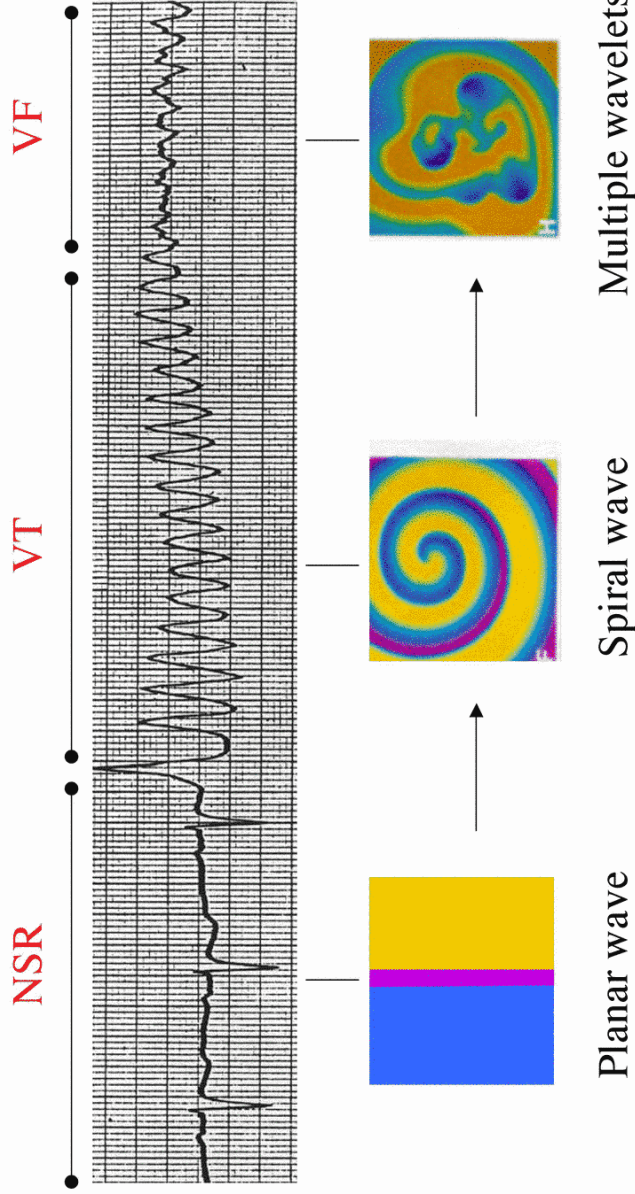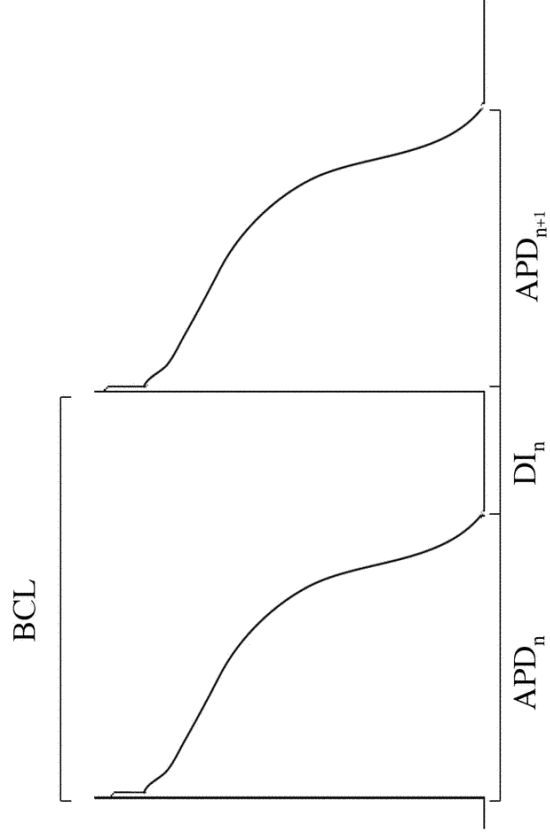# Dynamic Mechanism for Conduction Block in Heart Tissue

Robert F. Gilmour, Jr.
Department of Biomedical Sciences
Cornell University

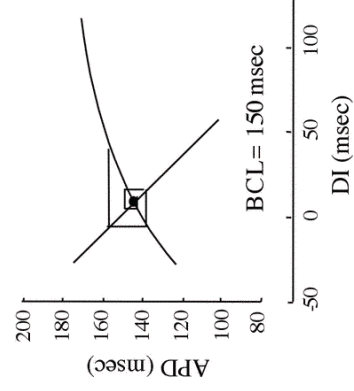Progression from normal sinus rhythm to VF

NSR   VT   VF

Planar wave   Spiral wave   Multiple wavelets

Restitution of action potential duration (APD)
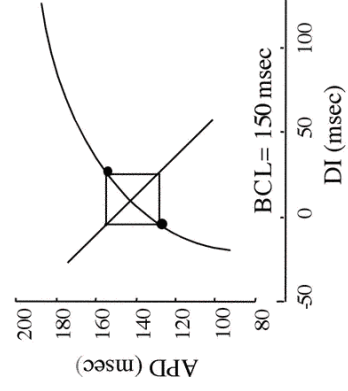
$$BCL = APD + DI$$

$$APD_{n+1} = f(DI_n)$$

Restitution and APD dynamics

BCL = 150 msec

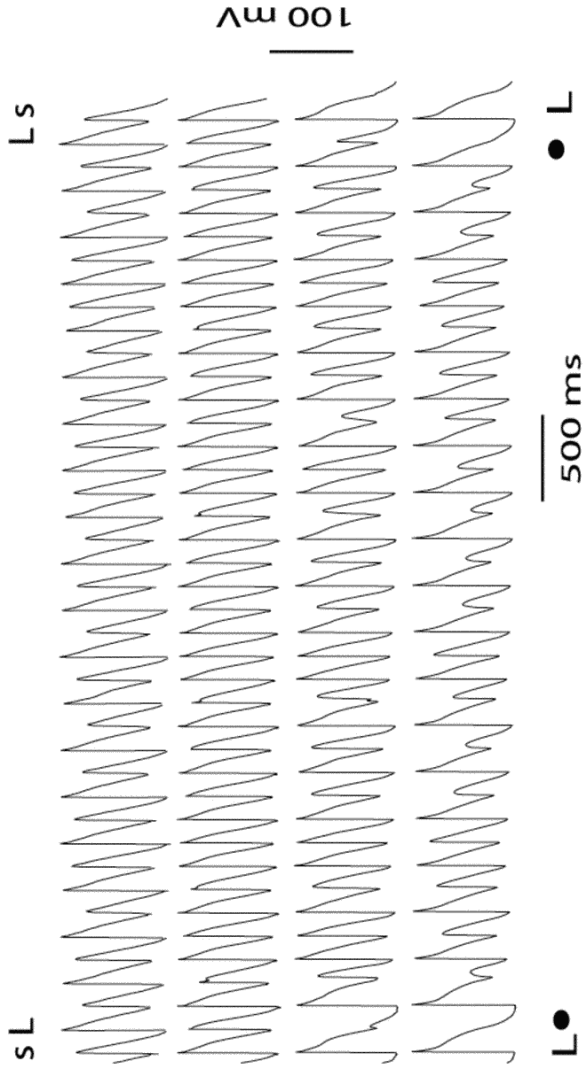**Slope < 1**

BCL = 150 msec

Slope > 1

Concordant and discordant APD alternans

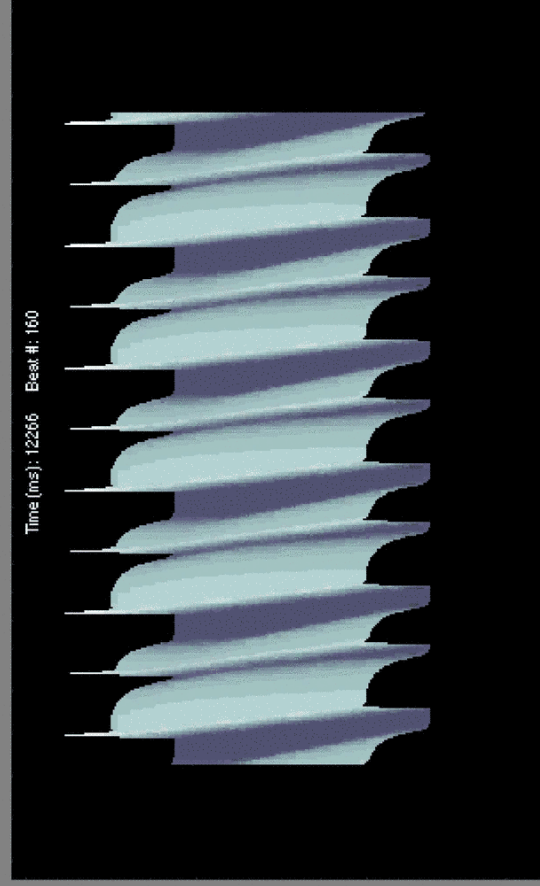Fox *et al*, Circ Res, 2002

Discordant APD alternans and conduction block
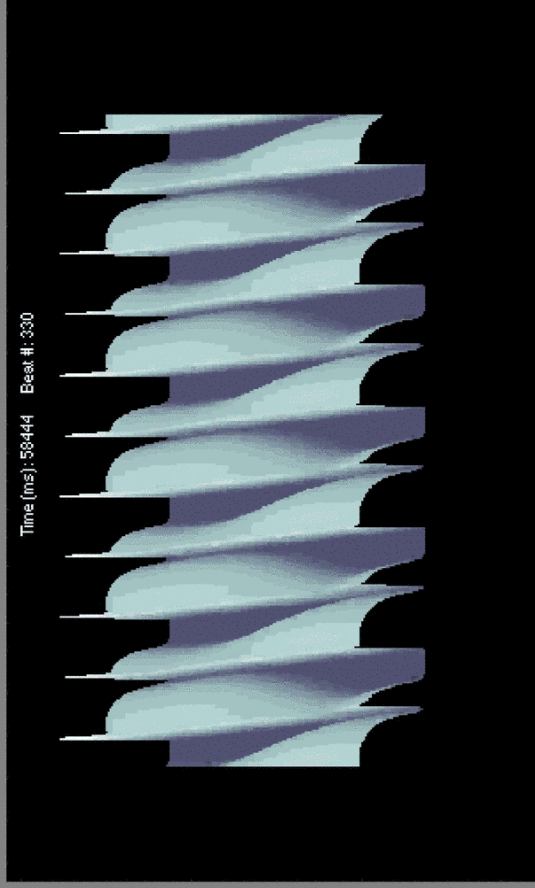
Paroxysmal conduction block

Concordant to discordant APD alternans

Discordant APD alternans to conduction block

Time (ms): 58444 Beat #: 330

Paroxysmal conduction block

Time (ms): 25549 Beat #: 150
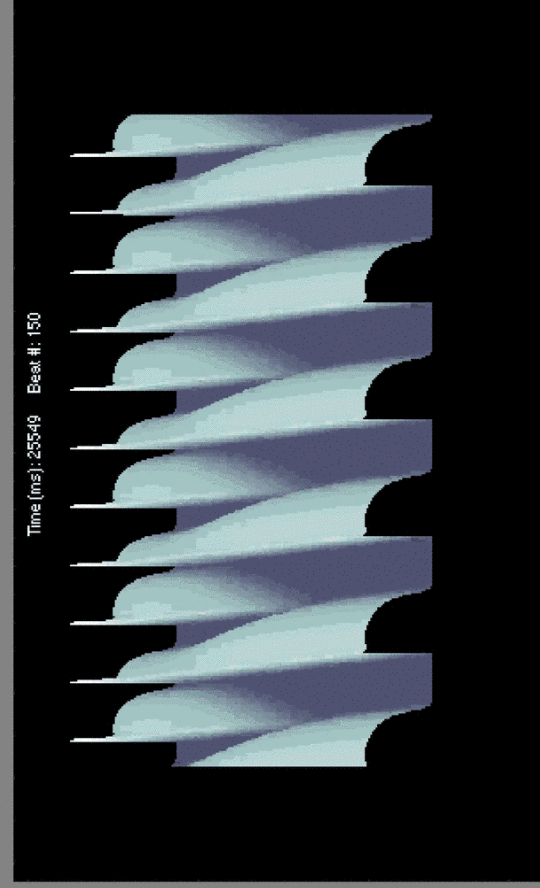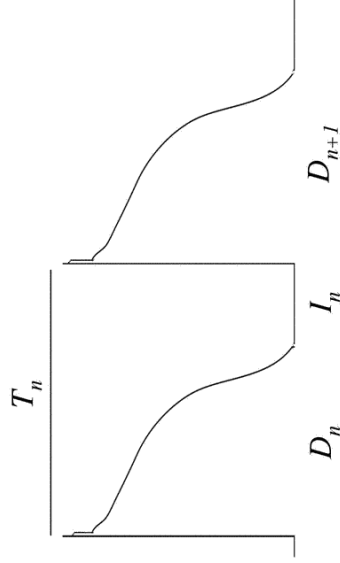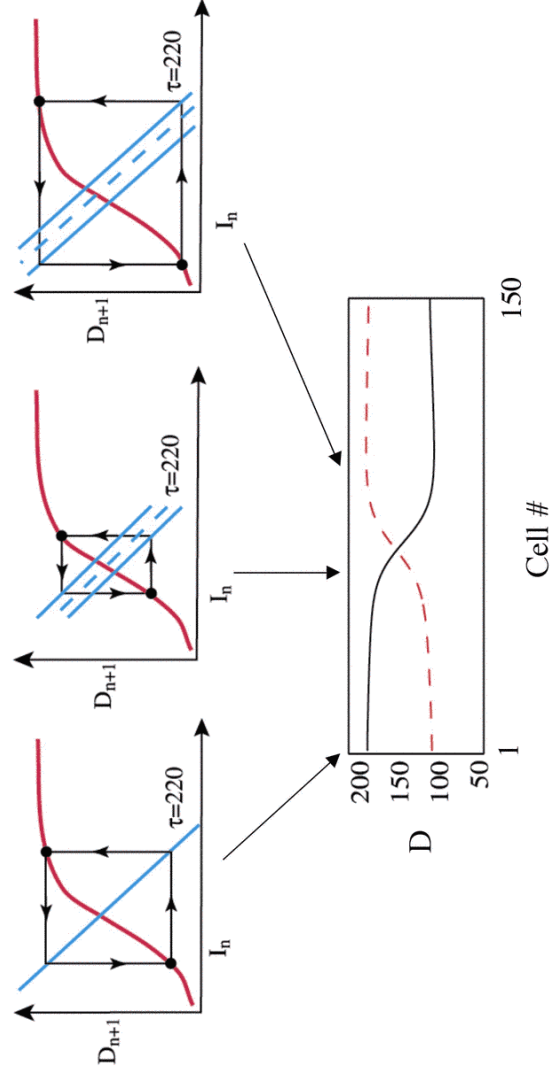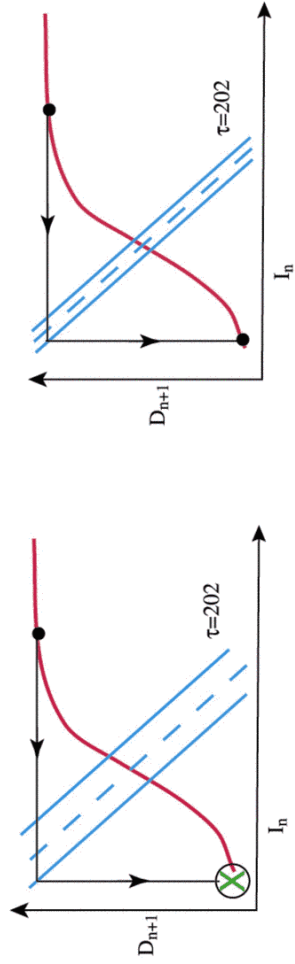
Coupled Maps Model

$$I_{n+1}(x_i) = T_{n+1}(x_i) - D_{n+1}(x_i) = \tau + \sum_{j=0}^{i} \frac{\Delta x}{c(I_{n+1}(x_j))} - \sum_{j=0}^{i} \frac{\Delta x}{c(I_n(x_j))} - D_{n+1}(x_i)$$

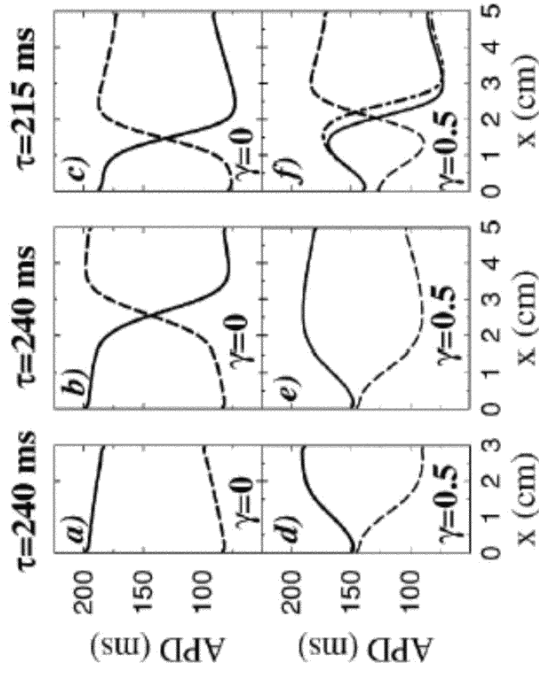## Mechanism for transition from concordant to discordant APD alternans

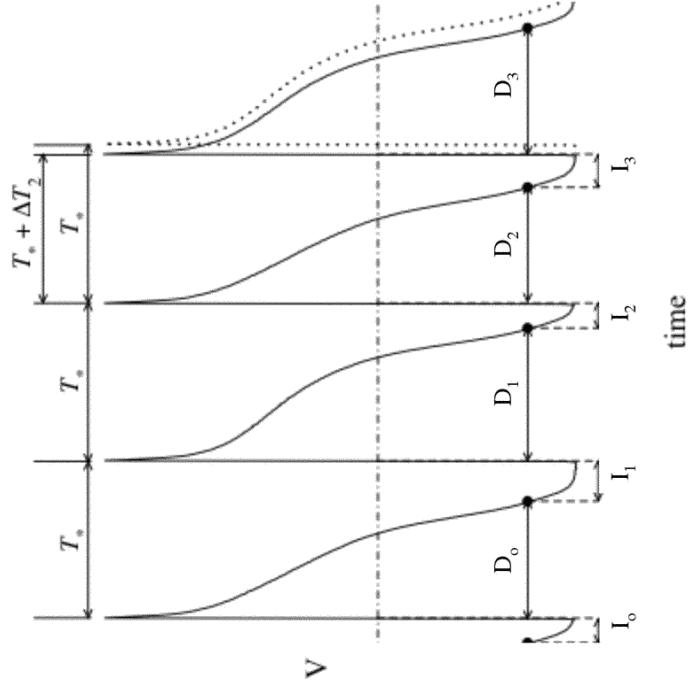## Mechanism for transition from discordant APD alternans to conduction block
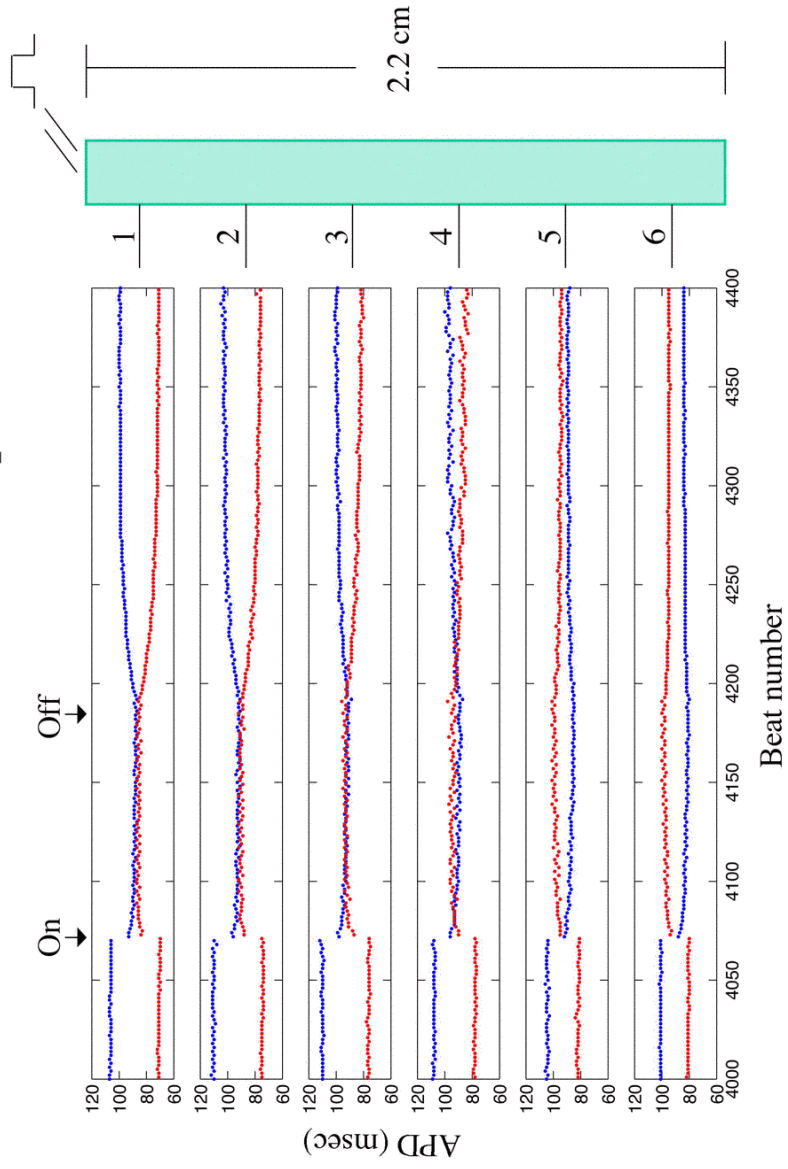

Alternans control: theory

Control equation: $T^n = \tau + \frac{\gamma}{2}(\mathrm{APD}^n - \mathrm{APD}^{n-1})$

Echebarria and Karma, Chaos, 2002

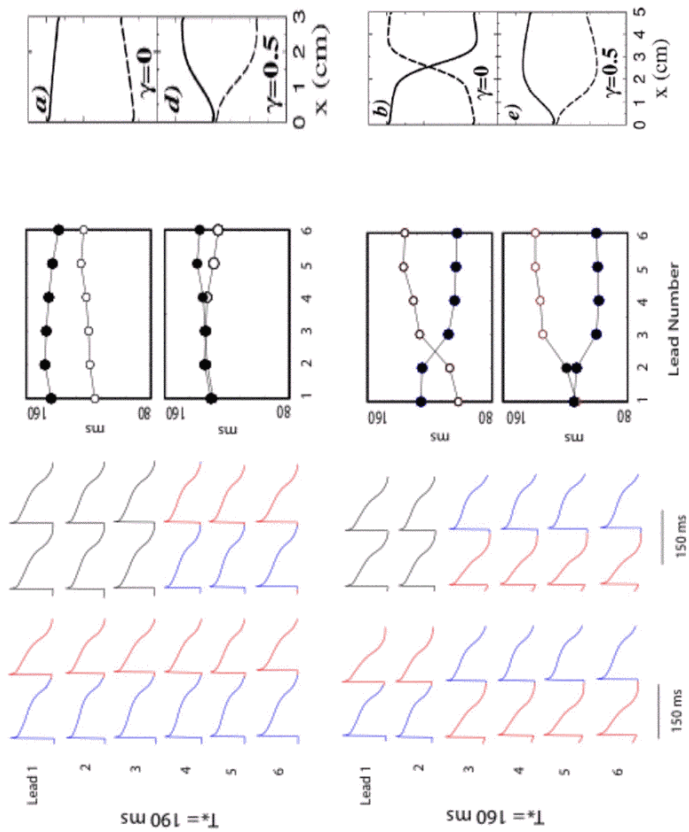## Alternans control: algorithm

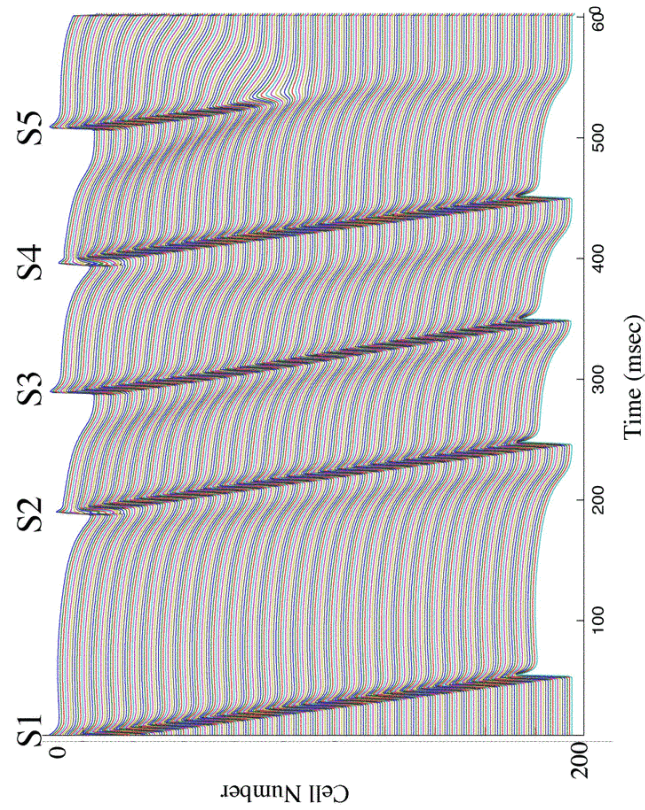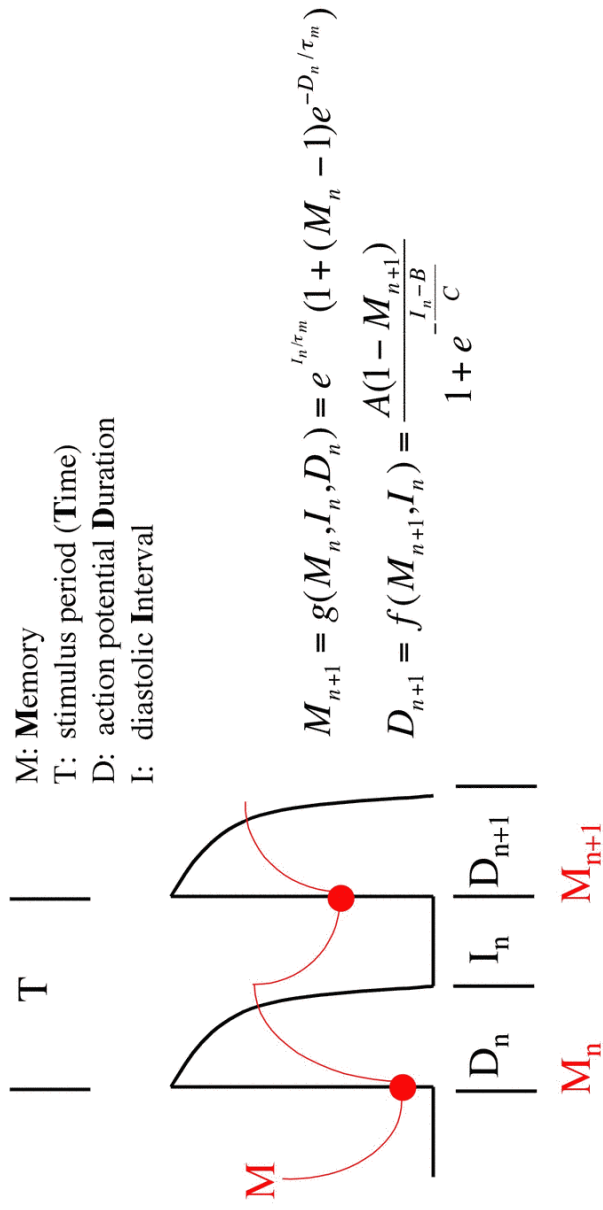## Alternans control: experiment

Alternans control: experiment vs theory

Discordant APD alternans to conduction block

Return map memory model

M: **M**emory
T: stimulus period (**T**ime)
D: action potential **D**uration
I: diastolic **I**nterval

$$M_{n+1} = g(M_n, I_n, D_n) = e^{I_n/\tau_m}(1 + (M_n - 1)e^{-D_n/\tau_m})$$

$$D_{n+1} = f(M_{n+1}, I_n) = \frac{A(1 - M_{n+1})}{1 + e^{-\frac{I_n - B}{C}}}$$
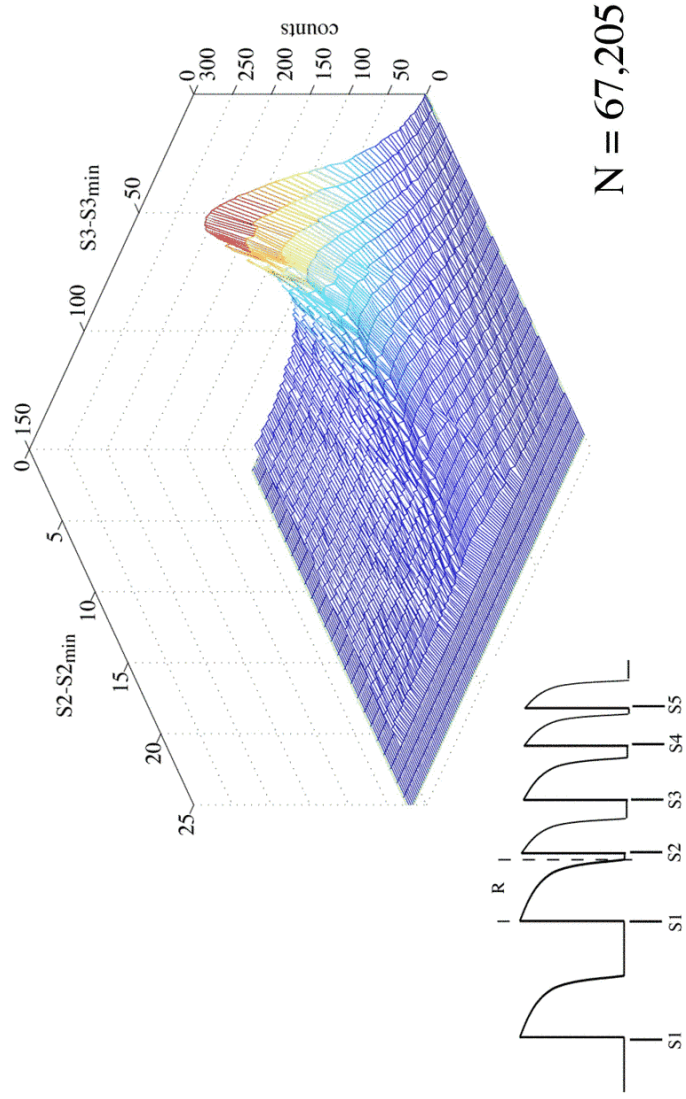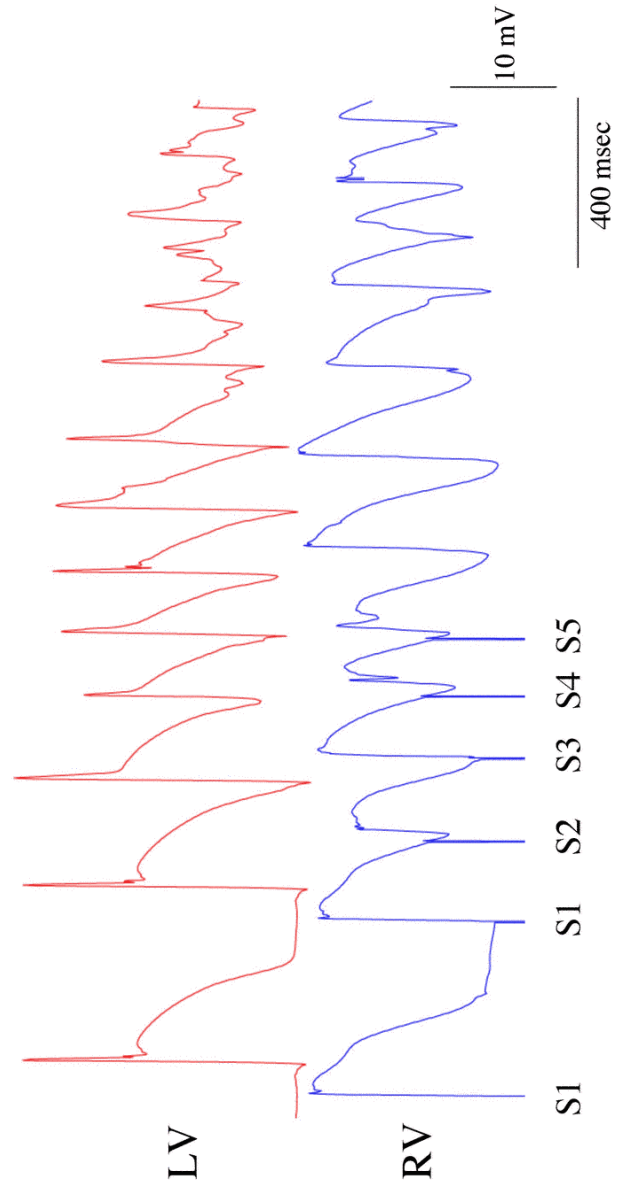

Fox *et al*, PRL, 2002

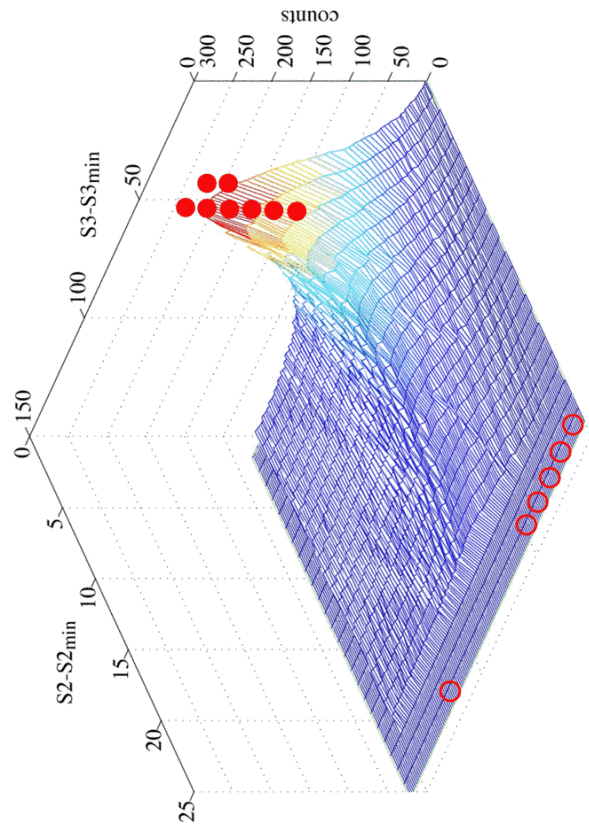## Induction of conduction block by premature stimulation
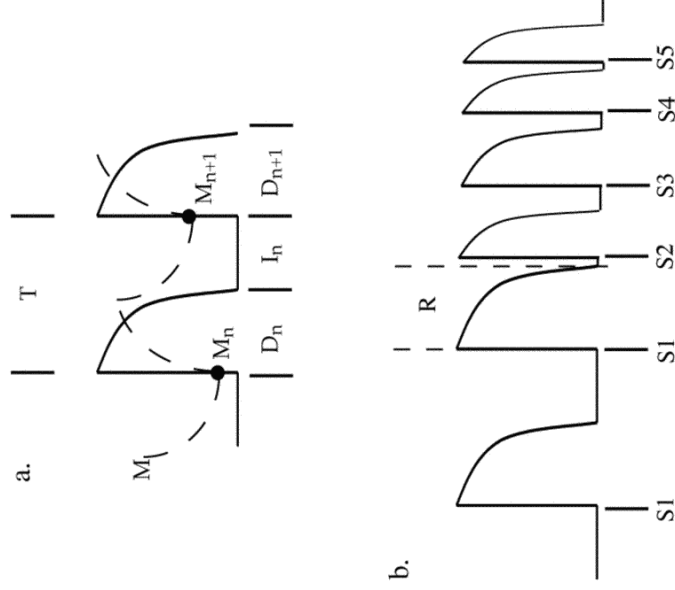
Incidence of conduction block for different patterns
of premature stimulation

N = 67,205

Induction of VF using ICB protocol

Incidence of conduction block for different patterns of premature stimulation

Eberhard Bodenschatz
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Jeff Fox
GNS

Mark Riccio
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Sydney Moïse
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Anna Gelzer
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David Christini
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Alain Karma (et al)
Northeastern