

Advanced MRI Center Facilities

The Advanced MRI Center (AMRIC) is located in Room SA-107L (Level A in School Building) of the UMASS Medical School, it facilitates a Philip's Ingenia CX dStream 3.0T system, and includes a RF coil labs, a nurses' station, two patient holding rooms, two patient changing rooms with lockers. It shares a contiguous research space of 7,520 square feet with the New England Center for Stroke Research (NECStR). One of the primary features of this center is having a state-of-the-art angiography suite immediately adjacent to the 3T scanner room, separated by a radiofrequency insulation door. The key details of this facility are listed below.

The Advanced MRI Center also facilitates a Bruker BioSpec 70/30 (i.e. 7T, 30 cm bore) USR horizontal bore MR system, it is a multipurpose high field MR scanner for both MR imaging and spectroscopy with preclinical, pharmaceutical, fundamental research and material science applications.

Ingenia 3T CX dStream MR System

The Ingenia 3.0T system comes with a dStream digital broadband architecture and a channel-independent RF technology, which results in an up to 40% more SNR. dStream digitizes the signal right in the coil, eliminating noise influences typical of analog pathways, to capture the MR signal without pre-distortion or compression. A fiber-optic connection from the coil to the image reconstructor enables lossless broadband data transmission.

This Ingenia 3.0T system has a higher order shim function which offers advanced shimming capabilities to obtain improved image quality in field-sensitive applications and techniques such as single-voxel spectroscopy, chemical shift imaging, single-shot EPI and balanced FFE.

This Ingenia 3.0T system features high performance whole body, non-resonant, self-shielded gradient technology with new amplifiers that deliver high peak and slew rates for the demanding requirements of the latest and emerging clinical imaging techniques. The Quasar Dual gradient system provides industry leading performance specifications for peak strength and slew rate with a dual mode capability that optimizes advanced applications requiring very high peak mode capabilities. The maximum gradient amplitudes and slew rates corresponding to the dual mode are 80 mT/m, 100 mT/m/ms and 40 mT/m, 200 mT/m/ms respectively.

This Ingenia 3.0T system has a multiple RF sources, which adapts the RF signals to suit each individual patient. This results in a faster scans, enhanced image uniformity/consistency, over a broader range of applications.

This Ingenia 3.0T system features MultiBand SENSE which allows you to use state-of-the-art acceleration factors in the brain by simultaneously exciting multiple slices. Due to a shorter minimum TR for fMRI, larger anatomical coverage or higher temporal resolution can be used. In the DWI/DTI sequences larger anatomical coverage or higher number of diffusion directions can be acquired. With MultiBand SENSE, fMRI and DTI exams can be performed with high speed and high resolution, simultaneously.

This Ingenia 3.0T system is equipped with a Multi-nuclear spectroscopy (MNS) system, which provide the ability to perform ¹³C, ³¹P, ⁷Li, ²³Na, ¹⁹F and other nuclei spectroscopy and imaging. The multiple RF amplifiers in this system includes two 18 kW solid-state 1H channel narrowband amplifier and one 4 kW broadband (10-130 MHz) Multi-nuclear amplifier.

This Ingenia 3.0T system has a bore diameter of 60 cm and provides a full-size 50 cm field-of-view.

Coils

As a dStream digital broadband architecture is applied in Ingenia 3.0T system, the system provides a full range of clinical solutions with two types of coils:

- Integrated coils combine to provide solutions for multiple applications
- Dedicated coils optimize imaging for a single application

FlexStream is hinged upon the unique FlexCoverage Posterior coil below the thin table top that provides neck-to-toe coverage without the need for any manual coil removal or patient repositioning. The FlexCoverage Posterior coil simply combines with other unique dS coils to enable imaging with fewer coils and reduce concerns for coil positioning and patient setup. These unique dS coils include:

- **dS TotalSpine 3.0T coil**, which provides an integrated coil solution for total spine related imaging. It includes the FlexCoverage Posterior and Base coil with 90 cm coverage, using 44 channels maximum.
- **dS HeadSpine 3.0T coil**, which provides an integrated coil solution for head and total neuro related imaging. It includes the Head coil combined with the FlexCoverage Posterior and Base coil with 30 cm coverage, using 15 channels maximum (Head) or 90 cm coverage, using 51 channels maximum (Total Neuro)
- **dS HeadNeckSpine 3.0T coil**, which provides an integrated coil solution for head, neck and total neuro related imaging. It includes the HeadNeck coil combined with the FlexCoverage Posterior and Base coil with 45 cm coverage, using 20 channels maximum (Head-Neck) or 90 cm coverage, using 52 channels maximum (Total Neuro)
- **dS Flex M 3.0T coil**, which provides an integrated coil solution for general-purpose imaging. It includes two medium-sized flexible general-purpose coils combined with the FlexCoverage Posterior with 15 cm coverage, using a maximum of 6 channels
- **dS Torso 3.0T coil**, which provides an integrated coil solution for body and peripheral vascular related imaging. It includes the FlexCoverage Anterior coil combined with the FlexCoverage Posterior coil with 60 cm coverage using a maximum of 32 channels

In addition to the T/R quad body coil available with the scanner, a wide range of dedicated, anatomy-specific coils are available:

- **dS Head 32ch 3.0T coil**: The coil is a 32-channel coil designed for advanced neuro applications including fMRI, Spectroscopy, Angiography. It is also designed to facilitate EEG studies. The coil includes both front and rear facing mirrors for visual stimuli and movie projection.

- **dS Knee 16ch 3.0T coil:** The coil is designed for ultra-high SNR imaging over an extended field of view of the knee and other extremities. The T/R design gives lower RF deposition and short RF pulses for increased speed and SNR. Two overlapping rings of eight elements extend the coverage area and minimize the need for precise positioning. dS-SENSE enhanced parallel imaging can be selected in all directions. The coil has a 20 cm coverage using a maximum of 16 channels.
- **dS SmallExtr 8ch 3.0T coil:** This semi-flexible coil is designed for imaging of elbows, hands and small knees. The coil has an inner diameter of 20 cm to match the size of the small extremities using a maximum of 8 channels.
- **31P T/R head coil from Clinical MR Solutions:** Volume 31P T/R coil covering head.
- **7Li T/R head coil from Clinical MR Solutions:** Volume 7Li T/R coil covering head.
- **Other custom-made coils for small animals:** Different size volume 1H and other nuclei T/R coils are also available for small animal studies.

fMRI Stimulus Delivery System

A fully integrated fMRI stimulus delivery system from MRA (Model: fMRI-0502-STD1; MRA; Washington, PA, USA; <http://www.mra1.com/>) and Presentation (Neurobehavioral Systems, Inc; Albany, CA, USA; <http://www.neurobs.com/>) is available for both clinical and research. The MRA complete system includes the fMRI stimulus delivery console, Windows computer system, patient response hand switches, video projection into the MRI bore, and MRI compatible patient headphones.

Presentation is the world's most popular experimental control software for neuroscience, is a stimulus delivery and experimental control program. It runs on PC, and delivers auditory, visual and multimodal stimuli with sub-millisecond temporal precision. Presentation is powerful enough to handle almost any behavioral, psychological or physiological experiment using fMRI, ERP, MEG, psychophysics, eye movements, single neuron recording, reaction time measures, other performance measures, and more.

MRI Compatible Goggle Set

MediGoggle Adult Research Set (Cambridge Research Systems Ltd, England; <http://www.crsLtd.com/>) has interchangeable prescriptive goggles suitable for use in MRI and fMRI environments. It is fully MRI compatible with no metallic components and an easy 'click' lens system -6 to +6 dioptre lens sets in 0.5 dioptre increments.

MRI Compatible Eye Tracking System

The SR Research Eyelink 1000 is the most powerful eye tracker on the market, customized for compatibility with the MRI environment (SR Research Ltd, Ontario, Canada; <http://www.sr-research.com/>). The system is capable of completely remote eye tracking at 500 Hz with an average accuracy of 0.5°. The Eyelink 100 integrates with the Philips Ingenia 3.0T system in real time through proprietary SR Research Experiment Builder© software.

MRI Compatible Insert Earphones for fMRI Research

The S14 insert earphones (<http://www.sens.com/products/model-s14/>) provide high-quality acoustic stimulus delivery while attenuating scanner noise. They are small enough to fit within any head coil, and can be covered with circumaural muffs for added protection if the coil allows.

In Vivo Physiological monitoring system and Injection system

Medrad Veris 8600 MR Vital Signs Monitor (Model: 8600; S/N: 023426; Medrad, Inc; Warrendale, PA, USA; <http://www.medrad.com/>) is available to monitor patients while they are undergoing an MR exam. It interprets and displays physiologic data as waveforms and numeric information which include ECG, NIBP, SpO₂, CO₂, respiration, temperature, O₂, anesthetic gases, and IBP.

Medrad Spectris Solaris EP MR Injection System (Model: 3010890; System Serial #: 20080; Medrad, Inc; Warrendale, PA, USA; <http://www.medrad.com/>) is available to offer the flexibility to meet the demands of complex contrast enhanced procedures.

In Vivo Physiological monitoring system for large animal research

The LifeWindow LW8 Lite is a multi-parameter large animal monitor with an intuitive 8.4 inch touch screen user interface. It interprets and displays physiologic data as waveforms and numeric information which include ECG, NIBP, SpO₂, CO₂. All vital sign measurements are saved in an MS Excel and PDF spreadsheets that can be easily transferred to any practice management software via networking or a USB drive. All reports and EKGs can be printed either to a standard printer, to a PDF document, or to an optional strip chart printer.

Small Animal Monitoring and Gating System

Small animal monitoring and gating system is from SAI (Model: 1025; SA Instruments, Inc; Stony Brook, NY, USA; <http://www.i4sa.com/>). SAI's monitoring and gating systems are compatible with MR imaging systems. Sensors measure ECG, respiration, temperature, pressure including invasive blood pressure, oxygen saturation and end-tidal CO₂ in sedated mice, rats and other small animals undergoing imaging research.

The system provides continuous monitoring of animal physiologic status while generating gate signals to synchronize scanner data acquisition with cardiac and respiratory motion. MR-compatible heater and ventilator options are available to control the temperature and ventilation of mice and rats during MR or other imaging procedures.

MR Compatible Anesthesia Delivery System

MR compatible anesthesia delivery system (VetEquip, Inc; Pleasanton, CA, USA) is available to deliver anesthesia gas while the animal is undergoing an MR exam.

Bruker BioSpec 70/30 MR system

The BioSpec 70/30 MRI scanner is a multipurpose system for high-resolution MR spectroscopy and imaging. It operates at 7 Tesla, and has a bore diameter of 30 cm. The system is equipped with an actively shielded high performance gradient with integrated high order shim coil set (B-GA12S HP), capable of generating maximum gradient amplitude of 660 mT/m, maximum linear slew rate of 4570 T/m/s, and optimal field homogeneity.

RF-coils are the interface to the sample and have a major impact on quality, acquisition time, and workflow. BioSpec 70/30 MRI scanner comes with a series of application-optimized RF-coils for head, brain, cardio, abdomen, spine, and arterial spin labeling, as well as RF-coils for non-proton applications for mice and rats. With the power to conduct limitless imaging applications, BioSpec opens a whole new world of applications:

- Angiography - flow contrast and flow analysis of the velocity of each voxel for glioblastoma and aneurysm studies
- Cardiology - investigation of cardiac strain, ejection fraction, and septum defects, using triggered sequences or Bruker's patented IntraGate for navigator based retrospective gating
- Diffusion - visualization of disturbed pathology, such as in multiple sclerosis, epilepsy, and stroke tumors
- fMRI - insight into the brain's function;
- Molecular MRI - imaging at the cellular level
- Perfusion - with and without CA for tumor- detection, -neoangiogenesis, and -vascularization, and disruption of the blood brain barrier
- Spectroscopy – quantification of metabolic disorders and long-term changes in metabolic processes
- Multi-Nuclei MRI such as ¹⁹F, ³¹P and ¹³C

1H RF coils

1H Volume RF coils

- **Large Volume Coil (154 mm):** Volume RF coil designed for investigations on animals with body weights of up to 3 kg.
- **Transmit/Receive Volume Coil for Mice and Rats (86 mm):** This volume coil is optimized for cross coil setups, i.e. for use as transmit RF coil in combination with receive-only surface coils and arrays. The coil can also be used as receive volume coil. Small rodents up to 650 g body weight can be examined.
- **Rat Head / Mouse Body Volume Coil (40 mm):** Volume RF coil designed for investigations of the rat head or mouse body.
- **Mouse Head Volume Coil (23 mm):** Volume RF coil designed for investigations of the mouse head.

1H Surface coils

- **Multi-Purpose Planar Surface Coil (30 mm):** 1H single loop receive-only surface coil

- **Multi-Purpose Planar Surface Coil (20 mm):** 1H single loop receive-only surface coil
- **Multi-Purpose Planar Surface Coil (10 mm):** 1H single loop receive-only surface coil

Arterial Spin Labeling Coil for Rats: ASL labeling coil for rats, integrated in a rat Tip of the split animal cradle setup. The coil instrumentation includes: 1H transmit and receive coil with active coil detuning; Coil optimized for arterial spin labeling of rat carotids; Integrated into a split animal cradle rat Tip; Coil position adjustable within the rat Tip

Multinuclear RF coils

- **1H/19F Rat Head / Mouse Body Volume Coil (40 mm):** Double resonant volume RF coil designed for 19F-nuclei investigations of the rat head or mouse body.
- **1H/13C Transmit/Receive Surface Coil (20 mm):** Double tuned surface coil for local 13C-nuclei signal excitation and detection.
- **1H/31P Transmit/Receive Surface Coil (20 mm):** Double tuned surface coil for local 31P-nuclei signal excitation and detection.

Electronic shop

The AMRIC houses an electronic shop that is used to construct RF coils and animal cradles needed for our MR studies. The shop contains a Philips PM 3355 oscilloscope (S/N: 9444 033 55000; Philips, Holland), Network analyzer (Agilent 8713B), Morris 405NV+ RF Sweeper (Model: 405NV+; Morris Instruments Inc; Ottawa, ON, Canada), Function generator, DC power supply, stores of variable and fixed capacitors, soldering equipment, a drill press, band saw and hand tools, etc. need to construct the requisite RF hardware.

Computer facilities

Each laboratory member has an on-line late-model PC. The computers are networked locally via PC client protocol. Xerox WorkCenter 7535 is available for copy, fax, print and scan. The UMMS Help Desk provides computer-aided assistance for software and hardware problems. Additionally, AMRIC maintains license to MatLab (Mathworks, Natick MA).

Other resources

Animal Facilities and Services

The University of Massachusetts has animal facilities consisting of over 93,000 gross sq. ft., in seven different sites, all fully AAALAC-accredited. The main animal housing area is located on the lower level of the University across the corridor from the AMRIC. The new LRB animal facility is a complete barrier facility and includes a mouse Transgenics Core Facility. A system of suites containing animal research labs and procedure rooms

provides the flexibility to house colonies of varying sizes and species. This state-of-the art facility utilizes ventilated animal housing racks and an automated cage processing system to maximize productivity. The main campus animal facility includes a major surgical area consisting of four fully equipped operating rooms and adequate associated storage and prep areas. A diagnostic lab is used for basic blood chemistries, CBCs, and other animal health monitoring procedures. There is 7-day-a-week coverage, veterinarians on call, and a cadre of veterinary technicians that will provide training of researchers in small animal handling and systemic administration of imaging drugs. Animal facilities include quarantine rooms for incoming animals of unknown or questionable health status. There is also a biocontainment suite for the use of certain biohazardous substances in animals and a DNA gun room for in vivo gene transfer. The UMASS animal facility and Radiology Medical Imaging Center has the necessary equipment for the histologic analysis of tissues.

Other Research Core Facilities and MR Instruments Available

The University of Massachusetts Medical School UMMS is a highly productive, highly collaborative research enterprise with outstanding scientific resources and facilities. Different core facilities are available through the university (<http://www.umassmed.edu/research/cores/index.aspx?linkidentifier=id&itemid=80096>). Addition to 3T Philips system, three 1.5T GE scanners and one 600 MHz NMR spectrometer are also available for clinic and research.