Effect of removing fixed fraction of active subunits from a CaMKII/PP1 Switch

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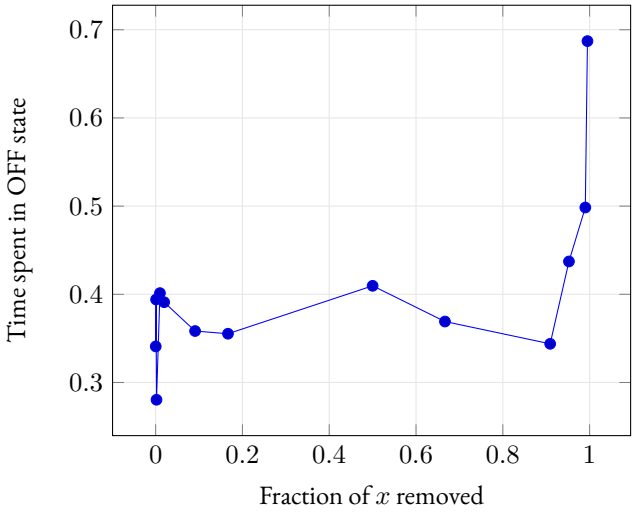
Previously (in experiment of `../exp_MANY_VOXELS_COUPLED_WITH_DIFFUSION/`), we saw that CaMKII/PP1 switch's ON state is sensitive to removal of active subunits x (due to diffusion of x out of voxel/compartment). In this labnote, we quantify the effect of removing a fraction of active subunits x from the system at rate comparable to diffusion of x.[1]

In this experiment, we quantify this effect.

1 Summary of this labnote

Contrary to previous experiment (see footnote), we found that removal of active subunit does not have very strong impact on switch unless all of active subunits have been removed.



[1] In a previous version of this experiment, we removed all x at different rate. See this labnote. Needless to say the effect of removing subunits was rather drastic. This labnote creates more realistic situation by removing a certain fraction of x. The diffusion process which is bi-directional is unlikely to remove all x from one system without replacing many of them with other xs from neighbouring system.

2 Experiment design

We setup additional reaction which converts x into a dummy molecule xs. Molecules xs does not play any role in system. The forward rate is fixed to 1 and the backward rate is changed in each run.

$$\mathrm{x} \underset{k_b}{\overset{k_f}{\rightleftharpoons}} \mathrm{xs}$$

Above reaction removes a certain fraction of x by converting it into xs. This fraction is given by $\frac{k_f}{k_f+k_b}$. This 'approximates' the effect of removing active subunits from the CaMKII-PP1 switch by diffusion.

For a diffusion coefficient of D in a 1-D compartment of length l, the rate constant $k_f = \frac{D}{l^2}$. For a typical value of $D = 1\,\mu m^2/s$ in a 1-D compartment of length 1 μm, $k_f = 1$.

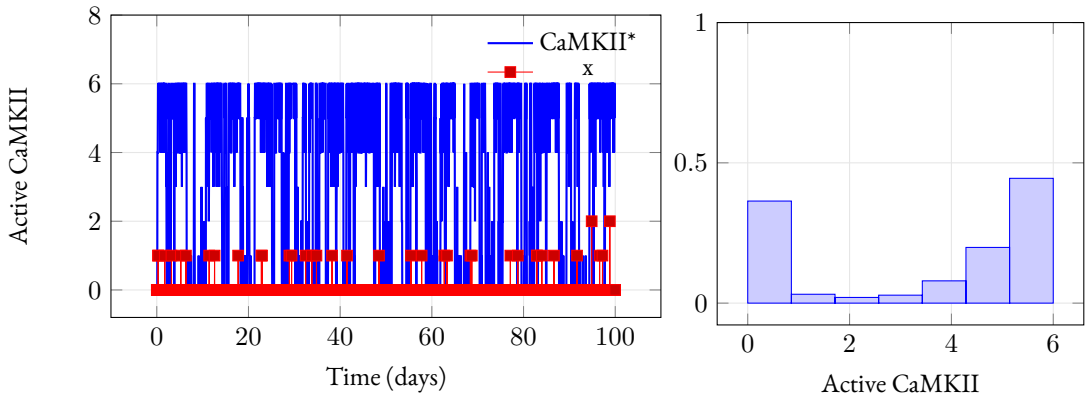
2.1 Model script

Since this model have non-trivial modifications, the script is maintained in this directory itself. If the reference model *../camkii_pp1_scheme.py* is changed significantly, then model file in this directory should be changed accordingly.

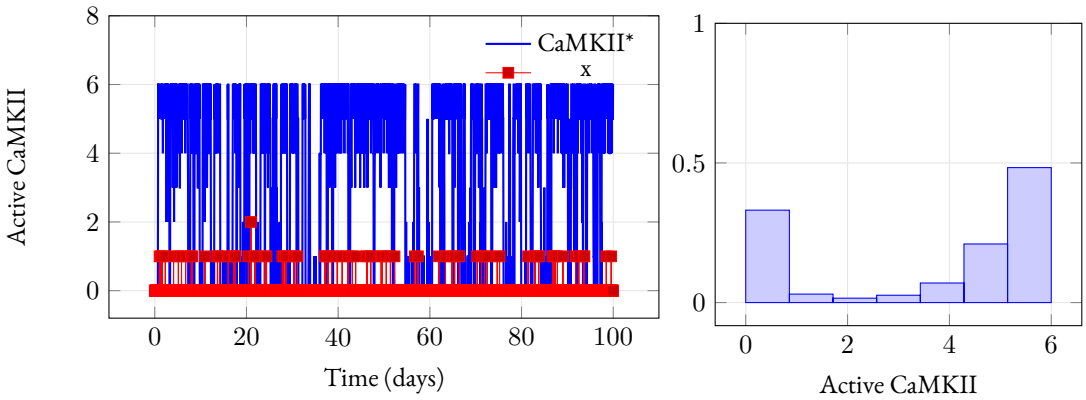
3 Results

Following the plot of some runs.

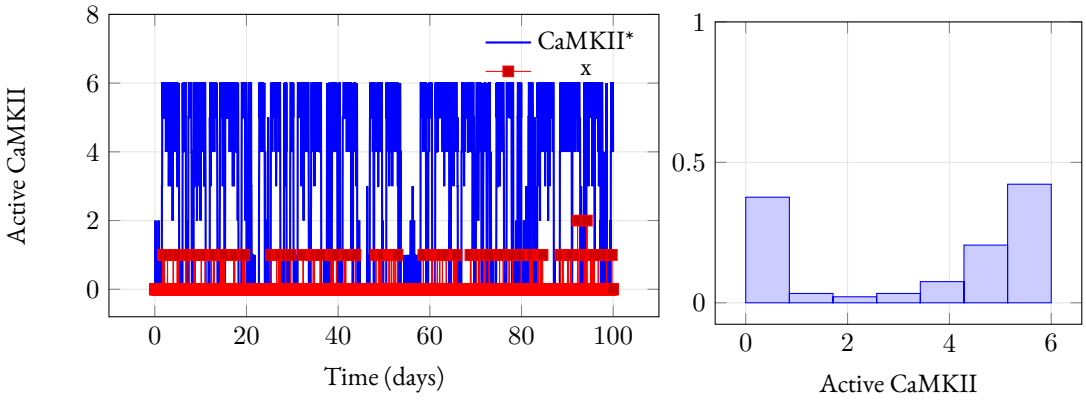
Rate of reaction (see reaction 2) $k_f = 1$ and $k_b = 1000$. Fraction of x removed 0.00099.



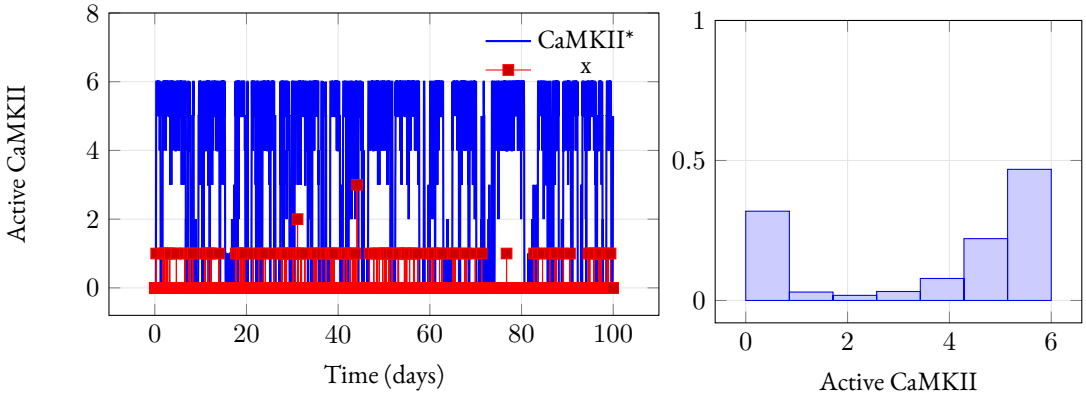
Rate of reaction (see reaction 2) $k_f = 1$ and $k_b = 10$. Fraction of x removed 0.0909.



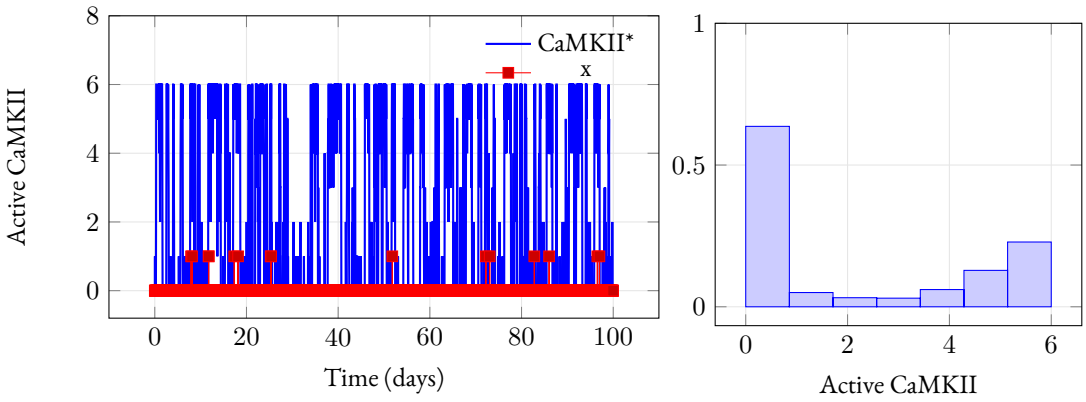
Rate of reaction (see reaction 2) $k_f = 1$ and $k_b = 1$. Fraction of x removed 0.5.



Rate of reaction (see reaction 2) $k_f = 1$ and $k_b = 0.1$. Fraction of x removed 0.9091.



Rate of reaction (see reaction 2) $k_f = 1$ and $k_b = 0.005$. Fraction of x removed 0.995.


Active CaMKII
8
6
4
2
0
0
20
40
60
80
100
Time (days)
CaMKII*
x
1
0.5
0
0
2
4
6
Active CaMKII