Computed Tomography

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Introduction

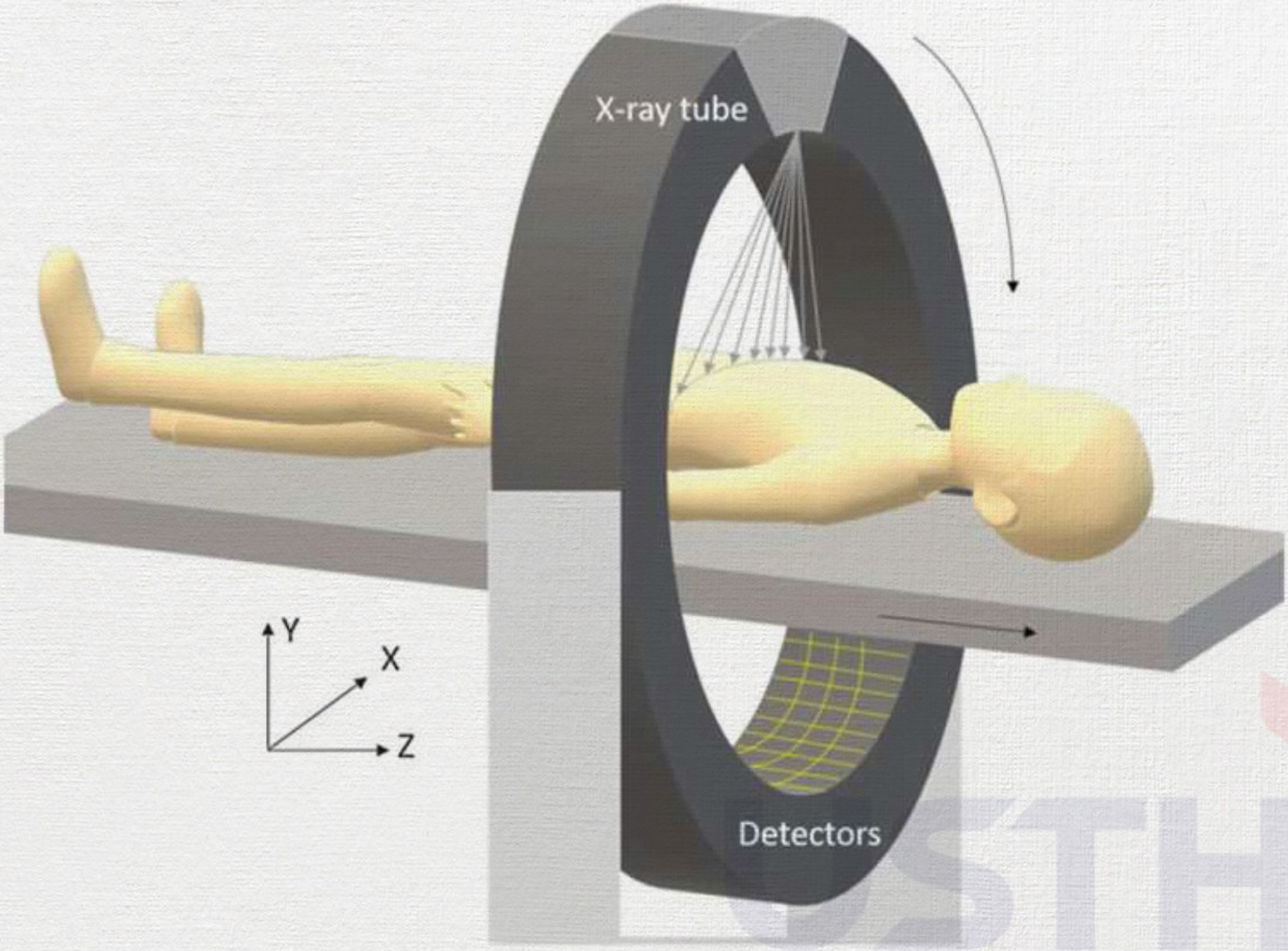
Medical Imaging

- Radiological technologies
  - X-ray
  - **computed tomography (CT)**
  - mammography
- Magnetic resonance imaging (MRI)
- Nuclear medicine imaging
  - single photon computed tomography (SPECT)
  - positron emission tomography (PET)
- Ultrasound (US)
- Other imaging techniques

Introduction

- Digital process
- Multiple projections from different angles
- Acquired around a single axis of rotation
- Generate a 3D volumetric representation of internal structure of the scanned body

Introduction

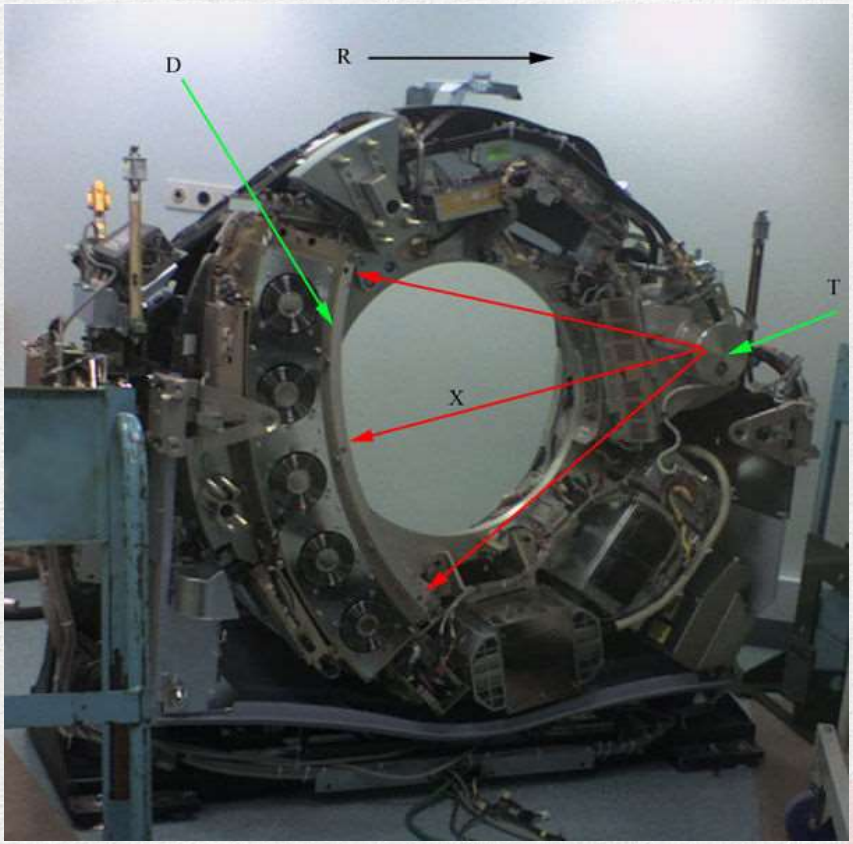


Introduction

- Invented in 1972 by Godfrey Hounsfield
- Use radiations
- Originally similar to X-ray scanner
- Additional mechanisms for rotation and movement

Introduction

- Widely, increasingly used
- 3D Imaging
- Better clarity



CT vs MRI

- CT Scans are usually cheaper
- CT Scans are typically better at showing bones than MRI
- CT scans are less effective at showing soft tissue
- CT scans take around 5 minutes, MRI's usually take 30 minutes
- CT scans can be harmful to the patient, while MRI's have no known biohazards
- Both used for for detecting cancer

Why not

- Better clarity needs more exposure to radiation
- Human error in reading scans
- Not very good at depicting soft tissue
- Move the patient to change the image plane

Scanners

GE Lightspeed

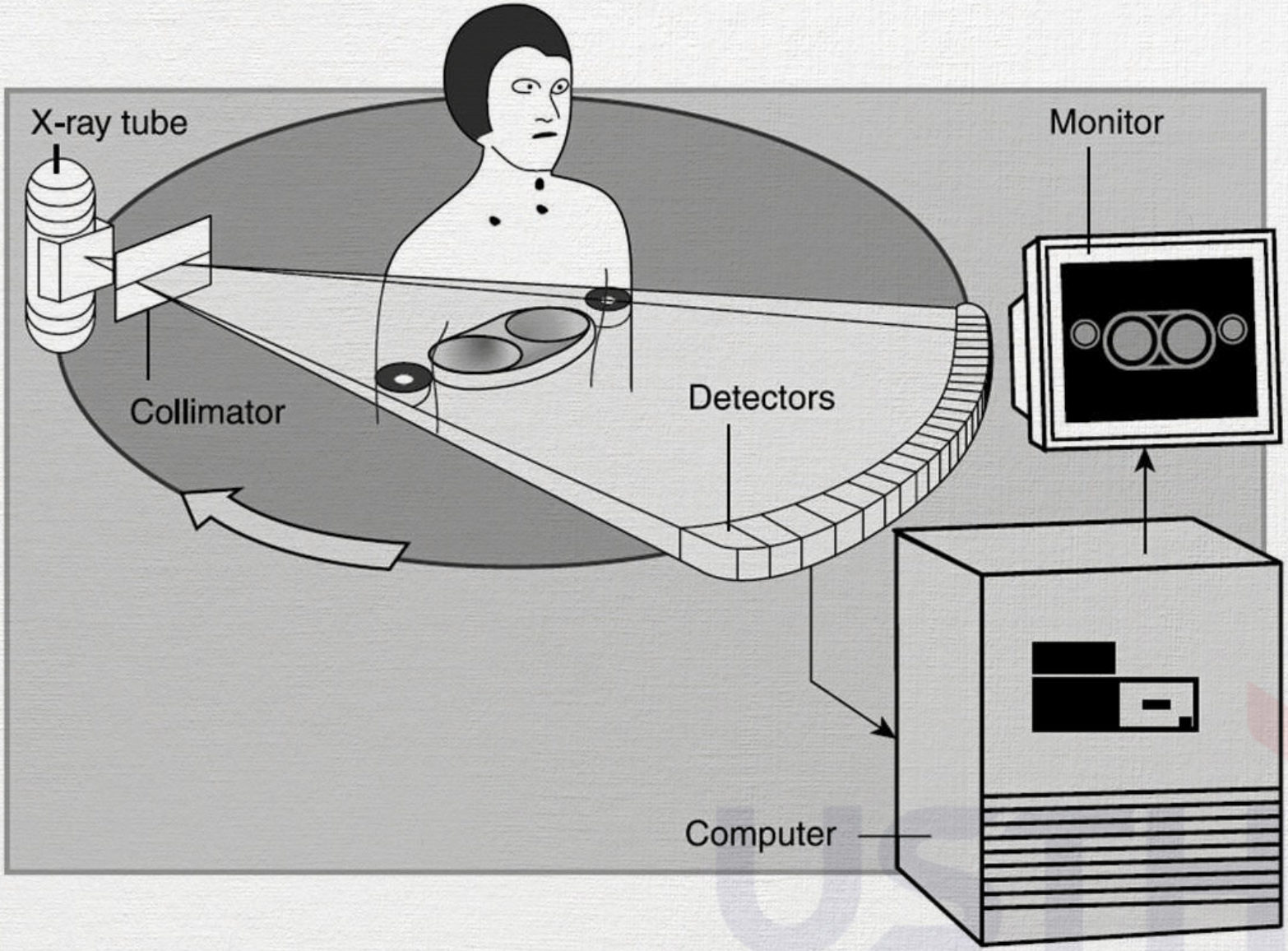
Phillips

Toshiba

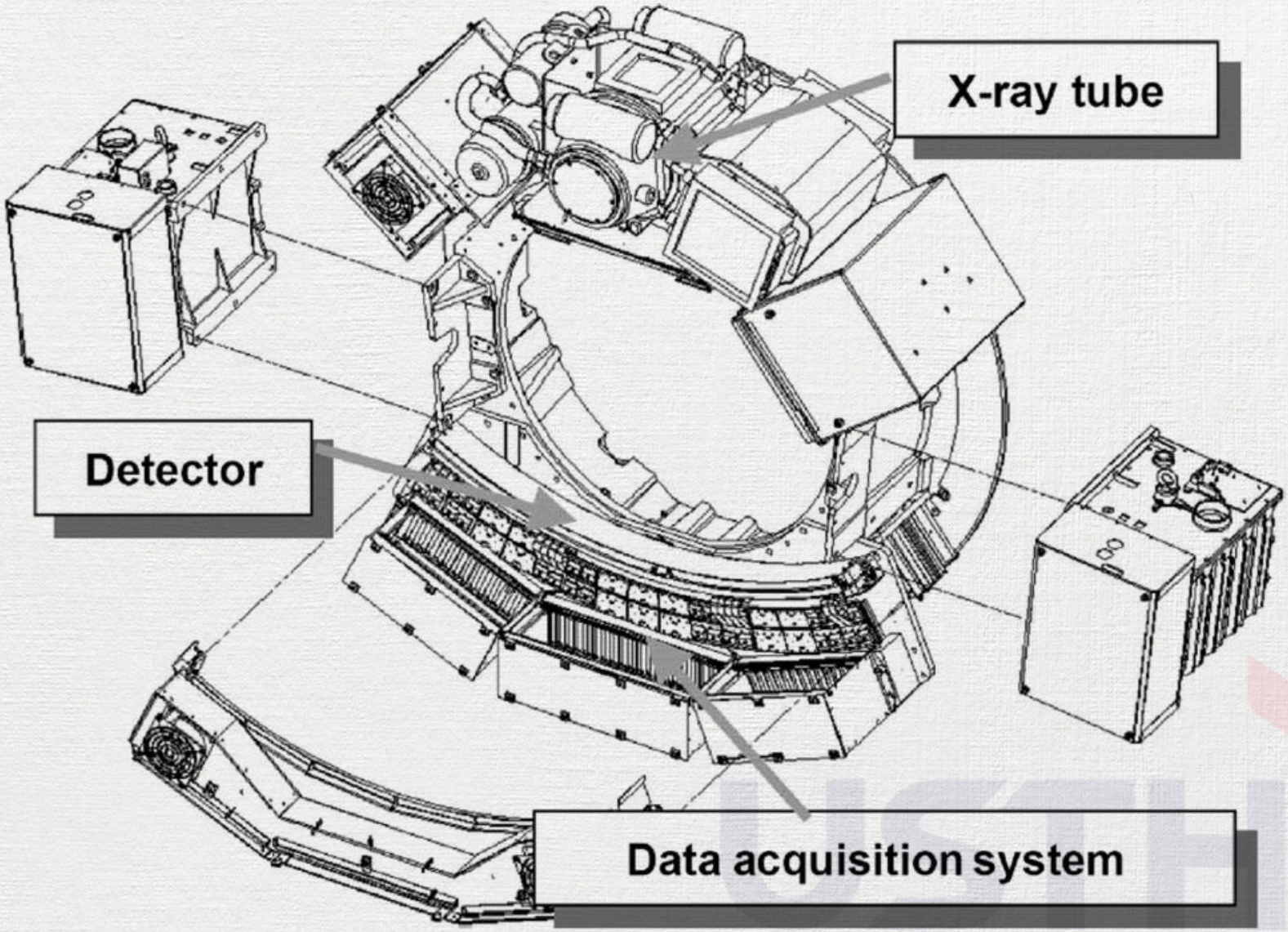
Siemens

Mechanism

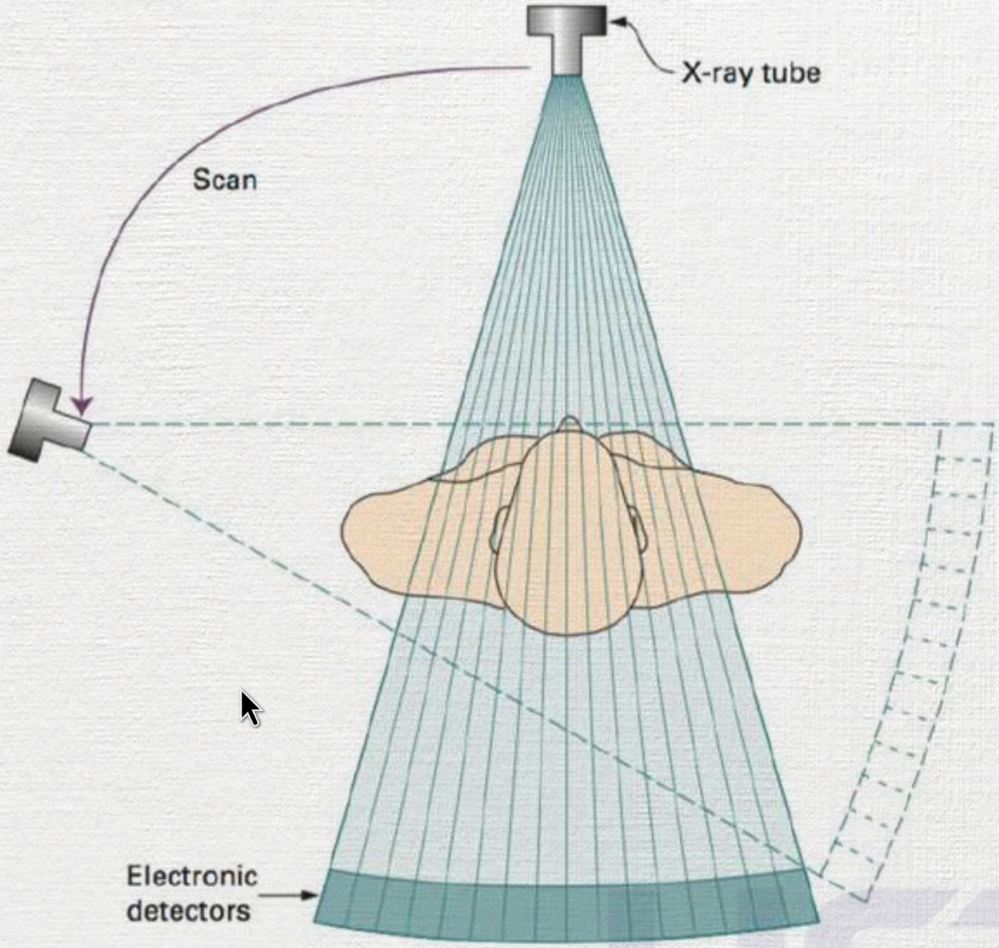
Scanner



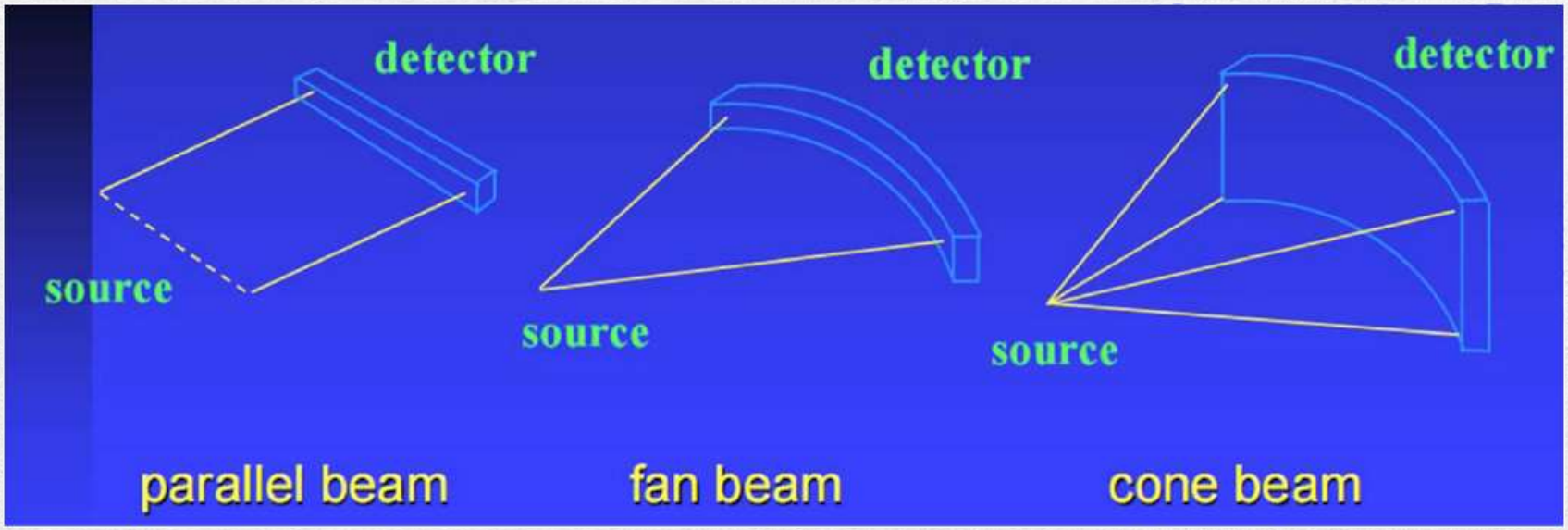
Scanner



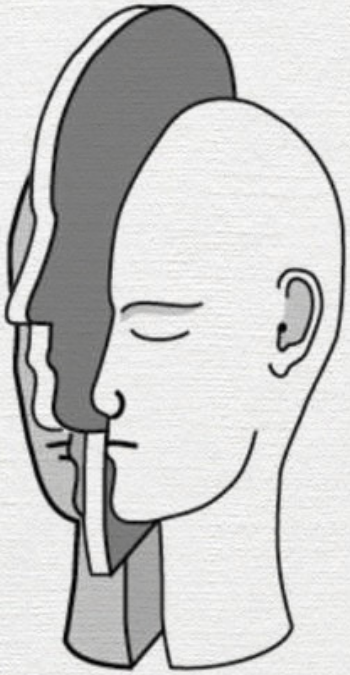
Scanner



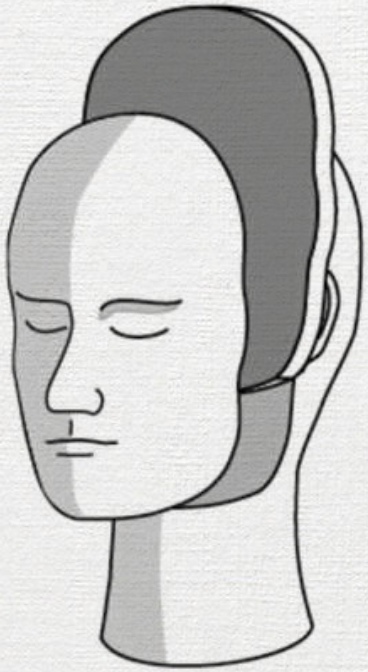
Scanner


detector
source
parallel beam
detector
source
fan beam
detector
source
cone beam

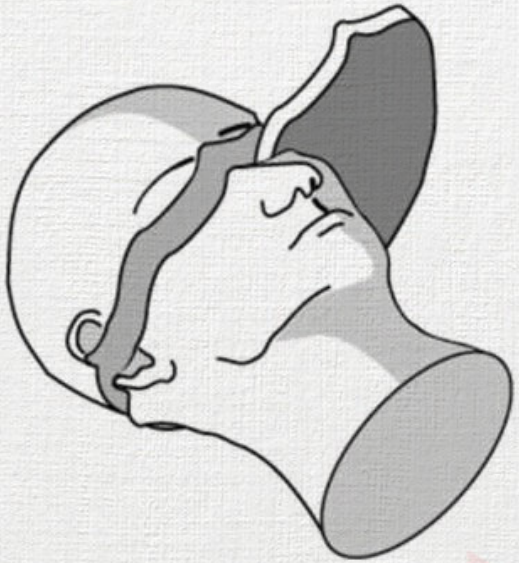
Scanner



A Sagittal

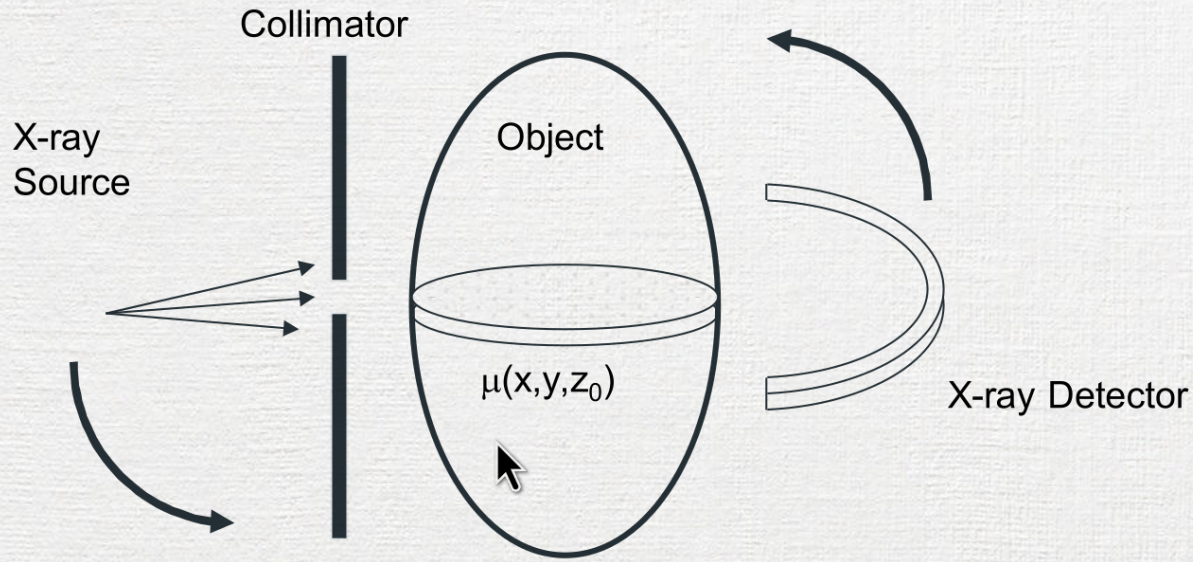


B Coronal



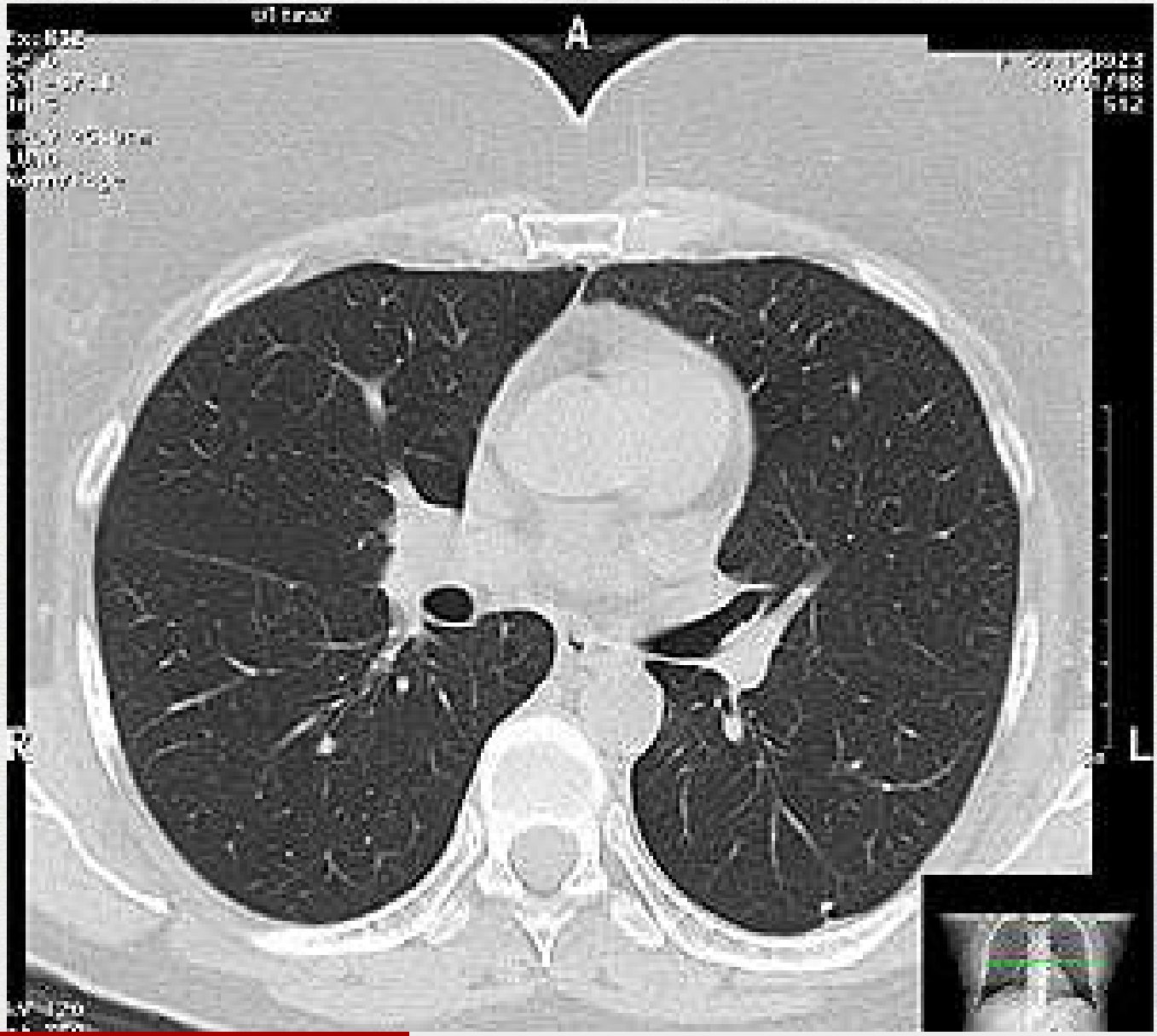
C Axial

Slicing

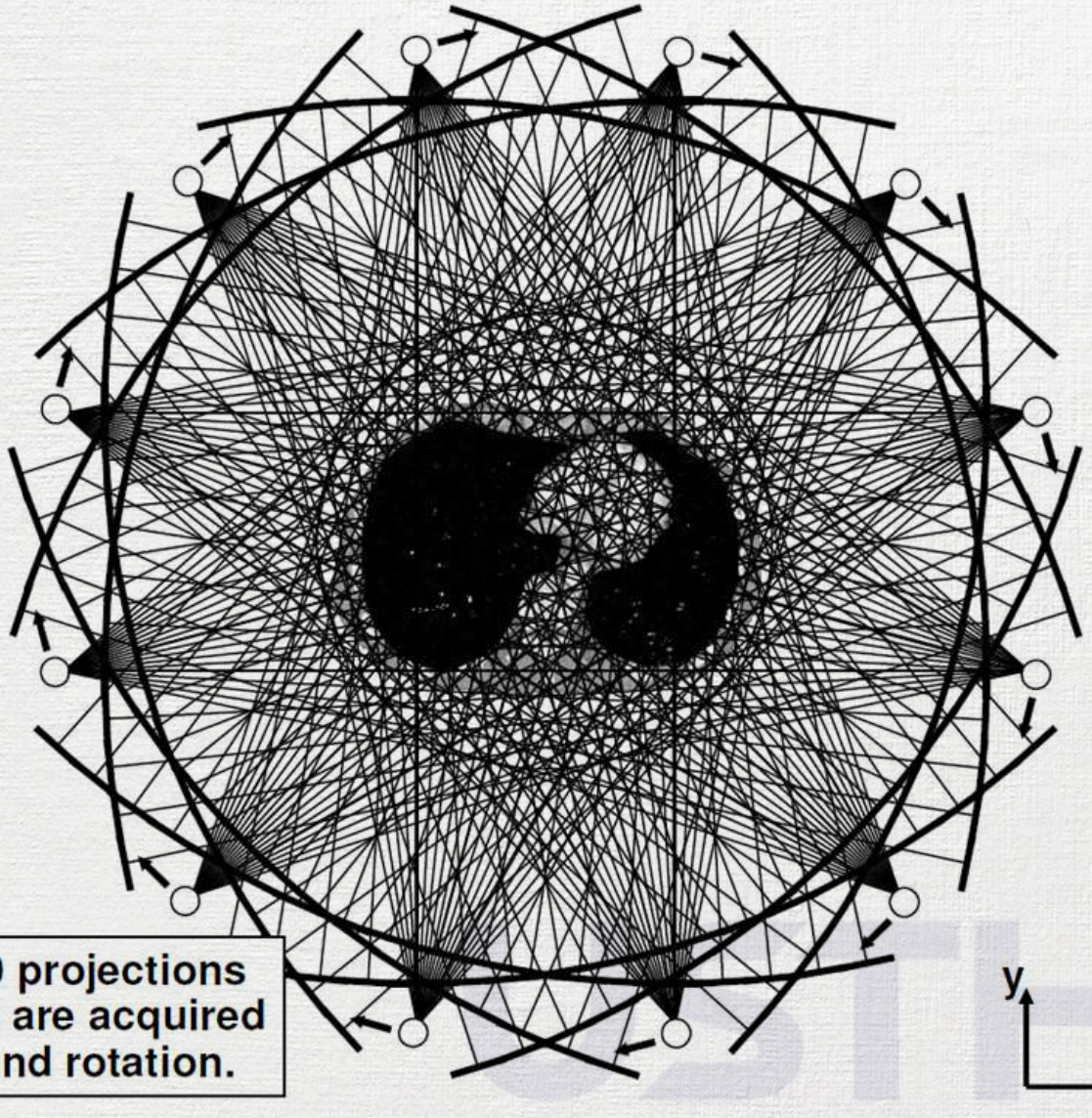


- Uses x-rays, but exposure is limited to a slice slices by a collimator
- Source and detector rotate around object - projections from many angles
- The desired image, $I(x, y) = \mu(x, y, z_0)$, is computed from the projections

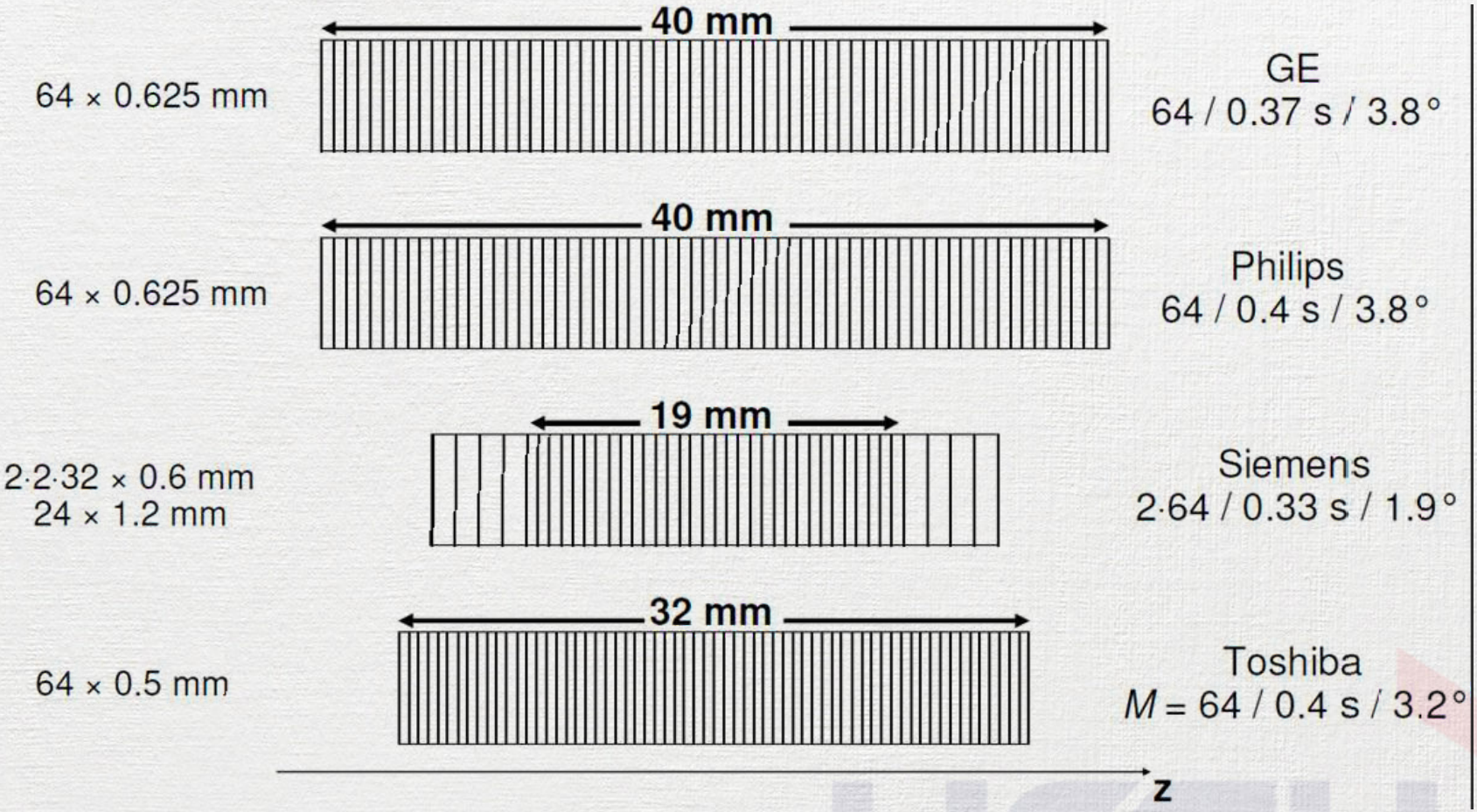
Slicing



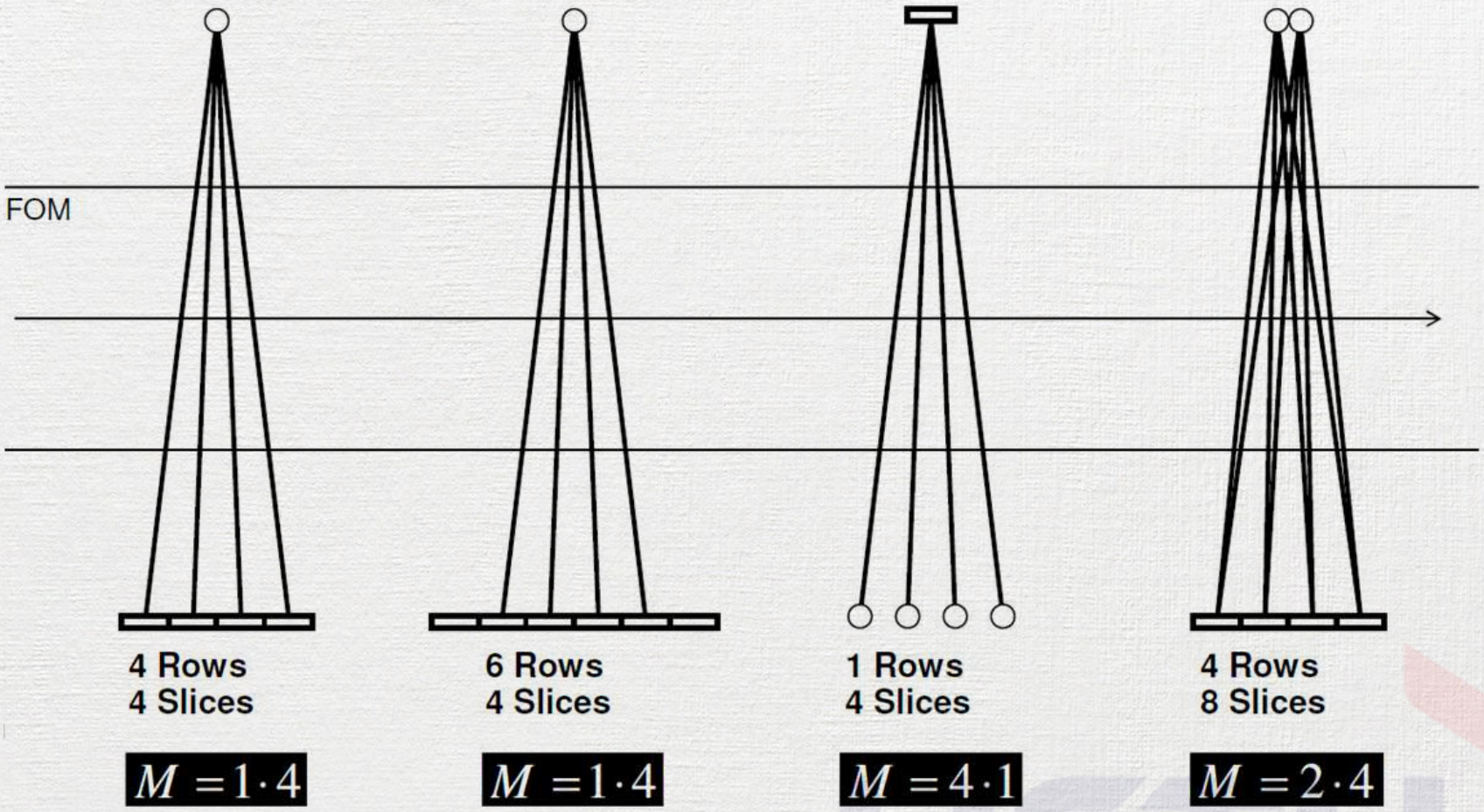
Slicing


In the order of 1000 projections
with 1000 channels are acquired
per detector slice and rotation.
y
x

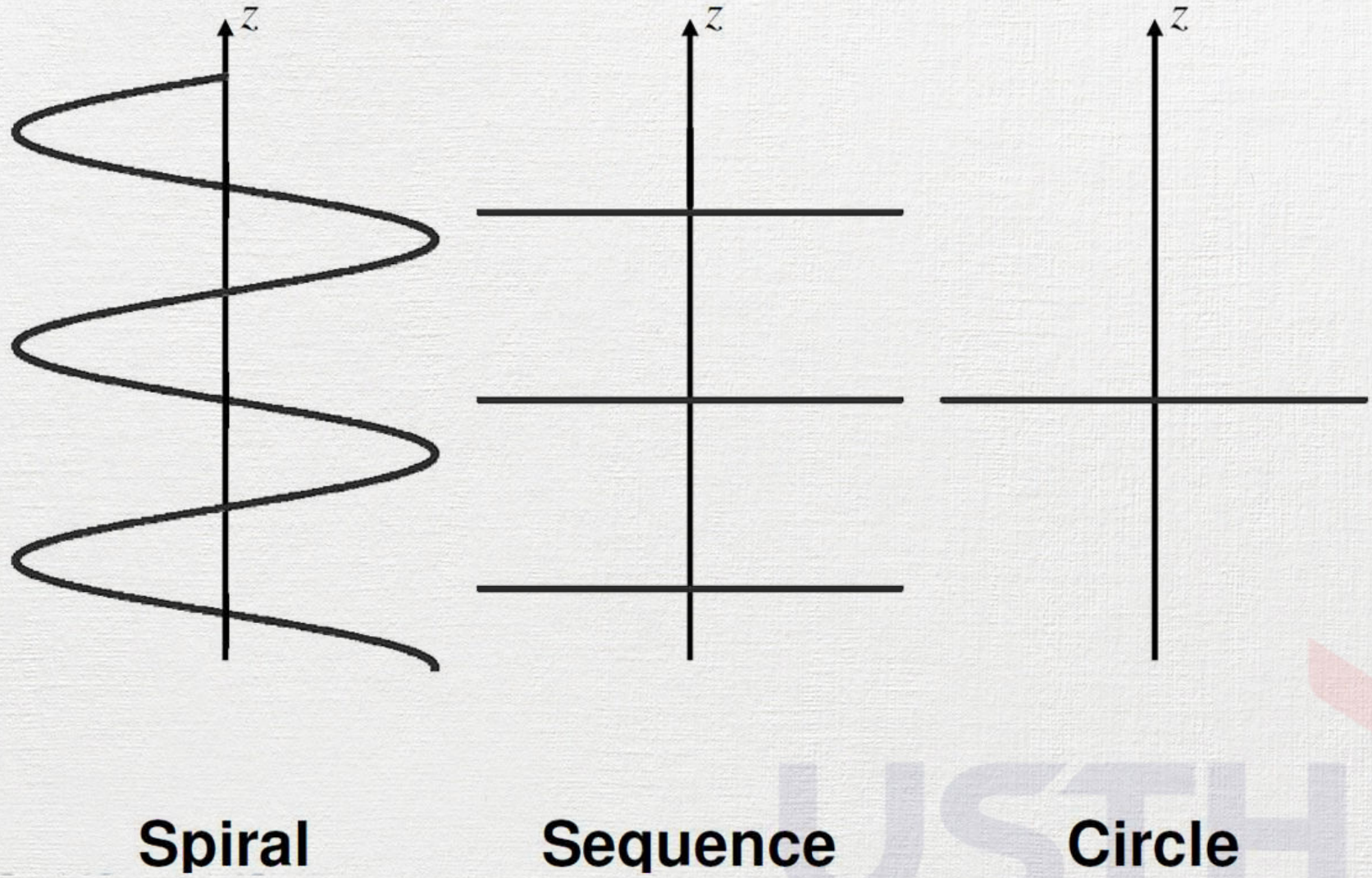
Multirow detector



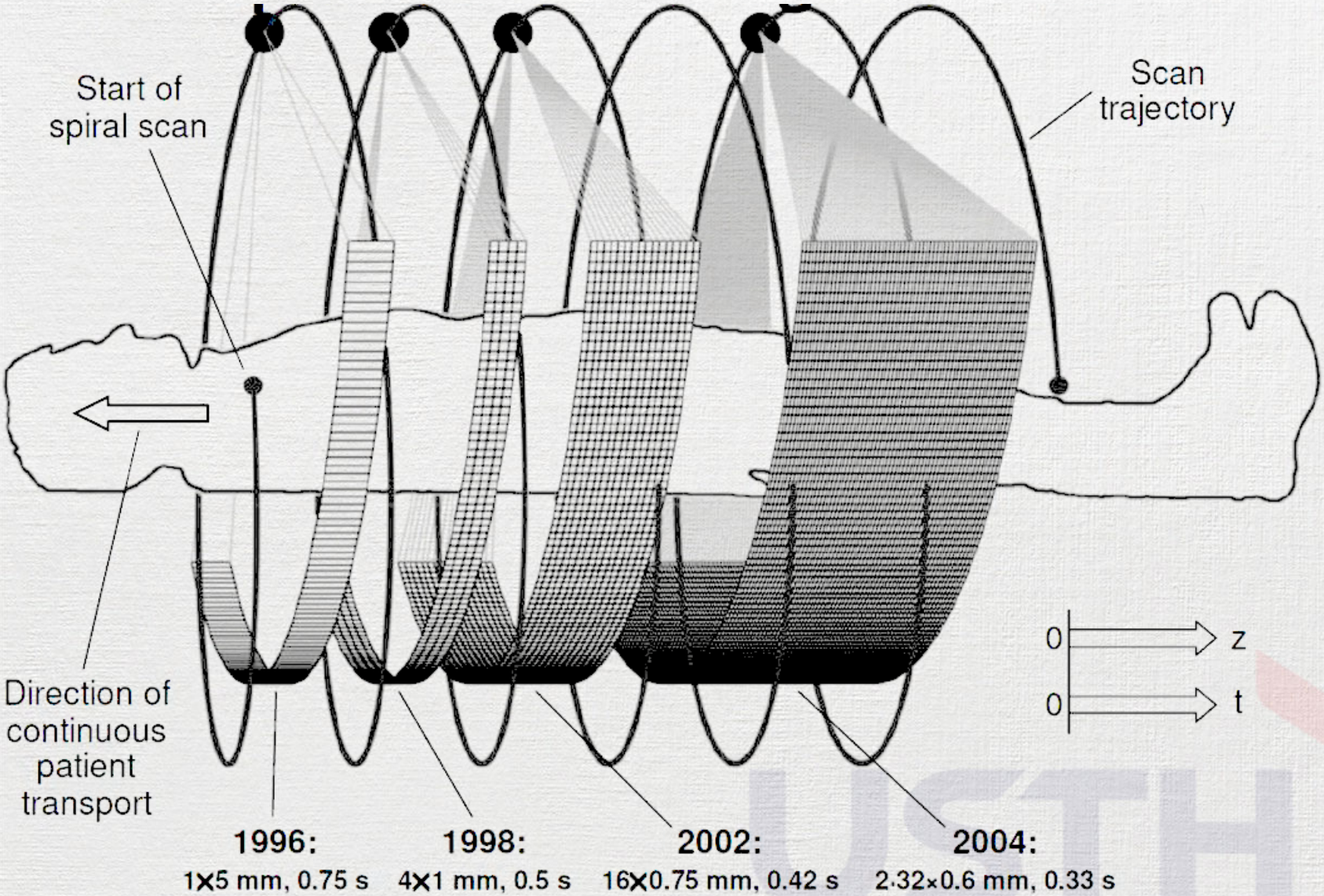
Row vs Slice


FOM
4 Rows
4 Slices
$M = 1 \cdot 4$
6 Rows
4 Slices
$M = 1 \cdot 4$
1 Rows
4 Slices
$M = 4 \cdot 1$
4 Rows
8 Slices
$M = 2 \cdot 4$

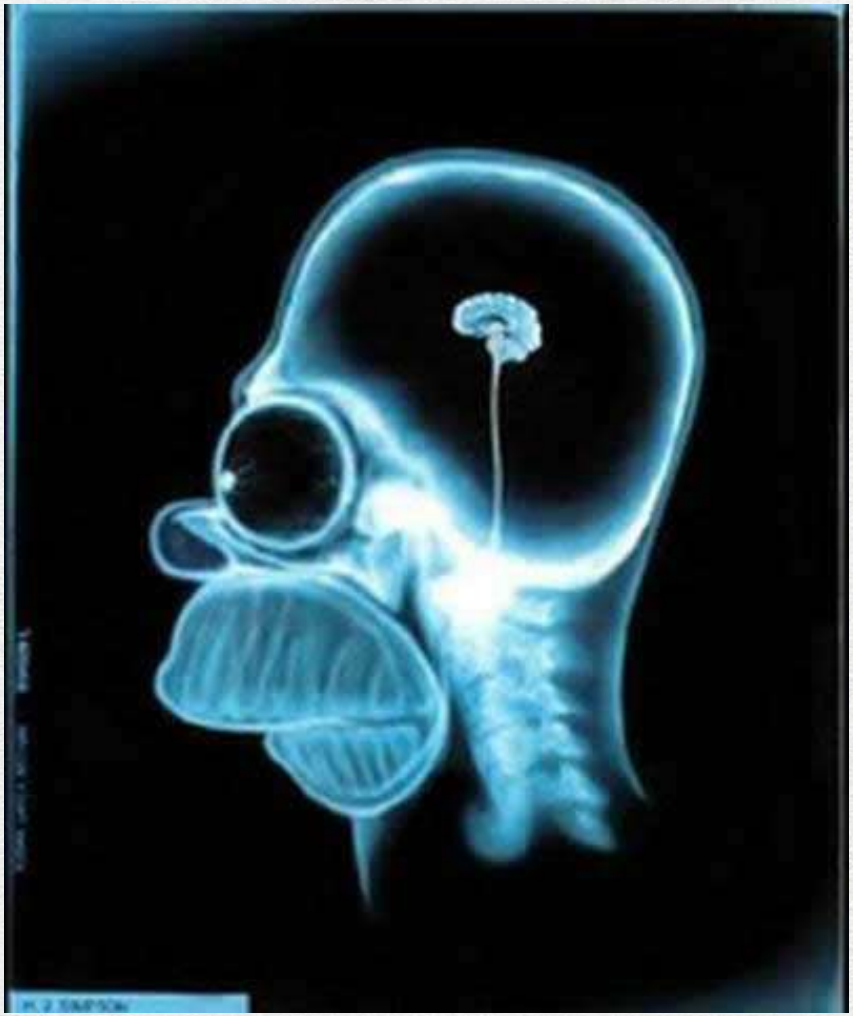
Trajectory



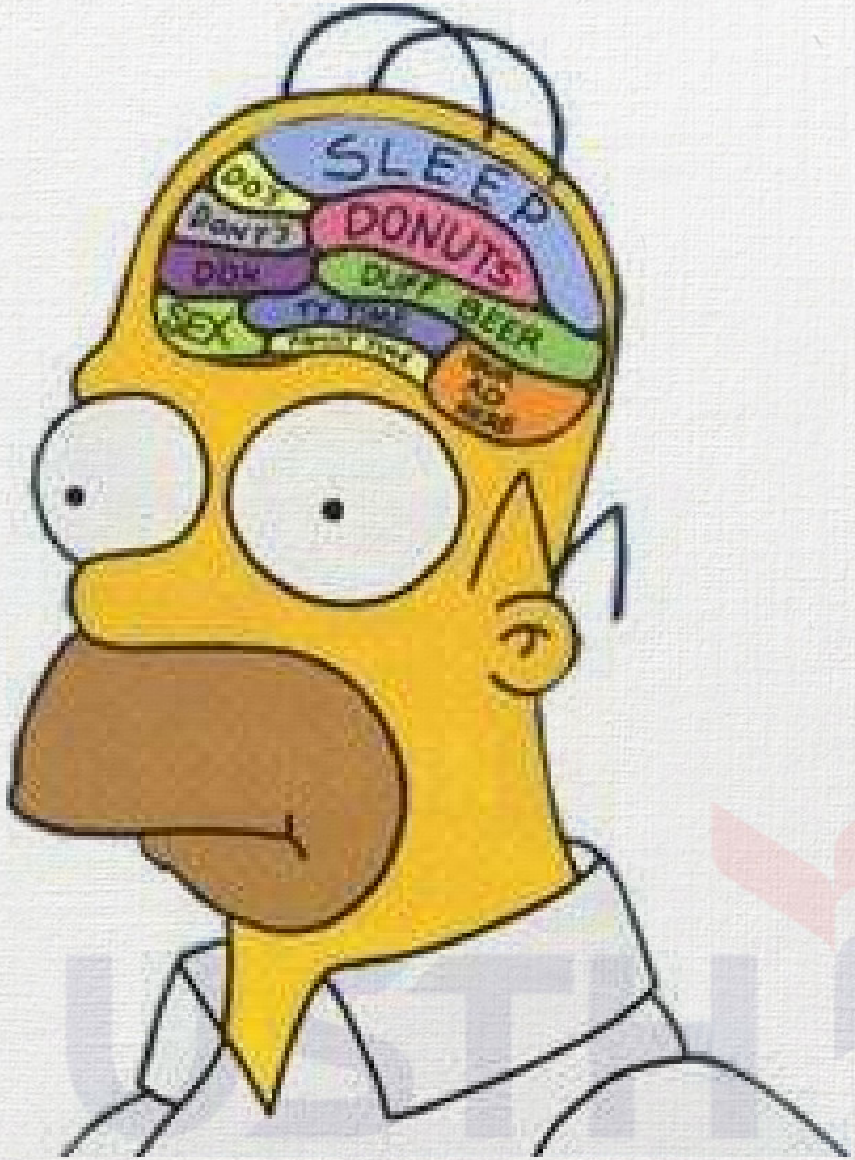
Spiral Trajectory



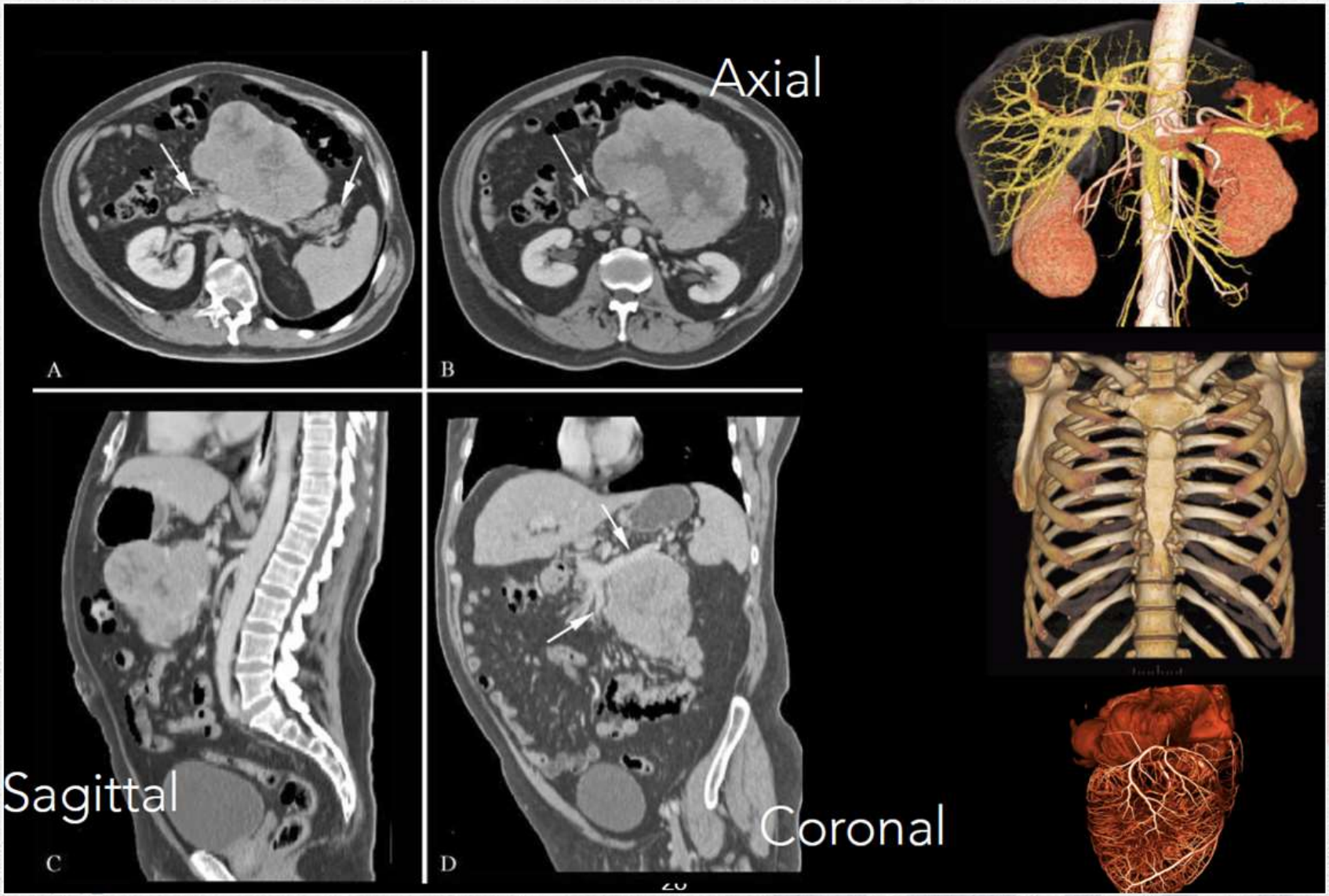
Anatomical vs Functional



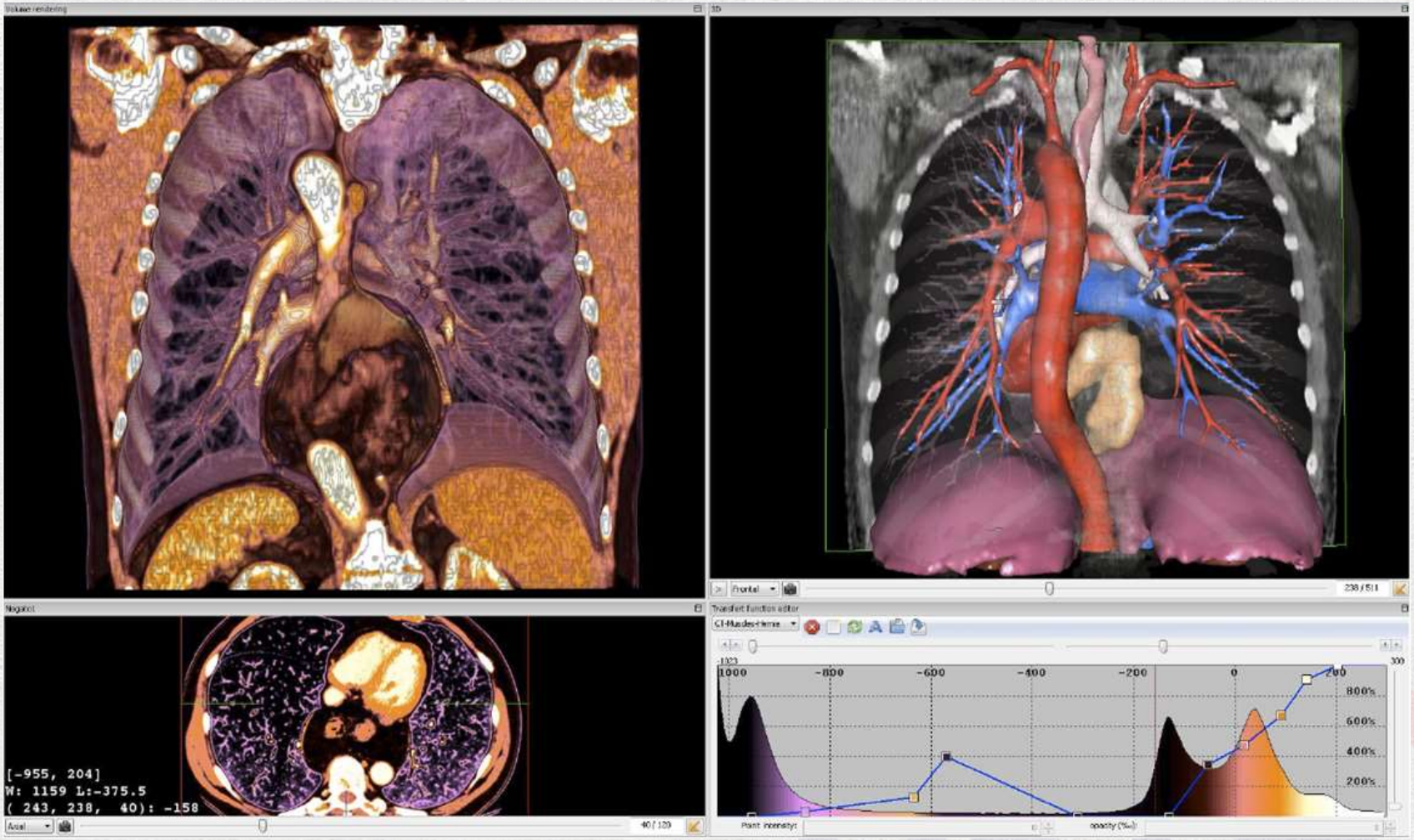
Anatomical



3D CT



3D CT


[-955, 204]
W: 1159 L:-375.5
(243, 238, 40): -158
1000
-800
-600
-400
-200
0
800%
600%
400%
200%

Hounsfield Unit

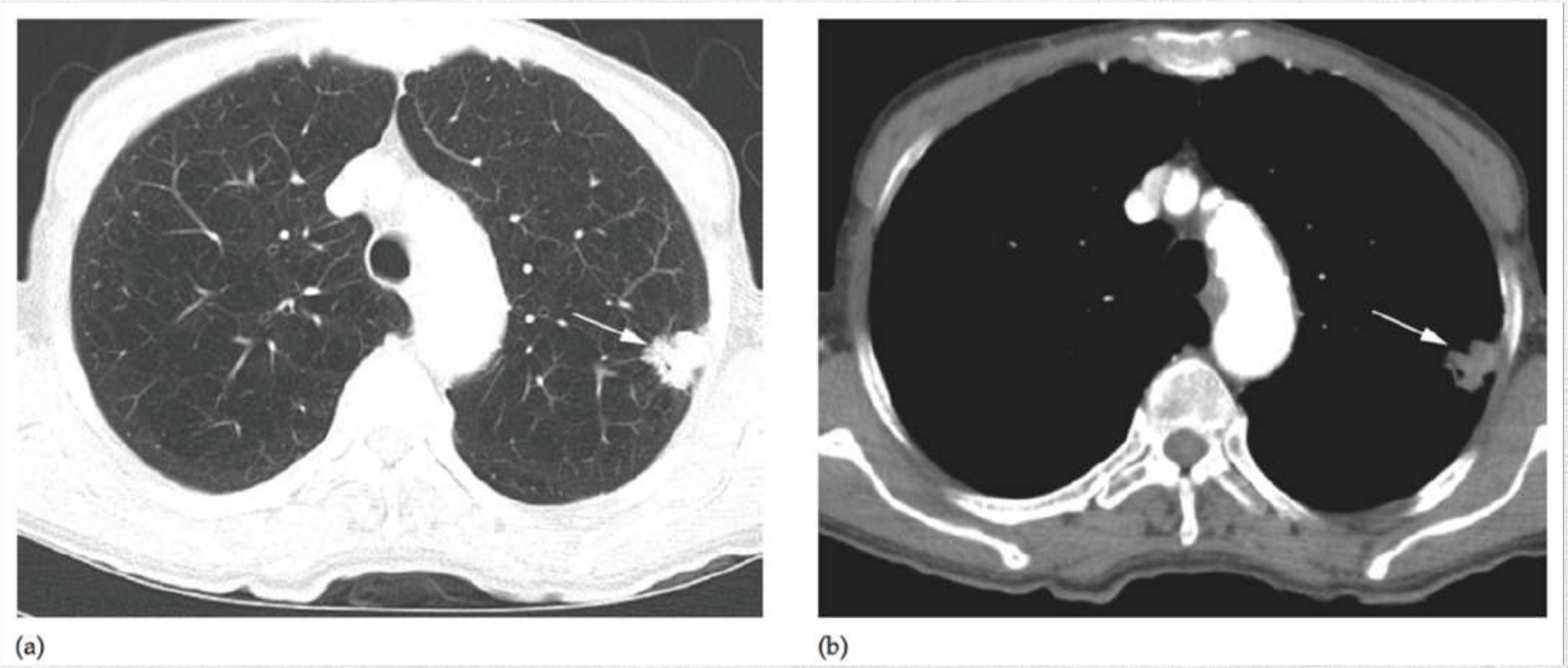
- Relative quantitative measurement of radio density
- Absorption/attenuation coefficient of radiation
- Linear transformation of the baseline linear attenuation coefficient of the X-ray beam

Hounsfield Unit

$$HU = 1000 \times \frac{\mu - \mu_{\text{water}}}{\mu_{\text{water}} - \mu_{\text{air}}}$$

- Air: -1000 HU
- Lung: -700 to -600 HU
- Distilled water: 0 HU
- Bone: 1000 HU
- Dense bone: 2000 HU
- Metal: 3000+ HU

Windowing



Lung window - Soft tissue

Practice!

Practical work 4

- Detection of Pulmonary Nodule from CT images
  - Download LUNA16
  - Explore the dataset
  - Build ONE machine learning/deep learning model to perform **volumetric (3D) detection** of pulmonary nodule in the input image.

Practical work 4

- Write a report (in LaTeX)
  - Name it « Report.4.tex »
  - Describe the dataset *in detail* that you have downloaded
  - Explain how you implement the model
  - Compare your results with other methods in the leaderboard
  - Try experimenting with different hyperparameter values
- Push the report and your code (Notebook and .py script) to your forked repository