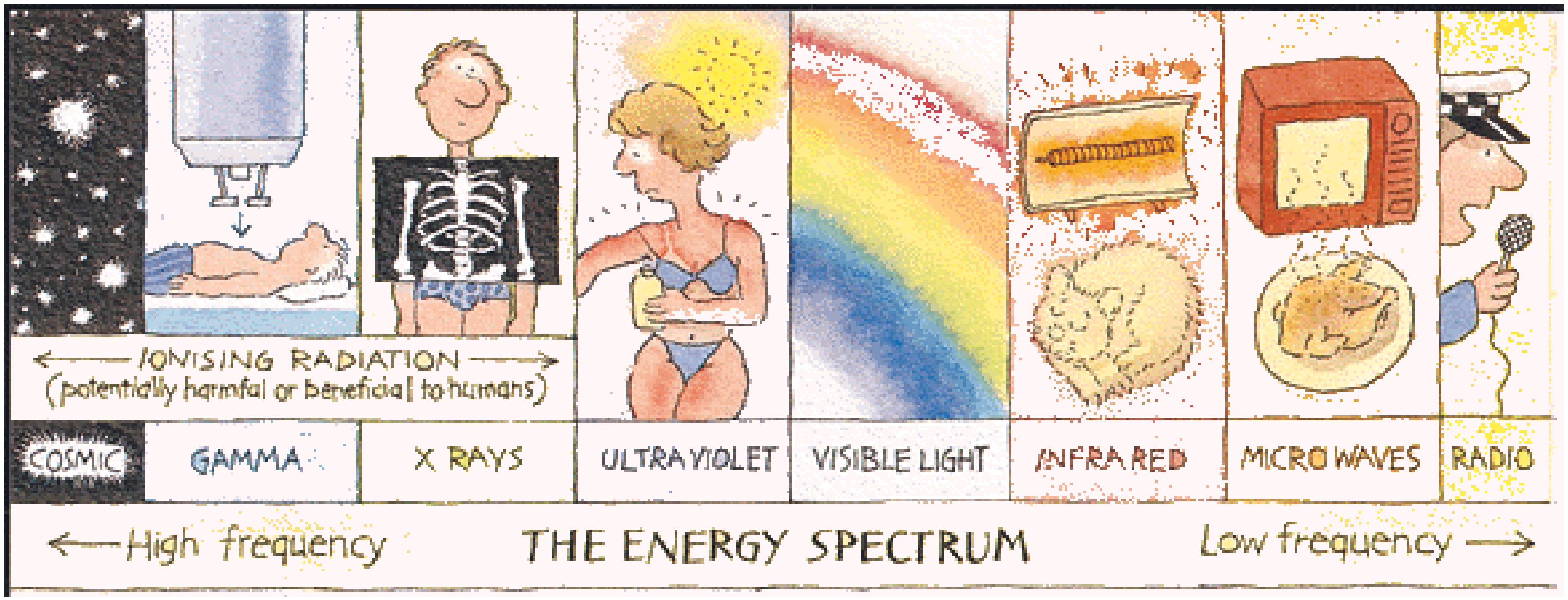
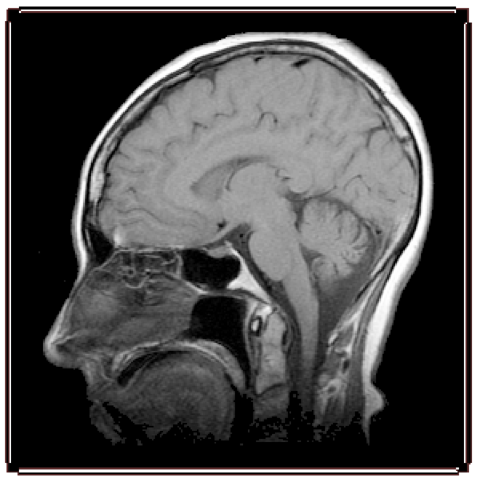

IONISING RADIATION
(potentially harmful or beneficial to humans)
COSMIC
GAMMA
X RAYS
ULTRA VIOLET
VISIBLE LIGHT
INFRA RED
MICRO WAVES
RADIO
High frequency
THE ENERGY SPECTRUM
Low frequency

… e nella diagnosi …

Risonanza magnetica

Imaging basato sull’assorbimento e l’emissione di energia nel range delle radiofrequenze



(oltre agli ultrasuoni)

Ecografia

Immagini generate dagli echi prodotti nell’interazione coi tessuti di un fascio di ultrasuoni

Radiazioni ionizzanti nella diagnosi:

Imaging radiologico

Immagini della trasmissione attraverso il corpo di un fascio di raggi X di frenamento prodotto da un apparecchio

Radiologia tradizionale

TAC

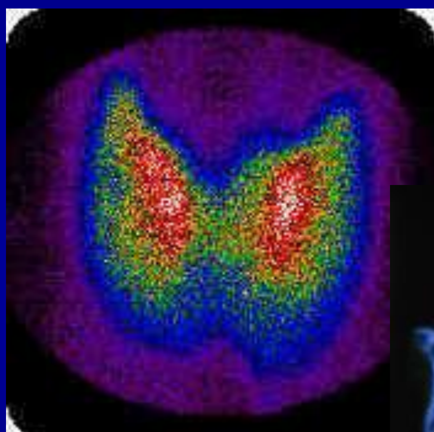
Applicazioni angiografiche, vascolari

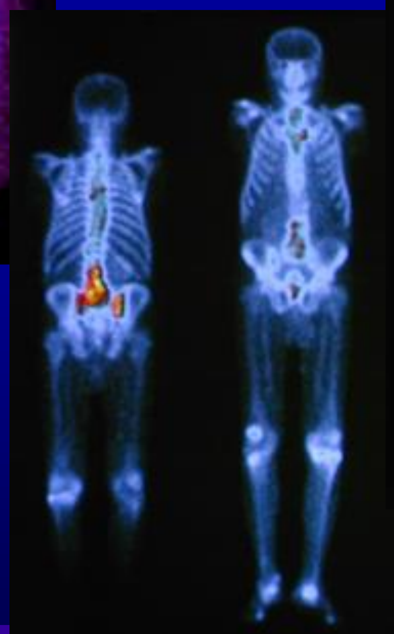
Radiazioni ionizzanti nella diagnosi:

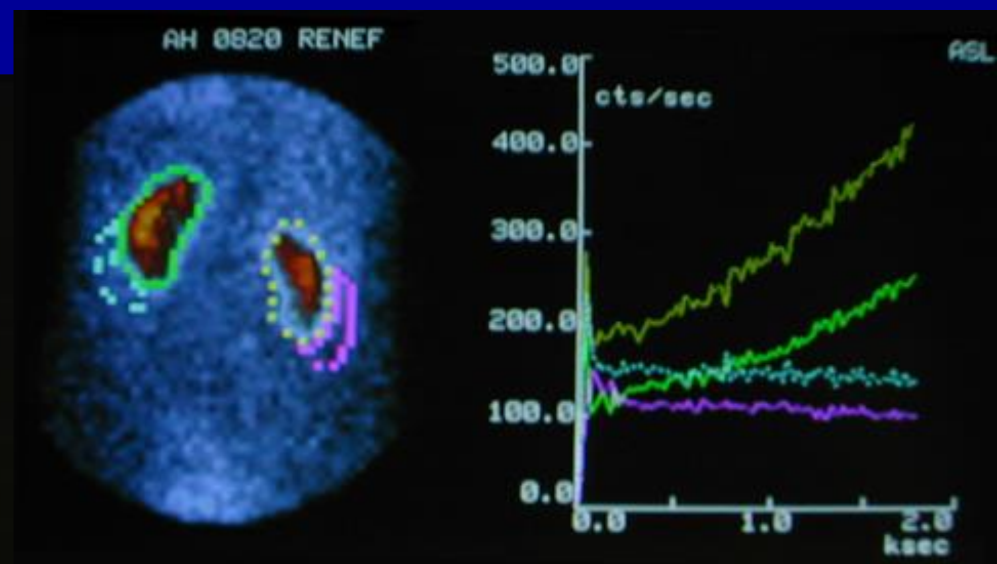
AZIENDA OSPEDALIERA DI PARMA

Medicina nucleare

Immagini della distribuzione nel corpo di un farmaco marcato con un radionuclide emettitore di radiazioni γ o di positroni







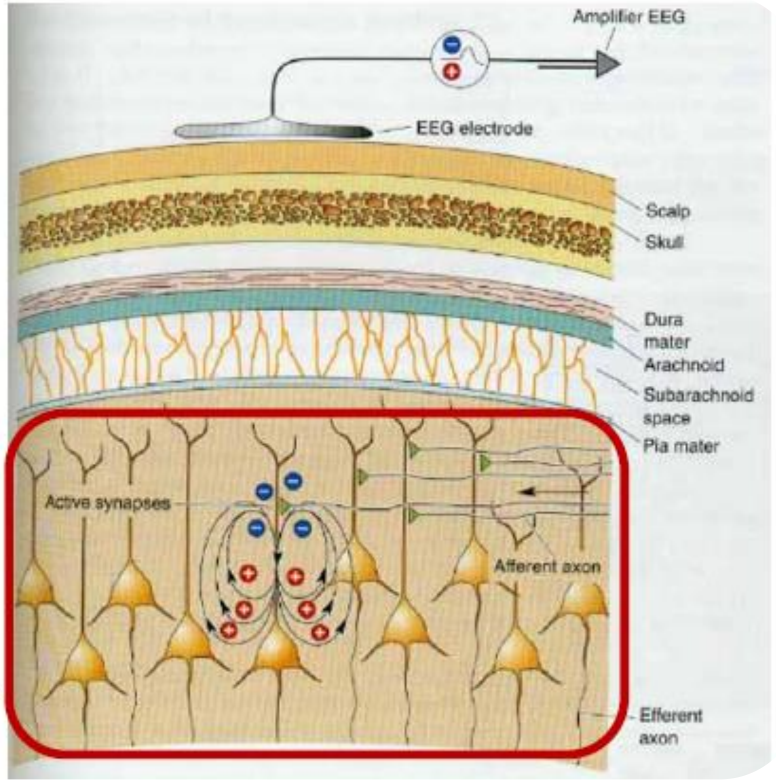
EEG: basic principles

- **Electroencephalogram** (EEG) electrodes
- Scalp recording of **electrical activity** of cortex => waveform signals
- **Microvolts** (μV) – small!
- Role of EEG in neuroimaging:
  - Identify **neural correlates**
  - **Diagnose** epilepsy, sleep disorders, anaesthesia, coma, brain death

http://opencc.co.uk/blog/out-of-touch-manual-keypads-and-controllers-face-competition-from-new-hands-free-computer-interfaces/

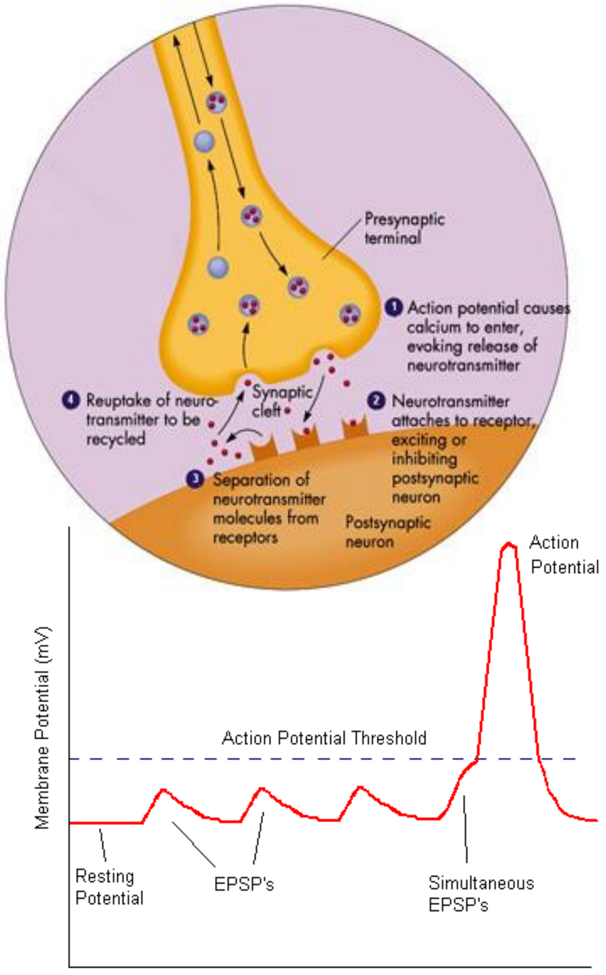
what is EEG?

- Is an **imaging technique** that reads scalp **electrical activity** (voltage) generated by **brain** structures across **time**
- The highest **influence to EEG** comes from electric activity of **cerebral cortex** due to its surface position.
- Primarily generated by **cortical pyramidal neurons** in the cerebral cortex that are oriented **perpendicularly to the brain's surface.**
- **Summation** of the excitatory and inhibitory **postsynaptic potentials** of relatively **large groups** of neurons **firing synchronously**



Neural basis of the EEG

Post-synaptic potentials



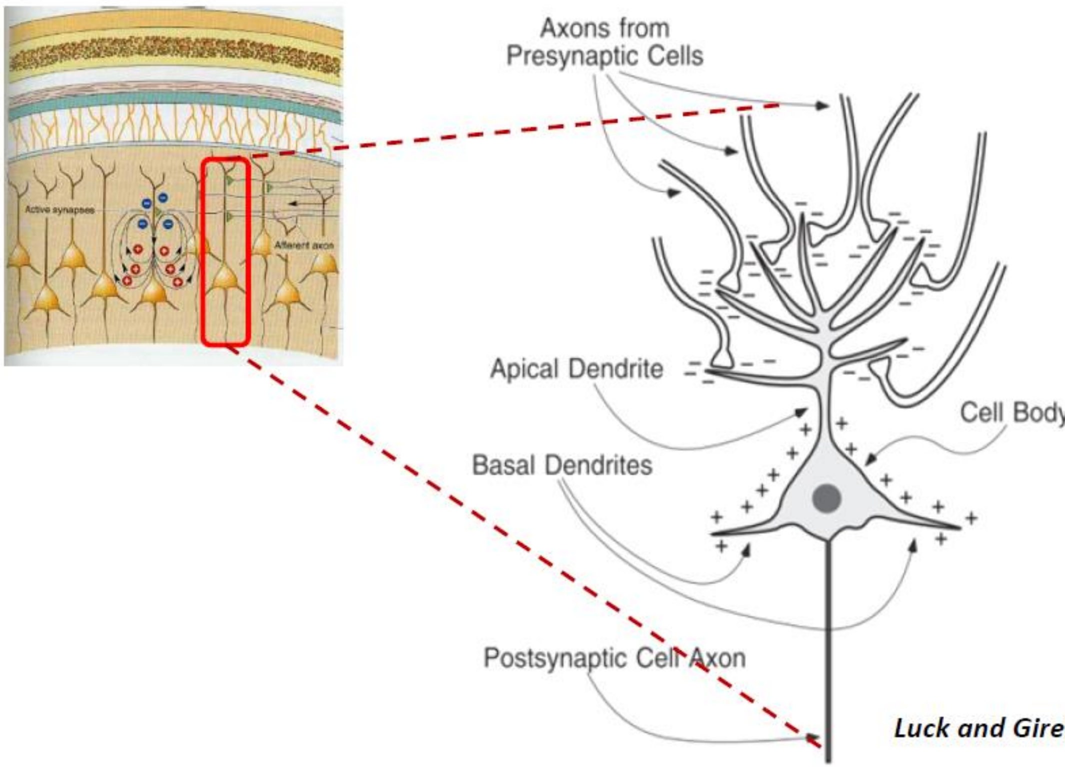
Scalp EEG is a summation of non-propogating dendritic and somatic post-synaptic potentials which arise relatively slower than action potentials (approx 10ms).

EPSPs – Excitatory Post Synaptic Potentials

IPSPs – Inhibitory Post Synaptic Potentials

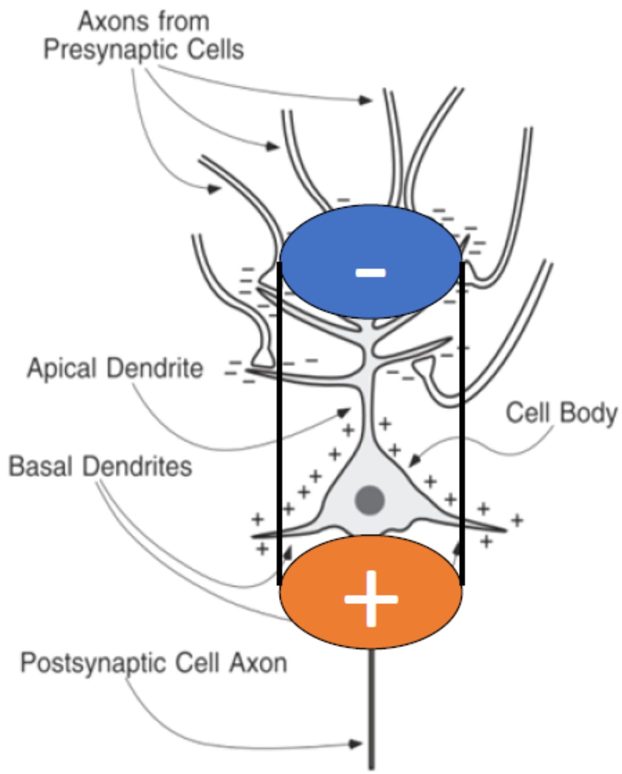
Post synaptic potentials summate spatially and temporally – A single pyramidal cell may have more than 10^4 synapses distributed over its soma and dendritic surface.

Neural basis and concept of Sink-Source



Luck and Girelli, 1998

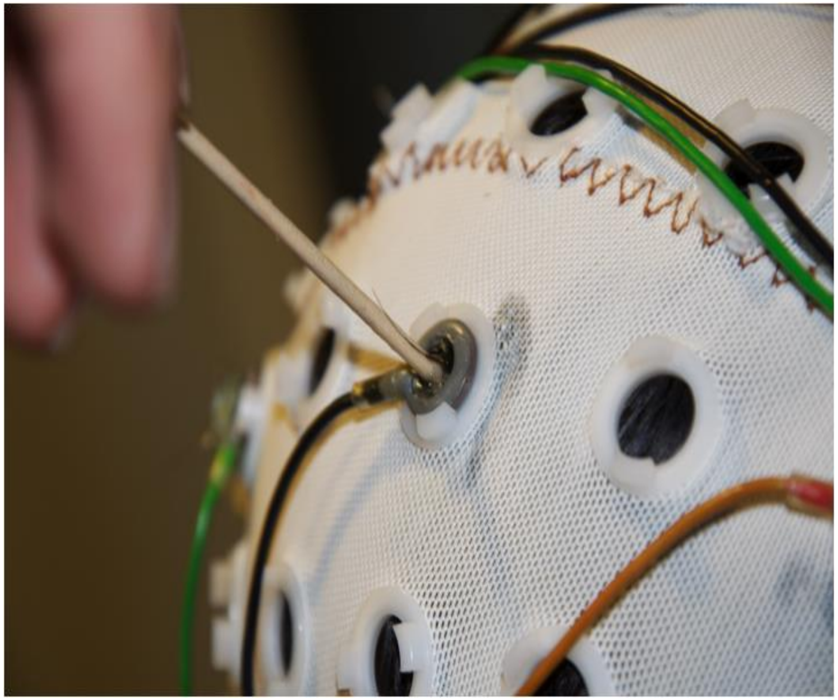
Neural basis and concept of Sink-Source



Luck and Girelli, 1998

AxXonet

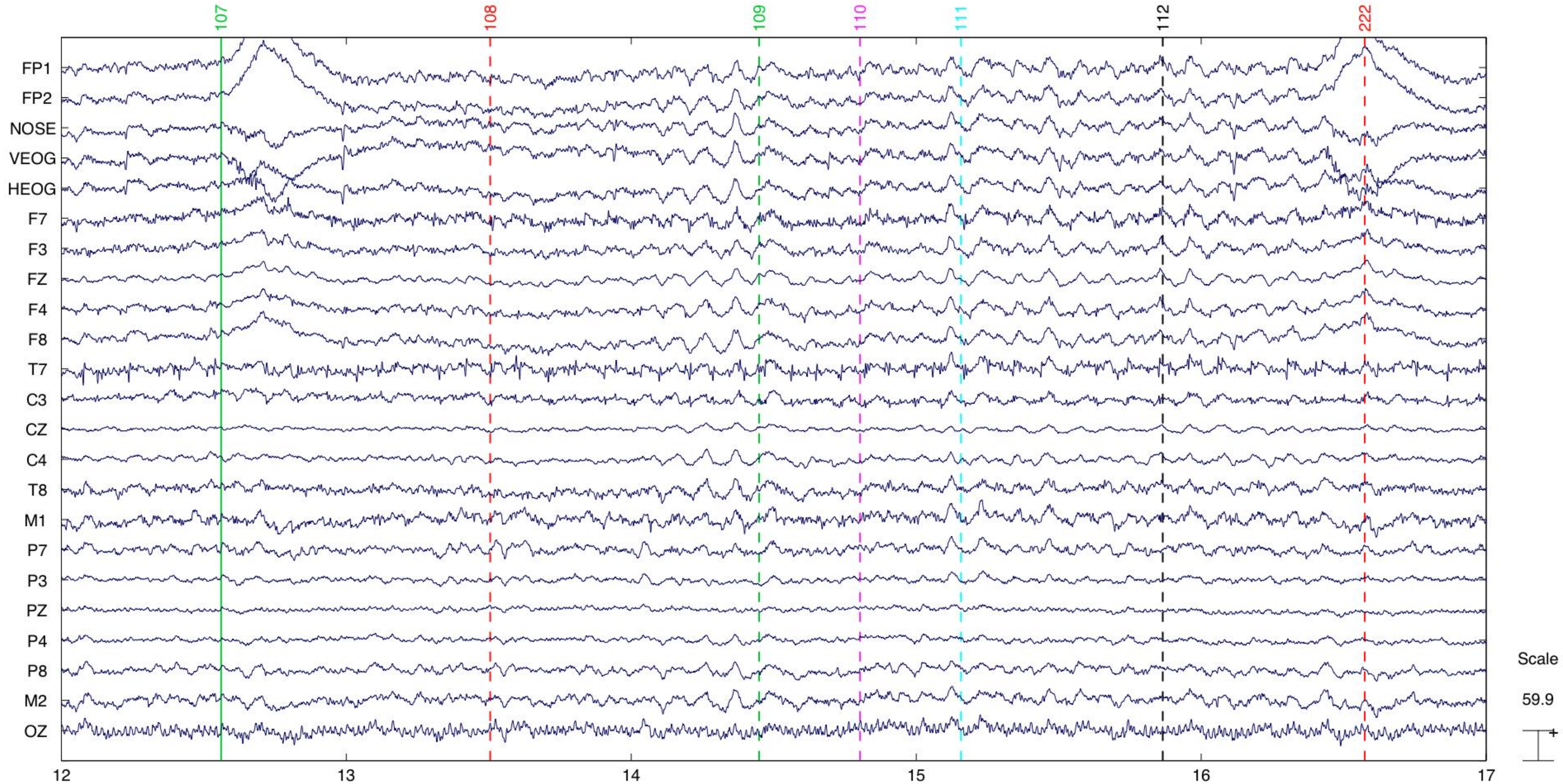
EEG Acquisition



Electrodes: Usually made of silver (or stainless steel) – active electrodes placed on the scalp using a conductive gel or paste. Signal-to-noise ratio (impedance) reduced by light abrasion. Can have 32, 64,128, 256 electrodes. More electrodes = richer data set. Reference electrodes (arbitrarily chosen "zero level", analogous to sea level when measuring mountain heights) commonly placed on the midline, ear lobes, nose, etc.

Amplification: one pair of electrodes make up one channel on the differential amplifier, i.e. there is one amplifier per pair of electrodes. The amplifier amplifies the difference in voltage between these two electrodes, or signals (usually between 1000 and 100 000 times). This is usually the difference between an active electrode and the designated reference electrode.

Continuous EEG recording



F = frontal, T = temporal, C = central, etc   Even number = right side of head, Odd number = left side

International 10-20 system – ensures consistency

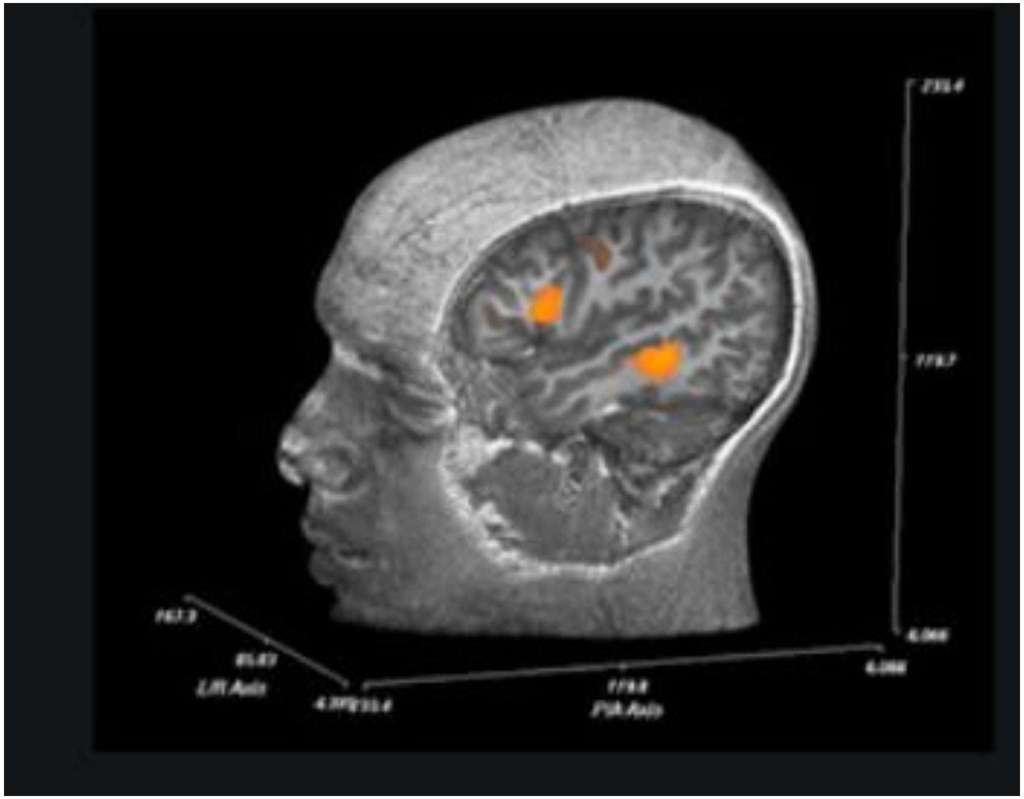
Outline

- MRI basics
- Standard MRI techniques (T1, T2, FLAIR …)
- Contrast enhanced MRI
- MR spectroscopy
- Perfusion MRI
- Angio MRI
- fMRI
- DTI
- MRI and multimodal imaging
- Very high and ultra-low field MRI

Introduction

MRI applications can be grouped into:

- Clinical Neurology
  - Neuroimaging, e.g. demyelinating diseases, dementia, cerebrovascular disease, neurodegenerative diseases (Epilepsy, Parkinson, Alzheimer, Huntington …), in general functional and structural brain abnormalities, development and aging
- Cancer
  - Breast, colorectal, Brain
  - MRI guided stereotactic surgery and radiosurgery

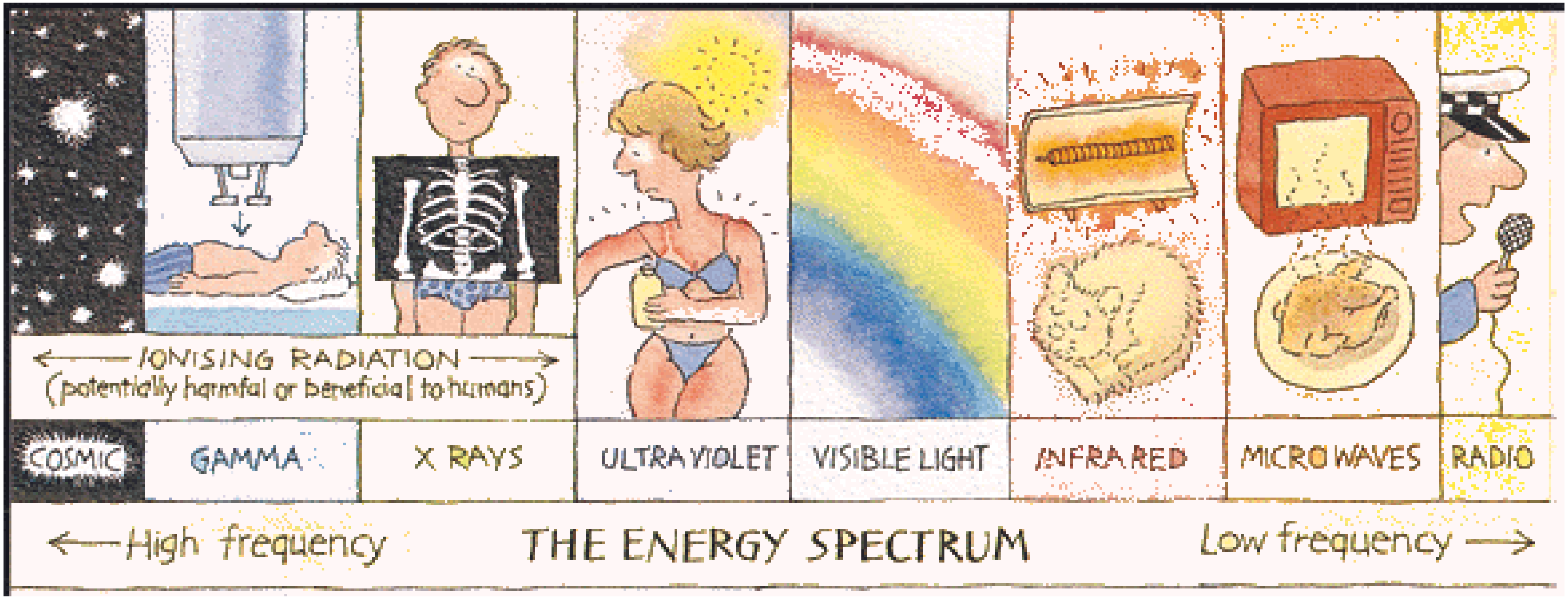


Identification of language areas in an oncological patient
Pre-surgical mapping
Safe resection of involved areas

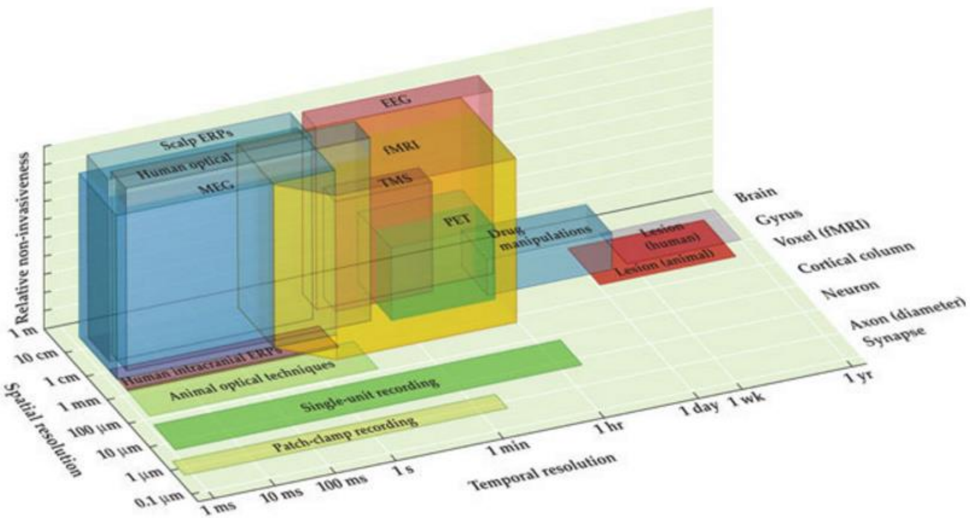
Introduction

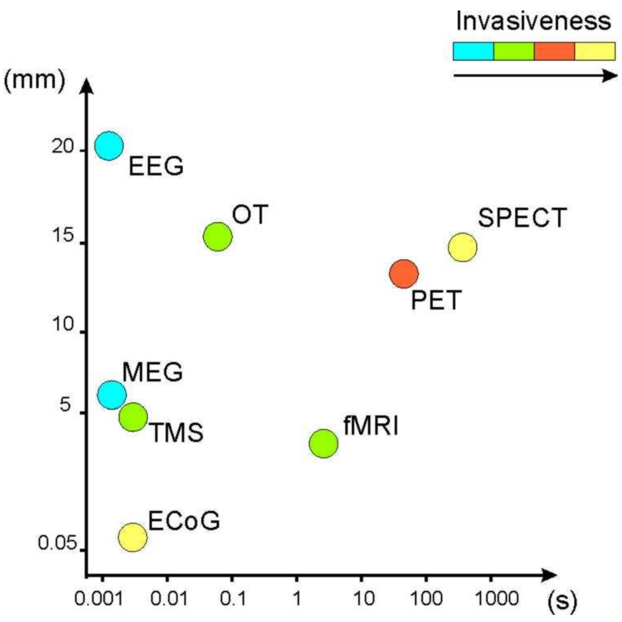
- Cardiovascular
  - Myocardial ischemia and cardiomyopathies, myocarditis, iron overload, vascular diseases and congenital heart disease
- Muscoloskeletal
  - Spinal imaging, assessment of joint disease and soft tissue tumors
- Liver and gatrointestinal

In energetic terms…



Comparison MRI vs other imaging techniques in terms of invasiveness





MRI advantages

- Excellent soft tissue contrast resolution
- Ability to obtain direct transverse, sagittal, coronal and oblique images
- No ionizing radiation
- No bone-air artifacts
- A very rich information coming from a large set of parameters determining the MRI contrast

some drawbacks…

"OK, Mrs. Dunn. We'll slide you in there, scan your brain, and see if we can find out why you've been having these spells of claustrophobia."

MRI disadvantages

- Long imaging time
- Complexity of equipment and scan acquisition
- High cost
- Low resolution for calcification or bone details
- Not all subjects can undergo MRI (any metallic fragment may become projectile, no pace maker, dental implants, heart valves, aneurism clips, claustrophobia?)

MRI compared to CT

COMPARISON	MRI	CT SCAN
Soft Tissue	Much higher detail in soft tissues	Less detailed in soft tissue
Bony Structures	Less detailed when compared with CT Scan	More detail about bony structures
Effects on the body	No hazards reported	Small risk of irradiation
Cost	Cost can vary from $1400 to $4000 (when used with contrast). Generally more expensive than CT Scans and x-rays	Cost ranges from $1200 to $3200. Generally less than MRIs
Also known as:	Magnetic Resonance Imaging	Computed Tomography
Exposure to Radiation	None	Moderate
Time Taken to scan	Typically 30 to 45 minutes	Generally within 5 minutes

MR exam clinical setting

- Equipe and responsabilities:

  - Patient

  - Technician
    - Patient registration (from informed consent)
    - Check patient compliance with MRI exam (clips etc…) sometimes a metal detector is used
    - Let the patient in the scanner
    - Patient positioning
    - Perform exam
    - Let the patient out the MRI room

MR exam clinical setting

- Physicist
  - Setup the imaging protocol
  - Quality control (B0 homogeneity, coils)
  - Develop new sequences or optimize existing ones
  - Data analysis

- Anesthetist (when contrast agent is administered)

- Nurse (difficult patients and help with the contrast agent administration)
- Physician (Radiologist / Neuro-radiologist)
  - Verify and sign the informed consent to allow patient in the MR room
  - Report on the MRI findings

MR clinical setting

FONDAZIONE SANTA LUCIA
ISTITUTO DI RICOVERO E CURA A CARATTERE SCIENTIFICO
Ospedale di rilievo nazionale e di alta specializzazione per la riabilitazione neuromotoria
00179 Roma - Via Ardeatina, 306 - Tel +39 06 515011 - Fax +39 065032097 - www.hsantalucia.it

QUESTIONARIO PER L'ACCESSO ALLA SALA DI RISONANZA MAGNETICA CON APPARECCHIATURA A 3 TESLA

Cognome ________________ *Nome* ________________

Luogo di nascita ________________ *Data di nascita* ________________

Luogo di residenza/domicilio ________ *indirizzo* ________ *Telefono/cellulare* ________

Protocollo di studio: ________________

Ricercatore con recapito telefonico: ________________

ATTENZIONE: I PORTATORI DI PACE MAKER CARDIACO, DI APPARECCHIATURE ELETTRONICHE IMPIANTATE O DI ELEMENTI METALLICI FERROMAGNETICI MOBILI NON POSSONO ESEGUIRE L'ESAME RM.
Per i portatori di impianto protesico occorre produrre al momento dell'esame RM la certificazione di compatibilità elettromagnetica del materiale utilizzato per la protesi rilasciata dal servizio che ha effettuato l'intervento.

	Sì	No
Ha già eseguito un esame di RM ?	❑	❑
E' portatore di PACE MAKER cardiaco?	❑	❑
E' portatore di defibrillatore cardiaco?	❑	❑
E' portatore di valvole o cateteri cardiaci?	❑	❑
E' portatore di protesi al cristallino?	❑	❑
Ha neurostimolatori o elettrodi nel cervello?	❑	❑
Ha cateteri e valvole di derivazione ventricolo-peritoneale?	❑	❑
Ha corpi metallici o impianti per udito?	❑	❑
Ha pompe per infusione di farmaci?	❑	❑
Ha clips per aneurismi, clips chirurgiche, viti, chiodi, fili o schegge metalliche?	❑	❑
Ha subito incidenti stradali o di caccia?	❑	❑
Ha mai lavorato come saldatore, tornitore, fabbro, carrozziere?	❑	❑
E' affetto da anemia falciforme?	❑	❑
E' portatore di piercing e/o tatuaggi?	❑	❑

	Sì	No
se sì, quando? ________		
Soffre di claustrofobia?	❑	❑
Per Pazienti di sesso femminile:		
E' in stato di gravidanza?	❑	❑
Data ultime mestruazioni: ________		
E' portatrice di corpi intra-uterini?	❑	❑
Ha mai subito interventi chirurgici? Se sì, indicare quali e in che data:	❑	❑

ACCESSO ALLA ZONA CONTROLLATA DI RM 3 TESLA

PRIMA DI ENTRARE NELLA ZONA AD ACCESSO CONTROLLATO OCCORRE TOGLIERE QUALSIASI OGGETTO METALLICO, MECCANICO O ELETTRONICO O MAGNETICO E ALTRI OGGETTI CHE POSSANO DANNEGGIARE IL PAZIENTE/VOLONTARIO O DANNEGGIARSI A SEGUITO DELL'ESPOSIZIONE AL CAMPO MAGNETICO E A ONDE DI RADIOFREQUENZA.

IN PARTICOLARE: lenti a contatto rigide, apparecchi per l'udito, protesi dentarie mobili, reggiseno con ferretto o parti metalliche, fermagli, mollette, occhiali, gioielli, orologi, carte di credito o schede magnetiche, ferma-soldi, monete, chiavi, ganci, bottoni metallici, spille, indumenti con lampo, punti metallici (quelli applicati in tintoria). E' necessario rimuovere prodotti cosmetici dal volto per la RM cerebrale.

Avete rimosso tutti gli oggetti metallici? **SI ❑** **NO❑**

Il paziente/volontario, informato sulle modalità di svolgimento dell'esame RM, sulle complicanze e rischi eventuali ad esso connessi,

Acconsente al trattamento dei suoi dati personali e sensibili secondo il *Testo Unico sulla privacy DL.vo 196/2003* per le finalità dell'esame RM: **SI ❑** **NO❑**

Acconsente al trattamento in forma anonima dei suoi dati e dei dati derivanti dall'esame RM per finalità di ricerca scientifica da parte dei medici e ricercatori della IRCCS Fondazione Santa Lucia: **SI ❑** **NO❑**

Letto e approvato, acconsente all'accesso alla sala RM **SI ❑** **NO❑**

Data: ____________________ **Firma del paziente/volontario** ________________________

Data ________________ ***Firma del Medico radiologo*** ________________________

CONSENSO ALLA SOMMINISTRAZIONE DI MEZZO DI CONTRASTO (COMPILARE SOLO SE LA SOMMINISTRAZIONE E' PREVISTA DAL PROTOCOLLO)

La somministrazione del mezzo di contrasto avviene per via parenterale e può, raramente, provocare disturbi di tipo allergico generalmente di scarsa entità, tipo orticaria a rapida risoluzione.

Ha mai avuto reazioni allergiche a sostanze o a mezzi di contrasto? **SI ❑** **NO❑**

In relazione alla nota informativa dell'AIFA del 26-06-2007 si informa che è stata osservata una possibile associazione tra l'utilizzo di mezzi di contrasto contenenti gadolinio e fibrosi sistemica nefrogenica. Questi mezzi di contrasto devono quindi essere utilizzati con cautela in pazienti con moderata insufficienza renale (GFR 30-59 ml/min/1,73m²) e sono controindicati in pazienti con insufficienza renale grave (GFR <30 ml/min/1,73m²).

E' affetto da insufficienza renale? **SI ❑** **NO❑**

Il paziente (Età>30 anni) ha effettuato il seguente esame: Creatininemia **SI ❑** **NO❑**

Informato dell'indicazione clinica, delle modalità di svolgimento e delle eventuali complicanze e rischi connessi, acconsento alla somministrazione di mezzo di contrasto: **SI ❑** **NO❑**

Data: ____________________ **Firma del paziente/volontario** ________________________

Data ________________ Firma del Medico ________________________

MR missile effect

Two magnets close to each other:

- Align themselves to one another positive-to-negative. In the case of a ferromagnetic object brought near an MRI, one weighs perhaps 12 tons and is bolted to the floor, the other is a pair of scissors that weigh a few ounces. Which of these two things is going to rotate to align itself?

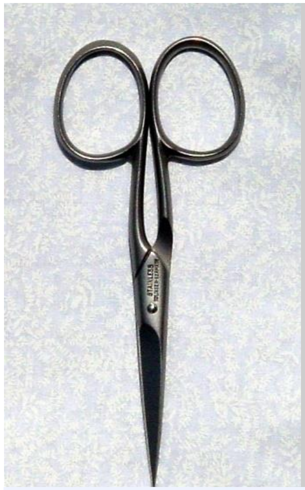
- Smaller ferromagnetic objects that we wear, carry, or have placed within our bodies can twist, turn and even tear whatever may be trying to hold them in place.

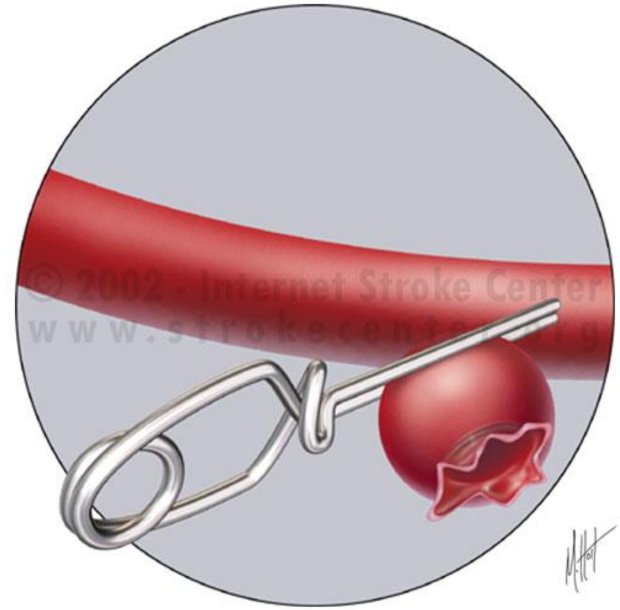
MR missile effect

- Attractive force: two aligned magnets are attracted (think about a magnet on the fridge door). Missile effect because ferromagnetic objects, propelled by enormous amounts of magnetic energy, can launch across the room with tremendous force towards an MRI. towards the peak of the magnetic field (typically the center of the MRI).

Oxygen tank example

MR safety





Aneurysm clips can be stripped away from the blood vesseles leading to death

Oggetti volanti possono uccidere la gente.
Anche se non creano incidenti gravi, possono volare nel magnete e danneggiarlo o richiedono un arresto costoso del sistema.

Image contrast

Radiation needs to interact with the body's tissues in a differential manner to provide a contrast:

- X-ray/CT: absorption rate (diff. in e^- density ρ) $\mu \approx \frac{\rho Z^4}{AE^3}$
- Ultrasound imaging: acoustic impedance (density and speed of sound) (z = ρv)
- Nuclear medicine: tracer concentration

But in MRI?

MRI parameters

MRI contrast depends on a large set of parameters:

- Intrinsic parameters include:
  - ✓ proton density velocity
  - ✓ spin-lattice relaxation time (T1) diffusion
  - ✓ spin-spin relaxation time (T2) perfusion
  - ✓ chemical environment temperature

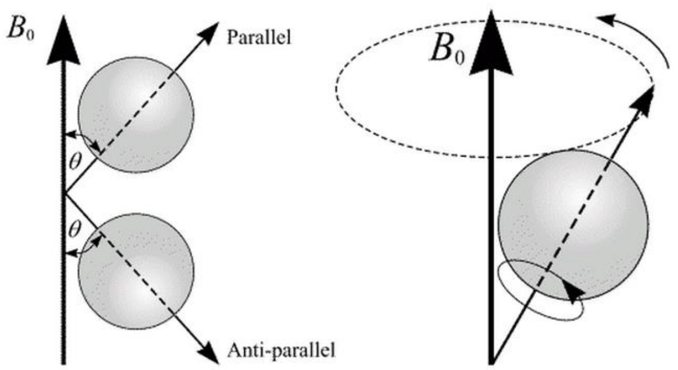
- Extrinsic parameters include:
  - ✓ echo time (TE) saturation pulses
  - ✓ repetition time (TR)
  - ✓ inversion pulses flip angle (α)
  - ✓ flow compensation pulses
  - ✓ contrast agents
  - ✓ diffusion sensitization pulses

Where do these parameters come from?

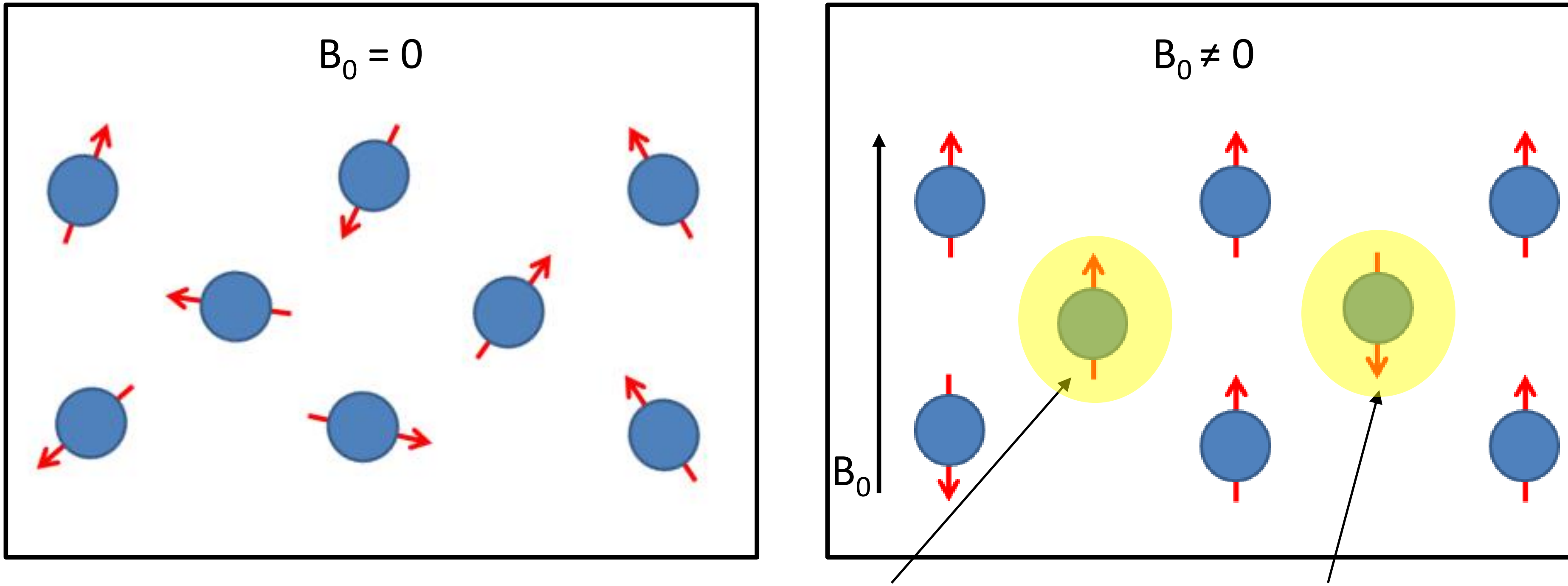
Risonanza Magnetica Nucleare

Magnetic Moment and Spin

Atomic nuclei with an odd number of neutrons and/or protons have a small *magnetic moment* and an angular momentum called *nuclear spin* *(e.g. H_2O)*



Nuclei	Unpaired Protons	Unpaired Neutrons	Net Spin	γ(MHz/T)
^{1}H	1	0	1/2	42.58
^{2}H	1	1	1	6.54
^{31}P	1	0	1/2	17.25
^{23}Na	1	2	3/2	11.27
^{14}N	1	1	1	3.08
^{13}C	0	1	1/2	10.71
^{19}F	1	0	1/2	40.08

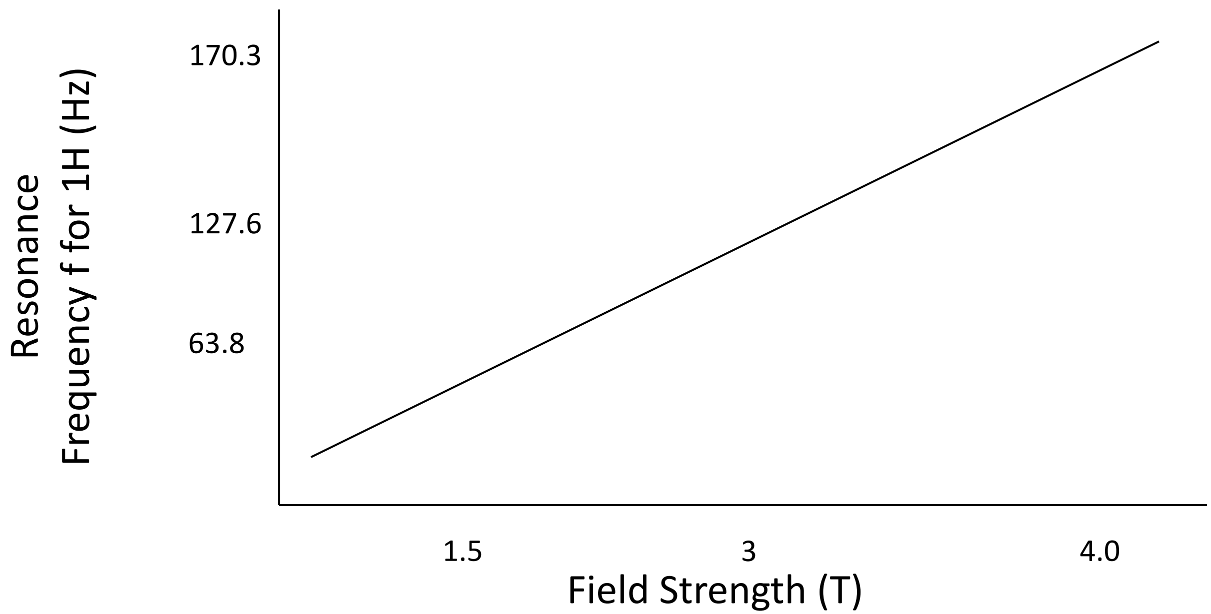


When $B_0 \neq 0$ protons will either align *parallel* to the magnetic field or *anti-parallel* to it and a small excess ($1/10^5$) of parallel vs antiparallel spins leads to a net magnetization M_0

Larmor equation

the energy difference between the high (antiparallel) and low (parallel) energy states is expressed by the Larmor equation:

$$\nu = \gamma B_0 \text{ with } (\gamma = 42.58 \text{ MHz/T})$$

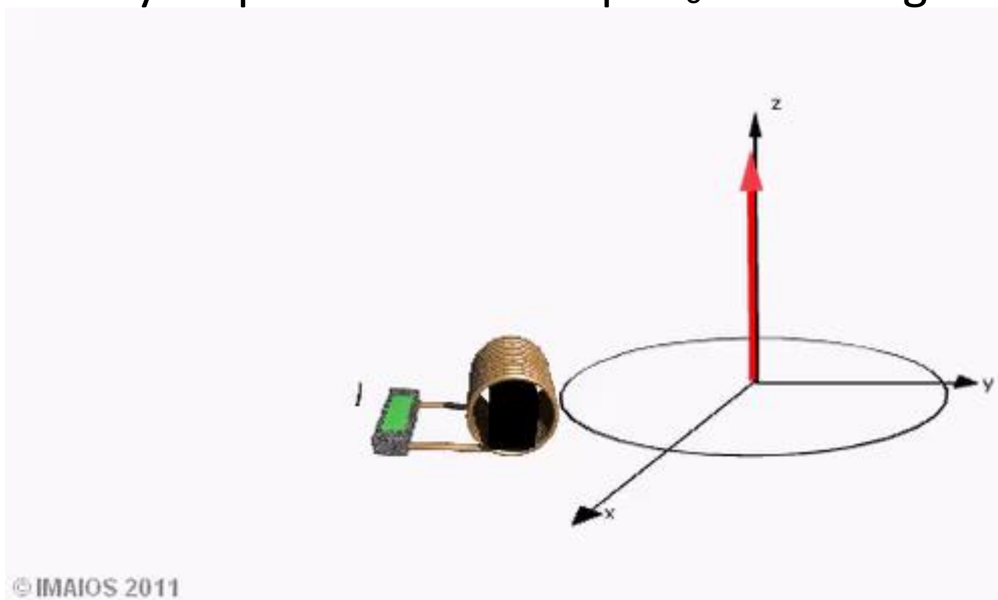


Resonance

Through Resonance protons can flip between energy states as long as the specific frequency is used

RF excitation

This is achieved by RF pulses used to flip M_0 out of alignment with B_0

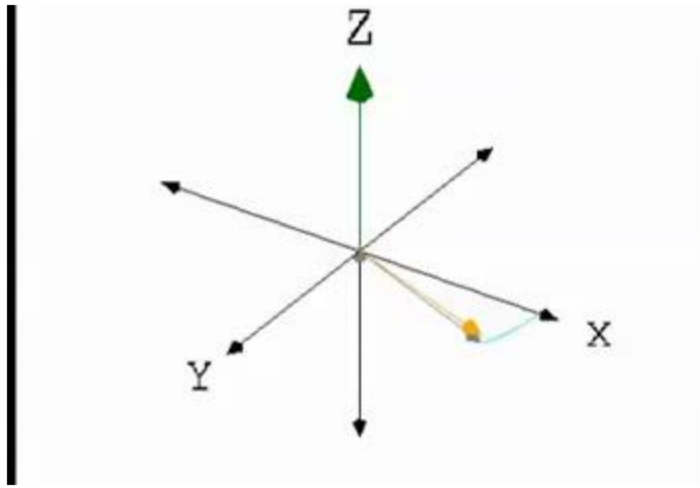


M_0 from a non-equilibrium state returns to the equilibrium distribution.

These two principal relaxation processes are described in terms of T_1 and T_2 relaxation times respectively.

T1 (Spin-Lattice) relaxation

T_1 relaxation involves redistributing the populations of the nuclear spin states to reach the thermal equilibrium distribution.



Relaxation mechanisms allow nuclear spins to exchange energy with their surroundings (*lattice)*

T_1 relaxation strongly depends on the NMR frequency and so varies considerably with B_0

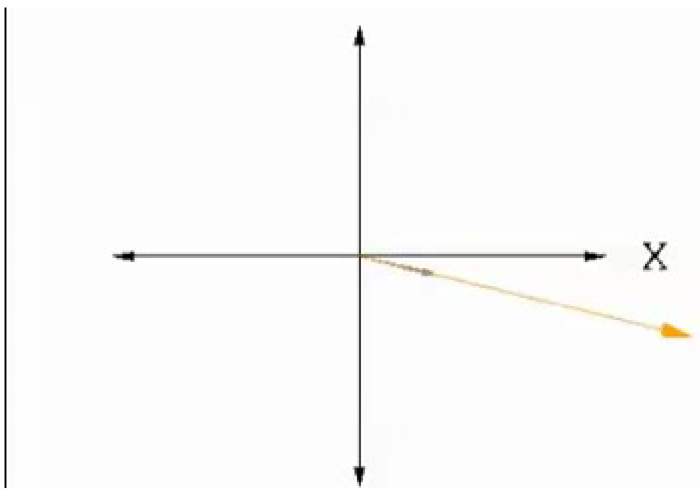
T2 (Spin-Spin) relaxation

T_2 relaxation corresponds to a decoherence of the M_{xy}

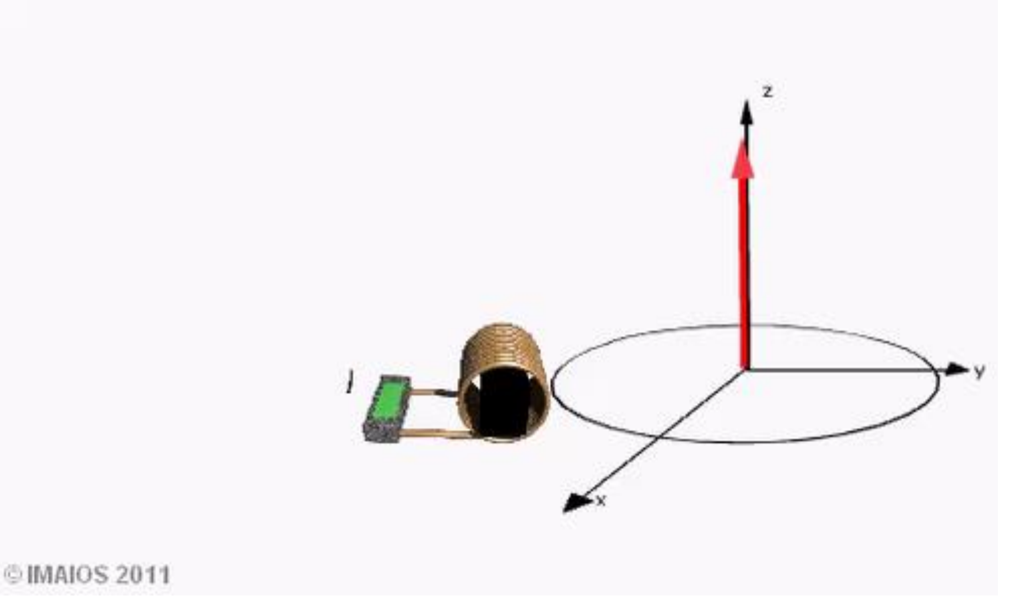
Random fluctuations of B lead to random variations of frequency of spins

The initial phase coherence is eventually lost

T_2 values are generally much less dependent from B_0 than T_1 values

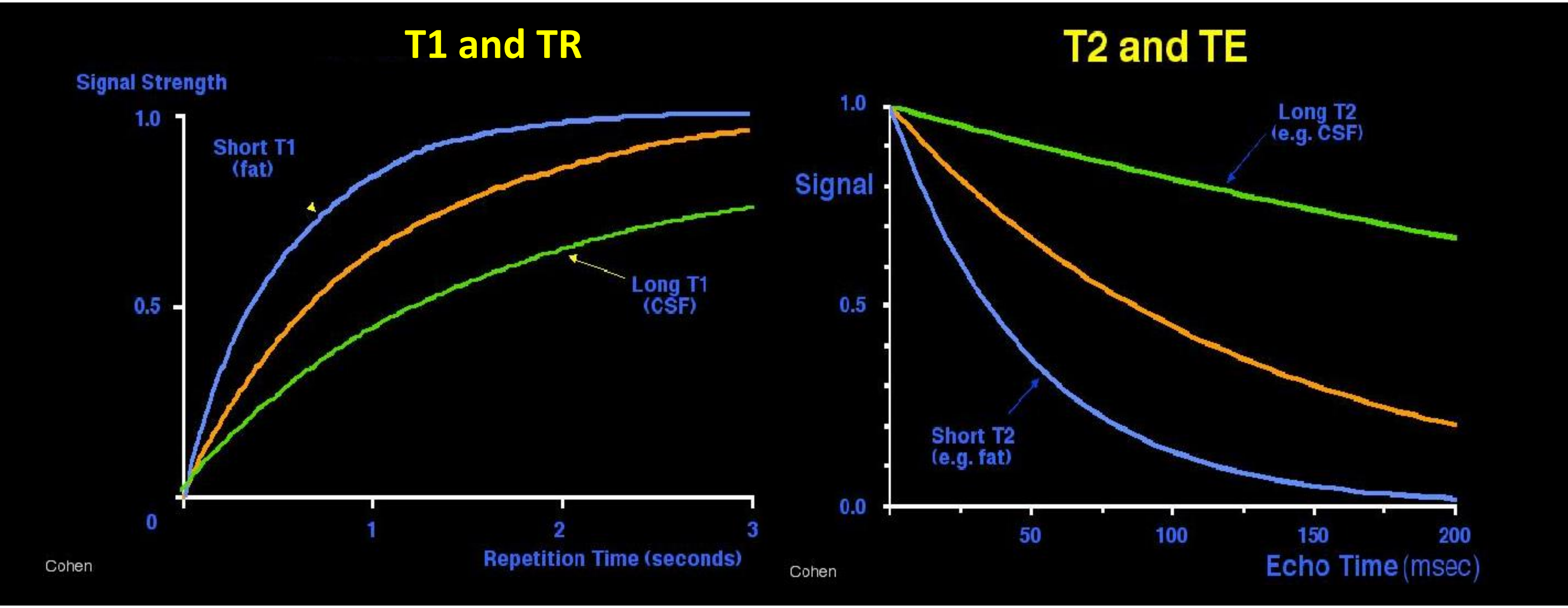


A FID signal is recorded as long as M is on the xy plane



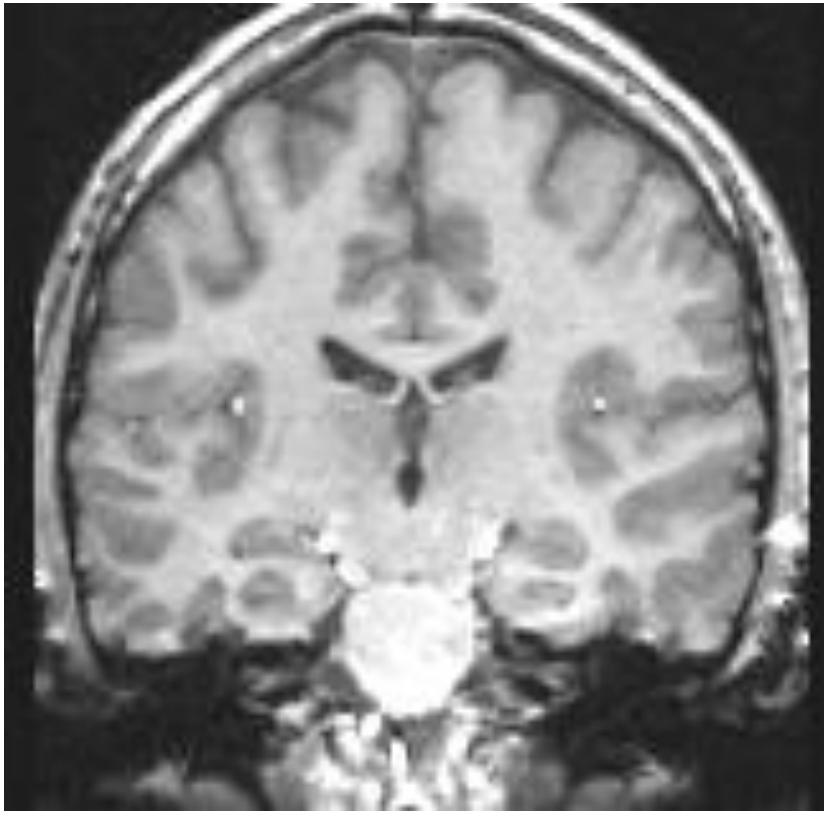
T1 vs. T2 decay

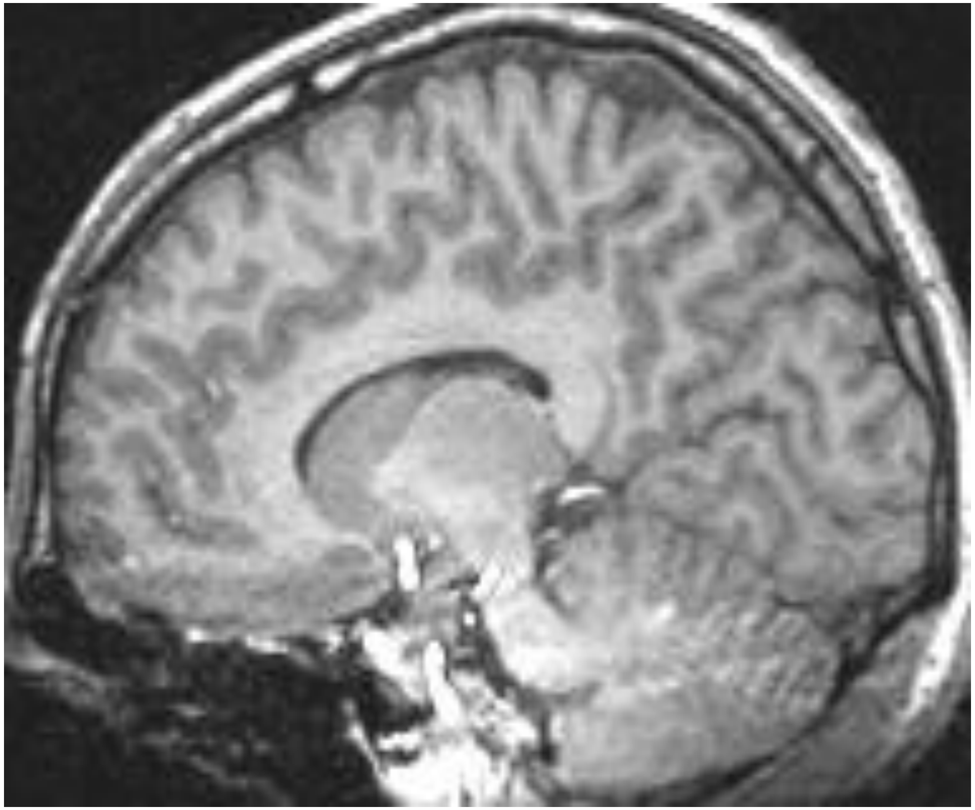
- T1 and T2 weighted images



Developing Contrast Using Weighting

- *Contrast* = difference in image values between different tissues
- T1 weighted example: gray-white contrast is possible because T1 differs between these two types of tissue

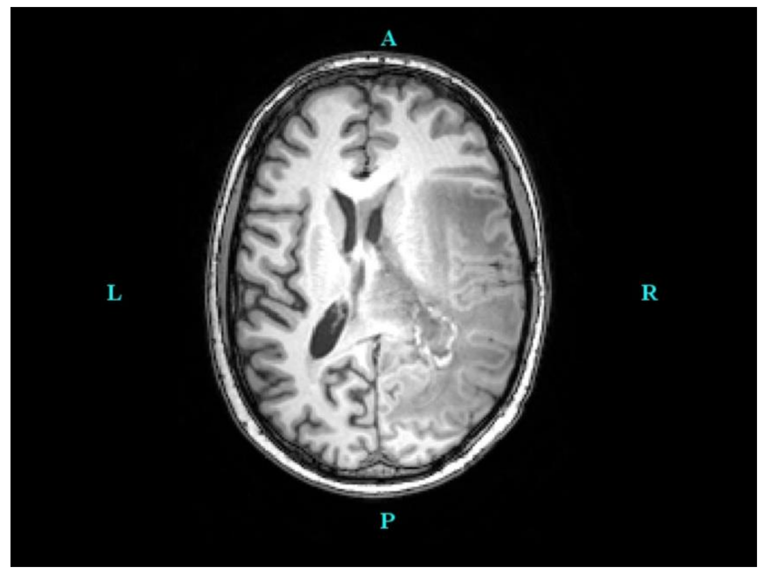




T1-weighted image (usually used for anatomical images) measures the rate at which different types of molecules (and by extension tissue) approach M_0 at different rates allowing us to differentiate things like white and grey matter:

Healthy subject

Tumor Patient

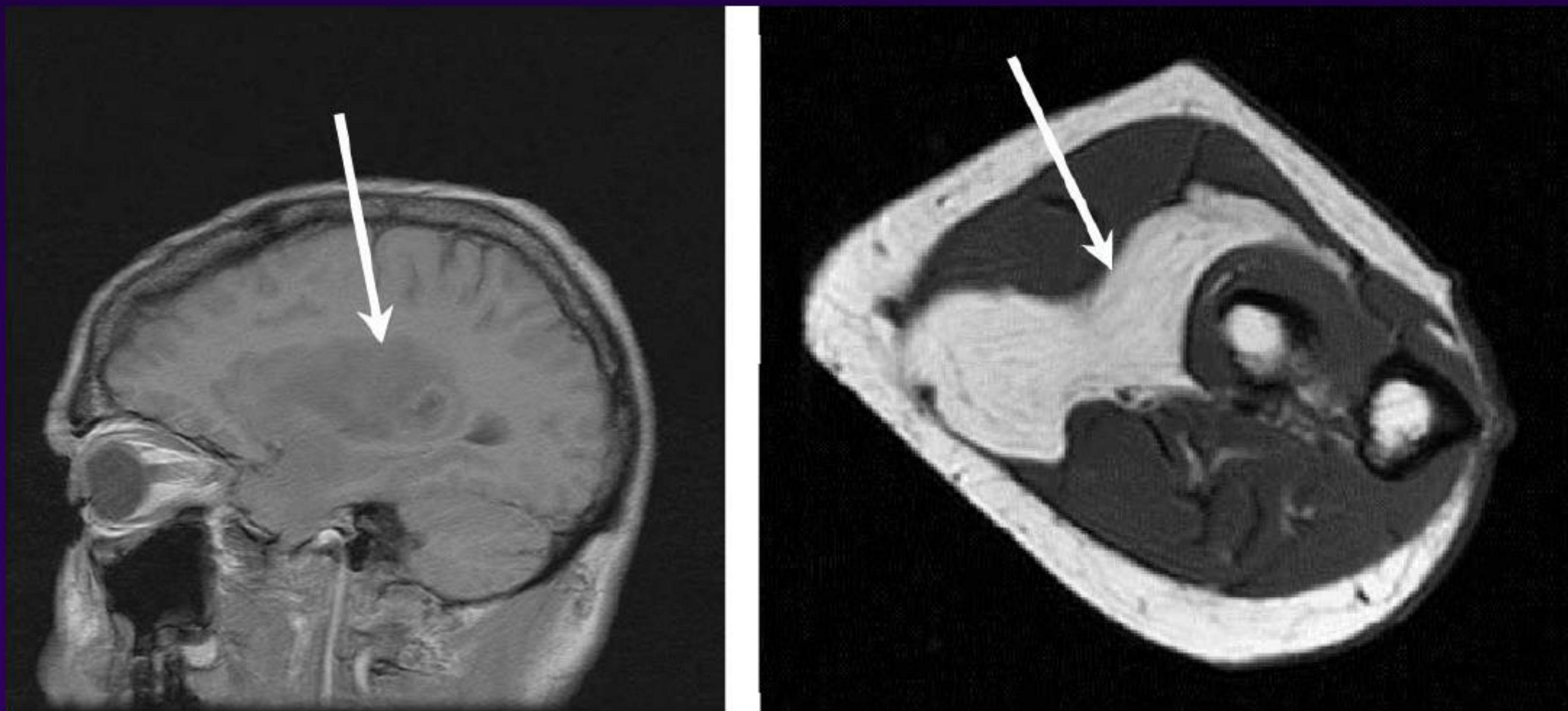


T1-weighted 'Anatomy' Images

(a) (b) (c)

Figure 3.2 T_1-weighted images of normal anatomy. (a) Oblique '4-chamber' view of the heart, (b) sagittal knee, (c) axial liver.

T1-weighted Pathology Images



(a) (b)

Figure 3.4 T_1-weighted images of pathology. (a) Sagittal slice through low-grade glioma, (b) lipoma in the forearm.

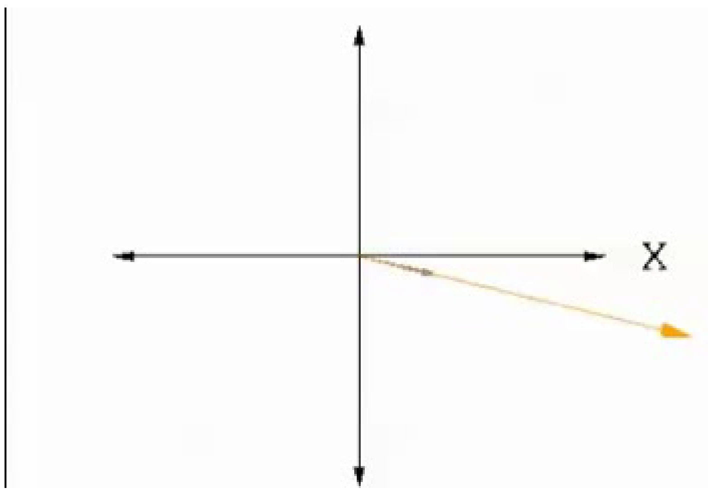
T2 (Spin-Spin) relaxation

T_2 relaxation corresponds to a decoherence of the M_{xy}

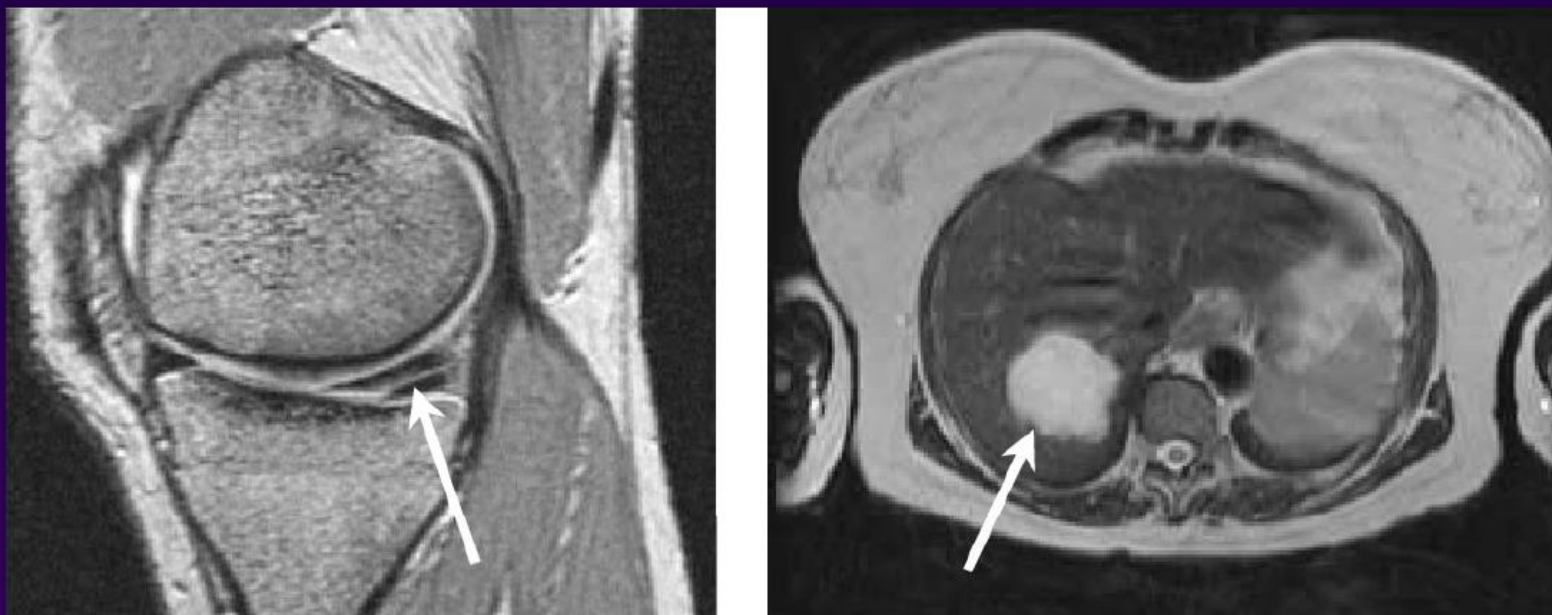
Random fluctuations of B lead to random variations of frequency of spins

The initial phase coherence is eventually lost

T_2 values are generally much less dependent from B_0 than T_1 values



T2-weighted 'Pathology' Images

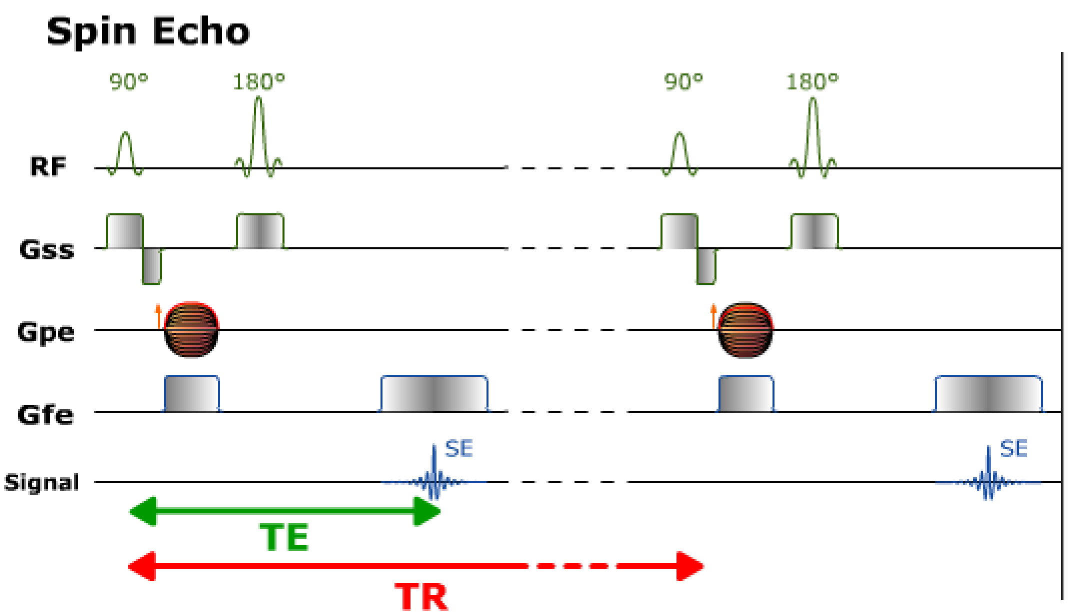


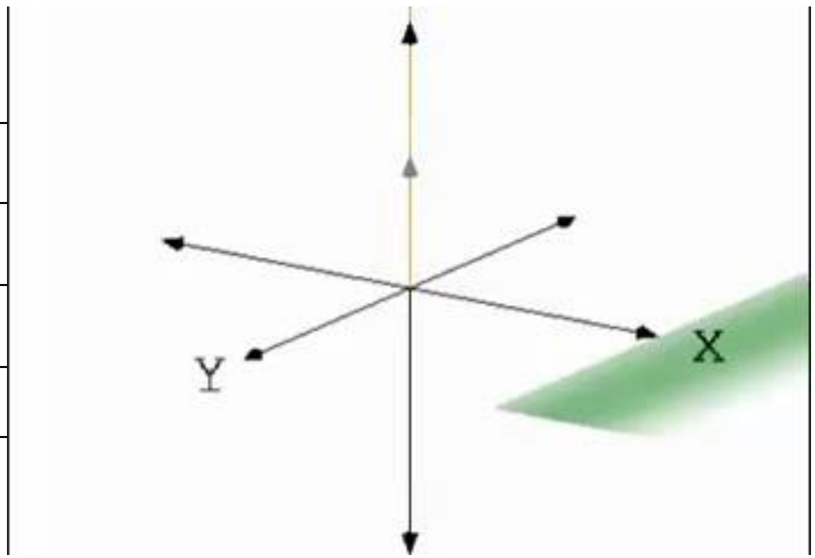
(a) (b)

Figure 3.5 T_2-weighted pathology images. (a) Sagittal image of meniscal tear (arrow) and (b) axial liver scan showing haemangioma.

Spin Echo (FSE, TSE)

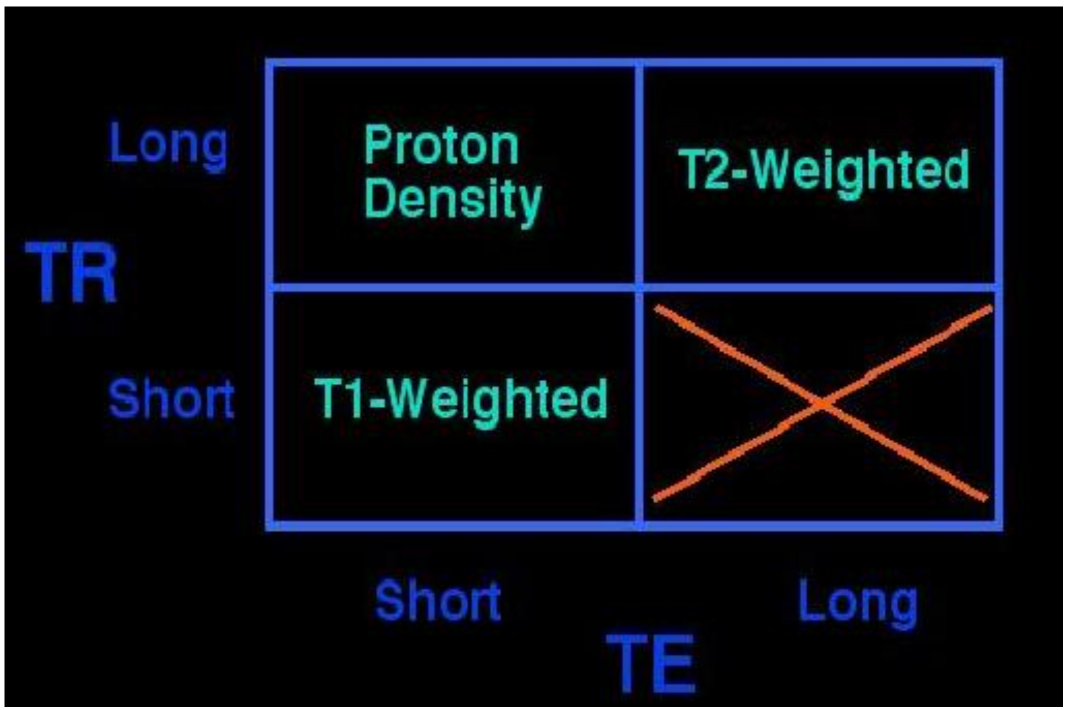
(T1 or T2 weigthed)



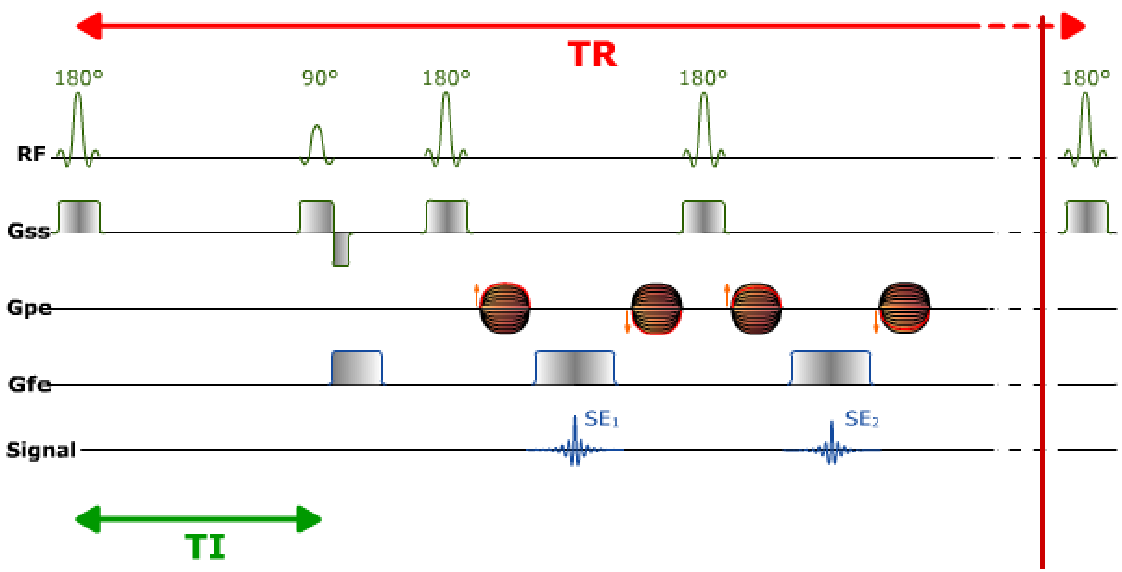


Role of TE and TR to obtain T1 or T2 weigthing

TE is the time interval between the 90° flip and receipt of the echo, Transverse magnetization decreases according to the time constant T2 of each tissue. Thus, if set a small TE (and TR) no transverse dephasing) thus T1 weighting.

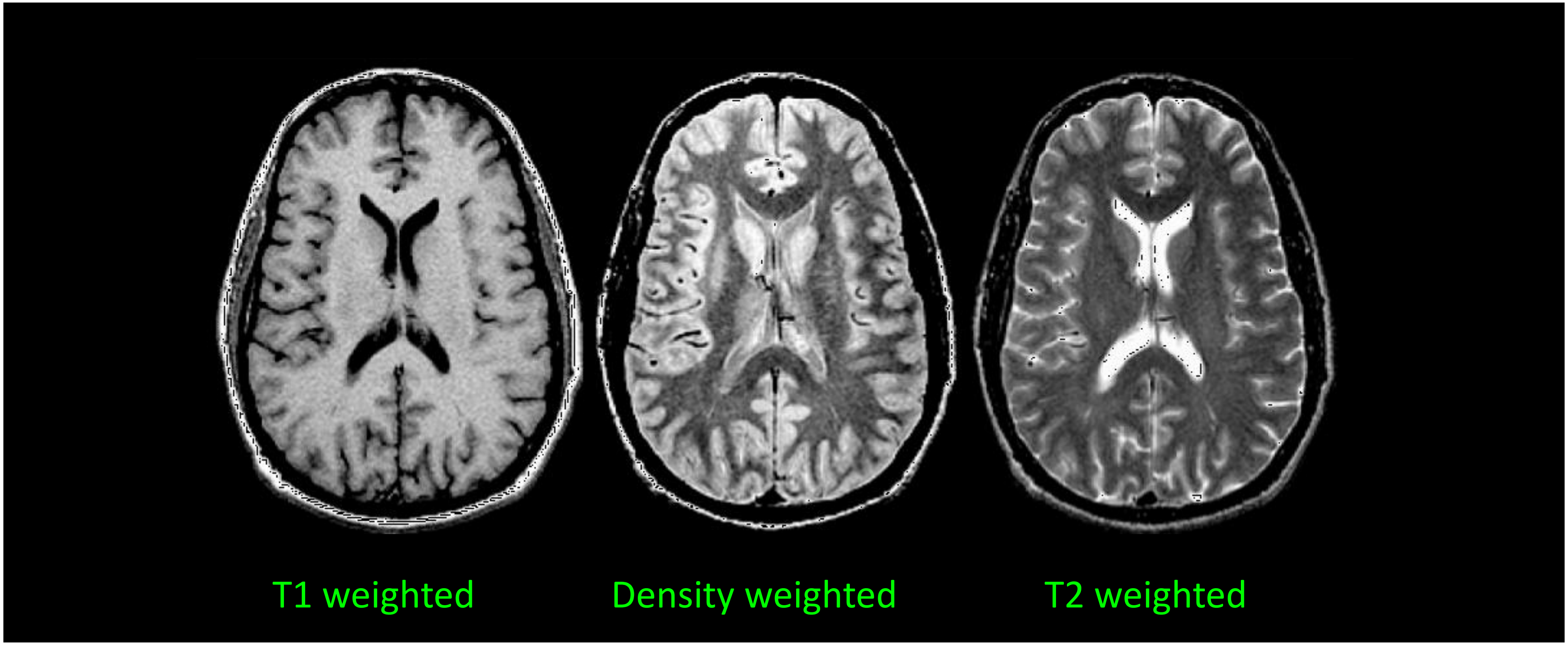


Inversion Recovery (IR, STIR, FLAIR)
(T1 or T2 weighted)



180° RF flips longitudinal magnetization Mz. Due to longitudinal relaxation, longitudinal magnetization will increase to return to its initial value, passing through null value. To measure the signal, a 90° RF wave is applied to obtain transverse magnetization. The delay between the 180° RF and 90° RF is the inversion time TI.

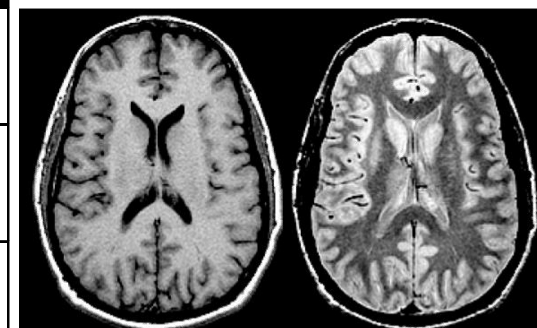
Proton density, recovery (T1) and decay (T2) times.



- By ‘weighting’ the pulse sequence (and point at which data is collected) different images of the brain are obtained
- Weighting is achieved by manipulating TE (time to echo) and TR (time to repetition of the pulse sequence)

Properties of Body Tissues

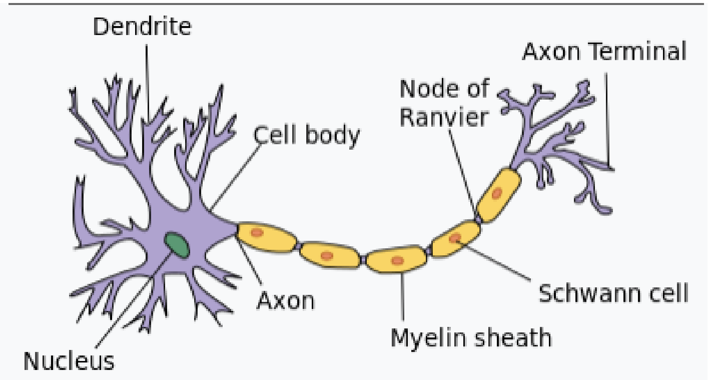
Tissue	T1 (ms)	T2 (ms)
Grey Matter (GM)	950	100
White Matter (WM)	600	80
Muscle	900	50
Cerebrospinal Fluid(CSF)	4500	2200
Fat	250	60
Blood	1200	100-200



T1 values for B_0 ~ 1Tesla.
T2 ~ 1/10th T1 for soft tissues

Multiple Sclerosis (MS)

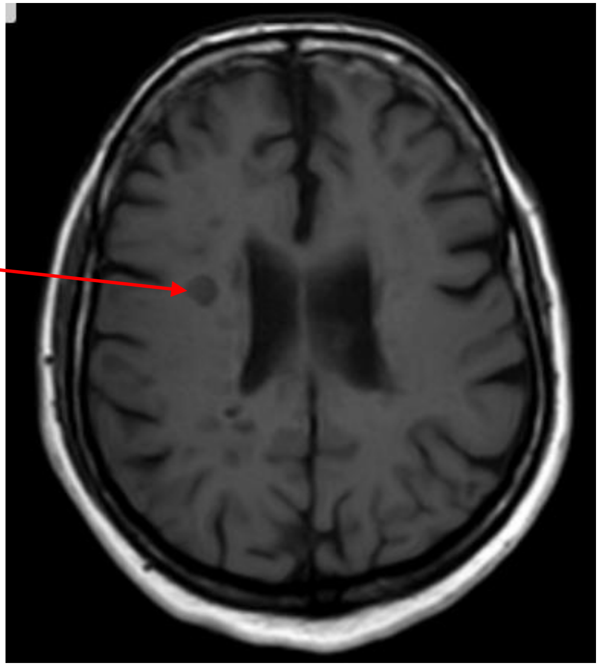
- Demyelination occurs in discrete foci, termed plaques which range in size from a few mm to a few centimeters and are typically periventricular.



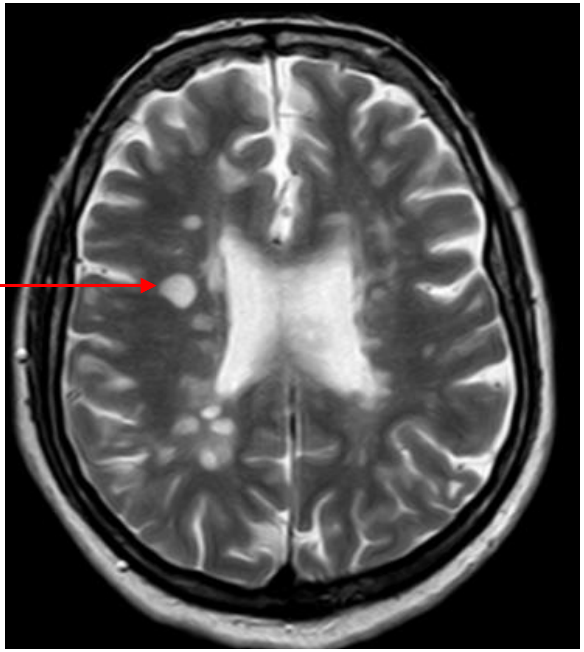
Structure of simplified neuron in the PNS

Action potential propagation in myelinated neurons is faster than in unmyelinated neurons because of saltatory conduction

- T1
  - lesions at chronic stage are typically iso- to hypointense (T1 black holes)
  - hyperintense lesions are associated with brain atrophy and advancing disease



- T2
  - lesions are typically hyperintense



MR spectroscopy (MRS)

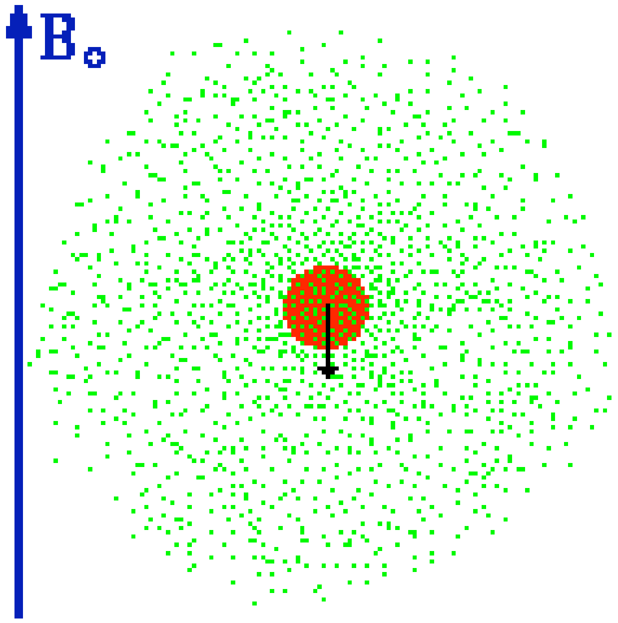
- Most common used nuclei are used are ^{1}H (proton), ^{23}Na (sodium), ^{31}P (phosphorus).
- Proton spectroscopy is easier to perform and provides much higher SNR.
- It can be performed within 10-15 minutes and can be added on to conventional MR imaging protocols.
- It can be used to serially monitor biochemical changes in tumors, stroke, epilepsy, metabolic disorders, infections, and neurodegenerative diseases

MRS Basic Principles

- ^{1}H nuclei resonate at a characteristic frequency dependent on the magnetic field strength B

- Within a given applied field B, ^{1}H nuclei in different chemical environments experience a slightly different effective field due to chemical shielding from surrounding electrons

Chemical Shielding

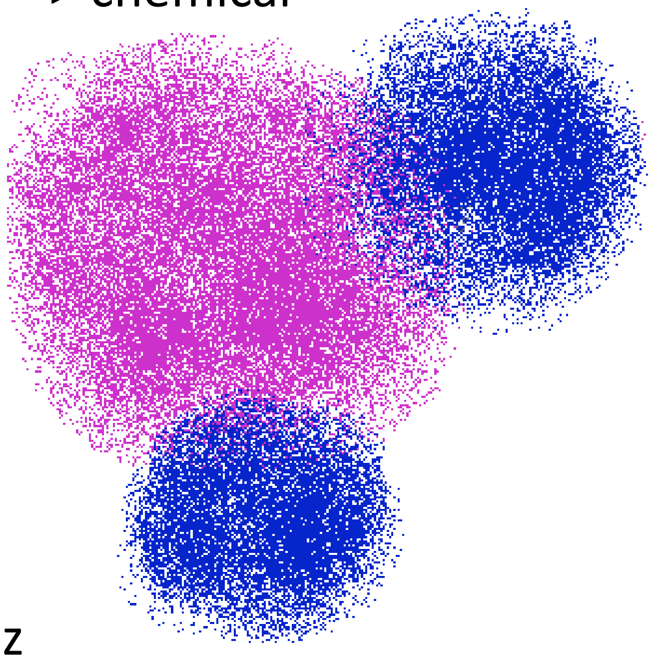


$$B = B_o\,(1\text{-}\sigma)$$

σ = diamagnetic screening constant

Chemical Shift

- Magnitude of σ depends on local electron density => chemical environment
  - ✓ Adjacent atoms
  - ✓ Bonds



- This causes the ^{1}H nuclei to resonate at
- slightly different frequencies => chemical shift
- new resonant freq. freq. becomes: $\nu' = \gamma B_0(1-\sigma)$ Hz
- $\delta = (\nu-\nu') = \gamma B_0 - \gamma B_0(1-\sigma) = \gamma B_0\sigma$ = chemical shift and it depends on B_0

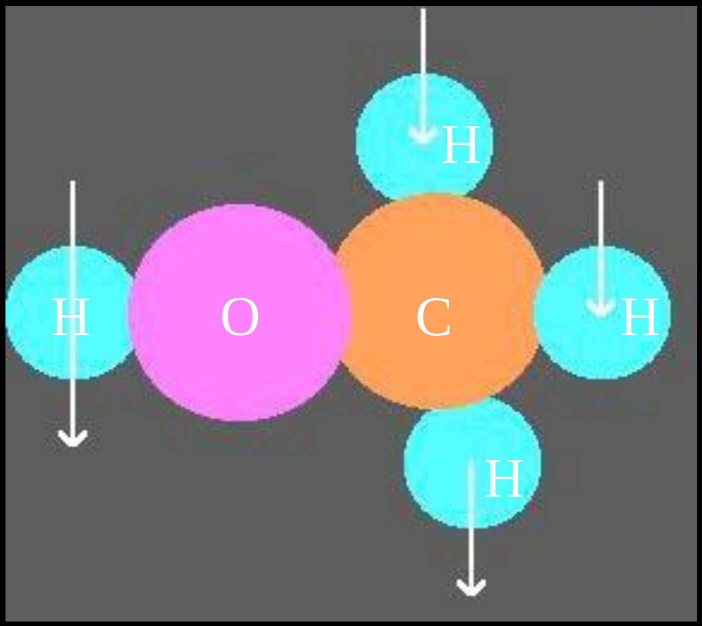
Hz vs ppm

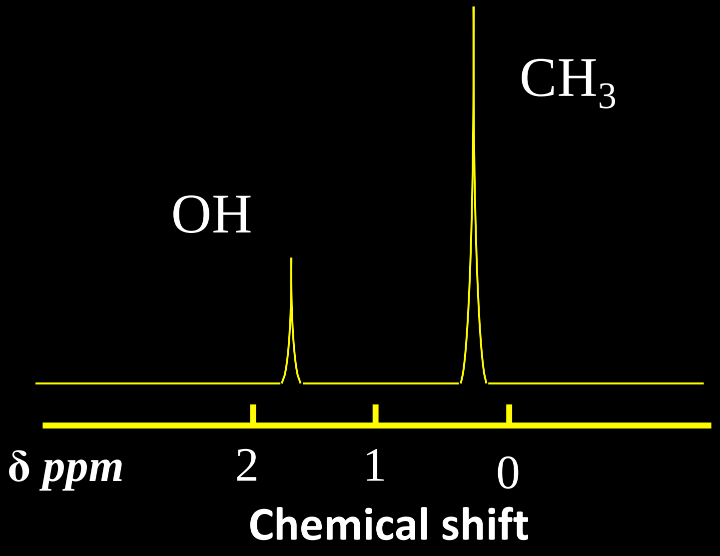
To make it independent on the field intensity B_0 the chemical shift is normalized to a reference value and expressed in parts-per-million (ppm)

$$\delta_{ppm} = (\nu - \nu_{ref})/\nu_{ref} \; 10^6$$

where ν_{ref} is typically the resonant frequency of tetra-methyl-silane (TMS)

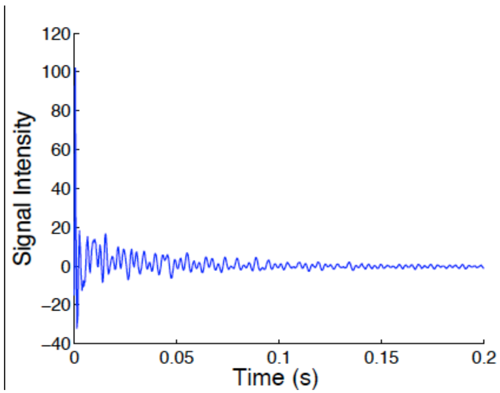
Chemical shift: Methanol



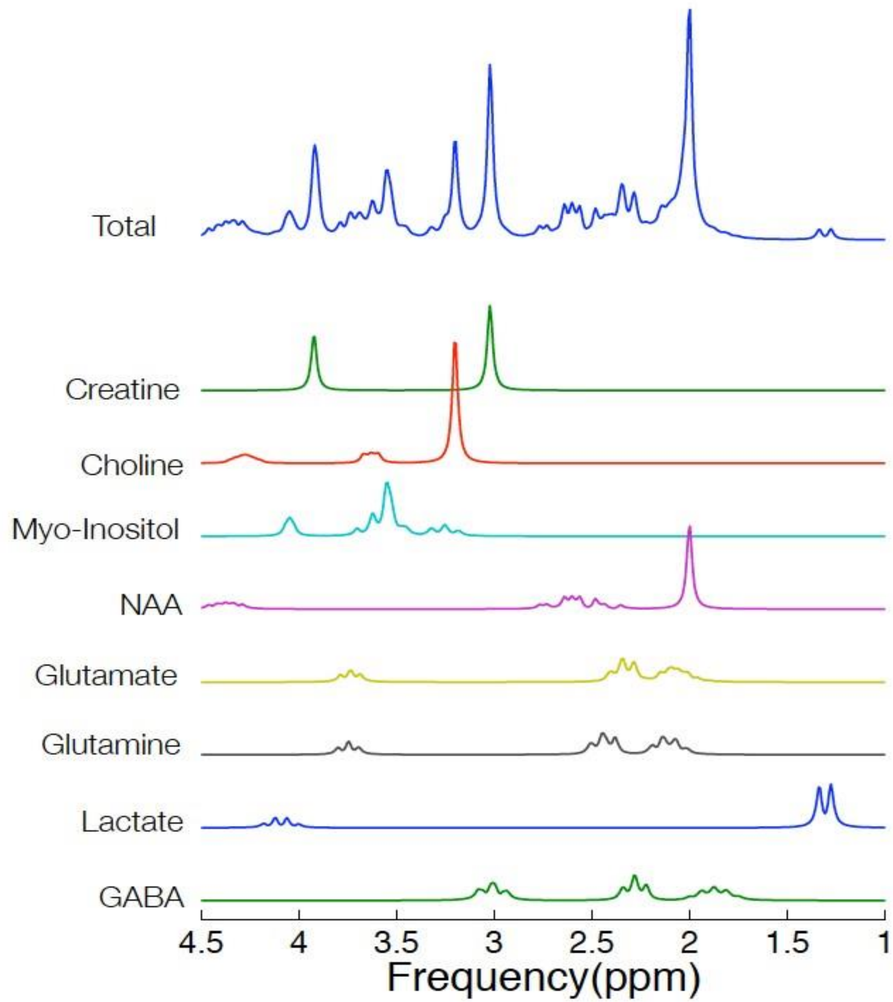


- Horizontal axis
  - Frequency (ppm)
- Vertical axis
  - Area proportional to concentration

The MRS frequency spectrum



Fourier
Transform



- Final spectrum composed of signals from multiple metabolites
- Each metabolite identified by a unique and highly-reproducible frequency distribution
- Why do different metabolites exhibit different resonance frequencies?

- **N-acetyl Aspartate** (NAA): decrease NAA indicates loss or damage to neuronal tissue, which results from many types of insults to the brain. Its presence in normal conditions indicates neuronal and axonal integrity.

- **Choline**: Increased choline indicates increase in cell production or membrane breakdown, which can suggest demyelination or presence of malignant tumors

- **Creatine:** tissue death or major cell death resulting from disease, injury or lack of blood supply. Increase in creatine concentration could be a response to cranialcerebral trauma. Absence of creatine may be indicative of a rare congenital disease.

- **Lipids** increase is indicative of necrosis

- **Lactate** presence of this peak indicates glycolysis has been initiated in an oxygen-deficient environment. Several causes of this include ischemia, hypoxia and some types of tumors.

- **Myo-inositol**: has been seen in patients with Alzheimer's, dementia, and HIV patients

- **GABA** (γ-aminobutyric acid)**:** inhibitory neurotransmitter in the human brain been that are epilepsy, schizophrenia and autism

Use of Magnetic Resonance Imaging in Food Quality Control: A Review

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ABSTRACT

Modern challenges of food science require a new understanding of the determinants of food quality and safety. Application of advanced imaging modalities such as magnetic resonance imaging (MRI) has seen impressive successes and fast growth over the past decade. Since MRI does not have any harmful ionizing radiation, it can be considered as a magnificent tool for the quality control of food products. MRI allows the structure of foods to be imaged noninvasively and nondestructively. Magnetic resonance images can present information about several processes and material properties in foods. This review will provide an overview of the most prominent applications of MRI in food research.

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Video Article

NMR Spectroscopy as a Robust Tool for the Rapid Evaluation of the Lipid Profile of Fish Oil Supplements

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Abstract

The western diet is poor in *n*-3 fatty acids, therefore the consumption of fish oil supplements is recommended to increase the intake of these essential nutrients. The objective of this work is to demonstrate the qualitative and quantitative analysis of encapsulated fish oil supplements using high-resolution ^{1}H and ^{13}C NMR spectroscopy utilizing two different NMR instruments; a 500 MHz and an 850 MHz instrument. Both proton (^{1}H) and carbon (^{13}C) NMR spectra can be used for the quantitative determination of the major constituents of fish oil supplements. Quantification of the lipids in fish oil supplements is achieved through integration of the appropriate NMR signals in the relevant 1D spectra. Results obtained by ^{1}H and ^{13}C NMR are in good agreement with each other, despite the difference in resolution and sensitivity between the two nuclei and the two instruments. ^{1}H NMR offers a more rapid analysis compared to ^{13}C NMR, as the spectrum can be recorded in less than 1 min, in contrast to ^{13}C NMR analysis, which lasts from 10 min to one hour. The ^{13}C NMR spectrum, however, is much more informative. It can provide quantitative data for a greater number of individual fatty acids and can be used for determining the positional distribution of fatty acids on the glycerol backbone. Both nuclei can provide quantitative information in just one experiment without the need of purification or separation steps. The strength of the magnetic field mostly affects the ^{1}H NMR spectra due to its lower resolution with respect to ^{13}C NMR, however, even lower cost NMR instruments can be efficiently applied as a standard method by the food industry and quality control laboratories.