PROTECTING PEOPLE AND PLACES HSE

# Particulate Matter sensors for the workplace

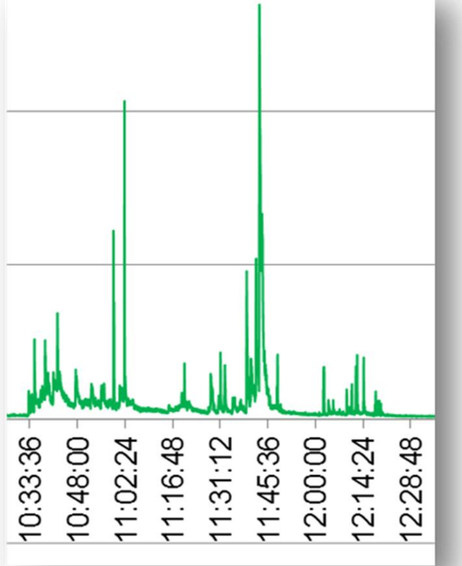
**Delphine Bard**
HSE Science Division
Health - Exposure and Control Group

delphine.bard@hse.gov.uk

# Introduction

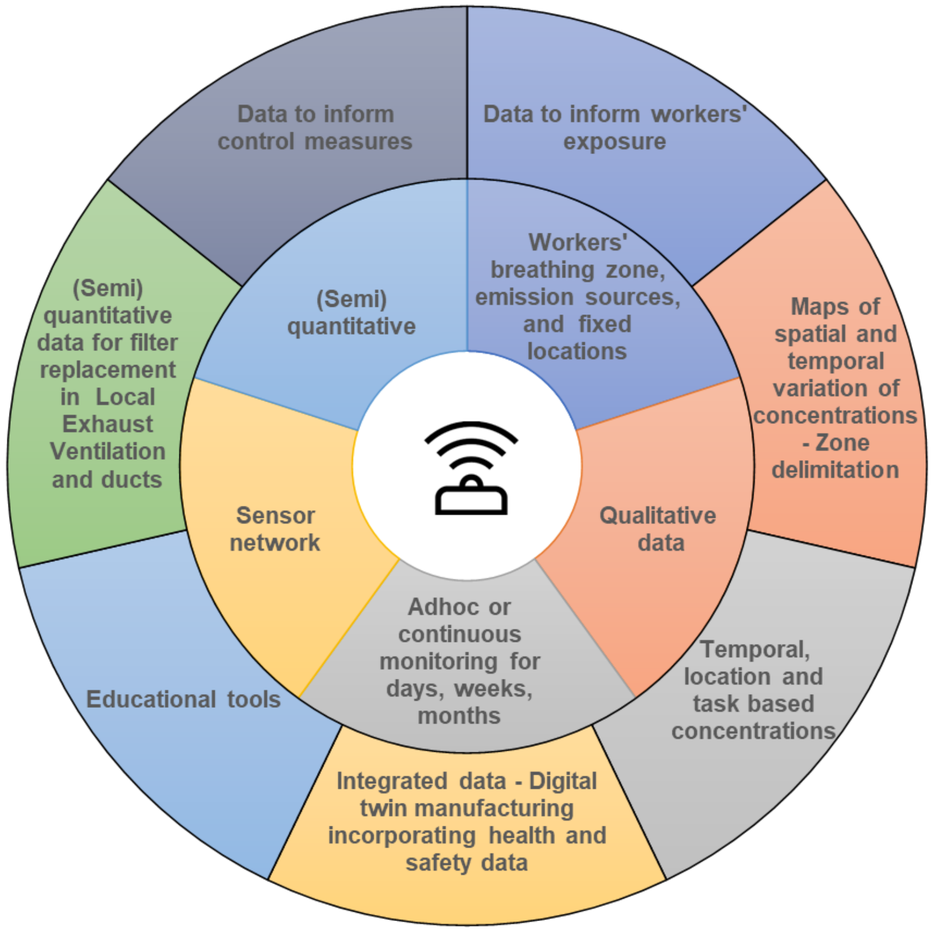
- Workplace measurements:
  - Collection of airborne particles on a filter, using e.g. respirable or inhalable sampler and an air pump.
  - Filters sent to laboratory for gravimetric and/or chemical analysis and time-weighed average mass concentrations derived.
  - Resource intensive and scare exposure data.

- Particulate matter sensor-based devices increasingly being seen as an attractive option for measurements of airborne particles in workplaces.
- Provide time-resolved data in real-time.




- Can they complement conventional filter-based gravimetric / chemical analysis methods for measuring airborne particles and how? Can they inform control measures in the workplace?

# Potential applications




**Workplace environments:**

- Airborne solid and liquid particles
- Mist/Sprays/Fumes
- Vapour and (Semi) Volatile Organic compounds (VOCs)
- Particles from few nm to > 100 µm of a wide range of composition and shape
- Complex mixed aerosols

**Indoor and outdoor environments**

- Including manufacturing and industrial processes, construction, healthcare, waste recycling, etc…
- Many type of particles e.g. silica, organic-based, metal-based, welding, diesel, oil and metal working fluids, nanomaterials.

# Sensors

- Mostly designed for the ambient air monitoring of PM1, PM2.5 and PM10 (conventions differ from those used in occupational settings).
- Most report PM mass but some as number concentration and size distribution.
- In general, no pre-selective inlet and use a fan rather than an active pump.
- Can be worn as wearables.

**Caveats**

- Light scattering devices. Response proportional to mass concentration, but depends on particle size, shape and refractive index.
- Calibrated with an aerosol different from those found in workplaces. Often, do not provide actual concentrations.
- Often incorporate proprietary algorithms.

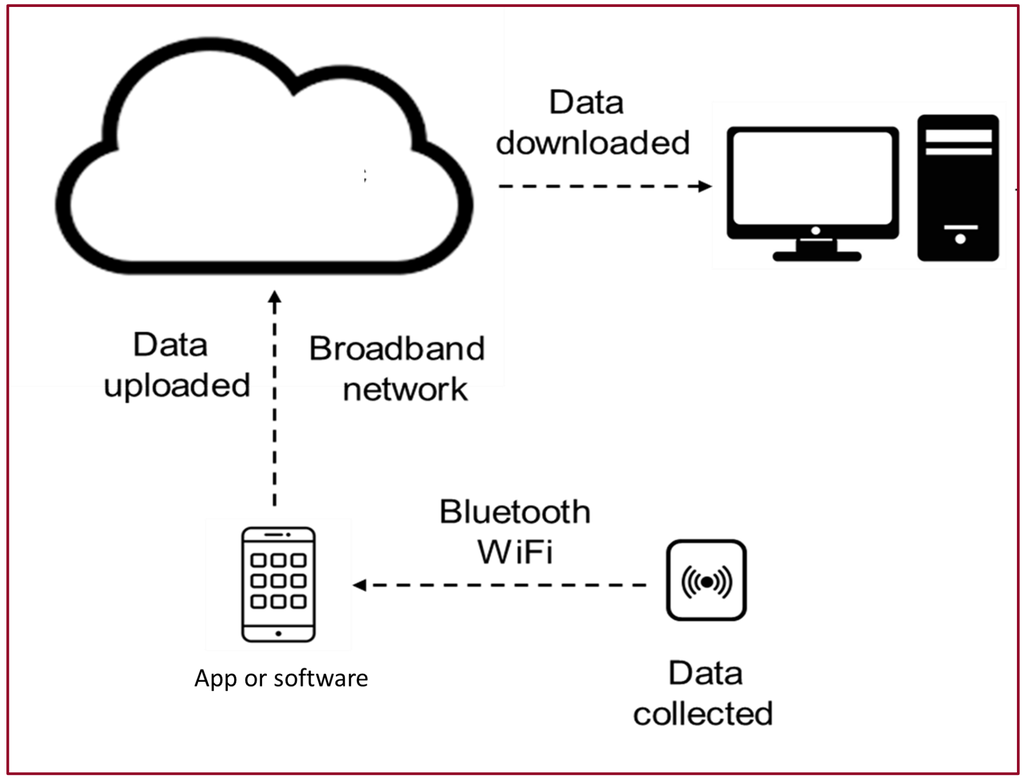
*Random selection of sensors available – This is not an indorsement of the devices*

# Data management

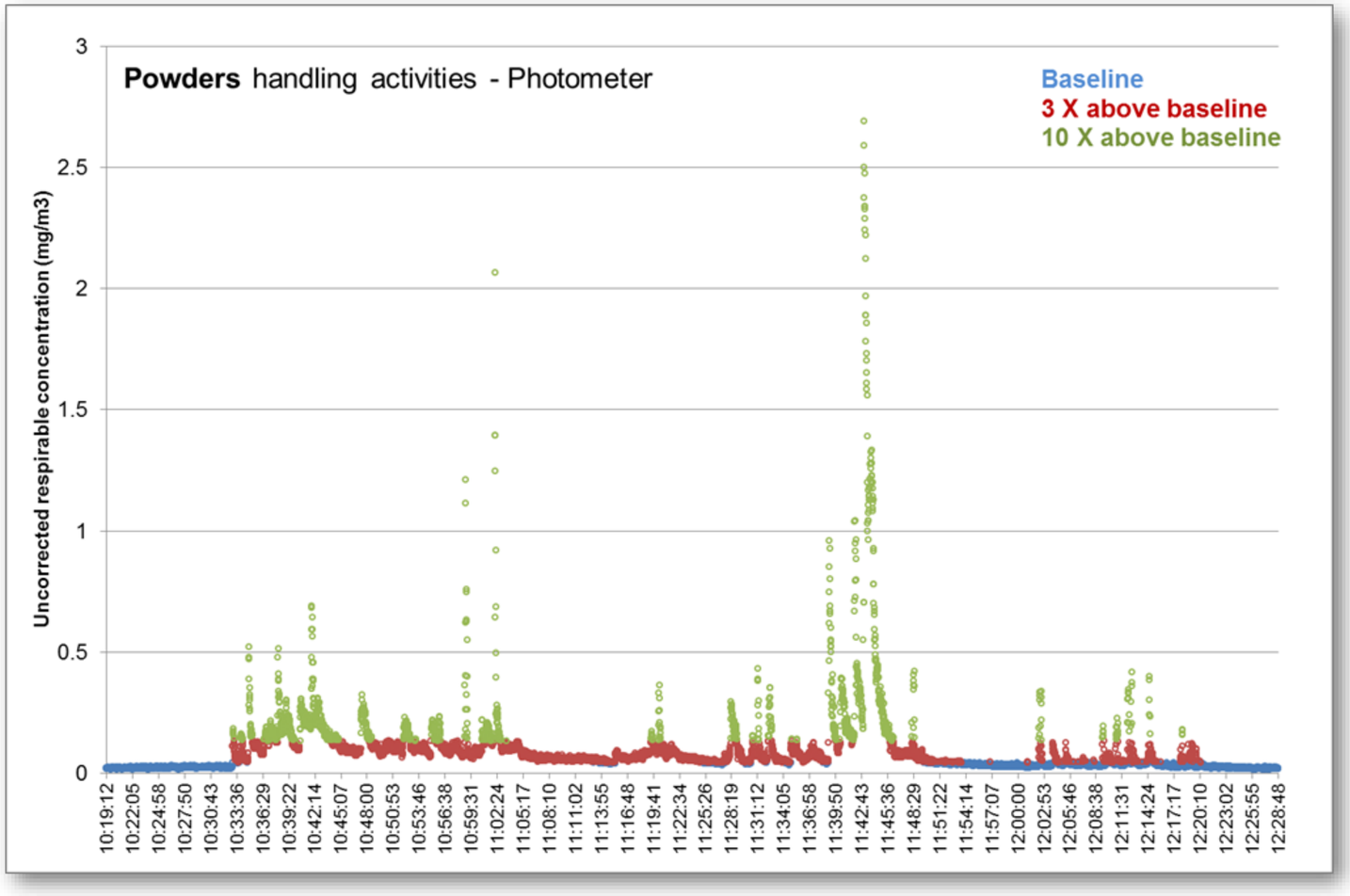
- Data accessibility in real-time and off-line
- Data security and ethics?
- Large data sets?

## End users

- Occupational hygienists
- Workers
- Employers
- Research scientists



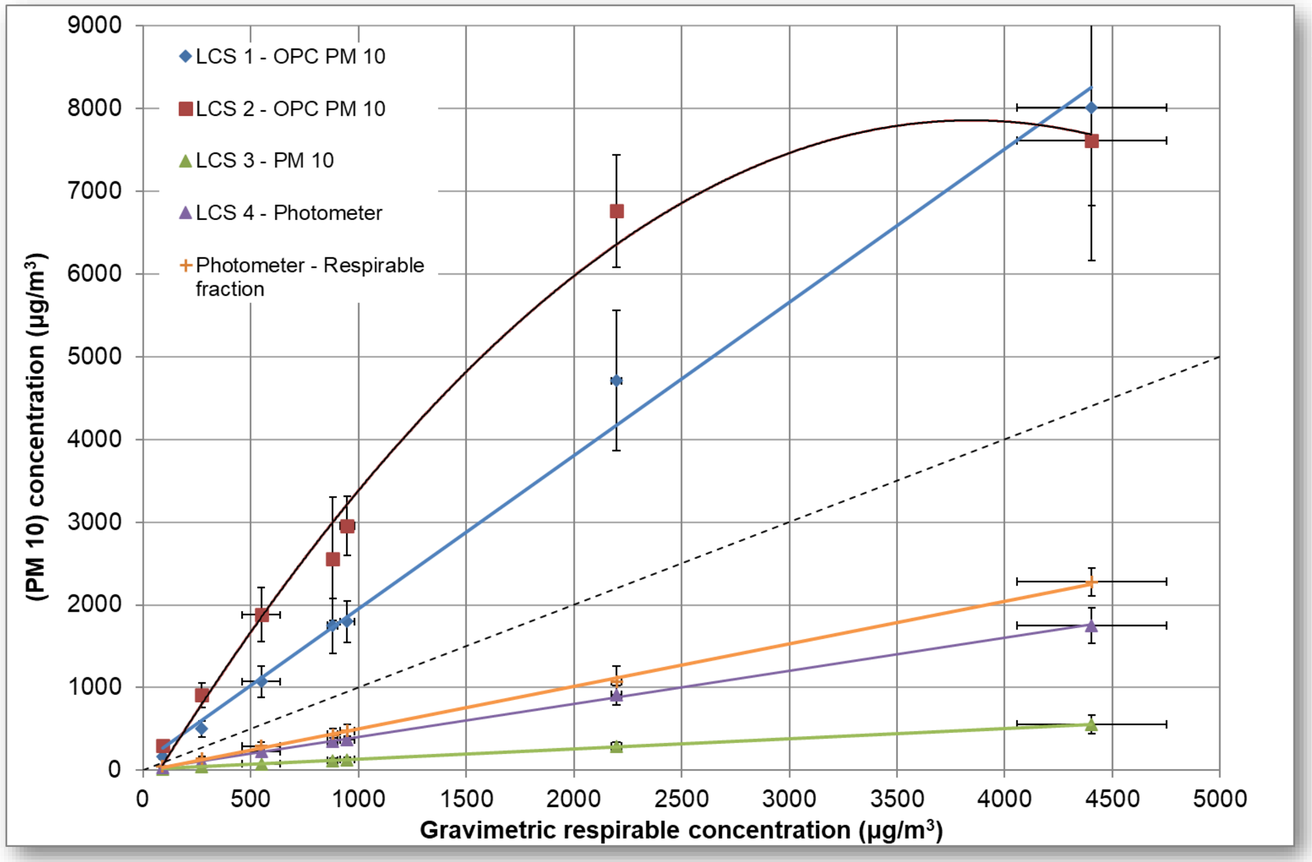
# Applications




- Data could inform management of controls

*Data analysis following: Measuring respirable aerosol with real-time optical monitors. E. Cauda, NIOSH*

# Laboratory evaluation - Calm air chamber – Four sensor models

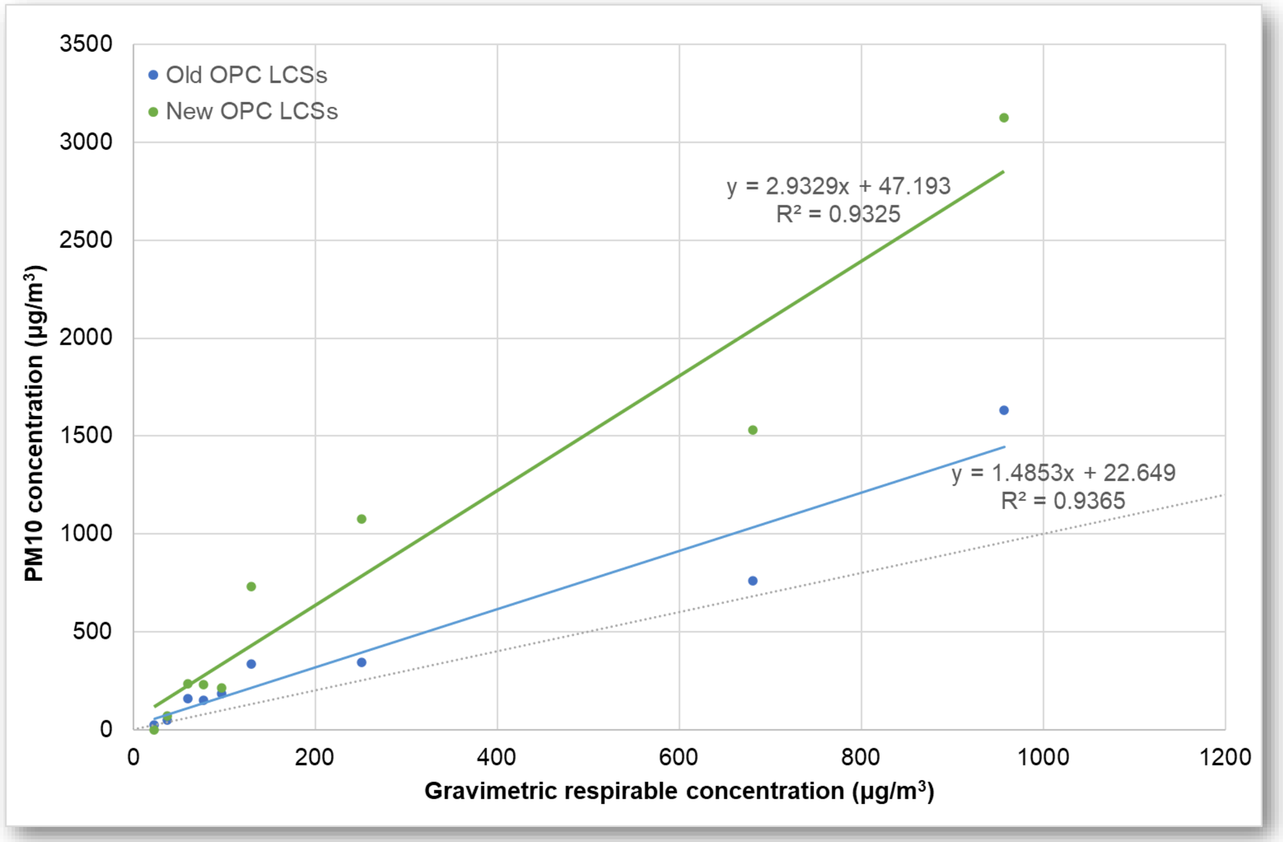



| | Slope | Intercept | $R^2$ | % bias |
|---|---|---|---|---|
| LCS 1 | 1.85 | 97 | 0.992 | 91 |
| LCS 2 | 1.74 | 955 | 0.875 | 198 |
| LCS 3 | 0.12 | 11 | 0.999 | -86 |
| LCS 4 | 0.82 | -15 | 0.897 | -16 |
| Photometer(1) | 0.51 | -10 | 0.999 | -49 |

- Adjustment / correction in workplaces required to estimate mass concentrations in terms of e.g. respirable fraction

**TNO/NIOSH/HSE SD collaboration -** D Bard, G Hunwin, E Kuijpers, S Ruiter, E Cauda, J-P Gorce, J Snawder, A Pronk , J Saunders , N Warren

# Workplace evaluation and measurements

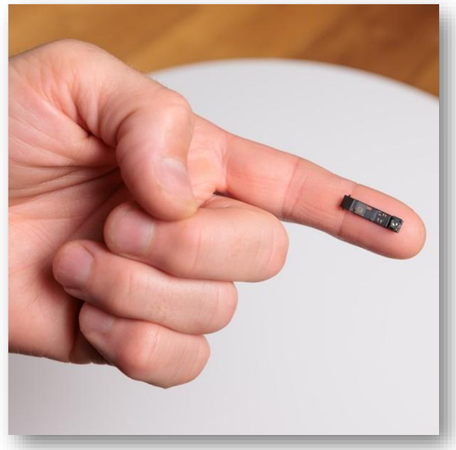



- 3 sites – each one-day measurements.
- Each site: total of 6 OPC sensor devices (same model, 3 used and 3 new), 3 different positions + respirable samplers and photometers
- Good correlation between PM10 and gravimetric (respirable fraction)
- Used sensor devices measuring lower than the new devices
- **Limitation of study**: Minimal data and one of the best sensors selected from the laboratory study and publications.

**HSE SD -** G Hunwin, S Hall, J Morton, L Leeze, P Stacey, D Bard

## Conclusions

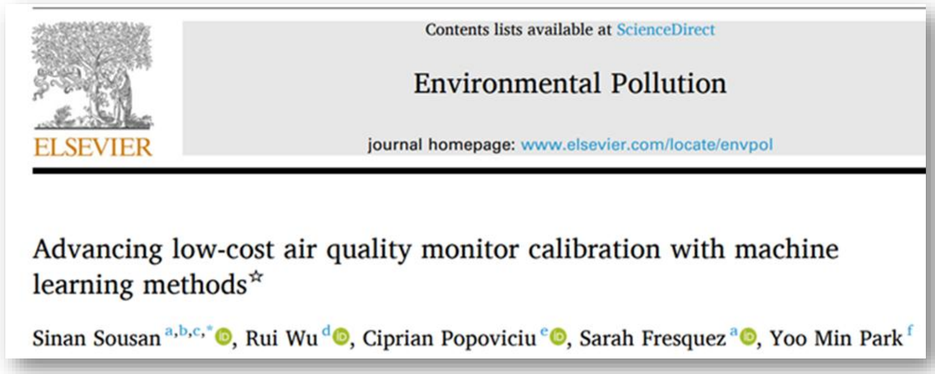
- The workplace environment can be challenging and the applicability and performance of sensors is still under evaluation.
- Most sensors measure PM for environmental use, not the respirable fraction; often black boxes.
- In long-term use sensor performance can drift so correction factors must be checked, adjusted or the sensors replaced.
- Data security, and large data sets.
- Accuracy/precision criteria needed especially for quantitative/semi-quantitative use.



World's smallest particulate matter sensor - Bosh

**However,**

- The data obtained using samplers is often limited and time-integrated.
- Sensor (networks) could raise awareness, change behaviour and reduce exposure.
- Qualitative data (peaks, time/space variation) useful for control management



## Acknowledgement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- TNO (Netherlands): Eelco Kuijpers, Sander Ruiter, Anjoeka Pronk

- NIOSH (USA): Emanuele Cauda, John Snawder


**Thank you for listening**