Medical Imaging Sensors
Introduction to the medical imaging techniques

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Medical imaging team

Group leader : Pr Brunotte

Localization: Dijon
➔ Faculté de Médecine / Medicine
➔ Service d'IRM - CHU de Dijon
/ MRI department - University Hospital of Dijon
➔ Service de Médecine Nucléaire – CGFL Dijon (Centre anti-cancéreux)
/ Nuclear Medicine department – Anti-cancer centre

Main topics :
➔ Functionnal study of the heart and the aorta from MRI
➔ MRI / MRS of prostate cancer
➔ PET in oncology (follow up of patients and use of innovative tracers)

Strength / Avalaible facilities :
➔ Clinical 3T and 1.5 T MRI
➔ Clinical PET
➔ Experimental PET / MRI system (pre-clinical experimentation)
➔ Close contact with physicists, medical doctors and computing engineers

- DICOM format
- General points
- Conventional radiology
- Computed tomography (CT scan)
- Magnetic Resonance Imaging (MRI)
- Scintigraphy
- Echography

What is DICOM ?

- The standard image format for medical images.

- **D**igital **I**maging and **Co**mmunications in **M**edicine.

- Developed by the National Electrical Manufacturers Association (NEMA) in conjunction with the American College of Radiology (ACR), with the assistance of American Association of Physicists in Medicine (AAPM) and the Radiological Society of North America (RSNA).

- Covers most image format for all of medicine.
- Specification for messaging and communication between imaging machines.

➔Both an image format and a network protocol.

- Each image acquired on a medical image system is unique : Several unique identification number are automatically generated in each DICOM header.

A little history of DICOM

1983 : ACR (American College of Radiology) and NEMA (National Electrical Manufacturer Assoc.) form a joint committee to develop an image standard to:

- Promote communication of image information, regardless of device manufacturer.
- Retrieve images and associated information from digital imaging equipment in a standard format using point-to-point connection.

1985 : First image format : ACR-NEMA version 1.0

1988 : ACR-NEMA version 2.0 (new material and major revisions, in particular definition of the point to point connection)

A little history of DICOM

1991: The name was changed to separate the standard from the originating body. Release of DICOM version 3.0 (corresponding to ACR-NEMA 3.0).

1993 : Convergence of format definitions coming from the different areas around the globe (USA, Europe (with the INTERFILE format, often used in nuclear medicine), and Japan) to define a consensual DICOM format.

Today : DICOM is still version 3 and has been update regularly since. There is an annual symposium on the DICOM format (DICOM International Conference & Seminar), an official website (http://medical.nema.org), and the publication of an official book and CD-ROM.

Why DICOM standard was created ?

- Many industrial manufacturers used their own image formats which were not always easily accessible on rival systems. Although, they provided some data and communication support, this situation pushed clients to reinvest in equipment from the same company.

- Images that you want to exchange between operators using another system is impossible without transcoding.

- To solve these compatibility problems, DICOM uses a specific language and concepts which are commonly used in object oriented software engineering.

Supported imaging modalities

Digital X-ray (and X-ray angiography)

Computed Tomography (CT)

Magnetic Resonance Imaging (MRI)

Nuclear Medicine (and Positron Emission Tomography (PET))

Ultrasound (Echography)

Electron Microscopy

Digital Microscopy

And more….

DICOM 3.0 – Object oriented approach

Structure (object classes - IOD)
- Image data
- Patient and recording information

Method (service classes)
- Storage and retrieval of the data
- Organization of the examinations

Protocol (DICOM message)
- Communication, network support

Structure : IOD
Information Object Definition

First part of the DICOM file : The header, with technical and patient information recording.
Second part of the DICOM file : The data (the image, for example).
Support one slice per file.

<u>File organisation</u>

Each elementary information is composed with 3 data fields

First field (8 bytes) : Tag of the DICOM dictionnary that indicates the following information (2 series of 4 bytes) :

- Group of information data set
- The name of the element

- Second field (8 bytes) : The length of the information (in bytes)
- Third field (Variable length, according the second field): The information.

One big header

Each data field has a unique tag (=key)

Even the image data is a tag and is part of the header.
➔ Pixel coded on 12 bits

Usually the image data is the last element in the header

Each header field is of variable length
Each field is generally optional
Length of the field is store after the tag
➔ Headers must be read sequentially

Tags are organized into groups by type

Examples of tags

Group	Meaning
0000	Command
0008	Patient relationship
0010	Patient identification
0018	Image modality
7FE0	Data

Element	Meaning
0008 0020	Study date
0010 0020	Patient ID
0010 4000	Patient comments (max 1024 char.)
0018 0081	Echo time (TE)
0018 1111	Distance from source to isocenter
0018 1150	Duration of X-Ray exposure

Example of information coding

Example of data stream (in DICOM data object) :
(0010,0010)DUPONT^ERIC(0010,0030)19840225(0010,0040)M
(0010,1010)025Y(0010,1030)70(0010,2150)France(0010,21A0)YES

(0010,0010) : Patient's name

(0010,0030) : Patient's birth date

(0010,0040) : Patient's sex

(0010,1010) : Patient's age

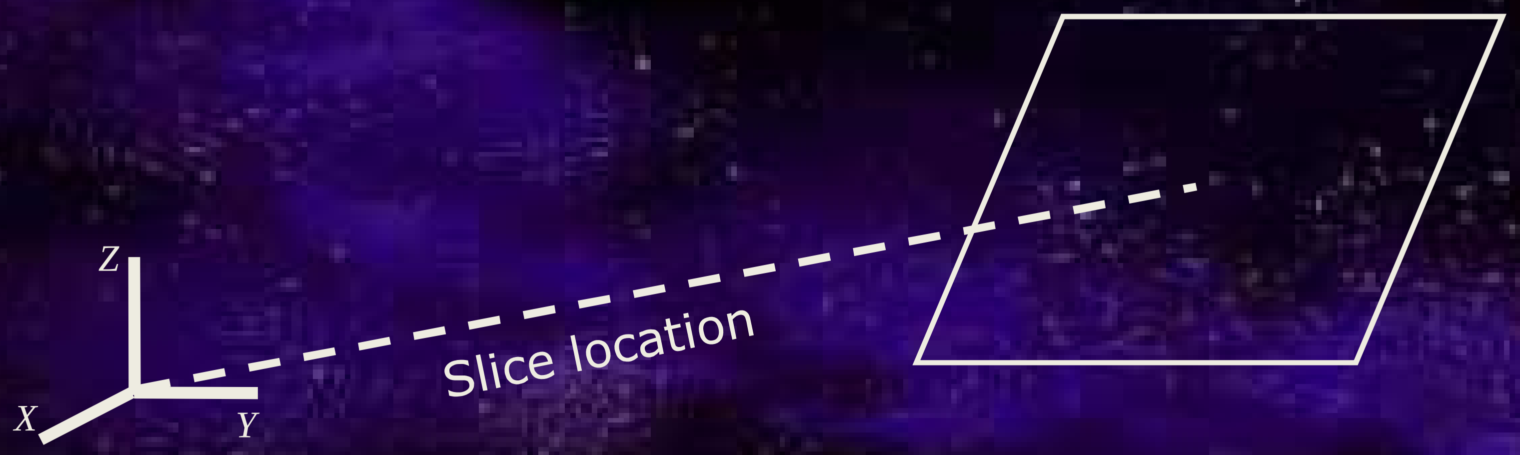
(0010,1030) : Patient's weight

(0010,2150) : Country of residence

(0010,21A0) : Smoking status

Important tags concerning image display

(0028,0010) :	Rows	320
(0028,0011) :	Columns	210
(0028,0030) :	Pixel spacing	1.09375\1.09375
(0018,0050) :	Slice thickness	5
(0020,1041) :	Slice location	-54.2455
(0020,0032) :	Image position	-96\-68\179.88
(0020,0037) :	Image orientation	0.45\0.88\0\0\0\-1



Reference coordinates

Important tags concerning image display

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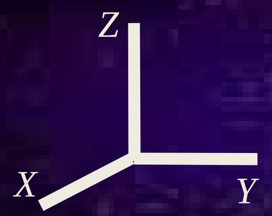
Image position
X\Y\Z



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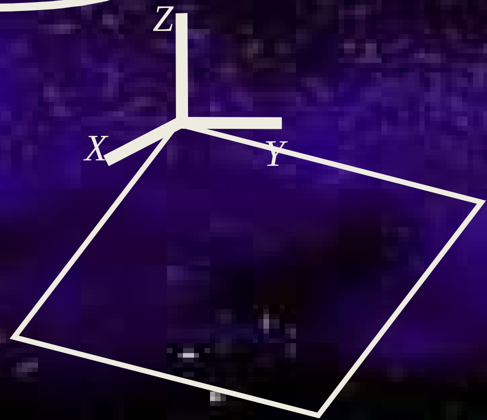
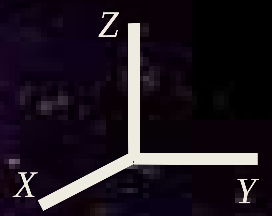
3 Cosinus associated with the angles between the **lines** of the image and the three axis of the reference coordinates

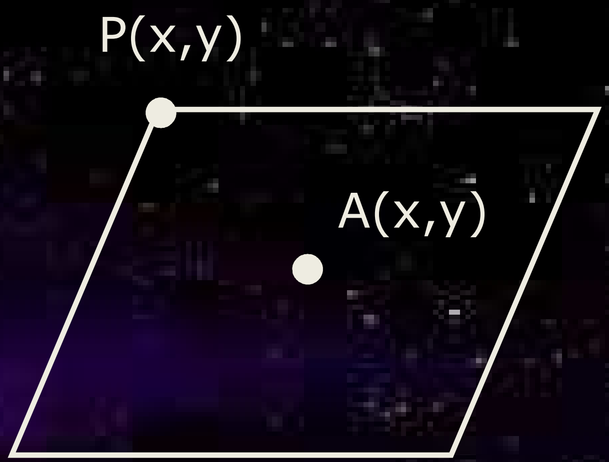
3 Cosinus associated with the angles between the **columns** of the image and the three axis of the reference coordinates



From the image coordinates to the reference coordinates



Reference coordinates



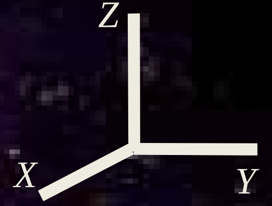
$$\begin{bmatrix} Rx \\ Ry \\ Rz \\ 1 \end{bmatrix} = M \begin{bmatrix} Ax \\ Ay \\ Az \\ 1 \end{bmatrix}$$

where M is a transformation matrix composed of a translation (T), rotation (R) and scaling (S)

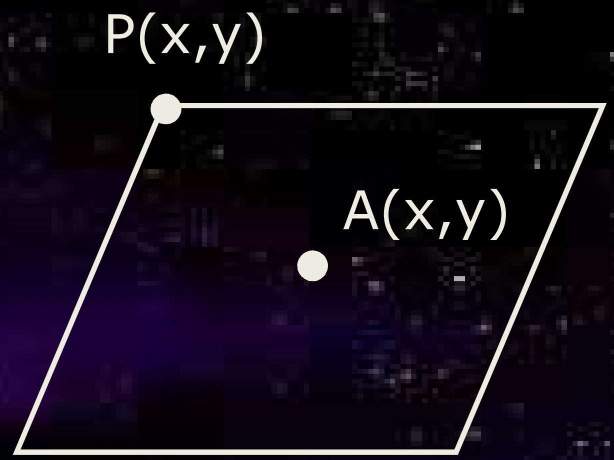
$$M = T \times R \times S$$

R_{xyz} are the coordinates of the pixel in the reference coordinate system

From the image coordinates to the reference coordinates



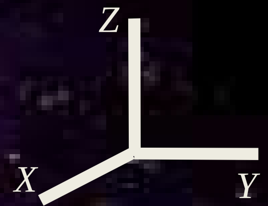
Reference coordinates



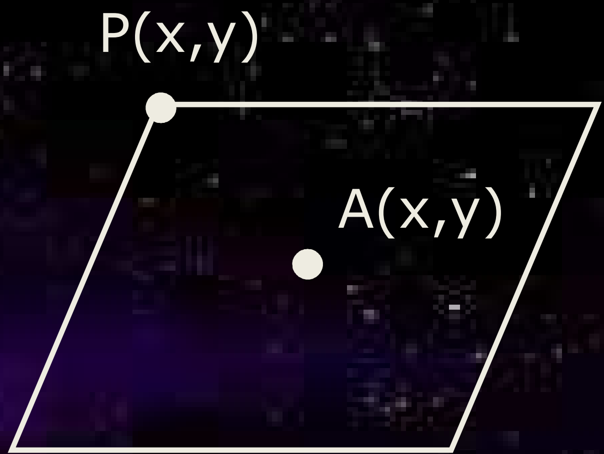
$$T = \begin{bmatrix} 1 & 0 & 0 & Px \\ 0 & 1 & 0 & Py \\ 0 & 0 & 1 & Pz \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Pxyz : Image position (in mm)

From the image coordinates to the reference coordinates



Reference coordinates



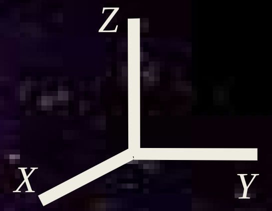
$$R = \begin{bmatrix} Lx & Cx & Dx & 0 \\ Ly & Cy & Dy & 0 \\ Lz & Cz & Dz & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Lxyz : Cosinus associated with the lines

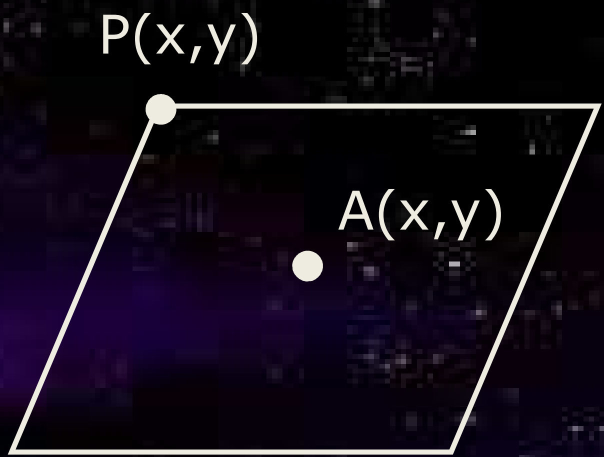
Cxyz : Cosinus associated with the columns

Dxyz : L × C, Slice direction

From the image coordinates to the reference coordinates



Reference coordinates



$$S = \begin{bmatrix} \Delta x & 0 & 0 & 0 \\ 0 & \Delta y & 0 & 0 \\ 0 & 0 & \Delta z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

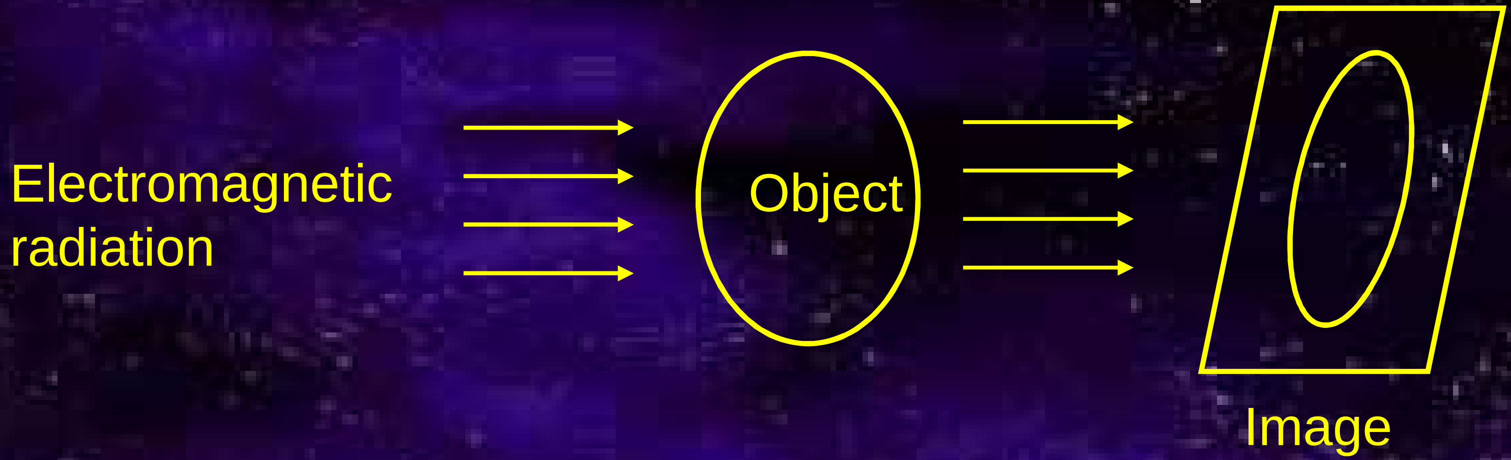
Δx and Δy are the Column and row resolution of Pixel Spacing in mm.

Δz is the spacing between slices in mm.

Medical imaging technique using electromagnetic radiations

Ionizing techniques

➔ Imaging by transmission

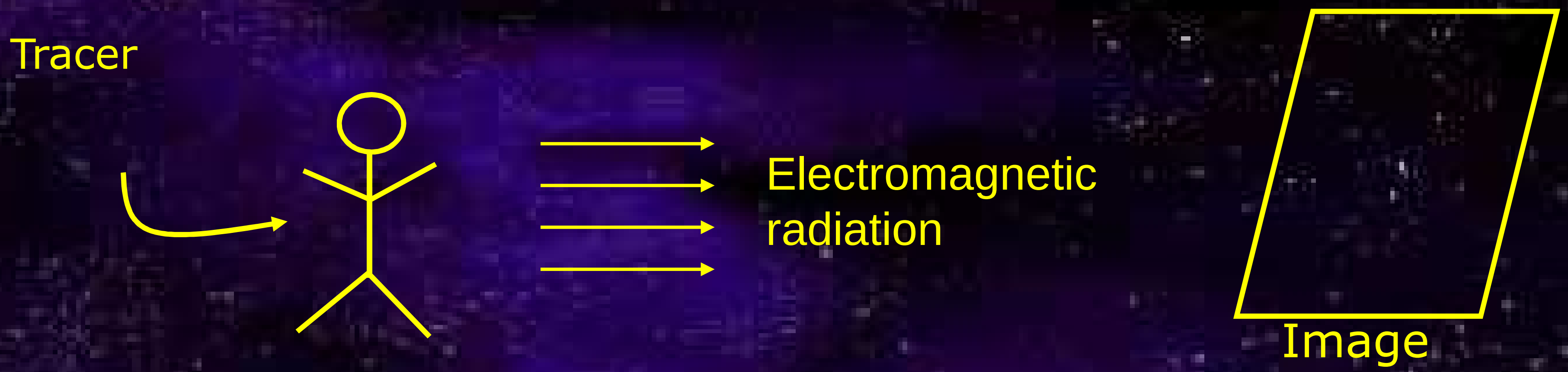


➔ Conventional radiography (X-ray radiography), Computed tomography (CT scanner)

Medical imaging technique using electromagnetic radiations

Ionizing techniques

➔ Imaging by emission



➔ Scintigraphy

Medical imaging techniques

Non-ionizing techniques using electromagnetic waves

Nuclear Magnetic Resonance (NMR)

➔ Magnetic Resonance Imaging (MRI)

Non-ionizing techniques using mechanic waves

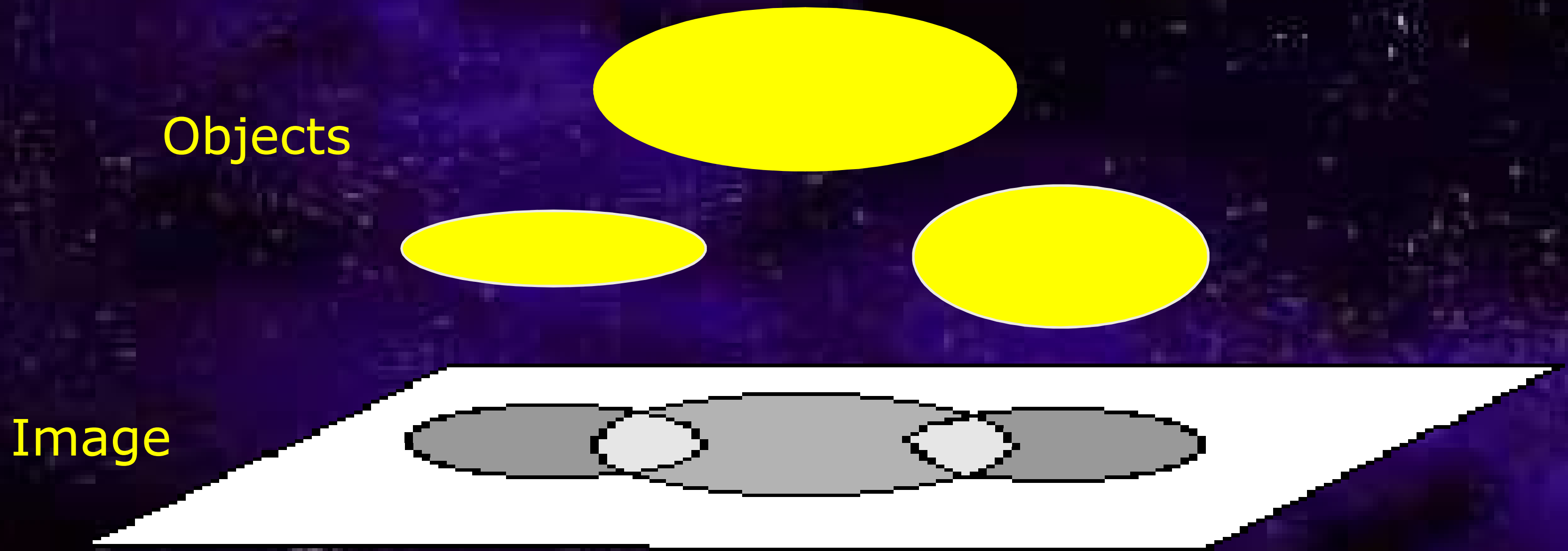
Ultrasoung imaging

➔ Echography (Imaging by reflection)

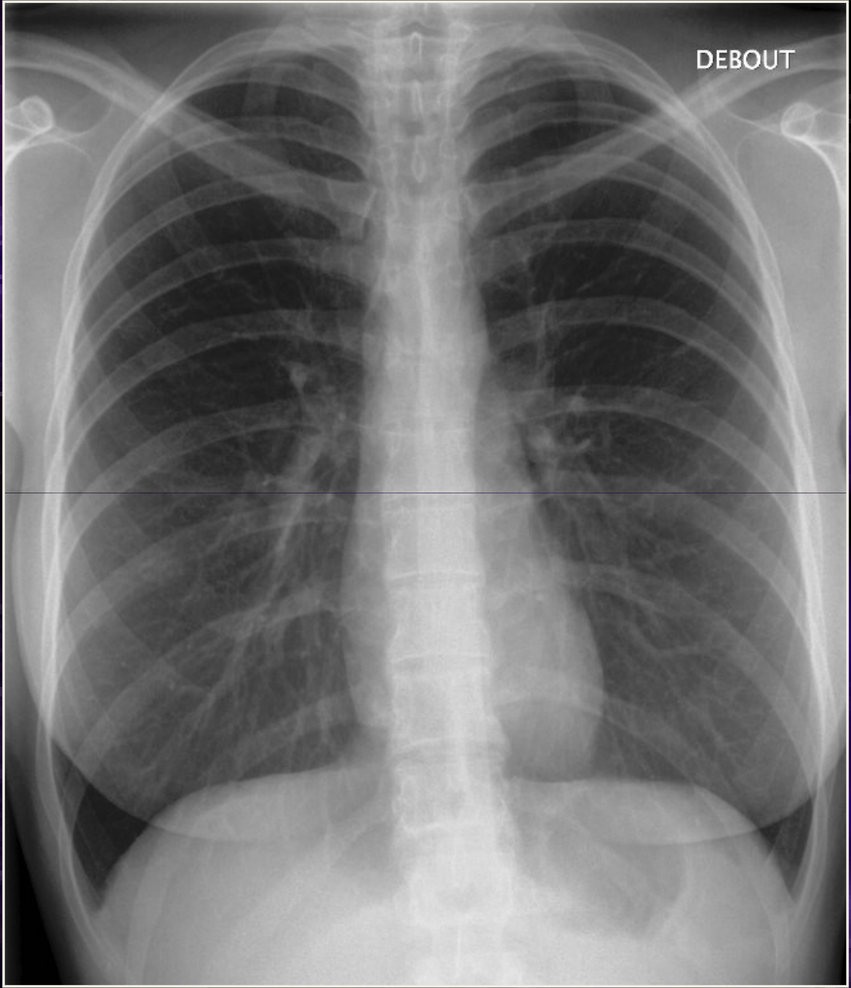
Planar imaging

(like conventional radiology)

- Perspective projection maps physical points into image space.
- Detection and classification of objects is confounded to over- and underlying tissue (not the case in general image processing).



Planar imaging

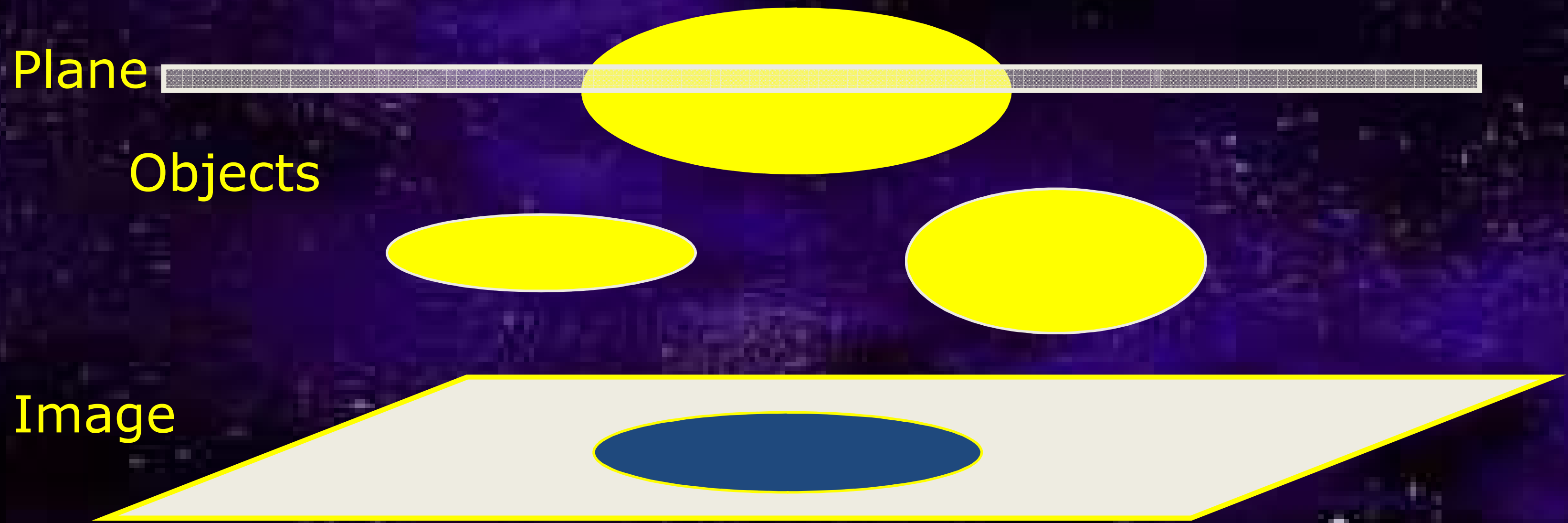


The front vs the back ?

Localization of the bone fracture ?

Tomography

- Imaging by section.
- Provide cross-sectional image of the structure in a body plane.
- Information outside the plane is not taken into account.
- Important parameters:
    - Thickness of the slice
    - Orientation of the plane
- Series of slices allows construction of 3D imaging (like Computer Tomodensitometry (CT)).



Impact of the slice thickness

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1 mm

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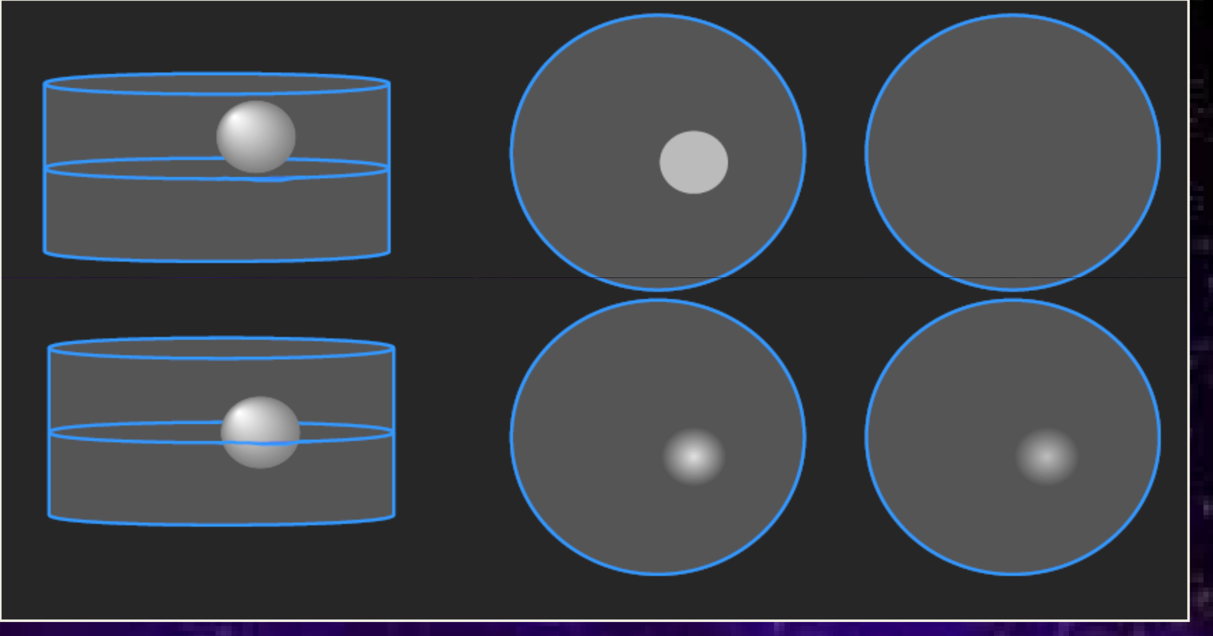
1 cm

Partial volume effect

The partial volume effect arises in volumetric images when more than one tissue type occurs in one voxel (in tomographic images).



In such cases, the voxel intensity depends not only on the imaging sequence and tissue properties, but also on the proportions of each tissue type present in the voxel. The partial volume effect depends on the slice thickness.

Principal slice orientations

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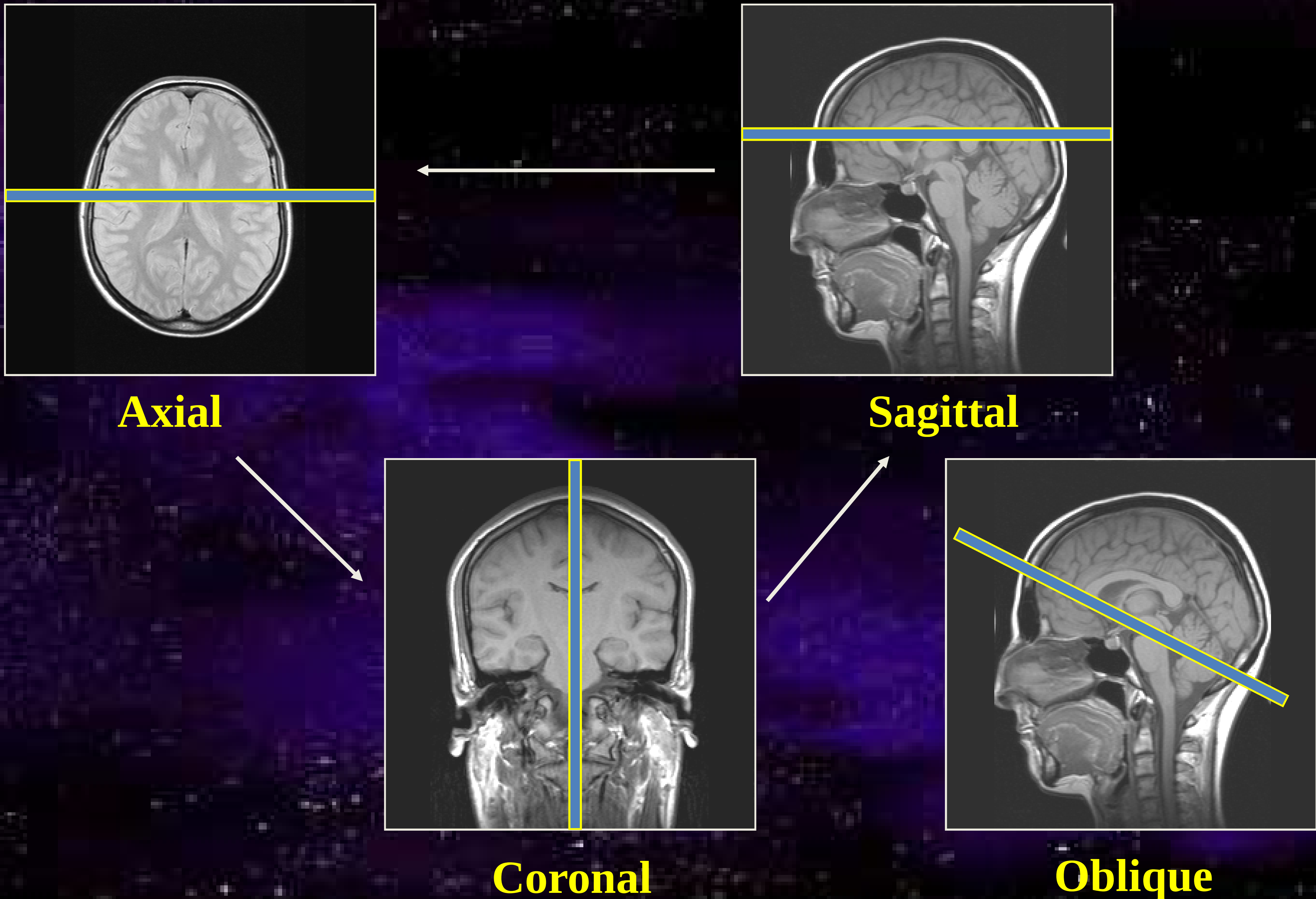
Feet → Head | **Left → Right** | **Front → Back**

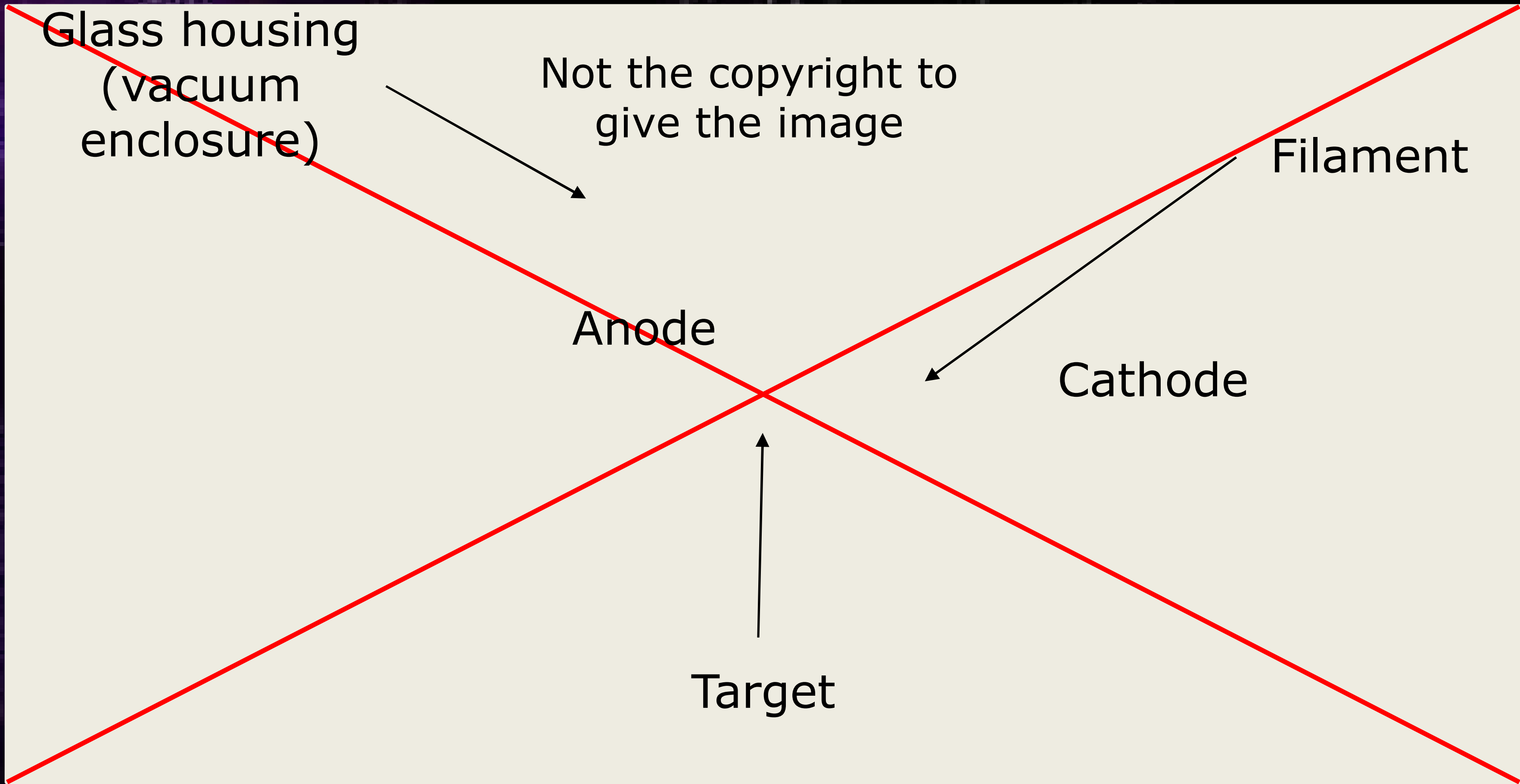
➔ Oblique orientation

Slice orientation – MRI example



Conventional radiology

Based on the X-Rays
➔ Use of a X-Ray tube



X-ray tube

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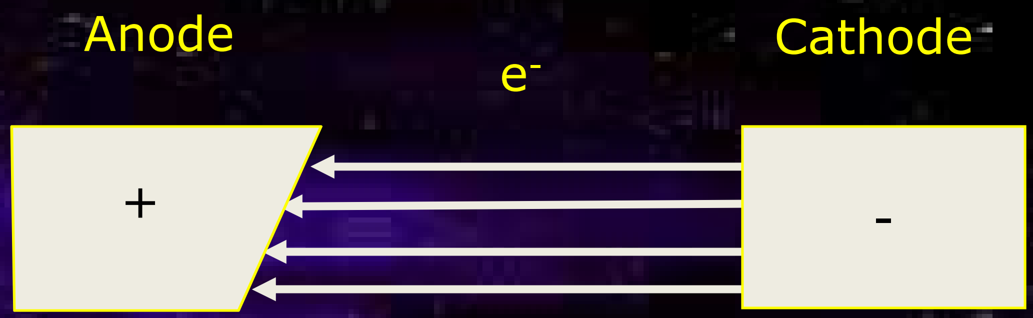
Conventional radiology

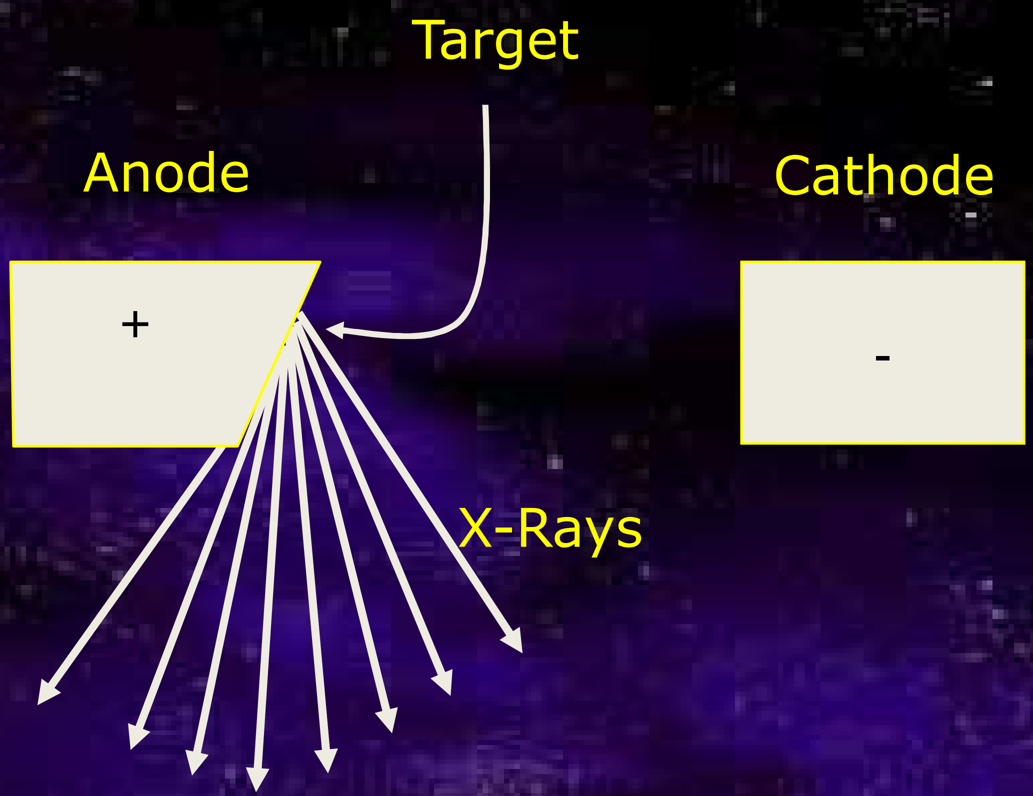


• Creation of an electron stream at the level of the cathode.

• Electron are accelerated between the cathode and the anode by a high voltage between the two places.

Conventional radiology

The target is the collision area between the electron stream and the anode.



• During the interaction between the electrons and the anode, kinetic energy is transformed in electromagnetic energy (between 1% to 5% of the hits), and in heat for 95% to 99 % of the hits…

Absorption of the X-rays

• Photoelectric effect

• Compton effect

Intensity I of the beam (of initial intensity I_0) after crossing the matter with a thickness x :

$$I = I_0 e^{-\mu x}$$

μ : Linear attenuation coefficient
• Reciprocal of length
• Vary according to the the type of material
• Vary according to the energy of the incident photons

➔Increase with the atomic number of the matter (Z)
➔Decrease with the photon energy

➔ High in the bones, low in the soft tissues.

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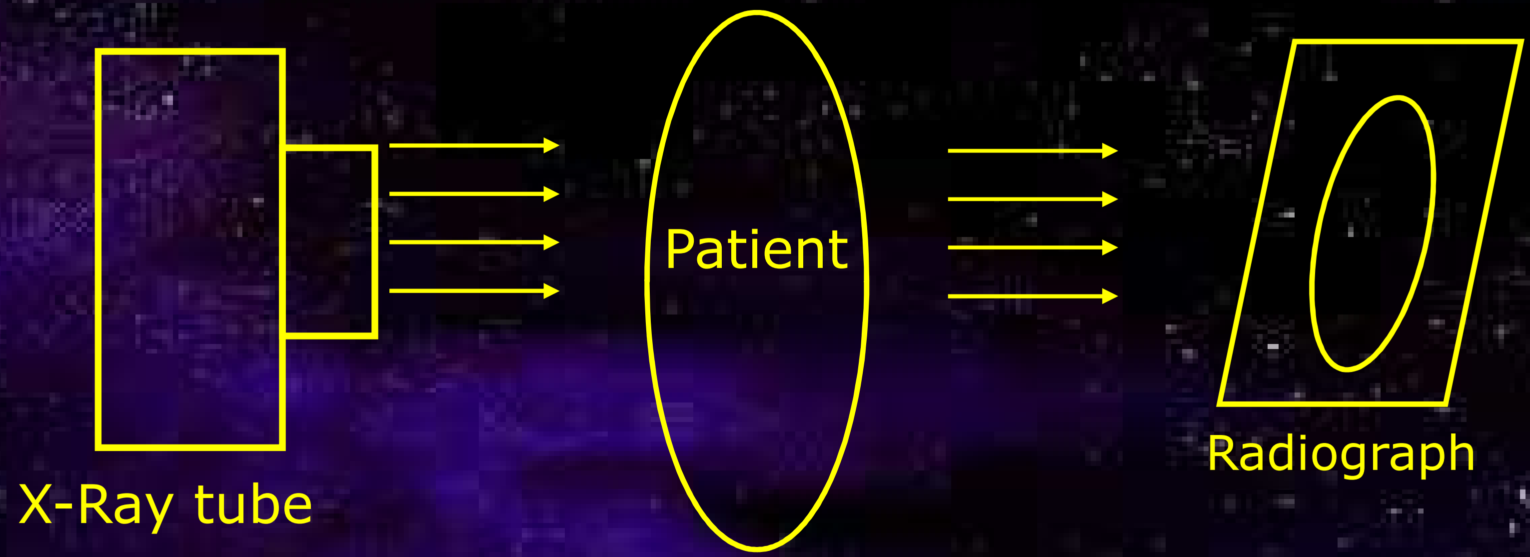
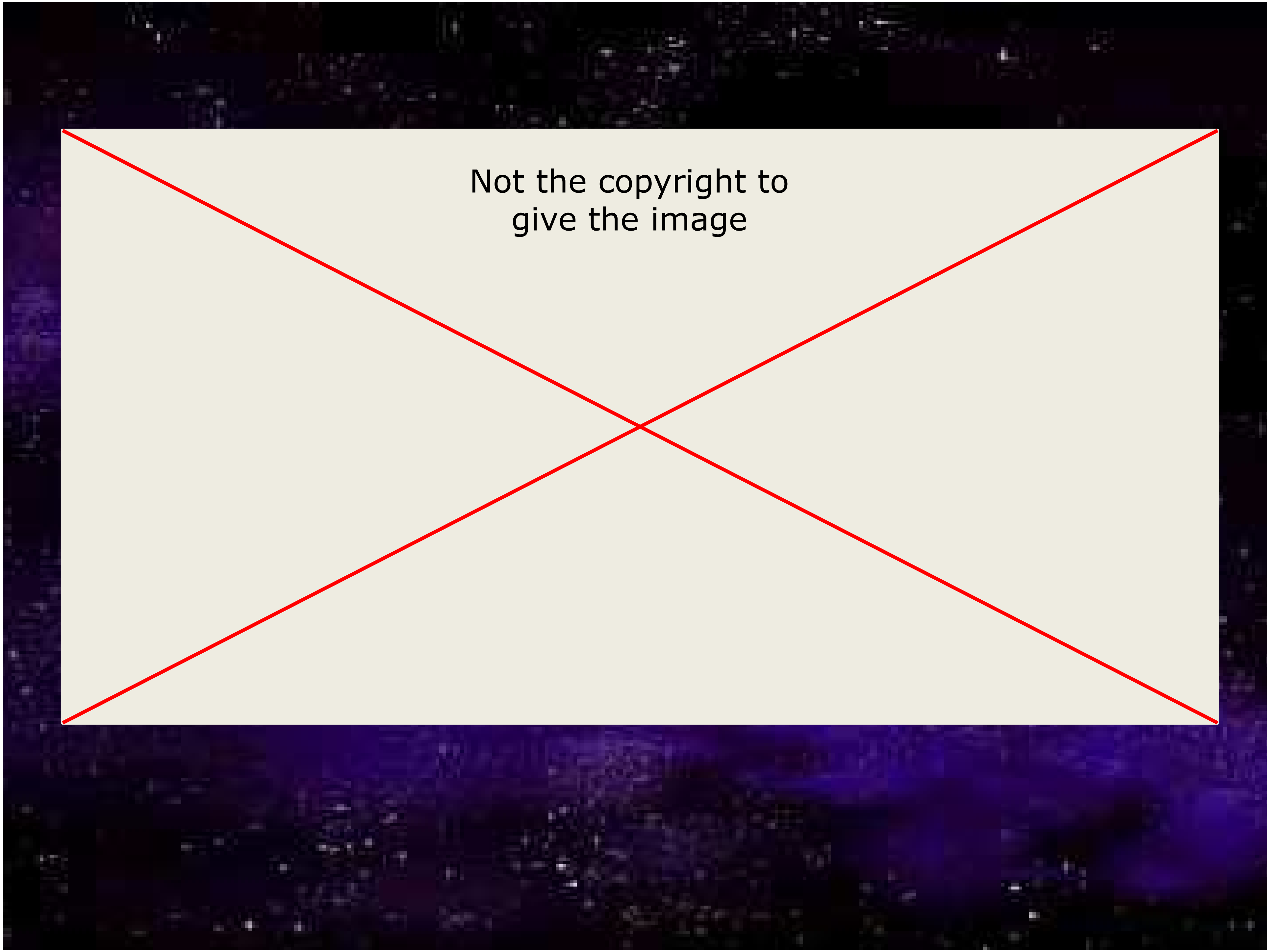
Standard radiology



X-rays photons beam generated during a brief moment by the tube are directed to the patient.

The X-Ray beam is variously attenuated according to the composition and the thickness of the different tissues.

The point in the image produced by this particular beam will be determined by only the fraction of photons that survive the entire trip through the patient.



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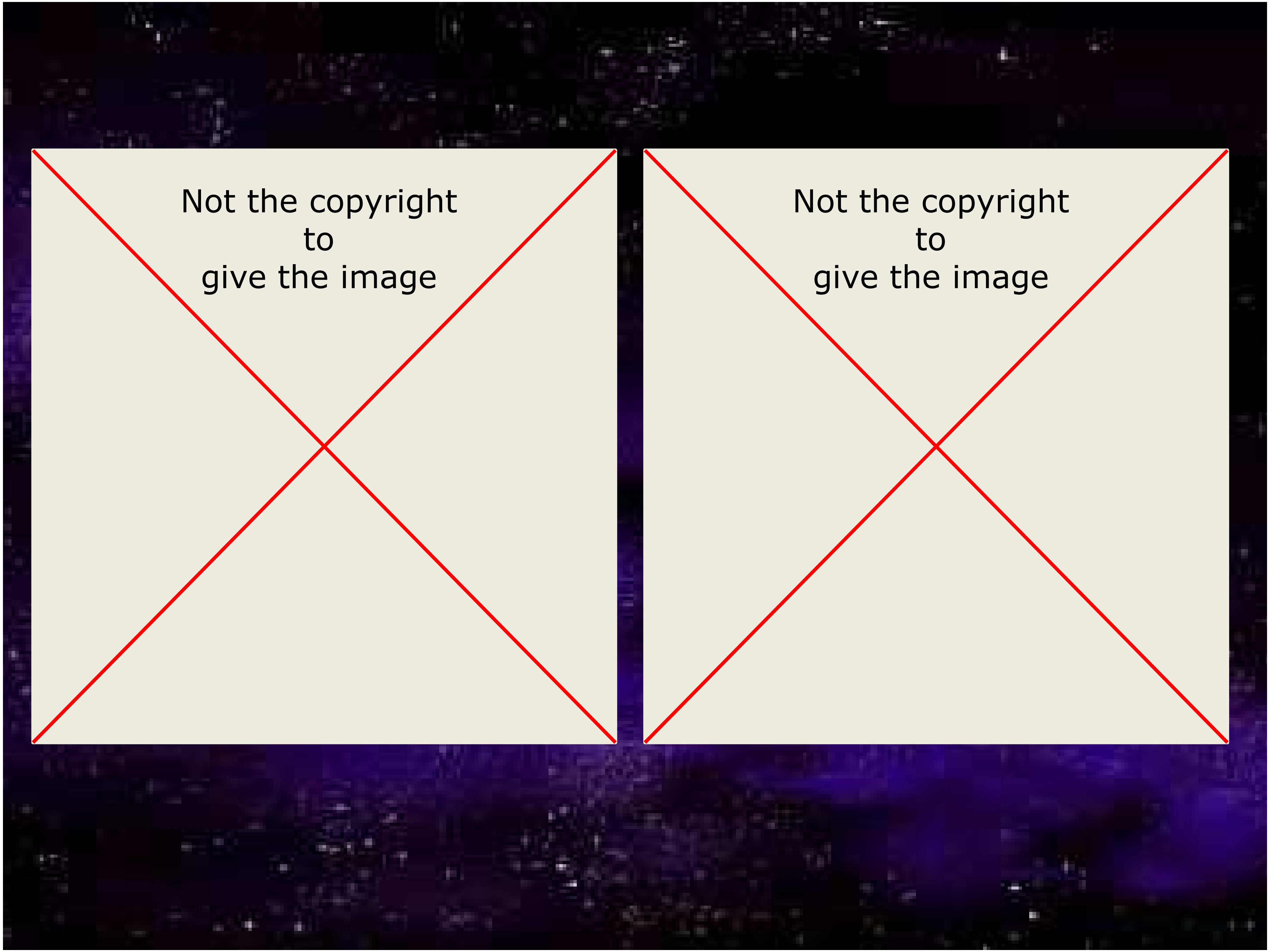
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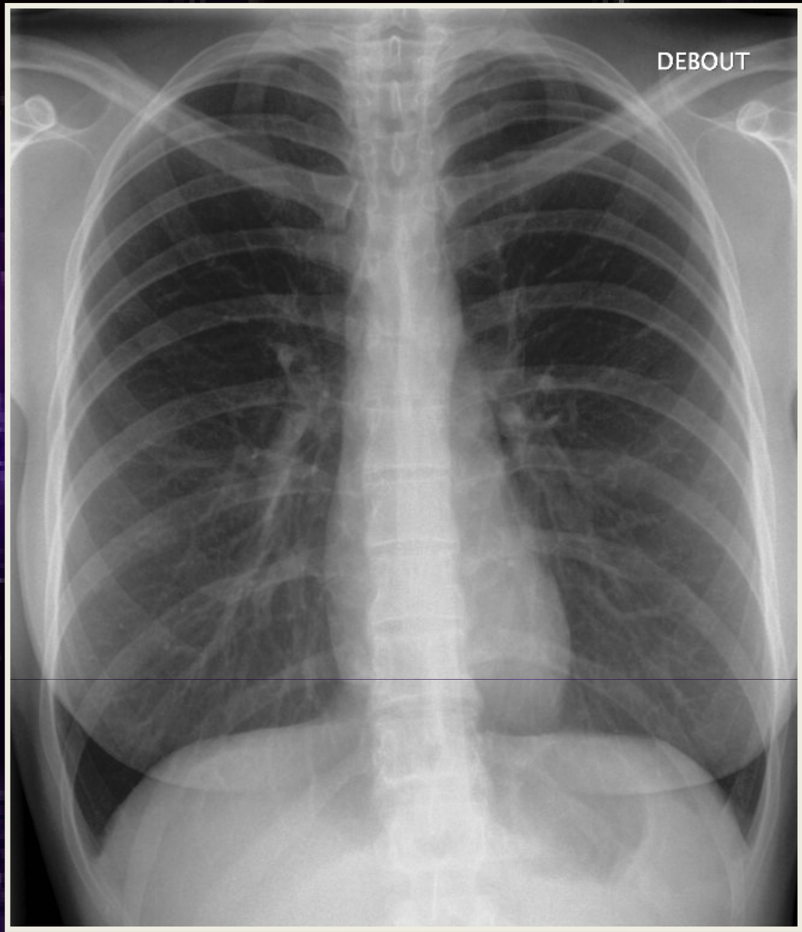


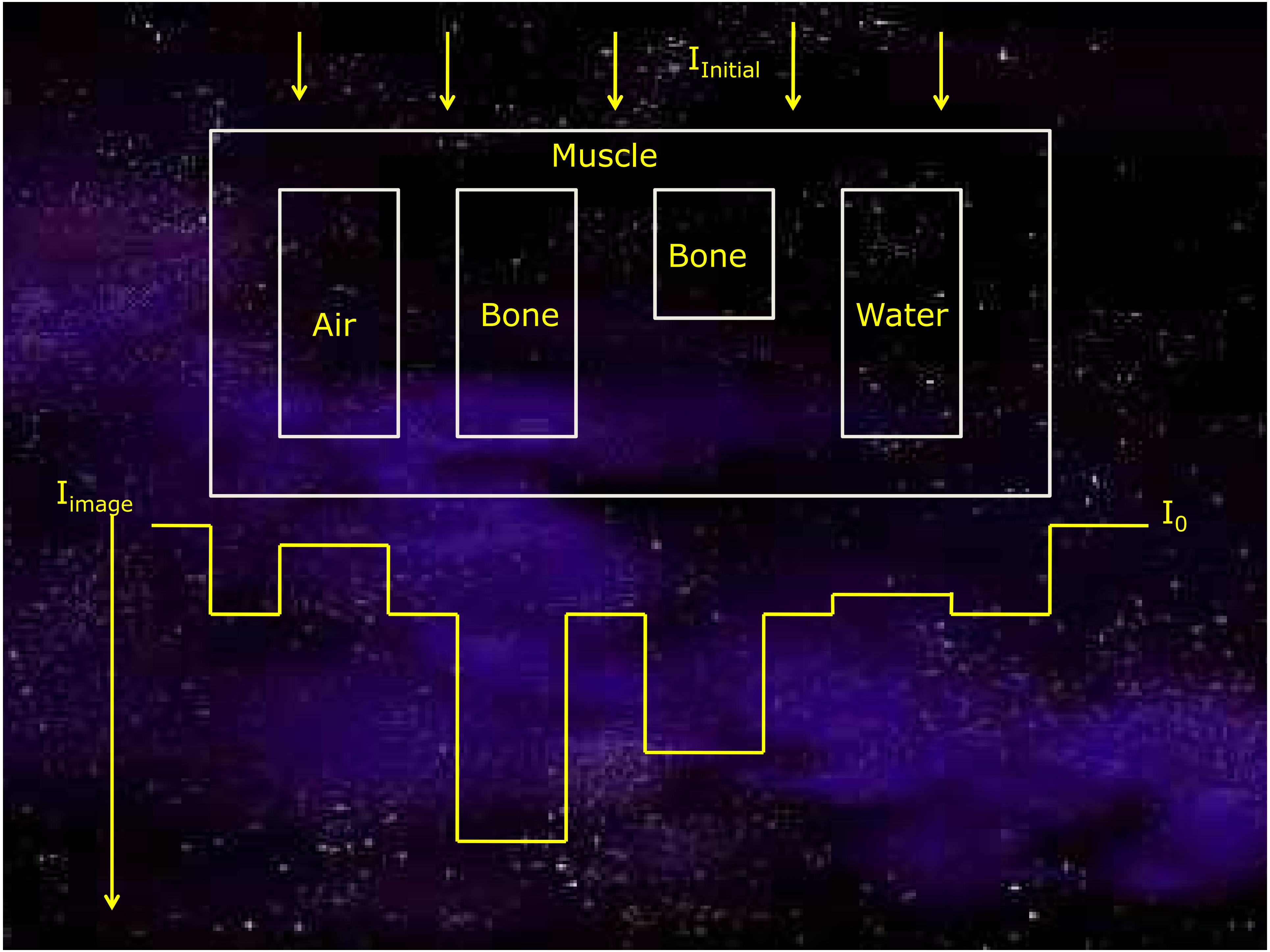
The grey level on the radiograph corresponds to the sum of all attenuations generated by the different tissues.

The image produced is a simple two-dimensional projection of the tissues lying between the X-ray source and the film. Radiography of overlapping layers of soft tissue or complex bone structures can often be difficult to interpret.

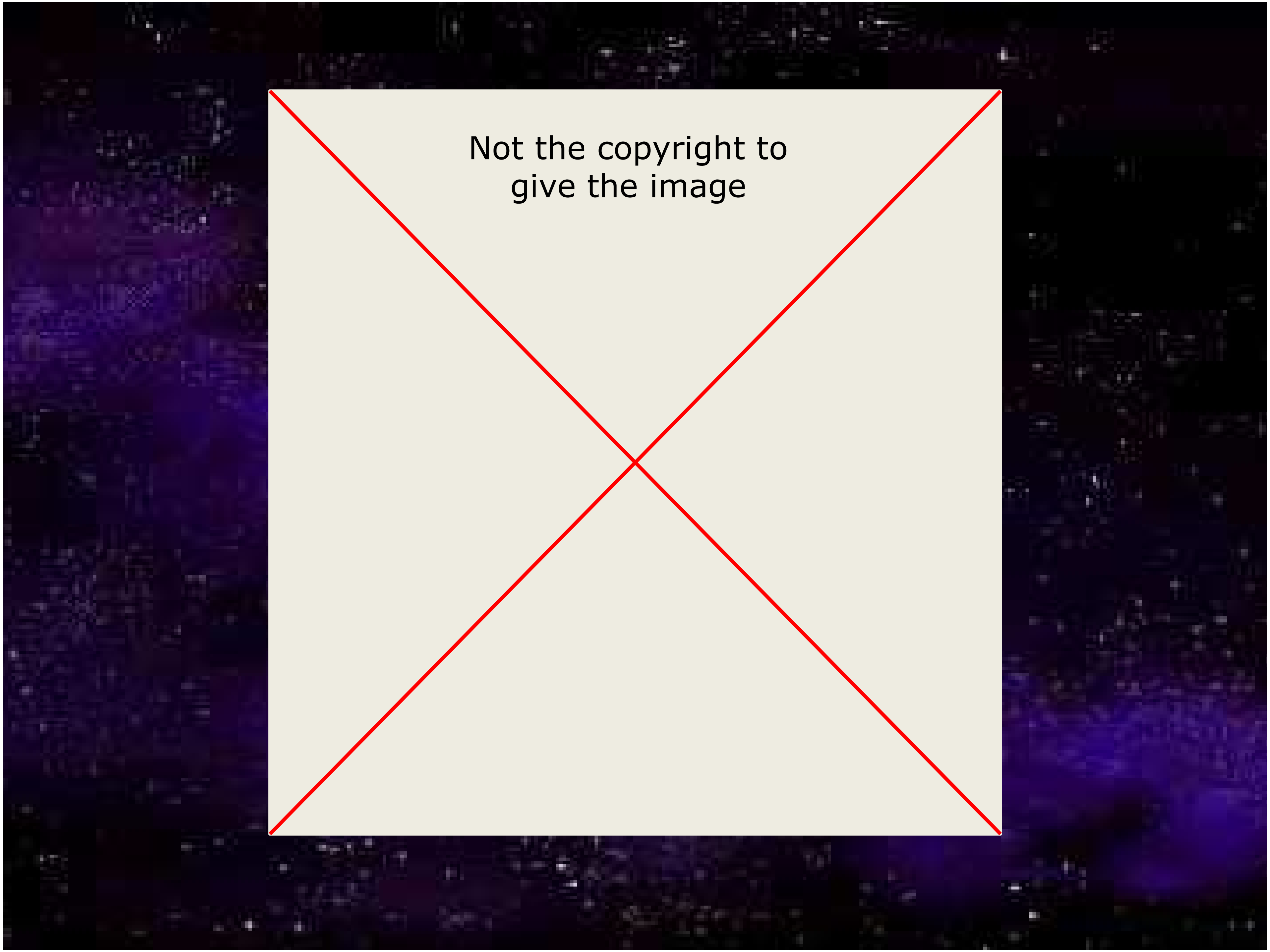
Total attenuation of X-ray beam go through n tissues :

$$I_{image} = I_{initial} e^{\int_{n\ tissues} \mu_n\ d_n}$$

Bones (highly opaques) appear in white on the photographic film.



I Initial
Muscle
Air
Bone
Bone
Water
I image
I 0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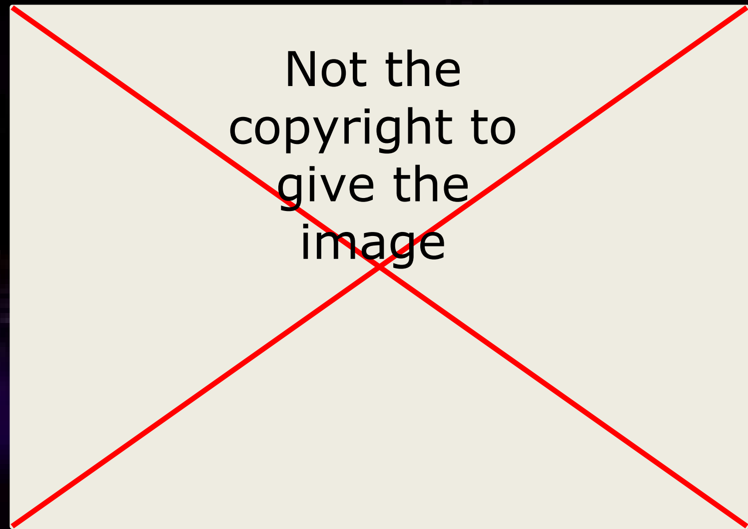
Fluoroscopy and numeric radiology

X-Ray fluoroscopy

X-ray fluoroscopy is a continuous imaging technique using X-rays with very low energies.
A fluorescent screen is used to monitor continuously the area of interest within the body.
Now, digital fluoroscopy is widely used.



➔ Kinetic study of certain organs (heart, lung)
Image guided surgery (visualisation of catheter radio-opaque, placement of stents)

Numeric radiology

Transformation of analogic image (such as photographic film, or information on a screen) into numeric image.

Interventional radiology

Application of radiology that enables minimally invasive surgery to be performed with the aid of simultaneous radiological imaging of the field of operation within the body.
Imaging can be a scout, a guidance or an optimal control of the surgery.

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Vascular and interventional radiology

The contrast

The contrast depends on the difference of attenuation between tissues.

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The contrast decreases when the voltage increases.
↘ Photoelectric effect
↗ Compton effect

To improve the contrast :

Use of X-rays with low energy
↗ μ
↘ Intensity of the X-rays received by the detector
→ Increase of the impression time
↗ Increase of the radiation exposure

Unfortunately, the contrast between soft tissues is often very weak (even when the voltage is optimized at the level of the tube).

Use of contrast agents

In order to reinforce the contrast between soft tissues, use of contrast agent having high atomic number (Iodine : Z = 53; Barium : Z = 56)

➔ Increase of the attenuation (when the contrast agent is present)

Iodinated contrast agent : Water-soluble media that allows the study of the vascular structures (and of the kidneys).

Barium (barium sulfate) : Insoluble white powder typically used for enhancing contrast in the gastro-intestinal tract.

Angiography (vessel imaging)

The contrast agent is injected via a catheter, placed as close as possible to the studied structure (for example: cardiac catheter)

➔ Invasive examination.

Injection of the contrast agent via a catheter

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Catheter

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Image subtraction

The numeric subtraction of the images obtained before and during the opacification of the vessels allows getting pure image of the vessels. The anatomical structures where the density do not change are removed.

Technique used for static tissues (principaly cerebral images)

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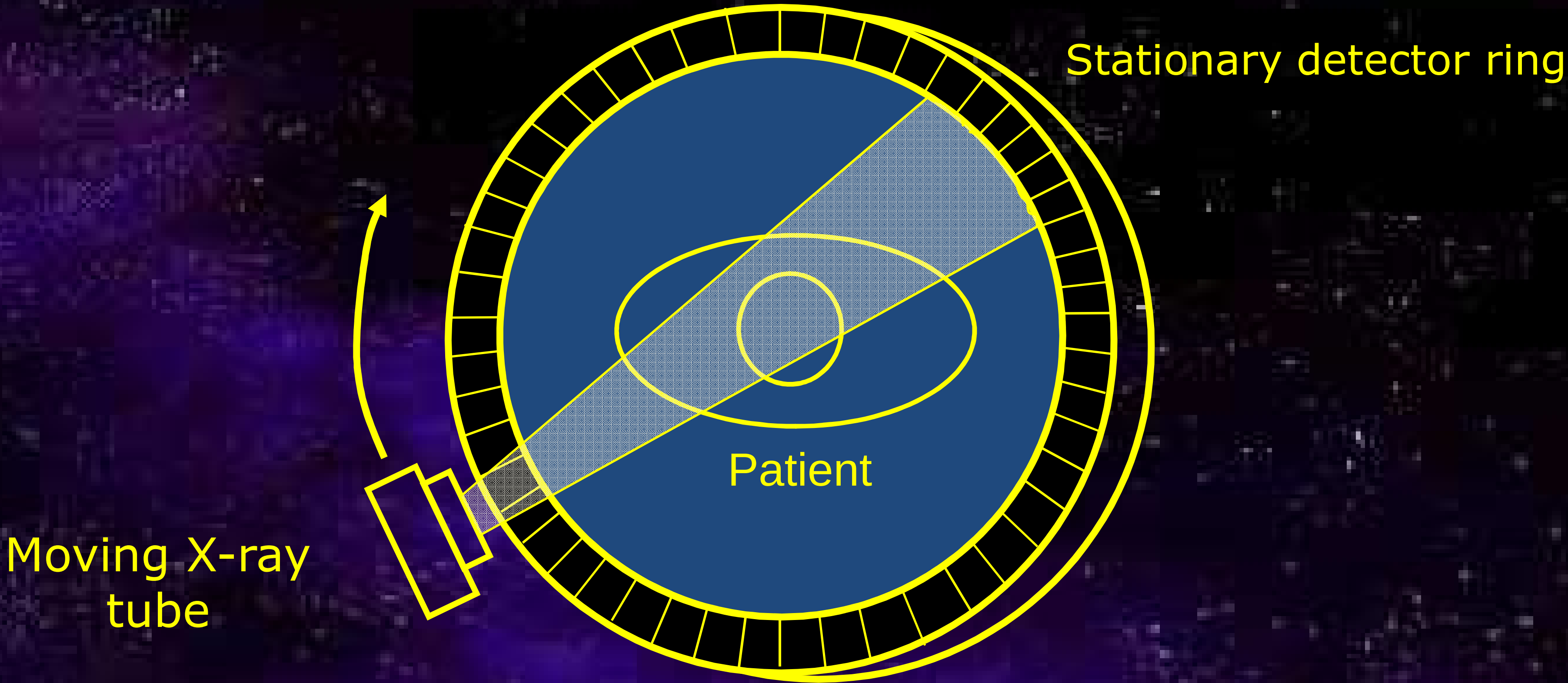
The tomodensitometry
Computed tomography (CT scan)

The tomodensitometry
Computed tomography (CT scan)



The moving X-ray tube turns around the patient.

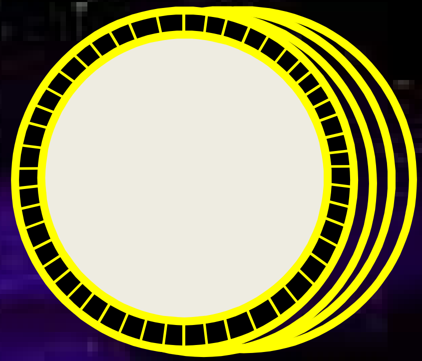
Opposite to the tube, the detectors measure the residual intensity of the X-ray beam. The intensity measure is obtained for each position of the tube.

The acquisition of several adjacent slices provides tridimensional information (3D modelling).

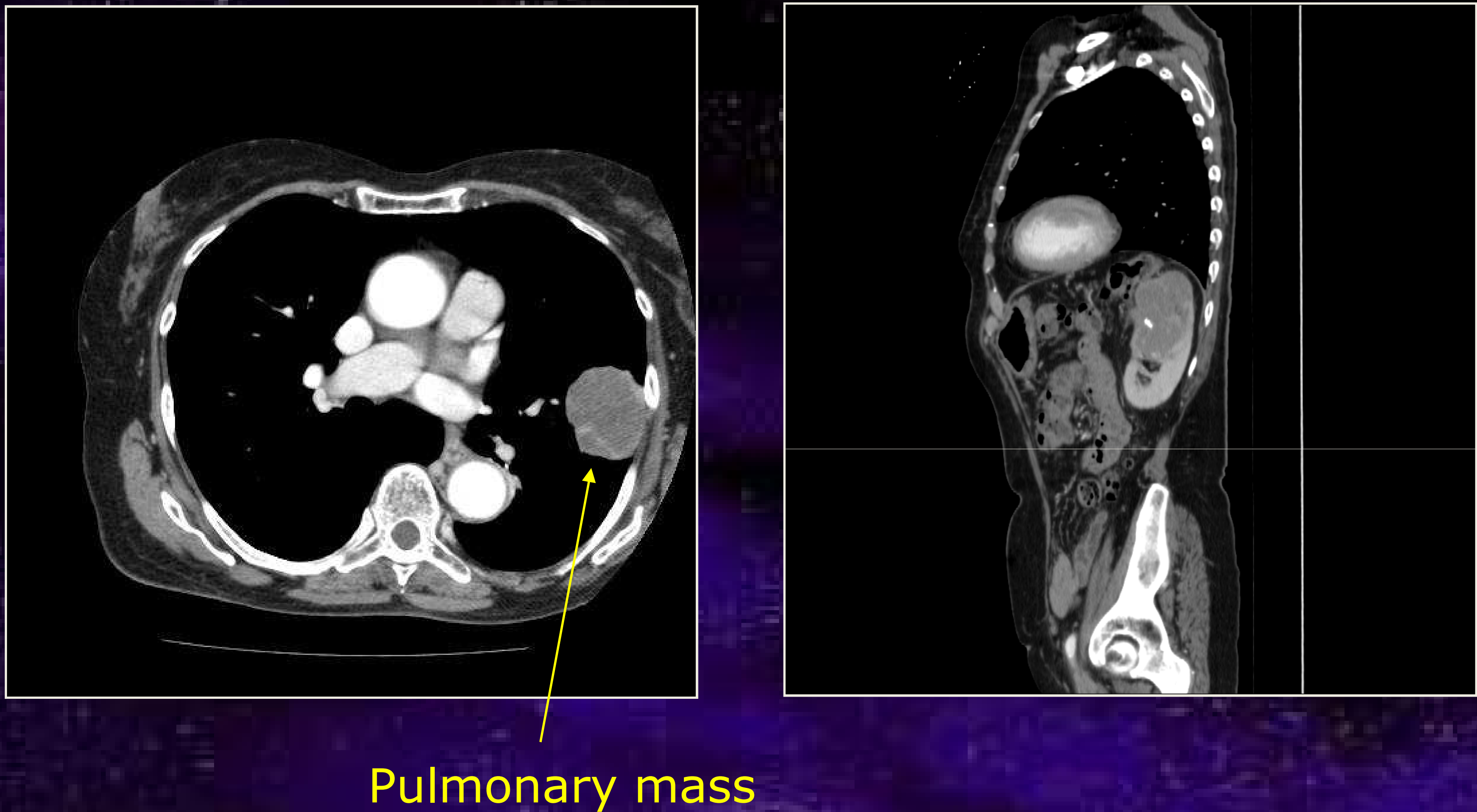

Video

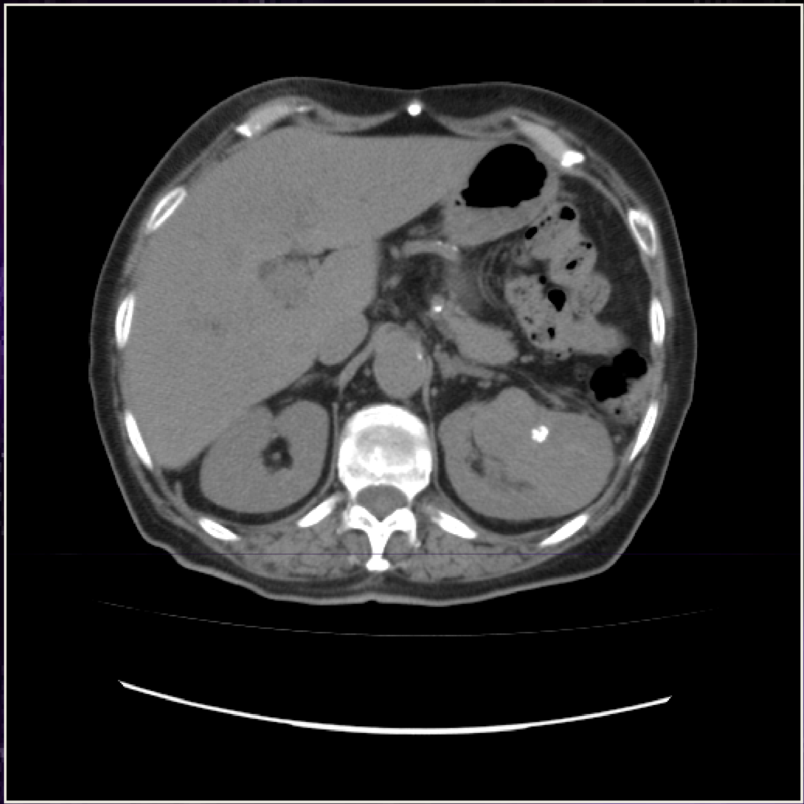
Multi-slice spiral Scanner

Multi slice scanner: Acquisition of several slices per rotation of the X-ray tube thanks to the multiplication of the rings of detectors.

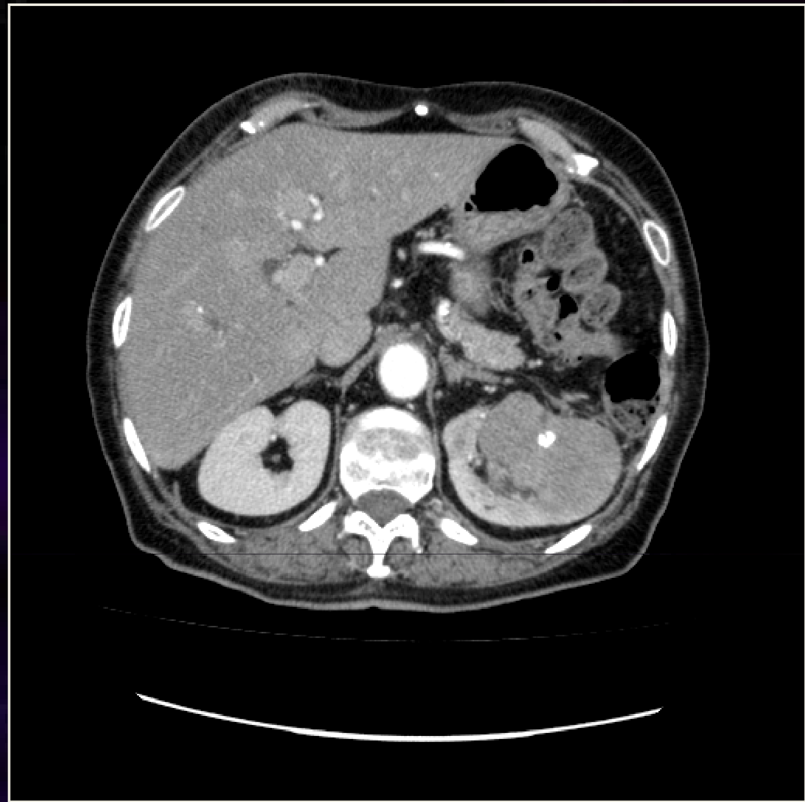


Spiral scanner : Instead of collecting data slice by slice, the patient is moved continuously as the beam rotates.


Pulmonary mass

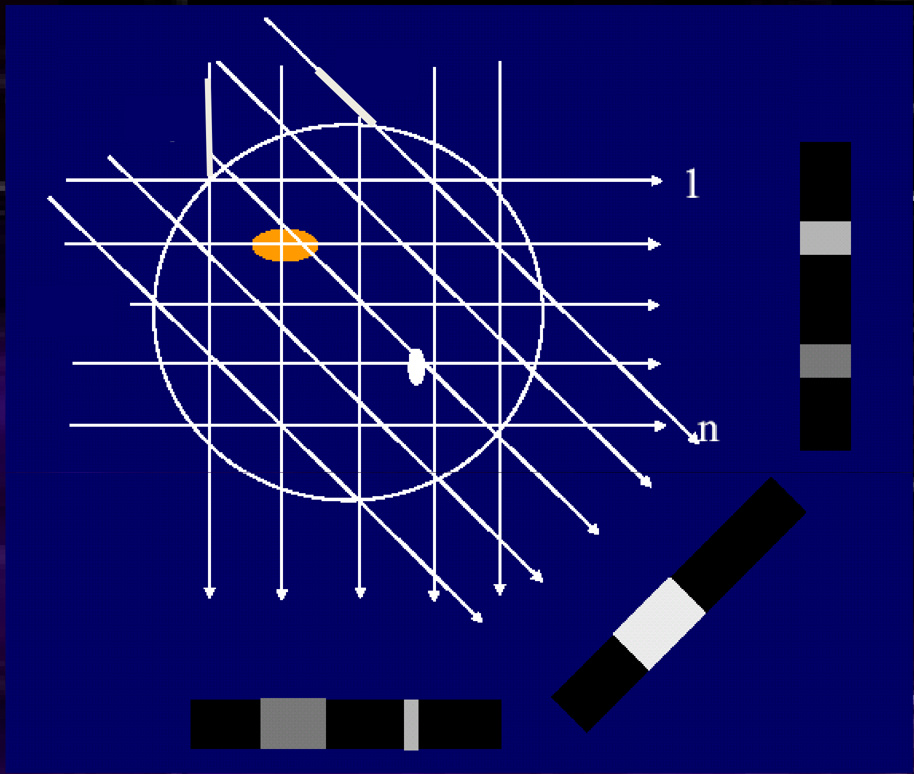


Without contrast agent



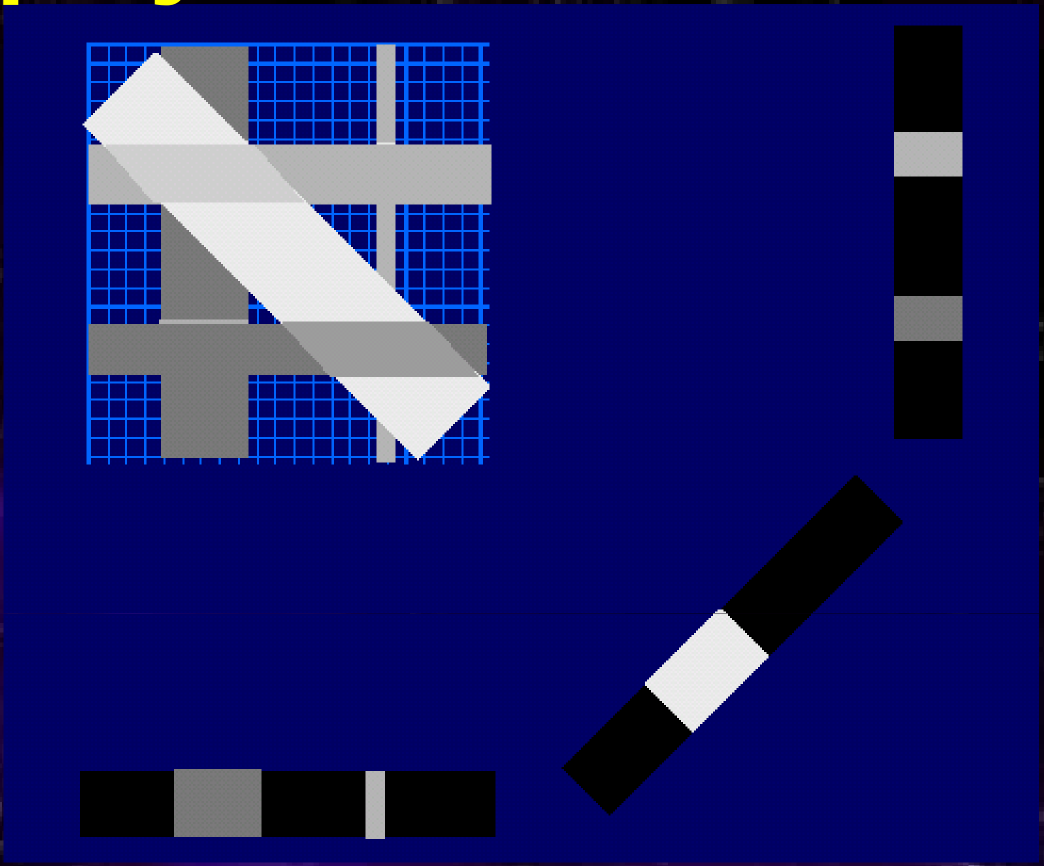
With contrast agent

Creation of an image
Backprojection reconstruction



During the acquisition, for each angle of projection, a global intensity profile is recorded. Each projection is constituted by a series of rays measured at the same moment along a particular line. The different projections arise from the different choices of beam direction.

Backprojection reconstruction

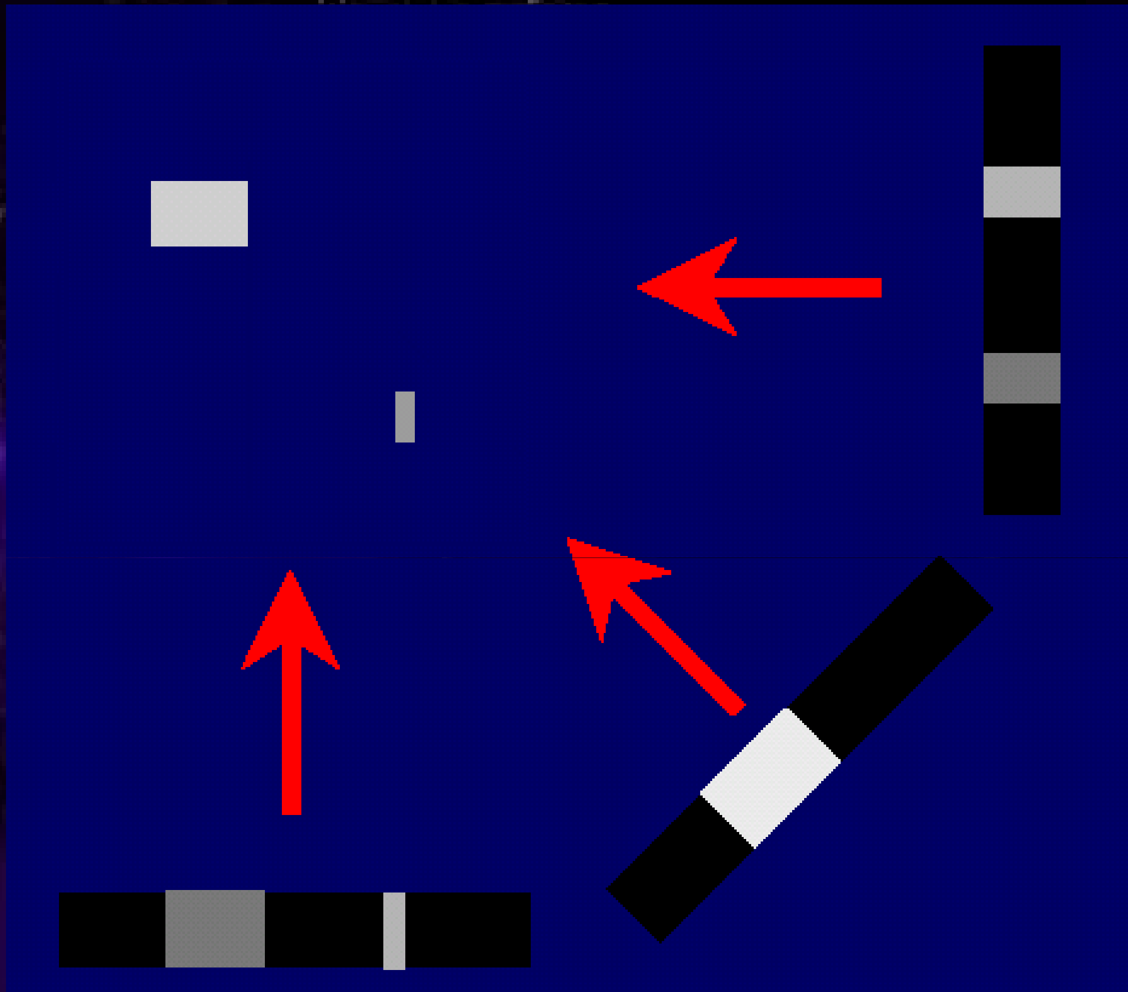


Backprojection of the profile on the plane. We make the hypothesis that any attenuation of the X-ray beam has occurred uniformly along the path followed from the tube to the detector.

A single projection is back-projected to give stripes across the entire image plane.

At each stage, we add the new average numbers to those already in the matrix.

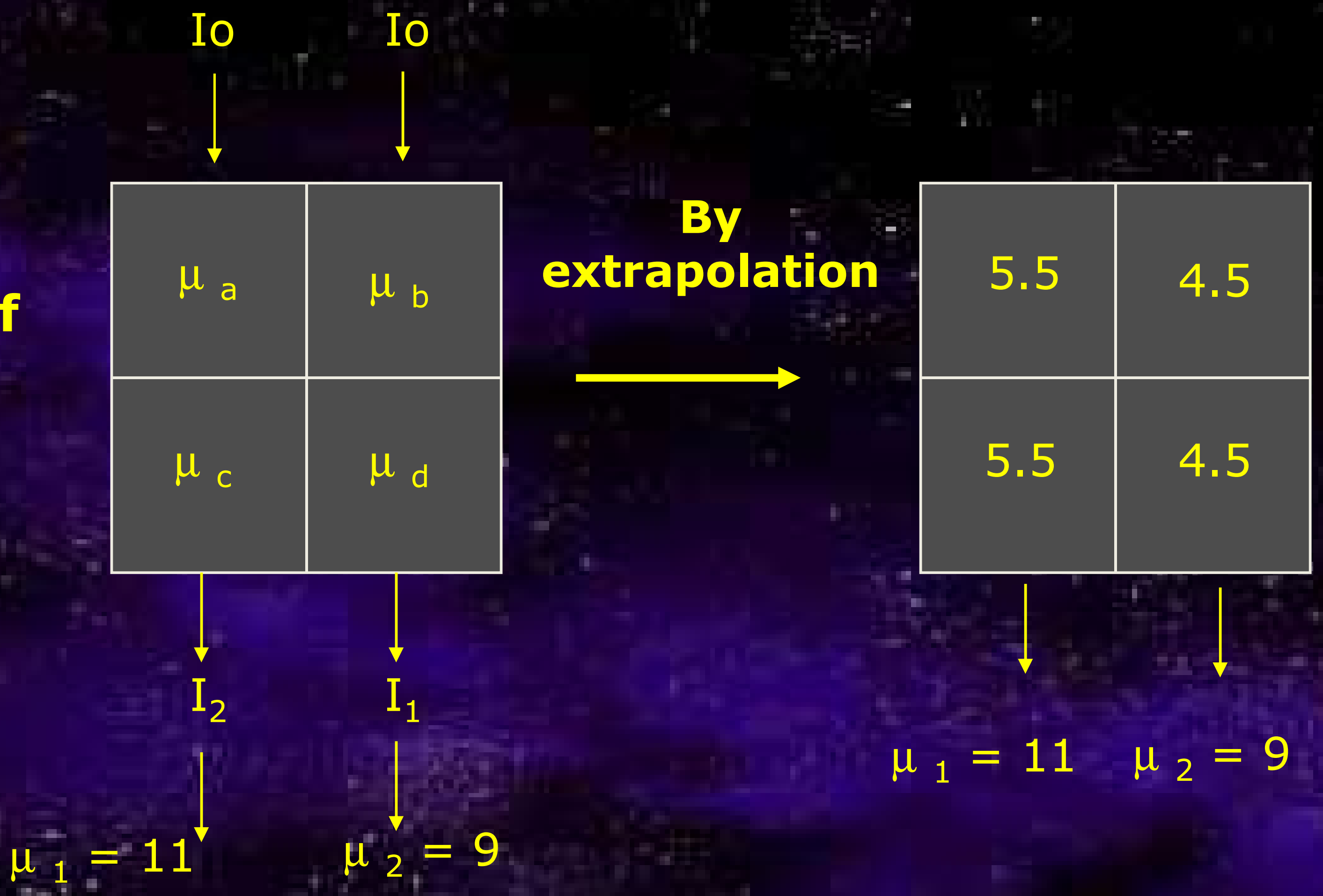
Backprojection : Filtering



Considering the whole projections for different angles, an image of the radio-opaque object begins to emerge. Finally, filtering is used to erase the undesirable streaking.

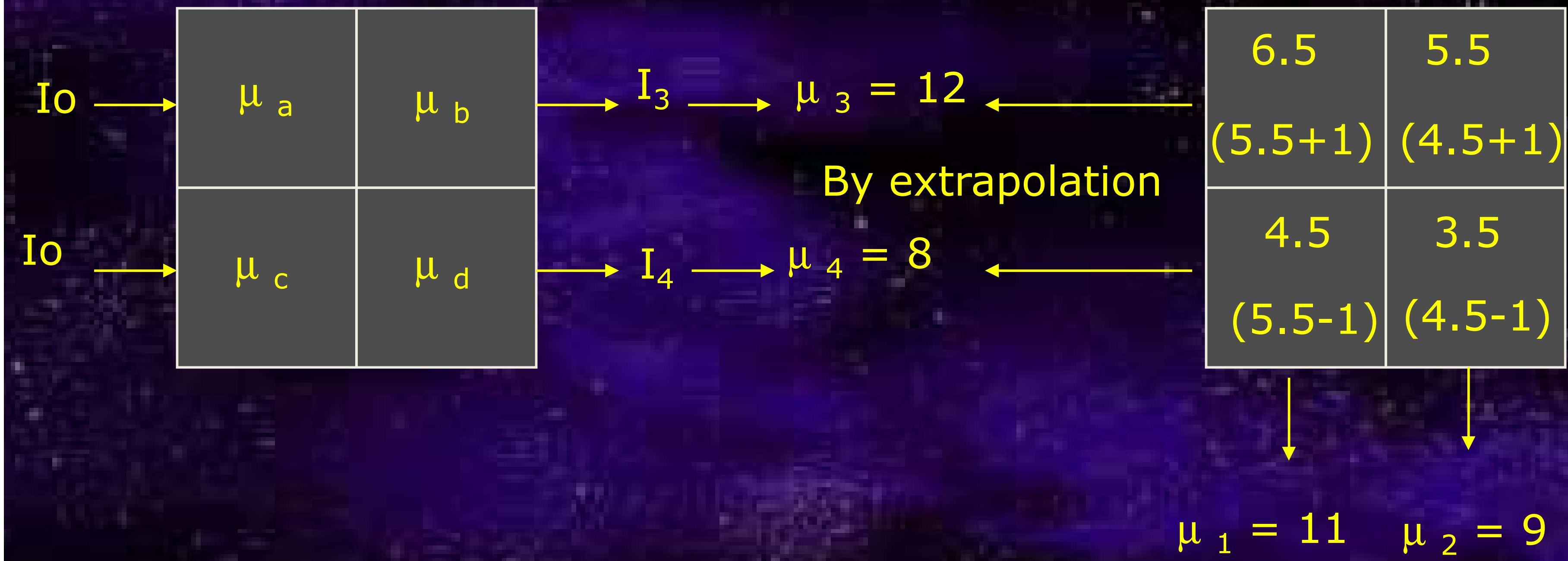
Example of backprojection

First angle of projection



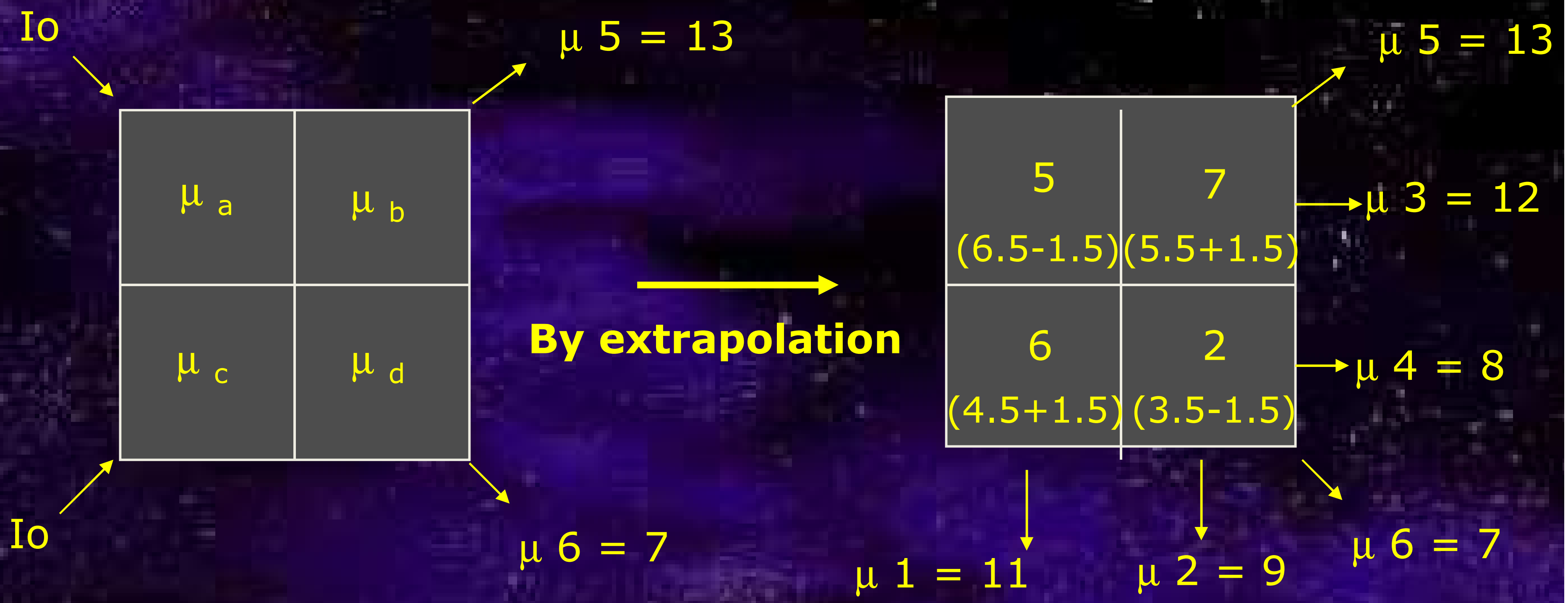
Example of backprojection

Second angle of projection



Example of backprojection

Other angles of projection



As the number of projections increases,

the quality improves

Example of backprojection

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Hounsfield Units

On the image, the intensity (pixel grey level value) of each element depend mainly on the global attenuation.

The values of attenuation are normalised to the value for water as a reference, scaled and presented as a Hounsfield Unit. This arbitrary scale combine to each pixel a value between -1000 (air) et + 1000 (compact bone).

Hounsfield Units : $HU = 1000 \times (\mu - \mu_{water}) / \mu_{water}$

For 100 kV, we have (μ depends on the voltage):

$\mu_{water} = 0.19\ cm^{-1}$

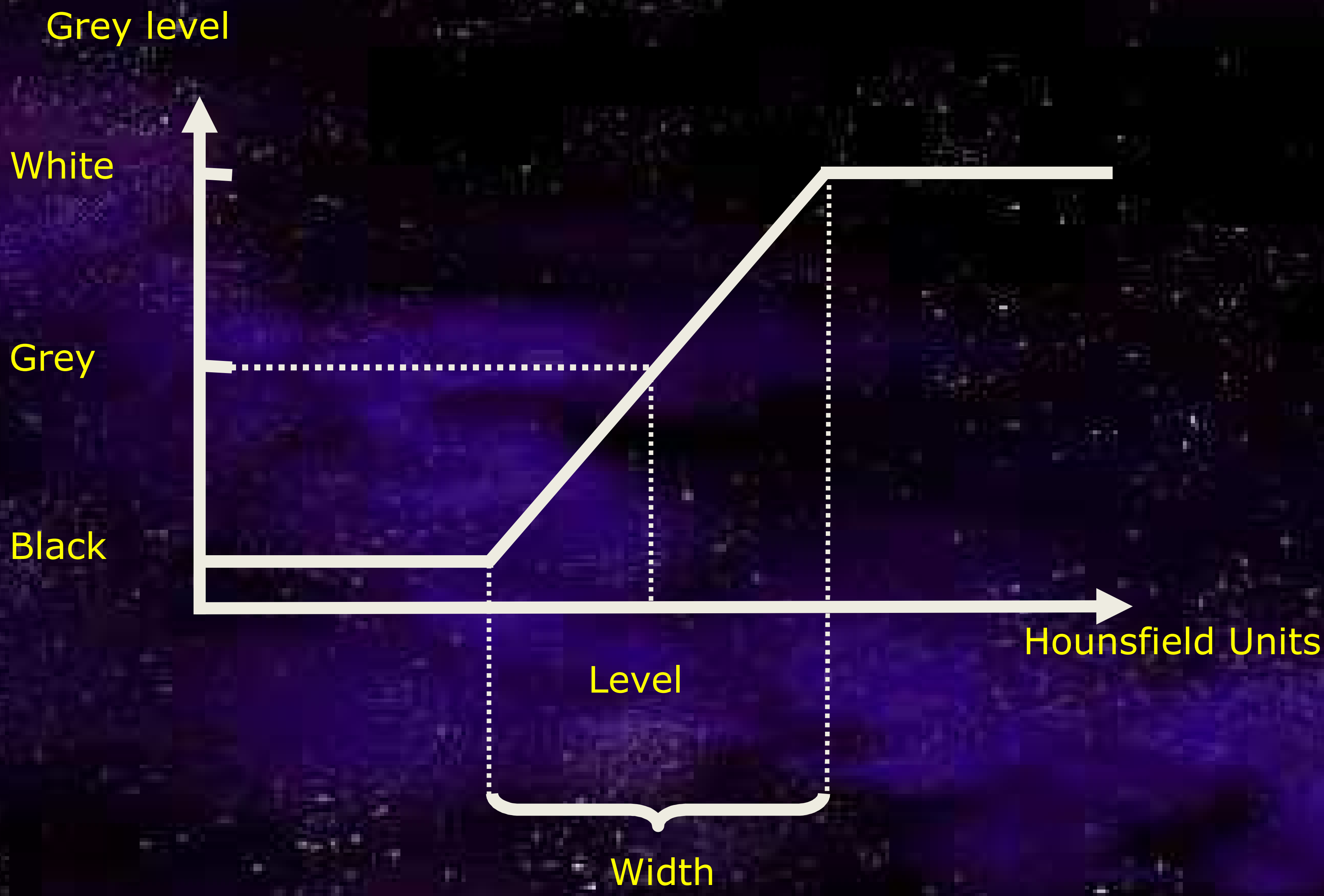
$\mu_{bone} = 0.38\ cm^{-1}$ $HU_{bone} = 1000 \times (0.38\text{-}0.19) / 0.19 = 1000$

$\mu_{muscle} = 0.23\ cm^{-1}$ $HU_{muscle} = 1000 \times (0.23\text{-}0.19) / 0.19 = 210$

$\mu_{lung} = 0.07\ cm^{-1}$ $HU_{lung} = 1000 \times (0.07\text{-}0.19) / 0.19 = -631$

$\mu_{air} = 0.00022\ cm^{-1}$ $HU_{air} = 1000 \times (0.00022\text{-}0.19) / 0.19 = -999$

Windowing



Example of windowing

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Total windowing
Level = 0
Width = 2000
(-1000 à + 1000)

Soft tissues windowing
Level = 0
Width = 300
(-150 à + 150)
Narrow windowing

Pulmonary windowing
Level = - 650
Width = 700
(-300 à – 1000)
Wide windowing

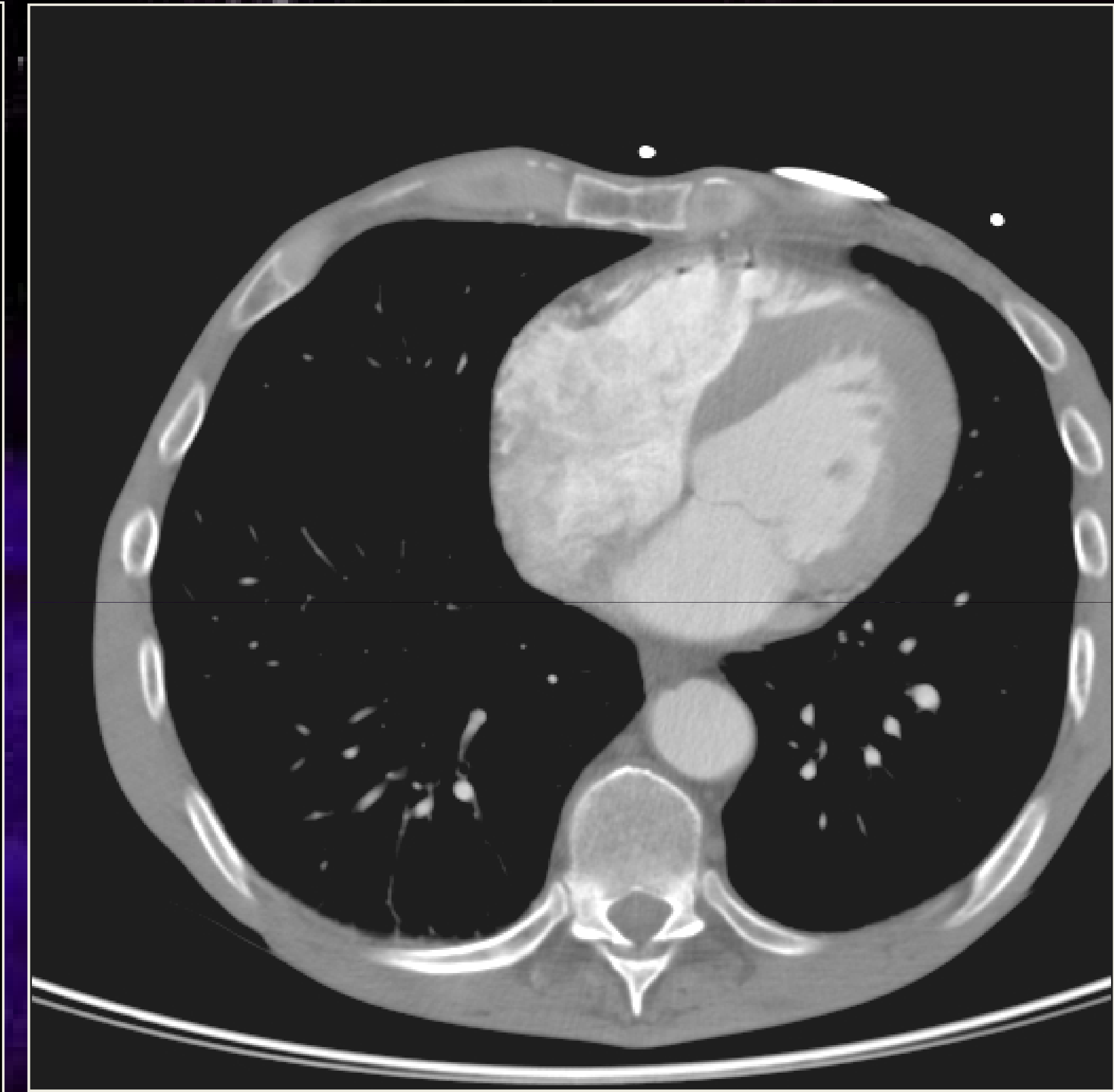
Reconstruction algorithms
MPR – Multiplanar Reformating

Multiplanar reconstruction (MPR) is the simplest method of reconstruction.

The software then cuts slices through the volume in the wanted plane.

The optimal plane can be chosen to display an anatomical structure.

In particular, for vascular imaging, curved-plane reconstruction can be performed. This allows bends in a vessel to be "straightened" so that the entire length can be visualised on one image

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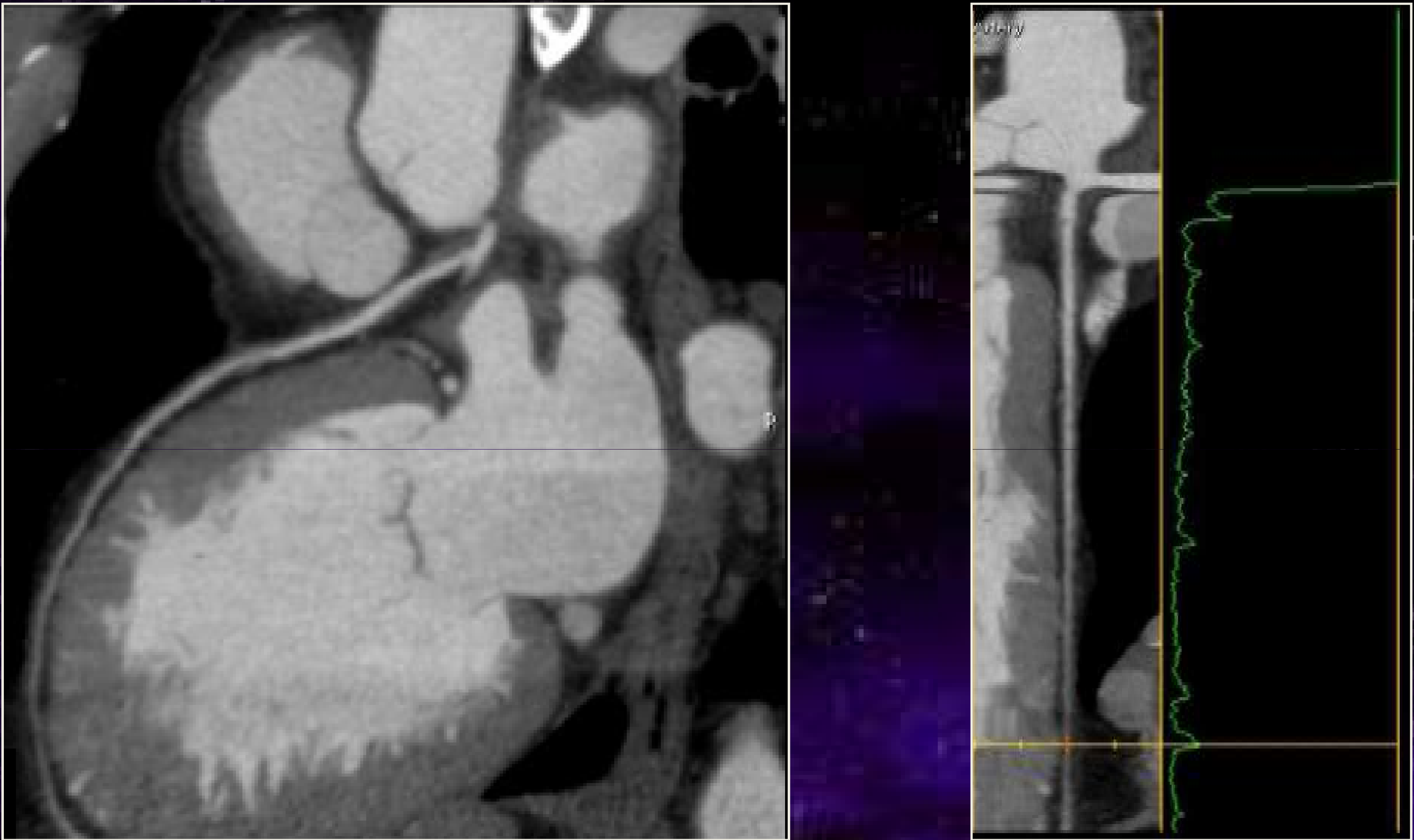
Coronary imaging



Curvilinear reconstruction

Reconstruction algorithms
MPR – Multiplanar Reformating

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The optimal plane can be chosen to display an anatomical structure.

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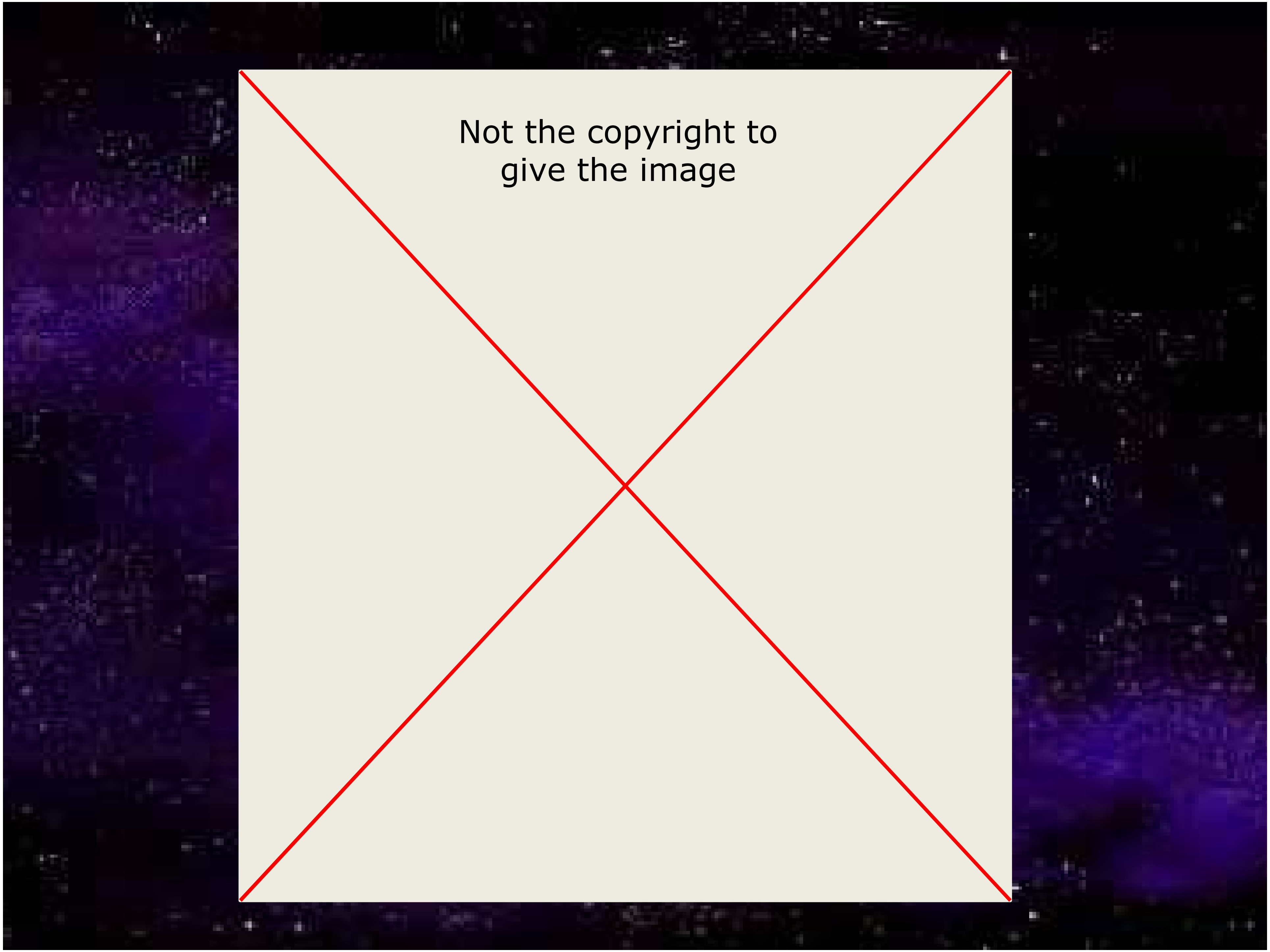
MIP - Maximum Intensity Projection

A MIP evaluates each voxel along each line of voxels through the volume to determine the maximum voxel value and forms an image using the values so determined for each line.

Persistance of the density information.

Use of iodine contrast agent for vascular studies.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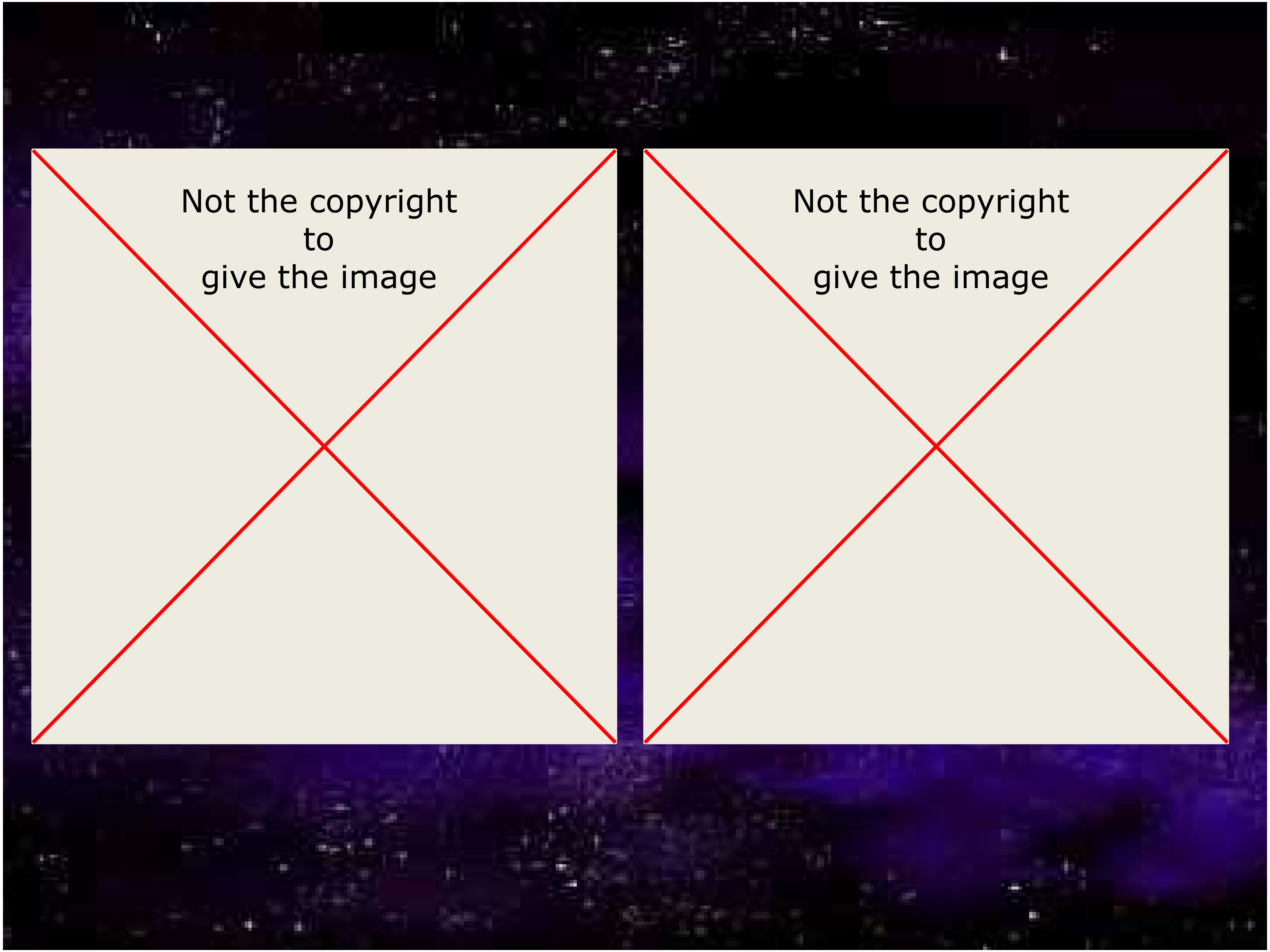
Reconstruction algorithms
SSD - Shaded Surface Display

A threshold value of radiodensity is set by the operator. From this, a three-dimensional model can be constructed by considering only the point having a Hounsfield Units higher than this threshold.

All the displayed pixels have the same value.

→ Lost of the density information (image of contours).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Reconstruction algorithms
SSD - Shaded Surface Display

A threshold value of radiodensity is set by the operator. From this, a three-dimensional model can be constructed by considering only the point having a Hounsfield Units higher than this threshold.

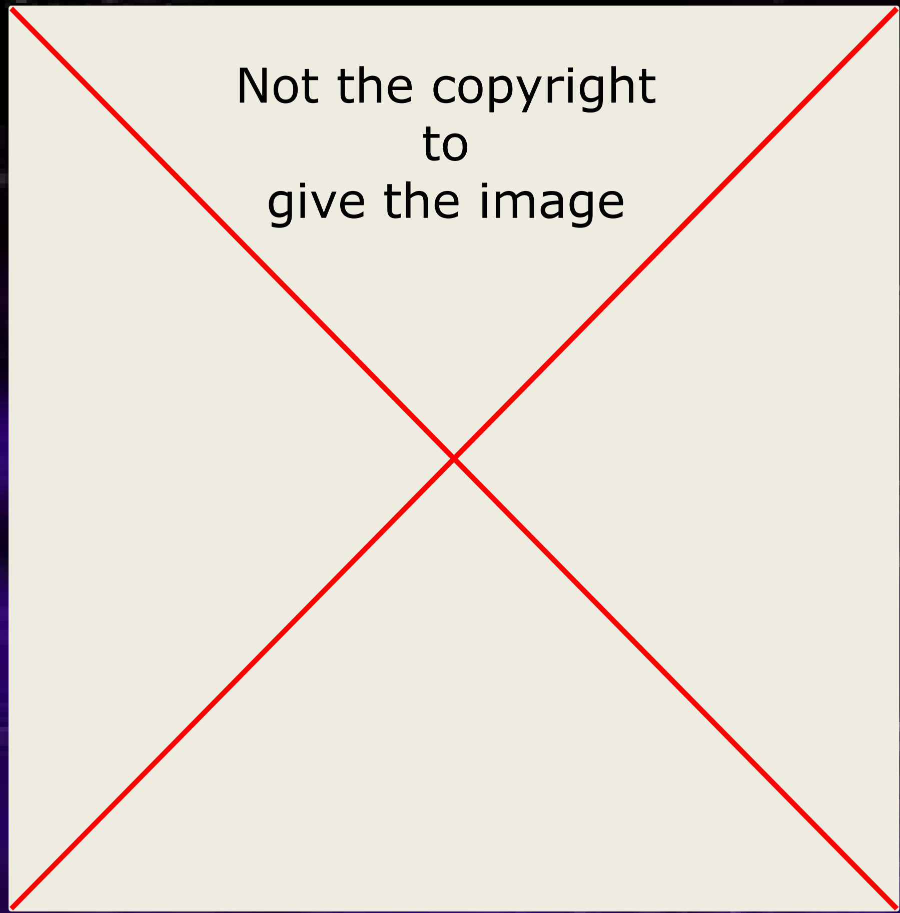
All the displayed pixels have the same value.

→ Lost of the density information (image of contours).

VRT - Volume Rendering Technique

Surface rendering (SSD) is limited in that it will display only surfaces that meet only one threshold density.

In volume rendering (VRT), more than one threshold are considered. Transparency and colors are used to allow a better representation of the volume to be shown in a single image.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to
give the image

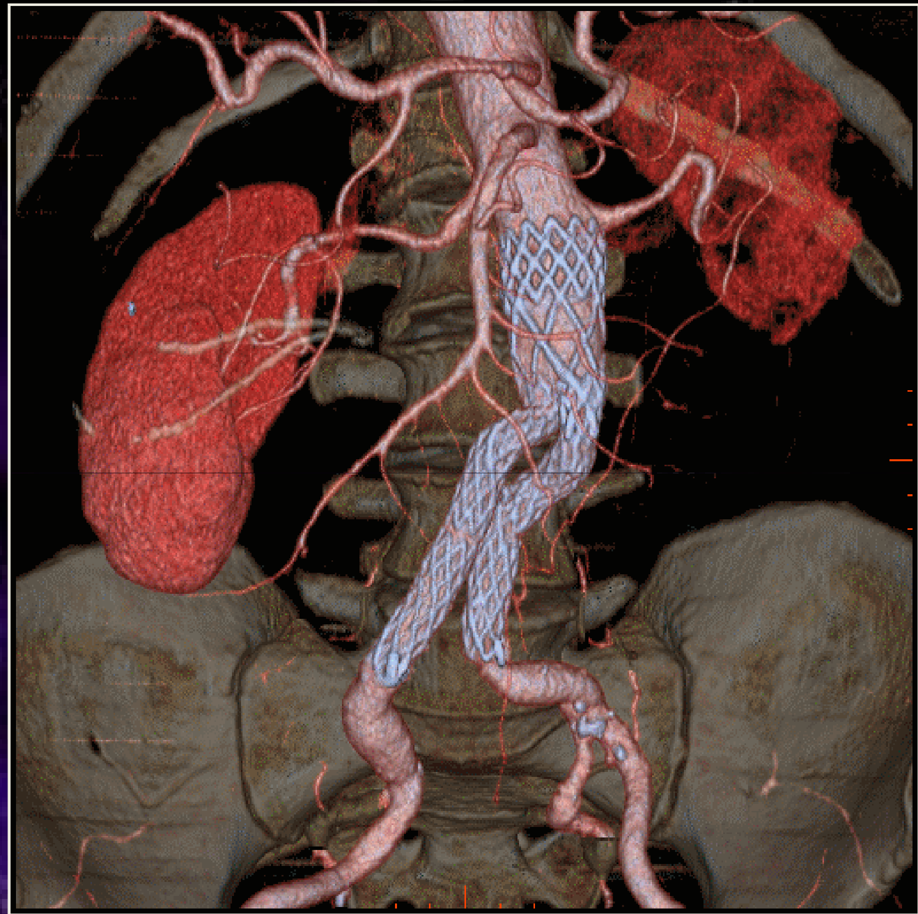
Example of cardiovascular imaging

Stenosis of the anterior Interventricular coronary artery (IVA)

VRT MIP

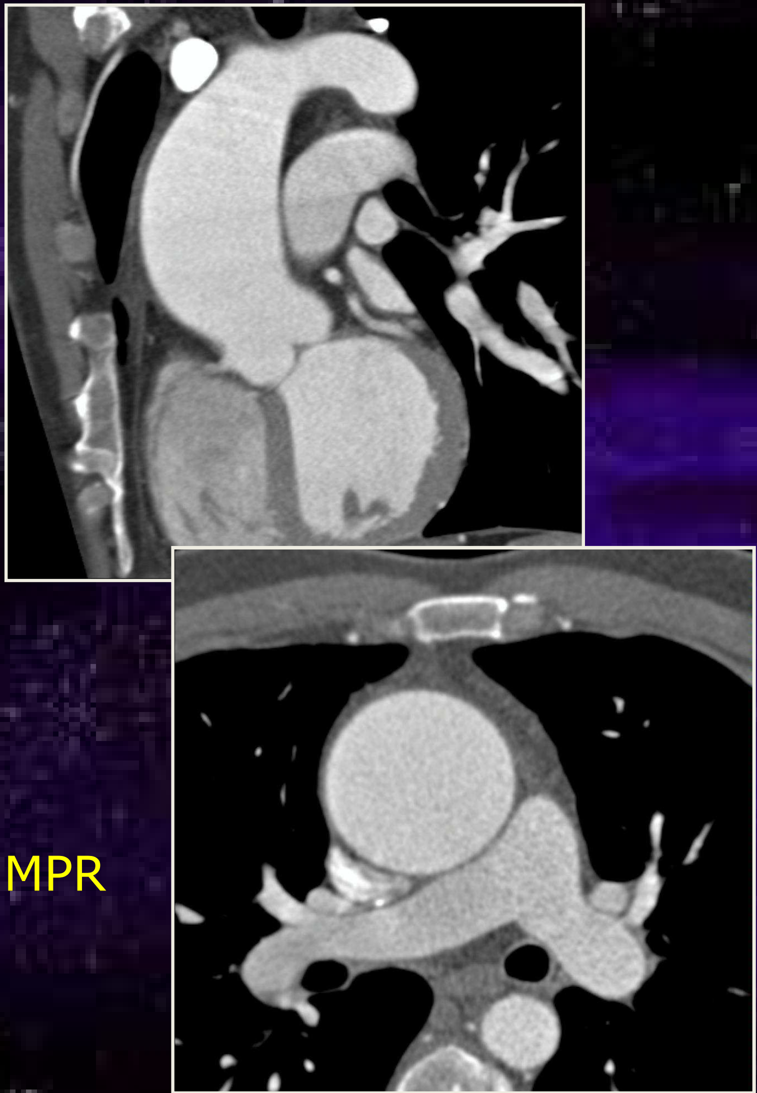
Follow-up of endovascular prothesis

MIP

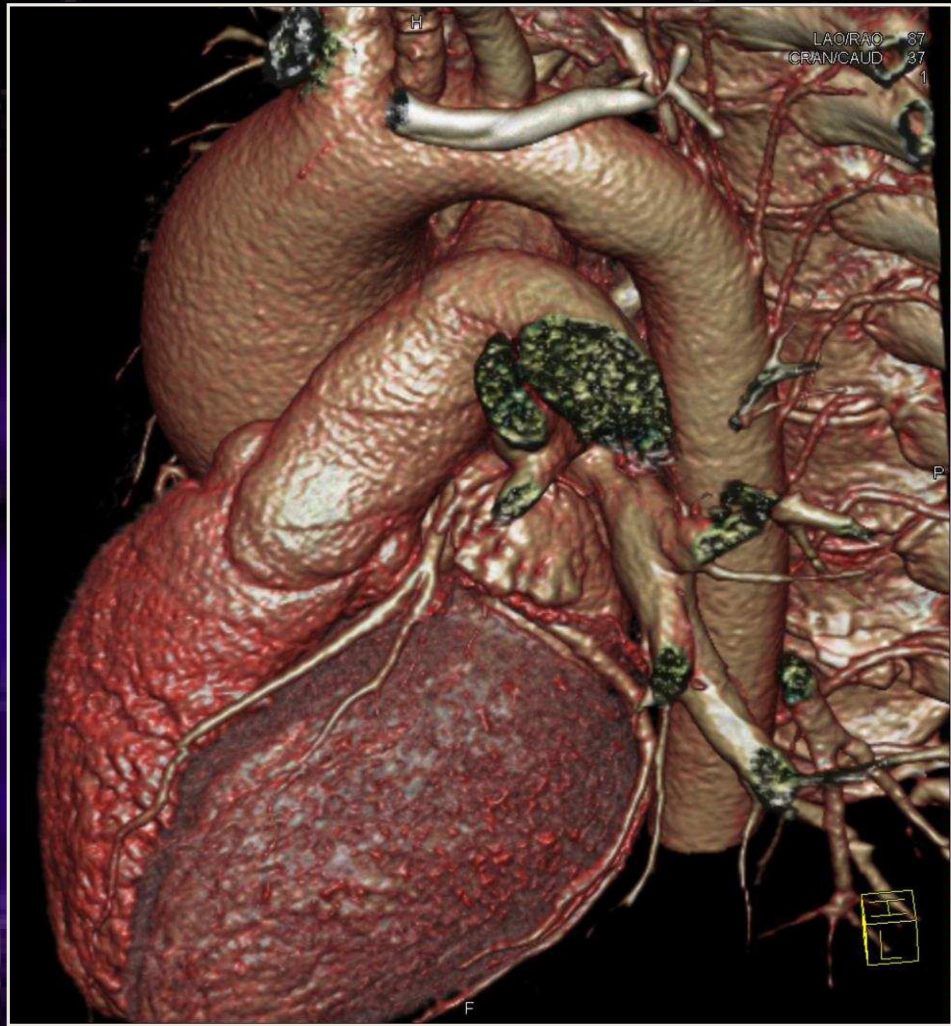


VRT
(bones in transparency)

Dilatation of the ascending aorta



MPR



VRT

Magnetic Resonance Imaging

Nuclear Magnetic Resonance (NMR)

Nuclear : Effect observed on some nucleus.

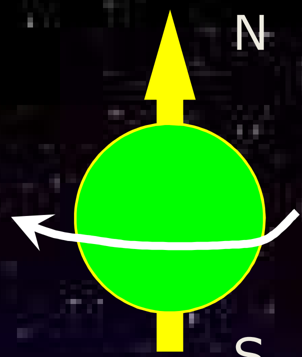
Magnetic : Magnetic field is necessary.

Resonance : Direct relationship between the magnetic field and the radiofrequency wave (RF).

1950-1960: Use of the NRM spectroscopy by chemists and biochemists to investigate the properties of organic molecules. NMR exploits the magnetic properties of certain atomic nuclei to determine physical and chemical properties of atoms or the molecules.

Magnetic Resonance Imaging (MRI)

Imaging technique based on the magnetic properties of the proton (Hydrogen nucleus).



Non-invasive imaging technique.

Proton = Magnetic dipole (spin).

The used magnetic field in medical imaging is in the order of the Tesla (20 000 times stronger than that of the earth).

<u>The intense magnetic field create the nuclear magnetic polarisation</u> :
Because of the spin characteristics of the proton, if it is placed in a large external magnetic field, it will assume one of two possible positions. It can be aligned (at a slight angle) in either a parallel or anti-parallel with the direction of the magnetic field.
The sum of these spins provides the creation of a macroscopic magnetization vector M.

MRI basics

Using an adapted RF excitation pulse, the protons absorb energy.

Modification of the orientation of the magnetization vector.
This RF pulse is used to tip M away from its initial equilibrium direction.

Then, at the end of the RF pulse, the magnetization vectors tend to return to equilibrium state (relaxation process), and this return is more or less long according to the tissue.

This return to equilibrium is associated with the emission of a RF signal (energy emission).

Coils for MRI

Coil for the head

Phased-array coil
(for the thorax)


SIEMENS

MR image weighting

The MR signal principally depends on three magnetic parameters of the tissue :

- The longitudinal relaxation time (T1)
➔ Return of M to equilibrium

- The transverse relaxation time (T2)
➔ Disruption of the coherent state

- The proton density

To priviledge one parameter, the radiographer has control over two important times :

- The repetition time (TR)
➔ Time between successive slice encoding pulse

- The spin echo time (TE)
➔ Time between the pulse and the reading of the signal

The longitudinal relaxation time (T1)
The transverse relaxation time (T2)

The longitudinal relaxation time (T1) is different according to the tissue

The shorter the T1 of a tissue, the brighter this tissue will appear on a T1 weighted image.

The longitudinal relaxation time (T2) is different according to the tissue

The longer the T2 of a tissue, the brighter this tissue will appear on a T2 weighted image.

Short T1 tissue: Fat

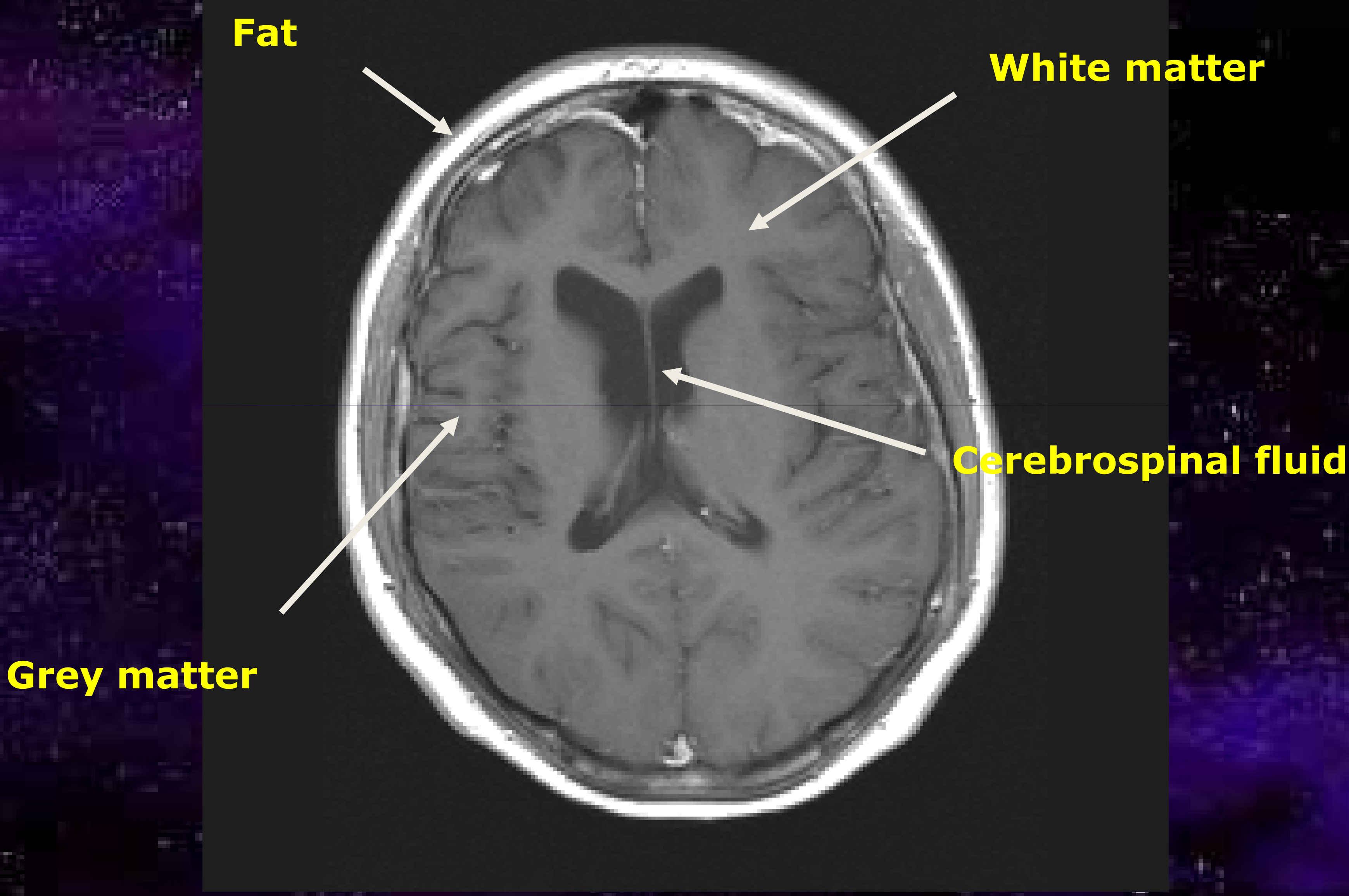
Long T1 tissue: Liquids

$T1_{\text{grey matter}} > T1_{\text{white matter}}$

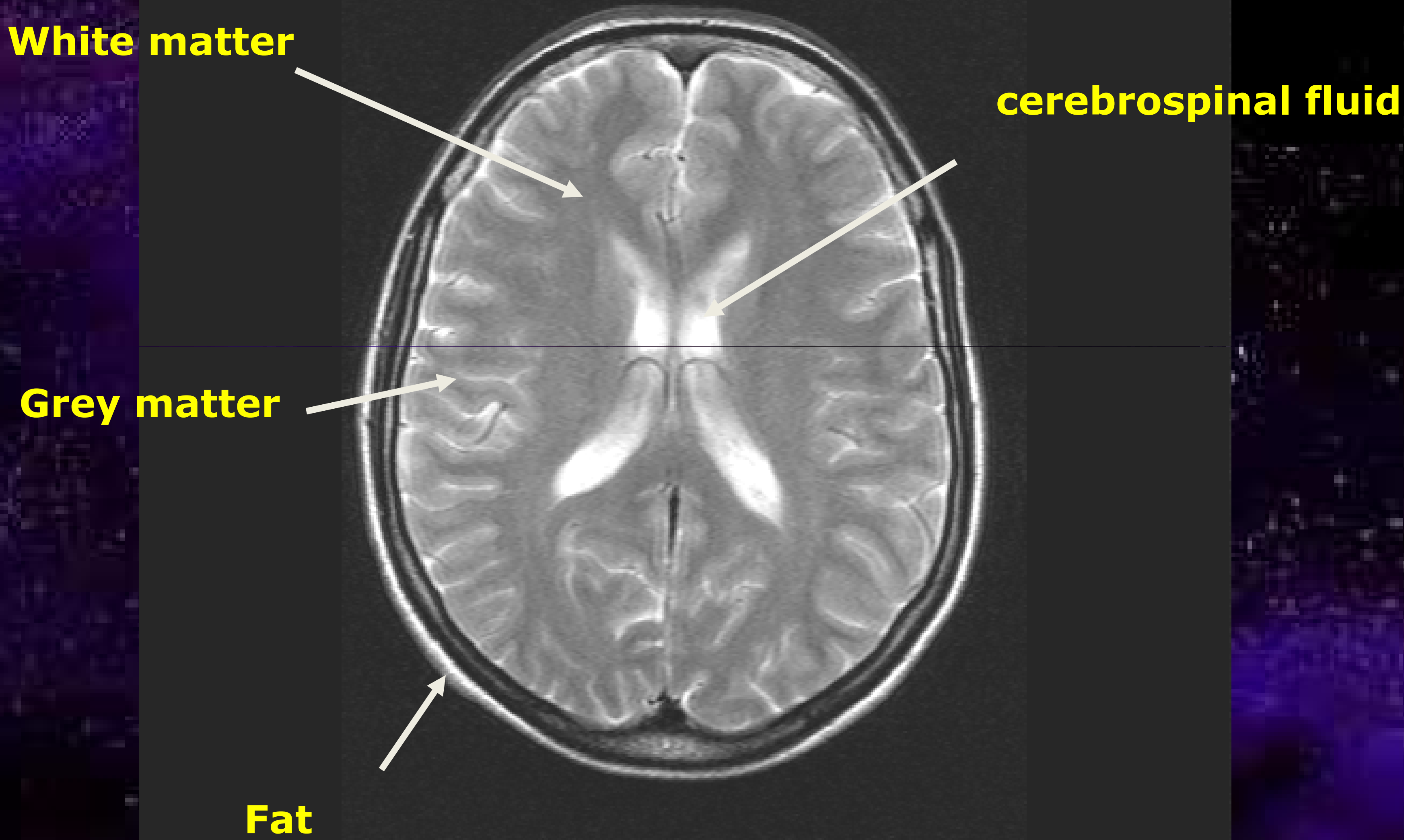
Long T2 tissues: Fat, liquids

$T2_{\text{grey matter}} > T2_{\text{white matter}}$

T1 weighted images



T2 weighted images



If there is a difference in proton density between the tissues, there is a difference of amplitude between the magnetization vectors M.
➔ Image in proton density

TR \ TE	Short	Long
Long	Proton density	T2 weighting
Short	T1 weighting	

Image characteristics

It is not an instantaneous acquisition

Acquisition line by line in the Fourier plane
(Use of the inverse Fourier transform to create the image)

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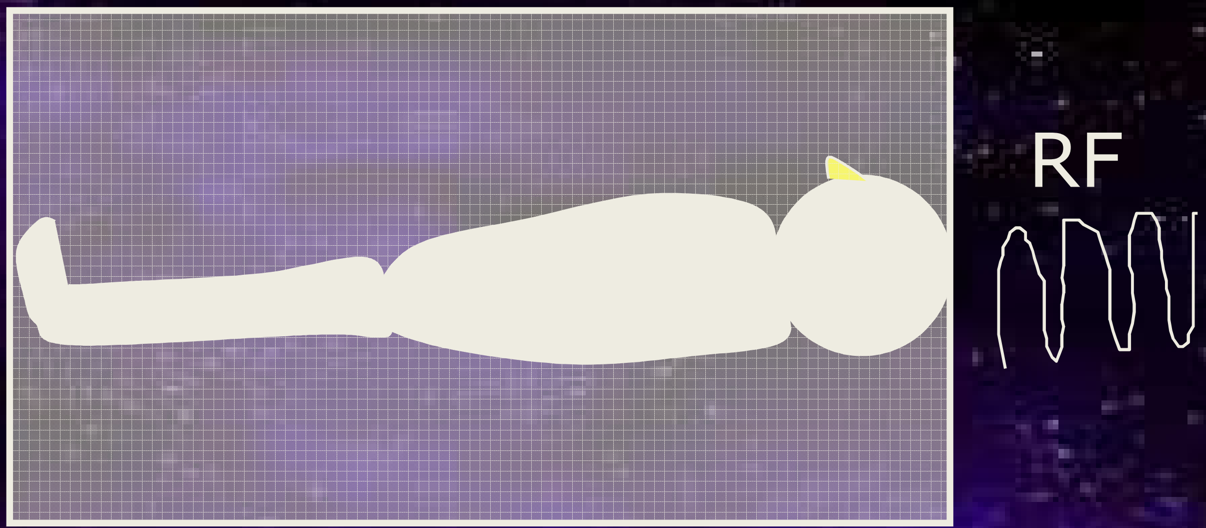
FT

IFT

Moving artifact

Spatial localisation – Slice selection

When we apply a RF wave to the patient, all the protons will absorb the energy.



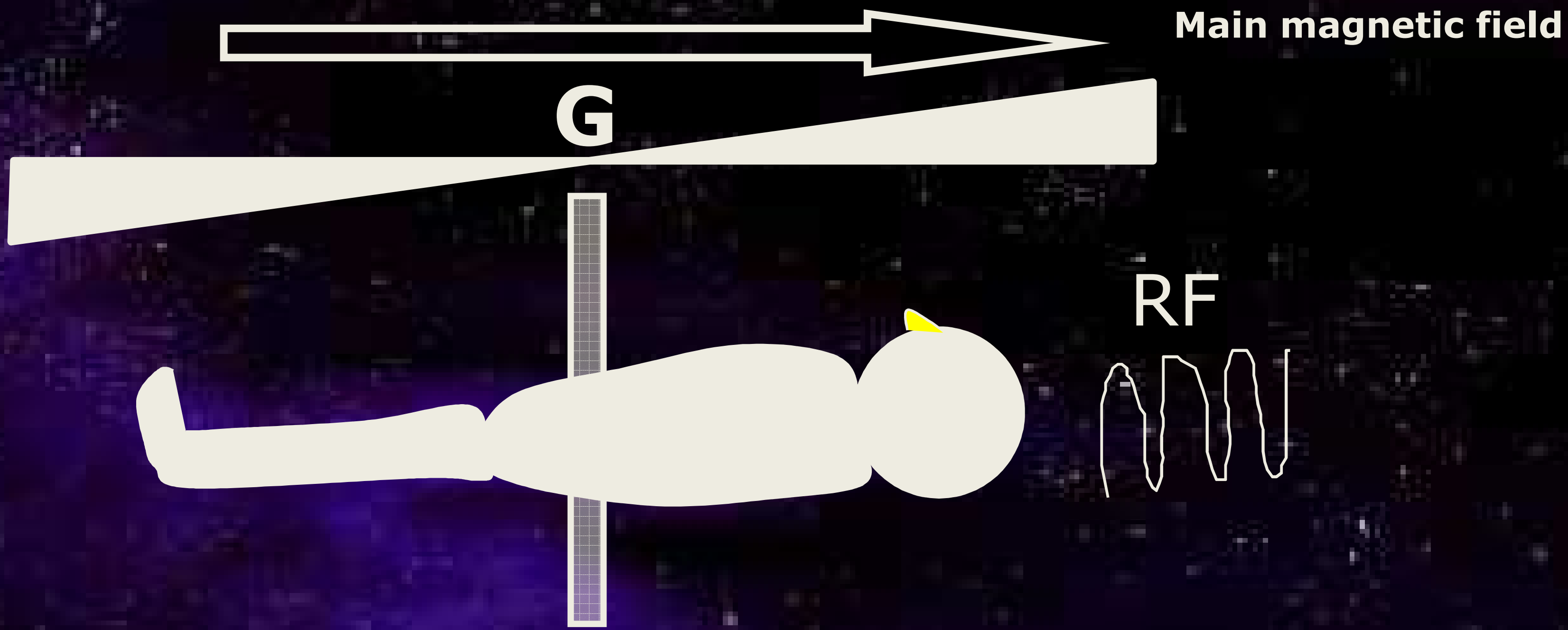
The frequency of the RF wave must be equal to a very specific frequency that depends on the magnetic field and on a paremeter specific to each nucleus.

Magnetic field gradients

The 3D volume is sliced by superimposing a linear static magnetic field gradient. Then, the specific frequency of the RF wave becomes different for the protons belonging to different slices.

This particular magnetic field is called magnetic gradient (or gradient).

Magnetic field gradients

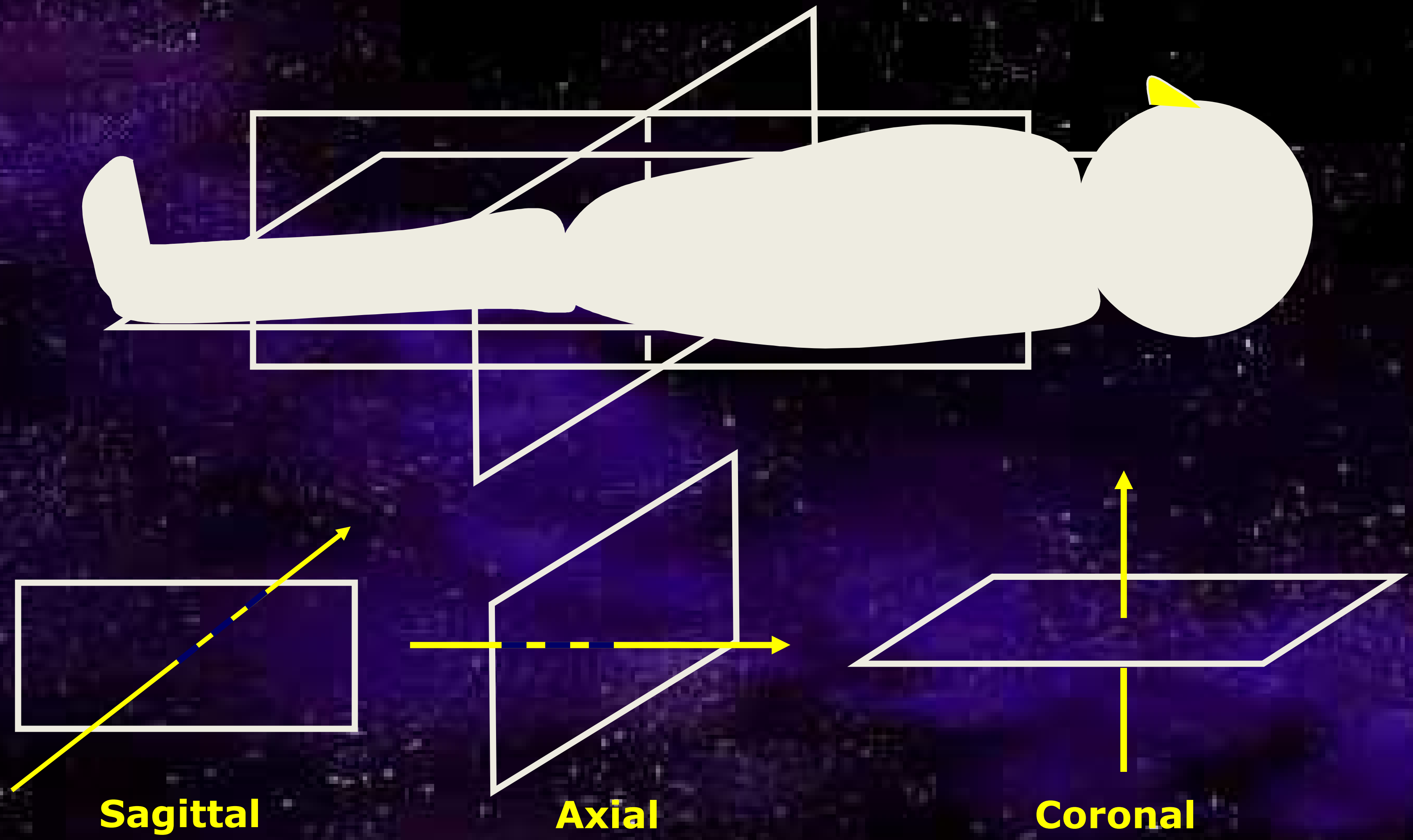


When we apply the RF wave, only the protons having a frequency equal to the RF wave will absorb the energy.

The gradient can be applied in any direction.

Plane orientation

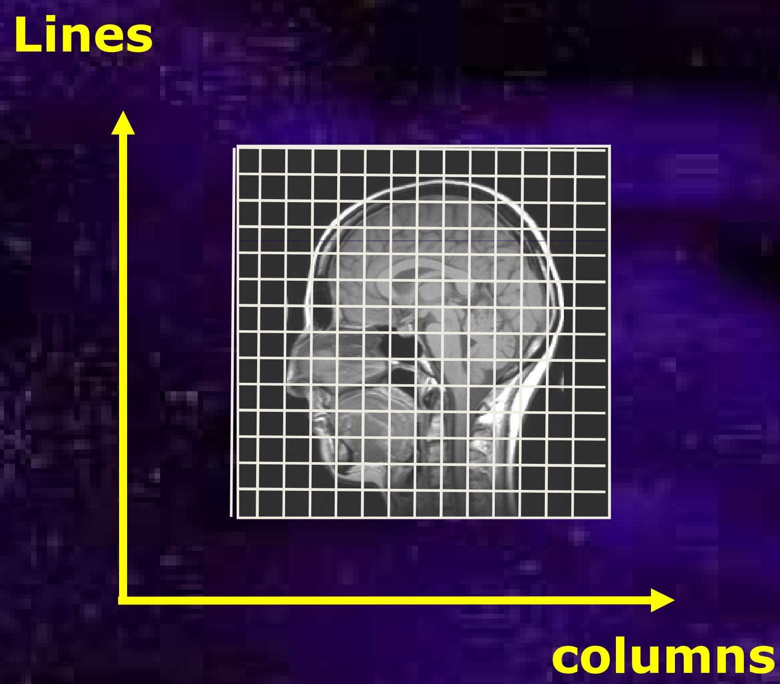
The plane orientation is perpendicular to the gradient

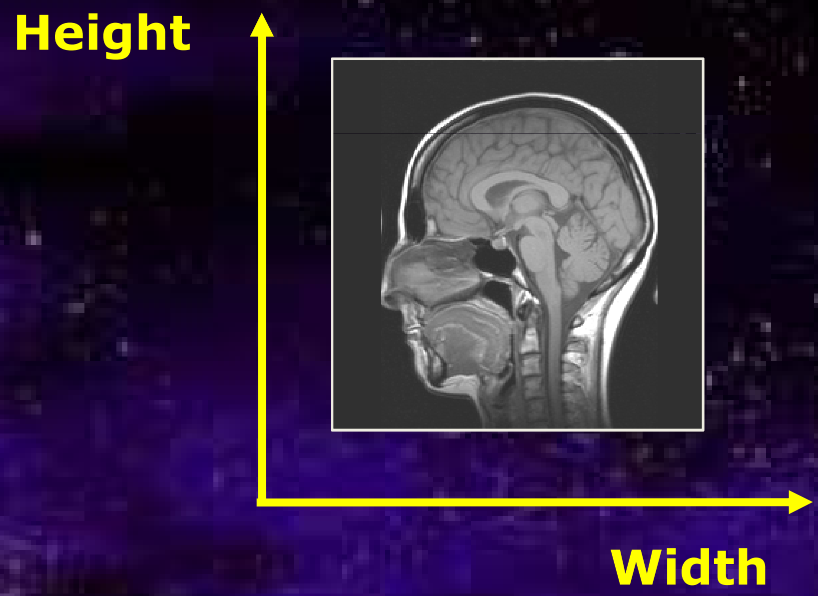


FOV (Field Of View)

Depict the real dimension of the image

In general in cm or in mm

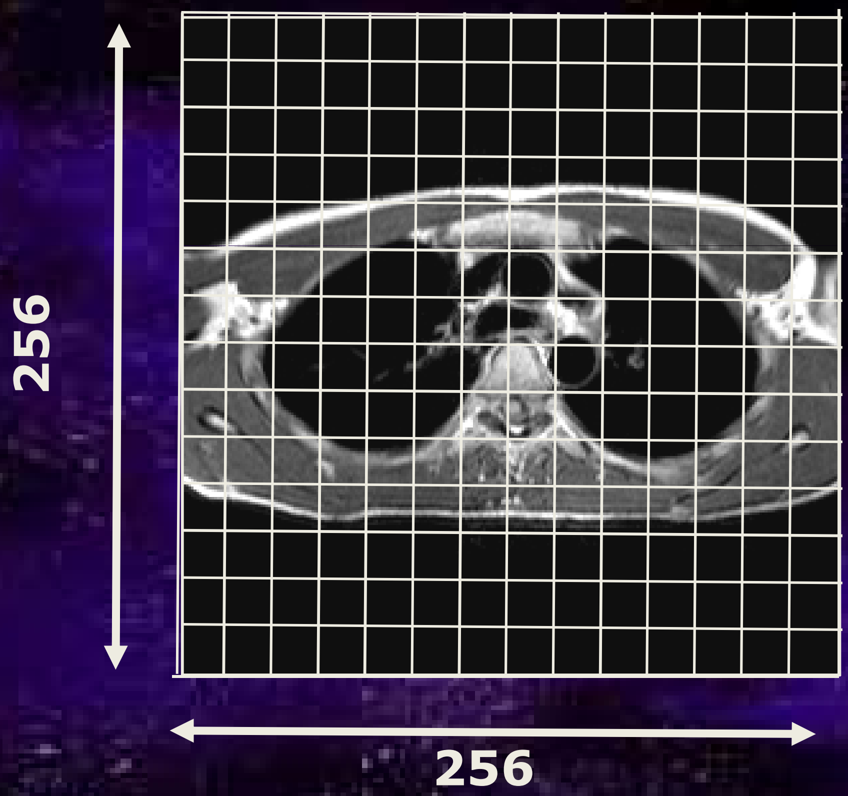




Matrix size:
n lines × m columns

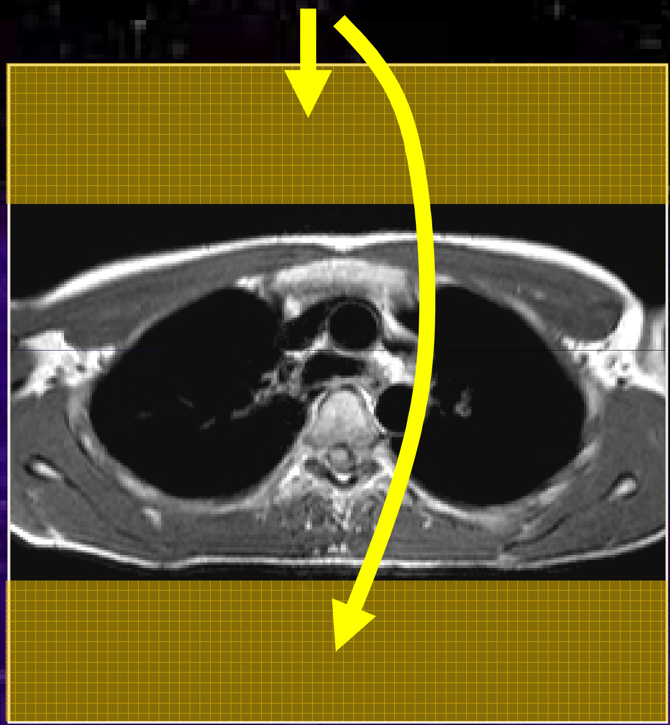
FOV : x cm × y cm

Rectangular field of view
Rec FOV



Rectangular field of view
Rec FOV

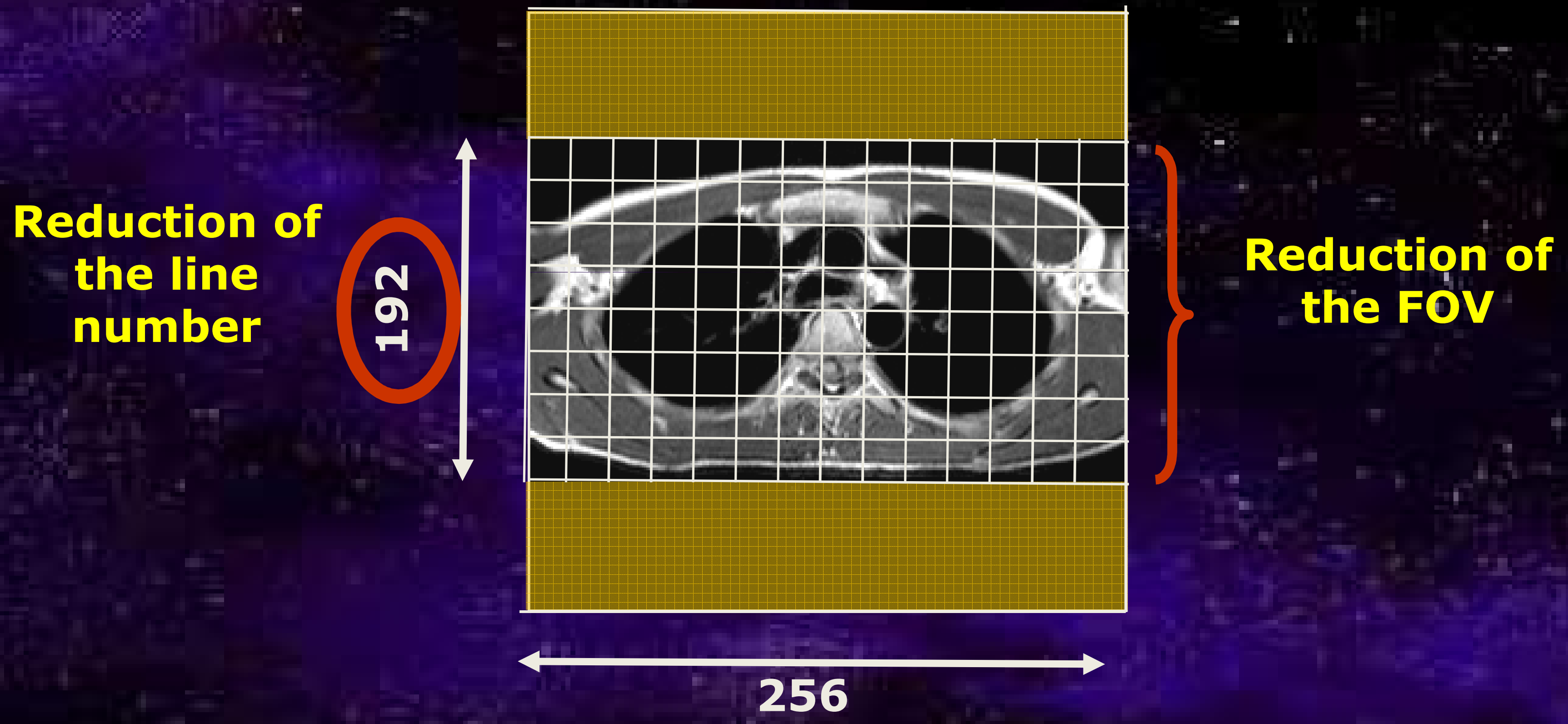
The acquisistion of these lines is unnecessary



By not considering the lines outside the body of the patient, we reduce the number of lines to be acquired.

Rectangular field of view
Rec FOV

Rec FOV : 3/4



Rectangular field of view
Rec FOV

Diminution of the number of lines with a diminution of the FOV
→ We keep the same spatial resolution

Advantage : Faster acquisition

Disadvantage: Reduction of the acquired line number
→ Reduction of the signal to noise ratio

Example : **FOV = 25 cm × 18,75 cm**
Matrix = 128 lines × 96 columns

Pixel size ~ 1,95 mm × 1,95 mm

Fat saturation
Suppression of the fat signal

The bright signal from fat is often an inconvenience to diagnosis in MR imaging.

Image without fat saturation

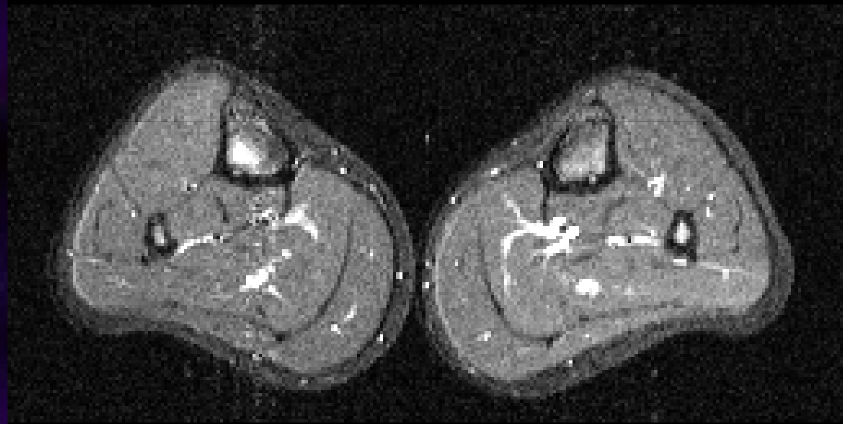


Image with fat saturation

Paramagnetic contrast agent

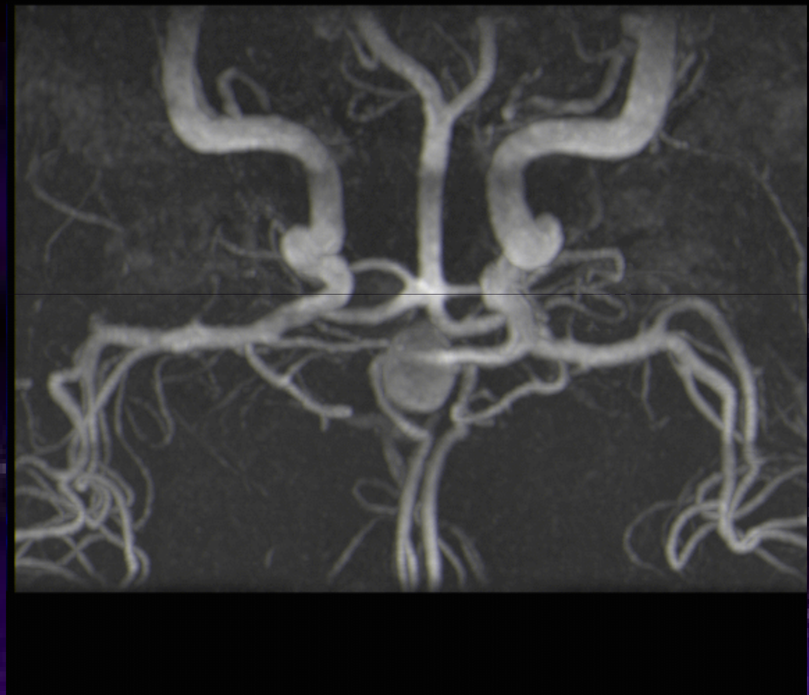
Decreased of the T1 relaxation time.

Increase of the contrast on T1 weighted images.

Gadolinium contrast MRI contrast agents are the most commonly used contrast agent.

MR-angiography : An important contrast between vessels and other parts of the body can be obtained by injecting the contrast agent in the blood (increase of the blood signal).

Magnetic Resonance angiography (MRA)



MRA - Carotids

Right carotid

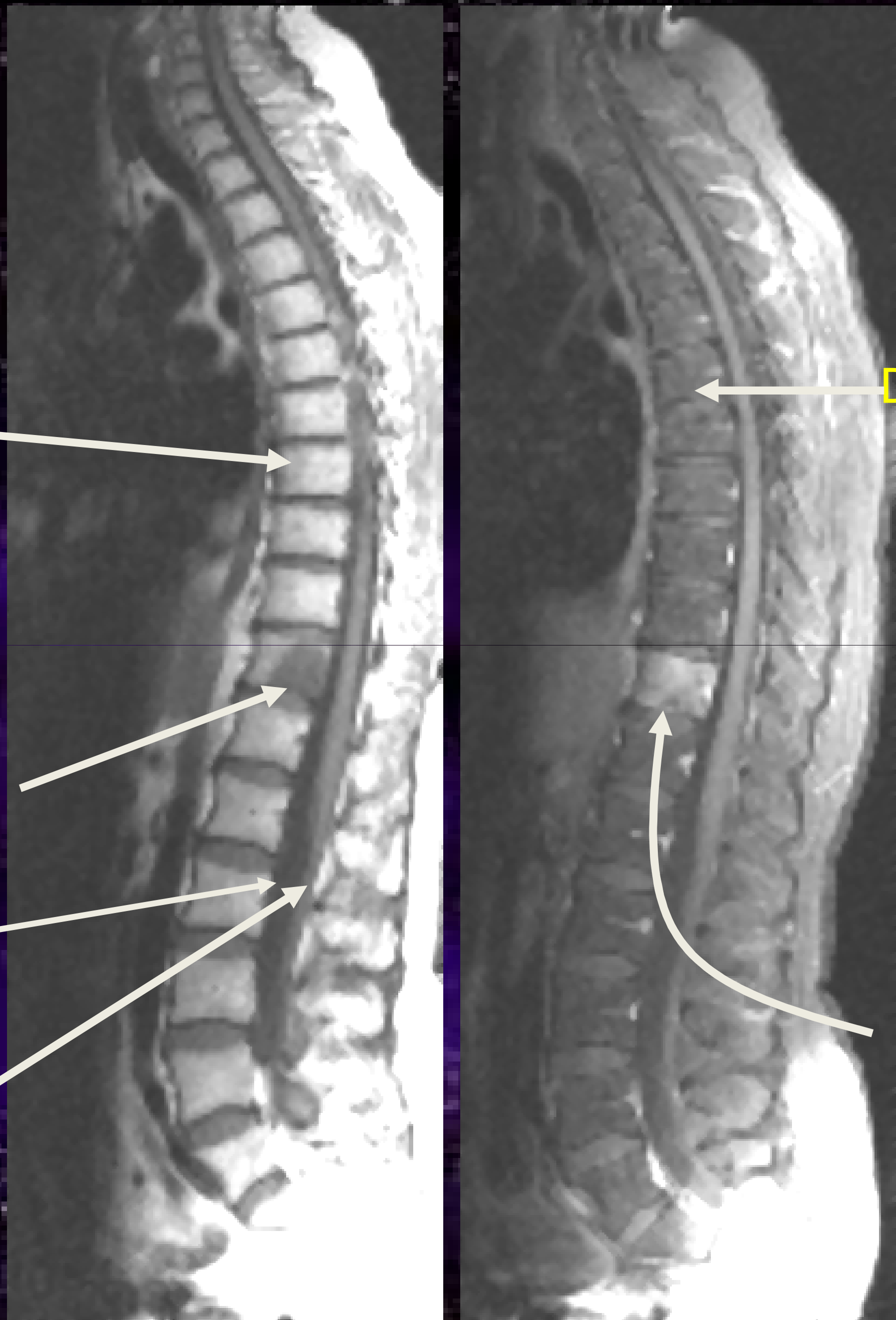
T1 weighting

There are fat and blood in the vertebras
→ Short T1

Long T1
Edema or tumor

Cerebrospinal fluid with low signal

Spinal cord with grey signal



T1 weighting
Fat saturation

Contrast agent

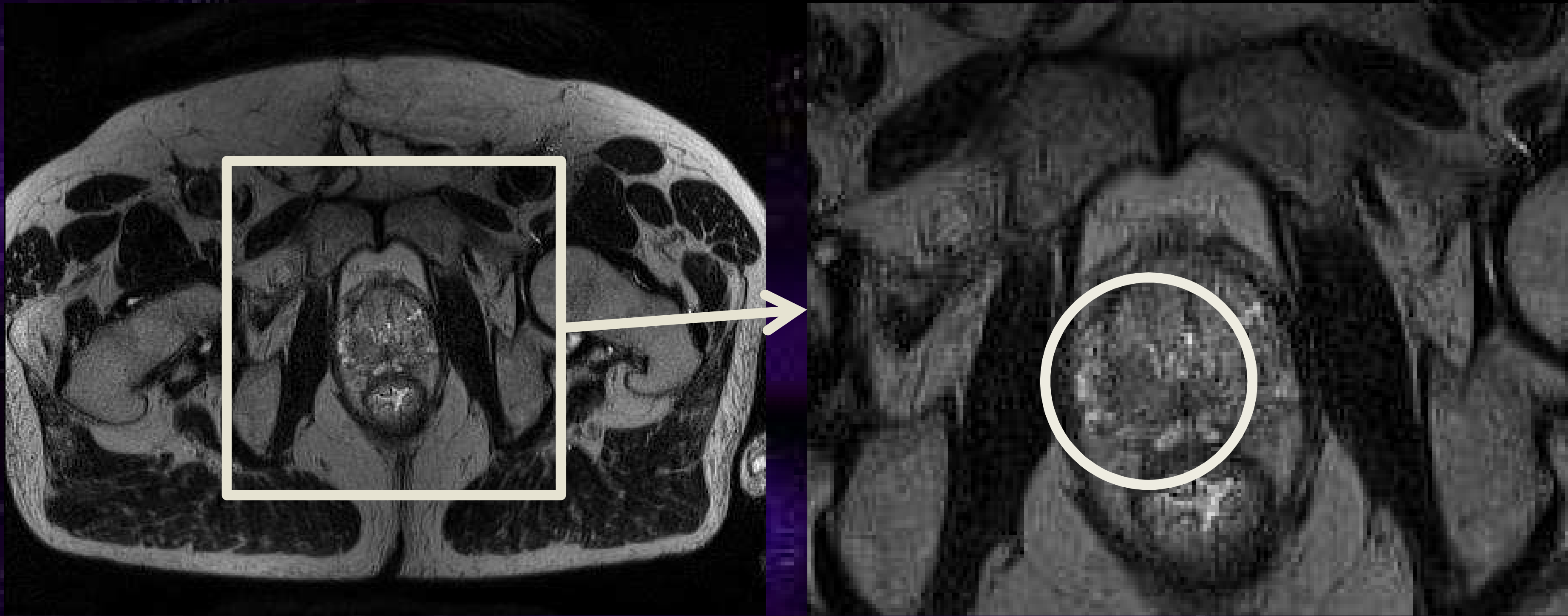
Discs with low signal

Cerebrospinal fluid with low signal

Spina cord with higher signal

Contrast uptake
→ Vascularization

Example of a prostate cancer

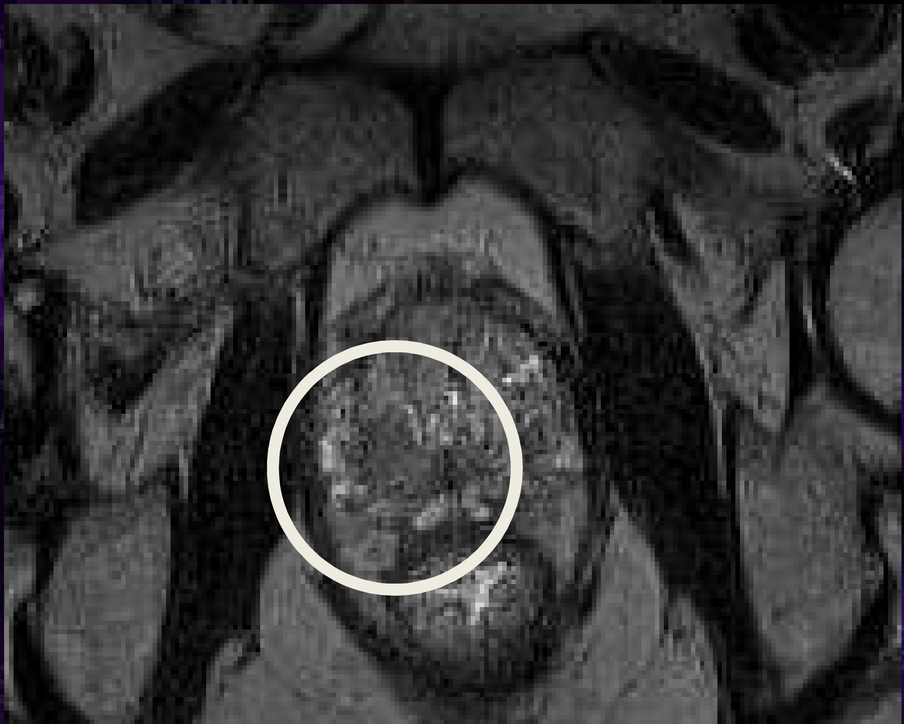


T2 Weighting

On T2 weighted image, high signal in the prostate gland.
→ Hyposignal at the level of the cancer

Pb : Hormonotherapy→ Iso signal on the whole prostate gland

Example of a prostate cancer



T2 Weighting

Perfusion imaging
(Use of a contrast agent)

Cancer : Neovascularization, with vessels relatively « porous »
→ Hypersignal at the level of the cancer

Spin echo sequence / Gradient echo sequence

Spin echo sequence :

+ Settings allowing a high contrast with T1 or T2 weighting
- Relatively long acquisitions

Gradient echo sequence :

+ Acquisitions that can be very fast
- Settings do not allow a correct T2 weighting

➔ Signal variable according to the settings, BUT in general the cortical bones appears in very dark grey, and the fat appears in white.

Kinetic imaging (cine-MRI)

Fast imaging technique (gradient echo sequence).

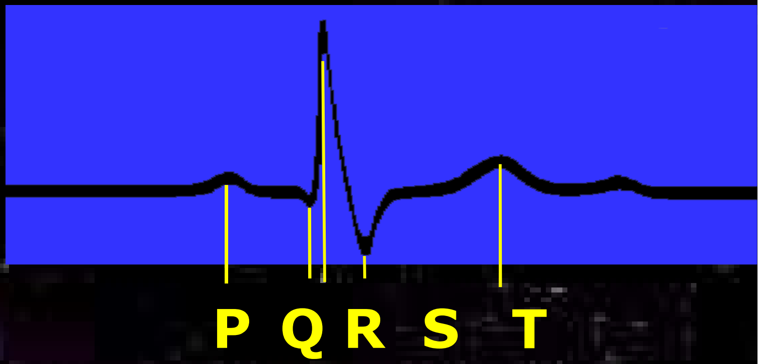


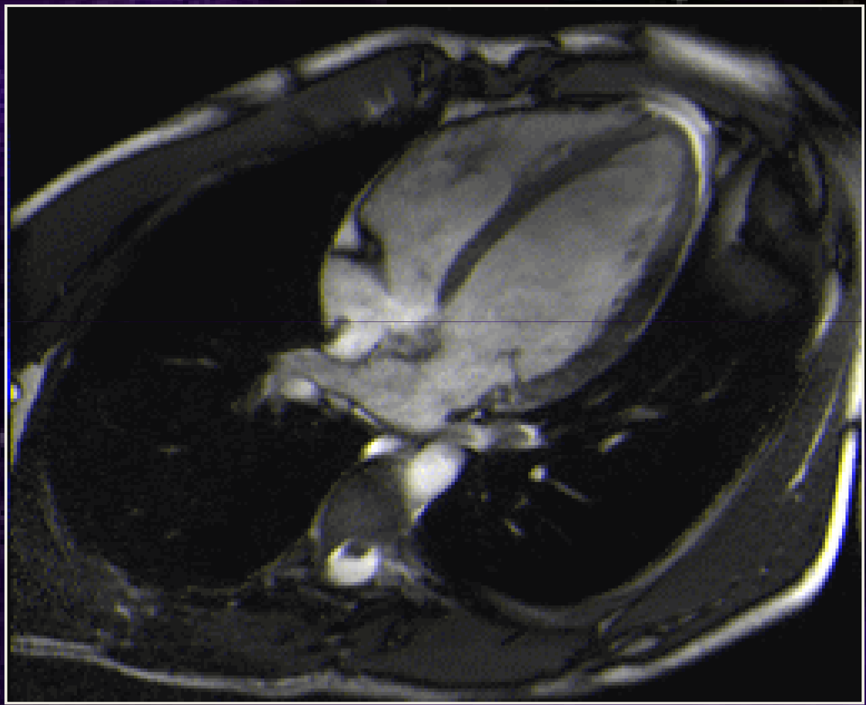
Image acquisition is not instantaneous, and must synchronized with the cardiac cycle.

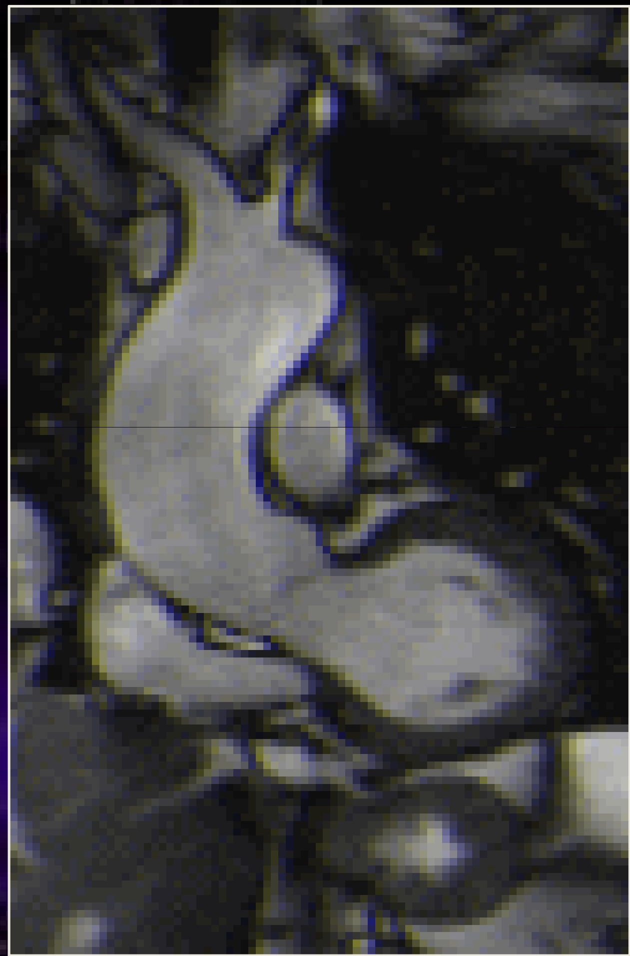
➔ The synchronization starts with the R wave of the ECG

Several images of the same slice can be acquired during a cardiac cycle. These images can be displayed in a kinetic format (➔ cine-MRI) The number of phases of the cardiac cycle corresponds to the number of TR intervals (of the sequence) that are enclosed in the RR interval.

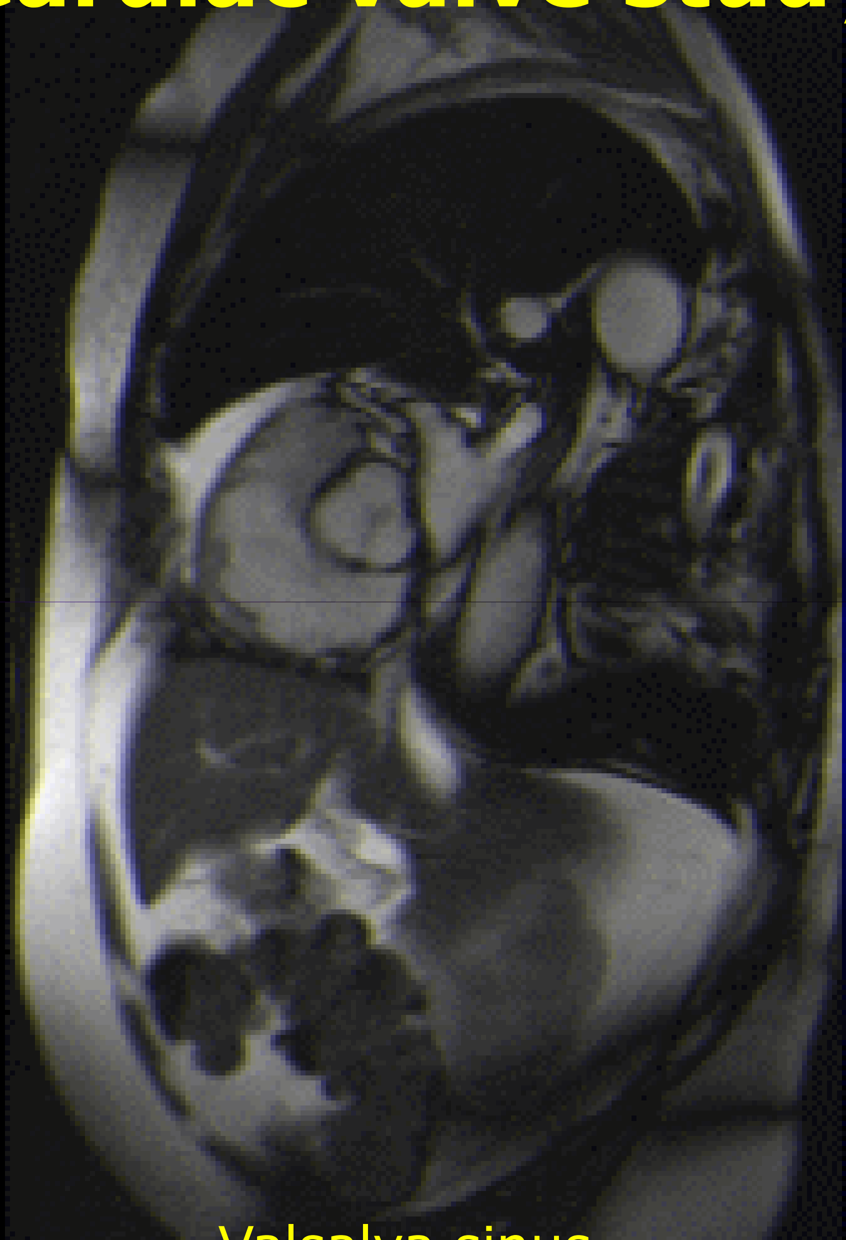
For the myocardium study, these sequences are usually performed during breathhold, in order to prevent the diaphragmatic movement (respiratory movement).

Kinetic imaging (cine-MRI)





Cardiac valve study



Valsalva sinus

How to easily make the difference between MRI and CT scan in 95% of the cases ?

	Cortical bone	Fat
CT scan	White	Very dark grey
MRI	Very dark grey	White