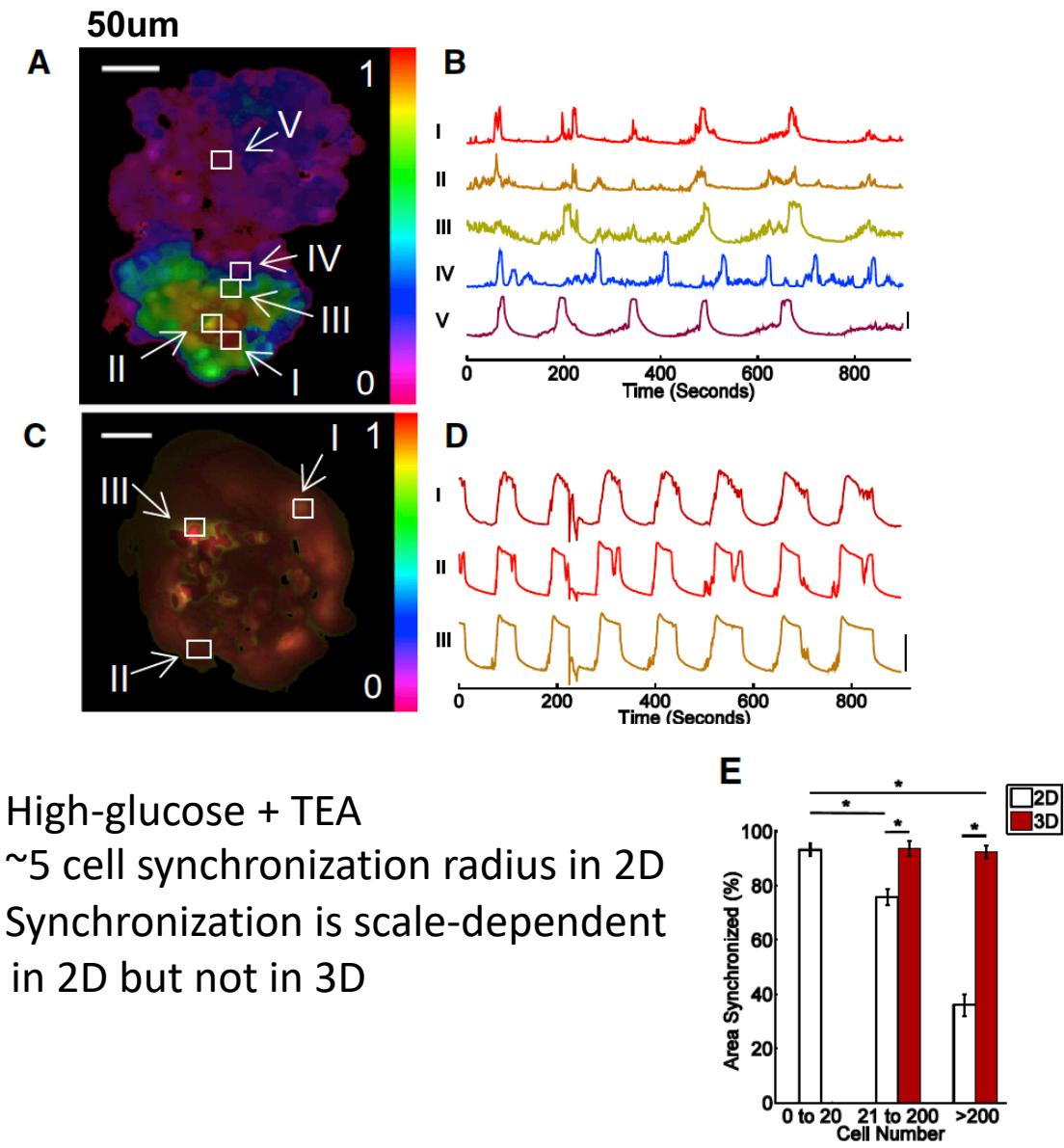
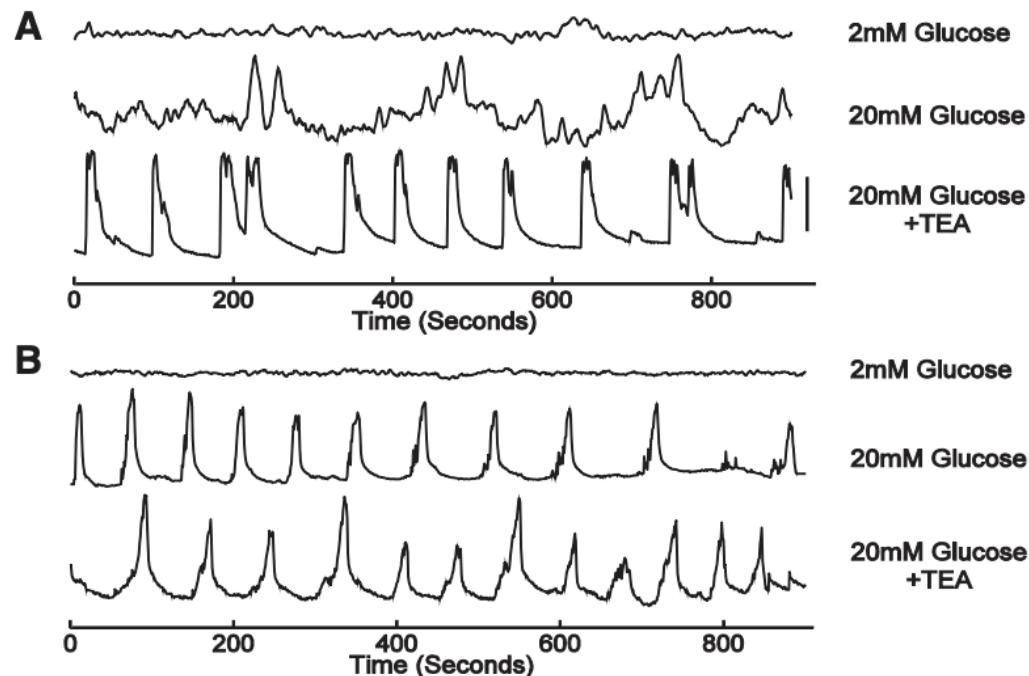


Dimension and size dependence of [Ca²⁺] synchronization

2D: ~4000 cells/mm² (MIN6)

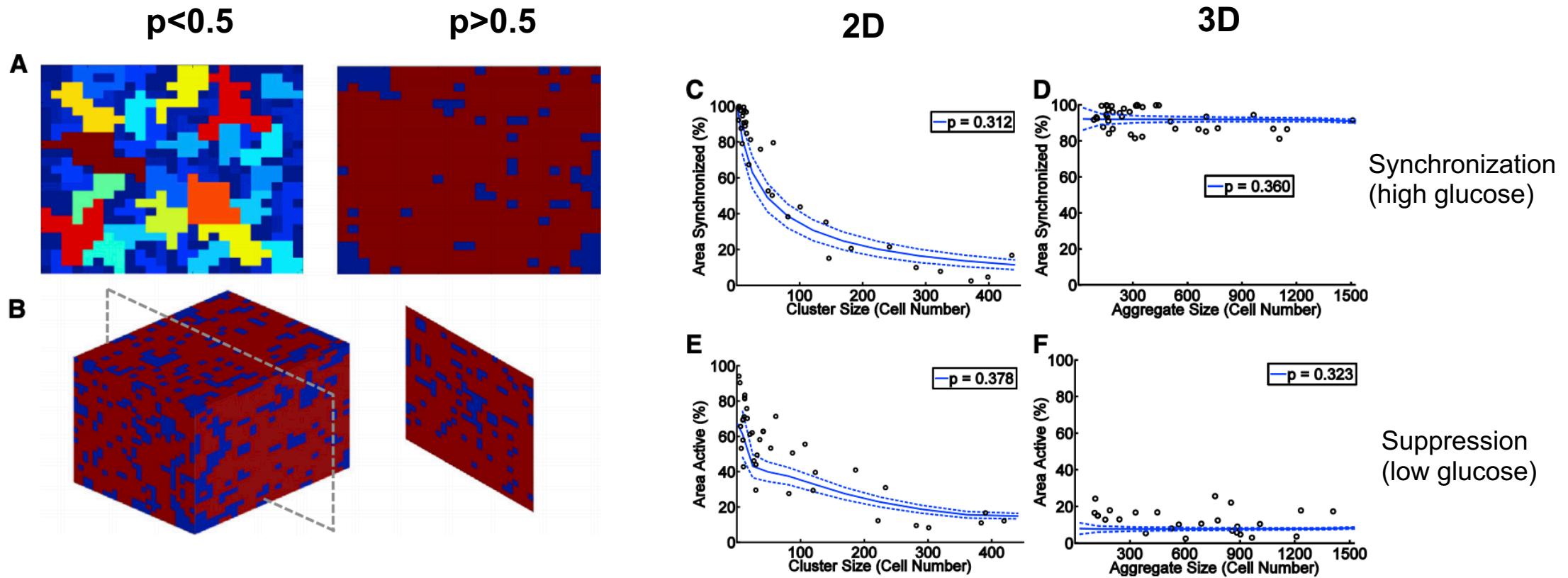
3D: ~520,000 cells/cm² in hydrogel microwell arrays

[Ca²⁺] readout using Fluor4

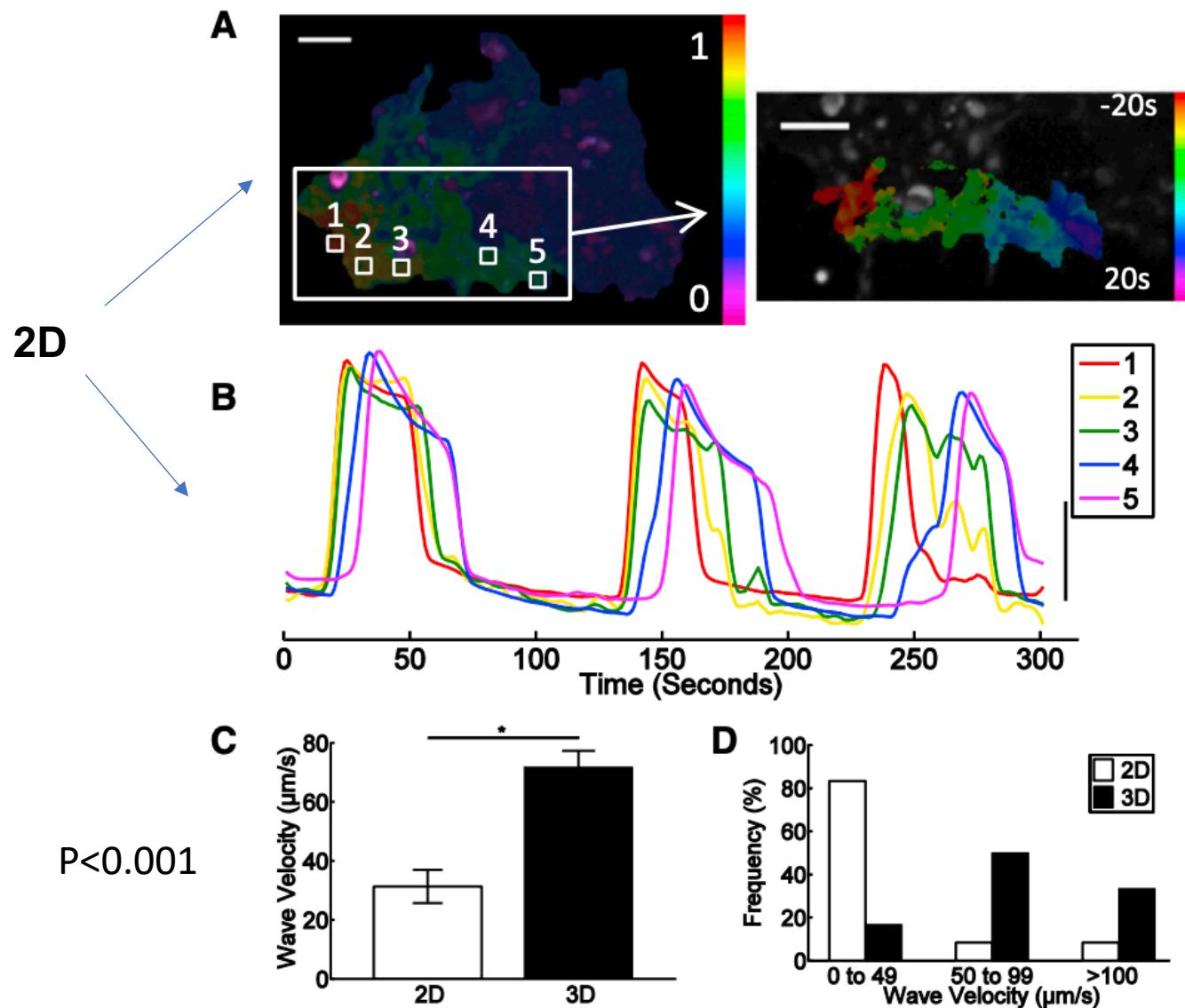


- High-glucose + TEA
- ~5 cell synchronization radius in 2D
- Synchronization is scale-dependent in 2D but not in 3D

Coupled-resistor network model

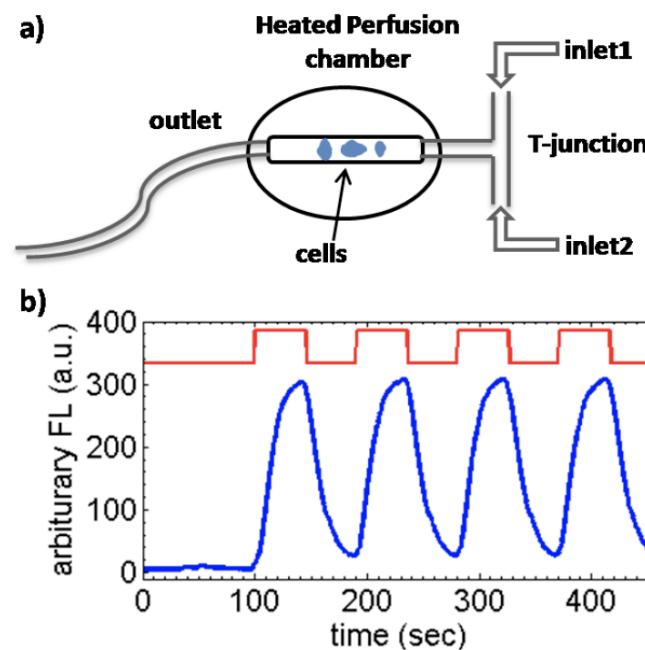
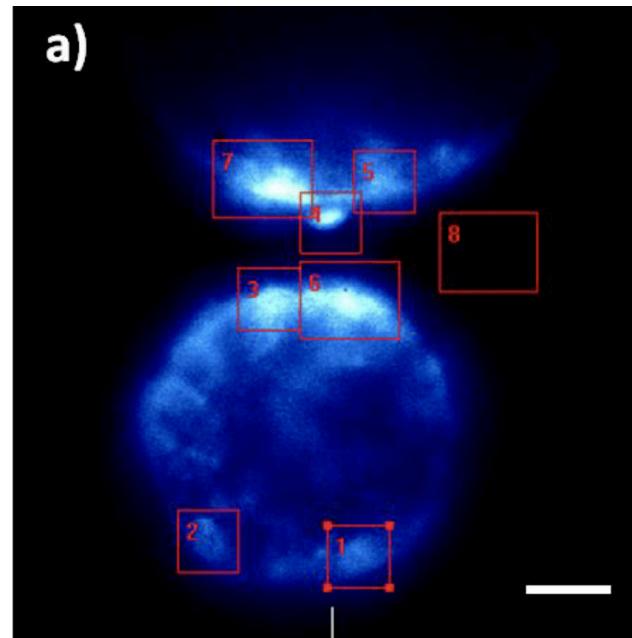


Wave velocity under 2D/3D coupling



Interesting points

1. Low-pass frequency response of beta cells
2. Only small populations of cells (pacemakers) sense glucose stimulus
3. Unknown degree of randomness and strength of coupling
4. Entrainment of cells to glucose stimulus



Coupled phantom burster model

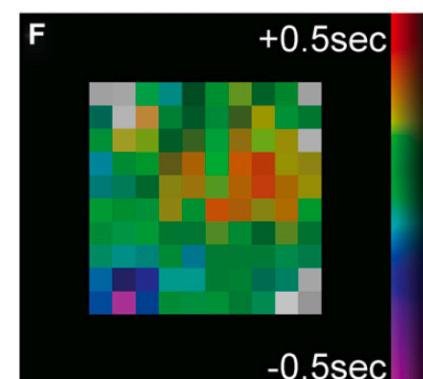
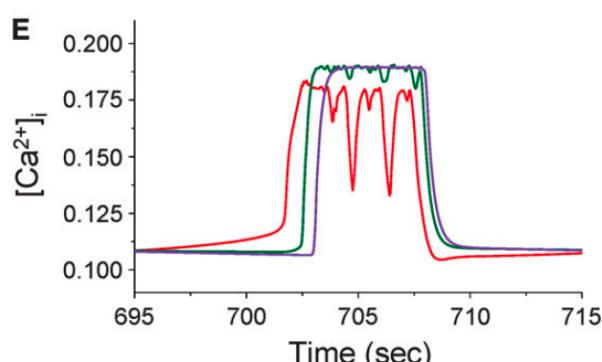
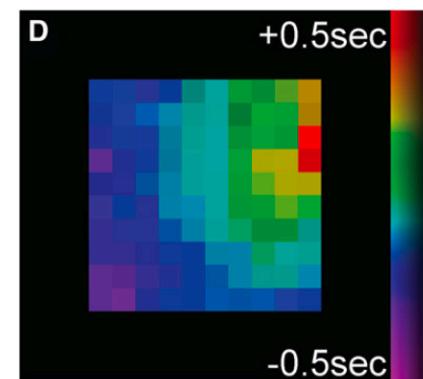
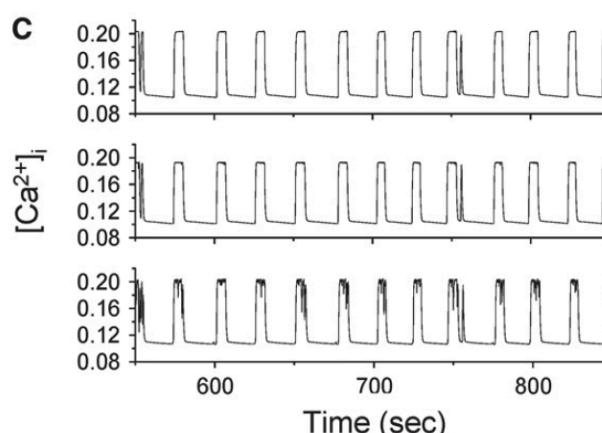
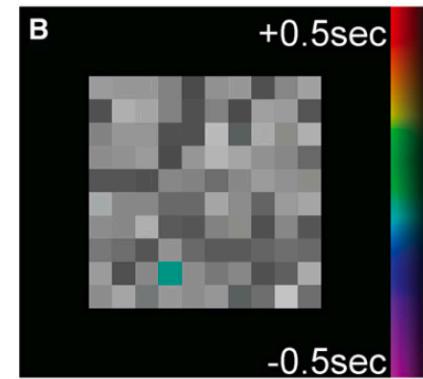
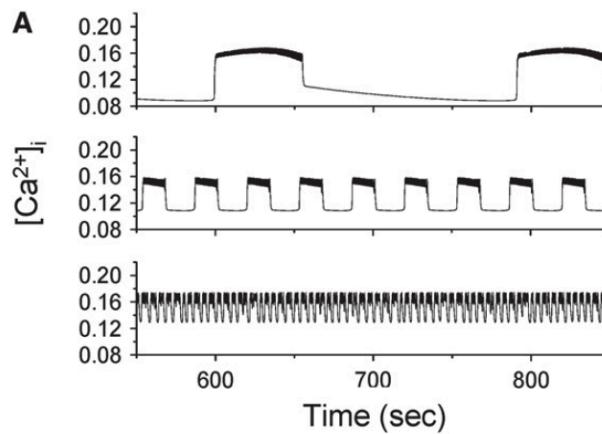
$$C_m \frac{dV_j}{dt} = -(I_{K(Ca)} + I_{K(ATP)} + I_{Ca} + I_K + I_{coupl,j})$$

$$I_{coupl,j} = g_c \sum_i^{\text{neighbor}_j} (V_j - V_i).$$

↑

How is this distributed?

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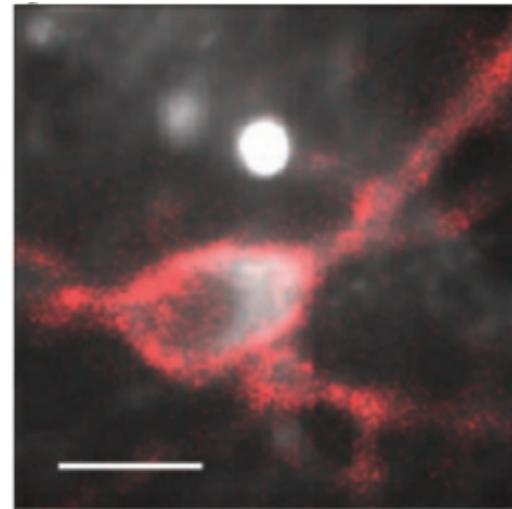


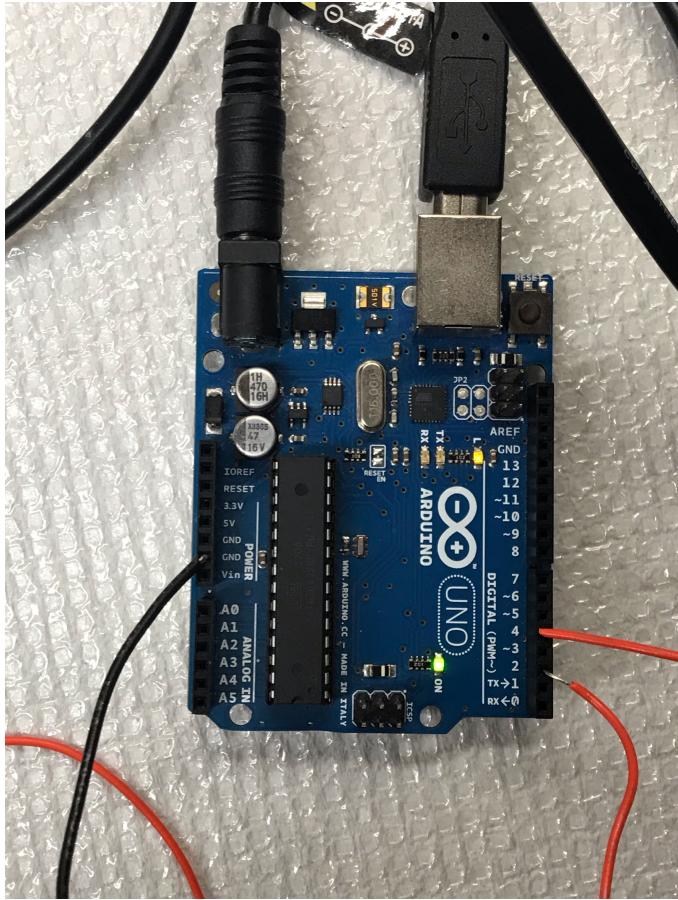
Estimating membrane potentials

$$S_i(t) = a_i + b_i V(t) + \varepsilon_i(t)$$

$$\langle \varepsilon_i(t_1) \varepsilon_j(t_2) \rangle = \sigma_i^2 \delta_{i,j} \delta(t_1 - t_2)$$

$$\zeta_i^2 = \left\langle (\hat{V}_i(t) - V(t))^2 \right\rangle \quad w_i \equiv \frac{1/\zeta_i^2}{\sum_i 1/\zeta_i^2}$$





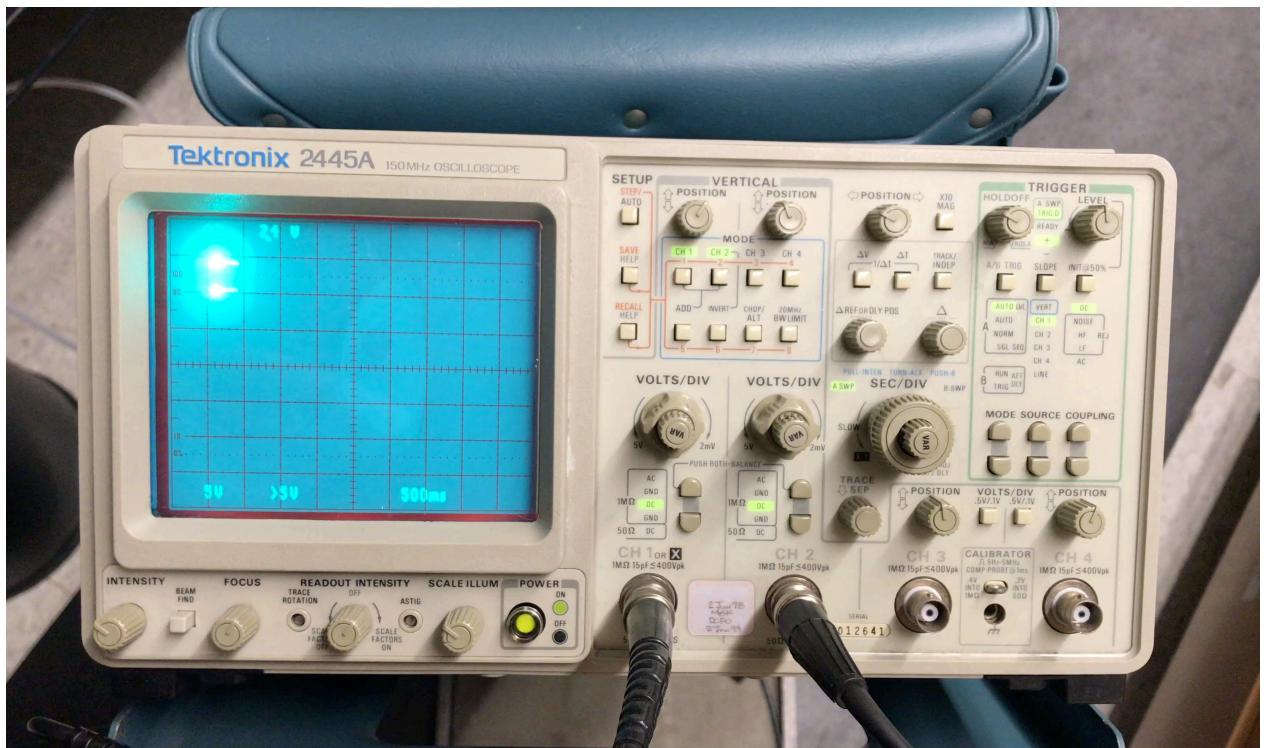
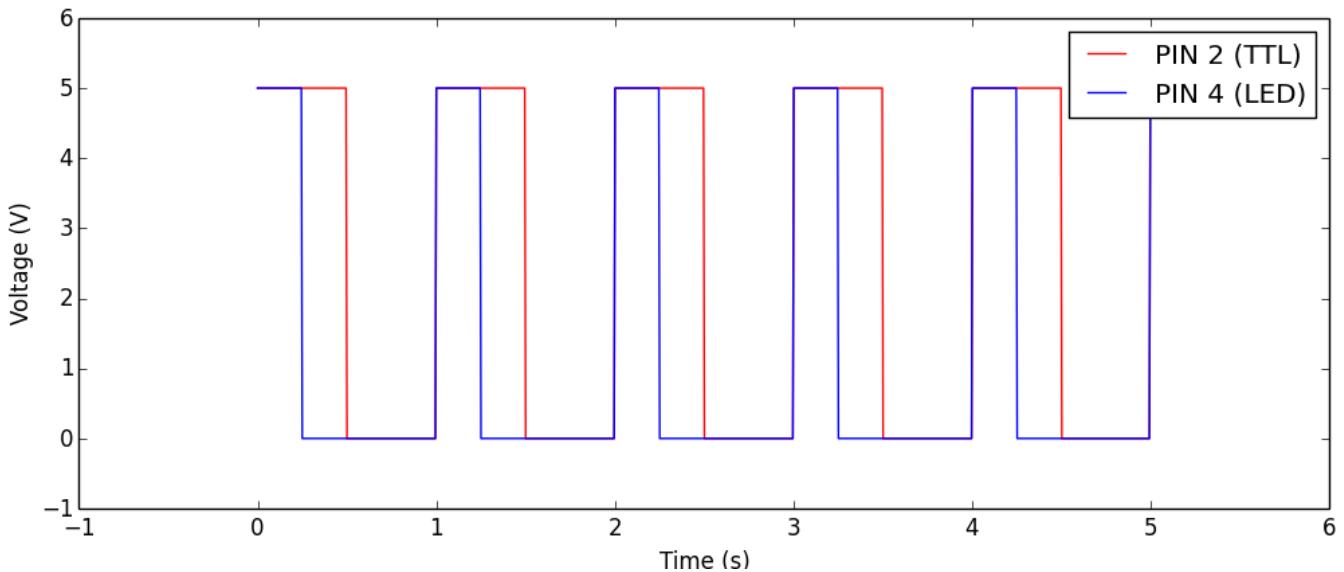
Analog Input

Onboard 10-bit ADC (6 channels)

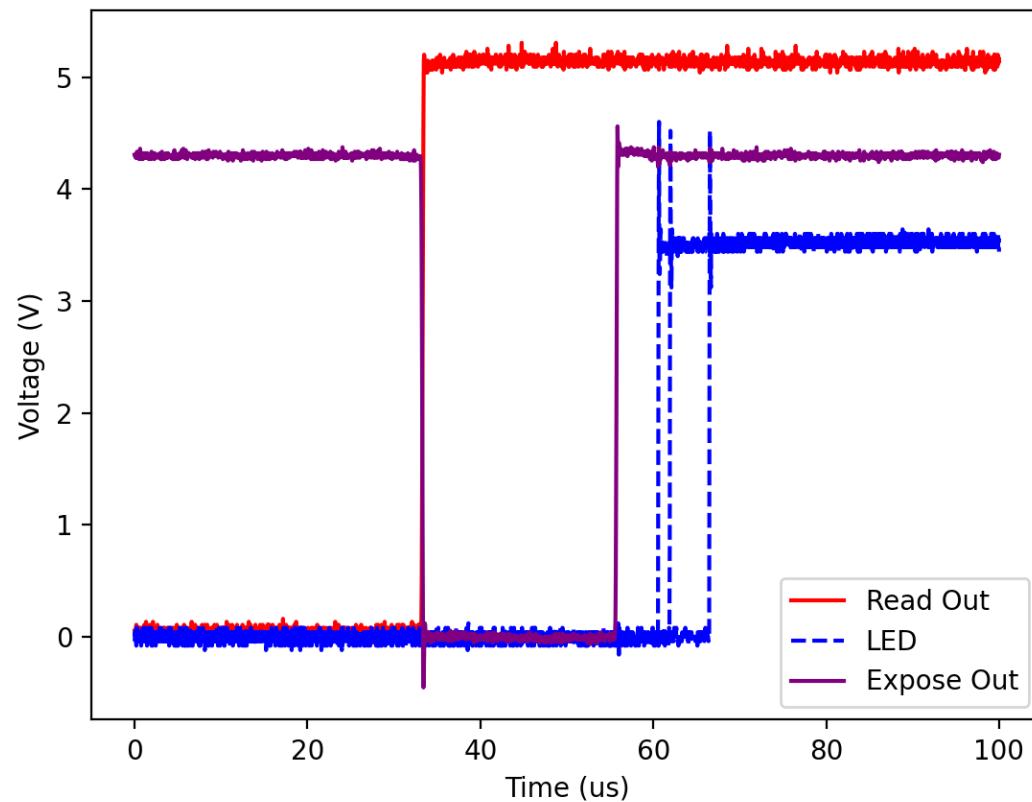
16 MHz Arduino has ADC clock set to 16 MHz/128
= 125 kHz. Each conversion in AVR takes 13 ADC
clocks so $125 \text{ kHz}/13 \sim 10 \text{ kHz}$

Digital Input

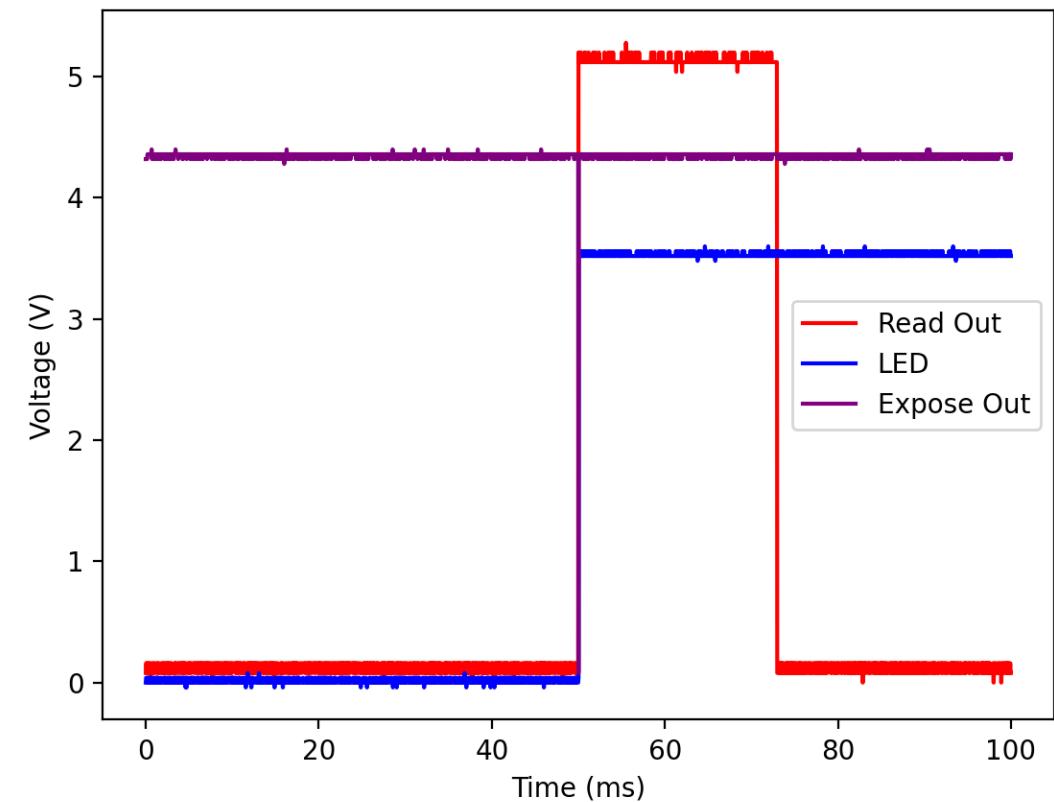
12 digital I/O pins. No analog to digital conversion
but input has to be 0 or 5V



Scope sample rate: 25MHz



Scope sample rate: 25kHz



Photometrics BSI Line-Time: 11.2us (23ms read time)