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UV-Laser Induced Fluorescence Remote Sensing Technology and Applications

Randy Schmitt
Bill Seng
Sandia National Laboratories
Lasers, Optics, and Remote Sensing Department 1118

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Overview of laser remote sensing

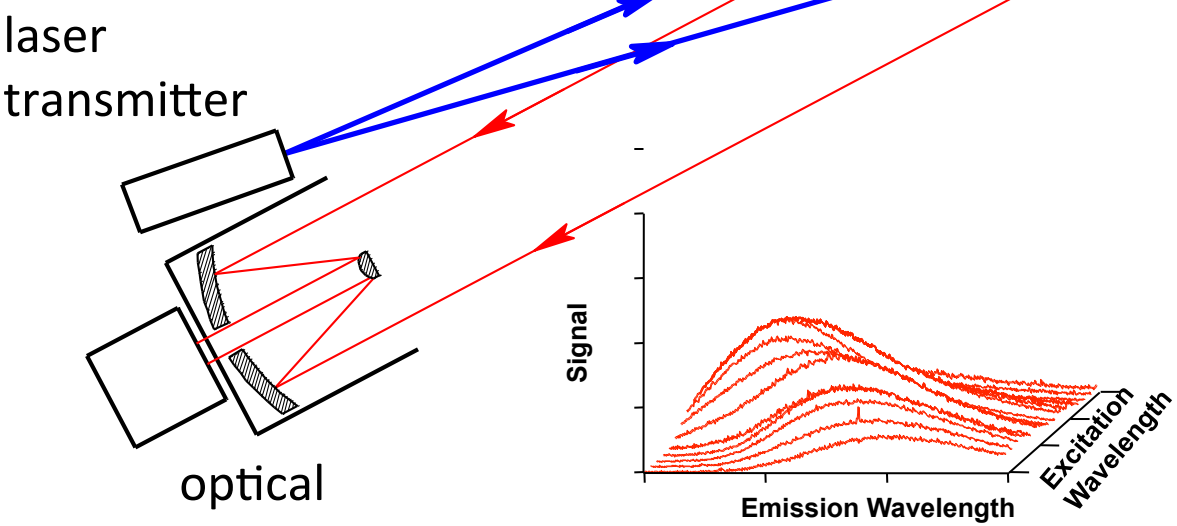
UV LIF is one of several useful signatures

Basic process:

- transmit laser light
- collect emitted / backscattered light
- analyze collected light

target

- solid
- liquid
- gas
- aerosol



Possible signatures:

- elastic backscatter
- shift in wavelength
  - fluorescence
  - Raman scattering
- change polarization

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UV LIF signatures can be used to detect/ identify WMD materials of interest

- LIF signatures can be used to aid in detection of
  - biological threat materials (spores, cells, viruses, toxins)
  - evidence of WMD proliferation activities

- fluorescence probes electronic energy states of an atom or molecule
  - for small molecules both excitation and emission vs wavelength can be quite unique – i.e narrow-linewidth features
  - for large molecules both excitation and emission can be broad and featureless, but still quite useful to ID molecule
- fluorescence lifetime can be used to discriminate some materials from background
- if target molecule does not fluoresce naturally, a taggant may be useful
- can be implemented airborne → handheld, depending on application and conops

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Key UV LIF LIDAR activities at Sandia

- Target phenomenology, signatures, and cross sections
  - UV LIF signatures of bio materials and interferrants
  - fluorescence and backscatter cross sections
  - methods for measuring BWA cross sections
- Develop and field test LIDAR systems
  - B70: lidar laboratory on wheels
  - AURA: airborne UV LIF lidar system
  - Ares: bio-aerosol standoff detection system in a van

Ares

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AURA flight system and Ares ground system developed under DOE Advanced LIDAR program

AURA Flight System

- Goal: Demonstrate airborne utility of UV LIF technology
- Primary Application: WMD Proliferation
- Secondary Applications
  - Support to military operations: Standoff detection of biological weapons agents (BWA)
  - Bomb damage assessment: WMD production and storage

Ares van-mounted LIDAR

- Goal: Rapid, cost-effective application of UV LIF technology.
- Primary Application – BW aerosol cloud detection and discrimination
- Secondary Application – Test bed for signatures measurements in WMD proliferation scenarios

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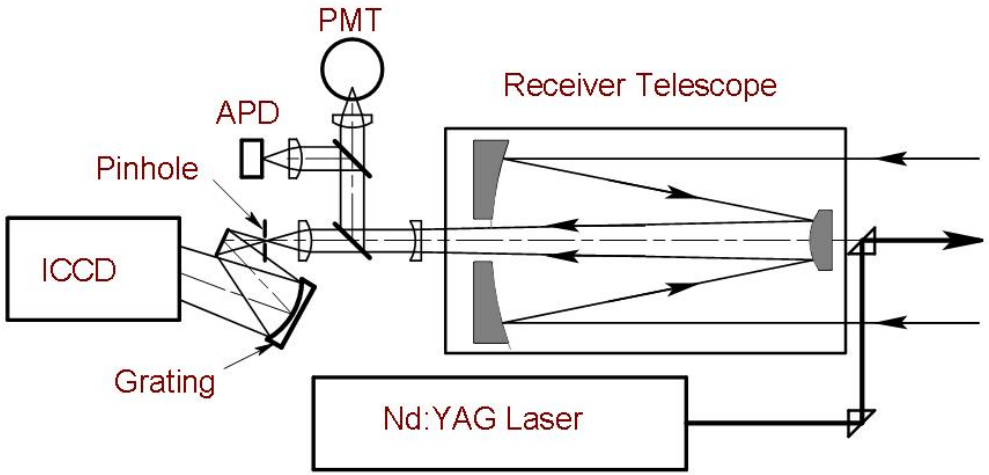
The Ares lidar is designed for standoff bio detection

Ares characteristics:

- 355-nm pulsed laser excitation
- Elastic backscatter for cloud finding
- Wavelength dispersed fluorescence for bio / non-bio discrimination
- Scanning platform
- Flexible data analysis architecture



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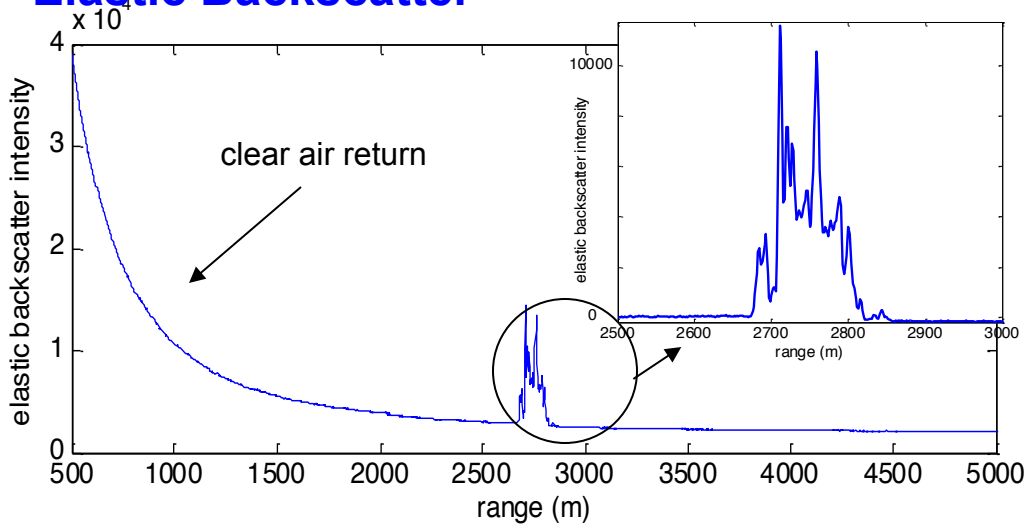
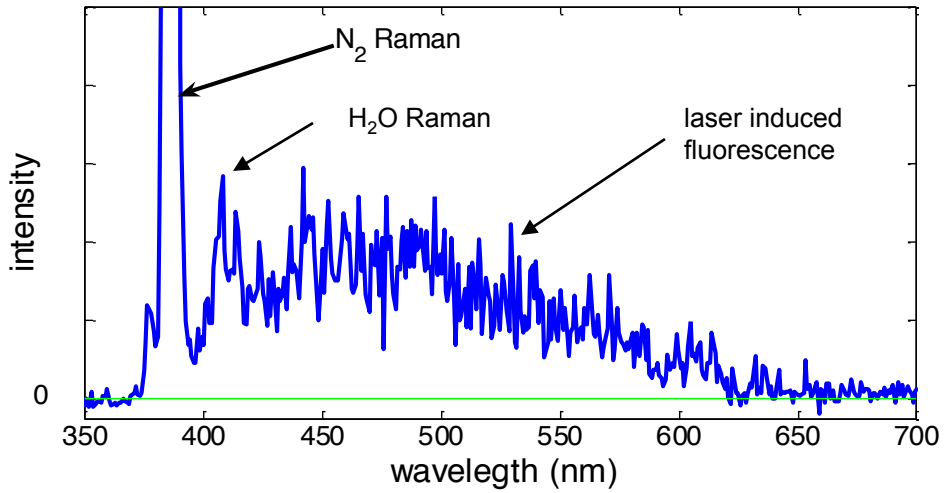
Wavelength-resolved fluorescence and elastic backscatter provide complementary information about the target

Elastic Backscatter



- Elastic backscatter at 355 nm used to detect aerosol clouds
- Algorithms determine the location and size of clouds

wavelength-resolved fluorescence



- Classical Least Squares analysis is used to compare measured LIF spectra to database spectra of simulants and backgrounds to discriminate between bio and non-bio
- This cloud was identified as BG with high confidence
- Test log confirms BG + kaolin release

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Spectral differences provide basis for bio / non-bio discrimination

- Lidar system performance is measured against biological simulants and background materials at Dugway and other locations:

Spore

Bacillus globigi (live)
Bacillus anthracis Sterne (killed)
Bacillus Thuriengensis (live)

Virus

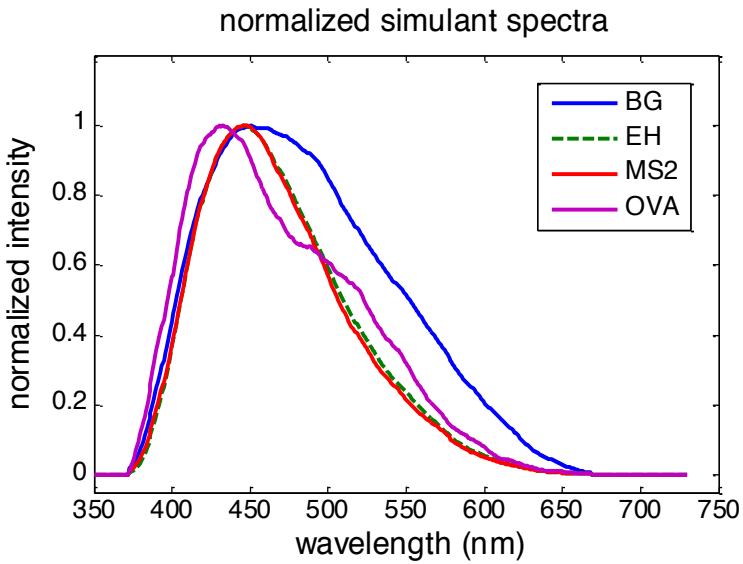
MS2 (live)

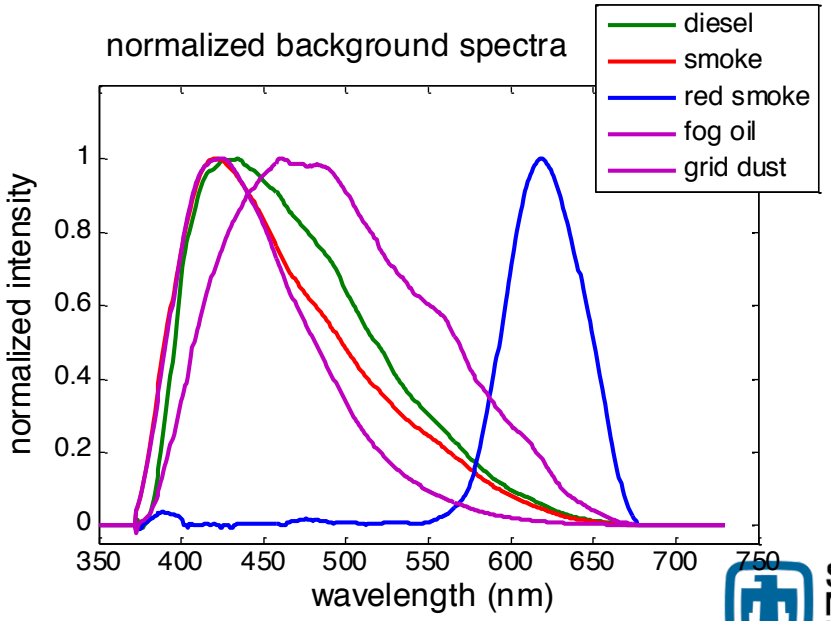
Vegetative Cell

Erwinia herbicola (live)
Yersenia Pestis Kim (killed)
Tulerensis LVS (killed)

Toxin

Ovalbumin





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UV LIF Remote Sensing can be implemented on a variety of platforms to suit the application

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Summary

- UV laser induce fluorescence has demonstrated utility for detecting WMD-associated materials
  - bio aerosol standoff detection
  - non-proliferation
- UV LIF technology can be implemented on a variety of platforms
  - UAV (AURA)
  - mobile (Ares)
  - fixed (Ares)
  - handheld (potential)
- Sandia has extensive experience designing, building, and field testing UV LIF remote sensing technology