

# PROJECT 9: STUDIES ON THE APPLICATION OF LASER- BASED REMOTE SENSING TECHNIQUES (LIDAR) IN THE MEASUREMENT OF ATMOSPHERIC POLLUTANTS

**Roberto Guardani**



Research Centre  
for Gas Innovation

cleaner energy for a sustainable future

## Project 9:

# STUDIES ON THE APPLICATION OF LASER-BASED REMOTE SENSING TECHNIQUES (LIDAR) IN THE MEASUREMENT OF ATMOSPHERIC POLLUTANTS

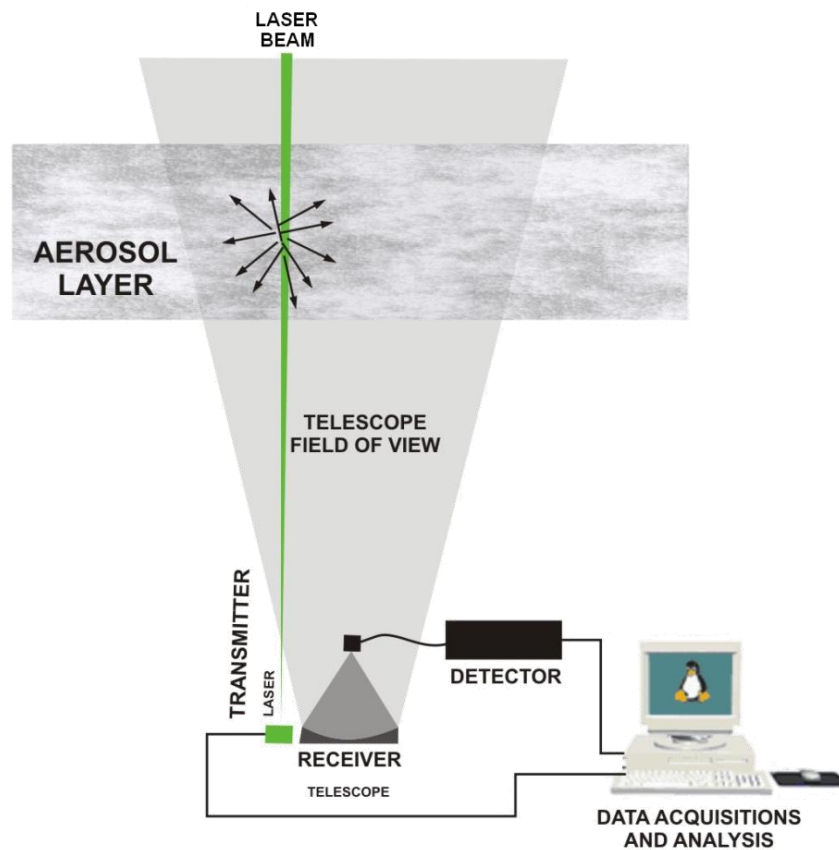
- **Leader:** Roberto Guardani
- **Reseachers:** Dr. Eduardo Landulfo (IPEN), Prof. Claudio A. Oller do Nascimento,
- Dr. Renata F. da Costa (post-doc)
- Fernanda de Mendonça Macedo (doctorant)
- Steffany Rincón Perez (M.Sc. Student)
- **Project Description and Scope:**
  - Application of remote sensing techniques (LIDAR) for monitoring atmospheric emissions of aerosols and fugitive gases (VOCs) .

## **Project 9:**

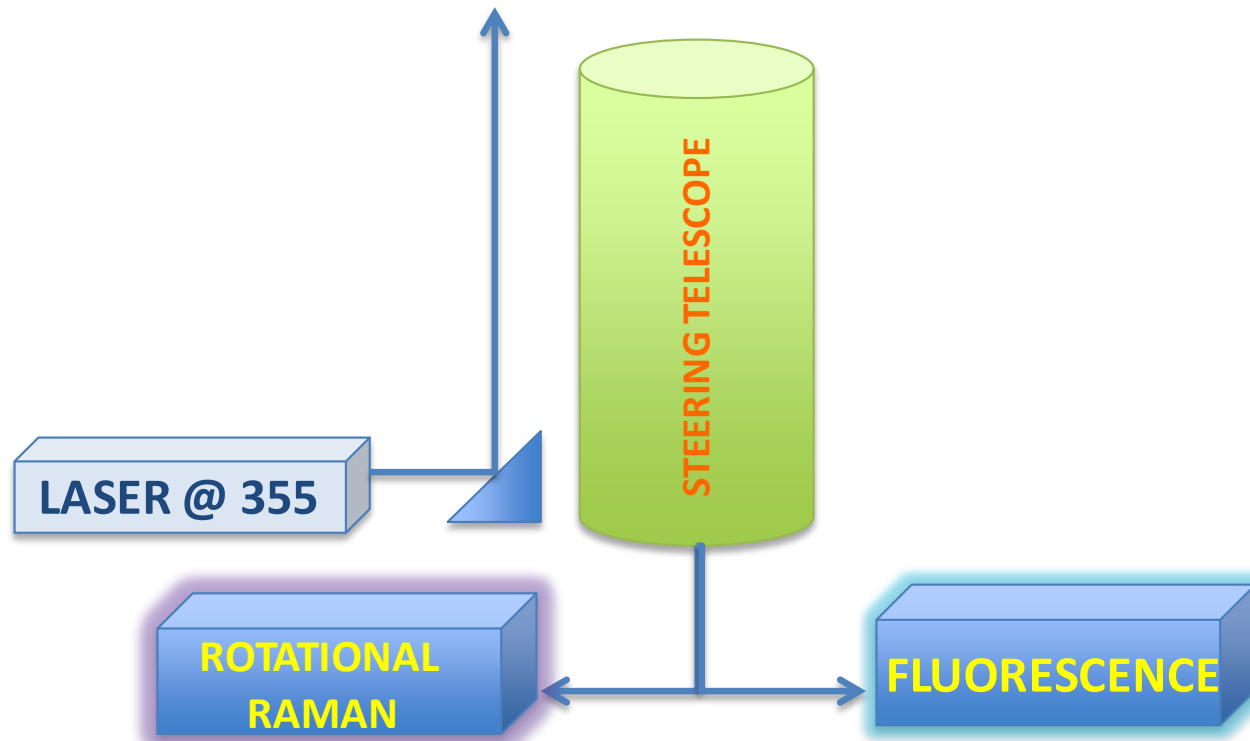
# **STUDIES ON THE APPLICATION OF LASER-BASED REMOTE SENSING TECHNIQUES (LIDAR) IN THE MEASUREMENT OF ATMOSPHERIC POLLUTANTS**

- **Application of Remote Sensing Techniques to the Monitoring of Atmospheric Industrial Emissions**
- **Development of Optical Sensors and Signal Processing Methods for Disperse Systems Monitoring**
- **Deliverables:**
  - **Equipment setup.**
  - **Algorithms and computer programs for signal processing and data treatment.**

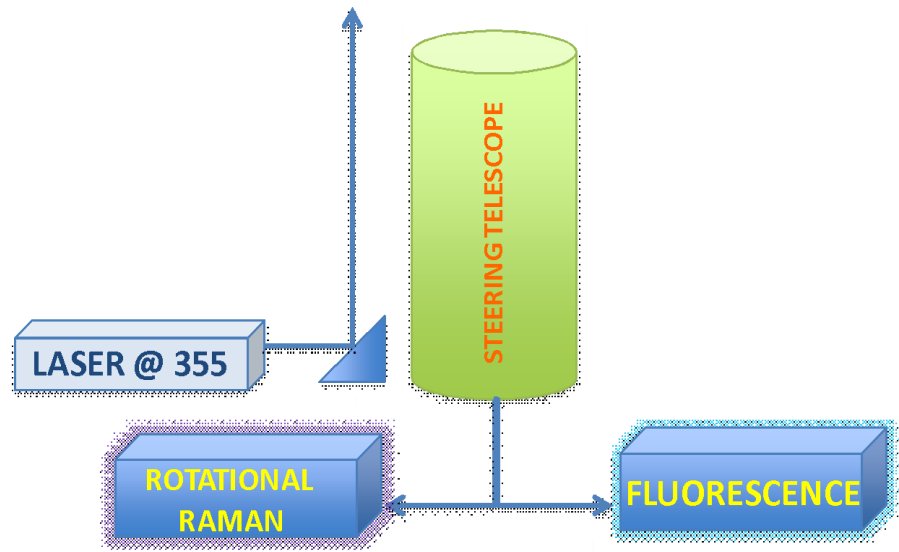
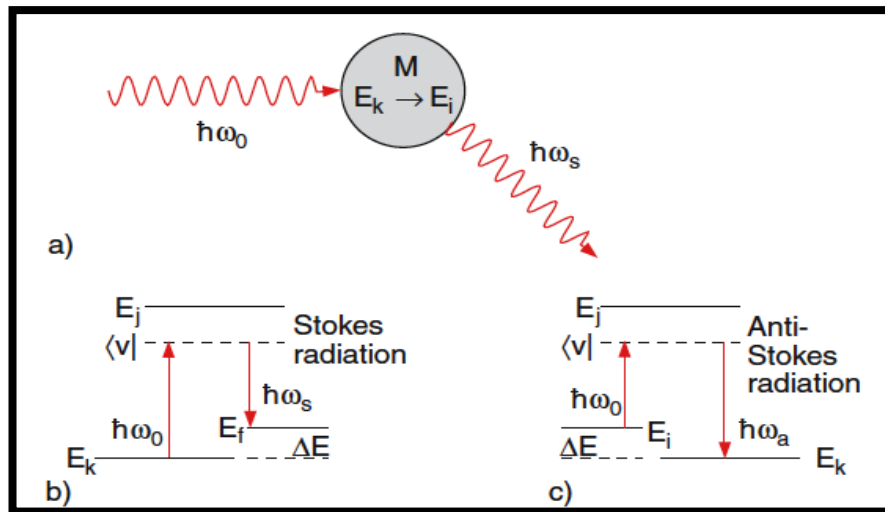
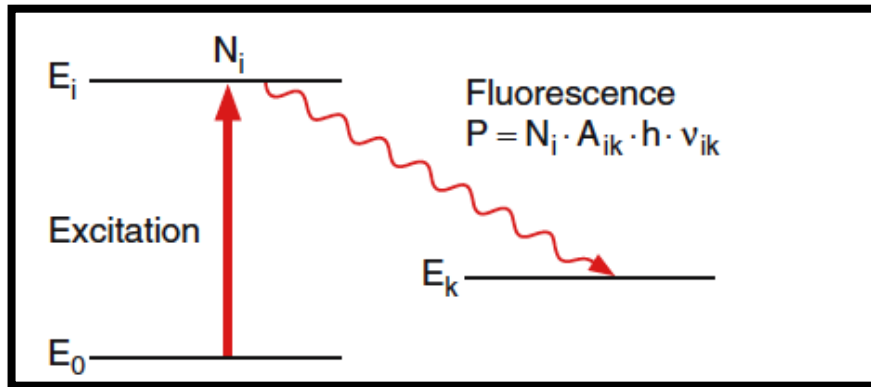
# LIDAR SYSTEMS



# Remote Sensing Gas Emission Sensor Lidar Spectrometer

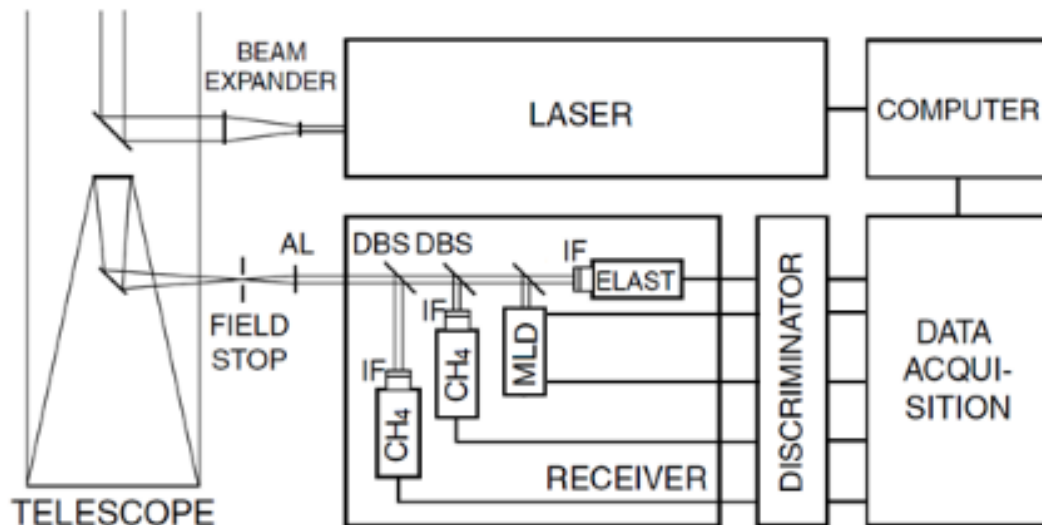


# Remote Sensing Gas Emission Sensor Lidar Spectrometer



# Fluorescence and Raman lidar

- Newtonian telescope (300 mm)
- Laser Quantel Q-smart 450 (pulse energy at 355 nm: 150 mJ, 4 nsec, 20 Hz pulses)
- Photodetection (PMT) Elastic scattering at 355 nm
- PMT Rotational and Vibrational Raman scattering at different wavelengths
- MLD 32 channel PMT with receiving electronics and spectrometer



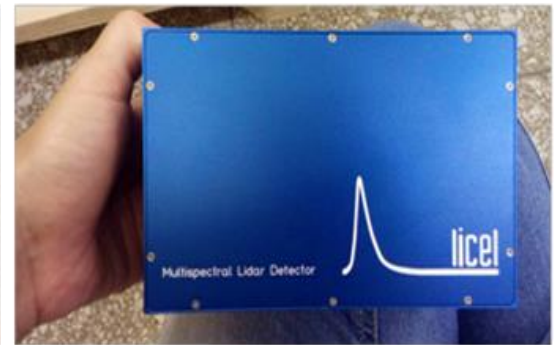
Scheme of lidar system developed. AL – achromatic lens, MLD – multispectral lidar detector, DBS – dichroic beam splitter, IF – interference filter.



MLD – multispectral lidar detector

# Activities in 2017

## Final assemblage of the LIDAR Spectrometer





# Activities in 2018

*January - March:*

Development of Monitoring Procedure; LIDAR Calibration

Visiting Researchers:

**Prof. Igor Veselovskii**

**Dr. Mikhail Korenskiy**

*Physics Instrumentation Center of the General Physics Institute,  
Moscow*

*with FAPESP support (extra from the RCGI)*

*April - July:*

Field Monitoring Campaigns

# Preliminary Results

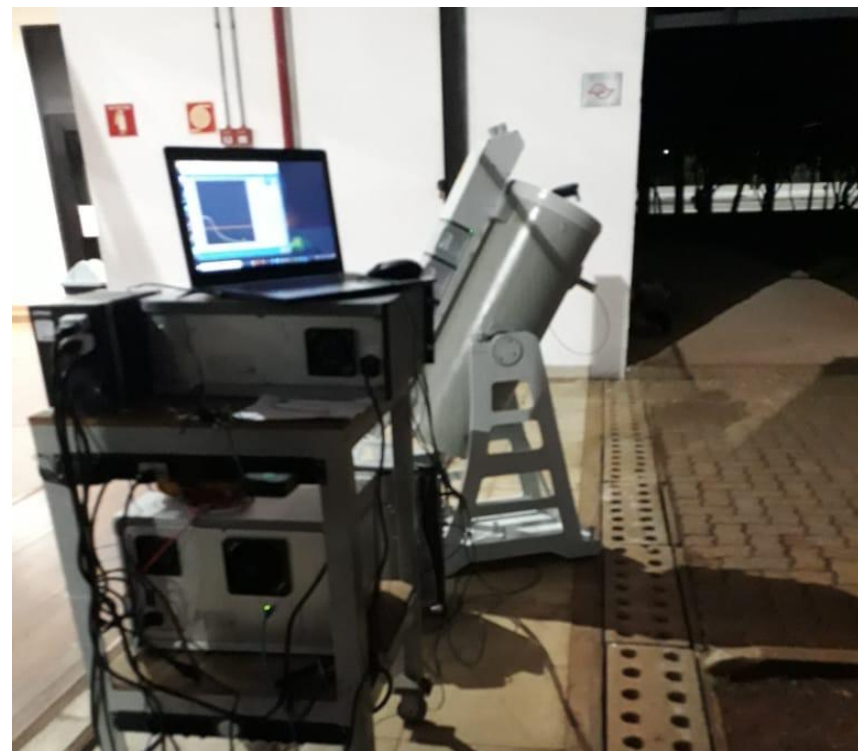
**Source calibration**

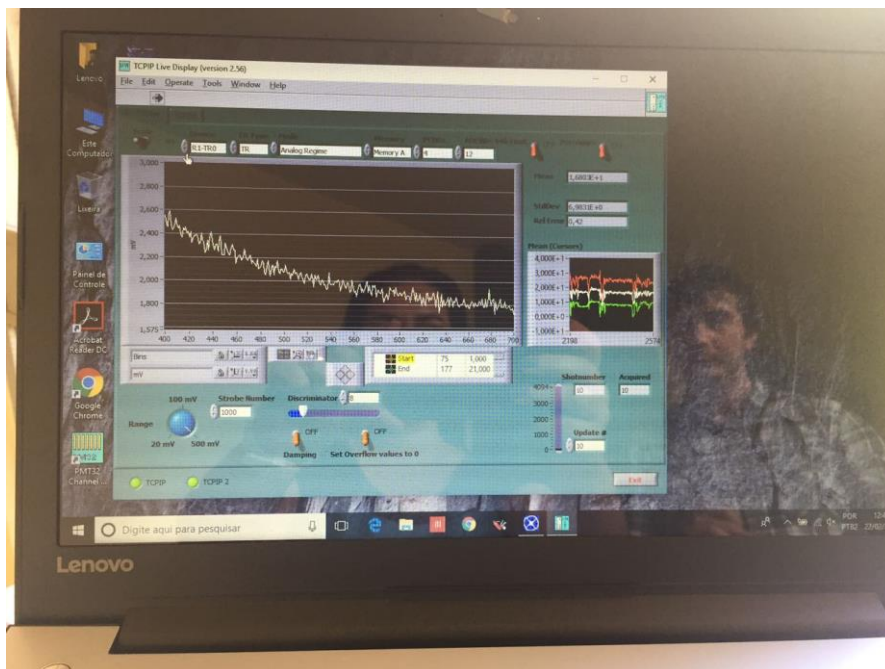
**Spectrometer tuning**

**Background fluorescence  
measurements  
(day and night)**

**Background atmospheric methane measurements  
(day and night)**

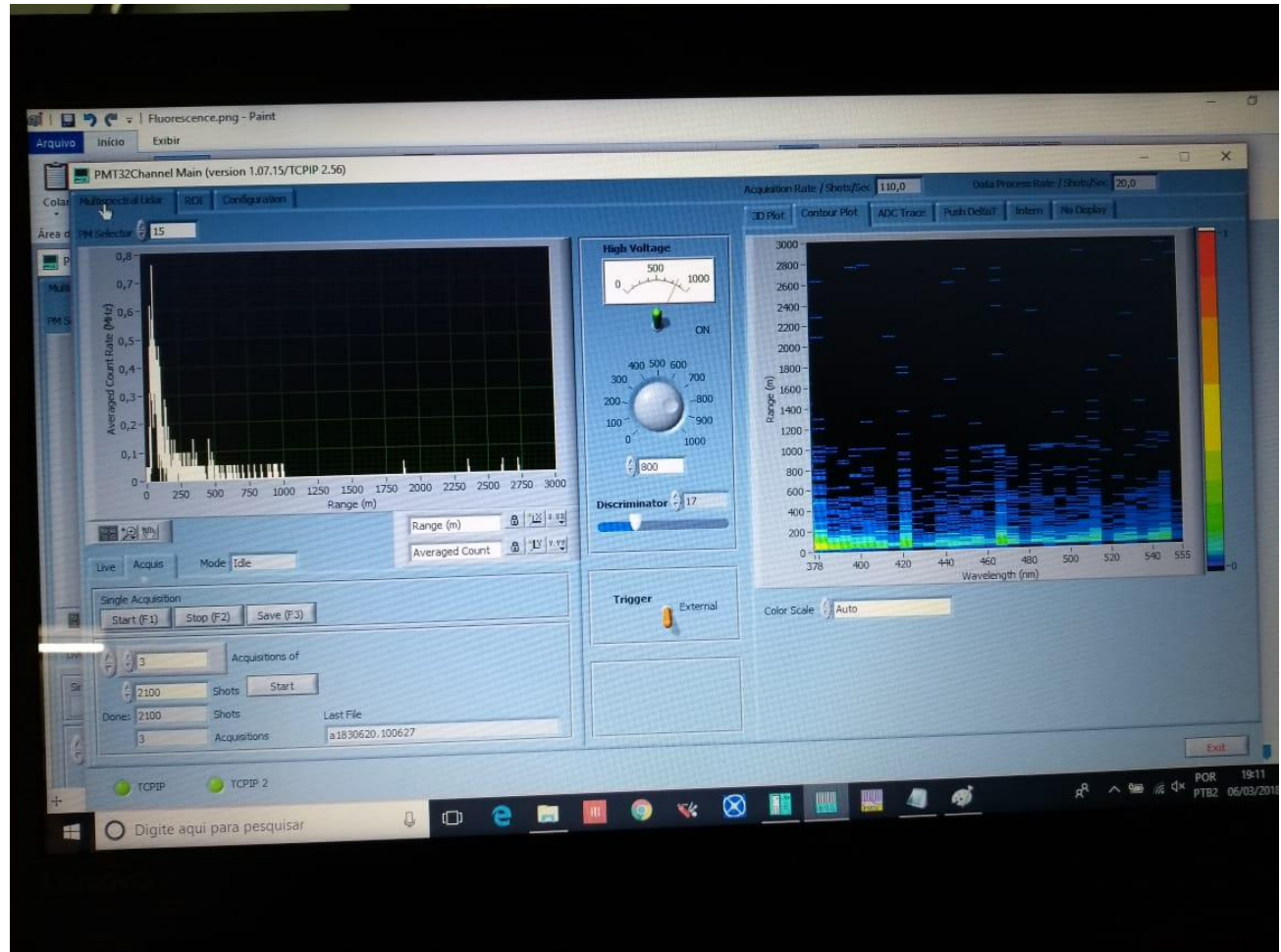
**Methane – air mixtures measurements  
in a Tunnel**





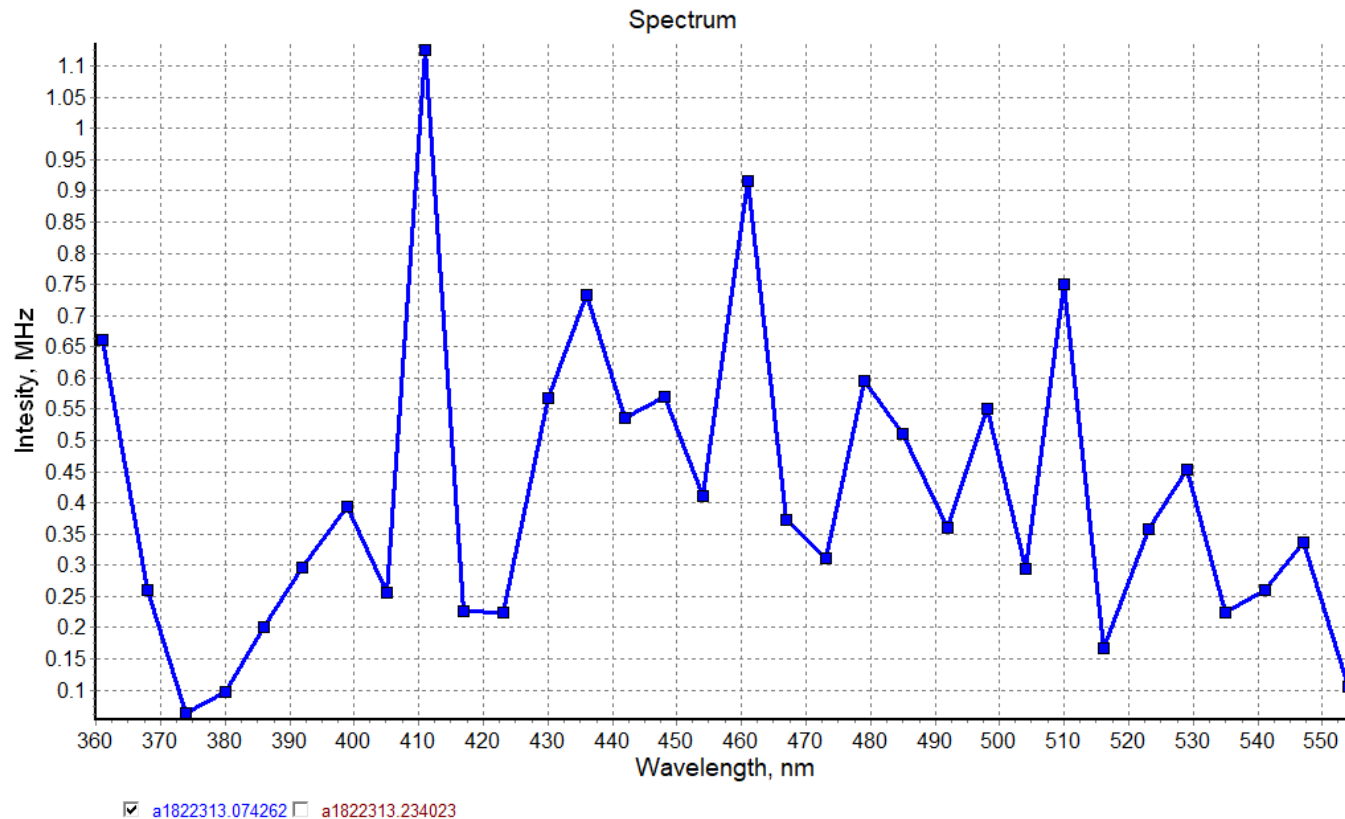
# Preliminary Results:

## *Night time atmospheric fluorescence*



# Preliminary Results:

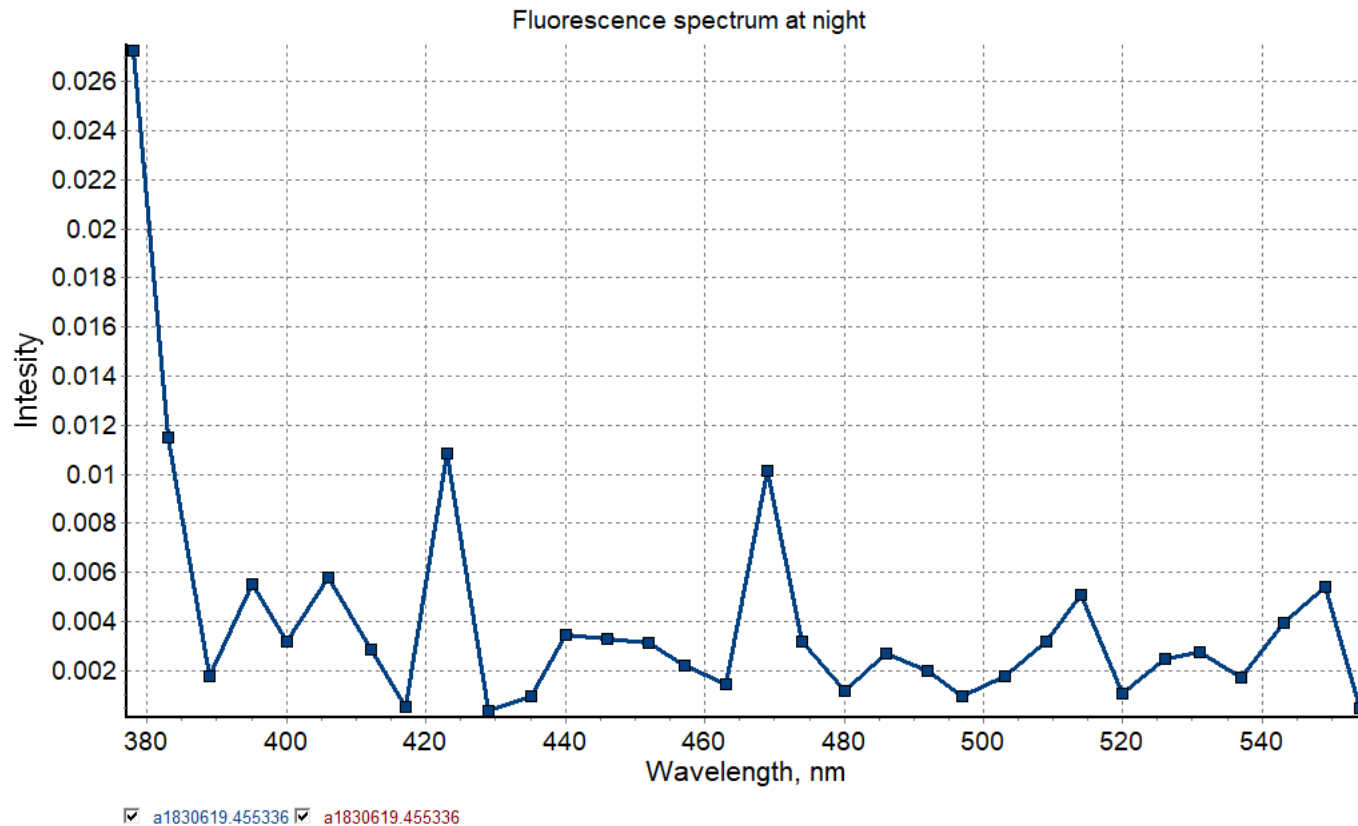
## *Day time atmospheric fluorescence*





# Preliminary Results:

## *Night time atmospheric fluorescence*

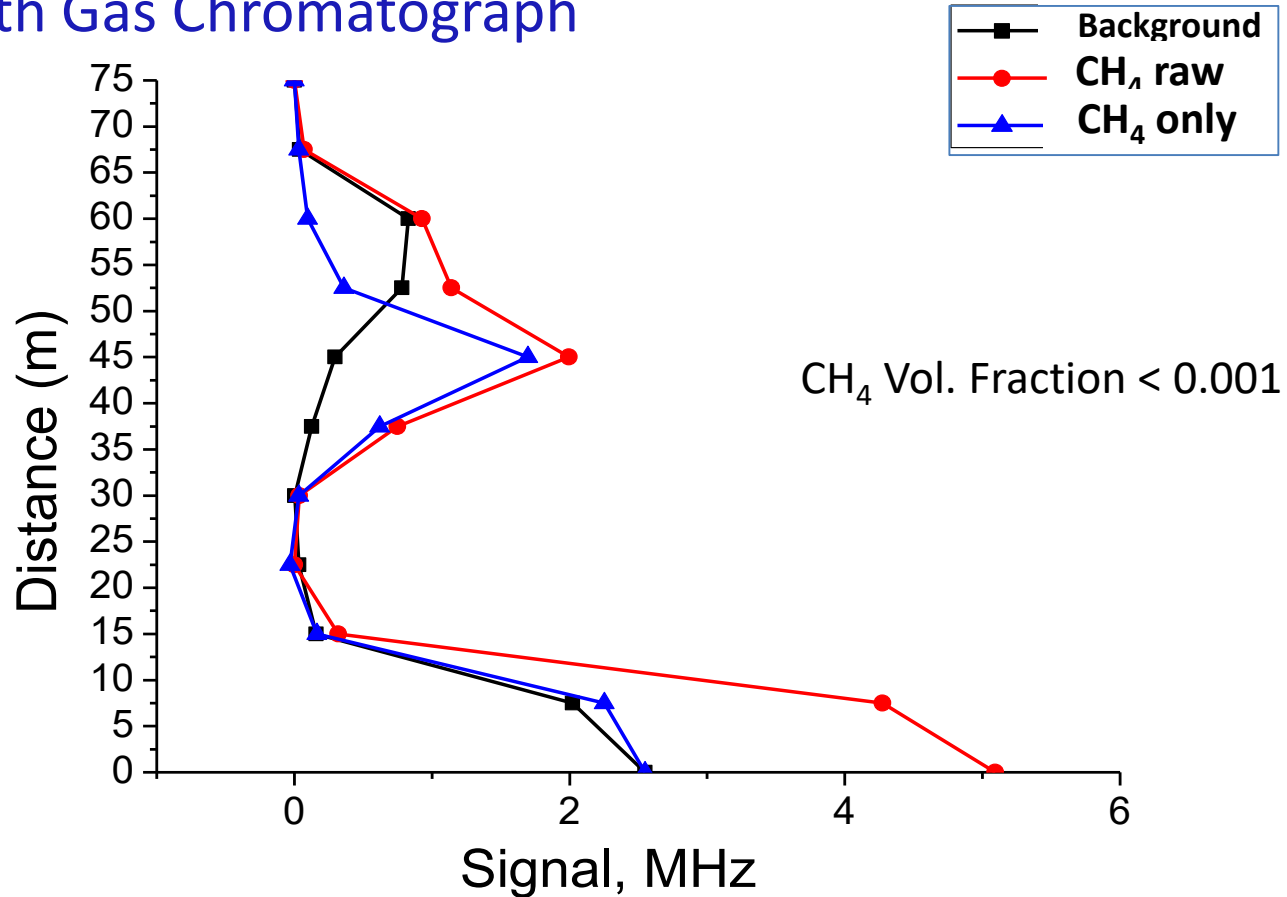


## *First tests in a Tunnel:*

for Methane Detection  
Check with Gas Chromatograph



## *First tests in a Tunnel:* Methane Detection Check with Gas Chromatograph

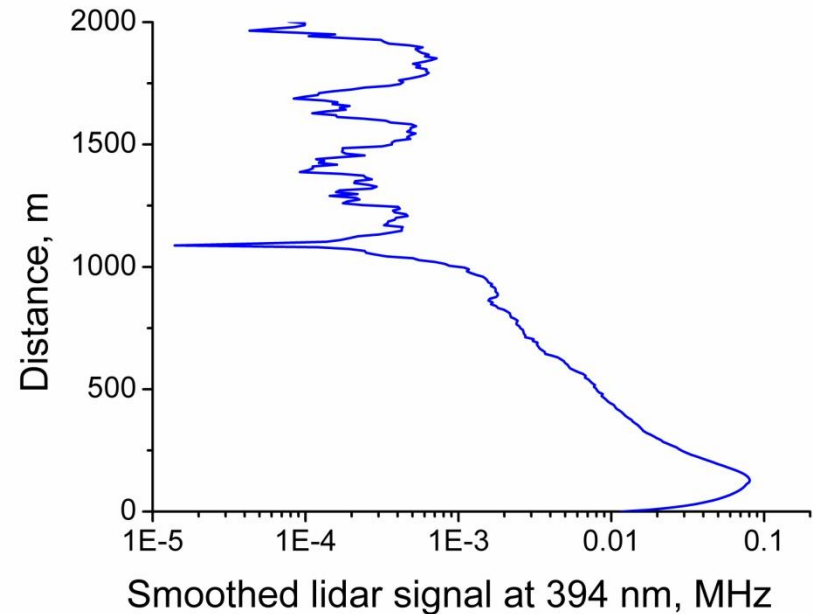
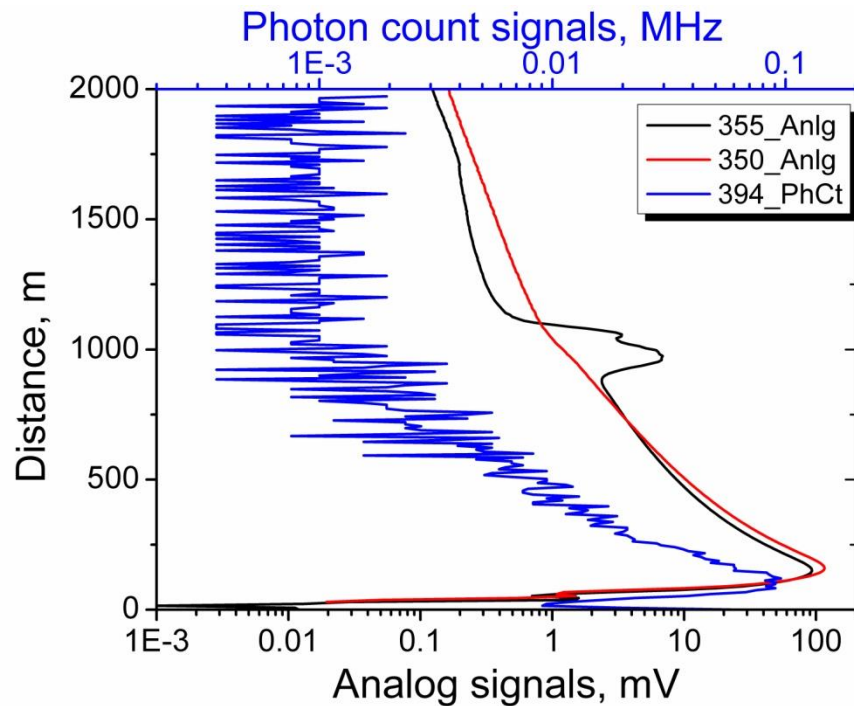




# Preliminary Results:

## *Atmospheric methane background*

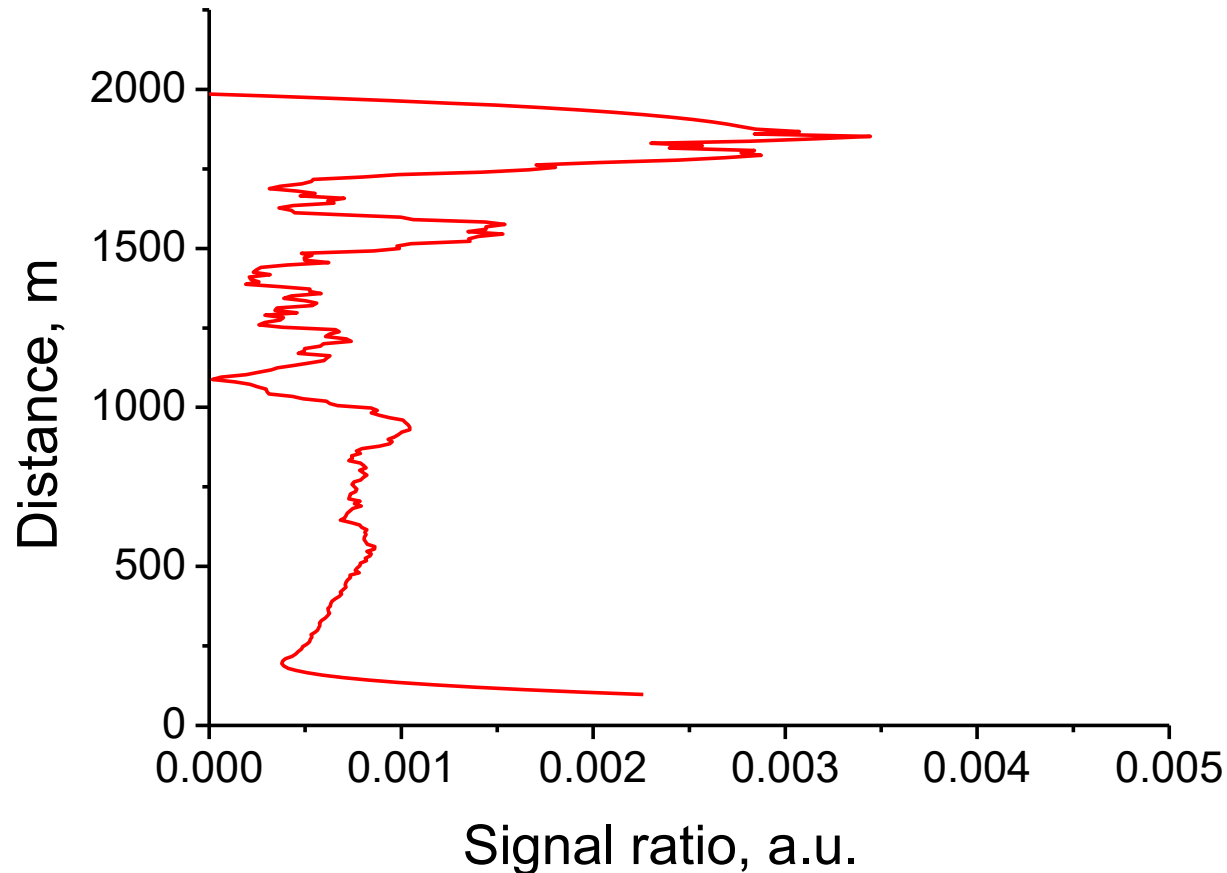
### *Raman signal*



## Preliminary Results:

*Atmospheric methane background (ca. 1.8 ppm)*

*Raman signal*





# Present Characteristics of the Lidar System

**Spatially Resolved Fluorescence from Atmosphere**

**Spectrometer tuning ability**

**Background fluorescence measurements (day and night)**

**Background atmospheric methane measurements (day and night)**

# European Lidar Conference

## Improving the Instrument and Analysis Capabilities of the São Paulo LALINET Lidar Station in the Framework of the APEL Project

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(2) Universidade de São Paulo, Instituto de Física, Rua do Matão 1371, São Paulo-SP, Brazil.

(3) Andalusian Institute for Earth System Research (IISTA-CEAMA), Av. del Mediterráneo s/n, 18006, Granada, Spain, (4) University of Granada, Fuentenueva s/n, 18071, Granada, Spain.

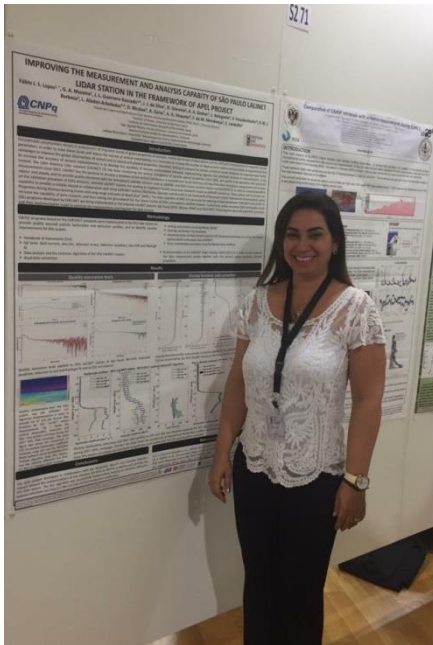
(5) National Institute of R&D for Optoelectronics, 409 Atomistilor Str., Magurele, Ilfov county – Romania.

(6) Ludwig-Maximilians-Universität, Meteorologisches Institut, Experimentelle Meteorologie, Theresienstraße 37, 80333 München, Germany.

(7) European Space Agency (ESA/ESTEC), PO Box 299, 2200 AG Noordwijk, Netherlands

### Acknowledgements

The authors would like to thank: The Research Centre for Gas Innovation - RCGI project, the CNEN/Eletronuclear scholarship project 081/2013, the CNPQ Posdoctoral program 150716/2017-6, FAPESP Project 2015/12793-0, by the University of Granada through "Plan Propio. Programa 9 Convocatoria 2013", European Space Agency – ESA and National Institute of Research and Development for Optoelectronics – INOE under the Project AO/1-8486/15/F/MOS - Assessment of atmospheric optical properties during biomass burning events and long-range transport of desert dust – APEL. This activity was initiated and financed by the ESA contract APEL, ESA contract number 4000117289. The authors also would like to thank the 2018 European Lidar Conference Committee for the travel grant award.



# Preliminary results:

***SPIE Conference, Berlin, Sept 10 -13, 2018***

**A novel lidar system for CH<sub>4</sub> and VOC's detection of fugitive emissions and environmental monitoring**

Eduardo Landulfo<sup>a</sup>, Roberto Guardani<sup>b</sup>, Fernanda M. Macedo<sup>a</sup>, Renata F. da Costa<sup>b</sup>, Antonio G. Arleques<sup>b</sup>, Mikhail Korenskii<sup>c</sup>, Igor Veselovskii<sup>c</sup>

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<sup>c</sup>A.M. Prokhorov General Physics Institute, Moscow, Russia;



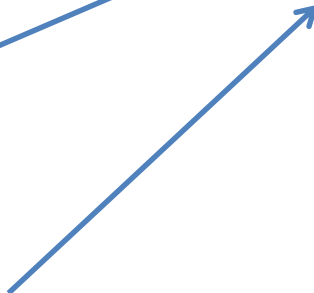
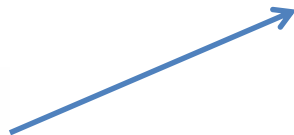
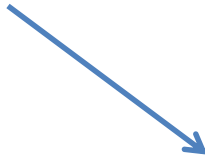
## Next Steps

*Measurements in Methane – Air Mixtures  
(long distances?)*

*Adjustment of Experimental Procedures*

*Data Treatment Algorithms*

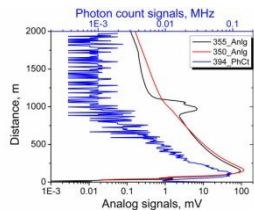
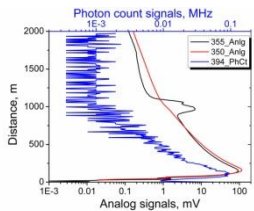
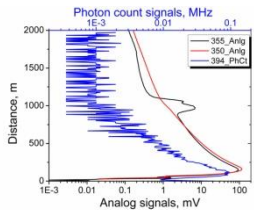
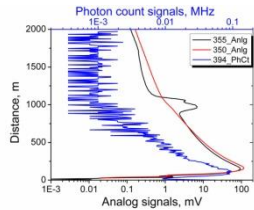
Meteorological Conditions



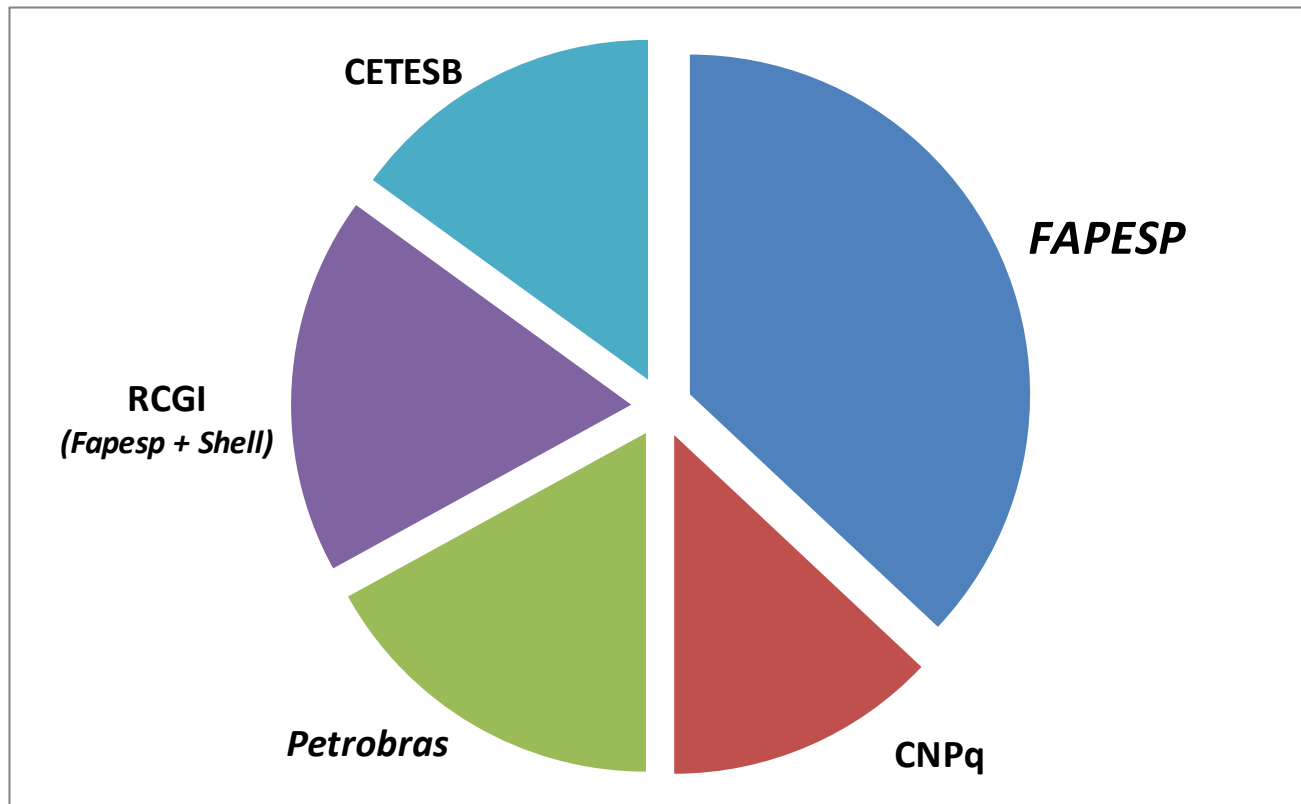
Multivariate Model (Pattern  
Recogn.)



Outputs



# Project Funding (*since 2010*)







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# THANK YOU



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