Magnetoencephalography at UMCP

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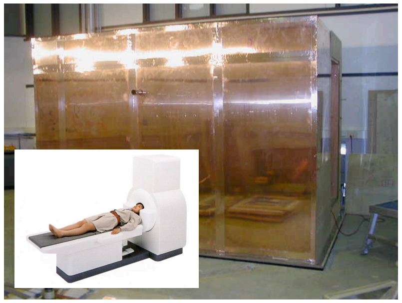
KIT-UMD MEG Laboratory

The KIT-UMD Magnetoencephalography (MEG) Lab at the University of Maryland is one of the best facilities of its kind in North America. The MEG facility is the result of a collaboration between the University of Maryland and the Kanazawa Institute of Technology (KIT), Japan.

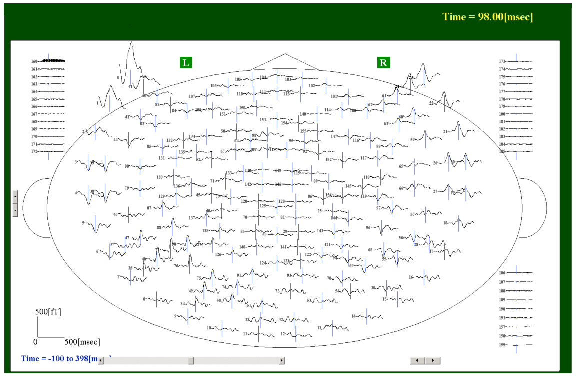
The KIT-UMD MEG device allows fully non-invasive measurements of neuronal activity in the brain, by recording magnetic fields at 160 different locations around the head. The KIT-Maryland MEG Lab in the Cognitive Neuroscience of Language (CNL) Laboratory builds upon research expertise in a diverse array of areas at the University of Maryland: cognitive neuroscience, biological signal processing, and low-temperature physics.



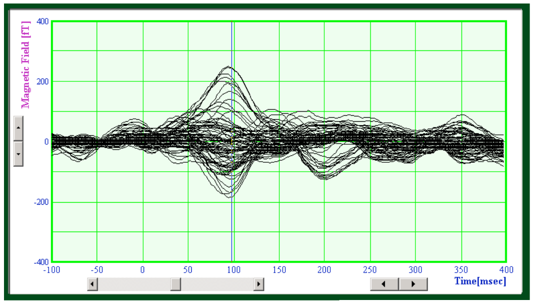
KIT-UMD whole head MEG system & shielded room. 160 axial gradiometers, 5cm baseline

What is MEG?

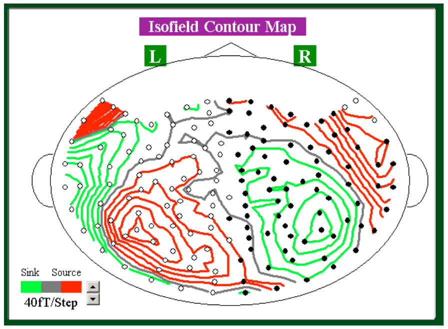
The neurons of the brain communicate using electrical signals. These signals give rise to minute magnetic fields in the brain. Magnetoencephalography (MEG) uses ultra-sensitive detectors to measure these magnetic fields from outside the head. Among the many emerging technologies for measuring brains in action, MEG is perhaps the most exciting, because it pinpoints brain activity with great precision in both space and time.



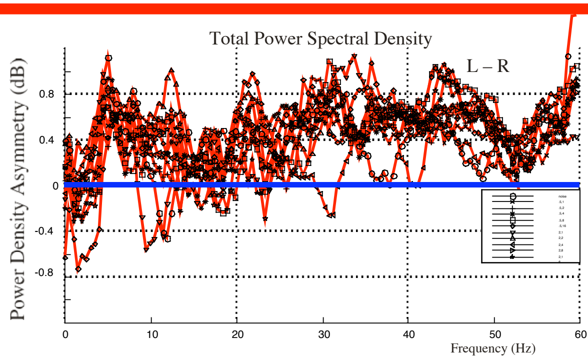
Sensor layout: 160 channel recordings (Response peak at 98ms, in the left and right temporal lobes.)



Butterfly plot: overlay of the channels over right temporal lobe (Peak at 98ms post onset of auditory stimulus.)



Contour plot: Distribution of magnetic field at peak response



Enhanced Power in Left Hemisphere above ~ 30 Hz.

Signal Processing Demands

A typical experiment records 160 Channels at 1 kHz, for 100 presentations of 15 sounds of 3 second duration, thus placing extreme computational demands on all signal processing. Poor Signal to Noise Ratio and the presence of artifacts (e.g. eyeblinks, heartbeat) necessitate non-linear filtering: we use Blind Source Separation, e.g. Independent Component Analysis (ICA). More traditional spectral methods (e.g. Thompson's multitapered windows used above) also permit credible detection of spectral peaks.

A Technical Tour de Force

The 160 axial gradiometers are SQUIDs (Superconducting Quantum Interference Devices) supercooled with liquid helium. The sensitivity is less than 100 femtotesla (fT), enough to detect the synchronized neural activity of ~10^4 neurons (~0.25 mm^3). The detectors are fast (≥ 1 kHz), completely non-invasive, and silent, making them ideally suited for research in auditory and linguistic neuroscience, as well as other neural and cognitive modalities.

MEG & Cognitive Neuroscience

MEG is a technique that allows:

(i) Recording brain activity directly (electrical activity, not hemodynamic), with temporal resolution ≤ 1 ms

(ii) Design of within-subjects experiments and evaluation of single-subject data

(iii) Testing models of cognitive processes and evaluating how these models map on to the brain.