

# *50 W Laser Concepts for Initial LIGO*

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**Laser Zentrum Hannover**

**LSC March 05  
Livingston**

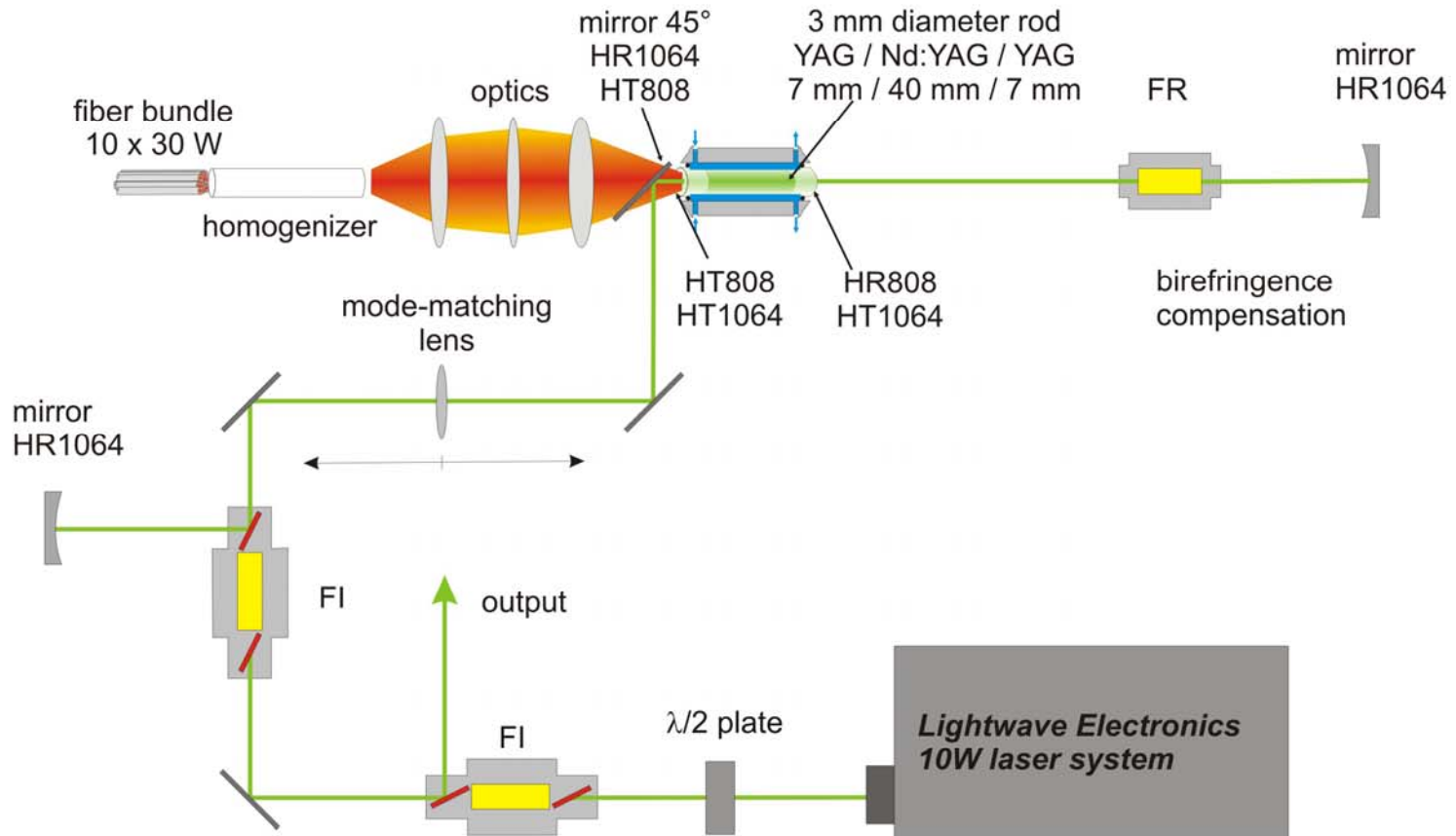
**G050161-00-Z**

# Overview:

- Two concepts for a 50W laser for initial LIGO
  - Conceptual design
  - Experimental Setup
  - Presentation of computational and measured data
- Comparison of both concepts
- Summary

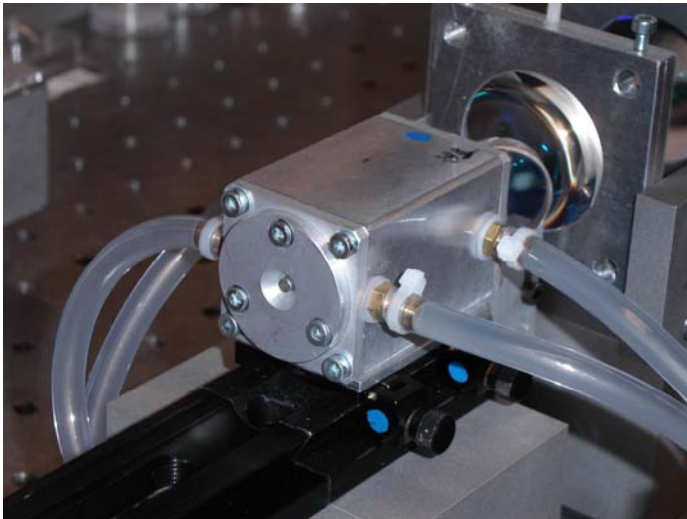
# First Concept

## High-Power Nd:YAG Multi-Pass Amplifier

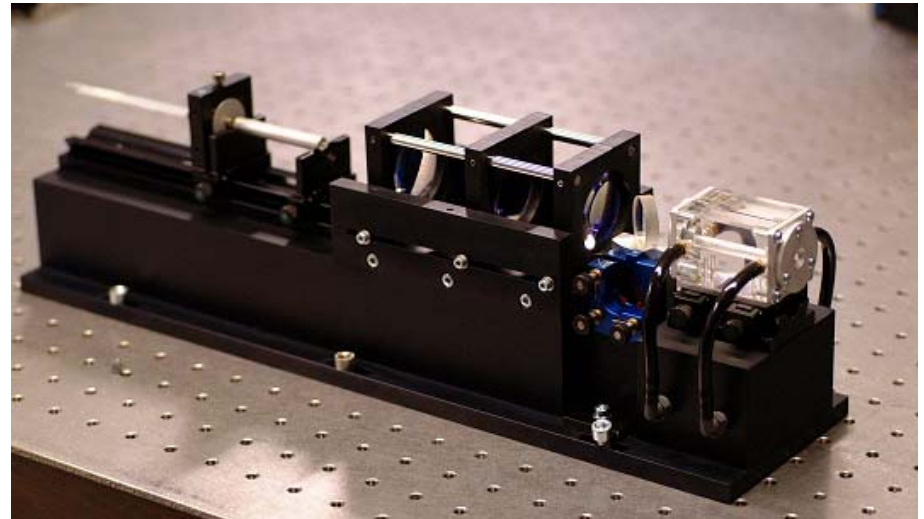


# First Concept

## *High-Power Nd:YAG Multi-Pass Amplifier*



- water-cooled rod mount
- 40 mm Nd:YAG 0.1at.% doped crystal with 7 mm undoped end caps on both sides

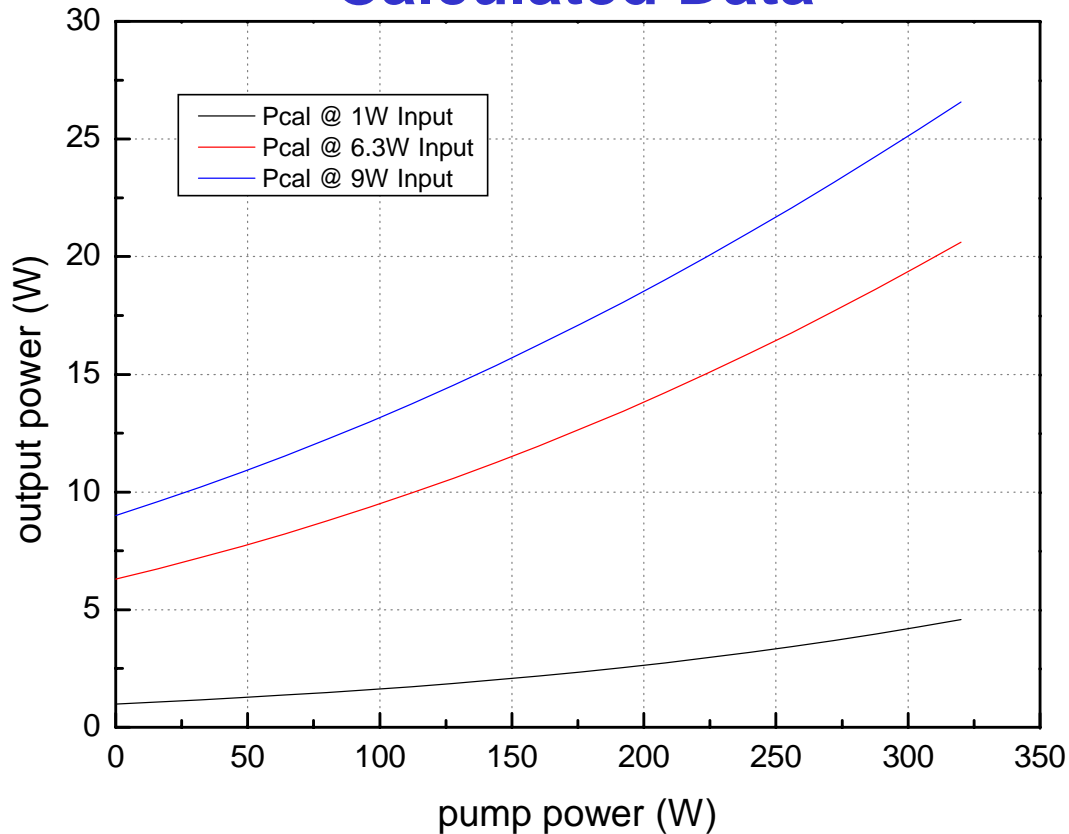


### laser-head with:

- 10x400  $\mu\text{m}$  fibers each 30 W
- pump light homogenizer
- pump light optics

# Single-Pass Output Power

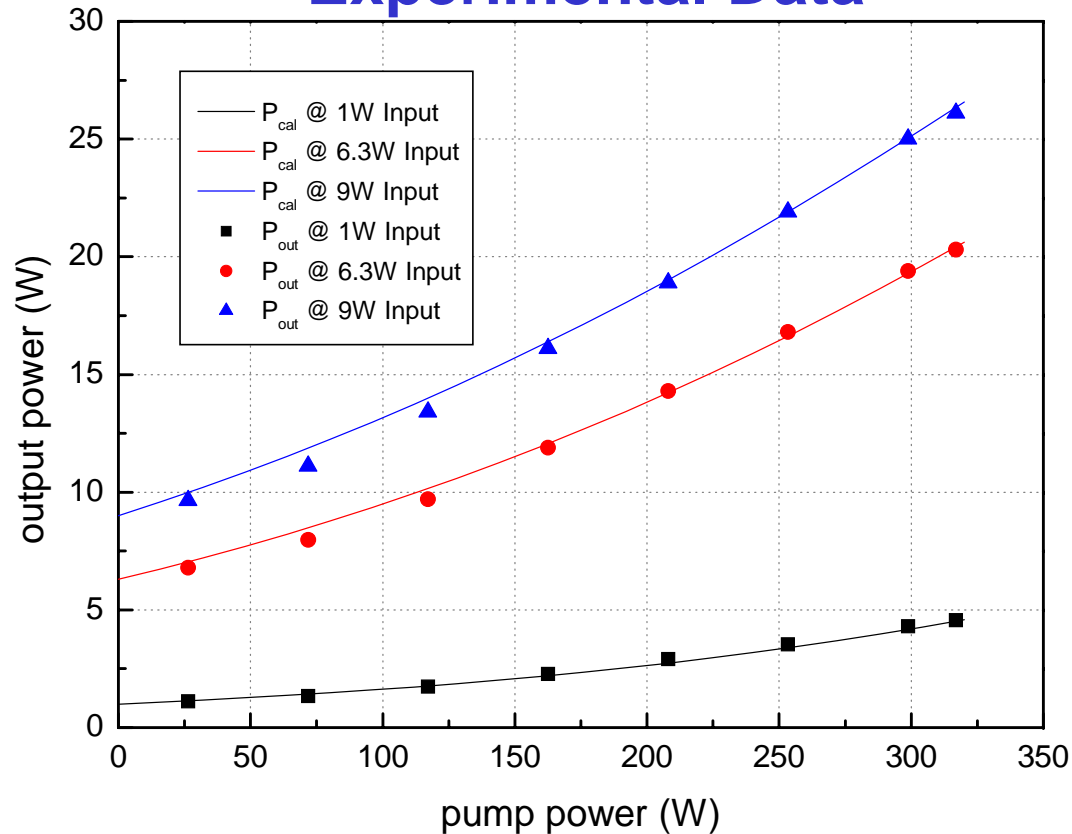
## Calculated Data



➔ max. estimated output power 26.5W

# Single-Pass Output Power

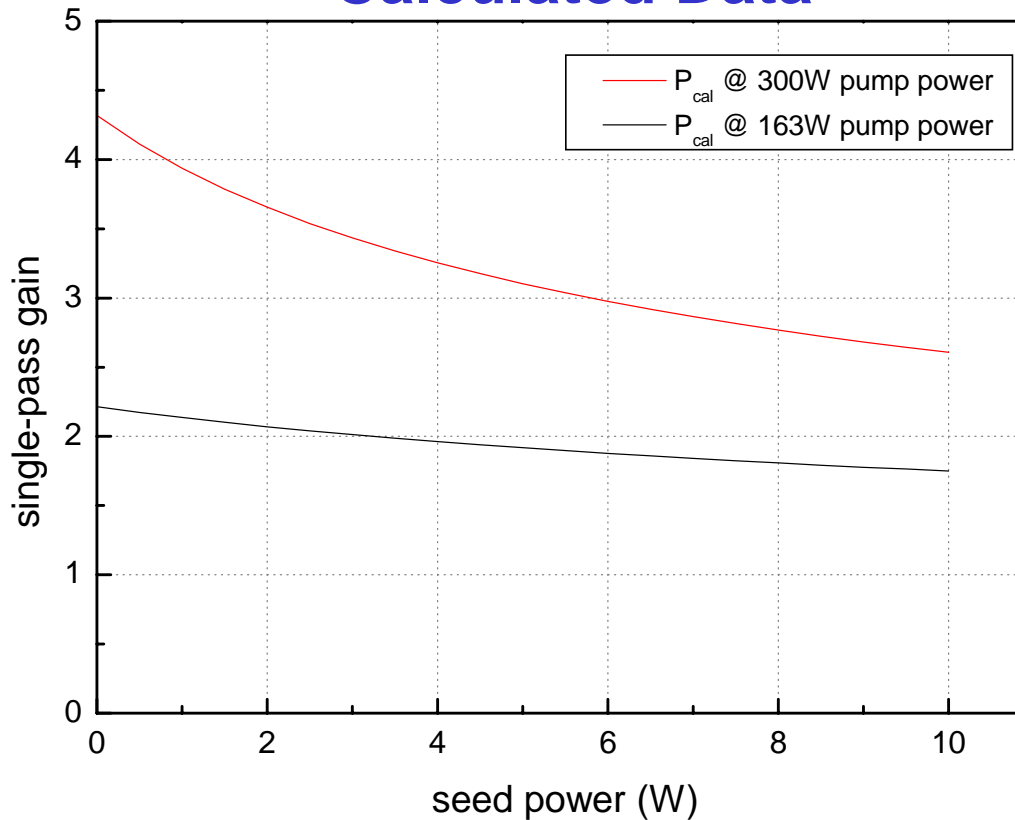
## Experimental Data



➔ max. measured output power 26.1W

# Single-Pass Gain

## Calculated Data

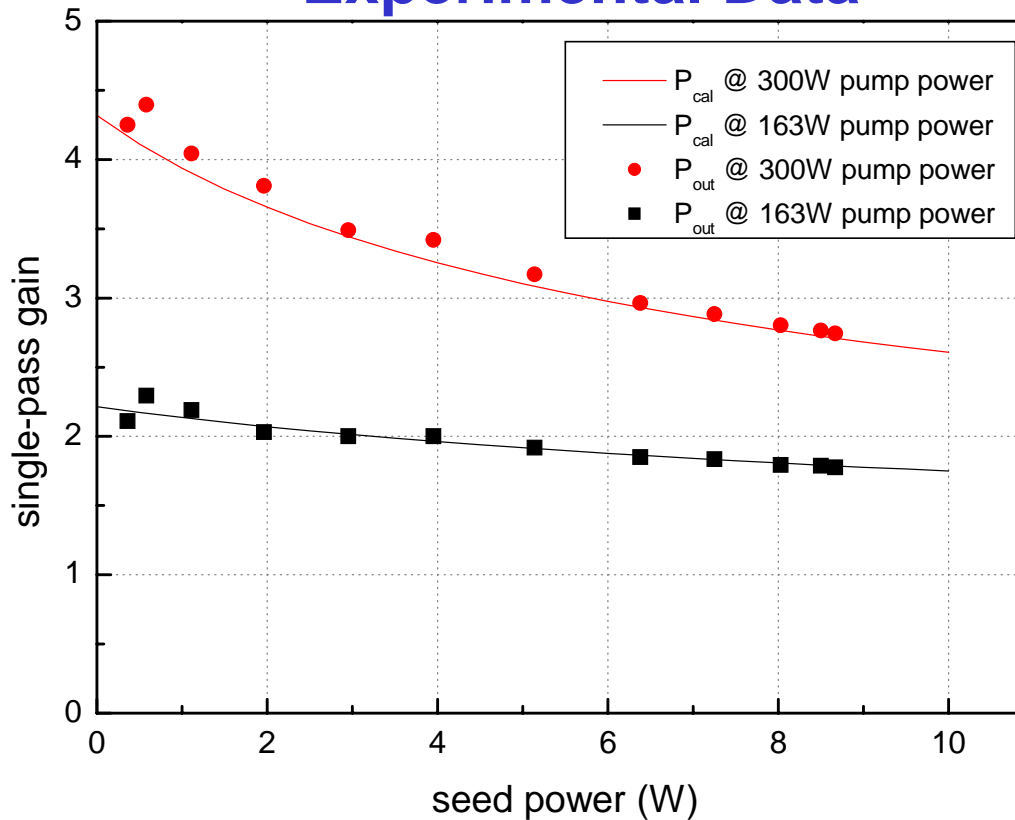


➔ max. estimated small signal gain of 4.3

@ 300W pump power

# Single-Pass Gain

## Experimental Data

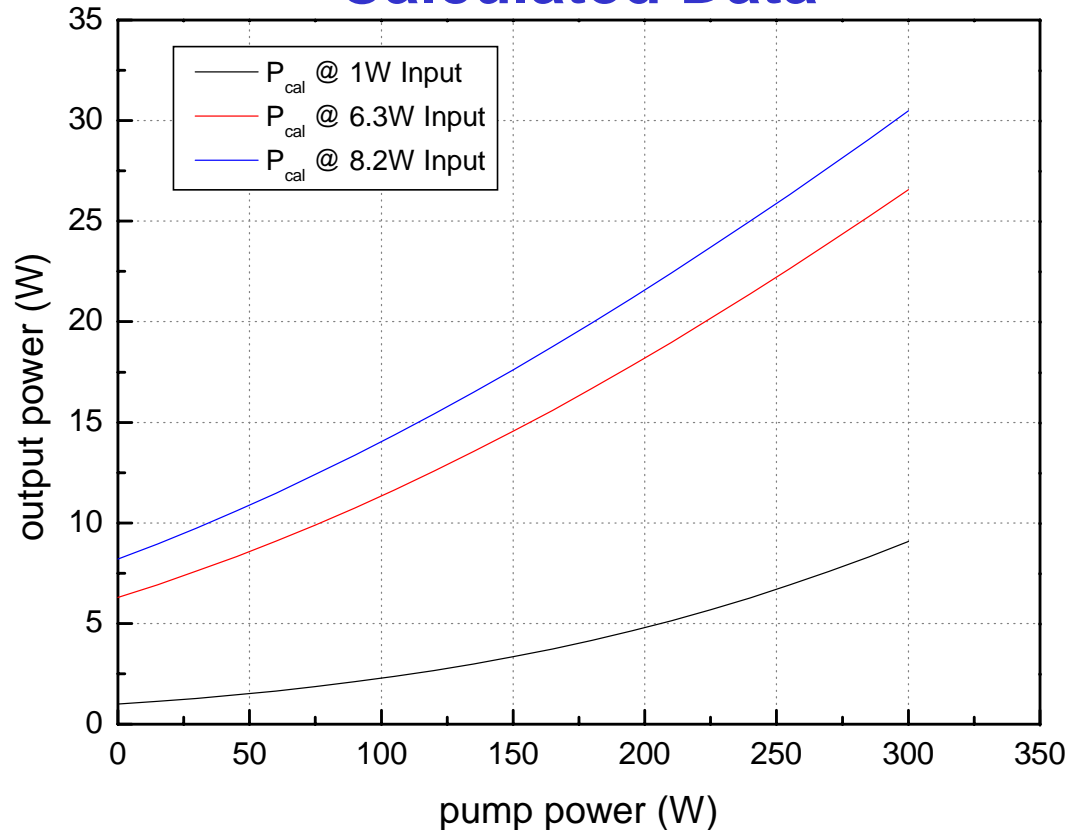


➔ max. measured small signal gain of 4.4  
@ 300W pump power



# Double-Pass Output Power

## Calculated Data

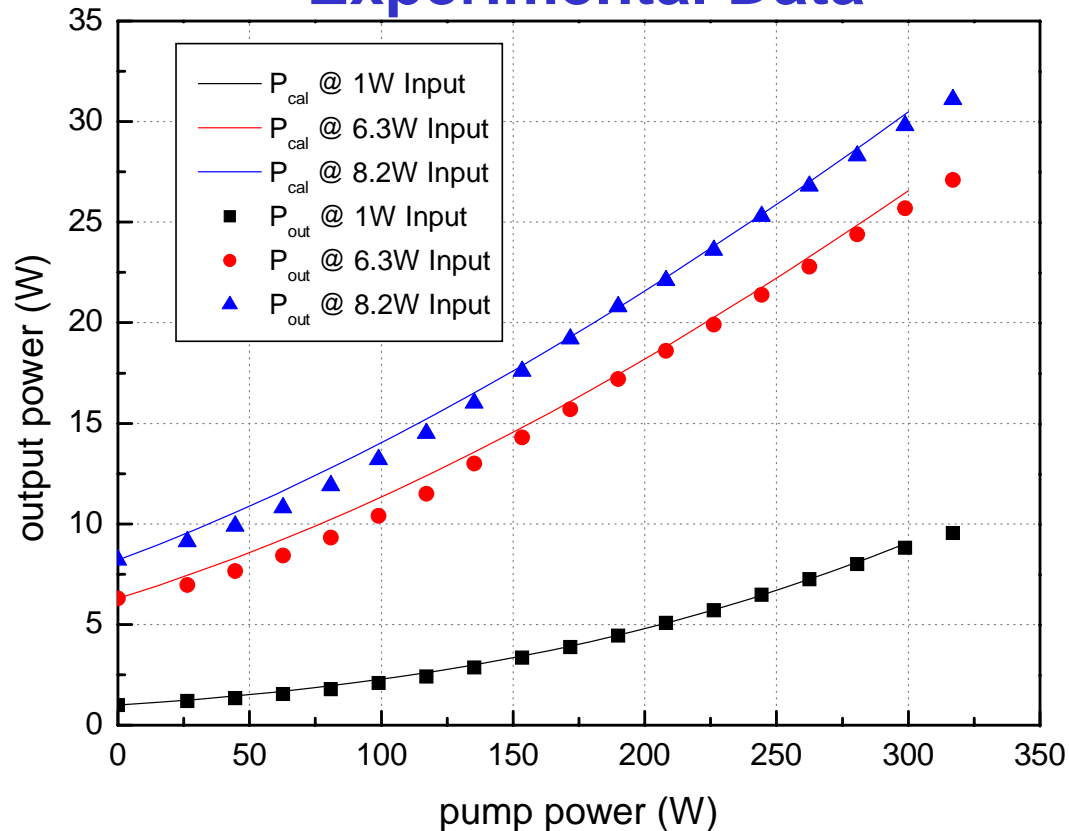


➔ **max. estimated output power 31W**

**@ 300W pump power**

# Double-Pass Output Power

## Experimental Data

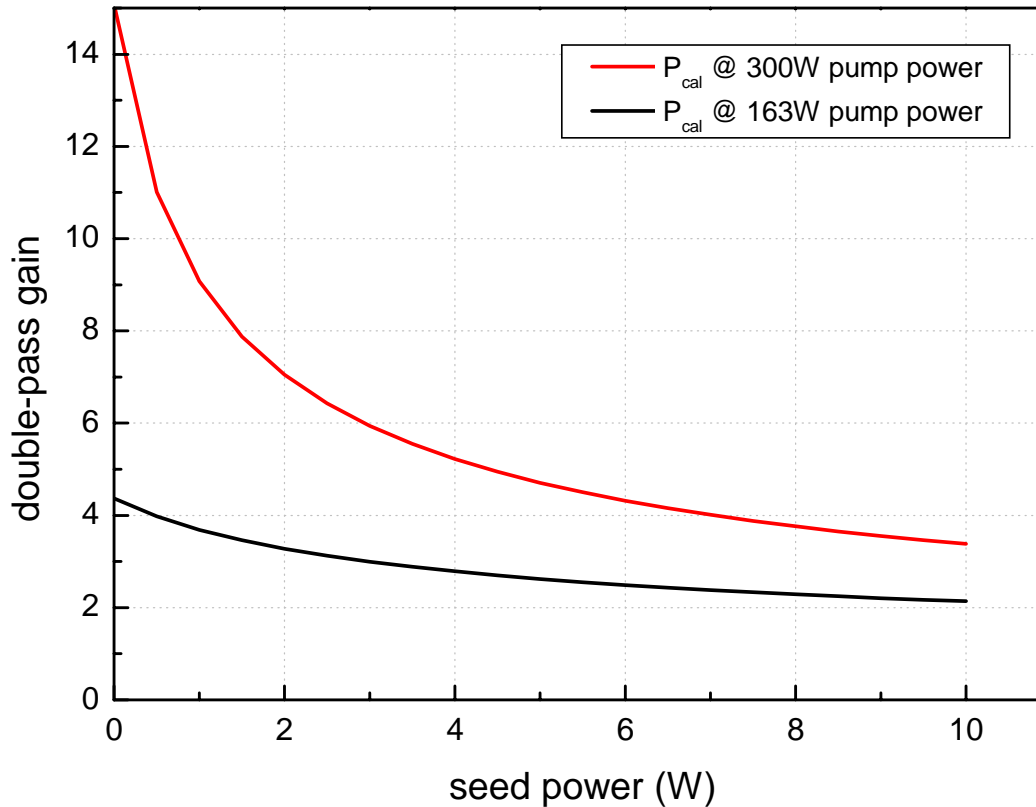


➔ max. measured output power 31.2W

@ 315W pump power

# Double-Pass Gain

## Calculated Data

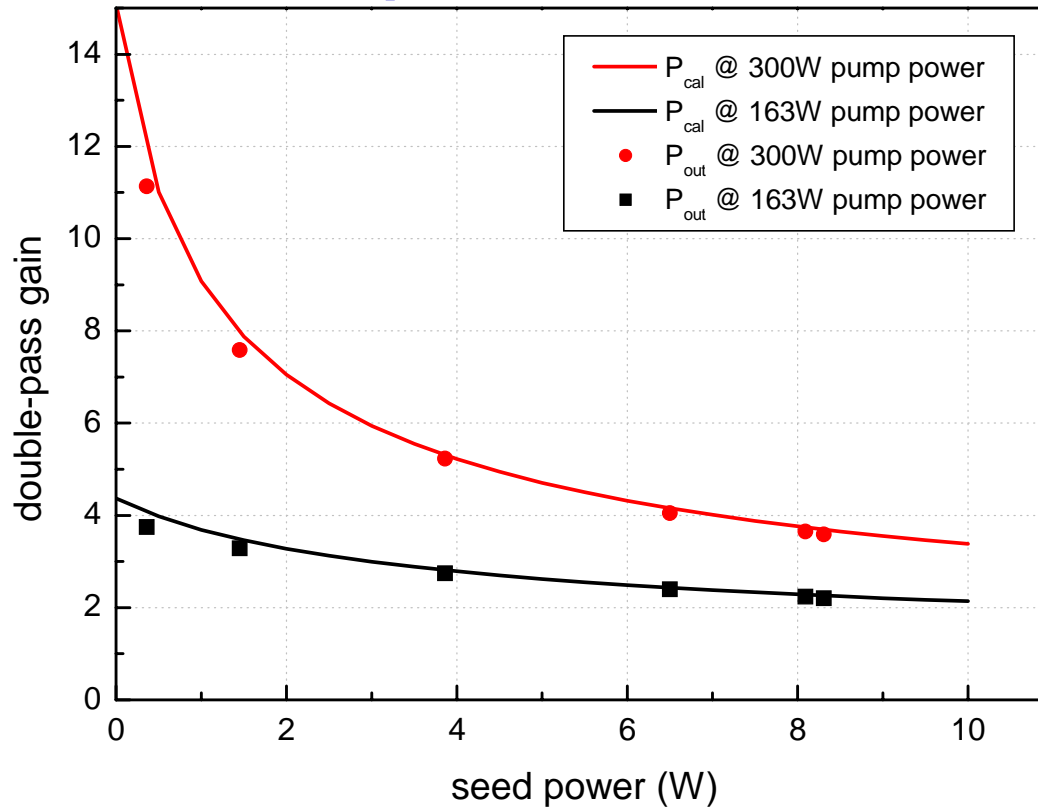


➔ max. estimated small signal gain of 15

@ 300W pump power

# Double-Pass Gain

## Experimental Data

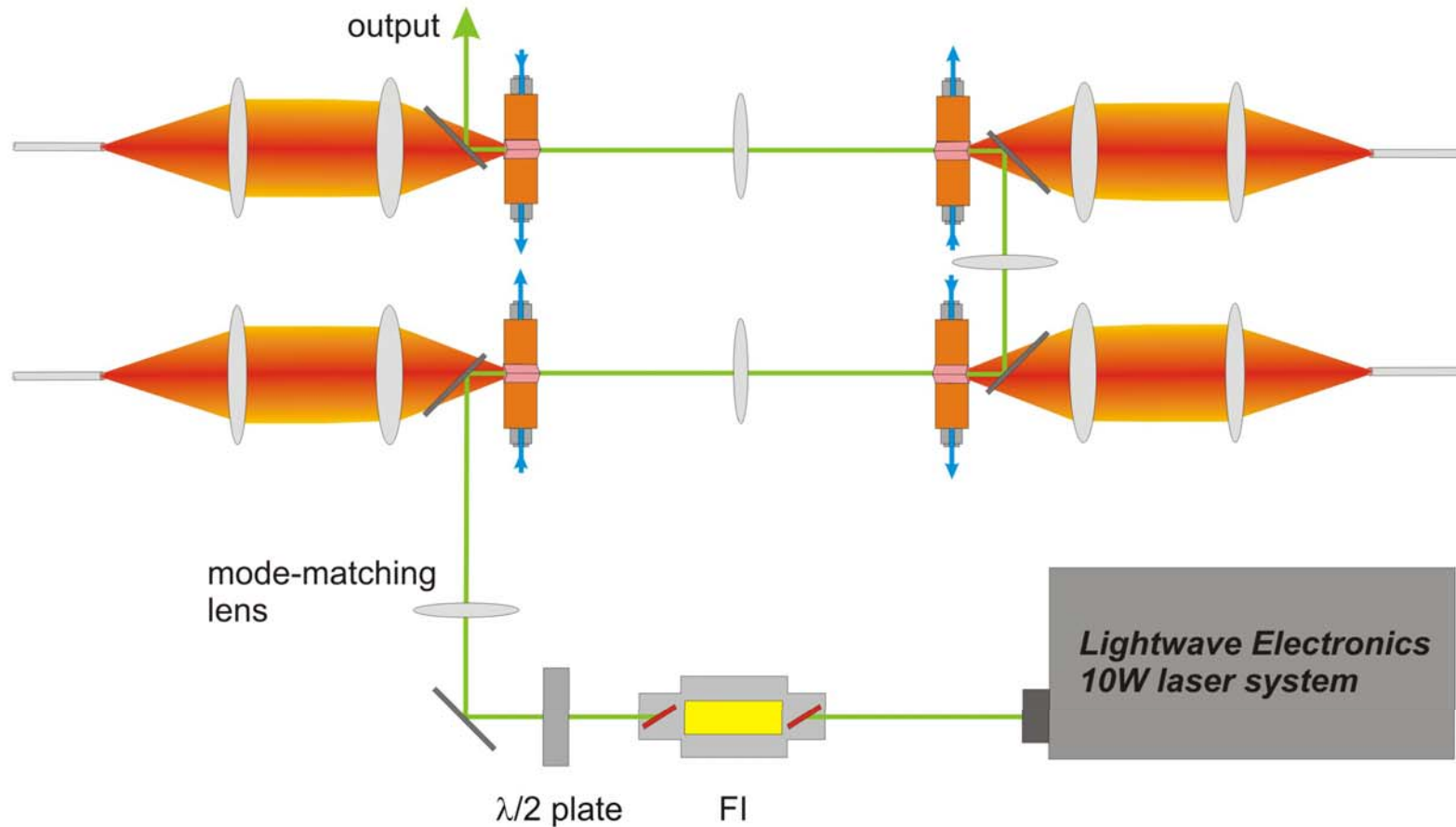


➔ max. measured small signal gain of 11

@ 300W pump power

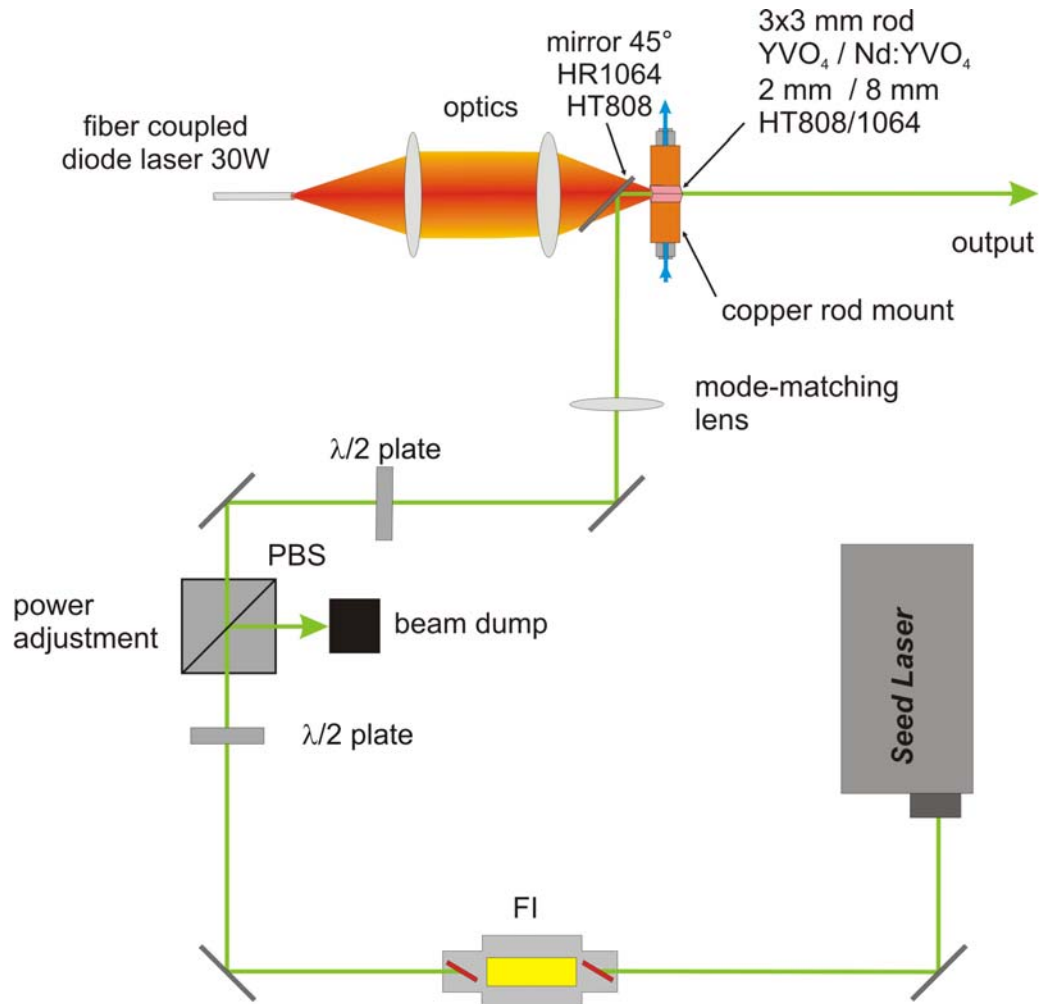
# Second Concept

## *Nd:YVO<sub>4</sub> 4 Rod Amplifier*



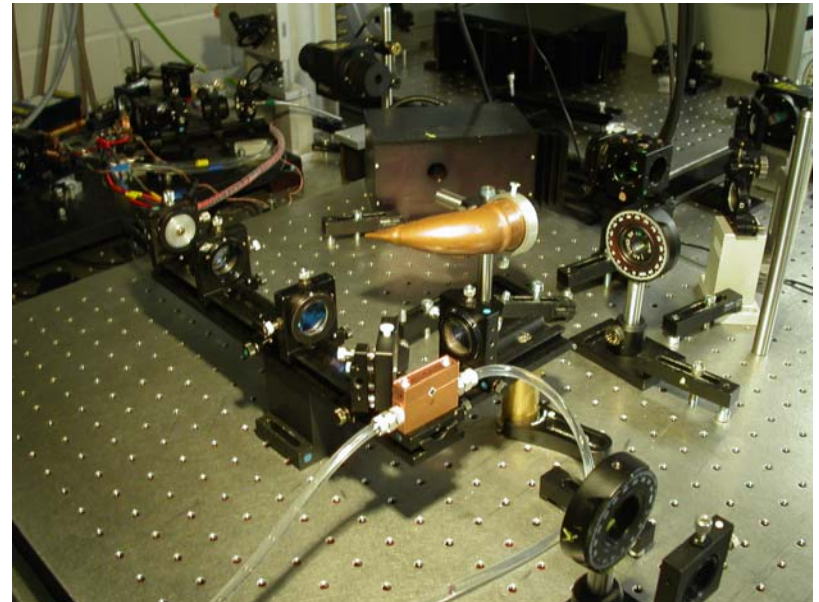
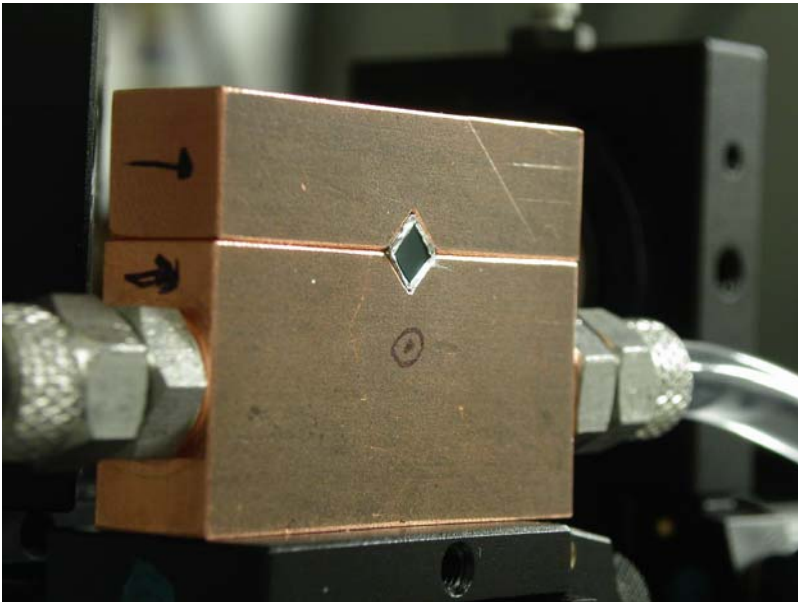
# Experimental Setup

## *Nd:YVO<sub>4</sub> Laser Amplifier*



# Experimental Setup

## *Nd:YVO<sub>4</sub> Laser Amplifier*

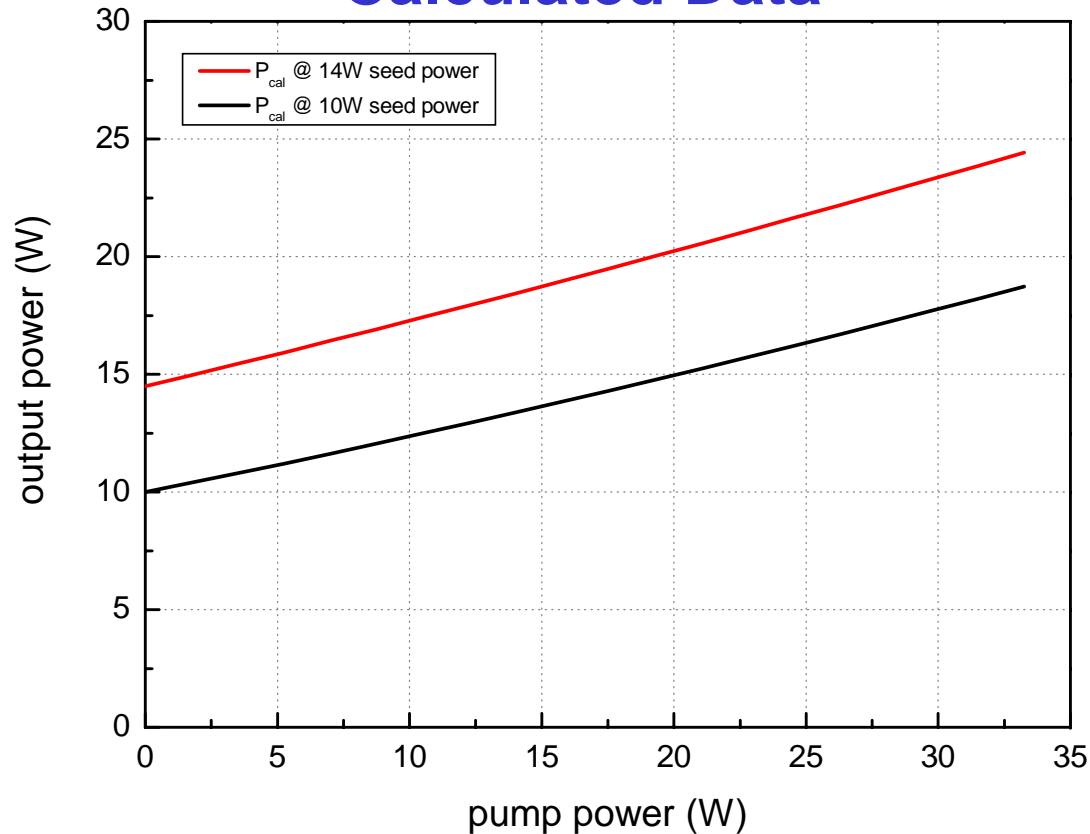


- passively cooled crystal mount
- 8 mm Nd:YVO<sub>4</sub> rod with 2 mm undoped end cap

- first experimental setup for single-pass measurements

# Single-Pass Output Power

## Calculated Data



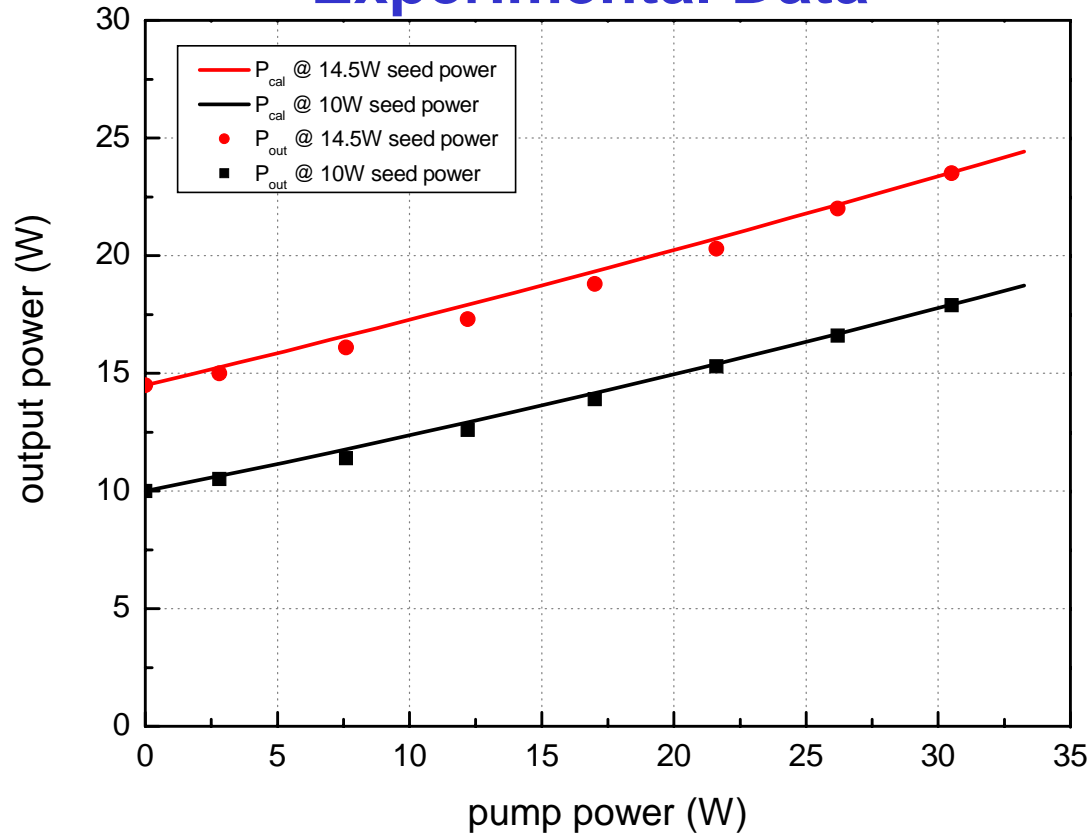
➔ max. estimated output power 18.2W

@ 10W seed power



# Single-Pass Output Power

## Experimental Data

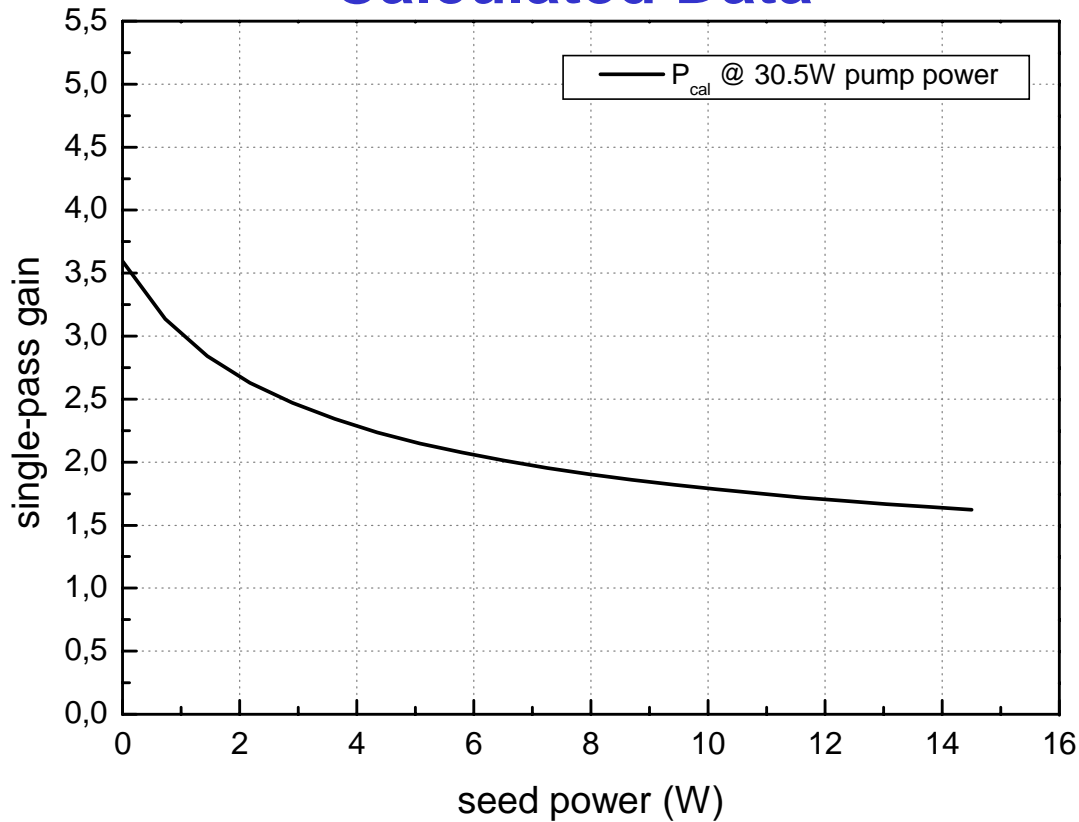


➔ max. measured output power 17.9W

@ 10W seed power

# Single-Pass Gain

## Calculated Data

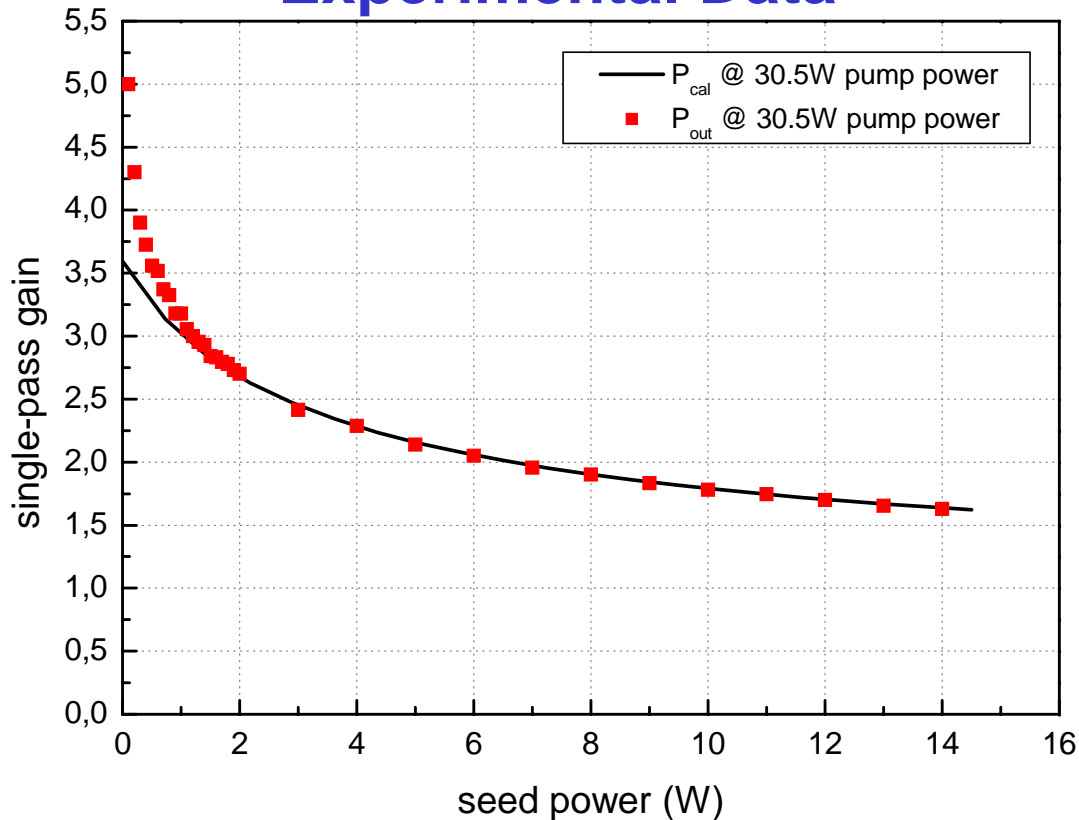


➔ max. estimated small signal gain of 3.6

@ 30.5W pump power

# Single-Pass Gain

## Experimental Data

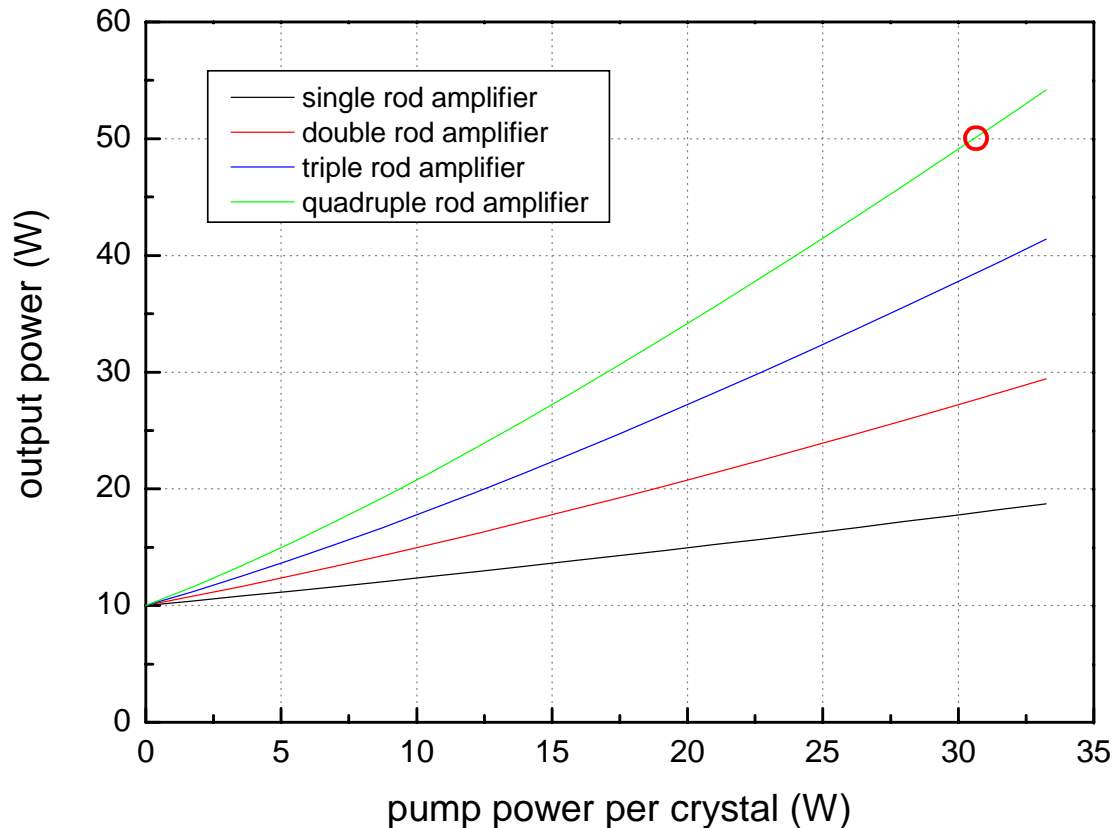


➔ max. measured small signal gain of 5

@ 30.5W pump power

# Simulation of a 4 Rod Amplifier

Amplifier with multiple single-pass rod cascade  $P_{in} = 10W$



➔ **estimated output power 50W  
@ 125W pump power**

# Comparison of Both Concepts

## Nd:YAG Amplifier

## Nd:YVO<sub>4</sub> Amplifier

Single-pass output power  
at 10W seed power:

26.1W

17.9W

Single-pass opt.-opt.  
efficiency:

8.3% in single-pass  
operation  
at 315W pump power

26% in single-pass operation  
at 30.5W pump power  
Estimated efficiency of 40%  
for 4 rod cascade

Depolarization  
compensation:

thermal birefringence  
=> compensation required

natural birefringence  
=> no compensation  
necessary

Mechanical design:

water-cooled rod mount

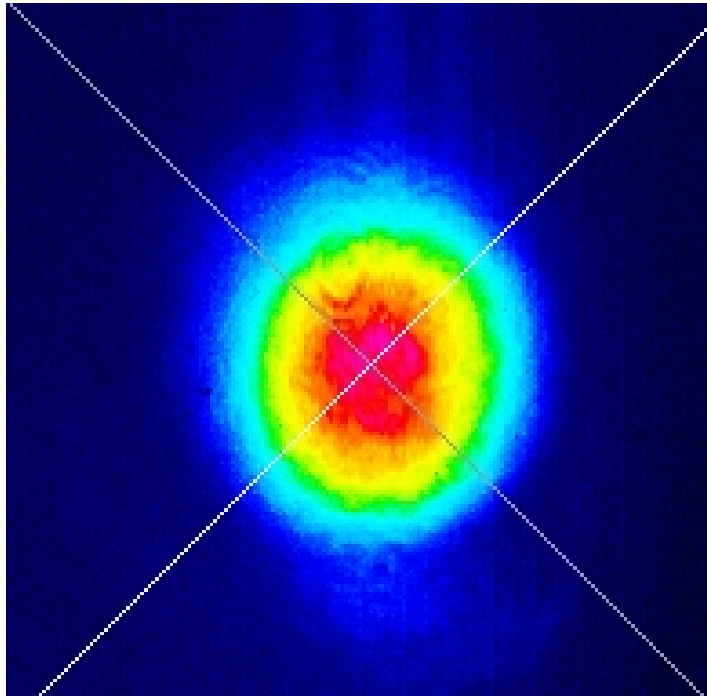
passively cooled rod mount

## *Summary*

- Both concepts seems to be suitable for the 50W initial LIGO laser
- More experimental measurements and simulations have to be performed to make a final decision

# *Beam Profile Measurements*

Seed source



Full pumped amplifier

