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TDLS complex development for Airplane-laboratory "Atmosphere"

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Introduction

Last year Russian State program started to build Airplane-Laboratories "Atmosphere" on IL-114 board.

Airplane-Laboratory contains complexes providing information about:

- Navigation
- Thermodynamics
- Aerosol
- Atmosphere molecules concentration
- Clouds
- Atmosphere electricity
- Atmosphere radioactivity

Development of above mentioned complexes is subject of broad collaboration. Central Airological observatory is responsible for coordination of this development.

In this paper we present development of Tunable Diode Laser Spectroscopy (TDLS) based complex to measure in real time concentration of main atmosphere molecular

IL-114

IL-114 view

Main IL-114 parameters:

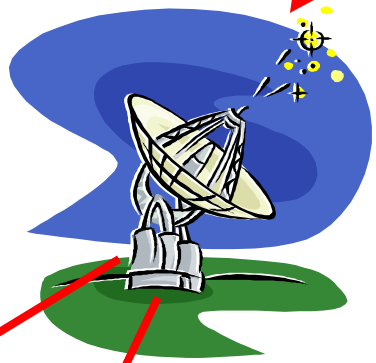
Fuselage length: 30 m
Wing spread: 26.9 m
Fuselage diameter: 2.9 m
Takeoff weight: 22700 kg
Fuel consumption: 650 kg/h
Highest altitude: 9000 m
Cruising speed: 350 – 500 km/h
Cruising distance: 4800 – 7000 km
Load-weight: 1500 – 7000 kg
Take-off distance: 950 m
Landing distance: 400 m

Data flow and information exchange

Communication satellite

Airplane-laboratory "Atmosphere"

Real time monitoring data



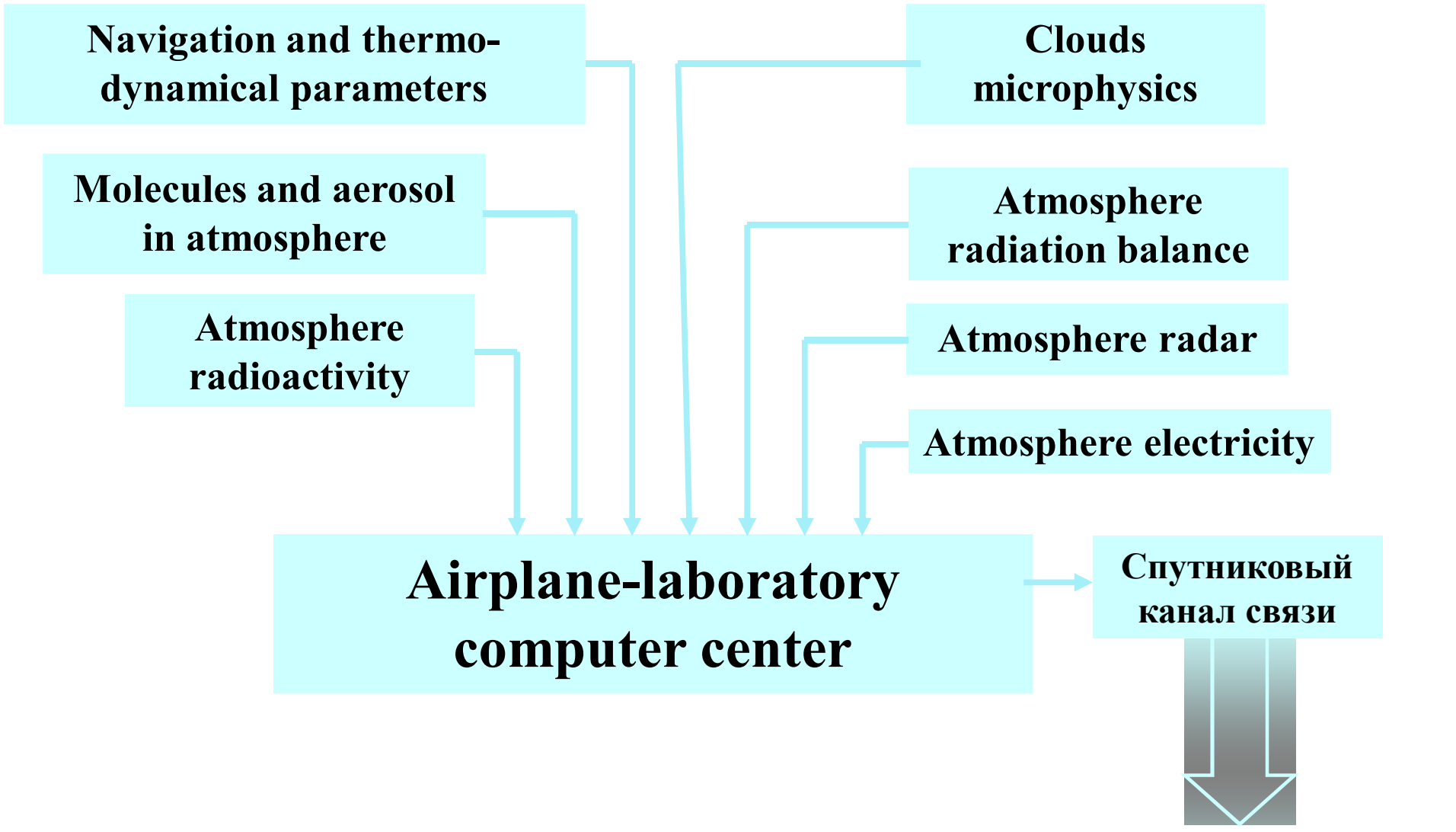
Satellite communication center of Rosgidromet

Radio communication c of Rosgidromet

Central Aerological Observatory of Rosgidromet

Rosgidromet

Airplane-laboratory complexes



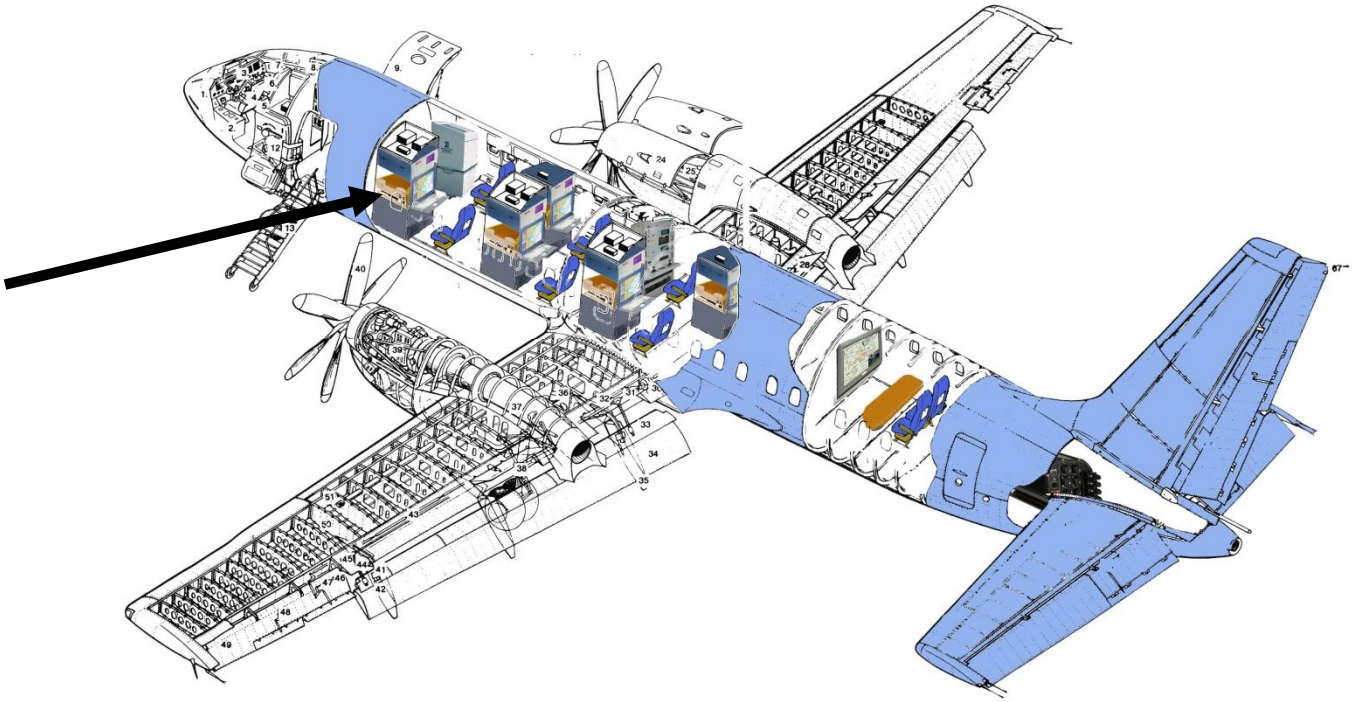
Real time monitoring data

-Airplane coordinates;
-Airplane altitude;
-Airplane speed;
-Wind speed and direction;
-Temperature;
-Humidity;
-Turbulence parameters;
-Atmosphere transparency;
-Atmosphere molecules concentrations;
-Electricity in atmosphere.

Central computer center

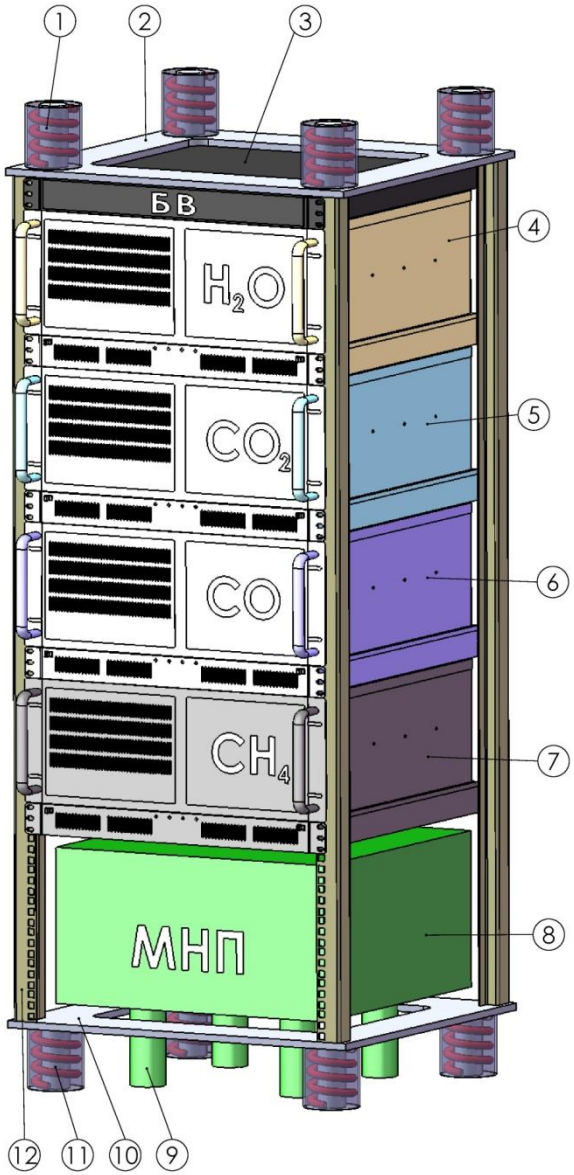
Airplane-laboratory scheme

TDLS complex location



In this paper we present development of Tunable Diode Laser Spectroscopy (TDLS) based complex to measure in real time concentration of main atmosphere molecular components and their isotopomers.

TDLS complex



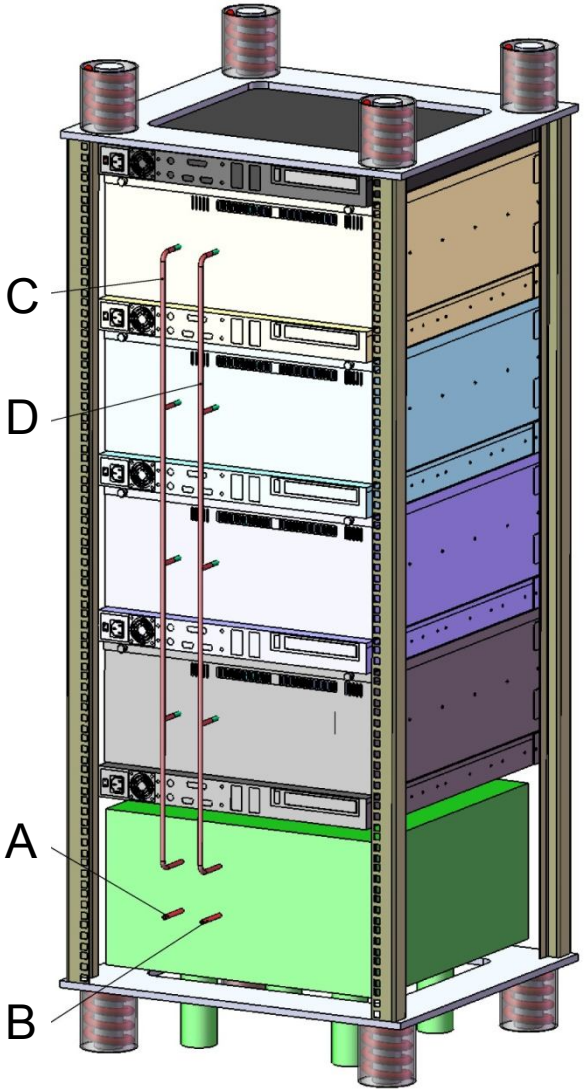
TDLS complex front view

TDLS complex consists of several modules.

4 identical modules to measure concentration of H_2O (4), CO_2 (5), CO (6), and CH_4 (7). These modules are installed in vibro-isolated hardware bay.

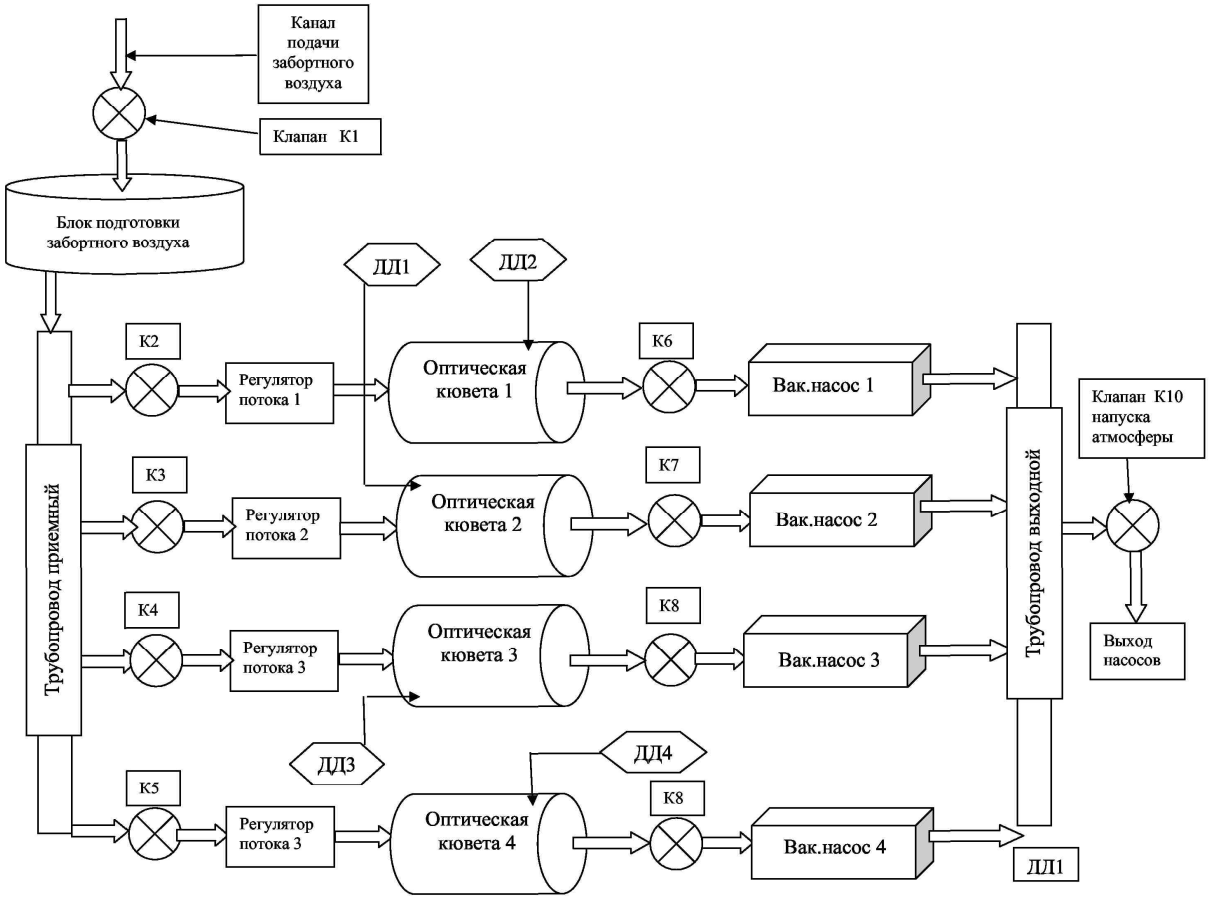
Module with pumps to provide air under investigation flow trough the system (8) and its preparation for measurements.

Gas connections: air in (A), air out (B), income line to TDLS modules (C), outcome line from TDLS modules.

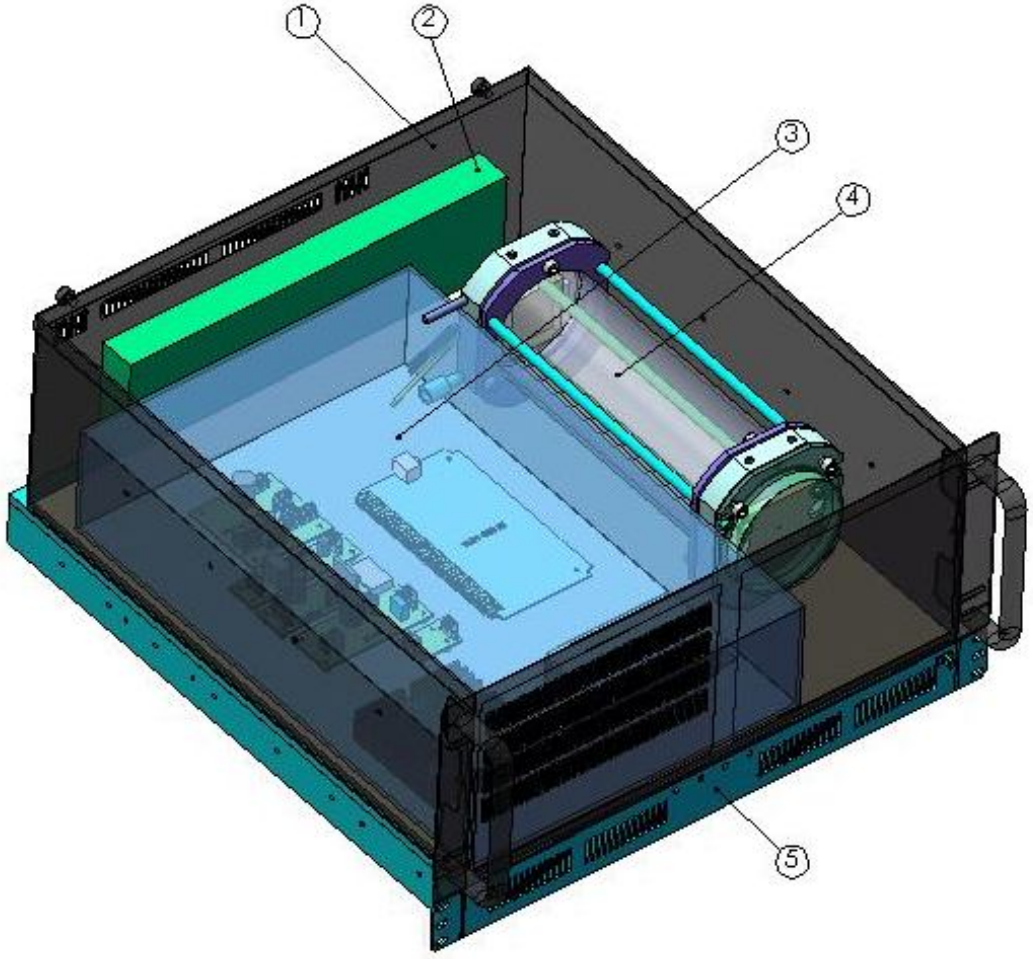


TDLS complex back view

Gas system of TDLS complex

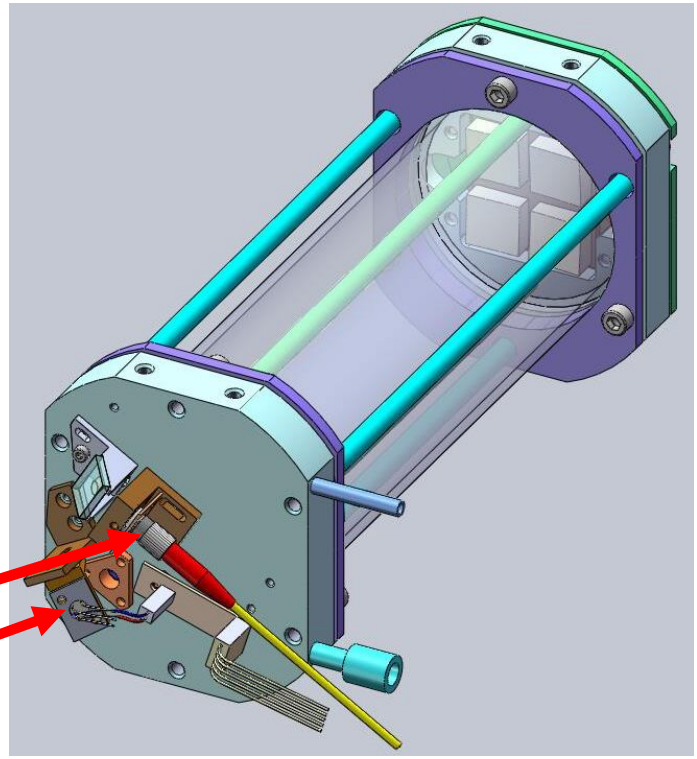


TDLS module



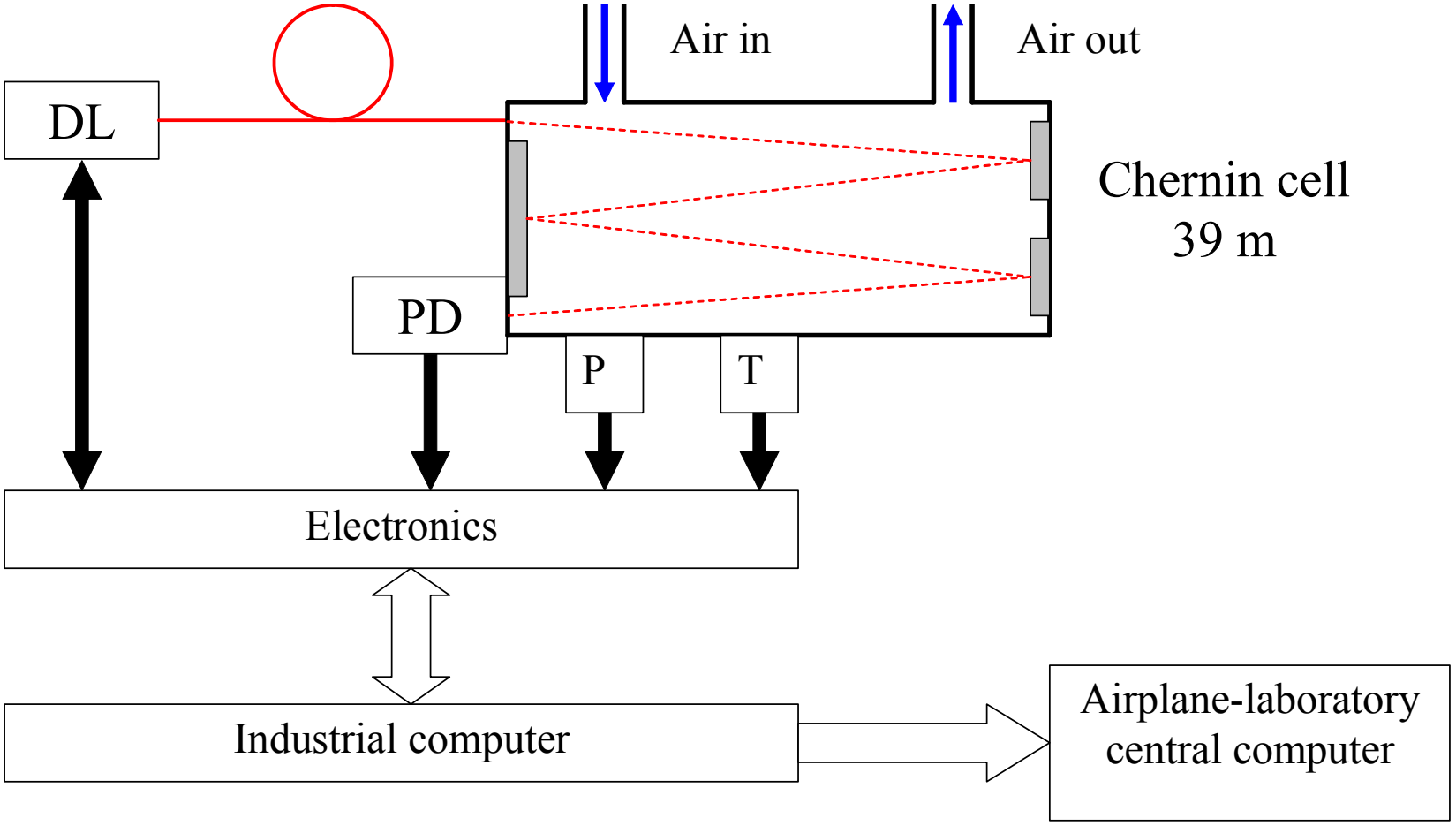
TDLS module:
1. Frame (4U)
2. Electrical and gas connectors.
3. Electronics and DL.
4. “Chernin” matrix optical system.
5. Industrial computer (1U).

“Chernin” matrix optical system.



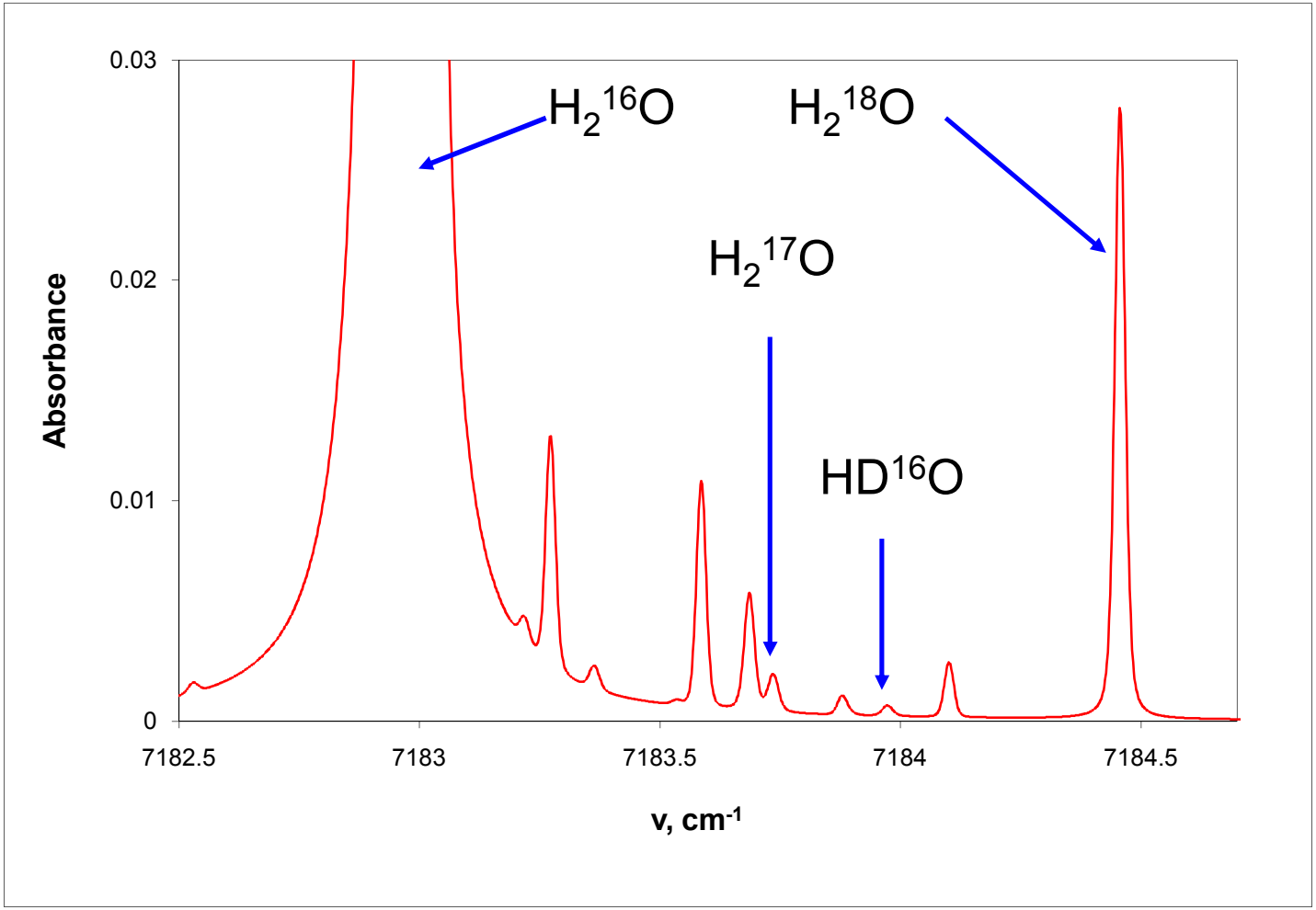
DL fiber input
PD to detect output DL light

TDLS module block-scheme



Computer and electronics control DL operation (DL temperature and excitation current, record signal from PD, and gas pressure and temperature from sensors.

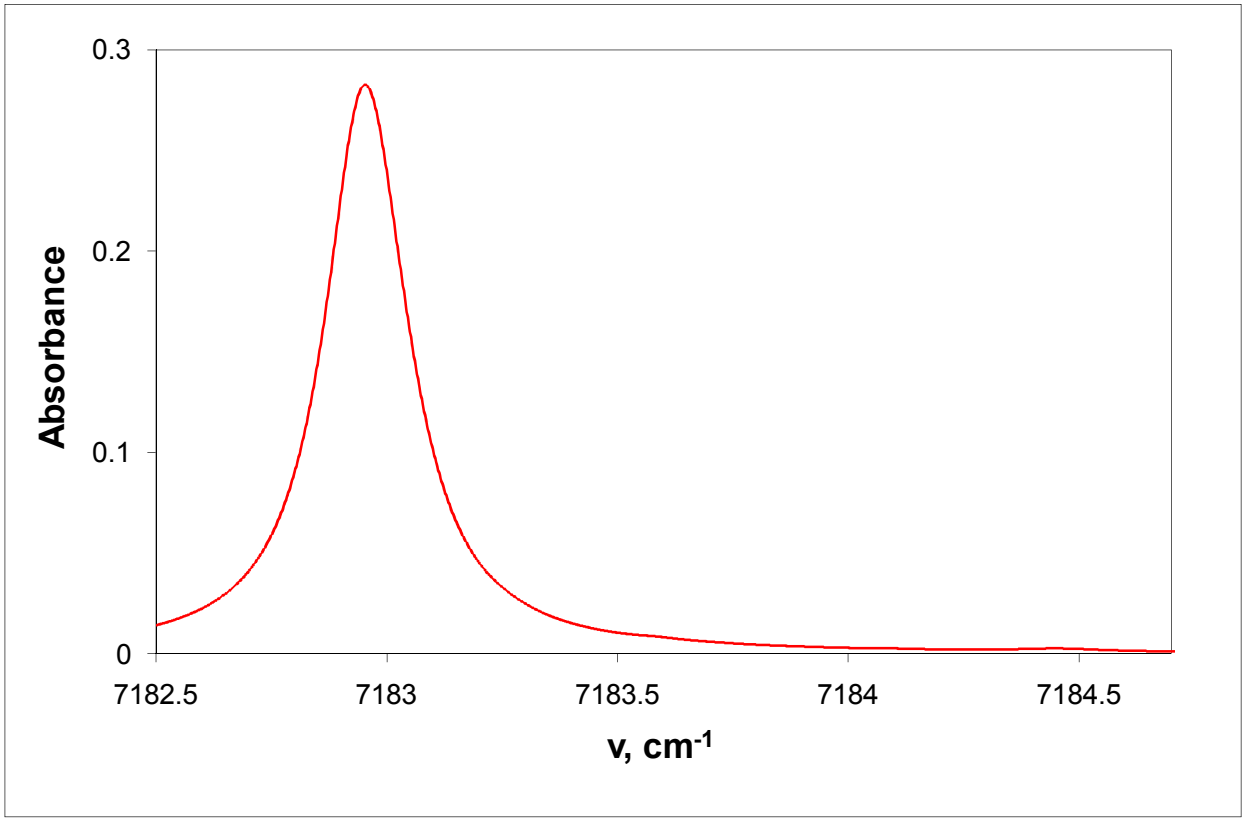
H_2O channel



DL spectral range to measure humidity (strong $H_2{}^{16}O$ line) as well as isotope ratio of oxygen and hydrogen isotopes: zero altitude, P_0 = 30 Torr, L = 39 m, humidity – 50 %.

Atmosphere turbulence channel

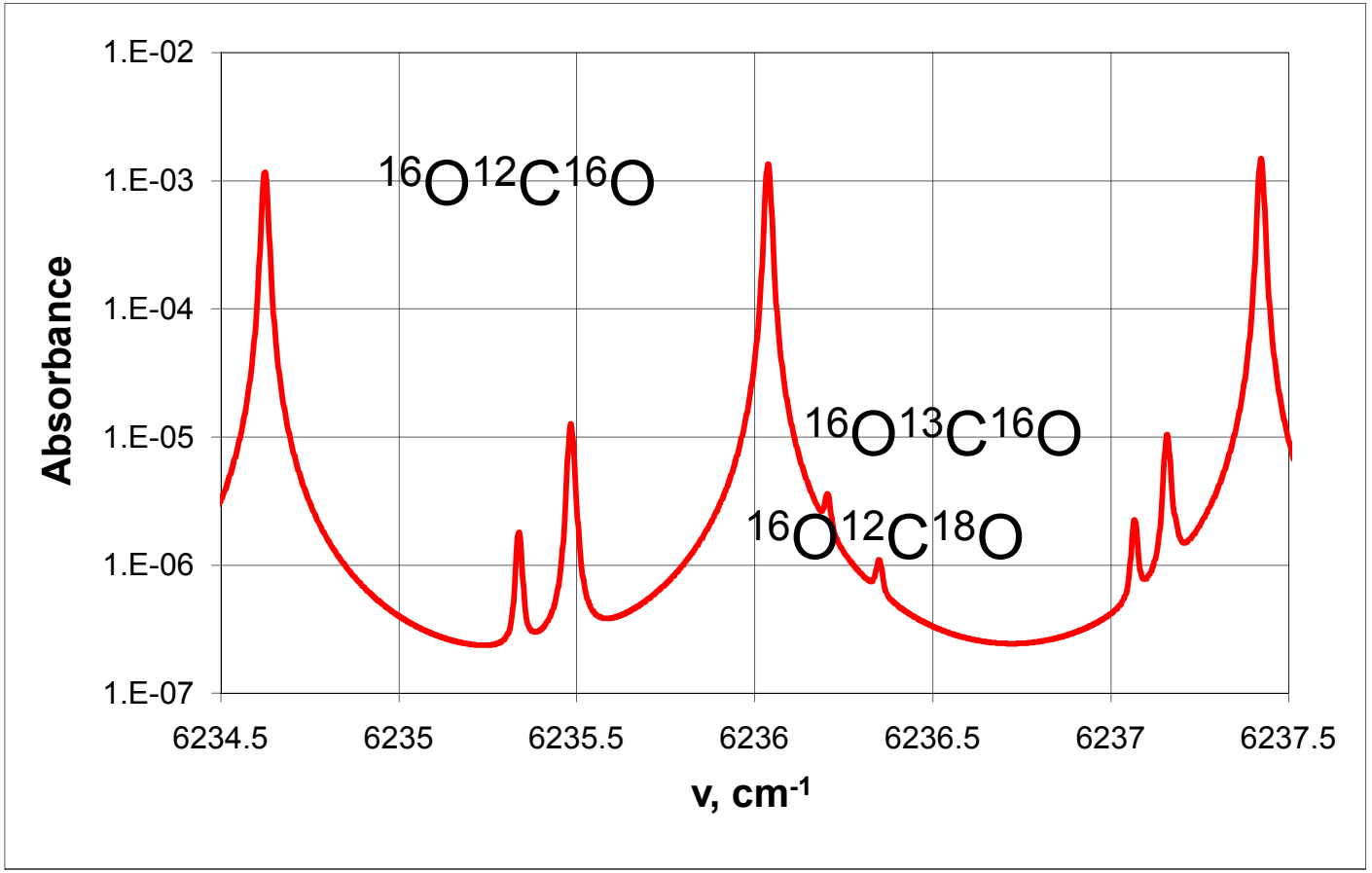
This channel is part of H_2O channel. Part of DL light by fiber splitter is directed to airplane illuminator reflected from reflector and collected by additional PD.



Absorbance of strong water line for DL in use: zero altitude, 50 % humidity, and 40 cm distance between illuminator and reflector.

30 msec time of single measurement and airplane-laboratory cruising speed - 500 km/h corresponds to atmosphere turbulence spatial resolution 4 m.

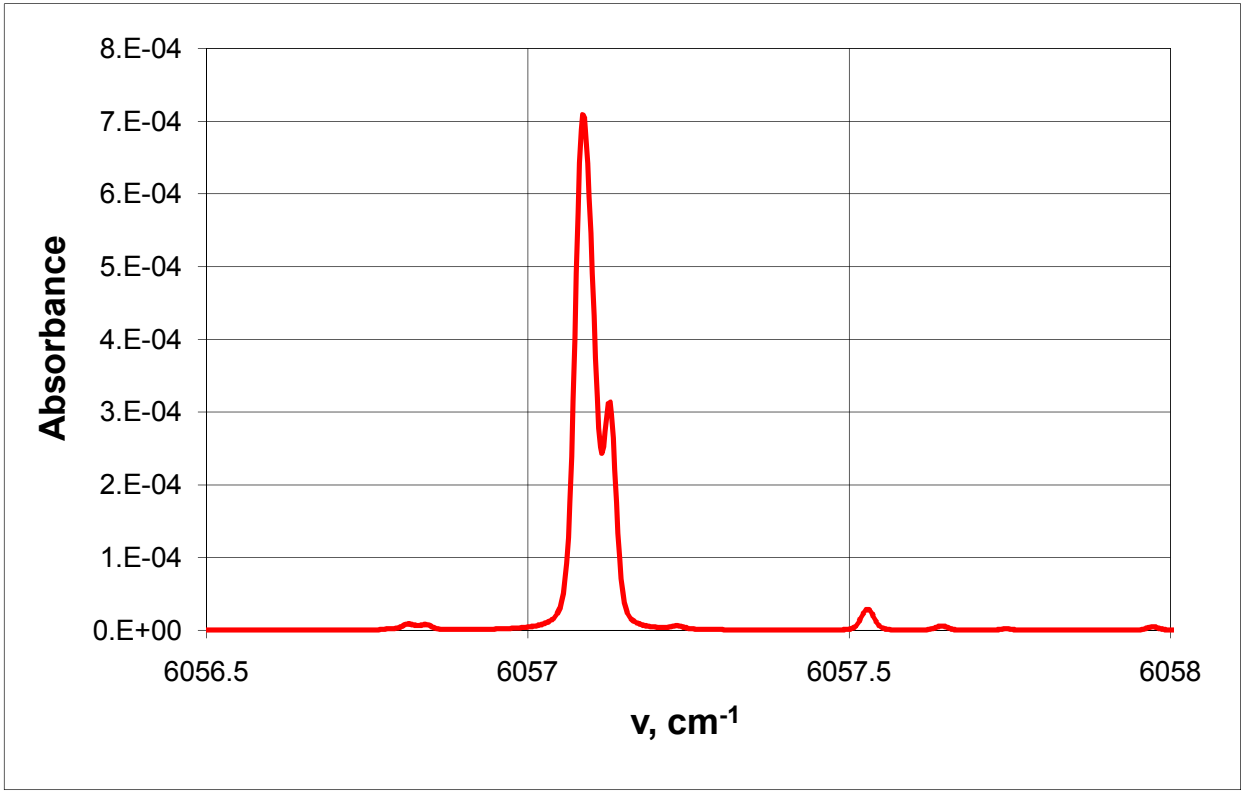
CO_2 channel



In this spectral range ^{13}C:^{12}C ratio measurement is temperature insensitive.

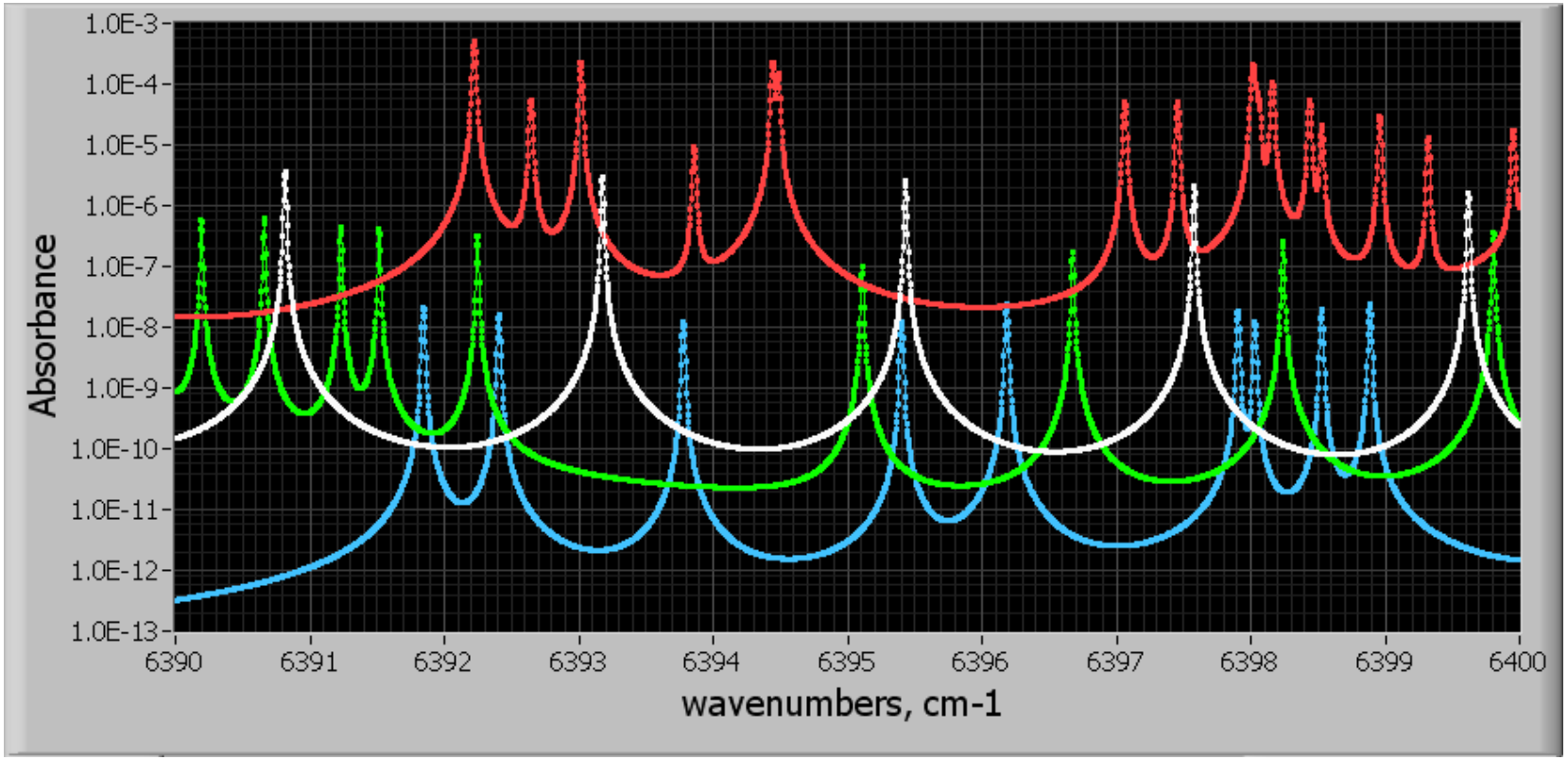
DL spectral range for CO_2 concentration (strong $^{12}C^{16}O_2$ lines), as well as isotope ratio of carbon and oxygen isotopes measurements. Parameters: zero altitude, P_0 = 40 Torr, L = 39 m, CO_2 concentration = 300 ppm, natural abundance.

CH_4 channel



DL spectral range for CH_4 concentration measurement. Strong methane line is free of interference with atmosphere water absorption. Parameters: zero altitude, P_0 = 40 Torr, L = 39 m, CH_4 concentration = 1.6 ppm.

CO channel



DL spectral range for CO concentration measurement. CO (white), H_2O (red), C_2O (green), CH_4 (blue)

Parameters: zero altitude, P_0 = 40 Torr, L = 39 m, CO – 1 ppm, H_2O – 1 %, CO_2 – 300 ppm, CH_4 - 1.6 ppm.

Electronics

Conclusion