(1) An overview of MRI
&
(2) A report on the Siemens MRI Workshop

Manson Fong

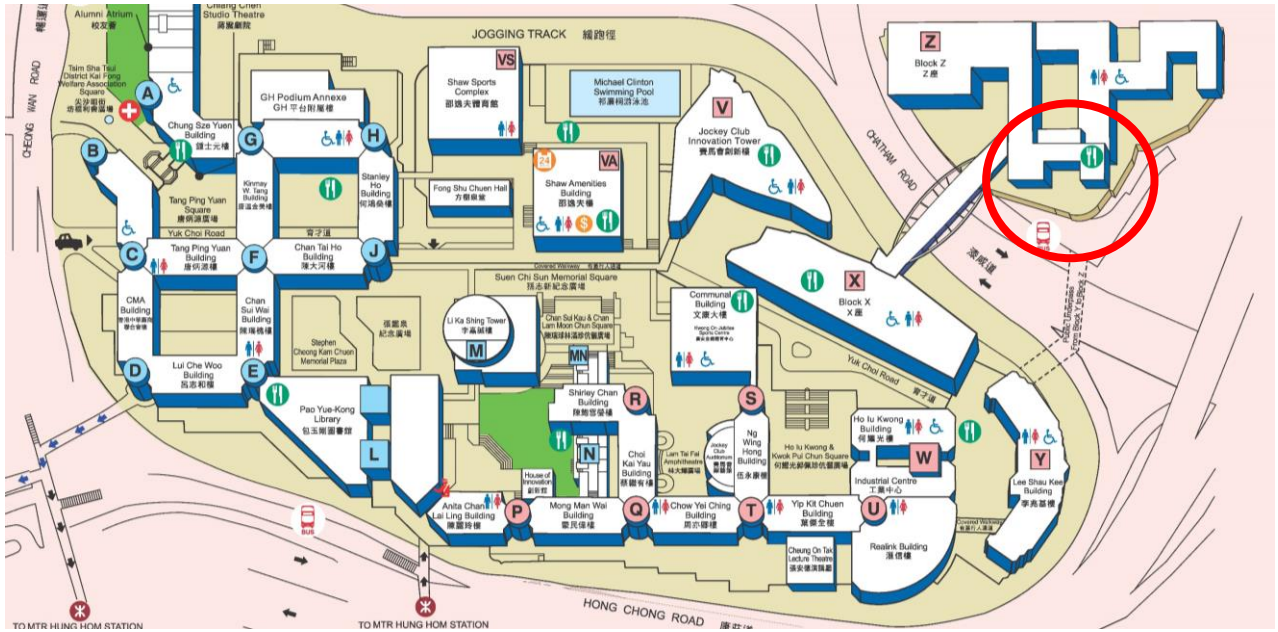
March 10, 2021

UBSN MRI facility

Siemens Prisma 3T MRI

Address:

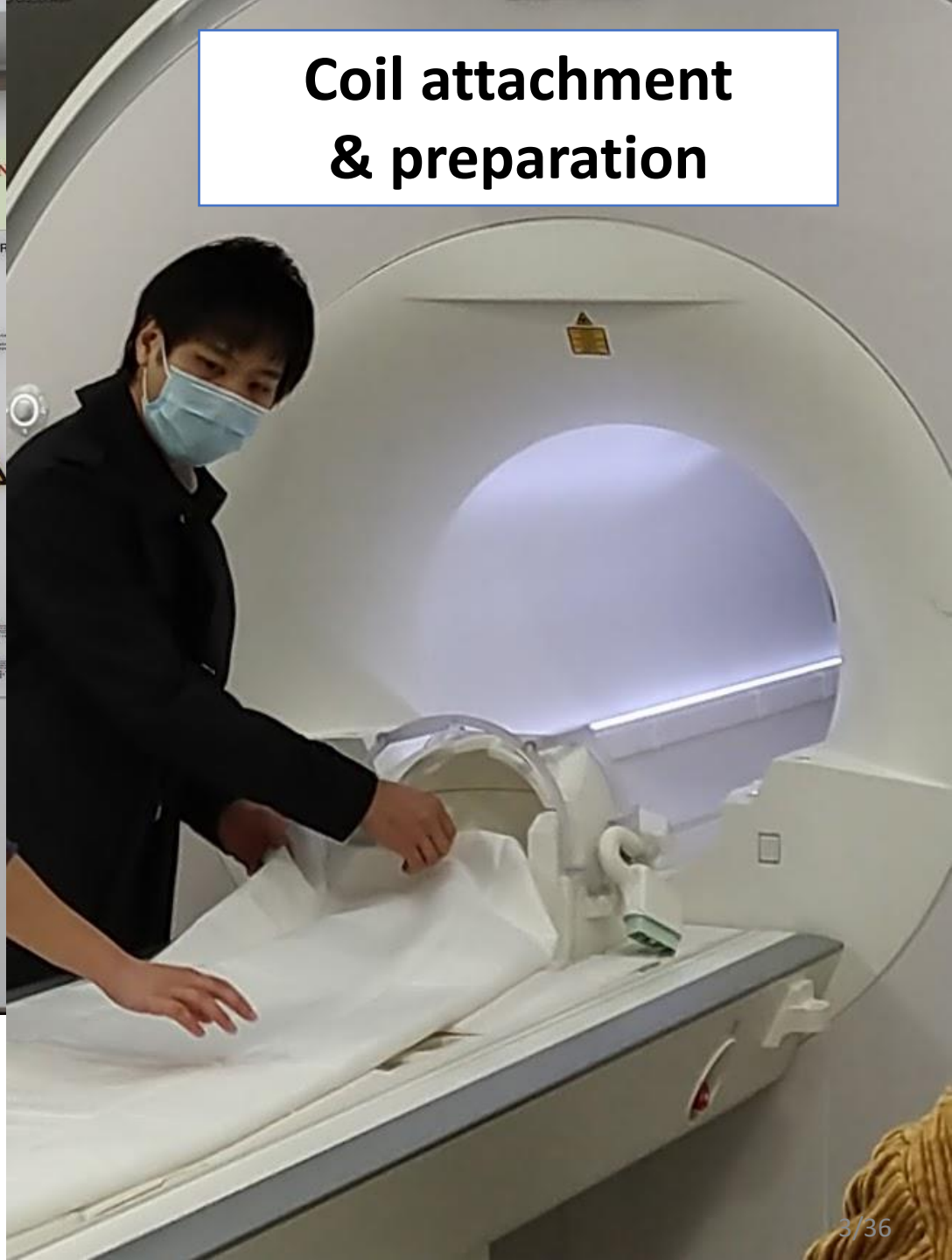
ZB216, LG2L, Block Z, Phase 8 building



https://ubsn.polyu.edu.hk/News/Detail/newsid/22

Control table outside the scanner room

Coil attachment & preparation




SINORAD
美德医疗
脑功能视听觉刺激系统
Visual & Audio Stimulation System for fMRI


SPHERICAL CONCAVE
10.00
9.00
8.00
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CYLINDER CONCAVE
2.00
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1.00
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0.25
SPHERICAL CONVEX
CYLINDER CONVEX
2.00
1.75
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1.00
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0.50
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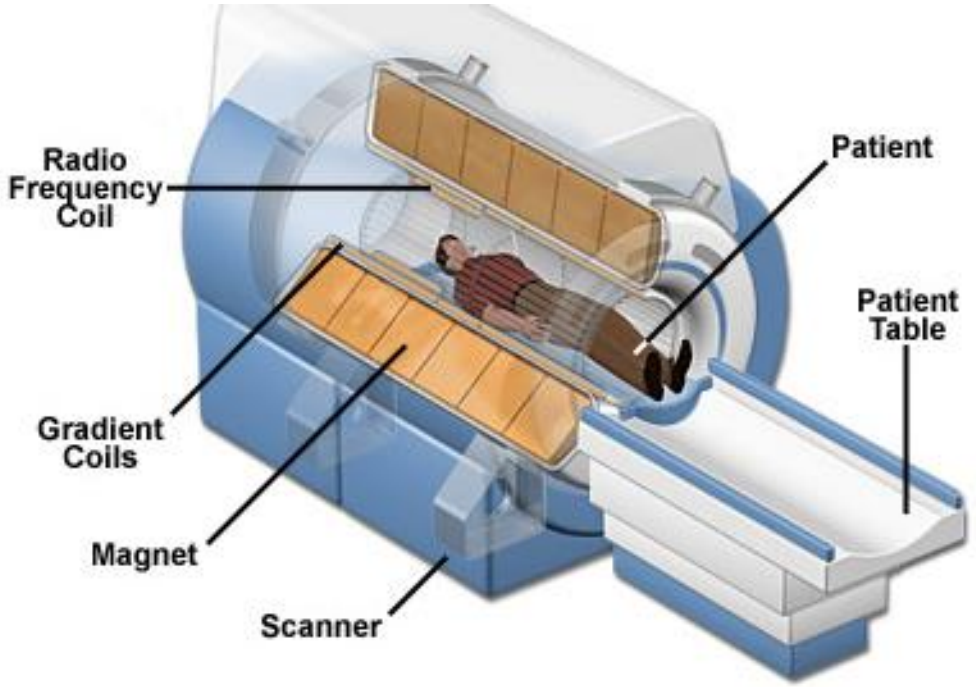
001
003
002
004

Outline

- **Overview of MRI**
  - Components of an MRI
  - How does an MRI machine work?
  - Conventional pulse sequences (spin echo & gradient echo)
- **Siemens MRI workshop**
  - System components
- **MRI modalities**
  - T1 / T2 / BOLD EPI / DTI / MRA / Perfusion
- **My current exploration with MRI data**

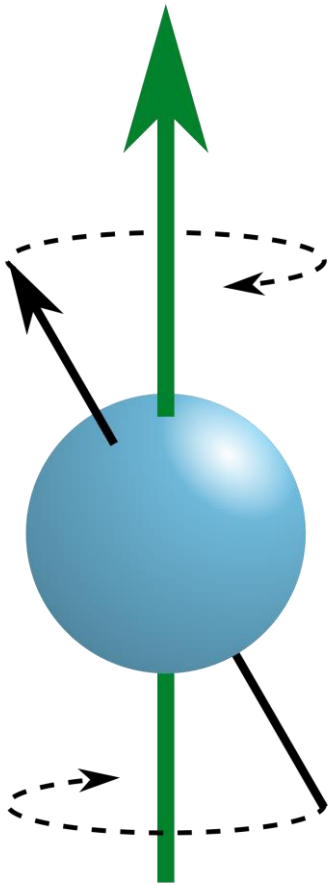
Overview of MRI

Components of an MRI machine

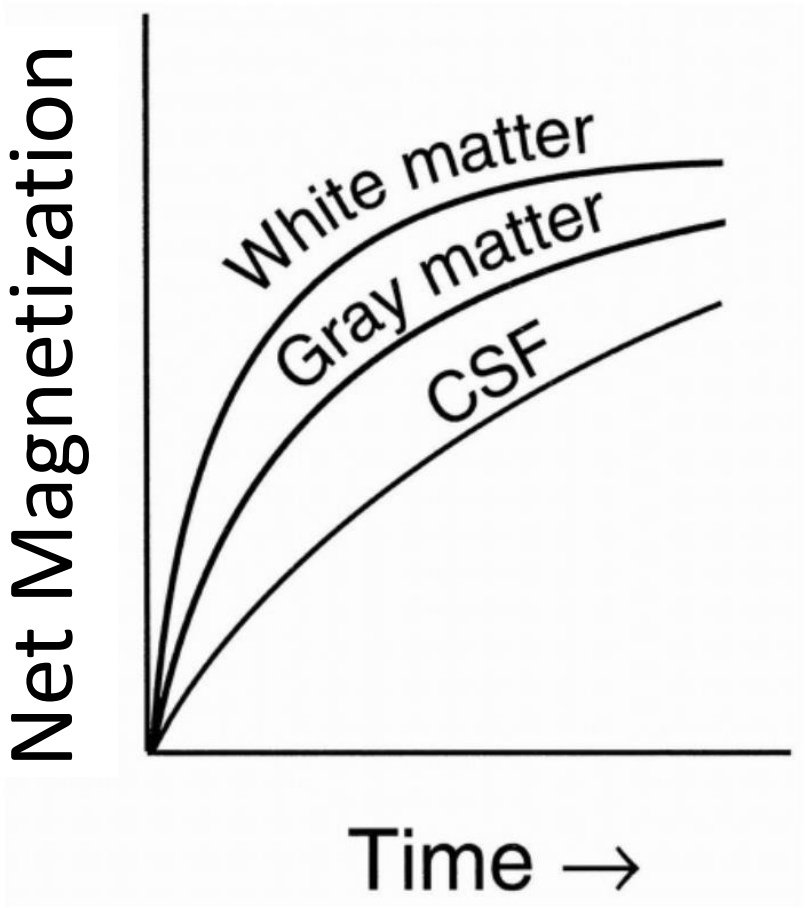


- **Main magnet**
  - Creates a static *homogeneous* magnetic field
  - **B0 ~ 1.5 / 3 / 7 T**
  - *c.f.* Earth's magnetic field (~ 5×10^{-5} T)
- **Gradient coils**
  - Three sets of coils arranged orthogonally
  - **B1 ~ mT**
  - Modulate the magnetic field in different positions and directions
  - Sources of the noises
- **RF transmitter & receiver coils**

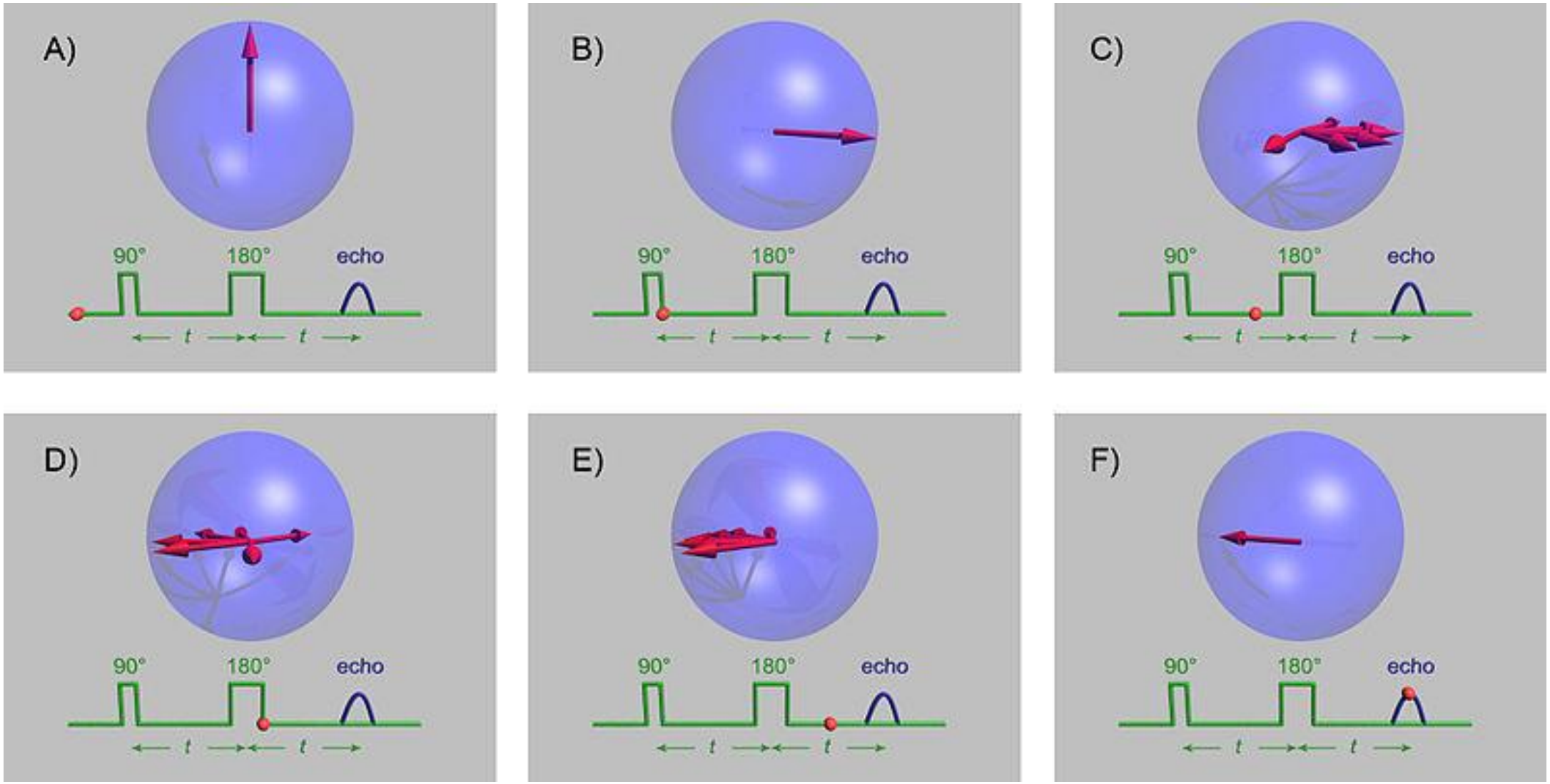
How does an MRI work?



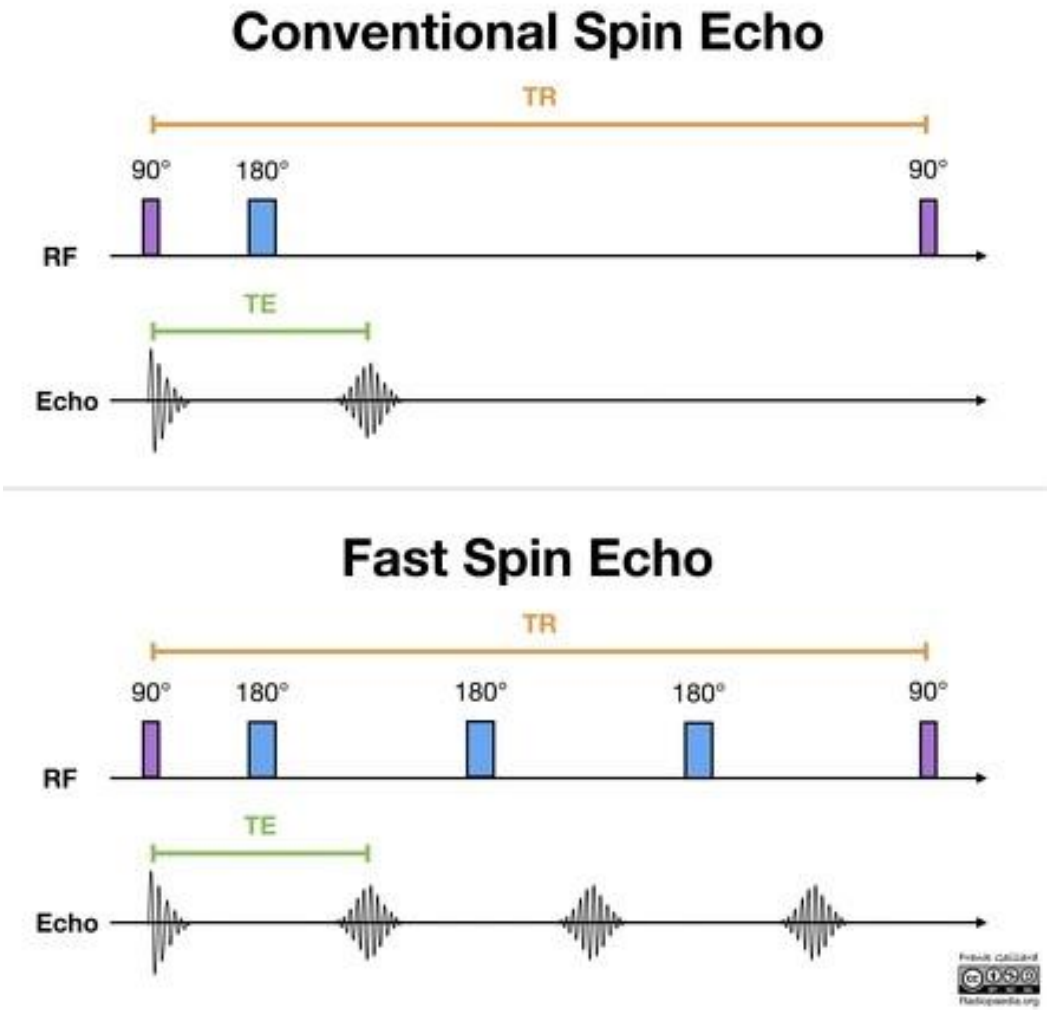
T1 relaxation



Spin echo pulse sequence

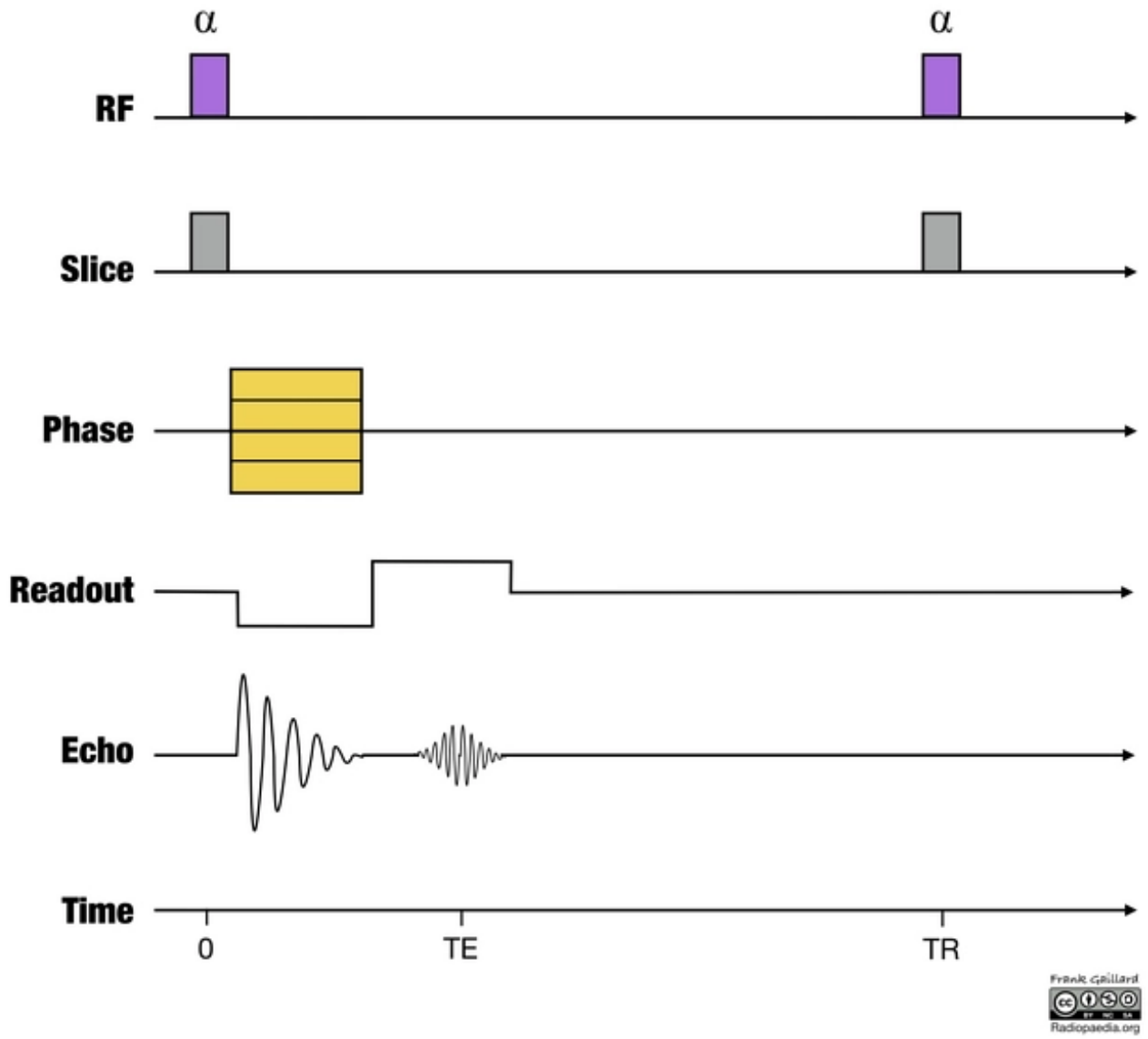


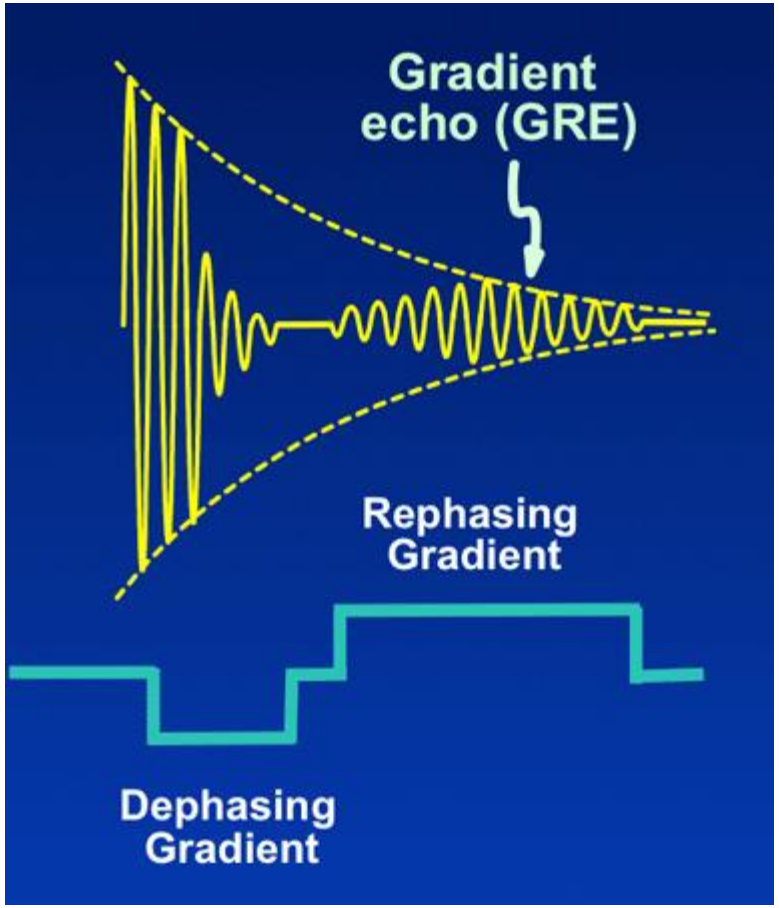
Spin echo pulse sequence



https://radiopaedia.org/articles/spin-echo-sequences

Gradient echo pulse sequence



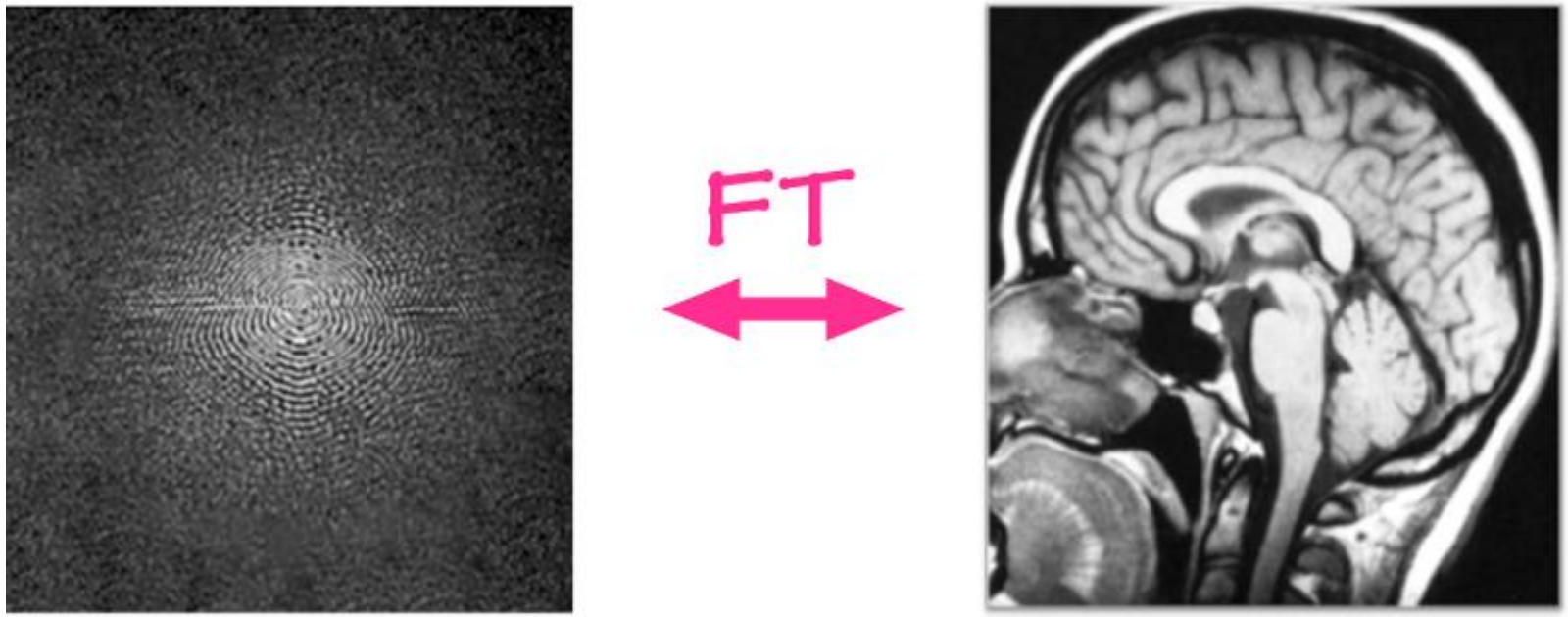


https://www.mriquestions.com/gradient-echo.html

https://radiopaedia.org/articles/gradient-echo-sequences-1

Pulse sequences

- The job of a pulse sequence is to traverse all coordinates (kx and ky) on the k-space.

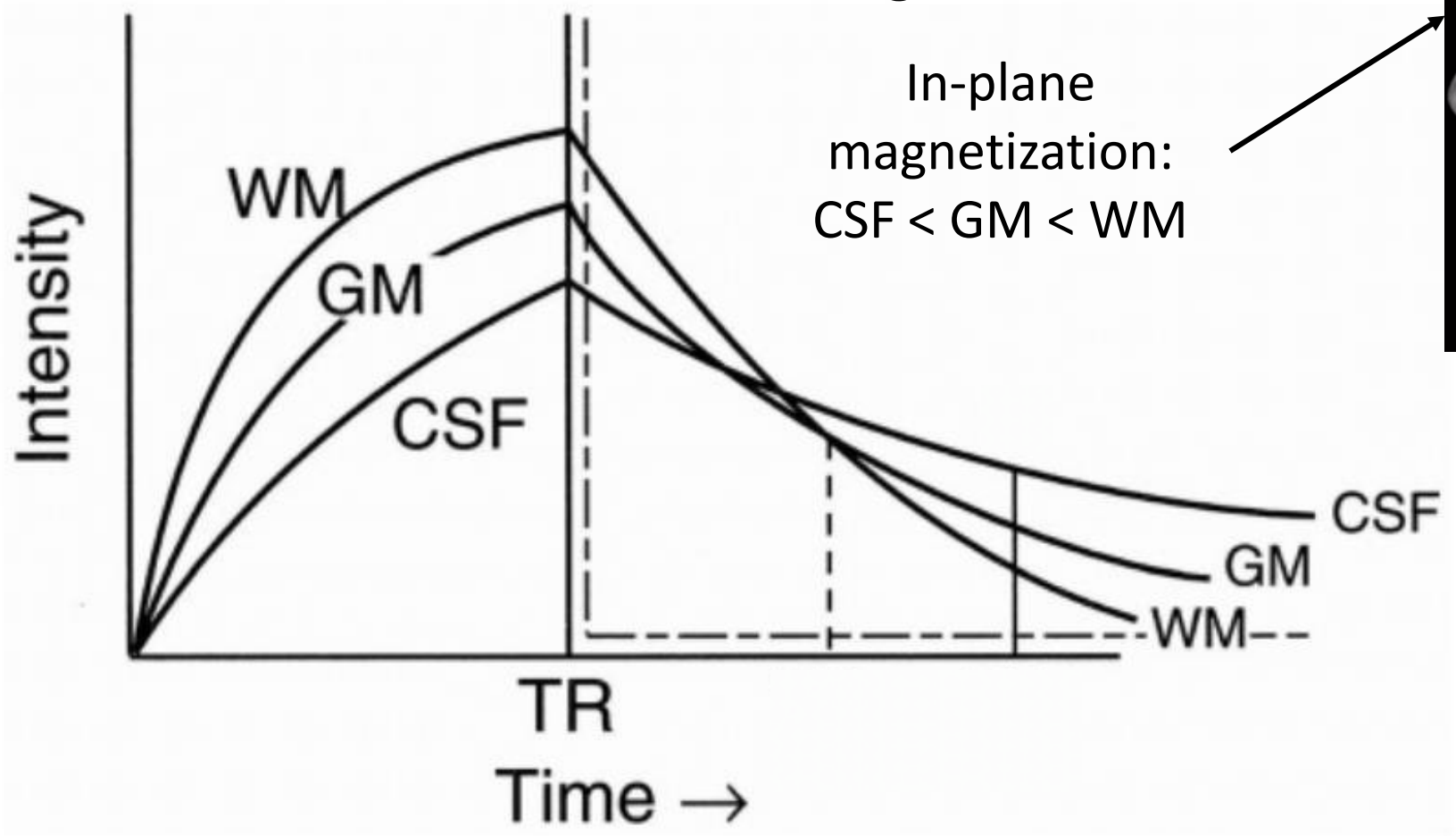


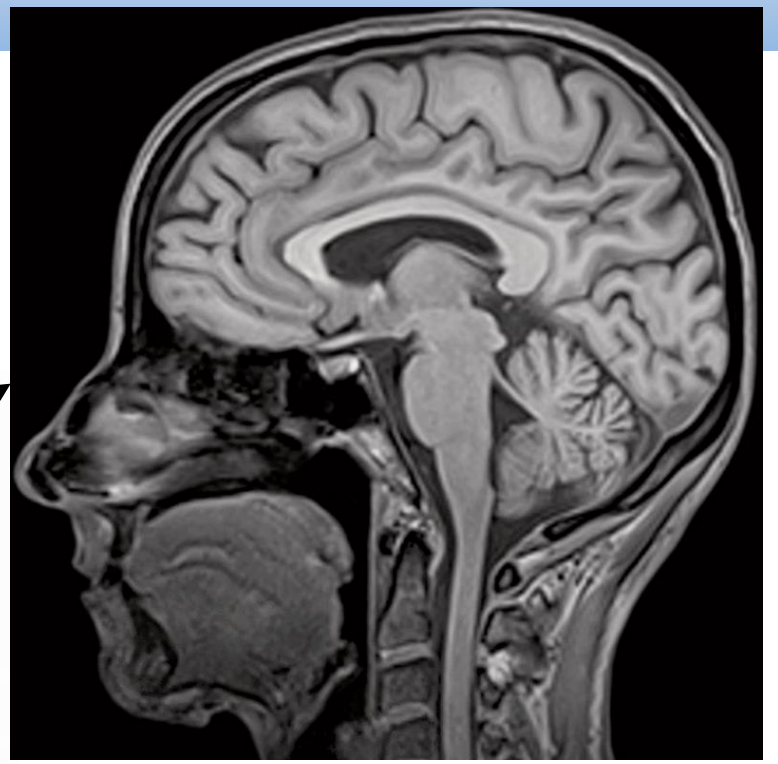
http://mriquestions.com/what-is-k-space.html

Case 1: T1 contrast

Long TR, short TE

In-plane magnetization:
CSF < GM < WM





T1 images

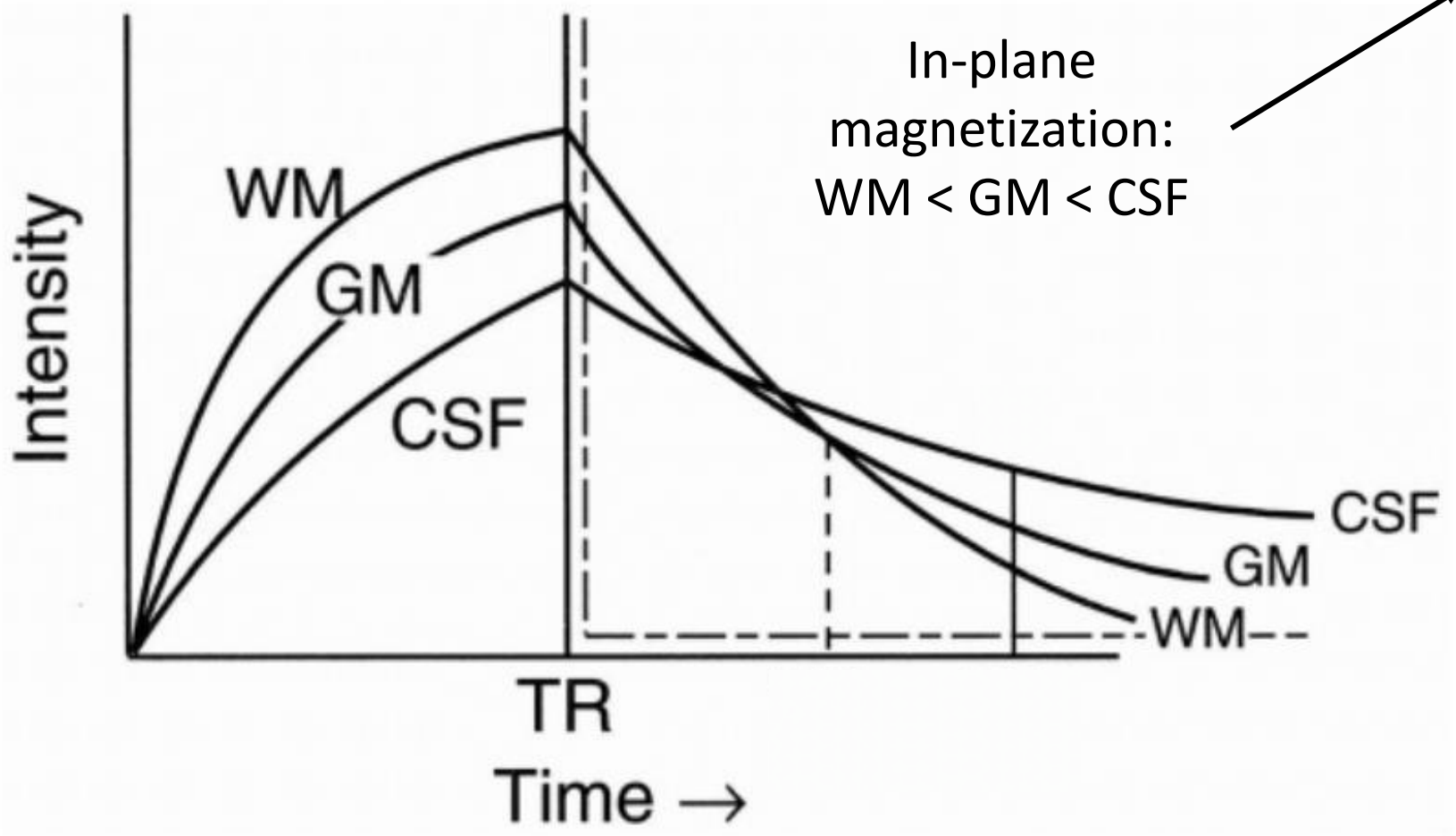
Tissue	T1 (ms)
WM	800
GM	1500
CSF	4000

Case 2: T2 contrast

Long TR, Long TE

In-plane magnetization:
WM < GM < CSF

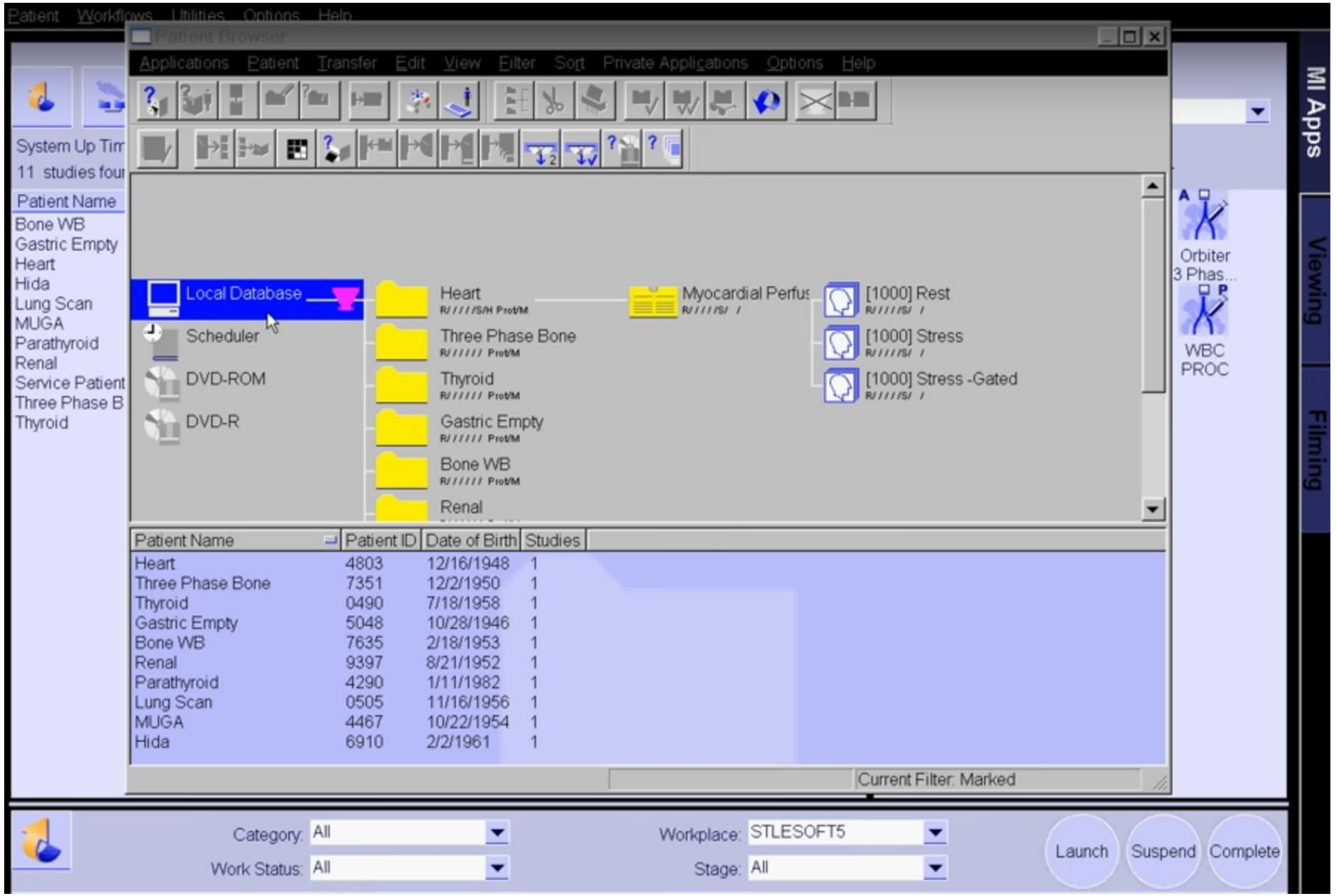
T2 images



Tissue	T2 (ms)
CSF	2000
GM	100
WM	90

Siemens Prisma 3T system

Siemens MRI workshop

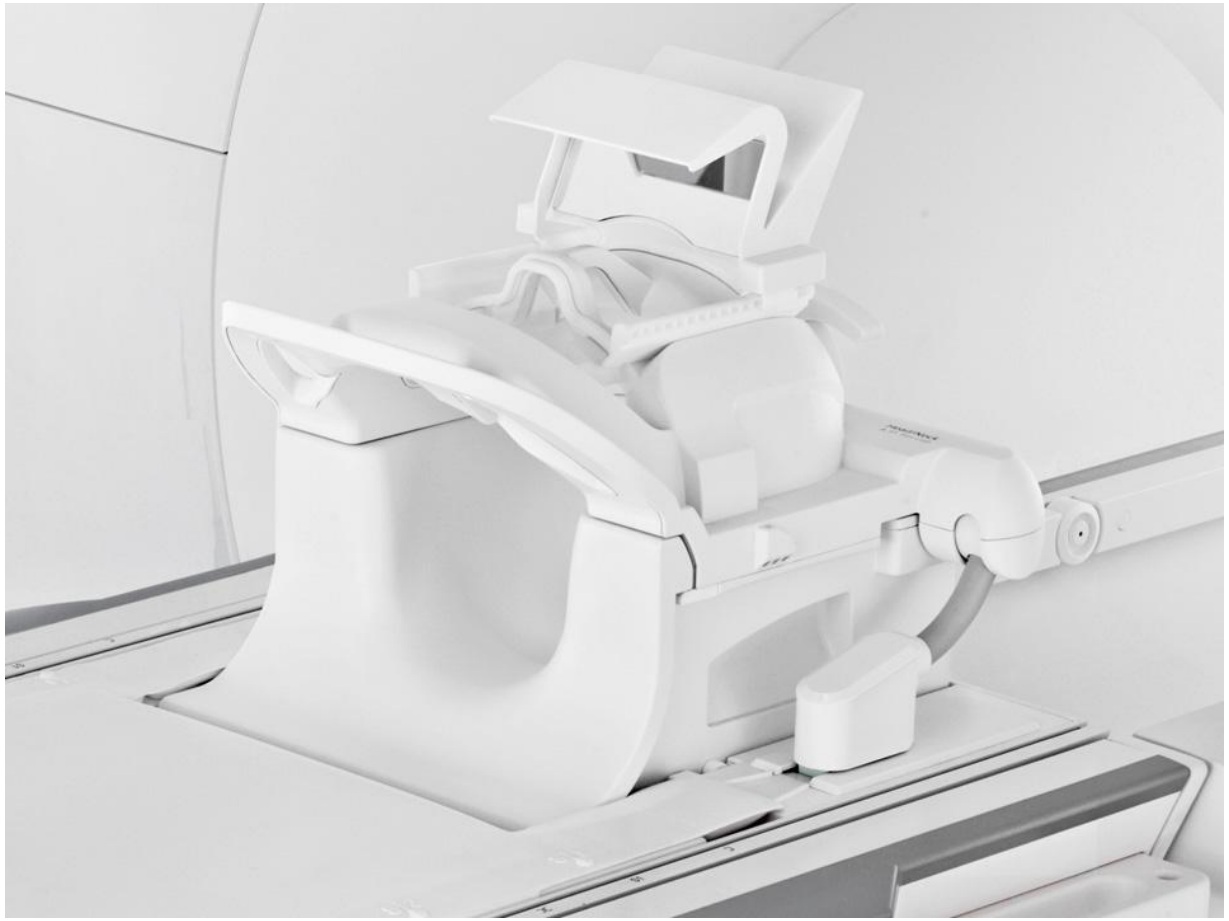


The software is currently **Syngo Browser MR.**

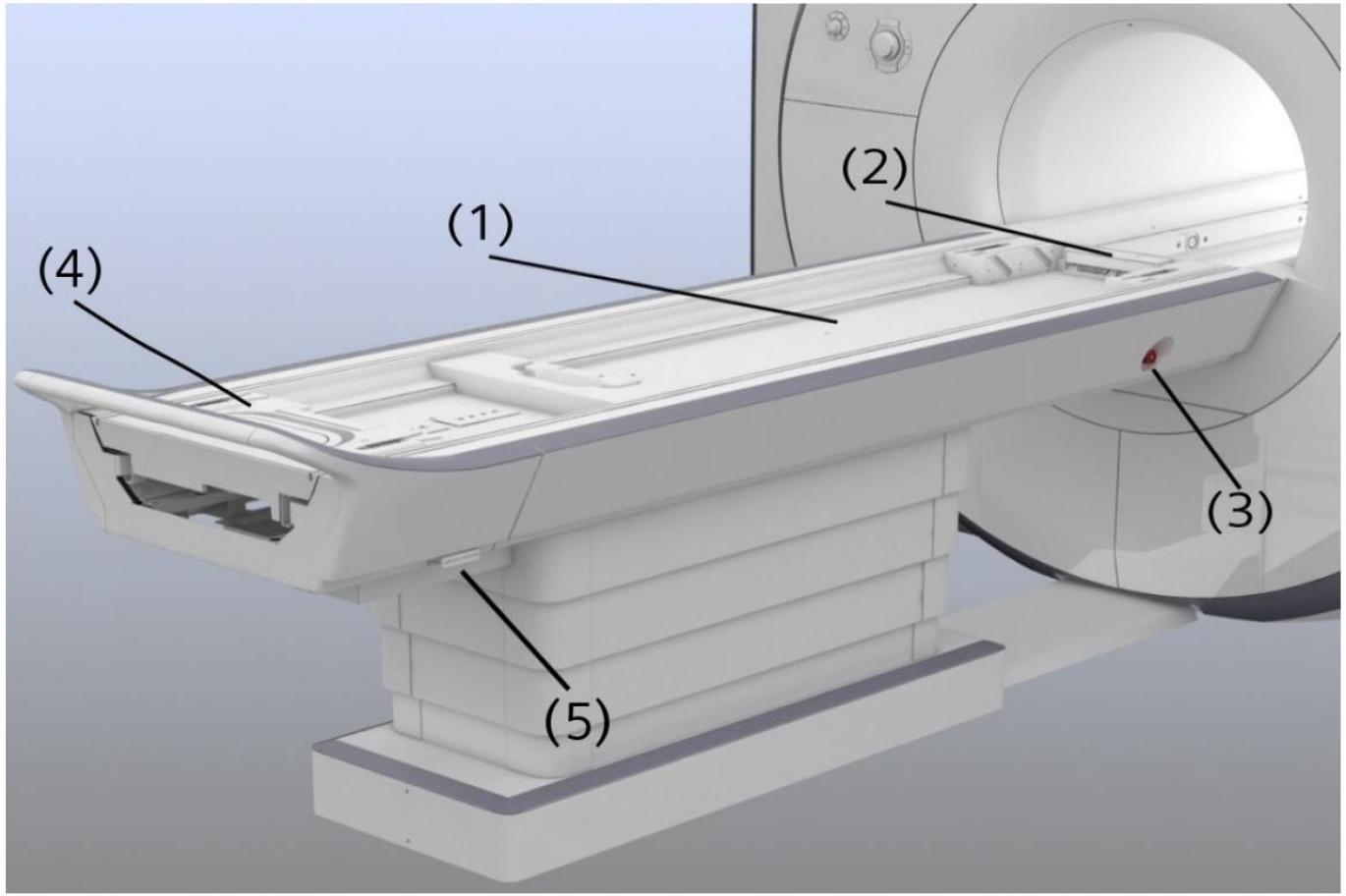
But it will be upgraded to a newer and more powerful user interface called **Syngo.Via** next year.

32-channel head coil

Head/Neck 64 coils



“Patient table”



(1) Tabletop

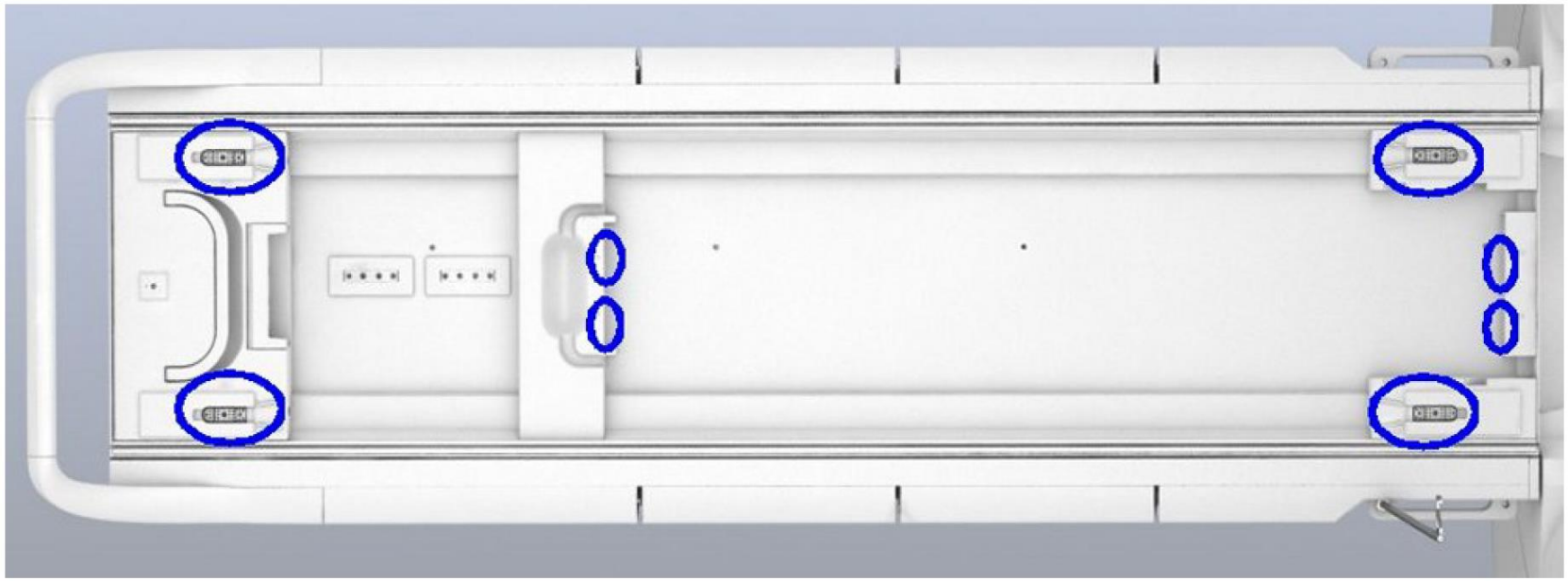
(2) Head end

(3) **Table Stop** button

(4) Handle to pull out the table top in case of emergency

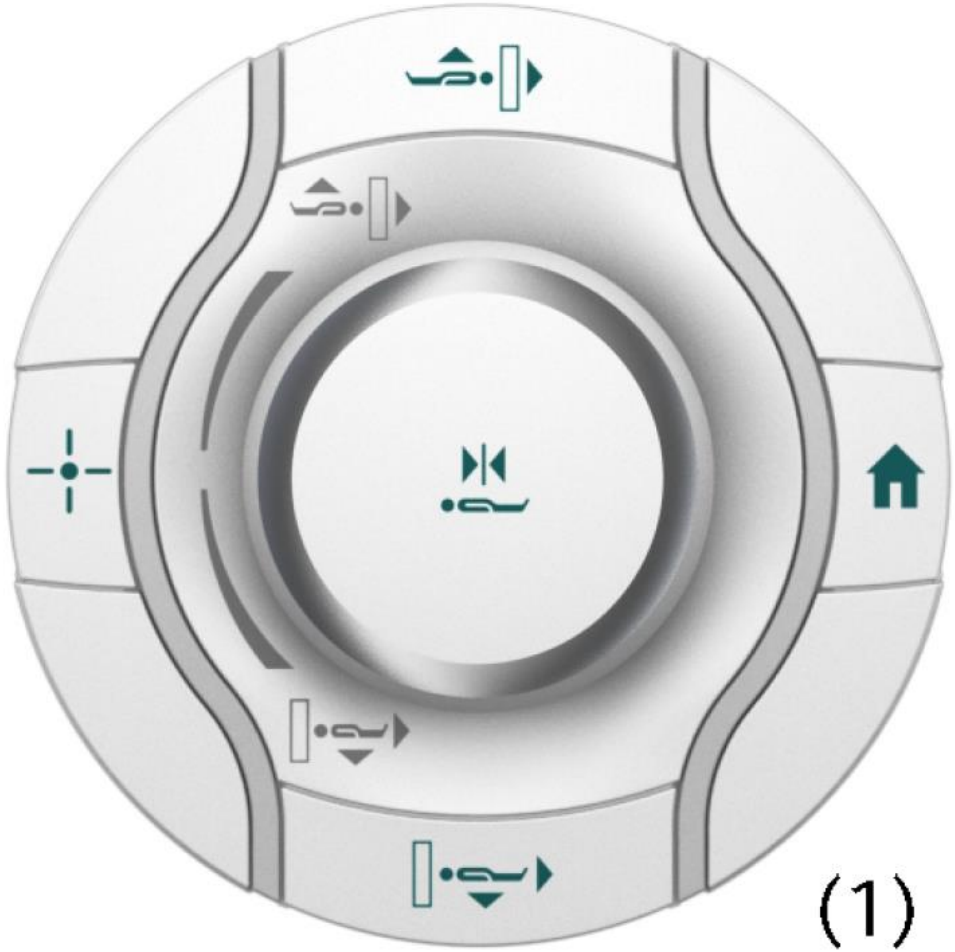
(5) Emergency release

Coil sockets



Head end

The coil sockets are located at the head and foot end of the patient table.



(1)

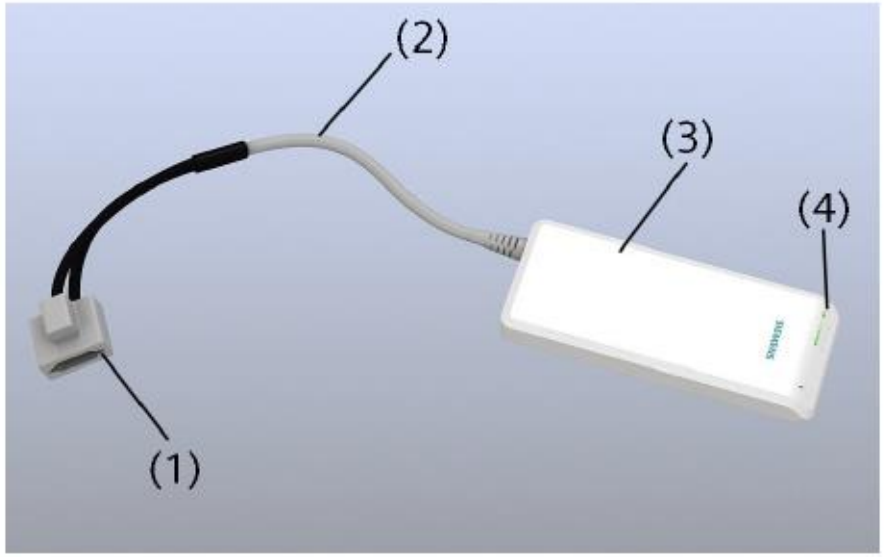
(2)

(1) Control unit for positioning the table

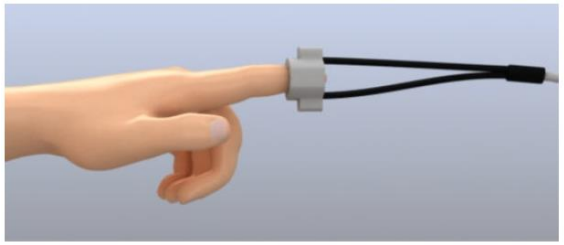
(2) Control unit for menu navigation and for adjusting settings for patient comfort

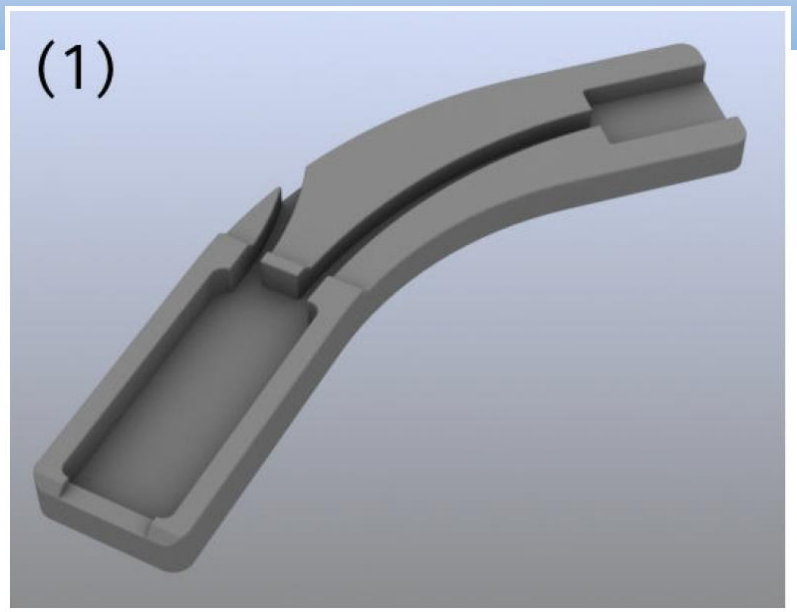
Wireless pulse sensor

The PPU acquires the patient's peripheral pulse. It consists of a transmitter unit, a fiber-optic sensor and a removable finger adapter (available in different sizes).



(1) Finger adapter
(2) Fiber optic cable
(3) Transmitter unit
(4) Control LEDs

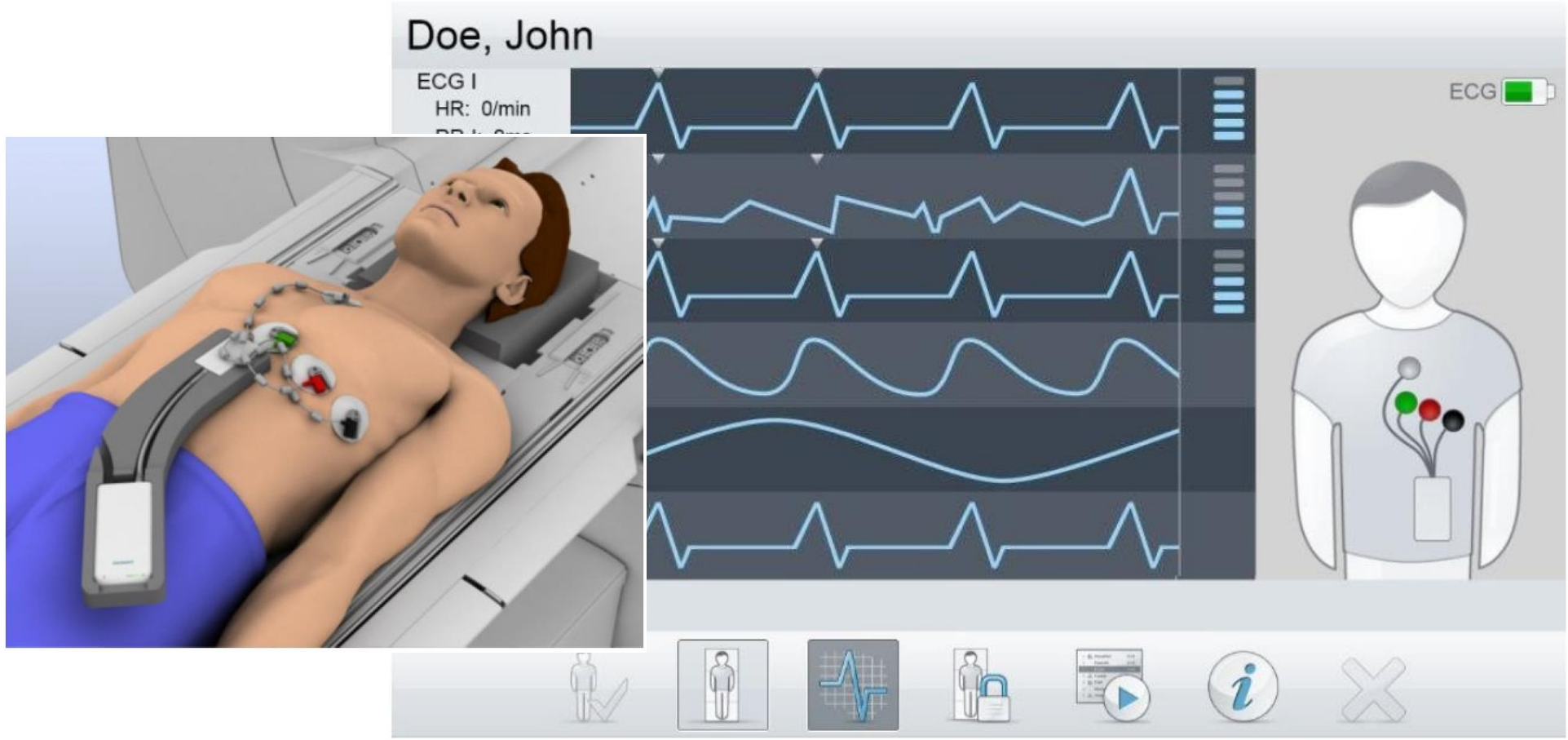




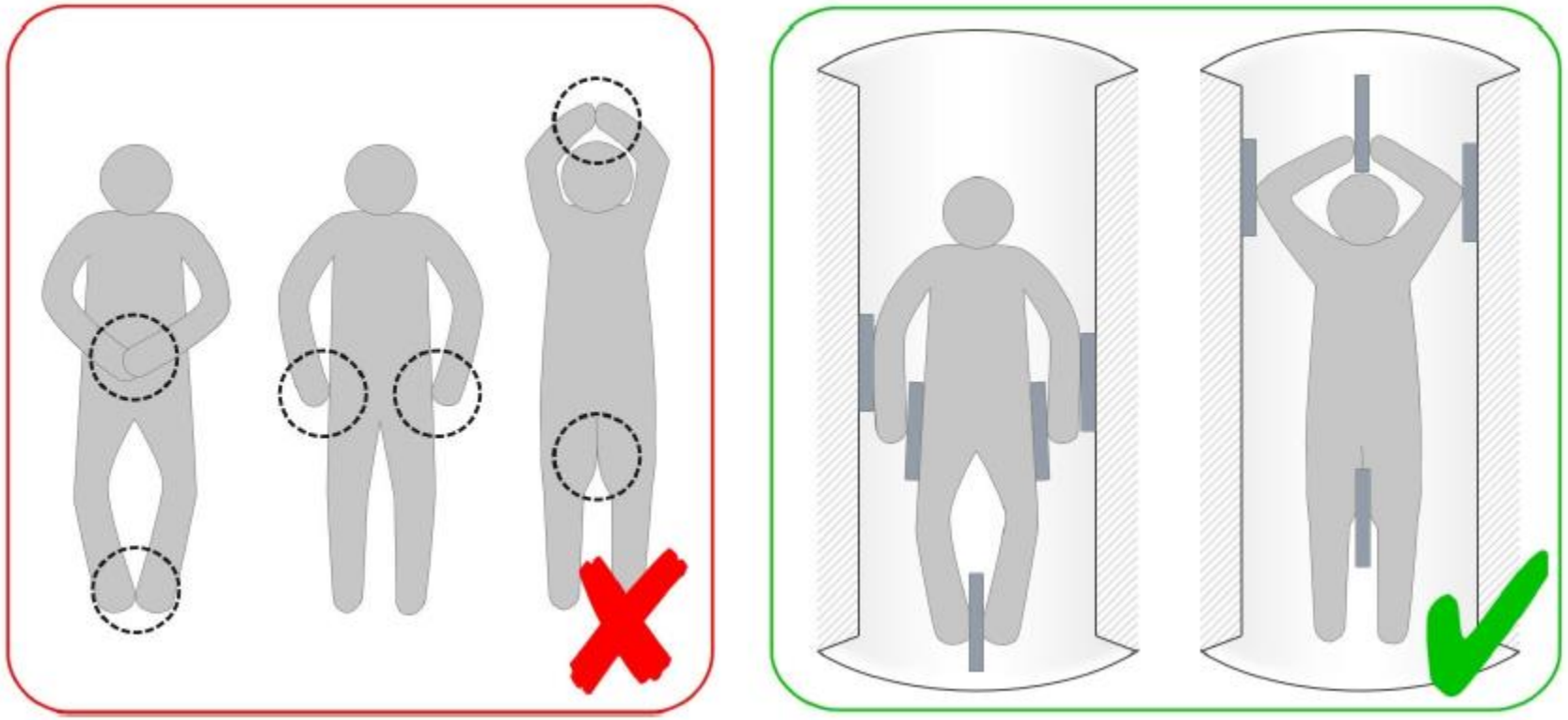
Application cushion

Charging Station

Electrocardiography (ECG)



Position the participant properly



Real-life pulse sequence

T1 weighted

T2 weighted

BOLD imaging

MPRAGE
(Magnetization Prepared RApid Gradient Echo)

FLAIR
(FLuid Attenuated Inversion Recovery)

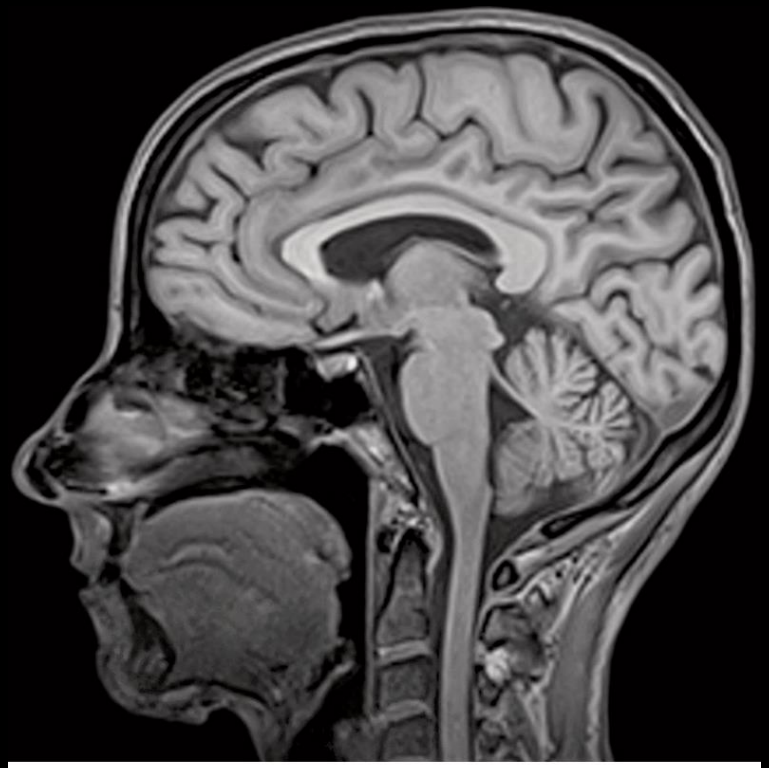
EPI
(EquiPlanar Imaging)

FLASH
(Fast Low Angle SHot)

TSE
(Turbo Spin Echo)

Imaging modalities

T1 MPRAGE



Head, T1 3D MPRAGE, GRAPPA 3

TR 1360, TE 3, TI 900, TA 2:20 min, effective SL 2 mm, partitions 88,
FOV 240x256 mm, matrix 240x256, 32-channel Head coil

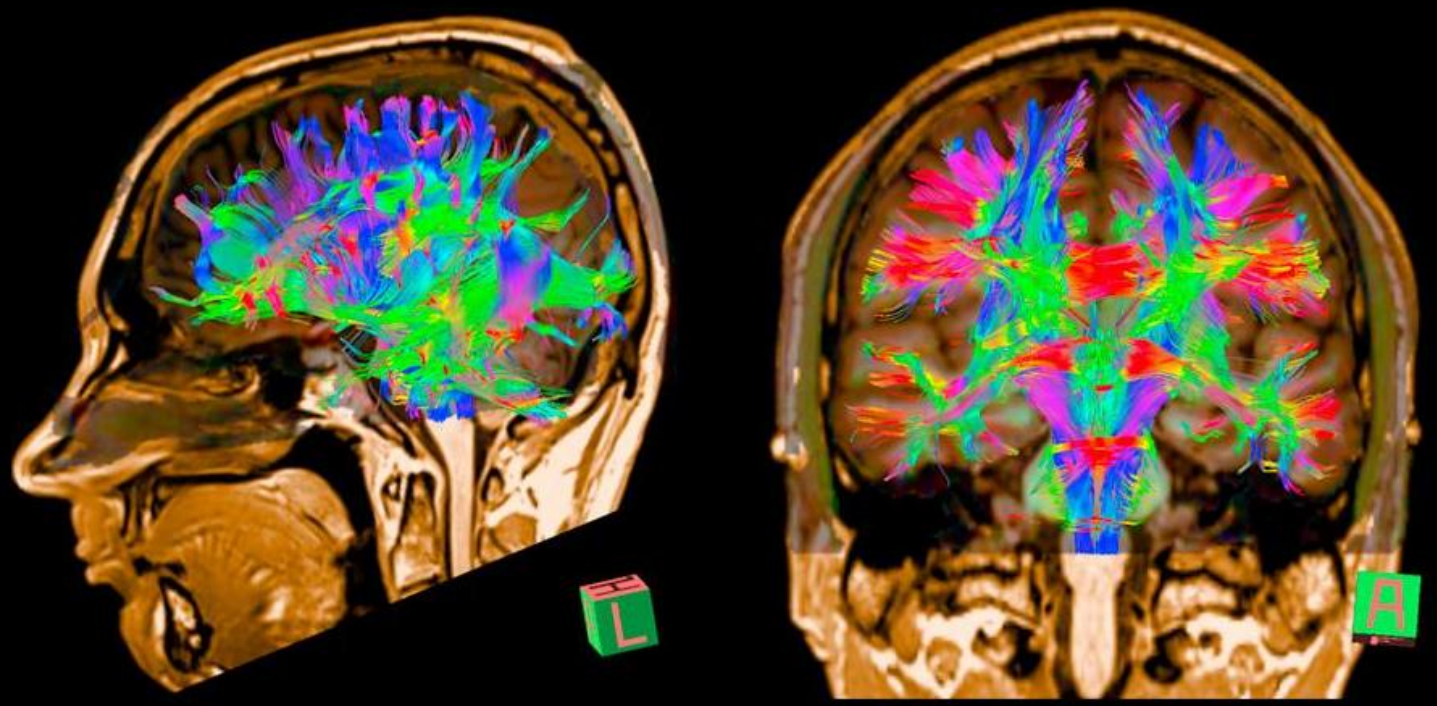
T2 TSE

Head, T2 TSE

TR 3500, TE 97, TA 4:01 min, SL 4 mm, slices 25, FOV 213x220 mm,
matrix 496x512
(Image: GP Radiologie & Nuklearmedizin, Frankfurt/Bad Nauheim,
Germany)

BOLD EPI

Diffusion Tensor Imaging (DTI)



Huisman (2010). Diffusion-weighted and diffusion tensor imaging of the brain, made easy. *Cancer Imaging*.

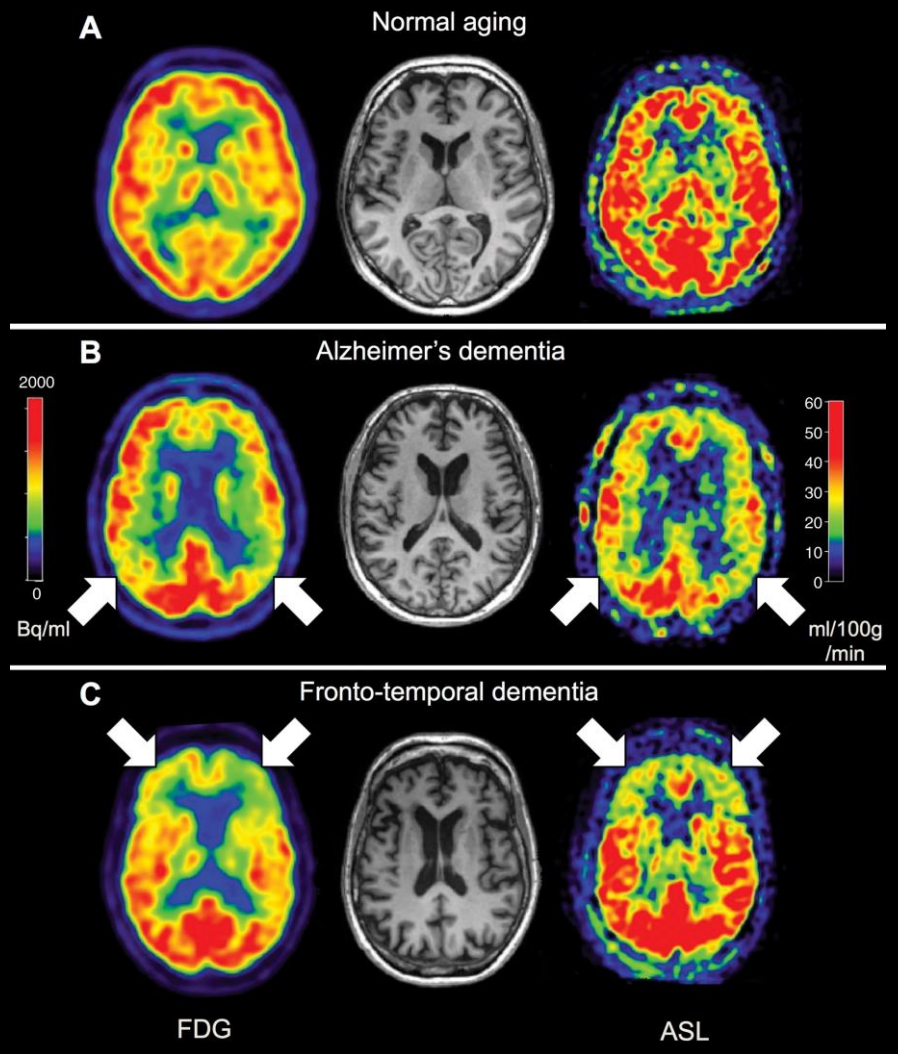
Magnetic resonance angiography (MRA)

Head Angiography, 3D FLASH TOF MIP, GRAPPA 2

TR 22, TE 3.7, TA 6:40 min, effective SL 1.2 mm, partitions 176, FOV 157x200 mm, matrix 317x448

Kiruluta & González (2016). Magnetic resonance angiography. *Handbook of clinical neurology*.

Perfusion MRI



Haller et al. (2016). Arterial spin labeling perfusion of the brain: emerging clinical applications. *Radiology.*

Open source tools for analysis

- **FreeSurfer**: analysis of structural data
- General-purpose MRI/fMRI software
  - **SPM (UCL)**
  - **AFNI (NIH / NIMH)**
  - **FMRIB Software Library or FSL (Oxford)**
- **NiPype**: provide Python wrappers to call the functions of different packages
- **Connectome Workbench** (from Human connectome project)

Ongoing MRI study on ageing

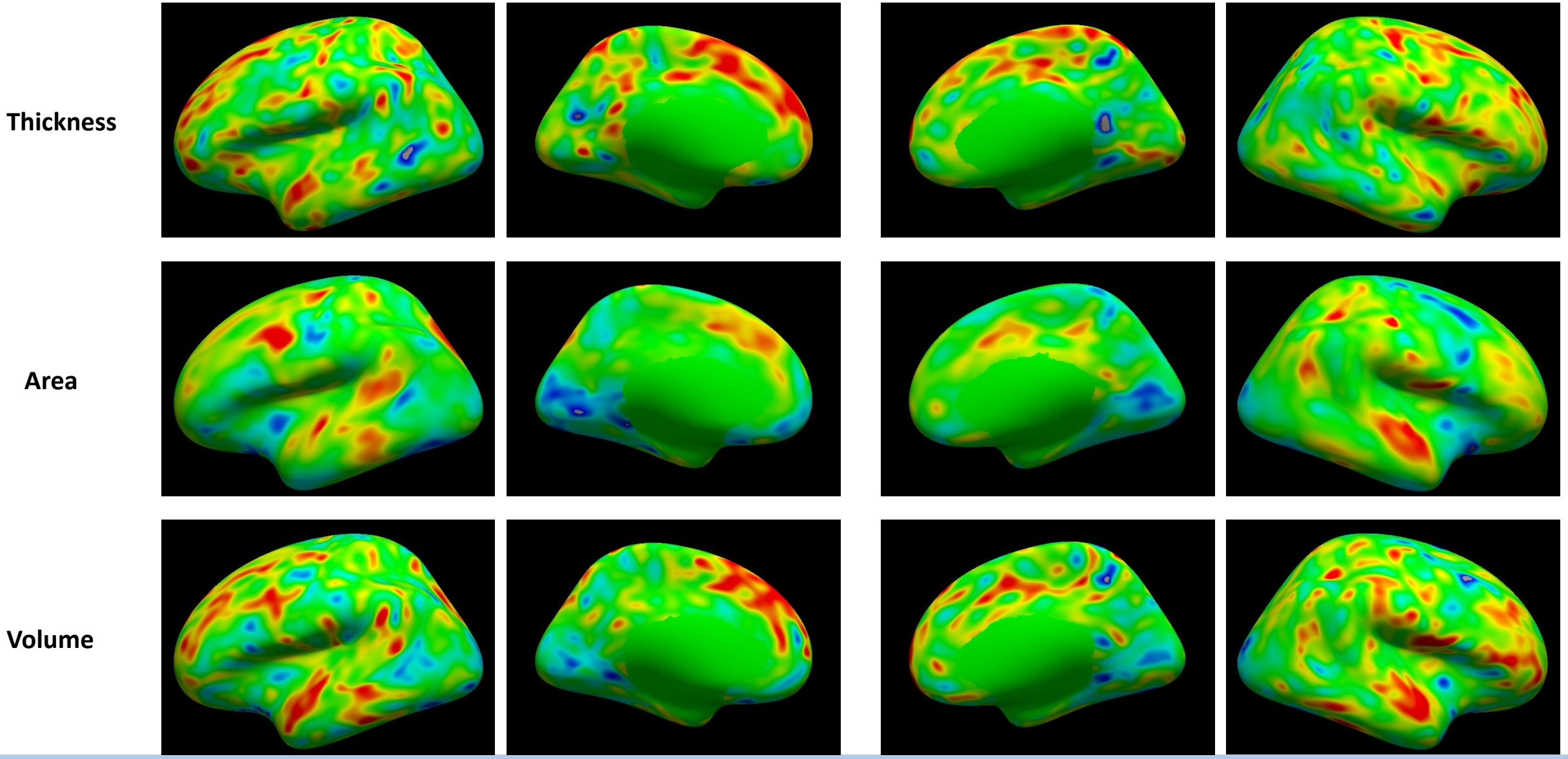
A small-scale study

- **Research question**:
  - Can we predict foreign language learning performance based on structural and resting-state fMRI measures?

- **Participants**
  - 8 young adults (4M) aged 18-25
  - 24 older adults aged 60-70 (11 F)

- **Method**: FreeSurfer was used to analyze the T1 structural data by extracting several surface-based measures:
  - Cortical thickness, cortical surface area, & cortical volume

Young–Old differences

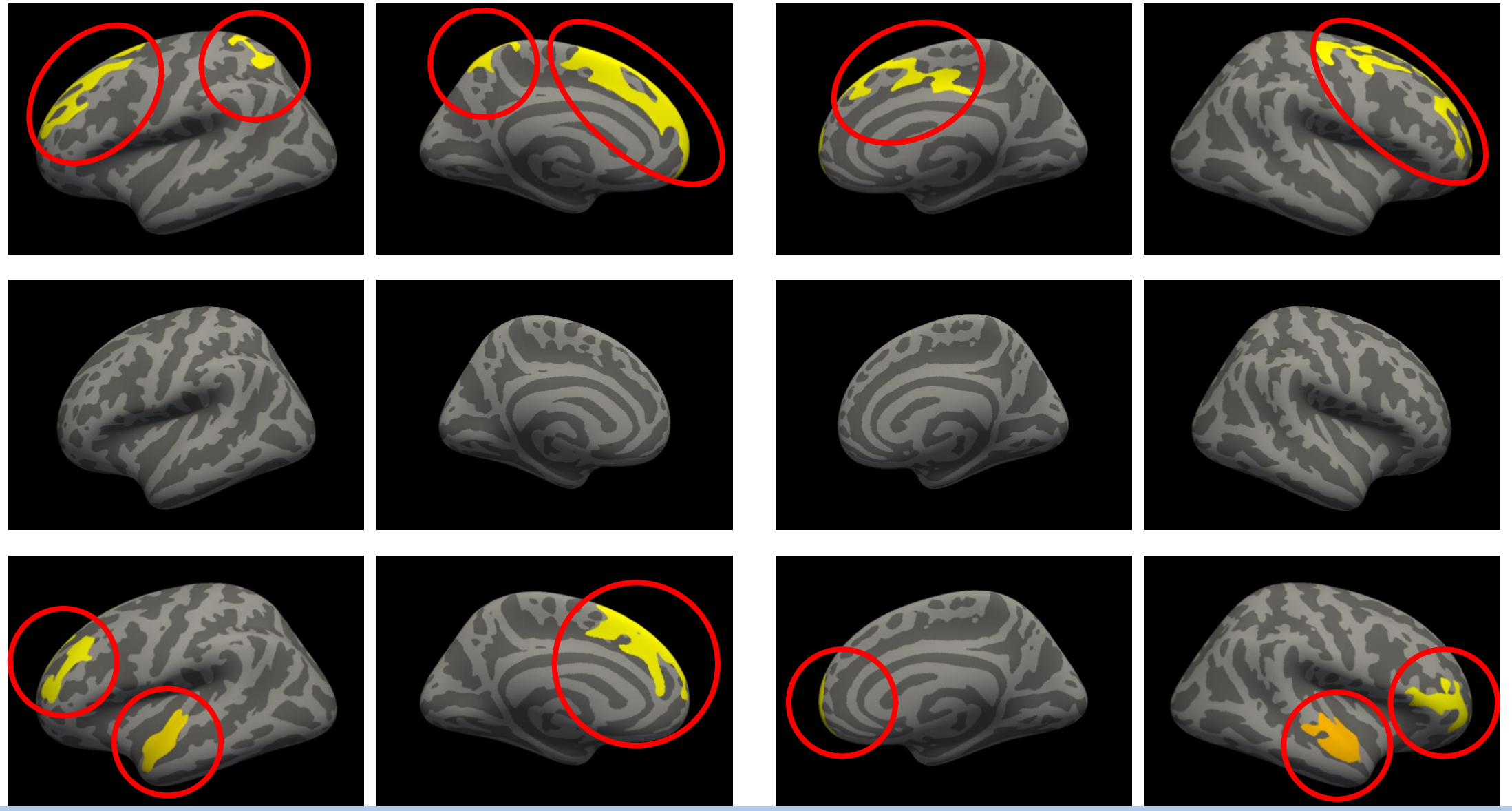


Young–Old differences

Thickness

Area

Volume



References

- T1 & T2 contrasts:
  - https://radiologykey.com/tissue-contrast-some-clinical-applications/#F3-6
- DWI/DTI
  - Huisman, T. A. G. M. (2010). Diffusion-weighted and diffusion tensor imaging of the brain, made easy. *Cancer Imaging*, *10*(1A), S163.
- MRA/Perfusion MRI
  - Kiruluta, A. J., & González, R. G. (2016). Magnetic resonance angiography: physical principles and applications. *Handbook of clinical neurology*, *135*, 137-149.
  - Haller, S., Zaharchuk, G., Thomas, D. L., Lovblad, K. O., Barkhof, F., & Golay, X. (2016). Arterial spin labeling perfusion of the brain: emerging clinical applications. *Radiology*, *281*(2), 337-356.