Australian Government
Department of Defence
Science and Technology

Contaminant Detection in the Submarine Environment

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Carbon Monoxide

Contaminant Detection in the Submarine Environment

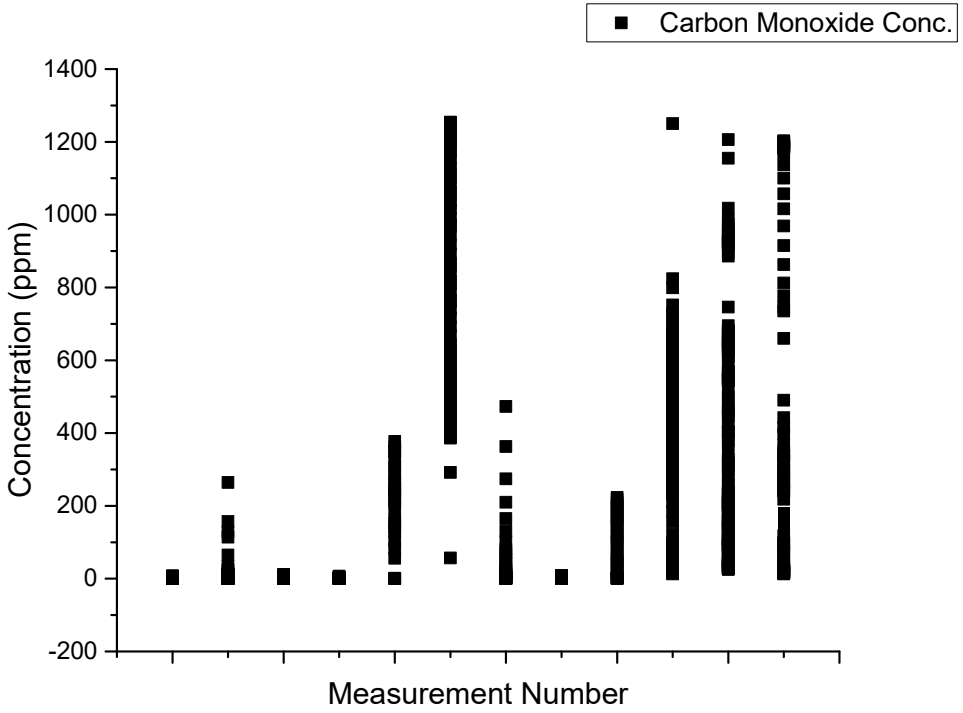
Commercial in confidence

Submarine Atmosphere Contaminant Detection

- Real time instrumentation
  - Distributed Sensor Network
    - Sensors distributed throughout the submarine
- Sensors must satisfy analytical requirements
  - Limits of Detection
  - Accurate
    - Free from cross sensitivities
  - Robust and reliable
    - Maintenance / boat schedules

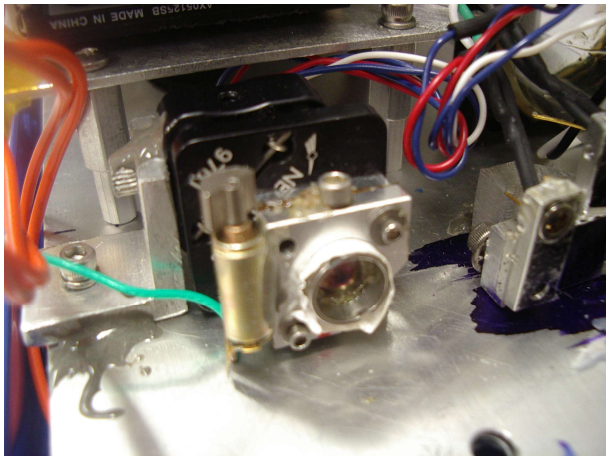
Submarine Atmosphere Contaminant Detection

Is it feasible to use low cost EC sensors to monitor toxic gases in a submarine?



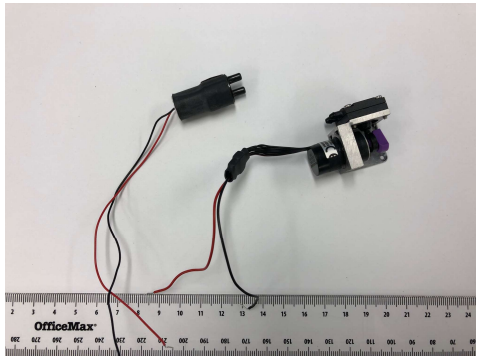
Submarine Atmosphere Contaminant Detection

- DST Prototype Tunable Diode Laser (TDL), Carbon Monoxide
- SAMAP 2015
  - Permanent mounting or portable use
  - Light weight, battery or boat power
  - Sensitivity, Stability, Selectivity,

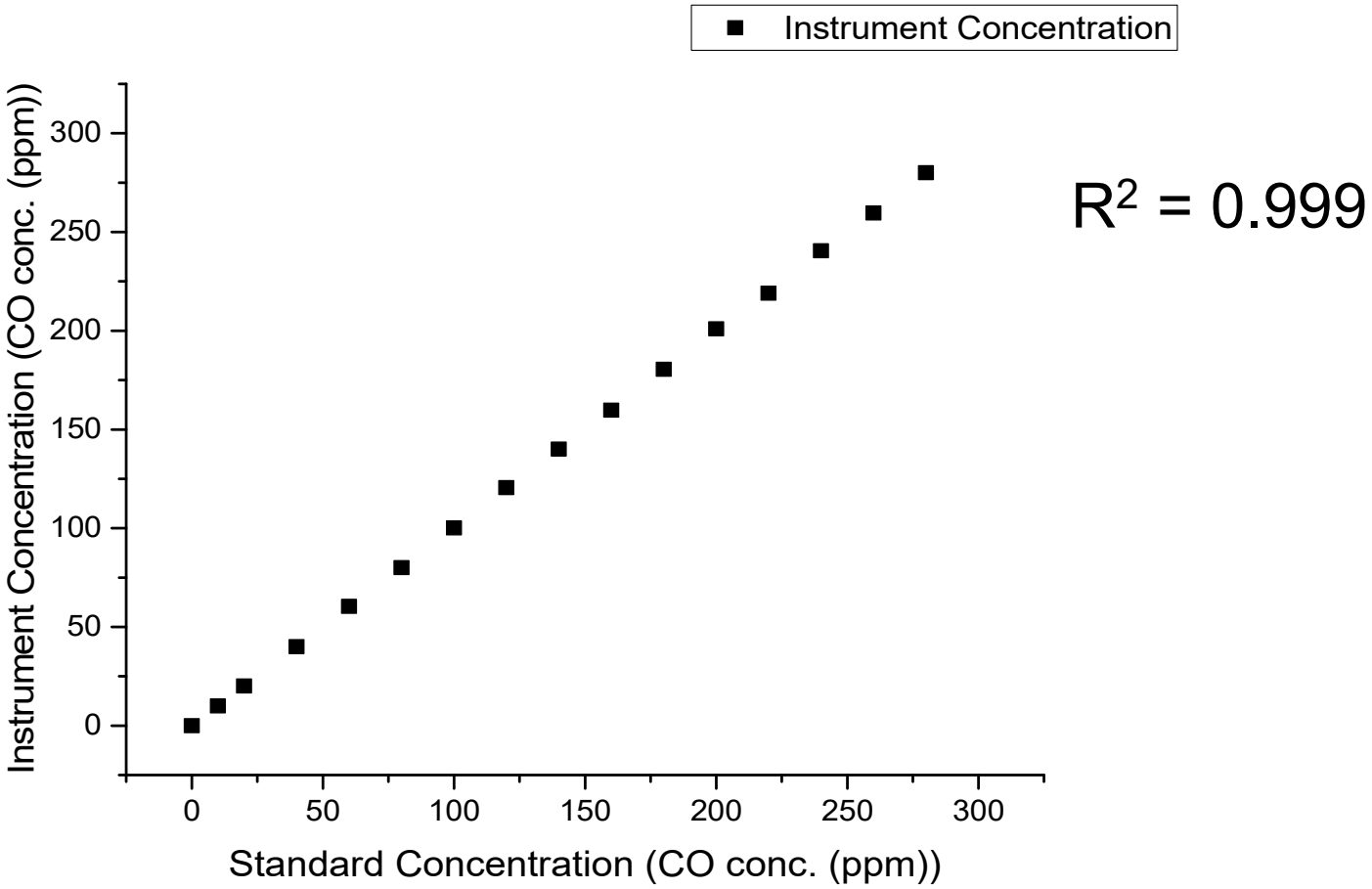


Submarine Atmosphere Contaminant Detection

- DST TDL Continual Development of the Instrument
  - Software/firmware modifications
  - Improved stability
    - Changes made to the TDL
  - Improving the longevity of the air intake pumps
  - Protection of the instrument from the Submarine environment



Submarine Atmosphere Contaminant Detection



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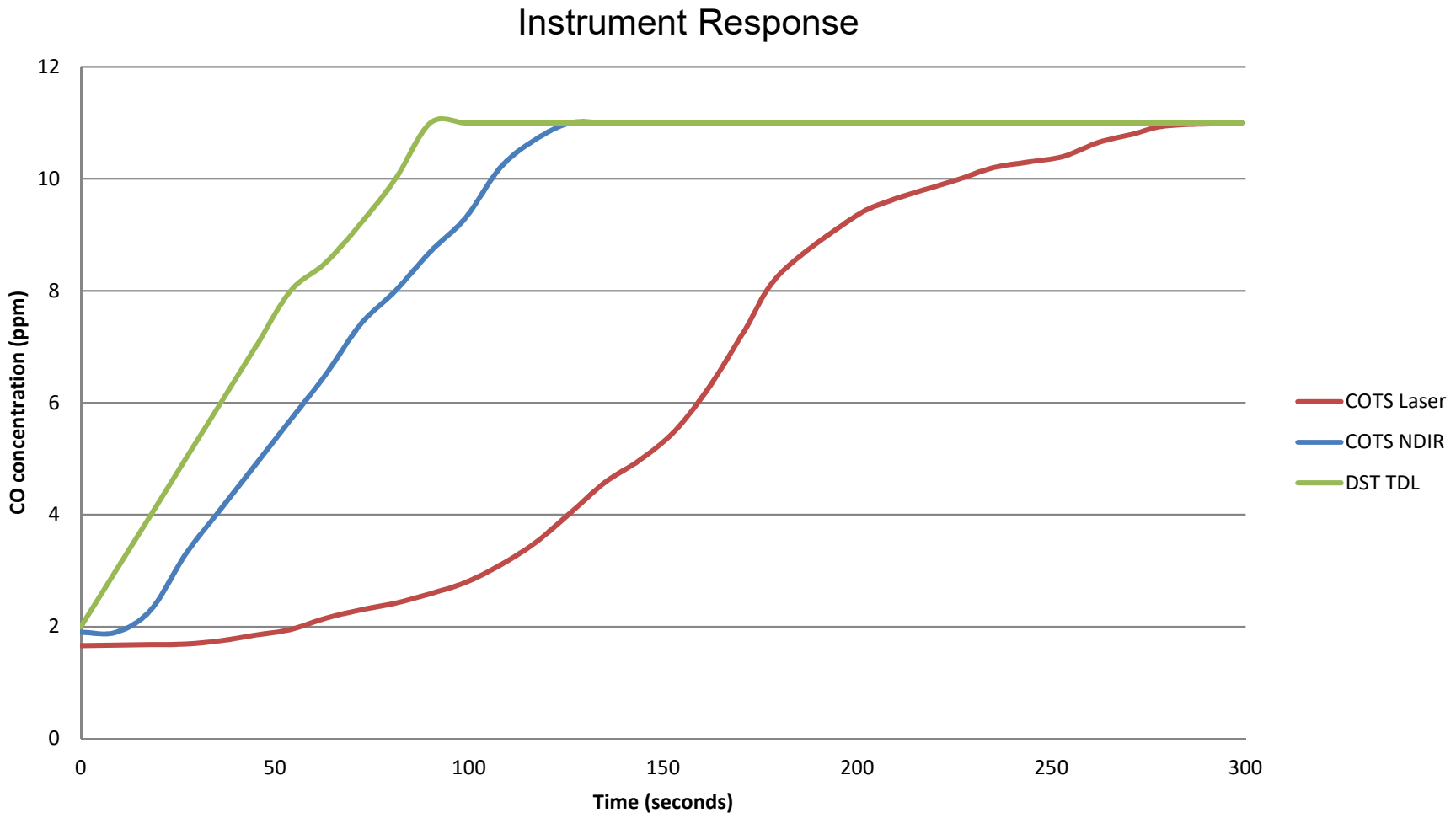
Submarine Atmosphere Contaminant Detection

- DST TDL Compared with COTS options
  - Laser Based Instrument
  - Nondispersive Infrared (NDIR)

- COTS options are;
  - Less flexible
    - Boat Power Only,
    - Higher Power Consumption,
    - Larger Footprint

Submarine Atmosphere Contaminant Detection



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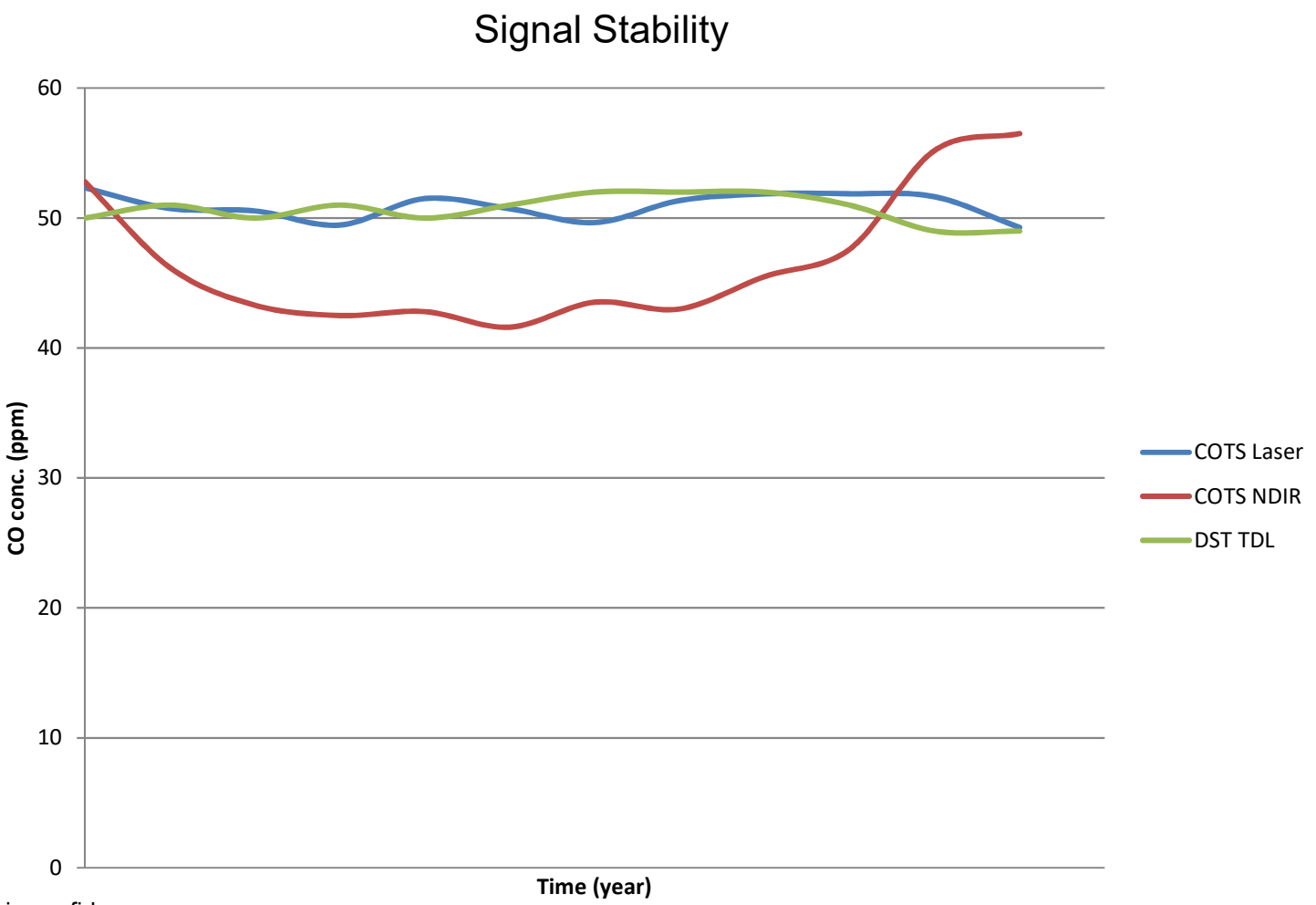
Submarine Atmosphere Contaminant Detection



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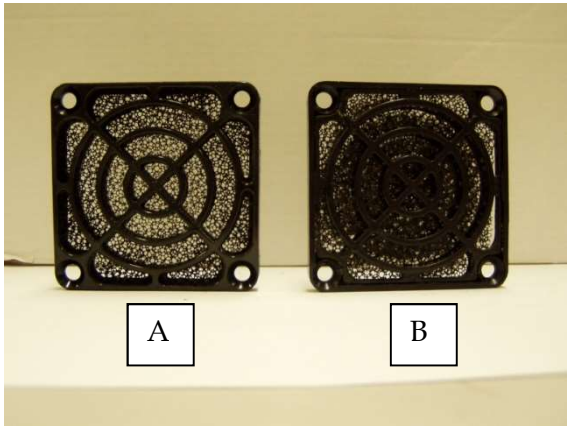
Submarine Atmosphere Contaminant Detection

DST TDL

COTS Laser Instrument



Particulate screen filter on air cooling
A = Clean, B = ~ 20 days

Diesel Exposure Assessment

Submarine Atmosphere Contaminant Detection

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Submarine Atmosphere Contaminant Detection

- Diesel Exhaust has two fractions
  - Gaseous & vapors
    - Major Components (99%) N_2, O_2, CO_2 & H_20
    - Minor Components (1%) CO, NOx, SO_2
  - Particulate (DPM)
    - DPM = (Organic Carbon, OC) + (Elemental Carbon, EC) + Minerals

Submarine Atmosphere Contaminant Detection

- Elemental Carbon (EC)
  - Often used as a surrogate for DPM
  - Provides the best fingerprint for diesel exhaust
  - Relatively free of interferences
  - Chemically stable.

- EC/TC can vary dramatically depending on ending load, tuning, fuel etc.

- Organic carbon (OC) is not used as a DPM surrogate because other sources of OC (e.g., cigarette smoke)

Submarine Atmosphere Contaminant Detection

- Currently no law in Australia governing DPM exposure
- SAFEWORK Australia yet to release industry standard
  - Exposure Standards currently under review
- AIOH recommendation (2004) 0.1 mg/m^3 EC
- NSW Mines (2006) 0.1 mg/m^3 EC
- WA Draft Guideline (2013) 0.1 mg/m^3 EC

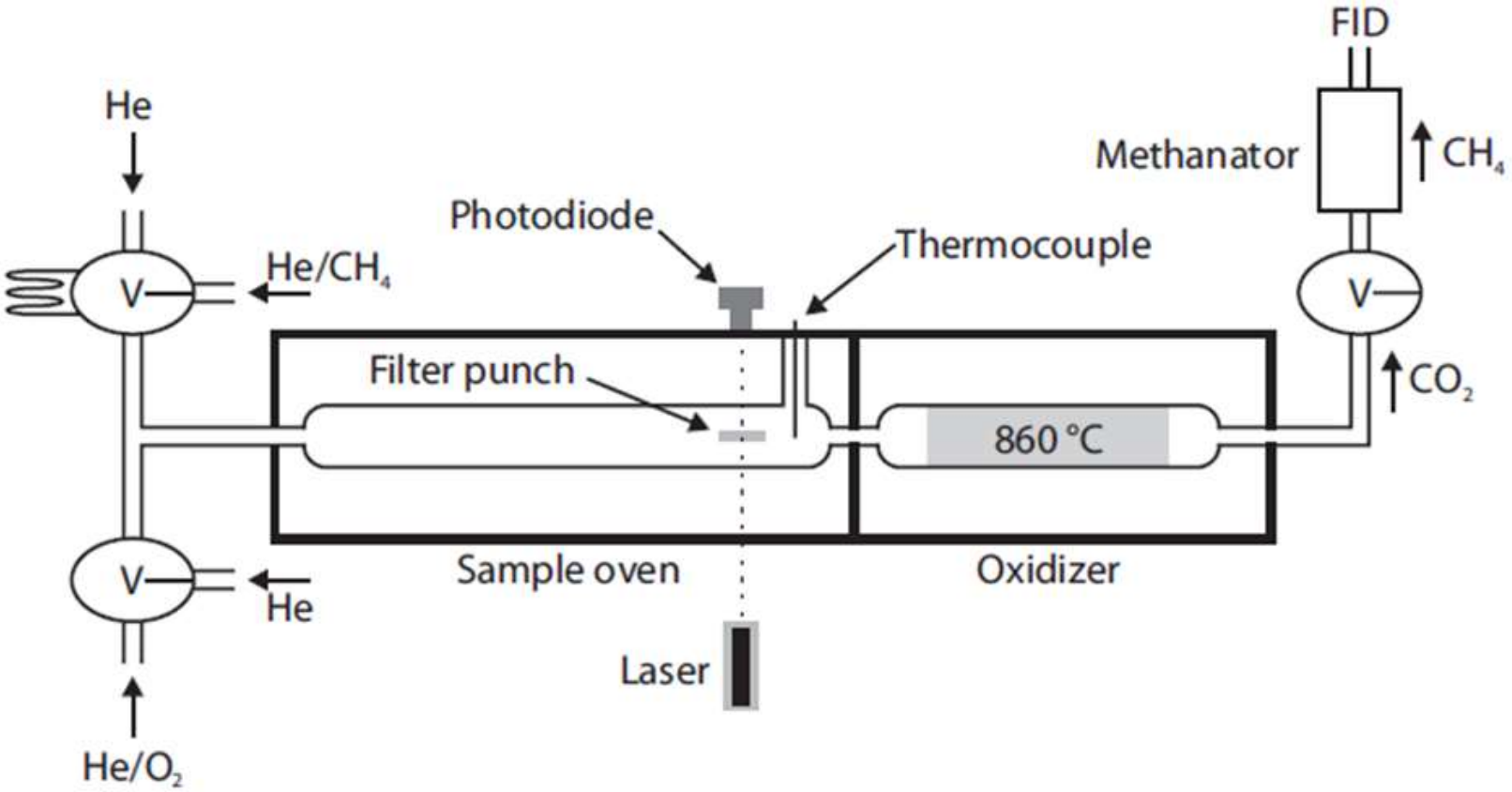
Submarine Atmosphere Contaminant Detection

- NIOSH method 5040 (measurement of EC)
  - A pump is used to draw air through a particle size selector and onto a quartz filter

- Downside of NIOSH 5040
  - Not real time, no feedback to crew
  - Crew involvement in the sampling process
  - Risk of sample degradation or contamination prior to analysis
  - Provides averaged result

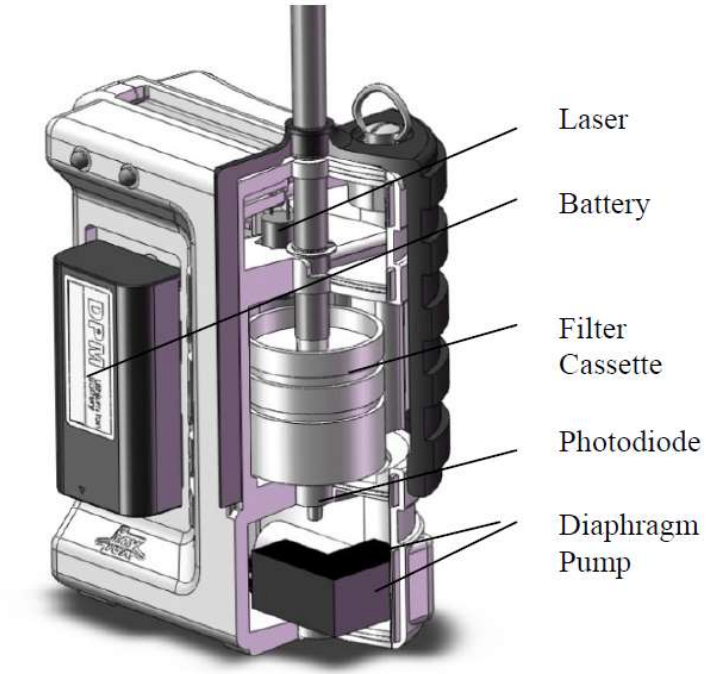
Submarine Atmosphere Contaminant Detection

- NIOSH 5040 - Thermal-optical analysis



Submarine Atmosphere Contaminant Detection

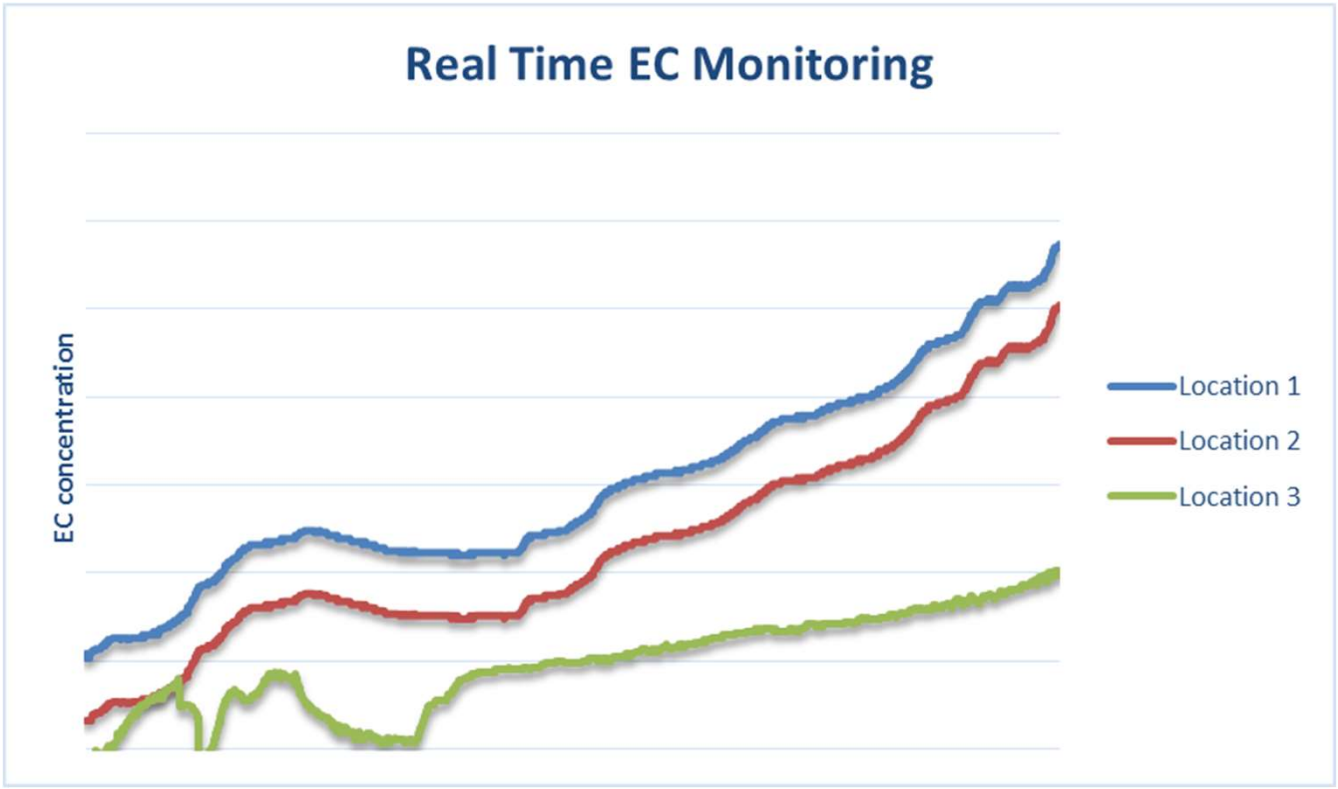
- Airtec Instrument
  - real time DPM (EC)
  - Air drawn into instrument using a diaphragm pump
  - Submircon particles collected on a filter
  - Laser illuminates the filter
  - As DPM particulates accumulate the lasers transmittance decreases



Submarine Atmosphere Contaminant Detection

External Cyclone (2) is used with the Airtec instrument
and connected conductive tubing (1)

Submarine Atmosphere Contaminant Detection



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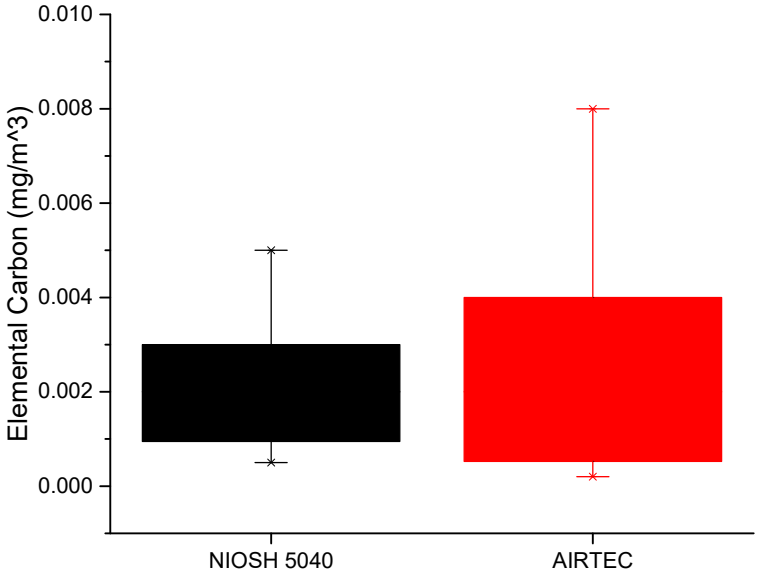
Submarine Atmosphere Contaminant Detection

- Elemental Carbon
  - Method NIOSH 5040 versus Airtec (Realtime)
  - Results obtained from NIOSH 5040 and Airtec are similar



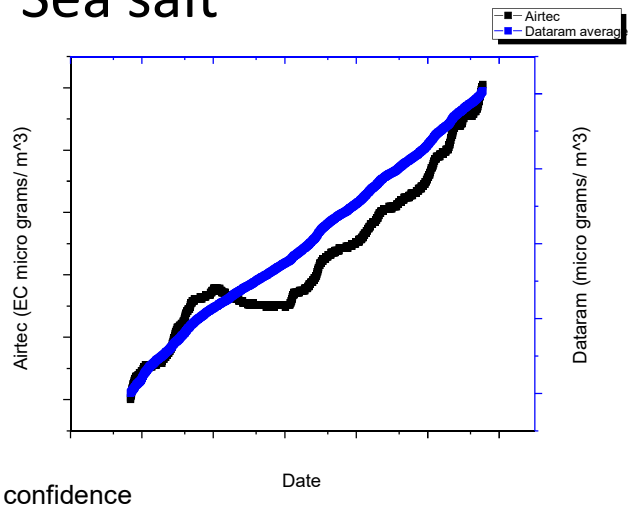
Differences between the two techniques are not statistically significant

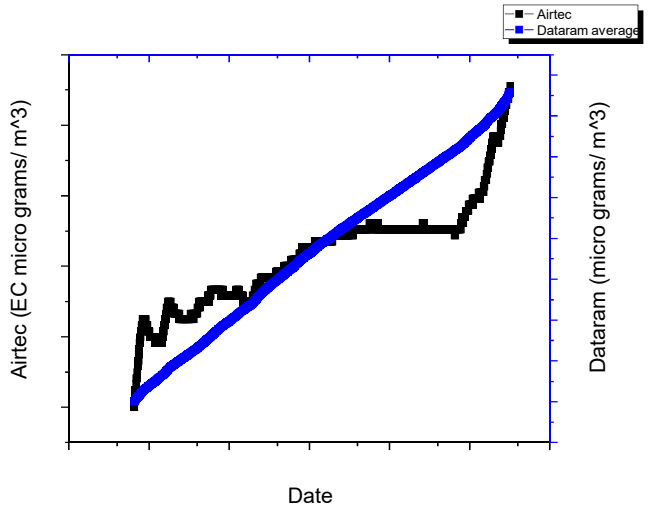
Submarine Atmosphere Contaminant Detection

- Aerosol monitors
  - Not calibrated for DPM
    - Typically Arizona Road Dust or A1 Test Dust
    - DPM has significantly different light scattering properties than of test aerosol
    - A light scattering photometric instrument response will not agree with DPM specific methods

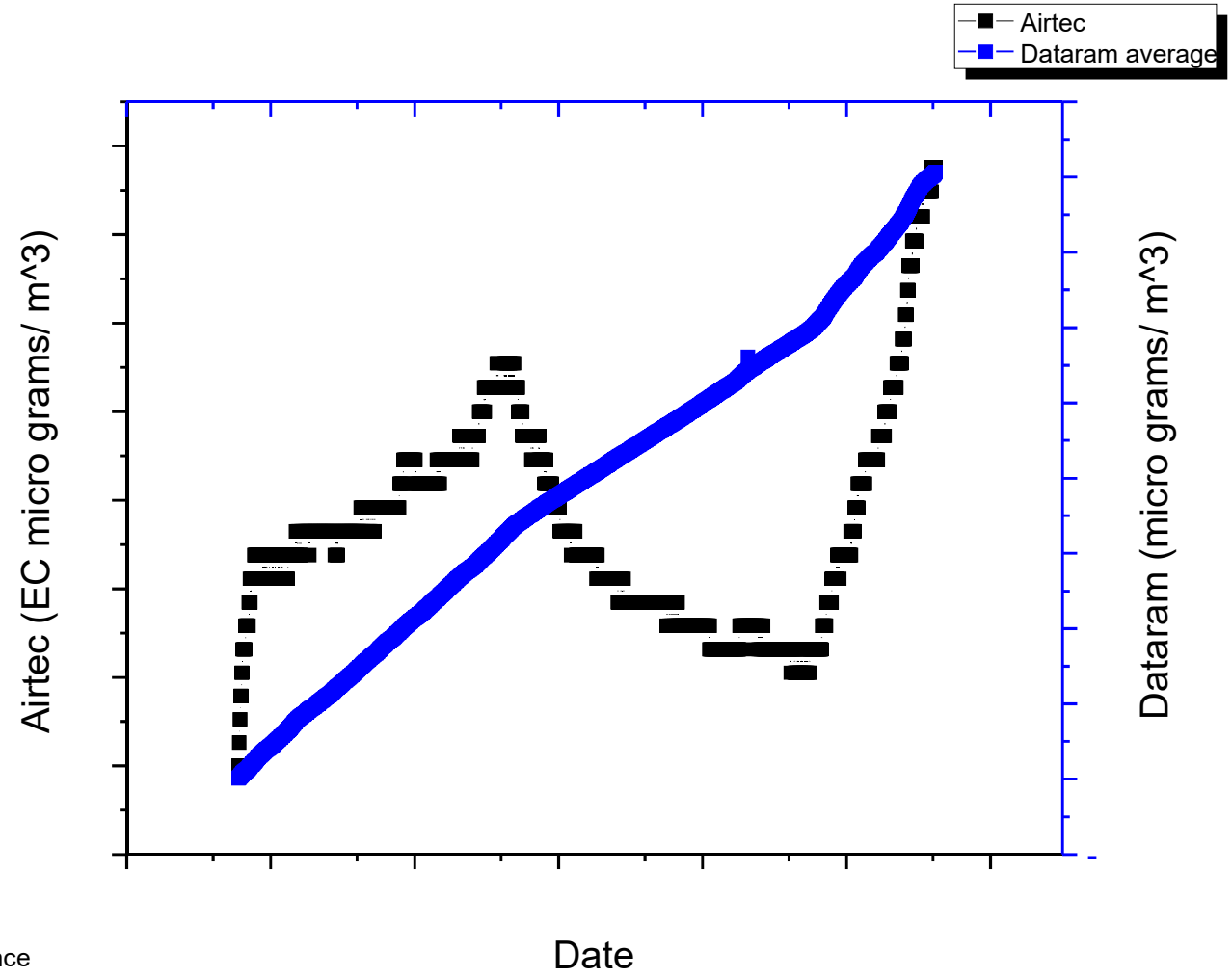
Submarine Atmosphere Contaminant Detection

- Aerosol Monitors Personal DataRam
  - Real time aerosol monitor
  - Passive sampler
  - Measures light scattering
  - No cyclone or filter
  - Sea salt



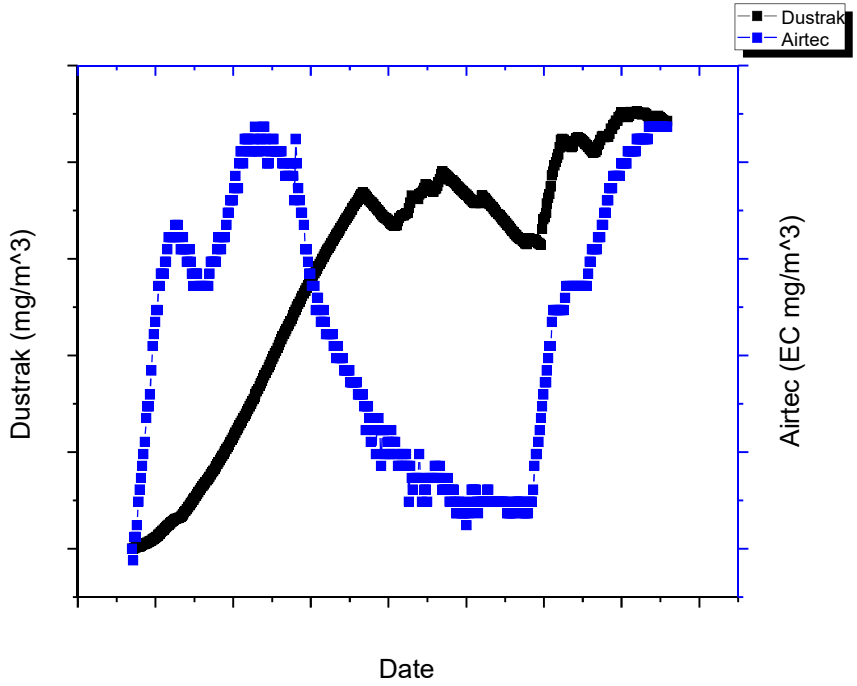


Submarine Atmosphere Contaminant Detection



Submarine Atmosphere Contaminant Detection

Dustrak (Aerosols)



Custom calibration factors used in conjunction with PM1 impactors can improve instrument response

Submarine Atmosphere Contaminant Detection

- Even if we detect EC accurately in the submarine atmosphere…

Are we capturing all potential risks sufficiently?

- Nanoparticle exposure
  - Does low EC guarantee low nanoparticle measurements, Answer = NO