

# La décussation inter-hémiphérique vue par la tractographie: fin des idées reçues ?

Lucie Hertz-Pannier, Audrey Bénézit  
Jessica Dubois

G Dehaene-Lambertz, et ML Moutard

*Groupe de Recherche en Imagerie Pédiatrique (GRIP)  
Neurospin, CEA, et Inserm U992 et U1129, Saclay  
Trousseau, APHP, Paris*

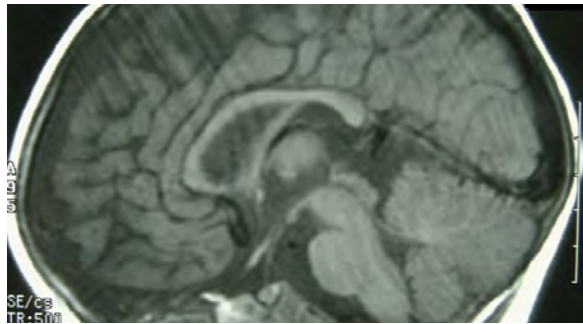


# Merci à

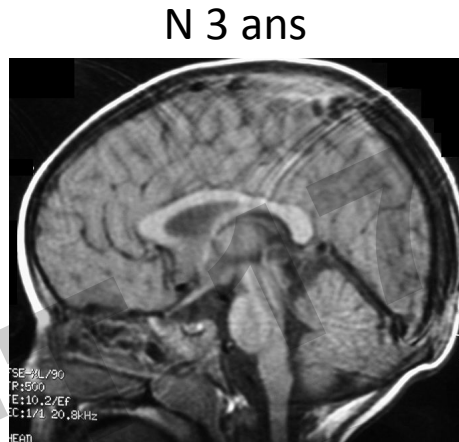
- T Billette, V Kieffer, C Garel
  - Pour leur expertise clinique et radiologique
- G Operto, C Fisher, P Guevara, C Poupon
  - Pour leur aide à l'analyse DTI
- D Germanaud, K Monzalvo, C Pinabiaux, F Leroy, H Glasel
  - Pour leur participation



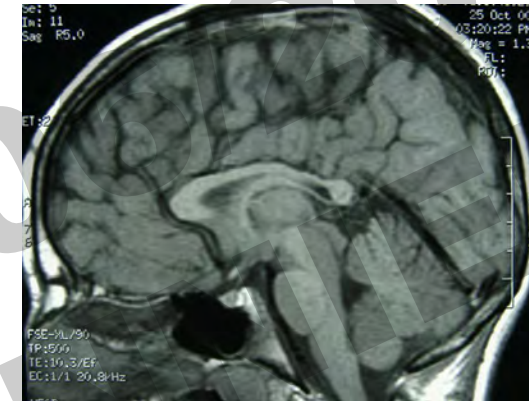
# Connaît-on bien le corps calleux?



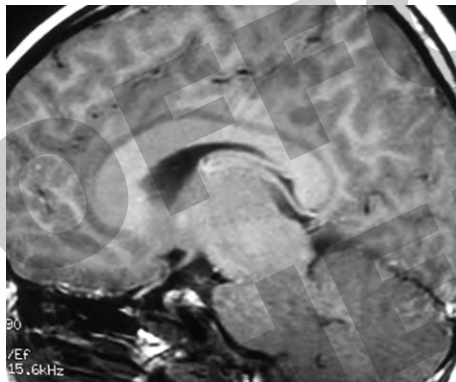
N 6 mois



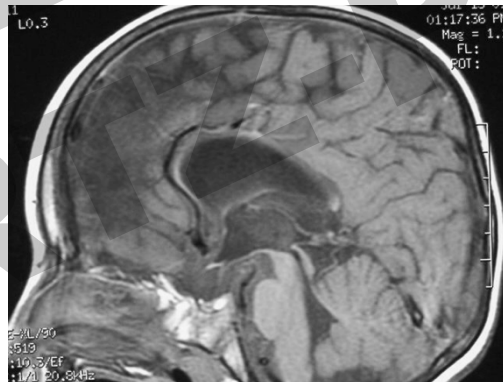
N 3 ans



LPV



NF1



Sotos

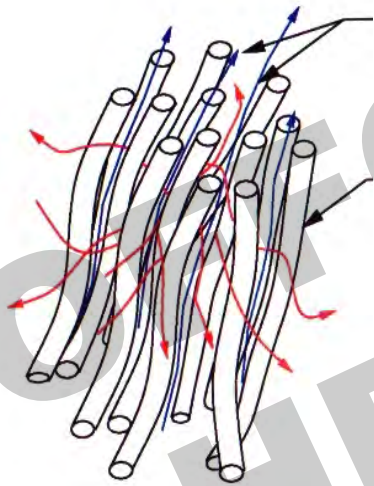


LDM

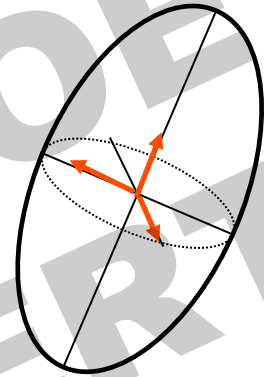




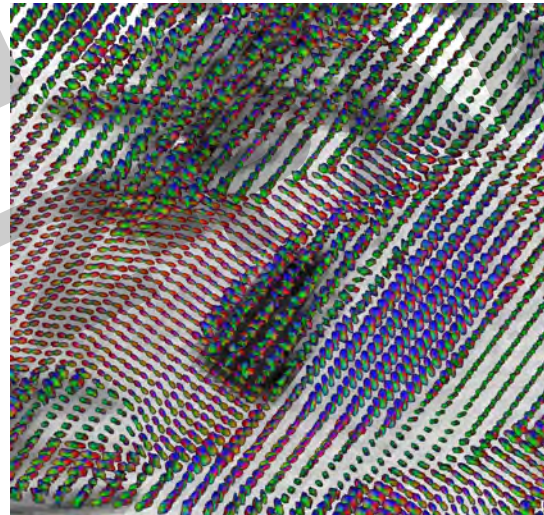
# L'imagerie de diffusion



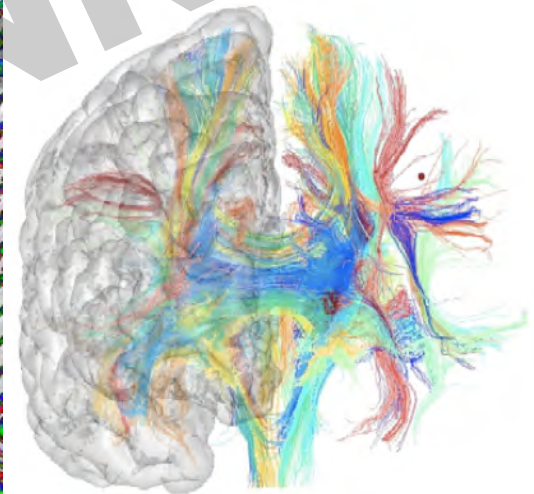
Anisotropie



Tenseurs

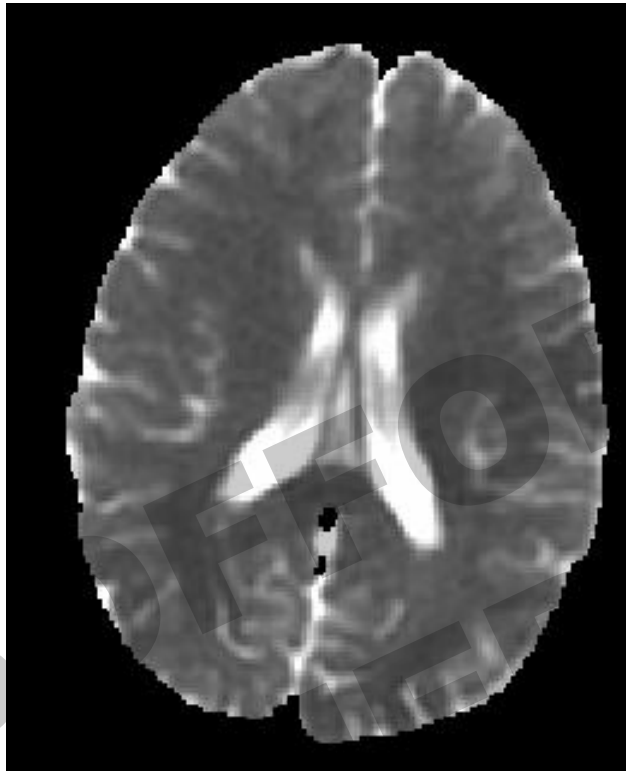


HARDI, Qball, ODF, et autres..;

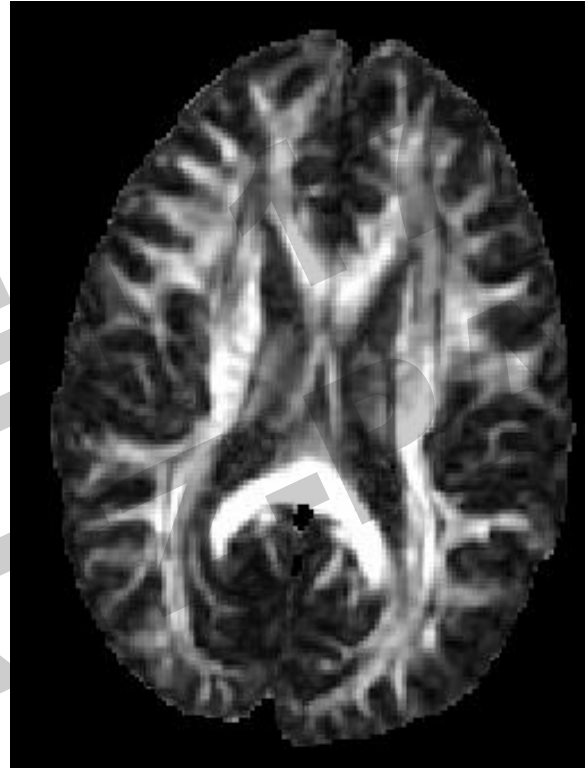


# Cartes DTI

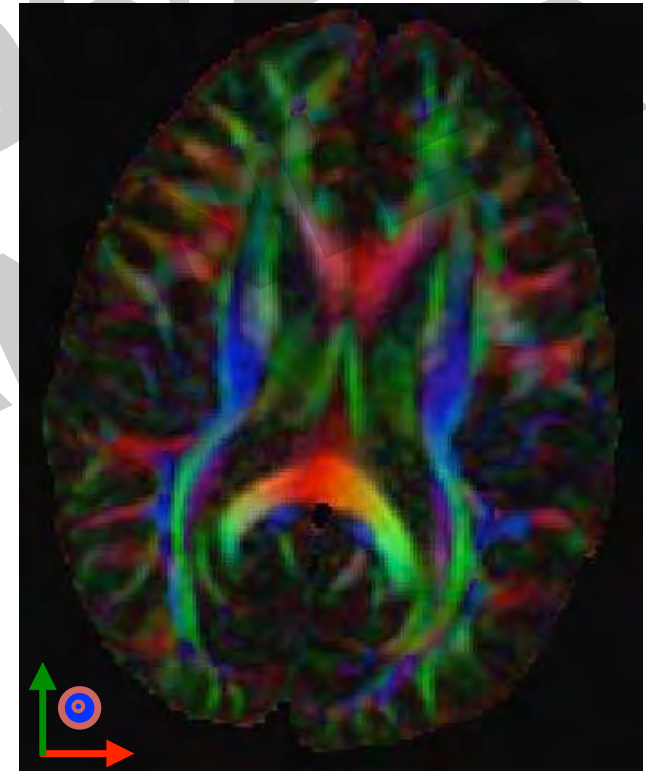
Diffusion moyenne



Anisotropie (FA)

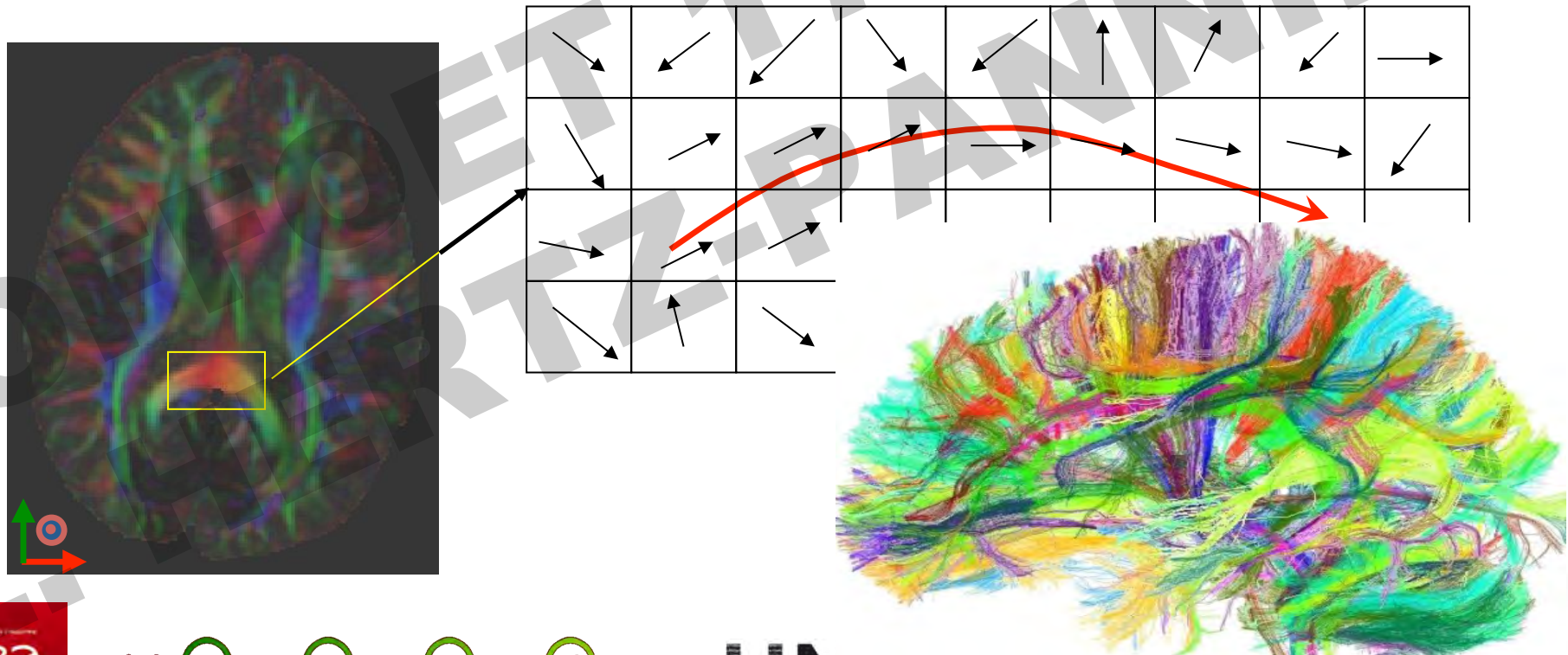


Orientations  
codées en couleurs

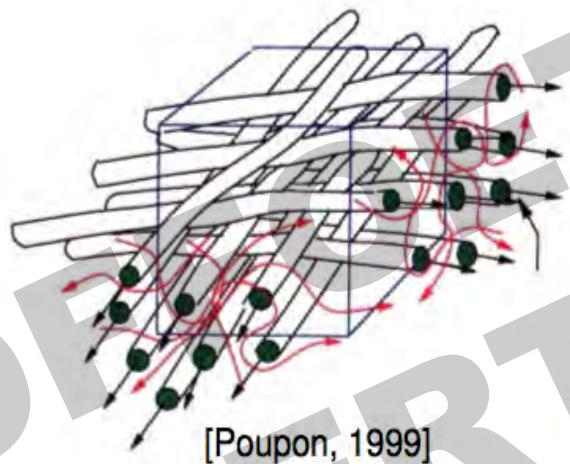


# Suivi de faisceaux de fibres (tractographie)

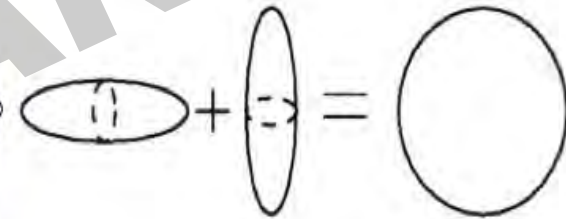
- Principe : utiliser l'information d'orientation dans chaque pixel et se propager de proche en proche pour **estimer la trajectoire** d'une « fibre » d'un faisceau de substance blanche



# Croisement des fibres



croisements de fibres  
=  
effets de volume partiel  
=  
tenseurs plats



# Croisement des fibres



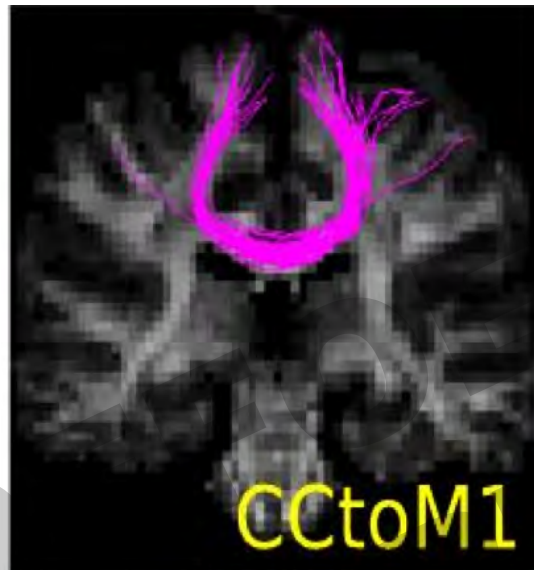


# Techniques de tractographie

Déterministe  
forme en U

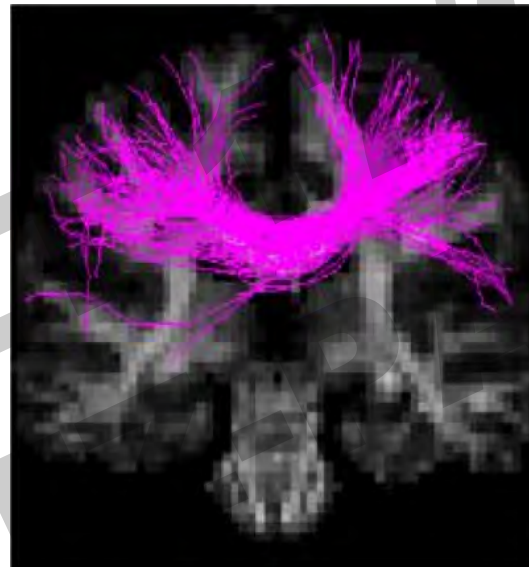
Probabiliste

Globale



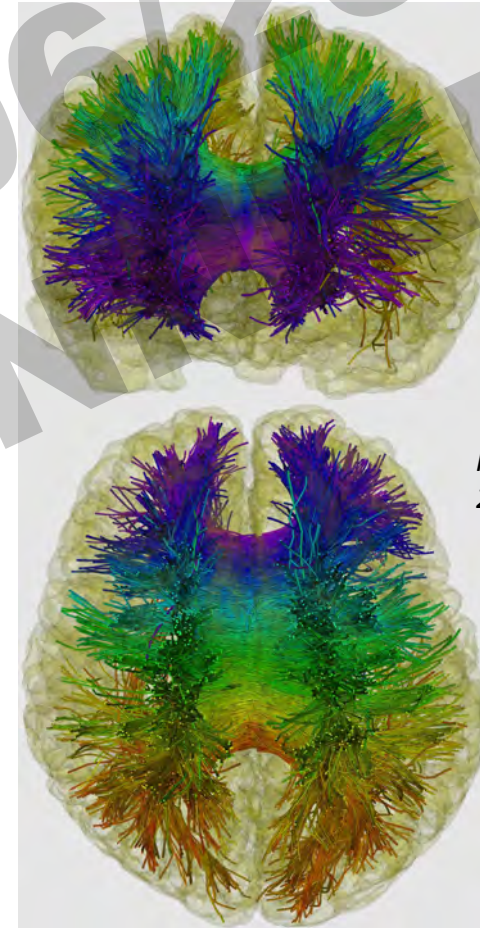
is

déterministe



probabiliste

versi



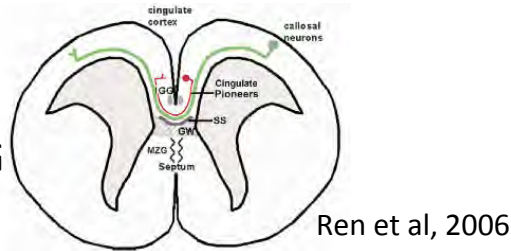
Fillard et al,  
2009

Connectivité cortico-corticale



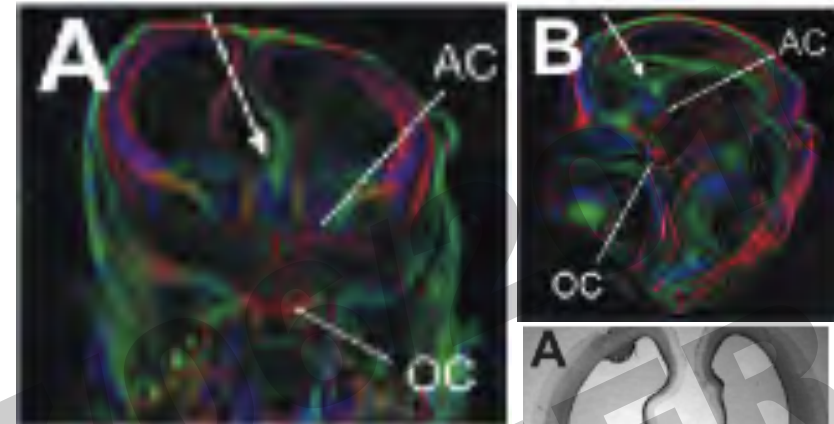
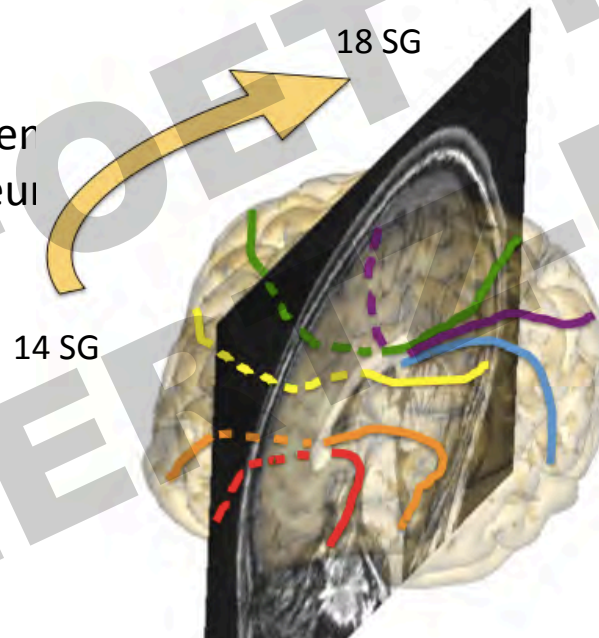
# Embryogenèse (1)

1. Formation de la ligne Médiane : 13 SG



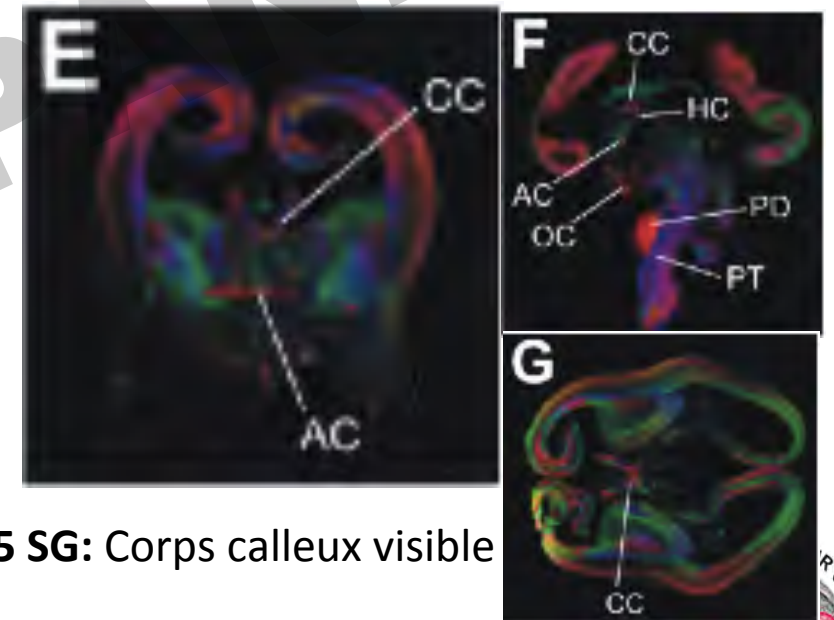
2. Axones Pionniers Cingulaires: 14 SG  
Puis axones néocorticaux

3. Développement antéro-postérieur s'achevant par le rostre



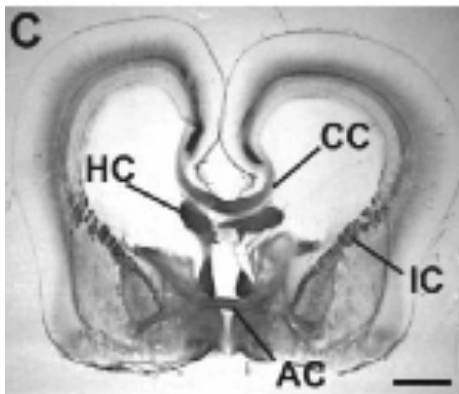
13 SG: formation de la ligne médiane

Ren et al 2006



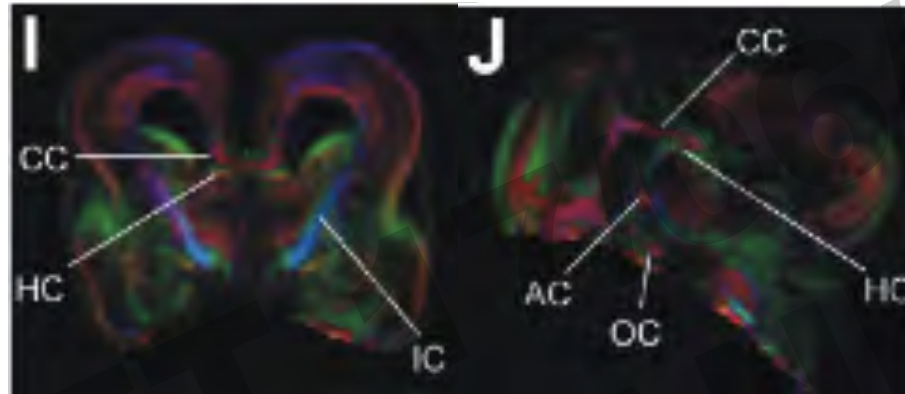
15 SG: Corps calleux visible

# Embryogenèse (2)

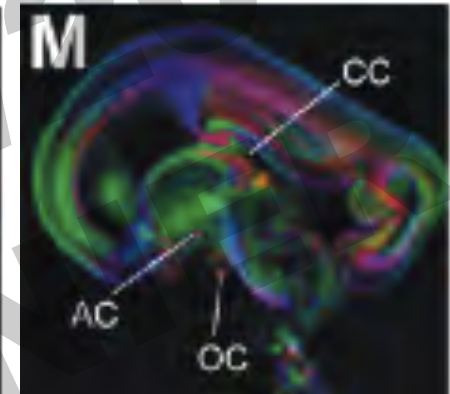


Ren et al  
2006

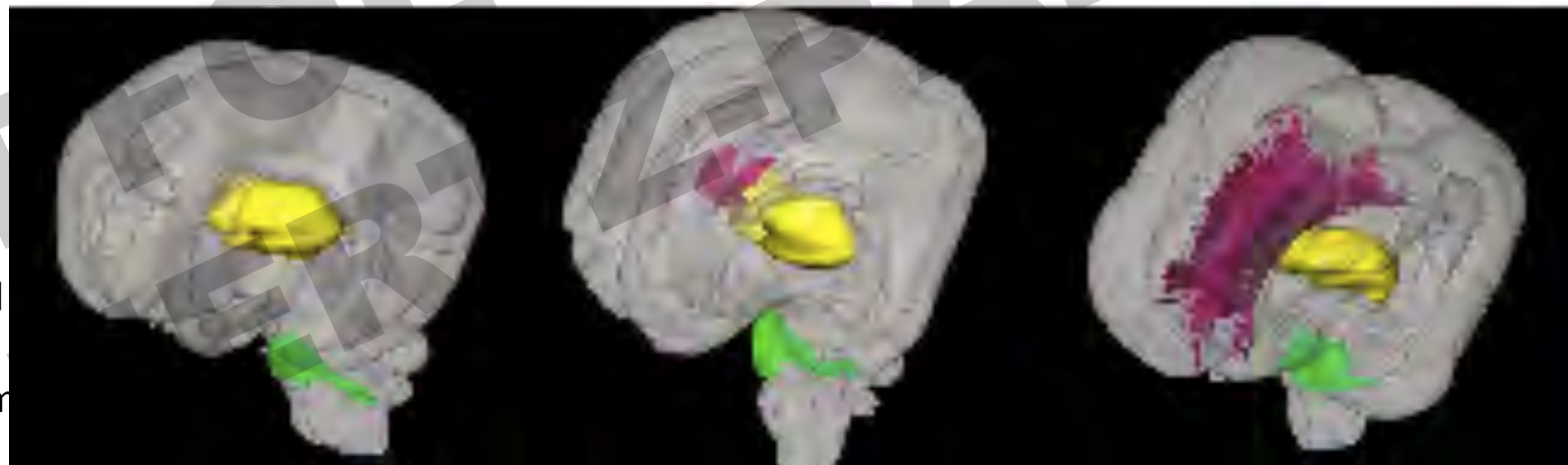
17 SG



18 SG



19 SG



13 SG

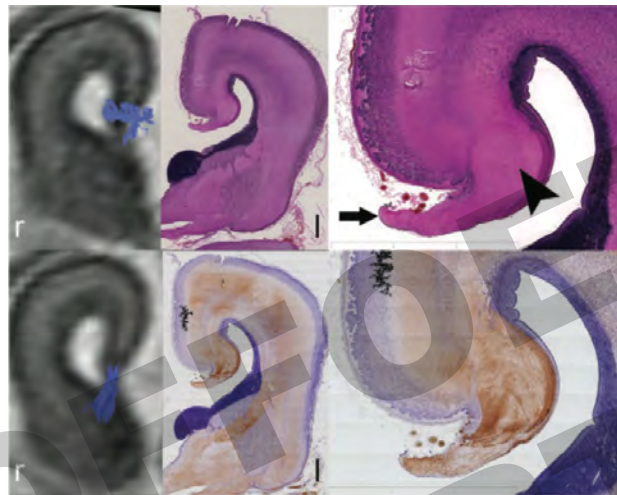
15 SG

19 SG

Huang et al  
2009  
Post mortem

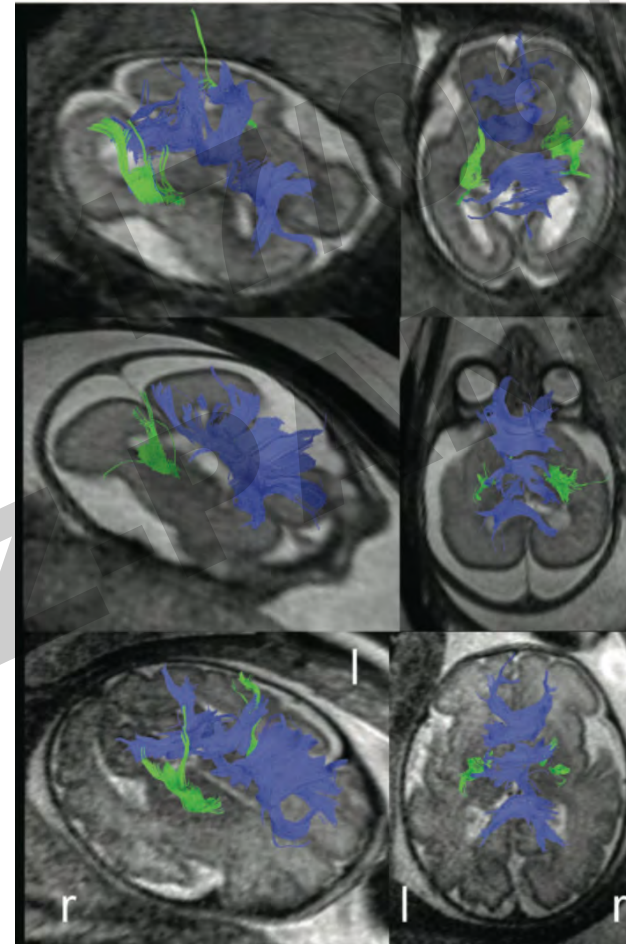


# Tractographie chez le foetus



ACC 21 SG  
Bandelettes de Probst

*Kasprian et 2013*



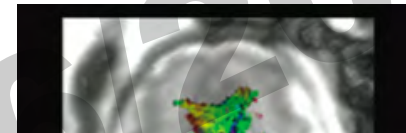
22 SG

27 SG

34 SG



# Indices DTI et modèles de maturation cérébrale

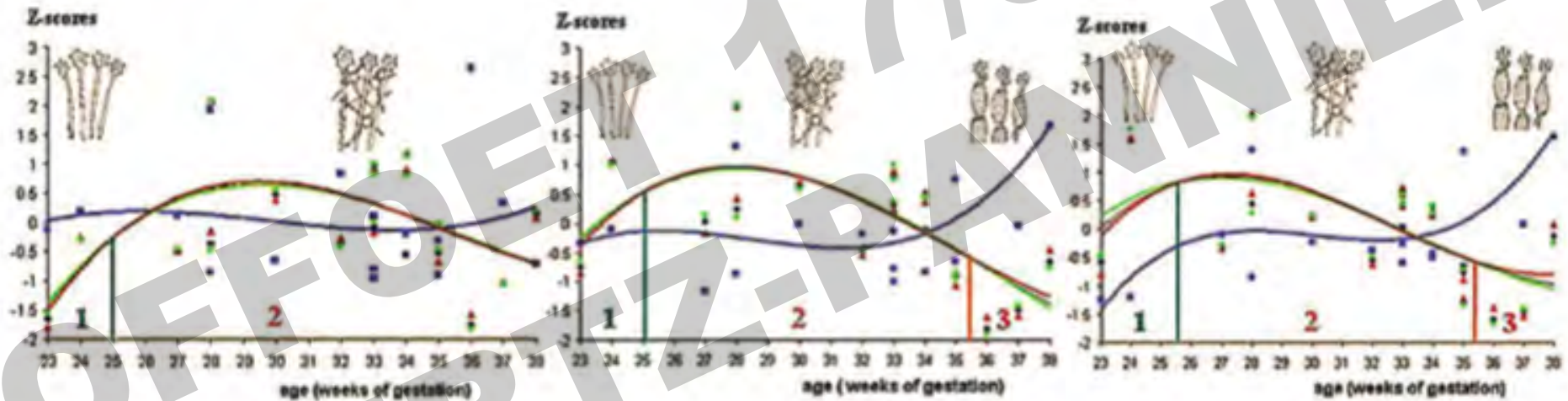


ADC  
FA

Genu

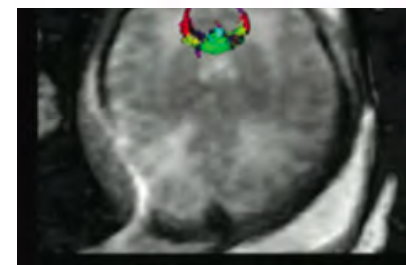
Body

Splenium

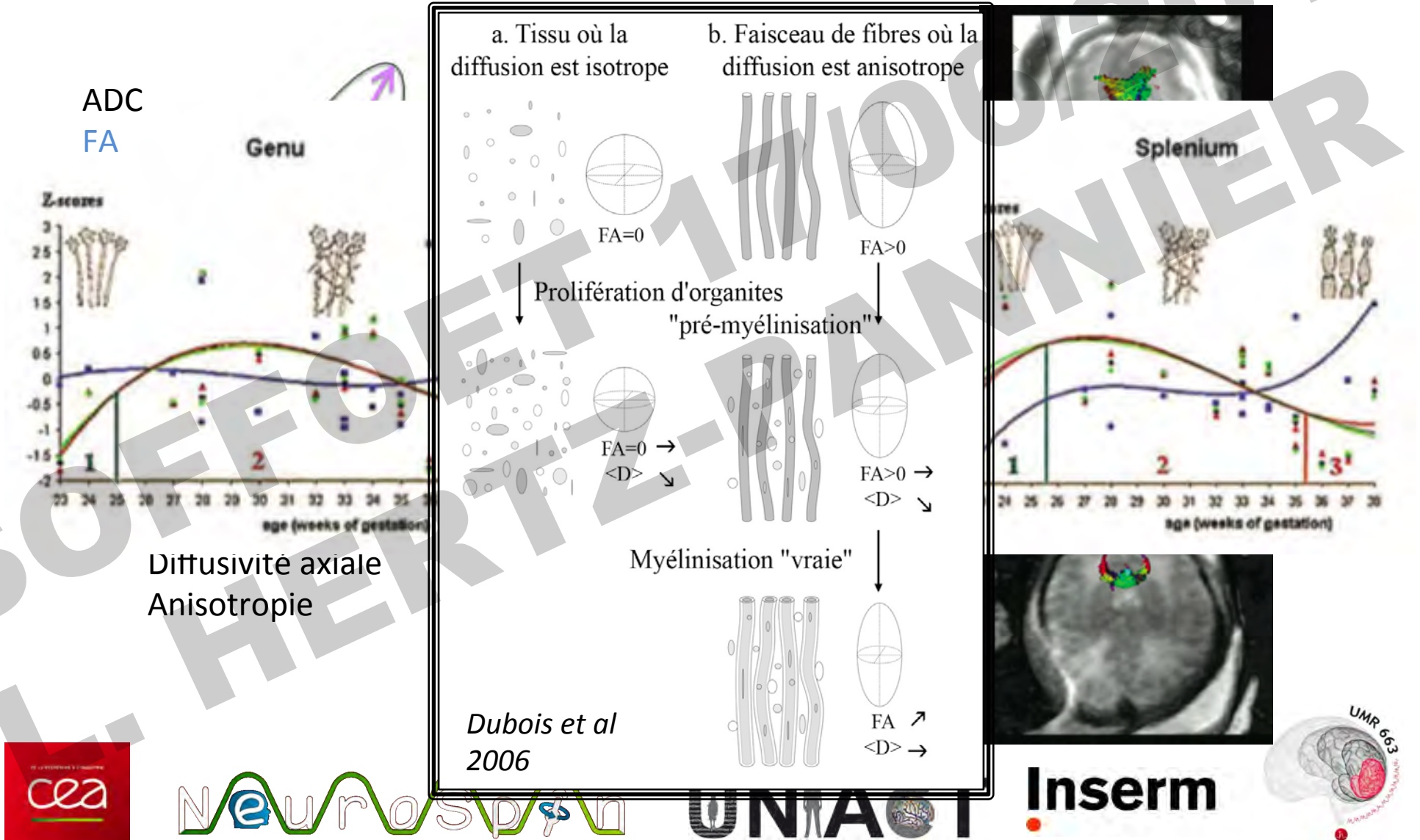


Diffusivité axiale  
Anisotropie

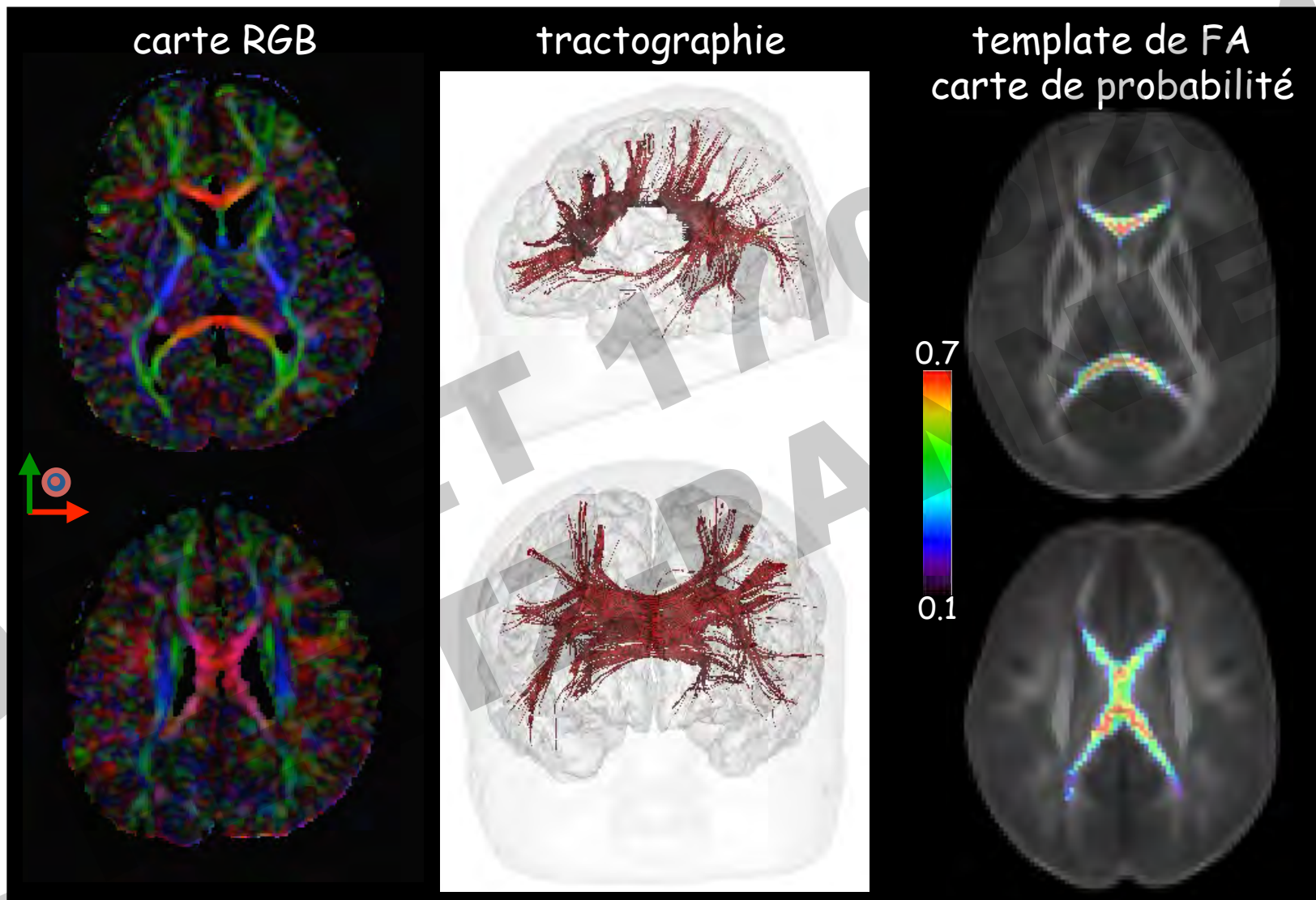
Zanin et al 2011



# Indices DTI et modèles de maturation cérébrale



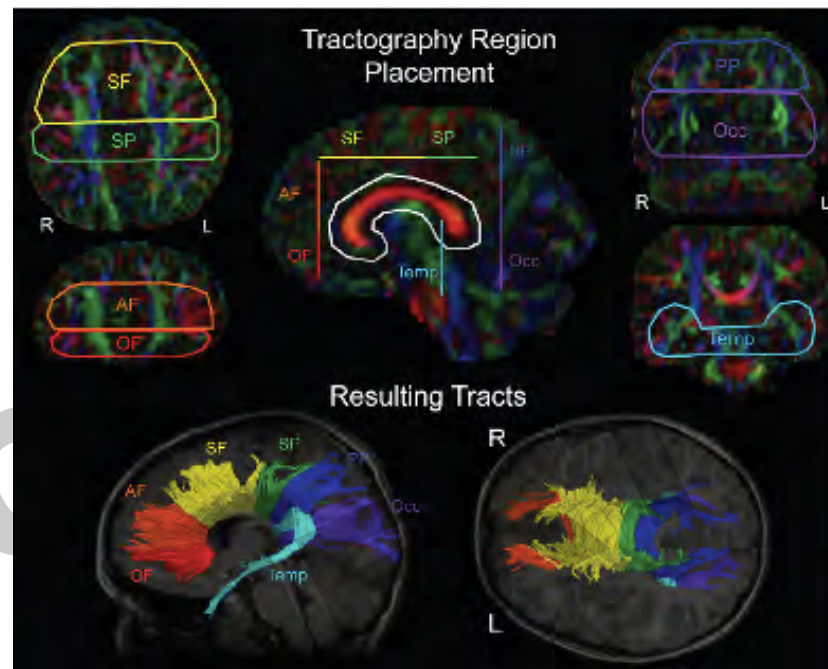
# Corps calleux chez le nourrisson



J Dubois, et al NeuroImage, 2006

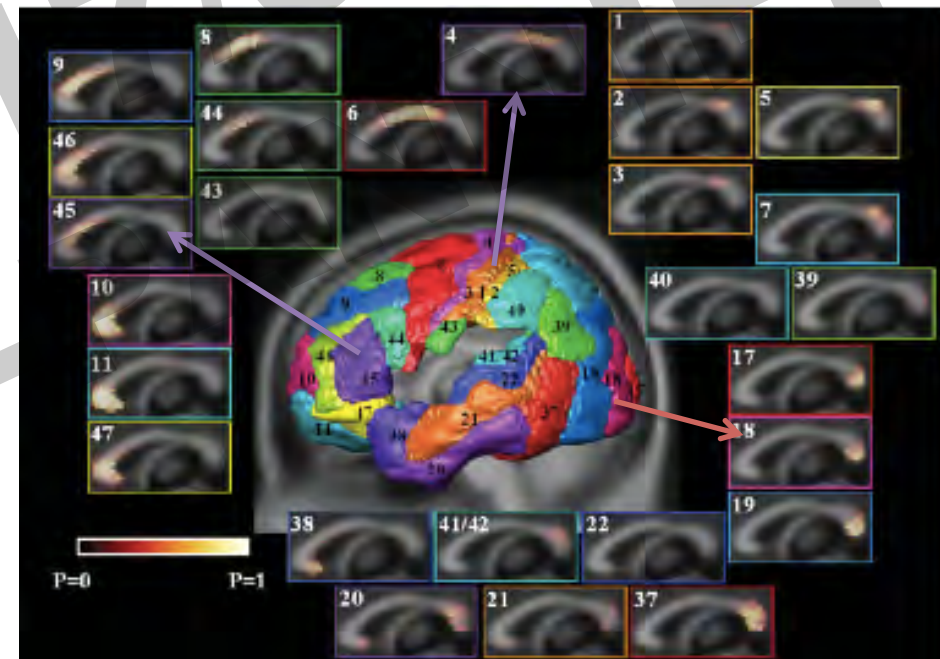
# Sous-segments du corps calleux

lobaire



*Lebel et al, 2010*

selon les aires de Brodmann:

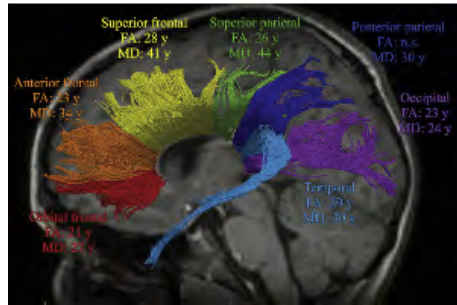


*Chao et al, 2009*

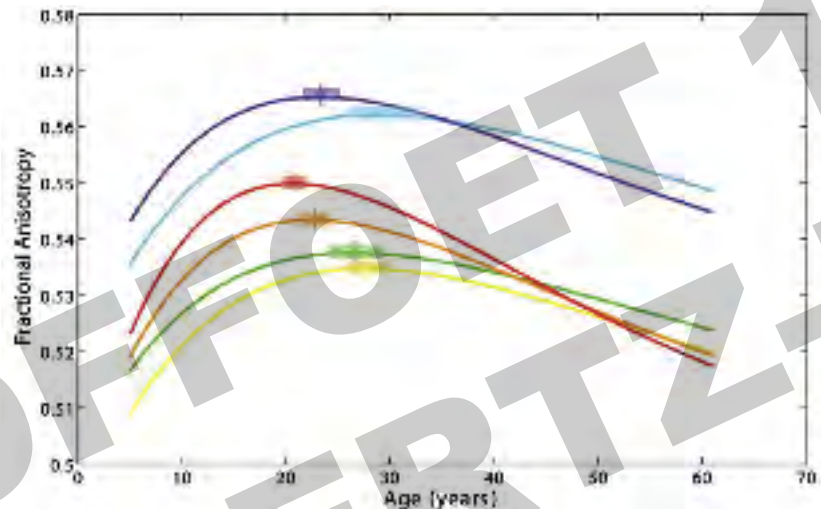


# Indices DTI adulte

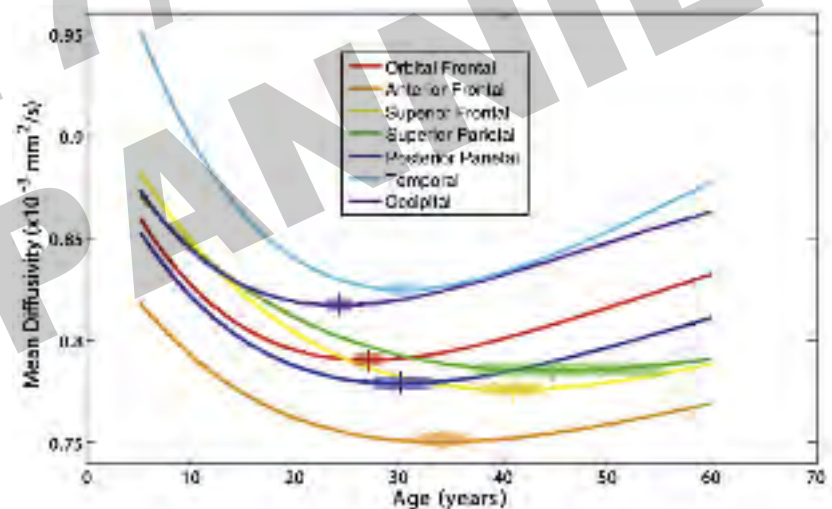
Lebel et al,  
2010



- Structure hétérogène selon l'axe antéro-postérieur.
- Modification de la structure avec l'âge.



Maturation axonale      Perte axonale  
Démyélinisation



Maturation axonale      Perte axonale  
Démyélinisation



# Diamètre axonal dans le CC

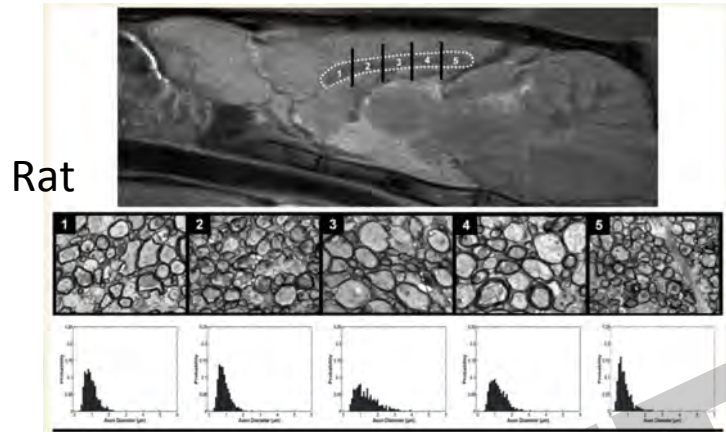


Figure 1 MRI and histological analysis of the corpus callosum. A mid-sagittal T<sub>2</sub>-weighted MRI of the rat brain with an inset containing the corpus callosum. The corpus callosum is sectioned into five segments from which histological specimens were taken. For each segment a representative electron-microscopy image is given along with the corresponding ADD histogram. Note the difference in ADD along different areas of the structure.

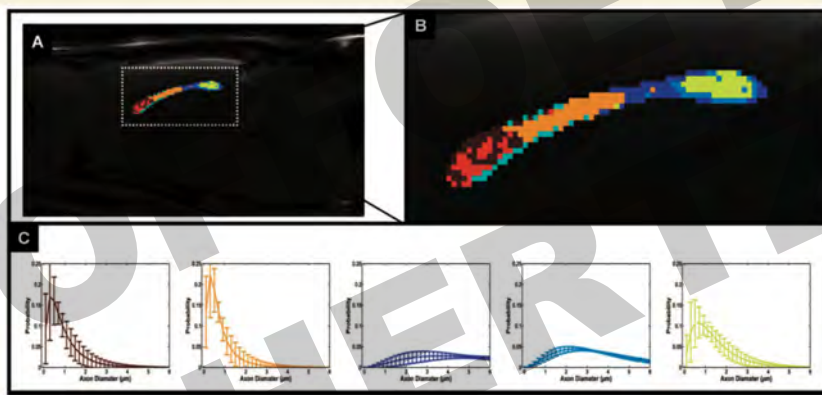
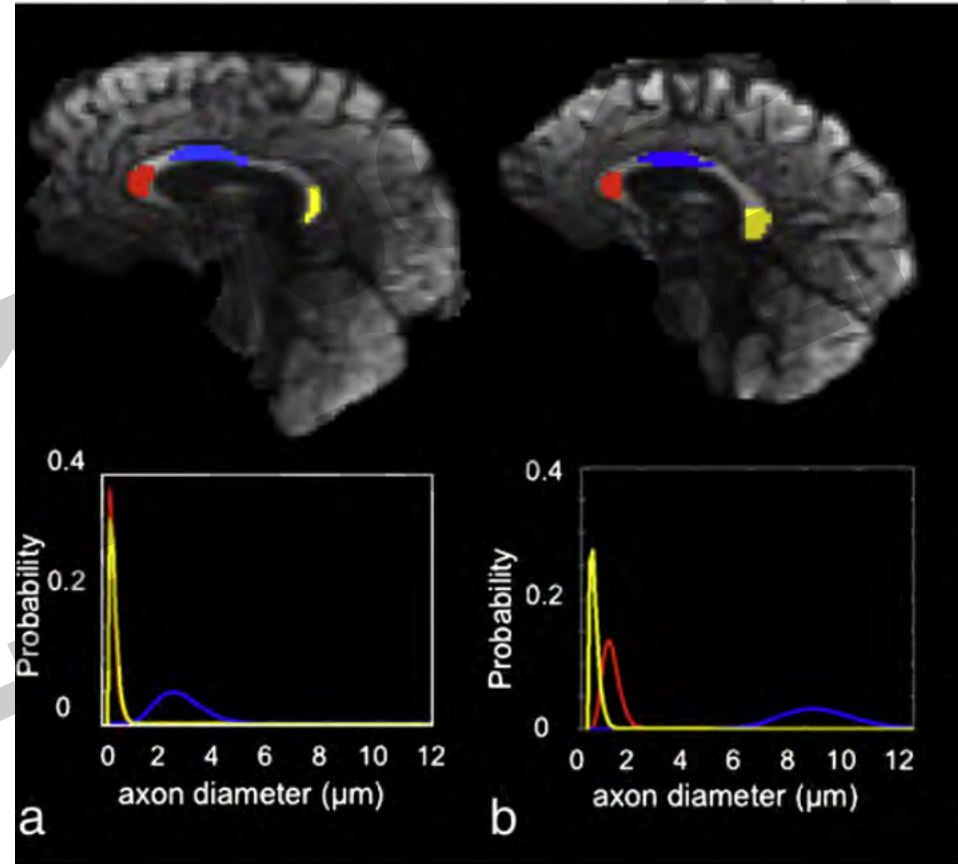


Figure 4 Cluster analysis of the axon diameter distribution along the corpus callosum. (A) A mid-sagittal T<sub>2</sub>-weighted MRI with the AxCaliber clusters superimposed, enlarged at (B). (C) The AxCaliber averaged ADDs for the different clusters given in (A) and (B); note that the colours of the graphs match the clusters' colours.



Homme

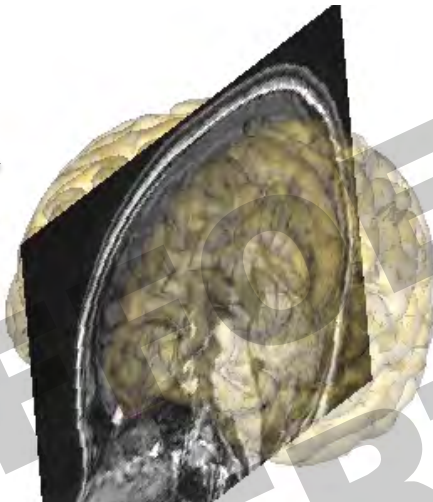
Mc Nab, 2013

Barazany, 2009



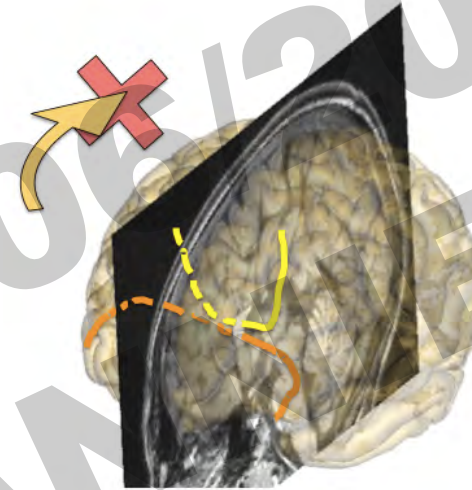
# Agénésies du corps calleux

4 ACC partielles  
6 ACC complètes  
10 ans  
QIT : 86-99

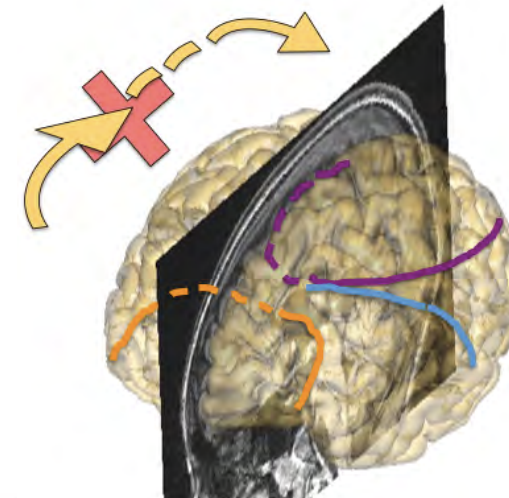


Agénésie complète

Syndromique  
Génétique  
Métabolique  
Toxique



Agénésie partielle clastique



Agénésie partielle segmentaire

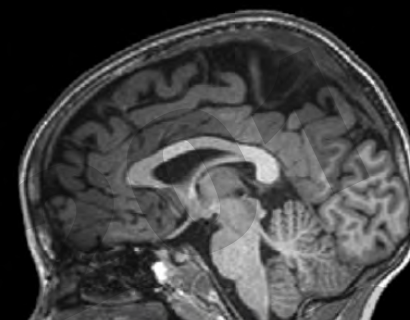
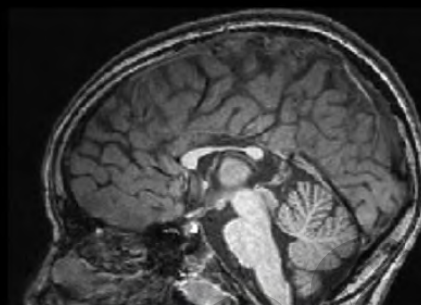
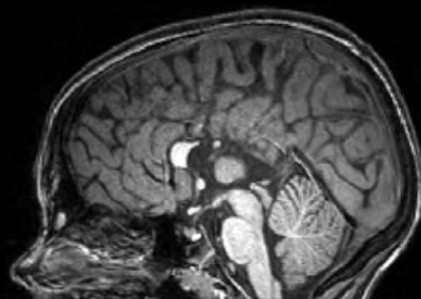
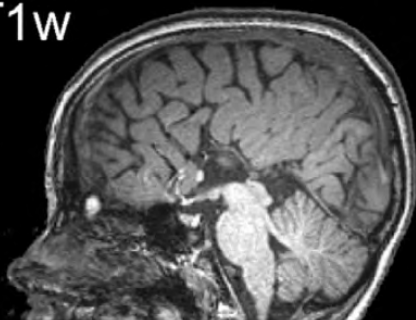
Complete CCAg

Partial CCAg

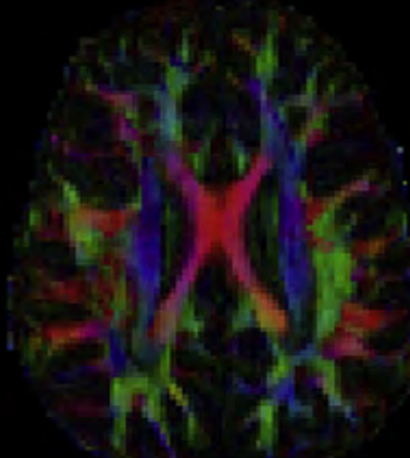
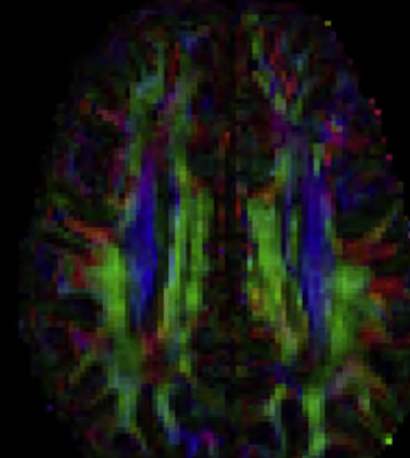
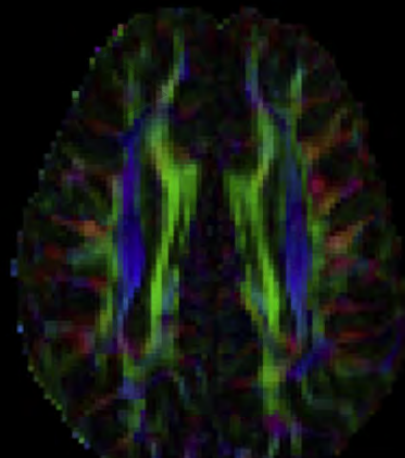
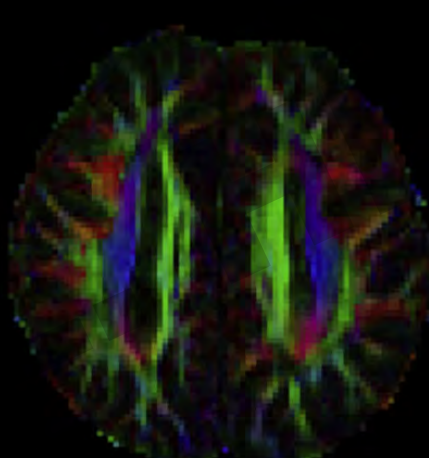
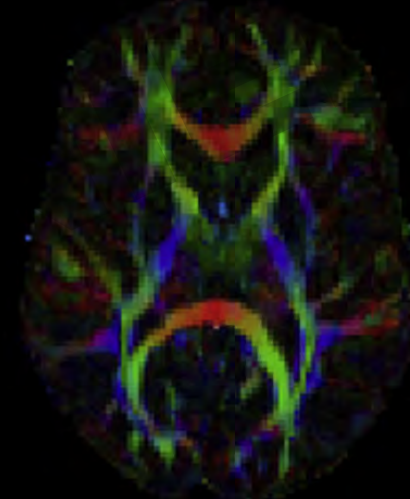
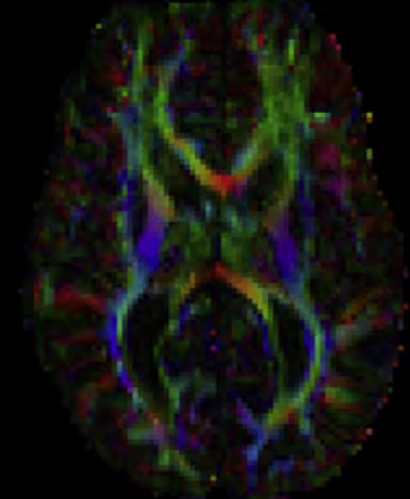
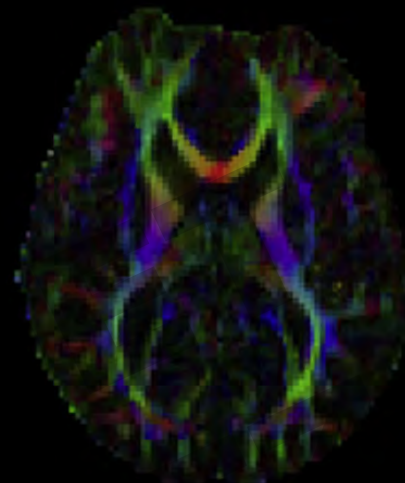
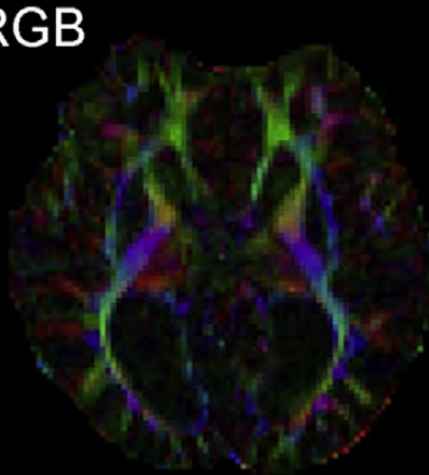
CC hypoplasia

Control

T1w

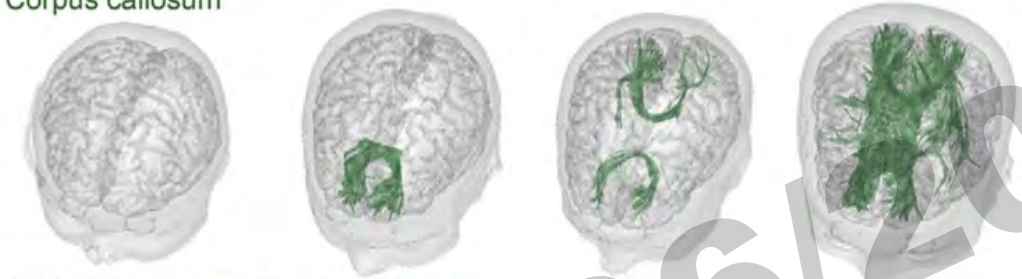


RGB

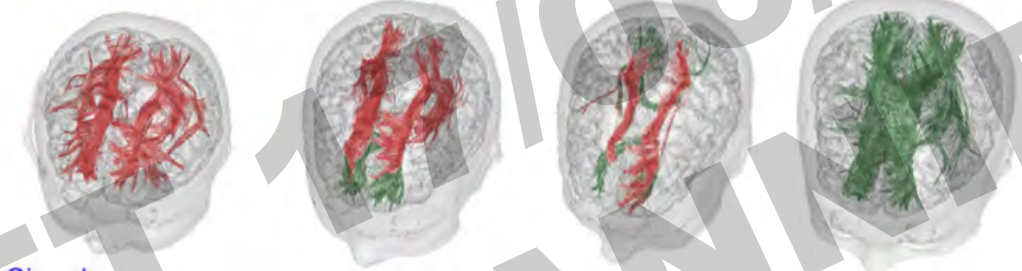


**a**

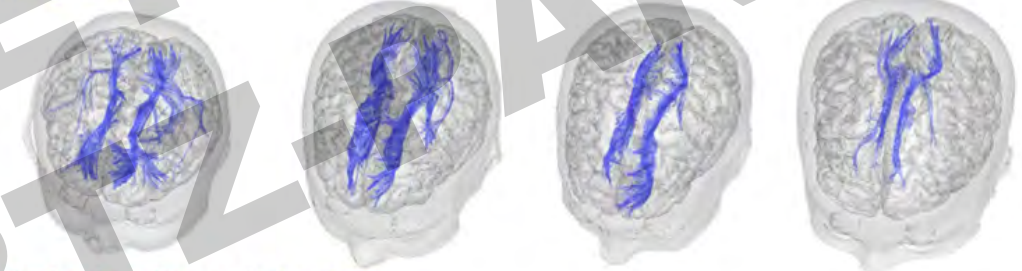
Complete CCAg    Partial CCAg    CC hypoplasia    Control  
Corpus callosum



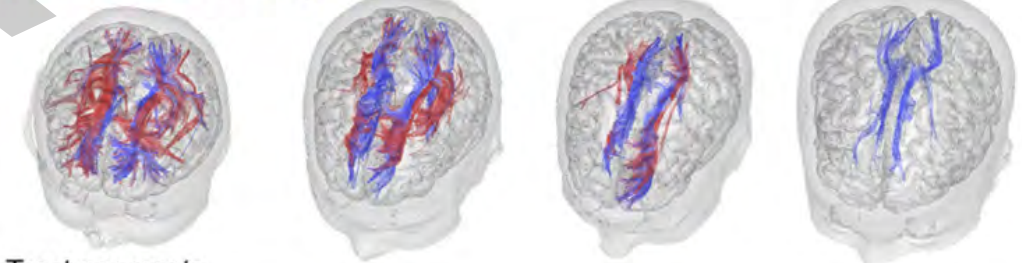
Probst bundles and corpus callosum



Cingulum



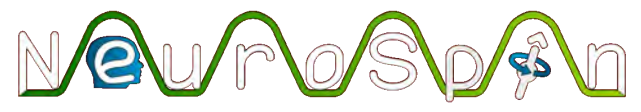
Probst bundles and cingulum



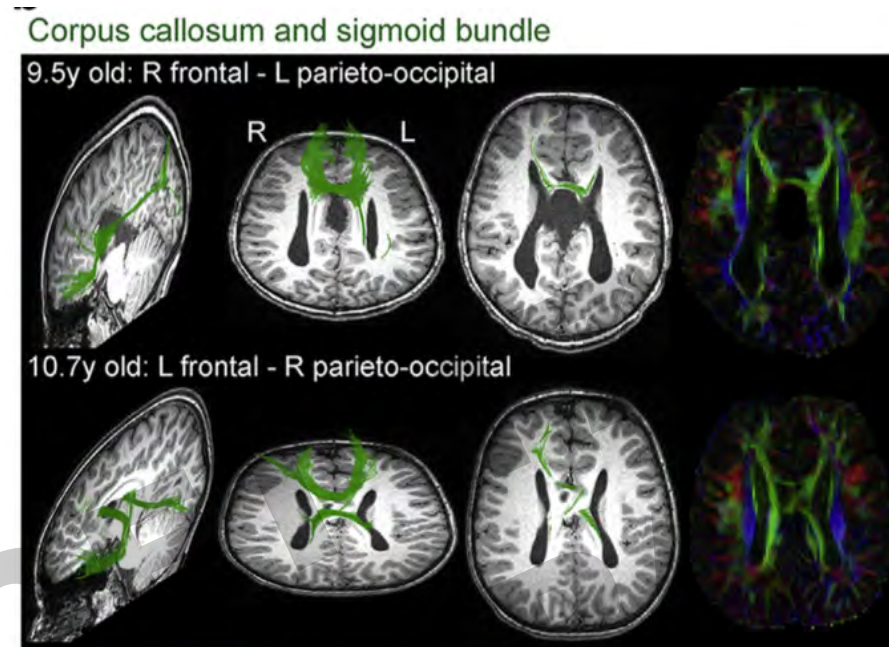
Les BP ne sont pas que AP !  
Connectivité cortico-corticale

Pas de gyrus cingulaire  
Mais un faisceau cingulaire  
Plus gros ?

SOFFERT  
L. HERITIER  
1106/2016  
ANNEXE



# Agénésie partielle et faisceau sigmoïde

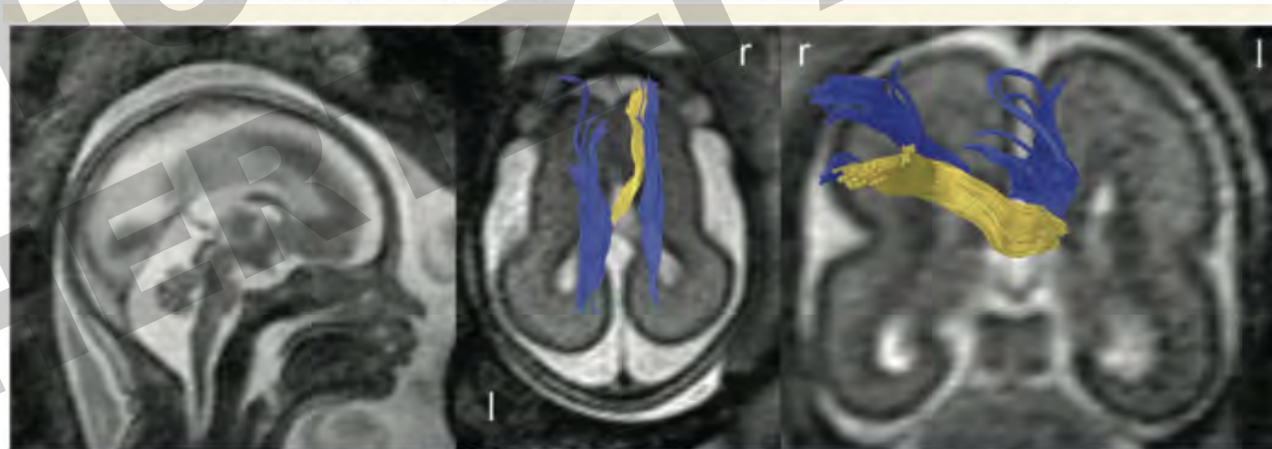


Benezit et al 2015

Tovar-Moll 2007

Lien avec le Pc  
cognitif  
réservé ?

Kasprian  
et al 2013

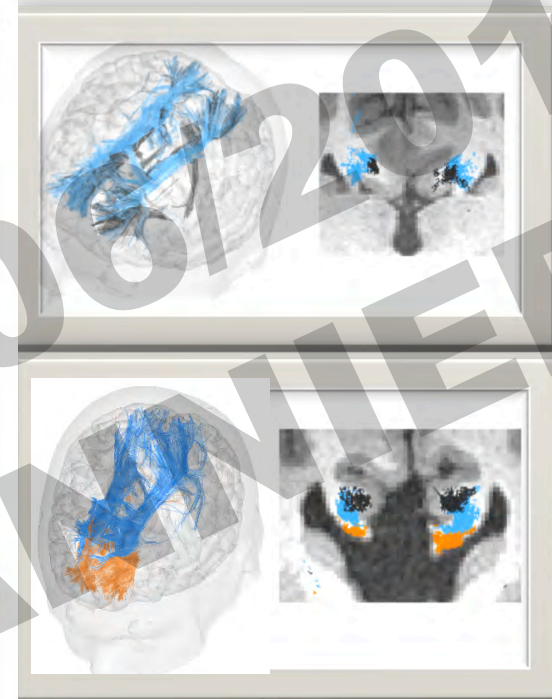
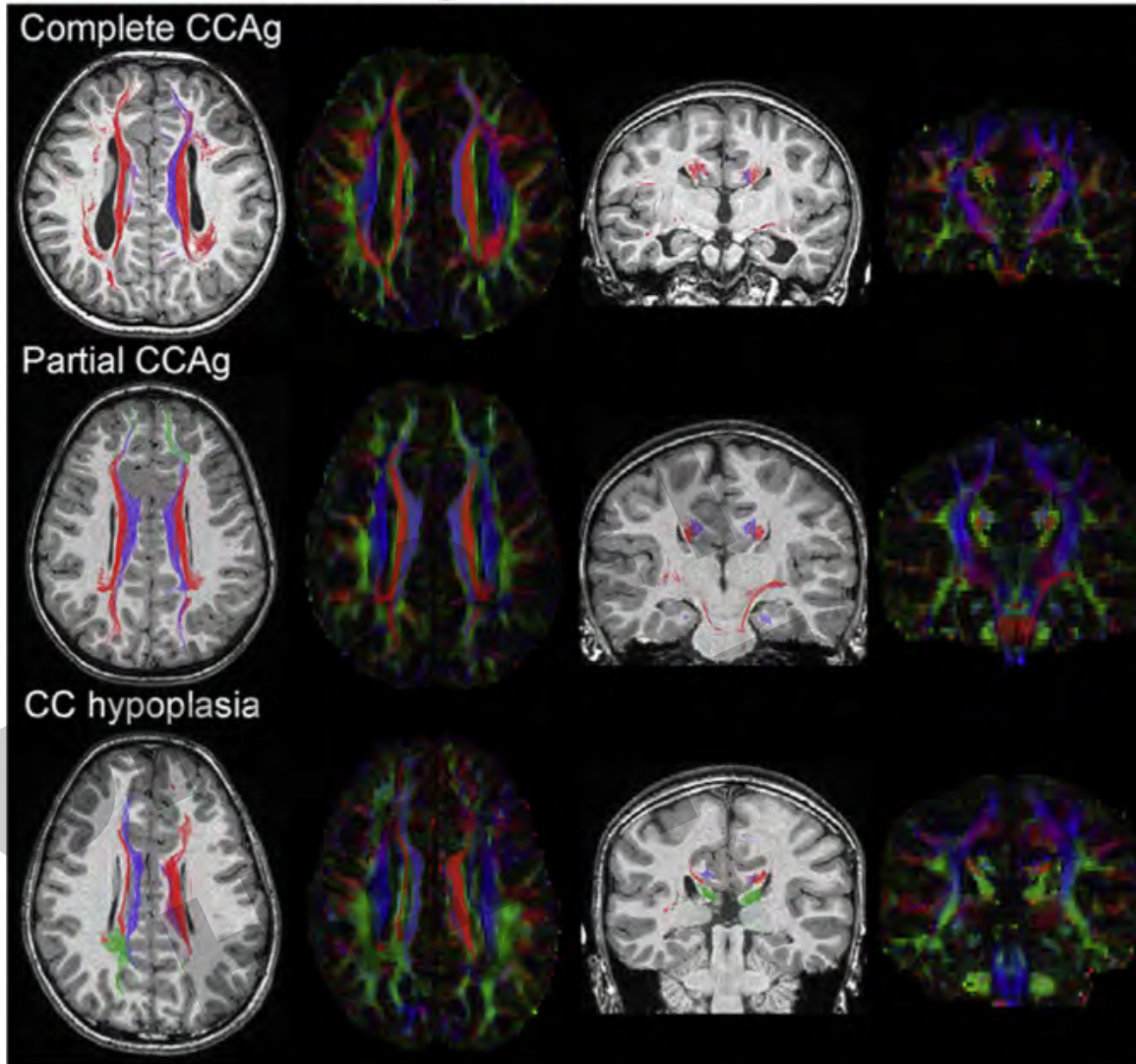


22 SG



# Bandelettes de Probst

## Probst bundles and cingulum

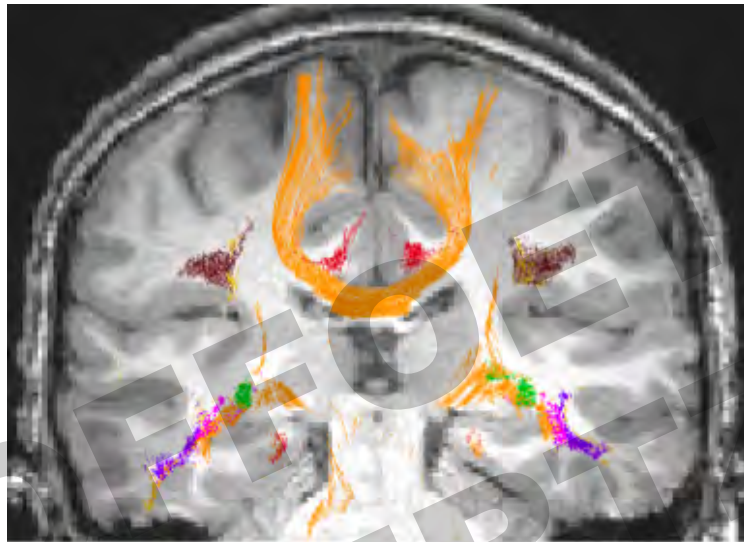


- Les BP sont dorsales par rapport au CC
- Leur microstructure est proche de celle du CC
- Informe sur l'origine précoce ou non de l'hypoplasie ?

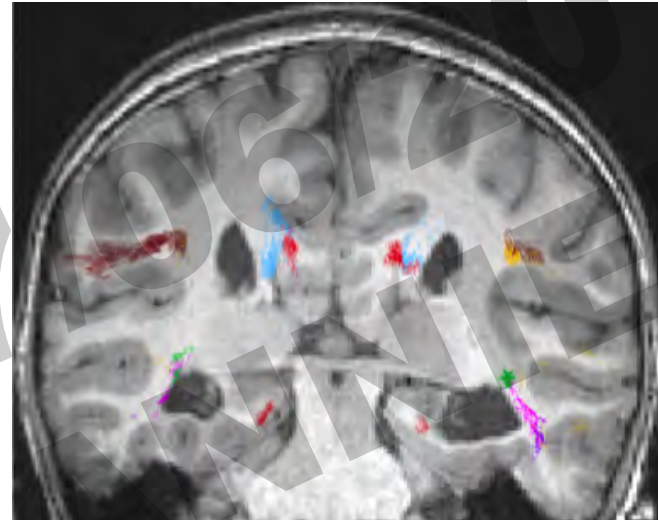
*Benezit et al 2015*

# Et la colpocephalie ?

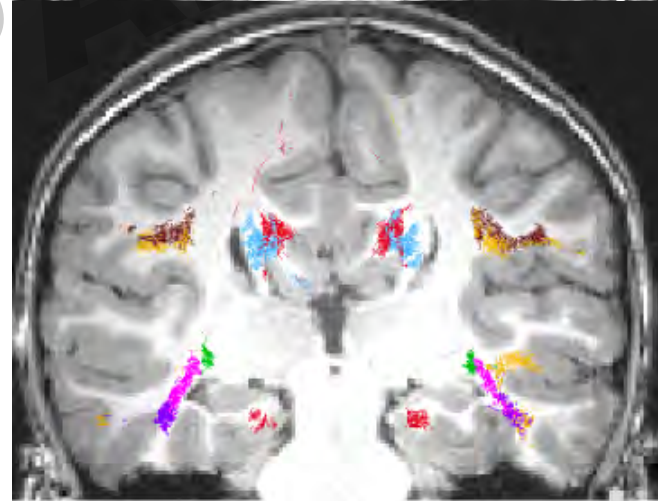
Organisation et microstructure  
'normale' des autres faisceaux



ACC  
complète



ACC  
partielle



Elle est exclusivement liée à  
l'absence de corps calleux



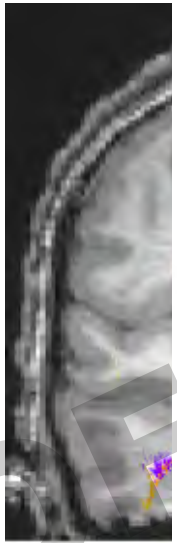
Complete CCAg  
Projection bundles

Partial CCAg

CC hypoplasia

Control

Organ  
'norm



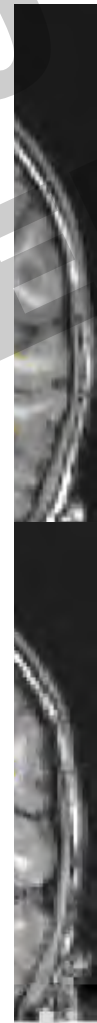
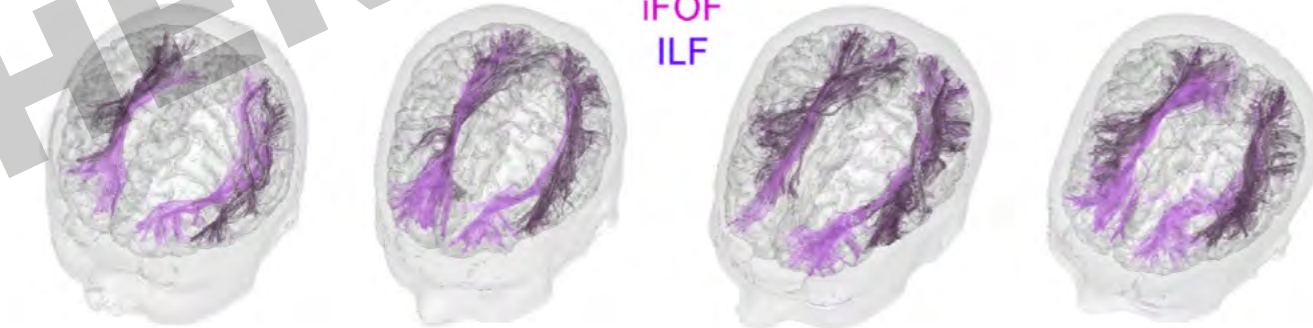
Association bundles

AF  
SLF  
postAF  
UF



Elle e  
l'abs

iFOF  
ILF



# Conclusion

Enorme potentiel pour

- Comprendre les anomalies de la connectivité anatomique
- Comprendre leur genèse
- Comprendre les déficits cognitifs associés
- Affiner le pronostic



# Ecueils

- Imagerie fœtale:
  - Mouvements fœtaux
  - Résolution spatiale
  - Distance antennes-cerveau foetal
- Temps d'acquisition (recherche vs clinique)
- Algorithmes de tractographie
- Temps d'analyse ....

