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National Physical Laboratory

Council on Ionizing Radiation Measurements and Standards

The Impact of New Technologies on Radiation Measurements and Standards, October 24-26th

NIST, USA

What is CIRMS?

- CIRMS is an open-membership non-profit society for scientific and educational purposes
- It aims to advance and disseminate metrology for ionising radiation
- Held annually at NIST, it is attended by staff from federal organisations, nuclear industry, instrument companies, international organisations, universities…

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Main trends identified

- Uncertainty of measurements is becoming more important
- New instrumentation is moving lab-based measurements out into field use
- The support needed for ‘first responders’ is also driving measurement technology
- ‘Personalised medicine’ and ‘clinical decision support’ are the major themes in pharmaceutical development

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Useful references

- MARSSIM = Multi-Agency Radiation Survey and Site Investigation Manual
- http://www.epa.gov/radiation/marssim/obtain.htm

- MARLAP = Multi-Agency Radiological Laboratory Analytical Protocols
- http://www.epa.gov/radiation/marlap/manual.htm

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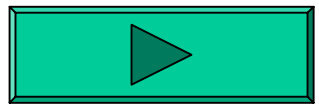
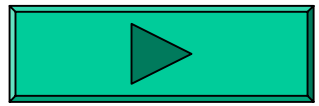
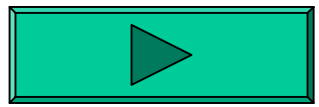
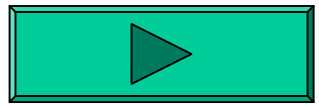
Topics covered

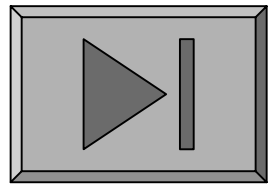
- Homeland security
- Surface contamination monitoring
- Medical applications
- Neutron Measurements











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Effect of a ‘dirty bomb’

- 1987 Goiania release in Brazil – 4 people died, 28 suffered radiation burns, 249 were contaminated, 112,800 people monitored
- A 100,000 Ci source would give measureable dose effects up to 300 m, inhalation dose up to a few km, 10x annual limit up to 1.5 km
- Work following an incident will need dose assessment, biodosimetry, medical treatment and long term health monitoring
- See www.bt.cdc.gov

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Bio-dosimetry

- The aim is to develop validated, automated, techniques for biodosimetry to enable correct treatment
- Techniques being studied include erythema, dosimetry, haematology, immunodiagnostics, molecular biodosimetry
- Developing transportable laboratories – bio-sensor based devices
- Detection limit could be around 100 mGy

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Trafficking in radioactive materials

- The IEC has established a new Working Group on instrumentation WG15B (under pressure from the IAEA)
- The UK representative is Ian Thompson
- IEC62244Id.1 will be published shortly (portal monitors)
- IEC62327 in preparation (hand-held instruments)
- IEC62401 in preparation (personal dosimeters)
- Some differences with ANSI standards on the radionuclides used for testing

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Nuclear Forensics

- The aim of ‘nuclear forensics’ is to identify and quantify radionuclides from human activity
- Eg, Cs-134/Cs-137 ratio can date a release
- Standard methods used in the US are given in MARSSIM and MARLAP (cover methods, performance, reporting)
- Mass spectrometers are being used ‘in the field’

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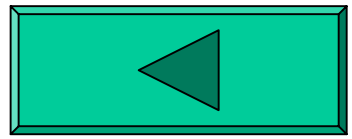
Monte Carlo Modelling

- Plastic detectors are useful for portal monitors but resolution is poor – Monte Carlo simulation with Gaussian broadening is looking promising

- Work in progress so that standard CAD files can be used as input to Monte Carlo modelling codes – being used to develop anatomically correct phantoms



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Issues with surface contamination / air filters

- The US priorities for measurement are U-238, U-235, Pu-239, Am-241, Sr-90, P-32
- NIST has investigated ‘p-factors’ – see NISTIR 6464 (2000) Berger M J ‘Counting yields for beta and alpha particle sources’
- NIST uses Monte Carlo simulations so they can report activity per unit area on sources in addition to emission
- Also uses a phosphor imager to test uniformity
- A cheap ($5000) gas flow large area counter is being developed

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Uniformity of surface contamination reference sources

- ISO8769 is ambiguous on the specification for the uniformity of reference sources
- Different manufacturers interpret the 10% figure as 1-sigma or 3-sigma.
- [ISO8769 seems to assume that the source is roughly the same area as the detector window – not the case in the USA or the UK]

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New ISO7503

- ISO7503 is being re-written
- Detailed presentation at IRMF
- Part 1: will cover direct measurement of surface contamination
- Part 2: will cover indirect measurement techniques
- Part 1 includes a technique using reference sources to estimate the approximate energy response of an instrument, and then sets out a procedure to apply this to assay radionuclides in surfaces
- UK representative is Tony Richards

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Minimum detectable activity for surface contamination monitoring

- The minimum detectable activity is dependent on the scanning technique used – what increase in count rate over background causes someone to pause and re-measure?

- (Study carried out at Pacific Northwest Laboratory – unpublished)

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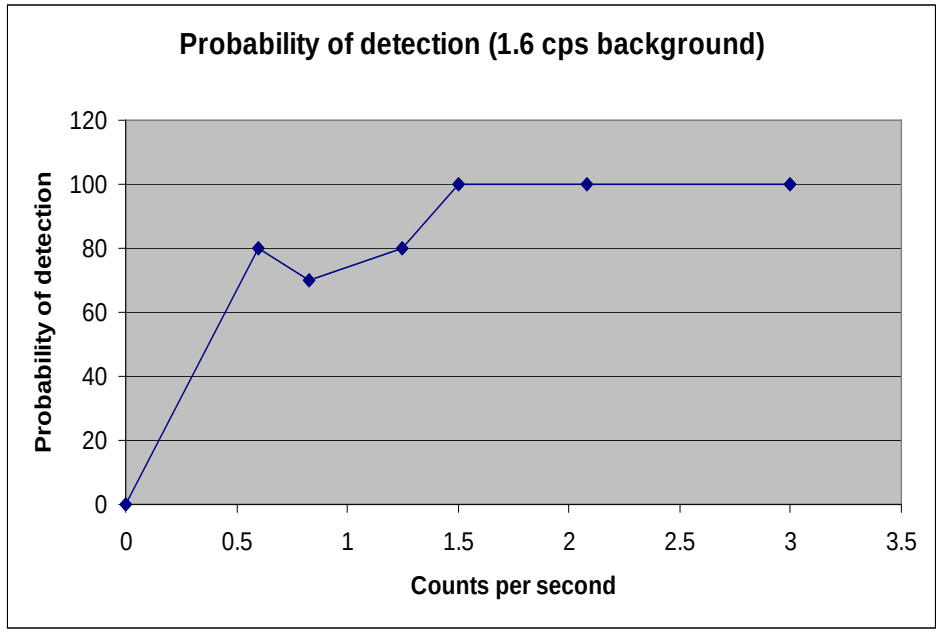
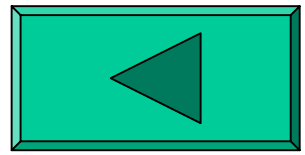
Experimental measurement of count rate

- Sources were placed on a motor-driven translation table
- The instrument under test was positioned above the table
- Technicians sat so that they could not see the source/instrument, and asked to indicate when they heard an increase in count rate



Findings

- To detect 0.2 Bq/cm^2 from ^{90}Sr, use a 100 cm^2 proportional counter and survey at 5 cm/s
- To detect 0.8 Bq/cm^2 from mixed fission products, use a pancake GM and survey at 5 cm/s
- To detect 0.08 Bq/cm^2 from alpha emitters, use an alpha probe and survey at 2.5 cm/s
- (The above limits are set in US regulations)



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Nuclear Medicine

- Many new ‘carriers are being developed
- Radiopharmacueticals have the advantage that very low masses are injected – biological processes are not disrupted. Very useful for drug screening and for selecting patients for treatment.
- Increasing use in pre-clinical studies – phosphor imaging is being used to quantify activity in slices of organs
- Small animal PET is reducing the need to sacrifice animals

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Nuclear Medicine

- The number of drugs being submitted to the FDA for approval is declining
- The FDA is changing its rules to simplify the submissions process
- PET is being used to estimate drug response but there is no agreed method to calculate the ‘standard uptake value’ & software tools are being written by academia and don’t meet regulatory requirements (cGMP)

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Radioimmunotherapy

- Studies being carried out on new radioimmunotherapy products (the work covers determining doses, dose rates, radiosensitivity…)
- Bi-213 being studied
- Bone marrow is the critical organ
- The MIRD model was developed for radioprotection – not ideal for radioimmunotherapy, work is going on to develop Monte Carlo models including simulating gamma camera responses

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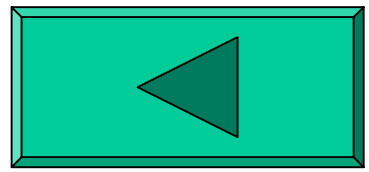
Other developments in medical physics

- Brachytherapy with Y-90 microspheres
- Implantable MOSFET dosimeters
- Tomotherapy – CT and LinAc combined to deliver the radiation dose to the tumour
- Electronic brachytherapy – mini X-ray tubes to replace radioactive sources



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New passive neutron dosimeter

- Disadvantages of current passive neutron dosimeters are track detectors need manual processing, bubble detectors are P&T sensitive, OSL is gamma sensitive, TLD is good only for thermal neutrons
- New approach – new crystal + radiophotoluminescence + fluorescence microscopy + 3-D image processing
- New material is Al2O3:C, Mg
- Crystals available up to 5cm diameter

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Neutron based inspection

- Neutrons are good for identifying explosives (high N, O content, low C, H content)
- A neutron generator has been developed so a pulse technique can be used
- Pulse lasts 1 ns so time of flight can be used to estimate distance
- Can distinguish a small amount of explosive in the presence of large amounts of other material
- One-sided system – the source and detector are on the same side of the vehicle being inspected

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- Copies of the presentations and more details will be available on:

www.cirms.org