Report “My stay in Hannover”

Noriaki OHMAE (Mio group, Univ. of Tokyo)

Period

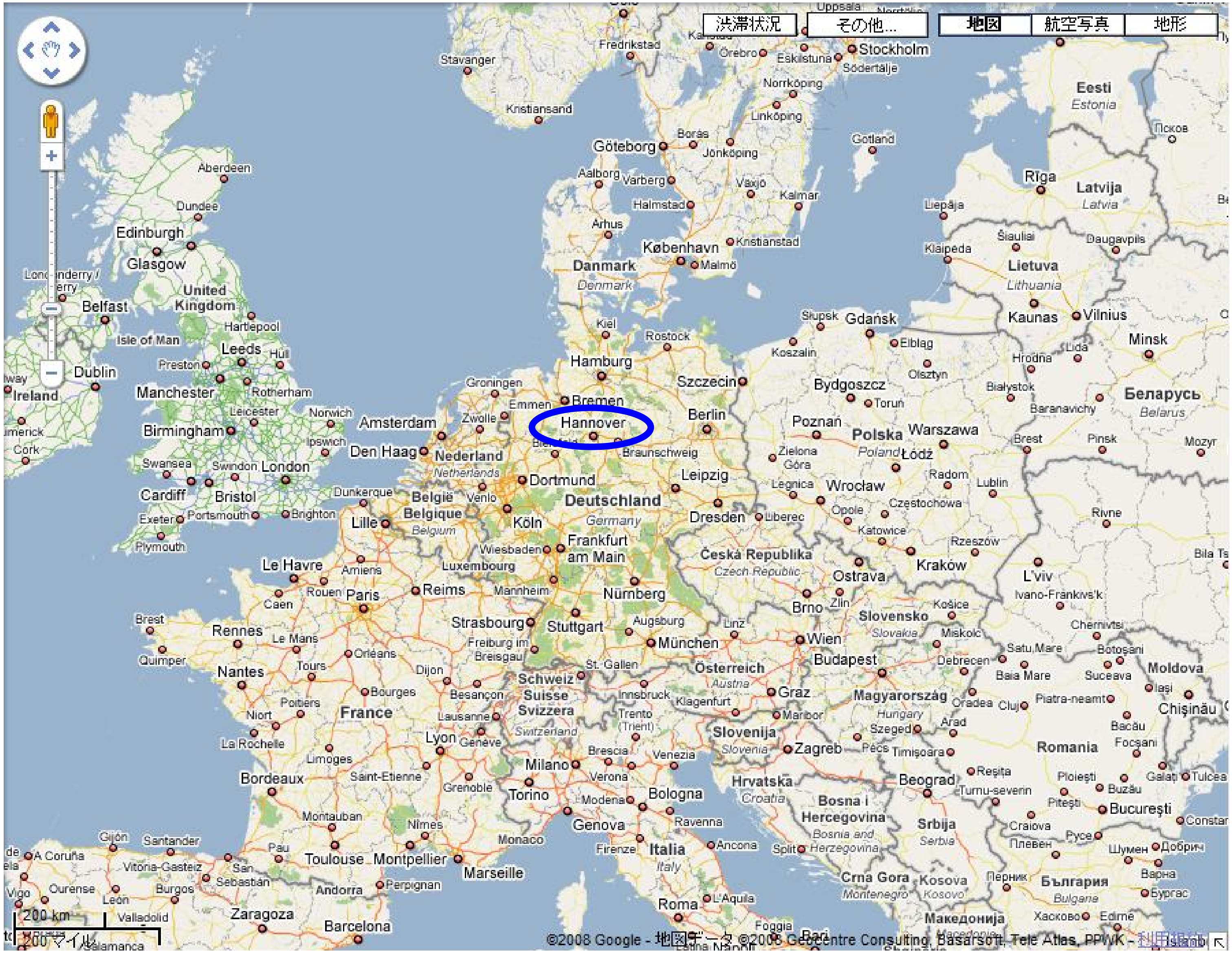
2008.10.20 – 2008.11.30 (6 weeks)

Place

Laser Zentrum Hannover e. V. (LZH)

Albert Einstein Institute (AEI)

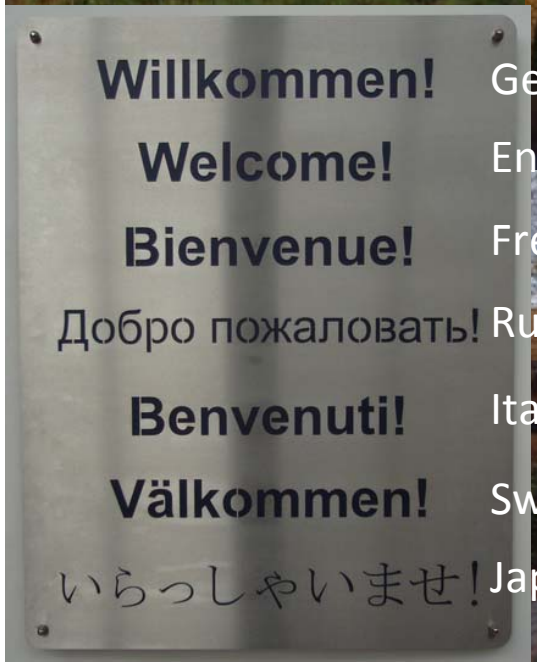
Where is Hannover?



Hannover

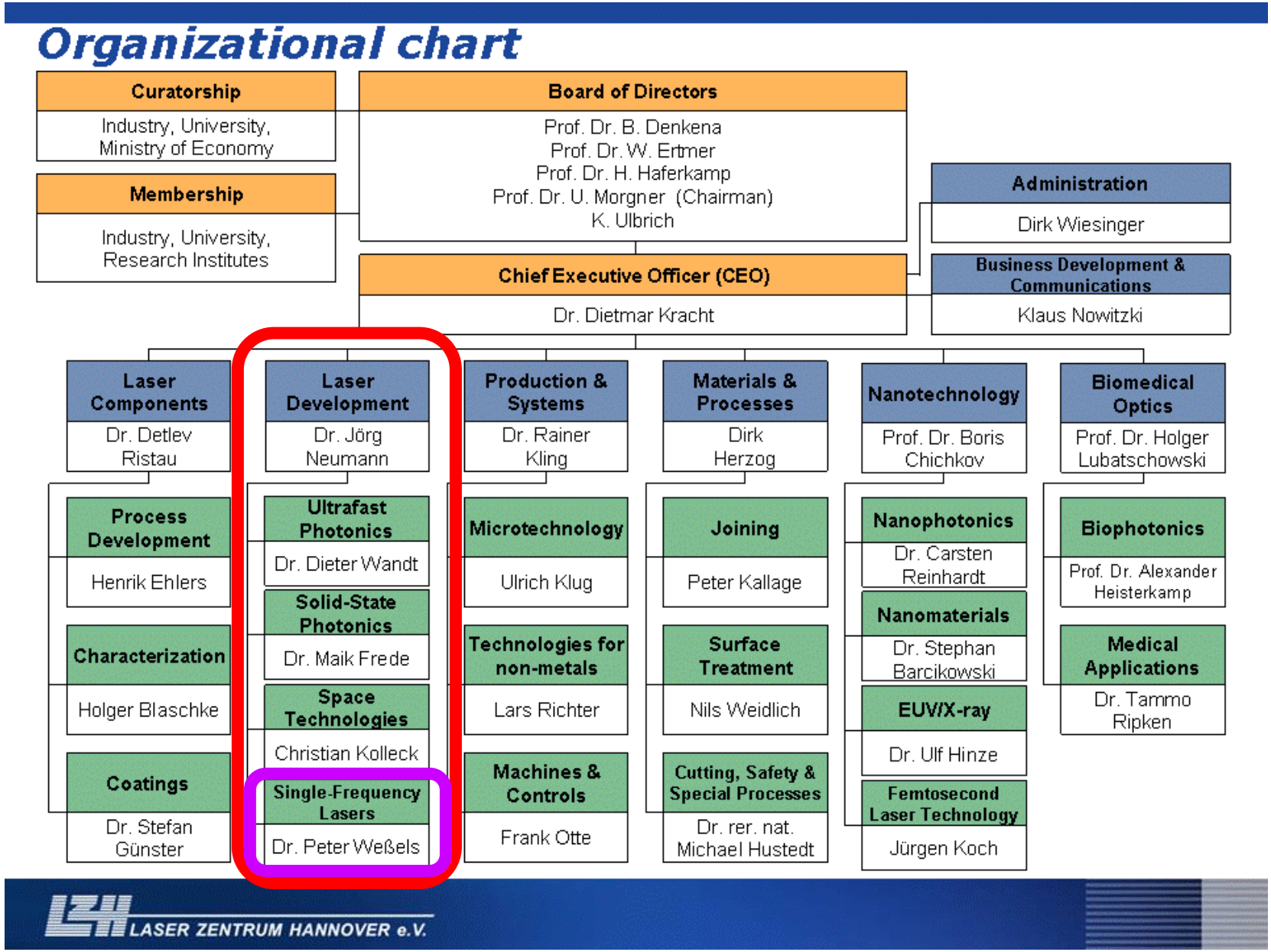

Airport
Hannover Airport
LZH
AEI
Hauptbahnhof
(Central station)
GEO600
Hannover
Garbsen
Seelze
Lohnde
Marienwerder
Stelingen
Engelbostel
Langenhagen
Meyenfeld
Berenbostel
Schulenburger Mühle
Godshorn
Isernhagen-Süd
Twenge
Isernhagen
Neuwarm
Rittergut Lohne
Basselthof
Kirchhors
Altwarmbüchen
Bothfeld
Sahlkamp
Vahrenheide
Lahe
Vinnhorst
Ledeburg
Burg
Stöcken
Letter
Vahrenwald
List
Groß-Buchholz
Misburg-Nord
Misburg-Süd
Eilenriede
Herrenhausen
Ahlem
Harenberg
Almhorst
Döteberg
Velber
Linden-Nord
Linden-Süd
Südstadt
Bult
Kleefeld
Anderten
Kirchrode
Davenstedt
Badenstedt
Lenthe
Königseiche
Kirchwehren
Bornum
Ricklingen
Bemerode
Seelhorst
Mittelfeld
Wülferode
Wülfel
Empelde
Oberricklingen
Northen
Everloh
Ditterke
Wettbergen
Gehrden
Ronnenberg
Hemmingen
Laatzen
Arnum
Ihme-Roloven
Redderse
Weetzen
Lemmie
Degersen
Sorsum
Linderte
Hiddestorf
Ohlendorf
Harkenbleck
Reden
Koldingen
Oesselse
Evestorf
Holtensen
Argestorf
Pattensen
Heisede
Bredenbeck am Deister
Lüdersen
Hüpede
Steinkrug
Bennigsen
Oerie
Sarstedt
Bremer Str
Ahlemer Str.
Südschnellweg
E30
E45
2
3
6
7
37
65
217
441
443

Laser Zentrum Hannover e. V.



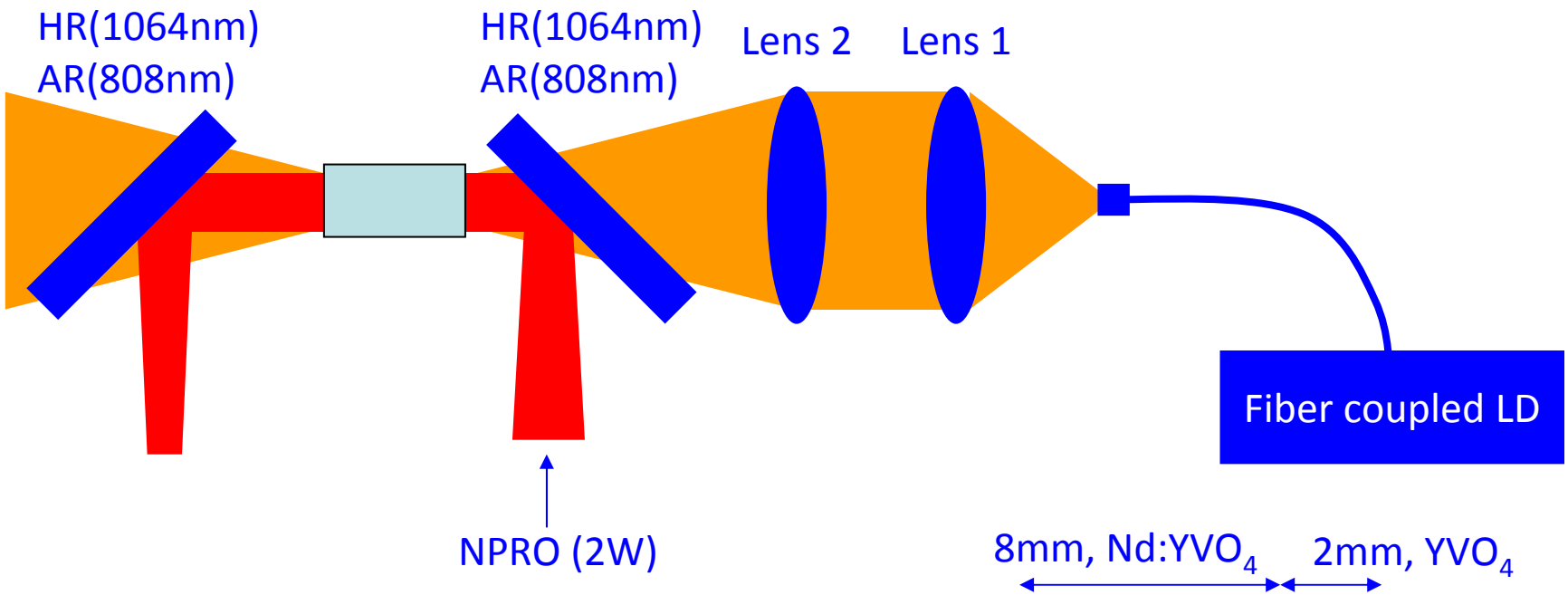
German
English
French
Russian
Italian
Swedish
Japanese

Organization chart of LZH



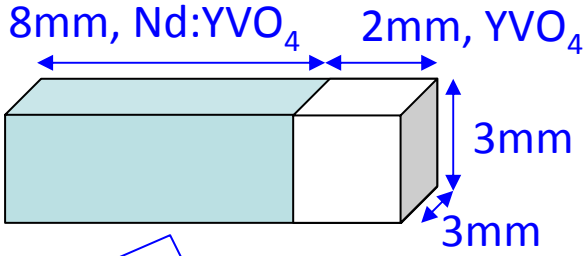
My work in LZH

- Optimization of a Nd:YVO_4 bulk amplifier



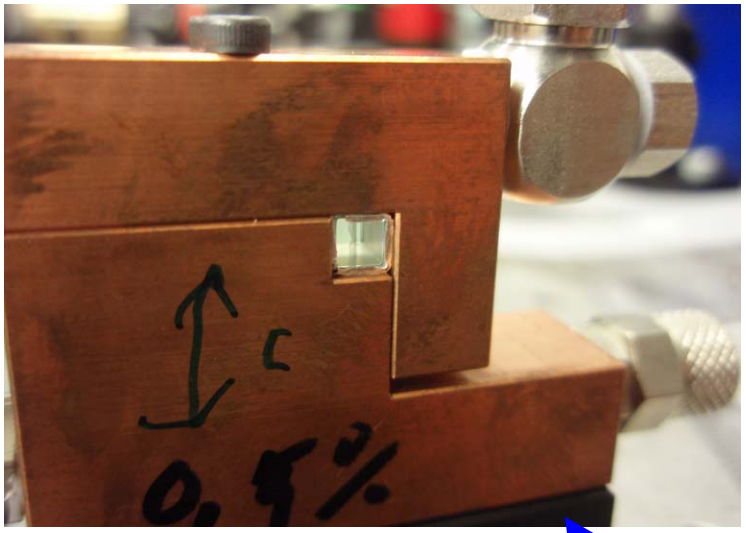
Parameters:
- Pump spot size
- Seed spot size
- Pump wavelength
- Seed wavelength

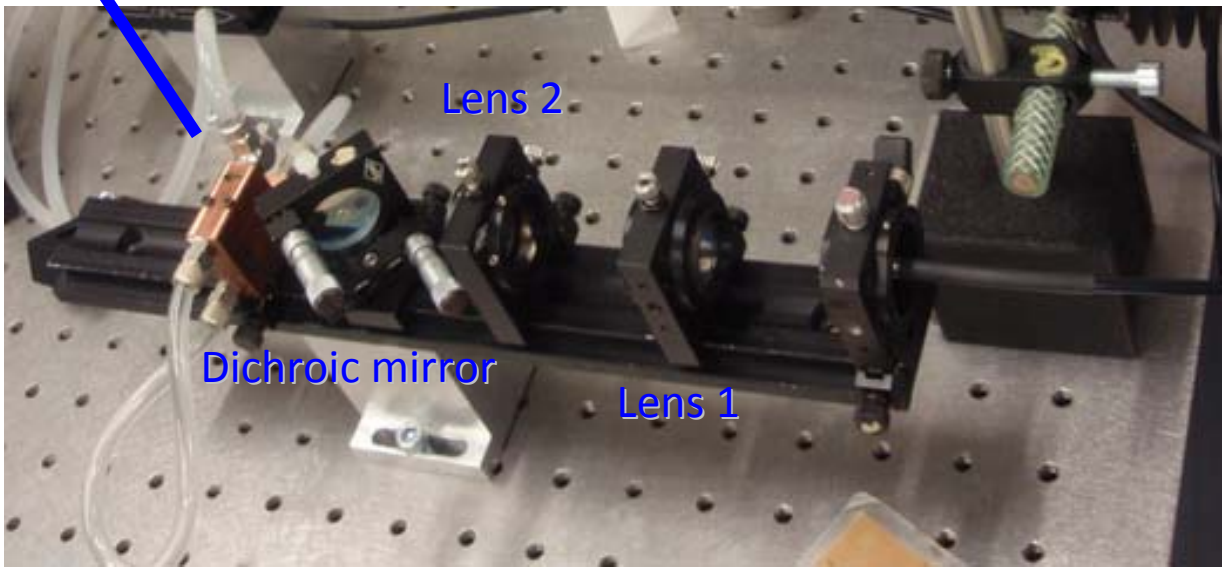
⇨ High efficiency
Good beam quality



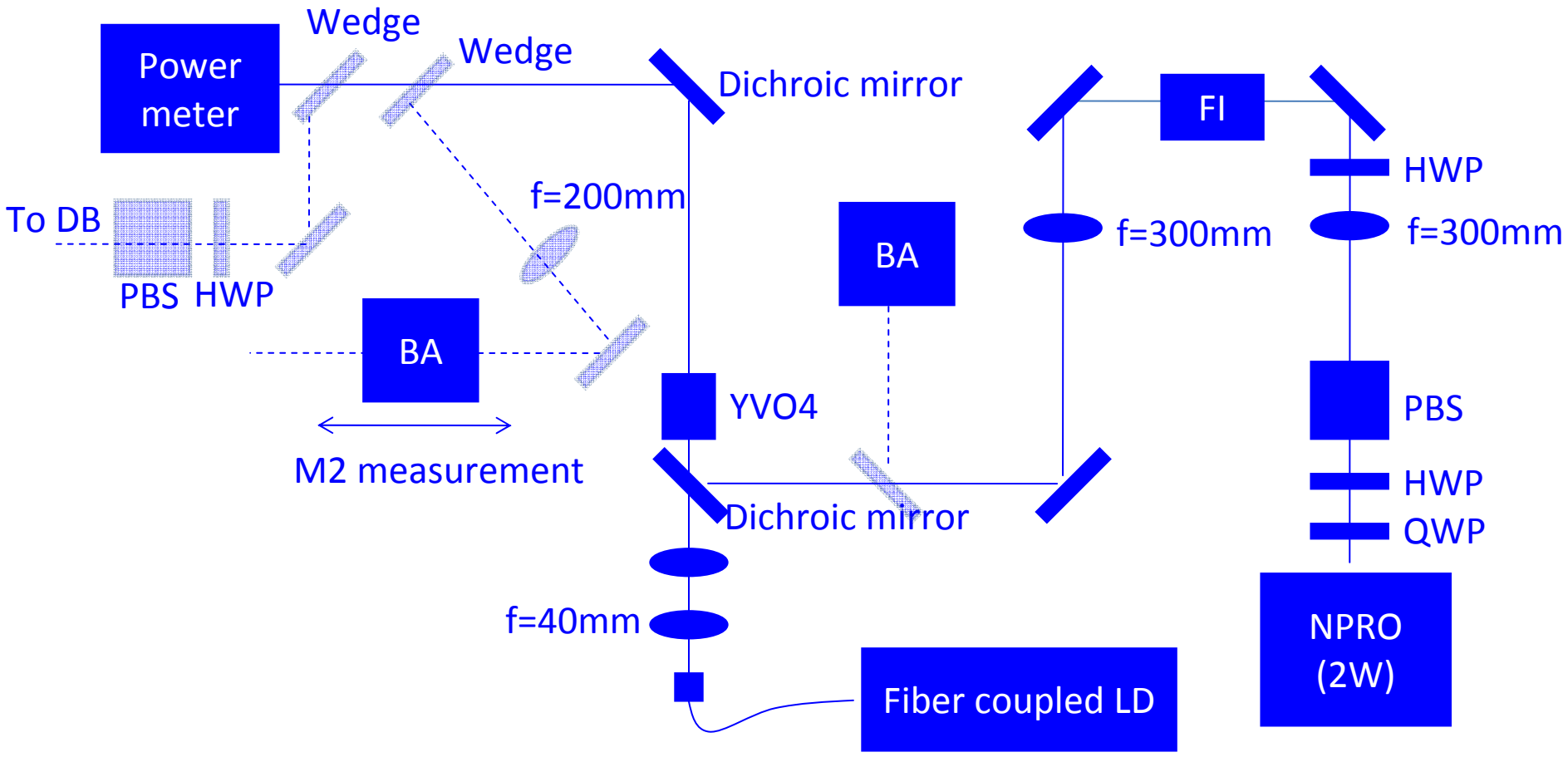
- 0.3 at.% doped
- 0.5 at.% doped

Nd:YVO_4 amplifier





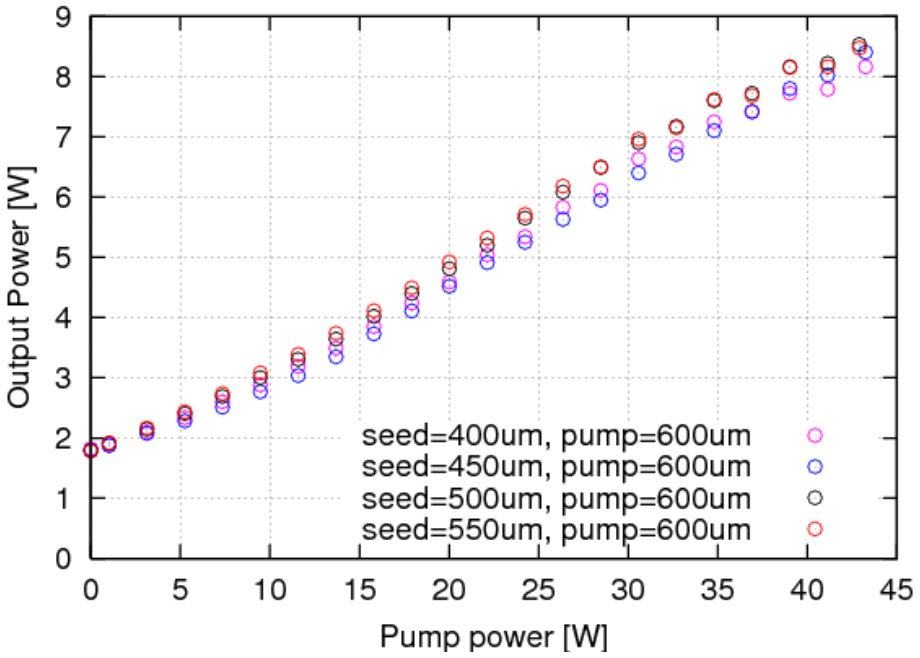
Optical layout

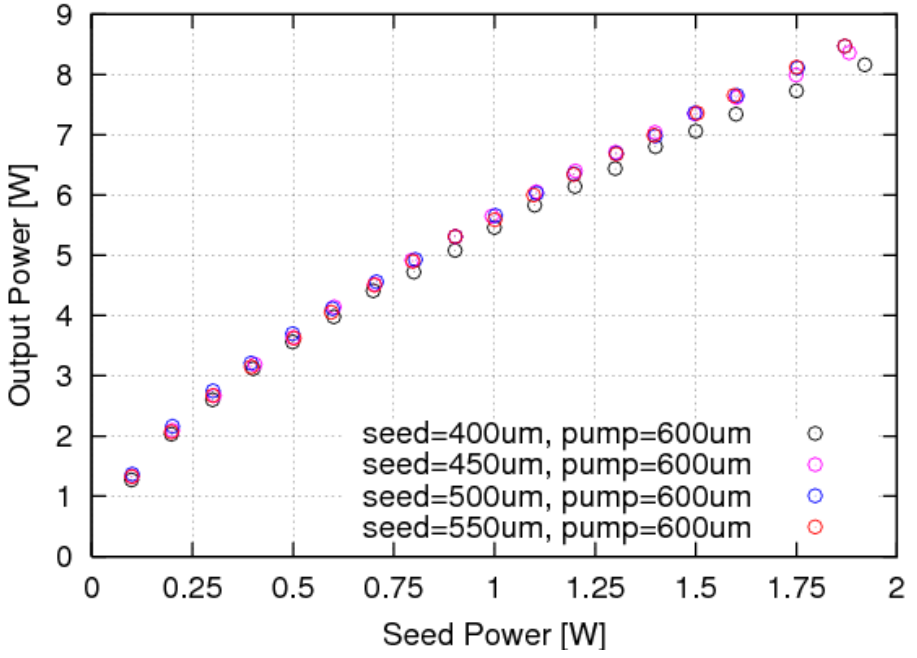


Ex.) pump spot size = 600um (0.3 at.% crystal)

- Pump power vs amplified power
  - Seed power = 1.8W
- Seed power vs amplified power
  - Pump power = 43W

When seed spot size = 500um, the efficiency of amplification was maximum.

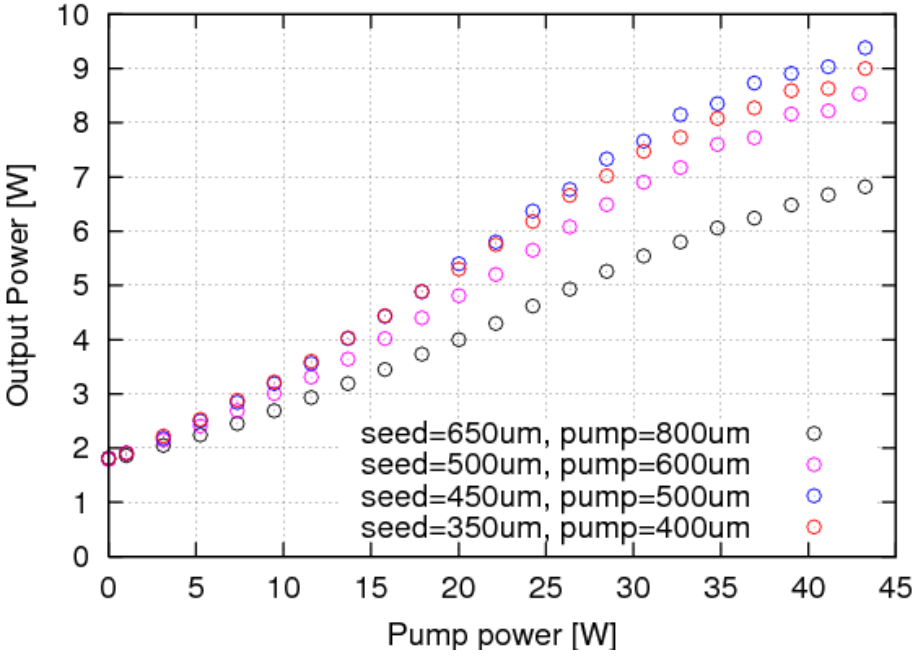


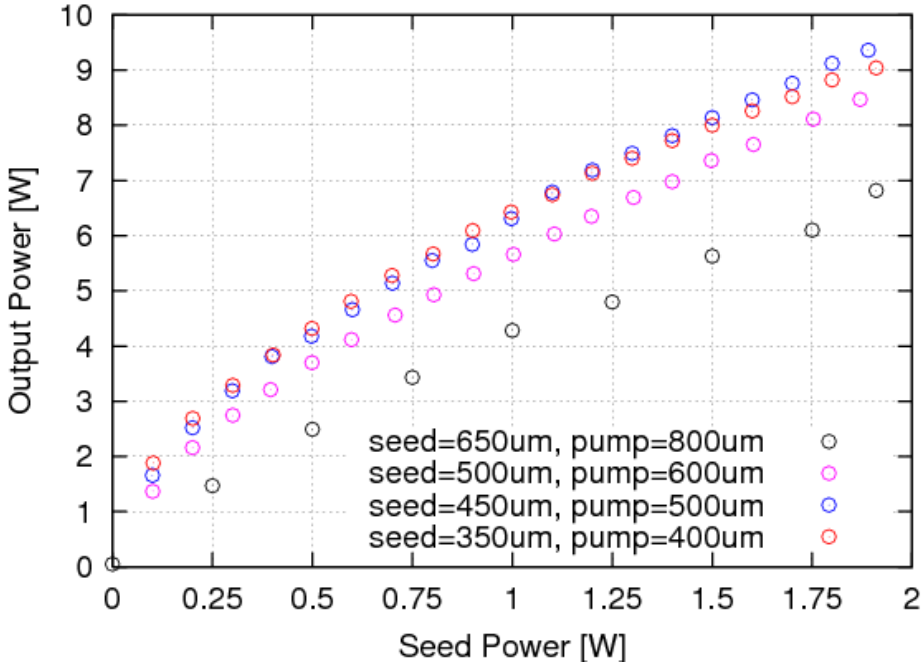


Highest efficiency amplification (0.3 at.% crystal)

- Pump power vs amplified power
  - Seed power = 1.8W
- Seed power vs amplified power
  - Pump power = 43W

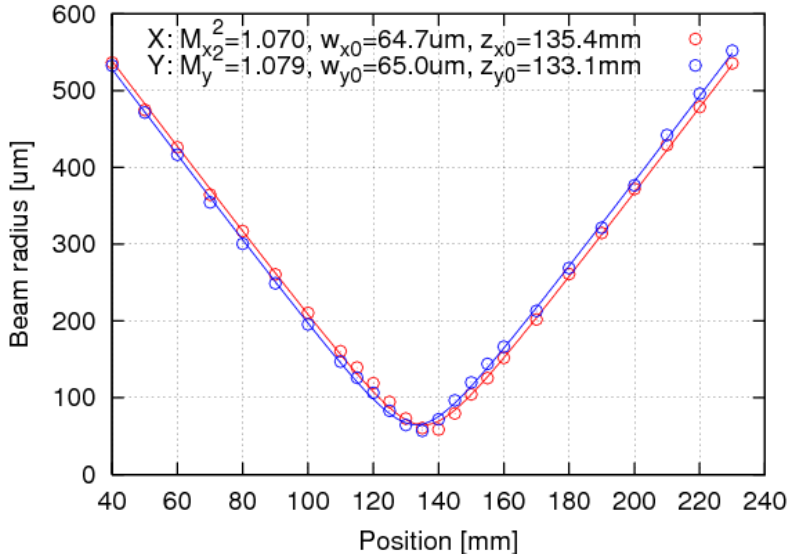
Maximum amplified power was 9.3W (pump = 500um, seed = 450um).





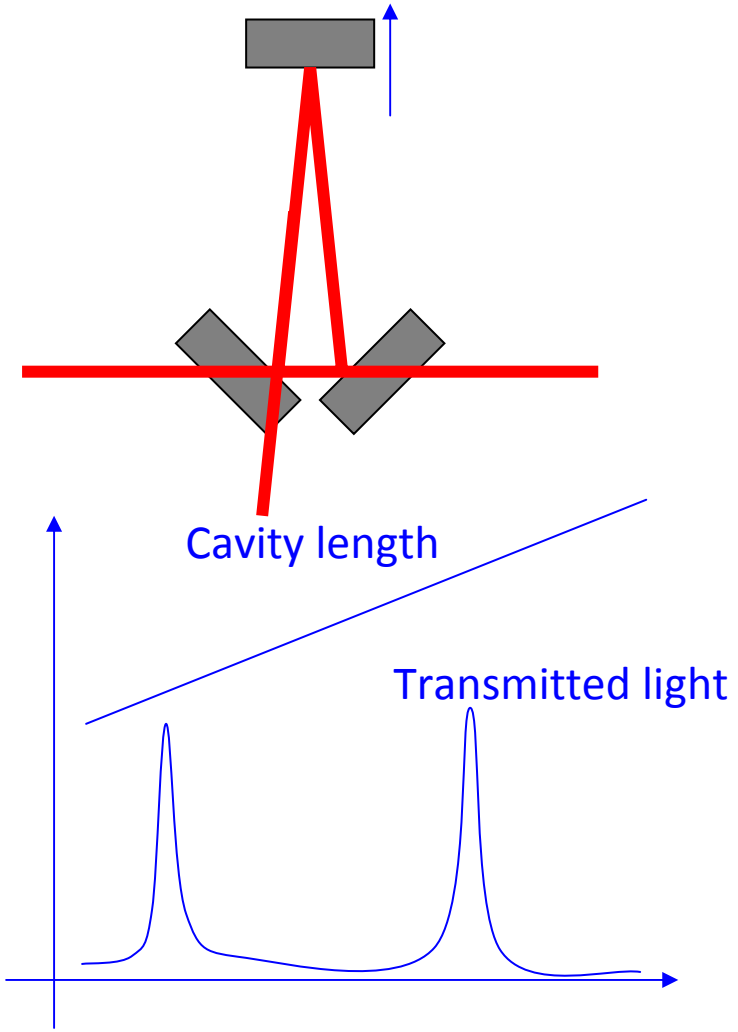
Beam quality (TEM_{00} power)

- M-squared
  - $M^2 < 1.2$ (all results)
    - Ex.)



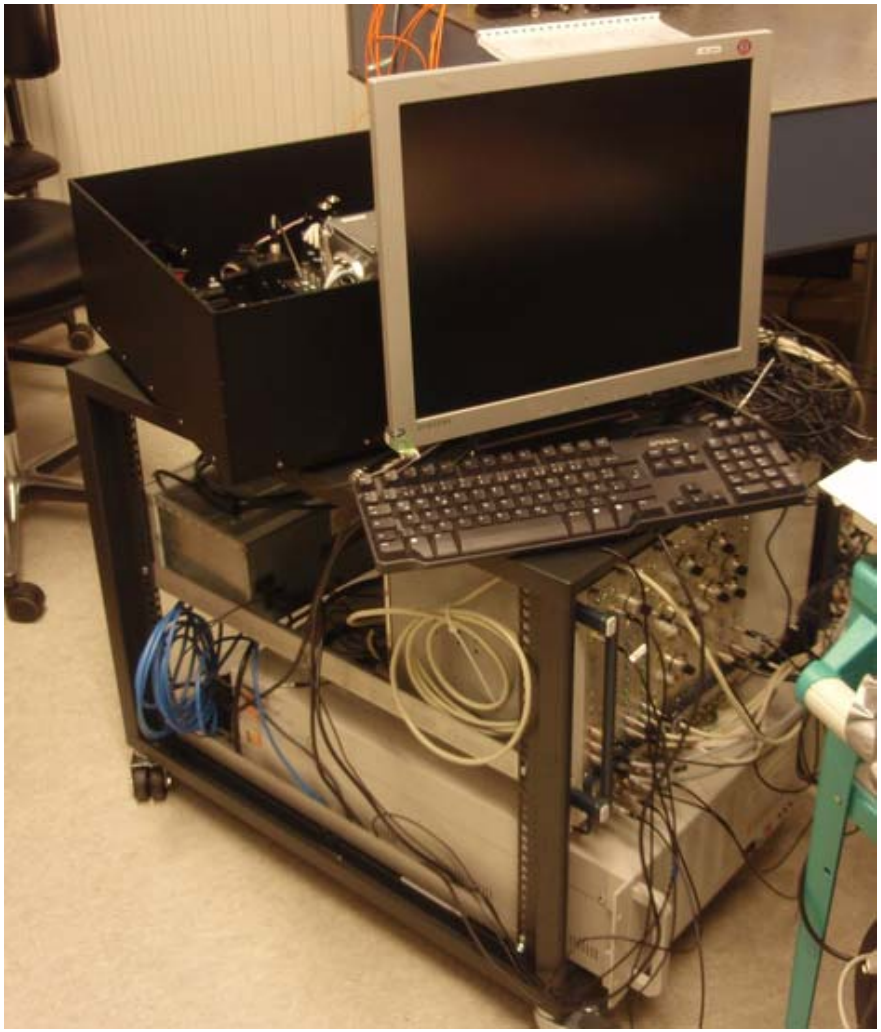
… ???

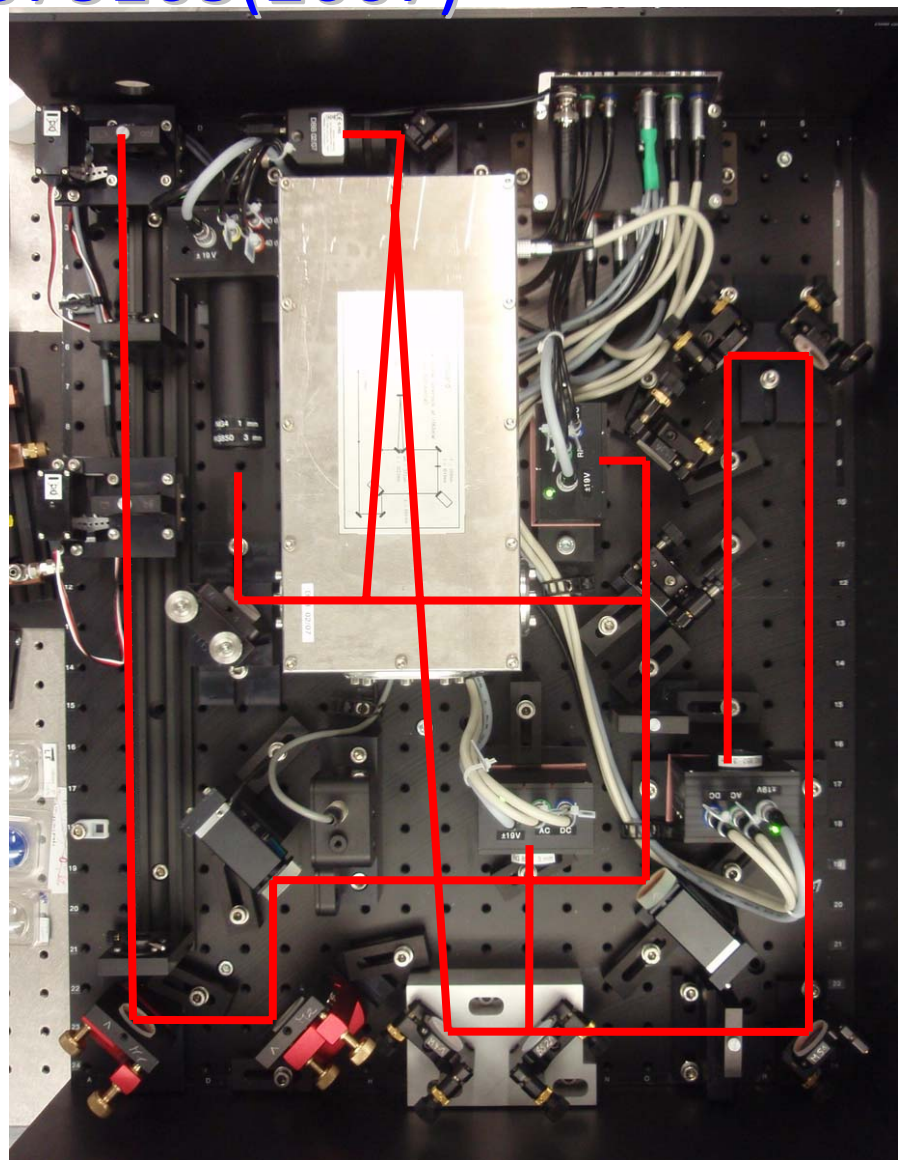
- Modescan
  - TEM_{00} power > 95% (all)



Diagnostic breadboard

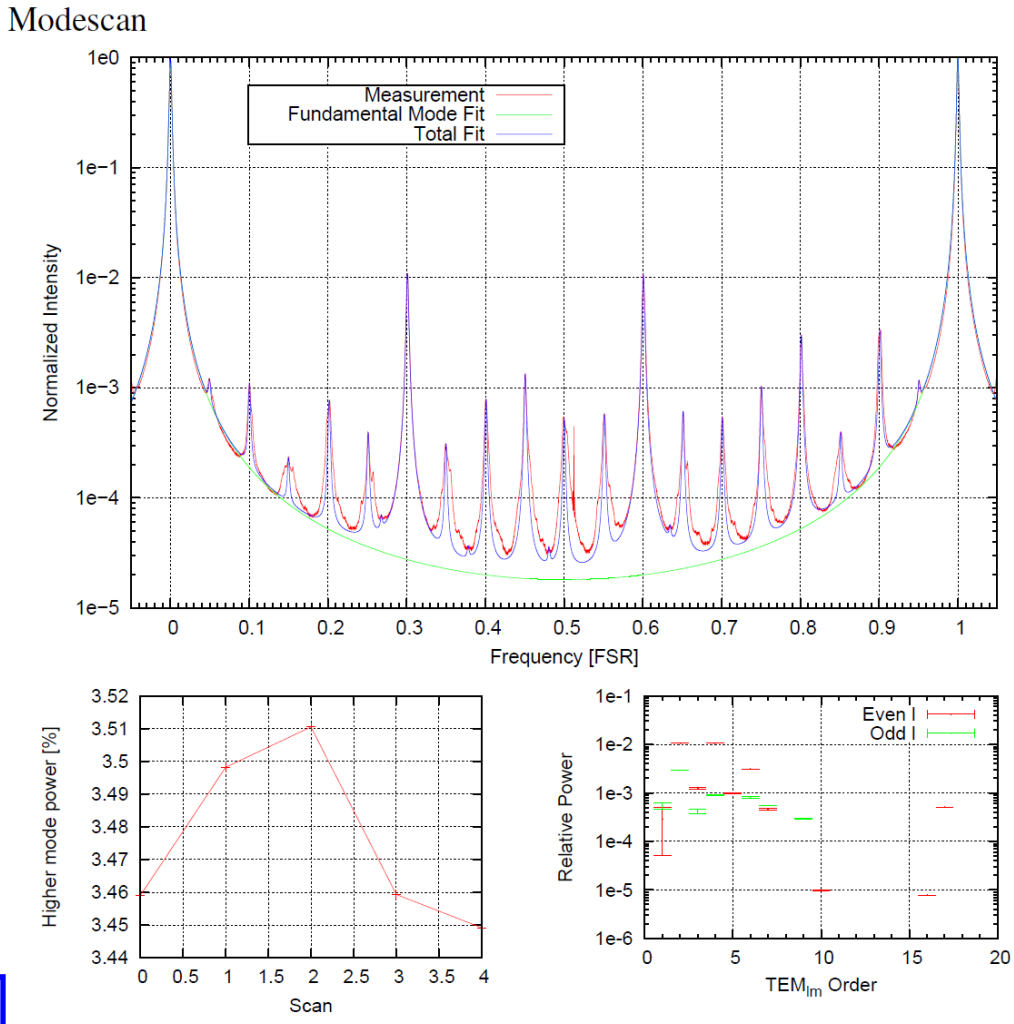
- P. Kwee et. al., RSI, 78, 073103(2007)
  - Made in AEI





Diagnostic breadboard

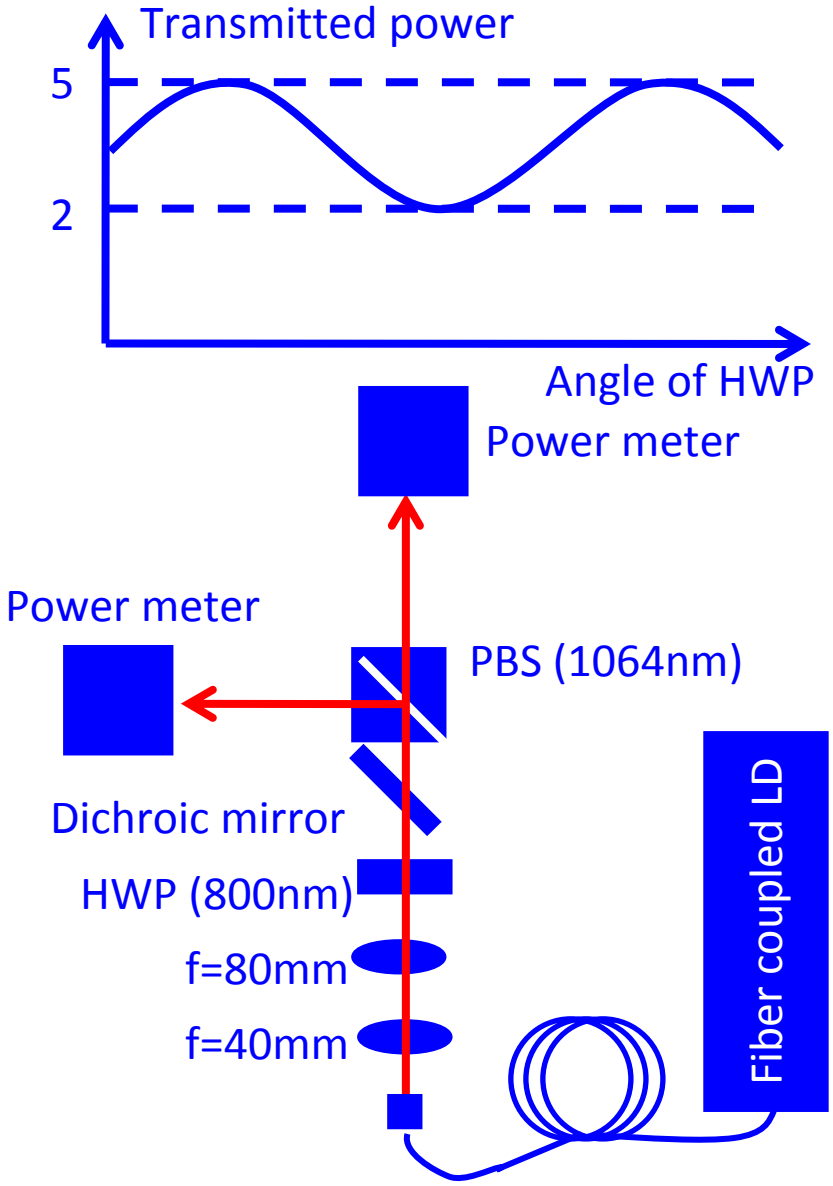
- Beam analysis
  - TEM_{00} power
  - Beam pointing
  - Frequency noise
  - Intensity noise

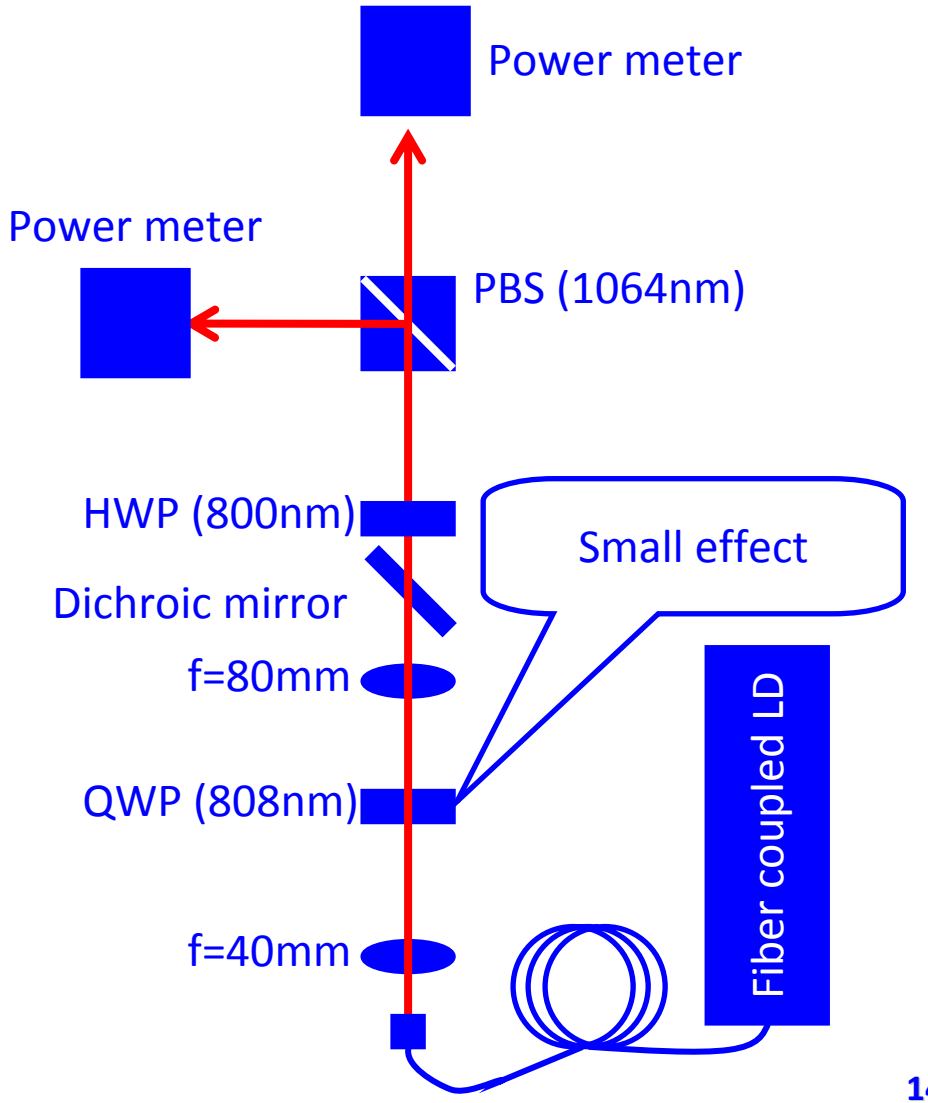


Higher mode power: 3.47522% ± 0.0243661%

Number of scans:	5	Relative power of one sideband:	-1 ± 0
Measurement duration:	5 s	Significant modes:	4 ± 0
Measurement start:	Fri Nov 07 13:49:02 2008	Average deviation:	-0.00502907 FSR
PD signal:	0.000133344 V . . . 4.52966 V	Relative horizontal (X) misalignment:	0.0230969 ± 0.00187634
Samples per FSR:	21983.8 ± 1.46969	Relative vertical (Y) misalignment:	0.0128532 ± 0.00152623
Calibration deviation:	-2.7685% ± 0.00455583%	Relative mismodematching:	0.103055 ± 0.000578782
Finesse:	372.717 ± 2.24088	Roundtrip Gouy phase:	0.15051 FSR ± 4.73388e-05 FSR
Higher mode count:	22 ± 0.632456		
Higher mode power:	3.47522% ± 0.0243661%		

Polarization of pump light





Summary (Experiment)

- It was difficult to find the “optimum” condition of a bulk amplifier …
  - because there are many parameters and their couplings.
    - Seed spot size
    - Pump spot size
    - Wavelength of the seed laser
    - Wavelength of the pump light
    - “Polarization” of pump light
- 0.3 at.% Nd:YVO4
  - “Pump size = 500 um, Seed size = 450 um” was the best condition of amplification.
  - Beam quality was very good in each condition (TEM00 power > 95 %).
  - But, the polarization of pump light was not discussed about this crystal.
- 0.5 at.% Nd:YVO4
  - Optimum condition could not be found because …
    - Polarization of pump light, and too large absorption of pump light.
    - I did not have enough time to measure.

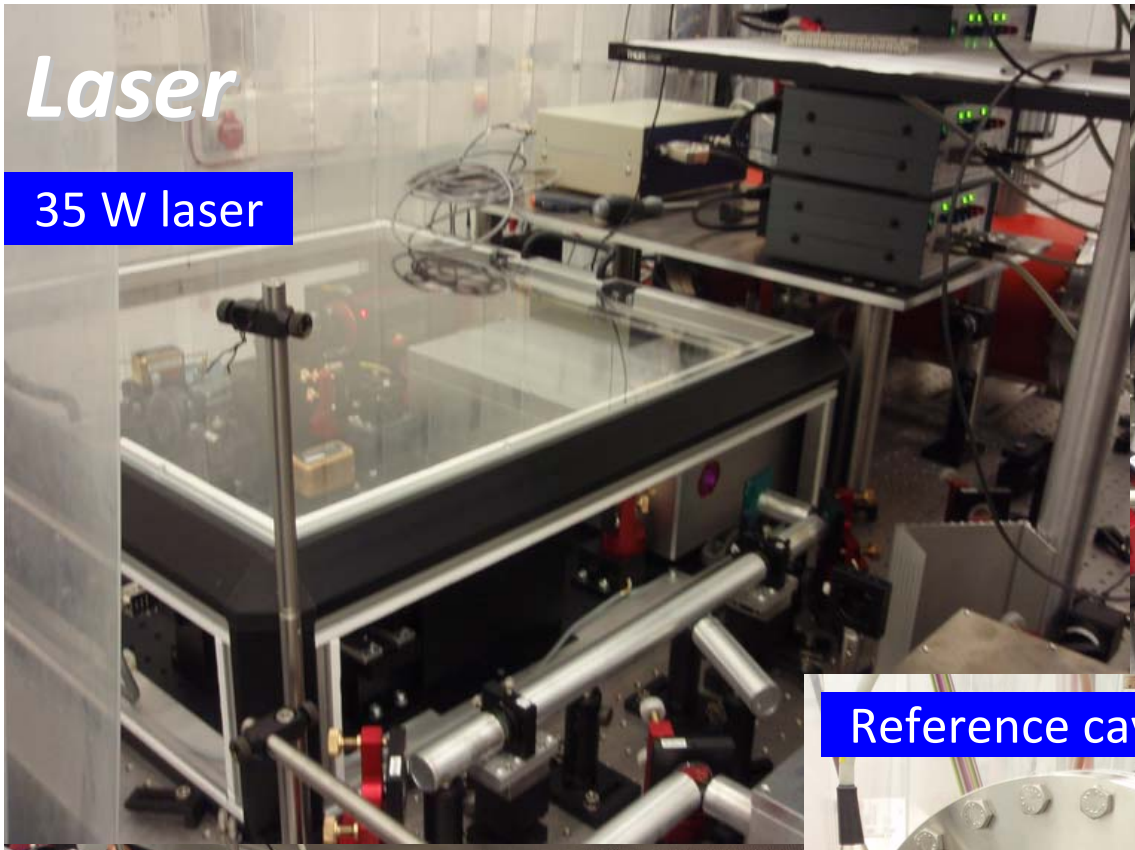
Laser system for Advanced LIGO

- I will talk about PSL for Advanced LIGO in Mio group seminar (2008/12/24?).
  - 180 W injection-locked laser, frequency and intensity stabilization
  - Comparison of our laser system with this PSL system

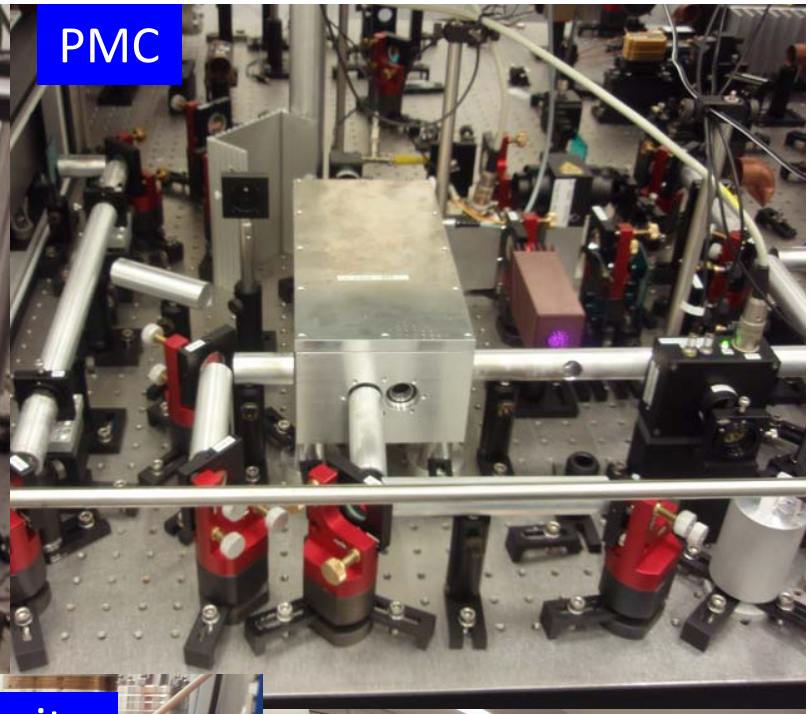
Albert Einstein Institute

Laser

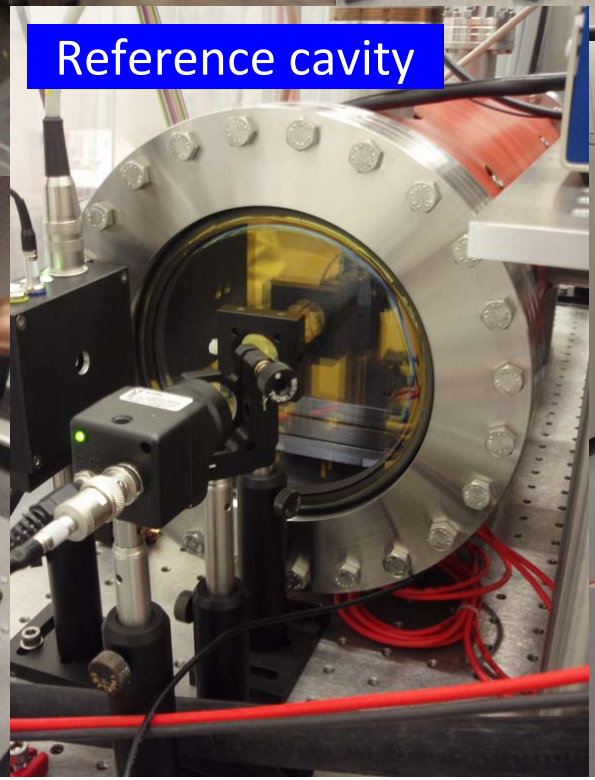
35 W laser



PMC

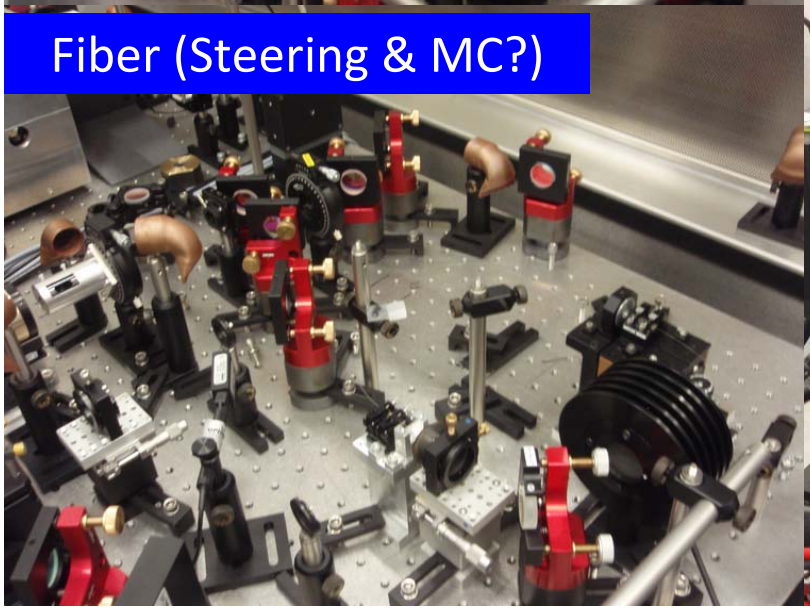


Reference cavity

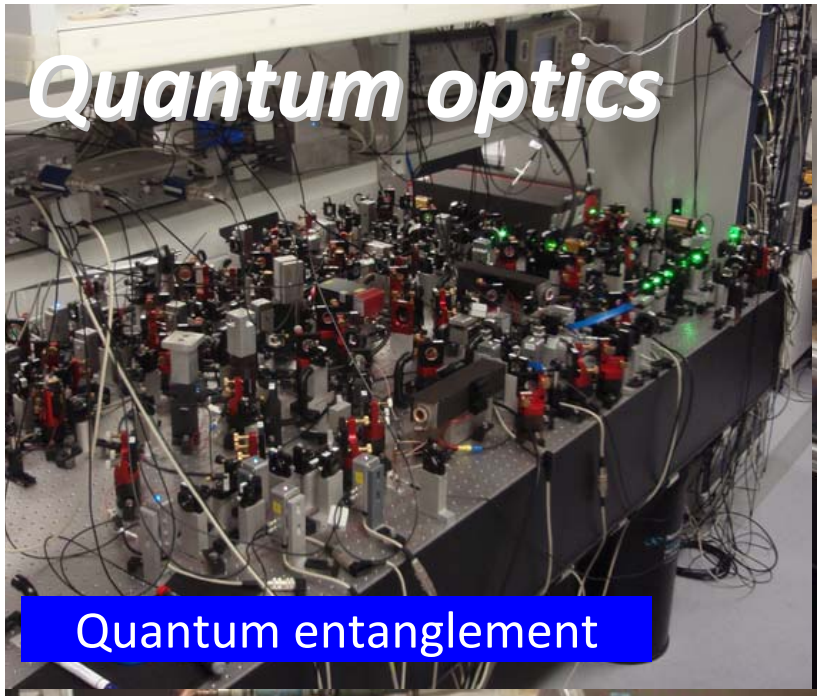


Optical table
for 200 W laser

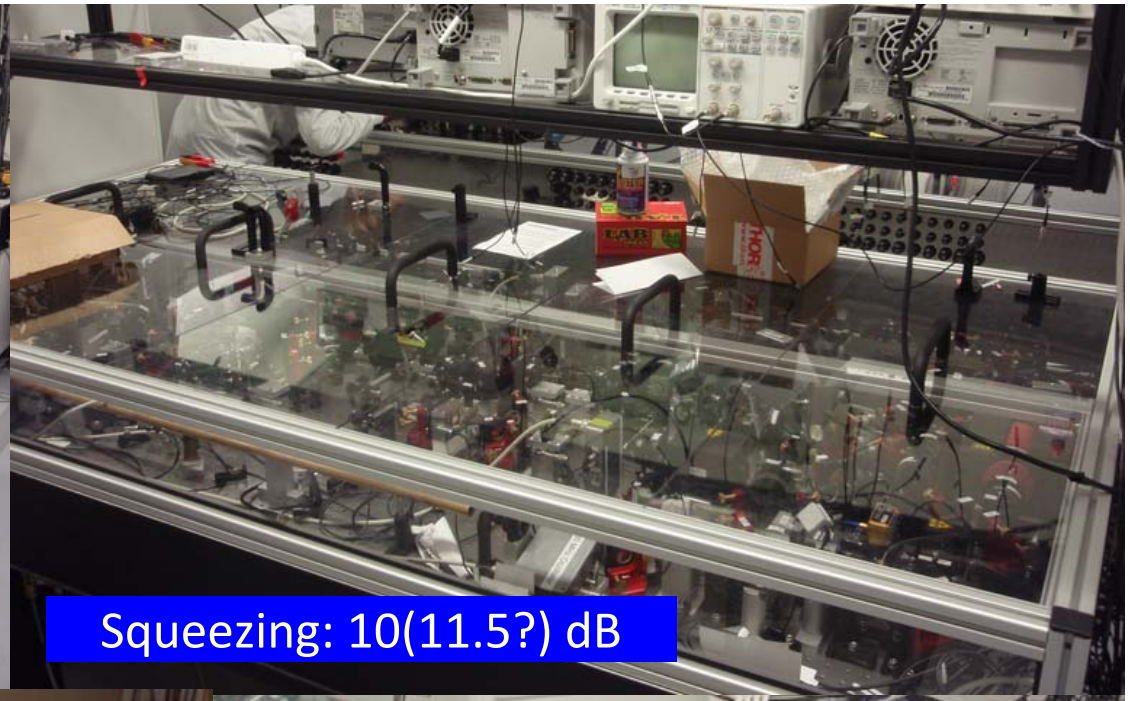
Fiber (Steering & MC?)



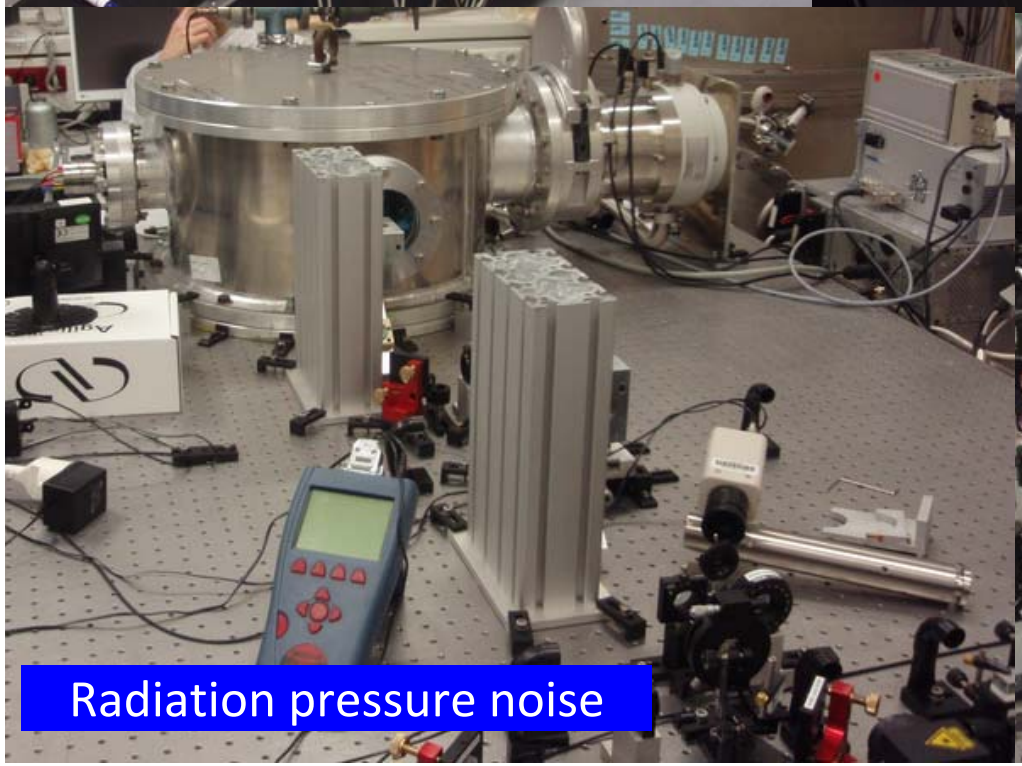
Quantum optics



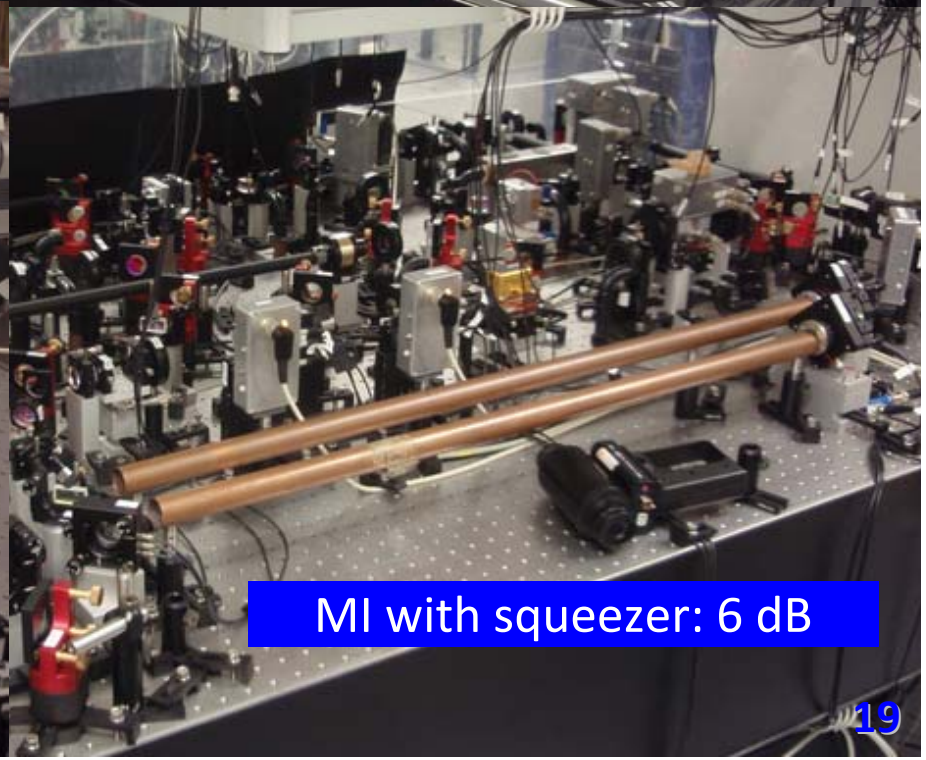
Quantum entanglement



Squeezing: 10(11.5?) dB



Radiation pressure noise



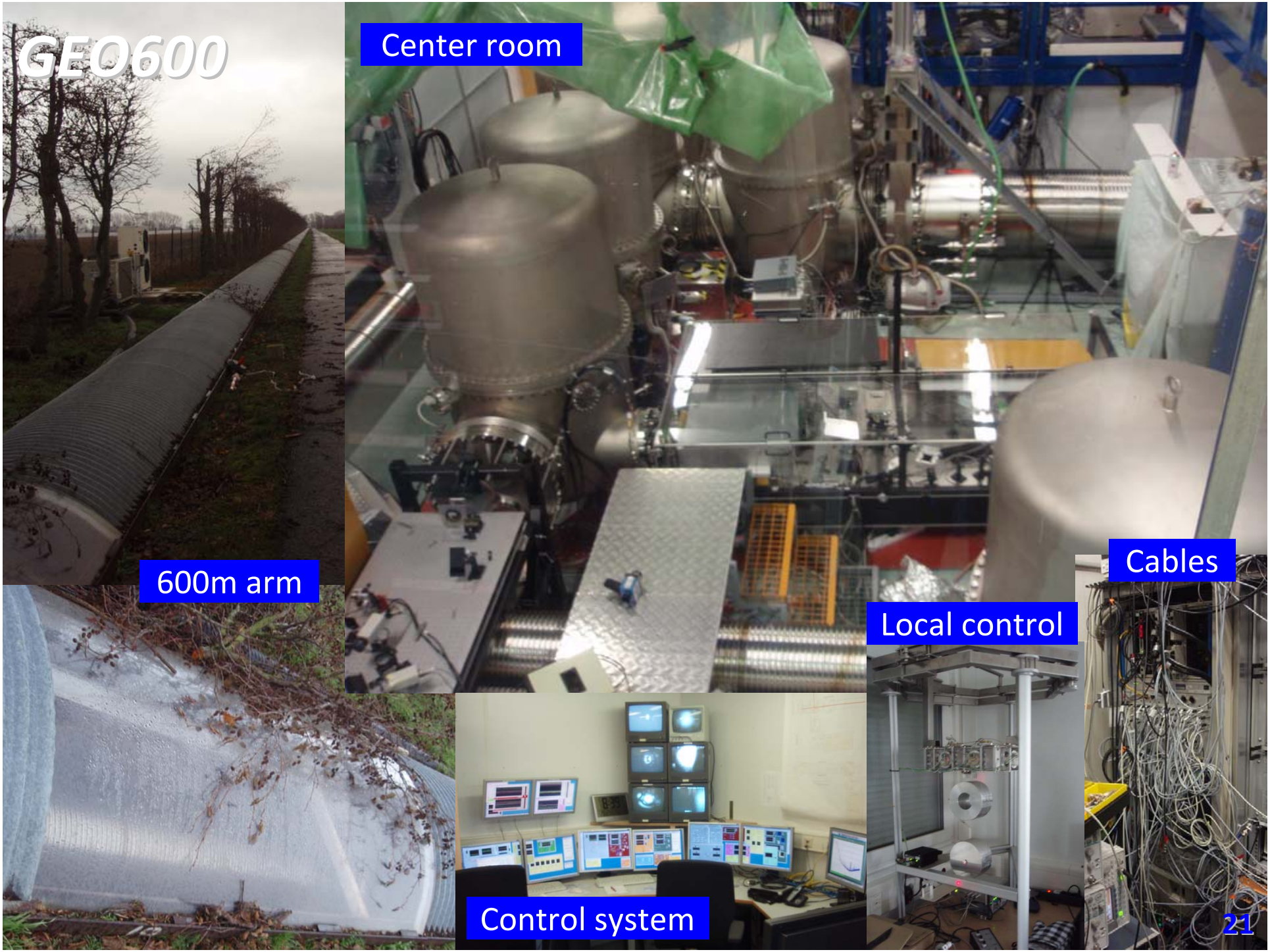
MI with squeezer: 6 dB

10m prototype

Lab

Poster

MI is not 10 m, only 1 m.
MC is 10 m.
Laser power is 35 W.
Mass of mirrors are 100 g.
Mirrors are not cooled.
A few coating.
Designed to observe the SQL.
Suspended optical table (LISA).


GEO600
Center room
600m arm
Cables
Local control
Control system

Summary

- LZH
  - Experiment (Bulk amplifier)
  - Research
    - Laser system for the E-LIGO and the A-LIGO
- AEI
  - Laser
  - Quantum optics
  - 10m prototype
  - GEO600