INTRODUCTION TO SOME ADVANCED MRI CONTRAST

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CIBM MRI EPFL

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PHYS-473

MRI Practicals on CIBM preclinical imaging systems

MAGNETIC RESONANCE IMAGING

https://nationalmaglab.org

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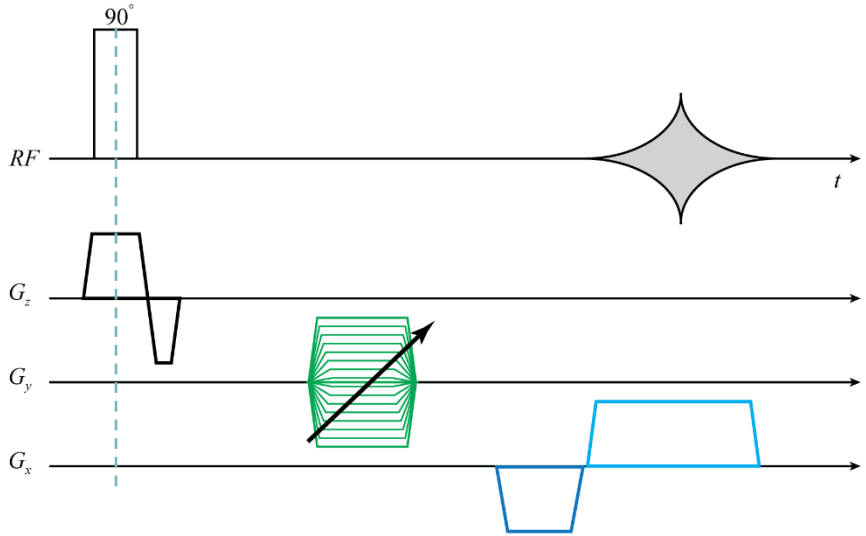
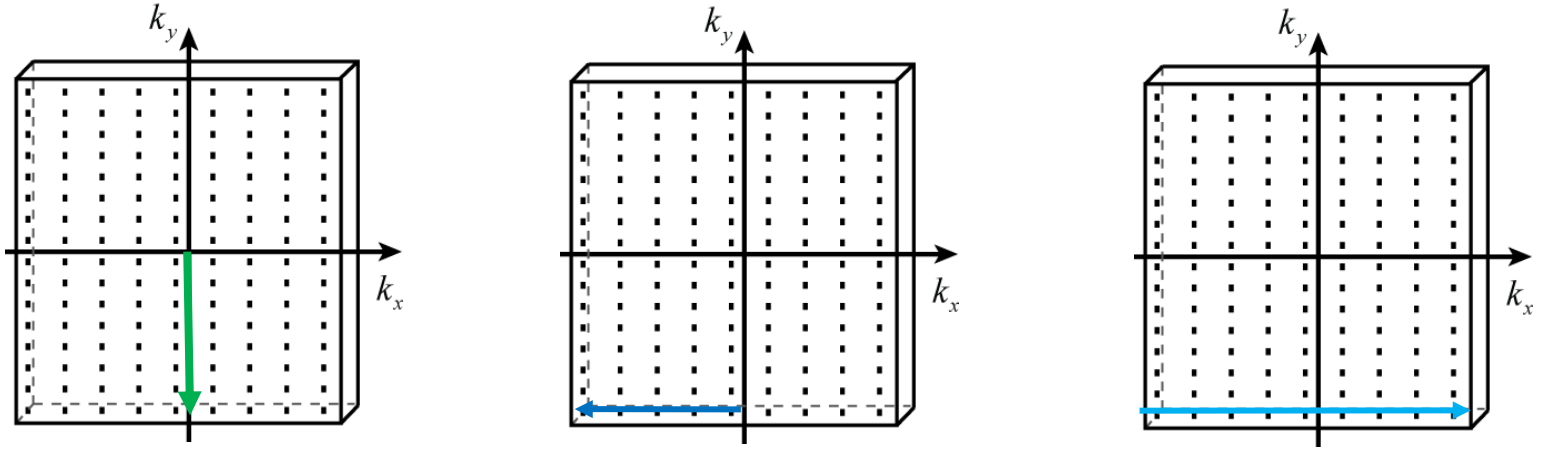
GRADIENT ECHO





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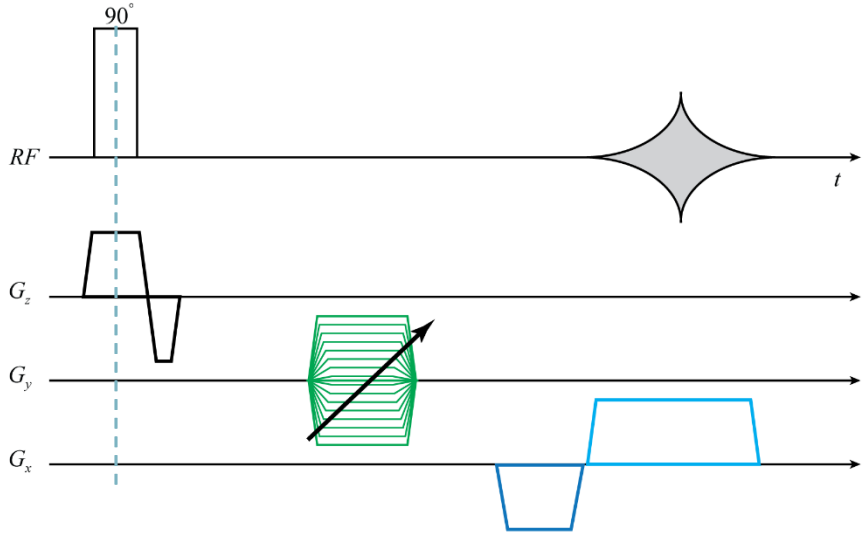

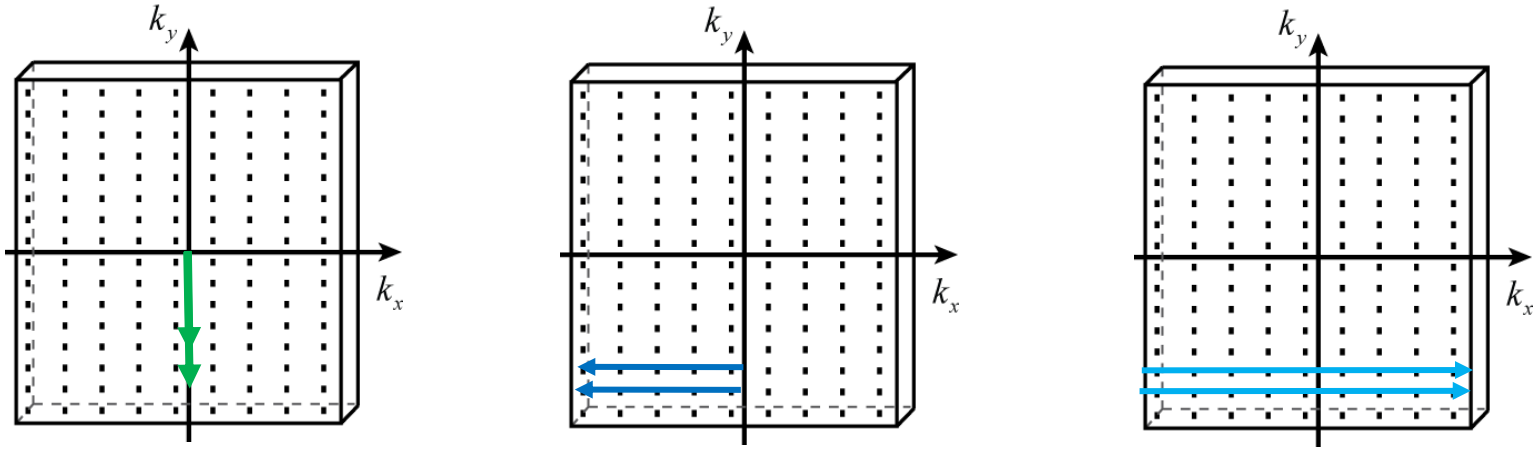

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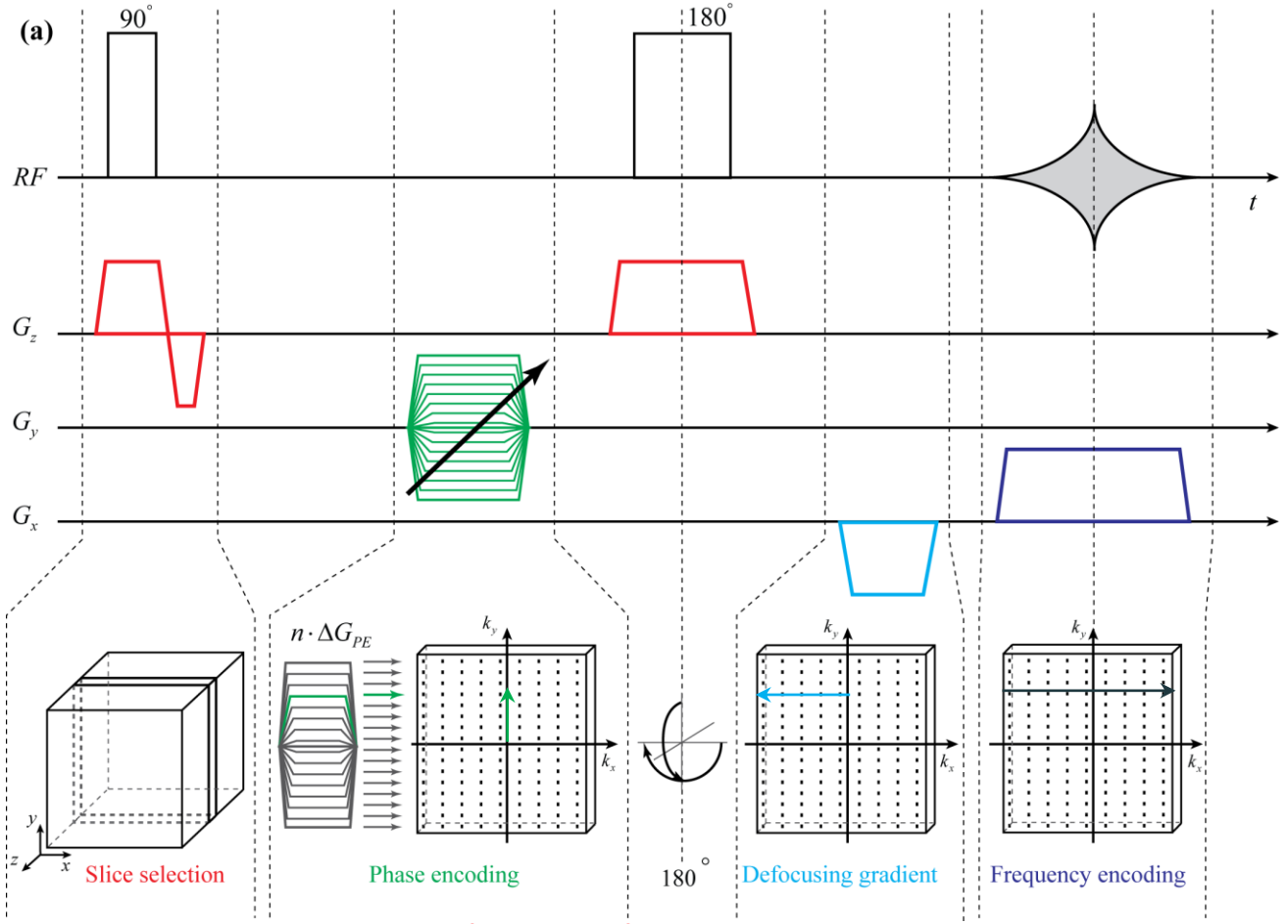
SPIN-ECHO



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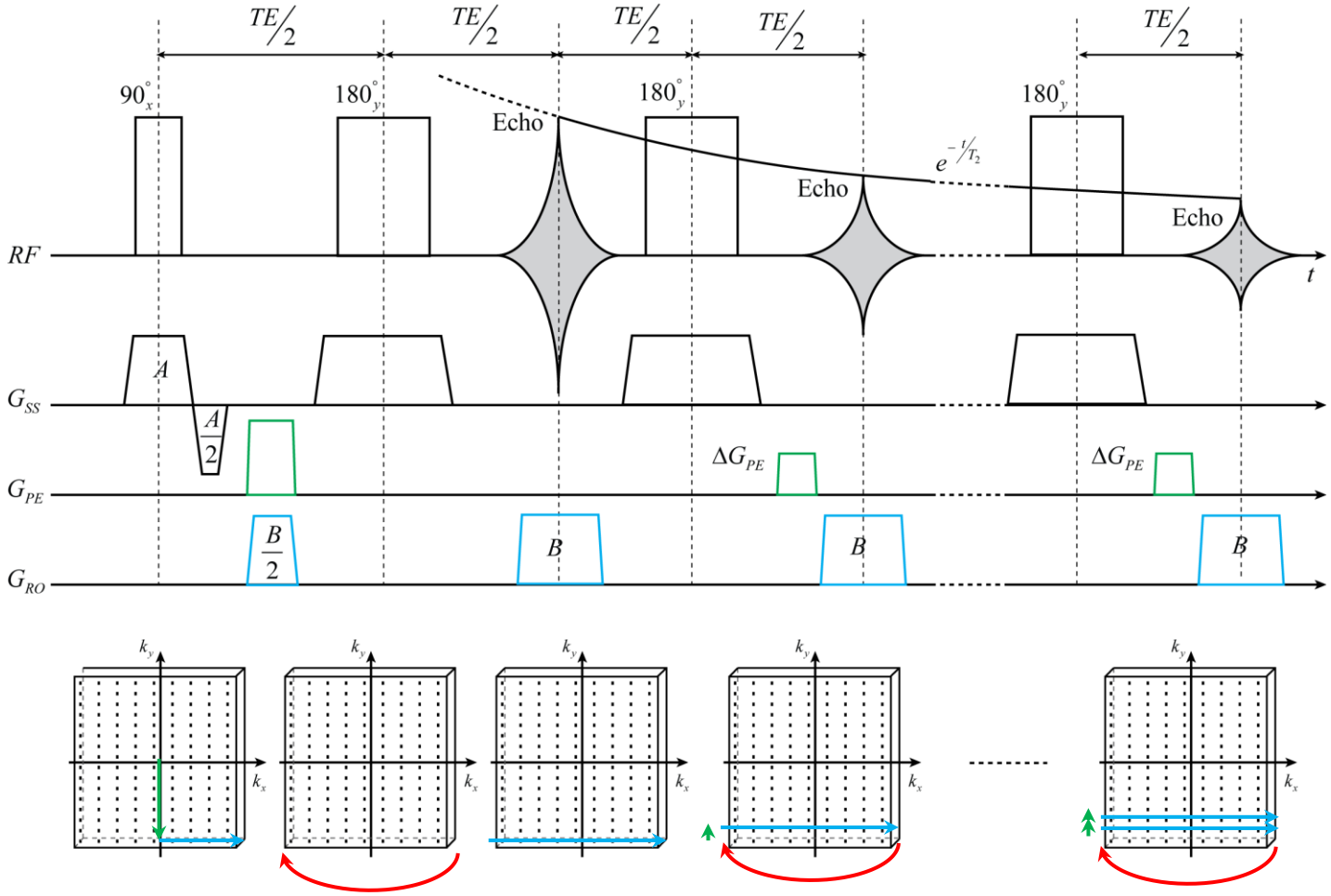
FAST SPIN ECHO – MULTIPLE ECHOES



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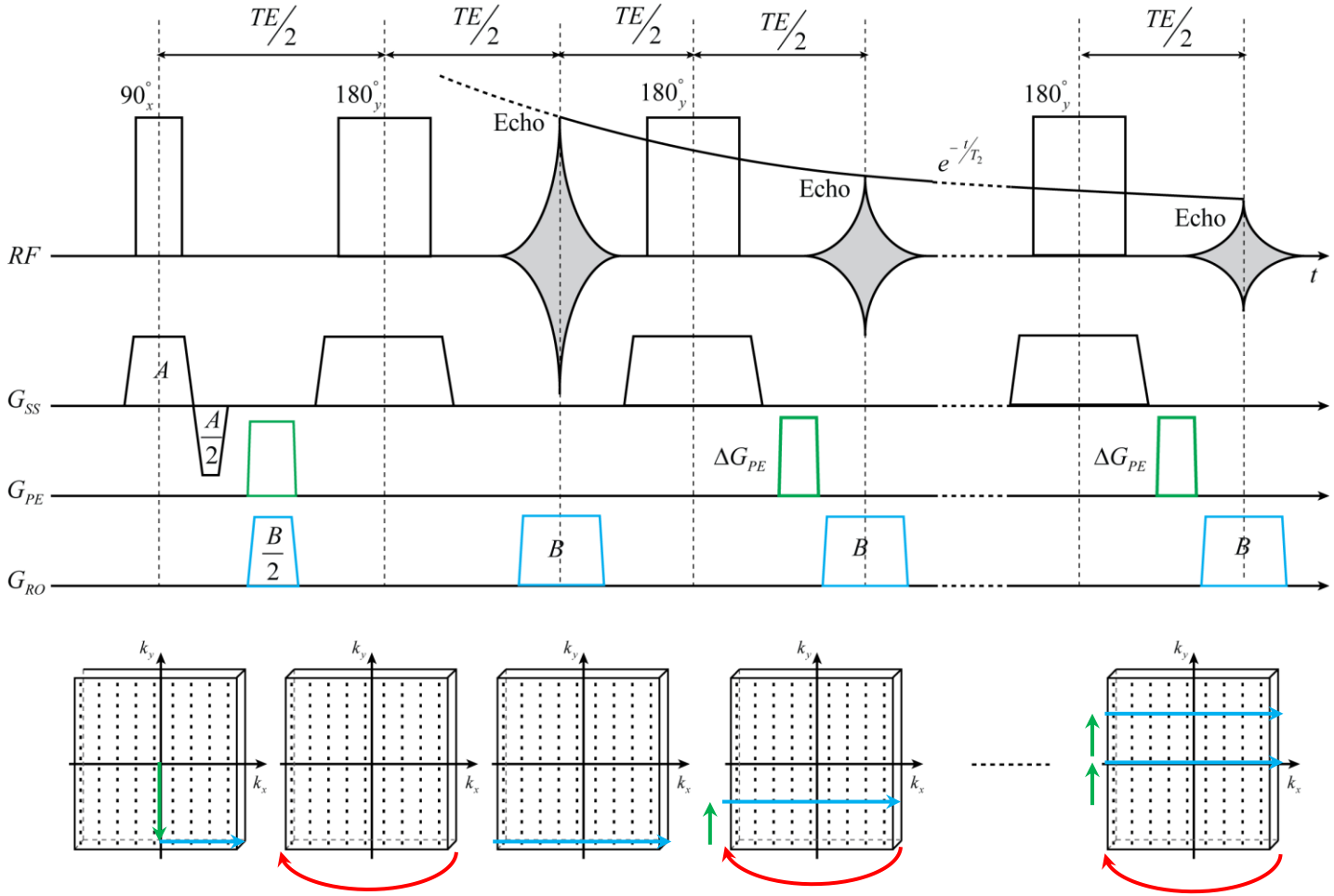
FAST SPIN ECHO – SEGMENTED (RARE)



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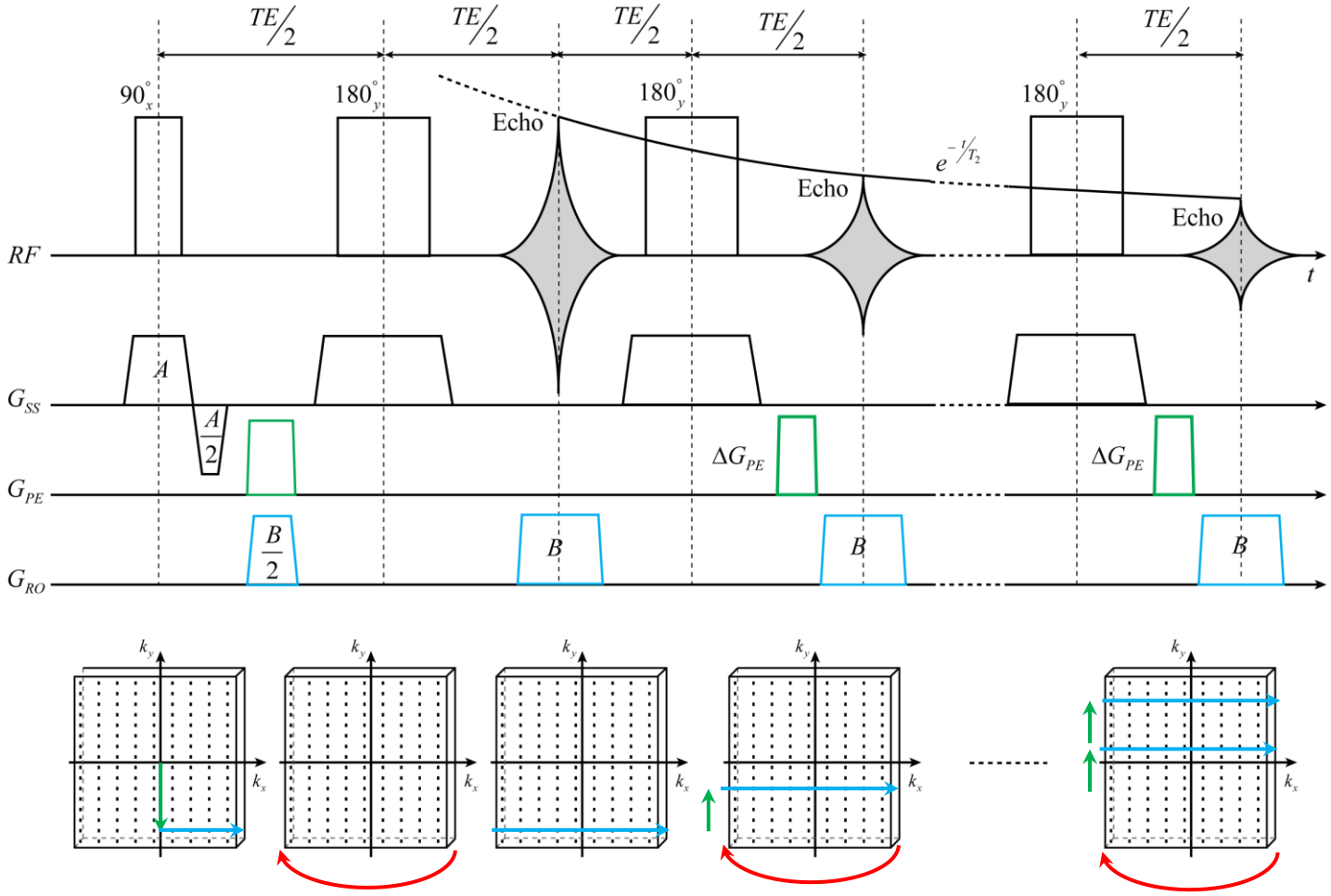

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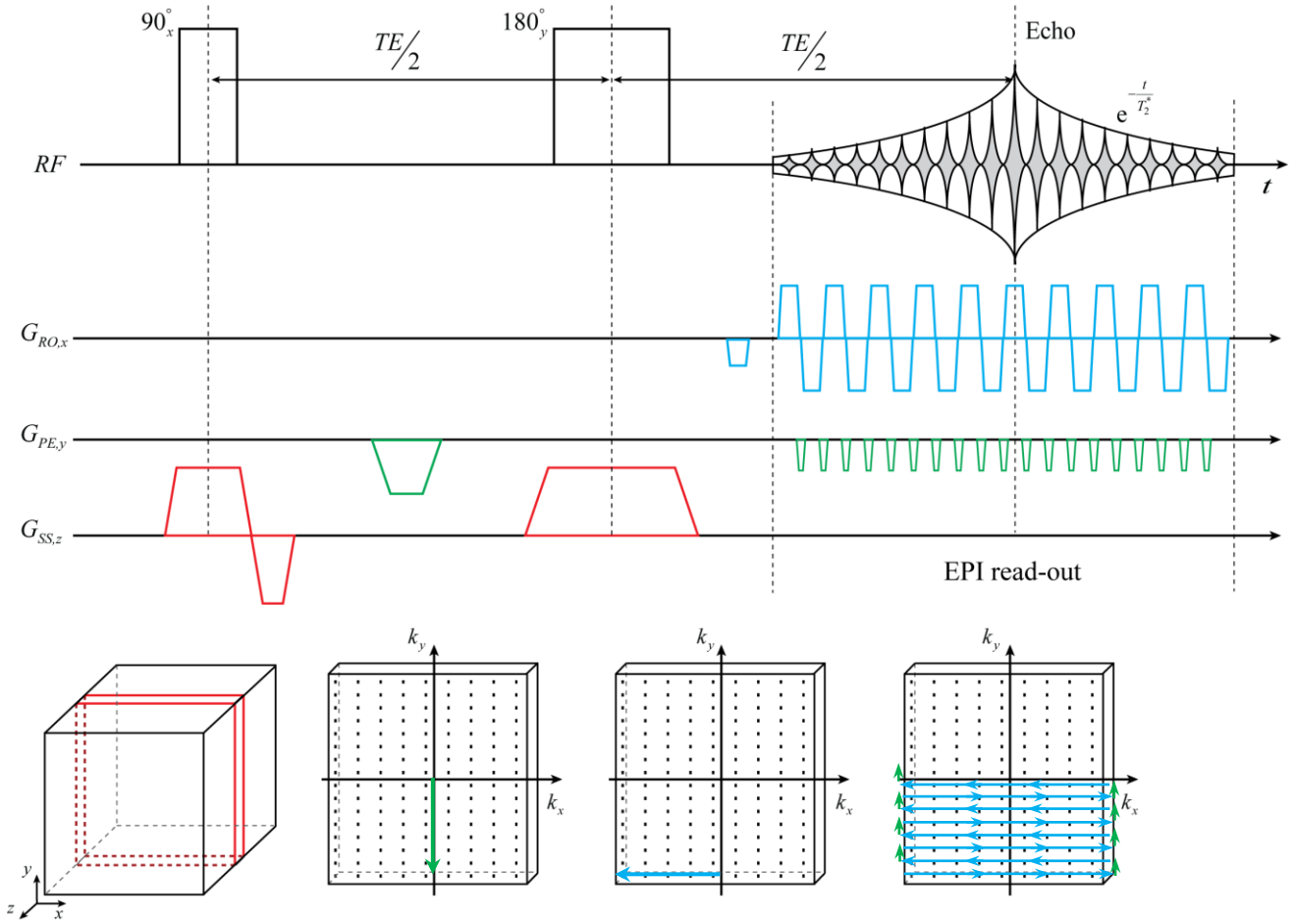
ECHO PLANAR IMAGING



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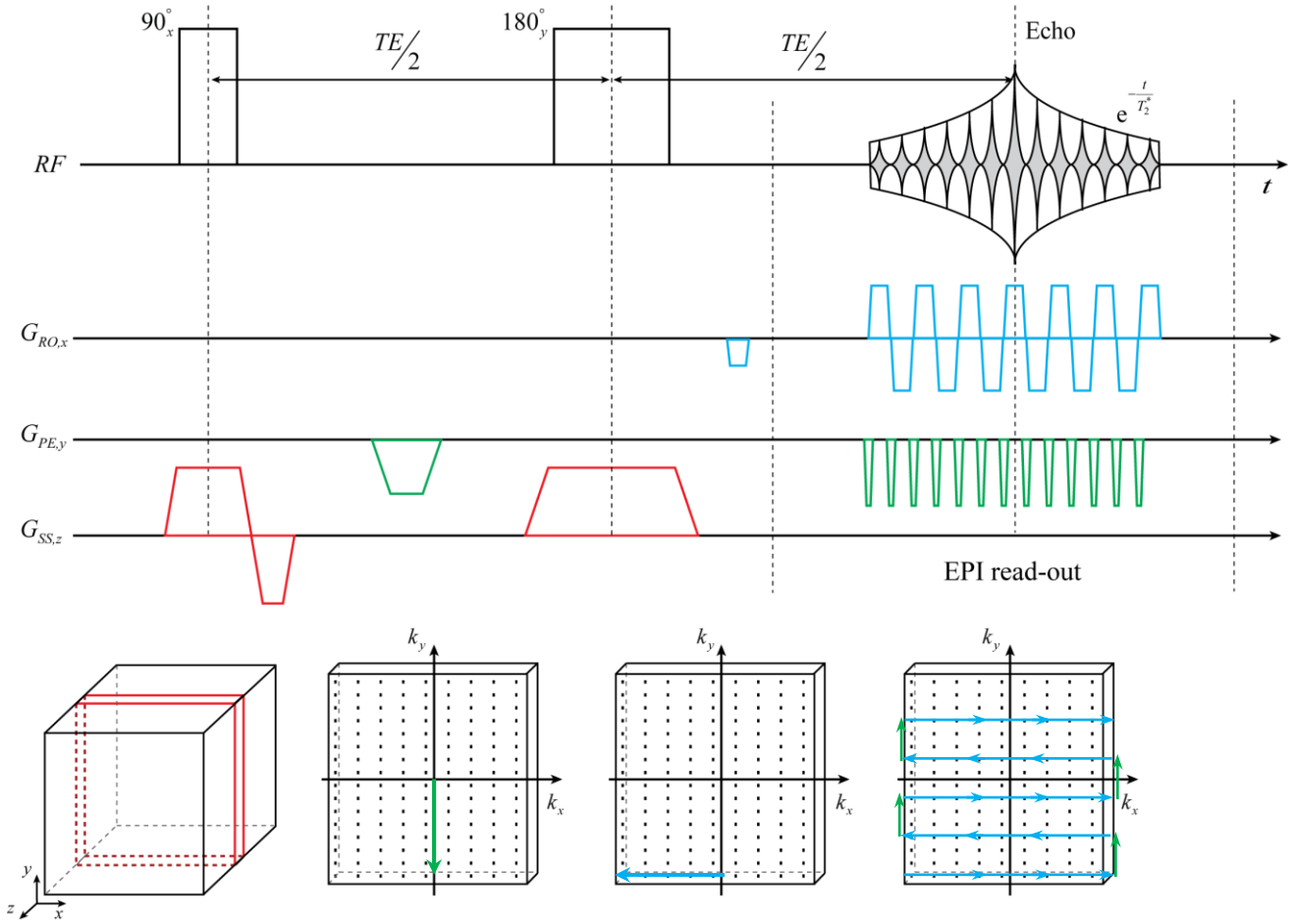

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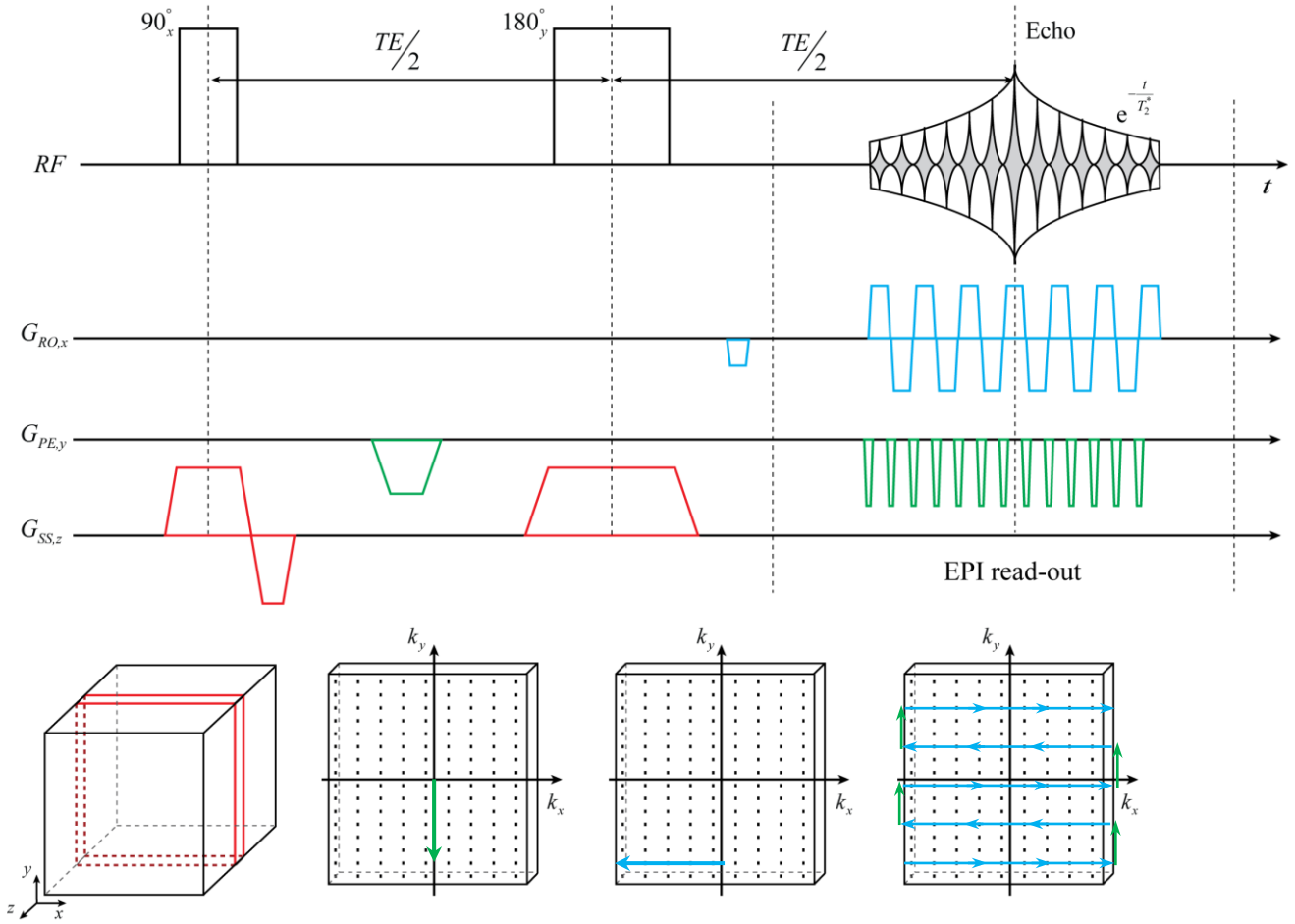

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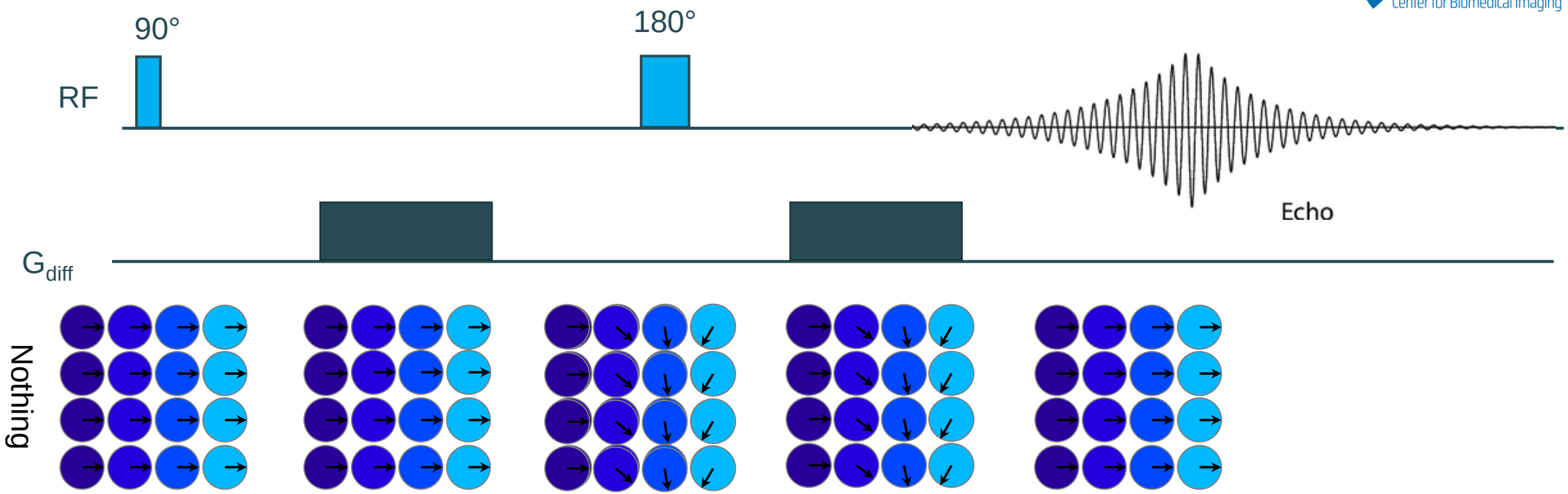
DIFFUSION MRI (SPIN-ECHO)



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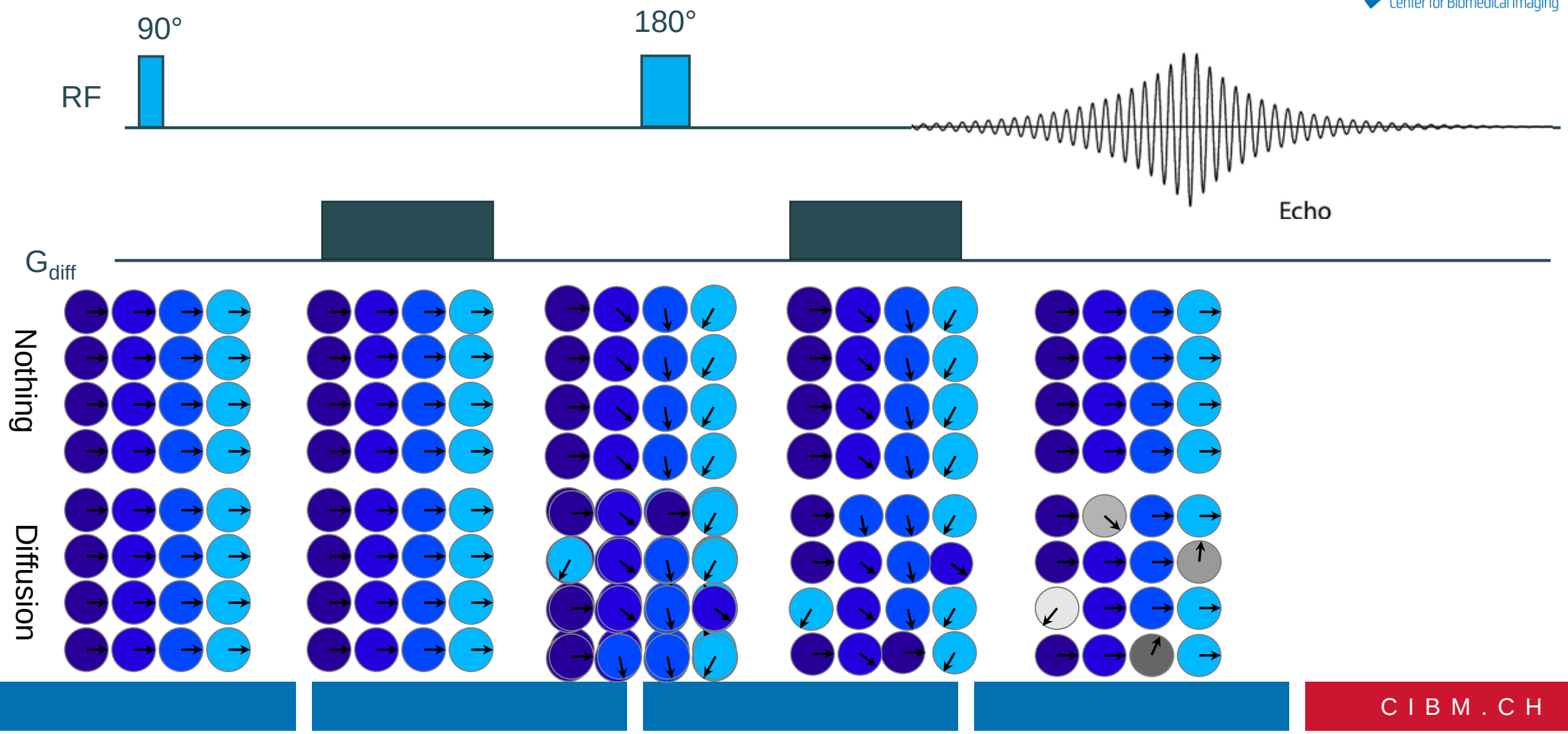
DIFFUSION MRI (SPIN-ECHO)



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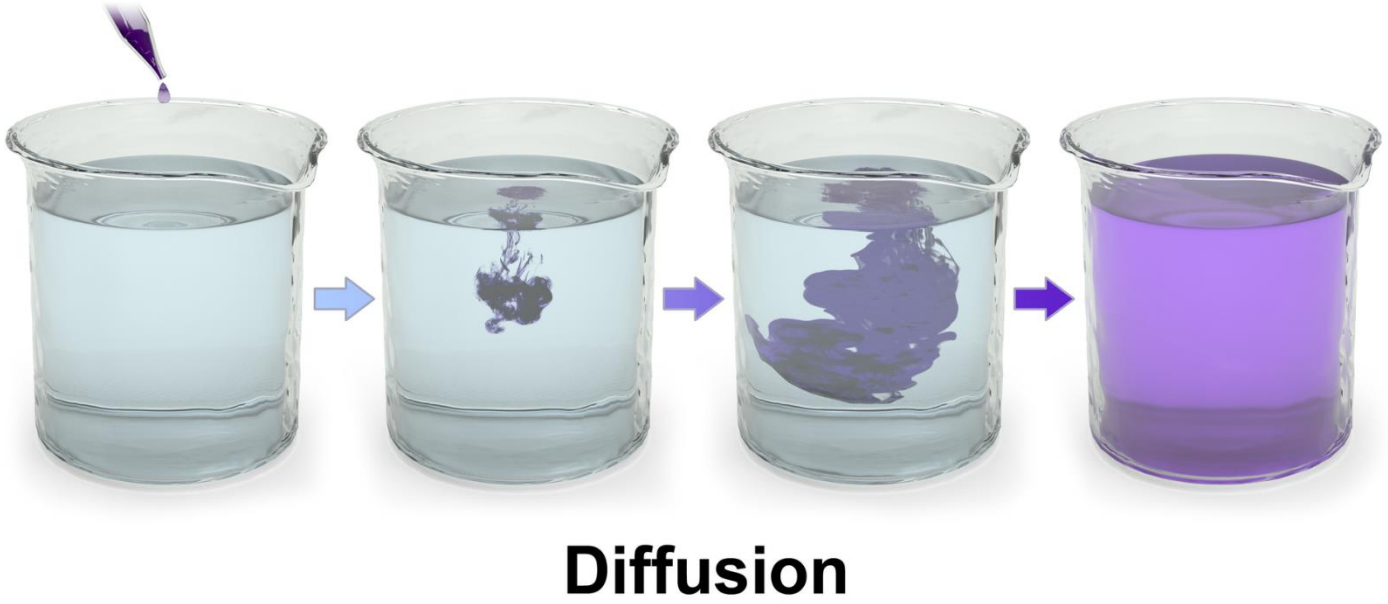
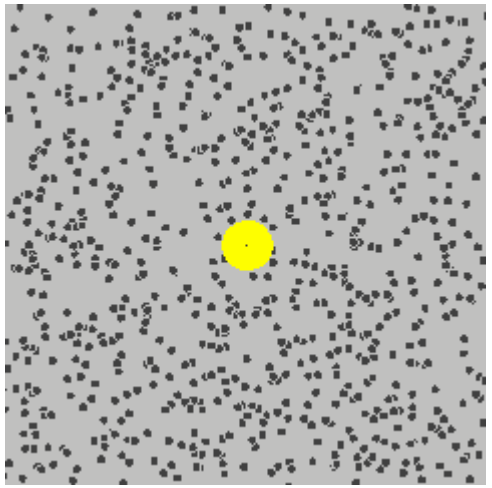
DIFFUSION MRI





https://en.wikipedia.org/wiki/Brownian_motion

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DIFFUSION MRI

- Brownian motion follows Einstein's equation (random walk):

$$\langle r \rangle = \sqrt{6D\Delta}$$

D self-diffusion coefficient
r displacement after time Δ

MR signal:

$$S = S_0 \exp(i\,\Delta\varphi)$$

S_0 signal without diffusion

$$|S| = |S_0|\,\exp(-b\,D)$$

With $b = (\gamma G \delta)^2 (\Delta - \delta/3)$

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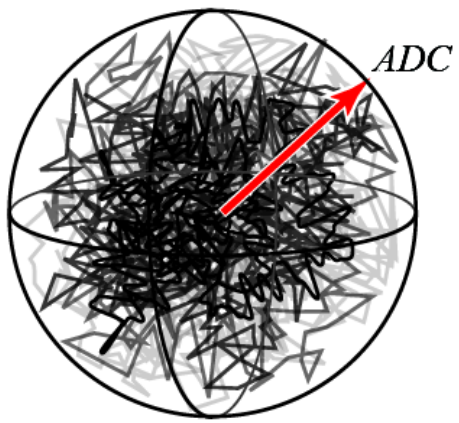
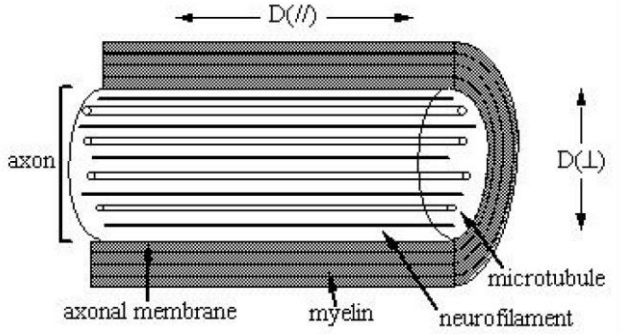
DIFFUSION MRI

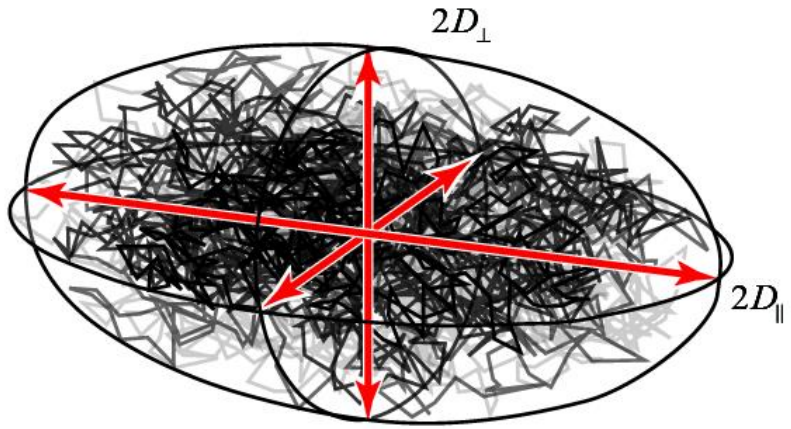
- Diffusion properties

Isotropic

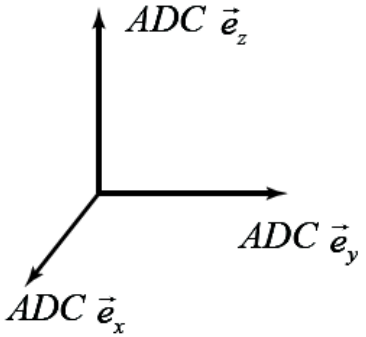




Anisotropic

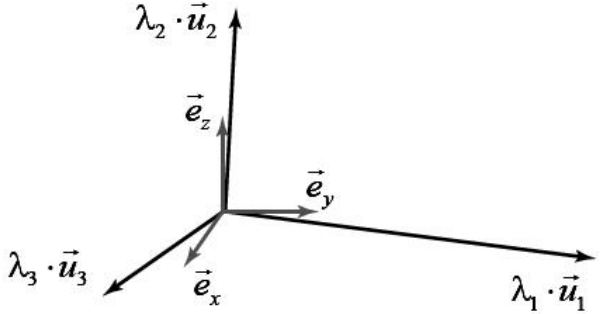


Diffusion coefficient depends on gradient orientation



-> Diffusion tensor

$$\mathbf{D} = \begin{bmatrix} D_{xx} & D_{xy} & D_{xz} \\ D_{yx} & D_{yy} & D_{yz} \\ D_{zx} & D_{zy} & D_{zz} \end{bmatrix}$$



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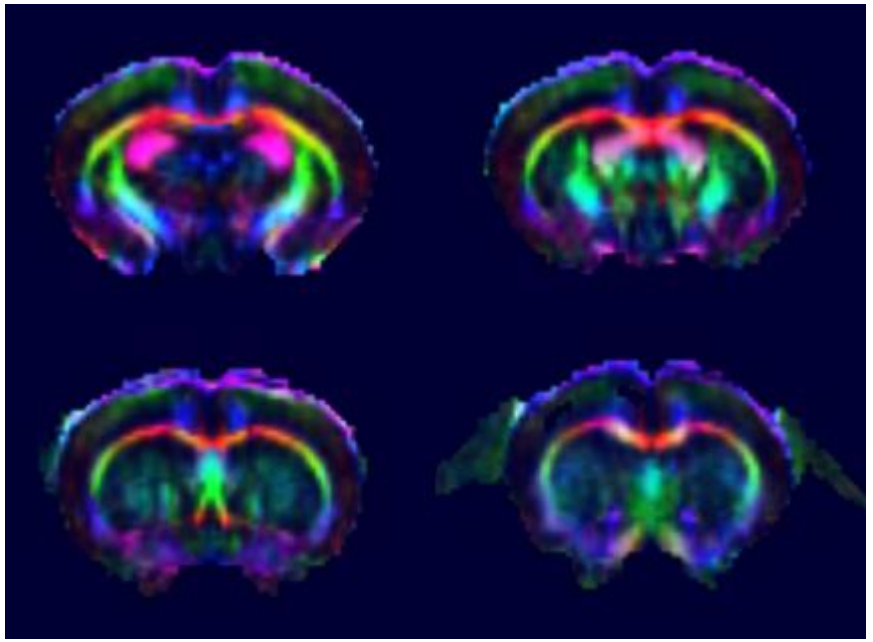
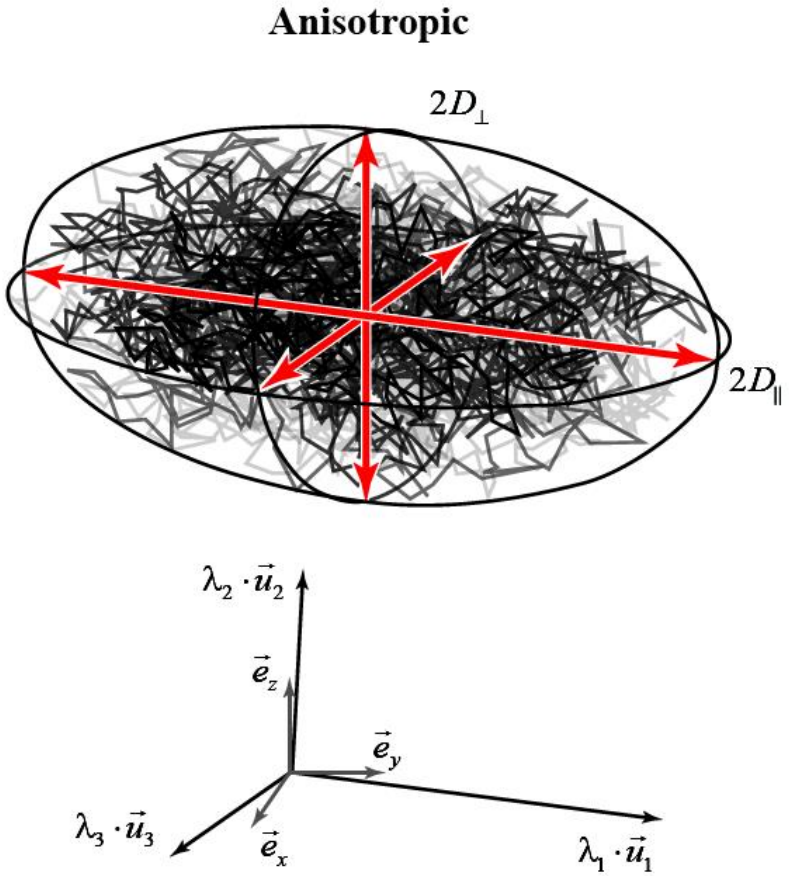
DIFFUSION MRI

- Diffusion tensor (symmetric) -> 3 orthogonal **Eigenvectors and eigenvalues**

$$\mathbf{D} = \begin{bmatrix} D_{xx} & D_{xy} & D_{xz} \\ D_{yx} & D_{yy} & D_{yz} \\ D_{zx} & D_{zy} & D_{zz} \end{bmatrix}$$





- **One can define the main diffusion direction**

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THANK YOU FOR YOUR ATTENTION

Questions ?

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