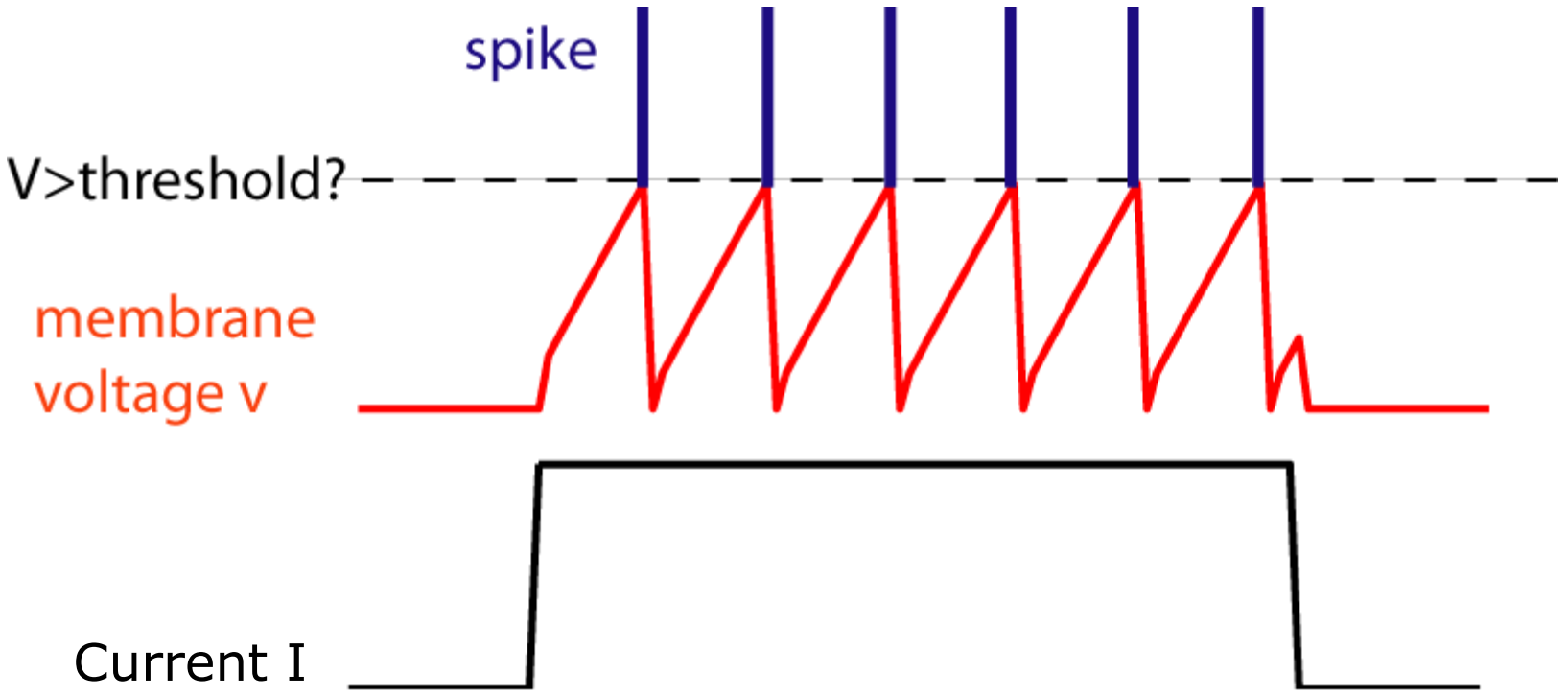
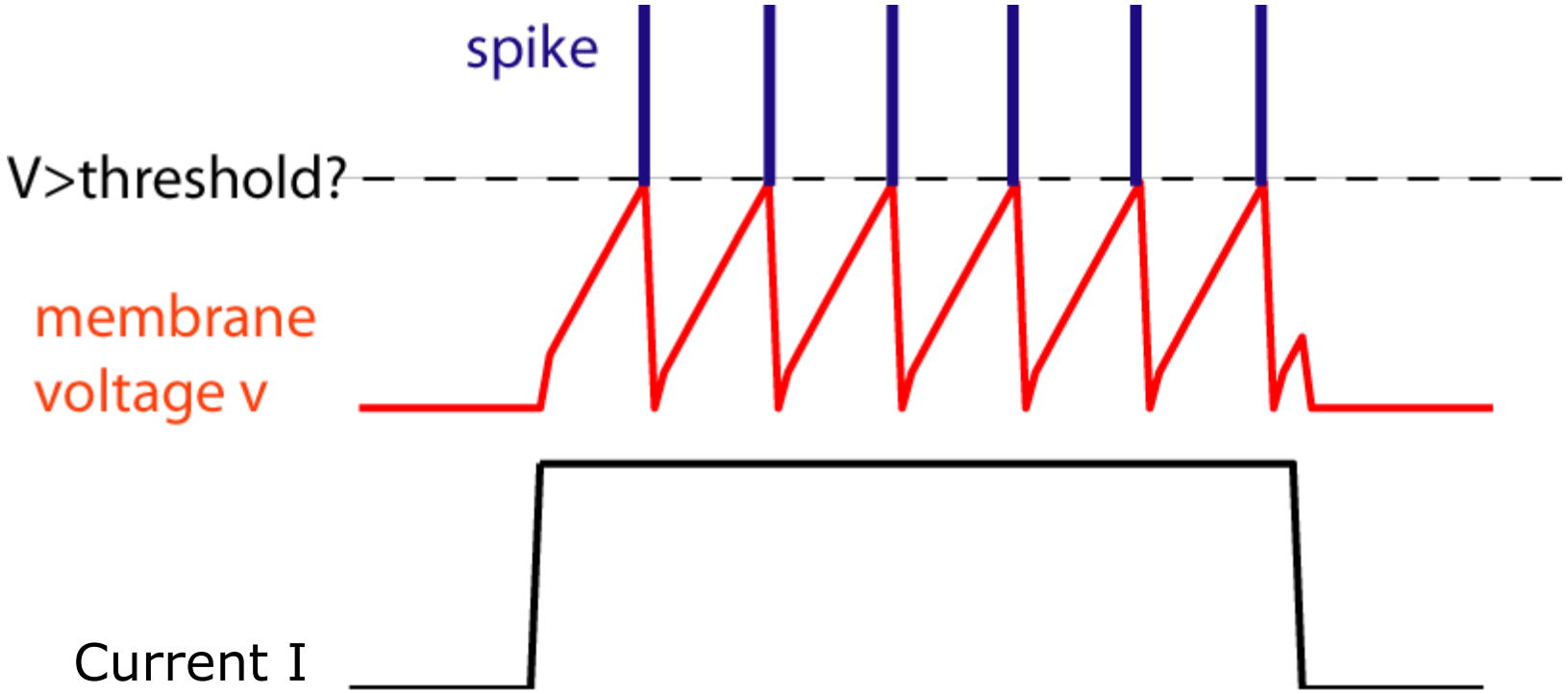
Leaky Integrate and Fire Model

- Describes some properties of voltage change over time and spiking activity
- Parameters correspond to known properties of neurons (and electrical circuits)
- Simple (doesn't model biophysical detail)
- Simple (DE can be solved, example, using separable DE!)
- Simple (Still widely used today in brain modeling, scales up to networks of neurons)

Membrane voltage and spiking



Leaky Integrate and Fire



Leak

$$\frac{dv}{dt} = \frac{-v}{\tau} + \frac{I}{C}$$

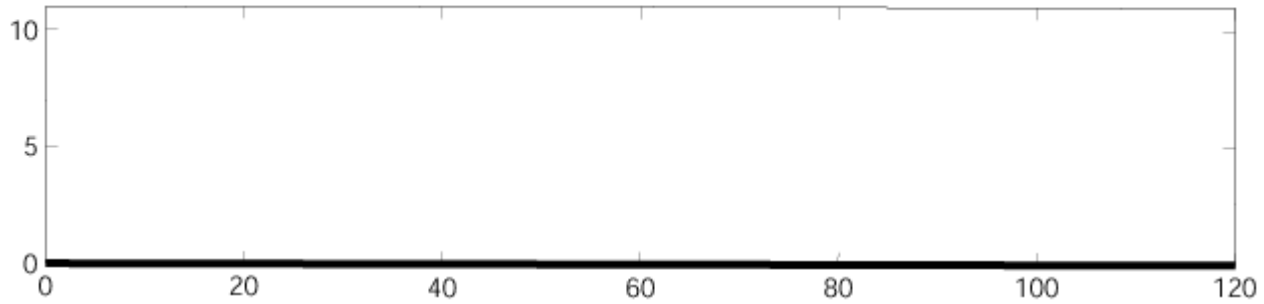
Leaky Integrate and Fire DE

- DE $$\frac{dv}{dt} = \frac{-v}{\tau} + \frac{I}{C}$$
- Change with time: v(t), t
- Assume constants: I, R, C, $\tau = RC$
- Putting in separable form and solving

$$v(t) = v(t=0)e^{-t/\tau} + RI(1 - e^{-t/\tau})$$

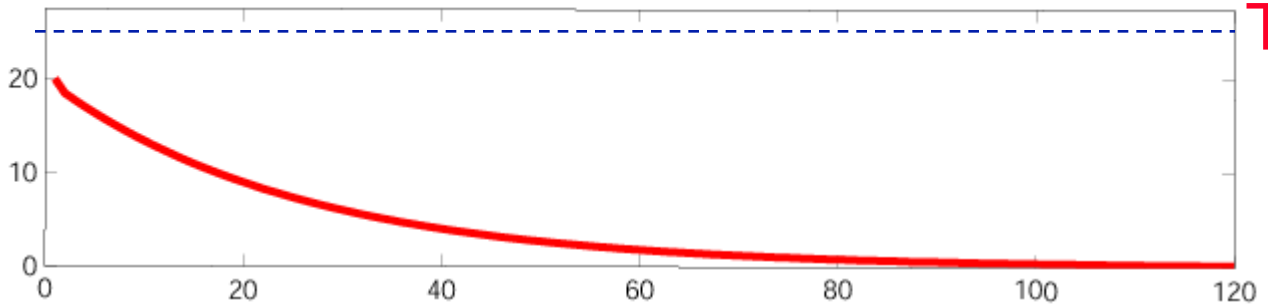
NO CURRENT I

Current

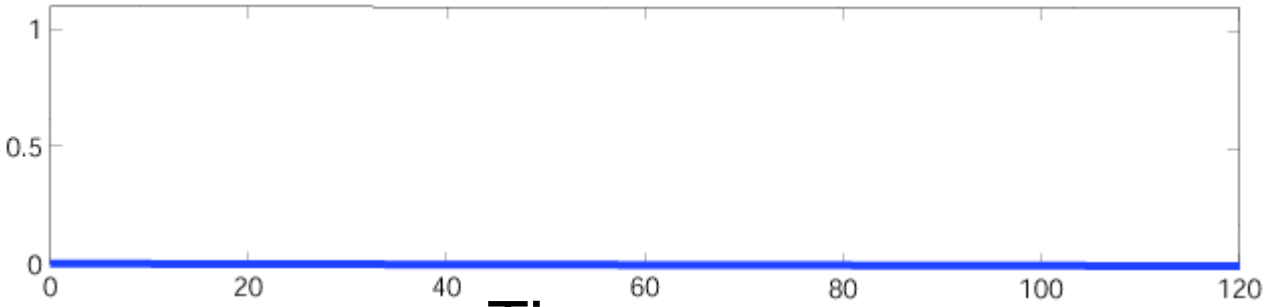


Membrane voltage

Thresh=25



Spikes

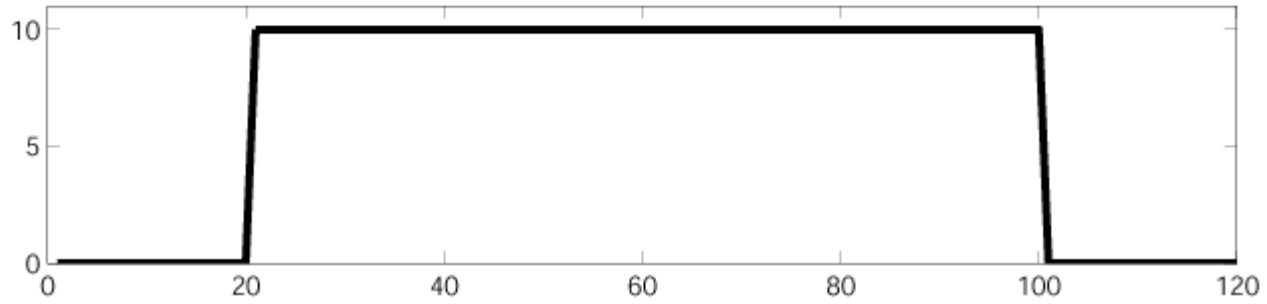


Time

$$v(t) = v(t=0)e^{-t/\tau} + RI(1 - e^{-t/\tau})$$

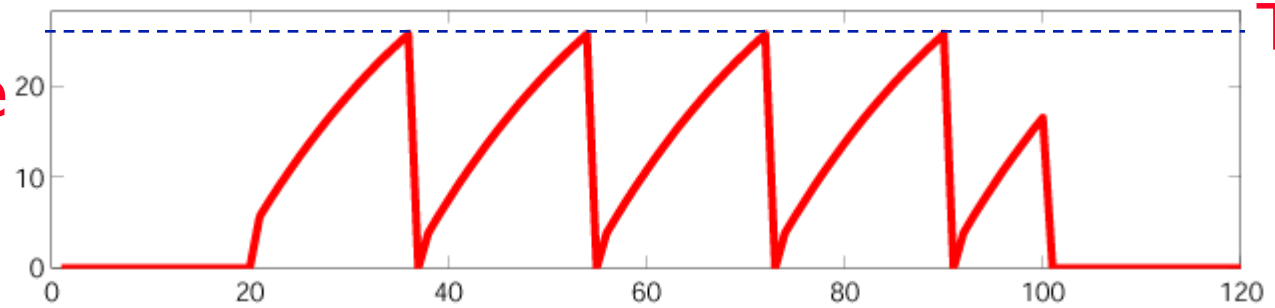
WITH CURRENT I and V(t=0)=0

Current

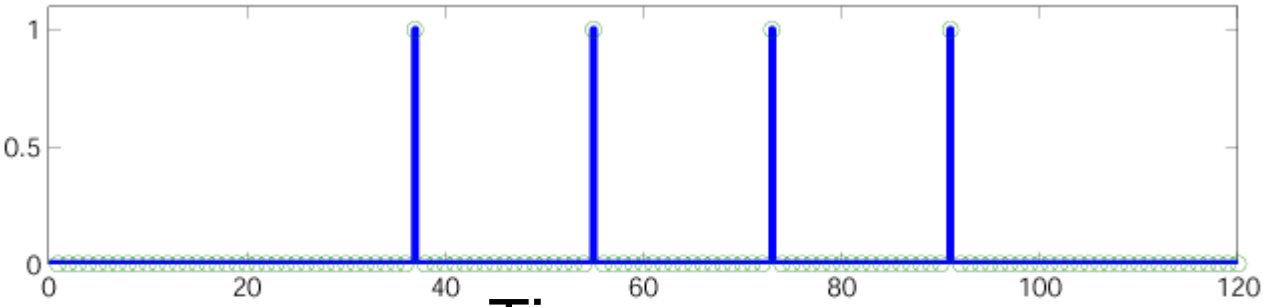


Membrane voltage

Thresh=25



Spikes

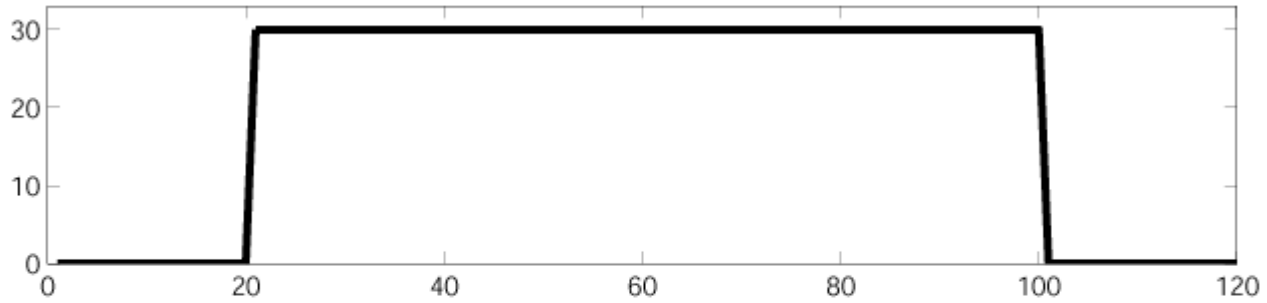


Time

$$v(t) = v(t=0)e^{-t/\tau} + RI(1-e^{-t/\tau})$$

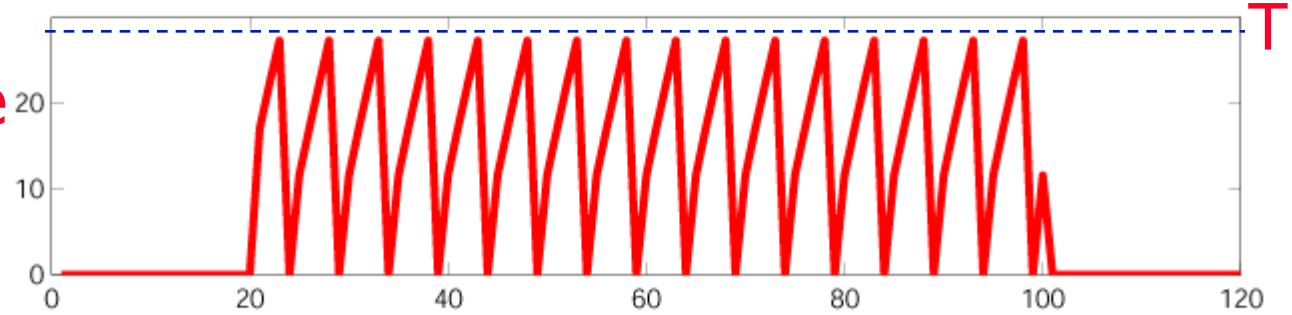
INCREASE CURRENT I

Current

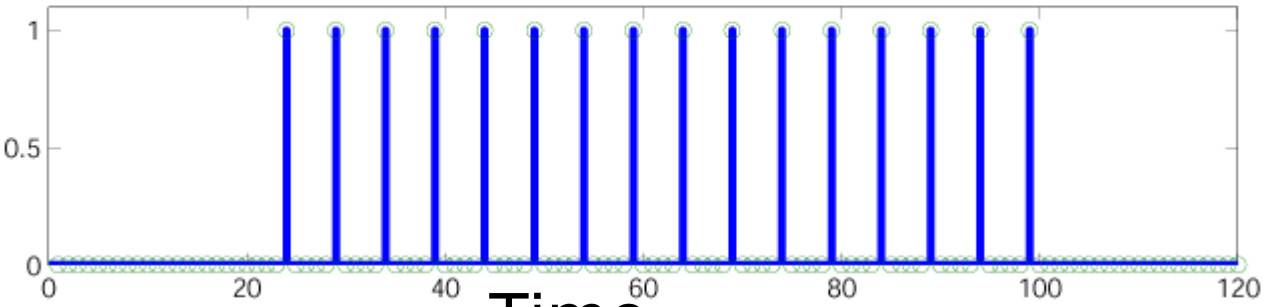


Membrane voltage

Thresh=25



Spikes



Time

$$v(t) = v(t=0)e^{-t/\tau} + RI(1-e^{-t/\tau})$$

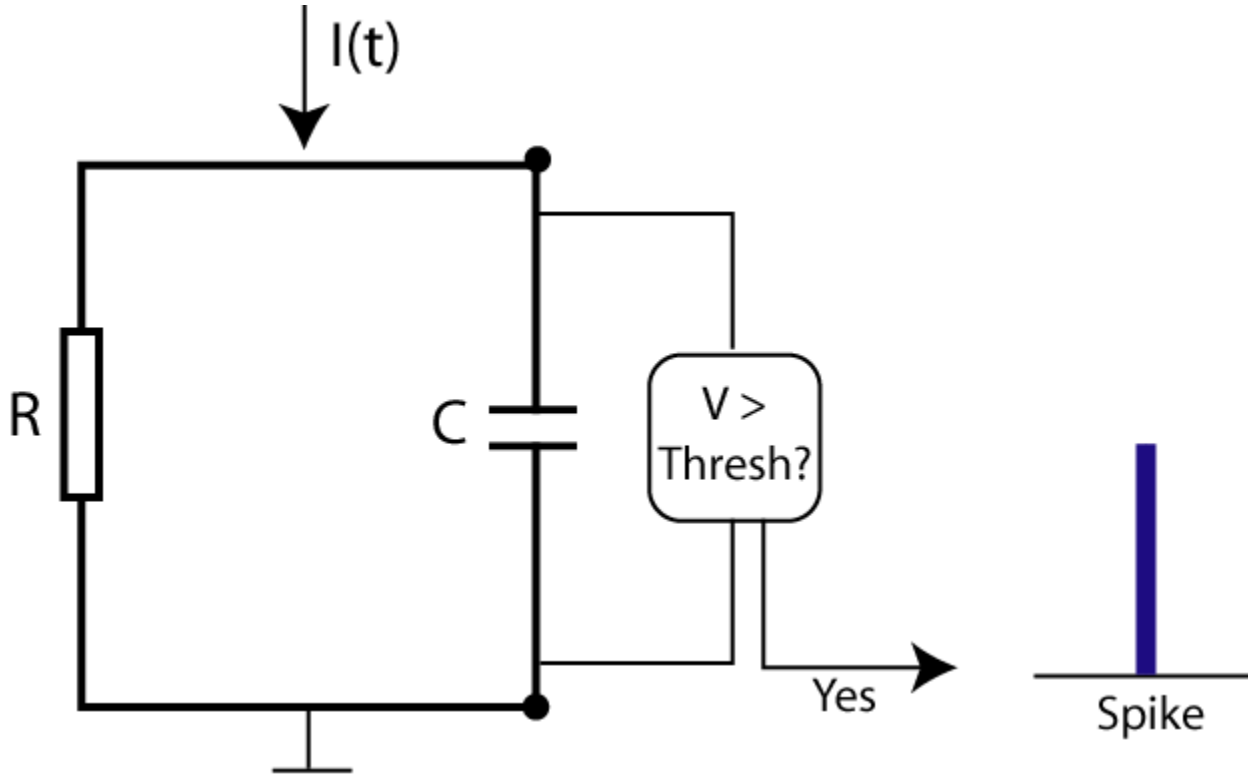
Leaky Integrate and Fire Circuit

- Solution to DE

$$v(t) = v(t=0)e^{-t/\tau} + RI(1 - e^{-t/\tau})$$

- After action potential, v reset to v(t=0), and time reset to 0.

Leaky Integrate and Fire Circuit



Leak

Current

$$C\frac{dv}{dt} = \frac{-v}{R} + I(t)$$