2013-10A

York NeuroImaging Centre
THE UNIVERSITY of York

Magnetoencephalography

The Very Basics

Table of Contents

List of Figures

1. The Very Basics of Magnetoencephalography (MEG)

What Is MEG?

If we break the name Magnetoencephalography into its component parts, it is easy to understand what MEG does.

- magneto-: Relating to a magnet or magnetism.
- encephalo-: Relating to the brain.
- -graphy: A technique of producing images.

Therefore, we can see that MEG is a brain imaging technique that records magnetic fields.

What Does the MEG Scanner look like?

The MEG scanner has a helmet into which a participant puts their head. This helmet is at the bottom of storage dewar, which is full of liquid helium. The storage dewar is mounted onto a gantry, (see Figure 1.1).

Figure 1.1. The MEG Scanner

When a participant is scanned, the gantry can be moved so as to position the MEG scanner over the participant. The chair on which the particpant sits is then raised up so that the particpants head rests inside the helmet of the scanner (see Figure 1.2 and Figure 1.3)

Figure 1.2. A Participant in the Scanner.

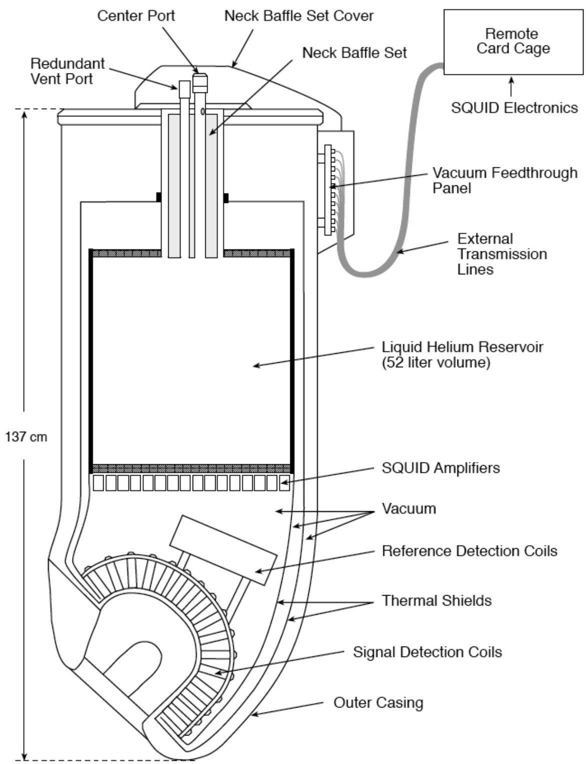
Figure 1.3. A Close Up of a Participant in the Scanner

How MEG Works

Magnetoencephalography (MEG) measures small magnetic fields outside the head that are generated by electrical activity in the brain. The magnitude of these magnetic fields is of the order of femtotesla (10^{-15} T), which can be sensed by Magnetometers; in the case of MEG these are Superconducting Quantum Interference Devices, SQUID Magnetometers, in the helmet of the scanner. Hence, MEG is a non-invasive imaging mechanism, and all the magnetic activity in the scanning environment is generated by the participant’s brain activity.

A schematic of the MEG sensor structure is shown in Figure 1.4. As the image shows, the Signal Detection Coils (in YNiC's case SQUID Magnetometers) are arranged around the helmet of the dewar, with the Reference Detection Coils just above them (a combination of SQUID magnetometers and gradiometers). There are then a layer of SQUID Amplifiers, which are directly beneath the Liquid Helium Reservoir. Surrounding all this are thermal shields and an outer casing. The signals that are amplified by the SQUIDS are then pased on to the Remote Card cage, then on to the DAS (Data Acquisition System).

Figure 1.4. MEG Sensor Interior



The sizes of the magnetic fields produced by the brain are tiny in comparison to the magnetic fields that we are exposed to in everyday life which are of the order of tens of microtesla (10^{-6} T), our hearts generate a field in the order of tens of nanotesla (10^{-9} T) and a car moving will generate a magnetic field that is still of the order of femtotesla when the field is recorded 1 mile away from the car. MEG scans are therefore performed within a magnetically shielded room to isolate the scanner from environmental noise. The magnetically shielded room is constructed from a special metal called mu-metal which is highly effective at screening magnetic fields.

MEG Signal Genesis

The magnetic fields measured with MEG are derived from synaptic activity. Neurones connect via synapses, which are chemically mediated junctions between two nerve cells. When neurones are active, the flow of neurotransmitter chemicals changes the electrical current into the recipient neurone, and affects the cell's electrical potential. This is referred to as a change in the Post Synaptic Potential (PSP), and can be excitatory (EPSP) or inhibitory (IPSP).

The summation of the neural currents produced by neural activity is what is indirectly observed using MEG. MEG measures the magnetic field associated with this electrical activity. However, SQUIDs are unable to sense the magnetic fields from such electrical activity in just one neurone. Approximately 50000 adjacent neurones need to be active at the same time to generate a collective magnetic field that SQUIDs are able to detect.

A schmatic of how this can be seen in (Figure 1.5). In the top left image, the white elipse represents neural activity. The black arrow in the top right image represents an electrical current related to the neural source. In the bottom left image, we see the magnetic field that is generated by the moving electrical current. And the final image at the bottom right schematically demonstrates how this magnetic field may be recorded by sensors close to the scalp.

Figure 1.5. Schematic Representation of MEG