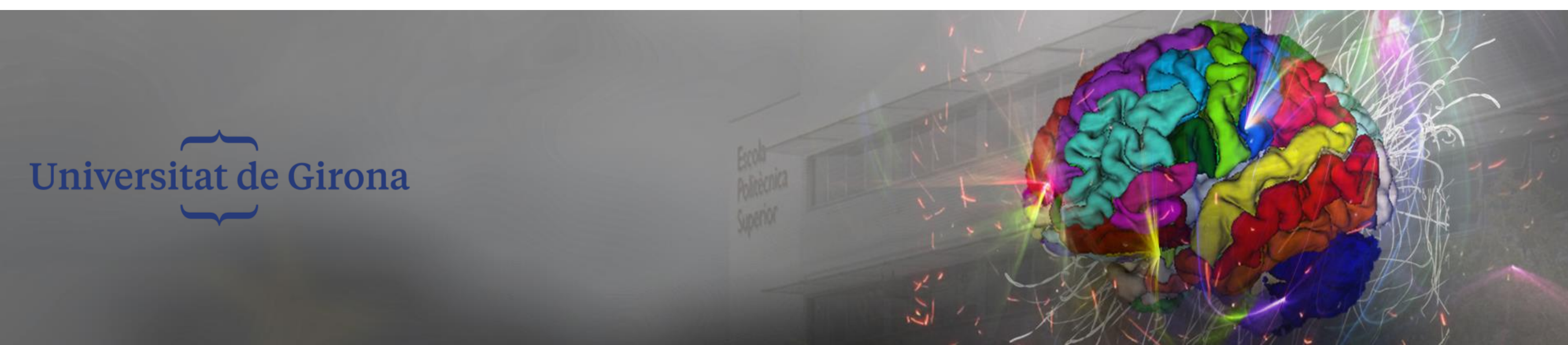
E-Health
Image Acquisition & Display

Robert Martí

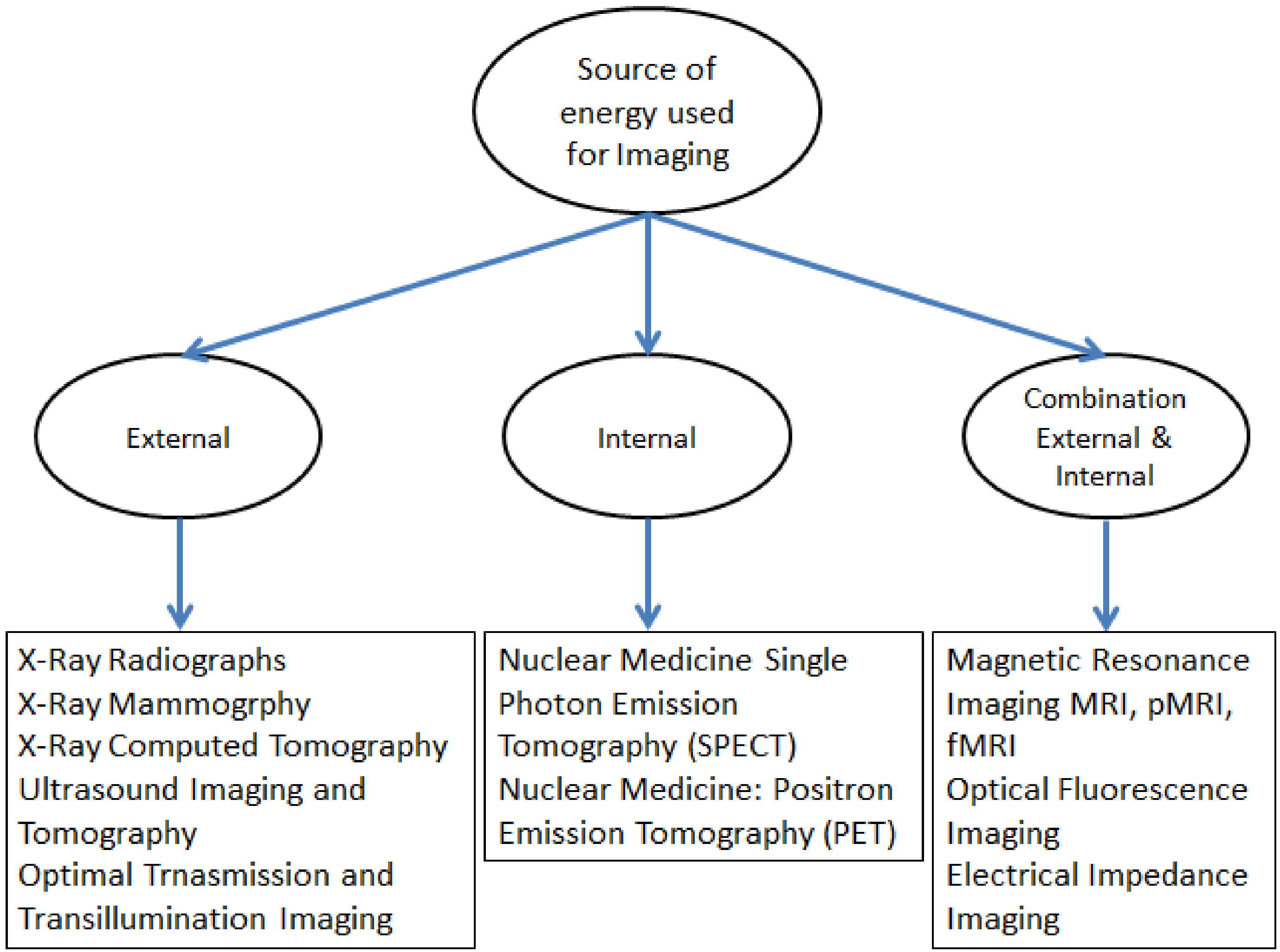


Acquisition and visualization

- Acquisition
  - From physical measure to signal (pixel intensity).
- Pre-processing (RAW -> for presentation).
- Reconstruction (tomographic reconstruction)
- PACS: storage, protocols.
- Visualization workstation
  - Hanging protocols
  - Reading time / tools.
  - Reporting and Annotation tools.
- CAD workstation.
  - How is CAD integrated?
  - Prompting / Interactive CAD?

Medical Imaging: classification

- According to the location of the radiation source



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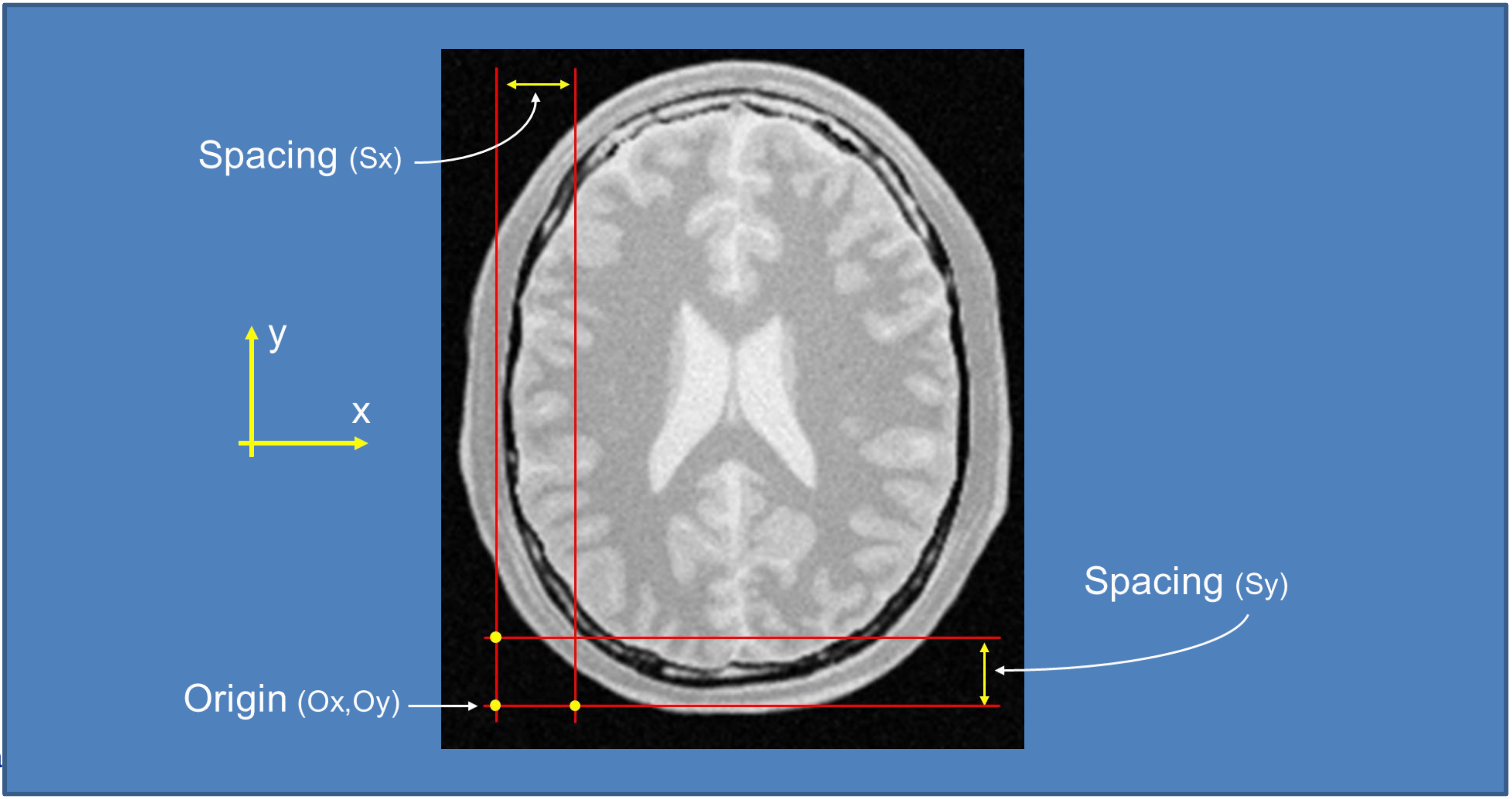
Medical image acquisition

- Resolution, dimensionality (2D/3D/4D) data.
  – Temporal information
- Typology of the information shown.
  – Functional imaging
  – Morphological imaging
- Multi-modality
  – Correspondence is already known.
  – Registration is needed to be performed.
  – 2D – 3D information (need of correspondence).

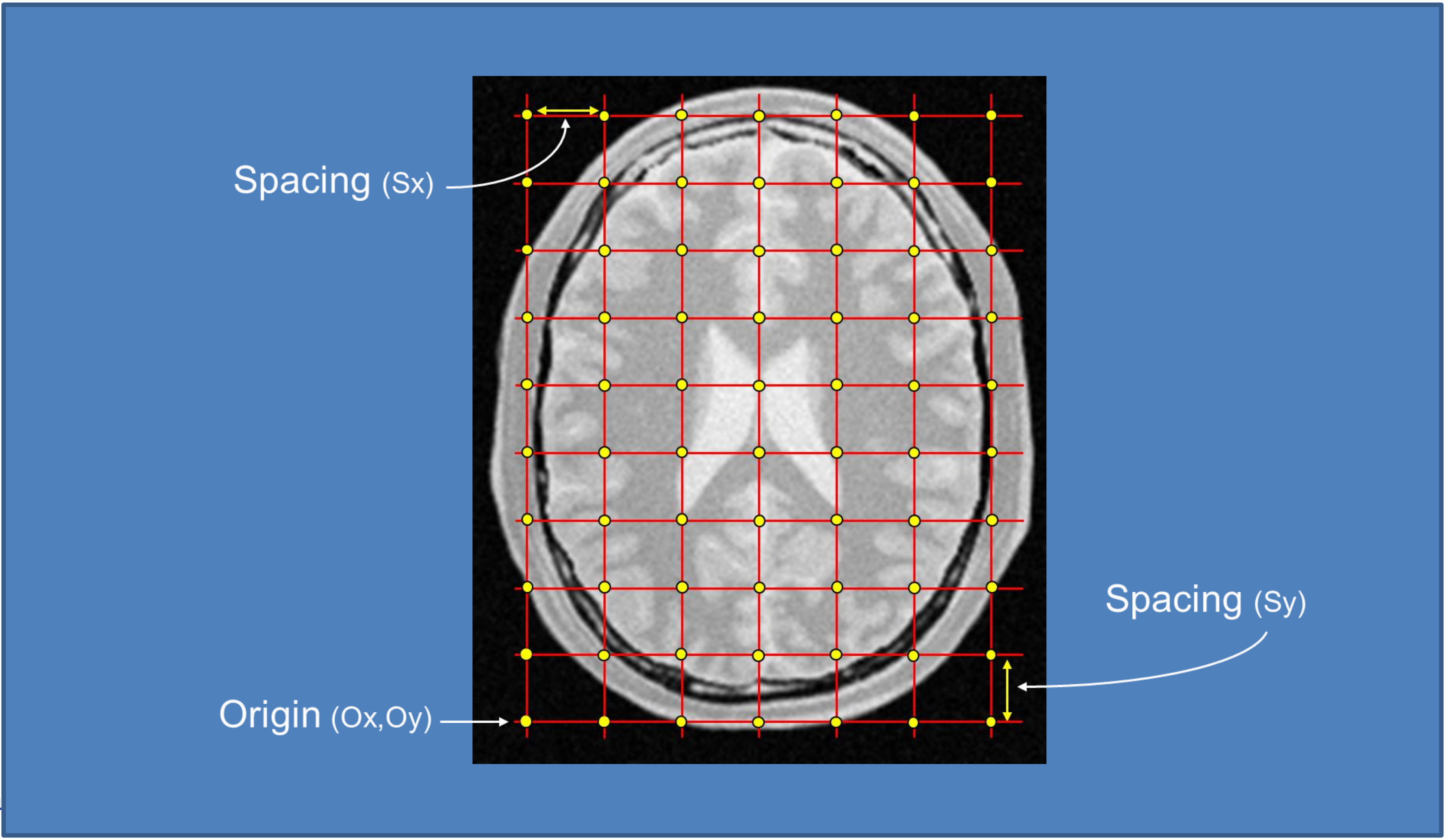
Resolution

- What is an image?
  - Sampling of a continous field using a discrete grid.



Images & Pixels (from itk slides)

- Sampling grid



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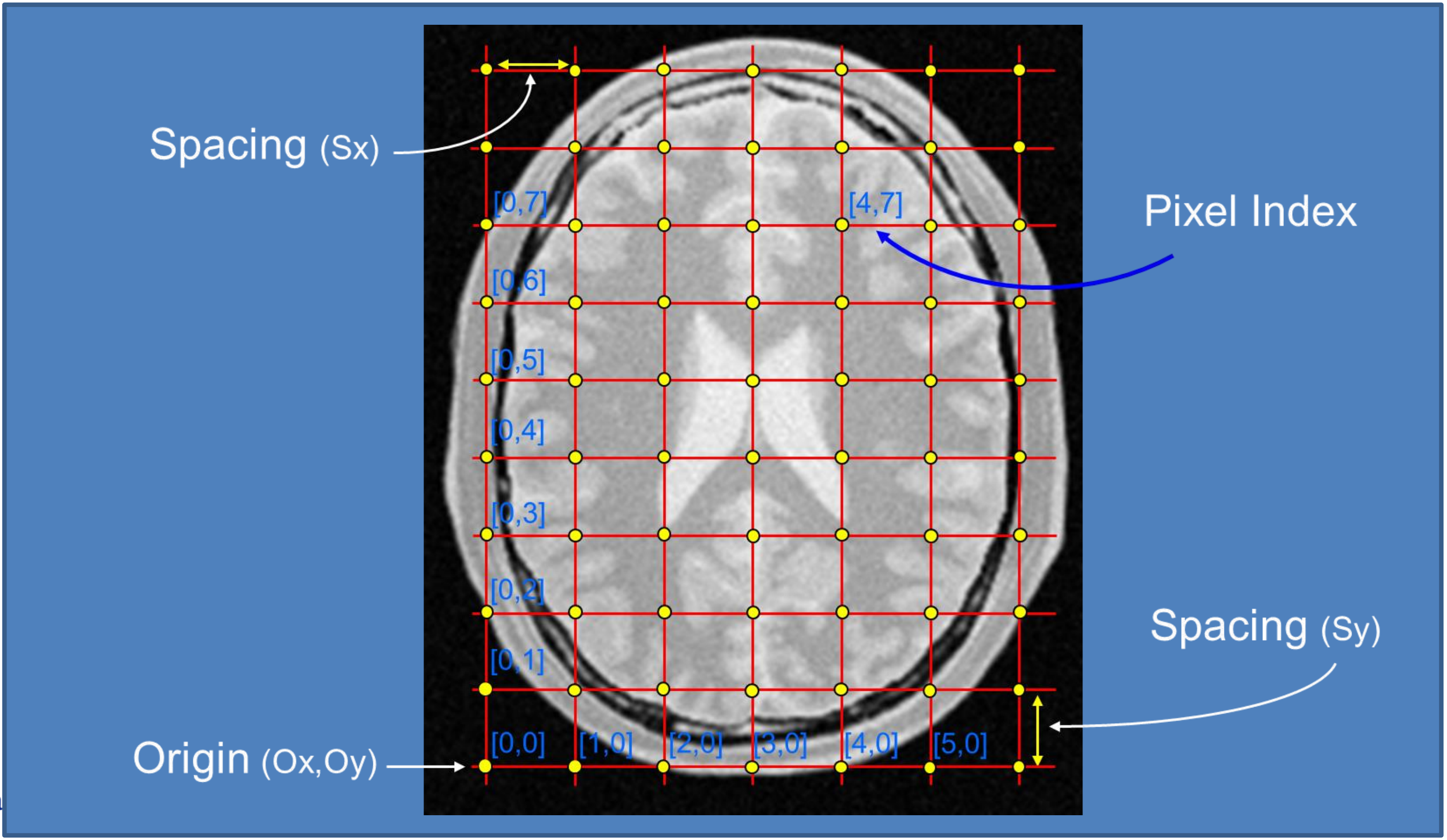
Images & Pixels (from itk slides)

- Image indices



Images & Pixels (from itk slides)

- Use pixel or physical coordinates?
- Convert from physical to pixel coordinates

$$P[0] = Index[0] \times Spacing[0] + Origin[0]$$
$$P[1] = Index[1] \times Spacing[1] + Origin[1]$$

$$Index[0] = floor((P[0] - Origin[0]) / Spacing[0] + 0.5)$$
$$Index[1] = floor((P[1] - Origin[1]) / Spacing[1] + 0.5)$$

- Activity: Physical coordinates example.
  - 3D Ultrasound. What is the size of the lesion?

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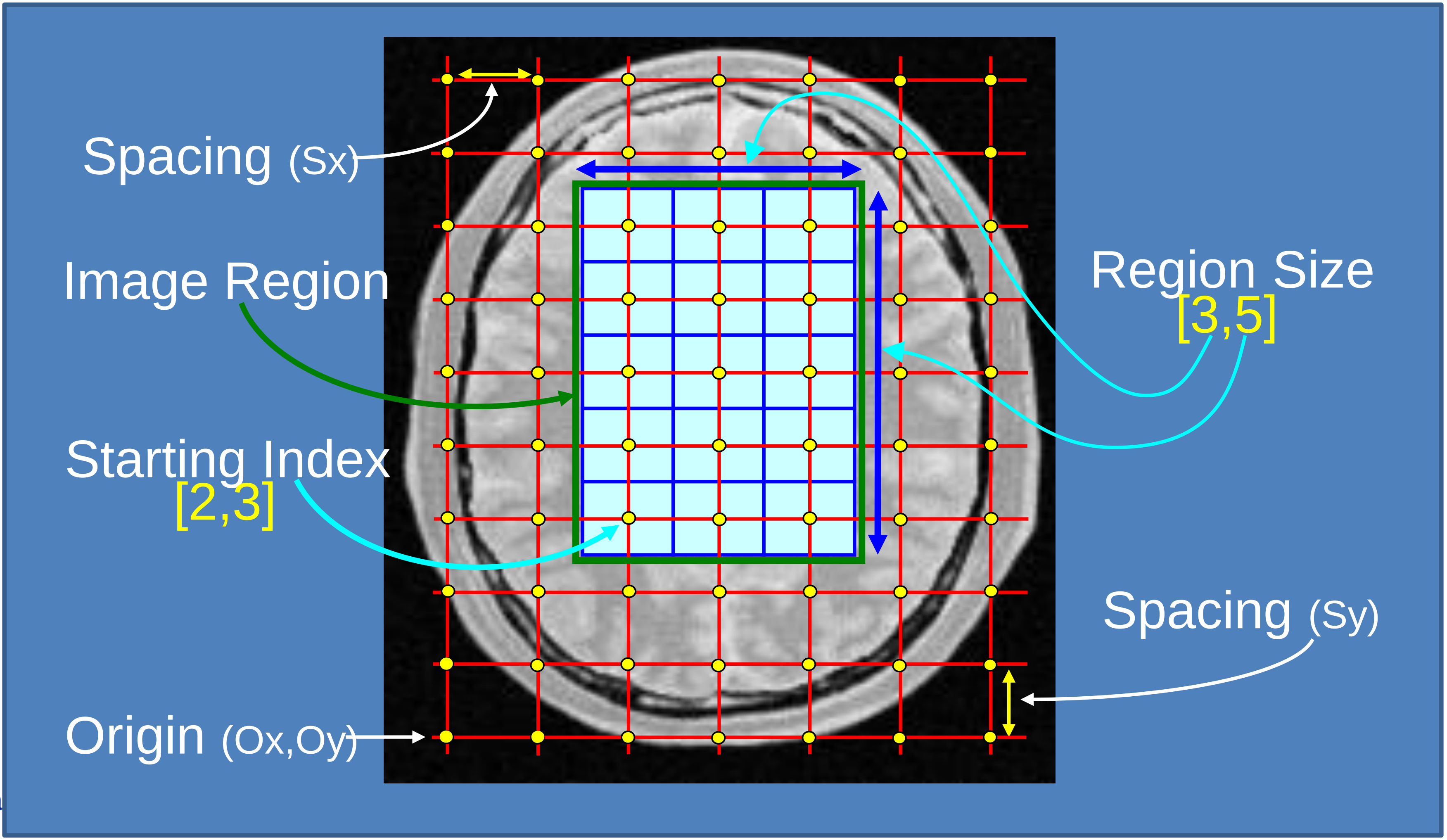
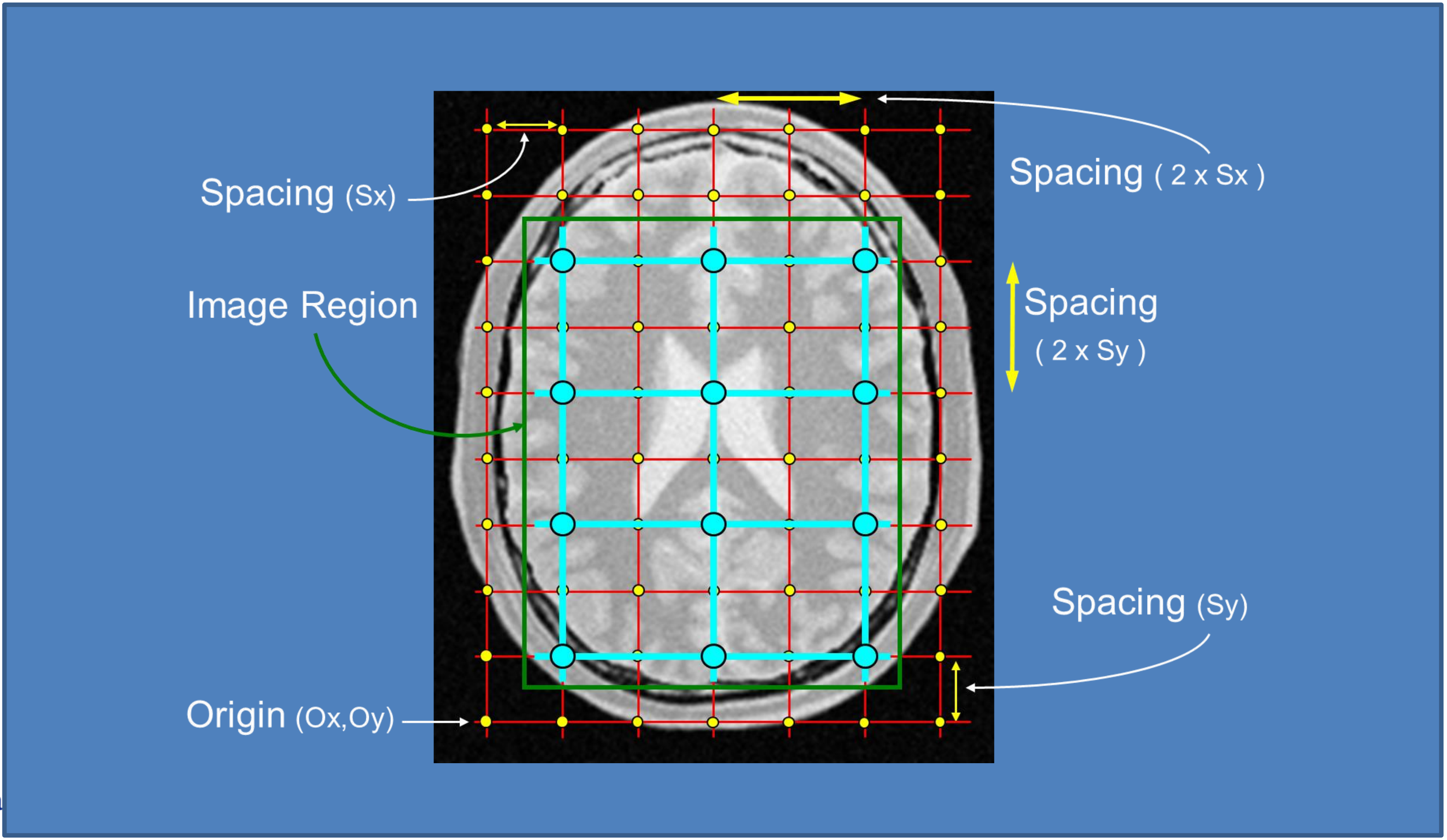
Images & Pixels (from itk slides)

- Image region



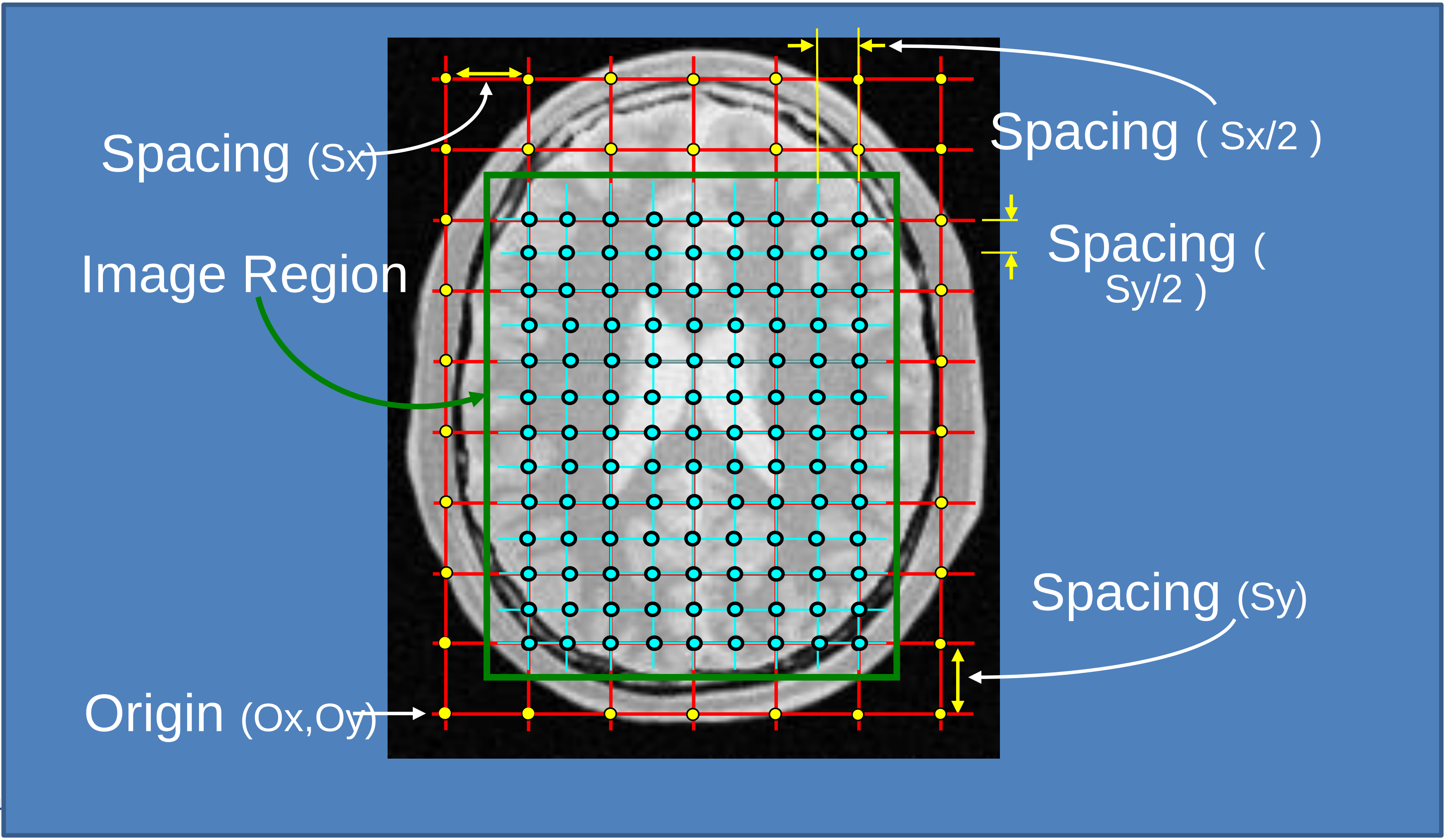
Images & Pixels (from itk slides)

- Resampling



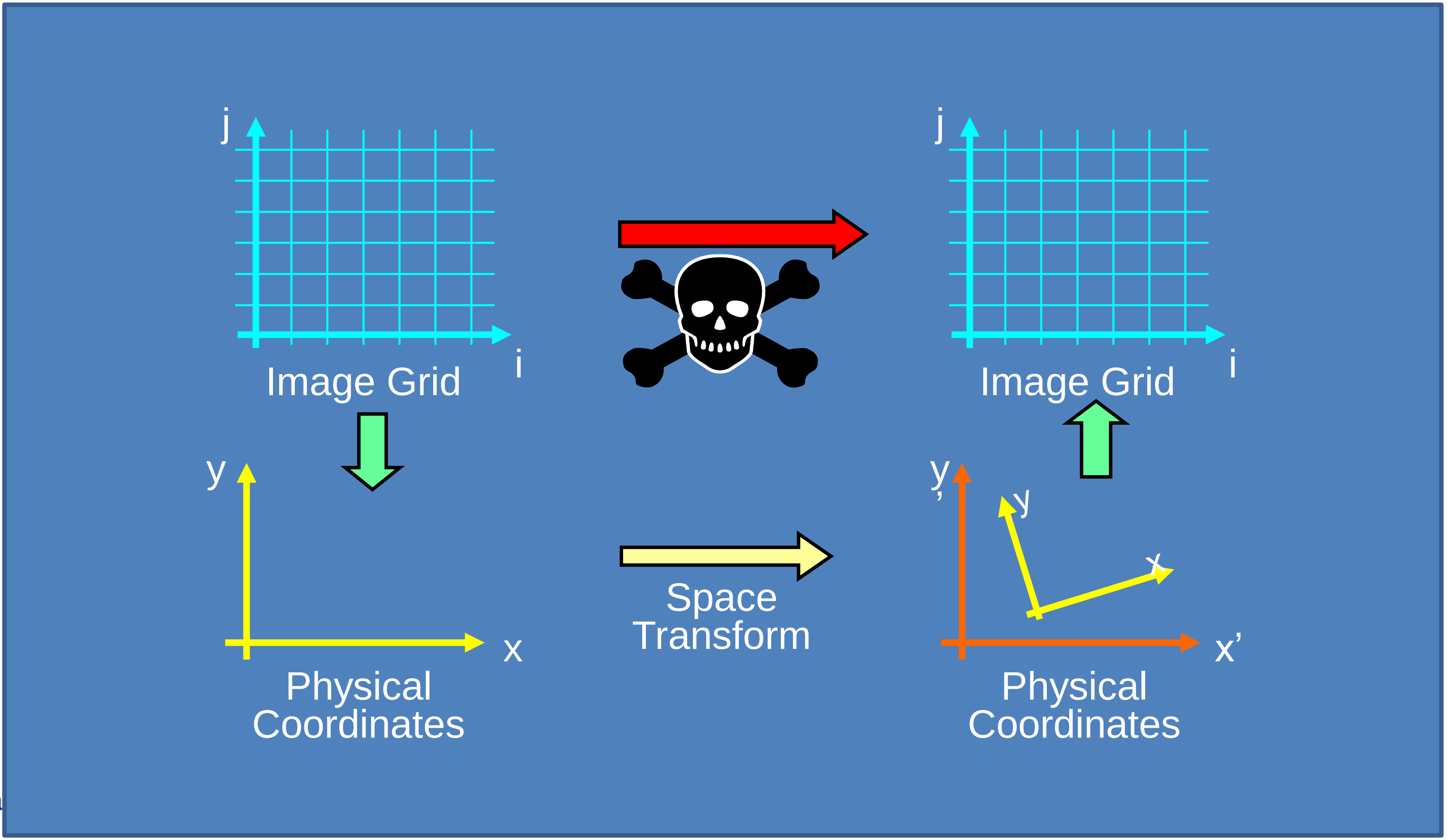
Images & Pixels (from itk slides)

- Super Sampling



Images & Pixels (from itk slides)

- Comparing images



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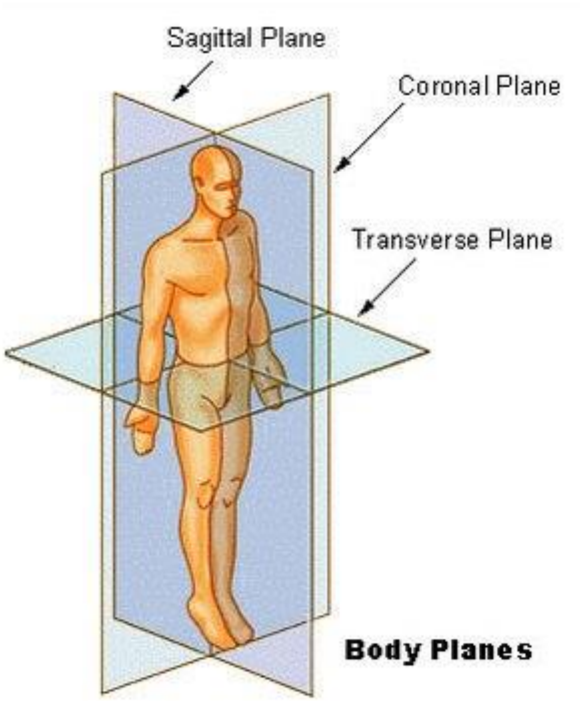
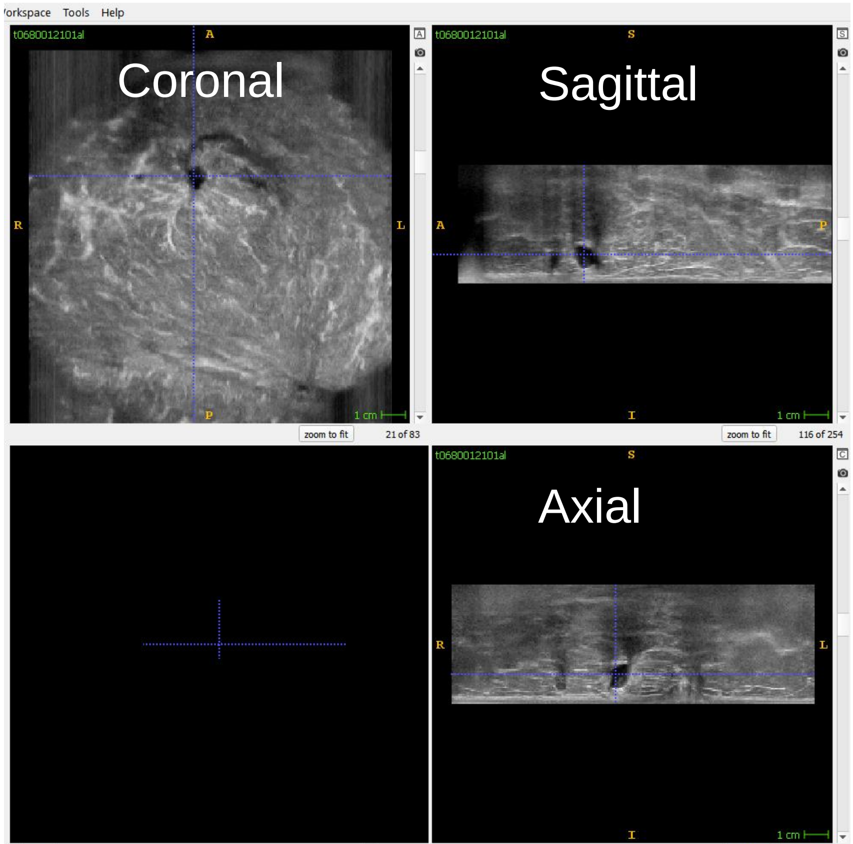
Dimensionality

- Anatomical views
  - Sagittal (left to right)
  - Coronal (front to back)
  - Transverse (axial) (top to bottom)
- Example: 3D ultrasound



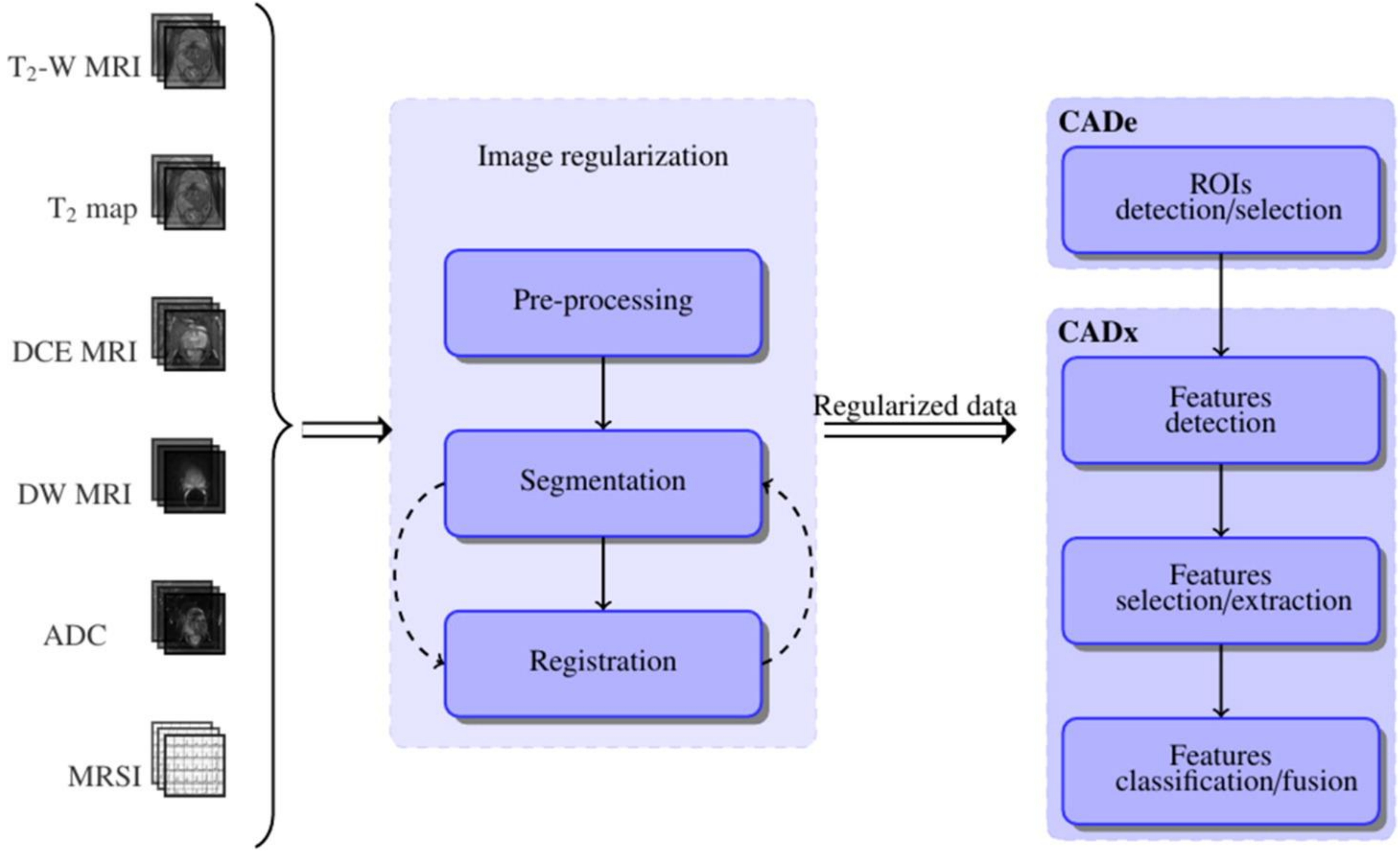


MRI: A good example

- Dimensionality: 2D/3D/4D,… nD?
  - Spin echo sequences (T1 / T2 / PD)
    - TR (repetition), TE (echo) variables
  - Inversion recovery sequences. (+ inversion time TI).
    - Short tau inversion recovery (STIR): fat is nulled
    - Fluid attenuated inversion recovery (FLAIR) or double inversion recovery (DIR). Fluid is nulled.
  - Dynamic Contrast Enhanced MRI (DCE).
  - Diffusion
  - DWI (coupled with T2)
  - Apparent diffusion coefficient maps (ADC)
  - Spectroscopy

Magnetic Resonance Imaging (MRI)

- Multi-modal image analysis / visualization



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Magnetic Resonance Imaging (MRI)

- Example: brain imaging, several sequences.

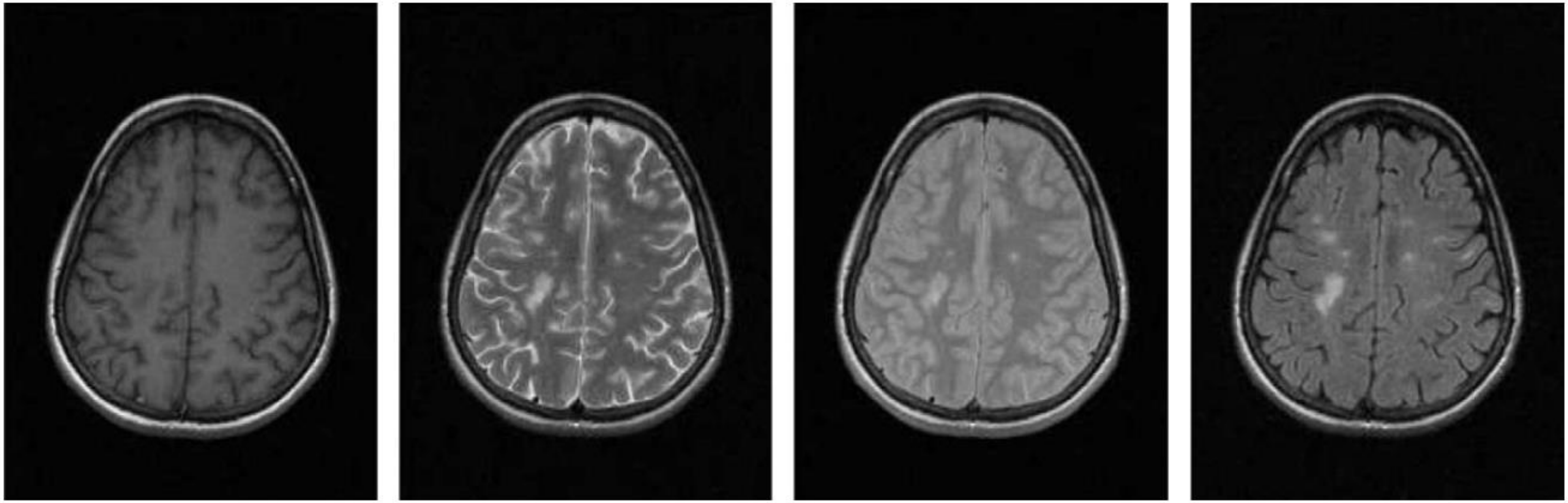
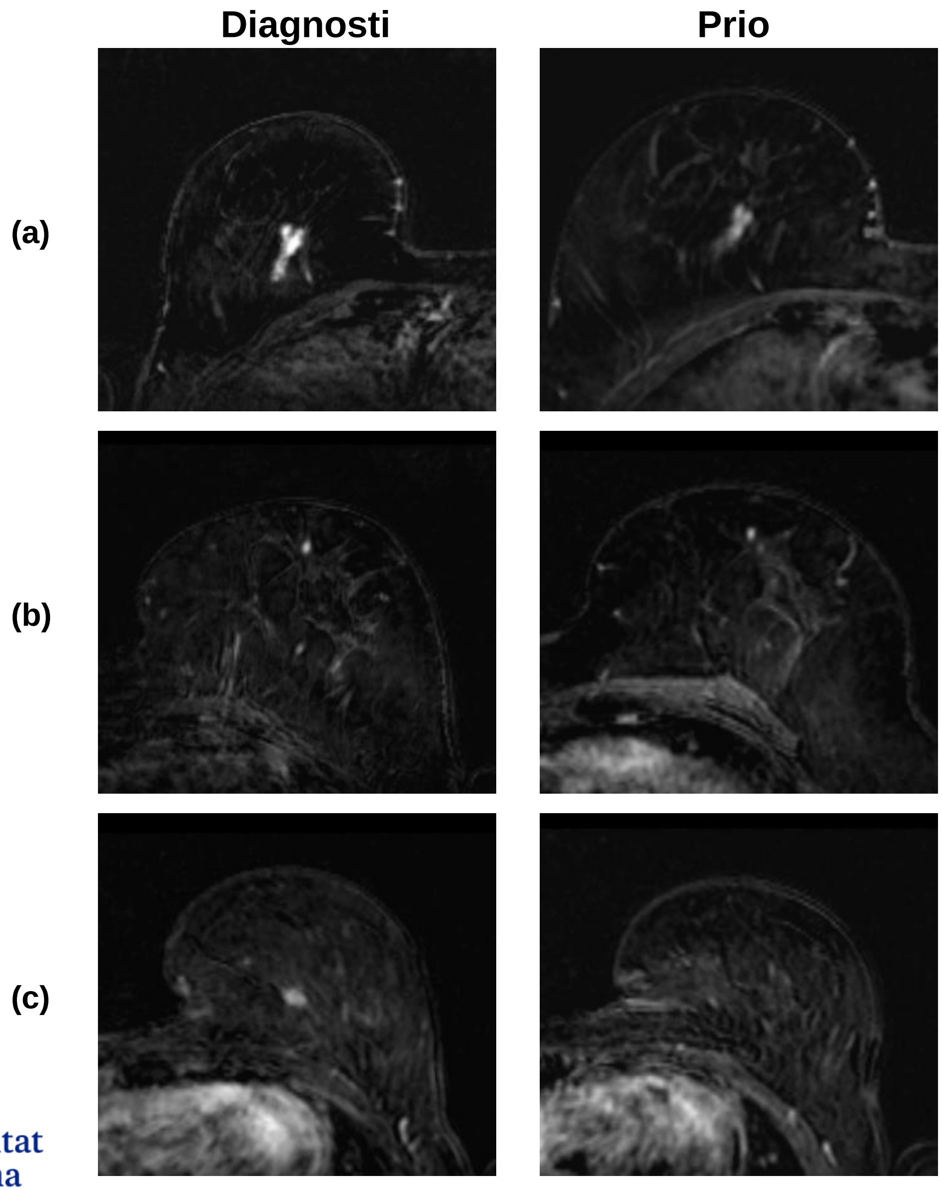
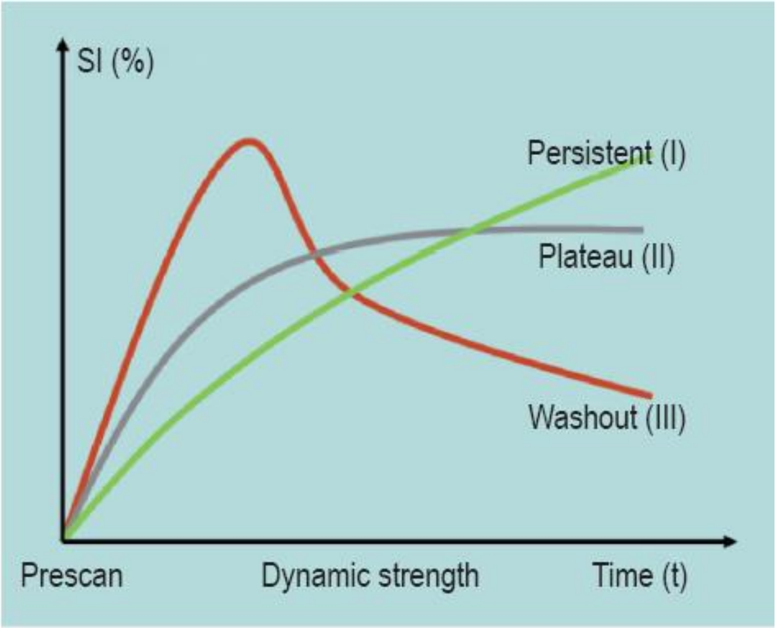


Fig. 1. MR images of a brain slice with MS lesions: (a) T1-w, (b) T2-w, (c) PD-w, and (d) FLAIR, respectively. Note that soft tissues are more distinguishable in the T1-w image, while lesions are usually better appreciated in the FLAIR one.

Magnetic Resonance Imaging (MRI)

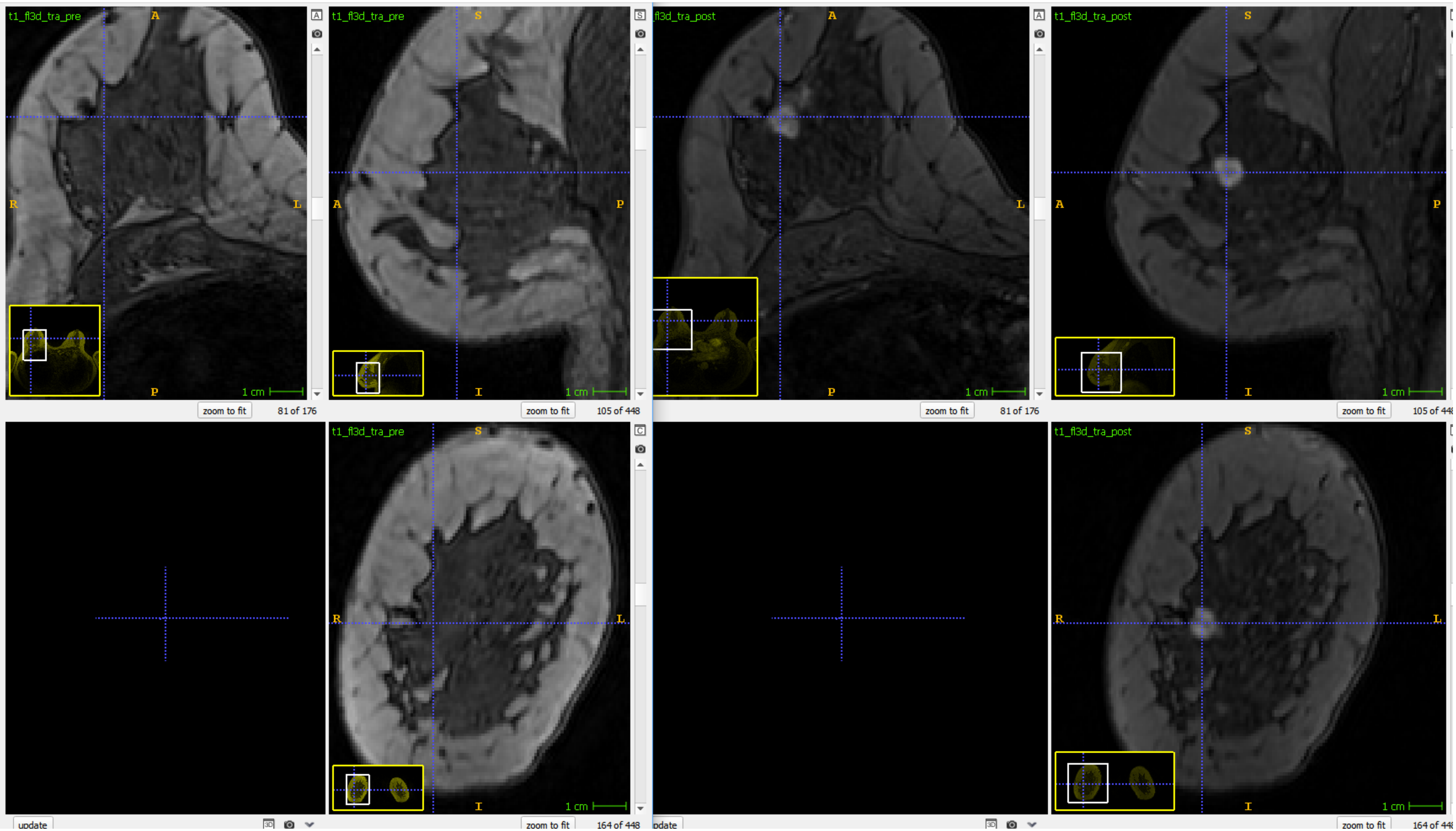
- DCE MRI.





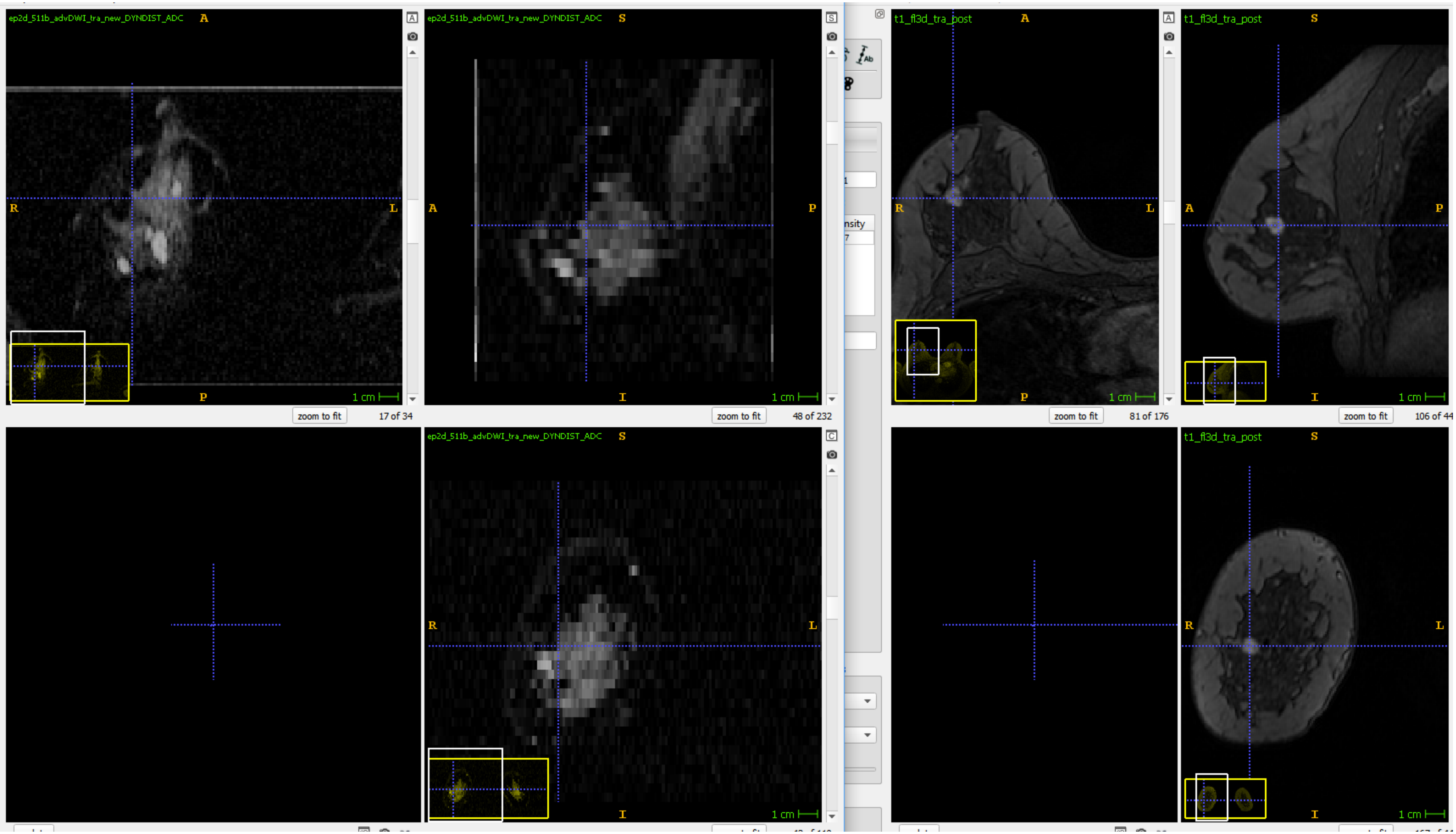
Magnetic Resonance Imaging (MRI)

- DCE MRI.



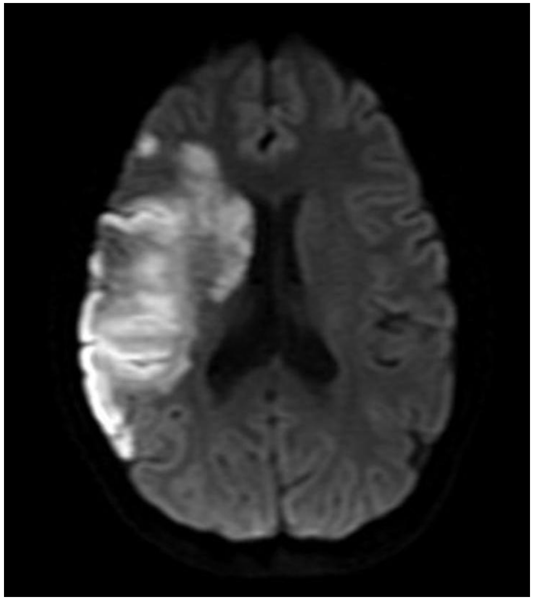
Magnetic Resonance Imaging (MRI)

- DWI / ADC

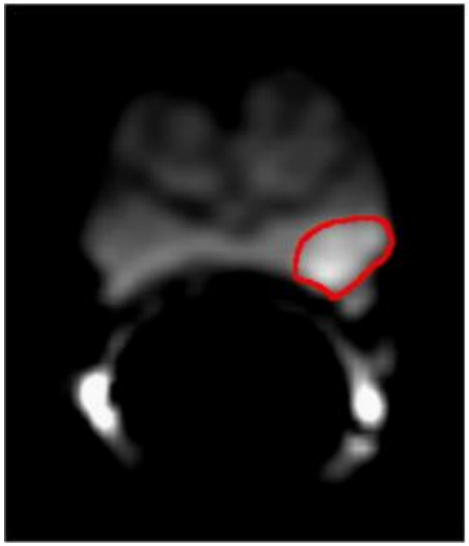


Magnetic Resonance Imaging (MRI)

- DWI / ADC
  - Diffusion Weighted Imaging / Apparent Diffusion Coefficient
  - The signal in DW MRI images is inversely correlated to the degree of random motion of water molecules.
  - In highly cellular tissues (i.e. tumour) there is more restriction o water movement -> lower diffusion (keep the signal)
  - Moving water molecules -> higher diffusion (signal loss).



DWI



DWI

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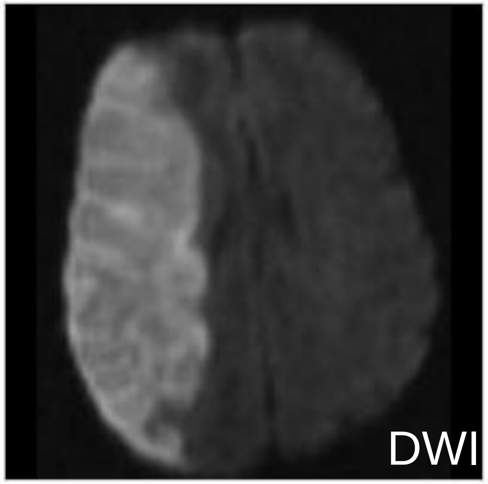
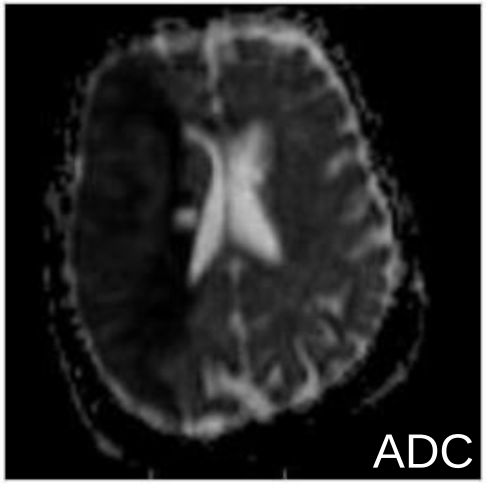
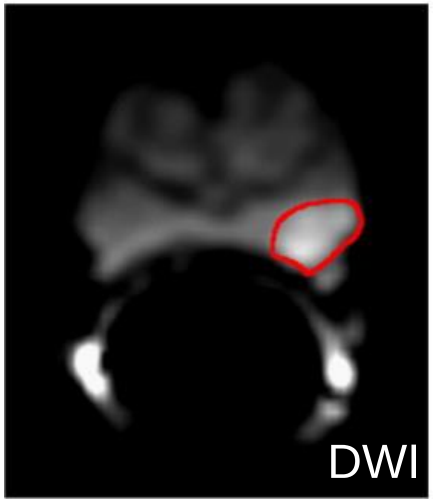
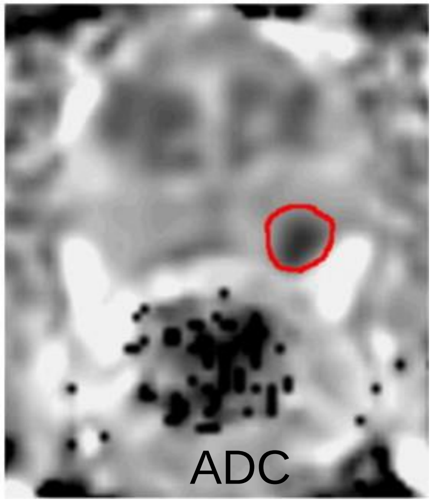
Magnetic Resonance Imaging (MRI)

- DWI / ADC
  - Apparent Diffusion Coefficient (diffussion of water molecules in tissue) build using different sequences (various b-values).
  - b- values: degree of the diffusion weighting (parameter).
  - ADC of a tissue is expressed in units of mm^2/s
    - white matter: 670-800
    - cortical grey matter: 800-1000
    - deep grey matter: 700-850
    - CSF: 3000-3400
    - Reestriction < 1.0 to 1.1 x 10^{-3} mm^2/s



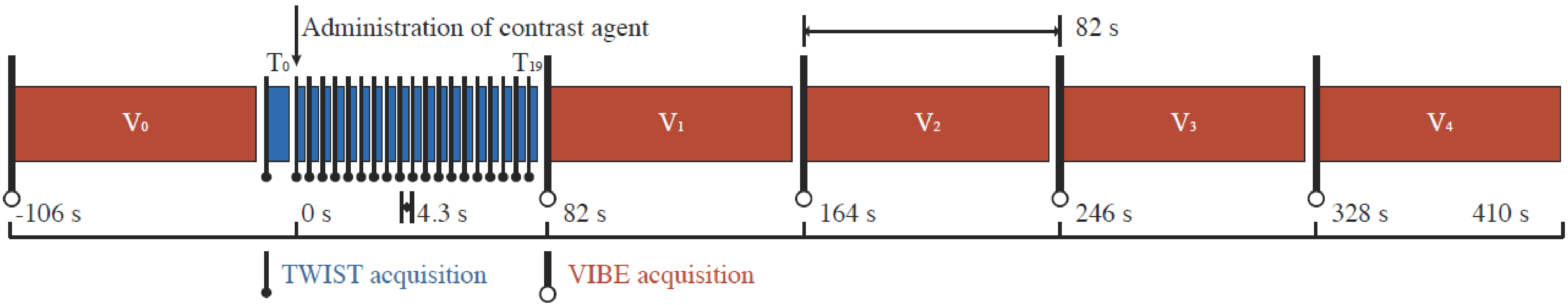


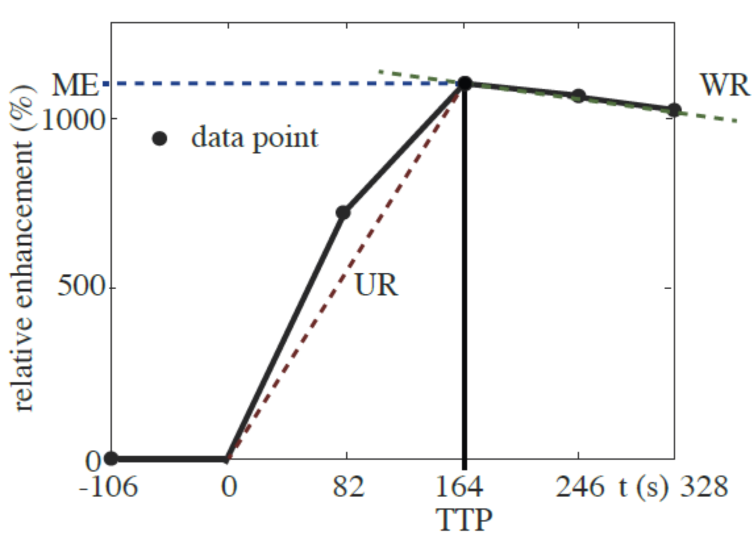


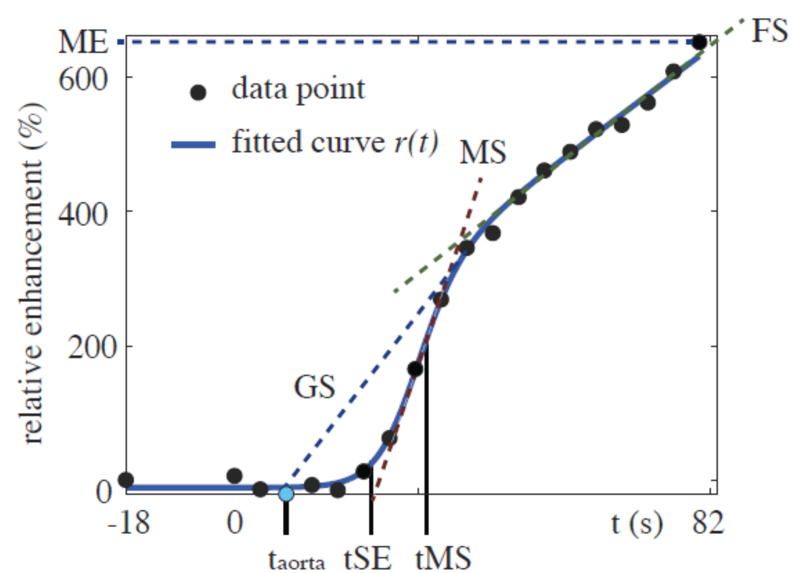


Magnetic Resonance Imaging (MRI)

- TWIST
  - Fast DCE MRI







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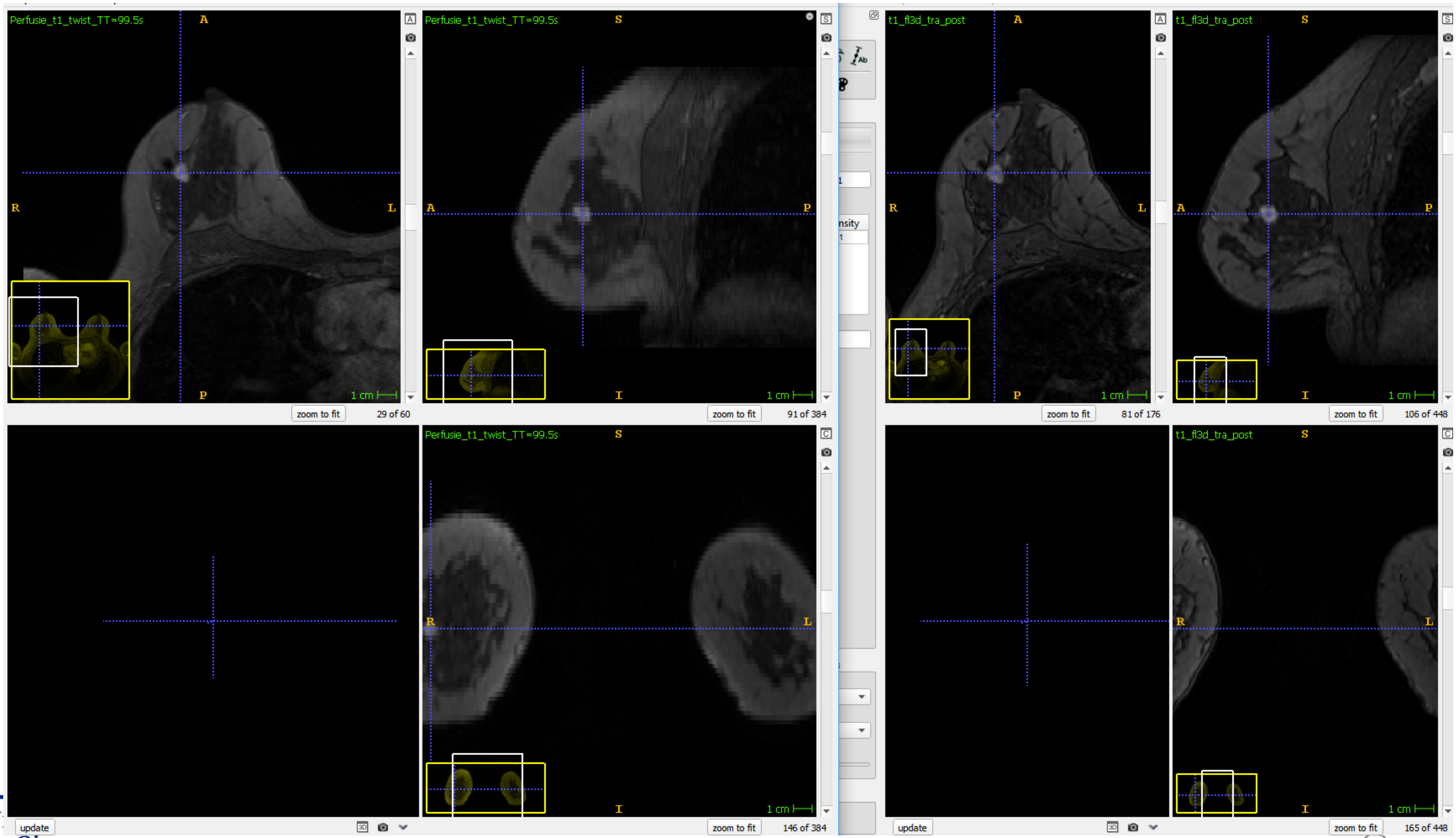
Magnetic Resonance Imaging (MRI)

- TWIST



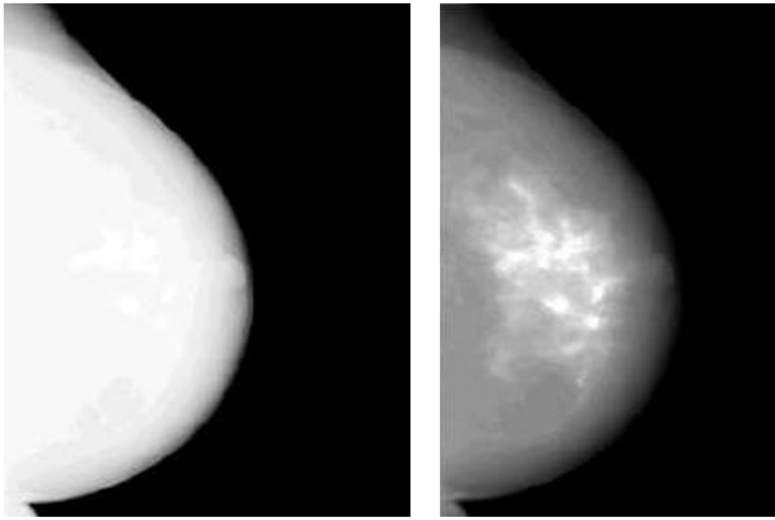
X-ray imaging

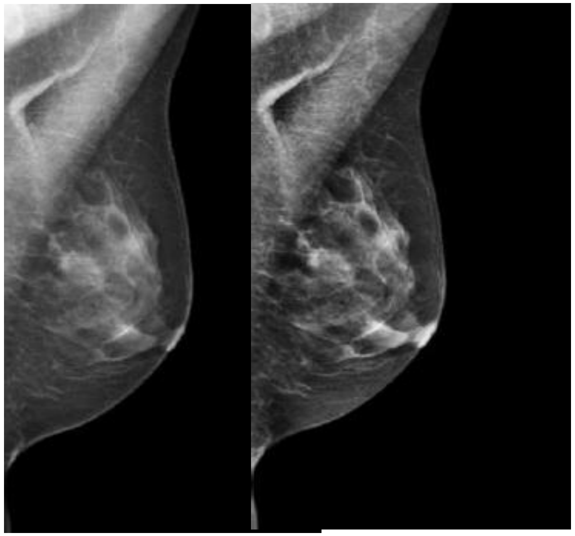
- What do you know about x-rays?
- Breast imaging?
- Tomosynthesis (CT) but Digital Breast Tomosynthesis (DBT)?

X-rays (image processing)

- '**For Processing**' and '**For presentation**' DICOM tag
  - Attenuation image
  - Contrast adaptation
  - Noise reduction
  - Sharpening

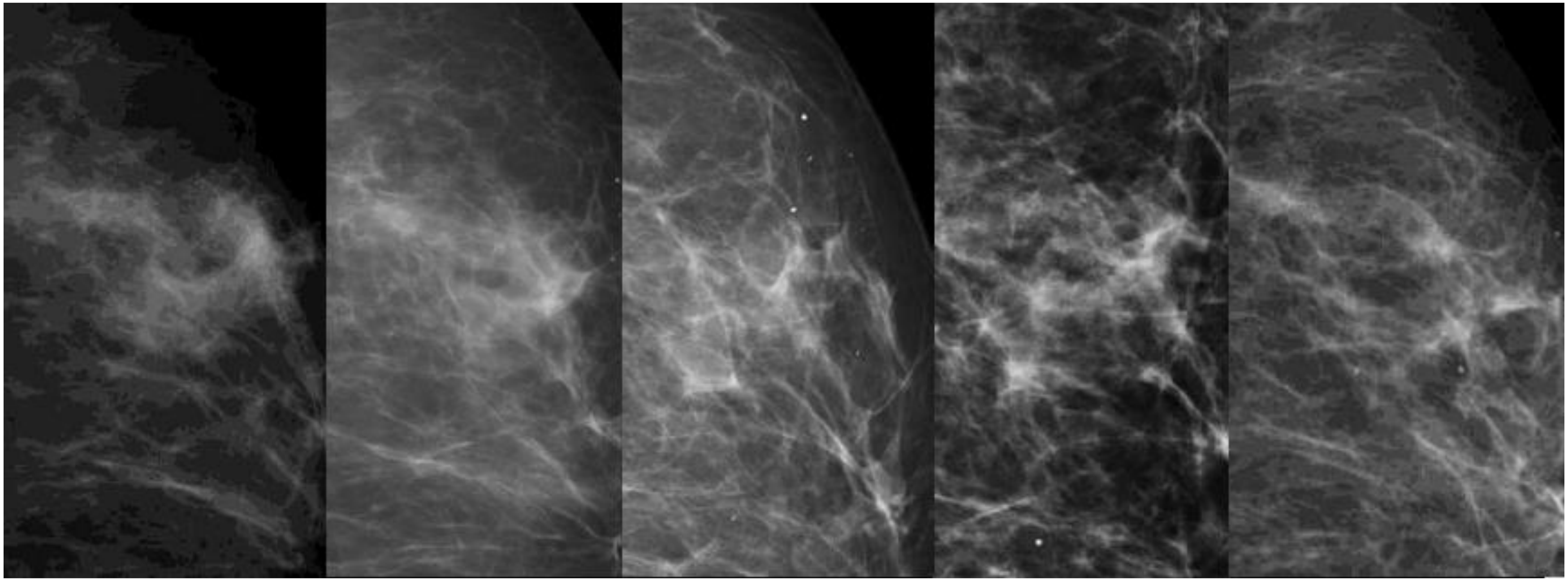
$$N = N_0 e^{-\mu x}$$





X-rays (image processing)

- Evolution of image processing algorithms



2005	2007	2009	2011	2013
Screen-film	FFDM	FFDM	FFDM	FFDM

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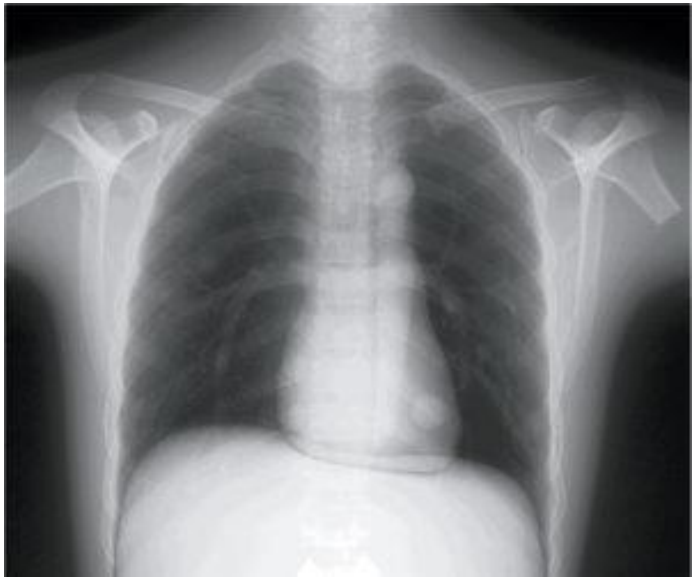
X-ray Imaging

- Projection (2D) Radiography
  - Used to image almost every part of the human body
  - There are specialized variants of projection radiography:
    - Mammography
    - Dental X-rays
    - Chest X-rays
    - Angiography
    - Fluoroscopy



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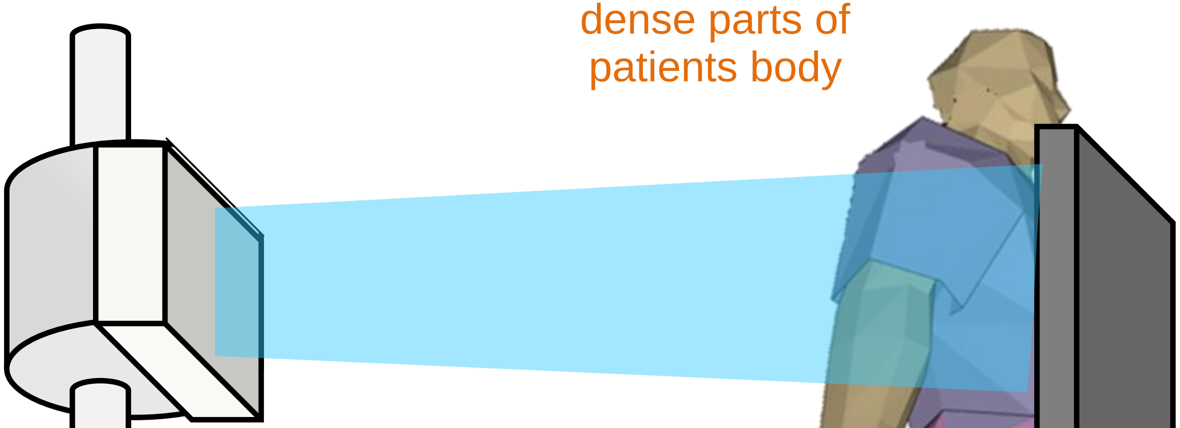
2D X-ray imaging

X-ray machine

X-rays absorbed by dense parts of patients body



Photographic plate or digital detector

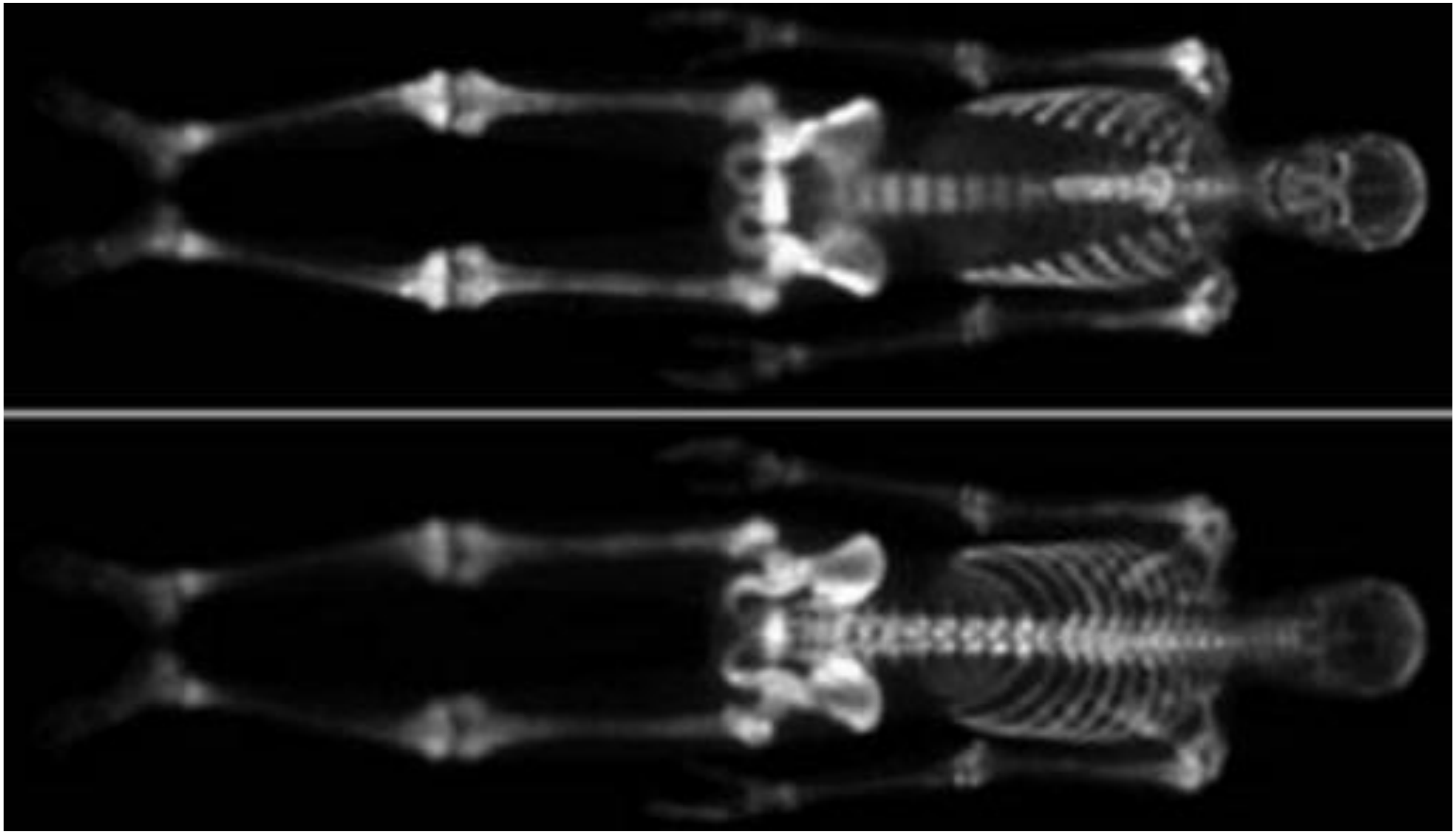
Radiograph

White indicates dense parts of body

Grey indicates less dense regions

2D X-ray imaging

- Examples: full body



2D X-ray imaging

- Examples: torax

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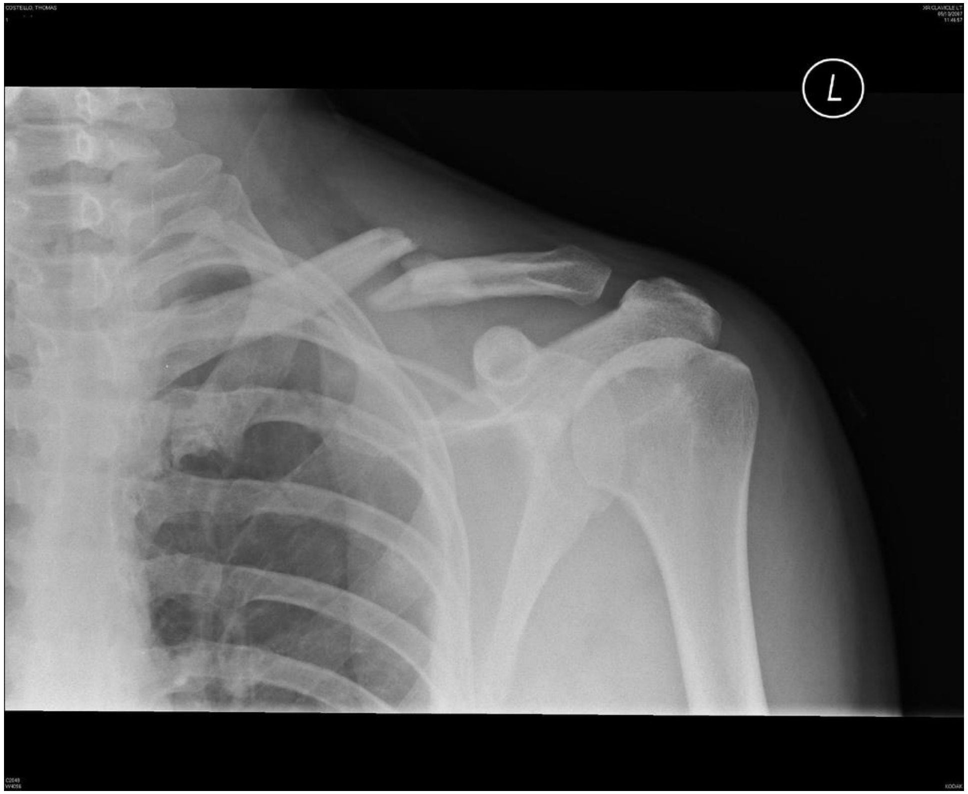
2D X-ray imaging

- Examples: dental

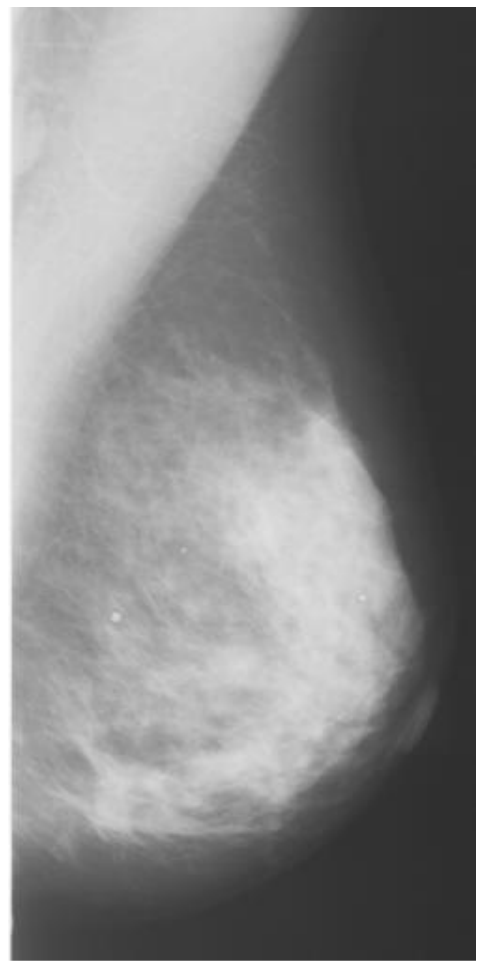
2D X-ray imaging

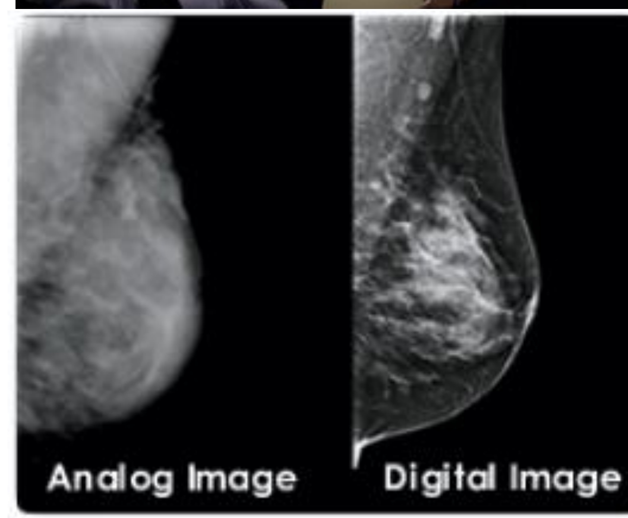
- Examples: bone information and injuries



2D X-ray imaging

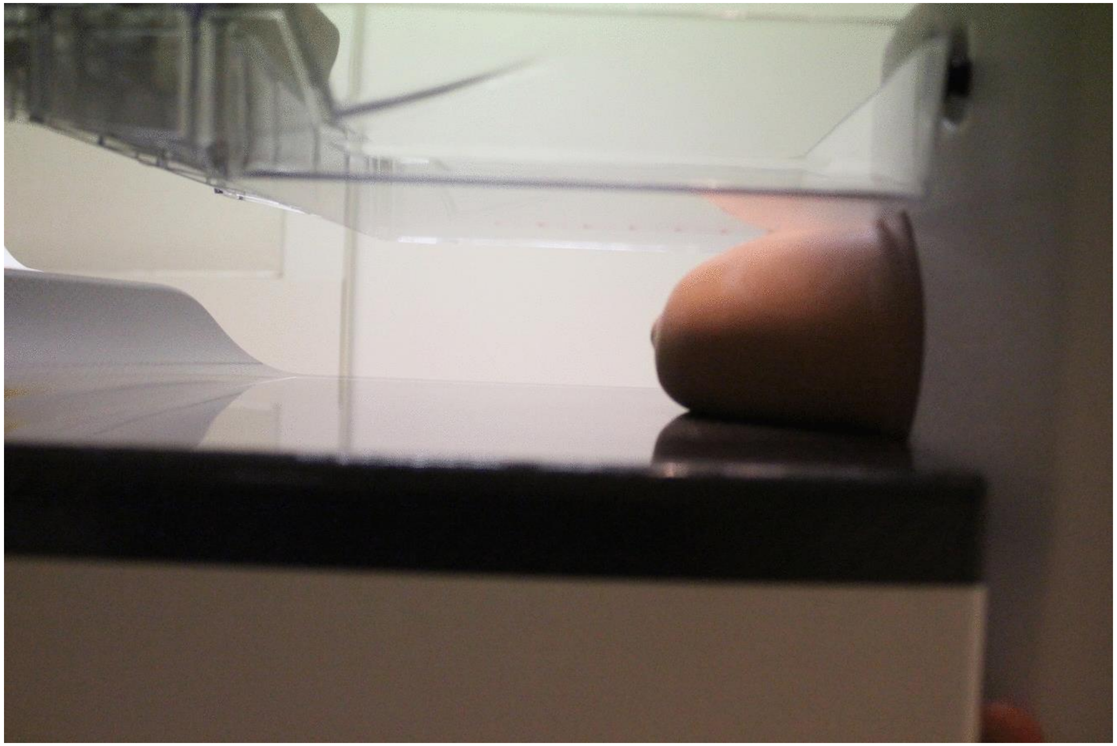
- Examples: mammography





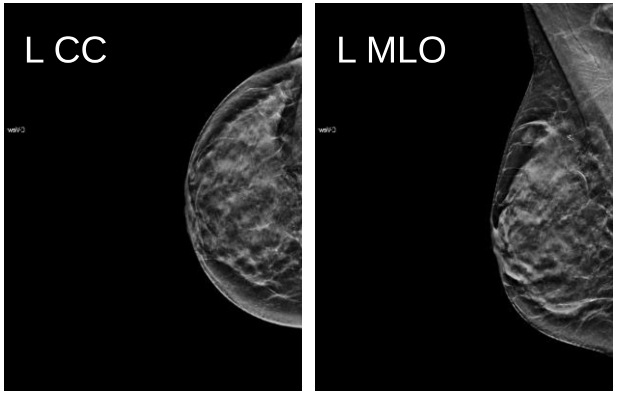
2D X-ray (breast) imaging

- Breast compression
  - Minimise patient's movement (reduce blurring)
  - Spread overlaying tissues (improve visualisation of lesions)
  - Reduce the effective thickness of breast (reduce scattering)



2D X-ray (breast) imaging

- Full-Field Digital Mammography (FFDM):
  - Low-dose x-ray imaging technique to examine breasts
  - Early detection of breast diseases in women
    - Breast cancer screening programmes
  - In FFDM, the x-ray film is replaced by solid-state detectors that convert x-rays into electrical signals
  - FFDM ranges from:
    - 50-100 µm in pixel size
    - 12-16 bits per pixel
    - Image size of 8-50 MB



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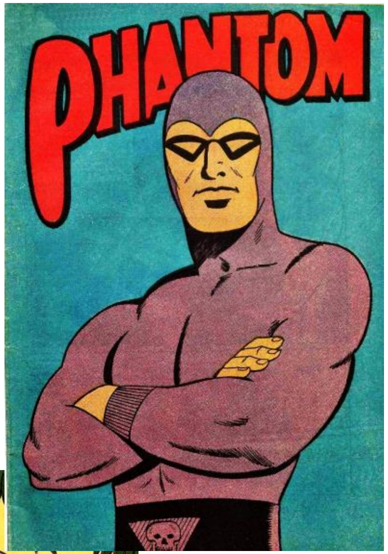
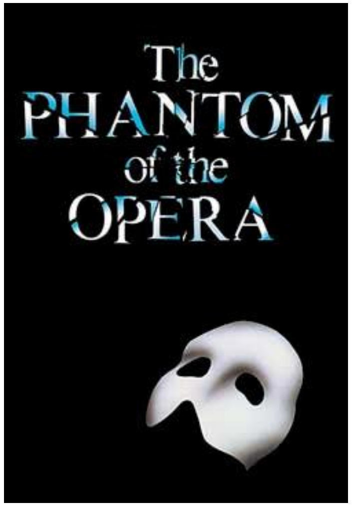
2D X-ray (phantom) imaging

- What is a phantom?

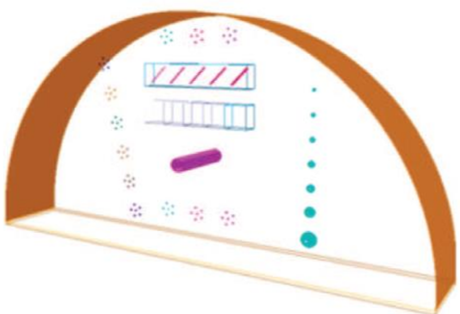




2D X-ray (phantom) imaging

- Phantom
  - Objects especially designed to be scanned using a medical imaging system in order to **evaluate**, **analise** and/or **improve** its performance.

CIRS 010/011A



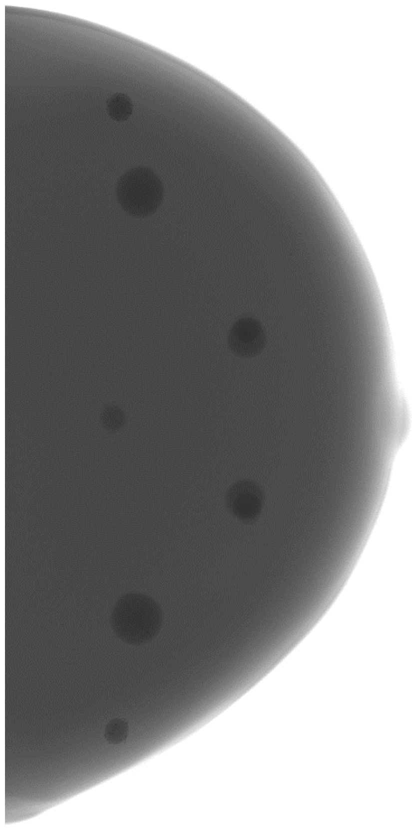
CIRS 010A

“LUNGMAN”

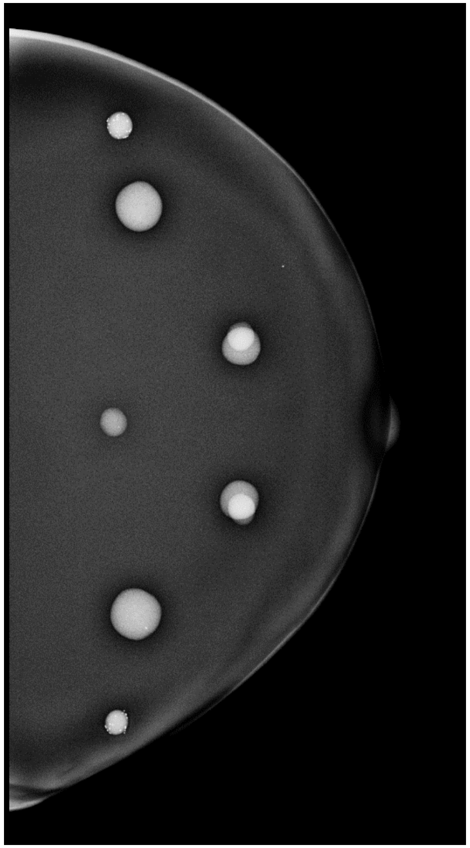
2D X-ray (phantom) imaging

- Phantom imaging

- CIRS 013



Raw

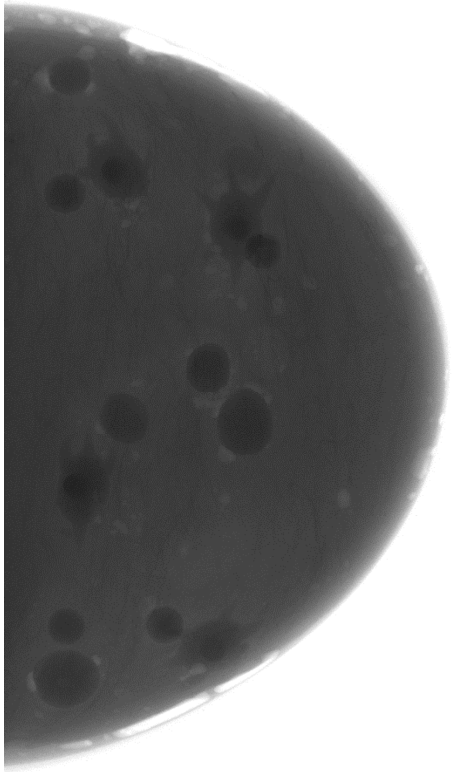


Processed

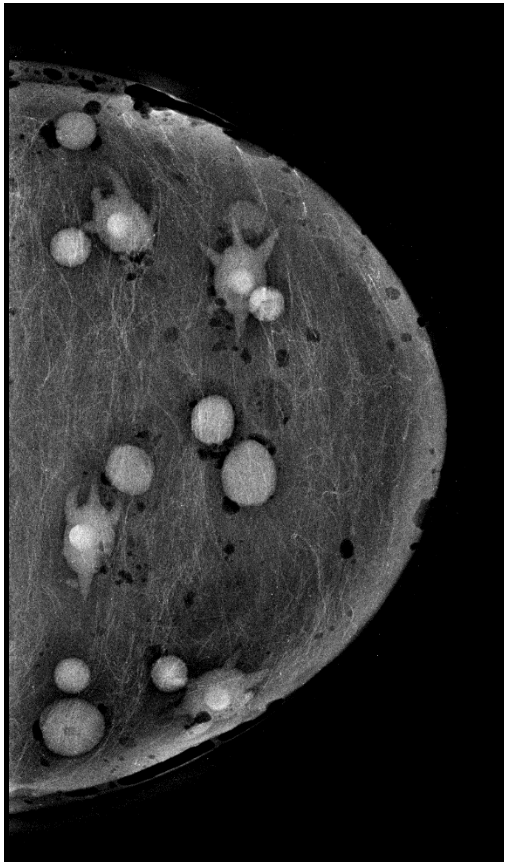
2D X-ray (phantom) imaging

- Phantom imaging

CIRS 073



Raw



Processed

2D X-ray imaging

- **Advantages**:
  - Fast and easy to perform
  - Equipment is relatively inexpensive and widely available
  - Low amounts of radiation; high spatial resolution
  - Useful for assessing parts of the body with high contrast resolution but require fine detail (chest, skeletal system)
- **Disadvantges**:
  - Poor differentiation of low contrast objects
  - Uses ionizing radiation
  - <u>Superposition of structures</u> makes interpretation difficult

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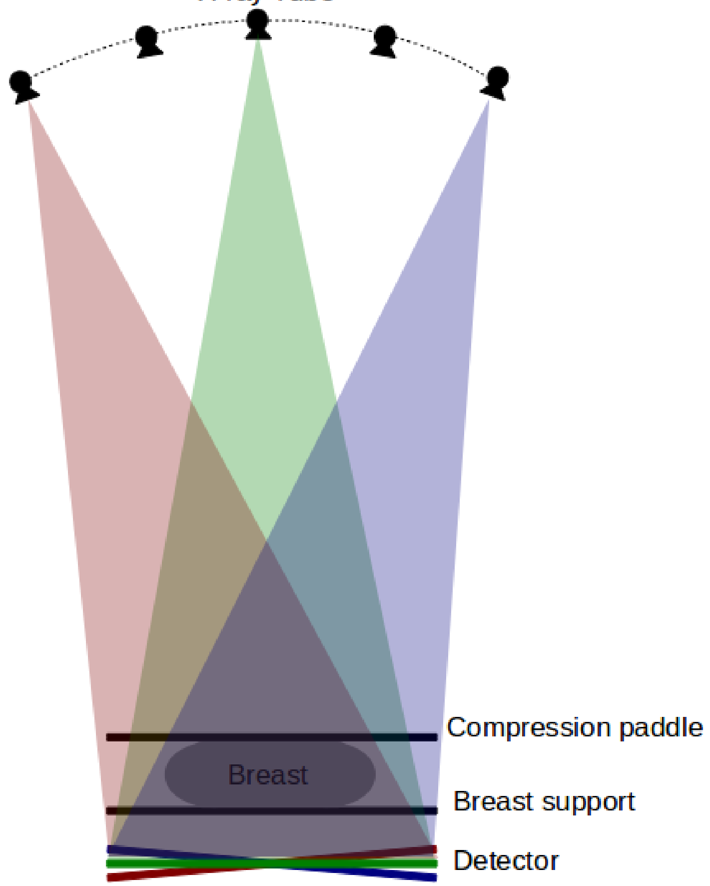
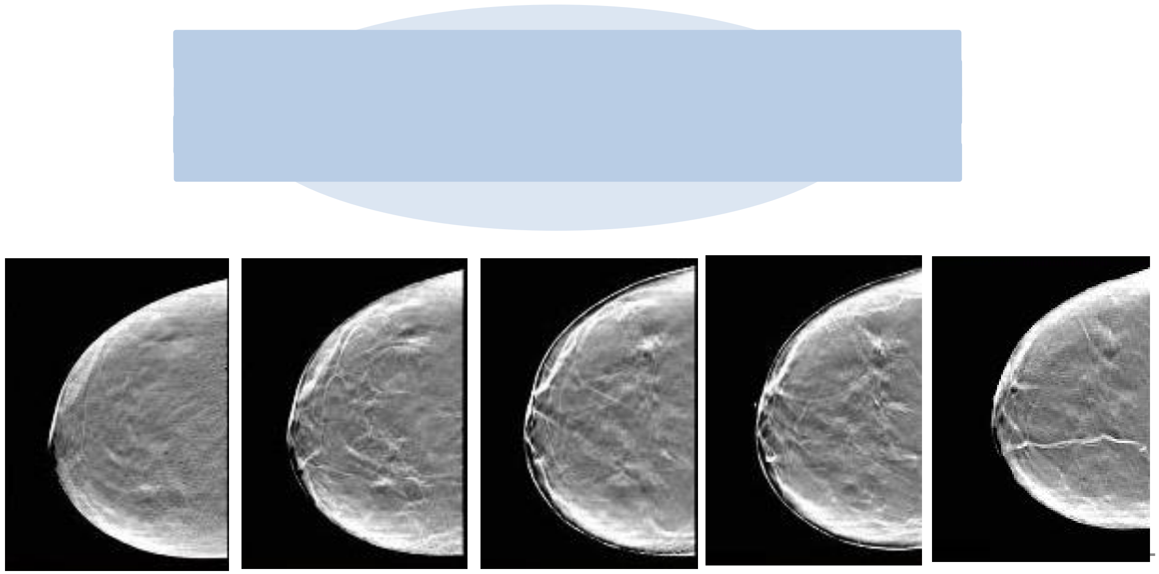
2D X-ray (breast) imaging



2D planar digital mammography

Tomosynthesis planes



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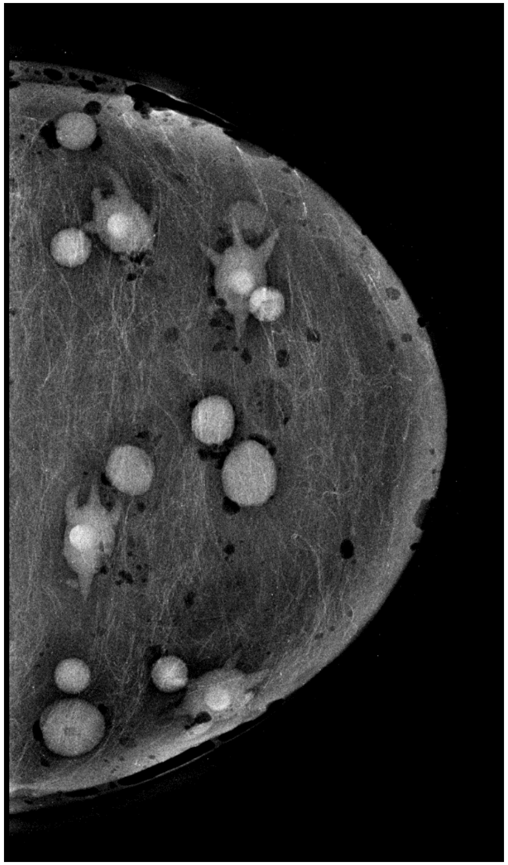
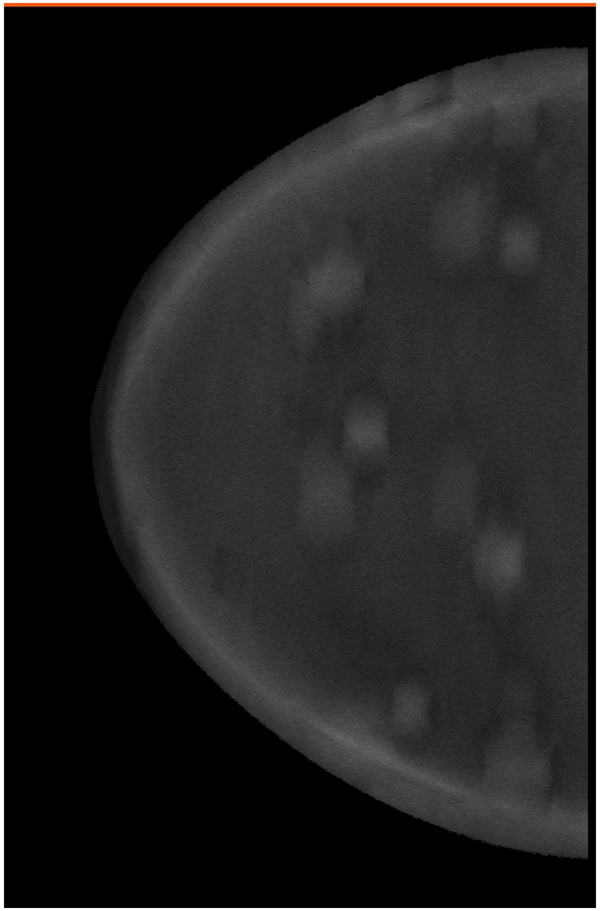
2D X-ray (phantom) imaging

CIRS 073

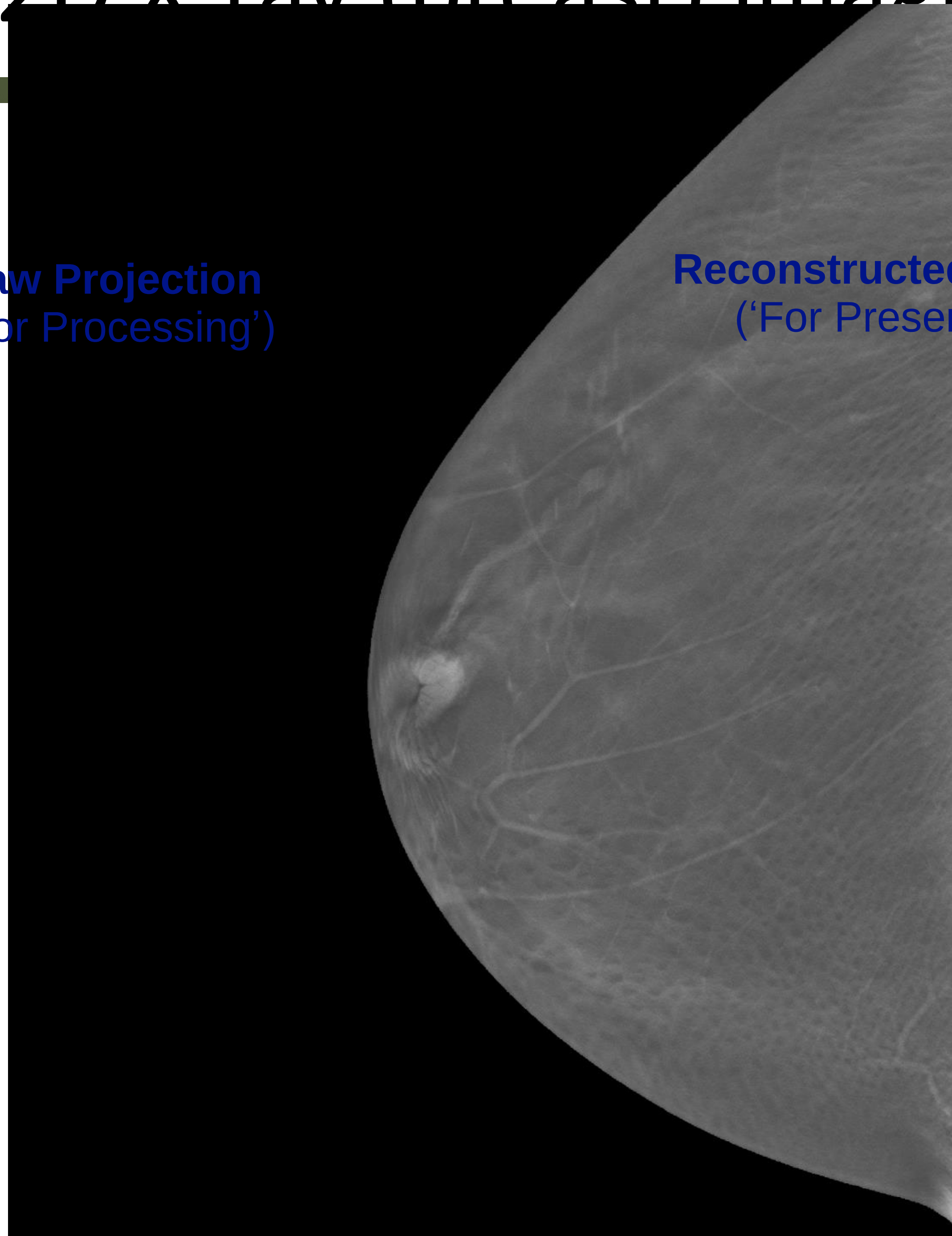




2D X-ray (breast) imaging

Raw Projection
(‘For Processing’)

Reconstructed volumen
(‘For Presentation’)

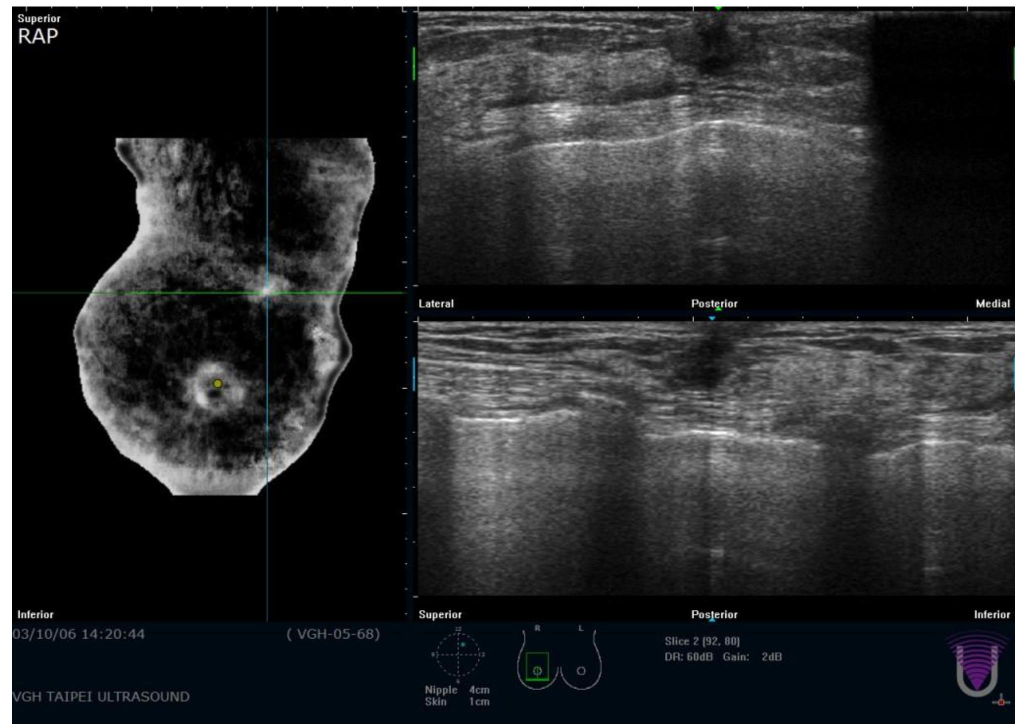


2D X-ray (breast) imaging

Advantages	Disadvantages
Better depth-resolution (than 2D)	Fast readout sequence (detector tech.)
Less tissue superposition	Higher scattered radiation (no grid)
Better visualisation	Angular range / No. of projections
Higher detection?	Higher dose?
	Long reading time (screening)
	Reconstruction algorithm

ABUS

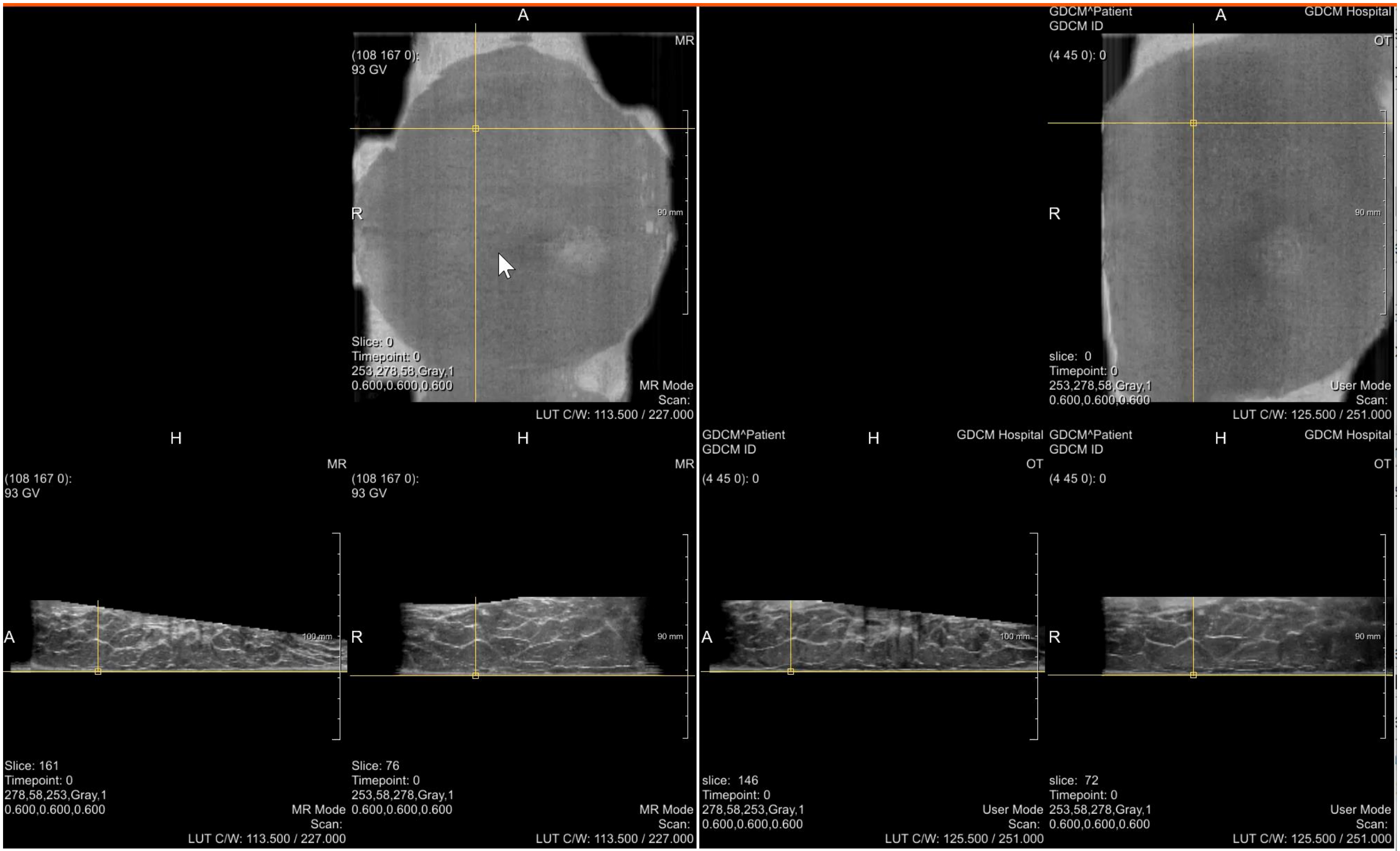
- 3D ABUS



http://www3.gehealthcare.com/en/Products/Categories/Ultrasound/somo_v_ABUS_Breast_Imaging/Invenia_ABUS
https://www.youtube.com/watch?v=IgPGpKXe2Gc

ABUS

- 3D ABUS (temporal information).



Bibliography

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- *Medical imaging : principles and practices* (2013). Taylor & Francis/CRC Press.
- *Informatics in medical imaging* (2012). Informatics in medical imaging.
- *Related Journals and Conferences: IEEE Transactions on Medical Imaging, Medical Image Analysis,* IEEE Transactions on Information Technology in Biomedicine, MICCAI (Medical Image Computing and Computer Assisted Intervention) Conference, IEEE Int. Symposium on Biomedical Imaging (ISBI), SPIE Medical Imaging Conference, CARS (Computer Assisted Radiology) Conference, …