Remote human detection

S.L. Malyugin, A.I. Nadezhdinskii, D.Yu. Namestnikov, Ya.Ya. Ponurovskii, I.P. Popov, Yu.P. Shapovalov

DLS
LAB

A. M. Prokhorov General Physics Institute of RAS
38 Vavilov str., 119991 Moscow, Russia.
E-mail: Nad@nsc.gpi.ru

Introduction

Remote detection is important application of TDLS. Between many possible scenarios, remote human detection is very attractive. Humans are source of several molecules that can be detected by TDLS. There are several sources of these molecules: human activity, human physiology, skin, breath, etc.

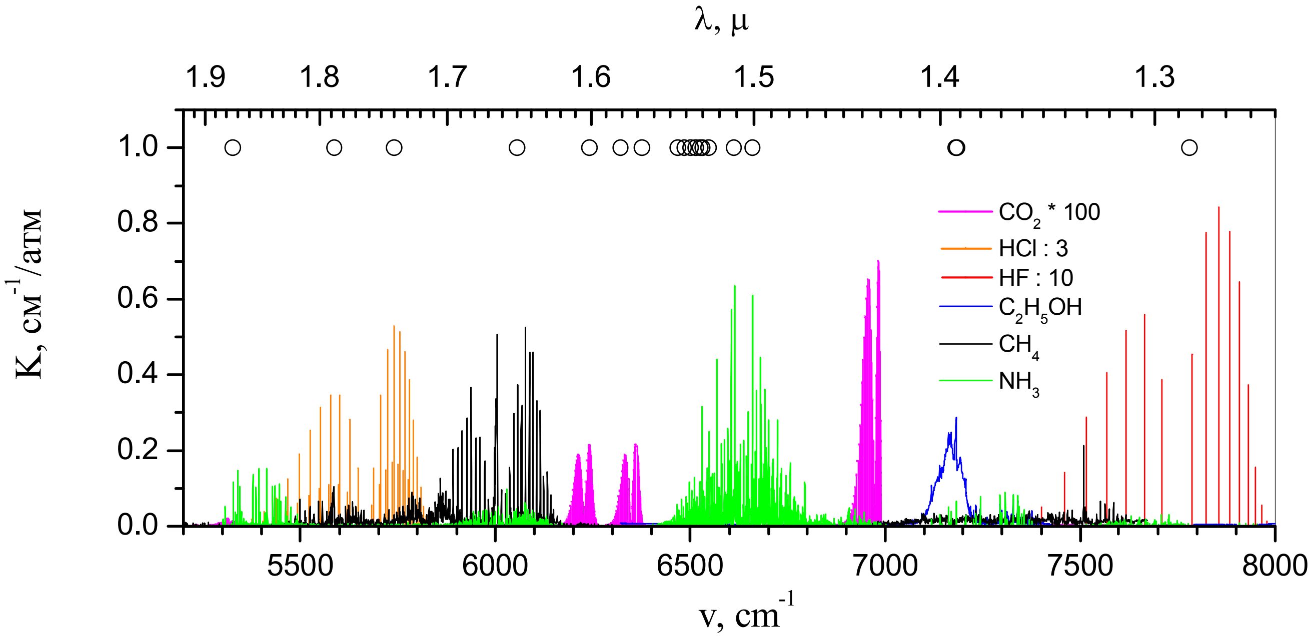
Molecules than can be considered as signatures of human presence or activity: ammonia, methane, CO_2, etc. (Table 1).

Table 1. Concentration of several molecules in atmosphere and human breath

Molecule	Ammonia	Methane	CO_2
Atmosphere	40 ppb	1.6 ppm	0.03 %
Breath	200 ppb	4 ppm	3 %

K.L.Moskalenko, A.I.Nadezhdinskii, E.V.Stepanov, Tunable diode laser spectroscopy application for ammonia and methane content measurements in human breath, Proc.SPIE, №2205, 448-452 (1994)

DL and molecular spectra in near IR

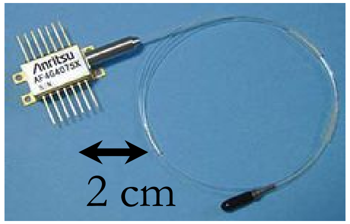


Absorption spectra of several molecules in near IR spectral range

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.

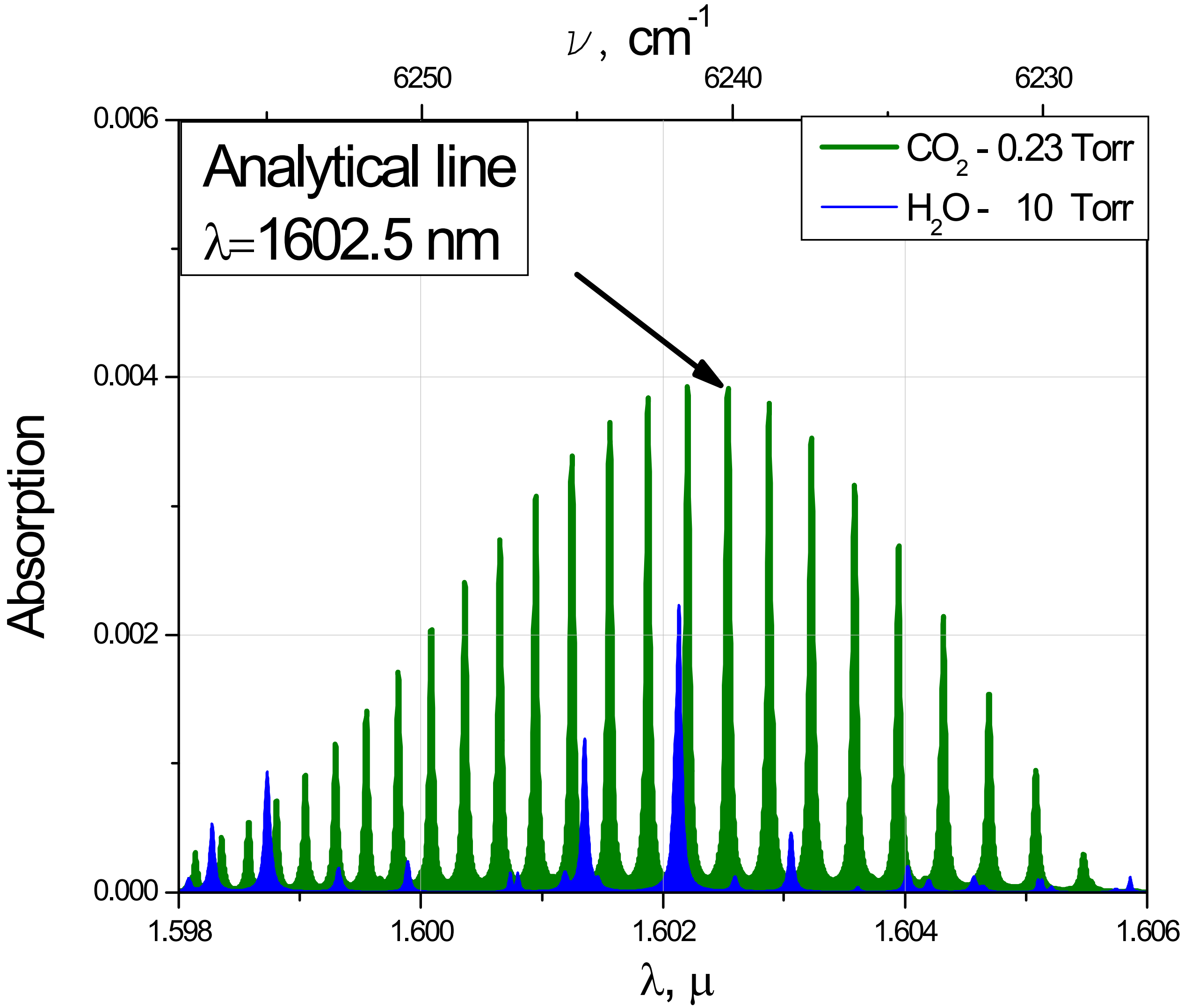
Commercially available diode lasers could be found for this range, that provides a possibility of various molecules detection.

Example of pig-tailed DL (with fiber output)



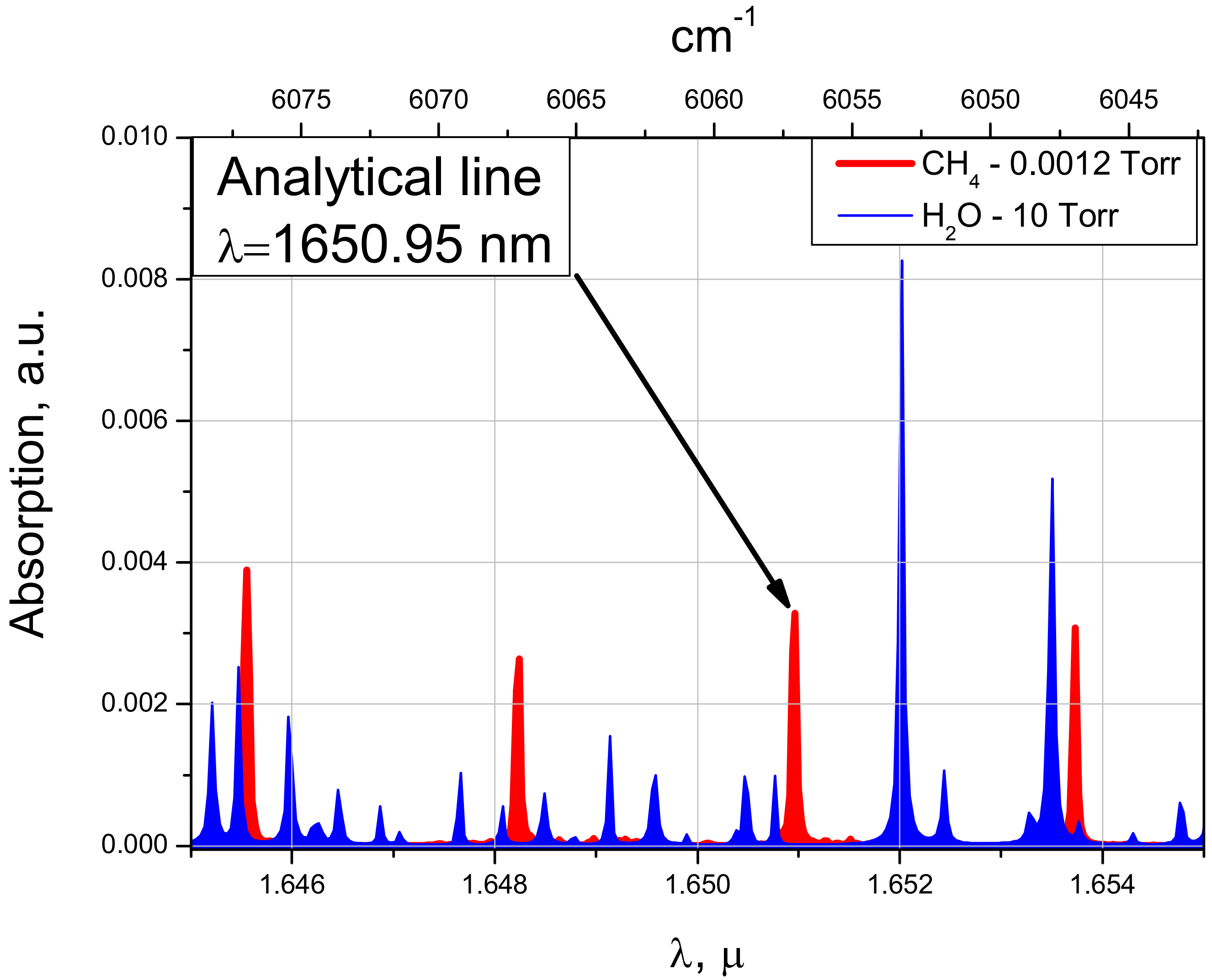
Set of DLs available at DLS Lab of GPI is shown on figure by open black cycles

CO_2 detection



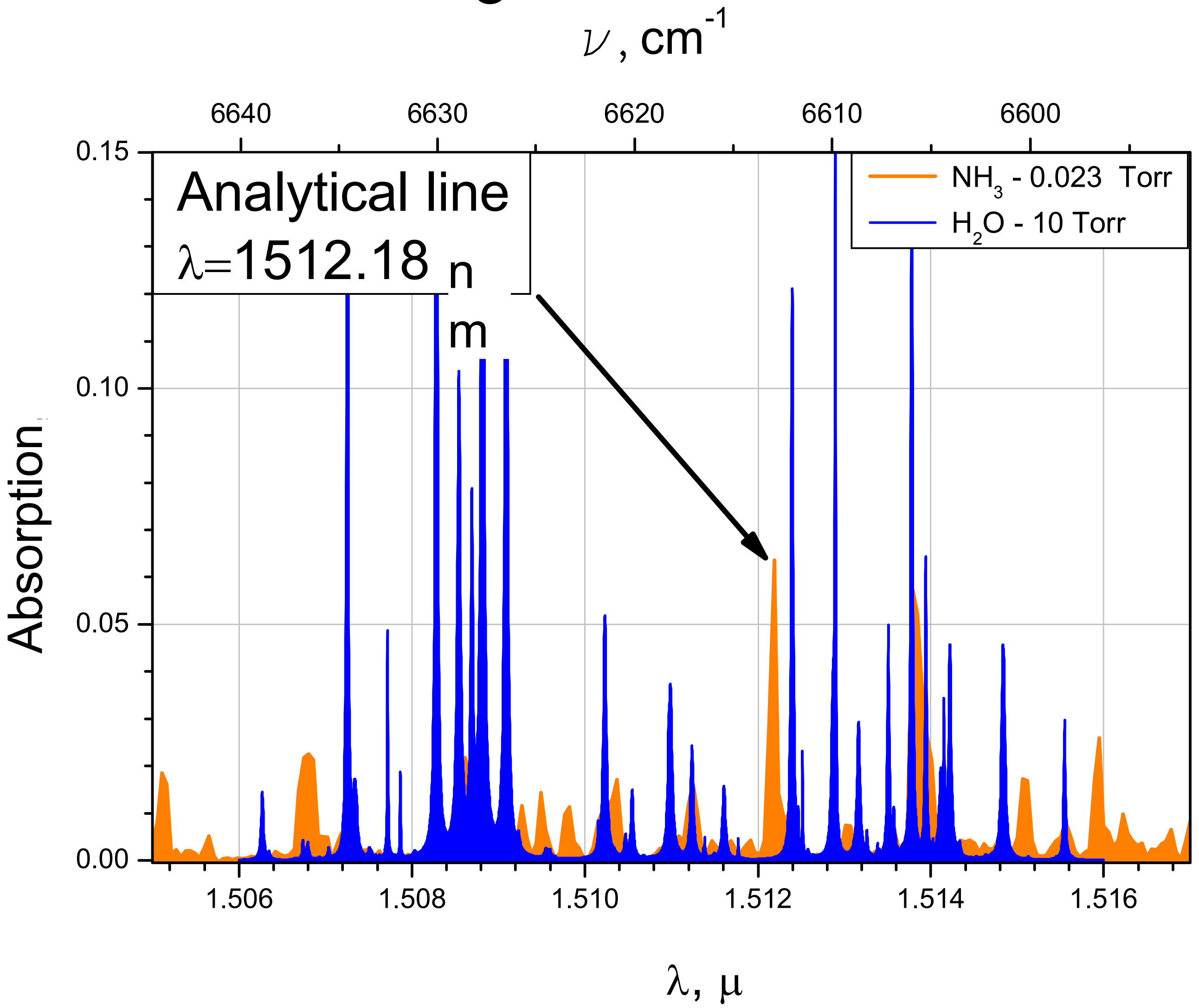
Choice of analytical line for CO_2 detection taking into account interference with water absorption.

CH_4 detection



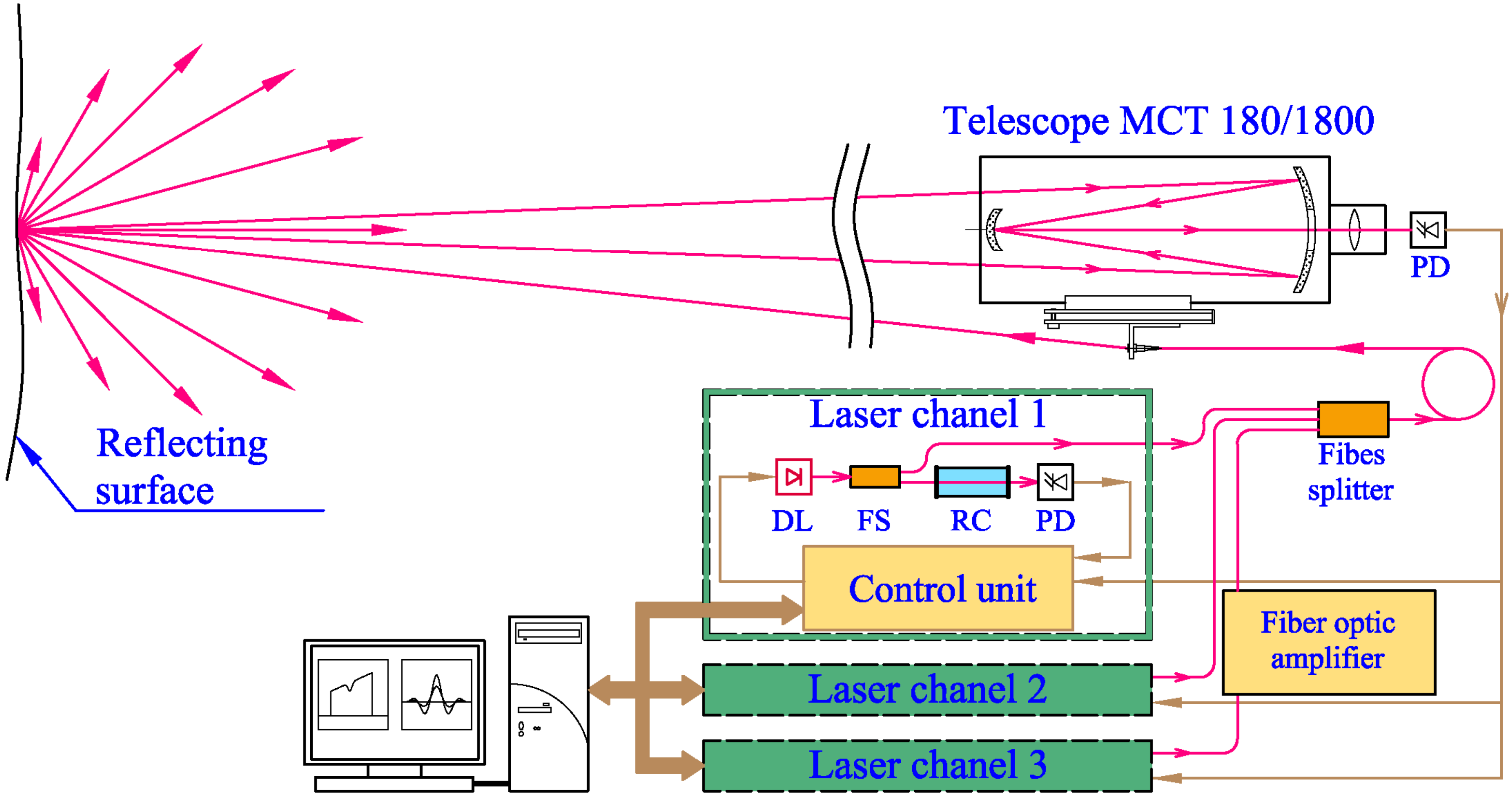
Choice of analytical line for methane detection taking into account interference with water absorption.

NH_3 detection



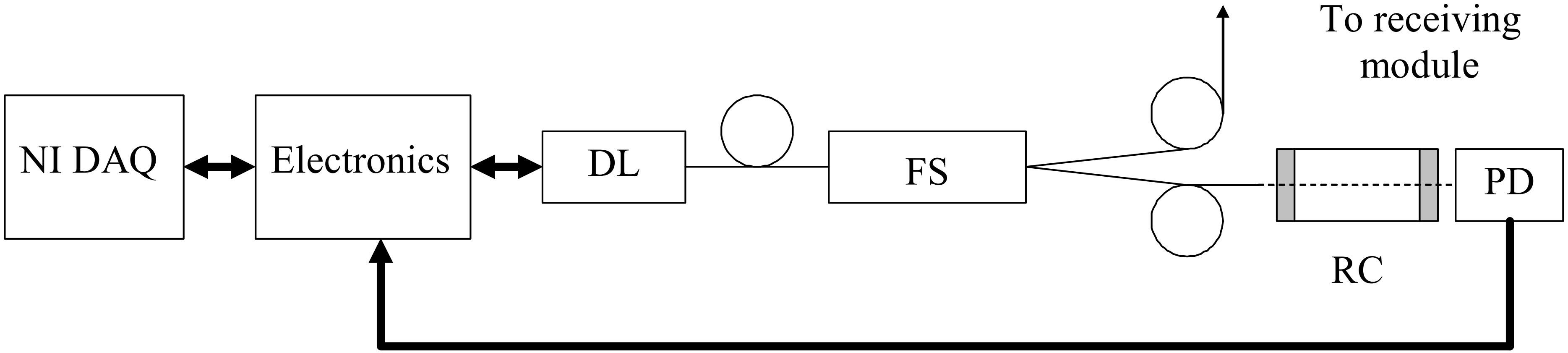
Choice of analytical line for ammonia detection taking into account interference with water absorption.

System layout



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

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

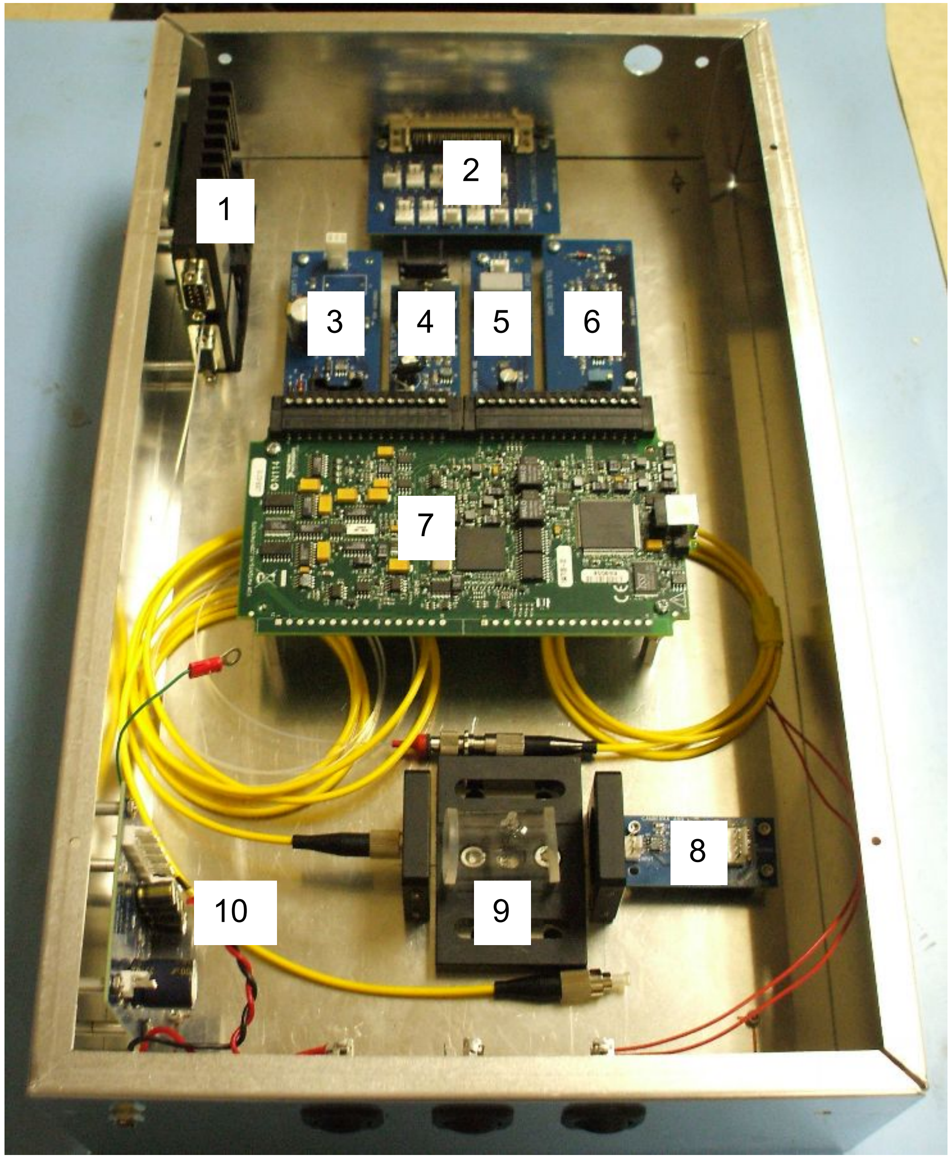
Part of DL radiation is directed to receiving module, other to reference channel

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

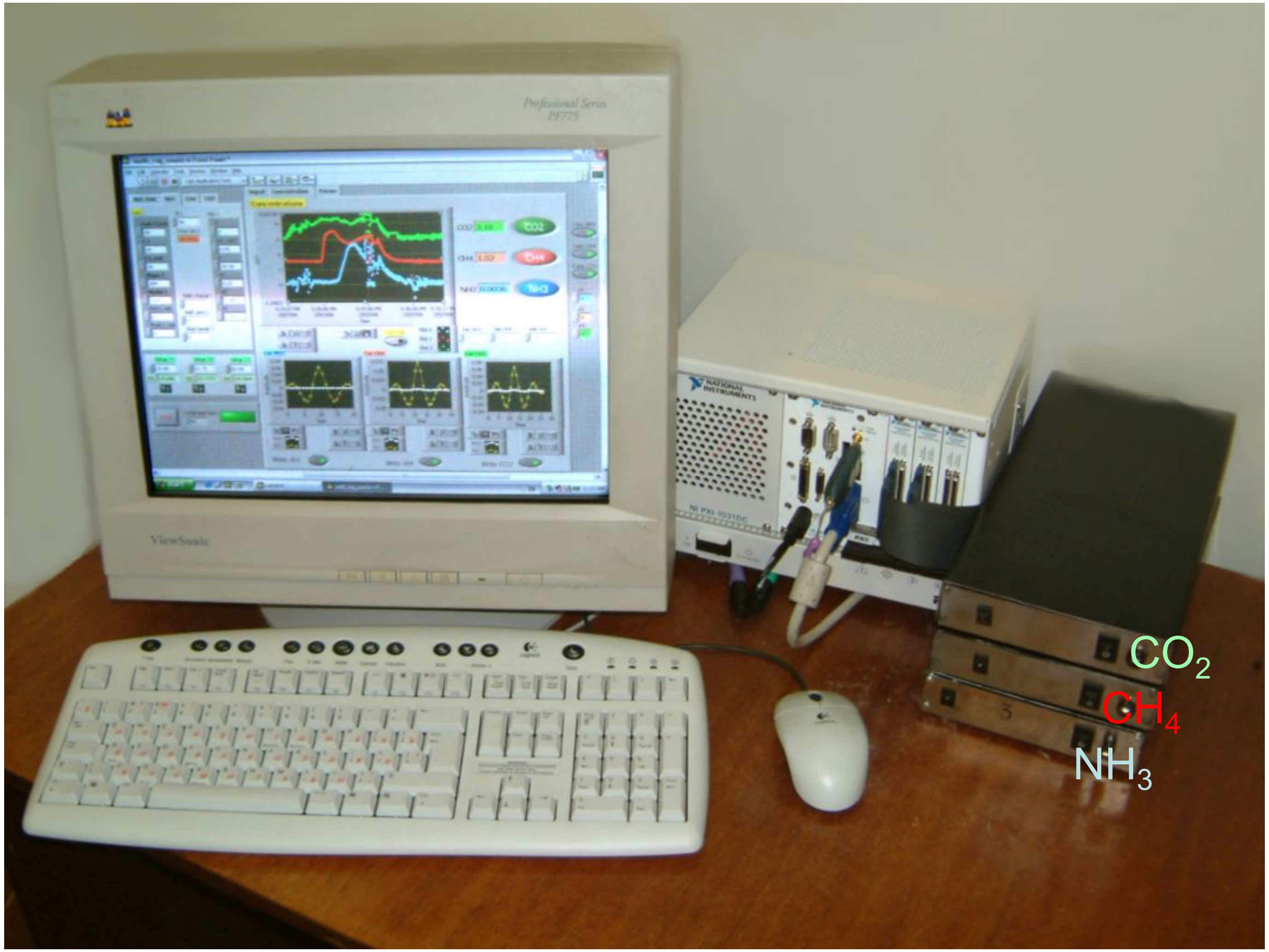


View of DL channel with electronics (see separate poster)

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

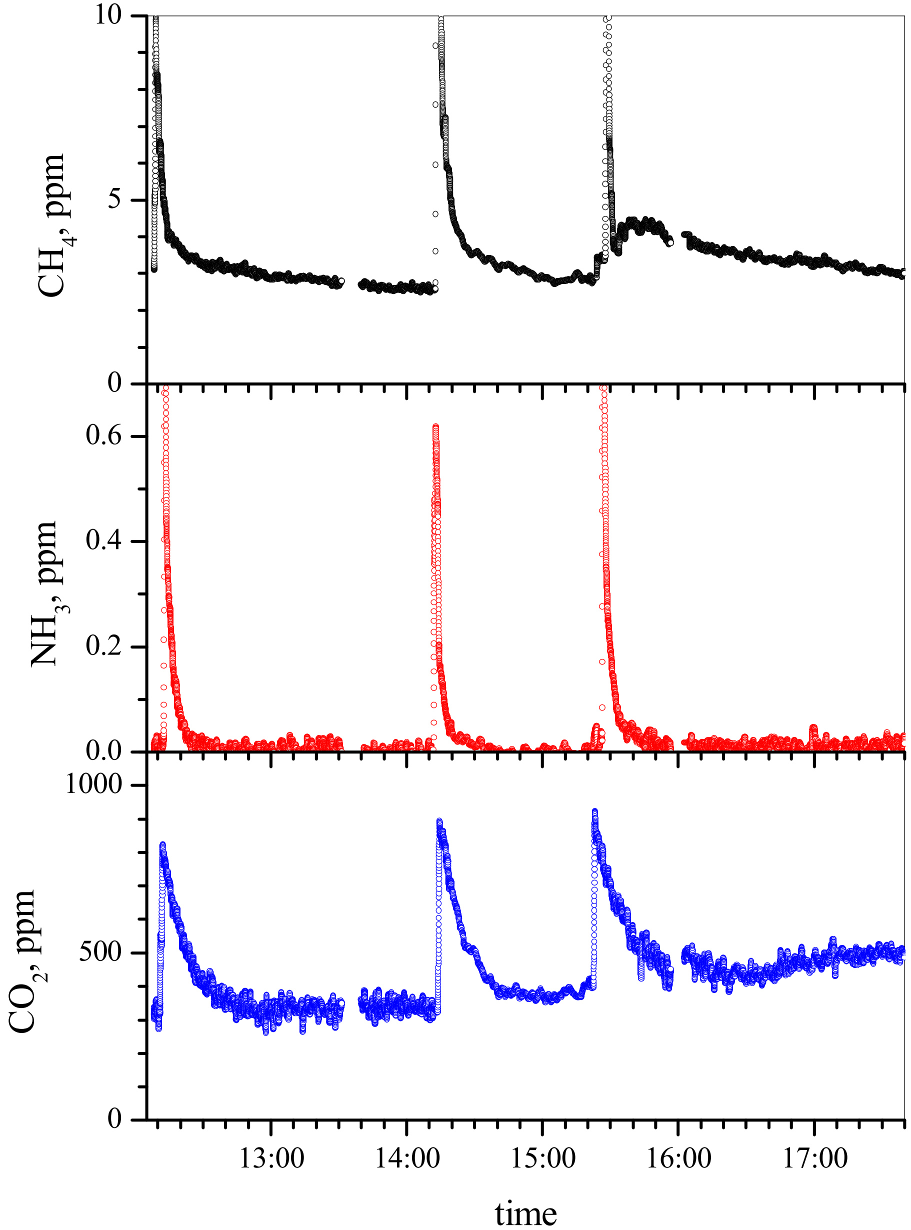


View of multi-channel electronics

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

View of electronics of trace gas multi-component remote monitoring system (see separate poster). Three laser channels were used in present instrument to detect ammonia, methane and CO_2

Simultaneous detection of 3 molecules

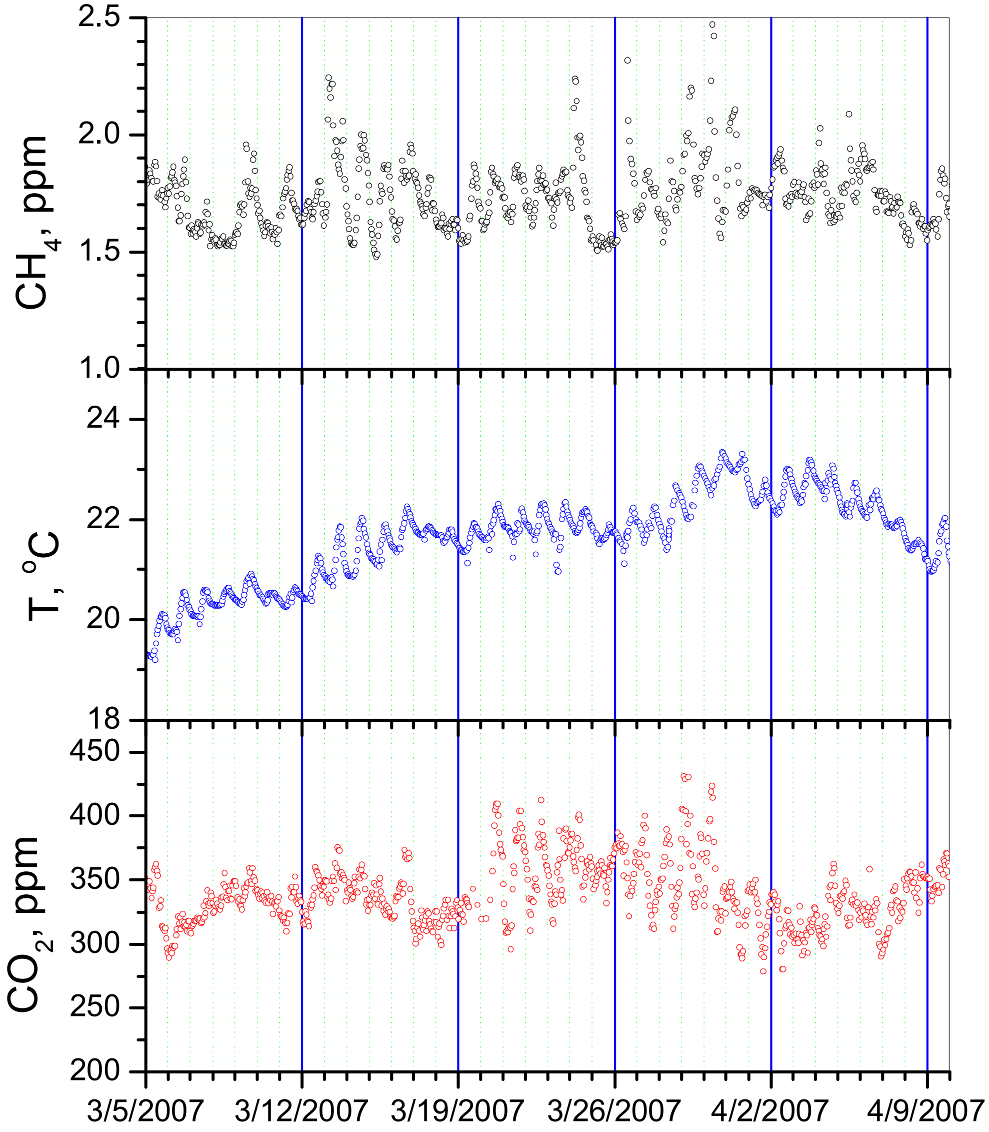


Indoor test. For test purpose the system was installed in DLS department corridor at 45 m distance from TR. Box with glass windows was installed in DL beam.

Simultaneous detection of methane (black), ammonia (red), and CO_2 (blue) when following samples volumes were injected in the box under investigation: CO_2 (99,96%) – 5 liters; CH_4 (99,99%)- 0,5 liter; NH_3 (99,99%) - 0,01 liter.

Simultaneous detection at the same time of all molecules under consideration is signature of human presence.

Remote detection of human activity

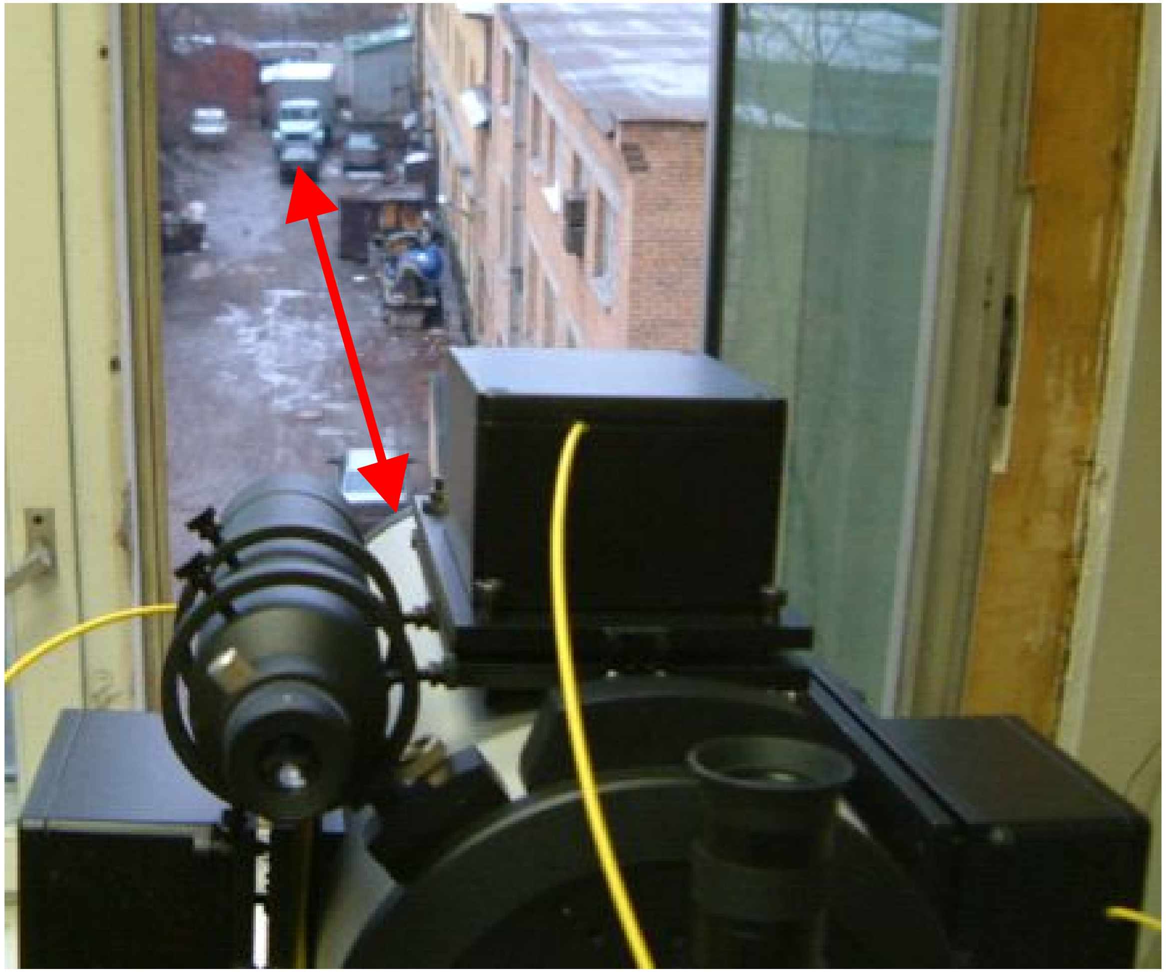


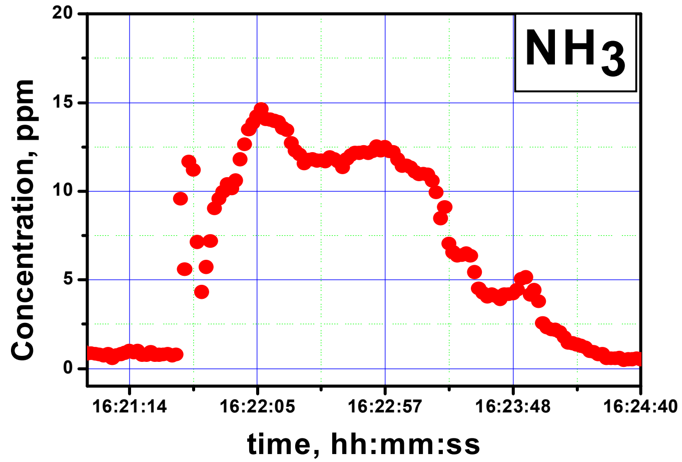
Indoor measurements: methane (black) and temperature (blue).

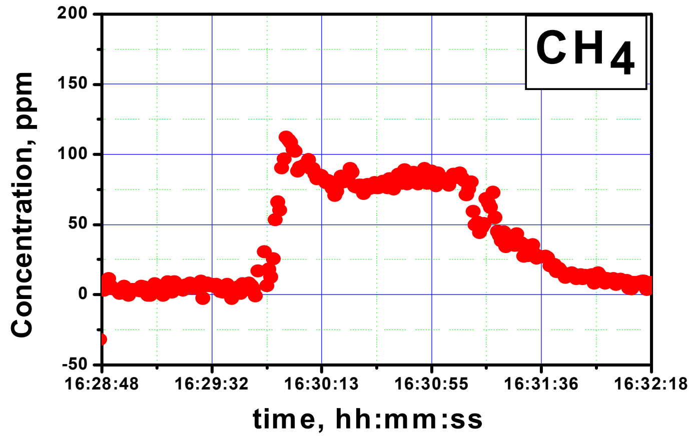
Outdoor measurements: CO_2 (red).

Week period of data presented demonstrates influence of human activity on methane and CO_2 concentrations.

Outdoor test

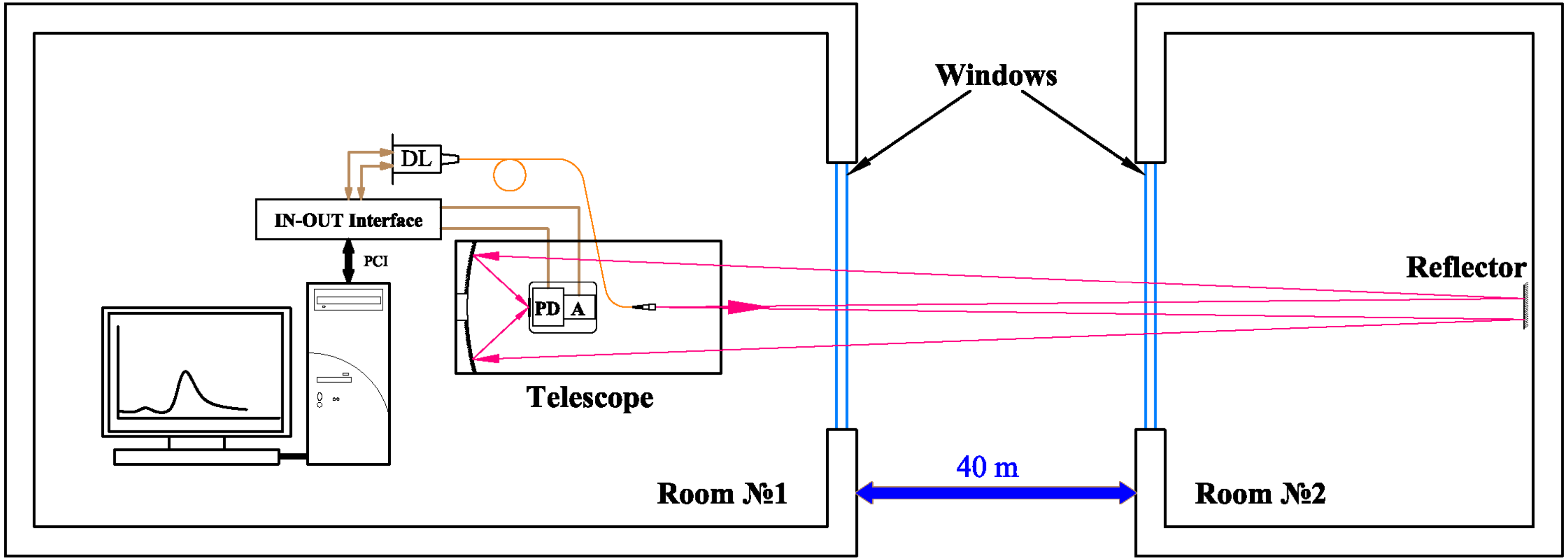






Remote detection of ammonia and methane when sample gases were injected in vehicle located at 100 m from instrument. Fiber amplifiers were used to increase receiving signal. Simultaneous detection at the same time of all molecules under consideration is signature of human presence.

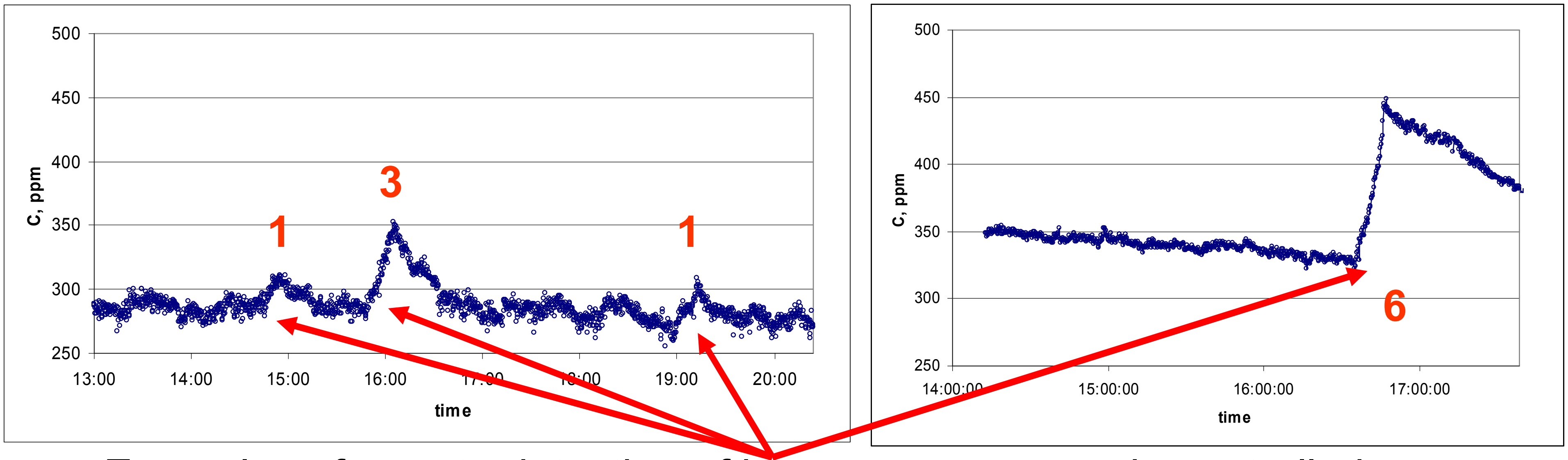
Human presence remote detection



To test the scenario of human presence remote detection CO_2 channel of the instrument developed was used. The instrument was installed in room №1. Collimated laser beam was directed through room windows to windows of room under control located in other building. Distance between buildings was 40 m. Scattered light was detected by receiving optics and focused on PD.

Human presence remote detection

Remote detection is important application of TDLS. Between many possible scenarios, remote human detection is very attractive. Humans are source of several molecules that can be detected by TDLS. One of these molecules is CO_2. CO_2 is one of atmosphere components (~ 300 ppm). CO_2 concentration in human breath is significantly higher (~ 3 %). Hence, presence of additional CO_2 concentration detected remotely can be signature of human presence in location under control.



Examples of remote detection of human appearance in controlled area (room №2) by measuring CO_2 concentration. Red digits presents number of persons visited the room. CO_2 decrease after visit is due to ventilation.