Python Utility: Laser-atmosphere interaction extended to Network Data Management

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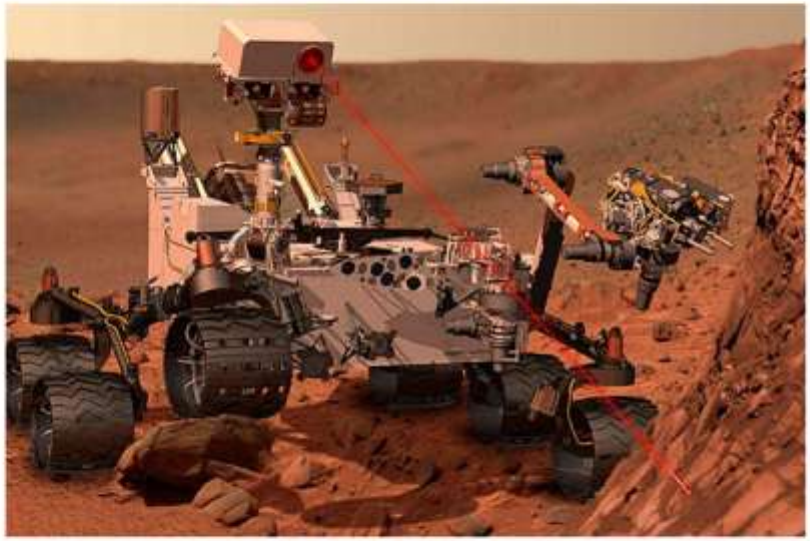
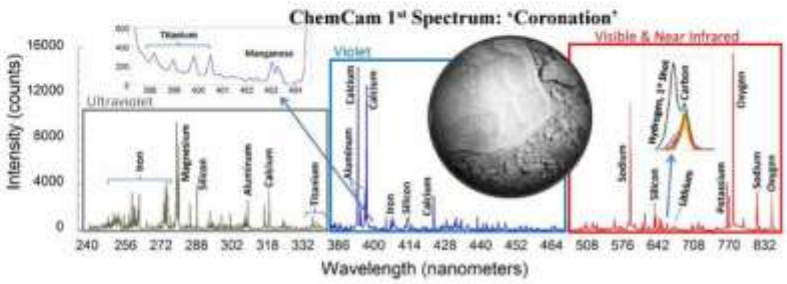
Remote Sensing by Laser-Induced Plasmas. http://libs.lanl.gov/

see also: The ChemCam Instrument Suite on the Mars Science Laboratory Rover Curiosity

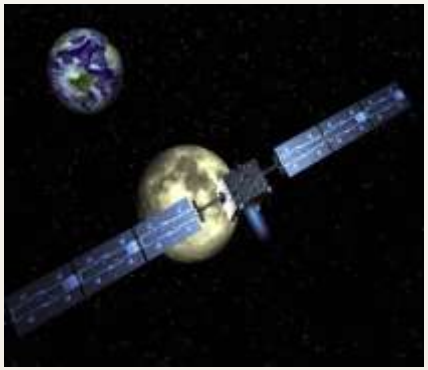


First laser spectrum from ChemCam, sent back from Mars on August 19, 2012



Erosion of Dielectric Walls in Hall Effect Thrusters (HET)

Context …



➢ **HET as propulsion solution for spacecrafts: ESA mission SMART-1 to the Moon (2003-2006)**

➢ **300 eV plasma in Xe; $BNSiO_2$ as typical material for the manufacturing of HET dielectric walls; Life-time limitation due to erosion**

➢ **Presence of numerous complex processes like electron secondary emission, sputtering, normal or ab-normal erosion, sheath potential modifications or solid particle emission - difficult to completely control and parameterize the dielectric wall behaviour**

➢ **Deposition of energy by the plasma discharge modifies the surface temperature and consequently affects the evolution of the different wall processes**

➢ **In order to better understand the effects of an energy flux on the wall, we try to simulate the energy deposition by irradiating the dielectric surface with a laser**

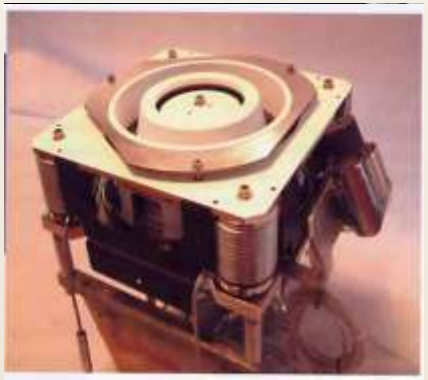
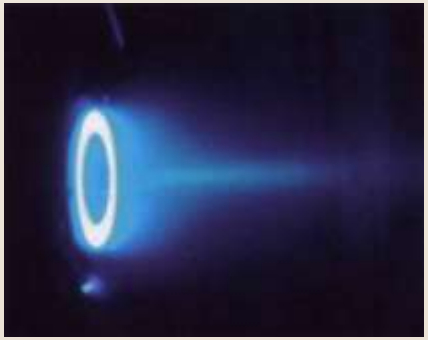


Figure 1. Démonstrateur technologique PPS 5000 : un banc d'essais des technologies. (Photo : Snecma Moteurs)

↳ ***Laboratory experiments (pulsed & cw lasers)***

↳ ***Implementation on the French national facility PIVOINE - Orléans***

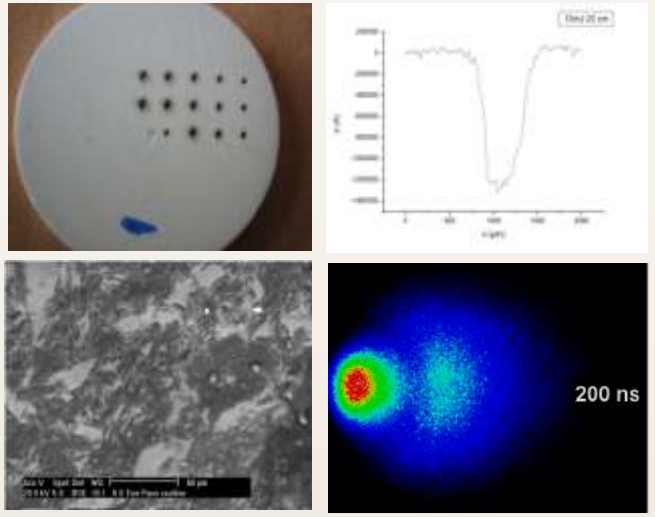


GdR « Plasma Space Propulsion »
CNES/SNECMA/CNRS/Universités

Laboratory experiments

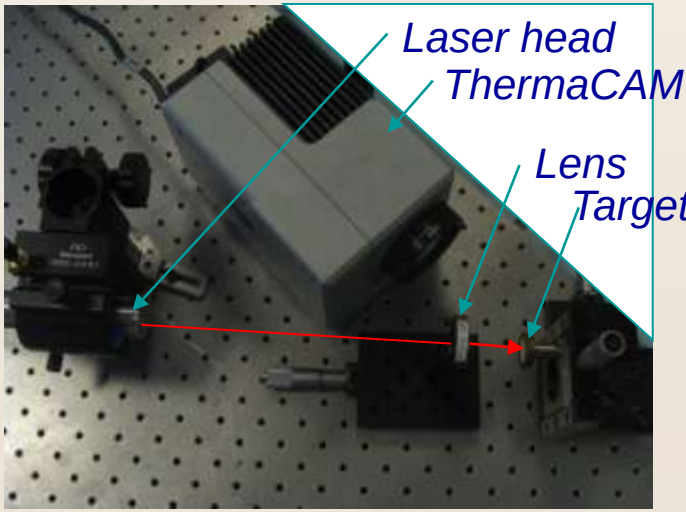
Pulsed Lasers …

- Nd:YAG (532 & 355 nm) laser irradiation of ceramic samples ($BNSiO_2$, Al_2O_3, MgO) placed in vacuum (10^{-6} Torr)
- The modifications induced by laser irradiation on the BNSiO2 targets are analysed by profilometry and scanning electron microscopy
- The plasma created by laser ablation is characterized by optical (ICCD) and spectral (OES) methods



CW Lasers …

- Laboratory experiments on $BNSiO_2$ samples in air
- CW YLF fiber laser (IPG, 1070 nm, 0-100 W) focused on the sample surface to spot diameters 0.1 – 1 mm
- ThermaCAM (FLIR) real-time thermal monitoring



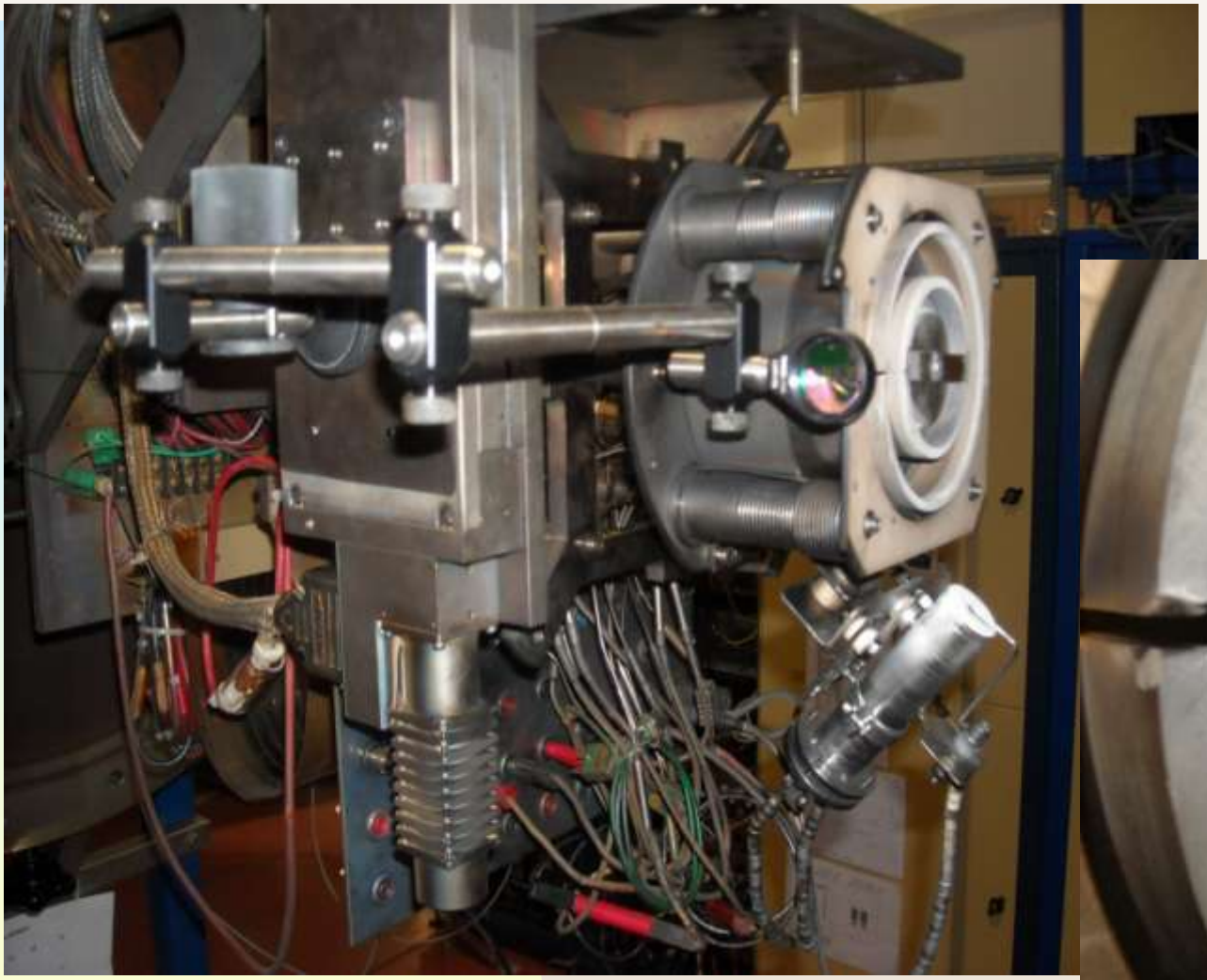
Experiments on the French national PIVOINE infrastructure

PIVOINE-2G

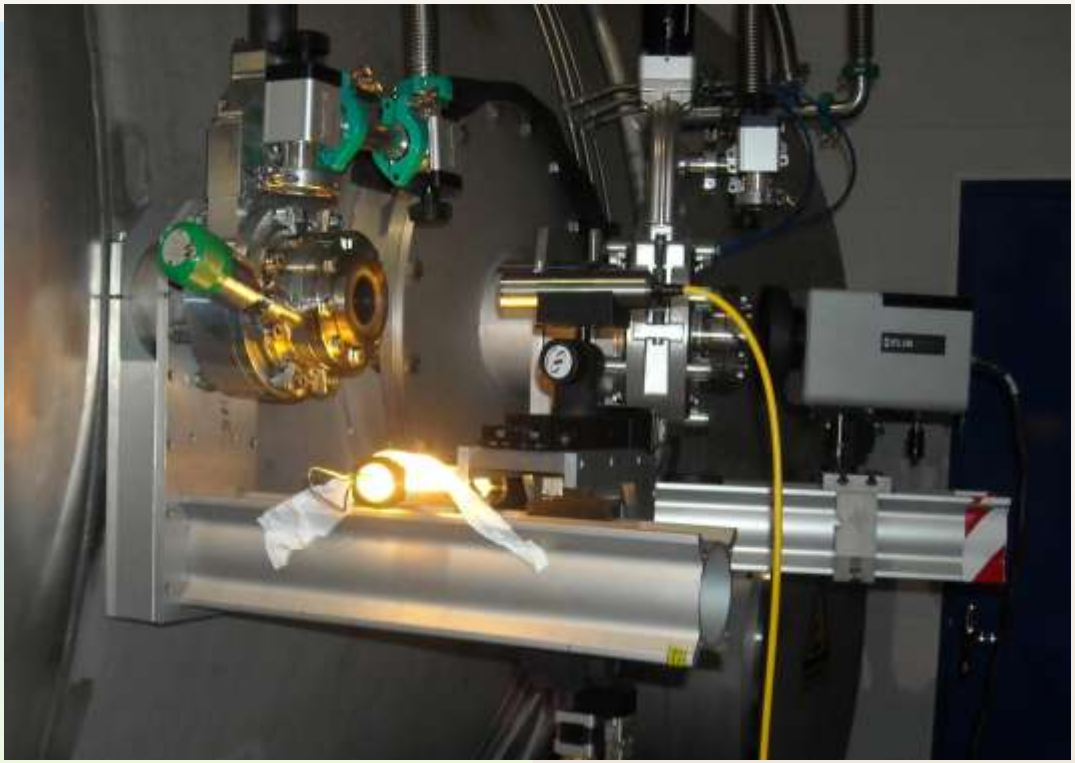
ICARE laboratory (Orléans, France)

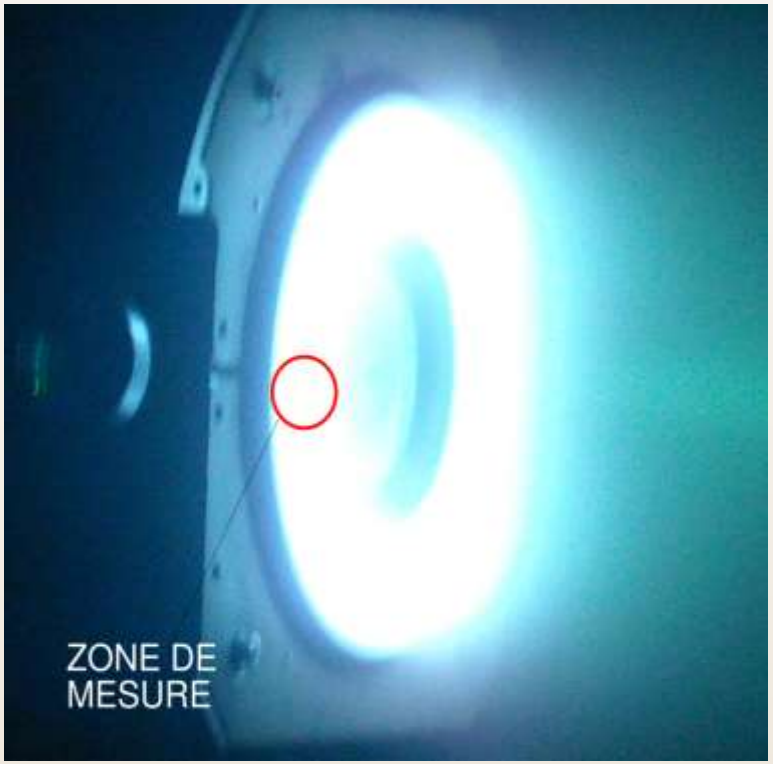
- **Large vacuum chamber (diameter 2 m, length 7 m)**
- **cryogenic pumping system (150 000 L/s)**

Pressure: 2. 10^{-5} mbar (with 5 mg/s Xe flow)



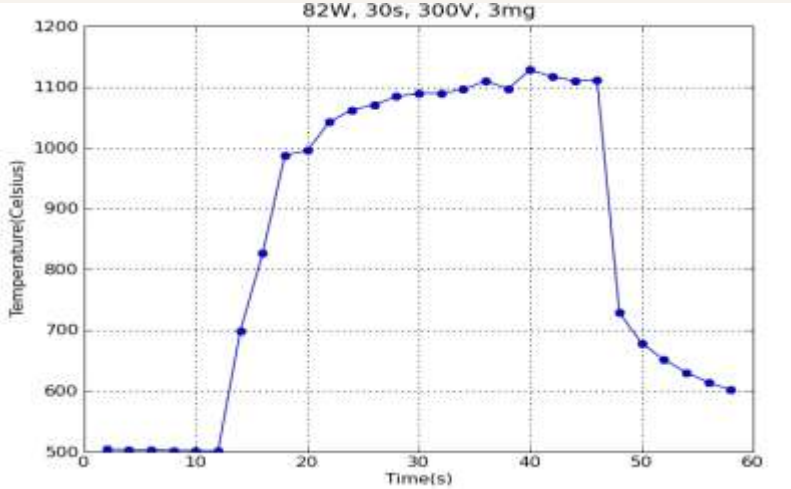
Use laser ablation in the running thruster
in order to generate an “accelerated erosion” of the walls.

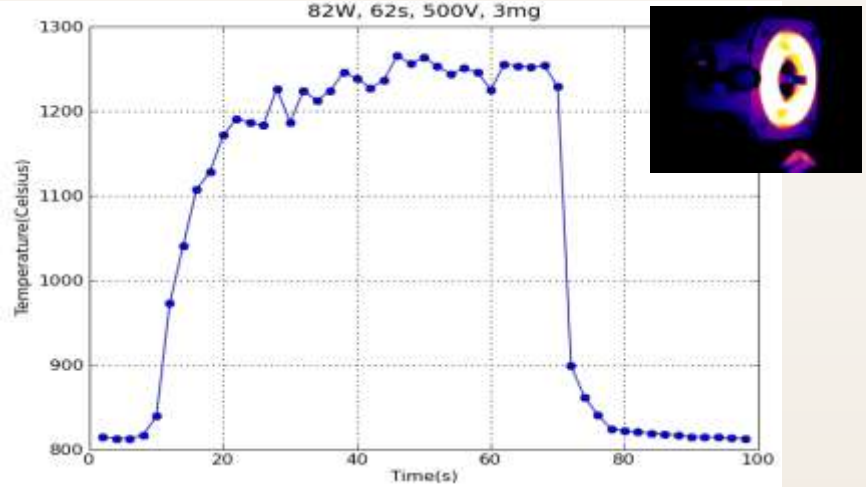




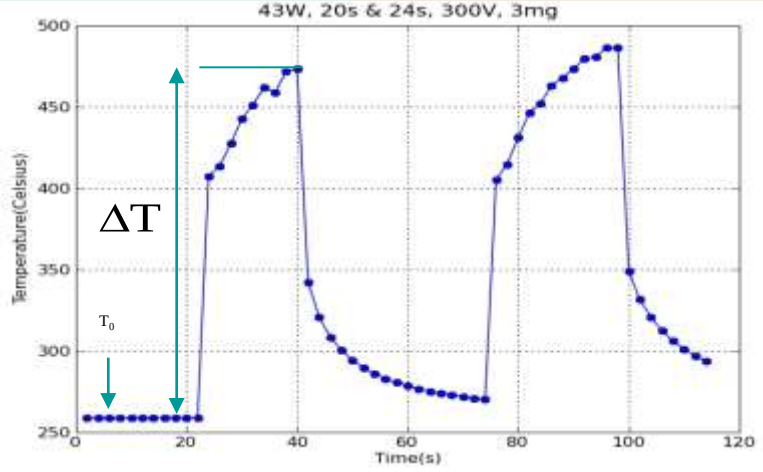
HOT SPOTS Problem …

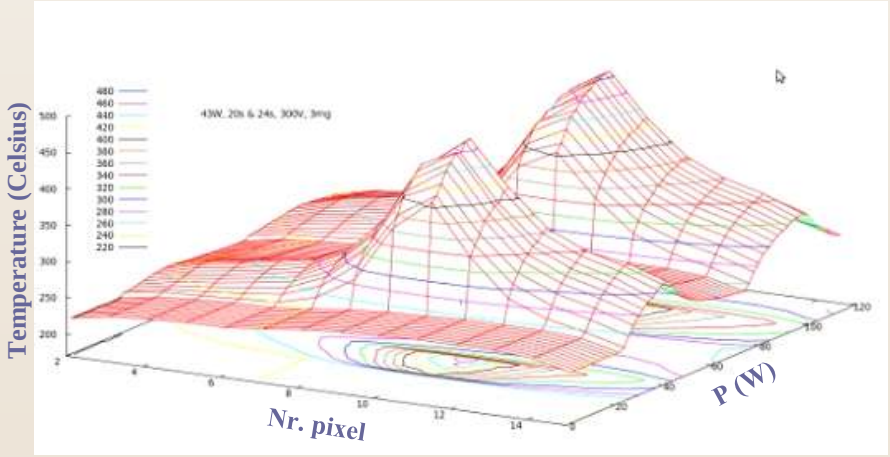
- ***Try to create topological and thermal defects by pulsed & CW laser irradiation***
- ***Various thruster regimes (PPS100 – ML)***
- ***IR thermography and optical emission spectroscopy***
- ***Profilometry and scanning electron microscopy***





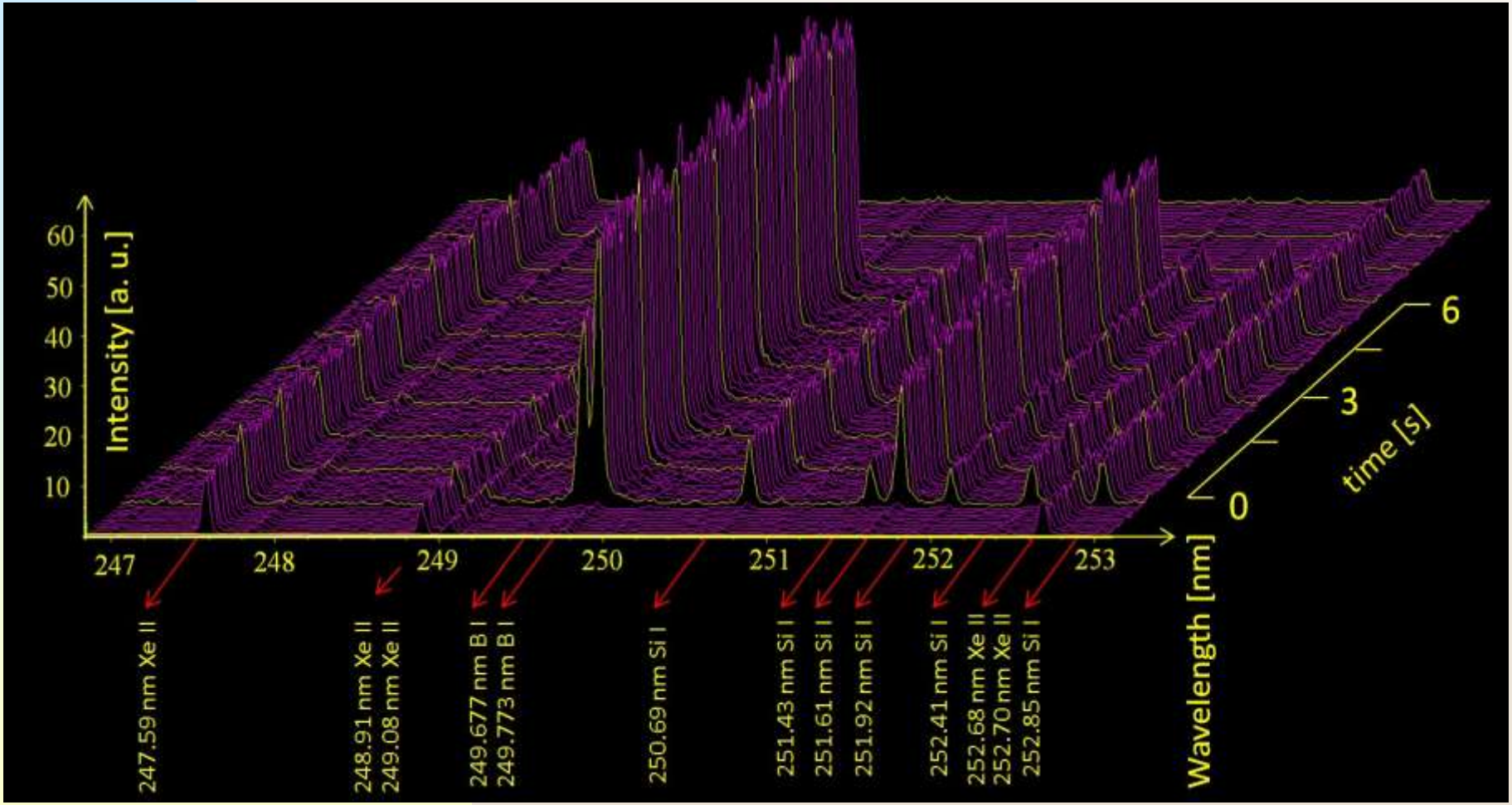
Temporal evolution of the temperature in the irradiated HET wall region
Experimental conditions: P_{laser} = 82 W, discharge voltage U = 300 V and 500 V





Temporal evolution of the temperature in the irradiated HET wall region for 20s and 24s successive laser irradiations. Experimental conditions: P_{Laser} = 43 W, discharge voltage U = 300 V

Acton 2750i, PI-MAX,
2400 l/mm, 25 ms gate, 255 gain



Laser-atmosphere interaction

Despite a large volume of publications, experimental results and theoretical data, because of theirs complex and multitudinous of transient processes, covering different time scales and different research fields of physics, **the laser-matter interaction mechanisms topic is far from being solved.**

• Depending on the space-time chemical compositions, source types activity or process, meteorological conditions, air pollutants (both organic and inorganic compounds), generally, air pollution causes significant damage to human health and environment, dramatically influencing the climate changes Thus, a complex panel of atmospheric pollution tools, satellite data and forecast models must be taken into account.

• **The impact of urban-enhanced aerosol concentrations, research subject of high interest, must include new models because they may induce a significant turbulence on the dynamics and microphysics of convective air masses but also upon the storm development and precipitations**.

ROLINET

(ROmanian LIdar NETwork)

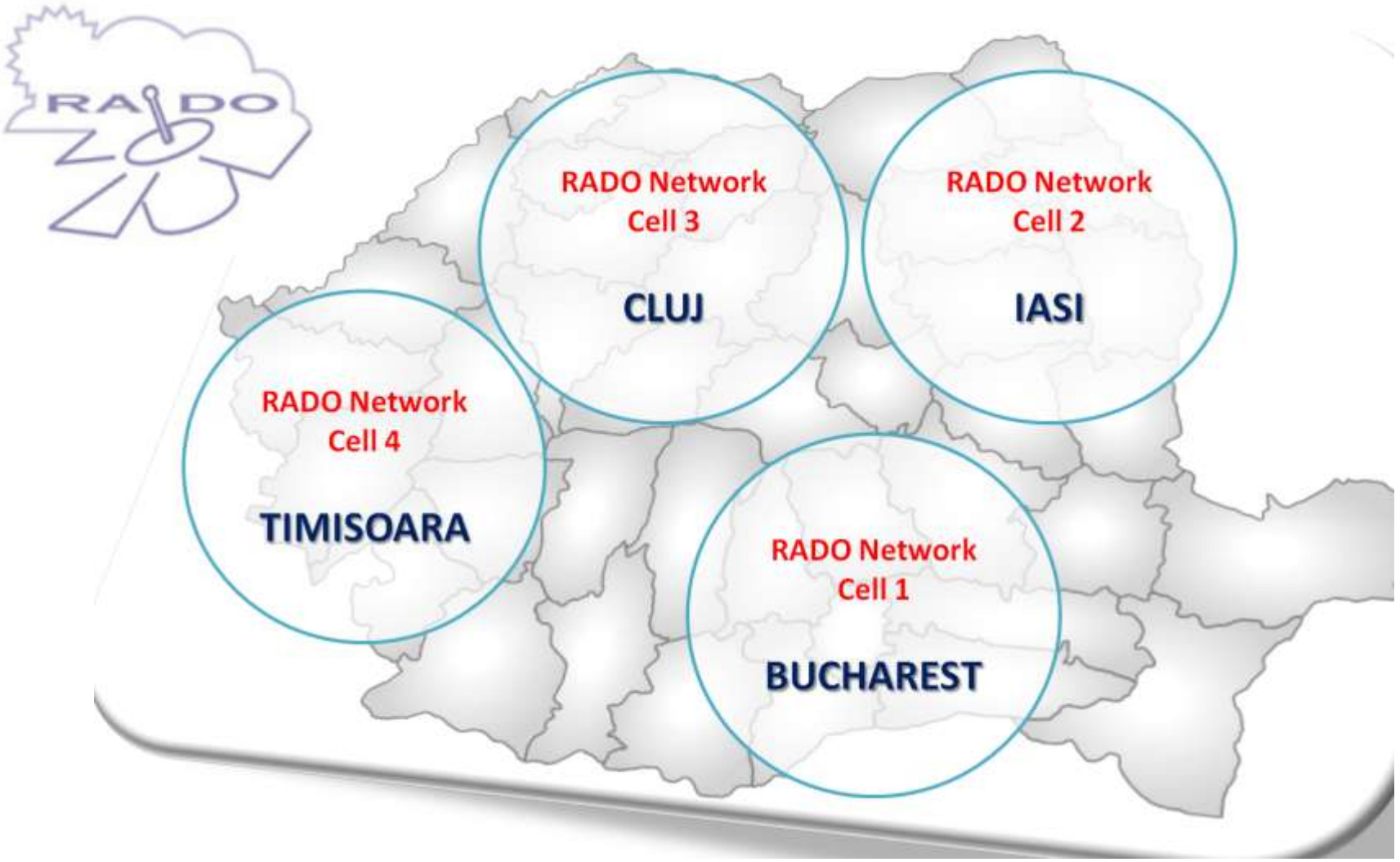
RADO

(Romanian Atmospheric 3D Observatory) projects

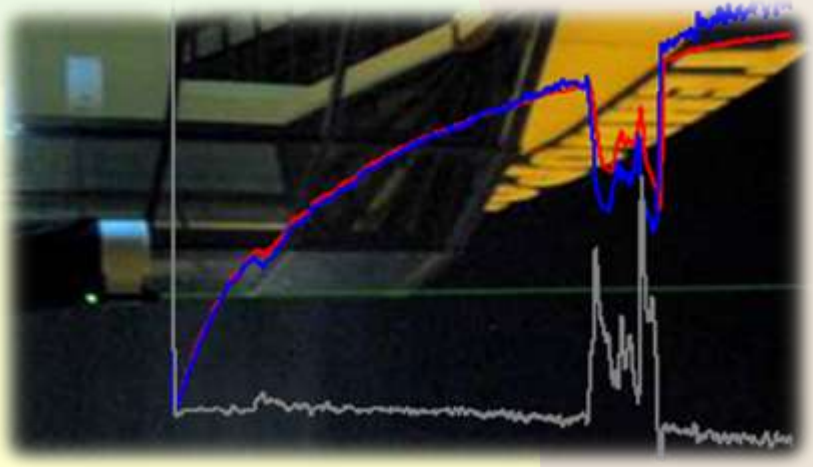
http://inoe.inoe.ro/ROLINET/

…..a complex research of the atmosphere requires cutting-edge remote sensing spectral techniques based on the LASER-atmosphere interactions, such as LIDAR (Light Detection And Ranging).

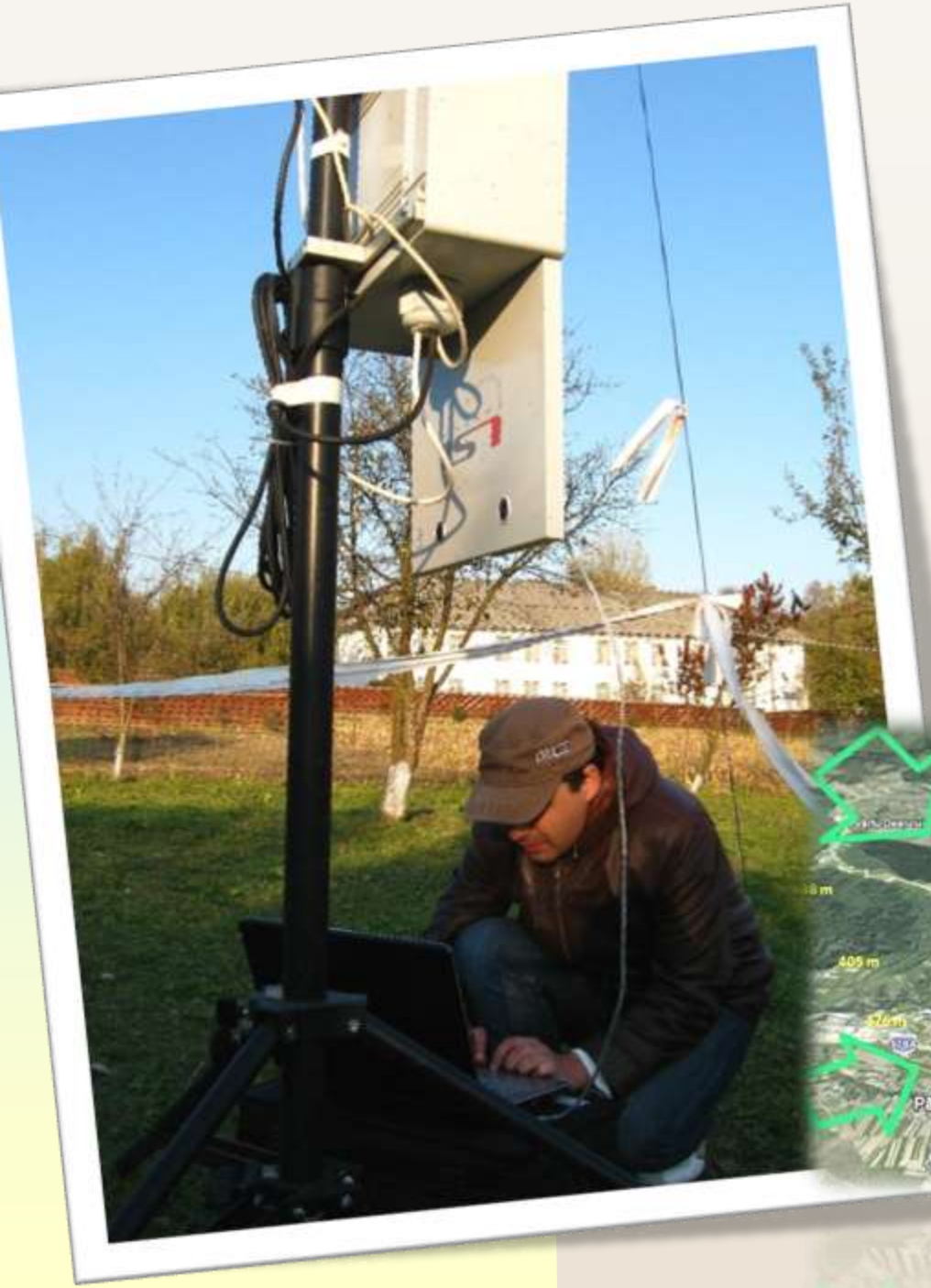
The high spatial and temporal resolutions (3.5 meters and 1 minute respectively) and the possibility to monitor Earth's atmosphere to heights up to 100 kilometers, make the LIDAR a very attractive and necessary system. The variety of interactions between the atmospheric constituents and the radiation emitted by the LIDAR, allows the determination of the atmospheric variables of state (i.e. temperature, pressure, air density) and the determination of the aerosol concentration.



The laser-atmosphere remote sensing spectral techniques study on the national RADO-network cell-grid infrastructure

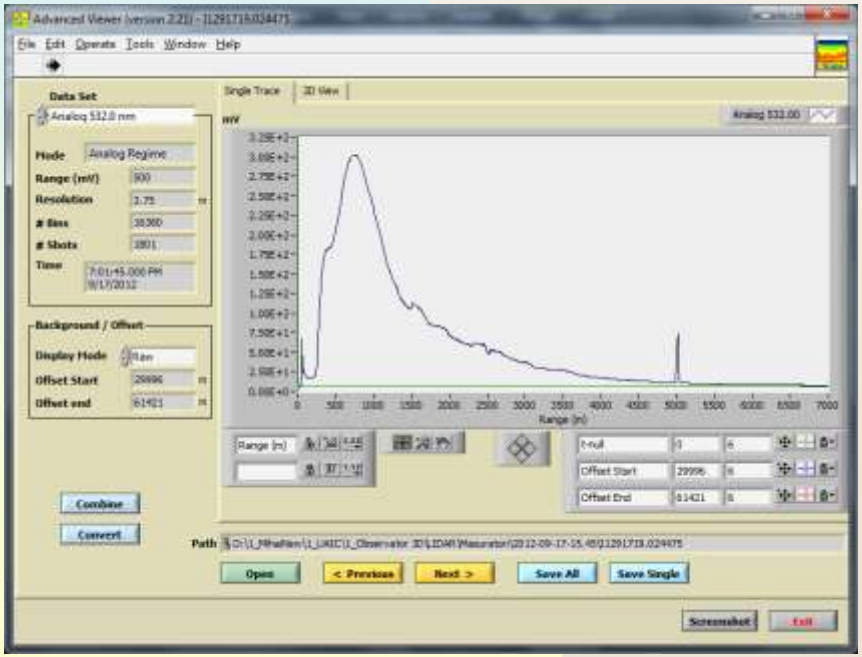


Cacica region

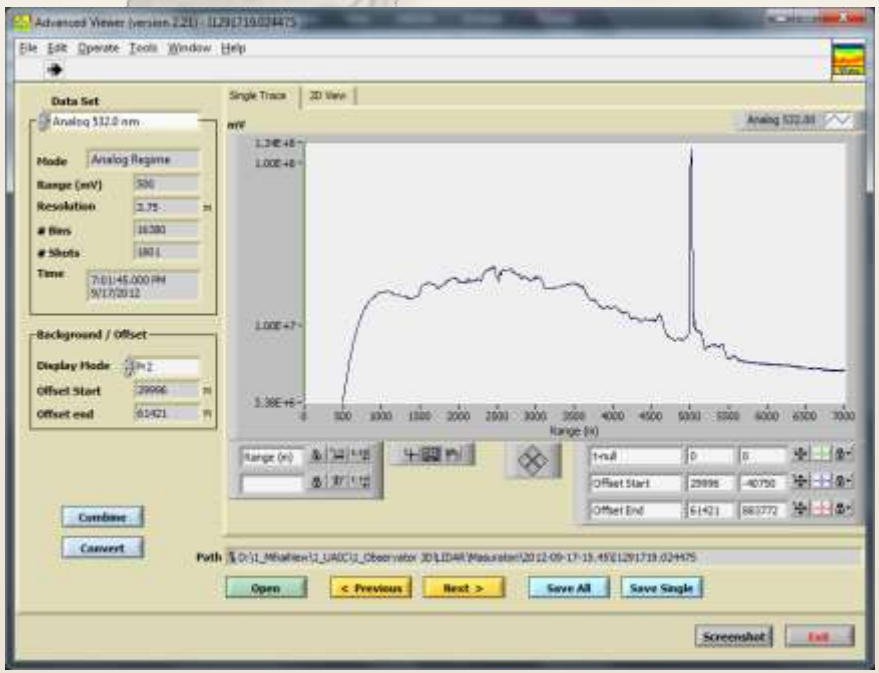


Campaign field measurements - Astronomical Observatory

Data Recorder procedures



LIDAR Profile – Un-processed
Signal 532 nm elastic channel, Spatial Resolution: 3.75 m,
Temporal Resolution: 60 s (1800 profiles/ min)



RCS LIDAR (Range Corrected Signal)
RCS = distance * squared signal

The implementation of **Python programming** for the analysis and interpretation of LIDAR signals may be a useful tool in obtaining **the Range Corrected Signal Time Series**, the atmosphere's molecular parameters and the atmospheric variables of state at the national GRID sites. Also, together with the Telecover method, one can determine if the LIDAR system is properly aligned. The measurements were made with the mini-LIDAR system from the Atmosphere Optics, Spectroscopy and Lasers Laboratory, "Alexandru Ioan Cuza" University of Iasi (LOA-SL)

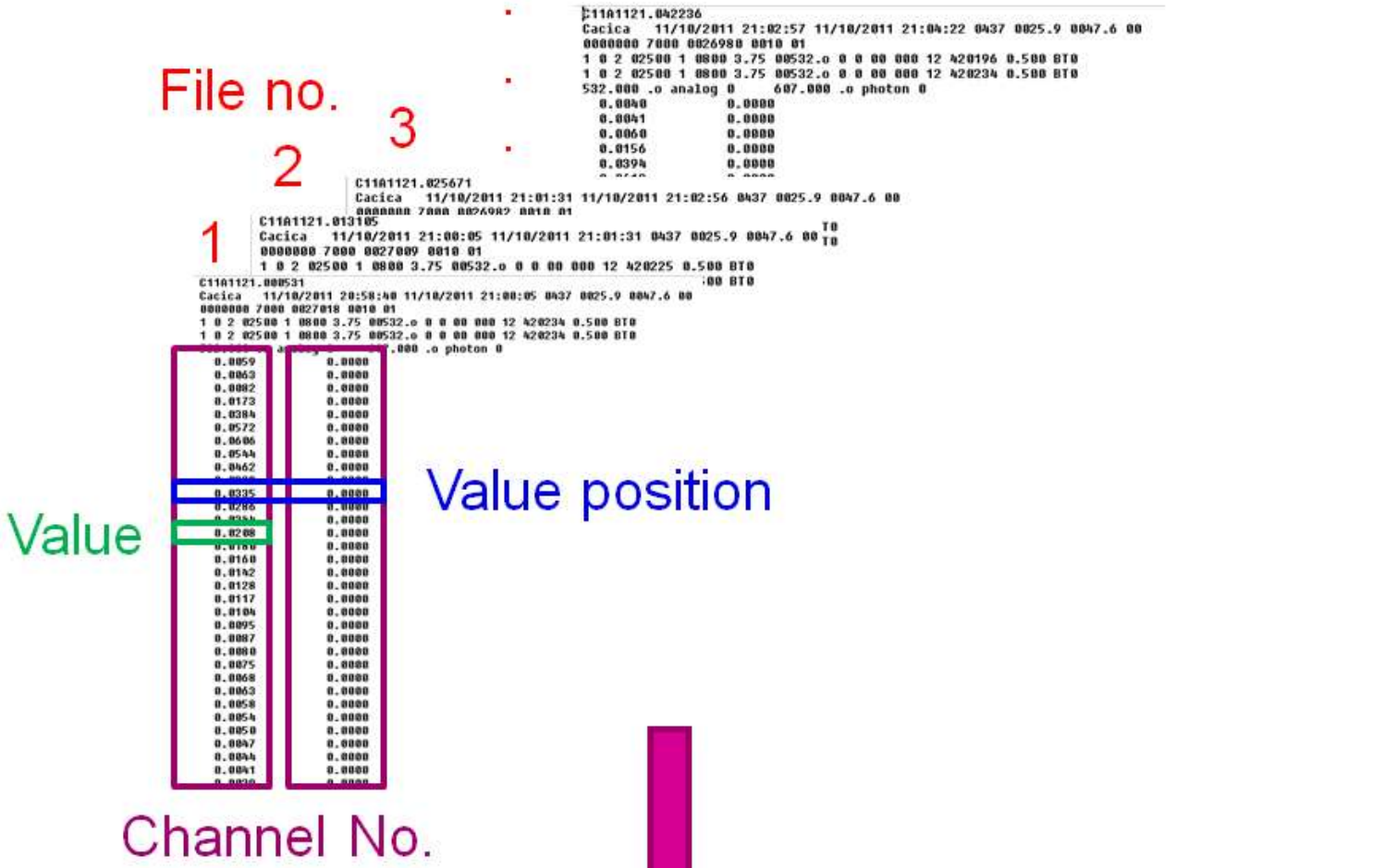
Transient Recorder

Data files processing

Dark File

subtract

Dark corrected files



3D array: values[fn][cn][vp] = value

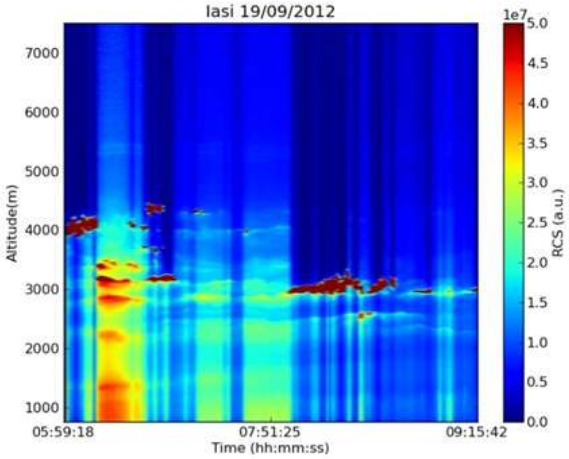
Value x (value position x spatial resolution) ^{2} = Range Corrected Signal (value)

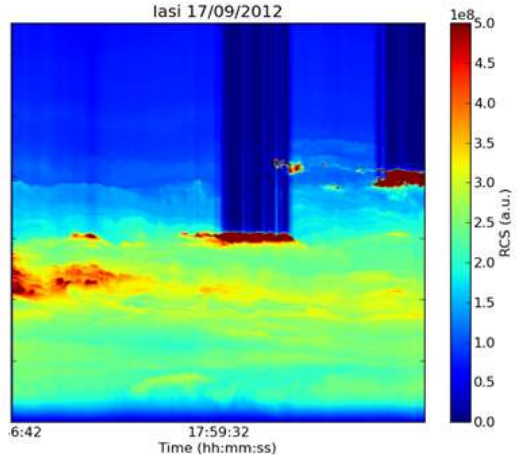
Altitude

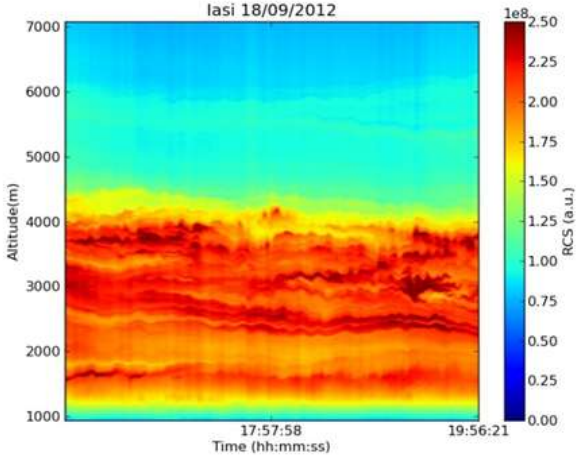
FROM ONE FILE!

3D array: RCS[fn][cn][vp] = value

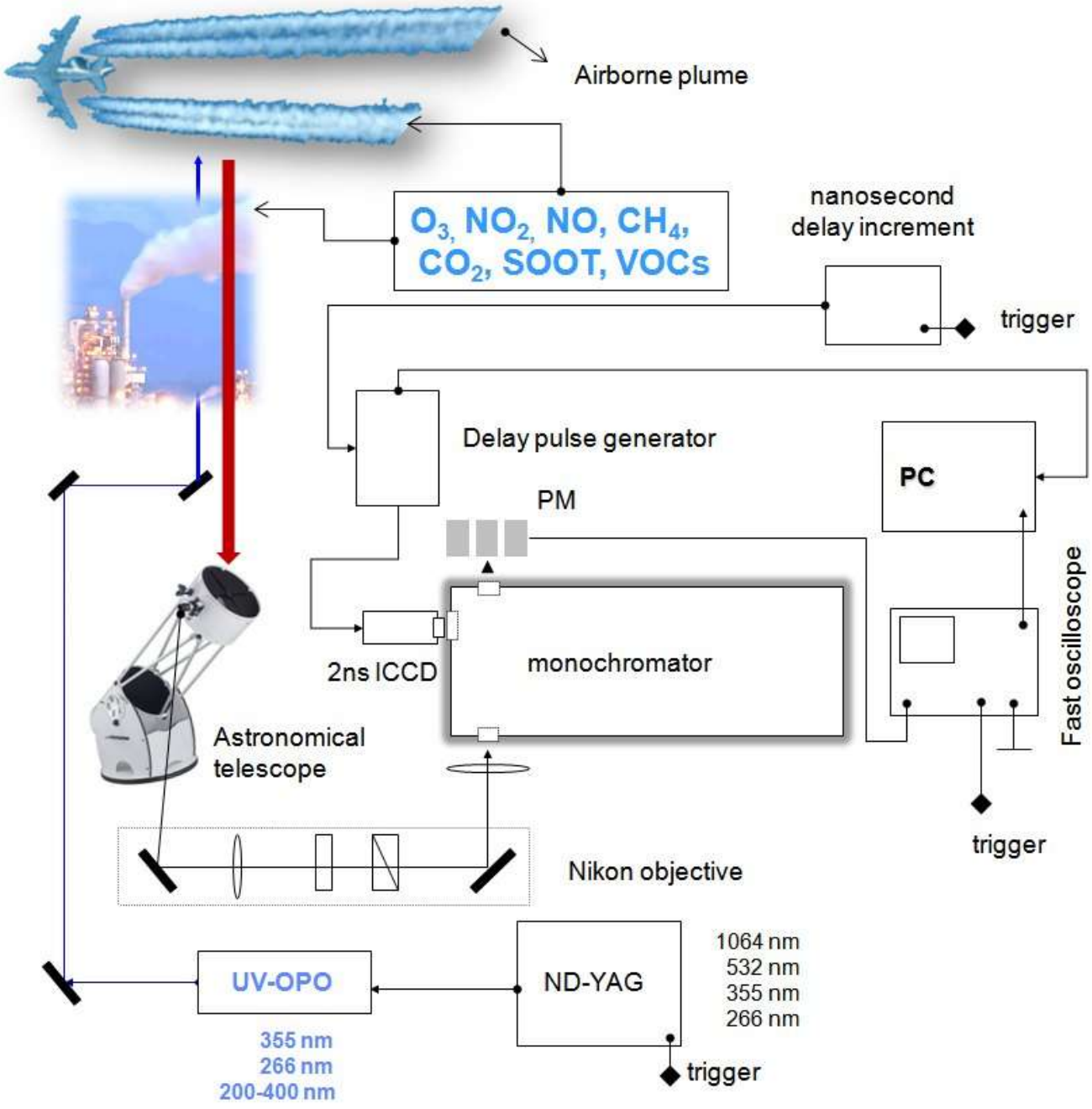
Plot 3D array







Future work


Airborne plume
O_3, NO_2, NO, CH_4, CO_2, SOOT, VOCs
nanosecond delay increment
trigger
Delay pulse generator
PC
PM
2ns ICCD
monochromator
Fast oscilloscope
Astronomical telescope
trigger
Nikon objective
UV-OPO
355 nm
266 nm
200-400 nm
ND-YAG
1064 nm
532 nm
355 nm
266 nm
trigger