Quantum Electronics and
Plasma Physics
Research Group

Università di Roma
Tor Vergata

Applicazioni laser per analisi ambientali, energetiche e nel settore della sicurezza

Pasqualino Gaudio[1],

Andrea Malizia[1], Michela Gelfusa[1], Daniele Di Giovanni[1], Mariachiara Carestia[1], Luca Antonelli[1,2], Francesco Barbato[1], Emmanuele Peluso[1], Stefano Parracino[1], Maria Del Vecchio[1], Orlando Cenciarelli[1], Ivan Lupelli[1,3], Fabrizio D'Amico[1], Alessandro Sassolini[1], Carlo Bellecci[1] and Maria Richetta[1].

1. Department of Industrial Engineering, Quantum Electronics and Plasma Physics Research Group, University of Rome "Tor Vergata", Via del Politecnico 1, 00133 Rome, Italy
2. Université Bordeaux 1, CNRS, CEA, CELIA (Centre Lasers Intenses et Applications), UMR 5107, F-33405 Talence, France
3. EURATOM/CCFE Association, Culham Science Centre, Abingdon, United Kingdom

Andrea Malizia , born 18/07/1980

-RESEARCHER AT DEPARTMENT OF INDUSTRIAL ENGINEERING, UNIVERSITY OF ROME «TOR VERGATA»
-DIDACTICAL COORDINATOR OF POST GRADUATE COURSES IN PROTECTION AGAINST CBRNE EVENTS
-TUTOR ASSISTANT in PHYSICS, LASER APPLICATION AND CBRNE PROTECTION

- **PhD in Quantum Electronics and Plasma Physics**
- **2° level Post Graduate Course in Protection against CBRN events**
- **Master Degree in Environmental Engineering**

Contacts:
Office : +39 0672597202
Mobile : +39 3666000132
E-Mail: malizia@ing.uniroma2.it

Senior **: Prof. Carlo Bellecci, Dr. Pasquale Gaudio, Dr. Maria Richetta, Dr. Piergianni Medaglia**

Researcher **: M.Gelfusa, A.Malizia**

PhD Students **: L.Antonelli, MC. Carestia, F.Conetta, A.Mattoccia, A.Moretti, D.Scarpellini, E.Peluso, D. Di Giovanni, M. Del Vecchio, S. Parracino, S. Talebzahed.**

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

NUCLEAR FUSION – Magnetic Confinement

- Energy production
- Material studies (Fast particle production and radioprotection)
- Safety studies (Loss of Vacuum Accident) with STARDUST facility
- Develope 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

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)

TOPICS

1. **Laser systems developed**
2. **Early detection of Forest Fires**
3. **Detection of TICs, TIMs , CWA**
4. **Detection of BWA**

Design and realization of lidar (Nd-YAG) and dial (CO_2) systems (mobile) to get:

- Water vapour and trace gases concentration profile measurements in low troposphere. (dial)
  - PBL evolution study.
- Plume evolution measurements: concentration maps. (dial & lidar)
- Forest fire detection (dial & lidar)
- Pollutants source detection (lidar)
- Particulate measurements (lidar)
- Absorption cell measurements: gas trace detection

gaudio@ing.uniroma2.it

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TECNIQUES INTEGRATION

LIDAR Tecnhique

- Used to detect accidental or intentional releases at long distances (from 0 to 2-3 Km) . It is useful for a first alarm

DIAL tecnhique

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

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The LIDAR technique is a quite powerful experimental method for the exploration of the atmosphere

LIDAR technique for forest fires detection has been investigated numerically and with laboratory tests

The QEP Research Group demonstrate the capability of the developed system (portable and automated)to detect smoke plumes of even small amounts of combusted material (equal to1kg).

1. Laser systems developed

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The LIDAR system, whose results are presented in this paper, consists of an optical apparatus of transmission/detection assembled in biaxial configuration.

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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1. Laser systems developed

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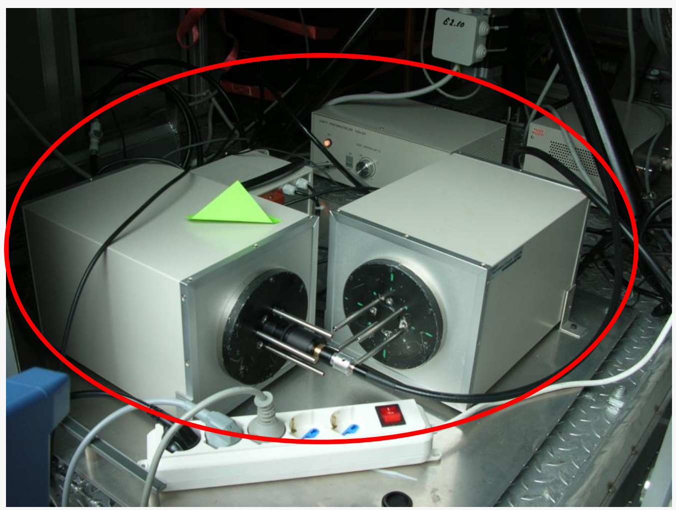
RECEIVER	
Telescope type	Newtonian
Nominal focal length	1030 mm
Primary mirror diameter	210 mm
Detector	Photomultiplier (PMT)
Photocathode sensibility	0.256 mA/W
Response time	28 ns



1. Laser systems developed

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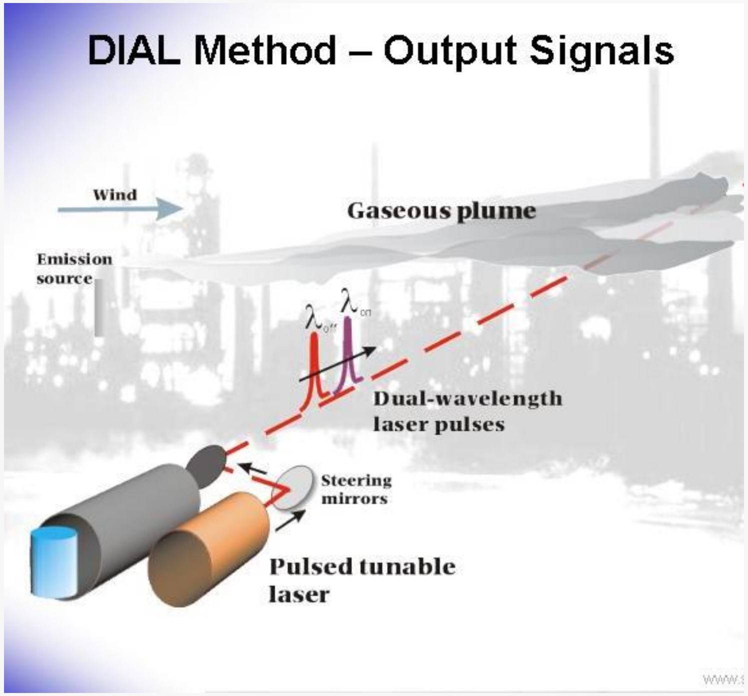
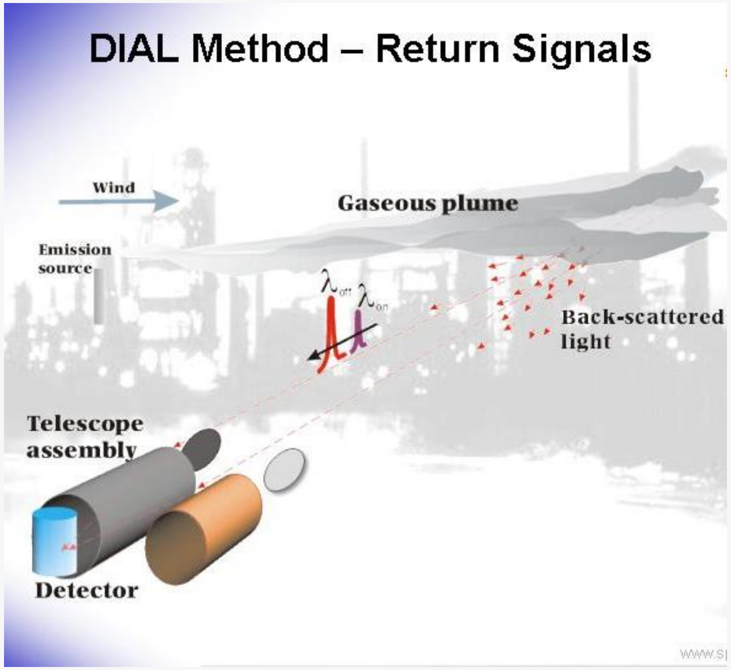
DIAL

DIfferential Absorption of Light





1. Laser systems developed

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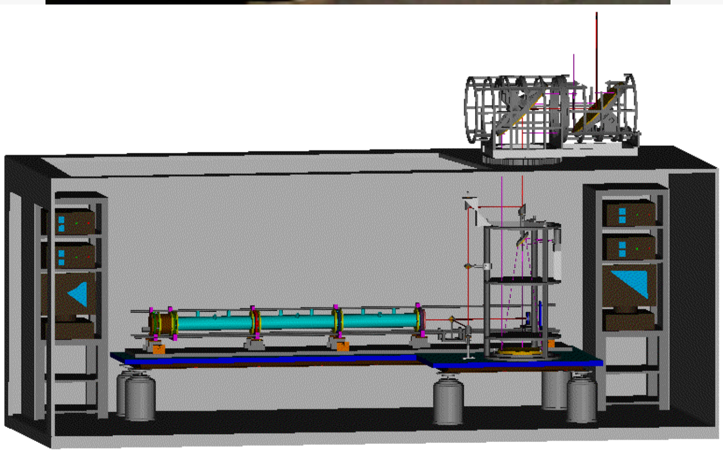

TEA CO2 laser (tunable on 80 lines)	
Output Energy	500 mJ
Pulse width	100 ns
Beam divergence	0.77 mrad
Spectral range	9÷11μm

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2. Early detection of Forest Fires

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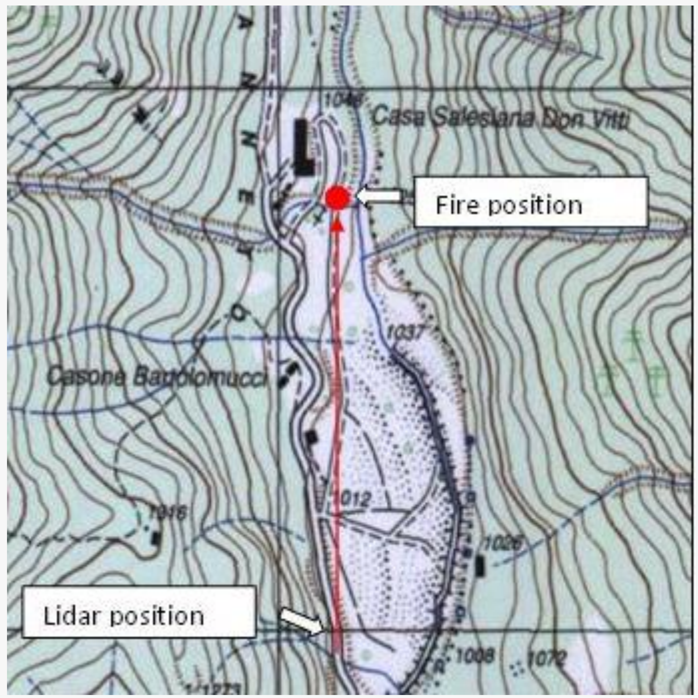
The purpose of the measurements performed is firstly to verify the capability of the system to detect particles in air

A quite small fire was lighted into a box at a distance of about 700 metres from the system



2. Early detection of Forest Fires

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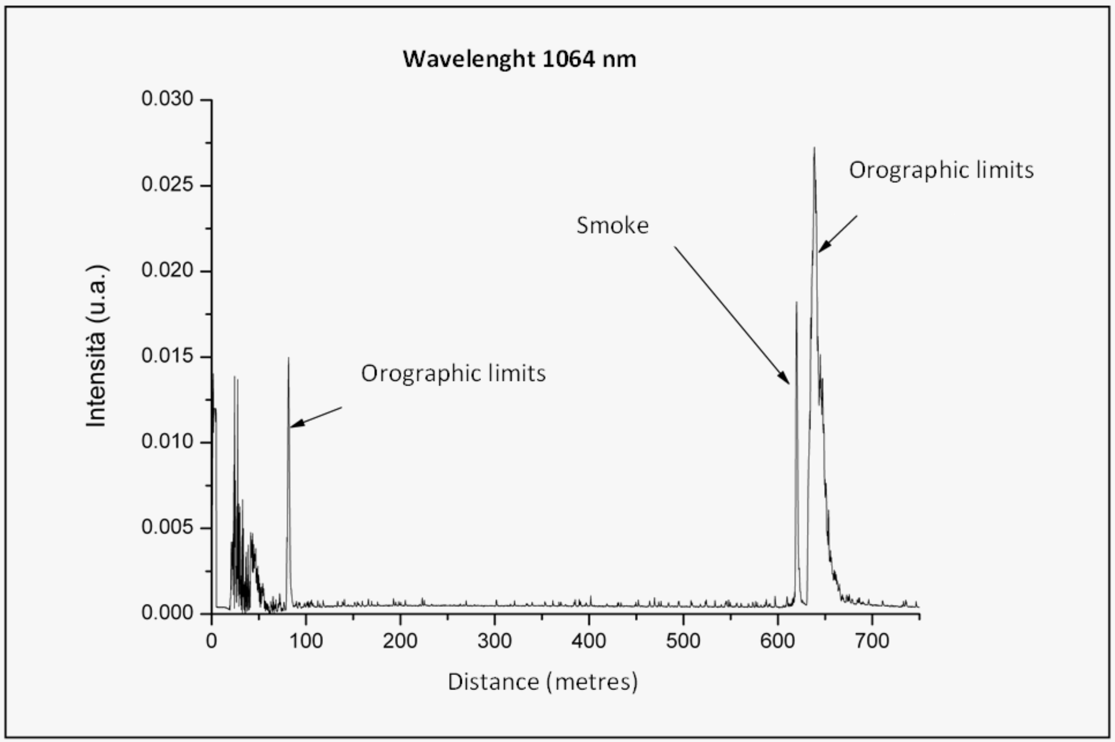
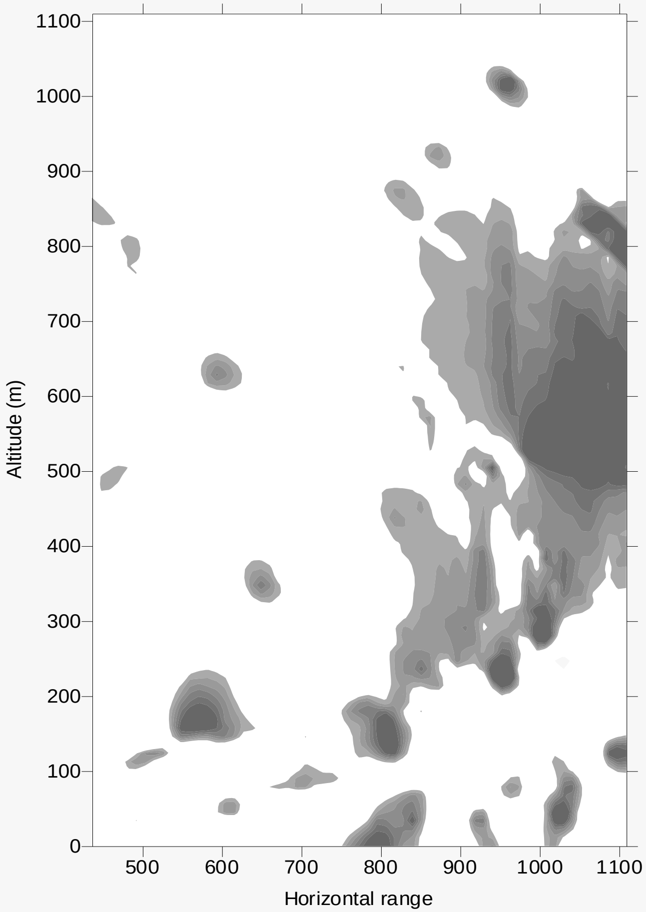
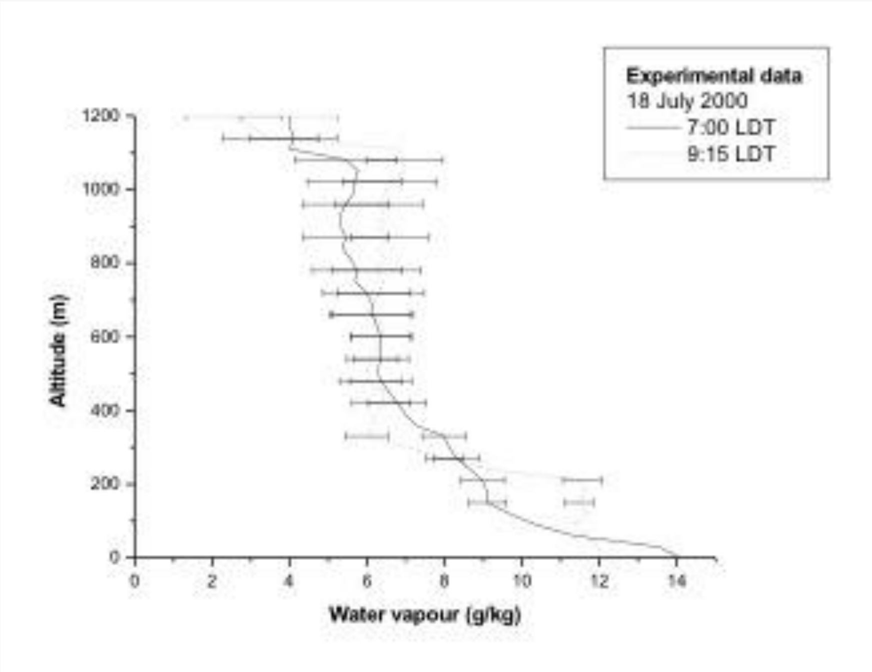
If the site orography remains unknown each peak will be attributed to a fire; in order to reduce false alarms it is necessary to have an information about the backscattered signal by the orographic obstacles



3. Detection of TICs, TIMs , CWA





3. Detection of TICs, TIMs , CWA

The development of methodologies (or "of a methodology") of a multi-wavelength analysis in order to identify in atmosphere CWA agents. Project result: development of a Stand Off system based on CO2 laser (demonstrator) in order to apply the above methodologies (o "methodology")“

3. Detection of TICs, TIMs , CWA

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- A fundamental problem is the identification in atmosphere of toxic agents or Volatile Organic Compounds (VOC), that lead to high risks for human life
- The question is ….
- Is it possible to identified a particular gas in atmosphere using only two wavelength (DIAL method)?
- No, it is not possible because of interfering substances with similar functional set

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- Our idea is …

Every molecule can be identified if its absorption spectrum is known... well...

Increasing the wavelengths used in DIAL method allows to identify chemical compounds in atmosphere

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NEED

NEED IN BIOLOGICAL DETECTION: A FAST ANSWER TO REDUCE THE RISK

↓

SOLUTION INVESTIGATED FOR RAPID STAND OFF BIOLOGICAL DETECTION: APPLICATION OF OPTICAL TECNHIQUES (LIKE THE FLUORESCENCE MEASUREMENTS)

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Materials and Methods

Wavelenght source → **Xenon UV Lamp (excitation λ: 266 nm; 355 nm)**

Acquisition system → **and a detector to acquire the Fluorescence signals from the samples used (simulats of biological agents).**

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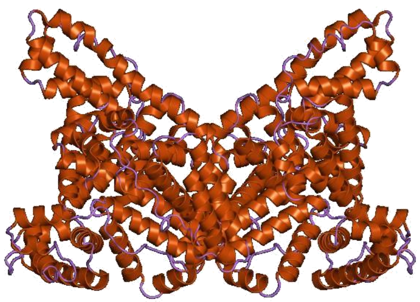
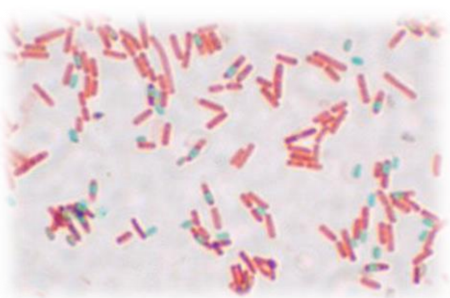
Materials and Methods

SAMPLES





PROTEINS	Ovalbumin	**OVA**
	Bovine serum albumin	**BSA**
BACTERIAL SPORES	*Bacillus thuringensis*	**BT**
	Bacillus globigii	**BG**
BACTERIAL VEGETATIVE CELLS	*Escherichia coli*	**coli**
	Bacillus subtilis	**subtilis**

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100° CONGRESSO NAZIONALE
Pisa, 22 - 26 settembre 2014

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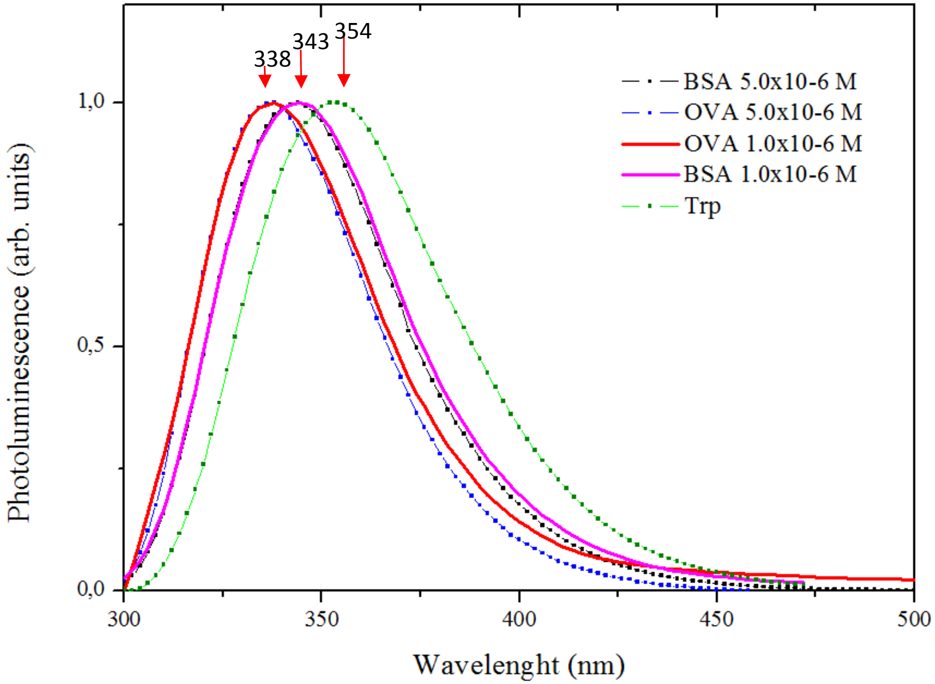
Experimental results – Fluorescence emission spectra

Excitation wavelenght: 266 nm



TOXIN SIMULANTS

Comparison between different concentration of two biological simulants (**OVA** and **BSA**) for toxines.

A **shift of the emission peak** is detectable, using exitation wavelenght = 266 nm, also with respect to the emission peak of the aminoacid Tryptophan (Trp), the main responsible for proteins intrinsic fluorescence.

Trp emission spectra is shown for comparison.

Normalized values

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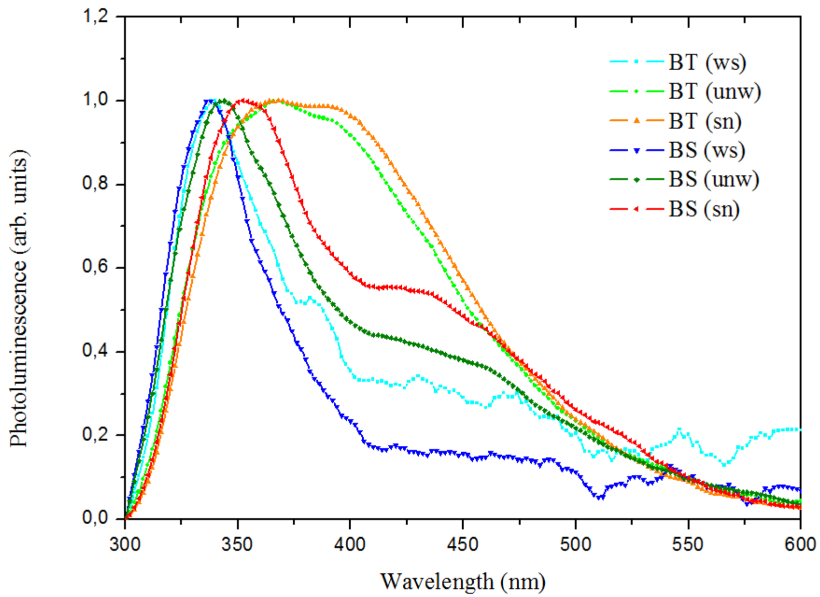
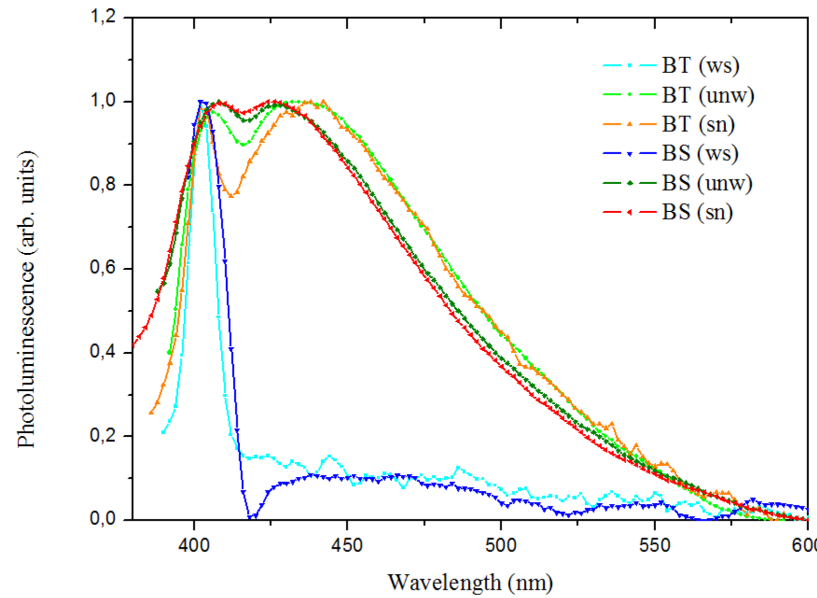
Experimental results – Fluorescence emission spectra

Excitation wavelenght: 266 nm



Excitation wavelenght: 355 nm



Comparison between washed (**ws**), unwashed (**unw**) and supernatant (**sn**) samples of *Bacillus subtilis* (**BS**) and *Bacillus thuringiensis* (**BT**) **spore** preparations. Spectra were acquired for the two excitation wavelenght: **266 nm** (left graph) and **355 nm** (right graph).

BACTERIAL SPORE SIMULANTS

Normalized values

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CONCLUSION

→In this first section was conducted a preliminary analysis to identify critical issues related to the **selection** of the biological simulants, showing that differences in the **spectral signature** may be the result of the **sample preparation method** and not of intrinsic structural and molecular differences.

→For this reason, **further analysis should be conducted** in order to identify best practices to implement **spectral signature databases** and exploit the potential of **UV-LIF** and other optical techniques, as tools for the early stand-off warning and detection of BWAs.

gaudio@ing.uniroma2.it

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감사합니다
Natick
Grazie
Danke
Ευχαριστίες
Dalu
Obrigado
Thank You
Köszönöm
Tack
Спасибо
Dank
Gracias
谢谢
Merci
Seé
ありがとう

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