A3

Water channel of TDLS complex for the airplane-laboratory

A.Kuzmichev[1], A.Nadezhdinskii[2], Ya.Ponurovskiy[2], D.Stavrovskii[2], I.Popov[2], I.Vyazov[2], Y.Shapovalov[2], V.Zaslavskii[2], V.Khattatov[3], V.Galaktionov[3]

[1] Moscow Institute of Physics and Technology, Dolgoprudniy, Moscow Region, Russia;
[2] A.M.Prokhorov General Physics Institute of RAS, Vavilov str. 38, 119991 Moscow, Russia
[3] Central aerological observatory, Dolgoprudniy, Moscow Region, Russia;

DLS LAB

Introduction

Russian state program to develop airplane-laboratory started some time ago. It contains TDLS complex [1] to measure H_2O, CO_2, CH_4, and CO. Time resolution of above mentioned measurements is important parameter of the complex operation. Refer to the program plan, water channel of TDLS complex has to be developed and to be installed on airplane this fall.
Goals of TDLS complex water channel: to measure humidity, isotopes abundance, and atmosphere turbulence parameters in real time during flight.
TDLS complex water channel was developed and tested subject of present paper.

[1] V.Galaktionov, V.Khattatov, A.Nadezhdinskii, Ya.Ponurovskiy, D.Stavrovskii, I.Vyazov, V.Zaslavskii, TDLS complex development for airplane-laboratory "Atmosphere", Abstracts of TDLS 2009, Zermatt, Switzerland, p.44.

Airplane - laboratory

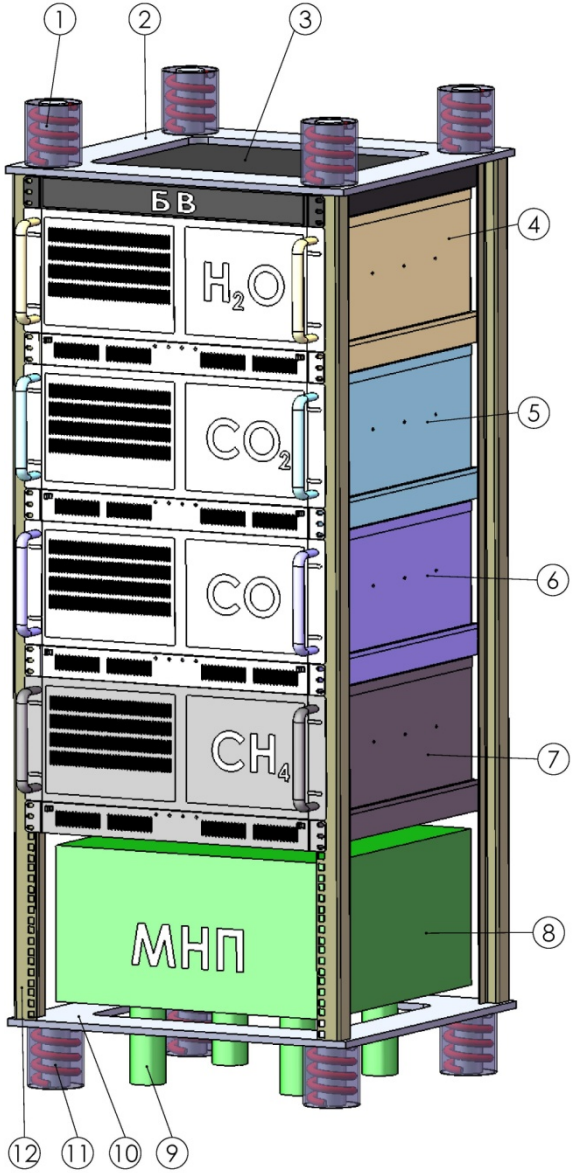
Due to Russian state program airplane-laboratory is under development.

Parameters of Jak-42d [2] airplane considered as carrier for the laboratory.

[2] http://www.aviaport.ru/directory/aviation/jak42d/

Jak-42d	
Airspeed	730 km/h
Distance	4100 km
Altitude	9.1 km

TDLS complex for airplane - laboratory



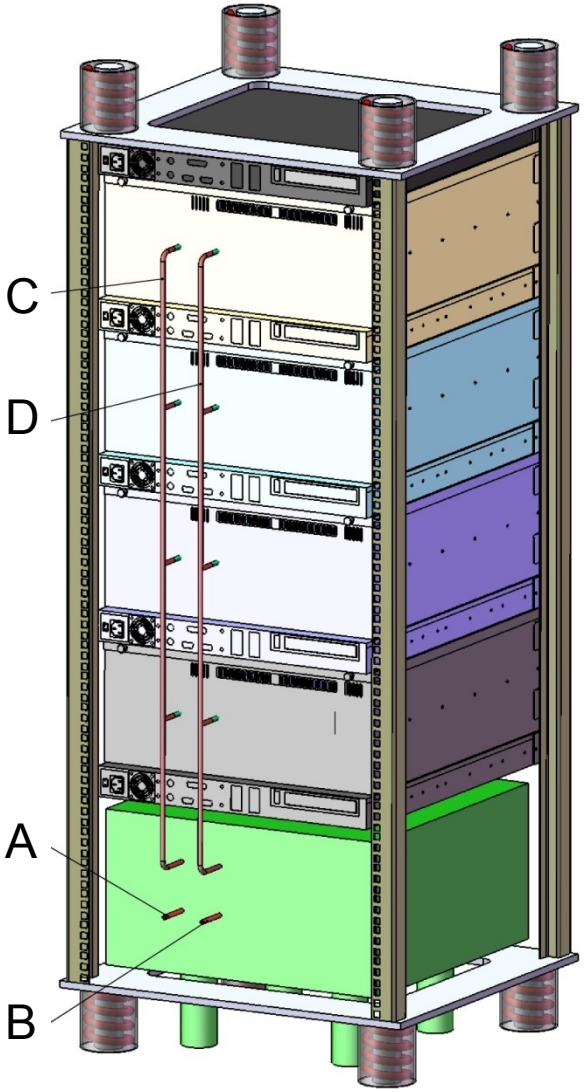
TDLS complex front view

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 vibration isolated hardware bay.

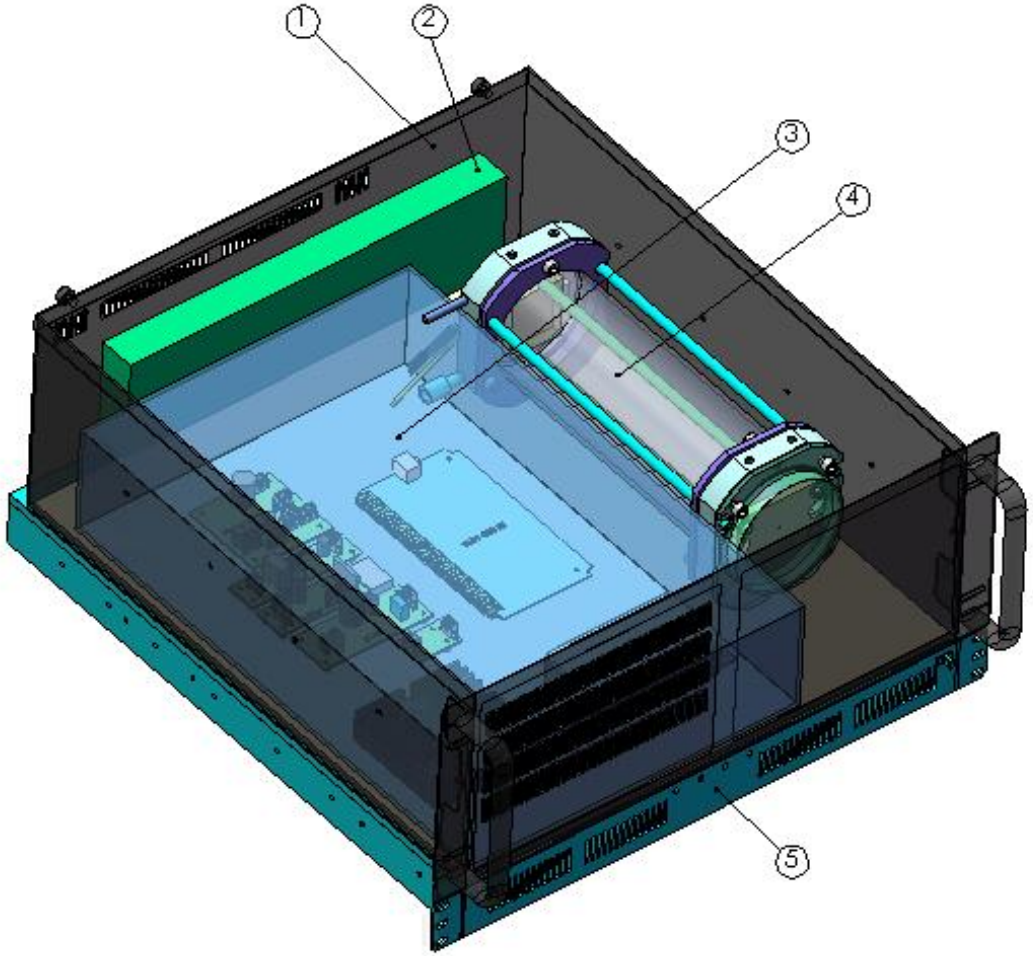
Module with pumps to provide air under investigation flow trough the system and its preparation for measurements (8).

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



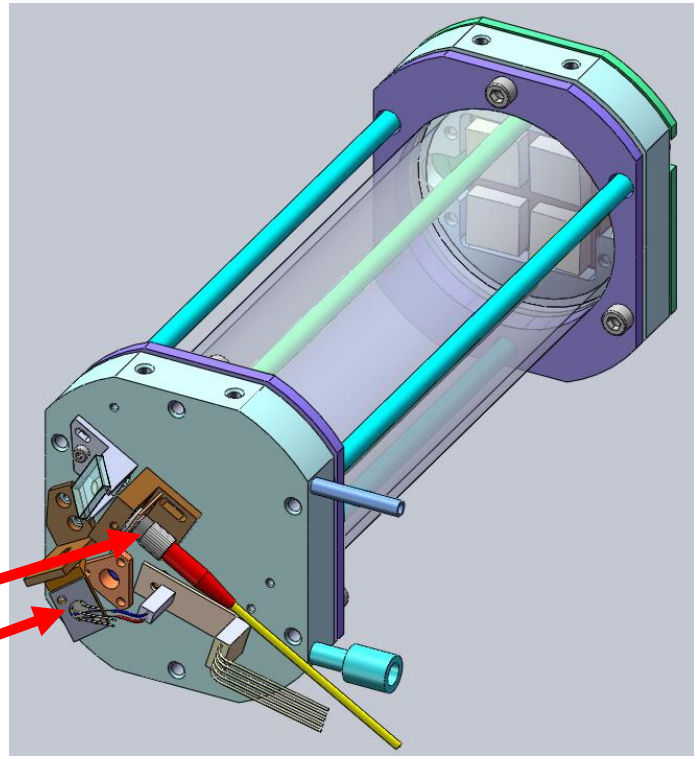
TDLS complex back view

TDLS module

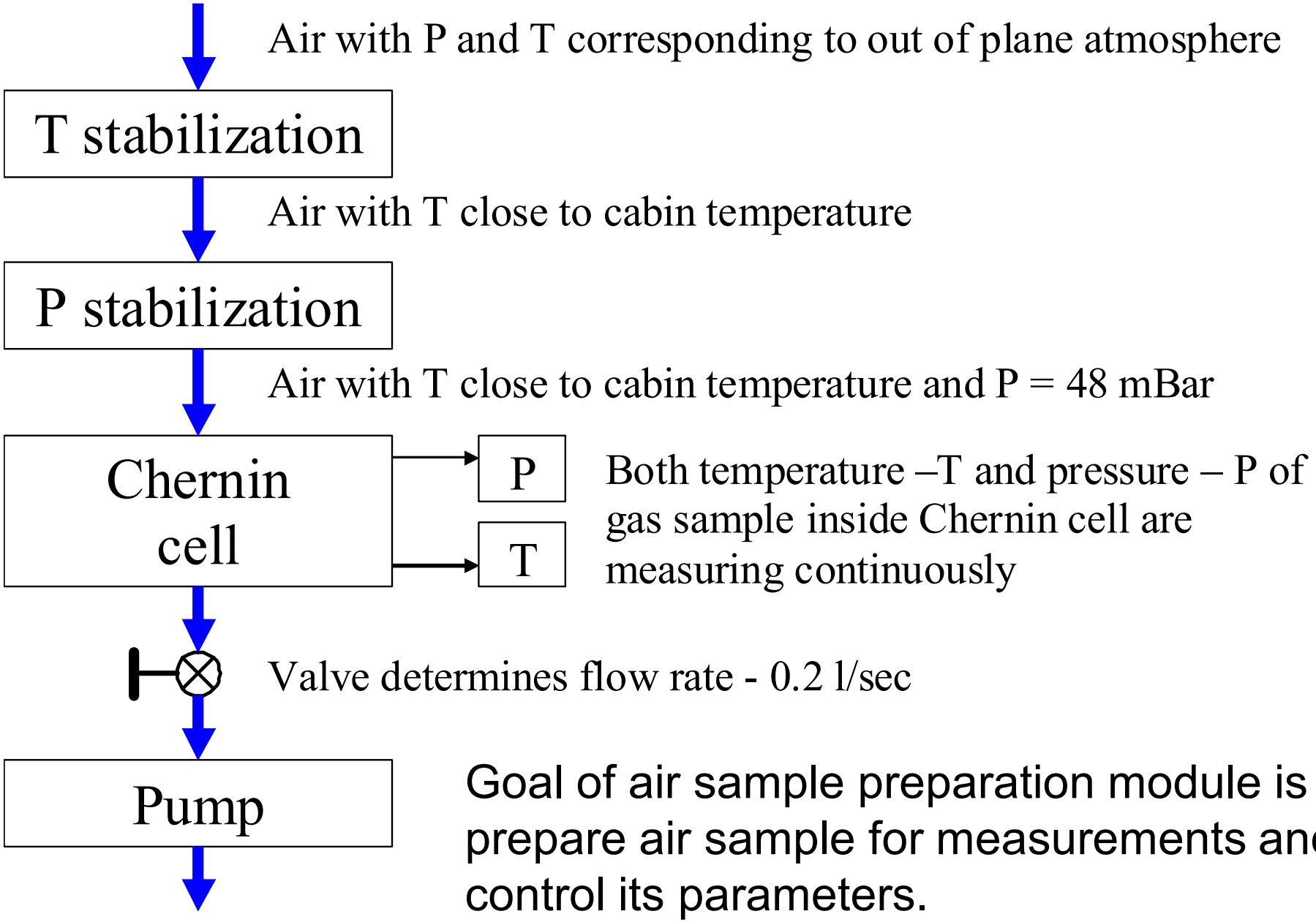


TDLS module:
1. Frame (4U)
2. Electrical and gas connectors.
3. Electronics and DL.
4. “Chernin” matrix optical system.
5. Industrial computer (1U).

“Chernin” matrix optical system.

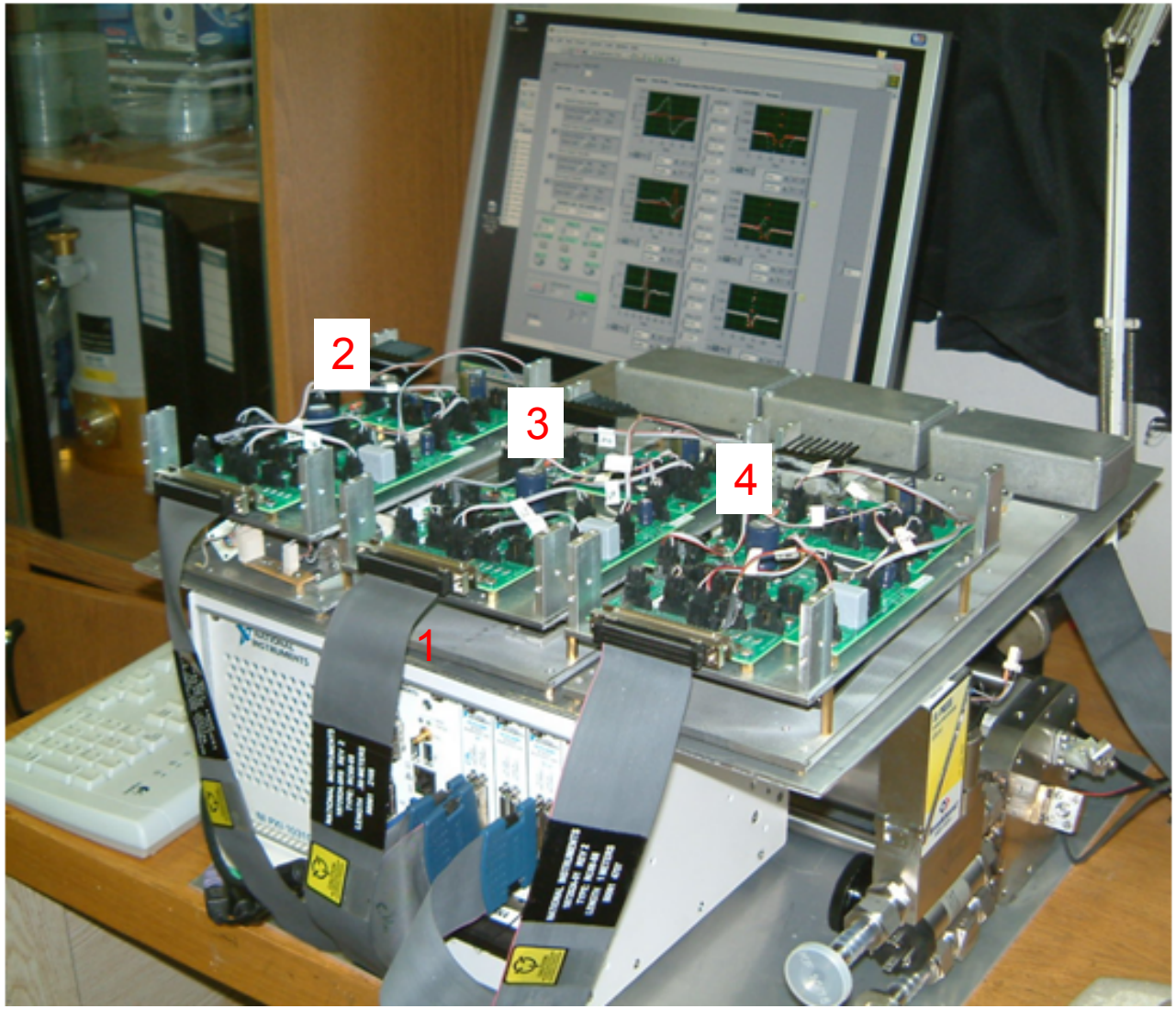


Air sample preparation module



Goal of air sample preparation module is to prepare air sample for measurements and control its parameters.

TDLS complex

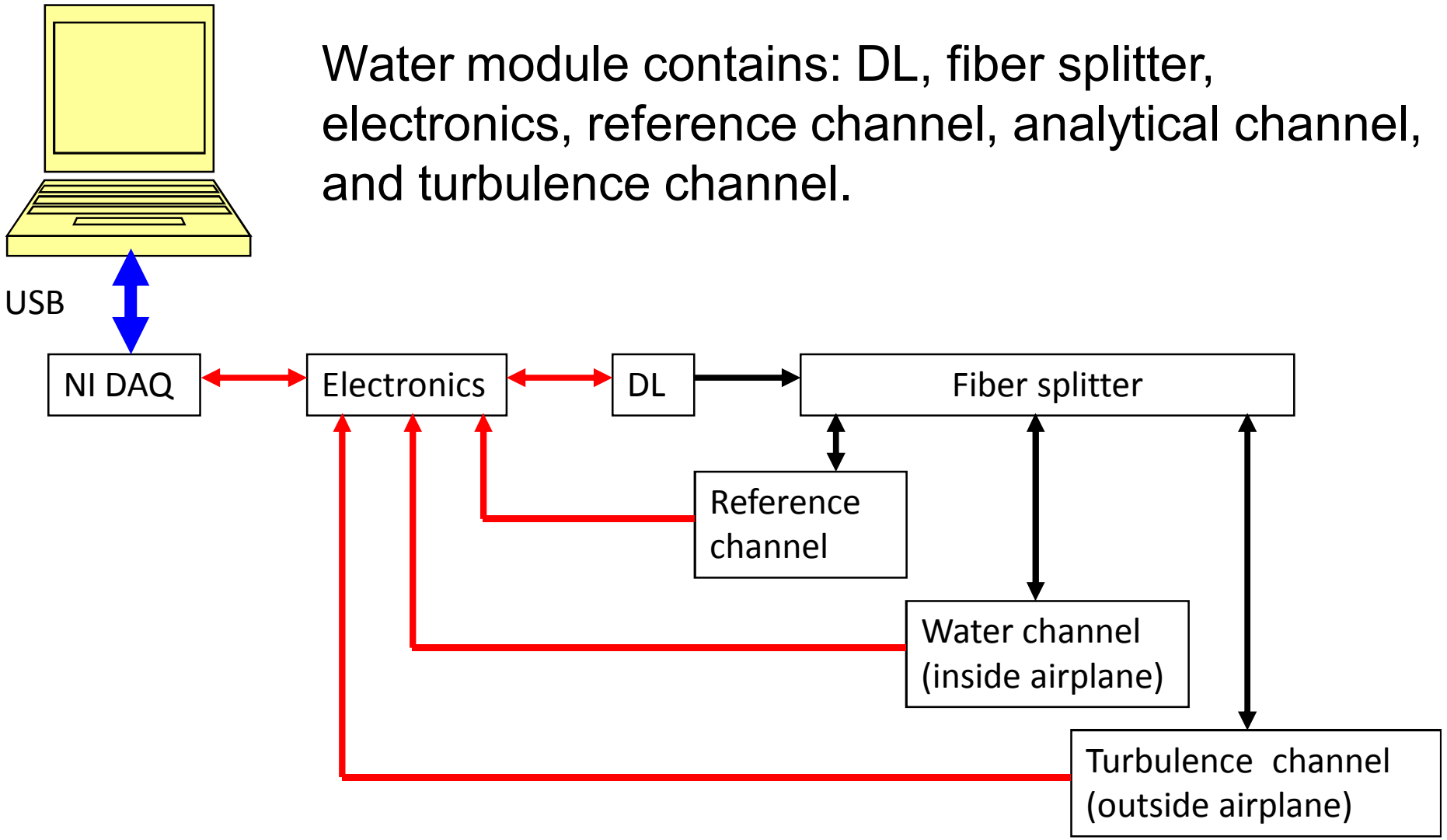


View of last version of TDLS complex for airplane laboratory prepared for lab tests.

The present complex version contains NI station (1) able to support operation of 6 DLs, and 3 channels to measure H_2O (2), CH_4 (3), and CO_2 (4). Electronics to support these channels is shown. Chernin cell, DLs, reference channels, and air sample preparation module are located under electronics.

Block scheme of water module

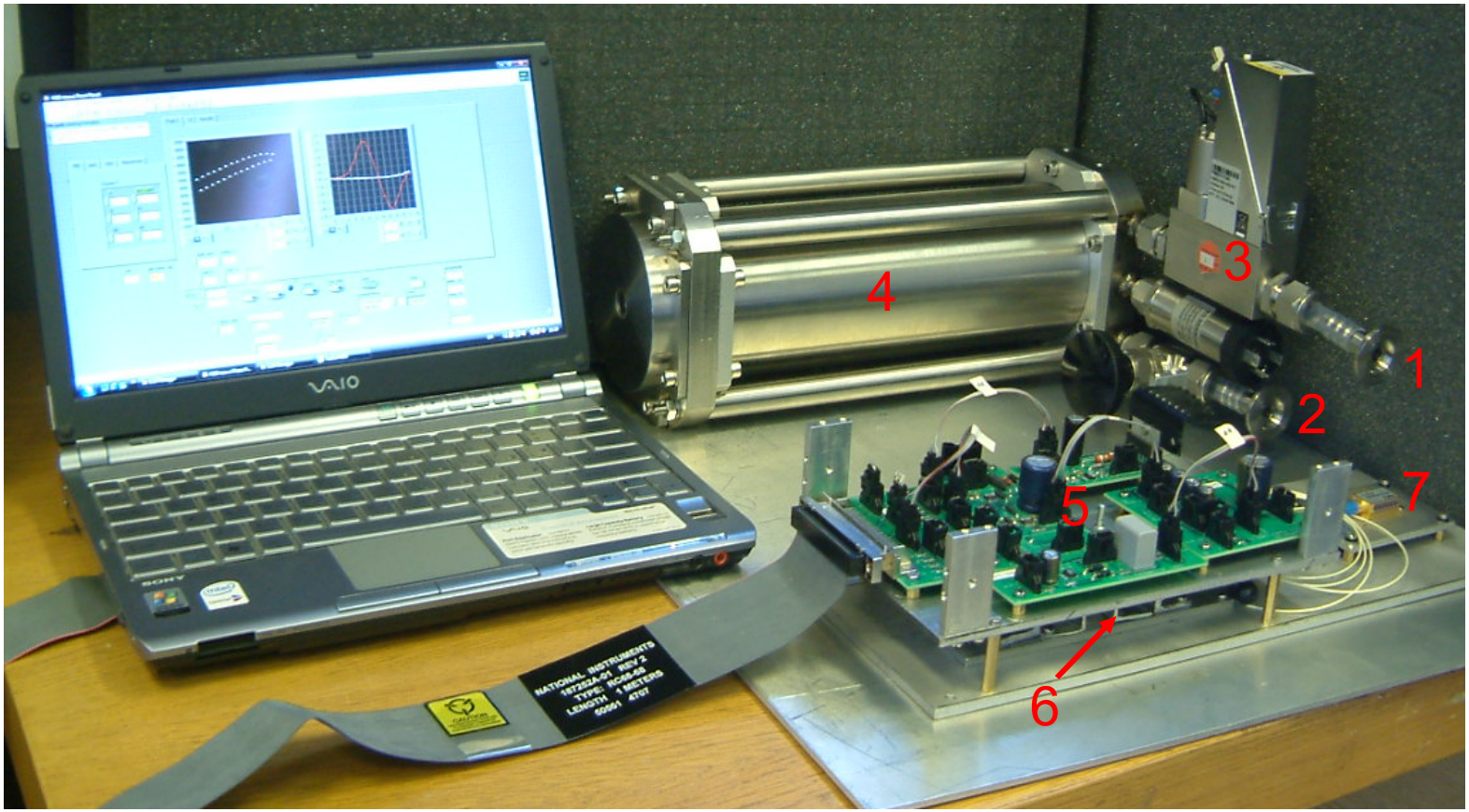
Water module contains: DL, fiber splitter, electronics, reference channel, analytical channel, and turbulence channel.



Arrows: blue – digital connection, red – analog signals, black – optical fibers.

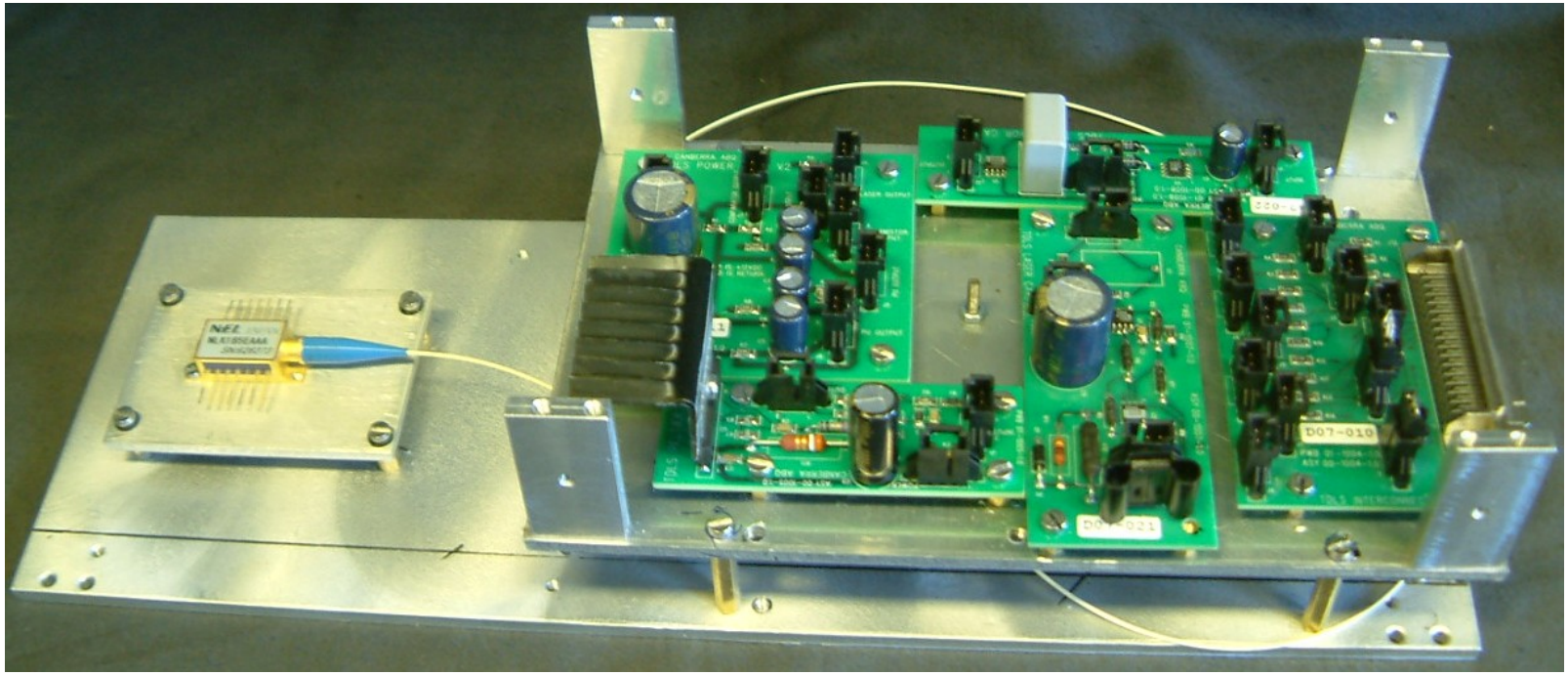
Water module view

View of TDLS complex water channel prepared for laboratory tests. Turbulence channel is not shown.



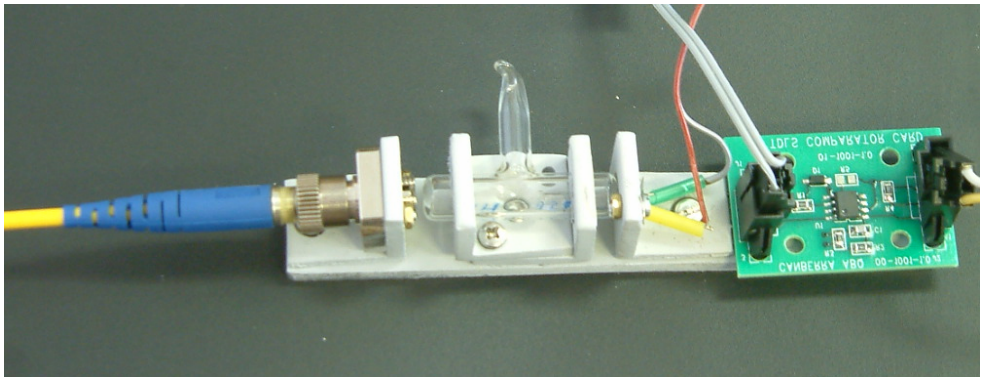
1 – air flow in after temperature stabilization, 2 – air flow out to pump, 3 – pressure stabilization, 4 - Chernin cell, 5 – electronics, 6 – reference channel, 7 – DL.

Electronics with reference channel

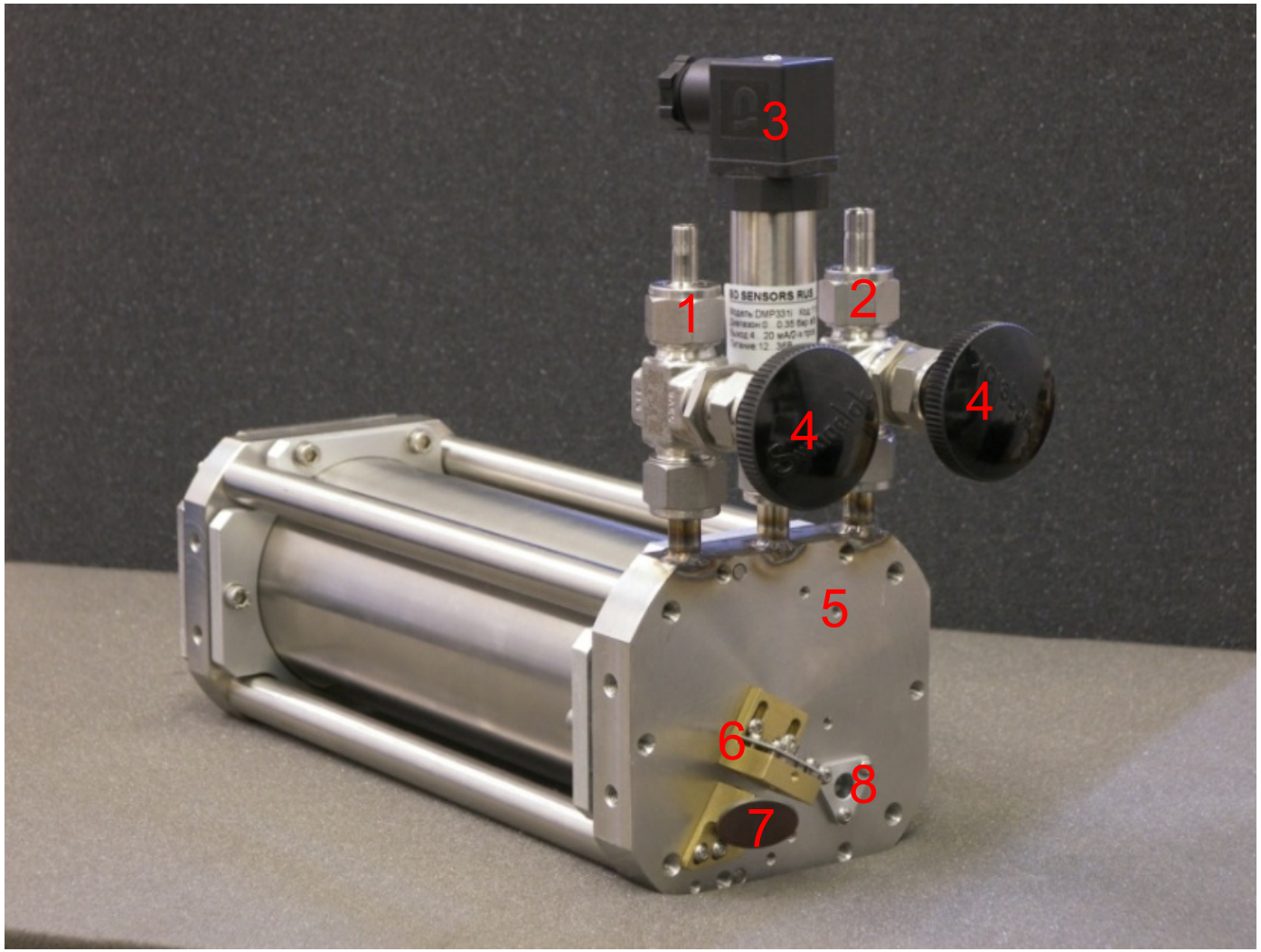


Electronics with DL and reference channel installed below electronics.

Reference channel view.



Chernin cell for analytical channel



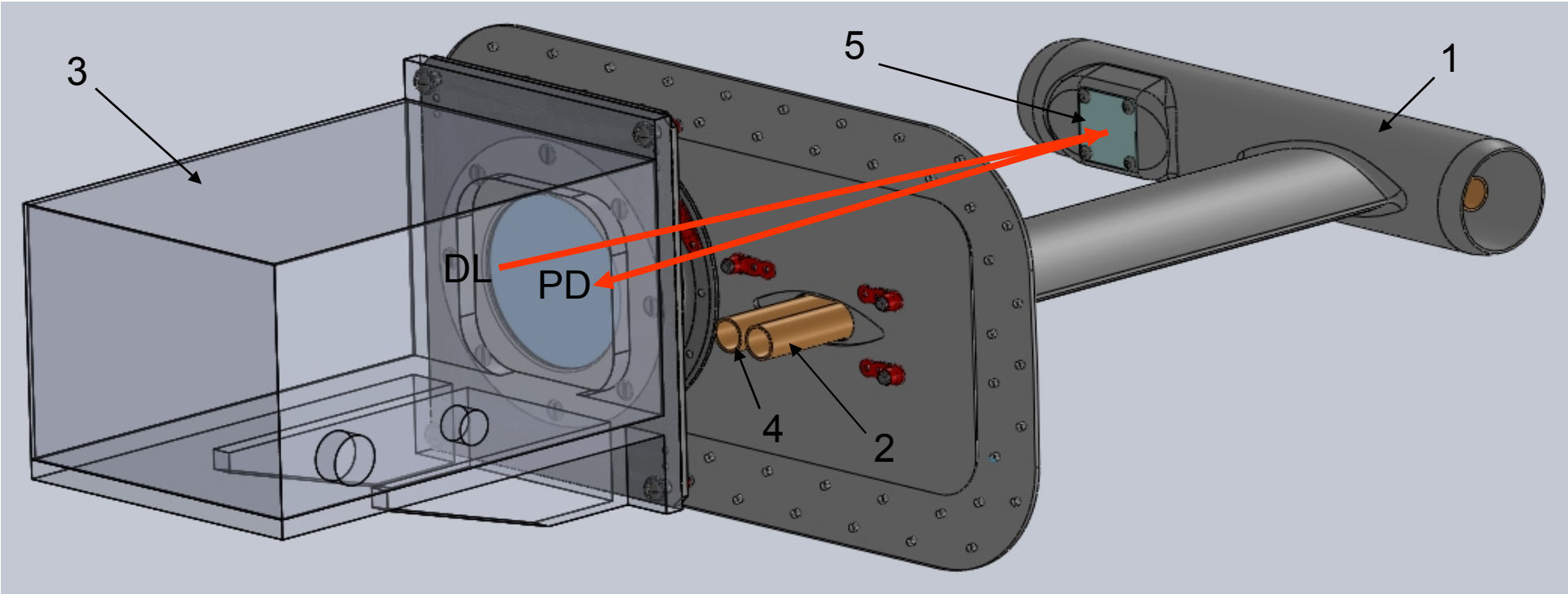
Distance between mirrors – 25 cm.

Number of passes N = 156.

Effective optical length L = 39 m.

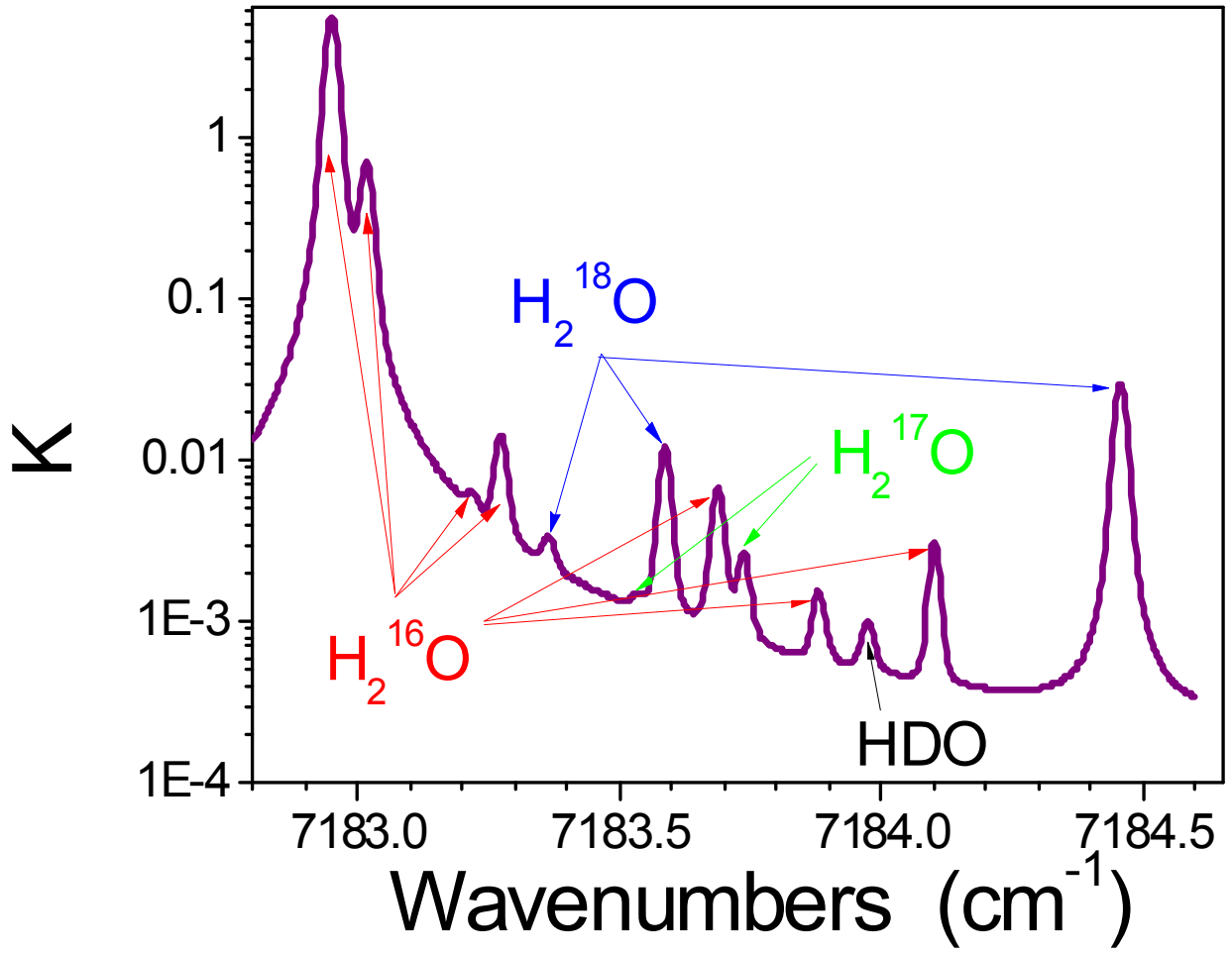
1 – air flow in, 2 – air flow out, 3 – pressure sensor, 4 – valves, 5 - temperature sensor, 6 – fiber connector with collimator, 7 – DL in, 8 – DL out.

Design of turbulence channel



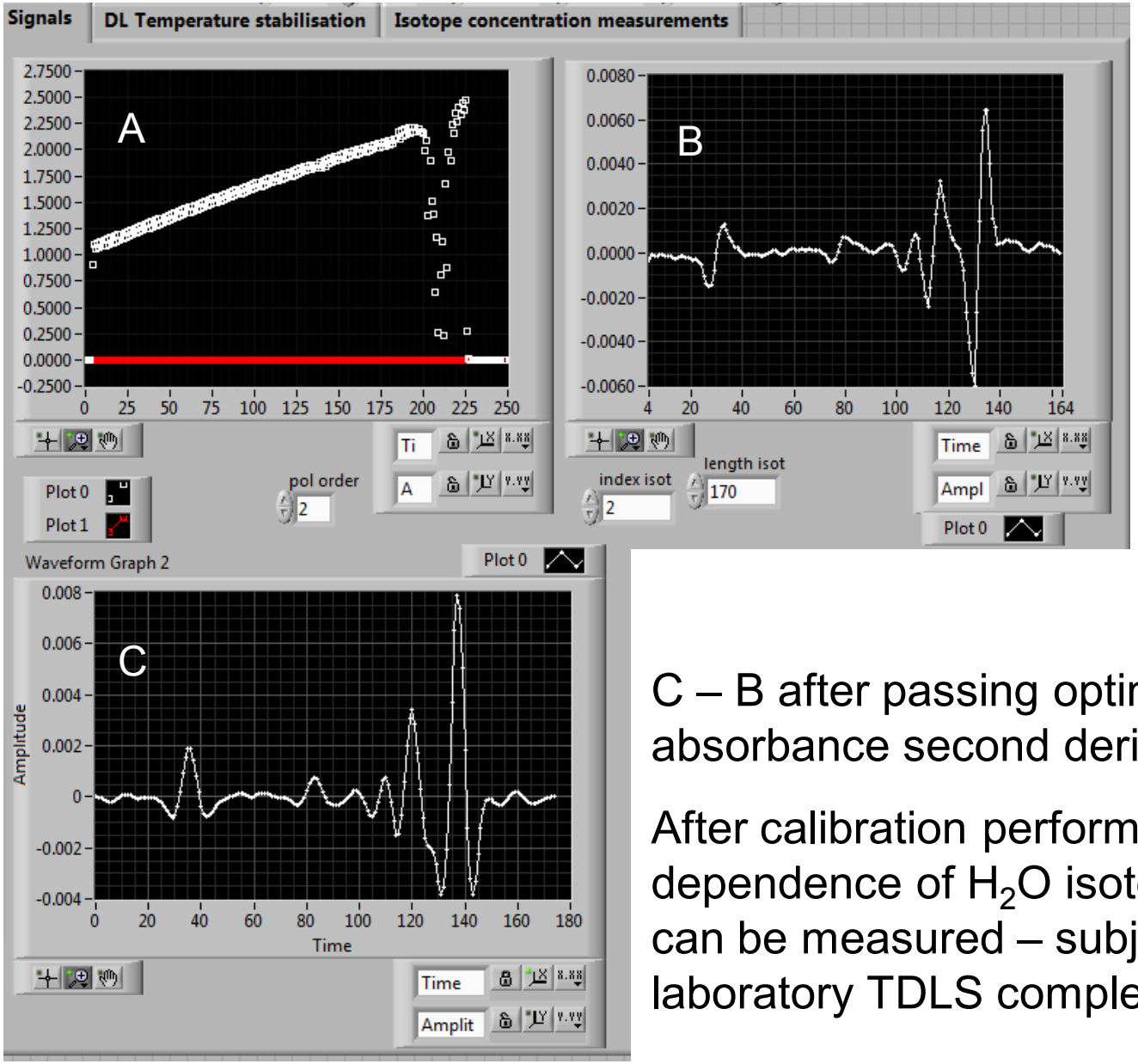
Part of DL radiation is directed to turbulence channel. Turbulence channel contains part located in box 3. Fiber output (DL) is located close to illuminator (4). DL radiation is reflected by mirror (5) and detected by PD located close to illuminator. Details can be found in B3.
1, 2, 4 belongs to TDLS complex air receiving module.

Spectral range of water channel DL



Model water vapor spectrum and lines identification (see C3).
Parameters: L = 40 m, P = 100 mBar, natural abundance.

H_2O channel interface

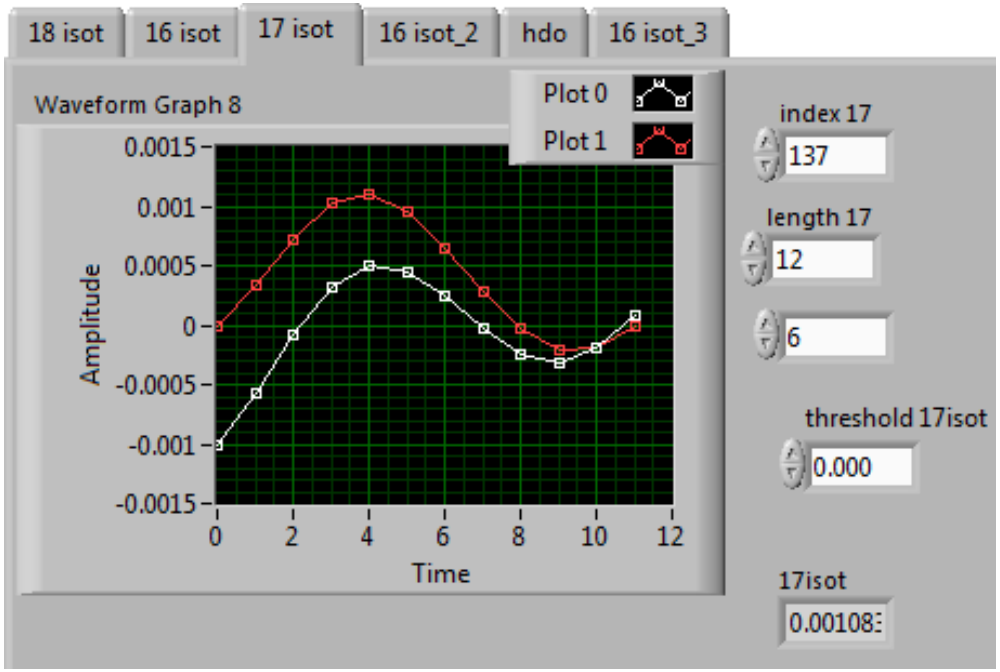


DL is excited by special excitation current pulse with modulation to measure both strong and weak lines.
A – recorded signal.
B - signal after passing Odd-Even program module looks like absorbance first derivative.

C – B after passing optimal filter looks like absorbance second derivative.

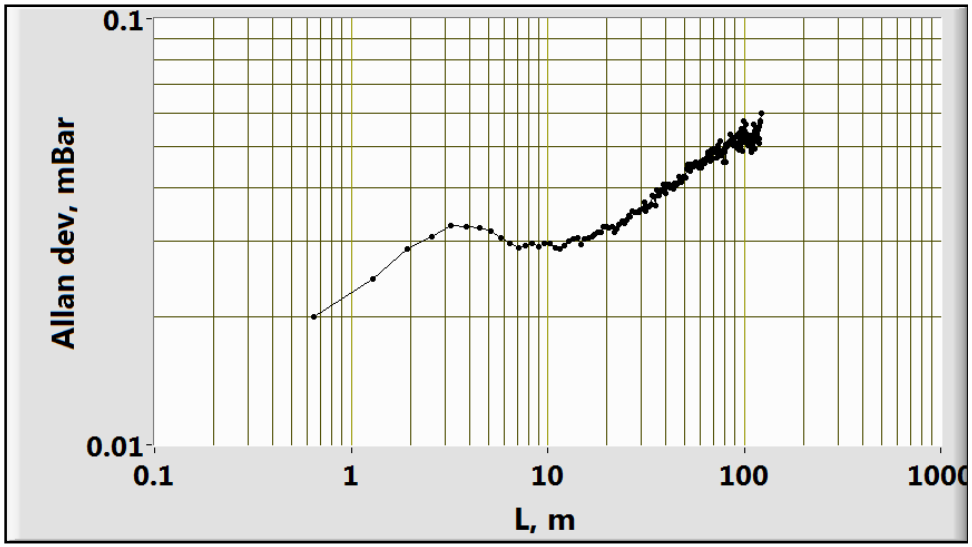
After calibration performed (see C2) time dependence of H_2O isotopomers concentration can be measured – subject of airplane laboratory TDLS complex water channel.

TDLS complex H_2O channel operation



Interface example when $H_2{}^{17}O$ concentration is measuring.

Atmosphere turbulence measurement using TDLS complex H_2O channel (for details see B3).



Conclusions

1. ***H_2O channel for airplane-laboratory was developed.***
2. ***Analytical spectral range for H_2O channel was selected.***
3. ***Analytical lines parameters were investigated and calibrated.***
4. ***Algorithms and software to measure concentration of water molecule isotopomers was developed.***
5. ***Lab tests were performed.***