High-Power Single-Frequency Nd:YAG Laser for Gravitational Wave Detection

Maik Frede, Ralf Wilhelm, René Gau, Martina Brendel, Ivo Zawischa
und Carsten Fallnich

Laser Zentrum Hannover
contact: mf@lzh.de

Frank Seifert und Benno Willke

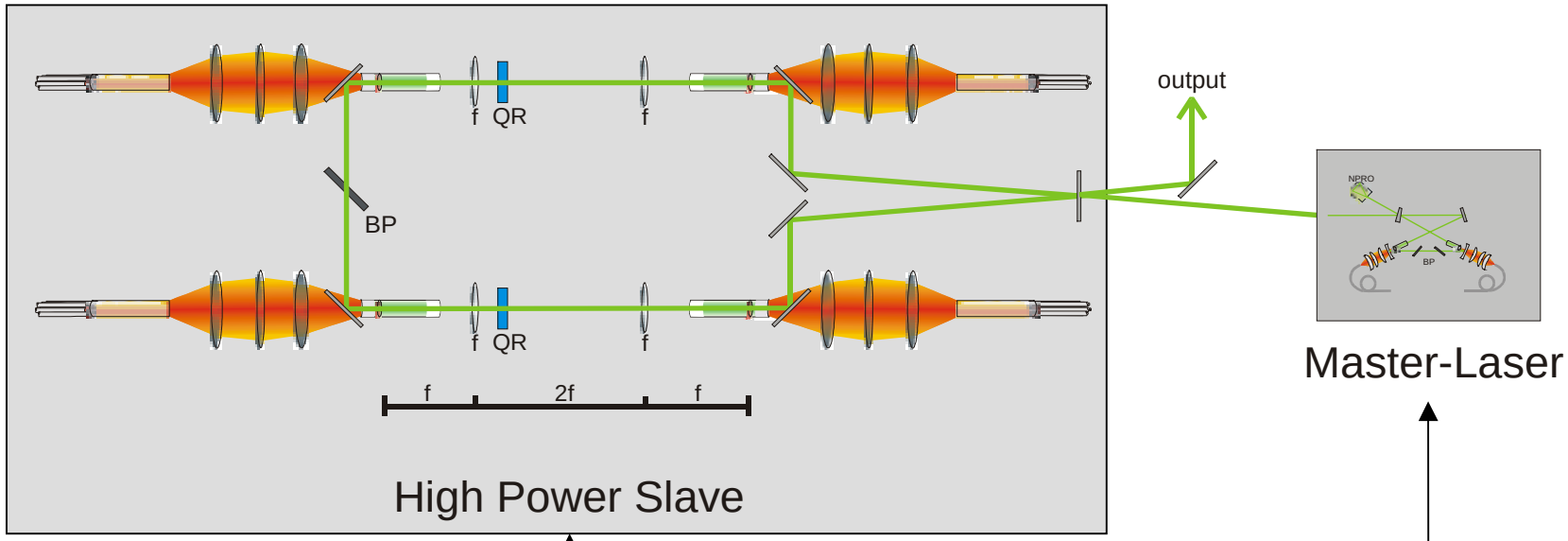
Albert-Einstein-Institut
für Gravitationsphysik Hannover

5 th Amaldi Conference

Laser Source for Advanced GWD

- ~ 200 W $TEM_{0,0}$
  - < 5% in higher order modes
- single frequency operation
- low frequency / amplitude noise
- high long term stability
  - high reliability
  - easy maintenance

Concept



P ~ 250W

M^2 ~ 1

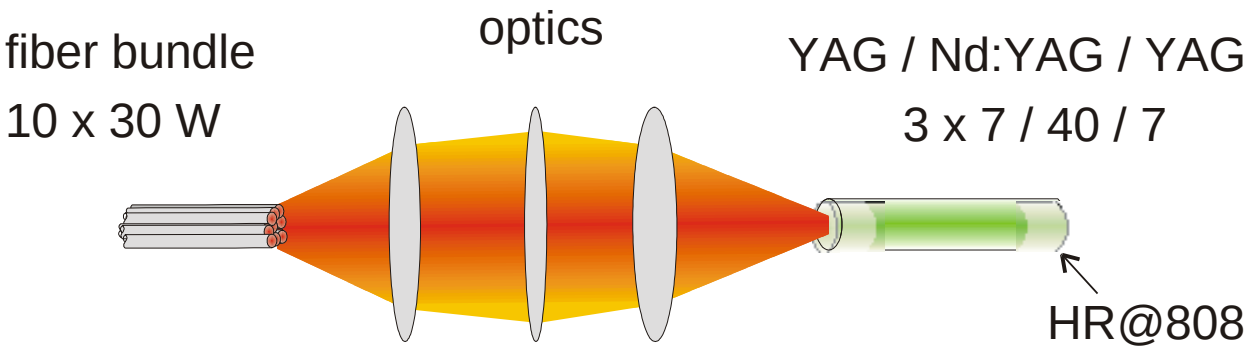
from simulations

Pound-Drever-Hall Injektion-locking

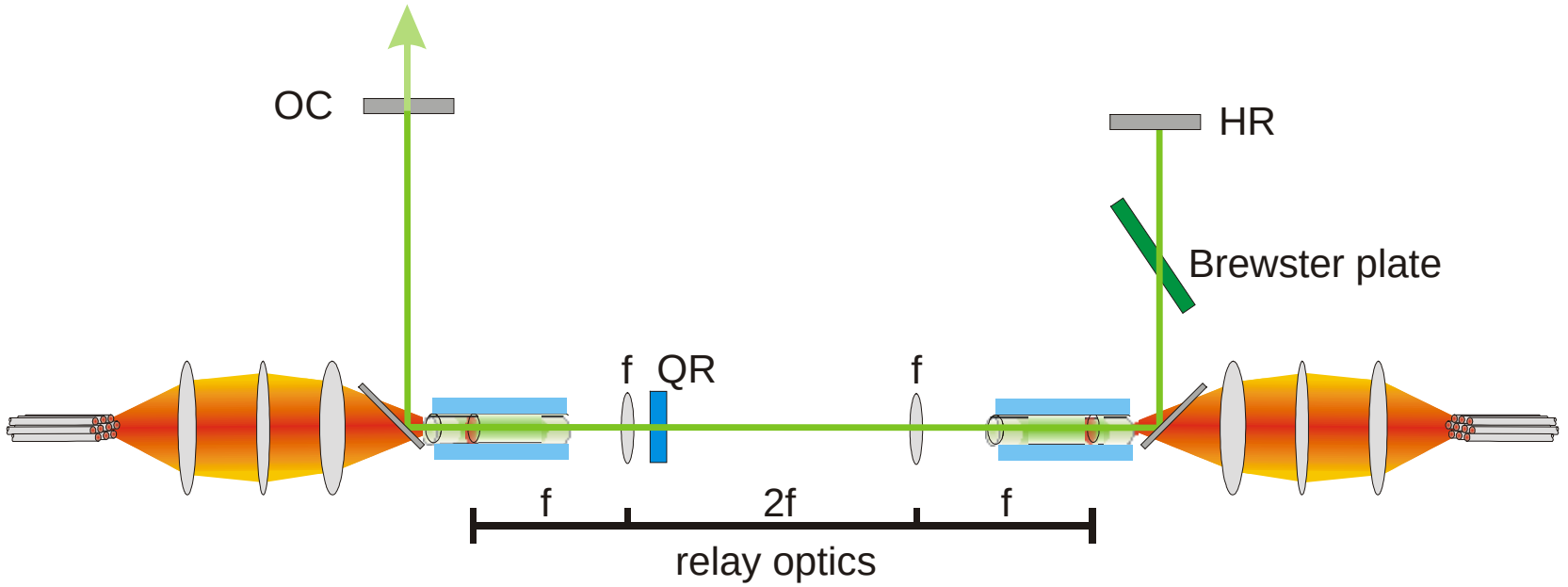
Why End-Pumping Rod Design ?

- laser rods → proved design
- cylinder symmetry → $TEM_{0,0}$
- end-pumping
  - high efficiency → good mode / pump overlap
  - good mode control → mode-selective pumping
  - conductive cooling → no water at the laser-crystal
  - fiber coupled pump → high reliability / easy maintenance

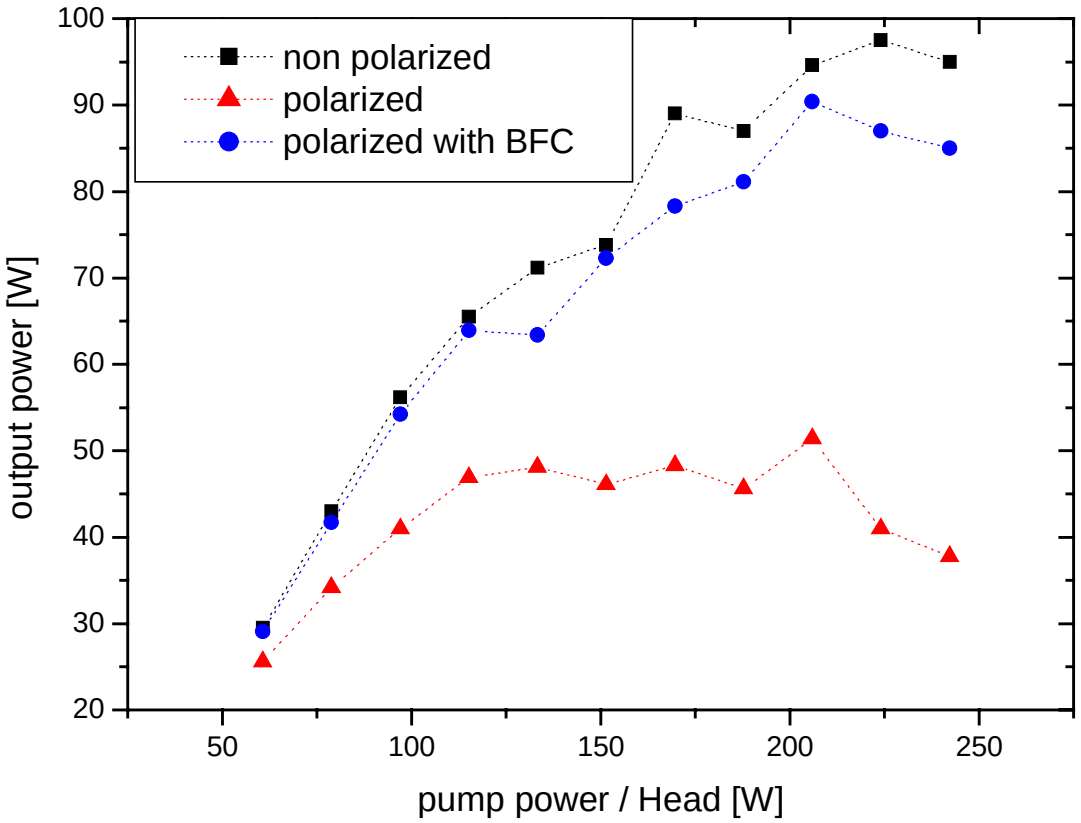
+ possibility of birefringence compensation



Birefringence Compensation

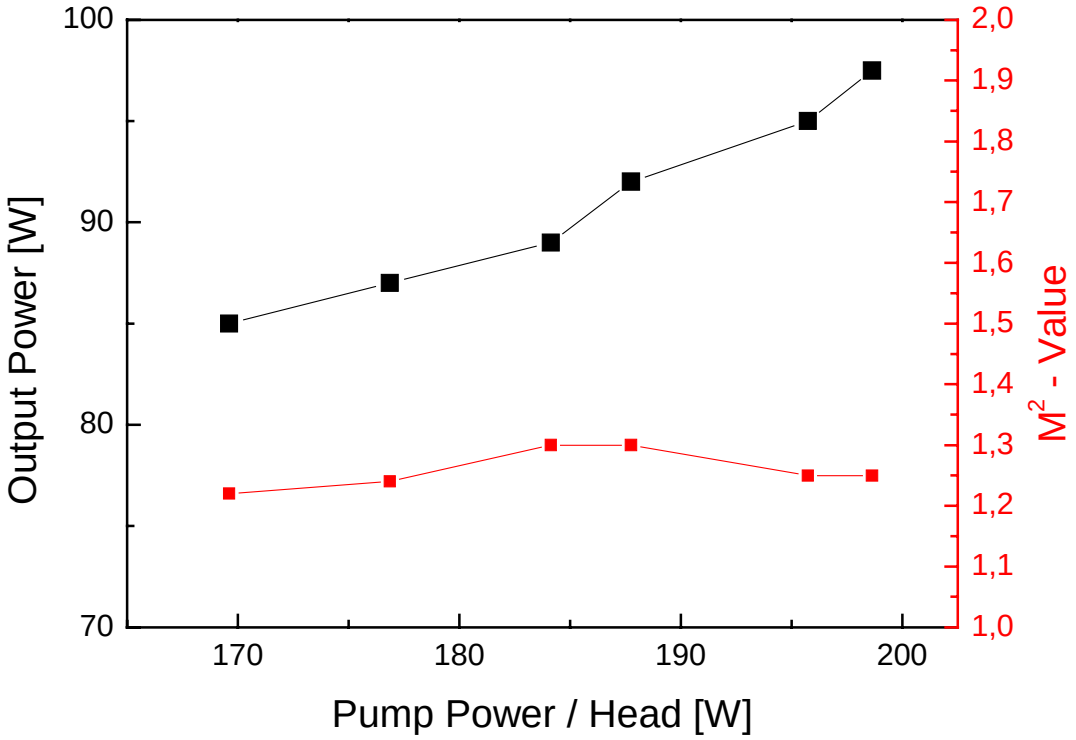


Efficiency of Birefringence-Compensation



⇒ compensation doubles lin. pol. output power

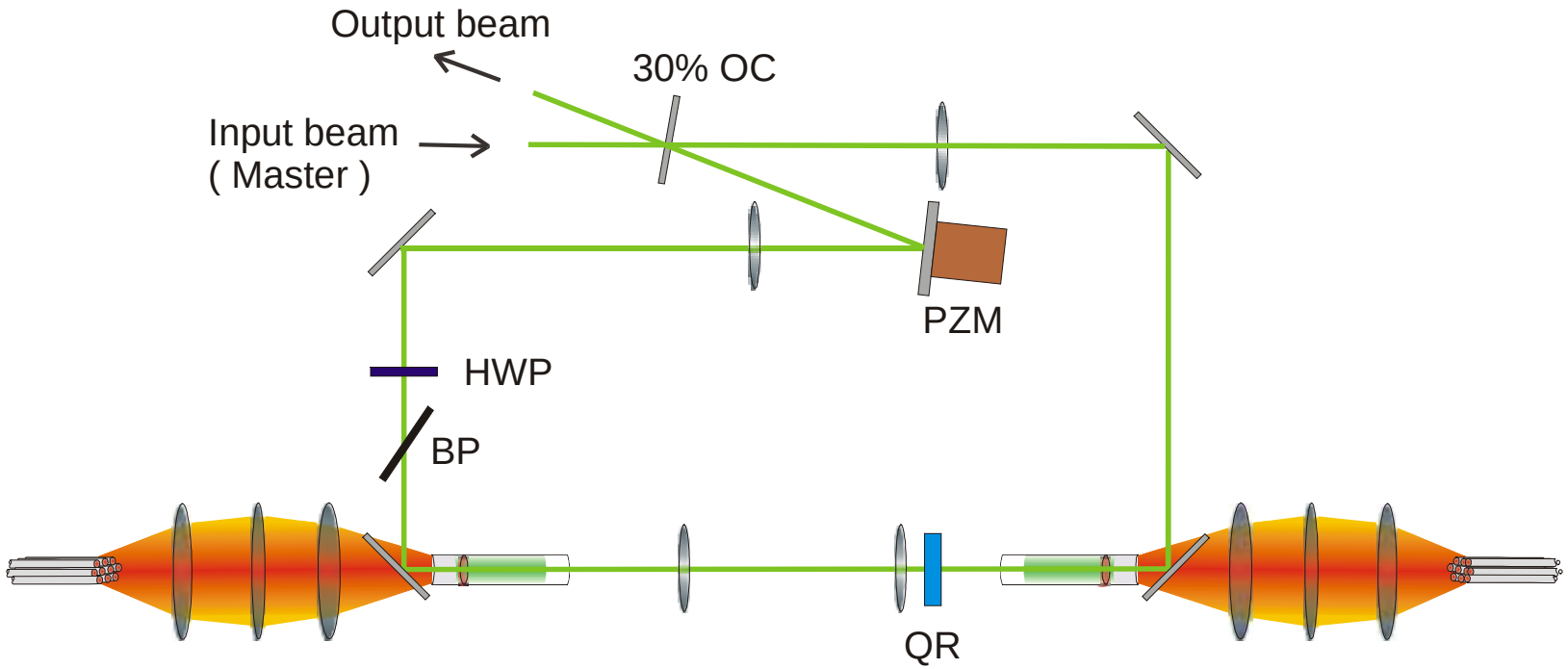
Fundamental Mode Operation



P:	97 W
$M^2_{x,y}$:	1.25
$\eta_{opt.}$:	25%
depol.-loss :	< 0,5%

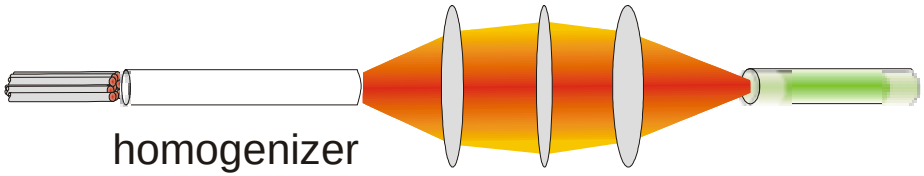
⇒ concept works for high power fundamental mode lasers

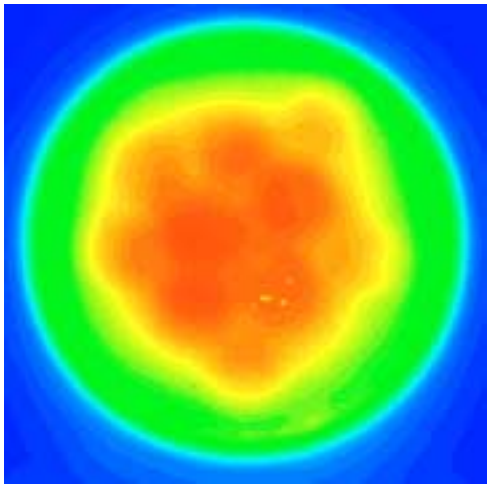
Single-Frequency Operation



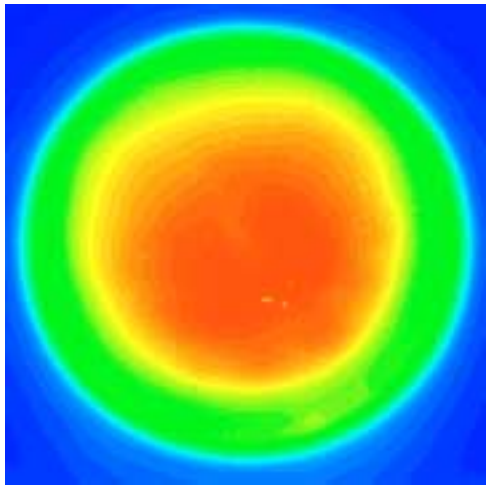
P: 87 W $M^2_{x,y}$: 1.1 $\eta_{opt.}$: 24%

Pump-Light Homogenization





fluorescence w/o homogenization

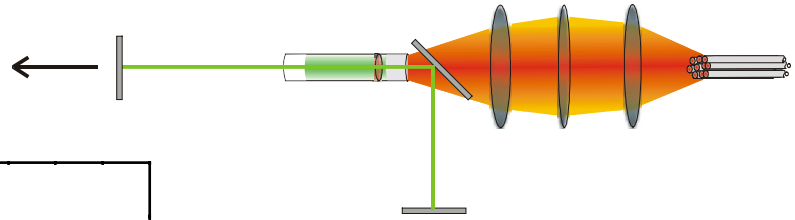


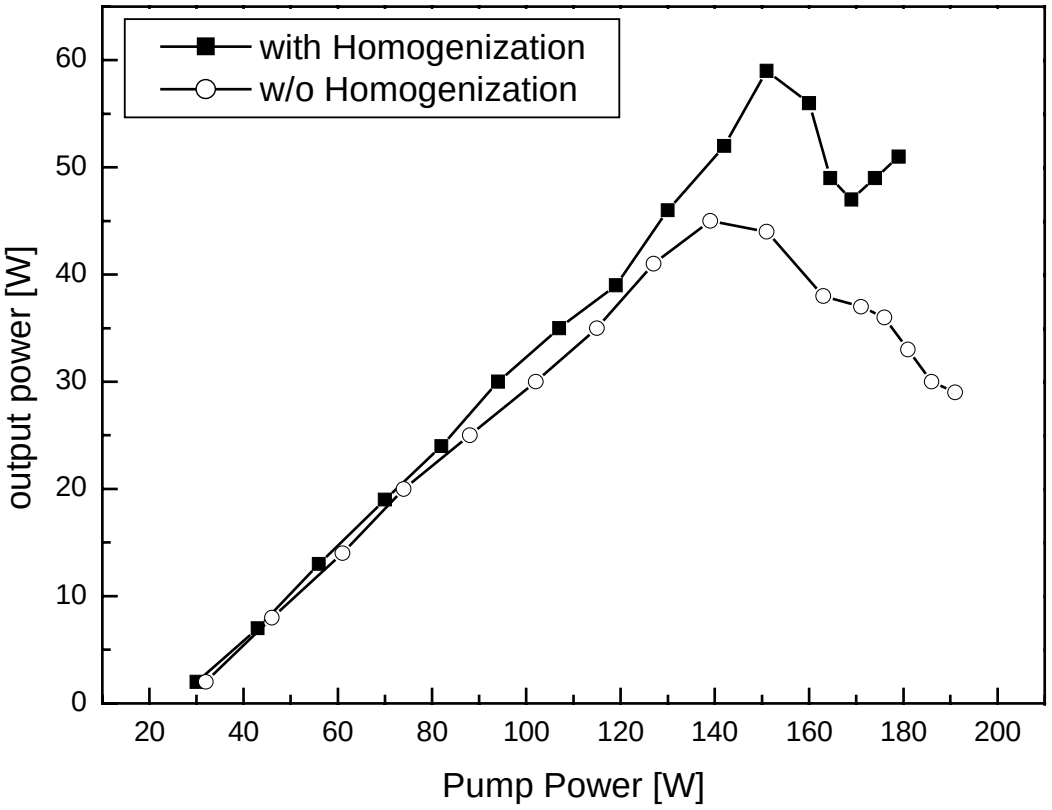
fluorescence with homogenization

⇒ more homogeneous and uniform pump-light distribution

⇒ compensation of laser diode degradation and failure

Pump Light Homogenization

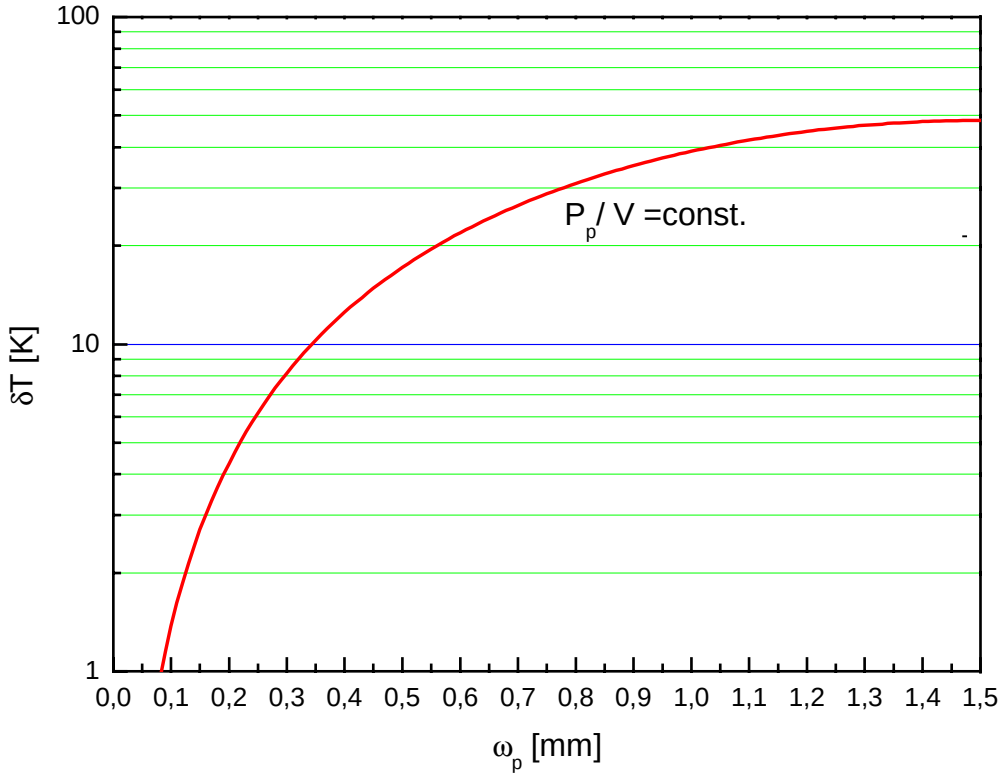


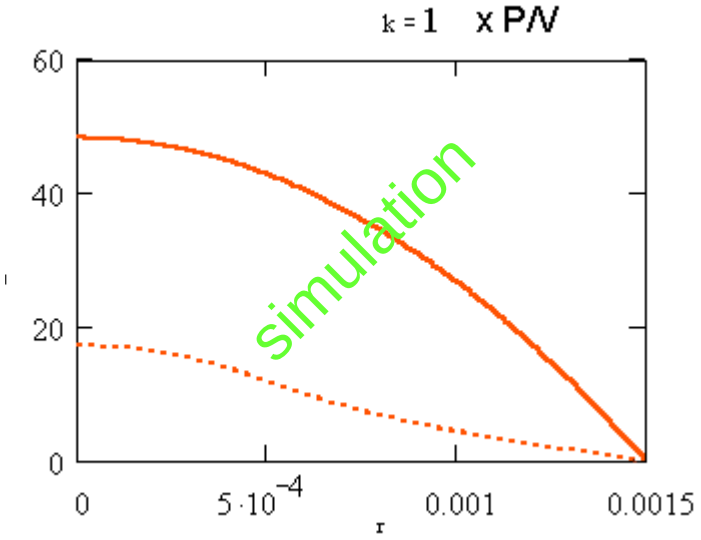


⇒ 30 % more output power with homogenization

⇒ better gain overlap and less distortion for low order modes

Optimized End-Pumping

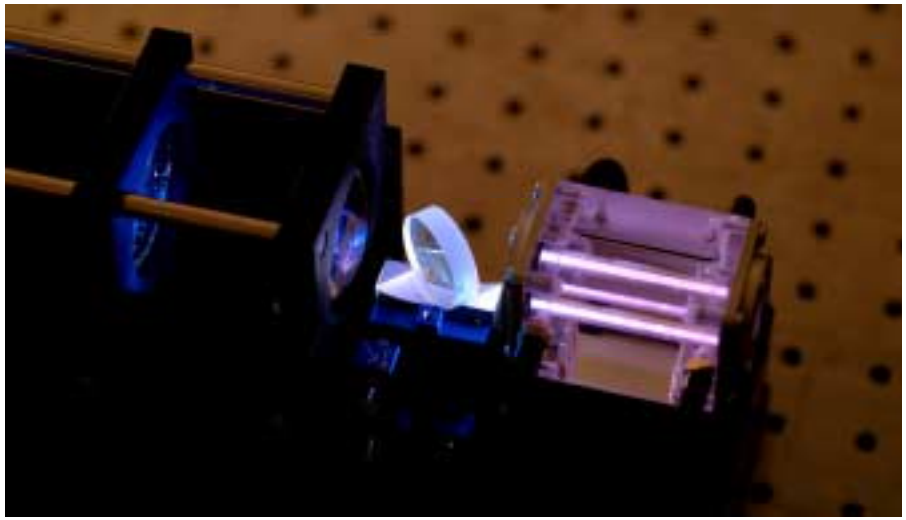


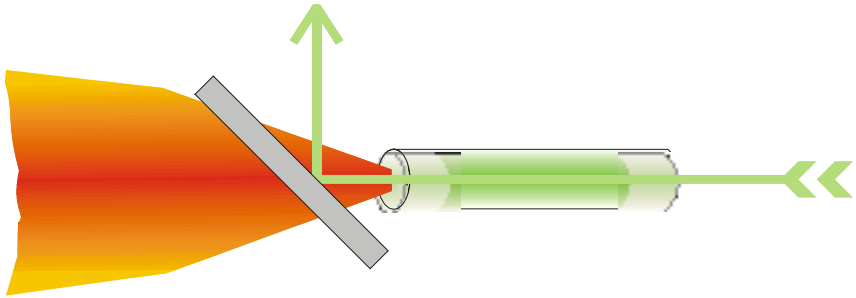


Measurement Setup

laser-head characterization:

- thermal lens
- aberrations
- depolarization
- small signal gain

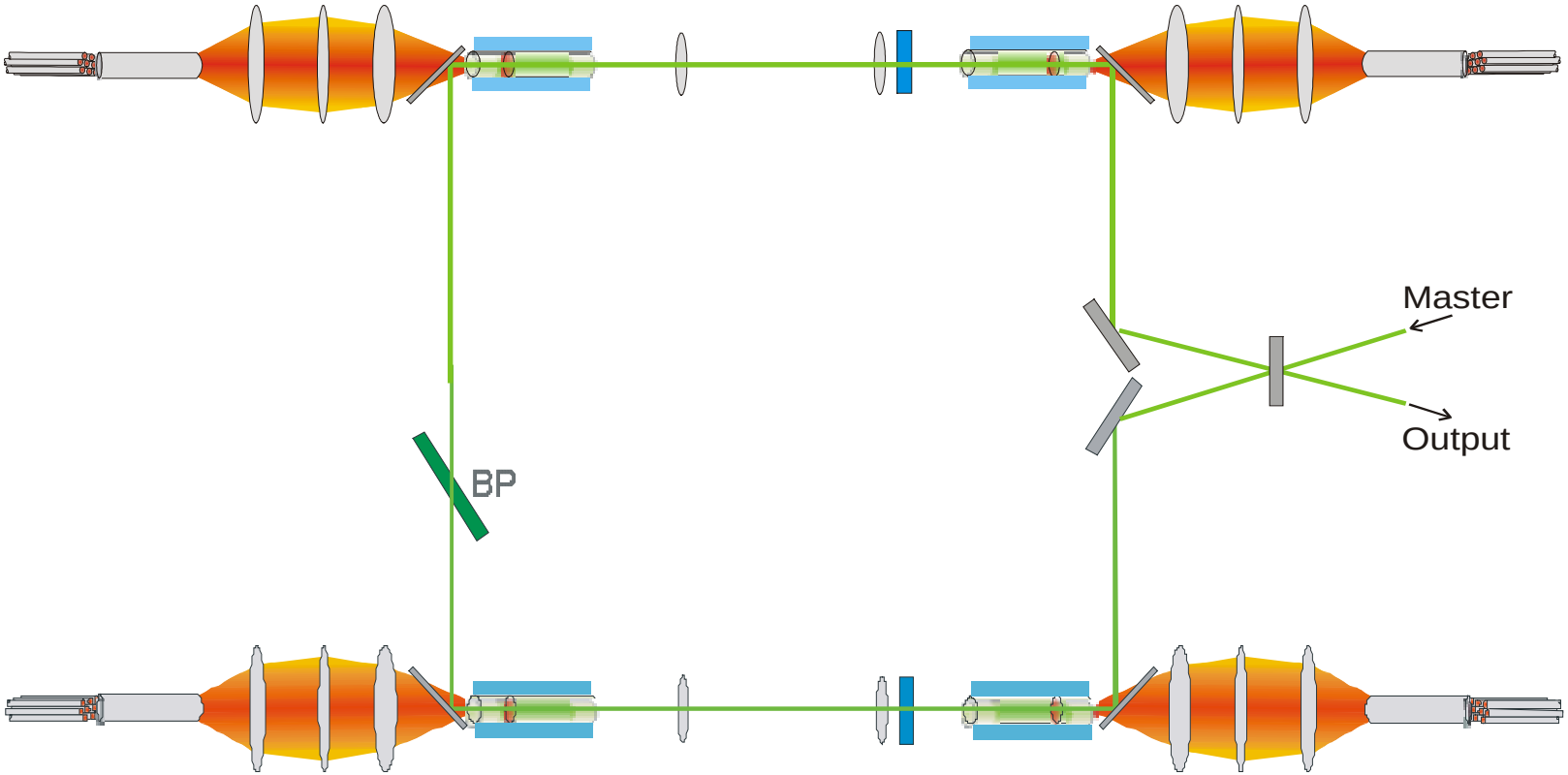




tunable fiber laser

⇒ optimized pump-spot with highest gain
and smallest distortions

High Power Scaling



⇒ no unknown thermal effects

⇒ no increase of circulating power by change from standing wave to ring resonator

Summary and Outlook

- in standing wave and also in ring-resonator configuration an effective compensation of the thermal induced birefringence was demonstrated
- results:
  - 97 W linear polarized fundamental mode
  - 87 W single frequency

- optimizing head design and pump-light distribution
- increase output power to 200 W