

# Trace gas multi- component remote monitoring system

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# Abstract

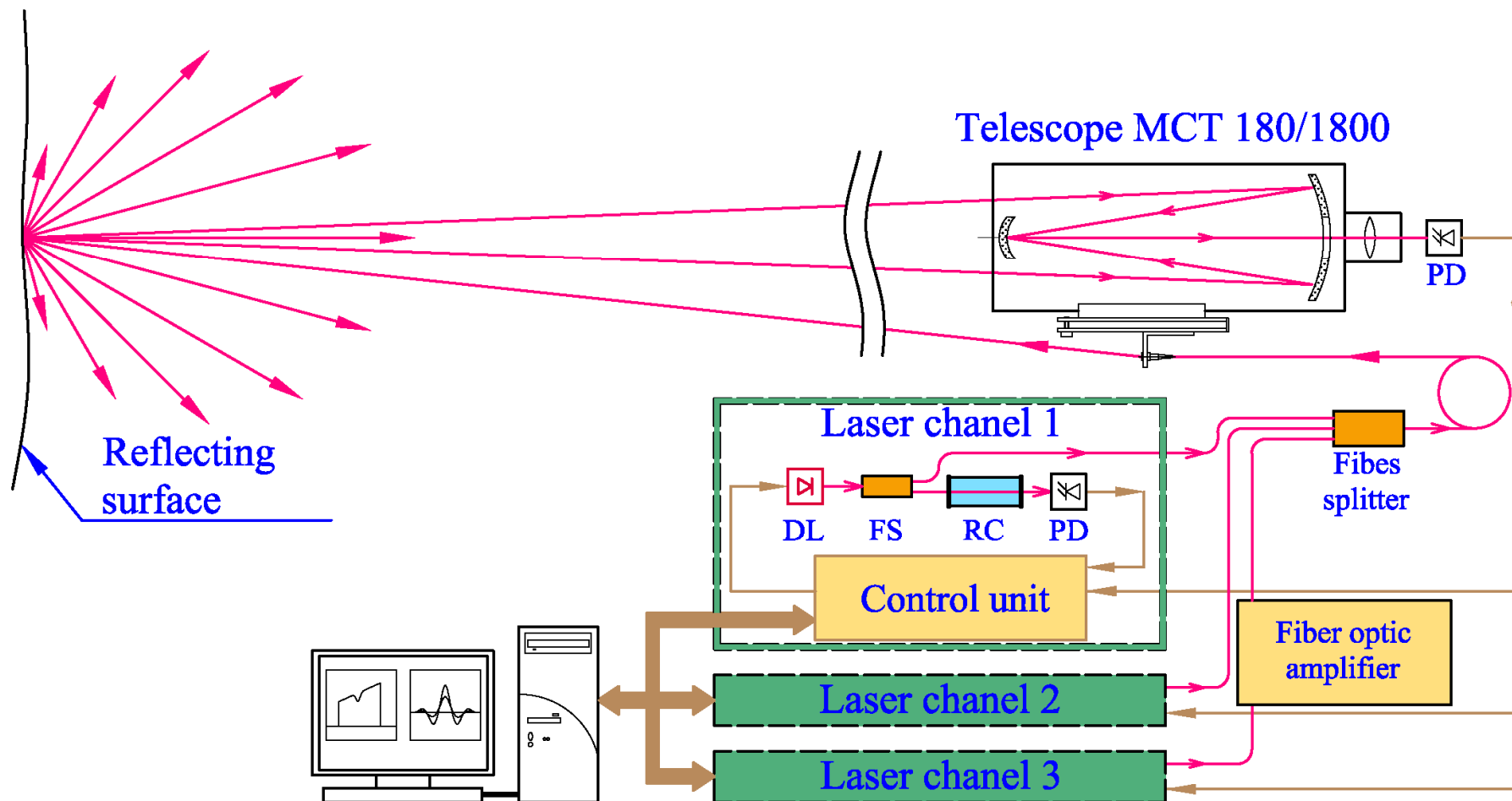
Multi-component DL based system was developed for remote monitoring of trace molecules concentration. The system incorporates: DL block with several laser channels; receiving module with telescope; electronics; computer.

General-purpose PXI chassis NI PXI-1031DC computer station has three input/output boards NI PXI-6289M. Each board supports operation of two laser channels. Each laser channel can detect at least one molecular object. The present configuration supports simultaneous detection of up to six molecules.

Near IR-range DFB DL with fiber output, all fiber optics connection, and fiber amplifiers for some modifications were used. The system operates with topography reflector when small part of scattered DL radiation reaches receiving optics.

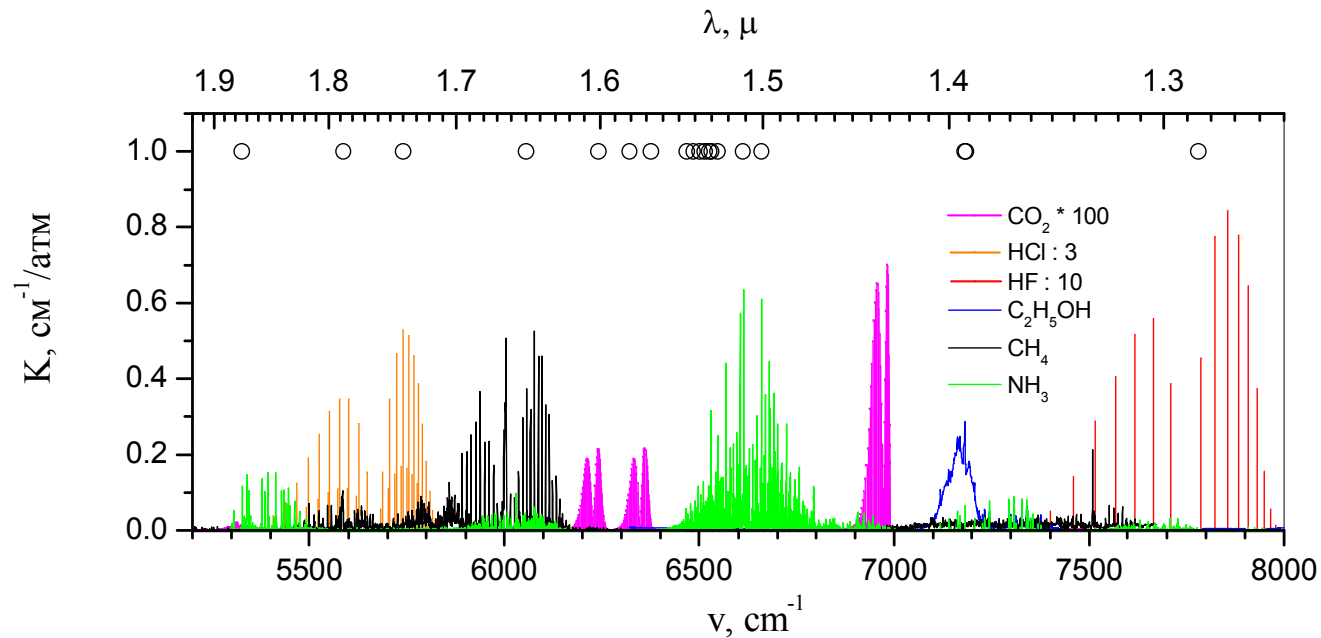
Software was developed using LabView 8.2. In order to detect several molecules simultaneously time multiplexing operation regime was applied. It implied successive operation of different lasers with a use of general synchronization. The time of single concentrations measurement for all six channels was 1.7 msec.

# System layout



Layout example of trace gas multi-component remote monitoring system  
PD – photo-diode, DL – diode laser, FS – fiber splitter, RC – reference cell.

# DL and molecular spectra in near IR

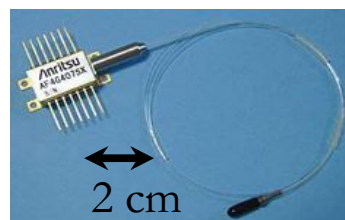


Absorption spectra of several molecules in near IR spectral range

In near IR spectral range overtones of C-H, N-H, O-H, C-O, etc. bonds are located. As practically all molecules of interest have these bonds, almost all molecules can be detected in near IR spectral range.

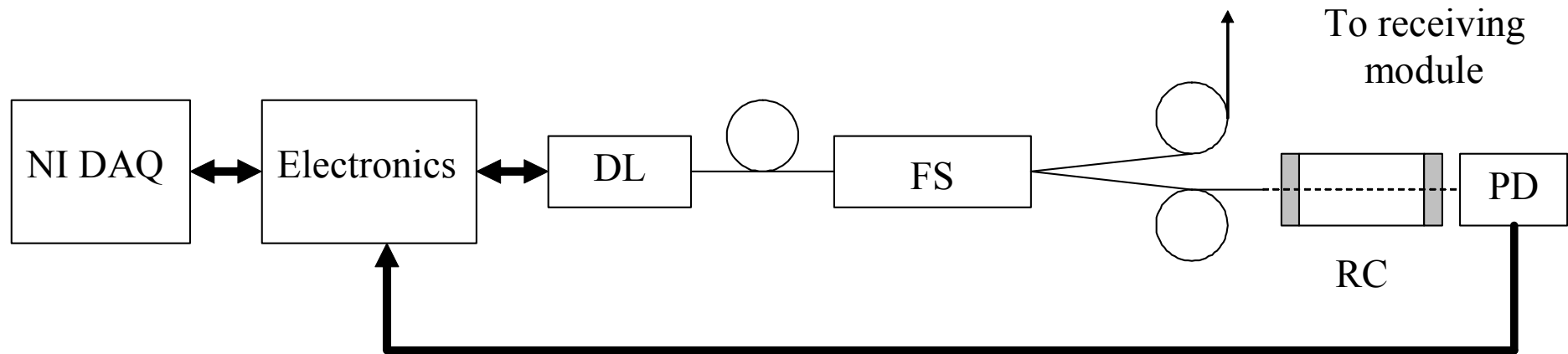
Commercially available diode lasers could be found for this range, that provides a possibility of various molecules detection.

Example of pig-tailed DL (with fiber output)



Set of DLs available at DLS Lab of GPI is shown on figure by open black cycles

# Laser channel block-scheme



## Laser channel:

Electronics (see separate poster) controls DL temperature and provides excitation current

DL – diode laser module with single-mode fiber output

FS – fiber splitter

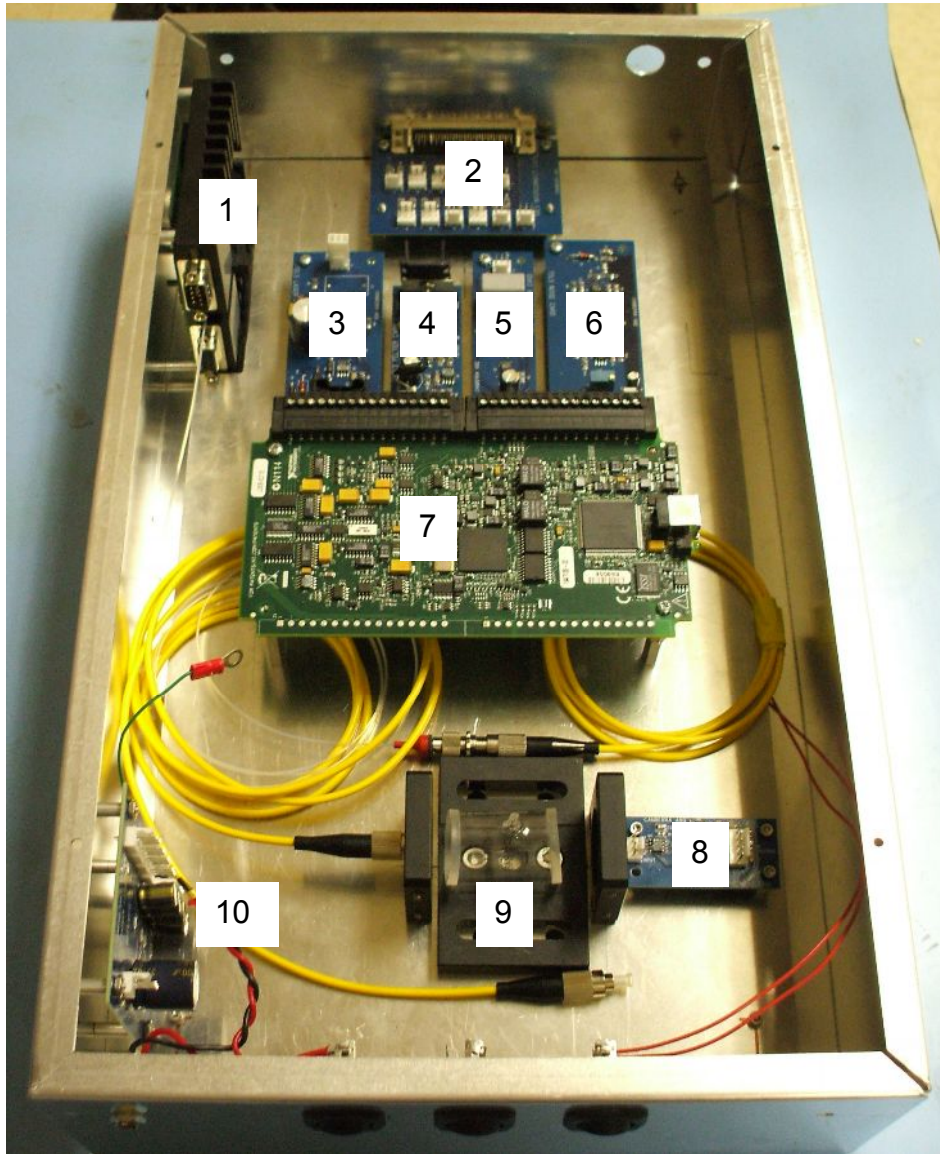
Part of DL radiation is directed to receiving module, other to reference channel

RC – reference cell with known concentration of molecule under detection

PD – photo-diode with preamplifier

Signal after preamplifier is recorded by NI DAQ

# Laser channel



*View of DL channel with electronics (see separate poster)*

## Primary Components:

1. Diode laser module
2. Interconnect board for PCI NI DAQ
3. DL excitation current board
4. Thermo Electric controller board
5. Thermo sensor board
6. Power distribution board
7. USB NI DAQ
8. Photo diode with pre amplifier
9. Reference gas cell
10. Power supply board with 12 V DC or AC power

# Multi-channels electronics

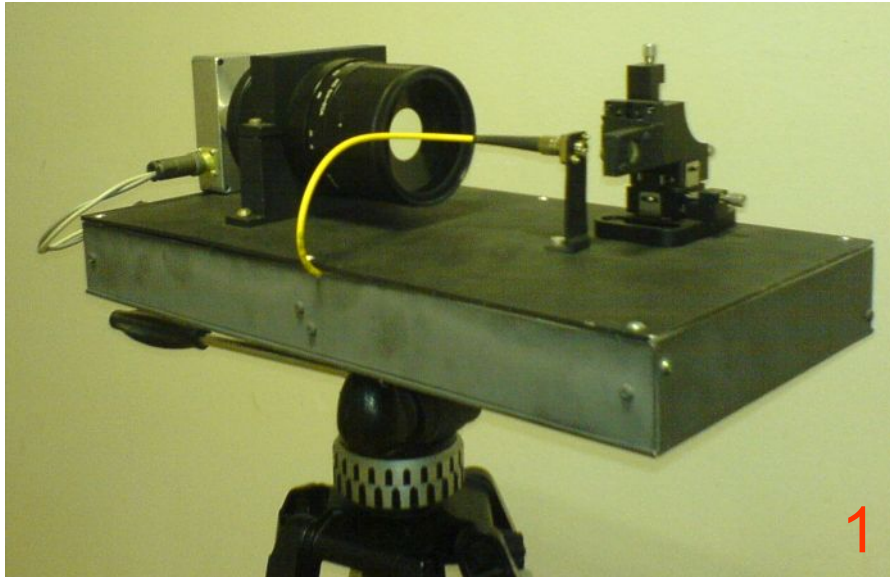


View of multi-channel electronics

1. Display and keyboard
2. NI PXI-1031DC computer station
3. Three laser channels

In present configuration the system can operate with up to 6 Laser channels

# Receiving modules



Family of receiving modules was used for different applications:

1. Handle - objective diameter 5 cm
2. Vehicle - objective diameter 10 cm
3. Helicopter - objective diameter 18 cm

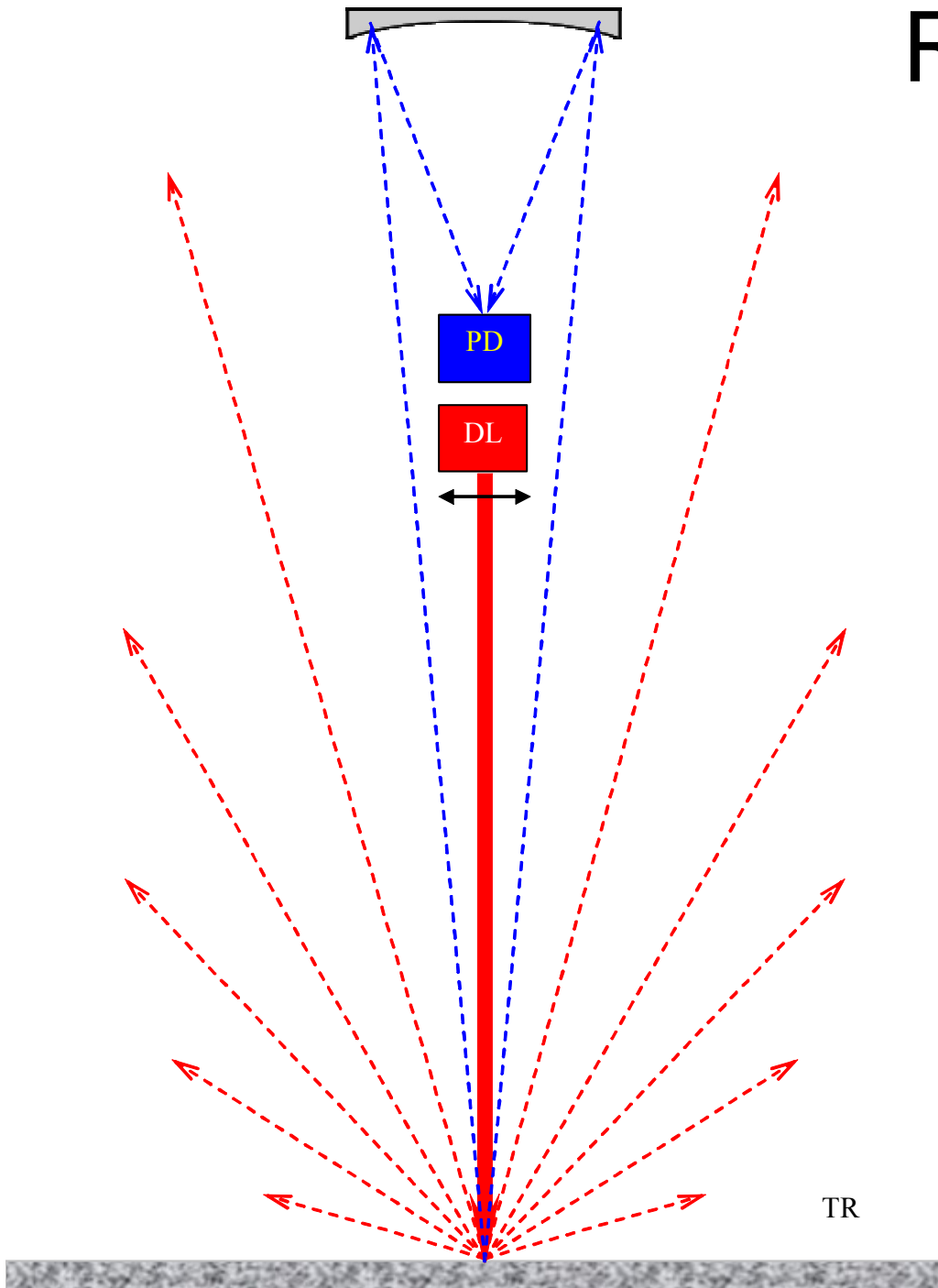


# Remote monitoring with TR

DL light from fiber is collimated in parallel beam and directed to topography reflector (TR).

Small part ( $10^{-3} - 10^{-9}$ ) of DL light scattered by TR is collected by receiving optics and recorded by photo-diode (PD).

For proper alignment DL beam image has to be inside PD image on TR.



# Laser channels beams configurations

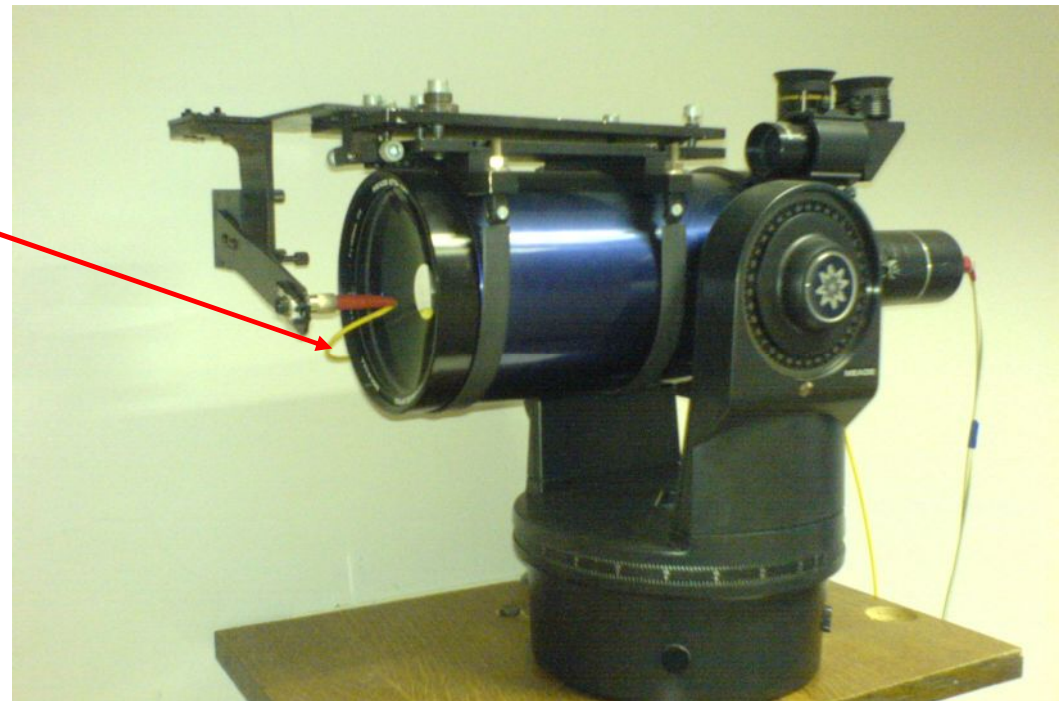
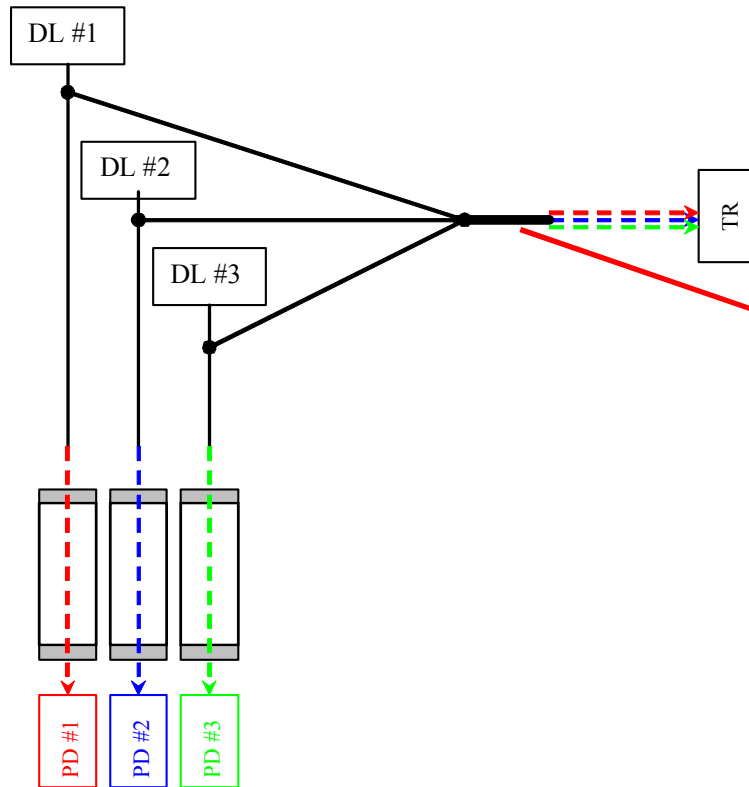
Depending on application there are several configurations of beams of different lasers



Individual focusing of different DL beams on TR. Individual fiber amplifiers were used in this configuration.

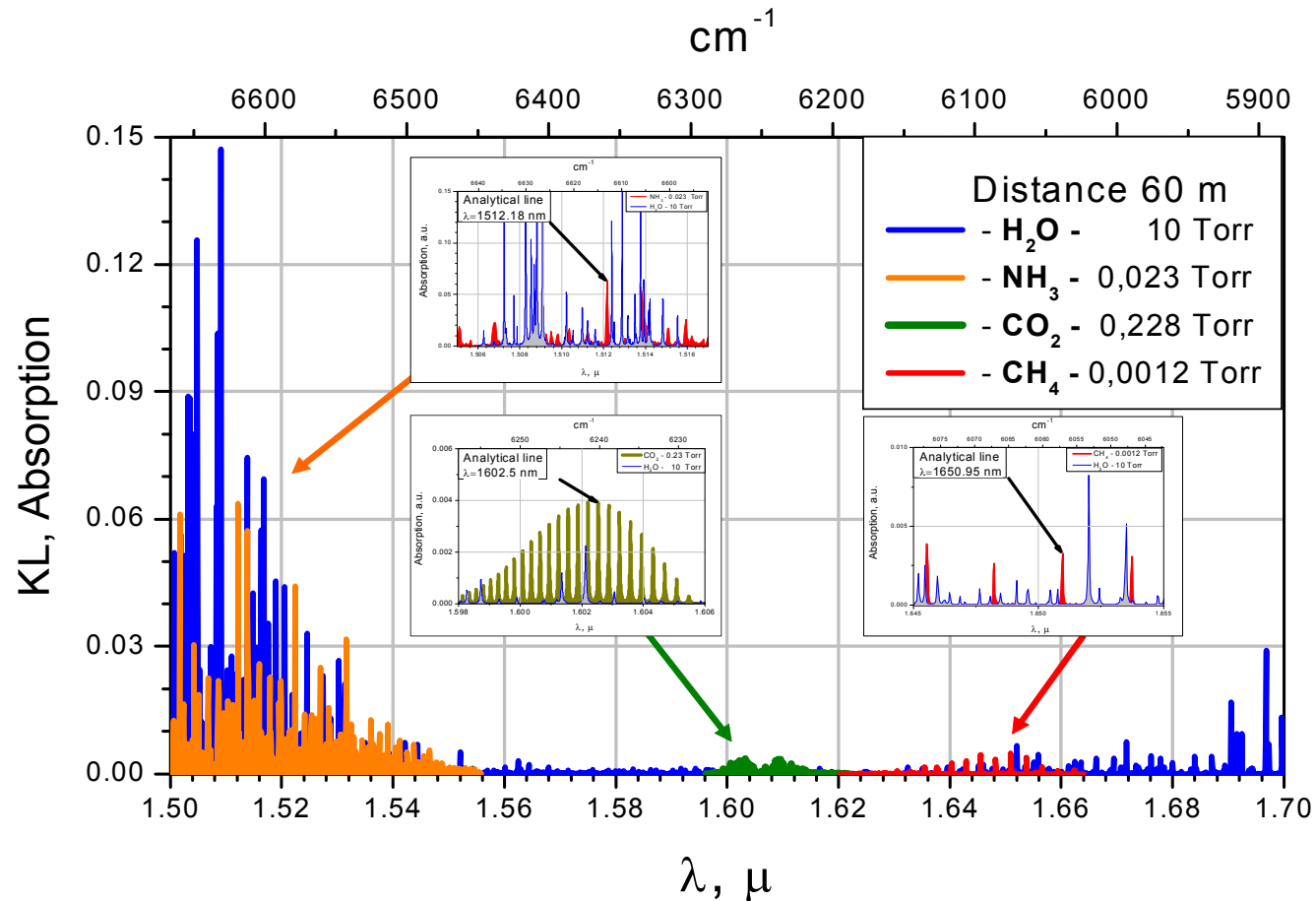
# Laser channels beams configurations

Depending on application there are several configurations of beams of different lasers



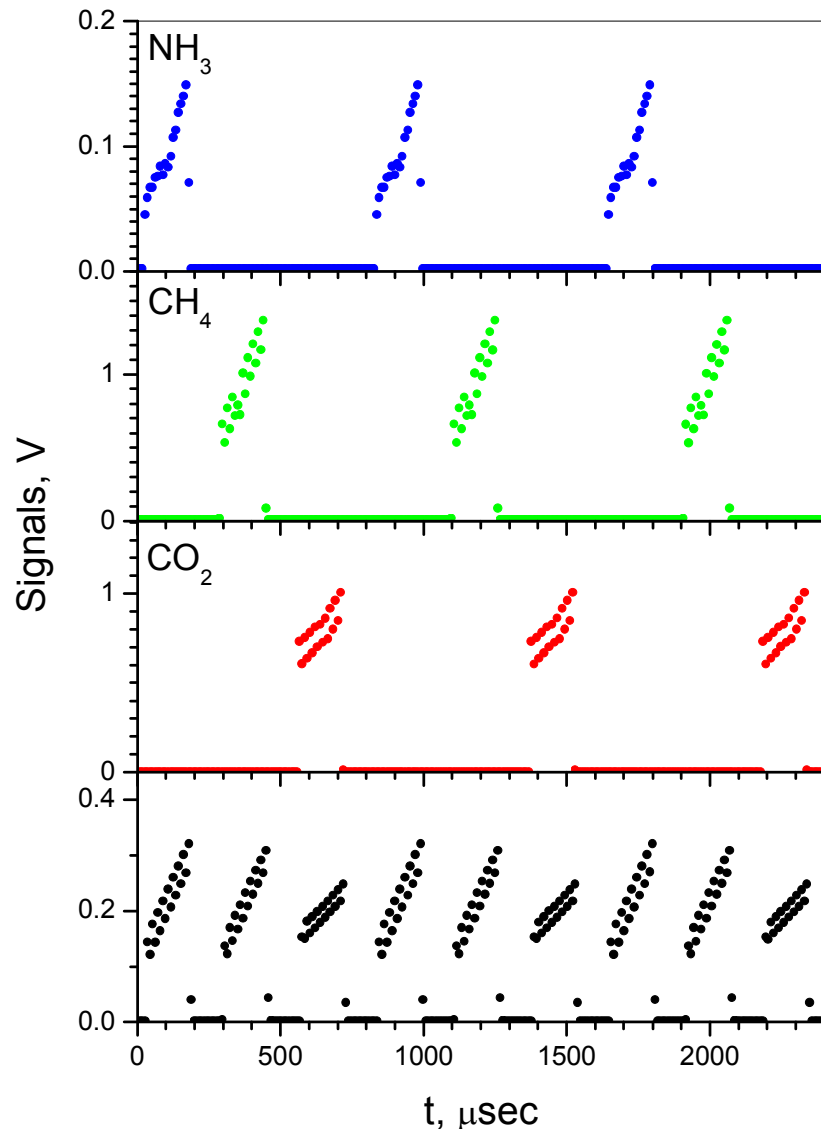
Radiation of all DLs by Y type fiber splitters is directed to one single-mode fiber and by collimator focused on TR. Both individual and common fiber amplifiers were used in this configuration.

# Selection of analytical lines



As one of applications, simultaneous detection of methane, ammonia, and CO<sub>2</sub> was considered. Example of analytical lines selection based on DL available and taking into account absence of interference with atmosphere water vapor absorption is shown

# Time multiplexing operation regime

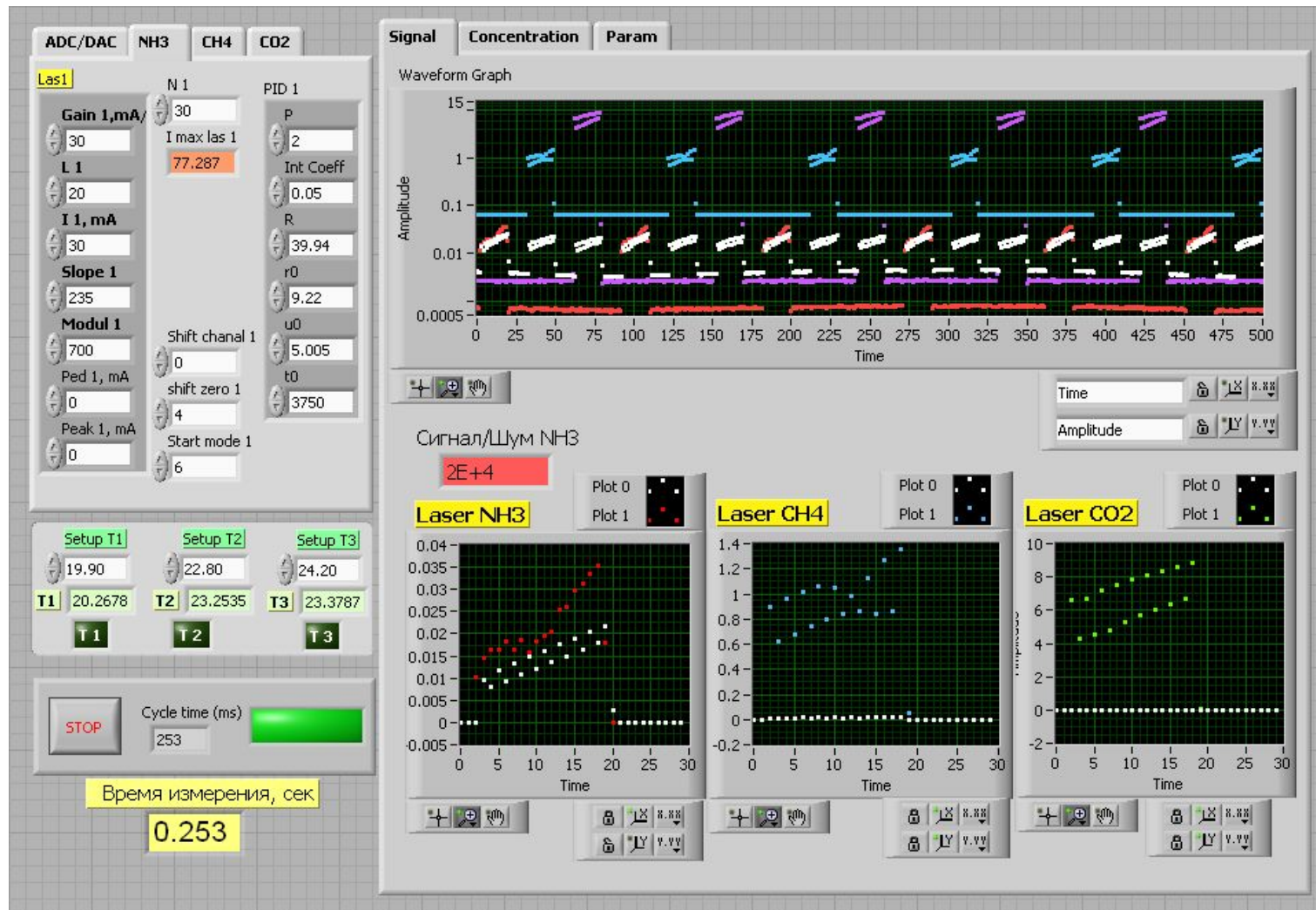


To increase selectivity of multiple molecular samples detection time multiplexing operation regime is used. Each laser operates at different time. Three upper graphs show signals recorded in three different reference laser channels.

DL radiation from these three channels was combined in one single-mode fiber. Radiation from the fiber was collimated into parallel beam and directed to TR. Laser light scattered by TR was recorded by receiving module (lower graph).

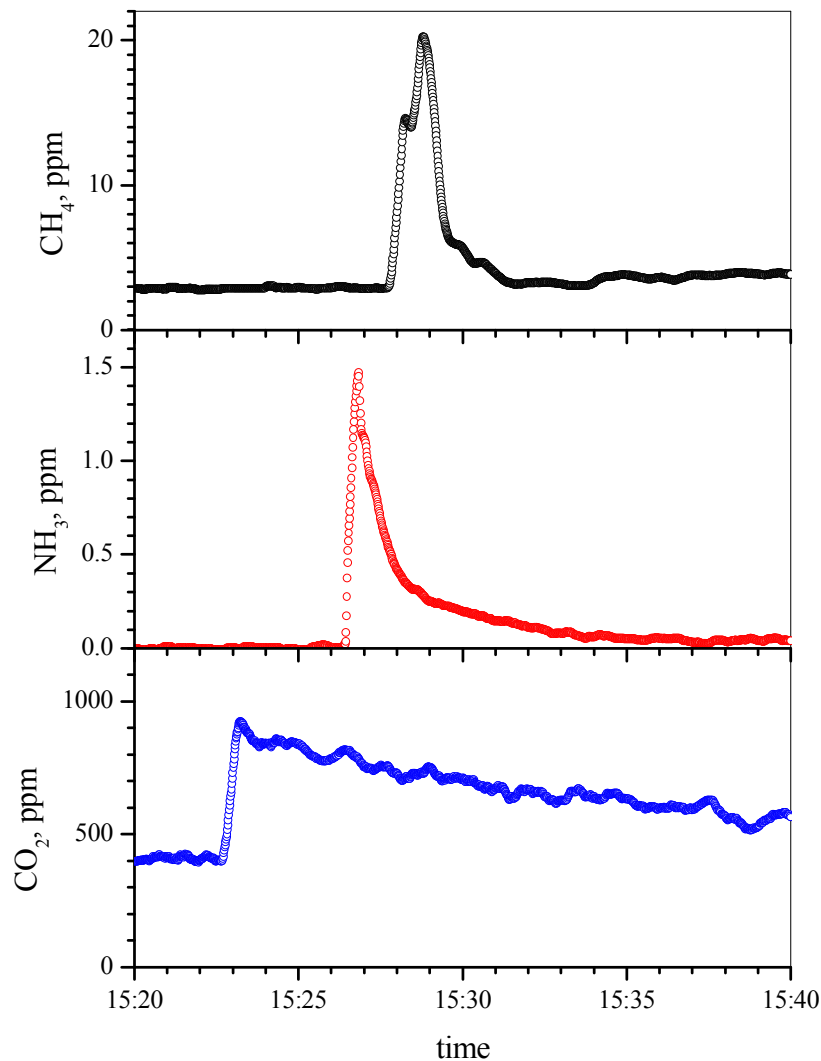
Simultaneous real time measurements of three molecules concentrations.

# Program interface



Software was developed using LabView 8.2 to support operation of trace gas multi-component remote monitoring system

# Operation of multi-component remote monitoring system



To increase remote monitoring operation distance fiber amplifiers were used. At present we have Raman fiber amplifier for C-H bond and Er fiber amplifier for N-H bond.

For test purpose the system was installed at 45 m distance from TR. Box with glass windows (car imitator) was installed in DL beam.

Simultaneous detection of methane, ammonia, and CO<sub>2</sub> when following sample volumes were injected in the box under investigation:

CO<sub>2</sub> (99,96%) – 5 liters

CH<sub>4</sub> (99,99%) - 0,5 liter

NH<sub>3</sub> (99,99%) - 0,01 liter

# Family of receiving modules



Family of receiving modules was used for different applications.