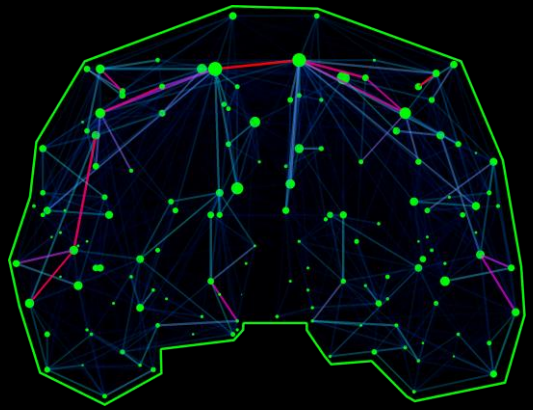
Advances in structural and functional connectivity *visualization* using the Fibernavigator



Maxime Chamberland

Computational Brain Connectivity Mapping

Winter School Workshop 2017 - November 20-24, Juan-les-Pins, France

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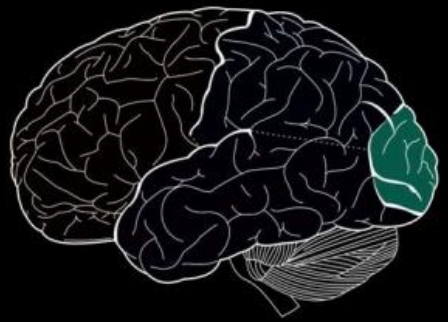
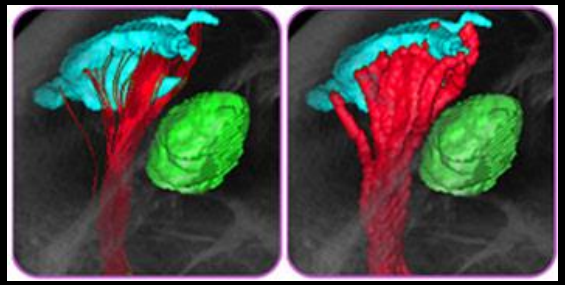
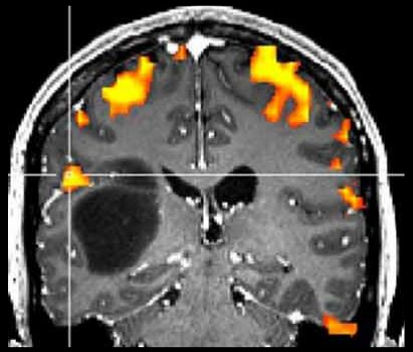
Disclaimer ⚠️

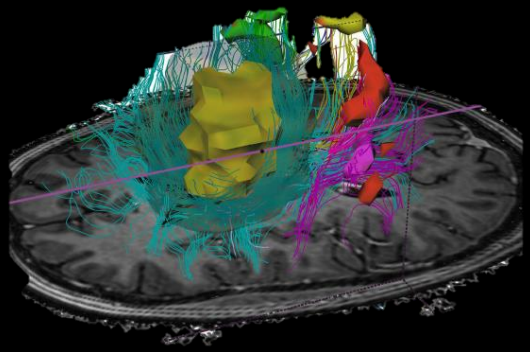
“Non-rocket science”

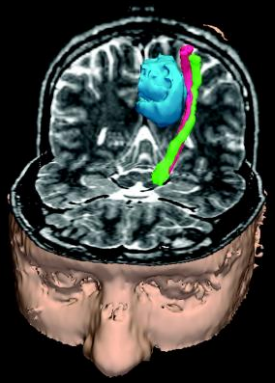


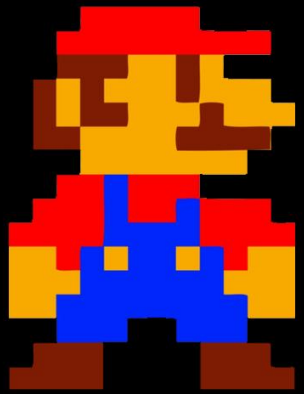
3D rendering - Medical imaging











1985

1996

2013

Source: Google images

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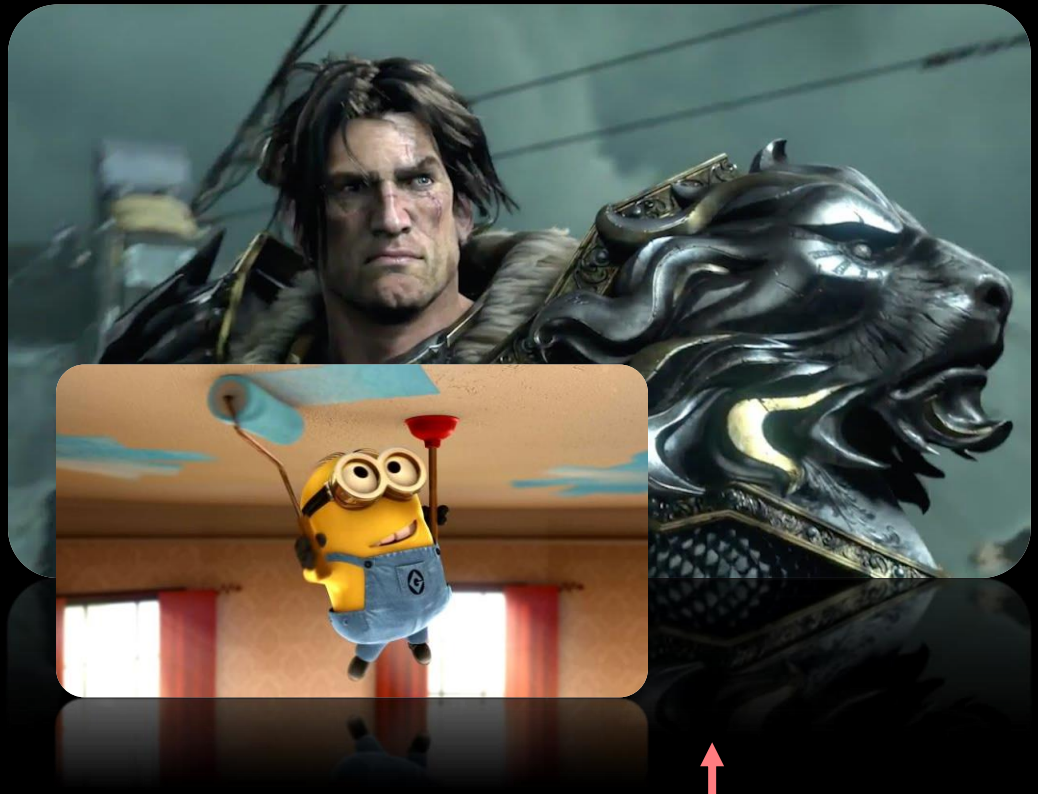
Real-time vs offline



Not real-time

- How fast these images or frames are generated in a given second, determines the method's real timeliness.
- Difference between real-time and non-real-time graphics is the interactivity desired in real-time graphics.

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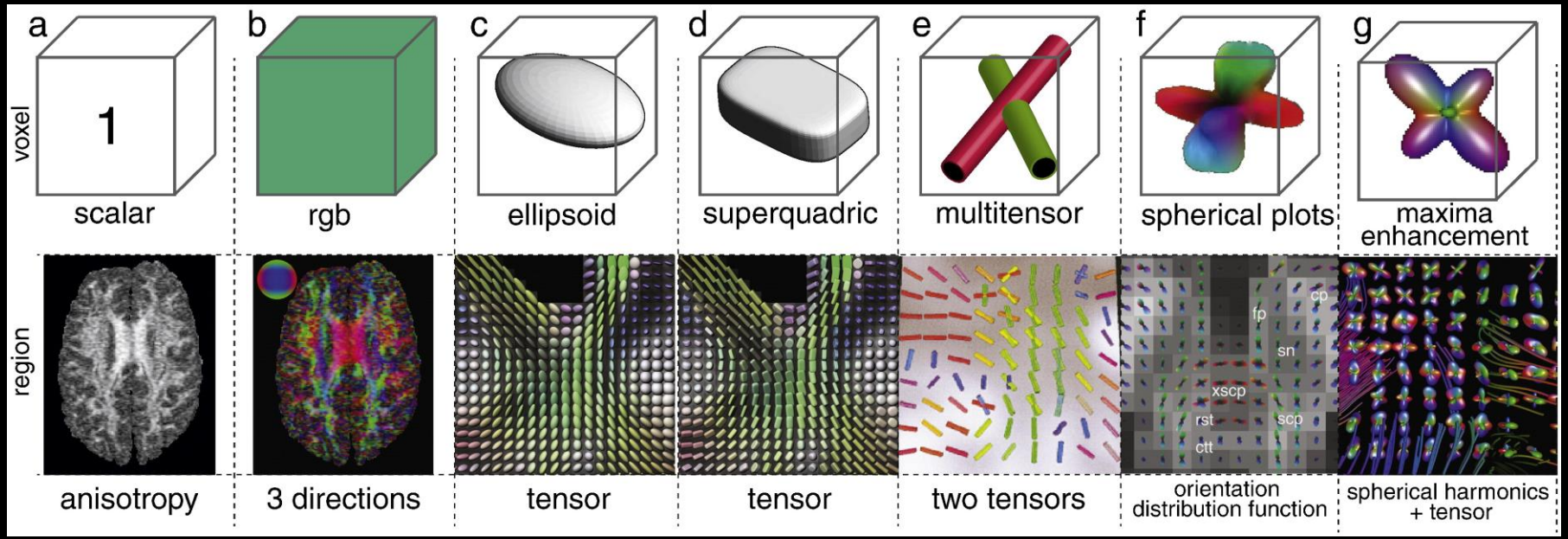
Scientific visualization - dMRI



Margulies, D. S., et al. (2013)
Visualizing the human connectome. *NeuroImage* 80 (2013): 445-461.

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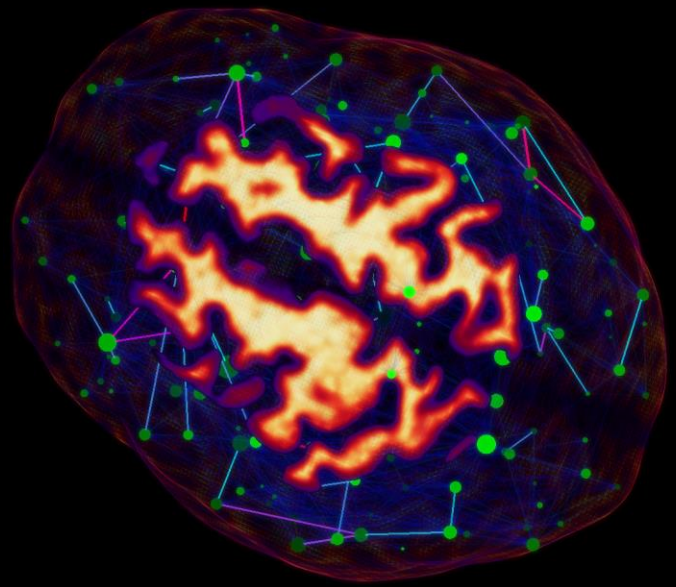
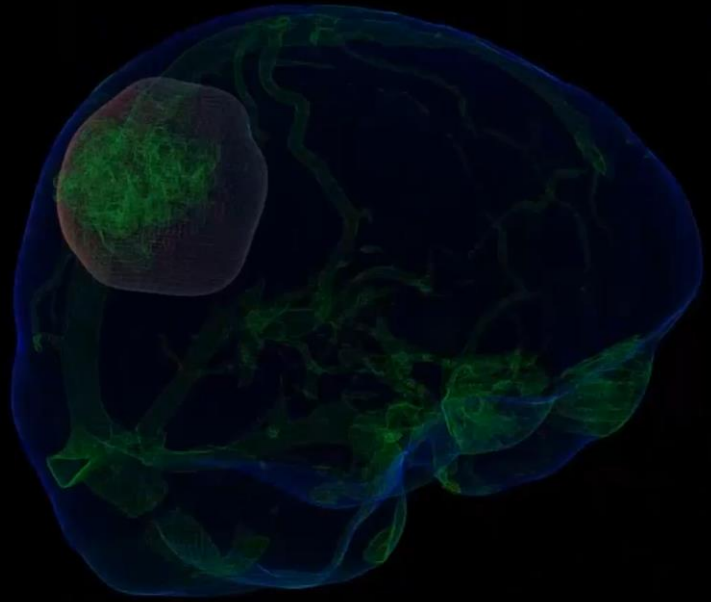
Providing interactivity





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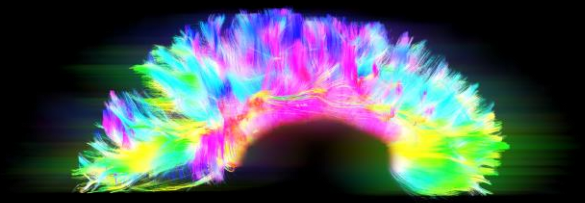
Outline

I. Real-time Connectivity
   I. Functional Connectivity *on-the-fly*
   II. FC-driven Tractography
   III. Real-time Tractography (RTT)
   IV. Tractography-driven FC

II. Visualization goodies
   I. Glass brain
   II. TDI / Slicing
   III. Opacity rendering
   IV. Connectomics



FiberNavigator

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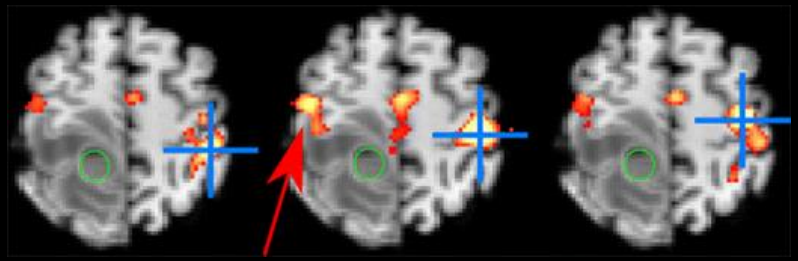
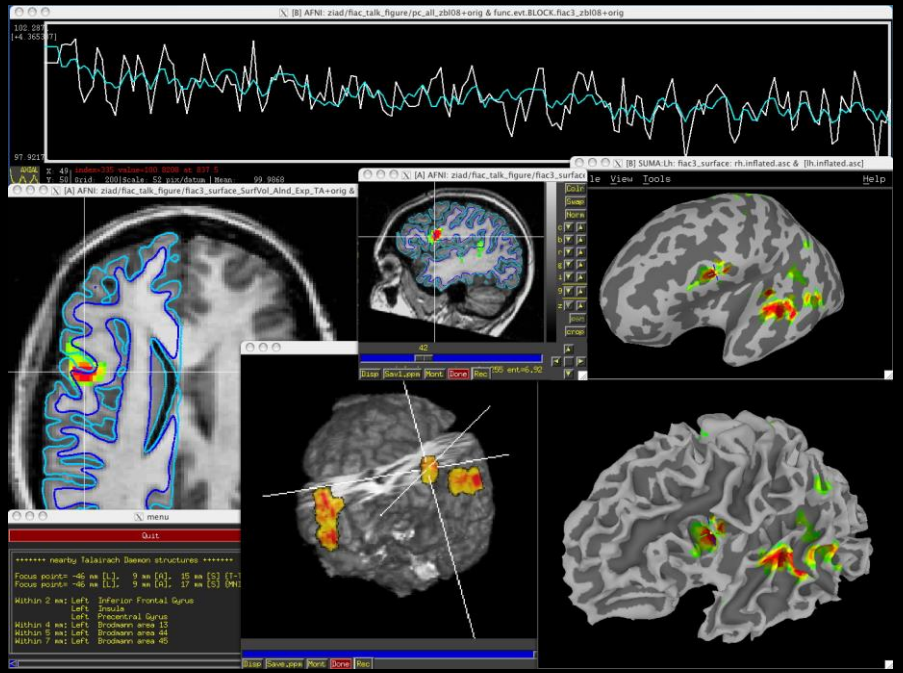
I.I Functional Connectivity *on-the-fly*





Böttger, J. et al. (2011). A software tool for interactive exploration of intrinsic functional connectivity opens new perspectives for brain surgery." *Acta neurochirurgica* 153.8 (2011): 1561-1572.

Taylor, Paul A., and Ziad S. Saad. "FATCAT:(an efficient) functional and tractographic connectivity analysis toolbox." *Brain connectivity* 3.5 (2013): 523-535.

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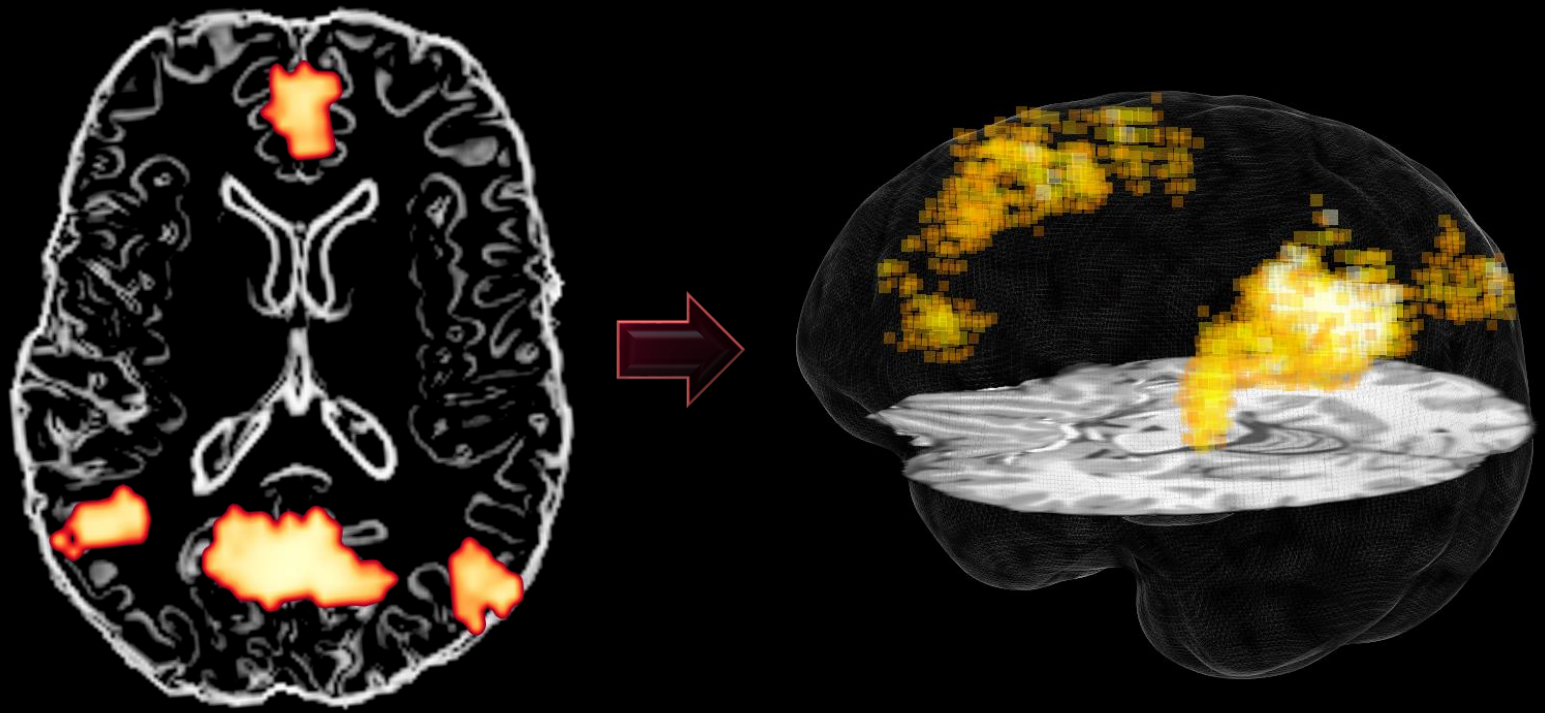
I.I Functional Connectivity *on-the-fly*

+Demo



Chamberland, M. et al. (2015).
3D interactive tractography-informed resting-state fMRI connectivity. *Frontiers in neuroscience*, *9*, 275.

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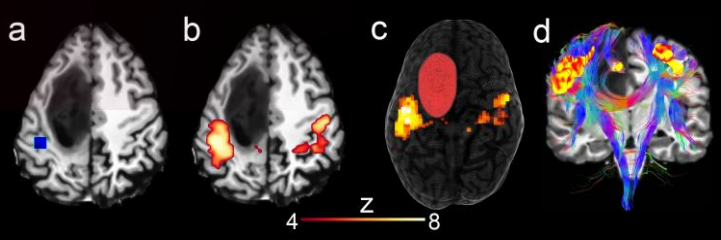
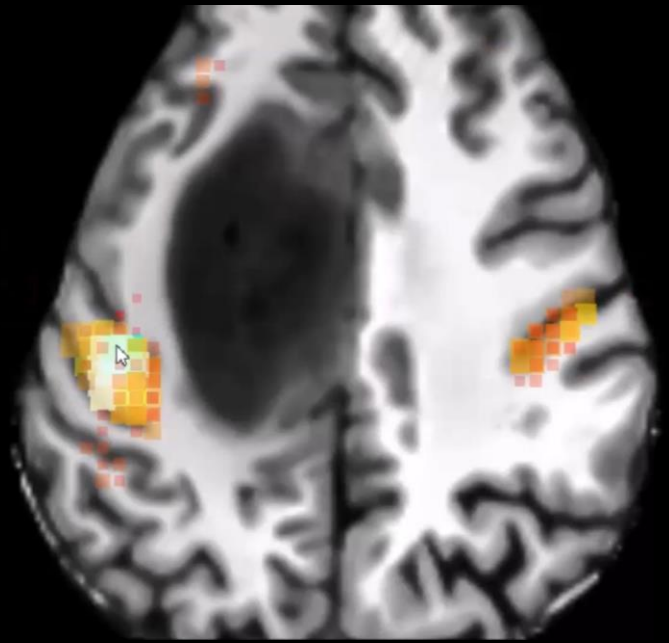
I.II fMRI-driven Tractography





Chamberland, M. et al. (2015).
3D interactive tractography-informed resting-state fMRI connectivity. *Frontiers in neuroscience*, *9*, 275.

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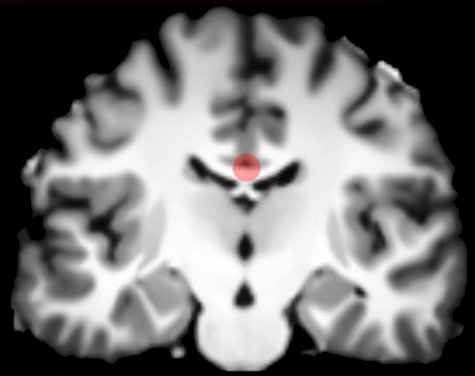
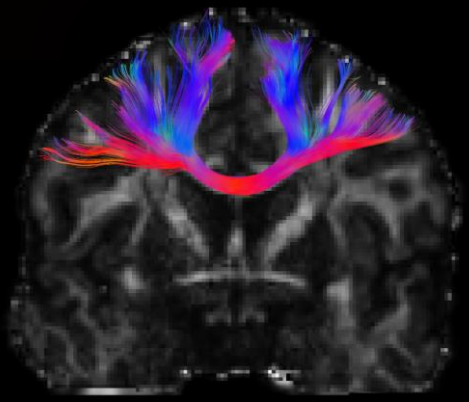
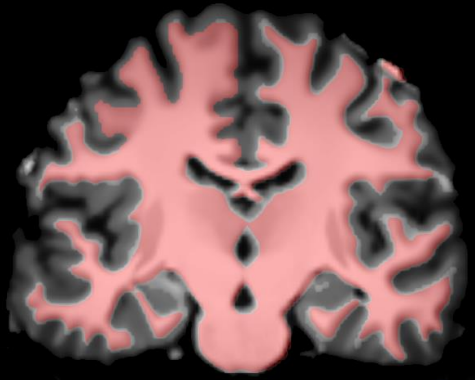
I.II Standard tractography

- Step size (0.1 - 1mm)
- Angular threshold (30 - 45°)
- Min/Max length (20 – 200mm)
- # of seeds (1k – 2M)
- …







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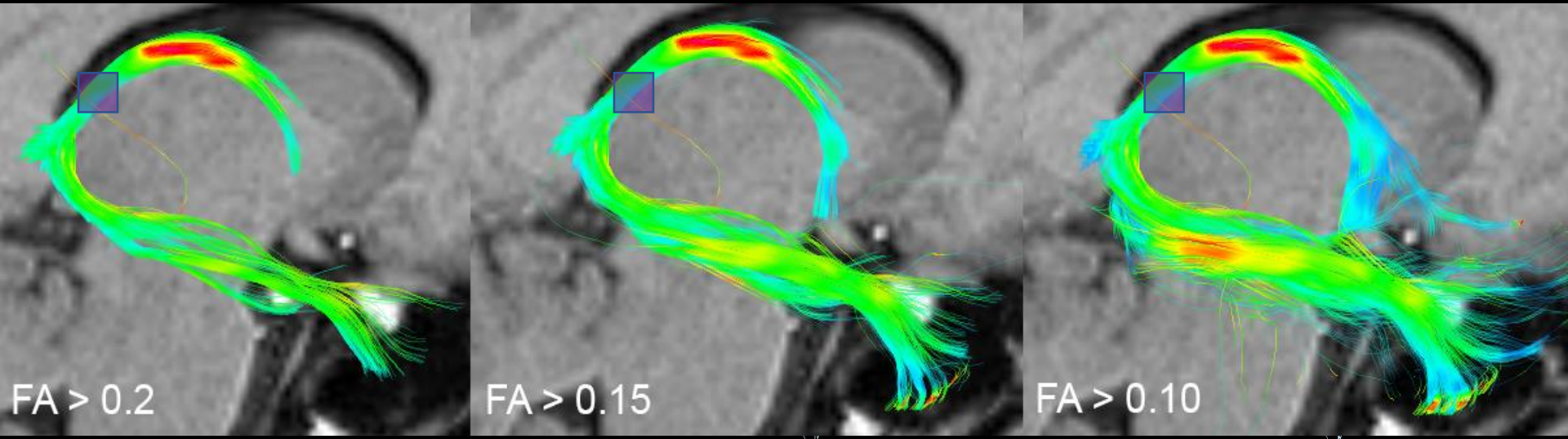
I.II **Real-time** Tractography

+Demo



(Step size, Angular Threshold, Mask Threshold, # of seeds, etc.)

Chamberland, M. et al. (2014).
Real-time multi-peak tractography for interactive connectivity display. *Frontiers in neuroinformatics*, 8.

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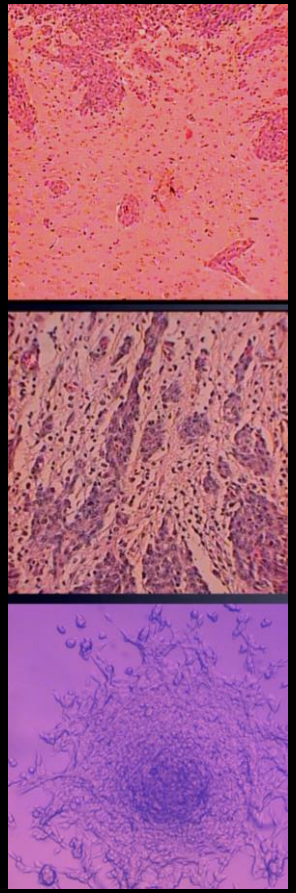
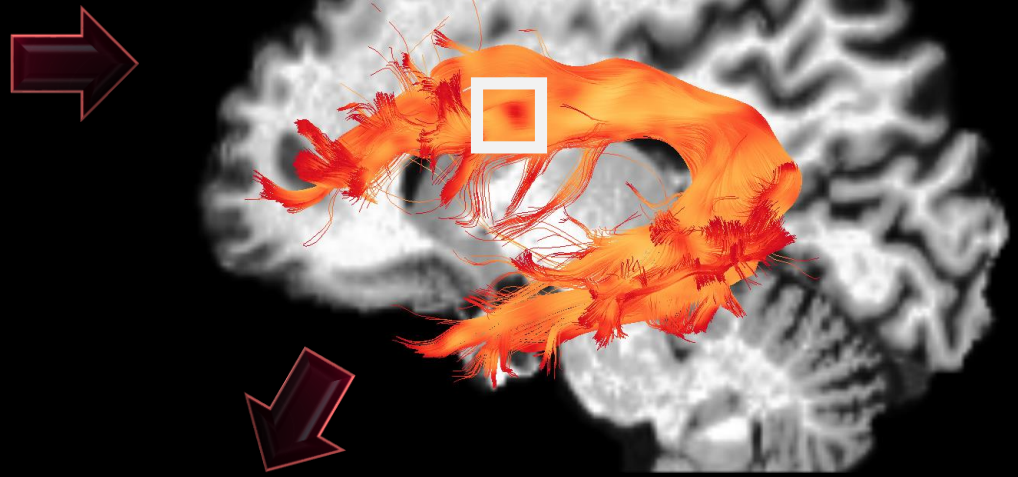
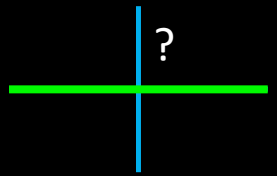
I.II Microstructural mapping *per* peak







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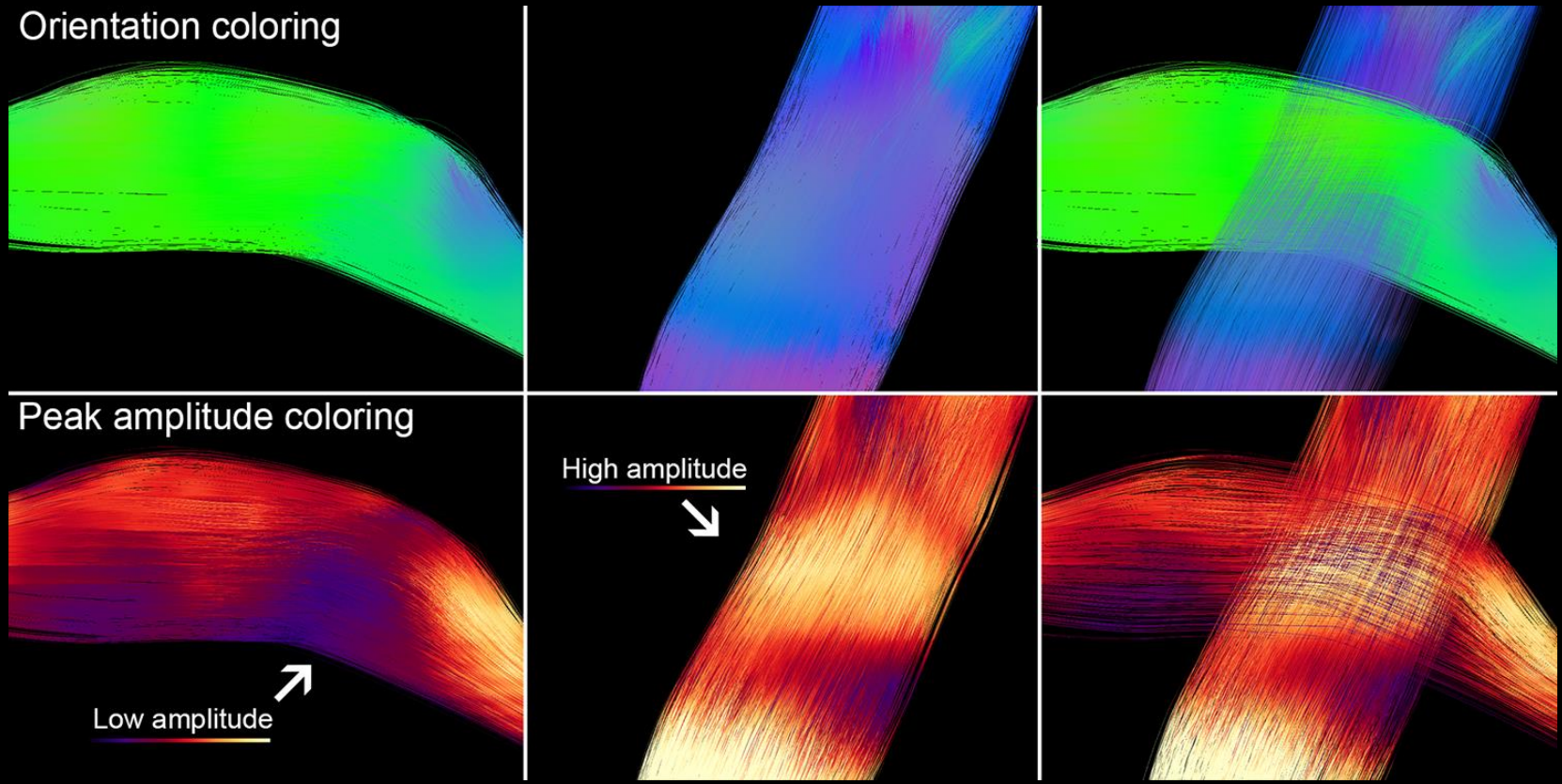
I.II Microstructural mapping *per* peak



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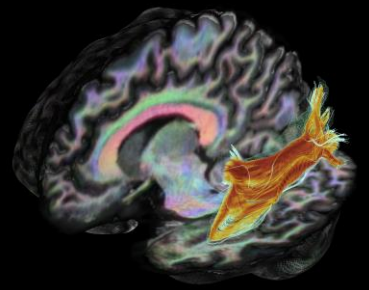
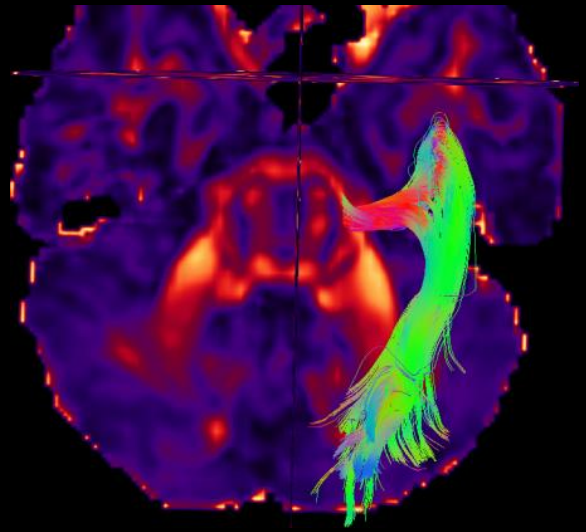
I.II **Real-time** Tractography: Meyer's loop





Chamberland, M. et al. (2017).
Active delineation of Meyer's loop using oriented priors through MAGNEtic tractography (MAGNET).
Human Brain Mapping, *38*(1), 509-527.

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I.II **Real-time** Tractography: Meyer’s loop

Chamberland, M. et al. (2017).
Active delineation of Meyer's loop using oriented priors through MAGNEtic tractography (MAGNET).
Human Brain Mapping, *38*(1), 509-527.

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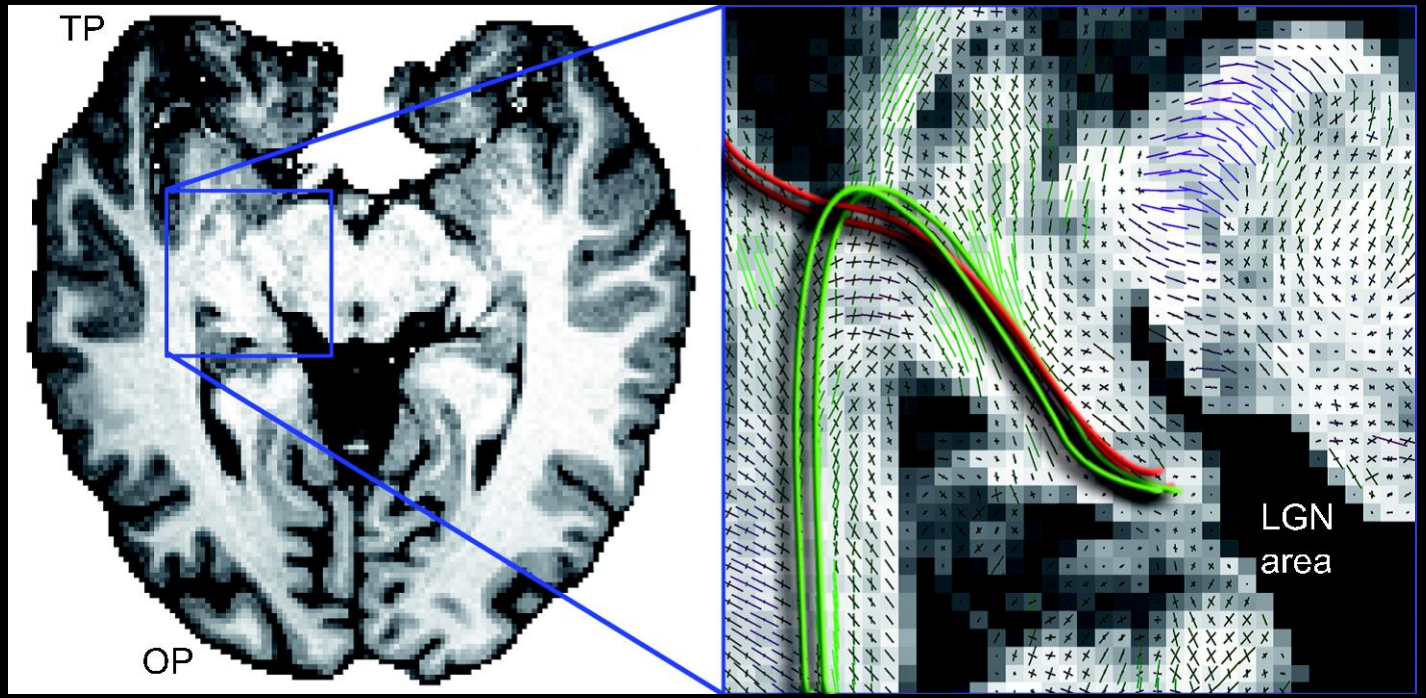
I.II **Real-time** Tractography: Meyer’s loop



Chamberland, M. et al. (2017).
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Human Brain Mapping, *38*(1), 509-527.

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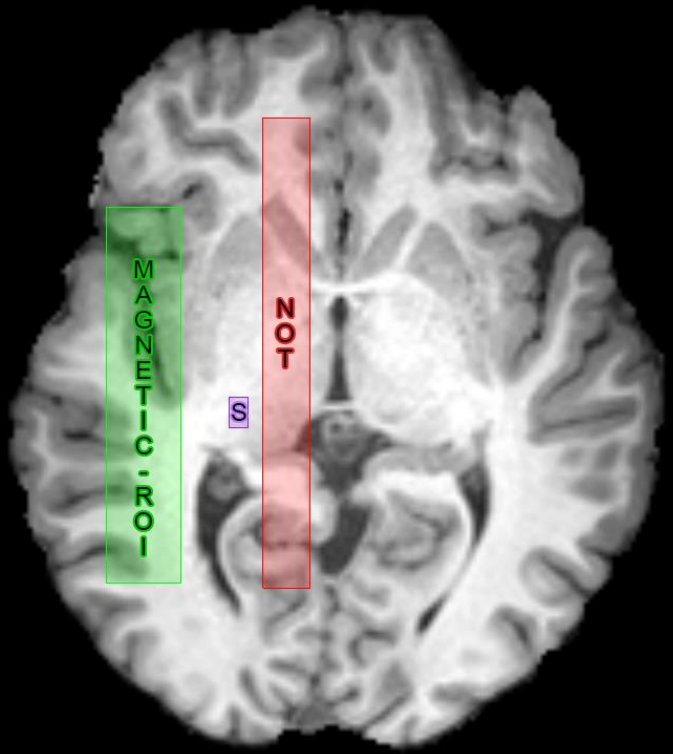
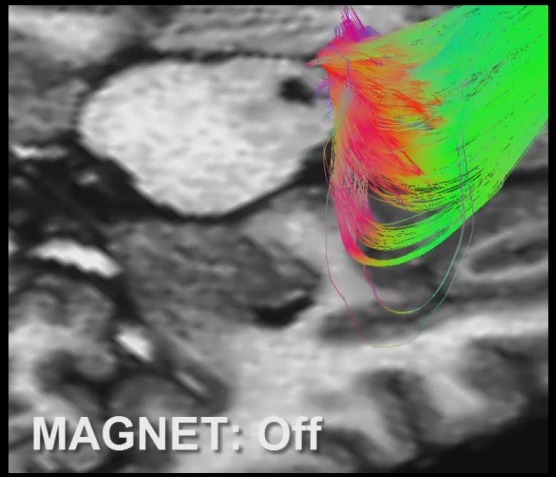
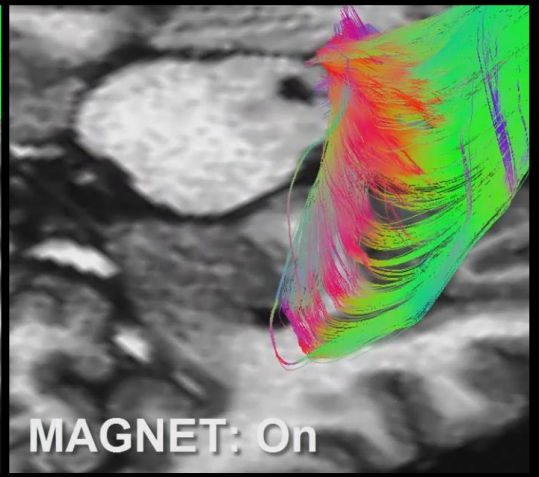
I.II **Real-time** Tractography: Meyer's loop







Chamberland, M. et al. (2017).
Active delineation of Meyer's loop using oriented priors through MAGNEtic tractography (MAGNET).
Human Brain Mapping, *38*(1), 509-527.

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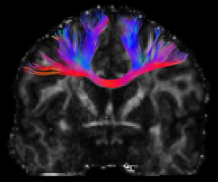
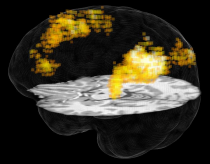
I.IV Tractography-driven fMRI



Functional Connectivity (FC) *on the fly*

Structural Connectivity (SC) *on the fly*



FC-derived SC (Tracts from blobs)

SC-derived FC (Blobs from tracts)?

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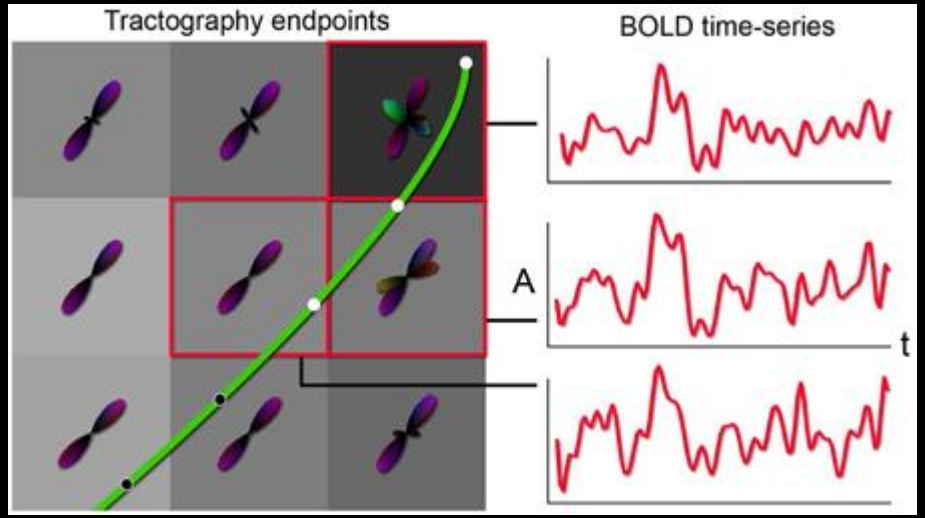
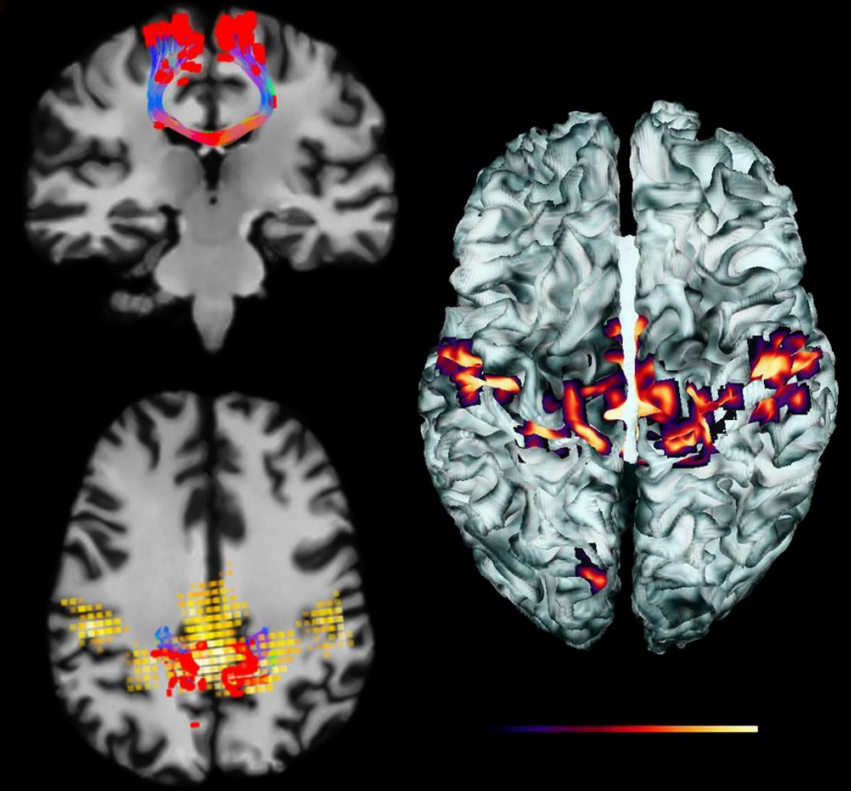
I.IV Tractography-driven fMRI





Chamberland, M. et al. (2015).
3D interactive tractography-informed resting-state fMRI connectivity. *Frontiers in neuroscience*, *9*, 275.

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II. Visualization goodies

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II.I Glass brain

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II.II Slicing Options

+Demo

Calamante, F. et al. (2010).
Track-density imaging (TDI): super-resolution white matter imaging using whole-brain track-density.
Neuroimage 53.4: 1233-1243.

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II.III Orientation-Dependent Opacity Rendering

Interactive real-time
orientation-dependent opacity rendering

Tax, Chantal MW, et al.
"Seeing more by showing less: Orientation-dependent transparency rendering for fiber tractography visualization." *PloS one* 10.10 (2015): e0139434.

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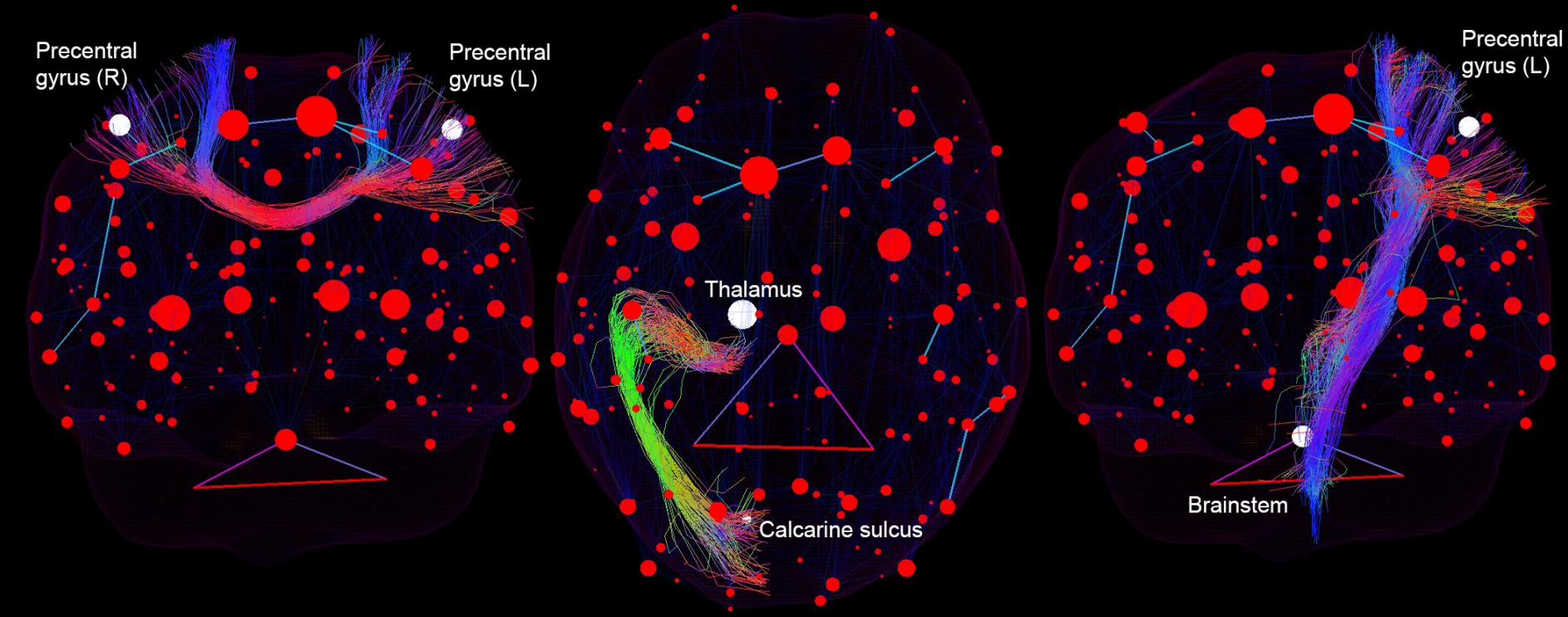
II.IV Connectomics



Chamberland, M. et al. (2017).
Interactive Computation and Visualization of Structural Connectomes in Real-Time.
MICCAI CNI Workshop, Québec, Canada.

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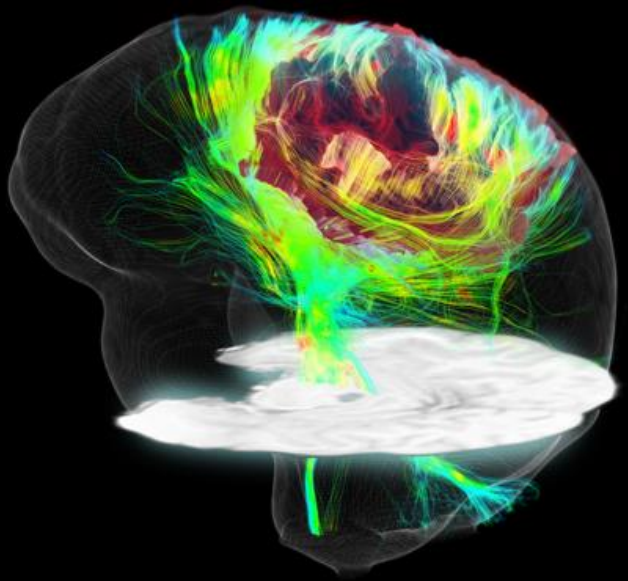
Overview



Sherbrooke Connectivity Imaging Lab, Québec, Canada
National Geographic, Feb. 2014

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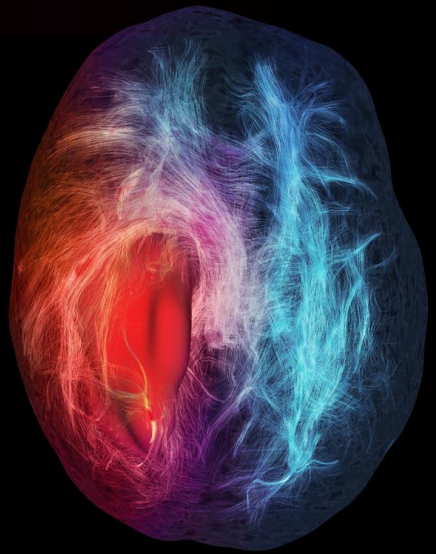
Acknowledgements

Derek Jones
Maxime Descoteaux
Kevin Whittingstall
David Fortin
Michaël Bernier
Gabriel Girard
William Gray
Alexander Leemans
Chantal Tax
Simon Warfield
Benoit Scherrer



Twitter: @MaxChamb

Website: chamberm.github.io

Email: chamberlandM@cardiff.ac.uk

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