Designing a Computer Simulation Tool for PET Neuroimaging

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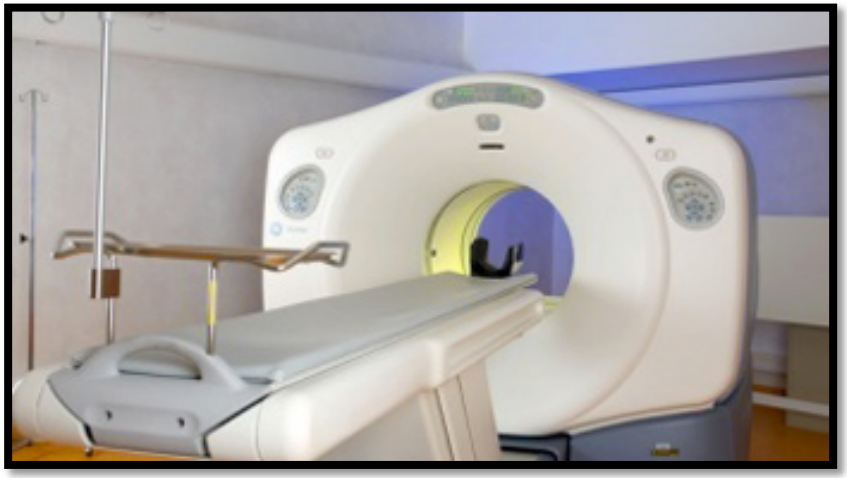
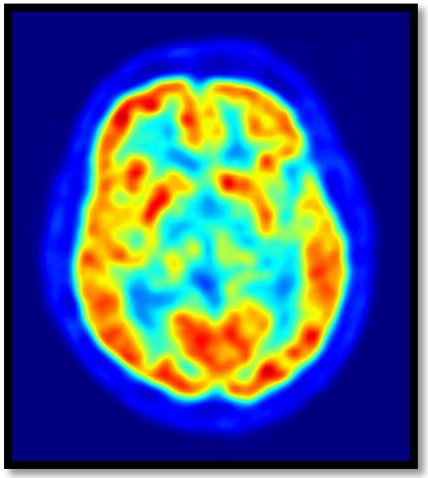
Positron Emission Tomography (PET)

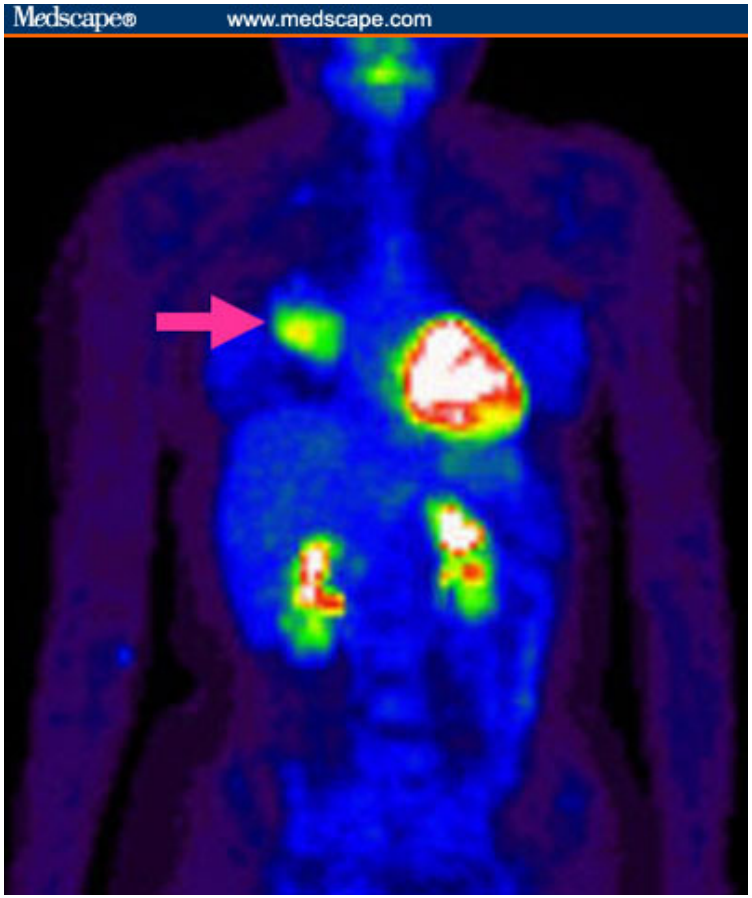


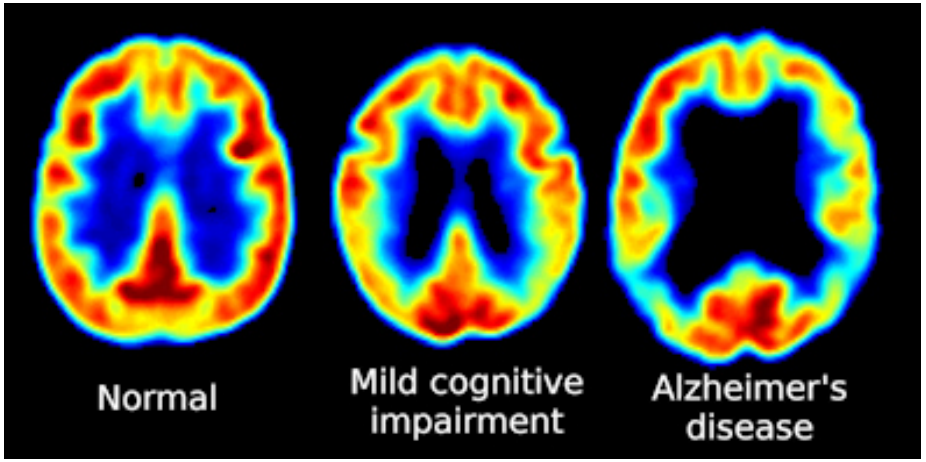


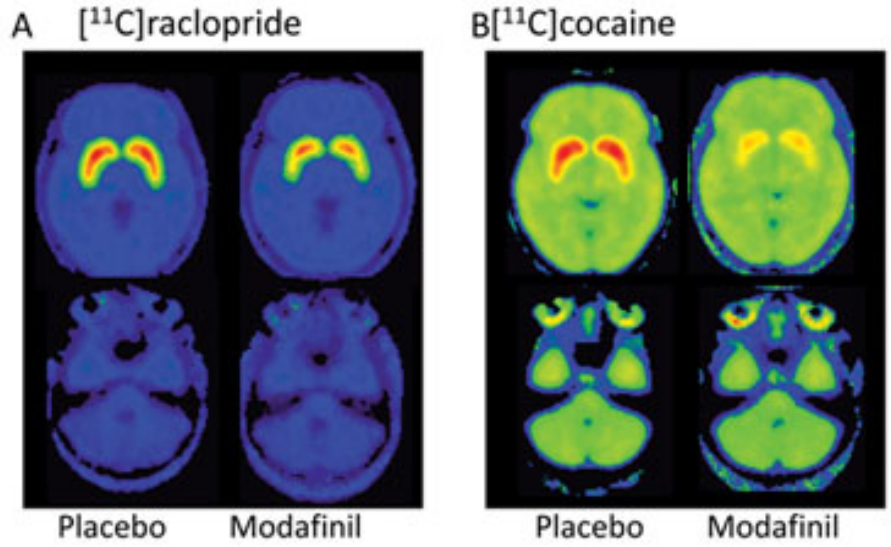
Procedure:

1. Inject a Radiotracer
2. Take the Scan
3. Get Blood Data (optional)
4. Analyze Data

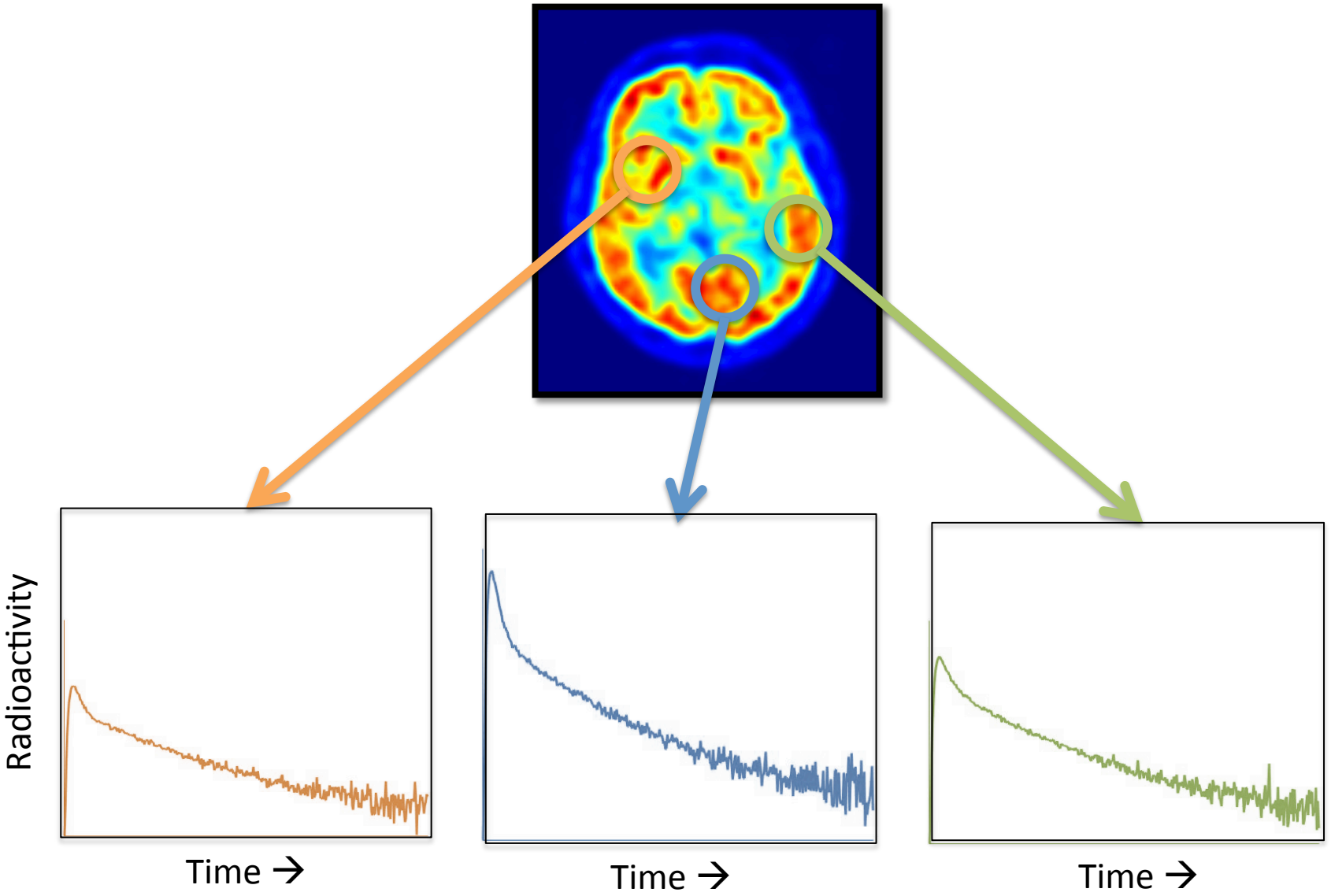
Applications of PET







Time Activity Curves (TACs)



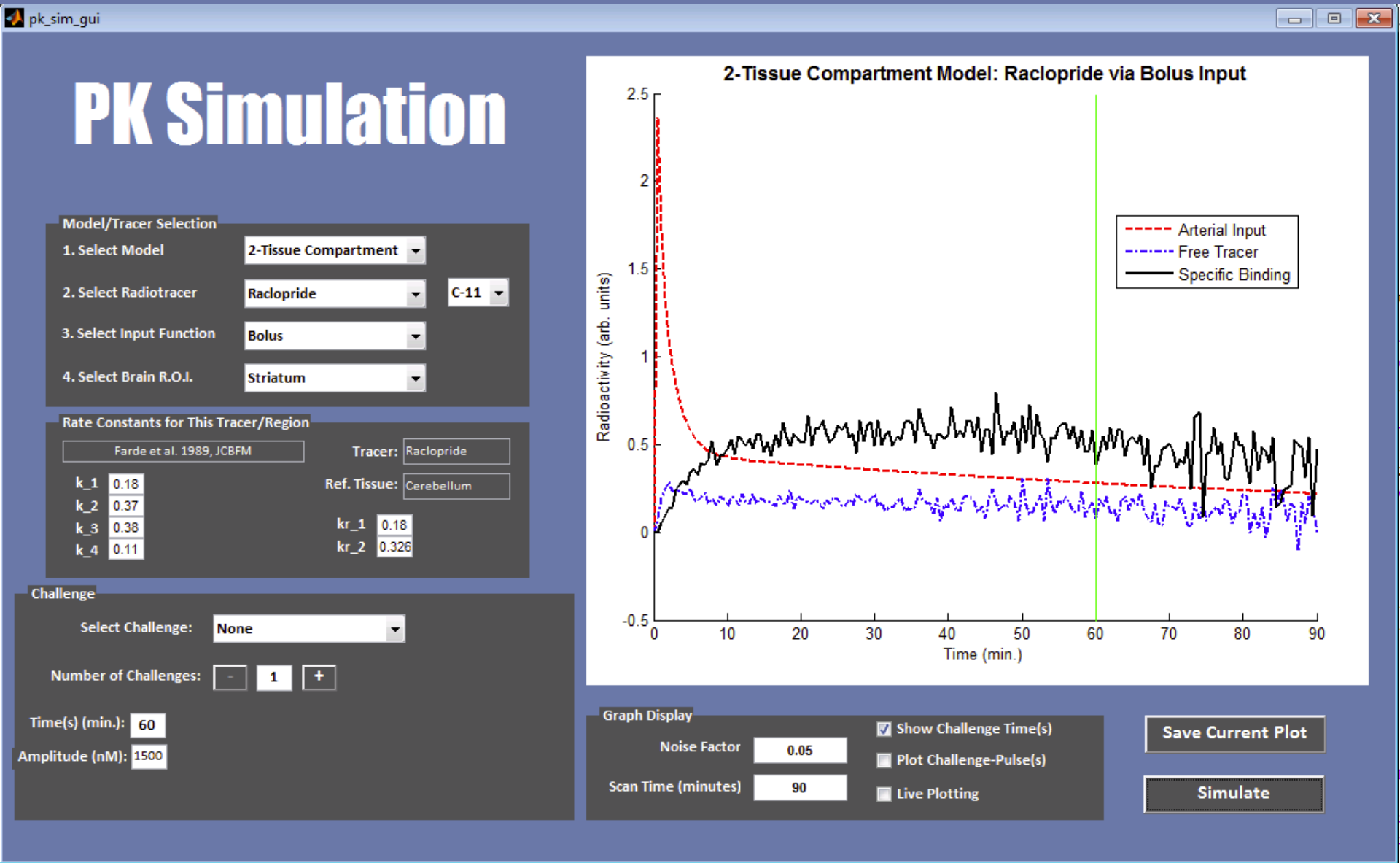
Problems With PET

- High cost machinery & staff
- Scan requires intense coordination and advanced planning
- Small procedural changes can have a big impact on results

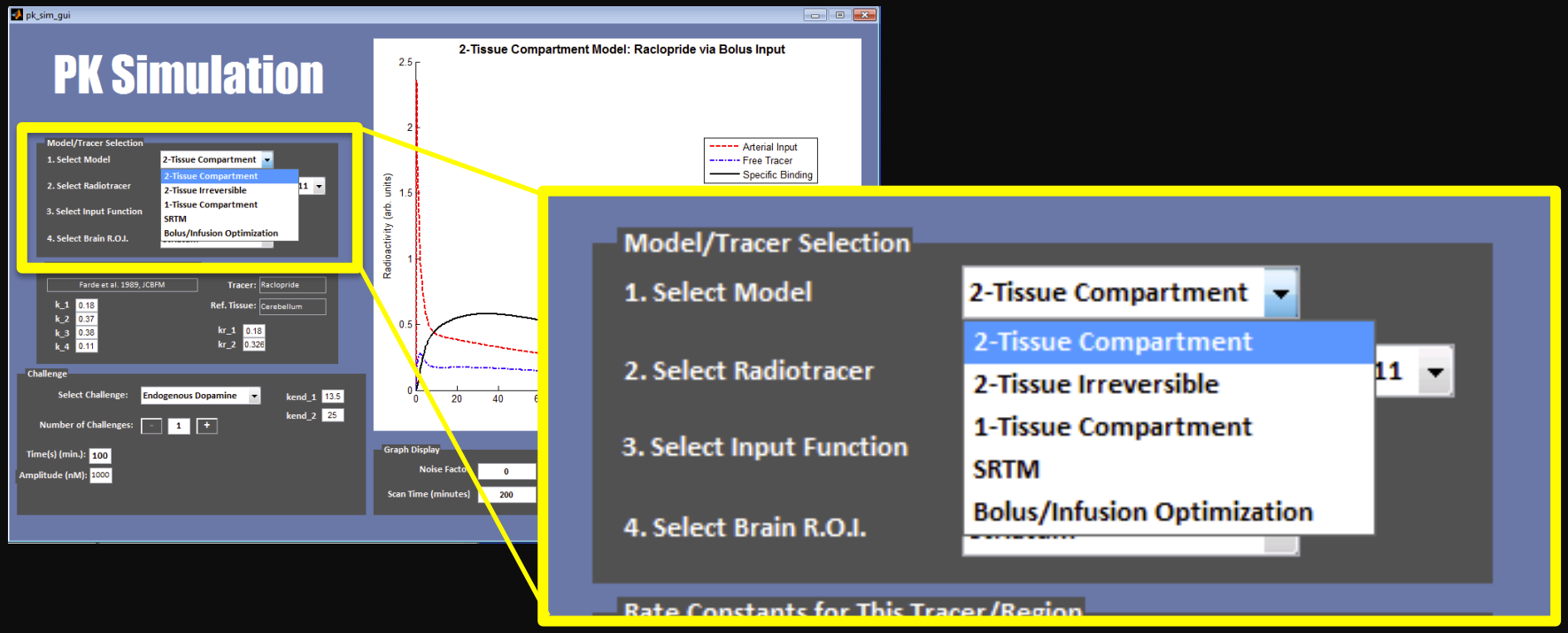
Why Use Simulation?

- Evaluate study feasibility (conserve resources)
- Strategically choose and optimize experimental design
- Facilitate new methods development

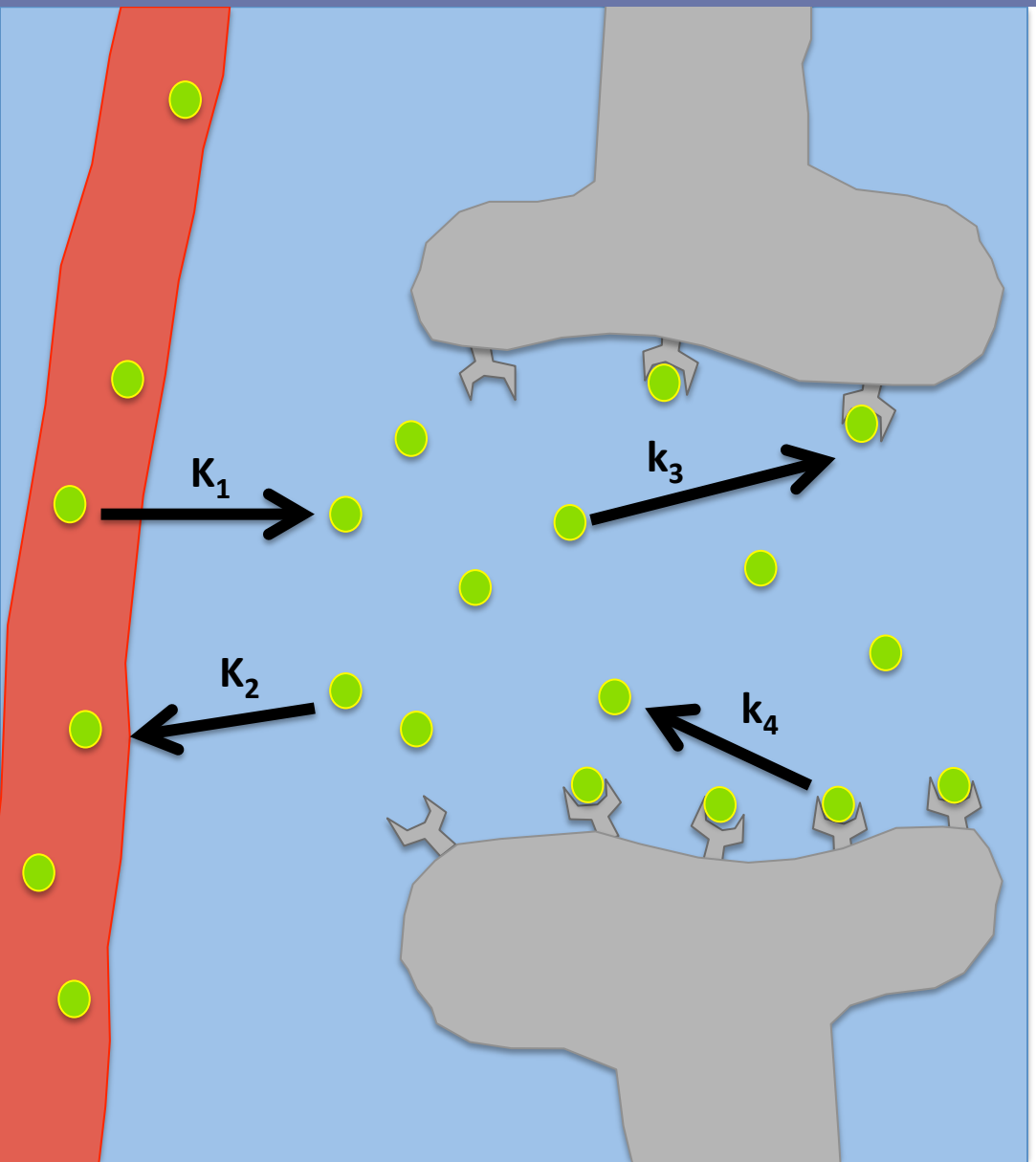
Simulation Tool Screenshot

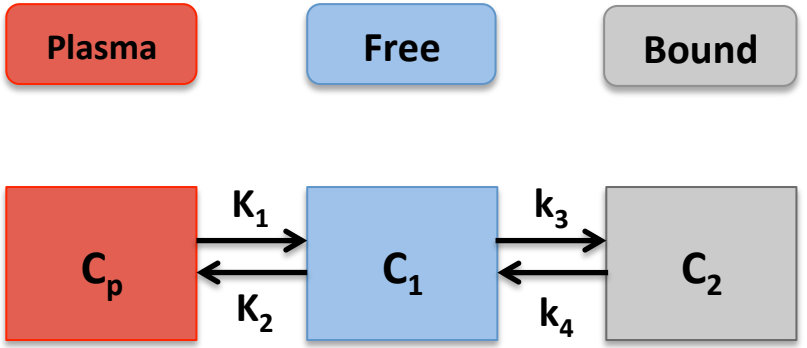


Kinetic Models



2-Tissue Compartment Model

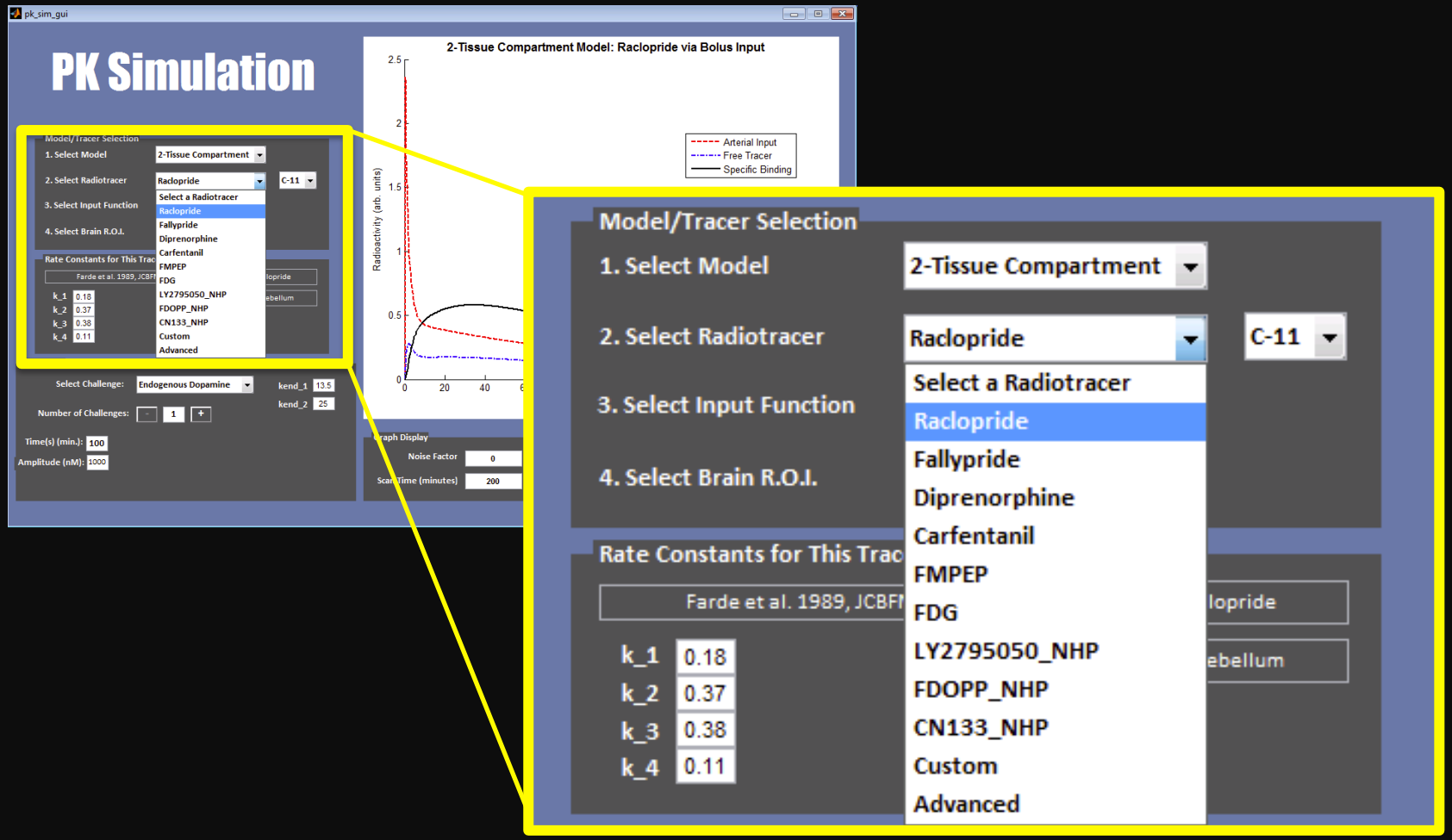




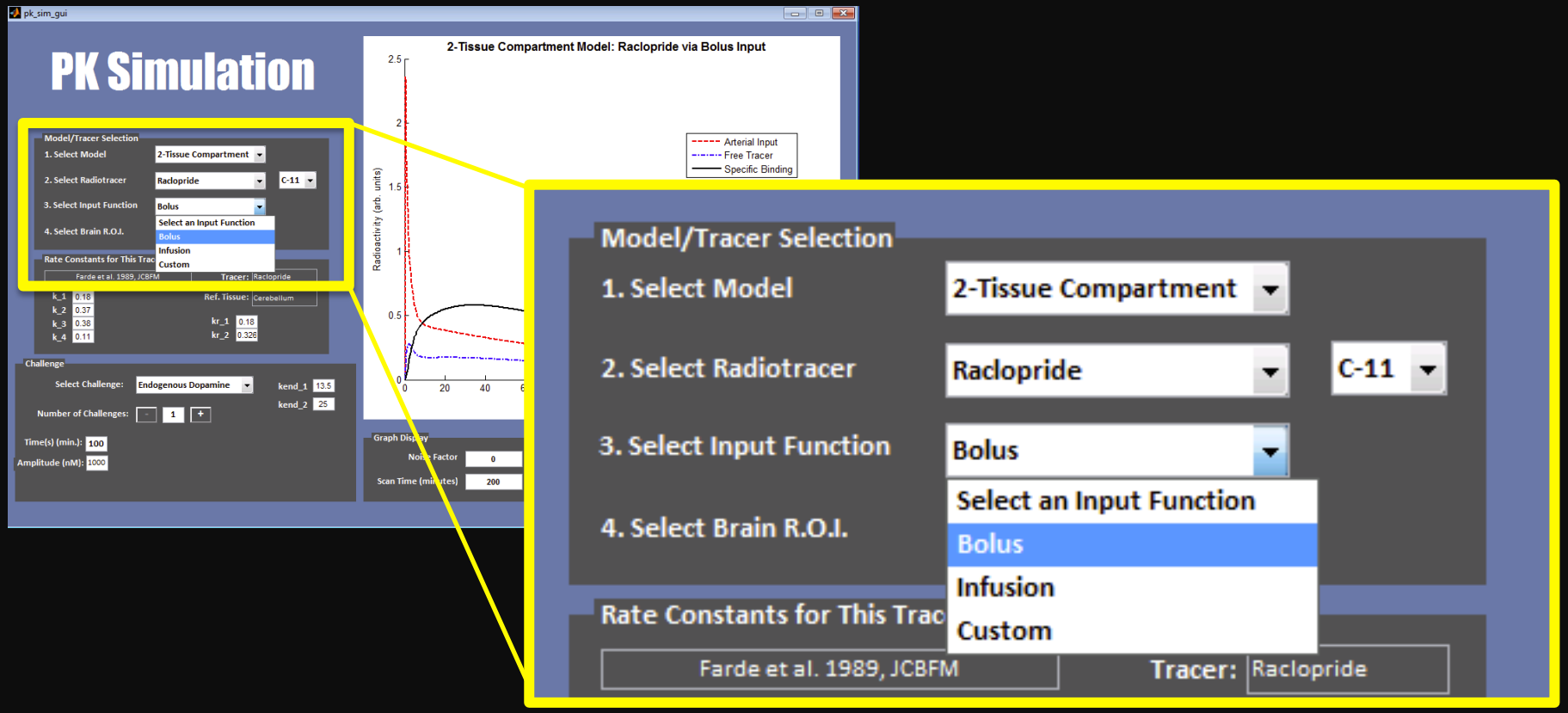
$$\frac{dC_1(t)}{dt} = K_1 C_p(t) - (k_2 + k_3) C_1(t) + k_4 C_2(t)$$

$$\frac{dC_2(t)}{dt} = k_3 C_1(t) - k_4 C_2(t)$$

Radiotracers



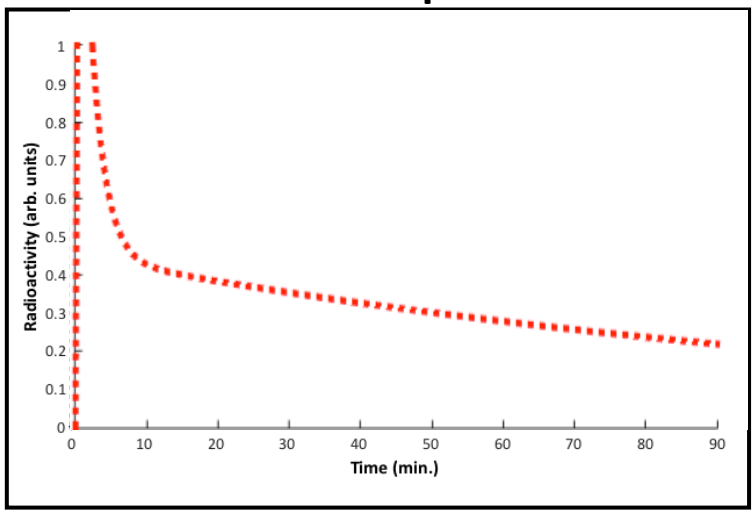
Plasma Input Functions



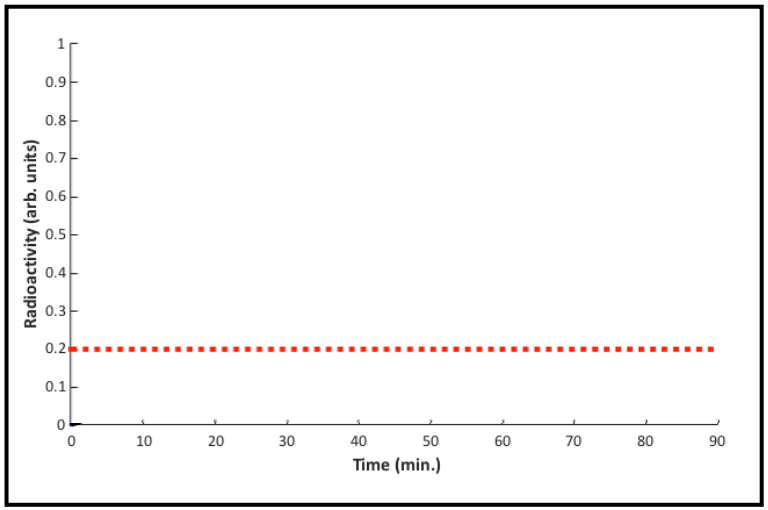
Plasma Input Functions

Example. [^{11}C]Raclopride (dopamine D2/3 selective)

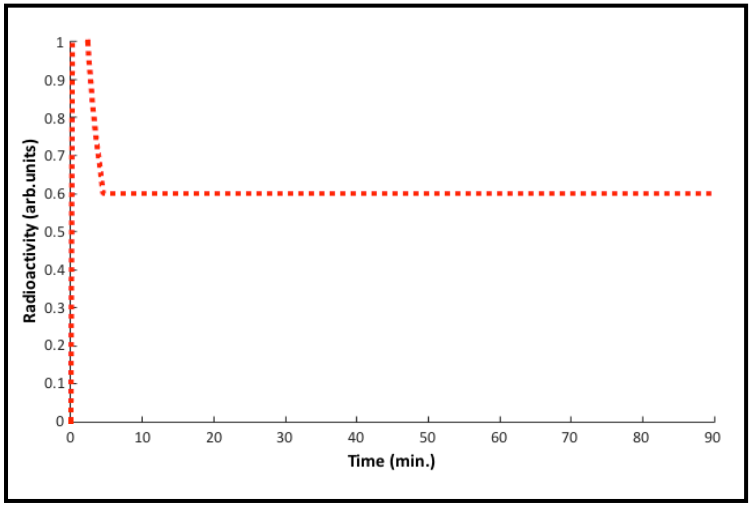
Bolus Input



Constant Infusion Input

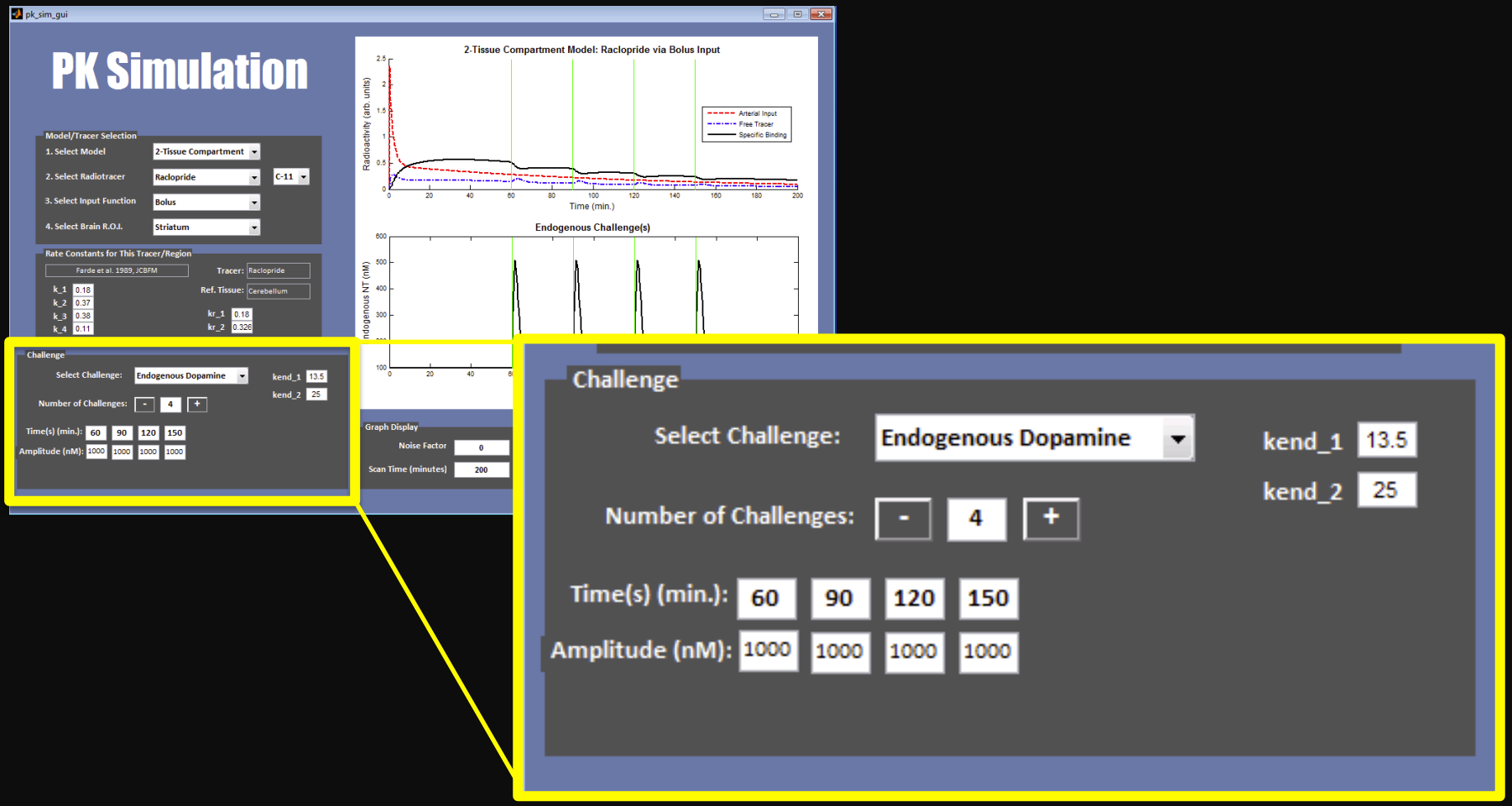


Bolus + Constant Infusion (B/I) Input



Plasma Input

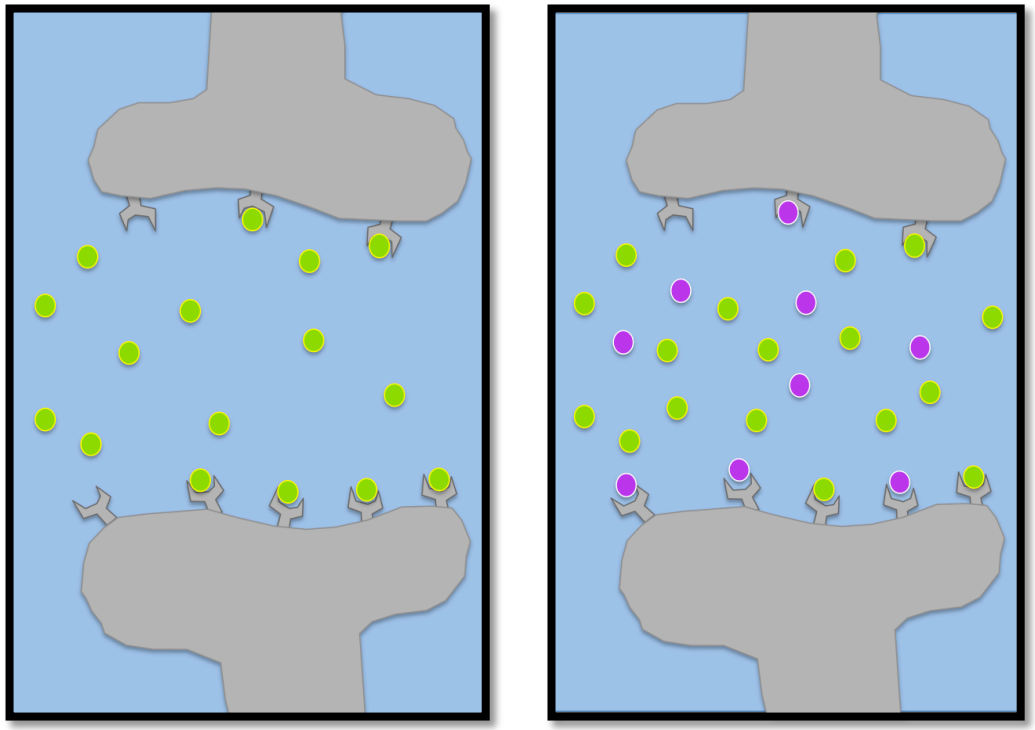
Competition



Competition

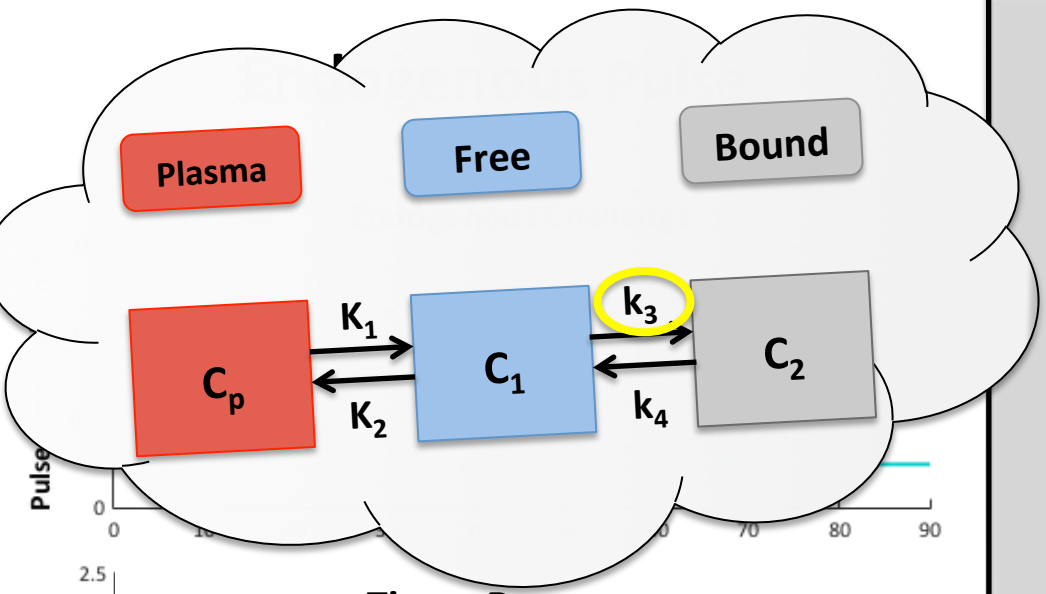
- **Endogenous**
  - ex. [^{11}C]raclopride & dopamine-releasing reward task
- **Exogenous** (pharmacological challenge)
  - ex. [^{11}C]carfentanil with morphine

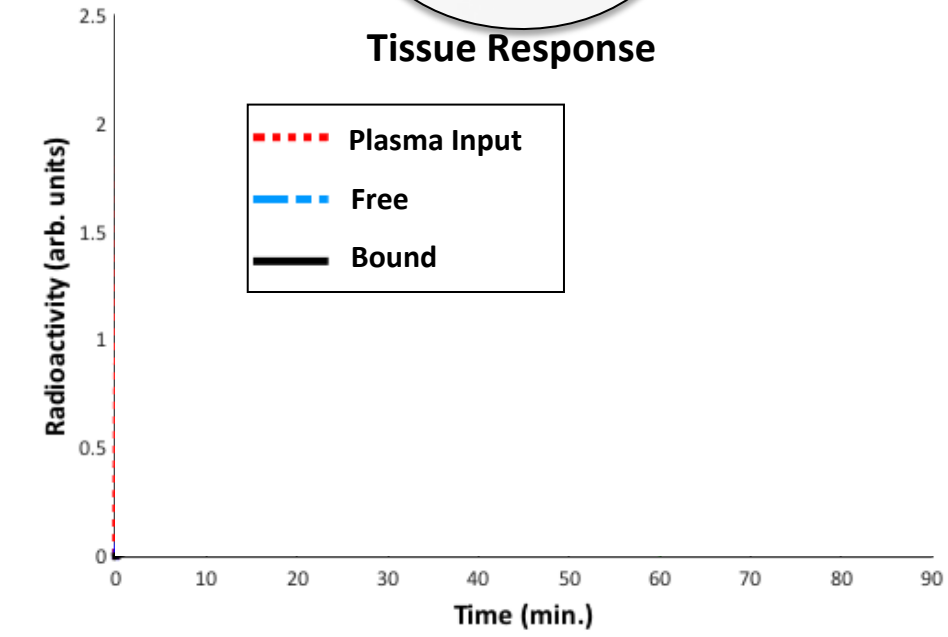
Before Challenge



After Challenge

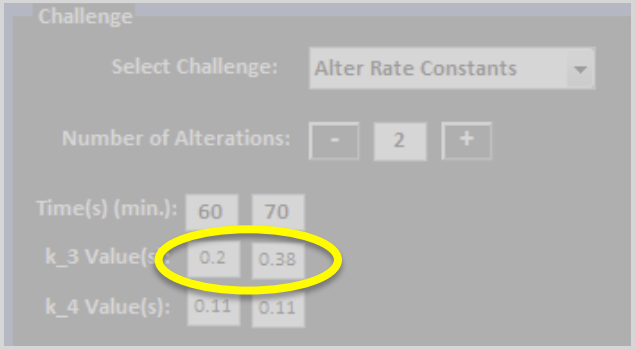
Simulating Competition

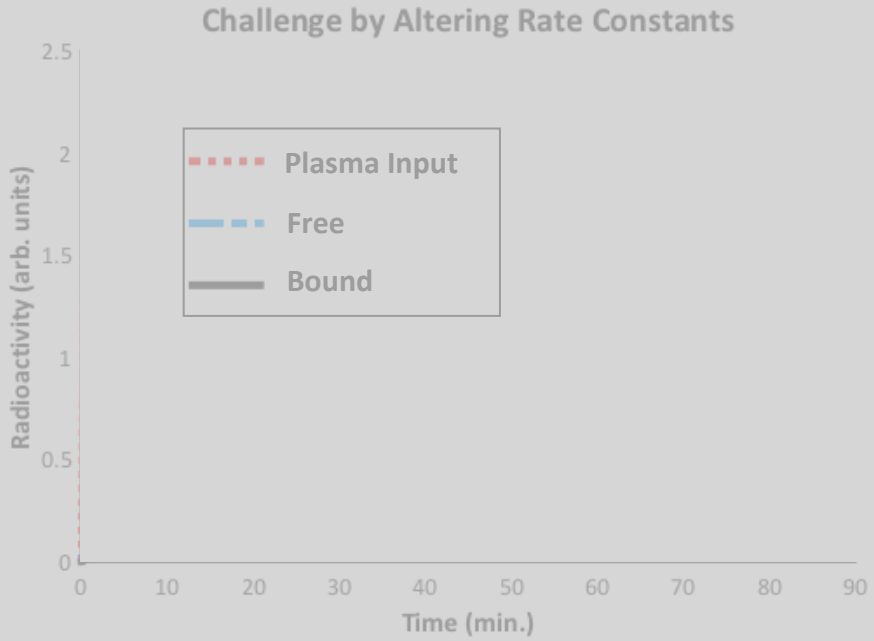




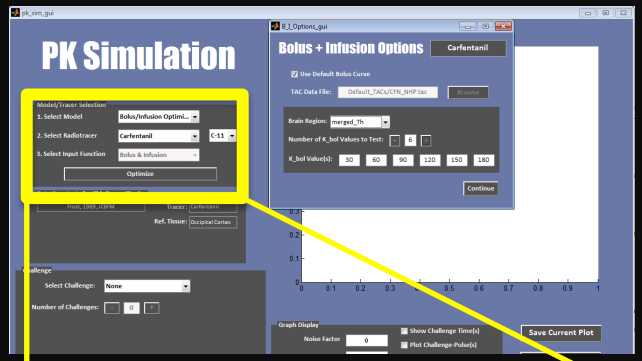
Alter Rate Constants

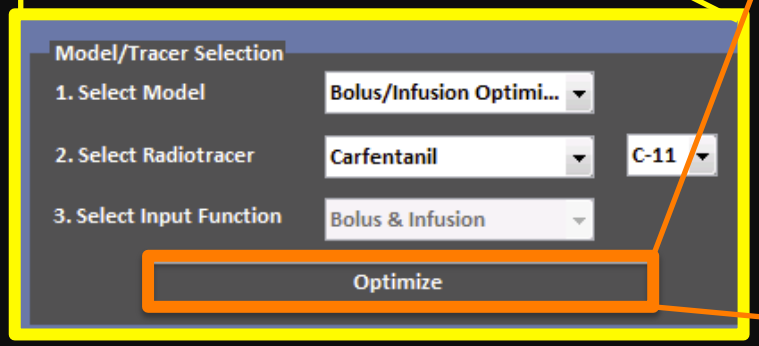
(One Method to Simulate Exogenous Challenge)

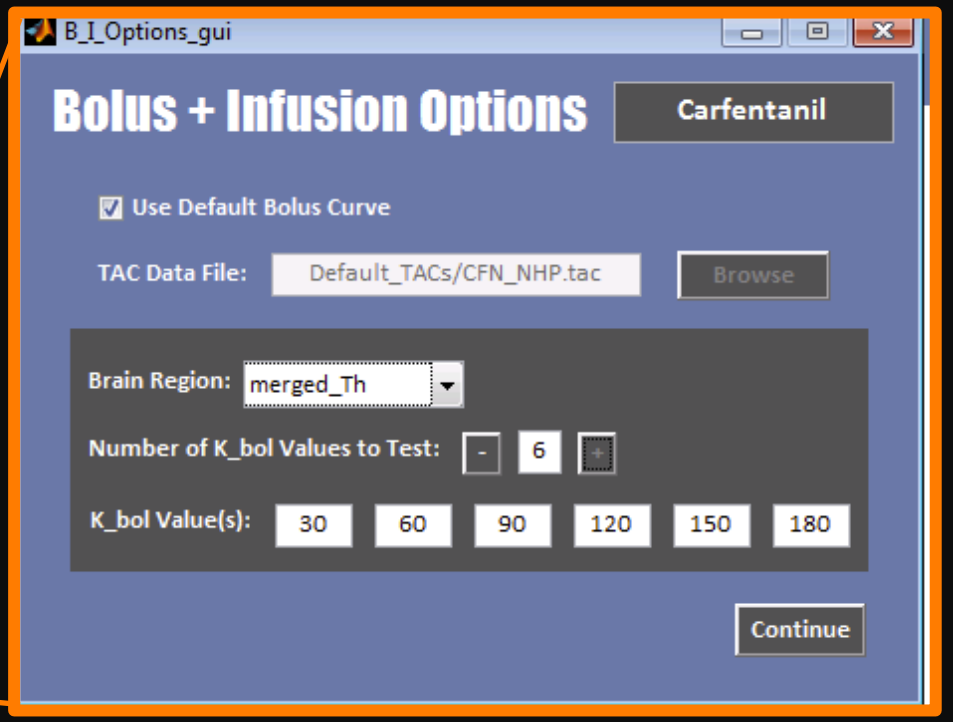




Bolus + Constant Infusion

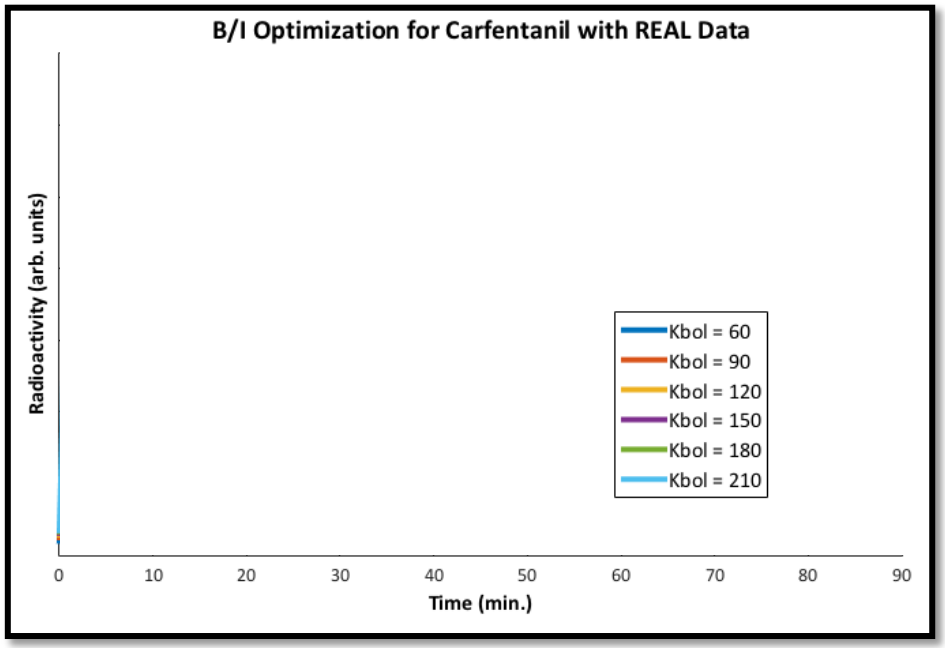


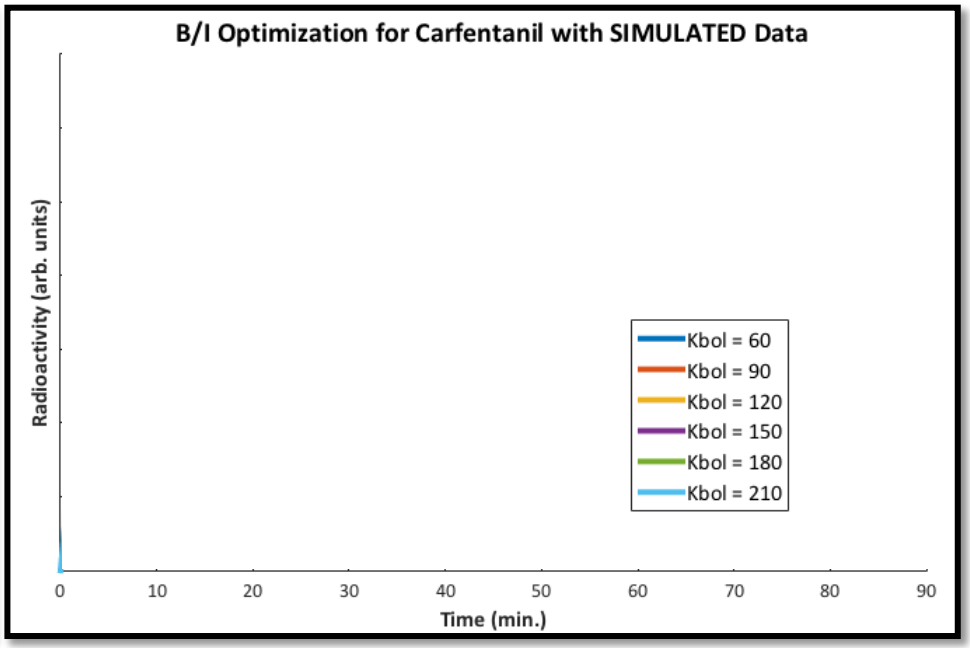




Bolus + Constant Infusion Optimization

- Regular bolus injection followed by continuous infusion
- K_{bol}
  - Bolus dose measured in minutes of infusion dose
  - Units = minutes
- Adjusting K_{bol} (adjusting how much radiotracer is initially injected), allows tracer to reach equilibrium more quickly
- Optimal K_{bol} will vary slightly between subjects and must be determined for each radiotracer

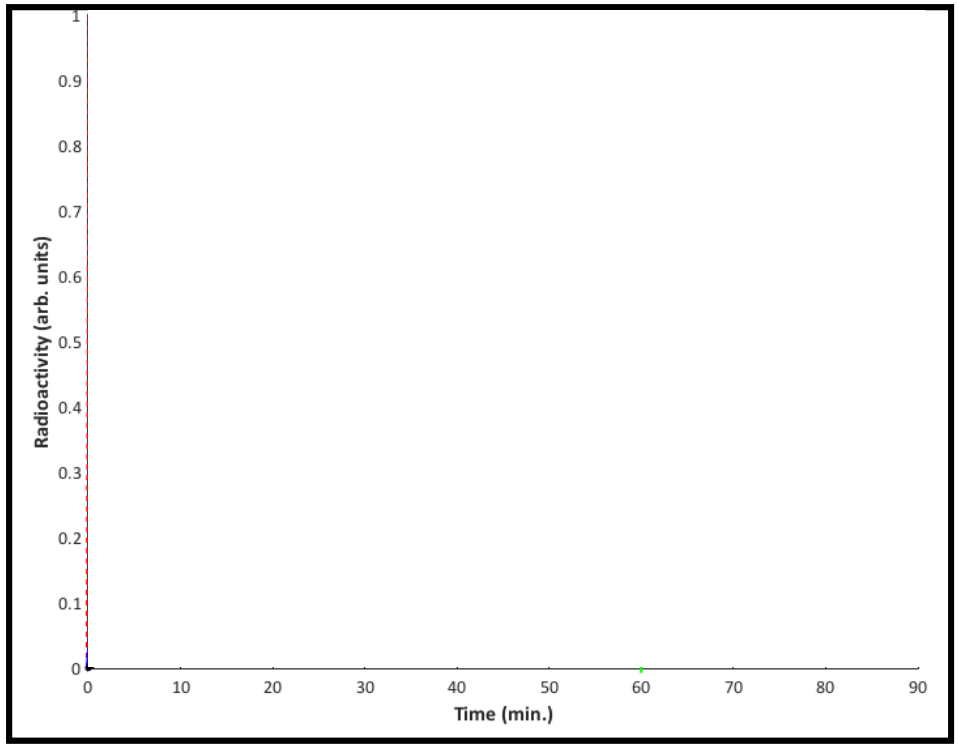




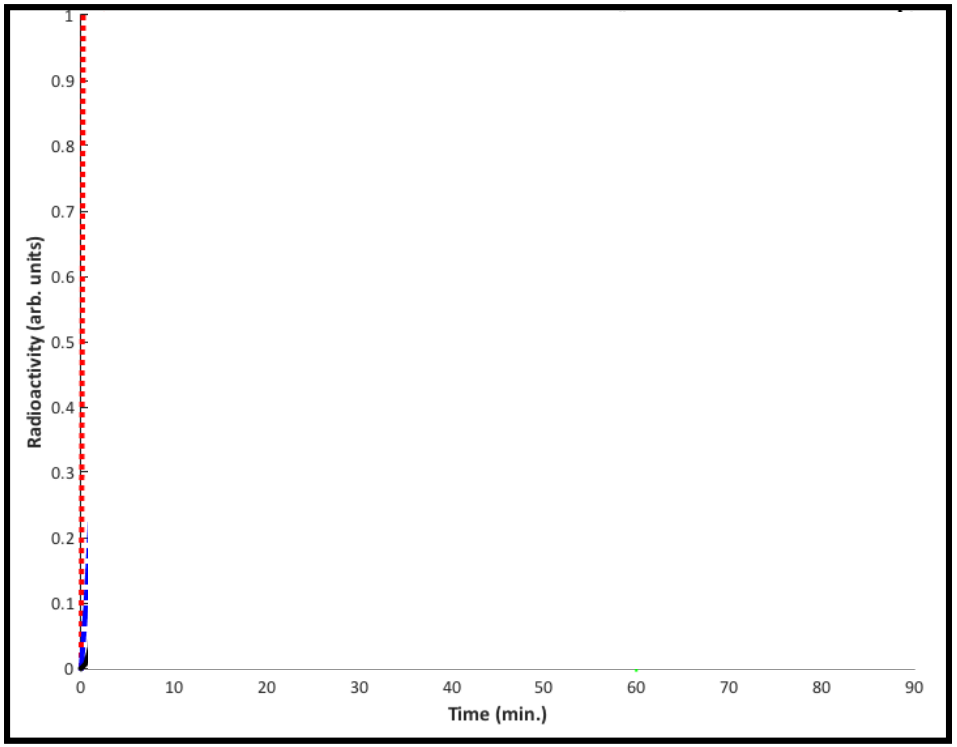
Competition with Bolus + Constant Infusion

Example: [^{11}C]Raclopride with Endogenous Dopamine Challenge at 60 min.

BOLUS Input



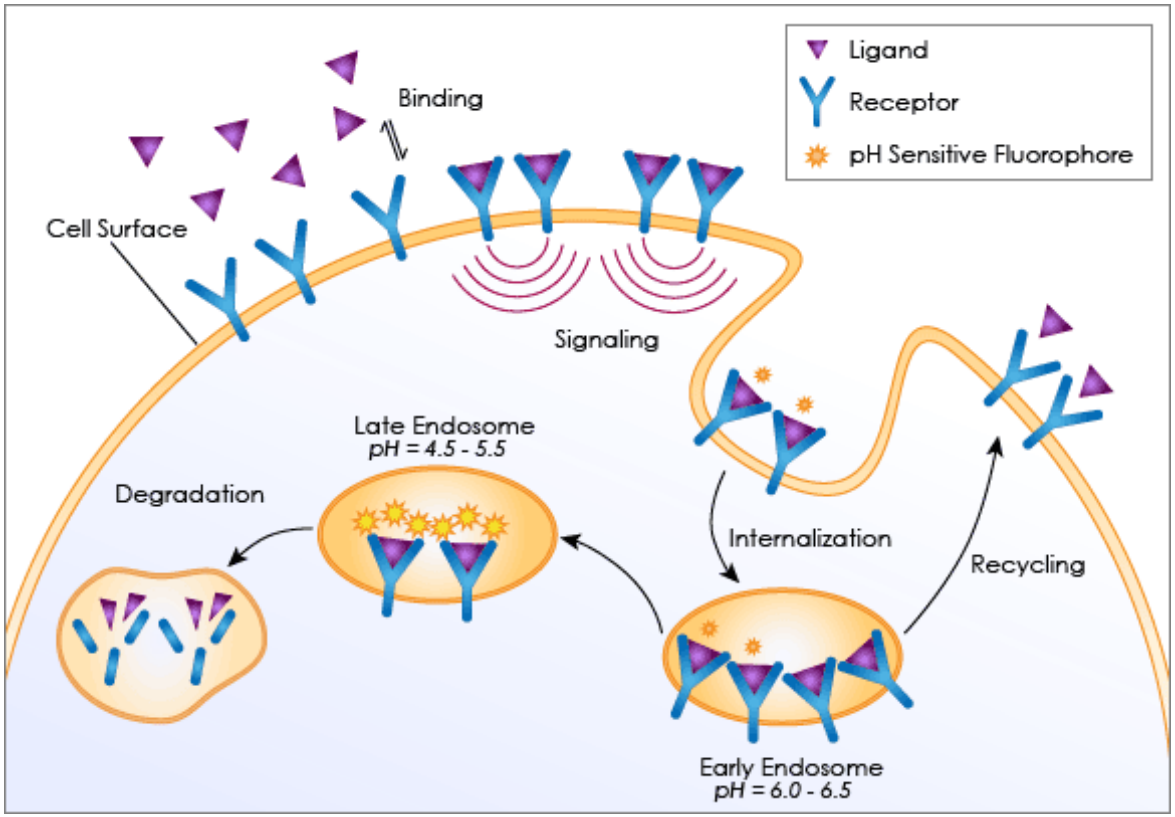
BOLUS + CONSTANT INFUSION Input



Plasma Input Free Bound

Future Direction

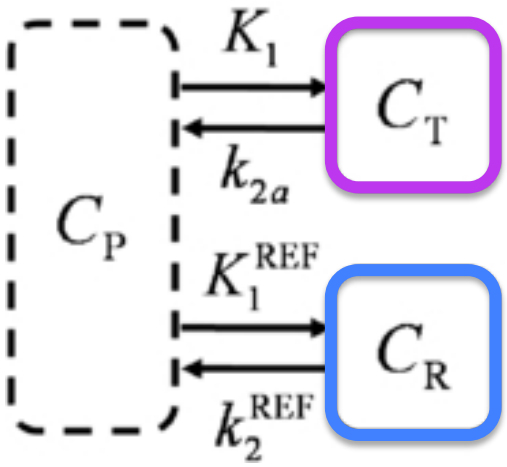
Receptor Internalization Models:



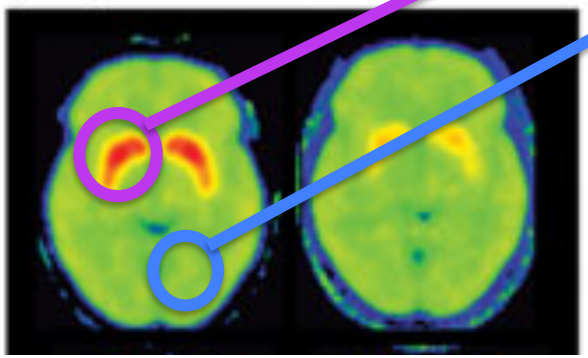
http://www.nexcelom.com/Celigo/receptor-internalization-assay.php

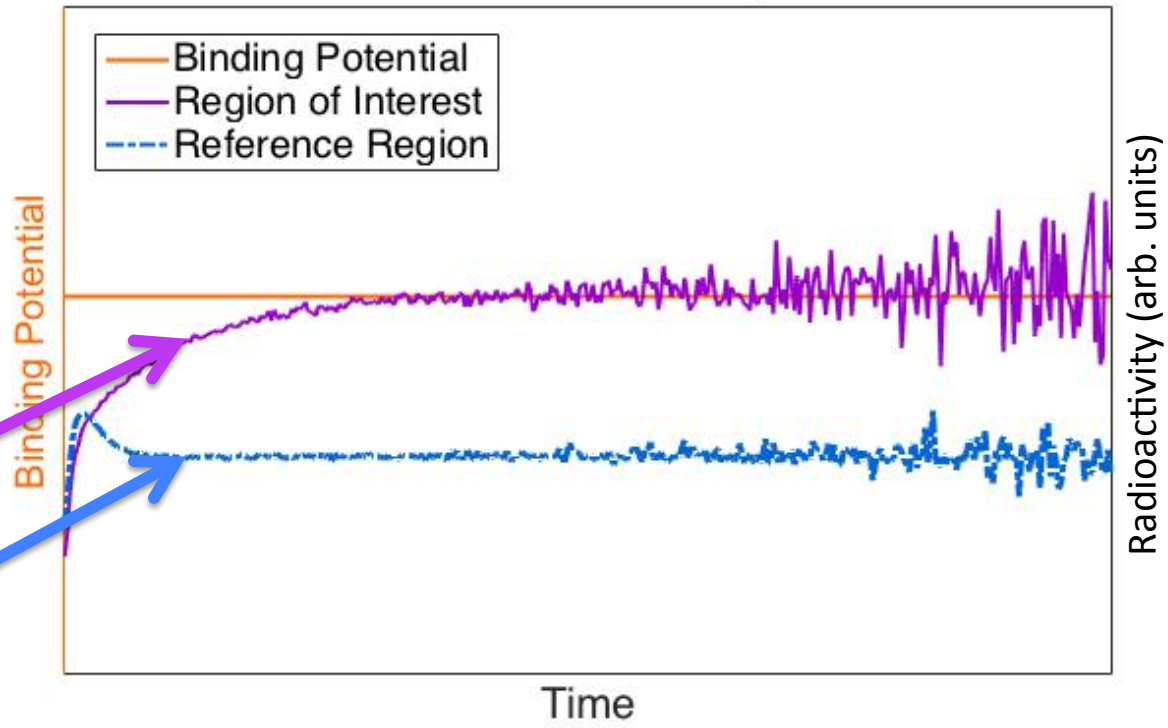
Future Direction

Reference Tissue Models:

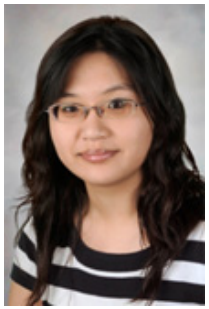


B[^{11}C]cocaine





Acknowledgements



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