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NOVEL WIRELESS SYSTEM FOR IN-SITU LAB-ON-A-DISC MULTI-PARAMETER WATER QUALITY ANALYSIS

22/8/12

SINO - EUROPEAN SYMPOSIUM
SESEH
ON ENVIRONMENT AND HEALTH

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22/8/12

@ cyrusmekon
#SESEH

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Contents

Centrifugal microfluidic analysis system: CMAS

- The desire for CMAS.
- Design of CMAS.
- Nitrite determination
- Conclusions.

About Clarity

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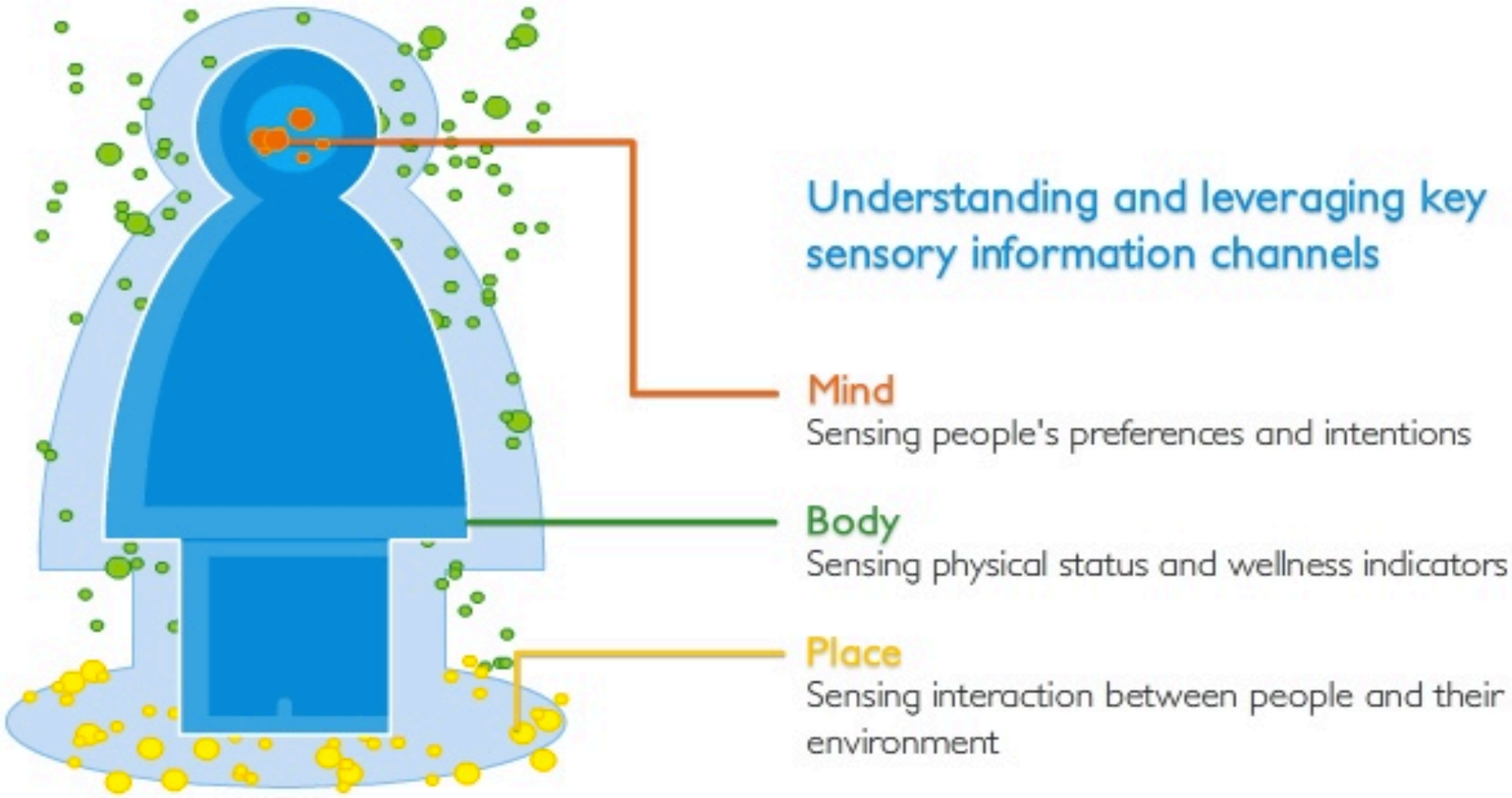
Vision: Sensing Mind, Body & Place



- Brings together fundamental materials science, functional polymers, device prototyping, energy management, adaptive middleware, wearable sensors, distributed environmental monitoring.

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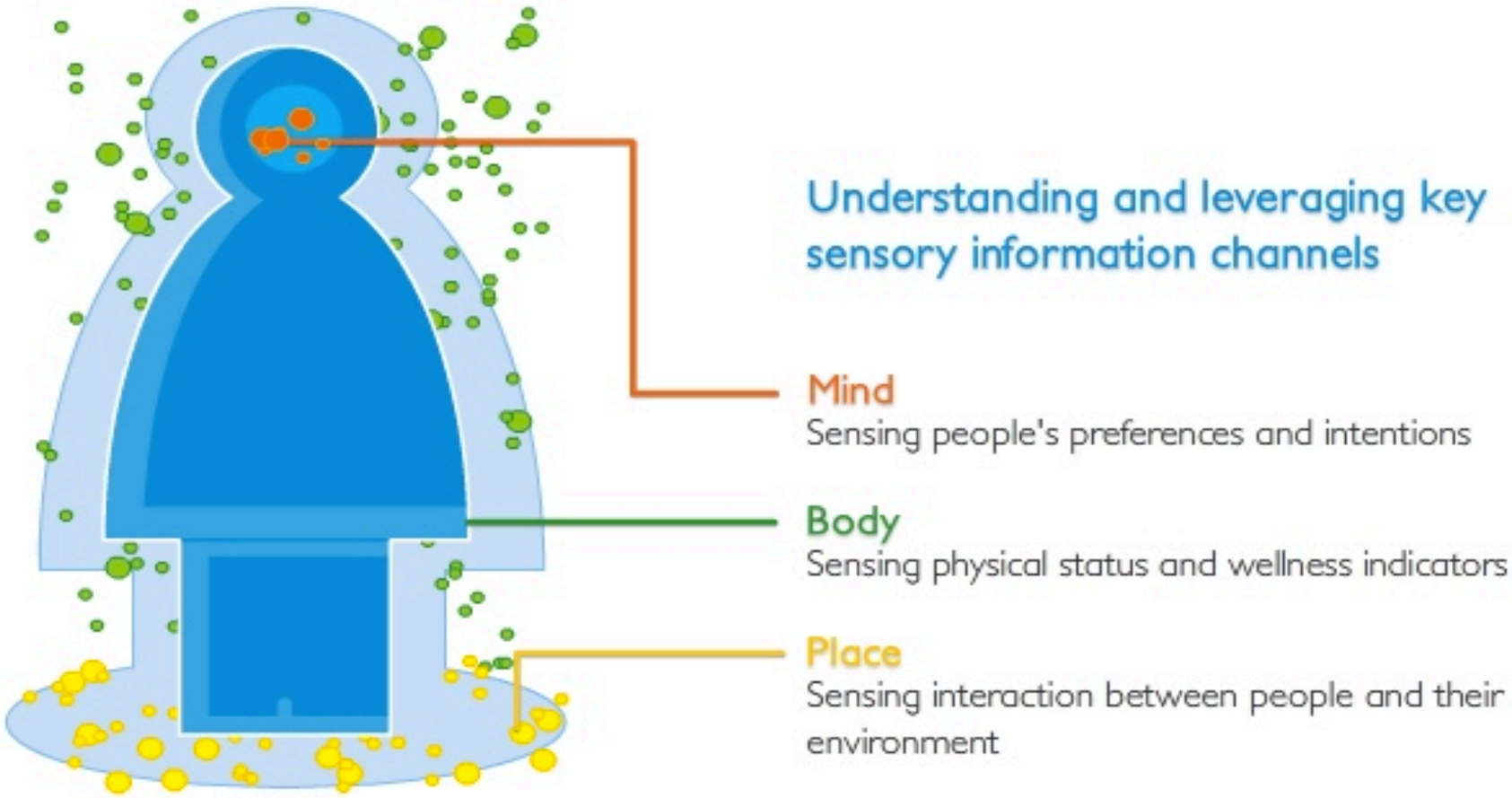

- Brings together fundamental materials science, functional polymers, device prototyping, energy management, adaptive middleware, wearable sensors, distributed environmental monitoring.

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The need for sensors.

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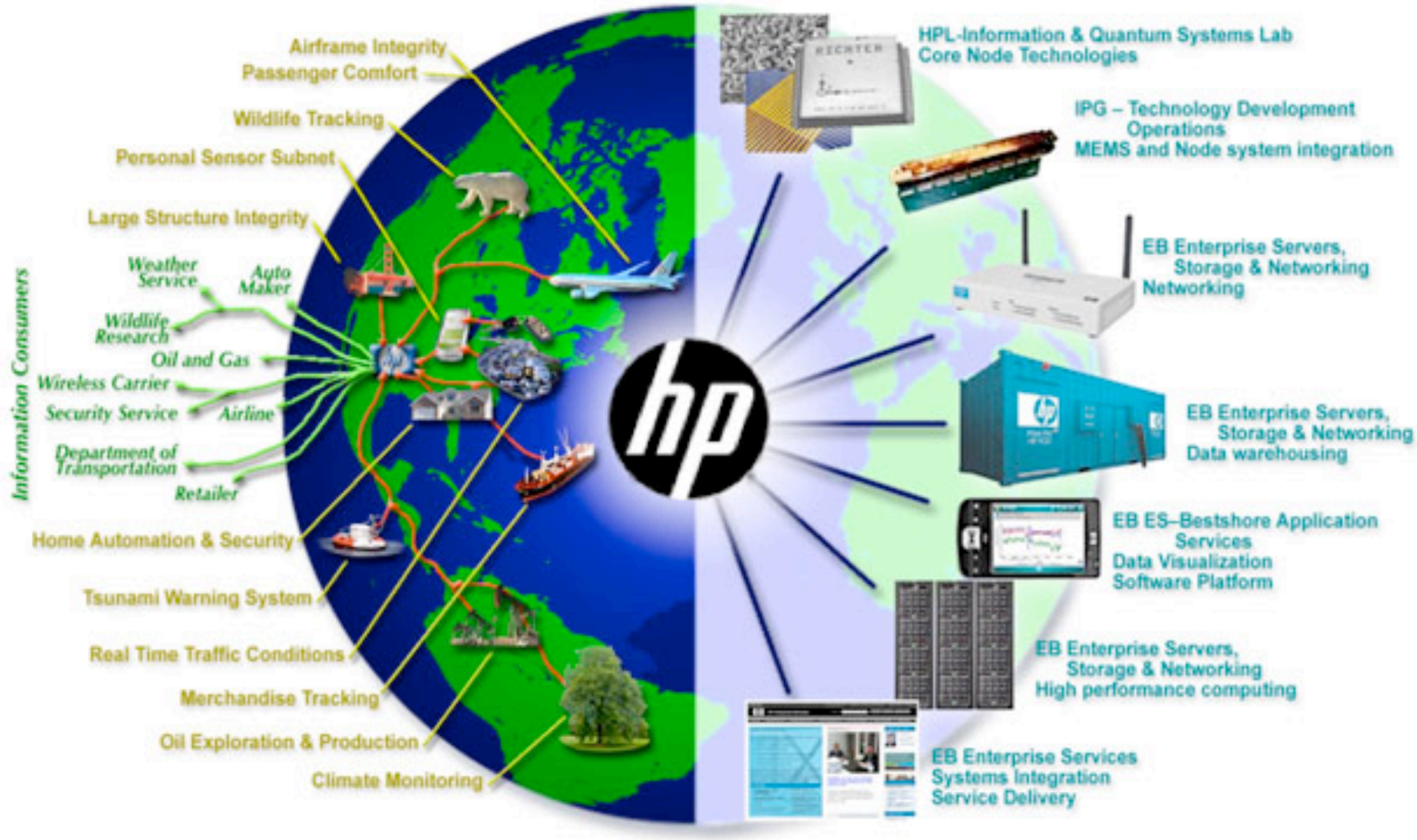

HP VISION

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The need for sensors.

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HP's Peter Hartwell: "one trillion nanoscale sensors and actuators will need the equivalent of 1000 internets: the next huge demand for computing!"

HP VISION

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The need for sensors.

Sensing Systems: $ 70 B global market by 2013 (Frost & Sullivan)

Sensing Services: $290 B Global market by 2013 (Harbour research)

HP VISION

The need for sensors.

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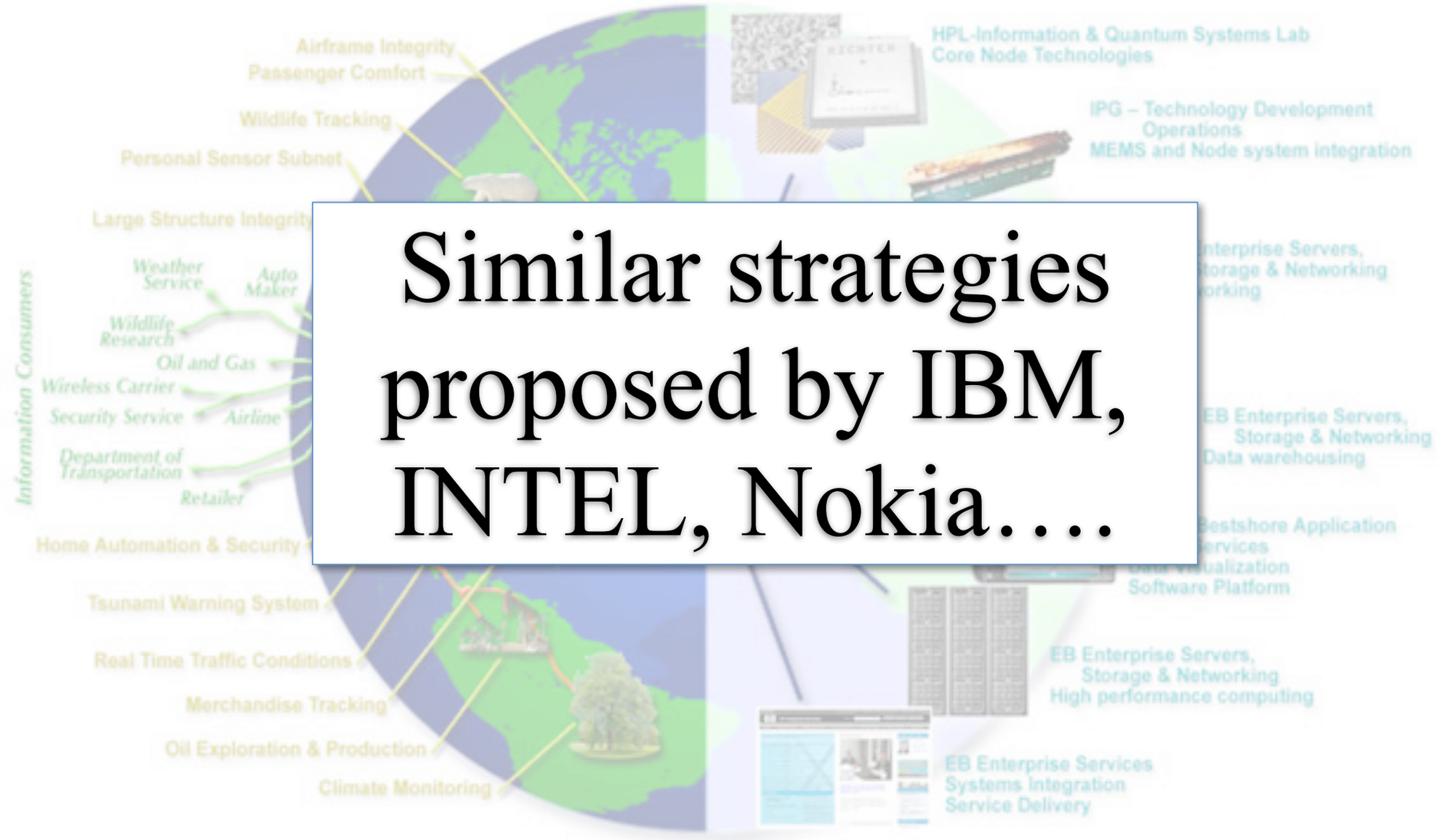

Similar strategies proposed by IBM, INTEL, Nokia….

HP VISION

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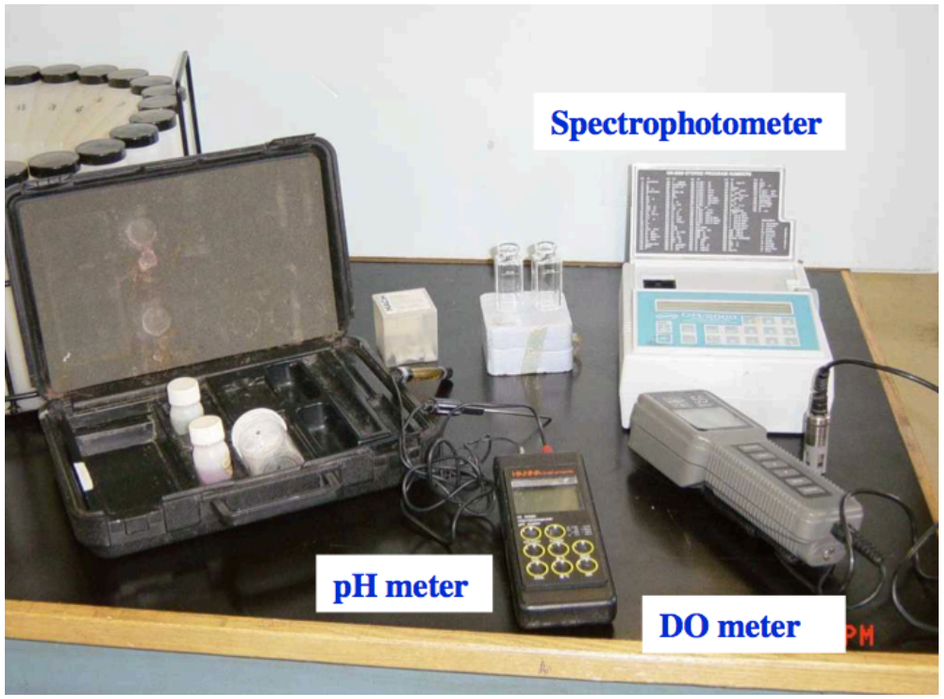
Brief introduction: The desire for CMAS.

- Existing analytical methods are very costly and time consuming, therefore simple, accurate sensing devices capable of multiple analysis would be of great benefit.



- portable
- cheap
- single probe
- no data saving

Model DS5 © 2005 Hach Company

- hand-held device
- ~14,000$
- multiprobe **(temperature, cond., pH, redox, DO, •turbidity (TSS), Nitrate, Ammomium, Sodium, Fluoride,, etc.)**

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Brief introduction: The desire for CMAS.

- Existing analytical methods are very costly and time consuming, therefore simple, accurate sensing devices capable of multiple analysis would be of great benefit.

- The availability of optical components like light emitting diodes (LEDs) or photodiodes in particular has opened the potential of optical sensing approaches to be widely employed in platforms for wireless sensor networks (WSNs).

The desire for CMAS.

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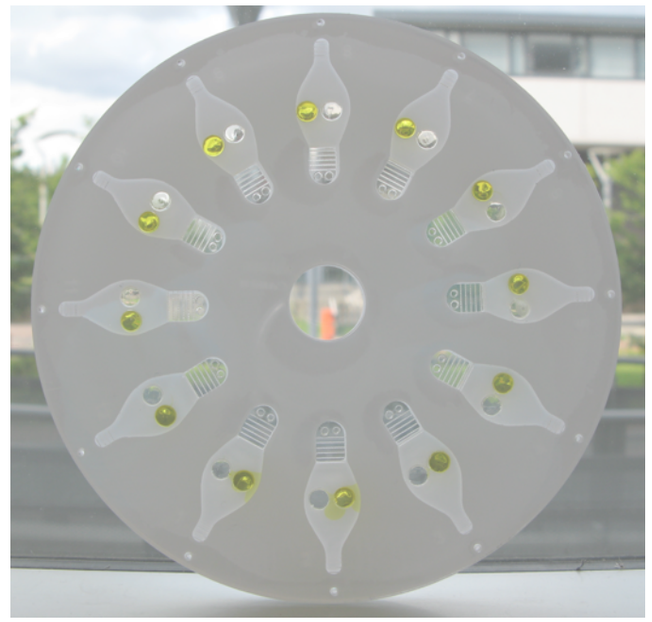
Why centrifugal platform?



- Elimination of large power supplies and external pump.
- Provides forces across the entire length of a fluid element.
- Multiple individual micro-fluidic systems can be placed on a single CD.
- Potential to include multi-parameter assays and / or multiple replicate assays with calibration.
- Potential for multi-stage assays involving several fluidic sub-compartments.

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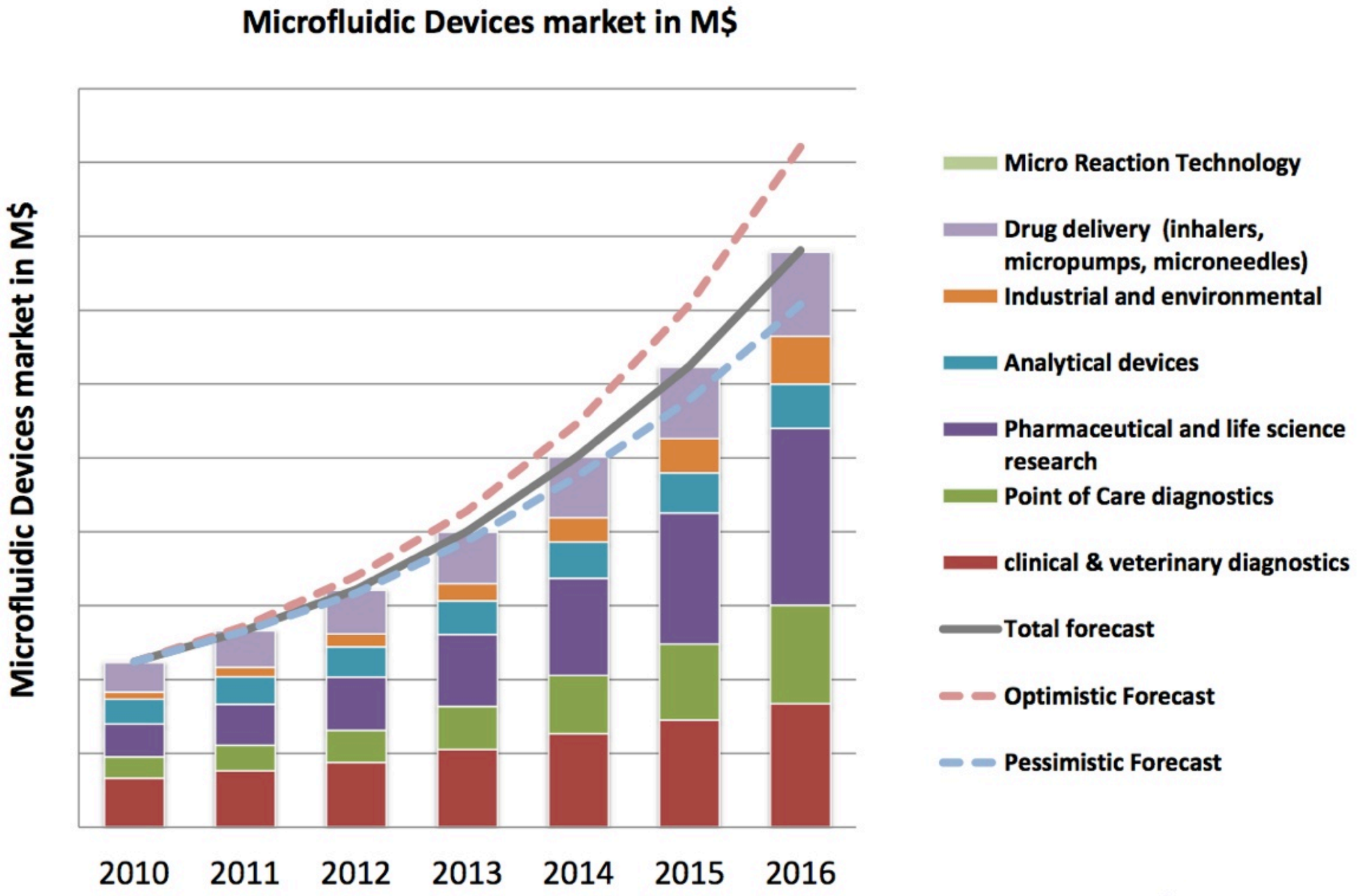
The desire for CMAS.



Yole Development: Large projected markets for microfluidics

Current CD platforms.

Abaxis Piccolo Xpress

"The Piccolo xpress is a convenient and compact clinical chemistry system developed for the on-site testing of patients.

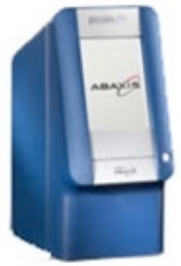
In size, it is almost like a shoebox. The easily understandable color touch screen commands enable health care providers to carry out everyday multi-chemistry

COST: $8500 USD

Current CD platforms.

Samsung Blood Analyser

Abaxis Piccolo Xpress



COST: $8500 USD

IVD-A10A compact blood tester. The company claims that its blood tester is smaller, faster and more accurate compare to traditional blood testing devices.

Samsung Analyser pdf

Current CD platforms.

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LaMotte Waterlink Spin

Chlorine Disk • Code 4330-H (50/pk)

Test Factor	Range	# Tests
Free Chlorine DPD	0-15.0 ppm	100
Total Chlorine DPD	0-15.0 ppm	100
Bromine DPD	0-33.0 ppm	100
pH	6.3-8.6 pH	100
Calcium Hardness	0-1200 ppm	100
Total Alkalinity	0-250 ppm	100
Cyanuric Acid	5-150 ppm	100
Copper	0-3.0 ppm	100
Iron	0-3.0 ppm	100

COST: $1000 USD

Abaxis Piccolo Xpress

)ST: $8500 USD

Samsung Blood Analyser

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Current CD platforms.

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LaMotte Waterlink Spin

Biguanide Disk* • Code 4331-H (50/pk)

Test Factor	Range
Biguanide	0-70 ppm
Biguanide Shock	0-250 ppm
pH	6.3-8.6 pH
Calcium Hardness	0-1200 ppm
Total Alkalinity	0-250 ppm
Copper	0-3.0 ppm
Iron	0-3.0 ppm

COST: $1000 USD

Abaxis Piccolo Xpress

COST: $8500 USD

Samsung Blood Analyser

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The design of CMAS

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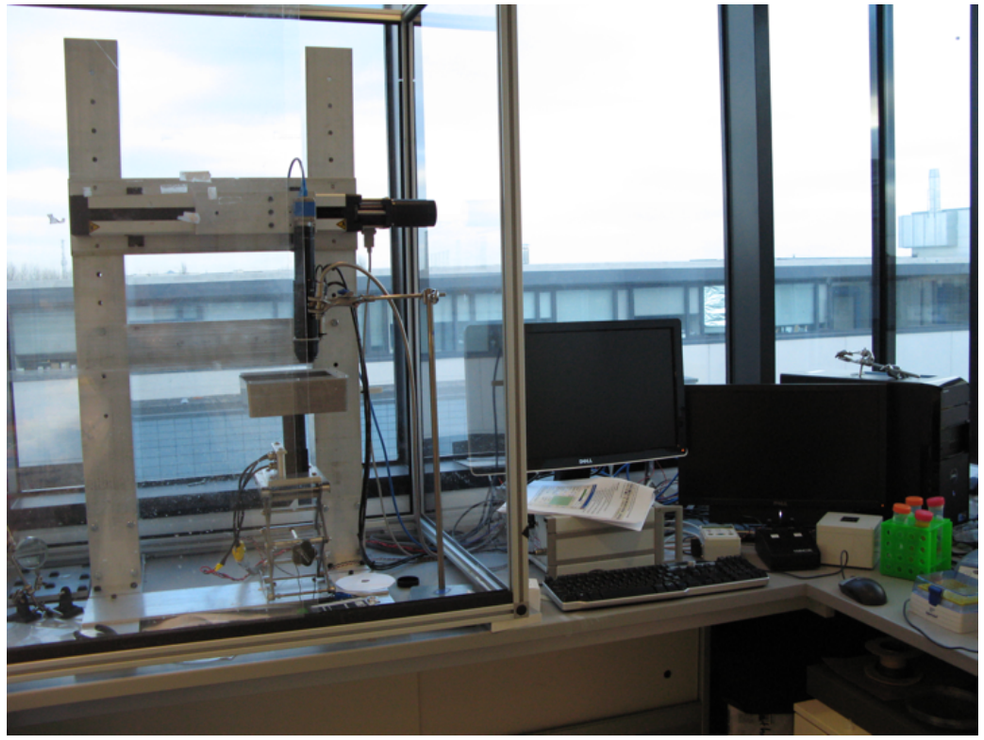
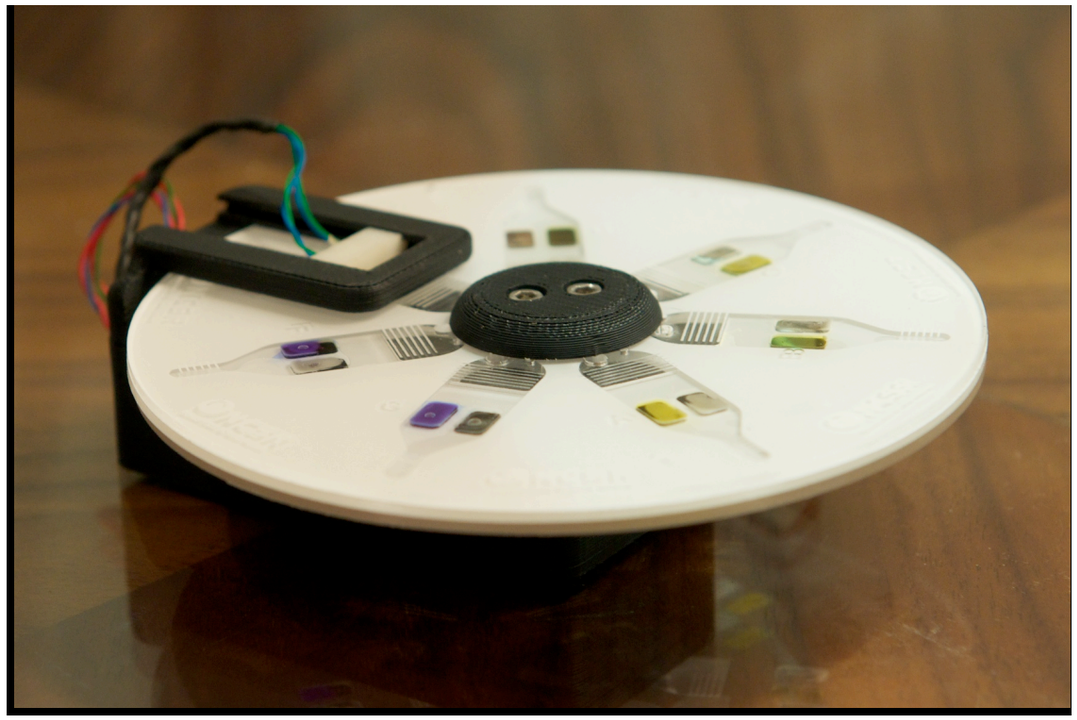


Fluid Manipulation (CD Spinning)



Colorimetric Analysis

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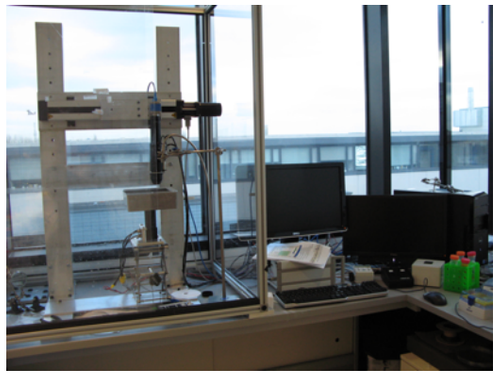
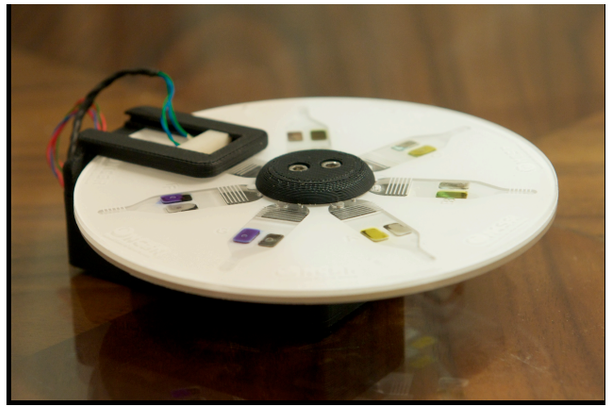
The design of CMAS



Fluid Manipulation (CD Spinning)



Colorimetric Analysis

Spinning + Colorimetric Analysis

The design of CMAS

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1. Modular LED unit

2. Centrifugal Disc

3. LED Detector Intensity

4. Wixel Shield for Arduino

5. Model Motor Size H

6. Two 9V, Li battery

7. Support unit

- Patent application no. GB 1207239.3

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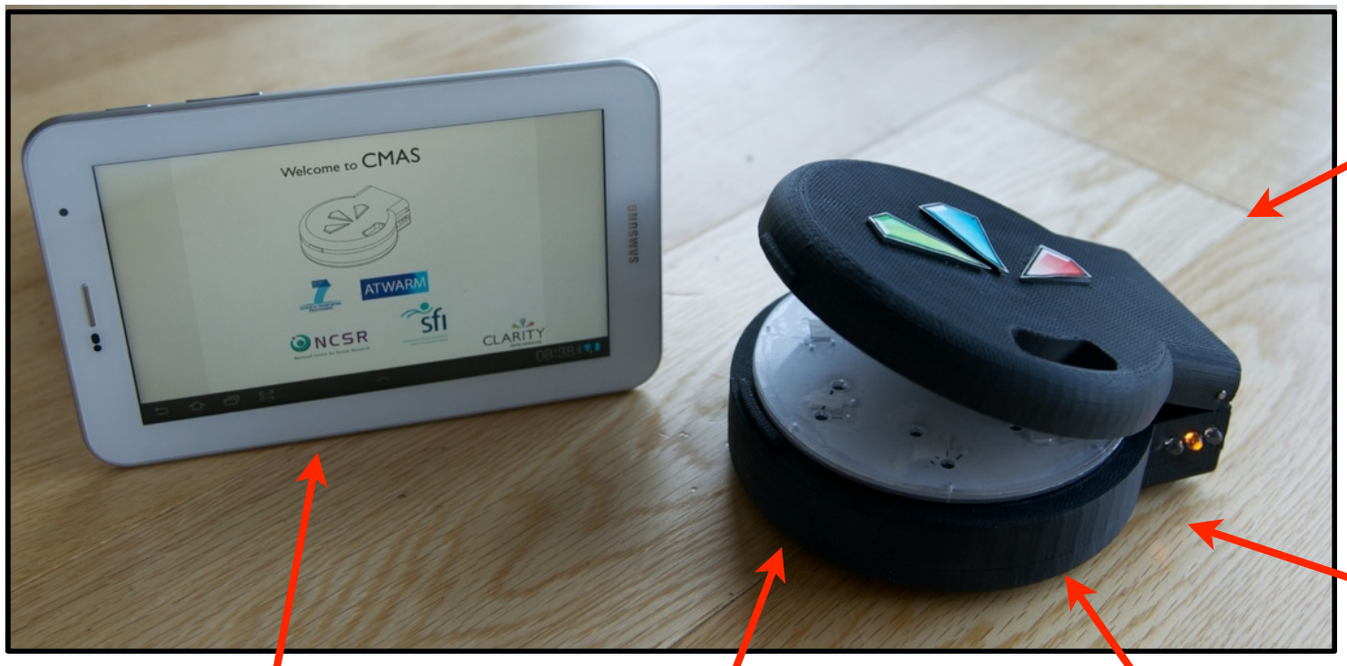
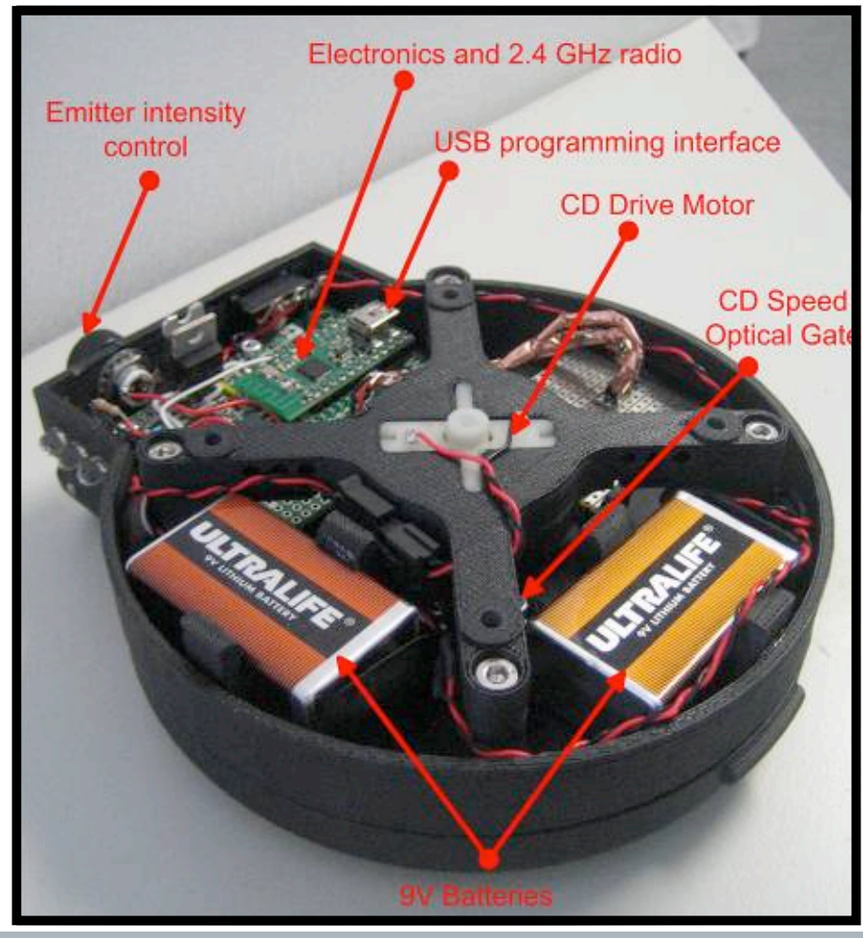
The design of CMAS

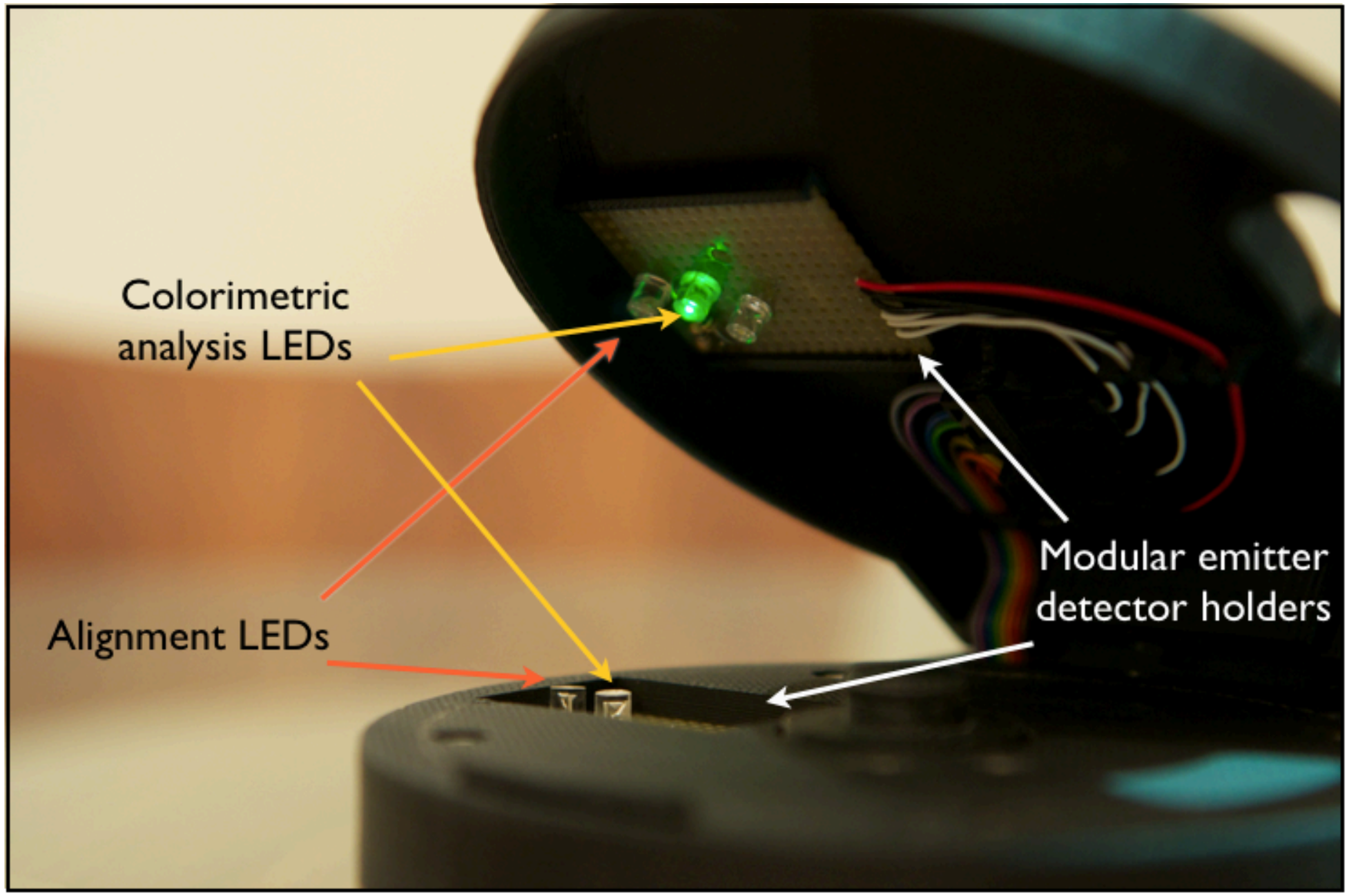
- Low cost colourmetric detector.
- Multiple samples analysis in a single micro-fluidic chip.
- Multiplexing capabilities (pH, turbidity, nitrite,...).
- Portable system: sample analysis at the point of need.
- Wireless communication system.





The design of CMAS

The design of CMAS



[1] K.-T. Lau, S. Baldwin, M. O'Toole, R. Shepherd, W. J. Yerazunis, S. Izuo, S. Ueyama and D. Diamond, Anal. Chim. Acta, 557, 111-116 (2006).
[2] M. O'Toole and D. Diamond, Sensors, 8, 2453-2479 (2008).

The design of CMAS

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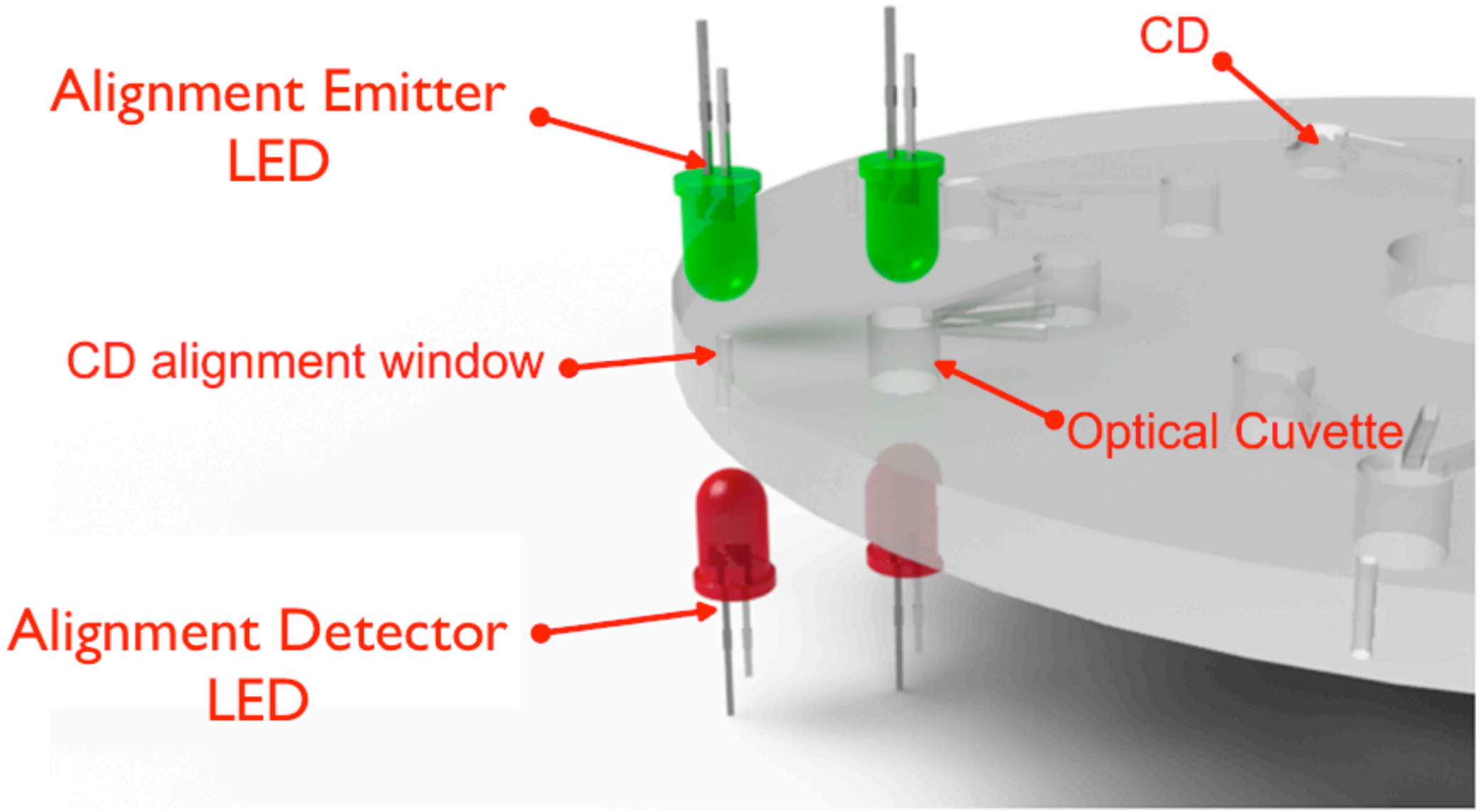
Manual alignment



The design of CMAS

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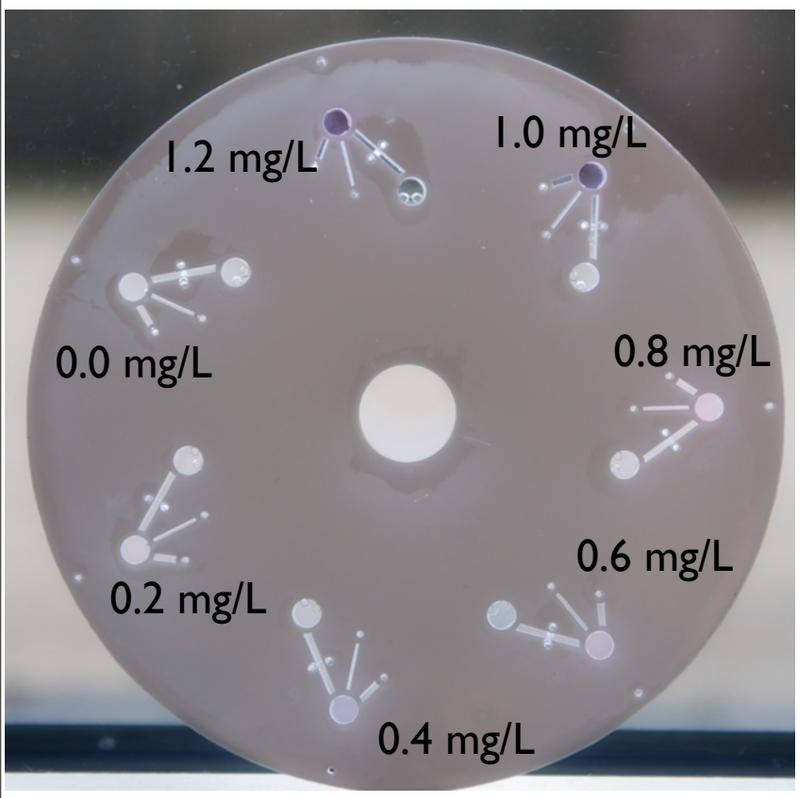

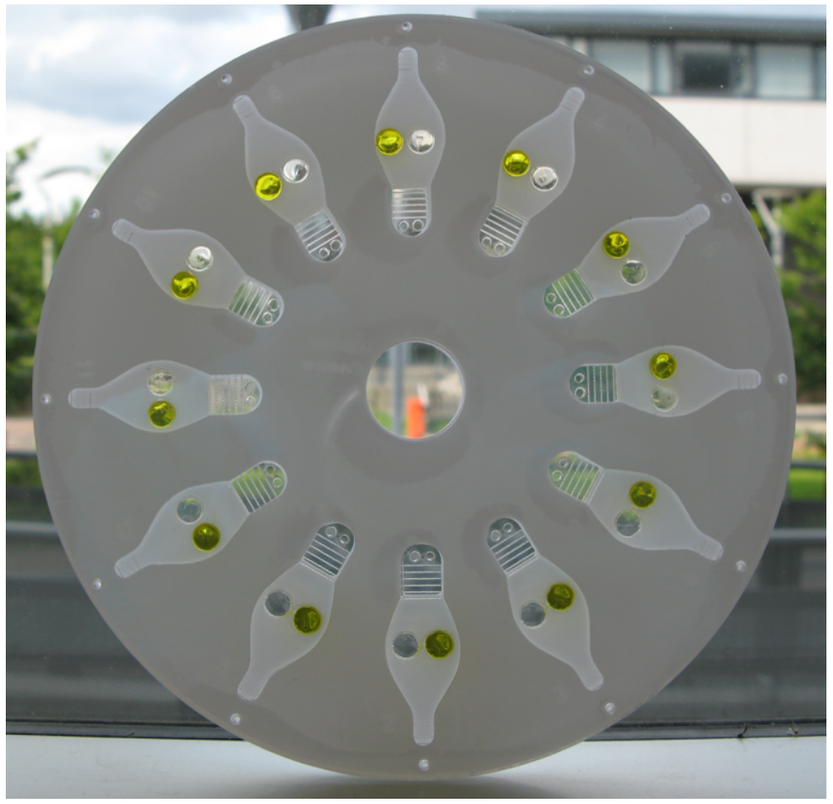

A) Environmental

B) Physiological

C) Biological

A versatile Modular Point of Care / Need device

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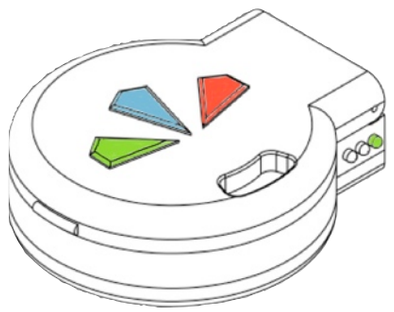
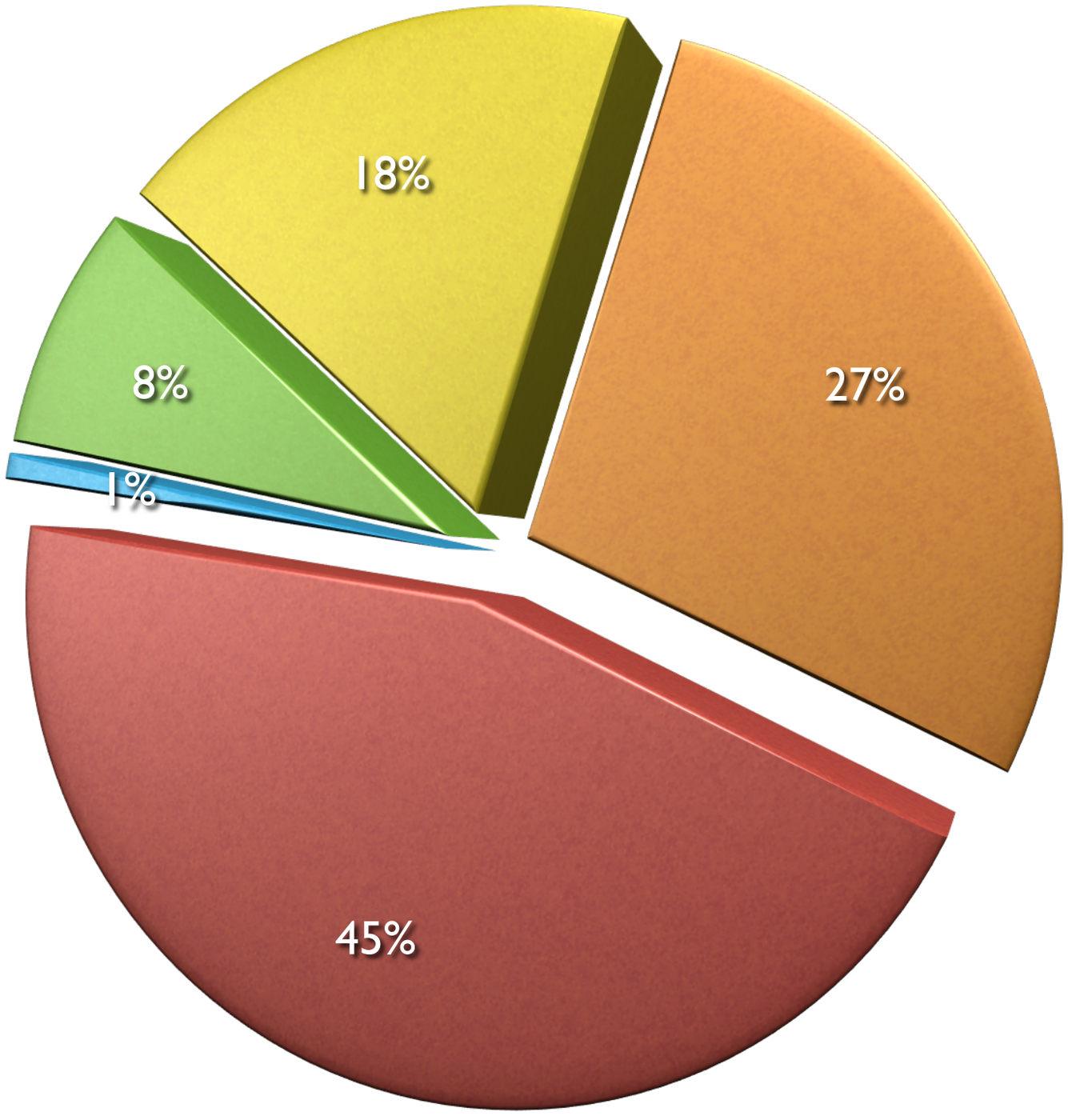
Cost.....

- LED's € 2.00
- Batteries € 18.60
- Misc Electronics € 40.00
- Custom PCB Board € 59.94
- Printed ABS case € 100.11



Cost.....



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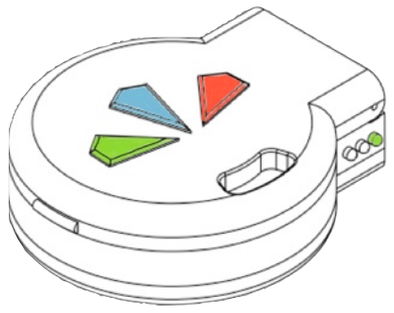

Software development-Beta testing

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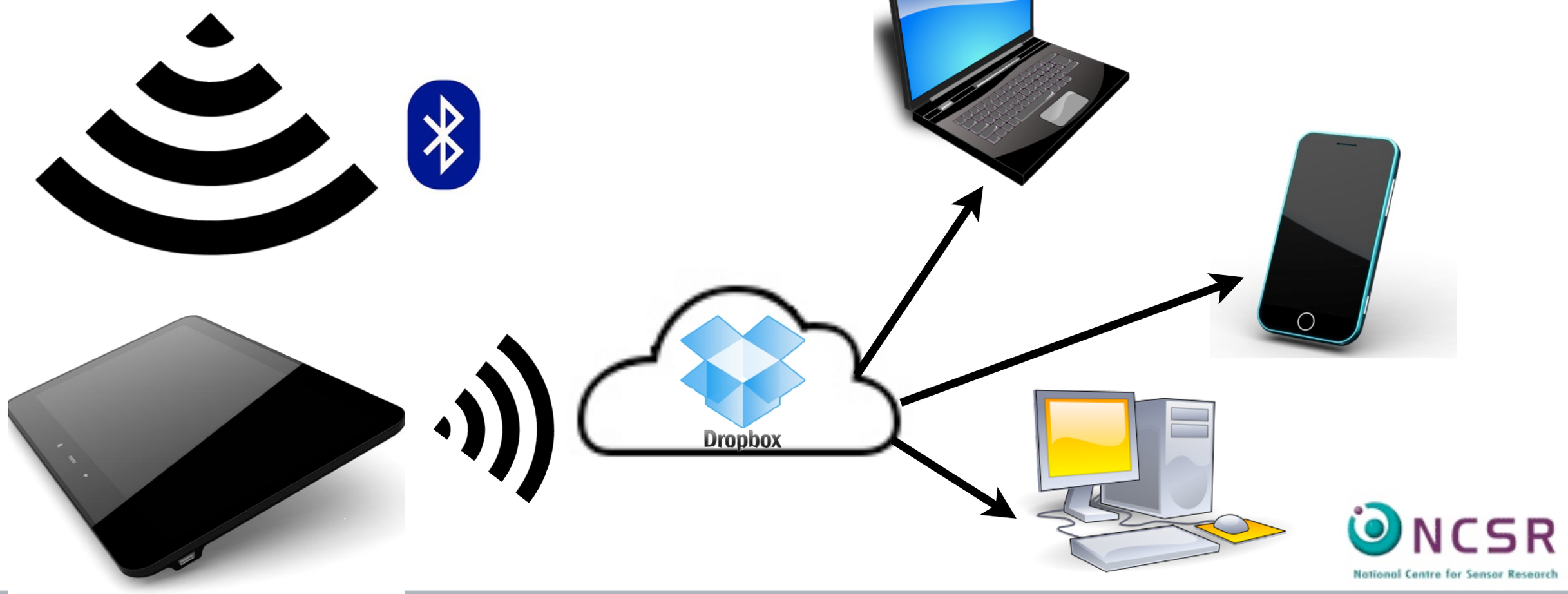
In collaboration with Prof Smeaton, School of Computing, DCU.



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Software development-Beta testing

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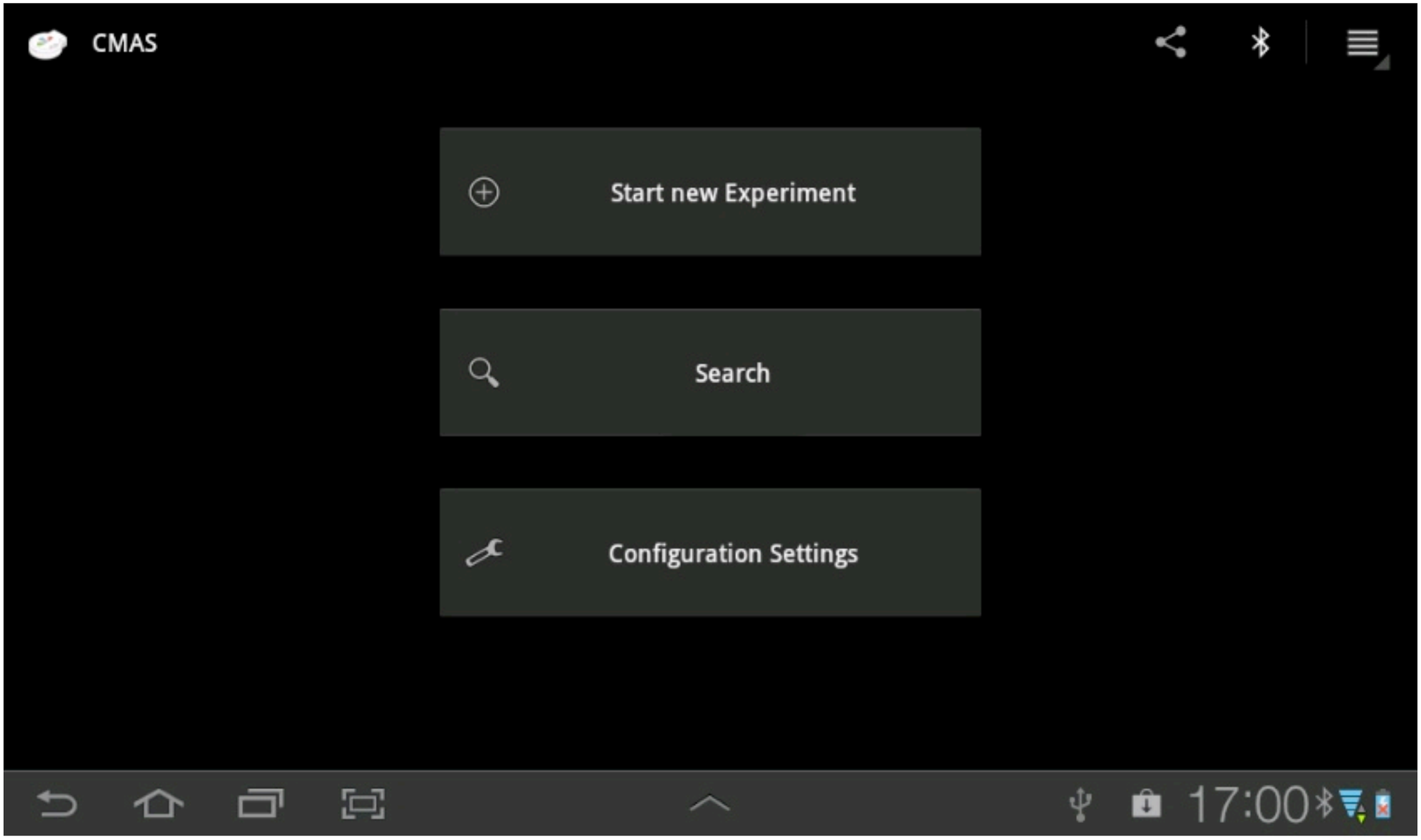
Software development-Beta testing



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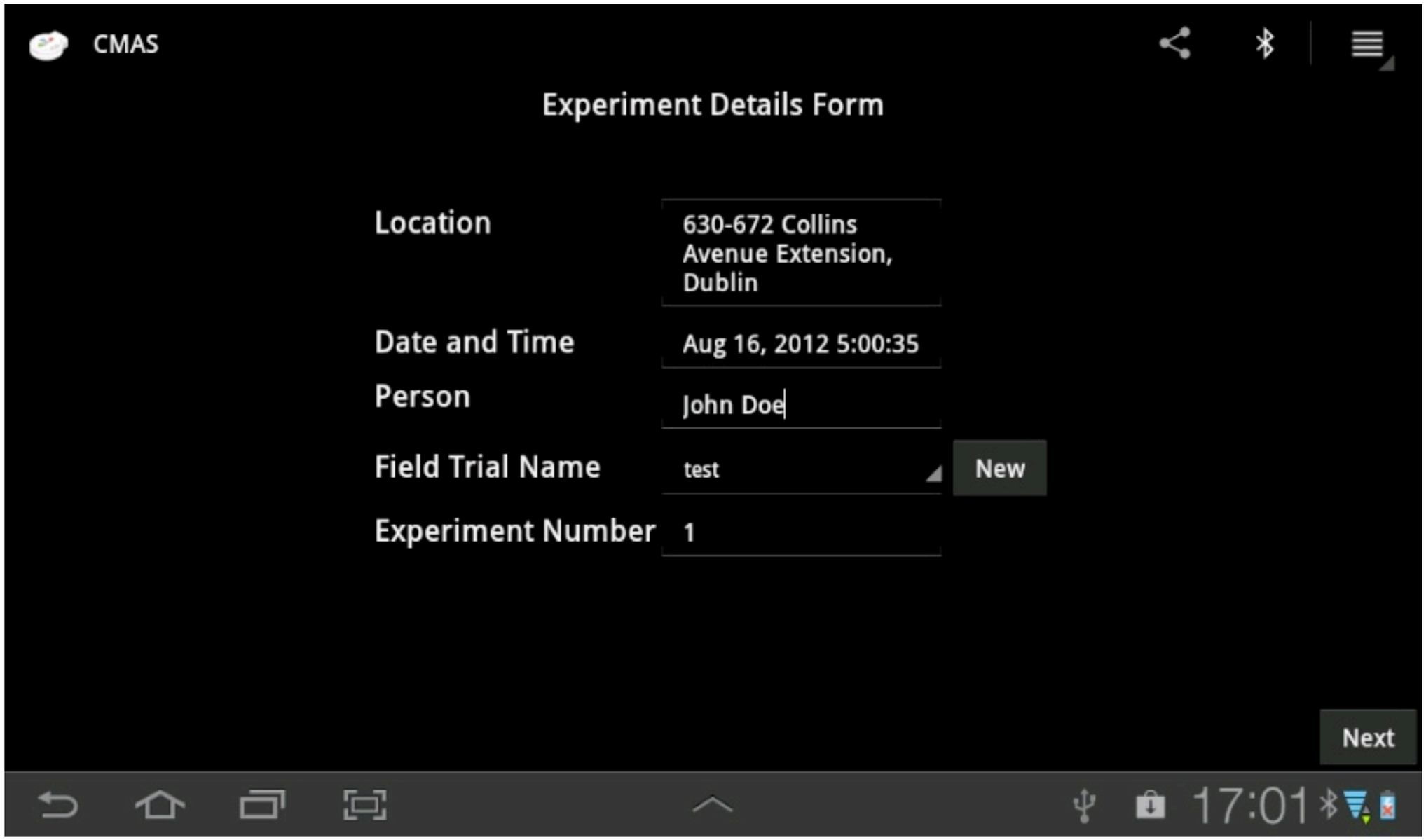

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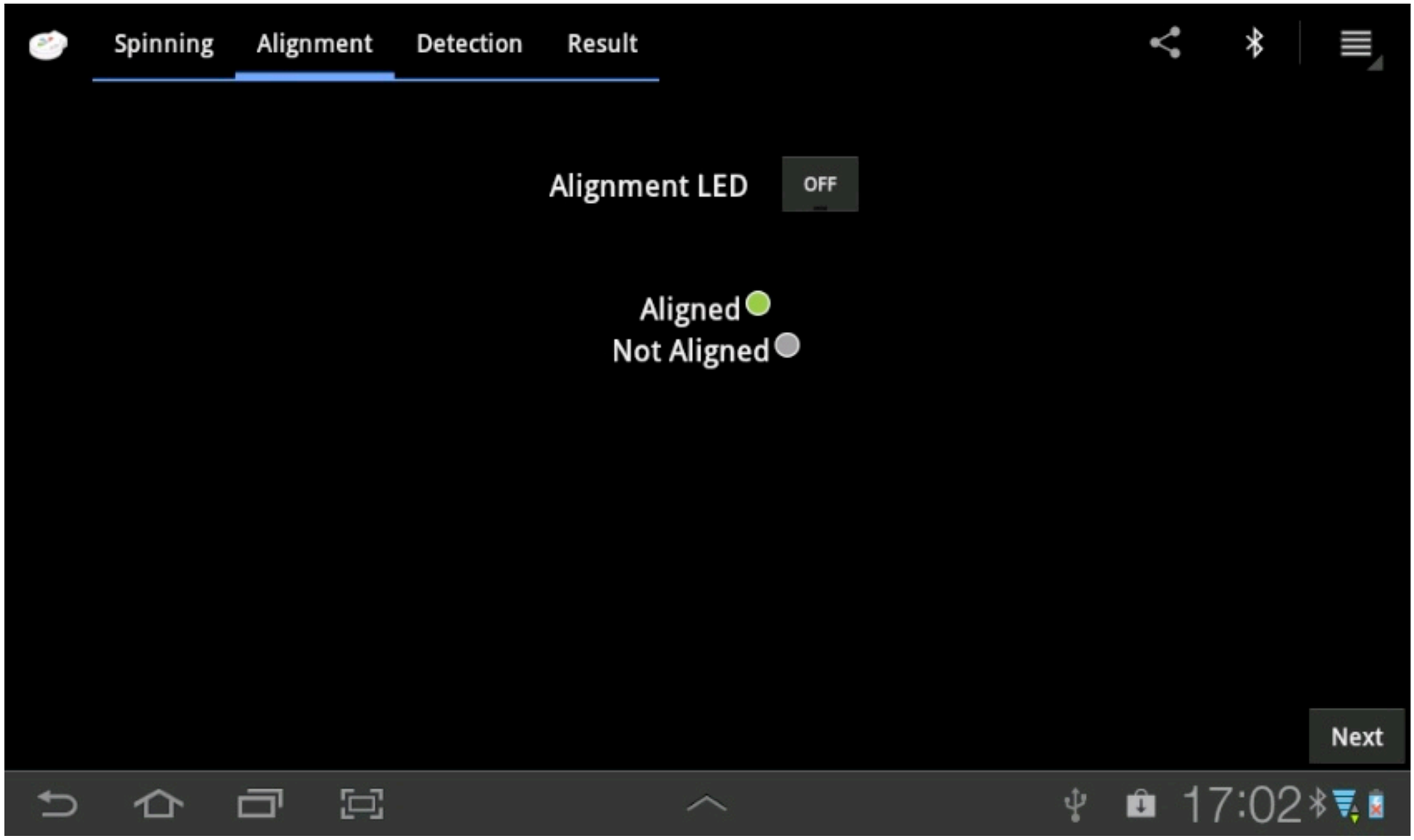
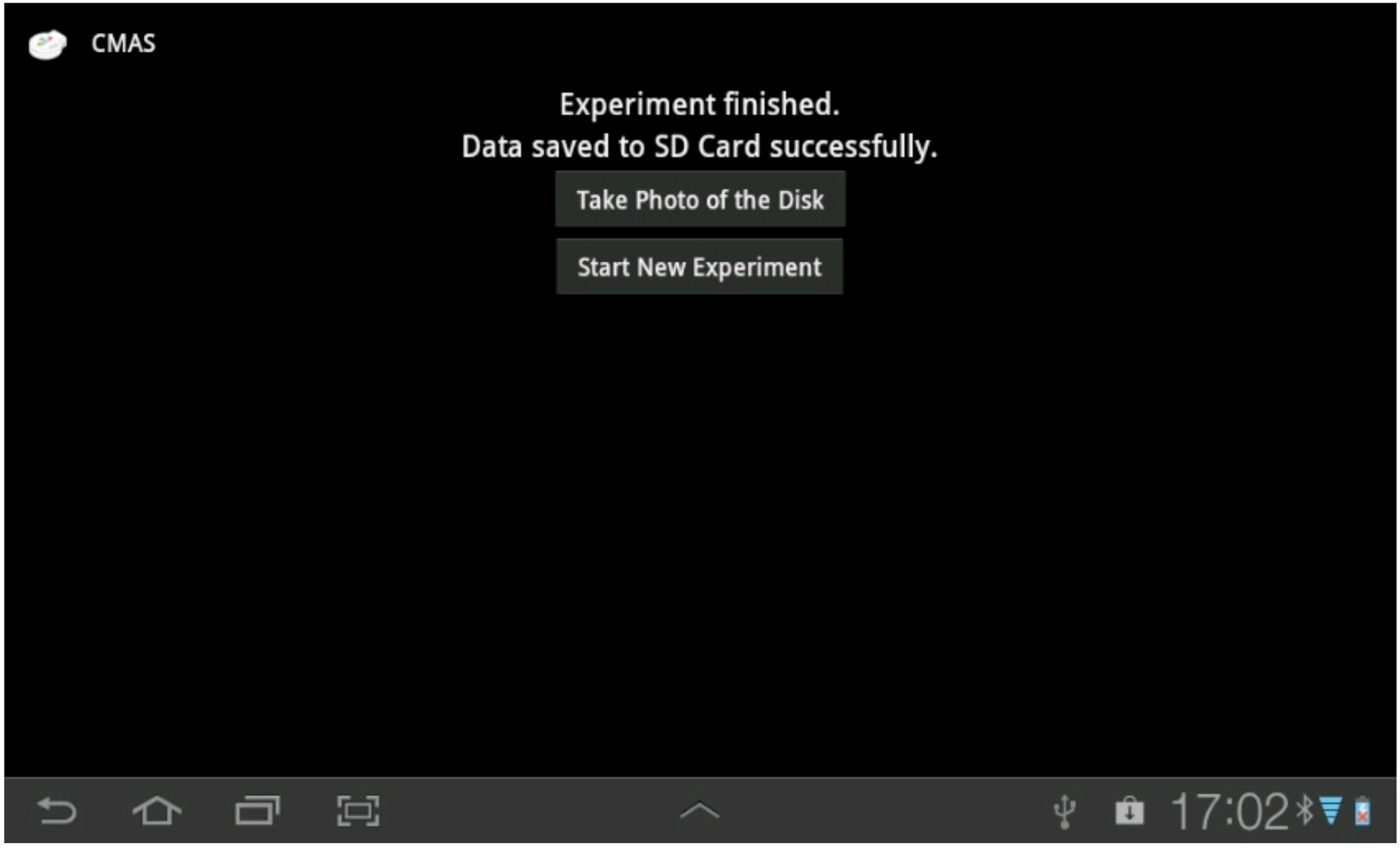
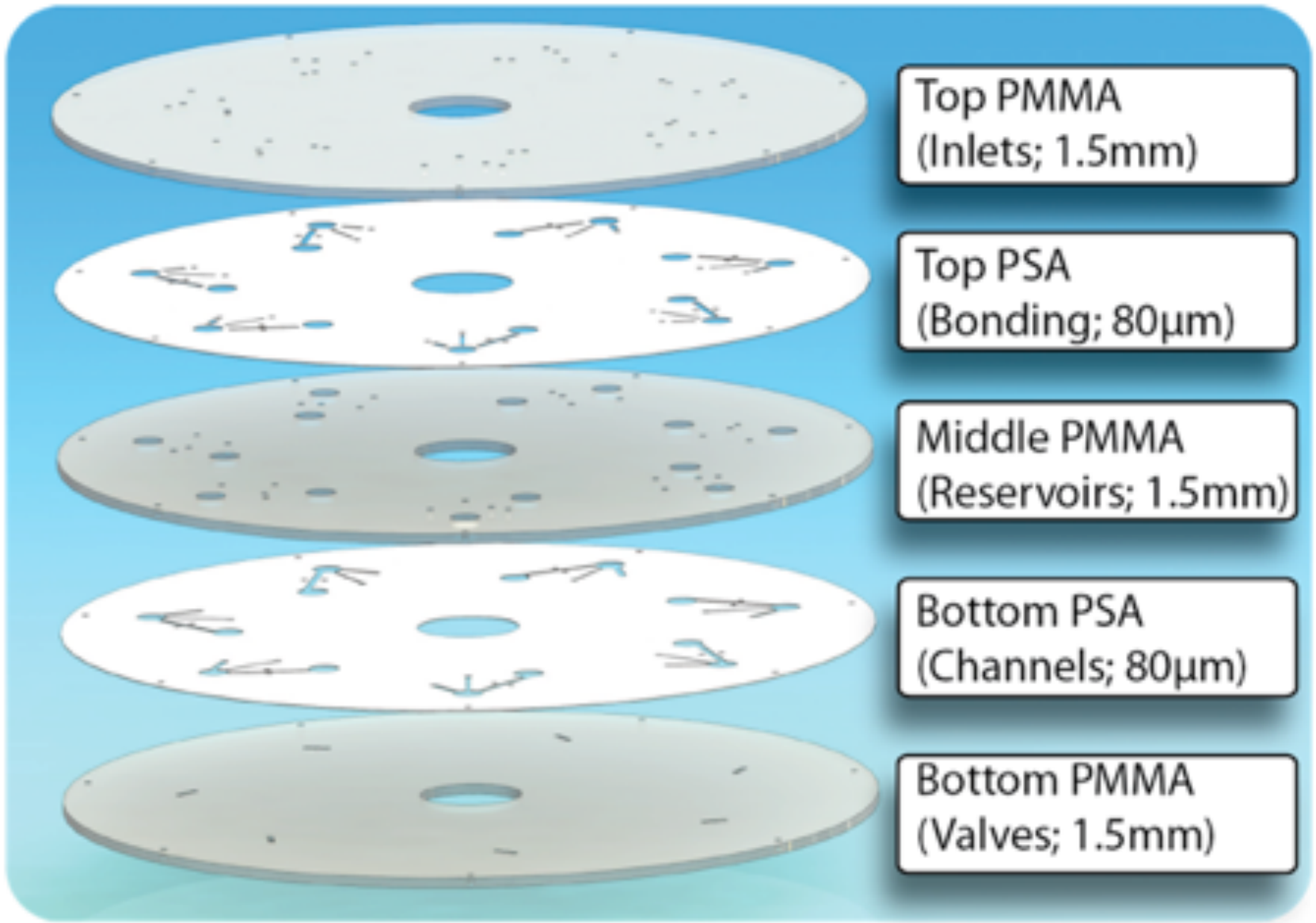


Software development-Beta testing



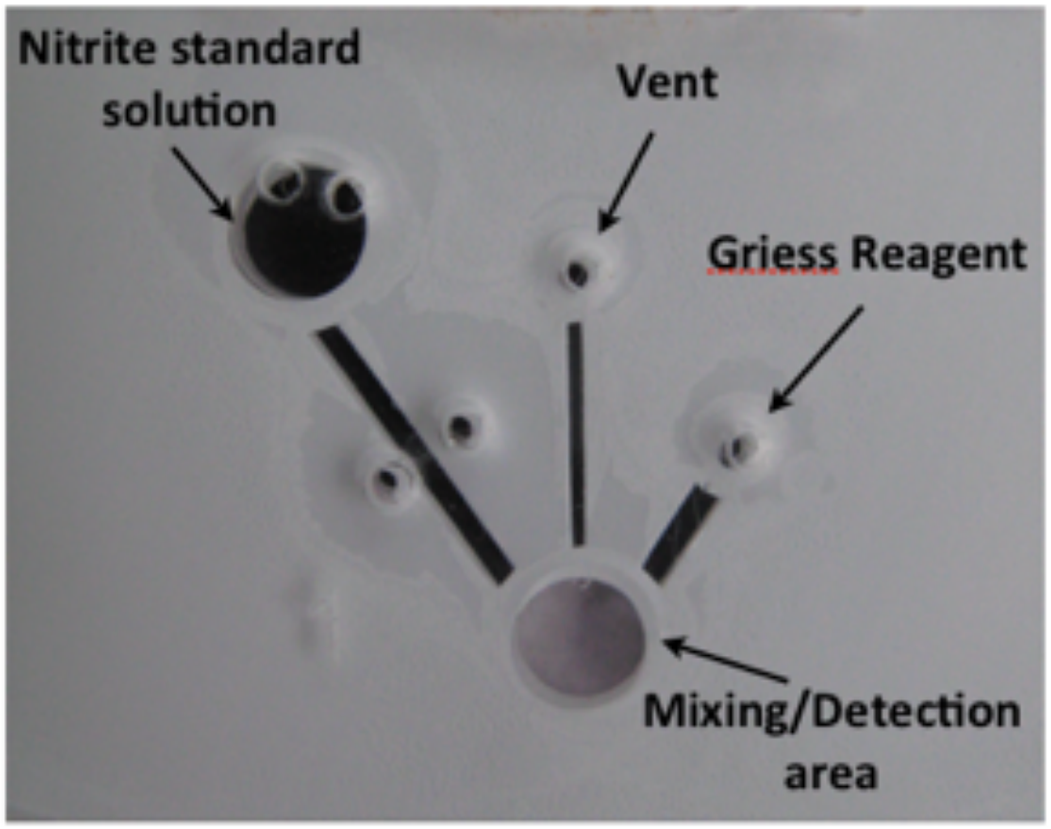
Nitrite detection in freshwater: CMAS

Nitrite detection in freshwater: CMAS



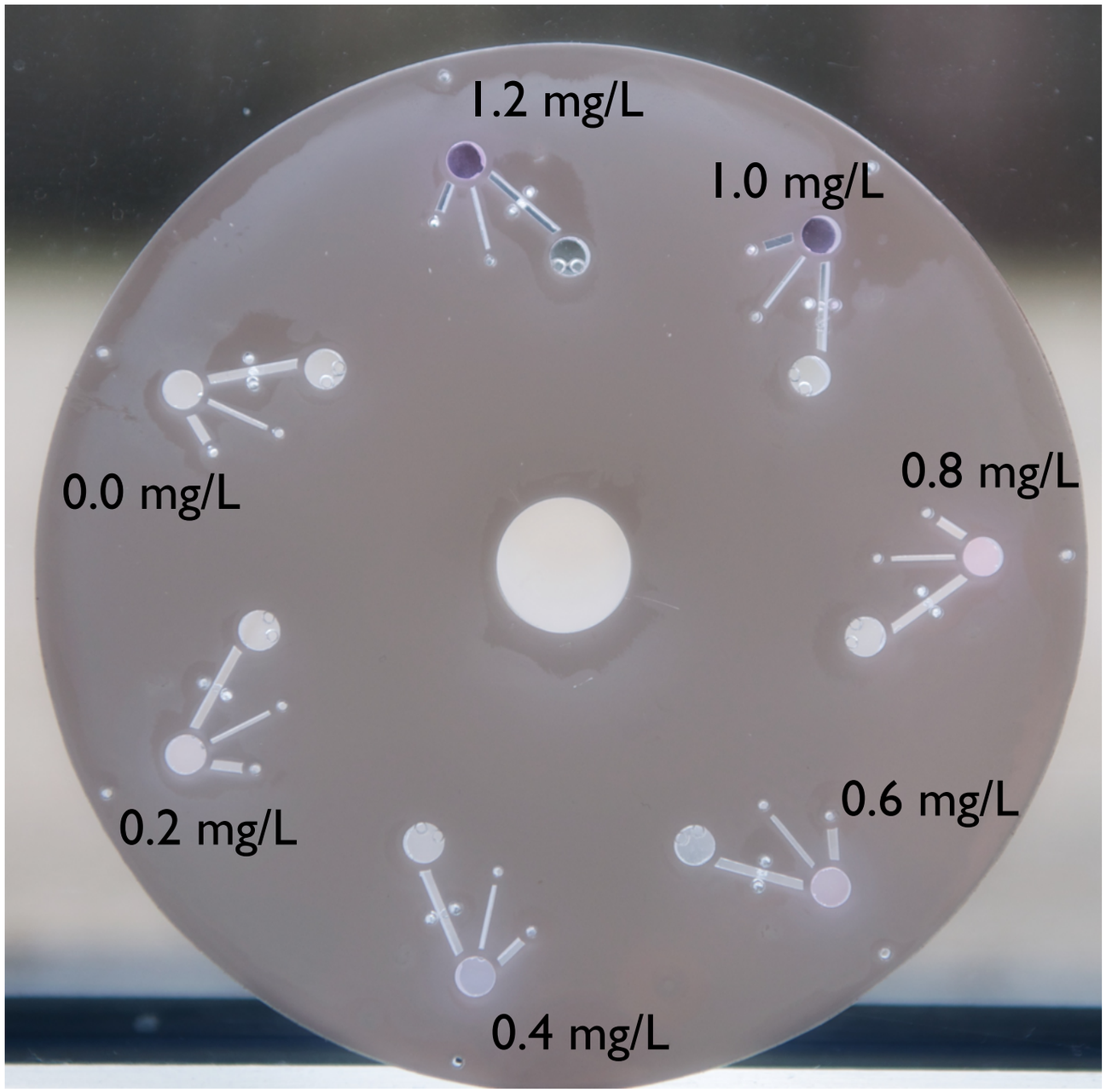
CD design

Nitrite detection in freshwater: CMAS



- Standard solution/Sample reservoir - 31.5 uL
- Air vent (bubble prevention)
- Griess Reagent reservoir - 2.1 uL
- Microchannels - 1000 um width
- Mixing/Detection area - 33.5 uL

Nitrite detection in freshwater: CMAS



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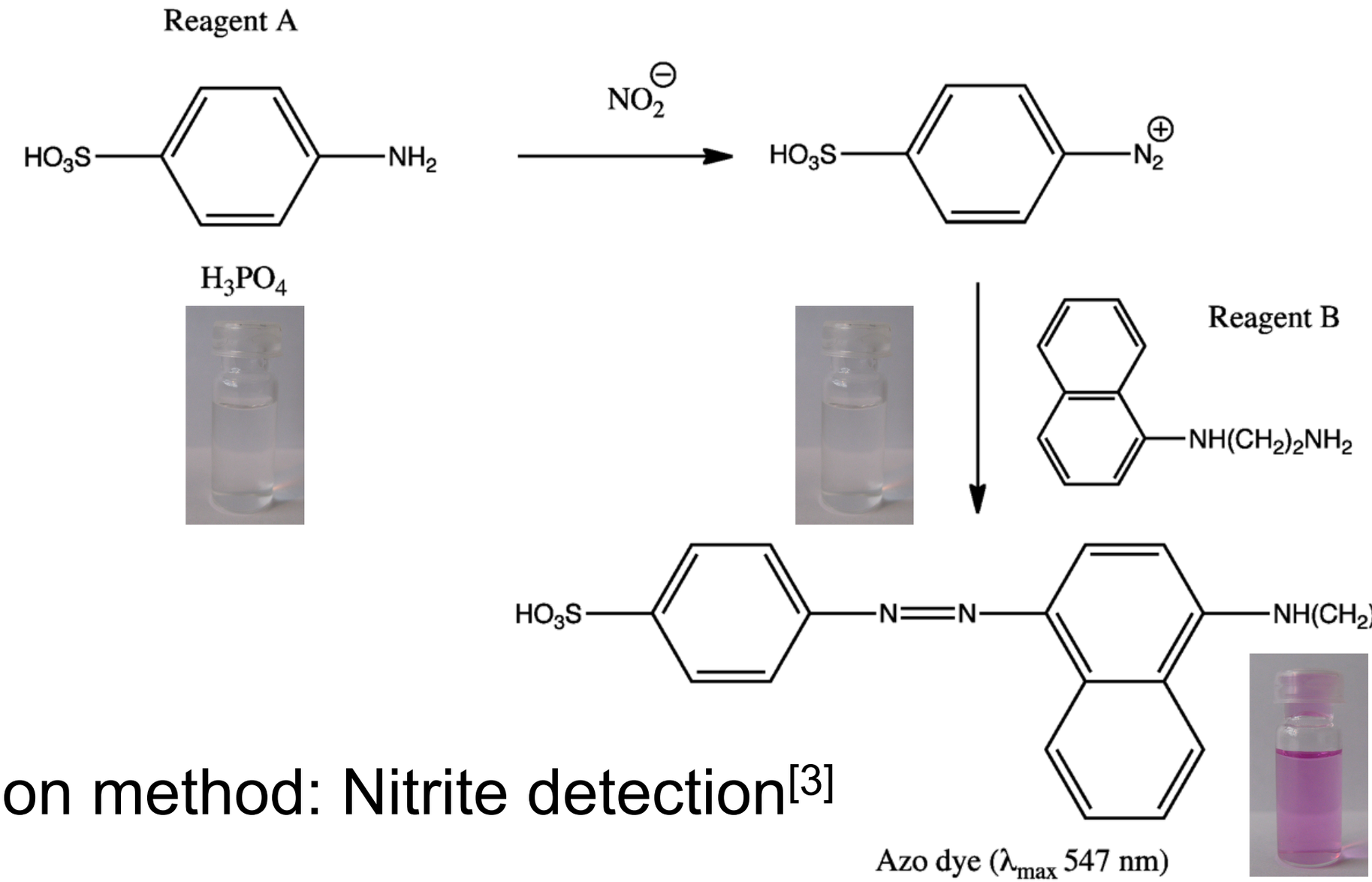
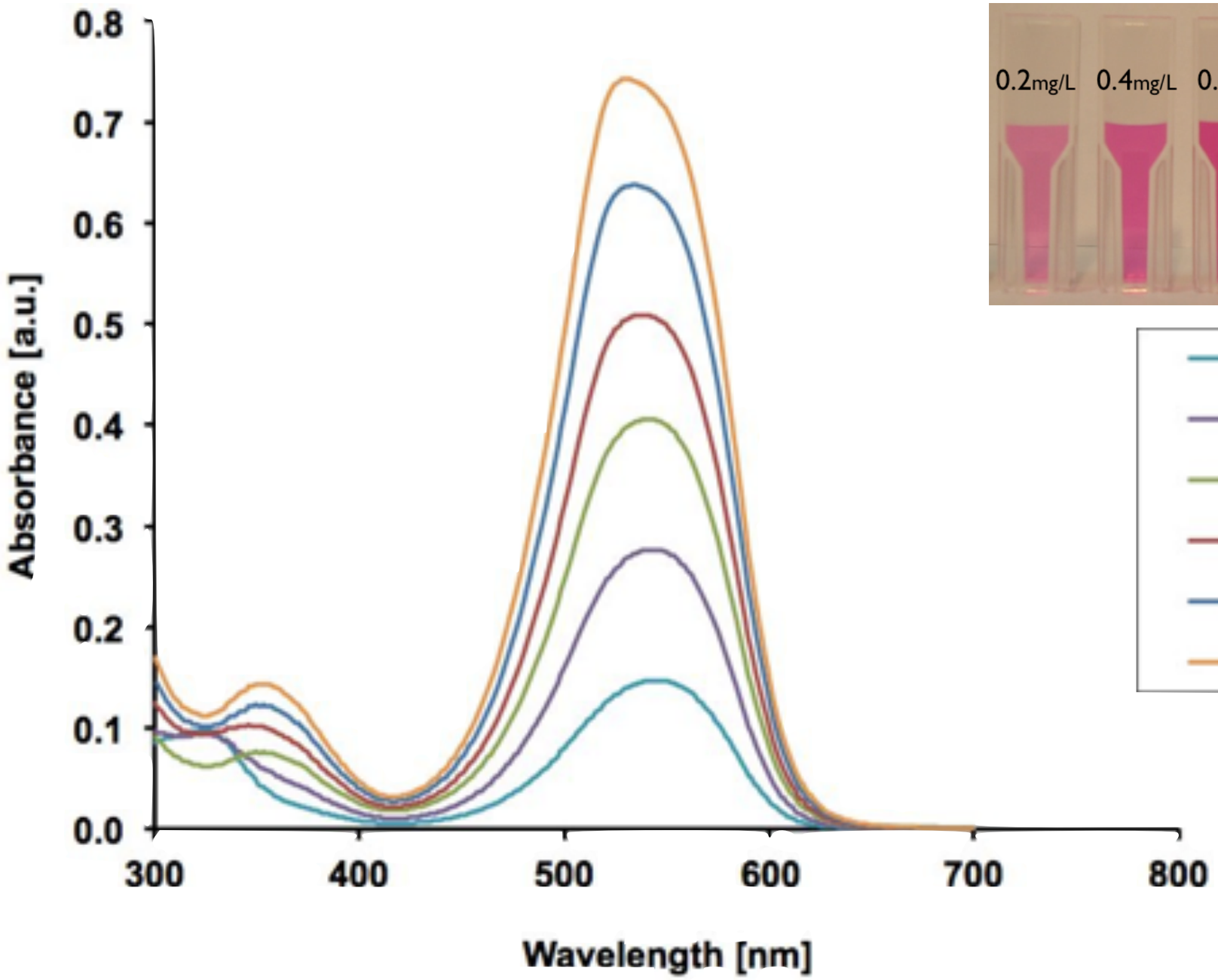


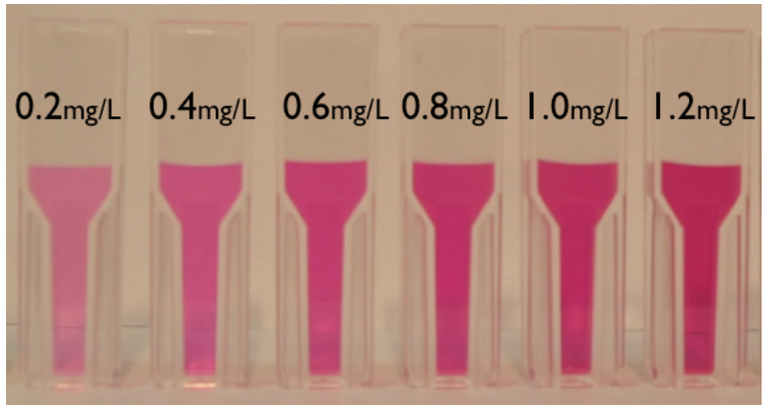
Griess reaction method: Nitrite detection[3]

[3] M. O'Toole and R. Shepherd, K. Lau and D. Diamond, (2007) Advanced Environmental, Chemical, and Biological Sensing Technologies V , 10 September 2007, Boston, MA, USA .

Nitrite detection validation: UV-Vis

Absorbance





Nitrite detection validation: UV-Vis

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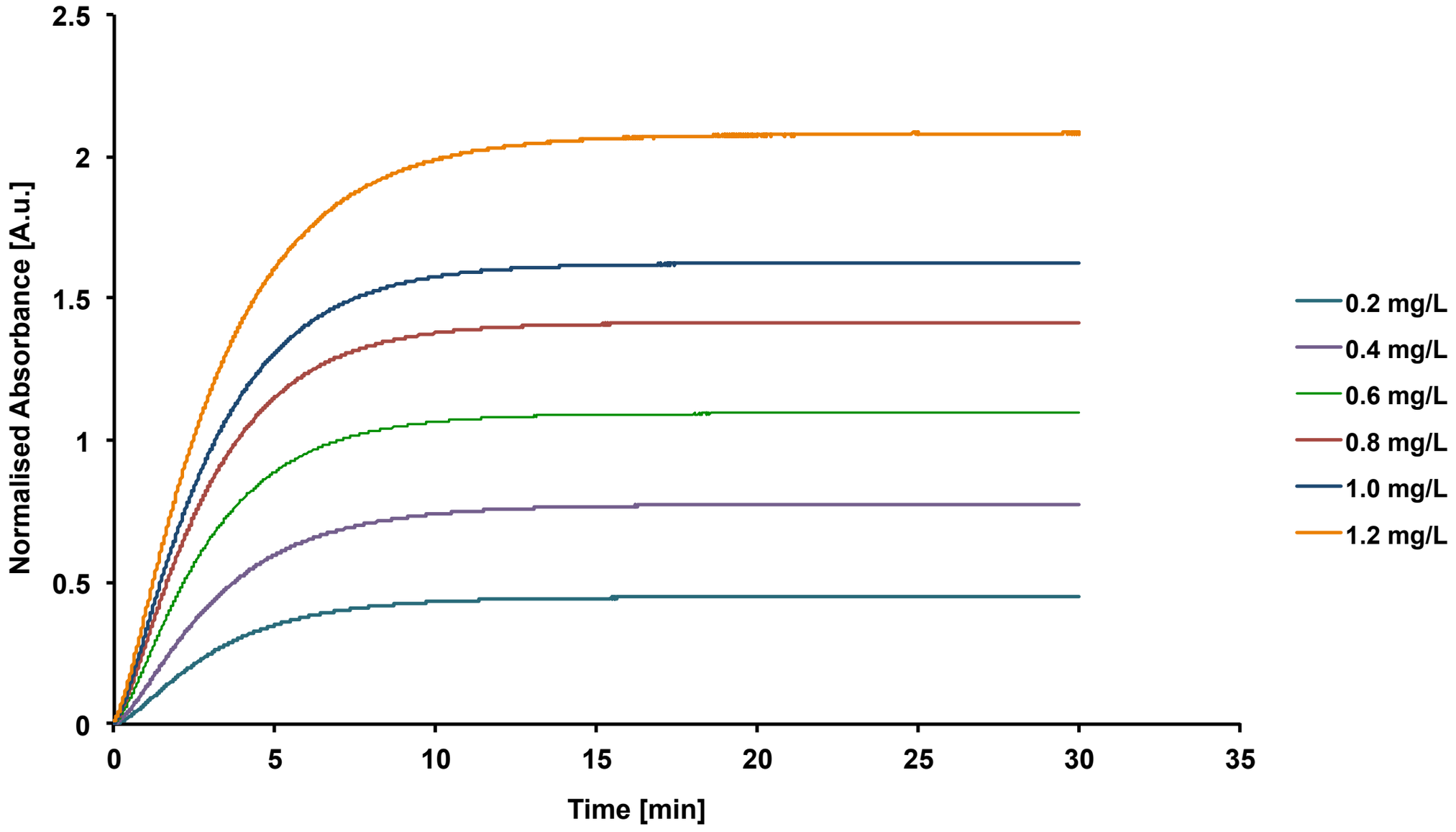
Kinetic profile of colour formation between NO_2^- and Griess reagent



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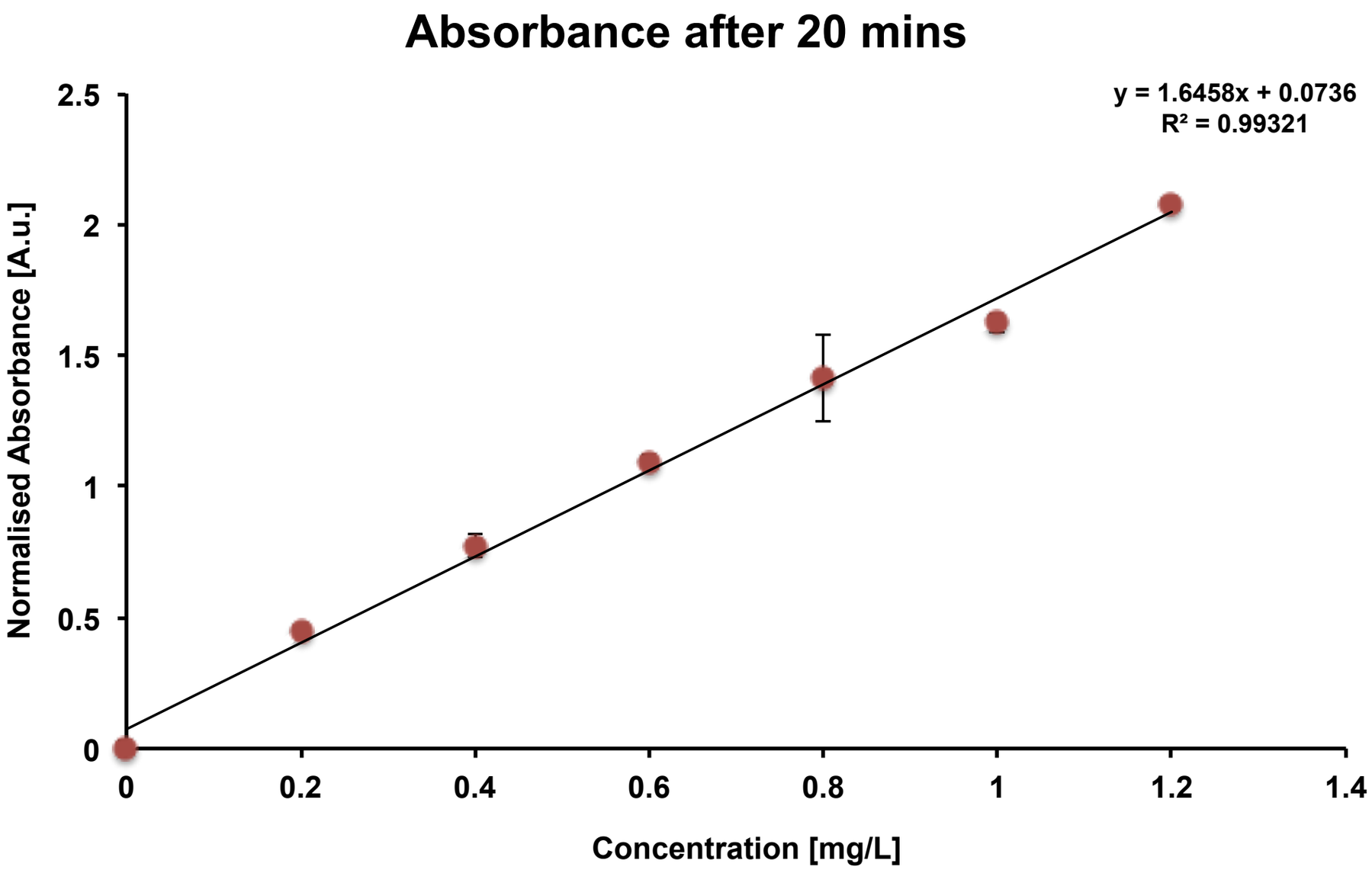
Nitrite detection validation: UV-Vis



Sequence of the Experiment: CMAS

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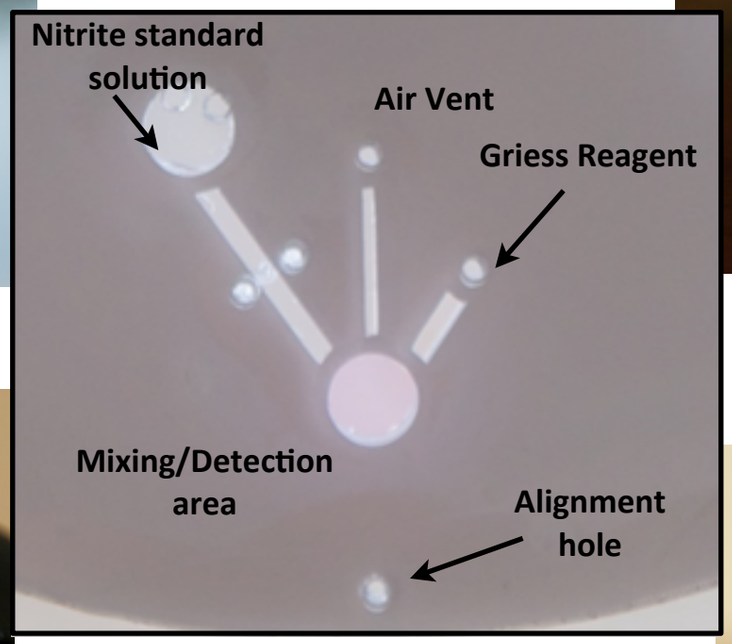
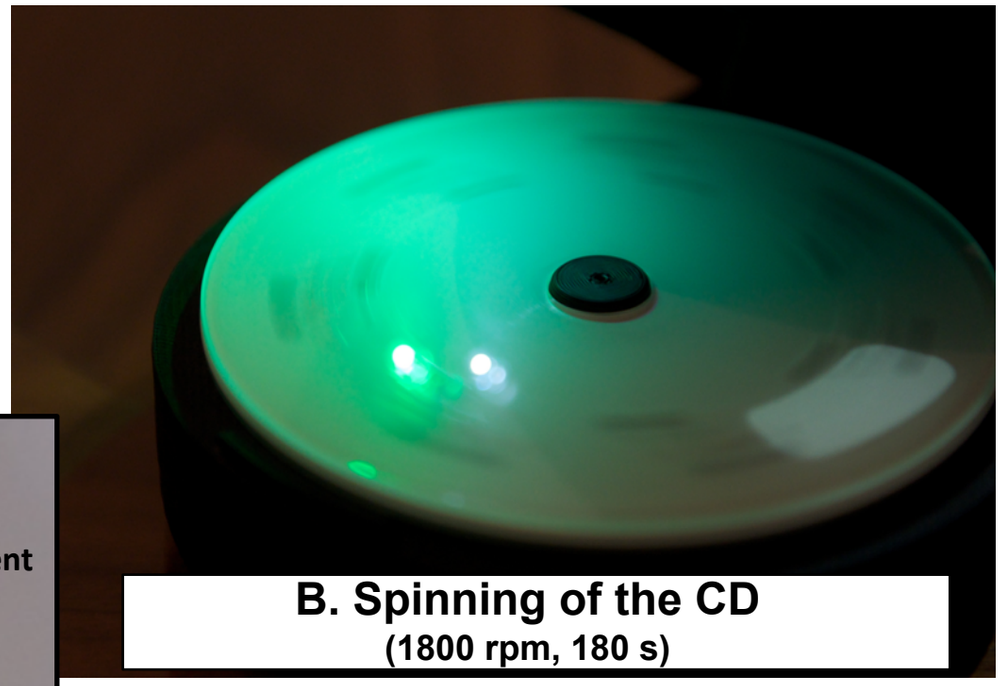
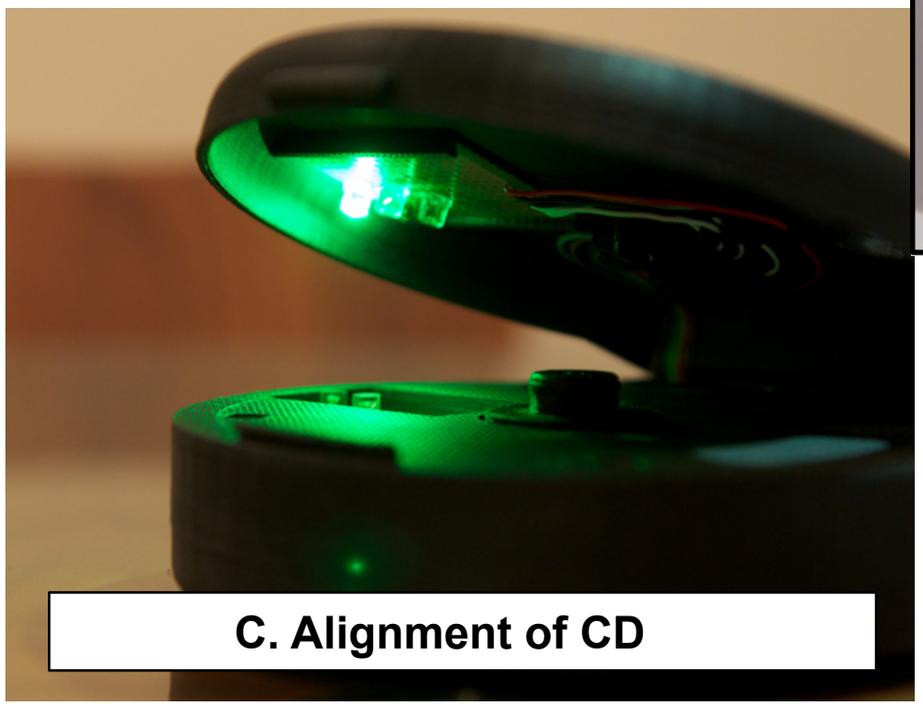
A. Loading the samples and reagent

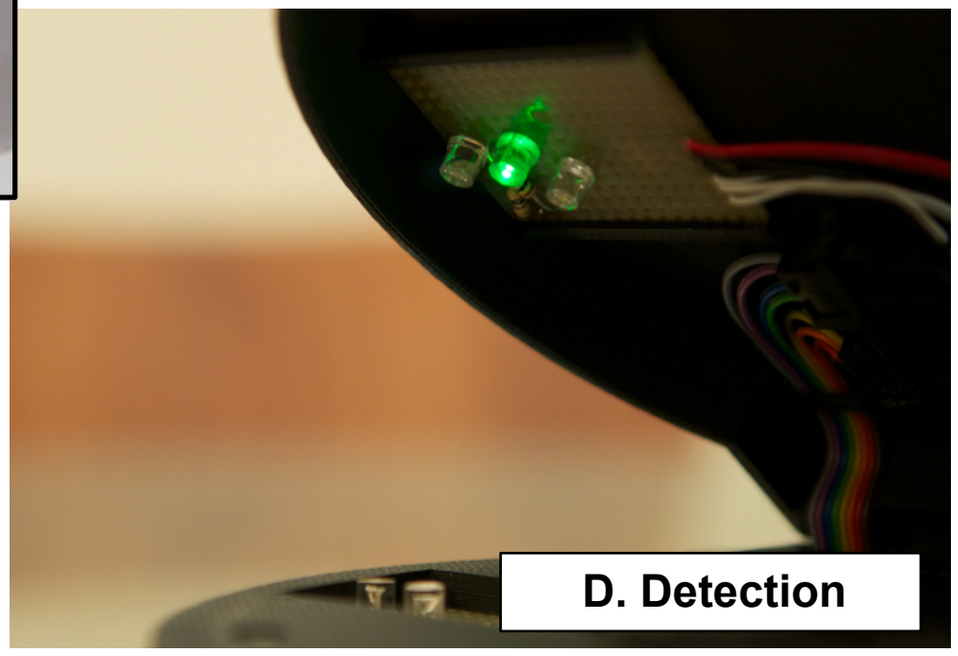




B. Spinning of the CD
(1800 rpm, 180 s)



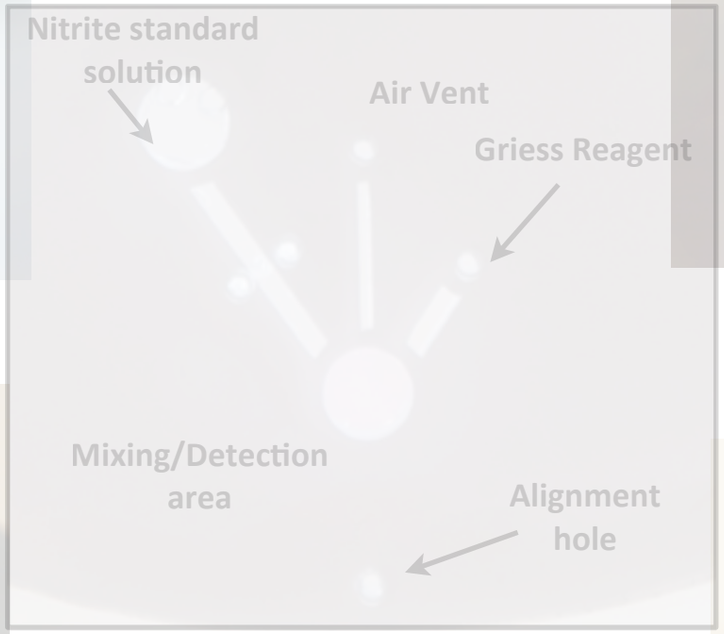
C. Alignment of CD



D. Detection

Sequence of the Experiment: CMAS

A. Loading the samples and reagent



B. Spinning of the CD
(1800 rpm, 180 s)

C. Alignment of CD

D. Detection

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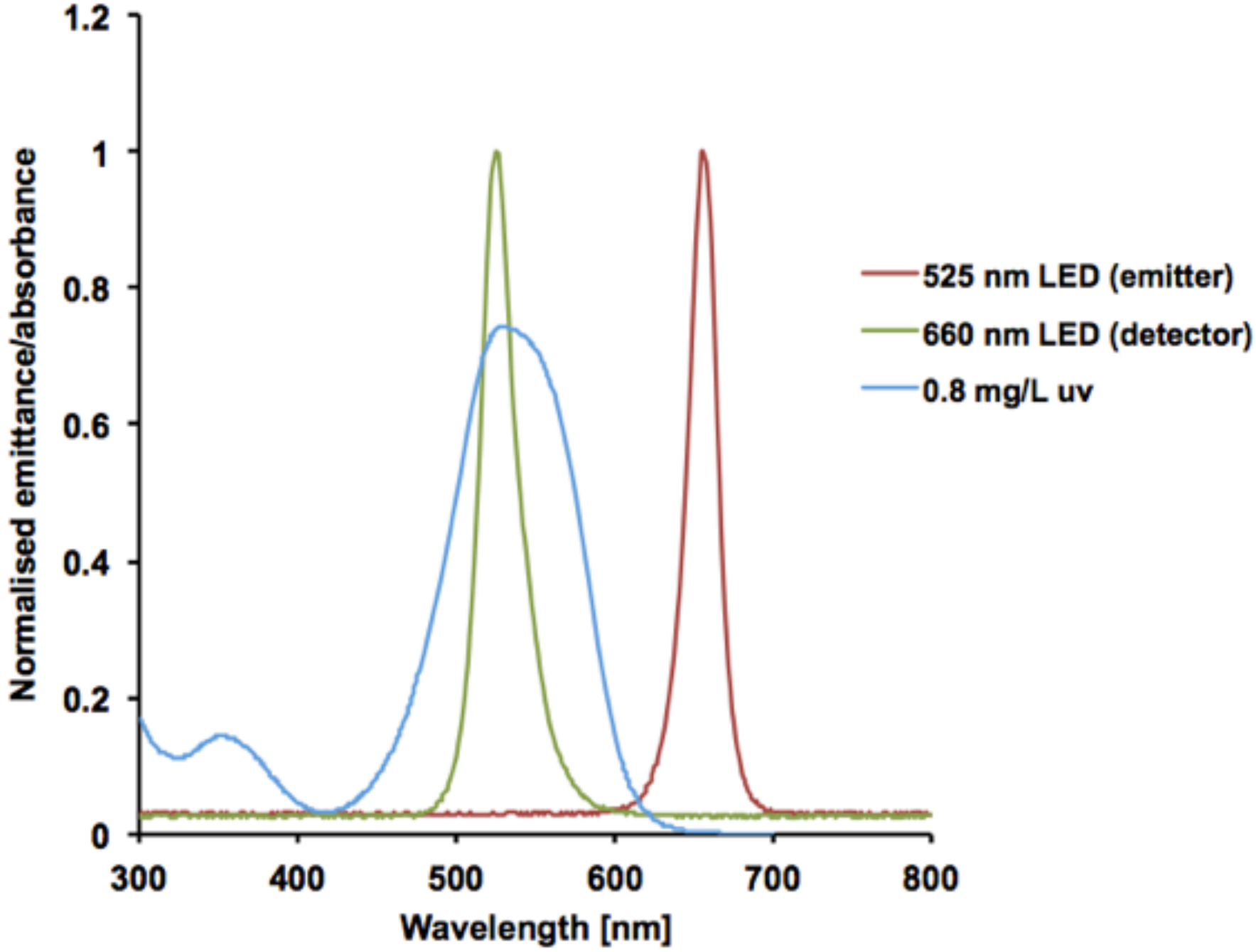
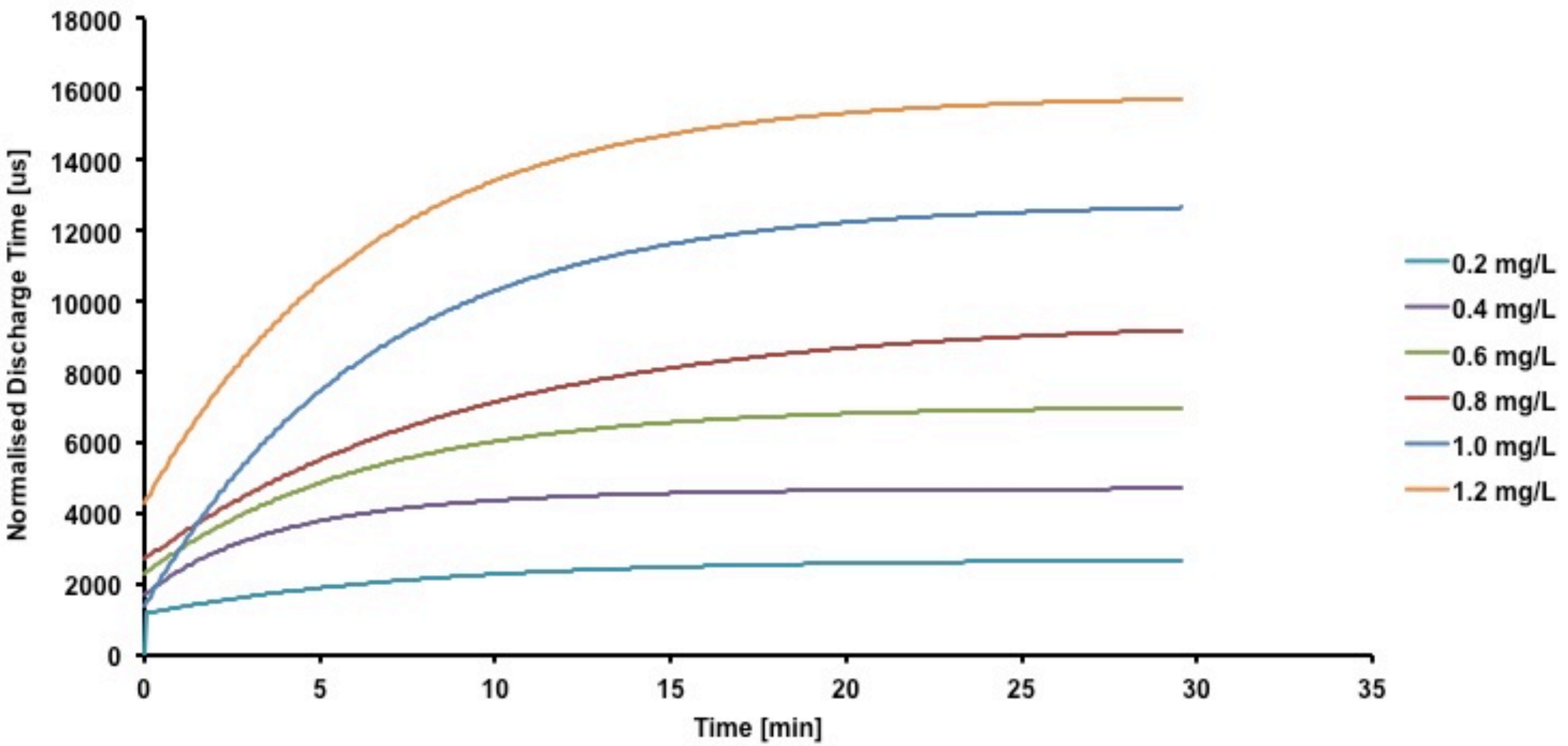
Nitrite detection validation: CMAS



Nitrite detection validation: CMAS



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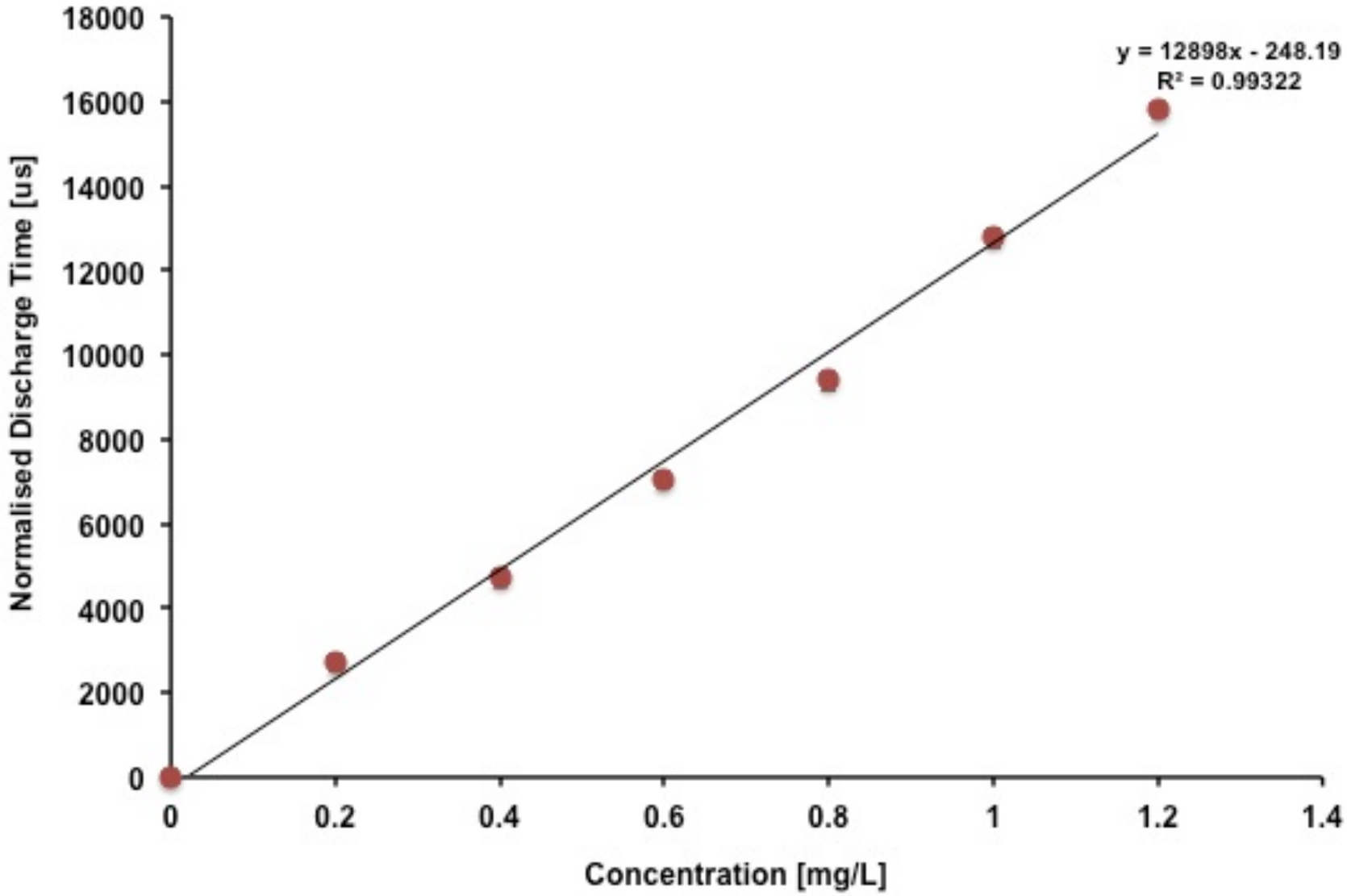
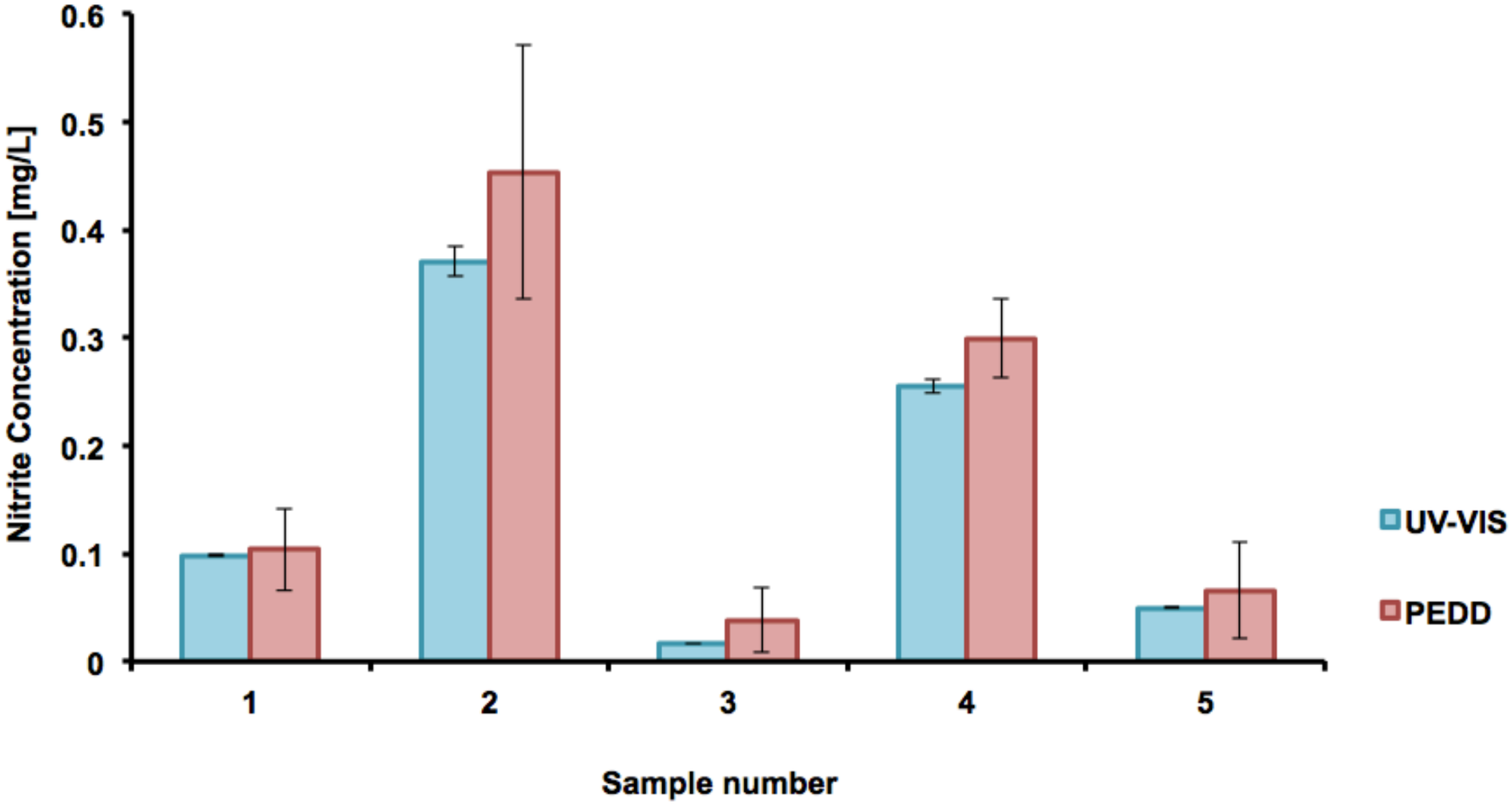
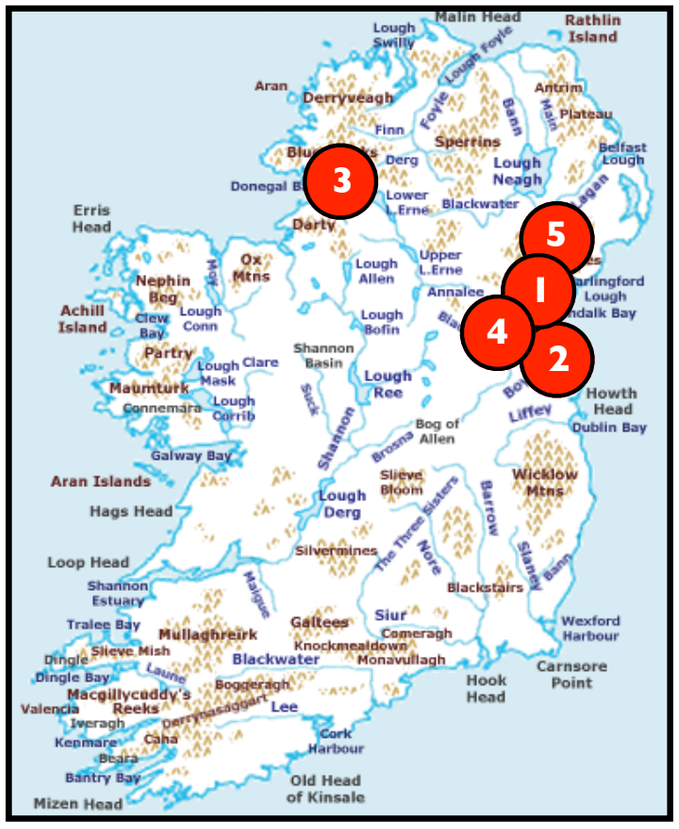


Limit of Detection: 40 ppb nitrite

Nitrite detection in freshwater : CMAS





Water nitrite analysis using a bench-top UV-VIS spectrometer and the CMAS device and a map of the sampling places (n = 3).

CMAS: Conclusions

Design

- A portable system for *in-situ* colorimetric water quality analysis has been developed.
- Integration of a wireless communication device allows data acquisition according to individual needs.
- Cloud Integration / data management via Android tablet.

Functionality

- System shows the huge potential for the CMAS to be a cheap and versatile alternative as point-of-need optical detector for lab-on-a-disc applications.
- LoD for Nitrite : 40 ppb

- Patent application no. GB 1207239.3

CMAS: Acknowledgments

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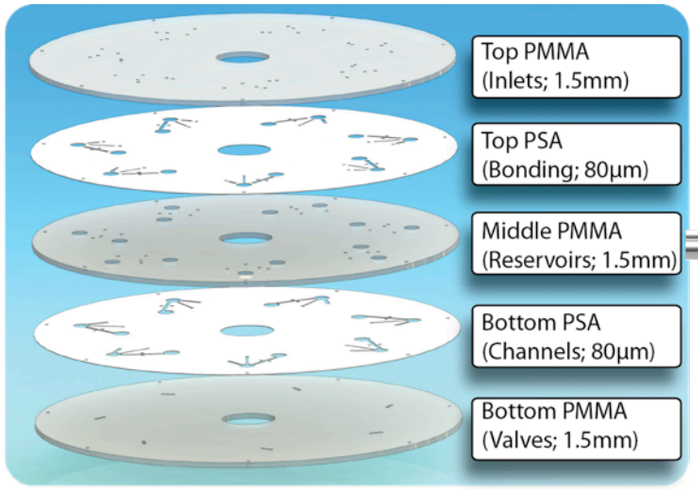


Materials

Monika Czugala

Fernando Benito-Lopez

Engineering

Damien Maher

Fiachra Collins

Dermot Diamond

Software

Frank Hopfgartner

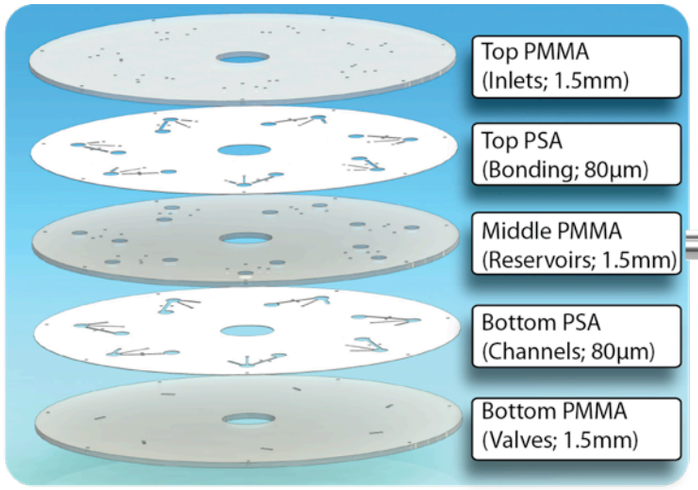
Yang Yang

Jiang Zhou

Alan Smeaton

sfi Fondúireacht Eolaíochta Éireann Science Foundation Ireland
SEVENTH FRAMEWORK PROGRAMME
ATWARM
MARIE CURIE ACTIONS
QUESTOR CENTRE
IRCSET Investing in People and Ideas Irish Research Council for Science, Engineering and Technology
NCSR National Centre for Sensor Research

CMAS: Acknowledgments



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Thanks for your attention

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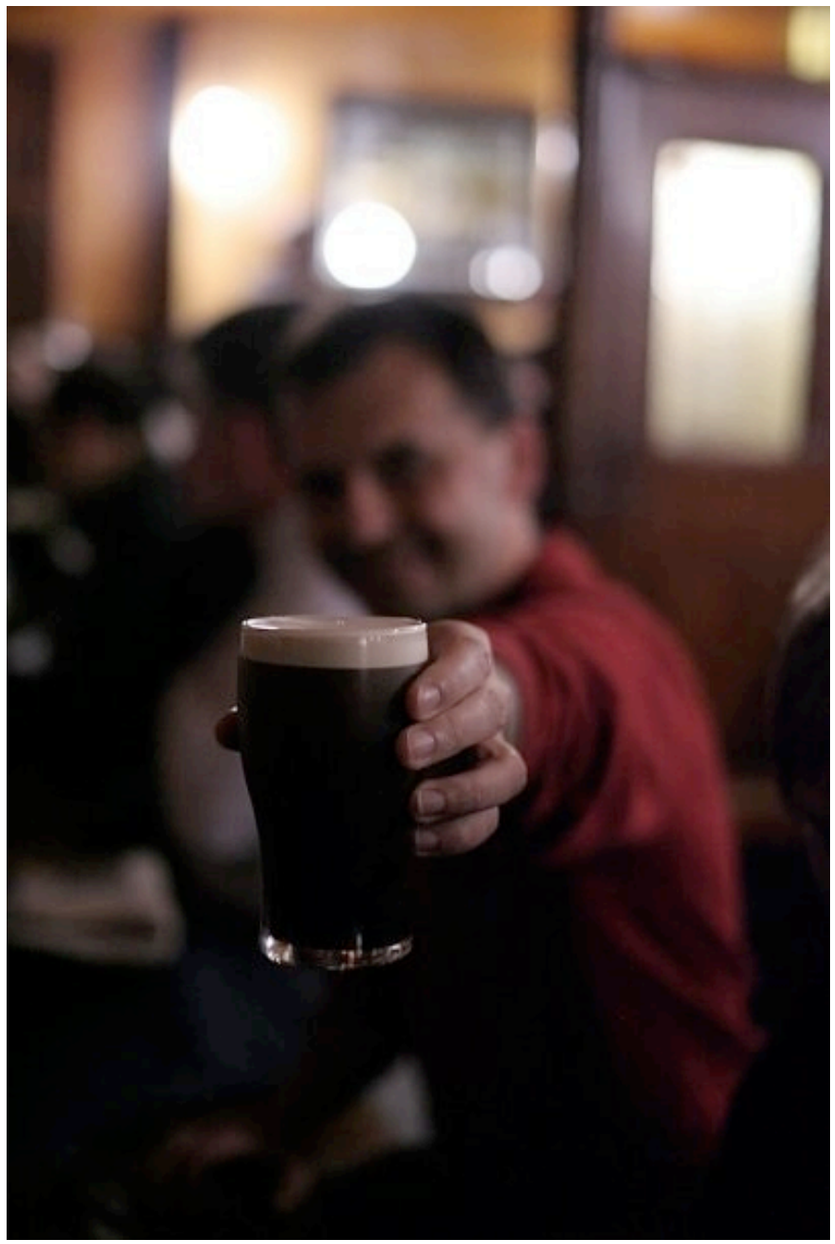

QUESTIONS?

Presentation available for download

NCSR
National Centre for Sensor Research