MEG @ McGILL

MEG = Magnetoencephalography
for millisecond functional brain imaging

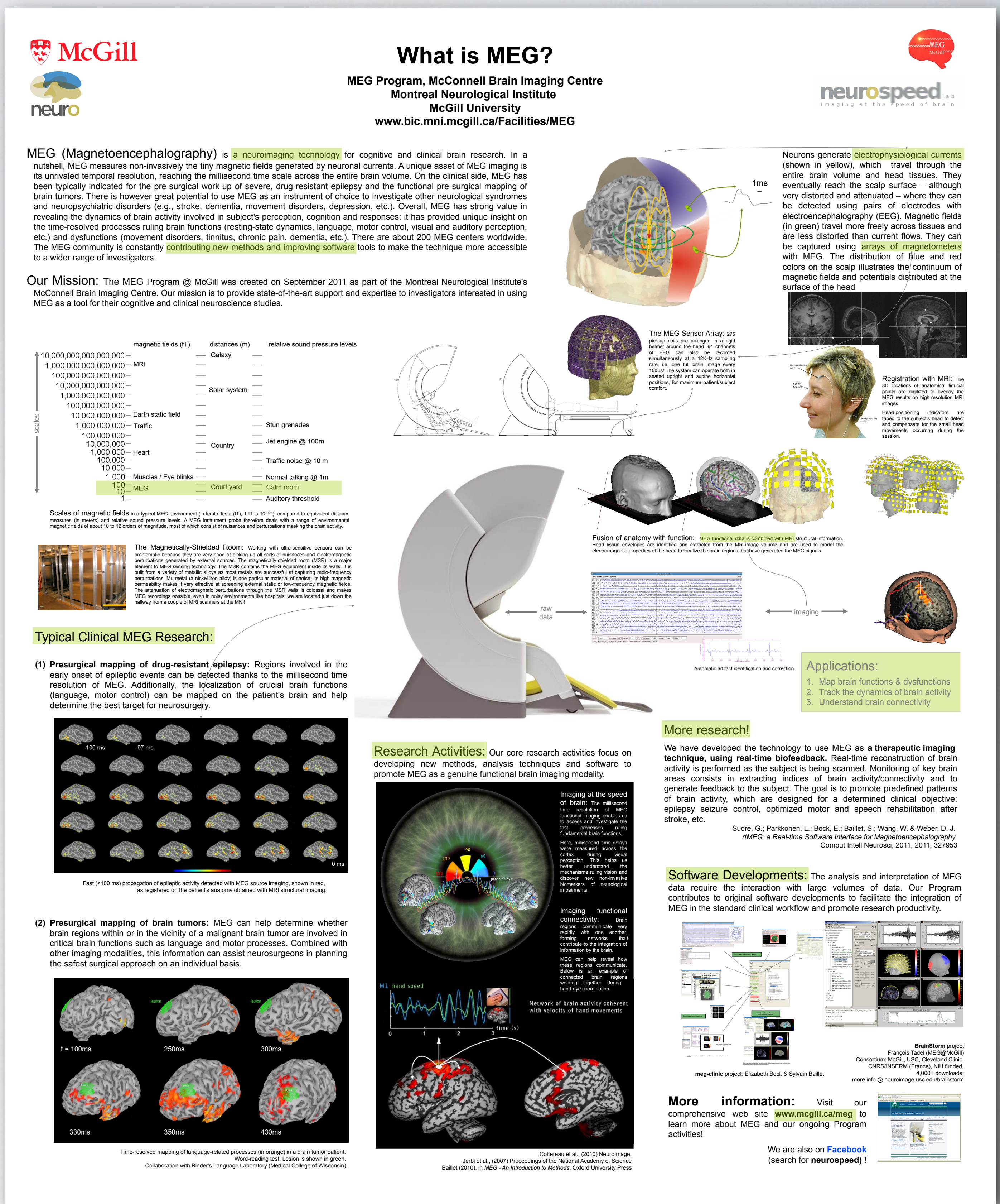
WHAT IS MEG?

MEG features functional brain imaging abilities
at the millisecond time scale.

The techniques and methods are distinct from fMRI's.

The next few slides are a short introduction to MEG.

For scanner access, training and more information, see last slide.



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What is MEG?

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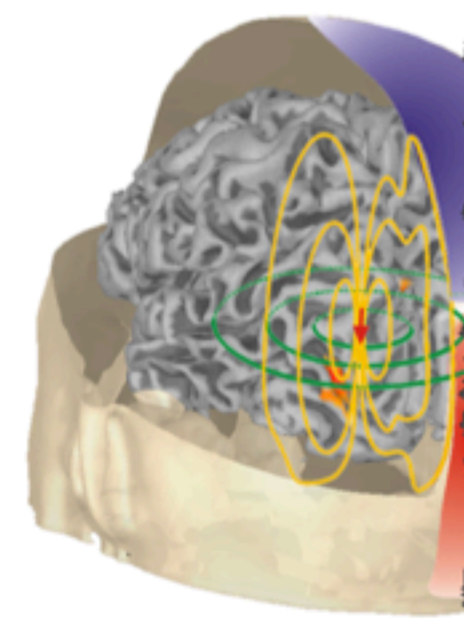
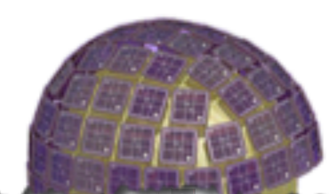
What is MEG?

MEG Program, McConnell Brain Imaging Centre
Montreal Neurological Institute
McGill University
www.bic.mni.mcgill.ca/Facilities/MEG

MEG (Magnetoencephalography) is a neuroimaging technology for cognitive and clinical brain research. In a nutshell, MEG measures non-invasively the tiny magnetic fields generated by neuronal currents. A unique asset of MEG imaging is its unrivaled temporal resolution, reaching the millisecond time scale across the entire brain volume. On the clinical side, MEG has been typically indicated for the pre-surgical work-up of severe, drug-resistant epilepsy and the functional pre-surgical mapping of brain tumors. There is however great potential to use MEG as an instrument of choice to investigate other neurological syndromes and neuropsychiatric disorders (e.g., stroke, dementia, movement disorders, depression, etc.). Overall, MEG has strong value in revealing the dynamics of brain activity involved in subject's perception, cognition and responses: it has provided unique insight on the time-resolved processes ruling brain functions (resting-state dynamics, language, motor control, visual and auditory perception, etc.) and dysfunctions (movement disorders, tinnitus, chronic pain, dementia, etc.). There are about 200 MEG centers worldwide. The MEG community is constantly contributing new methods and improving software tools to make the technique more accessible to a wider range of investigators.



Our Mission: The MEG Program @ McGill was created on September 2011 as part of the Montreal Neurological Institute's McConnell Brain Imaging Centre. Our mission is to provide state-of-the-art support and expertise to investigators interested in using MEG as a tool for their cognitive and clinical neuroscience studies.



The MEG pick-up coils helmet arou of EEG

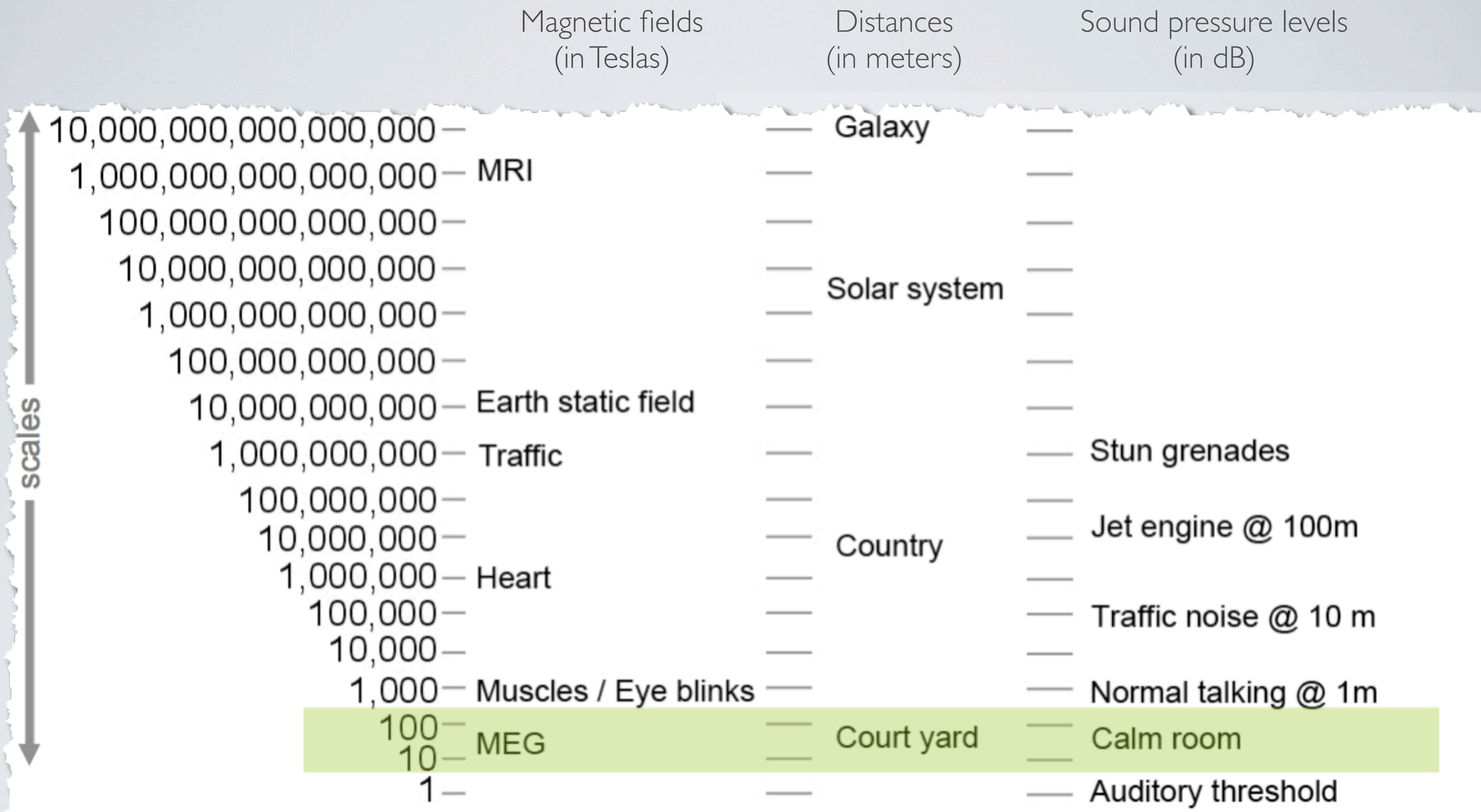
magnetic fields (fT) distances (m) relative sound pressure levels

10,000,000,000,000,000 Galaxy

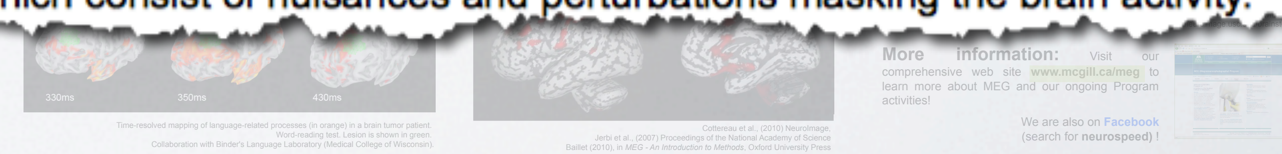
More information: Visit our comprehensive web site www.mcgill.ca/meg to learn more about MEG and our ongoing Program activities!

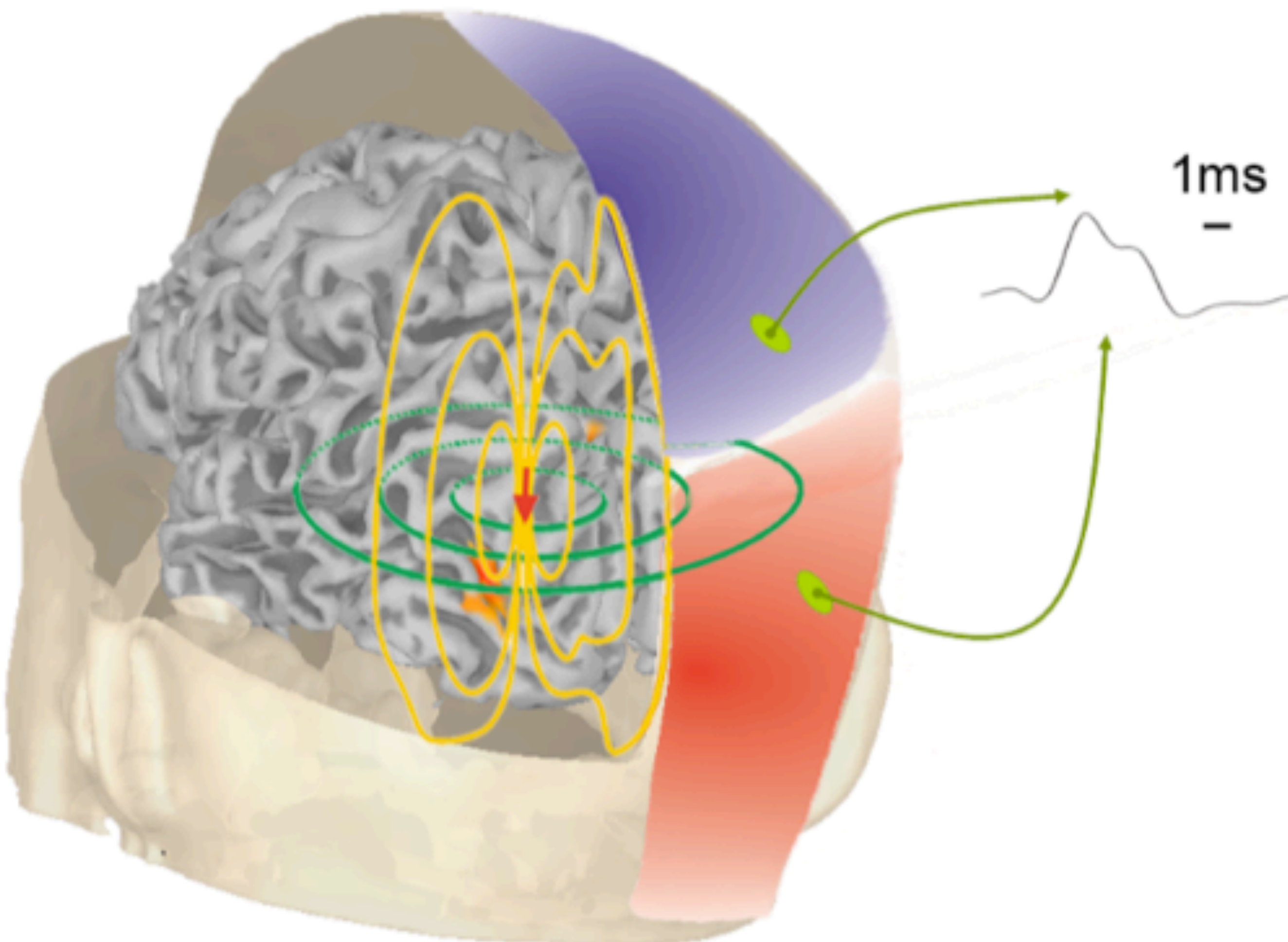
We are also on Facebook (search for neurospeed)!

neuro MEG @ McGill

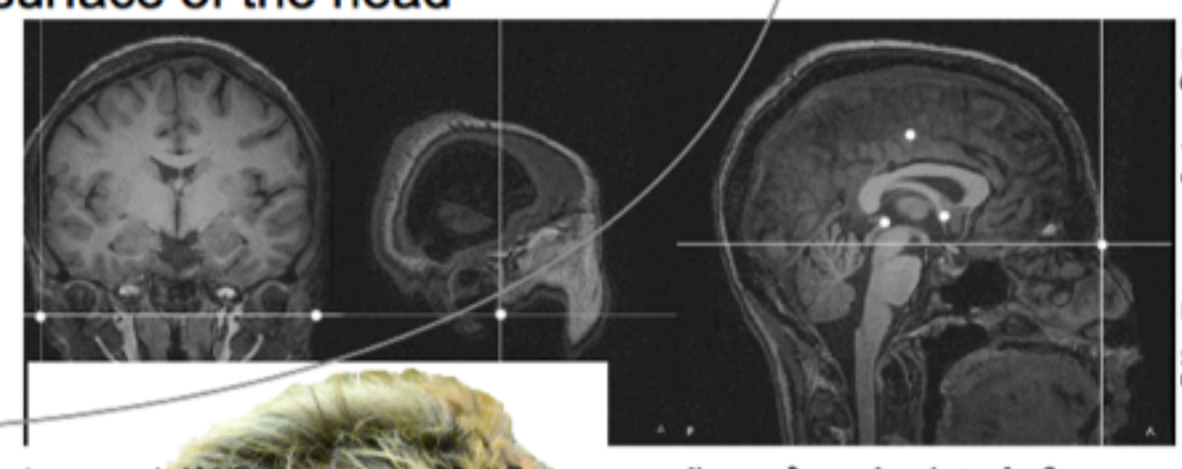


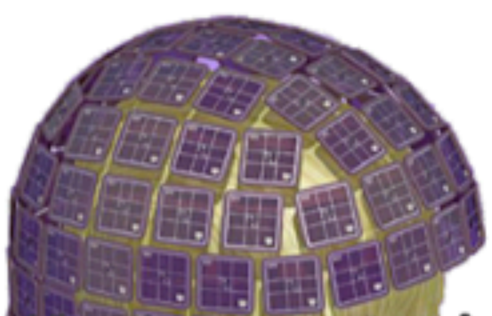
Scales of magnetic fields in a typical MEG environment (in femto-Tesla (fT), 1 fT is 10^{-15}T), compared to equivalent distance measures (in meters) and relative sound pressure levels. A MEG instrument probe therefore deals with a range of environmental magnetic fields of about 10 to 12 orders of magnitude, most of which consist of nuisances and perturbations masking the brain activity.





Neurons generate electrophysiological currents (shown in yellow), which travel through the entire brain volume and head tissues. They eventually reach the scalp surface – although very distorted and attenuated – where they can be detected using pairs of electrodes with electroencephalography (EEG). Magnetic fields (in green) travel more freely across tissues and are less distorted than current flows. They can be captured using arrays of magnetometers with MEG. The distribution of blue and red colors on the scalp illustrates the continuum of magnetic fields and potentials distributed at the surface of the head





The MEG Sensor Array: 275 pick-up coils are arranged in a rigid helmet around the head. 64 channels of EEG can also be recorded simultaneously at a 12KHz sampling

The Magnetically-Shielded Room: Working with ultra-sensitive sensors can be problematic because they are very good at picking up all sorts of nuisances and electromagnetic perturbations generated by external sources. The magnetically-shielded room (MSR) is a major element to MEG sensing technology. The MSR contains the MEG equipment inside its walls. It is built from a variety of metallic alloys as most metals are successful at capturing radio-frequency perturbations. Mu-metal (a nickel-iron alloy) is one particular material of choice: its high magnetic permeability makes it very effective at screening external static or low-frequency magnetic fields. The attenuation of electromagnetic perturbations through the MSR walls is colossal and makes MEG recordings possible, even in noisy environments like hospitals: we are located just down the hallway from a couple of MRI scanners at the MNI!

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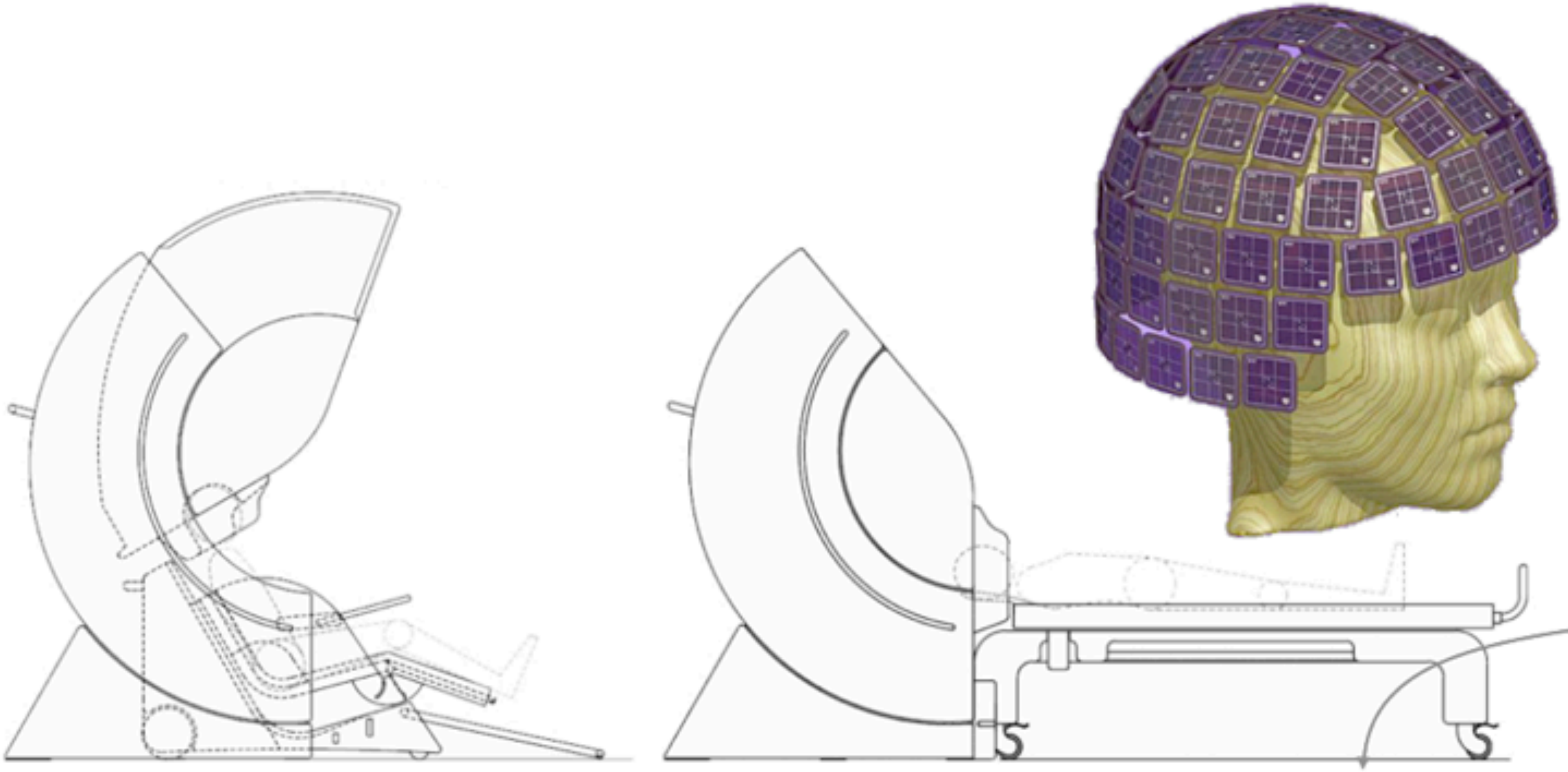
What is MEG?

MEG Program, McConnell Brain Imaging Centre
Montreal Neurological Institute

ise to clinical referrals and scientific
science studies.



The MEG Sensor Array: 275 pick-up coils are arranged in a rigid helmet around the head. 64 channels of EEG can also be recorded simultaneously at a 12KHz sampling rate, i.e. one full brain image every 100µs! The system can operate both in seated upright and supine horizontal positions, for maximum patient/subject comfort.

More information: Visit our comprehensive web site www.mcgill.ca/meg to learn more about MEG and our ongoing Program activities!

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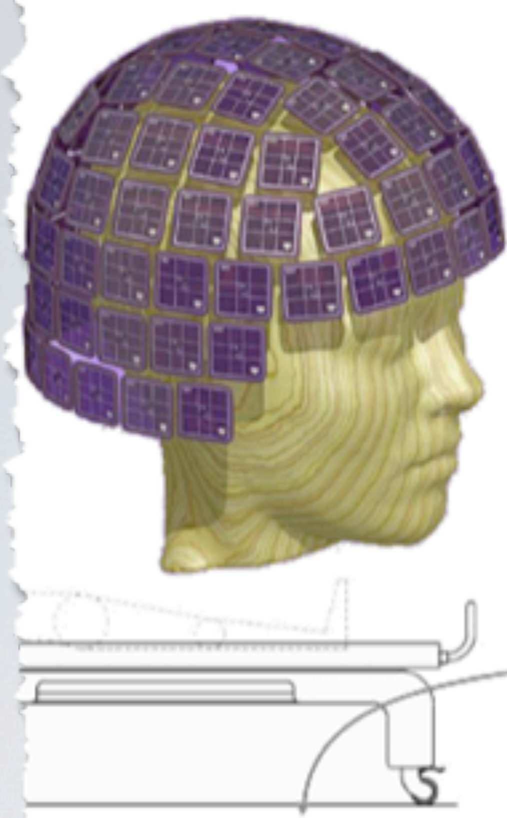

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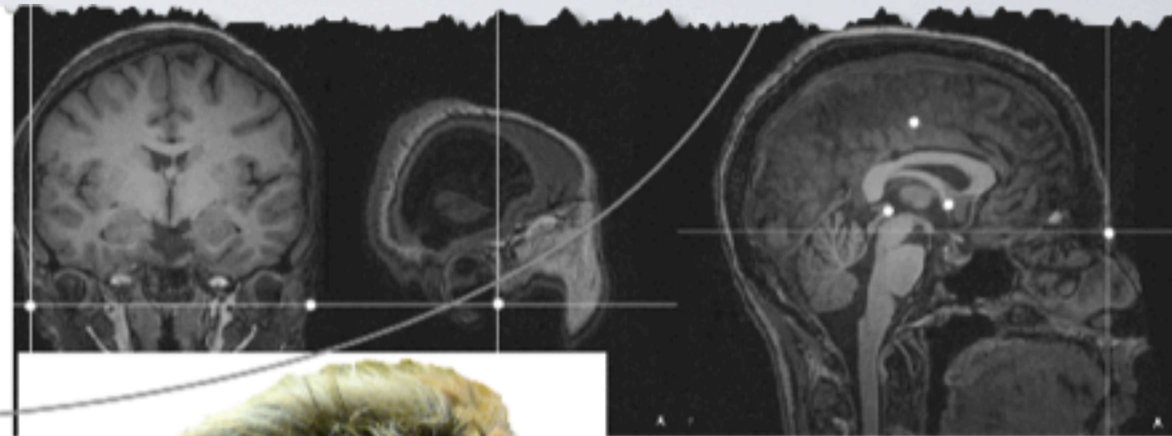
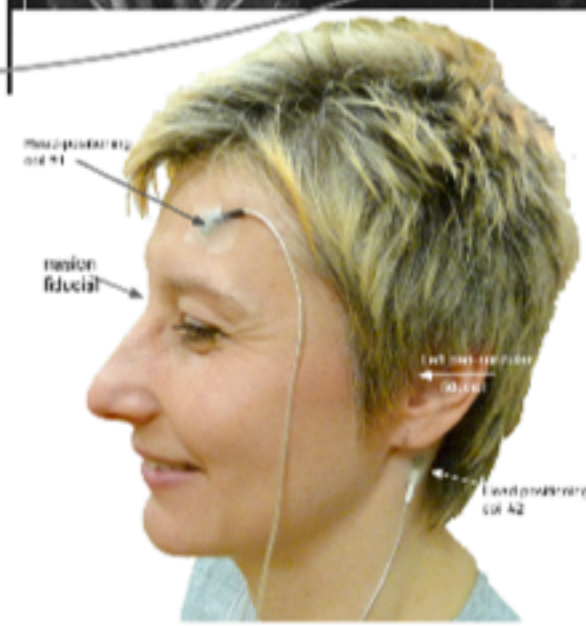
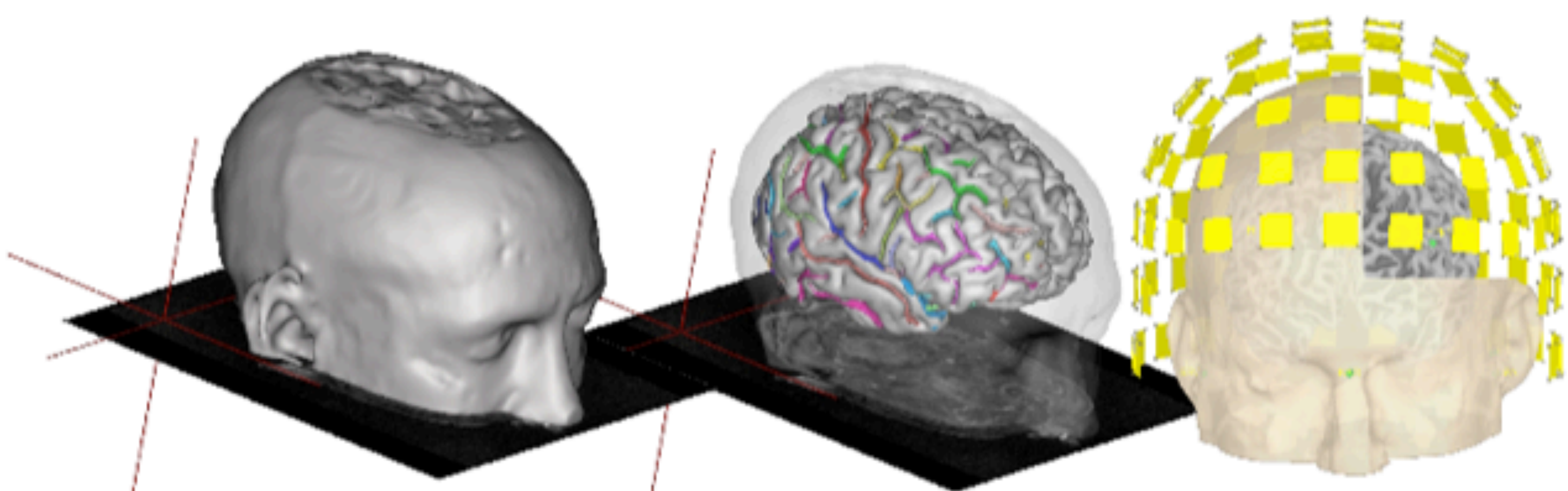
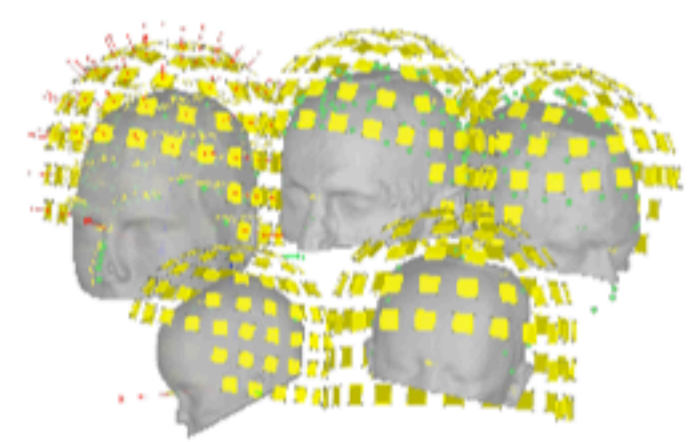


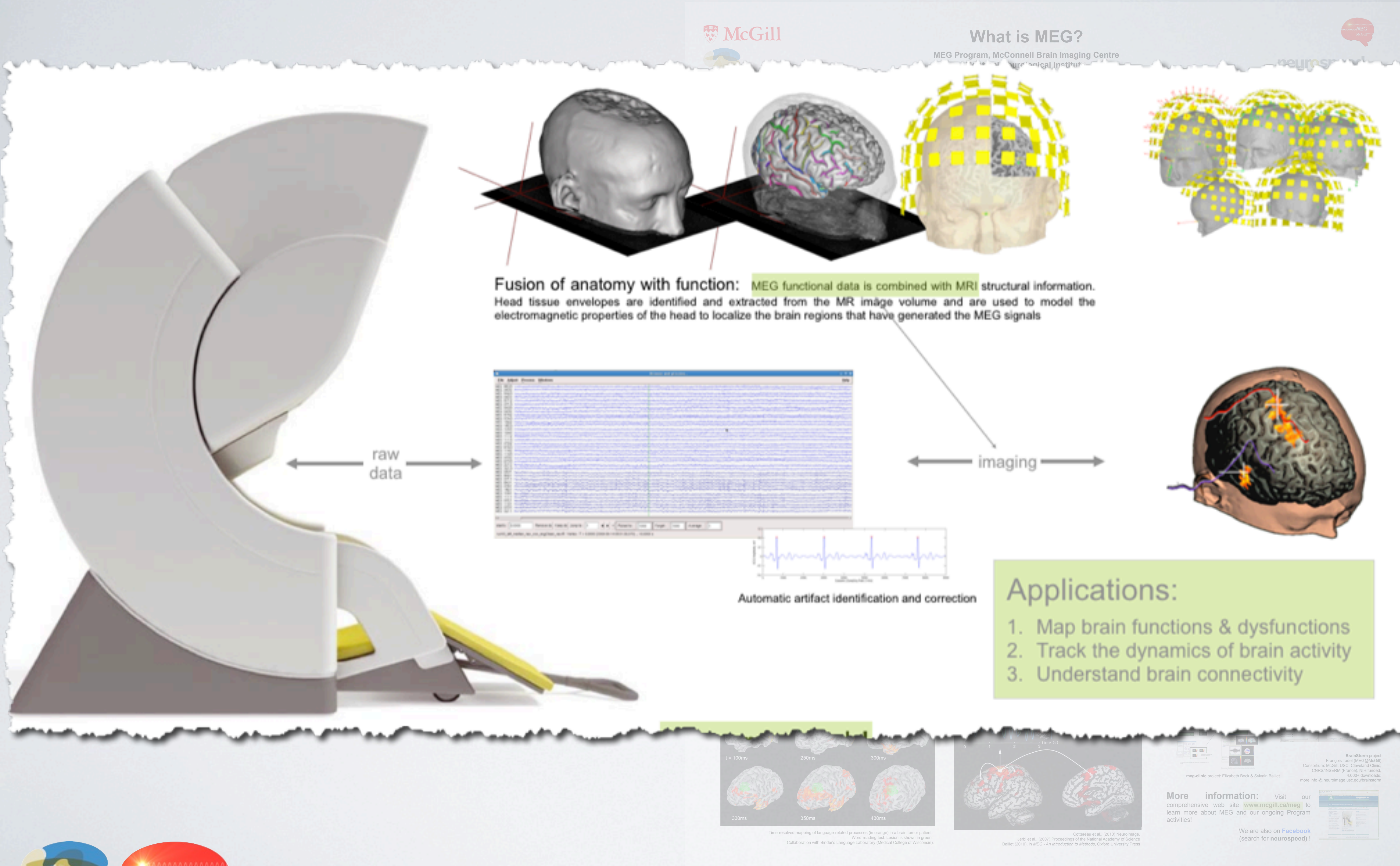


Registration with MRI: The 3D locations of anatomical fiducial points are digitized to overlay the MEG results on high-resolution MRI images.

Head-positioning indicators are taped to the subject's head to detect and compensate for the small head movements occurring during the session.







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What is MEG?
MEG Program, McConnell Brain Imaging Centre
Fusion of anatomy with function: MEG functional data is combined with MRI structural information.
Head tissue envelopes are identified and extracted from the MR image volume and are used to model the electromagnetic properties of the head to localize the brain regions that have generated the MEG signals
raw data
imaging
Automatic artifact identification and correction
Applications:
1. Map brain functions & dysfunctions
2. Track the dynamics of brain activity
3. Understand brain connectivity
More information: Visit our comprehensive web site www.mcgill.ca/meg to learn more about MEG and our ongoing Program activities!
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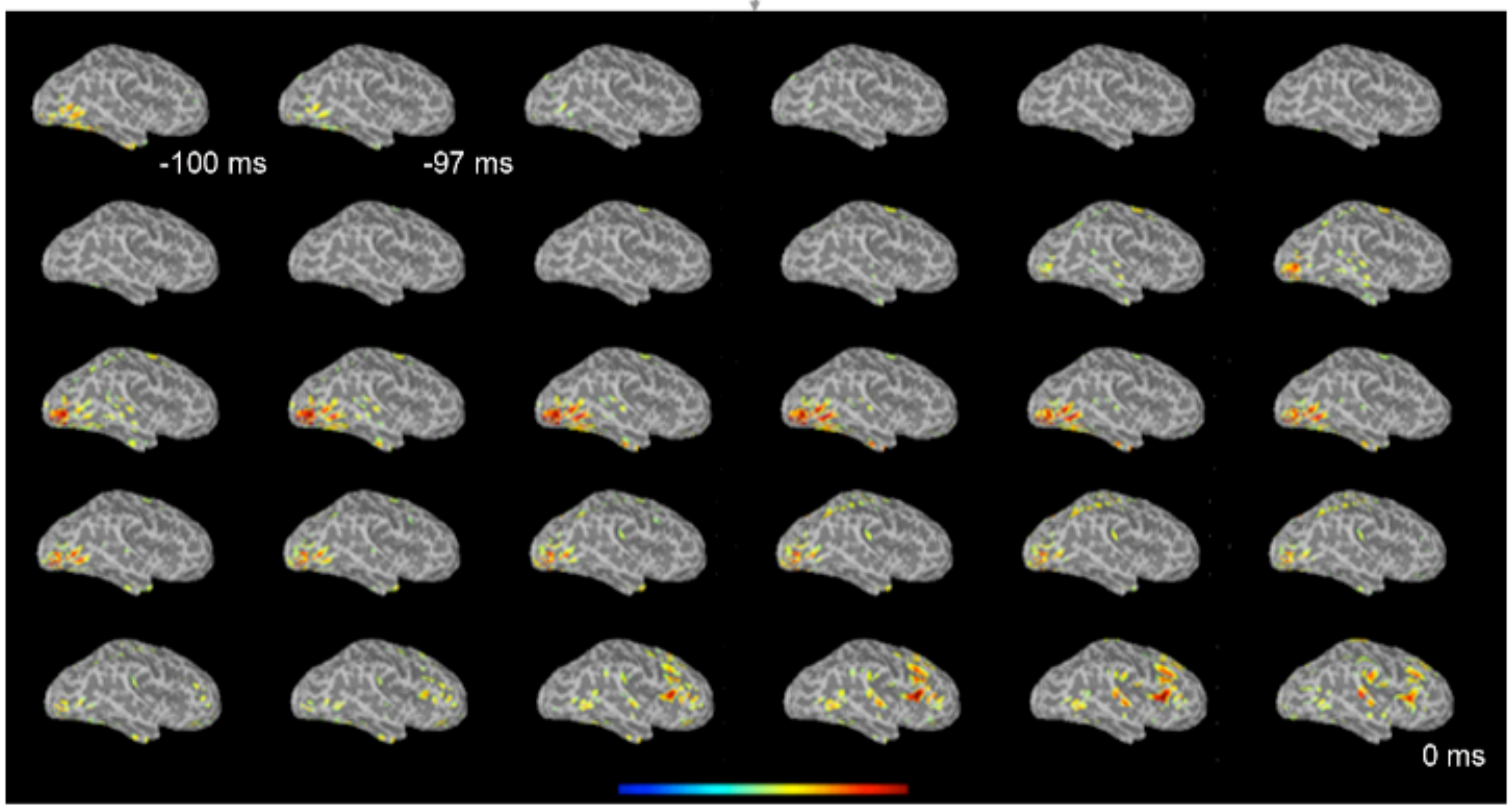
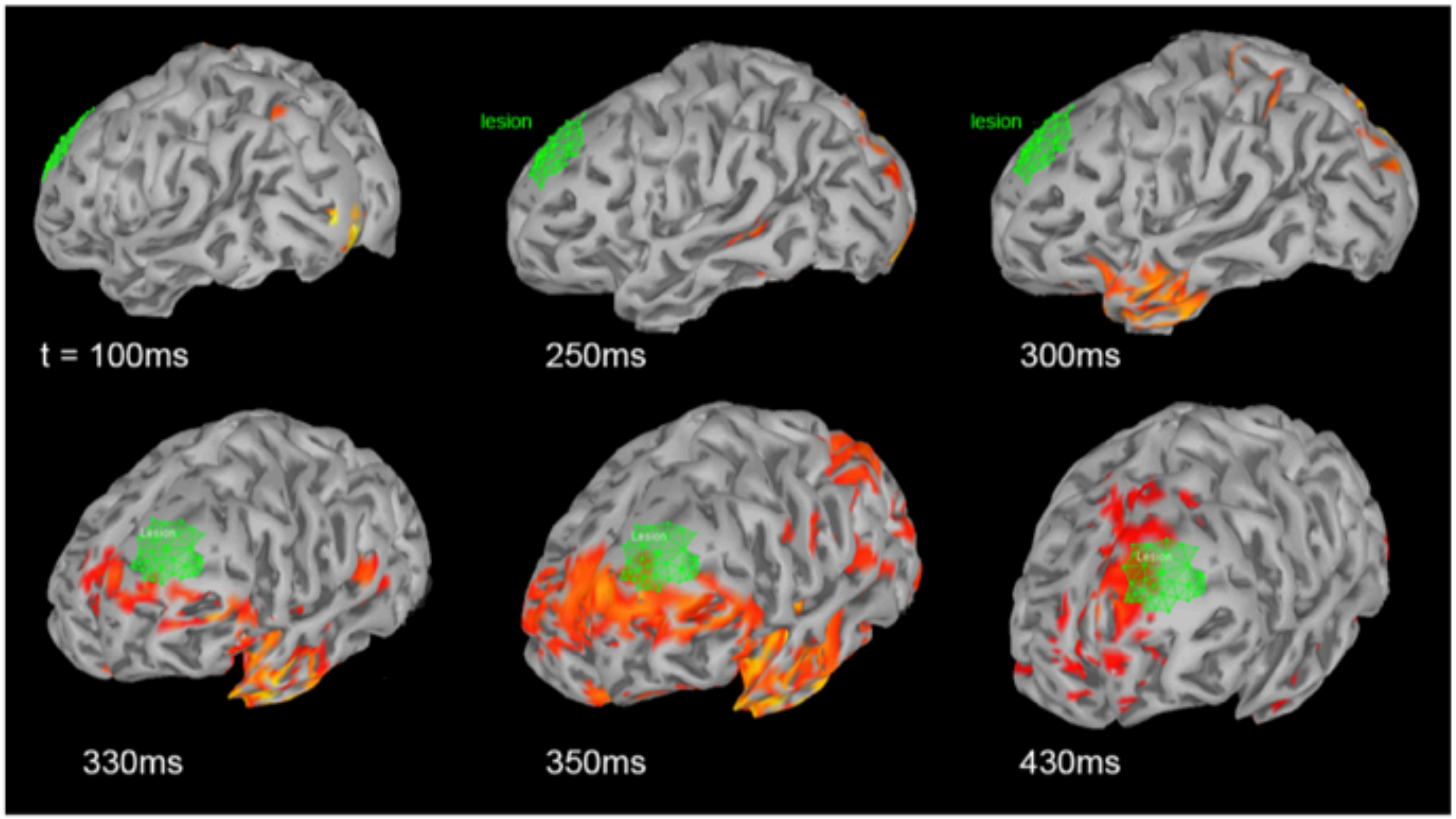
Typical Clinical MEG Research:

(1) **Presurgical mapping of drug-resistant epilepsy:** Regions involved in the early onset of epileptic events can be detected thanks to the millisecond time resolution of MEG. Additionally, the localization of crucial brain functions (language, motor control) can be mapped on the patient's brain and help determine the best target for neurosurgery.



Fast (<100 ms) propagation of epileptic activity detected with MEG source imaging, shown in red, as registered on the patient's anatomy obtained with MRI structural imaging.

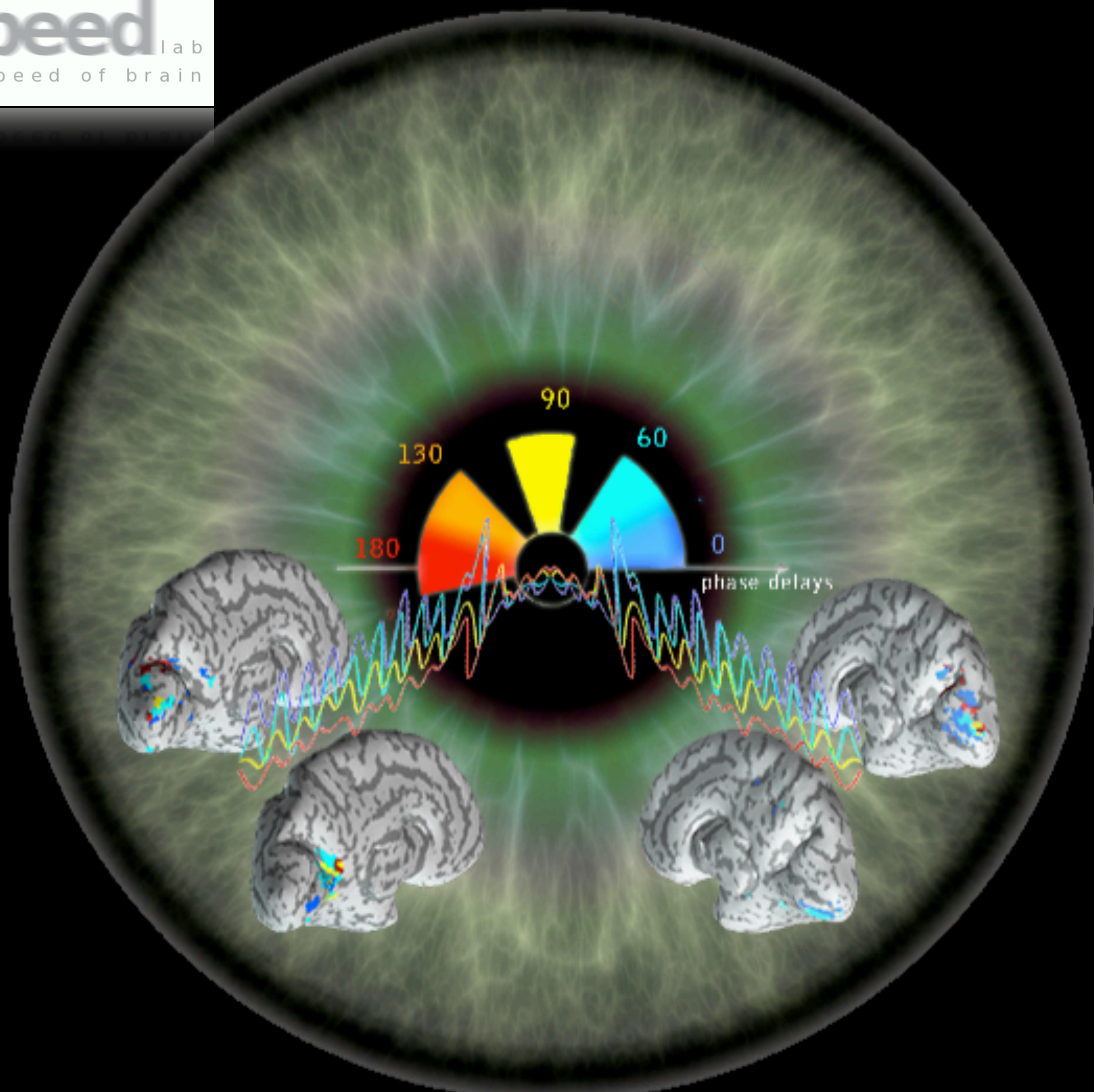
(2) Presurgical mapping of brain tumors: MEG can help determine whether brain regions within or in the vicinity of a malignant brain tumor are involved in critical brain functions such as language and motor processes. Combined with other imaging modalities, this information can assist neurosurgeons in planning the safest surgical approach on an individual basis.



Time-resolved mapping of language-related processes (in orange) in a brain tumor patient.
Word-reading test. Lesion is shown in green.
Collaboration with Binder's Language Laboratory (Medical College of Wisconsin).

Research Activities: Our core research activities focus on developing new methods, analysis techniques and software to promote MEG as a genuine functional brain imaging modality.

neurospeed lab
imaging at the speed of brain



Imaging at the speed of brain: The millisecond time resolution of MEG functional imaging enables us to access and investigate the fast processes ruling fundamental brain functions.

Here, millisecond time delays were measured across the cortex during visual perception. This helps us better understand the mechanisms ruling vision and discover new non-invasive biomarkers of neurological impairments.

Imaging functional connectivity: Brain regions communicate very rapidly with one another, forming networks that contribute to the integration of information by the brain.

MEG can help reveal how these regions communicate.

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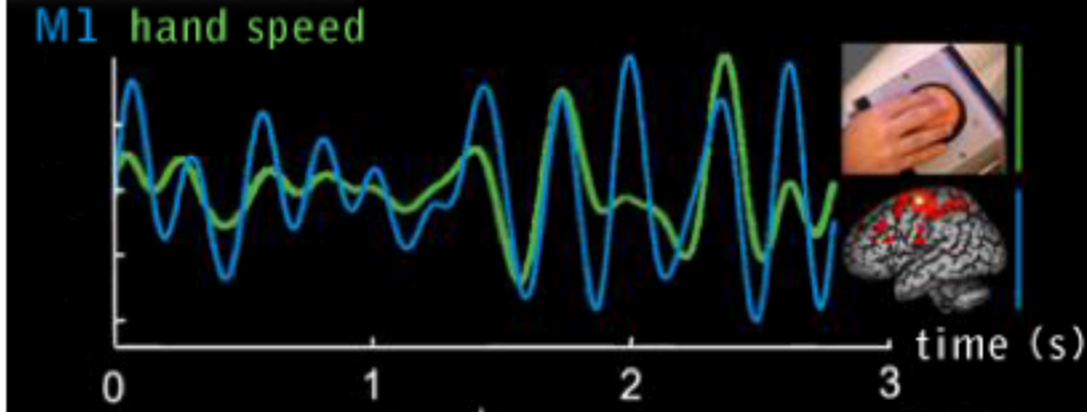
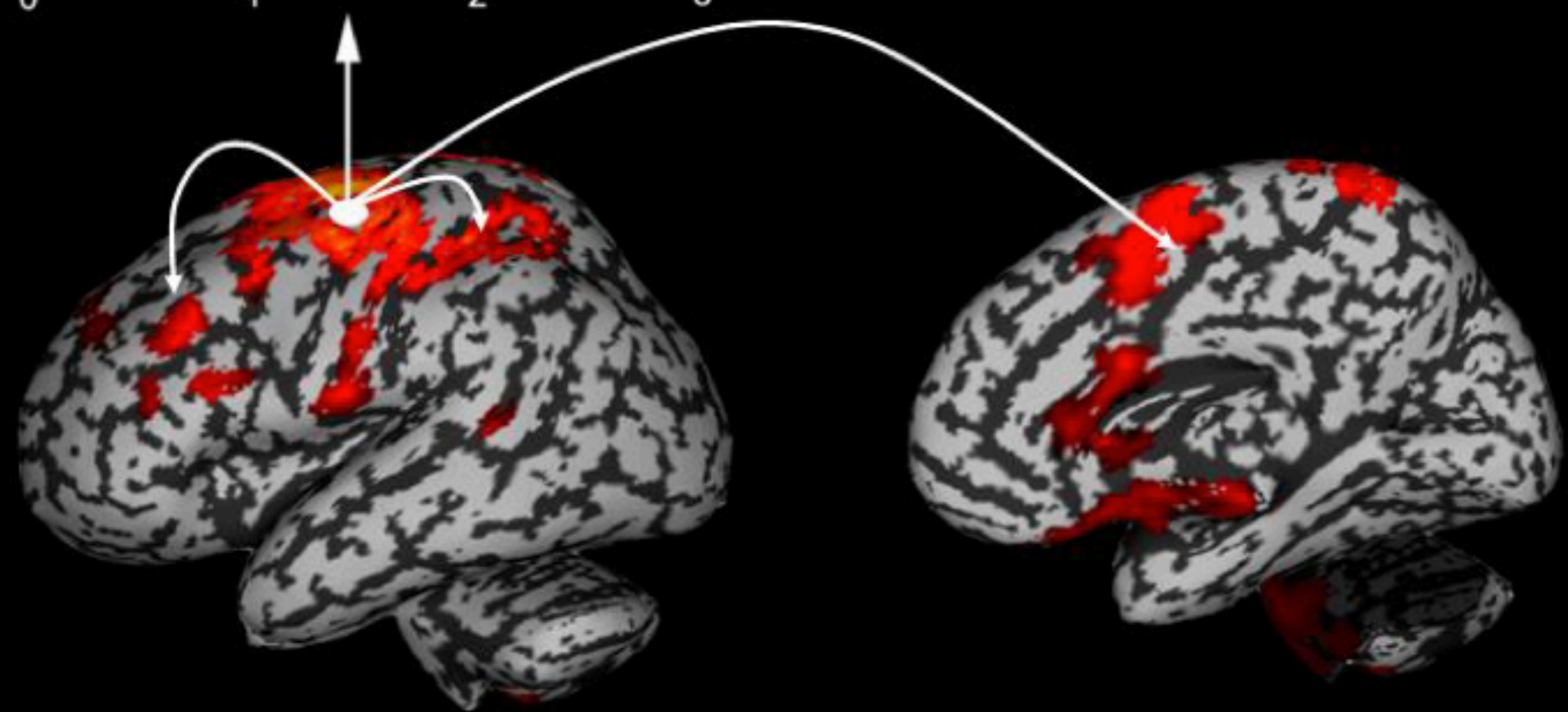
imaging at the speed of brain

contribute to the integration of information by the brain.

MEG can help reveal how these regions communicate. Below is an example of connected brain regions working together during hand-eye coordination.



Network of brain activity coherent with velocity of hand movements



Cottereau et al., (2011) NeuroImage,
Jerbi et al., (2007) Proceedings of the National Academy of Science
Baillet (2010), in *MEG - An Introduction to Methods*, Oxford University Press

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imaging at the speed of brain

1. Map brain functions & dysfunctions
2. Track the dynamics of brain activity
3. Understand brain connectivity

More research!

We have developed the technology to use MEG as **a therapeutic imaging technique, using real-time biofeedback.** Real-time reconstruction of brain activity is performed as the subject is being scanned. Monitoring of key brain areas consists in extracting indices of brain activity/connectivity and to generate feedback to the subject. The goal is to promote predefined patterns of brain activity, which are designed for a determined clinical objective: epilepsy seizure control, optimized motor and speech rehabilitation after stroke, etc.

Sudre, G.; Parkkonen, L.; Bock, E.; Baillet, S.; Wang, W. & Weber, D. J.
rtMEG: a Real-time Software Interface for Magnetoencephalography
Comput Intell Neurosci, 2011, 2011, 327953

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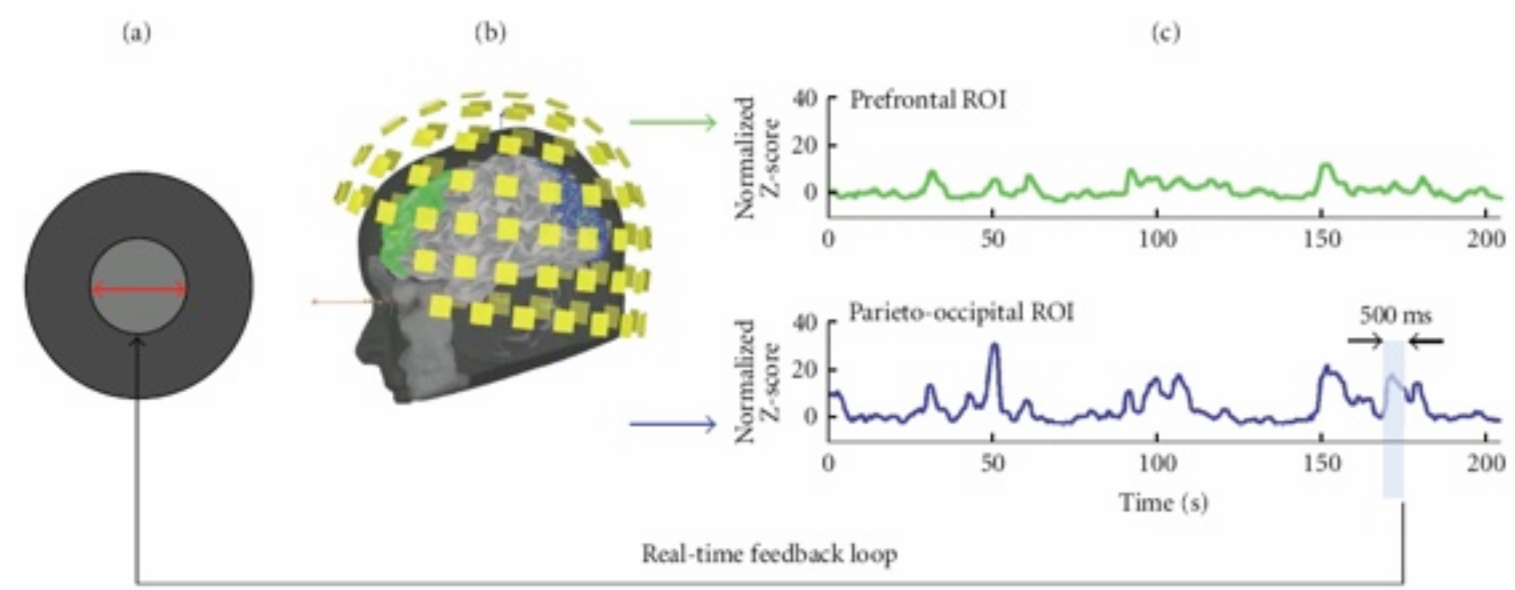

Figure 4: Real-time visual feedback on the power of alpha oscillations in brain regions of interest. (a) The subject was provided with a visual gauge of the real-time level of alpha power within the parieto-occipital (PO) region of interest shown in blue in (b). The radius of the light-grey disk in (a) evolved every 500 ms and increased as alpha power decreased during the eyes-open segment of the experimental run. The static, dark-grey disk was an incentive target for the subject. Its radius was indexed to 2 times the average PO alpha power captured during the baseline run acquired at the beginning of the session. (c) shows the ongoing, respective levels of alpha power variation in the two ROIs: prefontal (in green in b) and PO (in blue in b).

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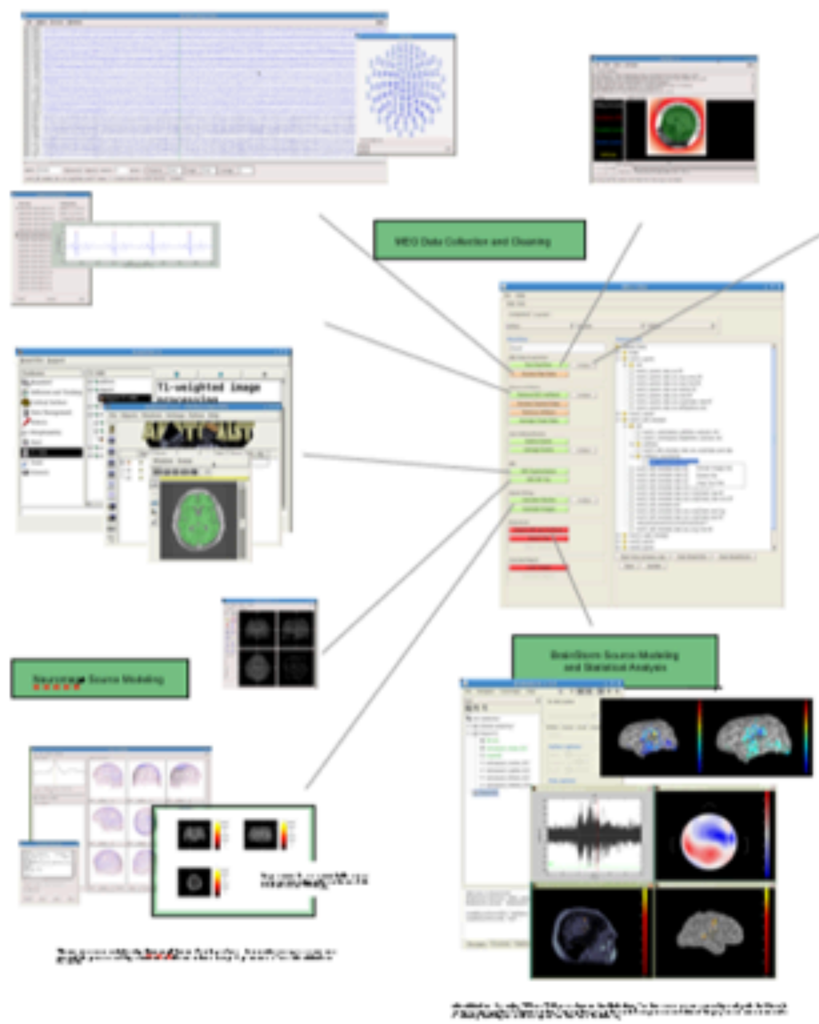
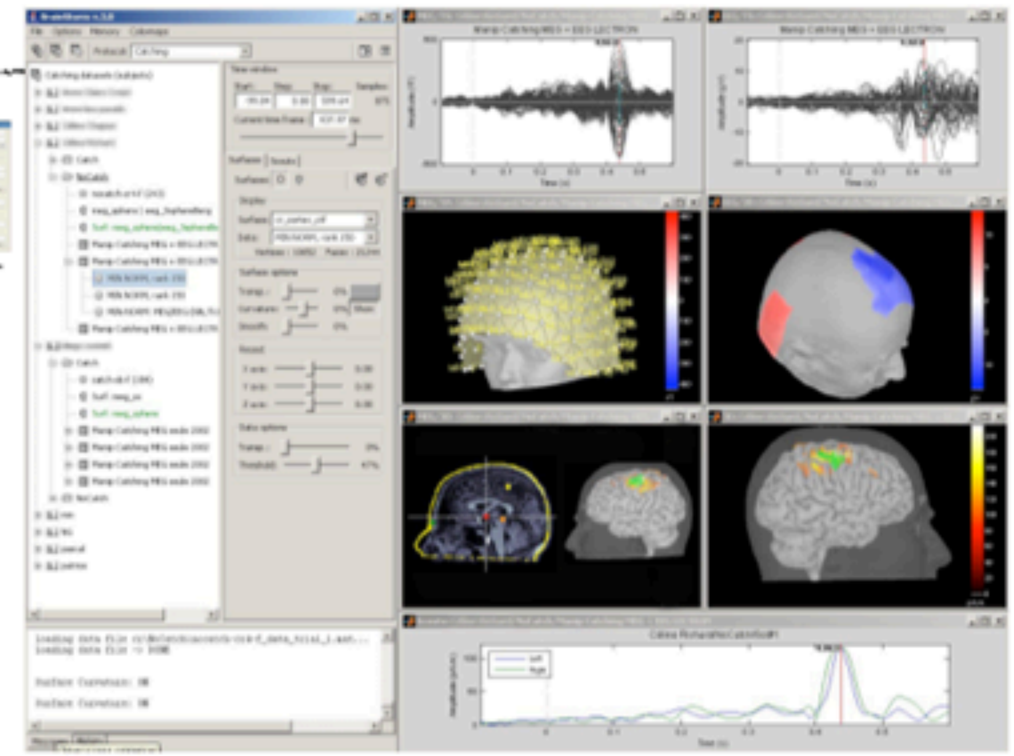
Software Developments: The analysis and interpretation of MEG data require the interaction with large volumes of data. Our Program contributes to original software developments to facilitate the integration of MEG in the standard clinical workflow and promote research productivity.



meg-clinic project: Elizabeth Bock & Sylvain Baillet



BrainStorm project
François Tadel (MEG@McGill)
Consortium: McGill, USC, Cleveland Clinic, CNRS/INSERM (France), NIH funded,
4,000+ downloads;
more info @ neuroimage.usc.edu/brainstorm

MEG SYSTEM @ McGILL

- 275 magnetometers (MEG sensors)
- 64 simultaneous EEG
- all channels sampled @ up to 12kHz
- multimodal stimulus presentation (video, audio, somesthetic, ...)
- audio, video subject monitoring
- operates in upright or supine positions
- located in the Neuro's new extension

neuro MEG @ McGill

LEARN MORE

Visit the MEG suite @ the BIC (MNI, McGill)

- contact: sylvain.baillet@mcgill.ca

Read the MEG tutorial @ www.Canada-MEG-Consortium.org

Train @ the upcoming **MEG educational workshop** at McGill

- November 17-19, 2011
- 3 days with lectures, scanner training and hands-on software
- Info & registration: www.Canada-MEG-Consortium.org

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LEARN MORE

Meet at the open-meeting series on MEG methods

- Meets every two-weeks @ 10am-11:30am
- Starts on Friday, October 7, 2011
- MNI, Penfield Pavilion - Room 282

Interested in getting started with MEG?

Plan to attend this informal meeting series and bring papers to discuss, your questions, your answers, project ideas and energy...

UPCOMING MEG LECTURES

- October 12, 2011 @ 1 pm, room 333 (McGill, Duff Building)
  - Sylvain Baillet (MNI, Director of MEG Research)

    Investigating the dynamics of the resting brain with time-resolved MEG imaging

- http://www.bmed.mcgill.ca/seminars.html

UPCOMING MEG LECTURES

- October 25, 2011 @ 1pm
  - Christophe Grova (McGill, Dept of Biomedical Engineering)

  EEG-MEG primer

- Brain Imaging Centre fall lecture series
- http://www.bic.mni.mcgill.ca/Seminars/BICLectureSeries

MORE

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