Monash Biomedical Imaging:  
Overview of  
Research Platform  
Facilities

Gary Egan  
Professor & Director  
Monash Biomedical Imaging
We have increased 104 places from 178 (2010-11) to 74 (2016-17) in the THE rankings - only three Universities globally have made such an improvement over these 5 years.

We have also made considerable improvement in the ARWU rankings, increasing 92 places from 171 (2010) to 79 (2016) in the ARWU rankings.
Monash Biomedical Imaging and Australian Synchrotron

Monash Biomedical Imaging

PET-CT, SPECT, MRI

Synchrotron Imaging &
Medical Beam Line (IMBL) - CT high
resolution phase contrast X-ray
Human imaging & procedures

Staffed Reception Area

3T Skyra MRI

simultaneous EEG - TMS

Consulting & Procedure rooms

• Scans performed by qualified radiographers from Monash Health
• Reported by MR & MR-PET neuroradiologists & physicians
• PET-tracers dispensed by nuclear medicine pharmacists
• MR & PET engineering & physics support
• MR & PET data analysis support
• research patient data management work flows
Human simultaneous 3T MRI - PET

PET-MRI Scanner
simultaneous Siemens 3T MR-PET

Patient & Clinician Resources
interview rooms  consulting & procedure rooms

Associated Facilities
Radio-Chemistry Lab  Radio-Pharmacy Dispensary
First MBI clinical MR-PET scan - 10 February, 2016

First MBI research MR-PET scan - 18 February, 2016
New CT Scanner Facility

- CT scanner installation - Nov 2017

3D Printing Applications

Above: Development of a hand surgery simulator using co-registered CT and MRI data. Prepared by Dr Raf Ratinam who is supervised by Prof Paul McMenamin, Dr Quentin Fogg and Dr John Crock.

Above: Taxidermied ‘Chaeropus ecaudatus’ or the Pig-footed Bandicoot (National Museum of Victoria state collection).

Far left & left: A virtual dissection of the extinct pig-footed bandicoot's (Chaeropus ecaudatus) chewing muscles guided by co-registered CT and MRI data (far left) from Monash Biomedical Imaging, and comparison of the unique front limb skeleton of the pig-footed and regular bandicoots (left). This work was in part created during an Honours project by Alexander McDonald, supervised by Dr Justin Adams.
Pre-Clinical Imaging Equipment

2 x 9.4T MRI Scanners @ Clayton & Alfred

2x PET-CT scanners @ Clayton & Alfred

Vivo 2100 Ultrasound

Surgery & Laboratories

Rodent – NHP - rabbit
Small bore 9.4T MRI system

rodent - NHP – rabbit
Small bore PET-SPECT-CT system
Locations: Clayton and AMPREP (Alfred Hospital)

rodent
Vivo 2100 ultrasound system.
Includes all vascular packages – microbubble compliant

rodent -> large animals
Dedicated animal surgeries & PC2 laboratory
Animal housing also available on-site
Pre-Clinical Imaging

**PET-SPECT-CT**
- FDG murine tumors
- Tumor
- Liver
- Inflammation/vascular injury
- Carotid injury
- PET-Cu$^{64}$-platelet accumulation
- Metabolic activity - FDG

**MRI – 9.4T**
- Brain Injury
  - Control
  - Injured
  - T1 weighted
  - T2 weighted
  - Oedema
  - Brain vasculature mapping

**Rodent Ultrasound**
- Blood flow
  - PW Doppler PA
  - Aortic wall thickness
  - M-mode
Imaging the human brain with MR-PET

connectivity

metabolism (FTD)

perfusion
Functional PET–functional MRI Imaging

- **Problem** - fMRI studies comparing two groups (e.g. young vs. old) can be confounded by group differences in brain activity and/or the relationship between haemodynamics and metabolism in the brain.

- **Objective** - use fPET-fMRI to quantitatively compare brain activity during cognition between groups

- **Study 1** - quantify how older people are able to compensate for age-related changes in the brain
  - Compensation refers to the observation that older people often show greater fMRI activity during a task than younger people
  - Compensation is a target for therapeutic intervention

- **Outcome** - determine where activation changes seen in older people are attributable to compensation, or group differences in the interaction between CBV, CBF and CMRO₂
Dynamic fPET-fMRI Method

- Task design

Villien et al.
Dynamic fPET-fMRI - Initial Results

PET signal (kcounts)

PET signal change (kcounts/sec)

Time (mins)

fMRI Activation Map

Mutual information map

fPET Activation Map

Complementary map
QSM Venography & Oxygen Extraction Fraction

- Challenge - to image and extract veins from SWI or contrast enhanced CT or MRI
- Requirements - algorithms and techniques to extract and quantify properties of venograms
- Method - QSM venography processing pipelines to combine QSM with other contrasts

- AIM - to quantify cerebrovascular venous density & venous oxygen extraction fraction (OEF)
Results - QSM Venography & Oxygen Extraction Fraction

- GRE
- QSM
- SWI
- Vein Map
- OEF
- Regional Density
- Regional OEF
- MPRAGE
- Parcellation
QSM Venography & Oxygen Extraction Fraction - Results

Veneous density

Anatomy colour coded based on density of veins in region.

Veneous OEF

Anatomy colour coded based on OEF measured within veins in region.
Australian Research Council

Centre of Excellence for Integrative Brain Function
Discovering how the brain interacts with the world.

A multi-scale and multi-disciplinary research program.
The windpipe and lungs contain small nerve fibres that send information from the airways to the brain, and irritating substances in the airways can stimulate these nerves that lead to coughing. The windpipe and lungs thus have two routes to the brain: one via the trigeminal nerve and another via the vagus nerve. 

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