Installation and integration of the PSL

Oliver Puncken

Outline

- Construction of the PSLs
- Preparation of the sites
- Sending lasers around the world
- Integration and user interfaces

Outline

- **Construction of the PSLs**
- Preparation of the sites
- Sending lasers around the world
- Integration and user interfaces

Time traveling

2003 04 05 06 07 08 09 10 11 12 13

Two-head systems,
Bow tie lasers

Laboratory prototype

Laboratory prototype

Laboratory prototype

Laboratory prototype

Functional prototype

Engineering prototype

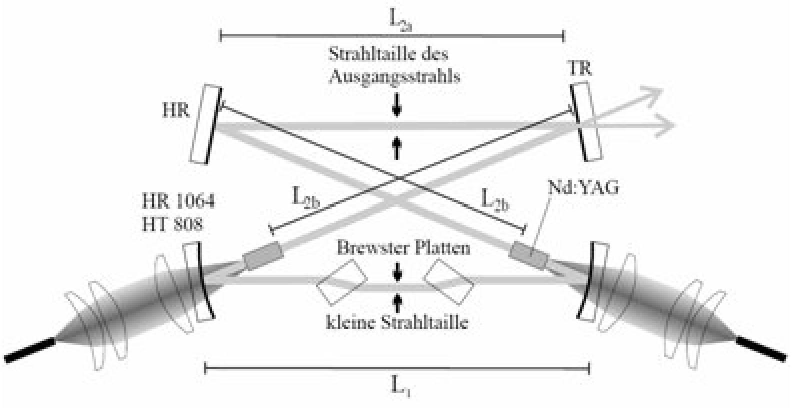
Reference system

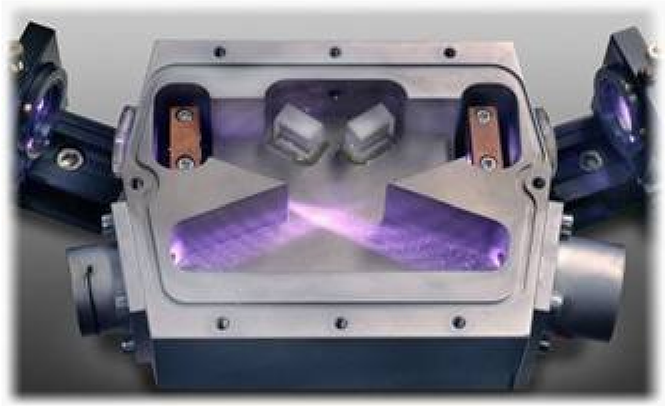
Observatory

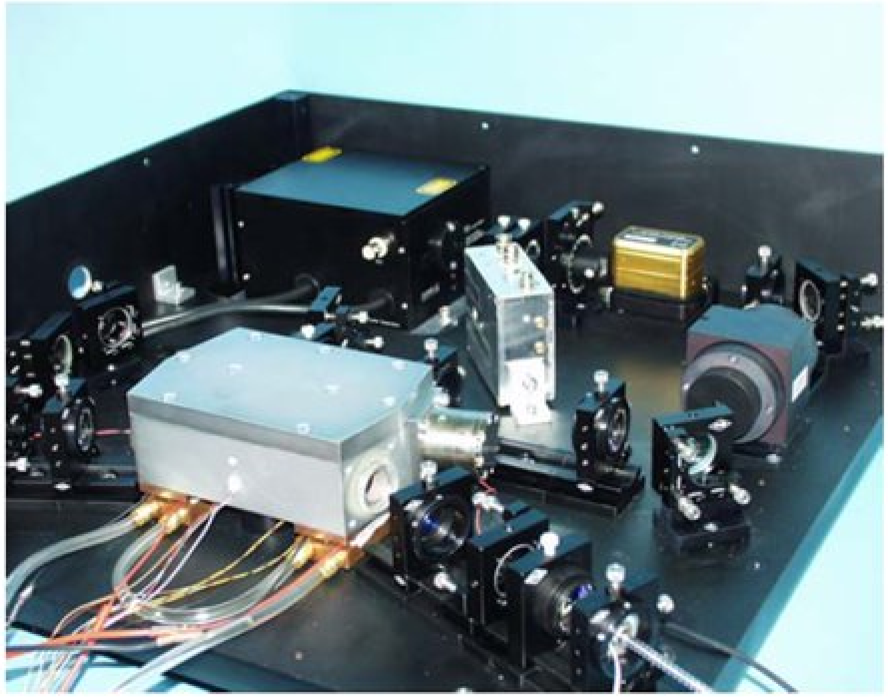
Time traveling

Bow-tie laser

2003 04 05 06 07 08 09 10 11 12 13





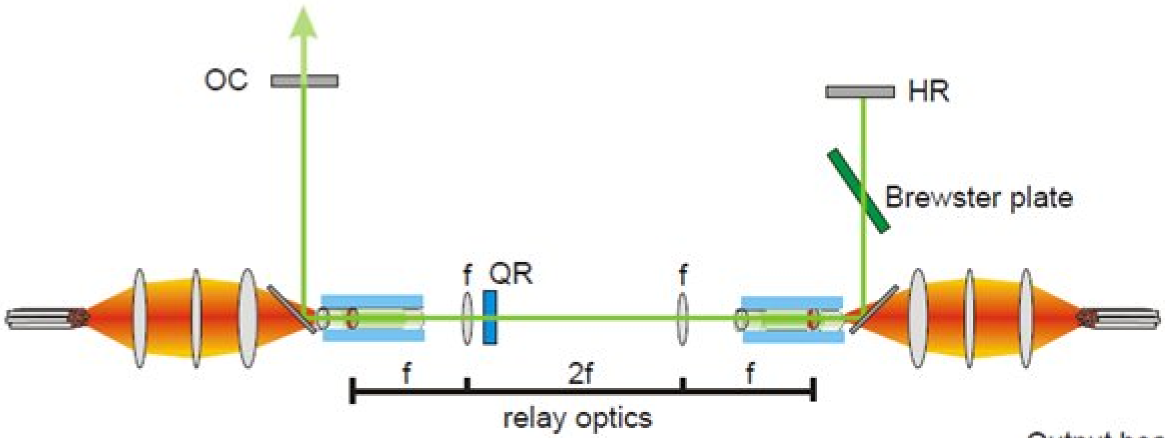


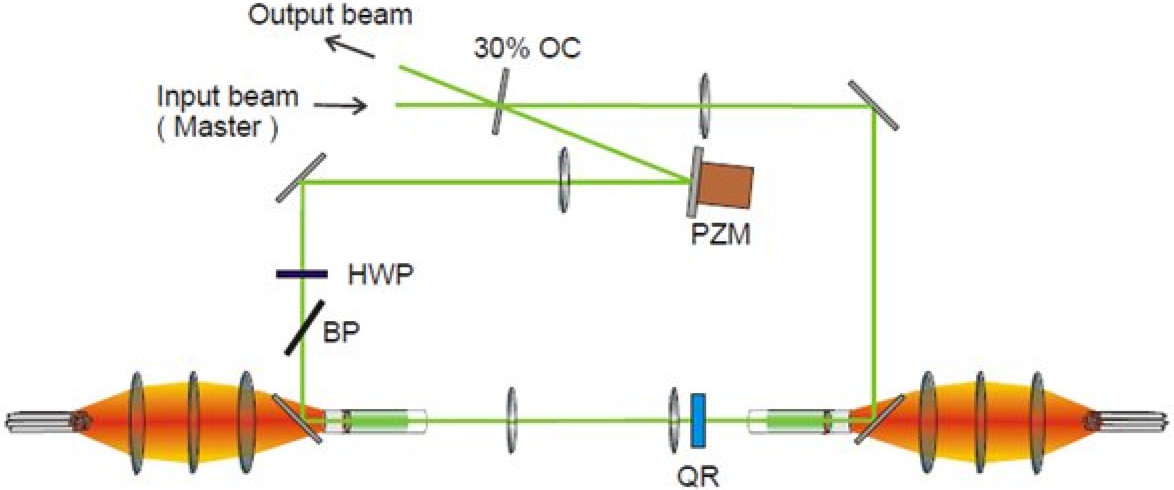
Nd:YAG, 14 W, M^2<1.05

Time traveling

Two-head system

2003 04 05 06 07 08 09 10 11 12 13

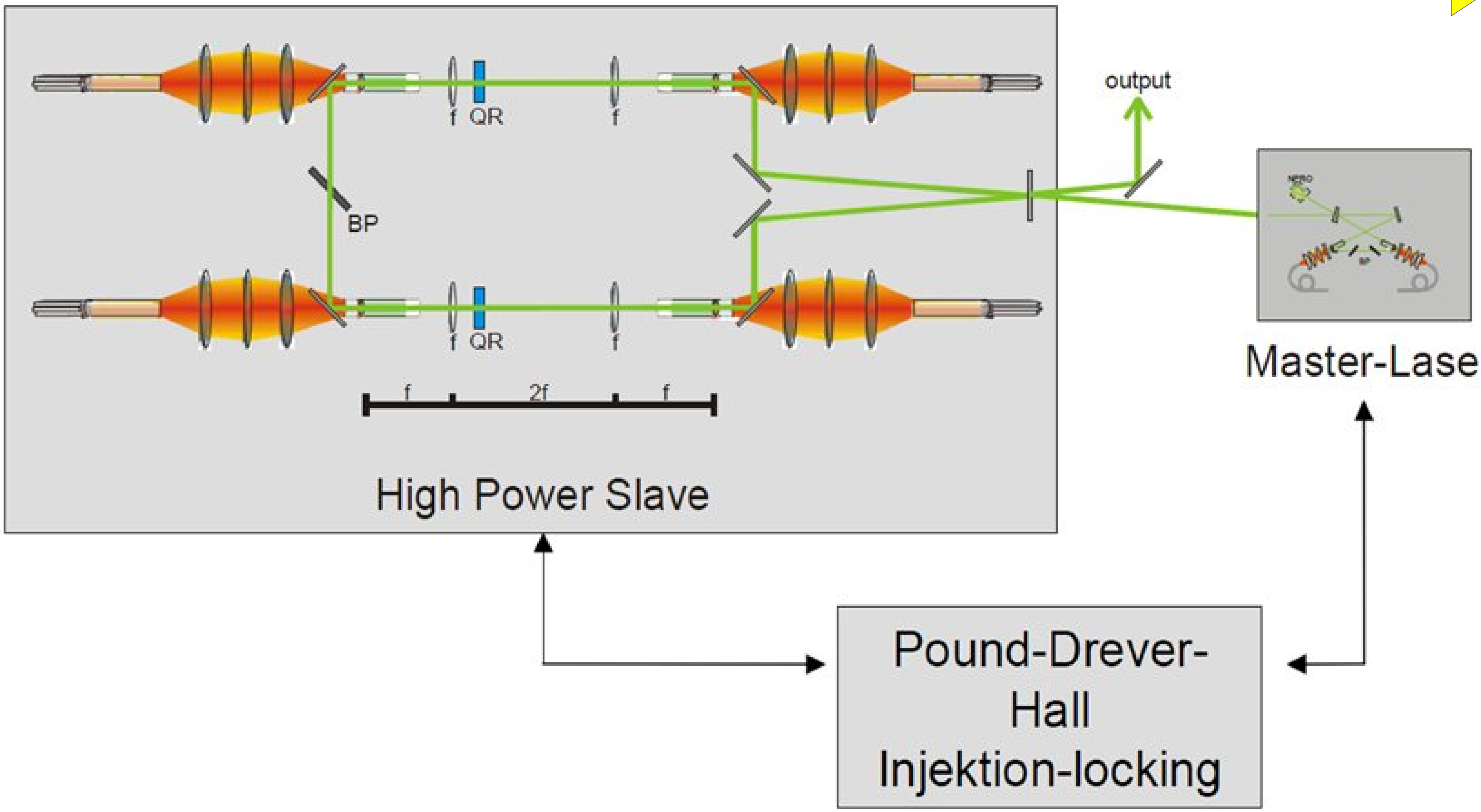




Time traveling

Laboratory prototype

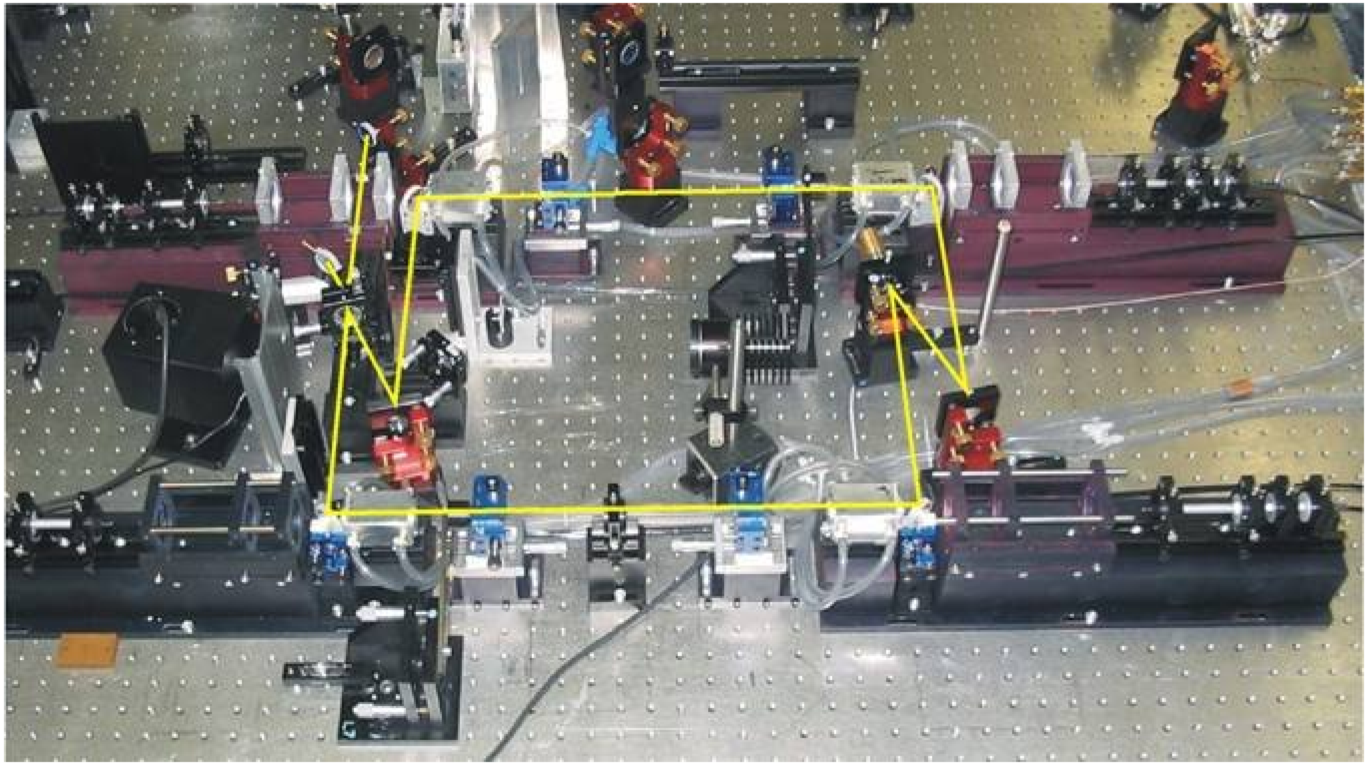
2003 04 05 06 07 08 09 10 11 12 13



Time traveling

Laboratory prototype

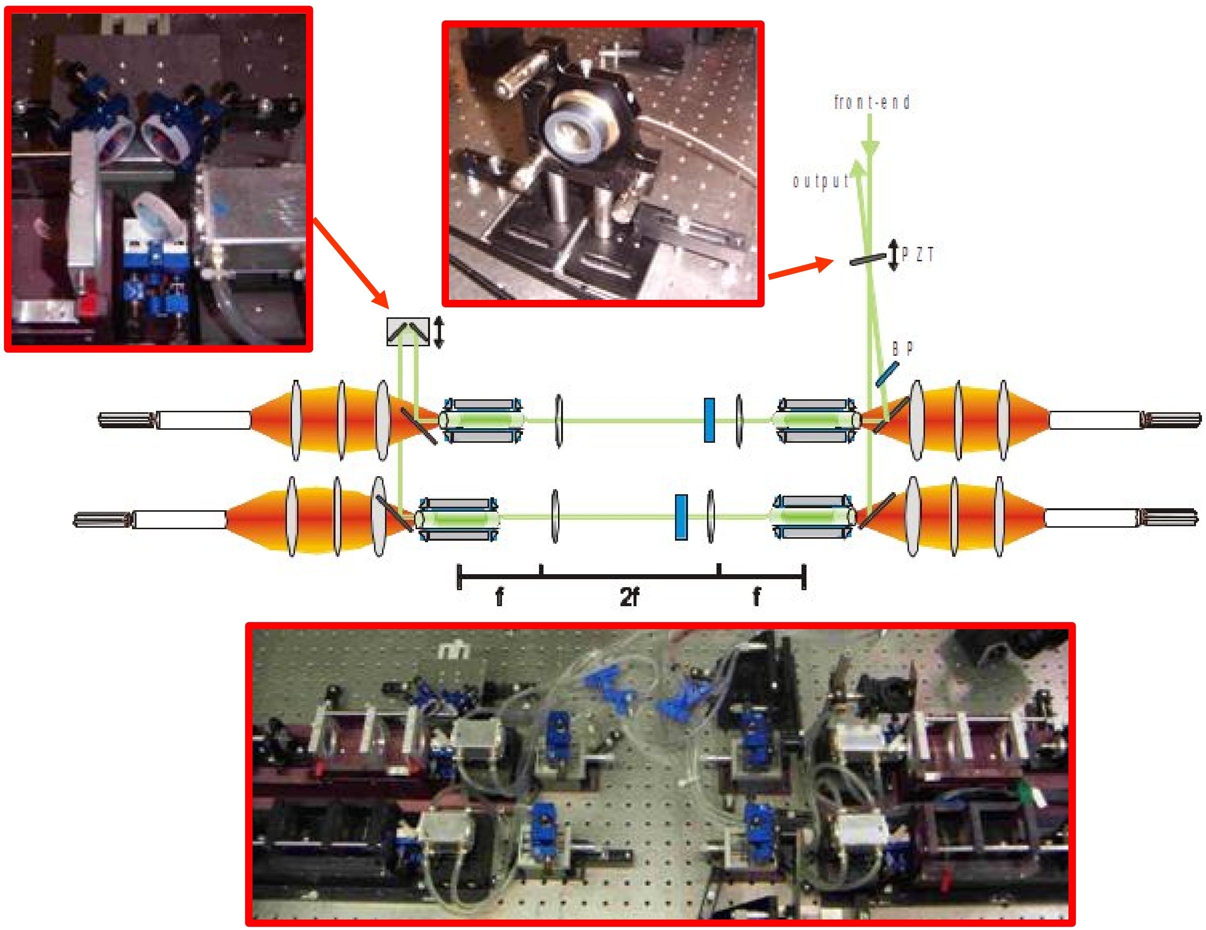
2003 04 05 06 07 08 09 10 11 12 13



Time traveling

Laboratory prototype

2003 04 05 06 07 08 09 10 11 12 13



Seed source:
4 stage Nd:YVO amplifier (35 W)

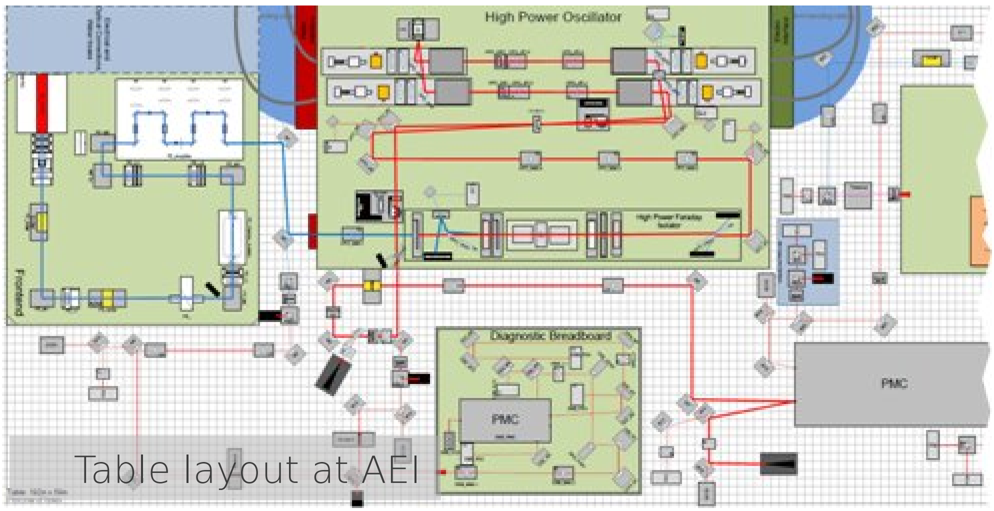
Asymmetric Resonator for better mode control

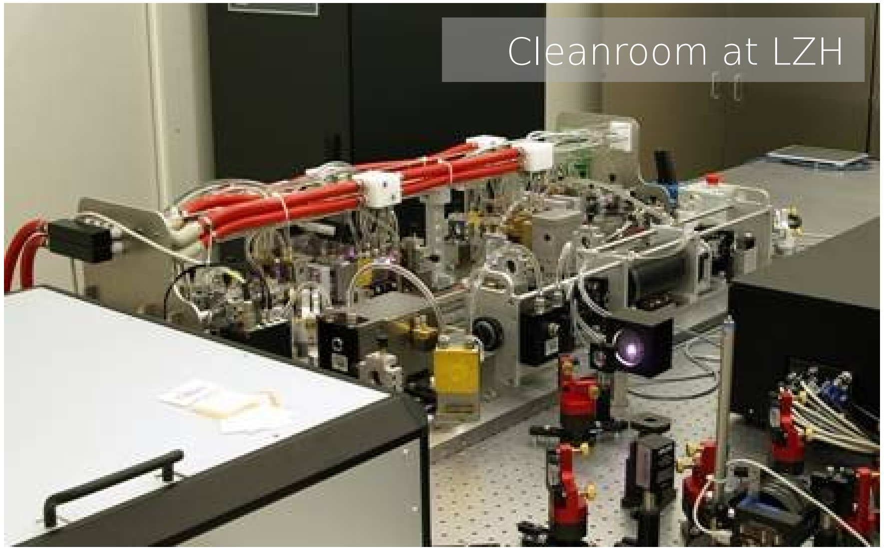
Output (injection-locked):
183 W

Time traveling

Engineering prototype ↓

2003 04 05 06 07 08 09 10 11 12 13





Fully boxed system

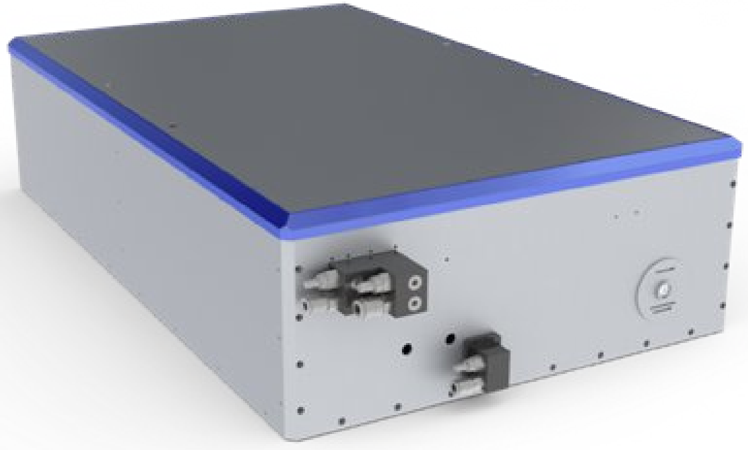
A lot of diagnostics

Output (injection-locked): 220 W upstream the PMC

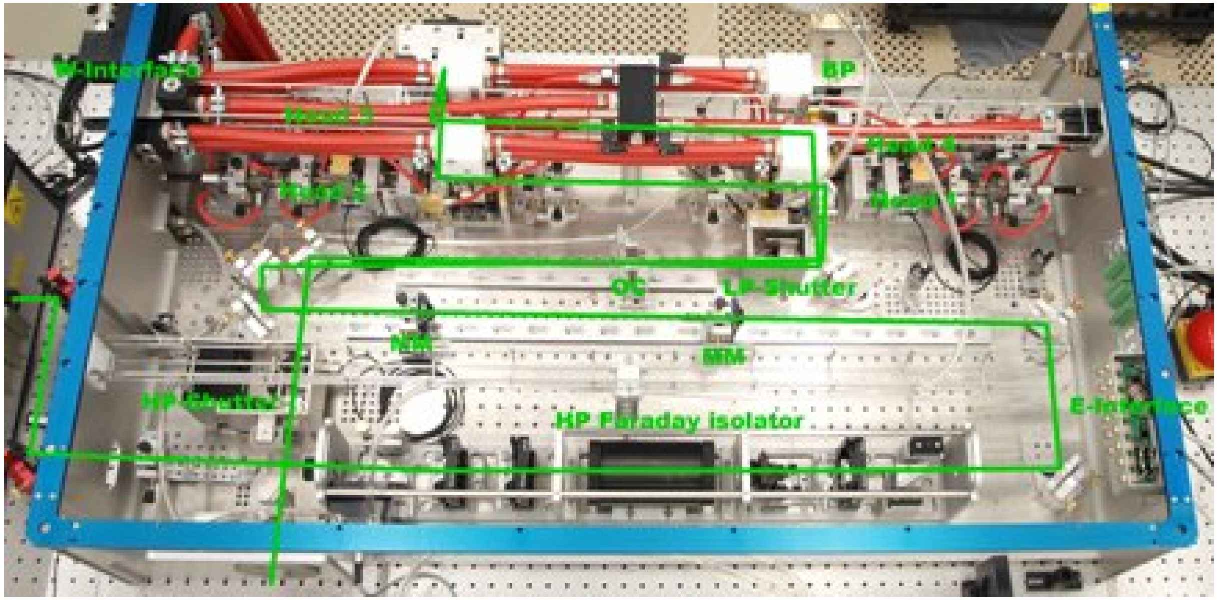
Time traveling

Reference system

2003 04 05 06 07 08 09 10 11 12 13

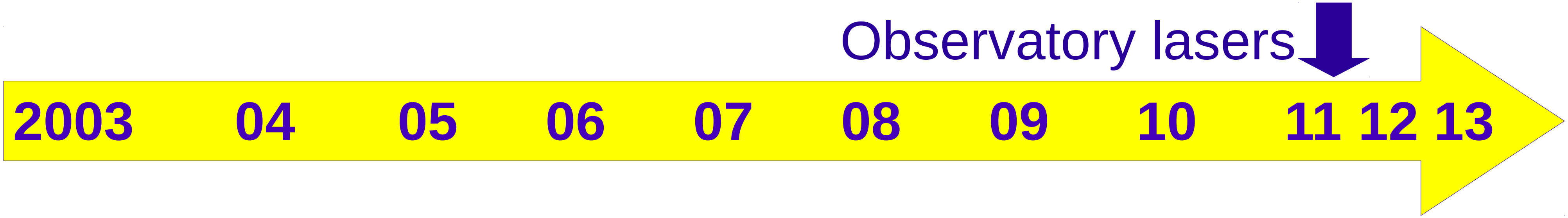


Rendered picture



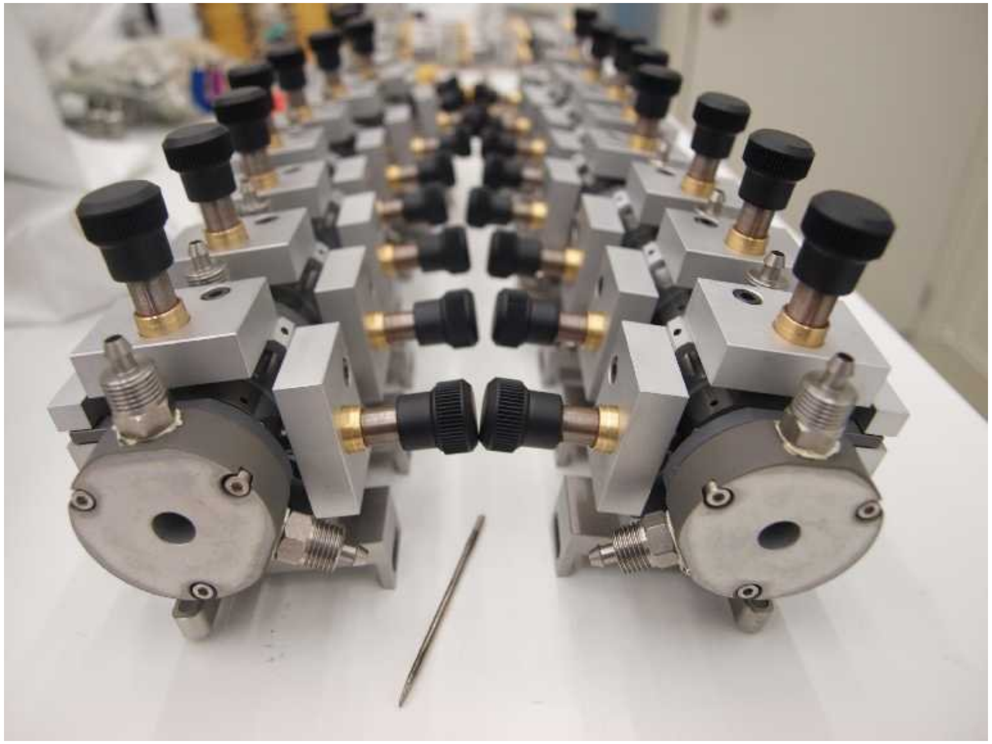
March 2010

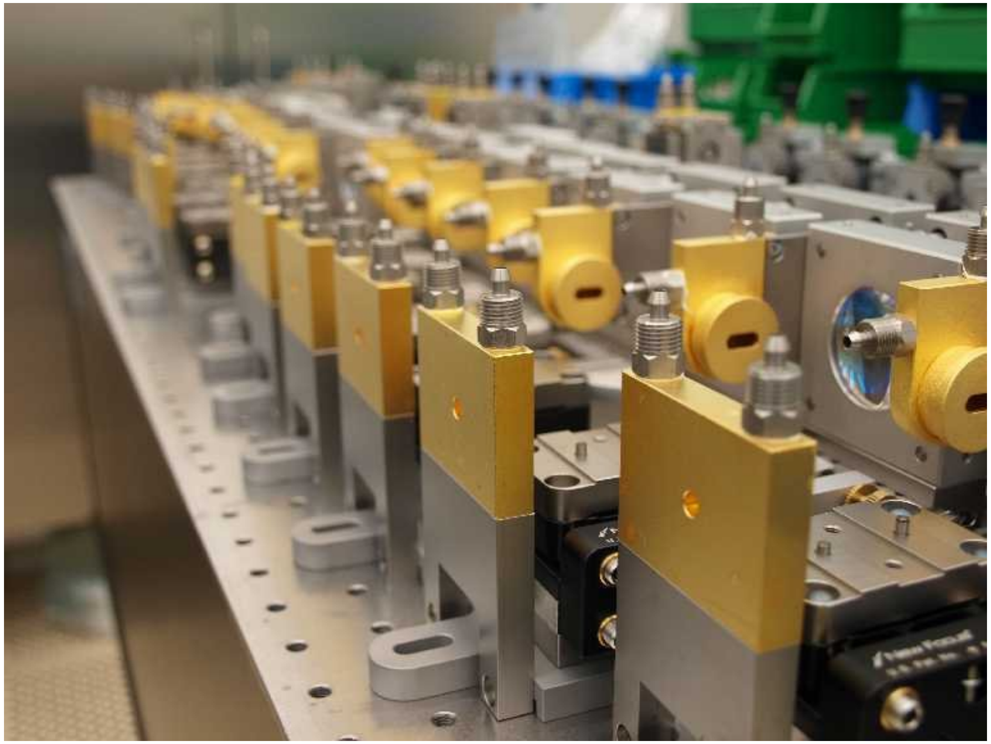
Time traveling



Building lasers for the sites

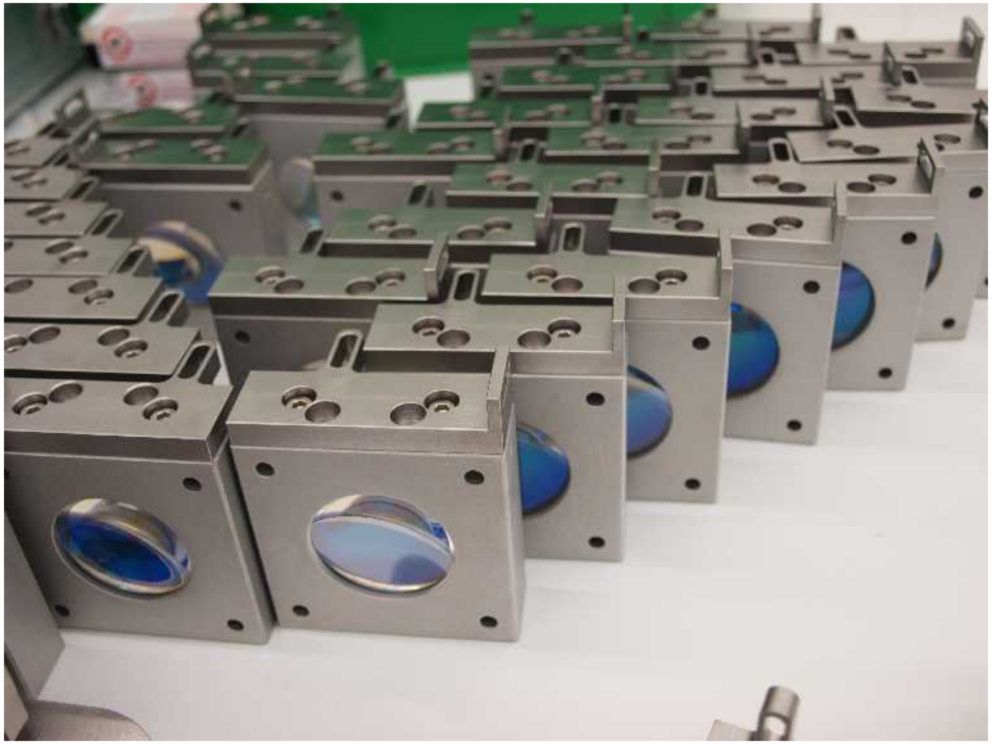
- Mechanics





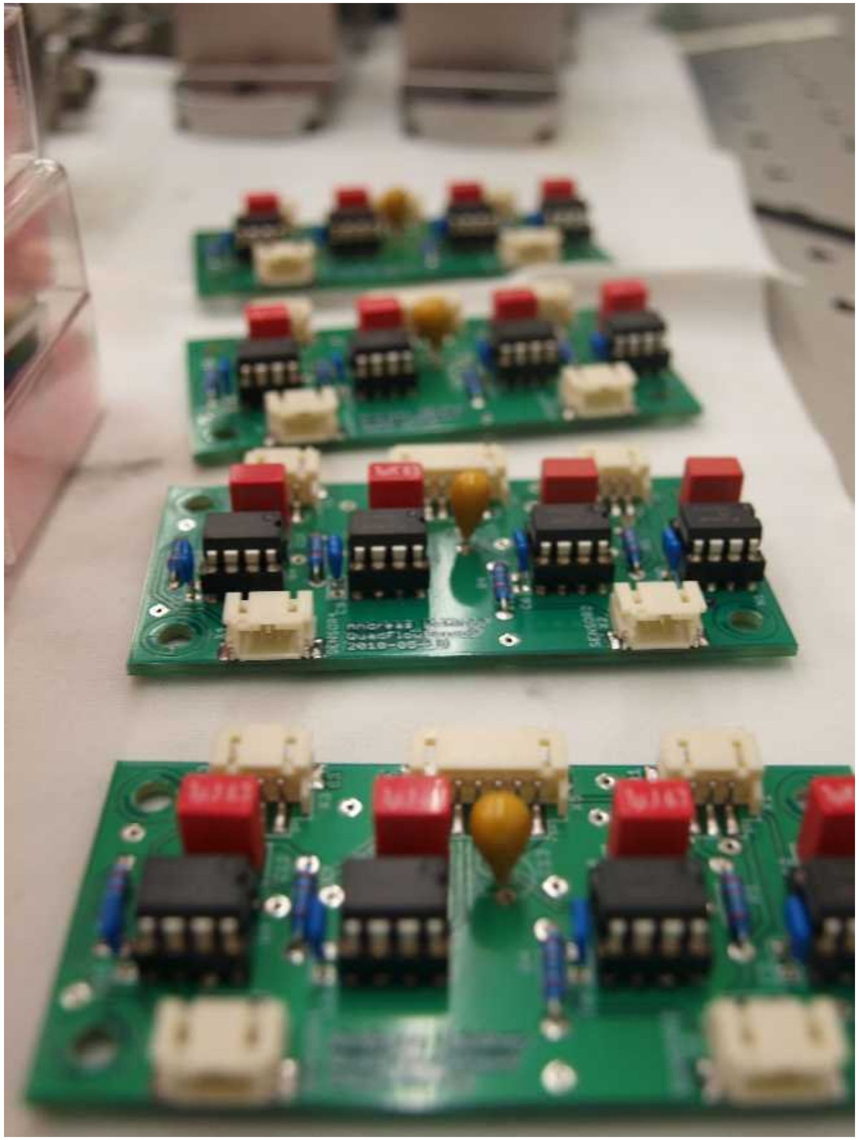
Building lasers for the sites

- Optics



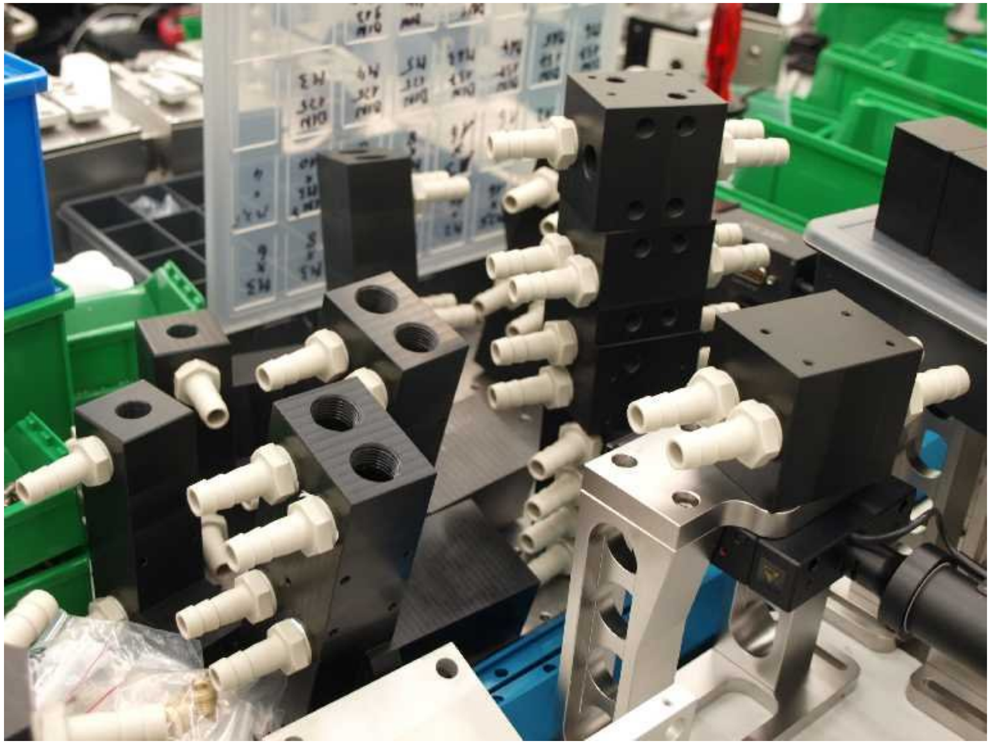
Building lasers for the sites

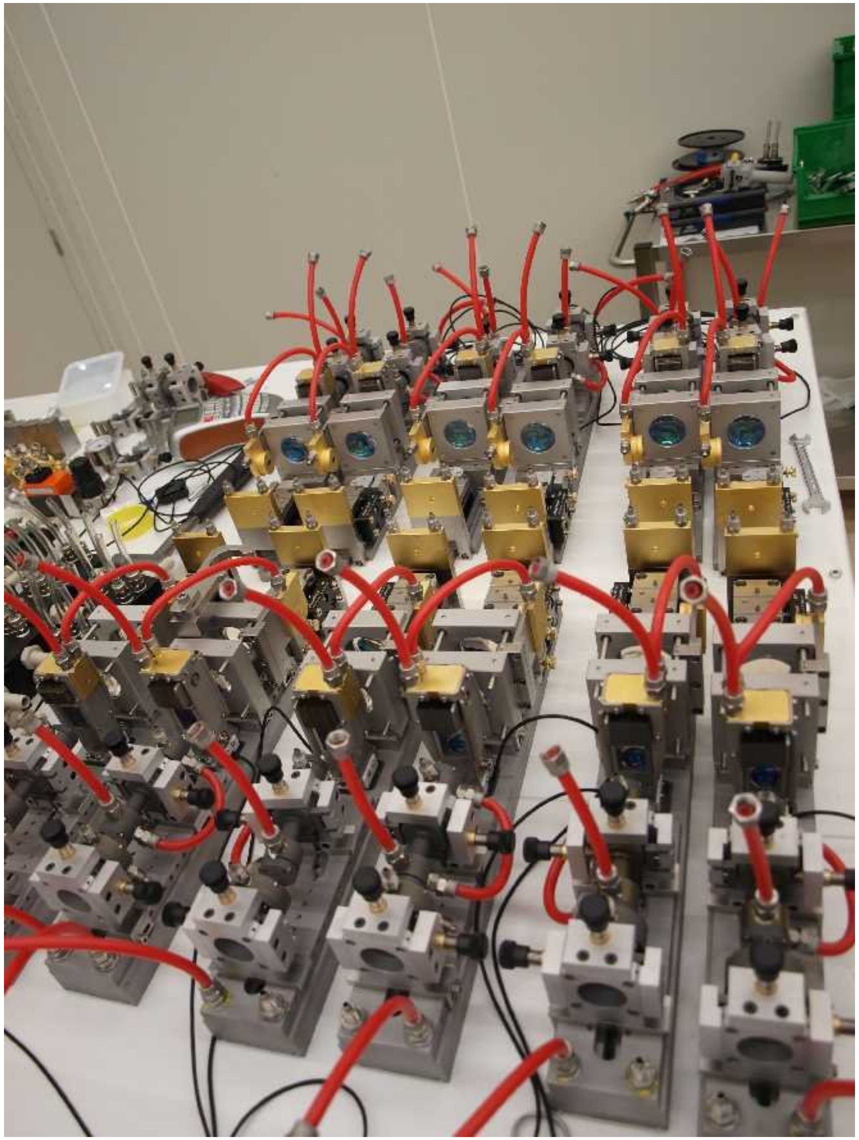
- Electronics



Building lasers for the sites

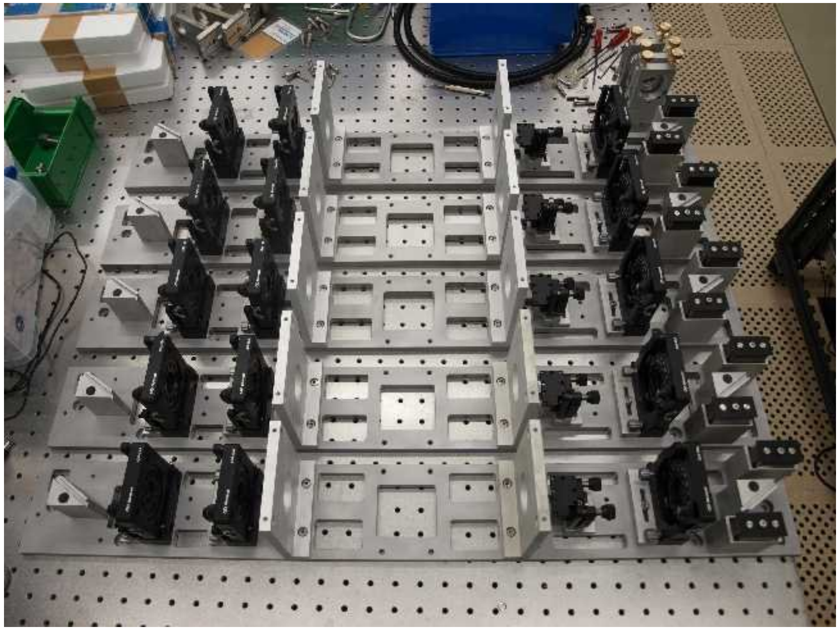
- Water supply

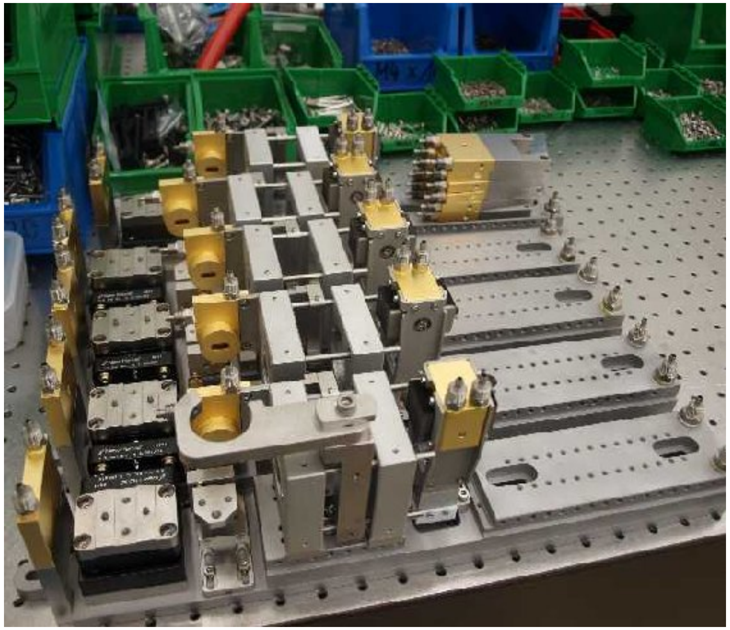


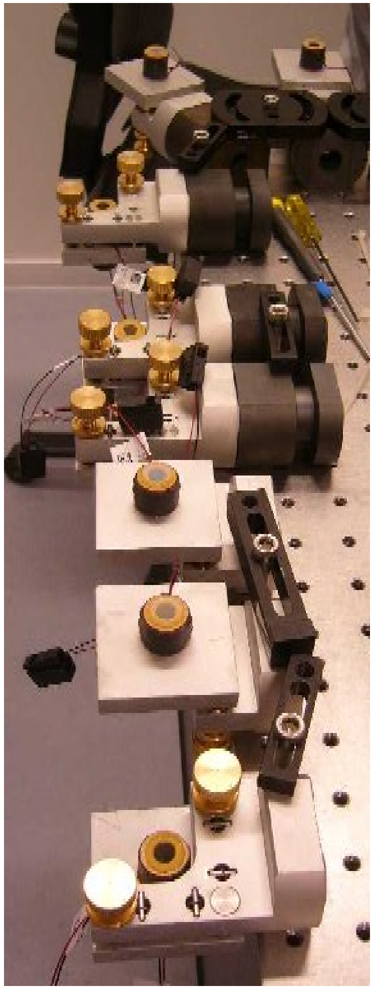


Building lasers for the sites

- Modules

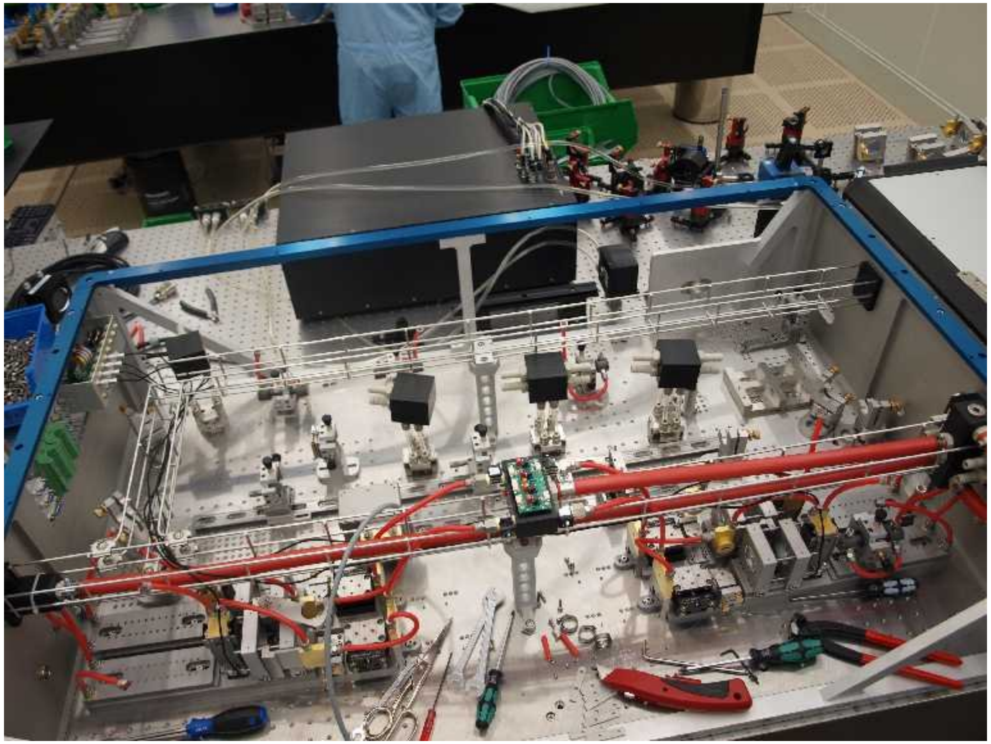






Building lasers for the sites

- Assembly and alignment



User manual

- Purpose: Operation and handling of the 200 W PSL


LASER ZENTRUM HANNOVER e.V.

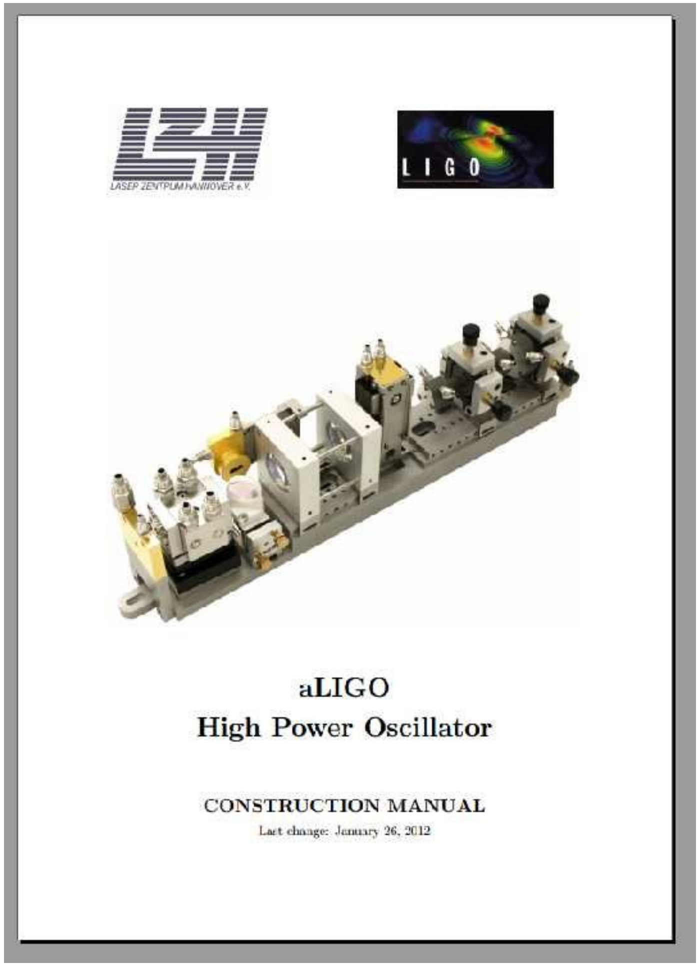
LIGO

Advanced LIGO
High Power Oscillator

USER MANUAL
- LIGO-T0900641-v1 -
Last change: June 28, 2011

Construction manual

- Purpose: construction, assembly and alignment of the aLIGO oscillator, initialization of the 200 W laser



Outline

- Construction of the PSLs
- **Preparation of the sites**
- Sending lasers around the world
- Integration and user interfaces

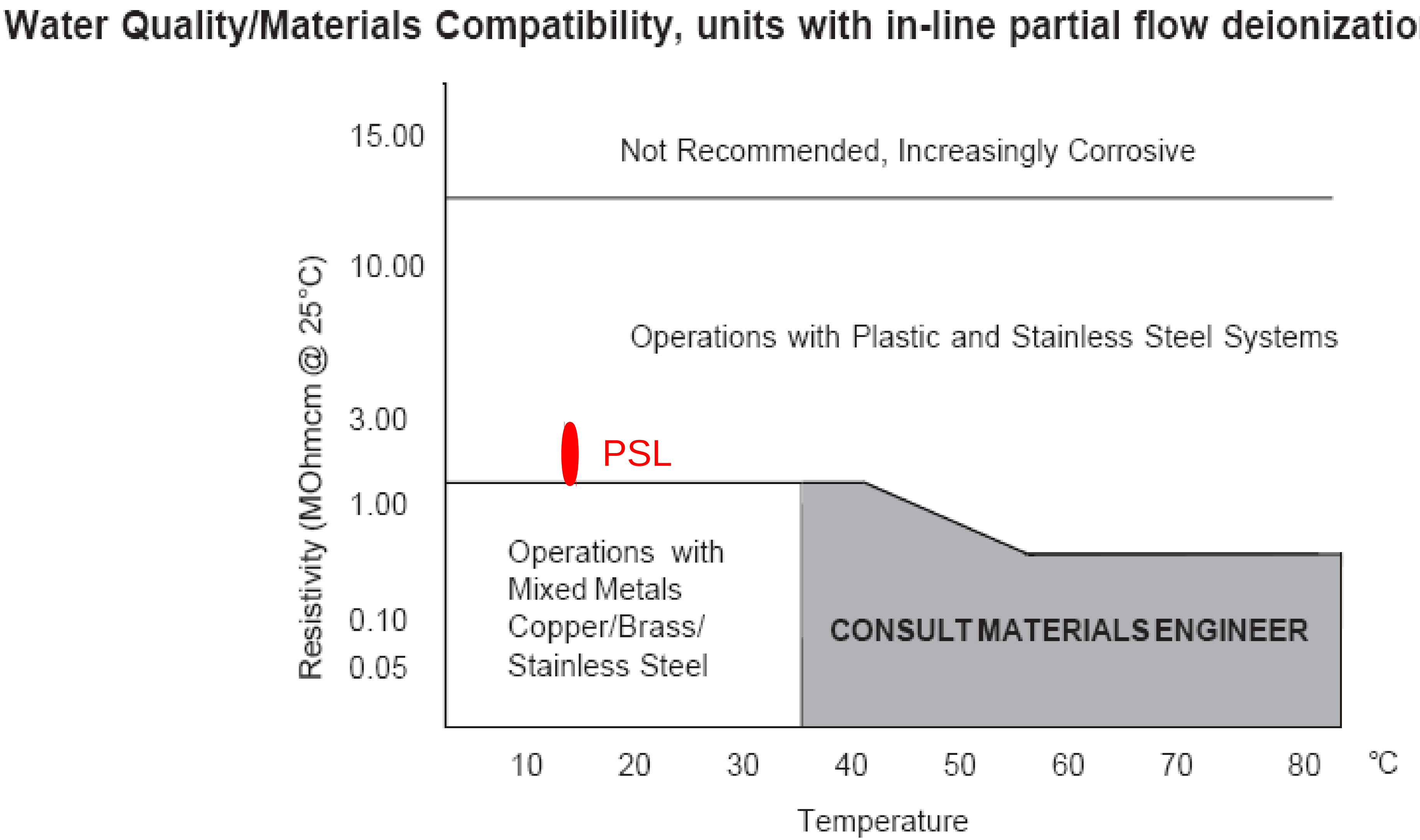
Infrastructure to prepare

- **Cooling water**
- Cleanliness

Water purity

- Distilled water
  - Has virtually all impurities removed through distillation
  - No biological contaminents or minerals
- Deionized water
  - Has minerals removed, such as cations from sodium, calcium, iron, copper and anions as chloride and bromide
  - Because the majority of impurities are dissolved salts, deionization produces similar water quality as distillation
  - However, deionization does not remove uncharged organic molecules (viruses, bacteria)

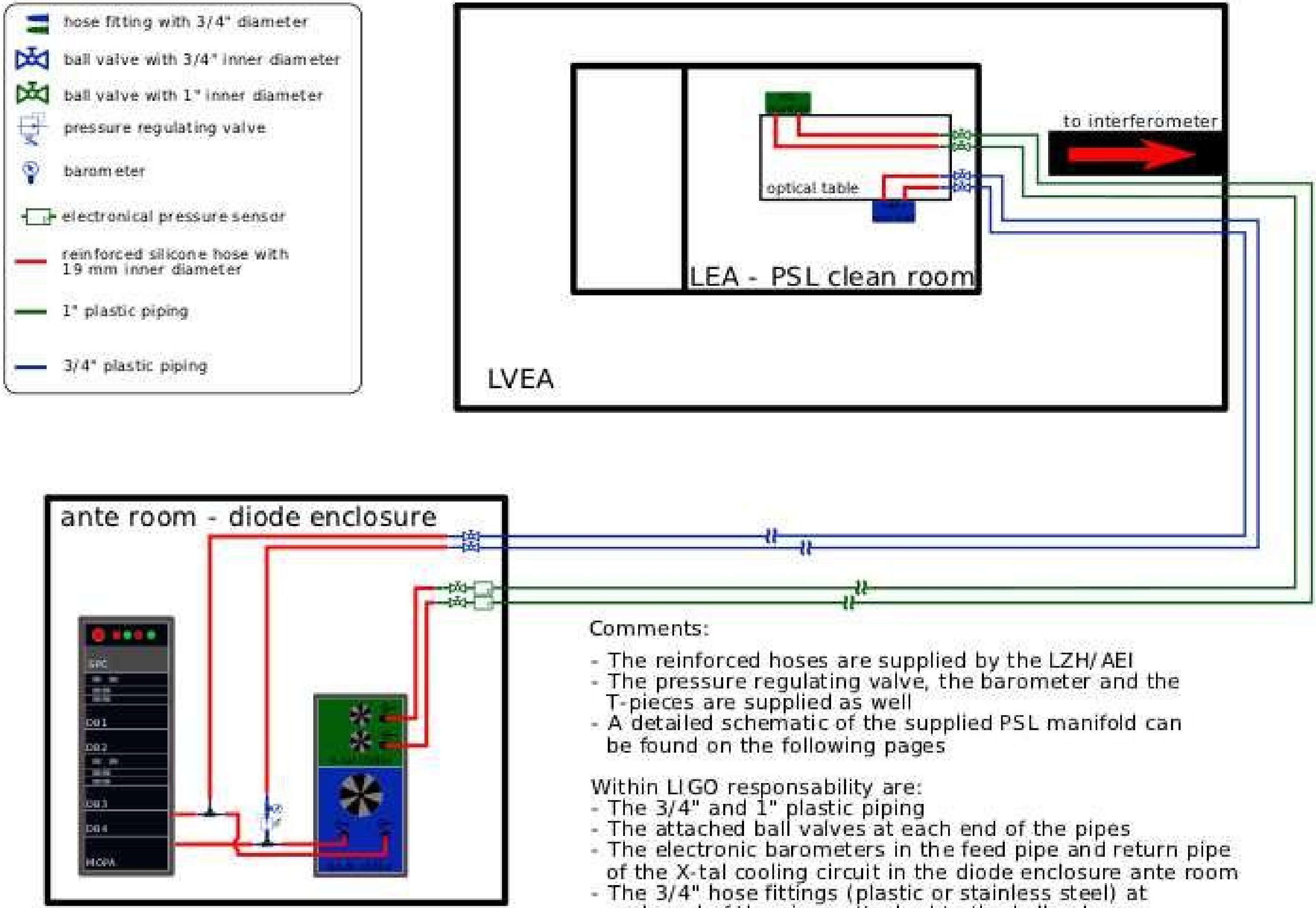
Water purity



Water purity

- Contamination on crystals occured with aluminum pump chambers and brass parts in the same water loop (galvanic corrosion)
- No contaminations with stainless steel / plastic components

Water distribution at the sites



Comments:

- The reinforced hoses are supplied by the LZH/AEI
- The pressure regulating valve, the barometer and the T-pieces are supplied as well
- A detailed schematic of the supplied PSL manifold can be found on the following pages

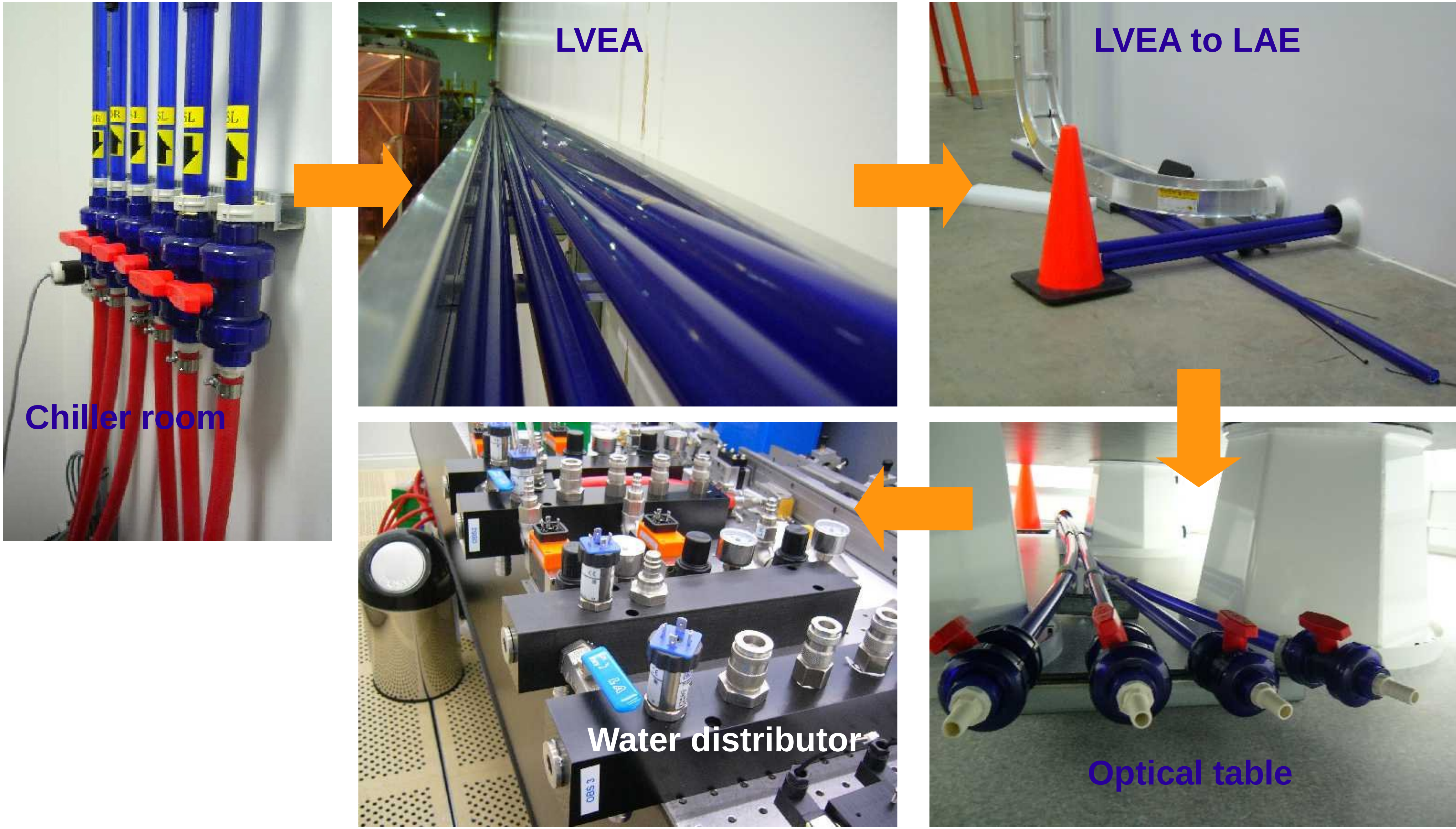
Within LIGO responsability are:

- The 3/4" and 1" plastic piping
- The attached ball valves at each end of the pipes
- The electronic barometers in the feed pipe and return pipe of the X-tal cooling circuit in the diode enclosure ante room
- The 3/4" hose fittings (plastic or stainless steel) at each end of the pipes attached to the ball valves

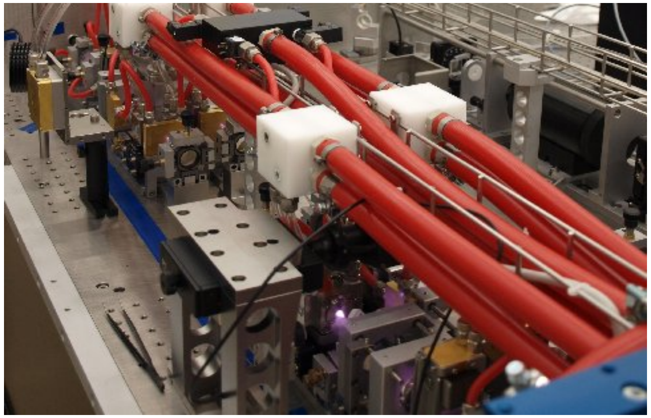
Chiller room (Livingston)

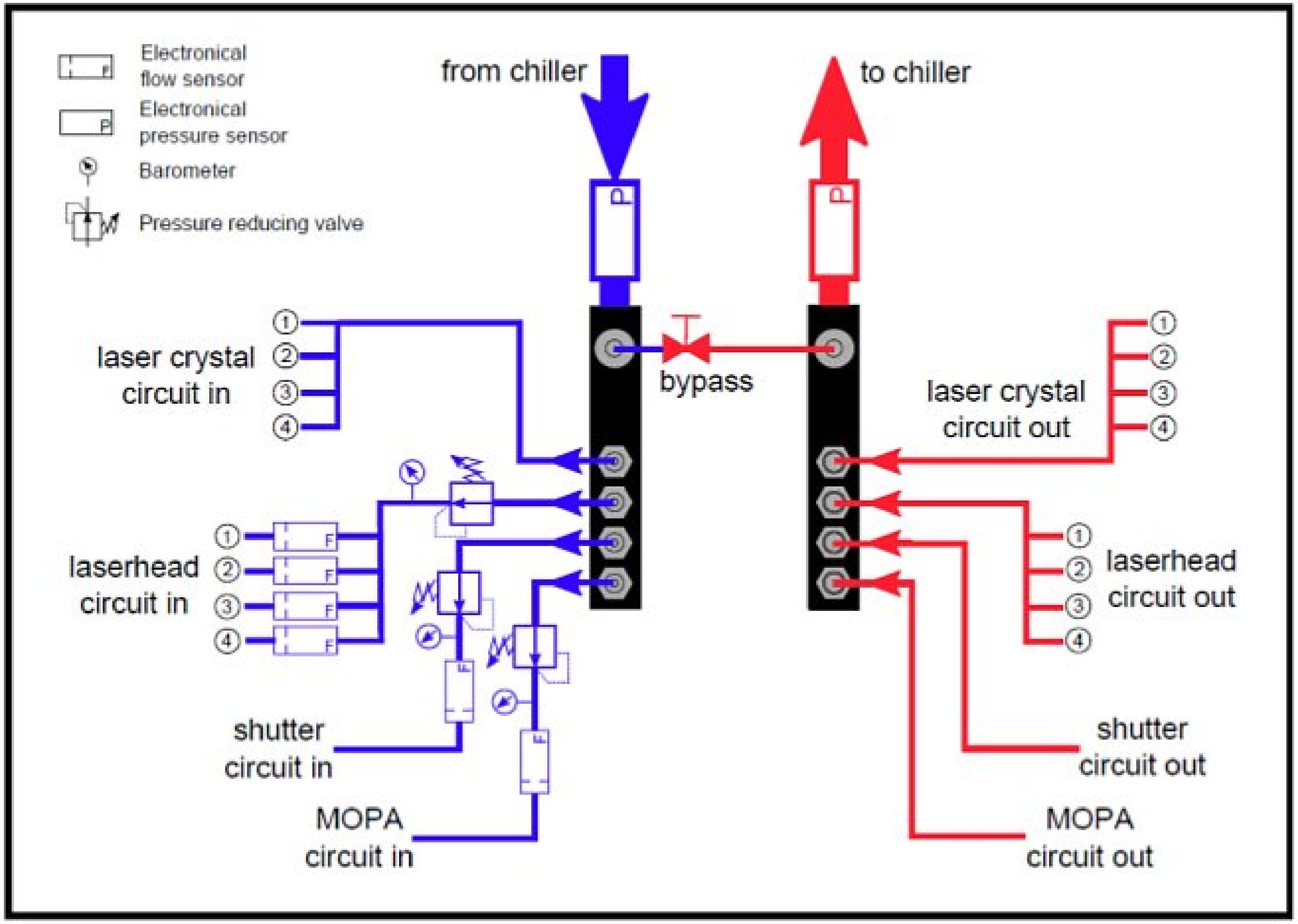
- Chiller racks
(in use + spare)
- Each one with two chiller
("diode chiller" and "crystal chiller")
- For one of the Hanford "sets": damped setup by chiller suspension

Water distribution at the sites



Laser table



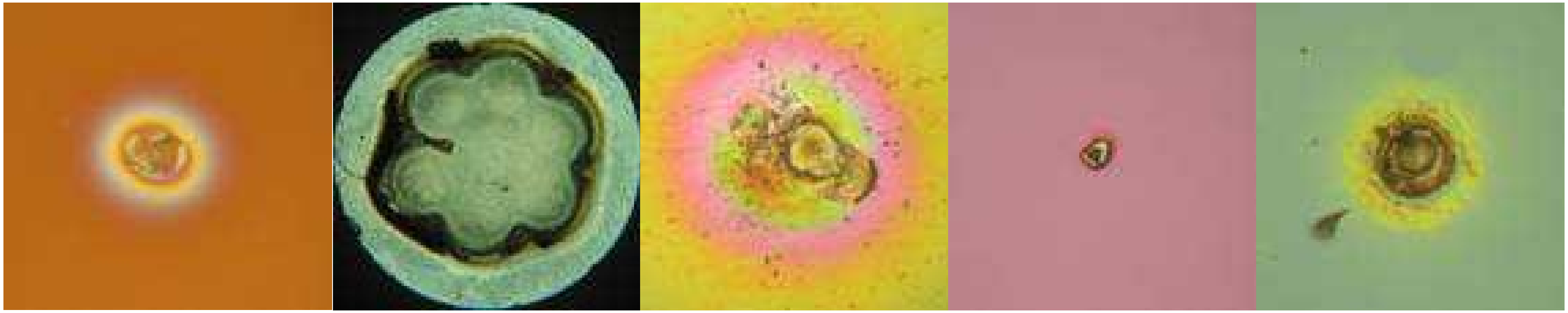

Electronical flow sensor
Electronical pressure sensor
Barometer
Pressure reducing valve
from chiller
to chiller
bypass
laser crystal circuit in
laser crystal circuit out
laserhead circuit in
laserhead circuit out
shutter circuit in
shutter circuit out
MOPA circuit in
MOPA circuit out

Infrastructure to prepare

- Cooling water
- **Cleanliness**

Cleanliness

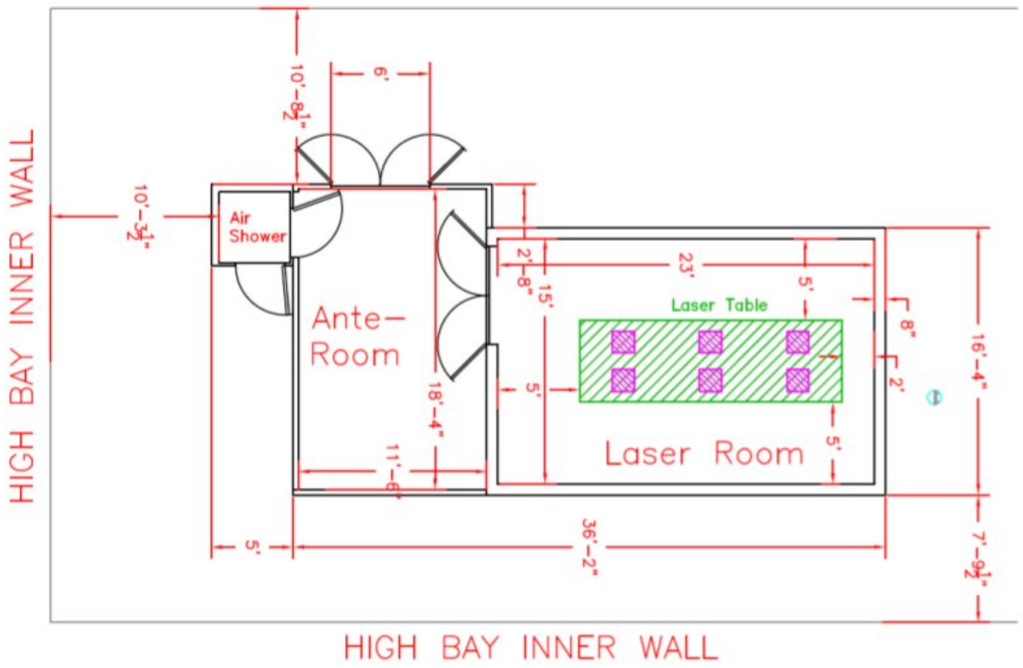
- Work as clean as possible
  - Flow benches
  - Cleanroom / enclosure / "boxed systems"
  - Proper gauning



Cleanroom at LZH

PSL laser area enclosure (LAE)

- Class 1000 clean room for PSL table
- Preparation and storage room
- 20 dB acoustic shielding
- Installation mode / science mode



Construction of the PSL enclosure

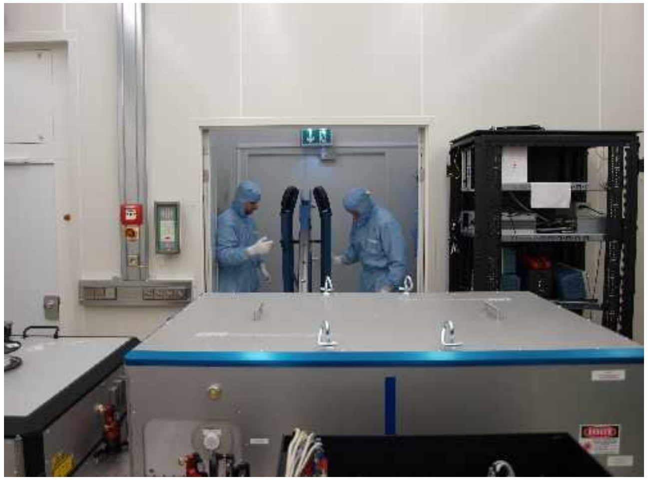
Cleanroom at Hanford

Outline

- Construction of the PSLs
- Preparation of the sites
- **Sending lasers around the world**
- Integration and user interfaces

Sending lasers around the world

- Step 1: packing

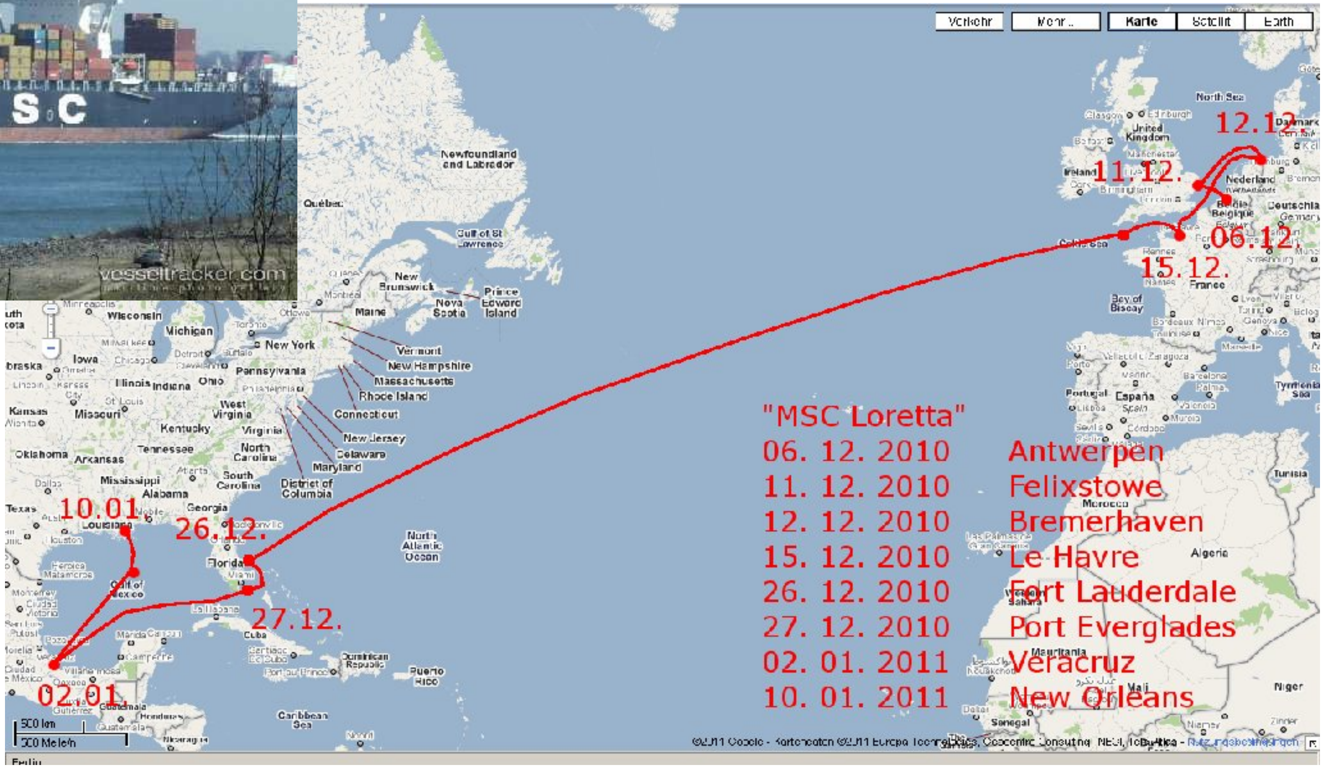



Sending lasers around the world

- Step 2: hire a carrier

Sending lasers around the world

- Step 3: getting a ship



Sending lasers around the world

- Step 4: let recipient unpack the container

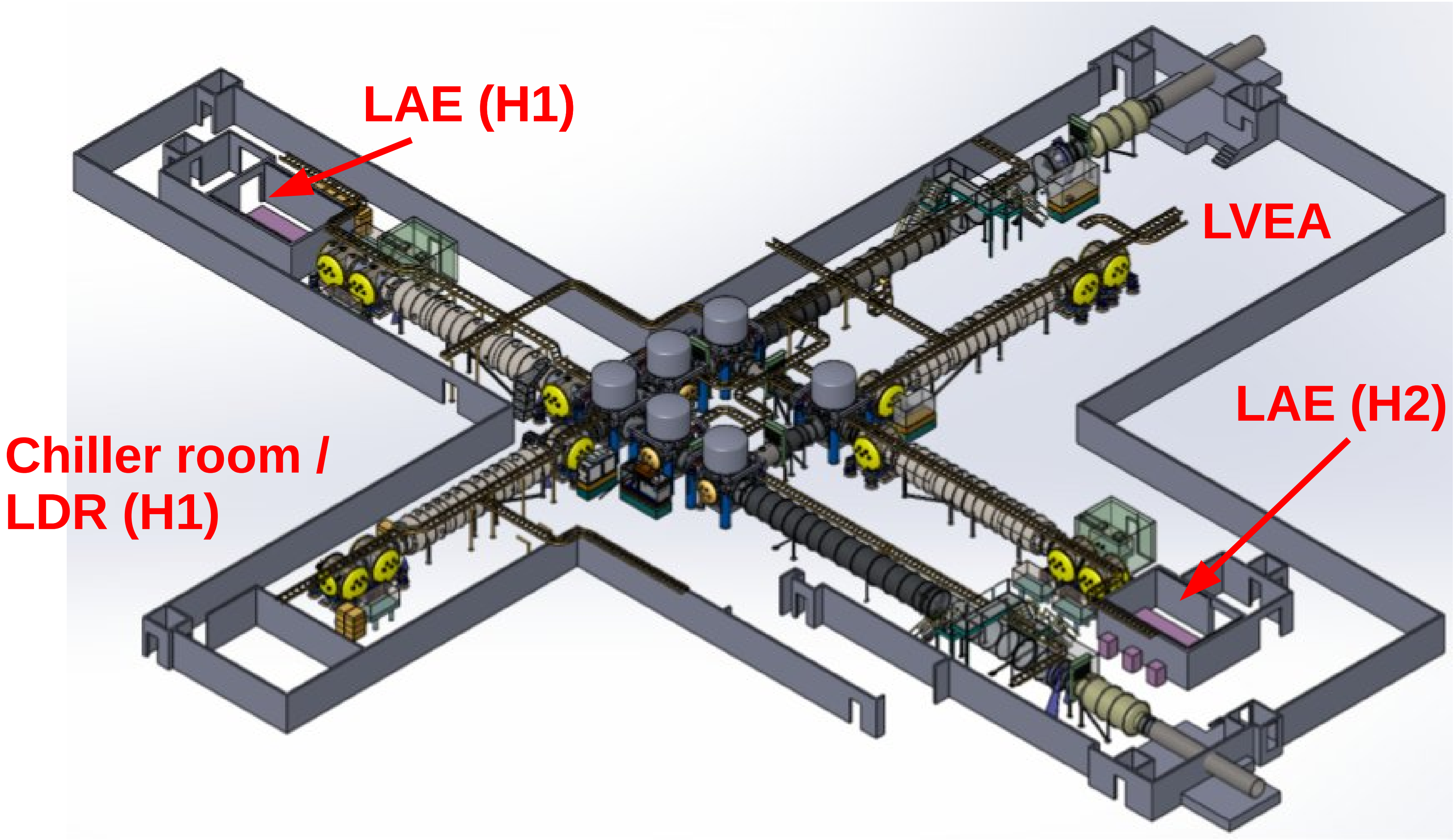

Sending lasers around the world

- Step 5: unpack the boxes



Sending lasers around the world

- Step 6: Arrange the stuff at the sides (here: LHO)



Sending lasers around the world

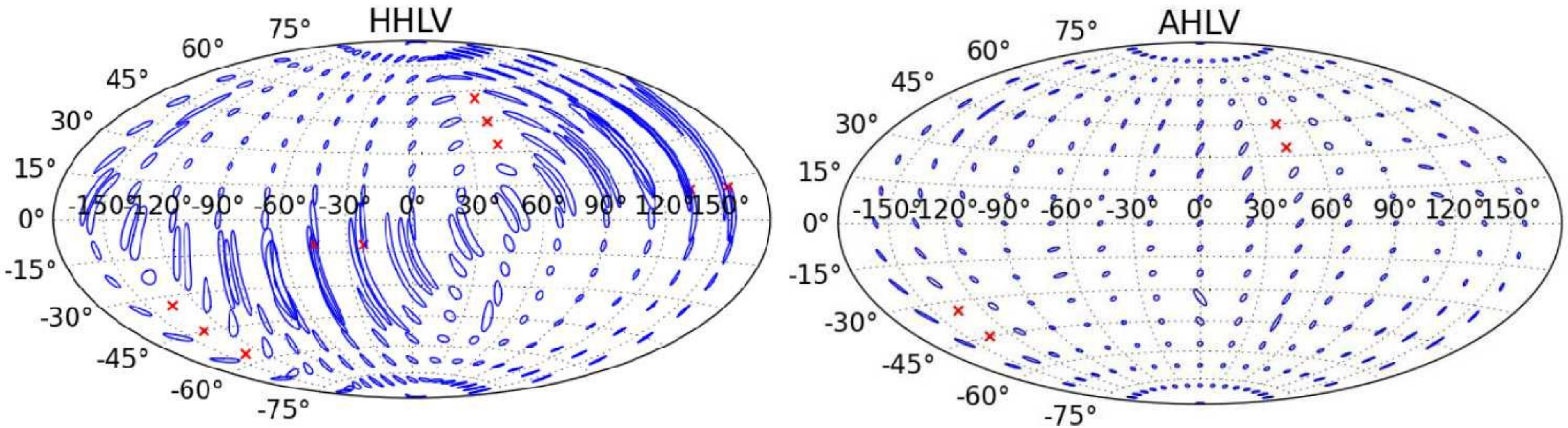
- Step 6: Arrange the stuff at the sides

Preparations for OBS 3

- OBS1 = LLO1 = "Livingston laser"
  - delivered and installed in March 2011
- OBS2 = LHO2 = "Hanford laser" at 2 km setup
  - delivered and installed in October 2011
- OBS3 = LHO1 was supposed to be Hanford laser at 4 km setup
  - delivered in March 2012 to LHO

"LIGO south" - Australia

- Increased event rates
- Improved duty cycle
- Improved detection confidence
- Improved sky coverage
- Improved determination of the two GW polarizations

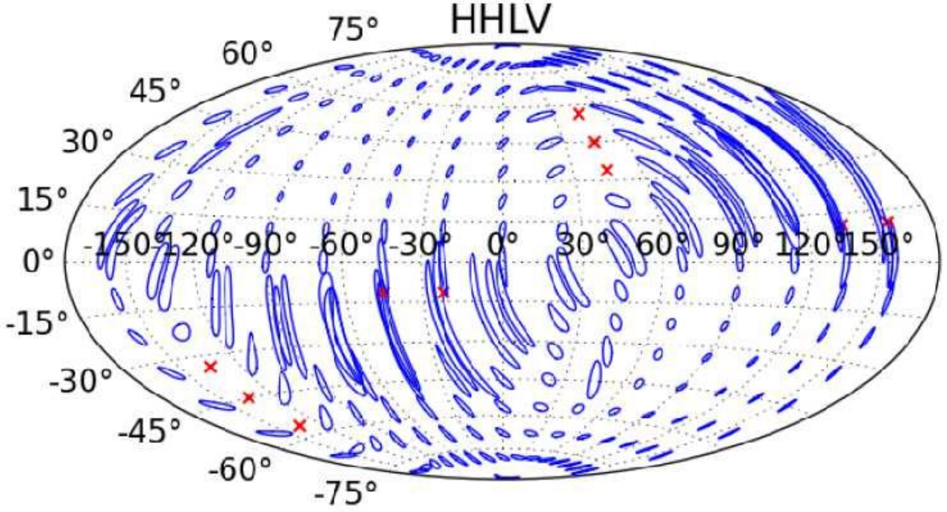


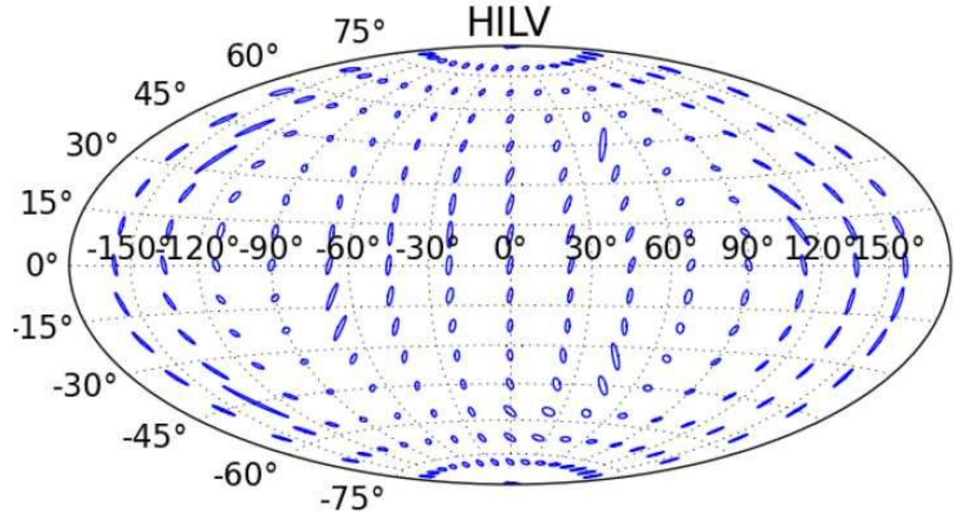
Source detection error wo LIGO south   with LIGO Australia

Pictures: S. Fairhurst: Class. Quantum Grav. 28, p.105021 (2011)

"LIGO south" - India

- Increased event rates
- Improved duty cycle
- Improved detection confidence
- Improved sky coverage
- Improved determination of the two GW polarizations





Source detection error wo LIGO south

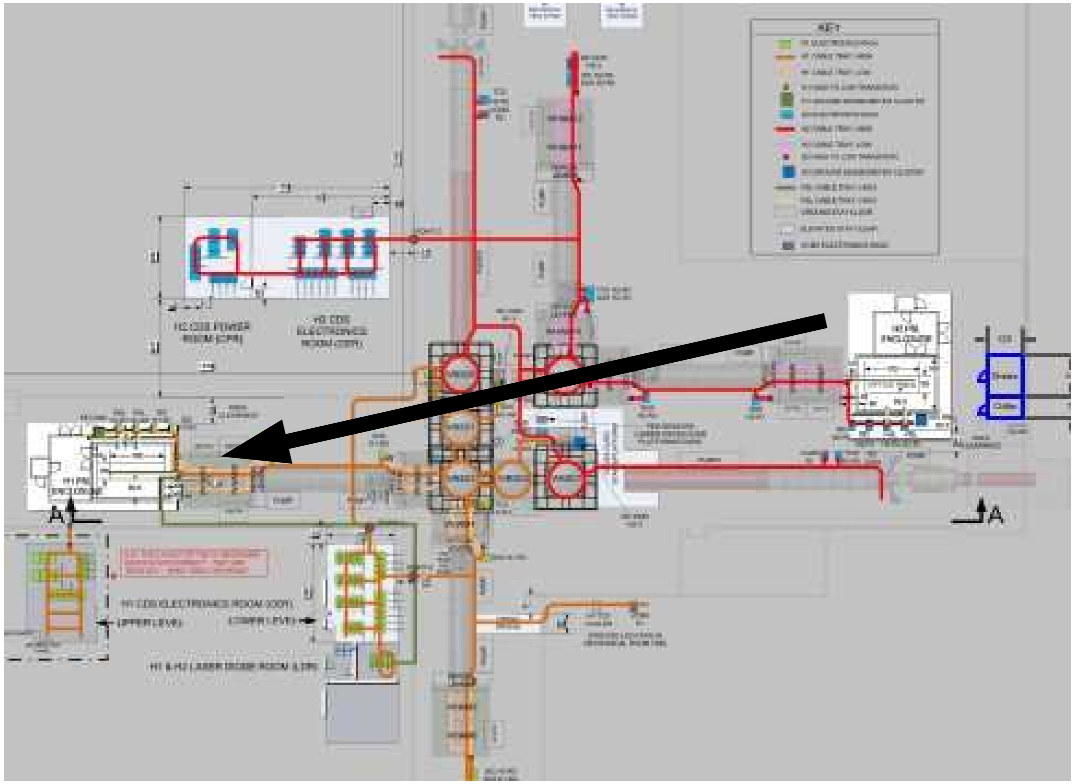
with LIGO India

Pictures: S. Fairhurst: Class. Quantum Grav. 28, p.105021 (2011)

The big move

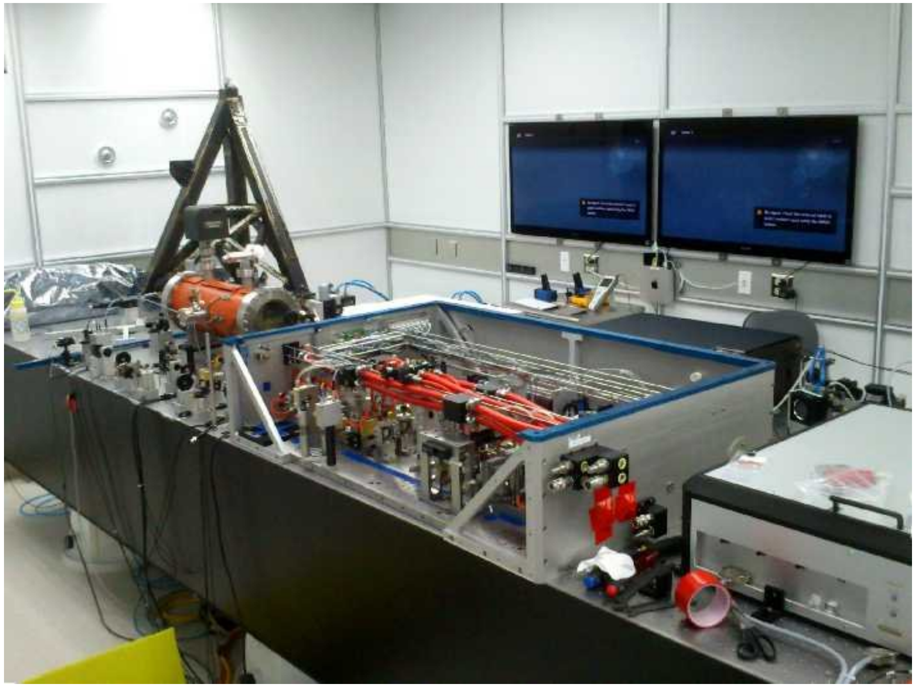
- OBS1 = LLO1 = "Livingston laser"
  - delivered and installed in March 2011
- OBS2 = LHO1 = "Hanford laser" at 4 km setup
  - Needs to be disassembled and reassembled in H1 enclosure
- OBS3 = LHO1 was supposed to be Hanford laser at 4 km setup
  - Needs to be stored in Hanford
  - Needs to be shipped to India

The big move



Disassembly and Reassembly

H2 (old setup)



H1 (new setup)

Day 1

Disassembly and Reassembly

H2 (old setup)

Day 4

H1 (new setup)

Disassembly and Reassembly

Day 5

Disassembly and Reassembly

H2 (old setup)

H1 (new setup)

Day 5

Disassembly and Reassembly

H2 (old setup)

H1 (new setup)

Day 6

Disassembly and Reassembly

H2 (old setup)

Day 7

H1 (new setup)

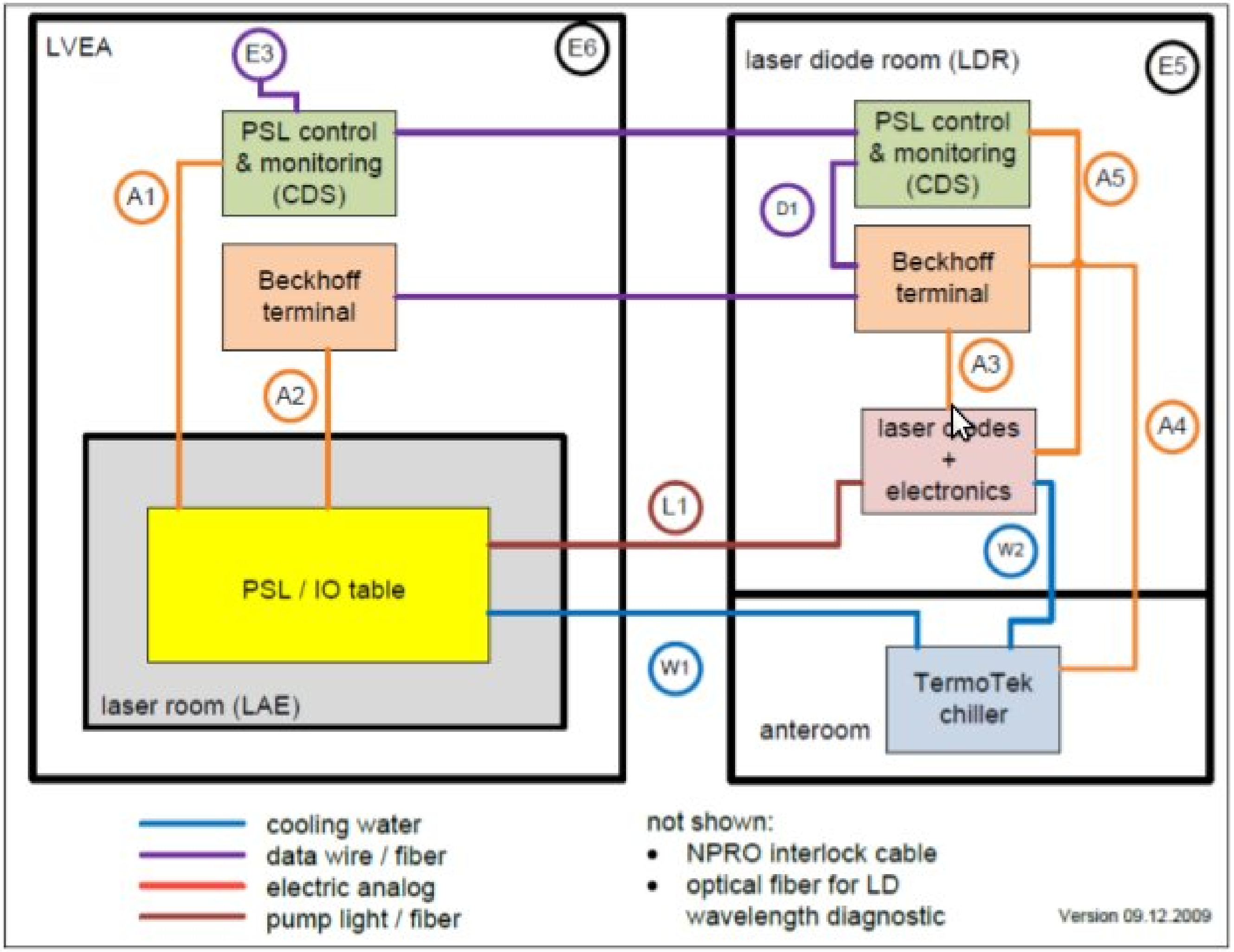
Disassembly and reassembly

- Other equipment had been moved as well:

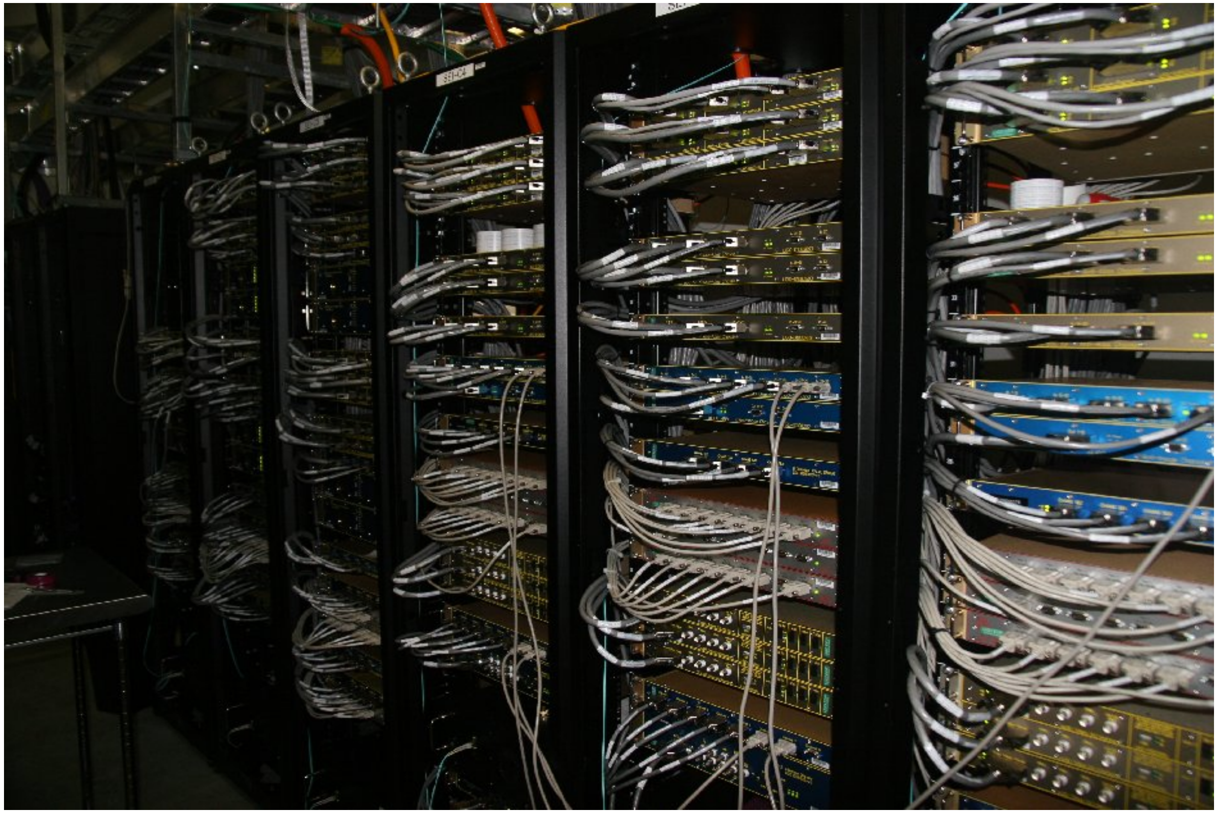
Outline

- Construction of the PSLs
- Preparation of the sites
- Sending lasers around the world
- **Integration and user interfaces**

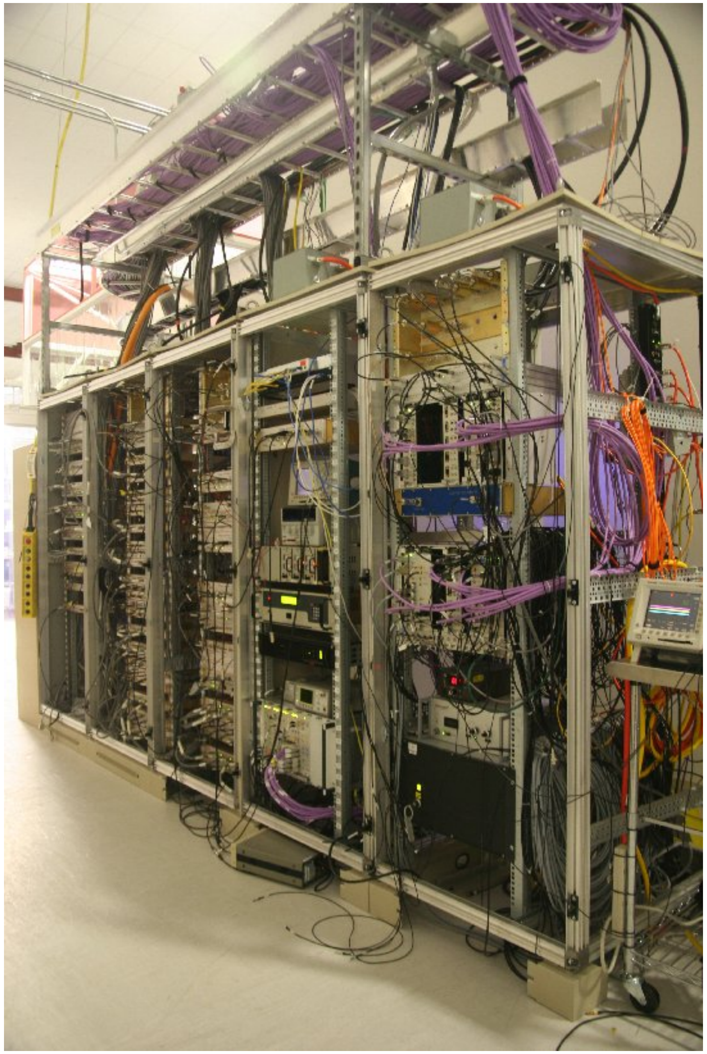
PSL interfaces



More Infrastructure



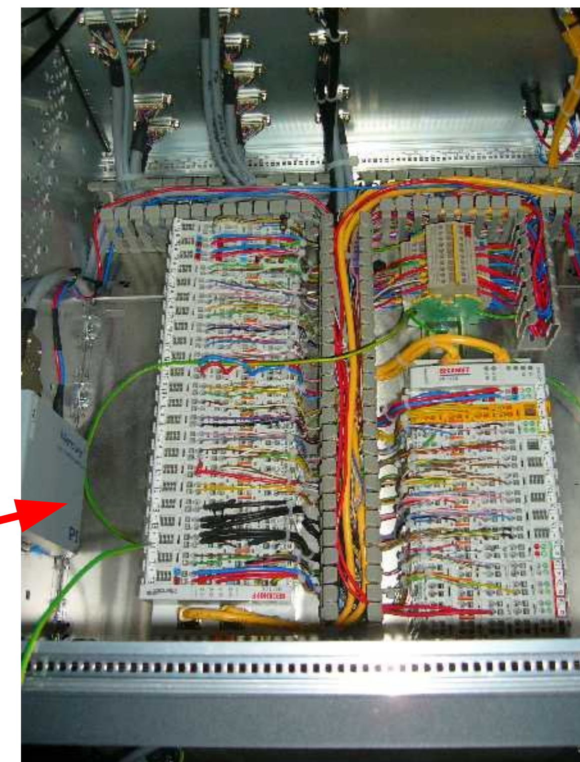
CDS Electronics room (CER)



PSL
racks

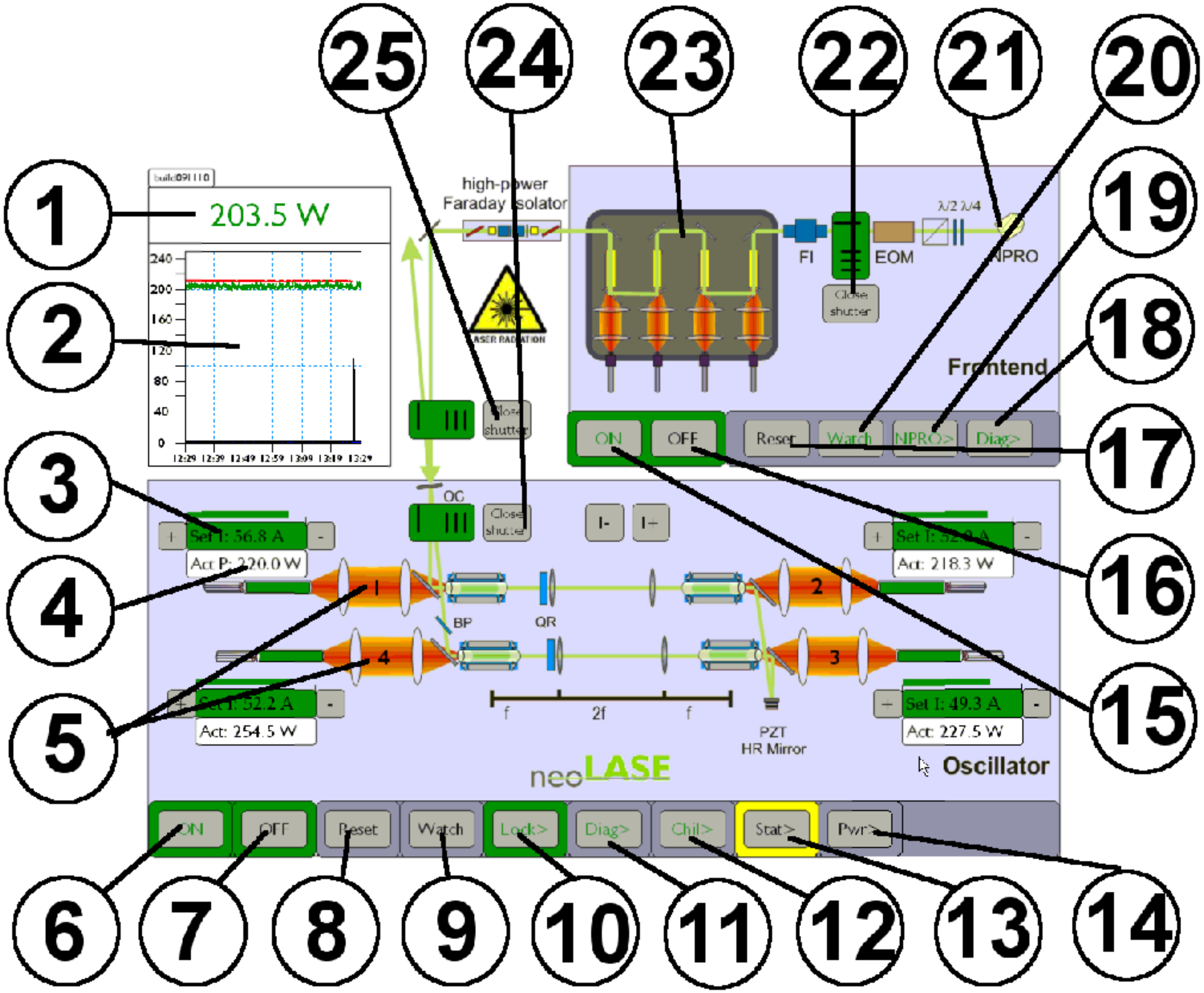
Beckhoff

- automation system, based on PC Control technology
- Modular fieldbus Components ("Terminals"), automation software ("TwinCAT")
- Lightbus system (up to Functional prototype)
- EtherCAT (real-time Ethernet solution) since Engineering PT



Beckhoff control

1) Output power monitor
2) Power vs time plot
3) Set value of the pump current
4) Relative value of measured pump power
5) View or change the pump light characteristics
6) Turn oscillator on
7) Turn oscillator off
8) Reset
9) Activate watchdog. The oscillator (not the amplifier!) will be switched off, if triggered
10) Injection locking menu
11) Diagnostics menu
12) Chiller menu
13) Status screen
14) Powermeter readings
15) Turns amplifier on
16) Turns amplifier off
17) Reset amplifier
18) Amplifier diagnostics
19) NPRO menu
20) Amplifier watchdog
21) NPRO menu
22) MOPA shutter switch
23) Amplifier menu
24) Internal shutter switch
25) External shutter switch

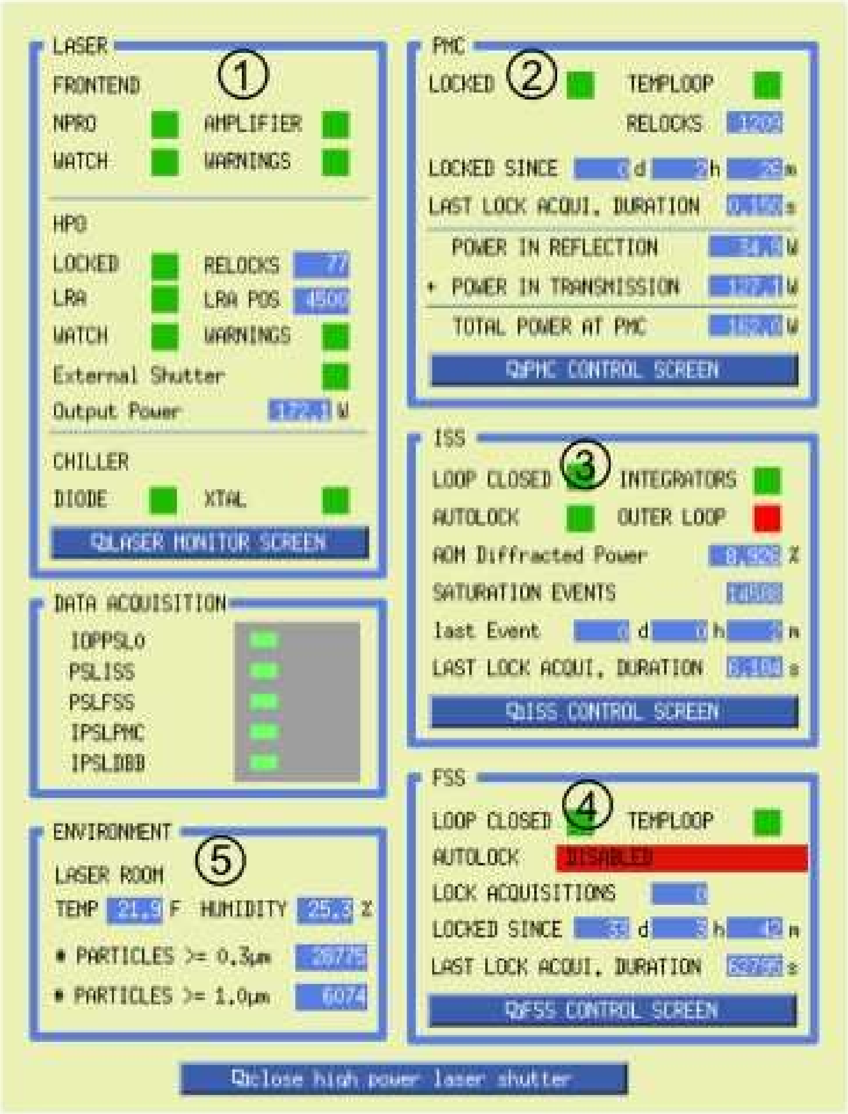


Epics control

- EPICS screens of the PSL consist of 6 MEDM screens belonging to the different controll objects:
  - the PSL Status
  - the High Power Laser
  - the Diagnostic Bread Board
  - the Pre-Modecleaner
  - the Power Stabilization
  - the Frequency Stabilization

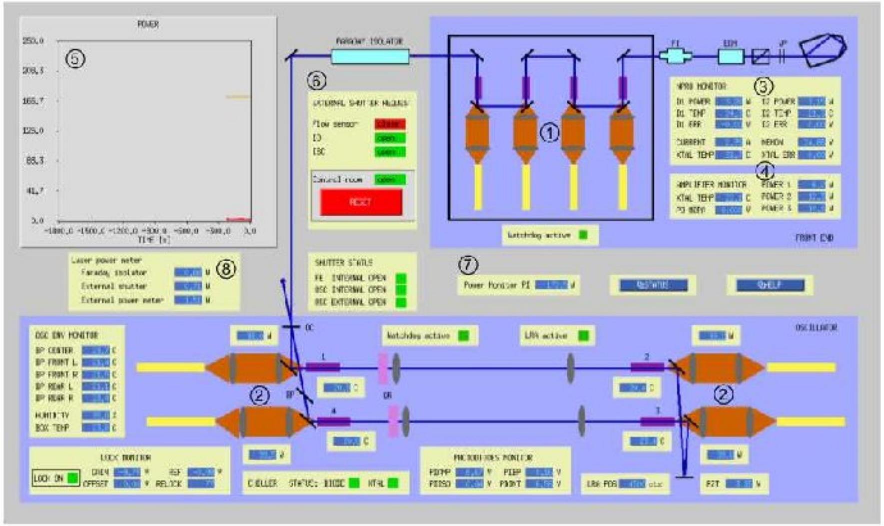
Epics control

- PSL Status



Epics control

- High power laser (read only)
- related displays to present more information about the different components:
  - pumpdiodes of the 35W front end laser
  - Values of the pump diodes
  - status of the two chillers (diode chiller and XTAL chiller)
  - information about the NPRO
  - status button opens a screen with top-level status indicators.

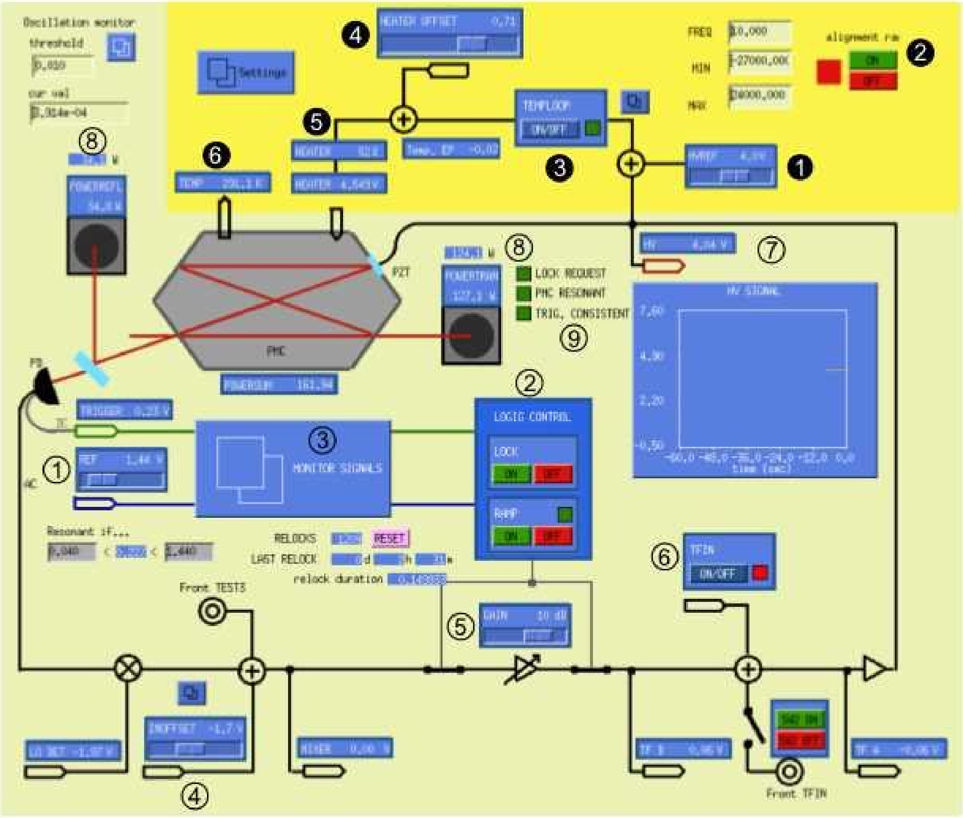


Epics control

- Diagnostic breadboard
- Six operation modes:
  - Interlock mode:
    outputs of the DBB set to default, shutter closed
  - Standby mode:
    as interlock mode, no measurements
  - Manual mode:
    adjust PMC length manually; pre-alignment
  - Scan mode:
    PMC scanned with a ramp, mode scans
  - Lock mode:
    PMC length ctrl. loop closed, pointing- and frequency noise measurements
  - Local mode:
    electronic modules are set by a switch, no computer control

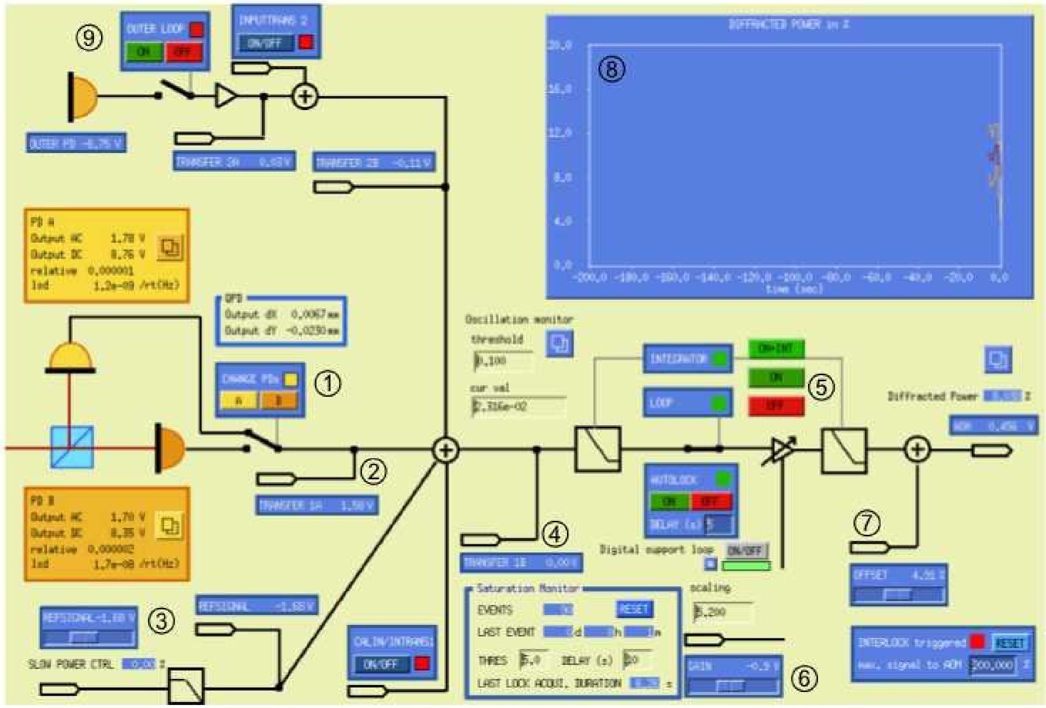
Epics control

- Pre-modecleaner
  - Automatic / manual lock aquisition
  - high voltage signal monitor
  - power monitors
  - Temperature control
  - PZT control (ramp settings)



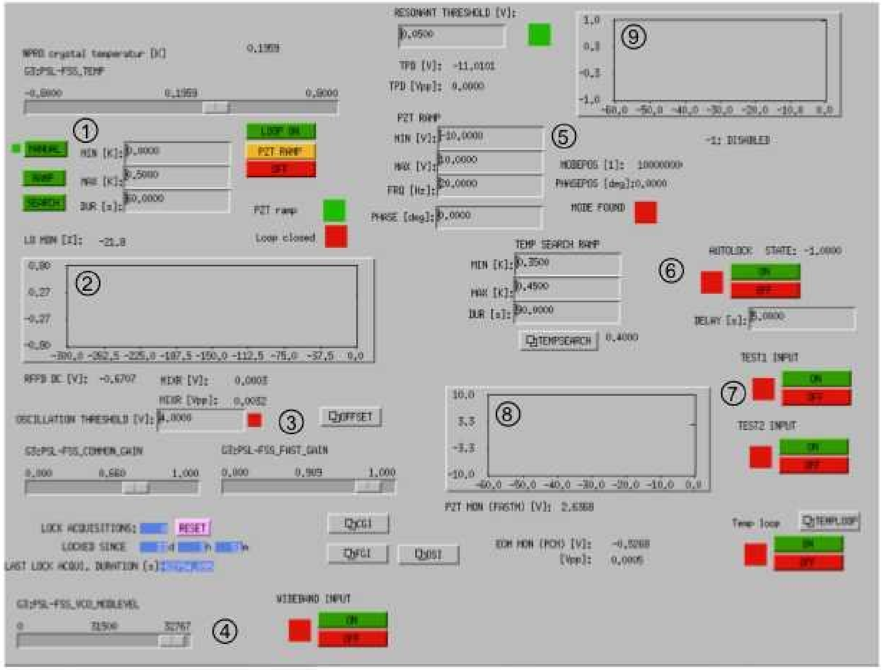
Epics control

- Power stabilization
  - Sensors: two identical photodiodes
  - set loop parameters
  - Automatic / manual lock aquesition
  - diffracted power monitor
  - 2nd loop stabilization implemented



Epics control

- Frequency stabilization
  - NPRO crystal temperature control and monitor (manual or ramp)
  - NPRO PZT control and monitor (manual or ramp)
  - Lock aquesition
  - additional test inputs



Acknowledgement

Data and pictures taken from:

(former) LZH researchers: Oliver Puncken, Marcin Damjanic, Maik Frede, Raphael Kluzik, Dietmar Kracht, Bastian Schulz, Christian Veltkamp, Peter Weßels, Ralf Wilhelm, Lutz Winkelmann et al.

(former) AEI researchers: Christina Bogan, Patrick Kwee, Jan Pöld, Frank Seifert, Benno Willke et al.

LIGO Document Control Center (DCC)

Thanks!