« STAND-OFF BIOLOGICAL DETECTION BY LIF (LASER INDUCED FLUORESCENCE) LIDAR »

OPTRO 2010 – 4TH INTERNATIONAL SYMPOSIUM

OPTRONICS IN DEFENCE AND SECURITY

4th February 2010

O. Meyer

C. Jacquelard, JM. Melkonian, P. Chardard, P. Lanson, D. Petitgas

CILAS

CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

Outline

1. Context
2. Principle of LIF Lidar
3. Overview of current LIF developments
4. CILAS First studies in stand-off detection
5. Recent activity
6. Perspectives
7. Conclusion

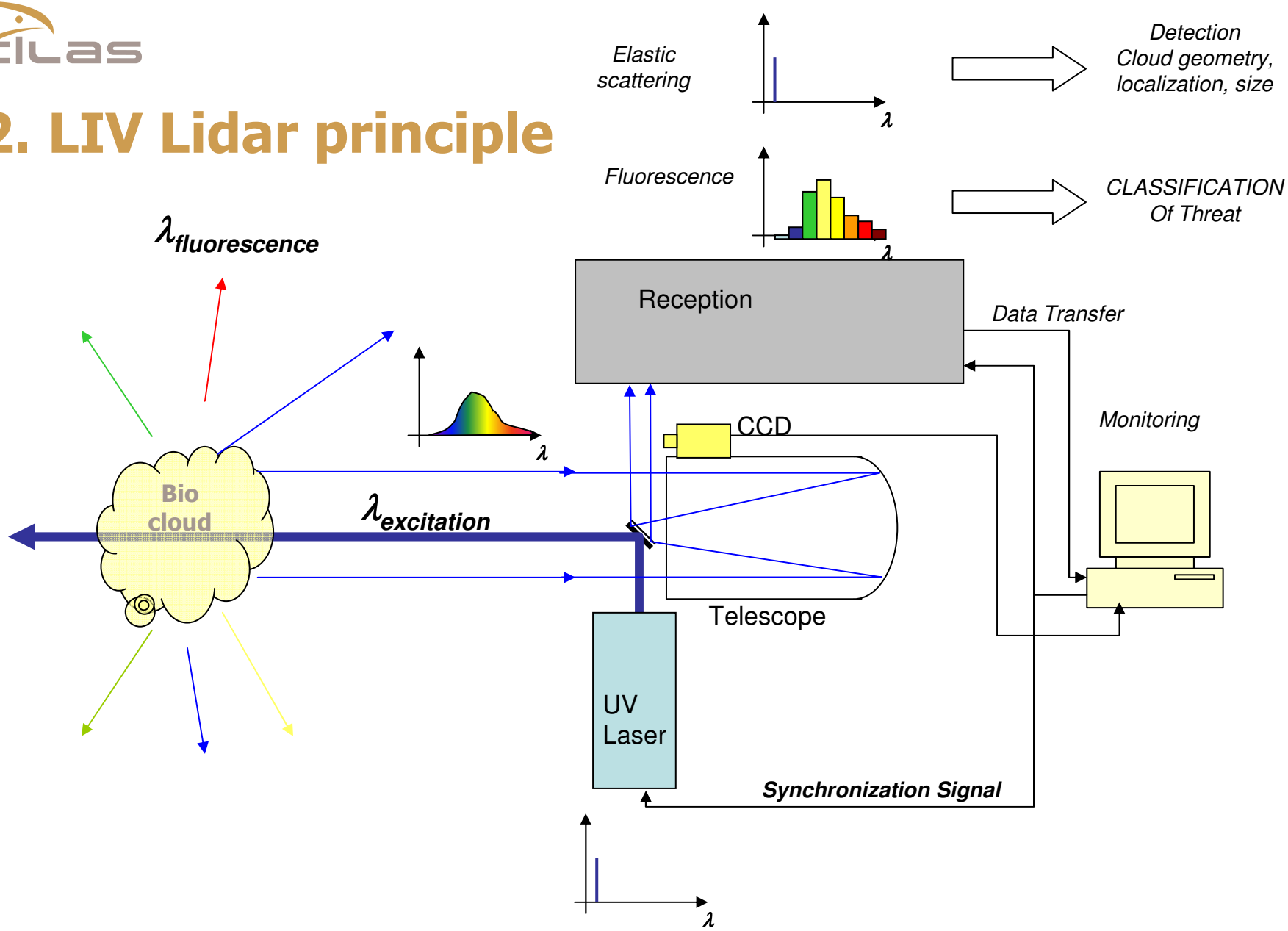
CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

1. Context

- Threat of biological attack is increasing
  - Terrorist attack
- Important benefit of a early warning system in term of countermeasure
  - Area evacuation
  - Individual protection
- Stand-off chemical detectors are available, but no stand-off biological detector (only local detector)
- Active developments under that field are investigated
  - LIF Lidar technology is one of the best candidate
  - Development either supported by Europe (European Commission) and the french MoD (DGA)
    - European Commission => BODE program
    - DGA => Perseïdes/Lidar Bio 2 program

CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

2. LIV Lidar principle



CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

3. Overview of current LIF developments

- Developments done by several countries
- UV laser emission
  - 355 nm
  - 266 nm
- Reception
  - Spectrometer coupled with
    - Photomultiplier Tubes
    - Intensified CCD
- Data processing for threat classification
  - Remains the more important challenge of this technology

	UV Emission	Reception
Canada	UV excimer laser 120-170 mJ/pulse @ 351 nm – rate = 125 Hz	Backscatter signal using photomultipliers Fluorescence signal using Intensified CCD + spectrometer
Germany	UV Solid State Laser 266 nm 355 nm	Information not released
Norway	UV Solid State Laser 150 mJ/pulse 355 nm – rate = 10 Hz	Backscatter signal using photomultipliers Fluorescence signal using Intensified CCD + spectrometer
UK	UV Solid State Laser 40 mJ/pulse 266 nm – rate = 10 Hz	Backscatter signal using photomultipliers Fluorescence signal using photomultipliers + spectrometer
USA	UV Solid State Laser 355 nm (at least)	Information not released

CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

4. CILAS First studies in stand-off detection

- First studies in the 1980s with french MOD to develop a chemical LIDAR demonstrator
  - Short range lidar
  - CO_2 emission laser

DETADIS

- In the 1990s, MIRELA program in cooperation with the US to develop a high range chemical LIDAR
  - Tunable CO_2 laser
  - DIAL and DISC method
  - Classification range > 5 km

MIRELA

CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

4. CILAS First studies in stand-off detection

- Studies continue to biological field at the end of the 90's
  - Lidar Bio : DGA program
    - Evaluation of biological stand-off capability through LIF Lidar
- Transportable system for field test
- Evaluation through 2 trials campaigns

Lidar truck and bio lidar working

Lidar set-up

CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

5. Recent activity

2008-2009 : 2 projects

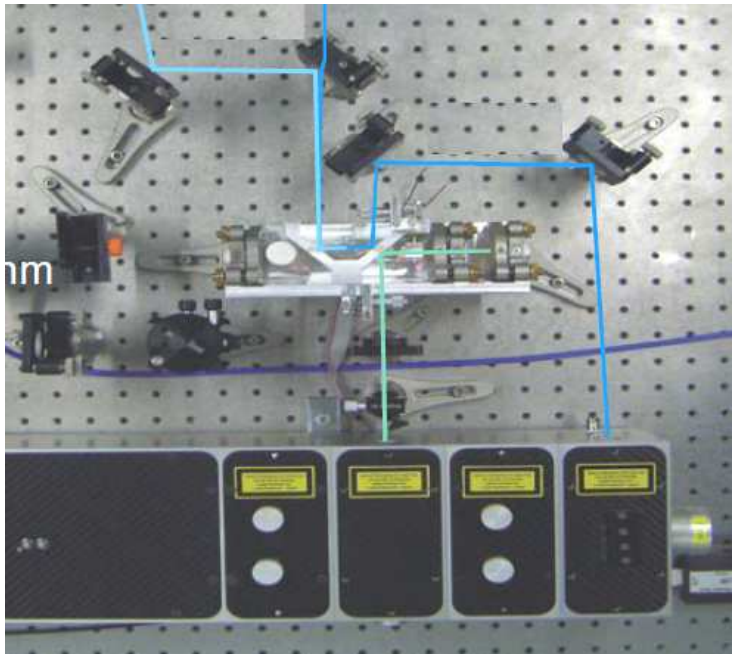
BODE (European Commission)

Perseïdes (DGA)

- BODE (Biological Optical Detection Experiment)
  - PASR FP6 program
  - 1st January 2007 to 31th March 2009
  - Consortium of 9 partners
- LIF Lidar demonstrator in the range of some 100s meters
- Development Steps
  - Identification of functional and operational requirements
  - System specification definition
  - Sub-assemblies specification, manufacturing, and tests
  - Demonstrator integration
  - Experimental trials: chamber demonstration then open field demonstration

BODE: Biological Optical Detection Experiment

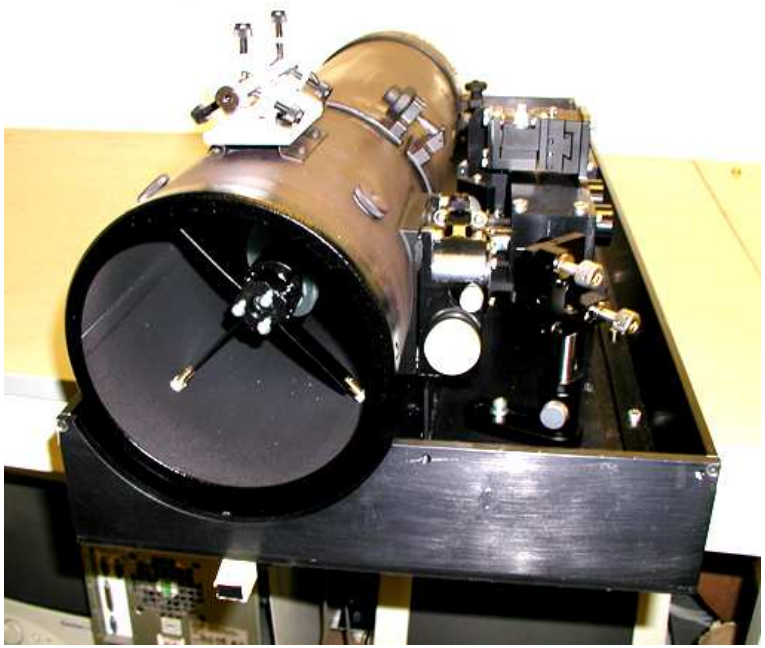
- *The emission with non linear crystals*: a specific OPO (Optical Parametric Oscillator) setup has been built in order to produce the most effective UV wavelengths **(DLR)**
- Dual UV emission to improve capability cloud classification (2 cloud signatures)



CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

BODE: Biological Optical Detection Experiment

- *The optoelectronic reception:* the emissions from fluorescent particles are collected into a telescope and directed to a multi-channels photomultiplier array via a series of dichroic filters **(BIRAL)**

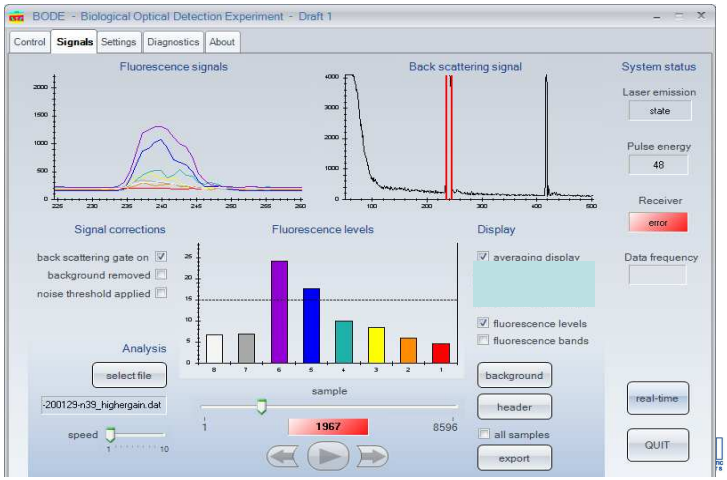


BODE: Biological Optical Detection Experiment

- *the Man Machine Interface (MMI) and data processing*: A preliminary version of an operational MMI was developed, containing the principal information **(CILAS)**

« Operational MMI »

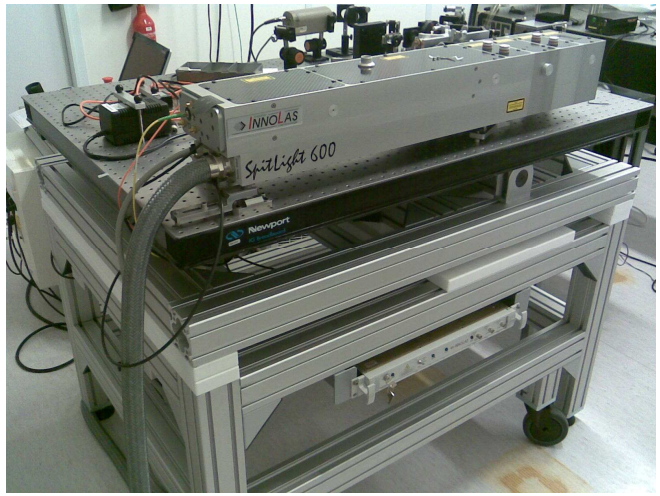
« Expert MMI »

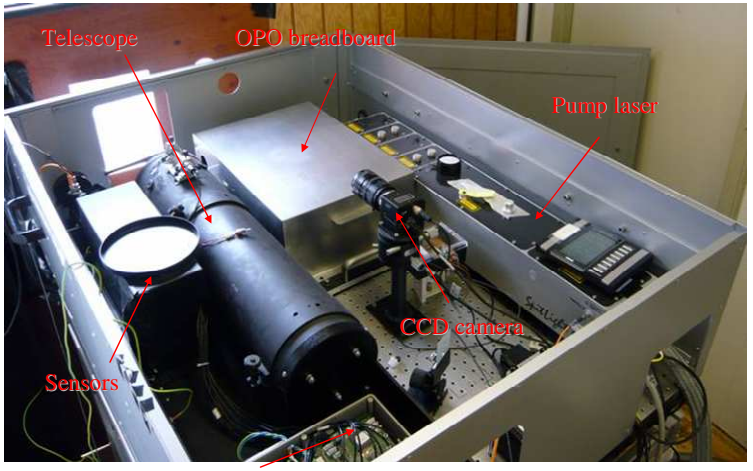


BODE

BODE: Biological Optical Detection Experiment

- *Pictures of the overall demonstrator*





BODE

CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

BODE: Biological Optical Detection Experiment

- Semi-closed chamber tests: the biological simulants were well localized and the concentration accurately measured and monitored,

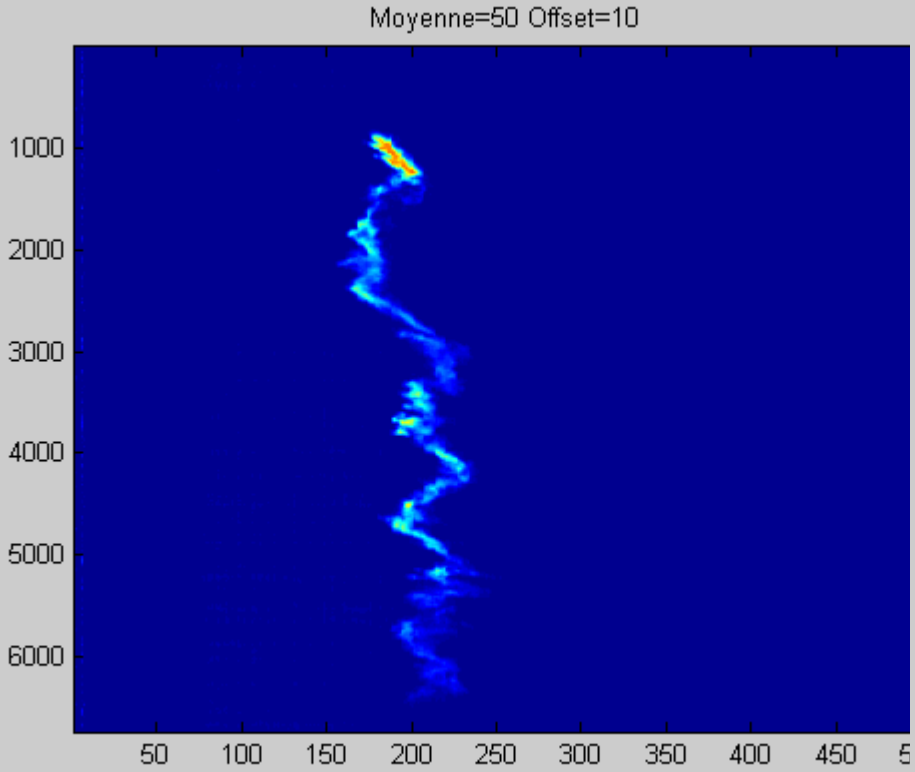
- Open-air tests: biological simulants were sprayed in the atmosphere in order to generate a cloud, that the LIDAR were requested to detect and localize

(FOI, DGA/CEB, CILAS, BIRAL)

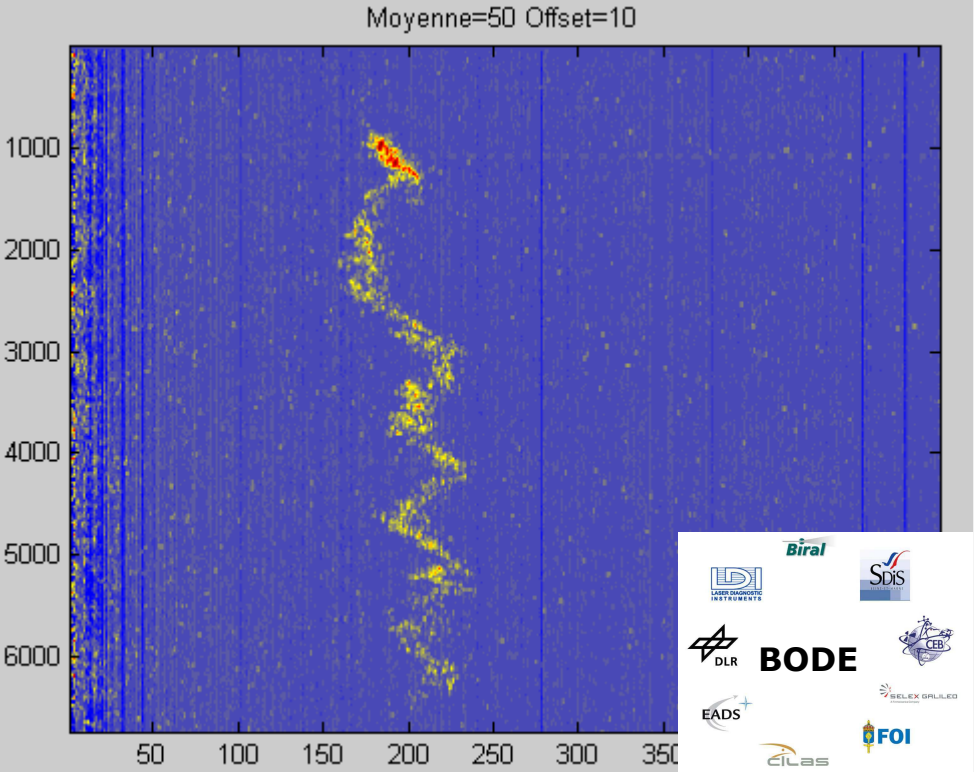
CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

BODE: Biological Optical Detection Experiment

Backscattered signal



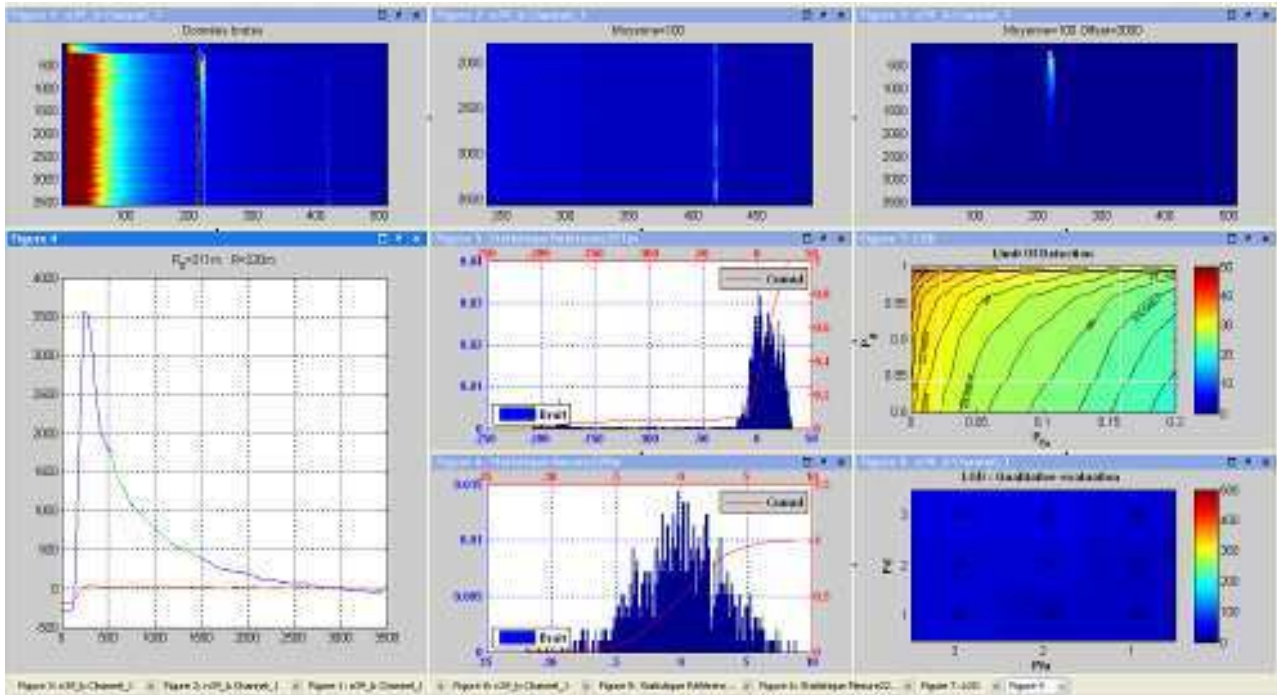
Fluorescence signal (1 channel)



Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

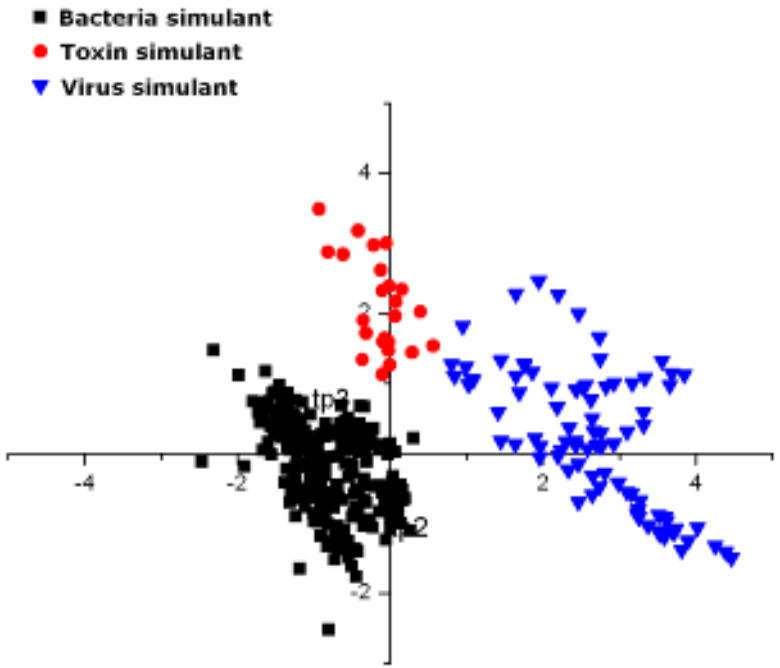
BODE: Biological Optical Detection Experiment

- *Data analysis (1/2) : numerical filtration and ROC analysis for lidar sensibility estimation* ***(DGA/CEB)***



BODE: Biological Optical Detection Experiment

- *Data analysis (2/2) : PCA algorithm processing for selectivity (cloud classification) estimation* ***(FOI)***



CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

5. Recent activity - BODE

- BODE conclusion
  - Complete evaluation of a LIF lidar (sensitivity, selectivity)
  - PCA classification seems promising
  - Dual UV excitation help to increase cloud classification (false alarm reduction)
  - Operational system need be to be optimised for low false alarm rate at the cost of false detection rate (real detection)
  - System R&T stage : TRL 4
  - Majors improvement points
    - Higher sensitivity
    - Higher selectivity
    - Lower size/weight

CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

5. Recent activity - Perseïdes

- Perseïdes program
  - R&T DGA program for the development of new technologies against RBC (Radiological Biological Chemical) threat
    - 2009 - 2012
  - One part is dedicated to biological stand-off detection
  - Upgrade the biological lidar already developed, to increase sensitivity and selectivity capability, and range
  - Important efforts on new classification algorithms investigation (neuronal network, SVM, …)
  - New field tests for validation in 2012

CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

6. Perspectives

- The number of R&T program let hoping than in middle term, this technology will be available for system production (already the case in the US army)
- The sensitivity is less challenging than the selectivity (classification) capability
- Not only the use of several excitation wavelengths improves the classification capability
  - Depolarisation ratio can provide information about the aerosol shape
  - Wavelength ratio can provide information about the size range of the aerosol
- Short term improvements must also be focus on
  - Size
  - Weight

  } Drive by the laser source technology

CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49

7. Conclusion

- The availability to get an early warning biological system drives the R&T programs in case of bio attack
- Except USA, all developments are on the status of demonstrator
- Most of the stand-off detection developments are based on LIF Lidar
- Signal processing and data analysis remain a challenge to push this technology on operational concept
- Availability to get operational system : middle term (5 years)

CILAS - 8, Avenue Buffon - Z.I. La Source - 45100 ORLEANS – France
Tel : + 33 2 38 64 15 55 – Fax : + 33 2 38 76 02 49