



# Status of the Advanced LIGO PSL development

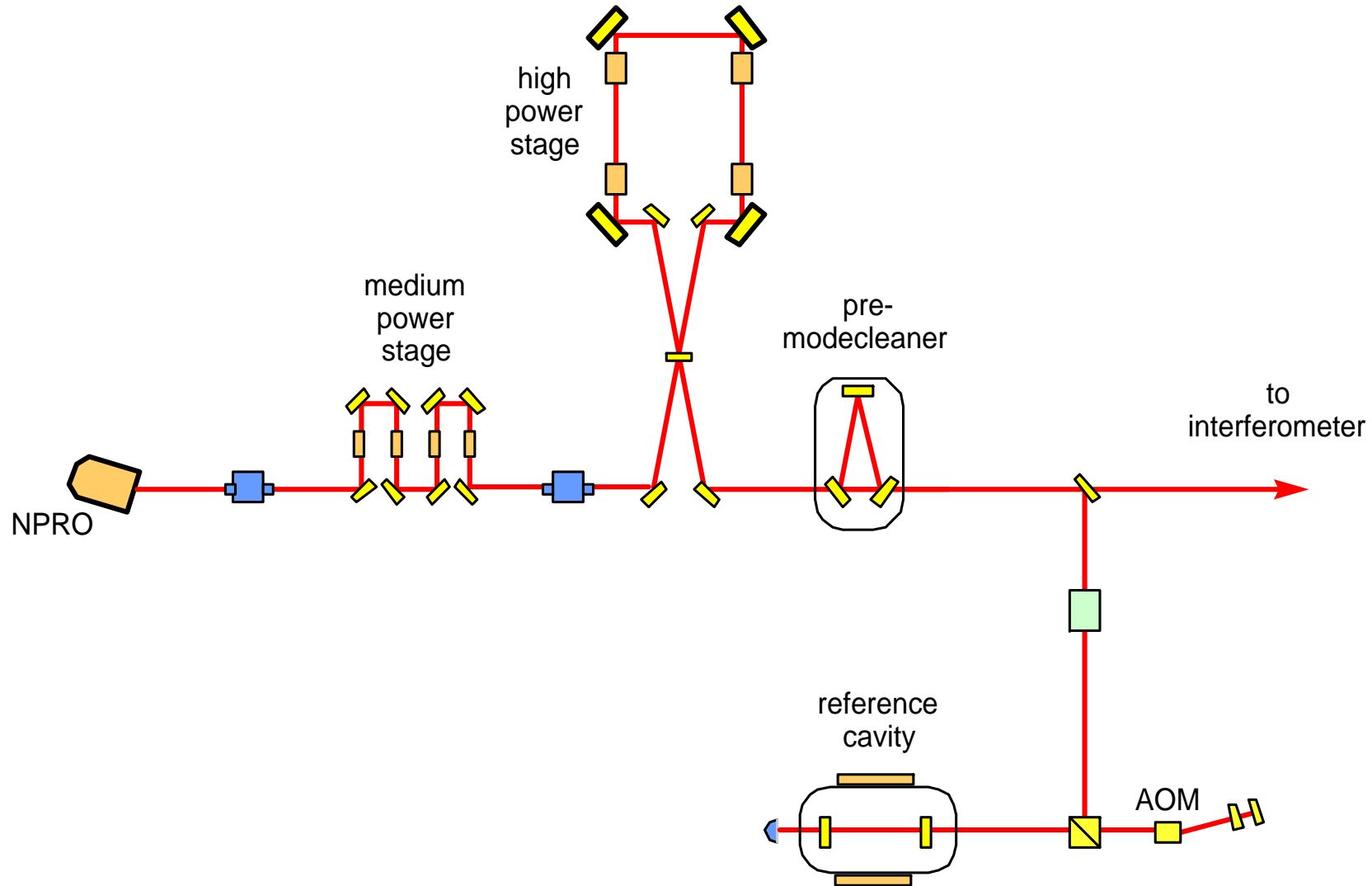
Benno Willke  
for the PSL team

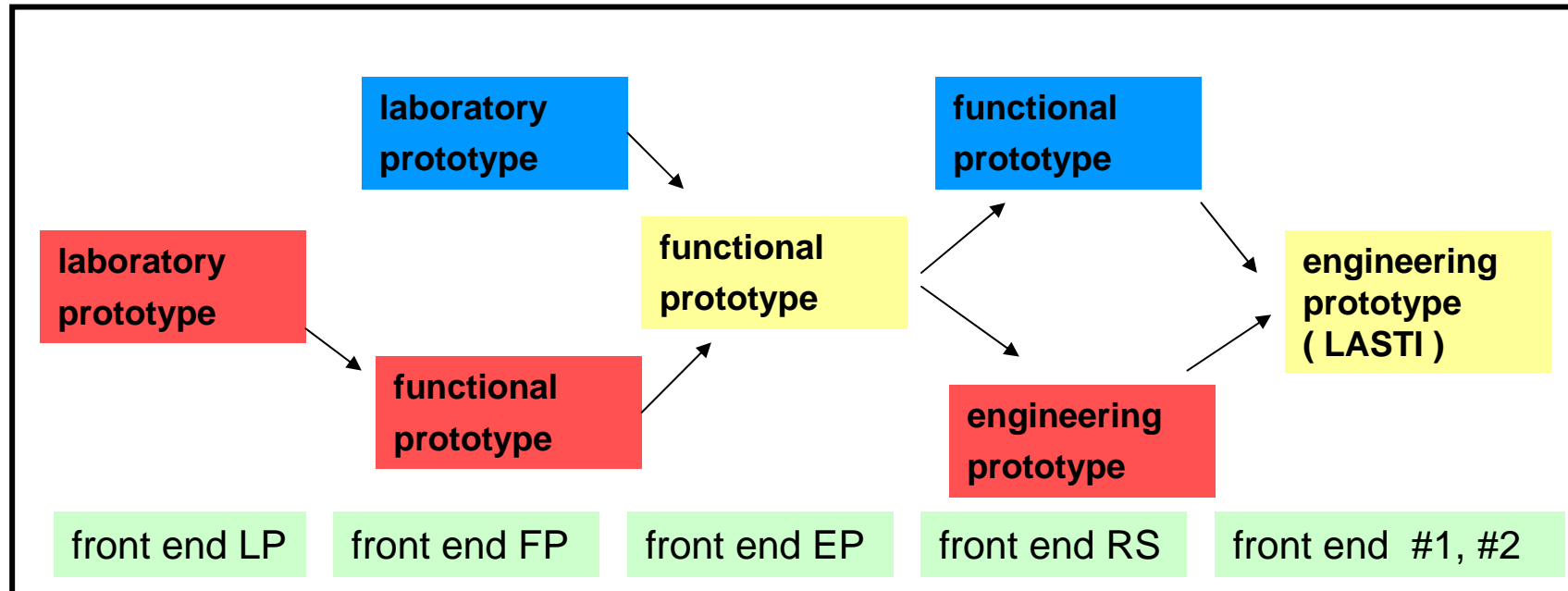
LSC meeting, Baton Rouge March 2007

G070137-00-Z



# Advanced LIGO prestabilized laser





- stabilization development
- laser development
- integration laser – stabilization

**laboratory prototype:** demonstrate concepts  
**functional prototype:** demonstrate specs  
**engineering prototype:** fit / form / function



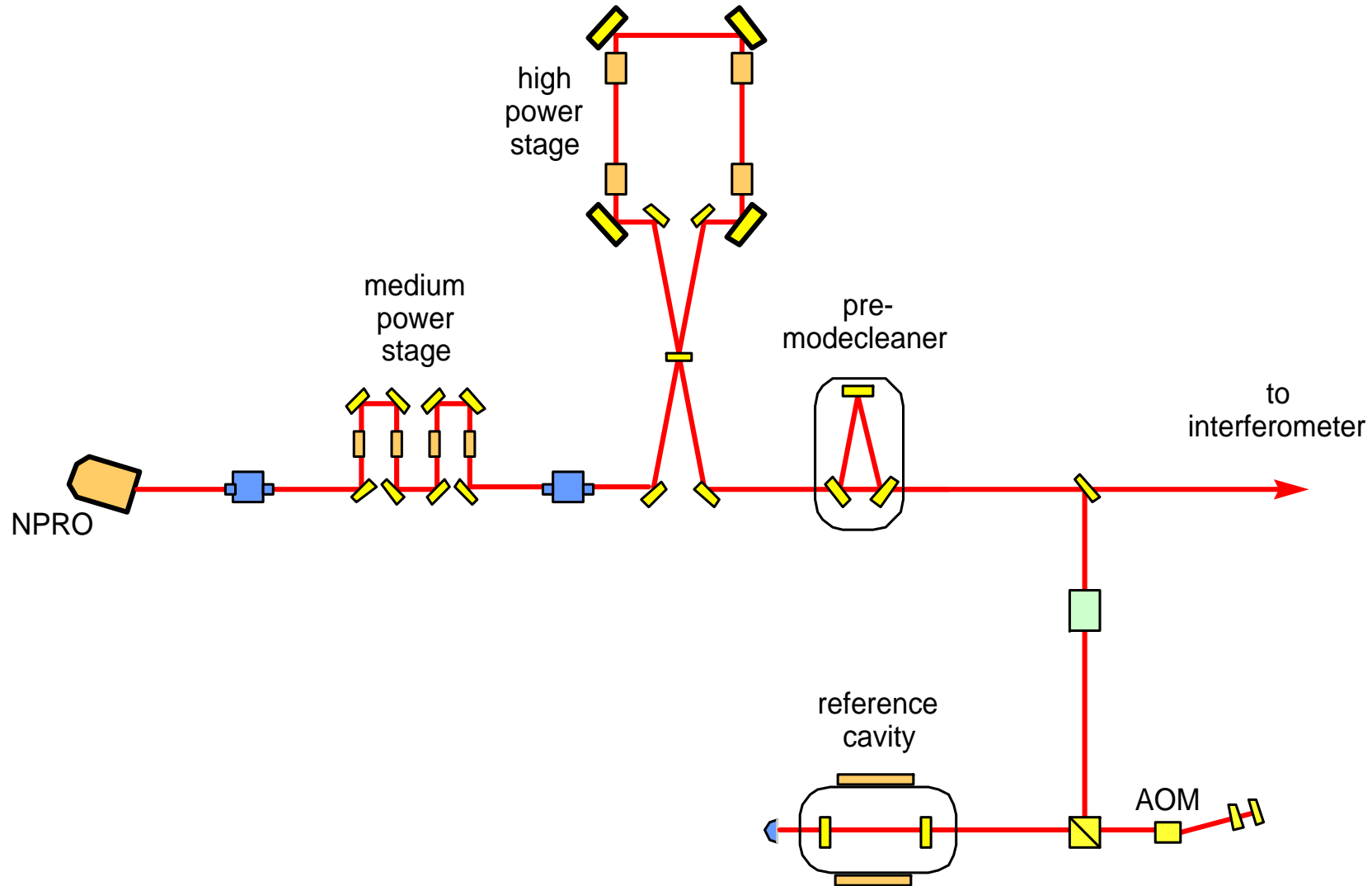
- AEI **funding** is approved
- **contract** between AEI and LZH is in place
- **fully staffed** (7 people @ LZH, 4 people @ AEI, spending money)
- LZH labs **renovated**
- **first NPROs** for the observatories arrived
- first Enhanced LIGO type laser **will be delivered** early summer
- **MOU** between AEI and LIGO Lab is in preparation



- new air condition
  - 15-20 air changes
  - higher temperature stability
  - Class 1000 Filter
- airlock
- particle counts:
  - floor: > 50.000
  - lab: ~ 2.000
  - table: 0
- 120 kVA UPS

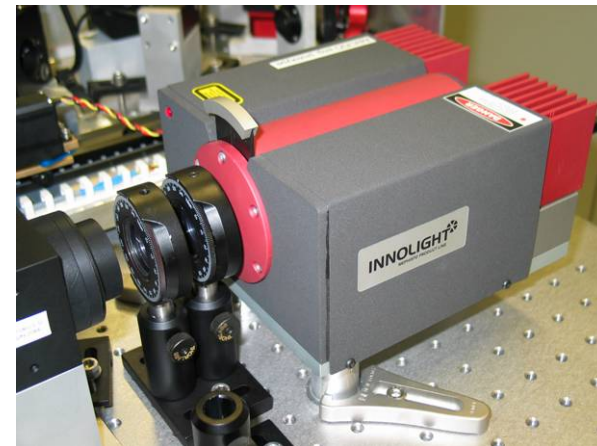


# Advanced LIGO prestabilized laser





- 4 out of 8 Master lasers (2W NPROs) are delivered
- they have a special interface
- characterization program
  - power, slope, power in p-pol
  - RIN:
    - noise spectrum 1Hz – 100kHz,
    - time series (60min) rms
  - frequency noise
    - spectrum 1Hz – 100kHz
    - upper limit for drift
  - PZT and slow actuator calibration
  - beam quality
    - higher order mode content
    - beam pointing



LD1 Power Monitor
GND
LD2 Power Monitor
GND
CTC1 Error
GND
n.c.
GND
n.c.
GND
LDTC1 Error
GND
LDTC2 Error
GND
Guard LDTC1
GND
Guard LDTC2
GND
n.c.
GND
n.c.
GND
NE Monitor
GND
Interlock

Set Temperature LD1
GND
Act. Temperature LD1
GND
Set Temperature LD2
GND
Act. Temperature LD2
GND
Set Temperature Crystal
GND
Act. Temperature Crystal
GND
Set Current
GND
Act. Current
GND
Status Laser ON
GND
n.c.
GND
Remote SW
GND
Remote SW ON
GND
Remote SW OFF



# Advanced LIGO NPRO characterization



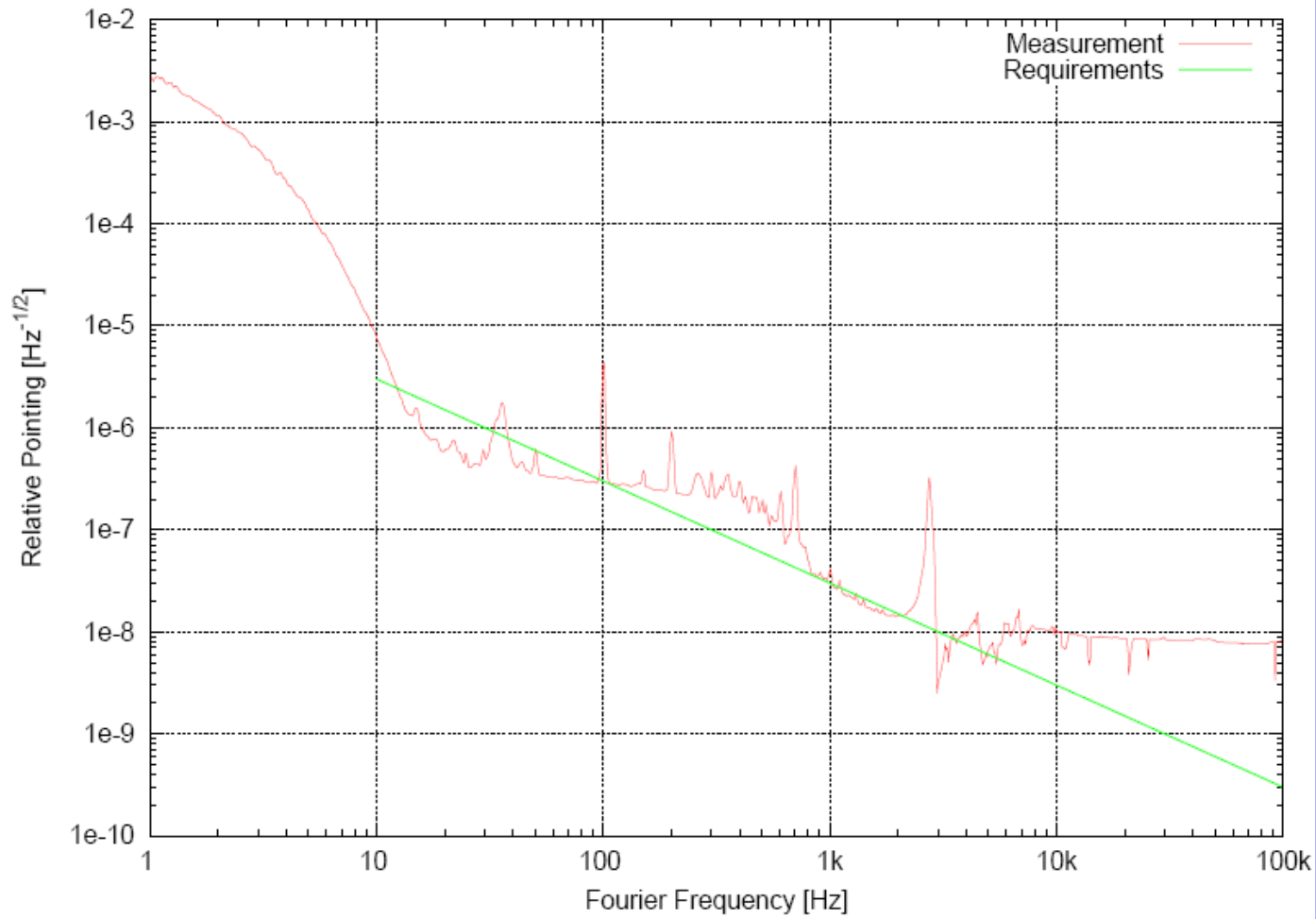
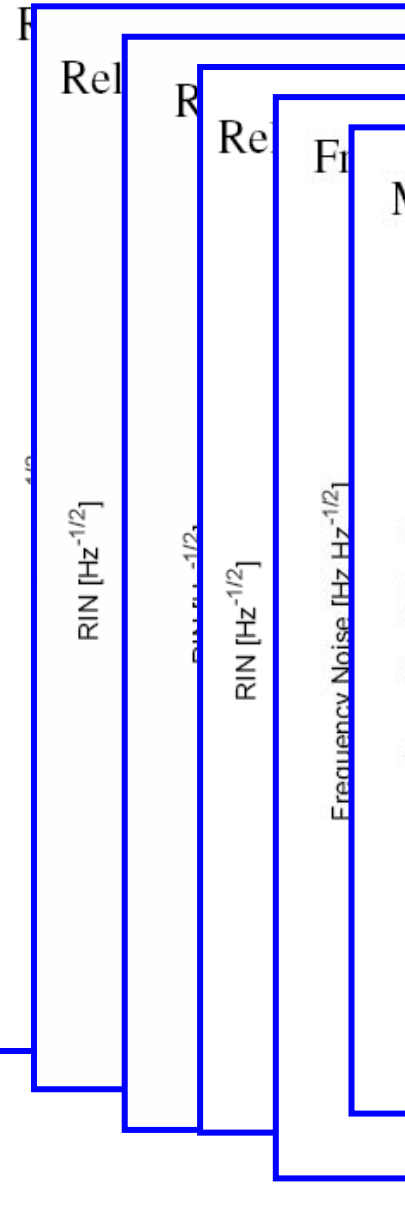
Engineering Prototype 3/07

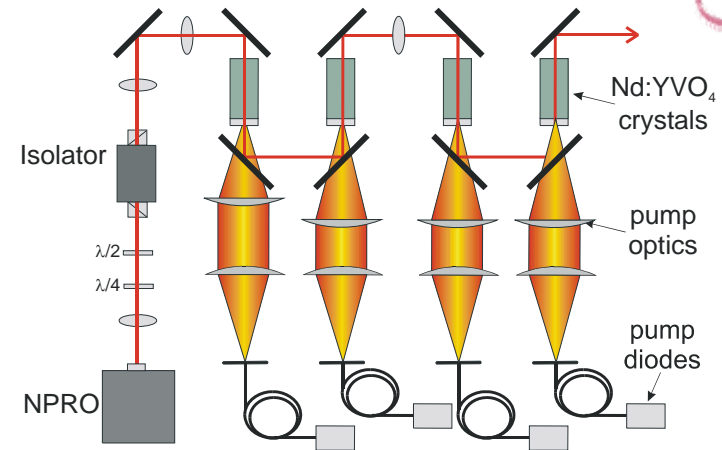
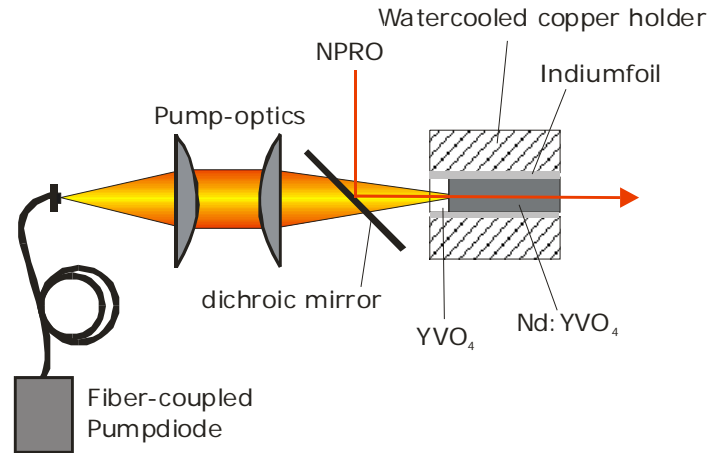
Engineering Prototype 3/07

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Engineering Prototype 3/07

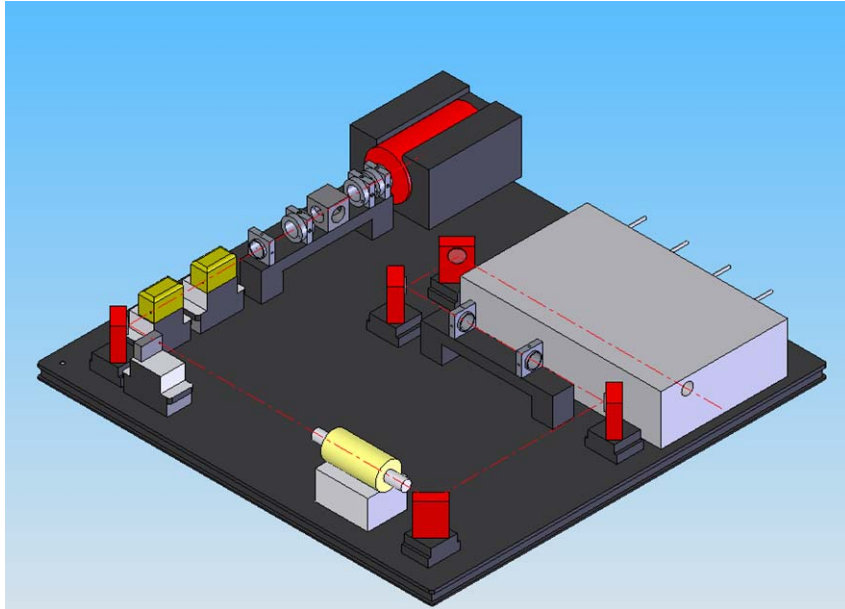
Pointing 2X



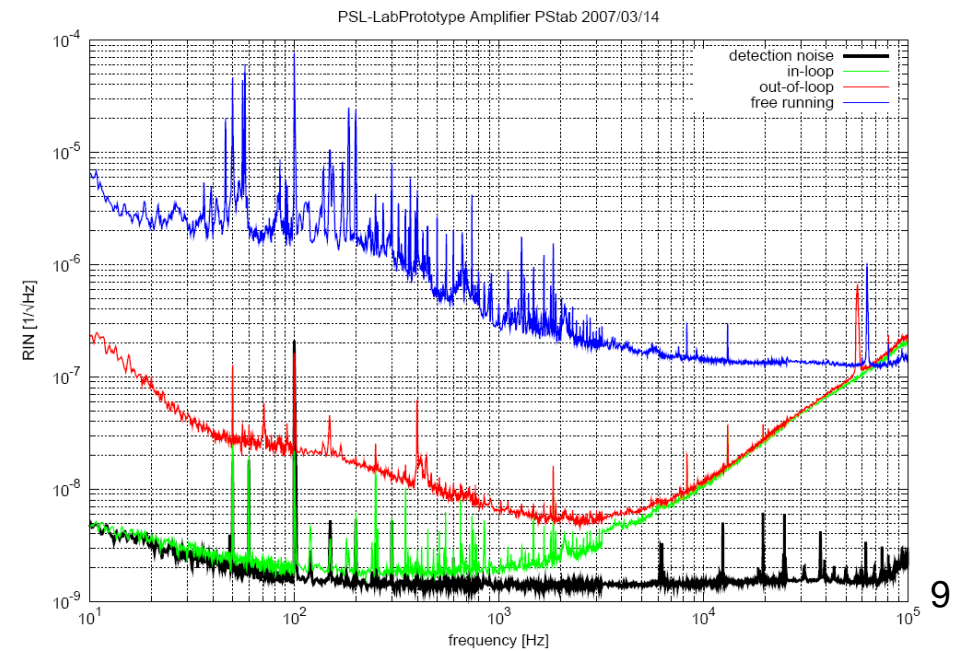
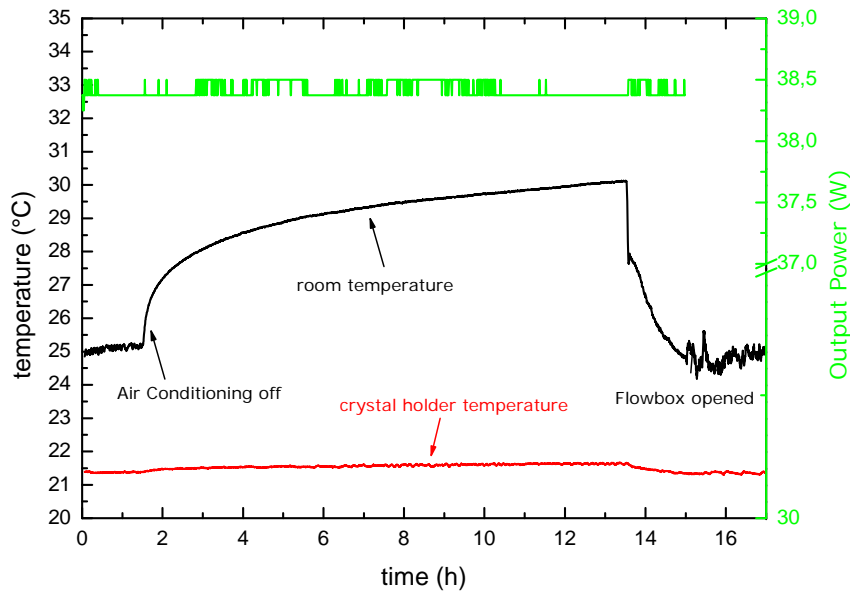


- Crystal:  
3 x 3 x 10 mm<sup>3</sup> Nd:YVO<sub>4</sub>  
8 mm 0,3 % dot.  
2 mm undoped endcap
- Pump diode:  
808 nm, 45 W  
400 μm fiber diameter  
NA=0,22
- amplifier:  
38W for 2W seed and 150W pump





- front end will be assembled on breadboard and delivered in single housing
- AOM and isolators included
- NPRO and amplifier controlled via Beckhoff touchpad
- interface to EPICS

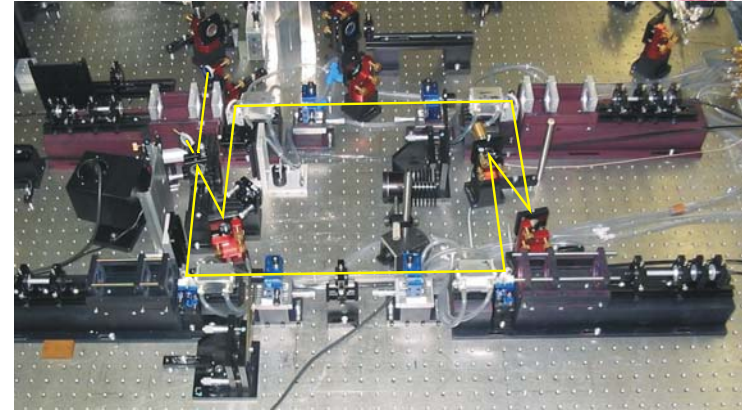
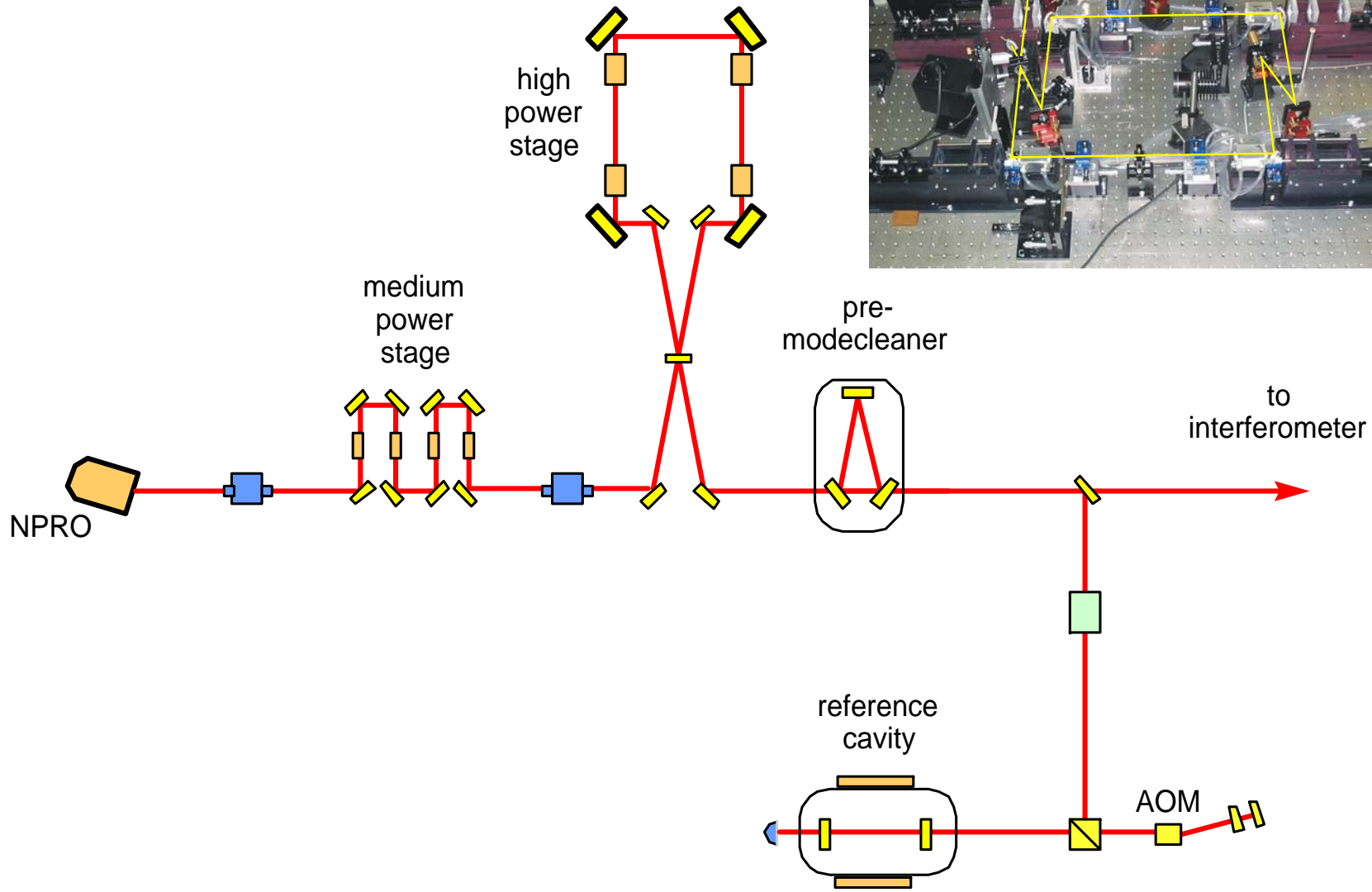




# front end – pump power and control

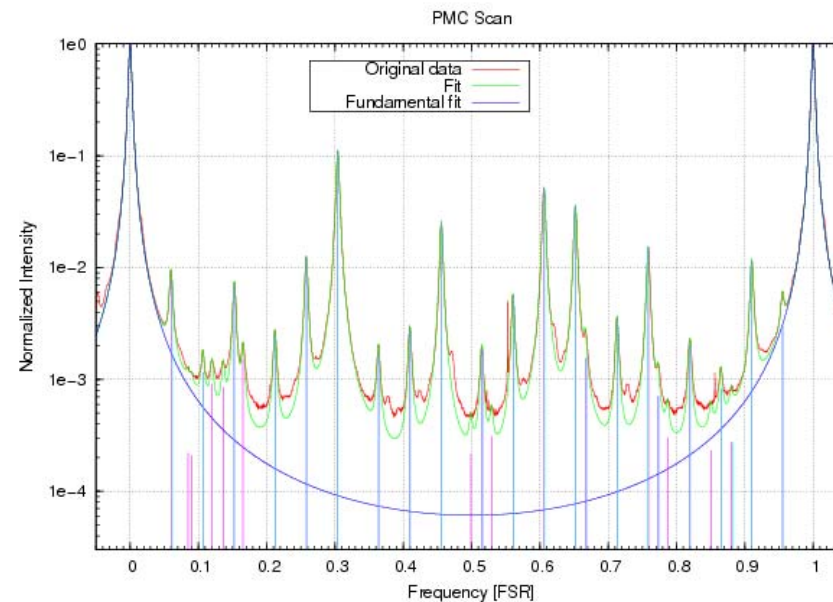
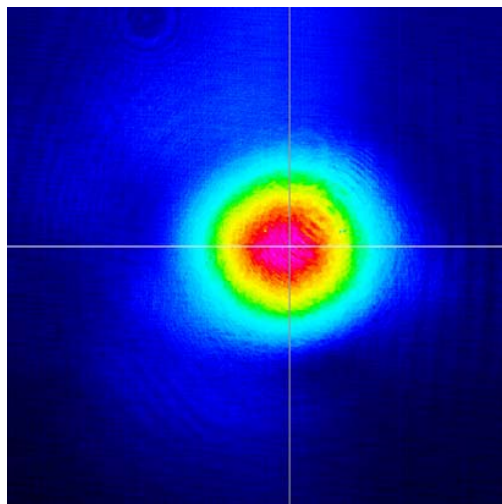
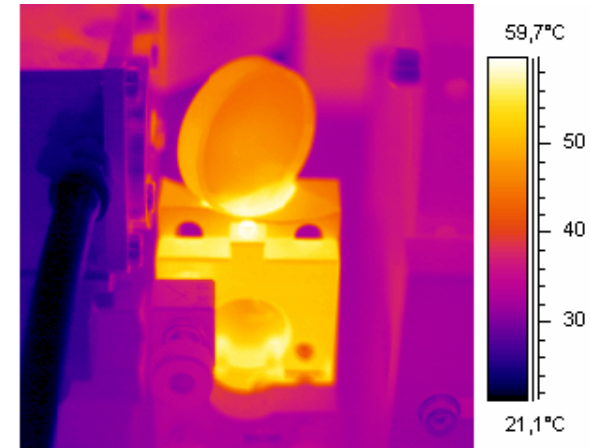


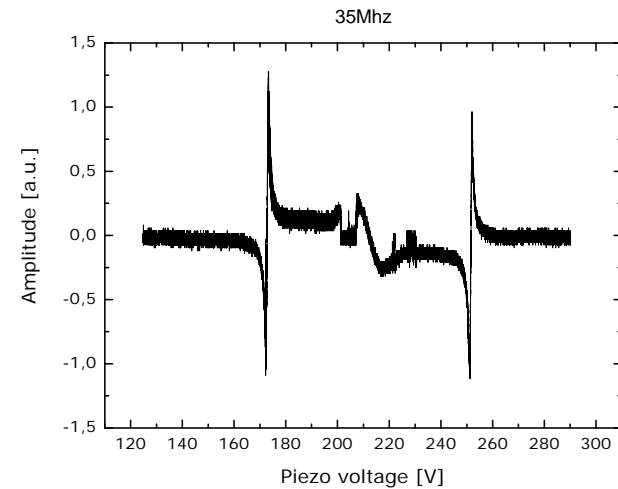
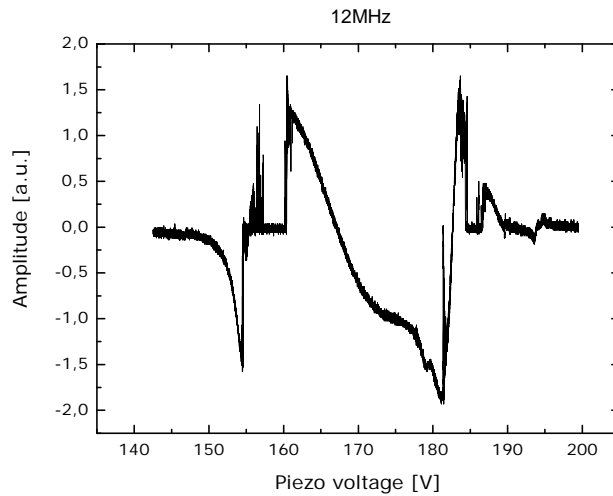
# High Power Stage



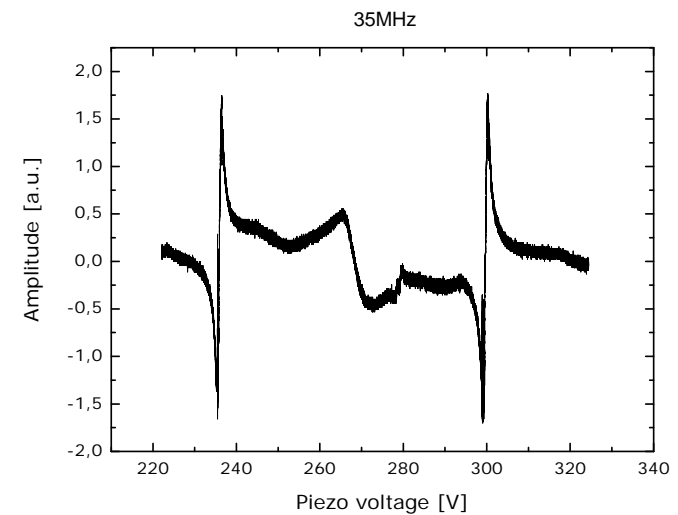
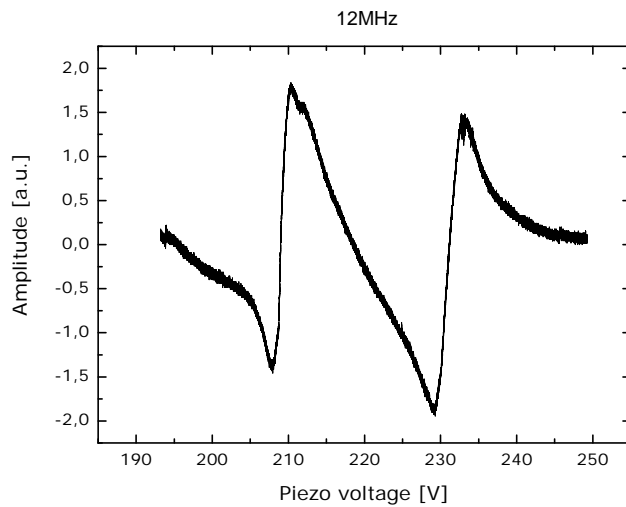


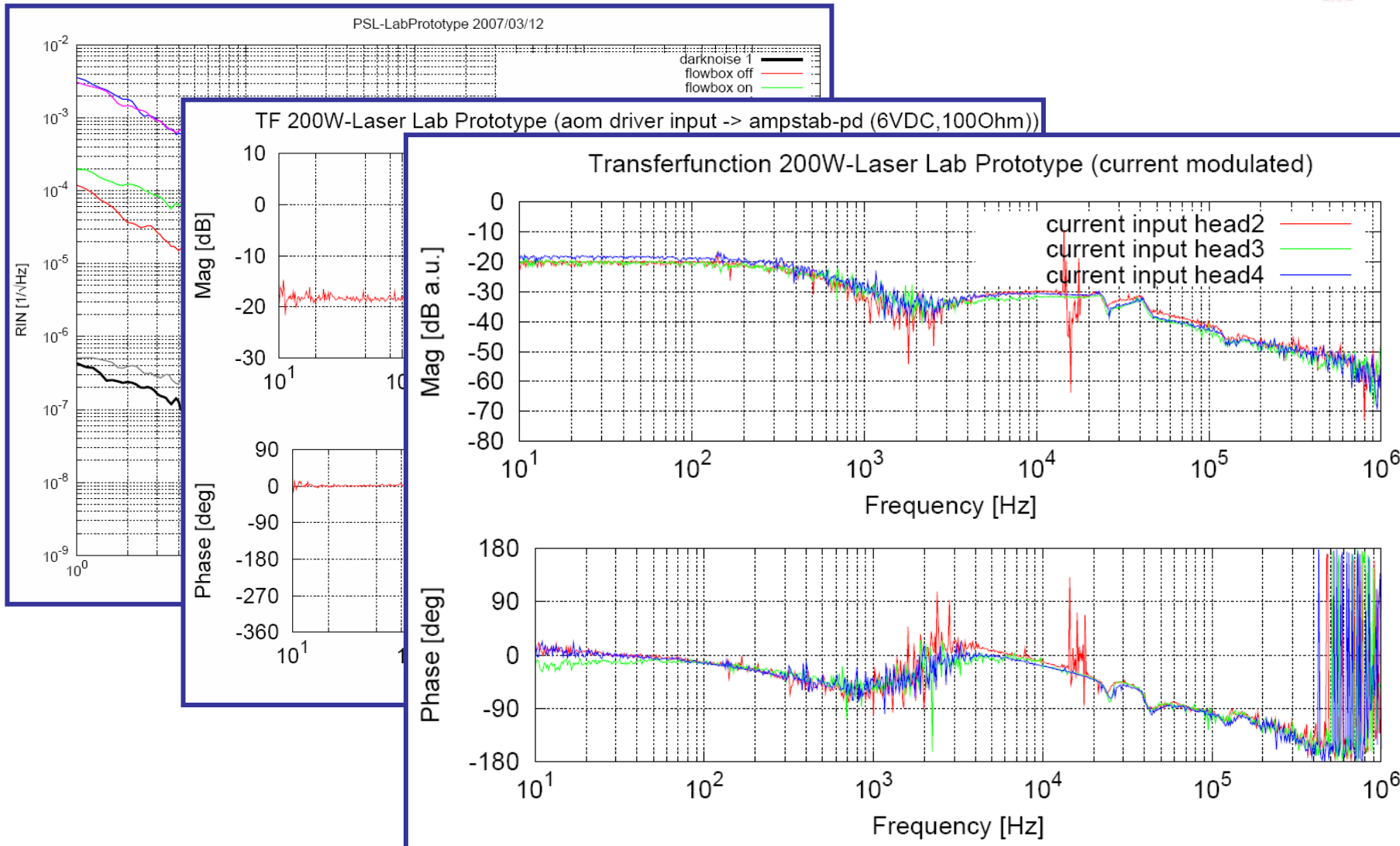
- changed front-end to Enhanced LIGO design
- optimize resonator design
- identify critical components
- improve beam quality
- improve injection locking
- current state:
  - 150W output power; 85% in TEM<sub>0,0</sub>





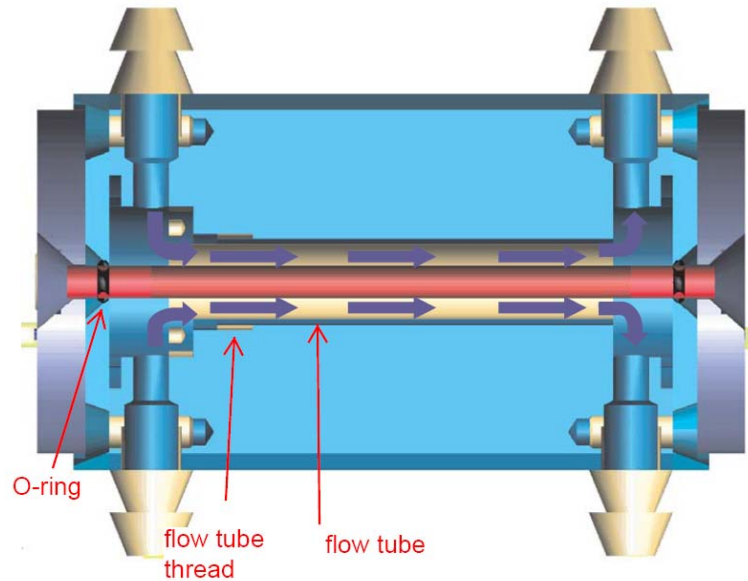
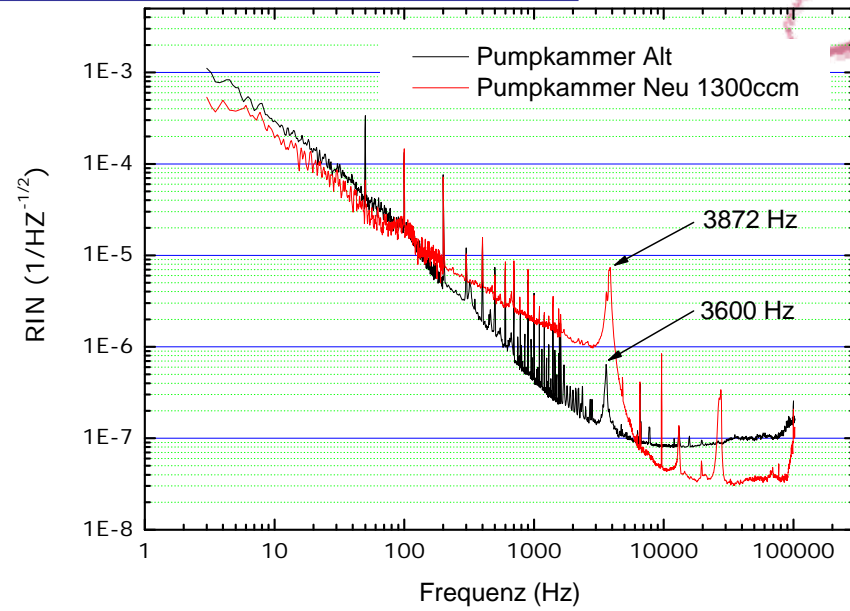
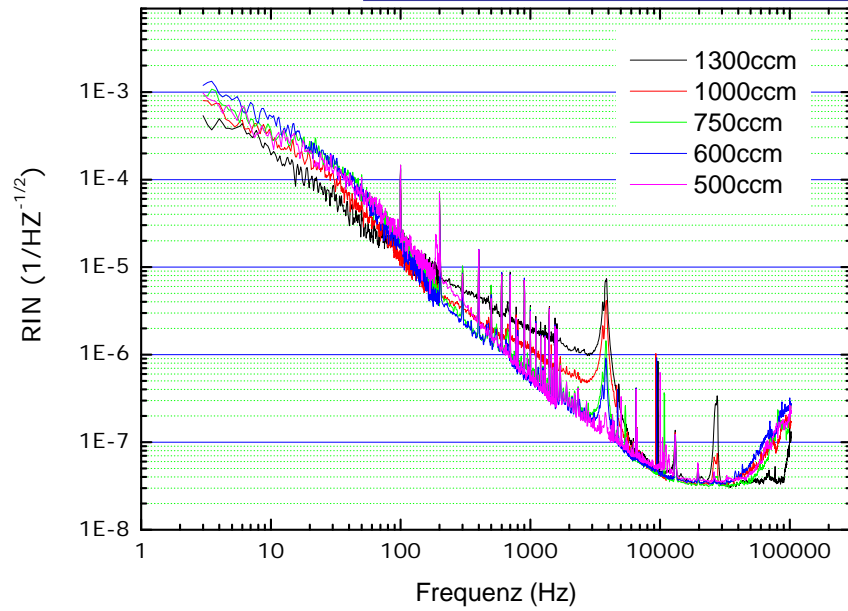
improved isolation





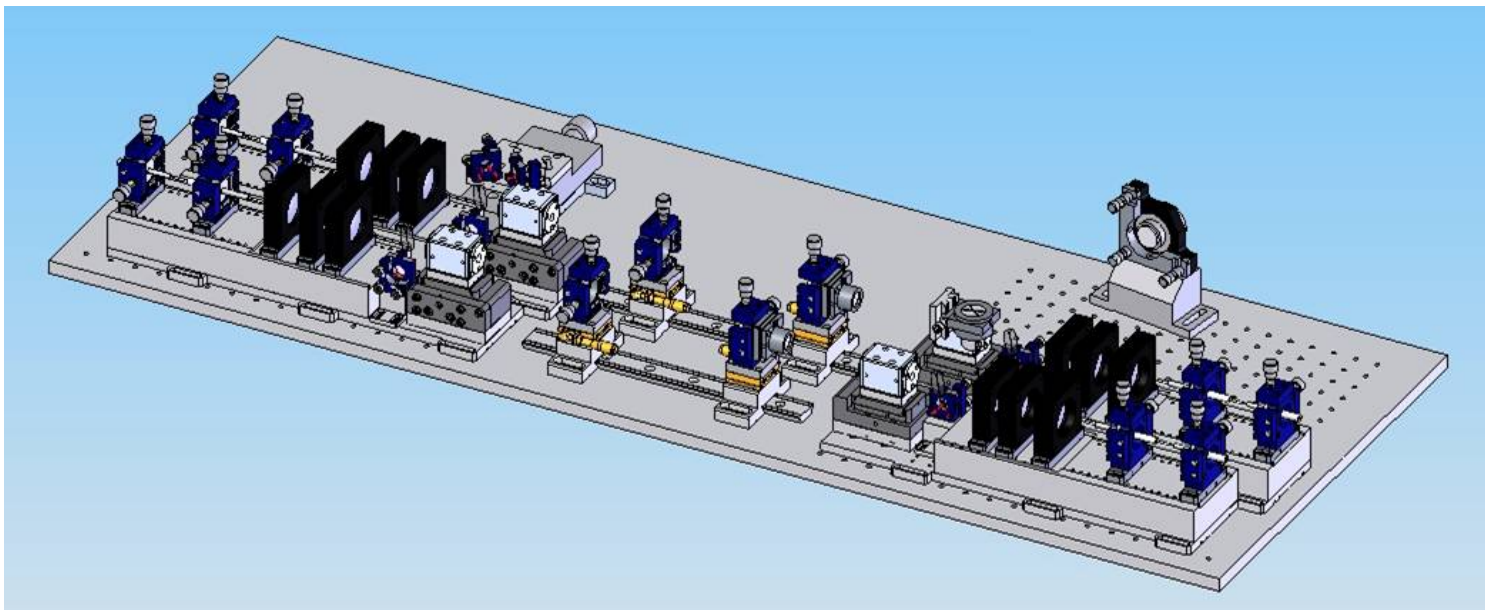
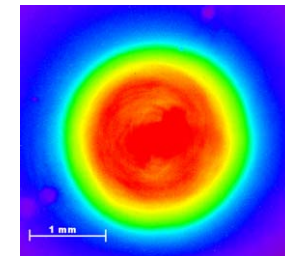


# pump-chamber design: RIN/ water flow

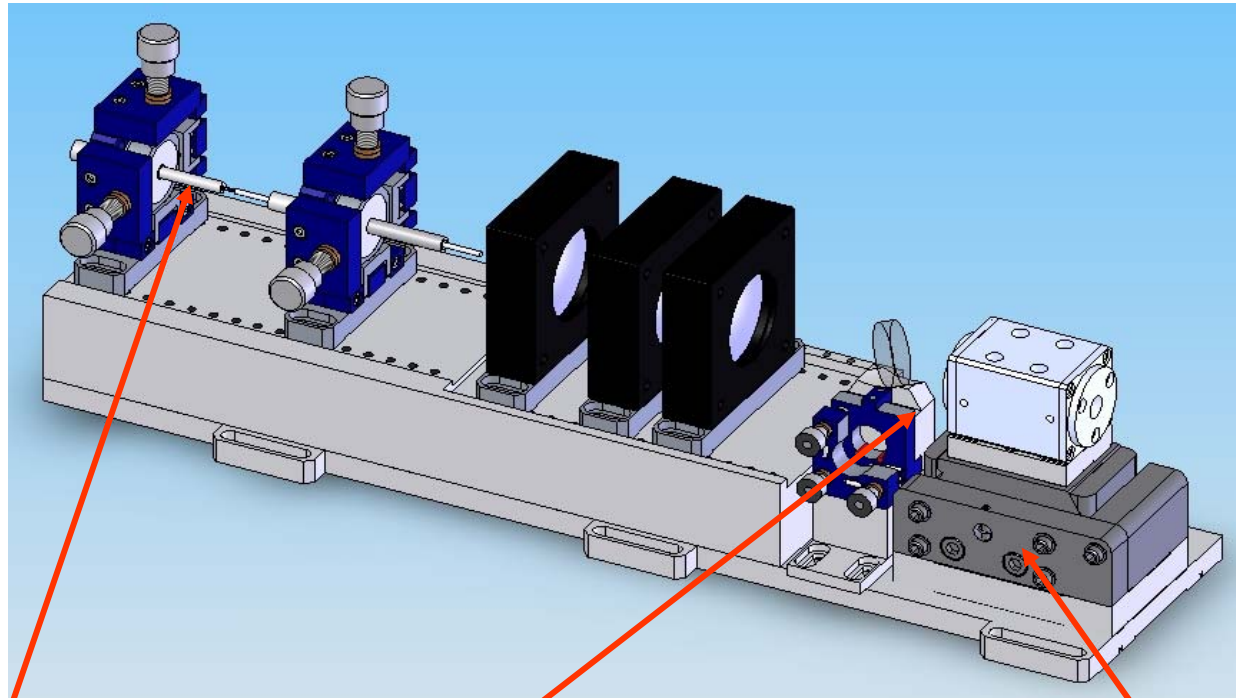




- 7 instead of 10 fibers
  - 7 x 45 W
- new homogenizer
  - higher pump brightness
- new laser head design
- whole resonator on base plate





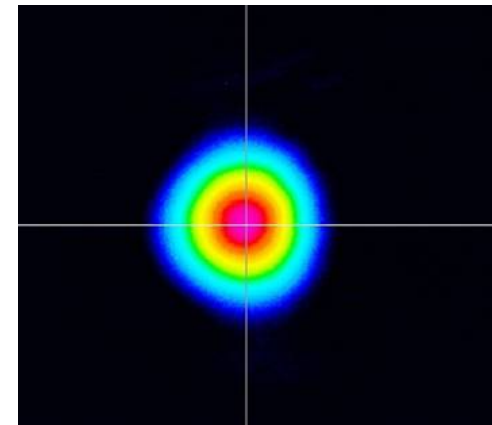


ceramic parts to prevent moving due to heat-load from spraylight

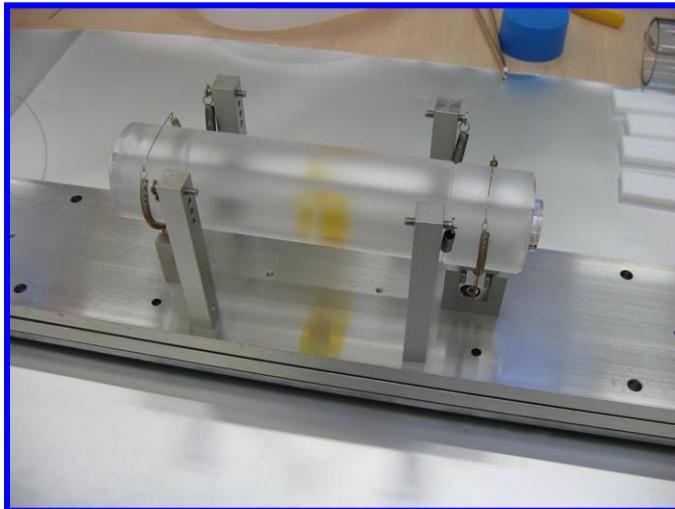
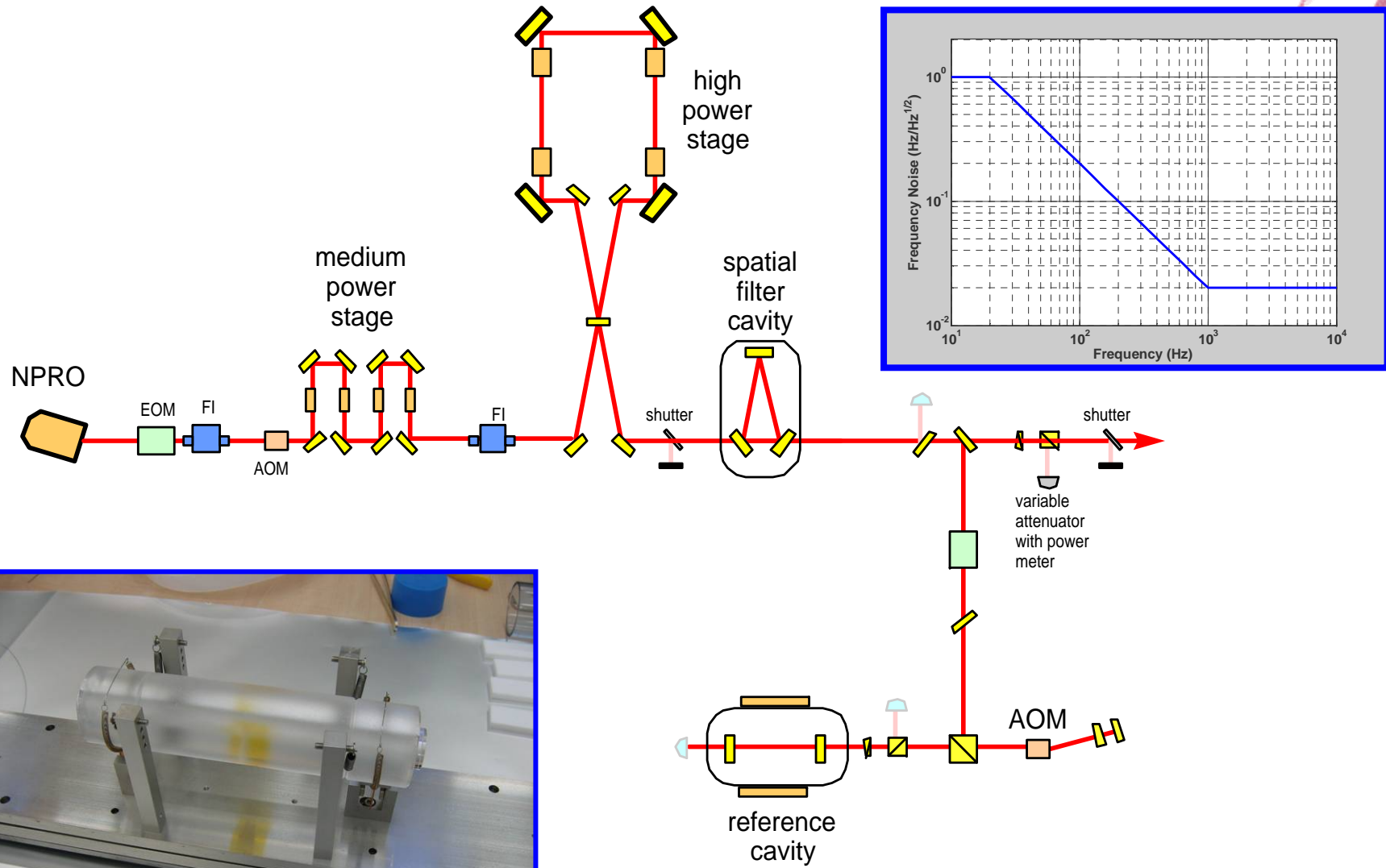
X-Y-Z translation and rotation stage for crystal alignment



- front end
  - components in house, setup starts next week
- high power stage
  - mechanical design ready
  - components in mechanical workshop
  - diode boxes currently build
- standing wave resonator test
  - new fiber design works
  - high brightness pumping gives similar results as achieved with 10 diodes
  - 90W TEM<sub>0,0</sub> output power



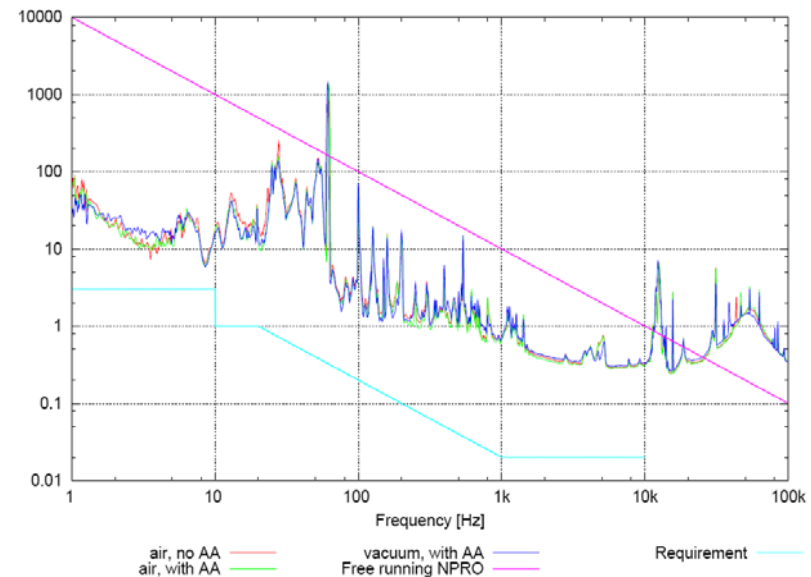
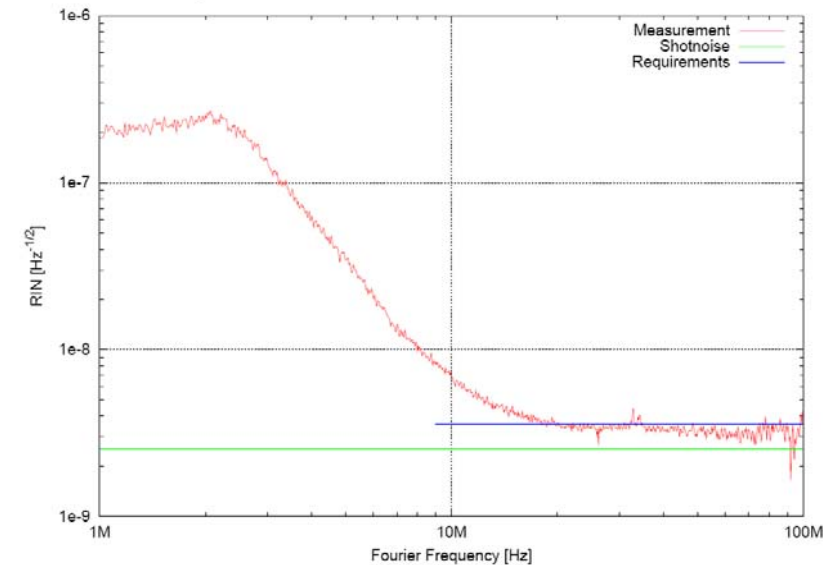
# frequency stabilization

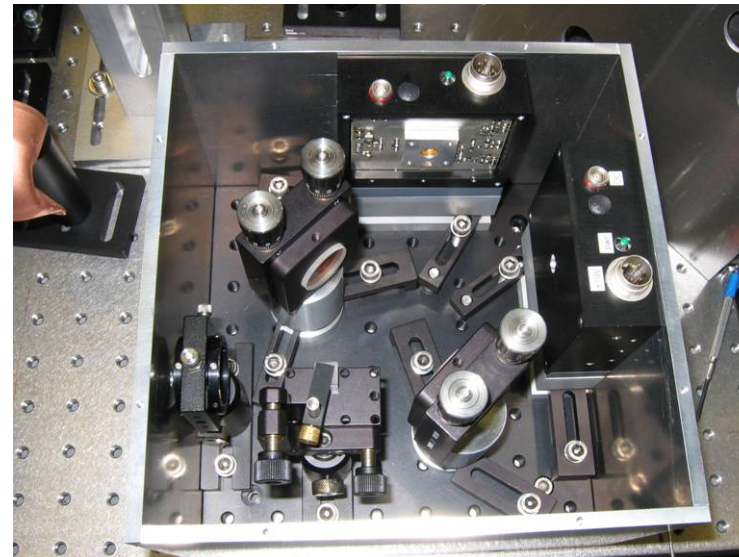
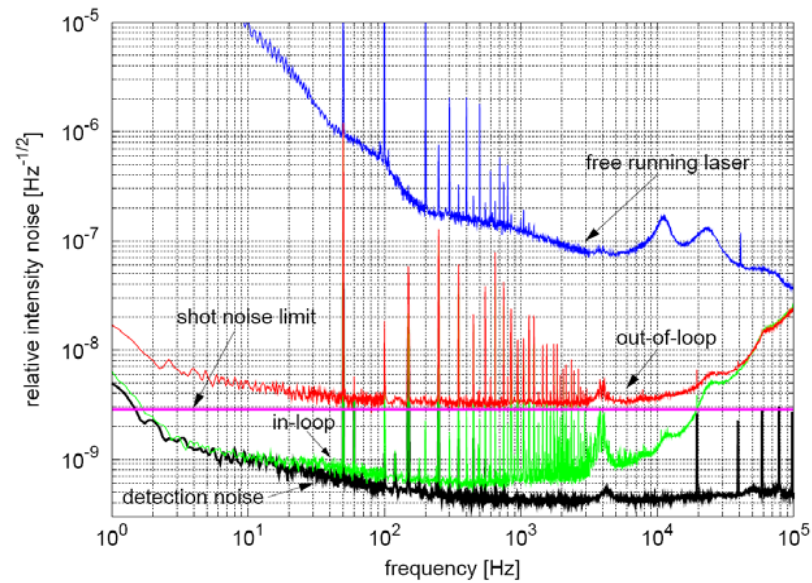
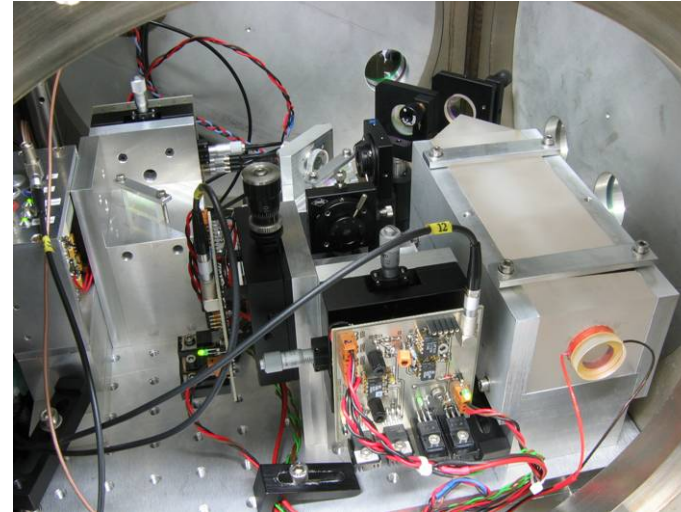
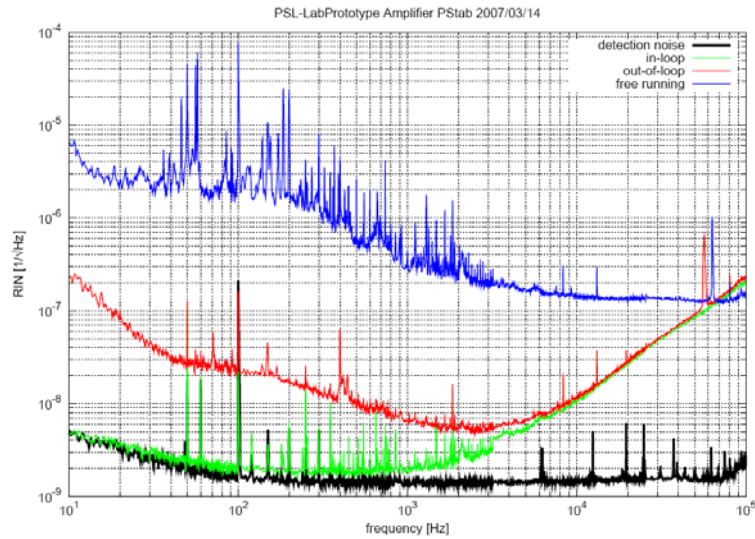


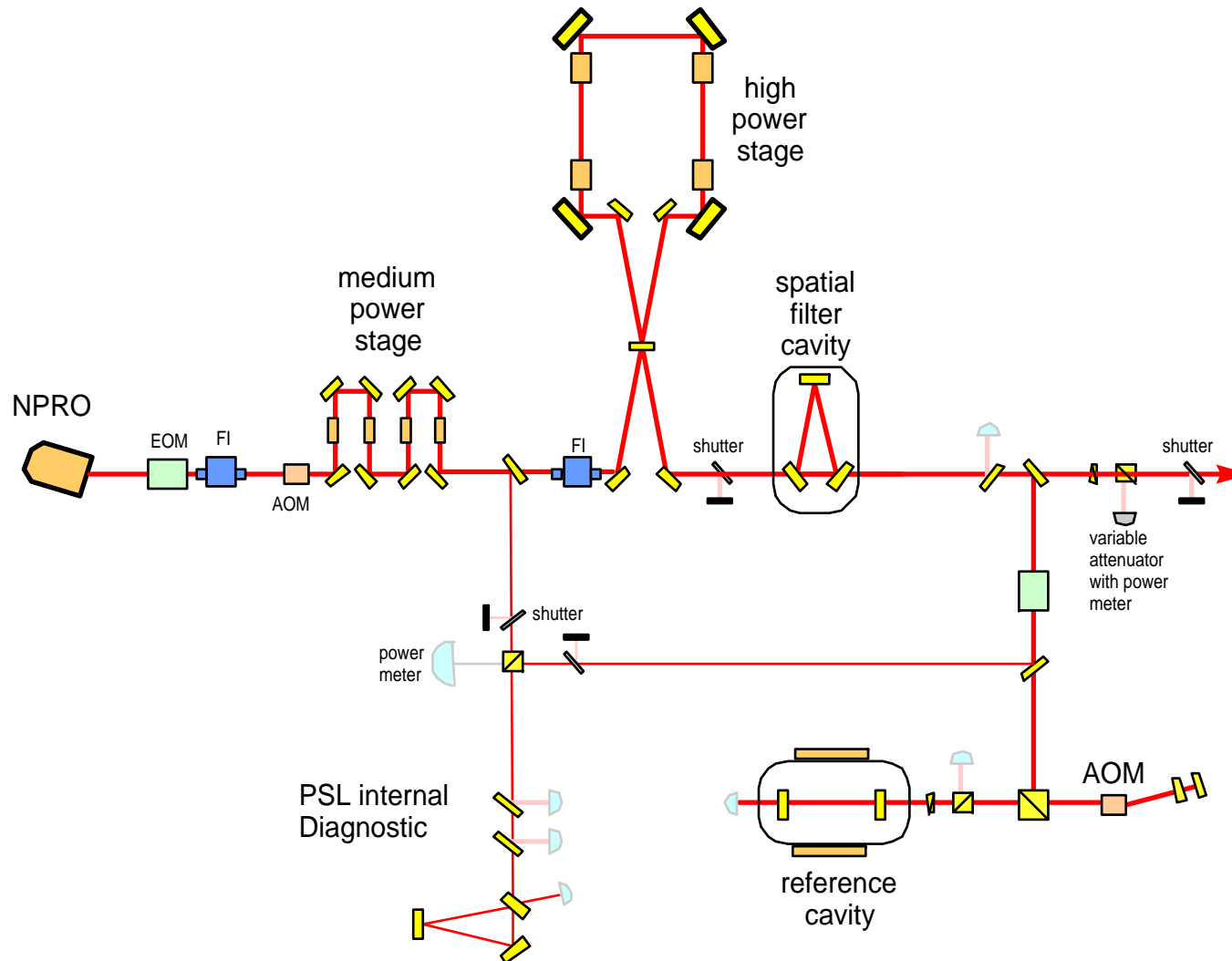


- thermal loading
  - PMC design based on thermal loading experiment by A. Bullington (Stanford)
  - assumption: less than 3ppm absorption
  - allow for a total of 10mW absorbed power
  - finesse 50 (3kW circulating power)
- in sealed housing, vacuum required ?
- rf filtering
  - 4dB @9MHz
  - sufficient? , increase length?

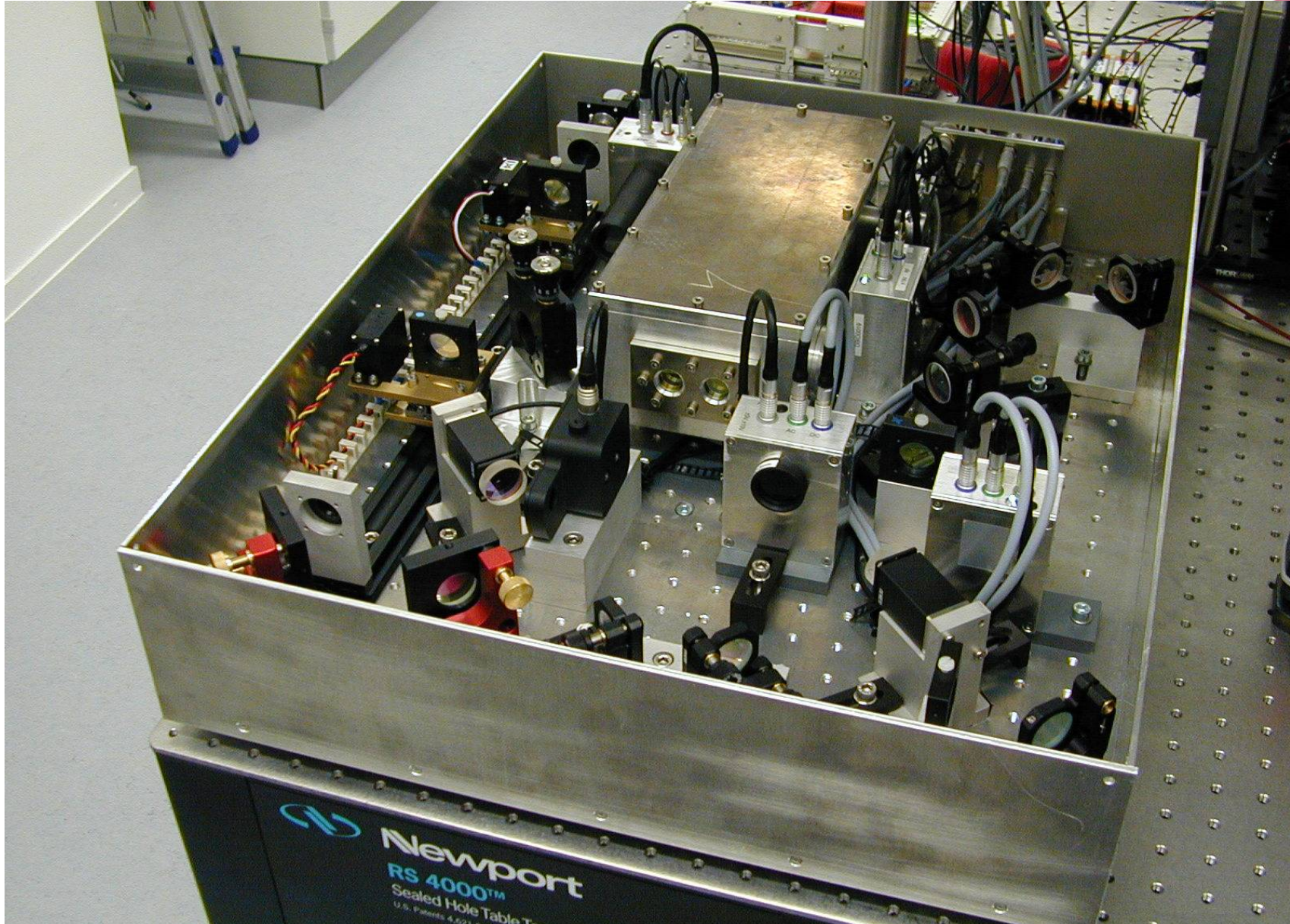
Relative Intensity Noise RF





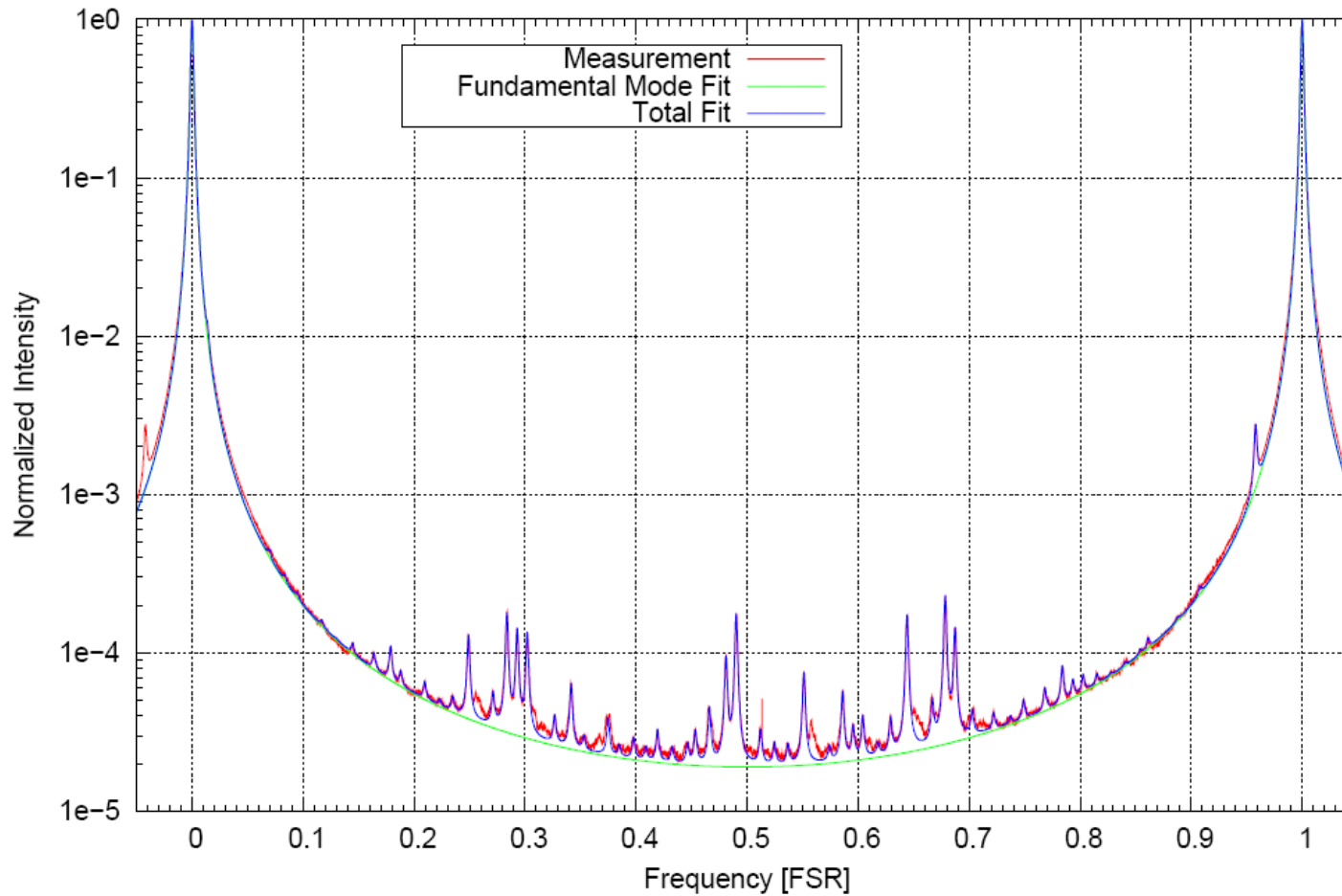


# beam diagnostic setup



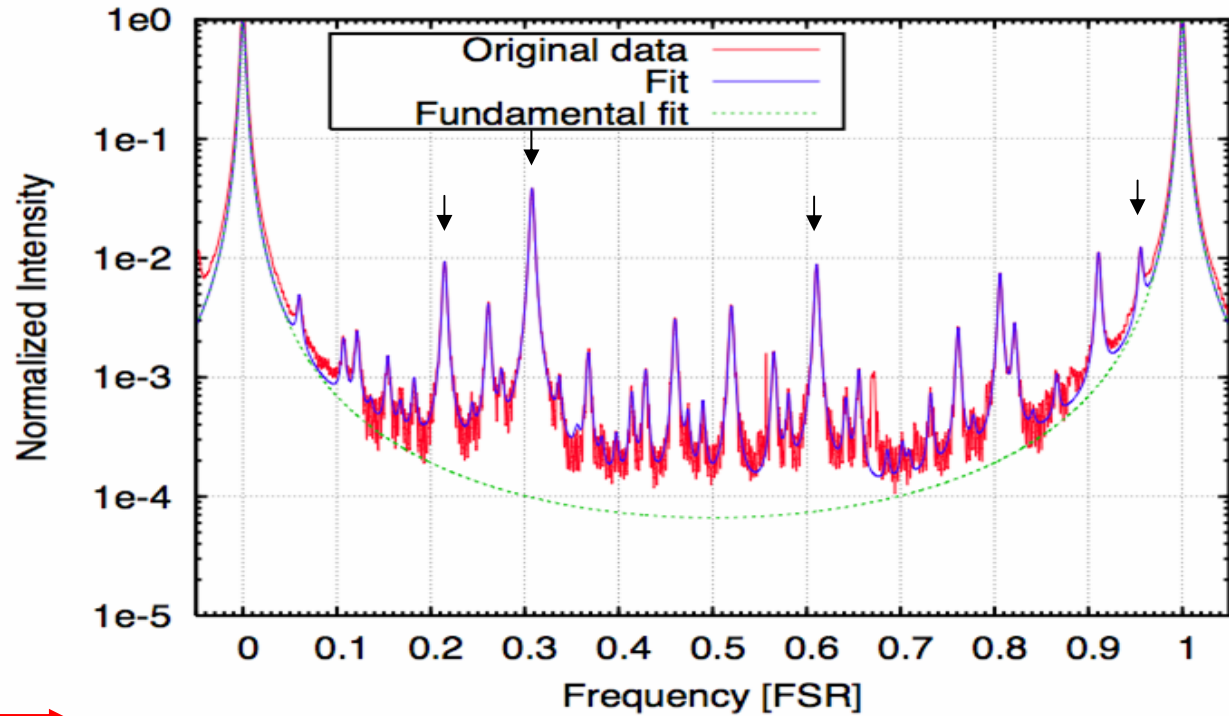
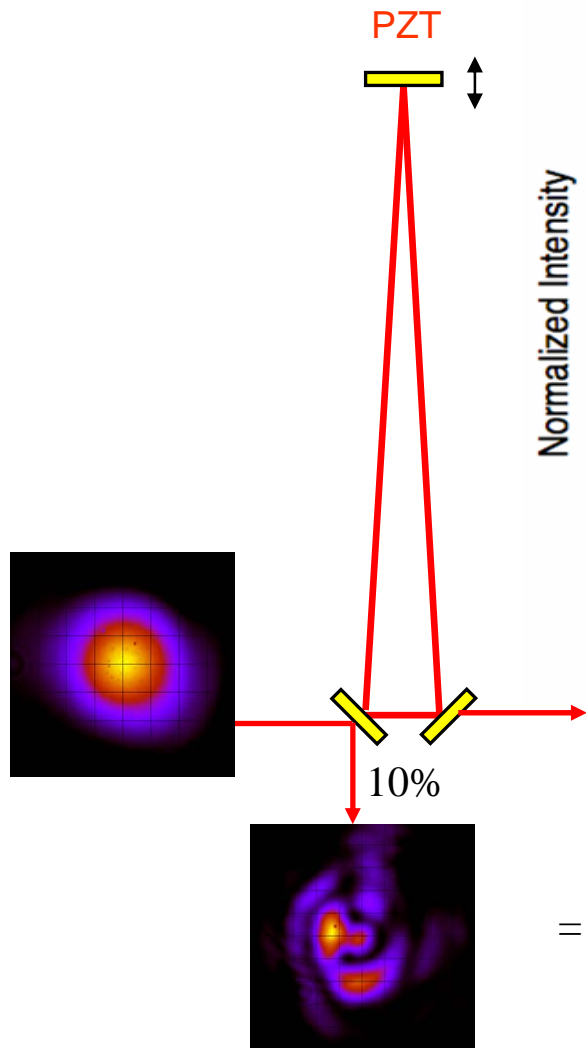


# NPRO (filtered by a fiber and PMC)



Finesse:  $366 \pm 5$   
higher order mode power:  $0.56\% \pm 0.3\%$



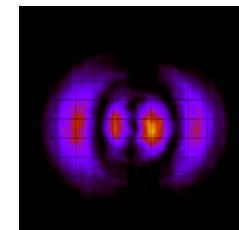
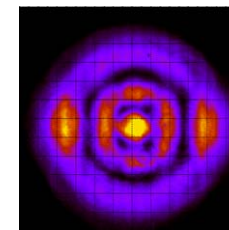
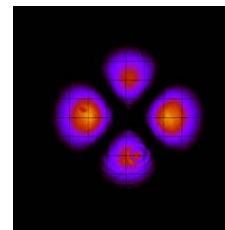
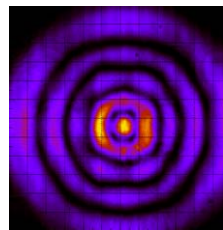


0,9%

3,9%

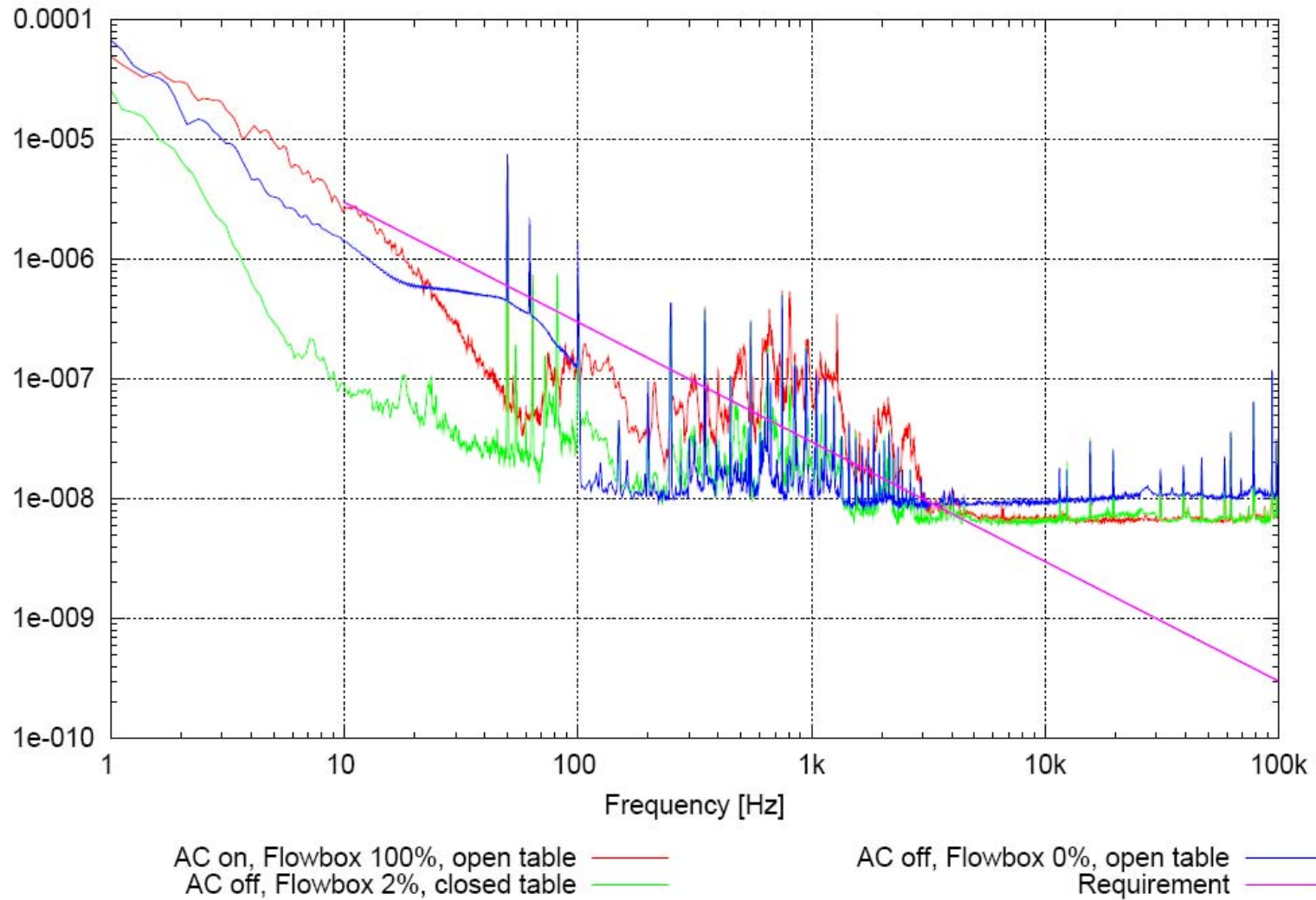
0,8%

0,8%



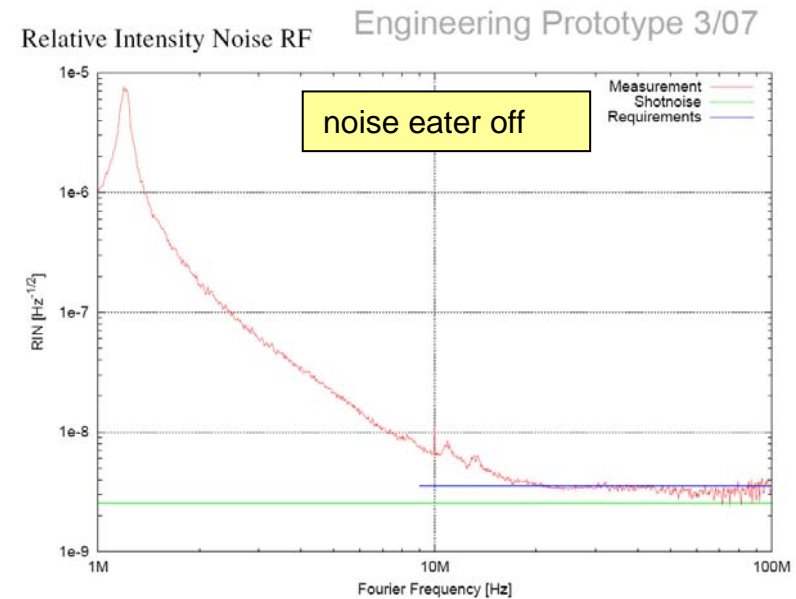
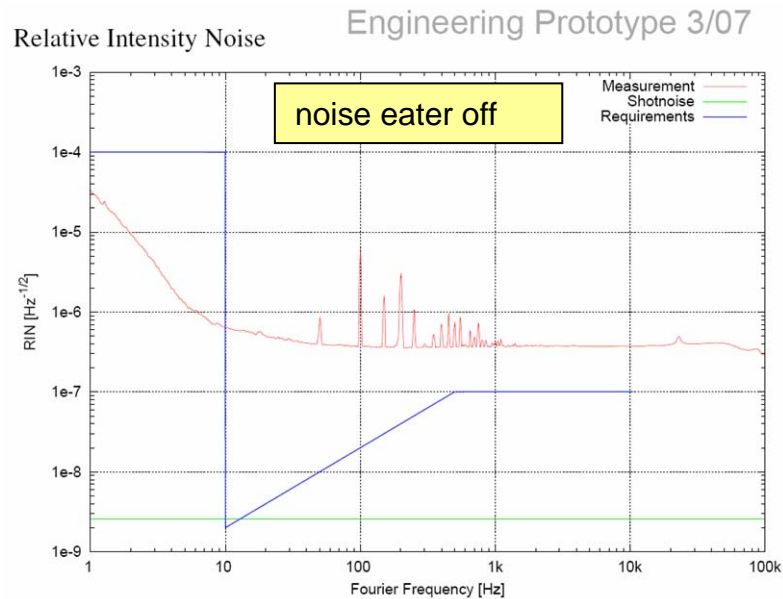
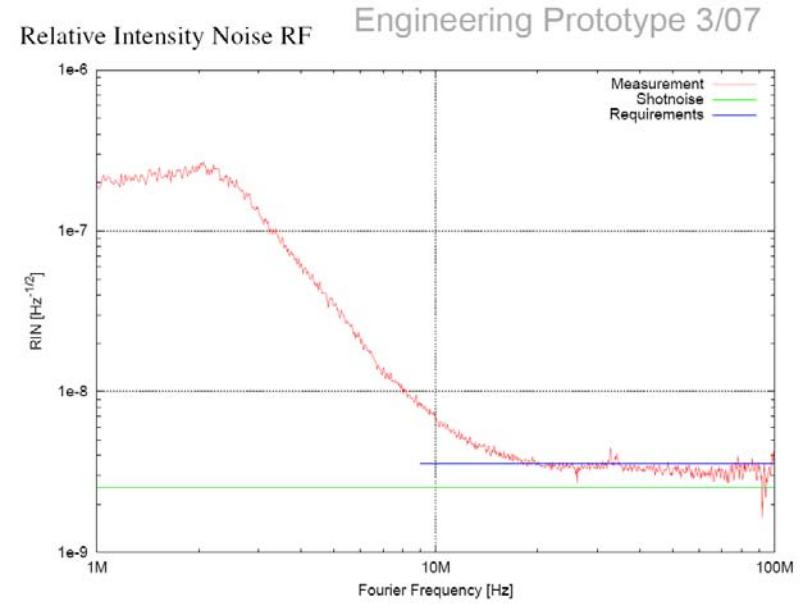
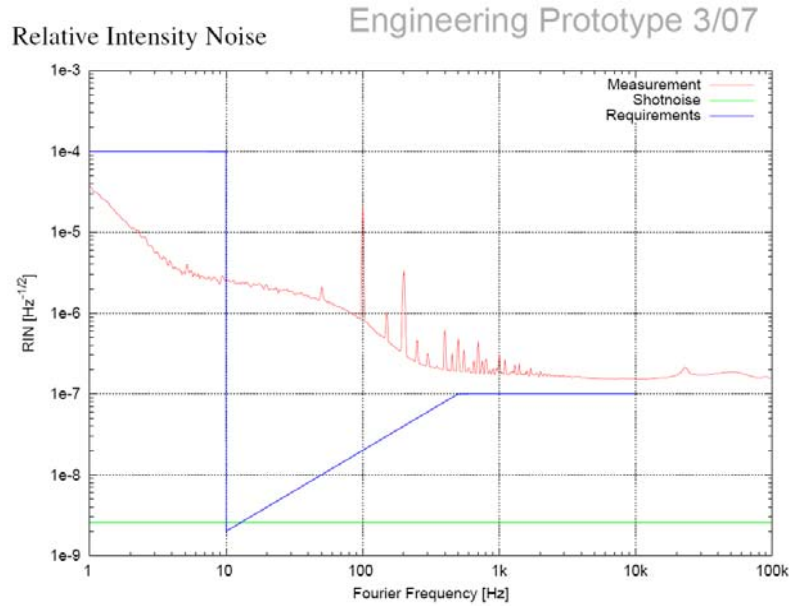


Pointing 12cm behind PMC, measured with QPD



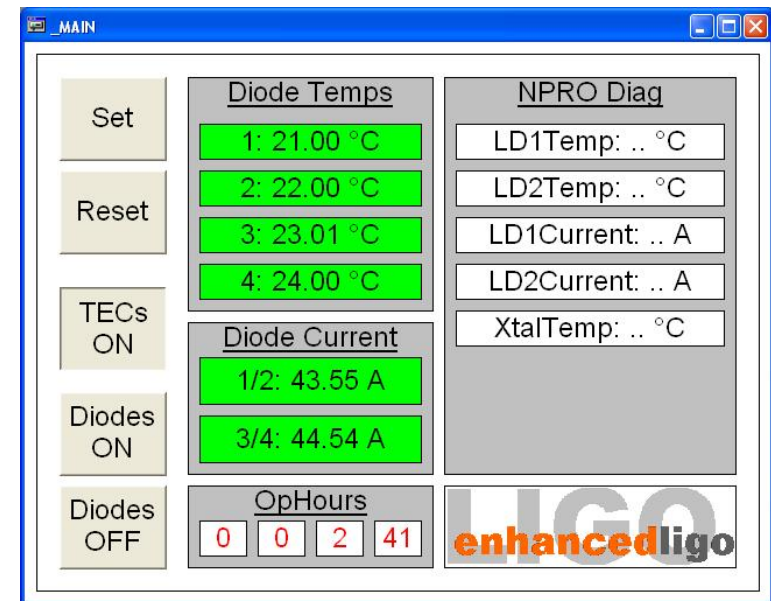
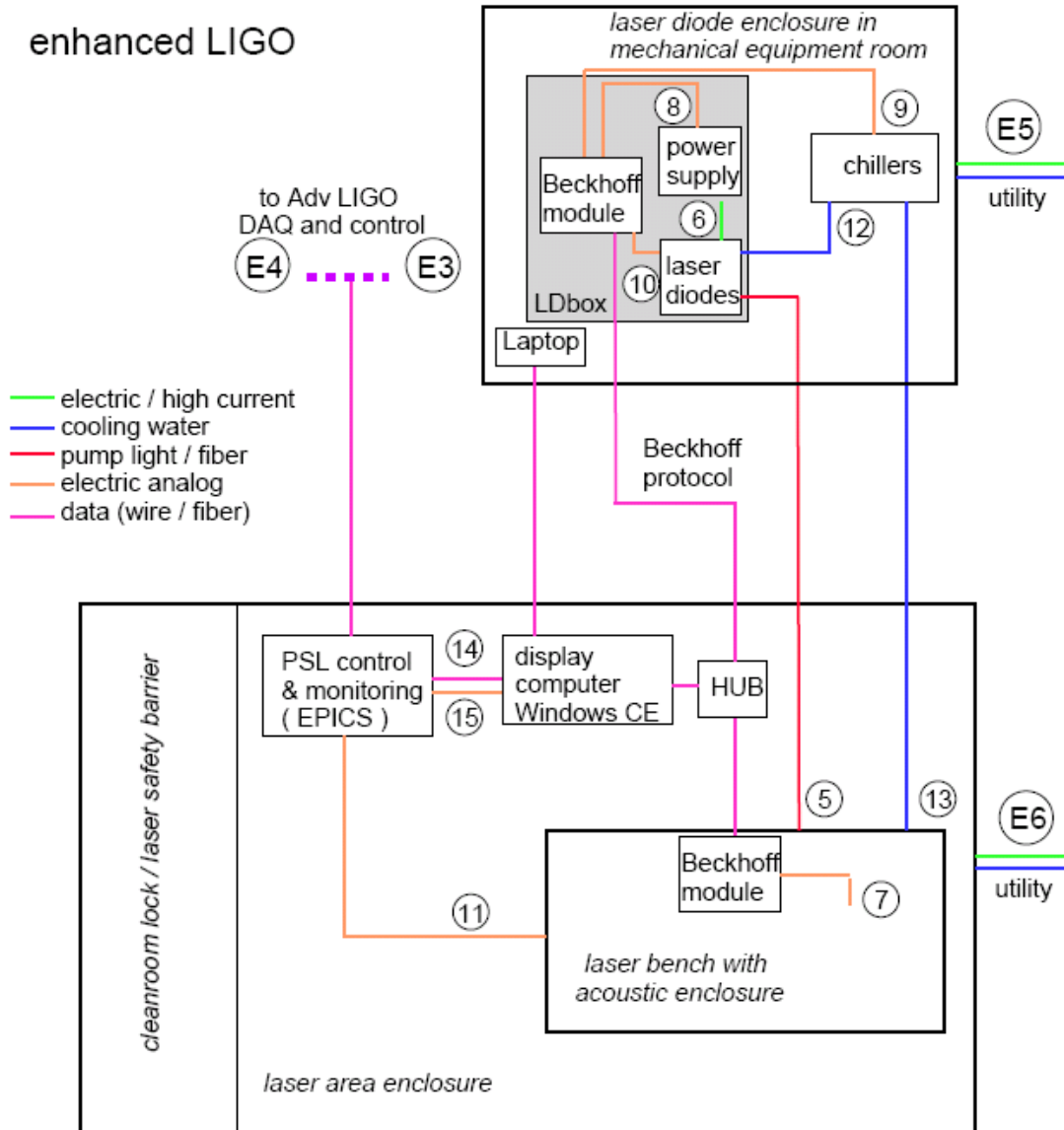


# RIN – Advanced LIGO NPRO





enhanced LIGO





Version: 07 Jan 19th

