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Resources

Ahmanson-Lovelace Brain Mapping Center
University of California, Los Angeles
2024

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The Brain Mapping Center

The faculty, staff and major physical resources to be used by this project are housed in the 13,000-ft² Ahmanson-Lovelace Brain Mapping Center. The Center's primary lab spaces include the PET/MR and cyclotron laboratory, the 3T MRI laboratory, and the neuromodulation laboratory (NML). In addition to laboratory space, there are offices for PI's and investigators, a 575-ft² conference/teaching and library space and a 410-ft² student center for trainees. The Ahmanson-Lovelace Brain Mapping Center is located adjacent to the Reed Neurological Research Center, the UCLA Center for Health Sciences and the Learning Resource Center.

PET Laboratory

The PET laboratory houses a Siemens RDS-111 cyclotron and a Siemens Biograph mMR 3.0 Telsa (PET/MR) scanner. The laboratory includes a 440-ft^2 scanner exam room, a 293-ft^2 control room, a 57-ft^2 radiotracer uptake/prep room, a 60-ft^2 hot toilet, a 222-ft^2 hot lab, a 200-ft^2 equipment room, and a 396-ft^2 cyclotron vault for a total laboratory dedicated area of 1668-ft^2. Additionally, a 73-ft^2 medical gas storage room is shared with other laboratories in the building.

Siemens RDS-111 Cyclotron

The Brain Mapping center cyclotron is manufactured by Siemens/CTI. This device (RDS-111) is capable of producing a full spectrum of positron-emitting radioisotopes including: ^{15}O, ^{13}N, ^{18}F and ^{11}C. In addition, this includes an on-line continuous synthesis system capable of converting cyclotron-produced ^{15}O into ^{15}O- labeled water, carbon dioxide, carbon monoxide and oxygen gas for continuous or bolus inhalation or intravenous infusion (water) to the subjects. This system is fully automated and computer controlled thereby severely limiting or eliminating radiation exposure to personnel.

Siemens Biograph mMR 3.0 Tesla Scanner (PET/MR)

The Biograph mMR 3.0 Tesla scanner is manufactured by Siemens and is capable of simultaneous PET and MRI imaging, allowing novel research applications. Simultaneous acquisition assures spatial alignment between MR and PET datasets and allows for correction of motion related PET artifacts, including MR based PET gating. The scanner is capable of both dynamic and static high-resolution PET imaging of the brain and whole-body. Simultaneous MR and PET acquisition also reduces subject burden by combining what would otherwise require two separate scans into one.

Overview of Technical Details	
Field strength	3 Tesla
Bore size	60 cm
RF Tim	[102 x 18] [102 x 32]
Gradient strength	MQ Gradients (45 mT/m @ 200 T/m/s)
Helium consumption	Zero helium boil-off technology
Slew rate	MQ Gradients: 200 T/m/s
Software	Syngo.mMR
Head/Neck Coil	16 channels
Spine Coil	
Flex Coils	4 channels

PET Detectors	
Crystal material	LSO
Crystal element dimension	4 x 4 x 20 mm
NEMA 2007 – Transverse spatial resolution	
FWHM @ 1 cm	4.4 mm
Sensitivity	13.2 cps/kBq
Peak NEC rate (@ 21.8 kBq/cc)	175 kcps
Axial FoV for PET	**258 mm**

An associated Siemens maintenance service agreement will cover quarterly preventative maintenance, annual replacement of radioactive sources, unlimited replacement parts, labor, travel, console replacement parts and unlimited phone and technical support.

Currently approved PET scanning rates are posted under the heading "PET Acquisition" on the Center's website and are set and periodically revised in accordance with UCLA procedures governing Sales and Service activities as overseen by CFS (Corporate Financial Activities) as part of the Brain Mapping Center's Sales & Service activity.

MRI Laboratory

The Magnetic Resonance Imaging (MRI) laboratory, occupies approximately 4,500-ft² of the Ahmanson-Lovelace Brain Mapping Center. This facility houses a Siemens Prisma 3.0 Tesla MRI Scanner.

Siemens Prisma 3.0 Tesla MRI Scanner

In January 2015, the 3T Trio MRI scanner at the Ahmanson-Lovelace Brain Mapping Center was upgraded to a **Siemens Prisma-FIT 3T** system, modeled after the custom made Skyra system originally developed for the Human Connectome Project. Relative to the prior Trio system, it offers enhanced features appropriate for MRI research projects.

1. Gradient performance
- 80 mT/m @ 200 T/m/s simultaneously, on all three axes (double that of Trio 40 mT/m)
- Ultra-high-performance cooling
- Force-compensated design for reduced vibrations
- Significantly increased SNR, long-term stability and minimized acoustic noise relative to Trio systems

2. Fully dynamic parallel transmit with TimTX TrueShape
- Selective excitation to highlight regions, organs, or even features of an organ
- Zoomed imaging with the parallel transmit application *syngo* ZOOMit
- Significantly higher resolution, reduced scan times and less artifacts relative to Trio systems

3. Tim 4G integrated receive architecture
- Tim 4G RF system with 64 independent channels
- Tim 4G coil technology with highest coil element density, Dual-Density Signal Transfer, DirectConnect, and SlideConnect technology
- Fully digital transmit and receive with DirectRF
- Real-time feedback loop for long-term stability

4. 3T magnet
- Benchmark magnet homogeneity
- FoV 50x50x50 cm^3
- Advanced higher order shims

The Prisma-FIT system is configured with array receiver head coils including a 20 channel head/neck, 32 channel head and 64 channel head/neck channels. The measurement and reconstruction system is designed for large image matrix sizes of up to 1024 x 1024. Unrestricted multitasking capability allows time-saving parallel scanning and reconstruction.

The computer system includes the following components:

- 2 Intel Xeon Multi-Core Processors
- Main memory (RAM): ≥ 48 GB,
- Hard disk for raw data: ≥ 3 x 300 GB
- Hard disk for system software: ≥ 300 GB

The high-end image reconstruction computer offers fast processing power for intensive algorithms, a high amount of data storage for large data sets acquired over long-term measurements, a large amount of main memory for fast processing of measurement data, and two general purpose graphic processing units for highly intensive computational calculations.

The high-end image reconstruction computer has the following specifications:

- 2x Intel W5690 (hexacore) processors 3.46 GHz
- 128 GB Main Memory (RAM)
- 750 GB Hard disk for raw data
- 100 GB Hard disk for system software

Overview of Technical Details	
Field strength	3 Tesla
Bore size	60 cm
RF Tim	[204 x 64] [204 x 128]
Gradient strength	XR Gradients (80 mT/m @ 200 T/m/s)
Helium consumption	Zero Helium boil-off technology

The service contract has been continually maintained since the initial warranty period. The Siemens maintenance service agreement covers quarterly preventative maintenance, parts, labor, travel, cold head replacement and repairs, console replacement parts and unlimited phone and technical support. The service contract also covers cryogen monitoring and fills per manufacturer recommendations and replacement of the magnet in the event of a catastrophic quench during a cryogen refill performed by Siemens.

Currently approved MRI scanning rates are posted under the heading “MRI Acquisition - 3T Scanner” on the Center’s website and are set and periodically revised in accordance with UCLA procedures governing Sales and Service activities as overseen by CFS (Corporate Financial Activities) as part of the Brain Mapping Center’s Sales & Service activity.

NeuroModulation Laboratory (NML)

The 150-ft^2 NML laboratory in the Ahmanson-Lovelace Brain Mapping Center is equipped with two Magstim 200-2 magnetic stimulators linkable by a Bistim-2 module for single and paired-pulse neurophysiology studies. The lab also has a Magstim Rapid-2 magnetic stimulator capable of repetitive and patterned stimulation trains such as theta-burst stimulation. Each stimulator can be used with a variety of different stimulation coils including circular, figure-8, angled figure-8 (for deeper stimulation), air cooled coils (for rapid repetitive stimulation). A sham-air-cooled coil is also available for blinded treatment trials.

The lab is also equipped with Brainsight software and hardware for frameless stereotaxy to allow registration and online monitoring of the subject's head position with his/her structural brain image and tracking the position of the magnetic stimulation coil with respect to the underlying brain structures. The tracking hardware uses a Polaris infrared stereoscopic camera to image the head and magnetic stimulation coils. Infrared reflective trackers are available to mount on the head and coils for tracking purposes.

The lab is also equipped with custom hardware, including a flexible coil holder and optional chin-rest and neck brace for holding the subject's head still during experiments.

Full neurophysiological tools are available including a 4-channel Delsys surface EMG amplifier, a pair of CED 1902 isolated preamplifiers, and general 6-channel Grass IP511 differential amplifiers. Experiments can be controlled either from a PC running Presentation (Neurobehavioral Systems) using an integrated parallel port breakout box or a PC running Signal (CED) using an linked CED 1402 micro2 analog/digital converter. The PC running Presentation is ideal for presentation and response recording with integrated TMS control during behavioral studies. The PC running Signal is optimal for detailed and complex neurophysiologic studies.

Currently approved TMS scanning rates are posted under the heading "Transcranial Magnetic Stimulation" on the Center's website and are set and periodically revised in accordance with UCLA procedures governing Sales and Service activities as overseen by CFS (Corporate Financial Activities) as part of the Brain Mapping Center's Sales & Service activity.

The Brain Mapping Computation and Analysis Facility

The Brain Mapping Center's Computation and Analysis Facility resides within the Department of Neurology at the UCLA School of Medicine. Located in the Laurie and Steven C. Gordon Neuroscience Research Building across the street from the Ahmanson-Lovelace Brain Mapping Center, the facility was designed and furnished for the acquisition, processing, and storage of brain image data from a variety of sources. Fiber optic connections between the Ahmanson-Lovelace Brain Mapping Center and the Brain Mapping Computation and Analysis facility allow both facilities to be managed as a single local computer network. In addition to the resouces detailed below, the facility also includes office space and workspace for faculty, post-doctoral fellows and students.

Physical Infrastructure: The facility occupies approximately 8,425-ft¬≤ of the Laurie and Steven C. Gordon Neuroscience Research Building's second floor. The space is comprised of a reception area, offices, a modern computer room, a user area, wet labs, a conference room, and the Data Immersive Visualization Environment (DIVE) discussed here within. The data center in this space includes a raised floor, a 130 KVa UPS/PDU capable of providing uninterruptible power to all equipment housed in the room, dual Leibert air conditioning units, humidity control, and a fire suppression mechanism. A sophisticated event notification system is integrated in this space to automatically notify personnel of any abnormal power, water, or HVAC issues that arise. Immediately adjacent to this machine room is a user space with eighteen individual stations separated by office partitions. Each station is equipped with a four copper Gigabit network ports and 802.11n wireless signals for networked image processing, visualization and statistical analysis. To provide telephony services, the facility relies on Voice over IP (VoIP) technology. VoIP units, including wireless handsets, are distributed throughout the laboratory. In addition, the conference room and the DIVE are equipped with supplementary H.232 videoconferencing systems.

Having reached the power, cooling, and physical capacity limits of the second floor data center, the facility was augmented with an additional 2,127-ft² space on the building's first floor containing a state-of-the-art data center and additional offices. The office space can support up to twenty researchers and is outfitted with the same technological specifications as the existing facility. The 580-ft¬≤ data center is outfitted with an "in-row" cooling solution that regulates temperatures strictly within the server racks-as opposed to the traditional raised floor, hot-cold aisle technique that uses more energy to cool the entire room. Multiple chilled water lines are fed from the building to a Rittal TS 8 rack system, which houses the servers and provides in-row cooling. The racks are fully enclosed and deliver chilled air to the front of the machines while recycling warm air exhausted at the rear. During normal operation, keeping the air within the system provides maximum efficiency, but should a component fail, once temperatures reach 80¬∞F the magnetic locks on the rack doors are programmed to release, forcing the doors open to provide ambient air to the machines. A 550KVa Eaton UPS provides uninterruptable power to the facility's current equipment and is sized to accommodate future large hardware expansions. In order to support the additional personnel and computational resources, the data center is equipped with multiple 10 Gigabit connections in a fault-tolerant, load-balanced configuration that interconnect with the primary data center.

Compute Resources: Rapid advancements in imaging technology have provided researchers with the ability to produce very high-resolution, time-varying, multidimensional data sets of the human brain. The complexity of the new data, however, requires immense computing and storage capabilities. To meet the computational requirement, the NRB Facility houses the following high performance computing (HPC) clusters:

- a 306-node Oracle V20z cluster. Each compute node has dual 2.4GHz AMD Opteron processors with 8GB of memory. (612 cores total)
- an 80-node Oracle X2200 M2 cluster. Each compute node has dual 2.2GHz quad-core AMD Opteron processors and 16GB of memory. (640 cores total)
- a 416 node HP ProLiant SL2x170z G6 cluster. Each compute node contains dual quad-core 2.66GHz Xeon 5500 processors and 24 gigabytes of memory (3,328 cores total)
- an 8 node HP DL580 G7 32-core 2.4Ghz X7550 "fat node" cluster, each with 256GB of RAM (256 cores total)
- a 16 node Agility (Intel OEM) cluster, each with Dual 2.6GHz 12-core Intel Skylake Gold 6126 Xeon Scalable Processors, 96GB DDR4 2666MHz ECC/REG Memory; 1TB Intel DC P4501 U.2 NVMe SSDs for local scratch; and 10GbE SFP+ Networking. (192 cores total)
- a 4 node Agility (Intel OEM) "fat node" cluster, each with Dual 2.3GHz 18-core, 2.3GHz Xeon Scalable Processors, 1024GB DDR4 2666MHz ECC/REG Memory; 1TB Intel DC P4501 U.2 NVMe SSDs for local scratch; and 10GbE SFP+ Networking. (72 cores total)

Storage Resources: The NRB facility is architected using a fault-tolerant, high-availability systems design to ensure 24/7 functionality. To complement its computational systems, the laboratory uses high performance network attached storage (NAS) and SAN technologies to accommodate current and projected storage requirements. The facility's current capacity is approximately 4 petabytes of online and offline storage.

To meet the extensive I/O demands of the laboratory's HPC clusters and address the bottlenecks inherent in traditional NAS technology, the facility has deployed two EMC-Isilon parallel storage clusters, with a combined capacity of 1.5 petabytes. These clusters accommodate a variety of network filesystem protocols including NFS, Samba and iSCSI. Each modular, self-contained Isilon storage node contains a standalone fileserver with both hard disk and solid state drives, processors, memory, and network interfaces. As additional nodes are added, all aspects of the cluster scale symmetrically, including capacity, throughput, memory, and fault tolerance. Each storage node is wired using dual 10 Gigabit Ethernet connections in order to provide maximum throughput to the computational resources. Additionally, a 4-node NetApp FAS8200 HA Storage Cluster with 1.1PB Usable Storage (8TB NVMe Flash; 360 x 4TB 7.2K RPM NL SAS Drives) provides storage that is solely dedicated to high-performance computing.

Finally, a Quantum i6000 tape silo provides 3.3 petabytes of LTO-5 tape storage, used to store mirror and archival copies of the facility's nearline data for disaster recovery.

Additional Resources: The NRB Facility houses over 100 additional servers that provide the basis of its Enterprise-grade infrastructure. Basic services including DNS, DHCP, and SMTP relays are all deployed in redundant pairs. Authentication is handled using Active Directory, with performance, security, and failsafe best-practice considerations in mind. The facility also contains a ten-node VMWare vSphere cluster, allowing for rapid deployment of non-critical services as well as dedicated development and Q&A environments. The facility employs two Juniper hardware load balancers that split TCP/IP traffic between multiple, identical servers. Aside from load balancing generic network traffic, the units accelerate SSL communication, which is particularly important in transferring bulk amounts of sensitive research.

Postproduction Suite: The NRB Facility has a format and resolution-independent postproduction suite with A/V capture equipment and multiple video decks, including a Sony DSR 80 and a UVW 1800, capable of playing and recording in digital, component, Y/C and composite video. For audio, the suite has a Sony V77 sound processor, a 16-channel Mackie mixer, a 120-watt Crown amplifier and a JBL surround speaker package. In addition, the suite utilizes a 16-channel A/D Sierra router, a Miranda A/D converter and a DPS transcoder to facilitate video and audio signal routing. This equipment is connected to the Reality Monster described above for video and audio capture of real-time 3-D content processed by the supercomputer. Uncompressed content creation is done with AJA's HD-capable digital disk recorder. To complement this hardware, the laboratory utilizes a variety of professional 3D and motion graphics packages, including Maya, Lightwave, and the full Adobe suite. The NRB Facility is also capable of virtual reality content creation to complement the visualization and stereoscopic capabilities of the DIVE, discussed below.

Network Resources: The NRB Facility intranet consists of 100baseT, Gigabit and 10 Gigabit Ethernet as well as an IEEE 802.11n compliant wireless network. Two Cisco Catalyst 3560G units and three Enterprise-grade Cisco Catalyst 6500 Layer 3 switches provide redundant routing and non-blocking switching from the outside world to and from public-facing services, end-user workstations, and the network's core. A Juniper MX960, which is capable of handling 5.12 Terabytes/sec of traffic, connects the compute clusters to the Isilon storage, separating them as much as possible the rest of the network in order to reduce latency and increase throughput. The facility's routers and twenty Juniper switches use the Open Short Path First protocol to provide fast and fault-tolerant routing. System configurations for networking devices, as well as kernel-level parameters for Linux clients, are highly tuned to provide near line-level rates.

The facility is connected to the Cenic backbone of Internet2 via dual fiber Gigabit lines and utilizes a Cisco Firewall Services Module for edge network security. Both software-based PPTP and hardware-based SSL Virtual Private Network communications are provided for remote productivity and collaboration via encrypted communication.

Data Immersive Visualization Environment (DIVE): The DIVE features a 12' 150-degree floor-to-ceiling curved screen, on which real-time computer graphics, high definition video, stereoscopic 3D visualizations, or even simple slideshows are projected. The space provides investigators with the unique ability to visually "step inside" their data and analyze it in new ways. The projection system of the DIVE is comprised of a spherical hard-shell screen and three ceiling-mounted 3-chip DLP active stereo capable projectors, each rated at 5000 ANSI Lumens with a native 1280X1024 SXGA resolution. The projectors support optical blending of 12.5%, digital image warping and CLO, or constant light option, to ensure that image quality is maintained throughout the array. Two visualization workstations, each with dual NVIDIA graphics cards, drive these projectors, producing a 3840X1024 immersive display. A sophisticated A/V matrix along with an AMX remote control system facilitate audio and video routing from the DIVE to the conference room or other displays throughout the facility.