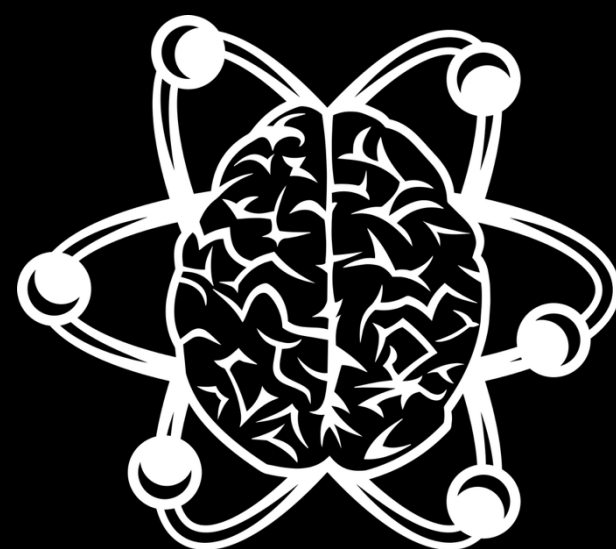
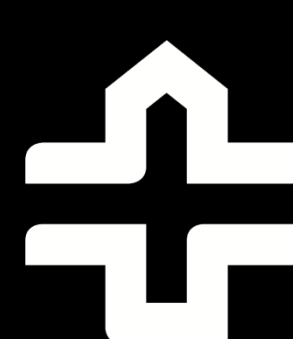




IMAGING WHOLE-BODY BIOLOGICAL CIRCUITS WITH TOTAL-BODY PET

Turku PET Centre Brain Imaging Course 2026

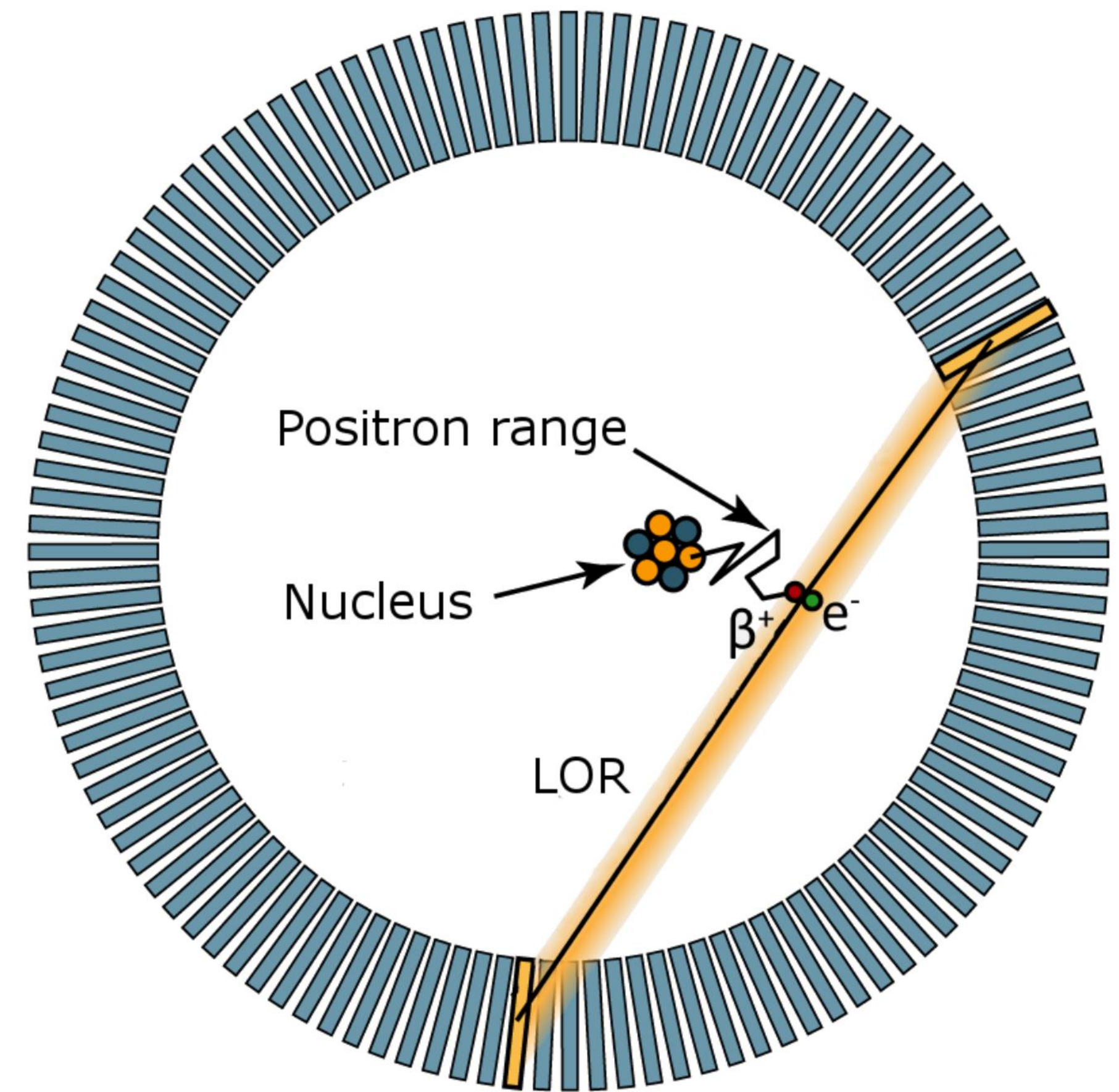
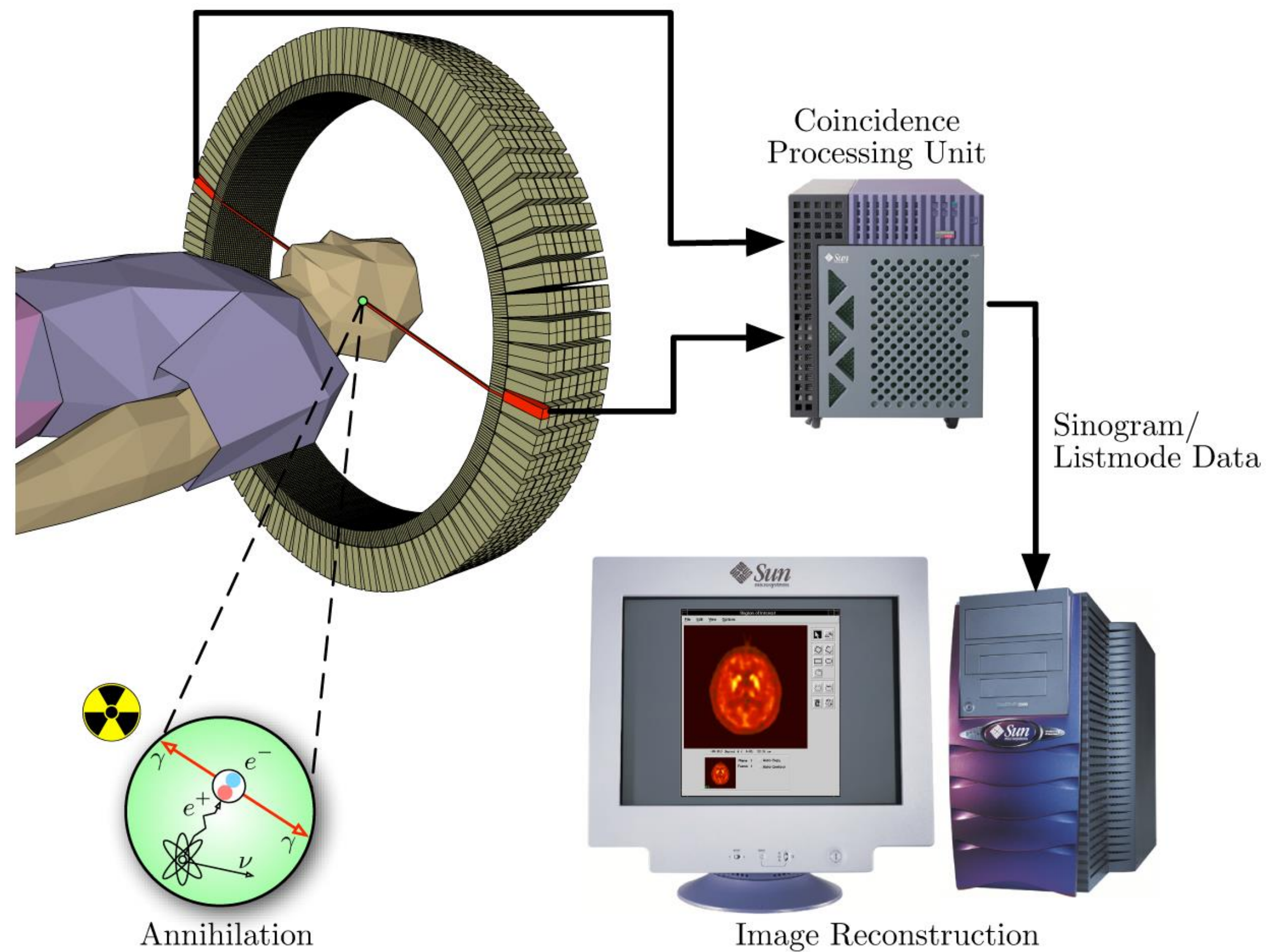
Lauri Nummenmaa, Turku PET Centre



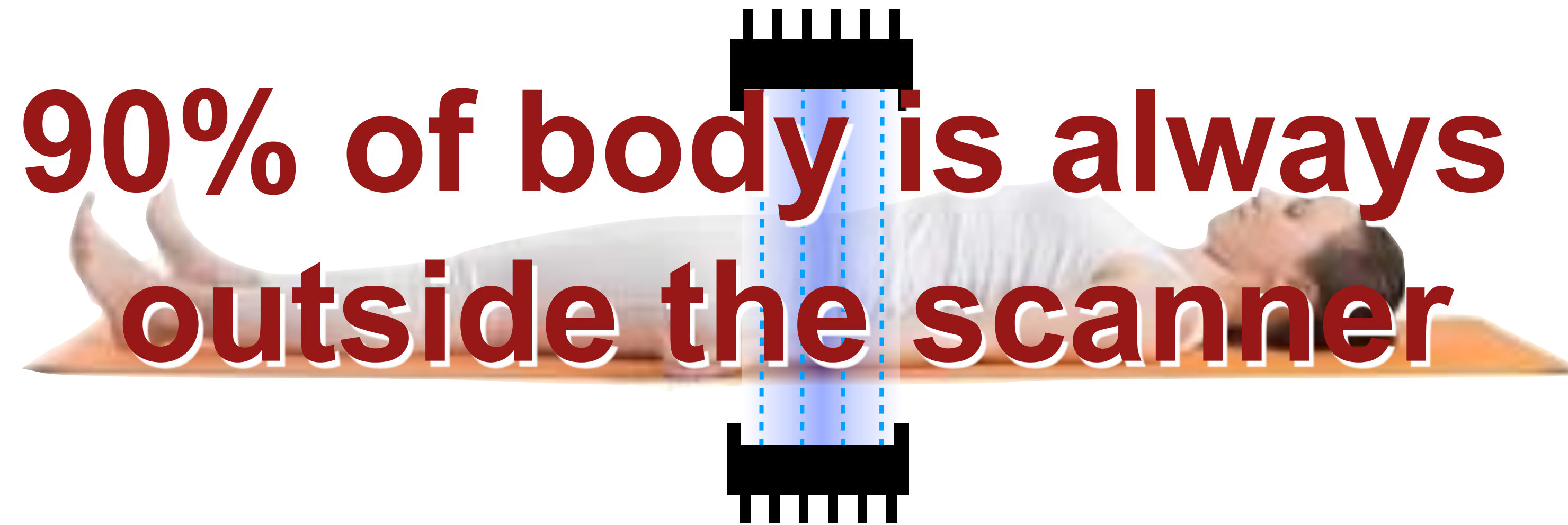
PET is great because...

- ...it has high biological specificity
- ...its targets are limited only by physics and the imagination of the radiochemists
- ...unlike MRI, it provides truly quantitative measurements

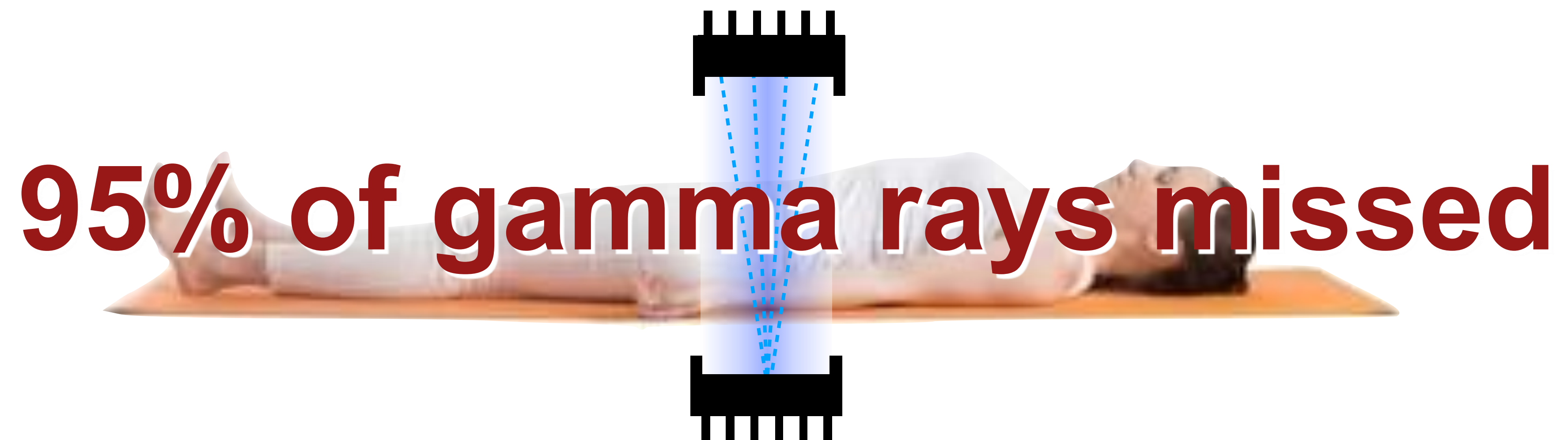
Why conventional PET sucks?

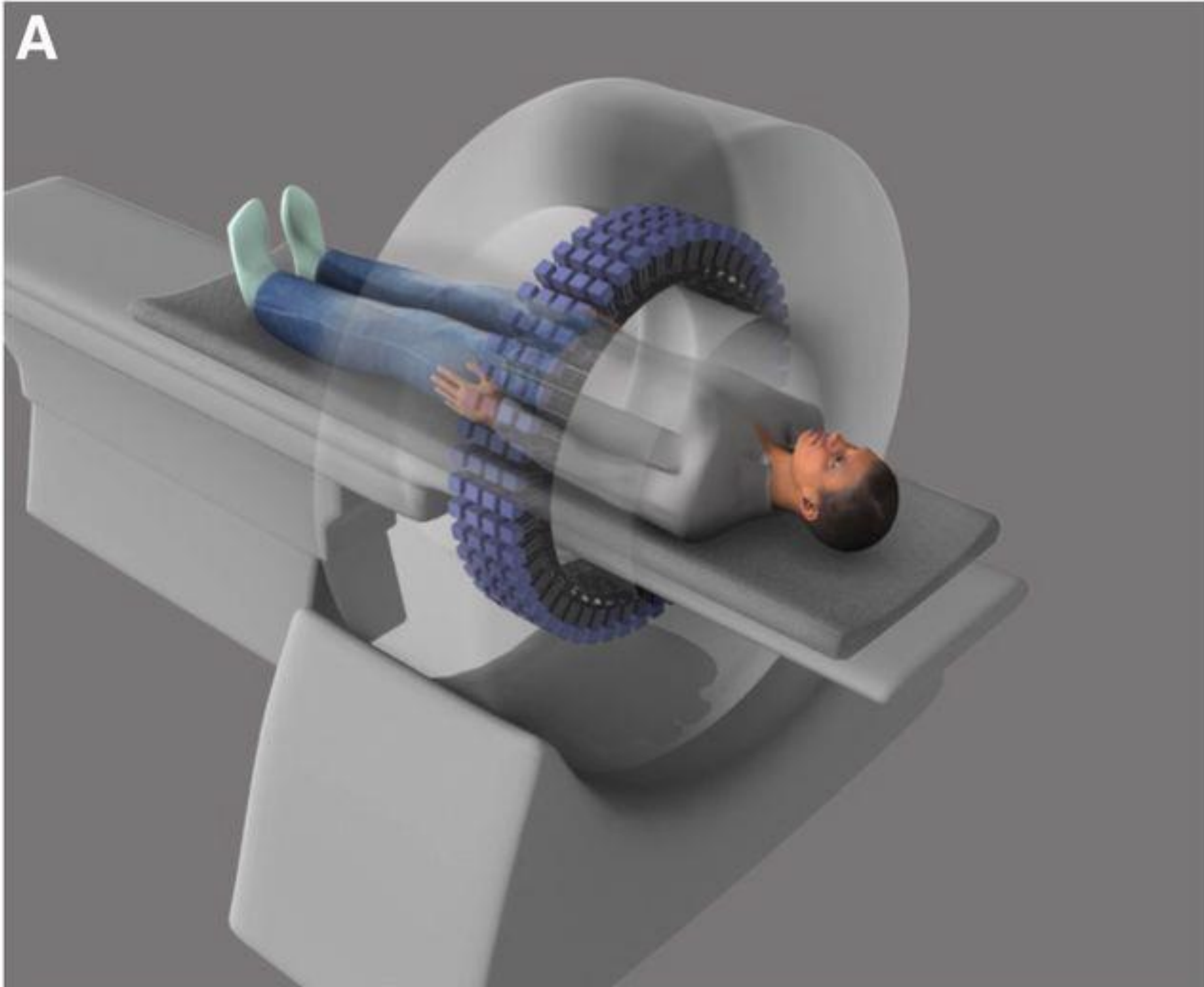


A) Linear lines of response

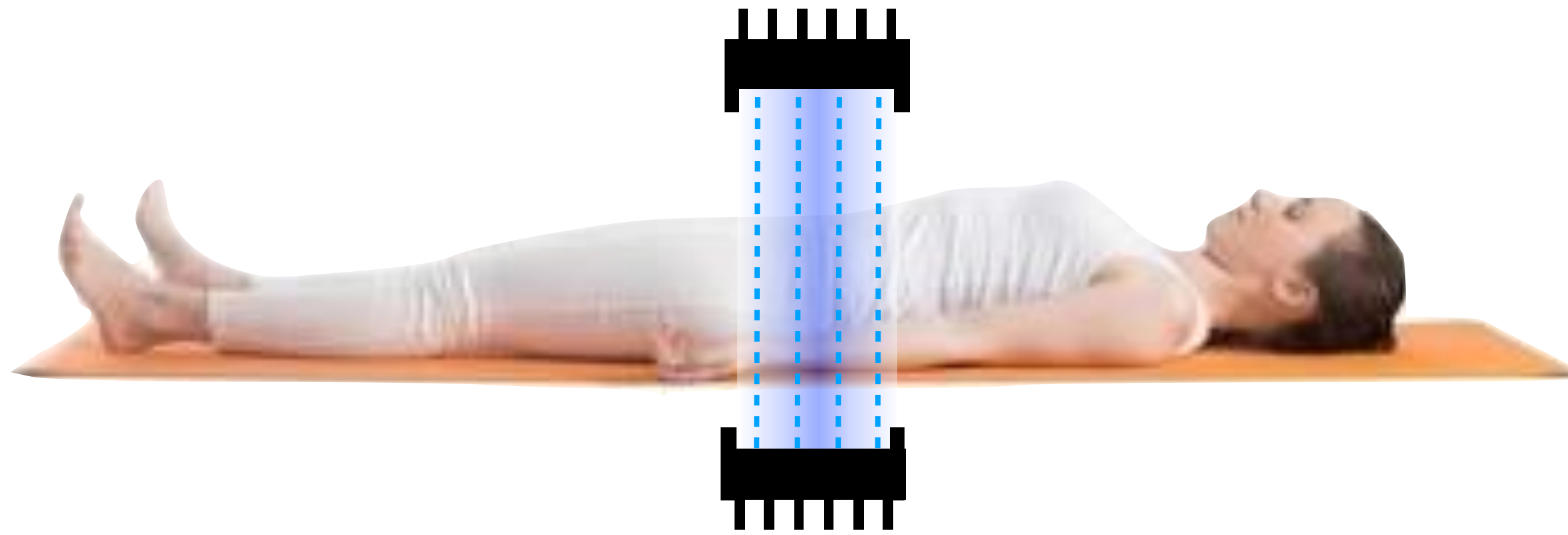


B) Angular lines of response

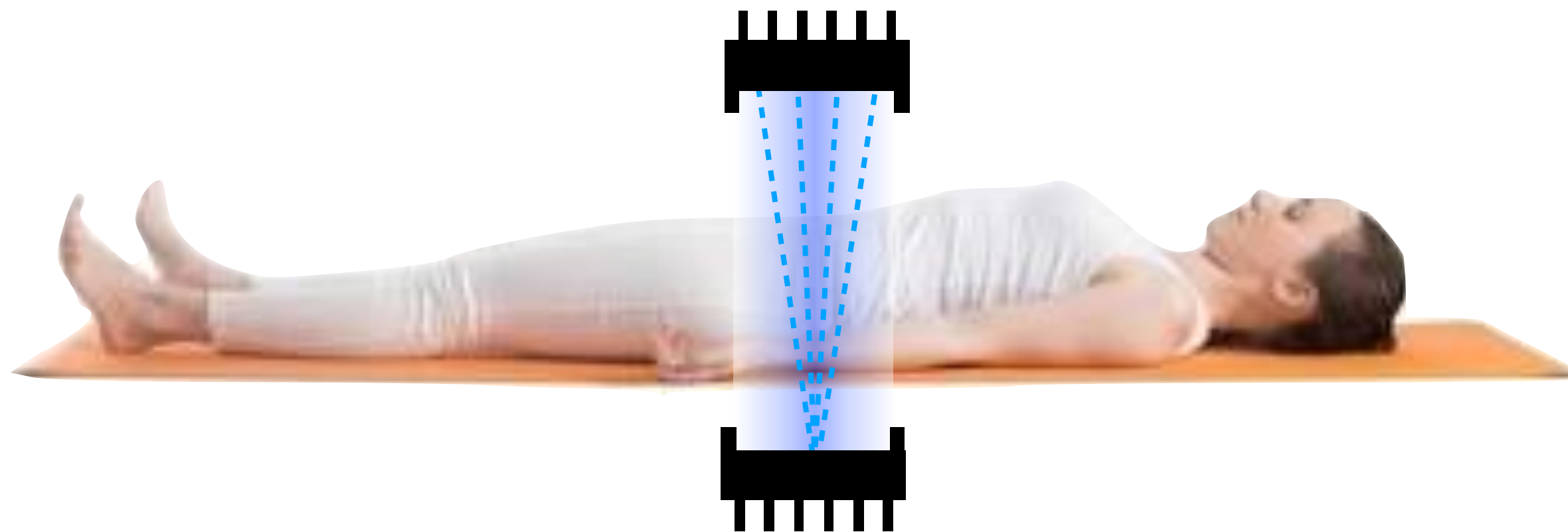




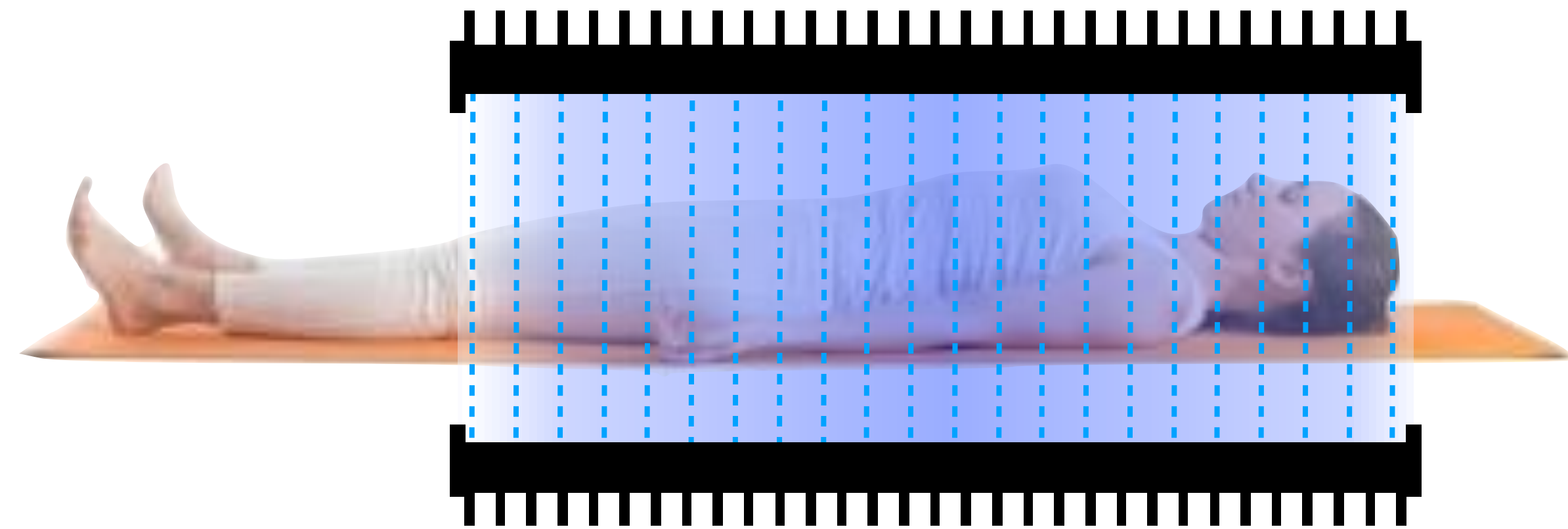
A) Conventional PET: linear lines of response



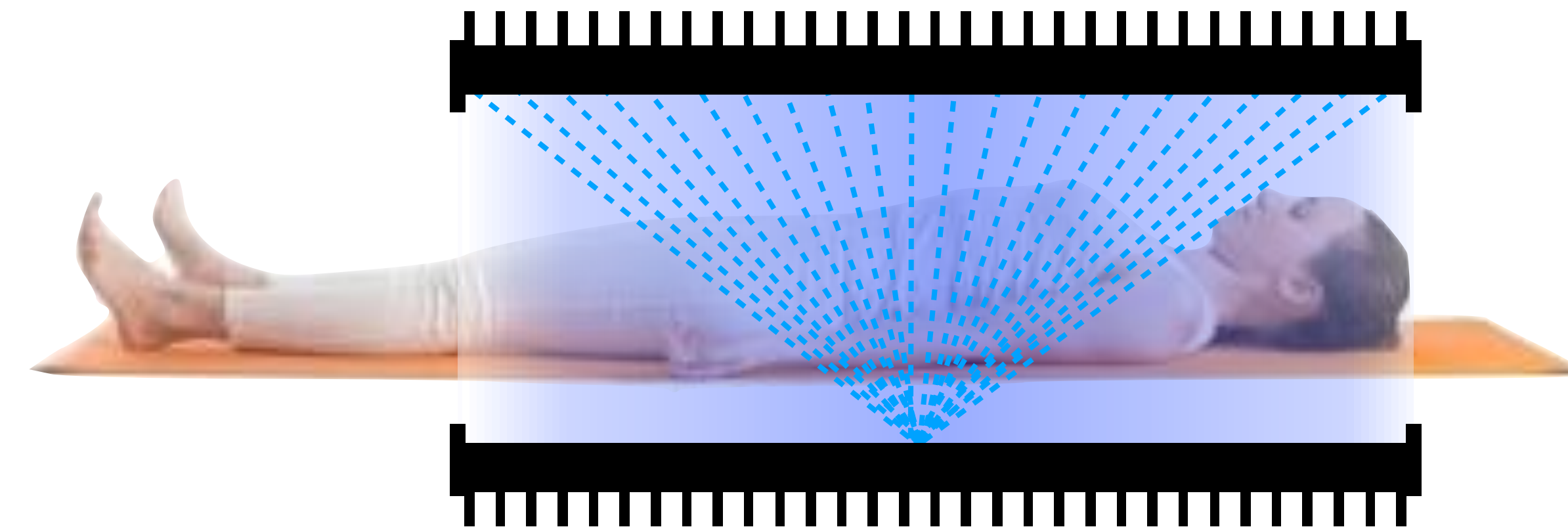
B) Conventional PET: angular lines of response



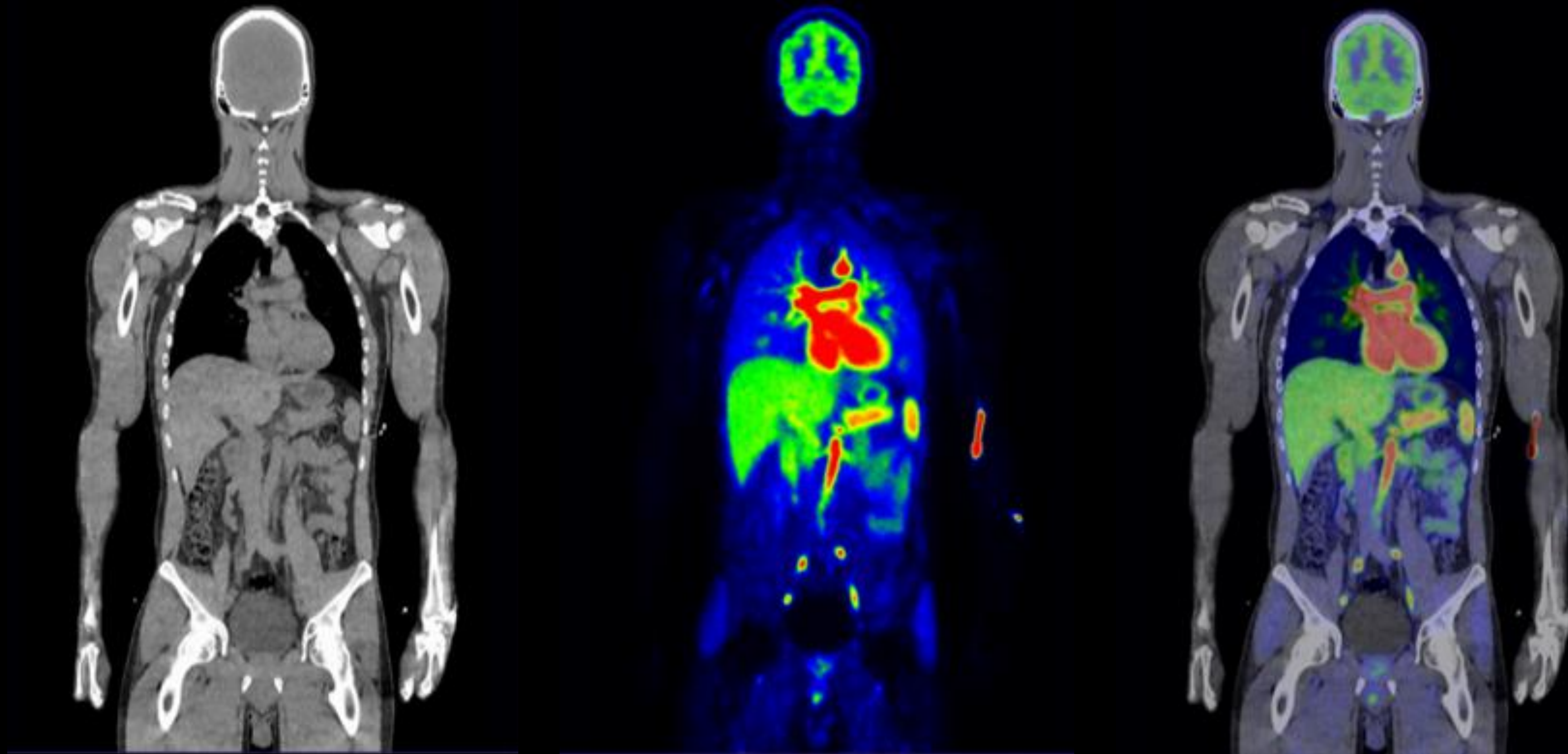
C) Total-body-PET: linear lines of response

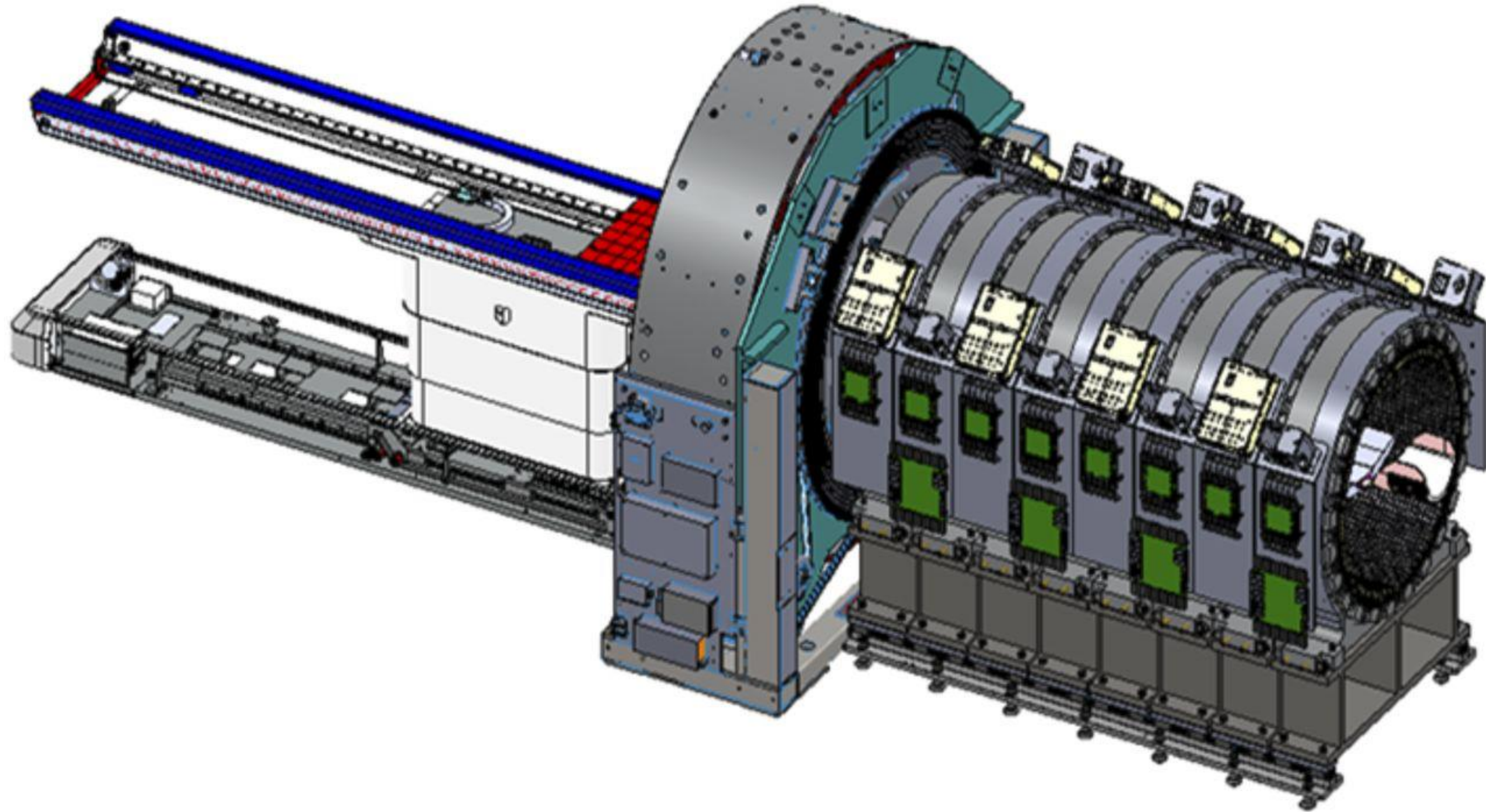


D) Total-body-PET: angular lines of response

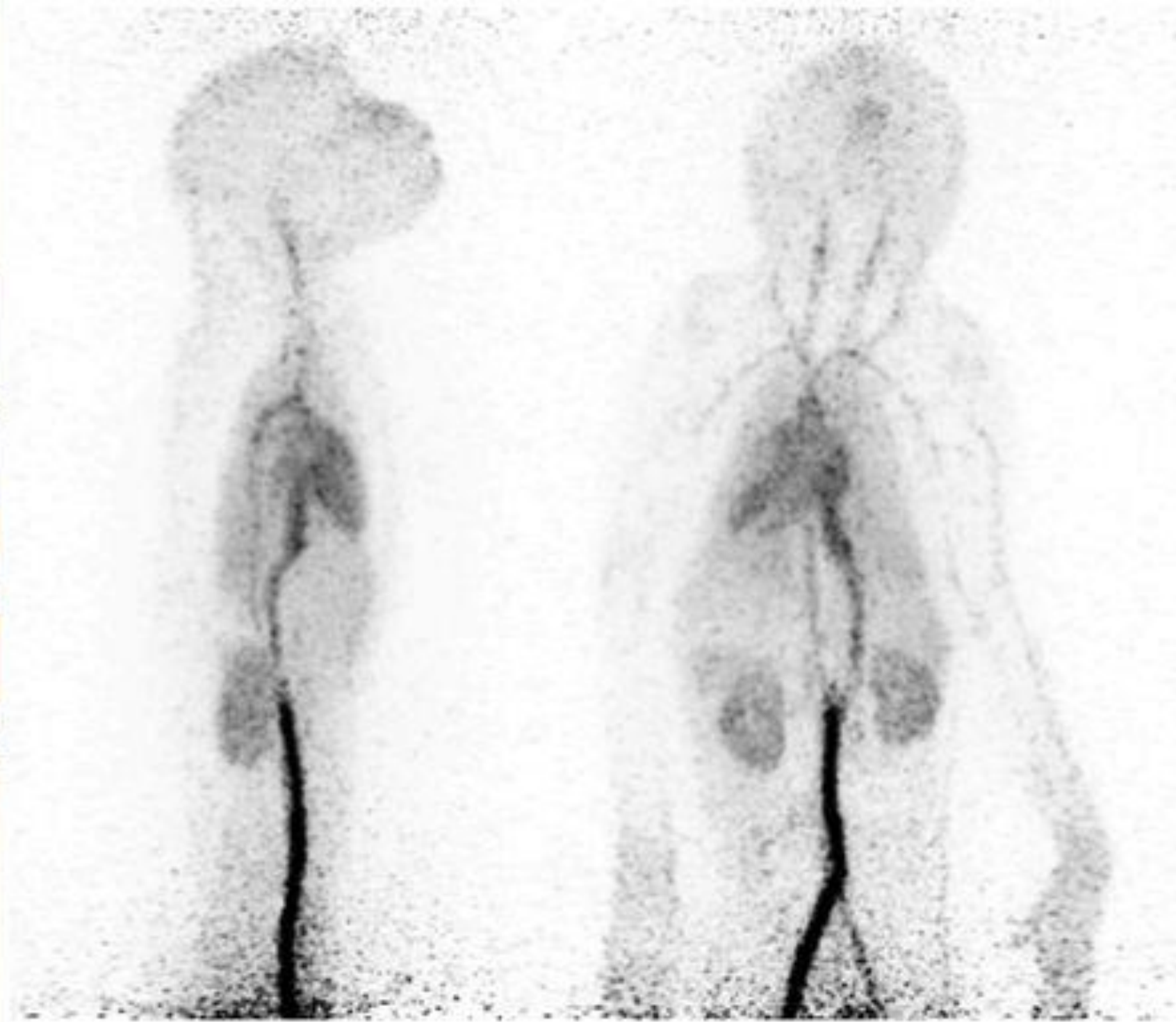


Imaging whole-body biological circuits

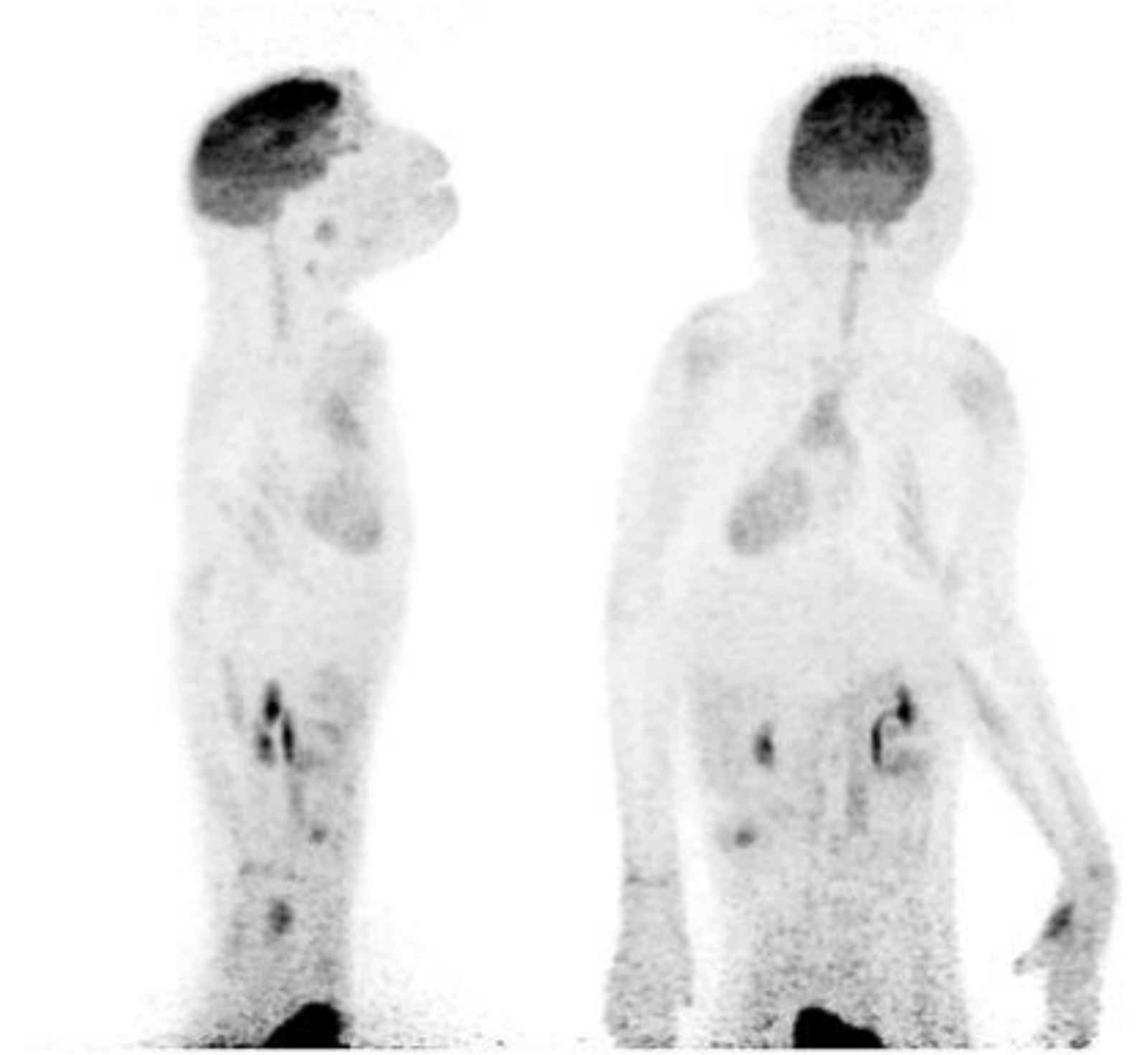








0- to 30-s scan



55- to 60-min scan



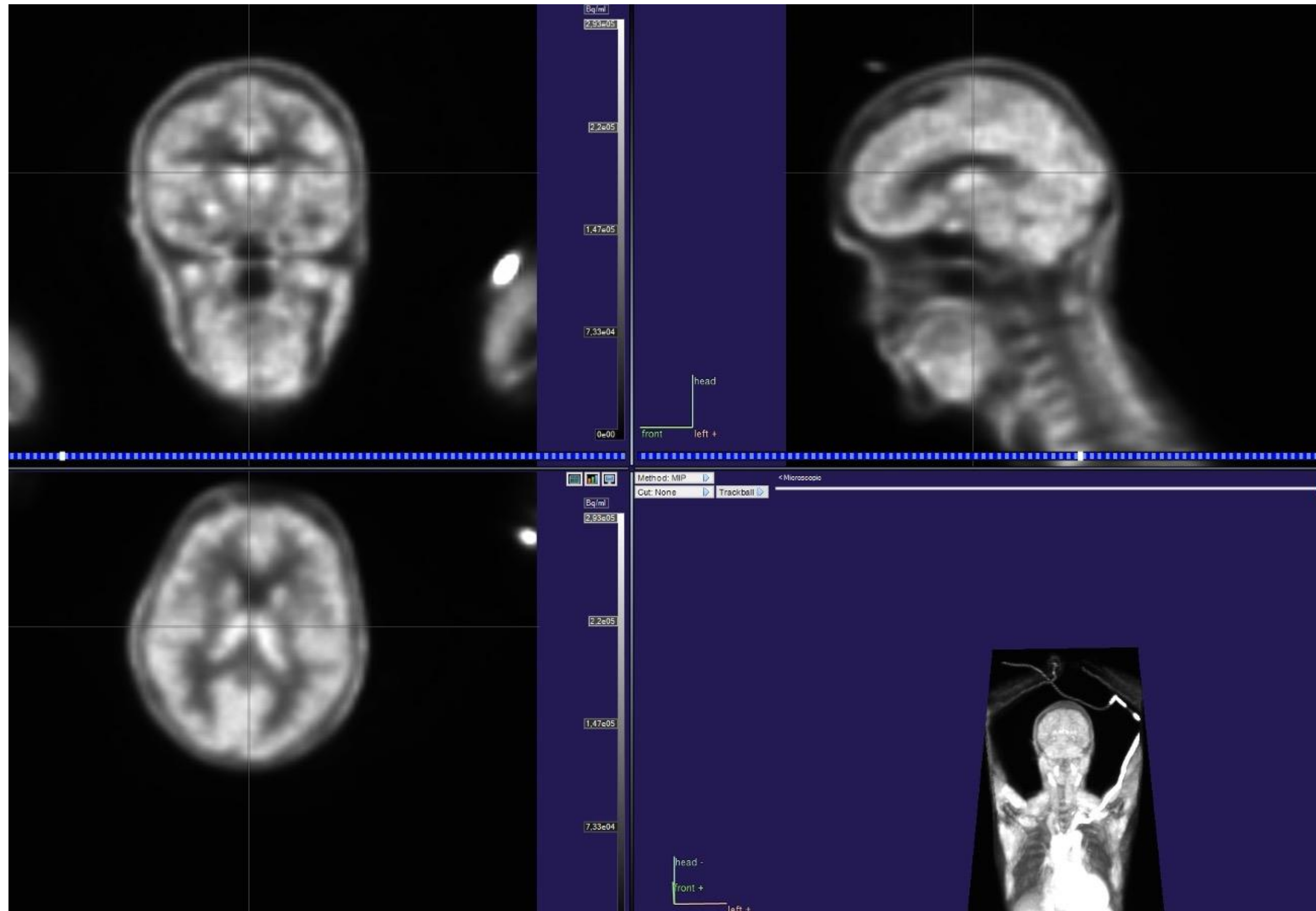


Image courtesy of Juhani Knuuti





Systems-level PET imaging

Perfusion imaging with $[^{15}\text{O}]\text{H}_2\text{O}$

5 s

10 s

15 s

20 s

25 s

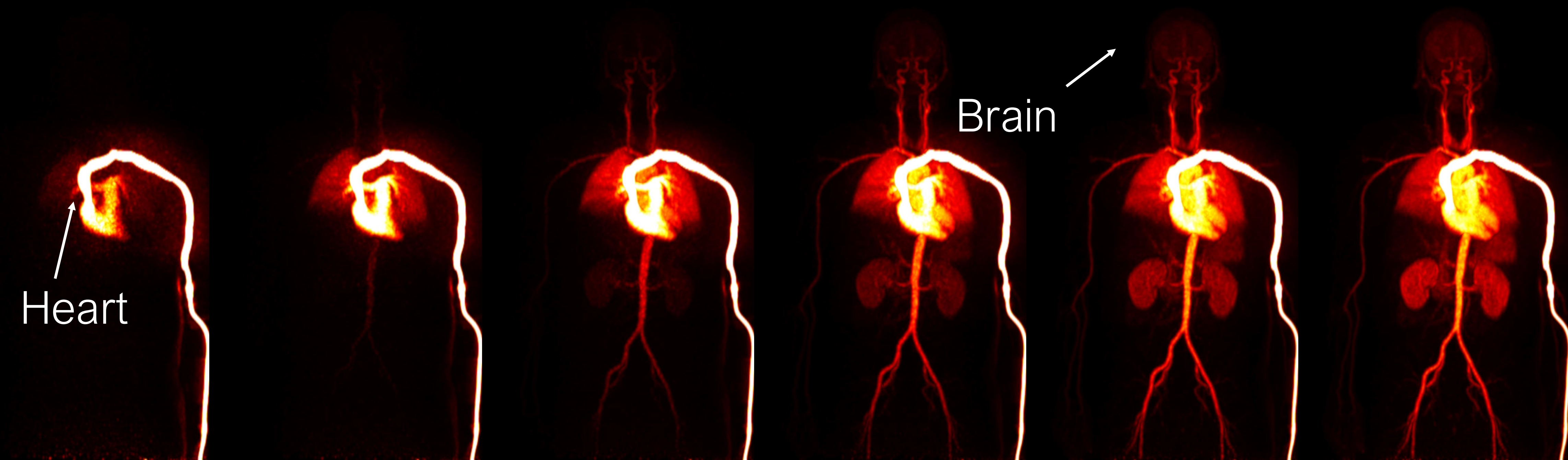
30 s

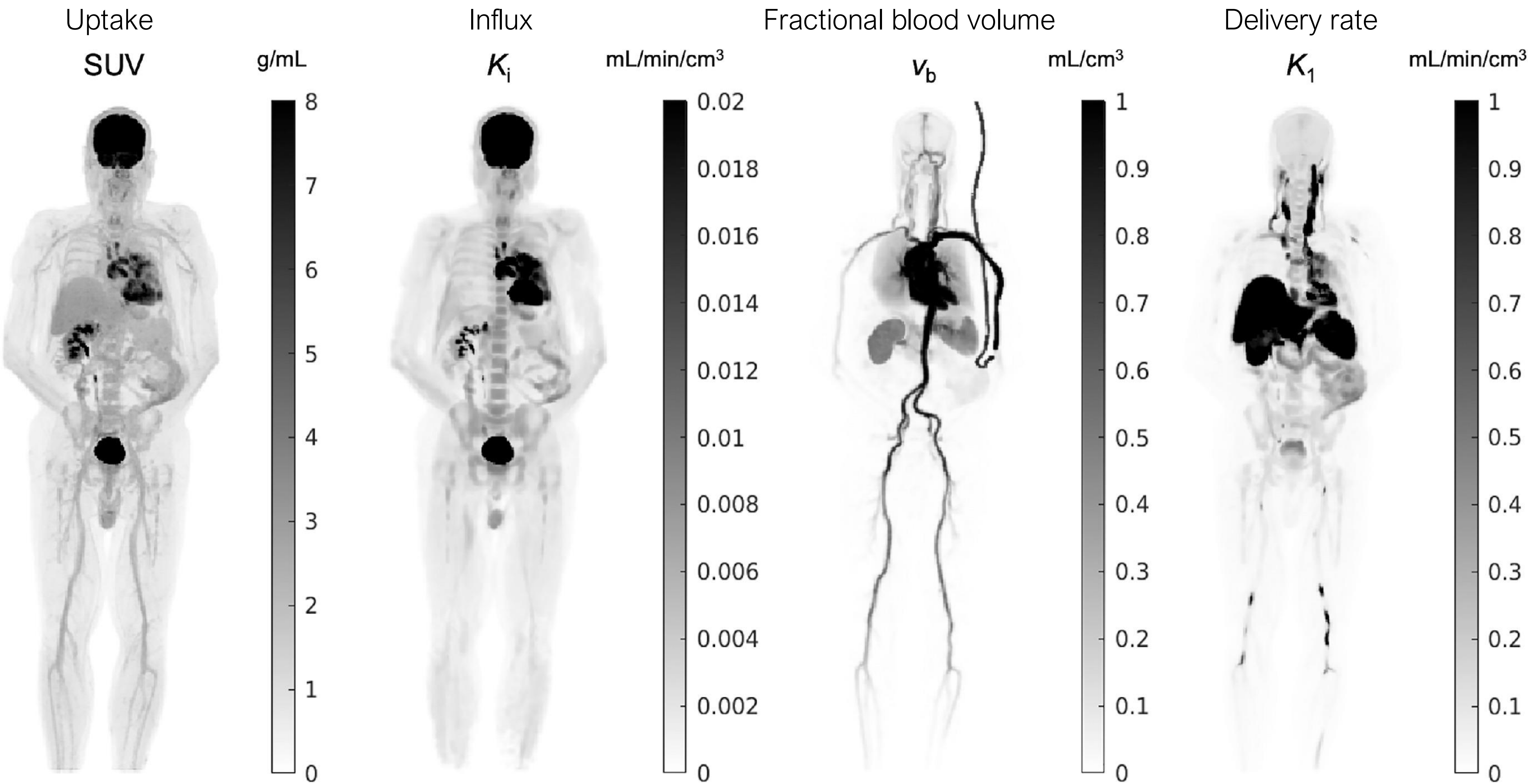
Heart

Brain

Injection

(Kunuuti et al 2023 J Nucl Med).





Ng et al (2022)

Improving the SNR

- **Siemens Quadra** scanner can pick up ~24 times more gamma counts than conventional PET-CT
- **SNR** of a reconstructed PET scan is $\sqrt{N}$ where N is the number of events
- **Event detection** depends on sensitivity (S), injected activity (A) and imaging time (T) scaled by constant (k), thus $SNR = k \times \sqrt{S \times A \times T}$

What to do with the increased sensitivity

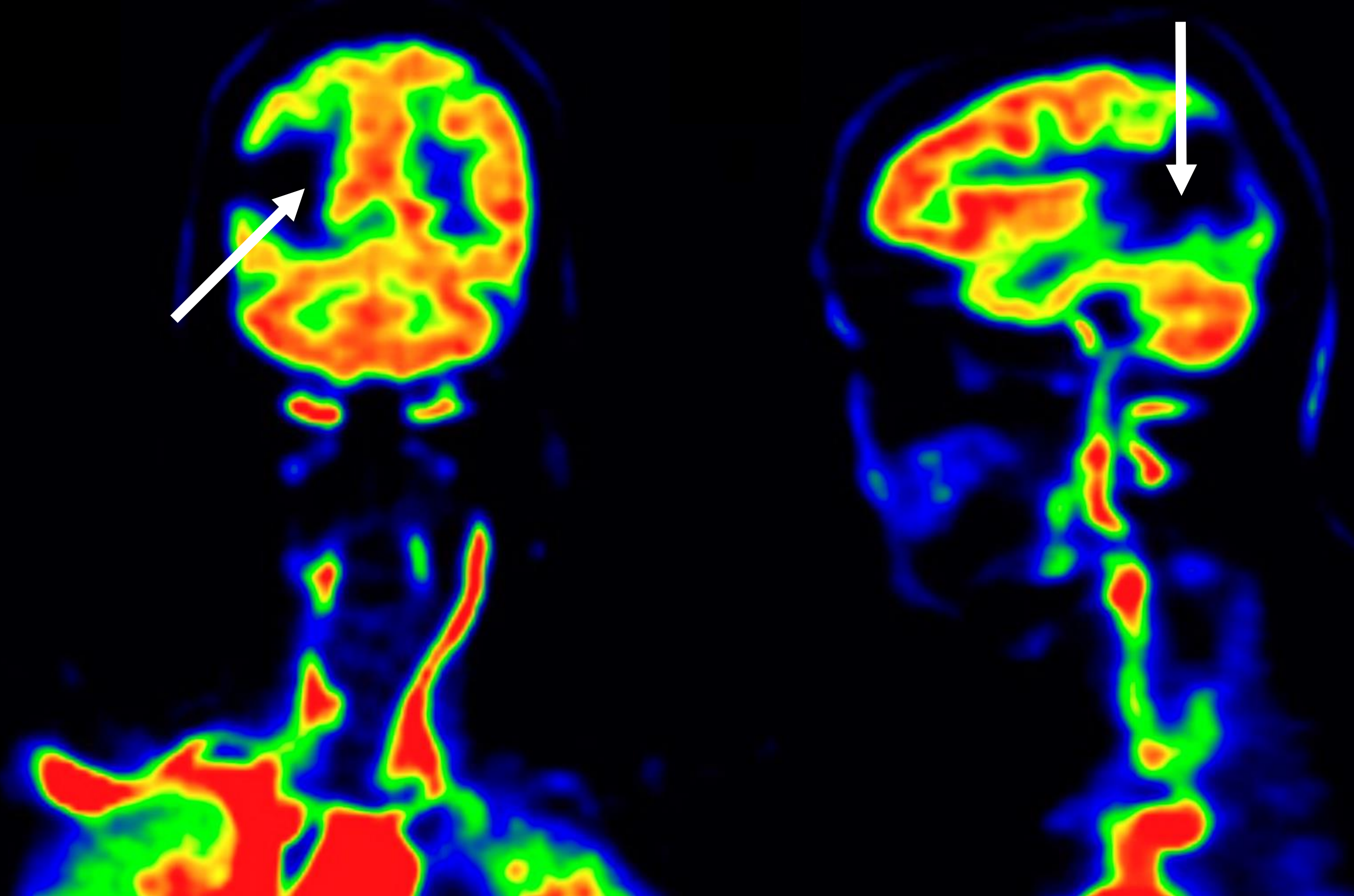
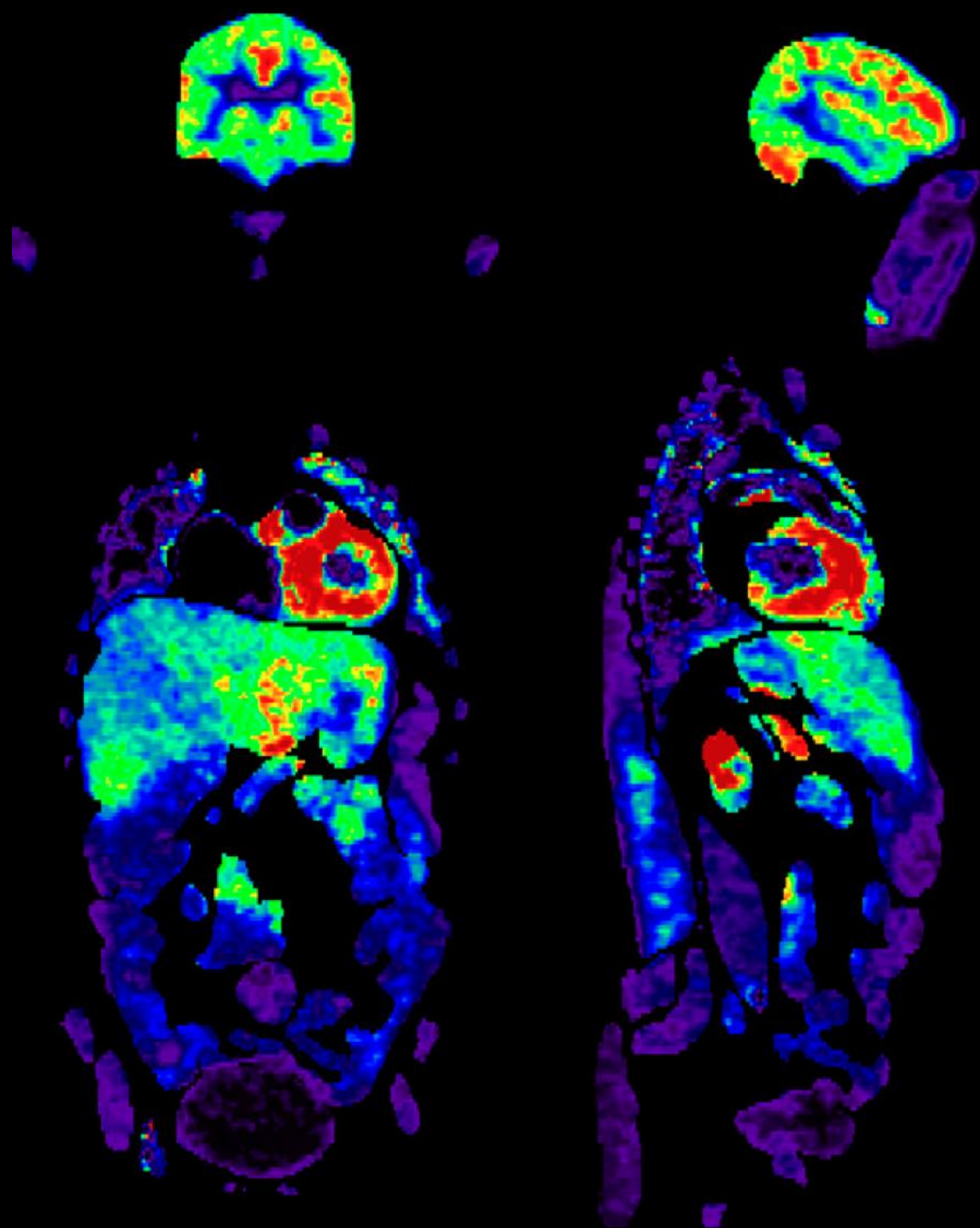
- **Increase SNR by a factor of $\sqrt{24} = 4.9$** while keeping the protocol otherwise fixed
- **Reduce imaging times with a factor of 24,**
 - Routine 24-minute [18F]FDG scan could be accomplished in just one minute.
 - Significantly increases patient throughput and comfort, which decreases subject motion, further improving image quality.
- **Image-based input** can be routinely used (e.g. carotid artery) as it will be most likely in the imaging —> reduced workload

What to do with the increased sensitivity

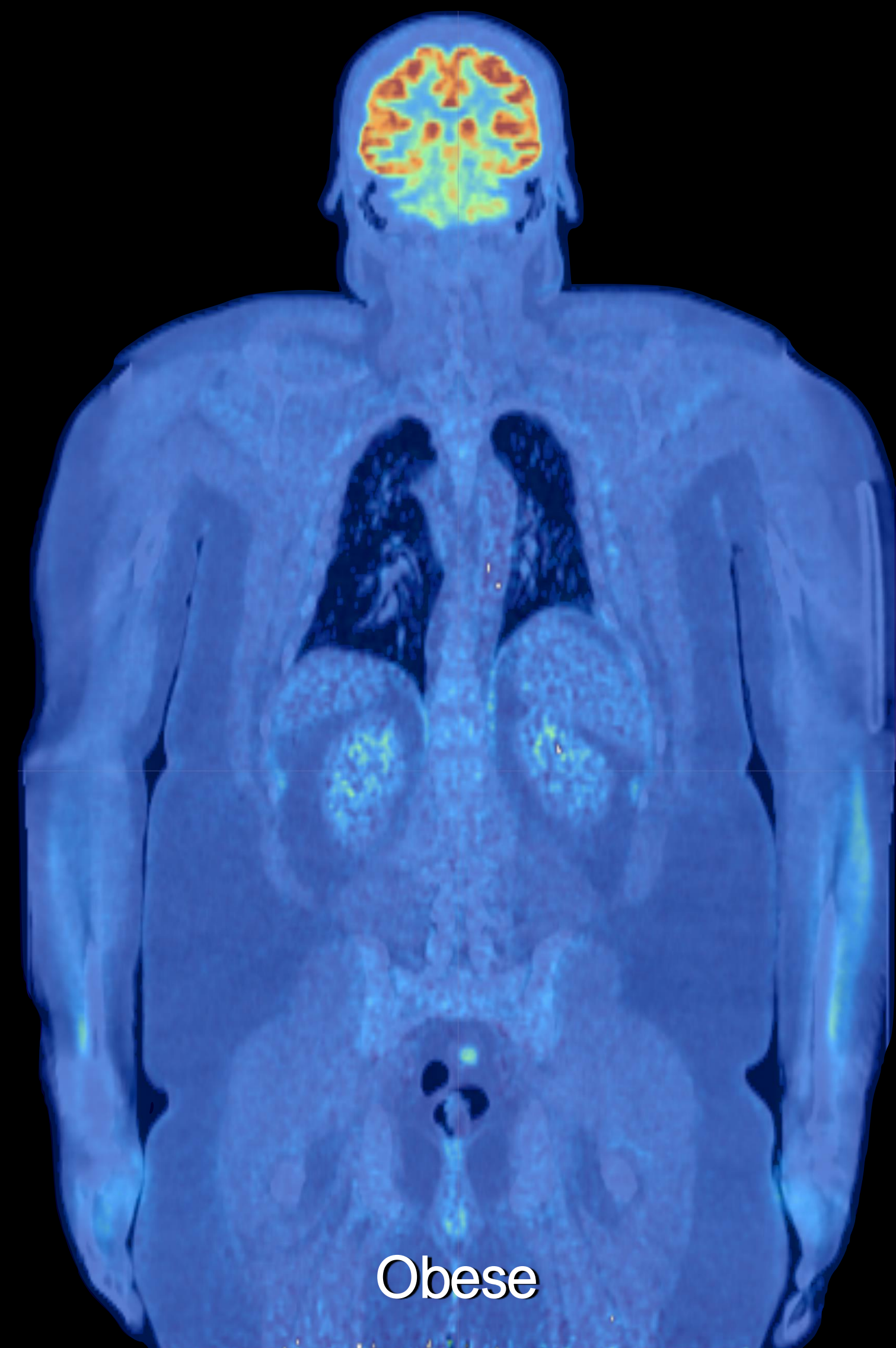
- **Reduce the injected activity by a factor of 24.**
 - Typical whole-body [^{18}F]FDG scan requiring ~480 MBq injected activity —> now injection 20 MBq —> effective doses < 0.3 mSv.
- **Up to 40 consecutive scans** with the same effective dose that is currently received from a single scan,
- **Permits multi-injection activation studies** with short-lived radiotracers ($^{15}\text{O}_2$), longitudinal studies with more datapoints, or multi-ligand studies
- **Routine whole-body imaging** allows diagnosis of conditions outside main target region

Whole-body perfusion

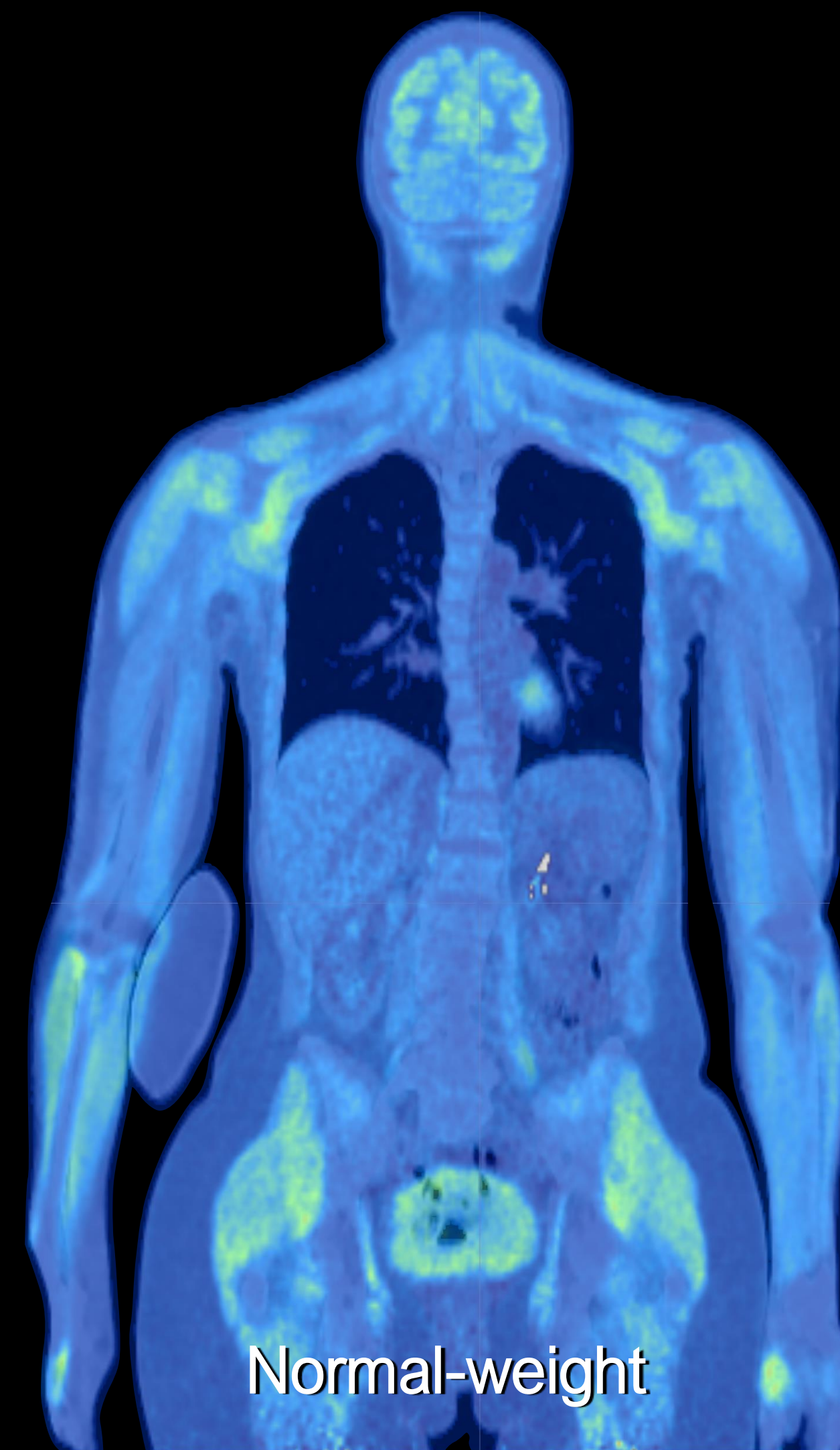
Brain infarction detected
during whole-body cardiac scan



Knuuti et al (2023 J Nucl Med)



Obese



Normal-weight

0.001

K_i

0

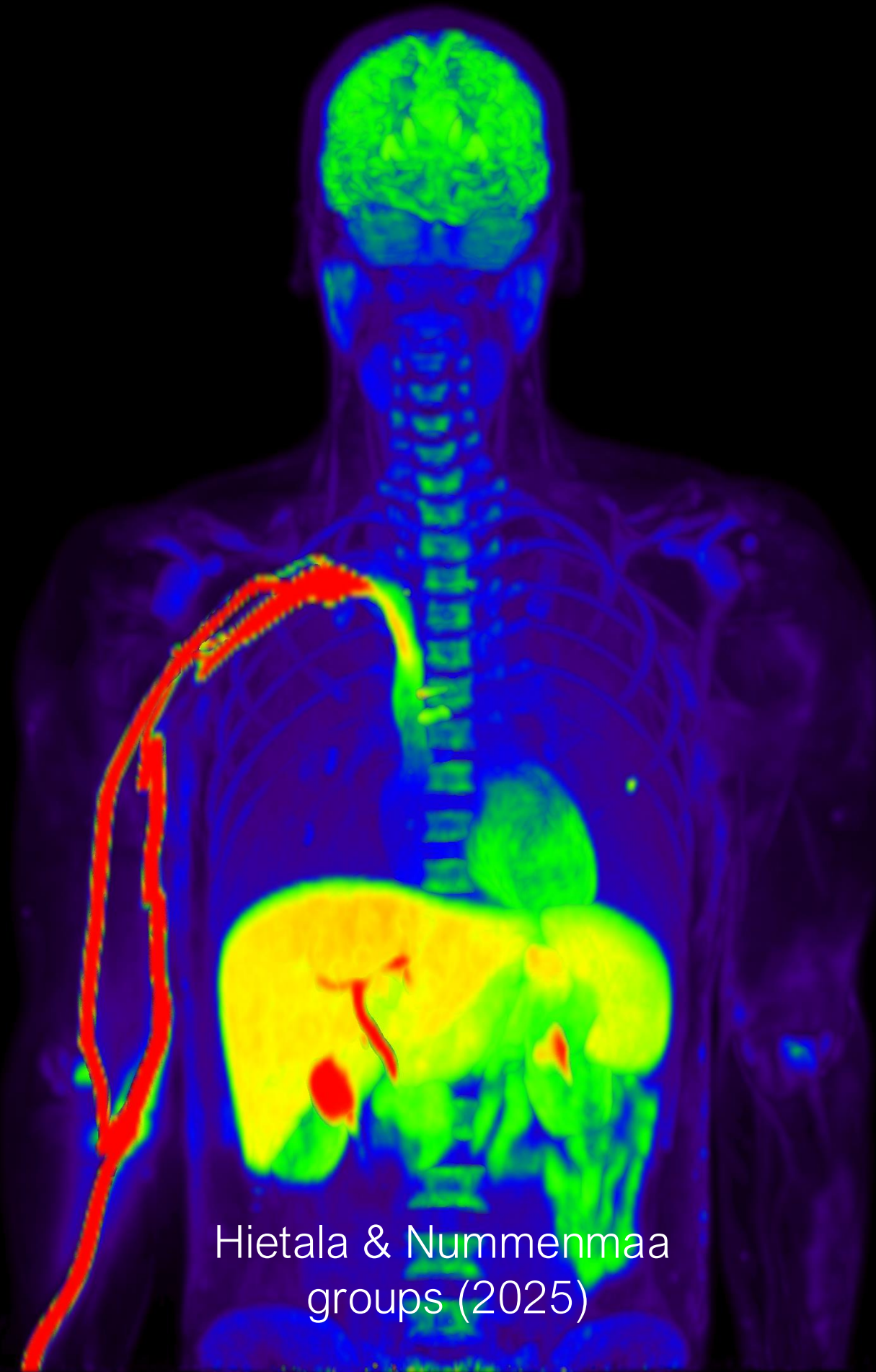
Molecular precision throughout the body

μ -opioid receptors
[¹¹C]carfentanil



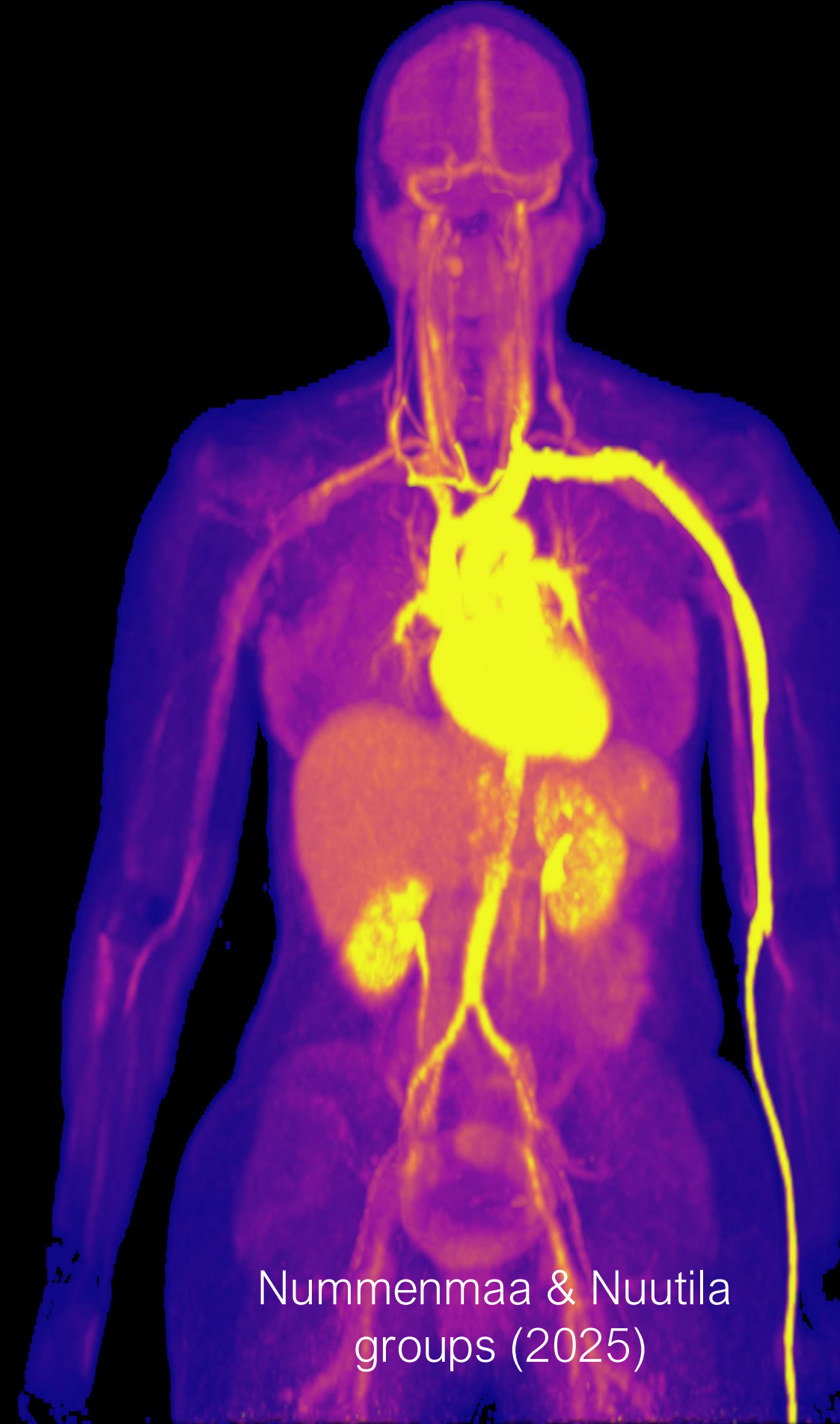
Virtanen & Nummenmaa
groups (2025)

CB1-receptors
[¹⁸F]FMPEP



Hietala & Nummenmaa
groups (2025)

Glucose metabolism
[¹⁸F]FDG



Nummenmaa & Nuutila
groups (2025)

Perfusion
[¹⁵O]H₂O

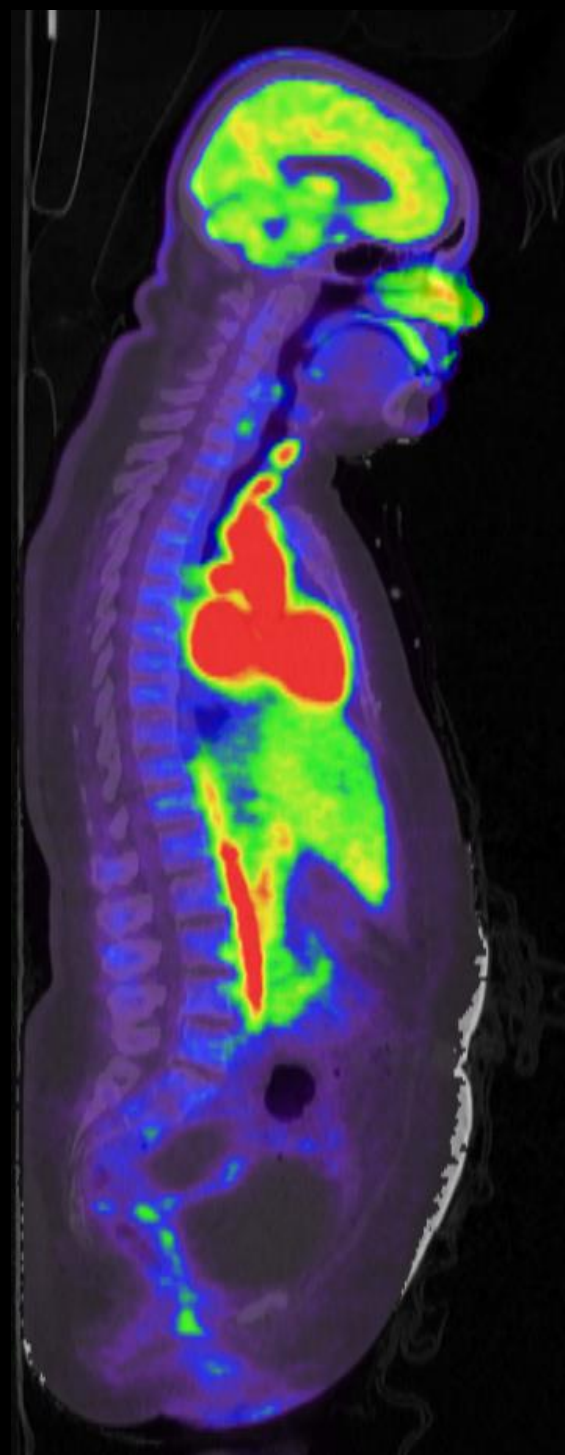


Nummenmaa & Knuuti
groups (2025)

Kinetic modelling of total-body PET data

Developing TOTALPET modelling framework

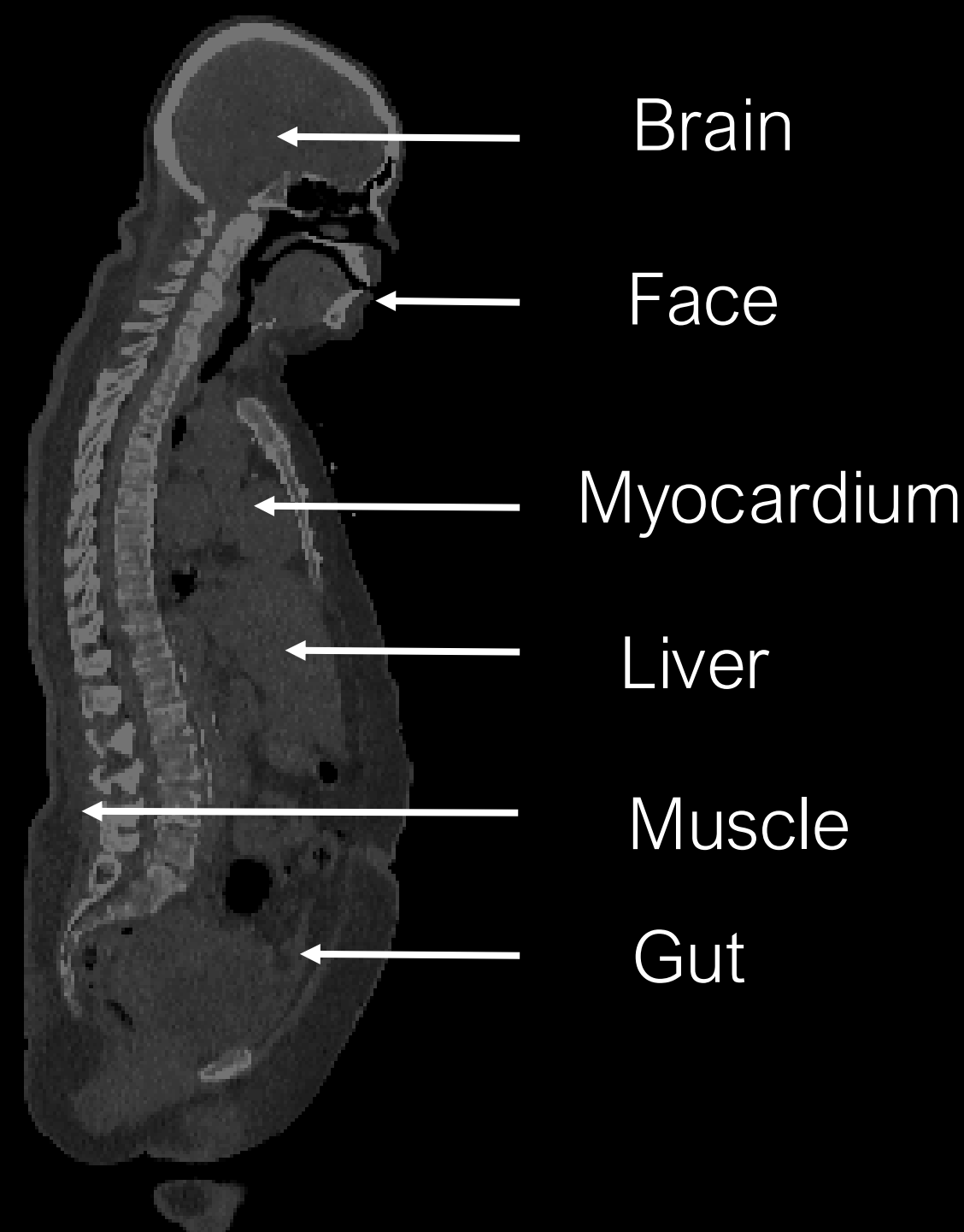
1) PET-CT images



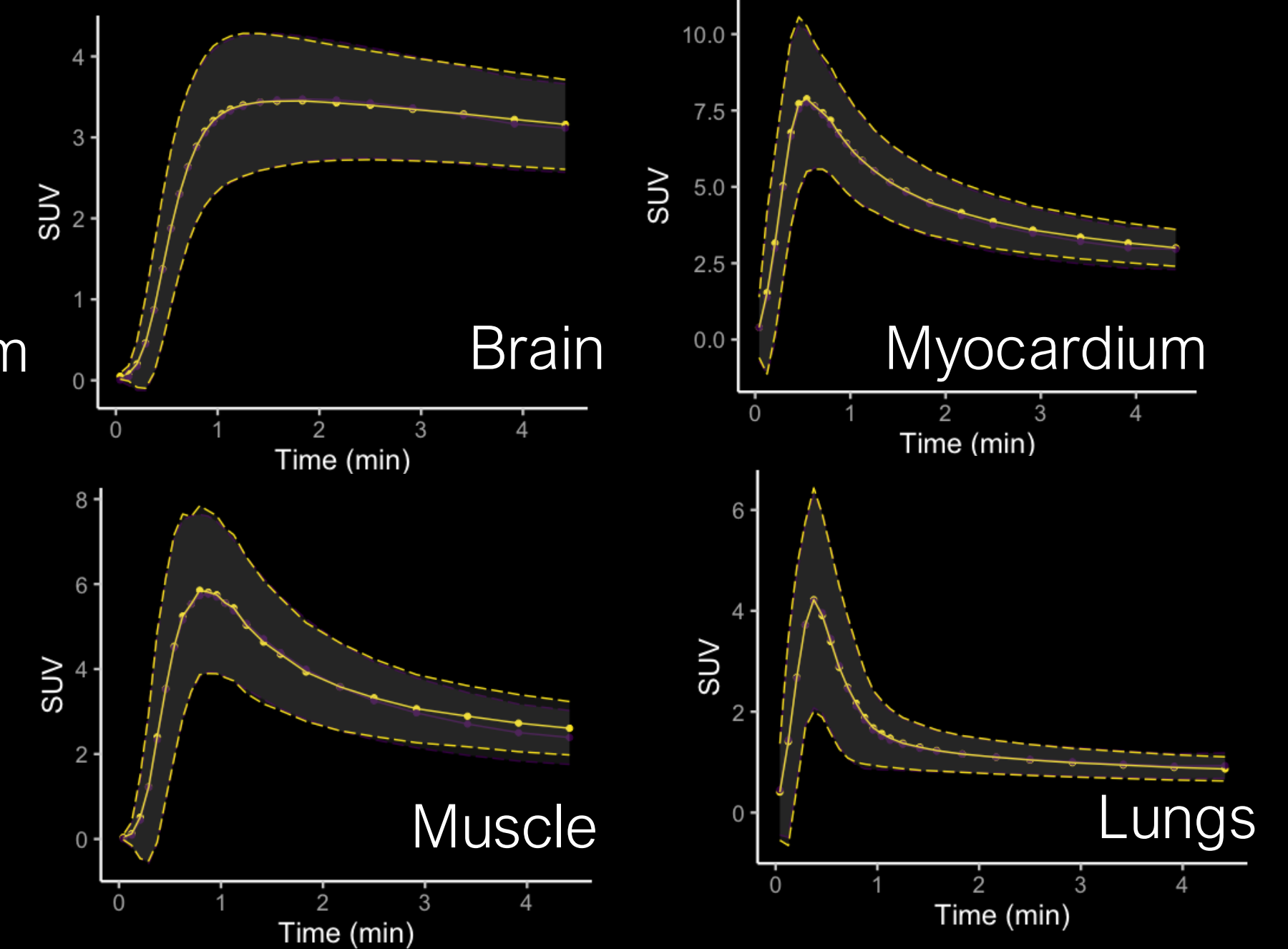
2) AI-based CT segmentation



3) Tissue-wise PET modelling



4) Regional time-activity curves and activity data (> 100 regions)



Subjective responses to adenosine challenge

Conscious feelings in the absence of BBB permeability

Imaging pharmacologically induced anxiety

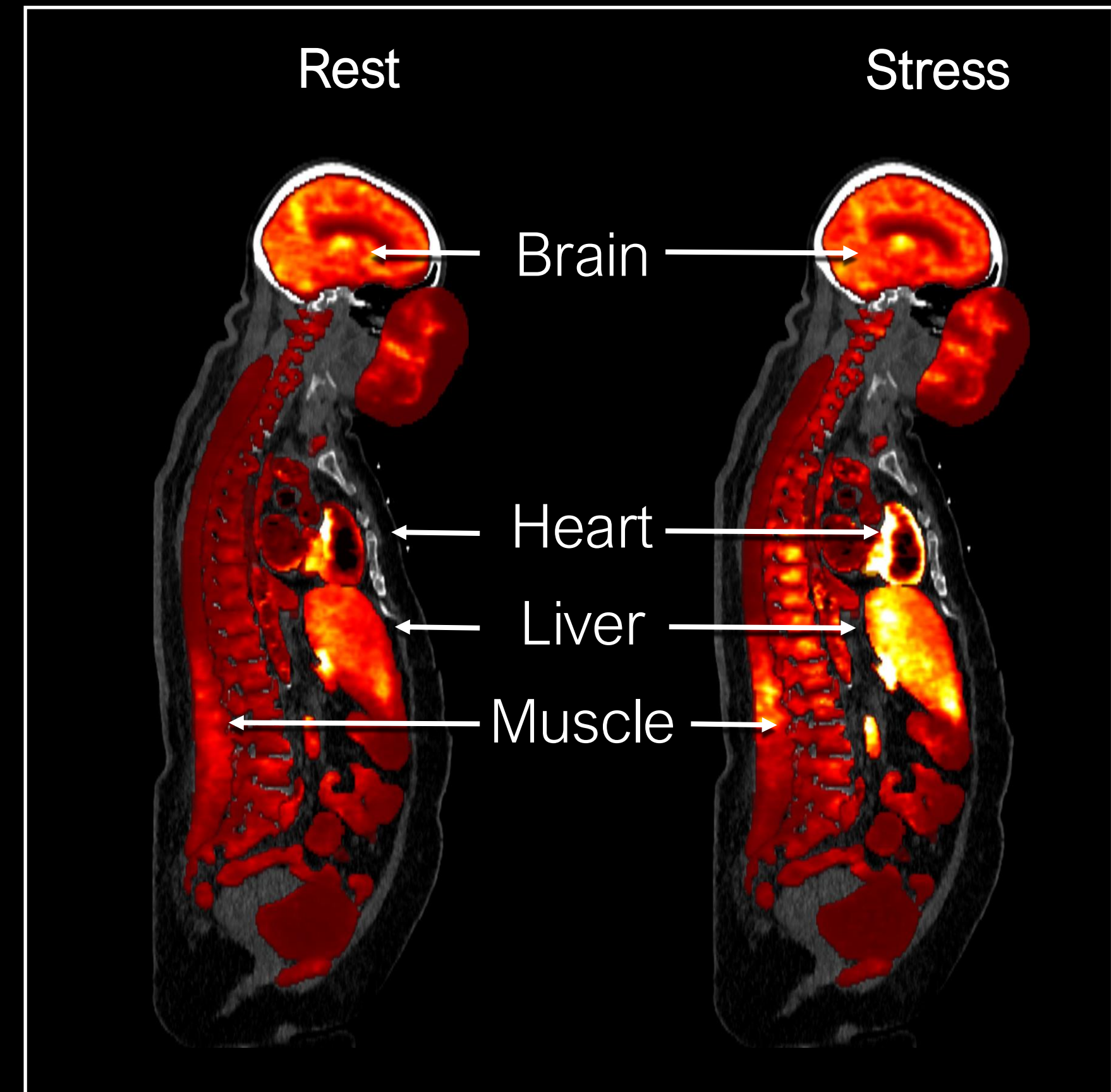
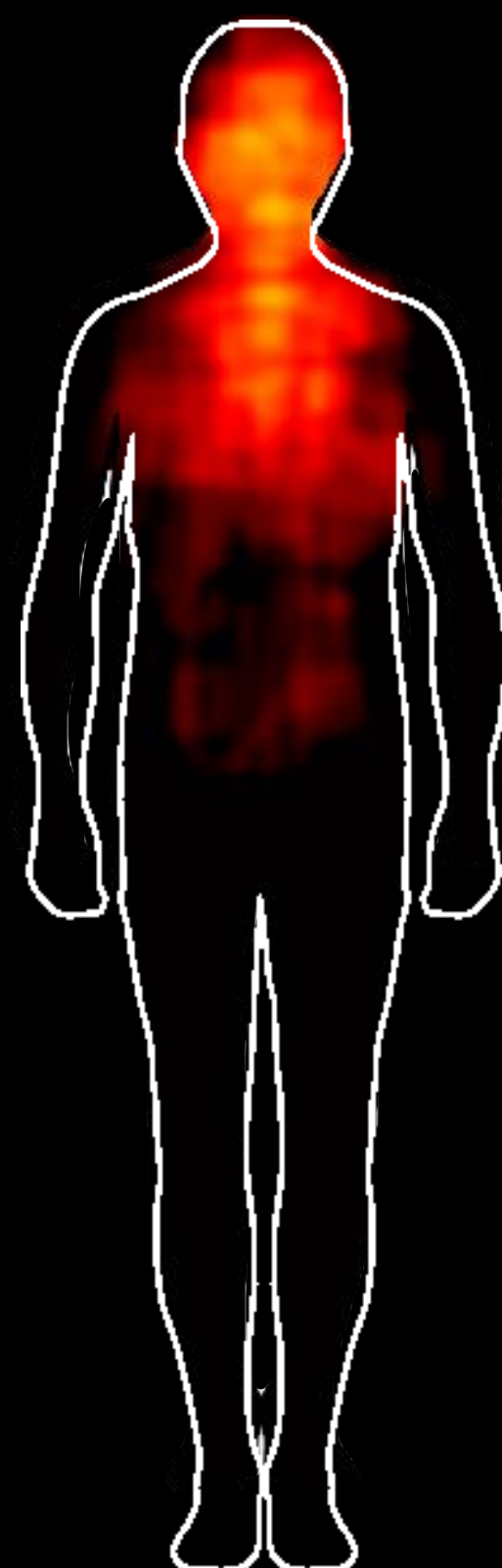
Bodily sensations

Perfusion

Pain

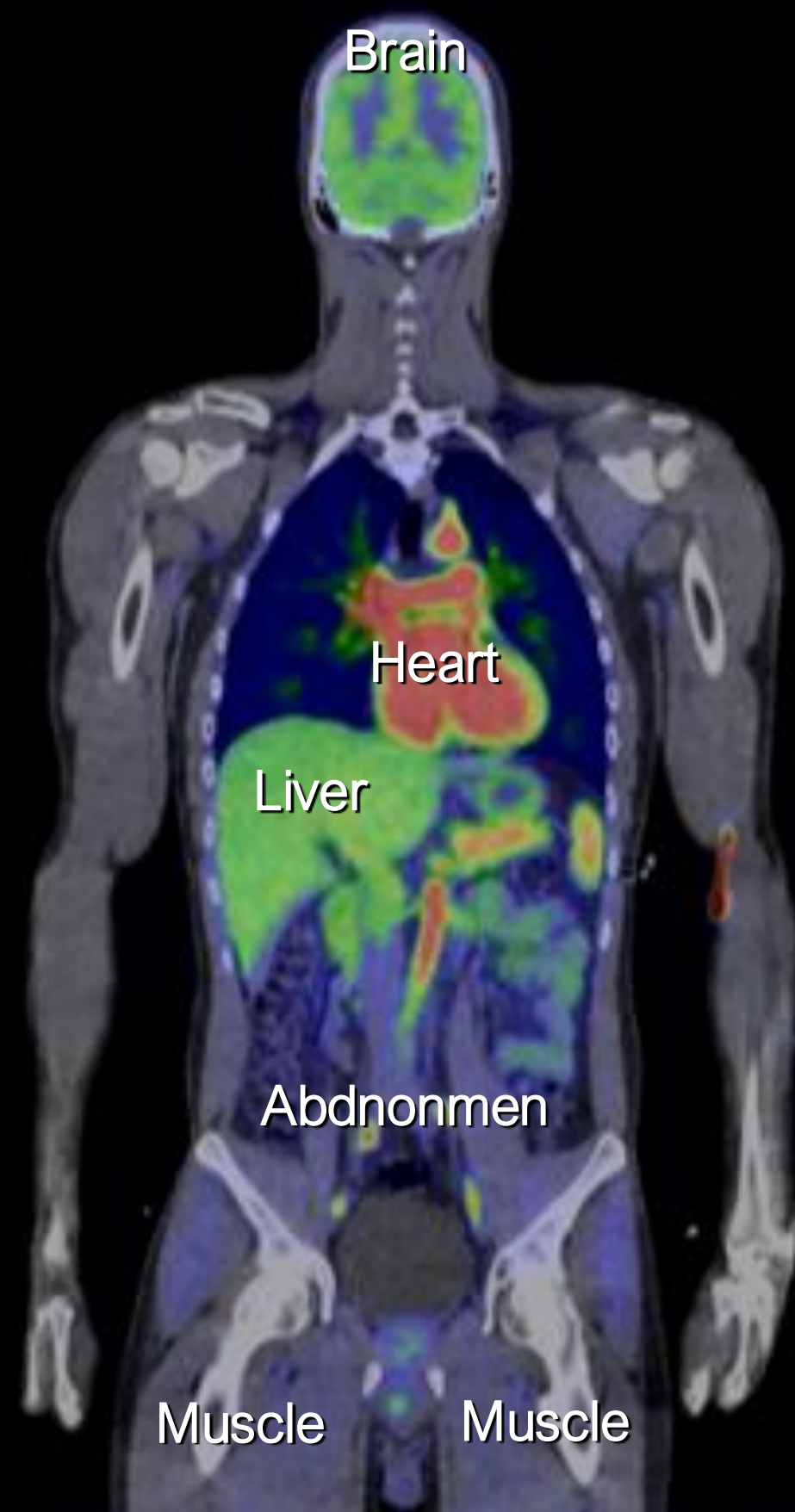
Heat

Pressure

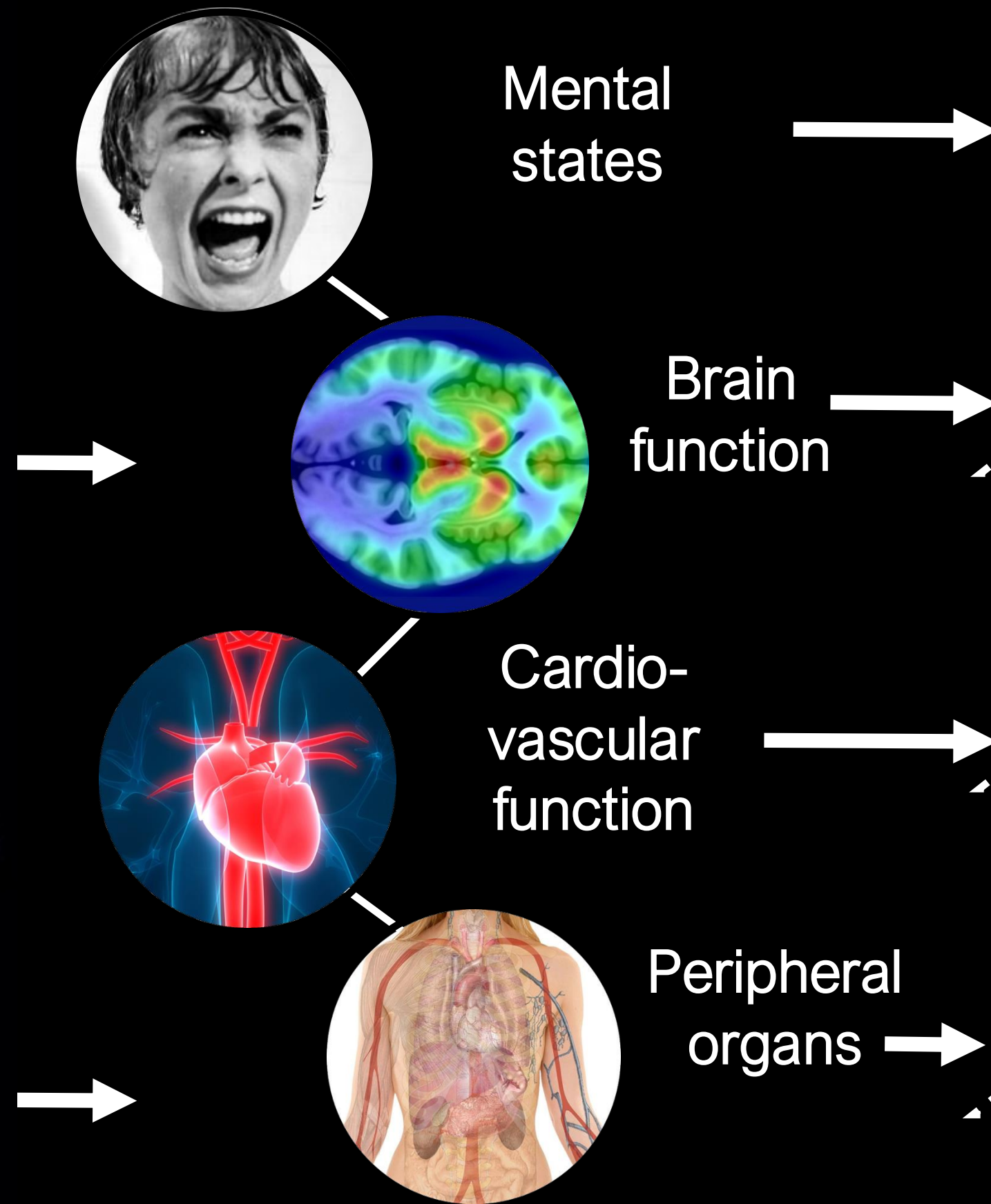


Next generation PET imaging

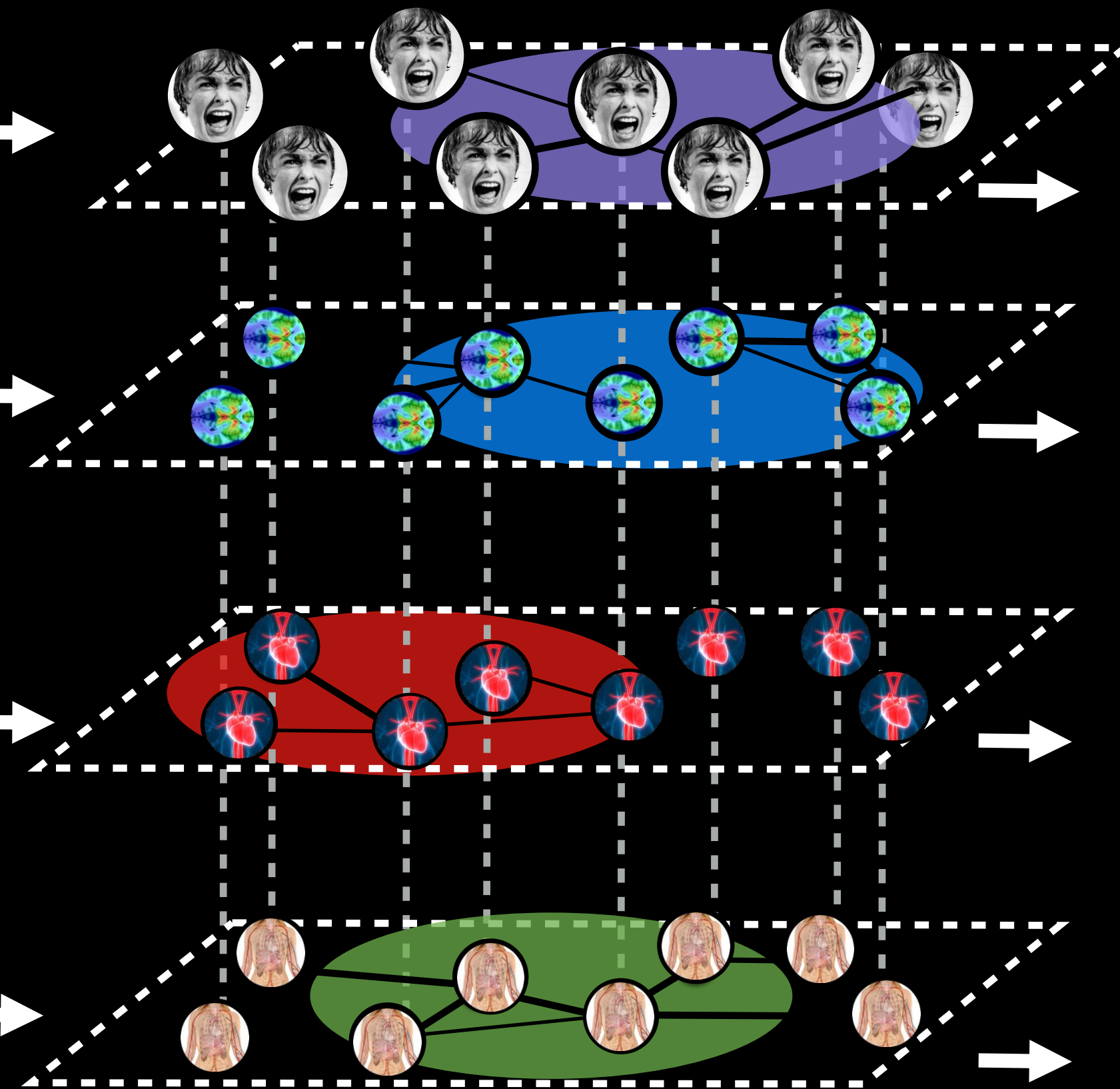
1. Ultrafast total-body imaging



2. Simultaneous multi-system studies of biological circuits



3. Unified modelling of multi-level data



4. Total-body biological circuits in health and disease

