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Overview of techniques for detecting and quantifying methane emissions from upstream facilities

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Outline of Presentation

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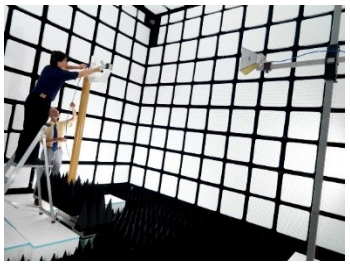
- Introduction
- Differential Absorption LIDAR (DIAL)
- Distributed sampling for leak detection
- Low cost sensors
- Validation: Controlled Release Facility
- Overview of techniques

Who we are

NPL National Physical Laboratory

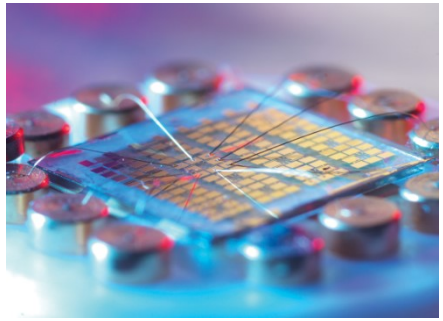
- UK's National Metrology Institute/ Public Corporation.
- ~750+ staff with ~200 visiting researchers/year.
- Partner with 200+ organisations and 80+ Universities.



NPL National Physical Laboratory **Consultancy**

NPL National Physical Laboratory **Calibration and Measurement Services**

NPL National Physical Laboratory **Training**



NPL National Physical Laboratory **Instruments**

NPL's position

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Concept

- Fundamental understanding

Development

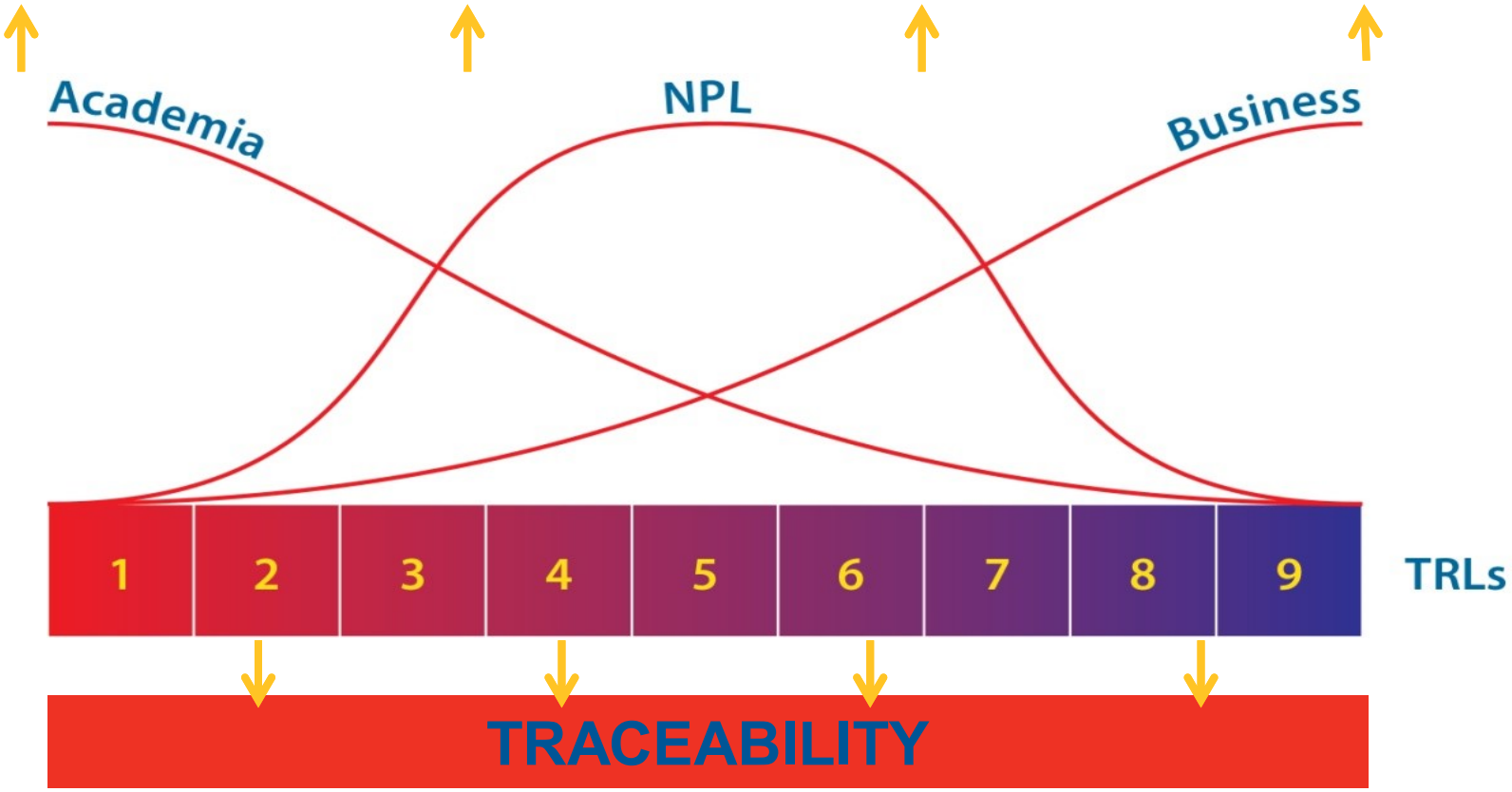
- Enhancement
- Verification
- Prototyping
- Characterisation

Operation

- Quality assurance
- Process
- Optimisation
- Uncertainty

Standardisation

- Standards
- Regulation



Emissions and Atmospheric Metrology Group

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- EAMG's activities are focussed on the accurate measurements of gases and particles in an air matrix – generally in the atmosphere or emissions to the atmosphere.
- >30 scientists, many working in the field.
- Three main technical areas:
  - Emissions monitoring;
  - Atmospheric science and climate change;
  - Sensor development and validation.
- Work with Gas and Particle Metrology.

Differential Absorption 'LIDAR'

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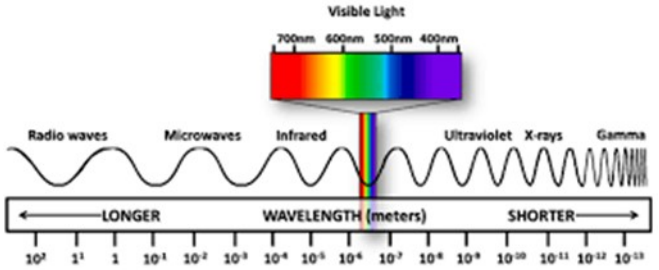
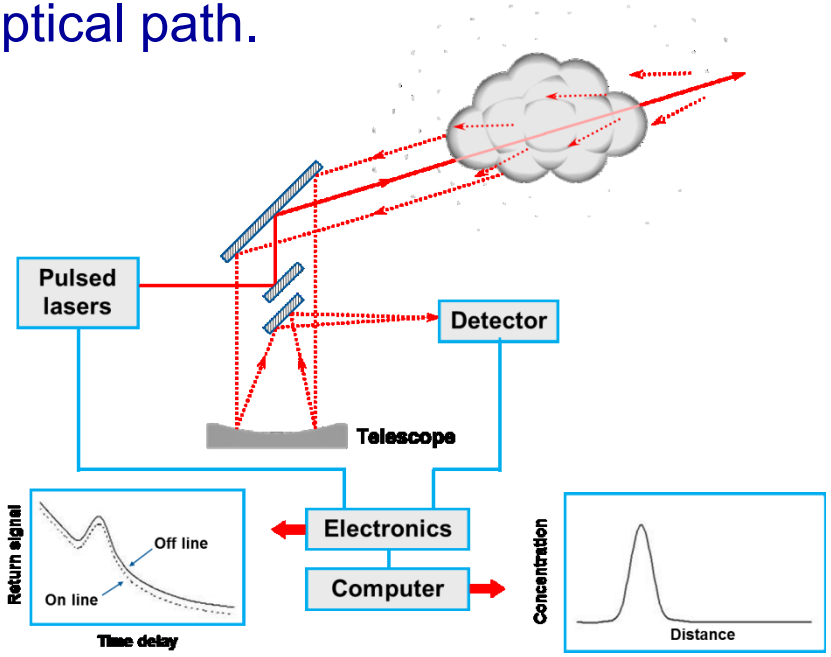


- LIDAR Laser Radar system.
- Target specific gas species.
- Mobile laboratory.
- Detect and quantify and wide range of species.
- Range resolved concentration along optical path.



Differential Absorption ‘LIDAR’

How do we detect methane?

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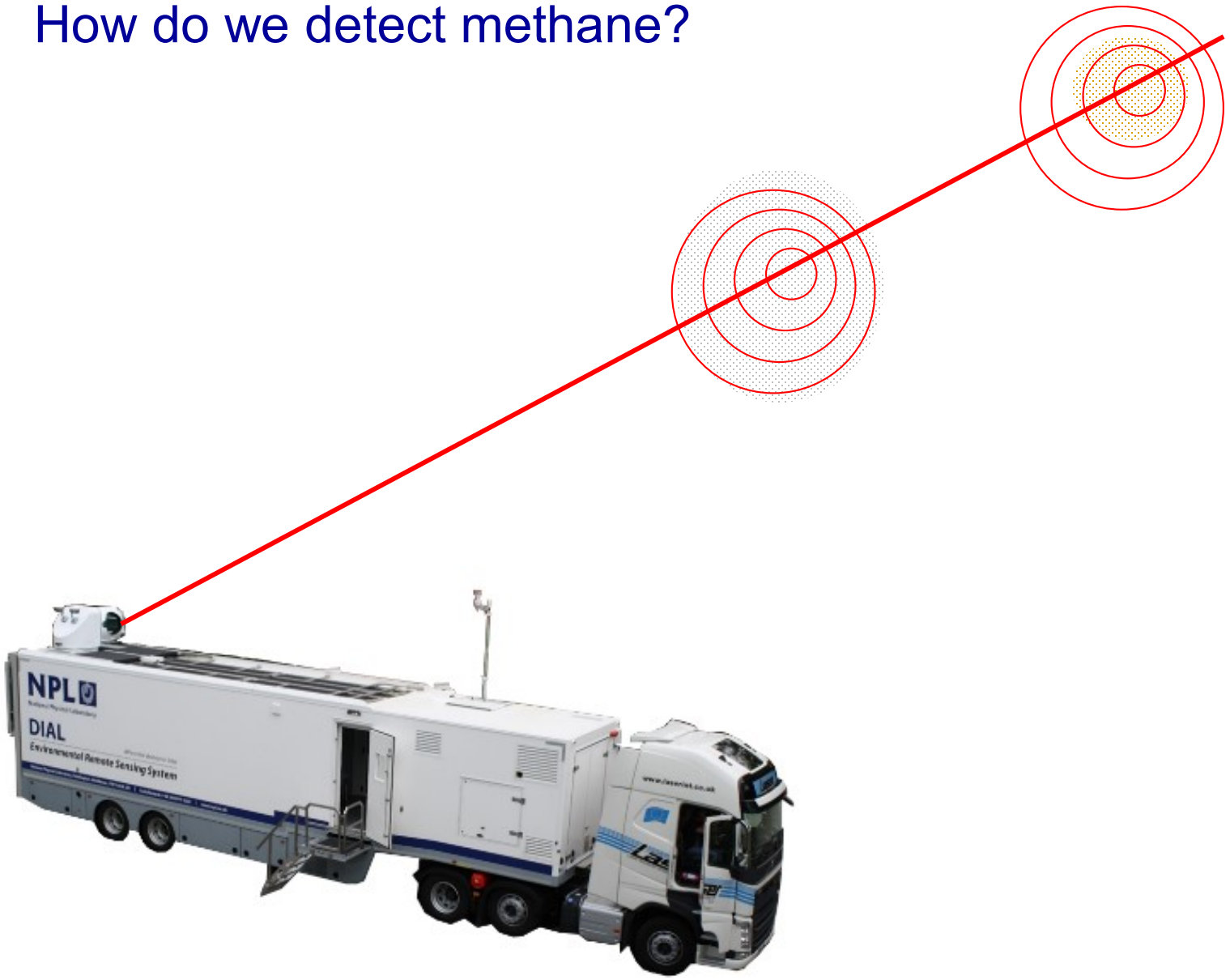
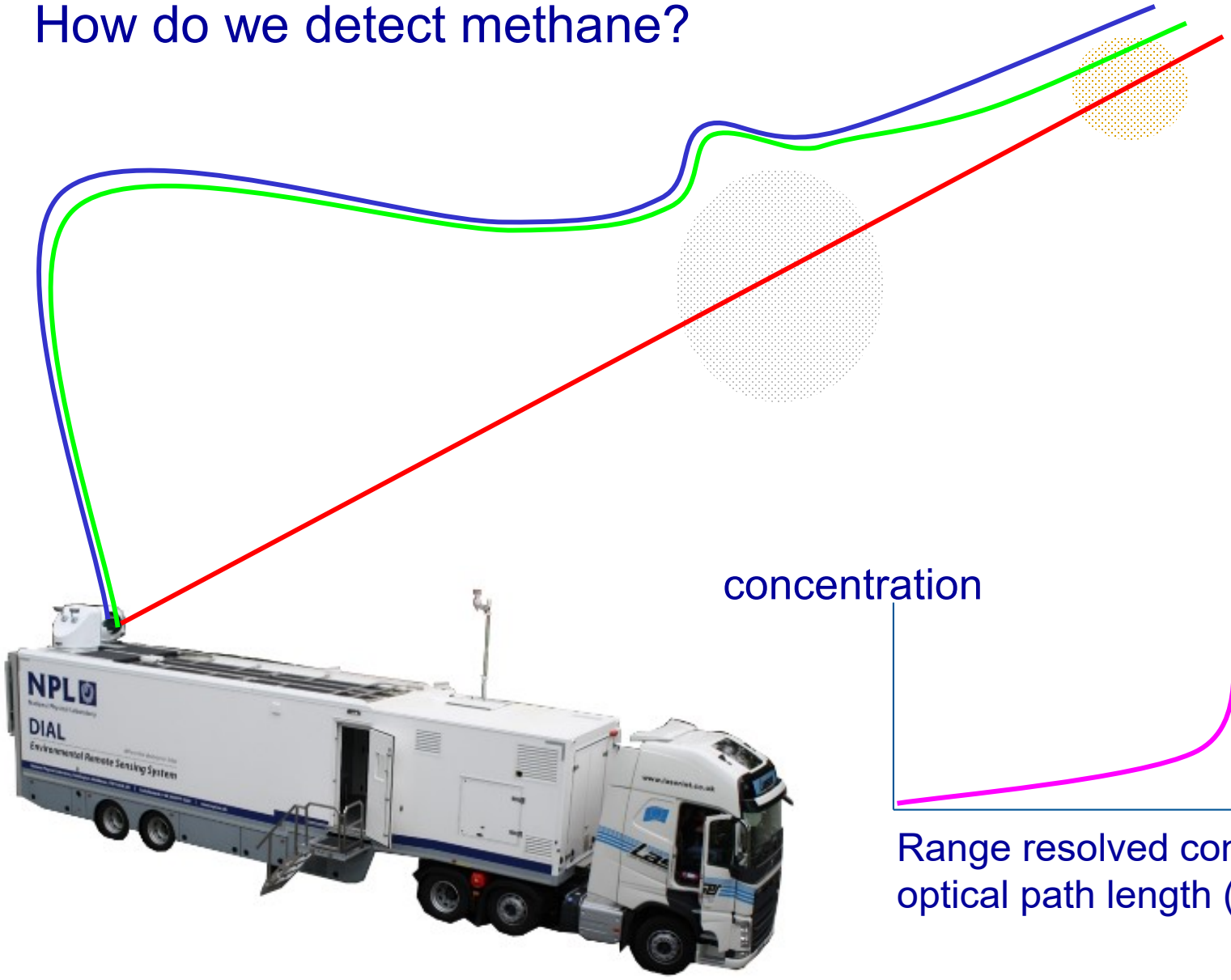


Differential Absorption ‘LIDAR’

How do we detect methane?



concentration

Range resolved concentration along optical path length (Range ~500m).

Differential Absorption ‘LIDAR’

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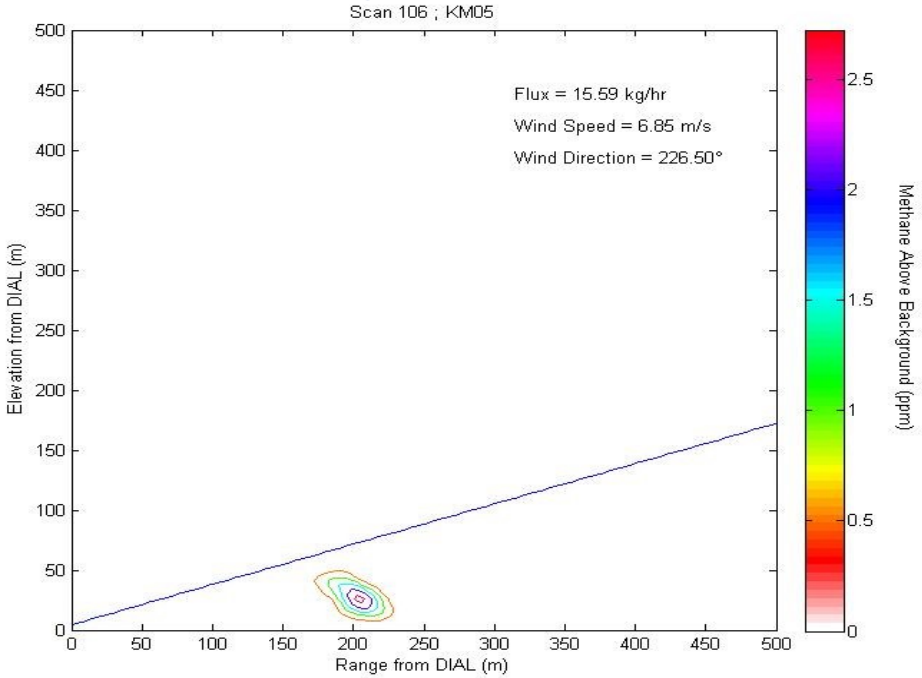
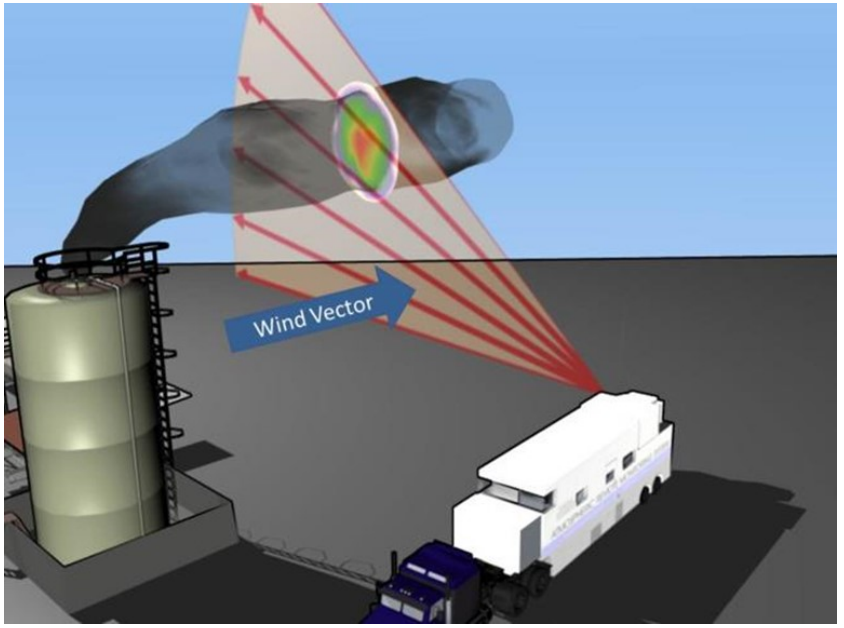
Calculated methane concentration and emissions rate

- Vertical scans enable plume mapping.
- Plume mapping gives concentration of target gas.
- Range-resolved concentration combined with wind field to give emission rate.





Differential Absorption 'LIDAR'

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Why use DIAL?

- The DIAL technique provides a method to identify and quantify methane emissions (and many other key industrial species).
- Measurements can be used for: Impact assessment, regulatory compliances, verification and validation.
- Established technique: NPL have been using the DIAL technique for such applications for over 25 years.
- Multiple validations of the technique have been done.
- Efficient way to measure total emissions from complex sites.
- Can cover all emission sources from a site, including fugitive and point sources.
- Do not need to access hazardous areas.

Differential Absorption ‘LIDAR’

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Onshore oil and gas production

- Measurement of methane emissions from (conventional) well.
- Carried out from outside facility.
- Demonstrator of capability (for DECC at the time) to find and quantify leaks from small sources.
- Showed we could unambiguously locate and quantify emissions.

Differential Absorption ‘LIDAR’

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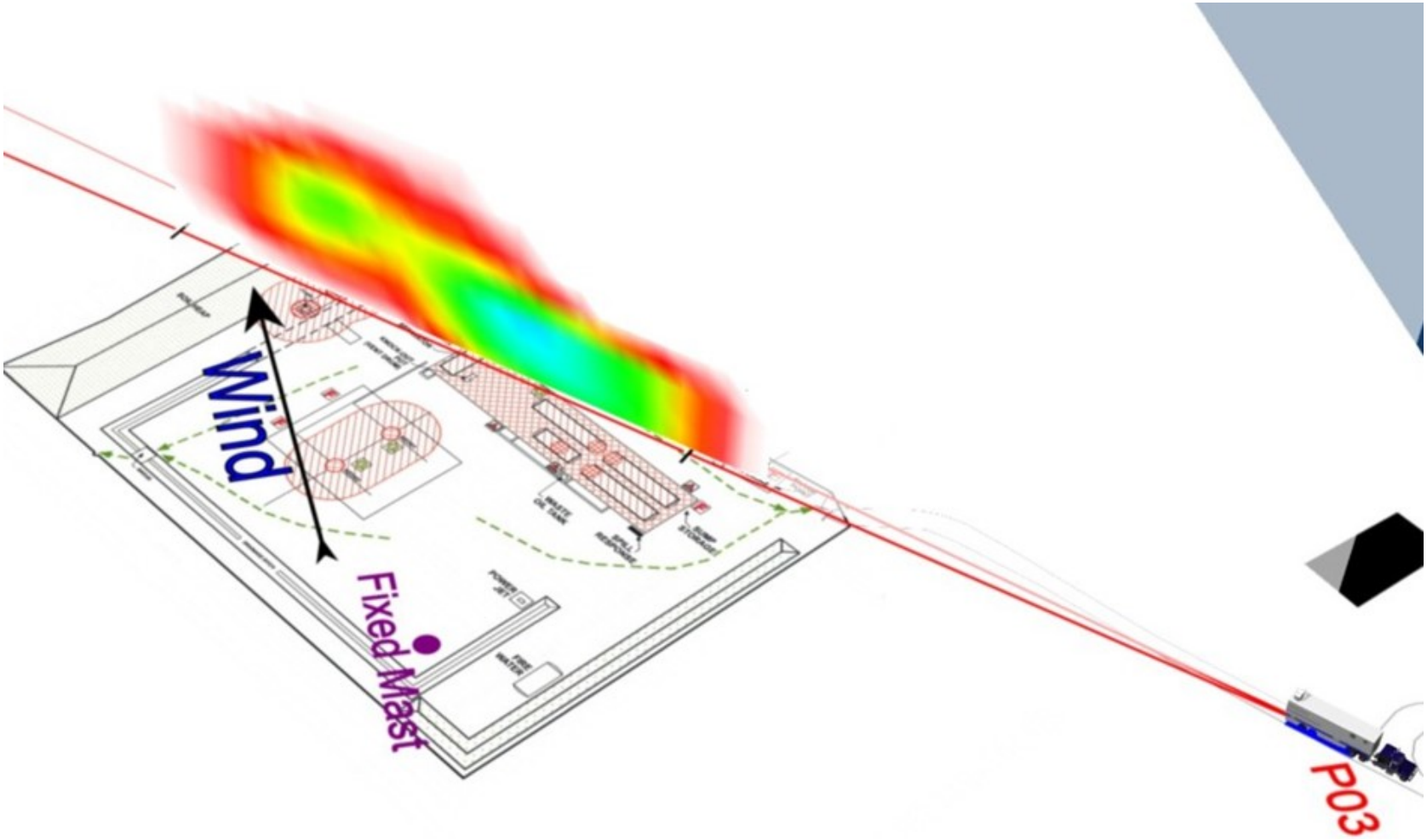
Onshore oil and gas production



Differential Absorption ‘LIDAR’

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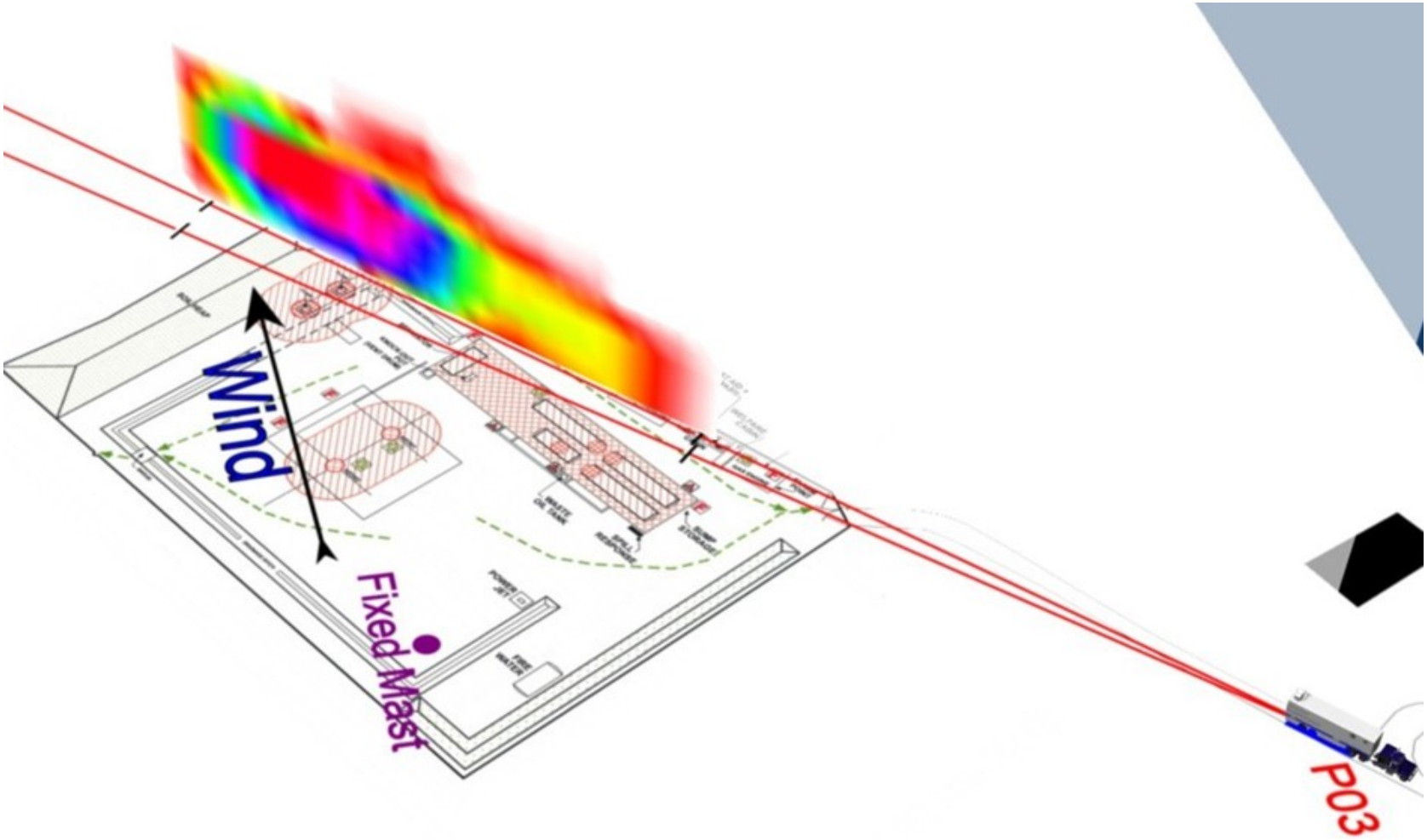
Onshore oil and gas production



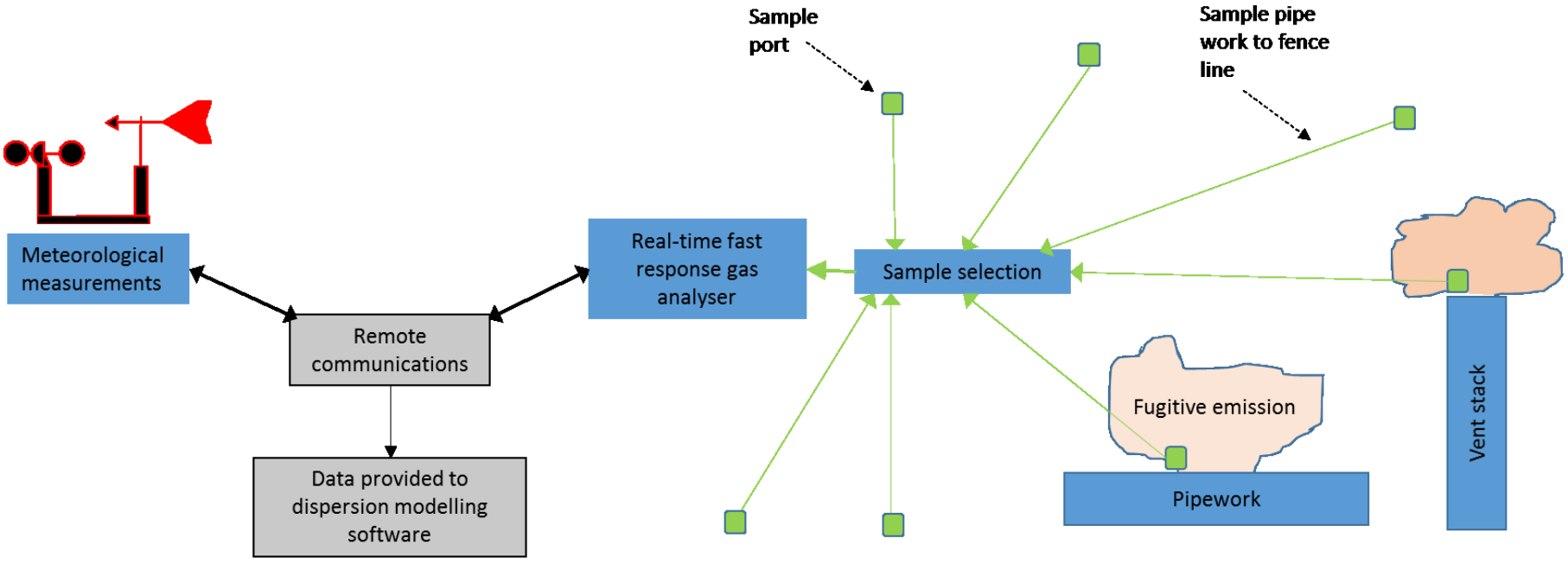
Next generation DIAL

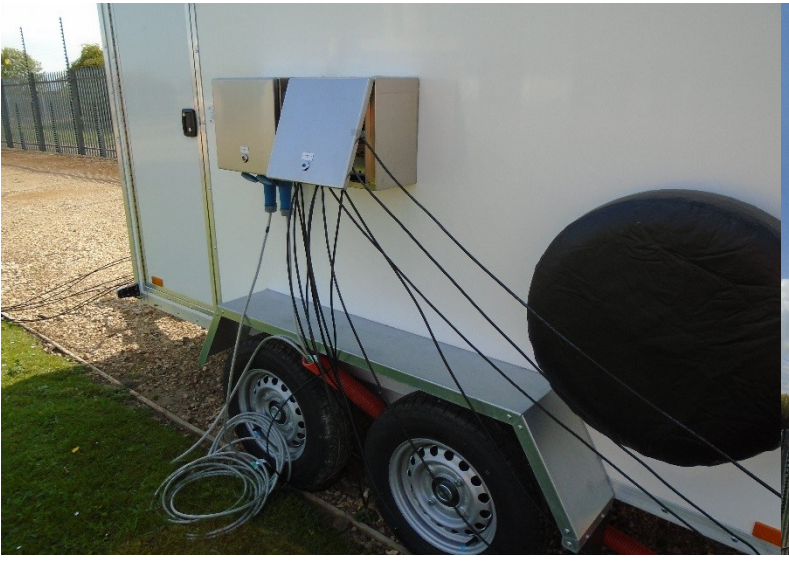
- NPL are developing a new service to make DIAL capabilities more widely available.
- Smaller more compact systems.
- New business model:

  Operated by measurement providers or industry.

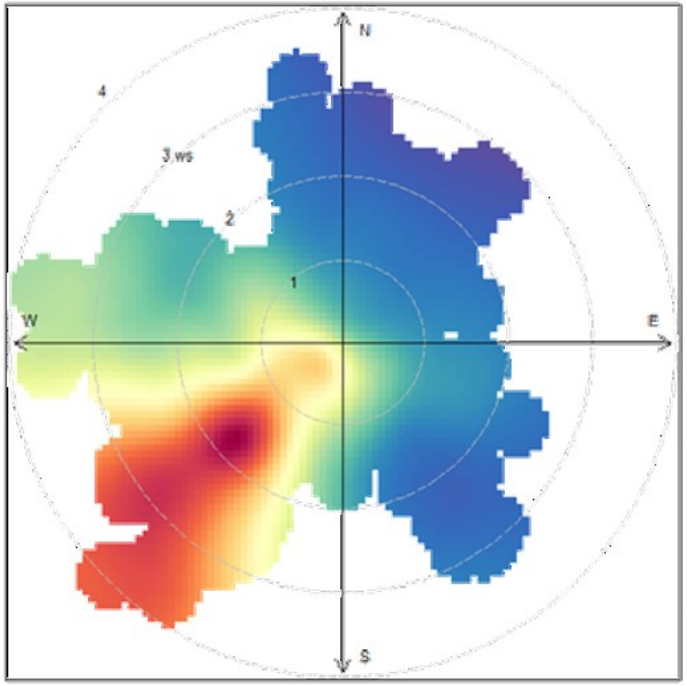
  Data processing and quality assurance carried out by NPL remotely.

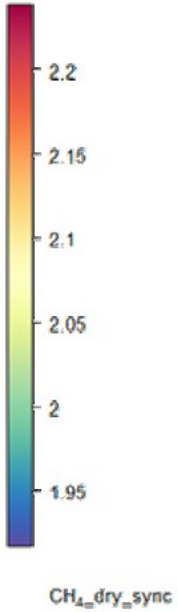
Distributed sampling technique





Distributed sampling technique

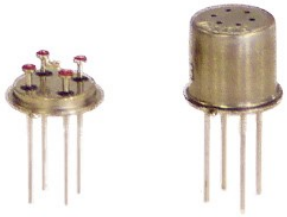




Low cost methane sensors

Metal Oxide Semiconductor (MOS) – Tin Dioxide

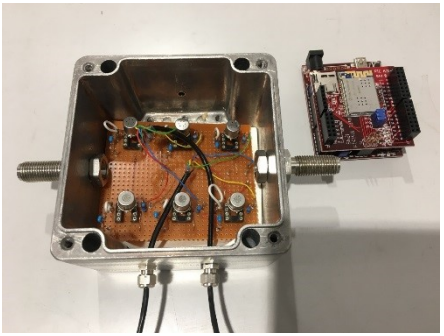
Advantages:



- Portable and small size.
- Low cost.
- Use a simple electrical circuit, low power consumption.

Disadvantages:

- Sensitive to other gases, including water vapour.
- Sensitive to variations in ambient temperature.
- Measurements can drift over the long term.



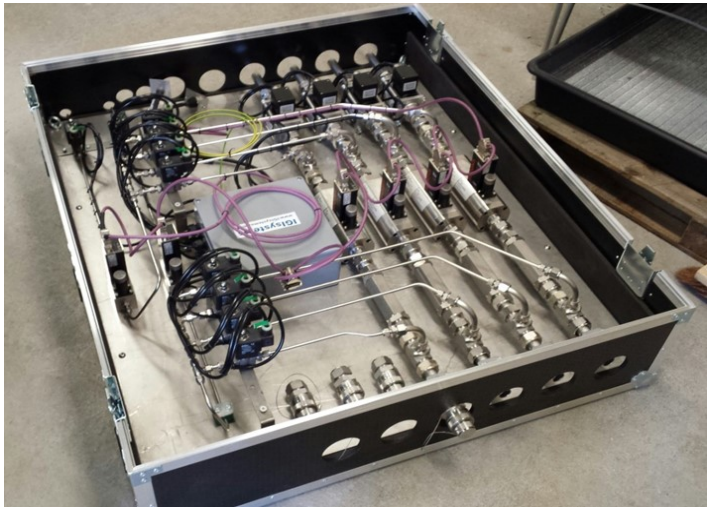
Controlled release facility

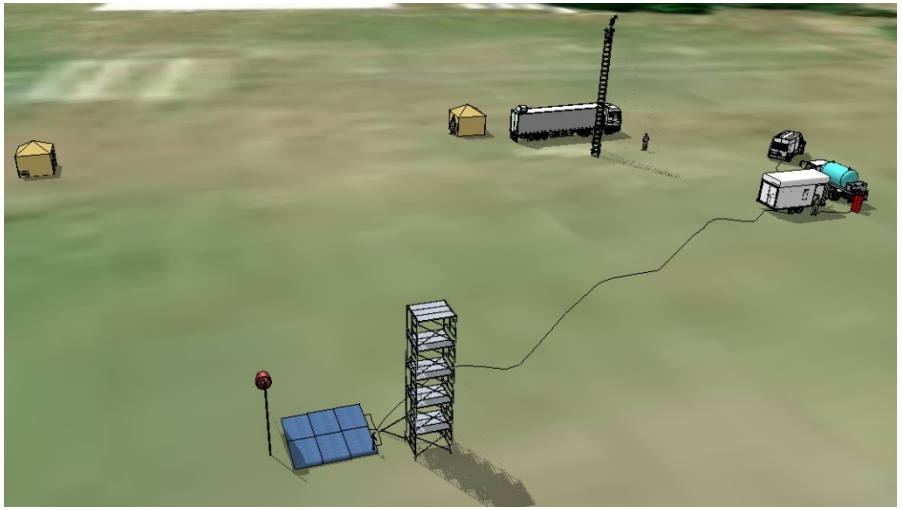
- Portable facility to test and validate techniques used for fugitive emissions monitoring.
- Able to reproduce a wide range of emission characteristics

  pure or mixed ratio gases.

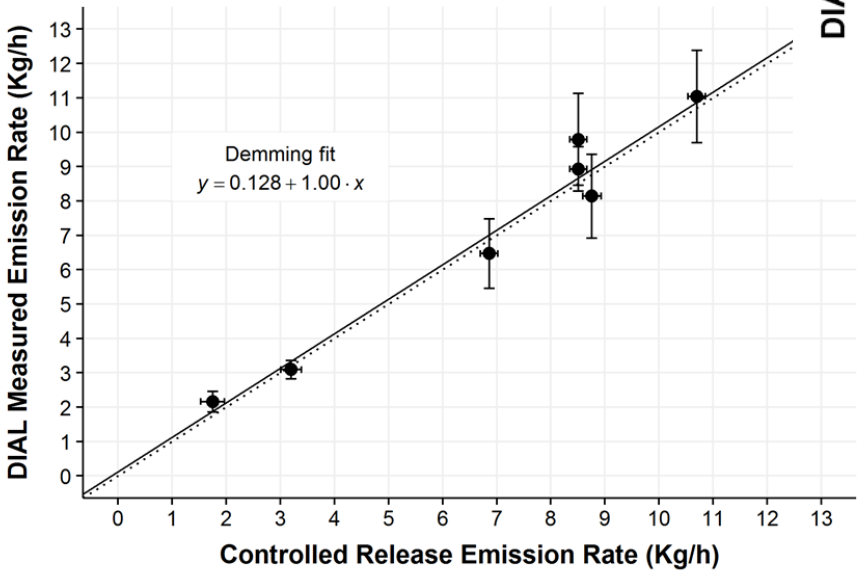
  traceable emission rates up to 55 kg/hr.

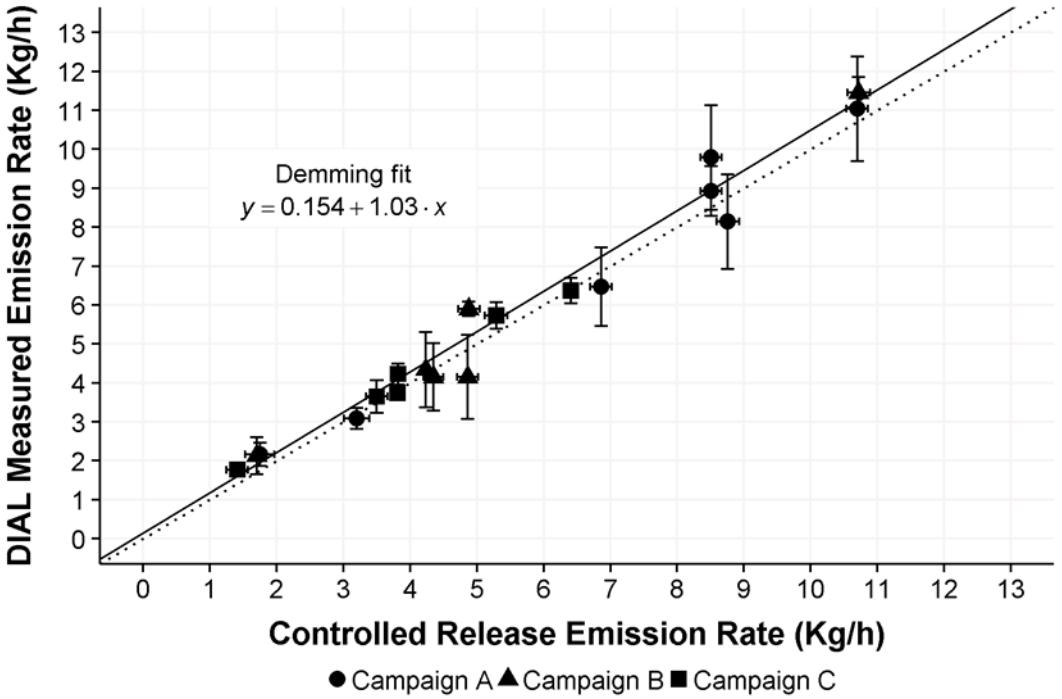
  different emission nodes (line, point, area sources) can be combined.
- Developing validation protocols
- Used in validation of European standard and protocols.





Field Validation – Controlled Release





Validation of mass emission rate measurements

Very linear, but also – no systematic offsets

Variability of measurements is a good indictor of uncertainty

Field Validation of Remote Sensing Methane Emission Measurements, Tom Gardiner, Jon Helmore, Fabrizio Innocenti and Rod Robinson, Remote Sens. 2017, 9(9), 956; doi:10.3390/rs9090956

Examples of other validation activities

- Assessment of performance of emission measurement technologies – hi-flow sampler (EDF/DECC/BEIS)

  Lab tests and use of CRF.

  Assessed failure modes of sampler.
- Testing gas imaging cameras against US EPA performance standards.
- Validation of Drone measurements (Manchester University).
- Validation of novel instruments (UK A4I project)
- QOGI testing – initial validation study using controlled releases.
- Sensor validation and performance tests.
- Development of long term emission measurement using point sampling and reverse modelling – validation with DIAL (Climate KIC FuME project and follow on work).

Techniques

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Data requirements:

- Different techniques have different scales: 10s of cm to 10s of km.
  Provide differing degrees of spatial information and coverage.
- Time period: continuous to snap shot in time.
- Optical techniques measure concentration over path length.
  Different methods use various levels of assumptions and models to determine concentrations.
- Emission rates combine concentration and flow rate (wind speed)
  Different approaches again include built in modelling or assumptions.

All techniques have built in assumptions and different techniques assume different things.

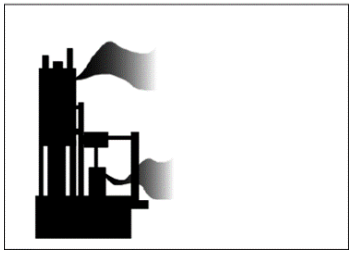
Important to perform field validation and intercomparison measurements.

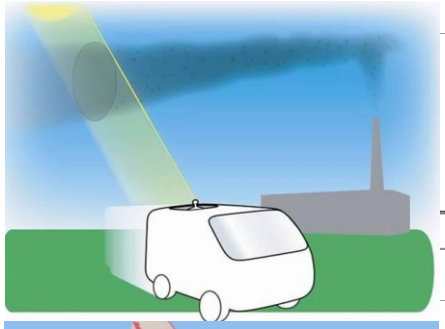
Test techniques performances – strength and weakness.

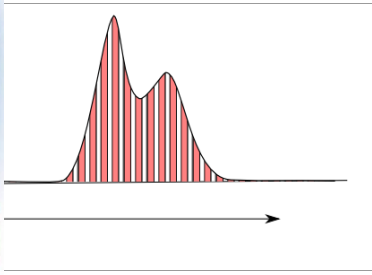
Develop protocols – achieve and reproduce these performances.

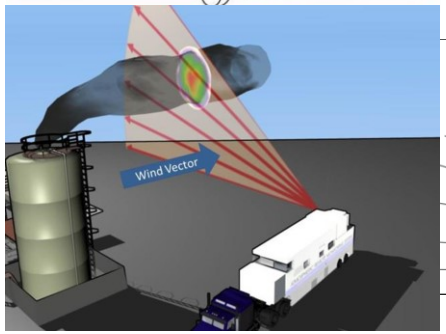
Techniques

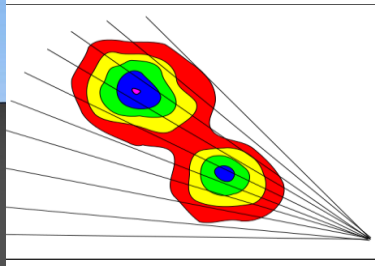
- Leak detection and repair (LDAR) – sniffing and correlation factors.
- Optical Gas Imaging (OGI) - IR Camera to image plumes.
- Solar Occultation Flux (SOF) - mobile measurement through plume using the sun as the light source.
- Differential Absorption Lidar (DIAL) - remote sensing using lasers to scan through plumes.
- Also added in Tracer Gas technique (release a tracer and measure VOC and tracer downwind) and Reverse Dispersion Modelling.

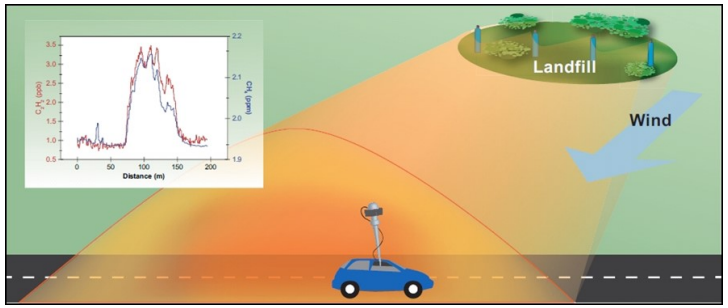












Summary

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- DIAL
  - Can detect and quantify methane emissions.
  - Remote sensing.
  - Well established technique.
  - Future: more accessible / smaller systems.

- Distributed sampling technique.
  - Continuous measurements.
  - Complimented with low costs sensors, cameras, sniffers.

- Validation
  - Controlled Release Facility.
  - NPL experience in validation.


Thank you
Any Questions ?