M. Marengo

MANAGEMENT OF RADIOACTIVE SOURCES CLASSIFICATION OF LABORATORIES

Medical Physicist
University of Bologna

mario.marengo@unibo.it

Outline

- Classification of areas
- Most used types of sealed sources
- Storage and inventory of sealed sources
- Record keeping in Radiopharmacy
- Examples of irradiation from most frequently used sources
- The patient as a soruce of radiation

Reference documents

- ICRP Publication 57 “Radiological protection of the worker in medicine and dentistry”. 1989

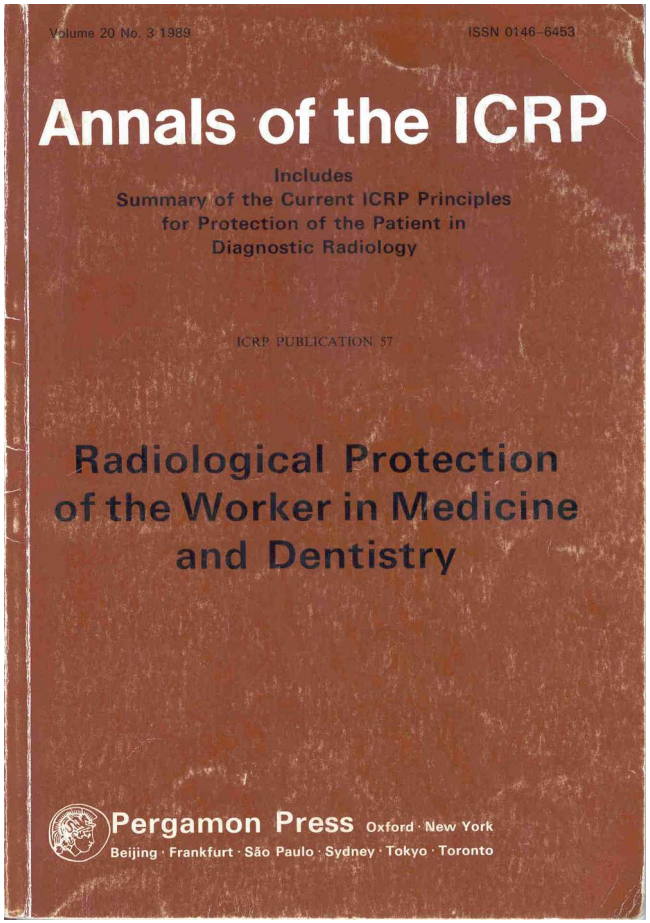
- ISO 7503-1 Standard: Evaluation of surface contamination -- Part 1: Beta-emitters (maximum beta energy greater than 0,15 MeV) and alpha-emitters. Ginevra, 1988

- Delcroix D. et al. “Radionuclide And Radiation Protection Data Handbook” 2nd Edition (2002). Radiation Protection Dosimetry Vol. 98 No 1, 2002

- IAEA: “Nuclear Medicine Physics a handbook for teachers and students”. IAEA, Vienna 2014.

- IAEA: “Radiation Protection and Safety in Medical Uses of Ionizing Radiation”. IAEA Safety Standards Series No. SSG-46 , 2018

- IAEA: “Nuclear Medicine Resource Manual. 2020 Edition”. Human Health Series No. 37, 2020.



Classification according to Publication ICRP 57

Class	Radionuclide	Weghting factor
A	^{75}Se, ^{89}Sr, ^{125}I, ^{131}I	100
B	^{11}C, ^{13}N, ^{15}O, ^{18}F, ^{51}Cr, ^{67}Ga, ^{99m}Tc, ^{111}In, ^{114m}In, ^{123}I, ^{201}Tl	1
C	^{3}H, ^{14}C, ^{81m}Kr, ^{127}Xe, ^{133}Xe	0.01

Type of operation or area	Weghting factor
Storage	0.01
Waste handling	0.1
Scintigraphic counting/imaging when administration is made elsewhere	
Patient waiting area	
Patient bed area (diagnostic)	
Local dispensing	1
Radionuclide administration	
Scintigraphic counting/imaging when administration is made in the same room	
Radiopharmaceutical preparation, simple	
Patient bed area (therapeutic)	
Radiopharmaceutical preparation, complex	10

Classification according to Publication ICRP 57

$$Risk_{Class} = Max_{Actvity}\left(MBq\right) \cdot W_{rn} \cdot W_{op}$$

Weighted activity	Category
Less than 50 MBq	Low hazard
50 to 50000 MBq	Medium hazard
Greater than 50000 MBq	High hazard

Example – Gammacamera diagnostic room

Radionuclide / Operation	Activity (MBq)	Weighting factor radionuclide	Weghting factor Type of operation	Weighted activity (Mbq)
Patient with 99mTc	1110	1	0.1	111
Patient administration with 99mTc	1110	1	1	1110
Patient with ^{131}I	185	100	0.1	1850
Patient with ^{201}Tl, ^{67}Ga, ^{111}In, ^{123}I	185	1	0.1	18.5
CQ with 57Co flood source	400	1	0.01	4
Installed 153Gd transmission source	5000	1	0.01	50

Max weighted activity (MBq)	Risk category	Classifcation
1850	Medium	Controlled Area

ICRP 57 – SPECT Radiopharmacy lab

Radionuclide	Activity (MBq)	Radionuclide weighting factor	Type of operation weighting factor	Weighted activity
Generators $^{99}Mo/^{99m}Tc$ (n. 4)	90000	1	1	90000
^{131}I	4000	100	0.01	4000
^{201}Tl, ^{67}Ga, ^{111}In, ^{123}I	400	1	0.01	4
^{90}Y	1000	100	1	100000

Max weighted activity(MBq)	Categoria di rischio	Classification
194004	HIGH	Controlled Area

Classification according to Publication ICRP 57

Category of hazard	Floor	Surfaces	Fume cupboard	Room ventilation	Plumbing	First aid
Low	Cleanable	Cleanable	No	Normal facilities	Standard	Washing
Medium	Non-permeable, easily cleanable	Cleanable	Yes	Good	Standard	Washing & decontamination facilities
High	Continuous sheet welded to walls	Cleanable	Yes	Extractor fan	May require special plumbing	Washing & decontamination facilities

?

Look at IAEA: "Nuclear Medicine Resource Manual. 2020 Edition". Human Health Series No. 37, 2020 for more recent information

Indications for classification of areas in IAEA SSG-46

4.65. Various areas and rooms in a nuclear medicine facility should be classified as controlled or supervised areas, in line with the requirements given in BSS.

Once designated, these areas should meet the requirements detailed in the BSS for controlled areas and for supervised areas, ***including requirements for area delineation, signage, protection and safety measures, control of access,*** provision of personal protective equipment, provision of individual and area monitoring, provision of equipment for monitoring for contamination, and provision of personal decontamination facilities.

All other rooms and areas, not so-designated, are considered as "public domain" and levels of radiation in these areas should be low enough to ensure compliance with the dose limits for public exposure. … it would be expected that final decisions by the licensee for a given medical radiation facility would be based on the expert advice of the medical physicist, qualified expert in radiation protection, or RPO …

Indications for classification of areas in IAEA SSG-46

From Para. 4.66.

In a nuclear medicine facility, rooms for:

- radiopharmaceutical preparation (i.e. radiopharmacies or hot labs)
- injection of the radiopharmaceuticals
- storage and decay of radiopharmaceuticals
- Imaging, particularly those housing radiopharmaceutical dispensing equipment (i.e. PET radiopharmaceutical and radioactive gas and aerosol dispenser devices)
- waiting rooms dedicated to patients who have been injected with radiopharmaceuticals (e.g. uptake rooms in a PET facility)
- hybrid machines that have an X ray component (SPECT-CT, PET-CT)
- patients undergoing radiopharmaceutical therapy

meet the criteria for controlled areas and should be so designated.

From Para. 4.67.

Supervised areas may include examination rooms with probes, gamma cameras (planar and SPECT systems, and PET scanners).

Type of sources – Sealed sources

In a Nuclear Medicine Department typically there is availbale a variety of sealed sources:

- ^{137}Cs and others radionuclide vials, to ckeck activity meters
- ^{57}Co flood sources, to test unifomity of gamma cameras
- Cylindrical or linear sources of $^{68}Ge/^{68}Ga$ for QC of PET/CT scanners
- Marker sources, of ^{57}Co or other

Sources should be properly identified and stored. Most have their proper shielded container, or are installed into a scanner.

Typical sealed sources used in NM

Typical radioactive sources used in NM include:

- Flood sources of ^{57}Co for testing uniformity of SPECT cameras;
- Other linear or quasi-puntiform sources for testing gamma cameras;
- Marker sources (pen like or quasi-puntiform) of ^{57}Co;

- Calibration sources for activity meters (^{137}Cs, ^{57}Co, ^{133}Ba, ^{60}Co):

- Test sources for uptake probes (in most cases ^{137}Cs):

- Linear sources of $^{68}Ge/^{68}Ga$ for calibration of PET scanners;
- Puntiform sources of ^{22}Na for calibration or test of PET scanners;
- Puntiform sources of of $^{68}Ge/^{68}Ga$ for testin alignement of PET-CT scanners;
- Calibration sources of $^{68}Ge/^{68}Ga$ for PET activity meters;

- Calibration / test sources for radiation protection insturments (frequently ^{137}Cs).

Keeping radioactive sources under control

In a Nuclear Medicine Department typically there is availbale a variety of sealed sources, e.g. for checking imaging equipment, activity meters, calibration of montoring instruments etc.

All of these sources should be kept under control:

- There should be an updated list of all sources.
- The place and condition for secure storing should be specified.
- All sources shoud be properly identified (labels, number).
- Sources should be periodically cross accounted.
- All sources should be regularly checked for any potential leakage.

Example of sealed sources inventory

Hospital ....

NUCLEAR MEDICINE UNIT – RADIOACTIVE LABORATORY SOURCES INVENTORY

Current date 23/04/2021

Nuclide	$T_{1/2}$ (years)	Serial Nr.	Calibration date	Activity at calibartion (Bq)	Activity at the current date (Bq)	Type of source / Geometry	Storage location	Date of the last test	Test results	Notes
Sources for gamma cameras										
Co-57	0.744	ASD-14253	01/06/2019	3.70E+08	6.33E+07	flood 40 x 50 cm	Lab ...		[] OK [] Not OK _____	
Sources for PET scanners										
Ge-68/Ga-68	0.742	EZ-879	25/07/2019	1.11E+08	2.17E+07	cilindro plastica	PET room 1		[] OK [] Not OK _____	
Sources for activity meters										
Cs-137	30.17	4354	25/10/2001	3.13E+06	2.00E+06	cilindro metallico	Lab. XZS		[] OK [] Not OK _____	
Co-57	0.744	AA123	01/06/2006	1.32E+06	1.23E+00	cilindro metallico	Lab ...		[] OK [] Not OK _____	
Ba-133	10.5	7578	29/04/1988	7.57E+06	8.57E+05	ampolla	Lab ...		[] OK [] Not OK _____	
Ge-68/Ga-68	0.742	X45	25/07/2009	1.99E+07	3.39E+02	cilindro plastica	Lab ...		[] OK [] Not OK _____	
Wide area beta sources for contamnation monitors										
Cl-36	3.01E+05	2100	18/12/1984	1.30E+02	1.30E+02	rettangolare 10x10 cm	Tehcnical room		[] OK [] Not OK _____	
Sr-90+Y-90	28.6	141	05/03/1991	1.23E+02	5.91E+01	rettangolare 10x10 cm	Tehcnical room		[] OK [] Not OK _____	
Sources for radiation procetion equipment										
Cs-137	30.17	EGDB1/969	17/12/2002	1.12E+09	7.33E+08	cilindro metallico	Tehcnical room		[] OK [] Not OK _____	
Cs-137	30.17	EGDC1/I	06/12/1990	5.00E+08	2.48E+08	cilindro metallico	Tehcnical room		[] OK [] Not OK _____	
Sources for upatke probe and gamma ray spectrometry										
Co-60	5.271	7275	08/09/1981	4.71E+04	2.56E+02	punti	Room xyz		[] OK [] Not OK _____	
Cs-137	30.17	8107	07/07/1981	4.61E+04	1.85E+04	punti	Room xyz		[] OK [] Not OK _____	
Eu-152	13.6	2481	14/02/1986	5.04E+04	8.37E+03	punti	Room xyz		[] OK [] Not OK _____	

Type of sources – Sealed sources

Nuclide	Costante Γ mSv/h per 1 MBq @ 100 cm	Typical activity of a MN sealed source (MBq)	Typical dose rate (uSv/h at 100 cm)	TVL (mm Pb)
Co-57	1.79E-05	370	6.6	0.9
Co-60	3.06E-04	2	0.6	45.3
Ga-68	1.34E-04	50	6.7	16.0
Ba-133	6.39E-05	9	0.6	5.7
Cs-137/Ba-137m	8.23E-05	7	0.6	21.8

The effective actity of sources may vary considerably; e.g. ^{68}Ge sources for scanners, according to the type, are in a range 1 – 10

- The emission from these sealed sources is limited, typically less than 10 µSv/h
- However they need to be handled, to be placed in position etc. At short distance, dose rates can be > 100 times greater !
- Handling time and close proximity should be kept to a minimum.
- Some quality control tests on scanners can take a long time; the presence of the sources must be clearly indicated.
- When not in use, sources should always be placed in their shielded containers and stored in the specified location.

Examples of containers for sealed sources

Testing sealed sources

- Monitoring of workplaces for surface contamination is not normally needed where only sealed sources are used.
- However, such sources may develop leaks and a programme of regular testing is needed.
- Testing at intervals of one or two years is normally adequate.

Type of sources – Packages for shipping radiopharmaceuticals

- Containers for shipment of radiopharmaceuticals are of approved type
- They include some shielding and containment, adequate to protect during transportation
- The are categorized on the base of the dose rate emitted
- In most part of the cases thaty are II-YELLOW
- In some case, e.g. some containers fo ^{18}F-FDG, may be III-YELLOW

Transport Index	Dose rate at the surface of the package H (mSv/h)	Category
0	H < 0.005	I - WHYTE
0 < IT < 1	0.005 < H < 0.5	II - YELLOW
1 < IT < 10	0.5 <H < 2	III - YELLOW
IT> 10	2 < H < 10	III - YELLOW

In most cases, dose rate at 100 cm < 5 μSv/h

Storage of sources

- In the past, was typical to ask that radioactive sources were stored in a “safe” ...
- This concept does not apply properly to medical applications and to the variety of sources used
- Radiopharmaceuticals may require specific conditions (e.g. temperature), or are best accomodated directly within an hot cell, or in a compartment of an hot cell
- Sealed sources are frequently too big to be placed in a safe, e.g. ^{57}Co flood sources
- It is necessary to have a variety of approaches, depending on the type of source, but keeping in mind the general principle of appropriate storage.

Security of sources

Security aspects also should be taken onto account at any stage of the process:

- All kind of sources should be secure at any time, from receipt to disposal
- Given the variability in type and size of sources, and in their location, the problem is not simply of storing in a “safe”, but of a general policy of control of access to the NM areas
- Security concepts should apply also to the storage of radioactive waste

RECORD KEEPING IN RADIOPHARMACY

IAEA "Operational Guidance On Hospital Radiopharmacy", STI/PUB/1342, 2008

The central objective of any documentation in Radiopharamcy is to provide an audit trail from the investigation request to equipment performance, the QC procedures and the administration of individual patient doses of radiopharmaceuticals.

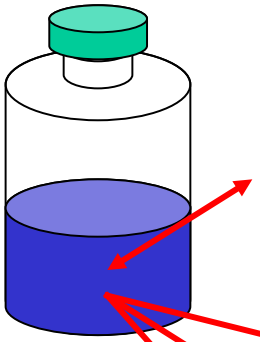
Records must be comprehensive and must cover all relevant details, such as:

- **Order**: date of order, supplier, type of preparation, quantity, expected delivery time
- **Reception**: time of delivery, received by, transport conditions, person checking and accuracy of delivered items (e.g. quantity and radioactivity)
- **Preparation & dispensing**: description of the product, including the radionuclide, product identification number, activity at the time of patient administration, volume, time of dispensing, patient's name, date, operator and checker id.

All of the above should be aimed to grant proper traceability of each radiopharmacetuical administered to a patient to the original product

See also SSG.46 para 4.81

Type of sources – Vials for radiopharmaceuticals



At short distance the contribution of beta particles to the dose may be predominant
depending strongly on type of material and thickness of the container

^{201}Tl at 100 cm 0.01 μSv/h per MBq

^{99m}Tc at 100 cm 0.02 μSv/h per MBq

^{18}F at 100 cm 0.14 μSv/h per MBq

Most important SPECT radionuclides

Radionuclide	T1/2 (h)	β Radiation (Avg Energy, MeV) > 10%	γ Radiation (MeV) > 1%	Specific Γ emission constant (μSv/h.MBq a 100 cm)
Ga-67	78.24	Auger 1.12E-3 , IC 8.65E-2	0.090, 0.184, 0.300	0.019
Tc-99m	6	Auger 7.63E-4, IC 1.39E-2	0.14	0.015
In-111	67.2	Auger 1.04E-3, IC 1.77 E-1	0.171, 0.245	0.076
I-123	13.2	Auger 2.3E-3 , IC 1.32E-1	0.159	0.038
I-131	192	1.82E-01	0.364	0.052
Tl-201	73.06	Auger 3.9E-3 , IC 2.70E-2	0.073 (X), 0.135, 0.167	0.011

Most important PET radionuclides

Radionuclide	$T_{1/2}$	β+ Emax (MeV)	Specific Γ emission constant (mSv/h per MBq a 100 cm)
^{11}C	20.5 min	0.96	0.148
^{13}N	9.96 min	1.19	0.148
^{15}O	122 sec	1.73	0.148
^{18}F	109.7 min	0.63	0.143
^{68}Ga	68 min	1.90	0.134

Examples of external irradiation from vials and syringes

- Handling a ^{99m}Tc unit dose — 1500 μSv/ora (hands)
- Handling a ^{99m}Tc vial — 7000 - 8000 μSv/ora (hands)
- Transporting the container of a ^{99m}Tc dose — < 20 μSv/ora (trunk)

Only Gamma dose !

(… when handling ^{111}In, ^{201}Tl ecc., beta/electrons radiation should be considered !)

- Hands should be maintained inside a hot cell only for the strictly necessary time
- When you are not using your hands (i.e. when measuring activity) take them out of the cell !
- Whenever possible, use shields for vials and syringes every
- Always close the cell's doors, when not in use
- Carefully follow your Operating Instructions

Examples of shieldings for vials and syringes, for use with ^{99m}Tc

Tungsten shields for vials
Typical thickness 4 – 6 mm W
Approx. Weight ~ 1.5 kg

Syringe transport carriers
Typical thickness 3 / 6 mm Pb
Approx. Weight 4 / 8 kg

Tungsten shields for syringes
Typical thickness 2 mm W, or leaded glass equivalent to 2 – 2.5 mm Pb
Approx. Weight ~ 0.2 kg

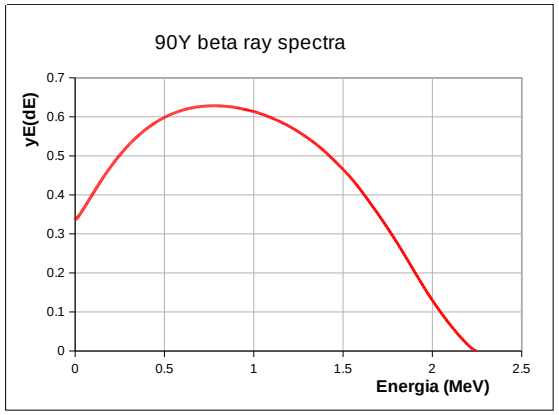
Examples of irradiation from ^{18}F

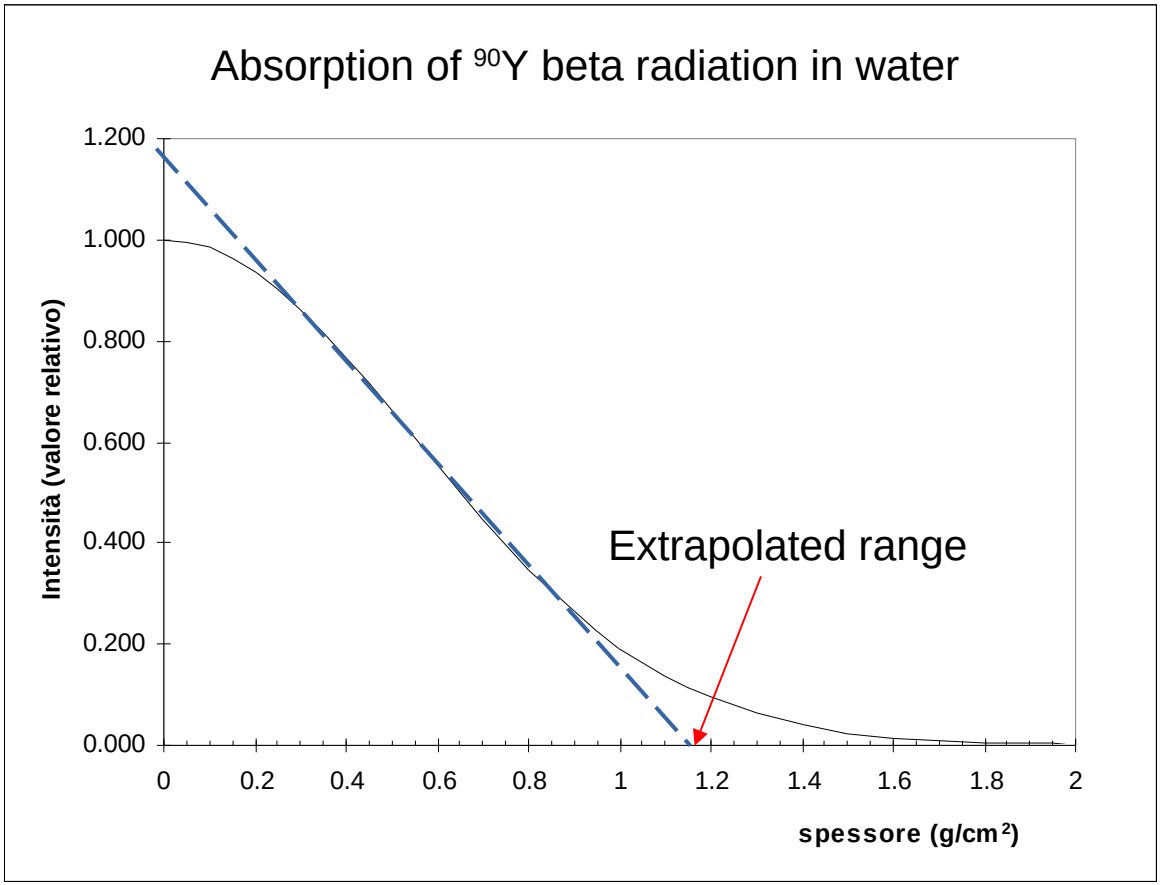
- manipulation of a unit dose of ^{18}F-FDG, no shielding — 6000 - 7000 µSv/h (hands)
- manipulation of a vial of ^{18}F-FDG, no shielding — 160000 µSv/h (hands)
- transport of a unit dose of ^{18}F-FDG, "typical" shielding — < 150 µSv/h (trunk)
- opening of a dispensing cell with residual activity at end of cycle (*depends strongly on the type of dispenser …*) — ~ 200 µSv/h (trunk)

Only Gamma dose ! Positrons increase significantly these values !
….calculations for gammas are much easier ….

- Hands should be maintained inside a cell only for the strictly necessary time
- When you are not using your hands (i.e. when measuring activity) take them out of the cell !
- Whenever possible, use shields for vials and syringes every
- Always close the cell's doors, when not in use
- Carefully follow your Operating Instructions

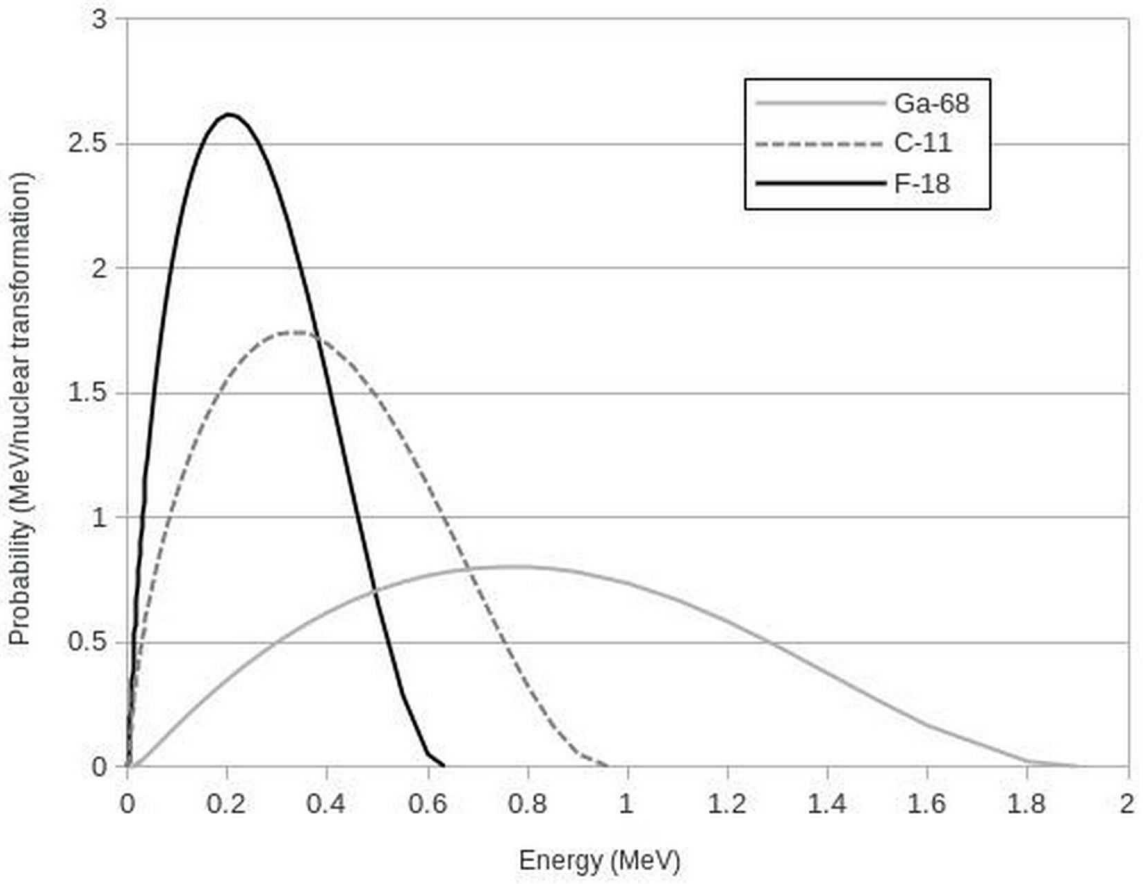
Irradiation from beta particles





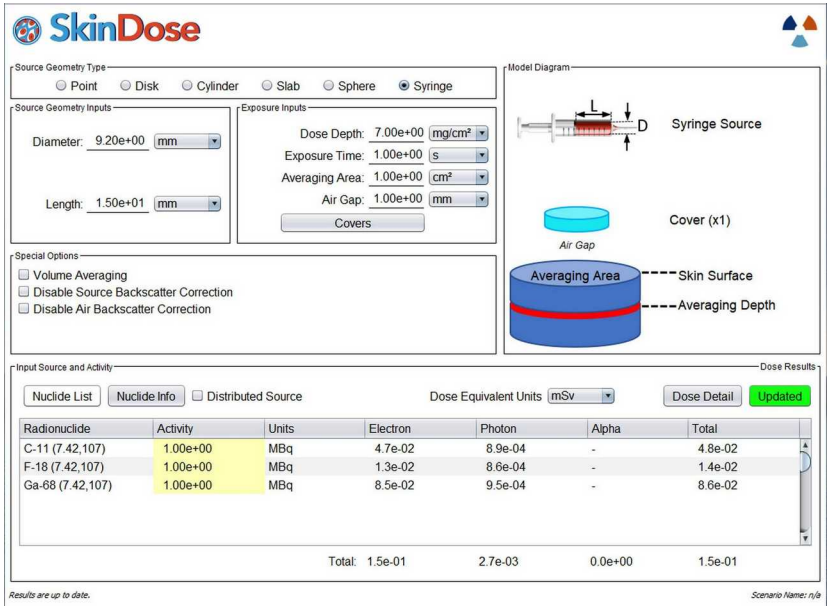
Handling radionuclides, which are intense beta emitters, can result in a high dose equivalent to the hands. This is particularly important in the case of radionuclides used in therapy.

Irradiation from positrons is not negligible

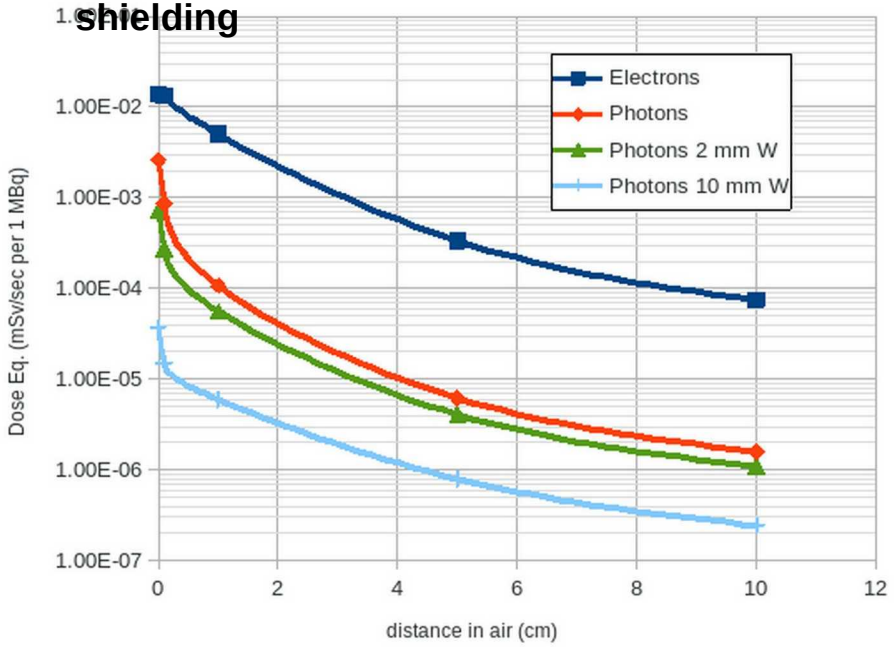


Self-absorption within the radiopharmaceutical and absorption in the syringe wall does not sufficiently reduce the radiation from positrons, especially in syringes smaller than 10 mL

Irradiation from positrons is not negligible



Dose in mSv to 1 cm² of skin per 1 MBq of ^{18}F per 1 second irradiation 3 mL syringe, no shielding



It is important that staff manipulating radiopharmaceuticals understands that the **biggest contribution to radiation dose from handling positron emitters** is not due to the high energy of the gamma photons, but **due to the positrons**.

Handling positron emitters without syringe shields, even for a small number of operations, can lead to exceeding the dose limit.

Protection from irradiation when injecting

- Syringes should ALWAYS be shielded during administration

- Not using shields is UNJUSTIFIED in any case !

- In PET, syringe shields are a mandatory requirement ! the first goal of syringe shields is to stop beta+ radiation; these are a strong contributor to operator hand's dose

- Attenuation of 511 keV photons requires relatively high thicknesses and heavy shields; in the case of direct administration, staff could prefer a light shields, like those used for ^{99m}Tc

- Administration protocol is of paramount importance: whenever it is possible, insert a line in patient's veins before injection, flush this line with saline solution and, when ready, inject trough a three way valve or a septa

Examples of shieldings for vials and syringes, for use with ^{18}F

Transport container for ^{18}F vials
Typical thickness 30 mm W
Approx. Weight ~ 15 kg

Tungsten shields for syringes for PET
Typical thickness 8 - 10 mm W
Approx. Weight 1 – 1.2 kg

Examples of shielding barriers useful while handling vials and syringes

- These are frequently reffered to as “L-block” shields
- Typical thickness 1 – 5 cm Pb
- Useful to protect the trunk in simple operations, e.g. if one receive ready to use syringes form radiopharmacy
- They do not replace a vented hot cell, and are not usable in case of labelling or sterile dispensing

Type of sources – Patients as a source of radiation

- Patients administered with radiopharmaceuticals are the main source of radiation in Nuclear Medicine; it is an unusual source.
- In general, in order to reduce the emission of radiation from a source, attempts are made to shield as close as possible to the source itself, for example by placing it inside a shielded container.
- Clearly, this is not possible for patients; it is also necessary to consider the volumetric extension and the fact that it is a "source" which, at least in many cases, can move independently.

Type of sources – Patients as a source of radiation
Some example data

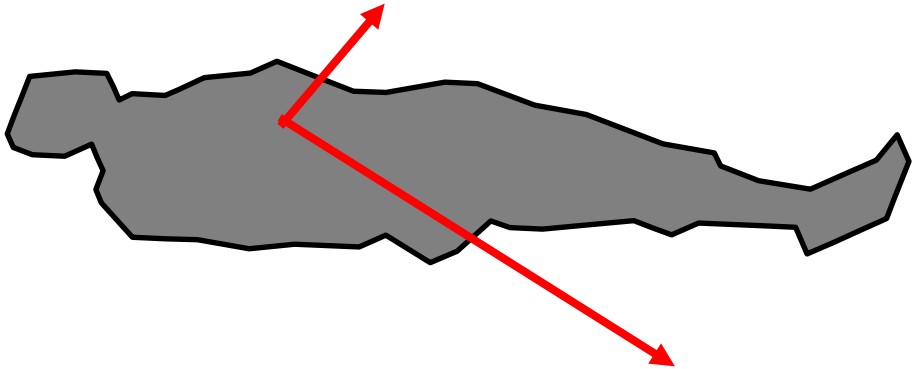
Radionuclide	Specific gamma ray constant (mSv/h per MBq at 1 m)	Administered activity (MBq)	Self absorption factor	Time after administration (hours)	Decay factor	Expected max dose rate at 1 m (uSv/h)
99mTc	1.84E-05	740	0.64	0.167	0.981	13
99mTc	1.84E-05	740	0.64	2	0.794	11
18F	1.43E-04	300	0.66	0.167	0.939	40
18F	1.43E-04	300	0.66	1	0.685	29
131I	5.47E-05	370	0.66	48	0.841	17
177Lu	4.92E-06	7400	0.63	2	0.991	36

- The values reported take into account self-absorption in the body, but do not fully include the effect of emission from a volumetric source (an extended source is a less “effective” radiation emitter than a point source).
- Furthermore, these calculations do not take into account biological half-life and urinary excretion.
- These values can be considered as an indicative upper limit.

Type of sources – Patients as a source of radiation
Diagnostic examinations

^{99m}Tc - sestamibi: < 10 µSv/ora @ 100 cm

120 min after administration of 740 MBq



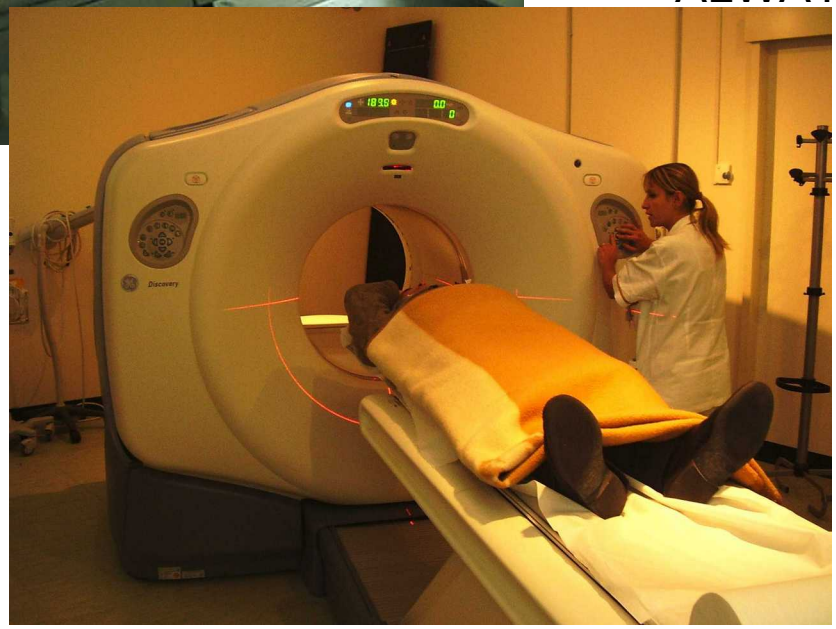
^{18}F-FDG : about 30 µSv/ora @ 100 cm

60 min after administration of 370 MBq

The concentration of patients in the administration / “hot” waiting rooms hot can be a problem of radiation protection, and an obstacle to diagnostic activities.

Use of spaces and the program of work should be carefully planned.

Patients as a source of radiation. Diagnostic examinations

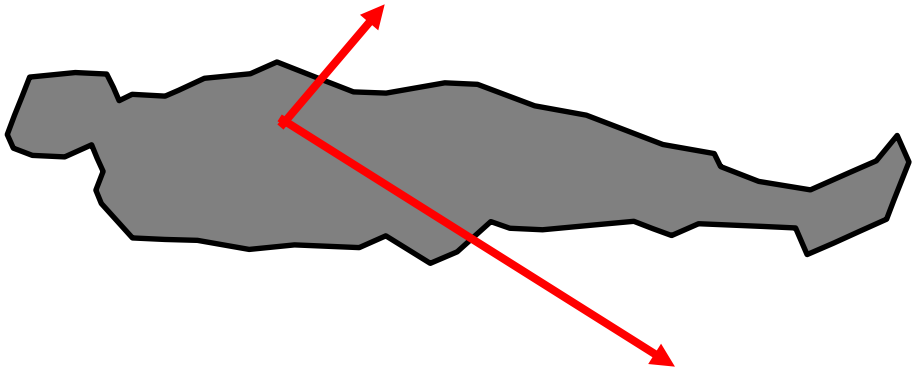


- Patients should be cared for as needed, avoiding any un-ethical behavior

- Limit time at short distance
- Whenever possible, stay at about 100 cm
- Wear your working clothes
- Wear gloves when manipulating sources or touching a patient
- ALWAYS remove the gloves properly

Type of sources – Patients as a source of radiation
Radionuclide therapy procedures

^{177}Lu: < 40 µSv/ora @ 100 cm
after administration of 7400 MBq



^{131}I: 1.5 – 2.0 mSv/h @ 100 cm after 60 min from administration of 3700 MBq decreasing to < 200 µSv/h after 24 hours

- Staying in close proximity to patients should be limited.
- Plan the work and try to always stay at least one meter from the patient.
- If the patient requires close contact assistance (e.g. uncooperative, disabled or pediatric patient), get the job done quickly, but without anxiety…

The CT component in multi-modality scanners

In the case of PET/CT scanners, the 511 keV emission has a much higher energy than the X-ray beam of the CT component. On the other hand, the 511 component has a relatively small but almost continuous dose rate, while the X-ray component is emitted only for a short time, but with a high dose rate.

In general, the thickness of the barriers calculated to attenuate the 511 keV photons will also be sufficient to absorb X-radiation.

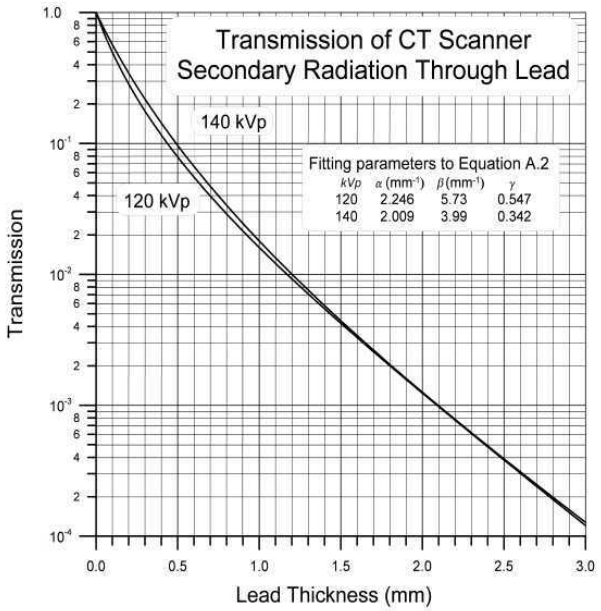


Fig. A.2. Transmission through lead of secondary radiation from CT scanners [data of Simpkin (1991) fitted to Equation A.2].

From NCRP 147

In the case of SPECT/CT the energy difference is smaller, but still exists (the average energy of the X-beams is < 50 keV. However, the dose rate due to radionuclides is also lower than in the case of PET. The shielding required by the CT component may be the highest.

Radioactive waste

- Should be collected in appropriate, dedicate containers
- Can be collected in separate containers, according to the respective $T_{1/2}$
- Avoid to throw conventional non radioactive waste into the radioactive waste
- Possibly, adopt containers for sharps
- Shielded waste containers should be available in radiopharmacy and in each place in which radiopharmaceuticals are administered

Radioactive waste is covered in detail in another presentation ....

^{131}Iodine - Capsules

Capsules suitable for oral administration, containing radioactive ^{131}Iodine as sodium iodide adsorbed onto a solid matrix, such as anhydrous sodium sulfate or anhydrous disodium hydrogen phosphate, which is contained in hard gelatine capsules.

^{131}Iodine

Z	Element	Nuclide	Half-life	Decay mode	Emitted energy (MeV/nt) Alpha	Electron	Photon	Total
53	Iodine	I-131	8.02070 d	B-	–	0.1918	0.3828	0.5746
			Xe-131m	1.1759E-02				
			Xe-131	9.8824E-01				

Note !

Nuclide	µGy/h per 1 MBq @ 100 cm	HVL	TVL
I-131	5.73E-02	2.74	9.93

For ^{99m}Tc is 2.06E-2

Radionuclide[a]	Physical half-life	Inhalation Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	Ingestion f_1	$e(g)$
I-131	8.04 d	F	1.000	7.6×10^{-9}	1.1×10^{-8}	1.000	2.2×10^{-8}

The o.d.m. of e(g) is 1E-8 Sv/Bq.
The incorporation of activities
of the order of 1 – 2 MBq leads to
the absorption of the dose limit of 20 mSv

Conclusions

Existing classification schemes are relatively old; while their general structure is still valid, not always the operative indications, equipment or protective systems suggested are updated;

A critical reading of the documents, still allows to find useful information and, in general, to correctly classify the level of risk;

Sealed sources should be stored, inventoried and accounted for;

Sealed sources should be periodically tested for any leakage

Unsealed sources, like radiopharmaceuticals, should always be manipulated according to instructions and using the necessary protective tools

Patients are a source of radiation ! Shulde be cared for as necessary, avoiding unjustified exposure.