

# Massively Parallel, Portable, and Reproducible Tractography (MaPPeRTrac) - Improvements, Distribution, and Horizon

Paul B Camacho, PhD

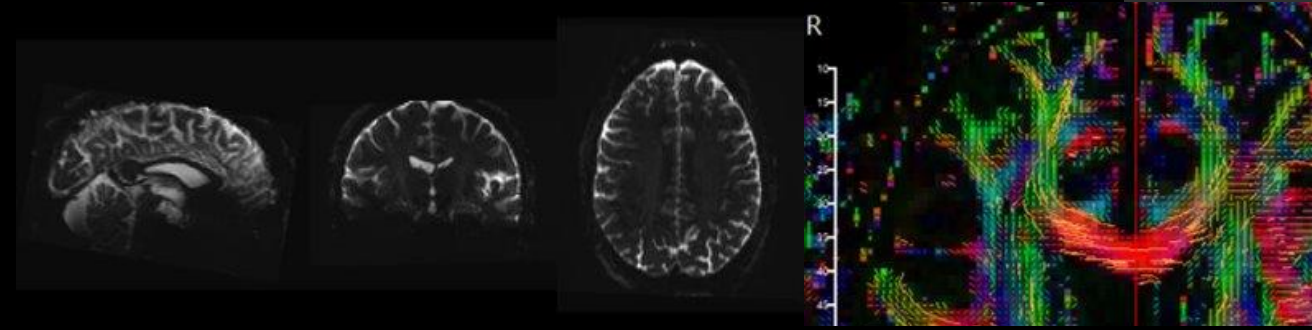
<https://github.com/pcamach2>

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# Overview

- Diffusion MRI & Tractography Primer
- MaPPeRTrac Overview



OCTOBER 7, 2020



USING PARSL IN CREATING MAPPERTRAC



**RAVI MADDURI**

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Data Science and Learning  
Argonne National Laboratory and  
University of Chicago

**COLLABORATORS**

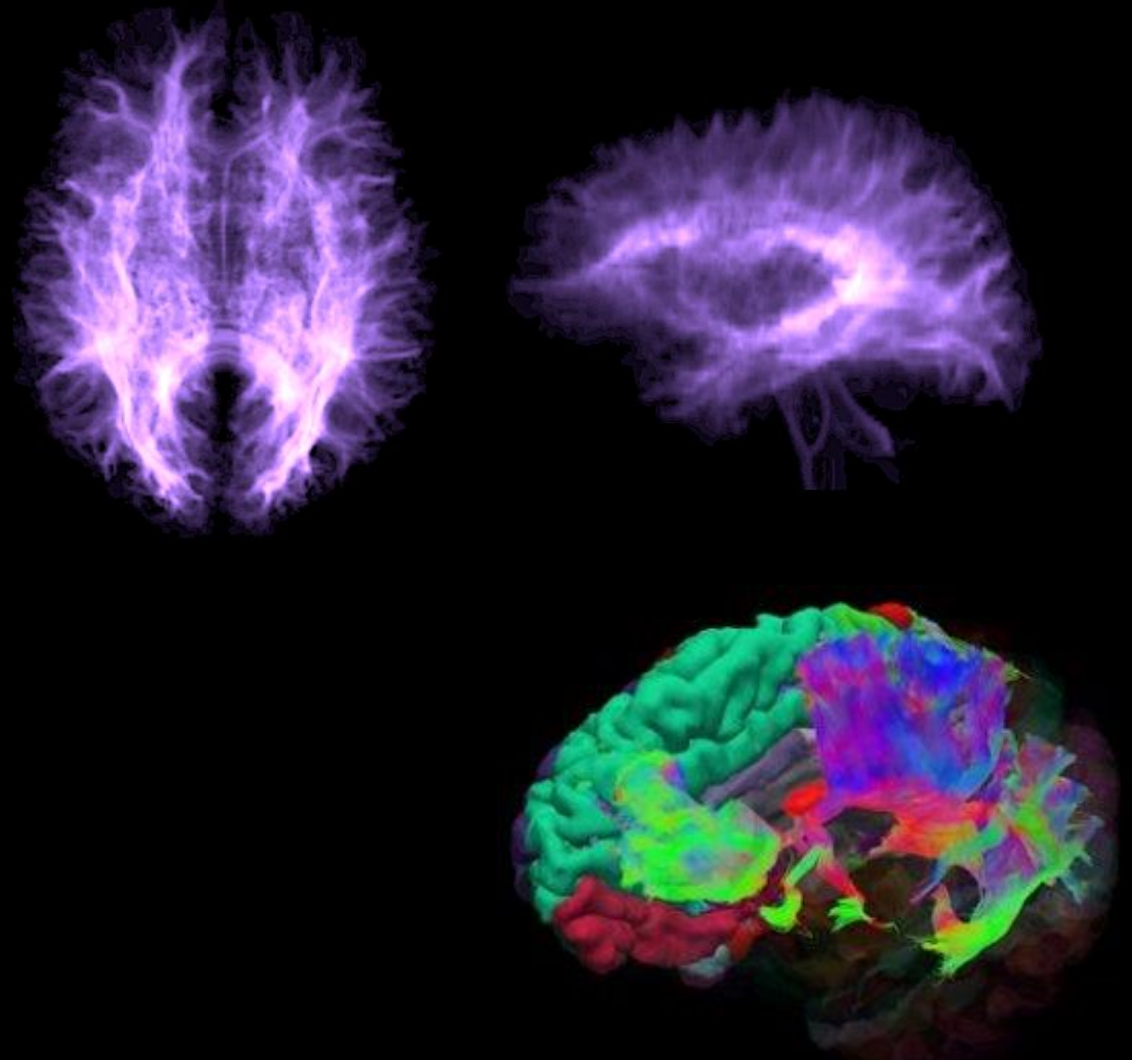
Joseph Moon, Timo Bremer,  
Pratik Mukherji, Eva Palacios,  
Mark Xiao and Alex Rodriguez



Argonne National Laboratory is a  
U.S. Department of Energy laboratory  
managed by UChicago Argonne, LLC.



ParslFest 2020



- Updates Since MaPPeRTrac Presentation @ ParslFest 2020
- Future Directions



# Diffusion Weighted Imaging in the Brain

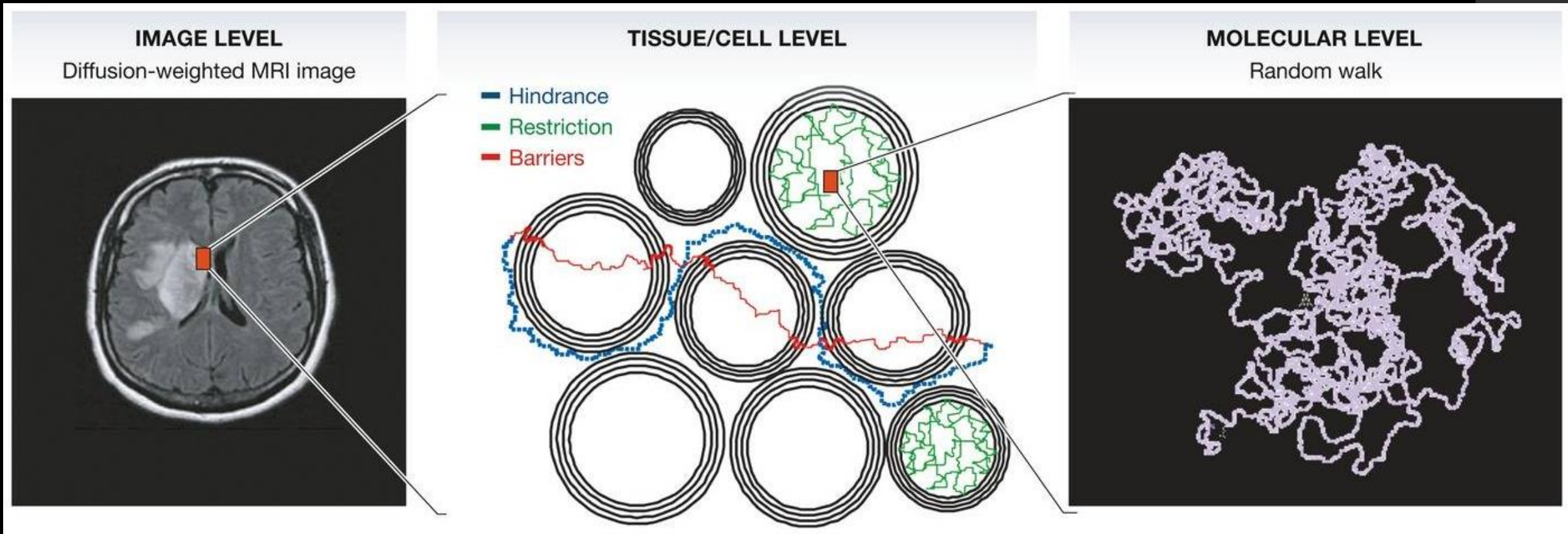
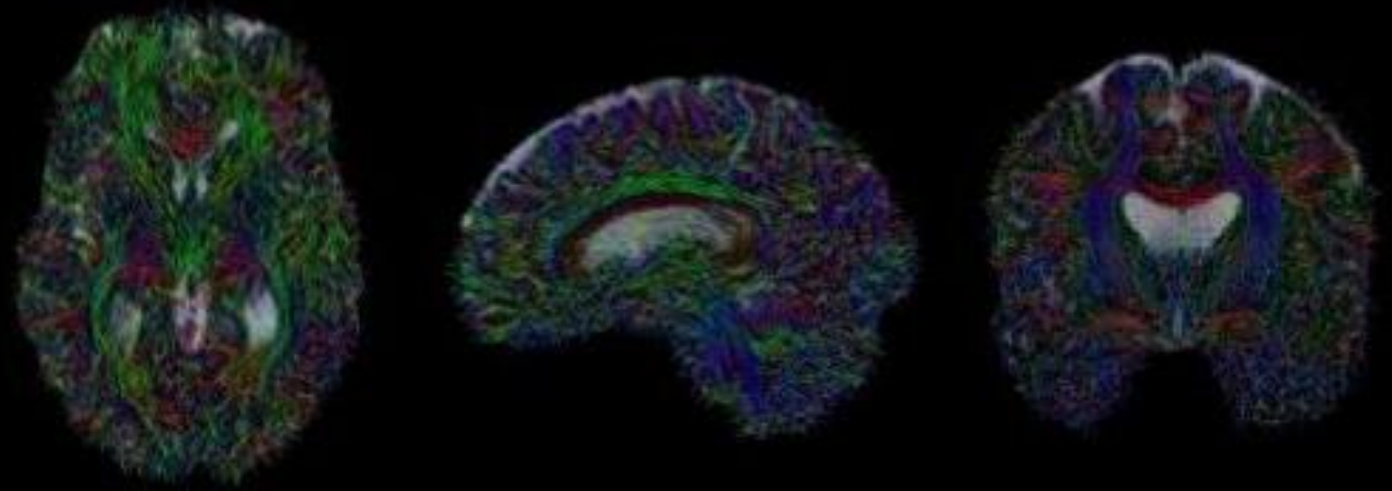
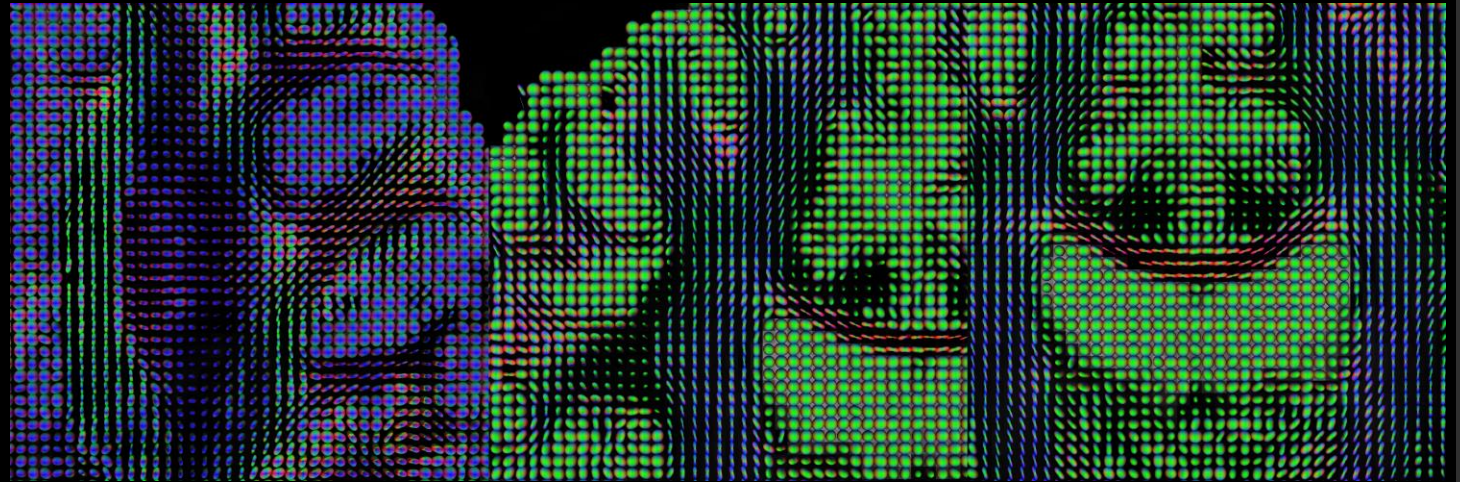
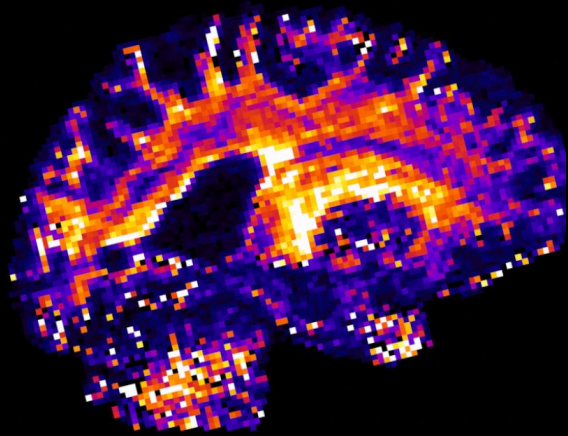


Figure from: Le Bihan D. (2014). Diffusion MRI: what water tells us about the brain. *EMBO molecular medicine*, 6(5), 569–573.  
<https://doi.org/10.1002/emmm.201404055>

# Diffusion signal reconstruction

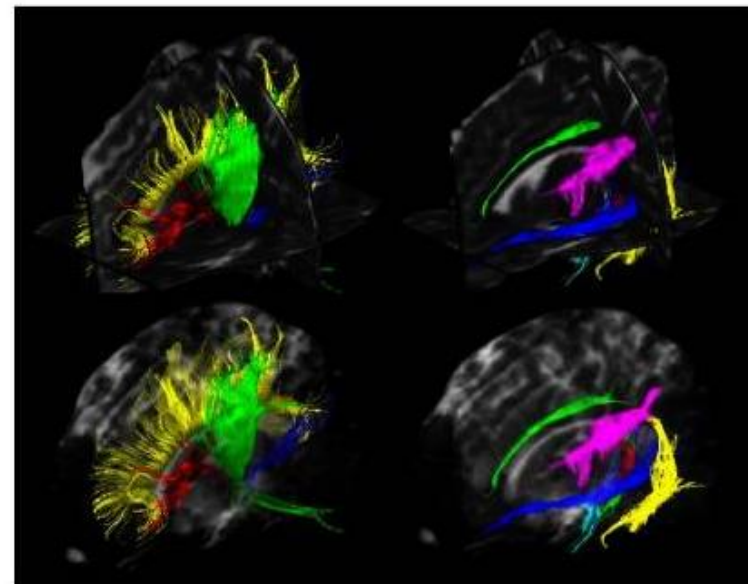
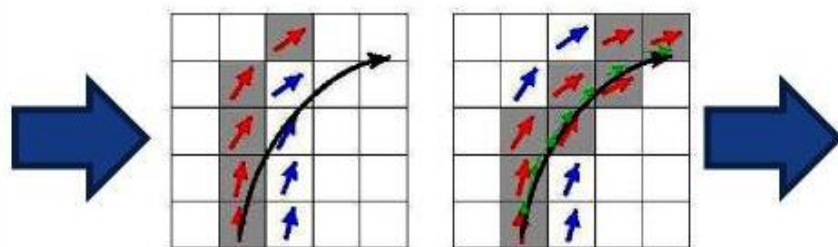
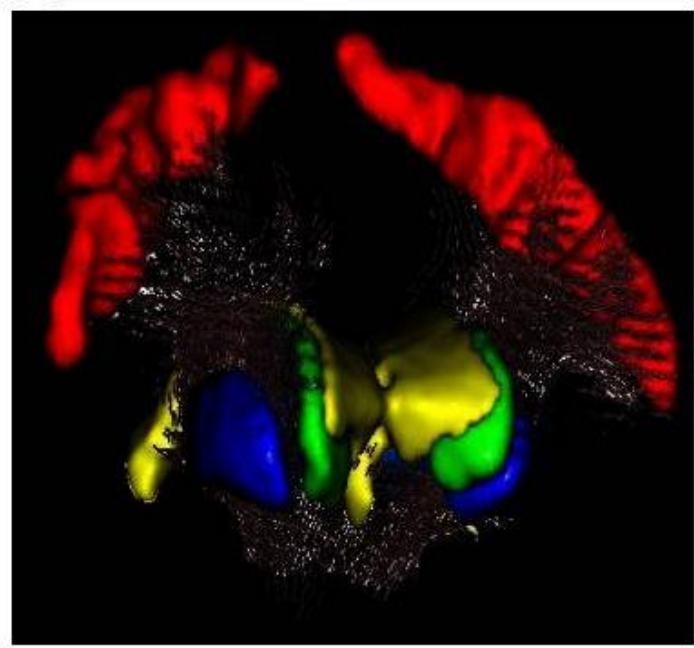
*Estimating the fiber population in each voxel*

- **Diffusion tensor imaging (DTI)**
  - le Bihan, et al. 2001
    - Early model, common in clinical applications
    - Microstructure characterization



- Probabilistic tractography





Probabilistic tractography - Figure from: Le Bihan, D., & Johansen-Berg, H. (2012). *NeuroImage*

# Tractography

Structural connectome - characterize the wiring of the human brain in health and neurodegeneration

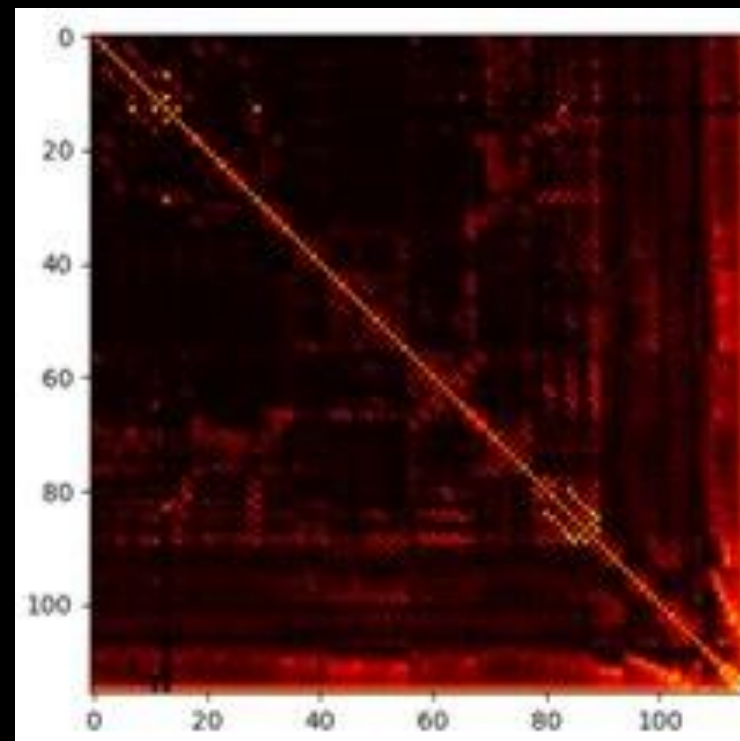
*Biomarker source for:*

Aging

Multiple Sclerosis

Traumatic Brain Injury

Etc.



# MaPPeRTrac: A Massively Parallel, Portable, and Reproducible Tractography Pipeline

A collaboration between the U.S. Department of Energy and TRACK-TBI\*

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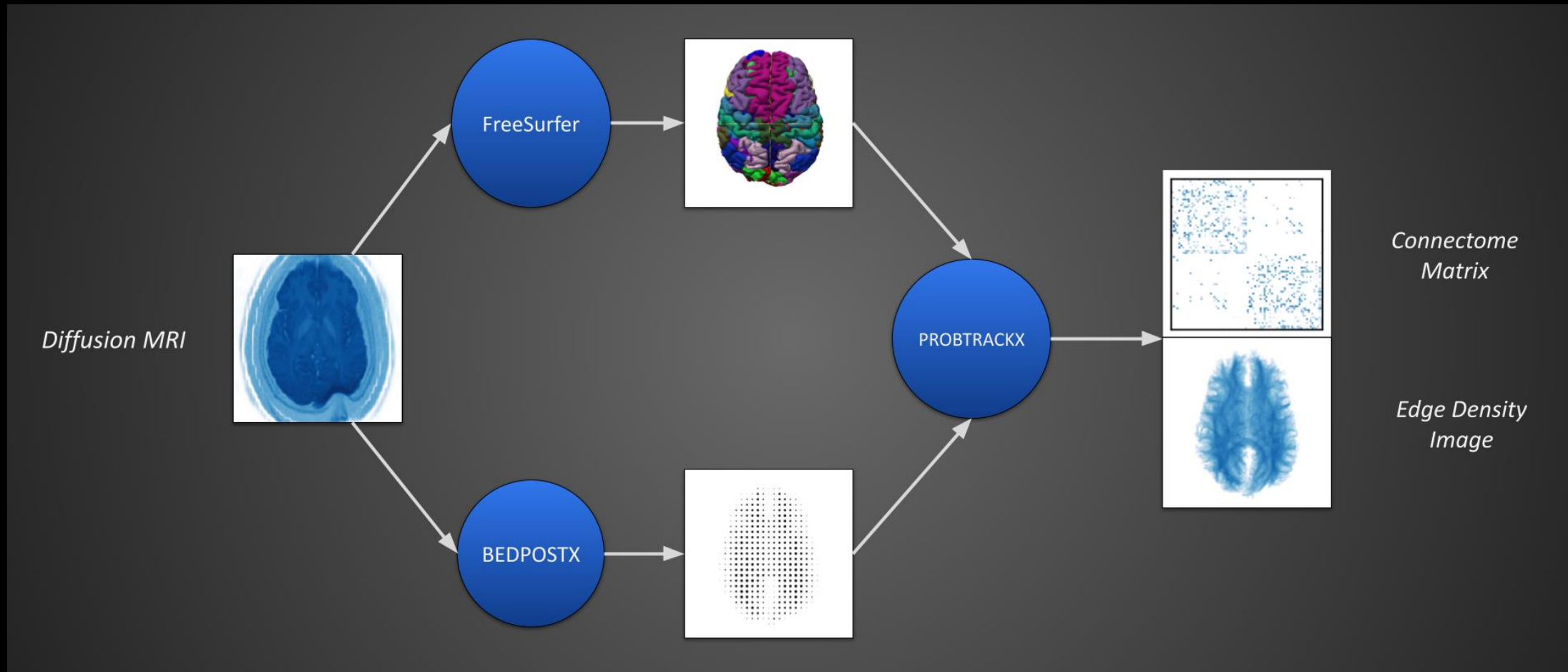
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†These authors contributed equally to this work.

In submission to *Neuroinformatics*

# MaPPeRTrac



- Edge density imaging (EDI)
- Structural connectome that maps the number of network edges that pass through every white matter voxel
- Focus on white matter pathways that constitute the edges of the network

# MaPPeRTrac Updates

- Dependency Updates Integration
  - Freesurfer, FSL, MRTrix3 versions
- Parsimonious containers -> faster deployment
  - Updated CLI for `--multi_container`
  - Recipe files & build directions
- Compatibility with DWI data including multiple interleaved `b=0` volumes
  - Supports better motion correction and denoising
- Enhanced parallelization
  - Parsl `python_apps` for `probtrackx2` instances for each edge chunk

mappertrac 1.3.1

```
pip install mappertrac
```

✓ Latest version

Released: Jun 29, 2023

<https://pypi.org/project/mappertrac/>

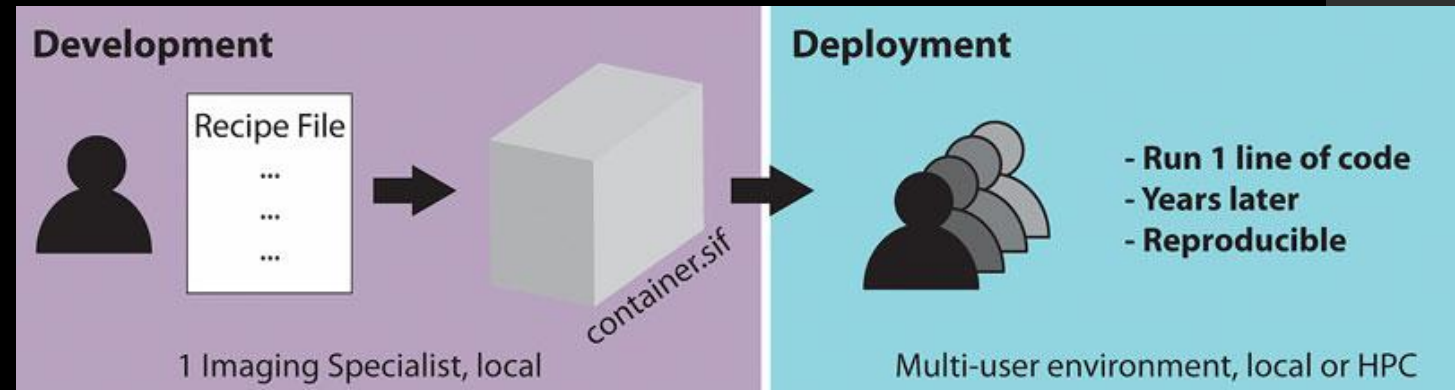


Figure from Mitra-Behura, *et al.* 2022 - <https://doi.org/10.3389/fbinf.2021.757291>



Example usage with DataLad:

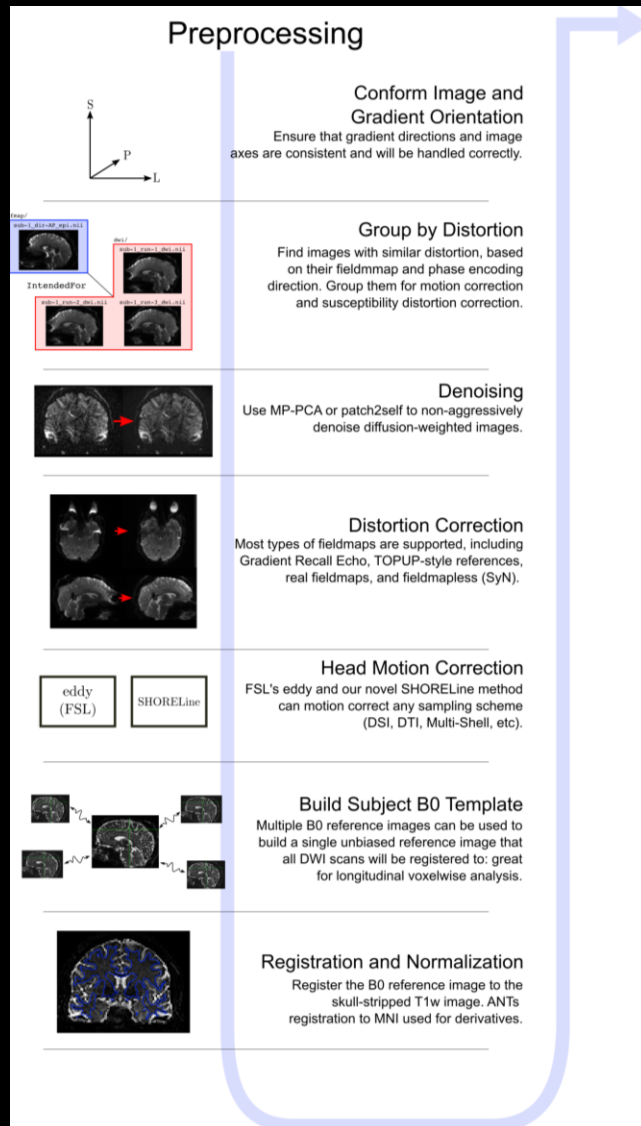


# Benchmarking v1.3.1

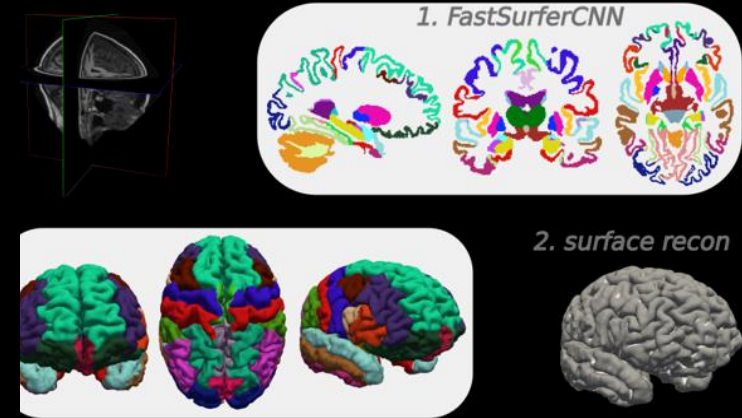
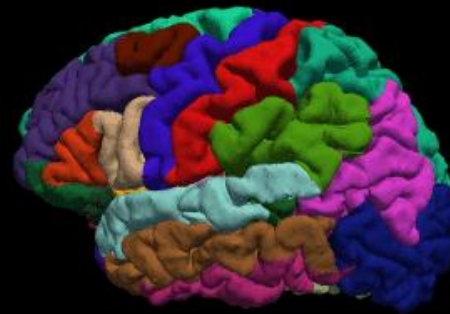
BIC HPC			
RAM	192 GB	Total Memory Used: 3.06 GB (Virtual Memory: 29.5 GB)	
CPU	Intel Xeon Gold 6138 @ 2.00 GHz (80 threads)	Total CPU Time: 04:52:43 (hours:minutes:seconds)	
GPU	Nvidia Tesla V100	Peak Memory Used: 1317 MB / 161160 MB	
Run-time (hours:minutes:seconds)			
	s1_freesurfer	s2_bedpostx	s3_probtrackx2
<u>TRACK-TBI Test Data</u>	04:20:26	00:03:00	03:27:50
<u>sub-THP0001_ses-THP0001MGH1</u>	04:20:55	00:02:59	04:24:19

- Anonymized TRACK-TBI dataset
- Traveling Human Phantom session from Siemens site (MGH)

# Future Directions



## FreeSurfer vs FastSurfer



Standard method for segmentation + surface reconstruction  
**20-48 hours** for 7T 0.7 mm isotropic MR2RAGE T1w

*FreeSurfer-equivalent* segmentation + surface reconstruction  
**~ 1 hour** for 7T 0.7 mm isotropic MR2RAGE T1w

# Acknowledgements

- Department of Energy
  - Grant #KJ040301
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- NIH-NINDS
  - TRACK-TBI (Grant #U01NS086090)
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- Abbott Laboratories
- One Mind
- Yale University School of Medicine