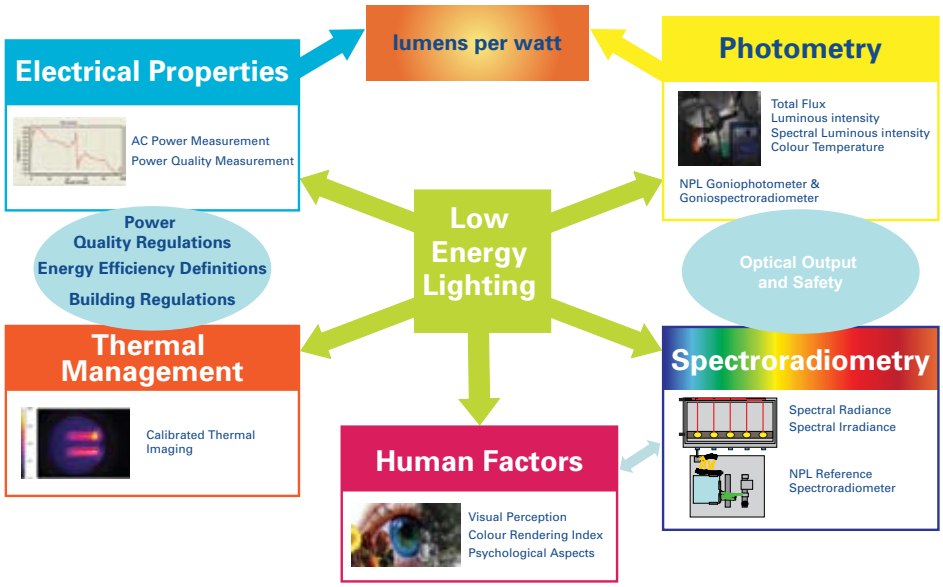
NPL
National Physical Laboratory

Environmental *Measures*

A National Measurement Newsletter

Autumn 2008 | Issue 5



NPL's holistic services for the low energy lighting community

Inside:

Low energy lighting: The measurement challenge

NPL's Optical Technologies Team is developing measurement techniques for the accurate characterisation of high efficiency lighting technologies, lamps and luminaires. These include accurate measurements of spectral and spatial distributions of lamp outputs and the development of holistic facilities – measuring optical, thermal and electrical properties simultaneously.

Lighting has been seen as the "low hanging fruit" for reducing our carbon footprints – lighting accounts for 20 % of our energy usage, yet reducing its impact is as simple as changing a light bulb. New legislation is likely to call for all lamps to meet a particular energy efficiency level defined in terms of lumens per watt (optical power out for electrical power in).

And yet people have not put compact fluorescent lamps in all their light fittings. There are concerns about mercury, colour rendering (whether coloured objects look 'right' under the lights), switch on time, dimmability and the reliability of brightness claims of these lamps. Many of these issues vary from manufacturer to manufacturer, but without meaningful standards and measurements it is hard for manufacturers to prove the quality of their products

Solid state lighting based on LEDs has huge potential within the next few years. These lamps, which contain no mercury, have efficiencies better than compact fluorescents while being dimmable and quick to switch on. For this industry to reach its full potential, quality measurements are required to prove the efficiency claims, colour rendering capabilities and lifetime. Lifetime itself is highly dependent on the temperature of the LED junction – something which is notoriously hard to measure in-situ.

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Department for **Innovation, Universities** & **Skills**

High efficiency lighting in general, and in particular solid state lighting, differs considerably from traditional light sources in that the lamps are more directional, more temperature sensitive and have more complex spectra. In addition their electrical behaviour is more complex. This means that measurement services need to be developed to meet these requirements and need to be more flexible.

The NPL team is developing facilities to make full-spectral optical measurements of these lamps at all angles using a goniospectroradiometer. This facility will also make in-situ measurements of the electrical power and power quality, providing direct measurements of efficiency. In addition we are carrying out research into junction temperature measurements.

We are actively applying for cofunding through DIUS and European funding mechanisms for research projects related to high efficiency lighting. If you are interested in working with us on this subject, please contact as below.

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An LED lamp on the goniospectroradiometer

NPL leads efforts on earth observation and climate data quality strategy

Earth observation data, particularly that collected by satellites, makes an important contribution to the study of climate change. An international Quality Assurance Framework for Earth Observation, to enhance data quality and traceability, is being established in response to a request from the Group on Earth Observation.

Earth observation data from satellites is crucial to the study of climate change and makes an increasingly significant contribution to environmental monitoring as a whole. Following a request from the Group on Earth Observations (GEO) (http://earthobservations.org/), an international quality assurance framework for earth observation data is being established by the Committee on Earth Observations Satellites Working Group on Calibration and Validation (CEOS WGCV) (http://wgcv.ceos.org). The Quality Assurance Framework for Earth Observation (QA4EO) (http://calvalportal.ceos.org/CalValPortal/qa4eoInfo.do), is based on a set of ten key guidelines and has recently completed a peer review, before submission to CEOS for its formal approval in November 2008. The guidelines, based on the adoption of "best practice", will allow all stakeholders (including non-experts) to assess at "face value" the suitability of a data product for their application through documented evidence of its traceability to international standards, and facilitate interoperability and harmonisation. The implementation of QA4EO will, in some cases, require new standards to be established. For example, in the optical domain, eight ground targets (deserts and snowfields) and the moon have been selected as references to calibrate satellite borne optical imagers. NPL has made a significant contribution to the development of this framework, leading the data quality aspects and drafting more than 70% of the key guidelines.

The QA4EO recommends the establishment of regular comparisons of instruments, both on the ground and in space, to identify potential biases and as a means of providing evidence of traceability. NPL is organising the first two ground-based comparisons of optical instrumentation, supported by funding from a number of the world's space agencies including the European Space Agency (ESA). These first comparisons will concentrate on infrared radiance emitted from the sea (sea surface temperature) and reflected solar radiation from land. In many ways these are analogous to key comparisons of the CIPM (Comité International des Poids et Mesures) mutual recognition arrangement that underpins the recognition of the national measurement standards from different countries (http://www.bipm.org).

Without the establishment of a new data quality assurance strategy it will be impossible to provide meaningful services based on earth observation data and, in particular, establish adequate records of key climate variables needed within climate change studies.

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Establishing traceability for measurements of mercury vapour in air

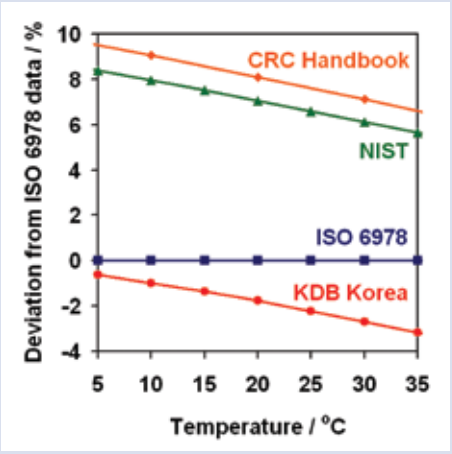
The accurate measurement of mercury vapour in air is crucial to monitor the exposure of the public to this important pollutant. Scientists at NPL have collaborated with a UK company to develop a method to ensure the traceability of these measurements, which are subject to European legislation.

Mercury is a highly toxic and persistent pollutant found in ambient, indoor and workplace air. It is released into the environment from sources such as coal-burning power plants, crematoria and waste treatment processes.

The vast majority of mercury vapour measurements currently undertaken are ultimately traceable to the vapour pressure of mercury. This is given in the scientific literature by several different empirical equations, but the agreement between these is not good, with data from different equations sometimes differing by 5% or more. There is also no current international agreement on which is the best equation to use.

In order to solve this important measurement issue, scientists at NPL have collaborated with PS Analytical (a UK-based company specialising in instrumentation for trace elemental analysis) to link mercury vapour measurements directly to standards of mass - thereby establishing traceability for these measurements to the SI system of units. These measurements are therefore no longer dependent on mercury vapour empirical equations and, crucially, measurements carried out by different laboratories at different times using different equipment, can be compared with confidence.

These outputs from the research are of great importance to the environmental chemistry community, particularly those engaged in air quality determination, and have many applications. For example, the traceability can be applied to the UK heavy metals monitoring network, which is operated on behalf of Defra by NPL (see *Environmental Measures* Issue 4 – Winter 2007) and requires the measurement of the ambient mercury vapour concentration at 15 monitoring sites across the UK. Other applications include the measurement of mercury vapour in indoor and workplace air – this is a particularly important issue as indoor levels of mercury are generally greater than those outdoors, and typical exposure times are longer.



Graph showing the relative difference between the four most commonly used empirical equations for the vapour pressure of mercury.

This research gives the UK an advantage in preparing for the introduction of new European ambient air legislation. For example, work is on-going to bring in a standardised automatic method for the analysis of mercury vapour in ambient air to replace the manual method in use in the heavy metals monitoring network.

The research has recently been published in *The Analyst* (2008, **133**, 946-953), the Royal Society of Chemistry's high-impact analytical science journal.

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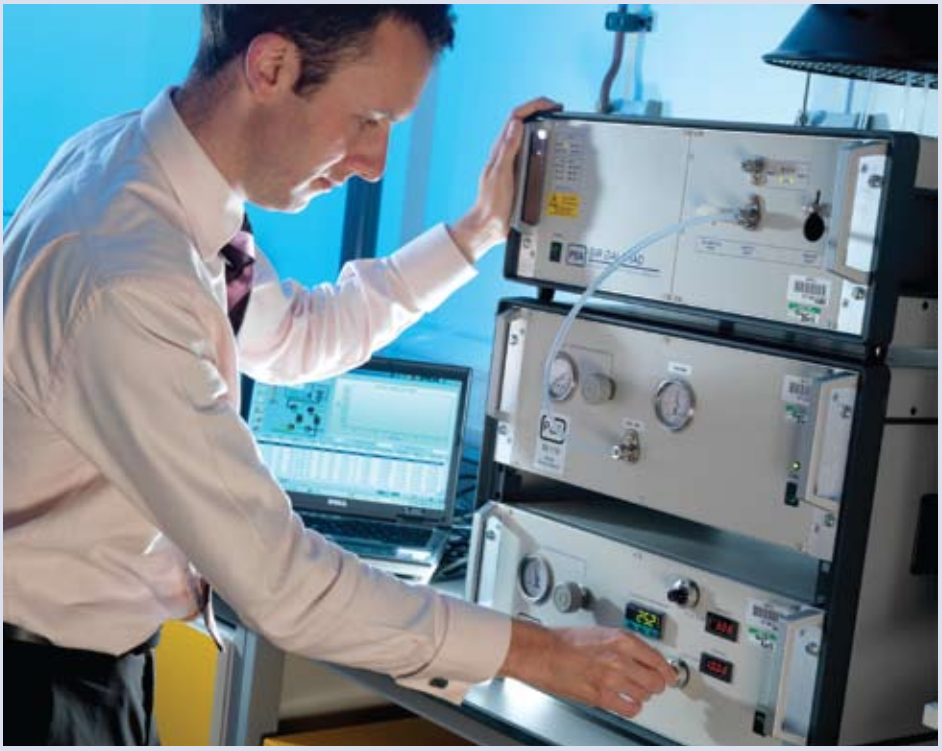


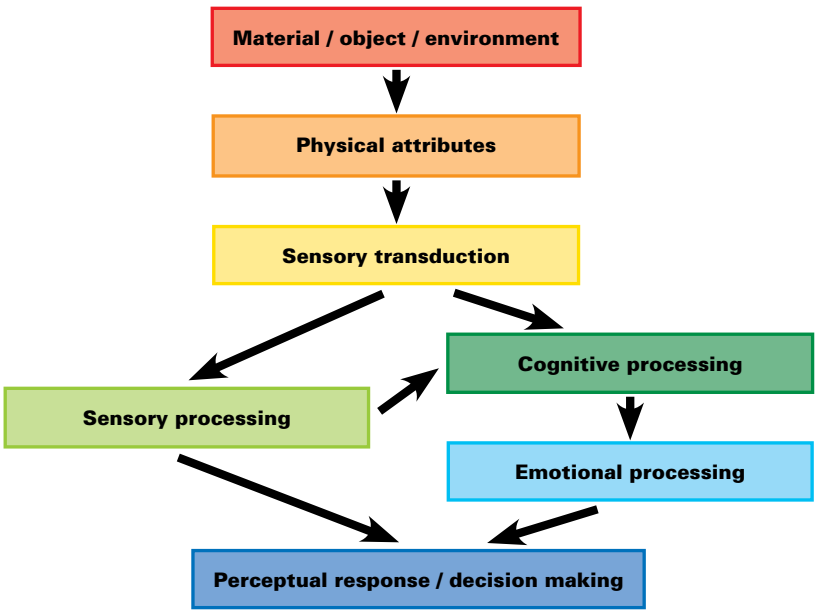
NPL's mercury vapour analysis facility.

Measuring naturalness

As the Earth's supply of natural materials dwindles there is a consumer need for synthetic products that are perceived as being natural. But what is it that tells our senses that a material is natural and how can "naturalness" be measured?

Natural materials are generally regarded as being highly desirable and can command high prices. For example, silk, cashmere, leather, angora, walnut and rosewood all have a long history of being associated with quality, craftsmanship and exclusivity - factors that have been exploited in markets as diverse as car manufacture, packaging, furniture and textiles. Many natural materials have an inner beauty that is hard to emulate in synthetic products, so although artificial materials are often cheaper, more durable and less scarce than their natural counterparts, they tend to be regarded by consumers as inferior to 'the real thing'. Additionally, 'natural' is often associated with health and well-being whereas 'synthetic' carries negative connotations. As consumer demand for natural materials grows, so does the pressure on the Earth's limited natural resources - already many hardwood forest habitats have been destroyed and trade in items such as ivory and fur has brought many animal species close to extinction.

Never has there been a greater need for improved materials that generate a perception of naturalness. So what are these elusive material properties and attributes, which determine whether people will perceive them as natural? After all, many of the plastics and synthetic fibres we meet in everyday life have remarkable properties too, but something is subtly different, some critical cues pertaining to naturalness are often lost – but which? And how do we make decisions based on these cues?



The perceptual process

An international team of researchers, led by measurement scientists at NPL, and including psychologists, neuroscientists and mathematicians, is now exploring these questions. We believe the answers lie in our ability to distinguish slight differences in the appearance and feel of different materials. Of the five senses we use to explore the properties of materials, sight and touch are the most important, not least because they sometimes give conflicting information: artificial silk can look realistic enough, but it just doesn't feel right.

The processes involved in deciding whether the look and feel of a material label it as 'natural' are complex and not well understood. The physical properties of a material or object, e.g. the roughness of the surface, its colour and texture can be assessed first by looking at it and then reinforced or changed by touching it. Interactions between the sensory transducers in our skin and eyes, and the material, generate sensory signals which pass along nerve fibres to the brain. The strength of these signals depends on factors such as the sensitivity of these transducers,

the physical properties of the material and the environmental conditions. Surface structure at the nano-scale, for example, will not be sensed by our fingertips but may affect the visual appearance of the surface. The interpretation of the nerve impulses in the brain, which depends on factors such as memory, expectation and emotional state, is just as important as the raw information transmitted by the nerve cells in our eyes and skin.

Thus although we have the feeling that we are in direct contact with our environment, and make decisions based solely on this information, this feeling is an illusion. Everything we perceive is determined indirectly, through transformation of physical stimuli into electrical signals and the transformation of these signals into conscious experience. By studying this sensory chain, from the properties of the material right through to what happens in the brain, we are unravelling some of the secrets of the perceptual process. Apart from its intrinsic scientific interest in increasing our understanding of how the brain processes sensory information, this will help scientists, engineers and designers create synthetic materials that closely mimic their natural counterparts, lead to an understanding of how to create more realistic virtual environments for gaming or design software, or find application in medical arenas such as engineering more realistic prostheses.

Exploring how our brains determine the degree of naturalness will be a highly demanding task, though we start with one advantage: 'naturalness' seems to be fairly objective. Concepts such as beauty or comfort are difficult to study because they are highly subjective, and depend on outside factors such as culture and preference. Our assessment of naturalness, in contrast, is more consistent and reproducible.

The project involves study of a range of specially selected materials that span the full range from completely natural to completely synthetic, each with several measurable properties that differ from one sample to the next. We are developing new techniques and instruments to measure colour, texture, reflectivity, compressibility, roughness and thermal diffusivity taking account of the particular characteristics of human vision and sense of touch.

As part of this work an 'artificial fingertip' is being created which can match the sensitivity of a real finger and be used to help to distinguish what properties of a material make it seem natural to the touch. Alongside this will run experimental work on human volunteers to find out how their nerves and brains react to the sight and touch of different types of material. Techniques used here include functional magnetic resonance imaging (fMRI), which shows which regions of the brain are involved in processing different types of stimuli, and psychophysical experiments designed to explore how people perceive naturalness. In essence, this is an innovative feasibility study to determine whether physical measurements of the visual and tactile material properties can be correlated with cognitive neuroscience investigations to predict observer perception. In our study the percept is 'naturalness' but it is anticipated that the underlying concepts, techniques and models that are being investigated and developed within the project will be equally applicable to a wide range of other perceptual phenomena such as 'cleanliness', 'ripeness', 'comfort' or 'quality'. We are now looking for ideas of what perceptual phenomena we should be tackling in the future.

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NPL supports UK industry in developing next-generation aircraft emission testing

NPL and Rolls-Royce recently teamed up using a DIUS Measurement for Innovators (MfI) secondment to carry out a feasibility study of next-generation aircraft particulate emission measurement techniques. An intensive period of laboratory measurements provided a valuable insight into the practical application of these techniques, helping ensure that the UK will play a key role in how they are used.

Concern over the impact of aviation on the environment, and global climate change in particular, features increasingly in scientific, economical and political agendas. The existing method for particulate emissions in this sector, the so-called Smoke Number, was developed several decades ago and is now becoming too insensitive for use with the latest engine models. The main targets of this secondment were to allow the evaluation of a surrogate particle source for instrument testing and calibration, and to compare Laser Induced Incandescence spectroscopy (LII) to other airborne nanoparticle measurements using NPL's airborne nanoparticle metrology laboratory. A team from the University of Reading, also took part in the study during a day of extended parallel measurements in support of ongoing collaborative work with Rolls-Royce.

The experiments yielded many interesting results, which have already been presented to the influential SAE-31 committee, helping steer ongoing efforts to redefine engine exhaust emission measurements.

The DIUS Measurement for Innovators programme, under which the secondment took place, is designed to promote innovation by linking industry with the world class expertise and facilities contained within the UK's National Measurement Institutes. An article on the scheme appeared in *Environmental Measures* Issue 3 - Summer 2007 (http://www.npl.co.uk/newsletters/).

To find out more about NPL's airborne nanoparticle metrology laboratory, please contact Richard Gilham 020 8943 6405 richard.gilham@npl.co.uk

To find out more about the Measurement for Innovators scheme and how your organisation could benefit from it, please email mfienquiries@npl.co.uk

NPL's first calibration service for airborne nanoparticle number concentration

Concern about the impact of nanotechnology on the environment and our health has emphasised the need to monitor our exposure to nanoparticles. In response to this, NPL has recently developed a calibration service for instruments that measure airborne nanoparticle number concentration, such as Condensation Particle Counters.

Measurement of particle number concentration is used in many applications, including ambient air monitoring and vehicle emissions assessments. These instruments have been increasingly used over the last 20 years to give a measure of the ultrafine fraction of particulate matter (typically below 100 nm in diameter). Their historical traceability to internationally recognised standards has been relatively weak, but the need to ensure worldwide comparability has recently become much apparent.

The drivers for this change are partly due to traditional mass-based techniques for particle measurements not being able to achieve the required sensitivity, as the amount of particulate matter from the latest generation of engines drops, and also the desire to understand the sources and behaviour of particulate matter in ambient air over the widest possible size range. NPL's calibration service is designed to help both these and other industry sectors. NPL is the first laboratory in the UK, and to the best of our knowledge the whole world, to have developed a procedure that has been ISO 17025 (UKAS) assessed for this service.

For more information on calibration of these or related instruments, please contact Richard Gilham 020 8943 6405 richard.gilham@npl.co.uk

NPL Environmental Measurements Group presenting at PHOTONEX

NPL's Environmental Measurements Group will be giving a presentation on the use of Differential Absorption LIDAR (DIAL) for industrial emissions monitoring at this year's PHOTONEX (www.photonex.com) exhibition being held on 15 October at Stoneleigh Exhibition Halls, Coventry. The presentation will be included in a seminar titled 'Solving Sensing Problems with Photonics' being organised by the Sensors & Instrumentation Knowledge Transfer Network (www.sensorsktn.com). Other presentations in the environmental gas sensing session will describe a combined NO, CO and visibility monitor for road tunnels and a novel approach to multi-gas/parameter sensing using multi-mode diode/microcavity-solid-state lasers. The seminar also includes presentations on the use of photonics techniques for solving sensing problems in the areas of industrial and medical diagnostic sensing.

NPL sponsors SciTech Challenges

The SciTech Challenges uses London 2012 as a catalyst to encourage innovation and collaboration between business and academia.

Designed by White Loop Ltd and funded by the London Development Agency, the SciTech Challenges is aimed at London-based businesses and is supported by six "sector champions": NPL, BBC, Institution of Civil Engineers, UK Sport, Sustain and the London Sustainability Exchange (LSx), the last championing projects relating to environmental legacy to make London 2012 recognised as the sustainable games. LSx is focussing on two challenges: to design systems and processes that support energy efficiency at public events, and to develop systems and approaches that support energy efficiency in the retail sector. Businesses respond with their ideas and are linked to relevant academics with the technical knowledge to help take the ideas forward. Interactive events and exhibitions in Spring 2009 will showcase the outcomes of these collaborations, providing a unique platform to profile university and college research expertise. NPL is championing the "Research and Monitoring Devices" challenges, namely:

- To develop systems to remove subjectivity from the judging of Olympic sports (e.g. both feet on the floor for competitive walking, hits in boxing or martial arts, offside or goal scoring in football).
- To investigate the development of systems to enhance spectator experience of sporting events.

For more details on how to get involved, please contact Will Leonard of White Loop Ltd, will@whiteloop.com, or visit http://www.scitechchallenges.com.

NPL wins £1 Million from Public Sector Research Exploration Fund

NPL has won almost £1 Million of funding from the Public Sector Research Exploration Fund, a non-NMS DIUS fund. The funding will enable NPL to further develop aspects of its technical capability to deliver four new services into the environmental sector:

- Monitoring and consultancy services for climate change gases
- Underwater acoustic services for marine species protection
- Airborne and contaminated surfaces bio-species monitoring
- Nanoparticle toxicology analysis services

The work will be delivered over three years by the Analytical Science (AS) and Acoustics and Ionising Radiation (AIR) teams.

The bid was led by Melanie Williams, group leader of the Environmental Measurements team supported by members of the AS, AIR and Business Development teams.

For further details please contact Melanie Williams 020 8943 6121 melanie.williams@npl.co.uk

If you would like further information on any aspect of
Environmental Measures, *please contact:*
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Forthcoming events

www.npl.co.uk/events

Neutron Users Club Meeting
14 October 2008
NPL, Teddington
http://www.npl.co.uk/server.php?show=ConWebDoc.325

Underwater Noise Measurement, Impact & Mitigation
Institute of Acoustics Conference
14 – 15 October 2008
Novotel, Southampton
http://www.ioa.org.uk/

Solving Sensing Problems with Photonics
at the PHOTONEX Exhibition
15 – 16 October 2008
Stoneleigh Exhibition Halls
Coventry
http://www.photonex.org/08/sensorsktn.php

25th Intelligent Sensing Programme
22 October 2008
IET, Savoy Place, London WC2
louise.dean@npl.co.uk
http://www.npl.co.uk/server.php?show=ConWebDoc.2862

30th ANAMET Meeting
RF and Microwave Metrology Club
24 October 2008
NPL, Teddington
Contact: gill.roe@npl.co.uk

Nano-Molecular Analyis for Emerging Technologies III (NMAET III) &
Surface Science of Biologically Important Interfaces 10 (SSBII 10)
5 – 6 November 2008
NPL, Teddington
http://conferences.npl.co.uk/nmaet/

Millimetre-Wave Users Group Meeting
11 November 2008
Rutherford Appleton Laboratory
Contact: gill.roe@npl.co.uk

Developing Advanced Scientific Engineering Spreadsheet Applications
A two day training course
12 – 13 November 2008
NPL, Teddington
http://www.npl.co.uk/server.php?show=ConWebDoc.2032

Airborne Radioactivity Monitoring Users' Group (ARMUG) Meeting
13 November 2008
http://www.npl.co.uk/server.php?show=ConWebDoc.1598

MTDATA Introductory Course
Software for Phase Equilibria and Thermodynamic Properties
24 – 25 November 2008
NPL, Teddington
Contact: john.gisby@npl.co.uk

Energy Harvesting Technologies - Enabling Remote and Wireless Sensing
26 November 2008
IET, Savoy Place, London WC2
louise.dean@npl.co.uk
http://www.npl.co.uk/server.php?show=ConWebDoc.2863

Ionising Radiation Metrology Forum Meeting
26 November 2008
NPL, Teddington
http://www.npl.co.uk/server.php?show=ConWebDoc.1599

MTDATA Users Group Meeting
26 November 2008
NPL, Teddington
Contact: jim.robinson@npl.co.uk

Time and Frequency Club Meeting
3 December 2008
IET, Savoy Place, London WC2
Contact: gill.roe@npl.co.uk
http://www.npl.co.uk/server.php?show=ConWebDoc.2812

Wheatstone Lecture – Time by Wire: 175 Years of the Greenwich Time Service
3 December 2008
IET, Savoy Place, London WC2
http://www.theiet.org/events/2008/wheatstone.cfm

Electromagnetic Materials Measurement Interest Group Meeting
9 December 2008
NPL, Teddington
Contact: kevin.lees@npl.co.uk

Monitoring Ambient Air 2008
Metals and Speciation in Ambient Air Quality
16 – 17 December 2008
SCI, London
http://www.npl.co.uk/server.php?show=nav.1076

14th International Congress of Metrology
22 – 25 June 2009
Paris, France
http://www.metrologie2009.com/index_en.php

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