



The Abdus Salam  
International Centre for Theoretical Physics



**2166-Handout**

**College on Medical Physics. Digital Imaging Science and Technology to  
Enhance Healthcare in the Developing Countries**

*13 September - 1 October, 2010*

**Implementation of a Radiation Protection Programme**

Cornelius LEWIS  
*King's College Hospital  
London  
United Kingdom*

# Implementation of a Radiation Protection Programme

*Dr Cornelius Lewis*

King's College Hospital

London, UK

# Elements of a Programme

- Monitoring
- Record Keeping
- Training
- Advice
- Audit



# Monitoring

- Personnel
- Contamination
- Equipment QA/QC
- Diagnostic Reference Levels

# Monitoring

- Personnel (*BSS article 9 et seq., article 25*)
- Contamination
- Equipment QA/QC
- Diagnostic Reference Levels

# Classification of Workers

- Classified
  - exceed 3/10 dose limit
  - monitor / record / health surveillance
- Non-classified
  - ensure limits not exceeded



# Monitors

- Electronic personal dosimeter
- Film badge
  - whole body exposure
- Finger stall
  - extremity exposure
- Contamination monitor



# Body and Thyroid Badges





# Extremity Badges



# Monitoring

- Personnel
- Contamination (*BSS article 24*)
- Equipment QA/QC
- Diagnostic Reference Levels

# Monitoring for Contamination



- Do it
- Understand it
- Record it

.....with a  
calibrated monitor

# Monitoring

- Personnel
- Contamination
- Equipment QA/QC (*MED article 8*)
- Diagnostic Reference Levels

# QA/QC Measurements

- IPEM 77/IPEM 91
  - Test reference
  - Parameter
  - Expertise
  - Frequency
  - Priority
  - Remedial level
  - Suspension level



# Expertise

- Level A
  - requires little expertise
  - radiographer, technologist
- Level B
  - relatively complex tests
  - physicist, engineer, experienced technologist

# Action Levels

- Remedial and Suspension levels set with regard to significance of additional hazard
  - Increase in dose
  - Deterioration in image quality
- Mammography levels taken from Breast Screening Programme

# IPEM 77 - examples

- IPEM 77

- Test reference
- Parameter
- Expertise
- Frequency
- Priority
- Remedial level
- Suspension level

***BIR***

***LBD***

***A***

***1/2 mth***

***2***

***± 1cm @ 1m***

***BIR***

***kV***

***B***

***1/2 y***

***1***

***± 10%***

***± 20%***



# QC at Level A

- Rometer/Radcheck Tests
  - Tests Output, kV accuracy, exposure time in a single exposure





# Monitoring

- Personnel
- Contamination
- Equipment QA/QC
- Diagnostic Reference Levels (*MED article 4*)

# Diagnostic Reference Level (EC)

**Dose levels in medical radiodiagnostic practices or, in the case of radiopharmaceuticals, levels of activity, for typical examinations for groups of standard sized patients or standard phantoms for broadly defined types of equipment. These levels are expected not to be exceeded for standard procedures when good and normal practice regarding diagnostic and technical performance is applied.**

# ICRP Guidance

- DRLs are advisory
- Restricted to diagnostic radiology and nuclear medicine
- Selected by professional medical bodies
- Use easily measured quantities

*Source : ICRP draft*

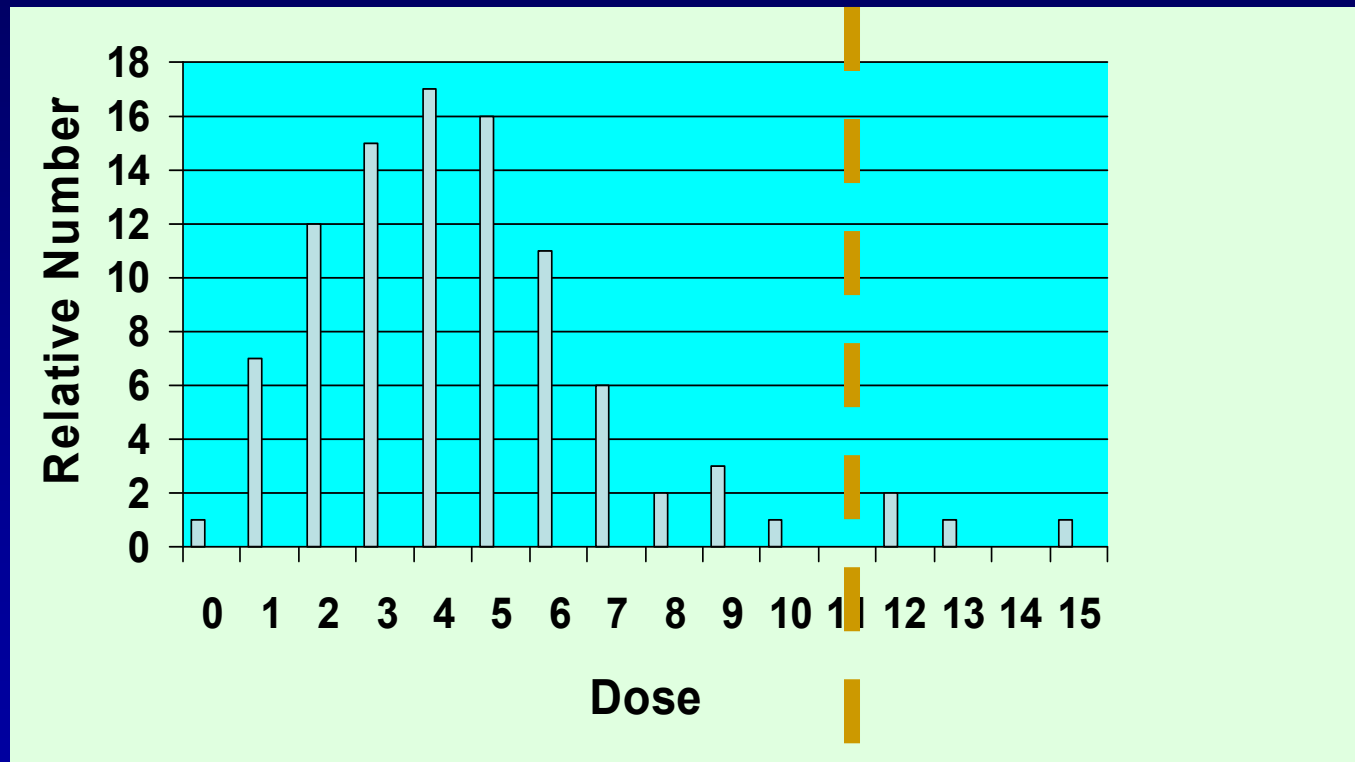
ICTP Summer School 2010

# Diagnostic Reference Levels

**“A practical tool to manage radiation dose to patients in diagnostic radiology and nuclear medicine.”**

# Setting a DRL

75% percentile



# DRLs in DR

- Dose Area Product (DAP) Gy.cm<sup>2</sup>
- Entrance Surface Dose (ESD) mGy
  - measure using TLD
  - calculate from QC data



# DAP meters

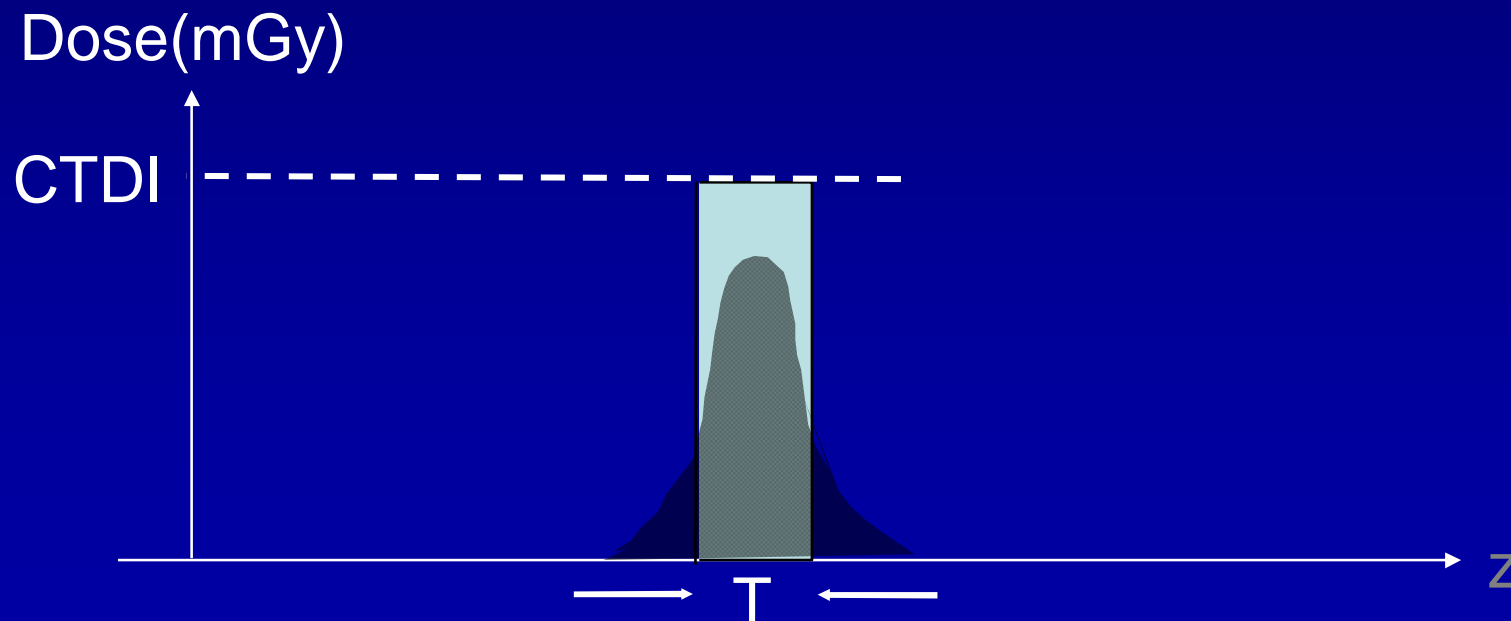


# DRLs in CT

- Computerised Tomography Dose Index (CTDI)
  - ctdose
- Dose Length Product (DLP)

# Computed Tomography Dose Index

$$\text{CTDI}_{100} = \frac{1}{T} \int_{-50\text{mm}}^{+50\text{mm}} D(z) dz$$

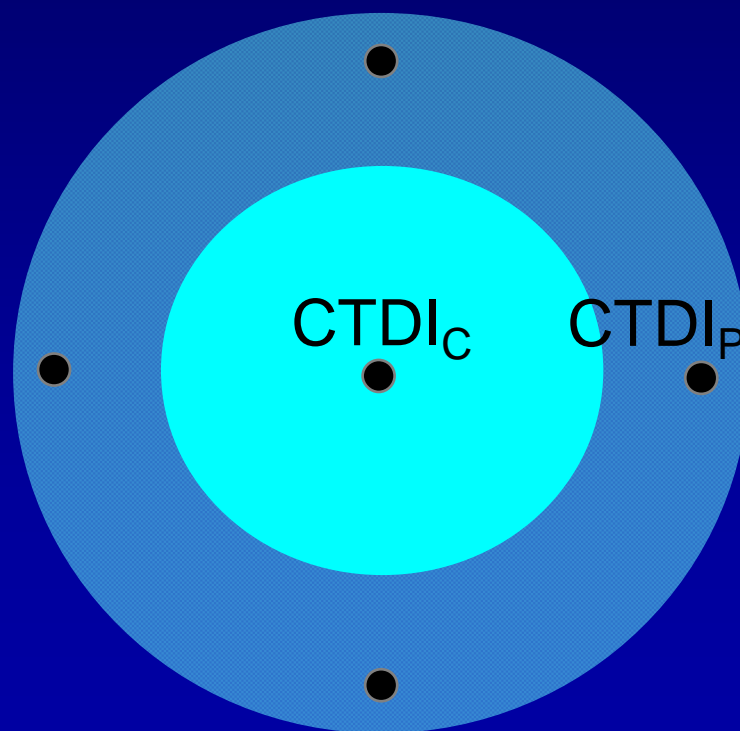


# CT dosimetry: CTDI in phantoms



# Weighted average CTDI

$$\text{CTDI}_W = 1/3 \text{CTDI}_C + 2/3 \text{CTDI}_P \text{ (mGy)}$$

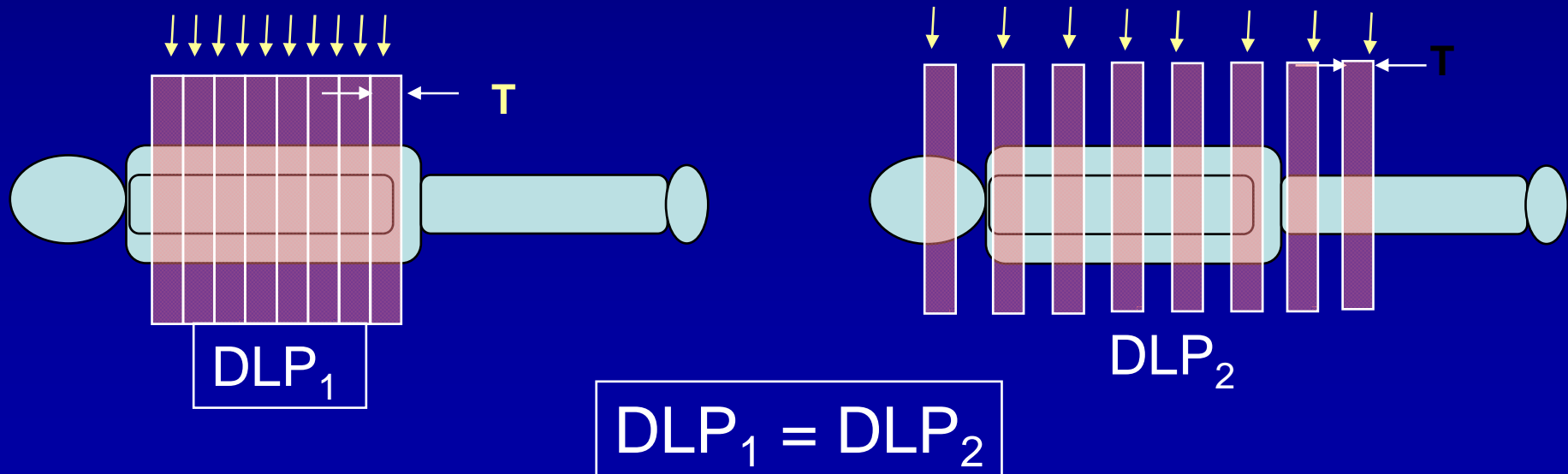


# Dose Length Product - DLP

$$DLP = CTDI_w \times L \text{ (mGy.cm)}$$

L = actual irradiated tissue

$$L = T \times \text{no. of rotations}$$



# Converting DLP to E

Region	$E_{DLP}$ mSv/mGy.cm
Head	0.0023
Neck	0.0054
Chest	0.017
Abdomen	0.015
Pelvis	0.019

# DRLs in NM

- Administered Activity
  - **M**edical **I**nternal **R**adiation **D**ose Committee
  - ICRP 53 *et seq*



# Who recommends DRLs?



European Commission



National Radiological Protection Board



AAPM, CRCPD (Conf. of Rad. Prog Control Dir.)



IAEA

# EC DRLs: Adult Radiography

Examination	DRL ESD in mGy
AP/PA Chest	0.3
AP/PA Skull	5
AP Lumbar Spine	10
Lat. Lumbar Spine	30
AP Pelvis	10








# EC DRLs: Paed. Radiography

Examination	DRL ESD in uGy
AP/PA Chest	100
AP/PA Skull	1500
AP Pelvis	900
AP/PA Abdomen	1000

# EC DRL's: Adult CT

Examination	CTDI mGy	DLP mGy.cm
Head	60	980
Chest	30	650
Abdomen	35	780
Pelvis	35	570

# Variation in DRLs

Examination	Lowest DRL	Highest DRL
<b>Adult</b>	<b>mGy</b>	<b>mGy</b>
AP/PA Chest	0.25 	0.4
AP Abdomen	4.5 	10 
<b>Paed.</b>	<b>uGy</b>	<b>uGy</b>
AP Skull	1100 	1500 
AP Abdomen	500 	1000 

# Administered Activities (MBq)

Test	UK	France	Germany	Italy	Sweden
HMPAO	740	750	500	740	830
Sestamibi	300			925	700
MDP	600			925	
MAA	200	300	200	220	105
DTPA	300	200	150		125
DMSA	80	200	70	185	50

*source : EC*

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*source : EC*

# Who sets DRLs?





# Practical Implementation

- **A**cquire information
- **A**nalyse data
- **A**dopt DRLs
- **A**udit



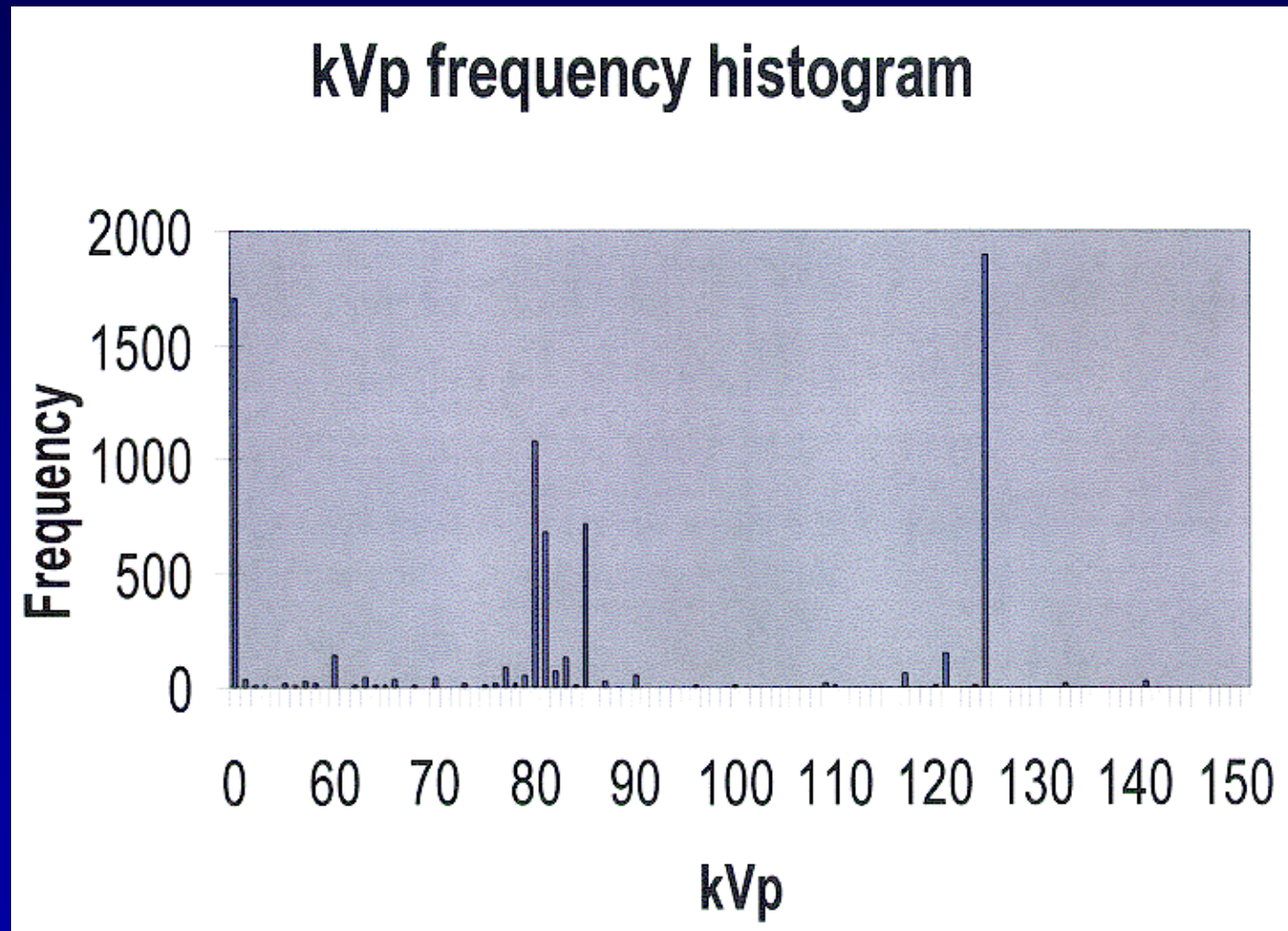
# Diagnostic Reference Levels

**“A practical tool to manage radiation dose to patients in diagnostic radiology and nuclear medicine.”**

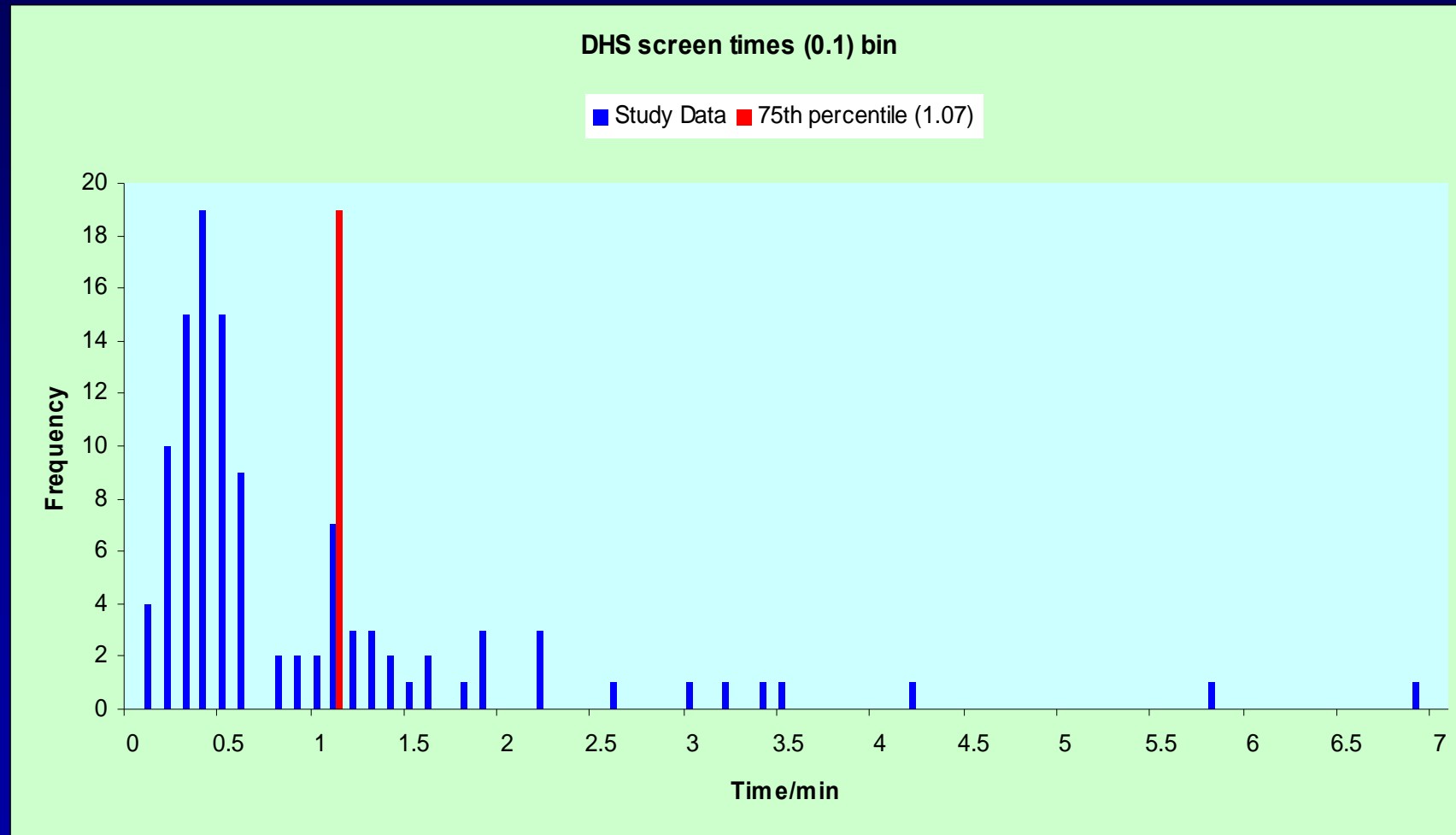
# Practical Parameters

- fluoroscopy time
- post exposure mAs
- number of CT slices
- number of films
- etc.....

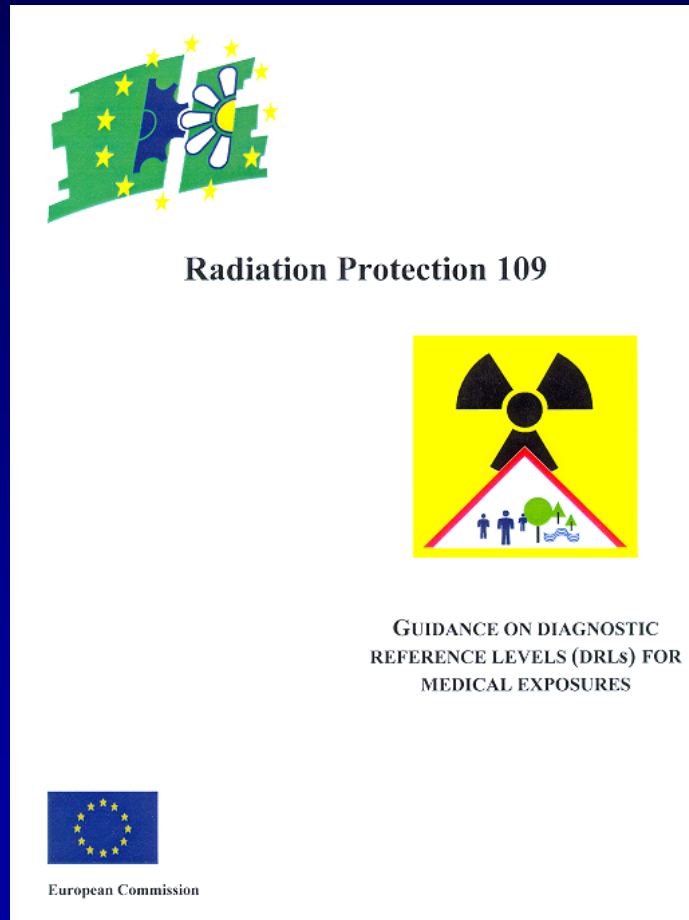
# Chest X-ray Survey



# Eg – Dynamic Hip Pinning



# DRL's : EU Guidance



<http://europa.eu.int/comm/environment/radprot>

# DRL's : ICRP Guidance

The screenshot shows a Microsoft Internet Explorer browser window with the title bar "ICRP - International Commission on Radiological Protection - Microsoft Internet Explorer provided by Kings College Hos...". The address bar shows "http://www.icrp.org/educational\_area.asp". The main content area features the ICRP logo and the text "INTERNATIONAL COMMISSION ON RADIOLOGICAL P...". Below this is a navigation menu with "Home", "News & Drafts", "Publications", "Activities", and "About ICRP". The "Educational Area" section contains a "News" icon and a paragraph: "Here, ICRP is launching an area with downloadable ICRP material aimed at promoting knowledge about radiology will focus primarily on radiation as used in medicine." Below this is an "Available Documents" icon and a list of four documents: "ICRP 84, Pregnancy and medical radiation (1.3 Mb)", "ICRP 85, Interventional radiology (1.4 Mb)", "ICRP 86, Accidents in radiotherapy (0.8 Mb)", and "ICRP 87, CT dose management (0.6 Mb)". Further down, there are links for "Radiation and your Patient: A Guide for Medical Practitioners" and "Diagnostic Reference Levels". The browser's taskbar at the bottom shows the Start button, several open applications, and the system tray with the time "18:53".

ICRP - International Commission on Radiological Protection - Microsoft Internet Explorer provided by Kings College Hos...

File Edit View Favorites Tools Help


Back Forward Stop Refresh Home Search Favorites History Mail Print Edit Discuss

Address [http://www.icrp.org/educational\\_area.asp](http://www.icrp.org/educational_area.asp) Go Links


## ICRP INTERNATIONAL COMMISSION ON RADIOLOGICAL P...

Home News & Drafts Publications Activities About ICRP

### Educational Area

 News

Here, ICRP is launching an area with downloadable ICRP material aimed at promoting knowledge about radiology will focus primarily on radiation as used in medicine.

 Available Documents

- [ICRP 84, Pregnancy and medical radiation \(1.3 Mb\)](#)
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- [ICRP 87, CT dose management \(0.6 Mb\)](#)

A summary called **Radiation and your Patient: A Guide for Medical Practitioners** can be downloaded [here](#) (142 k...

An explanatory note on **Diagnostic Reference Levels** can be downloaded [here](#) (53 kB).

Please note that while we encourage you to download and use these modules, ICRP has the copyright and you n... files.

Start | Internet | 18:53

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- Advice
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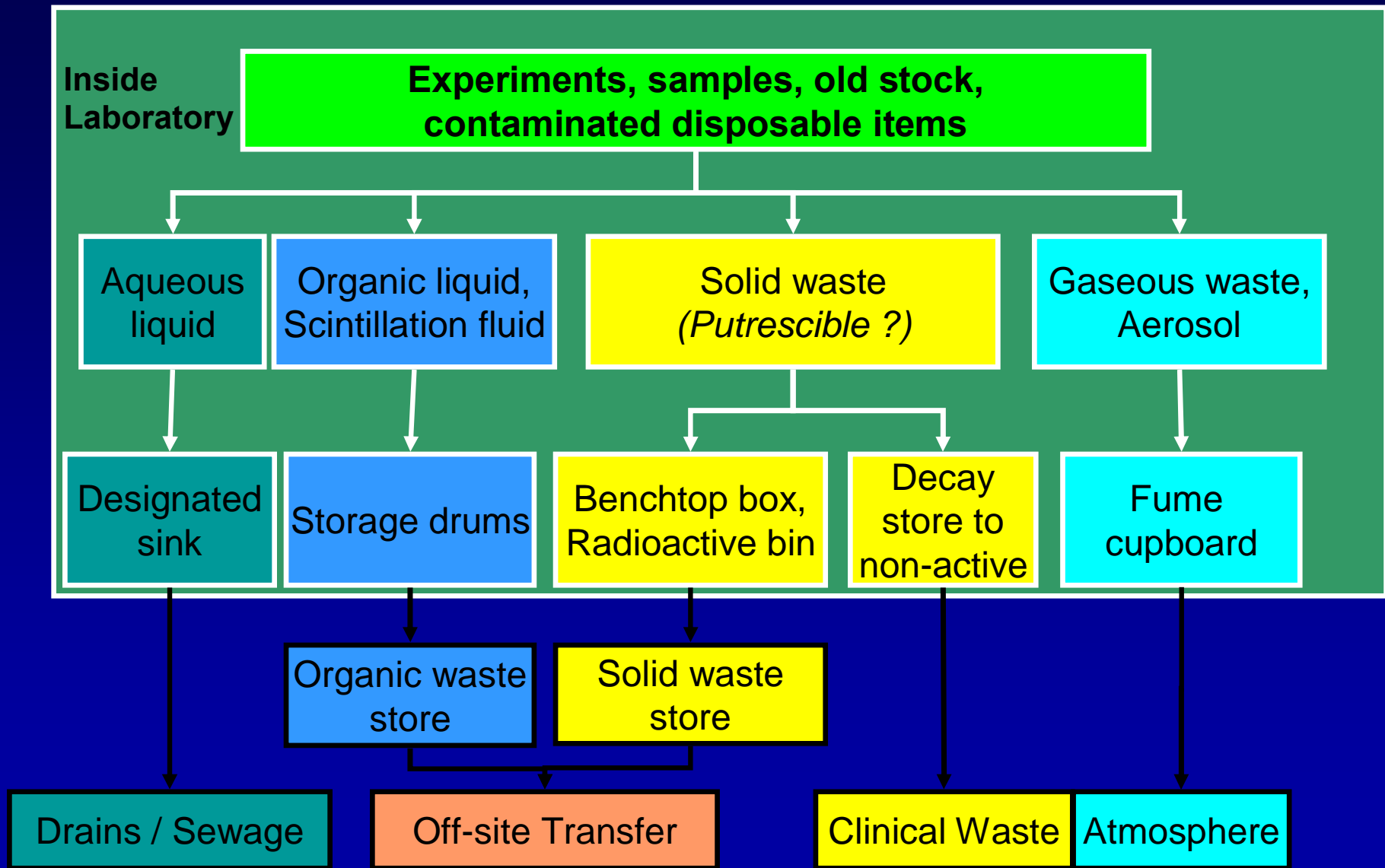


# Record Keeping

- Personnel dosimetry
- Storage of radioactive materials
- Accumulation and disposal of radioactive waste
- Use of radioactive materials
  - projects
  - licenses
- Training
- Responsible persons (RPS, Practitioner, Prescriber)



# Management of Radioactive Waste in Laboratory



# Storage Records

- date of receipt
- nuclide
- quantity
- location
- date of removal
- activity on removal
- activity on premises at end of each month



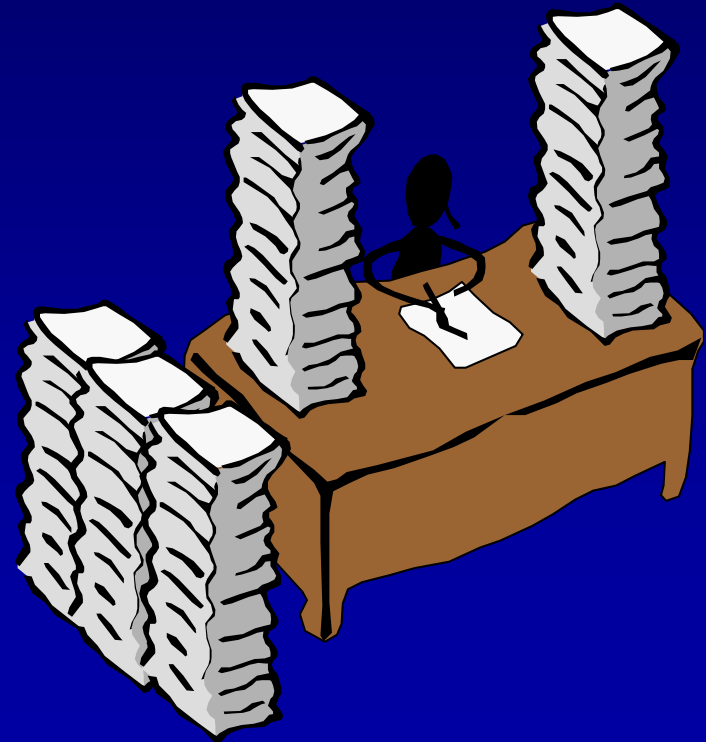
# Disposal Records

- date of disposal (or transfer)
- route
- radionuclide
- quantity
- total disposals (& transfers) at each month end



# Retention of Records

- Short-lived isotopes
  - 4 years
  - with written agreement of inspector
- Long-lived isotopes
  - forever
  - particularly for landfill



# Elements of a Programme

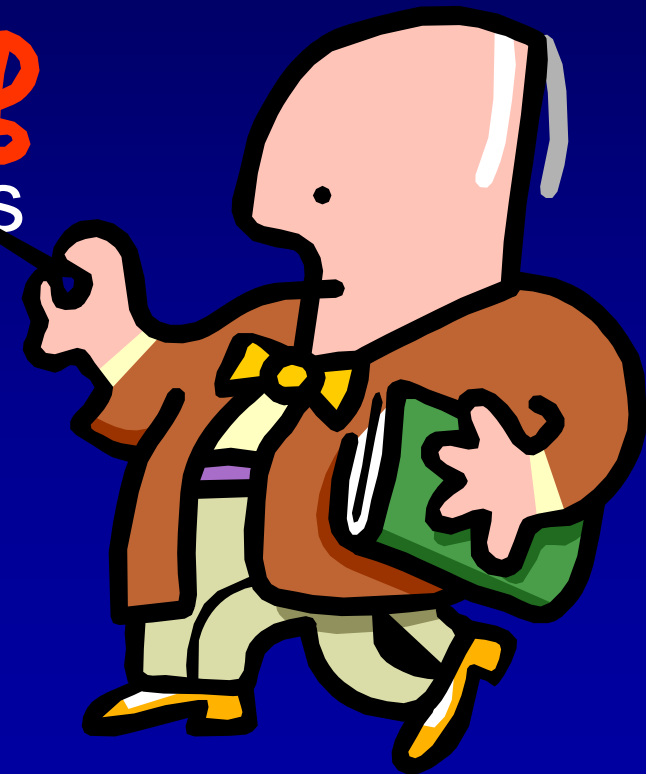
- Monitoring
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# Training

- General awareness
- Users of unsealed sources
- Radiation Protection Supervisors
- Radiation Protection Advisers

A B



# General Awareness

- Biological effects
- Framework and principles of protection
- General rules for radiation safety
- Perspective on radiation risk





# Laboratory Workers Course

An introduction to.....

**Principles of radiation safety in a  
laboratory environment**

**Radiation safety management at  
King's and KCSMD**

# Course Structure

**14:00 Biological Effects and Principles of Protection**

**14:30 Working Safely (video)**

**14:50 10 Golden Rules**

**15:05 Starting a Project**

**15:20 TEA**

**15:40 Contamination Control (video)**

**16:00 Dealing with Spills**

**16:15 Waste Control**

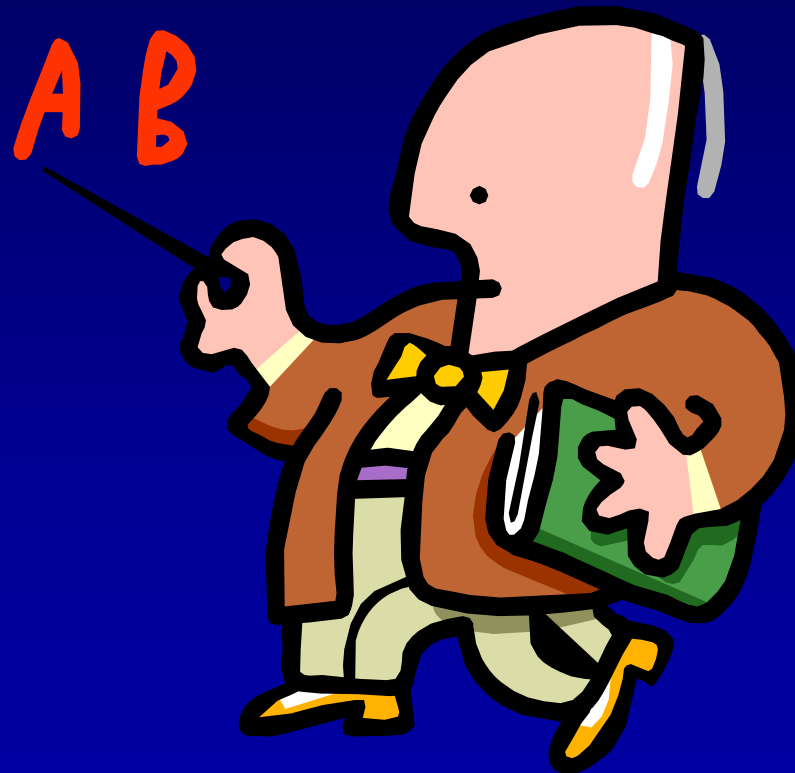
**16:30 Movement of Radioactive Substances**

**16:45 Spot the Deliberate Mistake (video)**

**17:00 Close**

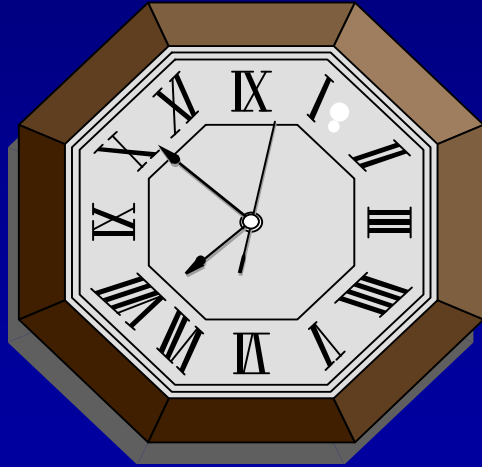
# 10 Golden Rules

# 1. Training

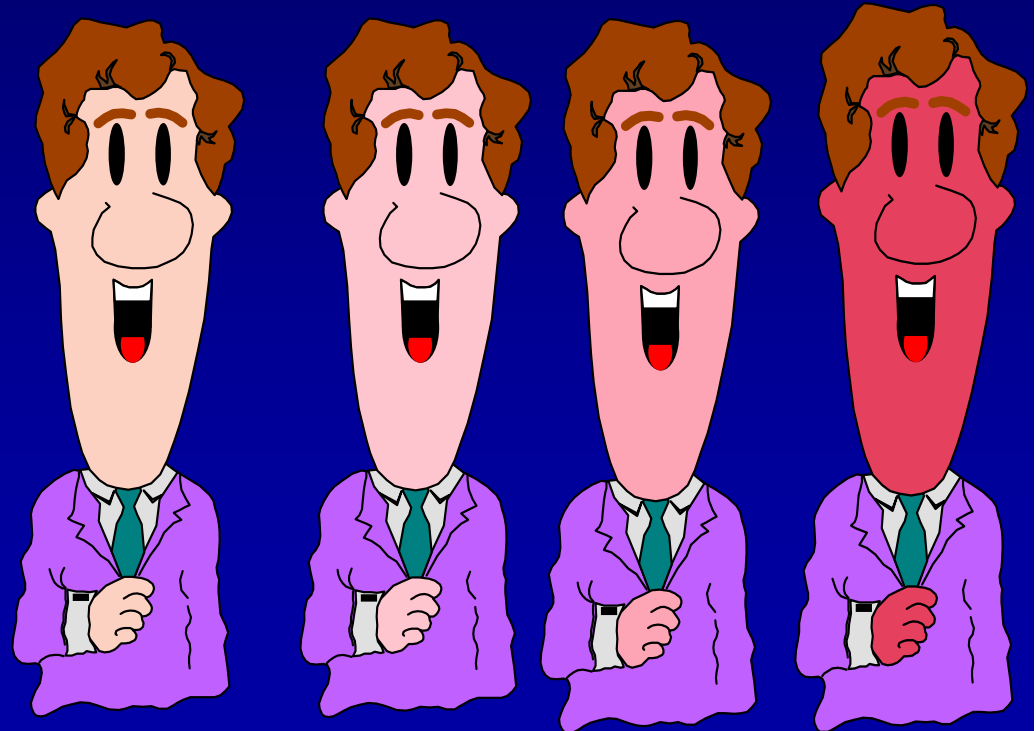


## 2. Plan Ahead

Reduce time

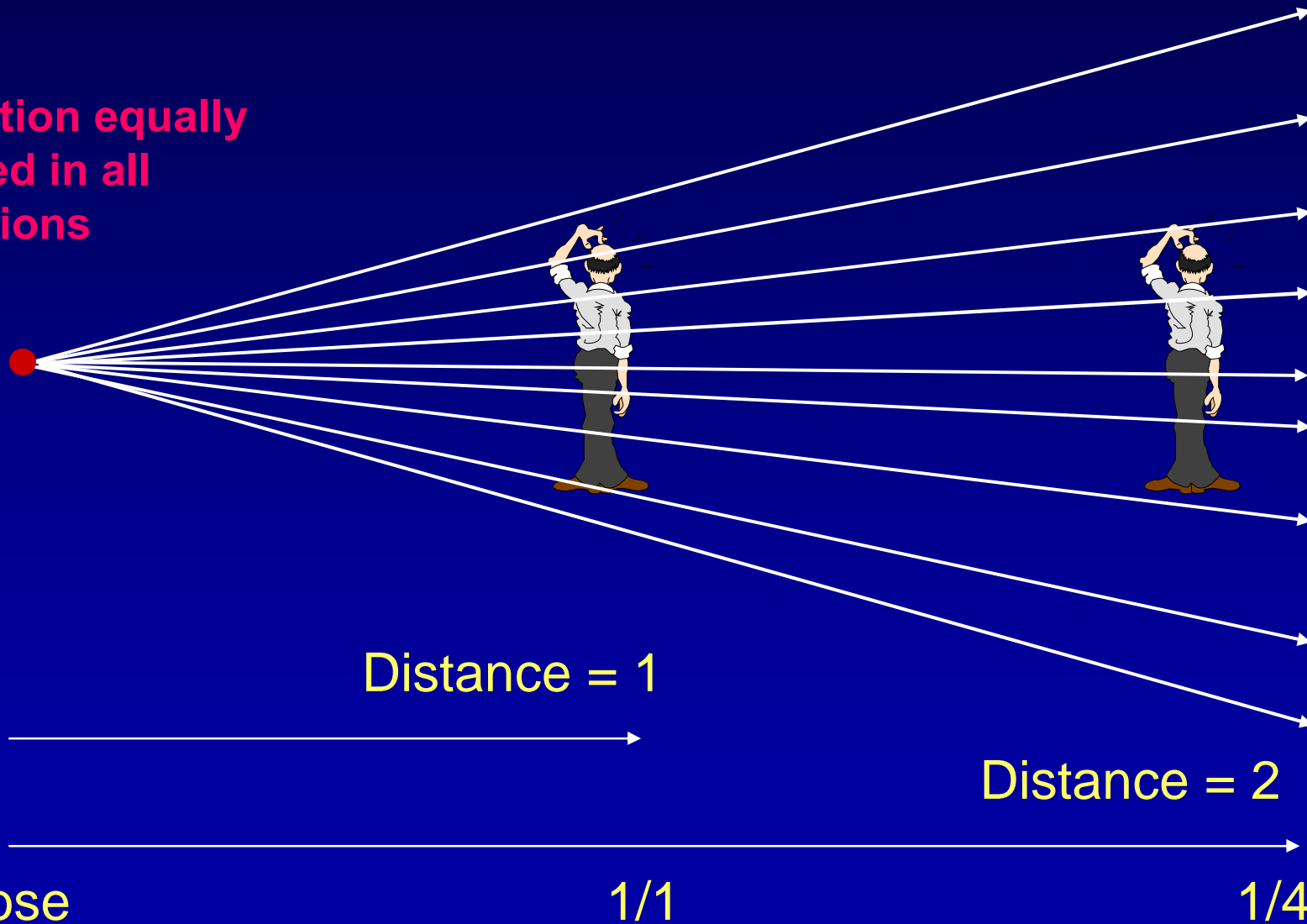


Reduce exposure



# 3. Distance

Radiation equally emitted in all directions



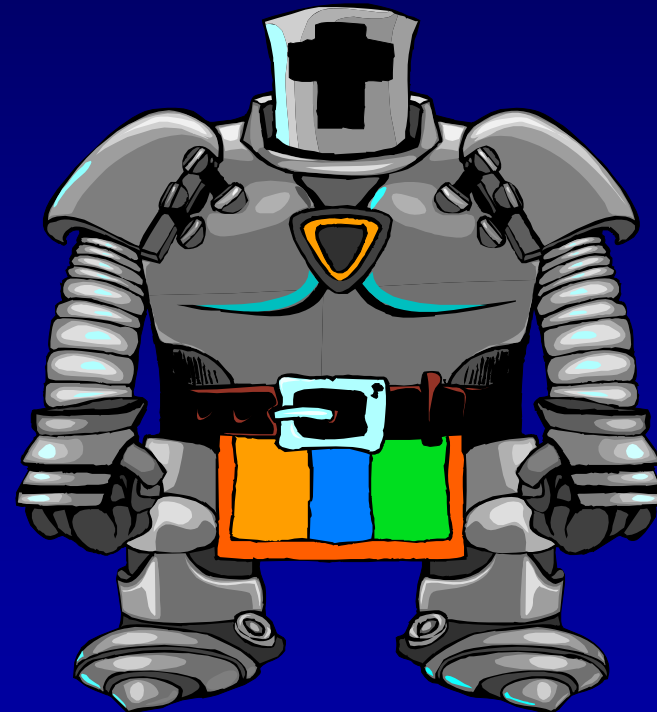
Dose

$1/1$

$1/4$

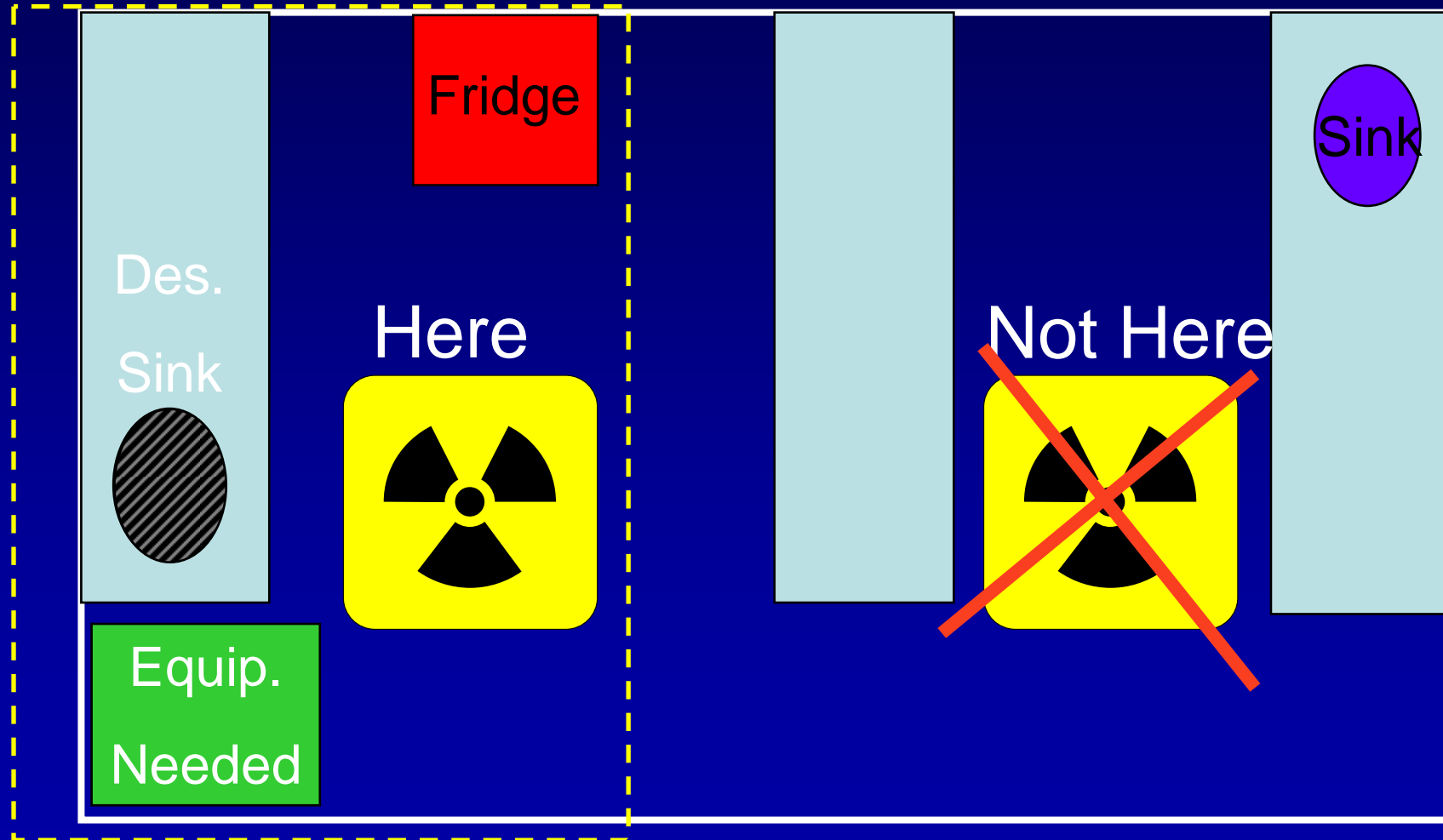
# 4. Shielding

- Perspex for Beta
- Lead for Gamma



# 5. Contain in Work Area

## Supervised Area





## 6. Protective Clothing .....

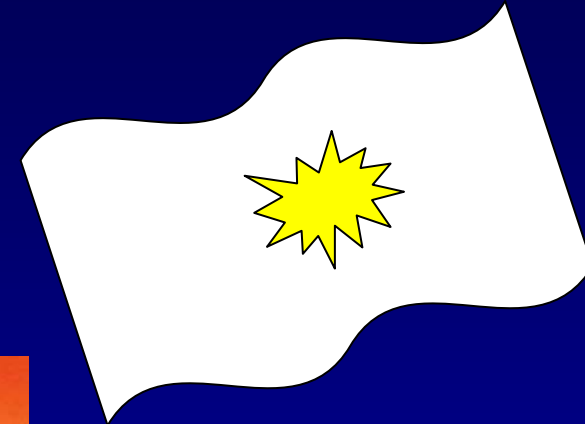
- Lab coat
- Gloves

## 6. .... and Dosemeters

- Film badge - NO!
- Finger stall - POSSIBLY
  - if handling high activities
    - >40MBq I-125; >100 MBq P-32
- Contamination monitor - DEFINITELY!

# 7. Monitor areas regularly

Tritium



Betas

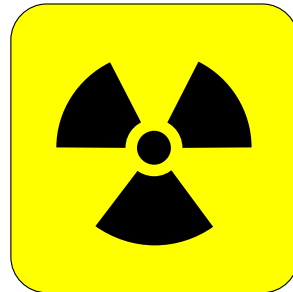


Gammas



# 8. Follow Local Rules

## Local Rules



Department  
Location

# 9. Dispose of Waste Properly

minimise



record

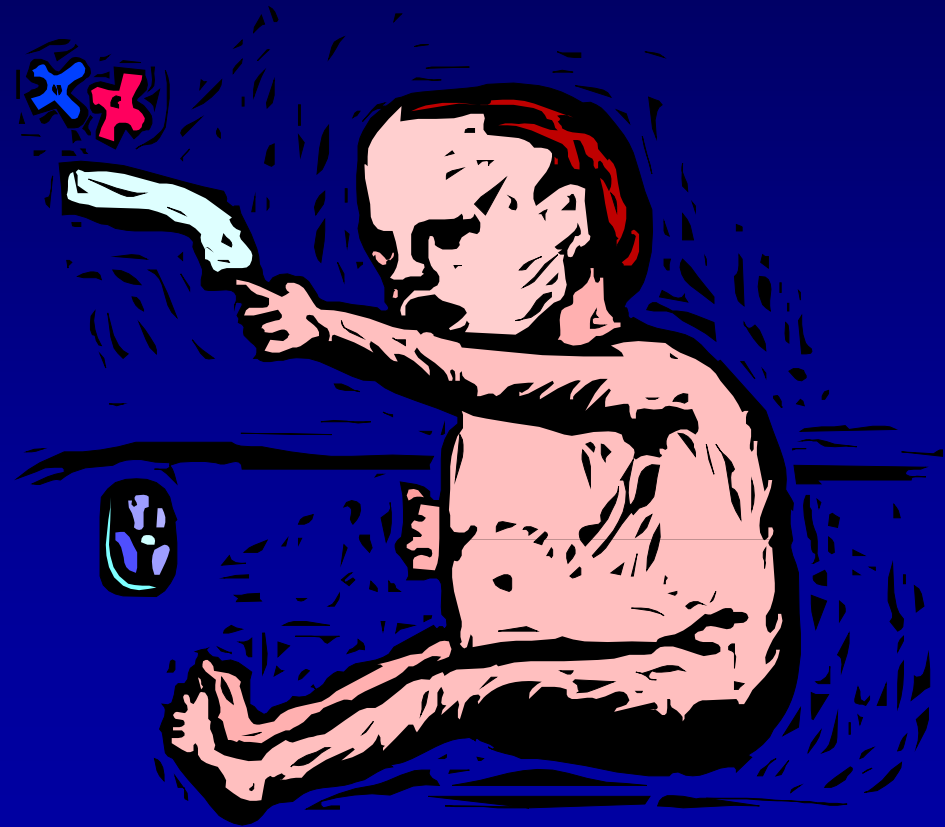


correct  
route



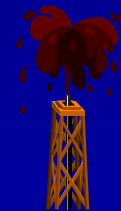
# 10. Clean up when finished

- Monitor areas
- Monitor self
- Wash
- Repeat as necessary
- **RECORD KEEPING!**



# Rule 11 !!!!!

Use the least activity possible



# RPS Course

- 3 day residential course
- Lectures on
  - basic science
  - legislation
  - principles of radiation protection
  - specific techniques
  - talks by inspectors
- Practical sessions and workshops





# RPA (Qualified Expert) Course

- 5 day course
- Detailed lectures by experts
  - Day 1 : Reviews; Effects of Radiation
  - Day 2 : Statutory Requirements
  - Day 3 : Radiation Protection in Hospitals
  - Day 4 : External Influences and Emergencies
  - Day 5 : Non-ionising Radiation Protection
- Workshops and discussions
  - Risk Assessment, DRLs, Role-Play

[www.icr.ac.uk/physics/courses/Rpcourse.htm](http://www.icr.ac.uk/physics/courses/Rpcourse.htm)

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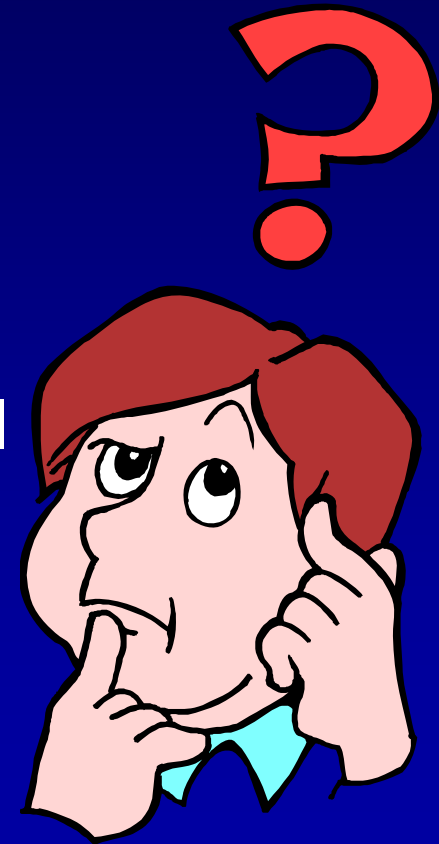
# Advice

- Policies and procedures
- Risk Assessment
- Pregnancy
- Research and development
- Equipment Selection



# Risk Assessment

- Nature of sources
- Dose rates
- Likelihood and levels of contamination
- Results of previous monitoring
- Advice - manufacturers, professional bodies
- Engineering controls, design features, access
- Systems of work



# Risk Assessment – the process

## Risk Assessment – a process

Parameter	Frequency	Severity	Risk = Product
<i>eg</i>	Low (1)	Low (1)	Low (1-2)
Dose Rate	Medium (2)	Medium (2)	Medium (3-4)
	High (3)	High (3)	High (6-9)

# Risk Coding

<b>FREQ.</b> \ <b>SEV.</b>	1	2	3
1	1	2	3
2	2	4	6
3	3	6	9

# Outcome of Risk Assessment

- Actions to ensure ALARP
- engineering controls, *etc* required
- PPE requirements
- dose constraints
- monitoring, maintenance *etc* requirements
- designations of areas and employees
- training requirements



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