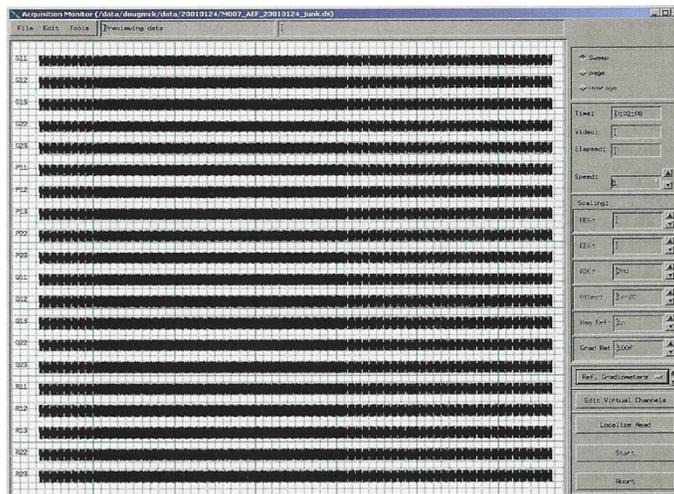


MEG CORE FACILITY

MEG

Data Acquisition Tutorial



MEG CORE FACILITY

MEG Data Acquisition Tutorial

National Institutes of Mental Health (NIH)
9000 Rockville Pike
Bethesda, Maryland 20892
Phone: 301/402-2362
<http://kurage.nimh.nih.gov/meglab>

*This manual contains information and images from CTF Systems Inc. MEG/EEG
Operation and Technical Reference Manual & Omega 2000 Software User
Manual, Version 4.14

Table of Contents

Instructions

Section I

SUBJECT PREP

A. Demetaling	5
B. Degaussing	5

Section II

MEG SETUP

A. Head Size / Fit Test	6
B. Fiducial Points / Head Coil Placement	6
C. Electroculogram Eye Lead Placement	7

Section III

EEG SETUP

A. Head Size / Fit Test	8
B. Fiducial Points / Head Coil Placement	8
C. Electroculogram Eye Lead Placement	9
D. Reference Electrodes Placement	10
E. EEG Easy Cap System	10
1. Marking Frontal, Cz & Occipital Locations	10
2. Mounting the Cap	12
Digitizing Electrode Positions	13
Reducing Skin Impedance	15
H. Applying Electrolyte	15
I. Electrode Impedance Meter Check	16
J. Electrode Jack Box	17

Section IV

STIMULUS / RESPONSE EQUIPMENT

A. Visual Stimulus	18
1. LCD Projector Setup	19
2. Optical Sensor System	23
2. Video Stimulus Presentation / Eye Tracking System	24
B. Auditory Stimulus	25
C. Somatosensory / EMG Stimulus	26
D. Response Pads	28
1. Lumitouch	28
2. FORP	28
3. NeuroScan	28

Section V

MSR & SUBJECT SUPPORT

A. Room Lighting	29
B. Door Operation	29
C. Positioning a Subject in the Chair	31
1. Head Coil Cable Module	31
2. Mounting the Jack Box to the Amplifier	31
3. Stabilizing Head cuff	32
D. Chair Adjustments	33

Section VI

SUBJECT MONITORING

INSIDE THE MSR

A. Video Display Monitor	39
B. Voice Intercom / Parabolic Speaker	40
C. Infrared Lighting	40
D. Video Cameras	40
E. VCR	41

Section VII

RECORDING DATA

A. Electronics / System Characteristics	43
1. ADC Setup	44
B. Data Acquisition / Collection Parameters	45
C. Acquisition Dialog	45
D. Channel Selection	46
E. MEG System EEG Impedance Check	46
F. Head Localization	46
G. Pushing Data to the MEG Server	48
H. Transferring Data to DVD	50
I. Transferring Data to a Remote Workstation	51

Section VIII

CLEAN UP PROCEDURE

A. MEG	
1. Subject Clean Up	53
2. Equipment Clean Up	53
B. EEG	
1. Subject Clean Up	54
2. Disinfection Procedure	54
3. Equipment Clean Up	54

Section IX

APPENDIX

Variance Reporting	55
--------------------	----

INDEX

E. Installing the Bed for Supine Recording	36
F. Positioning a Subject on the Bed	38

Instructions

This manual is designed to provide the user with didactic instructions for basic MEG / EEG setup and acquisition. It is intended to be a comprehensive but not exhaustive.

It is organized into major sections and then further divided into subsections in the order that a study might logically be conducted. Most sections are designed to provide step-by-step instructions to guide the user through the setup or acquisition process while other sections are intended to provide some general information about a procedure, process or equipment. In addition, there are notes interspersed throughout the text to provide the user with helpful hints, useful tips, warnings and /or precautions. Links are also included to provide more detailed information.

It is recommended that the new user start at Section I and proceed systematically through each section to the end. Some steps are optional depending upon the type of study that is needed or required. The more experienced user may wish to use this manual as a reference and may choose to skip from section to section as desired.

Subject Prep

De-Metaling

Before entering the MSR subjects must remove any metal from their person. There are no known risks associated with MEG recordings. Although wearing metal objects while in the MSR is not harmful to the individual, bringing metallic or magnetic objects into the MSR causes interference and high noise levels in the recording.



Non-Magnetic Clothing

- Subjects must remove:
- Bras with metal under wires
 - Makeup - mascara, eye liner, eye shadow
 - Clothing containing metallic shiny threads or glitter
 - Metal on clothing i.e., metal buttons, snaps or trimming
 - Belts
 - Keys
 - Watches
 - Rings or other jewelry
 - Coins
 - Eyeglasses
 - Cell phones
 - Pagers
 - Credit Cards
 - Small metal objects such as hair pins, paper clips, safety pins, etc.

Additionally, everyone entering the MSR must also **remove their shoes** to prevent magnetic dust from getting into the MSR.

It is recommended that subject are screened and given instructions before arriving for testing. However, if subjects arrive with metal on their clothing that can not be easily removed they may be issued non-magnetic (paper) clothing which will be provided by staff.

Degaussing

If a subject arrives with embedded metal on their person, i.e., a permanent retainer, which can not be removed it may be necessary to de-magnetize the subject. Care should be taken not to use the Degausser close to the computer monitors as it may permanently damage the screens. *The Degausser must **NOT** be used in the MSR.*



Degausser

1. Plug in the Degausser.
2. Move 3-4 feet away from all computer monitors.
3. Pass the Degausser in a circular motion in front of the area of interest 3 or 4 times.
4. Unplug Degausser.



**It is recommended that the subject not have had an MRI within 3-4 days before having a MEG scan because of the possibility of residual magnetization.*

MEG Setup

Head Size/Fit Test

Used to determine whether the subject will fit the MEG sensor helmet. The helmet will fit subjects within 98 percentile for head size.



- **Determine head size** by measuring the:
 1. Head Circumference,
 2. Nasion-Inion Distance and
 3. Preauricular Point to Preauricular Point Distance.
- **Determine fit** by placing the MEG helmet along with a protective cap over the head.
-
- **Record measurements.**

Used for Fit Test

Gantry Limits	Nasion-Inion	Preauricular	Circumference
MEG / EEG	≤ 40cm	≤ 40cm	≤ 60cm

Fiducial Points/Head Coil Placements

Used for head localization (the process of locating the subject's head in space relative to the Dewar). Used later to co-register the MRI Coordinate System with the MEG Head Coordinate System.



If the subject has had previous digital pictures of the fiducial points retrieve images to match placement.



Right Preauricular Point



Nasion



Left Preauricular Point

1. Place a small black dot at the nasion (indentation between the forehead and the nose) midline. *The dot may be placed slightly higher if the nasion curvature is such that it does not allow level placement of the head coil.
2. Place a small black dot below the left & right preauricular points centered (about 3-4cm) in front of the tragus. This may be measured for accuracy.
3. Take a picture of these locations using the [HP 715 Digital Camera](#). Download and print the pictures.



4. Attach **Small (MEG) Adhesive Washers** to head localization coils.

5. Attach head localization coils at the fiducial marks.
*Make sure the marks line up with the center of the head coils.



Head Coil Cables

Nasion	Right Ear	Left Ear
Blue	Red	Green

6. Place tape over the cables to secure.

Head Coil Placement

Head Coil

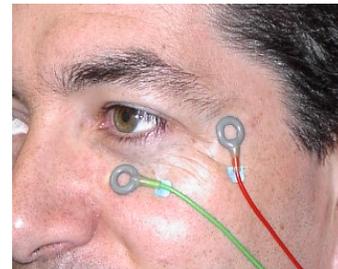
Electroculogram (EOG) Eye Lead Placement

Used to identify and monitor eye blinks and saccadic eye movements.

Left Infra Orbital (LIO) - Place electrode on the orbital ridge centered directly under the eye.

Left Outer Canthus (LOC) - Place electrode at the lateral junction of the upper and lower eye lid.

1. Clean the skin on the cheek near the eyes with alcohol and **Nuprep Skin Cleaner**. Wipe the skin to remove the gritty residue.
2. Attach the **Large EEG Adhesive Washers** to the electrodes.
3. Place the Infra Orbital electrode.
4. Place the Outer Canthus electrode.
5. Press the electrodes onto skin.
6. Apply **Elifix Electrolyte** through the electrode opening.
7. Check the impedances using the **Grass Impedance Meter**.



EOG Placement

Head Coil



- a. Plug in the left infra orbital electrode in jack 1 and the left outer Canthus electrode in jack 2.
 - b. Push the red **ON** button.
 - c. The **Electrode Selector** should be at 1 or 2.
 - d. **EOG impedance should be $\leq 50k$ ohms.**
8. Secure with tape.

*Refer to section entitled "Electrode Impedance Meter Check" for more detailed information

on reducing impedances.

EEG Setup

Head Size/Fit Test

Used to determine whether the subject will fit the MEG sensor helmet. The helmet will fit subjects within 98 percentile for head size. **This number is decreased slightly when using the EEG Cap.*



- **Determine head size** by measuring the:
 1. Head Circumference,
 2. Nasion-Inion Distance and
 3. Preauricular Point to Preauricular Point Distance.
- **Determine fit** by placing the MEG helmet along with a protective cap over the head.
- **Record measurements.**

used for Fit Test

Gantry Limits	Nasion-Inion	Preauricular	Circumference
MEG / EEG	≤ 40cm	≤ 40cm	≤ 60cm

Fiducial Points/Head Coil Placements

Used for head localization (the process of locating the subject's head in space relative to the Dewar). Used later to co-register the MRI Coordinate System with the MEG Head Coordinate System.



If the subject has had previous digital pictures of the fiducial points retrieve images to match placement.



1. Place a small black dot at the nasion (indentation between the forehead and the nose) midline. *The dot may be placed slightly higher if the nasion curvature is such that it does not allow level placement of the head coil.

Right Preauricular Point Nasion Left Preauricular Point

2. Place a small black dot below the left & right preauricular points centered (about 3-4cm) in front of the tragus. This may be measured for accuracy.
3. Take a picture of these locations using the [HP 715 Digital Camera](#). Download and print pictures.



4. Attach **Small (MEG) Adhesive Washers** to head localization coils.

5. Attach head localization coils at the fiducial marks.
*Make sure the marks line up with the center of the head coils.



Head Coil Cables

Nasion	Right Ear	Left Ear
Blue	Red	Green

6. Place tape over the cables to secure.

Head Coil Placement

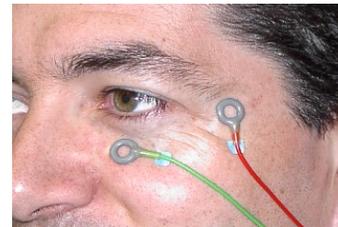
Electroculogram (EOG) Eye Lead Placement

Used to identify and monitor eye blinks and saccadic eye movements.

Infra Orbital (LIO) - Place electrode on the orbital ridge centered directly under the left eye.

Outer Canthus (LOC) - Place electrode at the lateral junction of the upper and lower left eye lid.

1. Clean the skin on the cheek near the eyes with alcohol and **Nuprep Skin Cleaner**. Wipe the skin to remove the gritty residue.
2. Attach the **Large (EEG) Adhesive Washers** to the electrodes.
3. Place the Infra Orbital electrode.
4. Place the Outer Canthus electrode.
5. Press the electrodes onto skin.
6. Apply **Elifix Electrolyte** through the electrode opening.
7. Check the impedances using the **Grass Impedance Meter**.



EOG Placement

Head Coil



- a. Plug in the left infra orbital electrode in jack 1 and the left outer Canthus electrode in jack 2.
 - b. Push the red **ON** button.
 - c. The **Electrode Selector** should be at 1 or 2.
 - d. **EOG impedance should be $\leq 50k$ ohms.**
 - e.
8. Secure with tape.

*Refer to section entitled "Electrode Impedance Meter Check" for more detailed information on reducing impedances.

Reference Electrodes / Mastoid Placement

Used to define the electronics common point.

Left and Right Mastoid Placement - Bone prominence behind the ear.



Mastoid Placement

1. Clean the skin behind the left and right ear with alcohol and **Nuprep Skin Cleaner**. Wipe the skin to remove the gritty residue.
2. Attach **Large (EEG) Adhesive Washers** to the electrodes.
3. Press the electrodes onto the skin.
4. Apply **Elifix Electrolyte** through the electrode opening.
5. Check the impedances using the **Grass Impedance Meter**.
 - a. Plug in the left mastoid electrode in **jack 1** and the right mastoid electrode in electrode **jack 2**.
 - b. Push the red **ON** button.
 - c. The **Electrode Selector** should be at 1 or 2.
 - d. Mastoid electrode Impedance should be less than or equal to 5K ohms.
*Refer to the section entitled "Electrode Impedance Meter Check" for more detailed information on reducing impedances.
6. Secure with tape.

EEG Easy Cap System

The Easy Cap is a modular EEG-recording cap system with 64 ring adaptor locations using Ag/AgCl sintered electrodes. *Other application methods may be used, however, careful attention should be given to the choice of electrodes; refer to [Electrode Criteria](#).

Measuring / Marking Frontal Polar, Cz & Occipital Locations

1. Measure the nasion – inion distance. Place a mark at 50% of the total distant. **This marks Cz.**
2. From the nasion place a horizontal mark at 10% of the nasion – inion distance. **This marks FPz.**
3. Place a vertical mark on the forehead midline nasion. For accuracy measure the distance between the eyebrows; mark midway crossing the horizontal mark. **This completes Fpz.**
4. From the inion place a horizontal mark at 10% of the nasion - inion distance. **This marks Oz.**
5. Measure head circumference from the Fpz position. Place a vertical mark at 50% of the distance of the circumference. **This completes Oz.**
6. Measure and mark 5% of the circumference distance on the left of FPz (on the same horizontal plane). **This completes Fp1.**

7. Measure and mark 5% of the circumference distance on the right of FPz (on the same horizontal plane). ***This completes Fp2.***
8. Measure and mark 5% of the circumference distance on the left of Oz (on the same horizontal plane). ***This completes O1.***
9. Measure and mark 5% of the circumference distance on the right of Oz (on the same horizontal plane). ***This completes O2.***
10. Measure from left to right preauricular points. Mark the midpoint. ***This completes Cz.***



Fp1, Fpz, Fp2 Locations

Mounting The Cap

1. Select a cap size based upon the head circumference measurement:

Small	Med	Large
≤ 56cm	≤ 58cm	≤ 60cm

2. Rotate the adaptors in the cap so that the narrow opening is toward the back of the head.
3. Place the **Large (EEG) Anchoring Adhesive Washer** on the inside of the cap on the adaptors at Fp1 & Fp2 locations.



4. Press Fp1 & Fp2 with the attached adhesive washers onto the forehead at the marked locations.
5. Have the subject hold Fp1 & Fp2 in place while turning the cap over the head.
6. Gently pull the cap over the head and ears into place.
7. Check and adjust the cap so that the Cz electrode is at the Cz mark.
8. Check and adjust Fp1 & Fp2 and O1 & O2 to assure that they are placed correctly; if not, choose another cap size.
9. Anchor the cap with the chest belt (or the chin strap).

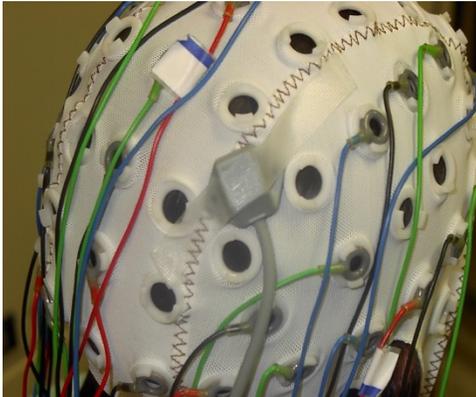
10. Snap the electrodes into the adaptors on the cap in a systematic manner starting at the back of the head. **This step isn't necessary if the electrodes are already on the cap.*
 - a. Insert the electrodes so that the lead wire points toward the narrow side of the adaptor.
 - b. Using an old ballpoint pen (or the fingers) where the mine (the point of the pen) has been removed push the electrode into the adaptor.



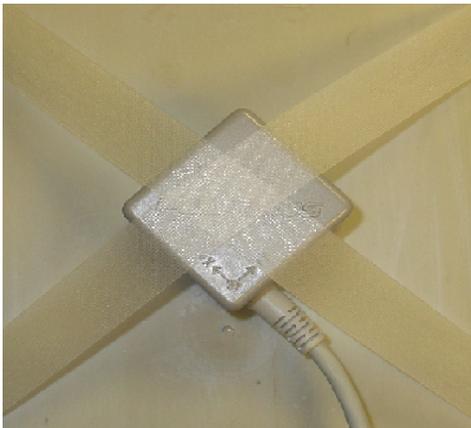
Do not to bend or place excessive pressure on the lead wire where it attaches to the electrode.

Digitizing Electrode Positions

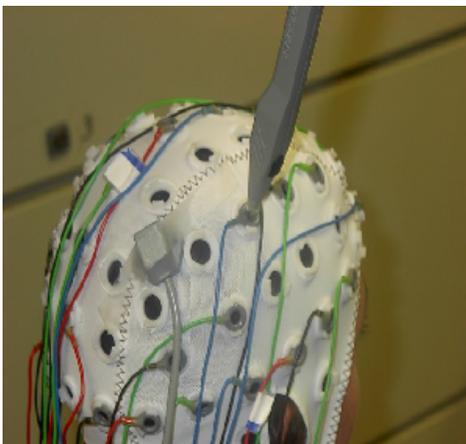
The Polhemus Digitizer is used for the digitization of the EEG electrode positions and for the determination of head shape. Digitize all electrode positions using the Polhemus.



Polhemus Receiver Module

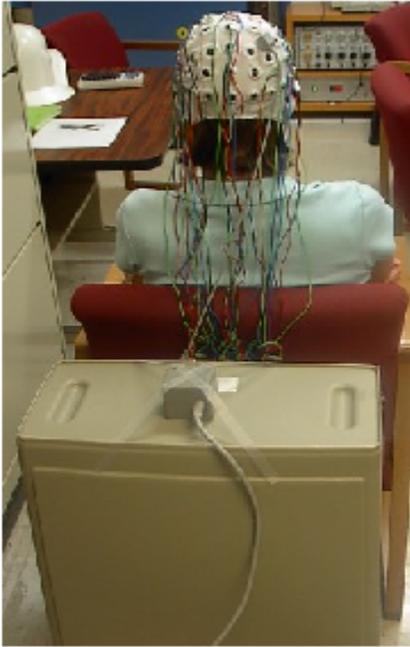


Polhemus Transmitter Module



Stylus Pen

1. After the Easy Cap has been placed on the subject, position the small **Receiver Module** on the back of the head on top of the cap near midline. Secure with tape.
2. Place the *large* **Transmitter** on a non-metallic stand midline directly behind the subject. Tape the transmitter to the stand to secure.
3. Turn on the laptop computer located on the portable cart.
4. **Open the Polhemus Electrode Digitizing Program:**
 - a. Double click on the **Electrode Digitizer** Program.
 - b. The software should detect two (2) stations: the receiver and transmitter.
 - c. If the software does not recognize both stations, check the connections then restart the program.
5. **Define Head Coordinates:**
 - a. Click on Define Head Coordinates.
 - b. Define the head coordinates by placing the stylus pen tip at the center of a head coil location (nasion, left preauricular, right preauricular) then press the stylus button. If a mistake is made,
 - i) Press the stylus pen until all head coordinates have been entered then,
 - ii) Press define Head Coordinates again. Do not save the previously acquired locations simply start over from the beginning.



6. **Digitize Electrode Locations:**
 - a. Click on **Digitizing Start / Stop**.
 - b. Place the stylus pen at the center of an electrode location as designated by the digitizing program then press the stylus button.
 - A single data point is collected each time the stylus button is depressed and a beep will alert the user to each acquired point.
 - The program will assign a number to the electrode position in the sequence the electrodes are selected, i.e., 1, 2, 3, 4, etc.
 - c. If a mistake is made, click on **Remove Last Point** and try that position again.
 - d. Click on **Digitizing Start /Stop** when all electrode locations have been done.
7. At the end the program a head diagram will appear on the screen.
 - a. If the diagram is:
 - i. Correct then continue with Step 8.
 - ii. Not correct then check to make sure that the receiver or transmitter did not move then repeat digitization (steps 6a –d).
8. Click on **File / Save Data**.
 - a. Save the data to the hard drive and
 - b. Save to a floppy disk.
 - *The filename is the current date.
9. Exit the program. Eject disk. Turn off laptop.
10. Transfer the Polhemus head coordinate file from the disk to the computer at the acquisition workstation / console.

***If performing EEG proceed to next section
“Reducing Skin Impedance & Applying Electrolyte”
otherwise skip to the
appropriate Stimulus Equipment section.***



*The operator and anyone within 10 feet of the transmitter and receiver should de-metal. The general rule of thumb is three times the separation distance between the transmitter and receiver from any metal in the room.
For example, if the separation distance is one foot, metal within three feet of the transmitter or receiver may cause distortion and inaccurate measurements.*

Reducing Skin Impedances

Nuprep is intended for to reduce skin impedance. It is a topical abrasive used to clean the skin to remove any natural or applied oil, lotions and/or dead skin. Remove with water.



Nuprep Skin Prep

1. Insert the wooden end of a cotton swab through the opening of the electrode to push hair aside (in one direction) until the skin is clearly visible.
2. If the hair is long, lift up the electrode a little and let it down again while moving back the swab to grab a new bunch of hair (this will prevent the hair from slipping back).
3. Dip the swab into the Nuprep (Abralyt or other skin prep) and insert through the electrode opening.
4. Twirl the swab against the skin using the thumb and index finger.

Applying Electrolyte

Elifix Conductive Cream is a white opaque, water soluble electrolyte used as a conductive medium. Remove with warm water.



Elifix Electrolyte

1. Fill a syringe with Elifix (Abralyt or other electrolyte).
2. Squirt Elifix into the middle of each electrode opening, completely filling the electrode space (the space from the skin to the electrode).



When ELECTROLYTE: If the electrodes are closely spaced, draw back the syringe concurrently to prevent electrolyte from swelling underneath the adaptor rim and bridging to the adjacent electrodes.

Electrode Impedance Meter Check

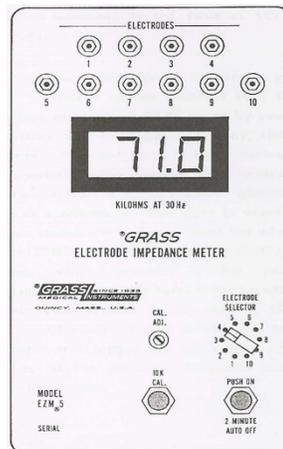
The Grass S88 Impedance Meter measures AC impedance (resistance and capacitance). An impedance check should be performed on all electrodes used for EEG or EMG.

When two or more electrodes are plugged into the electrode switch positions, all electrodes except the one selected electrode being measured are connected together and provide the reference for the one being measured.

1. The **Electrode Selector Switch** should be at position 1 or 2.
2. Plug the ground electrode (FPz) into electrode jack 1 position.
3. Plug the other electrodes into the jack 2 position in a systematic manner one at a time.
4. Press the Red ON Button to activate the impedance check. The power will automatically shutoff after approximately 2 minutes. (There is no OFF button.)
5. **If the impedance is too high** - take a cotton tip swab dipped in Nuprep (Abralyt or other skin prep) and twirl against the skin until impedance is at an appropriate level. Then re-insert Elifix electrolyte.

Impedance Recommendations	
EEG Electrodes	5Kohms
EMG Electrodes (EOG, ECG, etc.)	50Kohms

6. After checking the impedance of each electrode plug the electrode into the appropriate electrode jack box position.

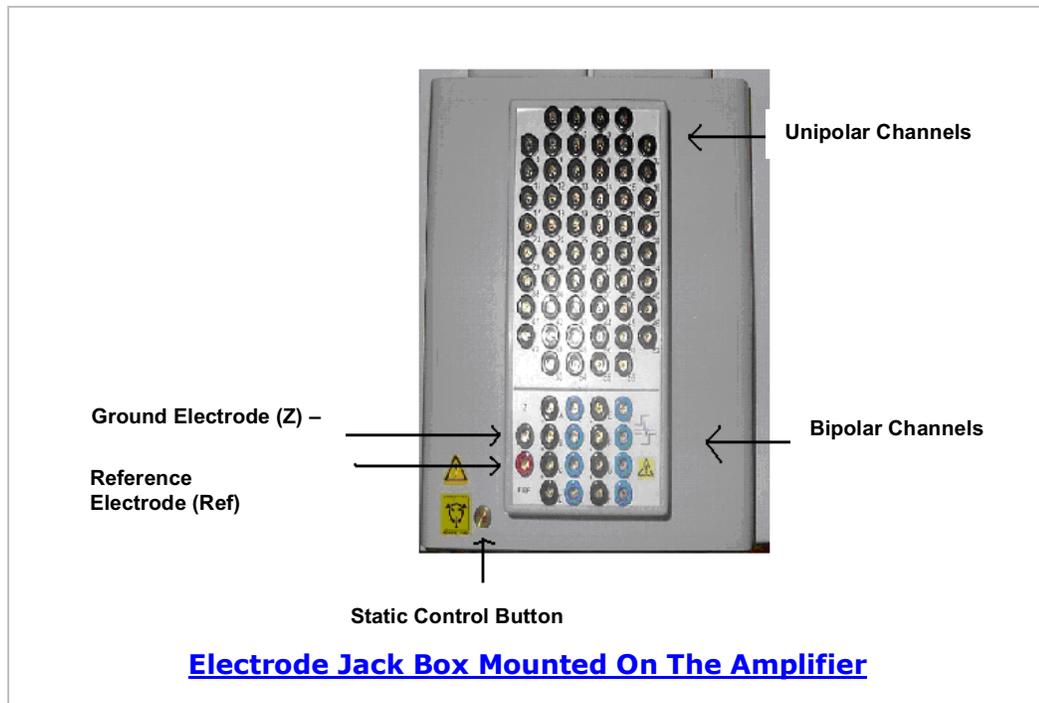


Impedance Meter



If the electrode impedance exceeds 199.9K ohm, a "1" will appear in the left display window with all other digits blanked out indicating the **impedance is too high**. Take a cotton swab that has been dipped in Nuprep and insert it through the electrode opening and twirl against the skin. Re-apply electrolyte. Re-check the impedance.

Electrode Jack Box



ELECTRODE	JACK LOCATION
FPz	Ground (green); Z position.
Linked Mastoids	Ref position (red).
EOG – Left Outer Canthus EOG – Left Infra Orbital	A+ (black); Bipolar Channel A- (blue); Bipolar Channel (EEG Channel 057)
Cerebral Electrodes	Place according to selected montage; Numbered jacks; Unipolar Channel.

If Using EOG:

1. Plug into a bipolar channel.

If Performing EEG:

1. Plug **FPz** into the **ground** (green / Z) electrode position.
2. Plug the **Mastoids** into a **Linked Electrode Adaptor** (Y Connector) then place the single end of the adaptor into the **(red)** position to link the mastoids together.
3. Plug the cerebral electrodes into the appropriate **MEG System Jack Box** unipolar connection according to the particular montage design.



Adaptor

Ref



**Care should be taken to make sure to plug electrodes in the correct jack box location. Check the montage. Electrode labels on jack box are in the lower right corner of each jack position.*

Proceed to the Magnetically Shielded Room (MSR).



Stimulus / Response Equipment

**The stimulus should be set up prior to the subject's arrival.*

Visual Stimulus

The visual software includes:

- **Stim** – a DOS based software program which delivers visual stimuli.
- **Presentation** – a stimulus delivery and experimental control software system for neuroscience. Runs on Windows and uses standard PC hardware. Allows more precise timing for stimulus delivery and experimental control. Provides millisecond temporal precision and complete timing information for all stimulus and response events.

Features include:

- Images stored as bmp, jpg, or pcs (picture stimuli).
- Use any adapter display mode from 32 bit color to palletized display modes.
- Synchronizes stimulus appearance with monitor vertical scan (Picture Timing Control).
- Shows a new stimulus up to every vertical scan.
- AVI and MPEG video (video stimuli).
- Animations.
- Built-in programming language for custom control (PCL).
- Controls stimulus presentation in real-time.
- Adjusts stimuli based on responses or external inputs in real-time.
- Reports times for any event of interest (logfiles).
- Verifies all timing to detect operating system problems.

The visual interface includes the:

- **Sharp LCD Projector System**
- **Avotec Silent Vision Binocular Fiber Optic Video Stimulus Presentation System**
- **Avotec Real Eye Tracking System**

LCD Projector System

The LCD Back Projection System consists of a projector and a screen mounted to the gantry. Images are projected through a hole in the shielded room wall into a set of mirrors which projects the image onto the screen. The image size is up to 40 degrees visual field for eye-screen distance of 37.2 to 52.5 cm.

The Sharp LCD Projector System

includes:

- LCD Projector
- Screen
- Mirrors
- Remote Control



Sharp LCD Projector

1. Turn on the power to the projector by pressing the **POWER ON** touchpad which is located on the under side of the projector. The power indicator will turn green.
 - If the power is turned off and then immediately turned on again, it may take a short while before the lamp turns on.
 - **STANDBY MODE:** If **OFF** is pressed twice, the POWER indicator will light up red and the cooling fan will run for about 90 seconds. The projector will then enter **standby mode**. The power can be turned on again by pressing ON. When the power is turned on, the POWER indicator and the LAMP REPLACEMENT indicator will be green.
 - **WARM UP MODE:** The **flashing green LAMP INDICATOR** shows that the lamp is warming up. Wait until the indicator stops flashing before operating the projector.
2. To turn the power **OFF** press the off button twice, it will enter the standby mode (the power indicator will light red) and after a short delay the power will turn off.

***The LCD Projector has a 30-40 ms delay before it displays an image.*



In order to preserve the bulb life, turn the projector off after each use.

Positioning the Projector:

The projector position may be adjusted manually by shifting slightly to the left or right and up or down.

Lens Adjustments:

Manual Adjustment

1. Images may be focused by turning the silver and black lens collar located on the projector.
2. The projector lens should be centered in the middle of the screen and should be perpendicular to the mirror; otherwise the image will be distorted, making viewing difficult.

Program Adjustment

This function can be used to adjust the focus, zoom, and keystone settings. *Generally only manual adjustments are necessary.

1. Press LENS to select mode. Each time LENS is pressed, the screen changes.
2. Press ENTER to display test pattern.
3. Press the arrow buttons to make adjustments.
4. Press LENS until normal screen appears.
5. To reset the KEYSTONE setting, press UNDO.

Mirror Adjustments

Wall Mirror Adjustments:

1. Project an image onto the mirror.
2. Adjust the wall mirrors:
 - a. Position the top mirror in front of the lens so that the image is reflected down to the bottom mirror.
 - b. Adjust the bottom mirror so that the image is projected centered onto the screen.



Top Mirror

Ceiling Mirror Adjustments (for Supine Recording):

1. Place the ancillary wall mirror on the 2nd set of wall brackets.
2. Project an image onto the mirror.
3. Slide the mirror back or forward so that the image is projected down onto the screen.



Bottom Mirror

Screen Adjustments:



1. Position the screen so that the image is projected centered onto the screen. If possible the screen should be perpendicular to the floor.
2. The screen distance can be increased or decreased by loosening the black knob located on the telescoping screen arm and adjusting the arm length.
3. If necessary, the screen can also be removed and flipped so that it is closer to the subject. Loosen the knob located on the telescoping screen arm. Pull the arm out, flip the screen and re-insert. Position the screen and tighten the knob.
4. Use the black knob located on the Gantry Mounting Bar to raise and lower the screen.

n inside the MSR

Black Screen Function:

This function can be used to superimpose a black screen over the projected image. The **Remote Control** or the **Touch Pad** located under the projector can be used to activate this function.



1. **Blacking out the Projected Image WITH On-Screen Display:**

- a. Press **BLACK SCREEN**. The screen turns black and “BLACK SCREEN” is displayed on the screen.
- b. To return to the original projected image, press **BLACK SCREEN** again.

*For remote control operation, slide the **MOUSE/ADJUSTMENT** switch to the **MOUSE** position.*

LCD Projector
Remote Control

Optical Sensor System

The optical sensor is positioned in front of the projector. It measures the light output of the LCD projector and is used to determine accurate timing of visual stimulus onset times.

The system includes:

- **Optical Sensor**
- **LCD Projector**
- **Illumination Sensor Box**



Illumination Sensor Box

1. Place the Power Switch for the Illumination Sensor Box which is located on the stand outside of the MSR in the ON position.
2. Adjust the **Optical Sensor** located in the projector tube. **Sensor may be taped to the lower mirror for better accuracy.*
3. Check the rack to ensure that the optical sensor output is plugged in. It is typically on ADC16.

Video Stimulus Presentation / Eye Tracking System

The [Avotec Silent Vision Video Stimulus Presentation / Real Eye Tracking System](#) allows simultaneous visual stimulation and eye tracking for MEG applications. The Avotec Binocular Fiber Optic Video Presentation System consists of an optic device for attachment to the MEG system gantry. The Real Eye Tracking System is an infrared eye position tracking system which takes a picture of the eyes.

It consists of four subsystems:



- **Avotec Silent Vision - Video presentation system**
- **Eye Illumination Sensor – infrared eye illumination**
- **Avotec Real Eye Tracker Interface – video based eye tracking system**
- **Eye Tracking Computer Interface (currently not available)**

Silent Vision Infrared System

1. Press the Power button for the **Silent Vision** which is located at the operator's console.
2. Press the Power Switch for the **Real Eye Tracker Interface** located at the operator's console.
3. Turn the **Real Eye – Infrared Level Knob (IR)** clockwise until (from high to low) approximately one-third of the LED indicator is lit.
4. The monitor of the Real Eye Tracker Interface should show an eye image.
5. If the eye image is rotated away from the horizontal, the image may be rotated using the Silent Vision Glasses Coupling Lens Assembly:
 - a. On the coupling lens assembly, slightly loosen the rotation lock screw by turning it counterclockwise.
 - b. The rotation lock screw may then be pushed to the left or right until the eye image on the monitor is correctly oriented.
 - c. Re-tighten the rotation lock screw.



Real Eye Tracker Interface

Auditory Stimulus

Uses **SoundBlaster** or **Presentation Software**.

The auditory stimulus interface includes:

- **Stereo amplifier.**
- **Binaural (stereo) auditory feed through a pair of low-distortion silicone tubes which have about a 10-11 msec delay and a bandwidth of 5kHz.**
- **Foam ear inserts (in various sizes) to fit in the subject's ears.**
- **Auditory tubing inserts.**
- **A sound level meter to calibrate sound delivered to the subject.**



Foam Ear Tip with
with Auditory Tubing Insert &
Low-Distortion Silicone Tube

1. Attach the short color coded **Auditory Tubing Inserts** onto the end of the **Low Distortion Silicone Auditory Tubes** which are hanging on each side of the Gantry mounting bar. Place Red on the right side and the Blue on the left.
2. Attach the **Foam Ear Tip Insert** into the **Auditory Tubing Inserts**. A connector (tube nibble) may be required to keep the insert from coming out.
3. Slowly roll (rather than squeeze) the Foam Ear Tip into as small a diameter as possible.
4. Quickly insert the compressed plug well into the ear canal.
5. Hold in the ear with finger tip until expansion is complete.
6. Repeat process for the remaining ear.
7. The tubing may be taped on the subject's cheek to assure that the insert does not become dislodged during testing.
8. Click on the SoundBlaster or Presentation software from the desktop on the Stimulus Computer located at the operator's console.
 - a. Adjust the sound intensity level (db).
 - b. Click on Start.



Insertion depth affects interaural attenuation. Be sure to select the correct size Foam Ear Tip to obtain the best fit in the ear canal. Insert as far as possible into the ear canal.

Somatosensory / EMG Stimulus

The [Grass S88 Nerve / Muscle Stimulator](#) features include:

- Two output channels for separate nerve locations (with independent control),
- Quartz crystal controlled digital timing circuitry,
- Variable pulse rates and durations,
- Variable train rates and durations,
- Variable delays, and
- Variable stimulus voltage.



Grass S88 Electrical Nerve/Muscle Stimulator

One Channel Single Repetitive Nerve / Muscle Stimulation

The Grass S88 consists of two stimulus channels: S1 unit controls are silver; S2 unit controls are black.

DIAL	Setting	MULTIPLIER SWITCH	Setting
Volt Control	Variable	Volt Multiplier	10 SIU
Rate	Variable	Rate Multiplier	X1
Duration	Variable	Duration Multiplier	X1
Delay (ms)	*Optional	Delay Multiplier	*Optional
		Function Switch	Single

1. Turn on the **Power for the S88**. The switch is located at the bottom right corner of the unit. The orange light should turn on.
2. Turn **ON** the **S1 UNIT**. The switch for the S1 (upper) unit is located in the right upper corner flanked by the ON pilot lamp and the red Overload Lamp.
 - a. Press the **ON Switch** in the upward direction.
3. Set the **S1 Volt Multiplier Switch** to 10 SIU.
 - a. Set the **S1 Volt Control Dial** to the lowest level. This will be equivalent to ≤ 1 volt. (This is important because if the voltage is too high when the electrodes are plugged in, the subject might experience extreme discomfort).
4. Set the **S1 Rate Multiplier Switch** to X1.
 - a. Select the **S1 Rate** (pulses per sec).
5. Select the **S1 Duration Multiplier Switch** scale. (It is recommended that the multiplier is set on the X1 scale).
 - a. Select the **S1 Duration** (pulse length in ms).
6. Determine the **S1 Delay Dial** (ms) if any.
7. Set the **S1 Function Switch** to **Single**.

8. Reduce the skin impedance at the stimulus site using **Nuprep Skin Prep**. Wipe the skin to remove the residual grit.
9. Apply **Elifix Electrolyte** to the electrodes.
10. Tape the electrodes securely to the skin.
11. Check the impedances using the **Grass Impedance Meter**. * Impedances should be $\leq 5K$ ohms. For further information refer to section entitled "Impedance Meter Check".



Stimulus Isolation Unit (SIU)

12. Plug the **Grass Stimulus Isolation Unit (SIU)** into the cable labeled **Grass S88 Stimulator – S1** (located on the front cabinet in the MSR).
13. Plug the stimulus electrodes (or electrode bar) into the **SIU**:
 - a. Select the **CURRENT RANGE** (generally 1-15ma).
 - b. Select the **POLARITY**; generally normal.
14. Gradually increase the stimulus intensity using the Grass S88 **S1 VOLTAGE CONTROL Dial**. Increase until motor threshold is reached (until there is a visible muscle twitch) then back off to sensory threshold (the subject can feel the stimulus but there is no visible twitch).



*For subject comfort and maximal stimulation with the least amount of voltage move the electrode until it is positioned directly over the muscle/nerve while at motor threshold then back off to sensory threshold; make sure the skin impedance is less than or equal to 5K ohms.

Response Pads

Lumitouch Response Pad

Lumitouch is a 5 key fiber optic response keypad. The system consists of absolutely metal free keypads connected via fiber optic cable to an opto-electronic controller unit. The cabling is fabricated from 100% plastic materials and therefore does not cause electromagnetic interference.

There are five response buttons which are arranged so that all or a subset of fingers can be used in a natural order and comfortable positioning when responding to a visual and/or auditory stimuli. Designed for placing on the arm rest.

1. Instruct the subject in the use of the Lumitouch Response Pad.



FORP Response Pad

The FORP (Fiber-Optic Response Pad) is a fiber optic based response device. The response pad is completely non-metallic and non-electronic. It is intended for use in MEG, MRI or other environments where metal or electronics could hinder data acquisition, degrade image quality, or pose safety risks.

There are 4 colored buttons which are arranged in a diamond pattern. It is designed to be held or cupped in the hand while using the thumb to respond to the appropriate color, position, number or pattern of the buttons.

1. Instruct the subject in the use of the FORP Response Pad.



NeuroScan Switch Response Pad

The NeuroScan is an electrical response device designed to use while lying on the arm rest to reduce the potential for arm movement.

There are four response buttons aligned for natural positioning of the fingers. There is an audible click with each button press.

1. Instruct the subject in the use of the NeuroScan Response Pad.



MSR (Magnetically Shielded Room) & Subject Support

The Magnetically Shielded Room is designed to shield out or reduce the influence of environmental noise (i.e., the earth's magnetic field, cars, elevators, etc) on the MEG signal. The walls consist of a layer of a special metal which has a high magnetic permeability (Mu Metal) and two layers of copper. Although the MSR greatly reduces the contribution of environmental noise, it does not adequately shield out lower frequency noise.

Room Lighting

Overhead Lighting

1. Turn the lights on in the MSR by depressing the square **green button** on the VAC Power Supply Unit which is located on the bottom shelf of the stand outside the MSR.
2. Dimming the lights in the MSR:
 - a. Use the **Brightness** (black) knob to dim the light.

Door Operation



MSR Door

Closing the Door:

1. Push the door up to the door possible.
2. Press (until the air locks release) the **OPEN/CLOSE** door.



Open/Close Button

frame as far as

activate) then quickly **BUTTON** to seal the

Opening the Door:

1. Press (until the air locks release) then quickly release the **OPEN/CLOSE BUTTON** (Black Button).
2. Pull the door open.





If the door fails to open, press the **EMERGENCY OFF BUTTON** (Red button) located on the outside and the inside of the MSR.

If the door fails to open when using the Emergency Off Button, then insert the **EMERGENCY DOOR KEY** in the upper and lower **EMERGENCY UNLOCK** (Yellow) keyholes and turn. This will manually release the door locks. Keys and keyholes are located on both sides of the MSR door.



Emergency Door
Key

Positioning a Subject in the Chair

The gantry should be at 15° tilt in the upright (sitting) position.

1. Move the attached **Visual Stimulus Screen** up out of the way by loosening the black knob (located on the gantry mounting bar) before placing a subject in the chair.
2. **Plug the Head Coil Cables** into the appropriate color-coded locations on the Head Localization Module. *Route the right Head Coil Cable around the back of the subject's neck so that it does not lie across the subject's chest. Route the other two cables in front of the subject's neck so that they do not touch the subject's chest.

Head Coil Cables

Nasion	Right Ear	Left Ear
Blue	Red	Green

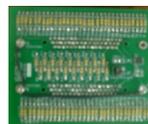


[Head Localization Module](#)



Note: If the head coil cables are placed in the wrong jack or placed on the wrong anatomical location the coil locations will be skewed and the calibration will fail. Repeat the calibration after changing the jacks the correct location in the jack box or switching the coils to the correct location on the subject.

3. **Mounting the Electrode Jack Box** onto the amplifier when performing EEG:
 - a. Touch the **Static Discharge Button** on the Amplifier Unit.
 - b. If the **Gain Calibration Card** (Shorting Plug - small green circuit board) is situated on the Amplifier Unit, carefully remove it before connecting the Electrode Jack Box.



Gain Calibration Card (Shorting Plug)

- c. Connect the Electrode Jack Box to the amplifier Unit. Align the corner with the brackets on the amplifier. Press down firmly.



Electrode Jack Box



Never check impedances using the Grass Impedance Meter when the jack box is connected to the MEG system amplifier.

4. Place the **Stabilizing Head cuff**:

- a. Open the valve stem and squeeze all the air out of the head cuff so that it is completely deflated.
- b. Close the valves.
- c. Place the protective head cover (cap) over the subject's head.
- d. Place the **Stabilizing Head cuff** on the subject's head so that the red cross mark is at the center front of the forehead and the connecting tubing is at center back. **Make sure the bladders are positioned so that they lie flat inside the headband.*
- e. Pull the head cuff over the ears.
- f. The "Y" shaped top piece should be placed so that the cross bar is at the back of the head and the other two arms of the "Y" are at the sides of the head.
- g. Adjust the top straps with the Velcro so that the headband does not cover the eyes.
- h. Place the hoses so that they run down the back of the neck; behind the chair.
- i. There are two pump valves; one to inflate the front of the bladder and the other to inflate the side bladders.



Protective Head Cover



Head cuff Pumps

- j. Instruct the subject to hold the pumps which will be inflated when the subject is properly raised up and inserted into the dewar.



Stabilizing Head cuff

5. Place a rolled up towel or pillow under the knees and so that the subject does not slide down in the chair.

6. Make **CHAIR ADJUSTMENTS**:

The chair is a pneumatic-hydraulic unit and there may be a 2-3 second delay when turning controls from the unlocked to the locked position or when making chair adjustments.

There are two kinds of controls: The **hand wheel** which controls the directions and rate of movement and the **valve** which controls which adjustment is selected or activated. Turn the hand wheel and valves slowly when making any adjustments.

After making any adjustment using the hand wheel or valve allow the air pressure to equalize.

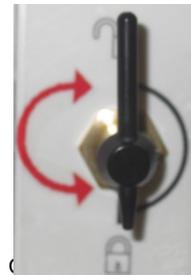


Hand Wheel Control

Chair Movement / Positioning

The **BRAKE** valve controls the back and forward movement of the chair; located on the side panel.

- a. Slowly turn the brake valve to the unlocked position.
- b. Physically push the chair back or forward **so that the subject's head is positioned directly under the gantry; the back of the head should at the back of the dewar.** Check the subject's posture. Ask the subject to scoot their hips all the way back in the chair so that they are sitting upright in the chair.
- c. After adjusting the chair set the valve to the locked position to prevent movement of the chair. The valve should always be in this position unless adjustments are being made.



**Check to make sure the optical cables are not on the track before moving the chair.*

Chair Backrest Tilt Adjustment

The upper valve controls the **TILT** of the chair backrest; located on the front panel.

- a. Slowly turn the **Tilt Control Valve** to the unlocked position.
- b. Adjust the backrest so the subject is sitting upright in the chair and **their head is positioned directly over the hips**. It is important make sure the subject is comfortable and therefore reduce the potential for fatigue.
- c. Turn the hand wheel:
 - **Clockwise** → to make the backrest move **forward**.
 - **Counter-clockwise** ← for **backward** motions.
- d. Turn the Tilt Control Valve to locked position. It should always be in this position unless adjustments are being made.



Tilt Control Valve

Chair Height Adjustment

The lower valve controls the **HEIGHT** of the chair; located on the front panel.



Control Valve

- a. Slowly turn the **Height Control Valve** to the unlocked position.
- b. Position the subject so that his/her head is at or near the top of the dewar. **When near the top of the dewar periodically ask the subject to raise himself/herself up in the dewar to determine how much room is remaining. Do not raise the chair while the subject is rising up in the chair.*
- c. Turn the Hand Wheel:
 - **Clockwise** → to make the chair move **upward**.
 - **Counter-clockwise** ← for **downward** motions.
- d. Turn the Height Adjust Valve to locked position unless adjustments are being made.



** Care should be exercised when adjusting the chair height while a subject is seated under the gantry. Until completely familiar with the operation of the chair adjust the chair very slowly in small increments.*

7. Instruct the subject to **inflate the Stabilizing Head cuff** to a comfortable level after positioning the subject's head into the dewar helmet.



- a. The subject's head should be centered in the helmet.
 - b. Instruct the subject to squeeze both pumps at the same time to inflate the front and side bladders simultaneously until his/her head feels comfortable (moderately confined) in the helmet.
 - c. When both bladders are inflated fold the tubing and clamp at fold so that air can not leak out.
 - d. Move the hand pumps to a location near the wall as far away from the dewar helmet as the tubing allows. Place the pumps so that they are stationary and there is no movement in the clamp or the pumps.
8. Tape the Head Coil Cables to the side of the dewar. **If applicable, tape the EEG Electrode Cables to the side of the dewar as far away from the Head Coil Cables as possible.*
 9. Place a Chin Head Movement Monitor using tape to give the subject feedback regarding head movement. Attach tape to each side of the dewar. The tape should just barely touch the subject's chin. **This step is optional.*
 10. Adjust the stimulus.
 11. Instruct the subject regarding the task.
 12. Allow the subject to practice the task.
 13. Begin recording.



**When done recording deflate the bladder by opening the pump valves. Some external pressure may have to be applied to deflate the air bladders fully.
Also move the chair forward, place the chair backrest in the upright position.*

Installing the Bed for Supine Recording

The gantry should be at a 90° tilt for supine recording.



**Never operate the gantry while a subject's head is in the helmet.*

1. Raise the screen.
2. Lower the Gantry to 90° tilt (horizontal position). Gantry Controls are located on the right side of base. The controls require the operator to use both hands to operate. If either handle is released the gantry motion will stop.
 - a. Raise the **Brake Control Lever** (lower / long handle).
 - b. Then raise the **Direction Control Lever** (upper / shorter handle). This will release the brake.
 - c. Then move the **Direction Control Lever** in the downward direction.
 - d. Using the **Angle Indicator** readout located on the gantry near the front pivot point position the gantry at 90°.
 - e. Release the Direction Control Lever to stop the motion. Release the Brake Control Lever.
3. Slide the chair forward.
4. Recline the chair backrest to approximately a 45° tilt.
5. Remove the arm rest from the chair. The back cushion may be removed or left in place.
6. If the bed will have its angle adjusted place the **Roller Wheel Assembly**. If the chair back cushion has been left in place, first slide the backrest cushion to its lowest position. Mount the Roller Wheel Assembly to the exposed seat back support plate.
7. Using two people, lift the bed by the ends using the hand grips which are mounted to the under side of the bed.
8. Set the bed onto the unpadded armrests of the chair. Align the holes.
9. Insert the four mounting bolts, which are tied to the base of the bed, through the holes in the bed base into the holes in the chair armrests.
 - a. All four bolts should be screwed in a couple of turns and
 - b. fully tightened when all four are engaged.
10. **Install bed side rail on one side.** One side rail must be in place before allowing a subject to get onto the bed. Tighten rail clamp to secure.



ed Side Rail



12. Raise the bed so that it is level with the dewar.

13. Slide the bed back so that it rests against the dewar.



**Lift the bed above the optical cables and any other sensitive equipment.*

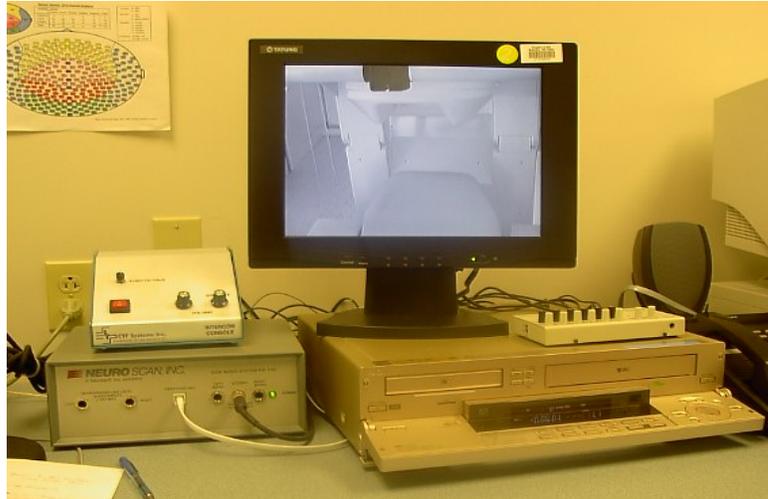
Positioning a Subject on the Bed

1. Place a sheet over the bed. Place a towel at the head of the bed.
2. Cover the Foam Pad Pillow and place inside the dewar.
3. Place the step stool on the opposite side of the rail to assist the subject in getting onto the bed.
4. Place a protective cap over the subject's head.
5. Have the subject sit on the edge of the bed then lie down. Care should be taken so that the subject does not bump his head on the screen or the dewar.
6. Ask the subject to bend his knees and use his legs to scoot himself up so that his head is inside the dewar.
7. Place a towel or pillow case over the subject's head to restrict head movement.
8. Place a rolled up towel or pillow under the subject's knees so that there is no pressure exerted on the back, tailbone, or knees.
9. Place the head coil cables so that they do not lie across the subject's chest. Plug into the jack box.
10. Once the subject is on the bed, place the side rail on the remaining side. Tighten the rail clamp to secure.
11. If necessary, make sure the ancillary mirror has been placed in the 2nd (middle) wall mirror slot.
14. The LCD projector image should be reversed / inverted to allow for the extra mirror bounce:
From the LCD Projector touchpad (or using the remote):
 - a. Press MENU.
 - b. Press ◀ / ▶ to select the "PRJ Mode".
 - c. Press ▶ / ▼ to select desired projection mode (Rear / Reversed image).
 - d. Press MENU to exit.
15. Re-position the ceiling mirror. Adjust the wall mirror.
16. Begin Data Acquisition.
17. When finished, remove the bed, move the chair forward, place the backrest in the upright position, replace the arm rest and back cushion.
18. Position the gantry at 15 degrees.

Subject Monitoring Inside the MSR

The operator can converse with and monitor the activities of the subject inside the MSR by:

- Voice Intercom / Parabolic Microphone / Flat Speaker
- Infrared Lighting for video in darkness
- Video Display at the operator console
- Video Cameras
- VCR for recording the video



Acquisition Workstation / Operator's Console

1. **Video Display Monitor:** Used to monitor a subject inside the MSR. Located at the acquisition workstation / operator's console.
 - a. Press the on/off switch is located on the front panel. 
 - b. Press the channel button once to access the next channels.
 - c. Continue to press to access other channels.

Channel 1	Camera 1 (Infrared Camera)
Channel 2	Camera 2 (Color Camera)
Channel 3	VCR Play back (connected to Color Camera)
Channel 4	(Blank)



**Always monitor the subject via the Video Display Monitor when running a study.
THE SUBJECT MUST BE OBSERVED AT ALL TIMES DURING TESTING.*

2. **Voice Intercom:** Used to communicate and listen to a subject inside the MSR. The Intercom Electronics Box is located on the acquisition workstation / operator's console. (There are no intercom controls inside the MSR, just a parabolic microphone and flat speaker).



Voice Intercom

- a. Press the Red power button to turn on the Intercom Electronics Box to listen to a subject inside the MSR.
- b. To speak to a subject who is inside the MSR press the PUSH TO TALK button located on the front of the Intercom Electronics Box. (Release the button to talk to the subject.)
- c. Adjust the volume in the MSR or at the Console by using the volume control knobs located on the front of the Intercom Electronics Box.

3. **Infrared Lighting:** Illuminates a subject inside the MSR when recording in a dark environment so that the subject may be seen via the Video Display Monitor. The Control box is located on the stand outside the MSR.



Infrared Lighting Control Box

- a. Press the Red On/Off switch to turn on the power for the Infrared Light Power Supply (SEC 1212).

4. **Video Cameras:** Used to view a subject who is inside the MSR on the Video Display Monitor. Located inside the MSR; reposition manually.

- a. Press the channel button located on the Video Display Monitor to change from Camera 1 to Camera 2.

Channel 1	Camera 1 (Infrared)
Channel 2	Camera 2 (Color)

*See Video Display Monitor for details.



Video Cameras & Microphone

5. **VCR:** The **Sony VCR** Located at the acquisition workstation / operator's console. Use the VCR to record a video of a subject during an experiment. The VCR has the ability to send time codes to the rack along with the data so that the video can be referenced during data analysis.



VCR Panel Closed



VCR Panel Open

- a. Make sure **Acq** has been launched,
- b. Turn on the VCR by pushing the power button located on the top left of the panel, just below the word "Sony."
- c. Click on **Windows > Collection Parameters**.
- d. In the Collection Parameters window under the **General** section select the **Time channel** check box.
- e. Put an appropriate description in the **Run Description** window (i.e. with VCR Recording).
- f. Setup the stimulus and instruct the subject.
- g. When ready to start recording, click on the **Acquire Data** button at the bottom of the **Run Description** window and the **Acquisition Monitor** will come up. The **Time display** box at the right side of the plot window will be blank.
- h. Open the front panel by pulling the front of the VCR down and towards you.
- i. Insert a tape in the appropriate slot. The **Time display** box will become active and the time displayed will match the time display on the VCR.
- j. Stop the tape and rewind to the beginning of the tape.
- k. Do the head localization and prepare to start recording.

- I. Press the record button  to begin recording and verify that the **Time display** box matches the VCR.
 - The time information will be stored as a separate channel in the MEG/EEG dataset.
 - The time data can be displayed in the plot window by selecting **TIME** in the **Channel Selection** dialog window.
 - This should be a series of upward steps occurring once per second, visible if you set the vertical scale to 1000. At minute and hour boundaries there will be a very large step in the data.
 - The Sony video equipment does not output the video frame number as part of the time code, so resolution less than a second has to be calculated based on the number of samples since the last step in the **TIME** data channel.

- m. To stop recording, press the stop button .

- n. Rewind by pressing the  button.

- o. Playing Back: The monitor has four channels that can be changed by pressing the **Channel** button on the video display monitor. The VCR channel is number three.

- p. Eject the tape by pressing the  button.

- q. When finished, close the panel.

Recording Data / Data Acquisition

Electronics / System Characteristics

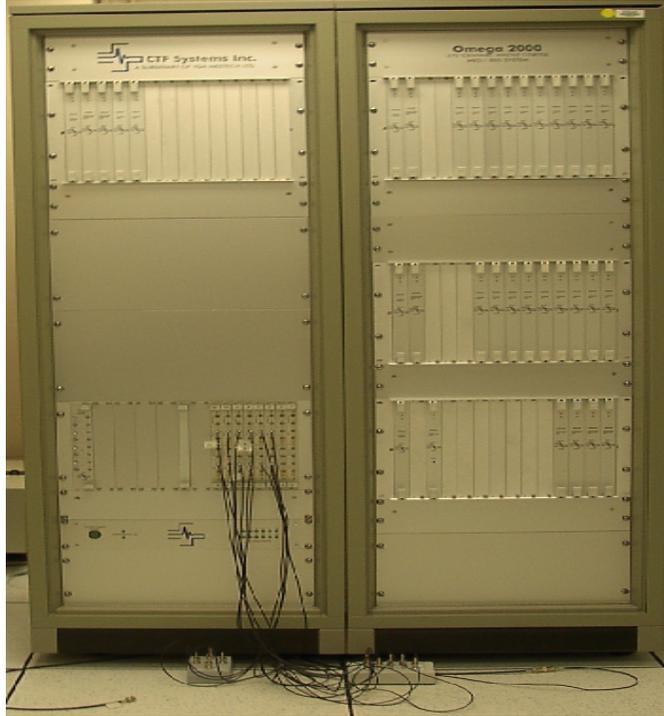
The electronics system is responsible for processing MEG and EEG data including amplifying, filtering, sample rate conversion and firmware gradient formation. It facilitates the measuring and recording of weak magnetic fields and electric fields produced by the nervous system simultaneously on many channels and provides sufficient processing power for user required algorithms to be implemented.

The electronics rack consists of the MEG DSQ bank and amplifiers and the EEG bank and amplifiers and the **Peripheral Interface Unit (PIU)** which includes the **ADC Channels Interface**. They are housed on the electronics rack.

System characteristics:

- 275 MEG Channels
- Total of 64 EEG Channels
(56 Unipolar EEG Channels & 8 Bipolar EEG Channels)
- 16 ADC Channels
- 8 Bits; 16 Trigger Channels
- 28 Reference Channels
- Signal detection down to DC (0 Hz)
- Dynamic range: 32 bits
- Linearity better than 10^{-6}
- Sampling rate: up to 4000 Hz.

*higher sample rate are possible for subsets of all channels.



MEG Electronics Rack

ADC Setup:

The Analog to Digital Converter is a device that converts the analog signal to a digital signal that represents equivalent information. The ADC Channel Interface is used to connect the input from various stimulus / stimulus response equipment to the electronics the signal can be recorded, displayed and stored along with the data. The ADC channel interface is located on the front panel of the electronics rack.

The ADC interface connections should always be checked prior to any collection. If using a stimulus response / reply system (Lumitouch, FORP or NeuroScan), before starting acquisition the user should check to make sure that the ADCs are connected to the proper response buttons. Ask the subject to push each button individually. Visually inspect the ADCs on the video display monitor to assure that the ADCs are connected to the correct response button in accordance with the research study design.

There are 16 ADCs. The head localization coils are internally connected to ADCs 1-3.



ADC Channels Interface Boards

The Lumitouch Response Pads are often plugged into ADCs 9-15.



Lumitouch Reply System Interface Box

The FORP is usually plugged into ADCs 5-8.



FORP Interface Box

The auxiliary BNC cable can be used for other stimulus equipment or other computer configurations.



Auxiliary BNC Cable

Data Acquisition

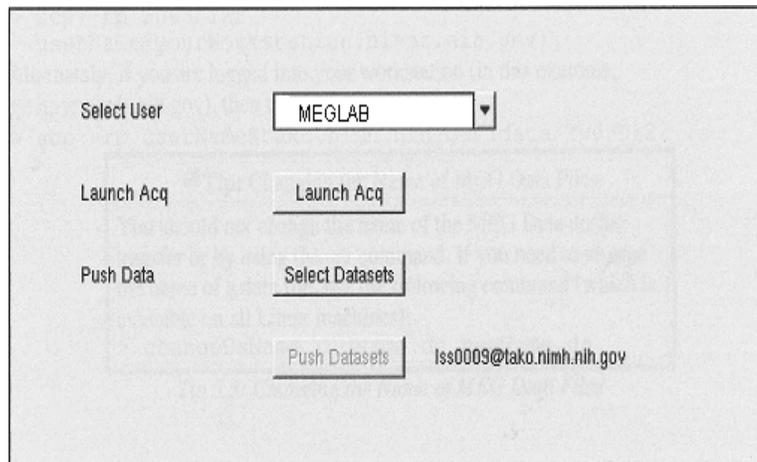
The main function of Acq is to set collection parameters such as sample rate, collection duration, set patient information, set data filters, set synthetic gradiometer order, set adaptive balancing, set up triggers and ADCs, collect and save data, perform head localization to co-register the sensors to the head coordinate frame, save collection parameters for future use. Collection Parameters are set via dialog boxes prior to recording and stored in a protocol file. However, these parameters can be adjusted for a given study without permanently changing the stored protocol file and should always be reviewed before starting a collection.

Data can be collected in one of three modes: 1) Continuous recording displays all data immediately while recording; 2) Triggered recording stores individual or; averaged sets of trials with specified time duration around some form of stimulus or external trigger; 3) Un-triggered recording stores trials of a specified duration in response to the operator's command without stimulus triggering.

The final preparation before recording is the localization of the subject's head with respect to the standard coordinate system. This is done by localizing the position of coils placed on the fiducial landmark points of the subject's head via the SQUID sensors after the subject's head is placed in the dewar helmet.

From the Acquisition Console / Workstation:

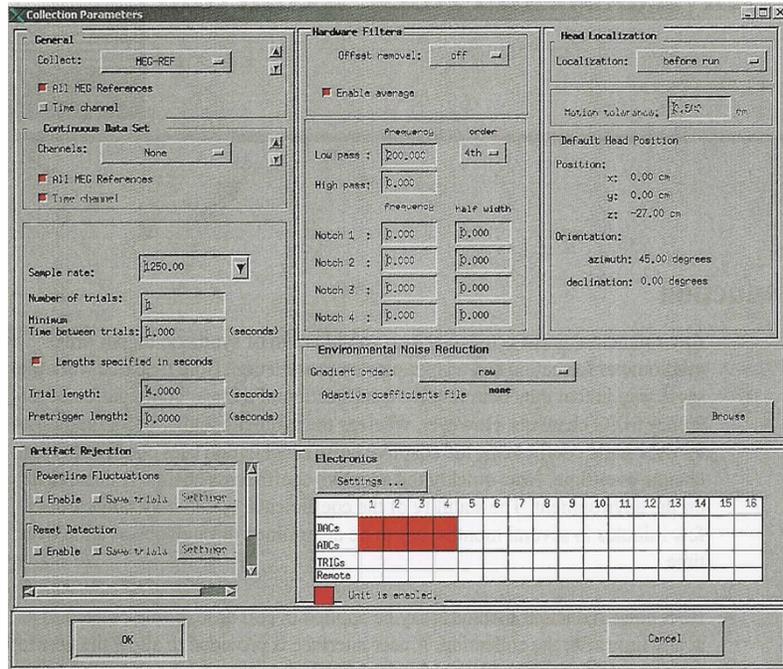
1. From the NIMH MEG Core Facility Acquisition Manager:
 - a. Select User
 - b. Launch Acq



NIMH MEG Core Facility Acquisition Manager

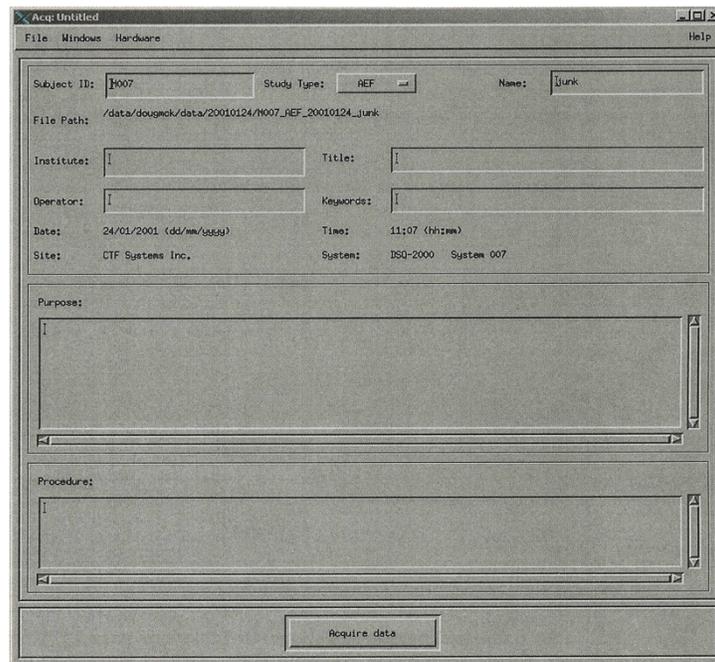
2. Select Study.

3. To view/edit Collection Parameters:
 - a. Click on Windows
 - b. Click on Collection Parameters



Collection Parameters Window

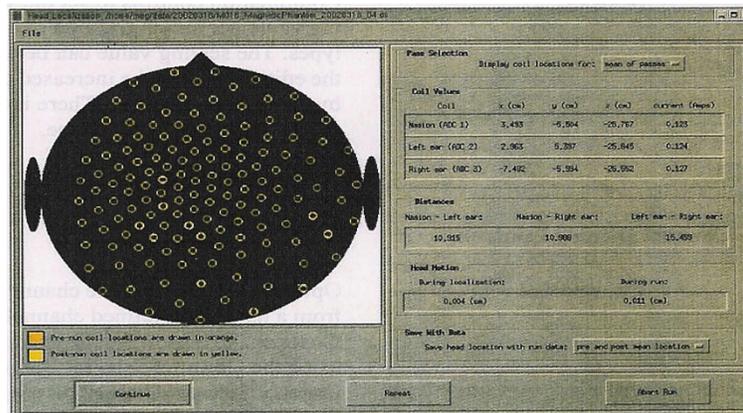
4. Click OK.
5. At the Acq Dialog Window enter:



Acq Dialog Window

- a. Enter **Subject ID (subject initials & MIS#)**.
- b. Enter **Procedure Description**.

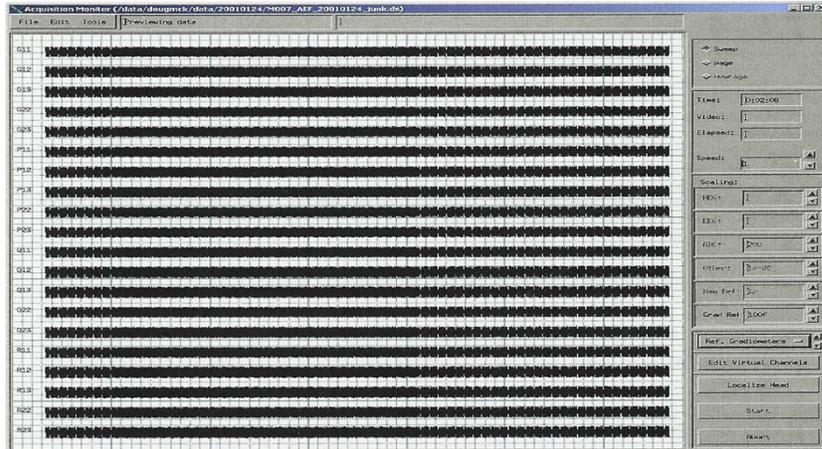
6. Click on **Acquire Data**.
7. Create Directory? Click **Ok**.
8. When performing EEG, an **IMPEDANCE CHECK** should be performed on the MEG system:
 - Select EEG Setup Window menu.
 - Click on CHECK IMPEDANCE. The results are displayed in the appropriate columns.
 - To check the impedance of all active EEG channels press the CTRL key on the keyboard at the same time as clicking on the impedance check button.
 - Please note: The impedance check requires 3 electrodes: The electrode being measured and at least 2 other electrodes.
 - Click OK / EXIT.
9. Click on **HEAD LOCALIZATION** button located on the side bar.
10. Instruct subject for task and Head Localization. If applicable **UNBLANK SCREEN**.
11. At the Stimulus Workstation: Click the mouse to activate the “**LOCALIZING HEAD**” prompt. *If there is no head localization prompt, omit this step.
12. Click on **OK** at the Head Localization Starter **TO START THE LOCALIZATION**.



Head Localization Window

13. Click on **CONTINUE** to accept the head localization results. (acceptable tolerance is < 0.5 mm)
14. STARTING THE **STIMULUS**:
 - a. If acquisition is **NOT TRIGGERED** click mouse on the Stimulus Computer simultaneously with the start of the Data Collection (Step# 15),
 - b. If trial is **TRIGGERED** click mouse after the start of collection (Step# 15).

15. To start **DATA COLLECTION** click on **START**.



Acquisition Monitor

16. To select the ADCs and Channels to be displayed during collection: Click on the **CHANNEL SET BUTTON** which is below the group of Channel Scale Indicators.

*Note: Select **Custom...** to customize the channel selection using the **Channel Selector** dialog.*

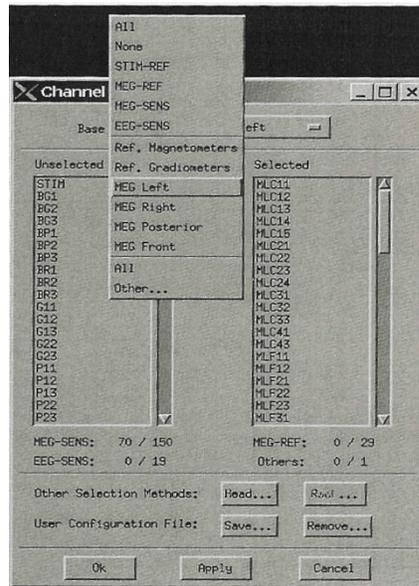


Note: Fluctuating Red lights in the [Collection Status Window](#) during acquisition indicates that the data is being buffered; a failure condition is indicated only if the collection status buffer is completely red (full).

Solid yellow lights on the DSQ cards during acquisition indicate those channels are actively acquiring data; not a failure condition.

17. Click on the **CHANNEL SELECTOR DIALOG**;
 - a. From the **UNSELECTED** Window click on the channels (i.e., Stim, ADC's, EOG, EEG and/or MEG channels) to be displayed.
 - b. Click on the **ARROW** to transfer those channels to the **SELECTED** window.

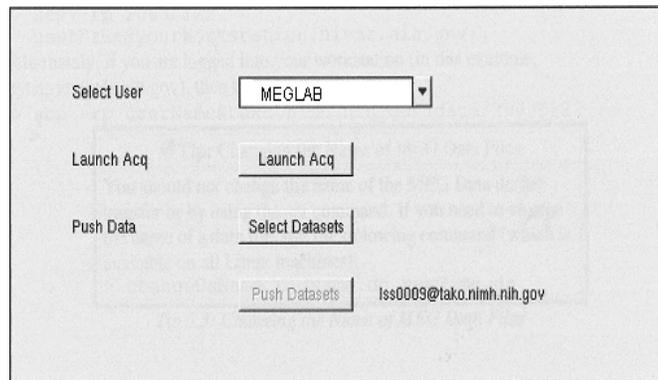
**Make sure the ADCs have been set up correctly and document.*
 - c. Click on **APPLY**.



Channel Selector Dialog

18. Adjust channel (display) scale.
19. When done acquiring (at the end of the trial) when data collection stops, head localization will start automatically. Wait for the **HEAD LOCALIZATION PROMPT**.
20. To Print the Head Localization results: When Head Localization is done Click at the bottom of the screen and the **Printer Icon**  will display. Click on the printer icon then click anywhere within the Head Localization dialog.
21. Click on **“Continue”** to accept the data. **If localization fails click on the REPEAT button to re-try localization. At the General Information window, click OK.*
22. When head localization is done instruct the subject to relax and blank the screen.

23. To begin another trial :
 - a. Click on **FILE**.
 - b. Click on **CLOSE WINDOW**.
 - c. **Acquisition Manager** window displays.
 - d. Edit the trial information in the Procedure area.
 - e. Click on **OK**.
 - f. Repeat steps 5 - 22.
24. When done inform subject of study completion and blank the screen.
25. To end recording session click on **CLOSE** window.
26. **EXIT** Acq.
27. Select Dataset to save.
28. Click on **OK**.
29. From **the Acquisition Manager** window select the dataset to push to the storage **RAID SERVER** (tako.nimh.nih.gov).
30. Click on **Push Data**.



NIMH MEG Core Facility Acquisition Manager

Transferring Data To DVD

The DVD burner is located on the analysis computer -Tako. Data must be pushed from the Acquisition Computer (Squid) to the Analysis Computer (Tako) and then copied to DVD. If the data has already been pushed to the RAID server (as outlined above) skip to step 4.

1. Log onto the Analysis Computer (Tako).
 - a. Login to Tako using your username and password.
 - b. Open a terminal window.
 - c. Type: "**cd data**".
2. Make sure that the staging area is empty.
 - a. Type: "**ls /tako_data1/dvd**".
 - b. If the staging area is not empty
Type: "**rm -r /tako_data1/dvd/(directory name)**".
3. Copy the data into the staging area.
 - a. Type: "**cp -a (directory name) /tako_data1/dvd**".
4. Write data to DVD.
 - a. Insert DVD.
Type: "**burndvd**".
5. Unmount volume.
 - a. Right click on **cdrom icon** (located on the Start Here menu).
 - b. Click on **Unmount**.
6. Delete (remove) the data from the Analysis Computer (Tako) staging area only:
 - a. Type: "**rm -r /tako_data1/dvd/(directory name)**".
(*this deletes the data from the staging area only; the data will remain on the server for several weeks before being deleted.)



When Someone Is Logged Into Tako

Occasionally when trying to use tako to burn a DVD someone else may be logged in. In this situation, start a new xterm window by clicking on the terminal icon on the bottom of your screen (it looks like a picture of a computer monitor). Then make yourself the user of that window using the following command:

```
> su - userName
```

Transferring Data To A Remote Computer

Tako, the analysis computer, is set up so that the data directory in your home directory is located on the RAID Array. So it is appropriate for the data to get pushed there.

1. After pushing data to the RAID array it can be acquired by logging onto Tako (tako.nimh.nih.gov) using your username and password.
2. Move to the data directory, i.e.,

```
"> cd data "
```

\$HOME/data directory structure:

```
date
|
subject_studyType_date_run.ds
|
your study data
```

3. Copy the data to the **Remote Workstation** for access. This can be done in two ways.

If logged into Tako

- a. From your \$HOME/data directory type in:

```
"> scp -rp (date of study in year/mo/day format) username@yourWorkstation.ninds.nih.gov:."
```

Example:

To copy data that was acquired on January 22, 2003 to a remote workstation called **synapse.ninds.gov** type the following command from your \$HOME/data directory:

```
"scp -rp 20030122 userName@synapse.ninds.gov:."
```

If logged into a Remote Workstation

- a. From your \$HOME/data directory type in:

```
"> scp -rp username@tako.nimh.nih.gov:data/(date of study in year/mo/day format)."
```

Example:

To copy data that was acquired on January 22, 2003 from the MEG workstation called **tako.nimh.nih.gov** type the following command from your \$HOME/data directory:

```
"> scp -rp userName@tako.nimh.nih.gov/20030122 ."
```



*Do not change the name of the MEG data during transfer or by using the "mv" command. If you need to change the name of a data file, use the following command:

Clean Up Procedures

MEG

Subject Clean Up

1. If applicable, remove the EOG / EMG electrodes.
2. Remove the black marker dots using an alcohol wipe.
3. Clean the skin with a soft cloth and water; rub gently.

Disinfection Procedure

1. Soak EOG / EMG electrodes in a freshly made 0.5% solution of Hypochlorite or approved hospital grade disinfectant for 10 minutes.
2. Rinse thoroughly and allow to air dry.

Equipment Clean Up

1. Clean **THE HEAD LOCALIZATION COILS** with alcohol.
2. Clean the EOG / EEG electrodes with distilled water and a mild detergent.
 - a. Gently rub the electrodes using a toothbrush to dislodge electrolyte residue.
 - b. Rinse well.
 - c. Pat dry using a soft towel.
 - d. Store in a dark dry environment.



**When done recording slide the chair forward. Also lower the chair to the floor (so that the bellows is about 2 inches deep); adjust the chair backrest so that it is completely upright (at approx 15^o angle).*

EEG

Subject Clean Up

1. When recording is finished, remove the cap (or electrodes).
2. If **PASTE** was used, take a damp cloth and gently rub the scalp in all electrode locations.
3. If **COLLODION** was used, apply a solvent to dissolve the glue. Use in a well ventilated area.
4. Instruct subject to wash hair as usual with shampoo.

Disinfection Procedure

1. If using the **EEG CAP**,
 - Remove the electrodes from cap.
 - Soak the **ELECTRODES** and **EEG CAP** in a 5% Sekusept-Plus solution or other hospital grade disinfectant for 10-15 minutes. Afterwards clean electrodes as described below.
2. If using a **COLLODION / ELECTRODE** application,
 - Soak electrodes in a freshly made 0.5% solution of Hypochlorite or approved hospital grade disinfectant for 10-15 minutes.
 - Rinse thoroughly and allow to air dry.

Equipment Clean Up

1. Clean **ELECTRODES** with distilled water and a mild detergent.
 - Gently rub electrodes using a toothbrush to dislodge electrolyte residue.
 - Rinse well.
 - Pat dry using a soft towel.
 - Store in a dark dry environment.
2. Clean the **EEG CAP** with warm tap water and a mild detergent.
 - Rinse well.
 - Pat dry using a soft towel; allow cap to air dry.
3. Clean **HEAD LOCALIZATION COILS** with alcohol.

Appendix

In The Event Of An Electronics/Software Variance The Following Procedures Should Be Followed:

1. **Head Localization Failure:**
 - a. Check Collection Parameters.
 - b. Check head movement.
 - c. Check head coil placement.
 - d. Repeat head localization.

2. **Acq Aborts (crashes):**
 - a. Check front panel for electronics failure. Record codes.
 - b. If no electronics failure then re-launch Acq.
 - c. Check collection parameters.
 - d. Re-enter Acq information.
 - e. Fill out a Variance Report.

3. **Boot Electronics Failure:**
 - a. **No LED's – no power.** If there is no fan noise or clicking of relays then it is likely that there is a problem with the power. Contact MEG Core staff for assistance.

 - b. **No LED's – no 12 kHz Sync signal is being received by the card.** Exit Acq then turn the power off and on and try again. Without the 12 kHz sync pulse all the cards in the sub-banks will be held in reset. Check the DSQ 2041 (the source of the sync signal). Check the DSQ2047 bridge cards and fibers. Check the DSQ 2043 is configured correctly for DSQ back or processing bank operation. If the problem persists contact MEG Core staff for assistance.

 - c. **Flashing yellow** – Exit Acq then turn the power off and on and try again. Indicates a failure in the self diagnosis. If the problem persists contact MEG Core staff for assistance.

 - d. **Solid yellow DSQ2045** - Exit Acq then turn the power off and on and try again. Indicates a problem in the self diagnosis of DSQ2045. If the problem is persistent contact MEG Core staff for assistance.

 - e. **Solid yellow DSQ2010 and/or DSQ2043** - Exit Acq then turn the power off and on and try again. Indicates that there is no clock signal supplied to a bank (via the DSQ2041 and DSQ2047 fiber link). If the problem is persistent contact MEG Core staff for assistance.

 - f. **An entire bank or even several cards within a bank fail to boot** - check the power supplied to the bank. Contact the MEG Core Facility staff for assistance.

 - g. **Slow boot** – if a DSQ2043 takes 60 sec to boot rather than the regular 12sec, this is because the data fiber optic link between banks is broken or somehow disconnected.

 - h. **Flashing Green Lights** – if green lights still flashing after launching Acq then exit Acq. Turn the power off for 5-10 minutes then turn on and try again.

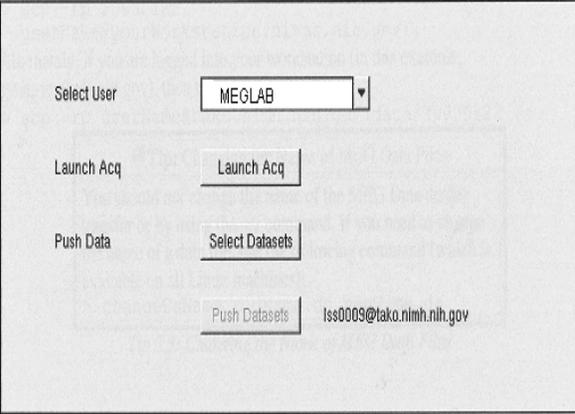
 - i. Report all occurrences; **Fill out a Variance Report**. Follow-up with the MEG Core staff.

Contact MEG staff for assistance if unable to resolve problem(s).

Rebooting / Powering the Rack Off & On After a Failure

The status of the power is indicated by the **On/Off Light Indicator (lamp)** adjacent to the pushbutton. When the green light is lit that indicates the power is ON. **The electronics must be on and ready for use before running Acq.**

1. **TO TURN THE POWER OFF** - Depress the green **ON/OFF Pushbutton**.
2. **Wait about 5-10 minutes before depressing the green ON/OFF Pushbutton again to turn the system back on.**
3. **AFTER TURNING THE RACK ON** - wait for the system to reach thermal stability, that is, until all yellow lights on the front faceplate of the electronics cabinet are OFF and all green lights are ON before running Acq.
 - **Green LED Indicators** - located on the front faceplate of the plug-in units in the electronics cabinet indicate the status of the individual units in the electronics. For normal operation all of the green LEDs on the front panel should be on.
 - **Yellow LED Indicators** - located on the front face plate of the plug-in units in the electronics cabinet indicate a fault has been detected in the unit; when lit there is a fault condition. The system will not boot properly when a fault condition exists.
4. **Login as root.**
Type: " **# insmod qla 2X00**".
5. **Select user then launch Acq.**



The screenshot displays a control interface with the following elements:

- Select User:** A dropdown menu currently showing "MEGLAB".
- Launch Acq:** A button labeled "Launch Acq".
- Push Data:** A button labeled "Select Datasets".
- Push Datasets:** A button labeled "Push Datasets" with the email address "Iss0009@tako.nimh.nih.gov" displayed to its right.

INDEX

A

Abralyt Skin Prep	15
Acq Aborts (Crashes)	52
Acq Dialog Window	46
Acquisition Console	43
Acquisition Monitor	50
Acquisition Workstation	43
ADCs	23,43, 44, 45
ADC Channel Interface	43
Adhesive Washers	6, 7, 9, 10, 12
Amplifier	31
Analog to Digital Converter	43, 44
Analysis Computer	50, 51, 52
Ancillary Mirror	20, 38
Applying Electrolyte	15
Auditory Foam Ear Tip Inserts	25
Auditory Stimulus	25
Auditory Tube Nibble	25
Auditory Tubing Inserts	25
Avotec Real eye Tracking System	18, 24
Avotec Silent Vision	18, 24

B

Bed Side Rail	37, 38
Binaural Auditory Silicone Tubes	25
Binocular Fiber Optic Video Presentation System	24
Bipolar Channel	17
Black Screen Function	22
BNC Cable	44
Boot Electronics Failure	52
Brake Valve Control	33

C

Cap, Protective	32
Ceiling Mirror	20
Chair Adjustments	31, 33, 34
Chair Backrest Tilt Adjustment	34
Chair Height Adjustment	34
Chair Movement / Positioning	33
Channel Selector	45, 46
Channel Set Button	48
Chest Belt, Easy Cap	12
Chin Head Movement Monitor	35
Clamp, Headcuff	35
Clean Up Procedures	49, 50
Collection Parameters	43
Collection Status Window	48
Continuous Recording	45
Custom Button	50
Cz Placement	10, 11

D

Data Acquisition	45
Data Collection	48, 49
Degaussing	5
Delay, Stimulus	26
De-Metaling	5
Digital Camera	6, 8
Digitizing Electrode Positions	13
Disinfection Procedure	53, 54
Door Operation	29

Duration, Stimulus	26
Dynamic Range	43
DVD, Transferring Data To	50

E

Easy Cap System	10, 54
EEG Easy Cap System	10
EEG Electrode Impedance	7, 9, 10, 16, 45
EEG Bank	43
EEG Channels	43
EEG Setup	10
Electroculogram (EOG) Eye Lead Placement	7, 9
Electrode Impedance Meter Check	16
Electrode Impedance Check , MEG System	47
Electrode Jack Box	16, 17, 31
Electronics Rack	43
Electrolyte	18
Elifix Electrolyte	7, 9, 10, 15, 16
Emergency Door Key	29
Emergency Off Button	29
Emergency Unlock	29
EOG	See <i>Electroculogram</i>
EOG Impedance	7, 9
Equipment Clean Up	49, 50

F

Fiber Optic Response Pad	28
Fiducial Points/Head Coil Placements	6, 8
Fit Test	6, 8
Foam Ear Insert Tips	25
Poam Pad Pillow	38
FORP Response Pad	28
FP1 Placement	10, 11, 12
FP2 Placement	10, 11, 12
Fpz Placement	10, 11
Function Switch, Stimulus	26
Flashing Green Lights	52
Flashing Yellow	52

G

Gantry	6, 8, 36, 38
Gantry Limits	6, 8
Gantry Mounting Bar	21, 25
Grass Impedance Meter	6, 7, 9, 10
Grass S88 Nerve / Muscle Stimulator	26
Grass SIU Unit	27
Grass Stimulator Duration Multiplier / Dial	26
Grass Stimulator Multiplier Switch	26
Grass Stimulator Rate Multiplier / Dial	26
Grass Volt Control Multiplier / Dial	26
Grass Stimulator Dely Multiplier / Dial	26
Ground Electrode	17
Gain Calibration Card	31

H

Hand Wheel Control, Chair	33, 34
Head Circumference	7, 8, 10, 12
Head Localization Coils	7, 9, 35, 44, 53, 54
Head Localization	31, 45, 47
Head Localization Failure	52
Head Size/Fit Test	6, 8
Height Adjust Valve, Chair	34

Horizontal Recording	36
HP 715 Digital Camera	6,8
Head Stabilizing Cuff	32

I

Illumination Sensor, Optical	23
Impedance	5, 7, 9, 16, 17
Impedance Check, Meg System	44
Impedance Meter Check	16
Infra Orbital	7, 9
Infrared Eye Position Tracking System	24
Infrared Light Power Supply (SEC 1212)	24
Infrared Light	29
Inion	6, 8, 10
Installing The Bed For Supine Recording	36
Intensity, Stimulus	27
Intercom Electronics Box	40

J

Jack Box	16, 17
----------------	--------

L

LapTop Computer	13
LCD Projector Remote Control	22
LCD Projector System, Sharp	19, 23, 38
Lens Adjustments	20
Lens Collar	20
Light, Infrared	29
Light, MSR	29
Linearity	43
Linked Electrode Adaptor	17
Linked Mastoids	17
Localization	46
Lumitouch Response Pad	28, 44

M

Magnetically Shielded Room	See MSR
Mastoid Electrode Impedance	10
Mastoid Placement / Reference Electrode	10, 17
Measuring / Marking Frontal Polar & Occipital Locations	10, 11
MEG Channels	43
MEG DSQ Bank	43
MEG Electrode Impedance Check	47
MEG Server	47
Mirror Adjustments	20
Motor Threshold	27
Mounting The Cap	12
MSR	5, 29
Multiplier Switch, Stimulator	26

N

Nasion - Inion Distance	6, 8, 10
Nasion	6, 8, 10
Neuroscan Switch Response Pad	28
No Led's	52
Nuprep Skin Cleaner	7, 9, 10, 15
Nerve / Muscle Stimulator	26

O

One Channel Single Repetitive Stimulation	26
Orbital Ridge	9

Overhead Lighting	29
Oz, Marking & Measuring	10, 11, 12
O1, Maring & Measuring	10, 11, 12
O2, Marking & Measuring	10, 11, 12
Operator's Console	24, 25, 38, 39, 40
Optical Illuminaton Sensor	23
Outer Canthus	7, 9

P

Parabolic Microphone	39, 40
Peripheral Interface Unit	See PIU
PIU	43
Polhemus Digitizer	13
Polhemus Stylus Pen	13, 14
Polhemus Transmitter Module	13, 14
Polhemus Receiver	13, 14
Positioning A Subject In The Chair	31
Positioning A Subject On The Bed	38
Positioning The Projector	20
Powering the Rack	57
Preauricular Point	6, 8
Presentation Software Program	8, 25
Protective Cap	32
Projector, Sharp LCD	19, 20, 22, 37, 38
Pushing Dataset To The Meg Server	46

R

RAID Array	50, 51, 52
Rate, Stimulus	26
Real Eye Tracking System	24
Rebooting	57
Receiver, Polhemus	13, 14
Recording Data / Data Acquisition	43
Reducing Skin Impedances	15
Reference Channels	43
Reference Electrodes / Mastoid Placement	10
Remote Control, LCD Projector	22
Remote Workstation	52
Response Pads	28
Room Lighting	29

S

Sampling Rate	43
Screen Adjustment 14, 19, 20, 21, 22, 36, 37, 45, 46	310
Seat Recording	310
Sensory Threshold	27
Sharp LCD Projector System	18, 19, 38
Shorting Plug	31
Side Rail	36, 37
Signal Detection	43
Silent Vision Video Presentation System	24
Silicone Tubes, Auditory	25
Single Repetitive Stimulation	26
SIU	See Stimulus Isolation Unit
Skin Prep	7, 9, 10, 15
Slow Boot	52
Solid Yellow Dsq2010 And/Or Dsq2043	52
Solid Yellow Dsq2045	52
Somatosensory / EMG Stimulus	26
Sony VCR	41
Soundblaster	25
Sound Level Meter	25
Squid	51, 52
Stabilizing Head Cuff	32
Step Stool	38
Stereo Amplifier	25
Stimulus Computer	47

Stimulus / Response Equipment	28, 44
Stimulus Isolation Unit	27
Stimulus Screen	21
Stimulus Software	25
Stimulus Workstation	45
Stylus Pen, Polhemus	13, 14
Subject Clean Up	49, 50
Subject Monitoring Inside The MSR.....	39, 40, 41
Subject Prep.....	5
Supine Recording	36

T

Tako.....	50, 51
Telescoping Screen Arm	21
Tilt Adjust Valve, Chair	34
Time Display Box	41
To Begin Another Trial	47
Touch Pad, Response	28
Touch Pad, LCD Projector.....	22
Tragus	6, 8
Transferring Data To A Remote Computer	51
Transmitter, Polhemus.....	13, 14
Trigger Channels	43
Triggered Recording	45
Tube Nibble, Auditory	25

U

Unipolar Channel	17
------------------------	----

Upright Seated Recording	33, 34, 35
Untriggered Recording	45

V

Valve, Chair	33, 34
Variance Reporting	38, 39
VCR, Sony	41
Video Display Monitor.....	39
Video Recording	41
Visual Interface	18
Visual Software.....	18
Visual Stimulus Screen.....	21
Visual Stimulus	18
Voice Intercom	40
Voltage Control, Stimulus	26

W

Wall Mirror.....	20
------------------	----

Y

Y Connector.....	17
------------------	----

Z

Z Position	17
------------------	----