# DIODE LASER BASED SYSTEM WITH TOPOGRAPHIC REFLECTOR FOR TRACE MOLECULES REMOTE MONITORING

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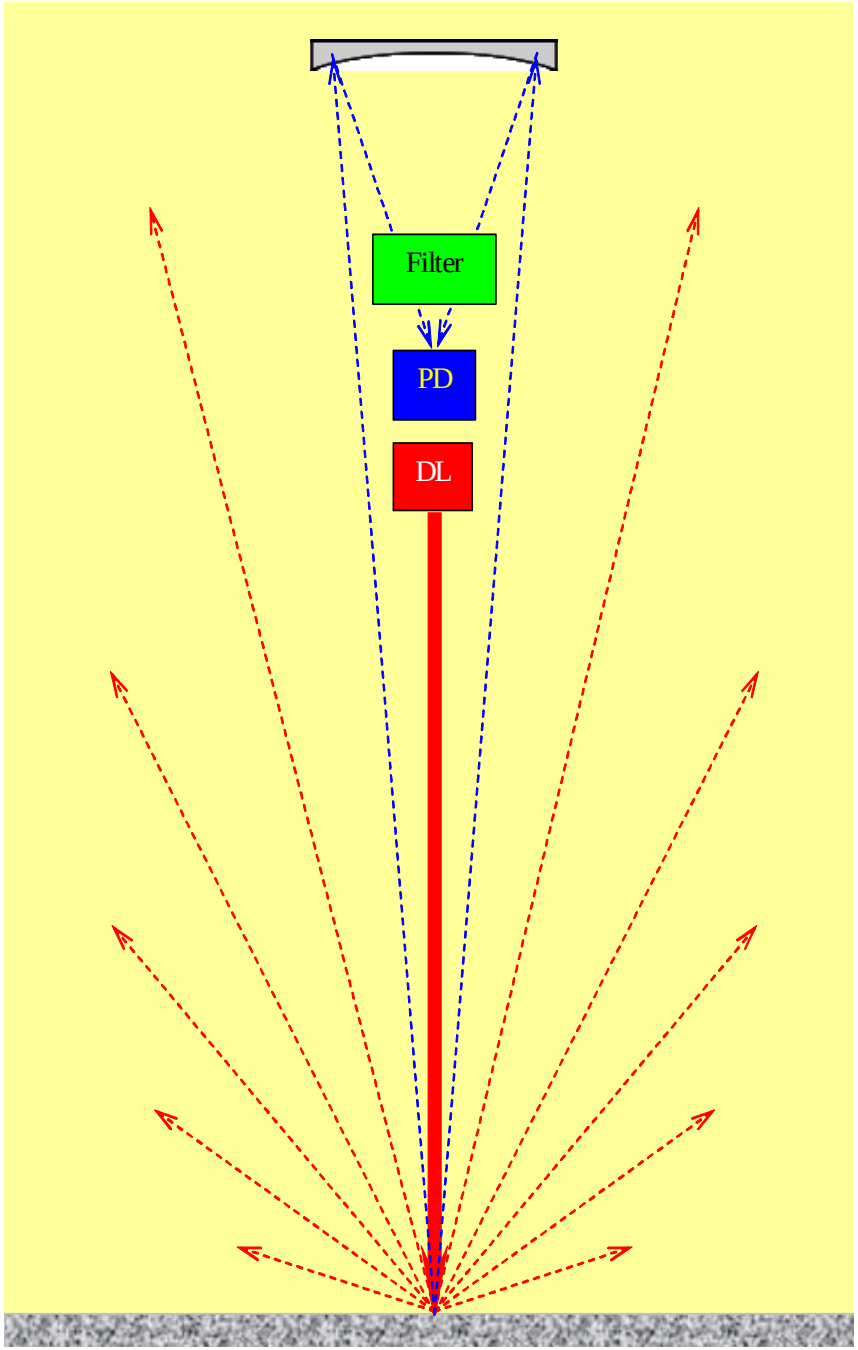
# Abstract

Trace molecules remote sensing using diode laser based systems with topography reflector is very attractive for different applications. Recently several groups reported about development of ground based systems [1-3]. However, a lot of applications needs helicopter or airplane based instruments. Main problem in this case is related to minimum allowed altitude of their flights (more than 80 m). Up to our knowledge, the first successful demonstration of such system was reported in our paper [4]. Results of the system testing was partially presented in [5].

In present paper we'll present new instrument developed. This instrument has higher sensitivity and can be efficiently used at higher flight altitudes (up to 600 m). Results of its tests are presented also. Future perspectives for high altitude airplanes and satellites are considered.

1 T.Iseki; H.Tai, K.Kimura, Meas.Sci.Technol. **11**, 594-602 (2000).
2 A.Berezin, O.Ershov, A.Nadezhdinskii, Appl.Phys., B 75, 203-214 (2002)
3 R.Wainner, B.Green, M.Allen, M.White, J.Stafford-Evans, R.Naper, Appl.Phys., B 75, 249-254 (2002)
4 A.Berezin, O.Ershov, A.Nadezhdinskii, S.Rudov, D.Stavrovskii, T.Shubenkina, in TDLS 2003, Abstracts of papers, Zermatt, 2003, p.86.
5. A.Berezin, O.Ershov, A.Nadezhdinskii, Appl.Phys., B75, 203-214 (2002)




# Operation of DL based system with topography reflector

1. Objects
2. Selectivity
3. Sensitivity
4. Reliability

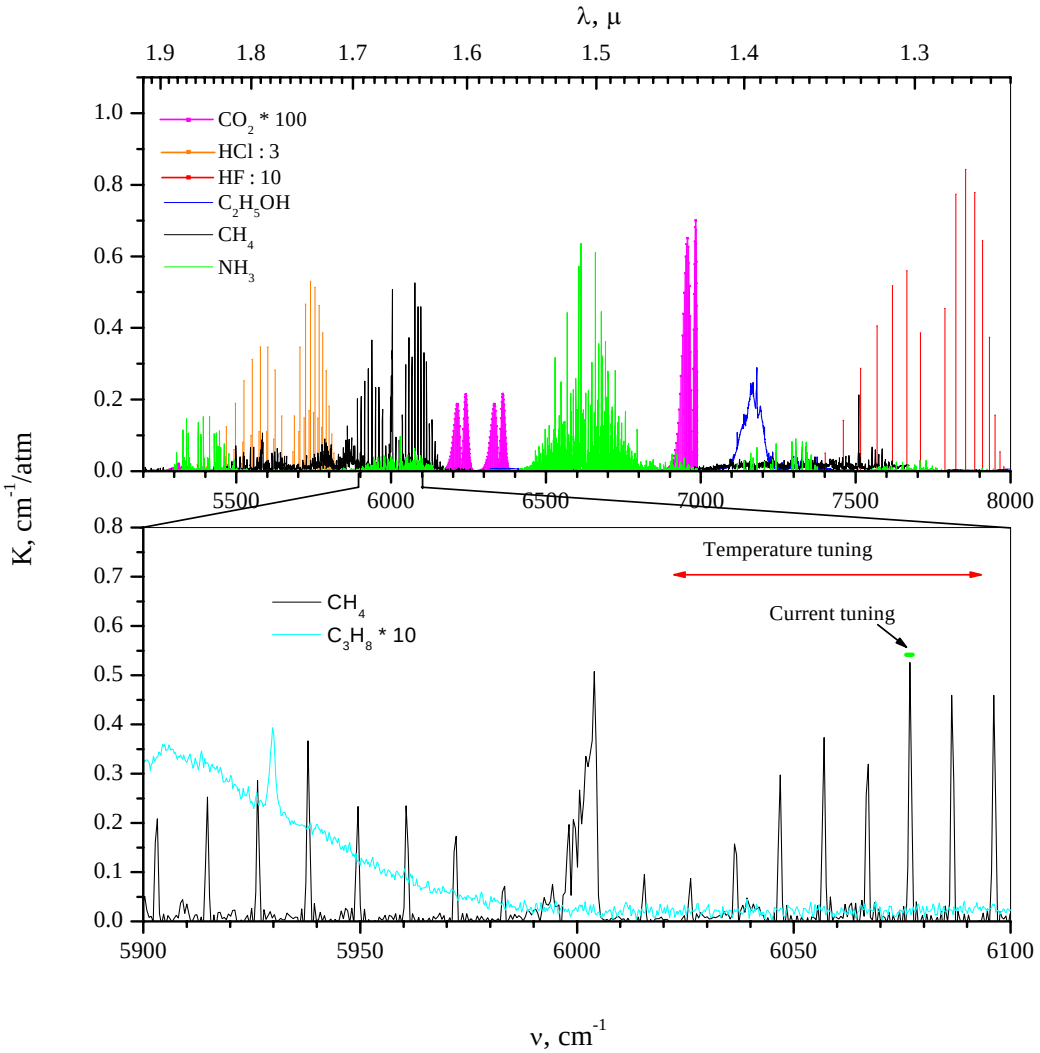
The system components determining its operation

- Emitter (output power of DL+amplifier)

- Receiving optics (Receiving mirror diameter)

- Registration system (photo detector, filter, electronics)

# Diode Lasers and Molecular Spectra in Near IR Spectral Range



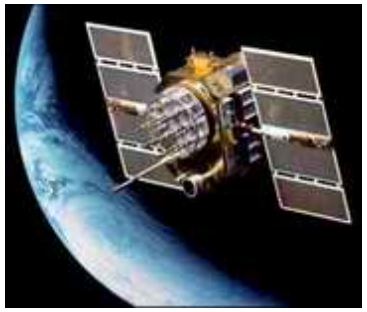

## Objects:

Practically all molecules have absorption bands between 1 and 2 μ. Located in this spectral range molecular bands are representative for C-H, O-H, N-H, etc. bonds. Moreover, this spectral range is eye-safety.

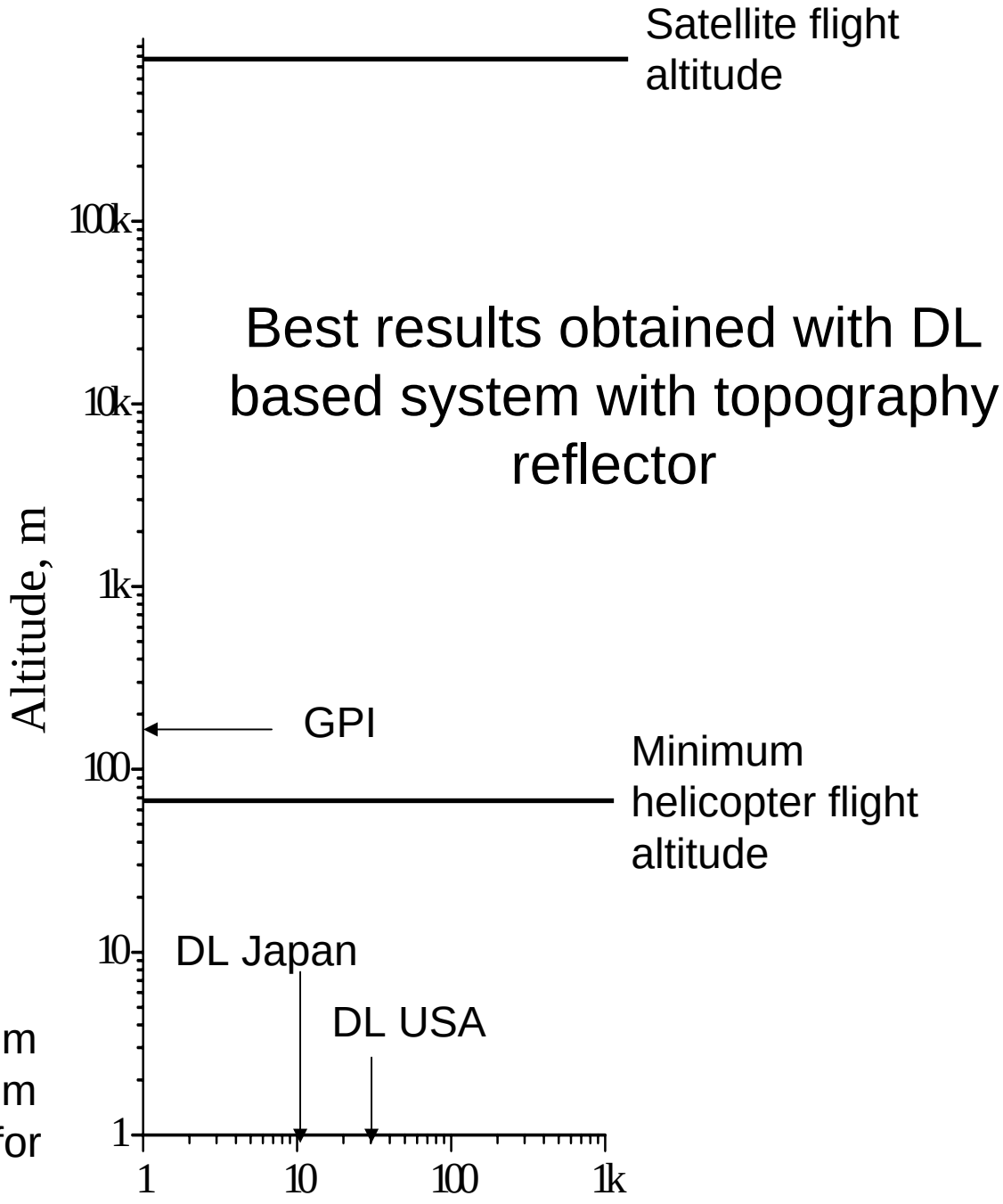
In present paper we'll considerer trace methane detection.

## Selectivity:

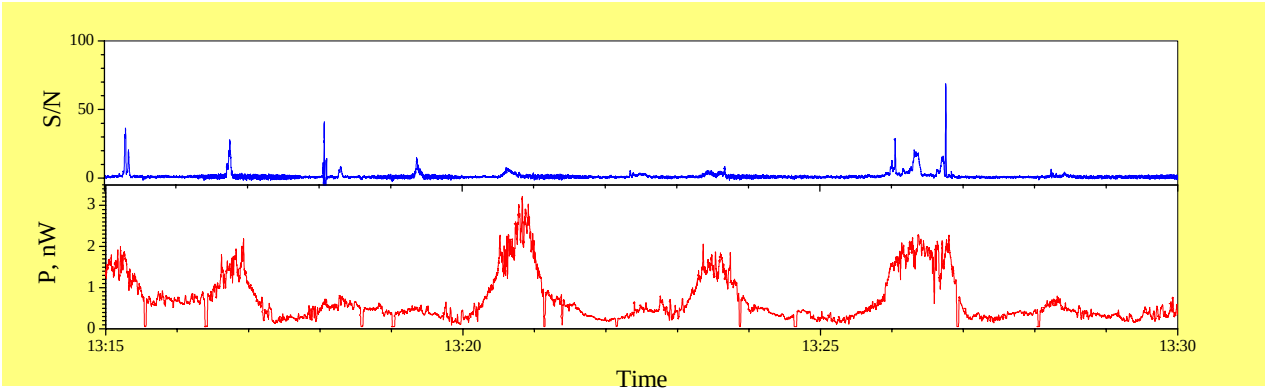
Methane and propane spectra in area of C-H bond near 1.65 μ. In experiment selectivity more than 10000 was demonstrated.




A lot of applications needs helicopter, airplane or satellite based instruments. Main problem in this case is related to minimum allowed altitude of their flights (for helicopter more than 80 m).



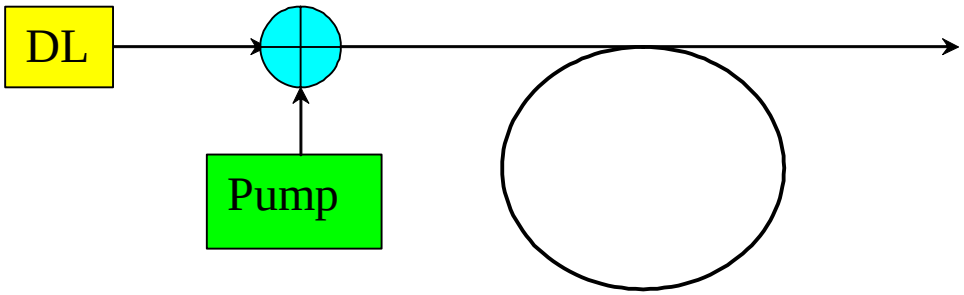
# Helicopter based Instrument

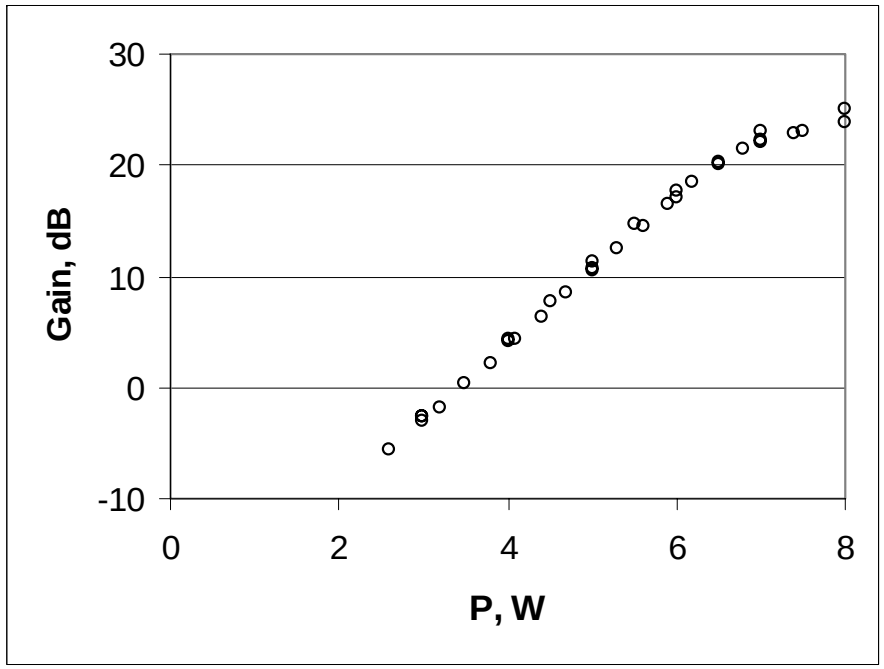

Measurement campaign
Sept-Nov. 2002
Torzhok, Krasnodar
May-July 2003
Ekatirenburg Russia

- Fragment of methane leakage detection from gas line using helicopter based instrument (blue)
- Variations in received laser light scatted from ground (red) are due to changes of helicopter altitude and surface reflectance.
- River crossing caused zero values of recorded laser light

# Emitter System Modernization




25 km single mode fiber

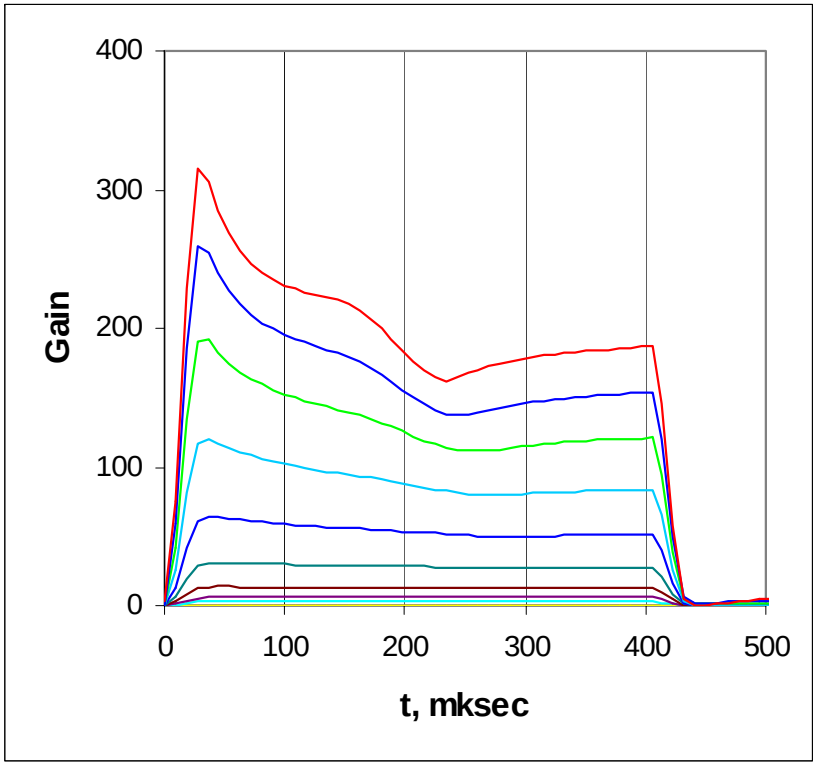



The instrument was modified by adding Raman fiber amplifier with 25 dB gain:

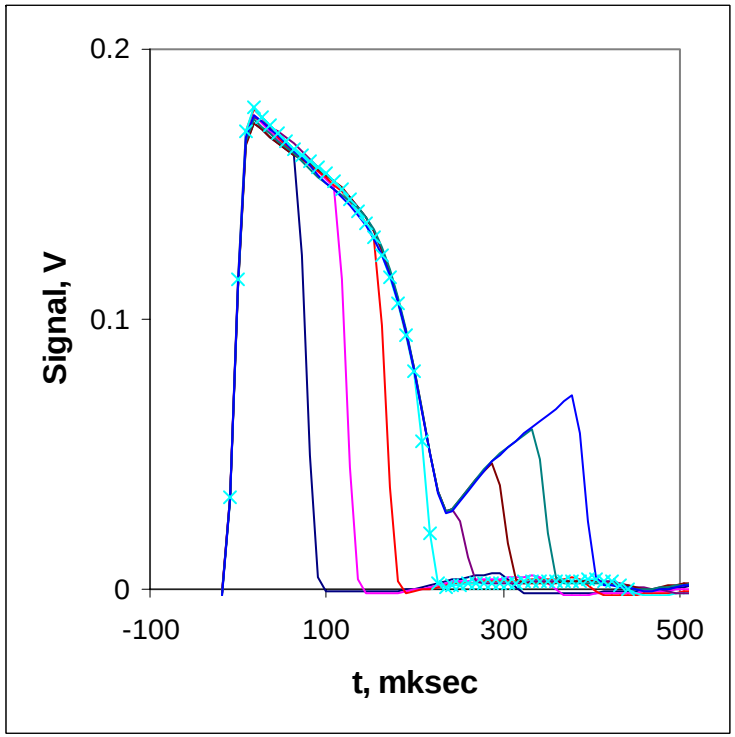
*A.G.Berezin, O.N.Egorova*, O.V.Ershov, A.S.Kurkov*, A.I.Nadezhdinskii, V.M.Paramonov*, **RAMAN FIBER AMPLIFIER AT 1.65 um FOR REMOTE SENSING APPLICATION, in TDLS 2003, Abstracts of papers, Zermatt, 2003, p.79**

Raman amplifier gain as function of pump power P.

# Amplifier operation

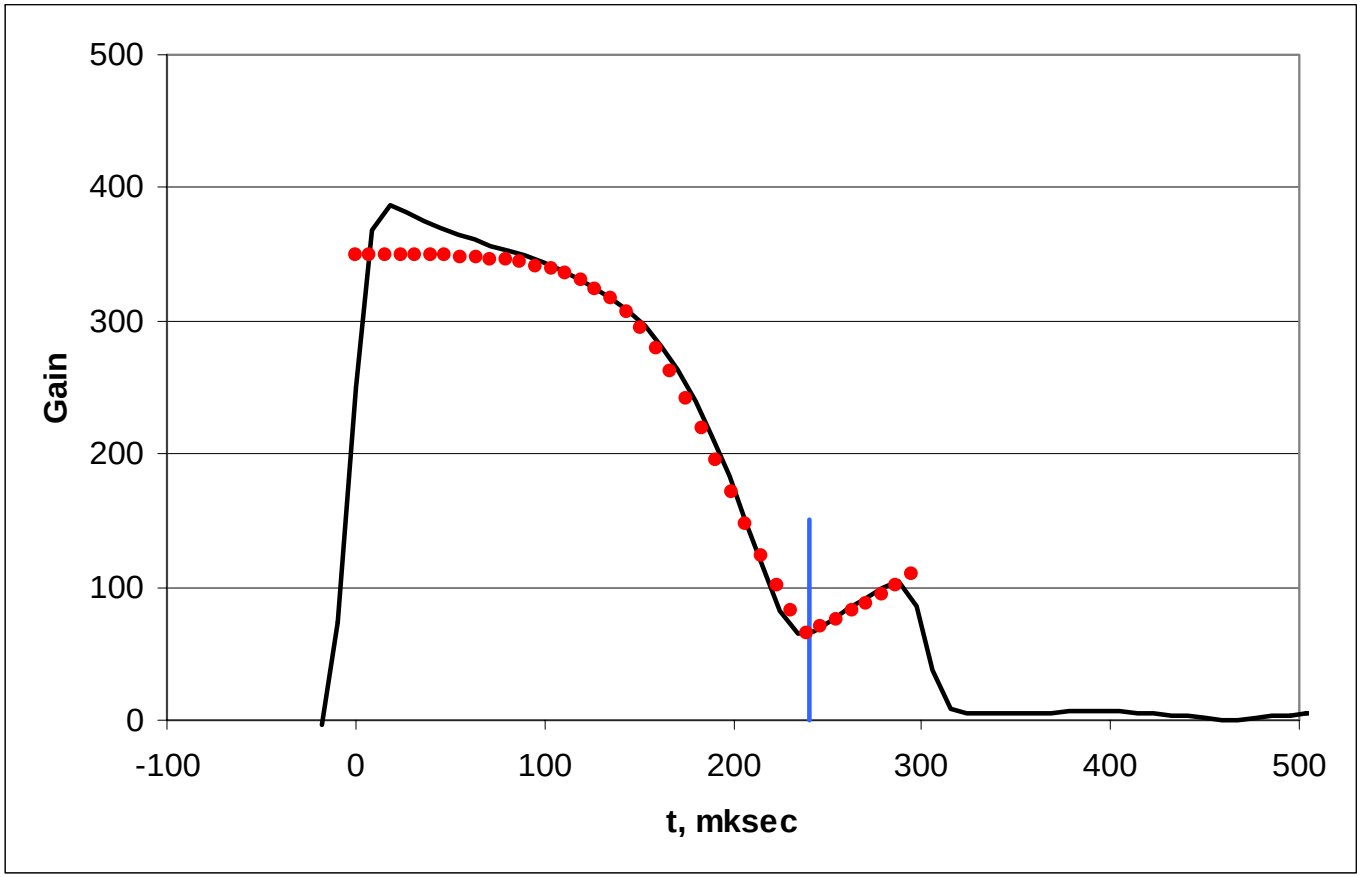



Raman amplifier gain shape for rectangular seeded DL pulse for different pump powers (0, 3, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8 W)




Recorded signal shape of amplified DL rectangular pulses of different duration; Raman amplifier was close to generation

# Raman Amplifier Operation Analysis




Raman amplifier gain shape for rectangular seeded DL pulse (Raman amplifier was close to generation) (black line). Model calculation taking into account gain suppression due to reflected laser intensity (red cycles). Blue vertical line corresponds to light travel time in 25 km fiber. Based on this modeling, reflectivity of both Raman amplifier facets was determined

# Receiving System Modernization

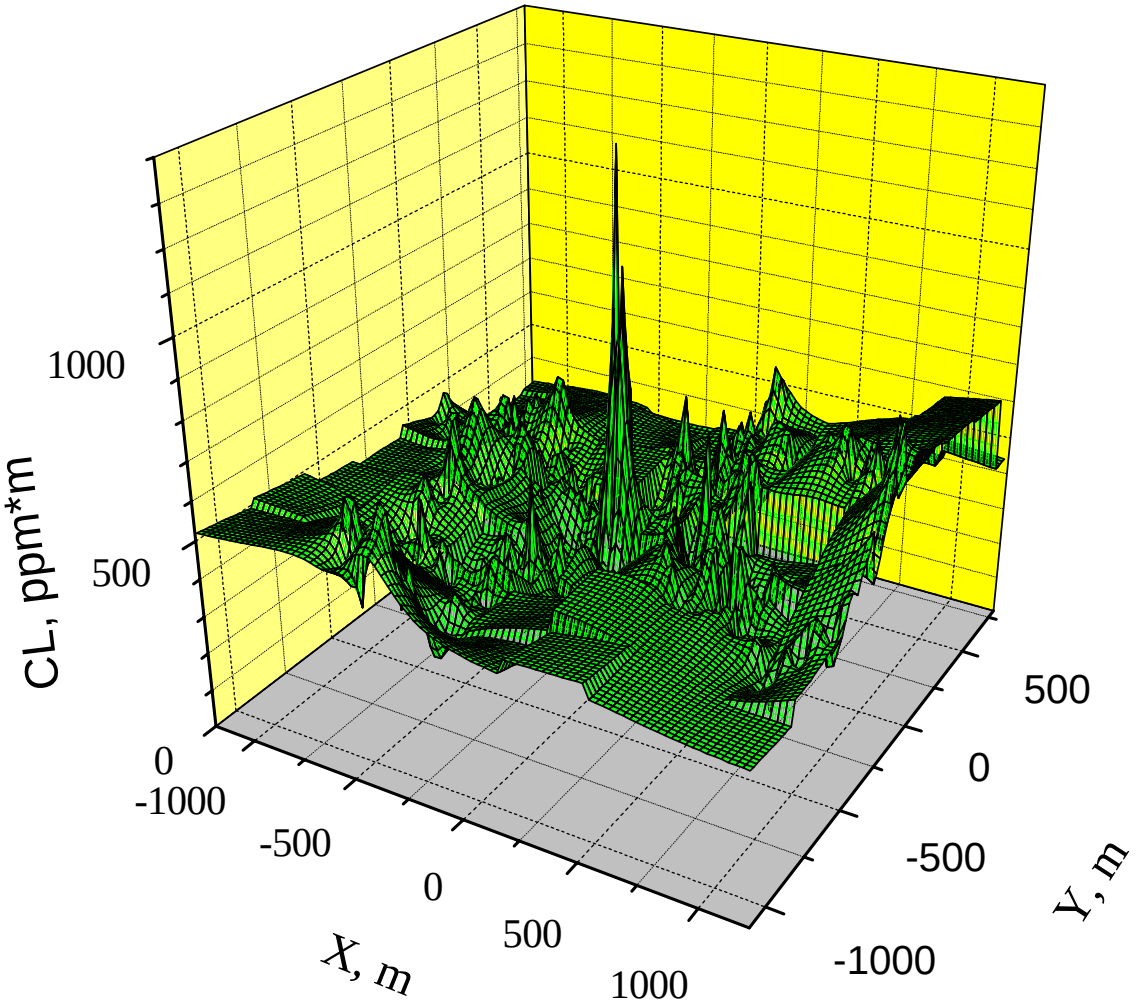

New instrument generation view

In previous instrument version its sensitivity was limited by shot noise of received Sun scattered light. Now this problem is solved. Receiving system is characterized by $D^*=2.6\ 10^{12}$ cm $\sqrt{Hz}/W$ $NEP = 1.04\ 10^{-13}$ $W/\sqrt{Hz}$.

Due to Raman amplifier usage emitted power was increased significantly and enable us to reduce receiving mirror diameter and increase flight altitude.

Now test flights on helicopters and airplanes are in preparation.

# Test Flight



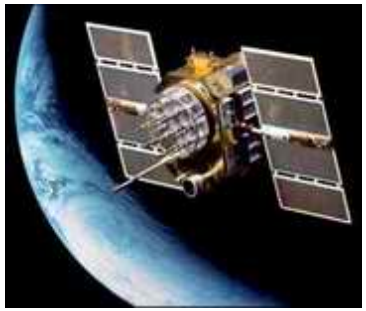

Example of test flight data,
helicopter flight altitude - 140 m

Instrument was equipped with GPS.

Detection of methane leakage from low pressure line.

After leakage detection helicopter made several loops in area under interest.

# Future



| Po, W | 150 |
|---|---|
| D, cm | 100 |

| Po, W | 0.5 |
|---|---|
| D, cm | 40 |

| Po, W | 0.02 |
|---|---|
| D, cm | 12 |

Satellite flight altitude

Minimum helicopter flight altitude