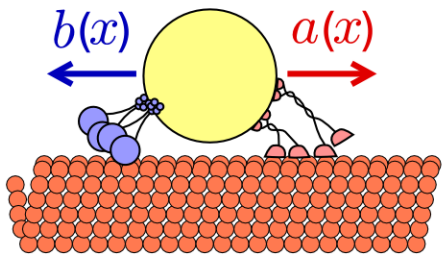
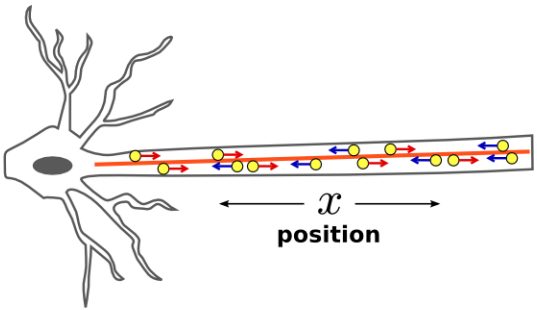
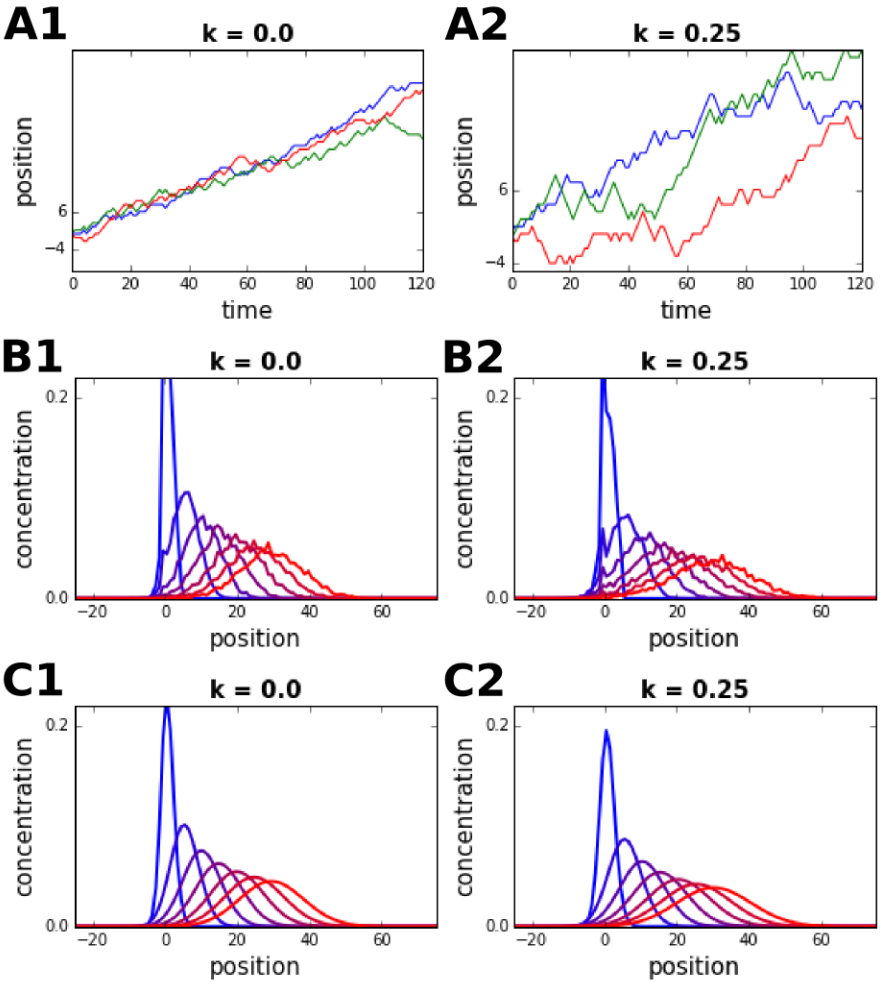
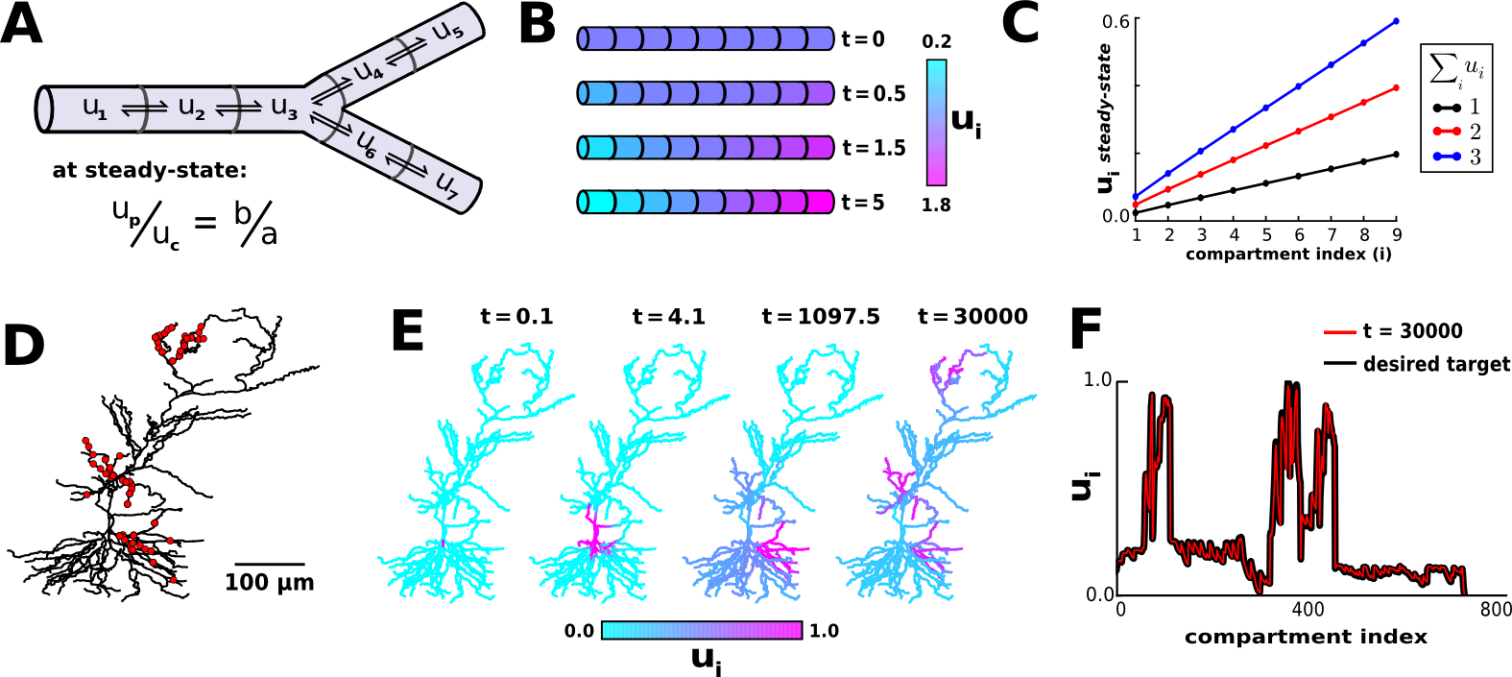


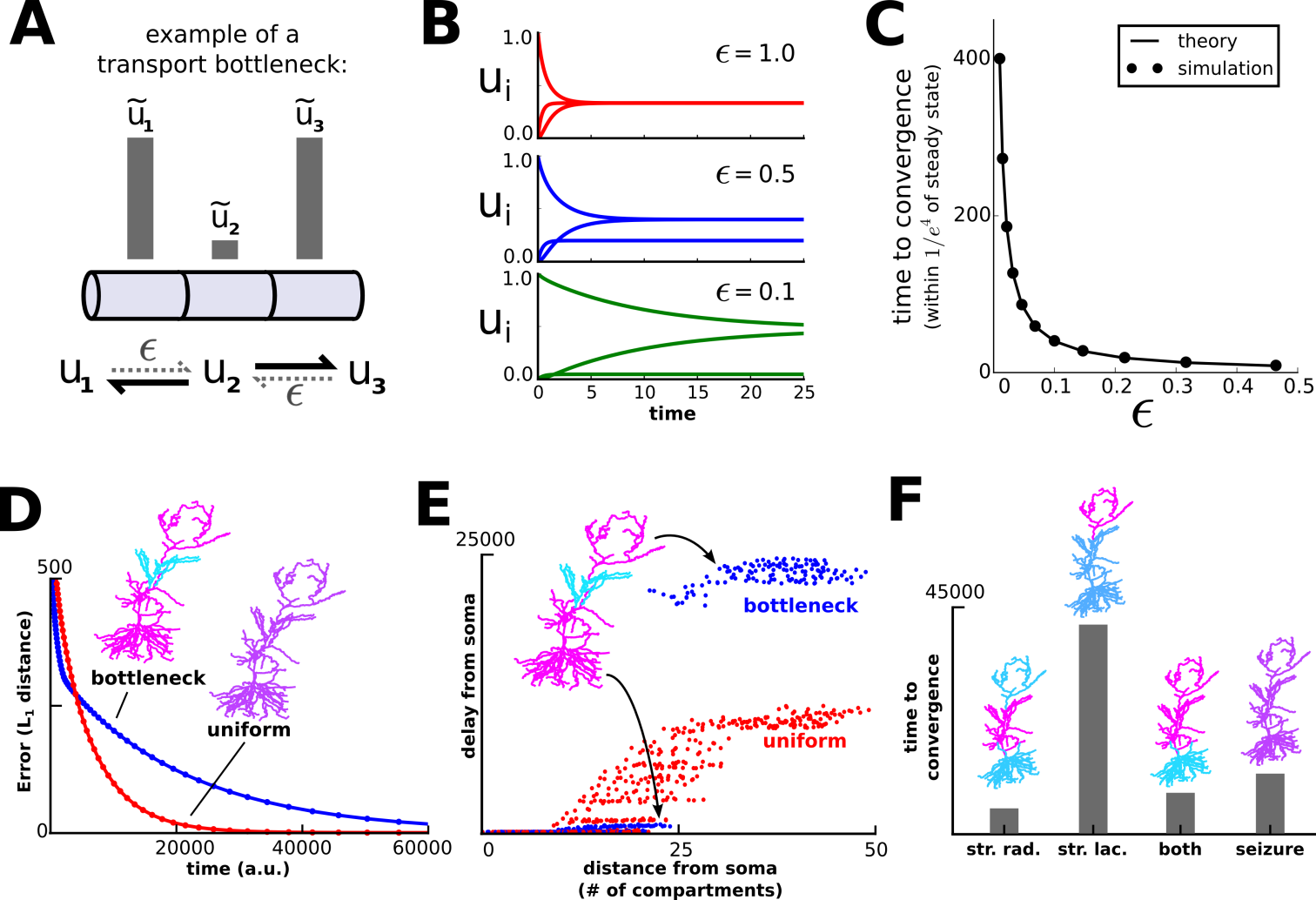


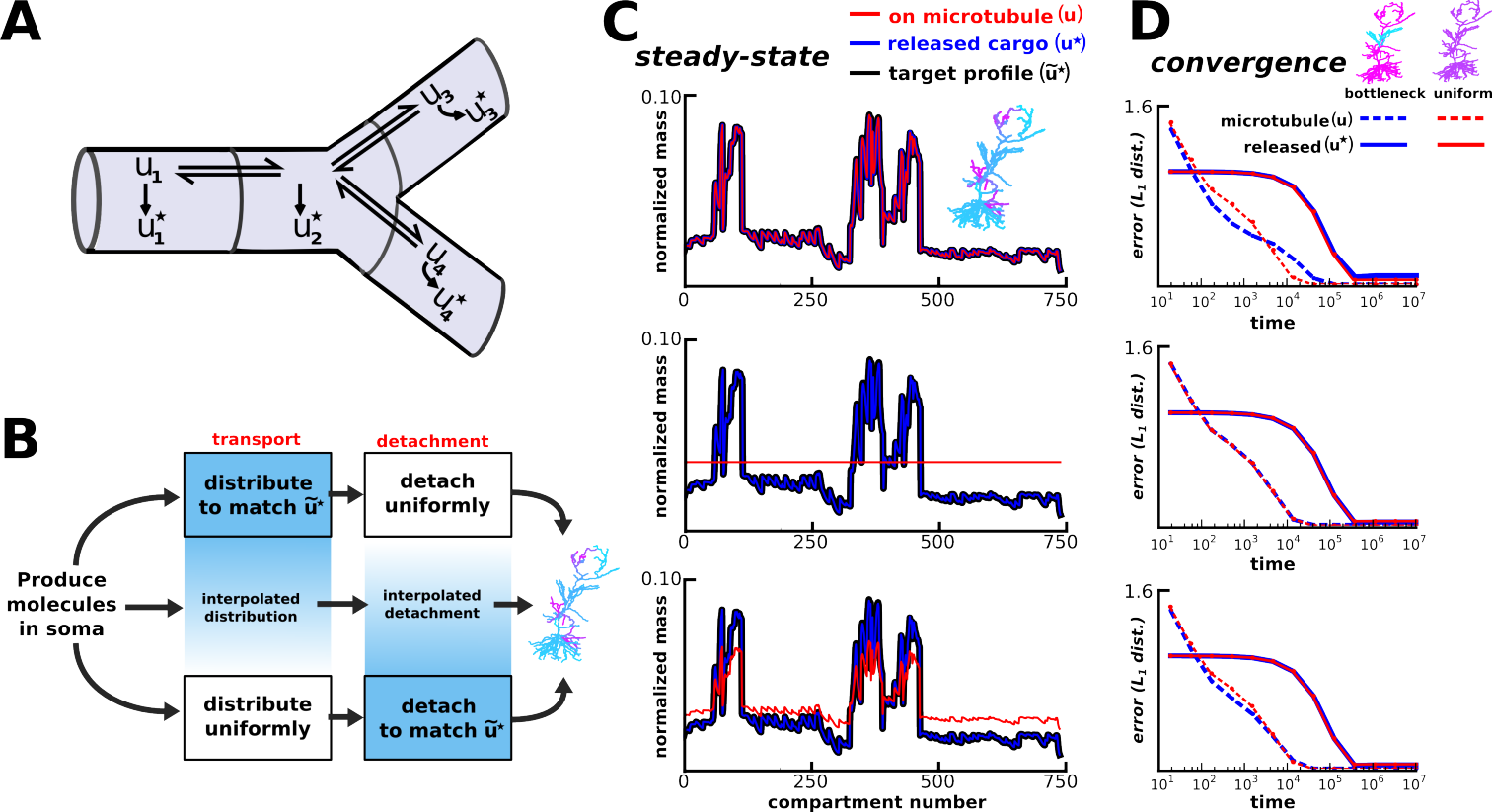
$$\frac{\partial u}{\partial t} = \left[b(x) - a(x)\right]\frac{\partial u}{\partial x}$$

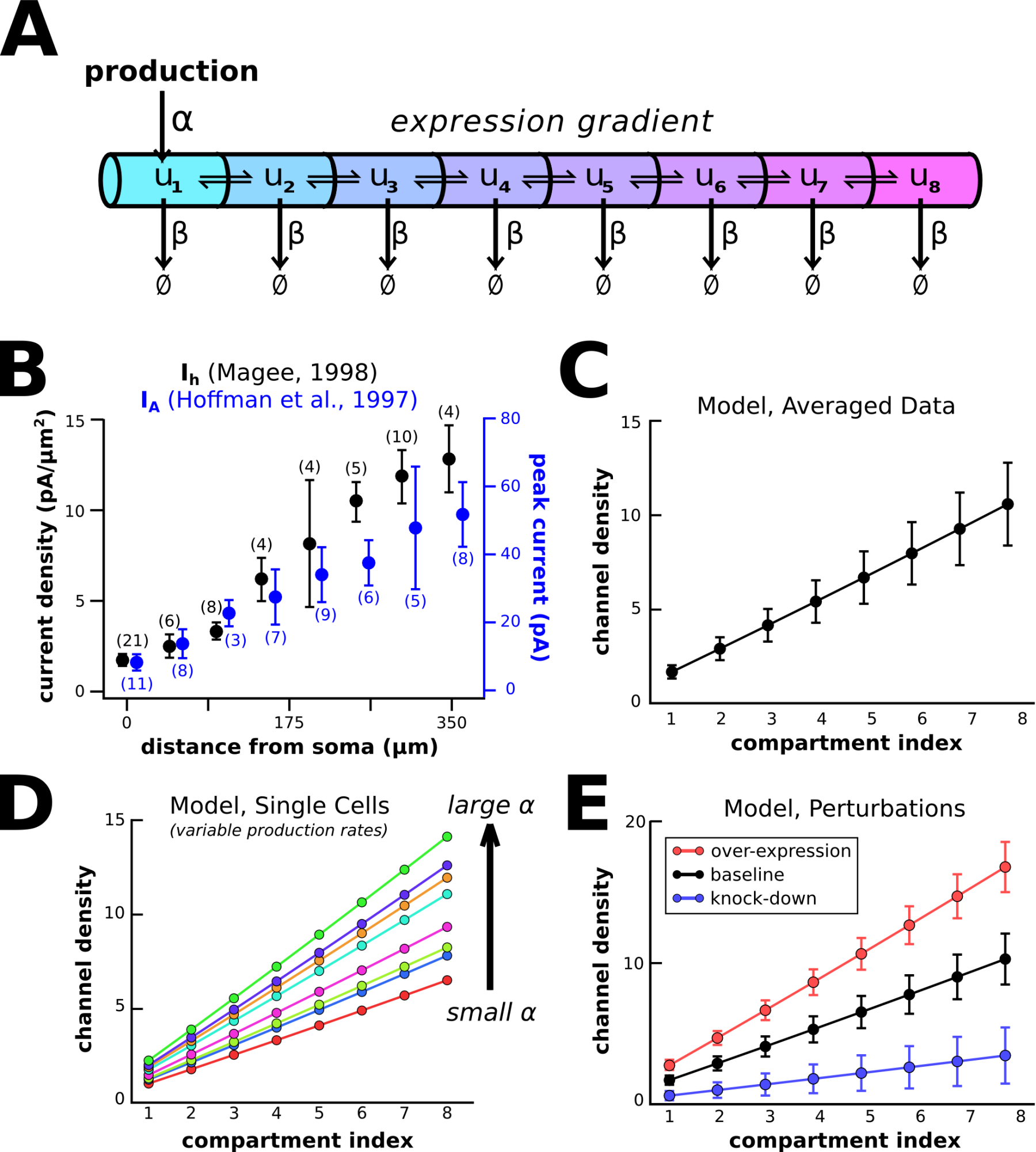
retrograde velocity **anterograde velocity**

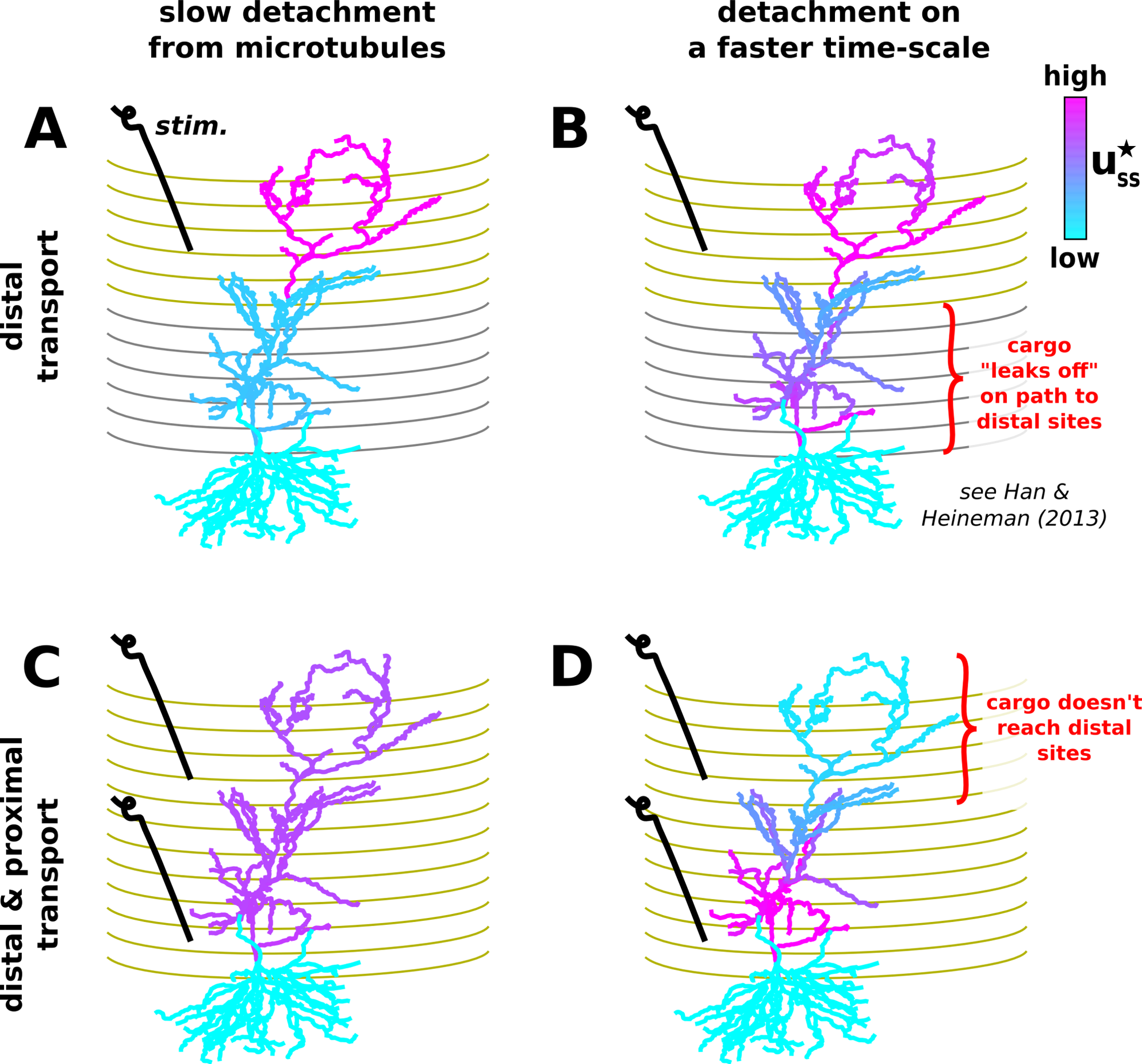



A
u_1 u_2 u_3 u_4 u_5 u_6 u_7
at steady-state:
$u_p/u_c = b/a$
B
t = 0
t = 0.5
t = 1.5
t = 5
0.2
u_i
1.8
C
u_i steady-state
0.6
0.0
1 2 3 4 5 6 7 8 9
compartment index (i)
$\sum_i u_i$
1
2
3
D
100 µm
E
t = 0.1
t = 4.1
t = 1097.5
t = 30000
0.0
1.0
u_i
F
t = 30000
desired target
u_i
1.0
0.0
0
400
800
compartment index


A
example of a
transport bottleneck:
$\tilde{u}_1$
$\tilde{u}_3$
$\tilde{u}_2$
ϵ
u_1
u_2
u_3
ϵ
B
u_i
1.0
0.0
$\epsilon = 1.0$
$\epsilon = 0.5$
$\epsilon = 0.1$
0
5
10
15
20
25
time
C
theory
simulation
time to convergence
(within $1/e^4$ of steady state)
400
200
0
0
0.1
0.2
0.3
0.4
0.5
ϵ
D
500
0
Error (L_1 distance)
bottleneck
uniform
20000
40000
60000
time (a.u.)
E
25000
delay from soma
bottleneck
uniform
0
25
50
distance from soma
(# of compartments)
F
45000
time to
convergence
str. rad.
str. lac.
both
seizure


A
B
transport
detachment
distribute to match ũ*
detach uniformly
Produce molecules in soma
interpolated distribution
interpolated detachment
distribute uniformly
detach to match ũ*
C
steady-state
on microtubule (u)
released cargo (u*)
target profile (ũ*)
normalized mass
0.10
0
250
500
750
compartment number
D
convergence
bottleneck
uniform
microtubule (u)
released (u*)
error (L1 dist.)
1.6
time


A
production
α
expression gradient
u1 u2 u3 u4 u5 u6 u7 u8
β
Ø
B
Ih (Magee, 1998)
IA (Hoffman et al., 1997)
current density (pA/µm²)
peak current (pA)
distance from soma (µm)
0
175
350
(21)
(11)
(6)
(8)
(8)
(3)
(4)
(7)
(4)
(9)
(5)
(6)
(10)
(5)
(4)
(8)
C
Model, Averaged Data
channel density
compartment index
D
Model, Single Cells
(variable production rates)
large α
small α
channel density
compartment index
E
Model, Perturbations
over-expression
baseline
knock-down
channel density
compartment index


slow detachment
from microtubules
detachment on
a faster time-scale
high
low
$u^{\star}_{ss}$
A
B
C
D
stim.
distal
transport
distal & proximal
transport
cargo
"leaks off"
on path to
distal sites
see Han &
Heineman (2013)
cargo doesn't
reach distal
sites