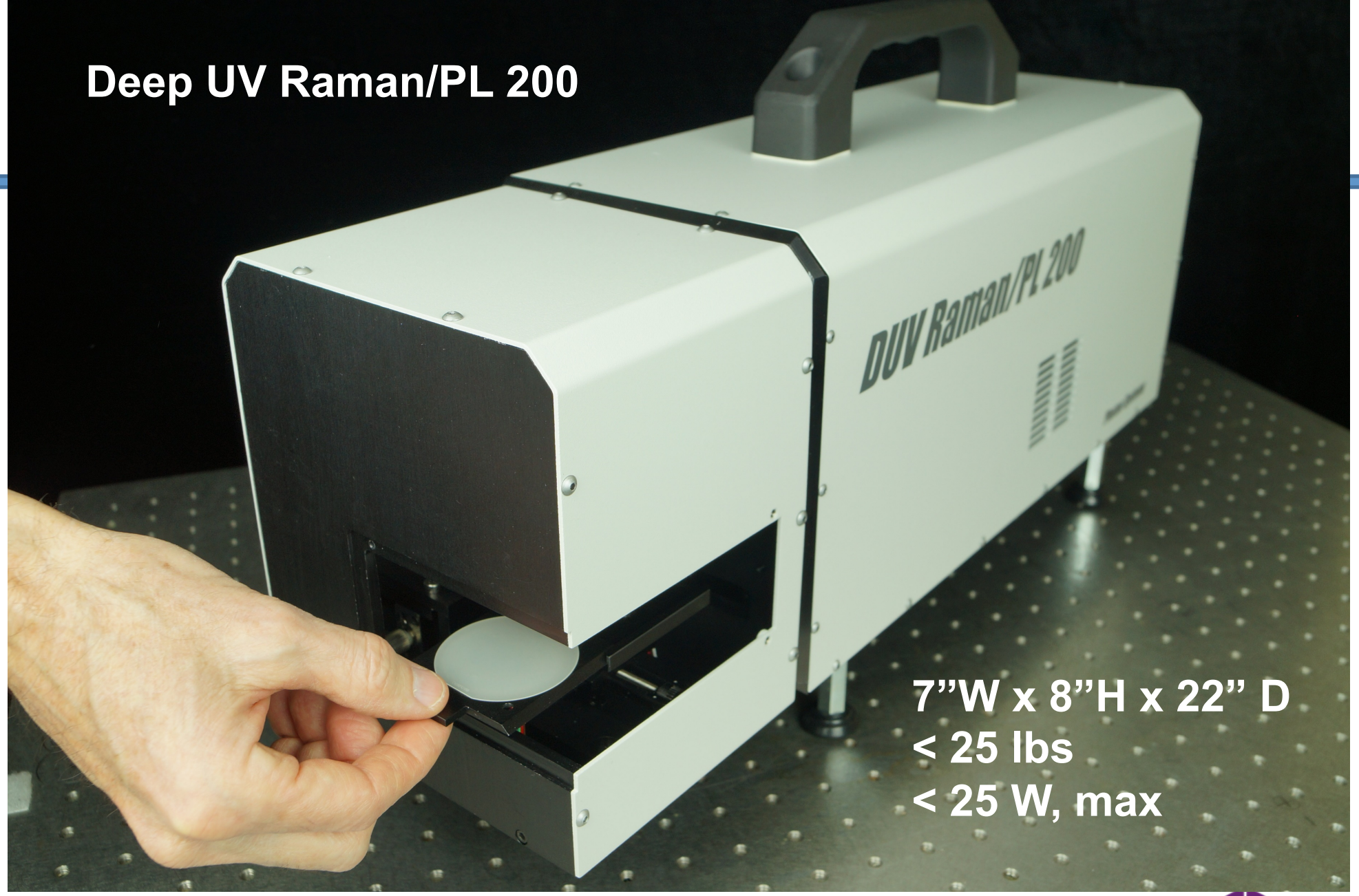
A New Deep UV Raman & Photoluminescence Spectrometer System

The DUV Raman/PL 200

by Photon Systems, Inc.

New Product Demonstration
SPIE DCS – Orlando, FL
April 16, 2018



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What's New

- Deep UV Raman spectroscopy, until now, has required a large and expensive spectrometer system with a large and expensive detector and laser with a liquid cooler and 15 kW power available, which requires a significant lab on a 4'x8' optical table plus peripherals.
- The new Photon Systems DUV Raman/PL 200 system is a fully self-contained instrument with deep UV laser, spectrometer, detector and electronics, computer controlled dual grating mount and sub-micron XY microscope stage sample positioner, all in a single package.
- Nothing external except your laptop or tablet.
  - ✓ Size: 7" wide x 8" high x 22" deep,
  - ✓ Weight < 25 lbs,
  - ✓ Power consumption < 25 W.
- Take it to the field with you. Run it on a battery.
- Take it on vacation with you.

Deep UV Raman/PL 200 Specifications

Fully Self-Contained except external computer or tablet

Excitation Wavelength: 248.6 or 224.3 nm.
Spectrograph: 200 cm Czerny Turner with dual computer controlled 3600 & 300 g/mm holographic gratings
Dispersion: 3.85 cm^{-1}/pixel (w 3600g/mm grating)
Resolution: <12 cm^{-1}, with 100 μm slit
Entrance Slits: fixed, selectable
Spectral Spread: 300-4000cm^{-1} (3600g/mm grating)
250nm to 650 nm (300g/mm grating) (0.75 nm res)
Detector: TE cooled, back illuminated, UV CCD Array
Obj. Lens: 3X, 5X, 15X, 40X DUV achromatic objectives
Context Imaging Camera: FOV: 1.3mm, 267μ, 100μ, 30μ; 2.4 M pixel
Motorized Position/Mapping Stage: 5 x 5 cm mapping area, <4 μm repeatability
Overall Size: 7.0" W x 7.3" H x 22" D (including XY mapper)
Weight: <25 lb
Power Consumption: Standby-8 W, Full power- 25 W
Input: 85VAC to 270VAC or 24 VDC
Safety: Class I, DHHS/CDRH
Command & Control: via external computer or tablet

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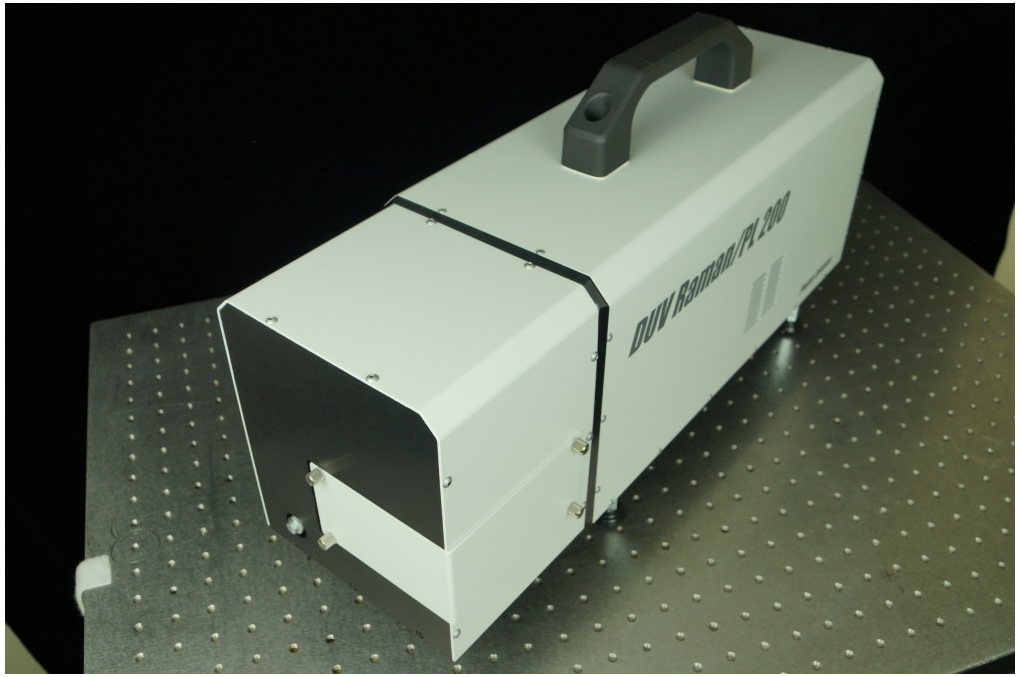
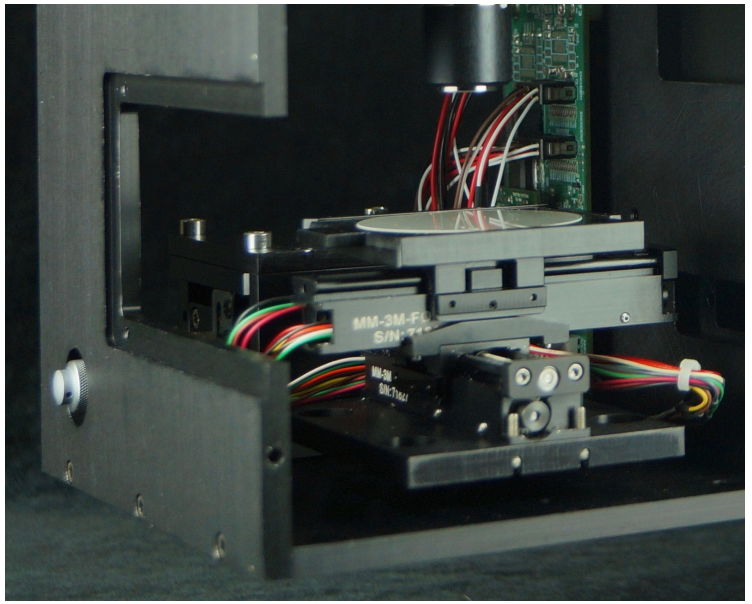
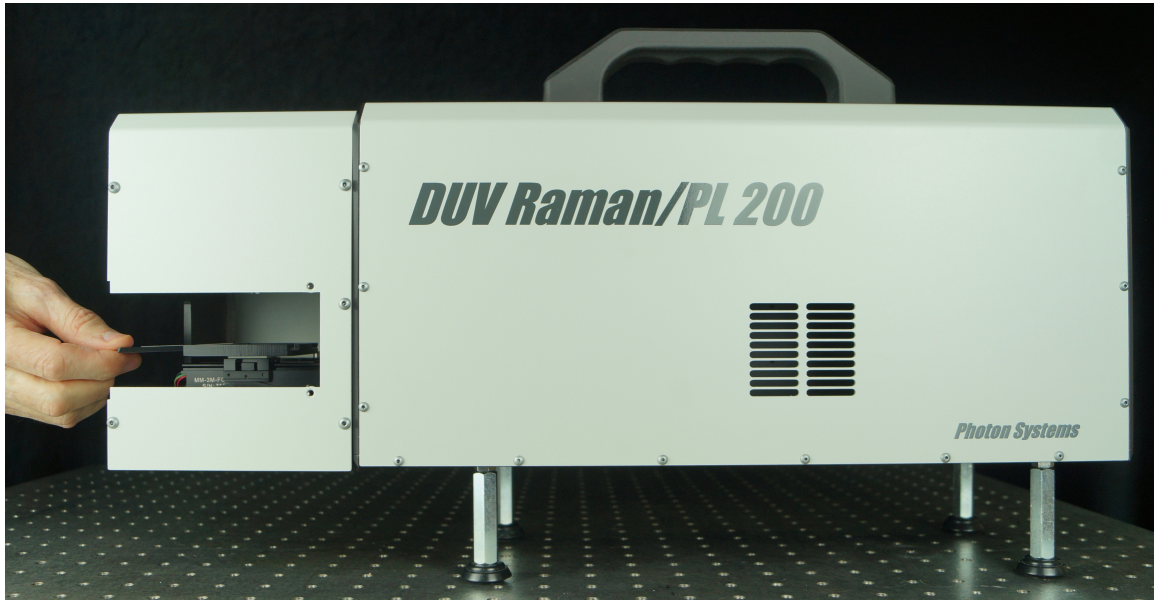
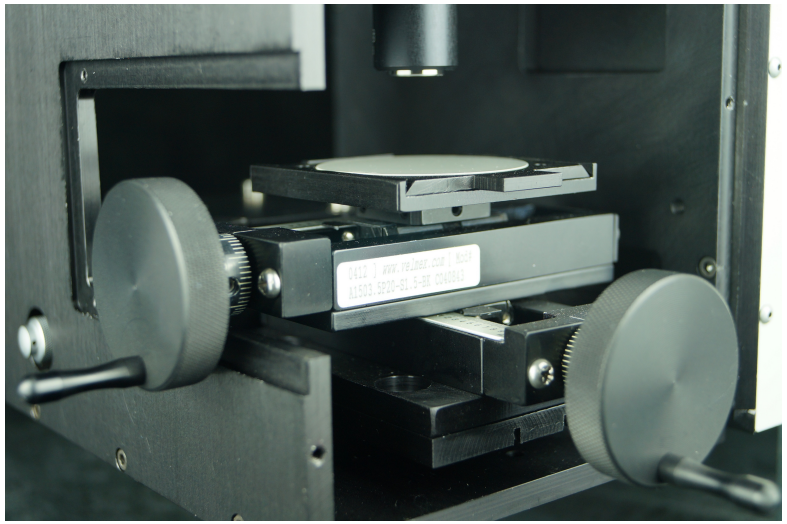




Computer controlled 5x5 cm XY





Manual 5x5 cm XY

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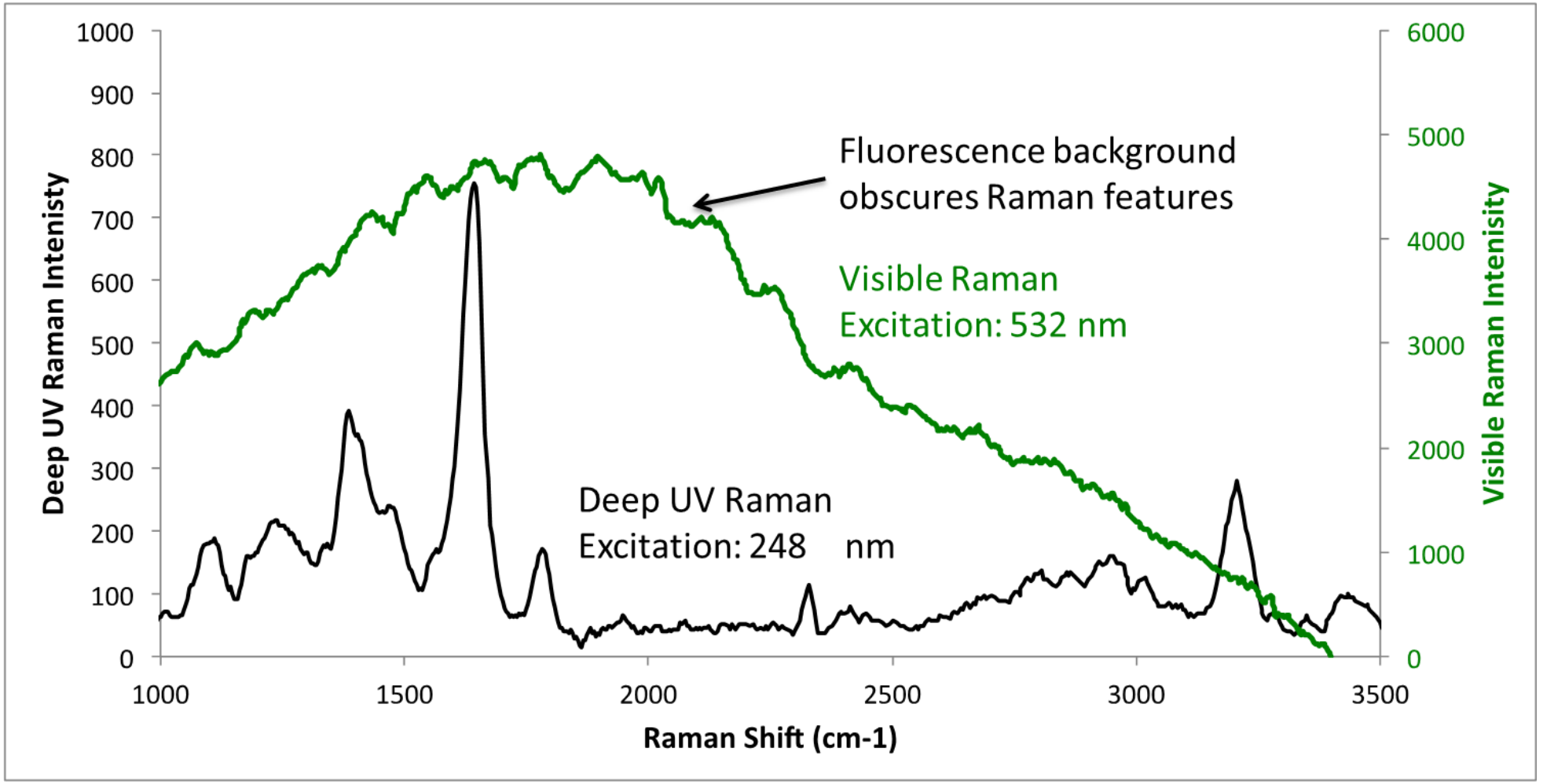
Why Deep UV vs Near UV , Vis, or IR

- The old saying is that fluorescence is the enemy of Raman.
- It is also true that Raman is the enemy of fluorescence.
- I'll explain.
  - ✓ Fluorescence cross-section are between 1 to 100 million times larger than Raman cross-sections.
  - ✓ As a result, any fluorescence within the Raman region of the spectrum from the targeted material or surrounding material within the laser beam spot, will alter or obscure the Raman spectra.
  - ✓ Native fluorescence spectra from a material are independent of excitation wavelength, although the spectra can be truncated if excitation does not occur below the threshold for fluorescence of the material, which is about 270 nm.
  - ✓ The Raman spectral region of a material is a dependent on the excitation wavelength. As excitation wavelength is made shorter, the wavelength spectral range for Raman and fluorescence emissions separate, with Raman below 270 nm and fluorescence above 270 nm.
  - ✓ When excitation wavelength is below 250 nm, the Raman spectral range is below the lowest emission wavelength of essentially all known natural materials. When this occurs, Raman emissions occur is a "fluorescence free" region of the spectrum.
  - ✓ When Raman is fluorescence free, fluorescence is also Raman free, enabling better identification.

Raman Spectra of Crude Oil at 248 nm vs 532 nm



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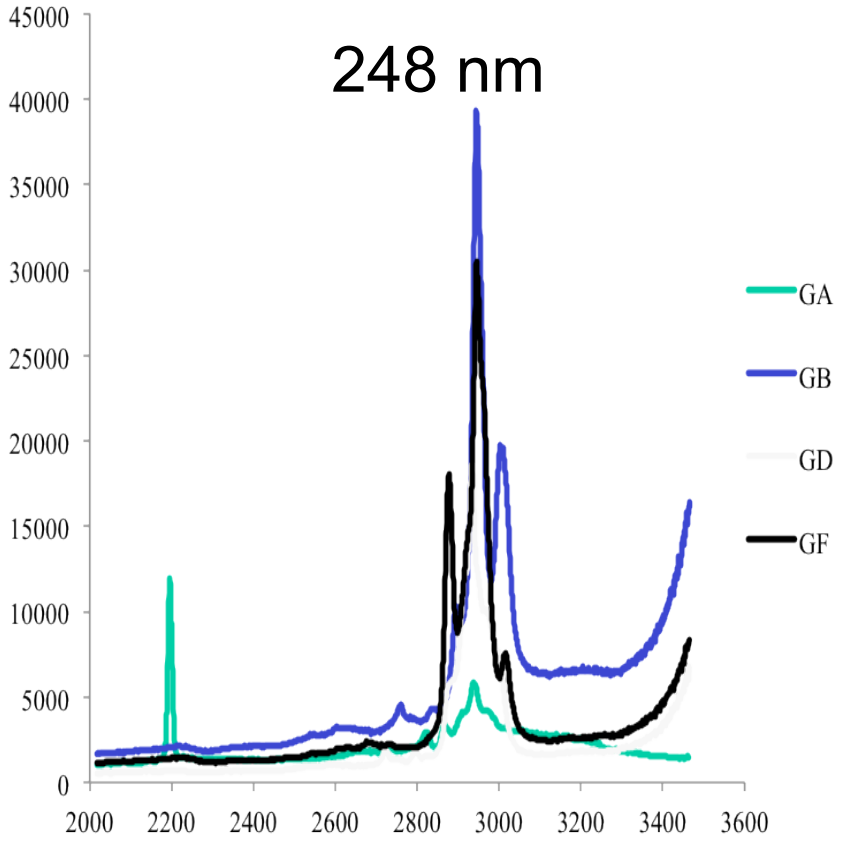
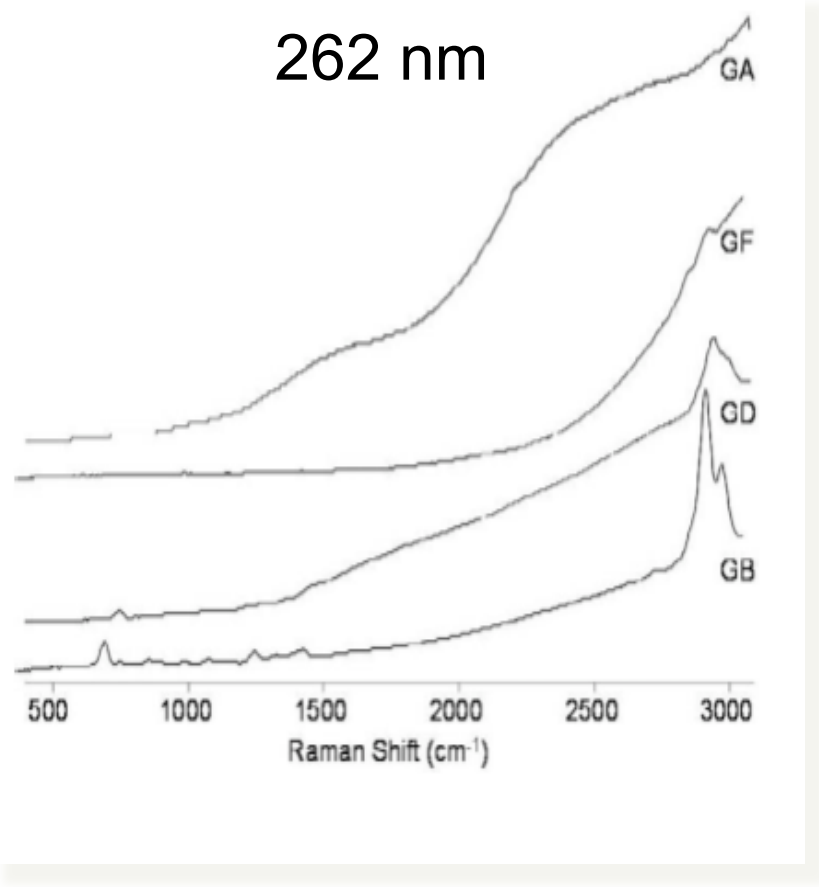
Sensitivity to Excitation Wavelength

Raman Spectra with Excitation at 248 nm versus 262 nm

(Example is G Agents)

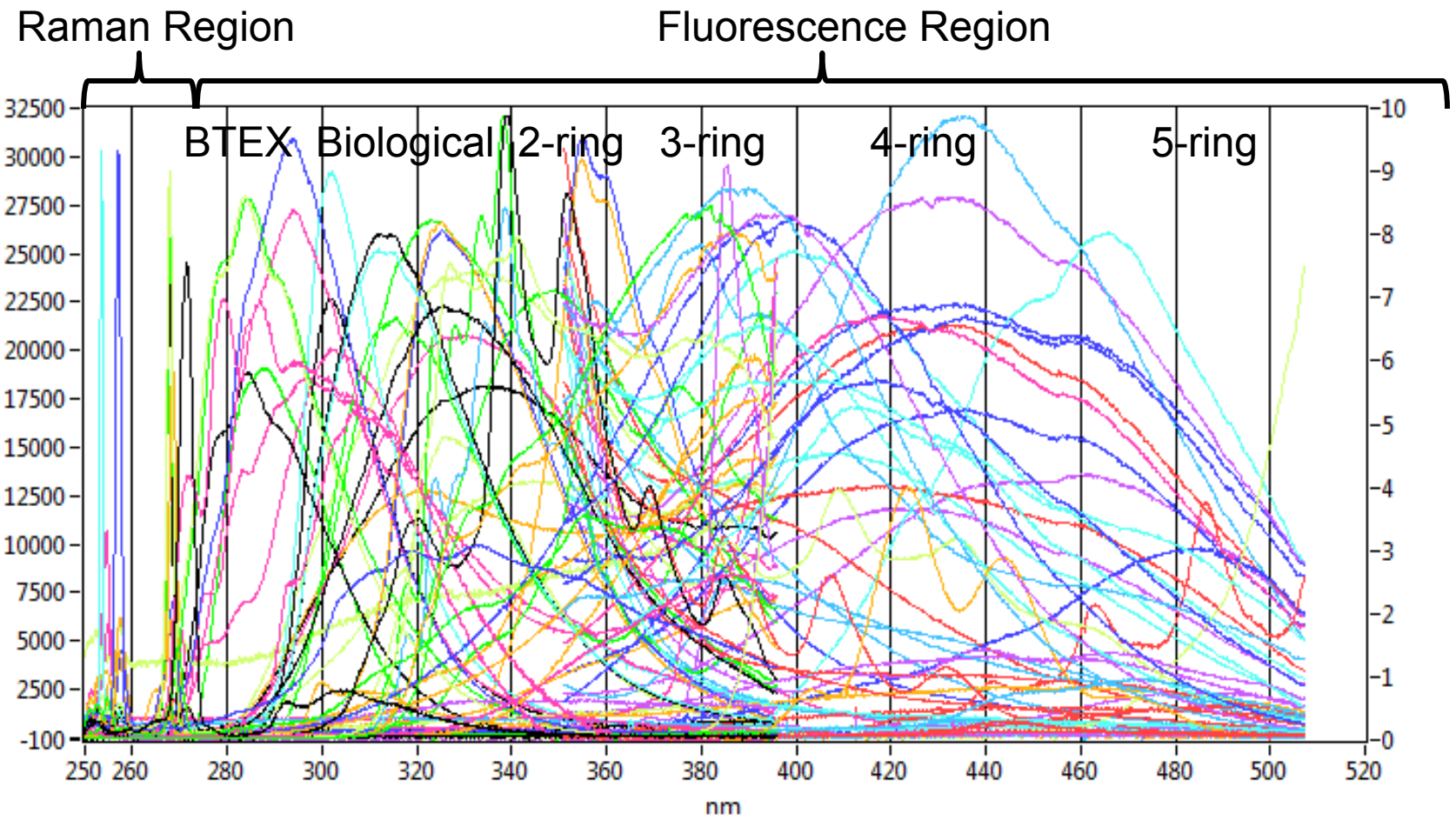




Adapted from Christesen, S.D. et al. Appl. Spec. 2008 Oct; 62(10):1078-83

Deep UV Fluorescence Spectra of 52 Compounds

with no baseline subtraction or compensation, Ex=248 nm



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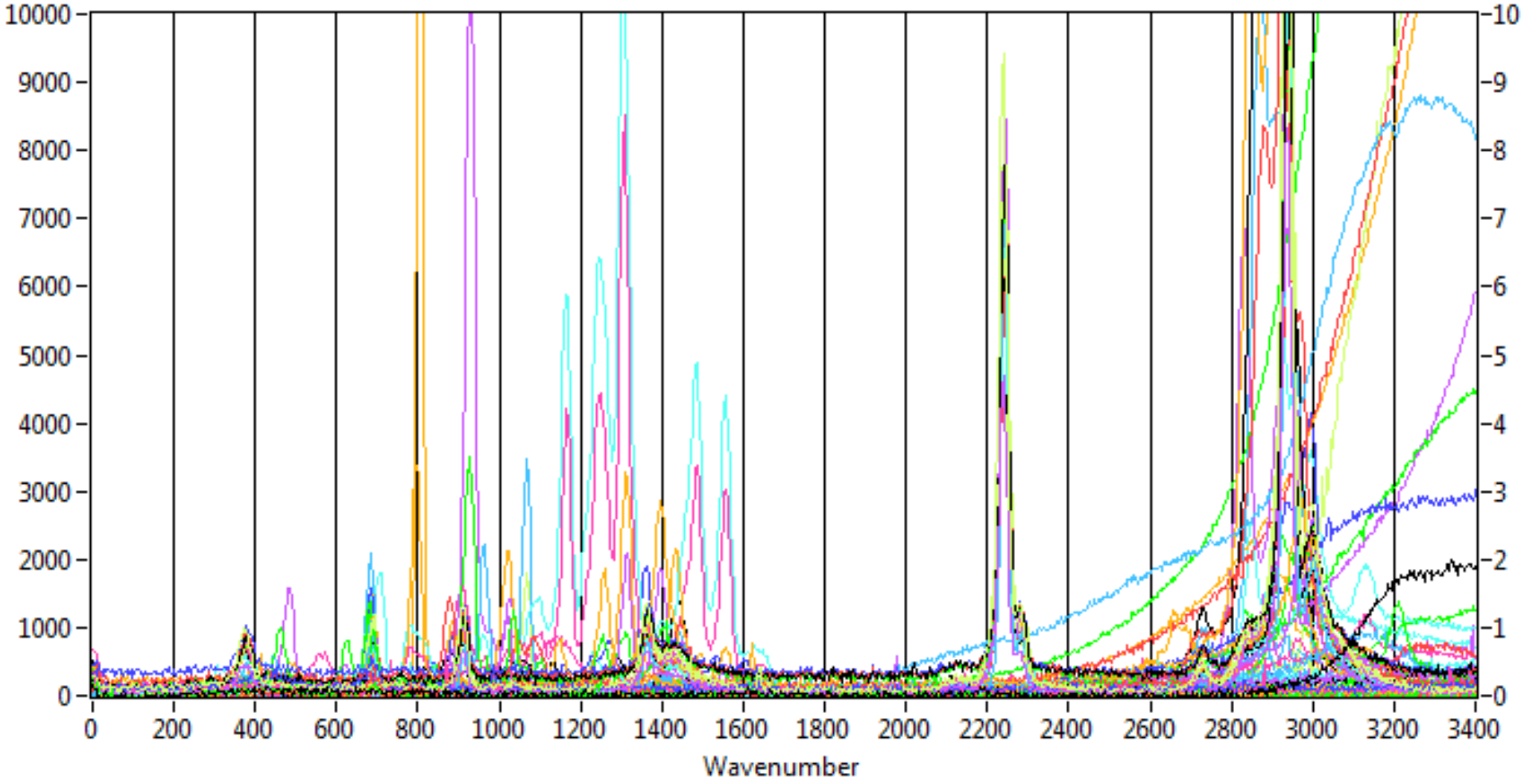
Deep UV Raman Spectra of 52 Compounds

with no smoothing, baseline subtraction or compensation, Ex=248 nm



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Deep UV Raman & Fluorescence as Independent & Orthogonal Modes of Detection

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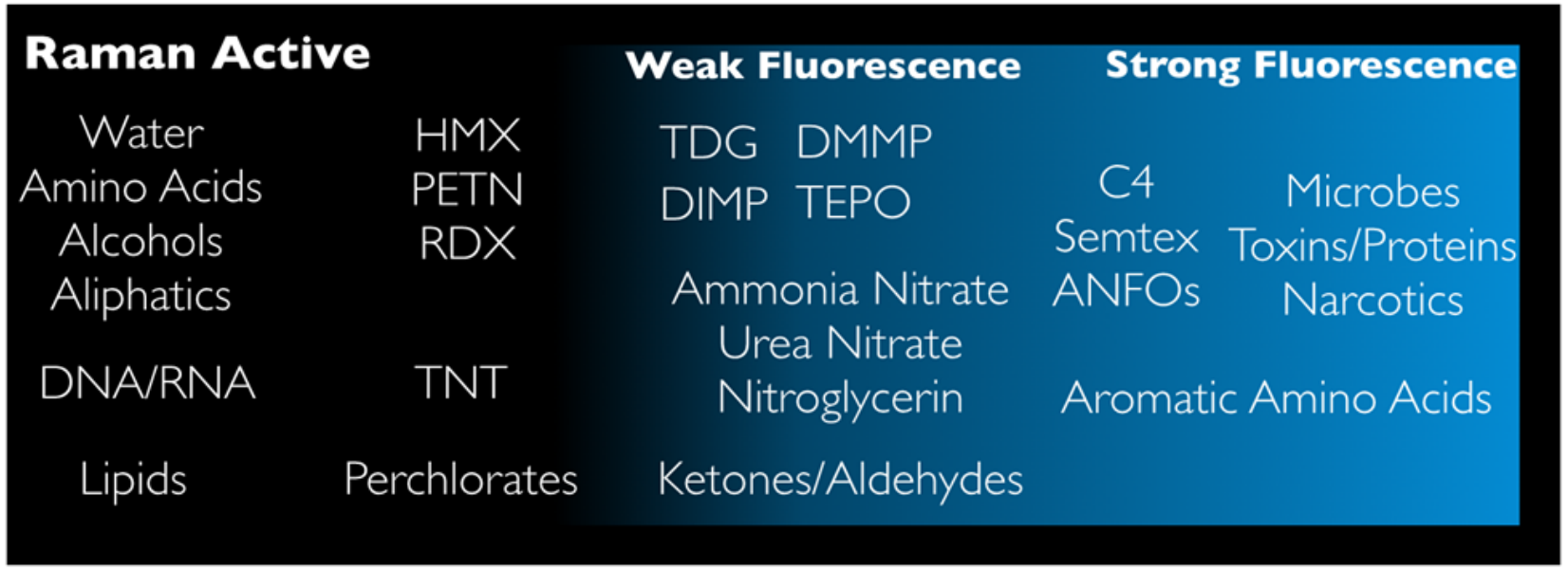
Combining DUV Raman & Fluorescence



- Raman provides information about chemical bonds and functional groups, including those that do not fluoresce (aliphatics and simple compounds)

- Fluorescence data provides information about the electronic structure of target & substrate ingredients (aromatics, ketones, aldehydes)

- Fluorescence is over 10^6 to 10^8 times more sensitive than Raman, providing longer standoff distances or detection at lower concentrations

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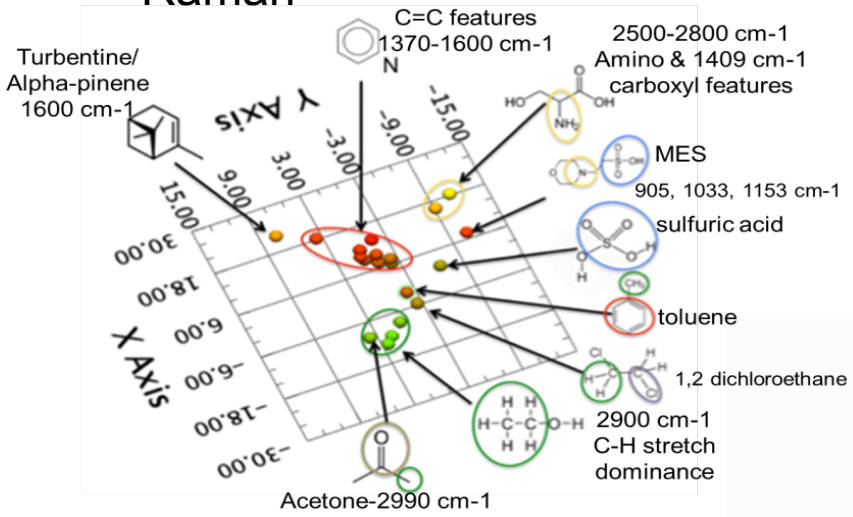
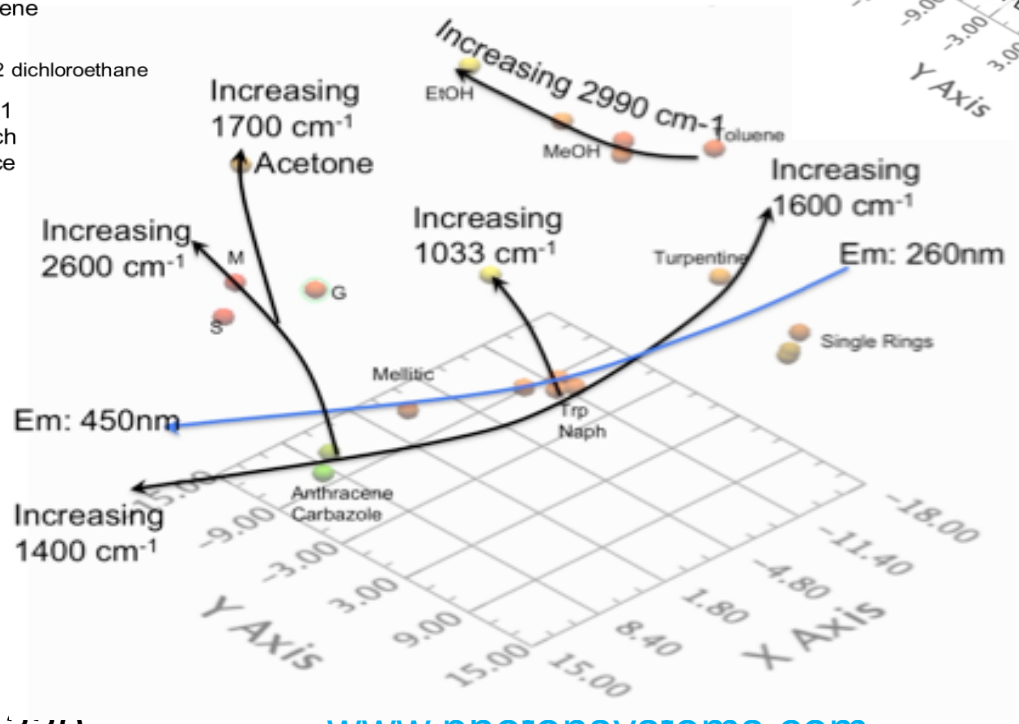
DUV Fluorescence/Raman Fusion

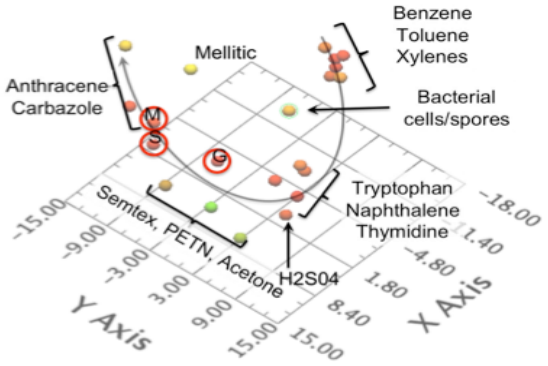
Raman



Raman & Fluorescence Combined



Fluorescence



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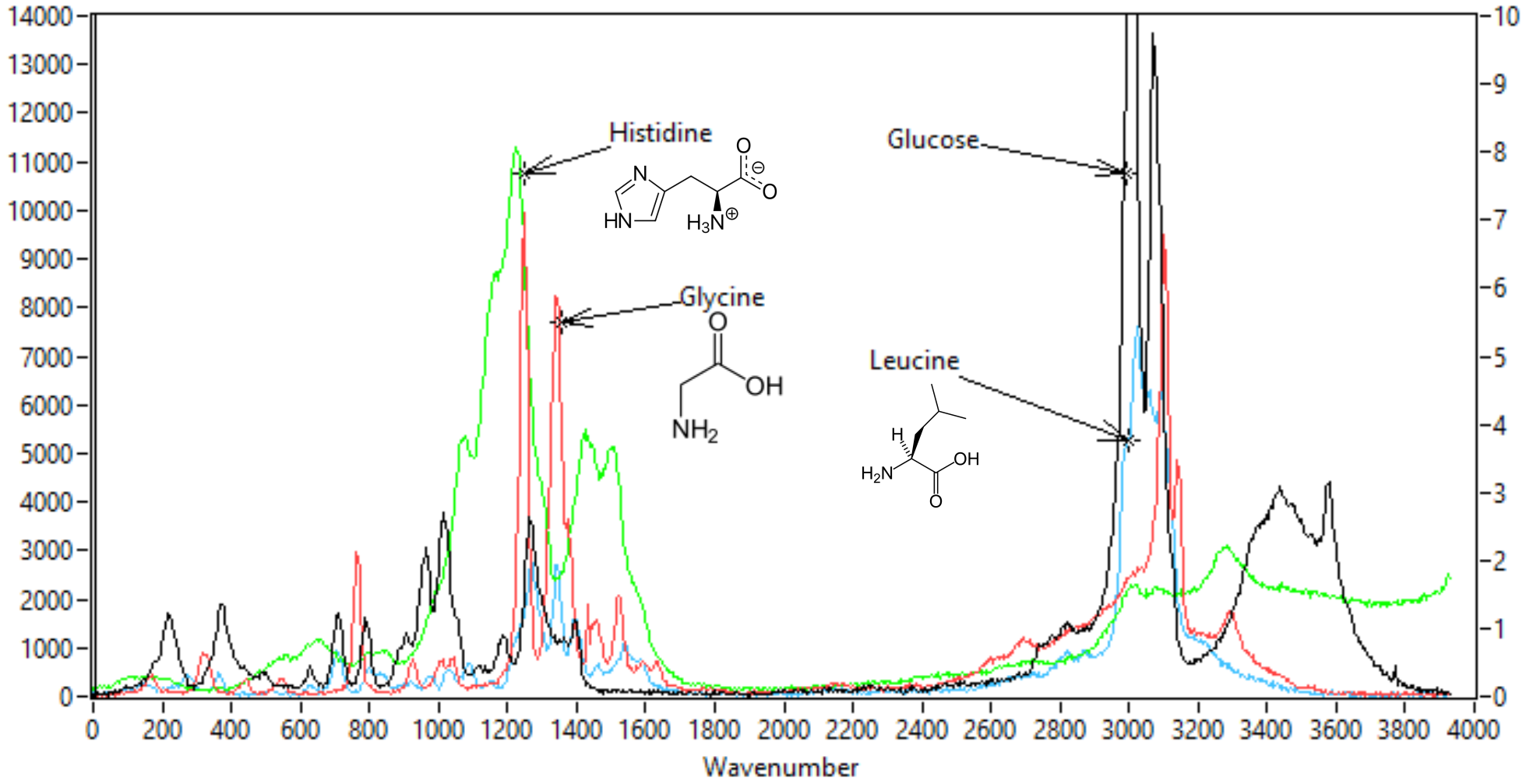
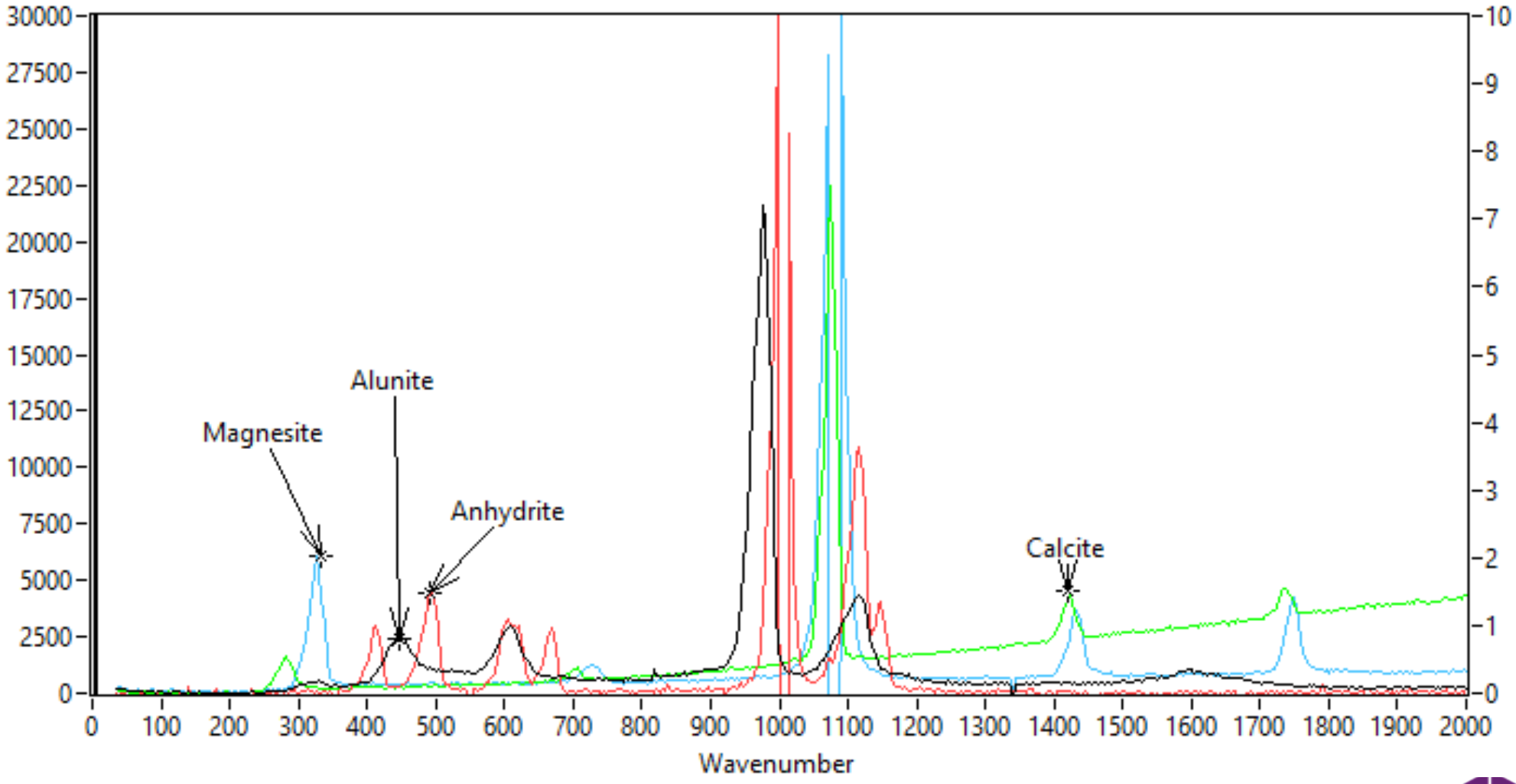
DUV Raman Spectra of Amino Acids and Glucose

with no smoothing, baseline subtraction, or compensation, Ex=248 nm



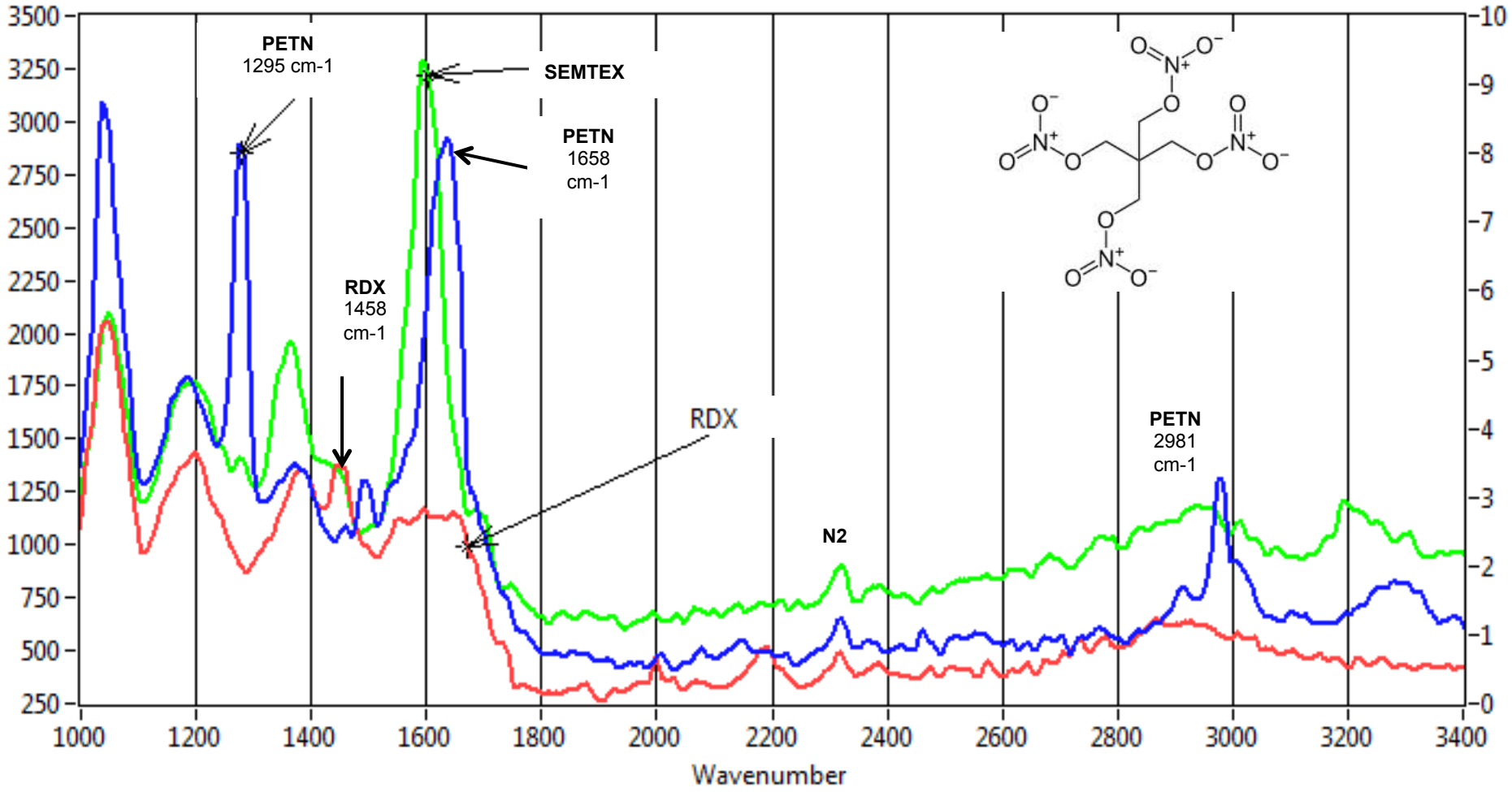
DUV Raman Spectra of Minerals

with no baseline subtraction or compensation, Ex=248 nm



DUV Raman Spectra of Bulk SEMTEX (PETN +RDX)

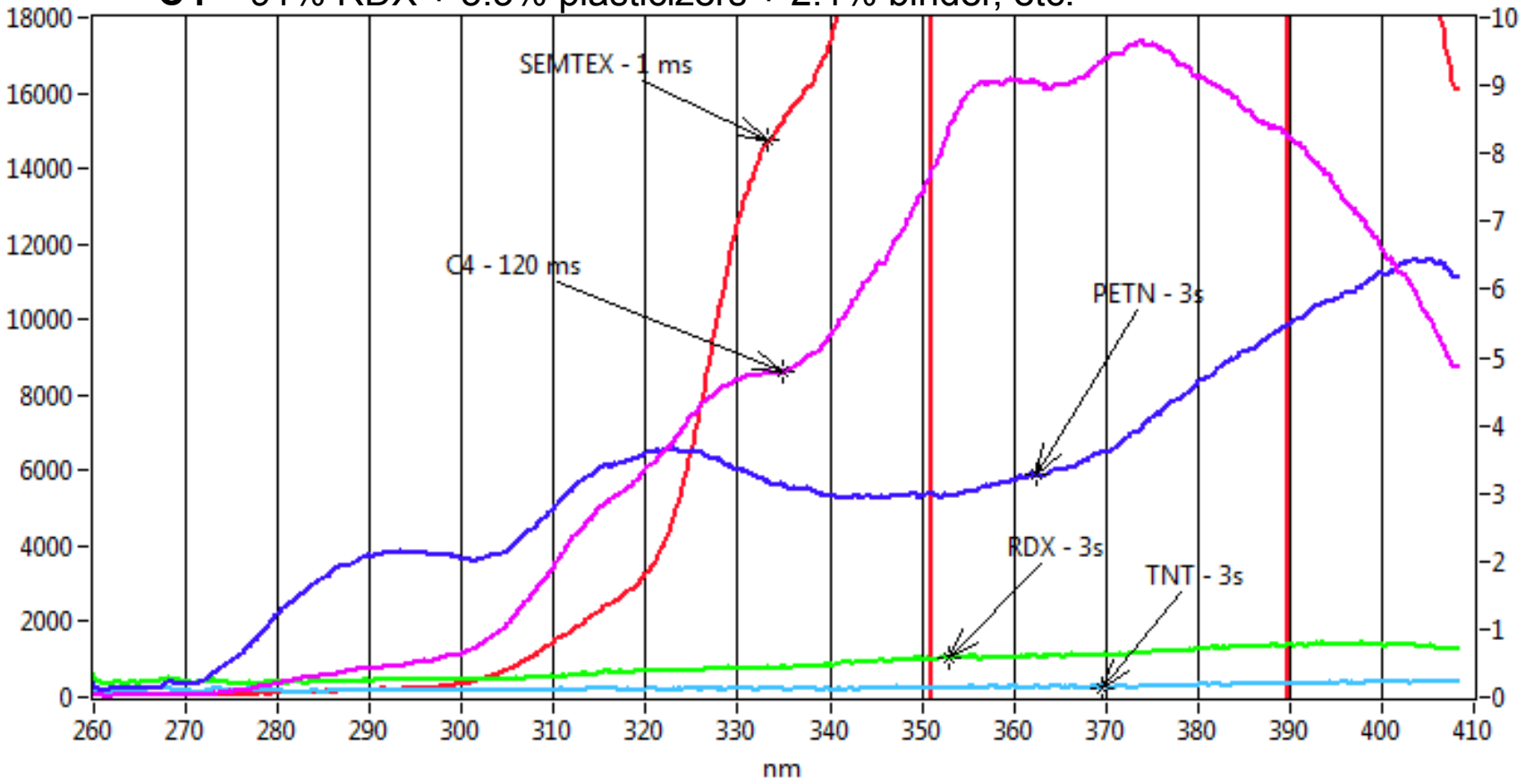
with no baseline subtraction or compensation, Ex=248 nm



DUV Fluorescence Spectra of Bulk Explosives

with no baseline subtraction or compensation, Ex=248 nm

SEMTEX = 76% PETN + 4.6%RDX + 9.4% binders + 9% plasticizers, etc
C4 = 91% RDX + 5.3% plasticizers + 2.1% binder, etc.



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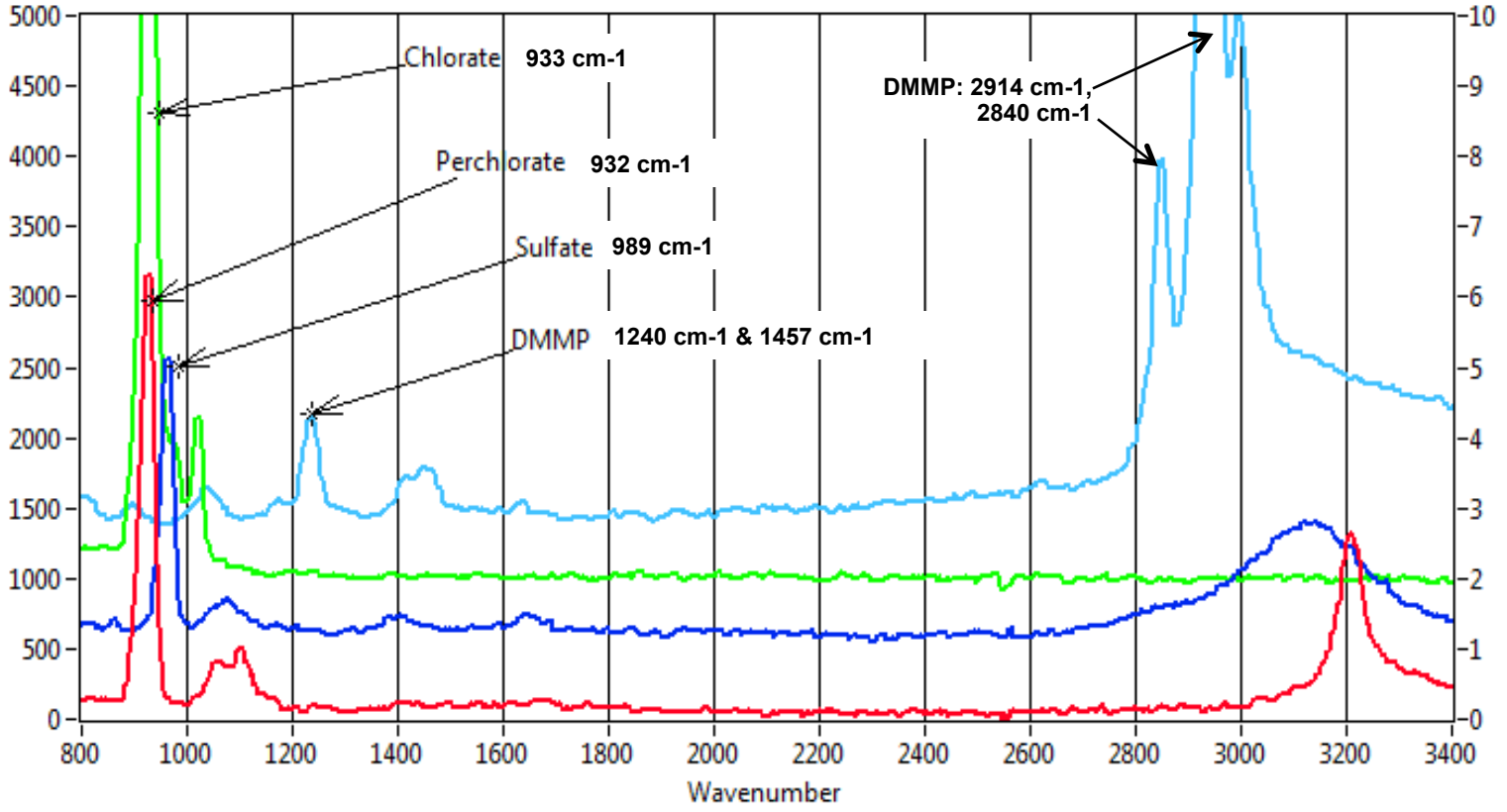
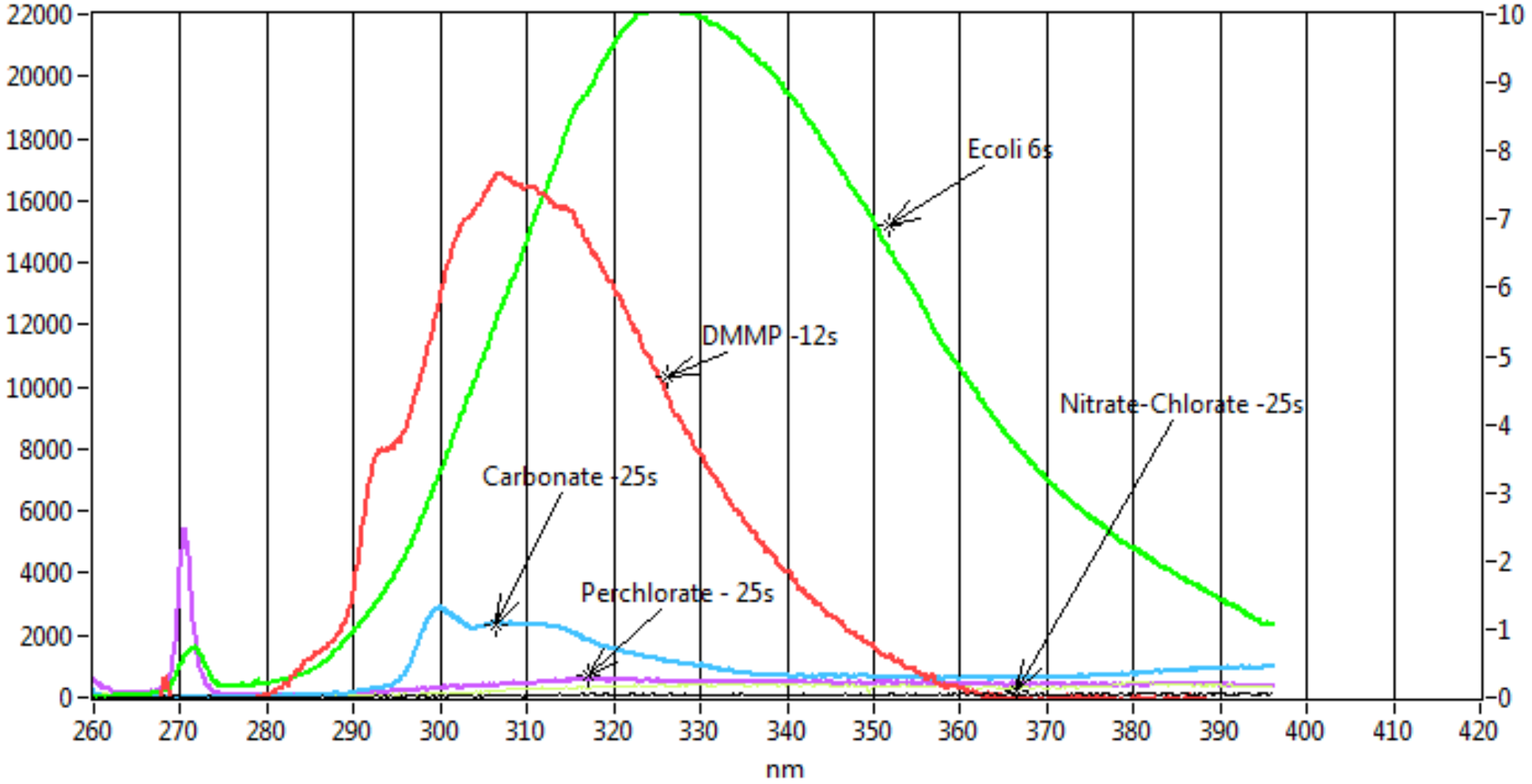
DUV Raman Spectra of Oxidizers & DMMP

with no baseline subtraction or compensation, Ex=248 nm
baseline offset for clarity



DUV Fluorescence Spectra of CBE Materials

with no baseline subtraction or compensation, Ex=248 nm



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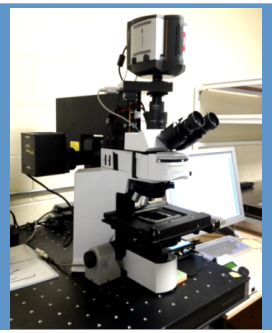
DUV Raman & Fluor Instruments for Surface Detection

Over wide spatial scales

			
	Microscopic (μMOSAIC)	Macroscopic Raman/PL 200 & MOSAIC	Standoff SHCBE, etc.
Working distance	1-10 mm	1-10 cm	1-10 m
Spatial resolution	0.2 -1 μm	10 - 200 μm	0.25 -10 mm
LOD	Small fraction of a single spore	Single spore or ng/cm^2 at 5 cm	60 spores or low μg per cm^2 at 5 m

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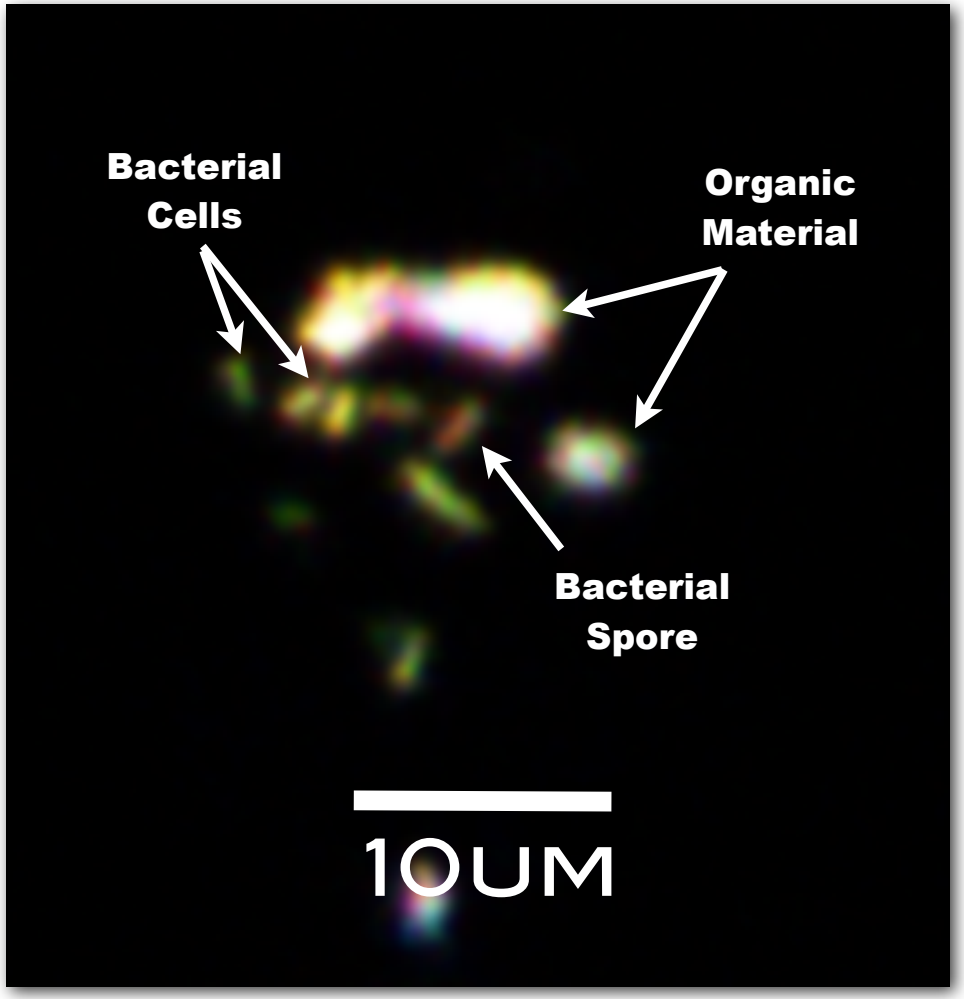
Microscopic Microbial Differentiation, Ex = 224 nm

Evidence of Speciation with native fluorescence



Bacterial Cells (GC%)

Staphylococcus epidermidis (32%)
Bacillus subtilis (44%)
Shewanella oneidensis (46%)
Escherichia coli (51%)

Bacillus atropheus spores

Tyr (and Phe) concentrations increase with decreasing GC-content (Lobry 1997)

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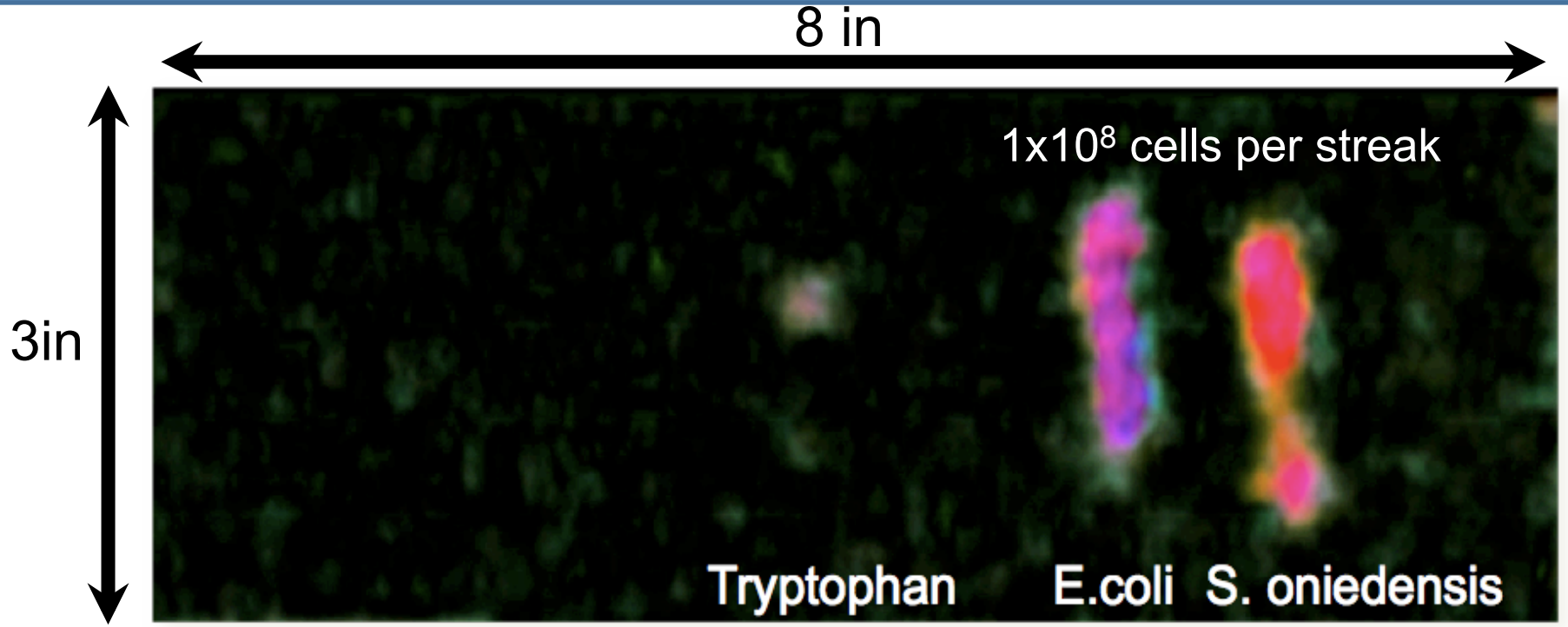
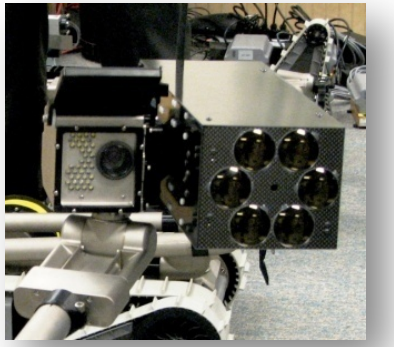
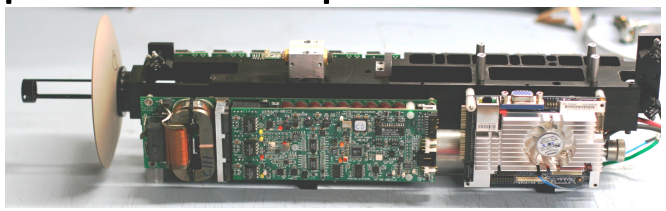
Standoff Bicrobial Differentiation on Painted Wall

@ 2 m with Gen 1.0, @ 6 m with Gen 2.0 (f/55)





- Differentiability of two gram (-) genuses, due to phenotypic traits associated with protein composition & conformation



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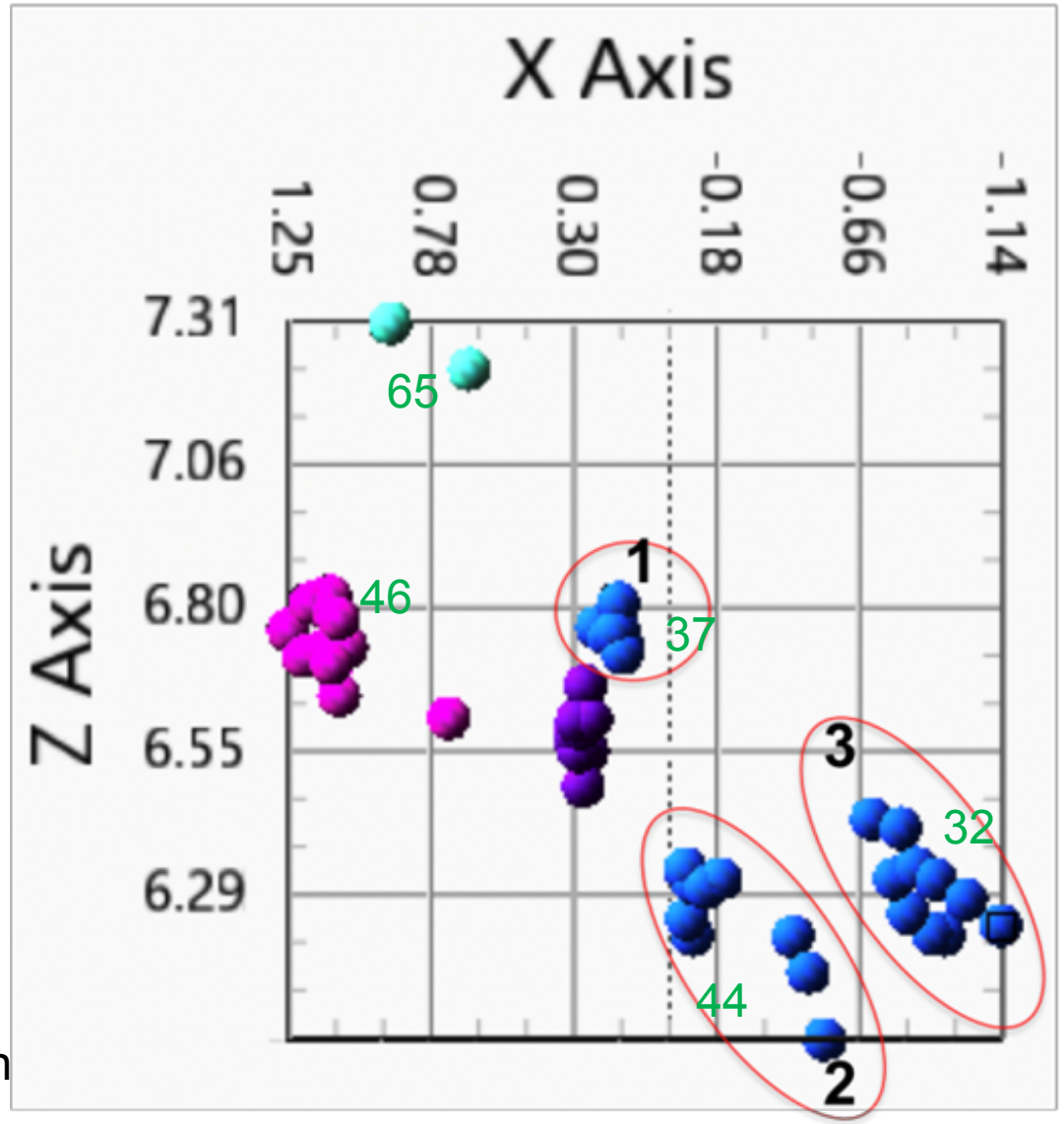
Differentiability of Microbes on Surfaces

- Detection diluted in talc down < 10 microbes in view volume or <1/50K w/w
- Multiple independent preparations and samples per organism



GC% content shown in green

E. coli
Bacillus sp.
1. B. megaterium
2. B. subtilus
3. B. cereus
S. Oneidensis
P. aruginosa

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