UNIVERSITÀ
DEGLI STUDI DI TRIESTE

INFN
Istituto Nazionale
di Fisica Nucleare
.trieste

Neurofunctional techniques
Neuroimaging

Renata Longo
Dipartimento di Fisica e INFN
Universita' degli studi di Trieste
rlongo@units.it

Neurofunctional techniques
neuroimaging

in vivo **techniques**

for human brain imaging and mapping

A critical overview of methodology and applications

You will run some simple
MRI experiments of brain mapping
9, 23 and 30 November

Neuroimaging
… in these lectures

A 2 hands course

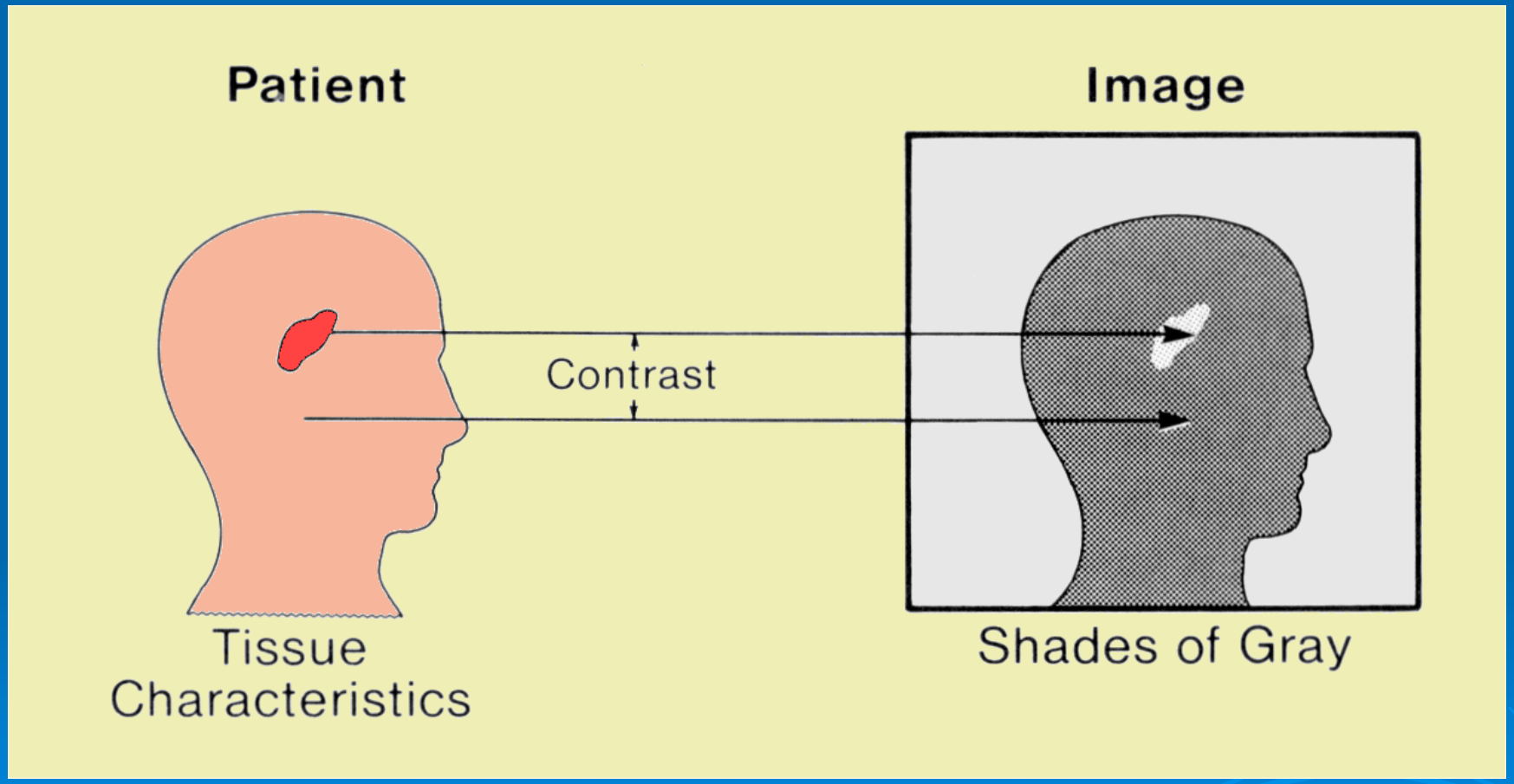
Renata Longo and Maja Ukmar

A physicist and a radiologist point of view

- The physicist is methodology oriented
- The radiologist is clinical oriented

Both of us are research oriented

Medical imaging techniques



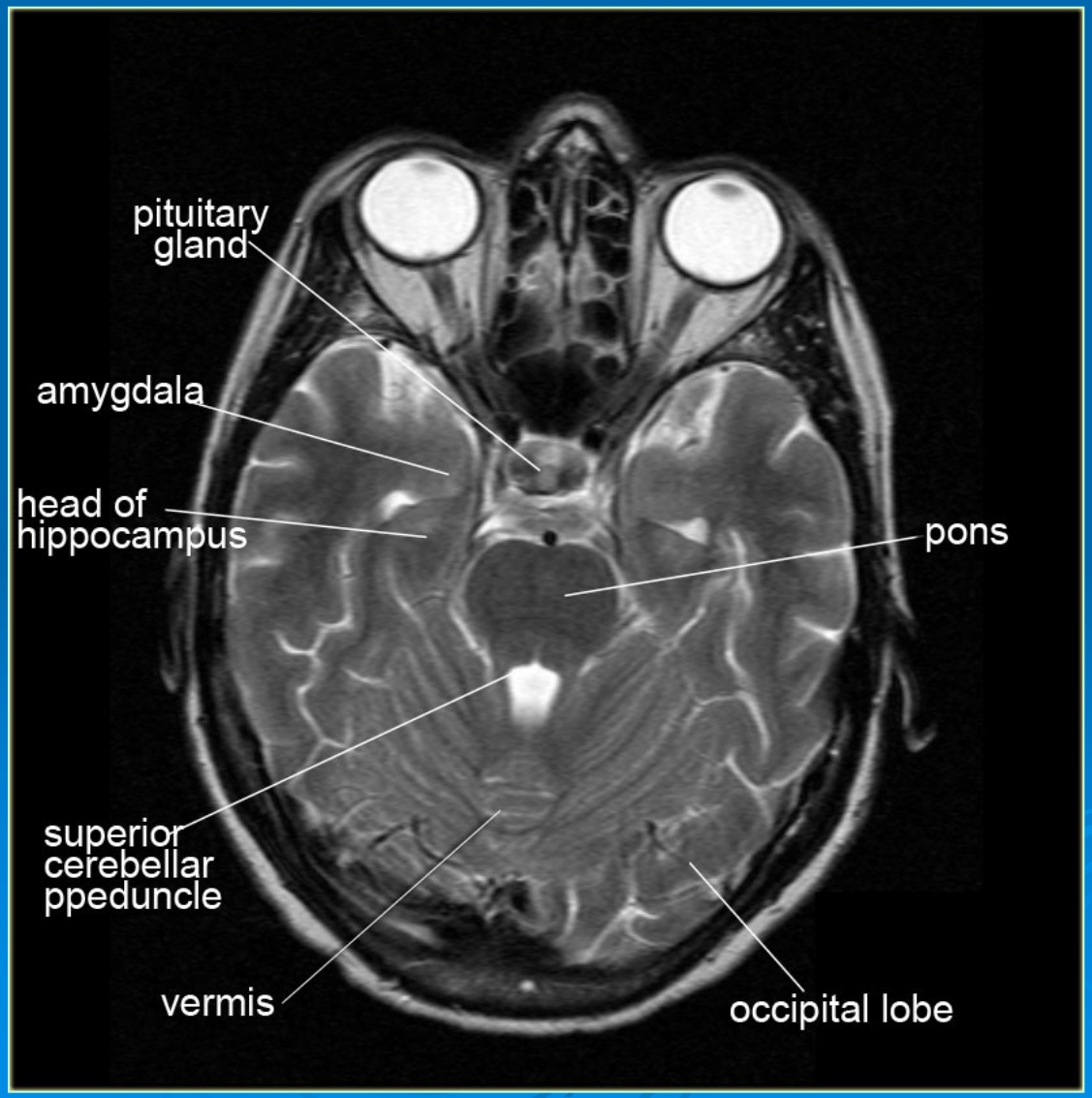
Medical Imaging is the Process of Converting Tissue Characteristics into a Visual Image

http://www.sprawls.org/ppmi2/IMGCHAR/#CHAPTER%20CONTENTS

Topics

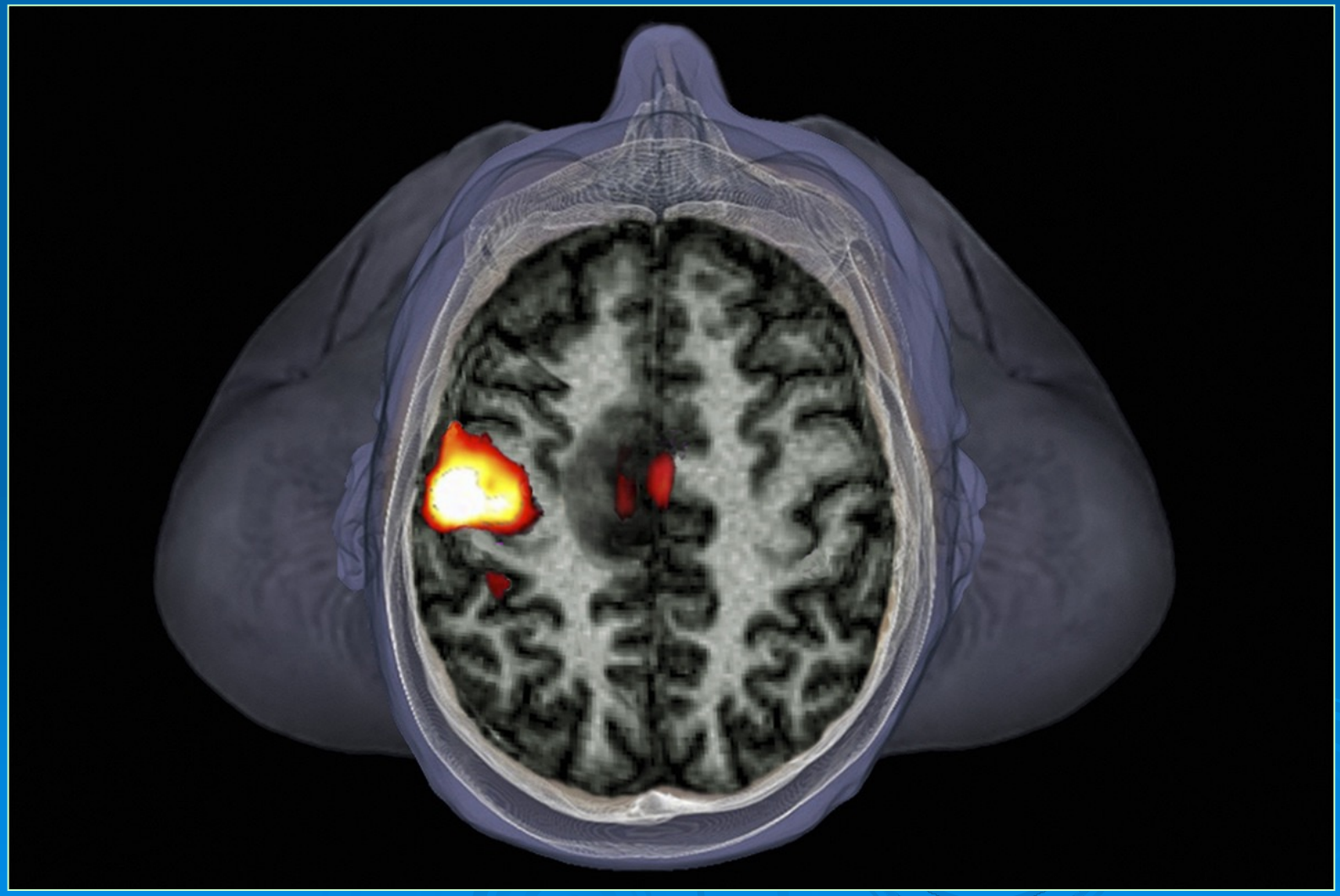
- **Nuclear Magnetic Resonance Imaging (MRI)**
  - **fMRI, DTI**
  - **Hands-on sessions at the clinical MRI unit**
- **Computed tomography (CT)**
  - **Basic principles, recent developments**
- **Nuclear Medicine techniques**
  - **Single Photon Emission Tomography (SPECT)**
  - **Positron Emission Tomography (PET)**
- **Radiobiology and radiation protection:**
  a short introduction
  - **for researchers and volunteers**

Nuclear Magnetic Resonance Imaging (MRI)

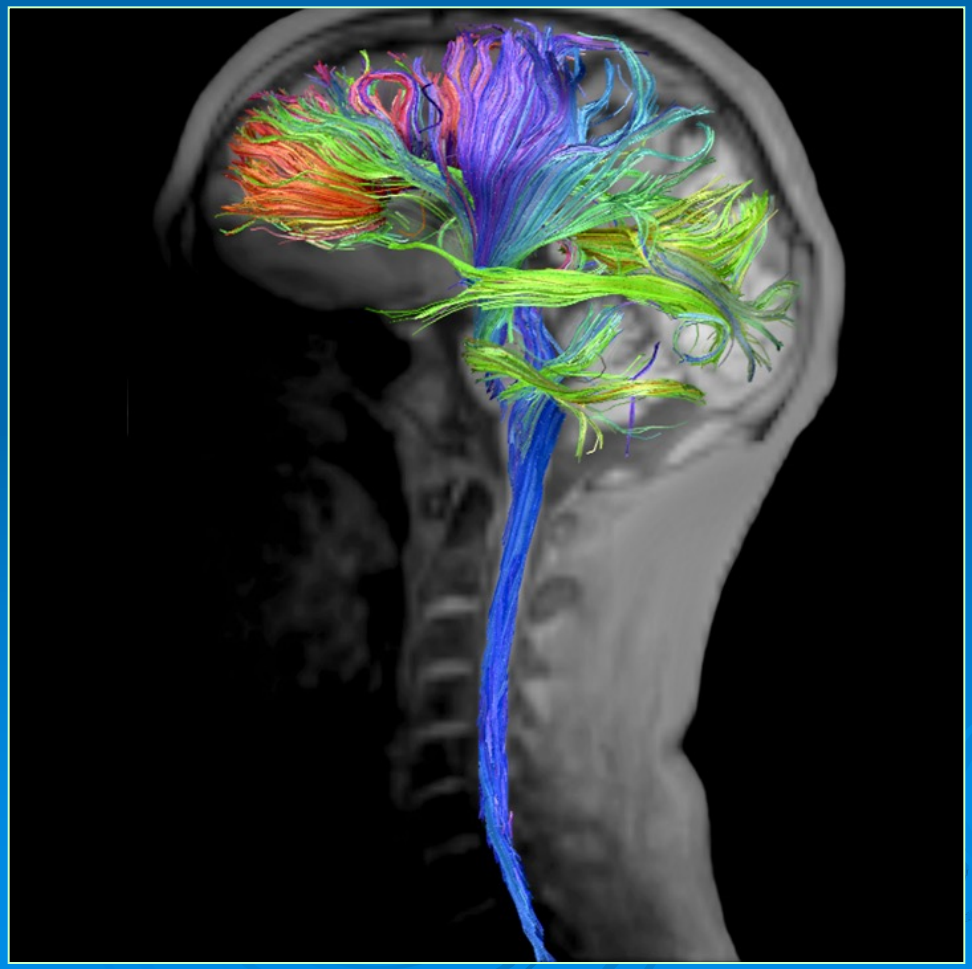


functional MRI

brain mapping



Diffusion Tensor Imaging
DTI-MRI
brain connectivity



Topics

- Nuclear Magnetic Resonance Imaging (MRI)
  - fMRI, DTI
  - Hands-on sessions at the clinical MRI unit
- Computed tomography (CT)
  - Basic principles, recent developments
- Nuclear Medicine techniques
  - Single Photon Emission Tomography (SPECT)
  - Positron Emission Tomography (PET)
- Radiobiology and radiation protection:
  a short introduction
  - for researchers and volunteers

x-ray Computed Tomography (CT)

https://www.imaios.com/en/e-Anatomy/Head-and-Neck/Head-CT

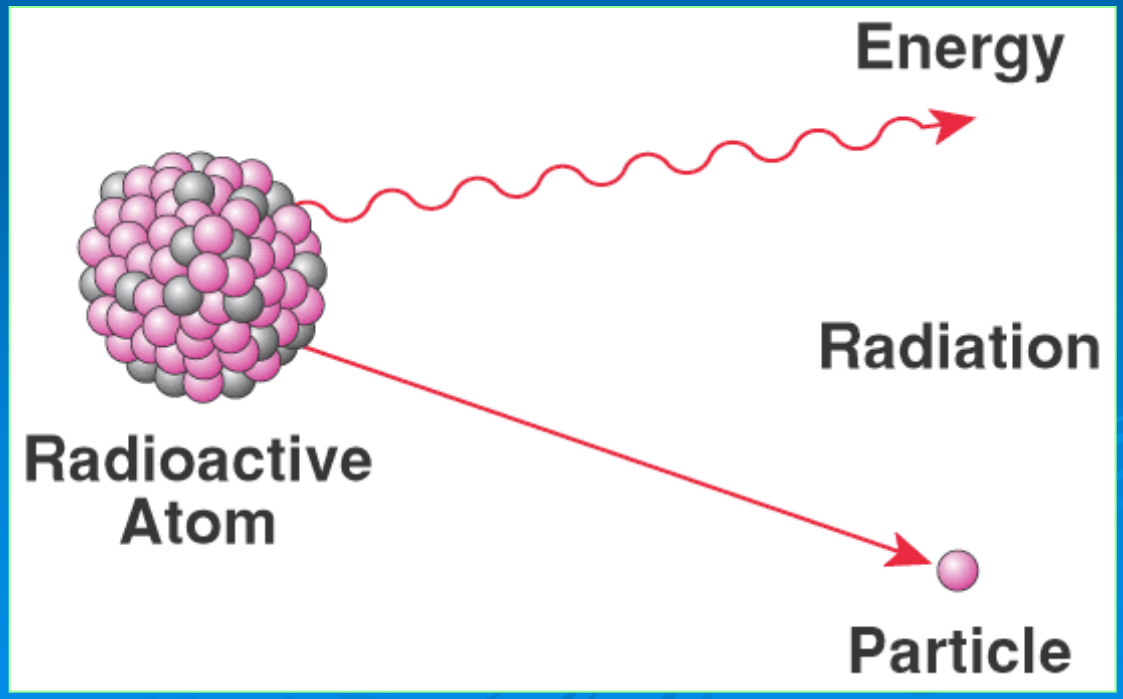
Topics

- Nuclear Magnetic Resonance Imaging (MRI)
  - fMRI, DTI
  - Hands-on sessions at the clinical MRI unit
- Computed tomography (CT)
  - Basic principles, recent developments
- Nuclear Medicine techniques
  - Single Photon Emission Tomography (SPECT)
  - Positron Emission Tomography (PET)
- Radiobiology and radiation protection:
  a short introduction
  - for researchers and volunteers

Nuclear Medicine

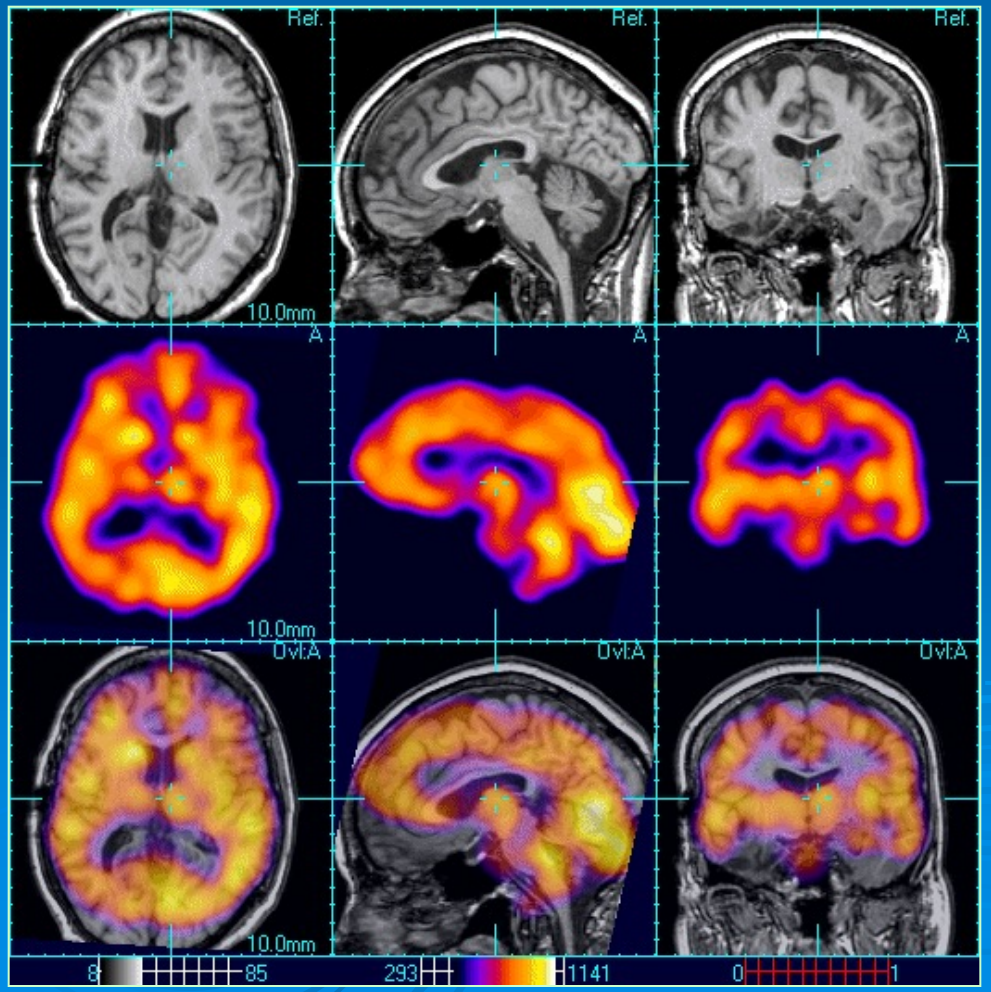
Radionuclide imaging

A radioactive compound is delivered to the subject and images are generated by the radioactive emissions from the body



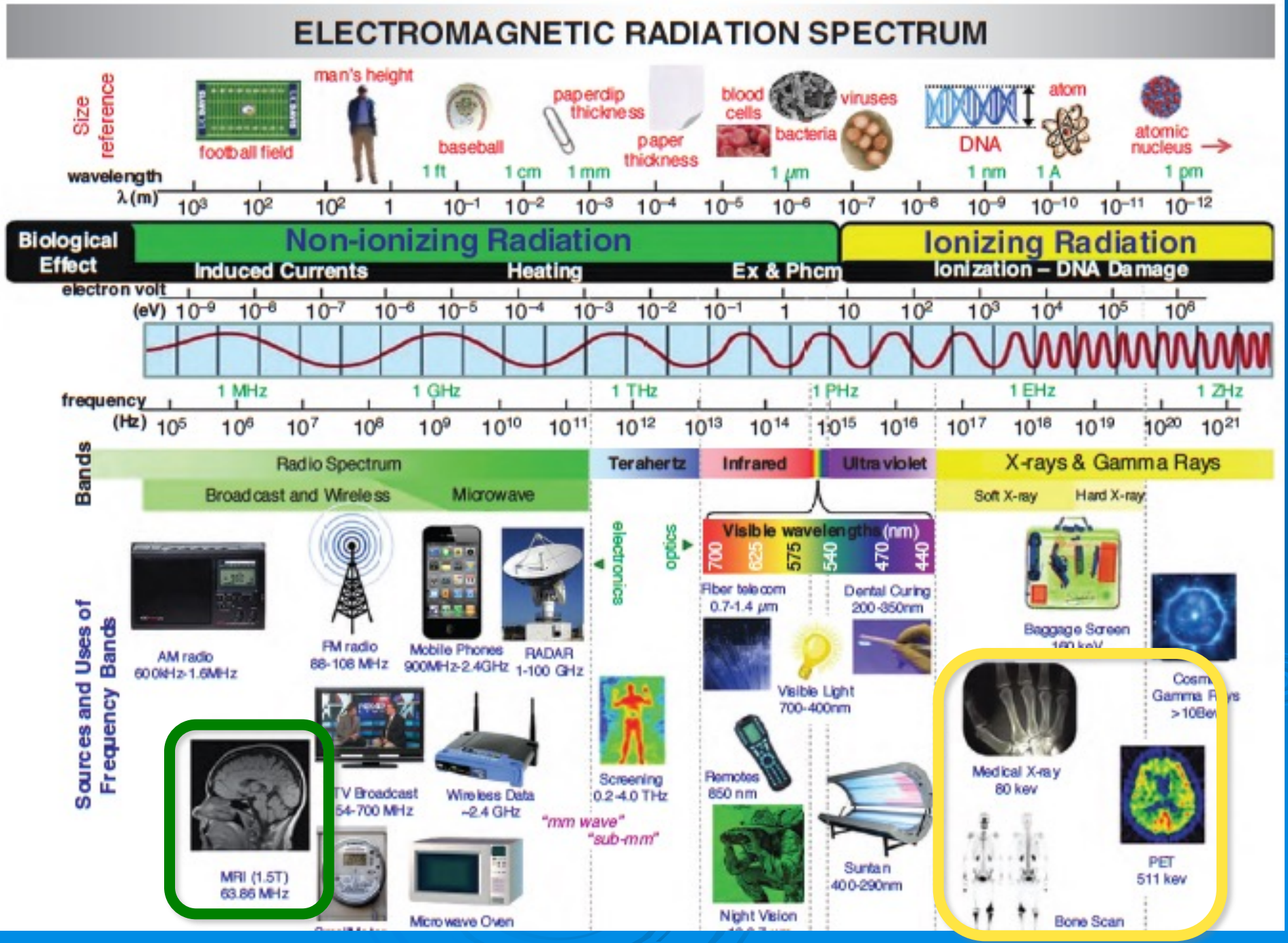
Nuclear Medicine
Radionuclide imaging
Functional (molecular) imaging

- **Anatomy MRI**
  - may be CT
- **Functional**
  - Positron emission tomography
- **Fusion imaging**



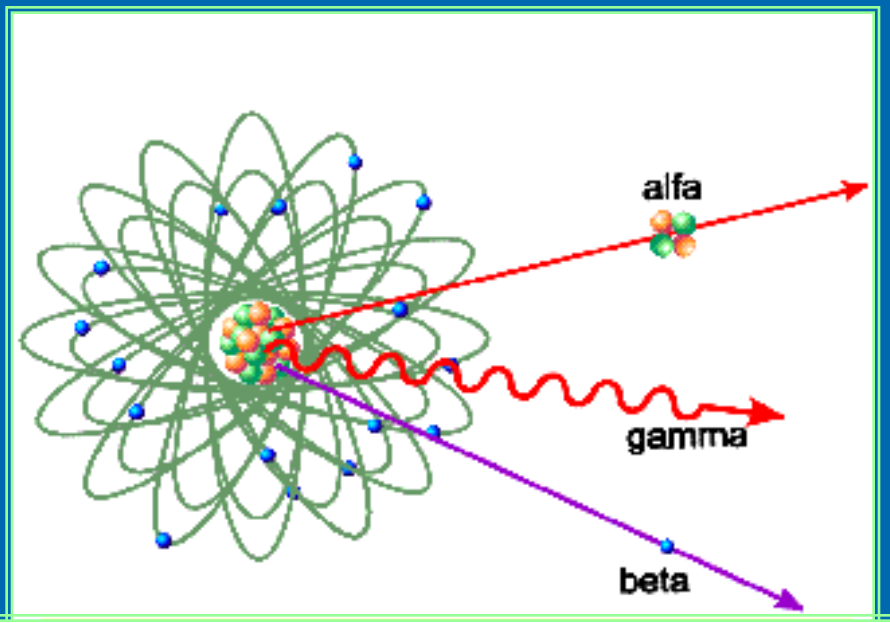
Topics

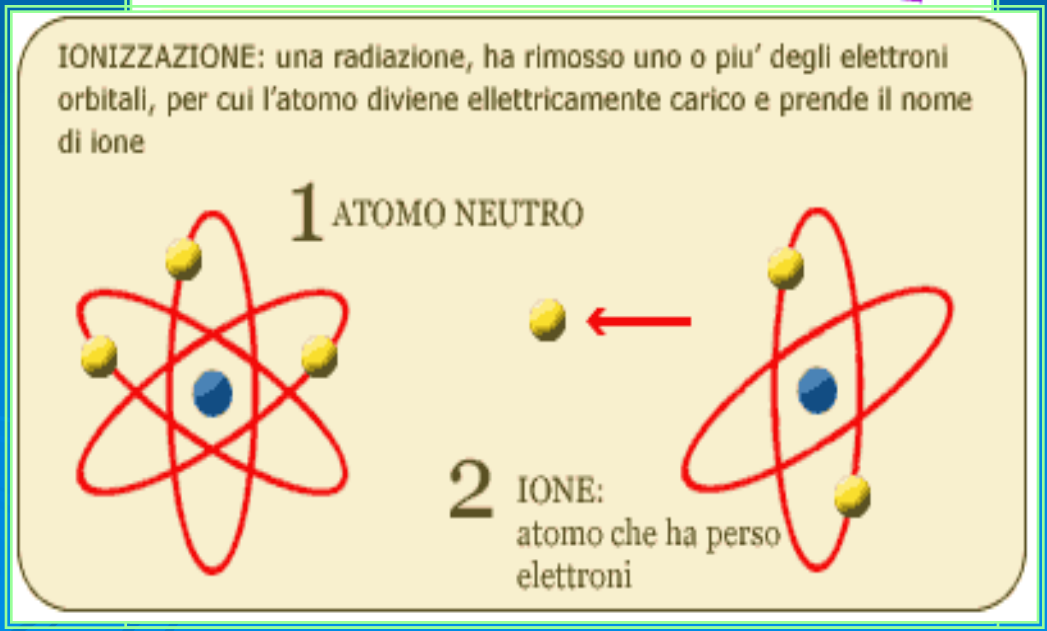
- Nuclear Magnetic Resonance Imaging (MRI)
  - fMRI, DTI
  - Hands-on sessions at the clinical MRI unit
- Computed tomography (CT)
  - Basic principles, recent developments
- SPECT & PET techniques and applications
  - Single Photon Emission Tomography
  - Positron Emission Tomography
- Radiobiology and radiation protection:
  a short introduction
  - for researchers and volunteers


ELECTROMAGNETIC RADIATION SPECTRUM
Size reference
man's height
football field
baseball
paperclip thickness
paper thickness
blood cells
viruses
bacteria
DNA
atom
atomic nucleus
wavelength λ (m)
1 ft
1 cm
1 mm
1 μm
1 nm
1 A
1 pm
Biological Effect
Non-ionizing Radiation
Induced Currents
Heating
Ex & Phcm
Ionizing Radiation
Ionization – DNA Damage
electron volt (eV)
frequency (Hz)
1 MHz
1 GHz
1 THz
1 PHz
1 EHz
1 ZHz
Bands
Radio Spectrum
Broadcast and Wireless
Microwave
Terahertz
Infrared
Ultraviolet
X-rays & Gamma Rays
Soft X-ray
Hard X-ray
Visible wavelengths (nm)
700
625
575
540
470
440
electronics
optics
Sources and Uses of Frequency Bands
AM radio
600kHz-1.6MHz
FM radio
88-108 MHz
Mobile Phones
900MHz-2.4GHz
RADAR
1-100 GHz
Fiber telecom
0.7-1.4 μm
Dental Curing
200-350nm
Baggage Screen
Visible Light
700-400nm
TV Broadcast
54-700 MHz
Wireless Data
~2.4 GHz
Screening
0.2-4.0 THz
"mm wave"
"sub-mm"
Remotes
850 nm
Medical X-ray
80 kev
MRI (1.5T)
63.86 MHz
Microwave Oven
Suntan
400-290nm
Night Vision
PET
511 kev
Bone Scan

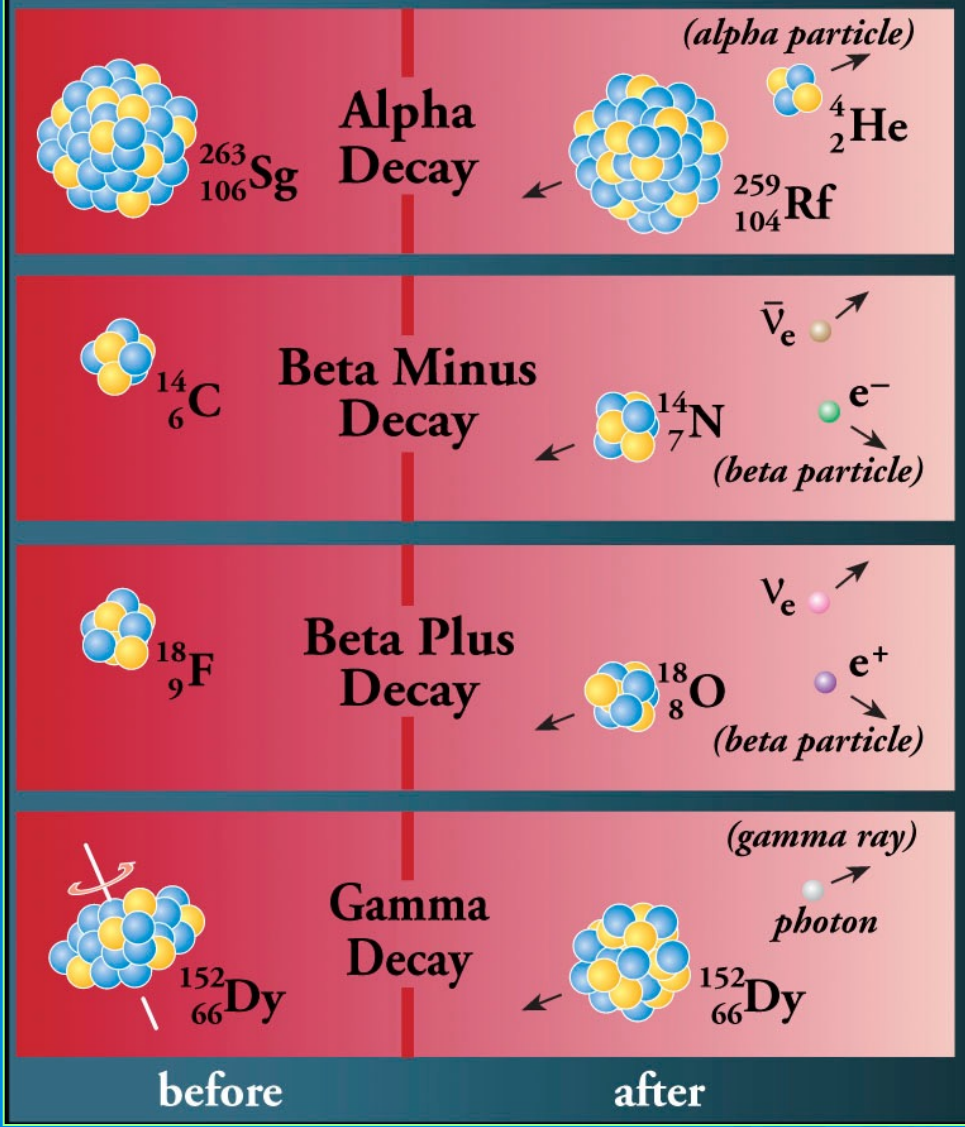
Ionizing radiation

- **Ionizing radiation** consists of **subatomic particles** or **electromagnetic waves** that are energetic enough to detach **electrons** from **atoms** or **molecules**, **ionizing them**
  - ✓ **X ray**
    - ✓ **CT**
  - ✓ **γ ray**
    - ✓ **Nuclear Medicine**
  - ✓ **α particle**
    - ✓ **Nuclear Medicine**
  - ✓ **β particle**
    - ✓ **Nuclear Medicine**

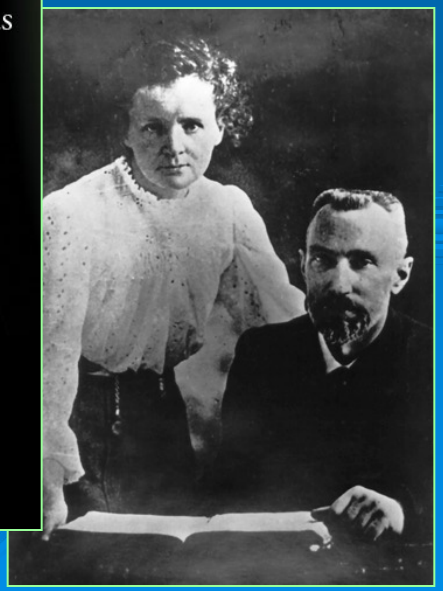




Radioactivity

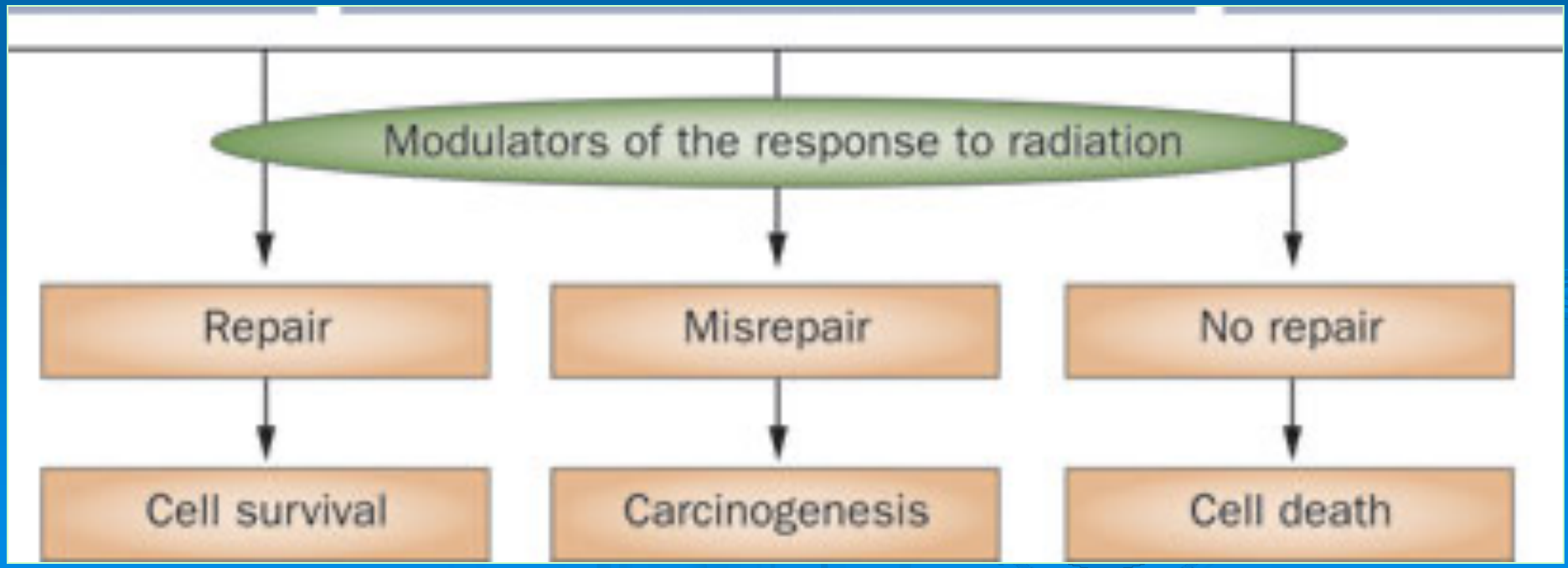


*R*adioactive decay transforms a nucleus by emitting different particles. In **alpha** decay, the nucleus releases a $^{4}_{2}He$ nucleus –an alpha particle. In **beta** decay, the nucleus either emits an electron and antineutrino (or a positron and neutrino) or captures an atomic electron and emits a neutrino. A positron is the name for the antiparticle of the electron. Antimatter is composed of antiparticles. Both alpha and beta decays change the original nucleus into a nucleus of a different chemical element. In **gamma** decay, the nucleus lowers its internal energy by emitting a photon–a gamma ray. This decay does not modify the chemical properties of the atom.



Biological effects of ionizing radiation

Biological risk is associate to the ionization of the DNA



From the syllabus our learning agreement

D1: Knowledge and understanding

- The purpose of the course is to provide theoretical, conceptual and practical basis about the functioning of the principal neuroimaging, useful to investigate the different aspects of the characteristics of the Central Nervous System, in the field of Cognitive Neuroscience

- Advantages and limitation of the different techniques should be acquired

http://ecahe.eu/w/index.php/Dublin_Descriptors

From the syllabus

D2 Applying knowledge and understanding

- The acquired knowledge will be useful to develop the needed capability to design the most appropriate experimental plans to investigate the characteristics of the Central Nervous System

http://ecahe.eu/w/index.php/Dublin_Descriptors

From the syllabus

D3 Making judgements

- The students develop critical abilities useful to better understand the functioning of neuroimaging tools
- The students will be able to evaluate the different cases in which the different techniques may be applied, depending on the experimental purposes

http://ecahe.eu/w/index.php/Dublin_Descriptors

From the syllabus

D4 Communication skills

- The requested written reports about experiments, and the oral examination will encourage the students to develop scientific writing abilities and oral communication skills

http://ecahe.eu/w/index.php/Dublin_Descriptors

From the syllabus

D5 Learning skills

- the students will be able to critically evaluate the scientific literature using neurofunctional techniques
- This will allow them to obtain the propaedeutic knowledge to plan research projects in the field of Cognitive Neuroscience

http://ecahe.eu/w/index.php/Dublin_Descriptors

Slides and additional material

- Slides are uploaded in Moodle
- Additional material available in Moodle
- Groups composition and reports delivery by Moodle

About exam neuroimaging module

- Students are required to take a final oral examination and present a report of the MRI experiment
- The oral examination consists in a discussion of 30 min, during which the student is invited to describe and comment on a few topics covered in the course
- The final registration, weighed average of the marks of the modules, is done by prof. Cingolani
  - Find the date in ESSE3

Calendar neuroimaging
prof. Renata Longo and prof. Maja Ukmar

Thursday 28 September	14-16	
Thursday 5 October	14-16	
Thursday 12 October	14-16	
Thursday 19 October	14-16	
Thursday 26 October	14-16	
Wednesday 8 November	16-18	
Thursday 9 November	14-16.30	group A
Thursday 9 November	16.30-19	group B
Wednesday 22 November	16-18	

Calendar neuroimaging
prof. Renata Longo and prof. Maja Ukmar

Thursday 23 November	14-16.30	group C
Thursday 23 November	16.30-19	group D
Thursday 30 November	14-16.30	group E
Thursday 30 November	16.30-19	group F
Wednesday 6 December	16-18	
Thursday 7 December	14-16	
Thursday 14 December	14-16 seminar by dott. G. Hagberg *TBC*	