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Quantum Electronics and Plasma Physics Research Group
Industrial Engineering Department

Applicazioni ottiche per la rivelazione ed identificazione stand-off di sostanze chimiche e biologiche

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PhD Students **: MC. Carestia, F.Conetta, A.Mattoccia, E.Peluso, D. Di Giovanni, M. Del Vecchio, S. Parracino, S. Talebzahed, L.A. Poggi, J.F. Ciparisse, M. Lungaroni**

Students of Bachelor and Master Degree in Physics, Enginnering and Biology

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NUCLEAR FUSION – Magnetic Confinement

- Energy production
- Material studies (Fast particle production and radioprotection)
- Safety studies (Loss of Vacuum Accident) with STARDUST facility
- Develop of genetic code to process database to find connection and physics law (computational work)

NUCLEAR FUSION – Inertial Confinment

-Controlled nuclear explosions for energy production
-Equation state in Warm Dense Matter (Stars, giant Planets core)
-Material studies (Fast particle production and radioprotection)
-Development in diagnostic and detectors (opteration in extreme regime)
-Hydrodynamic simulations

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LASER MONITORING

-SAI - LIDAR system (smoke/pollutants at long distance)
-TELEMACO (particle analysis with laser in air at long distance)
- SNIFF – LIDAR & DIAL systems (environmental pollutants source and diffusion control)

MATERIAL SCIENCE

-Material characterization (SEM, XRD, X-ray and Optical Spectroscopy)
-New structure growth and possible applications (new detectors, specific material properties,etc…)

DIDACTICAL ACTIVITIES

-Undergraduate Courses in General Physics, Laser Systems, Fusion Energy
-Post Graduate Courses in:

- CBRNe Protection : www.mastercbrn.com (info@mastercbrn.com)
- Nuclear fusion : (segreteriafusione@gmail.com)

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TOPICS

1. S.o.A
2. Chemical Detection
3. Chemical Identification
4. Biological Detection
5. Data mining

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Detection of Chemical and Biological Agents

The state of the art

Biological Integrated Detection System (BIDS)

Joint Biological Point Detection System (JBPDS)

Canadian Integrated Biological-Chemical Agent Detection System (CIBADS)/4WARN

Smart Air Sampler System (SASS 2000)

Point Detection

Real-Time PCR (Biorad)

BioThreat Alert Test Strips (Southern Scientific)

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DESIGN AND REALIZATION OF LIDAR (ND-YAG) AND DIAL (CO_2) SYSTEMS (MOBILE) TO GET

Vapour and trace gases concentration profile measurement in low troposphere (DIAL)

Plume evolution measurements: concentration maps (DIAL and LIDAR)

Forest fire detection (LIDAR)

Pollutants source detection (LIDAR)

Particulate measurements (LIDAR)

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TECHNIQUES INTEGRATION

LIDAR

Used to detect accidental or intentional releases at long distances (from 0 to 2-3 Km)

It is useful for a first alarm

DIAL

Used to identify extraneous/unknown/foreign substances at shorter distances (from 0 to 1 Km)

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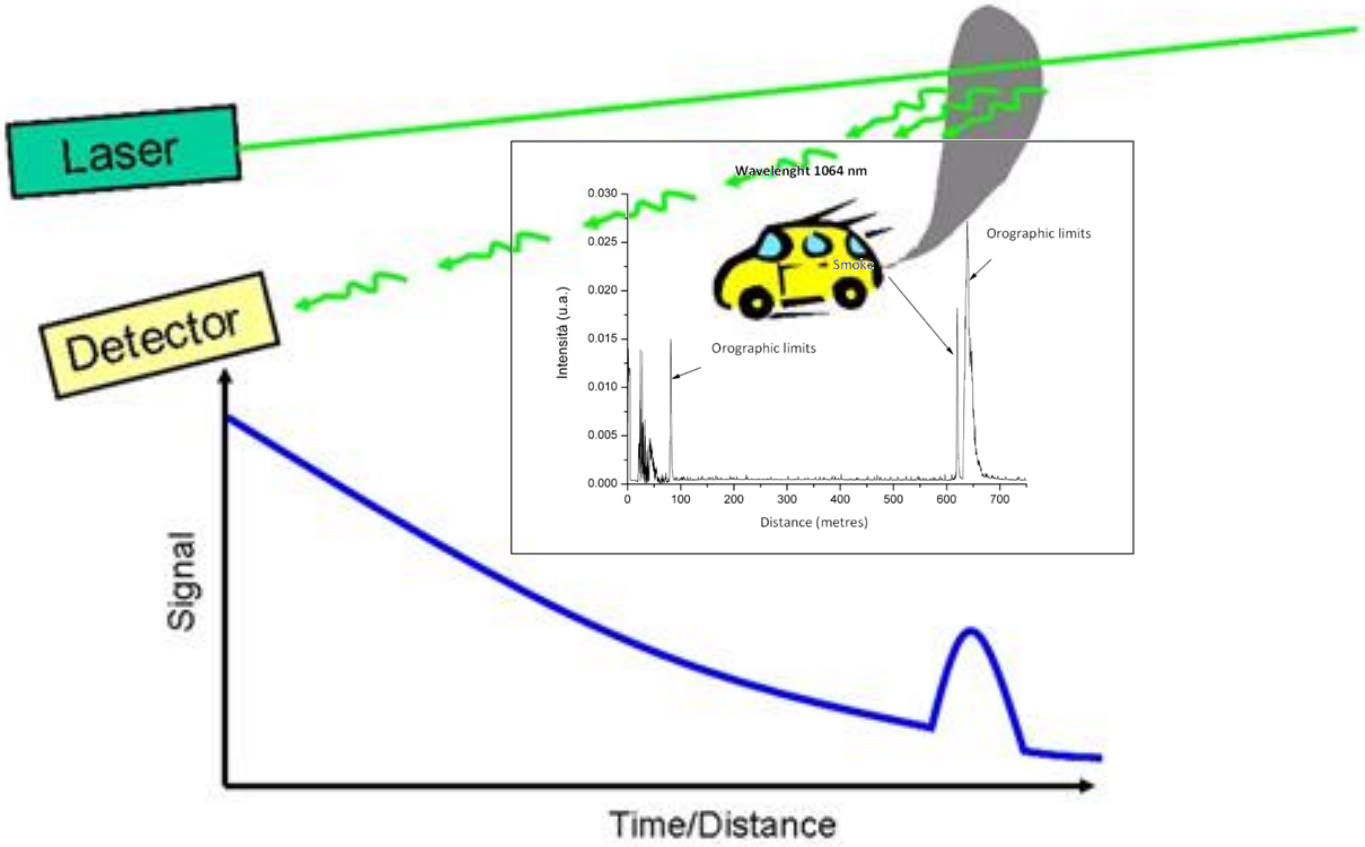
LIDAR – DETECTION



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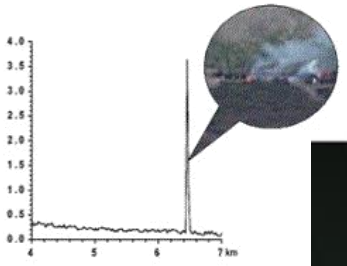
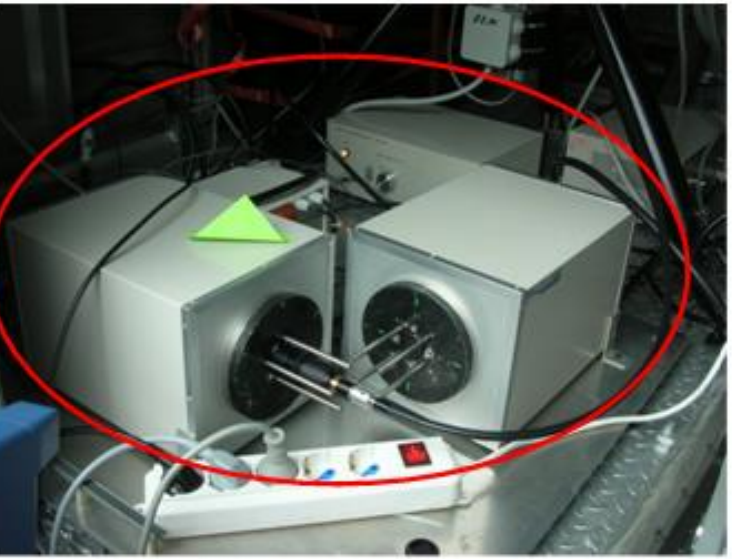
Chemical Detection

LIDAR – DETECTION

RECEIVER	
Telescope type	Newtonian
Nominal focal length	1030 mm
Primary mirror diameter	210 mm
Detector	Photomultiplier (PMT)
Photocathode sensibility	0.256 mA/W
Response time	28 ns





TRANSMITTER	
Laser	Q-switch Nd:Yag
Energy pulse at 1064 nm	360 mJ
Pulse time width	5 ns
Divergence angle	0,5 mrad
Pulse Frequency	10 Hz

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LIDAR – DETECTION

Mini-Lidar unit (operating at 1064 nm).

It consists of an assembled and easily transportable compact lidar system. In this picture the configuration is monostatic and biaxial. The transmitter is a Nd:YAG laser and the receiver system is based on a Cassegrain telescope and a Si-APD module. The whole apparatus is mounted on altazimuthal system.

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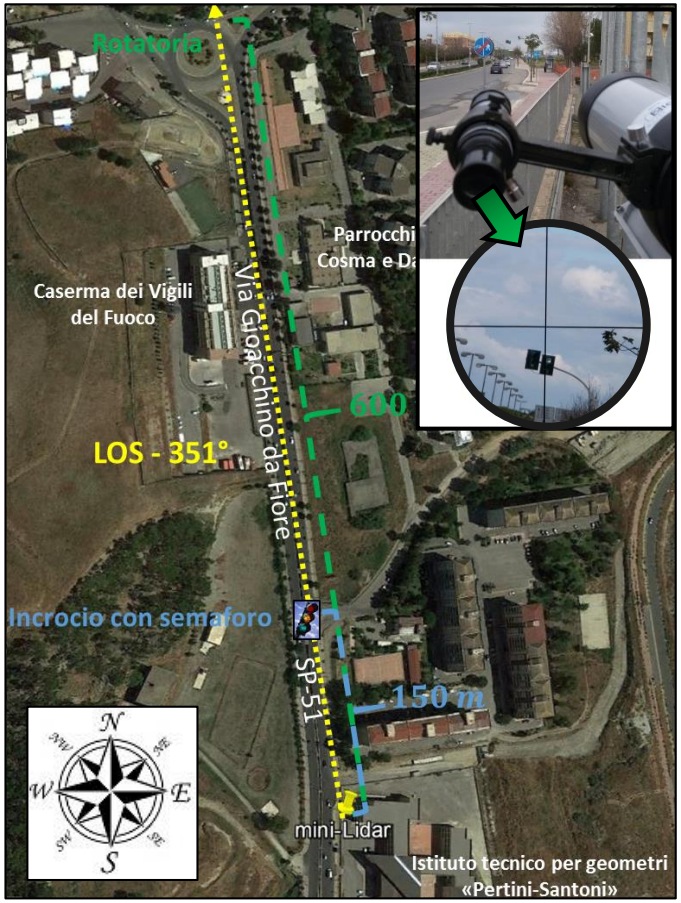
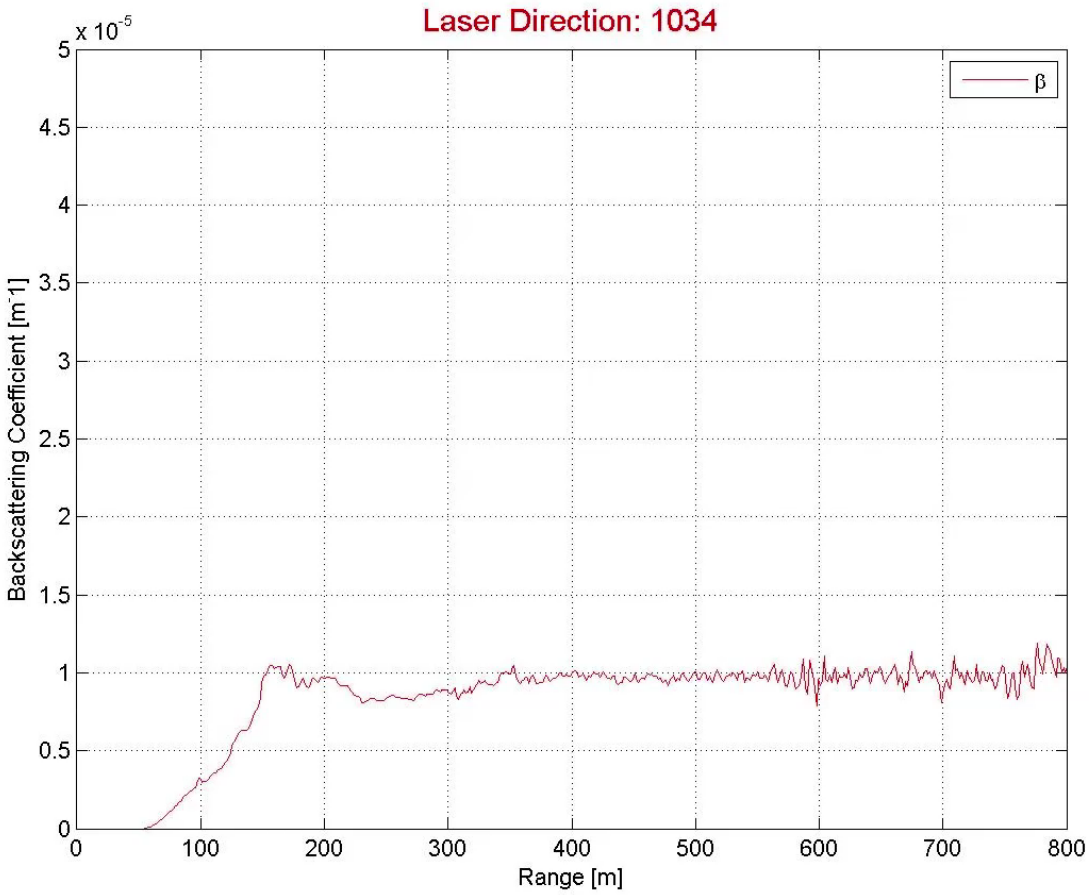
LIDAR – DETECTION





Chemical Identification

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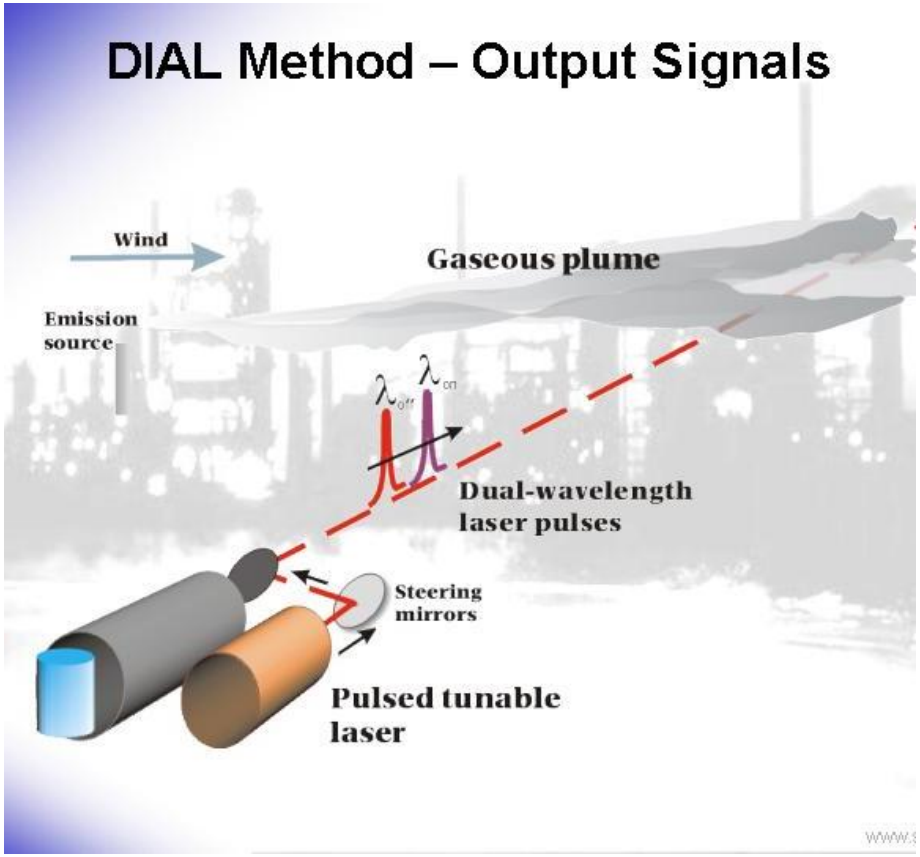

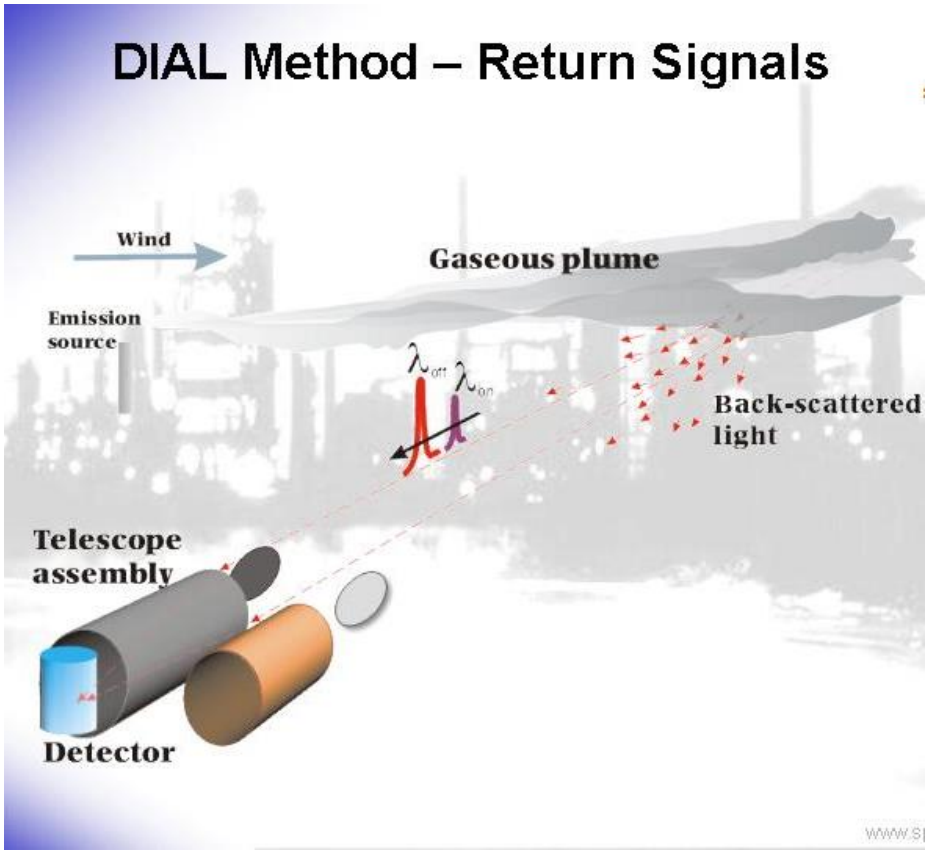

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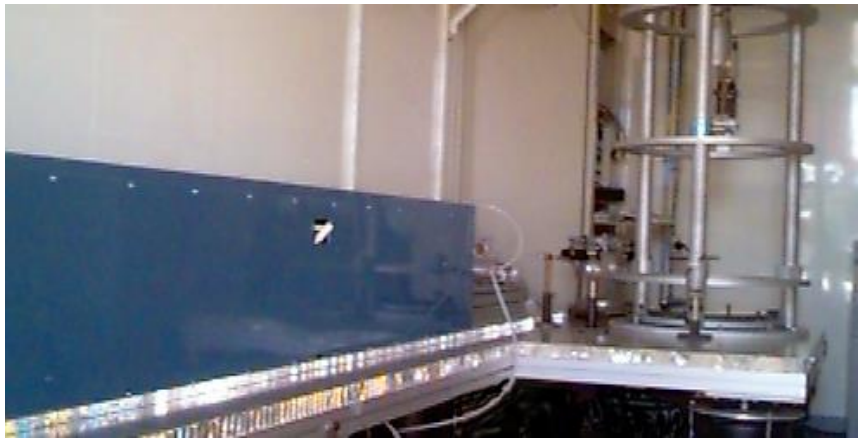

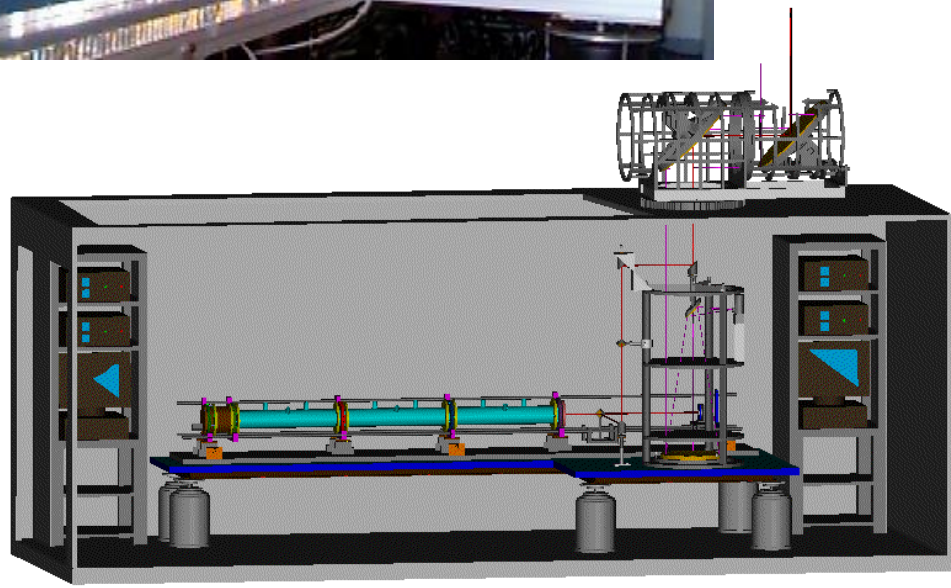

TEA CO2 laser (tunable on 80 lines)	
Output Energy	500 mJ
Pulse width	100 ns
Beam divergence	0.77 mrad
Spectral range	9÷11μm

Chemical Identification

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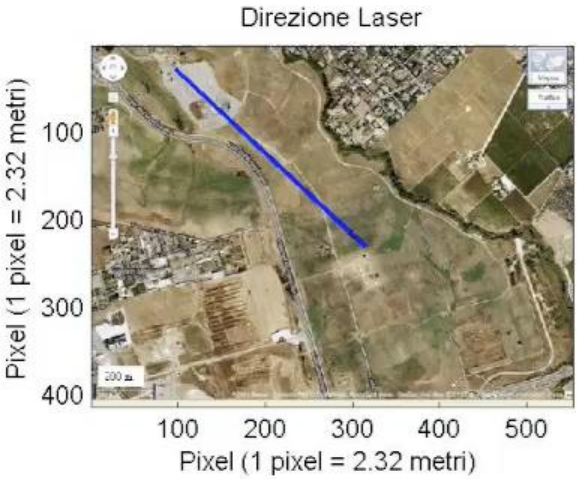

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Present Research

Development of methodologies of a multi-wavelength analysis in order to identify in atmosphere CWA agents.

PROBLEM

THE IDENTIFICATION IN ATMOSPHERE OF TOXIC CHEMICAL AGENTS

No, it is not possible because of interfering substance with similar functional set

Is it possible to identified a particular gas in atmosphere using only two wavelength (DIAL method)?

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Each molecule can be identified if its absorption spectrum is known

INCREASING THE WAVELENGTHS USED IN DIAL METHOD ALLOWS TO IDENTIFY CHEMICAL WA COMPOUNDS IN ATMOSPHERE

Chemical Identification

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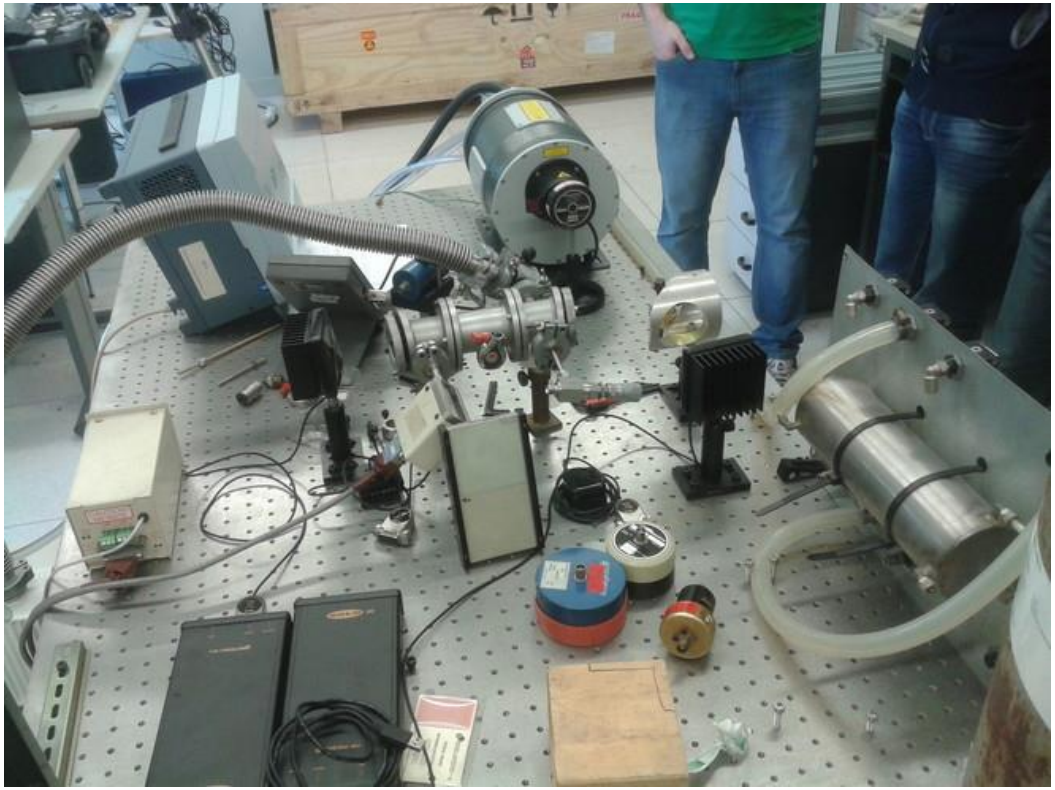

The **mini-CO_2** system developed, based on DIAL technique, is born by a research project in collaboration with Italian Army in order to obtain a remote, stand-off identification of (CWAs), (TIMs) and (TICs).

Chemical Identification

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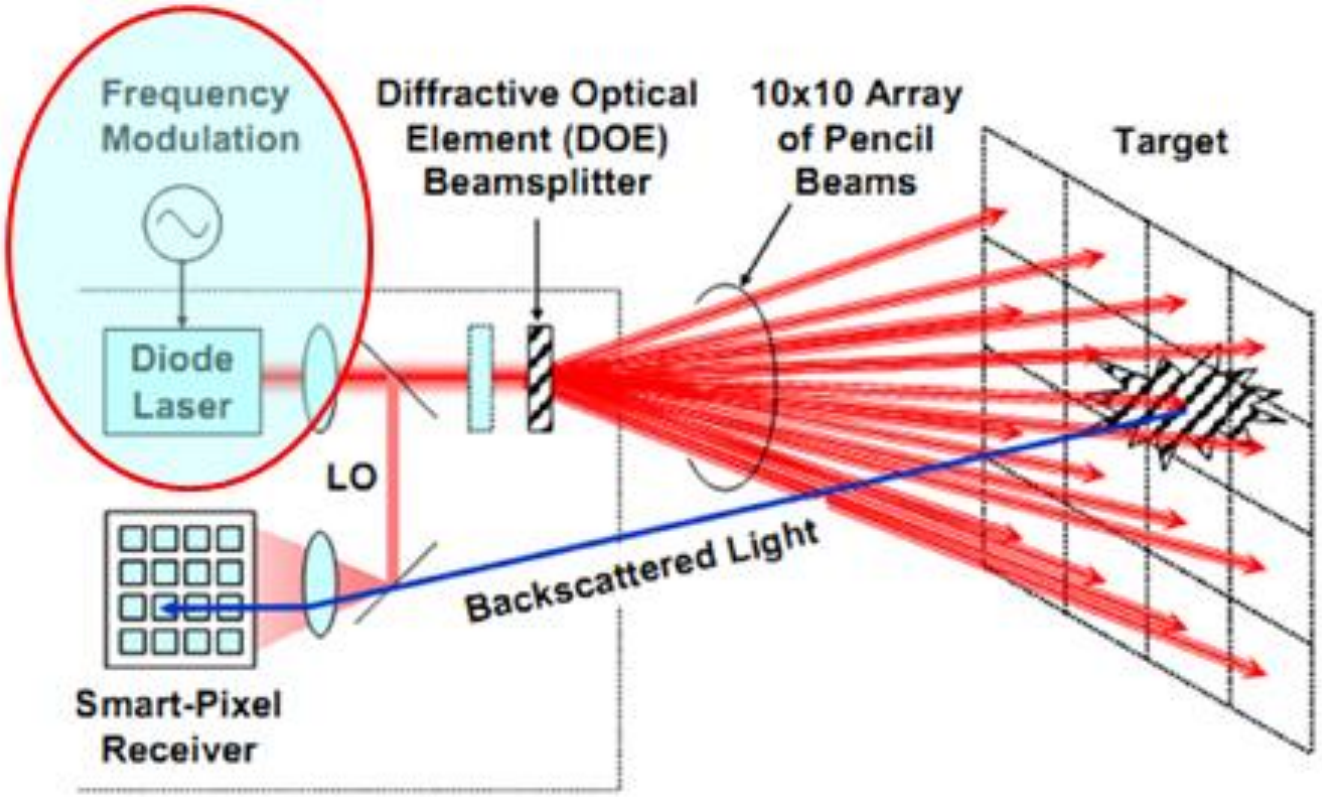

TO REDUCE THE COST FOR C detection/IDEN TIFICATION

LASER DIODE

DISVANTAGES : Reduced spatial range

Biological Detection

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We are currently investigating the capability of discriminating between different biological warfare agents simulants (BWA-S) through the analysis of the optical emission spectra.

Exploiting the endogenous fluorophores present in BAs and their ability to produce fluorescence when excited with UV radiation, we are currently design and realize a Biological Warfare Agents simulant (BWA-S) spectral database for the automatic discrimination in unconventional scenarios using a novel adaptative algorithm

LUMINESCENCE MICROANALYSIS TECHNIQUES

TOXINS, BACTERIA AND BACTERIAL SPORES

UMEL

UNIVERSAL TECHNIQUE BASED ON SUPPORT VECTOR REGRESSION FOR FUNCTION ESTIMATION.

Particular attention is paid to a standardization of the preparation of the sample and the method

First step towards the implementation of a spectral database and a laser-based biological stand-off identification technique

Biological Detection

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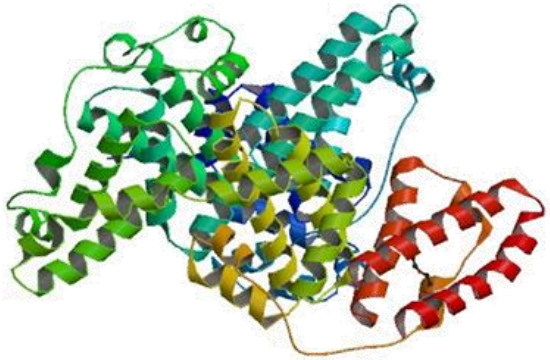
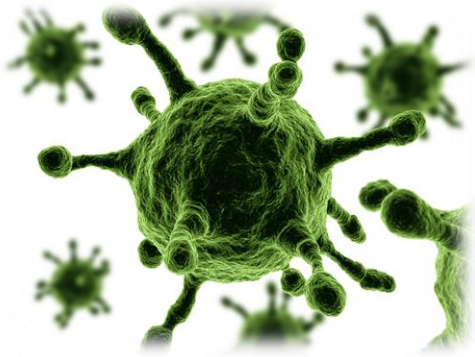
Toxins
- Bovine Serum Albumin (BSA)
- Ovalbumin (OVA)

RICIN
BOTULINUM



Bacterial spores
- *Bacillus subtilis* var. *globigii* (BS)
- *Bacillus thuringiensis* (BT)

BACILLUS ANTHRACIS



Vegetative bacteria
- *Escherichia coli* K12 (*E. coli*)
- *Bacillus subtilis* (*B. subtilis*)

GRAM -

GRAM +

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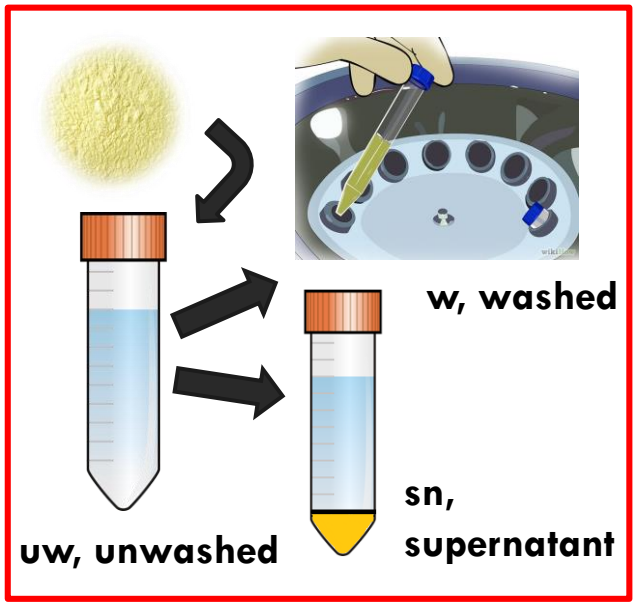
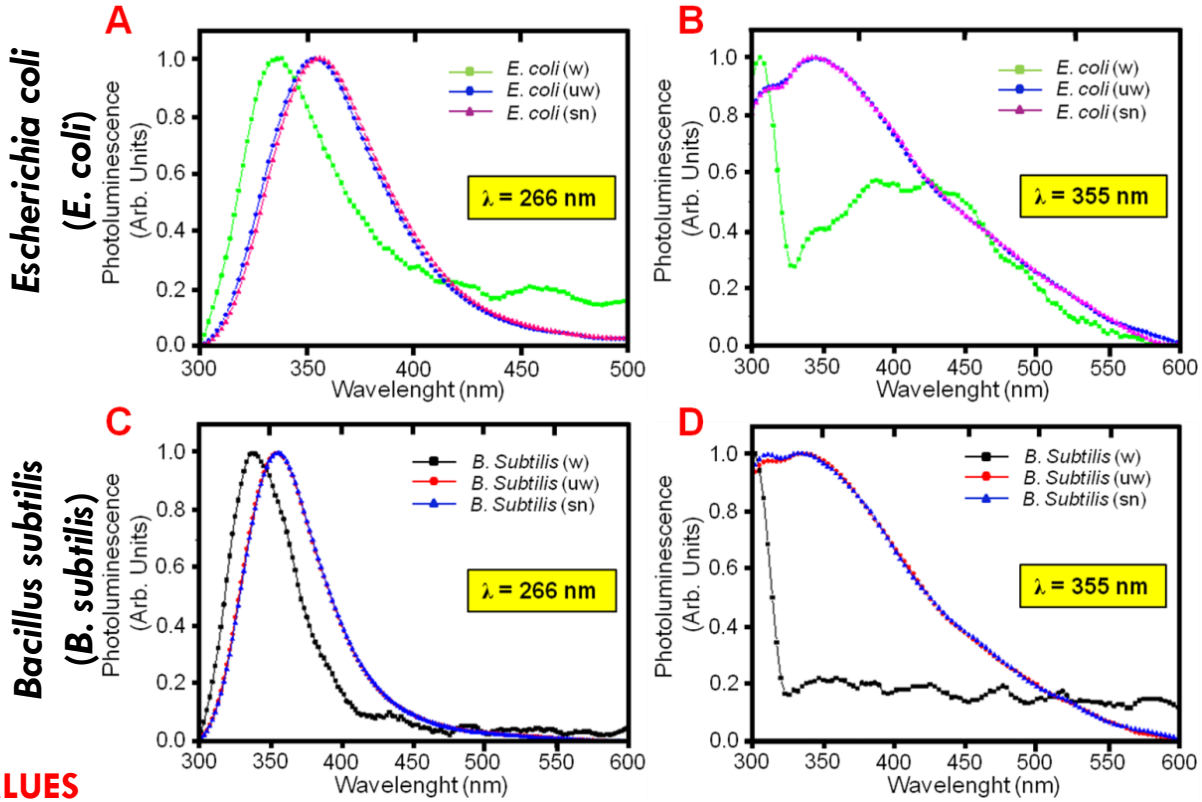
Fluorescence measurements of bacterial spores simulants and vegetative bacteria simulants





SPECTRA NORMALIZED AT THEIR PEAK VALUES

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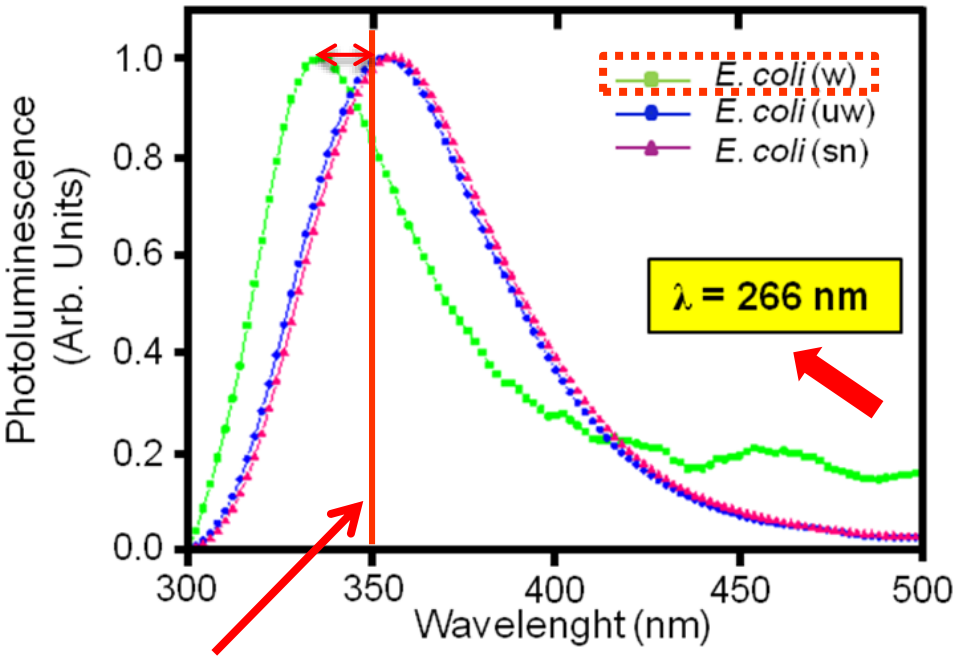
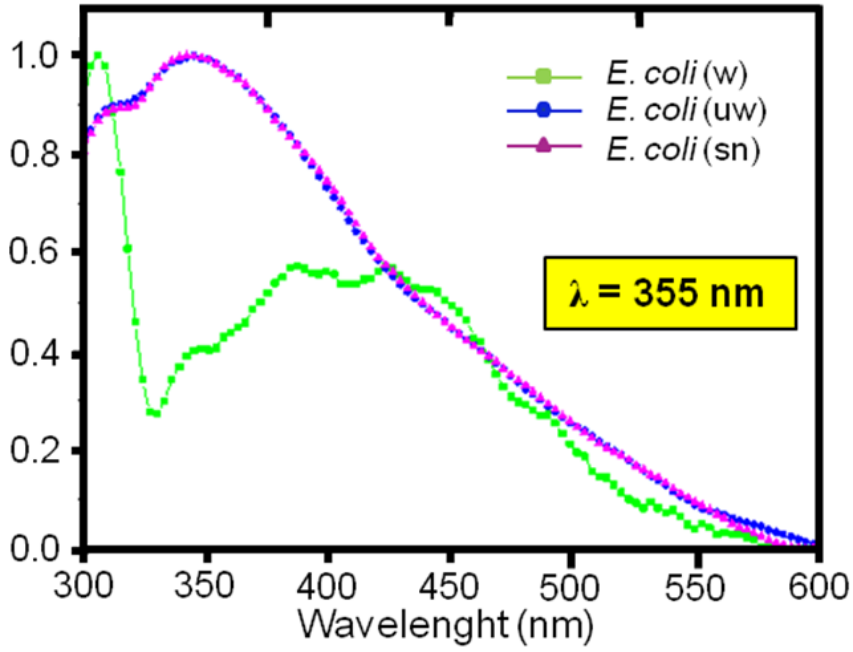
Fluorescence measurements of bacterial spores and vegetative bacteria simulants



Trp peak, 350 nm



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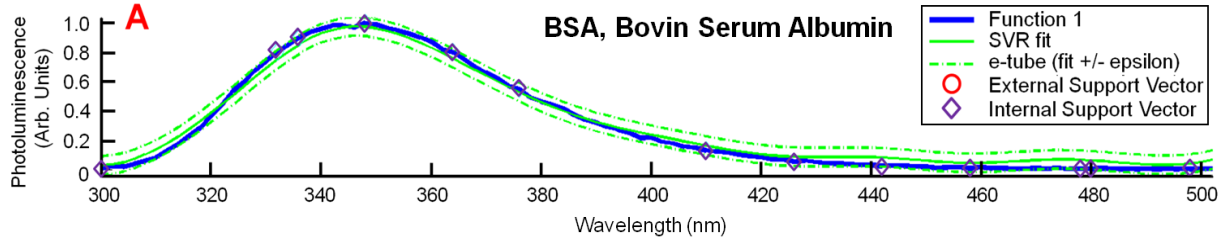
Application of the UMEL algorithm

DISCRIMINATION BETWEEN DIFFERENT CLASSES OF BIOLOGICAL AGENTS

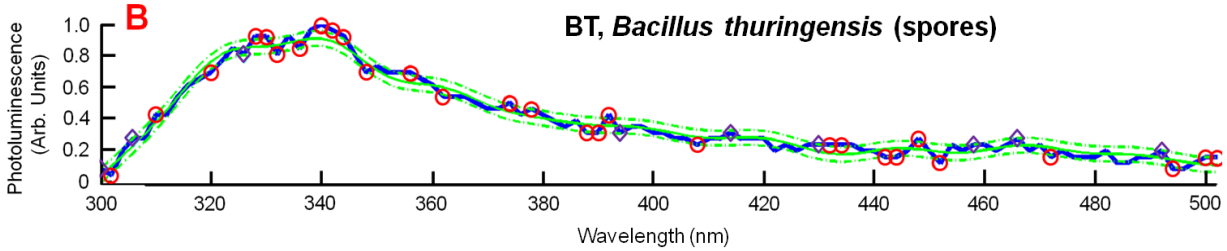
PROTEINS VS WASHED BACTERIAL SPORES AND WASHED VEGETATIVE BACTERIA

PROTEIN



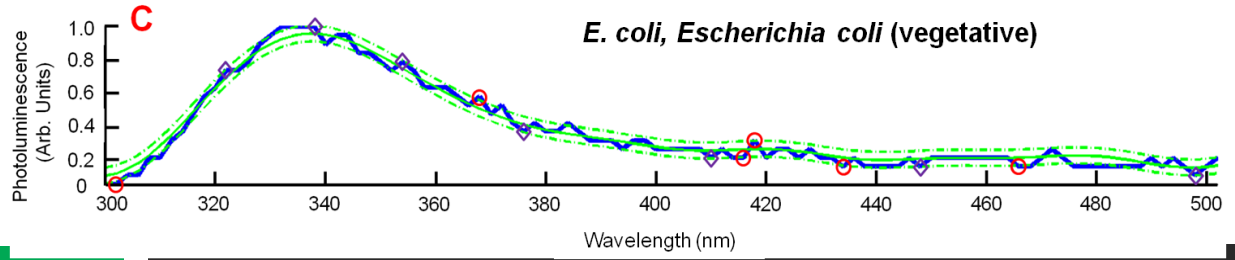
NO ESVs

SPORES



YES ESVs

VEGETATIVE BACTERIA



YES ESVs

λ_{exc} = 266 nm

Biological Detection

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