DIAGNOSTIC IMAGING
Radiology
and
Nuclear Medicine
(how and what we teach)

Assoc. prof. Ján **Lepej,** M.D., PhD**.**

Institute of nuclear and molecular medicine,
Clinic of nuclear medicine, Faculty of
Medicine UPJŠ,
KOŠICE

Co-funded by the
Erasmus+ Programme
of the European Union

ediTec

Education in medical imaging

1. Semester – 2 credits 1/1 (hours/week, **S**eminars/**L**ectures)

History of imaging and basic technical information (S,L)

Radioprotection (S)

Nuclear medicine (S+L) diagnostic process and methods

EBM in imaging (S) **TEST and examination**

---

2. Semester – 2 credits 1/1

Radiology - classical X-ray **Comparison**

- CT **and indication of methods**
- MRI new trends
- other methods **TEST and examination**

We use case reports to explain diagnostic validity of method and we direct show how the technology work

Education in medical imaging

1. Semester – 2 credits

History of imaging and basic technical information

Radioprotection

Nuclear medicine **diagnostic process and methods**

EBM in imaging **TEST and examination**

2. Semester – 2 credits

Radiology - classical X-ray **Comparison**

- CT **and indication of methods**
- MRI new trends
- other methods **TEST and examination**

We use case reports to explain diagnostic validity of method and we direct show how the technology work

History of imaging

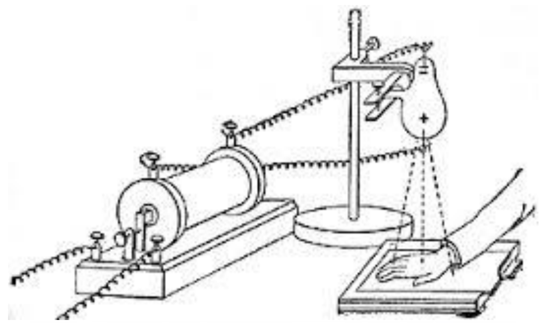
First, part of a human body imaged (paint) was HAND

X - RAY

8.11.**1895** – Wilhelm Conrad **Röntgen** discovered X-rays during his experiments with cathode tube he obtain - first X ray photo

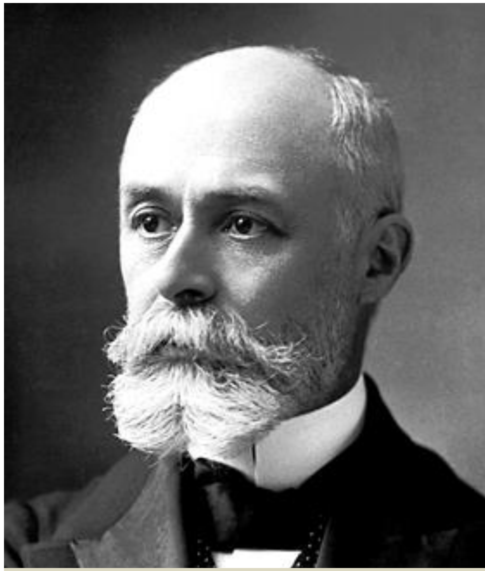
Medicine start to use TECHNOLOGY for IMAGING

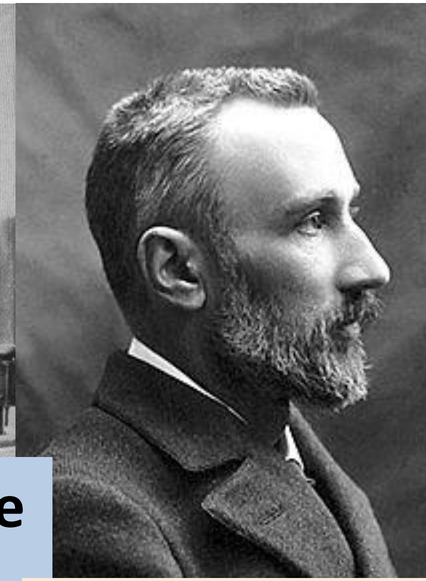
1901
Physics

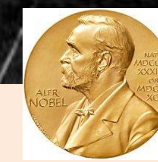


Anna Bertha Rontgen
Ludwig´s **hand** pictue

1896 - discover of radioactivity – Becquerel a Curie

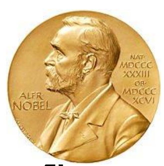






Antoine Henri **Becquerel**
1852-1908

Pierre **Curie**
1858-1906



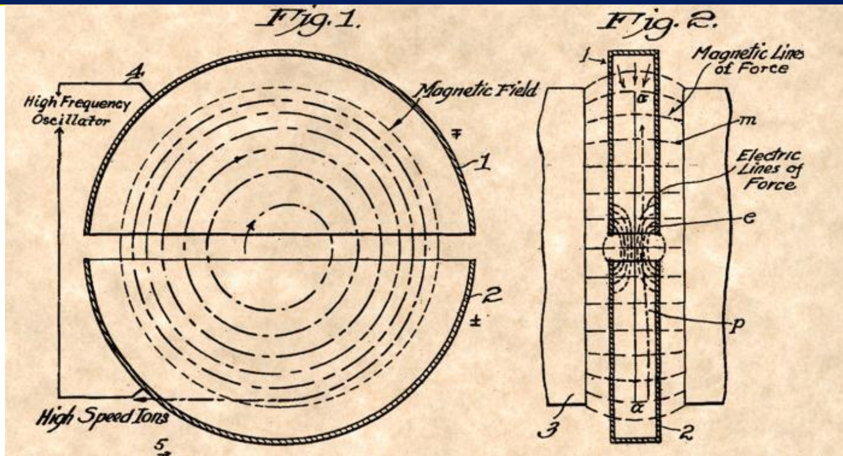
Maria **Curie Skłodowska**
1852-1908 (she die for **Leukemia**)

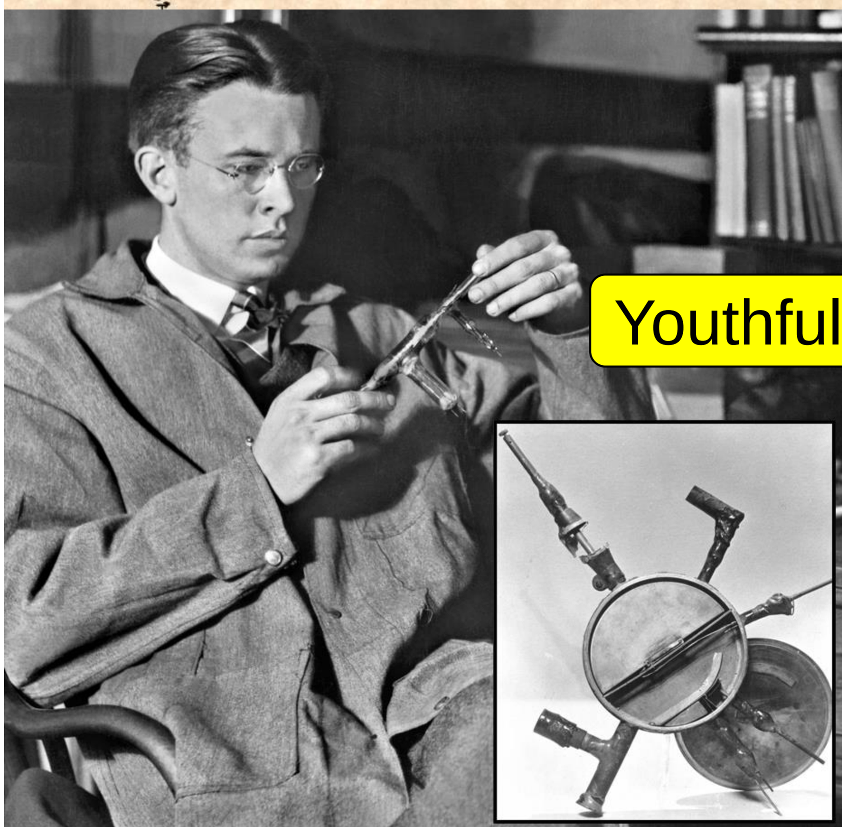
In **1896**, Becquerel studied uranium fluorescence. When photographic plate with uranium salts was closed 3-day in the table - . Together with the Curieans, they discovered natural radioactivity. In 1903, they received the Nobel Prize for Physics. Maria Curie Skłodowska made chemical analyzes of smolder from Jáchymov and discovered two new elements - Polonium and Radium. 1911 Nobel Prize: Chemistry

becquerel - **Bq** [s^{-1}] = 1 decay / 1 second

More usefull unites 1000 Bq = **1 kBq**, 1000 kBq = **1 MBq**, 1000 MBq = **1 GBq**

1929 - cyclotron - **production of radioisotopes**

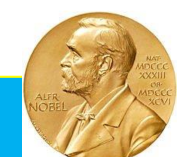




First model of Lawrence
CYCLOTRON
was made of wire and sealing wax and total cost for it was around **$ 25.**
And it was working: When Lawrence introduce
2 000 V into his model of cyclotron, he obtain 80 000 volt beams rotating around center.
In 1934 he obtain patent on cyclotron.

Youthful enthusiasm in the young science**...**

In **1939** Nobel Price for physics



1934

Ernest Orlando **Lawrence**

CYKLOTRON

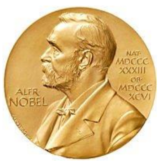
Zdroj: Wikipedia

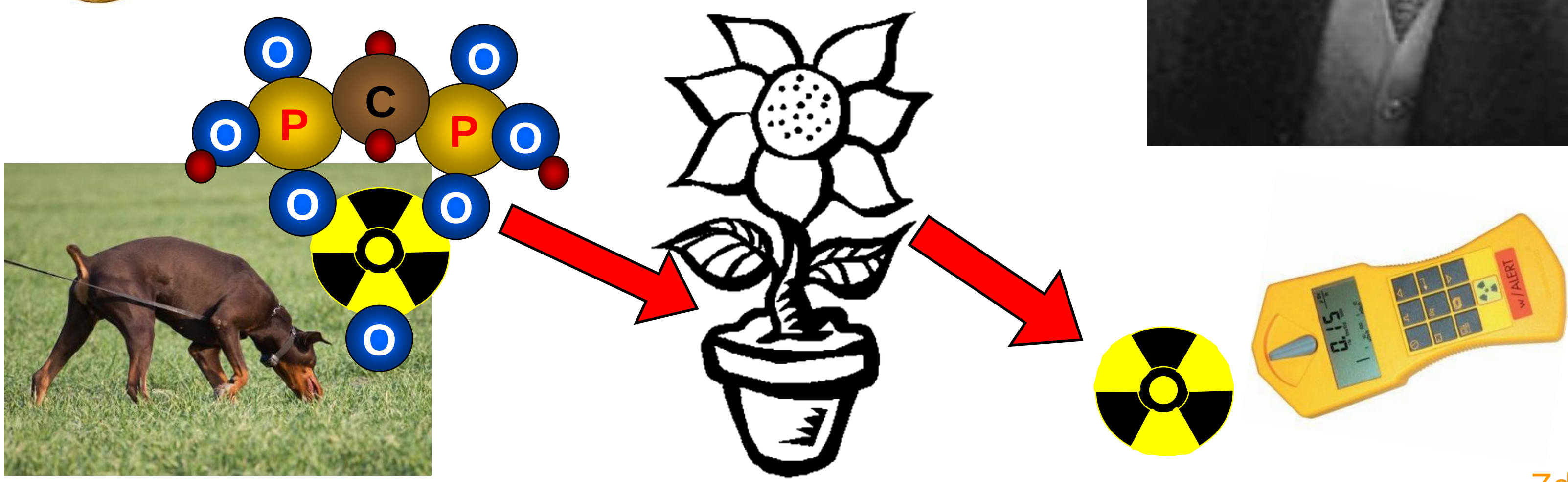
1932 - the **principle of how to monitor metabolism**

György Károly **Hevesy**(1885-1966)
father of NUCLEAR MEDICINE

He was first who use of isotopes to study biological systems

1943 - The Nobel Price for Chemistry



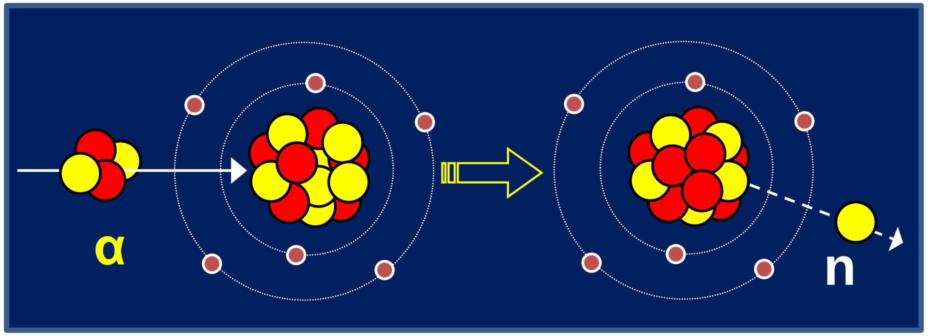


Zdroj Wikipedia

1933 - radioactive isotopes can be usable in humans

The success of hard, collective work and family tradition...

When they applied alpha irradiation (from polonium) on aluminum appeared in 1934 induced or artificial radioactivity.



$$^{27}_{13}\mathrm{Al} + ^{4}_{2}\alpha \rightarrow ^{30}_{15}\mathrm{P} + n$$

Created first artificial radioactive element phosphorus-30

Positron produced in laboratory

1935 Nobel prize for Chemistry

1934 Frederic a Iréne Joliotovci - Curieovci - Daughter Maria Skłodovska

Artificial radioactivity

Zdroje Wikipedia a vlastné vyobrzenie

Thyroid gland NM imaging - HISTORY

1939

Joseph Gilbert **Hamilton**, Mayo **Soley** and Robley **Evans** first published work on the use of iodine-131 for the diagnosis of patients.

1940

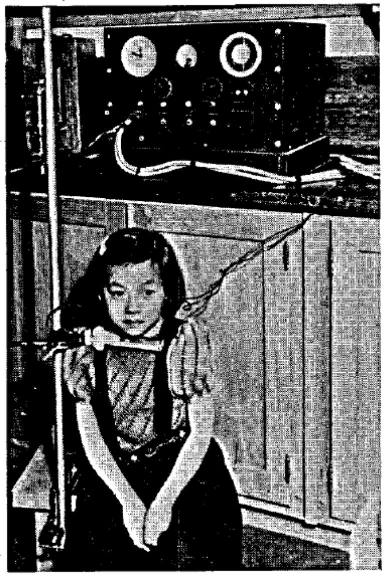
Group of Berkley, California, USA introduced the first clinical examination of thyroid function - **accumulation test of thyroid.**

1941

Saul ***Hertz*** apply to the patient the **first therapeutic dose of radioactive iodine**-130.

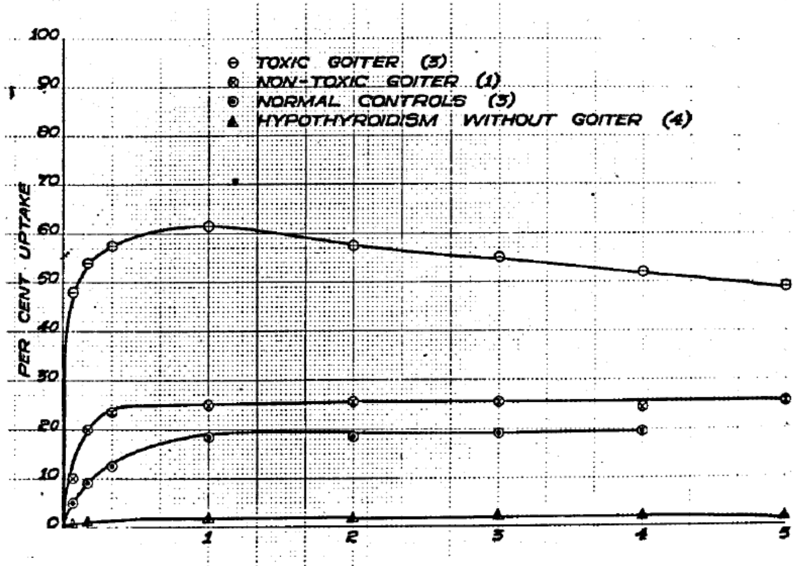
^{131}I Discovery

In the spring of 1938, Dr. Hamilton asked Dr. Seaborg if he could find an isotope of iodine with a half-life of "about one week." Dr. Jack Livingood prepared tellurium targets which were bombarded by deuterons and neutrons at the 37-Inch Cyclotron. After chemical separation, Drs. Seaborg and Livingood discovered ^{131}I (8-day half-life).



Right: The first kinetic study on the function of the human thyroid using ^{131}I and a Geiger-Muller counter.

Below: Disease diagnosis is made possible by patterns of the time variation of activity in the thyroid. The first studies were done by the Berkeley team in 1940.



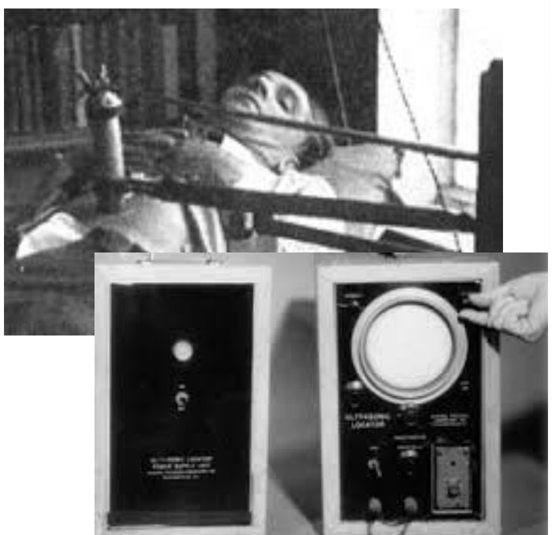
1940 Ultrasonography – USG – echography

Ultrasonic energy was first applied to the human body for medical purposes by George Döring **Ludwig**, M.D. at the Naval Medical Research Institute, Bethesda, Maryland **1922-1973**

1958 – usage ultrasound in gynecology and obstetrics

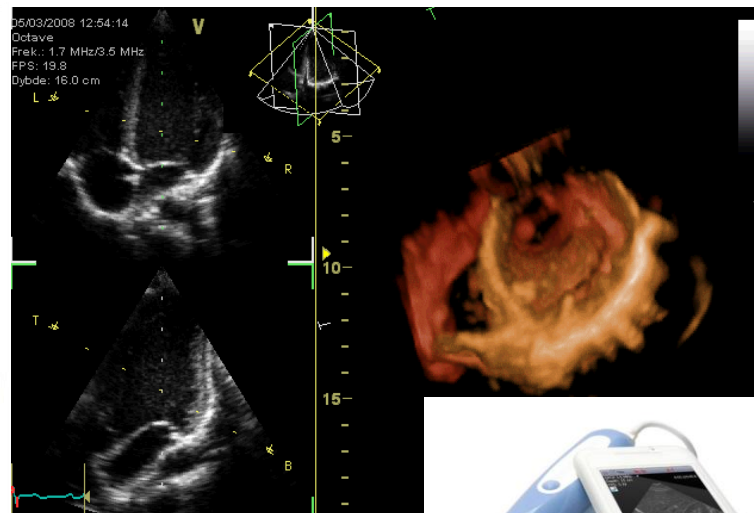
1960s – cardiology

1980s – enormous development started with use of modern computers.



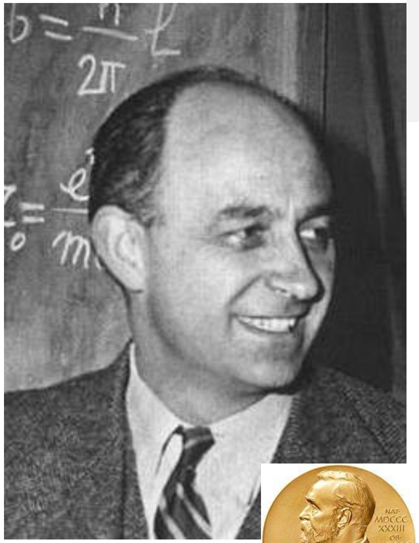
1940

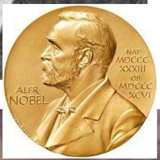
2015



Such a change in 75 years
during the length of human life.

1942 the first **nuclear reactor** to produce plutonium and the Manhattan project



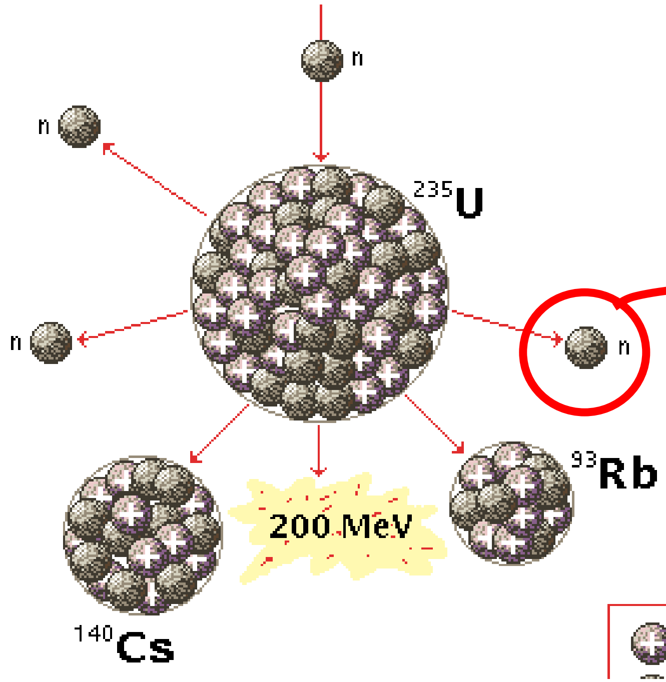


natural uranium contains 0.7% ^{235}U and 99.3% ^{238}U. For decay of urnium is necesary ^{235}U > 2.5%

The first **nuclear reactor** was built at the stadium in Chicago, (USA). Directed by **Enrico Fermi**. The main objective was to master the uranium-235 digestion and to prepare Plutonium for atomic bomb production.

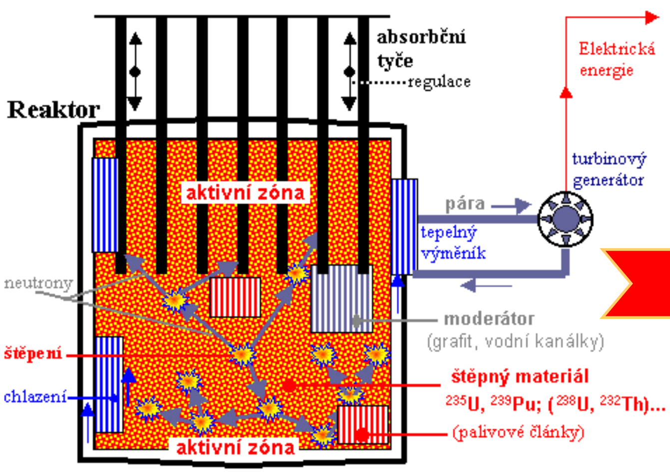
First use of Hiroshima 6/8/1945

Production of radionuclides – **nuclear reactor**



^{60}**Co -** 5,3 r	- tumors therapy
^{99}**Mo -** 68 h	- ^{99m}Tc-generator
^{131}**I -** 8 d	- therapy v NM

Used to bomb the target
for the production of radionuclides (^{99}Mo)



1947 first **radiopharmaceutical**

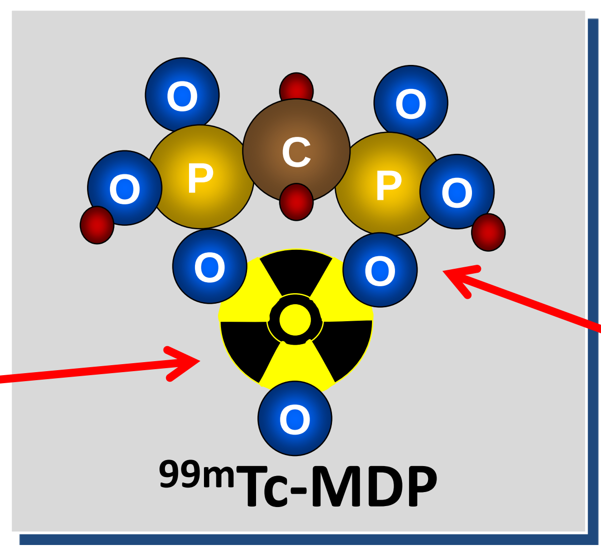
Georg **Moore** first used the labeled 131I-diiodofluorescein molecule as the "marker" to mark the brain tumor during surgery. The basis for the formation of labeled compounds - **radiopharmaceuticals** and **radionavigated surgery**.

Radiopharmaceuticals are pharmacological agents to be used in the diagnosis or treatment .

They must have good pharmacological and radiation properties.

Each containing a radionuclide, as most often coupled to various chemical and biological components

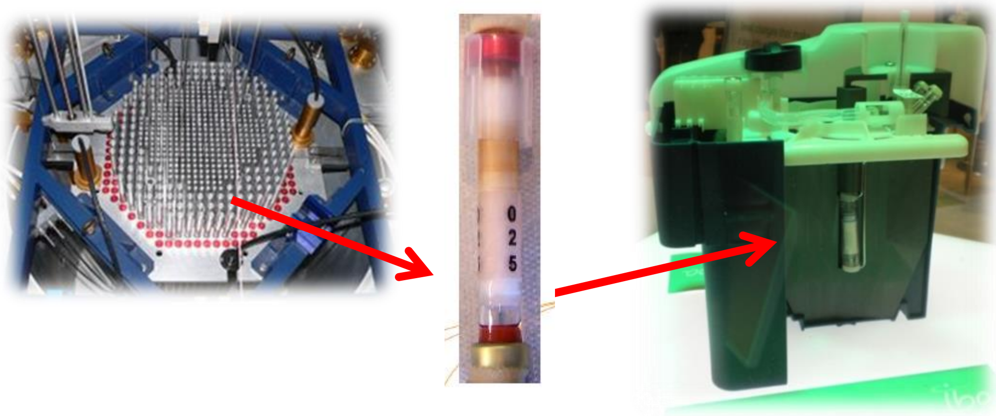
TRACER
(MARKER)
RADIONUKLID

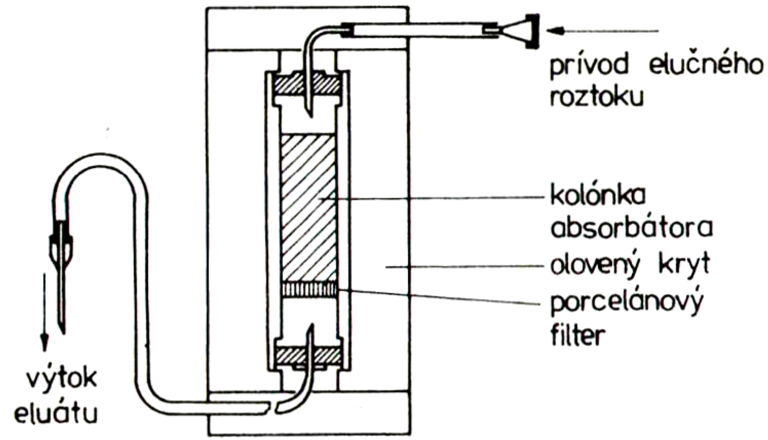


TARGET
molecule, cell
PHARMACON

Starts to use new term - **MOLECULAR IMAGING**

1966 production of short-lived isotopes in NM dpt.





radionuclide generator

is a device for the preparation of short-term emitters directly at nuclear medicine department. Decay of the mother element with longer half-life, to a daughter product – radionuclide with a very short physical half-life.

mother (F1/2)	**daughter** (F1/2)	Poznámka	Stab.izotop
^{99}**Mo**(67 h) →	^{99m}**Tc** (6 h)	**Technetium 85% RF**	^{99}**Tc** → ^{99}**Ru**
^{68}**Ge**(271 d) →	^{68}**Ga** (68 min)	**Galium radionuclid for PET**	^{113}**In**
^{81}**Rb**(4.6 h) →	^{81m}**Kr** (13 s)	**Krypton - ventilation**	^{81}**Kr**
^{195}**Hg**(41 h) →	^{195m}**Au**(30.5 h)	**Gold - angiography**	^{195}**Au**

Synthesis of radiopharmaceuricals

18F-FDG synthesis occurs in specialized automatically protected in the lead-shielded sterile boxes.

For each type of radiopharmaceutical we use another kit in the form of cassettes.

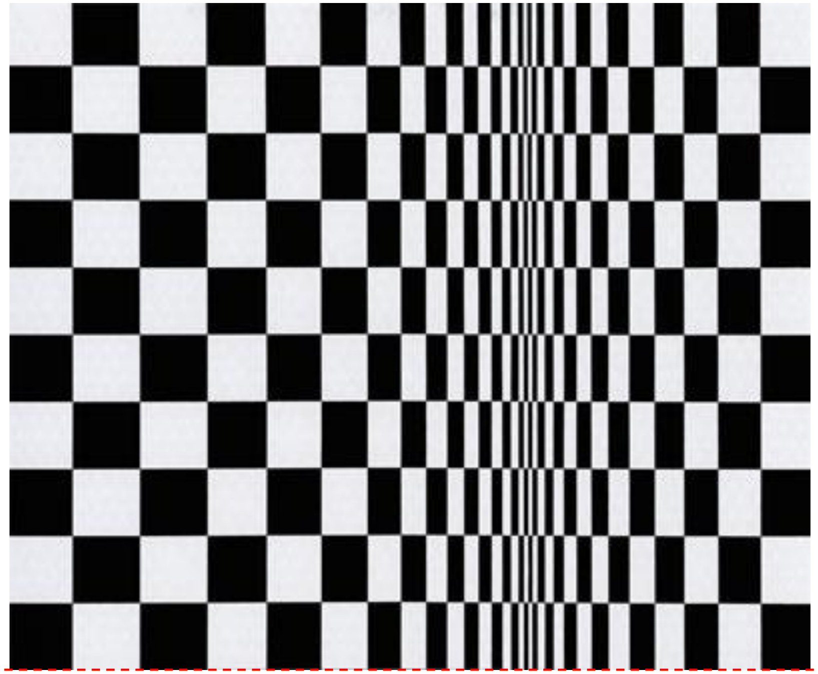
Developement of imaging methods in 1960

2000

1990

1980

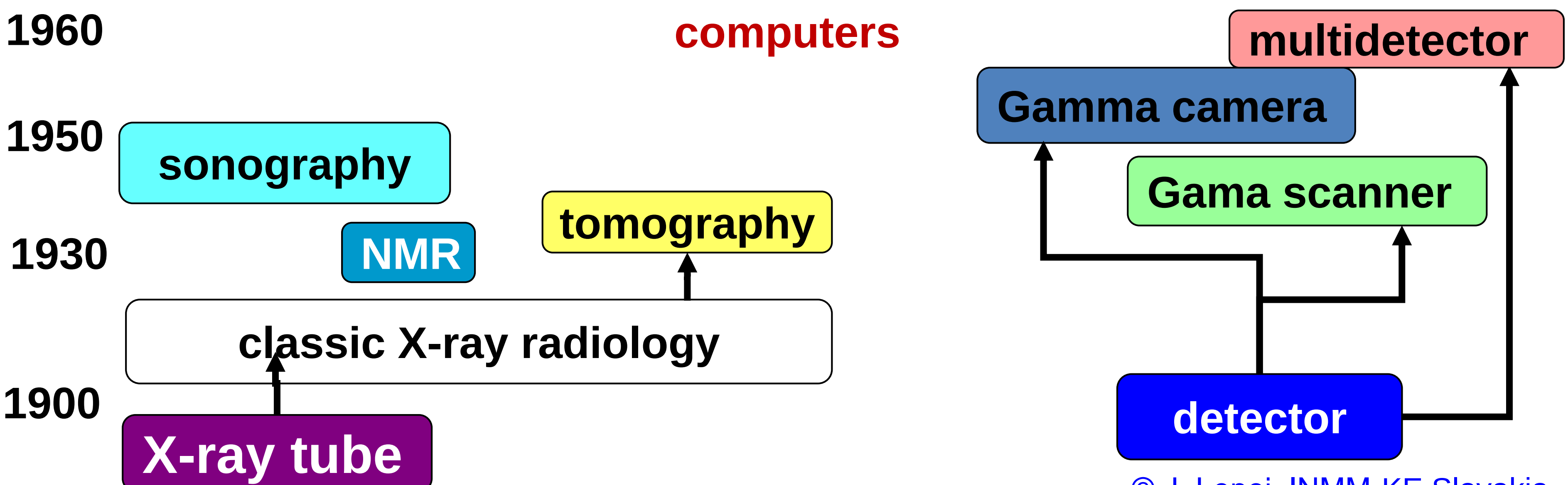
1970



Comes a **beautiful 60-ies**
in the art was running **OP-ART**
← Bridgett **Riley** in 1961

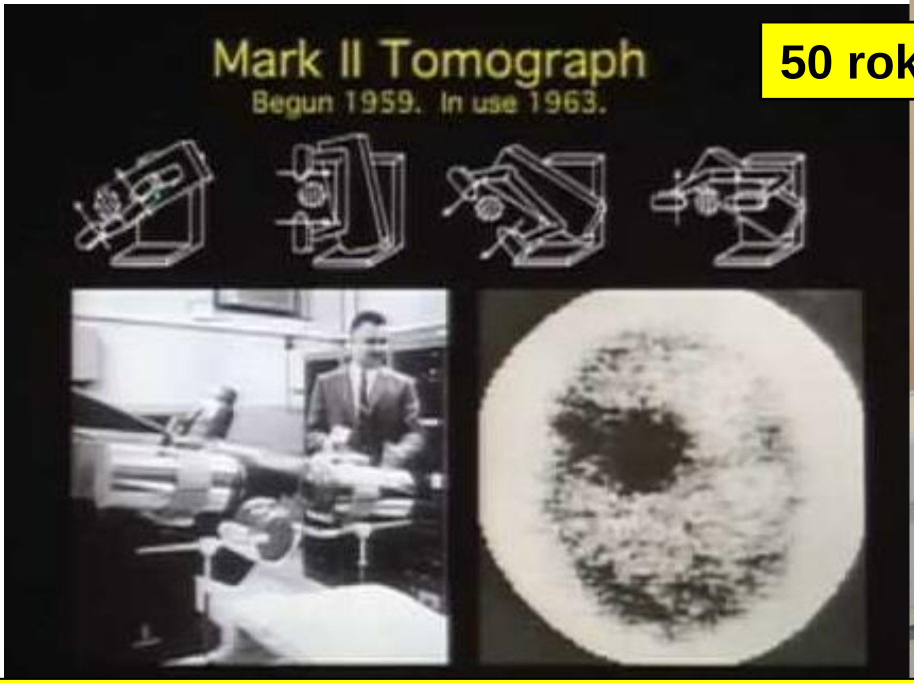
Symbol of next digital age ...
Computers have about 15 years,
Semiconductors was 10 years old

Diagnostic imaging looks like this diagram.
And **computers starts to** have the potential to **change everything**.

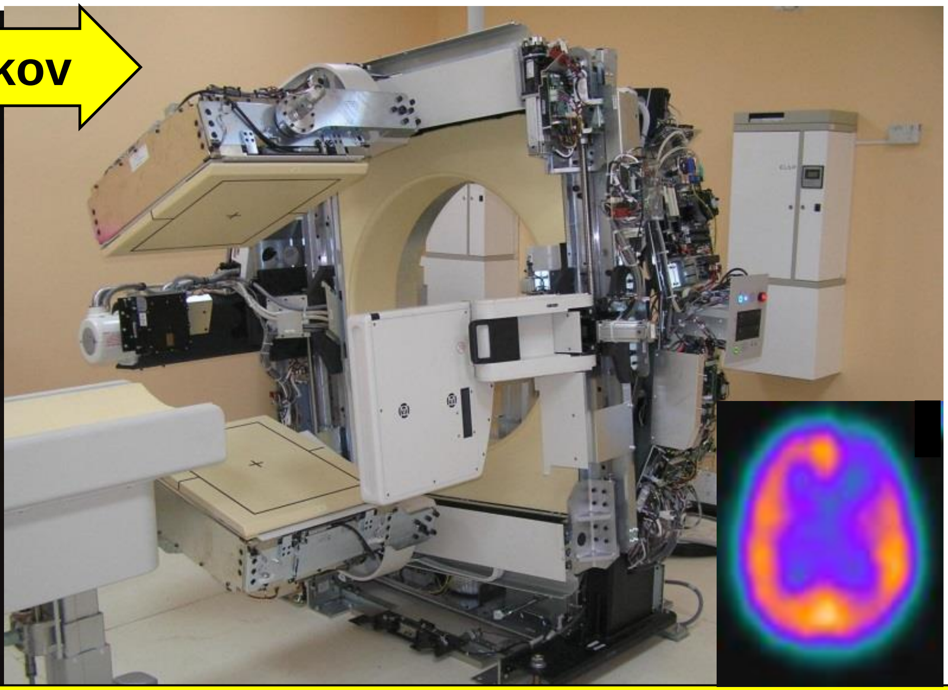


1963 The Principle of Emission Computed Tomography

David Edmund **Kuhl** (1929-2017) as a student at the MF invented in **1954** - a recording system to detect the distribution of radiopharmaceuticals.
Between **1959** and *1963*, the **single-photon emission tomography** (SPECT) construction, which later led to the improvement of PET and the discovery of CT (CT)



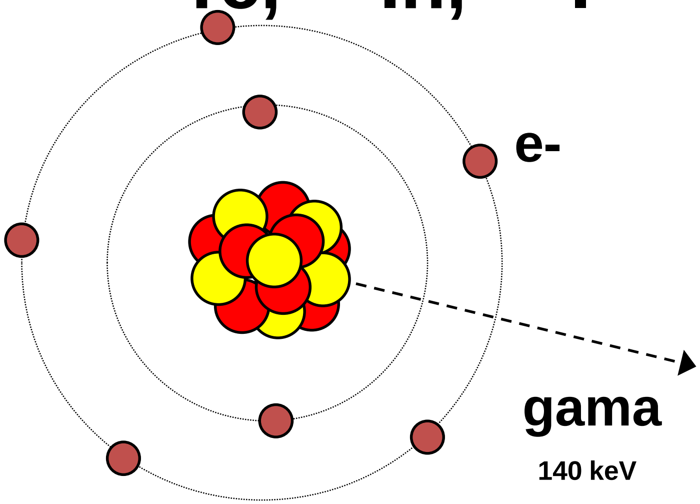
50 rokov

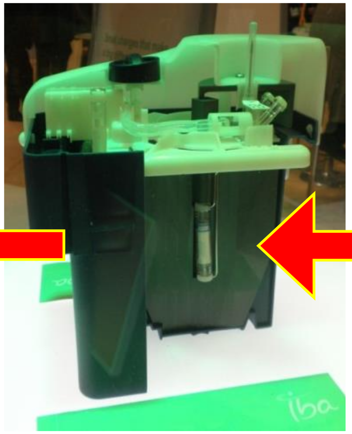


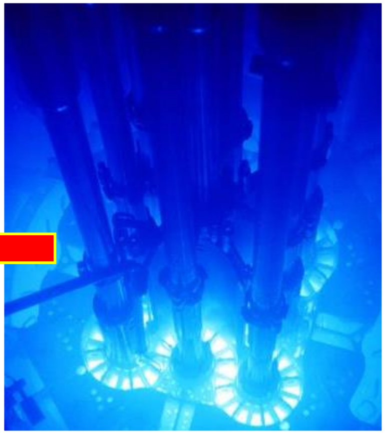
Father of the emission computed tomography **(SPECT, PET)**

1966 SPECT Single photon emission tomography

^{99m}Tc, ^{111}In, ^{123}I



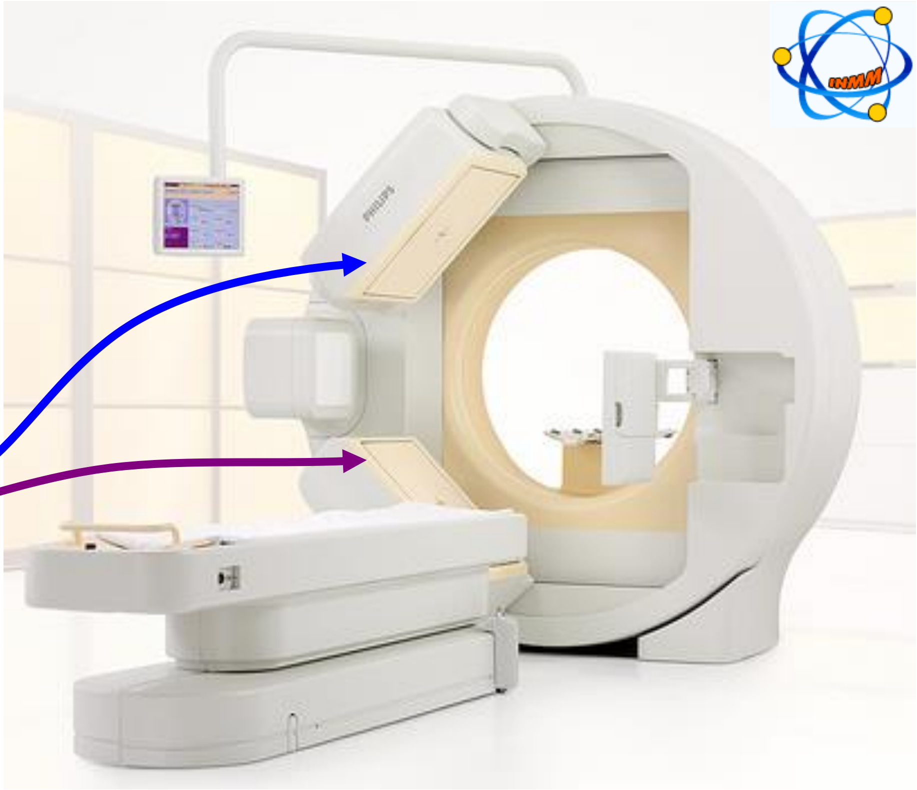




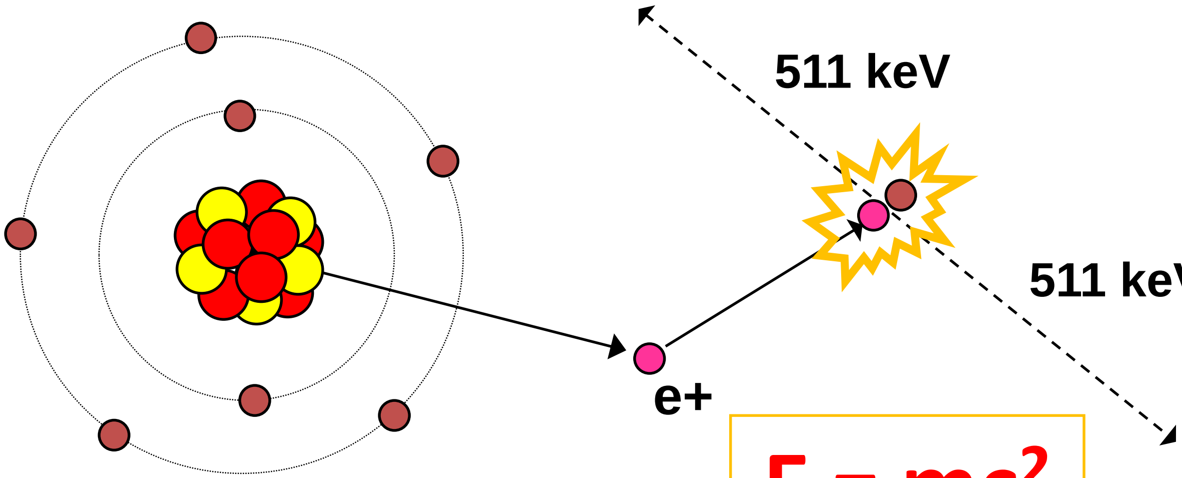
GAMMA RAY

It is emitted from nuclei to the excess energy of the previous transformations. The most commonly used is 99mTc. Photons are registered by gamma camera detectors

SPECT/CT



1968 PET Positron emission tomography



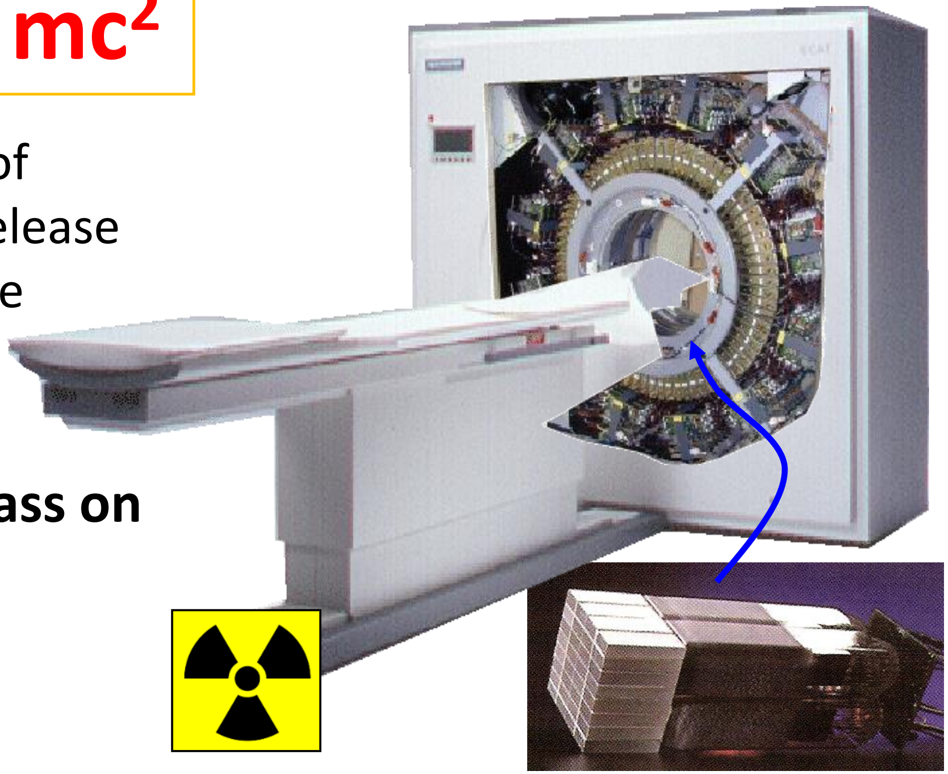
$$E = mc^2$$

POZITRON RADIATION

Is emitted from nuclei which have excess of protons. The transform into neutrons to release a positron with (+) charge. A positron is the antiparticle of the electron after meeting with him there is

ANIHILATION – transformation the mass on two quanta of gamma rays 511 keV.

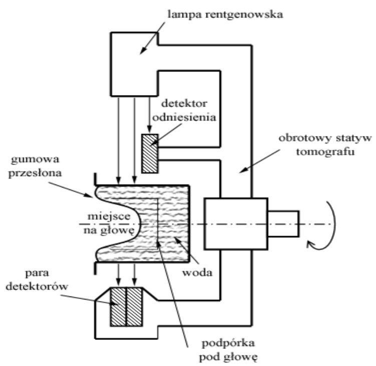
These are registered using a coincidence detector ring PET

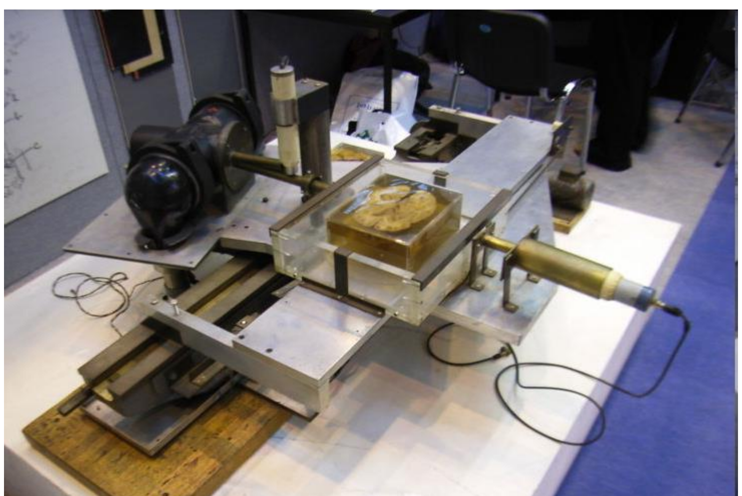


1971 - computerised tomography (CT)

Sir Godfrey **Hounsfield** (1919 – 2004) developed of the first **CT device. 1979** Nobel Prize for Physics.

The co. **EMI** has invested profit from the selling records of BEATLES





Used matrix 80 × 80 pixels

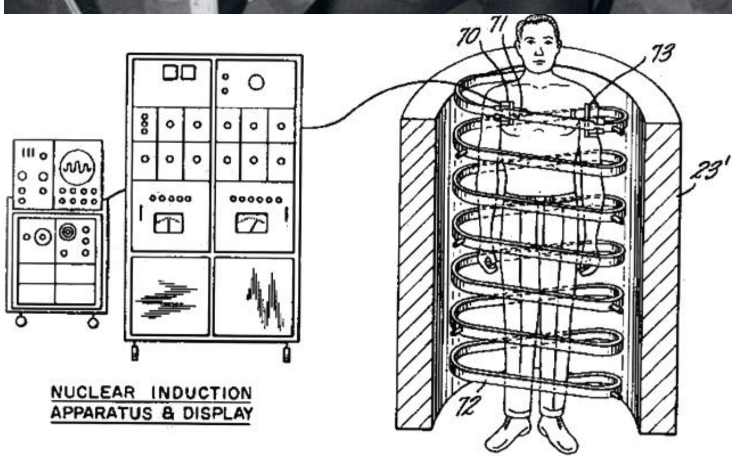
First CT from EMI company in 1972

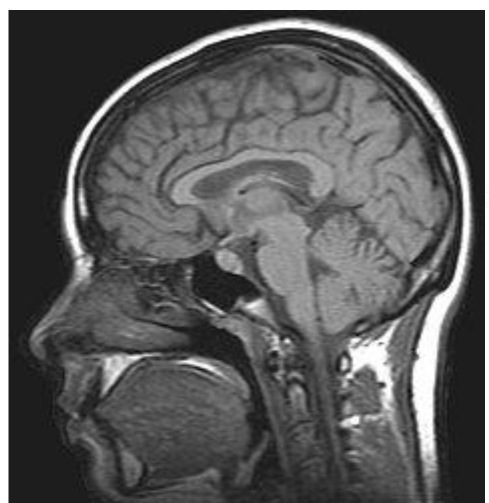
1977 - magnetic resonance imaging (MRI)

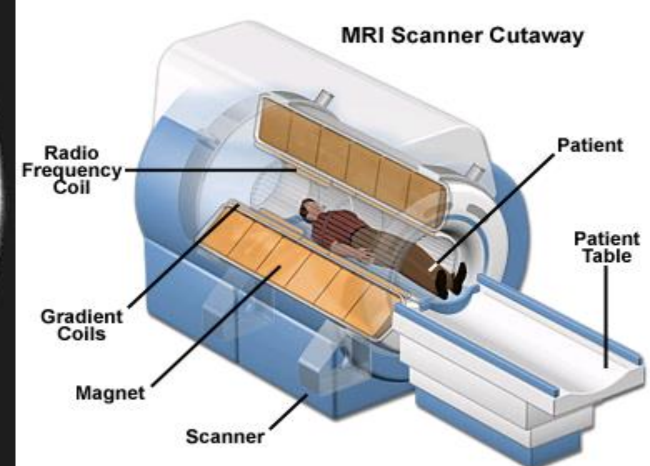
Raymond Vahan **Damadian** (1936) is considered the **father of MRI** - magnetic resonance although he has not received the Nobel Prize!

The Nobel Prize in Physiology and Medicine **2003** for research into imaging using MR was given to Paul **Lauterbur** and Sir Peter **Mansfield**

The first commercial equipment began to work in **1980**. A typical MRI image of the head.

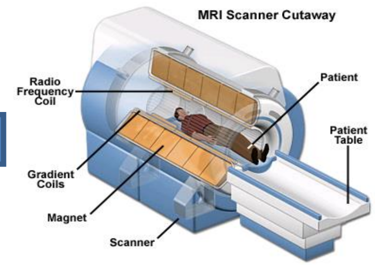


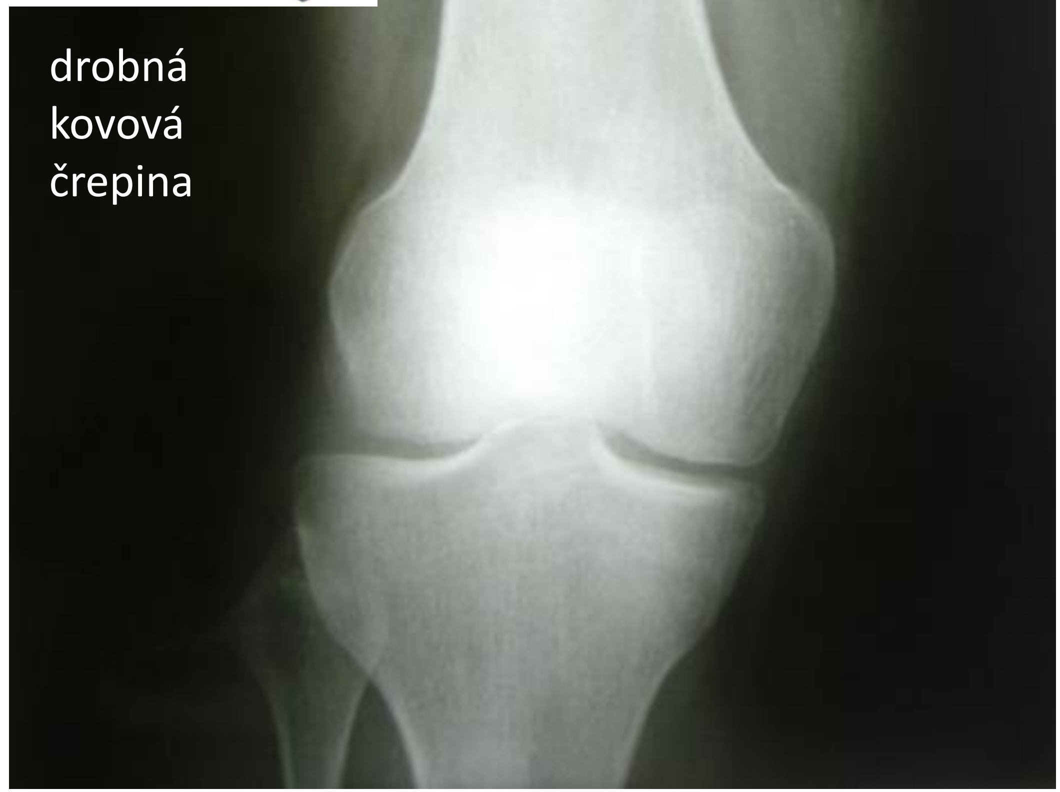




ARTEFACTS (problems) imaging by MRI

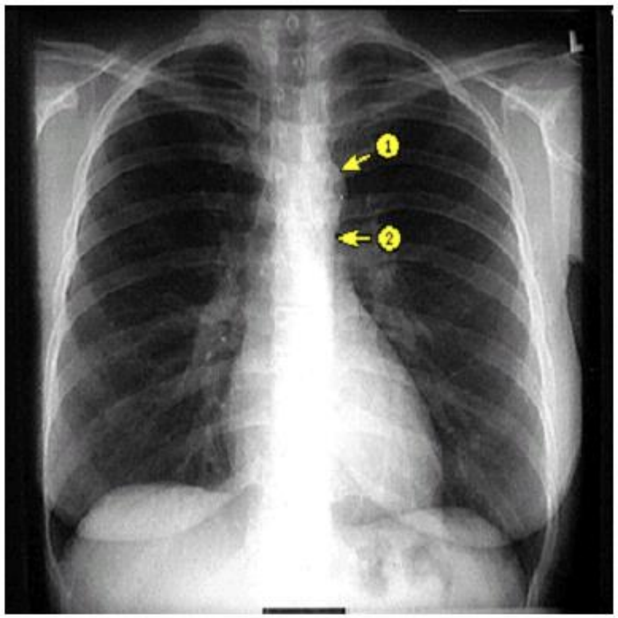
Significant destruction of the image can be caused by metal splinters





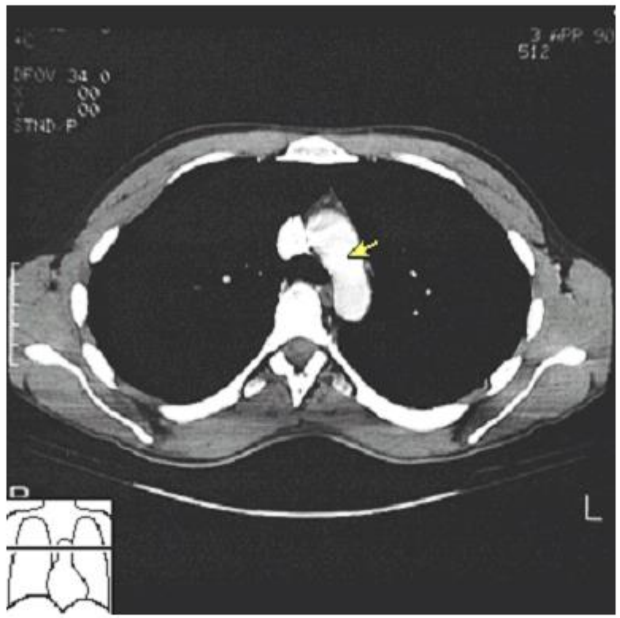
Differences between X-ray, CT and MRI

x-ray



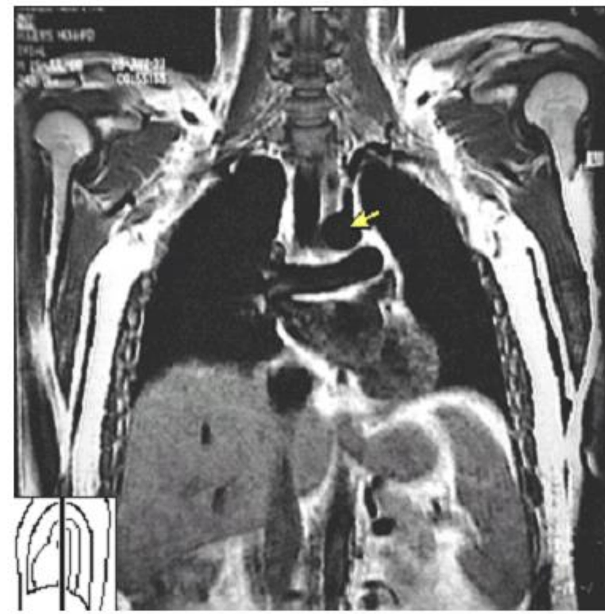
- Projection (only)
- Bones bright
- poor tissue contrast

CT



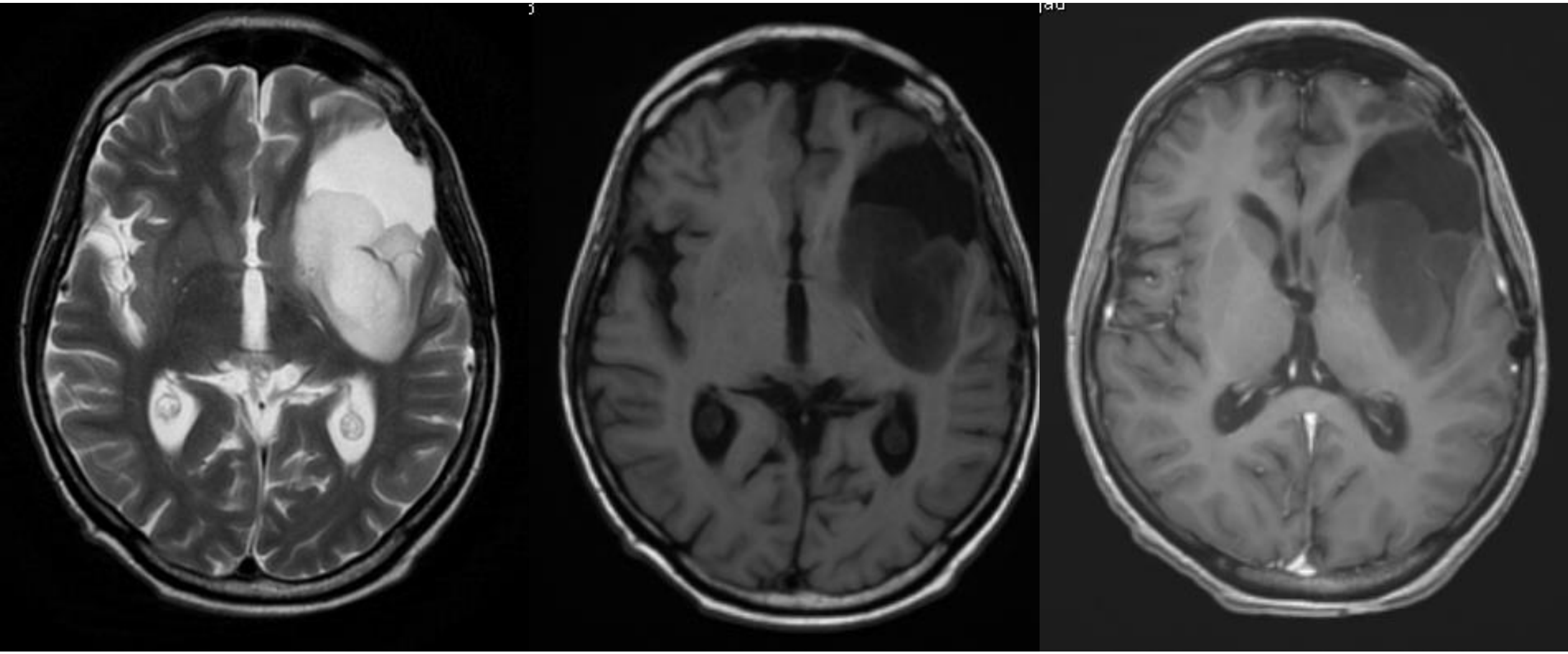
- Slices
  (only transversal)
- Bones bright
- moderate tissue
  contrast

MRI



- Slices
  (any direction)
- bone marrow bright
- nice tissue contrast

Differences between MRI imaging techniques

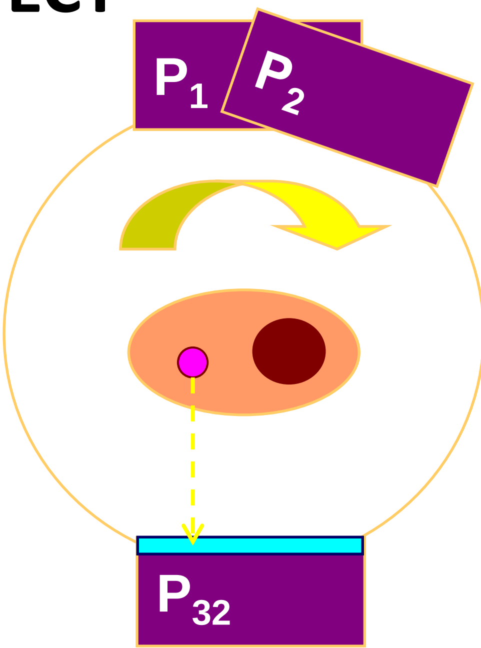


T2 **T1** **T1 +Gad**

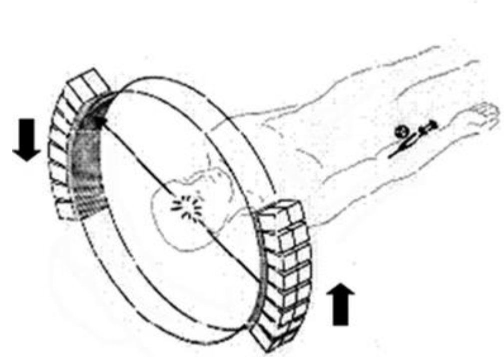
Low grade Astrocytoma

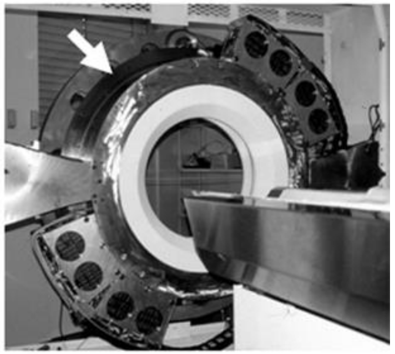
2000 Hybridy: PET (SPECT) a pripojenie CT skenera

SPECT

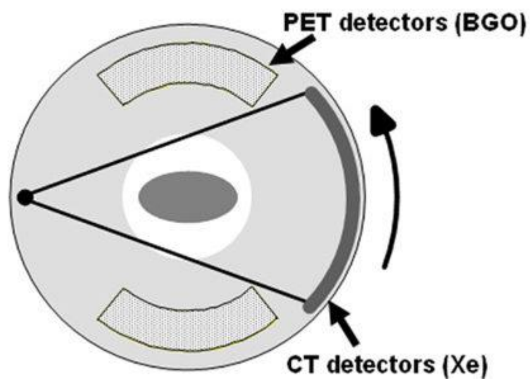


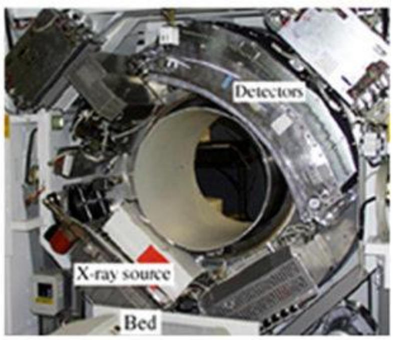
PET





PET/CT

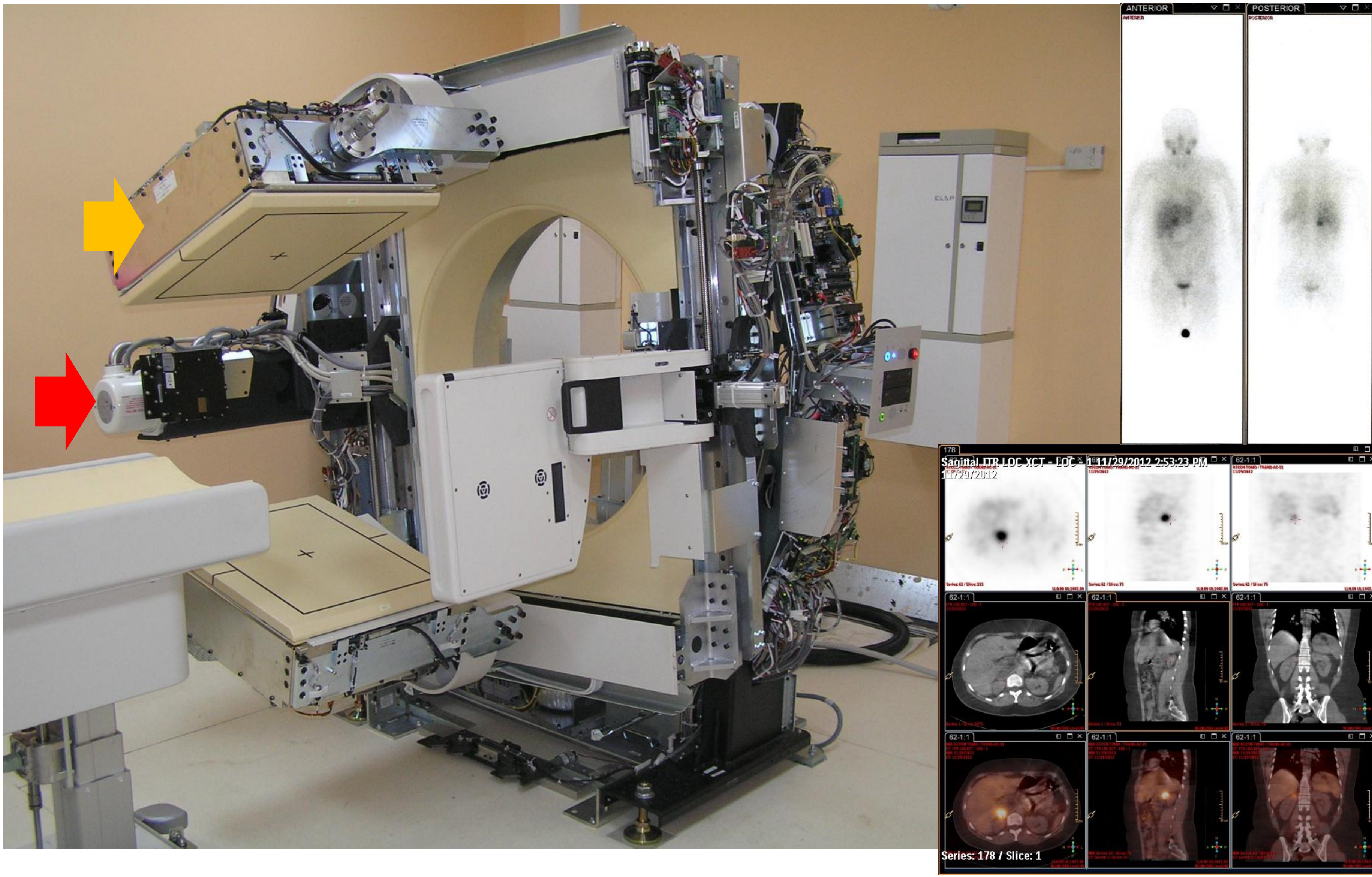




Ron Nutt a David Townsend boli nominovaní na **objav roku 2000 v medicíne**, za konštrukciu rotujúceho PET/CT skenera v ktorej sa dva boky BGO detektorov otáčali okolo pacienta a CT skener sa nachádzal medzi blokmi detektorov.

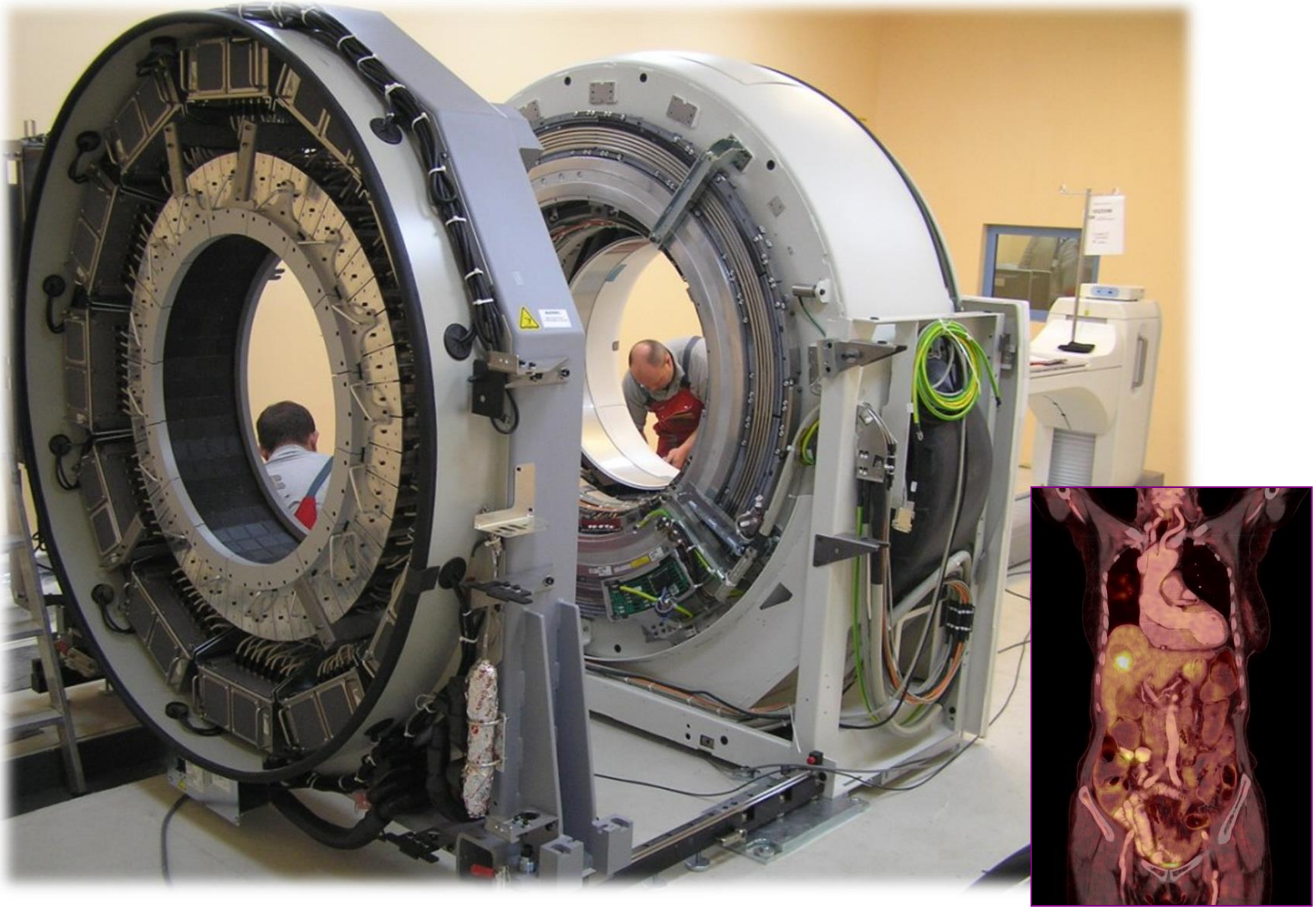
Na rozdiel od PET, kamera SPECT má dva veľkoplošné detektory, ktoré sa otáčajú pomaly okolo pacienta.

Nový SPECT/CT **Bright view** (Phillips) **2012 KE**



Gamma camera, whole body and SPECT/CT picture

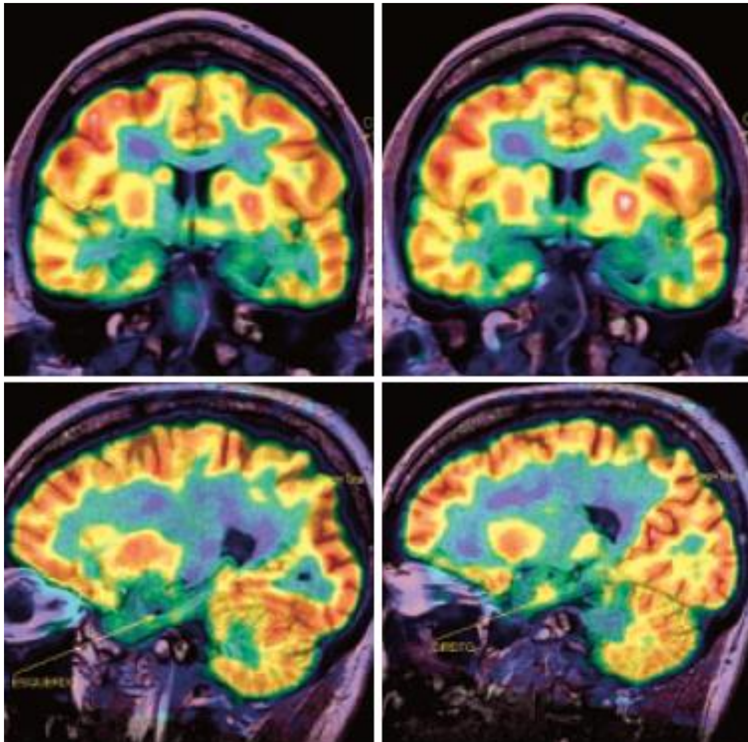
2014 – new PET/CT in Košice

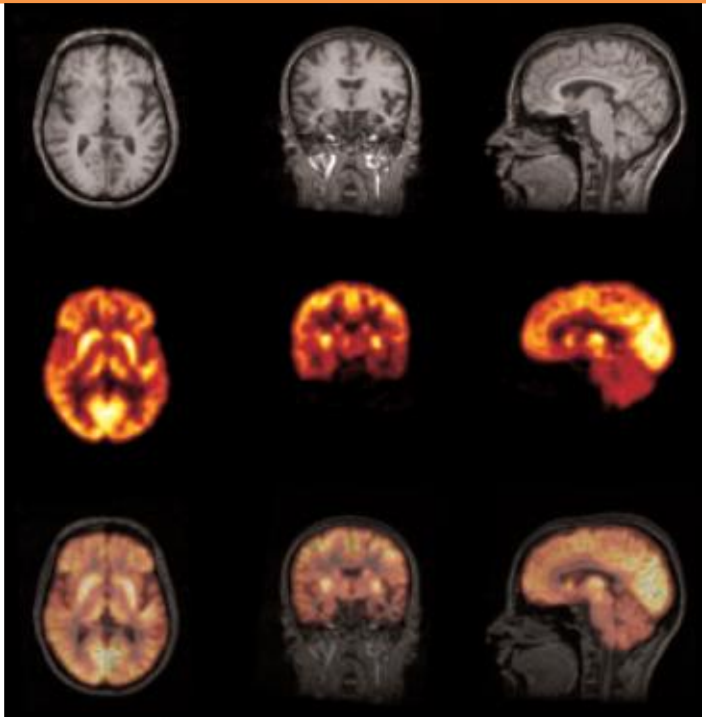


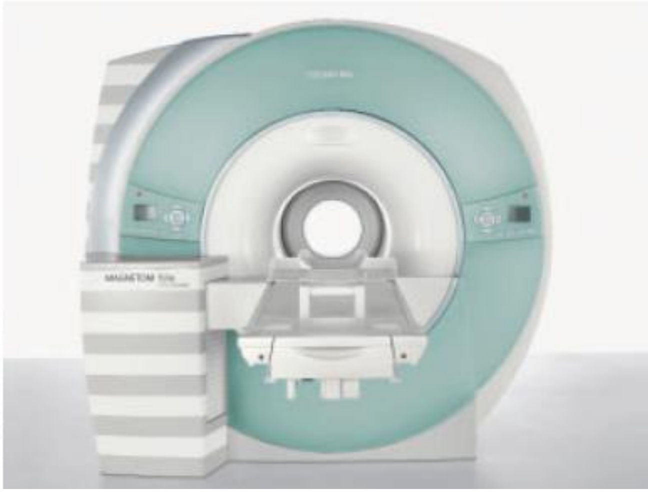
PET/CT Biograph mCT - molecuar CT (Siemens)

HYBRID SYSTEMS

PET/MRI

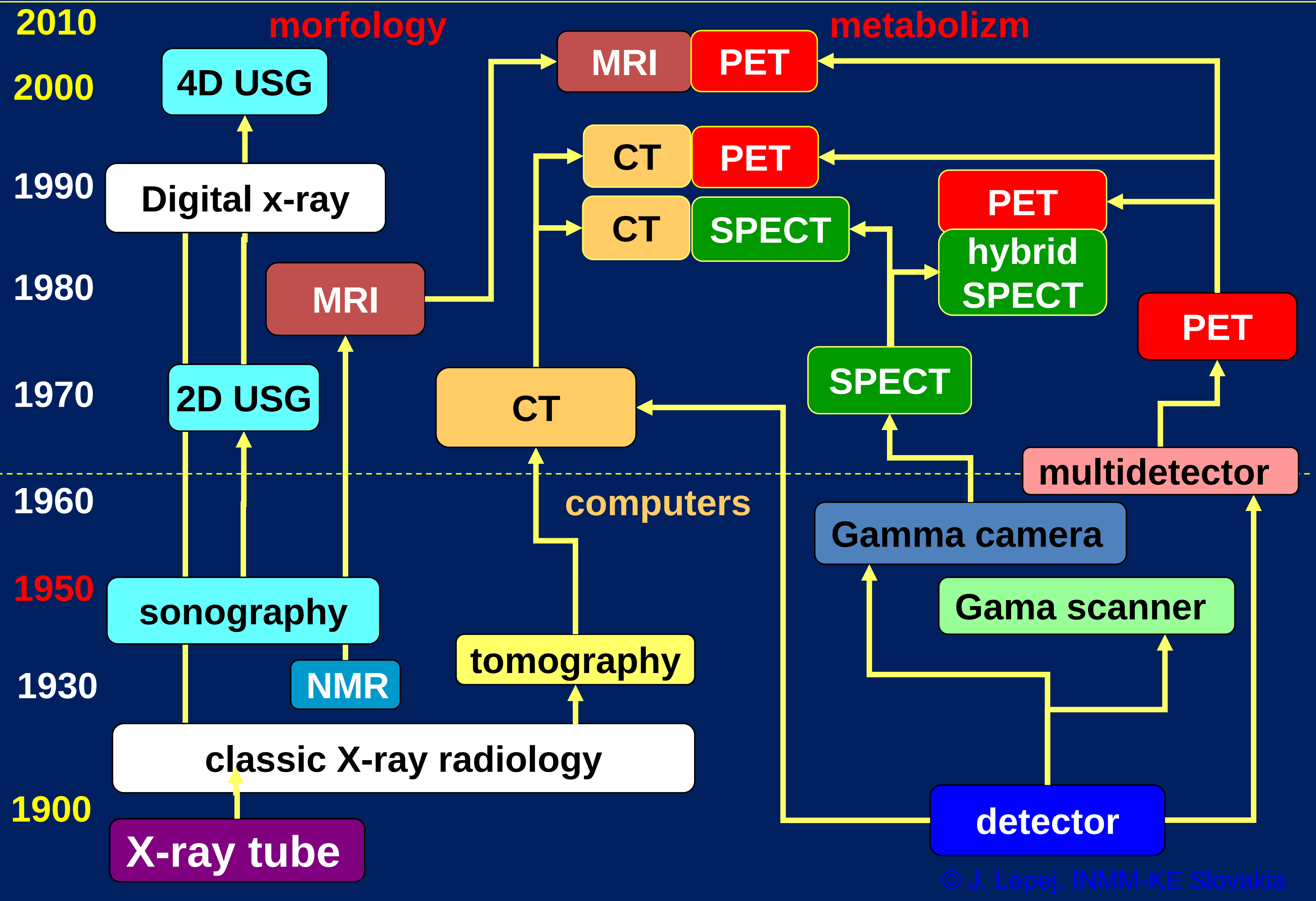




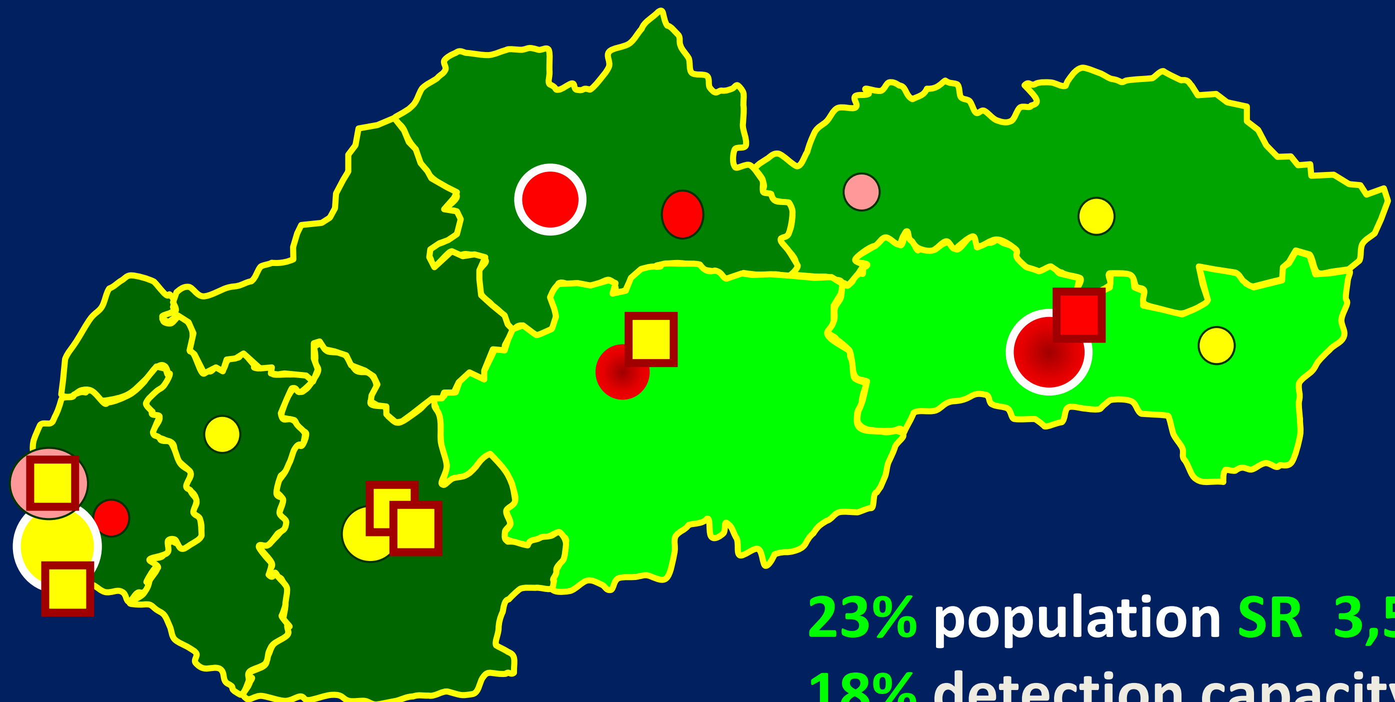


Spracované podľa: L. Mansi.: Is there a future in nuclear medicine without PET, DNM Nitra. 2007

Developement of imaging methods in - 2018



Institute of nuclear and molecular medicine
Area and detection capacity of our institution



23% population SR 3,5 milion
18% detection capacity GK

There are 12 Nuclear Medicine Departments in Slovakia. Red and pink marked are state and yellow are private. We have 3 therapeutic clinics (marked as white circles) in Bratislava, Martin and Košice. The population in our region (light) represents about **23%** of Slovakia and the **detection capacity** (GK detectors) is approximately **18%**. 1 **PET/CT** per 800 000.

Institute of nuclear and molecular medicine Košice – 3rd therapeutic unit in Slovakia




I-131 therapy of thyroid carcinoma

Container for application of I-131

Some special techniques (application of high therapeutic doses of iodine-131...) which students cannot see, we show by the short videos.

Institute of nuclear and molecular medicine Košice – 3rd therapeutic unit in Slovakia

At the therapeutic department we have **2 double** rooms and **6 single** rooms. All are above standard (HDTV + WIFI + separate bathroom) "included".

special radiohygienic conditions are essential. Well-cleaned surfaces and barium plaster on the walls...

Institute of nuclear and molecular medicine Košice – 3rd therapeutic unit in Slovakia

Entrance into 1-bed patient´s room. Special toilet with vacuum system.

The ecologic radioactive waste elimination

ROEDIGER vacuum decontamination system. 5 large tanks with a capacity of 25 cubic meters (2x2, 5m). After the filling (about 80-100 patients) tanks are closed for 128 days. Radiated after the check samples and subject to the strictest standards can be discharged into the public sewer system. Daily capacity max.706 l / pac. / Day

Education in medical imaging

1. Semester – 2 credits

History of imaging

Radioprotection (S)

Nuclear medicine **diagnostic process and methods**

EBM in imaging **TEST and examination**

---

2. Semester – 2 credits

Radiology - classical X-ray **Comparison**

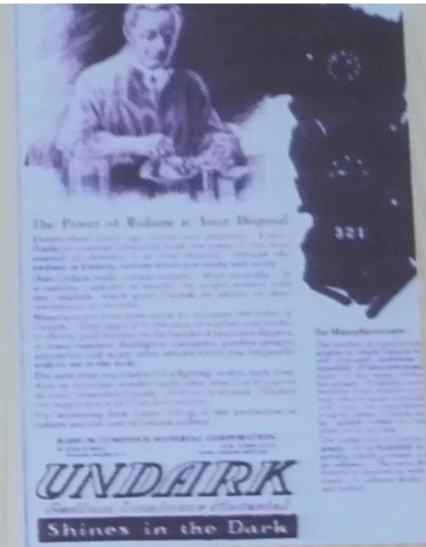
- CT **and indication of methods**
- MRI new trends
- other methods **TEST and examination**

We use case reports to explain diagnostic validity of method and we direct show how the technology work

First era of fascination

Radium was **super hit after its discovery**... Until it became known as alpha radiation actually marked effects on human organism...

1918



1921 Radium girls

1896 a **1902** The first radiation damage and the onset of radiation protection (RP)

27.1.1896 - **Grube** described the radiodermatidis of his hands after work with radiation. By the end of the year there were 23 cases. Therefore recommends patient shielding lead.

1902 - W. **Rollins** defined a safe level of X-ray radiation (Can not X-ray film exposed 7 minutes) that corresponded to today's **90 mSv per day** !!!

100 mSv / 5 years is current professional dose limit.

International Radiation Protection Organizations

ICRP - International Commission on Radiological Protection.

UNSCEAR - United Nations Scientific Committee on the Effects of Nuclear Radiation.

IAEA - International Atomic Energy Agency.

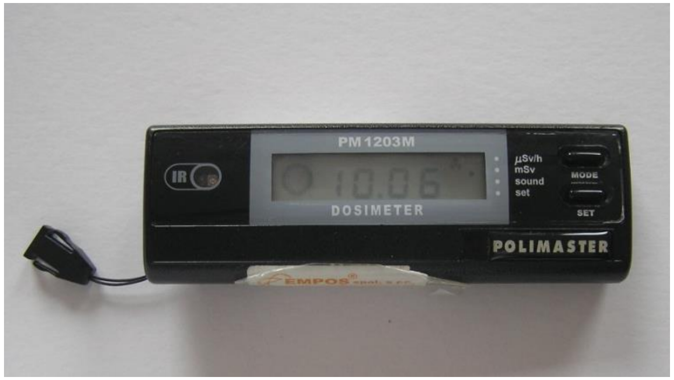
ÚVZ - Public Health Service (National authority in Slovakia)

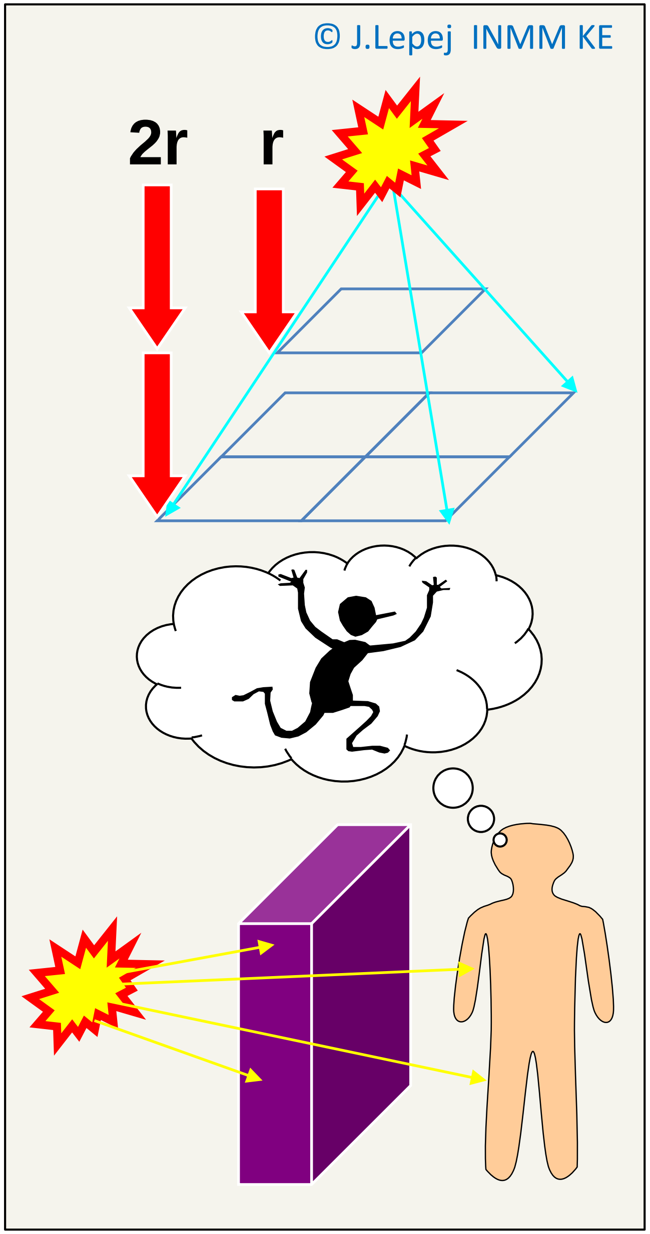
Methods of radiation protection

PROTECTION BEFORE EXTERNAL IRADIATION

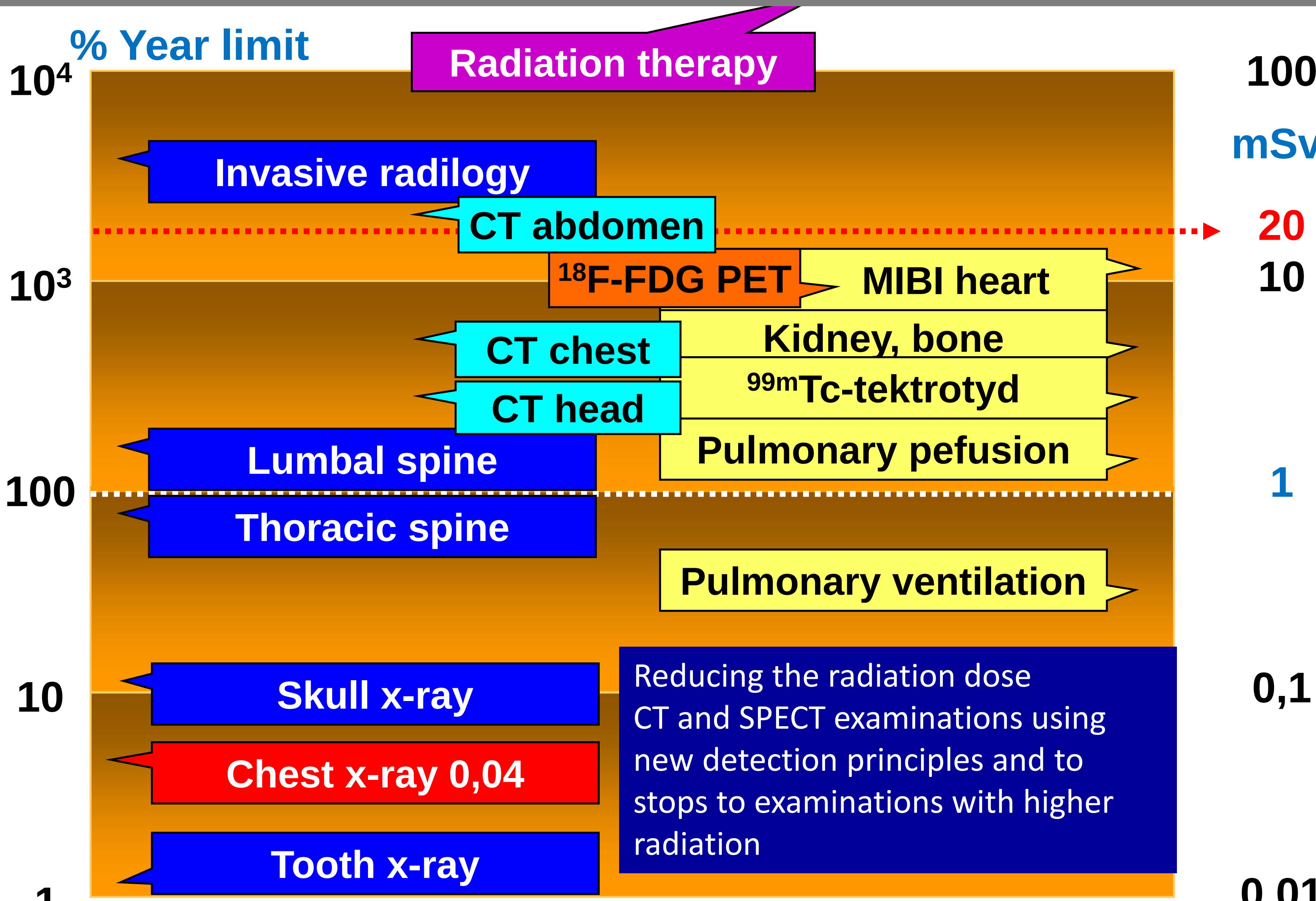
A. DISTANCE
B. TIME
C. SHILDING

MONITORING





Irradiation pts. from medical sources



Reducing the radiation dose
CT and SPECT examinations using new detection principles and to stops to examinations with higher radiation

Cormack, J., Towson, J.E.C., Flower, M.A.: Radiation protection and dosimetry in clinical practice. In: Clinical nuclear medicine 1998, s

Education in medical imaging

1. Semester – 2 credits

History of imaging (L)

Radioprotection (S)

Nuclear medicine **diagnostic process and methods**

EBM in imaging (S) **TEST and examination**

2. Semester – 2 credits

Radiology - classical X-ray **Comparison**

- CT **and indication of methods**

- MRI

- other methods **TEST and examination**

We use case reports to explain diagnostic validity of method and we direct show how the technology work

Diagnostic process in radiology

WHAT?	WHO?	HOW?
activity	**profession**	**metods for quality control**
1. INDICATION of EXAMINATION	**Clinician / M.D. solving diagnostic problem**	demand letter for actual diagnostic problem + date
2. ORDERING	**his NURSE**	
3. PT PREPARING	NURSE /NM staf	information to the patient
4. CHOOSING of the METHOD	**M.D. of NM** (physicians)	study of pacient´s data disscusing about the method
7. DETECTION	**TECHNECIANS** (T)	QC - gamacamera (physicist)
8. DATA ANALYSIS	**PHYSICIST / T**	QC - steps of examination QC - of the images / results
9. REPORTING	**M.D. specialist NM**	clinical seminars – case rep.
10. SENDING	**Administrative**	comparative studies

11. INTERPRETATION Clinician/physician dealing with diagnostic problem

12. USE of the RESULT for management of diagnosis or treatement

Diagnostic process in nuclear medicine

WHAT? activity	WHO? profession	HOW? metods for quality control
1. INDICATION of EXAMINATION	Clinician / M.D. solving diagnostic problem	demand letter for actual diagnostic problem + date
2. ORDERING	his NURSE	
3. PT PREPARING	NURSE /NM staf	information to the patient
4. CHOOSING of the METHOD	M.D. of NM (physicians)	study of pacient´s data disscusing about the method
5. PREPARING of radiopharmacon	PHARMACOLOGIST	check of radiopharmacon QC - quality control RF
6. APPLICATION	M.D. + NURSE / T	QC - quality control aplication
7. DETECTION	TECHNECIANS (T)	QC - gamacamera (physicist)
8. DATA ANALYSIS	PHYSICIST / T	QC - steps of examination QC - of the images / results
9. REPORTING	M.D. specialist NM	clinical seminars – case rep.
10. SENDING	Administrative	comparative studies

11. INTERPRETATION Clinician/physician dealing with diagnostic problem

12. USE of the RESULT for management of diagnosis or treatement

REPORTING of STUDY – reducing of information

The recorded "row" data (**A**) is reconstructed into individual sections (**B**) of which part is recorded in the archive or on the CD (**C**). This images are interpreted by the physician in the report (**D**). Reducing the of the information is enormous and requires high quality data processing - the software and the descriptor.

Transforming a large volume of data lasts considerably longer. That's why one evaluation and description of the one patient lasts an hour. = longer than the exam record.

A

5 000 000 kB

Asistant + softver

B

3 000 000 kB

Physicist / asistant + softver

C

500 000 kB

Physician

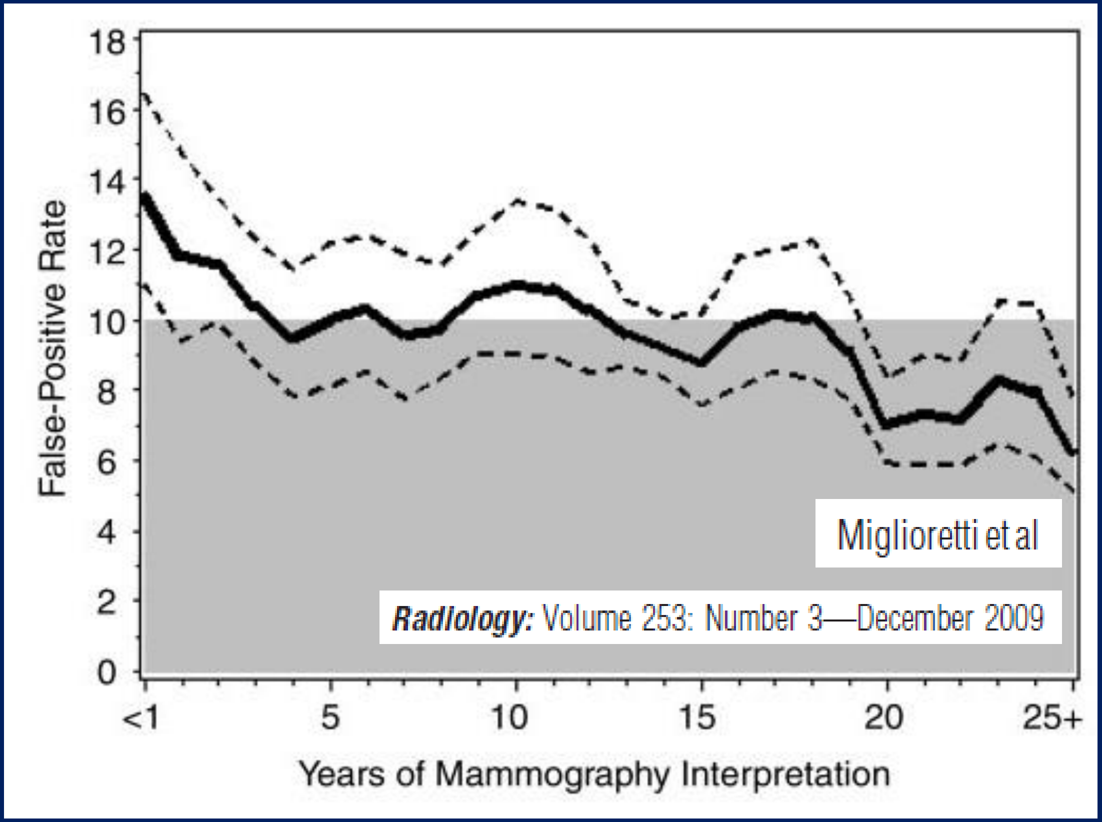
D

100 kB

The importance of radiologist's experience in assessing mammography findings

False positive findings have fallen faster over the first 5 years of the carrier.
This is indicative of improved diagnostic accuracy.
With an increase of experience false positives still fall **14% → 7%**

The authors highlight the great benefit of **double reading**, auditing and feedback for the quality of interpretation.



When Radiologists Perform Best:
The Learning Curve in Screening Mammogram Interpretation[1]

Radiology

Evidence Based medicine and IMAGING

Evaluation of DIAGNOSTIC ACCURACY

- **Positive predictive value**

  The likelihood that a patient with a positive test has a disease.

- **Negative predictive value**

  The likelihood that a patient with a negative test does not have a disease

All exams 550		**DISEASE**	
		yes (50) SP+FN	**no (500) FP+SN**
TEST	Pozit **(145) SP+FP**	**SP 45**	**FP 100**
	Negat **(405) SN+FN**	**FN 5**	**SN 400**

If the prevalence - 50 disease from 550 examined after the pre test probability OK

is very low **10,0%** **50%**

PPV = 45/145 = **31,0%** **81,8%**

post test probability

NPV = 400/405 = **98,8%** 88,9%

YOU NEED TO USE THE FURTHER TEST (more expensive)

to achieve a potential probability of at least 80%

Education in medical imaging

1. Semester – 2 credits

History of imaging (L)

Radioprotection (S)

Nuclear medicine **diagnostic process and methods**

EBM in imaging (S) **TEST and examination**

2. Semester – 2 credits

Radiology - classical X-ray **Comparison**

- CT **and indication of methods**

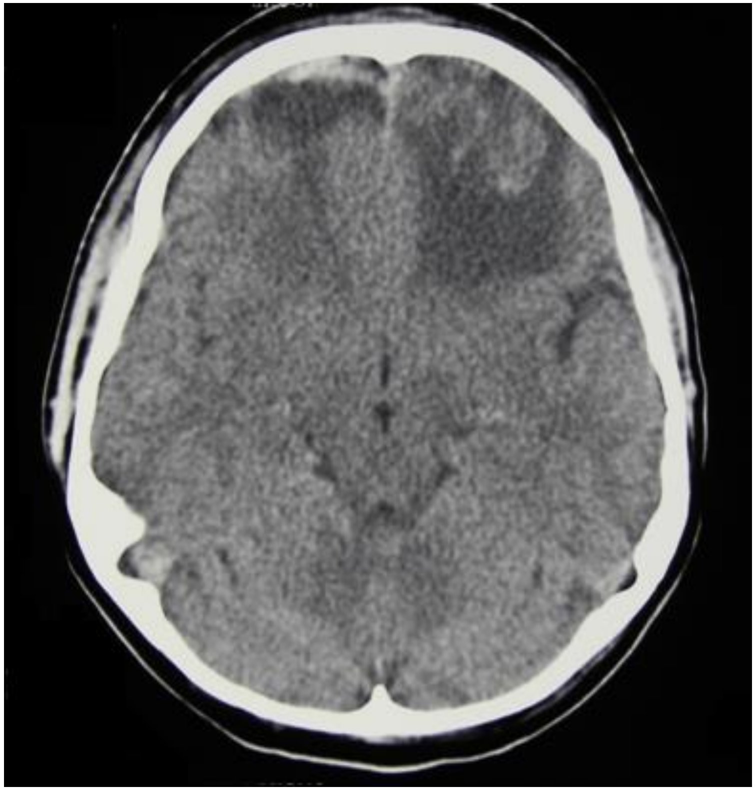
- MRI

- other methods **TEST and examination**

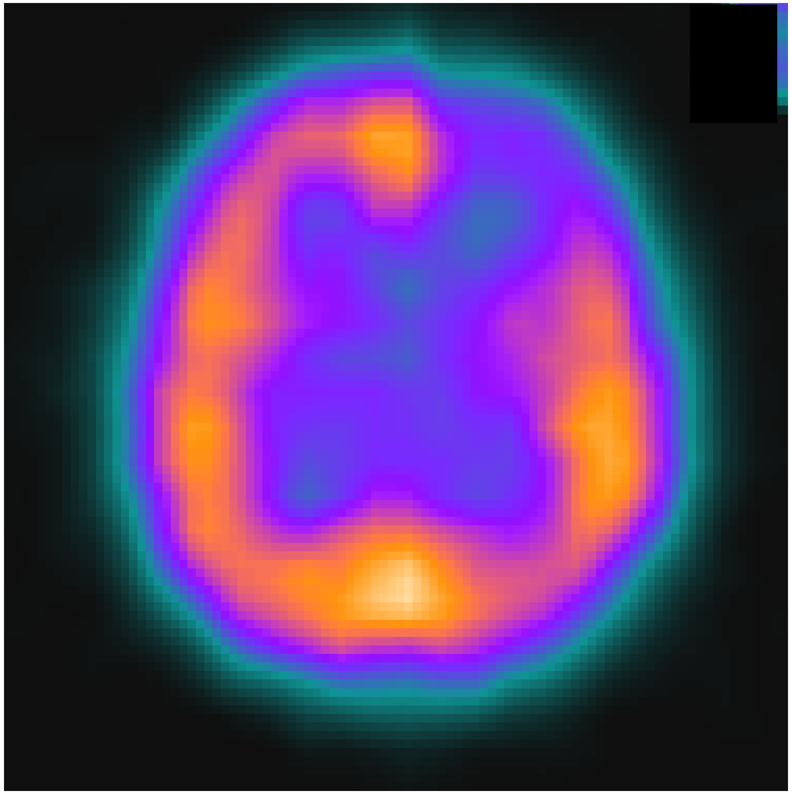
We use case reports to explain diagnostic validity of method and we direct show how the technology work

Example shows serious pathology after brain KCT?
Morphological and functional image pathology

A comparison of two types of examinations of the brain in the same patient after a serious KCT (A) **CCT** in the central transversal cross section and (B) functional image **rCBF** (regional cerebral blood flow) in the same section.



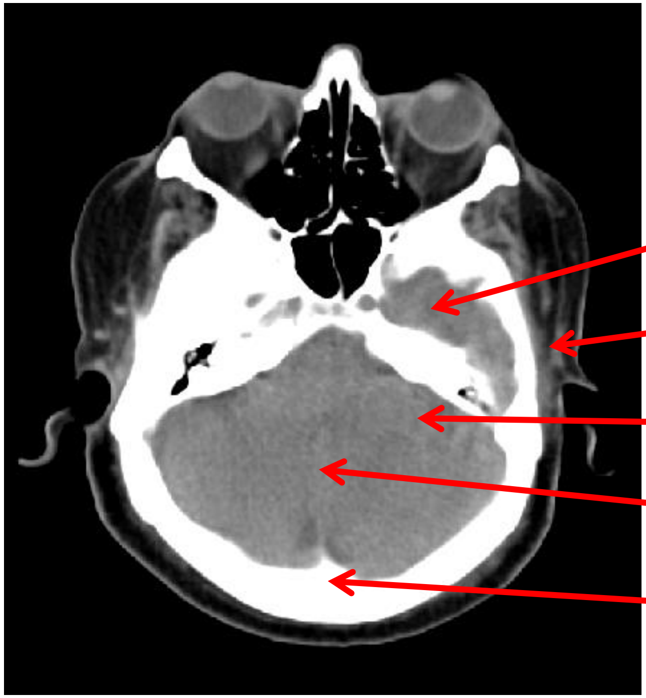
A



B

CT of BRAIN TUMOR

Patient examined for MM (malignant melanoma) 2008, in 2011 solitary MTS in brain operated 01/2012, recidiving to pelvis and OP 05/2013. From 2011 CA prostatae. PET/CT for localisation in brain and WB



CT/LD for localisation

Where is higher glucose metabolism On PET/CT ?

A – temporal lobe frontally
B – in soft tisue temporally
C – PC (ponto-cereberal) angle
D – midline of cerebellum
E – in occipital bone involving cortex

MRI examination

Patient examined for MM (malignant melanoma) 2008, in 2011 solitary MTS in brain operated 01/2012, recidiving to pelvis and OP 05/2013. From 2011 CA prostatae. PET/CT for localisation in brain and WB

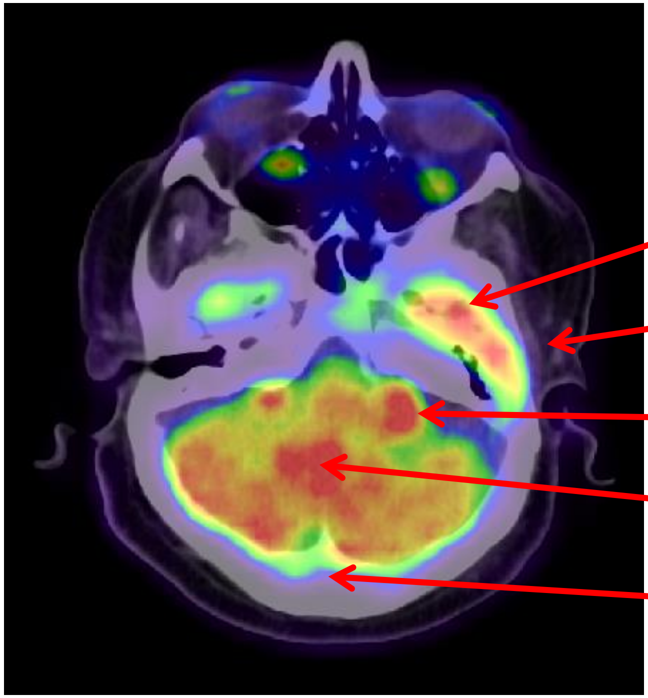
MRI examination

Where is higher glucose metabolism On PET/CT ?

A – temporal lobe frontally
B – in soft tisue temporally
C – PC (ponto-cereberal) angle
D – midline of cerebellum
E – in occipital bone involving cortex

18F-FDG PET/CT

Patient examined for MM (malignant melanoma) 2008, in 2011 solitary MTS in brain operated 01/2012, recidiving to pelvis and OP 05/2013. From 2011 CA prostatae. PET/CT for localisation in brain and WB



18F-FDG PET/CT

Where is higher glucose metabolism On PET/CT ?

A – temporal lobe frontally

B – in soft tisue temporally

C – **PC (ponto-cereberal) angle**

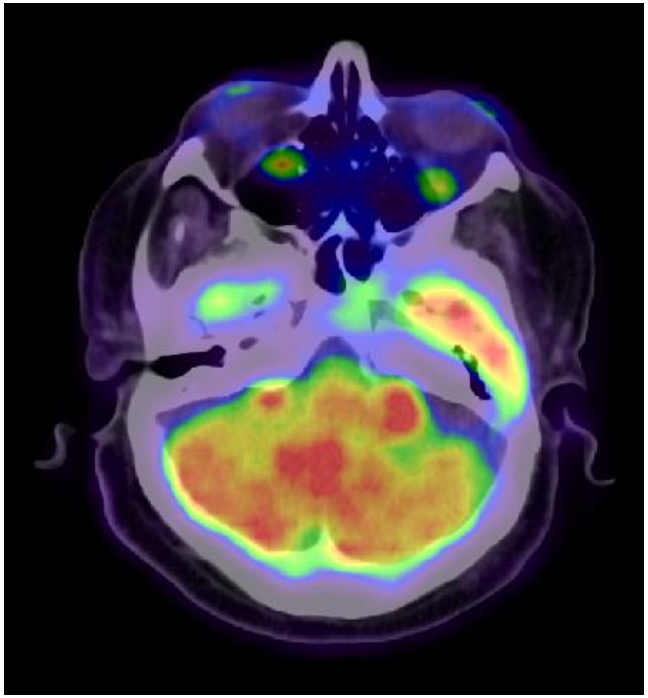
D – **midline of cerebellum**

E – in occipital bone involving cortex

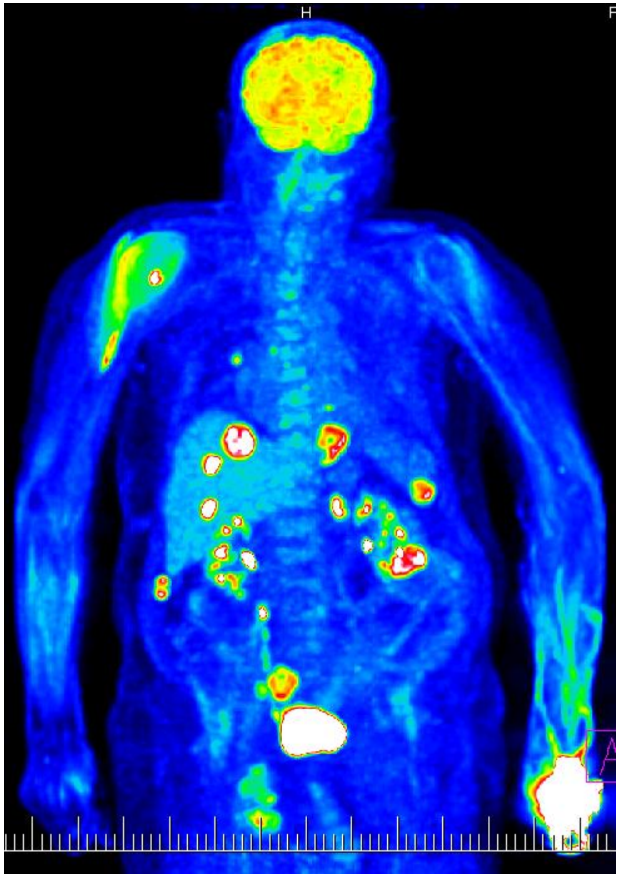
PET/CT 18F-FDG

Patient examined for MM (malignant melanoma) 2008, in 2011 solitary MTS in brain operated 01/2012, recidiving to pelvis and OP 05/2013. From 2011 CA prostatae. PET/CT for localisation in brain and WB

CT/LD for localisation



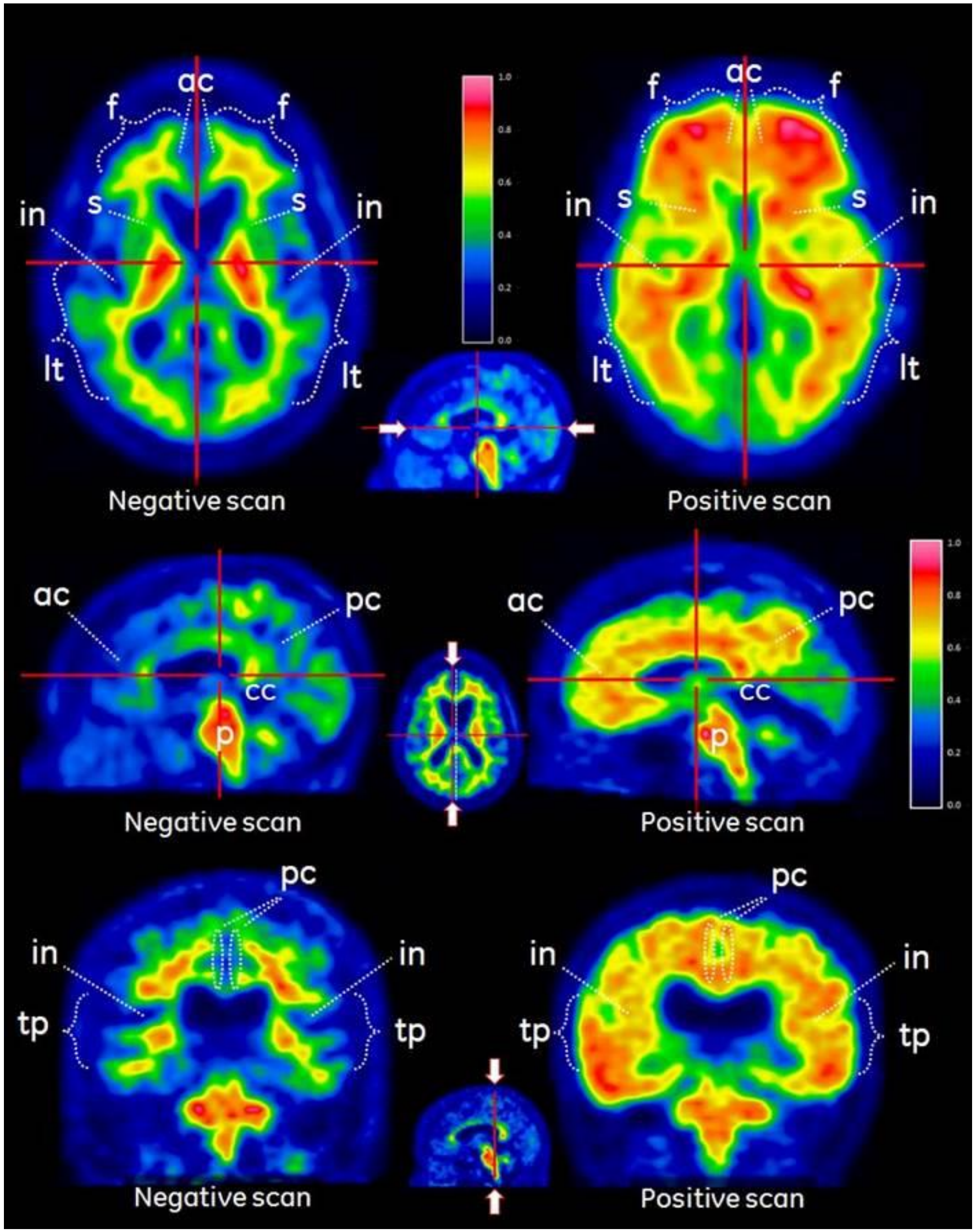
glucose metabolism PET/CT

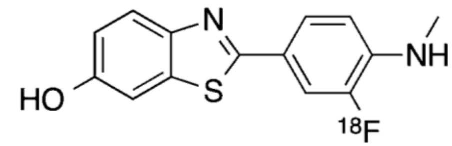


WB PET scan

^{18}F-Visamil PET/CT(MRI) in diagnostic of dementia

Normal



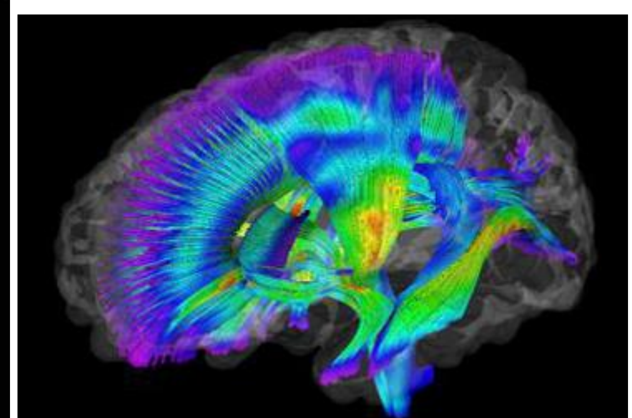


[^{18}F]GE-067
(Flutemetamol, Vizamyl)

Radiopharmacon

Alzheimer disease

MRI tractography

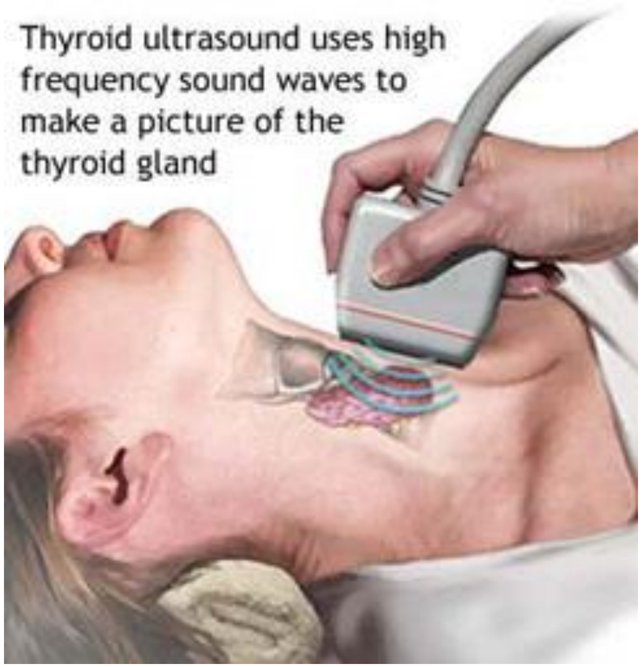


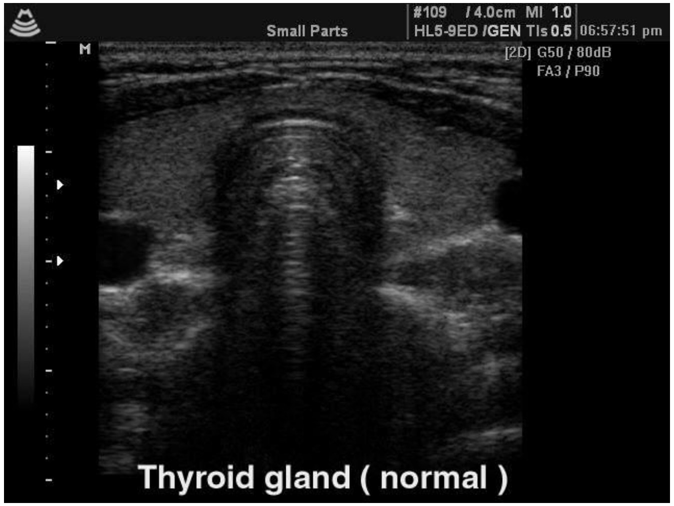
Ultrasound in endocrinology

BASIC imaging technique in endocrinology done directly by the endocrinologist.

Indications:

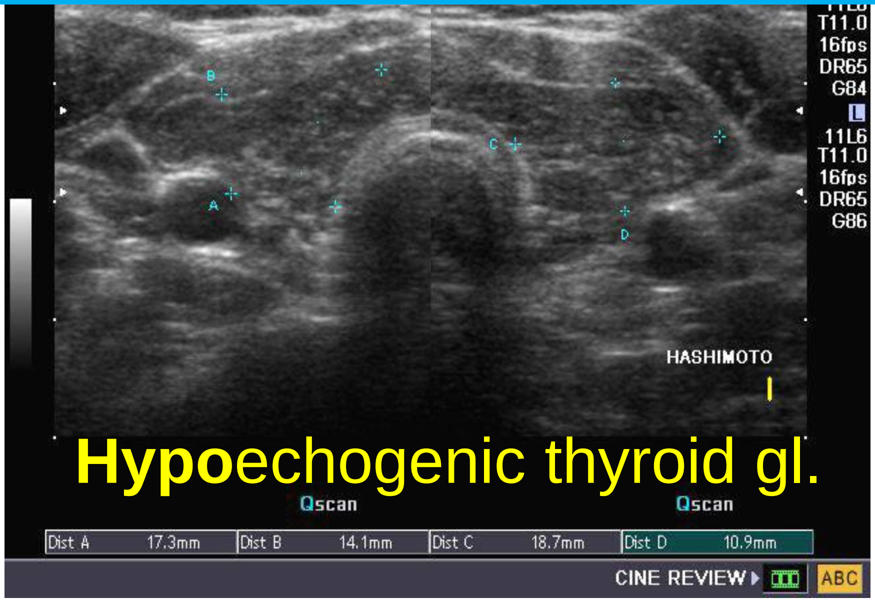
- Evaluate Nodules, Lumps.
- Exact measurement of size.
- Examination of Cysts, Fluid filled, calcified.
- Monitor the success of anti thyroid treatment for graves' disease.
- Guiding for FNA - to avoid sensitive neck structures.

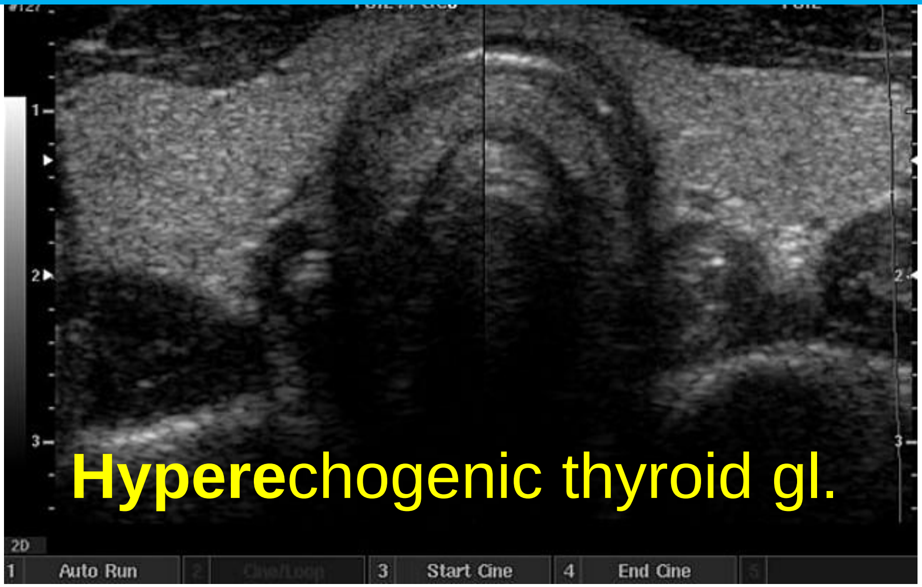


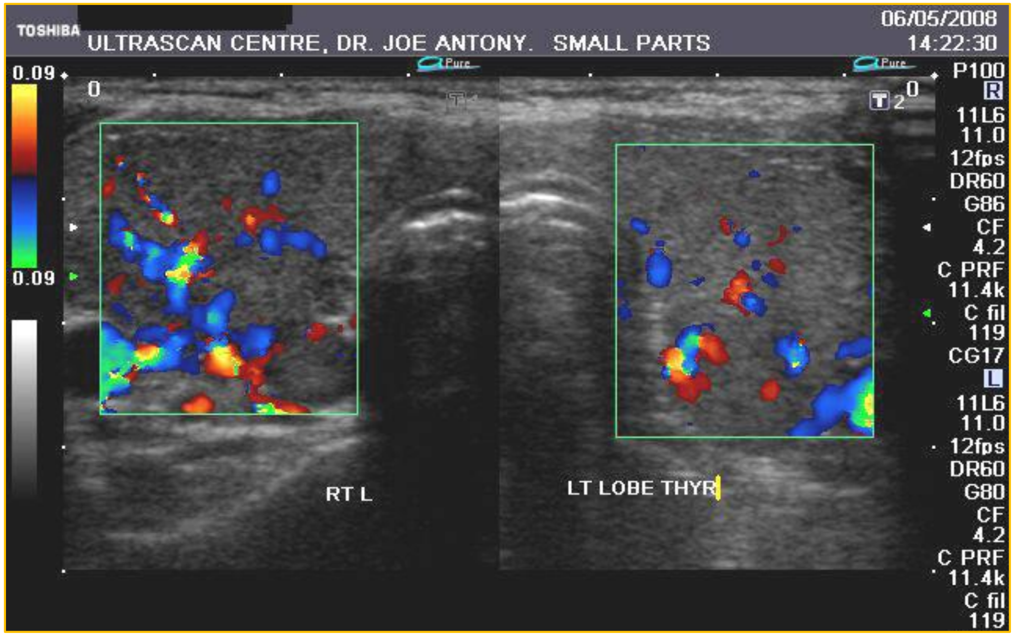


Palpable Thyroid nodules are found in 4-7% of the population.
Non-palpable nodules are found in **50% of persons over 60**.
US can help determine if a nodule is suspicious but a biopsy (FNA) is needed for a definitive diagnosis.

Ultrasound in endocrinology







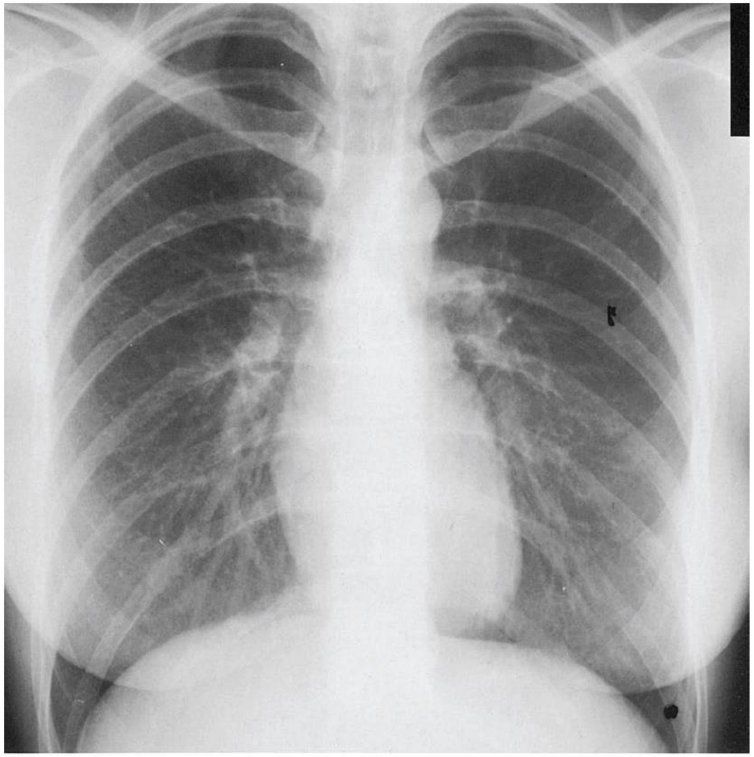
DOPLLER USG
Increase vascularity throughout thyroid gland
in hyperthyroidism

X-ray in Bone diagnostics

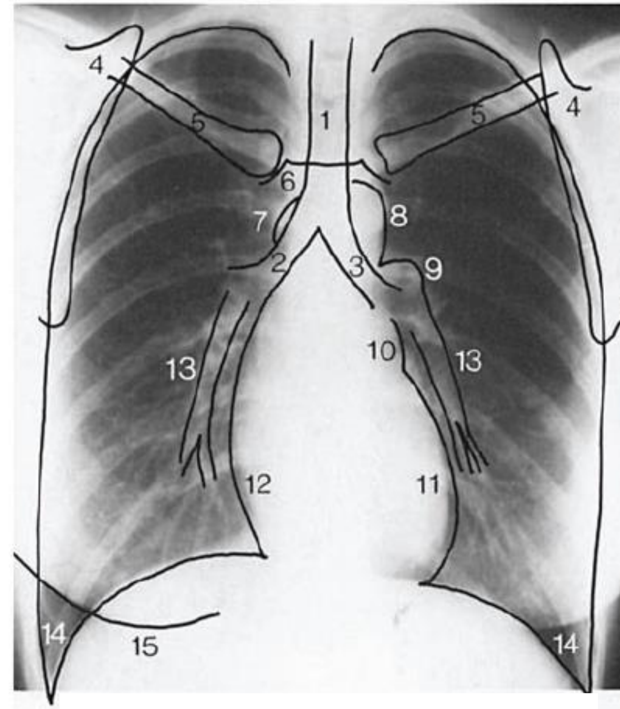
- **1st choice** - It is the **basic imaging examination for the study of skeleton** system and, most often, is sufficient by itself to make a correct diagnosis.
- Is usually the first imaging technique for a suspected bone lesion since it is inexpensive and easily obtainable. It is also the best for assessment of general radiological features of the tumor.
- X-ray examination includes not only **plain radiography**, but also **tomography**, arthrography and other specialized techniques.
- It is the **first diagnostic method that is used** in **traumatology** in patients with **fractures**, or in patients who had a skull injury after an accident.
- When used in imaging of the spine and ribs usually **fractures, bone overgrowth or deformities, tumours and abscesses** are checked. In many cases this examination must be completed by other methods.
- **WHERE IS PATHOLOGY on this picture?**

Chest X-ray anatomy

Chest Anatomy



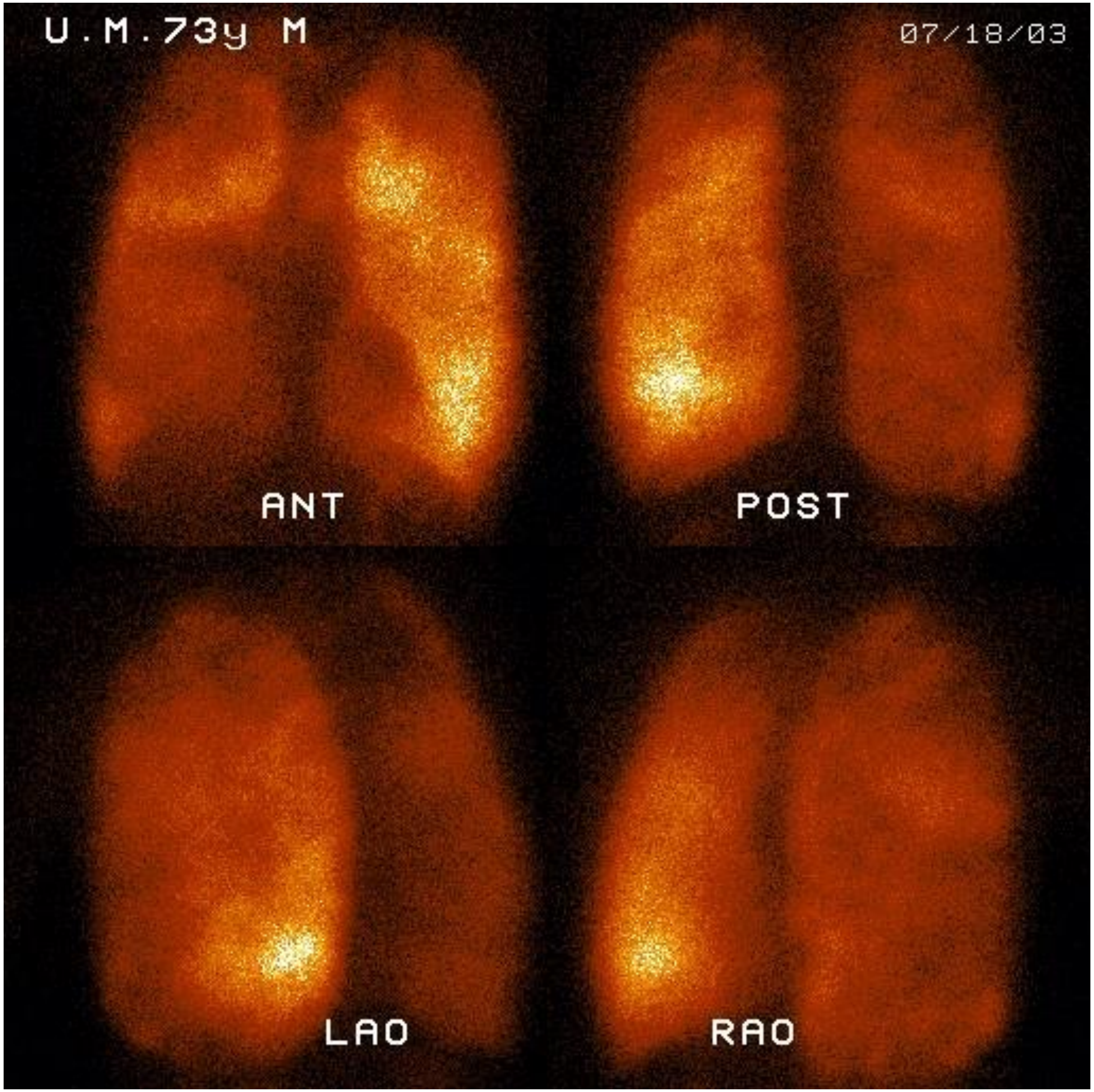
- Normal chest x-ray. woman, slim, small artefacts on film (black dots)



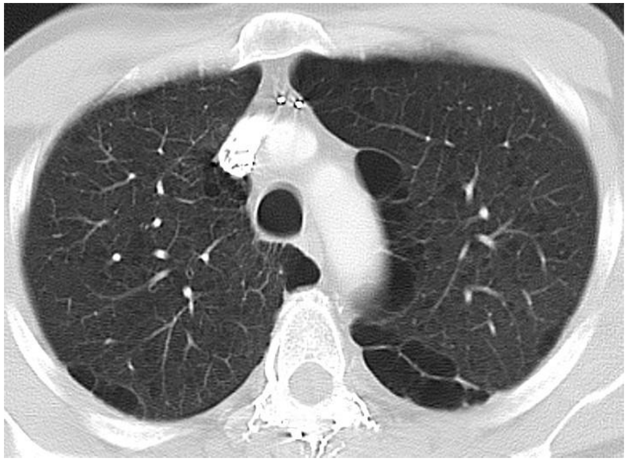
1. Trachea
2. Right main bronchus
3. Left main bronchus
4. Scapula
5. Clavicle
6. Manubrium sterni
7. Azygous vein
8. Aortic arch
9. Left pulmonary artery
10. Left atrial appendage
11. Ventricular curve of left heart
12. Right atrium
13. Lower lobe pulmonary artery
14. Lateral costophrenic sulcus
15. Breast shadow

- Gunderman R.B.: Essential Radiology, Thieme © 2006

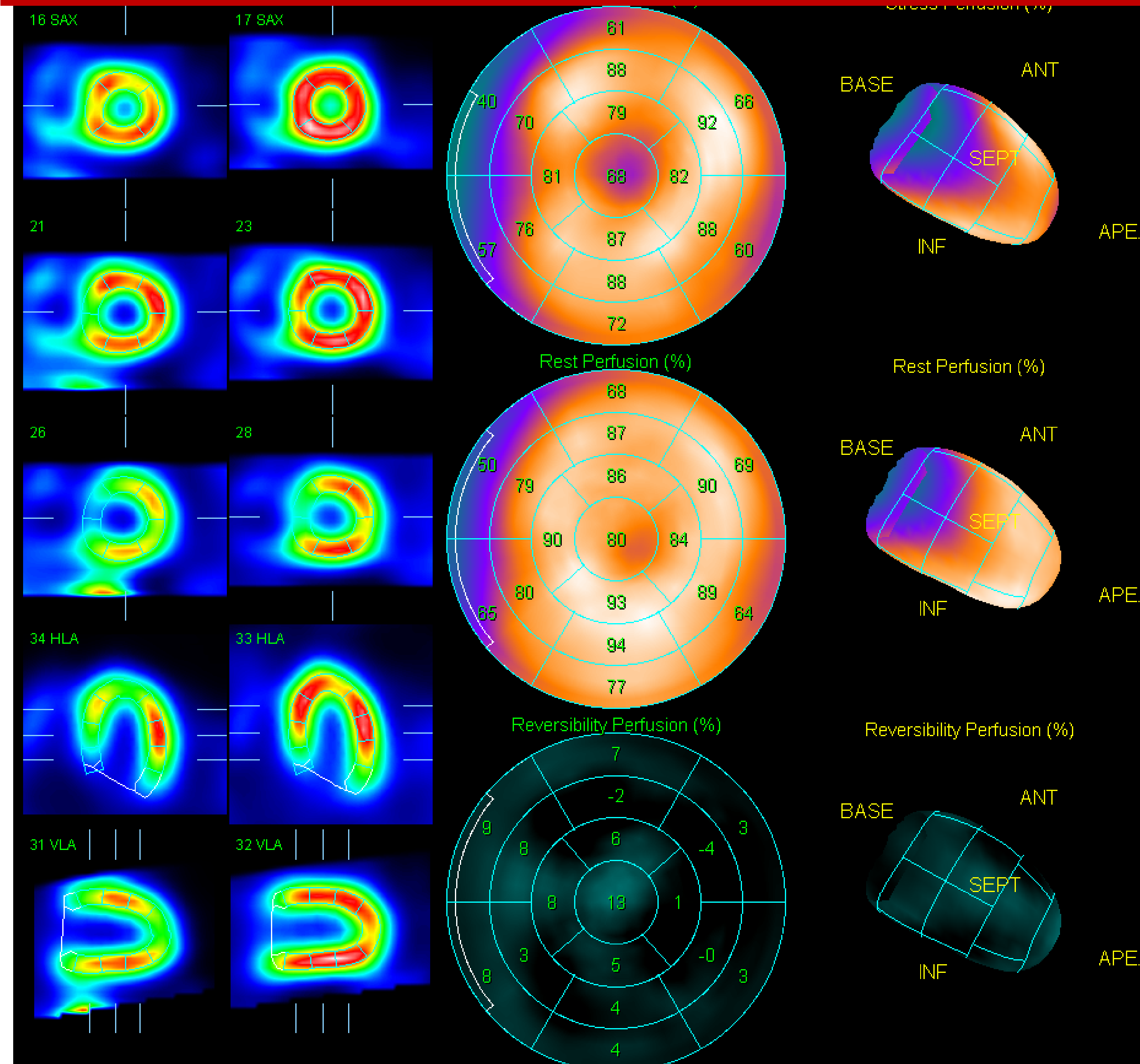
Pulmonary Nuclear Medicine - case



EMPHYSEMA



Nuclear Cardiology – case



Pat ID	A.L.1947 1
Sex	FEMALE
Limits	--
TID	1.00
LHR	0.41

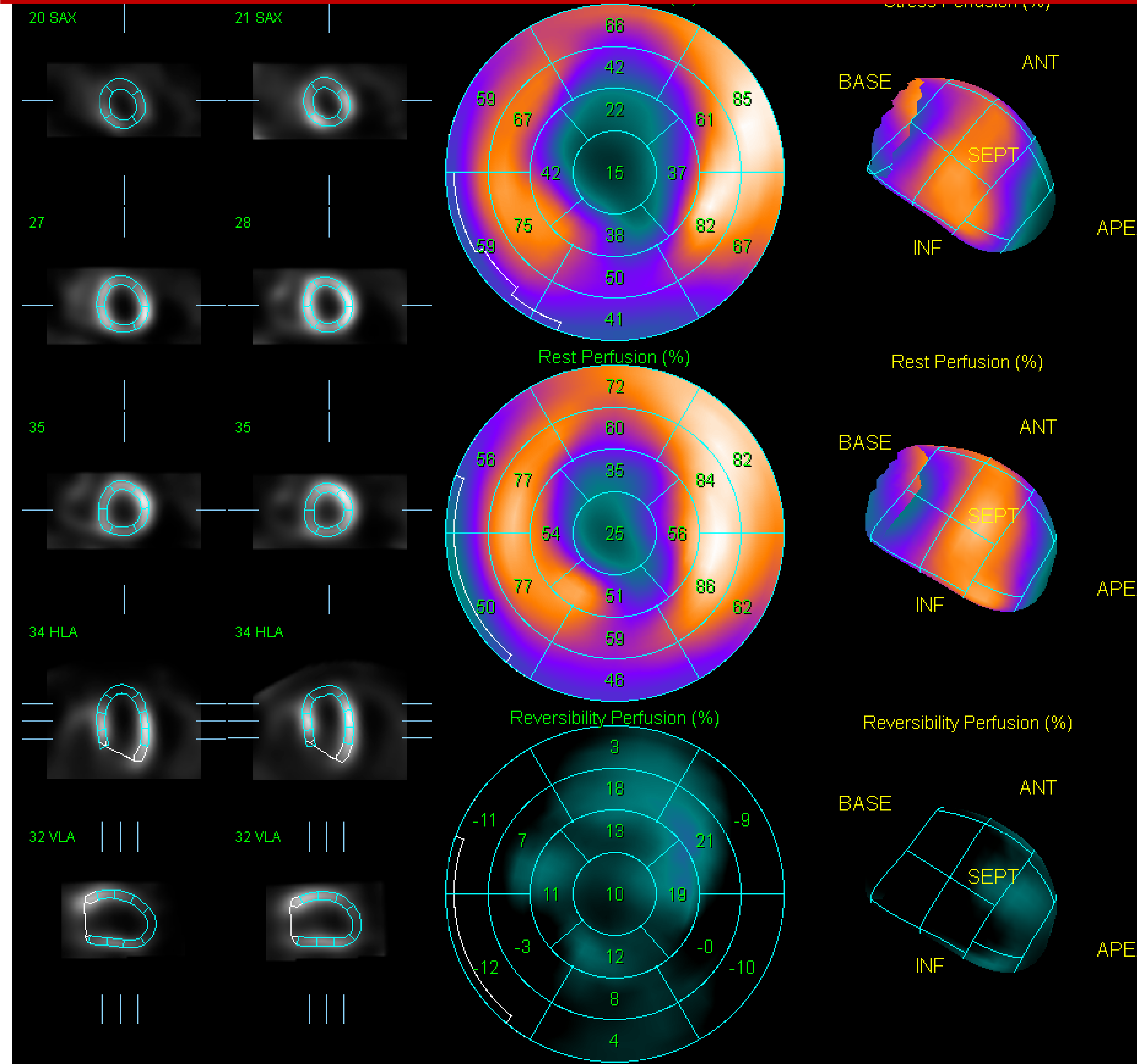
SSS	2	SRS	0	SDS	2
SS%	3	SR%	0	SD%	3

Proc ID	CARDIAC-AC ONE DAY
View ID	SAX-AST-AC-STR
Date	2013-07-02 10:17:06
Database	FemaleStressMB-AC
Volume	49ml
Wall	110ml
Defect	5ml
Extent	5%
TPD	4%
Shape	0.59 [SI], 0.81 [Ecc]

Proc ID	CARDIAC-AC ONE DAY
View ID	SAX-AST-RST
Date	2013-07-02 13:38:24
Database	FemaleRestMB
Volume	50ml
Wall	111ml
Defect	4ml
Extent	3%
TPD	4%
Shape	0.56 [SI], 0.82 [Ecc]

	Stress		Rest	
	Ext	TPD	Ext	TPD
APX	0	0.5	0	0.0
LAT	0	0.0	6	1.5
INF	0	0.0	0	0.0
SEP	26	3.6	10	2.1
ANT	0	0.0	0	0.0
TOT	5	4.0	3	3.5

Nuclear Cardiology - case



Pat ID 421128/138
Sex MALE
Limits --
TID 1.14
LHR 0.34
SSS 33 SRS 21 SDS 8
SS% 49 SR% 31 SD% 12

Proc ID CARDIAC-AC ONE DAY
View ID SAX-AST-STR
Date 2013-07-02 12:28:48
Database MaleStressMB
Volume 147ml
Wall 192ml
Defect 101ml
Extent 52%
TPD 47%
Shape 0.66 [SI], 0.81 [Ecc]

Proc ID CARDIAC-AC ONE DAY
View ID SAX-AST-RST
Date 2013-07-02 14:48:20
Database MaleRestMB
Volume 129ml
Wall 187ml
Defect 69ml
Extent 37%
TPD 31%
Shape 0.63 [SI], 0.81 [Ecc]

	Stress		Rest	
	Ext	TPD	Ext	TPD
APX	100	12.4	100	11.4
LAT	31	6.6	21	3.7
INF	56	10.4	20	4.3
SEP	33	5.0	27	3.6
ANT	60	12.8	44	8.3
TOT	52	47.2	37	31.3

Education in medical imaging

1. Semester – 2 credits

History of imaging (L)

Radioprotection (S)

Nuclear medicine **diagnostic process and methods**

EBM in imaging (S) **TEST and examination**

2. Semester – 2 credits

Radiology - classical X-ray **Comparison**

- CT **and indication of methods**

- MRI **new trends**

- other methods TEST and examination

We use case reports to explain diagnostic validity of method and we direct show how the technology work

MIRP- Minimally Invasive Radioguided Parathyroidectomy

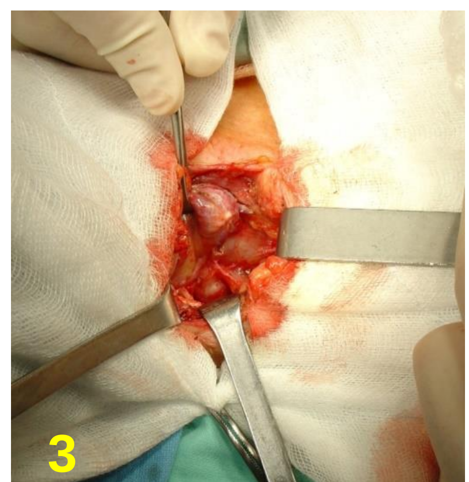
Step 0: Make the overproducing parathyroid gland radioactive

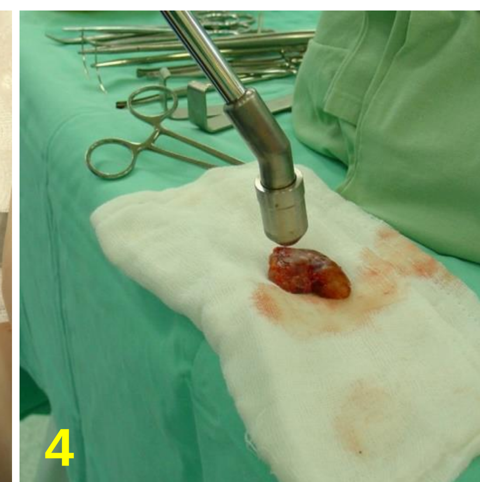
Step 1: Operate only where necessary

Step 2: Use a miniature hand-held radiation detecting probe to find the radioactive parathyroid.

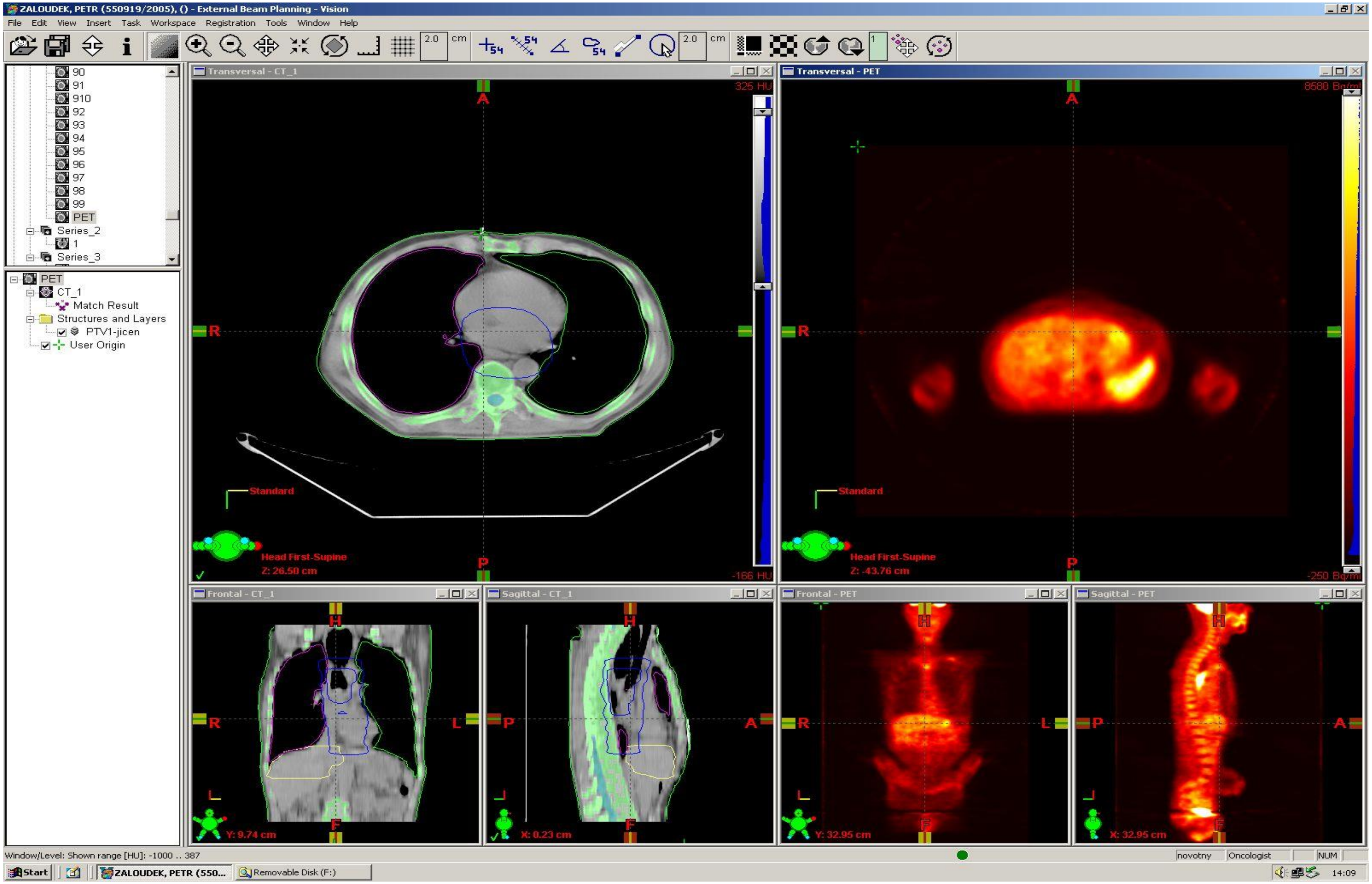
Step 3: Remove the radioactive parathyroid tumor.

Step 4: Measure the radioactivity in the parathyroid tumor to help make sure that the patient is cured of their disease.





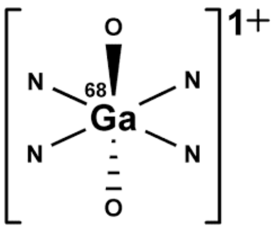
PET/CT imaging to improve radiotherapy planning



Obrázok s láskavým súhlasom: Bolčák, Bartl, Novotný.: MOU Brno

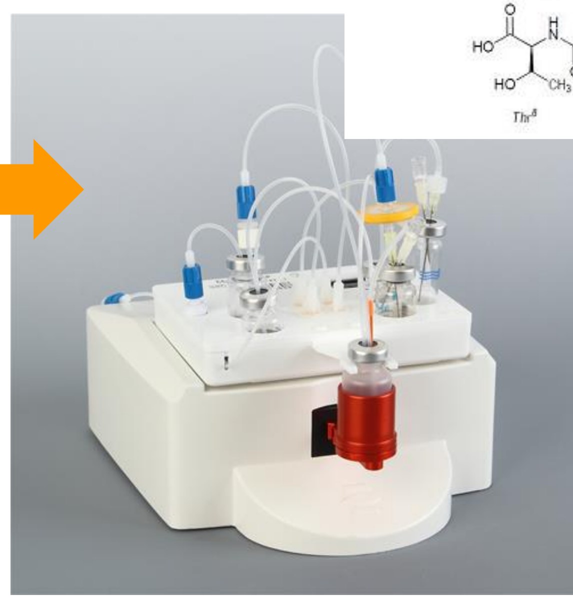
^{68}Ga-^{68}Ge generator and production of radiopharmaceuticals

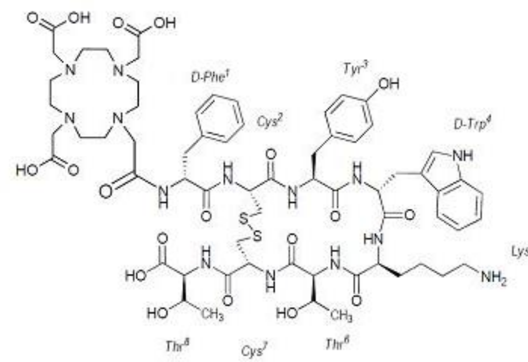
The benefits of the 68Ga-68Ge generator are its long service life (1st year) - PET/CT The **disadvantage** is its high price and more complicated handling, F1 / 2 - 68 minutes. Conversely, the synthesis and labeling of radiopharmaceuticals (DOTA-TOK) is considerably more demanding than Tekrotyd labeling. It is always tricky to control the final product by using the more demanding technology we use today.



^{68}Ga-^{68}Ge generator

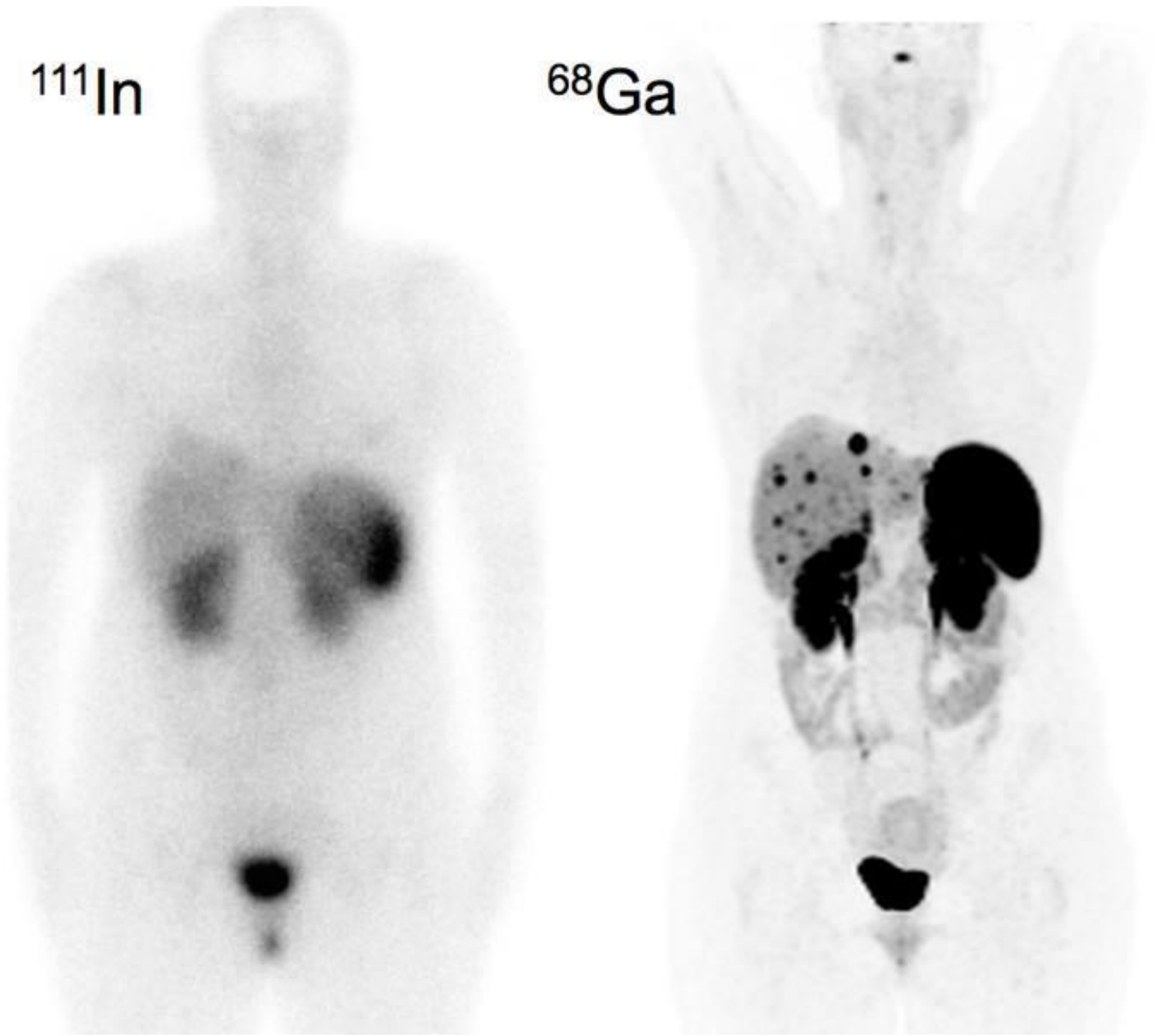
Synthesis Of DOTA-TOK





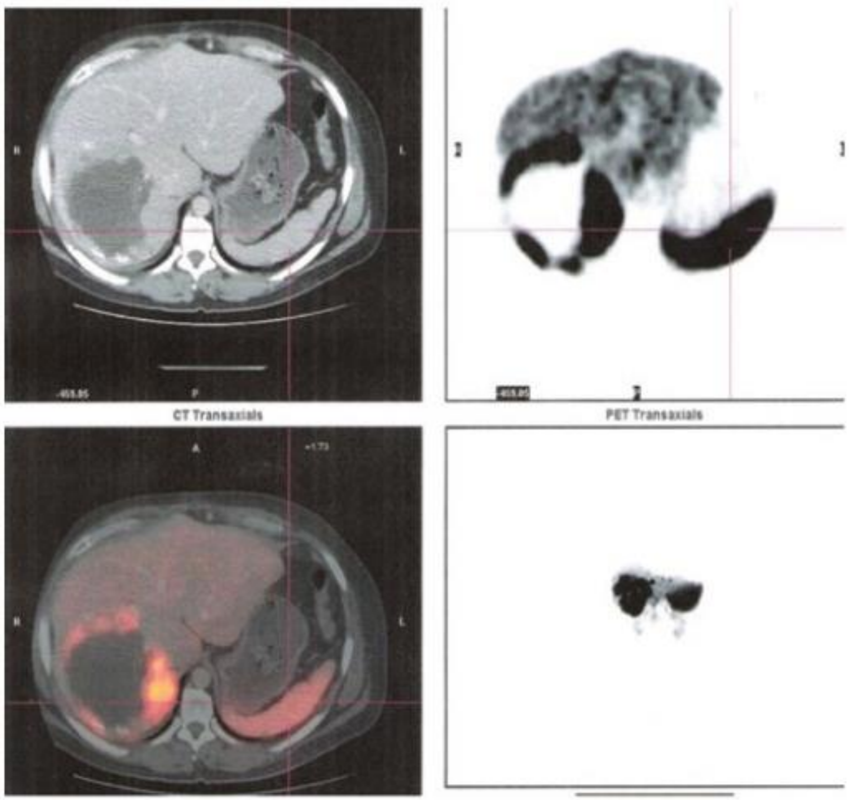
Quality control

2019 - INMM **PET/CT** ^{111}In v.s. ^{68}Ga-DOTA-TOC

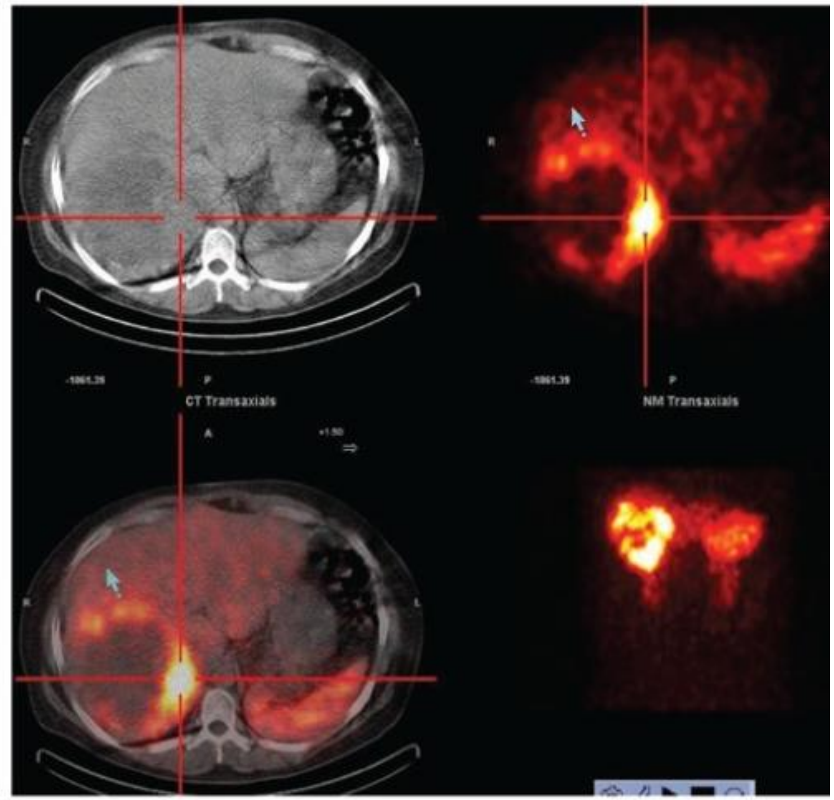


TERANOSTICS ^{68}Ga / ^{177}Lu Octerotid

68 Gallium Octreotide
PET CT



177 Lutetium Octreotide
SPECT - CT



Artificial Intelligence and IMAGING

Tools of artificial intelligence

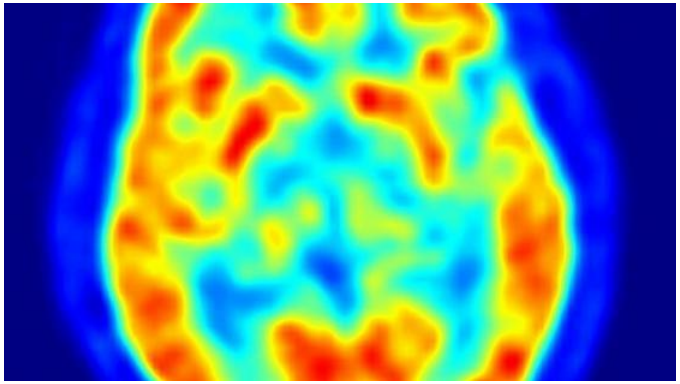
In solving artificial intelligence problems, it is experimented with various algorithms, methods, and combinations such as.:

Hardware: *from smartphon* *to supercomputer (IBM Watson)*

Software:

- Convolutional Neural Network (CNN)
- Machine Learning Theory
- Fuzzy logic
- Genetic algorithms
- **Expert systems** are computer programs whose role is to provide advice, decisions or recommend solutions in a particular situation.

Artificial Intelligence and IMAGING

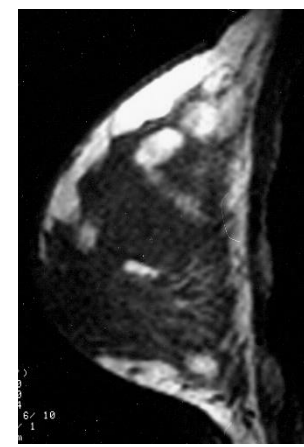


In **Nuclear Medicine**, Artificial Intelligence (AI) algorithms have been trained to distinguish 2100 of 18F-FDG **PET Brain Images** in AD patients (Alzheimer's Disease). A positive finding was found with 100% sensitivity and 6 years prior to clinical definitive diagnosis!

Publ. Nov. 6 in ***Radiology* 2018**

Breast MRI and **oncology results** were used to train AI using Convolutional Neural Network (CNN). They rated 3,107 volumes in 141 tumors **to predict patient response to chemotherapy**. The system achieved an **accuracy of 88%**

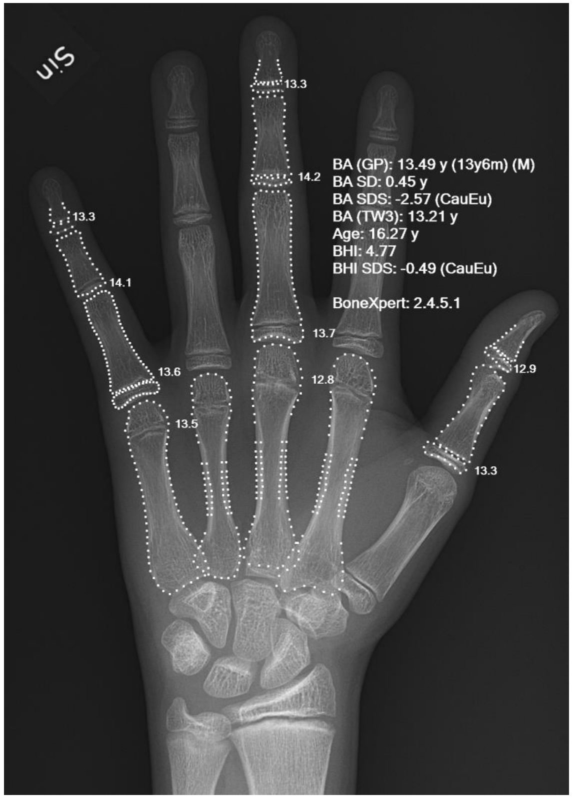
Journal of Digital Imaging 2018



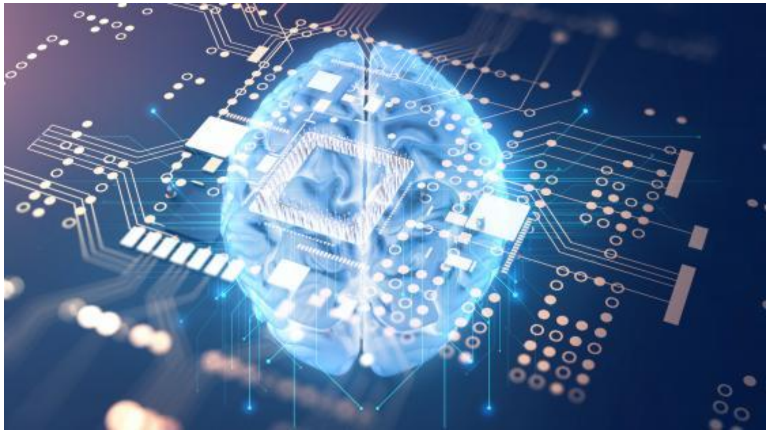
Artificial Intelligence and IMAGING

In **Radiology** is testing system that can rule out the negative results of **screening mammography**.

AI selects normal images that do not need to be further evaluated. Those that give an ambiguous or clearly pathological finding will pass on to a radiologist who does just the second reading and saves the time that can give them a more in-depth analysis.



Another example is a **system that can determine the bone age** of the patient from the X-ray image of the hand.



Education in medical imaging

1. Semester – 2 credits

History of imaging (L)

Radioprotection (S)

Nuclear medicine **diagnostic process and methods**

EBM in imaging (S) **TEST and examination**

2. Semester – 2 credits

Radiology - classical X-ray **Comparison**

- CT **and indication of methods**

- MRI new trends

- other methods **TEST and examination**

We use case reports to explain diagnostic validity of method and we direct show how the technology work

Test - You will fill out this form

Nuclear medicine - examination form

year: ☐ study group: ☐

Please only FAMILY name you write in capital letters
Circle on the correct answer. **Your first and FAMILY name:** ....

1	2	3	4	5	6	7	8	9	10	11
a)	a)	a)	a)	a)	a)	a)	a)	a)	a)	a)
b)	b)	b)	b)	b)	b)	b)	b)	b)	b)	b)
c)	c)	c)	c)	c)	c)	c)	c)	c)	c)	c)
d)	d)	d)	d)	d)	d)	d)	d)	d)	d)	d)
e)	e)	e)	e)	e)	e)	e)	e)	e)	e)	e)

Date of exam: ....

DEFINITVE MARK: ☐

RESULTS: Correct answers ☐ incorrect one ☐

ORAL EXAM:
Question/s number: ☐ text of question:

HERE is place for calculations – it must be clear how do you come to a results

3. encircle the correct sentences

Find two correct answers !

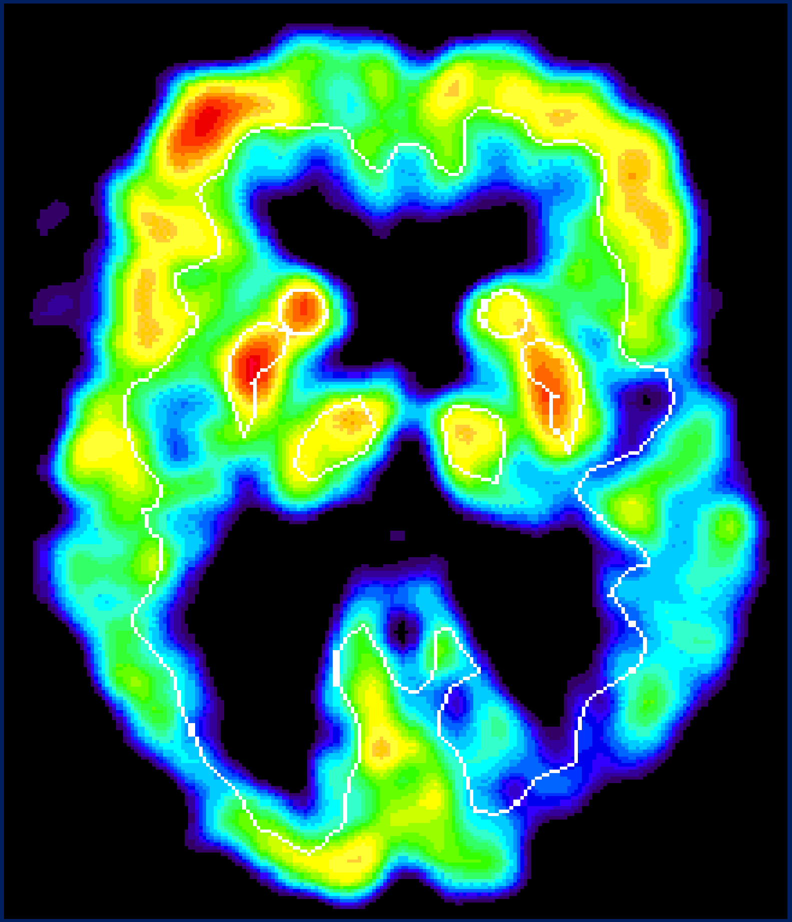
a) SPECT brain after administration of ^{123}I–ioflupane (DaT scan)

b) PET brain after administration of ^{18}F-FDG

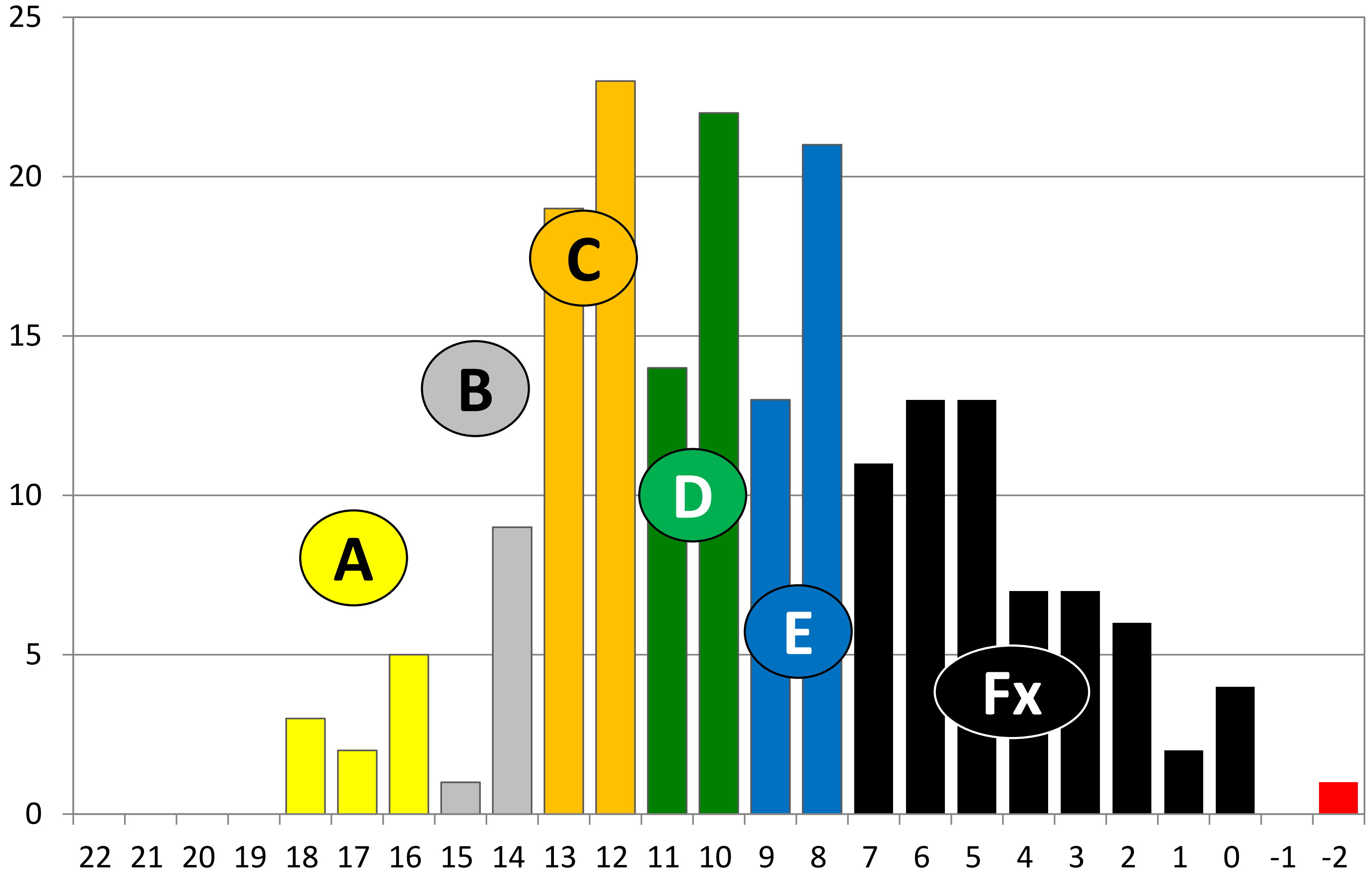
c) PET brain after administration $^{99m}TcO_4$

d) Ischemia left occipital region

e) Suspicious Alzheimer's disease with a prevalence of left



Distributions of tests results



Institute of nuclear and molecular medicine

Thank you for your attention