Neuroradiology and neuroimaging
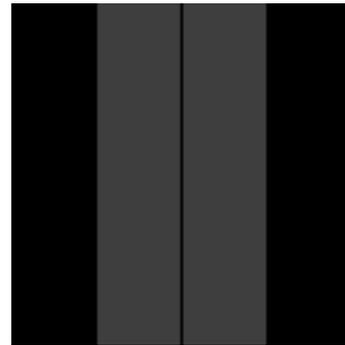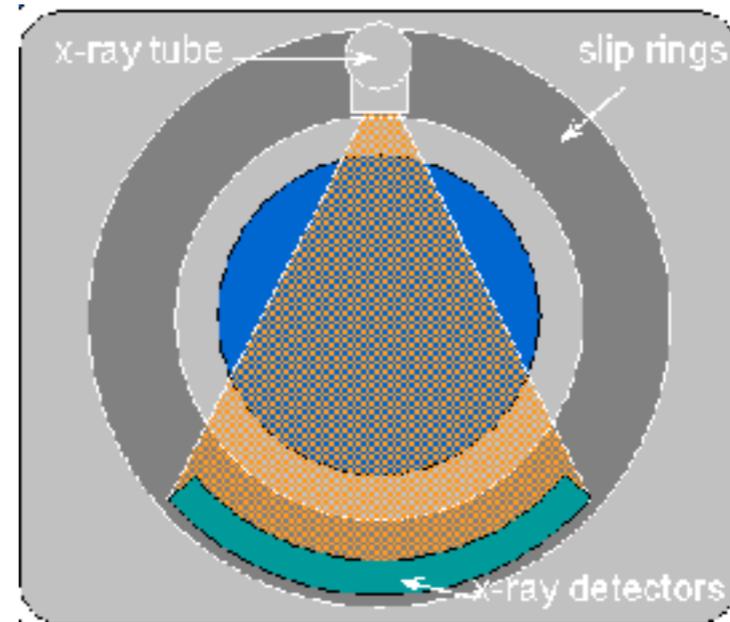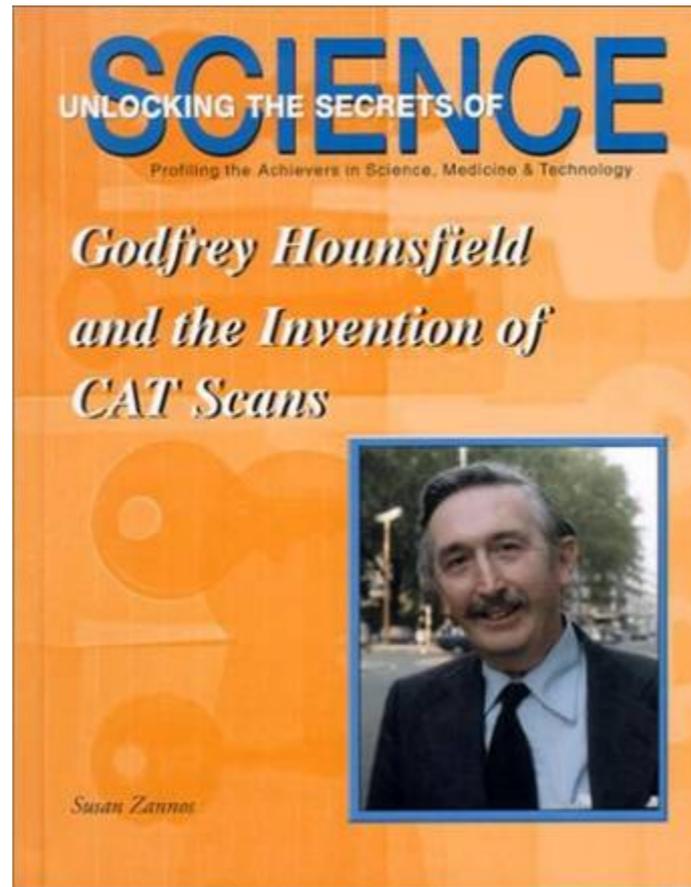
Zsigmond Tamas Kincses
Department of Neurology
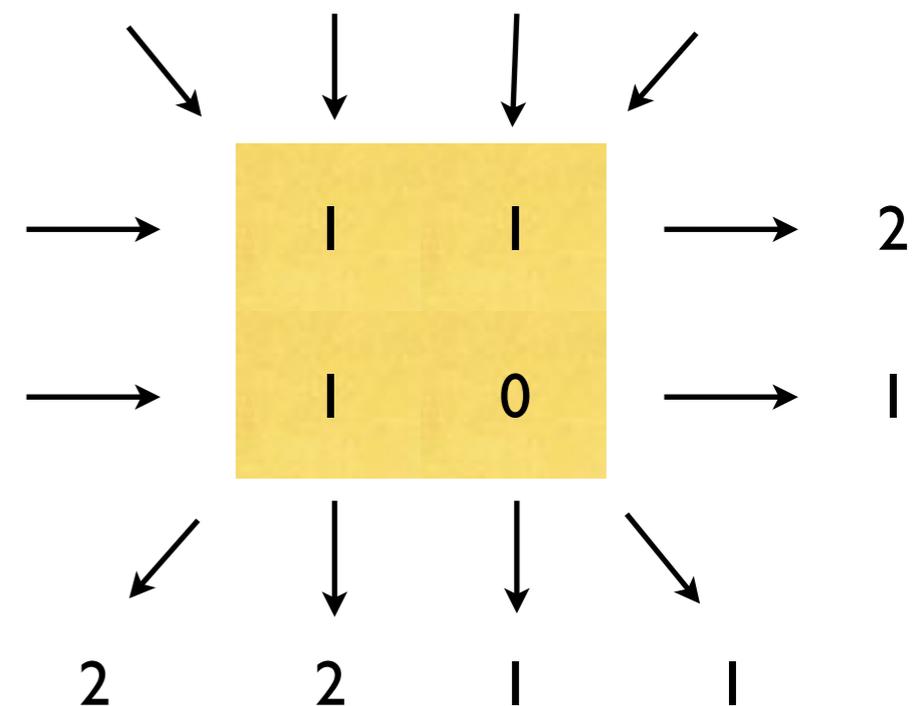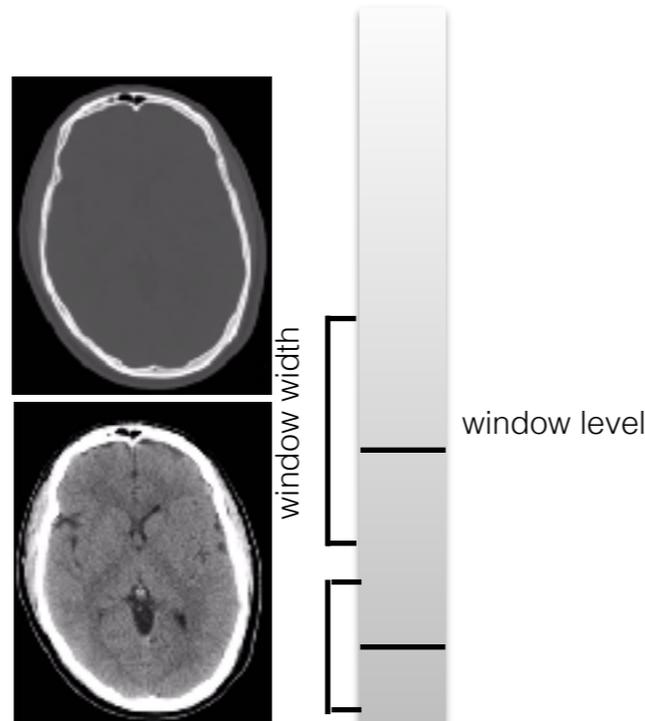University of Szeged

Computer tomography

- Attenuation coefficient (μ) :

  a degree to which x-ray intensity is reduced by the material

$$HU = \frac{\mu_{tissue} - \mu_{water}}{\mu_{water}} \times 1000$$

	HU
Air	-1000
Fat	-84
Water	0
CSF	8
White matter	30
Gray matter	45
Blood	70
Bone	700-3000

window width

window level

CT safety

Contrast (iodinated)

- Contrast reaction
  - anaphylactic reaction 1 in 10.000
  - 1 in 100.000 to 1 in 1.000.000 will die
- Medical issues
  - Acute renal failure
  - Lactic acidosis in diabetics
 - (stop metformin 48 hours before scanning)

Radiation

- Gray > absorbed dose (joule/kg)
- Sievert > dose equivalent
- Relative exposure
  - CRX=0.1mSv
  - head CT = 2mSv
  - chest CT = 8mSv
  - abdominal and pelvic CT = 20 mSv
- 1CRX appoximate the same risk:
  - watching TV for a year
  - 1 transatlantic flight
  - 2 days living in Denver
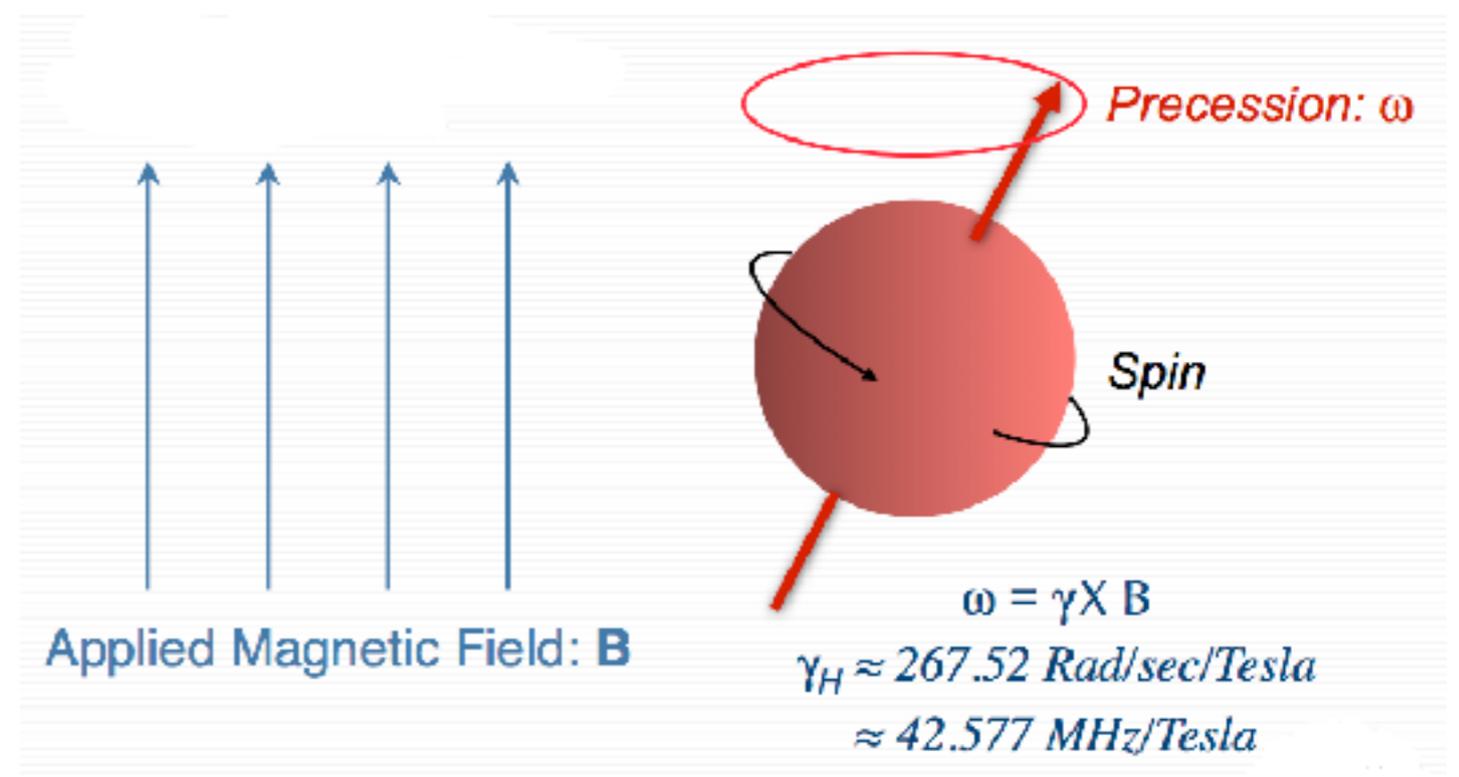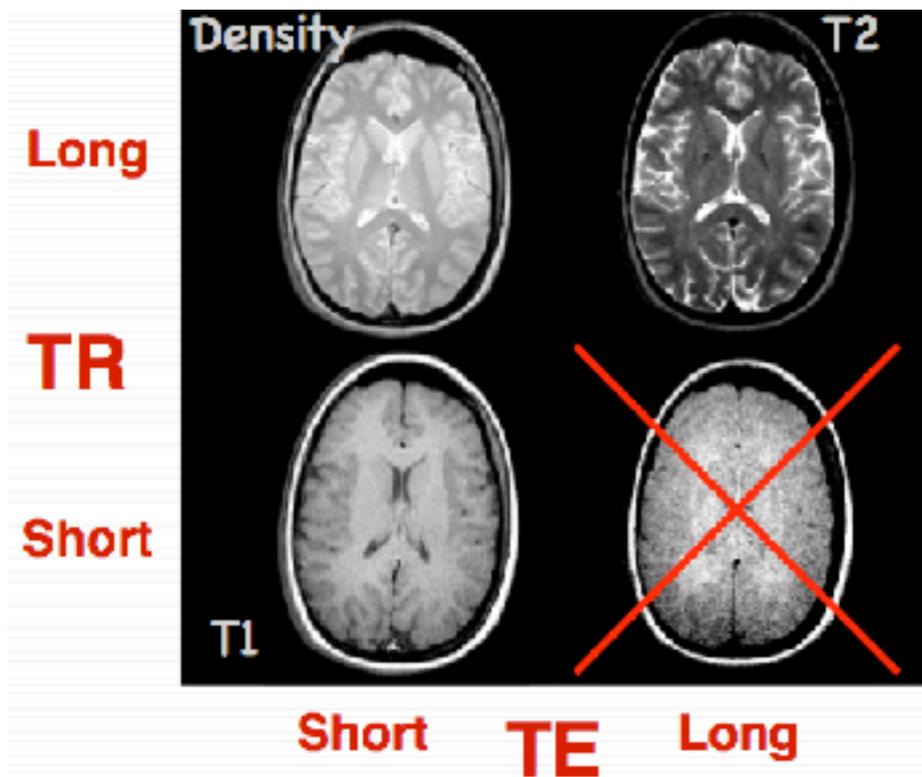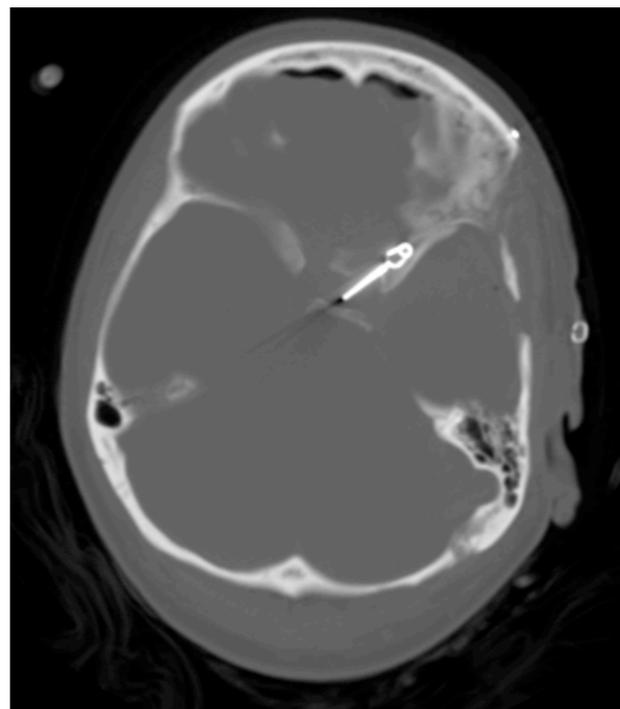
RADIATION

Magnetic resonance imaging (T1 and T2)

ω = γ X B
γ_H ≈ 267.52 Rad/sec/Tesla
≈ 42.577 MHz/Tesla
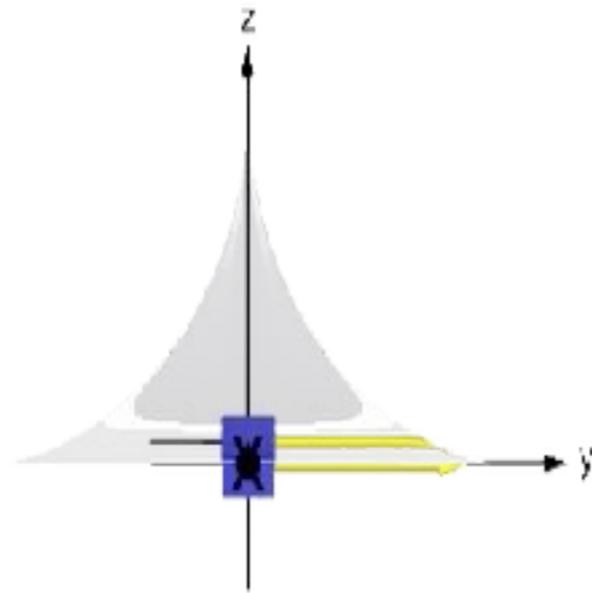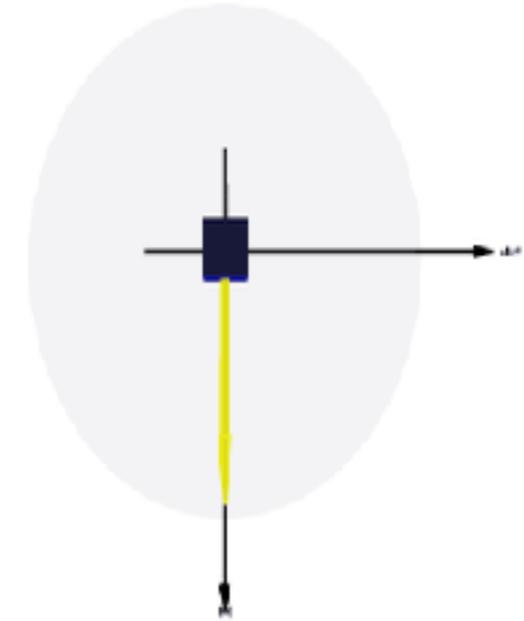
MRI safety

The magnet is always ON!!

24 hours/day

7 days/week

365 day/year

Even at Christmas

DANGER!
RESTRICTED ACCESS

STRONG MAGNETIC FIELD

This Magnet is Always On!

NO PACEMAKERS, NO METALLIC IMPLANTS, NO NEURO STIMULATORS
Persons with pacemakers, neuro stimulators or metallic implants must not enter this area.
SERIOUS INJURY MAY RESULT.

NO LOOSE METAL OBJECTS
Objects made from or containing ferrous metals should not be taken into this room.
SERIOUS INJURY OR PROPERTY DAMAGE MAY RESULT.
RESTRICTED ITEMS INCLUDE:
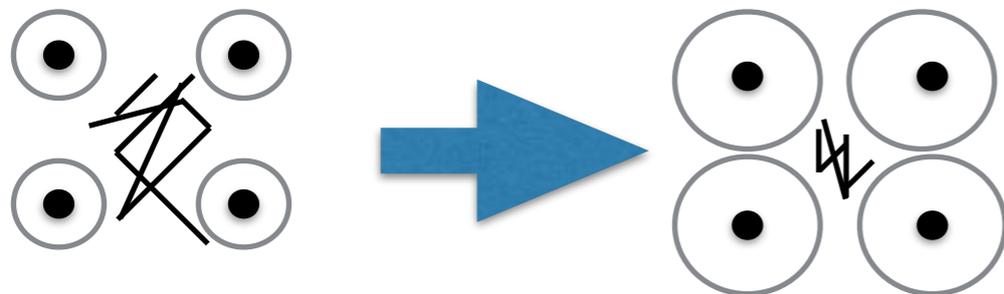CELL PHONES, HEARING AIDS, KEYS, JEWELRY & PAGERS

Ischaemic stroke

Early signs of ischaemia on CT

- Hyperdense media sign
- loss of grey-white matter differentiation
- Hypoattenuation of the lentiform nucleus
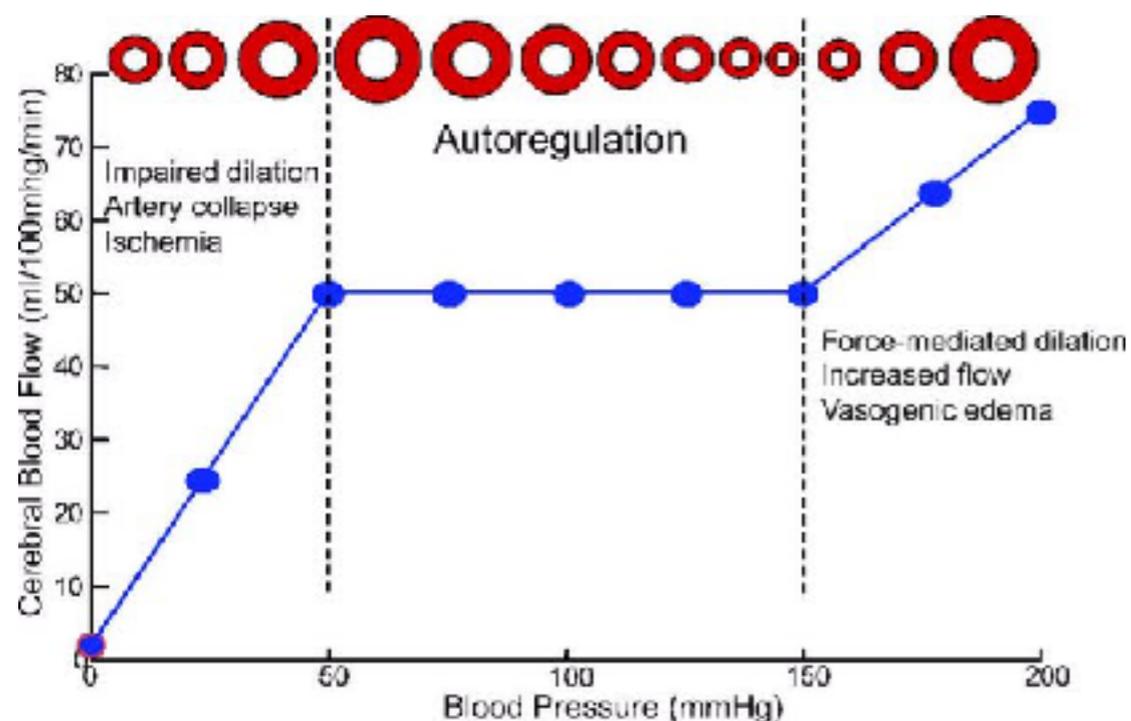- gyral effacement
- insular ribbon
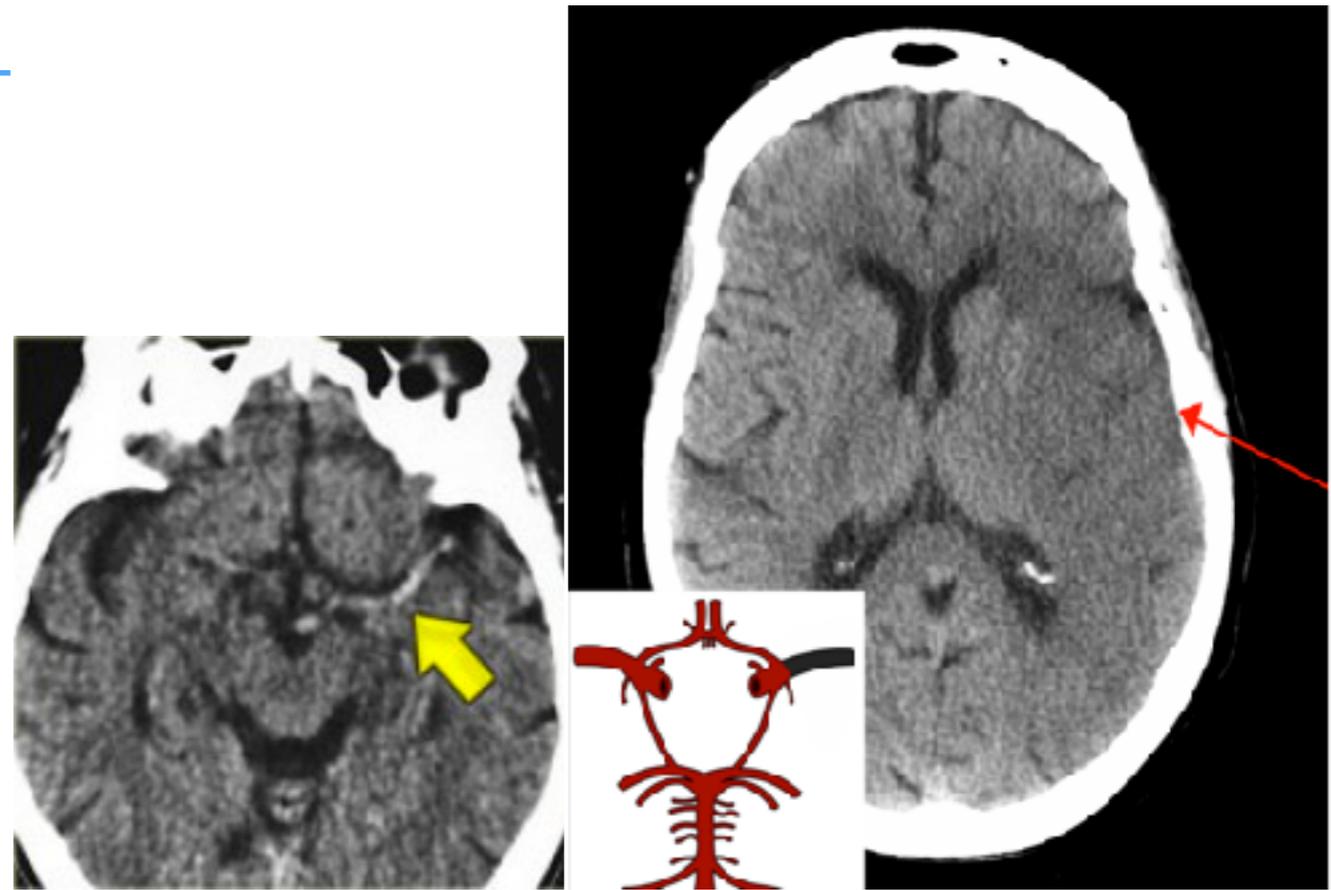
Ischaemia on DWI

- No oxygen > No ATP
- Na/K pump dysfunctional > intracellular oedema
- Restricted diffusion within minutes
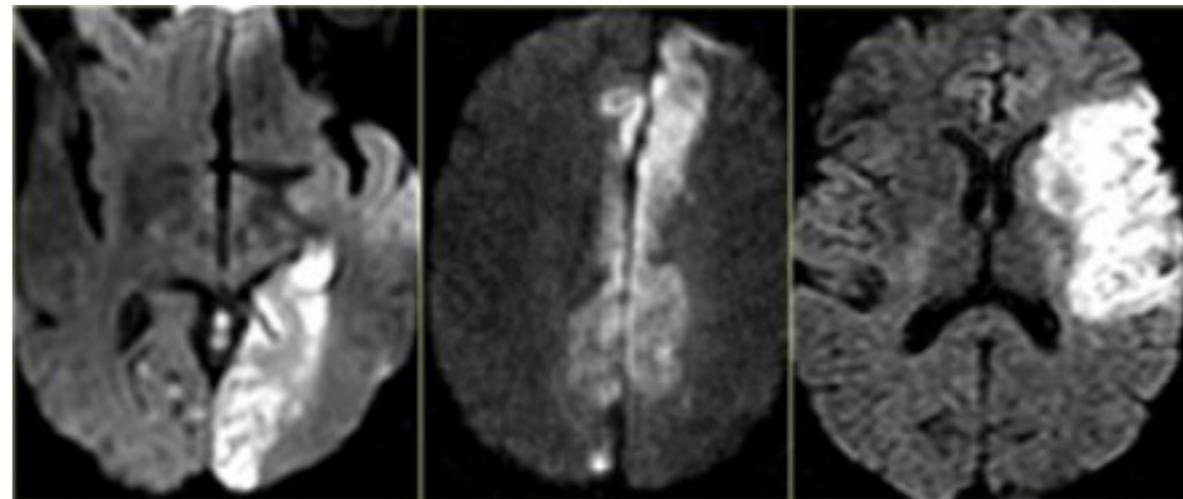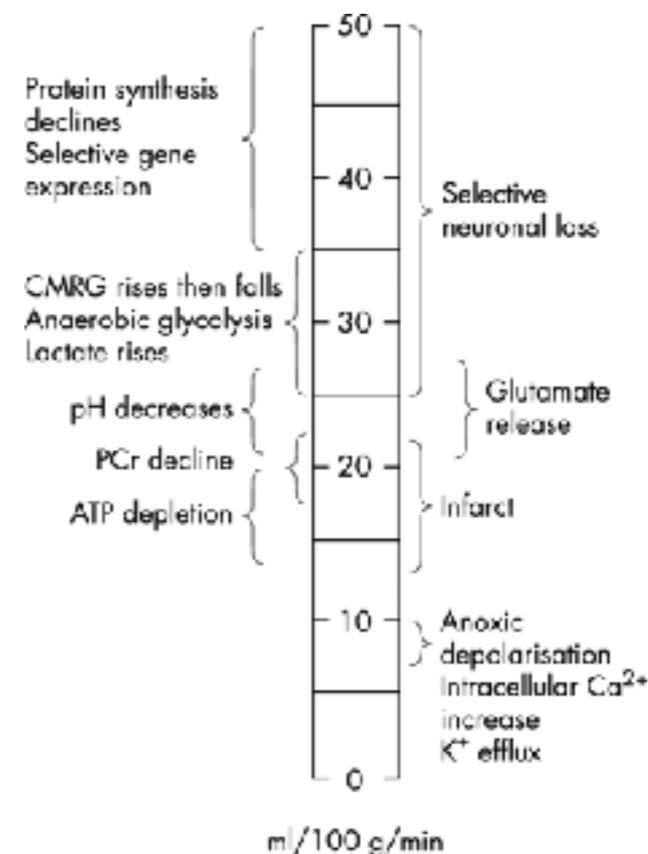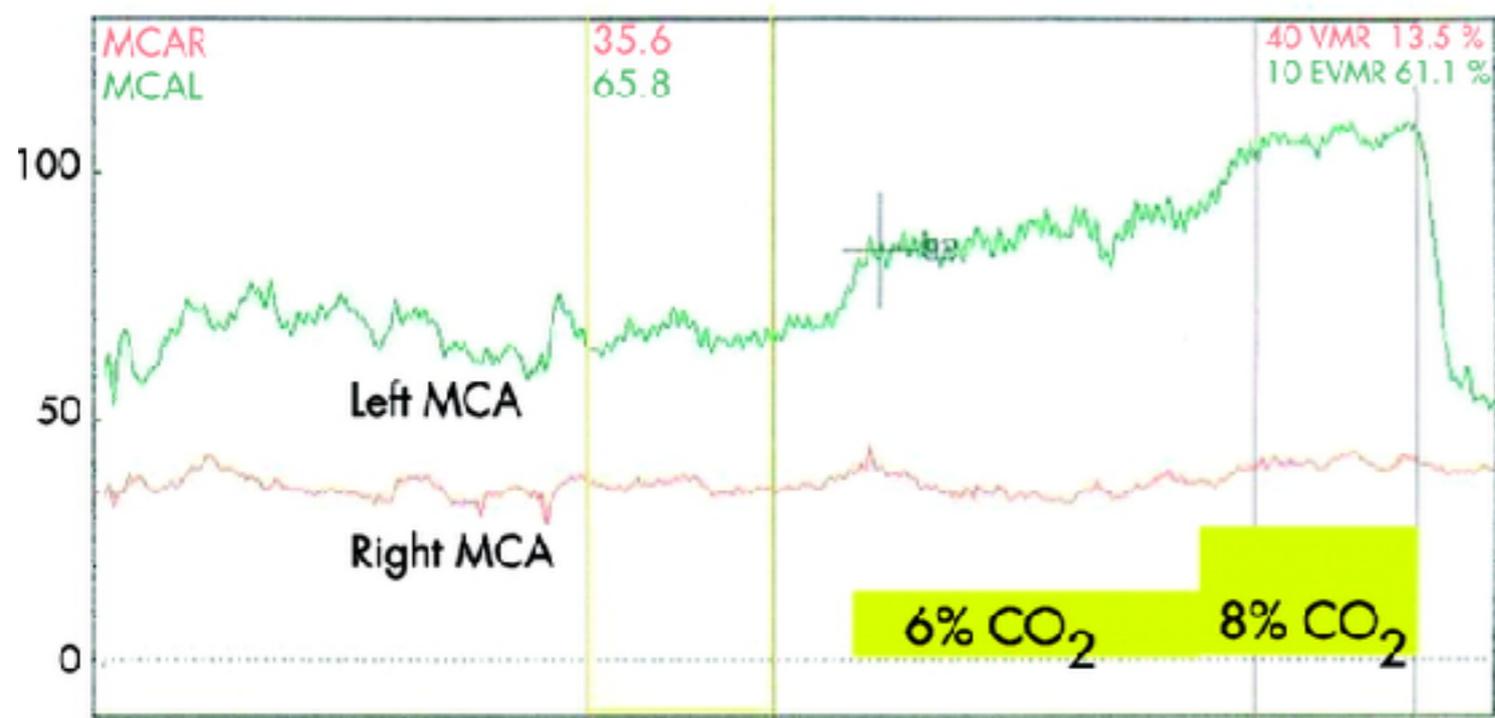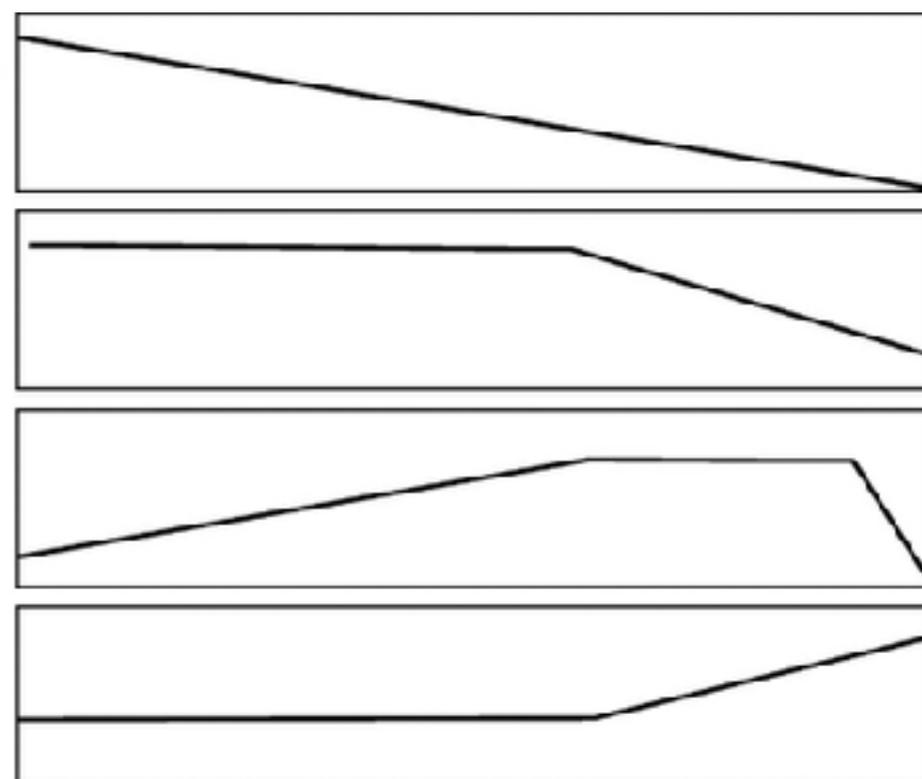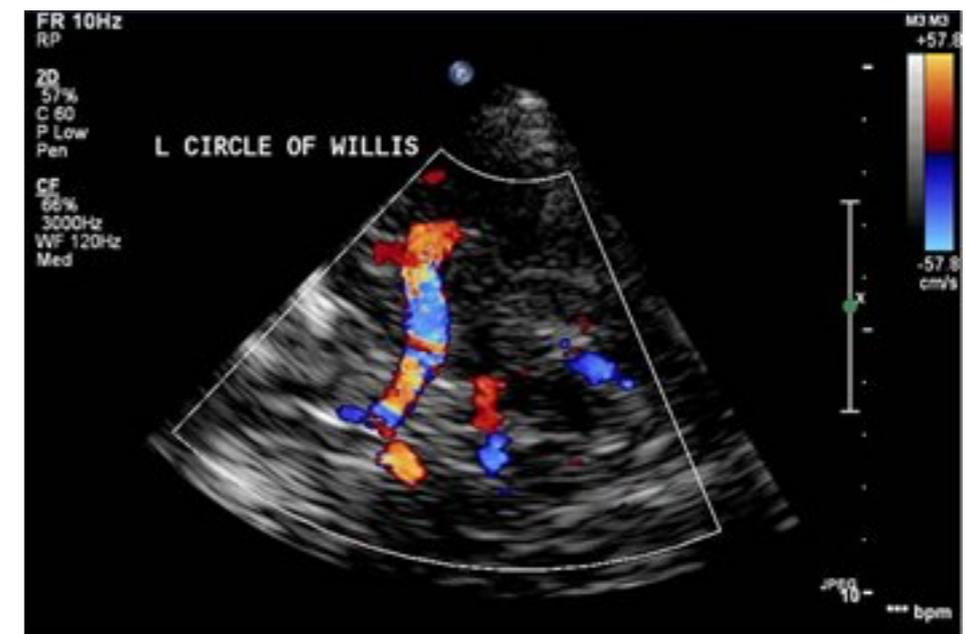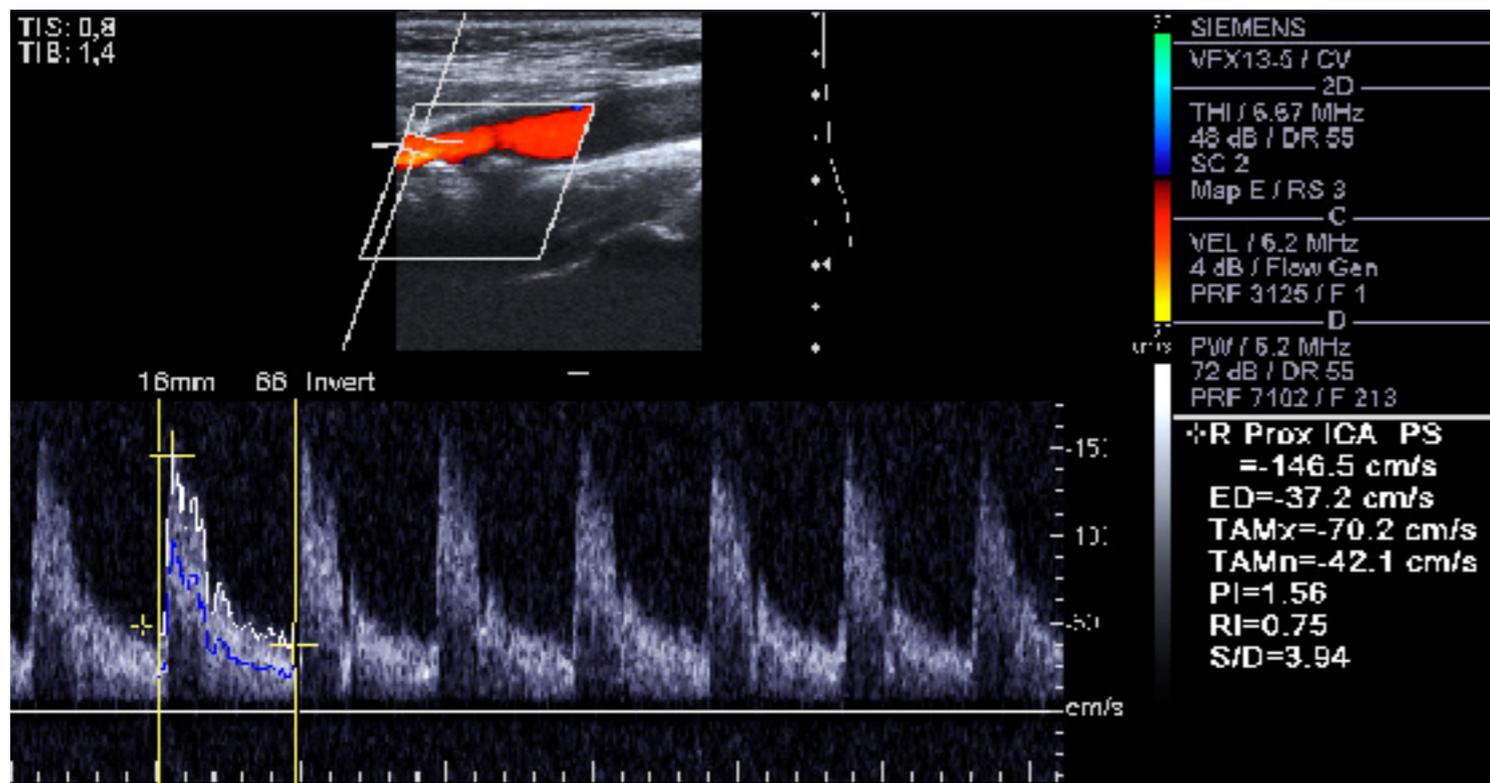
Brain perfusion in stroke
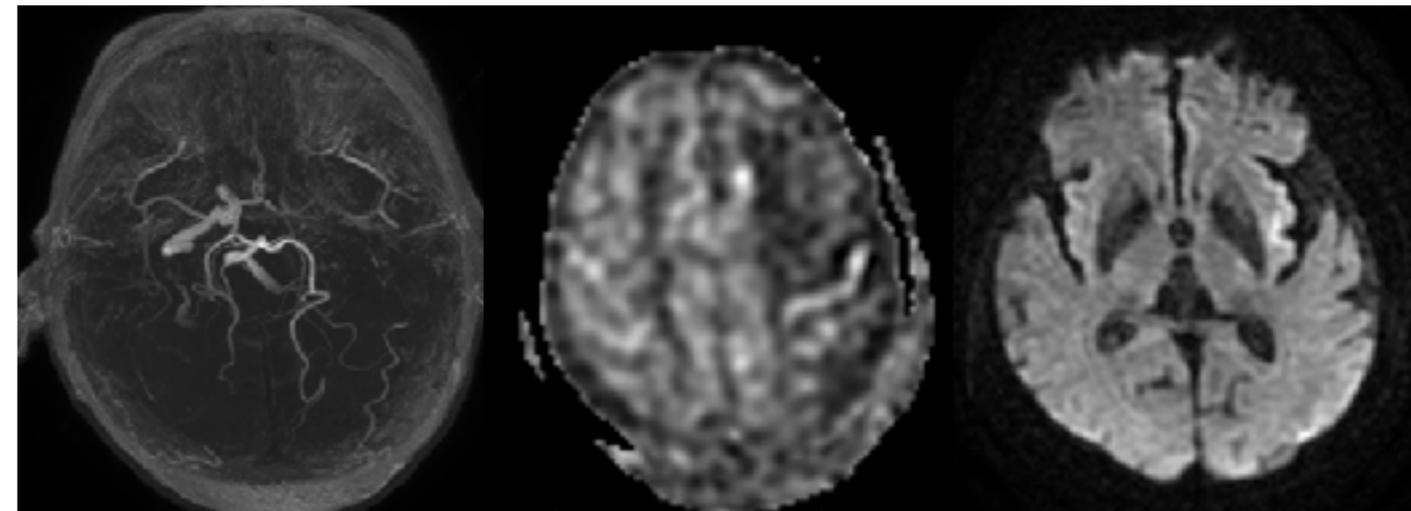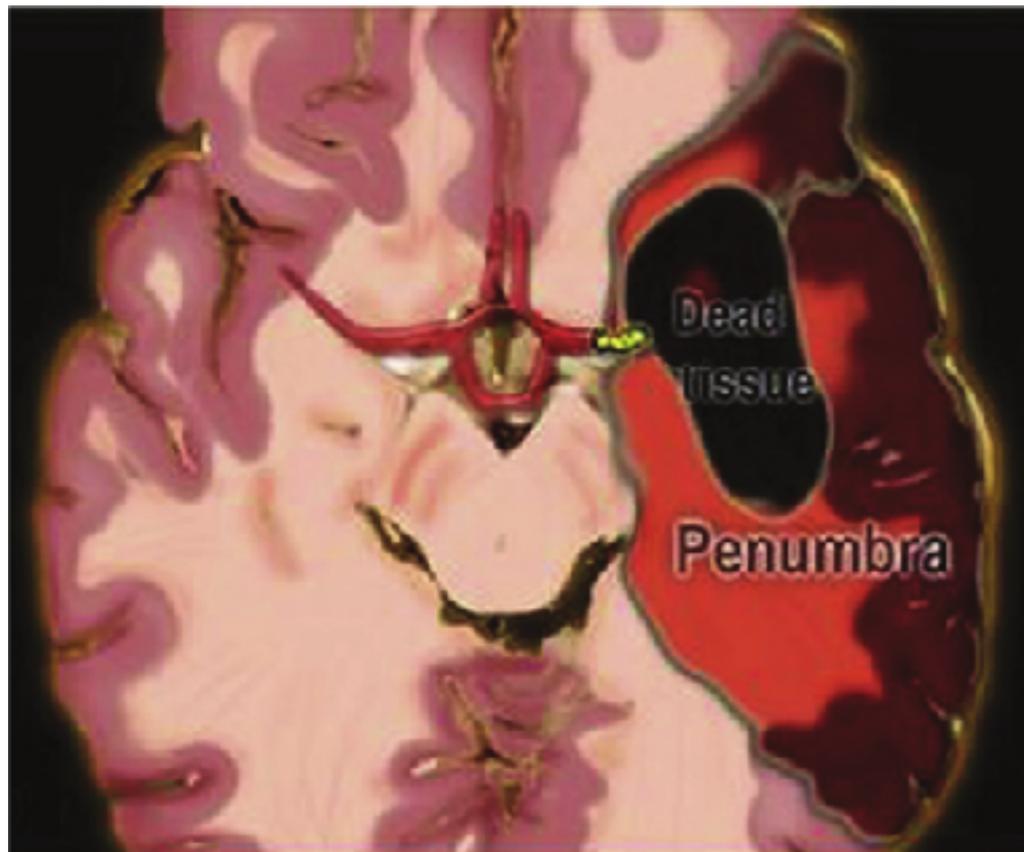
Perfusion imaging

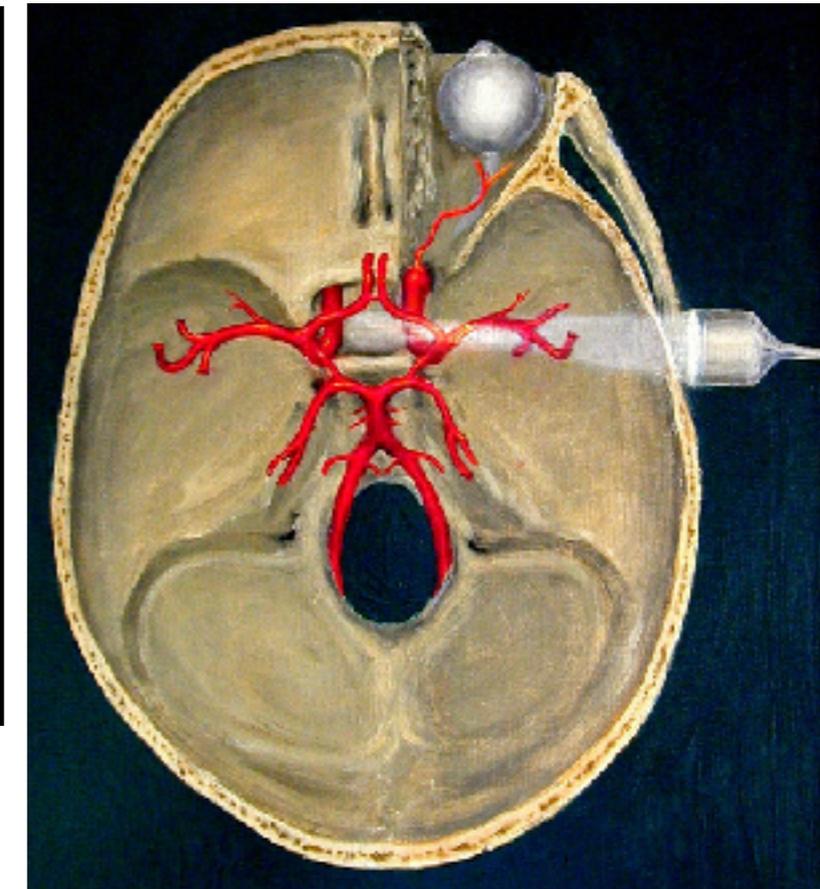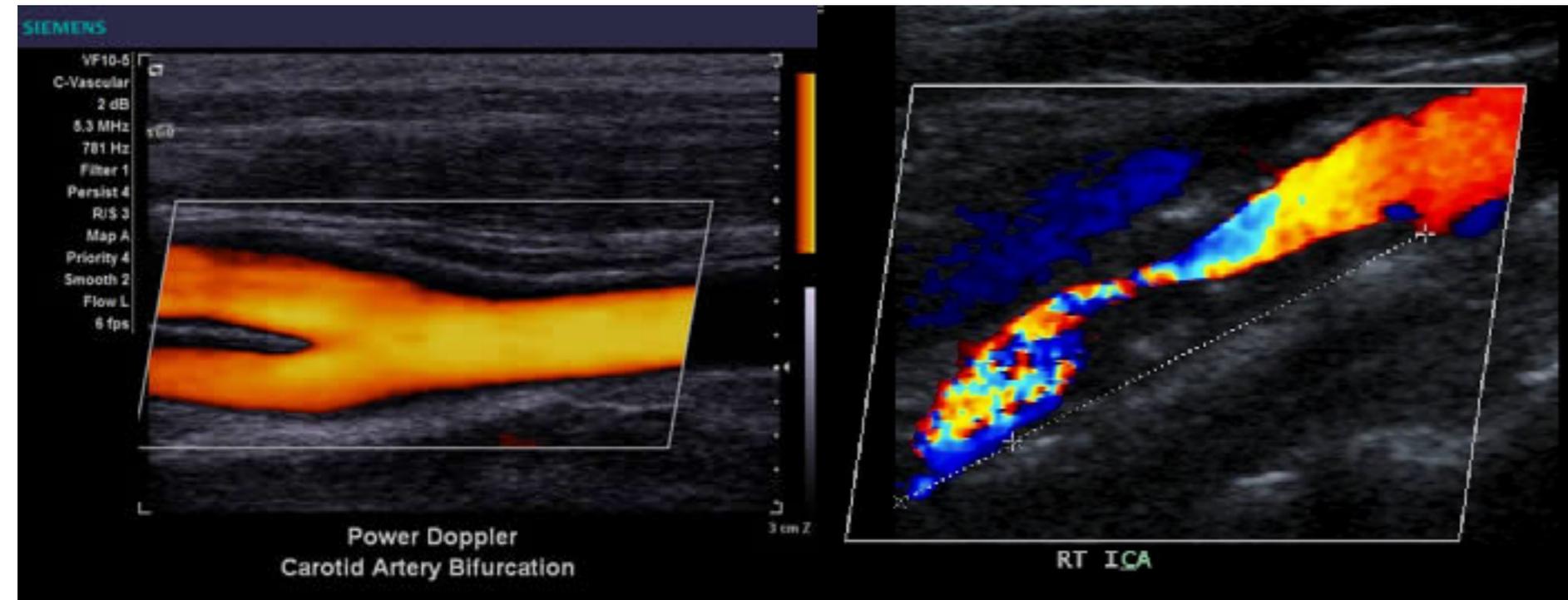
MTT=CBV/CBF

Cerebral Perfusion and Stroke
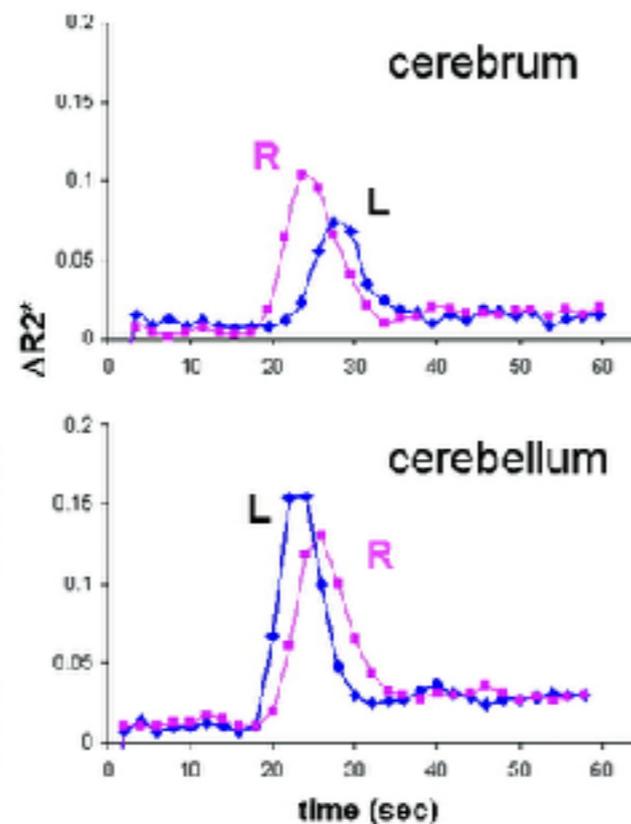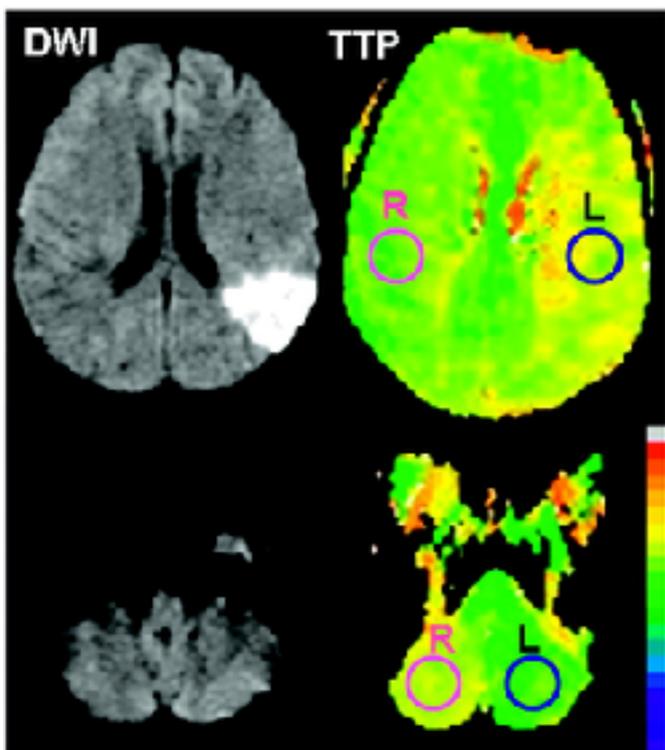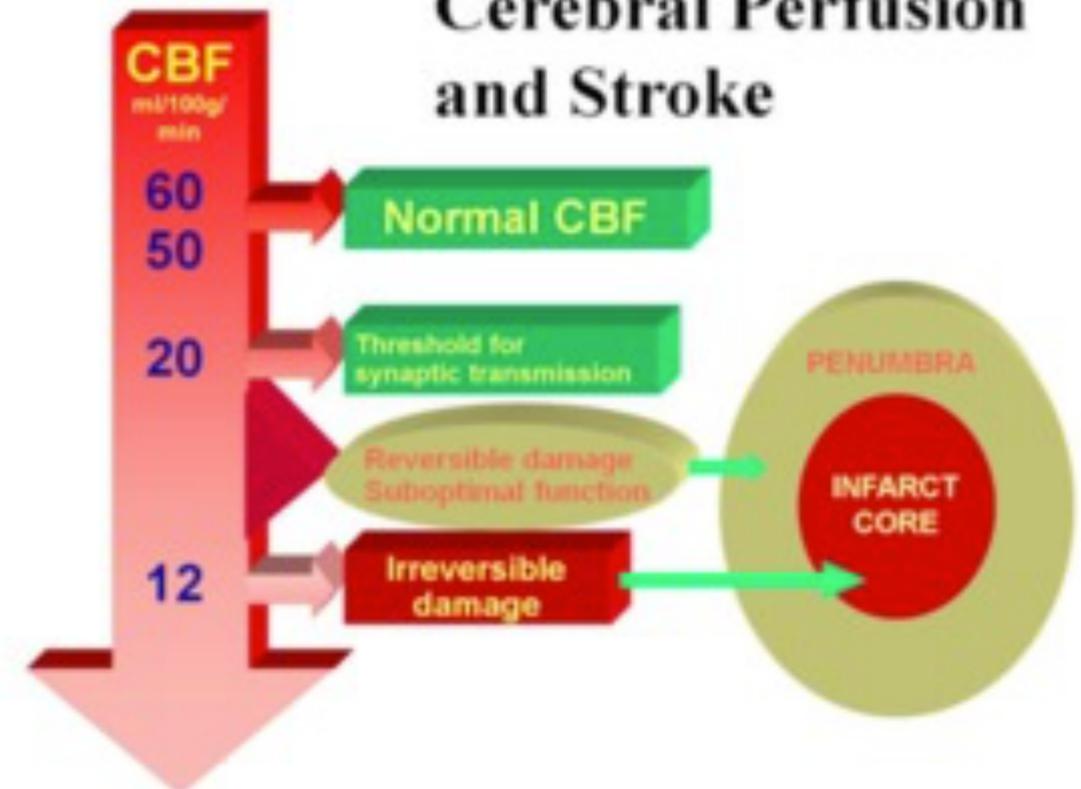
Doppler ultrasound of cerebral vessles

Power Doppler
Carotid Artery Bifurcation

RT ICA

R Prox ICA PS
=-146.5 cm/s
ED=-37.2 cm/s
TAMx=-70.2 cm/s
TAMn=-42.1 cm/s
PI=1.56
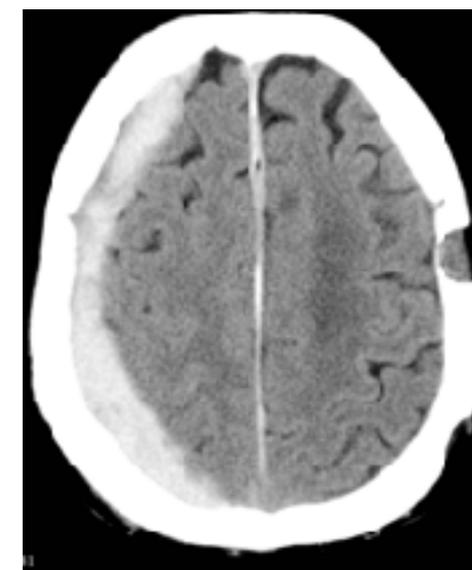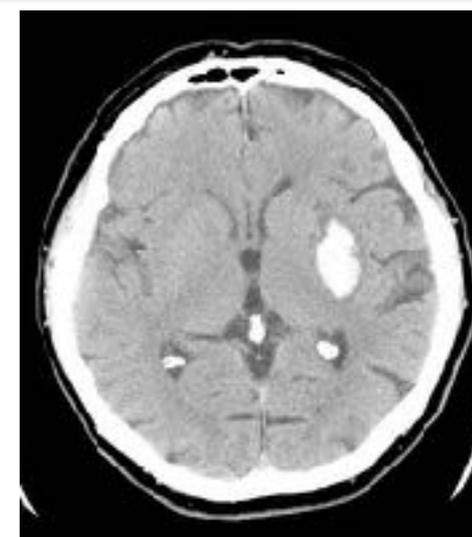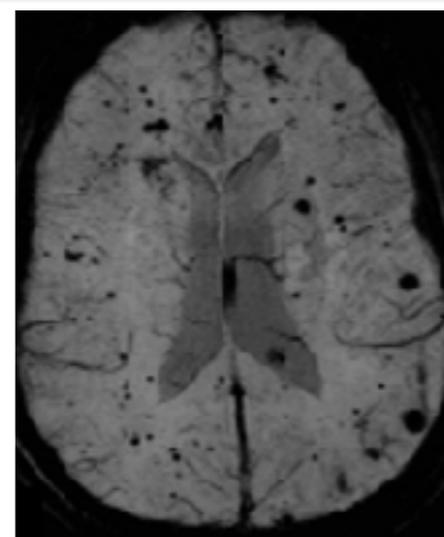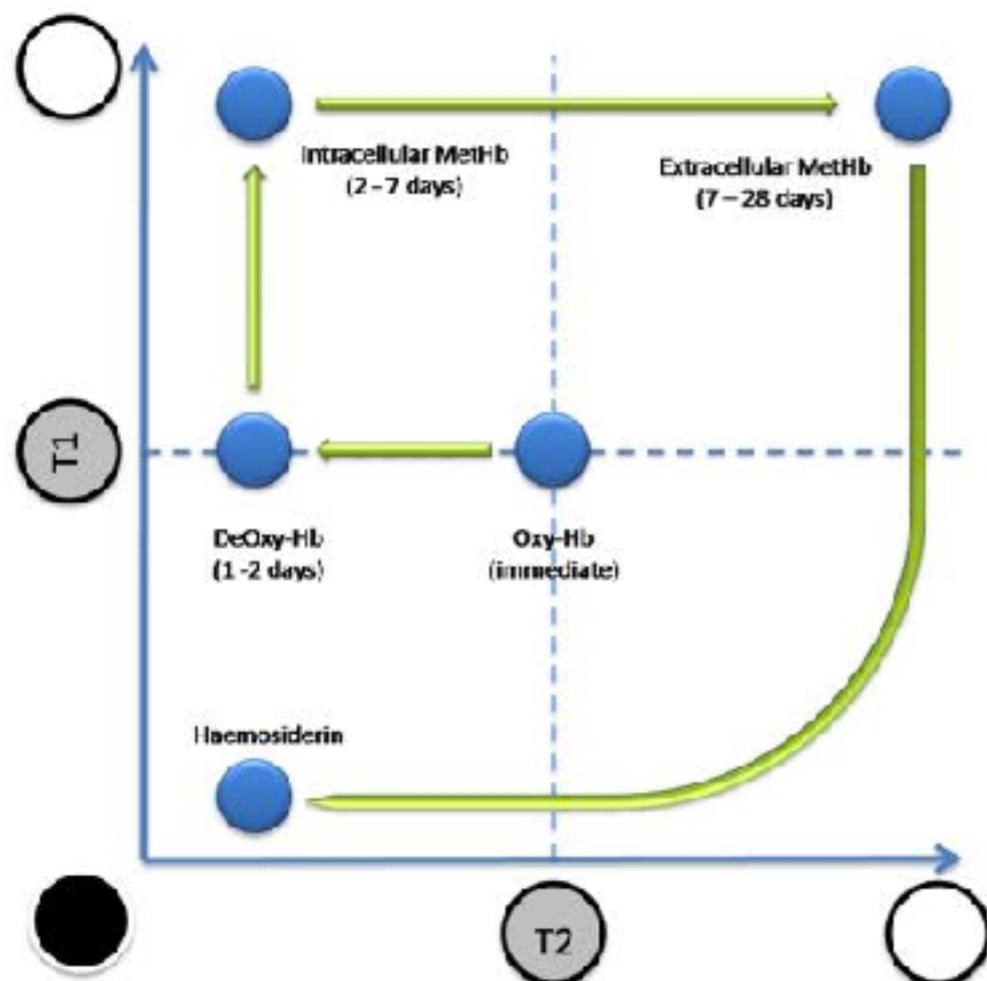RI=0.75
S/D=3.94

L CIRCLE OF WILLIS

Intracerebral bleeding

Haemorrhage on CT

- Hyperdense
- Mass effect
- Perifocal oedema

Haemorrhage on MRI

- Susceptibility weighted imaging (signal loss)
- hemoglobin degradation products disturb magnetic field
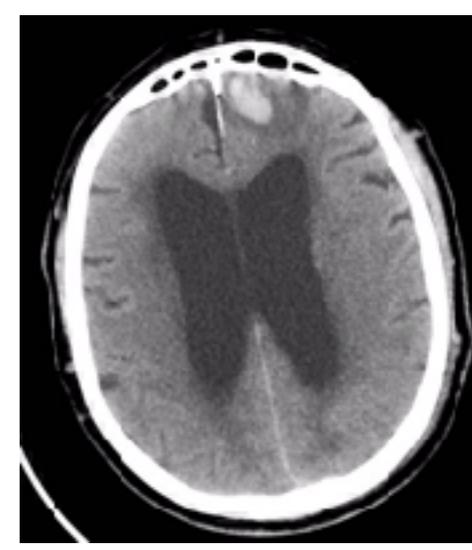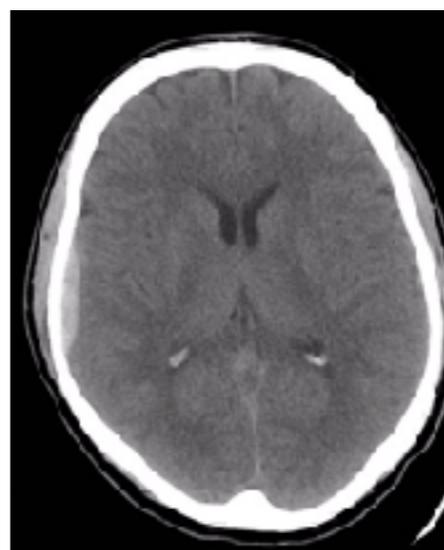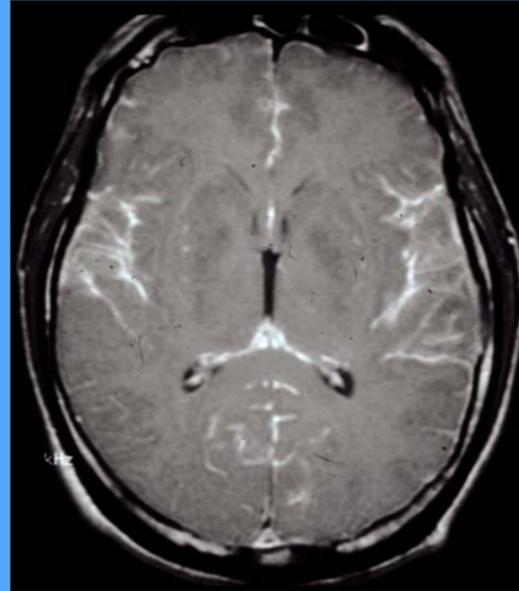
Inflammation

Infection

- meningitis
- encephalitis
- abscess
  - ring enhancement,
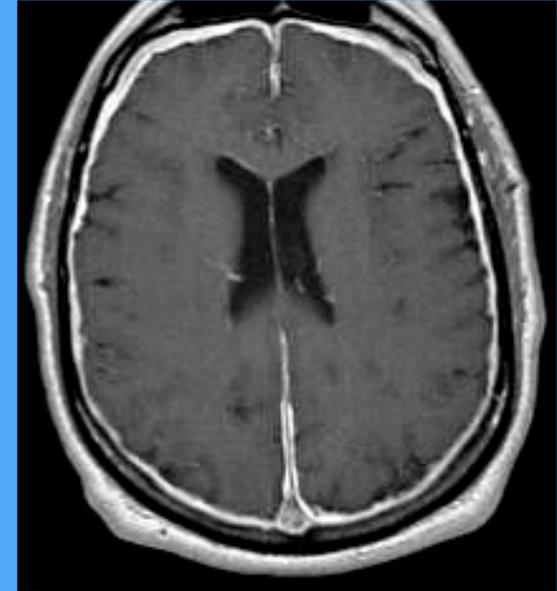 - oedema,
  - restricted diff.

Multiple sclerosis

- T2 hyperintense lesion
- T1 hypointense -> black hole
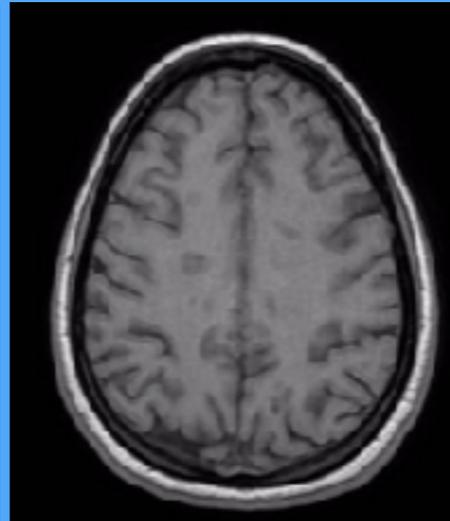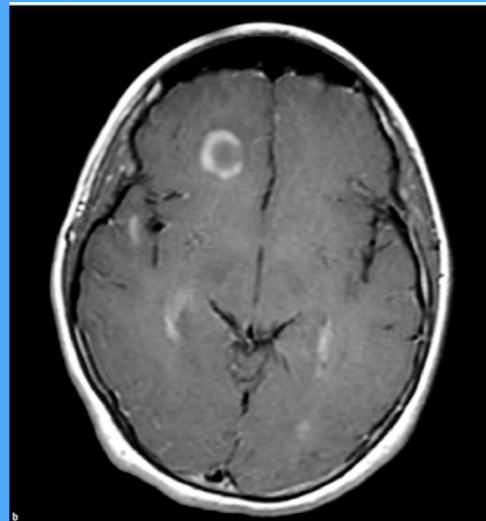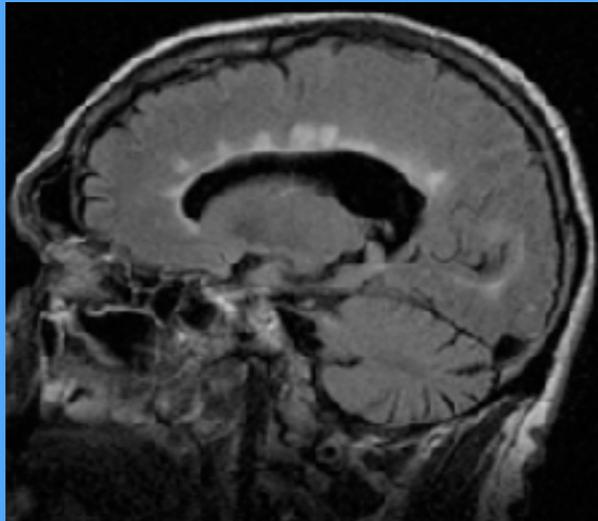- BBB disruption -> enhancement
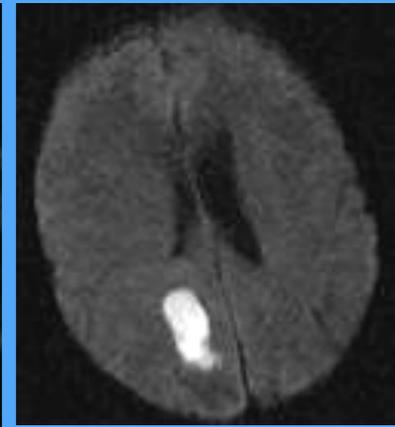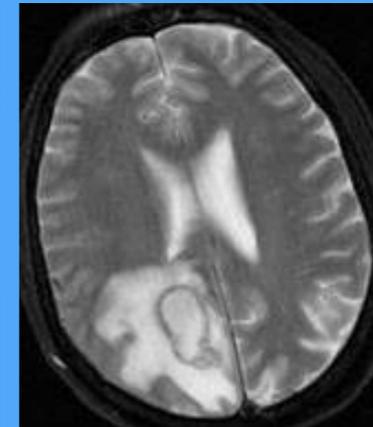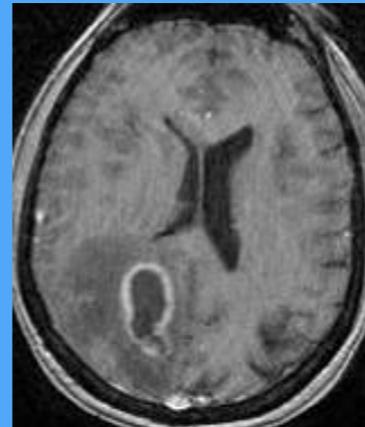- Dawson fingers

Leptomeningitis: arachnoid

Pachymeningitis: dura

Abscess

Tumor

Consider:

- age of the patient
- Single vs. multiple
- Location:
  - extra or intraaxial
  - which compartment
  - midline crossing
- CT and MRI
  - T1, T2, DWI, MRS
  - enhancement
  - calcification
  - cystic degeneration
- Effect on surroundings
  - mass effect
  - midline shift
  - cytotoxic oedema
    - finger like
    - gray/white matter diff maintained
    - CT: hypodense
    - MR: T2 hyperintens
    - No diffusion restriction

metastases

meningioma

GBM

Astrocytoma
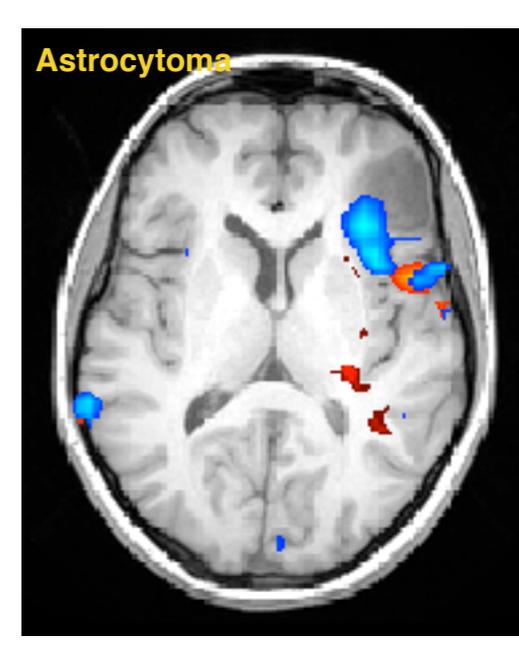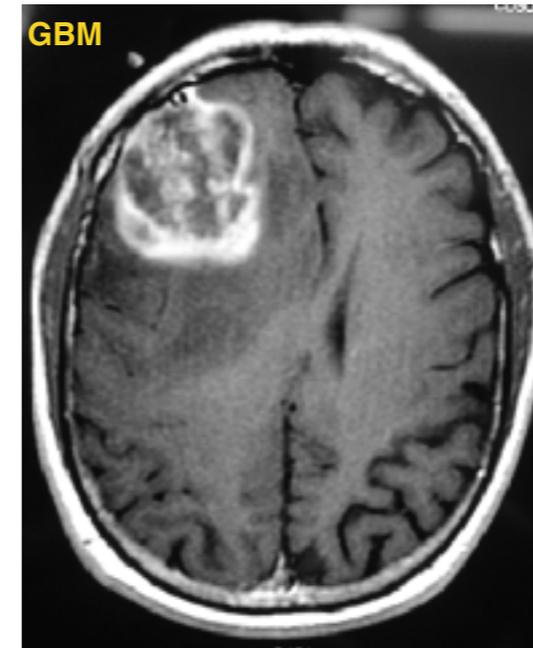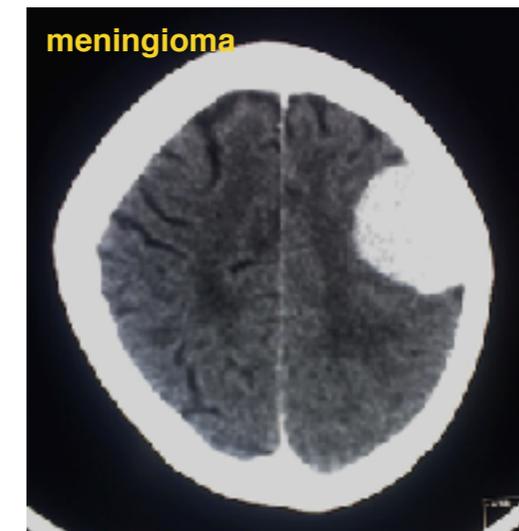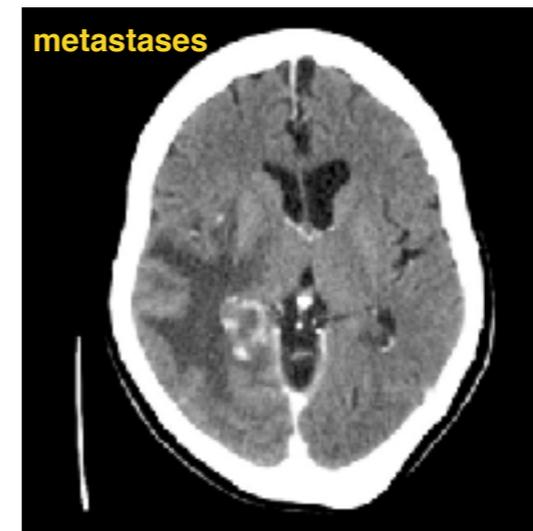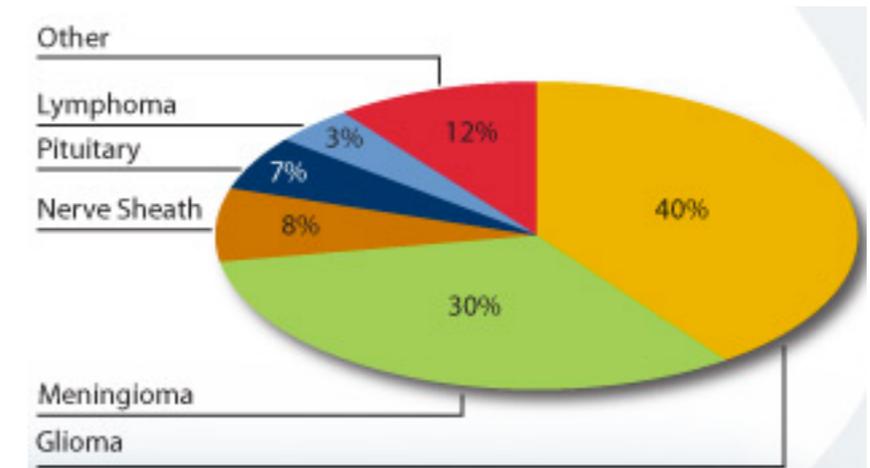
PET and SPECT

PET

- Cyclotron needed
- result is two gamma photons moving 180 degree
- F^{18} (108 min): Fluoro-desoxyglucose (glycolysis)
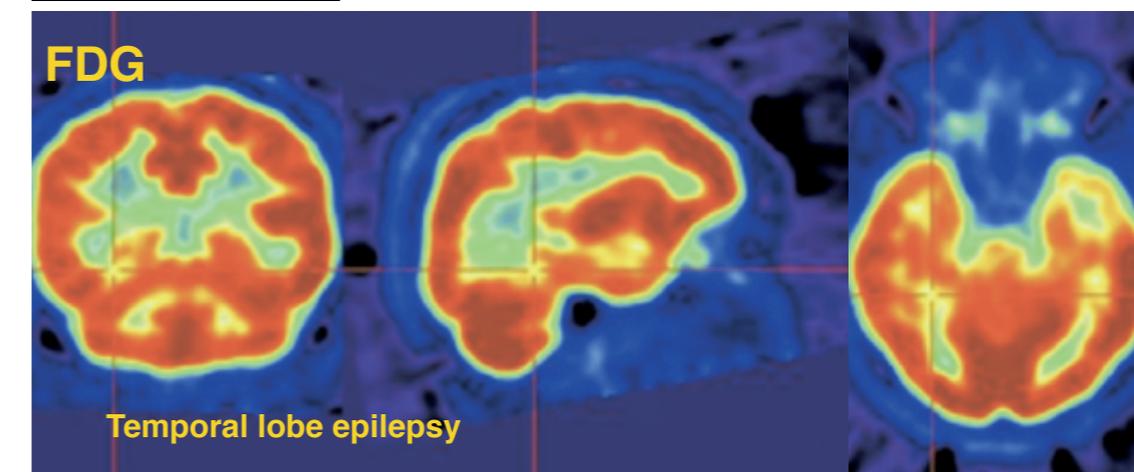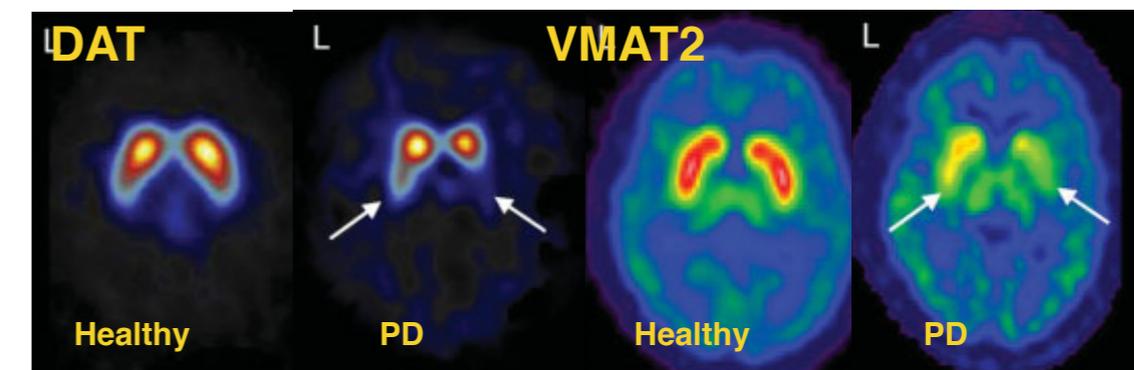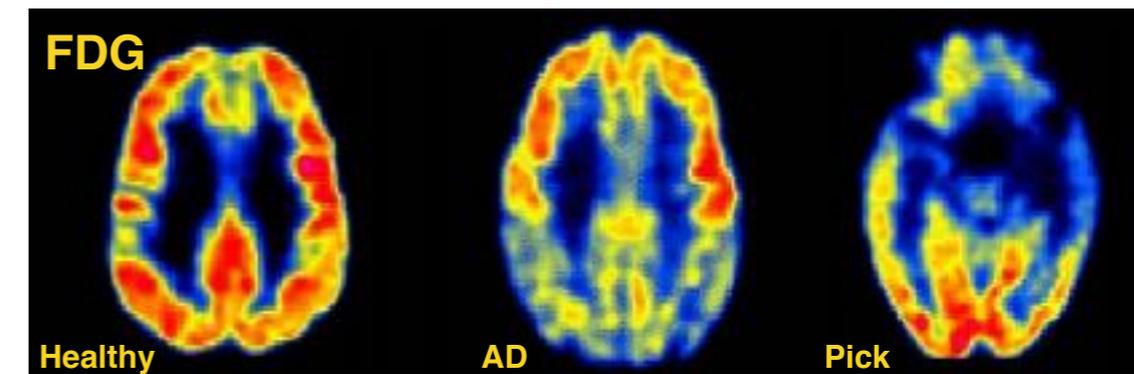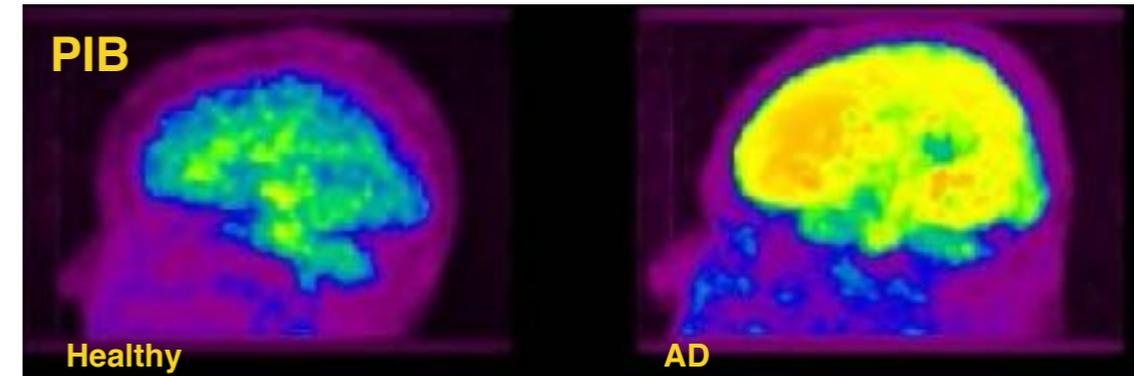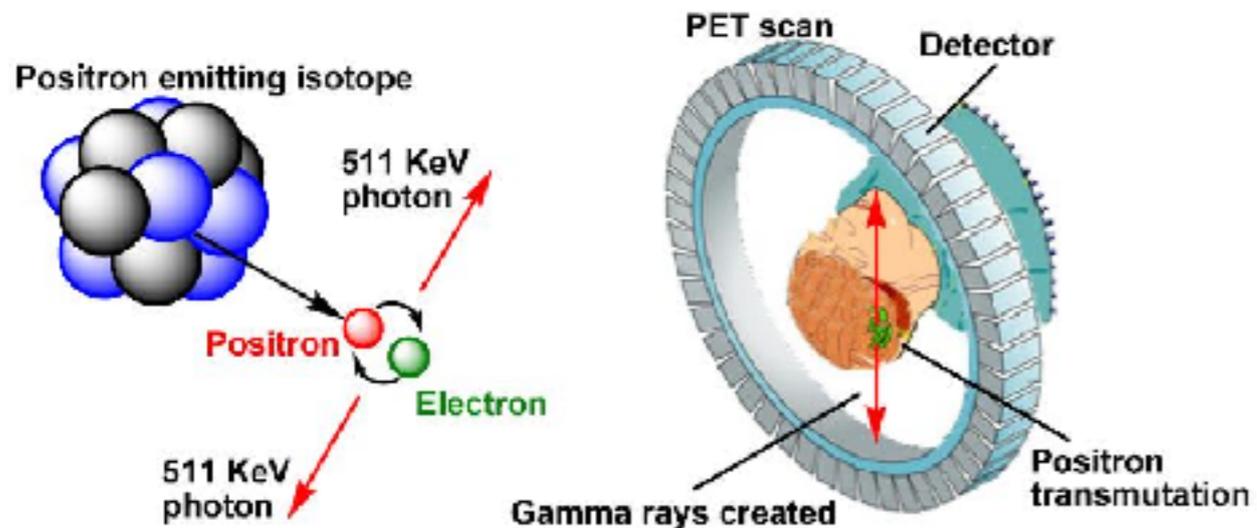- C^{11} (20 min):
  - ➡ methionine (amino acid metabolism)
  - ➡ Pittsburgh compound B (amyloid binding)
  - ➡ Vesicular monoamine transporter (C^{11}-DTZB)
- O^{15} (2 min): water (cerebral perfusion)

SPECT

- No cyclotron needed > cheaper
- gamma emitting isotopes (^{99m}Tc)
- ^{99m}Tc-HMPAO (cerebral blood flow)
- Dopamine transporter imaging (DAT):
  - ➡ ^{123}I-β-CIT
  - ➡ ^{99m}Tc-TRODAT
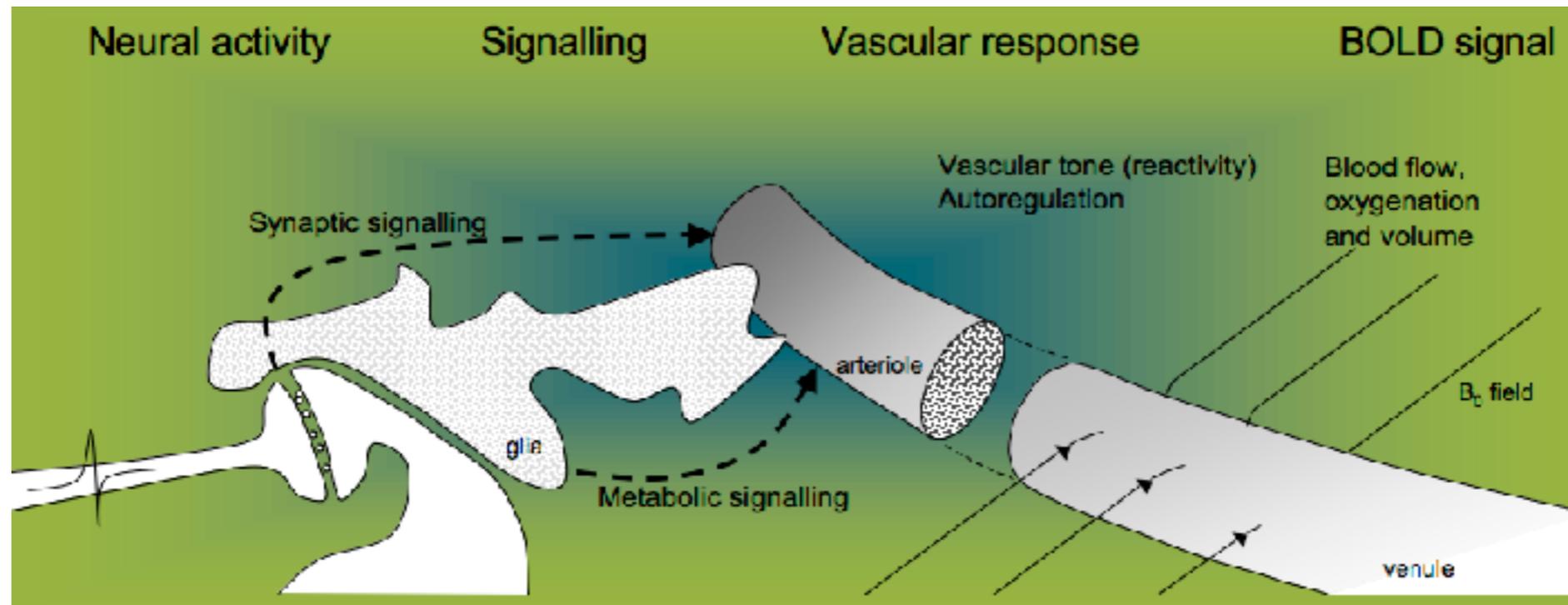- D2 dopamine receptor imaging:
  - ➡ ^{123}I-IBZM

Functional MRI

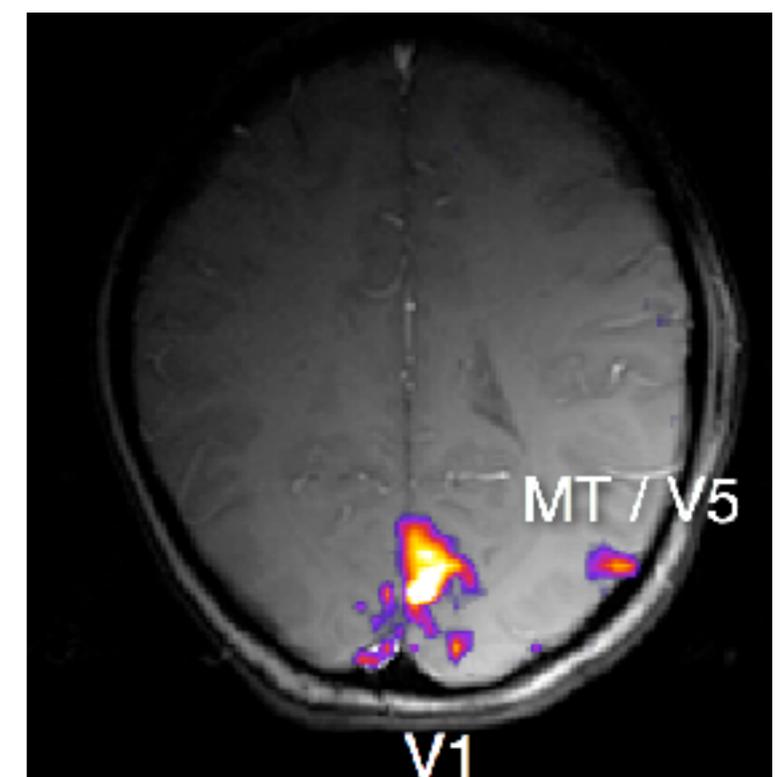$$\frac{1}{T2*} = \frac{1}{T2} + \frac{1}{T2'} + \frac{1}{T2_D} + \ldots$$

Molecular   Field Inhomogeneity   Diffusion
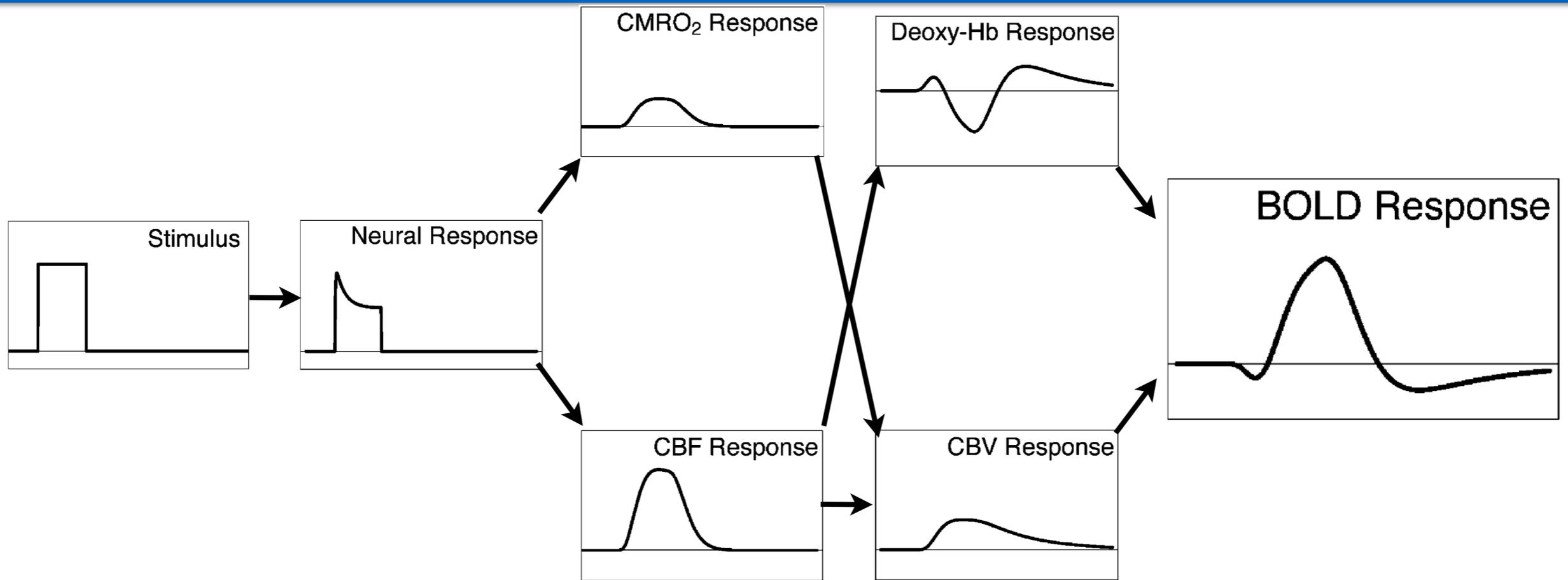

Neural activity   Signalling   Vascular response   BOLD signal

Synaptic signalling

Vascular tone (reactivity)
Autoregulation

Blood flow,
oxygenation
and volume

arteriole

glia

B_0 field

Metabolic signalling

venule

Functional MRI

Stimulus → Neural Response → CMRO₂ Response, CBF Response → Deoxy-Hb Response, CBV Response → BOLD Response

Photic Stimulation -- GE Images

MT / V5 · V1
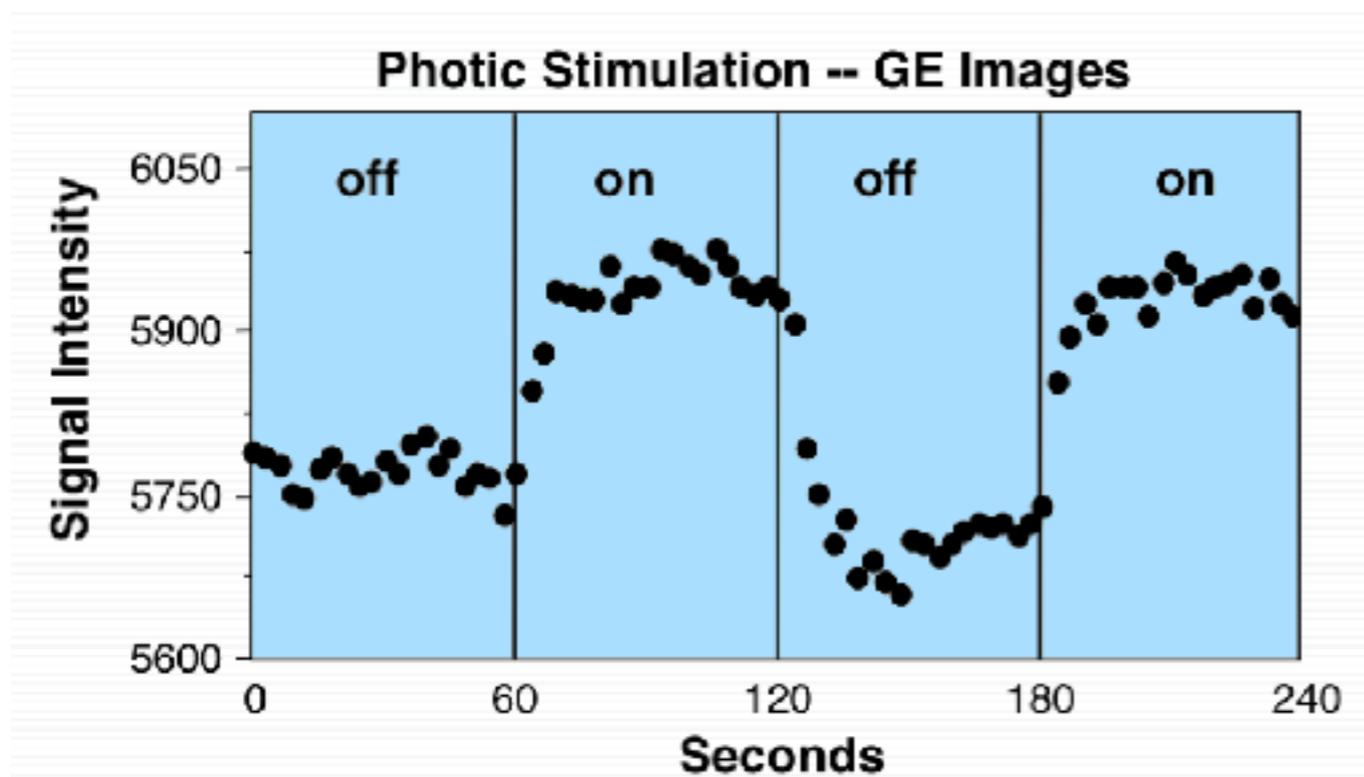
www.nepsy.szote.u-szeged.hu/seminar