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Radiation Measurements

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- Radionuclides in airborne dust
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Why monitor?

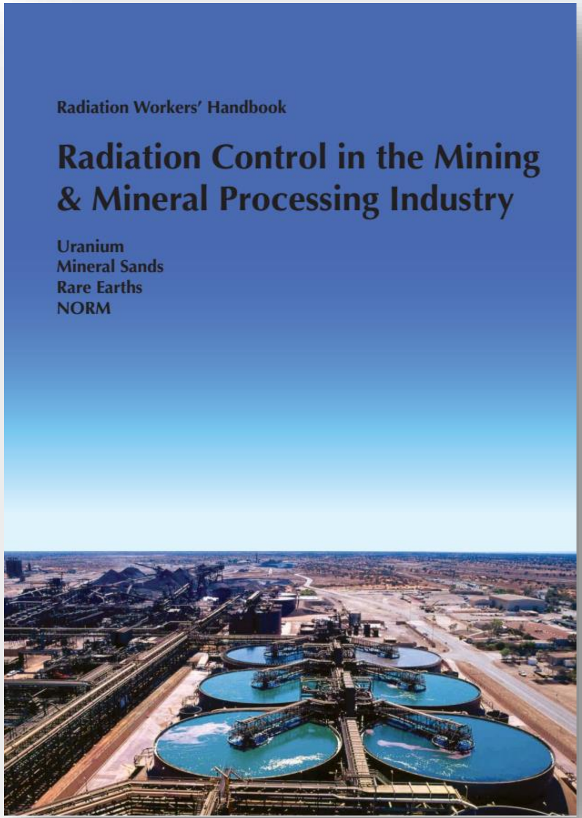
- To identify existing levels
- To confirm that the radiation controls are in place and effective
- To identify elevated levels of radiation that require control
- To confirm other measurements that may be occurring (eg; regulatory check)
- For investigative purposes
- For licence conditions
- For dose assessment and epidemiology

When to monitor?

- As part of baseline characterisation
- As part of routine or regular monitoring program
- Randomly
- When problems arise
- As required by regulatory agency or when requested by workforce

Occupational Monitoring

- Monitor the exposure pathways
- Workers
  - Gamma radiation exposure
  - Inhalation of radionuclides in dust
  - Inhalation of decay products of radon and thoron
  - Ingestion of radionuclides



General types of monitoring

- **<u>Personal</u>**
  - Workers wear the monitor
  - Portable and practicable
  - May not be able to sample everyone

- **<u>Workplace</u>**
  - Surveys in area
  - Where personal monitoring in not practical
  - Fixed locations (identifying trends)
  - May be used for sampling a workgroup or activity

Gamma radiation

- NORM material emit gamma radiation and require monitoring
- Documented survey strategies are required
- Portable instruments can be used for routine workplace monitoring for external gamma radiation exposure
- Personal monitoring is carried out with active dosimeters (e.g. during maintenance activities) or passive dosimeters

Gamma radiation

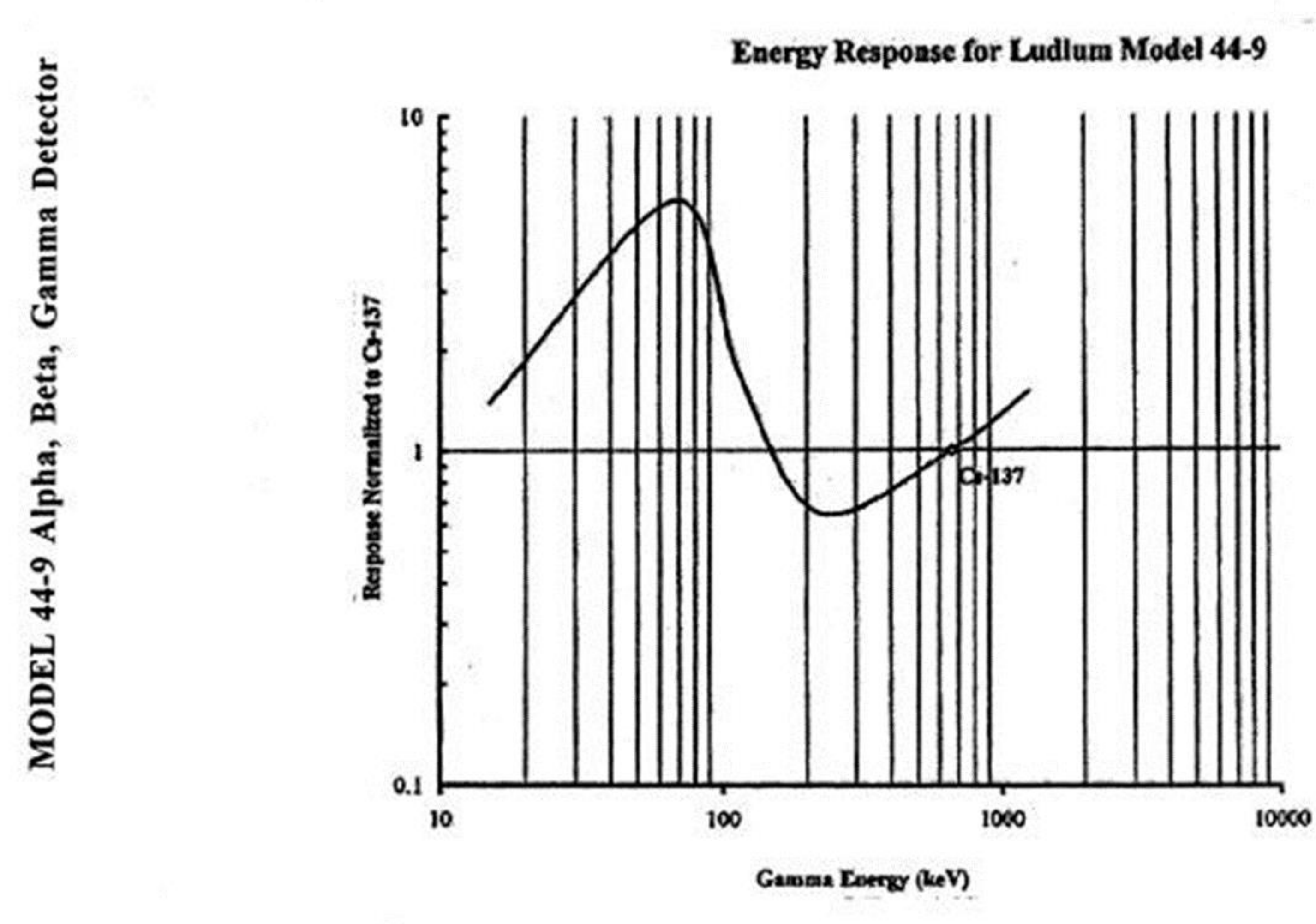
- Portable dose rate instruments:
  - Used for workplace and environmental monitoring
  - Dose rate can be displayed directly in µSv/h
  - Instruments with sensitive probes are capable of measuring down to background levels (0.05–0.1 µSv/h)

Gamma dose rate meters

- The detector characteristics must be chosen such that the energy response matches the energy of the radionuclides to be measured
- The detector must have a suitable response time to match the rate at which the dose rate varies
- The detector must be calibrated for the gamma ray energies of interest
- The detector must be sufficiently rugged for the environment in which it is to be used.
- Some instruments can identify the radionuclides present

Example of Instruments Energy Response

(From manufacturers documentation)



Gamma dose rate meters

- The instrument should be suitable for the application.
- An incorrect choice can lead to inaccurate or even erroneous assessments of the external hazard.

- Many different types
  - Gas filled detectors
  - Ionisation chambers
  - Proportional counters
  - Geiger-Müller counters
  - Scintillation counters
  - Solid state detectors

Gamma dose rate meters

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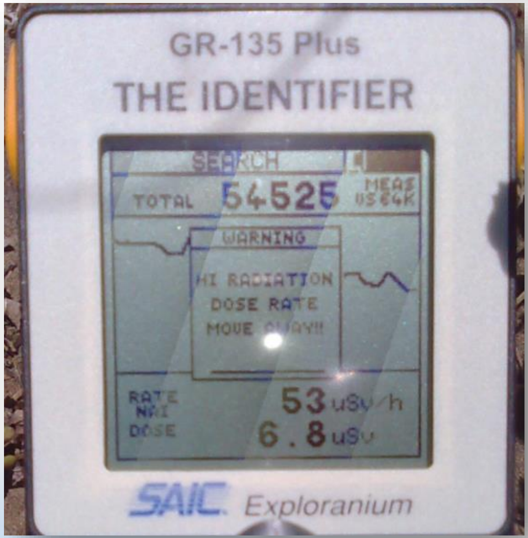
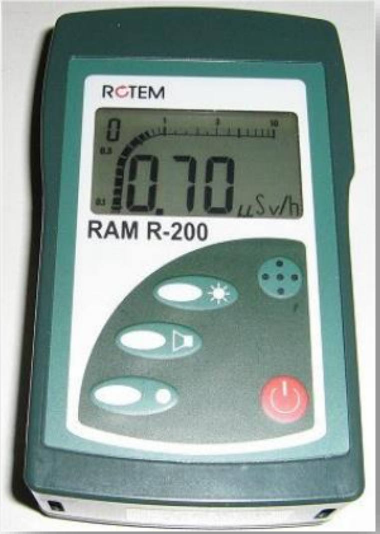
Survey monitors may have different scales:

- micro-Roentgens per hour (µR/hr)
  - amount of ionisation in air
- micro-Gray per hour (µGy/h)
  - absorbed dose in air
- micro-Sievert per hour (µSv/hr)
  - equivalent dose
- counts per second/minute





Gamma dose rate meters – Personal Monitoring

- Used for direct measurement of a workers exposure
- Integrates the dose rate over any period (for example, from 1 day up to 3 months)
- Can be attached to the clothing of the exposed worker
- Common types of dosimeter for exposure to NORM:
  - Thermo-luminescent dosimeters (TLDs)
  - Optically stimulated luminescent dosimeters (OSLDs)
- Direct reading dosimeters for higher dose rates:
  - Electronic dosimeters

Gamma dose rate meters – Personal Monitoring

Radionuclides in airborne dust

- Airborne contamination can occur wherever dry materials are handled or processed
- Dust sampling involves taking a sample of air through a filter medium
- The sample is then analyzed for radionuclides
- Sampling needs to consider:

- The occupancy time in the workplace
- The mass concentration of dusts
- The radionuclide activity concentration
- The size distribution and inhalation potential (sampler characteristics)

Types of Dust Sampling

Workplace Sampling:

- Locations where workers are working
- The frequency of sampling will depend on the level of dust concentration and its variability
- May have fixed location sampling (for identifying trends)

Personal sampling:

- Allocation of sampler to a representative worker
- Consider number of workers involved in a task
- Consider tasks that contribute to exposure – dust generation during work, job rotation, work shifts, special exposures
- Individual work practices
- Location and time in the workplace.

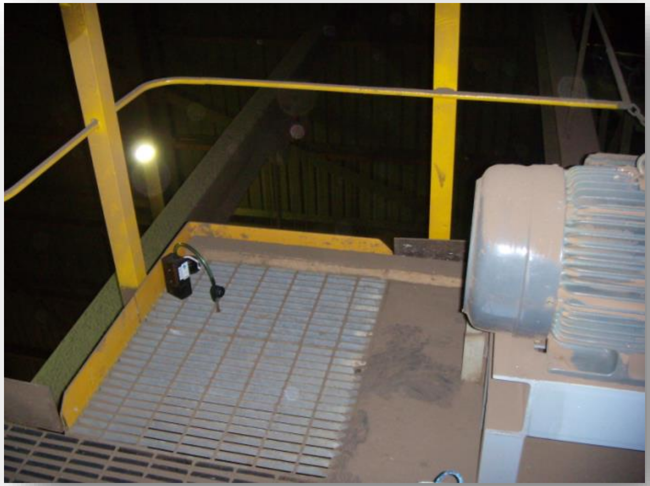
Sampling in practice – Locational sampling

<u>Good Location</u>

- Out of the way
- Good height (breathing zone height)
- Safe

<u>Poor Location</u>

- In the way
- Poor height
- Unsafe – workplace hazard



Types of sampling equipment

Static air samplers:

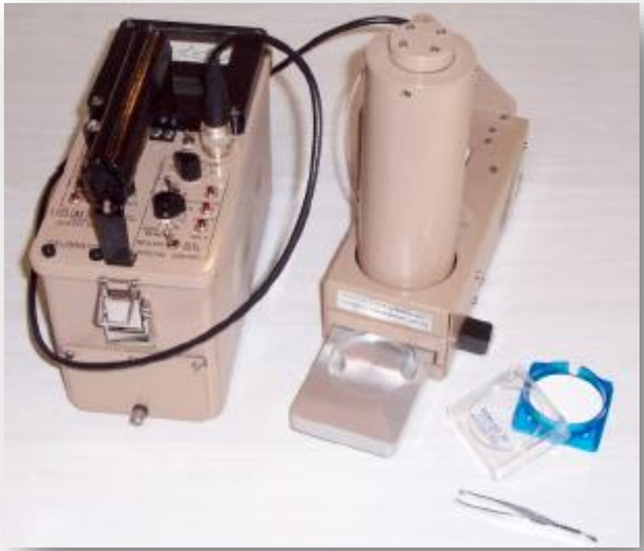
- Place at fixed locations
- Can be high volume or low volumes sampler
- Indicator of workplace conditions

Personal air sampling:

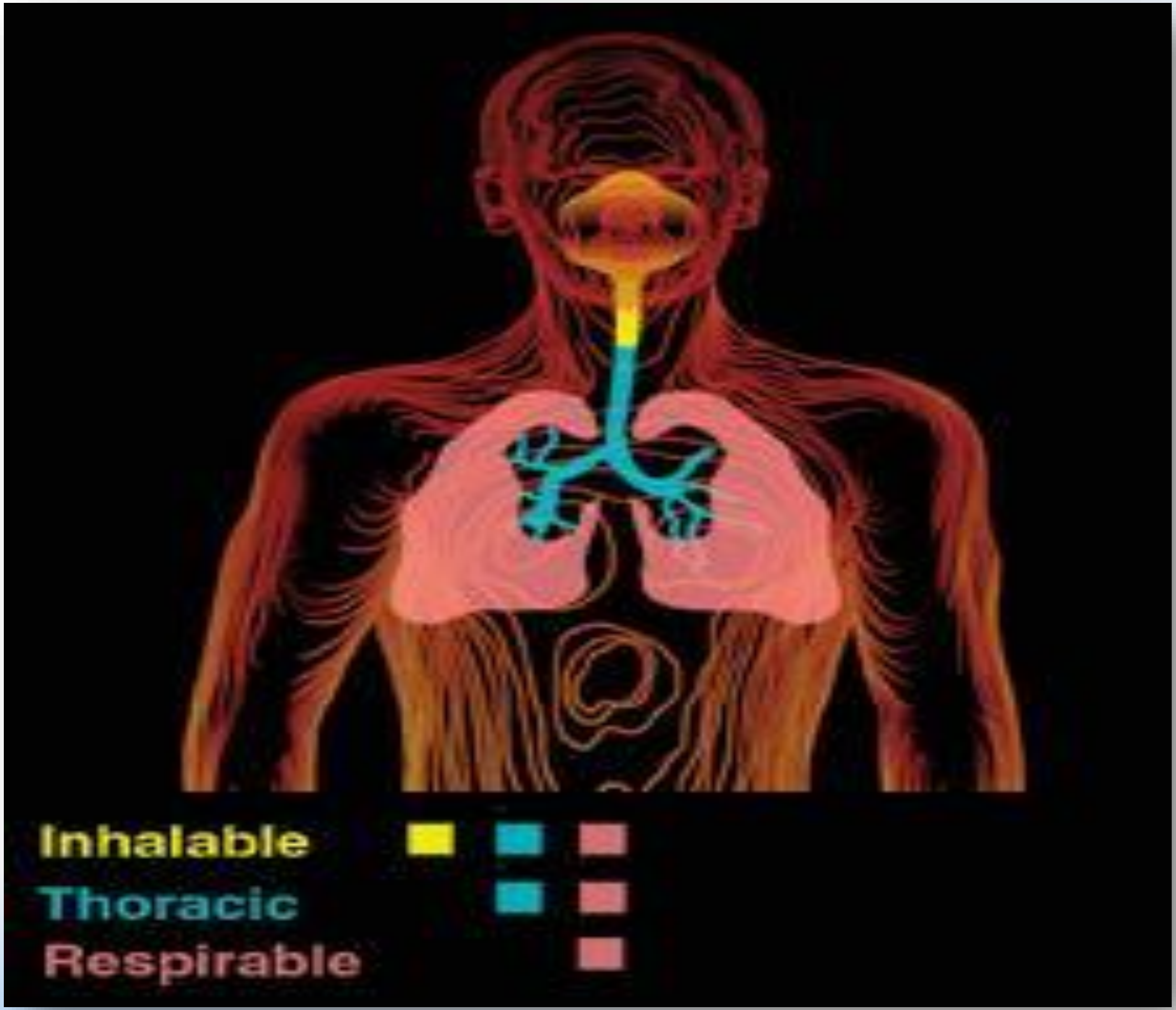
- Provides measure of worker exposure
- Should be small and practical

Types of sampling equipment

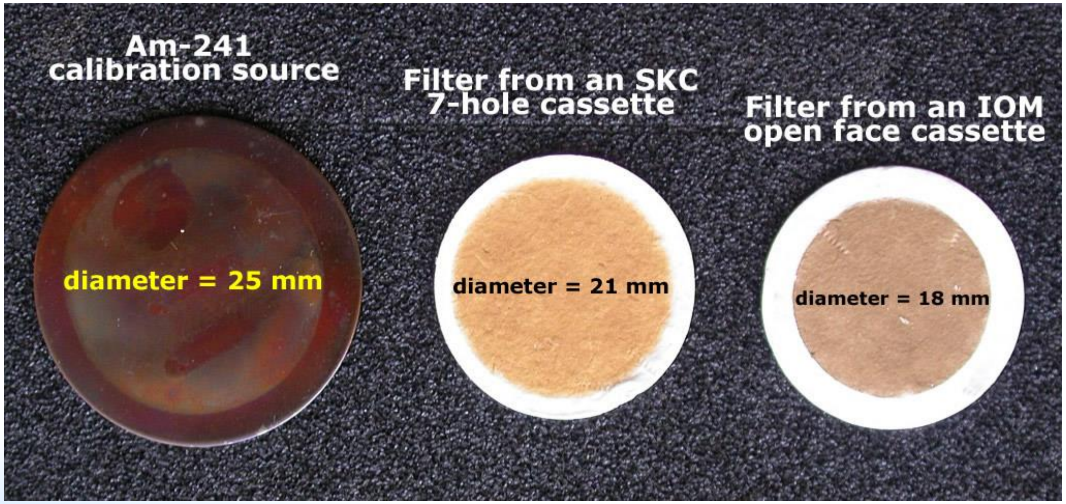
Equipment for analysis of dust samples



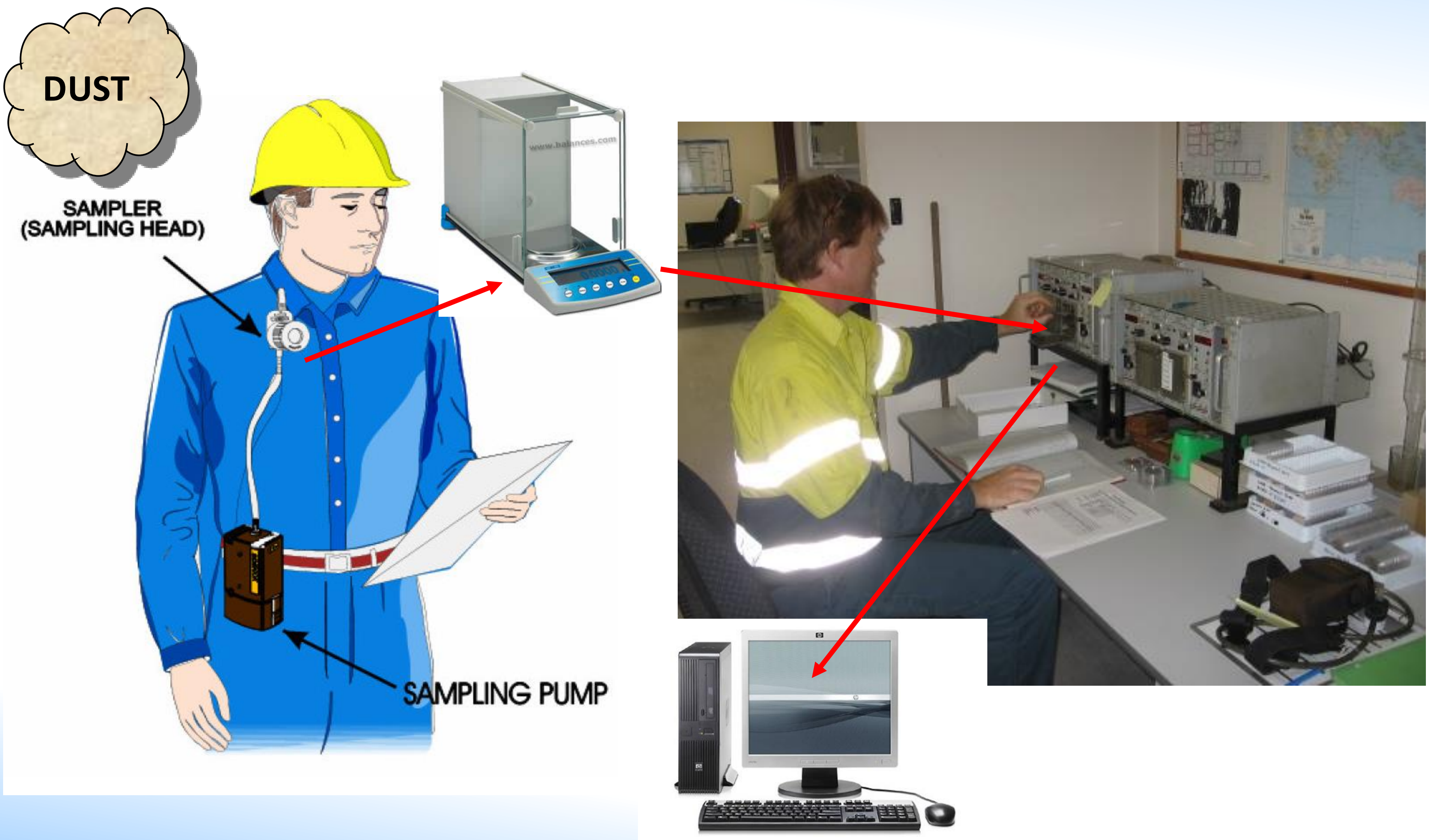
Sampling the right dust



Filter holders (sampling cassettes)



Radionuclides in airborne dust



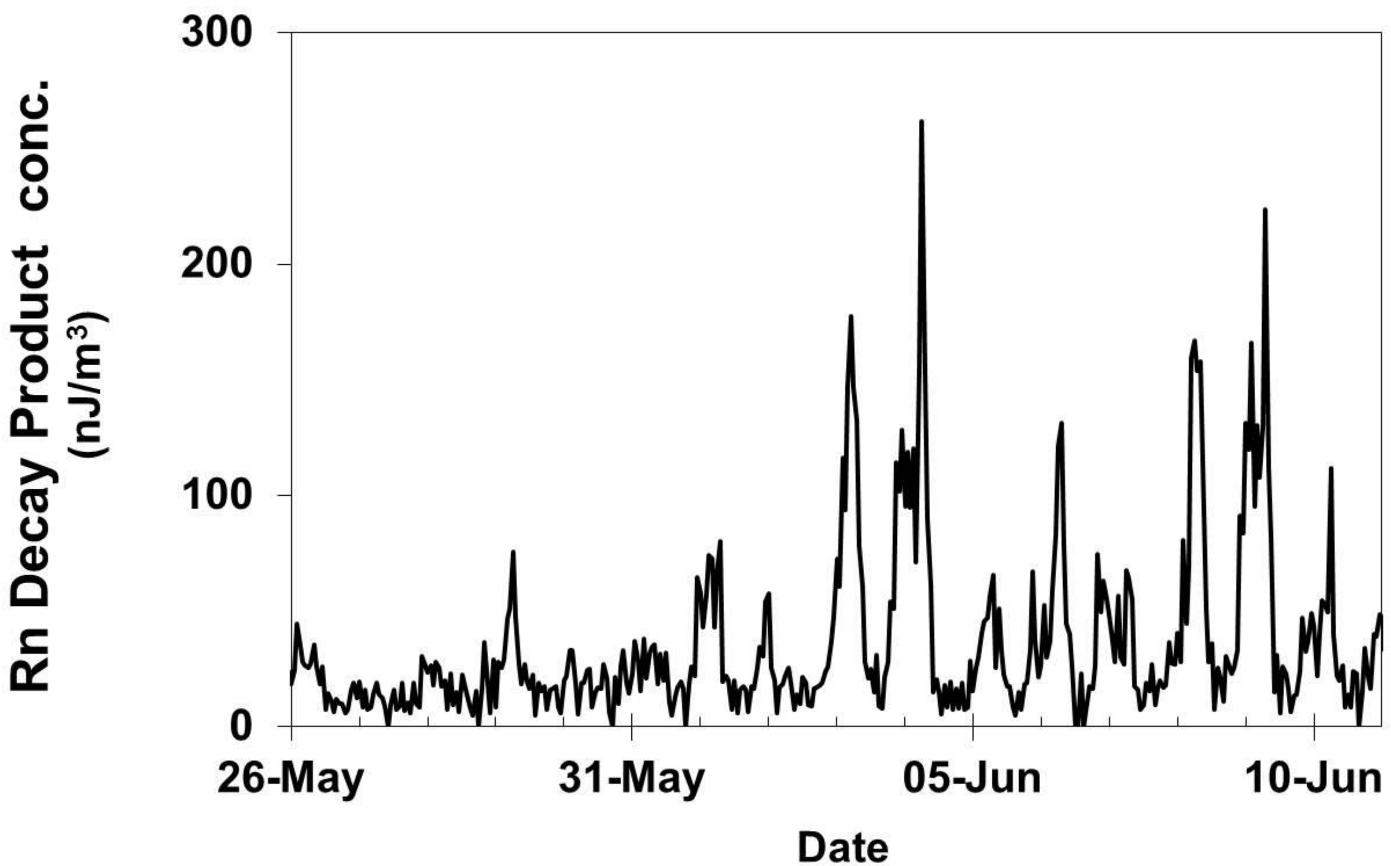
Exercise: Where would you monitor dust?

Sampling equipment

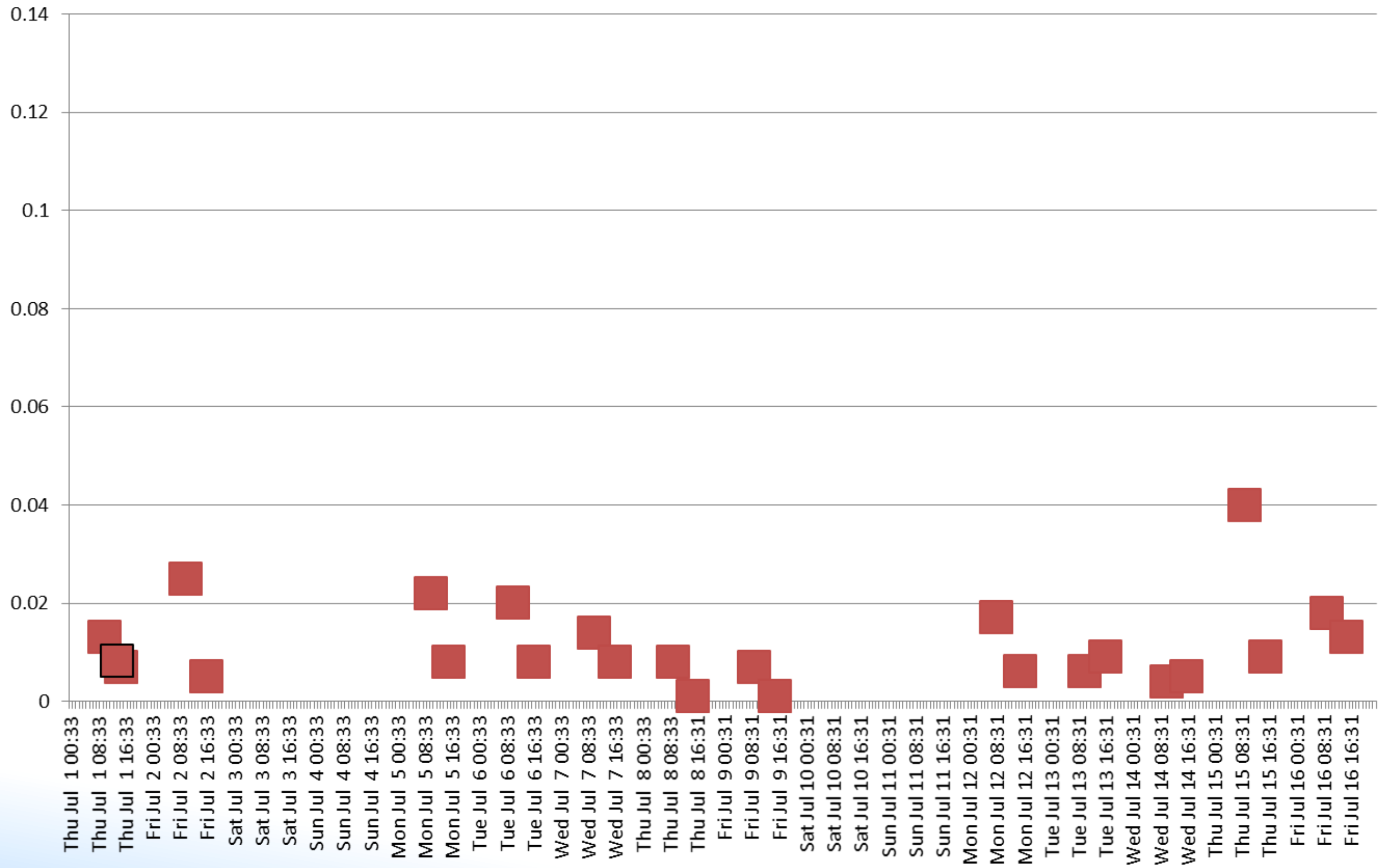
Radon and Thoron

- Radon is a gas – and it is chemically inert
  - If it is inhaled it does not accumulate in the lung
  - Resulting dose is quite small
  - Exposure occurs from the **decay products** present in the air
- Radon and thoron and transport mechanisms for the decay products
- Consider other factors such as;
  - Equilibrium factor
  - Unattached fraction
  - Particle size
- (Note that there is a more detailed lecture later)

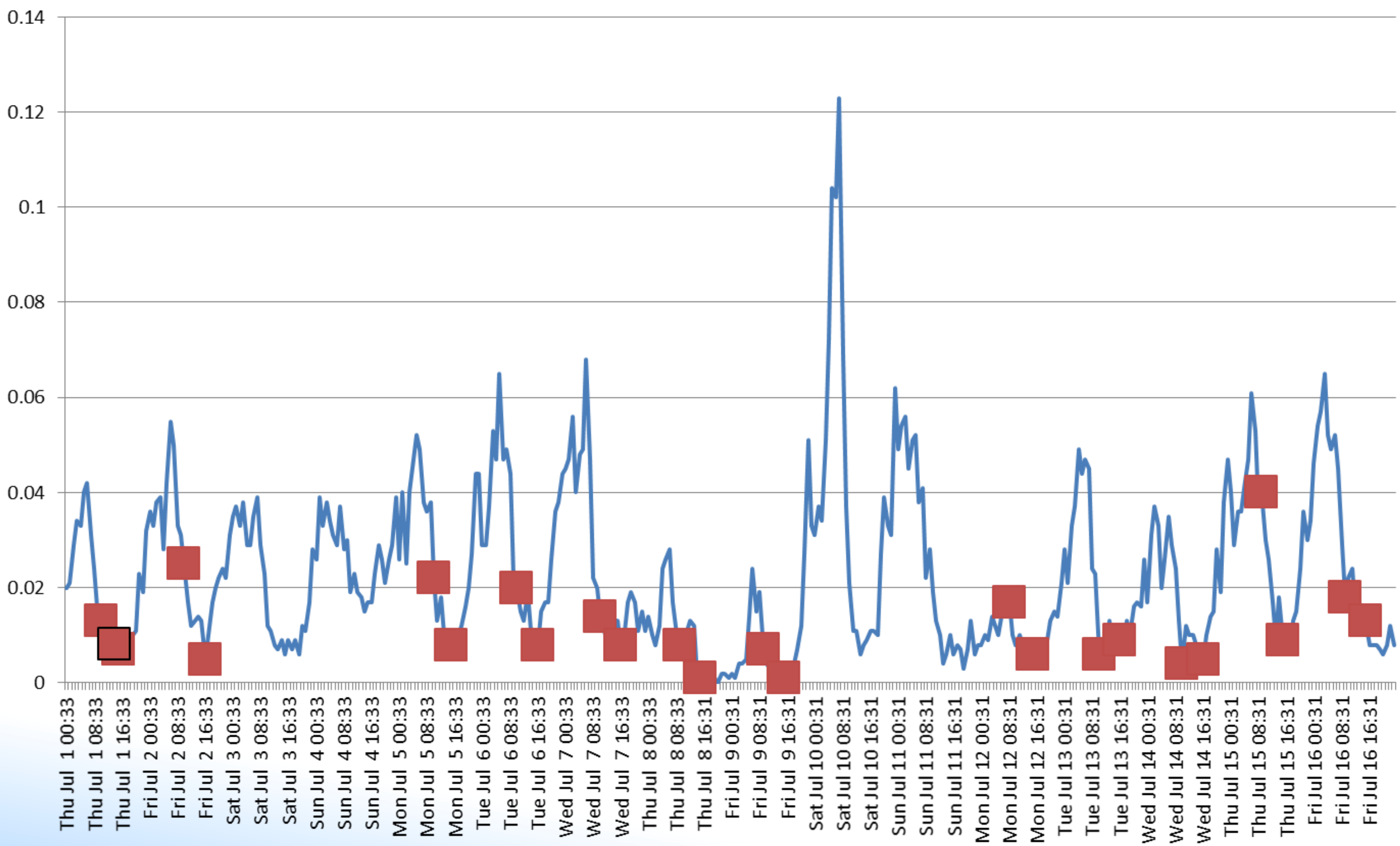
Workplace radon progeny concentrations are variable



Concentrations by Time (uJ/m3)



Concentrations by Time (uJ/m3)



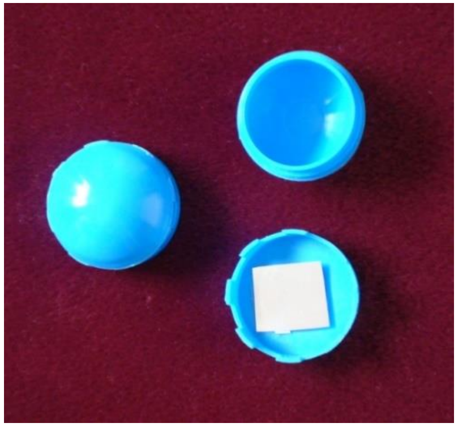
Radon and Thoron Monitoring

- **Passive monitoring**
  - Track etch
  - Inexpensive and easy to use
  - Can be used for personal, locational or environmental
  - Gives an average for the exposure period
- **Active monitoring**
  - Air sampling ("radon sniffers")
  - Sensitive equipment usually
  - Needs to be calibrated (radon chamber)
  - Can give either exposure averages or real time readings

Decay Progeny Monitoring

- **Grab sampling**
  - Various techniques
    - Take air sample and alpha count
    - Rolle, Borak, Kusnetz, environmental Rolle
- **Active monitoring**
  - Monitors that measure in real time
  - Can be expensive, require calibration
  - Able to differentiate between decay products
  - Advantage is that monitoring identifies concentration variations

Equipment

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LUDLUM
COUNT


bladewerx
SabreAlert

Measurement of radon

Radon monitoring in an underground mine using a portable continuous radon monitor with pulse-counting ionization chamber detector

Surface contamination

- Identify areas of removeable and non removeable contamination
- Monitor the actual surface contamination or take a wipe test for later analysis
- Wipe tests can be analysed for different radionuclides
- Also used to ensure that plant and equipment is free from contamination

Measurement of surface contamination

- Alpha monitors may unsuitable for NORM contaminated items, especially when the surface is rough and/or non-flat:
  - Limited penetrating ability of alpha particles
  - Probe must be held within 5 mm of the contaminant layer
  - Self-absorption within the contaminant layer
  - The surface of the alpha probe is easily damaged
- Beta monitors are generally more suitable for NORM, but self-absorption must still be taken into account
- Most beta detectors are sensitive to gamma radiation — care is needed to ensure that ambient gamma is not misinterpreted as contamination
- The radiological characteristics of the NORM contaminating layer may have to be established in advance

Measurement of surface contamination

Two examples of a surface contamination monitor

Measurement of surface contamination

Contamination monitor with beta probe and alpha–beta dual probe

Instrument calibration and maintenance

- For all measurement methods, instruments must be calibrated regularly and traceable to recognized national standards:
- Equipment should be maintained in good working order
- Not only radiation instruments – also applies to pumps, mass balances.

Practical guide for radiation measurement

- Identify what measurements are to be taken
- Identify what instrument to use
- Pre-use check of any instruments.
- Ensure calibration
- Are there any special considerations – such as access permits ?
- Make sure you are aware of any hazards or risks
- Check that personal protective equipment (PPE) is required
- Stow instruments and equipment securely and safely.

Practical guide for radiation measurement

- Make sure you know how to use the instrument
- Check that it is calibrated
- Conduct regular instrument checks and minor maintenance (e.g. battery changes) as required.
- Look and then take measurements at correct locations and times.
- Have some idea of what you are measuring
- Take a couple of measurements to ensure reliable data.
- If the results don't seem right, stop and work out why.
- Record data with the required precision, accuracy and units.
- Make notes of site conditions that might affect the data

Practical guide for radiation measurement

- Record results in accordance with procedures
- Check that recorded outcomes are consistent with expectations.
- Compare results with relevant radiation limits and identify and record any significant differences.
- Identify any issues as a result of the monitoring
- Identify any improvements that could be made.
- Maintain records that are complete, accurate, legible and secure.

Key Messages

- Many aspects to monitoring
- Different consideration for workplace and personal monitoring
- Different considerations for the different types of radiation
- Need to understand what you want to measure
- Need to understand what the instrument is measuring
- Instruments must be fit for purpose
- Many equipment options
- Only use calibrated and maintained equipment