Hand-held submersible real-time reagentless CBE sensor

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Sensor Goals

- To determine appropriate level of diver dress *in real time & on site*
  - Category 1; fully encapsulated diver w/ surface exhaust and positive pressure helmet
  - Category 2; fully encapsulated diver w/ in-water exhaust
  - Category 3; full face mask and wet suit
  - Category 4; standard dive dress (face mask)
- To replace or augment current 72 hour laboratory-based diagnostic protocol
- 2 operational scenarios:
  1. prior to water entry
  2. after water entry

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Types of Littoral Water Contamination

Chemical		Biological
Acrolein	Ir, V	*Escherichia coli* (*E. coli*)
Acrylonitrile	Tox, Car, V, Ir	*Salmonella typhi*
Benzene	Car, V	Vibrio (cholera)
Creosite	Car, Ir	*Shigella dysenteriae*
Ethylene glycol	Ir, Tox	*Pseudomonas aeruginosa*
PCBs	Car, Tox	*Burkholderia mallei*
Phosphoric acid	Car, Tox	Enterrococci
Phenol	Ir,	Cryptosporidium
Styrene	Tox, Ir	*Schistosoma sp.*
Toluene	V	Giardia
Vinyl acetate	V	Enteroviruses
Xylene	V	
Domoic acid	Tox	Algal blums

Ir = irritant, Car = carcinogen, Tox = acutely toxic, V = volatile

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Conditions for Biologically Hazard

- Presence of bacteria in the water column does not constitute a hazard
- The environment & physiologic state of the microbe determines it pathogenicity

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Toxicity Vectors

- Sewage runoff
  - *E. coli, enterococci* species
    - Shiga toxin, enterotoxin
- Storm water/terrestrial runoff
  - *Pseudomonas aeruginosa, Burkholderia pseudomolla*
    - Exotoxin A, Cytolethal distending toxin
    - Fertilizer (nitrates, phosphates), pesticides, BTEX, etc.
- Ship bilge effluent
  - Urine, oil, chemicals, detergents
  - Viral Hemorrhagic Septicemia
- Algal blooms
  - Red Tide
    - Neurotoxins, e.g. domoic acid, saxitoxin

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  Something in here about chemicals (nitrates, phosphates, petrochemicals…)
- Algal blooms
  - Red Tide
    - Neurotoxins, e.g. domoic acid, saxitoxin
- Bilge pumps
  - Urine, oil, chemicals, detergens
  - Viral Hemorrhagic Septicemia

- Only types of bacteria considered indicator organisms by the EPA
- Current process takes typically 72 hours

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Current Recommended Indicators for Assessing Water Hazards

Core Indicators	Supplemental Indicators
Pathogen indicators (*E. coli*, enterococci)	Other chemicals of concern
Nutrient load (nitrates, phosphates)	Hazardous chemicals
Chlorophyll concentration	VOCs
Dissolved oxygen	
Temperature	
pH	
Flow	
Secchi depth (turbidity)	

* EPA water monitoring and assessment program (2003)

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Currently, there are no methods for real time detection and characterization of bacteria

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Objectives of ONR-Funded Project

- Develop an instrument design for a hand-held, real-time, in situ, reagentless sensor to assess hazards in a water column
- Build & test an engineering model sensor that can be deployed at a dive site capable of monitoring:
  - Particulate material such as microbes
  - dissolved chemicals

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Method

The instrument includes two methods:

- A deep UV (DUV) Raman and Fluorescence spectrometer observing and analyzing a view volume in the water column allows detection of particulate (including microbes) and dissolved fraction in the water column.
- A gas chromatograph coupled to a differential mobility spectrometer (GC/DMS) with permeable membrane allows detection of mixtures of volatile compounds

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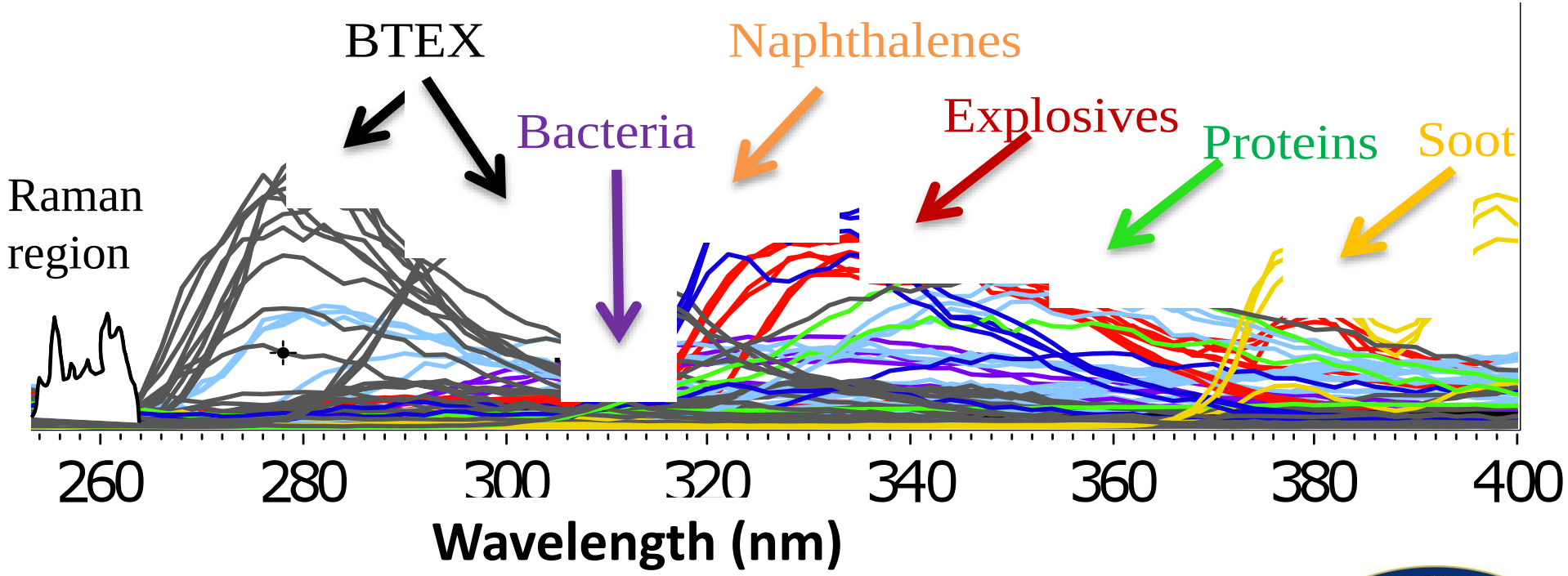
Deep UV Raman & Native Fluorescence

- Excitation below 250nm allows for the classification of microbes and a variety of organics
- Exciting below 250nm also allows for simultaneous collection of Raman and fluorescence information



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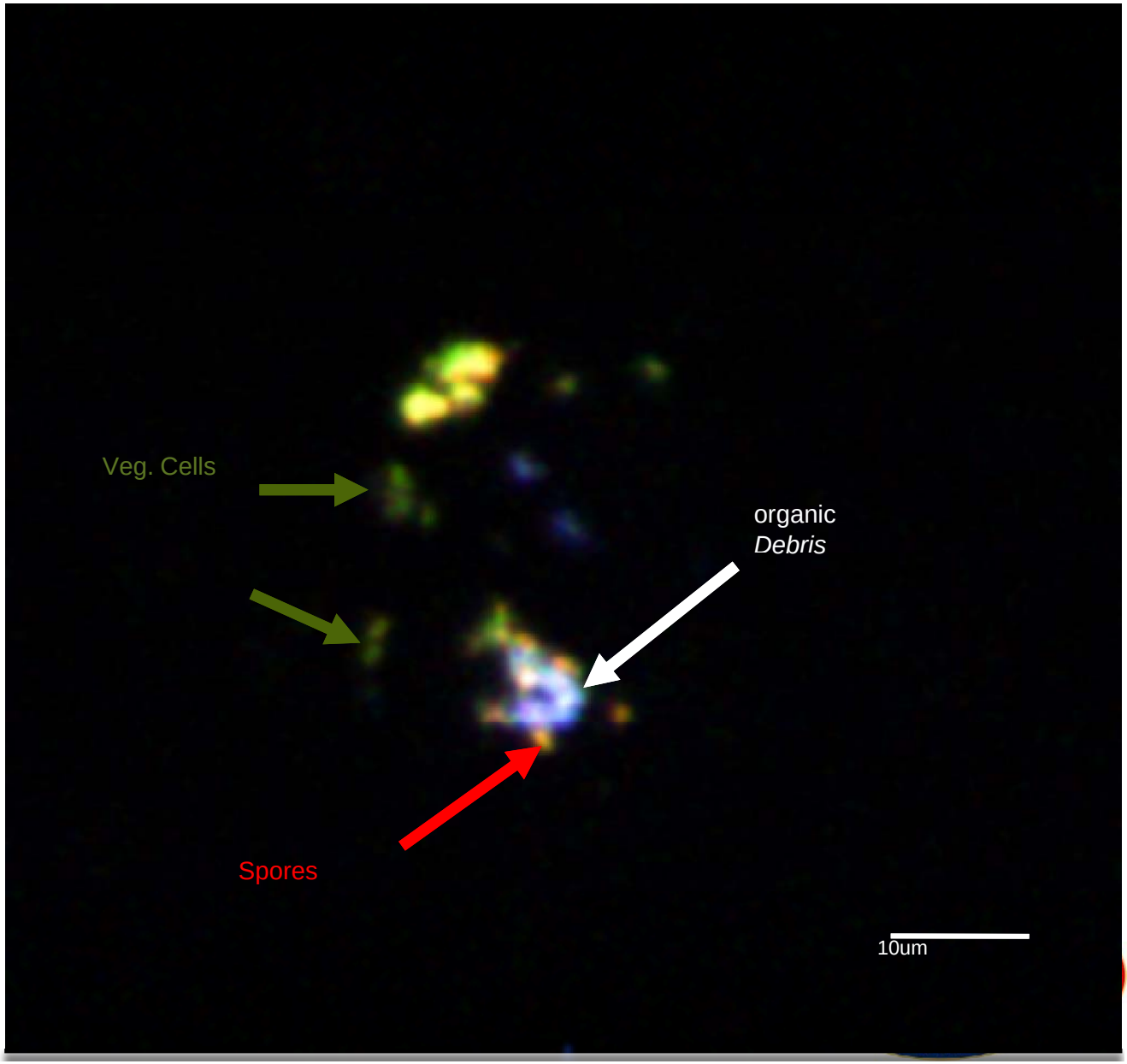
DUV Laser Induced Native Fluorescence

- DUV fluorescence allows for the non-invasive characterization of microbes in natural environments
- Allows for differentiation of cells vs. other particles & dissolved organics



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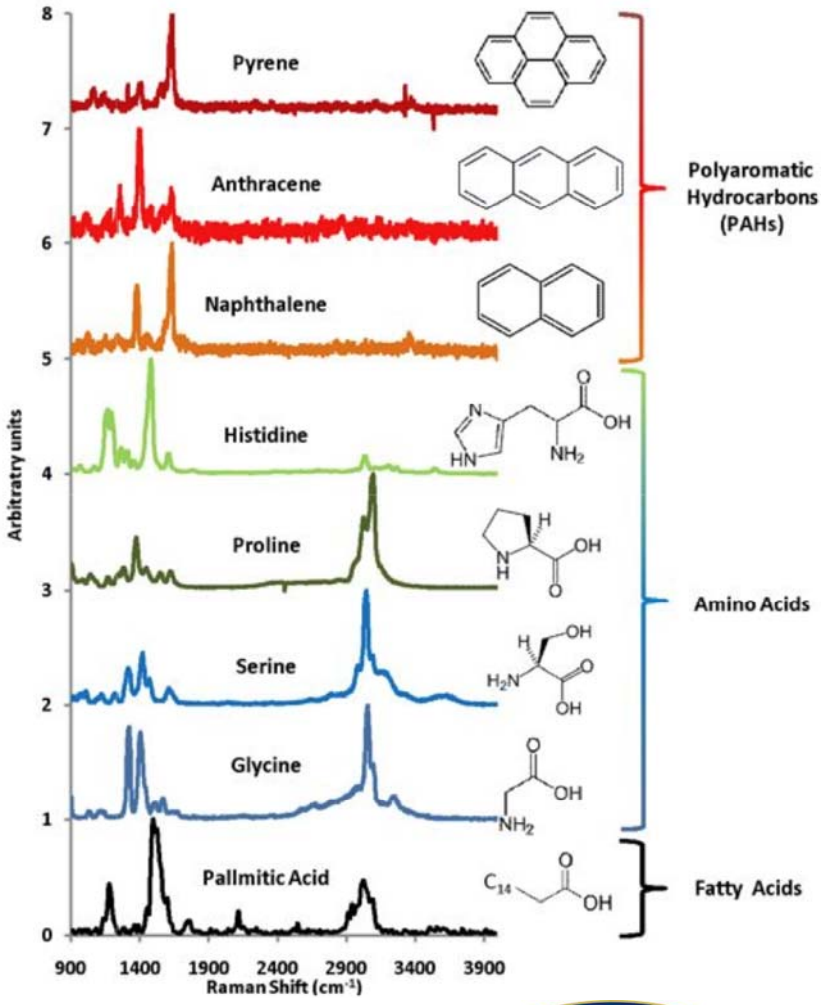
Deep UV Raman Spectroscopy

- Raman spectroscopy allows for specific chemical information
  - e.g., nitrates, phosphates
- Can detect and characterize compounds based on the types of chemical bonds, e.g. N-O, N-H, C-O, C-C



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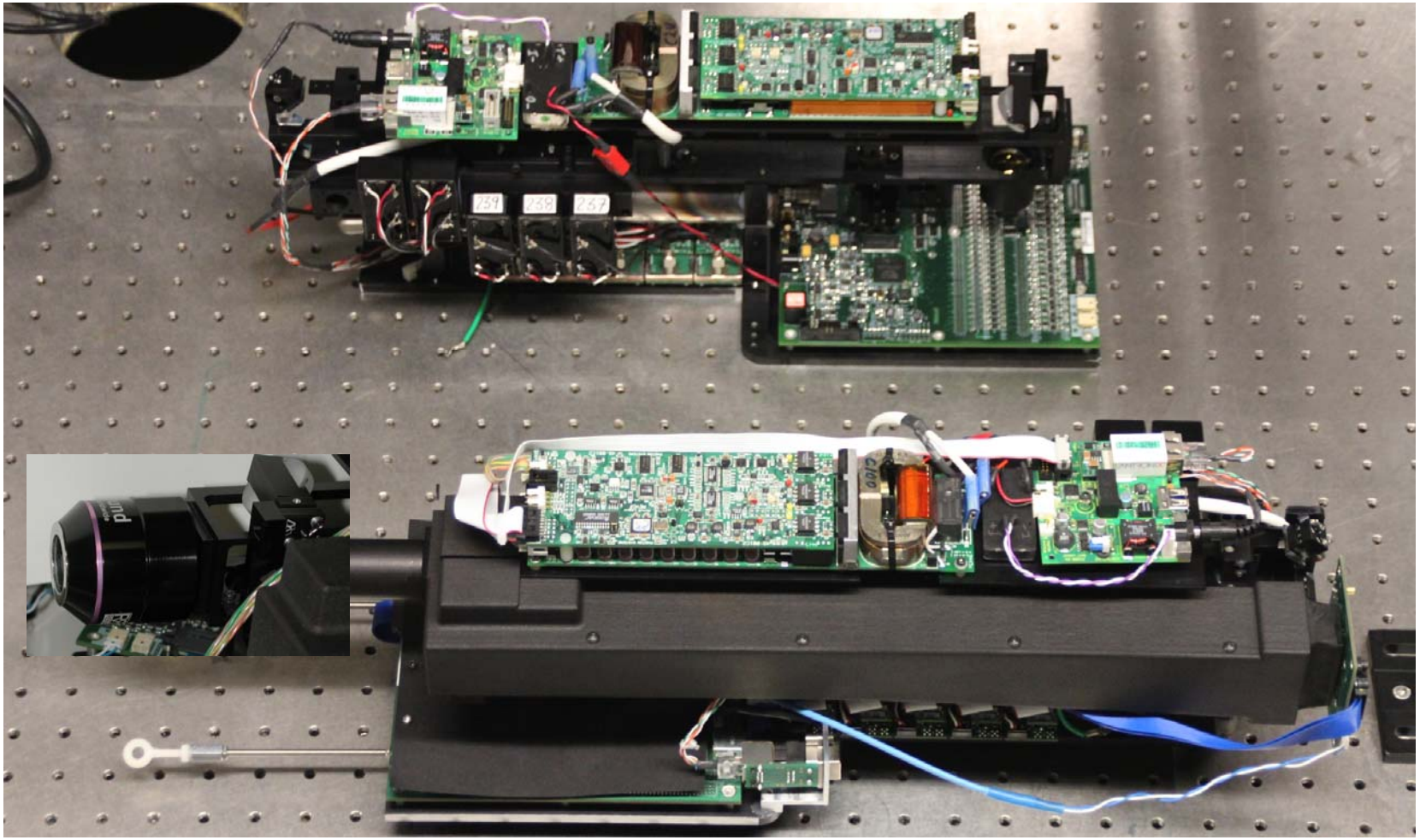
DUV Instrument



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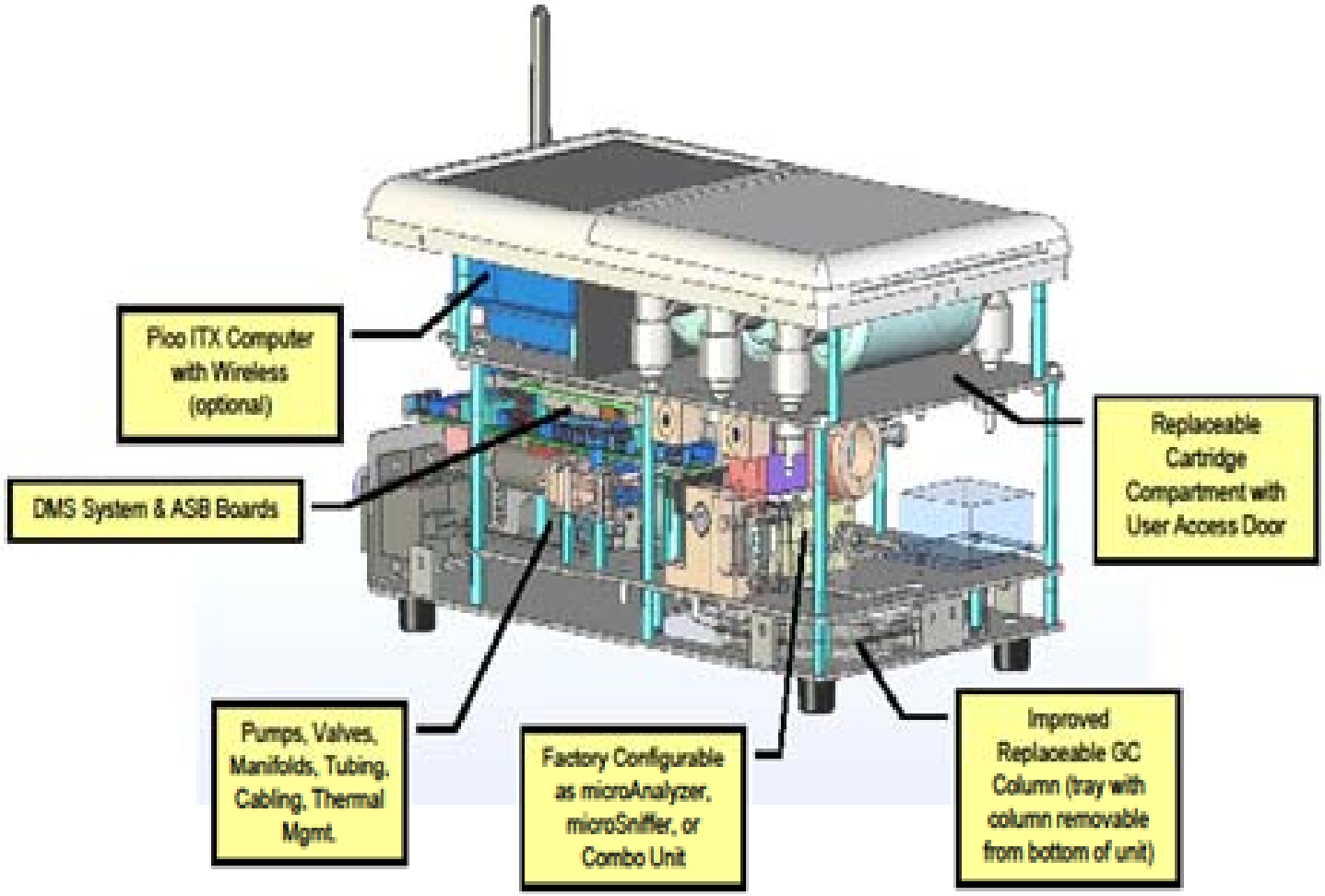
GC/DMS

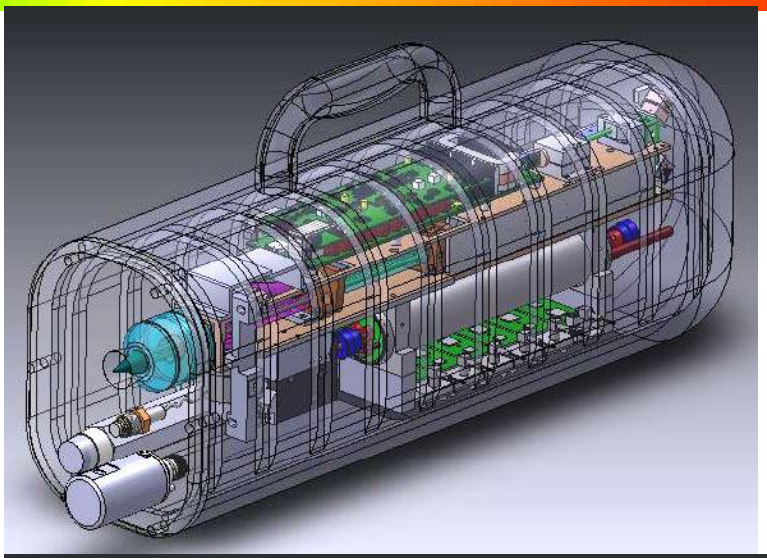


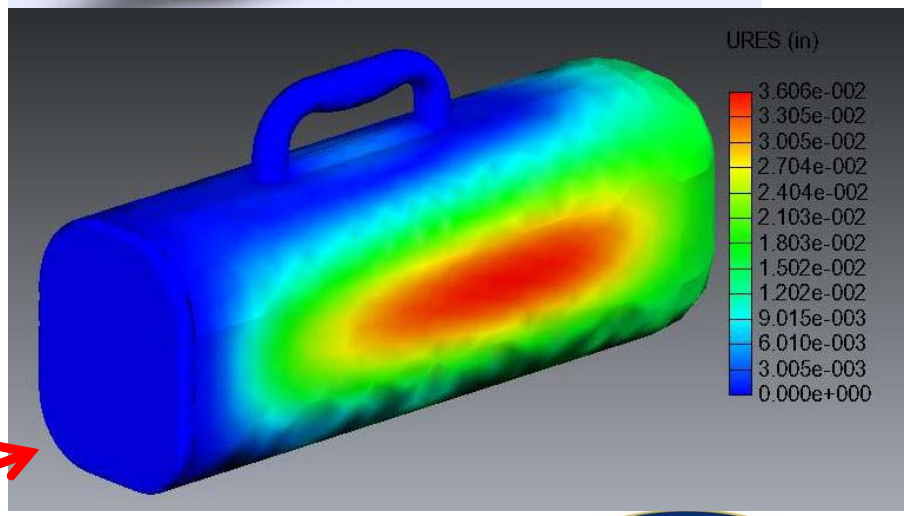
Membrane inlet GC-DMS sensor

- broad-range of volatile organic carbons (VOCs) from seawater

Handheld Submersible Chemical, Biological, and Explosives Sensor (SubCBE)

- Detection of trace levels of a wide array of water-borne chemical and biological hazards
  - Aromatic hydrocarbons
  - BTEX
  - Microbes
  - Explosives
- Detection of nitrates and phosphates & other chem (Raman)
- Context sensors: O_2, pH, Conductivity, temperature





Housing deformation at 100 m depth

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Goals for the Coming Year

- Complete the assembly of the sensor and pressure housing
- Test sensor in contaminated near shore settings
- Develop software and analysis for multi-sensor data fusion
- Develop information display and audio/visual alarms

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Summary

Detection of hazards in water requires pulling together multiple sources of information

Deep UV (<250 nm) based handheld systems can provide hazard assessments in real time

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Questions?