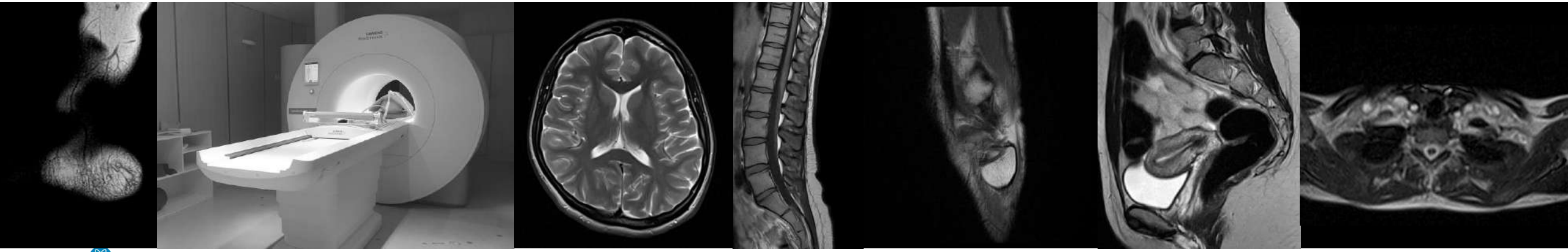
Les champs magnétiques: des hauts et des bas

Marie Poirier-Quinot



VLH, UHF: un concept qui varie au cours du temps

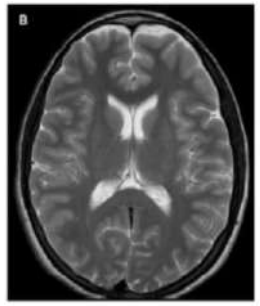
	80’	90’	2000’	2010’	2020’
>7T	-	-	-	UHF	UHF
3T - 7T	-	-	UHF	UHF	High Field
3T	-	UHF	High Field	Standard	Standard
1,5T	High Field	High Field	Standard	Standard	Standard
1T	High Field	Standard	Standard		Low Field
0,1T - 0,5 T	Standard	Low Field	Low Field	Low Field	Low Field
<0,1 T	-	-	-	-	VLF

J-P Dillenseger et al.

VLH, UHF: un concept qui varie au cours du temps

	80’	90’	2000’	2010’	2020’
>7T	-	-	-	UHF	UHF
3T - 7T	-	-	UHF	UHF	High Field
3T	-	UHF	High Field	Standard	Standard
1,5T	High Field	High Field	Standard	Standard	Standard
1T	High Field	Standard	Standard		Low Field
0,1T - 0,5 T	Standard	Low Field	Low Field	Low Field	Low Field
<0,1 T	-	-	-	-	VLF

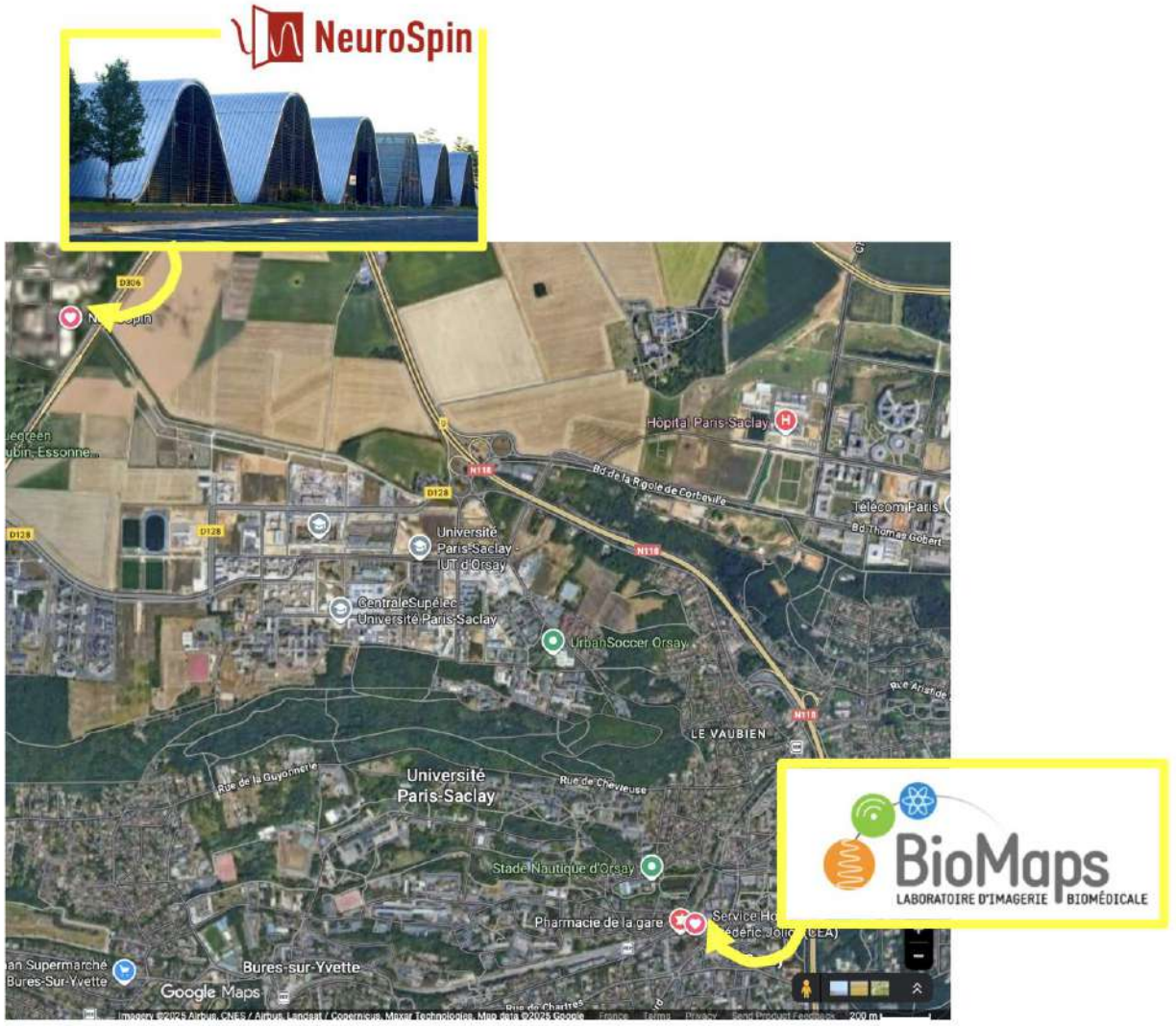
1986



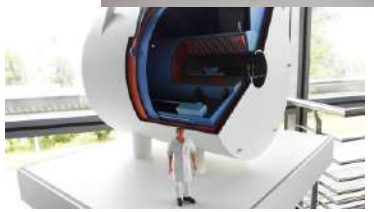
2009

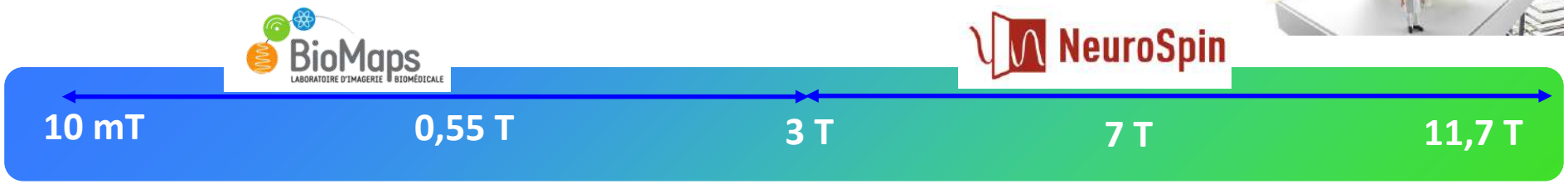
J-P Dillenseger et al.

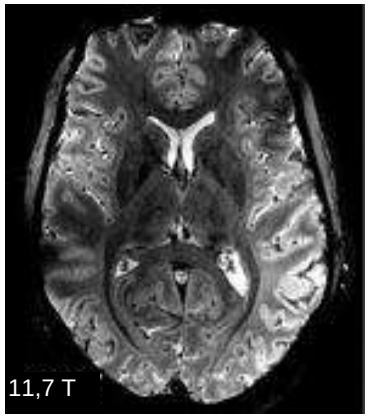
L’IRM à Paris Saclay



L'IRM à Paris Saclay

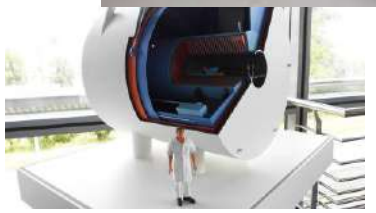






Neurospin
Zhao et al. 2024
Broche et al. 2019

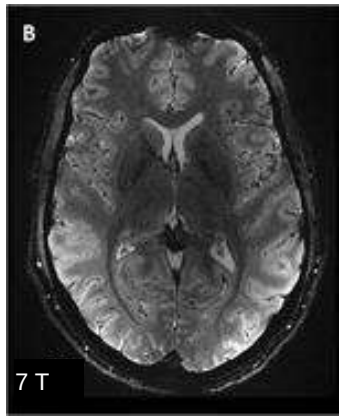
L’IRM à Paris Saclay

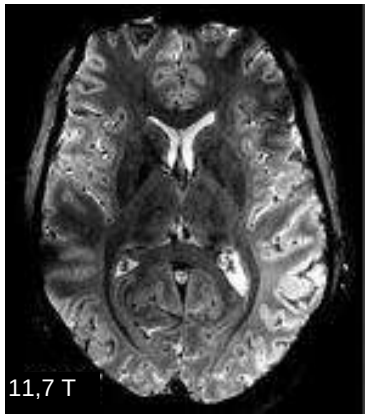


BioMaps
LABORATOIRE D’IMAGERIE BIOMÉDICALE

NeuroSpin

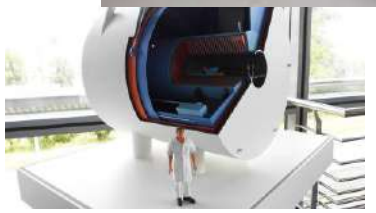
10 mT | 0,55 T | 3 T | 7 T | 11,7 T





Neurospin
Zhao et al. 2024
Broche et al. 2019

L’IRM à Paris Saclay



BioMaps LABORATOIRE D’IMAGERIE BIOMÉDICALE

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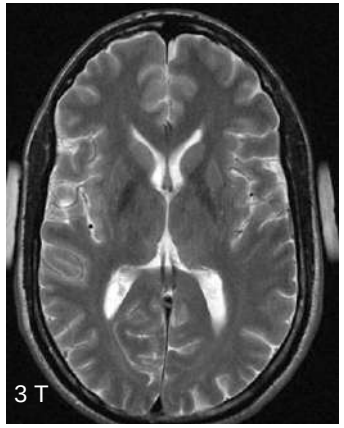
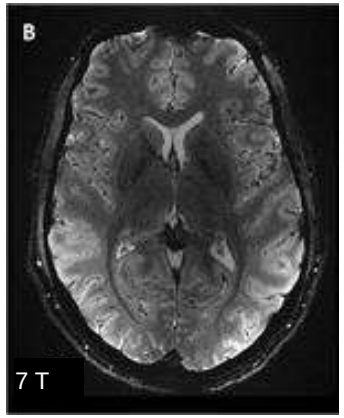
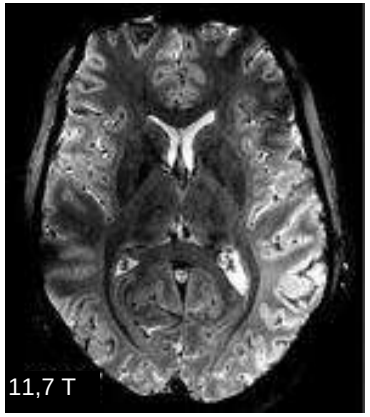




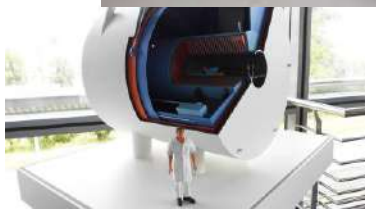


Neurospin
Zhao et al. 2024
Broche et al. 2019

L'IRM à Paris Saclay





BioMaps
LABORATOIRE D'IMAGERIE BIOMÉDICALE

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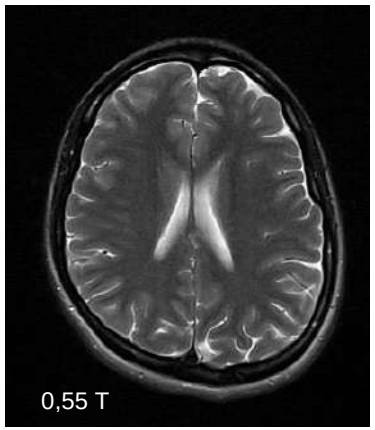
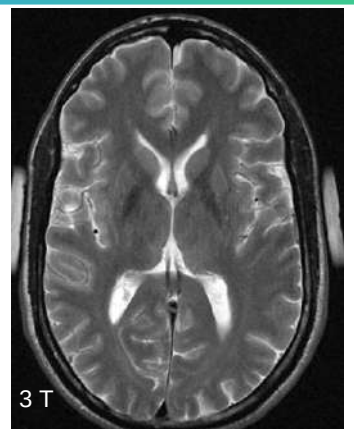
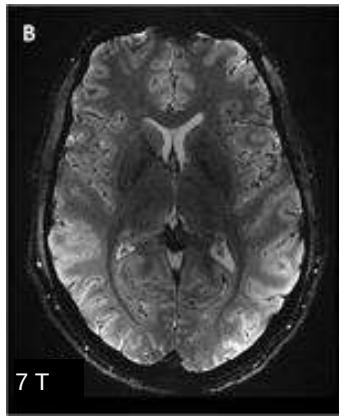
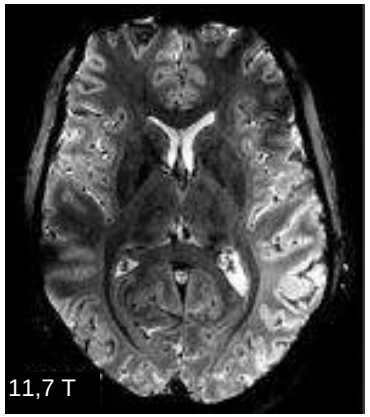


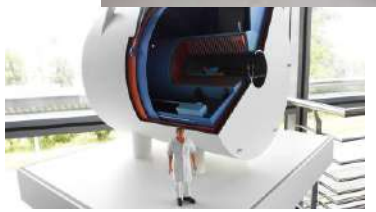






Neurospin
Zhao et al. 2024
Broche et al. 2019

L'IRM à Paris Saclay



BioMaps LABORATOIRE D'IMAGERIE BIOMÉDICALE

NeuroSpin

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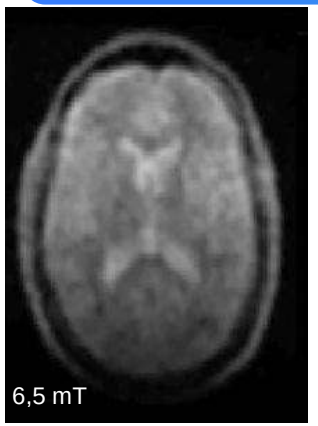
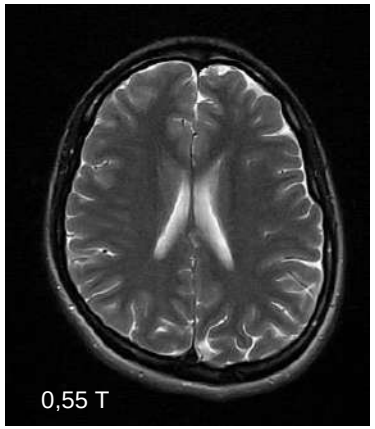
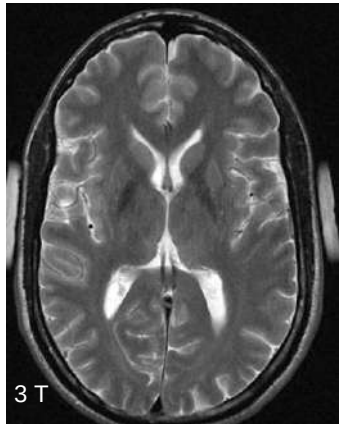
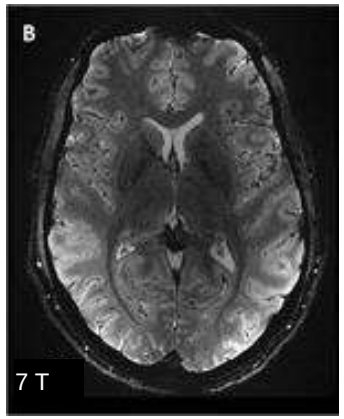
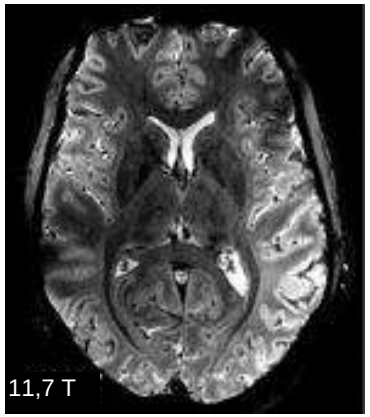




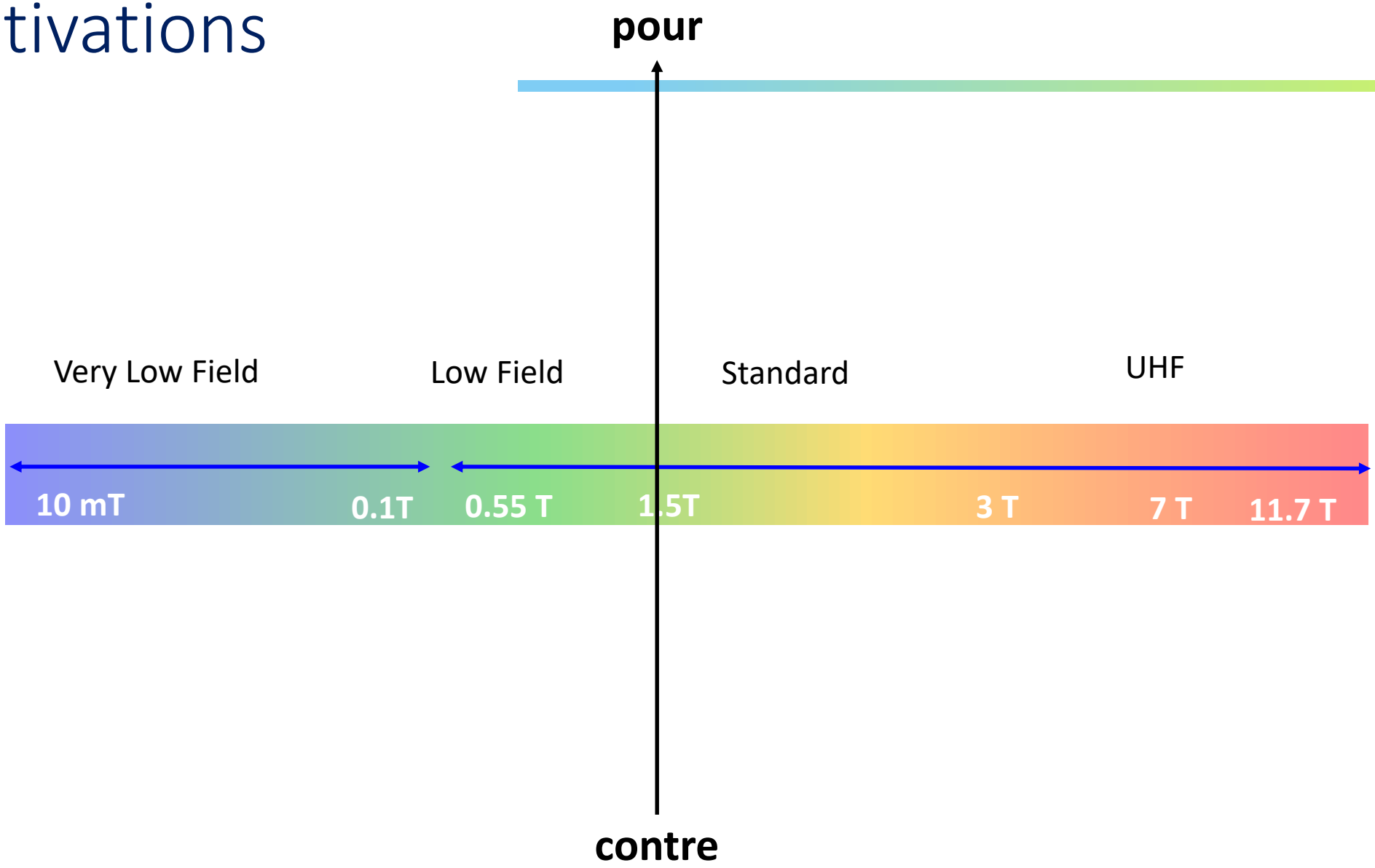






Neurospin
Zhao et al. 2024
Broche et al. 2019

Motivations



VLF MRI

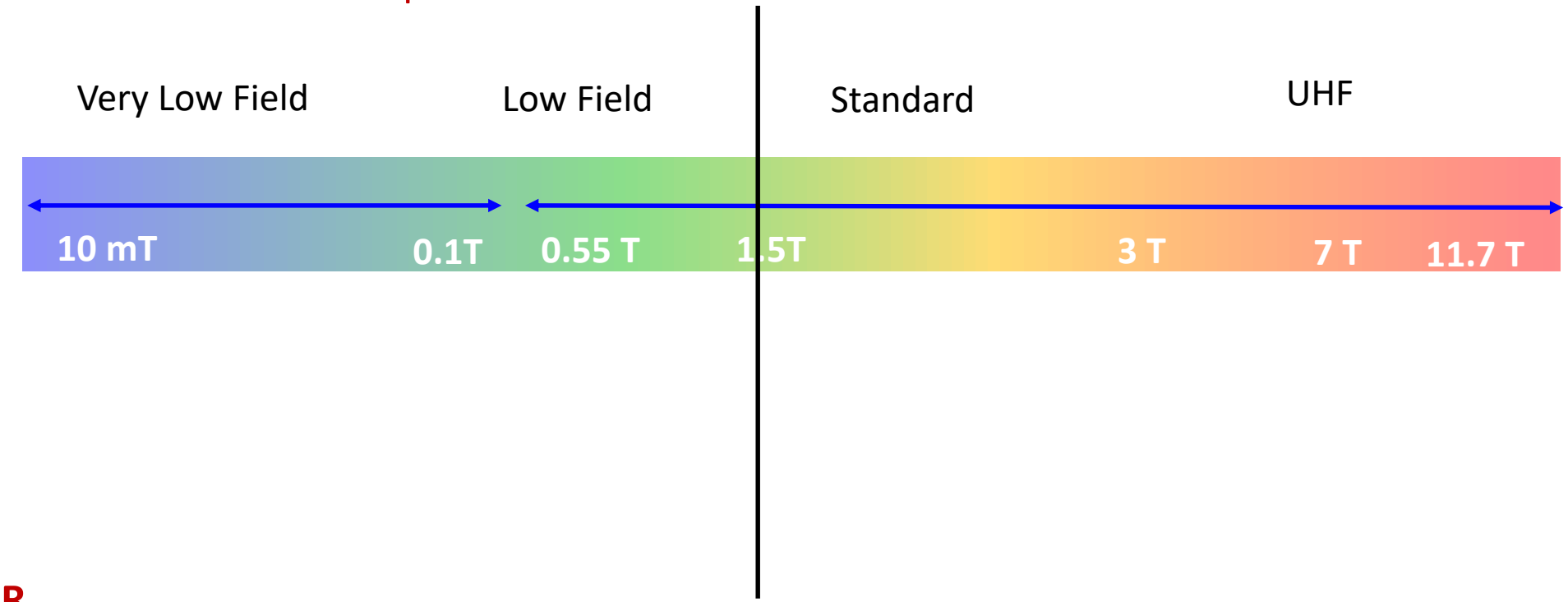
Motivations

pour

High SNR

$$SNR \propto B_0^{7/4}$$

T_{acq} : 1min @3T → 3 ans @ 50mT



Low SNR

contre

Motivations : économique, écologique

Supraconducteur (Nb-Ti)

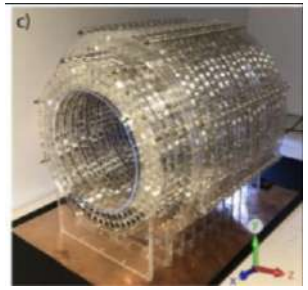
Cryogénie : système cryogénique

Hélium liquide (IRM/medical) :
35€/litre (35 k€/m³).
Volume IRM 3T : 1,65–1,8 m³
Volume IRM 7T : 2–2,5 m³
Volume IRM 0,55T: 0.7L

https://www.cnrs.fr/fr/actualite/crise-dhelium-le-cnrs-continue-dinsuffler-la-science

Motivations : économique, écologique

cuivre ou aimant permanent
Refroidissement: eau/air



Kimberly et al. 2023

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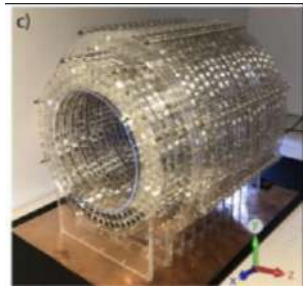

Kimberly et al. 2023

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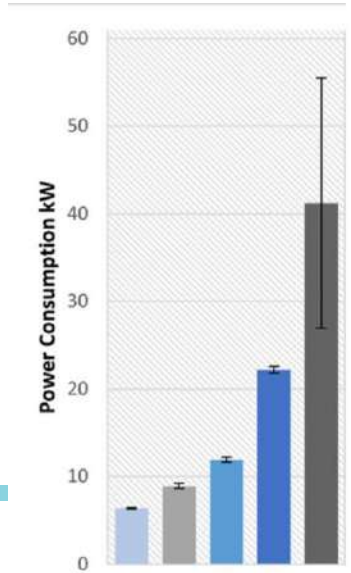
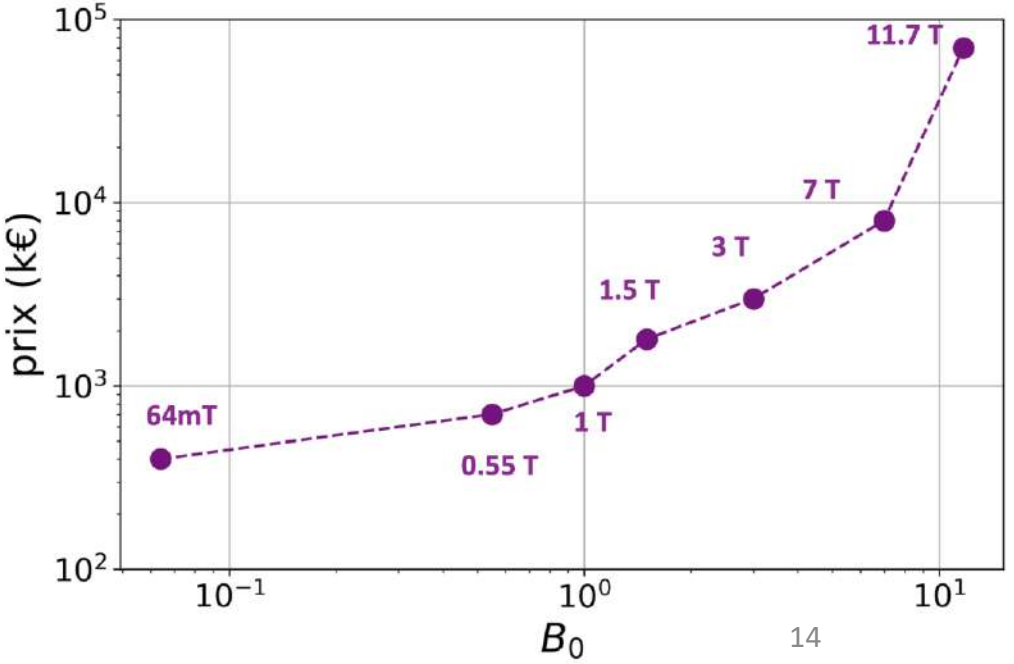


Coût: achat
fonctionnement
Infrastructure
Accessibilité aux patients



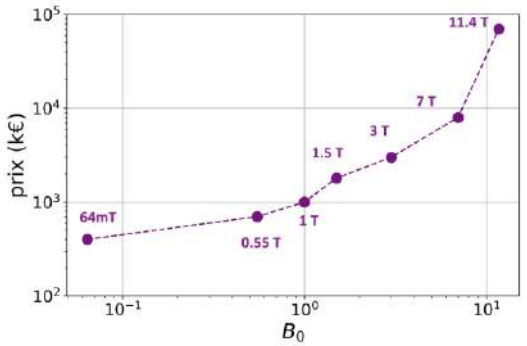
Motivations

pour

Bas coût
Infrastructure «légère»
Accessibilité

Ecologie

High SNR



Low SNR

contre

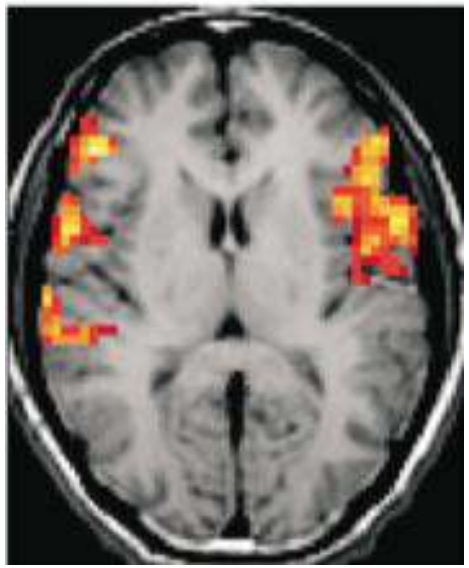
Extrêmement coûteux
Infrastructure
Access limité

Impact écologique
Environement cryogénique
Material supraconducteur

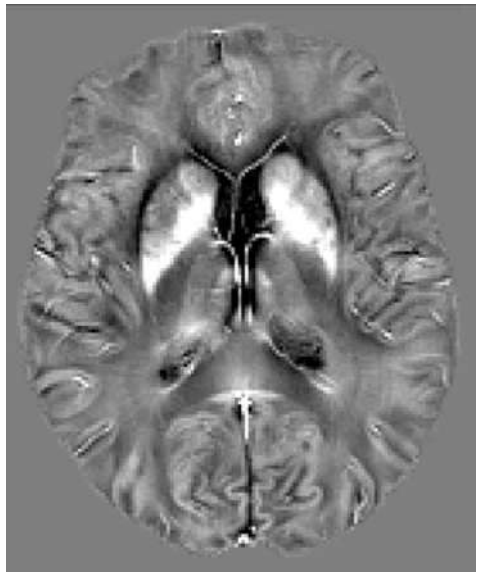
Motivations: effet de susceptibilité

Source de signal

Imagerie fonctionnelle: BOLD



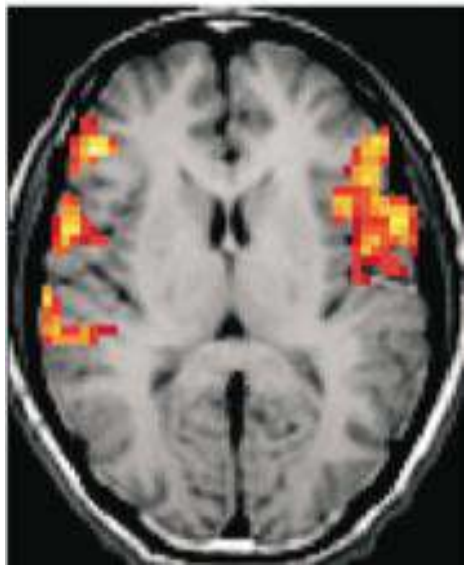
Imagerie de susceptibilité



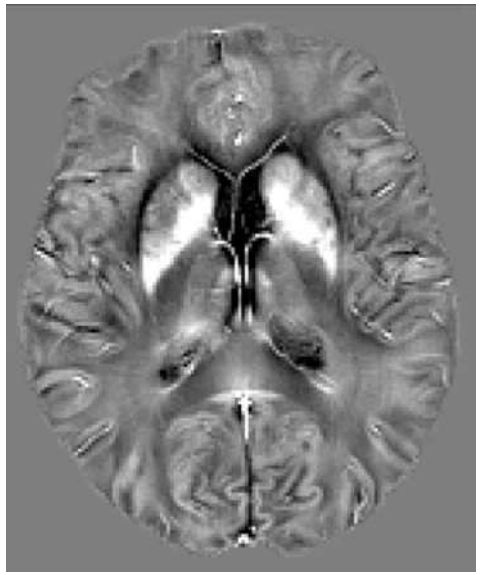
Motivations: effet de susceptibilité

Source de signal

Imagerie fonctionnelle: BOLD

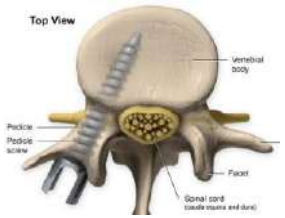


Imagerie de susceptibilité



Source de bruit

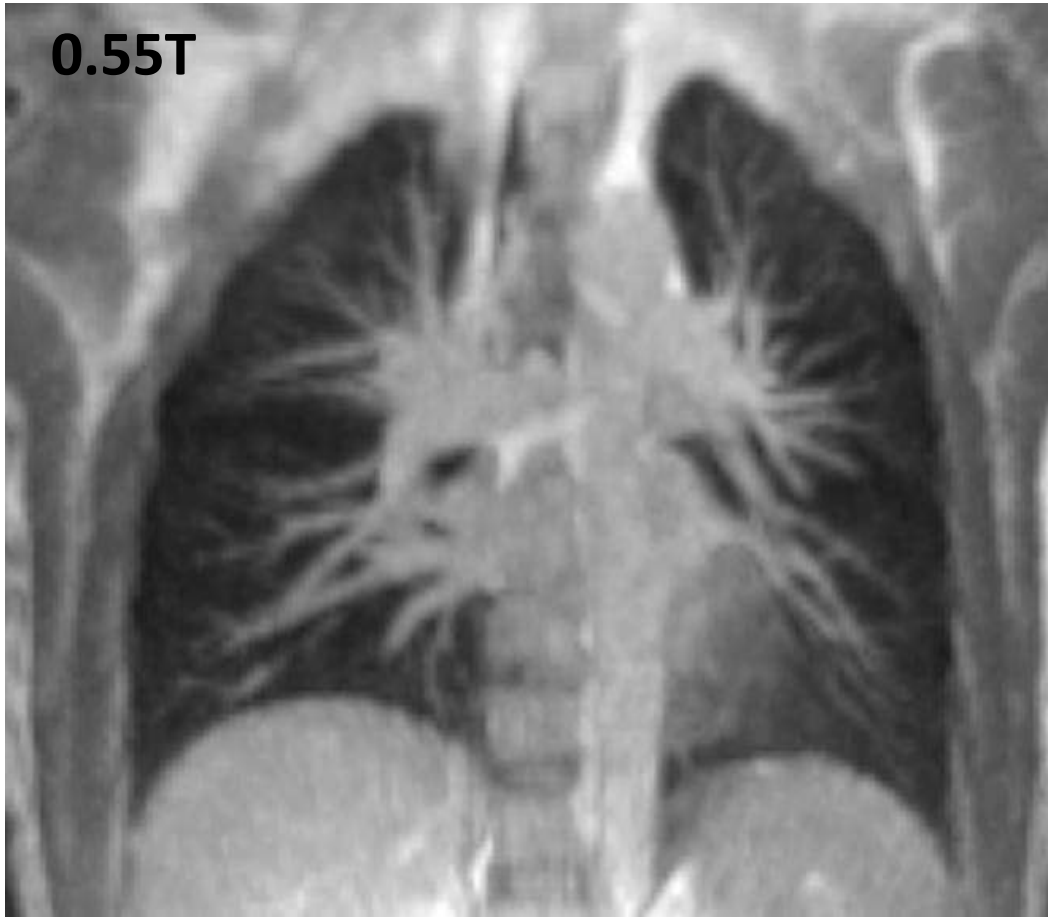
Distorsion géométrique aux interfaces des tissus



0.55T

1.5 T

Motivations: effet de susceptibilité



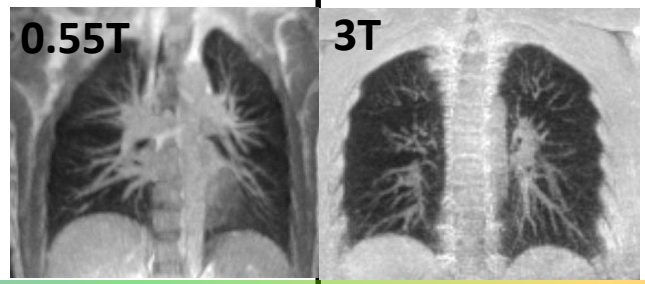
Timothée Caussin

Motivations

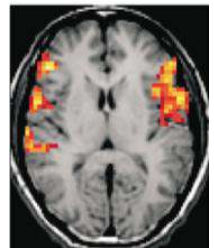
pour

Bas coût
Infrastructure «légère»
Accessibilité

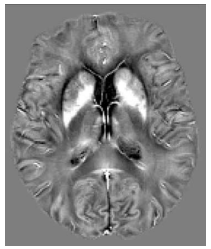
Ecologie

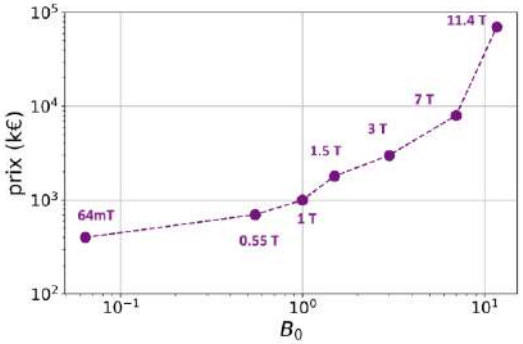


High SNR



BOLD effect
Susceptibility contrast





Extrêmement coûteux
Infrastructure
Access limité

Low SNR

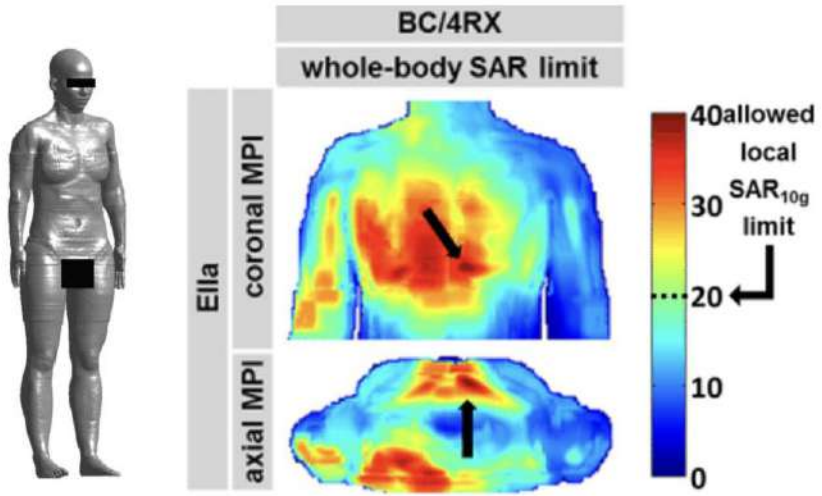
contre

Impact écologique
Environement cryogénique
Material supraconducteur

Motivations – effet du champ sur l'organisme

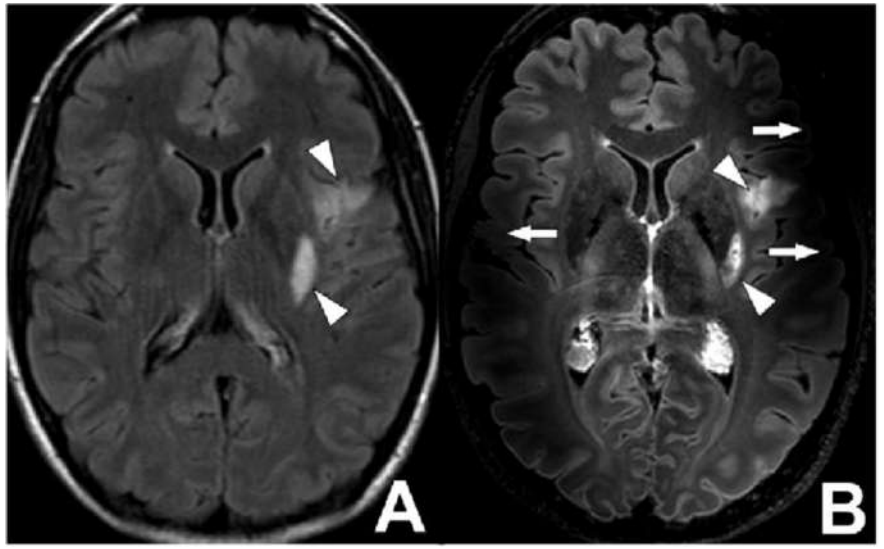
Courant de Foucault

Dépôt d'Absorption Spécifique (DAS)



Weinberger et al. 2016

B_1 inhomogénéité (λ vs taille de la région observée)



0.55T **7T**

L.J. De Cocker et al. 2016

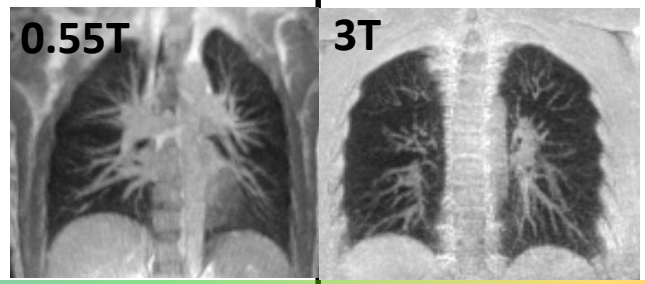
Motivations

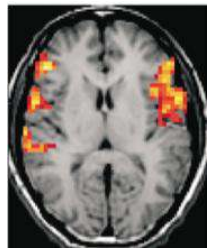
pour

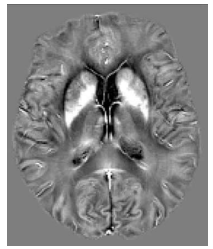
Bas coût
Infrastructure «légère»
Accessibilité

Ecologie

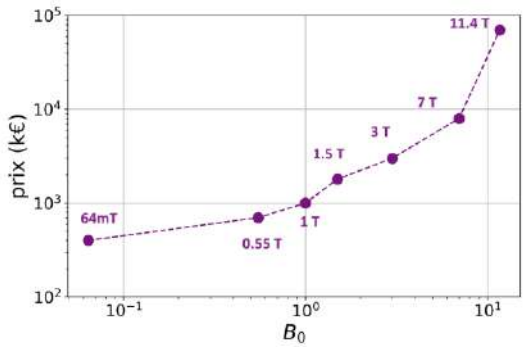
High SNR

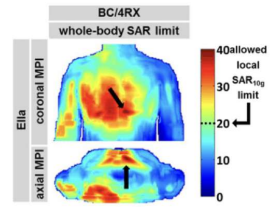






susceptibilité
BOLD effect
Contraste
artefacts





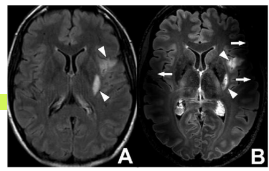
Extrêmement coûteux
Infrastructure
Access limité

DAS
B1 inhomogeneity

Low SNR

contre

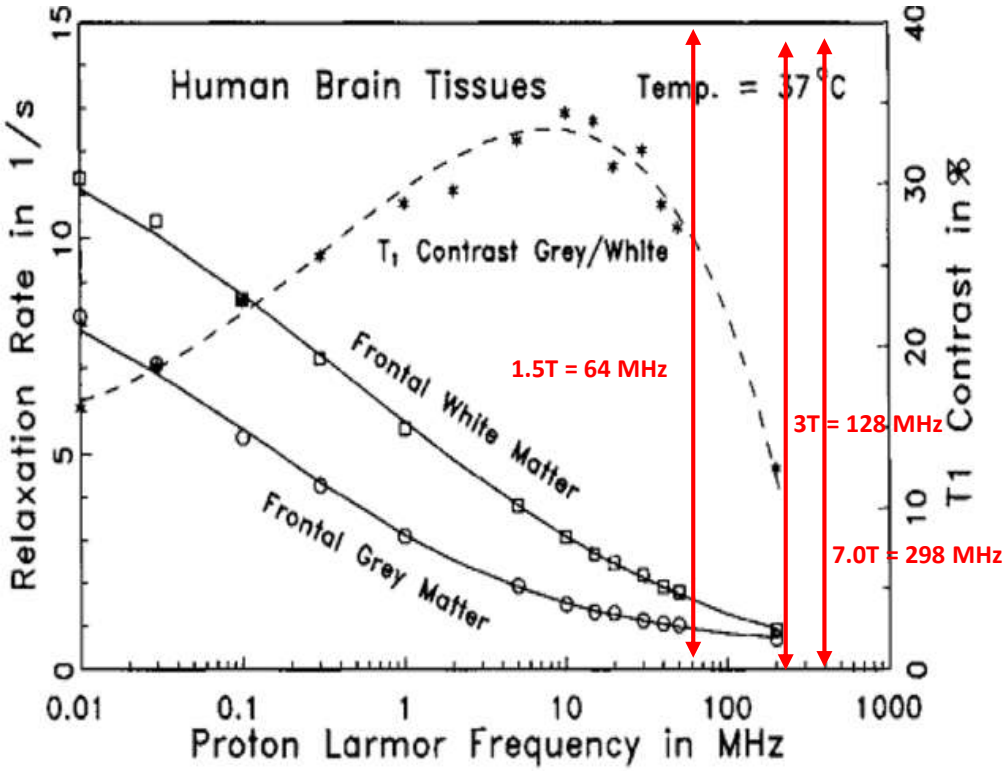
Impact écologique
Environement cryogénique
Material supraconducteur



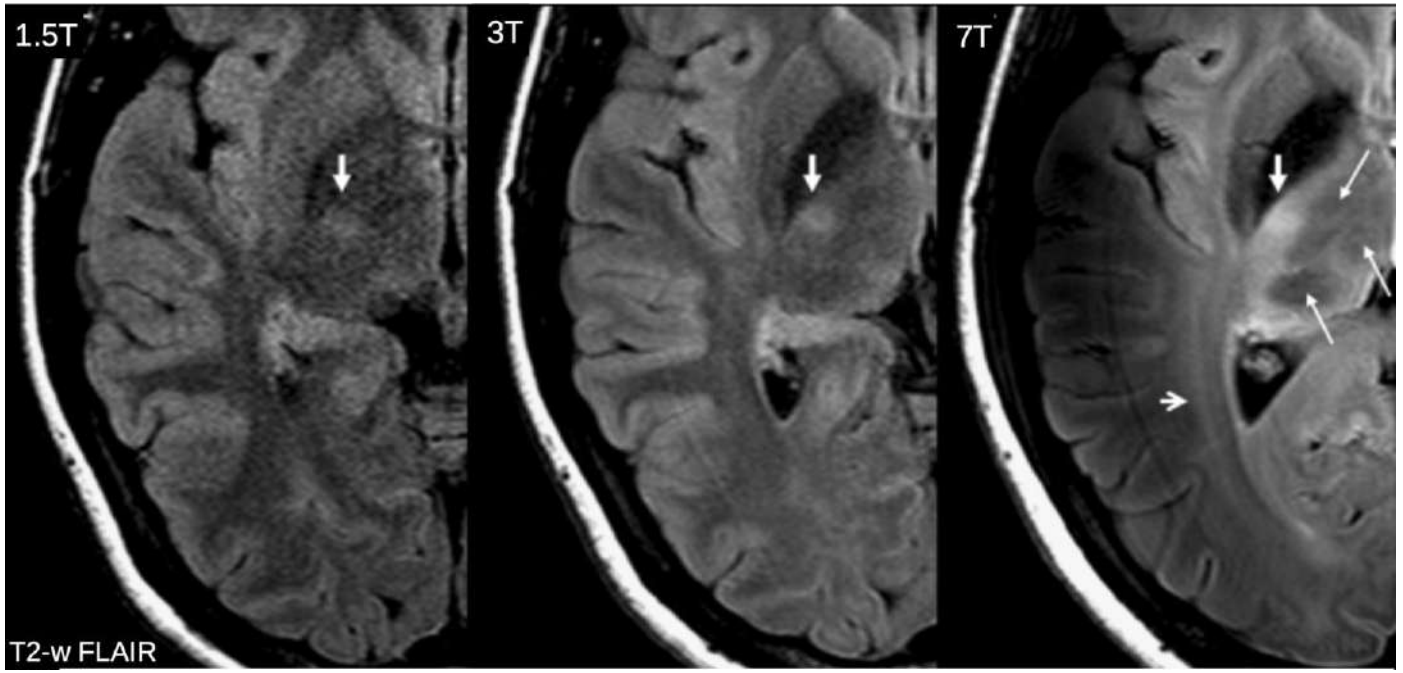
Motivations – la nature du signal : les contrastes

Mécanismes de relaxation T_1, T_2 dépendent de B_0

→ nouveaux contrastes



Fischer et al, MRM 1990
J. Zwanenburg et al., Eur. Radiol., 2010



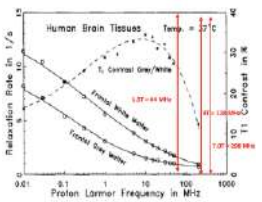
Motivations

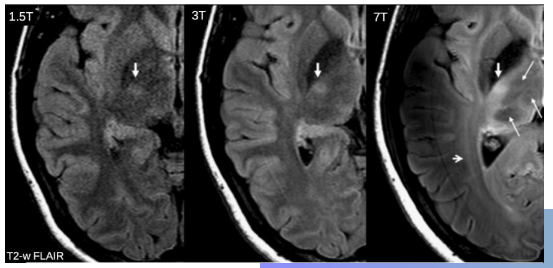
pour

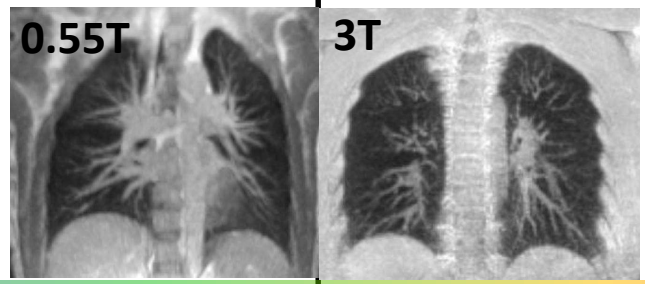
Bas coût
Infrastructure «légère»
Accessibilité

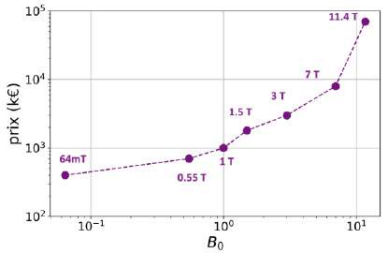
Ecologie

Mécanisme de relaxation T_1, T_2 = f(B_0)
→ Nouveaux contrastes

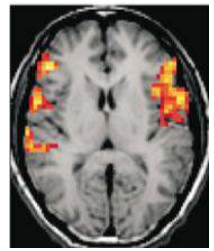


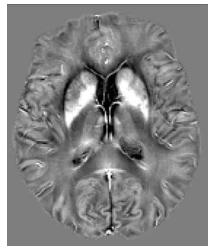




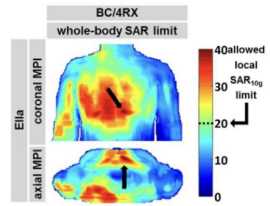


High SNR





susceptibilité
BOLD effect
Contraste
artefacts



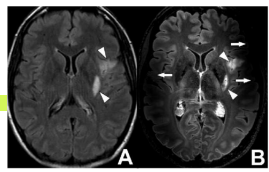
Extrêmement coûteux
Infrastructure
Access limité

DAS
B1 inhomogeneity

Low SNR

contre

Impact écologique
Environement cryogénique
Material supraconducteur



Motivations

pour

Bas coût
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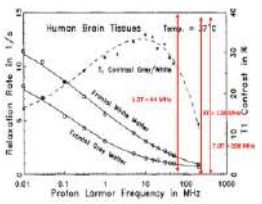
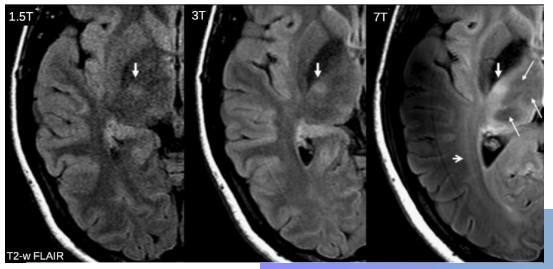
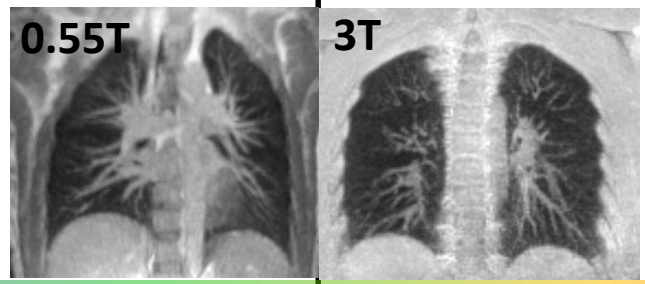
Accessibilité

Ecologie

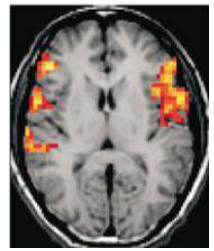


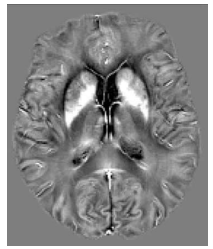
Mécanisme de relaxation T_1, T_2 = f(B_0)
→ Nouveaux contrastes





High SNR

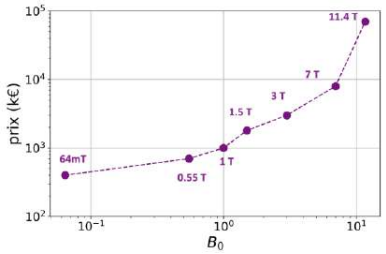




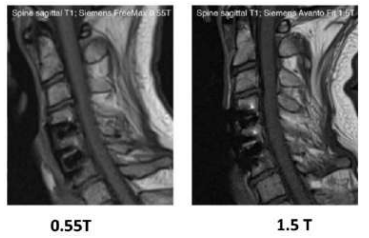
susceptibilité
BOLD effect
Contraste
artefacts

Nouvelles façons d'observer
le signal (trajectoire)
Instrumentation
IA – denoising

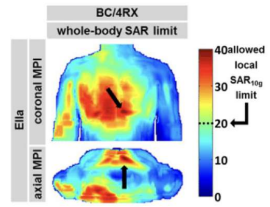
Low SNR



contre



Extrêmement coûteux
Infrastructure
Access limité



DAS
B1 inhomogeneity

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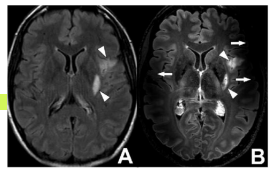
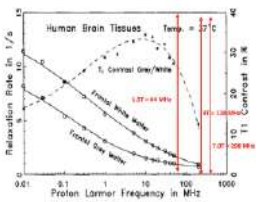


conclusion

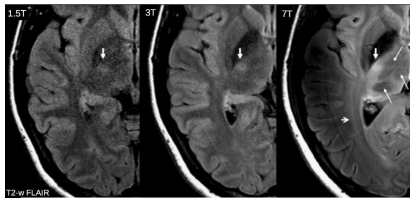
Bas coût
Infrastructure «légère»
Accessibilité

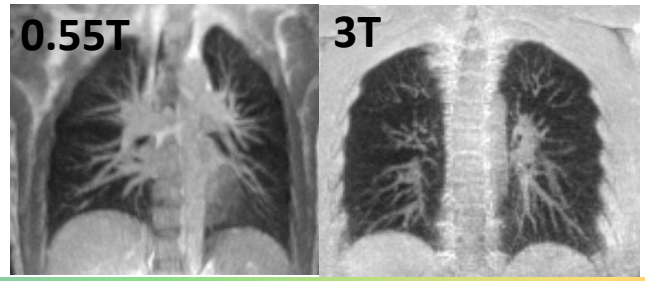
High SNR

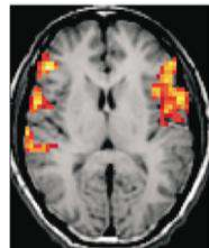


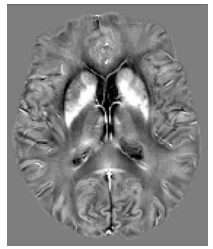
Mécanisme de relaxation T_1, T_2 = f(B_0)
→ Nouveaux contrastes

Ecologie









Complémentarité des approches en fonction de B_0

Nouvelles façons d'observer
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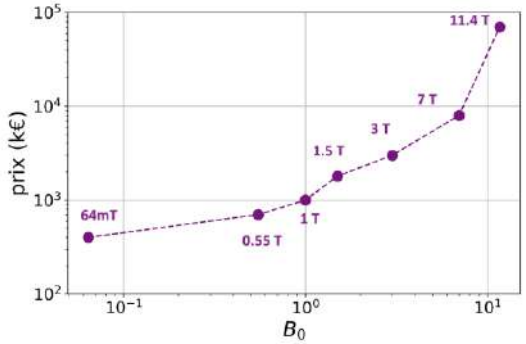
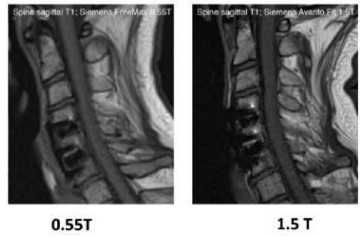
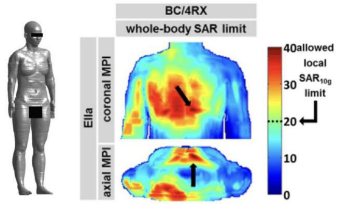
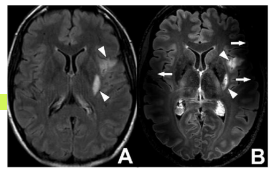




Extrêmement coûteux
Infrastructure
Access limité



DAS
B1 inhomogeneity



Impact écologique
Environement cryogénique
Material supraconducteur

Merci

Et un merci tout particulier à Rose-Marie Dubuisson