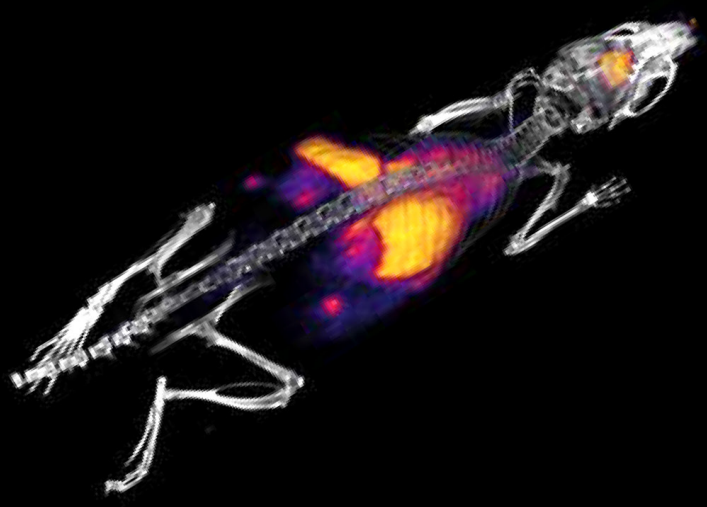
THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

THE CENTRE FOR ADVANCED IMAGING

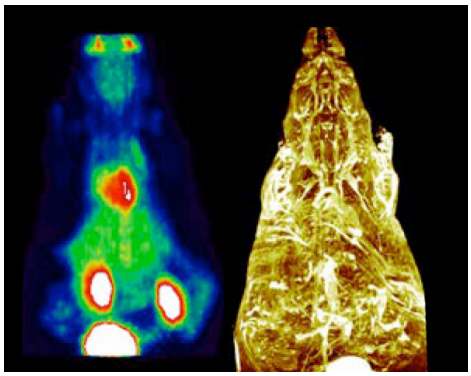


Molecular Imaging at CAI

The Centre for Advanced Imaging (CAI) contains a comprehensive range of molecular imaging technologies. Expertise and facilities are available for the development and imaging of radioactive tracers for Positron Emission Tomography (PET) and non-radioactive tracers for computed tomography (CT), optical, mass spectrometry and Magnetic Resonance Imaging (MRI) applications.

Access to the molecular imaging facilities is available on a fee basis. Expert staff at CAI offer the following services:

- Planning for *in vivo* projects
- Animal anaesthetising and other *in vivo* techniques
- Holding rooms for radioactive and non-radioactive animals
- Production, preparation and formulation of radiopharmaceuticals
- Reconstruction and analysis of static or dynamic image data
- Kinetic modelling of dynamic image data
- Biodistribution studies
- Autoradiography



Simultaneous PET (left) and 3D-MRI following injection of [^{18}F]-FDG and Gadolinium contrast agent (Gadovist) from a single syringe

In Vivo MS FX Pro Optical Scanner

The *In Vivo* MS FX Pro optical imaging system provides multimodal X-ray, multispectral fluorescence, luminescence and radioisotopic imaging within a single unit. The system is fully automated, facilitating high throughput imaging for detection of molecular and cellular biomarkers with anatomical localisation.

Capabilities:

- High speed X-ray images in just 3 seconds (ideal for co-registration with fluorescence or bioluminescence molecular images)
- Fluorescence excitation and detection filters across the full visible region and into the near infra-red for detection deep within the animal (14 excitation filters and 6 wide-angle emission filters)
- 4 megapixel digital CCD camera
- Field of View – 13.8 cm x 13.8 cm (with zooming capabilities) allowing simultaneous imaging of up to 6 mice
- Radiographic and radioisotopic imaging screens allow for rapid throughput imaging of radiolabelled materials
- Animal rotation system (MARS) for 360 degree coverage of the animal

Top image: PET/CT scan of Mouse with Glioblastoma injected with Cu-64-labelled mAb

Inveon PET/CT

The Inveon multimodality PET/CT imaging scanner is capable of providing three dimensional CT and PET images of live mouse and rat as well as fixed biological samples and materials.

Capabilities:

- Anatomical CT and functional PET images are automatically co-registered for easy analysis
- An integrated isoflurane anaesthetic gas system and physiologic monitoring system allow for image gating and animal monitoring during scanning
- The Inveon PET component delivers 1.4 mm full width at half maximum (FWHM) spatial resolution at the centre of field of view (FOV) with an axial FOV of 12.7 cm
- The PET scanner uses molecular imaging probes labelled with positron-emitting radionuclides (i.e. ^{18}F, ^{11}C, ^{64}Cu)
- The CT component has a large area 125 mm X-ray camera and incorporates a high resolution, low noise X-ray imaging detector with 3072 x 2048 pixels and can be configured for a FOV as large as 8.4 cm x 5.5 cm
- Delivers high spatial resolution *ex vivo* CT images down to 8 µm for a 20 mm FOV, allowing separate analysis of cortical and trabecular compartments of bone
- Multiple Inveon Research Workplace workstations for multimodality image review, fusion, and analysis
- Workstations support CT, PET and MR data in DICOM and Siemens CT and PET formats
- Quantitative analysis can be performed on static, gated and dynamic data

Higher resolution *ex vivo* and *in vitro* technologies are available at CAI for validation of pre-clinical *in vivo* PET imaging data:

- Biodistribution studies (Perkin Elmer Wizard Gamma well counter)
- *Ex vivo* autoradiography (Leica cryostat and a Beta-imager Autoradiography scanner)

This is a Flagship instrument of the National Imaging Facility (www.anif.org.au)

CT scan of echidna, 53 µm

Clinscan PET/MR

The Clinscan PET/MR allows simultaneous MRI and PET image acquisition and enables the most direct translation of research outcomes from animals to humans. This system is the first of its kind worldwide combining a high field MRI scanner, for high definition anatomical and functional MRI, with a PET insert that provides dynamic metabolic information. This is a powerful emerging multimodal imaging technology for studies of cancer and neurodegenerative disease.

Capabilities:

- Provides simultaneous acquisition of MRI and PET images of an animal or sample
- 7 Tesla, 30 cm bore superconducting magnet, with operating software identical to the Siemens clinical MRI platform (Syngo)
- Mouse and rat head and body coils for live animal and sample imaging
- 150 mm large sample RF coil
- PET insert has a FOV with a diameter of 5 cm and length of 6 cm
- PET image acquisition is performed with the Siemens Inveon Acquisition Workplace (IAW) software

This is a Flagship instrument of the National Imaging Facility (www.anif.org.au)

MALDI-TOF Mass Spectrometry Imaging (MSI)

A Bruker Autoflex MALDI-TOF/TOF MSI facility is available for both advanced MSI and protein analysis. MSI enables the spatial distribution of ions to be imaged directly in tissue sections down to a resolution of 50 µm. Example applications include biomarker studies in cancer and drug distribution. Tissue sections analysed by MSI can be subsequently stained and examined by histology. The technology is an ideal platform for mass analysis of biomolecules and characterisation of protein folding and sequencing. A robotic LC-spotter allows full-scale proteomic experimentation.

Capabilities:

- MS analysis of a wide range of molecules by MALDI-MS spot analysis
- Top-down proteomics of purified proteins by MALDI-ISD-MS
- LC-MS analysis of complex samples by LC-MALDI-MS
- Bottom-up proteomics of enzymatically digested protein samples by LC-MALDI-MS/MS
- Spatial distribution of molecules in tissues by imaging mass spectrometry

Optoacoustic Tomography

Optoacoustic imaging is able to detect, track and monitor the behaviour of molecules under physiological conditions, often without the use of a contrast agent. By operating in the near-infrared spectral region, the technique provides a direct means of interrogating relevant particle behaviour in living subjects and provides clear and quantitative insight into how their chemophysical properties affect biodistribution, accumulation and pharmacokinetics.

Capabilities:

- Highly sensitive, multiplexed imaging of biological processes with improved spatial resolution over traditional optical imaging (down to 150 µm)
- Direct differentiation between oxygenated and de-oxygenated haemoglobin, real-time analysis of tumour microenvironment
- Analyse tissue heterogeneity directly through quantitation of hypoxia, for example, in tumour tissue
- Observation of growth of some tumours through monitoring of endogenous molecules

Cyclone 18 Twin Cyclotron

The IBA *Cyclone 18 Twin* is a dual ion source, fixed energy cyclotron used to accelerate negatively charged hydrogen ions to an energy of 18 MeV. A feature of the Centre's cyclotron is the capability of irradiating solution, gas and solid targets, allowing a greater range of isotopes be prepared.

The Centre's cyclotron is currently equipped with targets to produce the following radioisotopes:

- [^{18}F]Fluorine – as aqueous fluoride
- [^{11}C]Carbon – as carbon dioxide gas
- [^{13}N]Nitrogen – as aqueous ammonia
- [^{124}I]Iodine – on solid matrix
- [^{64}Cu]Copper – on solid matrix

The *Cyclone 18 Twin* cyclotron

Radiochemistry Facility

Equipped with 14 Hot Cells (9 for research and 5 for GMP manufacture), the radiochemistry research labs provide unrivalled capabilities to facilitate the development of novel and established radiotracers.

The laboratories have capabilities to handle a wide range of radioisotopes including carbon-11, fluorine-18, copper-64, gallium-68, zirconium-89, technetium-99 and iodine-124.

The radio-analytical laboratory for the quality control of radiolabelled compounds includes high pressure liquid chromatography (radio-HPLC), thin layer chromatography (radio-TLC) and gas chromatography (GC) systems.

Autoradiography

The distribution of radiolabelled probes can be visualised in tissue sections created by a Leica cryostat CM 3050S.

The Biospace Lab Beta Imager is a digital autoradiography system providing real time imaging. The images are displayed on-the-flight as beta disintegrations occur.

The Beta imager consists of a gaseous particle detector with a scintillation foil Intensified CCD Camera allowing direct Beta counting.

Different energy of beta emitters can be separated: low energy (^{3}H, ^{125}I), medium energy (^{14}C, ^{35}S, ^{33}P) and high energy (^{32}P, ^{18}F, ^{11}C).

A Spatial resolution from 50 µm to 200 µm can be achieved depending on isotope and zoom.

The Beta imager is up to 500X more sensitive to tritium than X-ray film and 20X more sensitive than Storage Phosphor Screen.

National Imaging Facility

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