GLOBAL CLINICAL ENGINEERING ALLIANCE™

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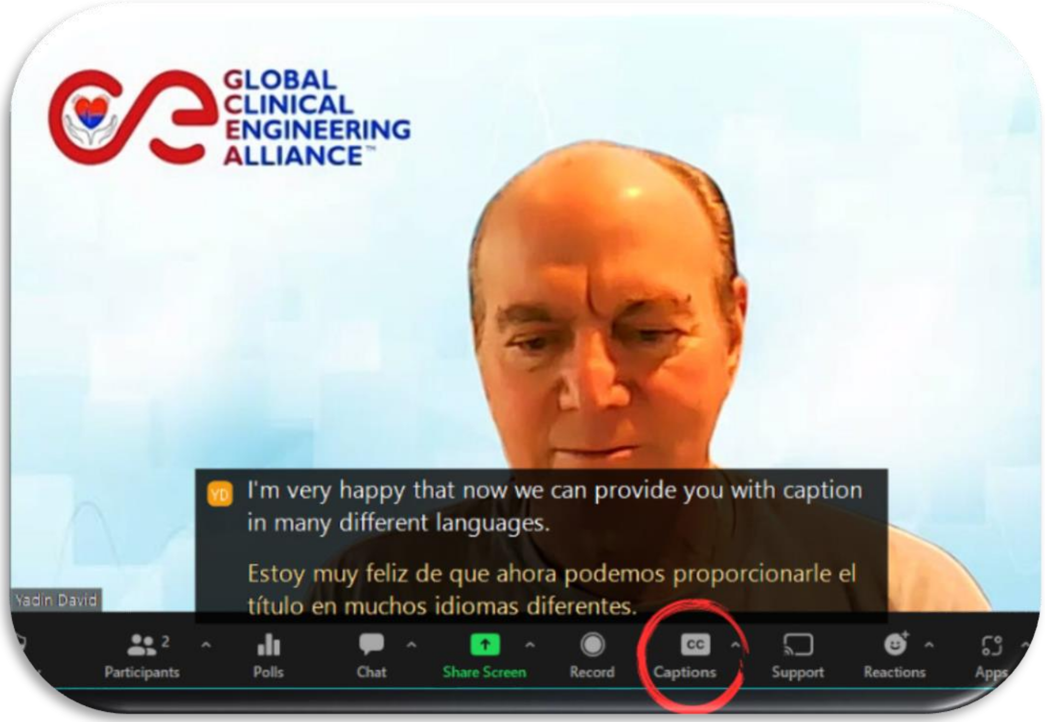
WEBINAR

Imaging Equipment: PET Scanner

Wednesday
MARCH 1 | 3pm UTC | 10am NY

Register for free: https://tinyurl.com/gceazoom

GCEA is excited to announce the addition of a new **live translation** feature that we believe **will bridge the language gap and enhance your video conferencing experience** through Global Clinical Engineering Alliance programs even further. As part of our commitment to delivering innovative and educational video communications training, we have incorporated a new captioning option that facilitates the ability of our members to elevate their understanding of the spoken content during GCEA education and meeting events, by simultaneously customizing captions in their preferred language.



Simply click on the Captions tab at the bottom of your screen and select the caption language you would like to read from the drop-down menu.

English, French, German, Spanish, Portuguese, Italian, Chinese (Simplified)(Beta), Russian, Japanese (Beta), Korean (Beta), Dutch, and Ukrainian

PET:
Basic Principles

Dr. Edna Marina de Souza, MS, PhD
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Biomedical Engineering Centre
Clinical Hospital
State University of Campinas - UNICAMP - Brazil
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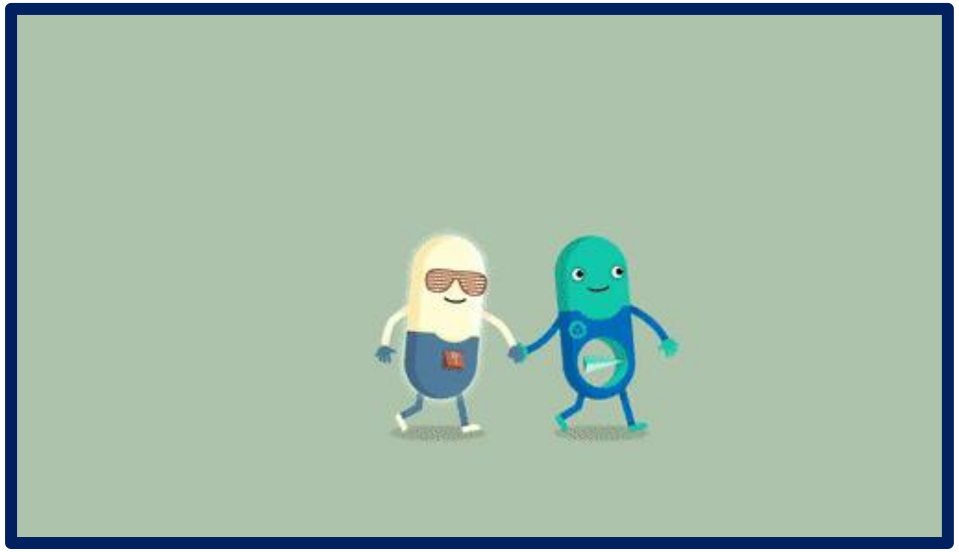
University of Campinas - UNICAMP

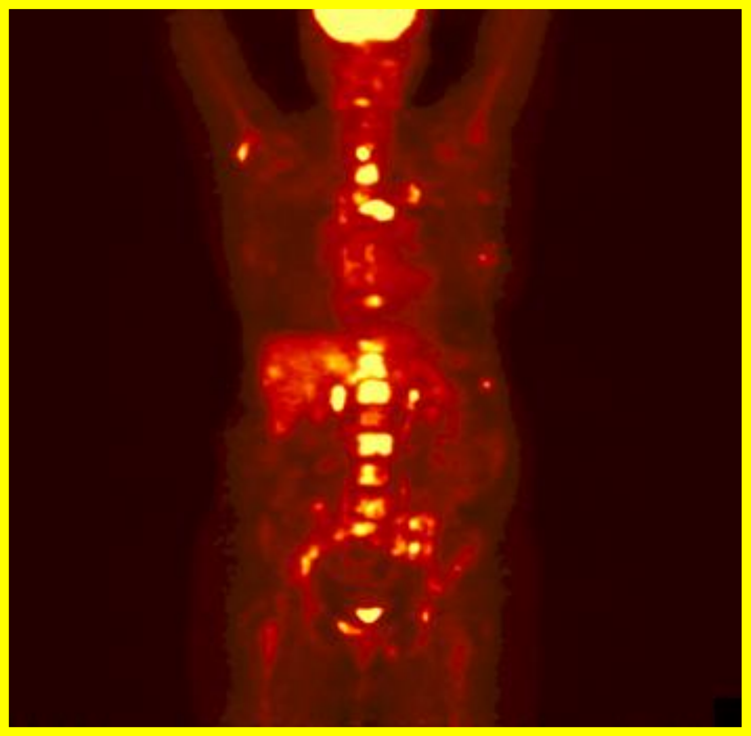
Nuclear Medicine

- Medicine area that uses radioactive materials + pharmaceuticals for diagnostic and therapeutical purposes.
- Diagnostic: metabolic images of the body
  - **PET**
  - Scintigraphy
- Therapy: use of radiopharmaceuticals to treat many kind of pathologies (e.g. tumors, thyroid diseases, osteoarticular diseases etc.)

RADIOACTIVE MATERIALS + PHARMACEUTICALS = RADIOPHARMACEUTICALS



https://makeagif.com/gif/-74tG26
Access: 20/01/2023



PET... Web Searching....

https://nfpet.com.br/blog/2020/01/banho-em-pet-shop-para-filhotes/
Access: 20/01/2023

https://www.iq.com.br/financas-pessoais/artigos/seguro-pet
Access: 20/01/2023

https://www.acasadoanimal.com.br/empreendedorismo-4-formas-de-investir-no-mundo-pet/
Access: 20/01/2023

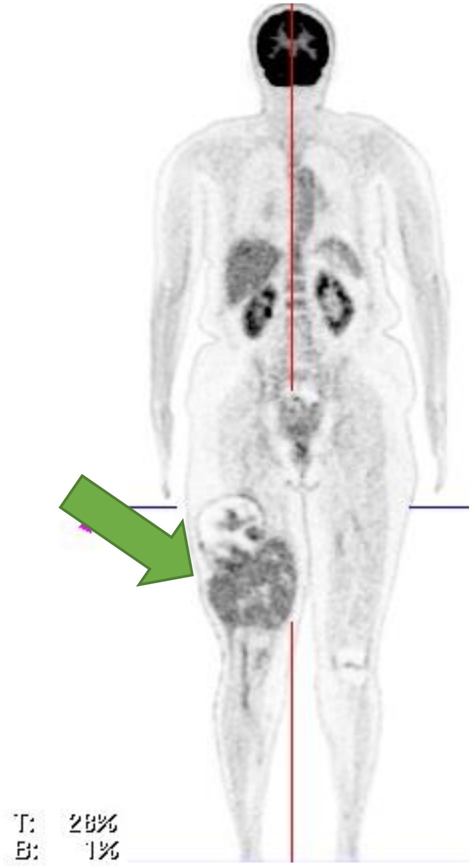
What is PET? Positron Emission Tomography

https://giphy.com/explore/scan
Access: 20/01/2023

PET-FDG – Applications - ^{18}F-FDG - Tumors

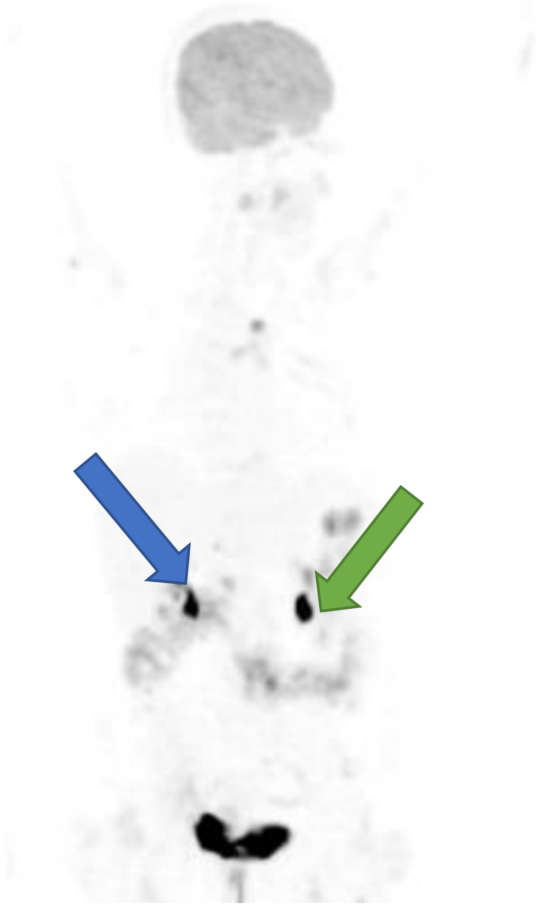
Breast Cancer

Sarcoma

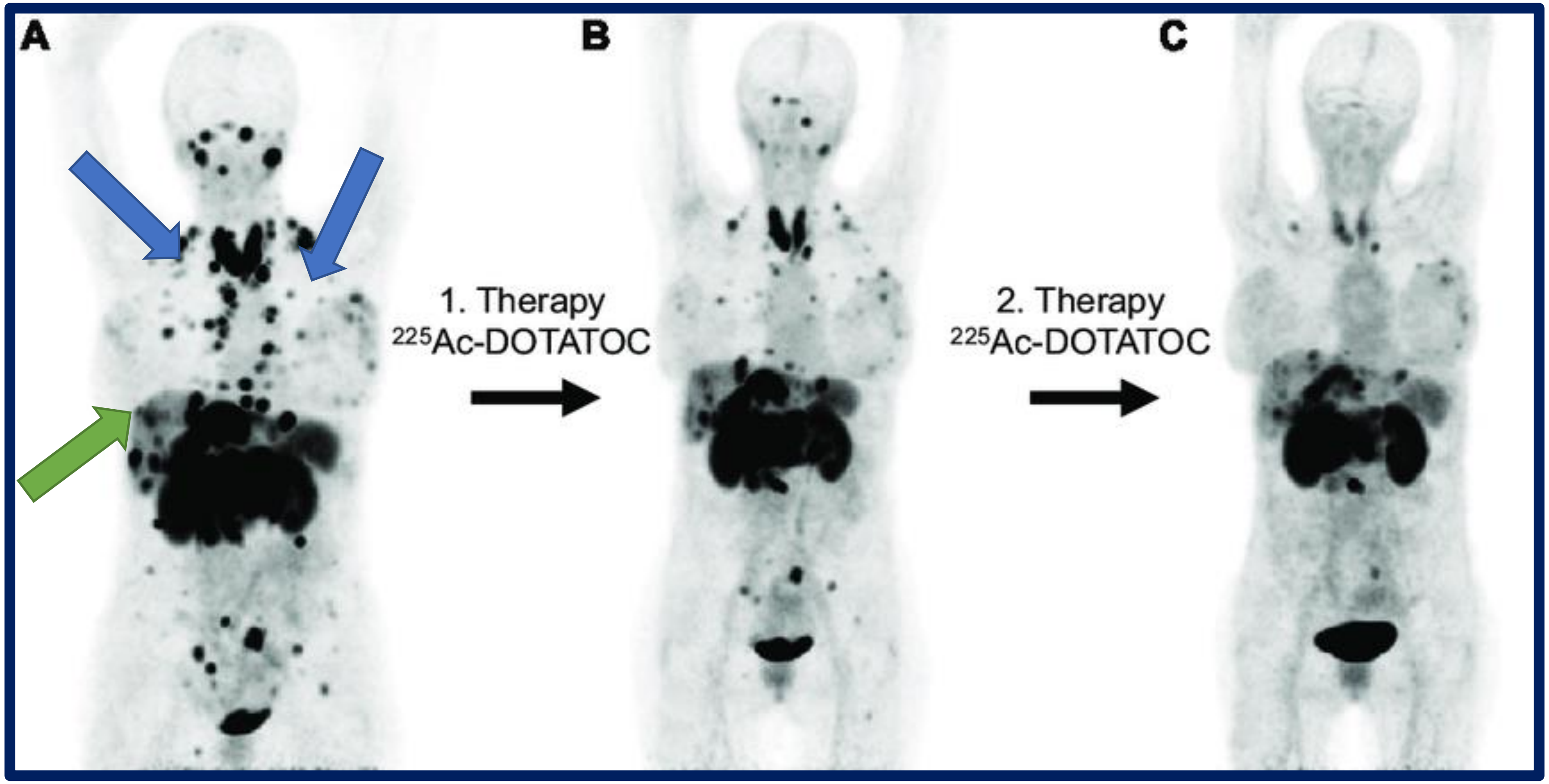


Melanoma

Colon Cancer



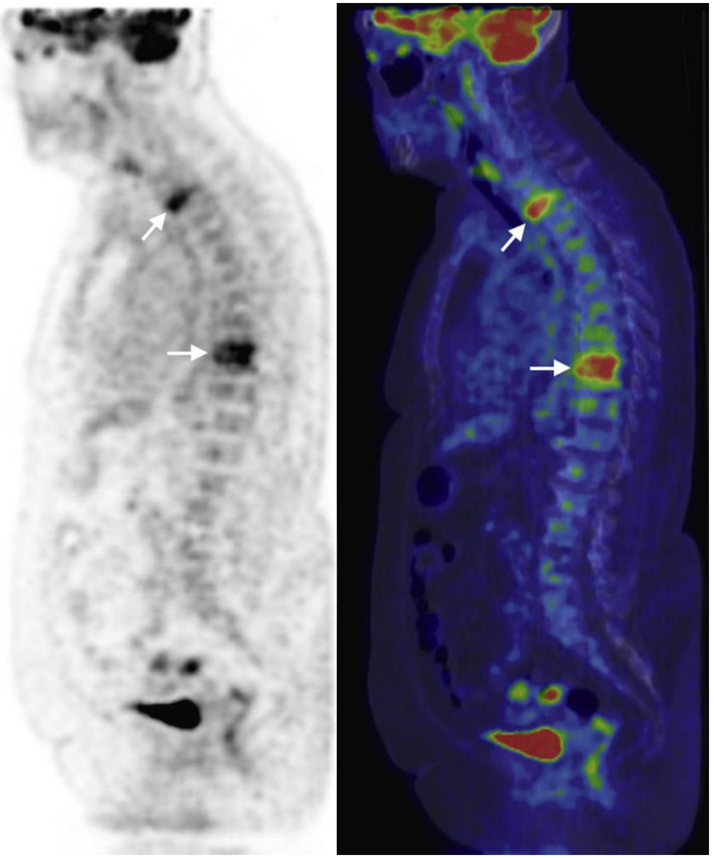
PET - ^{68}Ga-DOTATOC – Neuroendocrine Tumors



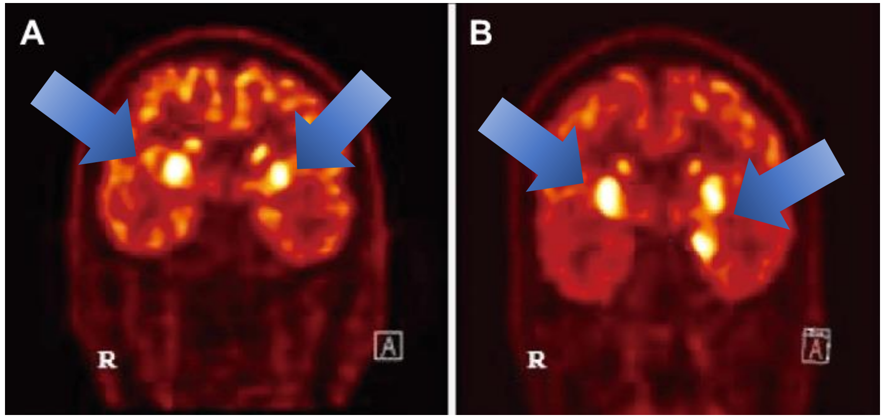
Morgerstern et. al. Current Radiopharmaceuticals, 2018, *11*, 200-208.

PET - ^{18}F-FDG – Applications – Infection and Inflammation

Bacterial Infection

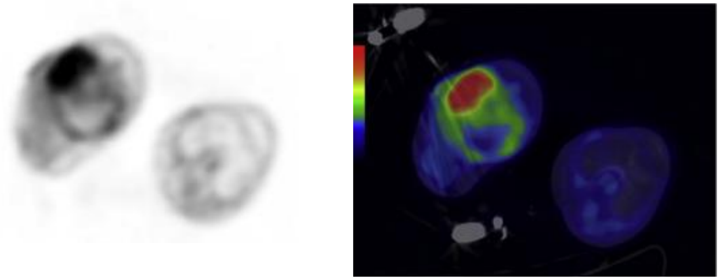


Autoimmune Encephalitis

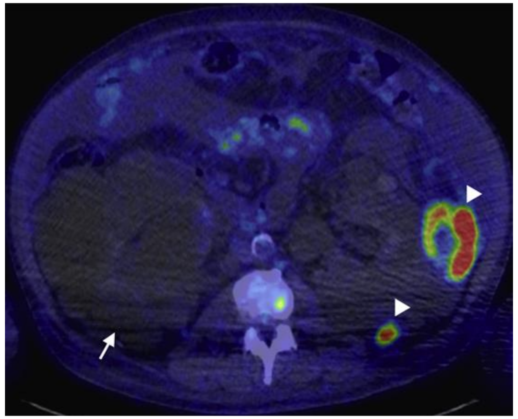


Lee. Journal of Epilepsy Research *Vol. 6, No. 2, 2016.*

Osteomylites

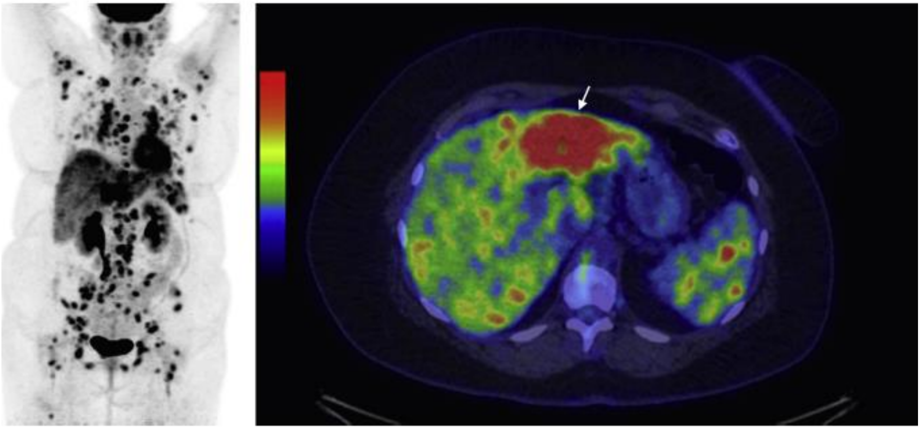


Polycistic Kidney Disease



Vaidyanathan et. al. Clinical Radiology 70 (2015) 787-800.

Sarcoidosis

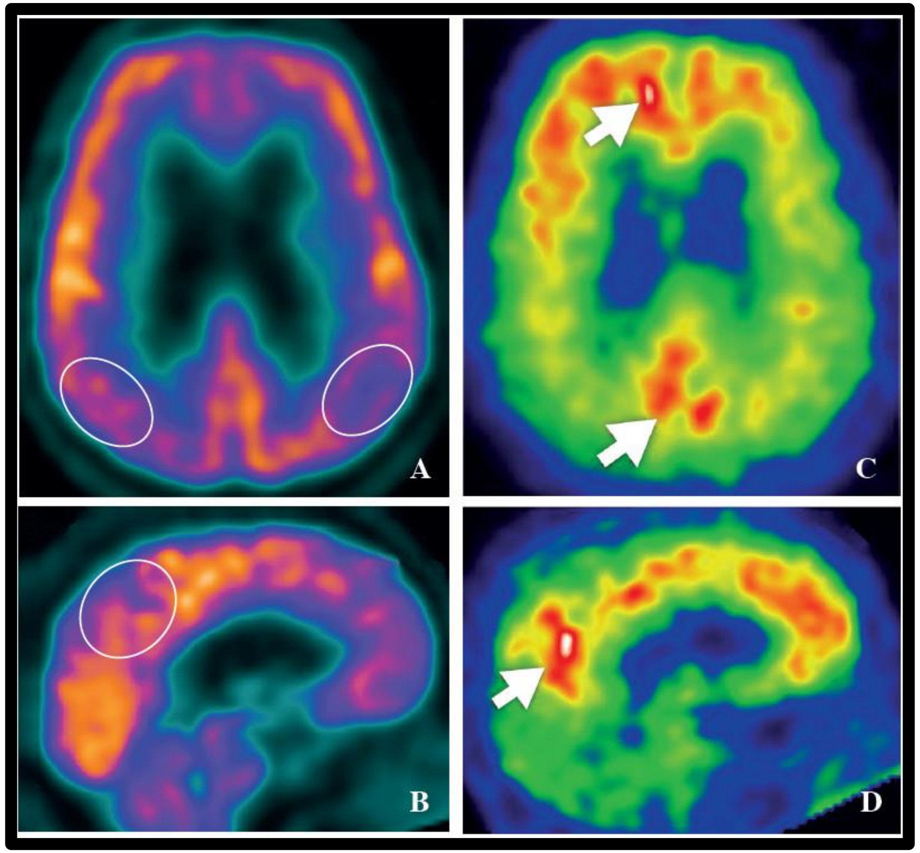


PET - Other Applications

^{18}F-FDG - Arteritis

Laurent et. al. Nature Scientific Reports | (2019) 9:12388 |
https://doi.org/10.1038/s41598-019-48709-w

^{11}C-PIB – Alzheimer's Disease



https://www.bangkokmedjournal.com/article/challenges-in-production-of-alzheimer-rsquo-s-tracer-c-11-pib/107/article
Access: 10/02/2023

Galligas - ^{68}Ga-MAA
Acute Pulmonary Embolism

Le Roux et. al. Semin Nucl Med 49:71-81 (2018).

Elements that Contribute to Development of PET Technique

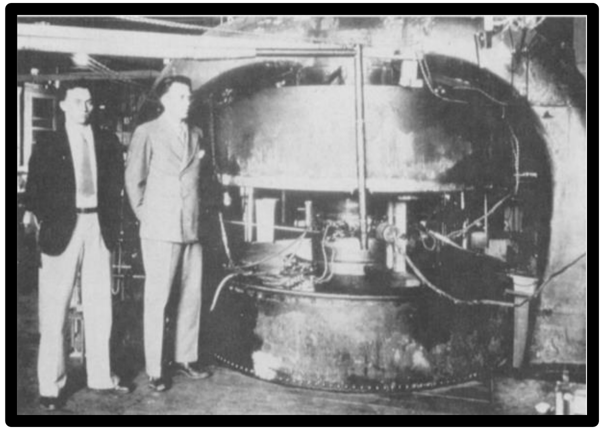
Radioactivity
Marie and Pierre Curie (1934)

https://pt.m.wikipedia.org/wiki/Ficheiro:Pierre_Curie_et_Marie_Sklodowska_Curie_1895.jpg
Access: 12/01/2023

Artificial Radioactivity
Iréne Curie and Frédérich Juliot (1934)

https://www.britannica.com/biography/Frederic-and-Irene-Joliot-Curie
Access: 12/01/2023

Cyclotron
Ernest Lawrence (1929-1930)

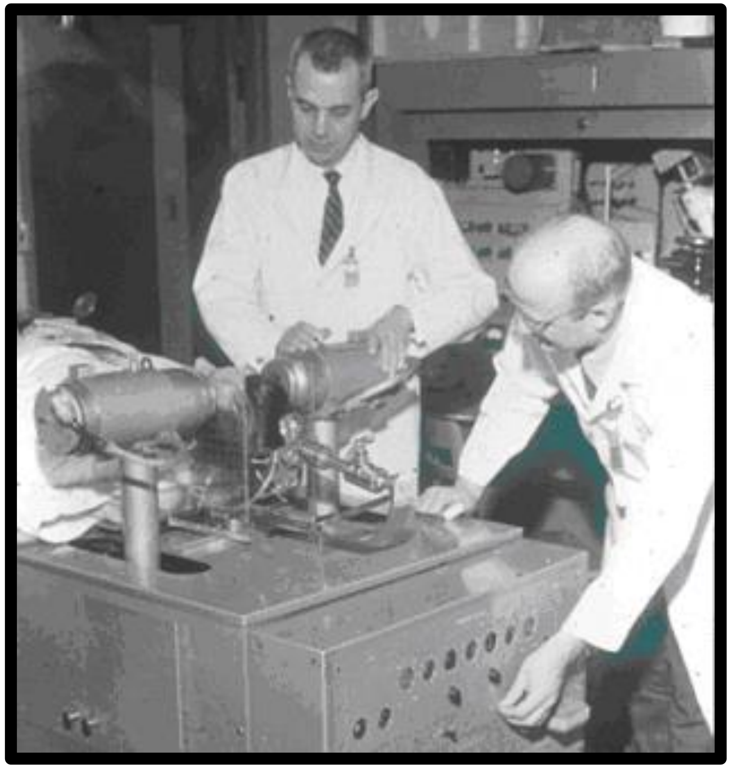


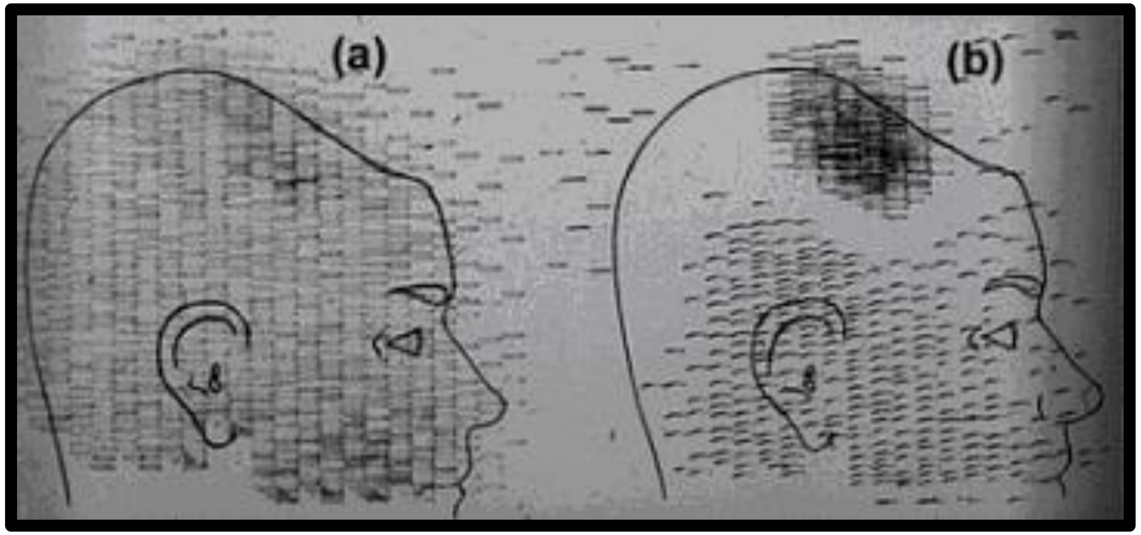
https://pt.wikipedia.org/wiki/Ernest_Lawrence
Access: 12/01/2023

Elements that Contribute to Development of PET Technique

PET Detection System (1953) - Brownell and Sweet

Described a multidetector system to acquire coincidence images from positron emissor (Cu-64 and As-75)

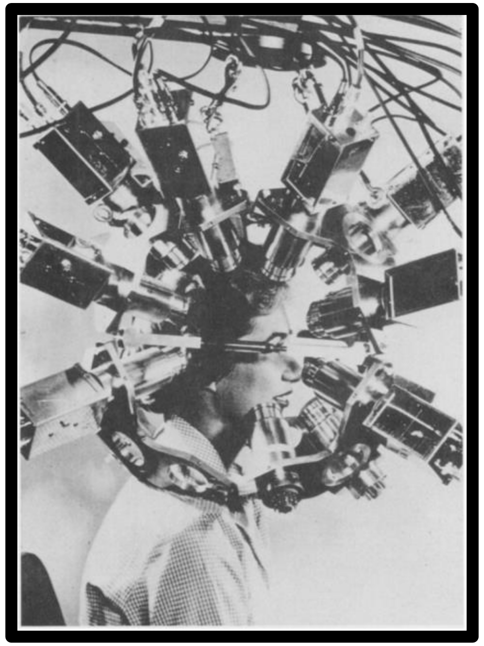




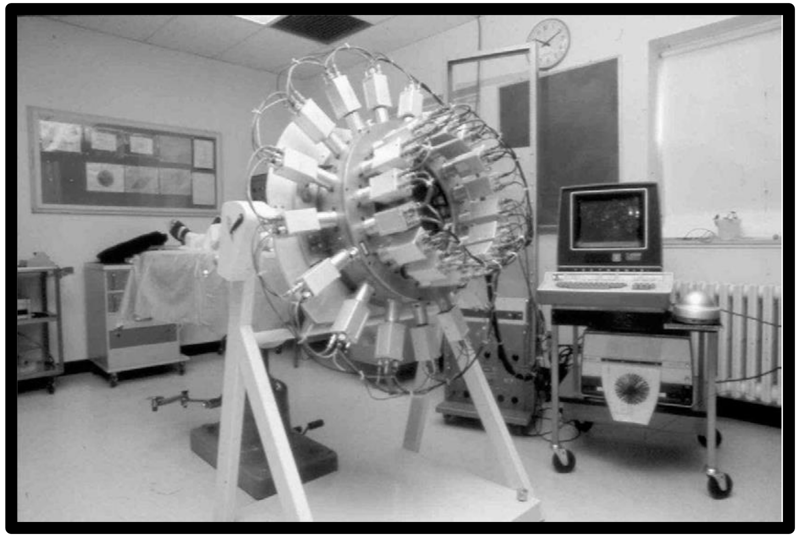
https://gordon.mgh.harvard.edu/gc/history/#gallery-1

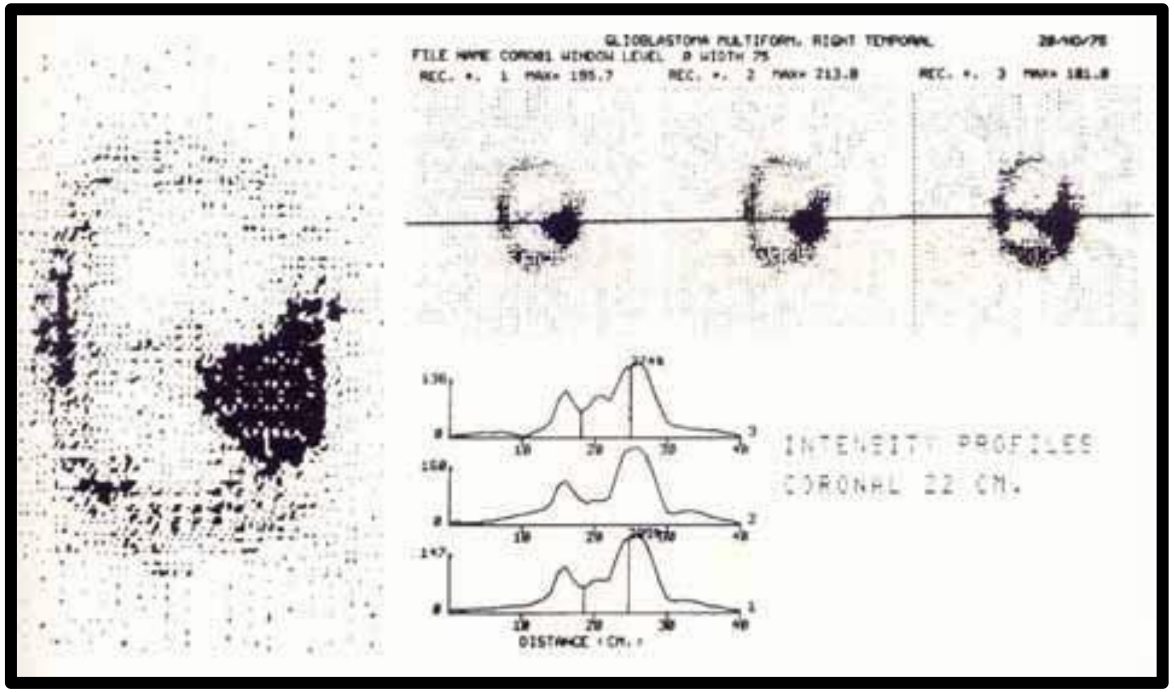
Access: 12/01/2023

Elements that Contribute to Development of PET Technique



Yamamoto, BrookHeaven Lab (1966)





Canadian Medical Physics Newsletter, 51(2),April 2005.

Modern PET Scanners...

First scanner as we know: Phelps and Hoffman (1973) Washington University School of Medicine

https://www.manhattanrarebooks.com/pages/books/439/michael-e-phelps-edward-j-hoffman-nizar-a-mullani-michael-m-ter-pogossian/application-of-annihilation-coincidence-detection-to-transaxial-reconstruction-tomography?soldItem=true
Access: 20/02/2023

https://www.gehealthcare.com/insights/article/evolving-petct-technology-for-improved-sensitivity-and-image-quality-to-increase-diagnostic-accuracy
Access: 12/02/2023

https://www.healthymatters.com.hk/pet-scan-hong-kong/
Access: 10/02/2023

https://www.nm.org/conditions-and-care-areas/imaging-services/pet-ct
Access: 10/02/2023

Characteristics of the main PET Radionuclides

Radionuclide	Half-Life (min)	Production
^{18}F	110	Cyclotron
^{68}Ga	68	Radionuclide generator
^{82}Rb	1.2	Radionuclide generator
^{11}C	20.4	Cyclotron
^{13}N	9.97	Cyclotron
^{15}O	2	Cyclotron

Radionuclide Generator

https://www.ntu.edu.sg/medicine/research/research-equipment/detail/itg-ga-68-generator
Access: 04/01/2023

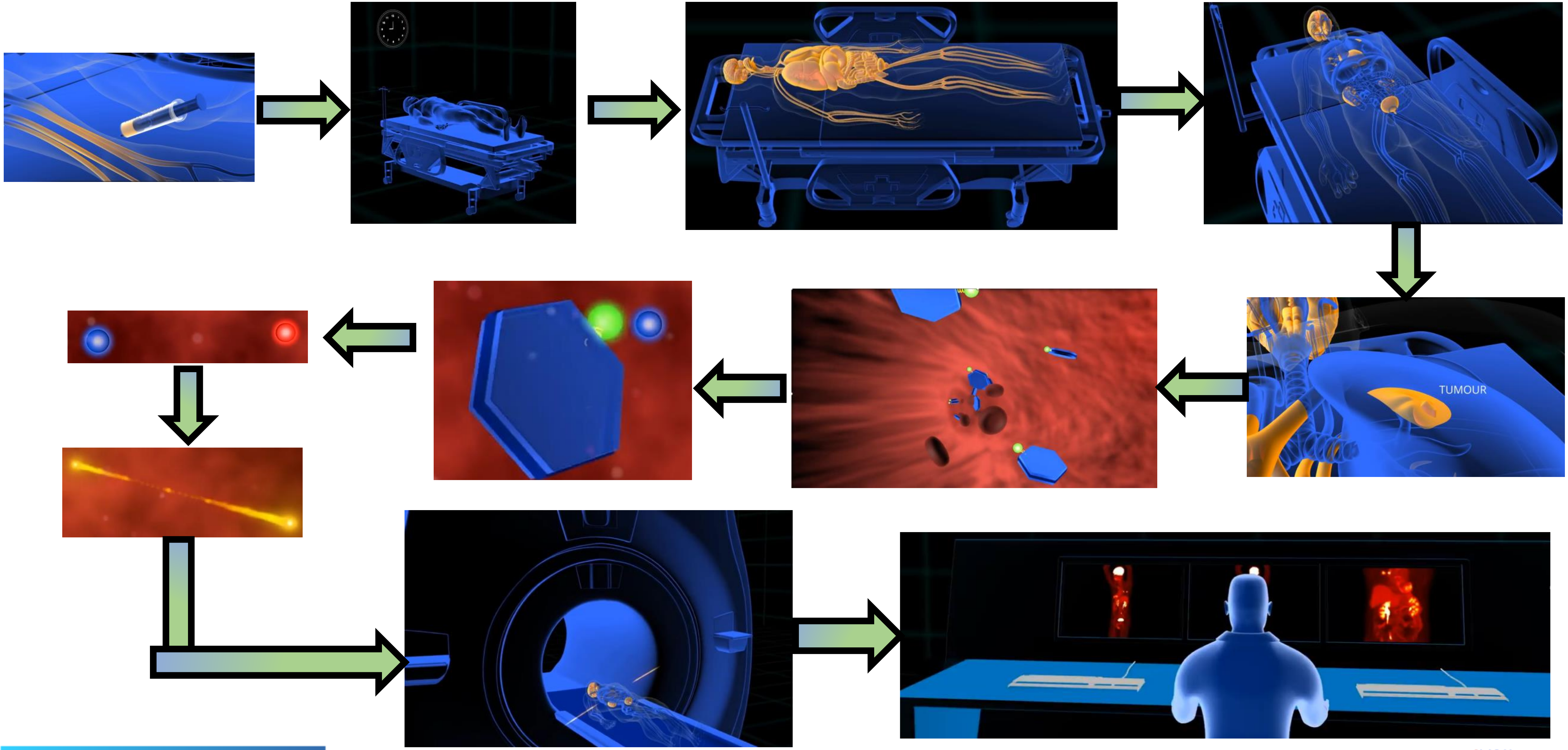
Cyclotron

https://www.iba-radiopharmasolutions.com/cyclone-70
Access: 12/01/2023

Some PET Radiotracers and Their Applications

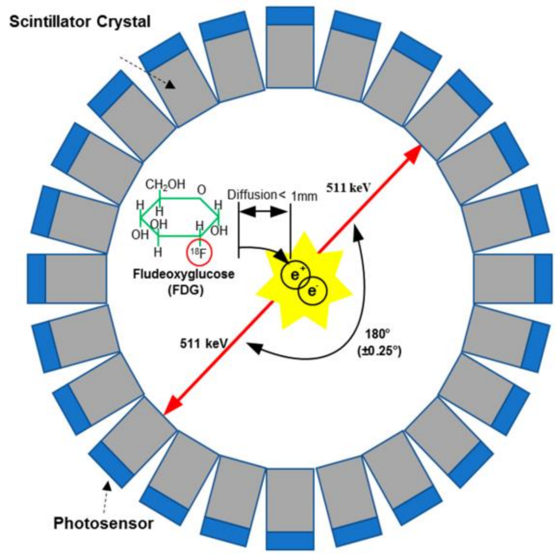
PET Radiotracer	Applications
^{18}F-FDG	Tumors detection and staging, inflammation and infection, neurological diseases, cardiovascular diseases etc.
^{18}F-Florbetaben	Detection of β-amyloid plaques in the brain
^{18}F-Fluorodopa	Dopaminergic receptors evaluation – Parkinson Disease
^{18}F-FMISO	Tumor hypoxia
^{68}Ga-PSMA	Prostate tumors
^{68}Ga-DOTATOC	Neuroendocrine tumors
^{11}C-Choline	Neurodegenerative diseases
^{13}N-Ammonia	Myocardial perfusion

PET - Imaging Formation (^{18}F-FDG)

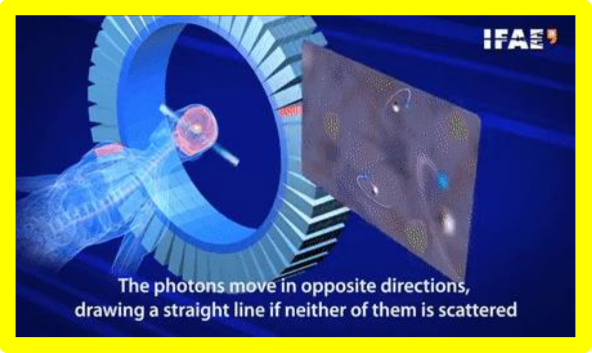


https://www.youtube.com/watch?v=oySvkmezdo0
Access: 12/02/2023

Signal Detection

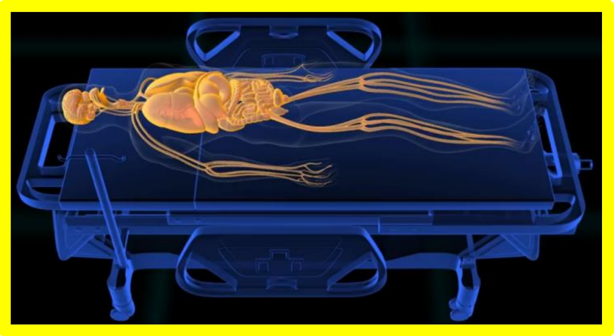


https://www.mdpi.com/1424-8220/19/22/5019
Access: 15/02/2023

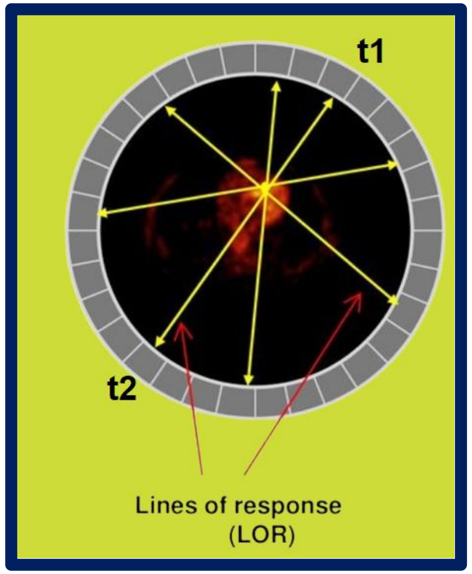


https://gfycat.com/defensivecharmingborzoi
Access: 20/07/2019

LORs are combined using reconstruction techniques to create the final image

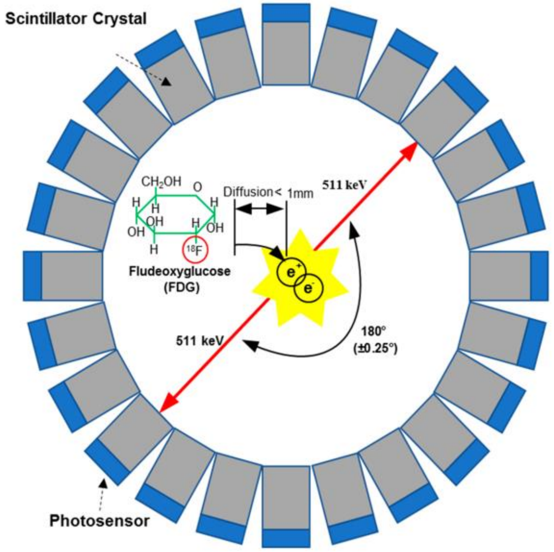


https://www.youtube.com/watch?v=oySvkmezdo0
Access: 12/02/2023

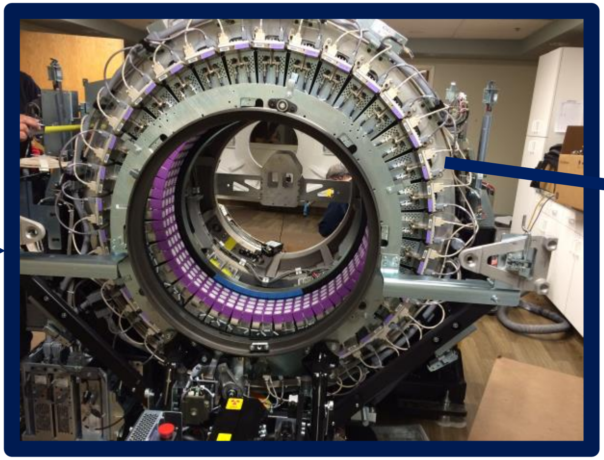


If Δt = t1-t2 < 6 to 15 ns
A coincidence is registered to compose the image. The position of events in the patients' body is calculated based on Δt and the speed of radiation in vacuum

Signal Detection

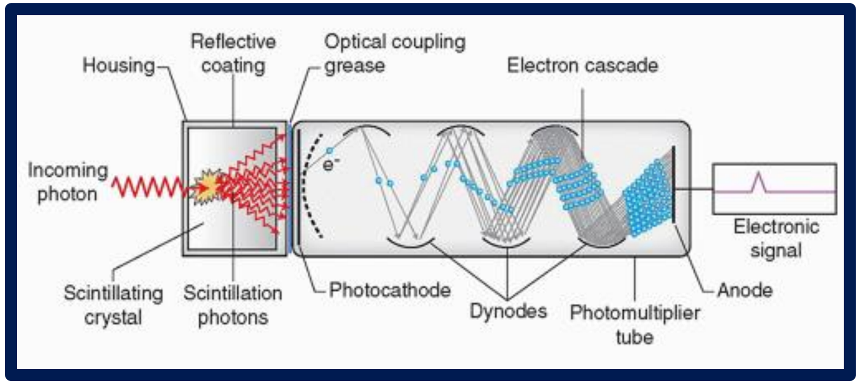


https://www.mdpi.com/1424-8220/19/22/5019
Access: 15/02/2023

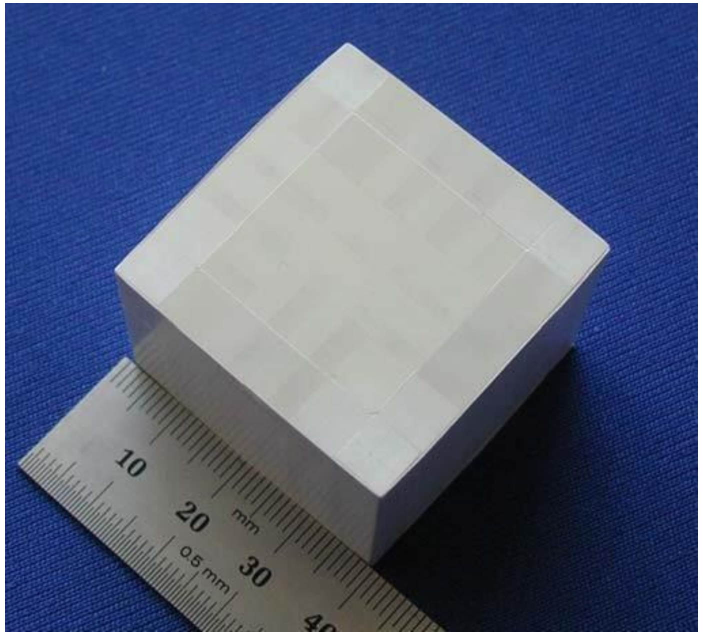


imgur.com/gallery/gCZLA/comment/612792646
Access: 15/08/2022

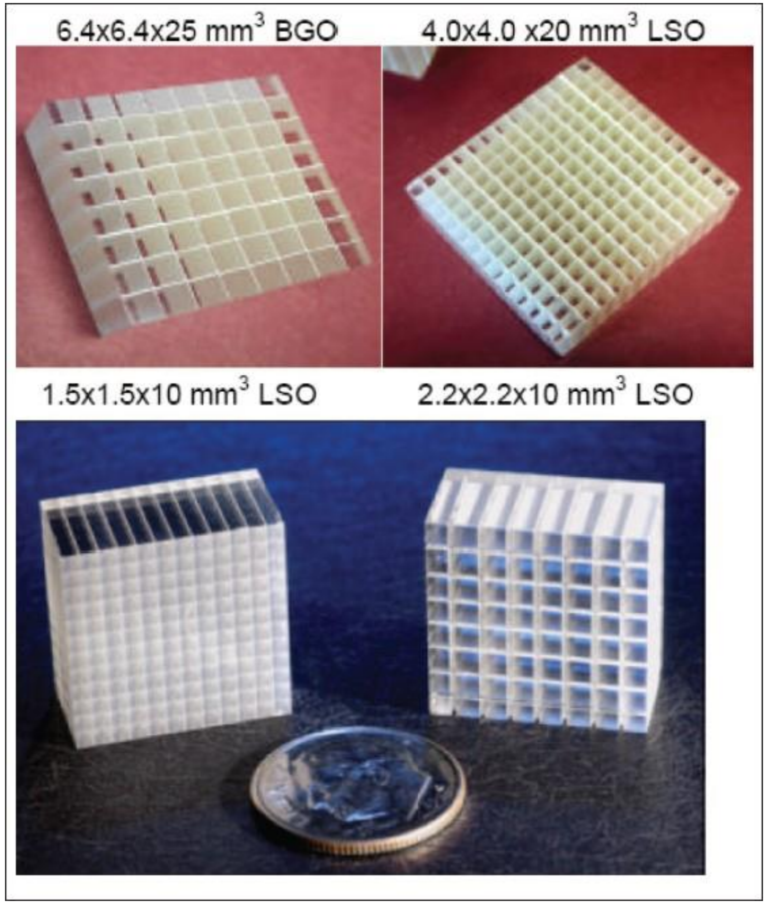
https://www.cockcroft.ac.uk/wp-content/uploads/2016/04/Lecture-7-PET.pdf
Access: 15/08/2022



View of Detectors

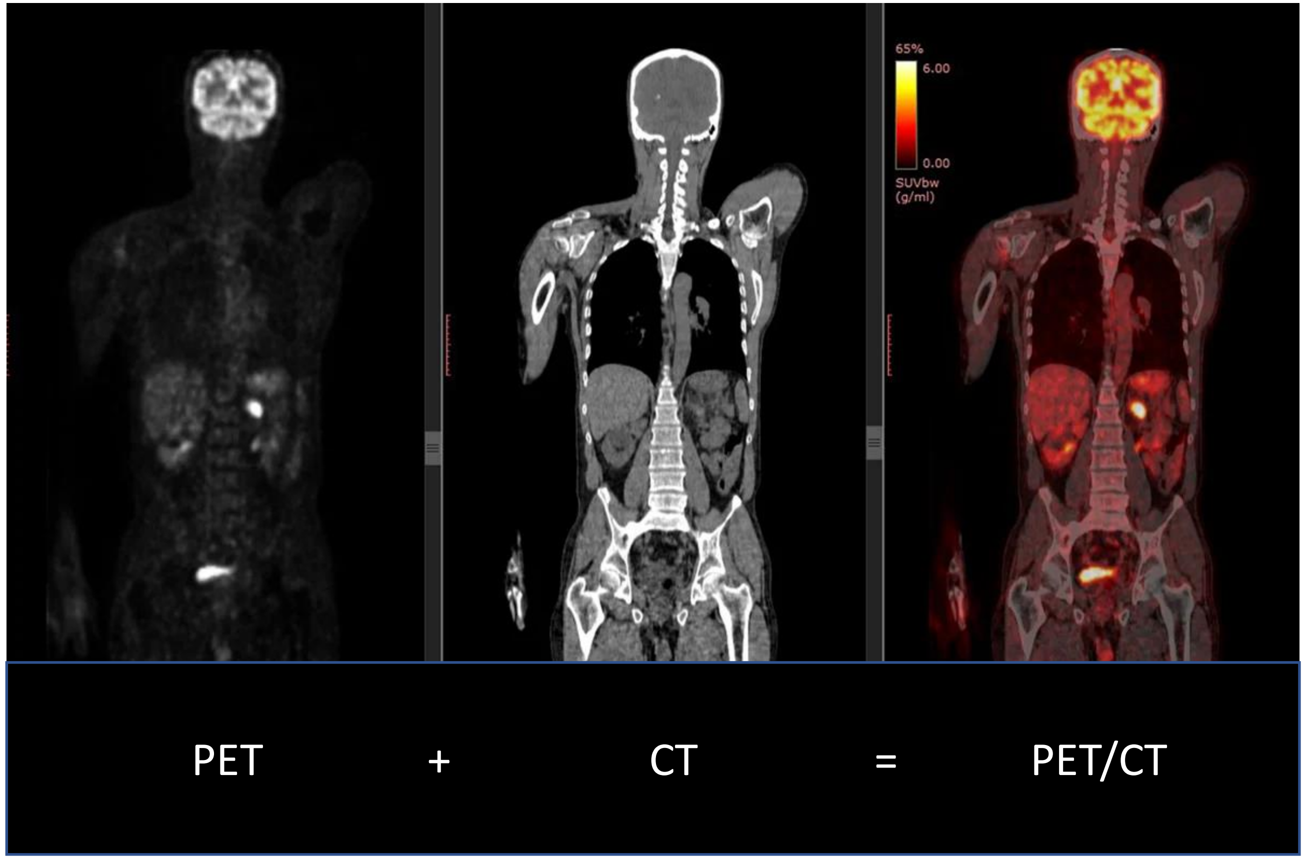


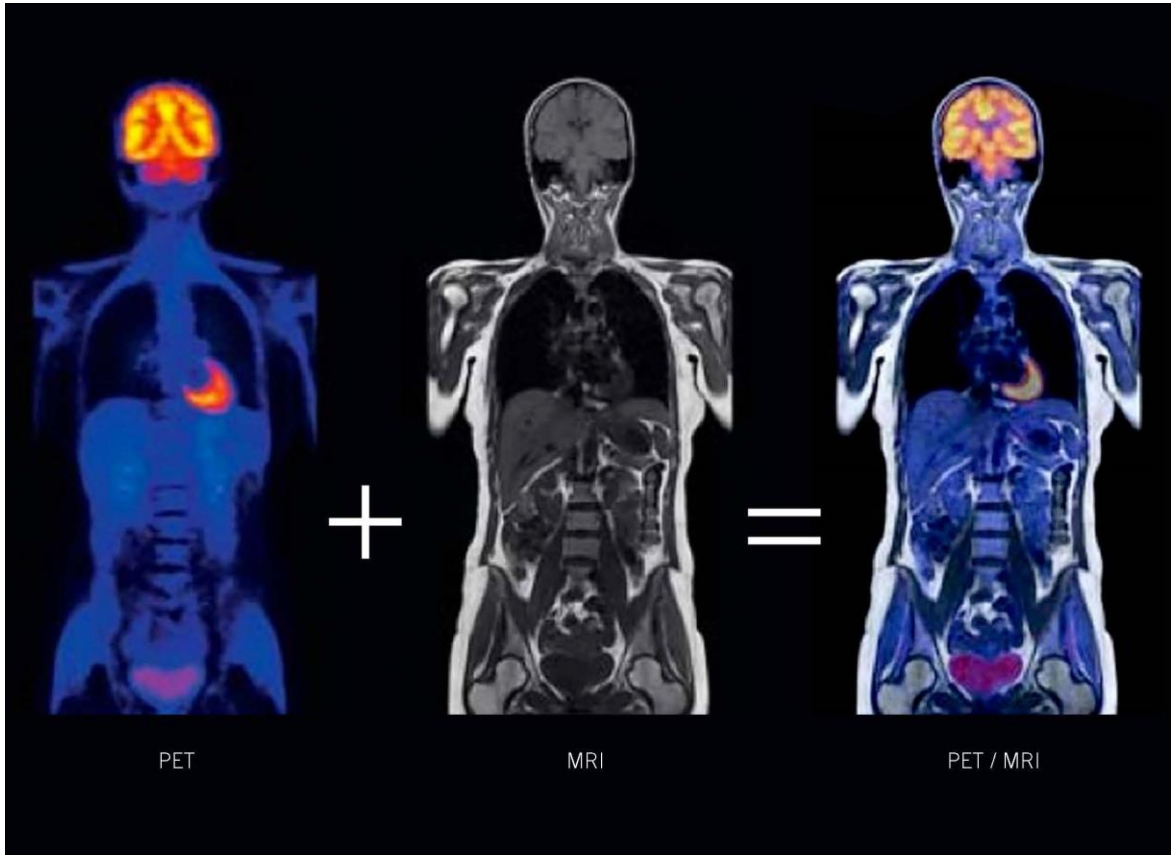
https://www.researchgate.net/figure/Left-6x6-BGO-crystal-array-for-original-Discovery-ST-block-detector-Right-8x6-Crystal_fig2_4224144
Access: em 12/08/2022



http://www.jmp.org.in/viewimage.asp?img=JMedPhys_2009_34_3_122_54844_u2.jpg
Access: 12/08/2022

PET/CT and PET/MRI





https://www.omegapds.com/pet-mri-scan/
Access: 12/08/2022



Thank You!!

emsouza@unicamp.br



GLOBAL CLINICAL ENGINEERING ALLIANCE™

Safety in PET

Clare Jacobs

Clinical Scientist

Nottingham University Hospitals

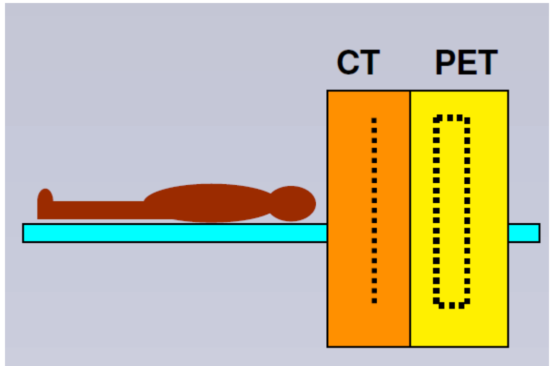
Risk assessment for PET

- Identifying the hazards
- Provide engineering controls, design features and warning devices
- Provide systems of work to restrict the exposure
- Providing personal protective equipment .

Hazard: Exposure to radiation.

Sources of radiation In PET –CT departments

X-ray emission from CT scanner



Radiation being emitted from the patient containing up to 400MBq

Radiopharmaceutical vials containing GBq's of activity

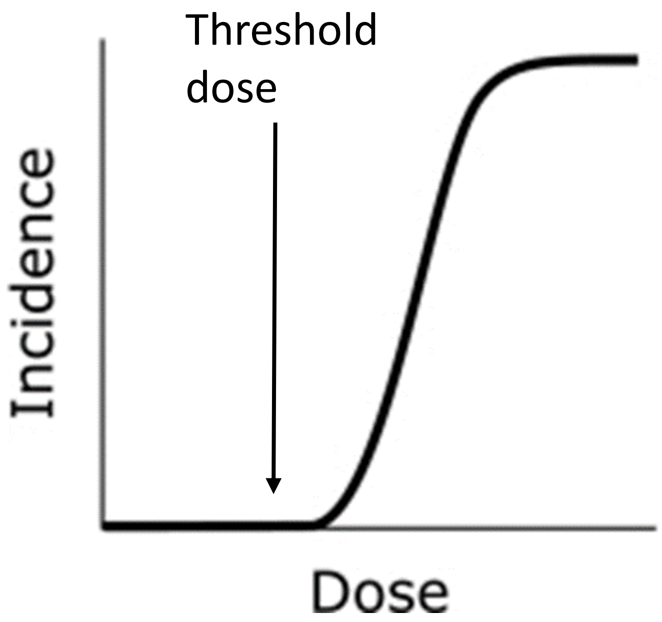
Sealed sources used for scanner QA~ 100's MBq's of activity

Effects of radiation

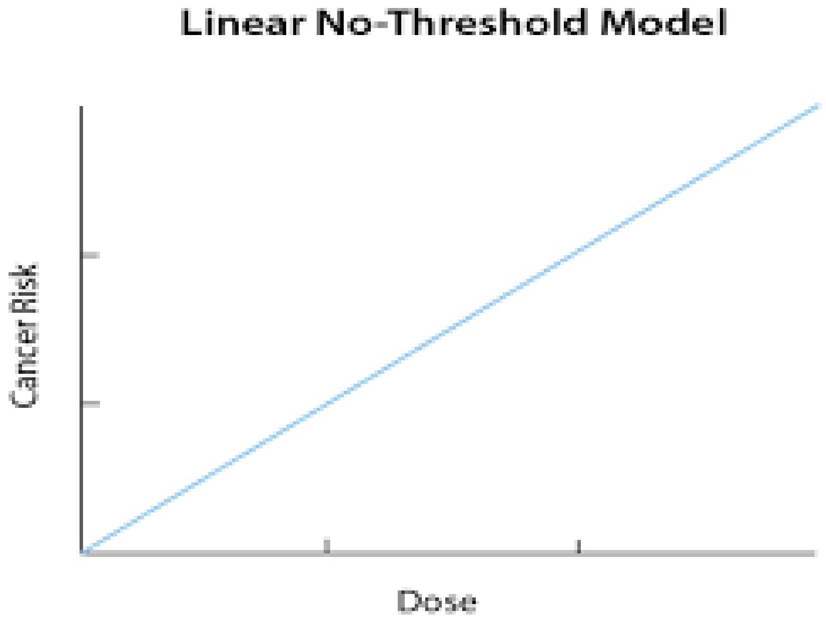
Deterministic –occur above a threshold dose (high radiation dose thresholds). The severity increases with increased dose Examples include radiation induced cataracts, acute radiation sickness syndrome.   Possible that high skin doses could result from directly handling vials of radioactivity resulting in erythema- deterministic effect.

Stochastic- Assume a linear no threshold model where the probability of the effect increases linearly with radiation dose received. No safe lower limit is assumed. Examples include cancer induction and hereditary effects.

Deterministic effects:



Stochastic effects:



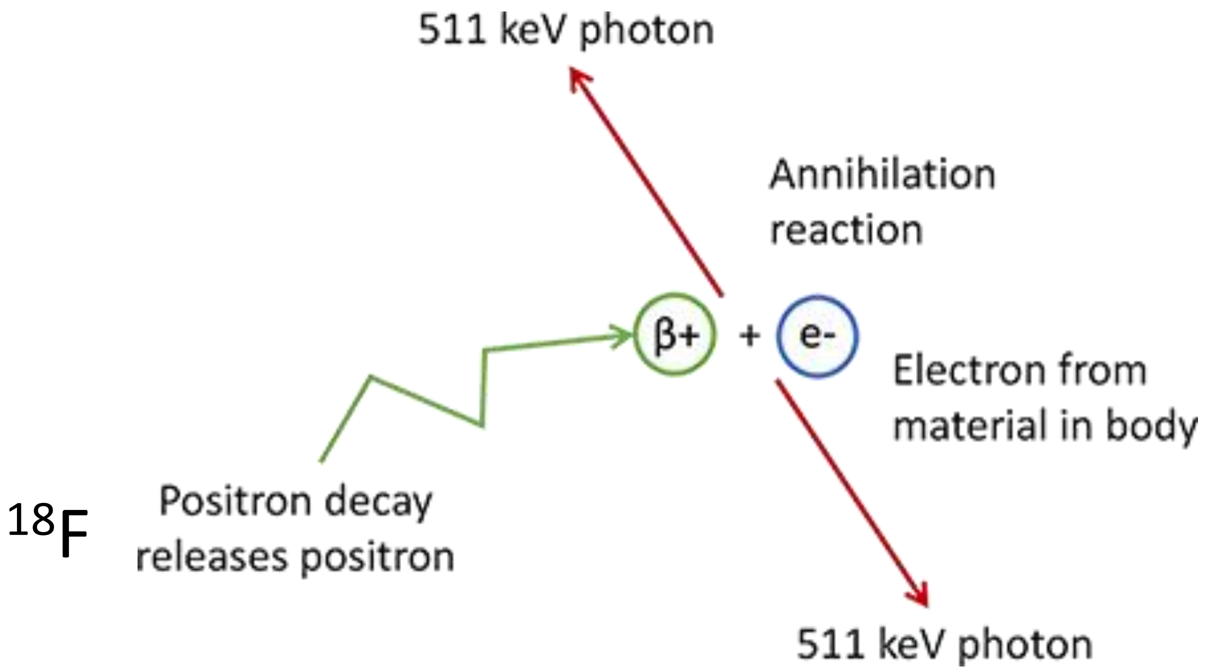
Who might be harmed and how

Radiation exposure to:

- Staff
- Members of the public
- Contractors
- Visitors

Hazards from external irradiation and contamination- which could get onto the skin or be ingested.

Gamma ray emissions from the radiopharmaceuticals



^{18}F has a half life of 109 minutes

neutrino

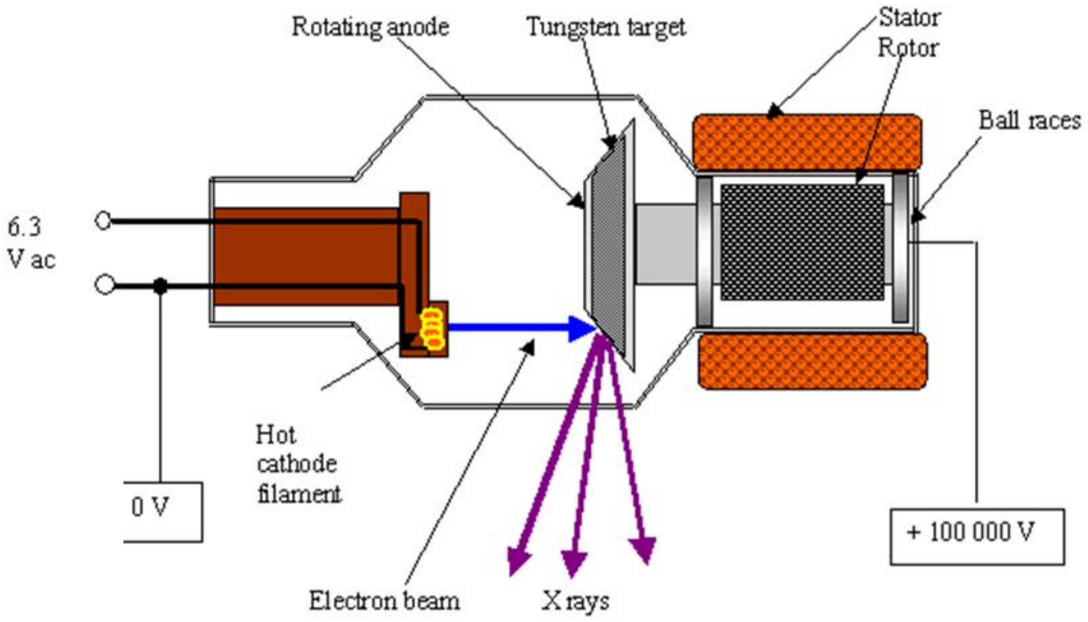
$$18_F \rightarrow 18_O + \beta^+ + \nu$$

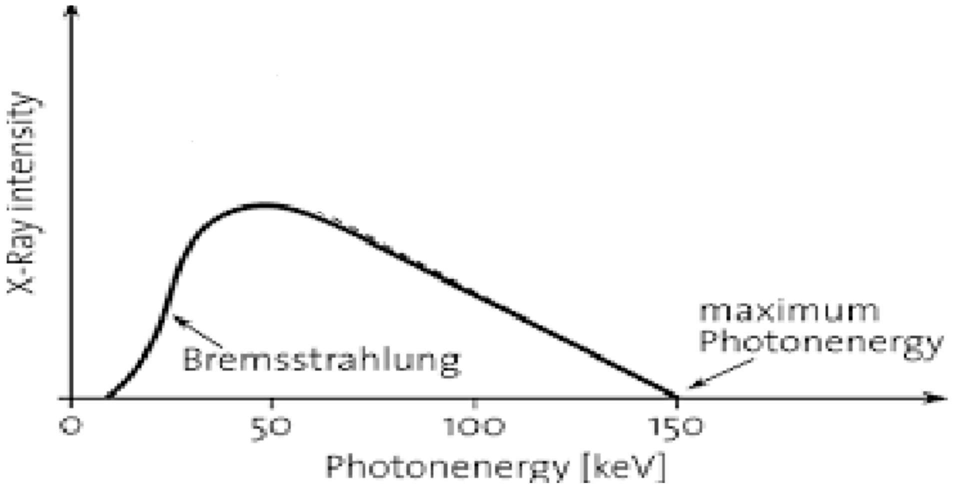
Positron

Most commonly used PET tracer is Fluorine 18
A proton in the nucleus is transformed into a neutron and a positively charged electron (positron).
Annihilation of the positron and electron yields two gamma photons each of 511Kev = rest mass energy of an electron

CT Scanner X-rays

- X-rays generated from orbital electron interactions



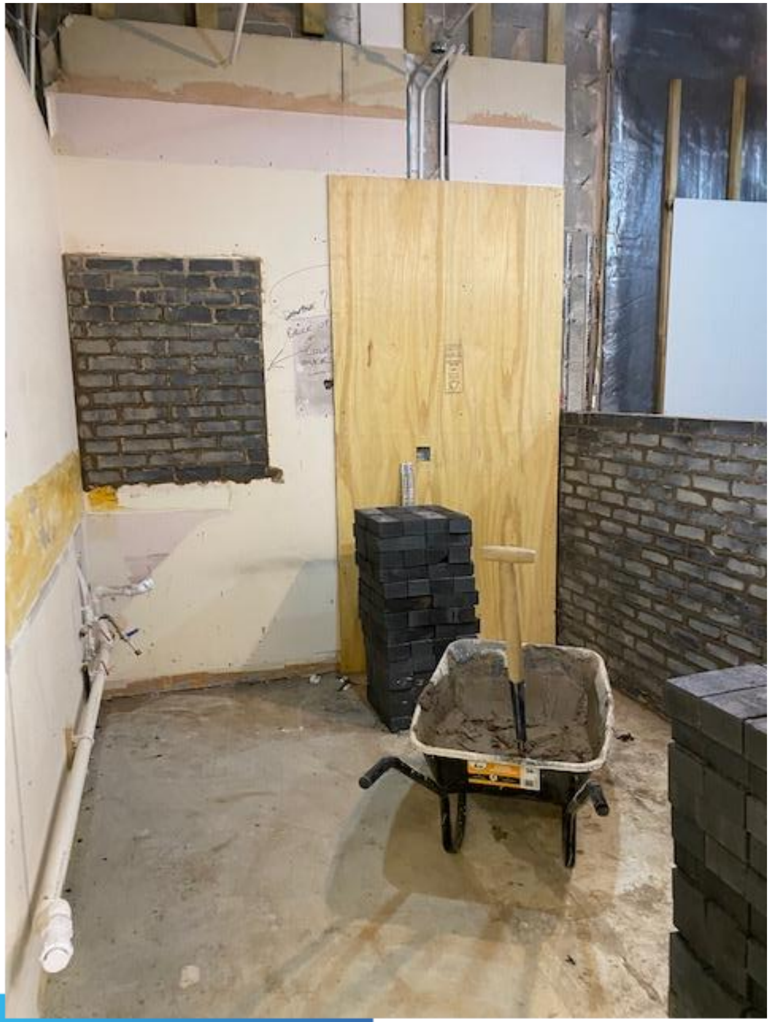


Peak of Bremsstrahlung is ~ 1/3 to ½ of the max X-ray energy~ 40-50KeV

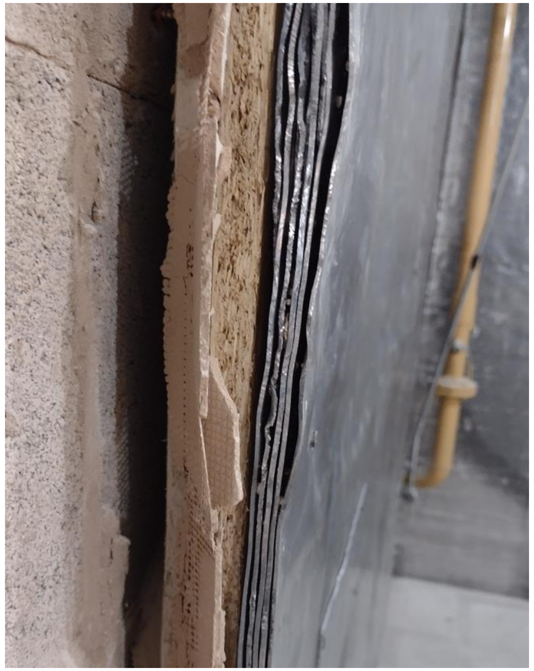
Lowering radiation dose in practice

- TIME- minimise time
- DISTANCE- maximise this
- SHIELDING- barrier between radioactive source and person
- CONTAINMENT
- GOOD Housekeeping

Facility design- shielding in walls



Engineering brickwork



Code 4 lead rolls

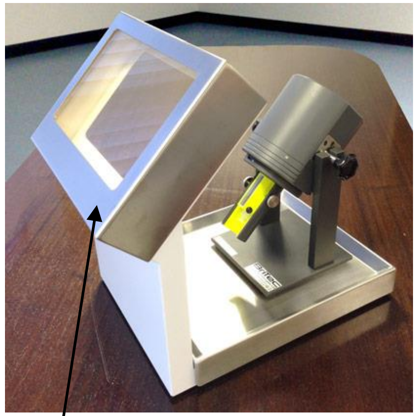
Multiple Layers of code 4 lead on the walls. Typically aim to have ~ 1cm lead equivalence in walls

Engineering controls- Shielding

Lead shielding in facilities used to draw up the activity.
Few cm of lead are used in shielded cupboards and body shields

Staff Dose reduction in PET

Syringe shield



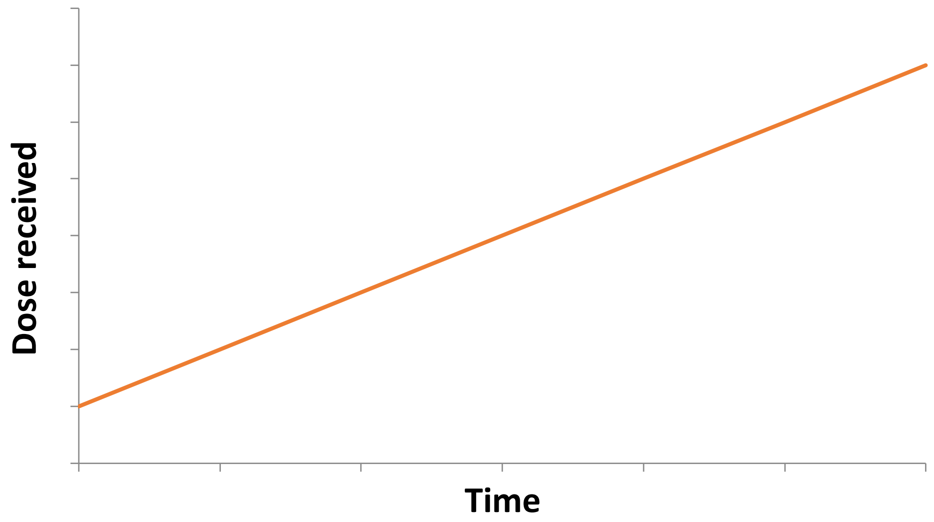
Lead glass several cm thick in body shield

Lead transport trolley

Automatic PET injector cart

Principles of Radiation Protection

Time

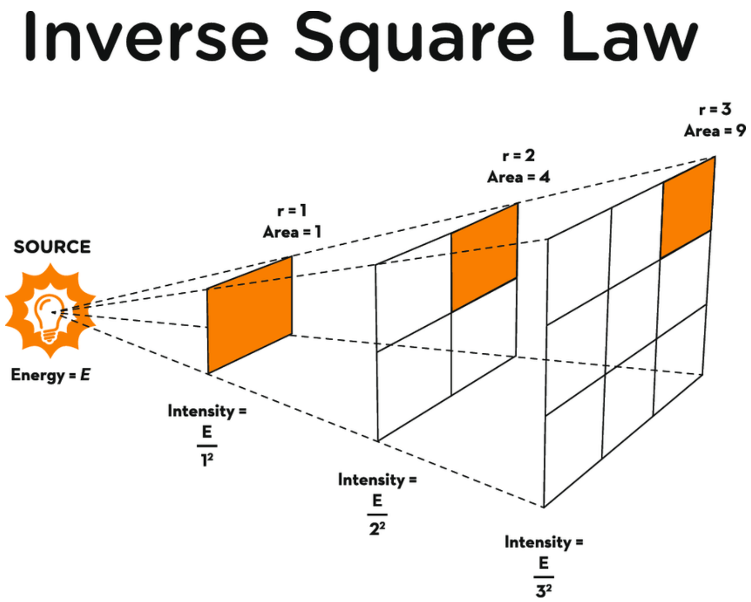


- Minimise time in close proximity to radioactive materials (patients and radiopharmaceutical preparations)
- Only remain in vicinity of exposure for as long as you need to be there

Principles of Radiation Protection

Distance: Assuming a point source of radiation

Doubling the distance results in a ¼ of the radiation flux intensity over the same area



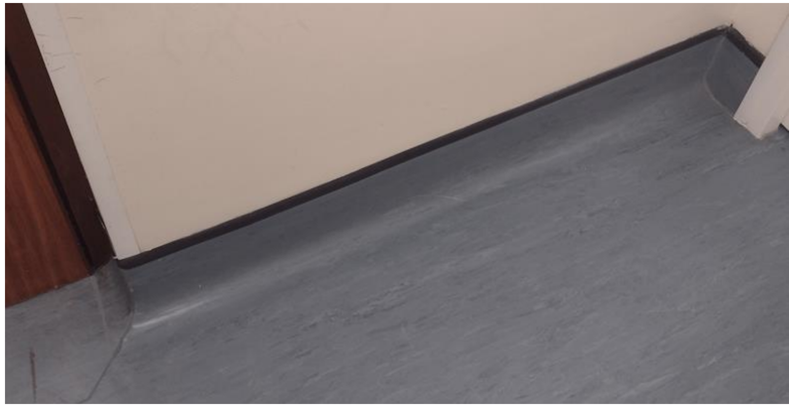
Maximise distance from patient when setting up for the scan

Warning signs

Principles of Radiation Protection

Containment

- Use drip trays when manipulating radioactive material
- Ensure the work area is clutter free
- Ensure work area is easy to decontaminate- consider surface finishes



Local Rules- written procedures

- Must identify the main working instructions intended to restrict any exposure in controlled or supervised areas.
- They should include steps needed to control exposure in the event of a radiation accident

Spill kits & rehearsal

PPE to minimise skin contamination

Monitoring for contamination

Contamination monitor

Hand and foot monitor

Monitoring staff for radiation exposure

Occupational dose limits for whole body, eye and extremity doses

Whole body badge

Finger ring

Finger Stall

Electronic personal dosimeter

Question: What are the three main methods which we use to lower the radiation dose received?

Question: What are the shielding materials used most commonly in PET facilities

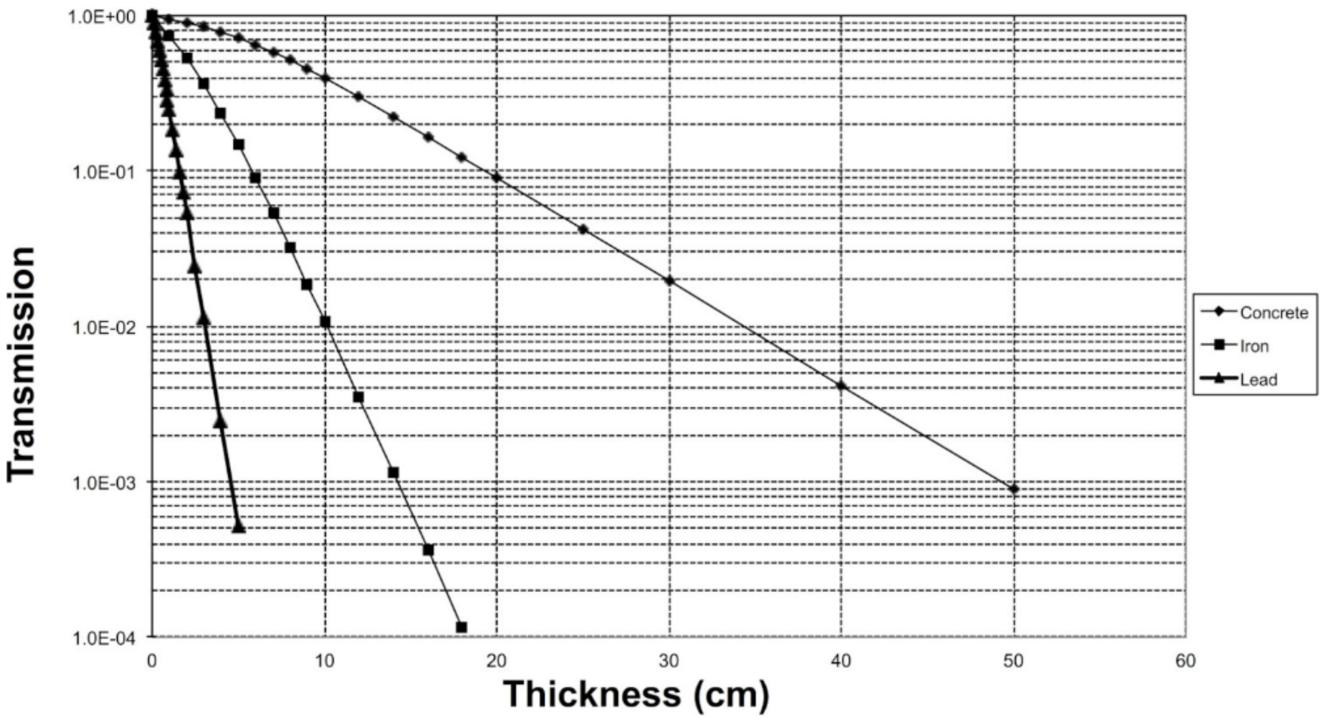


Figure 4.7 Broad beam transmission of 511 keV photons through lead, concrete and iron.

[Reference: Radiation Shielding for Diagnostic Radiology, 2nd Edition (birpublications.org)]

Thank you for listening

PET CT Center: the model of technology/service organization and delivery

Giulio Iachetti

Health Tech & Innovation Manager

Medipass S.p.a.

Partnership Service Model

Feasibility analysis

Analysis and assessment of clinical target and mid – long term goals to focus tech needs and best solution to be set up:

- assessment of catchment area considering clinical performance band,
- selection of methods and devices, IT requirement& systems included
- organization model, to guarantee feasibility and sustainability of the project

Design and building

Building up of site:

- accurate design, considering site constains and optimization of work and patient flow (both physical flow and data flow)
- leading of building phase to guarantee budget and timeline constrains
- management of legislation compliance and regulatory constrains to minimize time gap from site «ready to start» and clinical go live
- project Management from design to «first patient»

Tech procurement

Heath tech procurement:

- customer support in equipment selection considering tech specifications related to clinical performace of Customer Service
- negotiation with OEM taking benefit from Medipass position as large number of high tech devices owner and manager
- management of commissioning, SAT, installation & training for a faster and safer usage of devices in operations

Maintenance

Management of:

- full risk maintenance,
- full life cycle of devices, with activities striktly related to monito & controlquality % productivity
- upgrading plan, even considering HW & SW platform

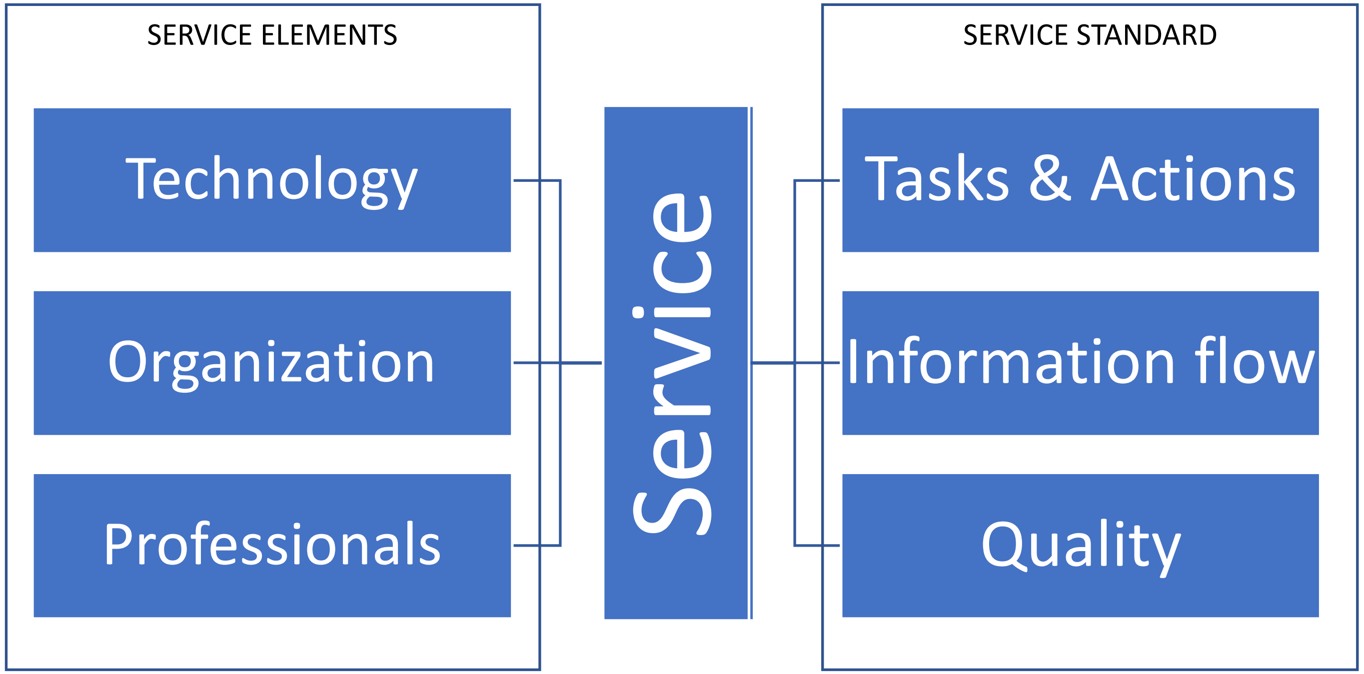
to guarantee planned availability of each device and regular clinical activities

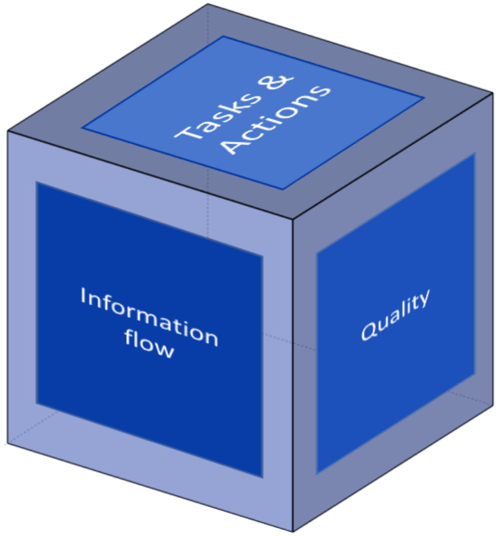
Clinical management

Selection and employment of qualified professionals (for clinics, tech management and support) to:

- reduce start up time
- improve Service to higher workload and productivity
- encourage knoledge transfert
- ensure a full exploitment of tech device and dignostic capabilities

Partnership Service Model





Medipass – Ongoing Services

Italy

Humanitas S. PioX Milano – 12 years*
Radiotherapy - SC
(2 Linac)

AO S. Antonio e Biagio Alessandria – 8 years
Radiology - SC
(MRI, CT, US)

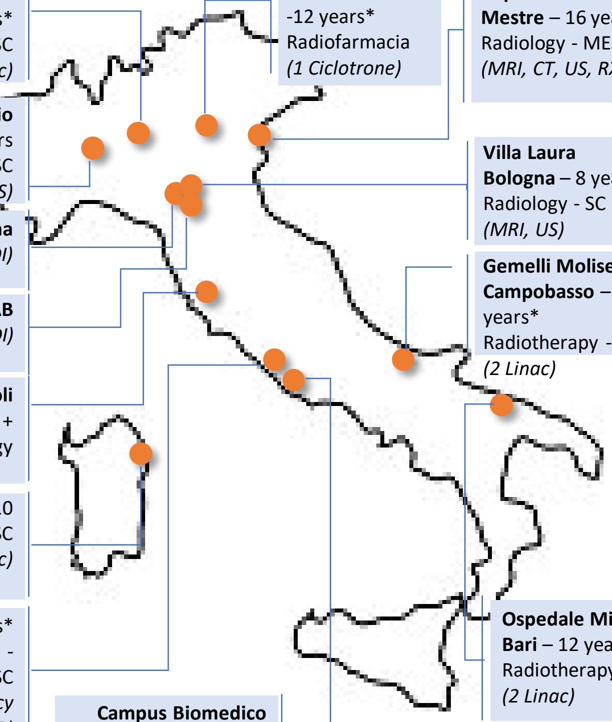
Elsida Bologna
Outpatient Clinic *(DI)*

AUSL Bologna -DAB
8 years *- 5 Outpatient Clinic *(DI)*

Ecomedica Empoli
Outpatient Clinic + Radiotherapy & Radiology

Ospedale Mater Olbia 10 years - Radiotherapy - SC
(3 Linac)

Policlinico Gemelli Roma – 22 years*
Radiotherapy, PET e Radiofarmacia - SC
(5 Linac, 2 PET-CT, 1 Radiopharmacy with Cyclotron + 1 Hybrid OR)



Campus Biomedico Roma – 10 years
Nuclear Medicine - SC
(1 PET-CT- + 1 Spect)

I.O.V. Padova
-12 years*
Radiofarmacia
(1 Ciclotrone)

Ospedale dell'Angelo Mestre – 16 years*
Radiology - MES
(MRI, CT, US, RX)

Villa Laura Bologna – 8 years
Radiology - SC
(MRI, US)

Gemelli Molise Campobasso – 10 years*
Radiotherapy - SC
(2 Linac)

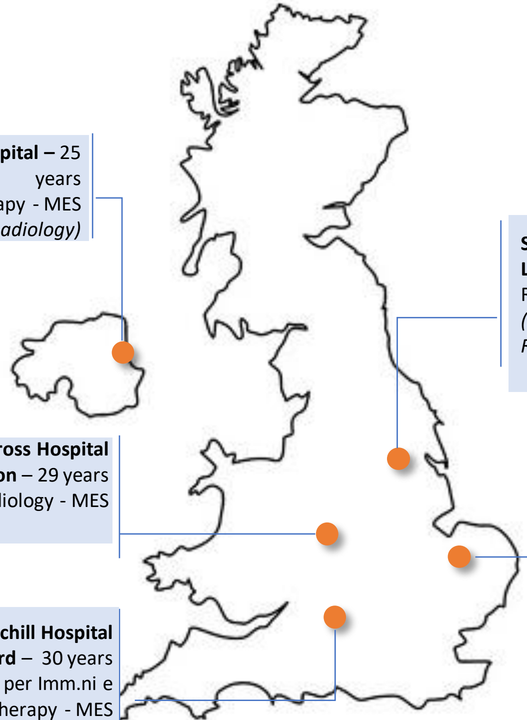
Ospedale Miulli Bari – 12 years
Radiotherapy - SC
(2 Linac)

UK

Belfast City Hospital – 25 years
Radiotherapy - MES
(10 Linac + Radiology)

New Cross Hospital Wolverhampton – 29 years
Radiology - MES

Churchill Hospital Oxford – 30 years
Diagnostica per Imm.ni e Radiotherapy - MES
(6 Linac + Radiology)



St. James Institute Leeds – 15 years
Radiotherapy - MES
(10 Linac + Radiology)

Norfolk & Norwich NHS Trust – 10 years
Radiotherapy - MES
(6 Linac + Radiology)

Medipass provides its services through long-term partnerships - between 8 and 30 years - to more than 15 public and private hospitals in Italy and the UK

SC: Clinical Service
DI: Dignostic Imaging
MES: Managed Equipment Services

Medipass – Ongoing Services

RON AT A GLANCE

RadioOnkologieNetzwerk DWS

RON is one of the German market leaders for outpatient physician services in radiotherapy, nuclear medicine and oncology

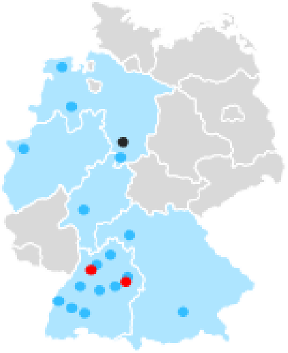
Germany

Overview

- RON is a leading and fast-growing operator of a radiation therapy practice network providing its services in 19 different locations in Germany, having grown from one practice to a supraregional healthcare network
- The company operates radiotherapeutic practices and oncology outpatient centers offering patients and employees the advantages of a networked corporate structure, as well as state-of-the-art technical equipment and great professional expertise at all practice locations
- Founded in 2008 (the first practice in Aalen, "Strahlentherapie Ostalb") by a team of renowned physicians that still lead the group today, RON has a strong track record of growth driven by (i) acquiring and integrating practices into the network and (ii) opening new practices (greenfield projects)
- The group includes a licensed basic care hospital – Einbecker Bürgerspital ("EBS") – that functions as holding vehicle for the MVZ network according to §108 SGB V[1)]
- RON employs c. 600 employees and is expected to generate c. € 106m revenues[2)] and € 28m EBITDA[2)] (c. 30% margin) in 2021 (Run rate)

Locations

- The group consists of
  - 7 MVZs – legal entity for medical centres
  - 16 radiotherapy practices and 2 oncological practices
  - 1 clinic as carrier vehicle according to §108 SGB V
- The group mainly operates in Western Germany – Germany wide expansion is planned

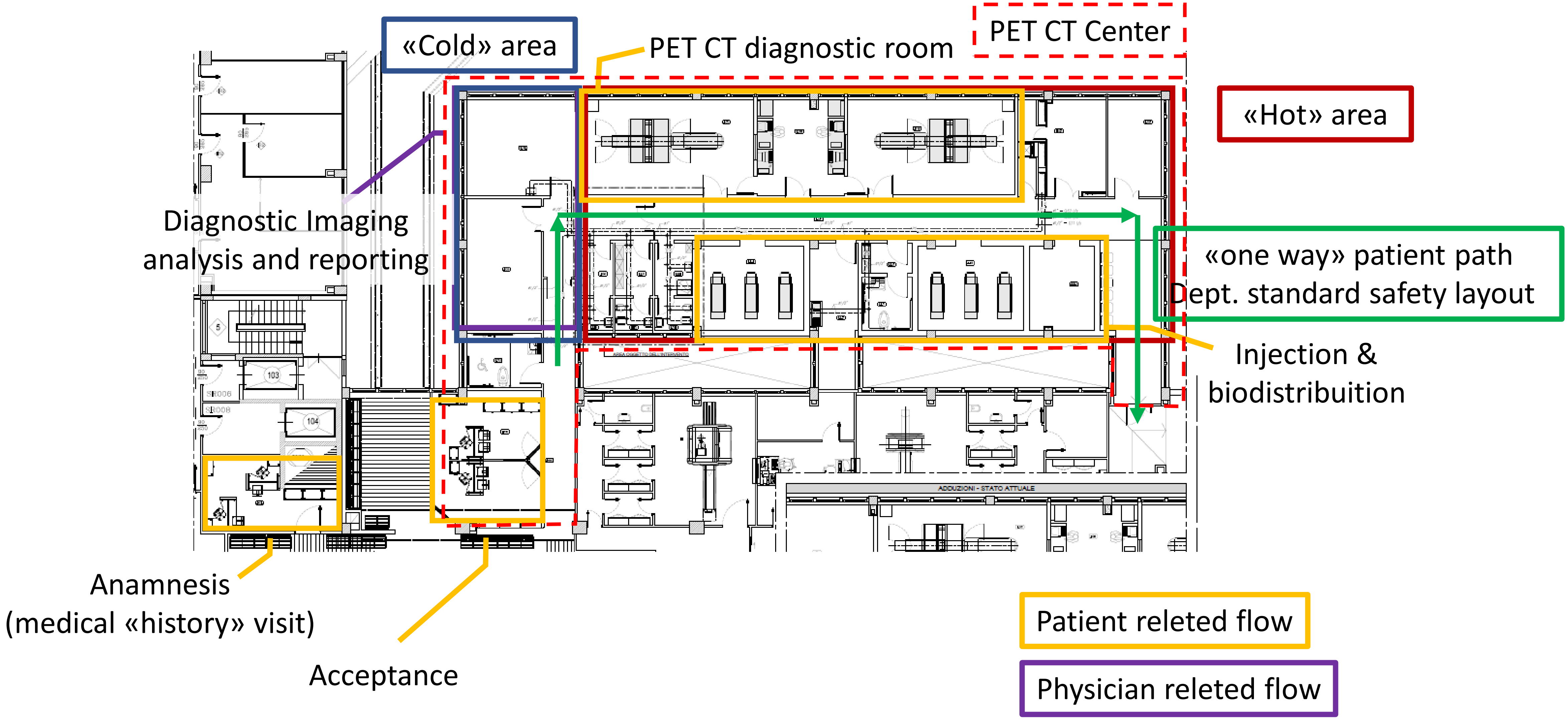


Services offered

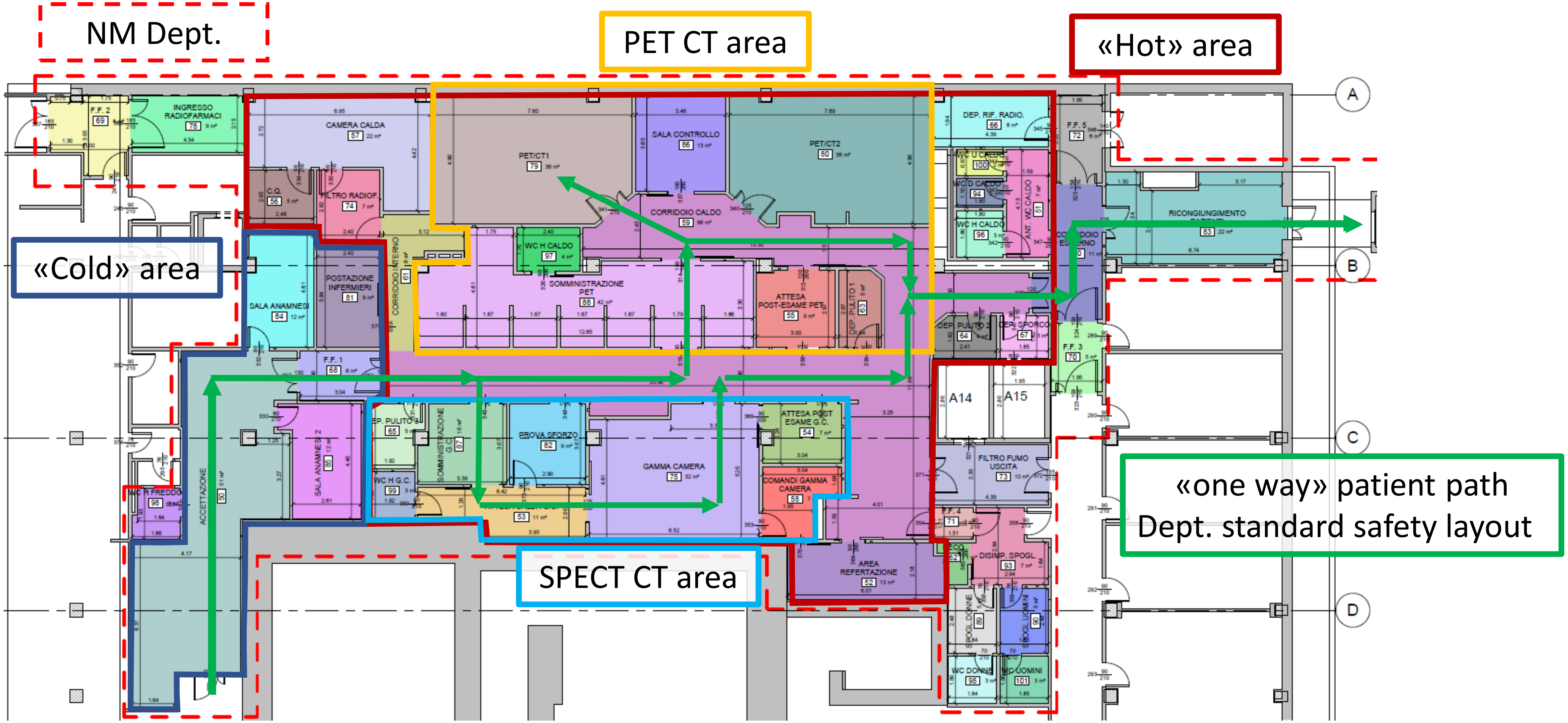
Radiotherapy	Nuclear medicine / MR	Oncology
		
Innovative technology enable complex & modern procedures *Various areas of treatment (e.g. tumors, arthrosis)*	*Several different MR and nuclear medicine services including mammography, angiography and thyroid*	*Services are focused on the area of hematology and internal oncology*

GLOBAL CLINICAL ENGINEERING ALLIANCE™

General layout of a PET CT Center



General layout of a Diagnostic Nuclear Medicine Dept.



GLOBAL CLINICAL ENGINEERING ALLIANCE

Question 1

- Why is important to keep in consideration a «cold» and a «hot» area, planning the layout of a PET CT Center?
  - For higher safety of patient
  - For higher safety of operators
  - Both

General layout of Hospital Radiopharmacy

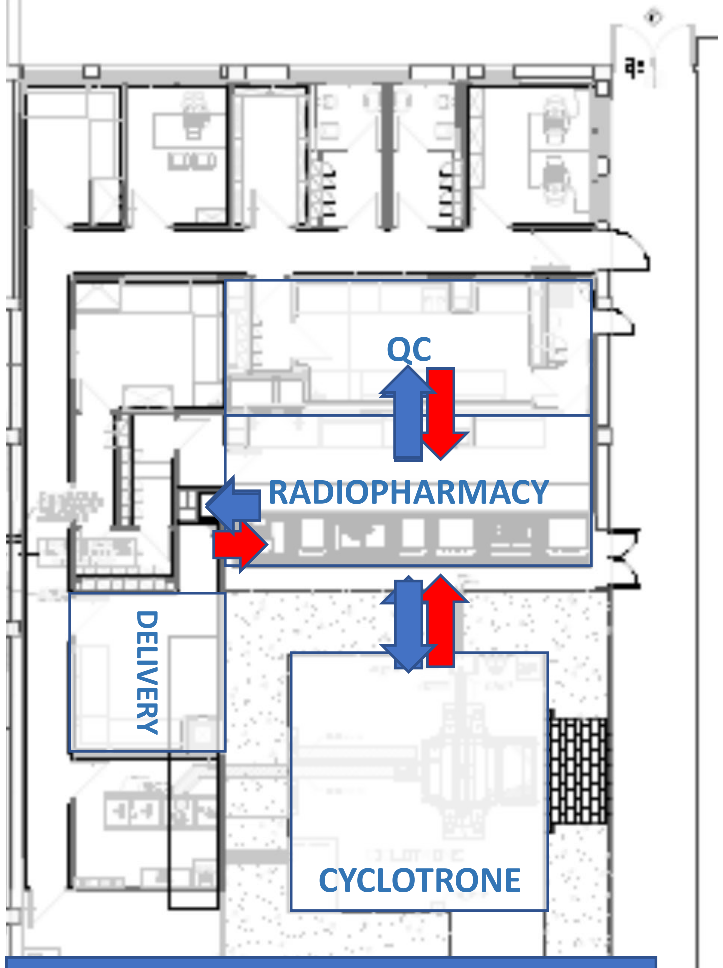
- Each room has tasks that can be done inside
- Each room has its own asepsis «grade» (like in an operating room)

Grade	Maximum permitted number of particles/m³ equal to or greater than the tabulated size			
	At rest		In operation	
	0.5µm	5.0µm	0.5µm	5.0µm
A	3,520	20	3,520	20
B	3,520	29	352,000	2,900
C	352,000	2,900	3,520,000	29,000
D	3,520,000	29,000	not defined	not defined

ISO classification number (N)	Maximum concentration limits (particles/m³ of air) for particles equal to and larger than the considered sizes shown below (concentration limits are calculated in accordance with equation (1) in 3.2)					
	0,1 µm	0,2 µm	0,3 µm	0,5 µm	1 µm	5 µm
ISO Class 1	10	2				
ISO Class 2	100	24	10	4		
ISO Class 3	1 000	237	102	35	8	
ISO Class 4	10 000	2 370	1 020	352	83	
ISO Class 5	100 000	23 700	10 200	3 520	832	29
ISO Class 6	1 000 000	237 000	102 000	35 200	8 320	293
ISO Class 7				352 000	83 200	2 930
ISO Class 8				3 520 000	832 000	29 300
ISO Class 9				35 200 000	8 320 000	293 000

- Workflow

- Design considering asepsis and radioprotection issues



Pressure Gradient for asepsis

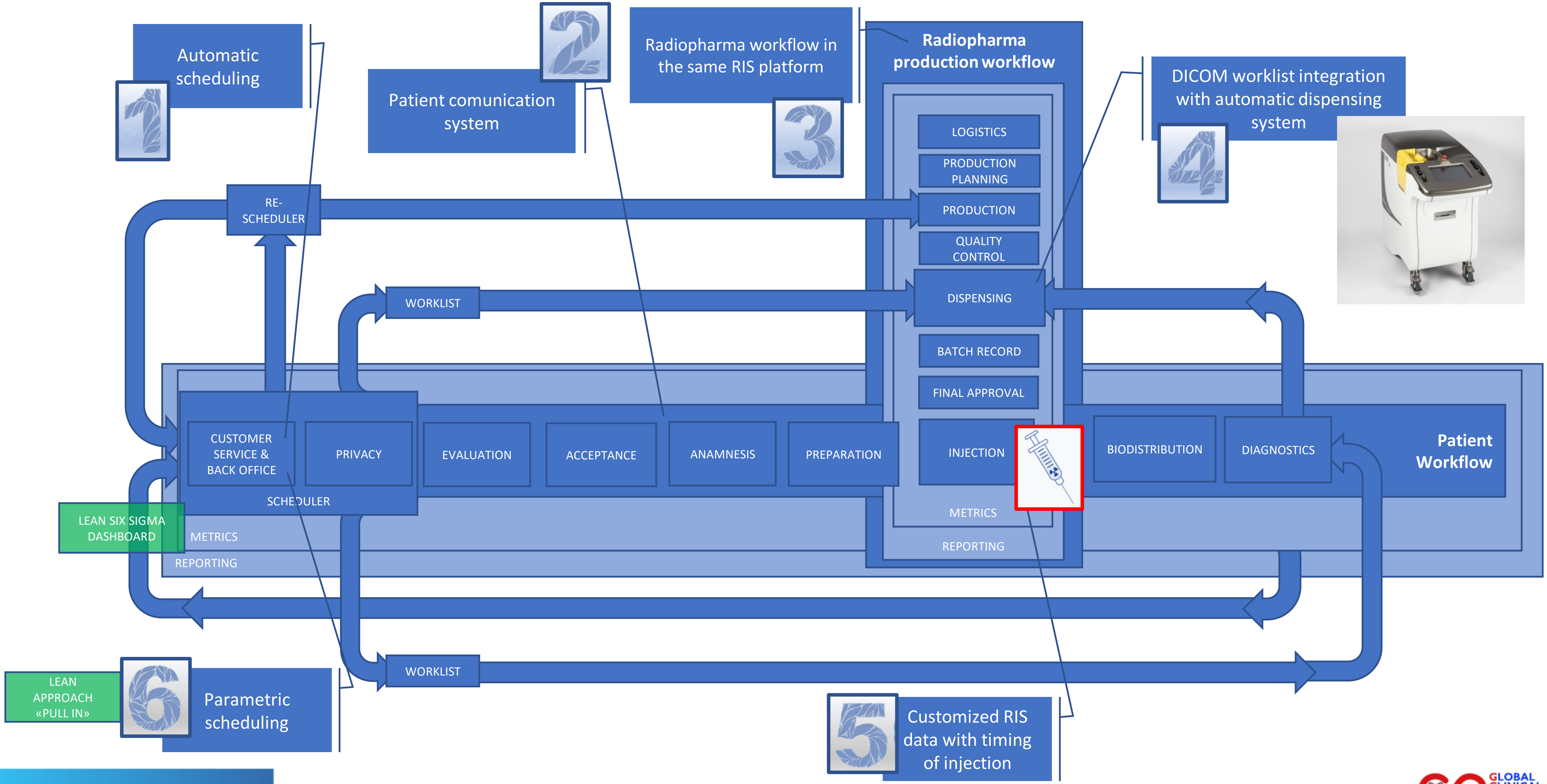
Pressure Gradient for Radioprotection

Radiopharma: Manufacturing or compounding?

	Manufactoring	Coumpounding
Producer	Manufacturer/Industry	Hospital radiopharmacy
Setting	Commercial	Clinical
Standard	GMP	Code of practice
Regulation	National medicial regulatory authority (e. g. FDA)	Professional bodies/istitution
Distribution	Public distribution	Practitioner-patient
Marketing	Yes	No
Permission	Investigational authority New drug application	Ethic committee

https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1342/Pub1342_web.pdf

General workflow - a question of coincidence…



Question 2

- What is the main issue in patient-dose pairing?
  - Patient recognition related to dose delivered
  - Timing of injection considering calibration activity and patient preparation
  - Both

General Protocol – syntetic dashboard

[^{18}F] FDG (FLUORODESOSSIGLUCOSIO)

Protocol name/code

a. Globale Corporea

i. Standard (PRO.823)

Protocol in acquisition workstation

Protocollo operativo	Siemens Biograph mCT	Siemens Vision
	PETCT_WHOLEBODY (ADULT)	PETCT_WHOLEBODY. CBM.ADULT

- dose prescritta secondo BMI
- Per pazienti pediatrici vedi tabella dedicata

Radioactive dose quantification related to protocol and patient

Biodistribuzione
- 50'-70'

Acquisizione
- Statica (base cranio – rotula)
- VISION: 1,4 mm/s (base cranio-collo-torace), 1 mm/s (cupola diaframmatica-piccolo trocantere), 2 mm/s (Arti inferiori) (Flow Motion Velocity) – 15' – 18'
- BIO: 15'-18' (acquisizione non inferiore a 120 s/lettino base cranio-pelvi)

Ricostruzione
- VISION: TrueX+tof(ulta HD-PET) - Utilizzo iMAR dove previsto (protesi, device cardiaci)
- BIO: TrueX+tof(ultraHD-PET)

Congedo paziente
- 5'

TOTALE 70-100 MINUTI BIO/VISION

General workflow (biodistribuition, adquisition, reconstruction)

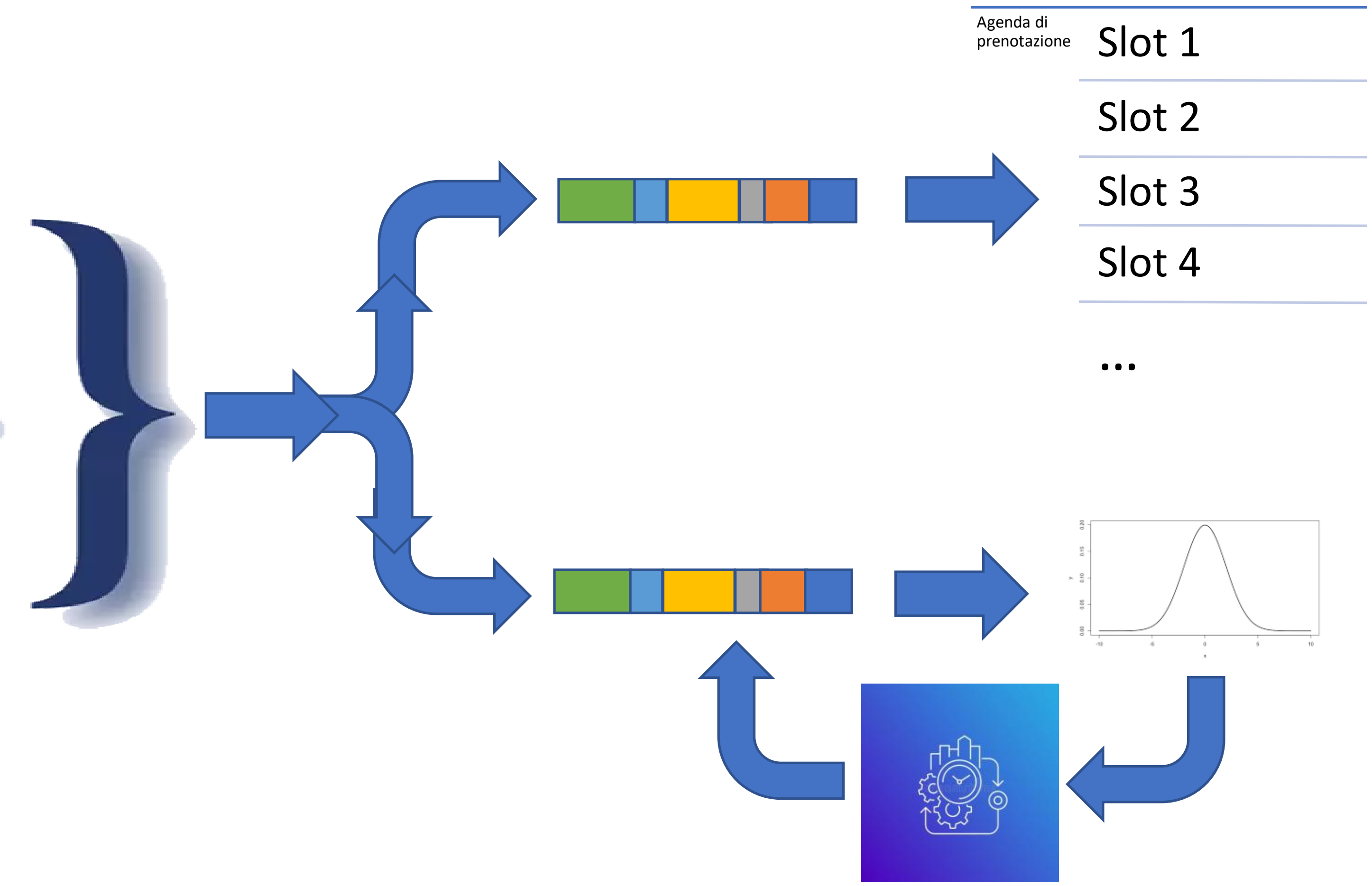
Medipass Advanced Medical Services

GLOBAL CLINICAL ENGINEERING ALLIANCE

Patient exam main phases – scheduling optimization

TEMPI SLOT TYPE:

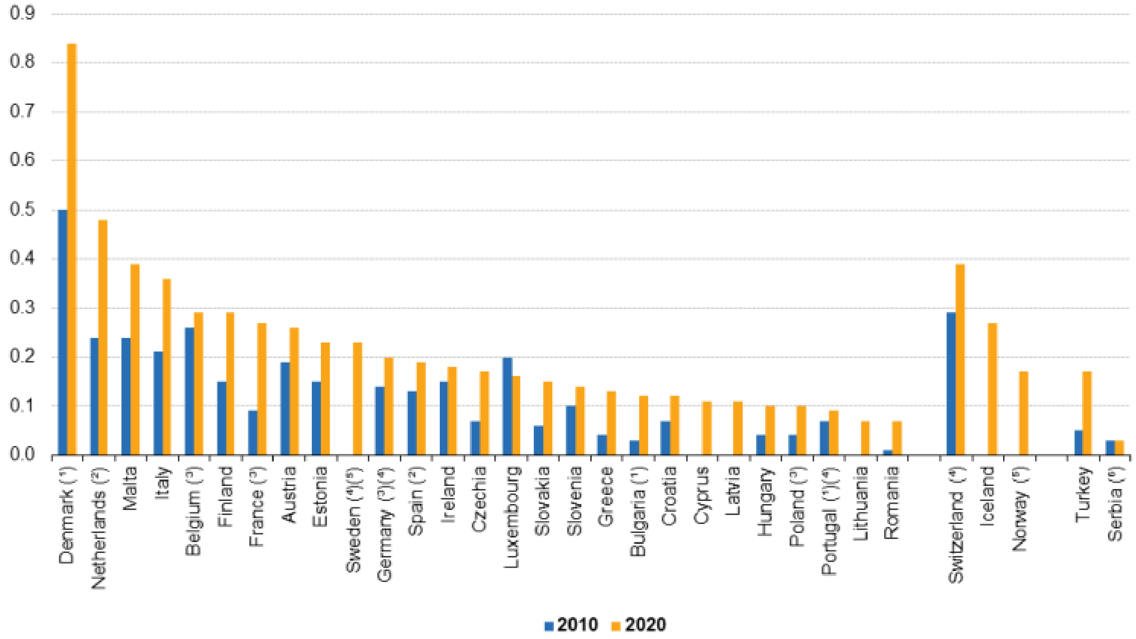
- Timing for patient acceptance
- Timing for anamnesis
- Timing for patient preparation
- Timing for injection
- Timing for biodistribution
- Tempo for diagnostic acquisition



Productivity – EU data

Availability of PET scanners, 2010 and 2020

(per 100 000 inhabitants)



Note: Liechtenstein, no PET scanners.
(1) 2011 instead of 2010.
(2) 2020: provisional.
(3) Break in series.
(4) Hospitals only.
(5) 2010: not available.
(6) 2012 instead of 2010.
Source: Eurostat (online data code: hlth_rs_equip)

eurostat

Use of imaging equipment, 2020

	Computed tomography (CT) scanners	Magnetic resonance imaging (MRI) units	PET scanners	Computed tomography (CT) scanners	Magnetic resonance imaging (MRI) units	PET scanners	Computed tomography (CT) scanners	Magnetic resonance imaging (MRI) units	PET scanners
	(number of scans)			(number of scans per machine)			(number of scans per 100 000 inhabitants)		
Belgium	2 365 903	1 008 721	99 649	8 541	7 642	3 020	20 494	8 738	863
Bulgaria	511 007	73 336	22 669	1 819	917	2 834	7 370	1 058	327
Czechia	1 155 945	616 821	53 544	6 643	5 227	2 975	10 805	5 766	501
Denmark	1 140 605	528 503	80 651	4 813	:	1 646	19 560	9 063	1 383
Germany (1)	*12 473 599*	*12 469 676*	151 100	*4 082*	*1 744*	239	*14 999*	*14 995*	182
Estonia	169 655	67 140	2 210	6 284	3 357	737	12 761	5 050	166
Ireland	:	:	:	:	:	:	:	:	:
Greece	*1 304 286*	*497 098*	*25 018*	*2 787*	*1 385*	*1 787*	*12 189*	*4 646*	*234*
Spain	*5 368 448*	*4 009 884*	*220 011*	*5 657*	*4 646*	*2 500*	*11 335*	*8 466*	*465*
France (2)	13 384 683	8 276 562	637 705	10 953	8 004	3 819	19 903	12 307	948
Croatia	412 170	226 795	11 269	4 580	3 658	2 254	10 184	5 604	278
Italy	5 200 916	3 846 088	275 952	2 333	2 071	1 278	8 748	6 470	464
Cyprus (3)	117 133	5 600	0	3 778	311	–	13 281	635	–
Latvia	363 939	135 937	866	5 126	4 531	433	19 150	7 153	46
Lithuania	309 528	151 496	2 959	3 558	3 787	1 480	11 075	5 420	106
Luxembourg	*119 300*	*52 458*	*3 423*	*8 521*	*4 769*	*3 423*	*18 924*	*8 321*	*543*
Hungary (4)	1 712 537	436 204	23 080	18 218	9 088	2 308	17 564	4 474	237
Malta	54 083	27 100	2 049	5 408	4 517	1 025	10 495	5 259	398
Netherlands	*1 987 410*	*1 021 986*	*133 406*	*7 763*	*4 386*	*1 588*	*11 395*	*5 860*	*765*
Austria	1 622 882	1 252 945	40 607	6 389	5 544	1 766	18 200	14 051	455
Poland	3 408 847	1 537 374	62 197	4 479	3 872	1 637	8 995	4 057	164
Portugal (3)	2 122 103	525 740	20 502	11 228	4 913	2 278	20 609	5 106	199
Romania	701 683	278 144	8 561	1 907	1 225	612	3 644	1 444	44
Slovenia	177 251	167 188	664	4 431	5 971	221	8 431	7 952	32
Slovakia	784 337	373 508	13 415	7 542	6 917	1 677	14 368	6 842	246
Finland	*247 109*	*228 276*	*3 480*	*2 629*	*1 351*	*218*	*4 469*	*4 128*	*63*
Sweden	:	:	:	:	:	:	:	:	:
Iceland	78 941	38 065	:	4 644	5 438	:	21 541	10 387	:
Liechtenstein	3 451	3 777	0	3 451	3 777	–	8 871	9 709	–
Norway (6)	455 821	632 305	15 279	2 729	6 199	1 698	8 473	11 754	284
Switzerland (5)	1 052 045	677 057	58 379	4 655	3 064	1 717	12 181	7 839	676
North Macedonia	56 752	14 107	1 320	:	:	:	2 738	681	64
Serbia	360 512	89 832	2 619	4 241	2 807	1 310	5 225	1 302	38
Turkey	22 608 923	:	333 461	18 116	:	2 316	27 114	:	400

(1) Number of scans per PET machine: hospitals only.
(2) 2019.
(3) 2019. Definition differs.
(4) Number of scans per machine: the number of computed tomography scanners and magnetic resonance imaging units concerns those owned by health care institutions with a contract for outpatient care with the National Institute of Health Insurance Fund Management.
(5) Hospitals only.
(6) Computed tomography scanners excluding dental and veterinary use. Magnetic resonance imaging units excluding veterinary use. PET/MRI is included under PET scanners.
Source: Eurostat (online data codes: hlth_co_exam and hlth_rs_equip)

eurostat

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthcare_resource_statistics_-_technical_resources_and_medical_technology

Question 3

- What is a high productivity PET CT Center?
  - Less than 1.000 patient/year/tomograph
  - From 1.000 to 3.000 patient/year/tomograph
  - More than 3.000 patient/year/tomograph

Next steps...

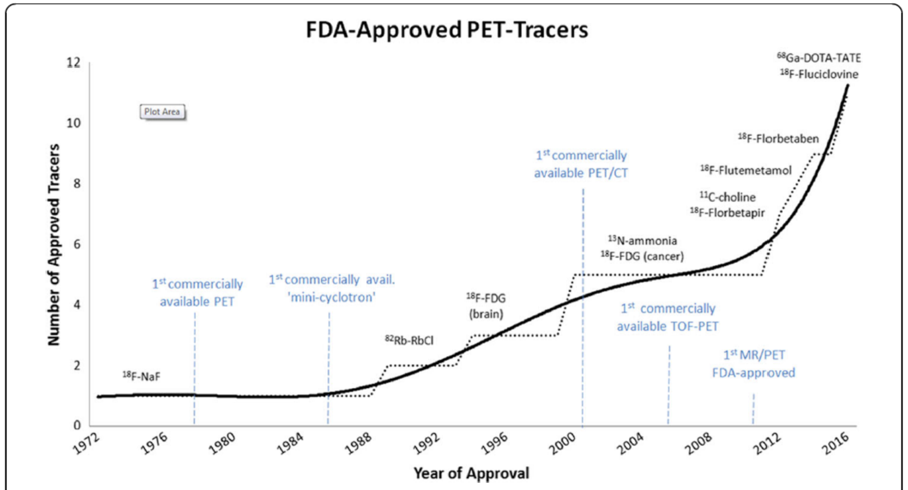


Fig. 1 Timeline of Food and Drug Administration (FDA)-approvals of PET tracers and technical milestones, from 1972 to 2016. Abbreviations: NaF: Sodium fluoride, RbCl: Rubidium chloride, FDG: Fluorodeoxyglucose, PET: Positron Emission Tomography, CT: Computed Tomography, MRI: Magnetic Resonance Imaging, TOF: Time-of-Flight

A. G. Wibmer, H. Hricak, G. A. Ulaner, W. Weber Trends in oncologic hybrid imaging European Journal of Hybrid Imaging (2018)

Journal of *Clinical Medicine*

MDPI

Conference Report

Imaging Bacteria with Radiolabelled Probes: Is It Feasible?

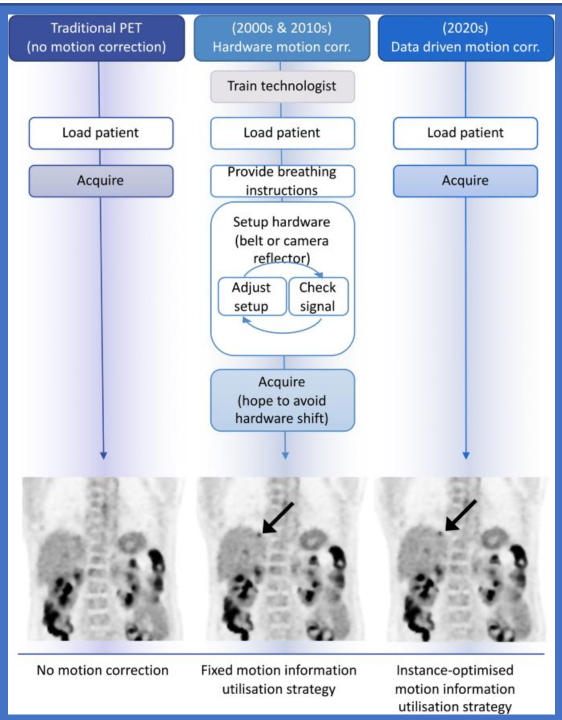
Alberto Signore [1,*], Vera Artiko [2], Martina Conserva [1], Guillermina Ferro-Flores [3], Mick M. Welling [4], Sanjay K. Jain [5], Søren Hess [6] and Mike Sathekge [7]

Long axial field of view PET scanners: a road map to implementation and new possibilities

Riemer H. J. A. Slart, Charalampos Tsoumpas, Andor W. J. M. Glaudemans, Walter Noordzij, Antoon T. M. Willemsen, Ronald J. H. Borra, Rudi A. J. O. Dierckx & Adriaan A. Lammertsma

European Journal of Nuclear Medicine and Molecular Imaging **48**, 4236–4245 (2021) | Cite this article

3158 Accesses | **17** Citations | Metrics



Aide, N., Lasnon, C., Kesner, A. et al. New PET technologies – embracing progress and pushing the limits. Eur J Nucl Med Mol Imaging 48, 2711–2726 (2021).

Thank you

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Q&A

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A list of additional topics and dates for next webinars will be soon announced through email campaign and on our website www.GlobalCEA.org

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for your participation