

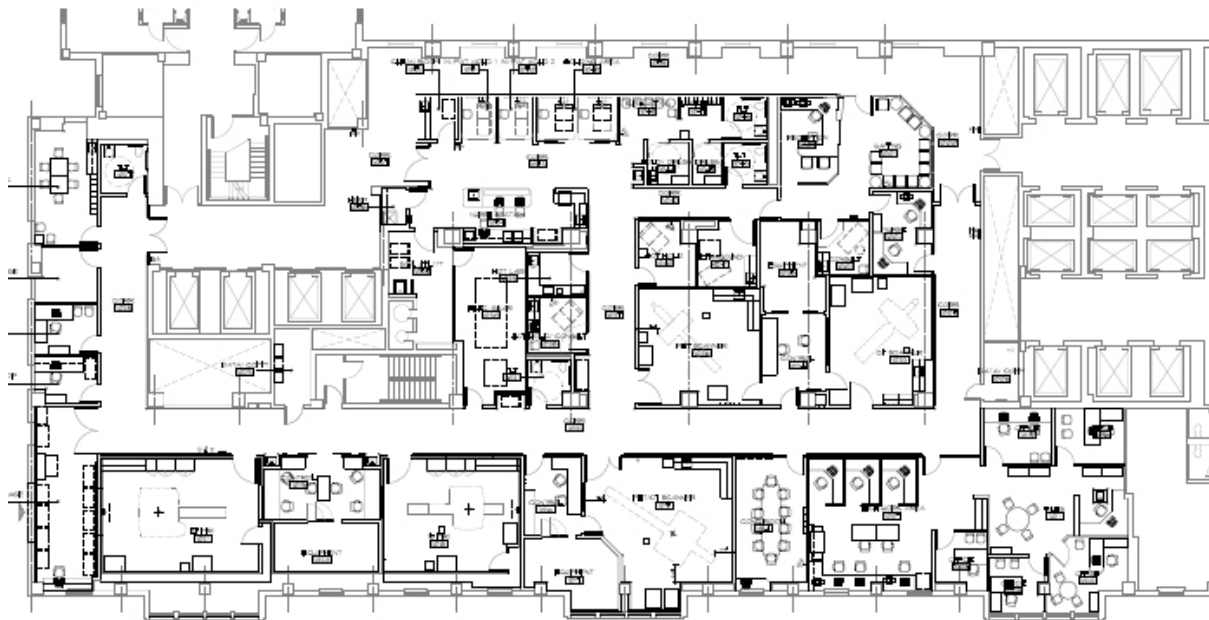
Resources & Environment

CENTER FOR CLINICAL IMAGING RESEARCH (CCIR)

Facility

The Center for Clinical Imaging Research (CCIR) at Washington University provides advanced imaging resources and multiple levels of support to our clinical investigators.

The CCIR is located on the 10th floor of the Barnes-Jewish Hospital West Pavilion, within the complex that contains nearly all of the inpatient beds, all the Intensive Care Units, the operating rooms, admissions, administration, many radiological services and most laboratories. The 10th floor of the West Pavilion connects directly to the other three inpatient hospital buildings. The site for the CCIR was selected to maximize accessibility of the valuable imaging resources to research patients, including inpatients (even intensive care patients), outpatients and control subjects. Inpatients can be safely and conveniently brought to the CCIR with minimal imposition on nursing care. Since the CCIR is located directly above the main entrance for the Barnes-Jewish Hospital, access is also simplified for outpatients and healthy control subjects. The CCIR is the first stop on the express elevators of the main hospital lobby. Valet parking and a self-park garage are located directly in front of this entrance, as well.



Schematic of CCIR space on the 10th floor West Pavilion, Barnes-Jewish Hospital.

The CCIR provides imaging services and state-of-the-art hardware in a central hospital-based location to enable investigators to pursue a wide variety of research objectives across diverse patient groups. The CCIR is housed in an 8,900 square feet facility and possess six dedicated research scanners, which include:

- 3T MRI scanner (MAGNETOM Trio, A Tim System)

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- 1.5T MRI scanner (MAGNETOM Avanto)
- PET/CT scanner (Biograph 40 TruePoint Tomograph)
- PET scanner (ECAT HR+ 962)
- CT scanner (SOMATOM Definition)
- Ultrasound scanner (ACUSON Antares)

More than 2000 square feet of the CCIR is devoted to staff work areas such as image workstations for data processing, a nursing station, research coordinator workstations, offices and conference rooms. Patient areas will also include holding rooms, dressing rooms with lockers, and consult rooms for exams and consenting.

The CCIR provides extensive imaging-related support including, 1) consultation on protocol design; 2) assistance with the Institutional Review Board applications; 3) scanner operation; 4) storage, transfer and archiving of image data; and 5) development of customized approaches to image analysis and assistance on structural/ functional/biological interpretation.

Equipment

3T MRI Scanner (MAGNETOM Trio, A Tim System)

The 3T Trio scanner is a fully integrated 3T system with high-matrix array coil technology (total imaging matrix, "Tim"). The 3T Tim Trio scanner also has proton spectroscopy, and has RF transmitter/receiver electronics for multi-nuclear spectroscopy. The magnet is actively-shielded and relatively short (1.98 m or 6'6" in length). A stainless steel cryostat provides structural stability and minimum eddy current and magnetic field effects. For body imaging, homogeneity is <1.5 ppm RMS within a 50 cm DSV. Homogeneity is much higher for brain imaging. The fringe fields are small, with a 5-Gauss line at 3.4 m radial and 5.9 m axial (without magnetic shielding). The 5-Gauss line is calculated to be completely contained in our magnetically-shielded MRI bay. The gradients are actively shielded with a maximum gradient strength of 45 mT/m on the z axis and 40 mT/m on each x/y axis. The maximum slew rate is 200 T/m/s on each axis (minimum rise time of 200 μ s to 40 mT/m). Gradient linearity enables fields of view (FOV) up to 50 cm with minimum distortion. The gradients and gradient amplifiers are water cooled, and can be run at 100% duty cycle, with all three gradients on at full strength (2000 V and 625 A on each axis). Hardware methods to reduce acoustic noise are used to reduce acoustic noise by 20 dB(A) (90% reduction in sound pressure) compared to conventional systems. The RF system is digital with a solid-state RF amplifier that has a 35-kW peak power. The receiver has a maximum 1-MHz bandwidth, with a minimum sampling interval of 100 ns. The transmitter amplitude can be digitized at 50 ns intervals.

The 3T Trio body RF coil is circularly-polarized and fully integrated. The system will have a head circularly-polarized volume coil for conventional imaging, and a head matrix coil for phased array/parallel imaging. The head matrix coil is a 12-element design with 12 integrated preamplifiers (one ring of 12 elements, grouped in 4 clusters of 3 elements each). The upper half of the head coil is completely removable. The system also has a neck matrix coil, spine matrix coil, body matrix coil, and peripheral angiography matrix coil. The neck matrix coil is a 4-element design (4 integrated preamplifiers), and the spine matrix coil is a 24-element design (24 integrated preamplifiers). The array coils can be used in combination (e.g., attaching both the head matrix coil and neck matrix coil) to scan with up to 32 RF channels and 102 coil elements. Parallel imaging is provided in 2 directions simultaneously (phase-encoded in-plane direction and phase-encoded slice-select direction for 3D sequences). The body matrix coil has 6

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elements with 6 integrated preamplifiers, in 2 clusters of 3 elements each. The peripheral angiography matrix coil has 36 elements with 36 integrated preamplifiers, in 6 clusters (leg levels) of 6 elements each. Finally, the system has an 8-channel knee coil and a 4-channel shoulder coil.

1.5T MRI Scanner (MAGNETOM Avanto)

The Avanto scanner is a fully integrated 1.5T "Tim" (total imaging matrix) system with up to 76 integrated coil elements with up to 32 RF channels. The magnet is a relatively short (150 cm or 5'3" in length), whole-body superconductive 1.5T magnet with 5th generation active shielding technology with counter coils and external interference shielding. The wide inner bore has a diameter of 60 cm (2 ft). A large DSV (diameter spherical volume) allows for homogeneity of over 50 cm (20 inches). Hardware and software methods result in acoustic noise reduction of up to 30 dB as compared to conventional systems. This is a reduction of 97% in sound pressure. The gradients have a maximum field strength of 45 mT/m (72 mT/m effective) and maximum slew rate of 200 T/m/s (346 T/m/s effective), which enables a large field of view (FOV) of up to 50 cm (or 20 inches) optimized for whole body examinations. The gradient amplifier is highly compact and water-cooled for best min. TR 1.5 ms and min. TE 0.6 ms (matrix 256²). For claustrophobic subjects, the Avanto enables feet-first exams for nearly all MR procedures. For obese subjects, the Avanto supports up to 200 kg (400 lbs), without table movement restrictions. Similar coil sets will be available as on the 3T Trio.

PET/CT Scanner (Biograph 40 TruePoint Tomograph)

The CCIR contains the Biograph 40 TruePoint Tomograph, which is a multi-faceted whole-body PET tomography capable of a wide variety of research imaging of the brain, heart and thorax, and whole-body. The 4-ring PET with greater than 21 cm field of view increases the axial coverage per bed position to provide faster whole-body PET/CT protocols. The Biograph 40 provides software applications that maximize efficiency of acquisition and processing.

The Biograph 40 provides a large gantry opening, continuous patient port and short tunnel length, high-count rate, positron emission tomography (PET) imaging of metabolic and physiologic processes combined with high performance spiral computed tomography (CT) applications.

PET System of the Biograph 40

The PET imaging capability of the Biograph 40 consists of a multi-LSO-detector ring system with 3D acquisition and reconstruction and 109 image planes with an extended 21.6 cm axial field of view, enabling the detection of 78% more photons (compared with conventional field of view). Features include:

- High spatial slice resolution (less than 5 mm) in trans-axial and axial dimensions.
- Slice spacing (2mm) optimized for speed and resolution.
- Pico-3D ultra fast electronics for decreased deadtime and high signal-to-noise.
- ACS III acquisition computer system for high countrate capability.
- PRS reconstruction system for fast reconstruction of PET data.
- Fast acquisition and reconstruction of 128 x 128 and 168 x 168 matrices.
- Unique block detector technology provides excellent temporal and energy resolution response.

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- Simultaneous data acquisition and image reconstruction for high patient throughput.
- Static, whole body, and list mode acquisition capability.
- 847 mm detector ring diameter.
- 70 cm gantry aperture.
- 21.6 cm axial field of view.
- Dual operator controls on gantry for positioning from either side of patient.
- TrueC advanced scatter correction technique.

CT System of the Biograph 40

The CT imaging capability of the Biograph 40 consists of a 40-slice CT featuring a full range of SPIRAL CT clinical applications with highest performance. Features include:

- Aperture: 70 cm; power supplied via low-voltage slipring.
- Rotational speed of the gantry: 162 rpm with a rotation time of 370 ms.
- Adaptive Array Detector (AAD) system based on UFC™ (Ultrafast Ceramics) with 26880 elements in 40 rows, 1344 channels per slice and up to 4640 projections per 360° rotation.
- Up to 40 images per rotation of below 0.6 mm isotropic resolution.
- STRATON tube high-performance X-ray system provide direct cooling of the anode with the ball bearings located outside the vacuum. The direct anode cooling and the small and compact design of the anode plate (120 mm diameter) eliminates the need for heat storage capacity (0 MHU) and enables an unprecedented cooling rate of 5.0 MHU/min. Therefore, cooling delays between multiple long range scans are eliminated, even for large patients.
- The STRATON X-ray tube utilizes an electron beam that is accurately and rapidly deflected, creating two precise focal spots alternating 4640 times per second. This doubles the X-ray projections reaching each detector element. The two overlapping projections result in an oversampling in z-direction, known as Double z-Sampling. The resulting measurements interleave half a detector slice width, doubling the scan information without a corresponding increase in dose. Siemens' high-speed UFC™ detector enables a virtually simultaneous readout of two projections for each detector element – 2 x 20 slices for every viewing angle – resulting in a full 40-slice acquisition.

PET Scanner (ECAT HR+ 962)

The ECAT HR+ 962 was originally purchased as a state-of-the-art whole body PET scanner capable of obtaining image resolution of 4.5 mm (FWHM) in the transaxial and axial directions in clinical research imaging conditions. This scanner is made of 4 rings of 72 high resolution block detectors made of high efficiency Bismuth-Germanium-Oxyde (BGO) scintillator subdivided in an 8x8 array of 4.05x4.39x30 mm deep crystals. The complete rings geometry arrangement of these block detectors confers to the system an axial field of view (FOV) of 15.5 cm and a radius of 82cm, leading to a transverse FOV of 56 cm. The sensitivity performance of this camera is 200 kcps/μCi/cc in 2D (900 kcps/μCi/cc in 3D). The crystal geometry of this scanner ranks it as one of the best among commercial PET systems with regards to its suitability for high resolution organ imaging. The system is equipped with retractable inter-plane lead septa (0.5 x 6.5cm) allowing for imaging in both 2D and 3D modes. The ECAT HR+ is also equipped with three rotating 68Ge/68Ga rod sources, enabling transmission measurements that can be acquired

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post-injection for improved emission/transmission image alignment. The scanner is capable of performing dynamic image acquisition at a maximum rate of 1 image frame every 2 seconds. Cardiac and respiratory rate gated studies are also possible on this system. The image reconstruction console is equipped with the latest acquisition and processing tools, the ECAT CAPP version 7.2. The available image reconstruction algorithms include Filtered Back-Projection (FBP) and Ordered-Subset Expectation-Maximization (OSEM) in both 2D and 3D modes.

Although this scanner is several years old, it has been relocated from the Mallinckrodt Institute of Radiology building to the CCIR because it offers high sensitivity crystal geometry and 2D acquisition capabilities. This feature, while not used in most clinical FDG applications, can provide high quality data for ¹⁵O-tracer brain and cardiac applications.

CT Scanner (SOMATOM Definition)

The SOMATOM Definition CT scanner is the world's first dual source CT. It uses two X-ray sources and two detectors at the same time (STRATON[®] tube technology). The design of this scanner removes cooling delays between multiple long range scans, even for large subjects. Rotation time of 0.33 sec with up to 64 slices per rotation acquisition enables early disease diagnosis or cardiac CT imaging. The scanner also enables high speed submillimeter volume coverage and whole body examinations within a breath-hold. Isotropic resolution is below 0.4 mm voxel size. The Definition's two detectors offer acquisition of 2 x 64 slices per rotation. It has a large bore of 78 cm, scan range of 200 cm, and 160kW generator power. Sub-millimeter volume coverage of 87 mm/sec enables whole body examinations within a few minutes, reducing breath-hold time significantly.

Ultrasound Scanner (ACUSON Antares)

The Antares ultrasound scanner is a fully integrated system with 2D, 3D and Doppler imaging, and 4D ultrasound imaging technology. The Antares system is equipped with many features to enhance the ultrasound experience. The Precision UpSampling feature allows for improved resolution in small parts imaging. The GigaProcessing technology increases processing speed and precision. Clarify Vascular enhancement technology allows the user to help clean up the image of a blood vessel in 2D imaging. Virtual Format Imaging expands visualization of anatomic information at the touch of a button. Panoramic imaging displays extended field-of-view ultrasound images in anatomical context. The system is equipped with eSieTouch, elastography and fatty tissue imaging. This feature gives the Antares the capability to image the density of a structure such as a thyroid nodule or breast lesion.

3D volume imaging gives the Antares the capability to acquire 3D volume acquisitions of any sonographically imaged structure and blood vessel. 4D imaging features allow the user to image in "real time" 3D.

Many different transducers are available for the Antares system. The system's advanced transducer technologies include the Hanafy Lens transducer which controls slice thickness without increasing transducer size, weight and complexity. The Multi-D[™] array transducer provides improved elevation focus for superior near-field performance. MultiHertz[™] multiple

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frequency imaging provides multiple frequency selection on a single transducer for clinical utility and versatility.