

Università degli studi di Ferrara

***CORSO di LAUREA in TECNICHE di RADIOLOGIA
MEDICA, per IMMAGINI e RADIOTERAPIA***

Contrasto & Sequenze



05 05 2012

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Contenuti:

- * Sequenze ad impulsi:
 - * Spin Echo Pulse Sequence (SE)
 - * Turbo Spin Echo (TSE)
 - * Fast Field echo (FFE)
 - * Echo Planar Imaging (EPI)
 - * Gradient and Spin Echo (GRASE)

- * Preimpulsi:
 - * STIR
 - * SPIR
 - * FLAIR

Fattori determinanti il contrasto in MRI

L'intensità del segnale RM è determinata da:

- * caratteristiche del tessuto
- * settaggio apparecchiature

Caratteristiche RM dei tessuti

Il **contrasto** nelle immagini è basato su:
differenze caratteristiche dei tessuti:

- * Proton Density
- * Longitudinal Relaxation Time T1
- * Transverse Relaxation Time T2

altre caratteristiche:

- * Flow
- * Diffusion
- * Contrast agent/perfusion
- * Magnetization transfer contrast
- * Temperature

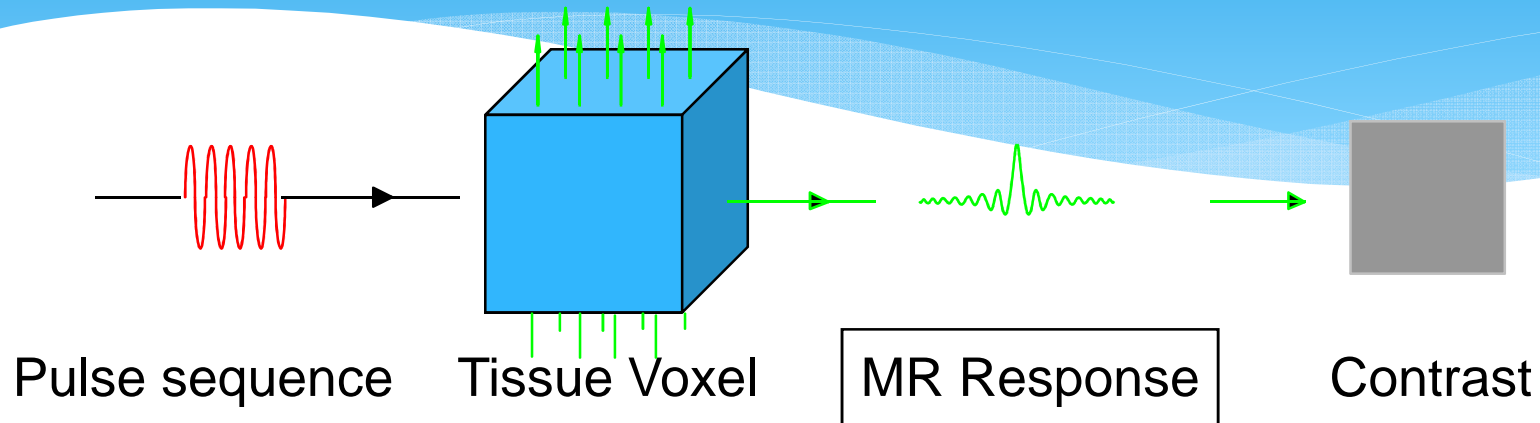
Caratteristiche RM dei tessuti

Tecniche di soppressione del segnale dei tessuti:

- * Fat suppression (STIR, SPIR)
- * Fluid attenuation (FLAIR)

Contrasto tissutale

Magnetic Field



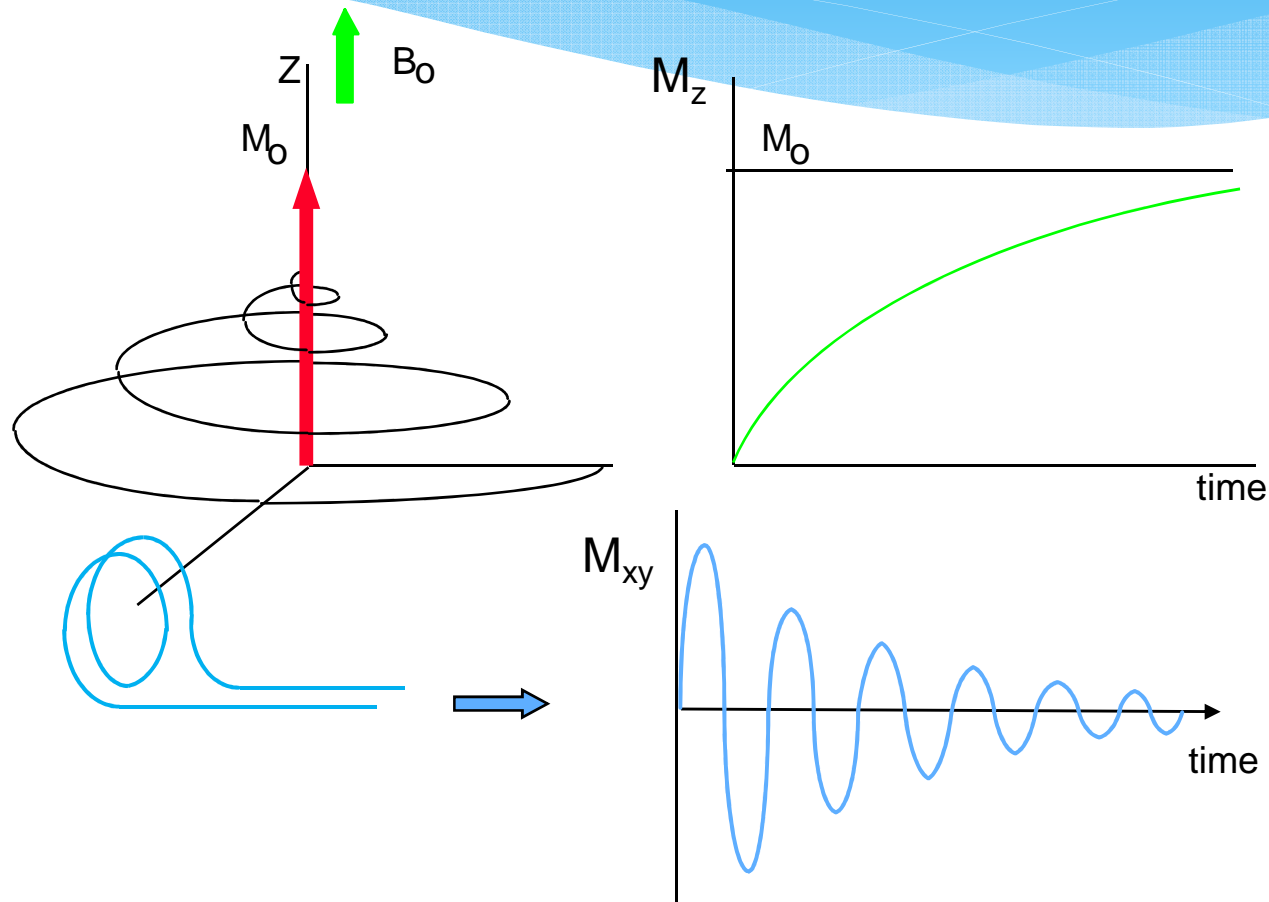
Spin Echo
Turbo Spin Echo
(Turbo) Field Echo
EPI
GRASE
Prepulse: IR, SPIR,
ProSet, DRIVE, MTC

Proton density
Relaxation time T1
Relaxation time T2
Flow
Diffusion
Perfusion
Temperatur

PD-W
T1-W
T2-W
T2*-W
Angio
DWI
BOLD

Caratteristiche del segnale RM

Rilassamento T1



Caratteristiche RM del tessuto

| Tissue | Proton density | T1 (msec) | T2 (msec) |
|---------------|----------------|-----------|-----------|
| Adipose | 100 | 260 | 85 |
| Bone marrow | 40 | 400 | 60 |
| White matter | 85 | 790 | 90 |
| Grey matter | 80 | 920 | 100 |
| Blood | 95 | 1200 | 100 |
| CSF | 100 | >4000 | >2000 |
| Cortical bone | <10 | | |
| Air | <1 | | |

Settaggio della strumentazione

→ Tipo di sequenze ad impulsi

- (Turbo) Spin Echo ($90^\circ - 180^\circ$)
- Inversion Recovery ($180^\circ - 90^\circ - 180^\circ$)
- (Turbo) Field Echo
- EPI
- GRASE

→ Pulse sequence characteristics

→ Signal preparation

Settaggio della strumentazione

- Tipo si sequenze ad impulsi
- Pulse sequence timing
- Signal preparation

Settaggio della strumentazione

- Type of pulse sequence
- Settaggio parametri sequenze:
 - repetition time (TR)
 - echo time (TE)
 - inversion time (TI)
 - flip angle
- Signal preparation

Settaggio della strumentazione

- Type of pulse sequence
- Temporizzazione sequenze ad impulsi
- Signal preparation

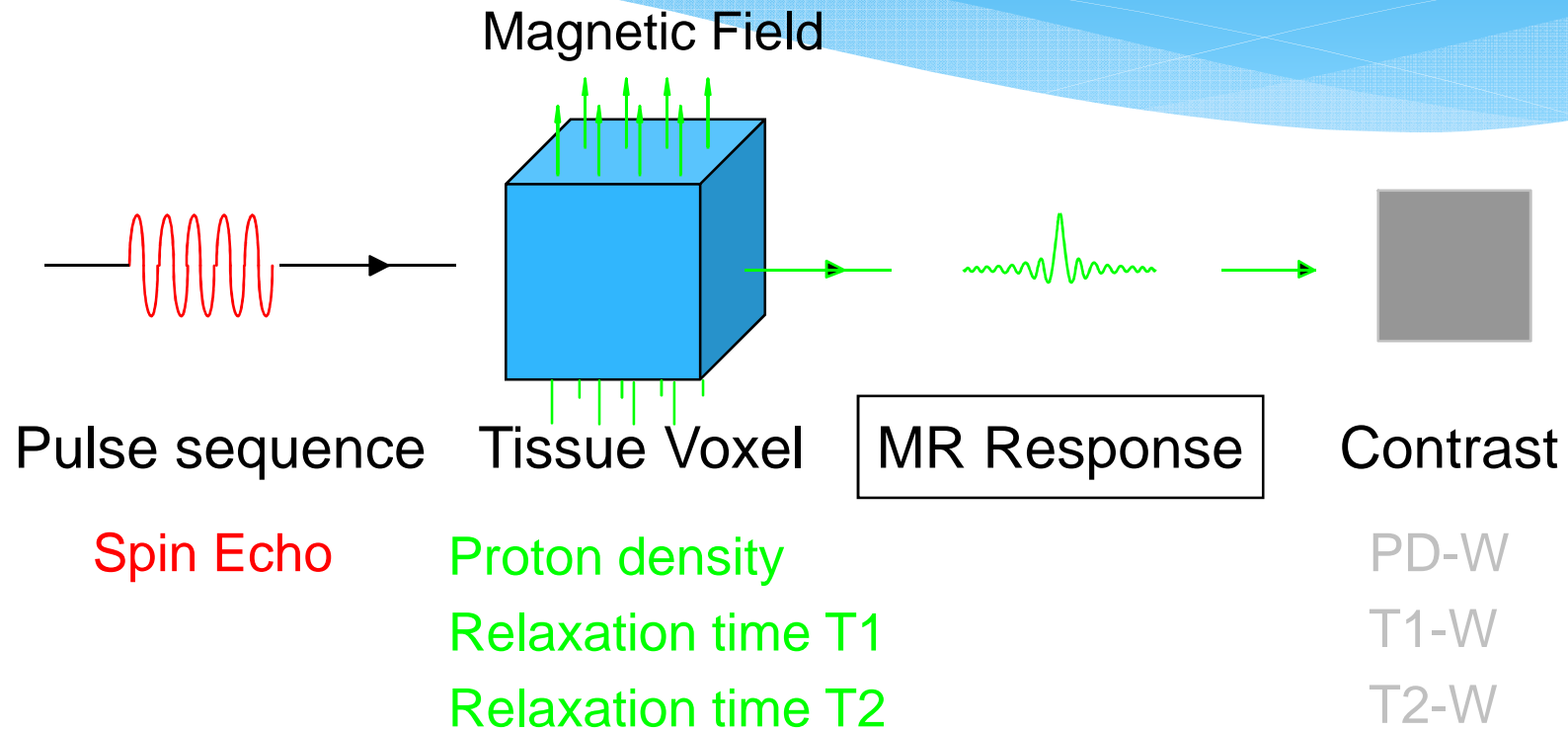
Settaggio della strumentazione

- Type of pulse sequence
- Pulse sequence timing
- Preparazione del segnale
 - Fat suppression (STIR, SPIR, ProSet)
 - Fluid attenuation (FLAIR)
 - Dual Inversion
 - DRIVE
 - MTC
 -

Settaggio della strumentazione

- Tipo si sequenze ad impulsi
- Settaggio parametri sequenze
- Preparazione del segnale

Contrasto in Spin Eco



Pulse sequence design

Tissue Preparation

Signal acquisition

Image production



(ST)IR
SPIR
MTC
BB
T2-prep

Excitation

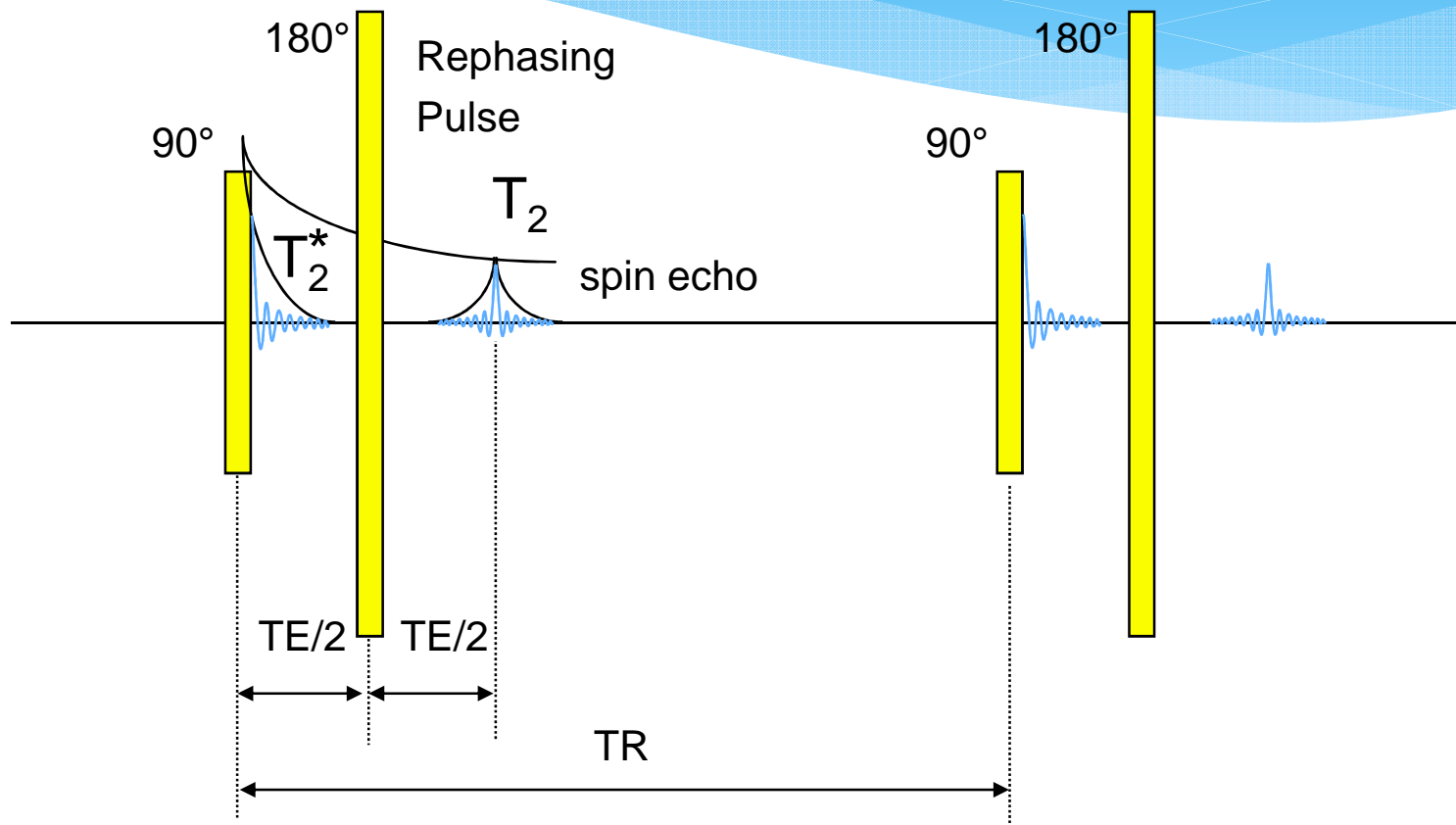
- water & fat
- ProSet
 - water only
 - fat only

T1W
T2W
PDW

Spin Echo

Sequenza ad impulsi

Spin Echo (SE)



Spin Eco

Sequenza ad impulsi

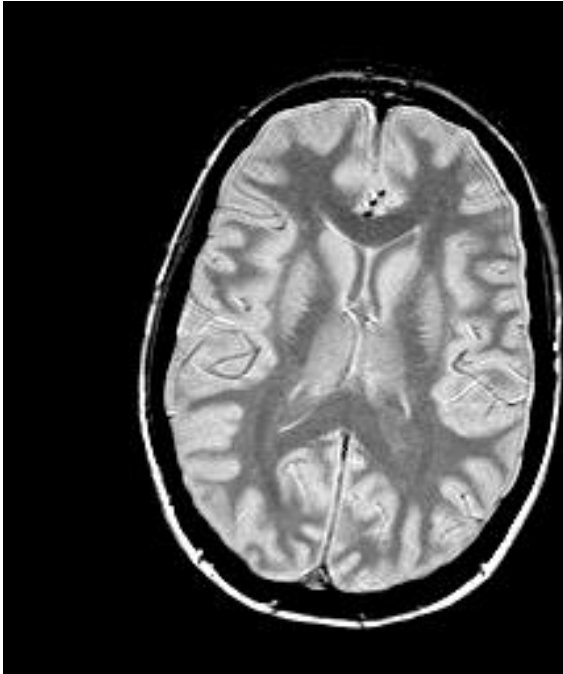
- * Contrasto in Spin Echo images è un mix di:
 - * T₁
 - * T₂
 - * proton density
- * Selezionando le variazioni dei tempi TR e TE si determina la predominanza di:
 - * T₁-weighted
 - * T₂-weighted
 - * proton-density-weighted

Spin Eco Contrasto

Le immagini spin eco possono mostrare differenti tipi di contrasto:

| | Short TR | Long TR |
|----------|------------------|-------------|
| Short TE | T1-weighted | PD-weighted |
| Long TE | Non constructive | T2-weighted |

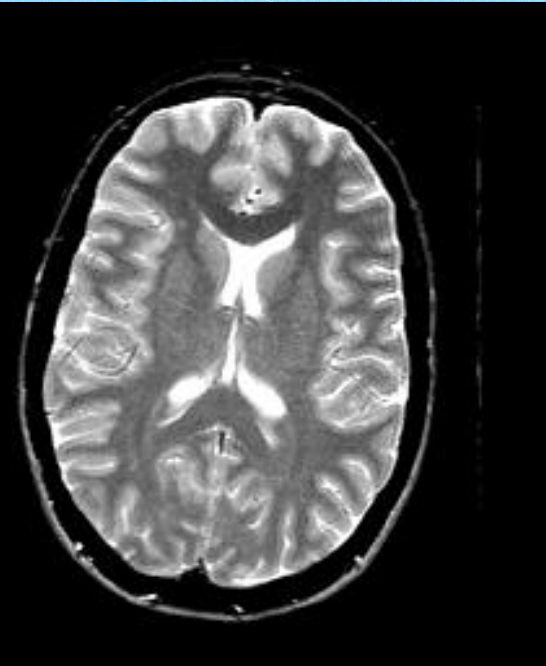
Contrasto in SE



Long TR, short TE
Proton density



Short TR, short TE
T1-weighted



Long TR, long TE
T2-weighted

Come appaiono le immagini clinicamente

T1 Effects on Image

Short T1 - bright

- Fat, subacute bleeding
- paramagnetic contrast agents (gadolinium)

Long T1 - dark

- neoplasm, edema, inflammation, pure fluid, CSF

Come appaiono le immagini clinicamente

T2 Effects on Image

Short T2 - dark

- Iron deposition in liver, magnetic susceptibility effect

Long T2 - bright

- Neoplasm, edema, inflammation, gliosis, pure fluid, CSF

Come appaiono le immagini clinicamente

Proton density effects

Low proton density - dark

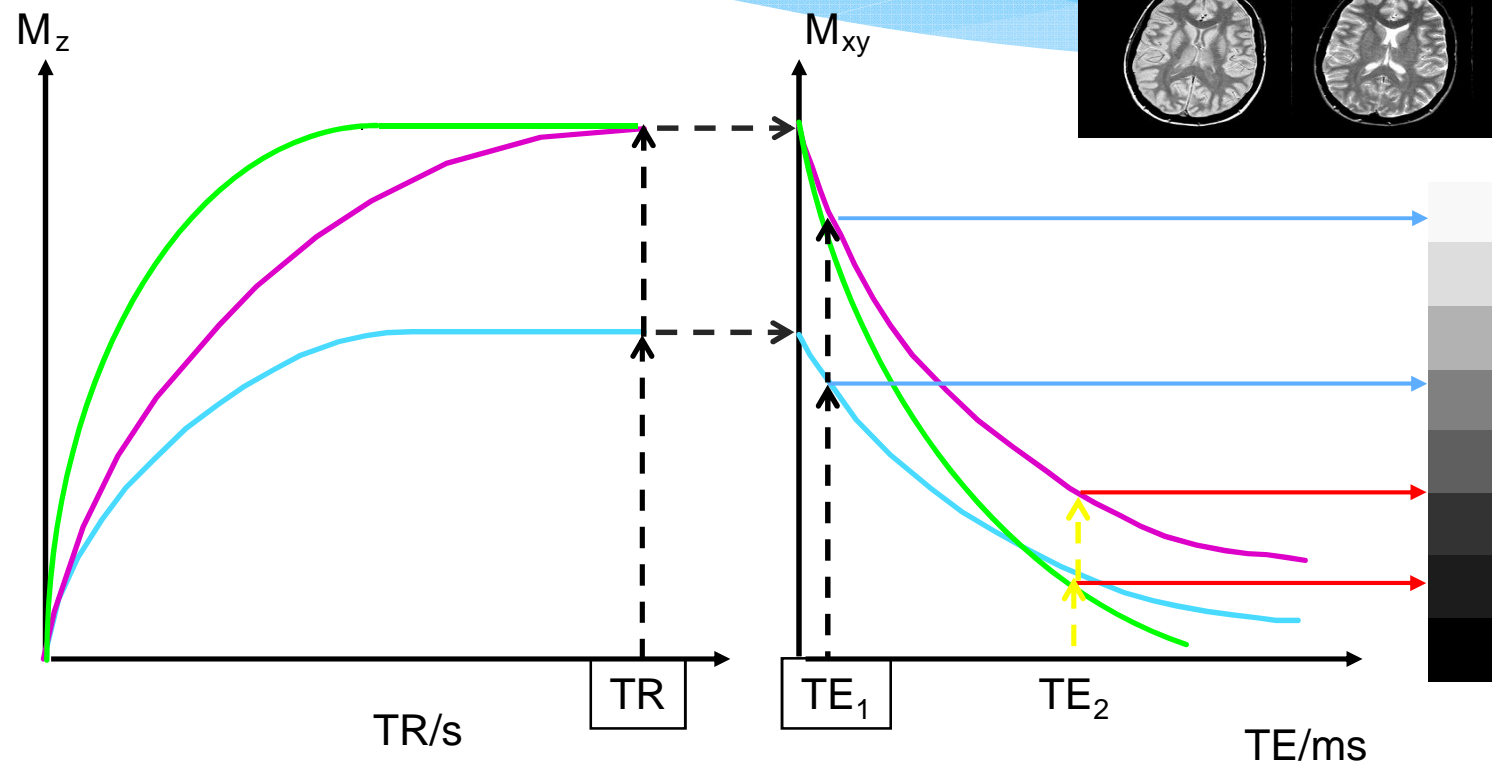
- calcium, air, cortical bone, fibrous tissue

High proton density - bright

- fat

Doppio Eco Spin Eco

Long TR, Short TE/Long TE



Riassumendo: Spin Eco

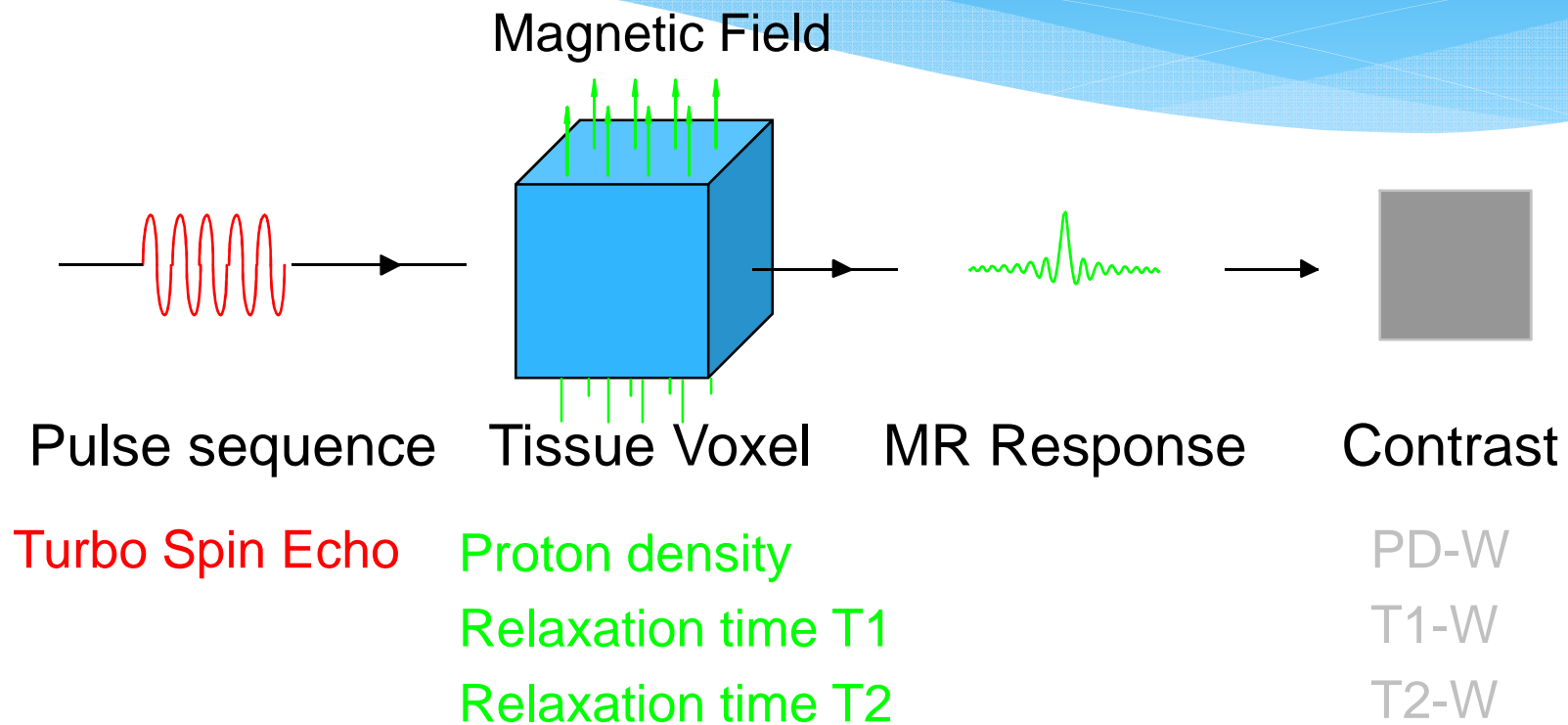
- * Vantaggi:

- + eliminano la perdita di segnale causata da:
 - * disomogeneità del campo magnetico
 - * suscettibilità
 - * chemical shift
- + determinano un eccellente contrasto T2
- + "golden standard"

- * Svantaggi:

- * tempi di acquisizione
- * sensibilità agli artefatti da movimento

Contrasto nelle Turbo Spin Eco



Sequenze Turbo

Introduzione

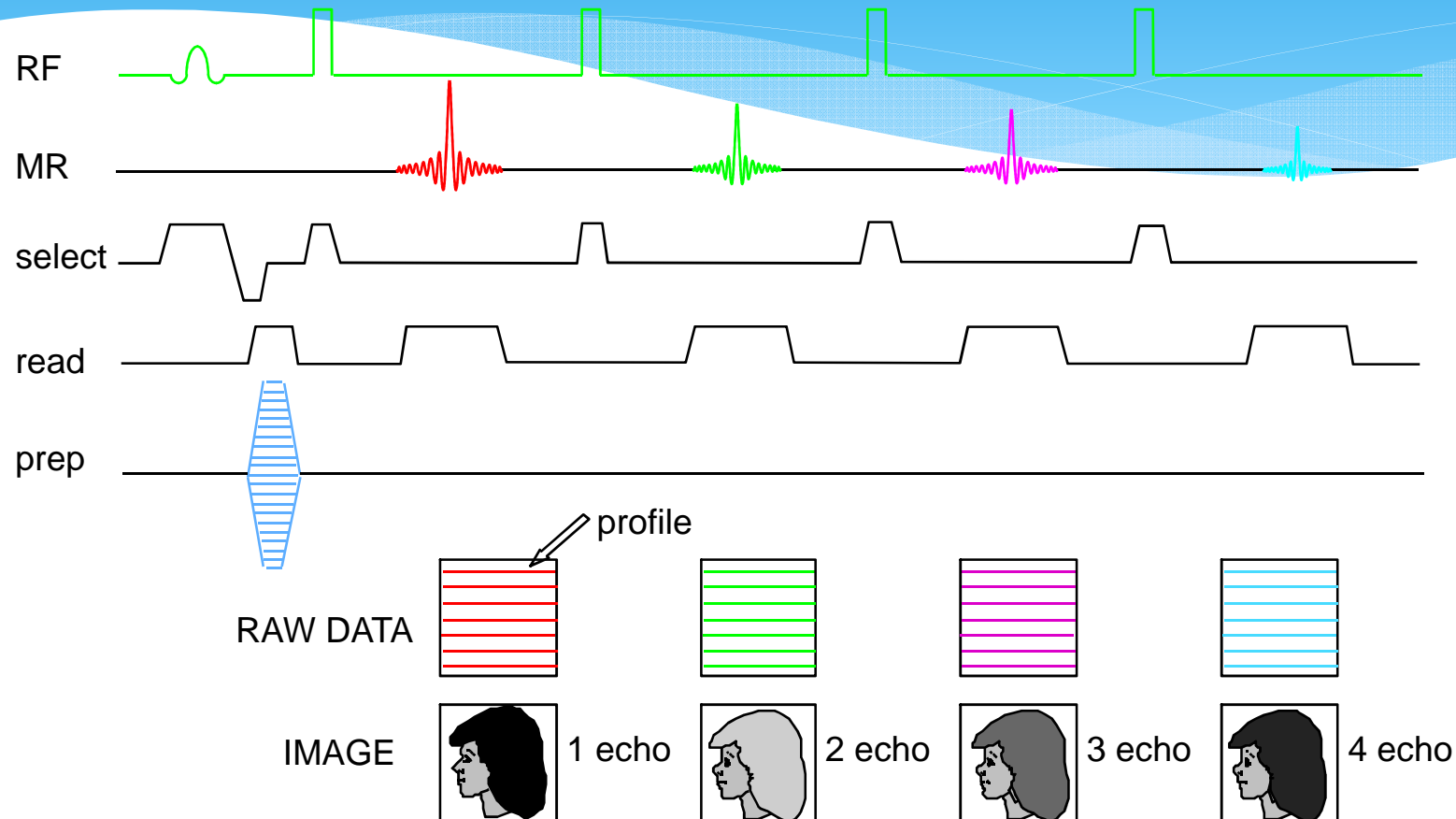
Tecniche di immagine:

- * Imaging convenzionale
- * Sequenze turbo o fast

Sequenze di imaging **convenzionali** (e.g. SE, IR or FE):
one excitation \Rightarrow one phase encoding (profile)

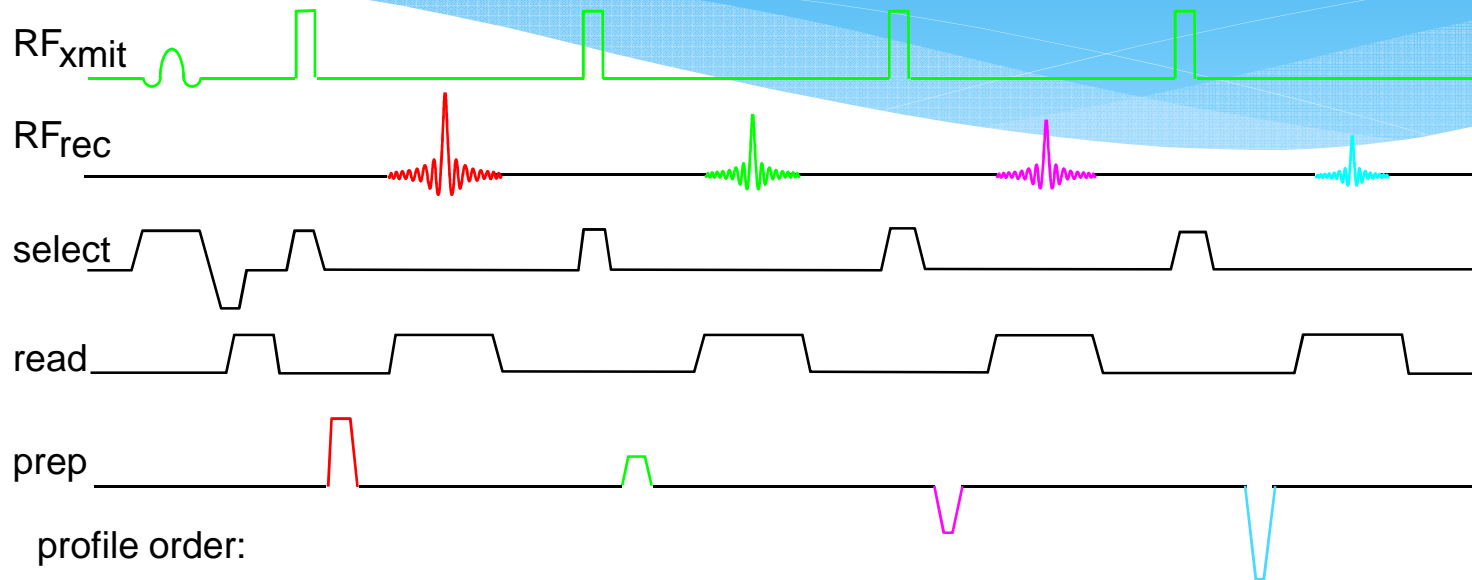
Sequenze **turbo** (TSE, GRASE, EPI)
one excitation \Rightarrow **multiple** phase encodings (profiles)

Spin echo convenzionale con 4 echi equidistanti

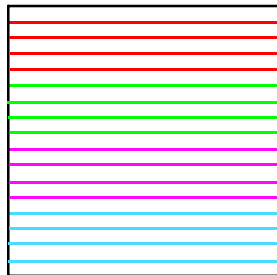


Turbo Spin Eco

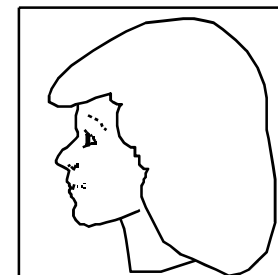
Turbo factor 4



RAW DATA



2D-FT
→



IMAGE

Confronto performance SE vs TSE:

- * Spin Echo 256^2

TR = 2000 ms, 256×256 matrix, NSA = 2 17.06 min

- * Turbo Spin Echo 256^2

TR = 2000 ms, 256×256 , NSA = 2, TSE factor 10 1.7 min

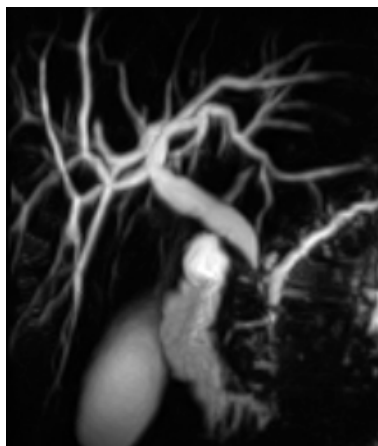
- * Spin Echo 512^2

TR = 2000, 512×512 matrix, NSA = 2 34.14 min

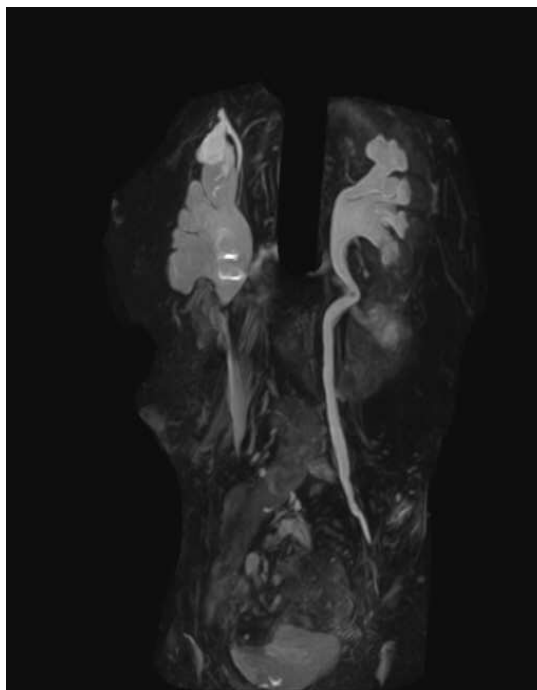
- * Turbo Spin Echo 512^2

TR = 2000, 512×512 matrix, NSA = 2, TSE factor 10 3.4 min

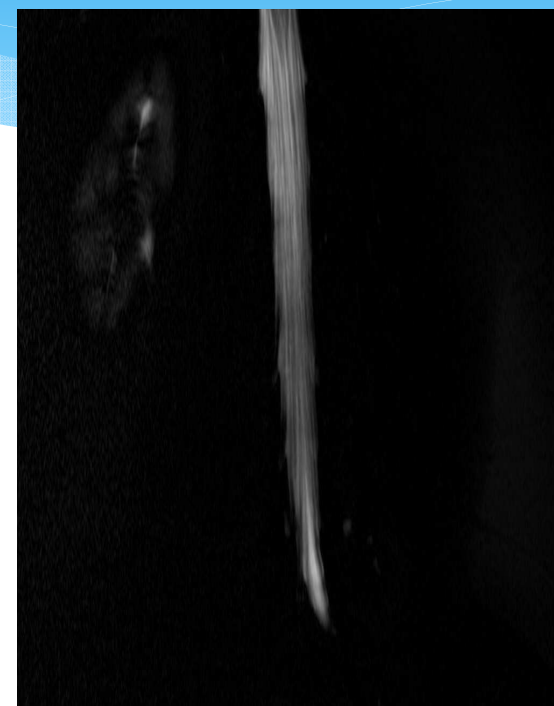
Applicazioni speciali delle TSE



MRCP



PielORM



MR myelography

Riassumendo: Turbo Spin Eco

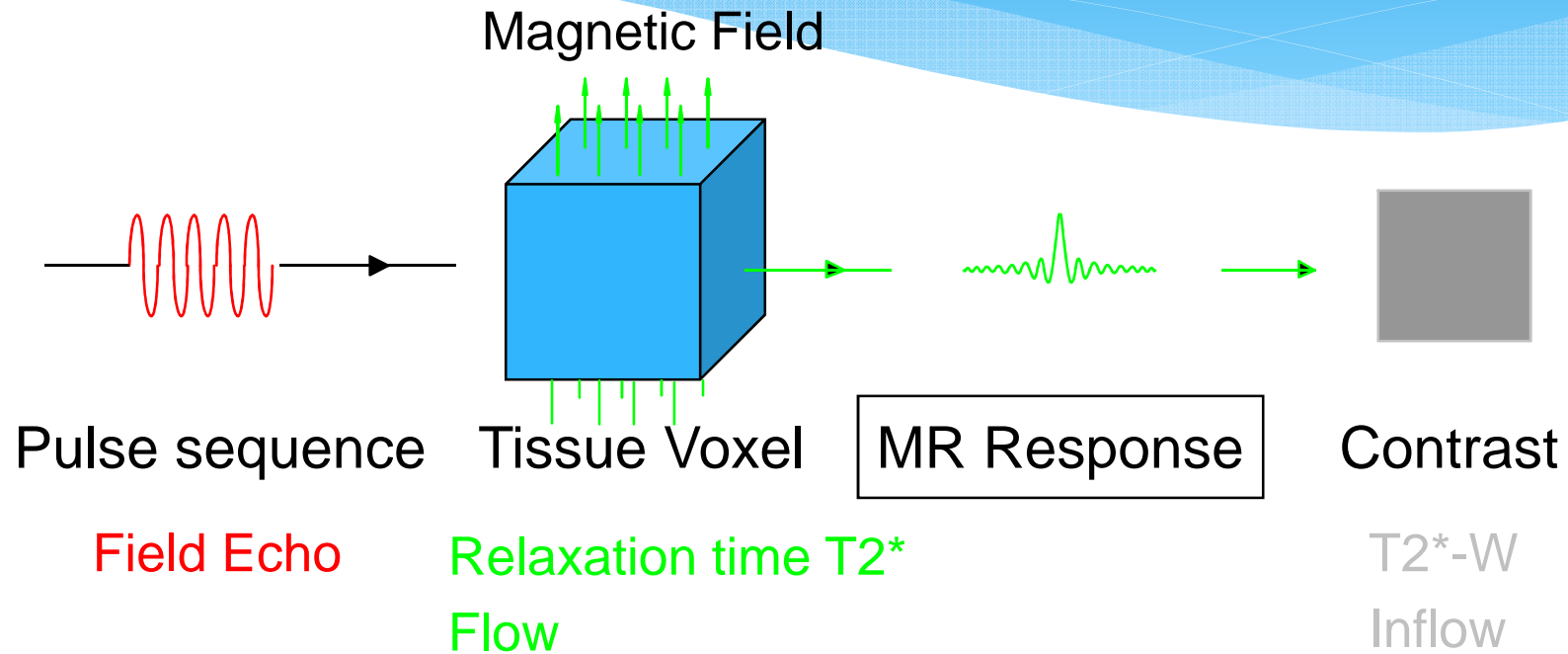
Vantaggi:

- + riduzione tempo di acquisizione
- + eccellenti immagini T2 weighted
- + eliminazione contaminazione T1 grazie al TR lungo
- + facile implementazione senza aggiunta di hardware

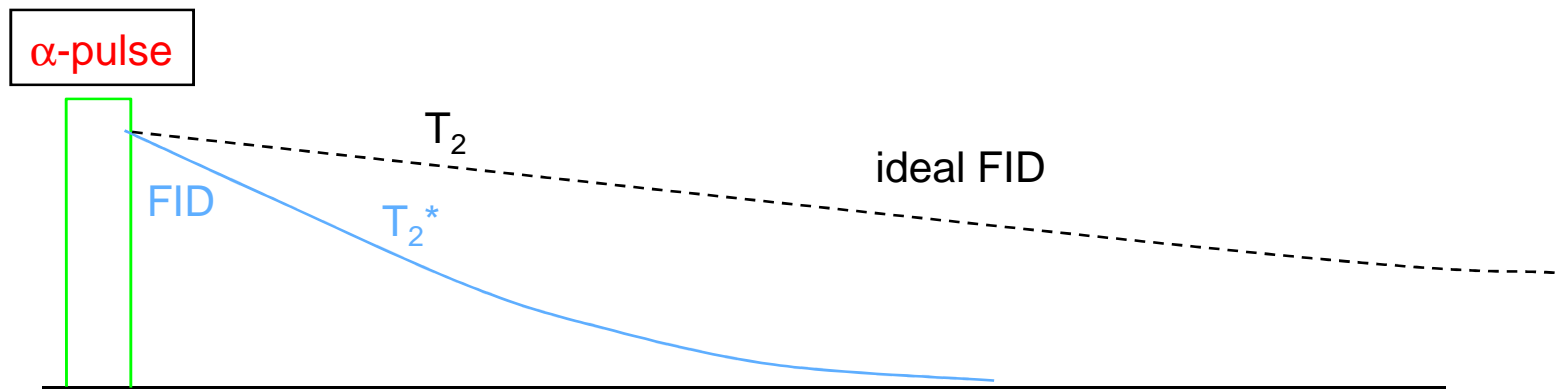
Svantaggi:

- + Alto valore SAR
- + iperintensità tessuto adiposo

Contrasto nelle Field Echo

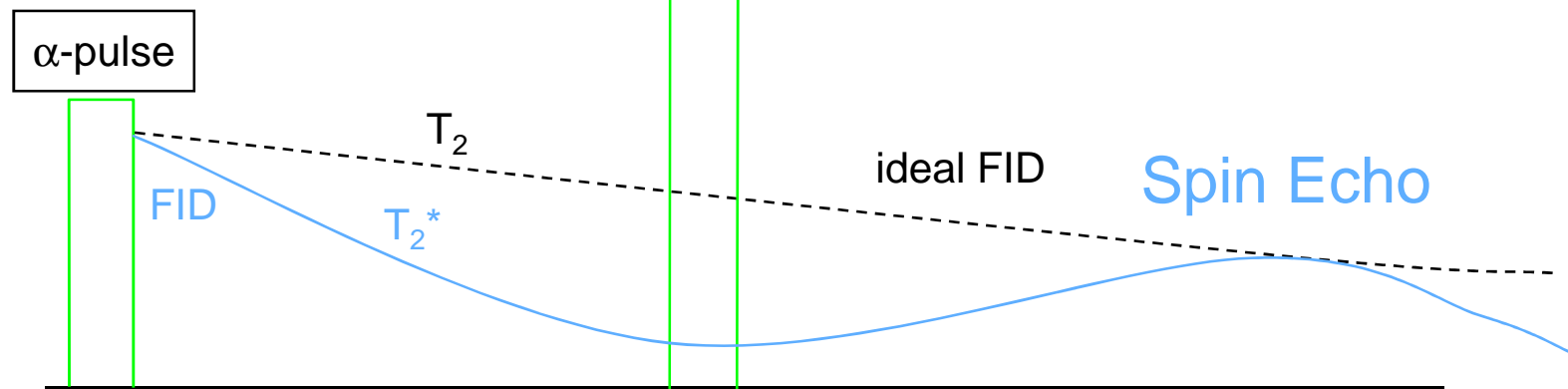


Fast Field Echo (gradient eco)

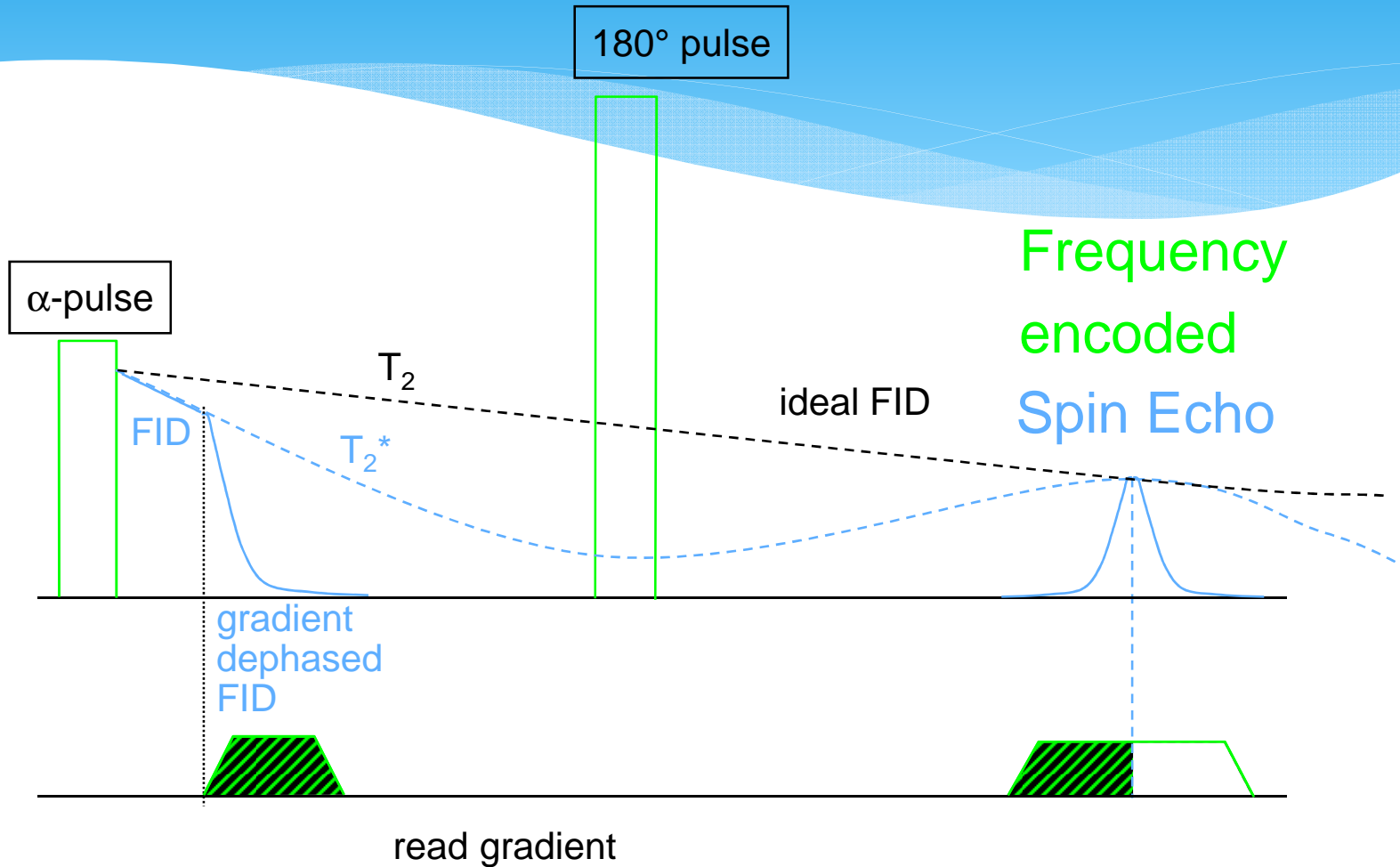


Fast Field Echo (gradient eco)

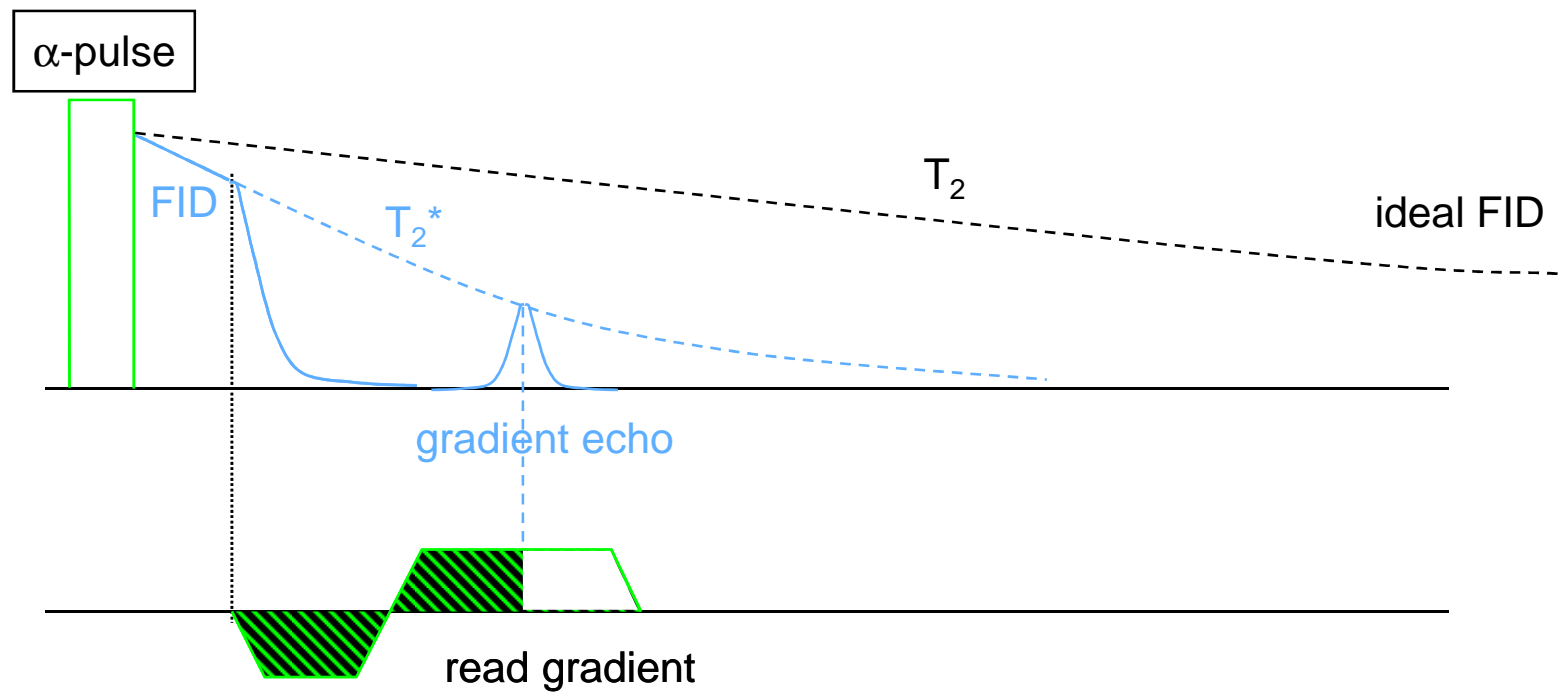
180° pulse



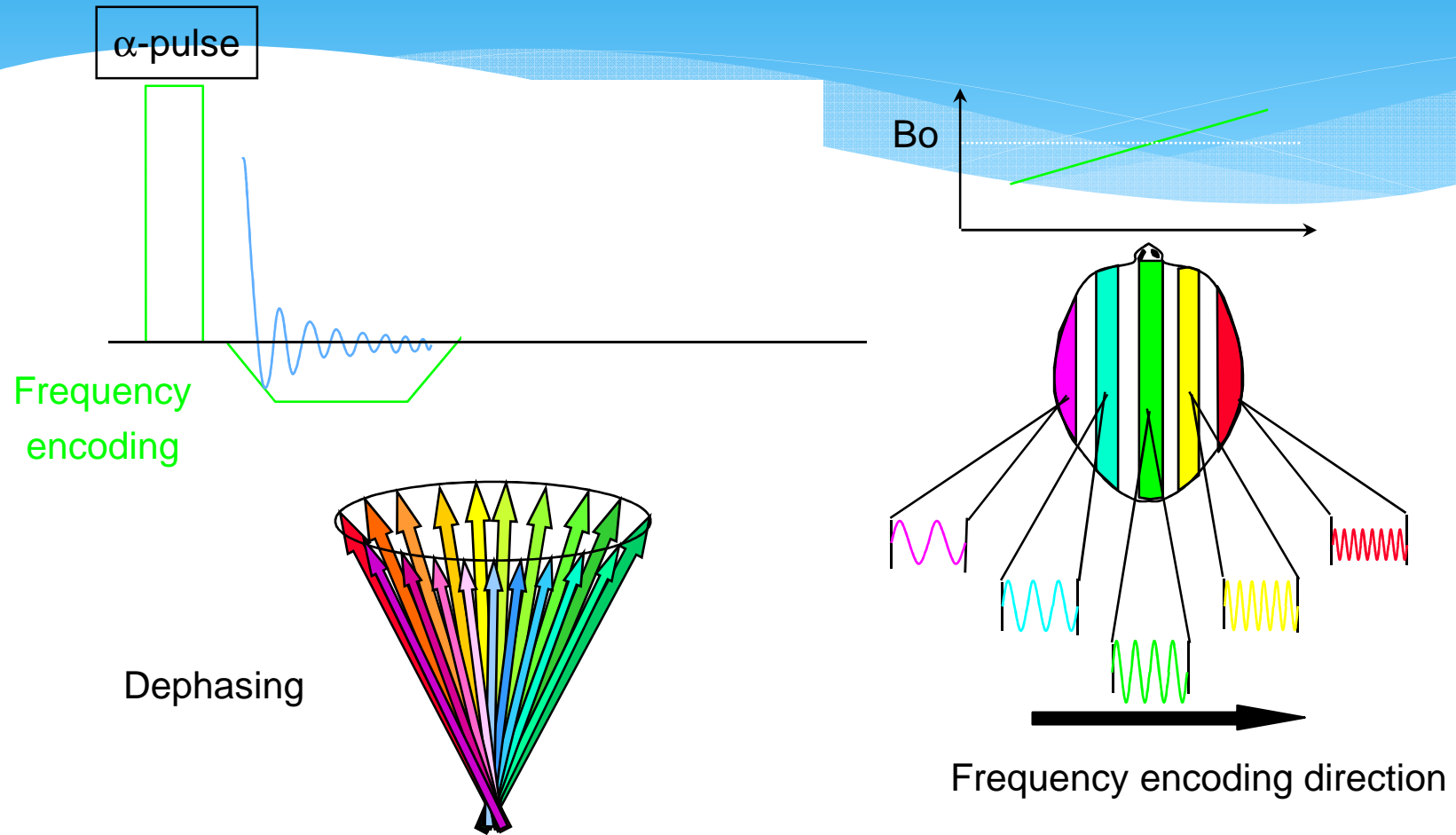
Fast Field Echo (gradient eco)



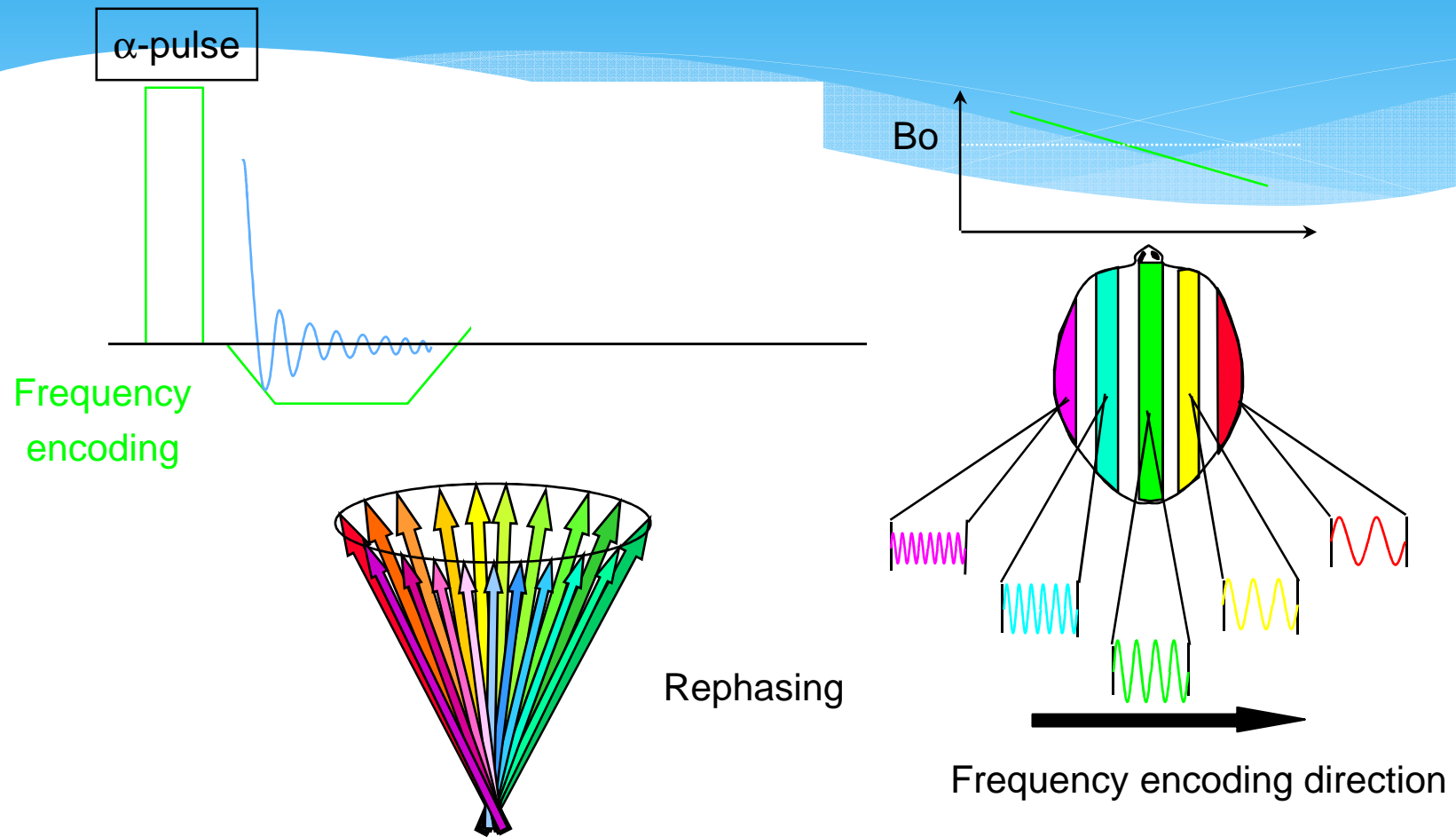
Fast Field Echo (gradient echo)



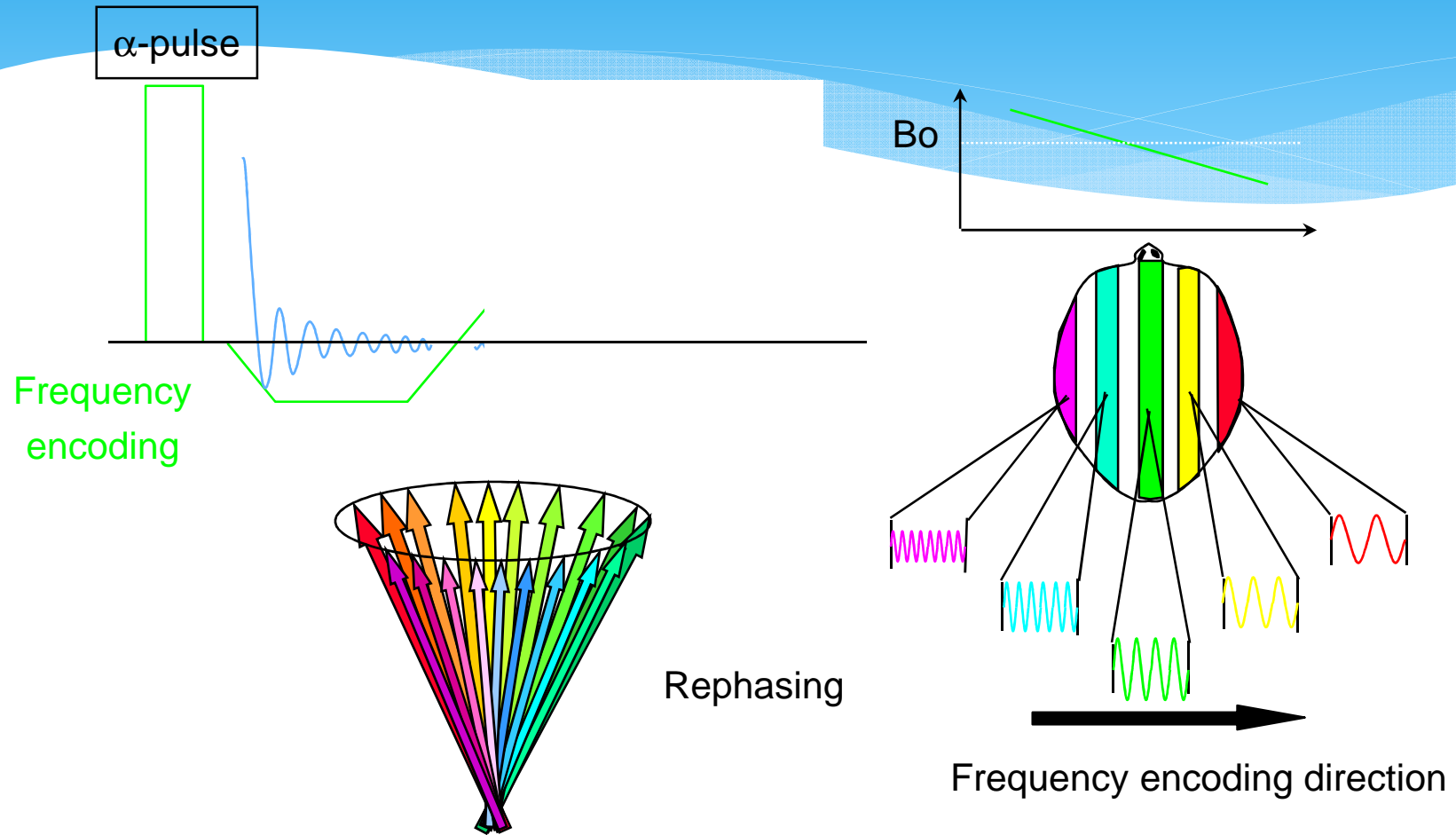
Immagini gradient eco



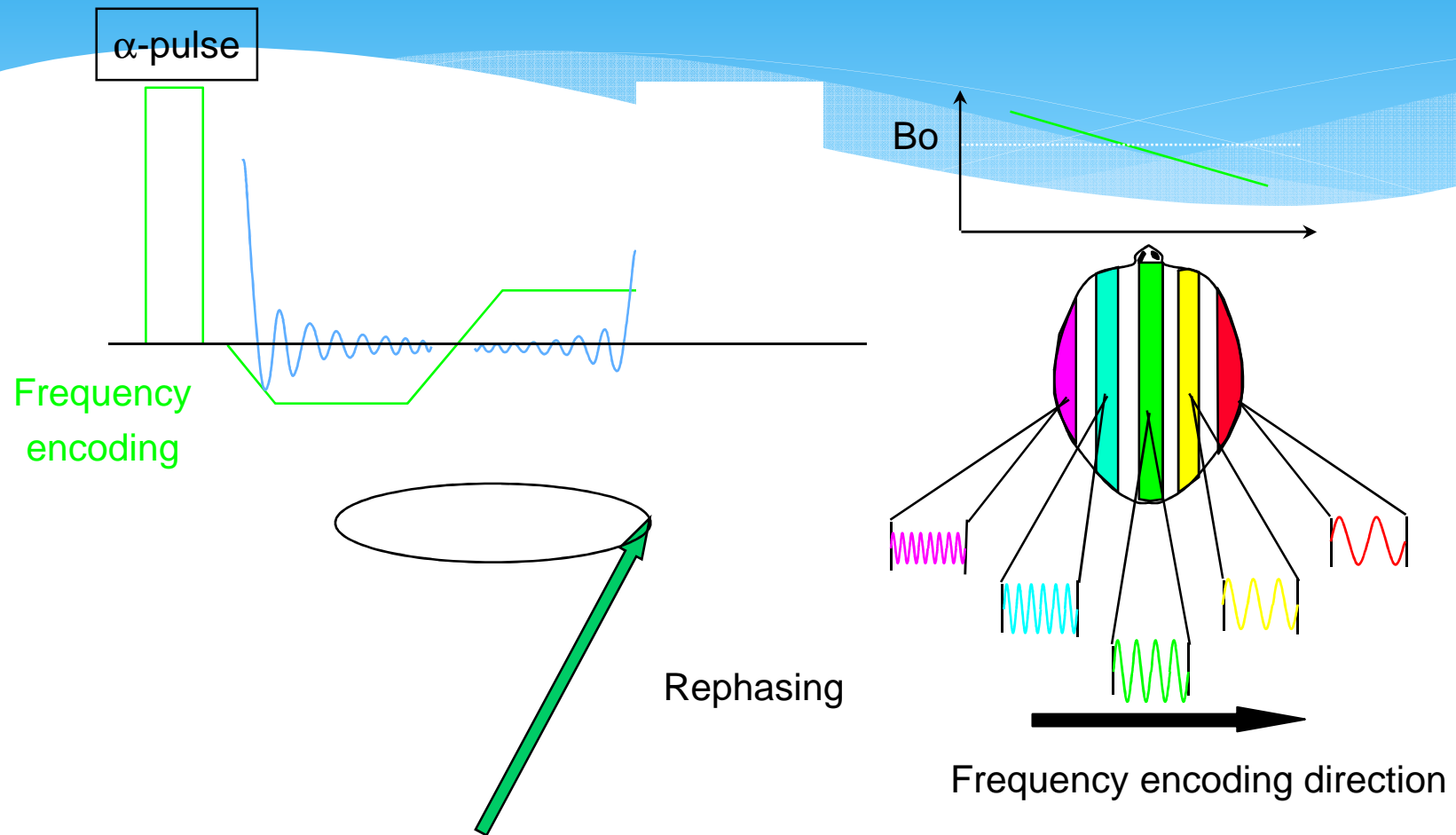
Immagini gradient eco



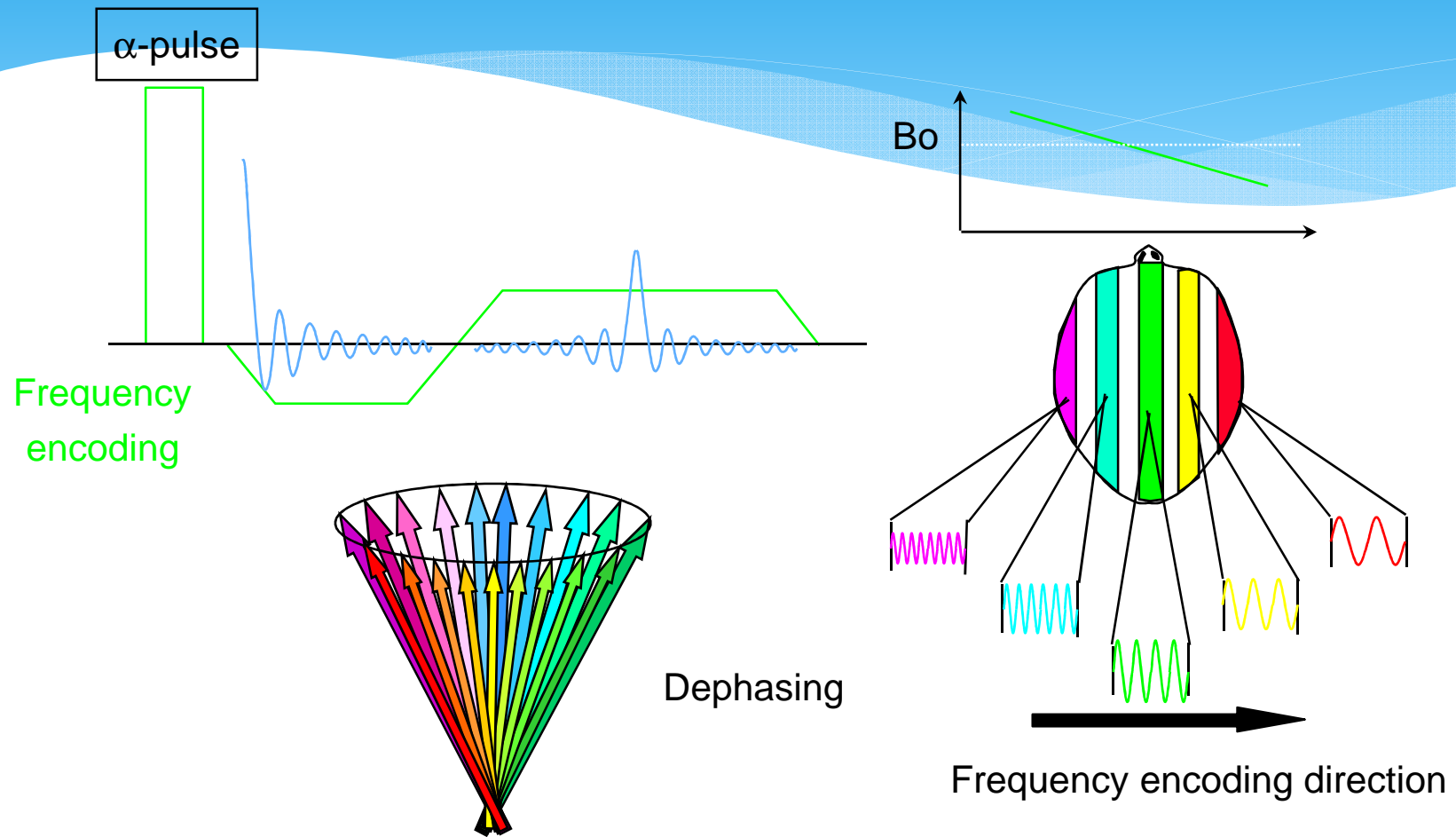
Immagini gradient eco



Immagini gradient eco



Immagini gradient eco



Immagini gradient eco

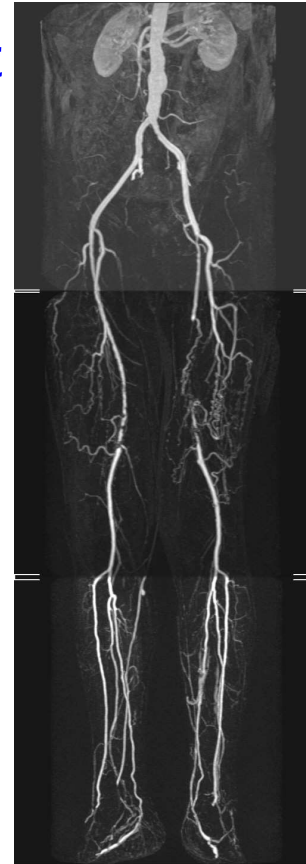
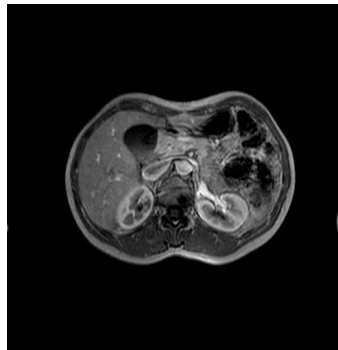
Proprietà

- * tempo di scansione breve
 - per aumentare la collaborazione del paziente
 - per ridurre gli artefatti da movimento
- * bassa esposizione agli impulsi RF
- * T_2^* - T_2 -weighting

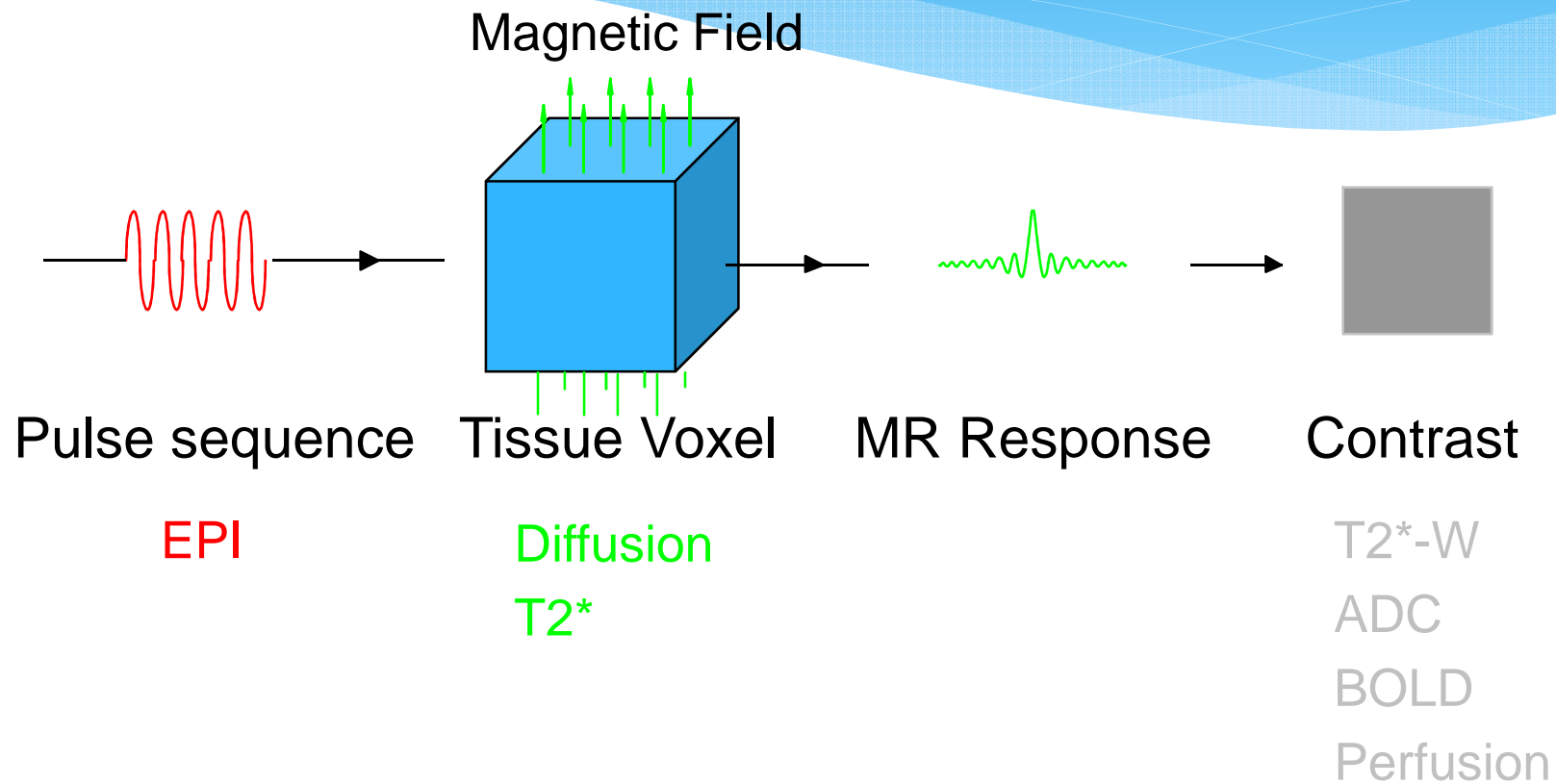
Immagini gradient eco

Tipiche applicazioni delle gradient

- + scansioni volumetriche
- + studi dinamici
- + scansioni in apnea
- + MRA



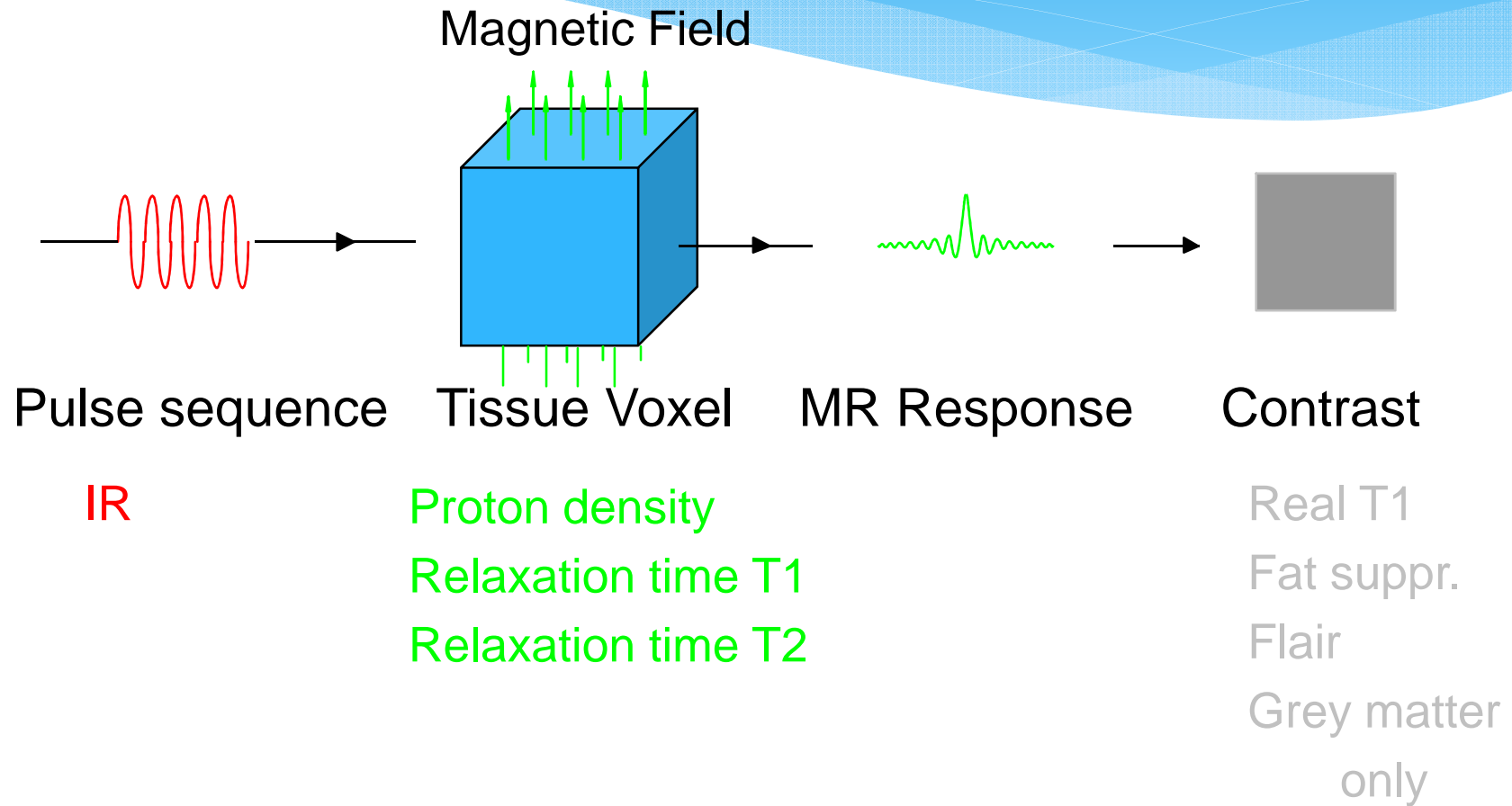
Contrasto nelle immagini Eco Planari



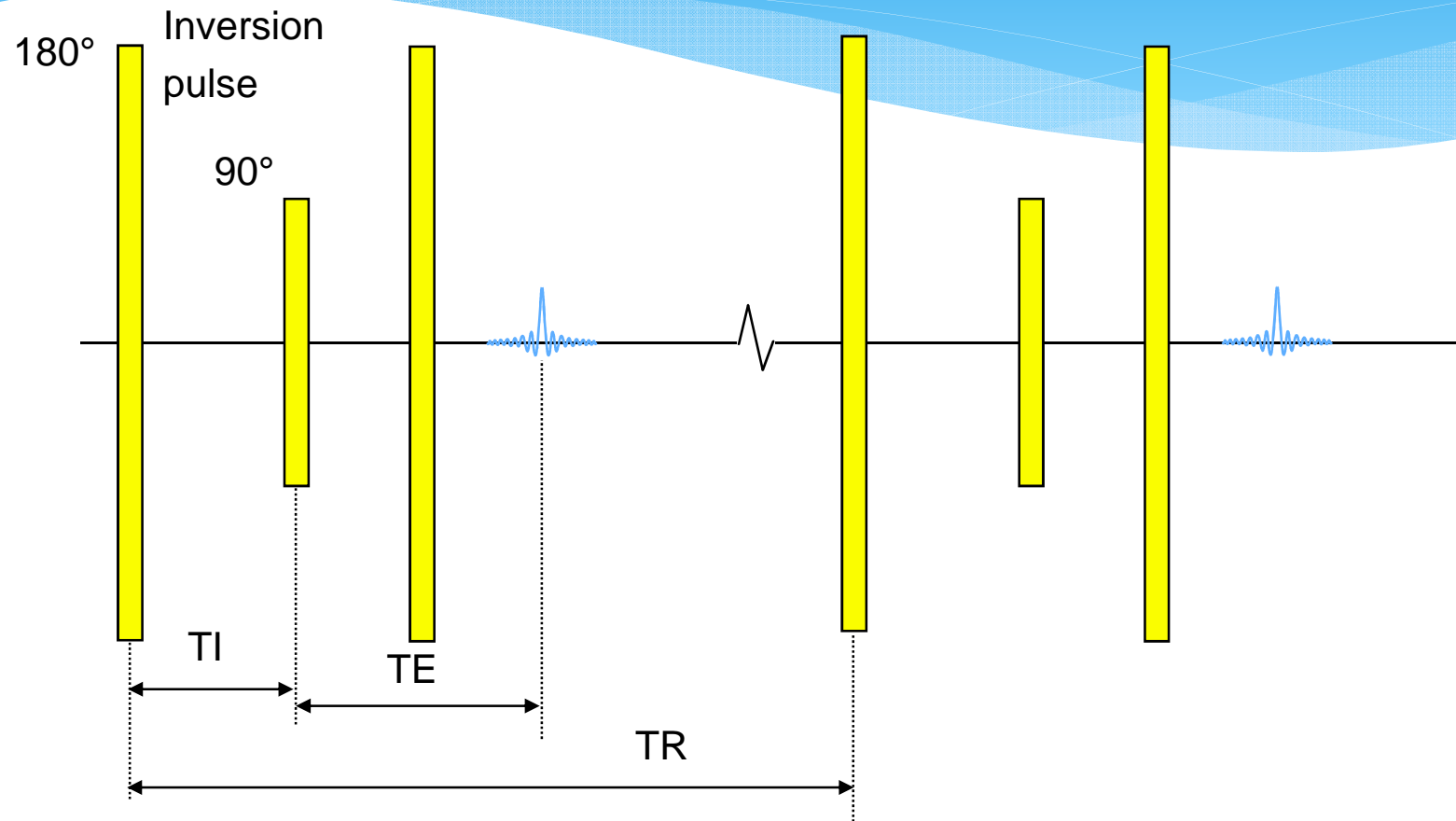
ECHO PLANAR IMAGING (EPI)

- + Ampio rapporto segnale/rumore con tempi di acquisizione brevi
- + Tempo di acquisizione 30 -130 ms/ per 1 codifica
- + Sequenze con potenzialità “real time”
- Artefatti (susceptibilità, blurring)
- Alte performance hardware sistema (omogeneità, intensità del gradienti di campo magnetico)

Contrasto nelle IR



Inversion Recovery (SE con pre-impulso)



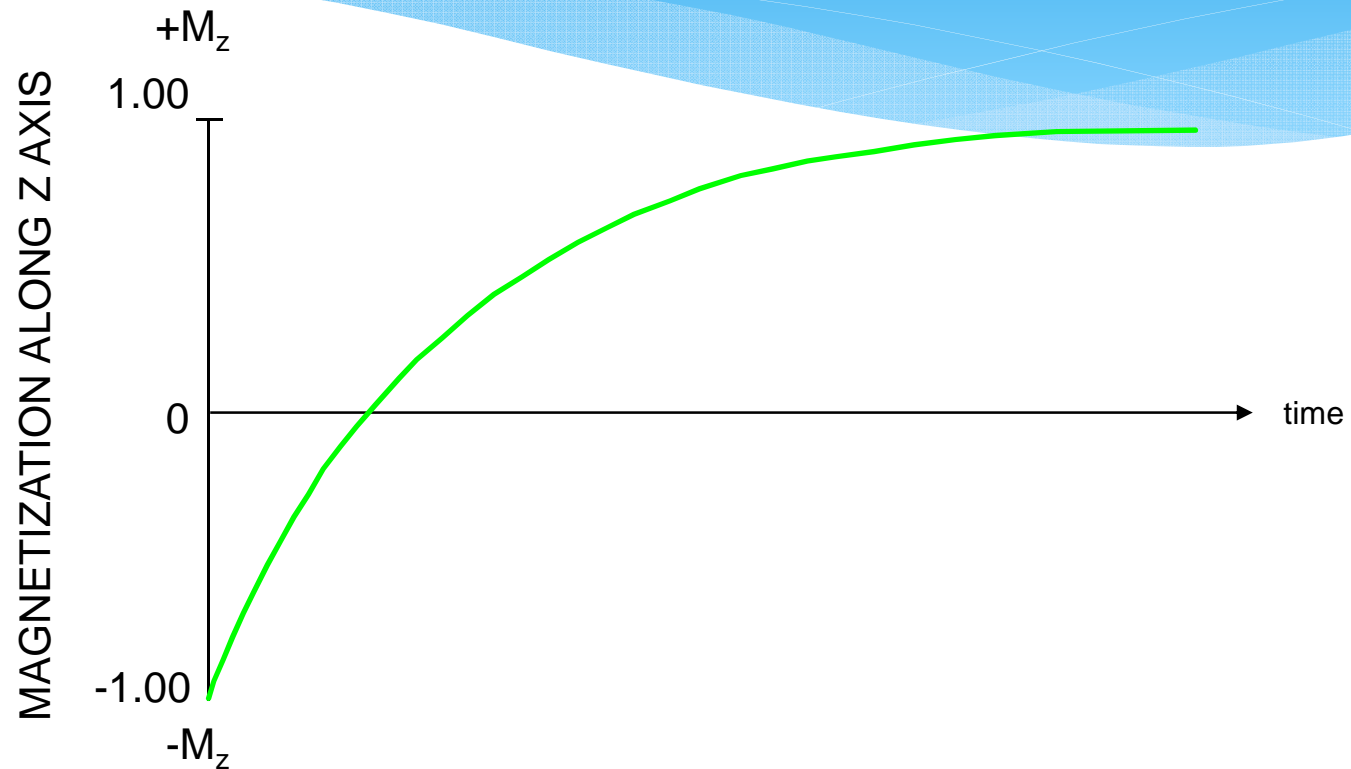
Inversion recovery

Rilassamento T_1 dopo impulso a 180°



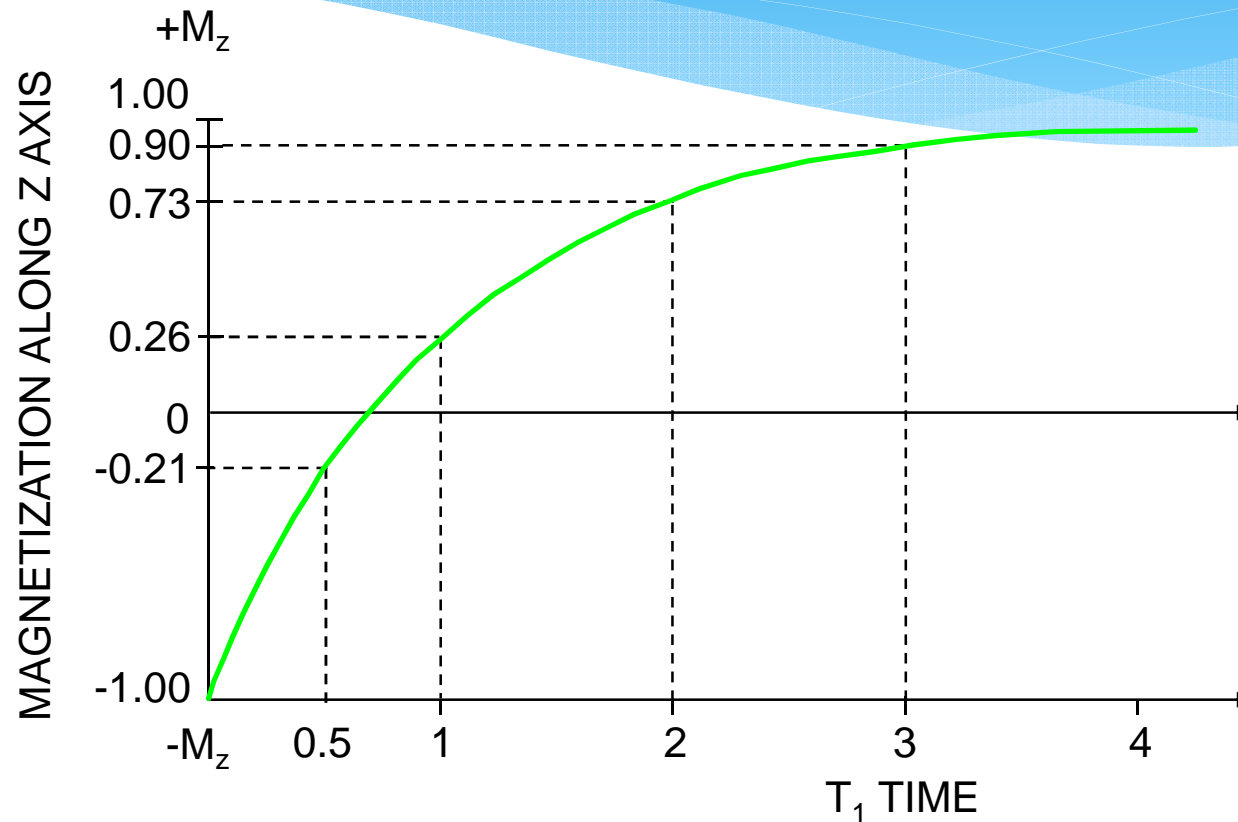
Inversion recovery

Rilassamento T_1 dopo impulso a 180°



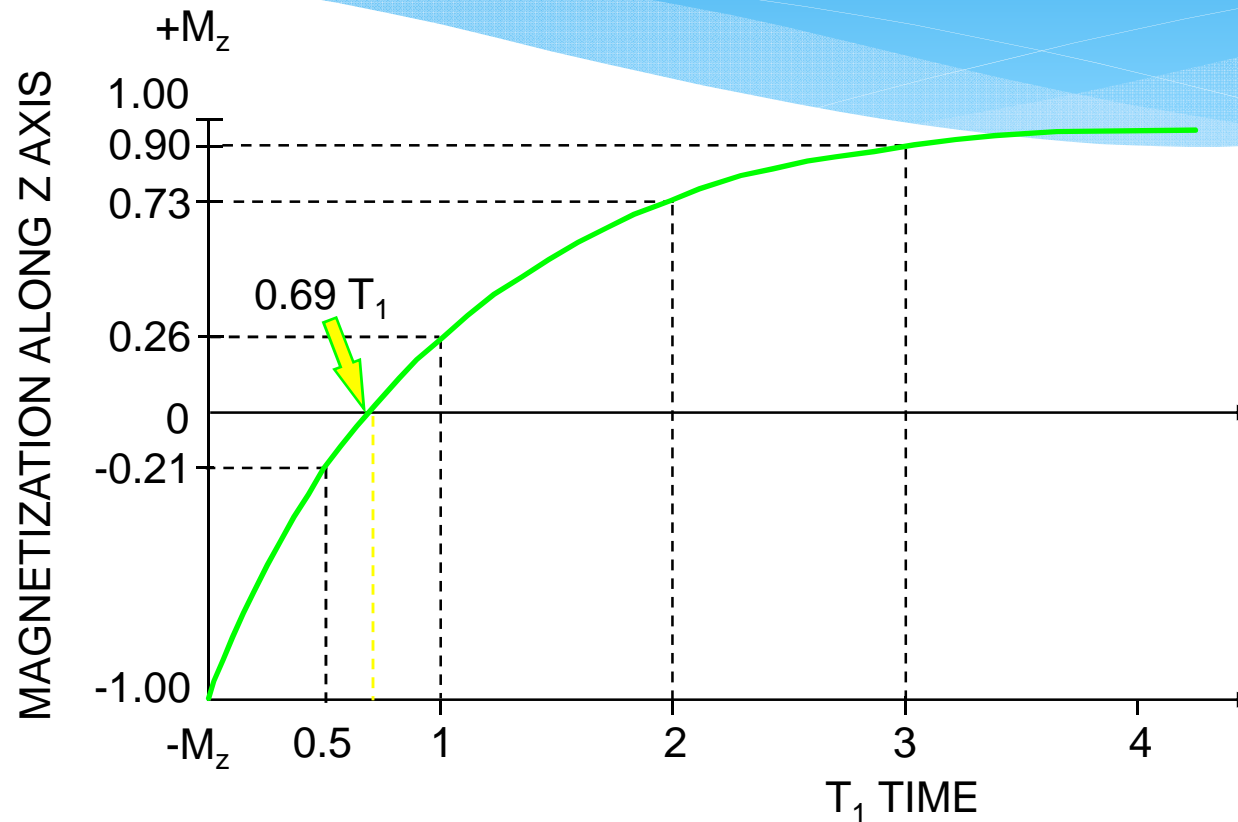
Inversion recovery

Rilassamento T_1 dopo impulso a 180°

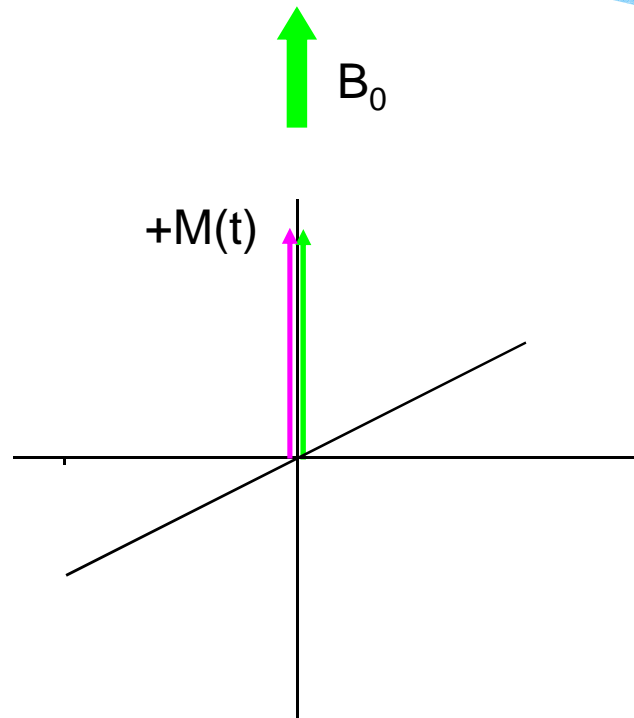


Inversion recovery

Rilassamento T_1 dopo impulso a 180°

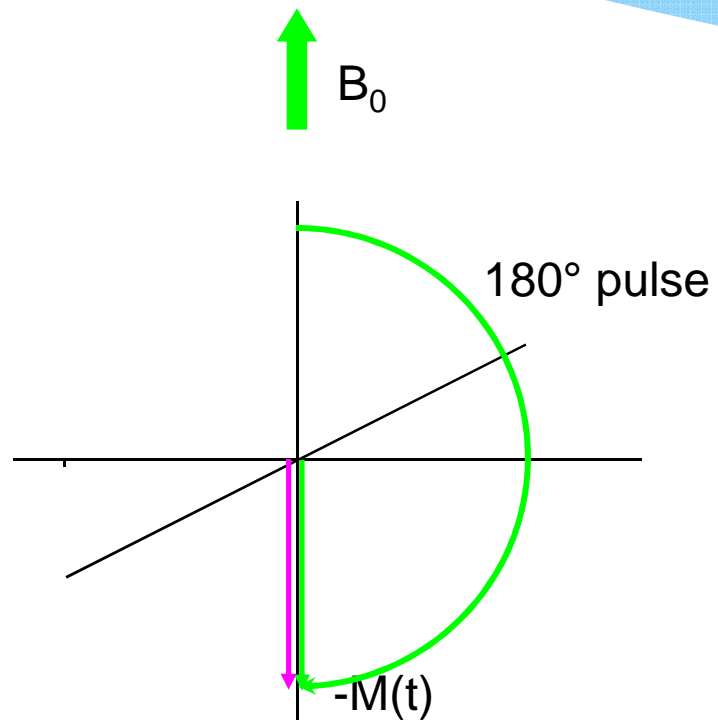


Inversion Recovery Phase sensitive detection



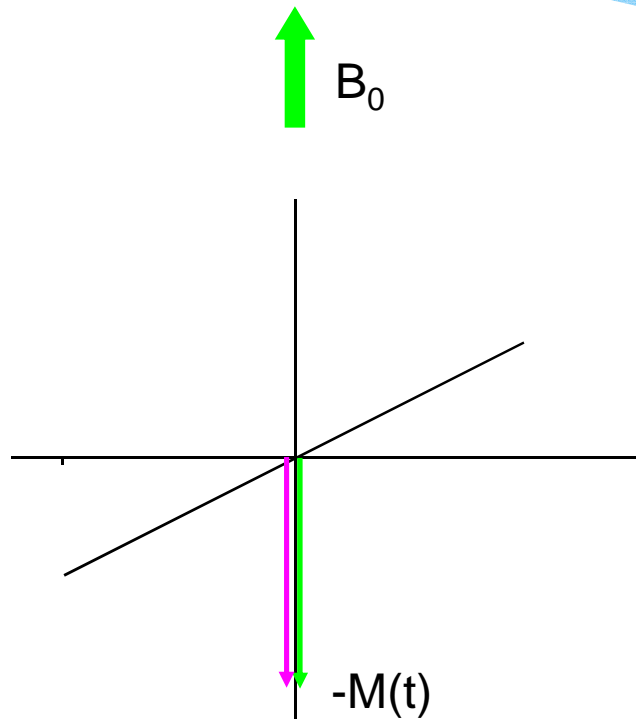
Inversion Recovery

Phase sensitive detection

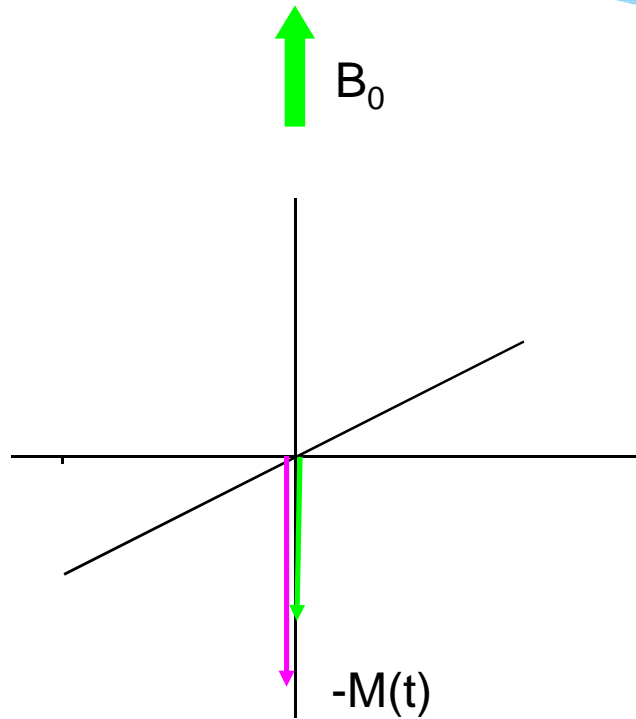


Inversion Recovery

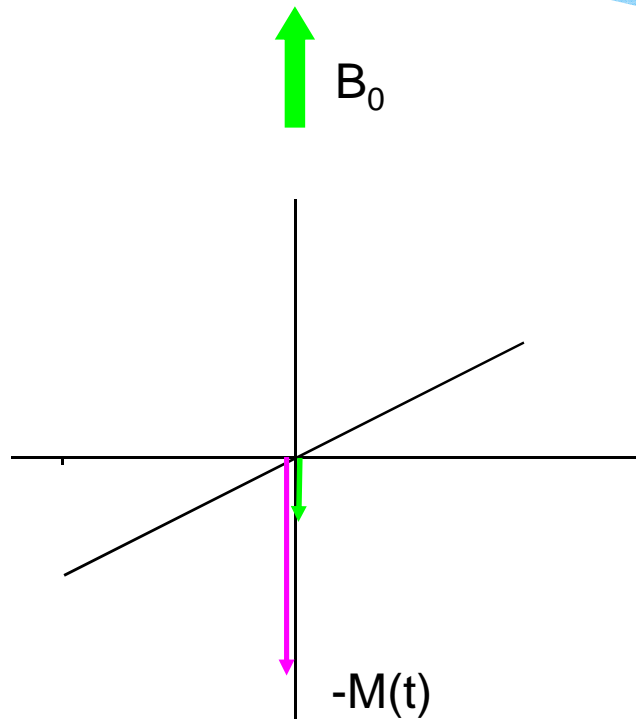
Phase sensitive detection



Inversion Recovery Phase sensitive detection

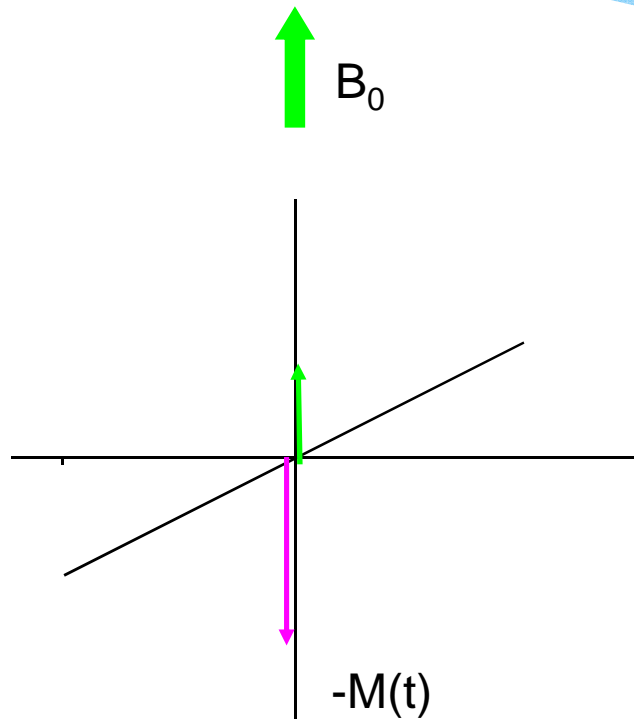


Inversion Recovery Phase sensitive detection



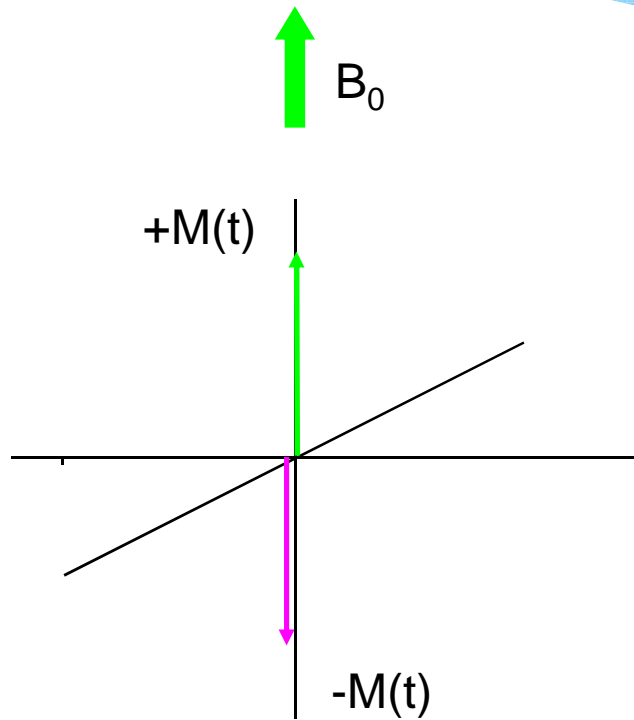
Inversion Recovery

Phase sensitive detection

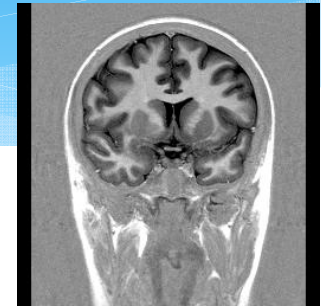
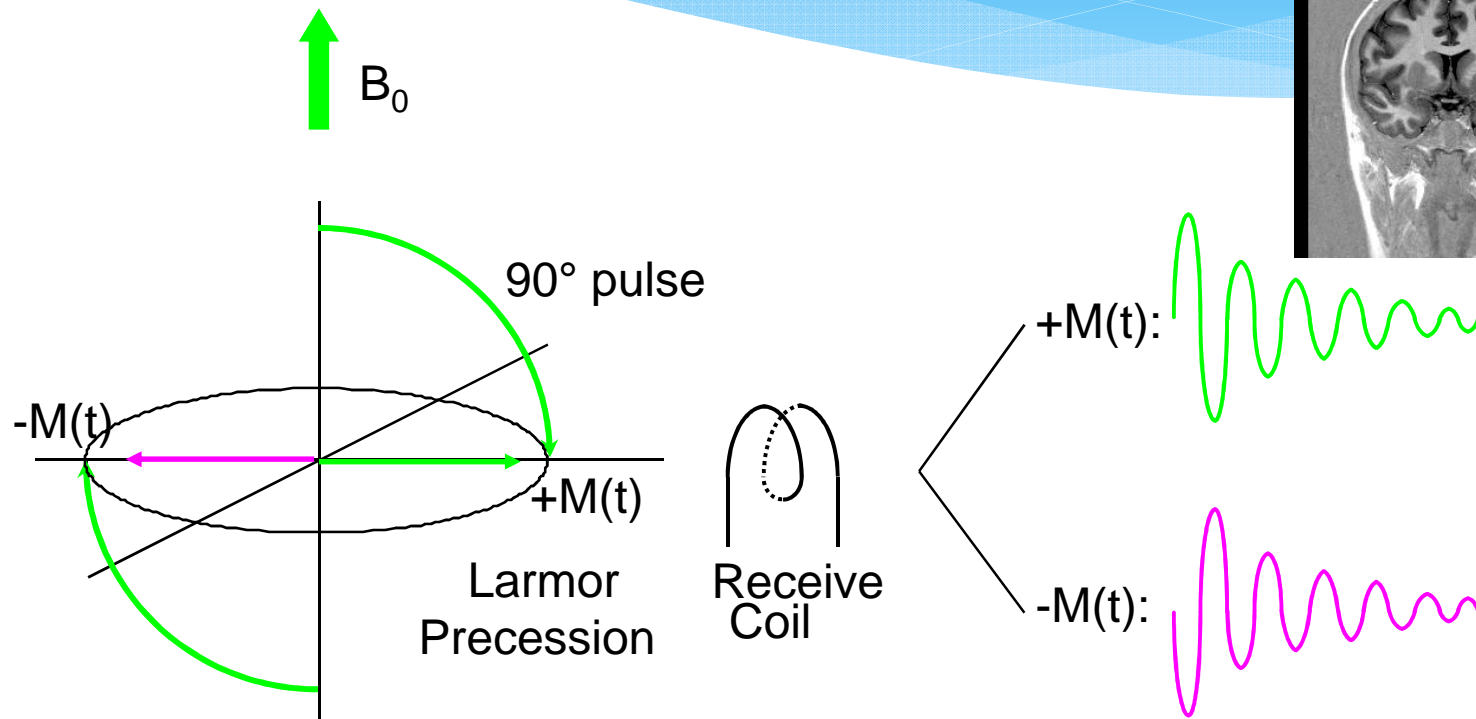


Inversion Recovery

Phase sensitive detection



Inversion Recovery Phase sensitive detection

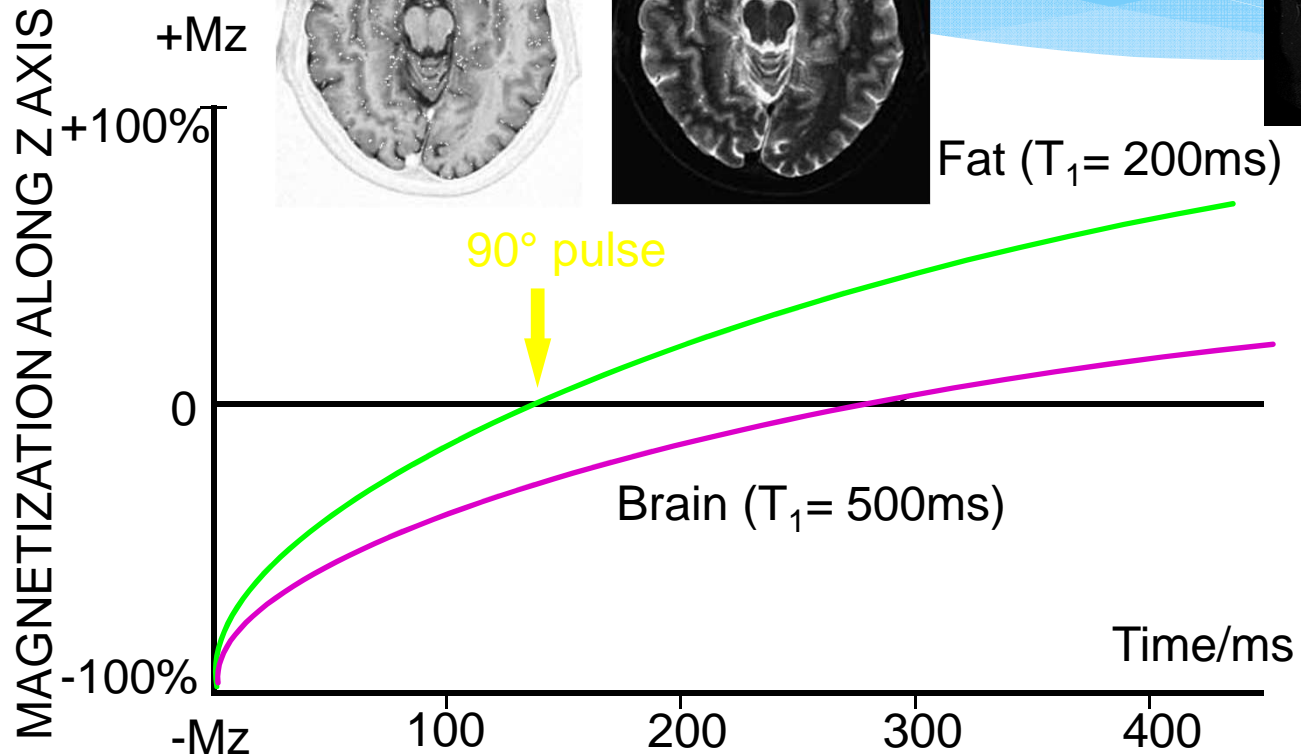
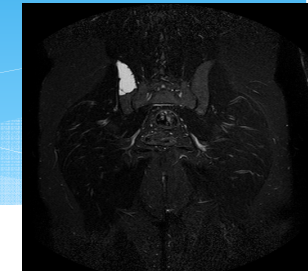
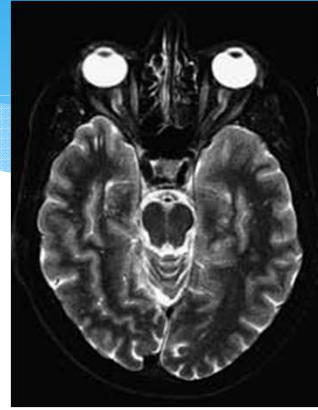


Fat Suppression: STIR

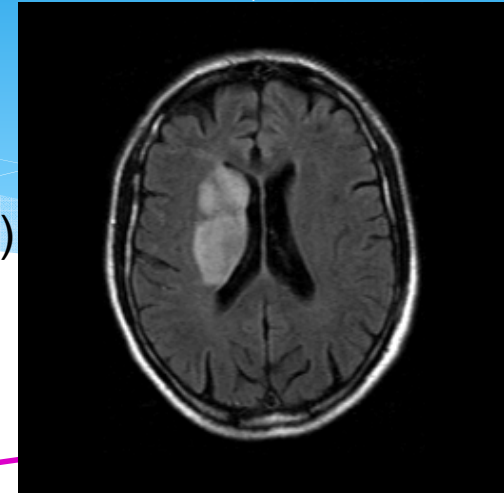
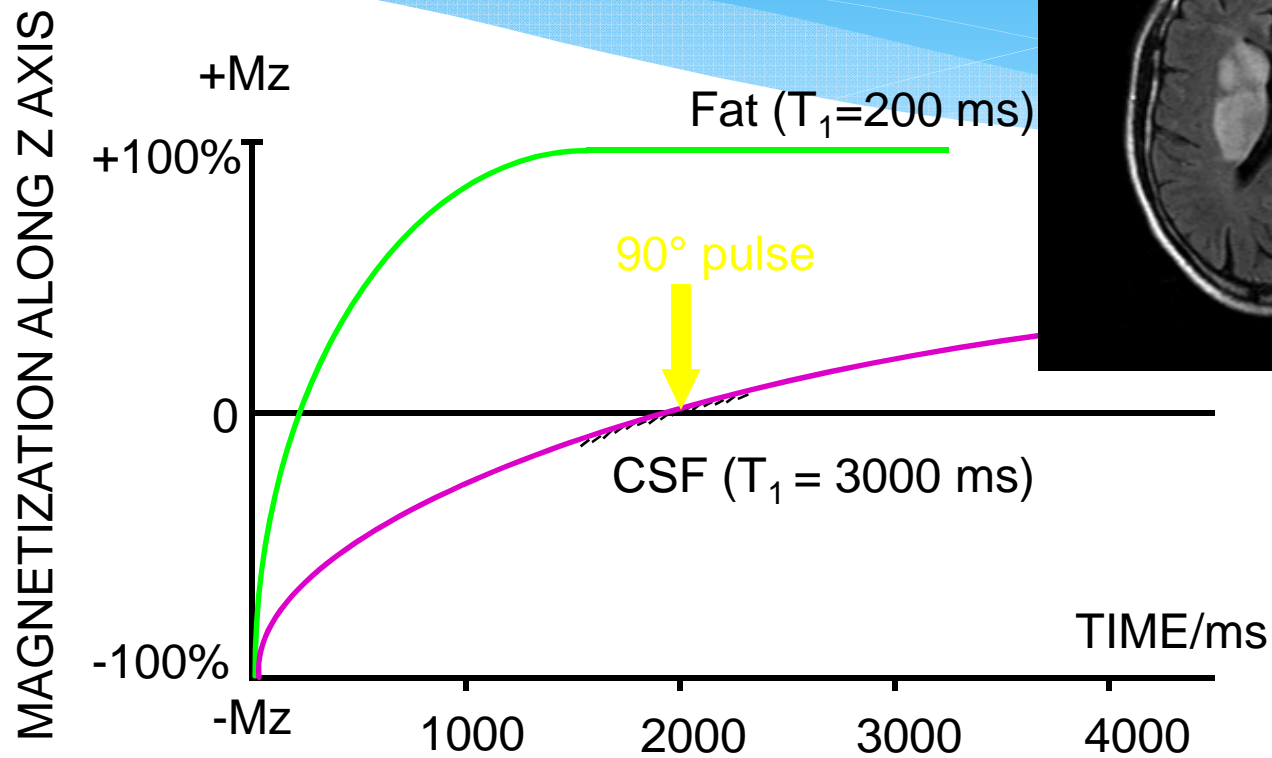
real



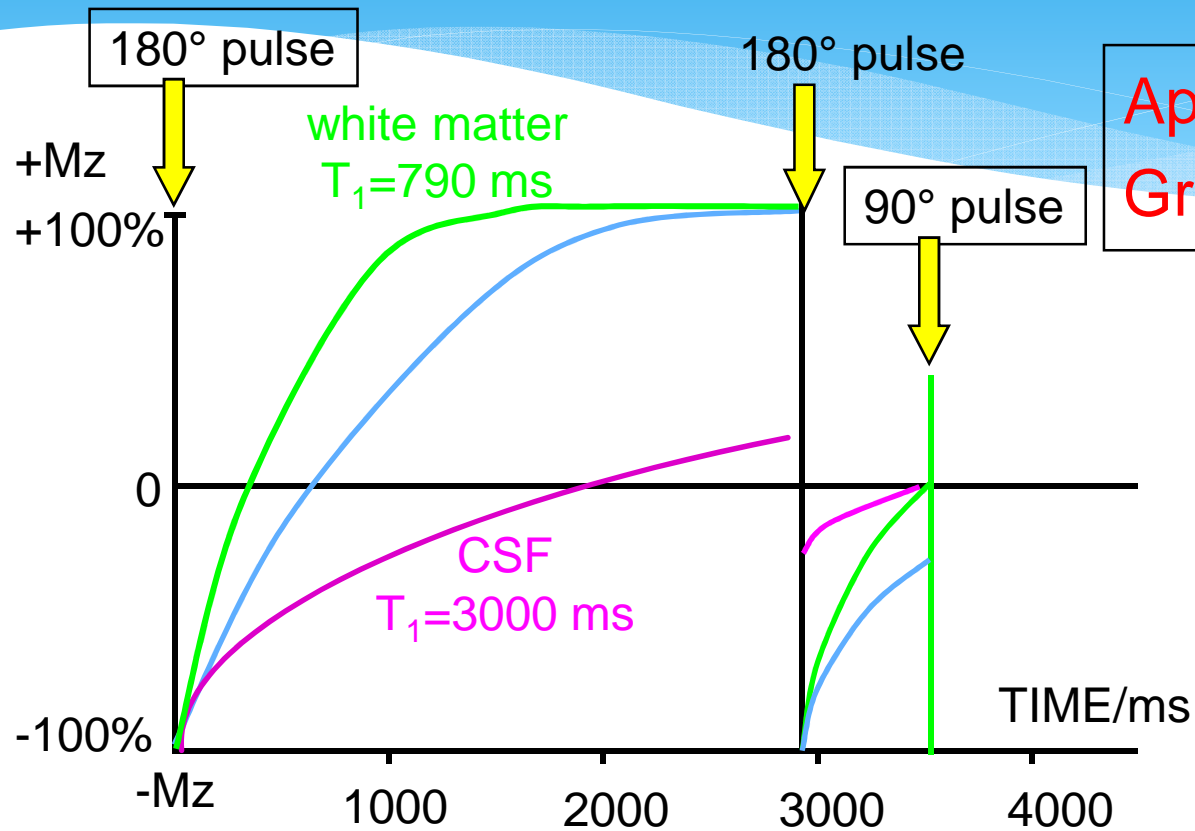
modulus



Fluid Attenuation IR (FLAIR)

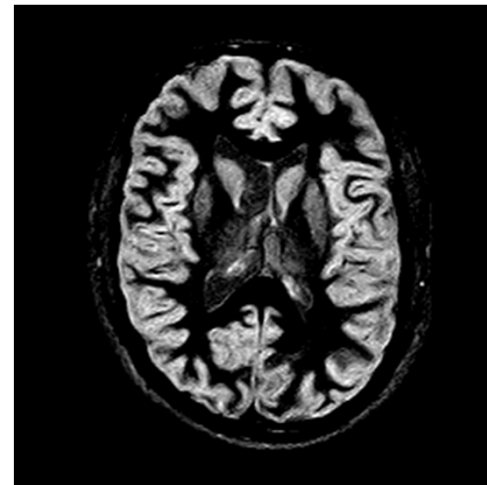
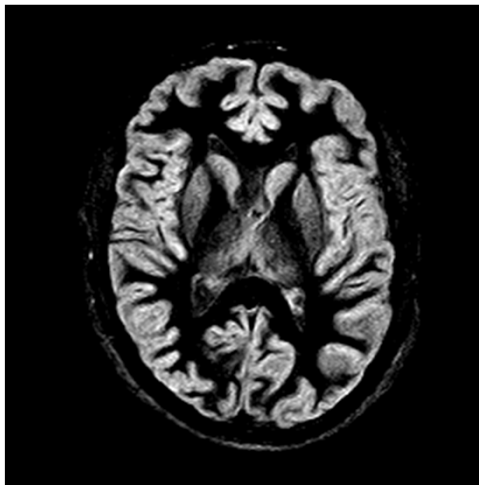
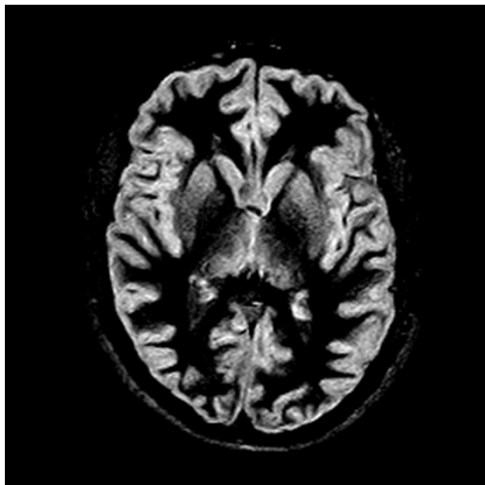
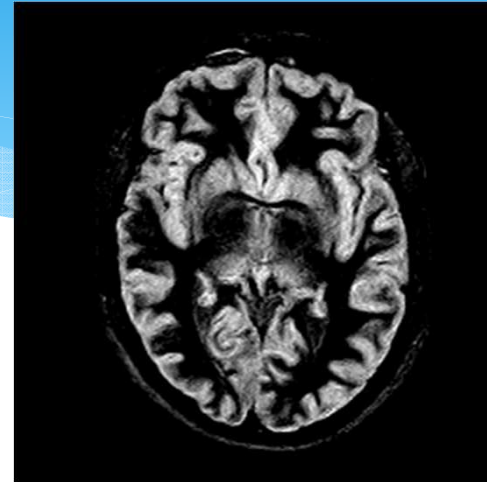
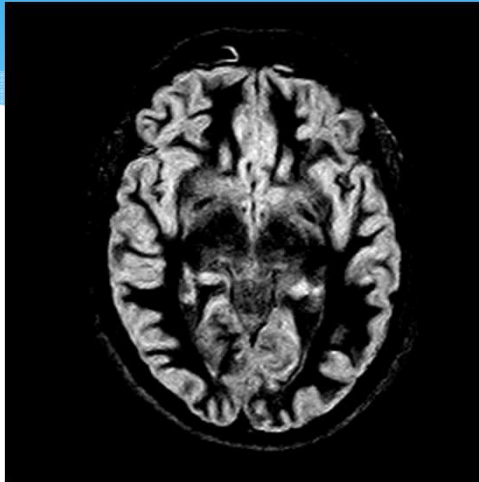
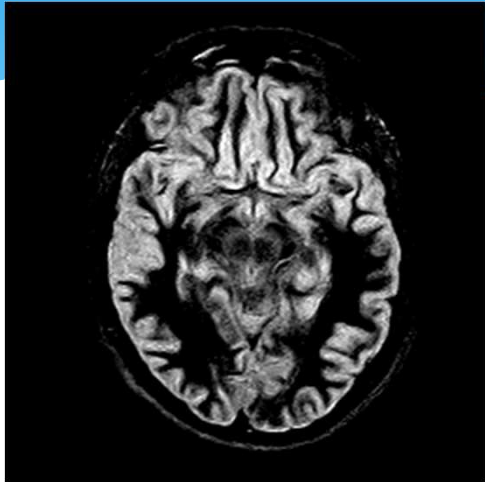


Dual Inversion Recovery

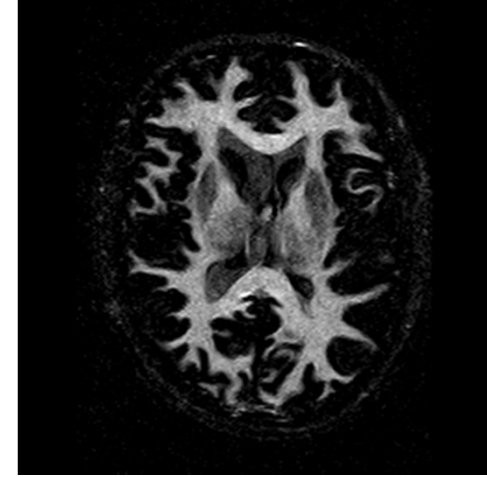
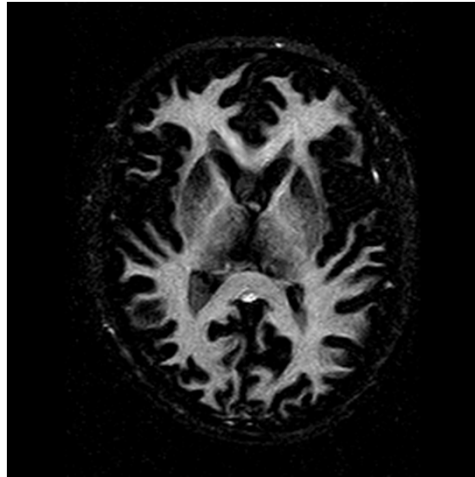
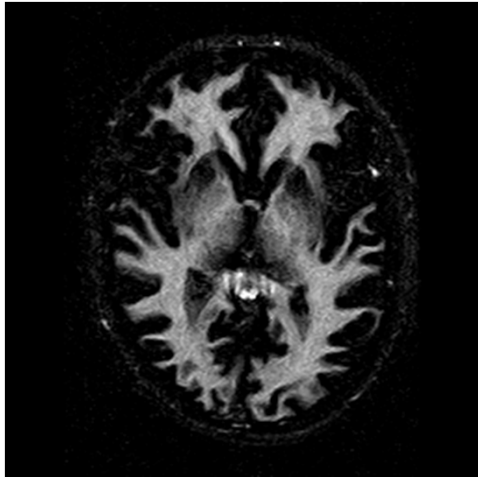
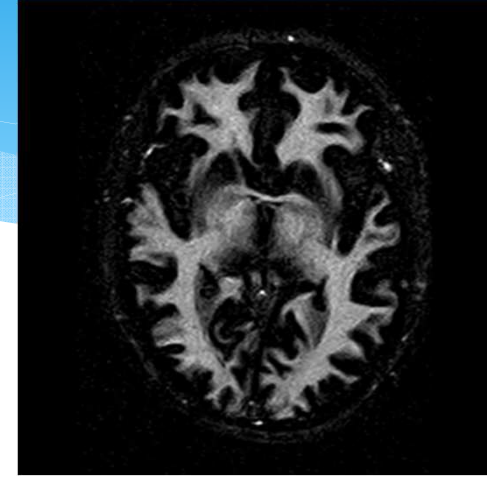
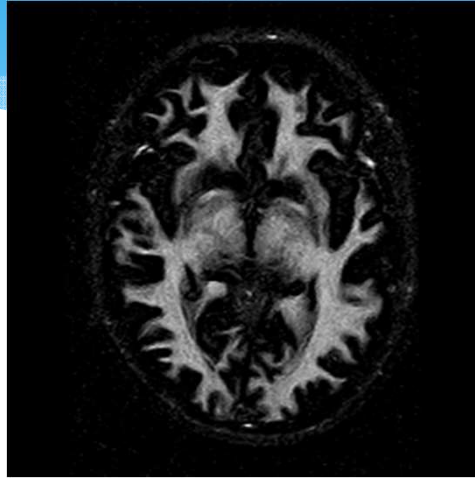
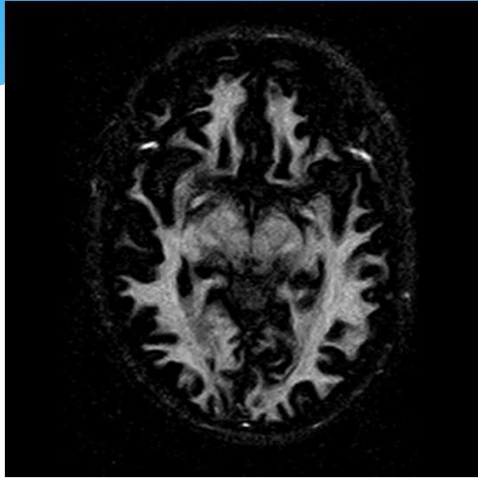


Application:
Grey matter only

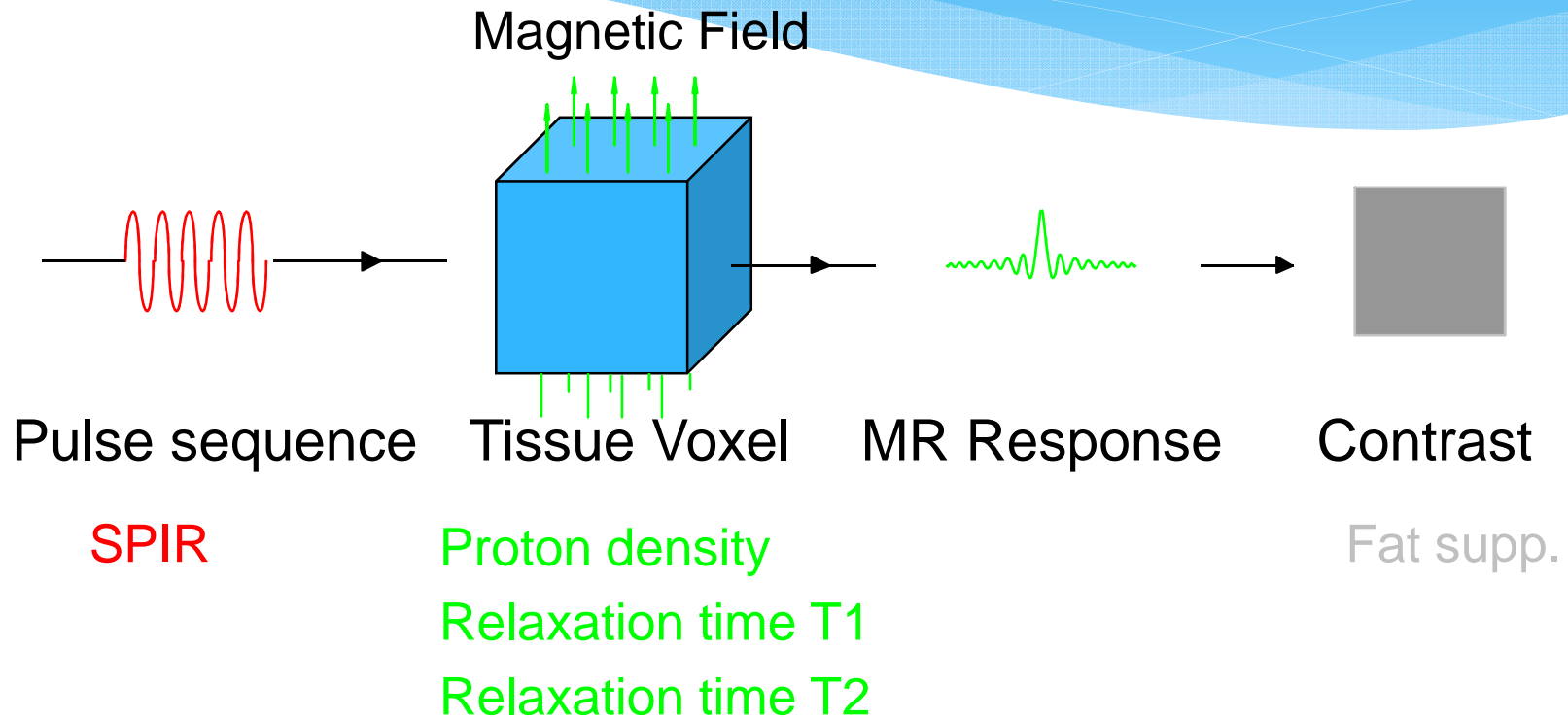
Solo sostanza grigia



Solo sostanza bianca



Spectral Presaturation IR (SPIR)



Fat Suppression (SPIR)

Frequency selective
Fat saturating
pulse

