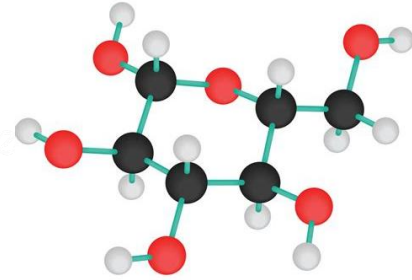


Principles of ^{18}F -FDG Tracer Kinetics

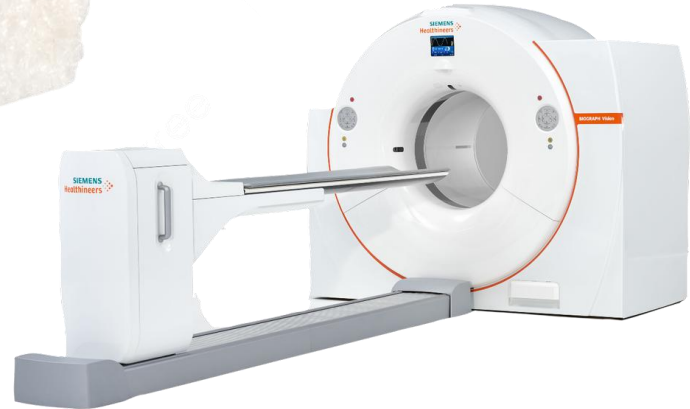
From Injection to Quantification

Dr Florentin Kucharczak, Eng., MSc, PhD, MD

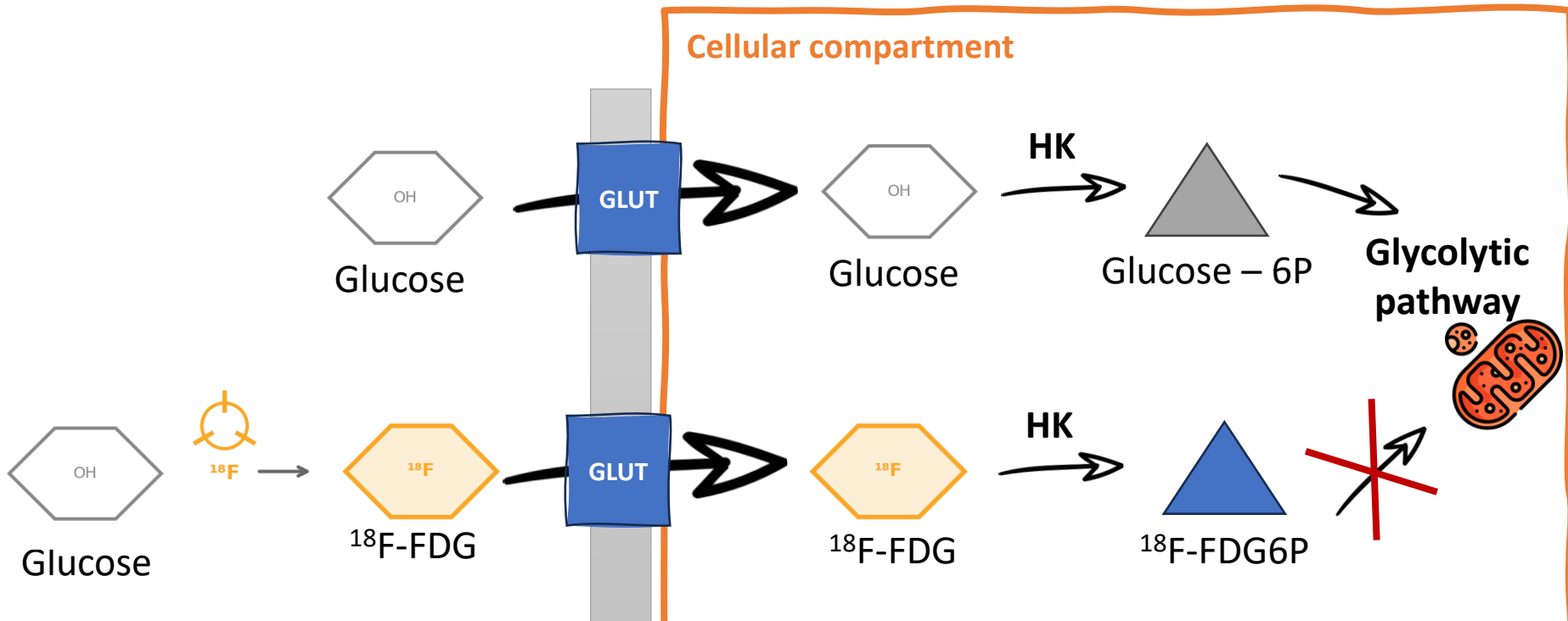
University of Montpellier



Giovanni Domenico Tiepolo



^{18}F -FDG: A Trapped Glucose Analog

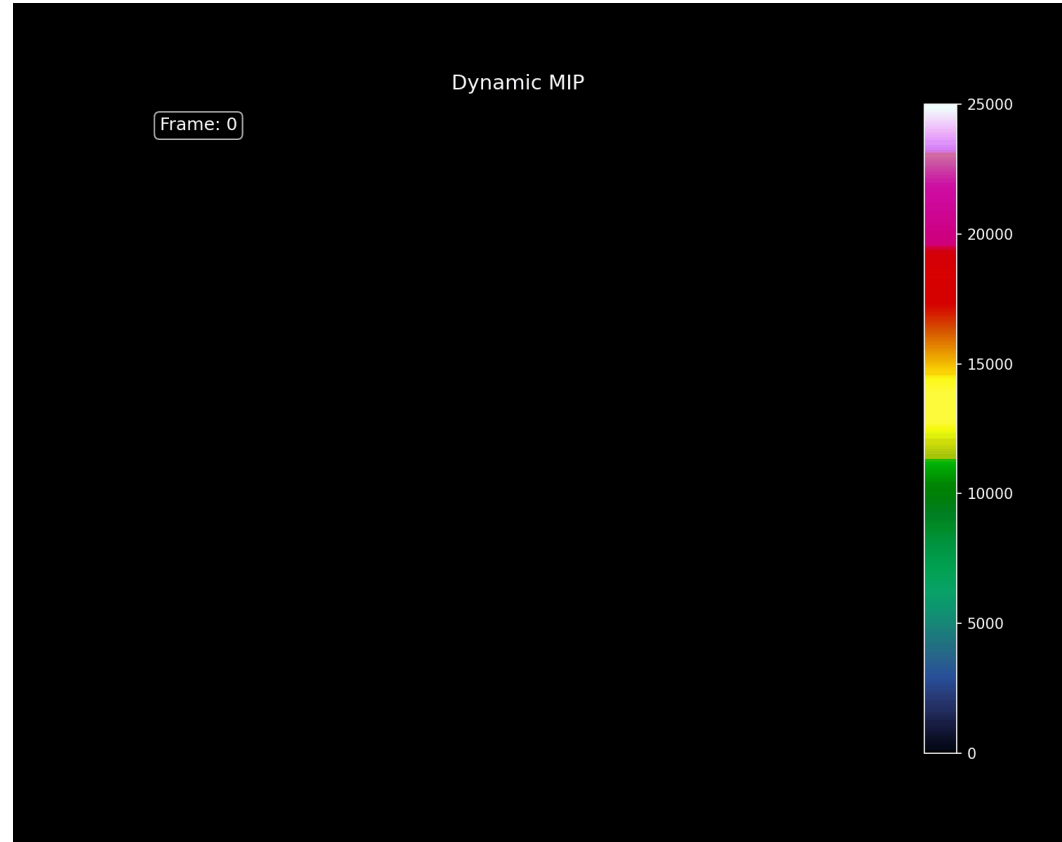


Key principle: FDG-6-P cannot be further metabolized

→ Accumulates proportionally to the **rate of glucose utilization** by the brain

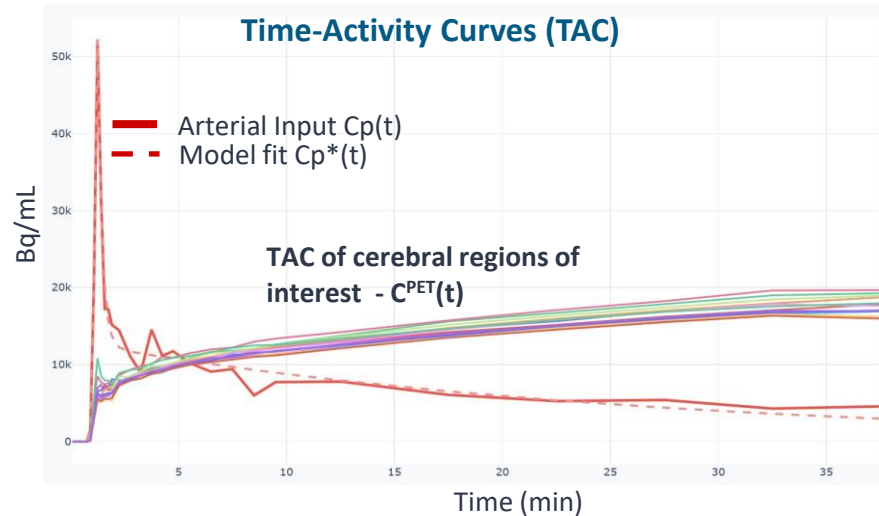
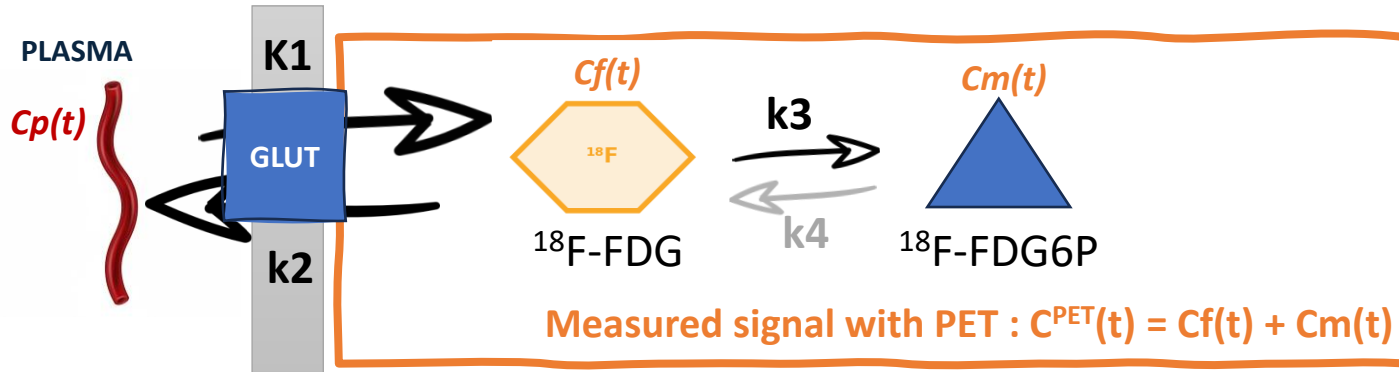
^{18}F -FDG: A Trapped Glucose Analog

Dynamic Uptake Over Time



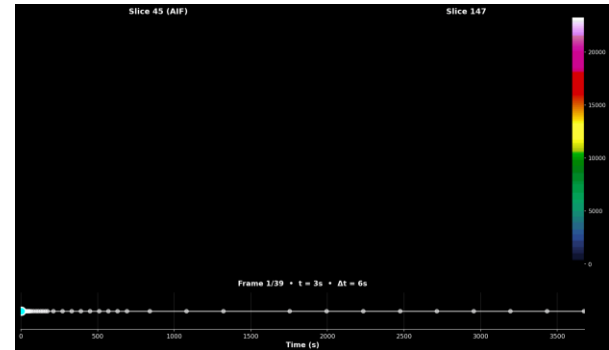
Courtesy of Department of Nuclear Medicine, CHU Liège

Two-Compartment Kinetic Model



Protocol: Variable frame duration

- 0-5 min:** short frames (10-30s) for arterial peak
- 5-60+ min:** longer frames (2-5 min)



Injection to Quantification: Two Strategies



After injection, FDG accumulates over time. Around 30 after injection, the uptake reaches a stable plateau: the **steady state**. From this point, two approaches to quantification are possible.

0 min Injection

~30-45 min Steady State

→ 10 min

60+ min

Approach 1 – Static PET

OR

Approach 2 – Dynamic PET

- Acquire a ~10 min **single frame** once steady state is reached (~45-60 min post-injection)
- The accumulated signal is proportional to glucose metabolism: normalised as **SUV**
- Fast, simple, no arterial sampling — **routine clinical practice**

- Record **all time points** from injection: the full kinetic curve (TAC)
- Solve a system of equations to recover the model parameters (K1, k2, k3...)
- Lots of strategies to estimate parameters : **NLLS** (non-linear least squares), **linearisation** (Patlak graphical, LLS), etc.

Output: SUV / SUVr (semi-quantitative)

Output: K1, k2, k3, CMRGlucose (absolute quantification)

From Steady State to Clinical Practice

Static PET vs. Dynamic PET: what parameters can you obtain?

STATIC PET

Acquired ~30-45 min post-injection (steady state)

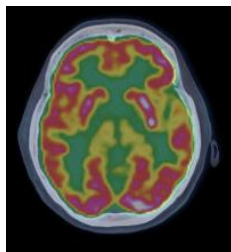
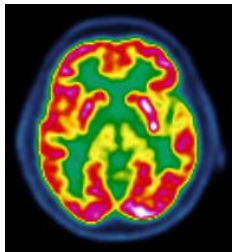
SUV

Activity / (Dose/Weight)
Semi-quantitative; no
input function

SUV_r

SUV / SUV_{reference}
Reduces inter-subject
variability

- ✓Fast, simple, no arterial sampling
- ✗Cannot separate delivery from metabolism



VS

DYNAMIC PET

Acquired continuously from injection onward (0-60+ min)

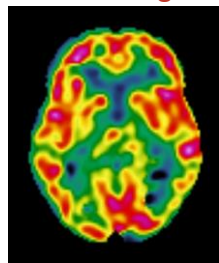
K1 FDG delivery (flow x
extraction) - mL/g/min

k3 Phosphorylation
(hexokinase) - min⁻¹

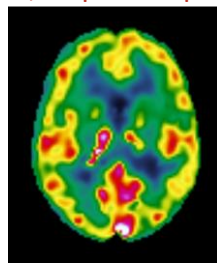
k2 Clearance to plasma
- min⁻¹

CMR_{glu}
umol/100g/min

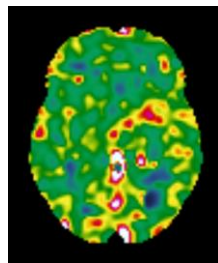
- ✓Absolute quantification; separates delivery vs metabolism
- ✗Longer scan; requires input function



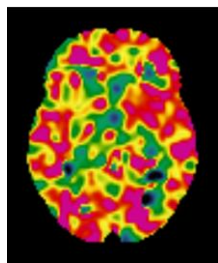
CMR_{glu}



K1



k2



k3

Take-Home Messages

- 1 FDG is trapped as FDG-6-P \rightarrow signal \propto glucose metabolism
- 2 Compartment modelling : K_1 (delivery), k_2 (clearance), k_3 (phosphorylation)
- 3 CMRGlu = Cerebral Metabolic Rate of Glucose
 \rightarrow an absolute measure ($\mu\text{mol}/100\text{g}/\text{min}$)
- 4 Static PET provides a semi-quantitative measure of relative regional glucose metabolism



Thank you!
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