TNEU

Tecnologie MRI per le neuroscienze

Federico Giove

federico.giove@centrofermi.it

Courtesy Archive of the Department of Physics - Sapienza Digital Library

TNEU Tecnologie MRI per le neuroscienze

- **Coordinators:** Dr. Federico Giove, Prof. Bruno Maraviglia
- **Participants:**

	Project	Name	Position	Until…
Current staff	T-MENS	**Federico Giove**	Primo ricercatore (Senior researcher)	Tenured
		Daniele Mascali	Assegno di ricerca (postdoc fellowship)	1/2020
		Marta Moraschi	Assegno di ricerca (postdoc fellowship)	9/2020
	H2020 MICROBRADAM	**Maria G. Di Trani**	Assegno di ricerca (postdoc fellowship)	6/2020
		Riccardo De Feo	Assegno di ricerca (fellowship)	12/2019
External collaborators	GR MOH @ Fondazione Santa Lucia	**Michela Fratini**	Resercher CNR	
		Mauro Di Nuzzo	-	
		Fabio Mangini		
		Laura Maugeri	Postdoc fellowship CNR	
Associates		**Bruno Maraviglia**	Full professor La Sapienza (retired)	
		Fabrizio Frezza	Full professor La Sapienza	
		Silvia Capuani	Researcher CNR	

Place of Work & Collaborations:

Centro Fermi MARBILab @ Santa Lucia Foundation

Company/Consortium/Public-servicecorporation/Research infrastructure

Charles River Oy, Kuopio, Finland

Fondazione Santa Lucia IRCCS, Roma

Policlinico Sant’Andrea, Roma

Siemens Healthineers

University/research institution

Cardiff University Brain Research Imaging Centre (CUBRIC), Cardiff, UK

Center for Magnetic Resonance Research (CMRR), University of Minnesota, Minneapolis, MN, USA

CNR, Istituto dei sistemi complessi, Roma

CNR, Istituto di Nanotecnologia, Roma

Department of Physics, University of Eastern Finland

Dipartimento di Neuroscienze, Università di Chieti-Pescara

Dipartimento di Scienze Biomediche, Università di Modena e Reggio Emilia

Dipartimento di Scienze Neurologiche, Università La Sapienza, Roma

Magnetic Resonance Research Center, Yale University, New Haven, CT, USA

T-MENS MRI Techniques for brain investigation

H2020 MICROBRADAM

New techniques for assessment of brain damage (reporting closes 12/2019)

TNEU

T-MENS

Brain metabolism and energetics

(f)MRS, fMRI (Physiology, epilepsy, cancer)

Computational approaches/simulation

Advanced MRS methods

Brain steady state networks

fMRI (physiology, neurodegeneration)

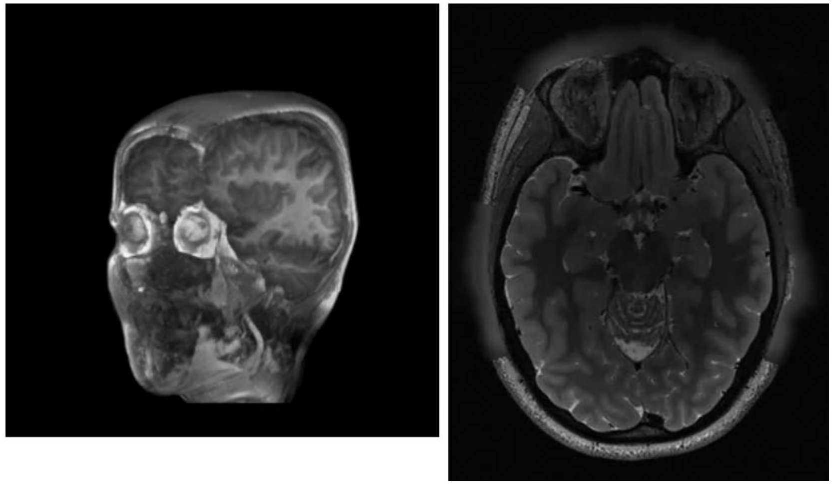
Methods

Spinal cord fMRI

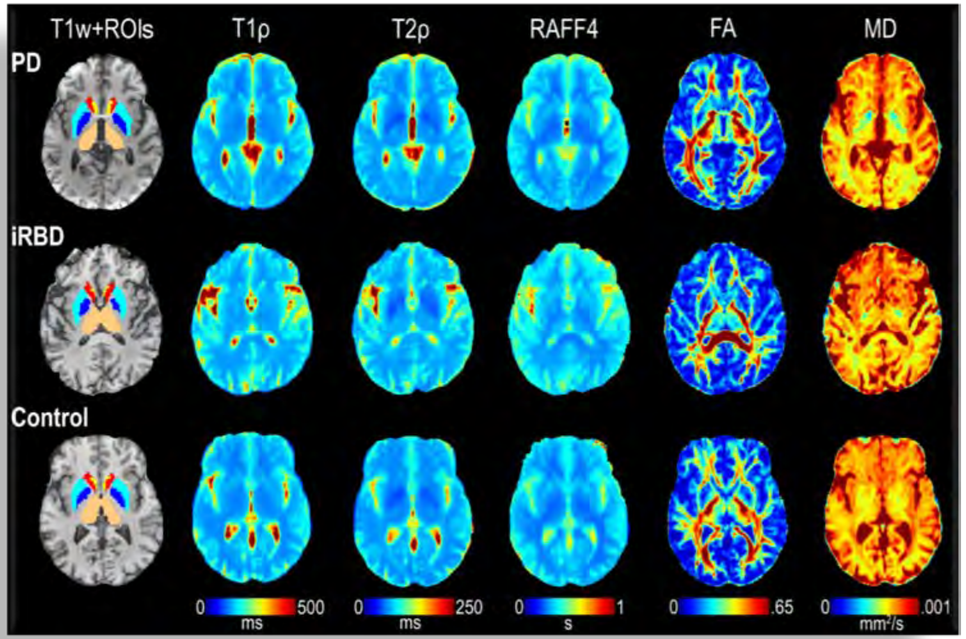
function, microstructure

Biophysics

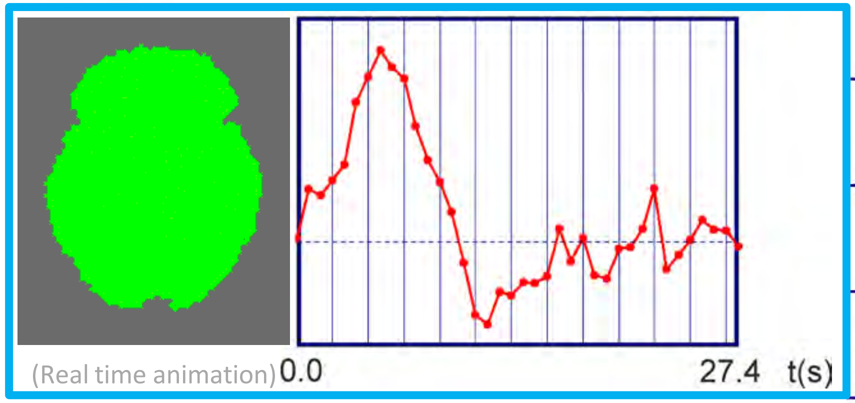
↓**Multiparametric structural imaging** with high spatial resolution and fast acquisition



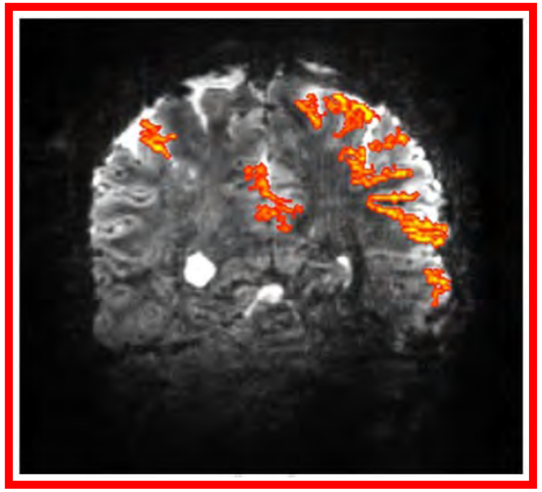
↘**Quantitative approaches** for the characterization of neurological and psychiatric diseases (investigation of new contrast mechanisms)



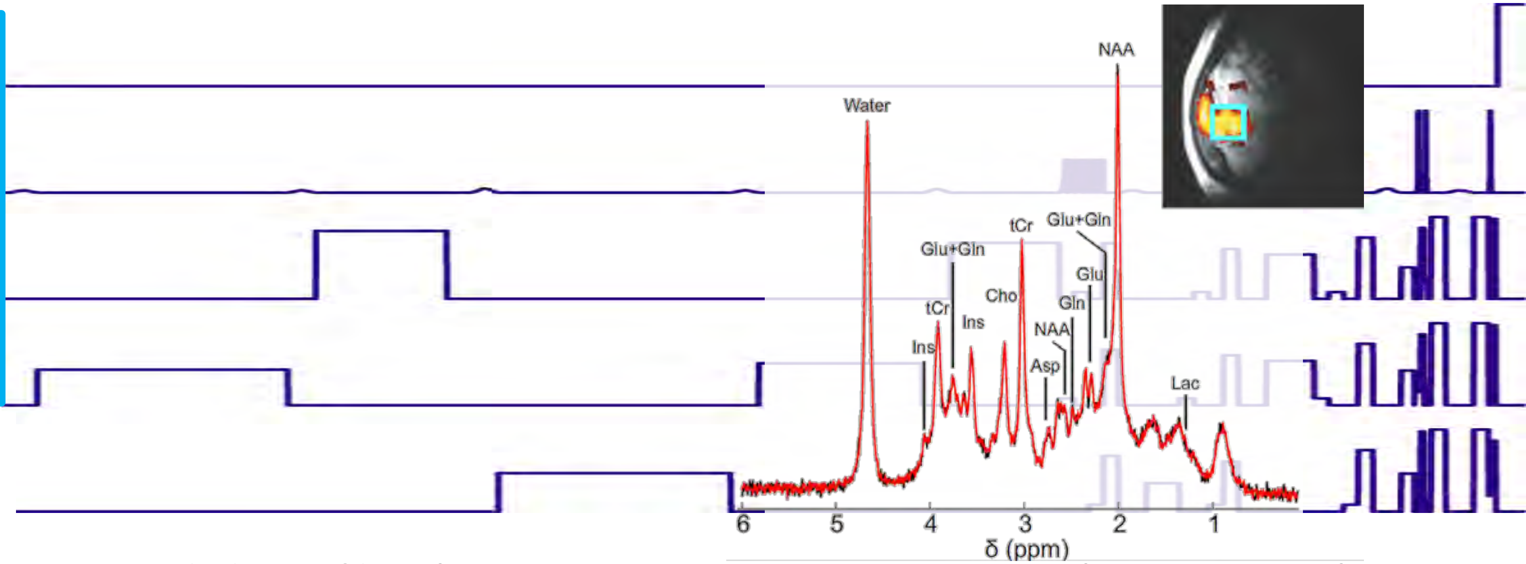
(H2020 691110 MICROBRADAM)



Development of functional imaging with high spatiotemporal resolution with simultaneous multislice excitation

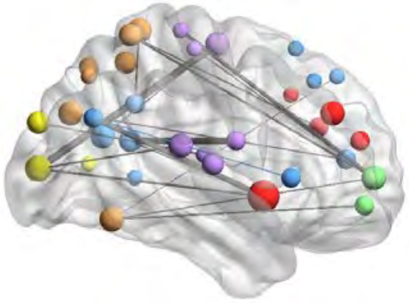


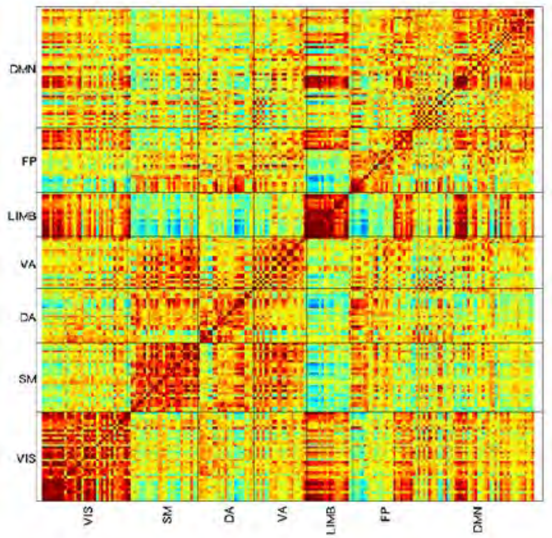
(S Moeller et al., MRM 2016)



Metabolic profiling for investigation in Neurosciences and fingerptinting of pathologies

Dynamics of brain connectomics: acute and chronic changes associated to function





Publications 2019

International journal

1. Riccardo De Feo and Federico Giove. Towards an efficient segmentation of small rodents brain: a short critical review. Journal of Neuroscience Methods 323 (2019), 82–89. DOI: 10.1016/j.jneumeth.2019.05.003.
2. Maria Giovanna Di Trani, Lucia Manganaro, Amanda Antonelli, Michele Guerreri, Riccardo De Feo, Carlo Catalano, and Silvia Capuani. Apparent Diffusion Coefficient Assessment of Brain Development in Normal Fetuses and Ventriculomegaly. Frontiers in Physics 7 (2019). DOI: 10.3389/fphy.2019.00160.
3. Maria Giovanna Di Trani, Marco Nezzo, Alessandra S. Caporale, Riccardo De Feo, Roberto Miano, Alessandro Mauriello, Pierluigi Bove, Guglielmo Manenti, and Silvia Capuani. Per- formance of Diffusion Kurtosis Imaging Versus Diffusion Tensor Imaging in Discriminating Between Benign Tissue, Low and High Gleason Grade Prostate Cancer. Academic radiology 26 (10 2019), 1328–1337. DOI: 10.1016/j.acra.2018.11.015.
4. Mauro DiNuzzo, Daniele Mascali, Marta Moraschi, Giorgia Bussu, Laura Maugeri, Fabio Mangini, Michela Fratini, and Federico Giove. Brain networks underlying eye’s pupil dy- namics. Frontiers in Neuroscience 13 (2019), 965. DOI: 10.3389/fnins.2019.00965.
5. Heidi Gröhn, Bernadette T. Gillick, Ivan Tkac, Petr Bednarik, Daniele Mascali, Dinesh K. Deelchand, Shalom Michaeli, Gregg D. Meekins, Michael J. Leffler-McCabe, Colum D. MacK- innon, et al. Influence of Repetitive Transcranial Magnetic Stimulation on Human Neuro- chemistry and Functional Connectivity: a Pilot MRI/MRS Study at 7 T. Frontiers in Neuro- science (2019). DOI: 10.3389/fnins.2019.01260.
6. Fabio Mangini, Mauro DiNuzzo, Laura Maugeri, Marta Moraschi, Daniele Mascali, Fab- rizio Frezza, Federico Giove, and Michela Fratini. Numerical simulation of the Blood Oxy- genation Level-Dependent functional Magnetic Resonance Signal using Finite Element Method. International Journal for Numerical Methods in Biomedical Engineering (2019). DOI: 10.1002/cnm.3290.
7. Juan Miguel Valverde, Artem Shatillo, Riccardo De Feo, Olli Gröhn, Alejandra Sierra, and Jussi Tohka. “Automatic Rodent Brain MRI Lesion Segmentation with Fully Convolutional Networks”. In: Machine Learning in Medical Imaging. Ed. by Heung-Il Suk, Mingxia Liu, Pingkun Yan, and Chunfeng Lian. Lecture Notes in Computer Science. Springer International Publishing, 2019, pp. 195–202. DOI: 10.1007/978-3-030-32692-0_23.

Publications WIP

Submitted/under revision

1. Michela Fratini, Ali Abdollahzadeh, Mauro DiNuzzo, Raimo A. Salo, Federico Giove, Olli Gröhn, and Alejandra Sierra Lopez. Unveiling neurodegeneration in the CNS with a multi- disciplinary and multiscale approach. Frontiers in Neuroscience (202?). Under revision.
2. Daniele Mascali, Marta Moraschi, Mauro DiNuzzo, Silvia Tommasin, Michela Fratini, Tom- maso Gili, Richard G. Wise, Silvia Mangia, Emiliano Macaluso, and Federico Giove. Evaluation of denoising strategies for task-based functional connectivity. Neuroimage (202?). Under revision.
3. Paolo Miocchi, Alejandra Sierra, Laura Maugeri, Eleonora Stefanutti, Ali Abdollahzadeh, Fabio Mangini, Marta Moraschi, Inna Bukreeva, Lorenzo Massimi, Francesco Brun, et al. Steerable3D: an ImageJ plugin for neurovascular enhancement in 3-D segmentation. Physica Medica (202?). Submitted.
4. Marta Moraschi, Daniele Mascali, Silvia Tommsain, Tommaso Gili, Ibrahim Eid Hassan, Michela Fratini, Mauro DiNuzzo, Richard G. Wise, Silvia Mangia, Emiliano Macaluso, et al. Network modularity during a sustained working-memory task. Frontiers in Physiology (202?). Submitted.

~ready to be submitted (1-2 months)

1. Riccardo De Feo, Alejandra Sierra, Artem Shatilo, Juan-Miguel Valverde, Olli Gröhn, Federico Giove, and Jussi Tohka. Multi-task U-Net for automated segmentation and skull-stripping in mouse brain MRI. Nature Communications. (202?). In preparation.
2. Fabio Mangini, Marta Moraschi, Daniele Mascali, Michela Fratini, Silvia Mangia, and Federico Giove. Towards whole brain mapping of hemodynamic response function. (Neuroimage OR Human Brain Mapping (202?). In preparation.
3. Daniele Mascali, Giorgia Bussu, Mauro DiNuzzo, Silvia Mangia, Emiliano Macaluso, TBD, and Federico Giove. Global reorganization of brain networks during visuospatial attention. TBD (202?). In preparation.
4. Marta Moraschi, Mauro DiNuzzo, Julien Cohen-Adad, Laura Maugeri, Fabio Mangini, Daniele Mascali, Federico Giove, and Michela Fratini. Towards a standard pipeline for the analysis of human spinal cord fMRI Echo Planar Imaging. TBD (202?). In preparation.
5. Douglas L. Rothman, Gerald A. Dienel, Kevin L. Behar, Silvia Mangia, Mauro DiNuzzo, Federico Giove, and Fahmeed Hyder. Glycogenolysis and glucose sparing determines the relationships between brain glucose metabolism and glutamate/GABA neurotransmission. PNAS USA (202?). In preparation.

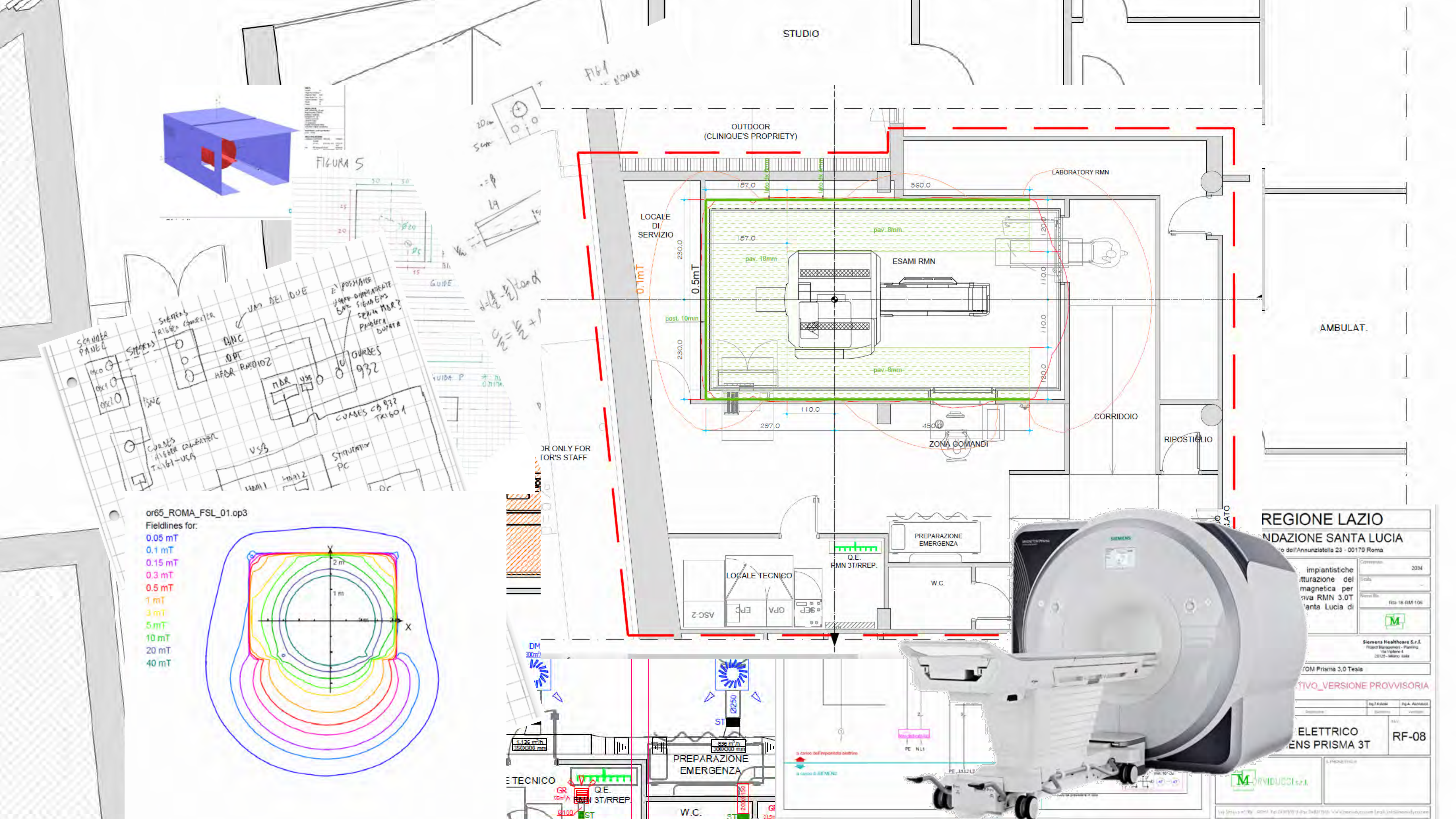
Dissemination overview

- Published on international journal: 7
- Ongoing: 4+5
- 4 communications to international congress (2 given, 2 submitted)
- 1 special issue under editing (Frontiers in Physics, Frontiers in Neuroscience, Frontiers in Physiology. Proceedings of ISMRBF, Erice, 2018)
- 1 Workshop being organized (ISMRBF, Erice, November 2020)
- Seminars to PhD and undergraduate students
- Outreach to population with general press, open days
- web site(s) (www.marbilab.eu, ismrbf.marbilab.eu, microbradam.marbilab.eu)


CENTRO FERMI
MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI
PROCEEDINGS OF THE INTERNATIONAL SCHOOL ON MAGNETIC RESONANCE AND BRAIN FUNCTION – XII WORKSHOP
EDITED BY: Federico Giove and Itamar Ronen
PUBLISHED IN: Frontiers in Neuroscience and Frontiers in Physics
CREATED: 28 OCTOBER 2019
H2020 MICROBRADAM results: new diagnostic tools for neurological diseases diagnosys
About Us
The MICROBRADAM Consortium was started in 2015 and is involved in the development of innovative MR methods.
Popular Tags
Magnetic resonance imaging (MRI) is a main resource for neuroscience and clinical practice.
La risonanza magnetica nucleare: tecniche d'elezione per lo studio della struttura cerebrale e delle relative patologie
Neuroscienziati confidano in tecniche innovative per la diagnosi precoce della sclerosi multipla
Un progetto europeo coordinato dal Centro Fermi studia nuove tecniche di rilassamento che permettono di identificare prontamente i processi di demielinazione cerebrale
CENTRO FERMI
MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI
11/1/2019 h 14
MARBILab
Magnetic Resonance for Brain Investigation Laboratory
open day
The open day is addressed to undergraduate and PhD students with interests in Medical Physics, with a focus on MRI. Techniques for the study of brain physiology and neurological diseases will be discussed. Attendants with whichever background are welcome as well, but please contact us in advance.
ISMRM ONE
LOG IN
HOME ABOUT NEWS EVENTS COMMUNITY MEMBERS EDUCATION CAREER CENTER
ISMRM-Endorsed Meetings
The ISMRM endorses the following programs, which reflect a theme consistent with the mission of the Society and may be of interest to its membership. No financial liability is assumed by the ISMRM nor is the ISMRM involved with the organization of the programs. Any inquiries regarding these programs should be directed to the organizers, who can be contacted through each program's website.
Arterial Spin Labeling Workshop
University of Michigan, Ann Arbor, MI, USA
09-10 March 2019
9th International Workshop on Magnetic Particle Imaging
New York, NY, USA
17-19 March 2019
Gordon Research Conference: Tissue Microstructure Imaging
Mount Holyoke, MA, USA
07-12 July 2019
The Future of Molecular MR: A Cellular & Molecular Imaging Workshop
St. John's, Newfoundland, Canada
14-17 July 2019
5th Workshop on MRI Phase Contrast & Quantitative Susceptibility Mapping (QSM)
Seoul, S. Korea
25-28 September 2019
International School on Magnetic Resonance and Brain Function (IMRBF)
Erice, Italy
May 2020
FUTURE WORKSHOPS
PAST WORKSHOPS
VIRTUAL MEETINGS
VIRTUAL MEETINGS ARCHIVE
CHAPTER MEETINGS
ISMRM-ENDORSED MEETINGS & EDUCATION
If you are interested in having your program endorsed by the ISMRM, please note that endorsement requests are only submitted to the ISMRM Board of Trustees for review and approval at designated times during the year. Please contact Roberta A. Kravitz, ISMRM Executive Director, for more information.
BI ITALIA

- **Milestones 2019**
  - TMENS:
    - New scanner commissioning (75%)
    - Study on hemodynamic and metabolic response (30%)
    - Publications on metabolic and functional response with dissociation and on networks modulation by attention (100%)
    - Spinal cord biophysical modelling, optimization of pipelines (70%)
  - MICROBRADAM:
    - Publications on multimodal structural imaging in spinal cord MRI (80%)
    - Secondments to CMRR, USA and CR/UEF, Finland (100%)
    - Publications related to secondments (100%)
    - Project end, final reporting (100%)

- **Milestones 2019**
  - TMENS:
    - New scanner commissioning (75%)
    - Study on hemodynamic and metabolic response (30%)
    - Publications on metabolic and functional response with dissociation and on networks modulation by attention (100%)
    - Spinal cord biophysical modelling, optimization of pipelines (70%)
  - MICROBRADAM:
    - Publications on multimodal structural imaging in spinal cord MRI (80%)
    - Secondments to CMRR, USA and CR/UEF, Finland (100%)
    - Publications related to secondments (100%)
    - Project end, final reporting (100%)



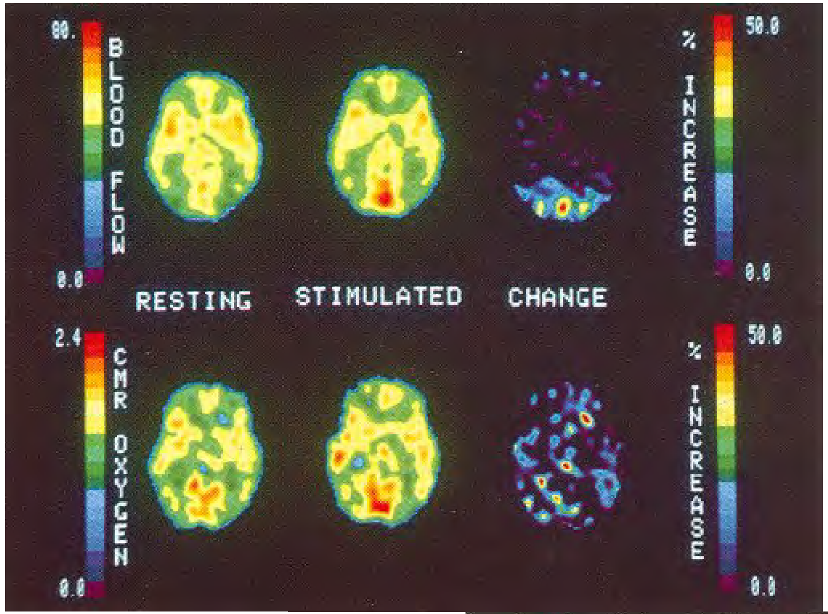
STUDIO
OUTDOOR
(CLINIQUE'S PROPRIETY)
LABORATORY RMN
LOCALE
DI
SERVIZIO
ESAMI RMN
0.5mT
0.1mT
pav. 8mm
pav. 18mm
post. 10mm
CORRIDOIO
RIPOSTIGLIO
ZONA COMANDI
AMBULAT.
PREPARAZIONE
EMERGENZA
Q.E.
RMN 3T/RREP.
LOCALE TECNICO
W.C.
FIGURA 5
or65_ROMA_FSL_01.op3
Fieldlines for:
0.05 mT
0.1 mT
0.15 mT
0.3 mT
0.5 mT
1 mT
3 mT
5 mT
10 mT
20 mT
40 mT
REGIONE LAZIO
NDAZIONE SANTA LUCIA
RF-08
TIVO_VERSIONE PROVVISORIA
ELETTRICO
ENS PRISMA 3T

- **Milestones 2019**
  - TMENS:
    - New scanner commissioning (75%)
    - Study on hemodynamic and metabolic response (30%)
    - Publications on metabolic and functional response with dissociation and on networks modulation by attention (100%)
    - Spinal cord biophysical modelling, optimization of pipelines (70%)
  - MICROBRADAM:
    - Publications on multimodal structural imaging in spinal cord MRI (80%)
    - Secondments to CMRR, USA and CR/UEF, Finland (100%)
    - Publications related to secondments (100%)
    - Project end, final reporting (100%)

CENTRO FERMI

MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI

MARBILab
Magnetic Resonance for Brain Investigation Laboratory

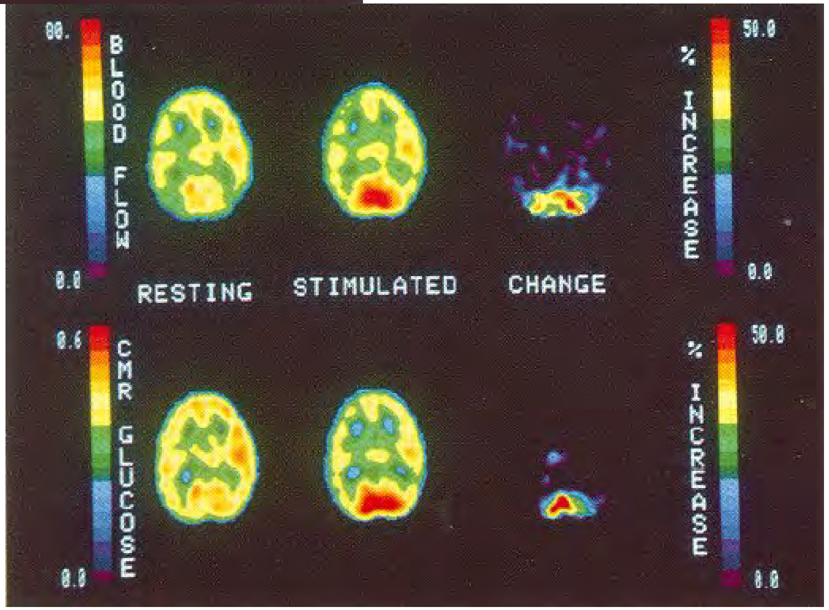


Proc. Natl. Acad. Sci. USA
Vol. 83, pp. 1140–1144, February 1986
Neurobiology

Focal physiological uncoupling of cerebral blood flow and oxidative metabolism during somatosensory stimulation in human subjects

(positron emission tomography)

PETER T. FOX*†‡ AND MARCUS E. RAICHLE*†



SCIENCE, VOL. 241

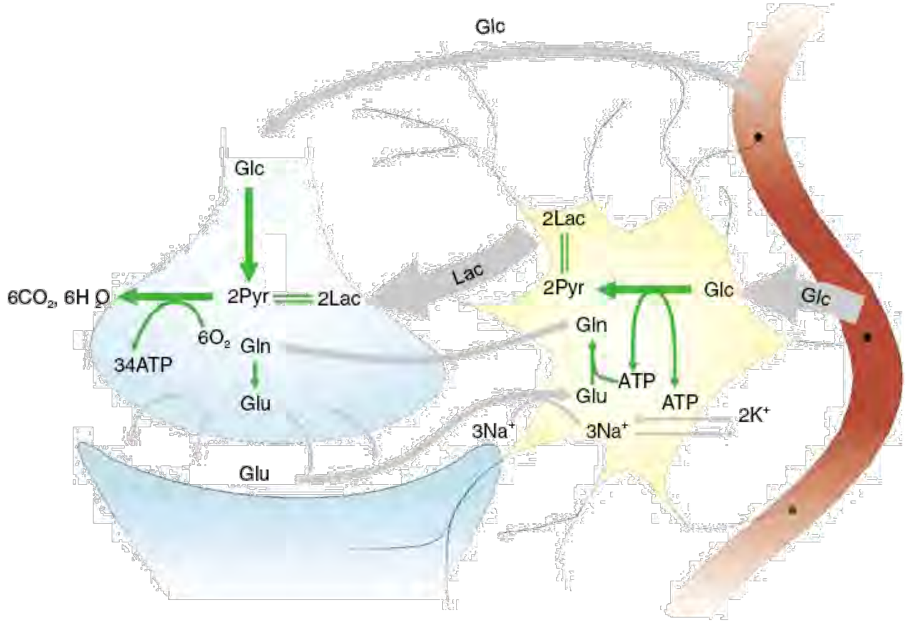
Nonoxidative Glucose Consumption During Focal Physiologic Neural Activity

PETER T. FOX,* MARCUS E. RAICHLE, MARK A. MINTUN, CARMEN DENCE

CENTRO FERMI

MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI

MARBILab
Magnetic Resonance for Brain Investigation Laboratory



CENTRO FERMI

MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI

MARBILab
Magnetic Resonance for Brain Investigation Laboratory

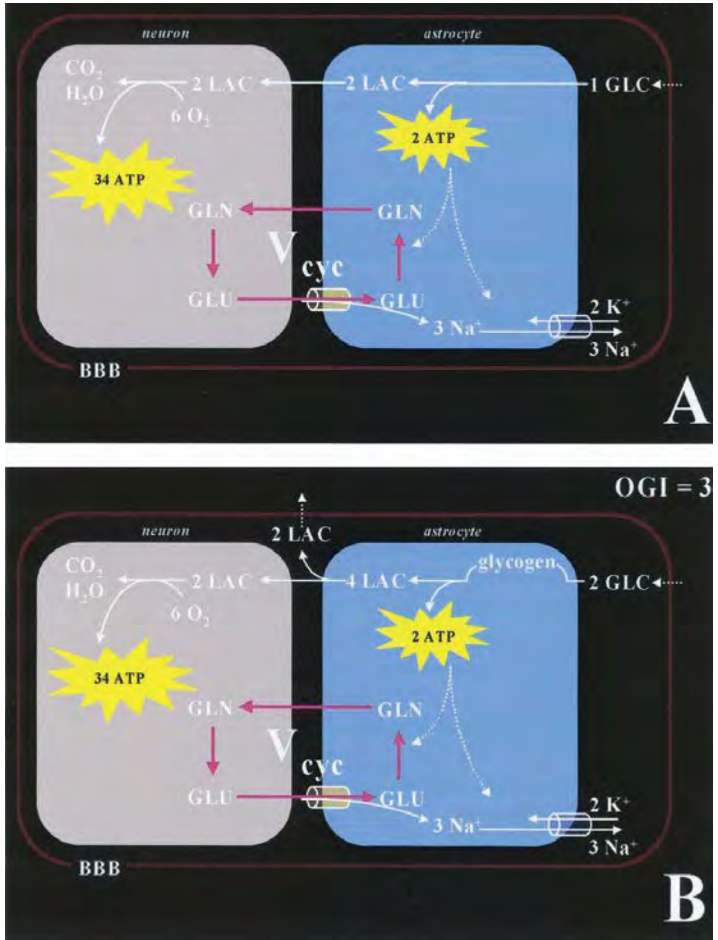
Cerebral energetics and the glycogen shunt: Neurochemical basis of functional imaging

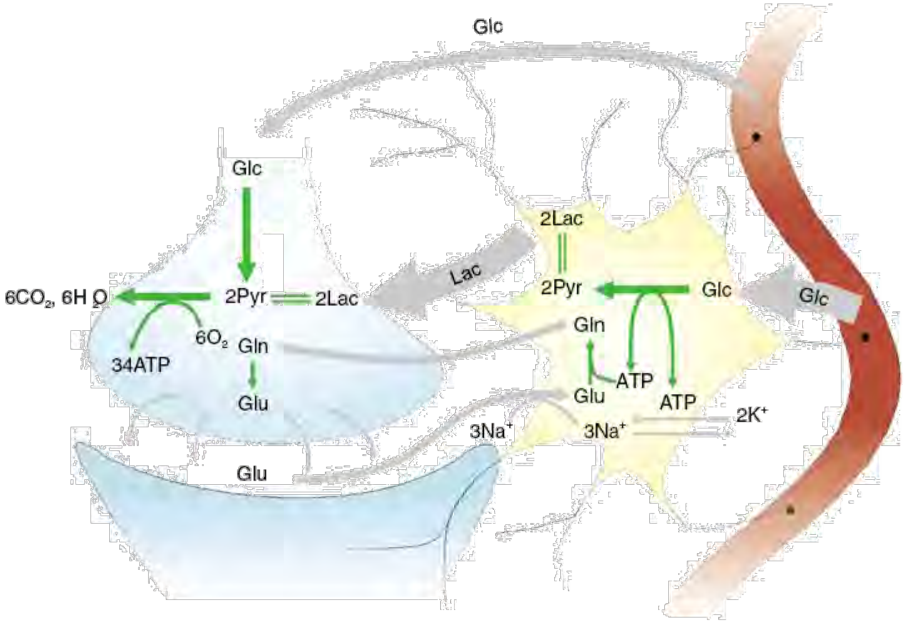
Robert G. Shulman*[†‡], Fahmeed Hyder*[§], and Douglas L. Rothman*[§]

Departments of *Diagnostic Radiology and [†]Molecular Biophysics and Biochemistry, and [§]Section of Bioimaging Sciences, Yale University, New Haven, CT 06510

Contributed by Robert G. Shulman, March 14, 2001

www.pnas.org/cgi/doi/10.1073/pnas.101129298 PNAS | May 22, 2001 | vol. 98 | no. 11 | 6417–6422





CENTRO FERMI

MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI

MARBILab
Magnetic Resonance for Brain Investigation Laboratory

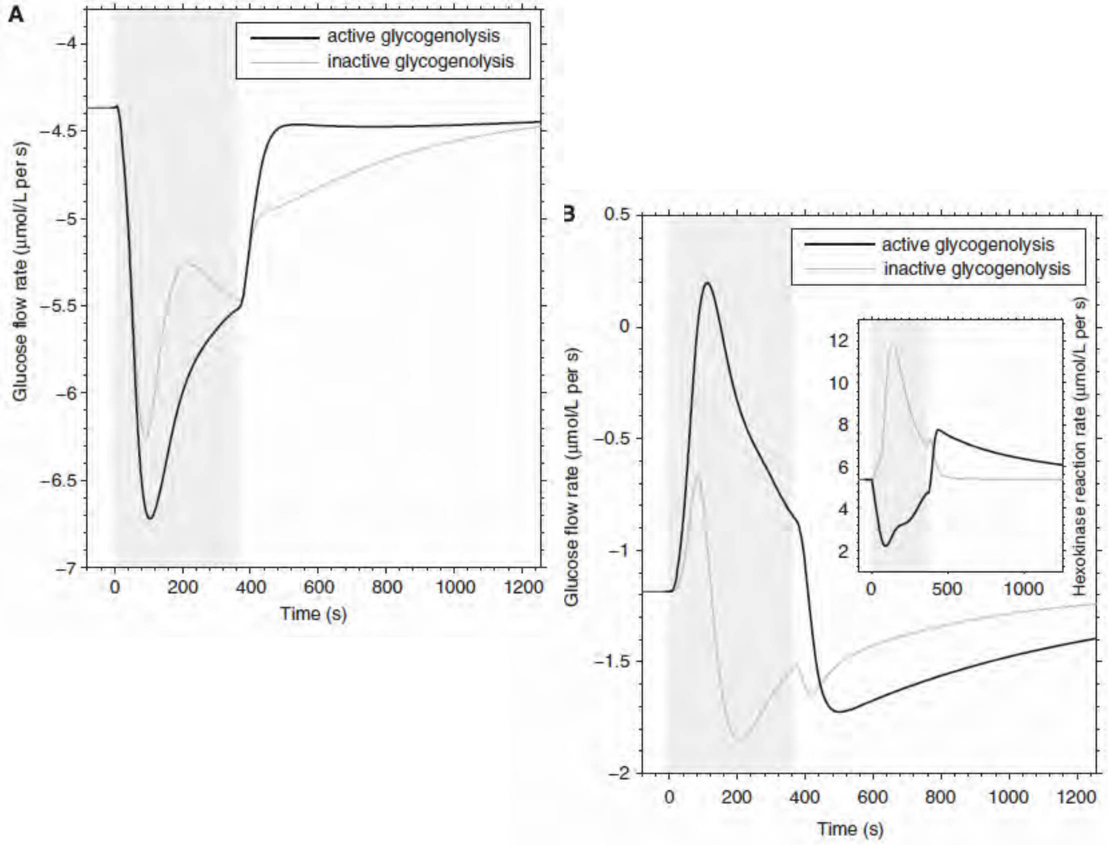
Journal of Cerebral Blood Flow & Metabolism (2010) 30, 1895–1904

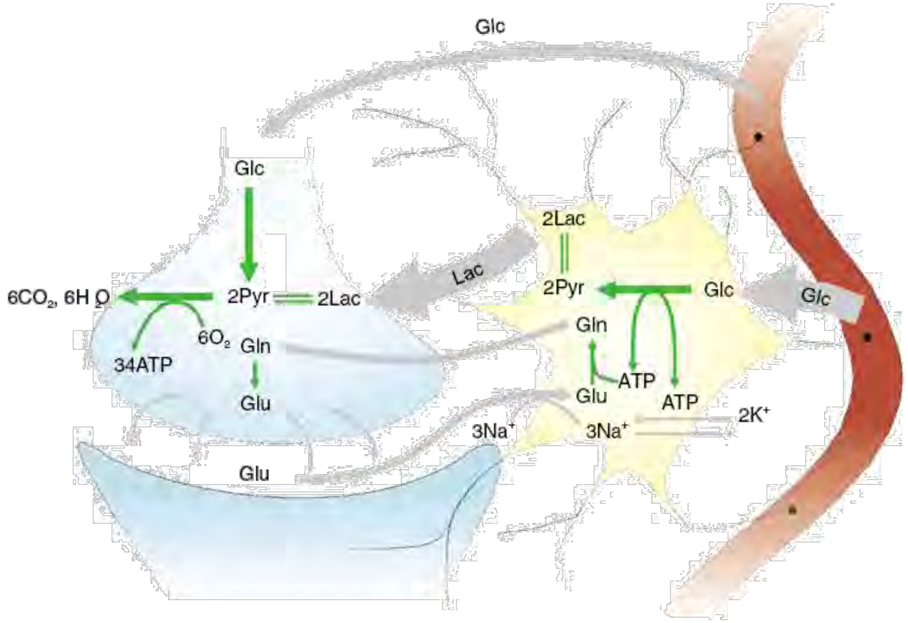
www.jcbfm.com

Feature Article

Glycogenolysis in astrocytes supports blood-borne glucose channeling not glycogen-derived lactate shuttling to neurons: evidence from mathematical modeling

Mauro DiNuzzo[1], Silvia Mangia[2], Bruno Maraviglia[1,3] and Federico Giove[1,4]



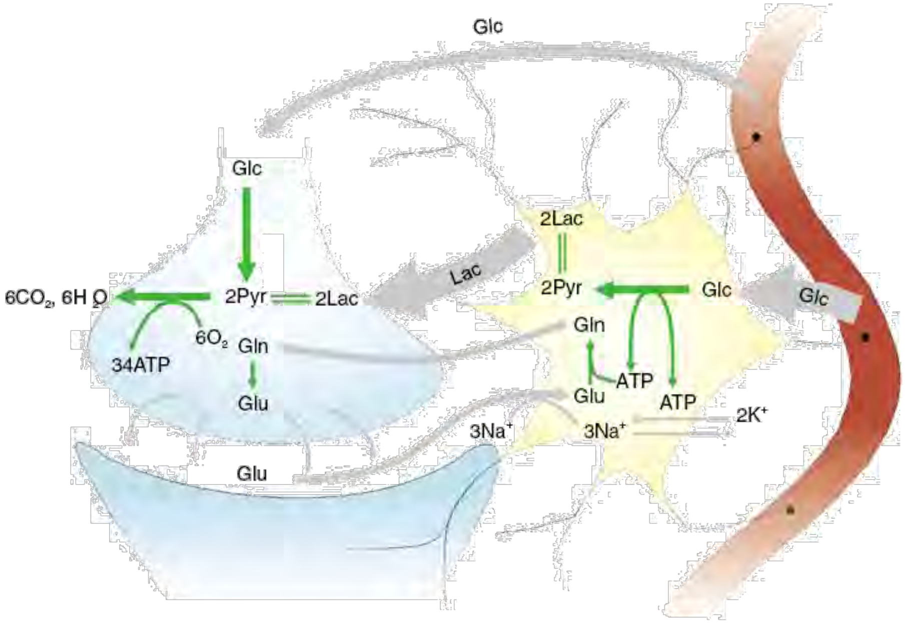


CENTRO FERMI MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI

MARBILab Magnetic Resonance for Brain Investigation Laboratory

~~The~~ A glycogenolysis and glucose sparing determines the relationships between brain glucose metabolism and glutamate/GABA neurotransmission

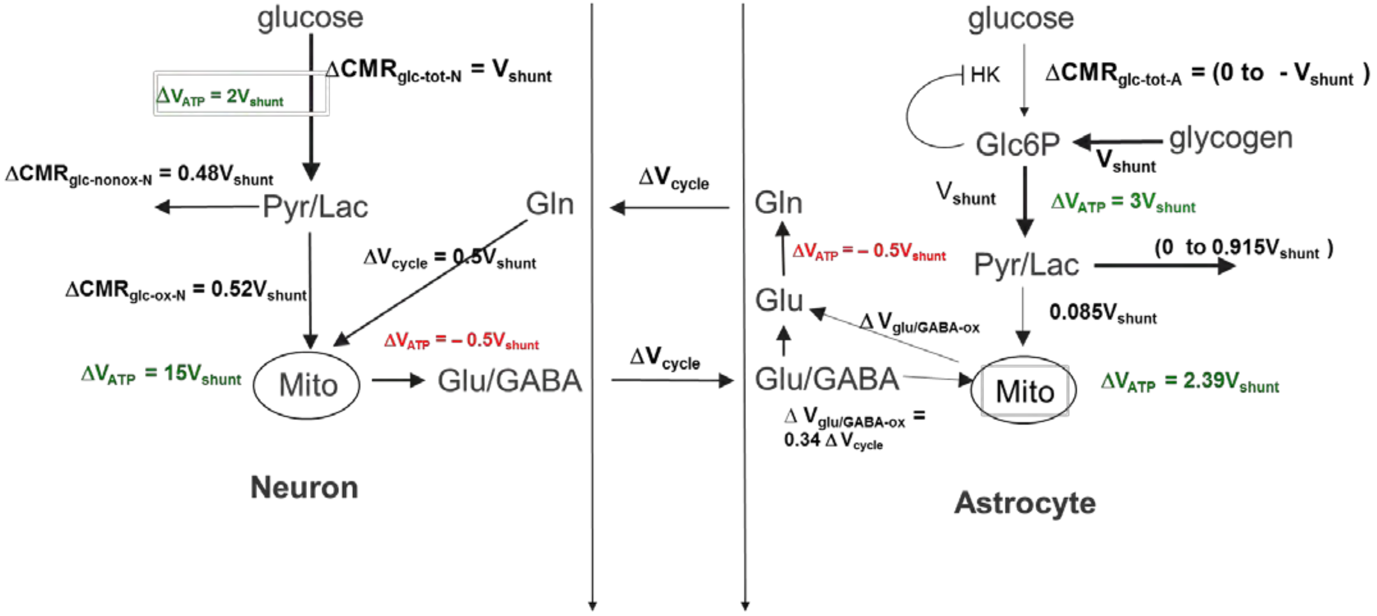
Douglas L Rothman[a,1,2]*, Gerald A Dienel[b,1]*, Kevin L Behar[c], Sylvia Mangia[d], Mauro DiNuzzo[e], Federico Giove[f], Fahmeed Hyder[g]



[1] $\Delta CMR_{glc\text{-}tot\text{-}N} = \Delta Vphos$

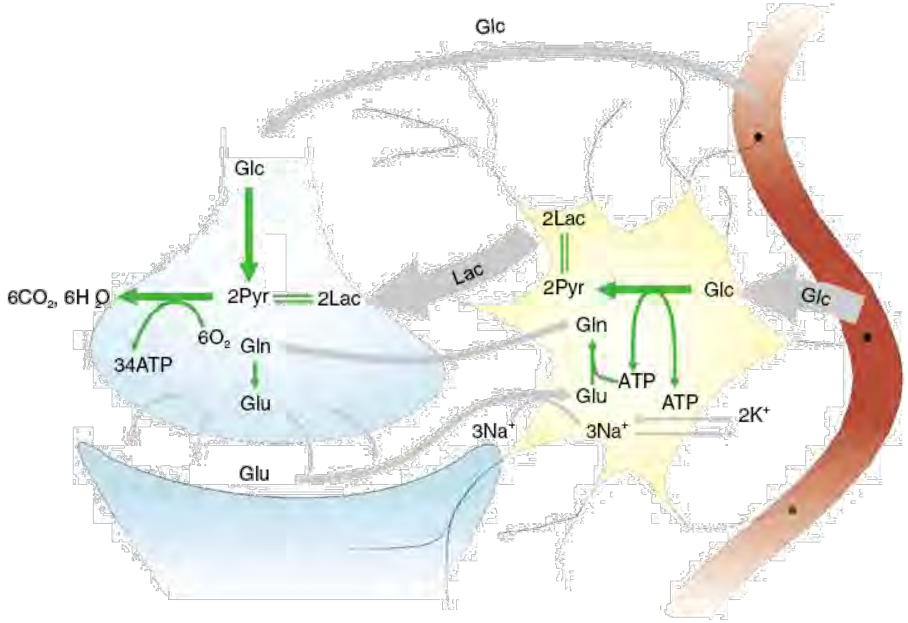
[4] $F = \Delta Vphos/\Delta CMR_{carb\text{-}tot\text{-}A}$

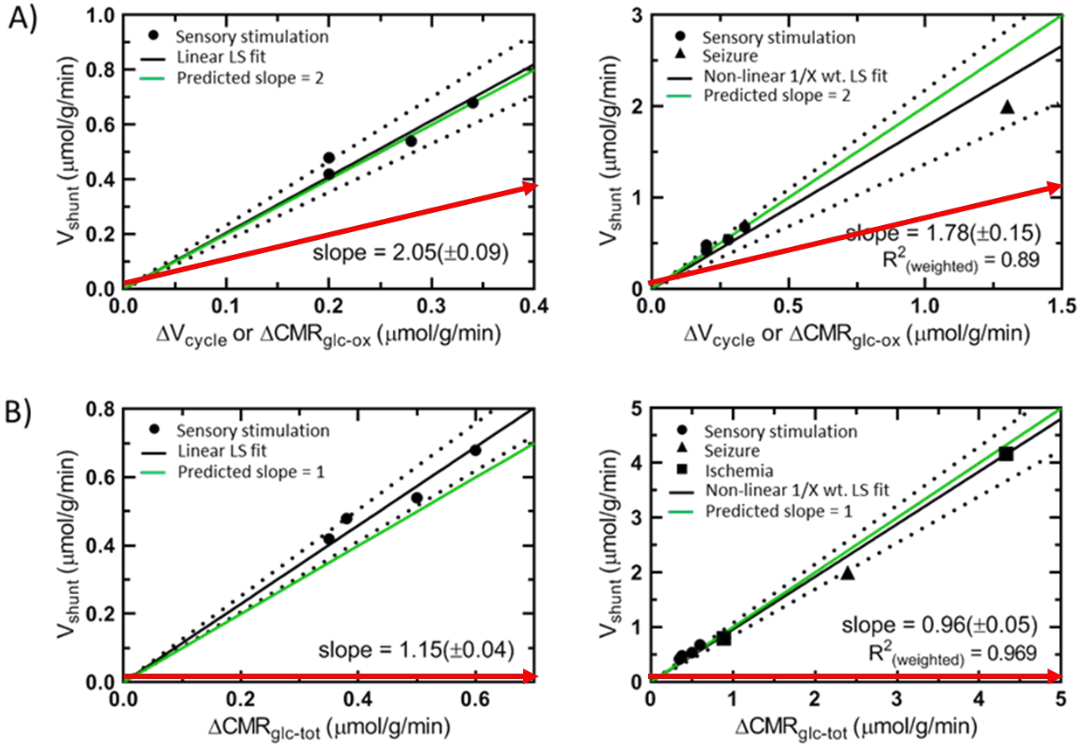
[6] $\Delta\ CMR_{glc\text{-}tot\text{-}N} = \Delta VGT - \Delta CMR_{carb\text{-}tot\text{-}A}*(1-F)$

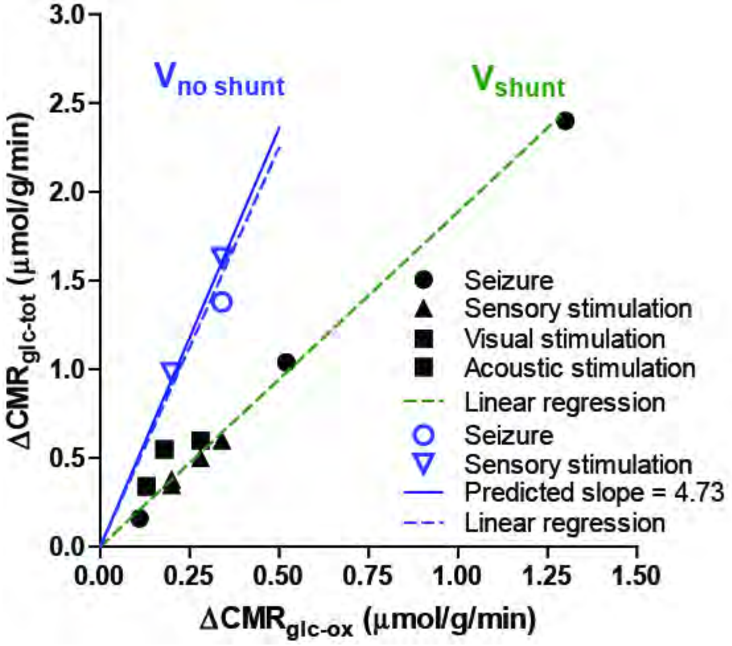


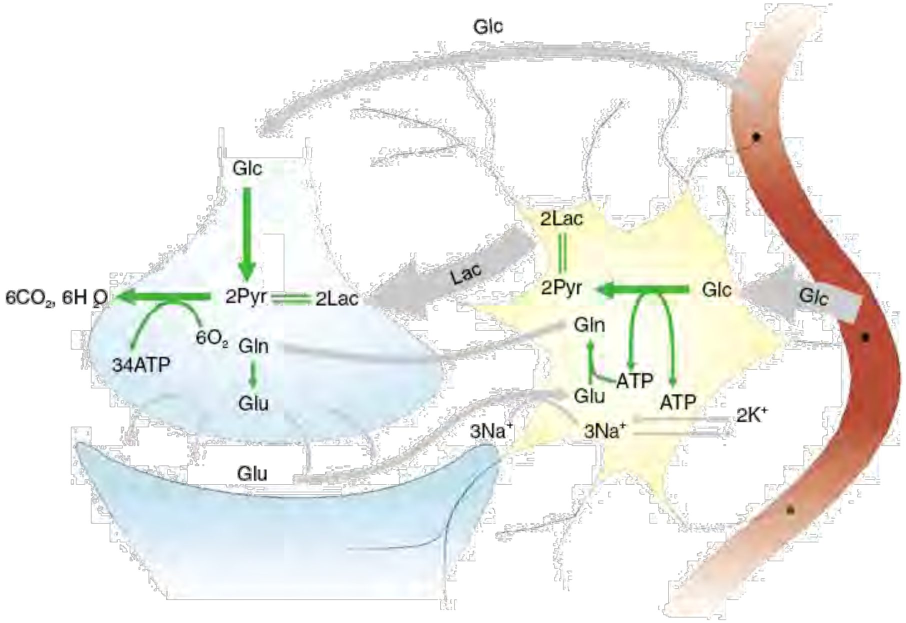
CENTRO FERMI
MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI

MARBILab
Magnetic Resonance for Brain Investigation Laboratory

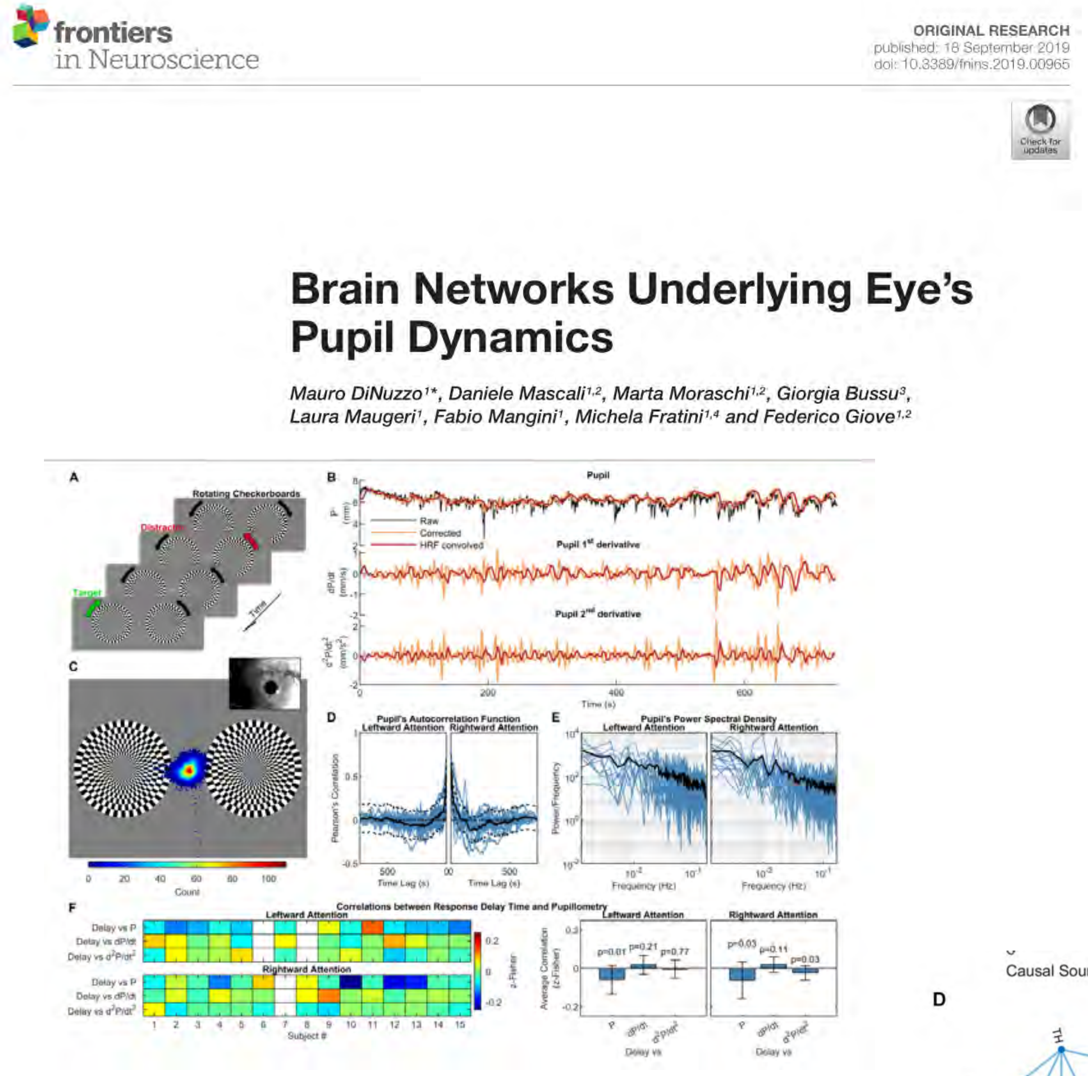





3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
ΔCMR glc-tot (μmol/g/min)
ΔCMR glc-ox (μmol/g/min)
V no shunt
V shunt
Seizure
Sensory stimulation
Visual stimulation
Acoustic stimulation
Linear regression
Seizure
Sensory stimulation
Predicted slope = 4.73
Linear regression


Glc
Glc
2Lac
Lac
6CO2, 6H O
2Pyr
2Lac
2Pyr
Glc
Glc
6O2
Gln
Gln
34ATP
Glu
ATP
Glu
ATP
2K+
3Na+
3Na+
Glu

- **Milestones 2019**
  - TMENS:
    - New scanner commissioning (75%)
    - Study on hemodynamic and metabolic response (30%)
    - Publications on metabolic and functional response with dissociation and on networks modulation by attention (100%)
    - Spinal cord biophysical modelling, optimization of pipelines (70%)
  - MICROBRADAM:
    - Publications on multimodal structural imaging in spinal cord MRI (80%)
    - Secondments to CMRR, USA and CR/UEF, Finland (100%)
    - Publications related to secondments (100%)
    - Project end, final reporting (100%)



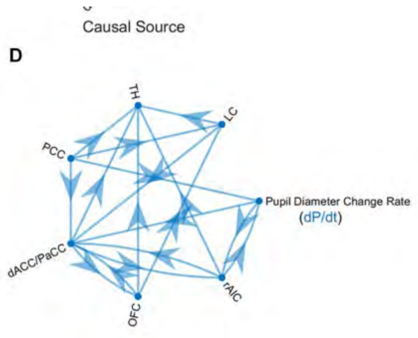
frontiers in Neuroscience

ORIGINAL RESEARCH
published: 18 September 2019
doi: 10.3389/fnins.2019.00965

Check for updates

Brain Networks Underlying Eye's Pupil Dynamics

Mauro DiNuzzo[1*], Daniele Mascali[1,2], Marta Moraschi[1,2], Giorgia Bussu[3], Laura Maugeri[1], Fabio Mangini[1], Michela Fratini[1,4] and Federico Giove[1,2]



- widespread visual and sensorimotor BOLD-fMRI deactivations correlated with pupil diameter.
- activations correlated with pupil diameter change rate within a set of brain regions known to be implicated in selective attention, salience, error-detection and decision-making (LC, thalamus, PCC, dorsal anterior cingulate and paracingulate cortex (dACC/PaCC), orbitofrontal cortex (OFC), and right anterior insular cortex (rAIC).
- Granger-causality analysis performed on these regions yielded a complex pattern of interdependence, wherein LC and pupil dynamics were far apart in the network and separated by several cortical stages

- **Further details on methodological aspects of resting state fMRI in the following slides**

CENTRO FERMI
MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI

MARBILab
Magnetic Resonance for Brain Investigation Laboratory

TMENS

Evaluation of denoising strategies for task-based functional connectivity

Daniele Mascali

Project coordinator: Federico Giove

by Zenina

Giornate di Studio: Progetti del Centro Fermi 2020-2022

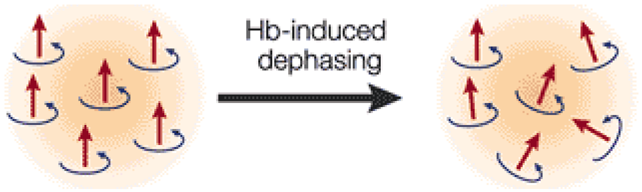
Functional Connectivity and BOLD

Functional connectivity (FC) is defined
as statistical dependencies among remote neurophysiological events

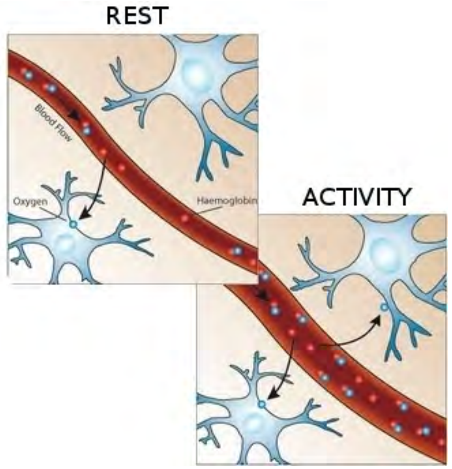
Blood Oxygenation Level-Dependent **(BOLD)**

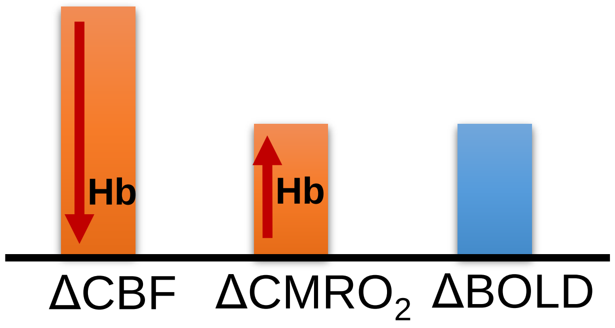
Hemoglobin:

HbO_2 Oxygenated state -> isomagnetic
Hb De-oxygenated state -> paramagnetic

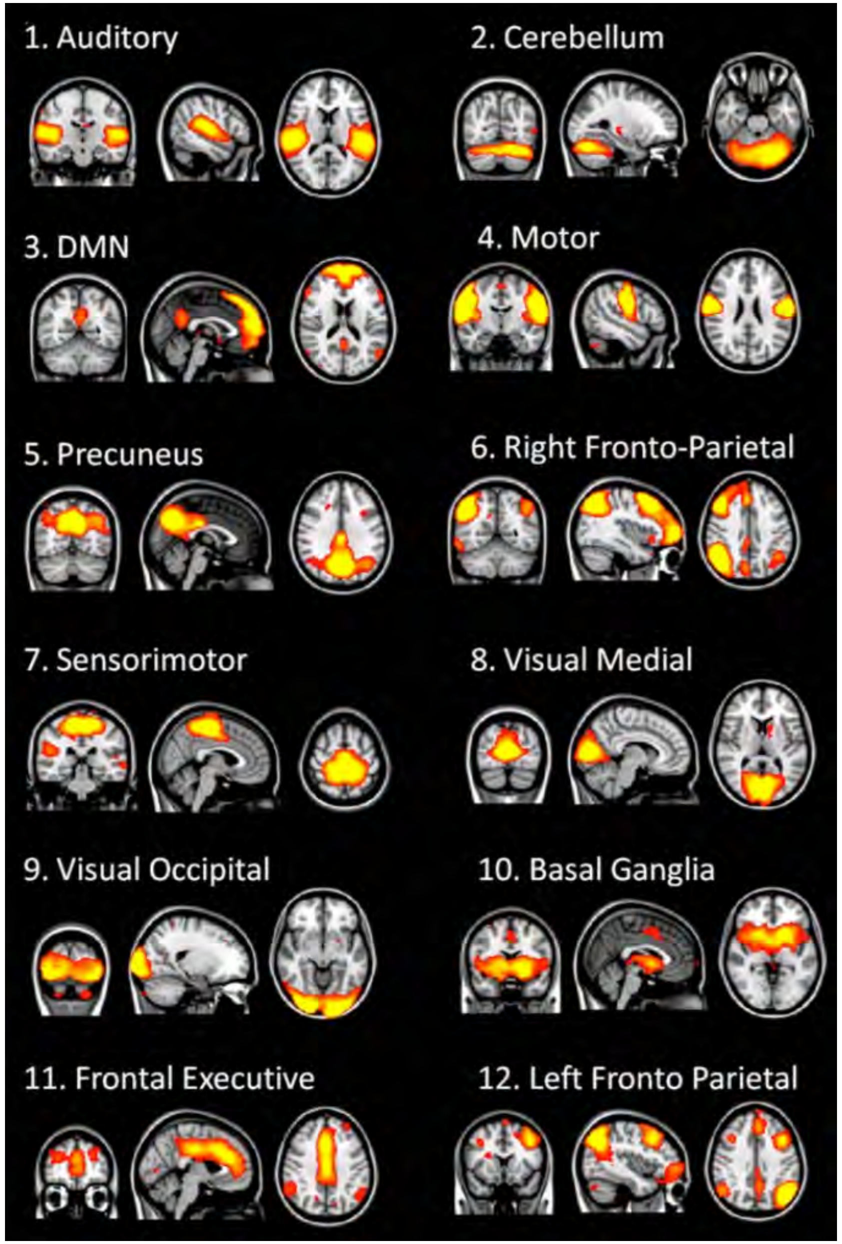


Response to neuronal activity:





Example of BOLD data



Sources of correlations in BOLD data

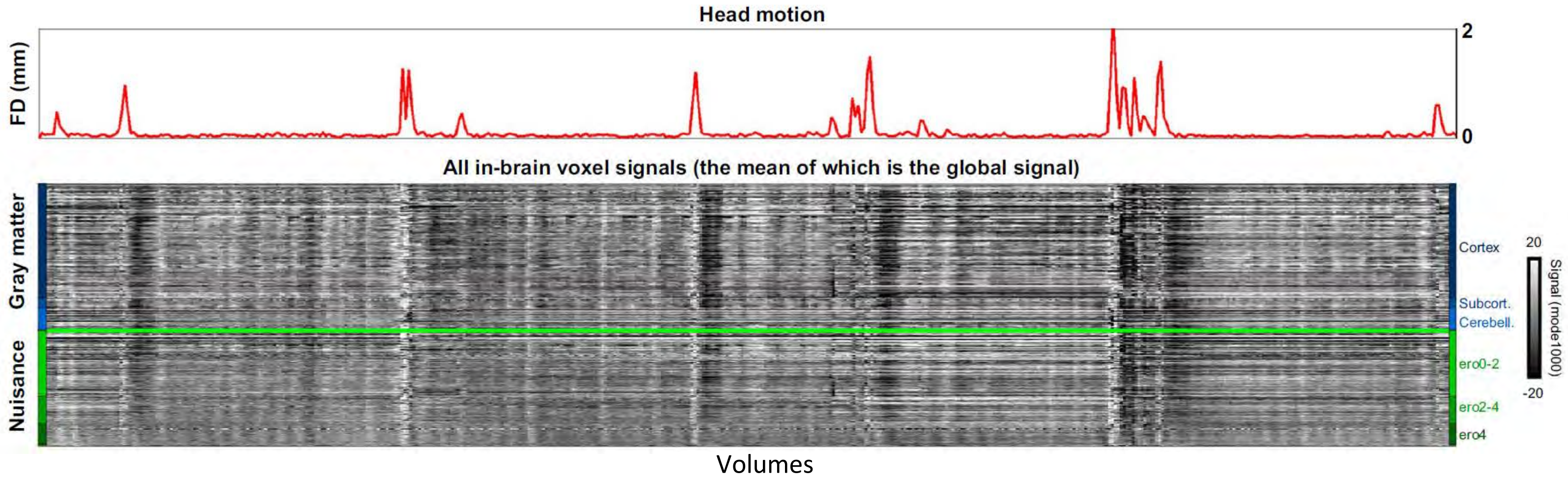
Correlations between BOLD signals

Spurious correlations

- **Head motion**
- Respiration
- Heart beat
- Scanner artifacts

Neuronal driven correlations

Functional Connectivity



Head motion differs between factor of interest:

Different populations, e.g.,:

- Patients move more than healthy people
- Children/elderly move more than adults

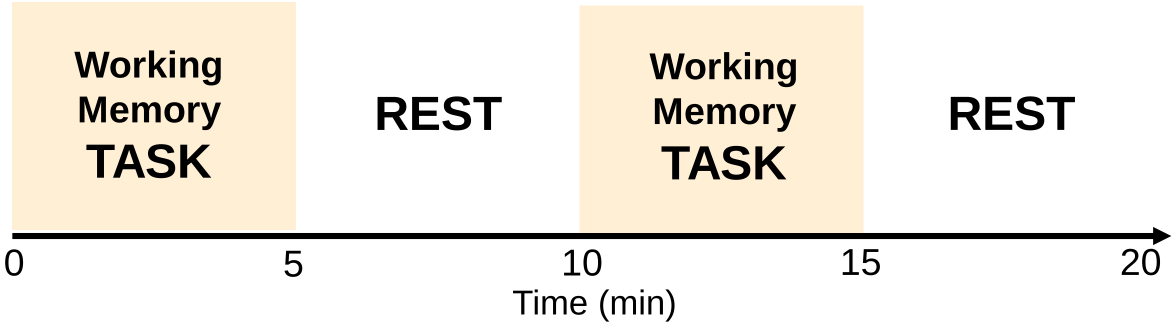
Within the same population, e.g.,:

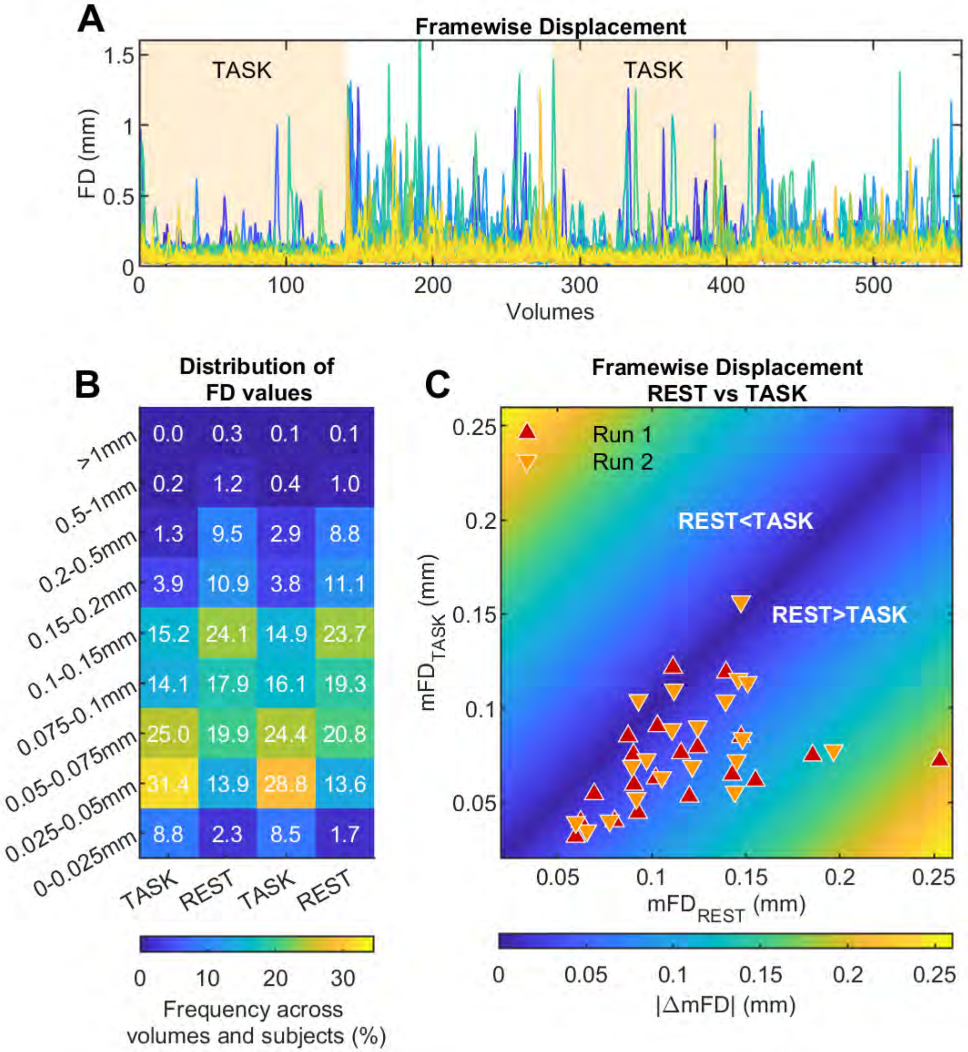
Subjects move less when cognitively engaged

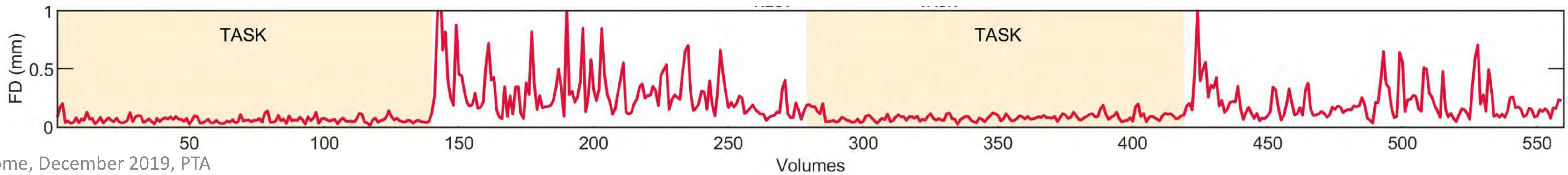
Goals and experimental design

To evaluate popular denoising strategies for cleaning up BOLD data spanning different cognitive conditions

We collected 40 scans from 20 subjects







Denoising strategies

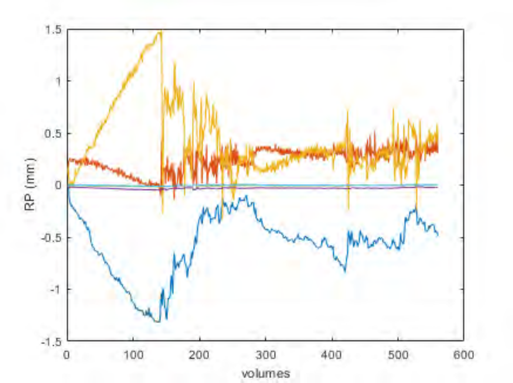
Confound regression

Band-pass filter

to keep only frequency within 0.008-0.1 Hz

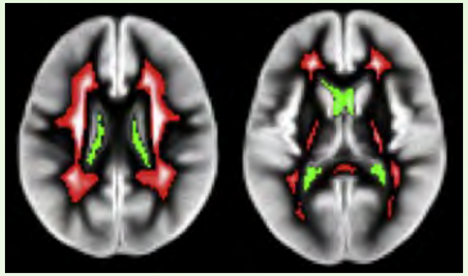
Realignment parameters (6RP)

- 12RP (6RP + first derivatives)
- 24RP (6RP + first derivatives + quadratic terms)



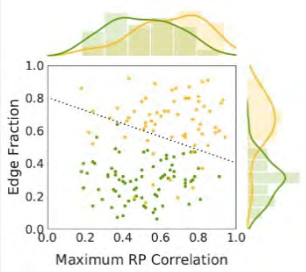
Signal from nuisance masks (i.e., WM and CSF)

- WM&CSF (average signals)
- aCompCor (PCA, first 10 components)
- aCompCor 50%



ICA-AROMA

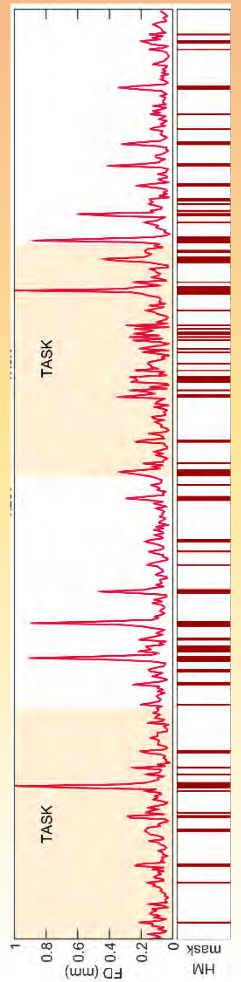
ICA + automatic classification of noise components



Global signal regression (GSR)

- 2GSR (include derivative)
- 4GSR (include derivative+ quadratic terms)

Censoring



Denoising strategies and benchmarks

N	Model name	tDoF
1	12RP	202
2	24RP	190
3	24RP+8WM&CSF	182
4	24RP+aCompCor	180
5	24RP+aCompCor50%	129.7 ± 4.1
6	ICA-AROMA	131.3 ± 20.7
GSR-based		
7	24RP+8WM&CSF+4GSR	178
8	24RP+aCompCor+2GSR	178
9	24RP+aCompCor50%+2GSR	127.7 ± 4.1
10	ICA-AROMA+2GSR	129.3 ± 20.7
Censoring-based		
11	24RP+8WM&CSF+4GSR+Tcens	145.7 ± 27.4
12	24RP+8WM&CSF+4GSR+Pcens	42

Correlations
between BOLD signals

Spurious correlations

- **Head motion**
- Respiration
- Heart beat
- Scanner artifacts

Neuronal driven correlations

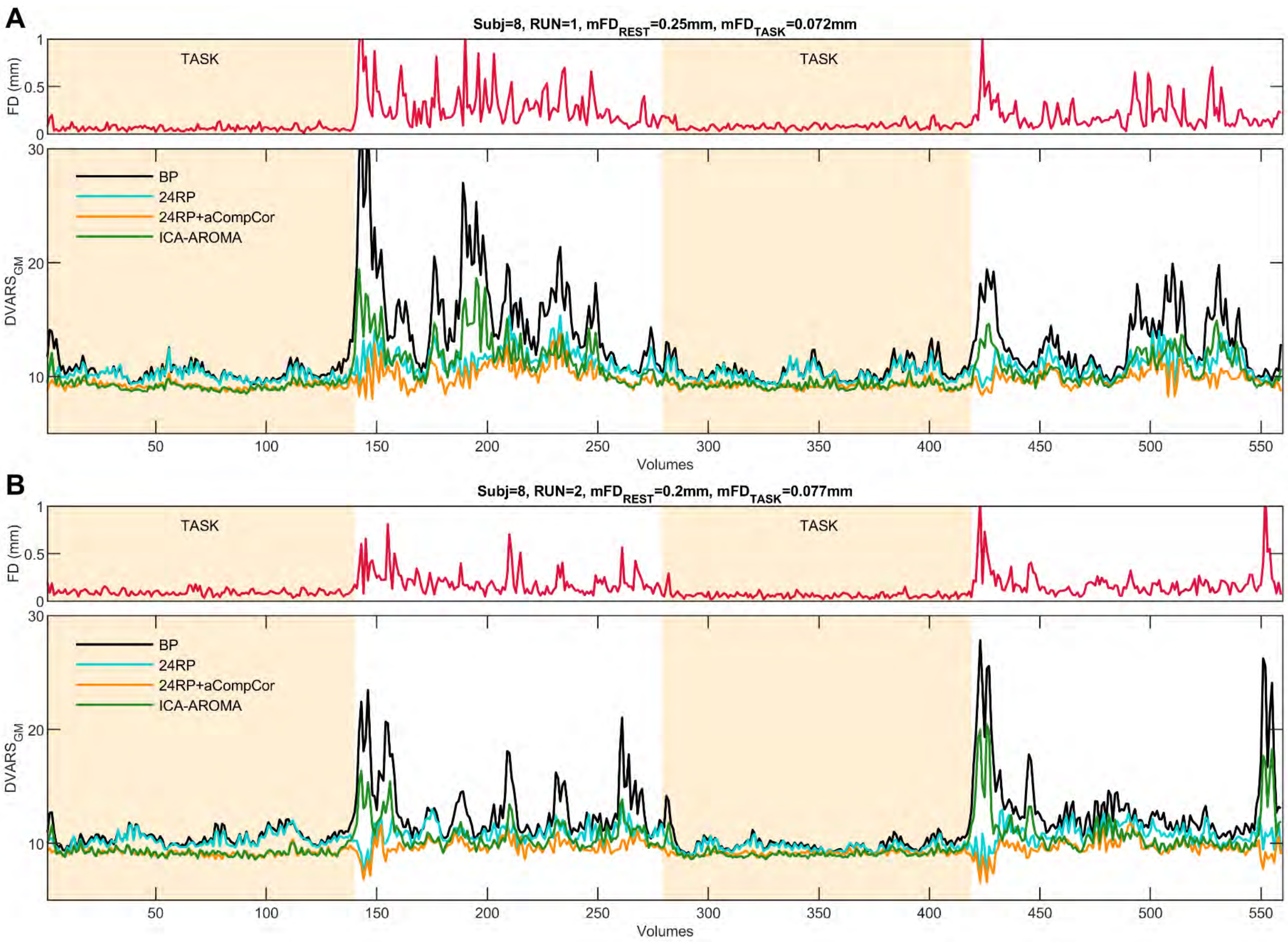
Functional Connectivity

Benchmarks based on minimizing **residual motion artifacts**:

- DVARS
- QC-FC plots
- QC-FC distance dependency
- Δr plots

DVARS

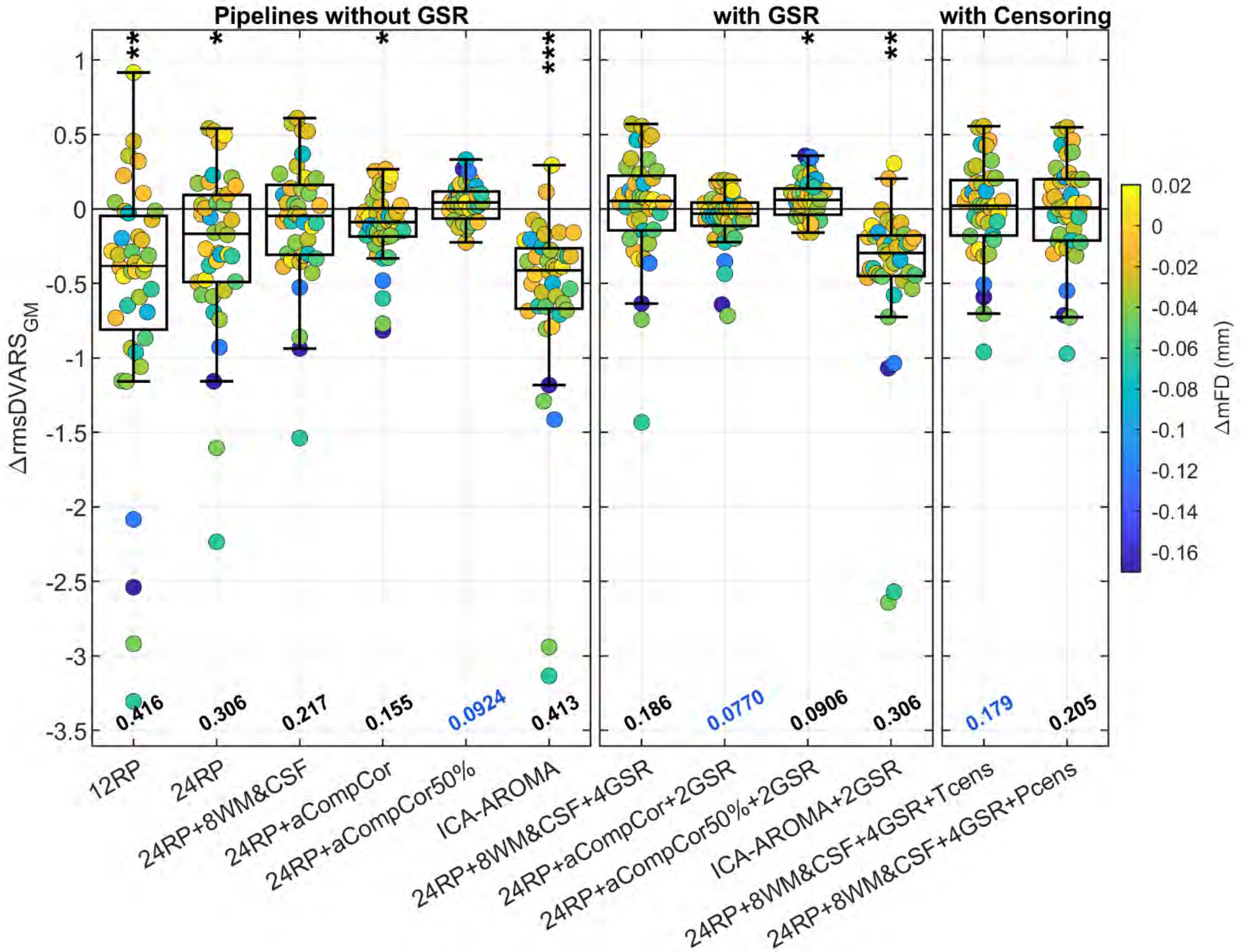
$$\mathrm{DVARS}(\Delta I)_i = \sqrt{\left\langle \left[\Delta I_i(\vec{x})\right]^2 \right\rangle} = \sqrt{\left\langle \left[I_i(\vec{x}) - I_{i-1}(\vec{x})\right]^2 \right\rangle}$$



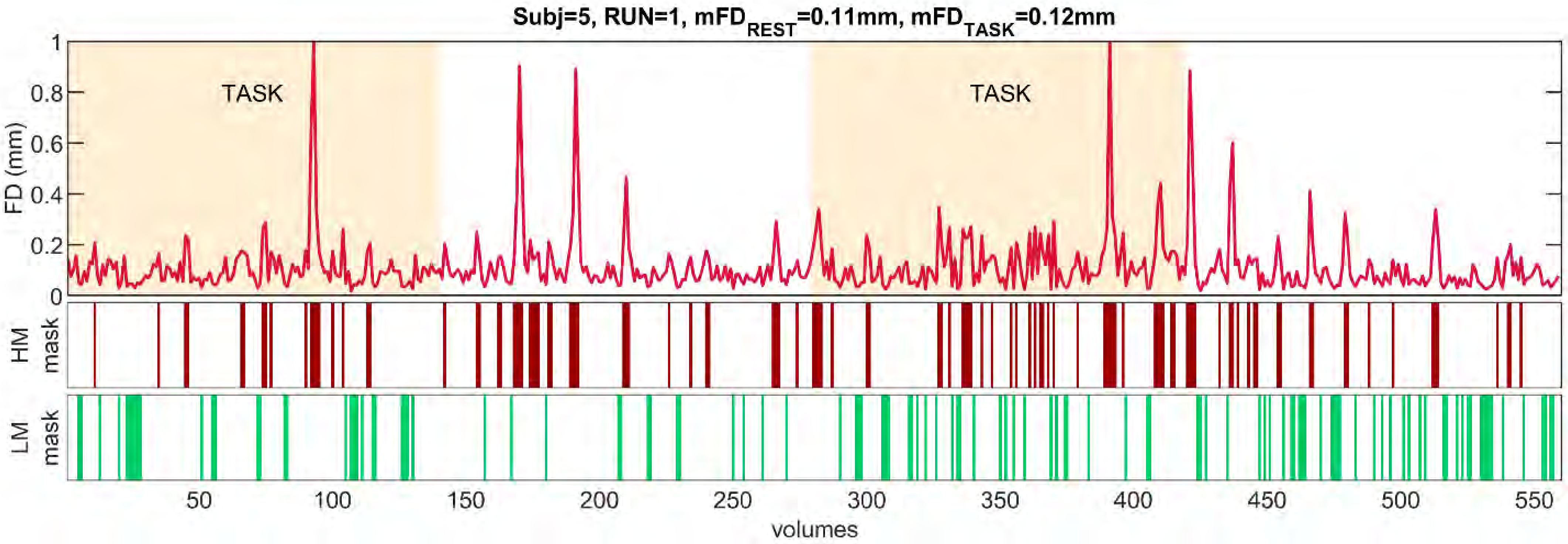
DVARS

$$\mathrm{DVARS}(\Delta I)_i = \sqrt{\left\langle \left[\Delta I_i(\vec{x})\right]^2 \right\rangle} = \sqrt{\left\langle \left[I_i(\vec{x}) - I_{i-1}(\vec{x})\right]^2 \right\rangle}$$

$$\Delta \mathrm{rms}(\mathrm{DVARS}_{GM}) = \mathrm{rms}(\mathrm{DVARS}_{GM|TASK}) - \mathrm{rms}(\mathrm{DVARS}_{GM|REST})$$



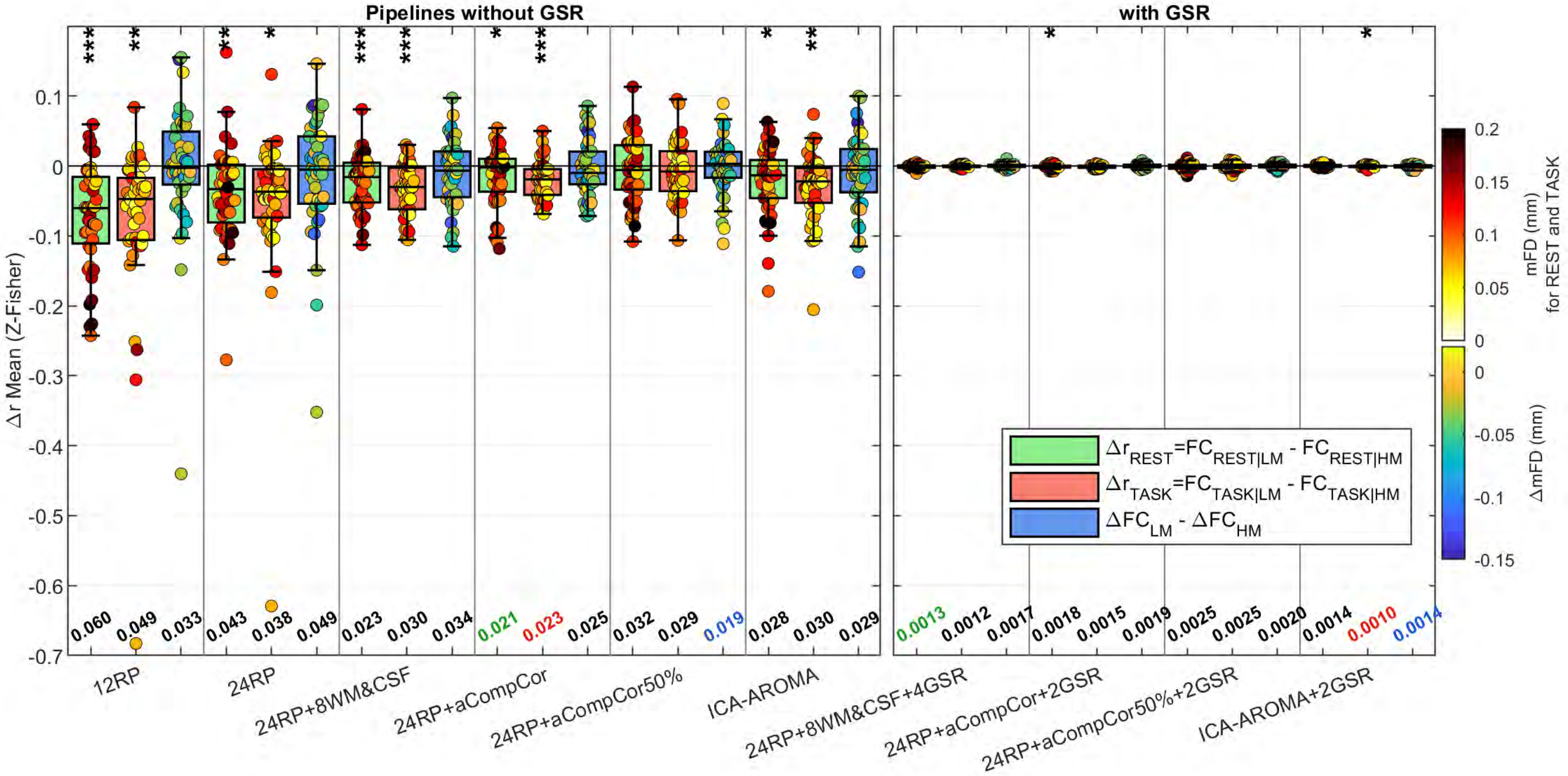
Δr plots



$$\Delta r_{REST} = FC_{REST|LM} - FC_{REST|HM}$$

$$\Delta r_{TASK} = FC_{TASK|LM} - FC_{TASK|HM}$$

Δr plots


Pipelines without GSR
with GSR
Δr Mean (Z-Fisher)
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
0.060 0.049 0.033 0.043 0.038 0.049 0.023 0.030 0.034 0.021 0.023 0.025 0.032 0.029 0.019 0.028 0.030 0.029
0.0013 0.0012 0.0017 0.0018 0.0015 0.0019 0.0025 0.0025 0.0020 0.0014 0.0010 0.0014
12RP
24RP
24RP+8WM&CSF
24RP+aCompCor
24RP+aCompCor50%
ICA-AROMA
24RP+8WM&CSF+4GSR
24RP+aCompCor+2GSR
24RP+aCompCor50%+2GSR
ICA-AROMA+2GSR
$\Delta r_{REST}=FC_{REST|LM} - FC_{REST|HM}$
$\Delta r_{TASK}=FC_{TASK|LM} - FC_{TASK|HM}$
$\Delta FC_{LM} - \Delta FC_{HM}$
mFD (mm) for REST and TASK
0.2
0.15
0.1
0.05
0
ΔmFD (mm)
0
-0.05
-0.1
-0.15

Denoising strategies and benchmarks

N	Model name	tDoF
1	12RP	202
2	24RP	190
3	24RP+8WM&CSF	182
4	24RP+aCompCor	180
5	24RP+aCompCor50%	129.7 ± 4.1
6	ICA-AROMA	131.3 ± 20.7
GSR-based		
7	24RP+8WM&CSF+4GSR	178
8	24RP+aCompCor+2GSR	178
9	24RP+aCompCor50%+2GSR	127.7 ± 4.1
10	ICA-AROMA+2GSR	129.3 ± 20.7
Censoring-based		
11	24RP+8WM&CSF+4GSR+Tcens	145.7 ± 27.4
12	24RP+8WM&CSF+4GSR+Pcens	42

Correlations between BOLD signals

Spurious correlations

- **Head motion**
- Respiration
- Heart beat
- Scanner artifacts

Benchmarks based on minimizing **residual motion artifacts**:

- DVARS
- QC-FC plots
- QC-FC distance dependency
- Δr plots

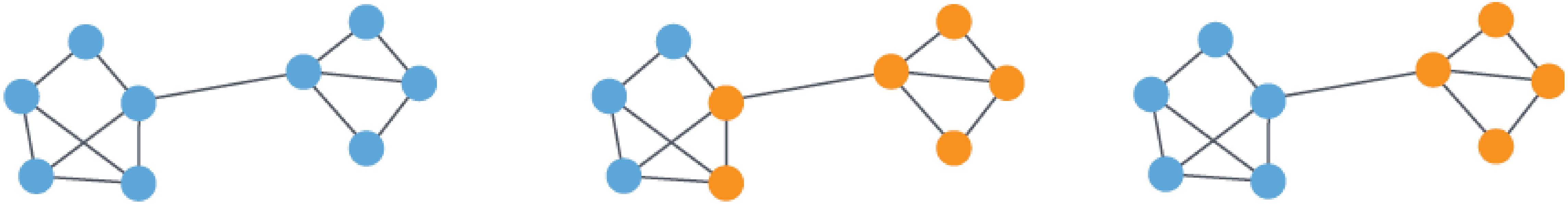
Neuronal driven correlations

Functional Connectivity

Benchmark based on **network identifiability**:

- Modularity

Modularity (Q)

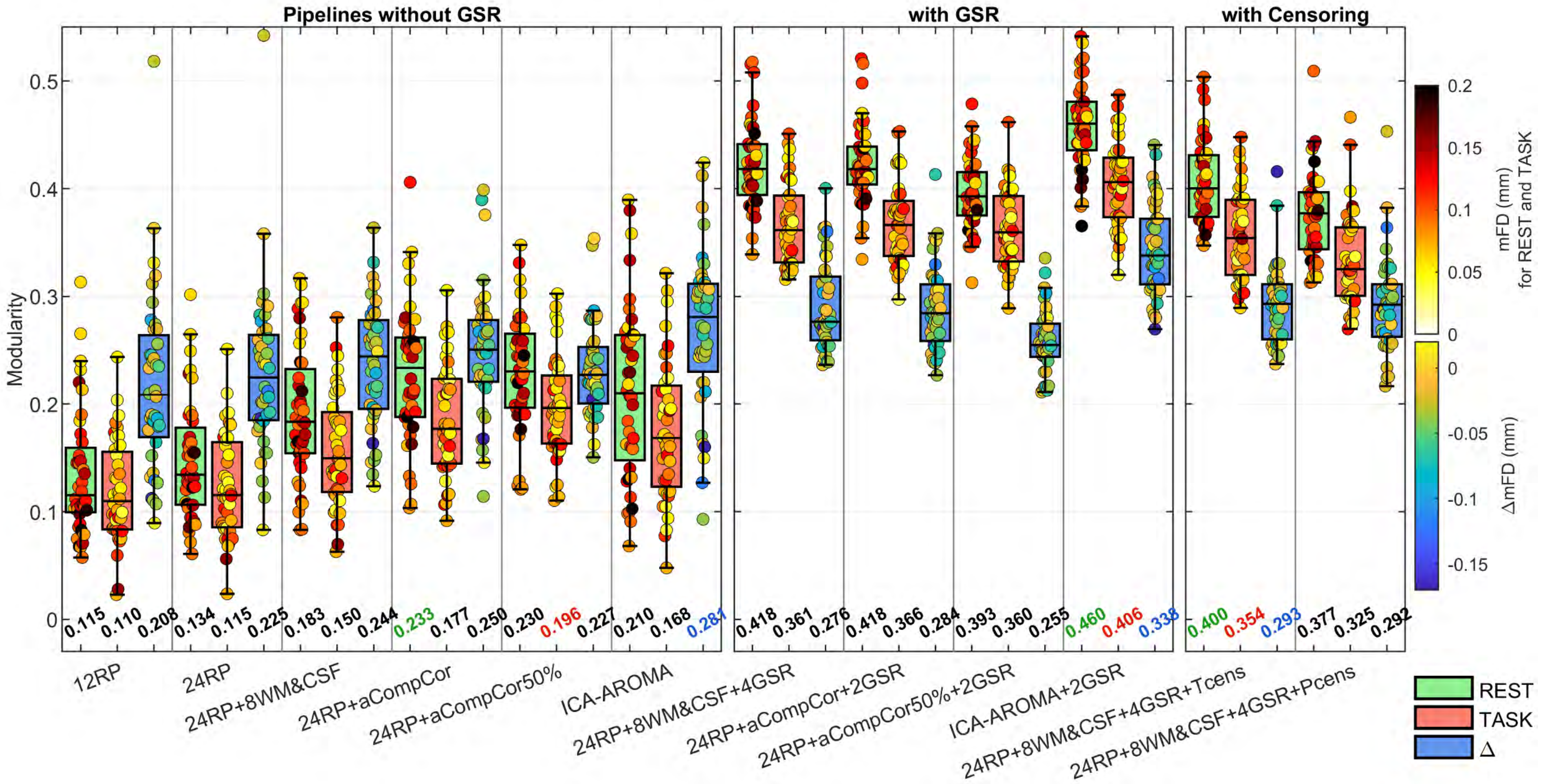


Q = 0   Q = 0.22   Q = 0.41

Community 1

Community 2

Modularity (Q)



Conclusions

- Subjects move more during rest than during the execution of a working-memory task
- Many denoising strategies are inadequate to balance residual motion artifacts between conditions
- aCompCor50% / GSR performed well across many benchmarks
- We underscore the importance of reporting the residual motion-related artifacts alongside functional connectivity results

Acknowledgments

Marta Moraschi

Mauro DiNuzzo

Silvia Tommasin

Michela Fratini

Tommaso Gili

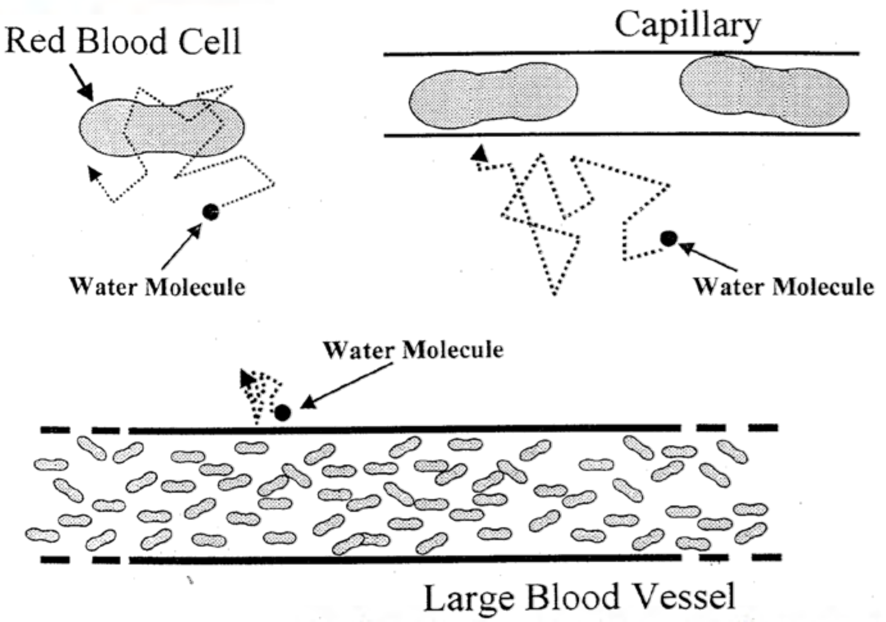
Richard G. Wise

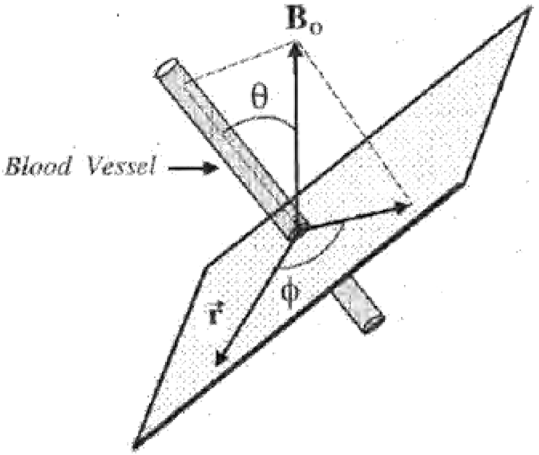
Silvia Mangia

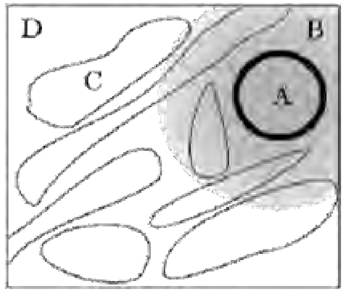
Emiliano Macaluso

END OF THE INSERT ON METHODOLOGICAL ASPECTS OF rsfMRI DOCUMENT CONTINUES WITH THE OVERALL REPORT

- **Milestones 2019**
  - TMENS:
    - New scanner commissioning (75%)
    - Study on hemodynamic and metabolic response (30%)
    - Publications on metabolic and functional response with dissociation and on networks modulation by attention (100%)
    - Spinal cord biophysical modelling, optimization of pipelines (70%)
  - MICROBRADAM:
    - Publications on multimodal structural imaging in spinal cord MRI (80%)
    - Secondments to CMRR, USA and CR/UEF, Finland (100%)
    - Publications related to secondments (100%)
    - Project end, final reporting (100%)

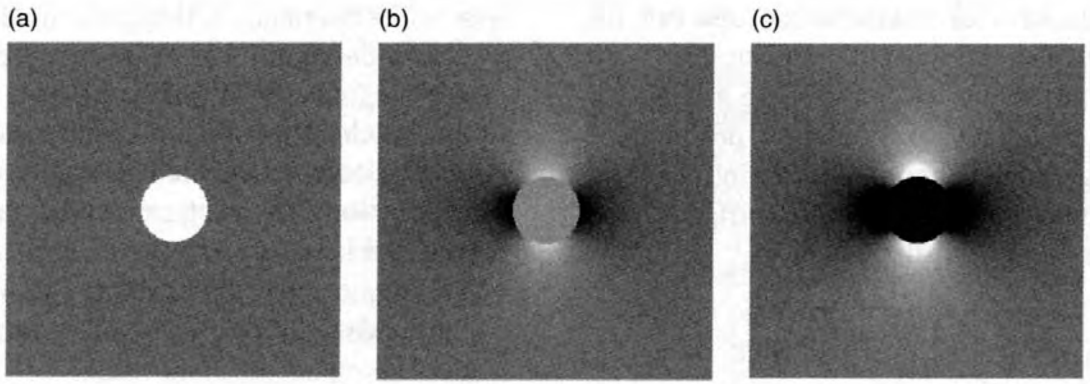






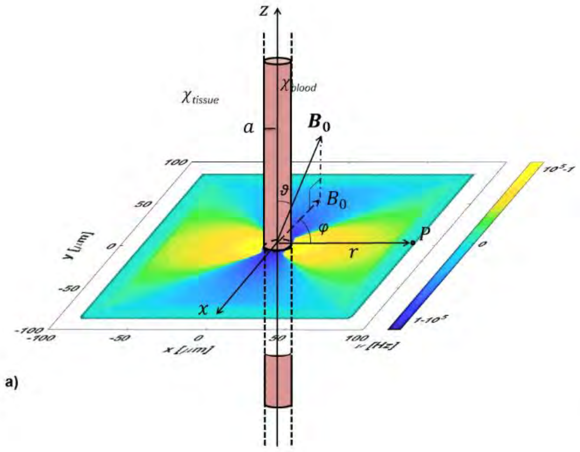
$$\Delta\omega_B^{in} = 2\pi\Delta\chi_0(1-Y)\omega_0\{\cos^2(\theta) - 1/3\},$$

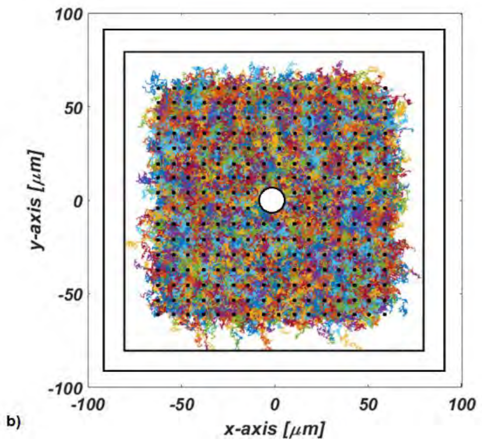
$$\Delta\omega_B^{out} = 2\pi\Delta\chi_0(1-Y)\omega_0\{r_b/r\}^2\sin^2(\theta)\cos(2\phi),$$

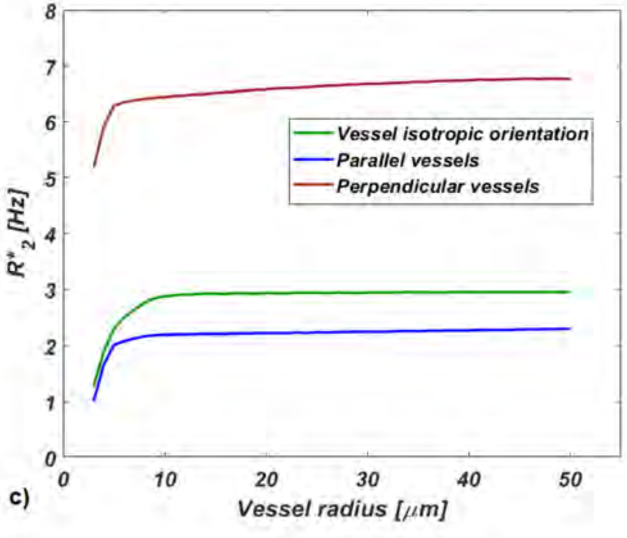


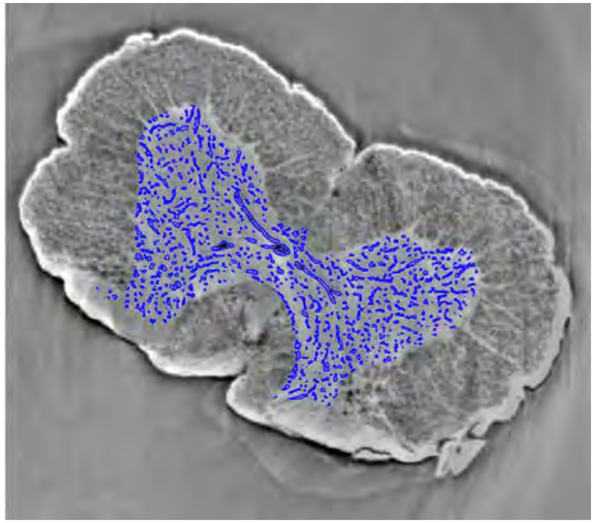
Numerical simulation of the Blood Oxygenation Level-Dependent functional Magnetic Resonance Signal using Finite Element Method

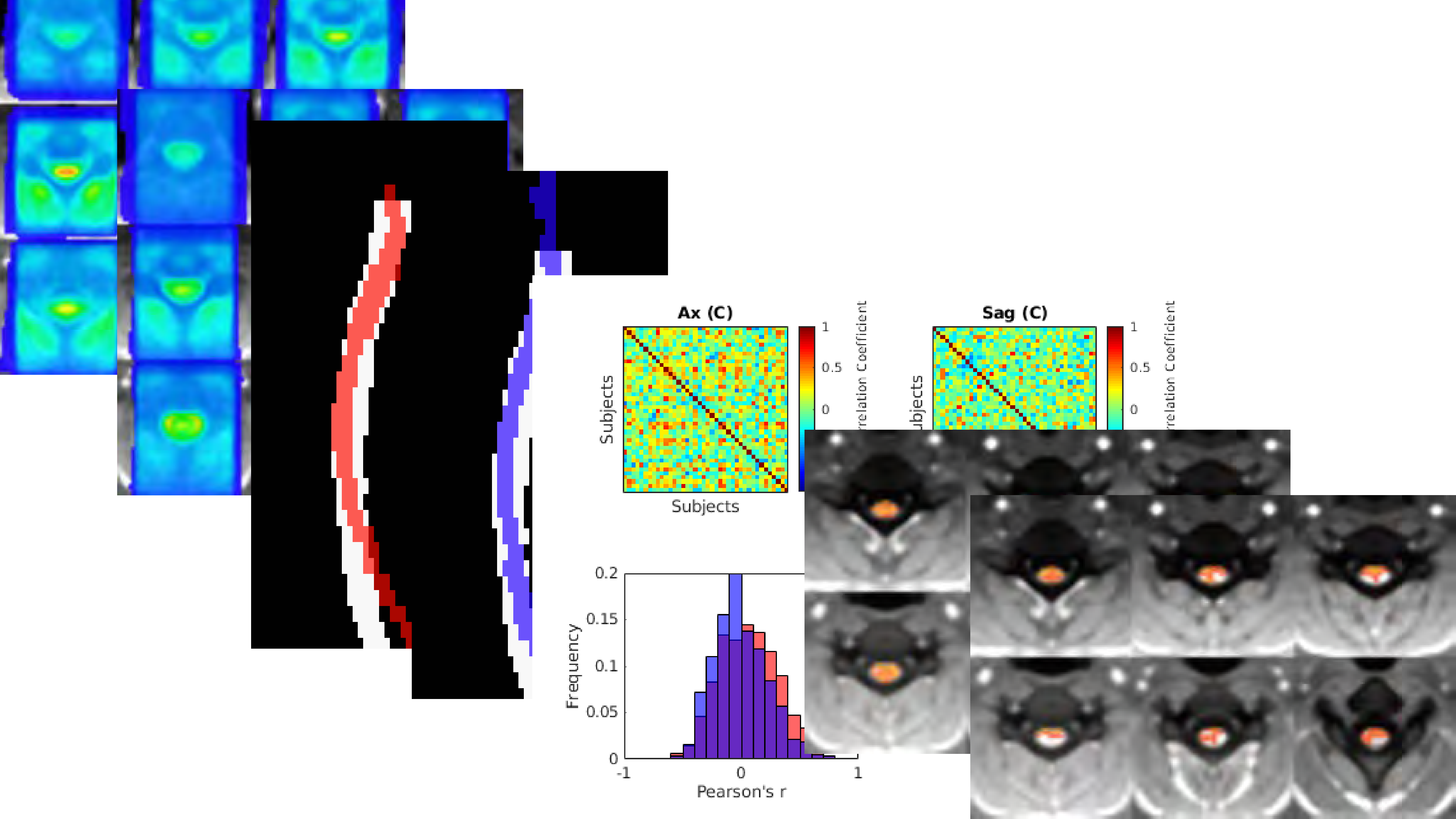
F. Mangini*[1] | M. DiNuzzo[1] | L. Maugeri[1] | M. Moraschi[2] | D. Mascali[2] | F. Frezza[3] | F. Giove[1,2] | M. Fratini[1,4]





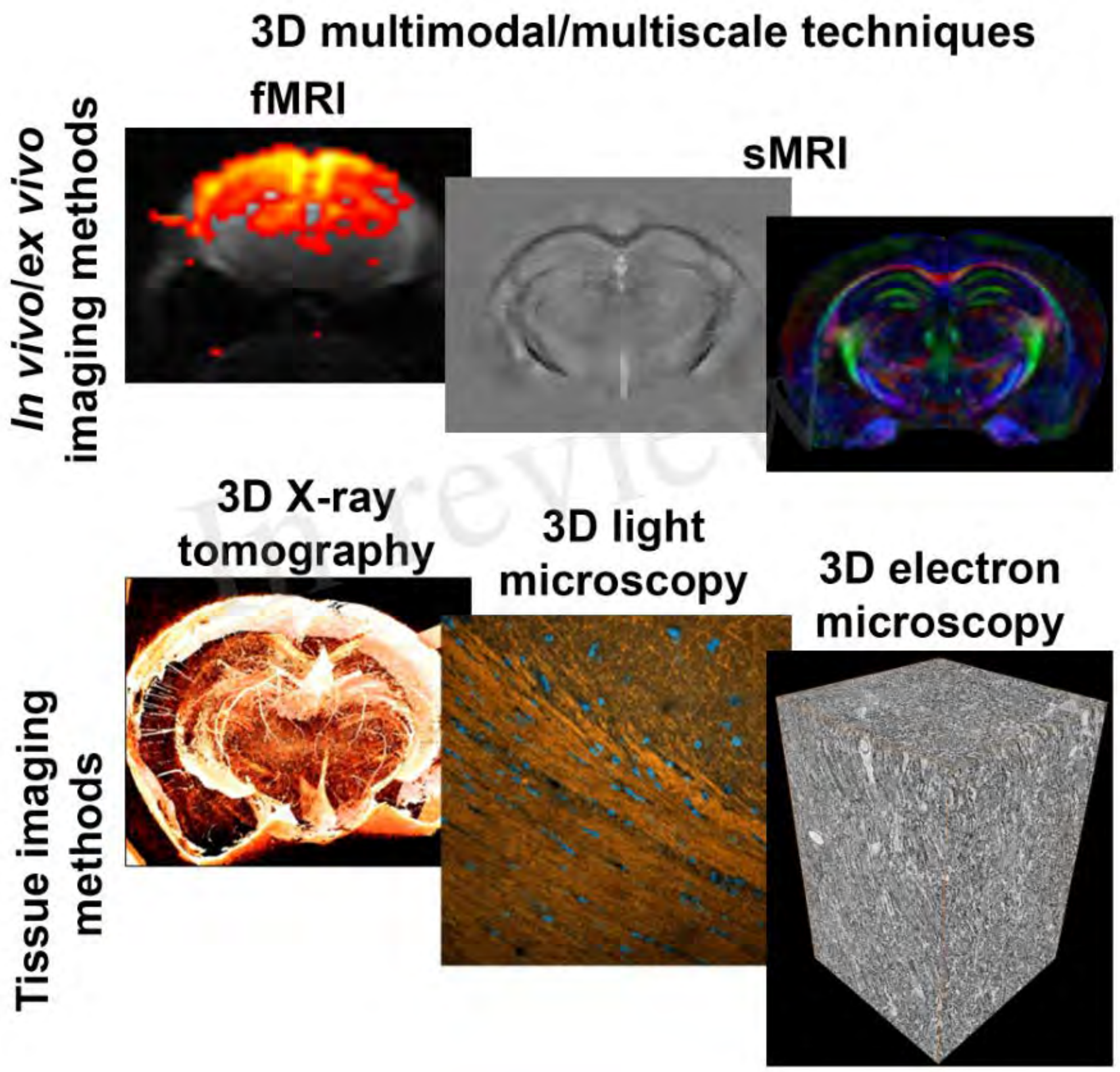


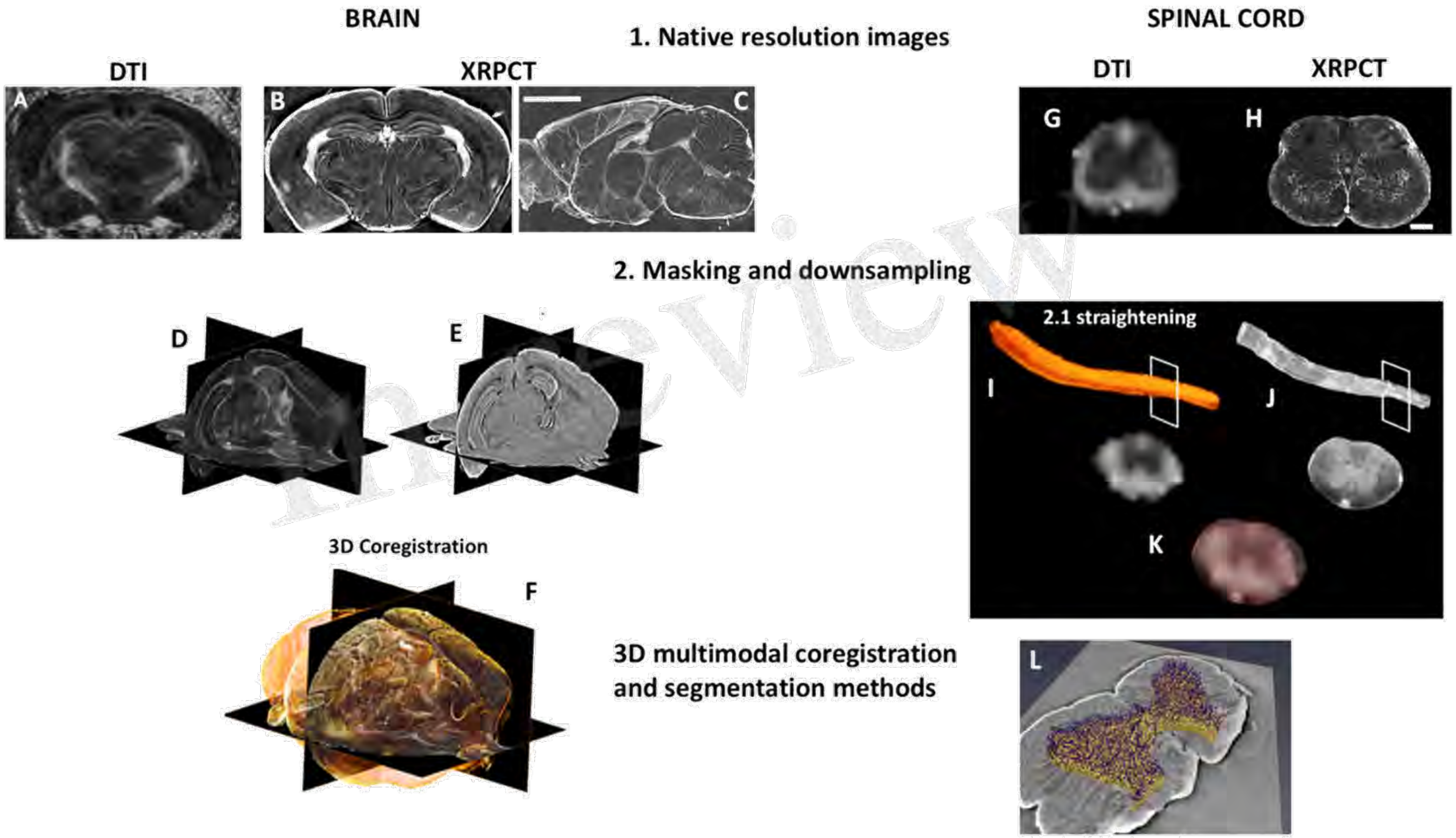




Ax (C)
Sag (C)
Subjects
Subjects
1
0.5
0
Frequency
Pearson's r
0.2
0.15
0.1
0.05
0
-1
0
1

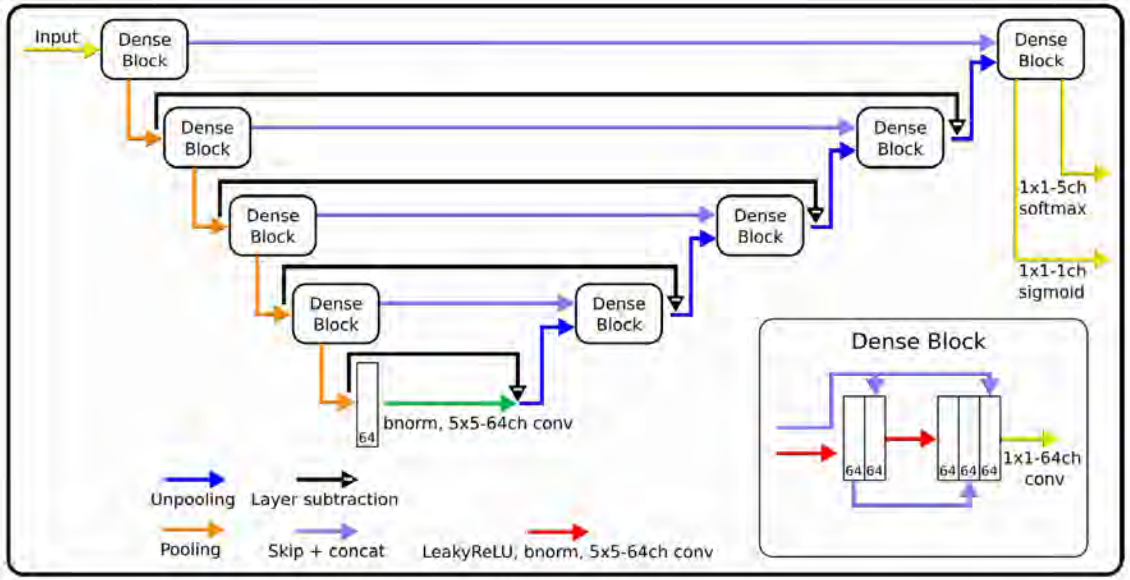
- **Milestones 2019**
  - TMENS:
    - New scanner commissioning (75%)
    - Study on hemodynamic and metabolic response (30%)
    - Publications on metabolic and functional response with dissociation and on networks modulation by attention (100%)
    - Spinal cord biophysical modelling, optimization of pipelines (70%)
  - MICROBRADAM:
    - Publications on multimodal structural imaging in spinal cord MRI (80%)
    - Secondments to CMRR, USA and CR/UEF, Finland (100%)
    - Publications related to secondments (100%)
    - Project end, final reporting (100%)

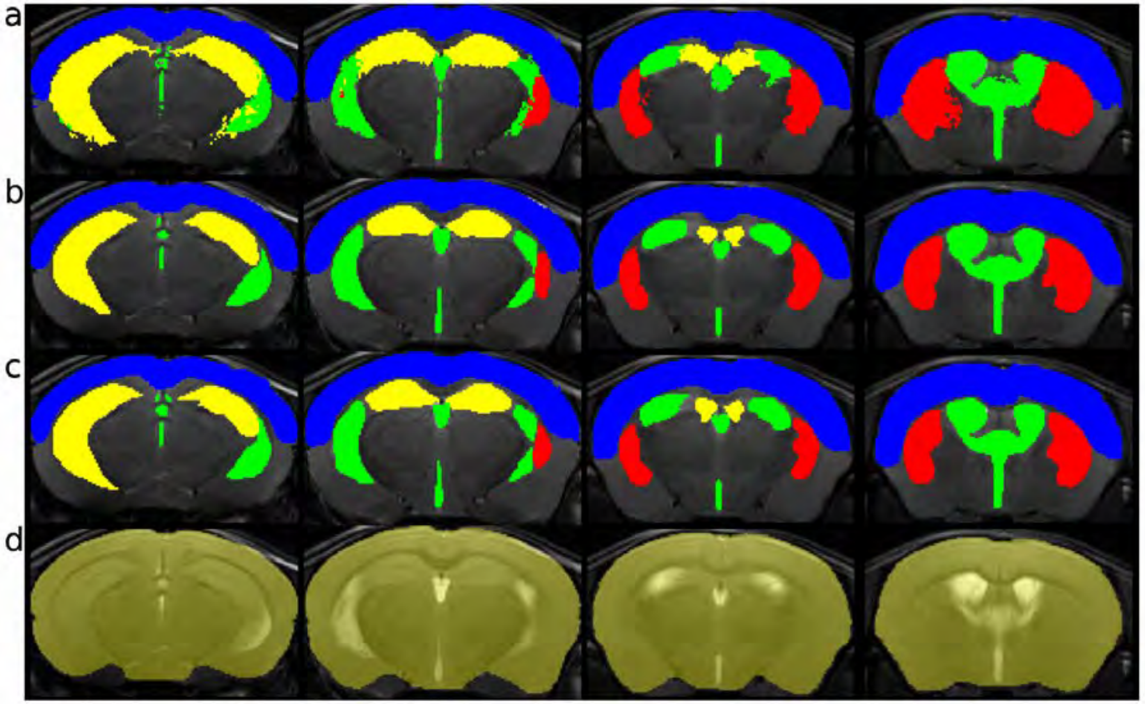

3D multimodal/multiscale techniques
In vivo/ex vivo imaging methods
fMRI
sMRI
Tissue imaging methods
3D X-ray tomography
3D light microscopy
3D electron microscopy

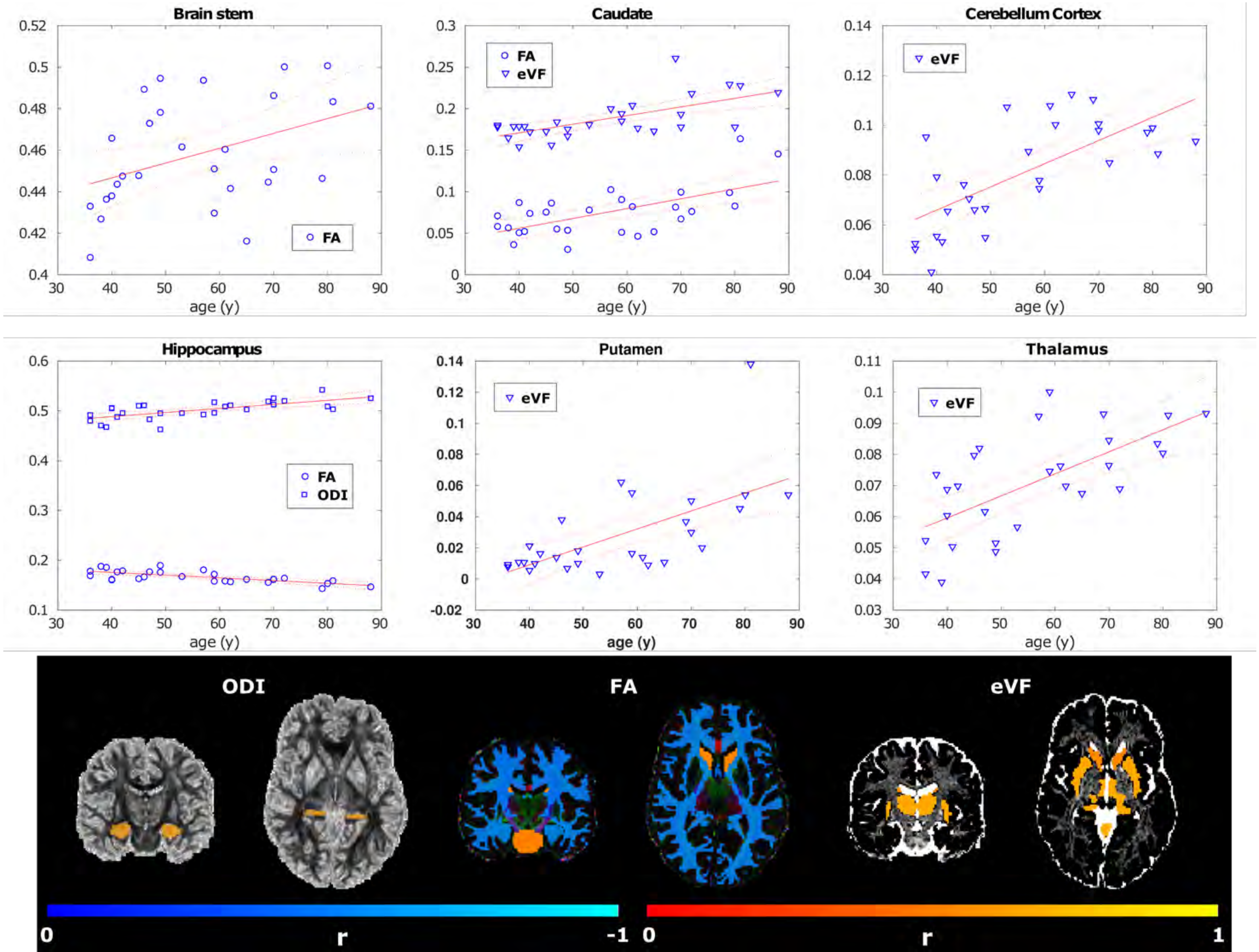

BRAIN
1. Native resolution images
SPINAL CORD
DTI
XRPCT
A
B
C
DTI
XRPCT
G
H
2. Masking and downsampling
D
E
2.1 straightening
I
J
K
3D Coregistration
F
3D multimodal coregistration
and segmentation methods
L

- **Milestones 2019**
  - TMENS:
    - New scanner commissioning (75%)
    - Study on hemodynamic and metabolic response (30%)
    - Publications on metabolic and functional response with dissociation and on networks modulation by attention (100%)
    - Spinal cord biophysical modelling, optimization of pipelines (70%)
  - MICROBRADAM:
    - Publications on multimodal structural imaging in spinal cord MRI (80%)
    - Secondments to CMRR, USA and CR/UEF, Finland (100%)
    - Publications related to secondments (100%)
    - Project end, final reporting (100%)

Multi-task U-Net (MU-Net) is a convolutional neural network designed to accomplish simultaneously skull striping and brain segmentation, achieving higher spatial accuracy than state-of-the-art multi-atlas segmentation methods with an inference time of 0.35 seconds and no pre-processing requirements.







Brain stem
Caudate
Cerebellum Cortex
Hippocampus
Putamen
Thalamus
FA
eVF
ODI
age (y)
ODI
FA
eVF
0
r
-1
0
r
1

TNEU Tecnologie MRI per le neuroscienze

CENTRO FERMI
MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI

MARBILab
Magnetic Resonance for Brain Investigation Laboratory

- **Expected funding in the 3-year period:**
- **Request of funding by Centro Fermi**
- *Grants : complement the external grants, in order to have always at least 2 young researchers involved in the core activities (2 postdocs. Evolution to 1 researcher + 1 postdoc when feasible)*
- *One postdoc cofunded by Fondazione Santa Lucia*
- *Cofunding for other grants if awarded and if needed*
- *Consumables/inventory per year: about 15 k€*
- *Contribution (studentships for young scientists, general organization) for the biennial Erice Workshop (next date: November 2020, http://ismrbf.marbilab.eu)*

- **External funding applied for or forthcoming**
- *MAECI ITA-ISR bilateral project MLrehab (monitoring of rehabilitation in MS, applied for)*
- *Regione Lazio Progetti strategici NBP (PAMINA follow-up, development of calibrated MR for CMRO2, applied for)*
- *Ricerca Finalizzata (applied for)*
- *BRAMIFUN (H2020 MICROBRADAM follow up, extension to function and neuromodulation, deadline April 2020*)*

- **First attempt rejected with ranking in top 20% (cutoff for funding top 16%) with positive comments and suggestion to resubmit. Looking for a credible industrial partner, whose absence hindered the previous application*

- **Activity 2020**
  - New scanner commissioning. Pipelines for QA and automated processing Integration into PAMINA. Experimental activity from March.
  - top-down modulations of metabolism: multiparametric study with spectroscopy and imaging (tonic response and steady-state networks).
  - Impact of physiological parameters on steady state networks.
  - Structural study on aging: publication
  - Finalization of modelling of glycogen sparing hypothesis. Possible extension to time-resolved approaches.
  - Applications of spinal cord fMRI in MS patients: finalization of processing and publication. Modelling of BOLD signal in realistic geometries. MB EPI on spinal cord. Simultaneous brain-spinal cord fMRI.
  - Collaboration with VIEWLAB (synergistic biomedical physics/biophysics perspectives, shared computational resources…)
  - Public presentation of PAMINA

- **Activity 2021-2022**
  - Increased collaboration with UniChieti (RG Wise). Development of calibration methods for quantitation of CMRO2 and vascular reactivity.
  - Aging: functional counterparts of structural changes
  - Energetic budget on a network (in collaboration with MNL)
  - Development of new metrics for the detection of BOLD fluctuations spatial scale

CENTRO FERMI
MUSEO STORICO DELLA FISICA E CENTRO STUDI E RICERCHE ENRICO FERMI

Acknowledgements

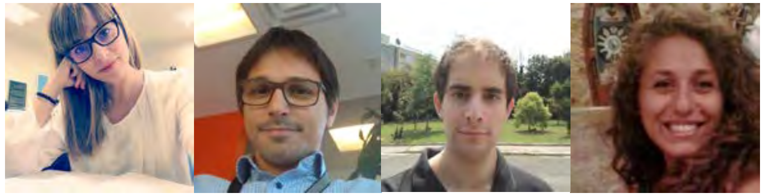
MARBILab
Magnetic Resonance for Brain Investigation Laboratory

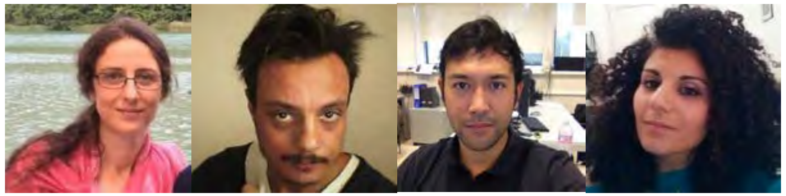
- All colleagues @ TNEU project
- Michela Fratini, *Mauro Di Nuzzo, Fabio Mangini*, Laura Maugeri, Marco Bozzali (Santa Lucia Foundation/CNR)
- Richard G. Wise, Kevin Murphy (U Cardiff/U Chieti)
- Silvia Mangia, Petr Bednarik, Ivan Tkac (U Minnesota)
- A Sierra-Lopez, O Grohn, J Tohka (U Eastern Finland)

- Giulia Festa for starting the VIEWLAB collaboration
- Centro Fermi and its staff

REGIONE LAZIO

SANTA LUCIA
NEUROSCIENZE E RIABILITAZIONE





This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 691110
Parzialmente finanziato dalla Regione Lazio grant PAMINA
The content is solely the responsibility of the authors and does not necessarily represent the official views of the funding bodies