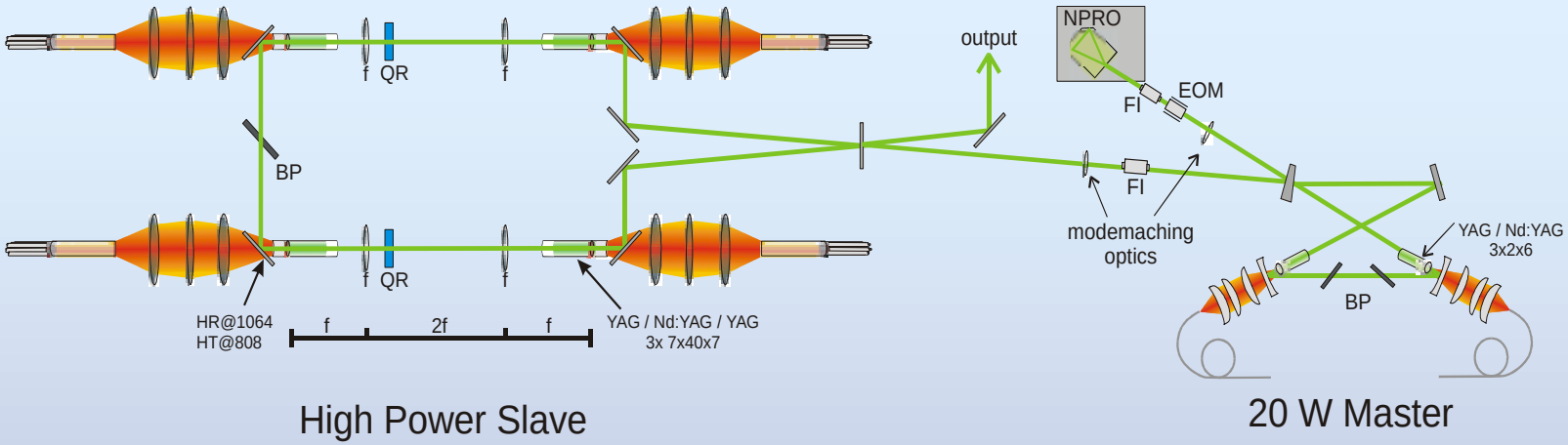
Advanced Ligo Laser 2st. Step



- Doubling laser heads to double output power !
- Thermal effects and distortions are well known !
- Birefringence compensation work !

⇒ **no indication against power scalability**

Advanced LIGO Laser Design



- Injection locking on a 20 W Master

$\Rightarrow$ above 200 W single frequency output power possible !

Outlook / Summary

- 87 W single frequency operation demonstrated
- after some optimization above 100 W possible
- Stable locking and fast relock was shown

- 1 st. Laser head design was done to get stable and reliable system for advanced LIGO
- concept and plan to scale to 200 W is prepared