AIR POLLUTION ANALYSIS, IN THE WESTERN ROMANIA AND THE NECESSITY OF COMPLEMENTARY VERTICAL RESOLVED LIDAR OBSERBATION

Ioana Ionel[1], Francisc Popescu[1], Vetres Ion[1], Nicolae Doina[2], Talianu Camelia[2]
Luisa-Izabel Dungan[1]

1 "Politehnica" University of Timisoara, Faculty of Mechanical Engineering, Timisoara,

2 National Institute of Research & Development for Optoelectronics, INOE Romania

INTRODUCTION

Atmospheric research nowadays is hard to conceive without the use of remote-sensing techniques. Light detection and ranging (lidar) is, along with radiowave detection and ranging (radar), one of the backbones of the research field that deals with the profiling of the atmosphere.

Lidar has largely contributed to our knowledge of the Earth’s atmosphere during the past decades. Lidar helps monitor emission rates and concentration levels of trace gases. The stratospheric ozone depletion is documented globally with lidar. The role of polar stratospheric clouds is investigated and the classification of polar stratospheric clouds is based on their scattering properties as seen with lidar. Lidar is used to distinguish water droplets from ice crystals in clouds. Lidar contributes to our knowledge of the climatic effects of aerosols.

A basic configuration of an LIDAR system is presented in Figure 1.

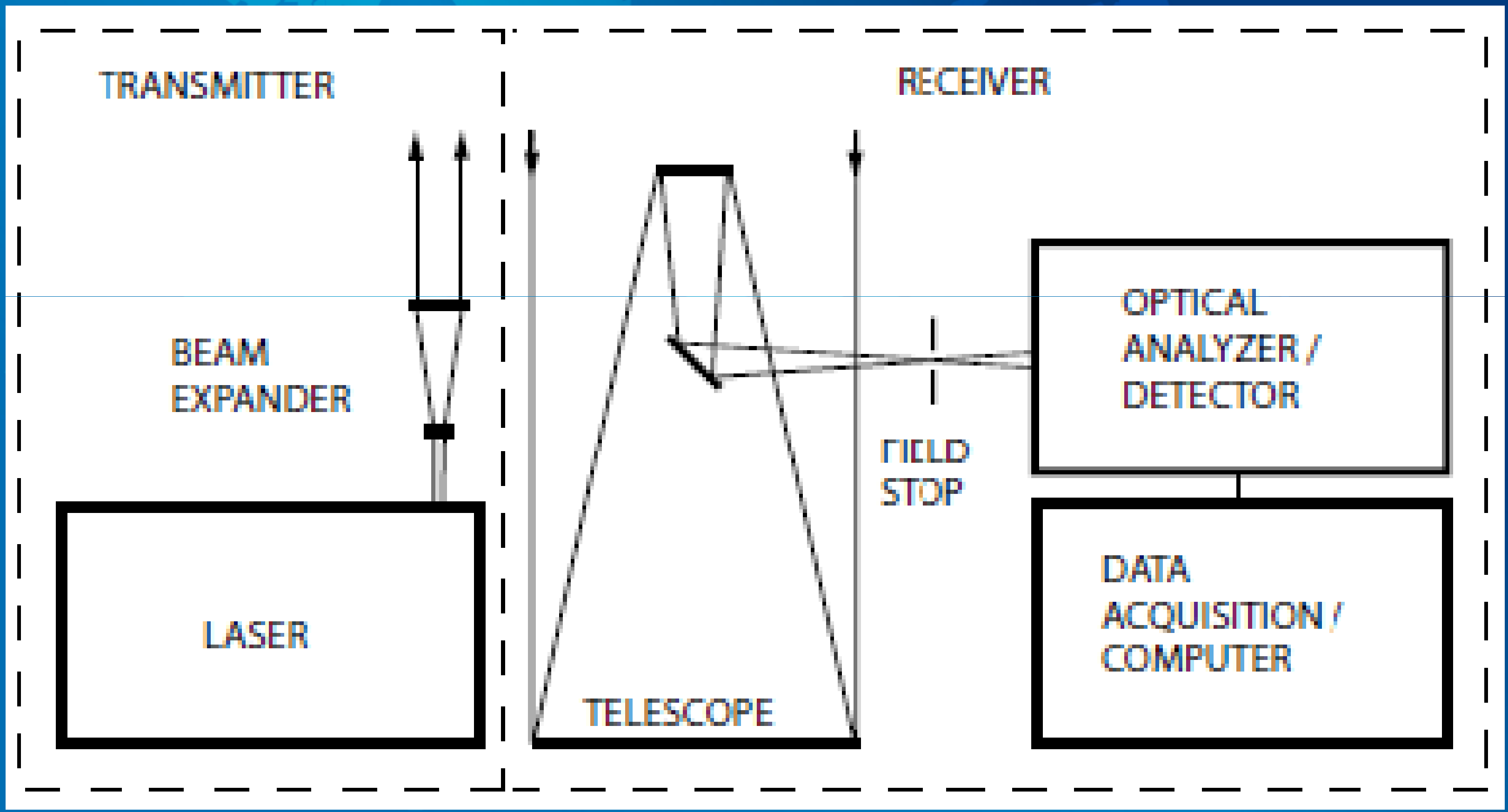


Fig. 1 Principle setup of a Lidar system

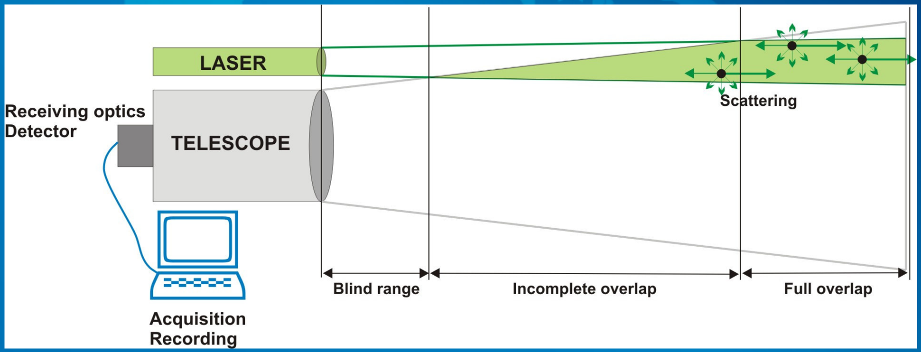
EXPERIMENTAL

Fig. 2 Configuration of the Lidar system in Rolinet Project for Timisoara location

The system that has been build in the Rolinet project it is represented in Figure 2, it is an elastic lidar.

It is an elastic Lidar with two channels for acquisition on 532nm.
The main parts of the system are:

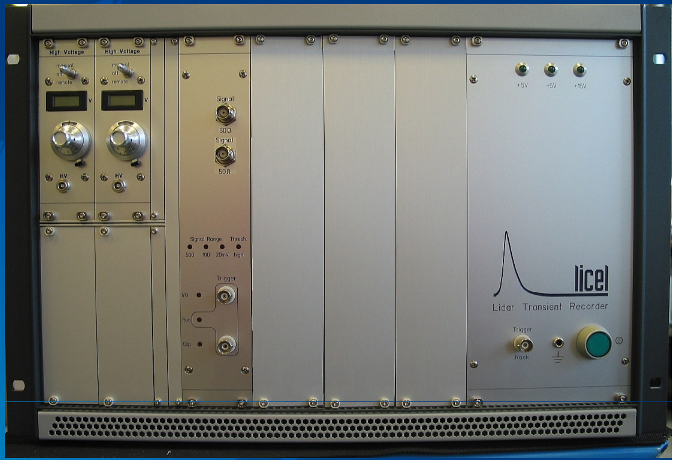
- Newtonian telescope of 406 mm;
- Nd:YAG laser with three wavelengths;
- Licel acquisition TR20;
- 3 λ Beam expander;
- Photomultipliers: analogue and photon counting.



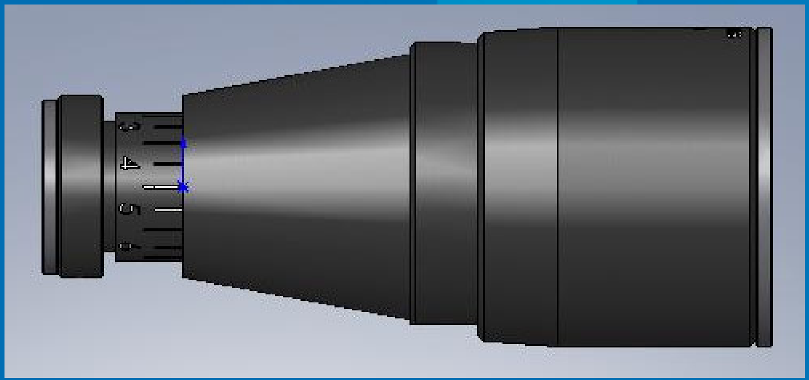
Main components:

Telescope

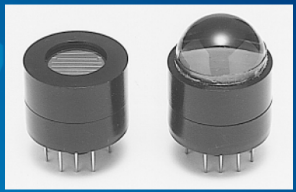
Laser



Acquisition card



Beam expander



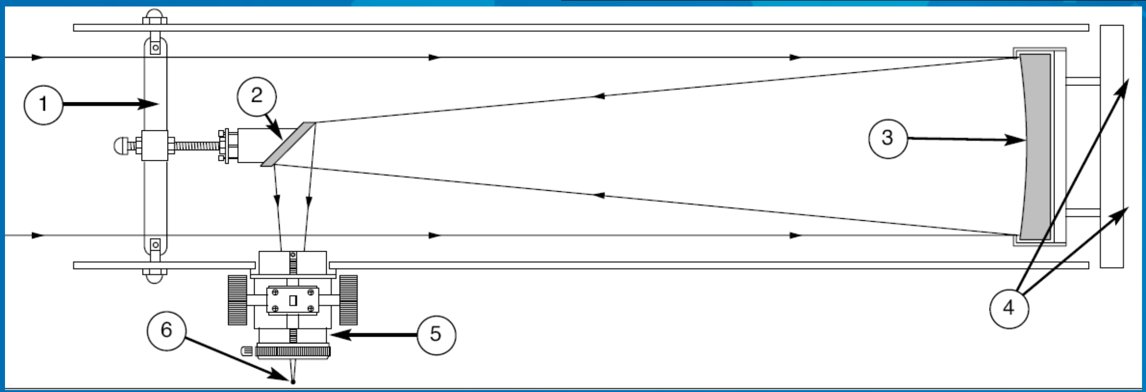
PMT

Telescope characteristics:

The principal components and the trajectory of the beam thru the Newtonian telescope:

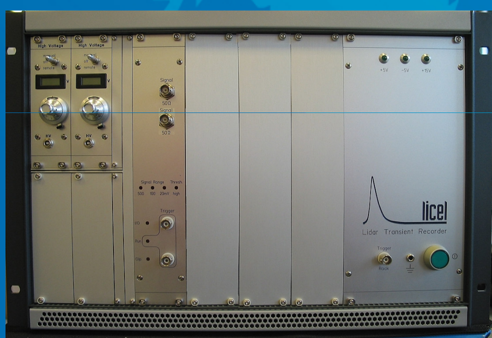
1 - entrance aperture;
2 - secondary mirror;
3 - parabolic primary mirror;
4 - main mirror support;
5 - various eye support;
6 – image formation.

Optical Telescope	Optical design: Newtonian reflector
	Mirrors with magnesium fluoride over coat and with maximum reflectivity's in spectral range 266 -1064 nm
	Diameter of principal mirror: 30 - 40 cm
	Focal length: 1500-2000 mm
	Focal Ratio (F/D): f/4-f/5
	50.8 mm Crayford style focuser with 31.75 mm adapter
	Eye piece: Focal Length: 26 mm; Filed of view: 70°
	Supports, frames and fixations



Telescope configuration

Acquisition characteristics:



Data Acquisition Card	Type: transient recorder - time of fly
	Mode: Analogue and Photon Counting
	Input signal range: 0... –20, –100, –500mV
	A/D resolution: 12bit
	Sampling rate: 40MSPS
	Bandwidth: DC–20MHz
	Buffer Memory: 2 canals with 4 094 acquisitions
	Photon Counting Rate: 10-250MHz with temporal resolution of 25 ns
	Trigger: 2 individual entrances BNC type, 50 Ohm, 2.5 V positive, time delay 25ns
	Dynamic detection: 10E+5 by coupling Analog with Photon Counting
	Threshold voltage: 0...–25mV, with 64 discrimination levels for each input by command software
	Interface connection with PC :Ethernet (RJ45) with controller possibility of 6 acquisition cards
	Rack Support-Box for 6 acquisition cards

"OPTOELETRONIC TECHNIQUES FOR ENVIRONMENTAL MONITORING"

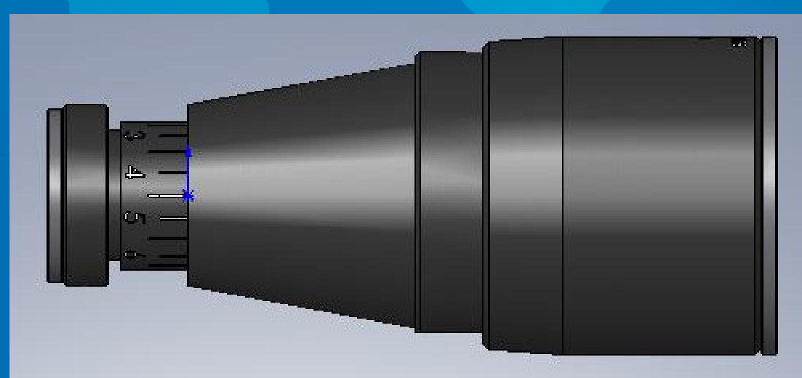
Laser characteristics:

Laser Nd:YAG, 30 Hz

Laser system with power supply and air – water cooling system in closed circuit	Laser type: Nd:YAG solid state
	Wavelengths: 1064, 532, 355 nm;
	Energy per Pulse: 200 mJ la 1064 nm, 100 mJ la 532 nm, 35 mJ la 355 nm
	Pulse duration: 6-9 ns
	Spectral line bandwidth of laser: 1 cm^{-1}
	Repetition rate: 1 – 30 Hz;
	Laser beam diameter : 6 mm
	Laser beam divergence : < 0.75 mrad
	Energy stability: 2.0; 0.6 (3σ ±%) at 1064 nm , 4.0; 1.3 (3σ ±%) at 532 nm, 6.0; 2.0 (3σ ±%) at 355 nm
	Operation condition: 18 - 30° C
	Geometry of optical head : 32.5 x 8.5 x 9.5 cm
	Weight of Optical Head : 3.6 Kg
	Geometry of Power Supplier: 56 x 43 x 27 cm, rack 19"
	Weight of Power Supplier: 30 kg
	Controller software PC compatible - Windows OS
	Warranty in number of shots = 50 000 000

Beam expander characteristics:

Beam Expander	Wavelength: 532 nm
	Input aperture: minimum 6 mm diameter
	Energy Density for 6mm beam diameter: 200 mJ at 1064 nm, 100 mJ at 532 nm, 35 mJ at 355 nm/30HZ
	Transmission > 90%
	Zoom factor : 4 - 8
	Support and frame for fixing

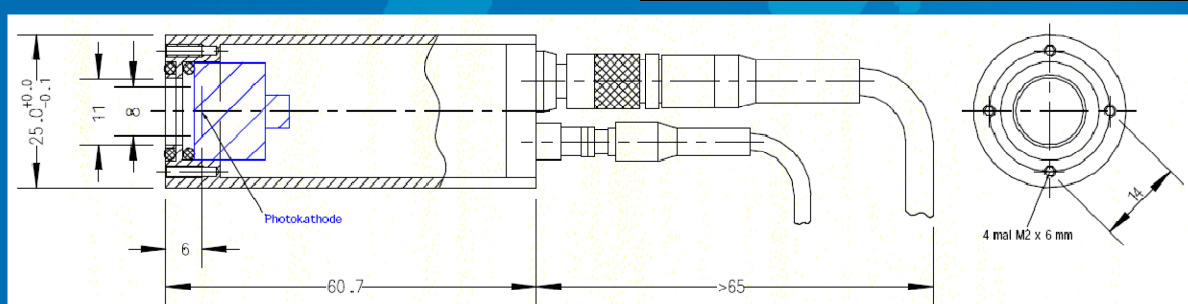


Beam expander

Photo detector characteristics:

Photo detector

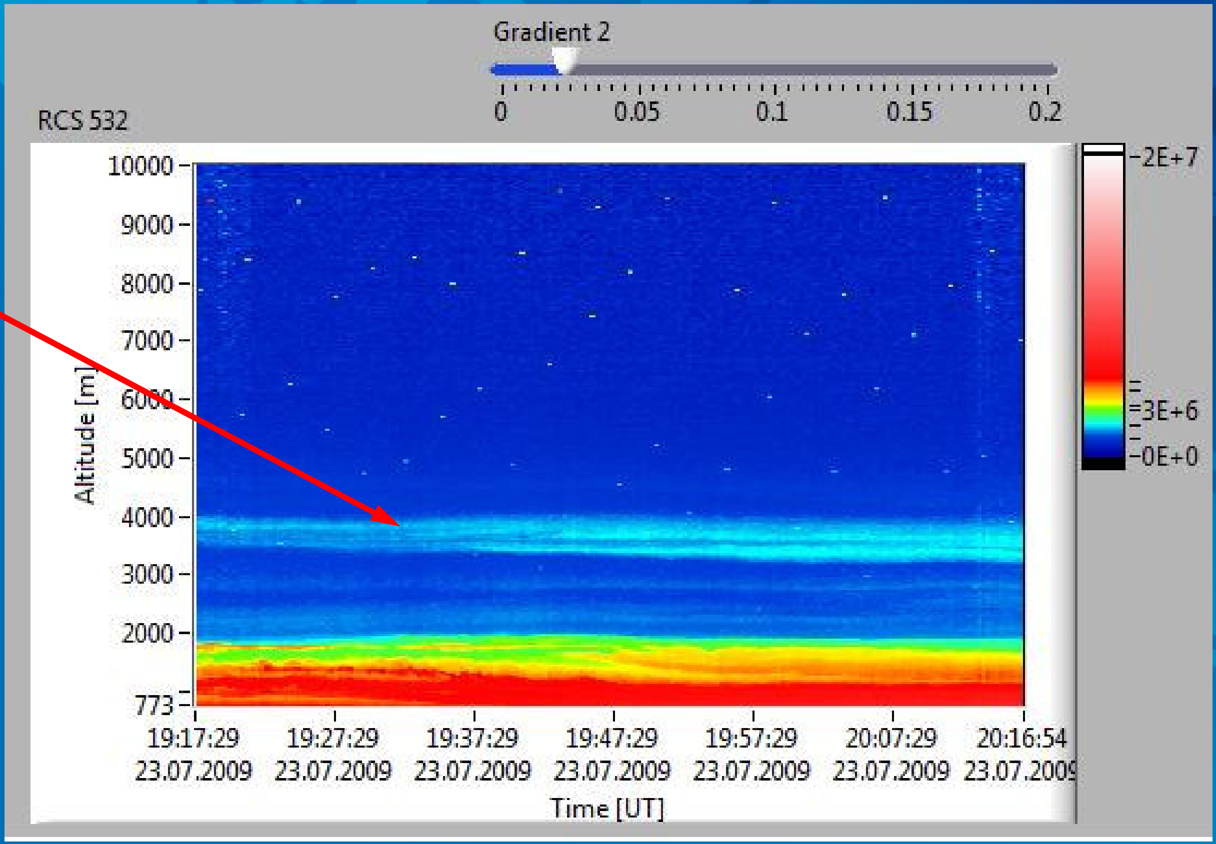
Photo detector	Type : mini photomultiplier tube Super Bialkali, (optimized for lidar application)
	Module for power supply with High Voltage : 50-1000V
	Effective area: 8 mm
	Wavelength range: 270 – 650 nm;
	Width single photon pulse < 2 ns
	Rise time: ~ 0.7 ns
	Operational conditions: -30°C … + 50°C
	Dark current: max 400 s -1
	Frame Support with cables for signal and HV supply



RESULTS AND DISCUSION

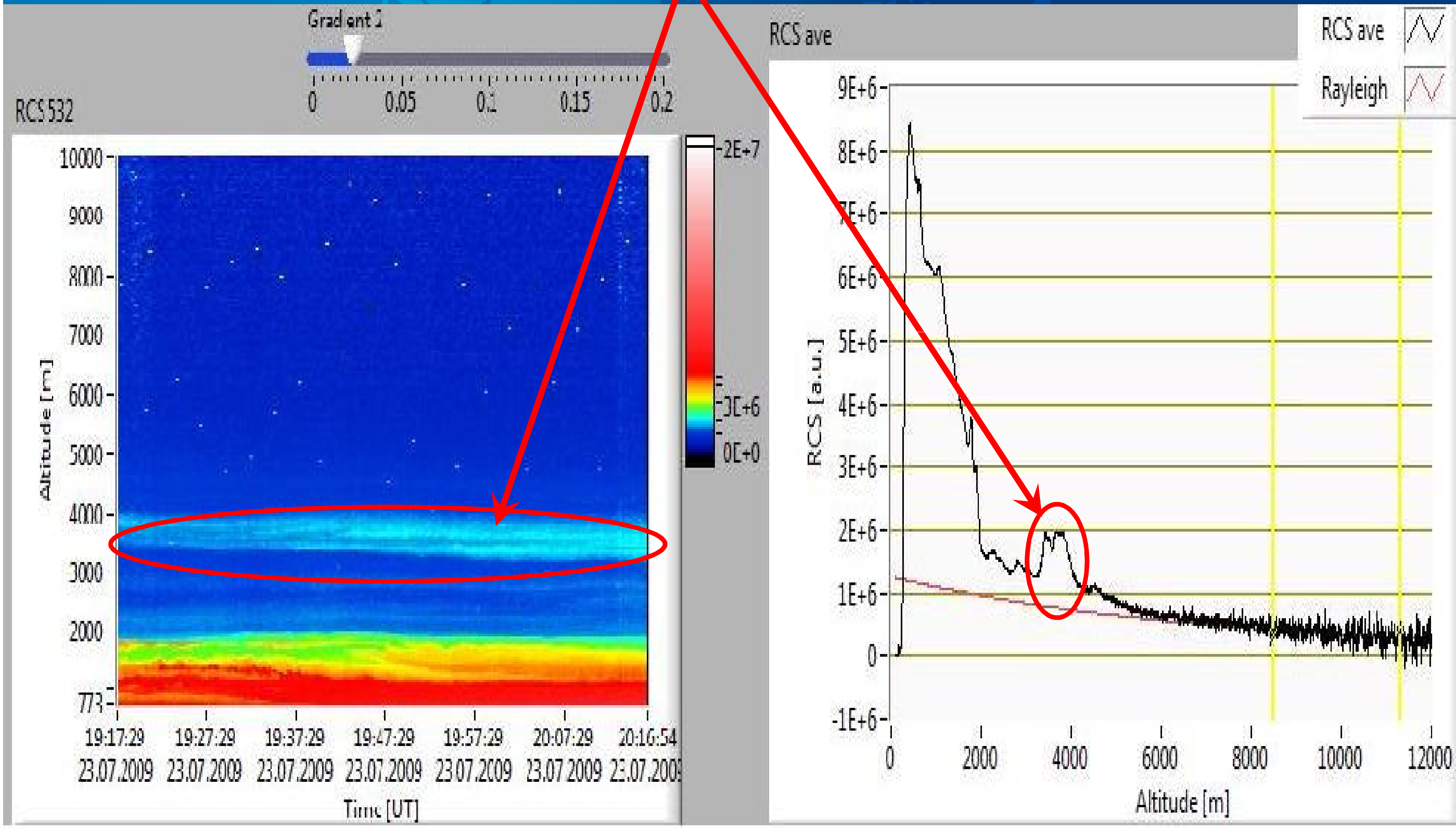
Example of RCS (range corrected signal) from measurement made at INOE location. We can see in the picture at ~4000 m a layer of Saharian dust that was also receptioneted by the Raymatrics Lidar system from INOE.

Saharian dust layer



"OPTOELETRONIC TECHNIQUES FOR ENVIRONMENTAL MONITORING"

Saharian dust layer



CONCLUSION

⇨ Tests conducted both in Iasi and Bucharest have shown that this system is stable and has a very good potential. It can be easily upgradeable with more channels;

⇨ A simple architecture;

⇨ Easy to operate;

⇨Can be up-gradable;

⇨Ideal configuration for tropospheric aerosol concentration