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Edinburgh Neuroscience

CCBS
Centre for Clinical Brain Sciences

THE UNIVERSITY of EDINBURGH
Centre for Cardiovascular Science

THE UNIVERSITY of EDINBURGH
School of Physics and Astronomy

Positron Emission Tomography (PET) and Total Body PET

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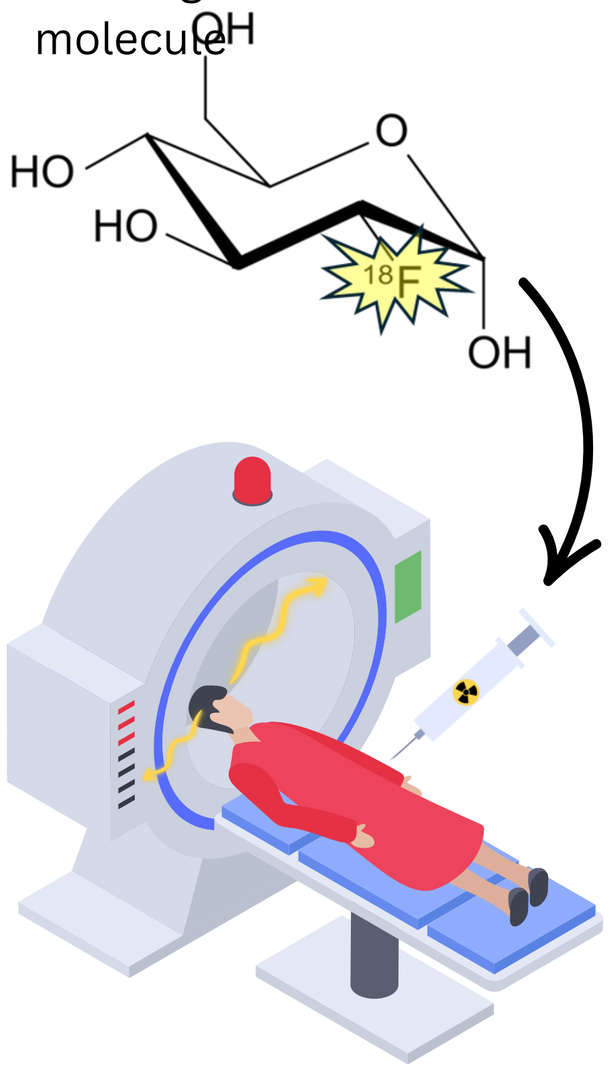
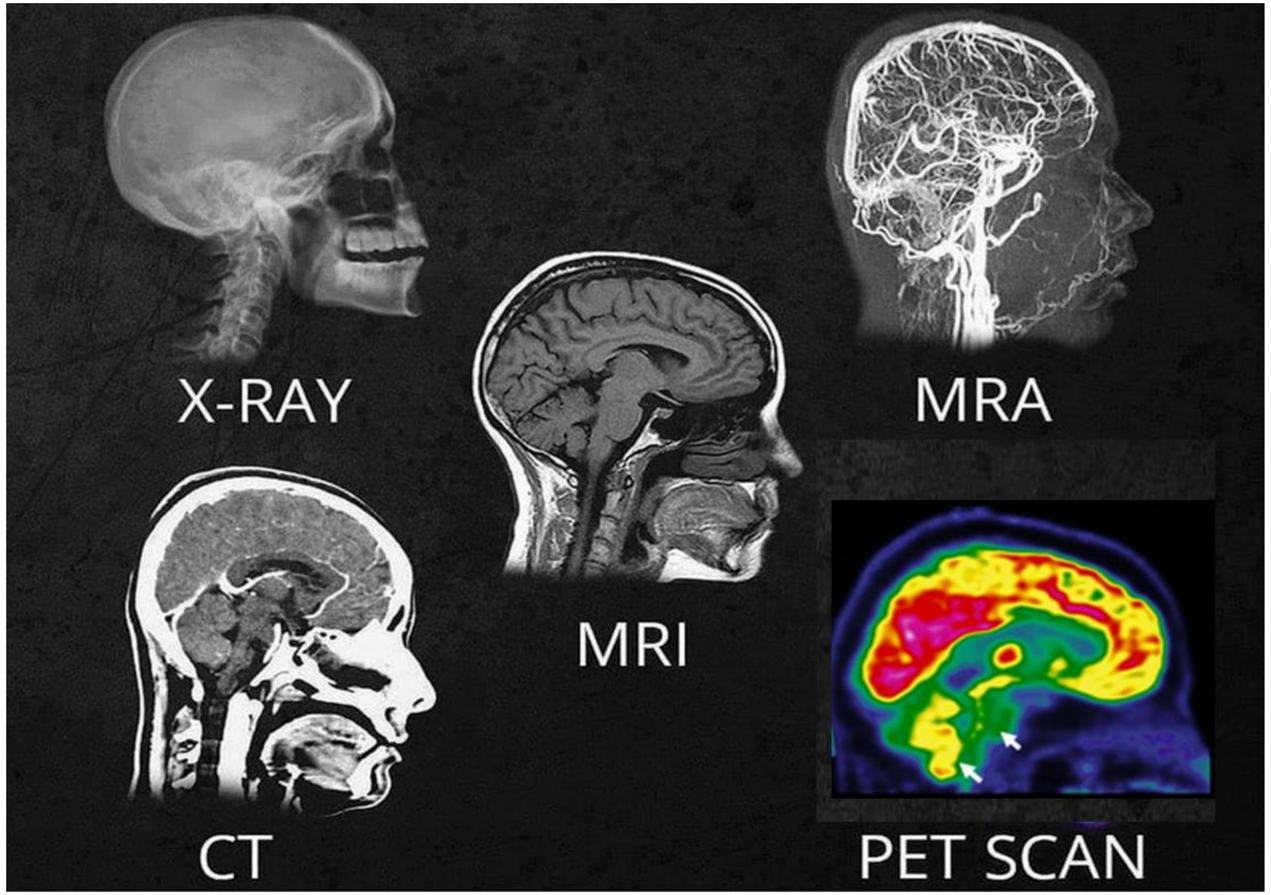
Centre for Biomedical Physics
workshop
26th May 2025

Radioactive glucose molecule

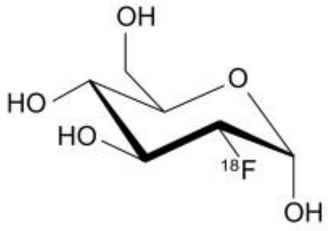




Glucose metabolism across the brain

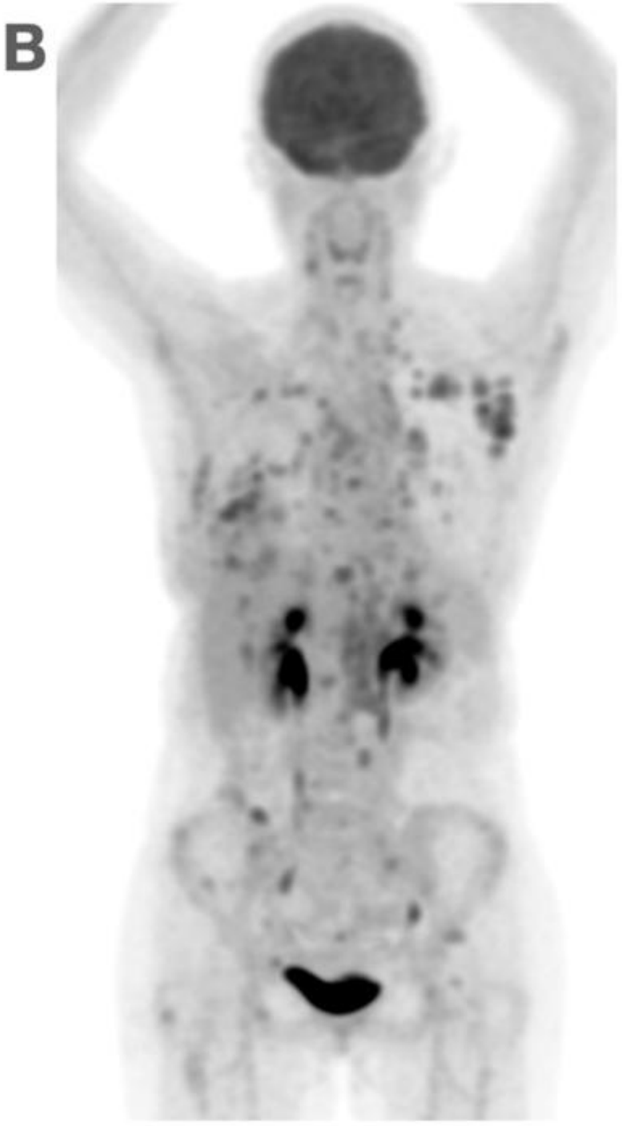
Verger et al. EJNMMI 2022, https://sdbif.org/whats-the-difference-between-all-the-different-head-scans/

Cancer imaging



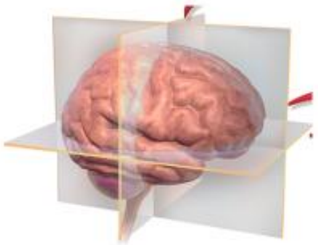
- ^{18}FDG – most commonly used tracer
- Radioactive analogue of glucose

Normal, healthy



Metastisized cancer

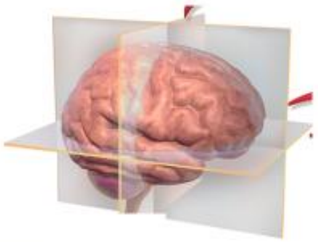
https://www.snmmi.org/AboutSNMMI/Content.aspx?ItemNumber=5657



Alcohol reduces brain metabolism

Measuring activity in the brain using ^{18}FDG

Thanos et al. 2008



Radioactive drugs

Schou et al. 2015

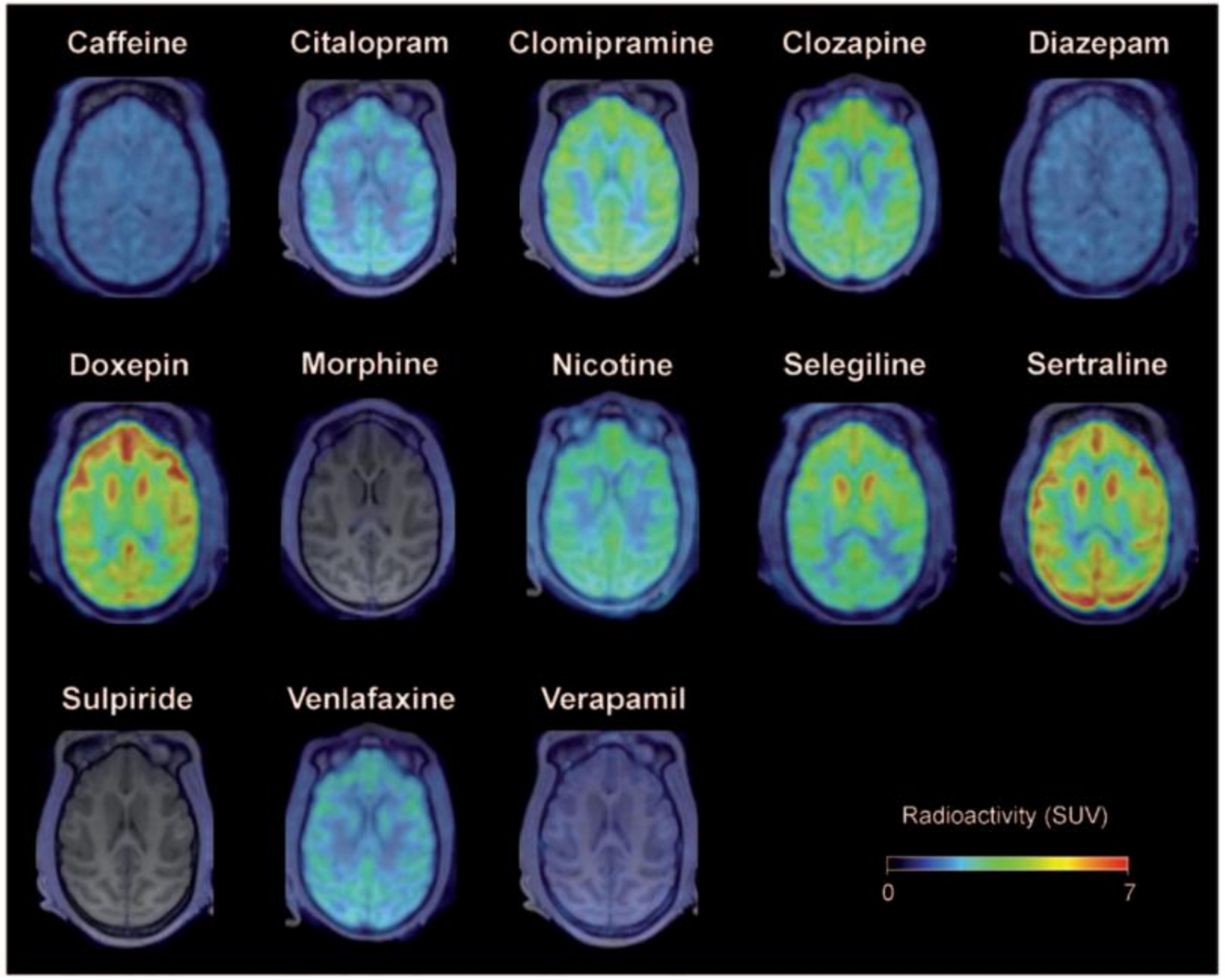
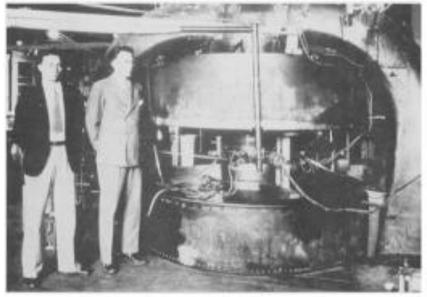
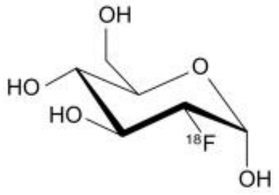


Figure 3. Color-coded summation brain positron emission tomography (PET) images obtained for the time period between 3 and 93 minutes after injection of a series of radiolabeled commercially available drugs.





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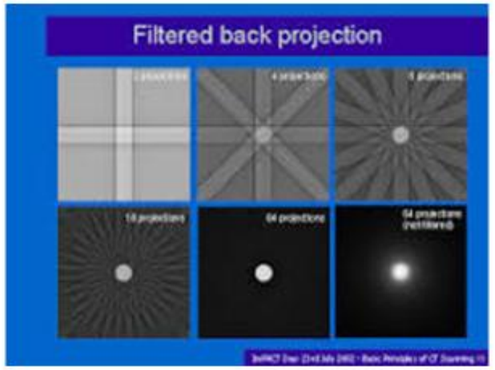

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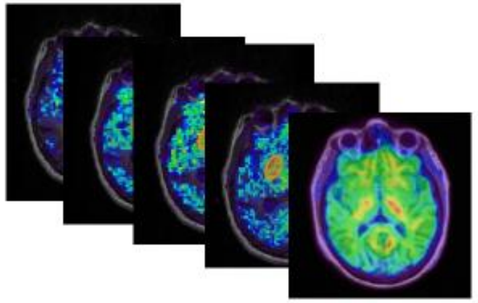
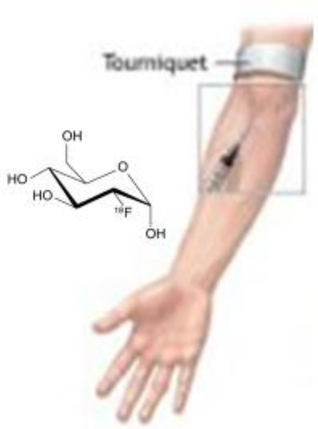


Bequerel/mL

7



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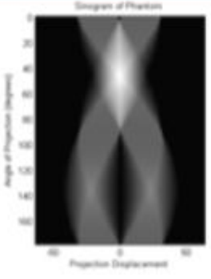
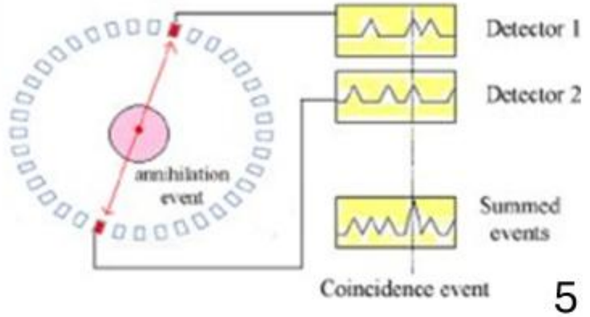
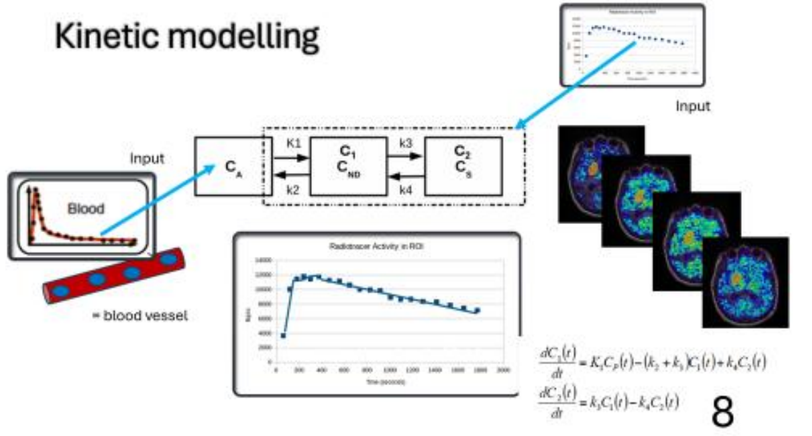


Raw PET data



5

Kinetic modelling



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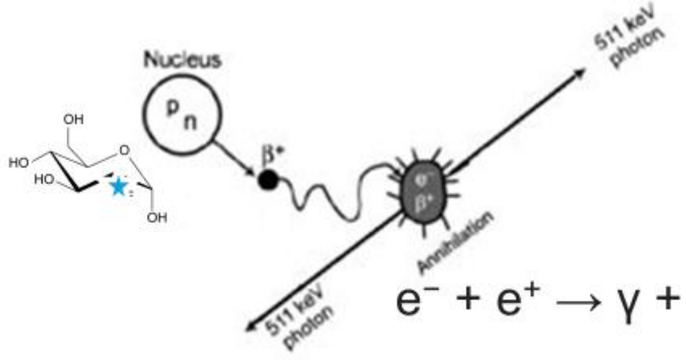
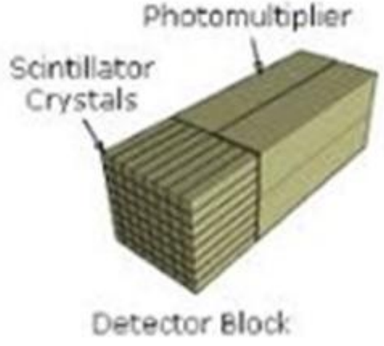


$e^- + e^+ \rightarrow \gamma + \gamma$

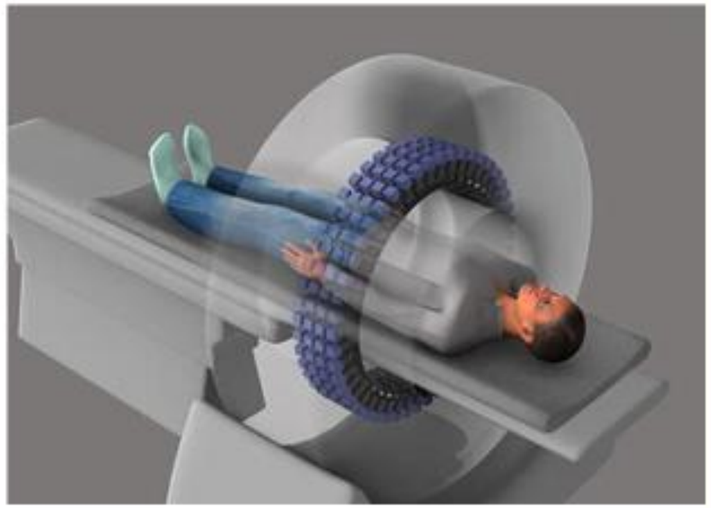
3

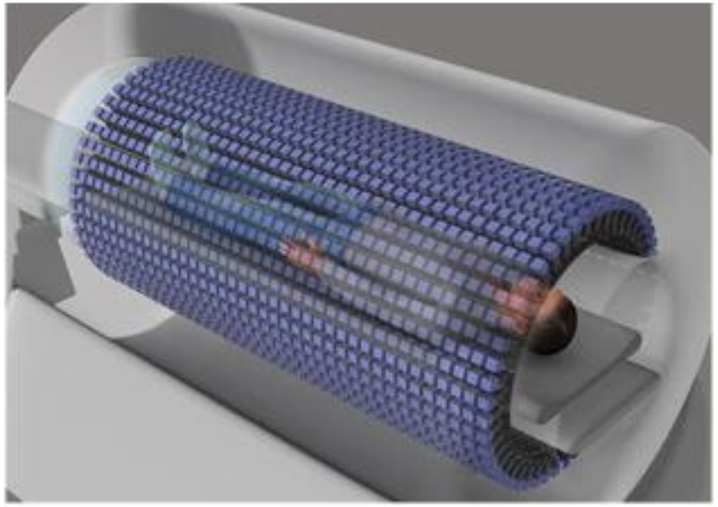


4

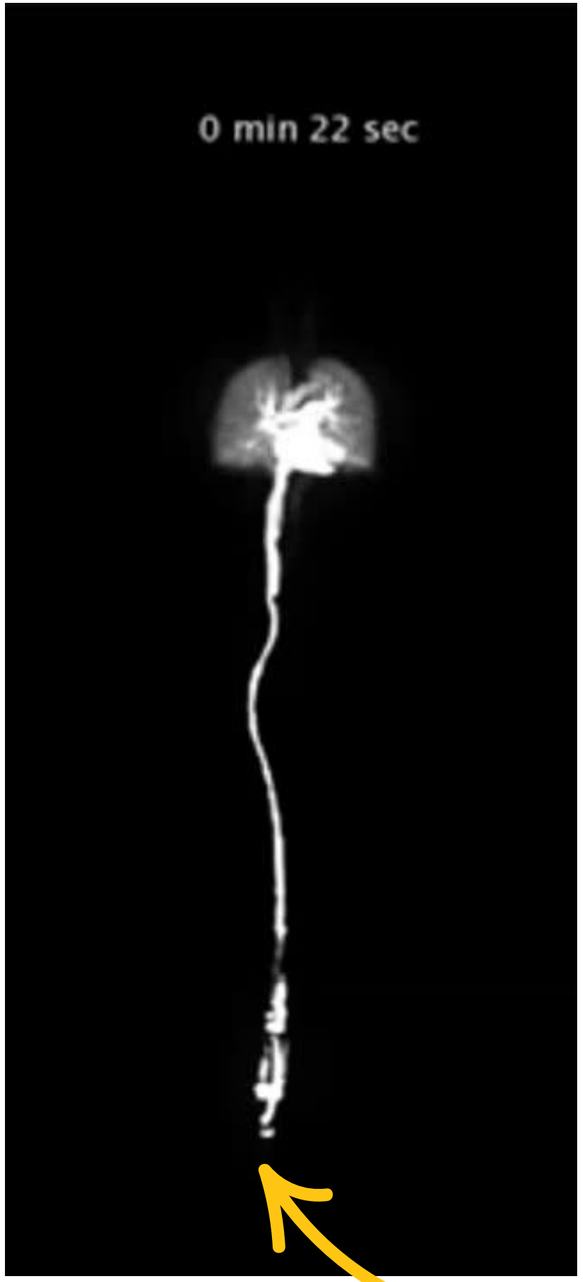
Positron Emission Tomography (PET) process

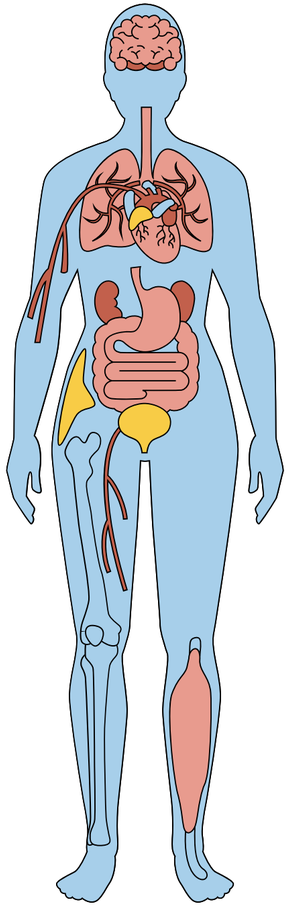
Standard PET

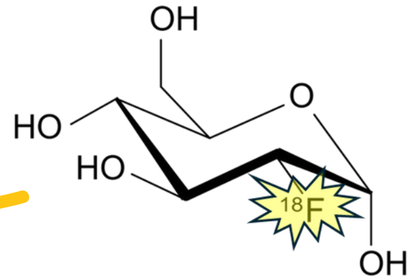




Total-body PET







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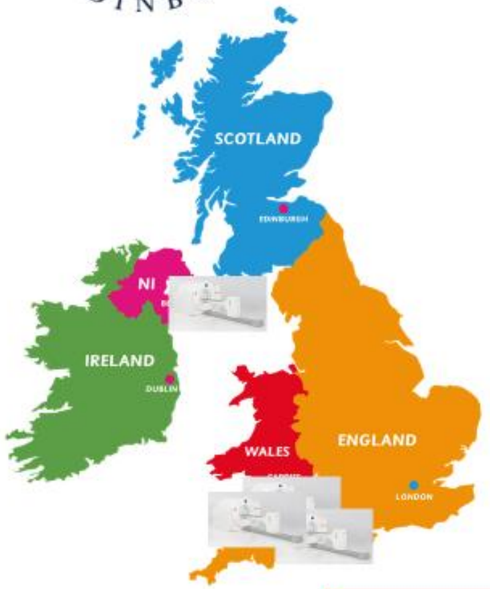
Four Total Body PET scanners installed in UK

NPIP



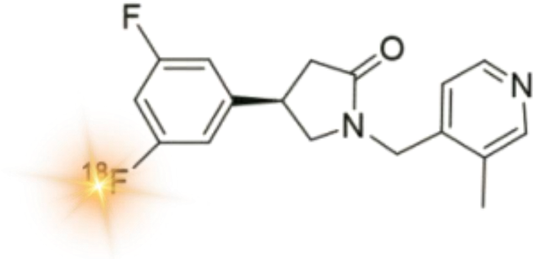
Imperial College London

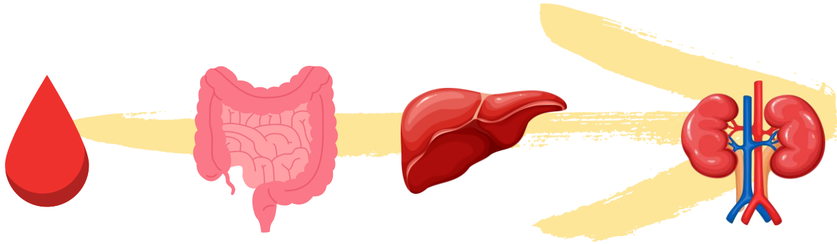
KING'S College LONDON

Siemens Total Body Biograph Vision Quadra PET
3 in London, 1 in Edinburgh

A big challenge for PET and Total Body PET!

Radiopharmaceutical

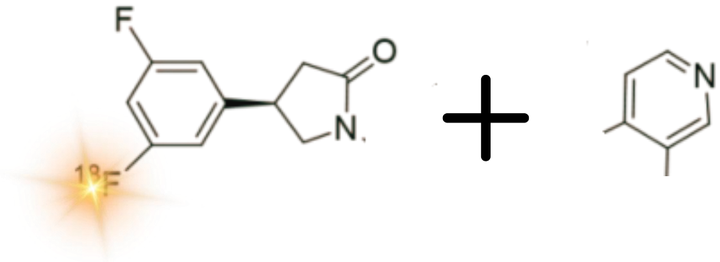


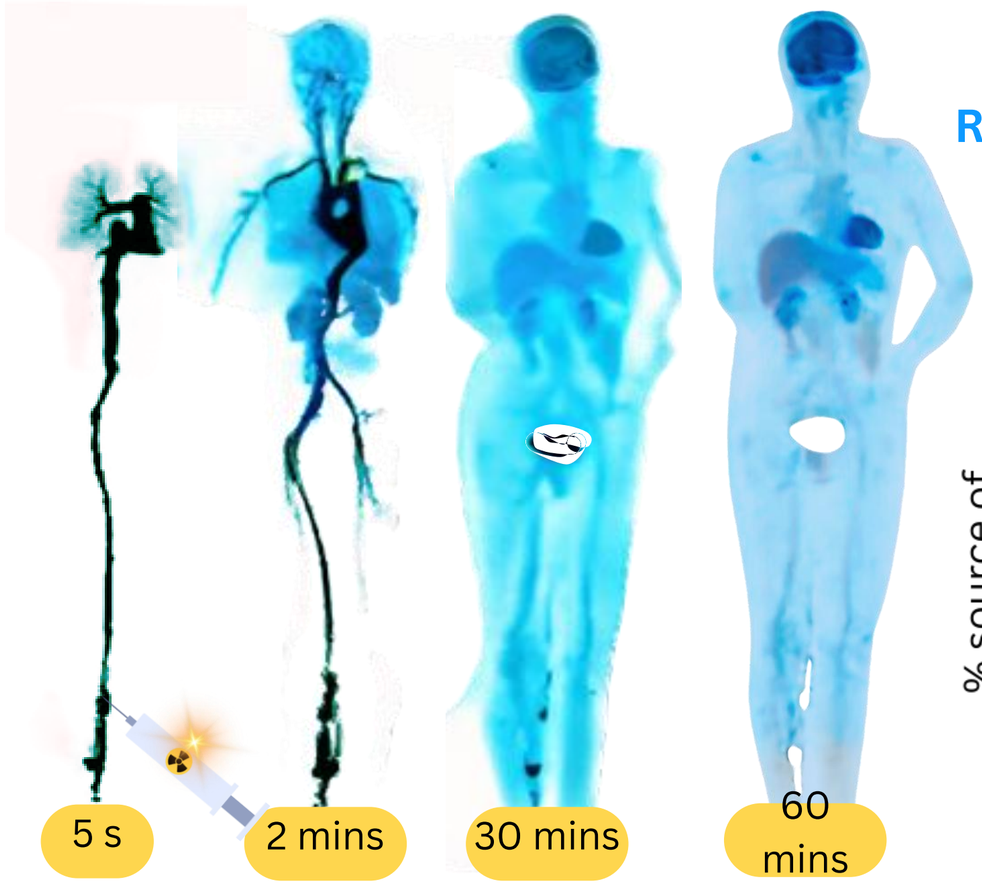


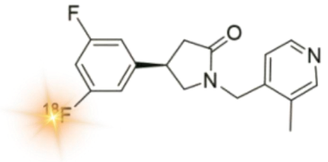
Blood Liver Gut Kidneys

Sites of drug breakdown

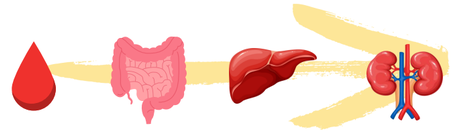
Breakdown products: radiometabolite and metabolite

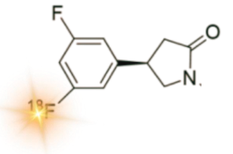




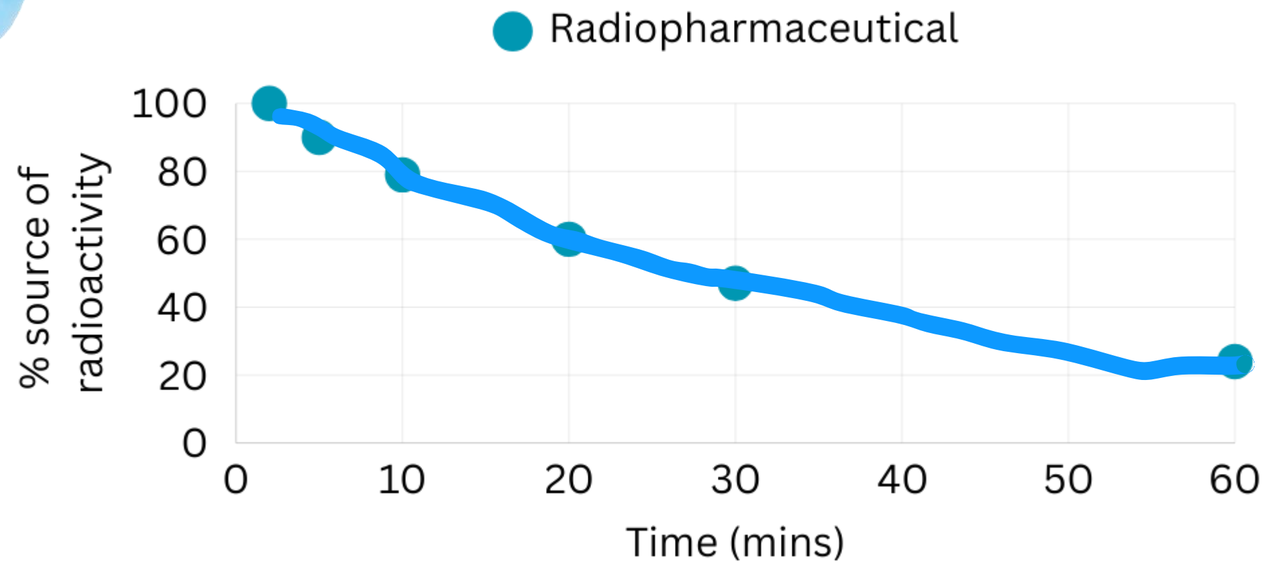


Radiopharmaceutical

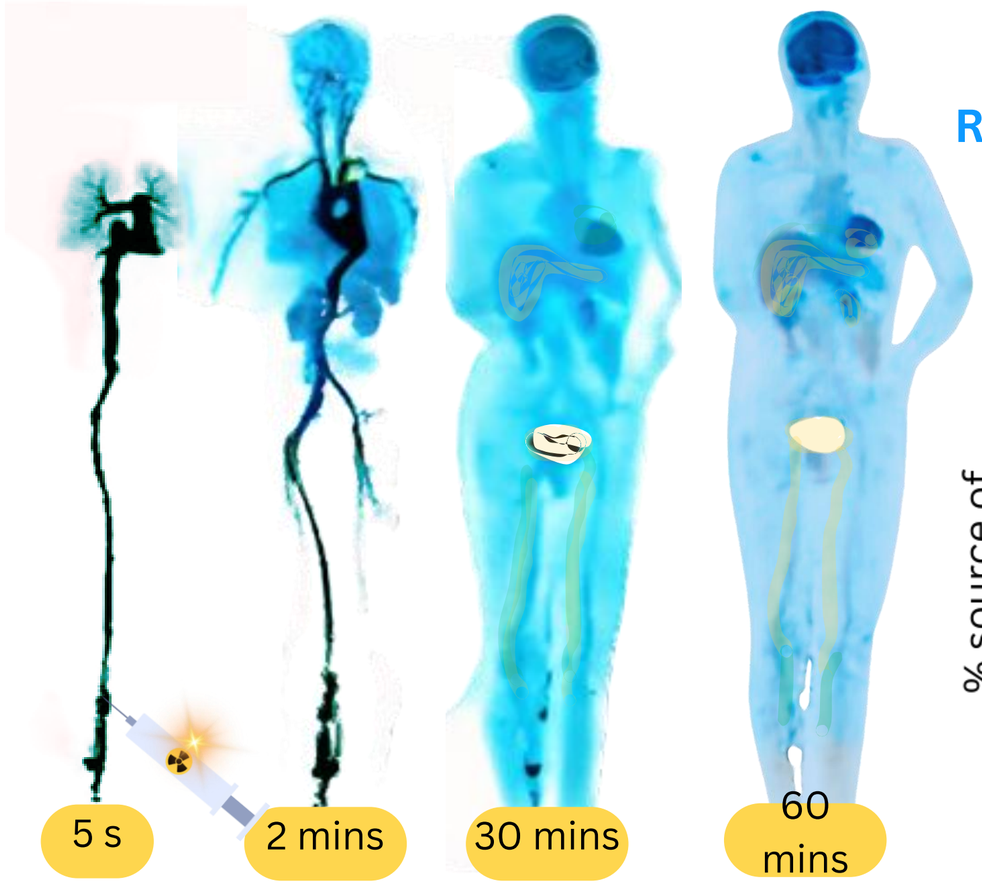


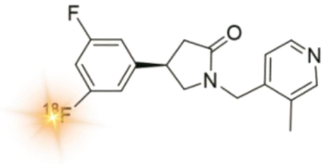


Radiometabolite

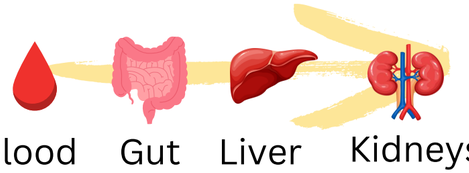


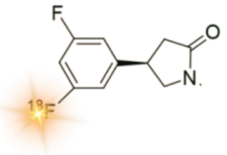
PET scan



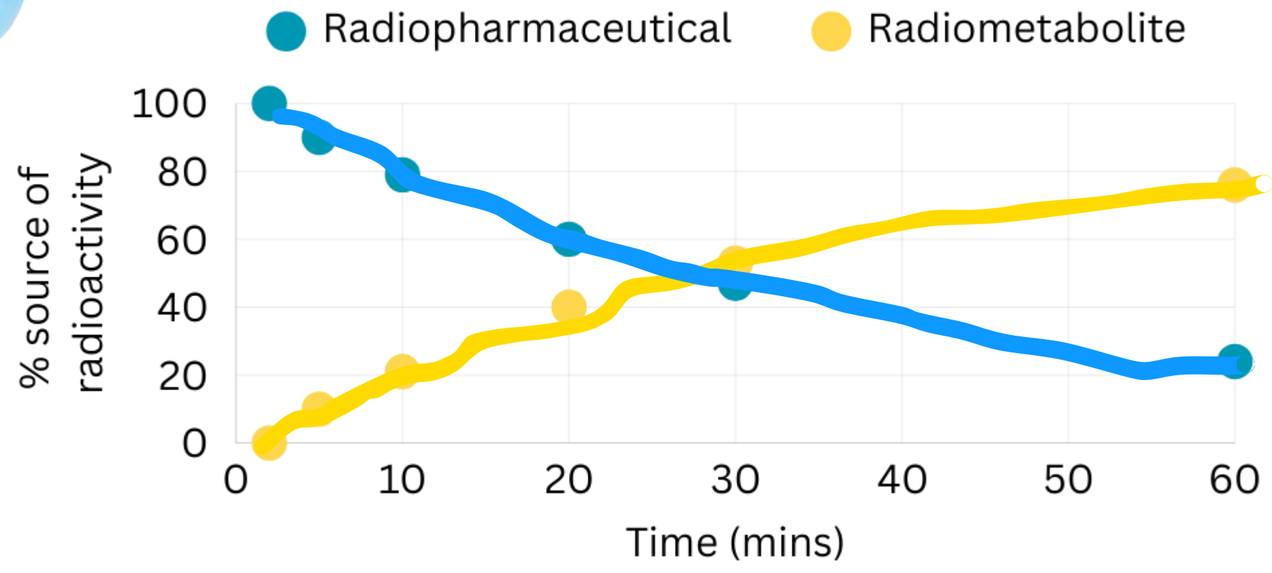


Radiopharmaceutical

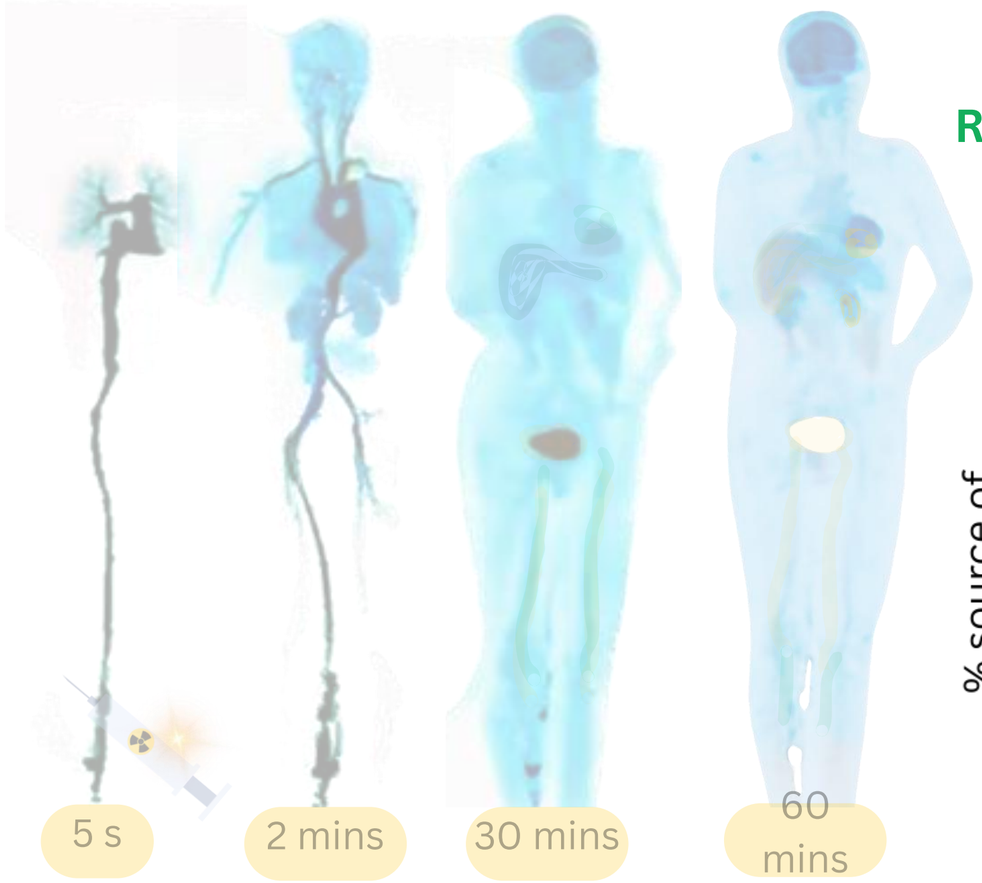


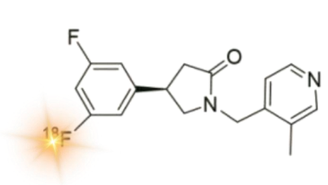


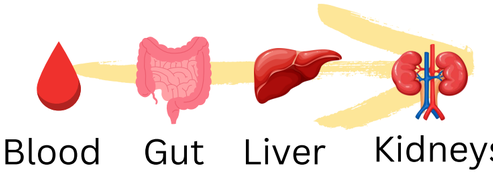
Radiometabolite

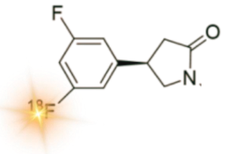


PET scan

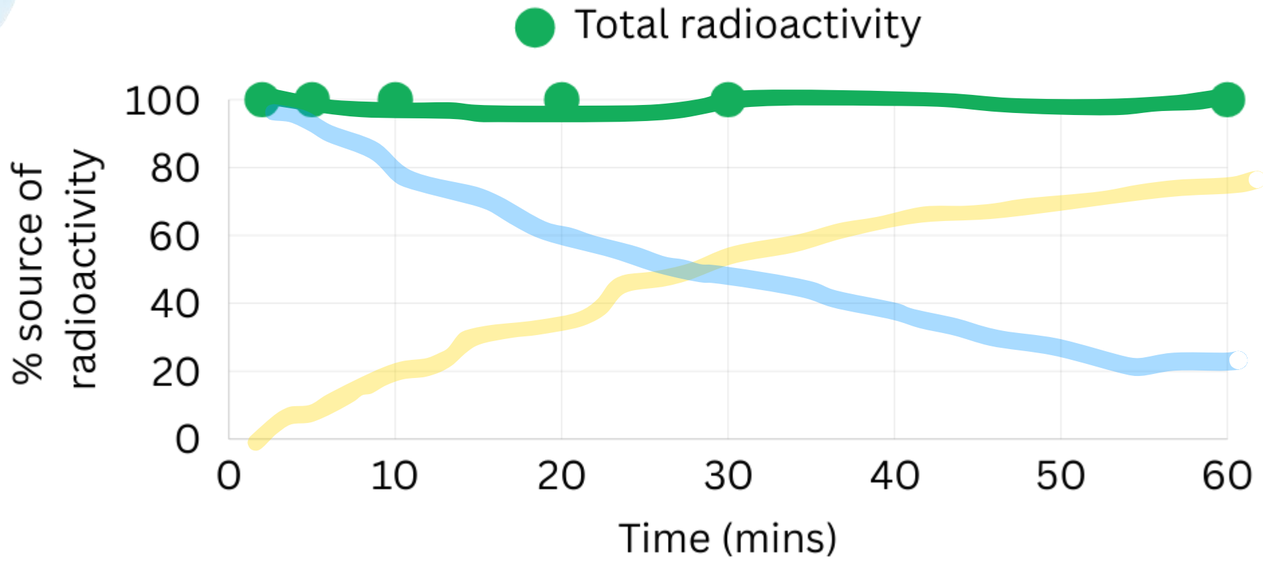






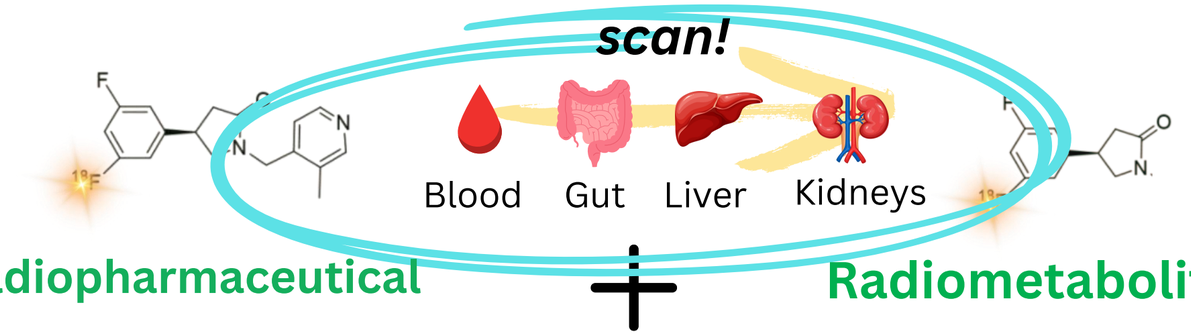


Radiopharmaceutical + **Radiometabolite**

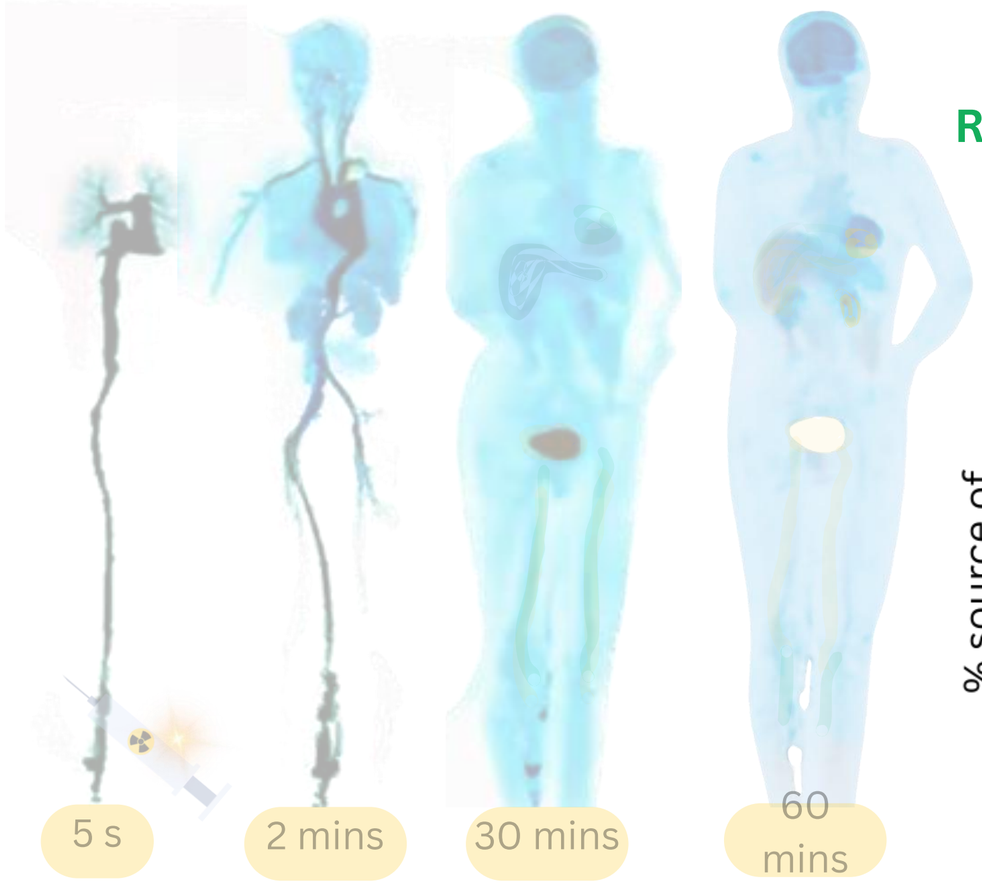


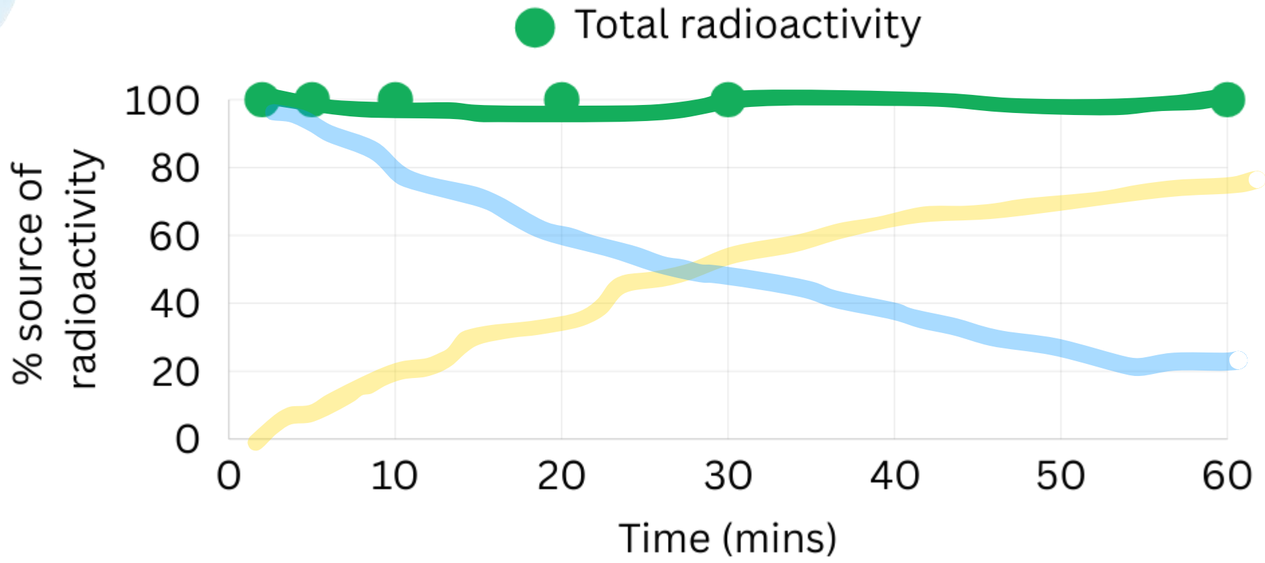
PET scan

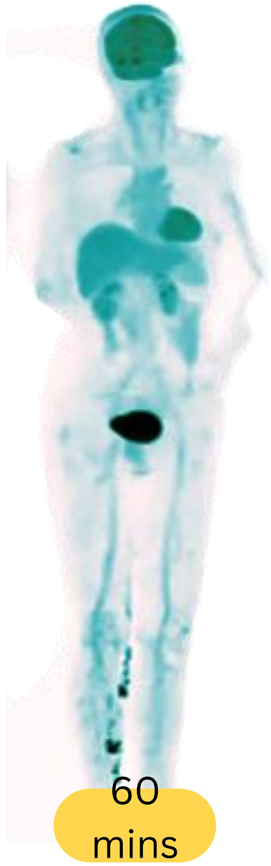
The organs responsible are identifiable in the TBPET scan!



Radiopharmaceutical + **Radiometabolite**

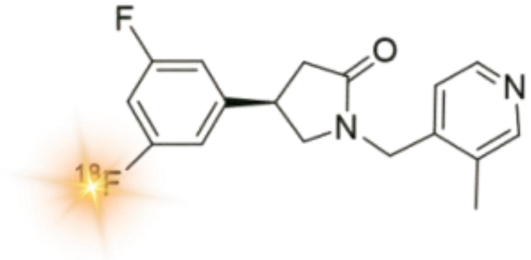


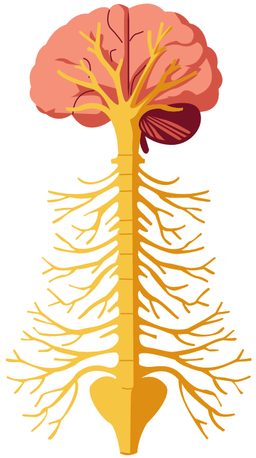


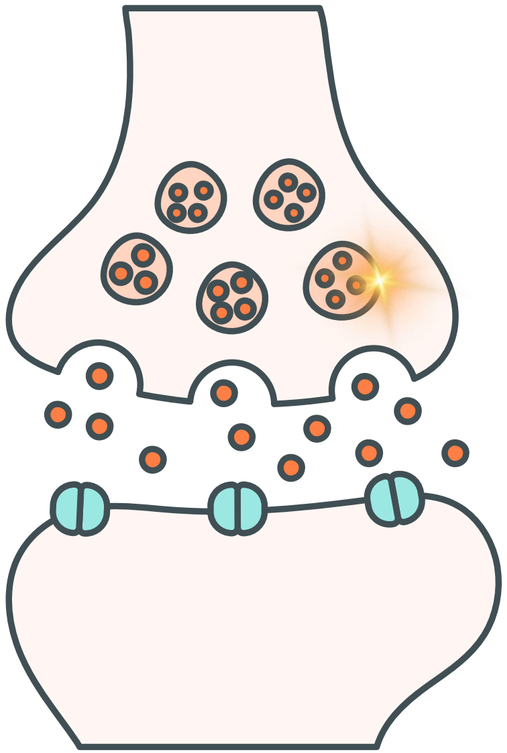


PET scan

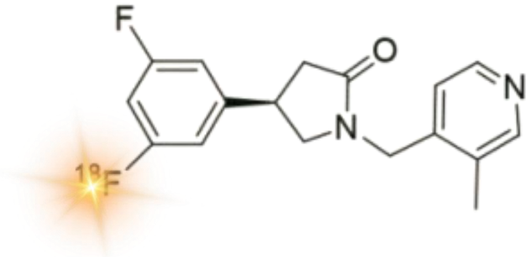
[18F]SynVesT-1 PET

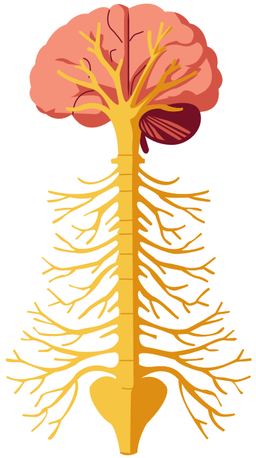


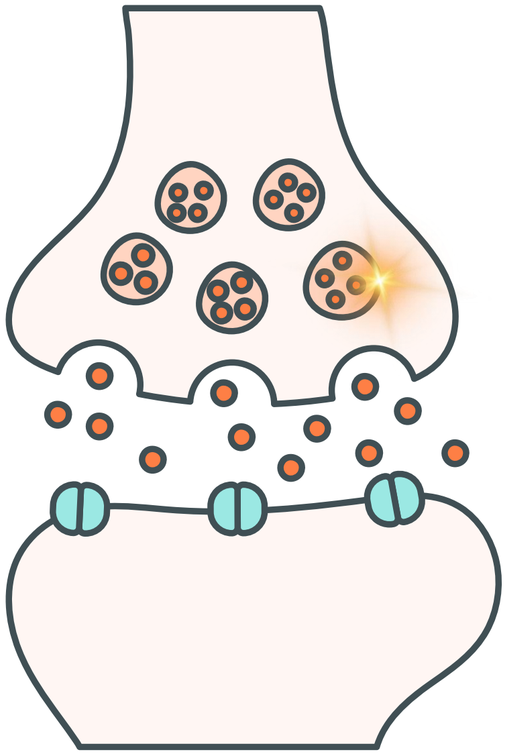


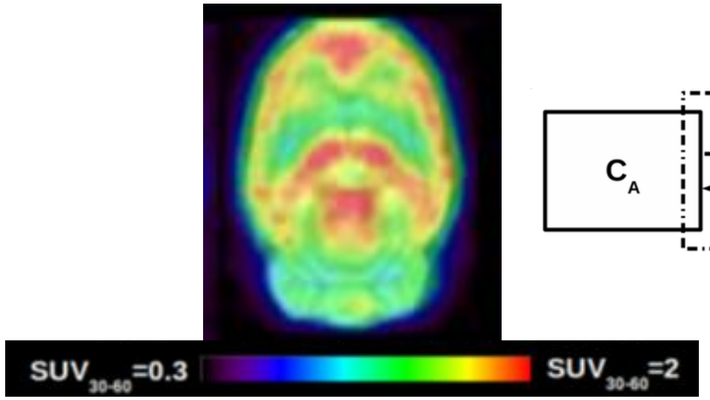


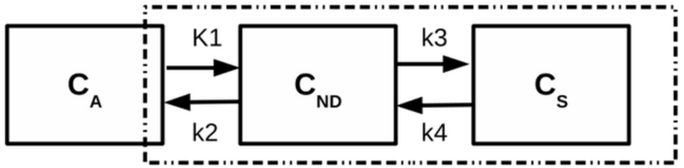
[18F]SynVesT-1 PET









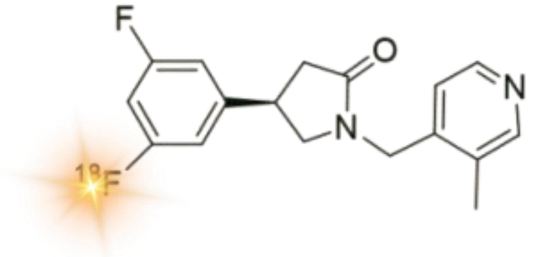


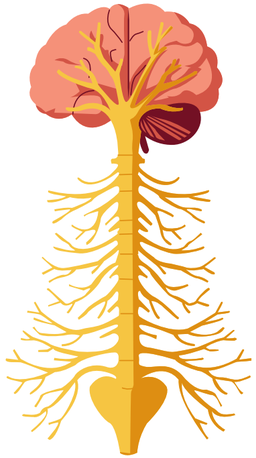
[18F]SynVesT-1 binding in the rat brain quantified

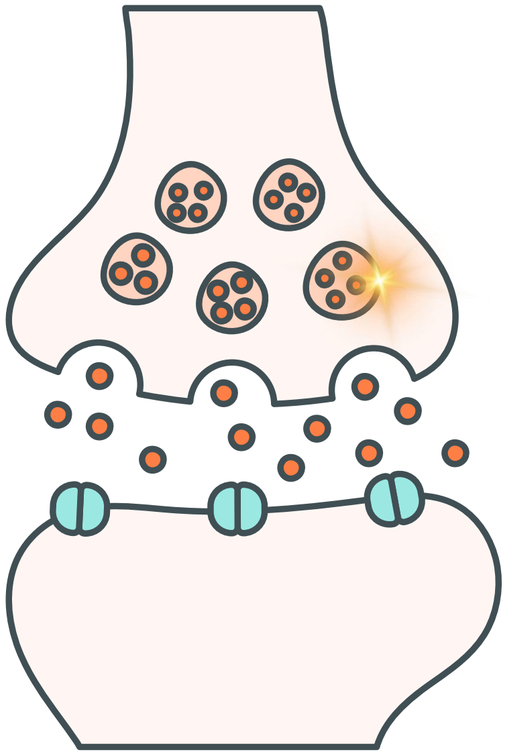
Wimberley et al. 2025 submitted EJNMMI Research

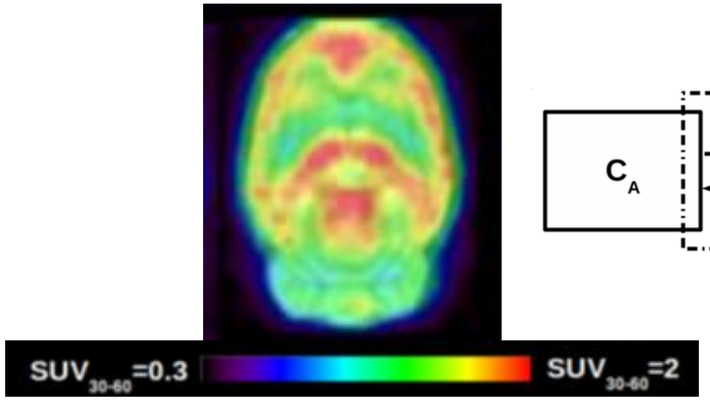
PI: Prof Adriana Tavares, Wellcome Trust grant

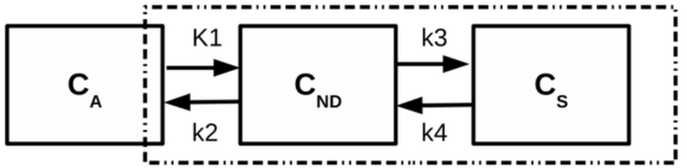
[18F]SynVesT-1 PET







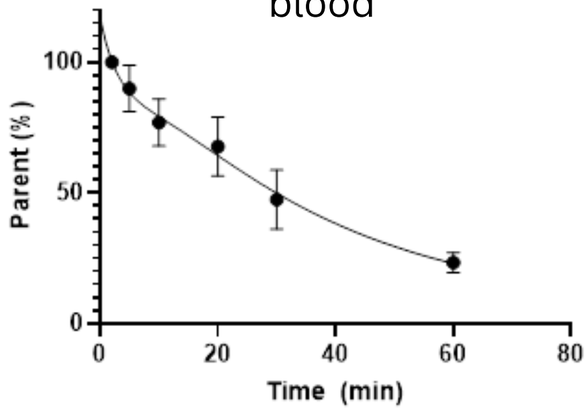




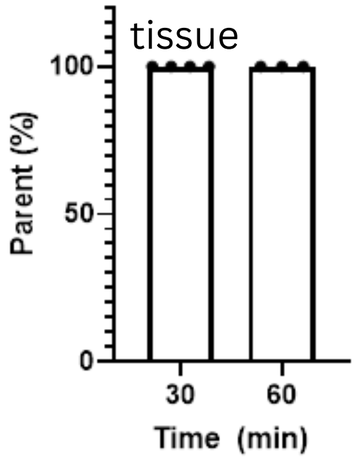
[18F]SynVesT-1 binding in the rat brain quantified

Radioactivty in from true tracer

% in blood



% in brain tissue

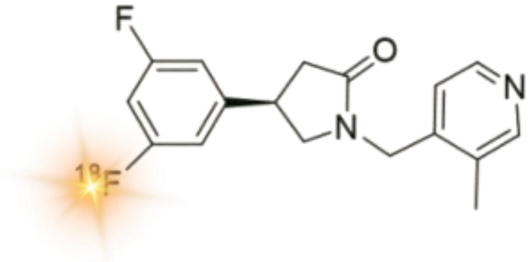


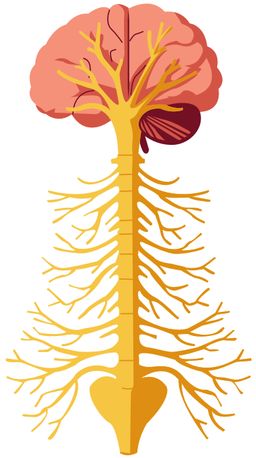
[18F]SynVesT-1 radiometabolites in the rat quantified

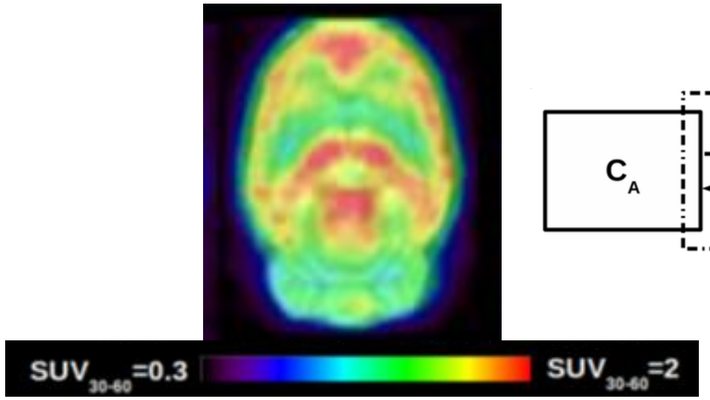
Wimberley et al. 2025 submitted EJNMMI Research

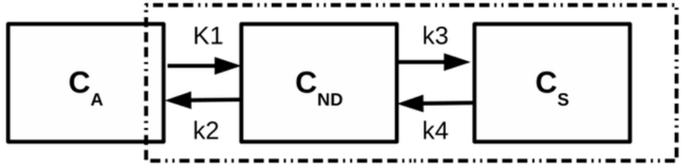
PI: Prof Adriana Tavares, Wellcome Trust grant

[18F]SynVesT-1 PET

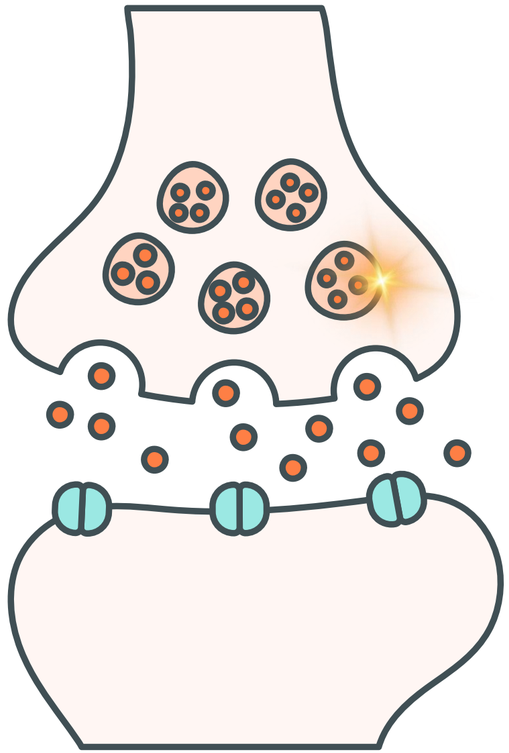


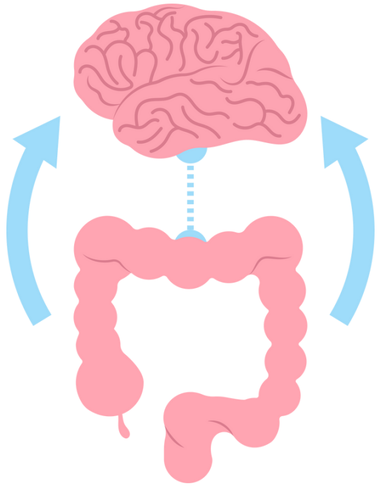






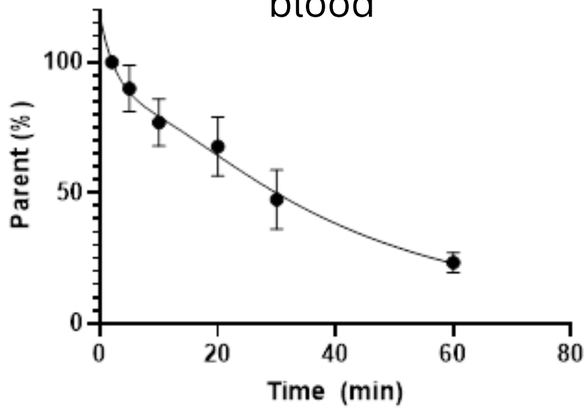
[18F]SynVesT-1 binding in the rat brain quantified



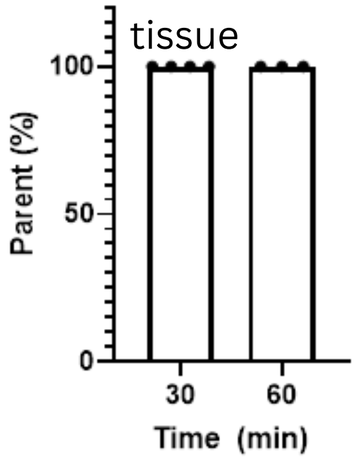


Radioactivty in from true tracer

% in blood



% in brain tissue

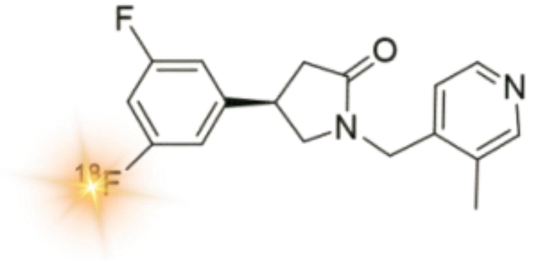


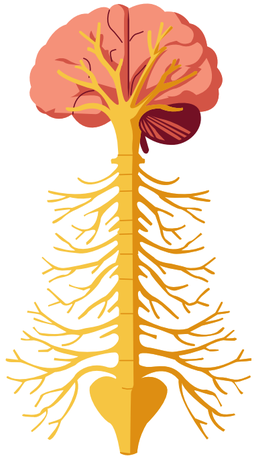
[18F]SynVesT-1 radiometabolites in the rat quantified

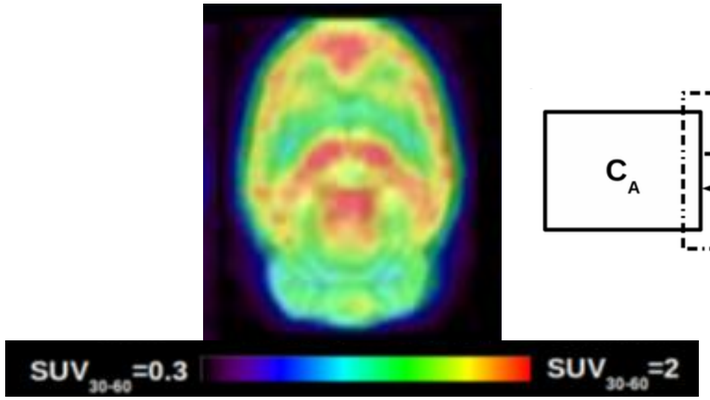
Wimberley et al. 2025 submitted EJNMMI Research

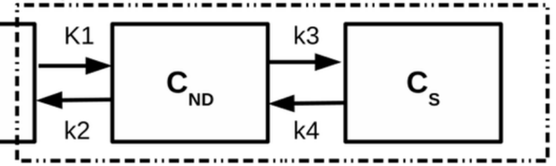
PI: Prof Adriana Tavares, Wellcome Trust grant

[18F]SynVesT-1 PET

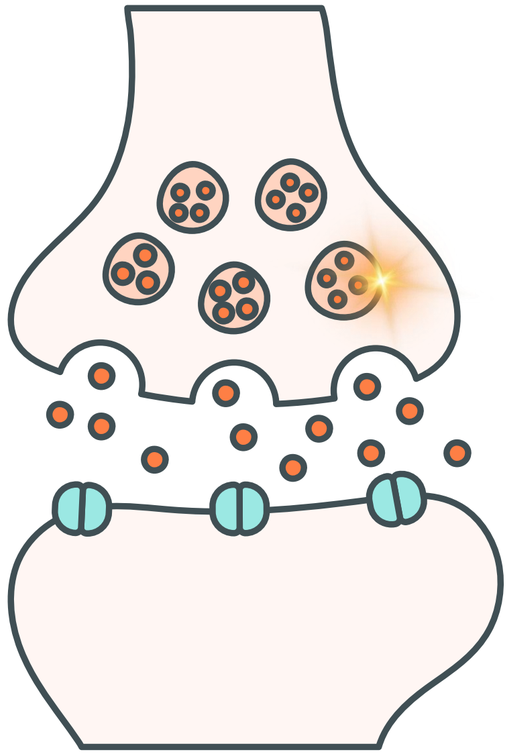


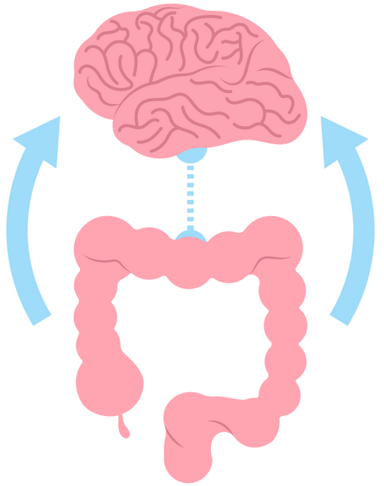


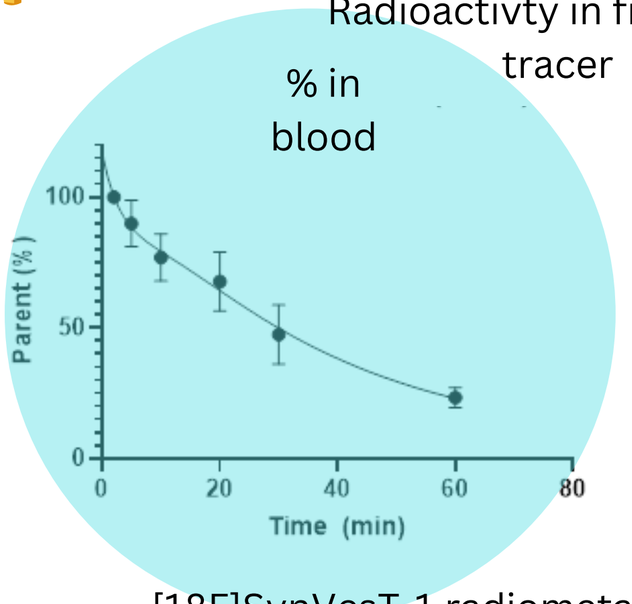


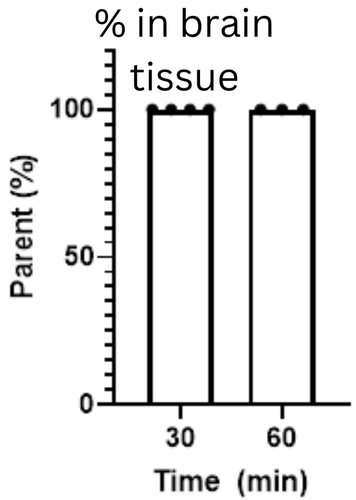


[18F]SynVesT-1 binding in the rat brain quantified









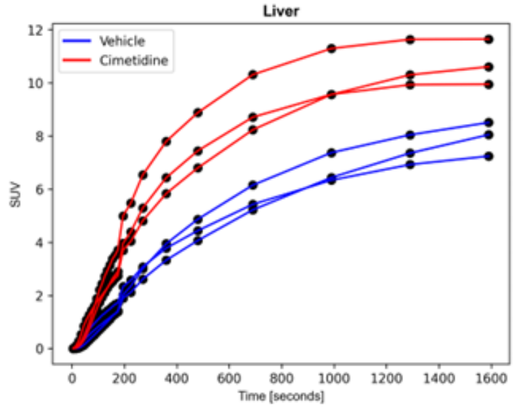
[18F]SynVesT-1 radiometabolites in the rat quantified

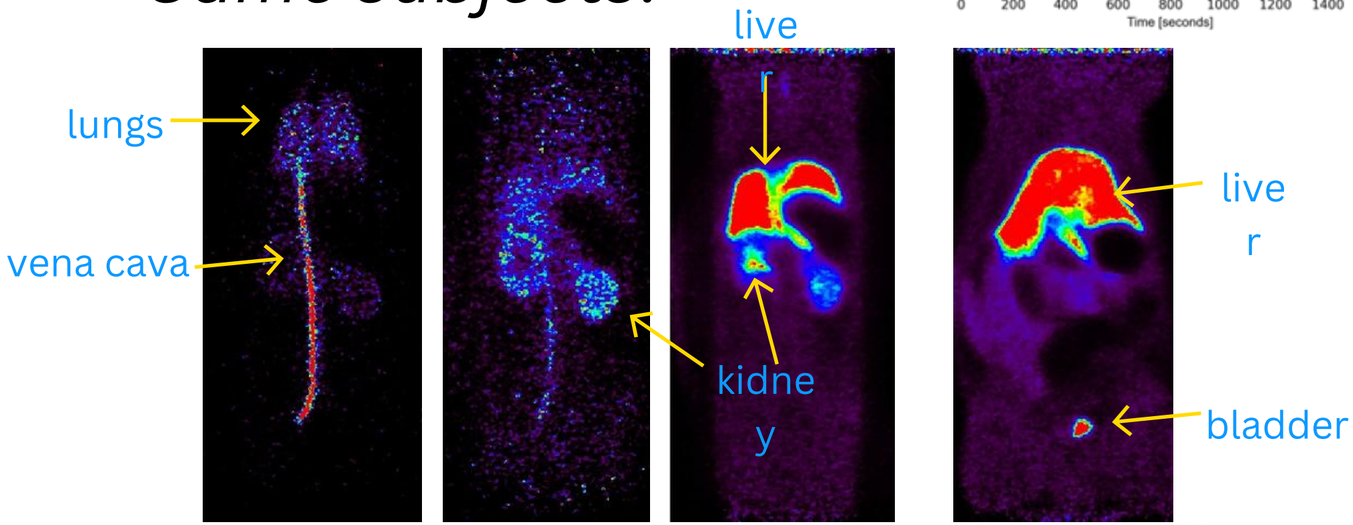
Wimberley et al. 2025 submitted EJNMMI Research

PI: Prof Adriana Tavares, Wellcome Trust grant

Data collection PET and radiometabolites for [18F]SynVesT-1

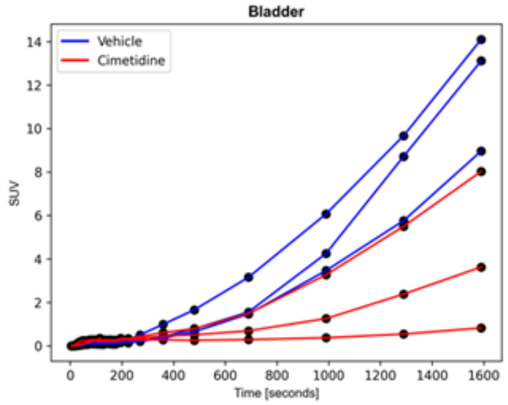
Same subjects!



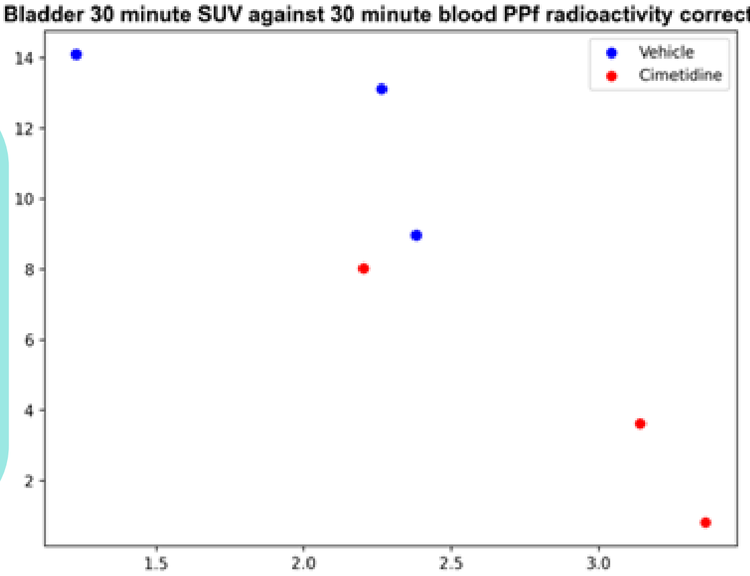


0-0.5 mins | 2.5-3 mins | 25-30 mins | 25-30 mins (different slice)

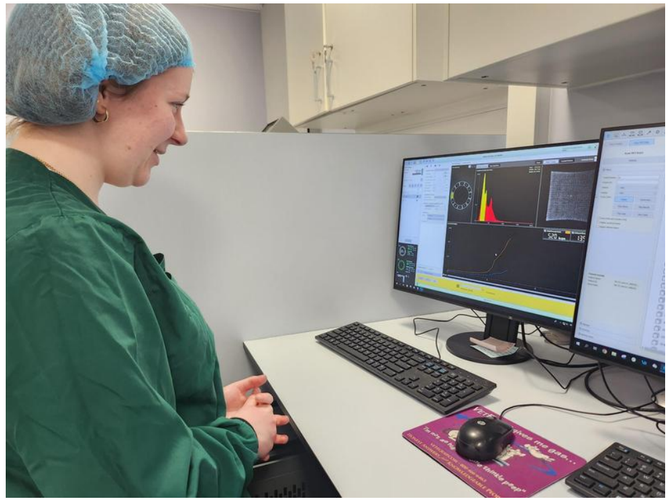
PET scan of a rat



Bladder PET sigfnal at 30 mins



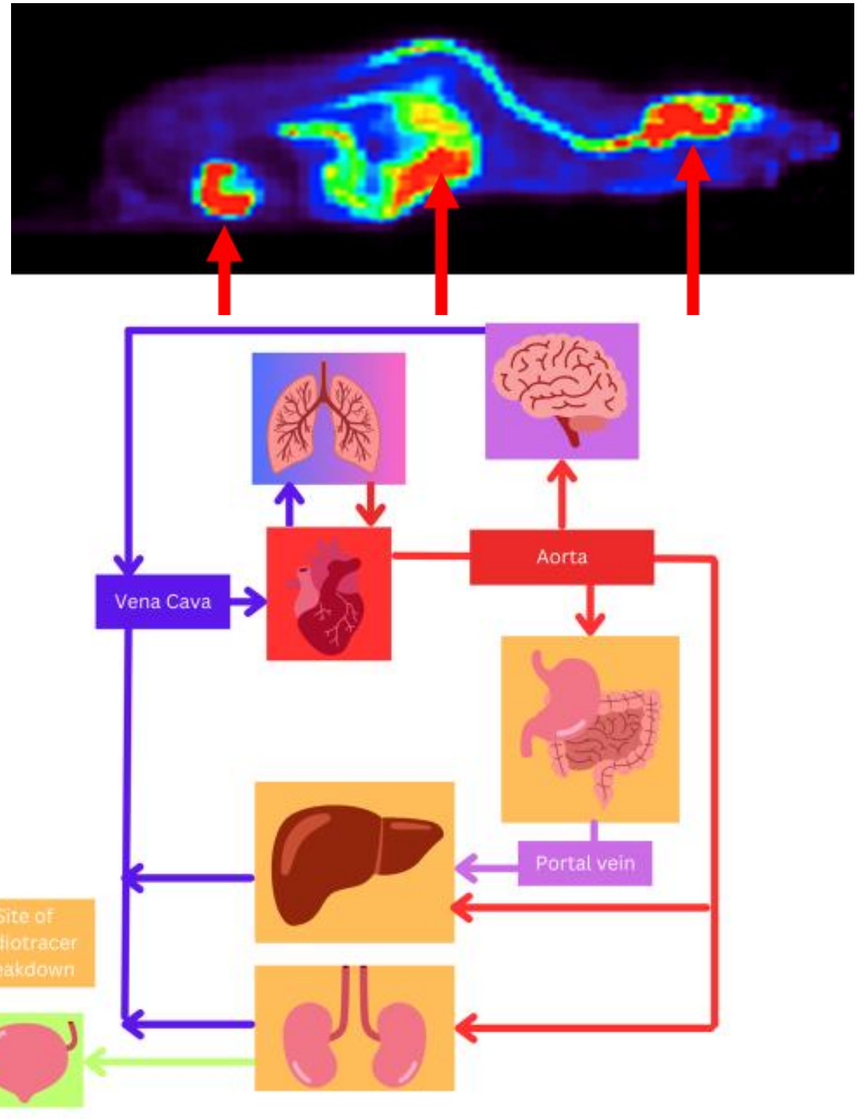
Radiometabolites at 30 mins measured with radio High Performance Liquid Chromatography

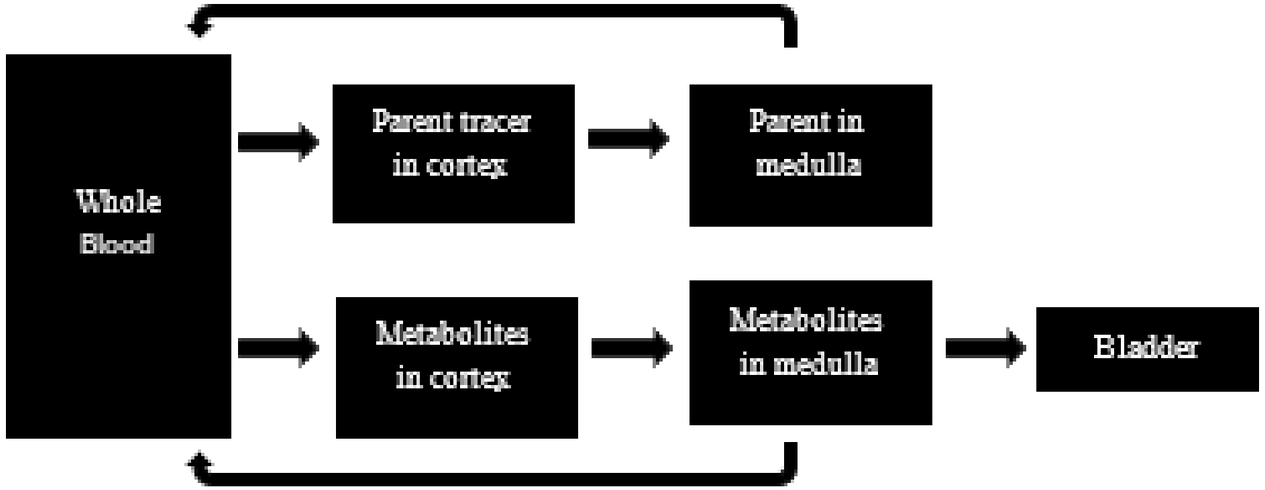


Bea Andrews, PhD student
Collaboration with PET is Wonderful group

Next steps: develop models and correction techniques

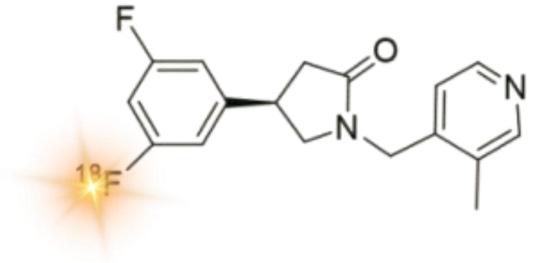
PhD work of Bea Andrews

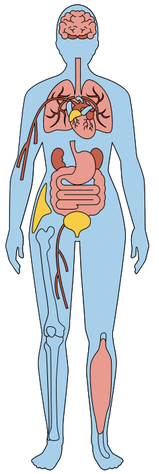




Fit models to PET data for rate of radiotracer breakdown and radiometabolite elimination - validate against measured radiometabolites

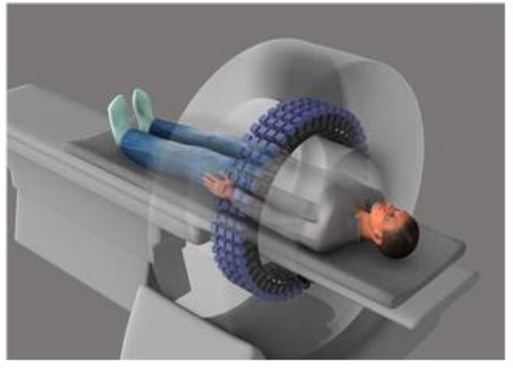
and then translate to human

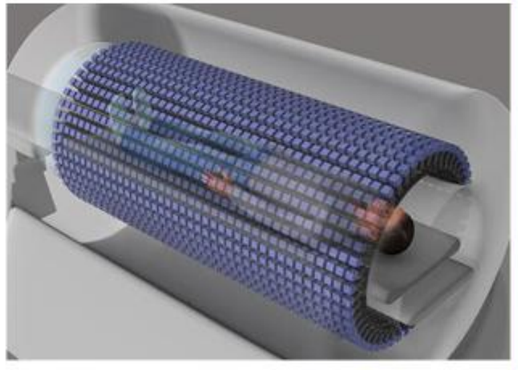




State of the art scanner:

Standard PET





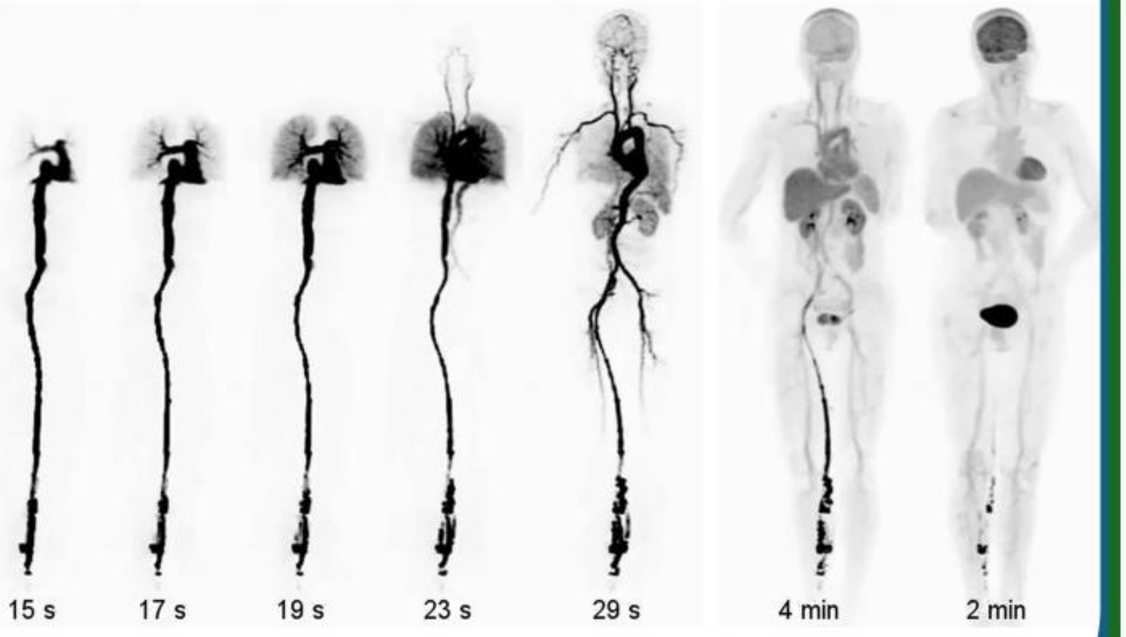
Total-body PET

Image: Prof Simon Cherry, UC Davis

Total-body PET scan

Standard PET (20-30cm)

Time

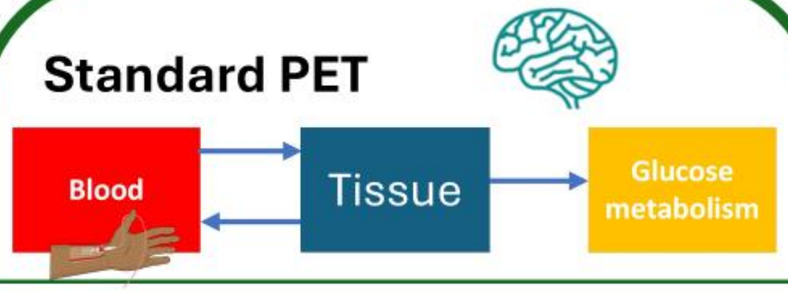


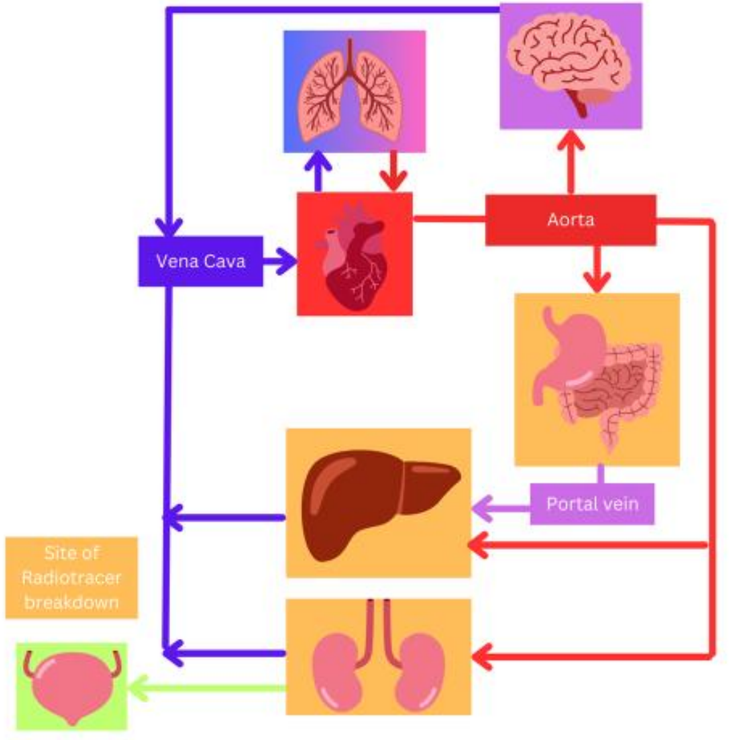
Total-body PET (100-200 cm)

Badawi et al., First Human Imaging Studies with the EXPLORER Total-Body PET Scanner, JNM 2019

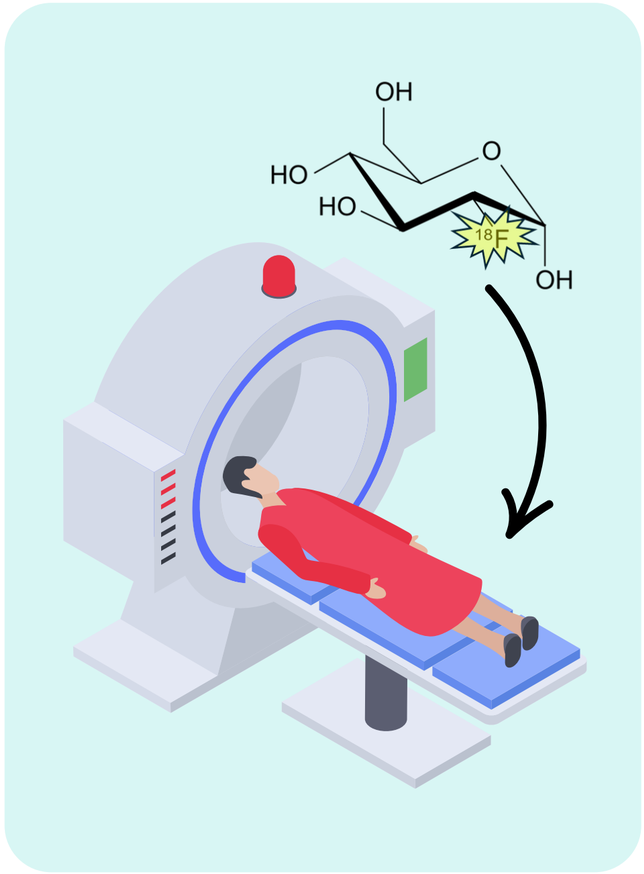
Total-body biomarkers

Standard PET

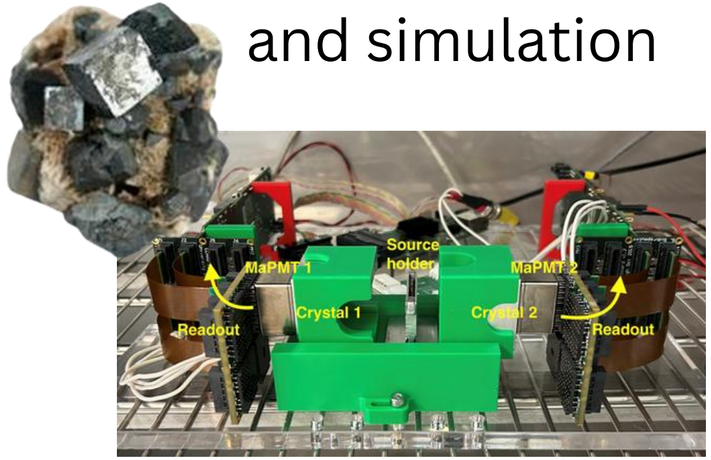


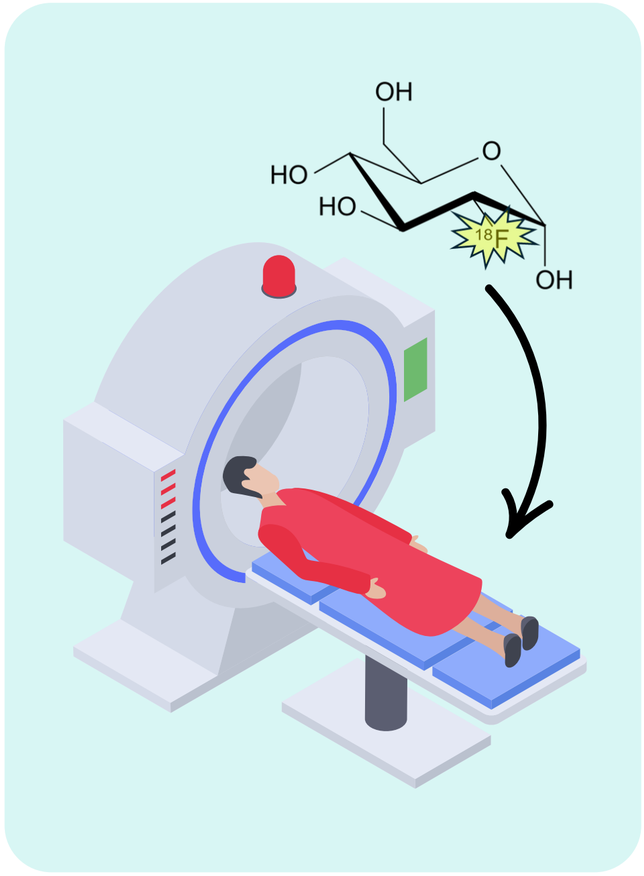


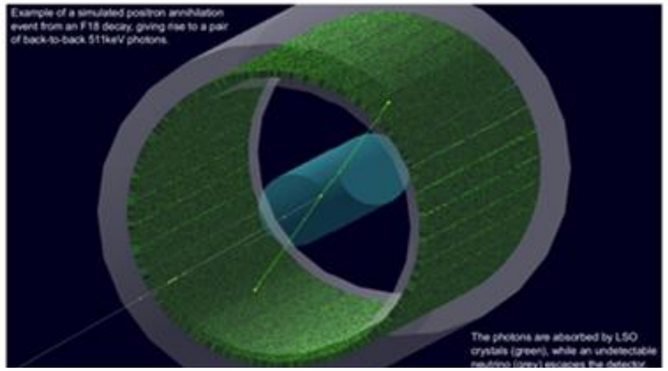
Total-body PET


OH
HO
HO
O
18F
OH

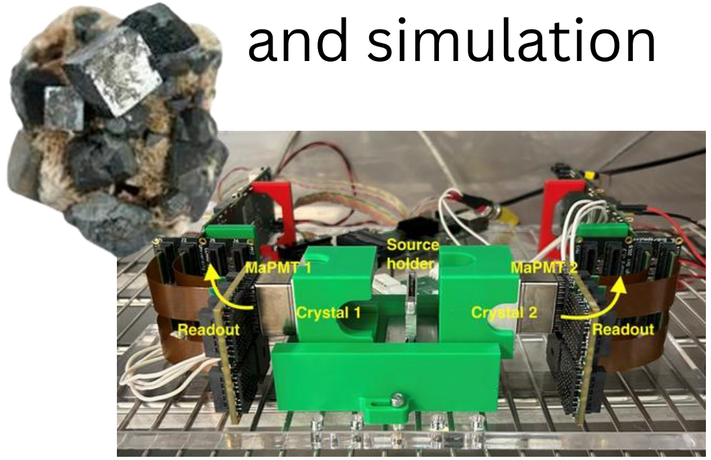
Detector development and simulation

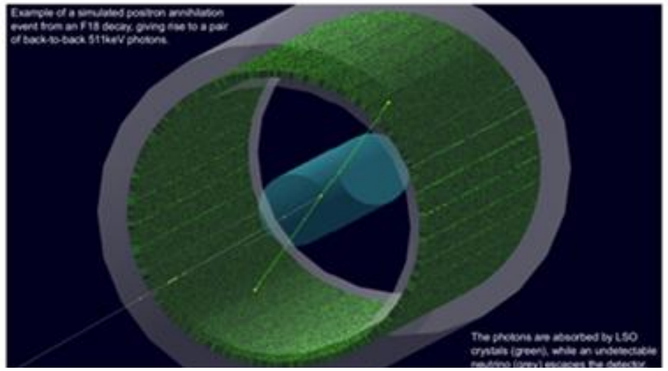






Detector development and simulation





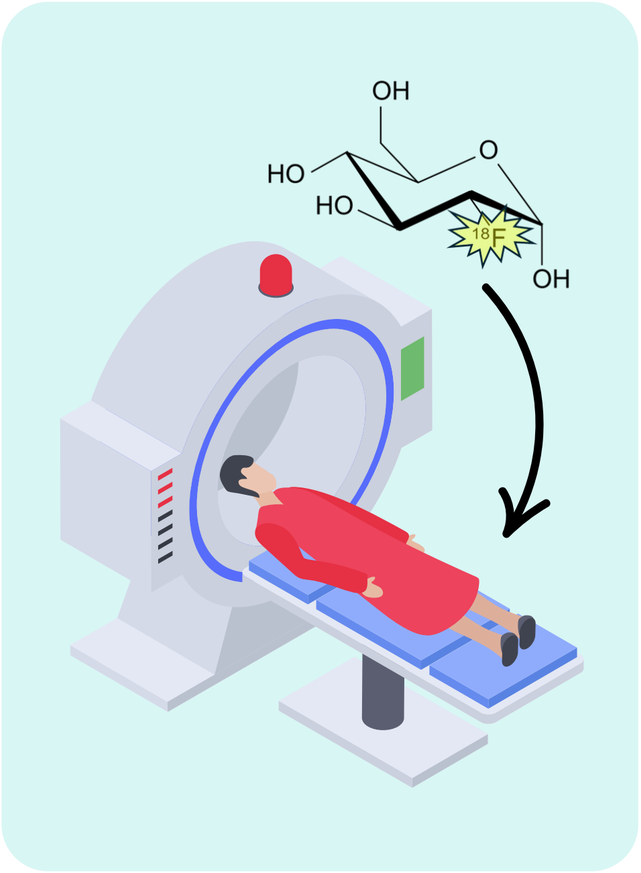
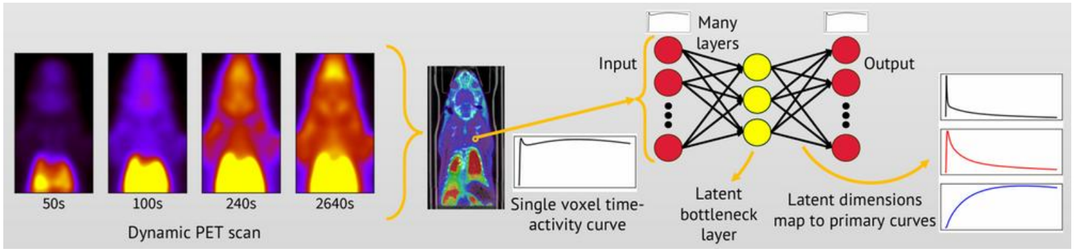
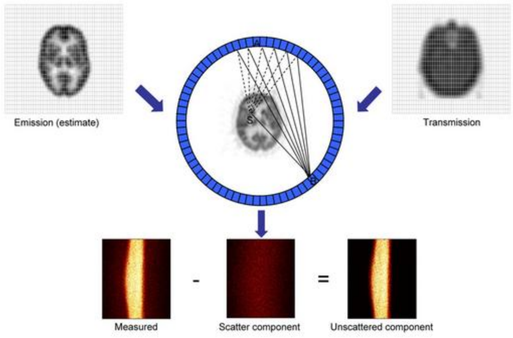
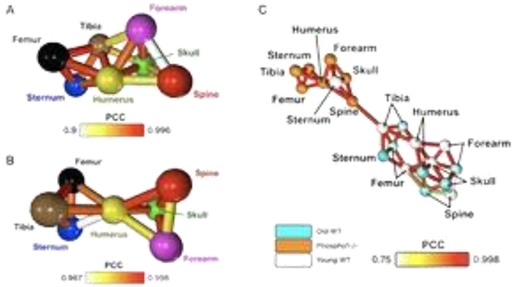
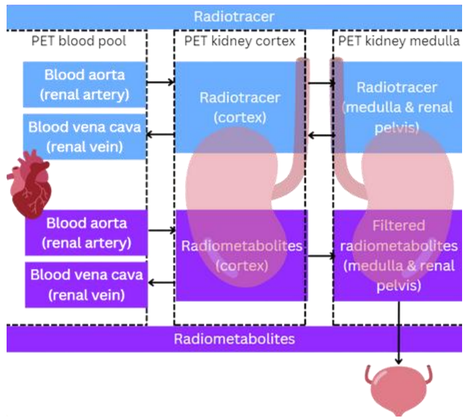


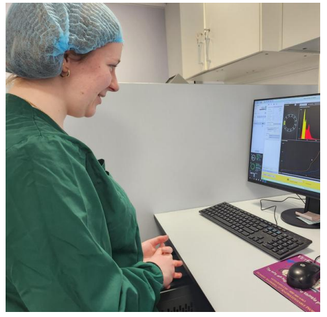
Image reconstruction, correction, analysis and modelling











Excellent colleagues, collaborators and acknowledgements

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Prof Paul Clegg
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Bea Andrews
Prof Franz Muheim
Dr Matt Needham
Dr Hanna Borecka Bielska
Dr Ben Wynne
Aparna Jayaraj
Robbie Haynes

Particle Physics Experiment group

Queens Medical Research Institute

Edinburgh Imaging QMRI

- Scanning facility
- NHS radiographers
- Radiologists
- Clinical physicists: inc. Michelle Rooney
- MRI research physicists
- Cardiologists, neurologists and biologists
- Prof Adriana Tavares & the PET is Wonderful group

THE UNIVERSITY of EDINBURGH
Centre for Cardiovascular Science

Edinburgh Imaging
www.ed.ac.uk/edinburgh-imaging

NHS Lothian

KING'S College LONDON

THE UNIVERSITY of EDINBURGH
Edinburgh Neuroscience

CCBS
Centre for Clinical Brain Sciences

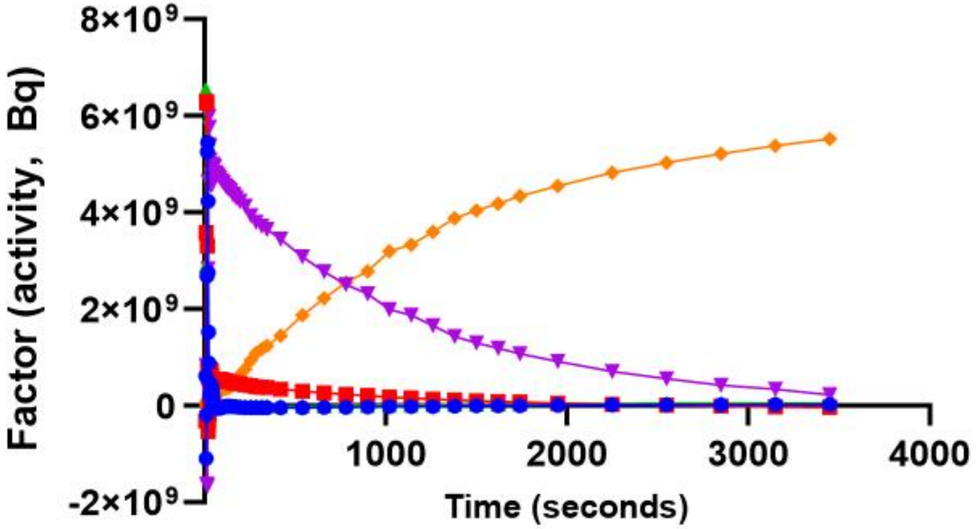
SINAPSE

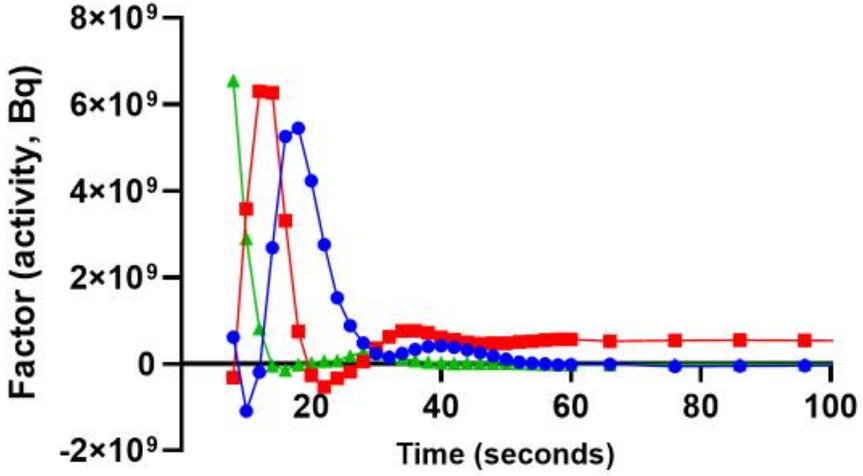
wellcome

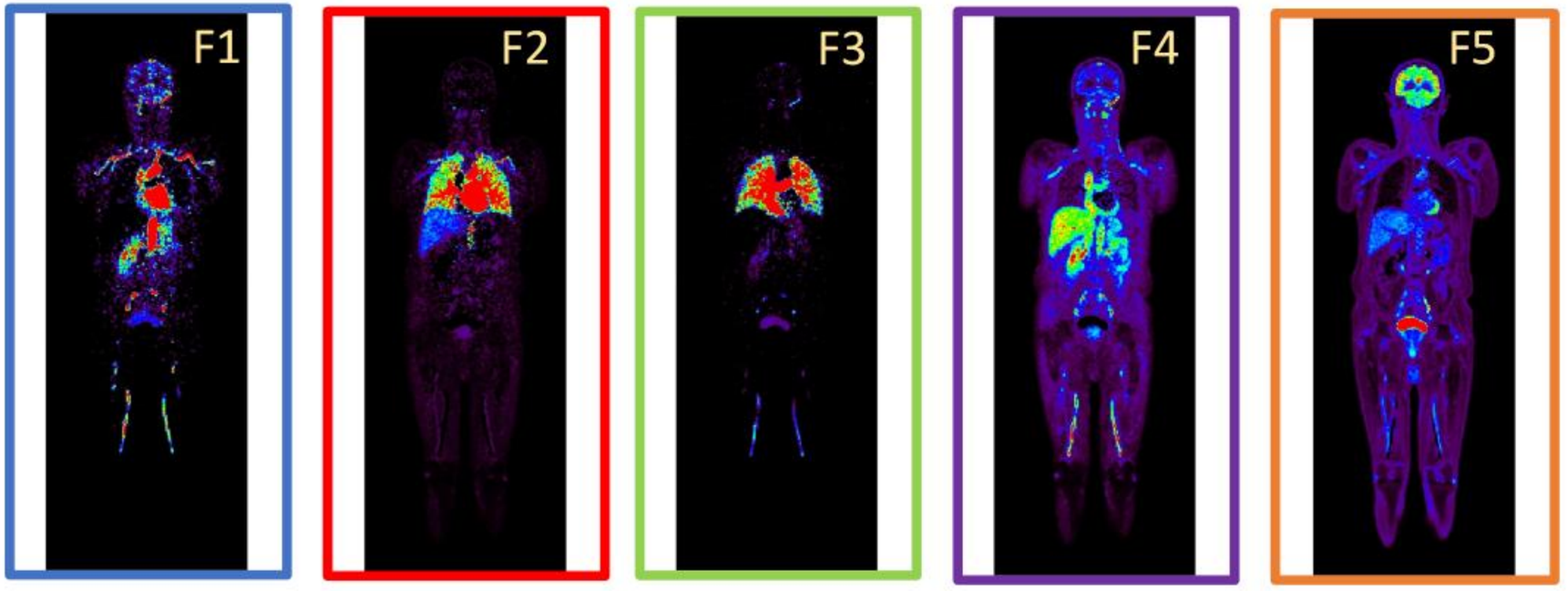
PET is Wonderful

British Heart Foundation

Results: factor curves and images

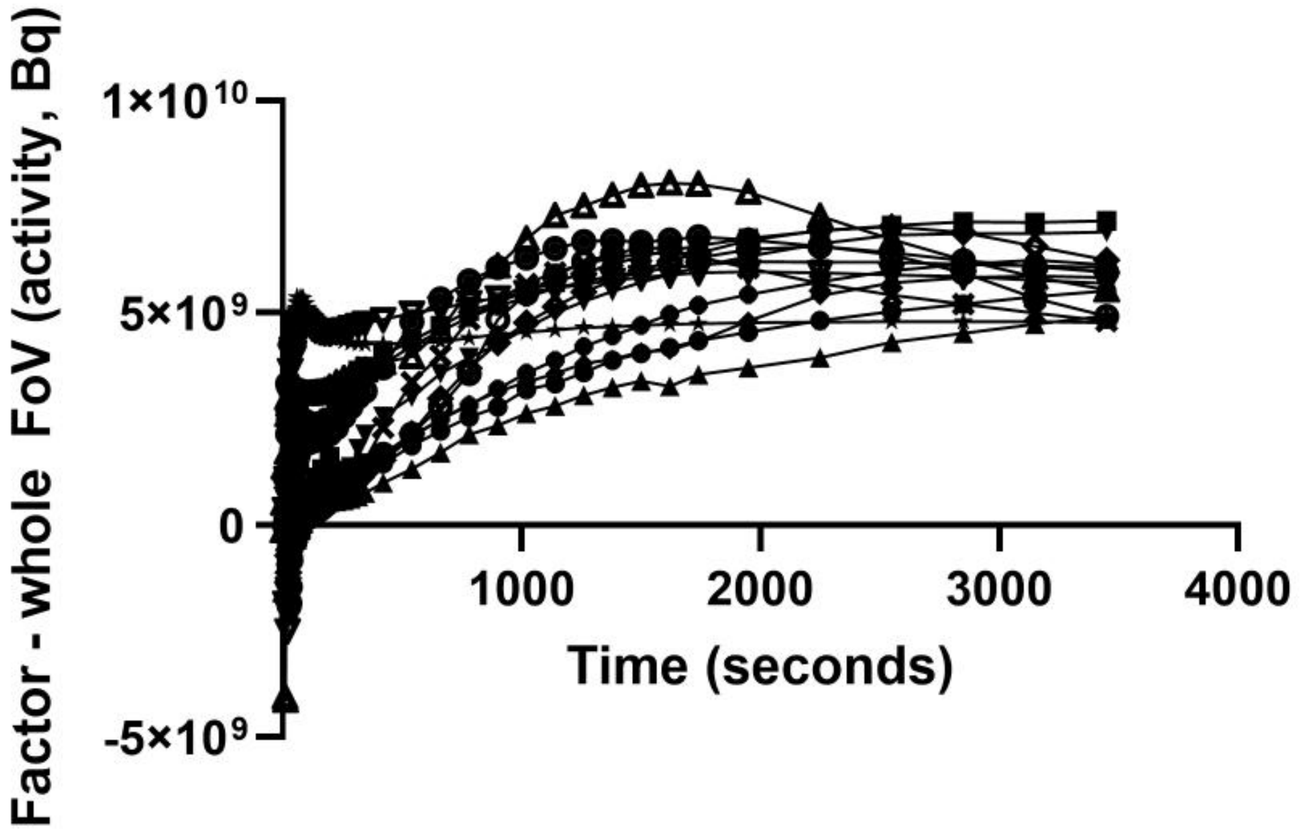


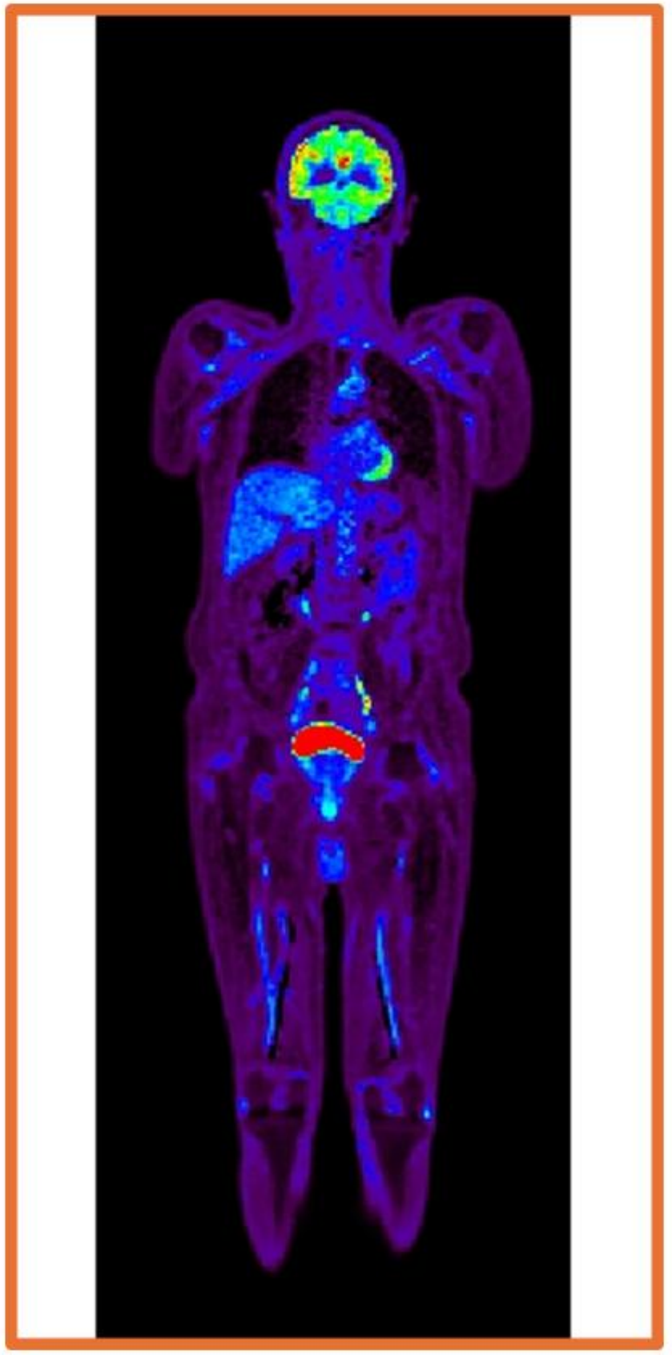




Factor curves, metabolism

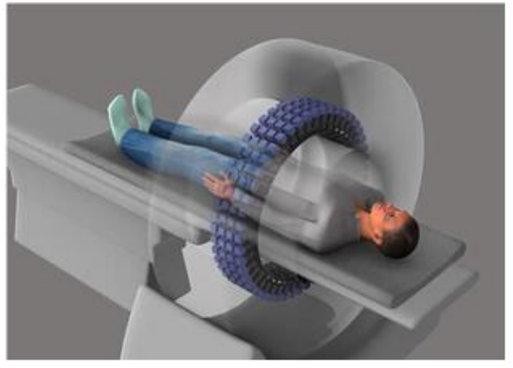
– all subjects – whole FoV

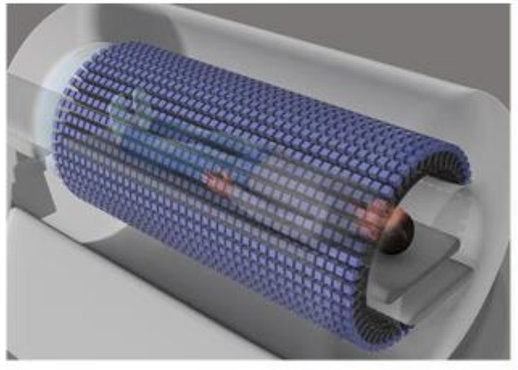




State of the art scanner:

Standard PET





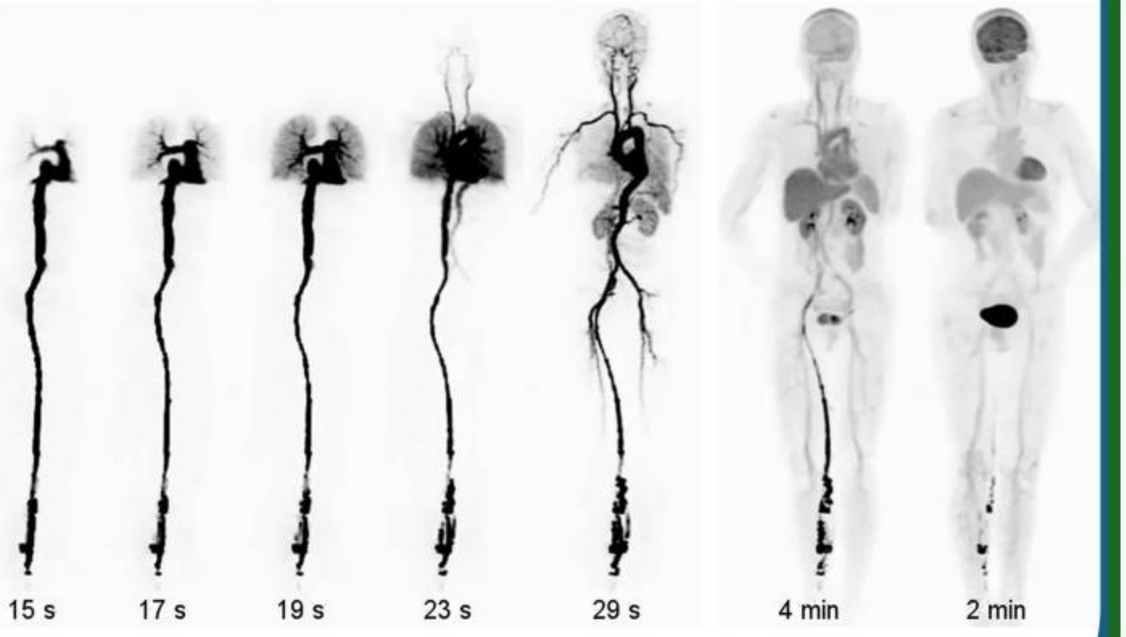
Total-body PET

Image: Prof Simon Cherry, UC Davis

Total-body PET scan

Standard PET (20-30cm)

Time

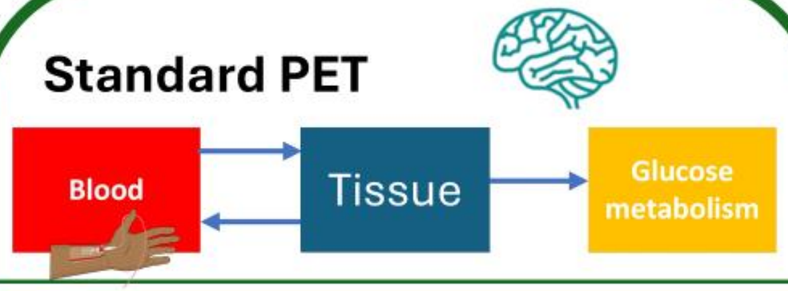


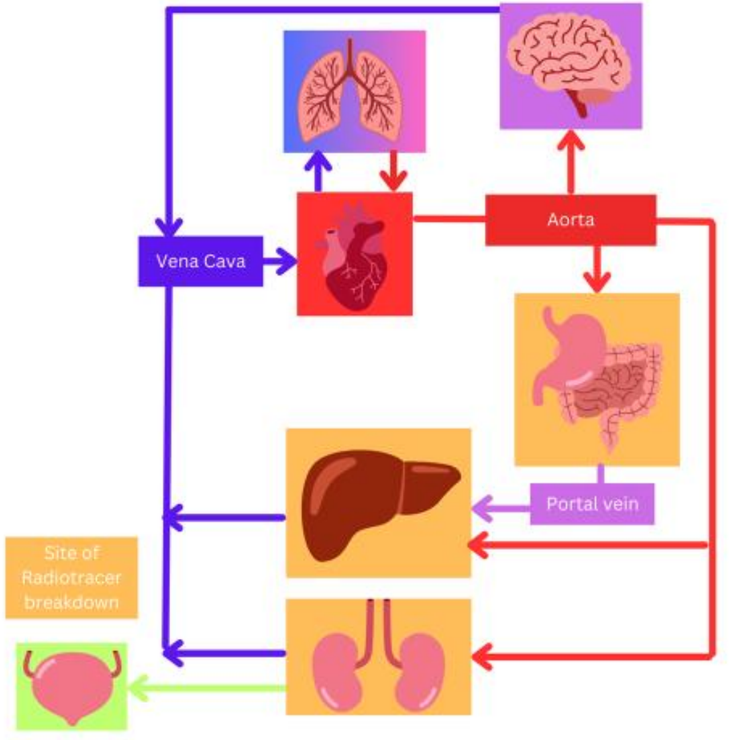
Total-body PET (100-200 cm)

Badawi et al., First Human Imaging Studies with the EXPLORER Total-Body PET Scanner, JNM 2019

Total-body biomarkers

Standard PET





Total-body PET

Simulation platform for optimization & development test bed

Simulations of organ/pathology TACs (kinetic models)

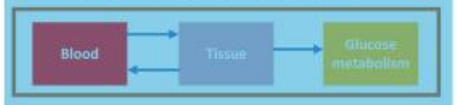
4D total body phantom

Simulation of scanner geometry using Geant4

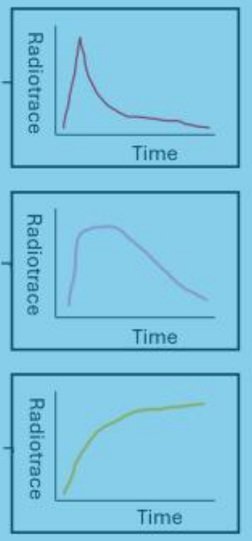
Develop, test & optimize reconstruction methods

Develop, test & optimize signal separation techniques

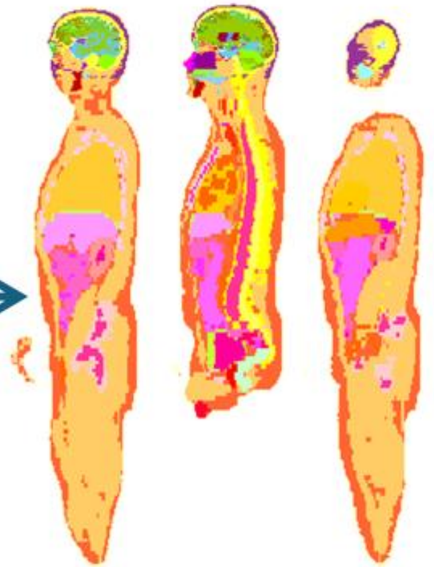
Radiotracer 1

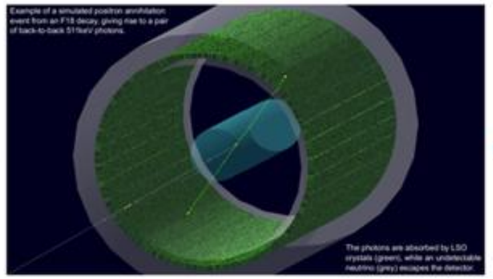


Radiotracer 2

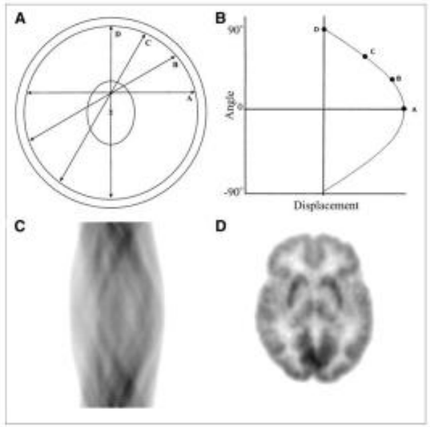


Ground truth



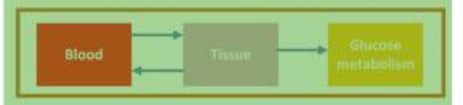


- **+++faster than GATE and getting faster!**
- **Lower disk space**
- **Can run on a laptop**

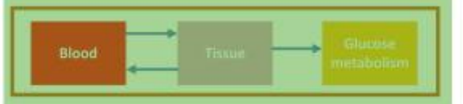


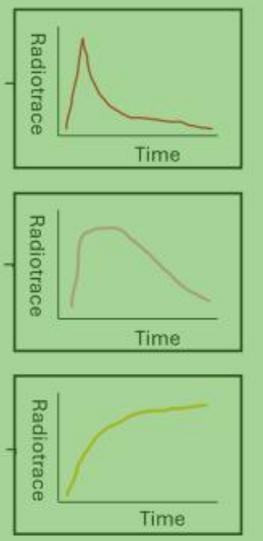
Plenty of room for ML & AI developments

Radiotracer 1



Radiotracer 2





Simulation output

Compare & optimize