Radiation Dosimetry

Course on Medical Use of Radioisotopes (CMR)

May 12, 2026

10:00 AM

Outline

- Introduction
- Review: Radiation Quantities & Units
- Properties of Radiation Dosimeters
- Types of Dosimetry Systems
- International Measurement Systems
- Summary

LEARNING OBJECTIVES

1. Review radiation dose quantities & units
2. Understand radiation dosimetry basics
3. Identify dosimeters & their properties
4. Understand the relevance of the International Measurement System (IMS) for radiation metrology

Classification of Radiation Quantities

RADIATION FIELD

Energy, Fluence, Fluence Rate

Describe the radiation beam/field

INTERACTION / DOSIMETRIC

Exposure, KERMA, Absorbed Dose

Describe ionization, energy transfer, or energy deposition

RADIATION PROTECTION

Equivalent Dose, Effective Dose

Estimate biological/risk significance

OPERATIONAL

Hp(10), Hp(3), Hp(0.07)

Practical quantities used for monitoring

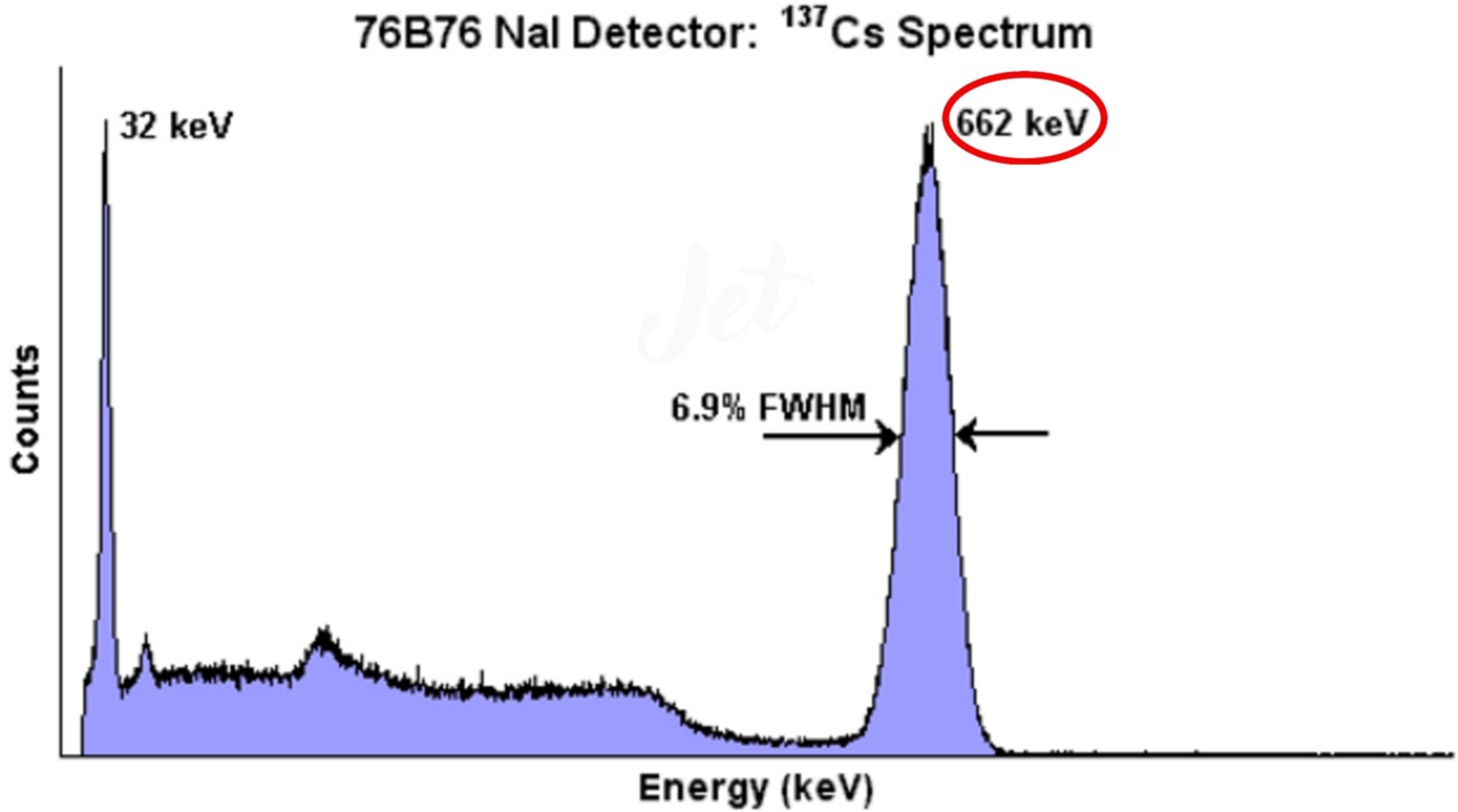
RADIATION FIELD QUANTITIES

Energy

- Energy of ionizing radiation is commonly expressed in electronvolts (eV)
- SI unit of energy: joule (J)
- 1 eV = energy gained by an electron accelerated through 1 volt
- Radiation energy influences **penetration** and **depth of dose deposition**

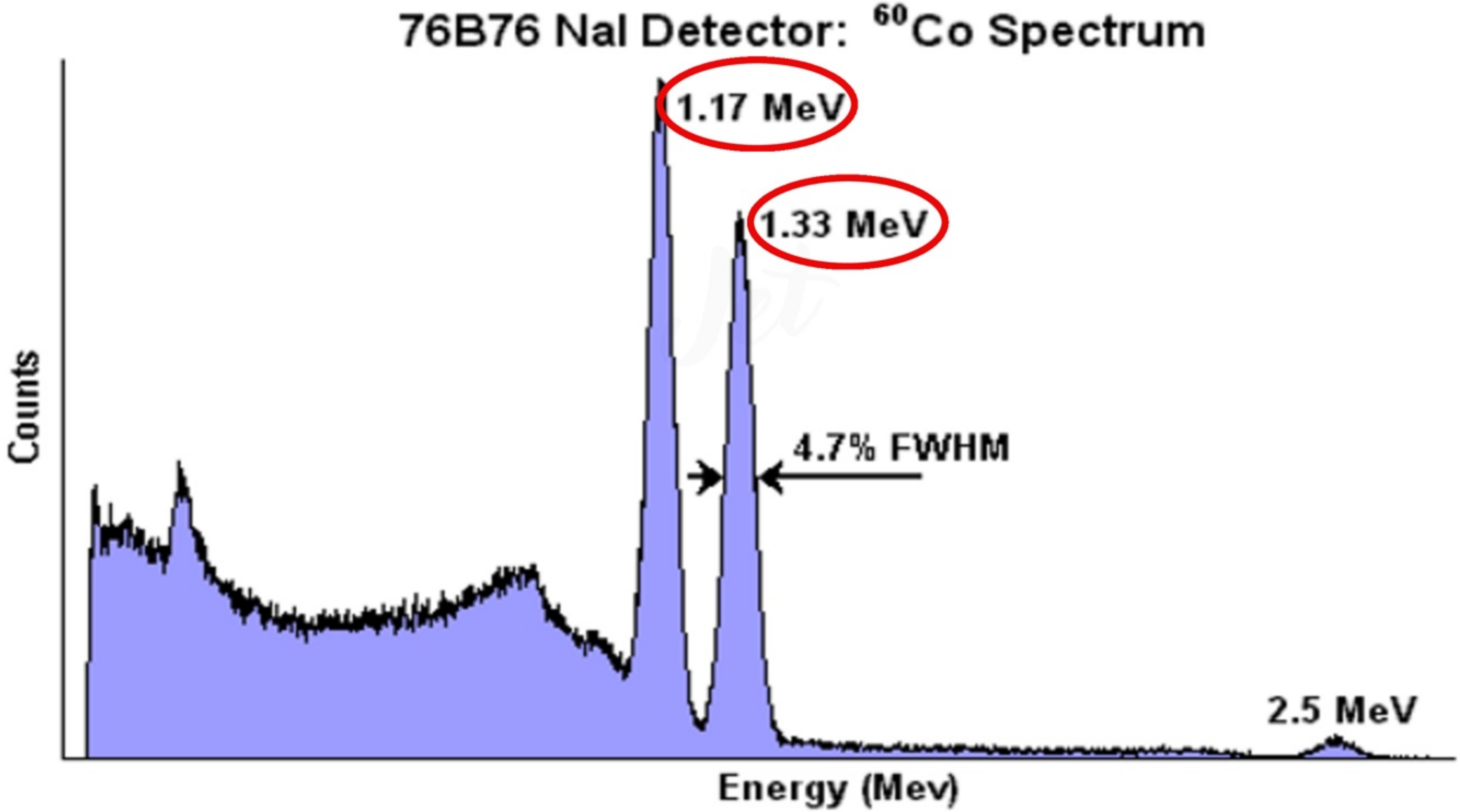
$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

Energy



Gamma Spectrum (Cs-137)

Energy



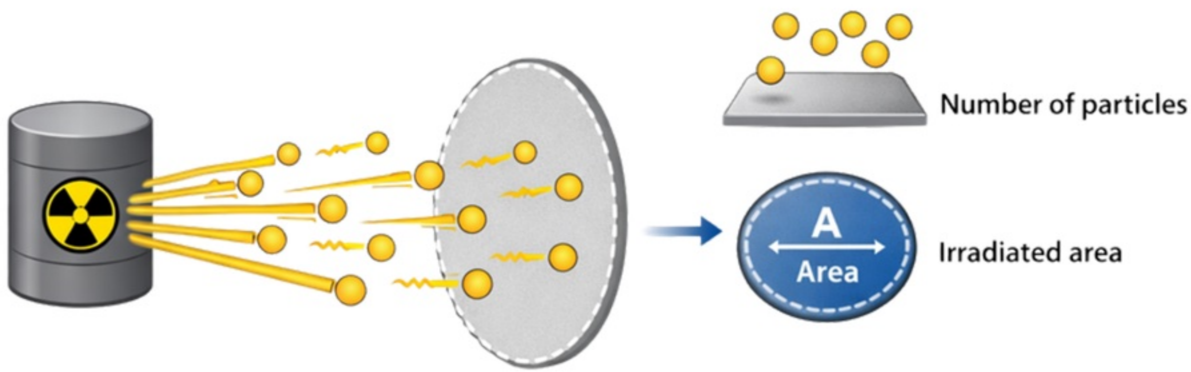
Gamma Spectrum (Co-60)

Fluence (Φ)

- number of particles (or photons) passing through an area.
- measured in **particles per square metre** (**particles · m^{-2}**)

Fluence Rate (ϕ)

- the number of particles/photons passing through unit area in unit time (**particles · m^{-2} · s^{-1}**).



$$\text{Fluence } (\Phi) = \frac{N}{A}$$

N = Number of particles
A = Area irradiated

Φ = **Particles per unit area**

Classification of Radiation Quantities

RADIATION FIELD	Energy, Fluence, Fluence Rate Describe the radiation beam/field
INTERACTION / DOSIMETRIC	Exposure, KERMA, Absorbed Dose Describe ionization, energy transfer, or energy deposition
RADIATION PROTECTION	Equivalent Dose, Effective Dose Estimate biological/risk significance
OPERATIONAL	Hp(10), Hp(3), Hp(0.07) Practical quantities used for monitoring

Exposure (X)

- quantifies the ionization produced by X-rays or gamma rays in air
- It is defined as the **charge of ions of one sign produced per unit mass of air**. $X = dQ / dm$
- SI unit: **coulomb per kilogram (C/kg)**
- Traditional unit: **Roentgen(R)** (named after the discoverer of x-rays, Wilhelm Roentgen).
- Exposure is used mainly for photons in air and is now largely replaced by **air kerma** in radiation dosimetry.

$$1\ R = 2.58 \times 10^{-4}\ C/kg$$

KERMA (K)

- **K**inetic **E**nergy **R**eleased per unit **Ma**ss
- A measure of the **kinetic energy transferred from uncharged radiation** (photons or neutrons) to charged particles in a material.
- SI unit: **Gray (Gy)**

1 Gy = 1 J / kg

KERMA (K)

- For x- and gamma-ray energies up to 1 MeV, the interactions which take place between the radiation and the particles of air are nearly the same
- exposure measurement ≈ kerma measurement.
- At x- and gamma ray energies above 1 MeV interactions occur which lead to different measurements of air kerma compared with exposure.

Absorbed Dose (D)

- **measure of the energy** deposited in any medium by any type of radiation.
- SI unit: **Gray (Gy)**

1 Gy = 100 rad

radiation **a**bsorbed **d**ose

Classification of Radiation Quantities

RADIATION FIELD	**Energy, Fluence, Fluence Rate** Describe the radiation beam/field
INTERACTION / DOSIMETRIC	**Exposure, KERMA, Absorbed Dose** Describe ionization, energy transfer, or energy deposition
RADIATION PROTECTION	**Equivalent Dose, Effective Dose** Estimate biological/risk significance
OPERATIONAL	**Hp(10), Hp(3), Hp(0.07)** Practical quantities used for monitoring

Equivalent Dose (H)

- measure of the **biological effect** of a particular type of radiation on organs or tissues.
- SI unit: Sievert (Sv) **1 Sv = 100 rem**

roentgen **e**quivalent **m**an

- absorbed dose ($D_{T,R}$) x **radiation weighting factor (W_R)** and summed over all radiations:

$$H_T = \sum_R w_R D_{T,R}$$

Equivalent Dose (H)

Type of Energy Range	Radiation Weighting Factor (wR)
Photons, gamma rays, x-rays	1
Electrons, beta, and muons	1
α-particles, fission fragments, heavy ions	20
Neutrons (energy dependent):	Continuous function of neutron energy

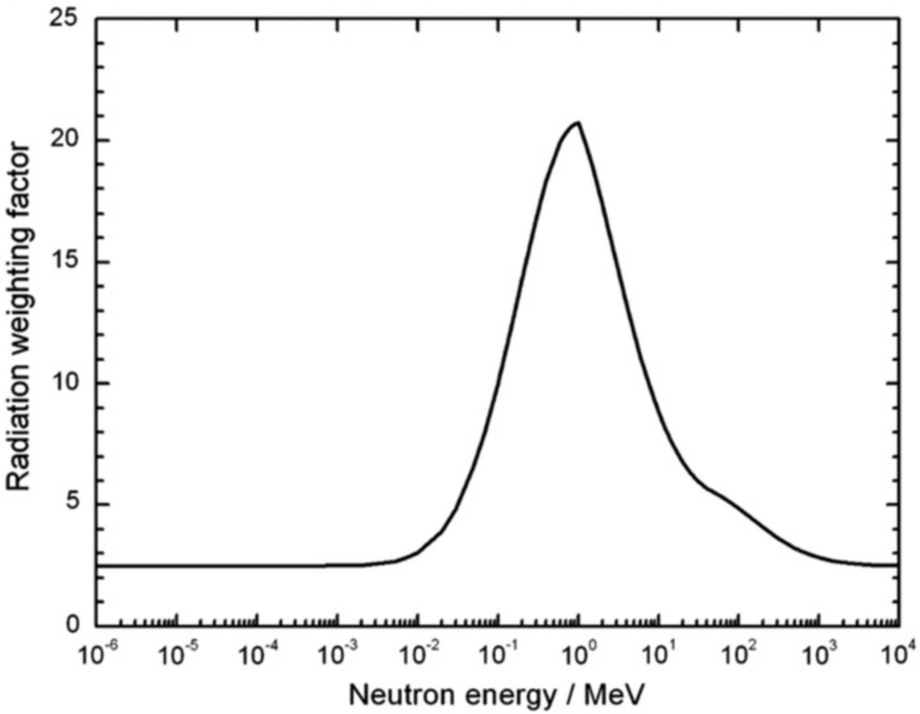


Fig. 1. Radiation weighting factor, w_R, for neutrons versus neutron energy.

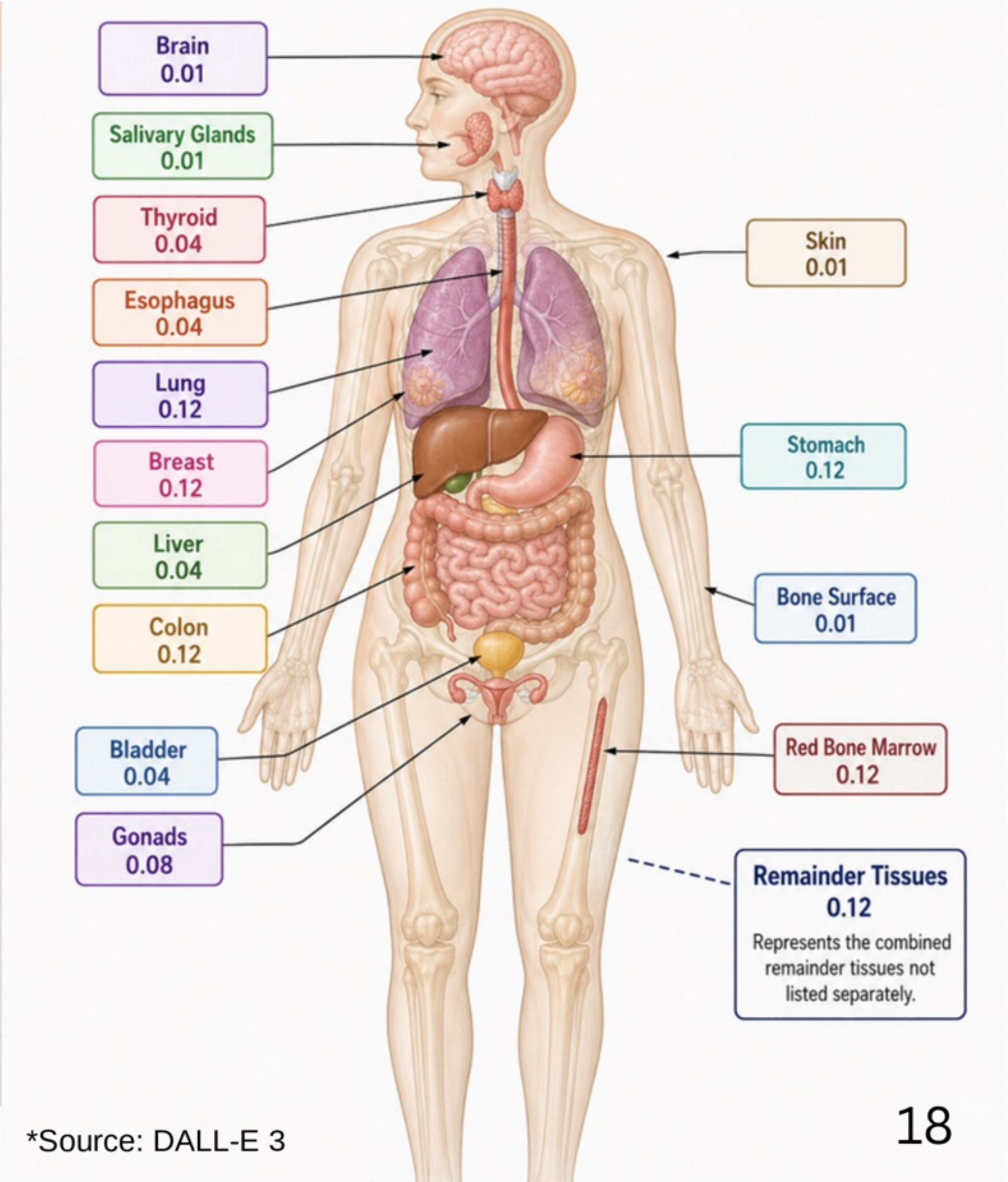
Ref: ICRP 103

Effective Dose (E)

- Combines **organ doses** and **tissue sensitivities** to estimate whole-body radiation risk.
- **Tissue Weighting Factor (W_T)**
  - takes into consideration the different radiosensitivities of the different organs and tissues.
  - Some tissues and body organs are more sensitive to radiation than others.

Tissue Weighting Factors (W_T)

Tissue / Organ	w_t (ICRP 103, 2007)
Gonads	0.08
Red Bone Marrow	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Bladder	0.04
Breast	0.12
Liver	0.04
Esophagus	0.04
Thyroid	0.04
Skin	0.01
Bone Surface	0.01
Remainder Tissues	0.12
Brain	0.01
Salivary Glands	0.01



*Source: DALL-E 3

Effective Dose (E)

- SI unit: **Sievert (Sv)**
- Formula:

$$E = \Sigma\, w_T H_T$$

- Where $\mathbf{H_T}$ = equivalent dose
  $\mathbf{w_T}$ = tissue weighting factor

! ! PROBLEM SOLVING ! !

DIFFICULTY: EASY

A nuclear medicine technologist receives an estimated absorbed dose of **0.68 mGy** to the whole body from **gamma (wR = 1)** radiation while assisting an I-131 therapy patient. Calculate the **equivalent dose**.

! ! PROBLEM SOLVING ! !

DIFFICULTY: EASY

A nuclear medicine technologist receives an estimated absorbed dose of 0.68 mGy to the whole body from gamma radiation while assisting an I-131 therapy patient. Calculate the equivalent dose.

$$H_T = w_R \times D_T$$

$$H_T = 1 \times 0.68 \text{ mGy}$$

$$\boxed{H_T = 0.68 \text{ mSv}}$$

! ! PROBLEM SOLVING ! !

DIFFICULTY: MEDIUM

During handling of an **alpha**-emitting therapeutic radiopharmaceutical, a small contamination event occurs. The estimated absorbed dose to a small region of skin is:

- Alpha particles: **0.03 mGy (wR=20)**
- Gamma radiation: **0.10 mGy (wR=1)**

! ! PROBLEM SOLVING ! !

DIFFICULTY: MEDIUM

During handling of an **alpha**-emitting therapeutic radiopharmaceutical, a small contamination event occurs. The estimated absorbed dose to a small region of skin is:

- Alpha particles: **0.03 mGy) [wR = 20]**
- Gamma radiation: **0.10 mGy [wR = 1]**

$$H_T = (w_R D_{T,R})_\alpha + (w_R D_{T,R})_\gamma$$

$$H_T = (20)(0.03\ \text{mGy}) + (1)(0.10\ \text{mGy})$$

$$H_T = 0.60\ \text{mSv} + 0.10\ \text{mSv}$$

$$\boxed{H_T = 0.70\ \text{mSv}}$$

! ! PROBLEM SOLVING ! !

DIFFICULTY: HARD

A radiopharmacy staff member is involved in handling an alpha-emitting therapeutic radiopharmaceutical. Due to a small internal contamination event, the estimated absorbed dose to the liver is:

Alpha radiation absorbed dose: **0.02 mGy (wR = 20)**

Gamma radiation absorbed dose: **0.30 mGy (wR = 1)**

Calculate:

- The **equivalent dose** to the liver
- The **effective dose contribution** from the liver (wT = 0.04)

DIFFICULTY: HARD

CALCULATE EQUIVALENT DOSE:

$$H_T = \sum_R w_R D_{T,R}$$

$$H_{\text{liver}} = (w_R D)_\alpha + (w_R D)_\gamma$$

$$H_{\text{liver}} = (20)(0.02\ \text{mGy}) + (1)(0.30\ \text{mGy})$$

$$H_{\text{liver}} = 0.40\ \text{mSv} + 0.30\ \text{mSv}$$

$$\boxed{H_{\text{liver}} = 0.70\ \text{mSv}}$$

! ! PROBLEM SOLVING ! !

DIFFICULTY: HARD

CALCULATE EFFECTIVE DOSE FROM LIVER:

$$E = w_T H_T$$

$$E_{\text{liver}} = (0.04)(0.70\ \text{mSv})$$

$$\boxed{E_{\text{liver}} = 0.028\ \text{mSv}}$$

OPERATIONAL QUANTITIES

- the quantities of **equivalent dose** and **effective dose** are **not measurable in practice**.

- Operational quantities are intended to give reasonable **approximations** to equivalent and effective doses.

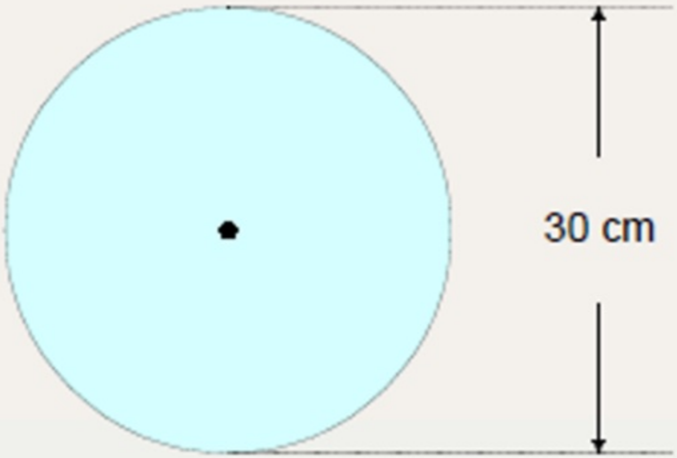
- ICRU quantities refer to a 30 cm diameter, tissue-equivalent **sphere** (known as the ICRU sphere) which **represents the human body**. They relate to the type and energy of the radiation existing at that point.

OPERATIONAL QUANTITIES

The ICRU sphere, 30 cm in diameter, is a tissue-equivalent sphere.

Composition:

Oxygen	76.2%
Carbon	11.1%
Hydrogen	10.1%
Nitrogen	2.6%

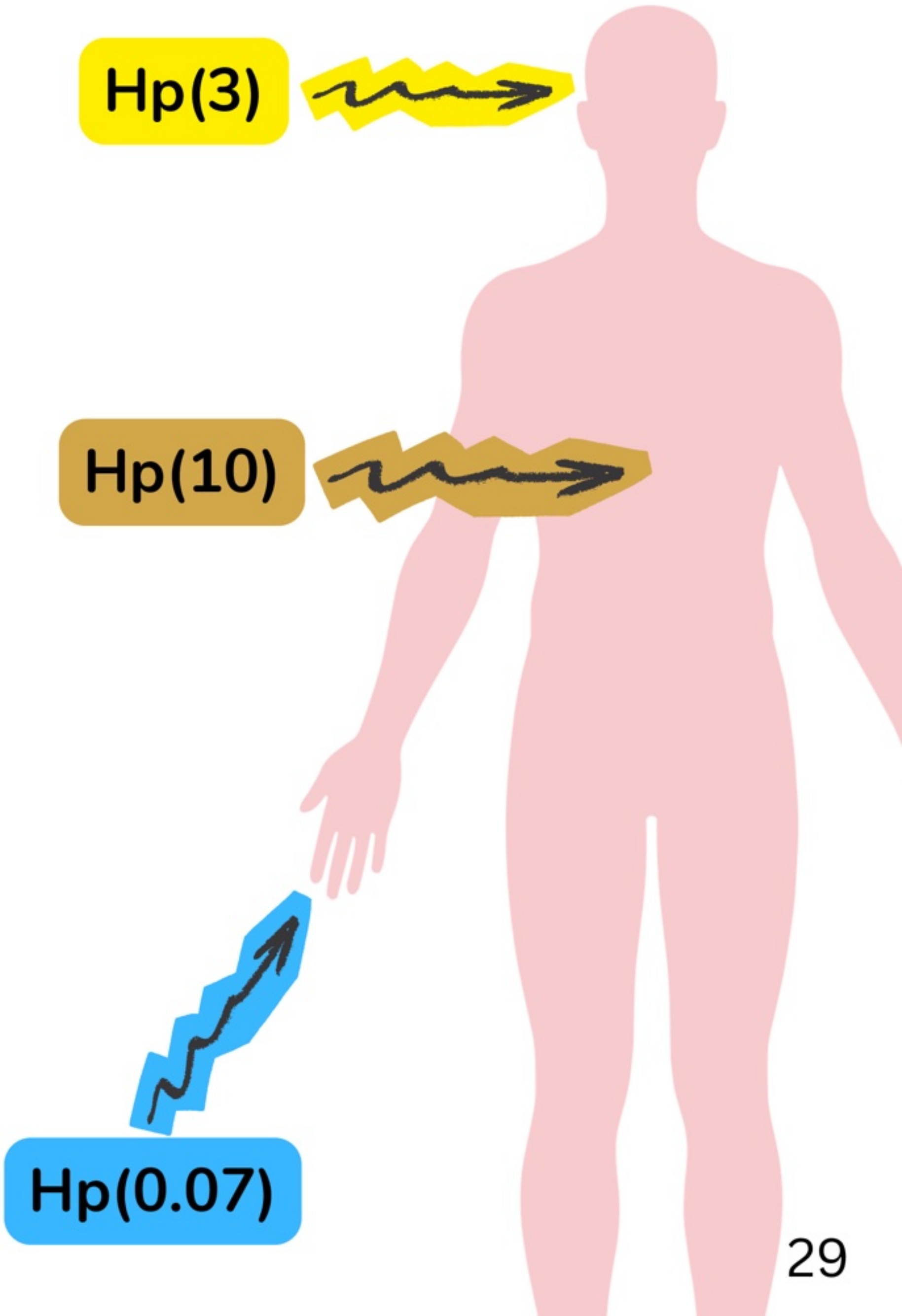


Task	Area monitoring	Individual monitoring
Monitoring of effective dose	*Ambient dose equivalent*, $H^*(10)$	*Personal dose equivalent*, $H_p(10)$
Monitoring of equivalent dose to the skin and the hands/feet	*Directional dose equivalent*, $H'(0.07,\Omega)$	*Personal dose equivalent*, $H_p(0.07)$
Monitoring of equivalent dose to the eye lens	*Directional dose equivalent*, $H'(3,\Omega)$	*Personal dose equivalent*, $H_p(3)$

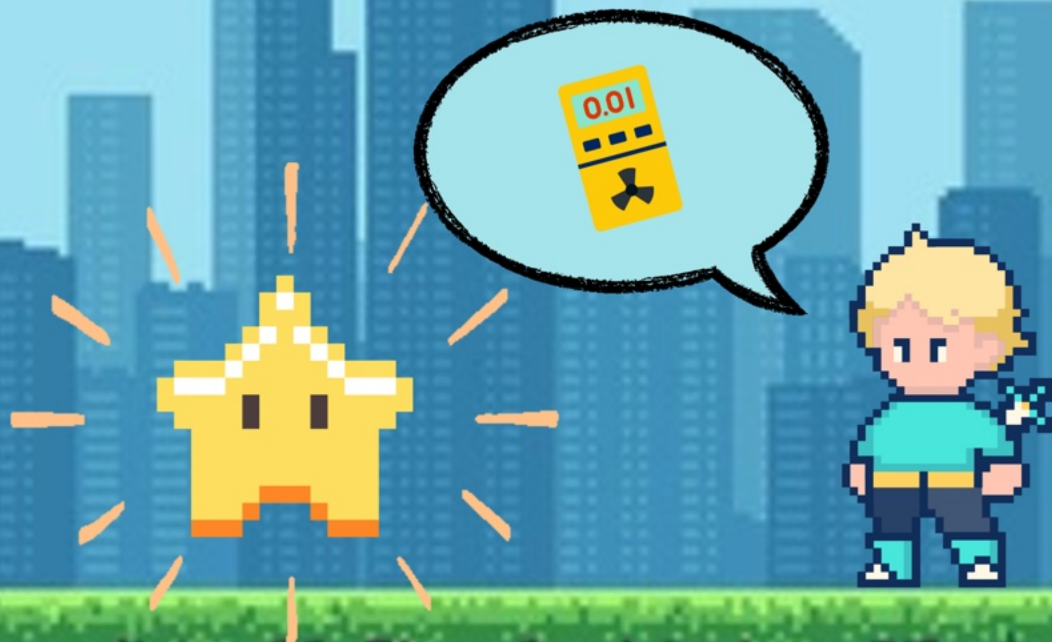
OPERATIONAL QUANTITIES

Personal dose equivalent [Hp(d)]

- dose equivalent in soft tissue below a specified point on the body at a depth (d) in millimeters (mm).
- depth can be taken as:
  - **0.07** mm for skin/extremities
  - **3** mm for the eye for weakly penetrating radiation
  - **10** mm for the whole body exposed to strongly penetrating radiation



RADIATION DOSIMETRY



RADIATION DOSIMETRY

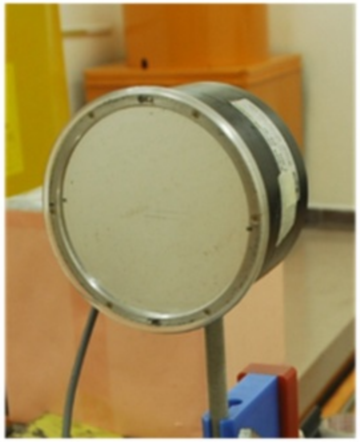
DEFINITION

- Quantitative determination of the **physical**, **chemical**, and/or **biological** changes that a radiation field produces in a target.
- Determination of radiologically relevant quantities: **exposure**, **kerma**, **fluence**, **dose equivalent...**
- Performed using **radiation dosimeters**

IMPORTANCE

- Occupational Protection: ensures worker exposures remain within safe limits.
- Radiation Safety:
  - patient-specific diagnostic/therapeutic dose considerations
  - radiopharmaceutical handling
  - contamination control
  - occupational monitoring
- Calibration of radiation monitoring instruments
- Regulatory Compliance: required documentation and traceability for audits and licensing.

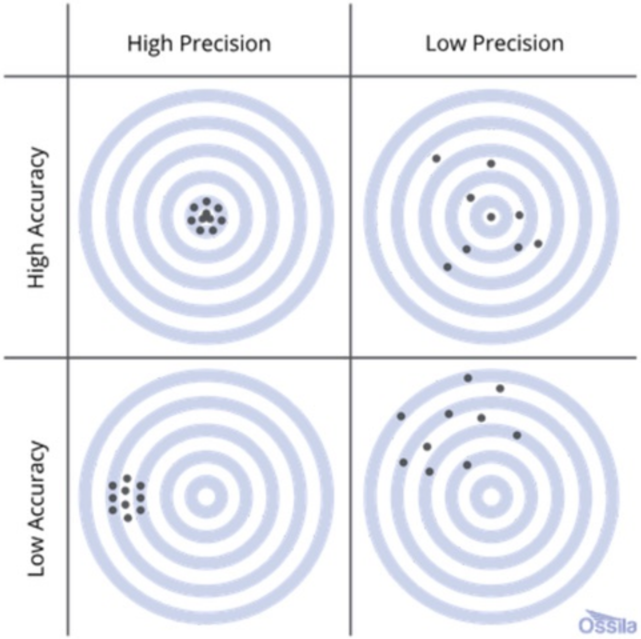
RADIATION DOSIMETERS



PROPERTIES OF RADIATION DOSIMETERS

Accuracy & precision

- Accuracy refers to the proximity of the expected value to the 'true value' of the measured quantity.
- Precision specifies reproducibility of measurements under similar conditions.



Linearity

- dosimeter reading should be linearly proportional (or corrected for) to the dosimetric quantity.

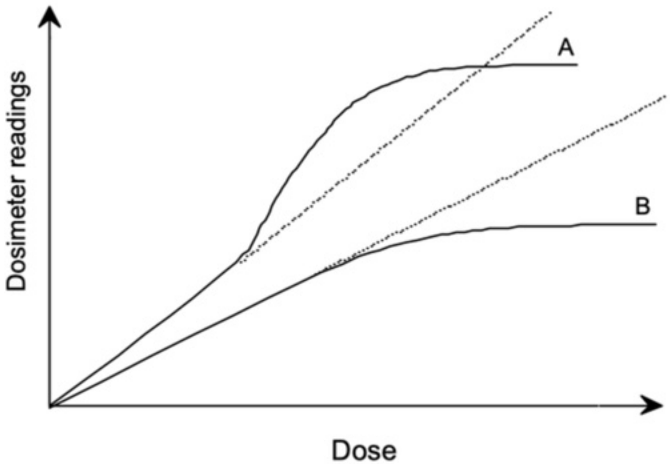


FIG. 3.1. Response characteristics of two dosimetry systems. Curve A first exhibits linearity with dose, then supralinear behavior, and finally saturation. Curve B first exhibits linearity and then saturation at high doses.

PROPERTIES OF RADIATION DOSIMETERS

Uncertainty

- parameter that describes the dispersion of the measured values of a quantity. Evaluated by:

TYPE A UNCERTAINTY	TYPE B UNCERTAINTY
• Obtained from **statistical analysis** of repeated measurements • Defined as the **standard deviation of the mean** ($u_A = \sigma_{\bar{x}}$) • Can be reduced by **increasing the number of measurements**	• Based on **scientific judgment or information** from sources other than repeat measurements • Includes instrument specifications, calibration data, reference literature, correction factors, environmental effects • Assumes a **probability distribution** (commonly normal or rectangular) • Estimated by determining limits within which the true value lies, and using a fraction of that range as (u_B)

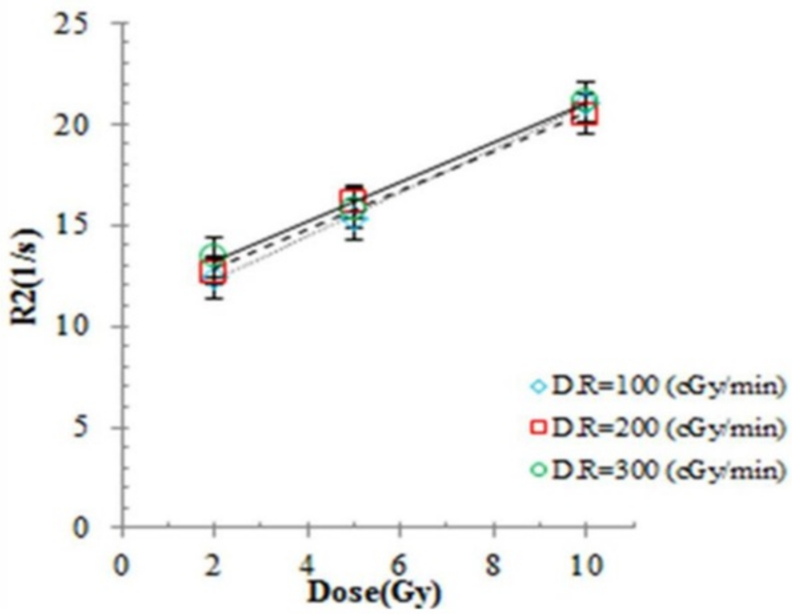
Error

- Difference between a measured value and the true value
- Has magnitude and sign (can be positive or negative)
- Errors are usually estimated and corrected as much as possible
- After all corrections, the expected average error should be zero — only uncertainties remain relevant.

PROPERTIES OF RADIATION DOSIMETERS

Dose-Rate Dependence

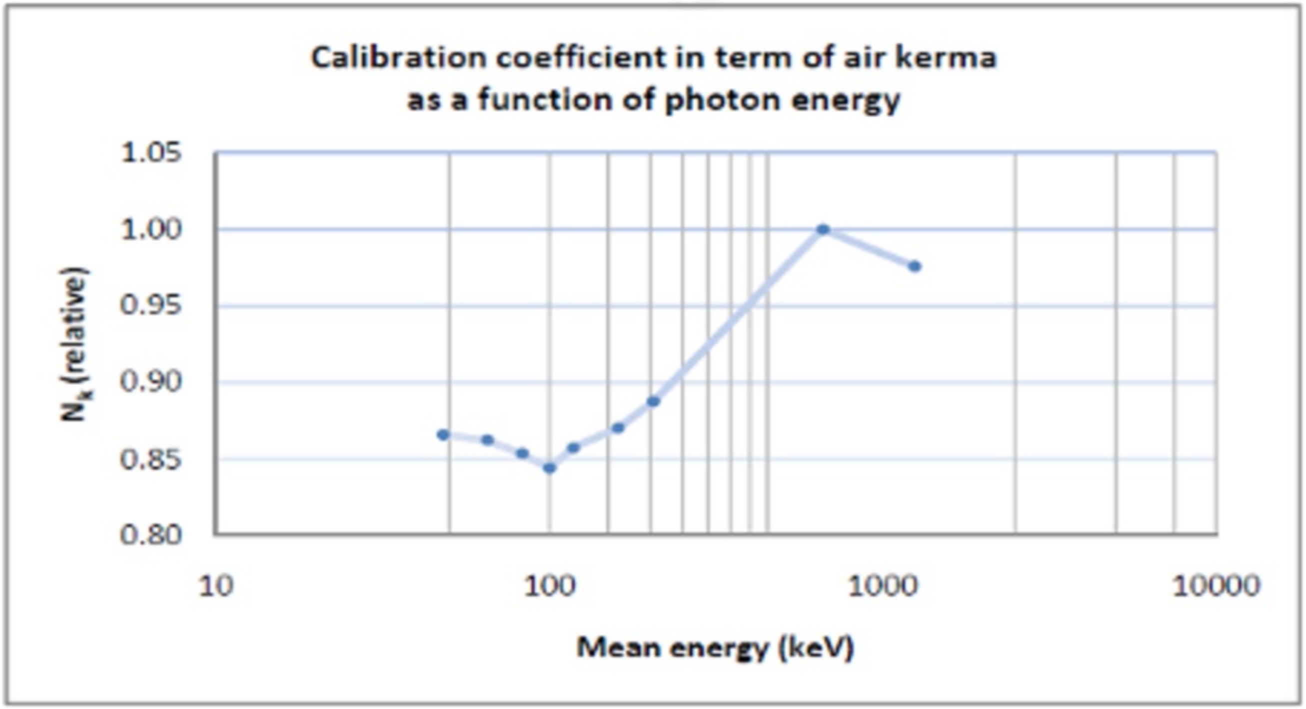
- Integrating dosimetry systems (accumulates dose) measure total dose in a period.
- Ideally, the response should remain constant at different dose rates
- In practice, dose rate can affect readings → corrections may be needed
- Example: recombination corrections in ionization chambers in pulsed beams.



PROPERTIES OF RADIATION DOSIMETERS

Energy Dependence

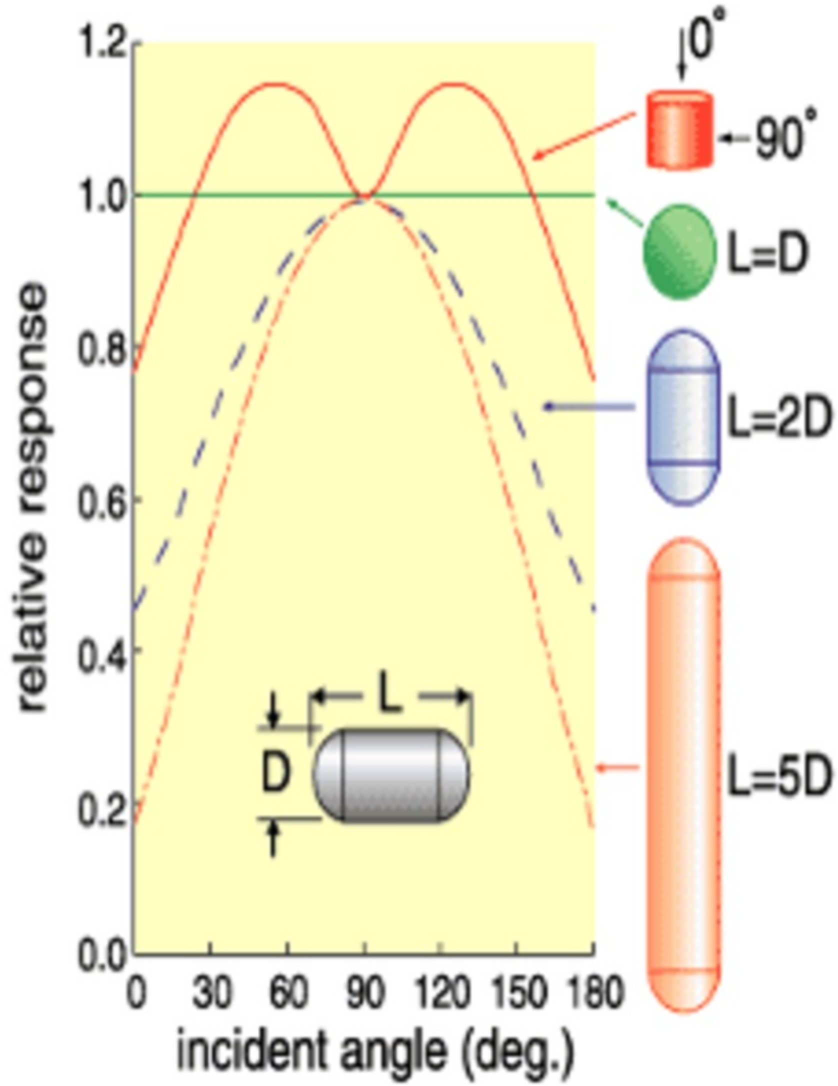
- Response varies with radiation beam quality (energy).
- Dosimeters are calibrated at a reference energy, but may be used across wider ranges.
- Ideally: Flat energy response (energy-independent)
- Reality: Energy correction factors are needed.



PROPERTIES OF RADIATION DOSIMETERS

Directional (Angular) Dependence

- Dosimeter response changes with angle of radiation incidence
- Due to physical shape, internal structure, and energy
- Importance:
  - Personnel monitoring, where dosimeters may be exposed from many angles during work movements,
  - In vivo dosimetry, particularly when using small semiconductor diodes placed on patients,
  - Complex fields, such as interventional fluoroscopy, where scatter dominates.

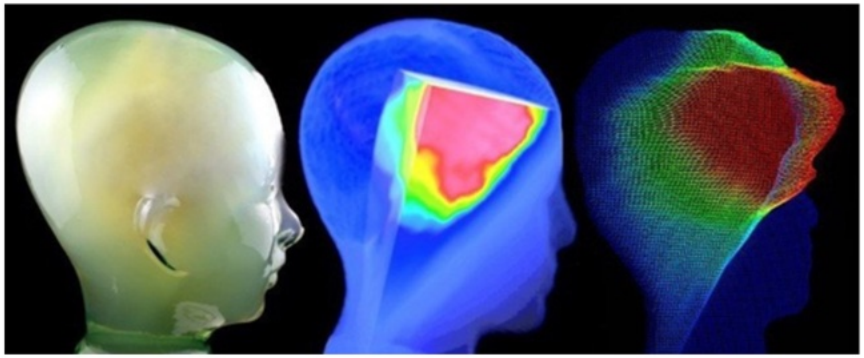


PROPERTIES OF RADIATION DOSIMETERS

Spatial Resolution & Physical Size

- Ability to distinguish **dose variations over small distances**
- Like **image sharpness** in a photo
- Small dosimeter → more detail
- Large dosimeter → averaged result
- Important near edges and small areas
- Trade-off: high resolution vs signal strength

Ion chambers



Gel dosimeter

Ring TLD

Eye lens TLD

Wrist TLD

PROPERTIES OF RADIATION DOSIMETERS

Stability before irradiation

- The characteristics of a dosimeter should be stable with time until it is used
- **Effects of temperature, atmospheric oxygen or humidity, light**, and so on can cause a gradual change in the dose sensitivity or the instrumental background
- The latent reading in some types dosimeters (e.g., photographic, chemical, solid-state) may be unstable, suffering "fading" losses during the time interval between irradiation and readout

RADIATION DOSIMETRY SYSTEMS

- Ionization chamber dosimetry systems
    - Dose Calibrator
- Personnal Dosimeters
    - Luminescence Dosimetry
- Survey Meters
- Contamination Monitors
- Area Monitors

Ion Chamber

- Standard instrument for **absolute dose measurement** and **beam calibration**
- Widely used in **radiotherapy** and **diagnostic radiology**
- Constructed as a **gas-filled cavity detector**
- Consists of a conductive **outer wall** and a **central collecting electrode**
- Polarizing voltage applied to **collect ionization charge**
- Guard electrode reduces leakage current and improves stability

Key principle:

- Collected charge ∝ energy deposited in the gas

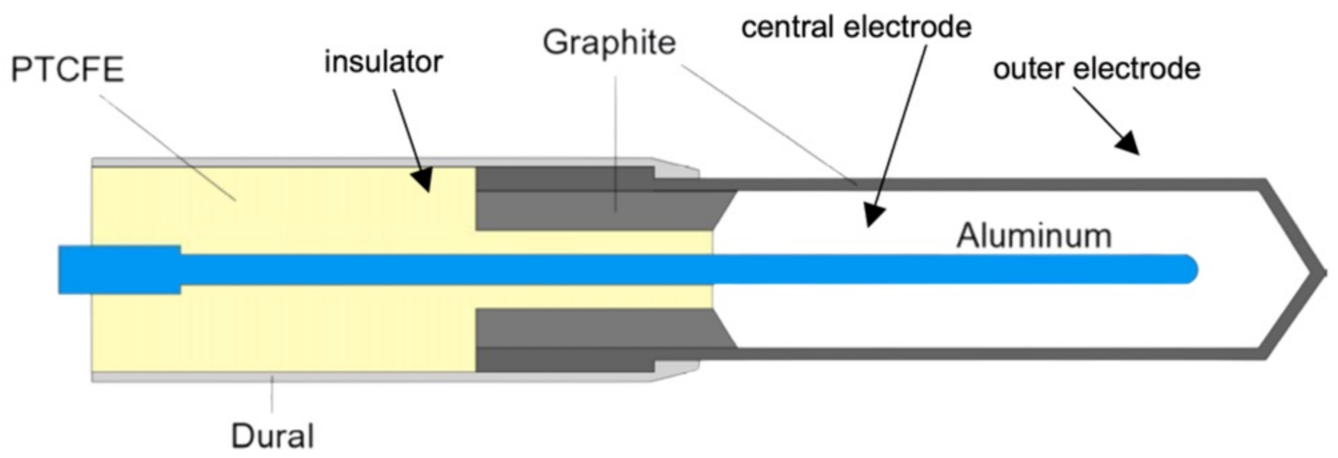
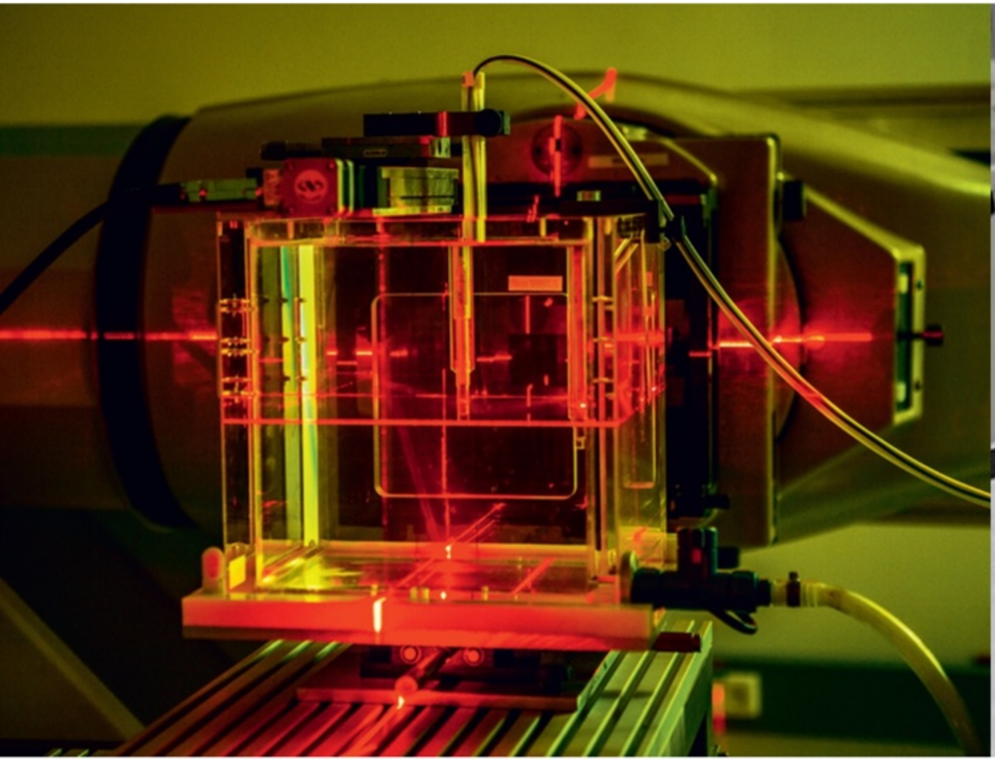
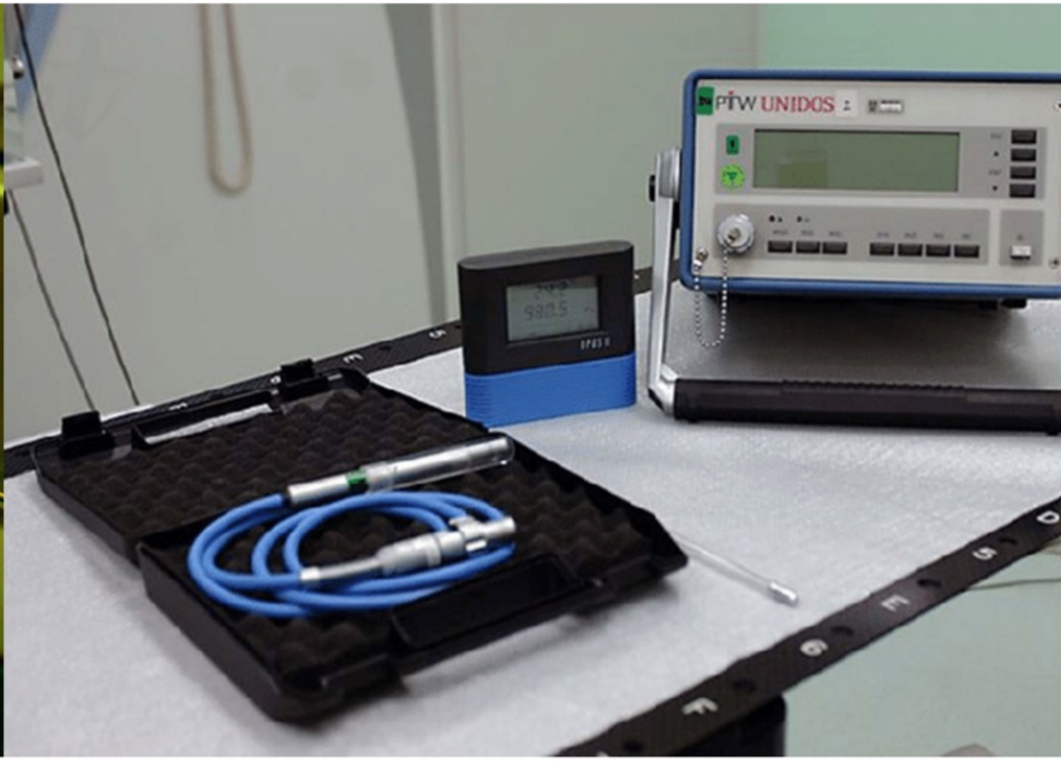


FIG. 3.2. The basic design of a cylindrical Farmer-type ionisation chamber.

Electrometer (with Ion Chamber)

- Measure extremely **small electrical currents** (≈ 10^{-9} A or lower)
- Used with ionization chambers to measure collected charge or current
- Operate as high-gain amplifiers with standard resistor or capacitor feedback

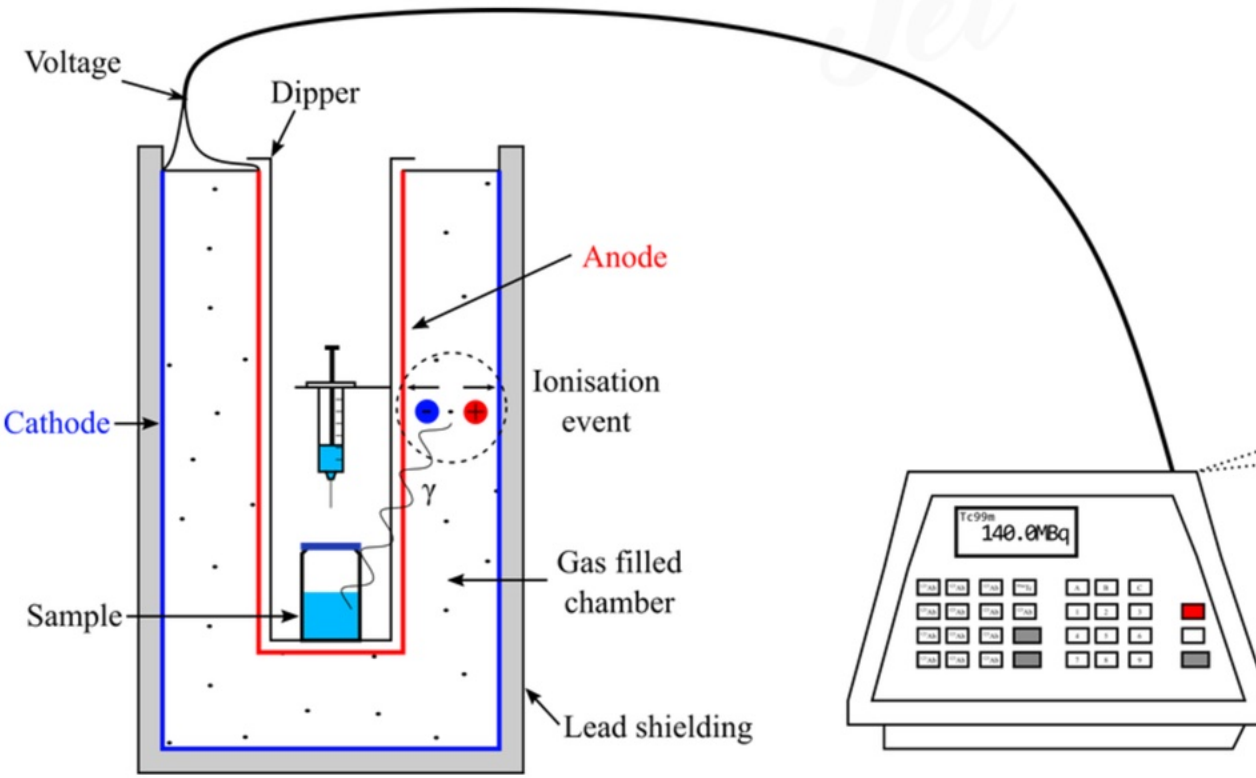


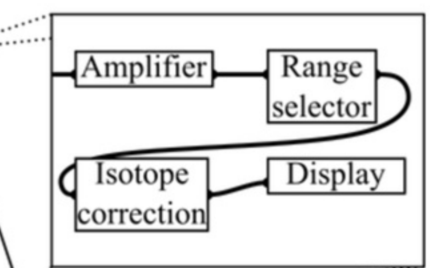


IONIZATION CHAMBER SYSTEMS

Radionuclide Calibrator / Dose Calibrator (Well-type)

- measures activity in **syringes** and **vials**
- used before **radiopharmaceutical administration** or **dispensing**
- requires constancy, accuracy, linearity, geometry, and background checks
- Unit meas: **Ci or Bq**
- calibration must be traceable





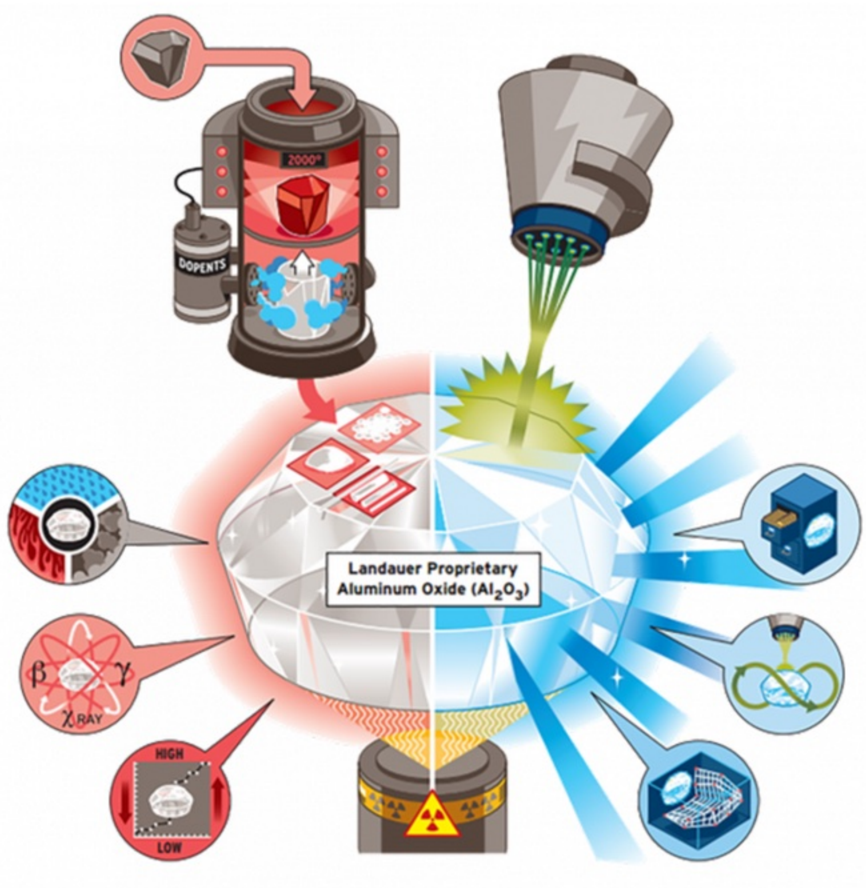
FILM DOSIMETRY

Radiographic Film

- Acts as a **radiation detector** and **2D dose image**
- Records dose as a **darkened film image**
- Made of plastic film with **silver bromide** (**AgBr**)
- Radiation creates a **latent image** → visible after chemical development
- Dose response measured via Optical Density **(OD): $OD = \log_{10}(I_0 / I)$**
- Darkness of film relates to radiation dose
- Limited dose range, strong energy dependence, sensitive to handling
- Radiation quality measured: Effective Dose (Sv)

LUMINESCENCE DOSIMETRY

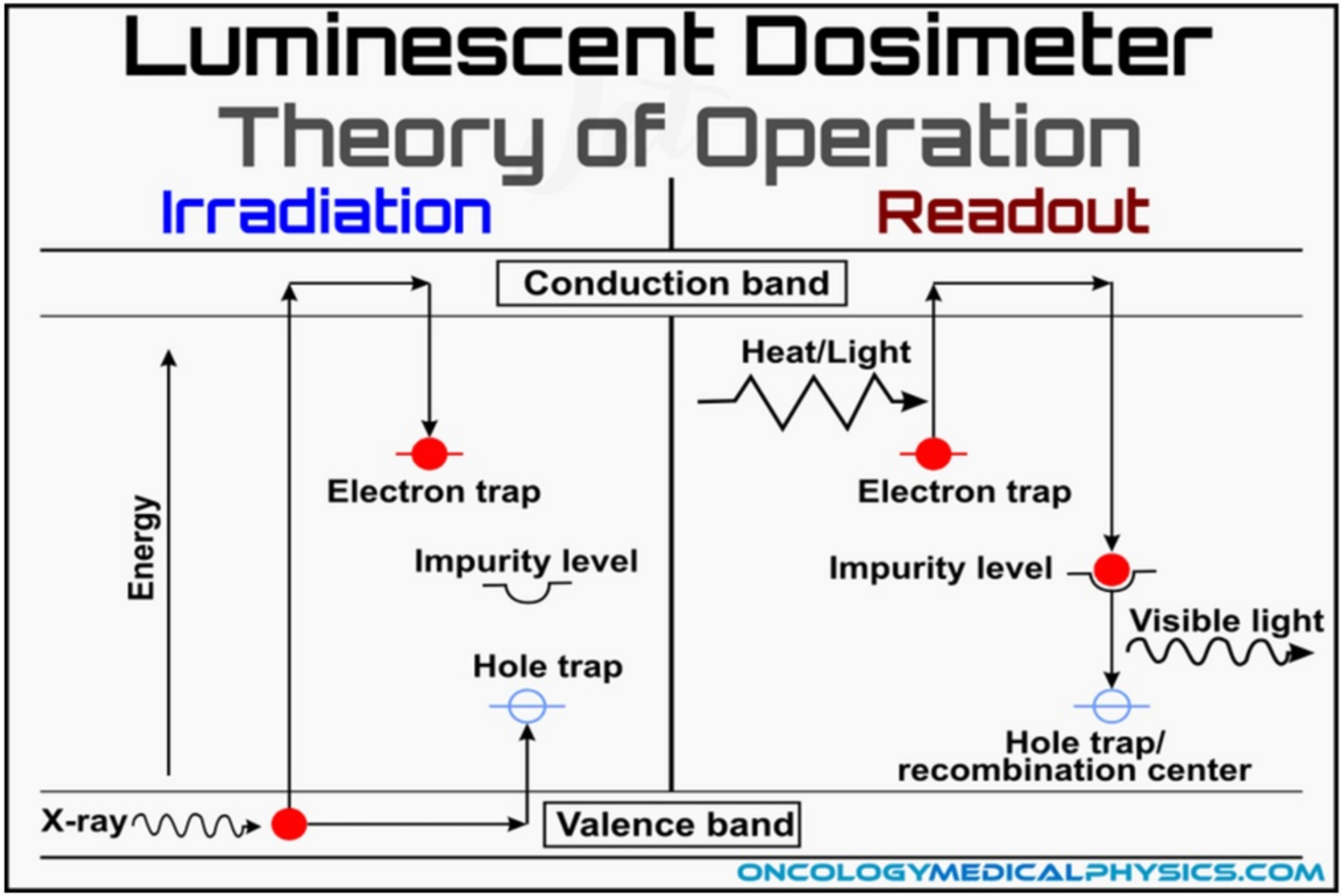
- Some materials store energy after radiation exposure and later release it as light (luminescence)
- Two types by stimulation method:
  - **TLD** = thermoluminescence (stimulated by **heat**)
  - **OSL** = optically stimulated luminescence (stimulated by **light**)
- Typically used in personnel dose monitoring



LUMINESCENCE DOSIMETRY

Mechanism

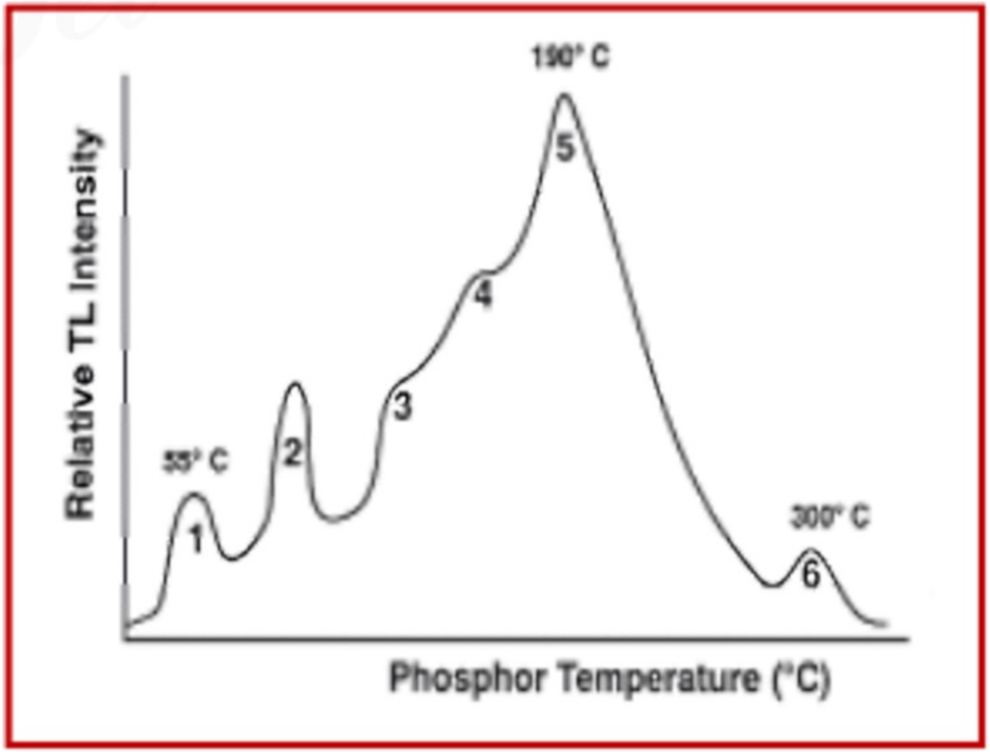
- Radiation creates **electron–hole pairs** that become **trapped** in crystal defects
- When stimulated, trapped charges recombine → **light emitted ∝ dose**
- Light output measured using photomultiplier tubes (**PMTs)** or **photodiodes**



LUMINESCENCE DOSIMETRY

THEMOLUMINESCENCE DOSIMETER (TLD)

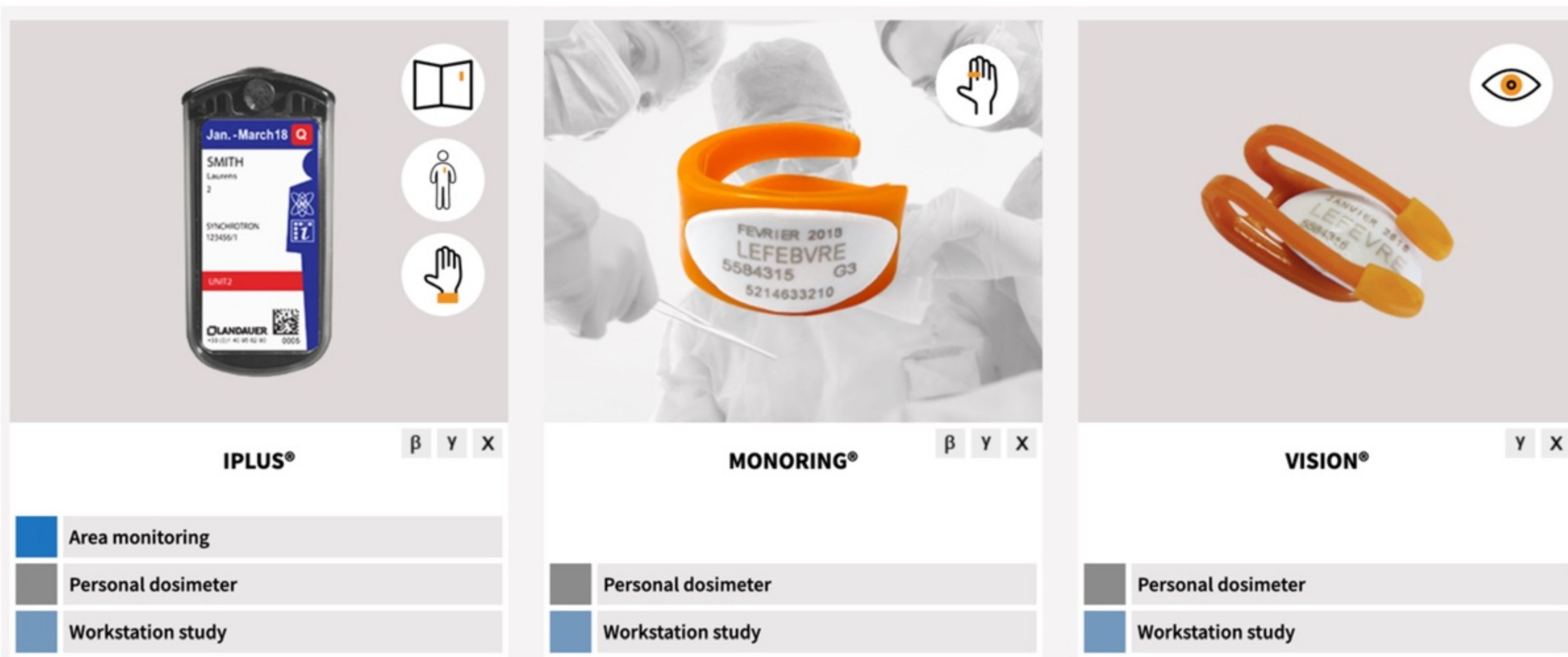
- Common TLD materials: **LiF:Mg,Ti, LiF:Mg,Cu,P, $Li_2B_4O_7$:Mn**
- Available as powders, chips, rods, ribbons
- After reading, **signal is already lost/erased** due to heat (annealing)
- Output appears as glow curve; **area under curve ∝ dose**
- Subject to **fading, energy dependence, and non-linearity** at high doses



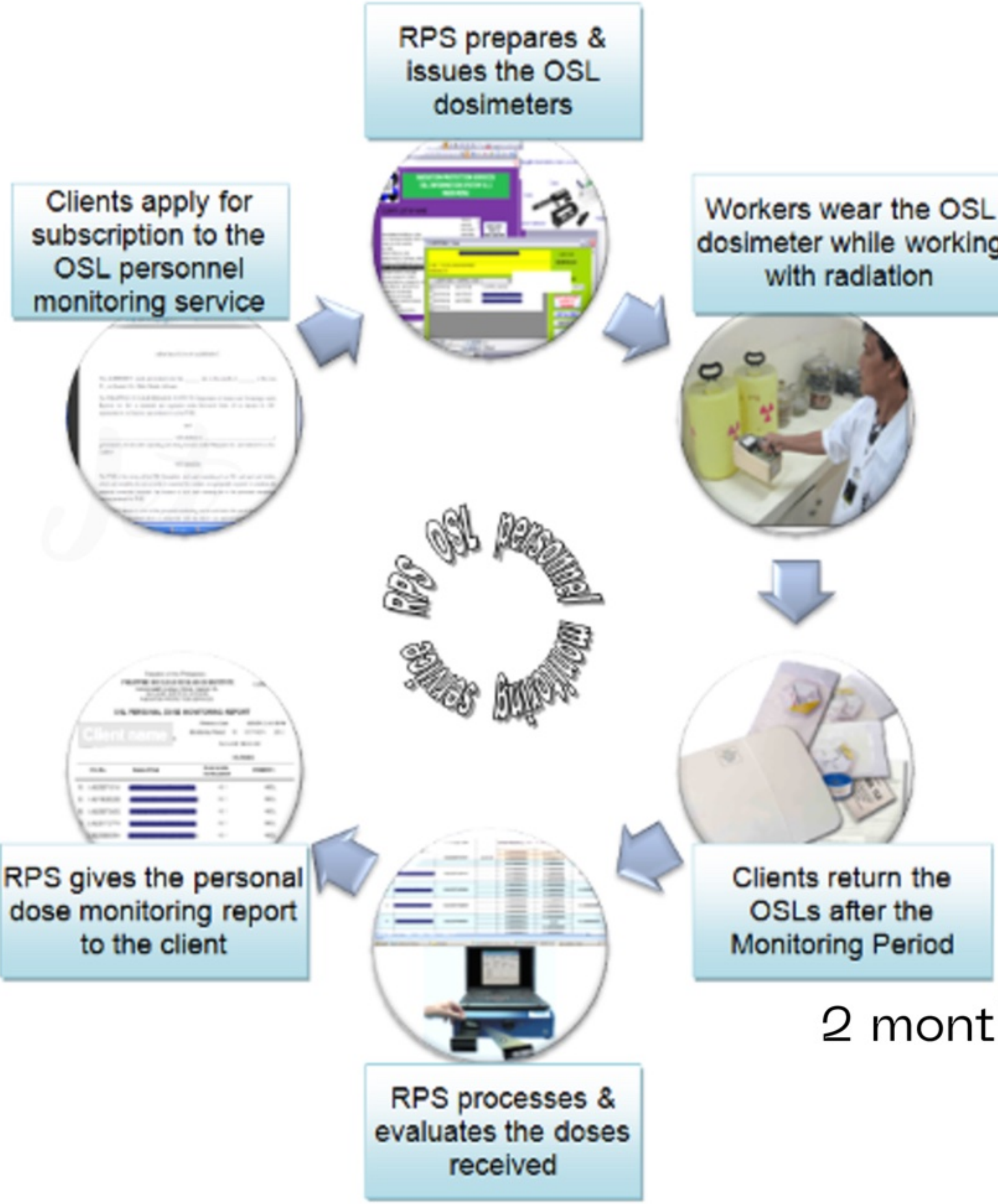
OPTICALLY STIMULATED LUMINESCENCE (OSL) DOSIMETER

- Radiation energy is stored in the detector
- **Light stimulation** releases the stored signal
- Made of solid materials (e.g. **Al_2O_3:C, BeO**)
- Can be **read multiple times**
- Wide dose range and good sensitivity
- Used for **personal and area monitoring**

Radiation quantity measured:
Effective Dose (Sv)
Deep Dose (10 mm) [Hp(10)] (Sv)
Shallow dose (0.07 mm) [Hp(0.07)] (Sv)



OSL Service Process



2 months

https://services.pnri.dost.gov.ph/portal/Appoint/schedule

Sample OSL Dose Report

Republic of the Philippines
Department of Science and Technology
PHILIPPINE NUCLEAR RESEARCH INSTITUTE

Radiation Protection Services Section Laboratory
PERSONAL DOSE MONITORING REPORT

OSL PERSONNEL MONITORING SERVICE

1. *Customer Name:*
   Customer Code:
2. *Address:*
3. *Contact:*
4. *Monitoring Period (MP):* JUL-AUG 2025
5. *Classification:* SERVICE PROVIDER

METHOD USED:

Purpose:	Assessment of occupational exposure due to external sources of radiation.
Dosimeter System:	InLight XA Whole Body Optically-Stimulated Luminescence Dosimeter (OSLD)
Algorithm:	InLight LDR Model 2-NVLAP[A] Algorithm
Quantity and Unit:	Doses are reported in terms of Personal Dose Equivalent Hp(10) and Hp(0.07)[B] in units of milli-Sievert (mSv).
Traceability:	Results are traceable to the National Institute of Standards Technology (NIST).

REMARKS:

Below MDL - the evaluated radiation dose is below the Minimum Detection Limit (MDL) of the dosimeter. Any evaluated dose below this level is not recordable and not considered as occupational exposure. The MDL of the OSLD system is 0.10 mSv.

Below or Above IL - the evaluated dose is below or above the Investigation Limit (IL). For Below IL, dose levels are within prescribed safety limits, and no immediate radiation controls from the RPO are necessary. For Above IL, the RPO should initiate the review of the facility's radiation safety program and investigate why the personnel was exposed to such level. Additional radiation controls and safety measures may be introduced as necessary. The equivalent IL is 0.50 mSv per month for Hp(10) and 12.50 mSv per month for Hp(0.07).

Above AL - the evaluated dose has reached the Action Level (AL) and exceeded the dose limit for that monitoring period. The monthly AL limit for Hp(10) is 1.67 mSv and for Hp(0.07) is 41.67 mSv, and continued exposures to such levels may lead to over exposure. The RPO should therefore take necessary actions to ensure that the doses received by the personnel are as low as reasonably achievable (ALARA).

Ratio Error (RAT Error) - OSLD reading errors occur when they are exposed abnormally, such as being partially shielded by certain artifacts, used without the dosimeter holder, and/or worn without following the proper orientation, among other reasons.

Damaged/Opened Dosimeter/Returned without Security Pin - the returned dosimeter was returned damaged, opened or removed without security pin. The dosimeters are locked inside the plastic badge holder and must not be opened or removed in any way as it may damage the dosimeters or affect the accuracy of the dose evaluation.

Exposed Control - during evaluation of the dosimeters, the control badge was found to exceed the limit for the monitoring period. The RPO should conduct investigation to determine the cause of this occurrence. Please be guided that the control badge should be placed in a normal background area, away from radiation sources.

The reported doses reflect results of the processing and evaluation of dosimeter when it was received by the RPSS Laboratory. The laboratory is not responsible for the veracity of the results as affected by the collection, receipt, manner of use, and handling of the dosimeter while in custody with the customer.

[A]Whole Body Dose Algorithm for the Landauer InLight Model 2 Dosimeter. (2003). Stanford Dosimetry LLC, Anacortes, WA.
[B]Not within the scope of ISO 17025:2017 accreditation

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CERTIFIED CORRECT:

Analytical Team Leader

Address: Commonwealth Avenue, Diliman, Quezon City
PO Box 213 UP Quezon City | PO Box 923 Manila | PO Box 1314 Central, Quezon City
Telephone (632) 8929-60-10 to 19 local 262 | Email: rps@pnri.dost.gov.ph

Radiation Protection Services Section Laboratory
PERSONAL DOSE MONITORING REPORT
OSL PERSONNEL MONITORING SERVICE

Customer Name: *Monitoring Period (MP):* JUL-AUG 2025

Customer Code: *Subscription Type:*

Reference Date	Return Date	Report Date
July 04, 2025	September 02, 2025	October 03, 2025

Serial Number	Name of User	Hp(10) in mSv[C]	Remarks	Hp(0.07) in mSv[D]	Remarks
XA02928423E	CONTROL BADGE	<0.10	Below MDL	<0.10	Below MDL
XA02807110X		<0.10	Below MDL	<0.10	Below MDL
XA029283765		<0.10	Below MDL	<0.10	Below MDL
XA03095596V		<0.10	Below MDL	<0.10	Below MDL
XA027833637		<0.10	Below MDL	<0.10	Below MDL
XA03437578Z		<0.10	Below MDL	<0.10	Below MDL
XA03094498U		<0.10	Below MDL	<0.10	Below MDL
XA03076676Y		<0.10	Below MDL	<0.10	Below MDL
XA03099782W		<0.10	Below MDL	<0.10	Below MDL
XA033544848		<0.10	Below MDL	<0.10	Below MDL
XA030318759		<0.10	Below MDL	<0.10	Below MDL
XA03353120T		<0.10	Below MDL	<0.10	Below MDL
XA036192967		<0.10	Below MDL	<0.10	Below MDL
XA02625348A		<0.10	Below MDL	<0.10	Below MDL
XA030961764		<0.10	Below MDL	<0.10	Below MDL
XA03412606H		<0.10	Below MDL	<0.10	Below MDL
XA03094995Q		<0.10	Below MDL	<0.10	Below MDL
XA030942772		<0.10	Below MDL	<0.10	Below MDL
XA03030309J		<0.10	Below MDL	<0.10	Below MDL
XA03619411L		<0.10	Below MDL	<0.10	Below MDL
XA029426836		<0.10	Below MDL	<0.10	Below MDL

[C]The relative expanded uncertainty in the measurement of Hp(10) is 16% at k=2 and 95% confidence level.
[D]Hp(0.07) is not within the scope of current ISO 17025:2017 accreditation

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ANALYZED BY

Laboratory Analyst

SURVEY METER

- Portable radiation monitoring instruments used to measure **radiation levels in an area**.
- Used for area monitoring, hot lab checks, and radiation safety surveys
- Helps detect radiation hotspots, source leakage, or contamination
- Common units: **μSv/h, mSv/h, cps, or cpm**
- Common types: GM survey meter, ion chamber survey meter, scintillation survey meter
- Must be calibrated regularly and checked before use

CONTAMINATION MONITORS

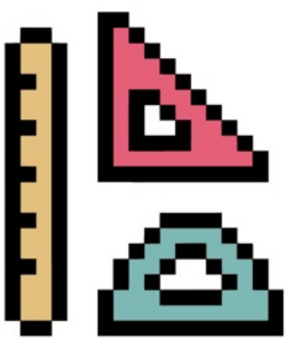
- Radiation instruments used to detect **radioactive contamination on surfaces, objects, hands, shoes, or clothing.**
- Used for surface contamination checks in hot labs, injection rooms, and waste areas
- Helps detect spills, leaks, or accidental spread of radioactive material
- Commonly used after handling **unsealed** radioactive sources
- Readings may be displayed in **cps, cpm, Bq/cm², or kBq/m²**
- Common detector types: GM pancake probe, scintillation probe, proportional counter

AREA MONITORS

Fixed or portable radiation monitoring instruments used to continuously measure radiation levels in a specific area.

- Installed in areas where radiation levels may change, such as **hot labs, cyclotron rooms, PET facilities, waste storage areas,** and **controlled areas**
- Provides **real-time dose rate monitoring**
- May include **visual** and **audible** alarms when radiation levels exceed preset limits
- Helps support **occupational safety**, **access control**, and **emergency response**
- Common units: **μSv/h or mSv/h**

INTERNATIONAL MEASUREMENT SYSTEMS

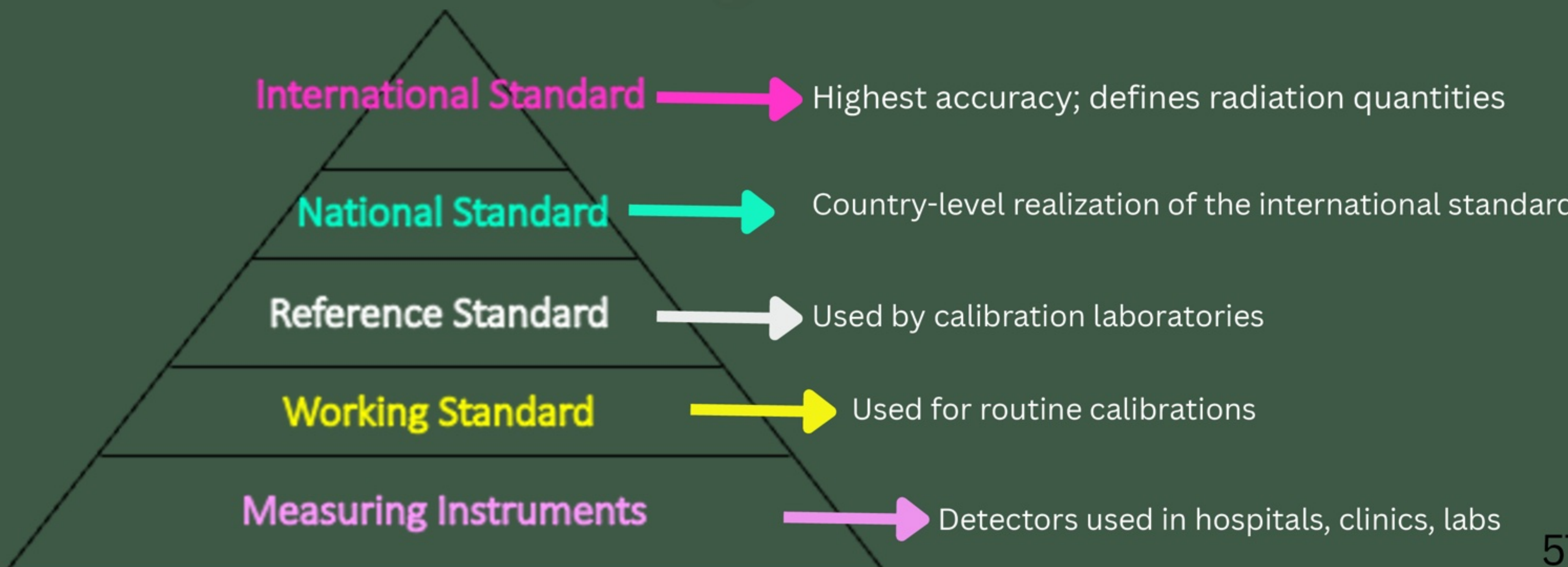


International Measurement System (IMS) for Radiation Metrology

- Ensures consistent and accurate radiation dose measurements worldwide
- Achieved through calibration traceability to international standards
- Connects user instruments to primary reference standards
- Maintained through a hierarchy of standards laboratories

KEY LABORATORIES:

Primary Standards Dosimetry Laboratory (PSDL)
Secondary Standards Dosimetry Laboratory (SSDL



INTERNATIONAL MEASUREMENT SYSTEM (IMS) FOR RADIATION METROLOGY

PRIMARY STANDARDS DOSIMETRY LABORATORY (PSDL)

- A national standardizing laboratory designated for the purpose of developing, maintaining & improving primary standards in radiation dosimetry
- A primary standard is an instrument of highest metrological quality that permits determination of the unit of a quantity from its definition
- At least 20 affiliated PSDLs participating in the IAEA/WHO network.

INTERNATIONAL MEASUREMENT SYSTEM (IMS) FOR RADIATION METROLOGY

SECONDARY STANDARDS DOSIMETRY LABORATORY (SSDL)

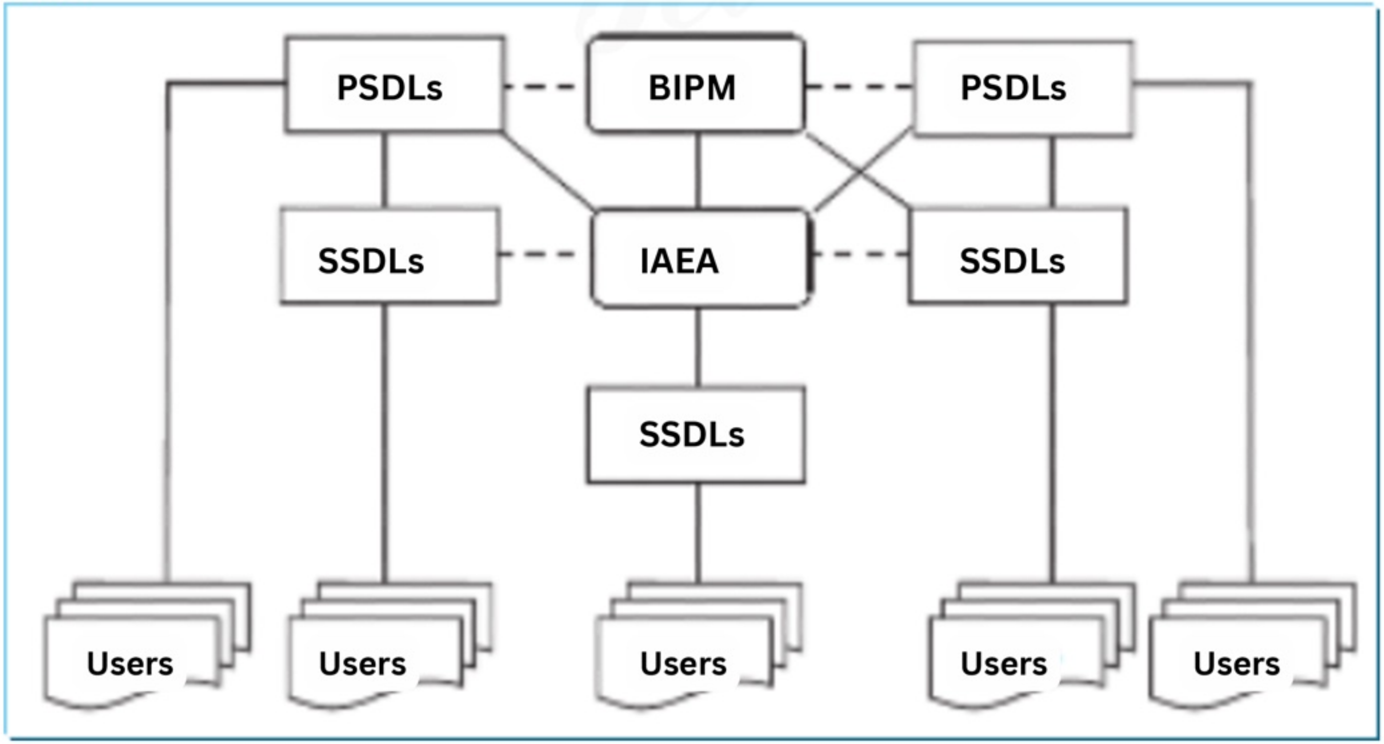
- National laboratory authorized to provide dosimeter calibration services
- Maintains secondary standards calibrated against a primary standard
- Serves as the link between PSDLs and users (hospitals, clinics, industry)
- Ensures traceability of measurements to international standards

Under the RA 9236: National Metrology Act 2003

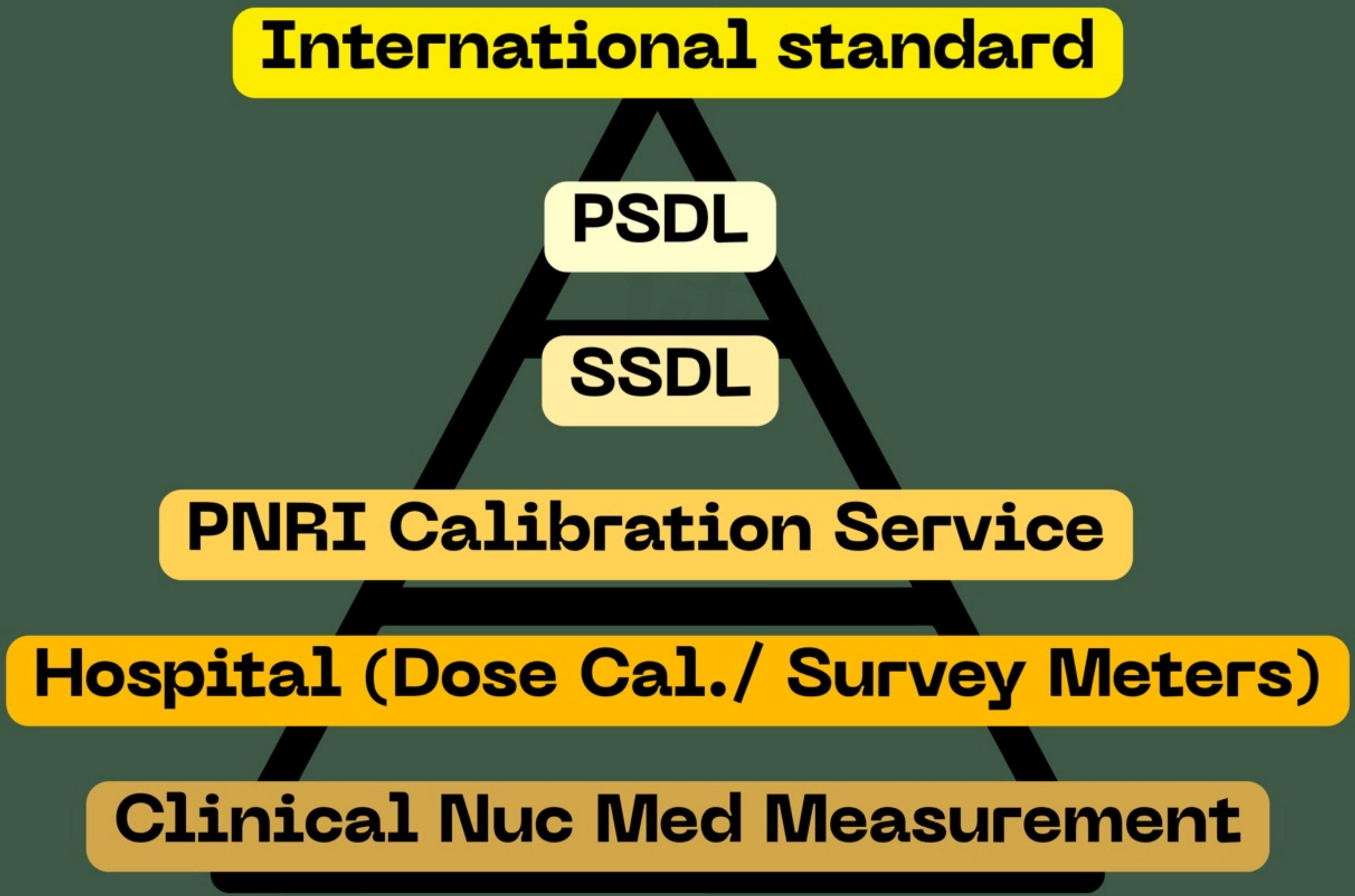
- 2 SSDLs in the PH: PNRI & DOH SSDLs are the highest accuracy in the metrological pyramid in the country
- All measures & equipment shall be internationally traceable the national metrology laboratory

International Measurement System (IMS) for Radiation Metrology

- Calibration follows a **hierarchy of standards**
- Each instrument is calibrated against a higher-quality reference
- Traceability continues **step-by-step** up to the national and international level
- Ensures consistency and comparability of dose measurements worldwide



International Measurement System (IMS) for Radiation Metrology



SUMMARY

- Personnel radiation dosimetry involves the measurement and assessment of radiation doses received from external and internal sources.
- Radiation dose quantities describe different aspects of exposure:
  - Exposure – Roentgen (R): amount of ionization in air
  - Absorbed dose – Gray (Gy): energy absorbed per unit mass
  - Equivalent / effective dose – Sievert (Sv): biological effect of radiation
- Radiation dosimetry systems
- International Measurement System (IMS) ensures accuracy, consistency, and traceability of radiation measurements through national and international standards.

References

[1] “What is Dosimetry? Facts & Fundamentals.” Landauer, Inc. Blog, 9 April 2024.
[2] International Atomic Energy Agency. Occupational Radiation Protection: IAEA Safety Standards Series No. GSG-7. Vienna: IAEA, 2018.
[3] Boice Jr, J. D., et al. “Evolution of radiation protection for medical workers.” Radiology Physics & Technology, vol. 13, no. 3, 2020, pp. 187-196.
[4] ICRP, 1991. 1990 Recommendations of the International Commission on Radiological Protection. ICRP Publication 60. Ann. ICRP 21 (1-3).

Thank you for listening!!!