Cardiac Position Sensitivity Using Stochastic Collocation

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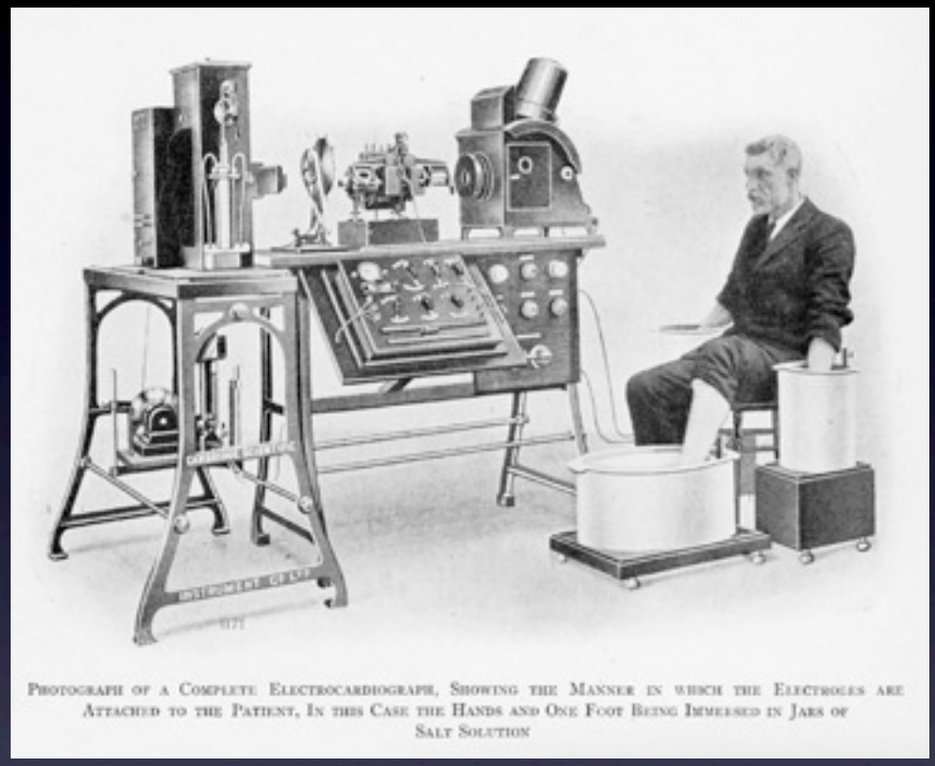
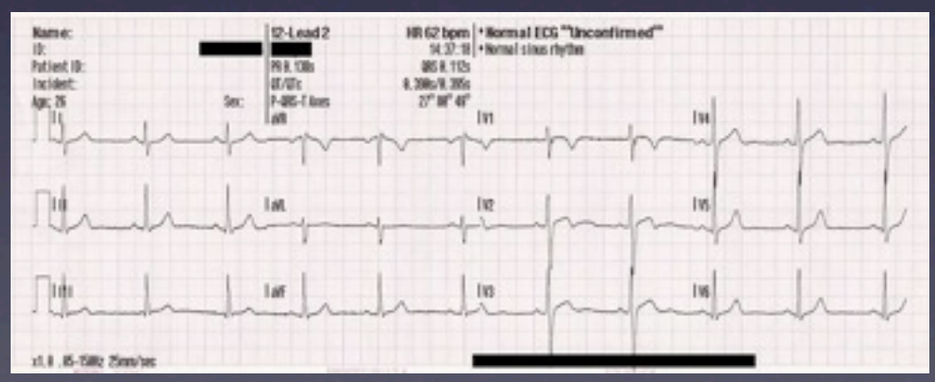
ECG

Electrocardiogram

- Heart conduction from body surface
- Monitoring, diagnostics, treatment
- Rhythm disturbances, ischemia, infarctions, prolongation of QT

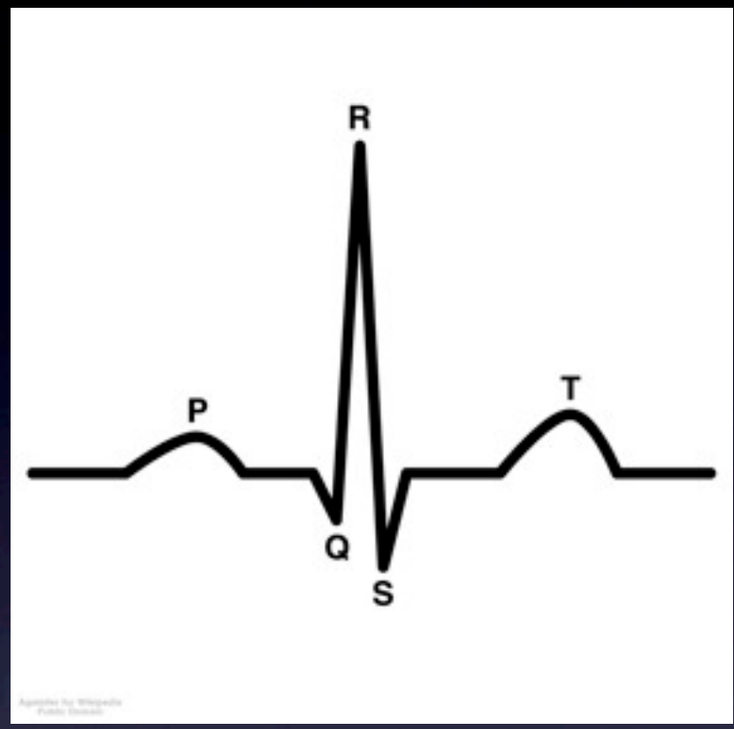


Photograph of a Complete Electrocardiograph, Showing the Manner in which the Electrodes are Attached to the Patient, In this Case the Hands and One Foot Being Immersed in Jars of Salt Solution



Diagnostic Markers

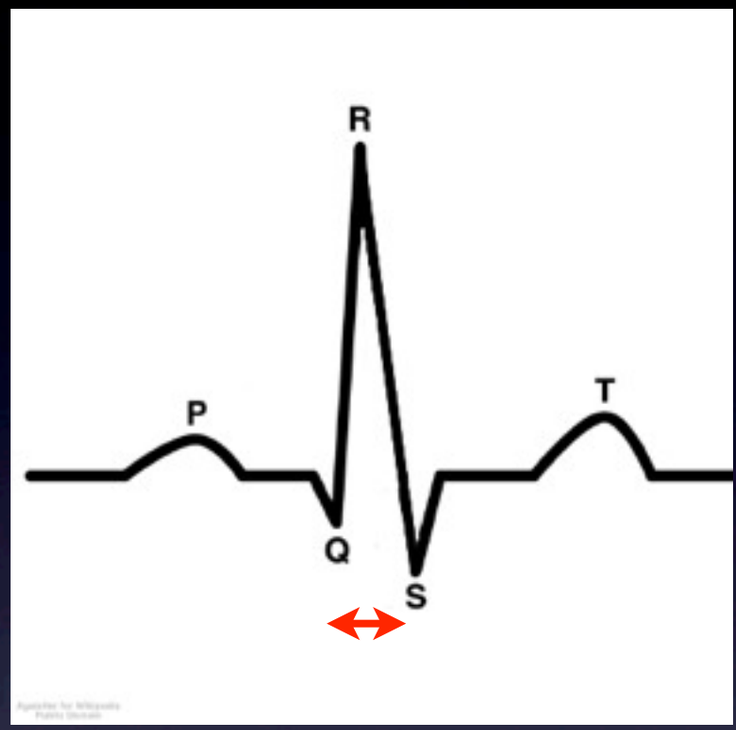
Morphological Changes



Diagnostic Markers

Morphological Changes

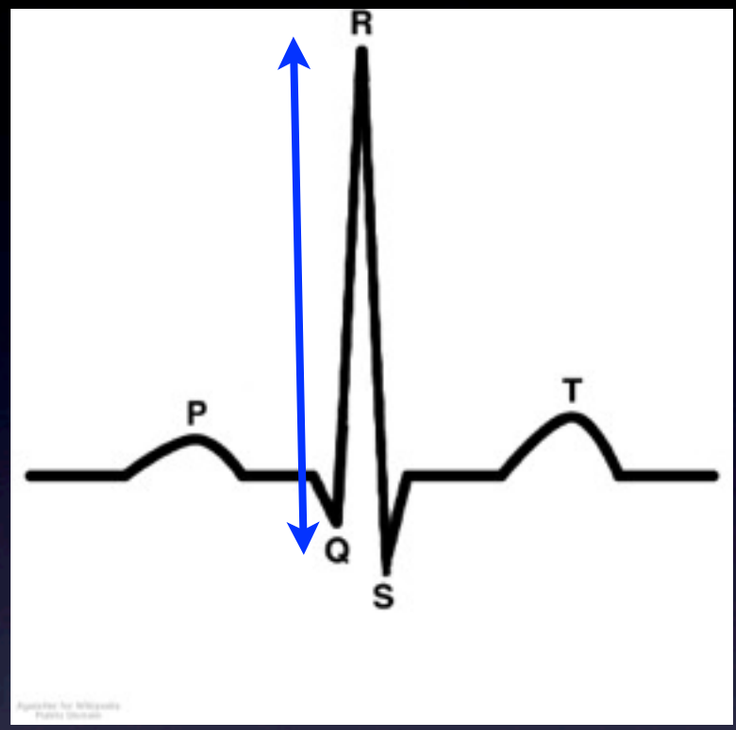
- QRS elongation



Diagnostic Markers

Morphological Changes

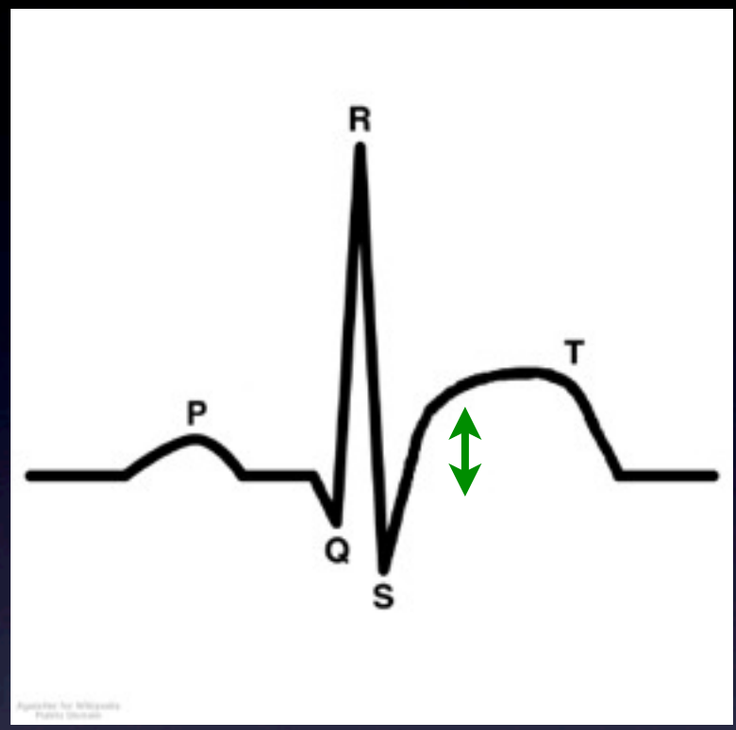
- QRS elongation
- R wave amplitude



Diagnostic Markers

Morphological Changes

- QRS elongation
- R wave amplitude
- ST - elevation/depression



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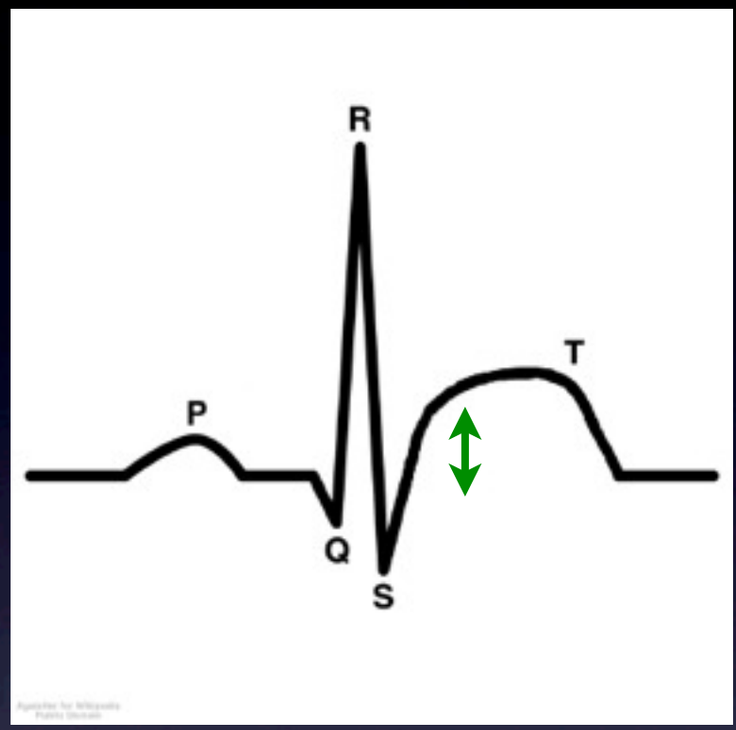


Extensively studied/not well understood

- 50-70% accurate
- 13 Billion $ per year
- ECG Morphology is sensitive to other variables

Heart Motion

Heart Motion

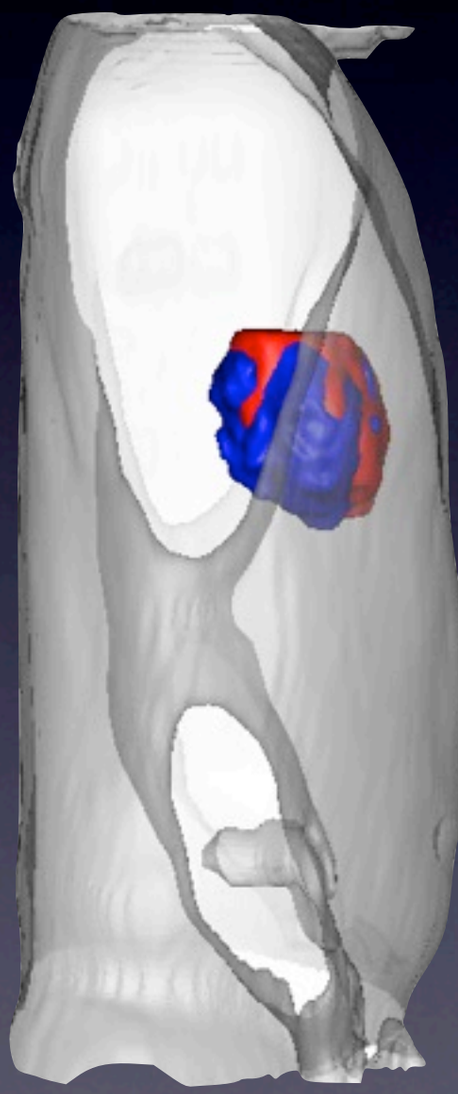
Heart Motion

Heart Motion

Translation
2 cm

Body Position

Supine to Prone



Pendulum motion
Pivot 30°

ECG Error

Hypothesis: Body position can cause

- False positives
- False negatives

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Shown experimentally

ECG Error

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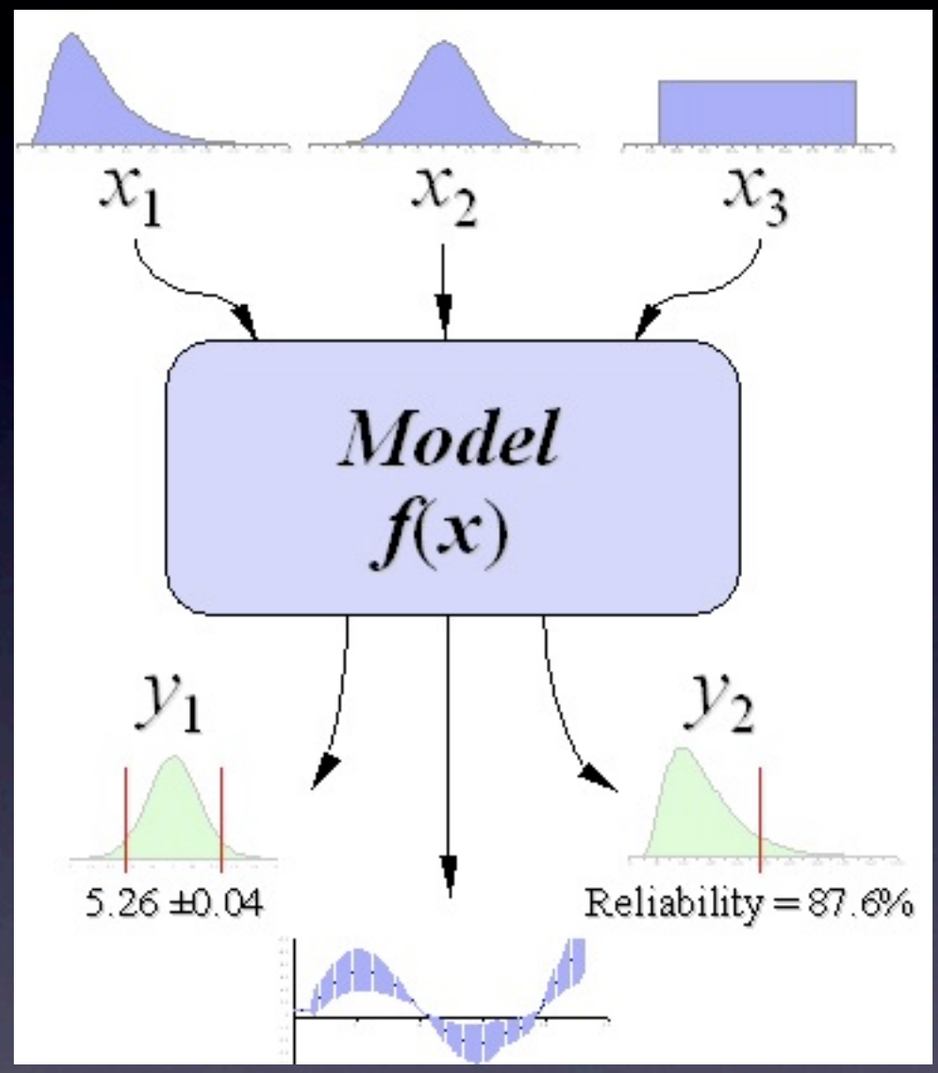
Can we quantify it?

Sensitivity Studies

Answers probabilistic questions

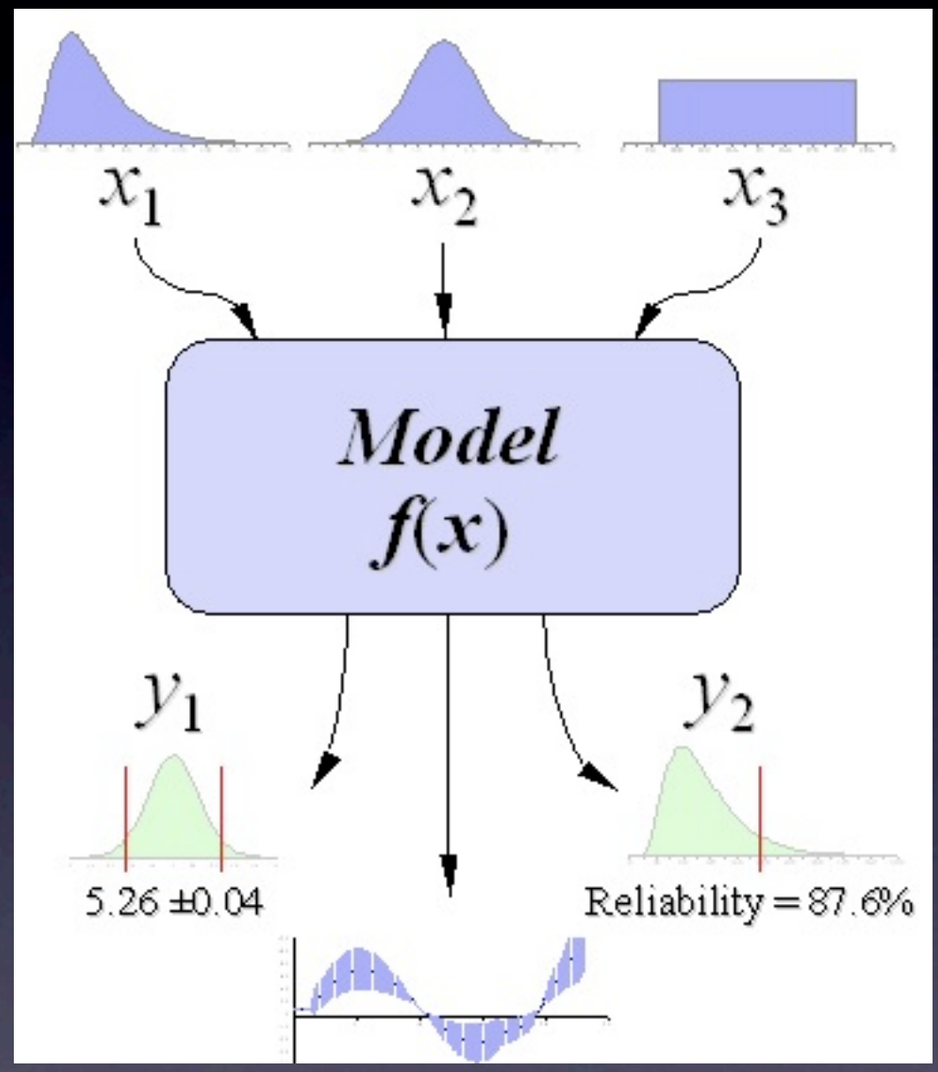
- Gives statistical means, variations, probabilities
- Mathematically rigorous
- Monte Carlo



Sensitivity Studies

Answers probabilistic questions

- Gives statistical means, variations, probabilities
- Mathematically rigorous
- Monte Carlo
- Huge Computational Cost



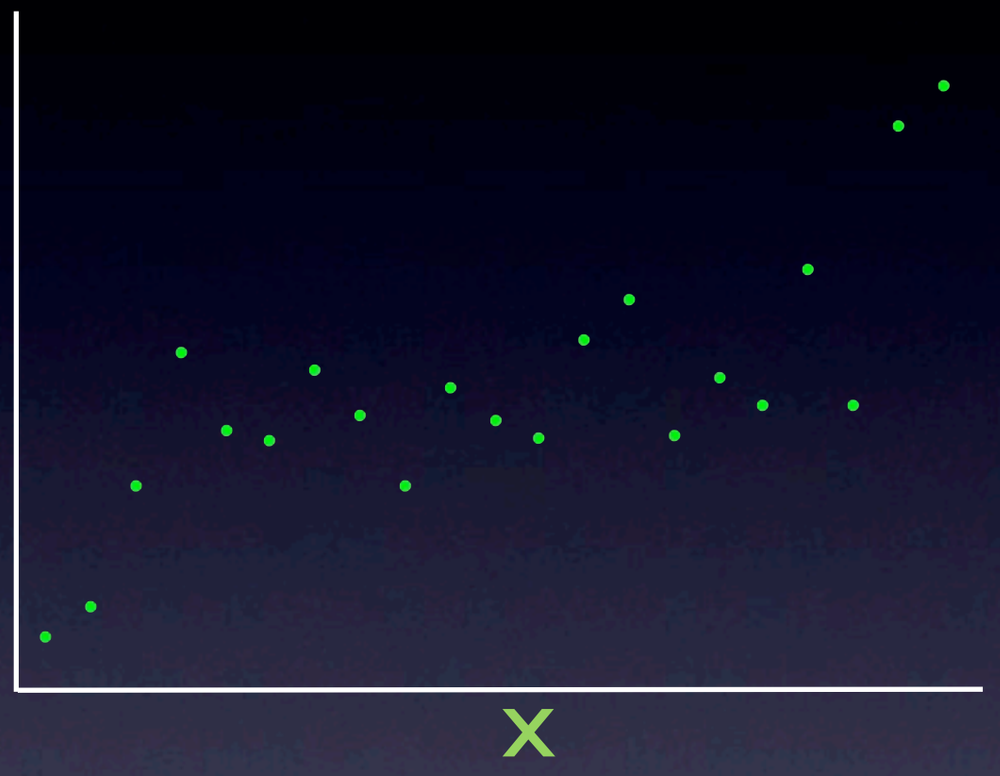
gPC-SC

Generalized polynomial chaos

- Represents stochastic process via polynomials of random variables
- Significantly reduce polynomial degree

Stochastic collocation

- Takes advantage of quadrature rules to calculate means, variances, and moments



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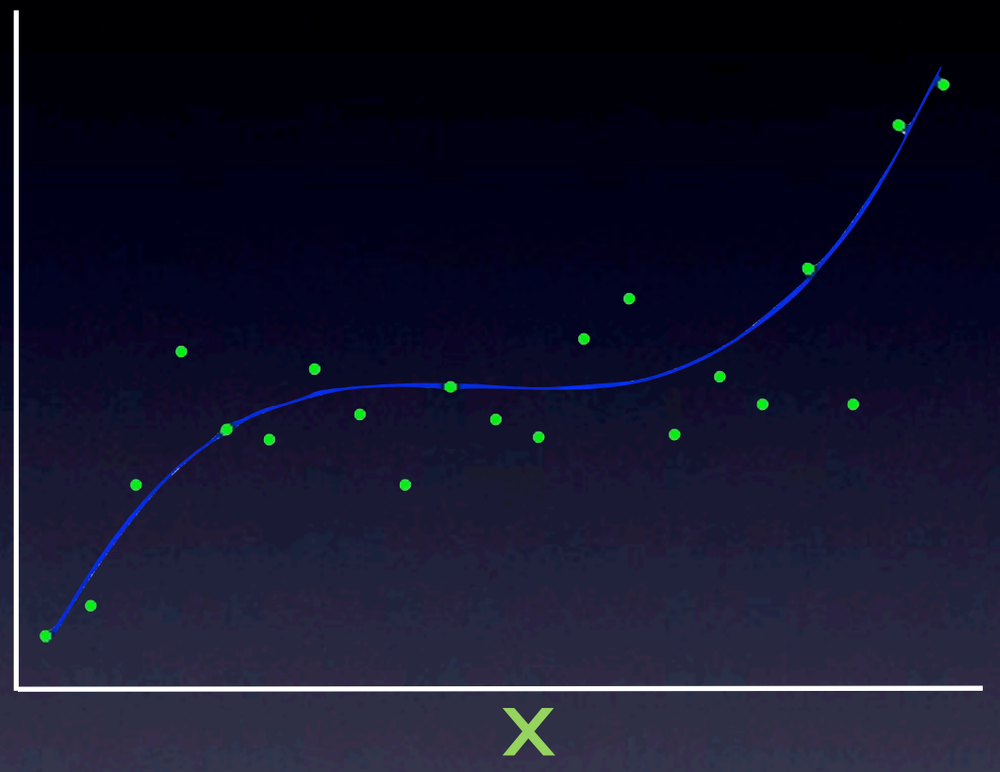


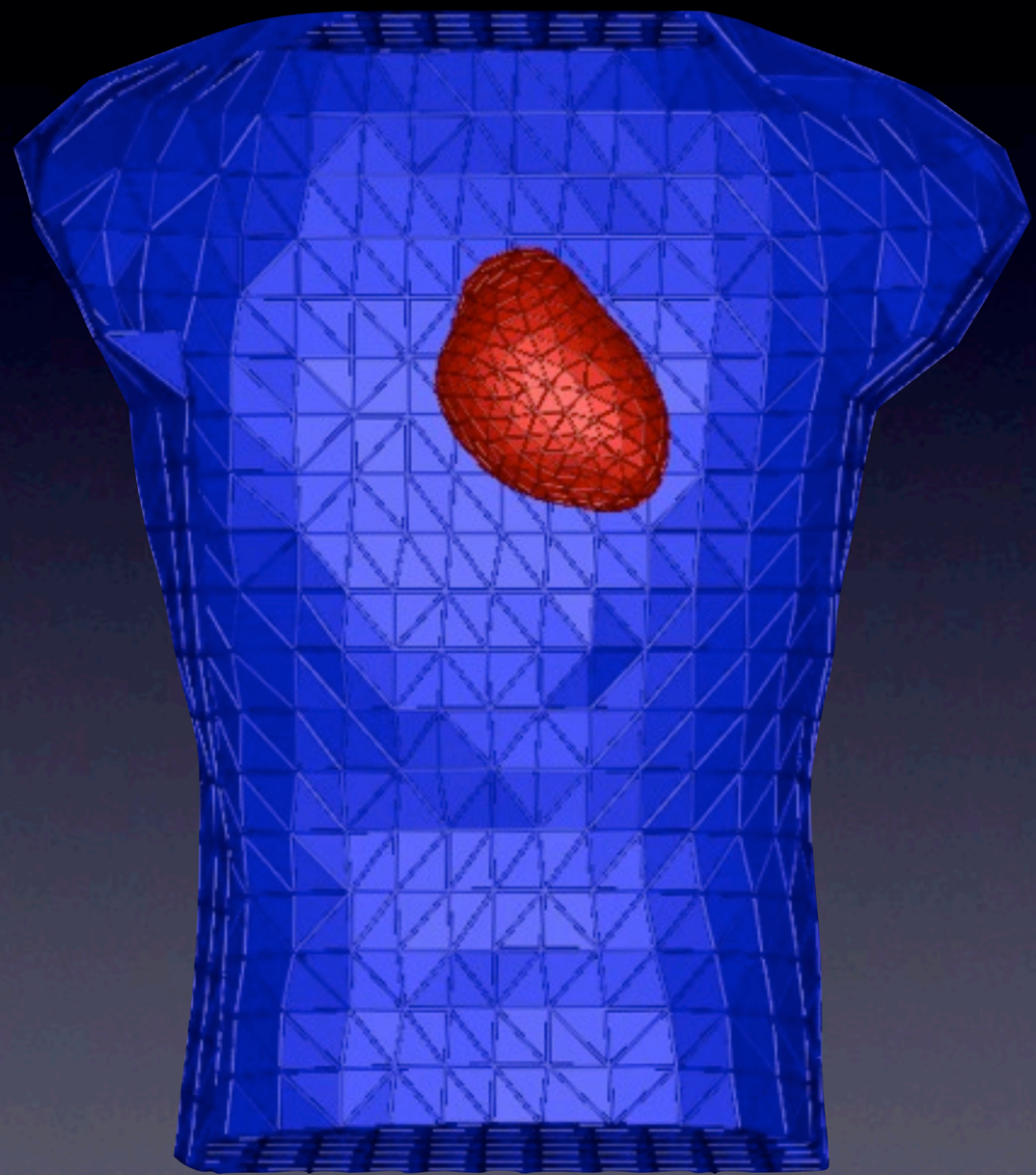
Stochastic collocation

- Takes advantage of quadrature rules to calculate means, variances, and moments

Boundary Elements

Torso Tank

- model 10-year-old boy
- 771 vertices



Epicardial Potentials

- 247 electrode sock
- Acute ischemia study of canine heart

Boundary Elements

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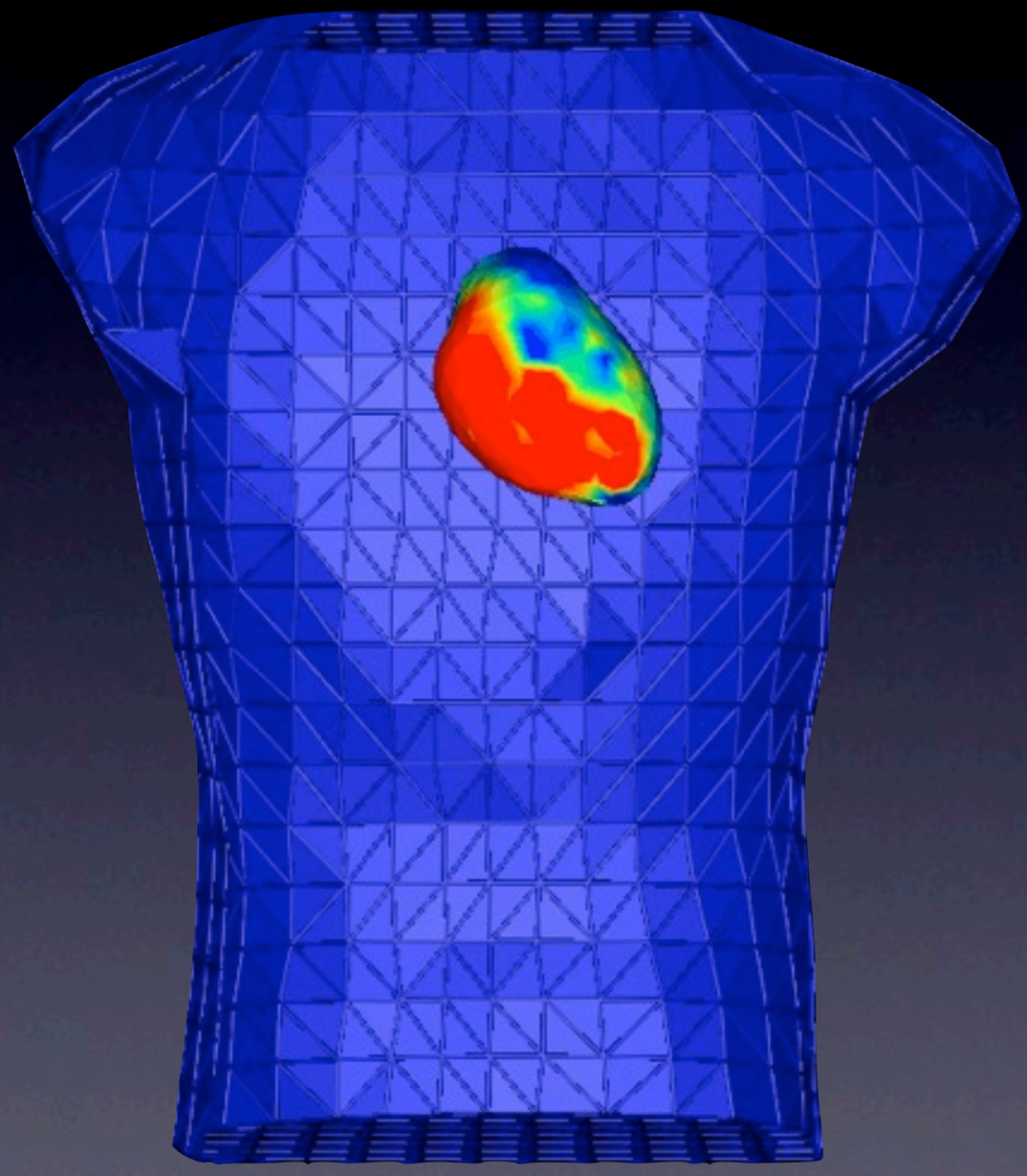

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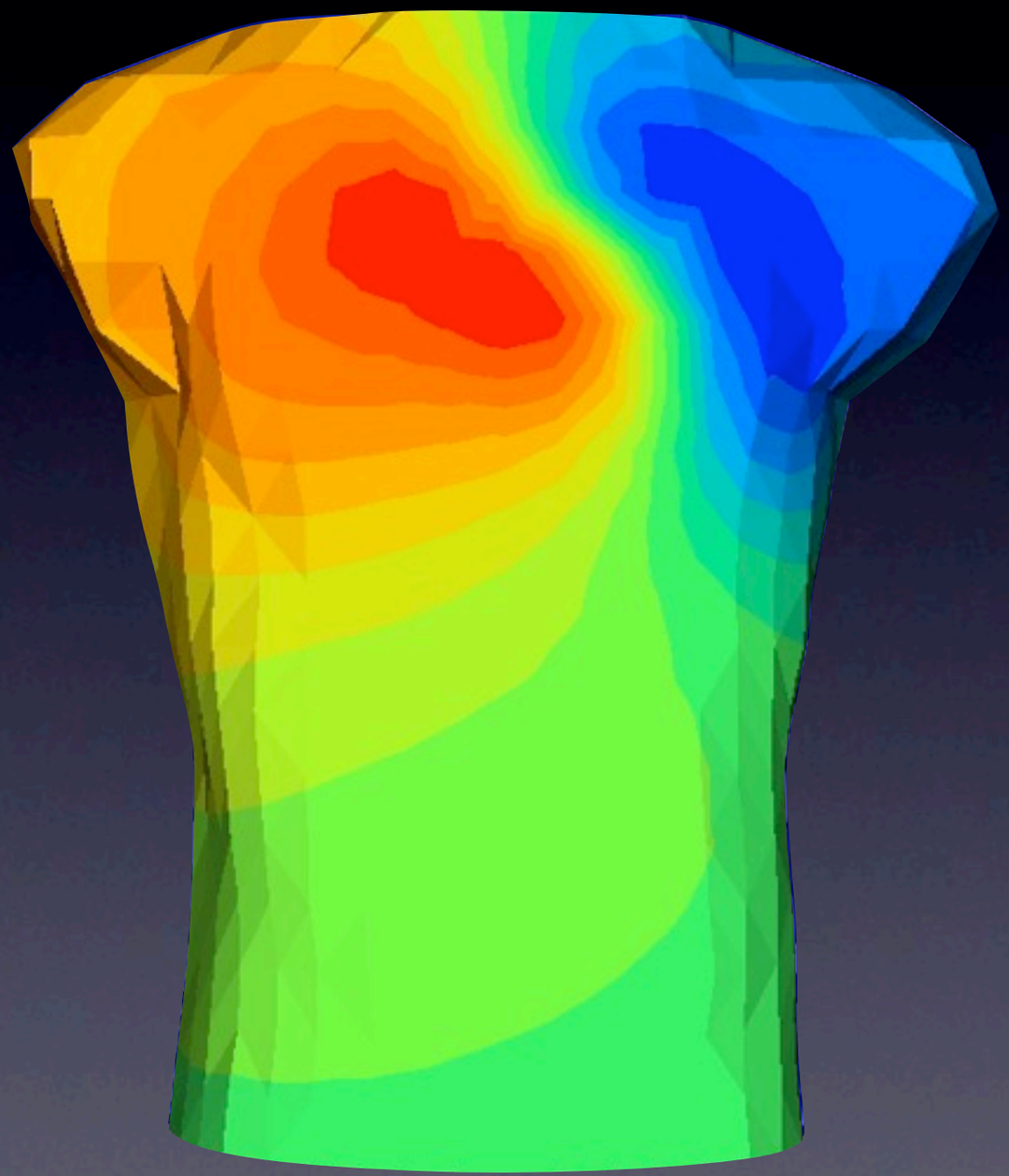

Epicardial Potentials

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Heart Motion

Pivot about
y-axis

35°

Pivot about
x-axis

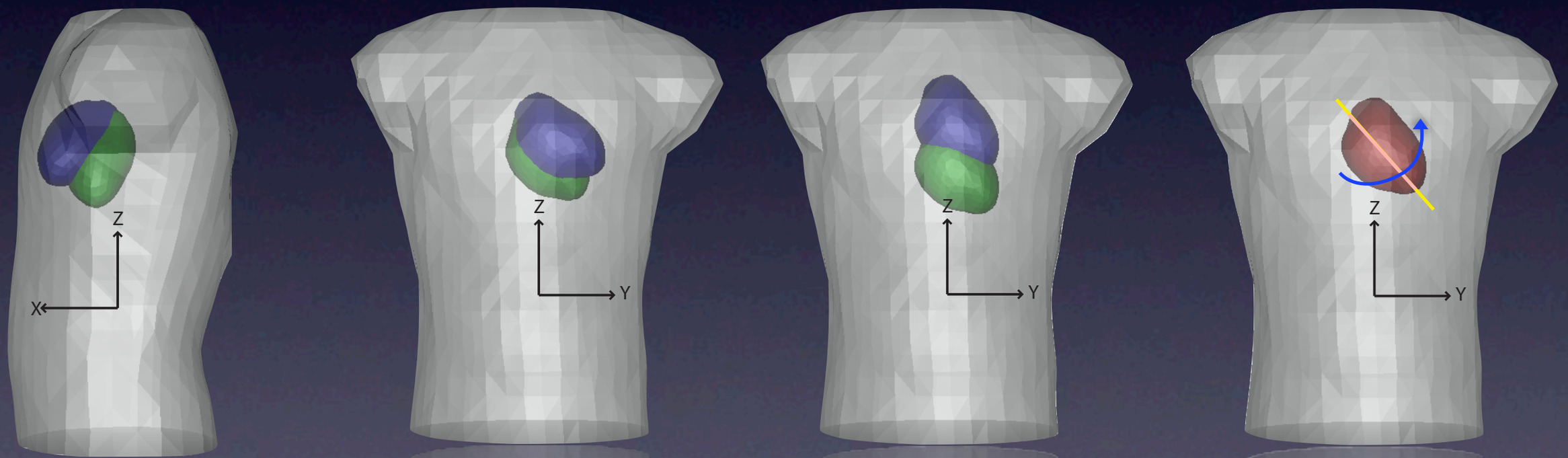
35°

Translation
z-axis

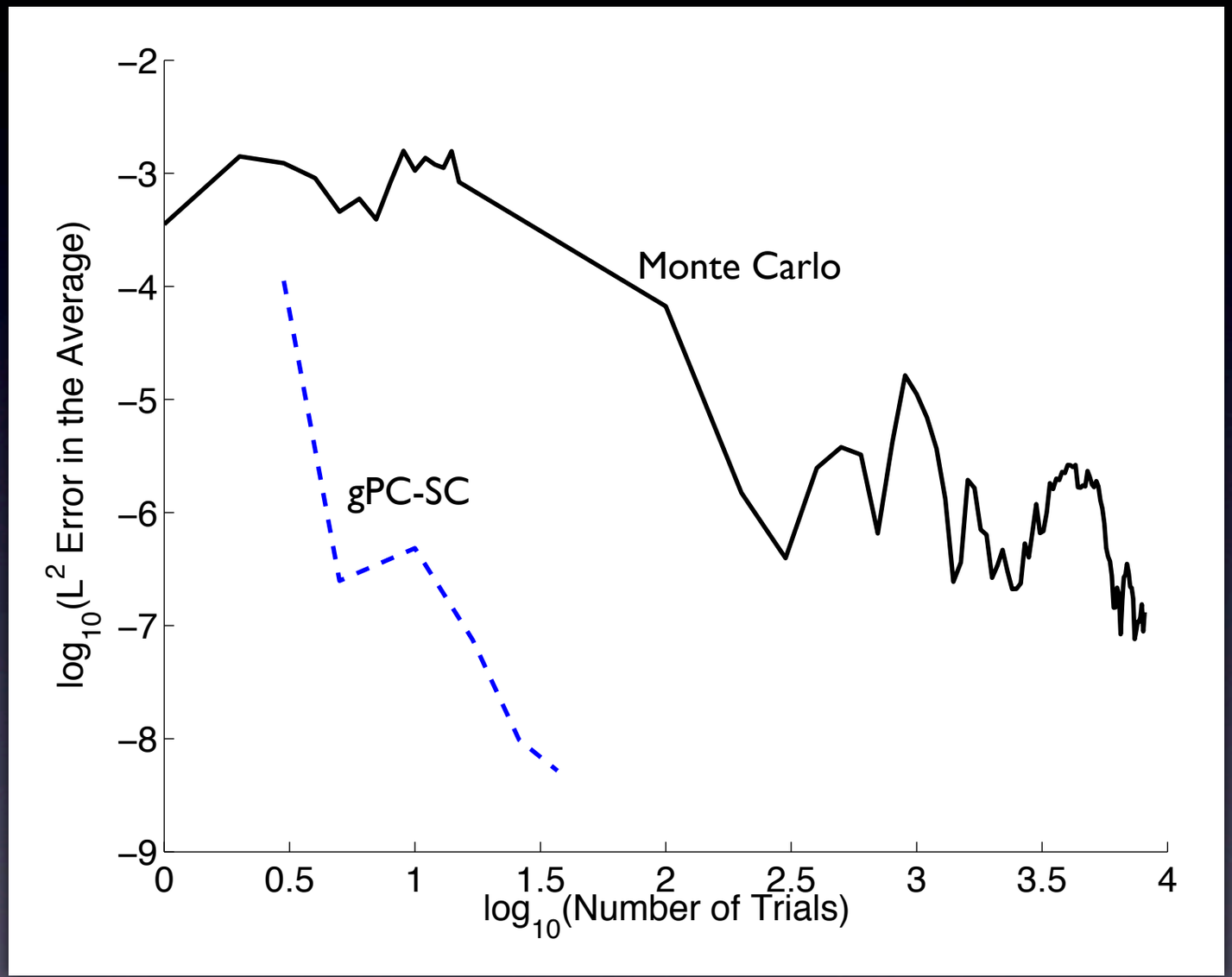
2 cm

Rotation
long axis

20°



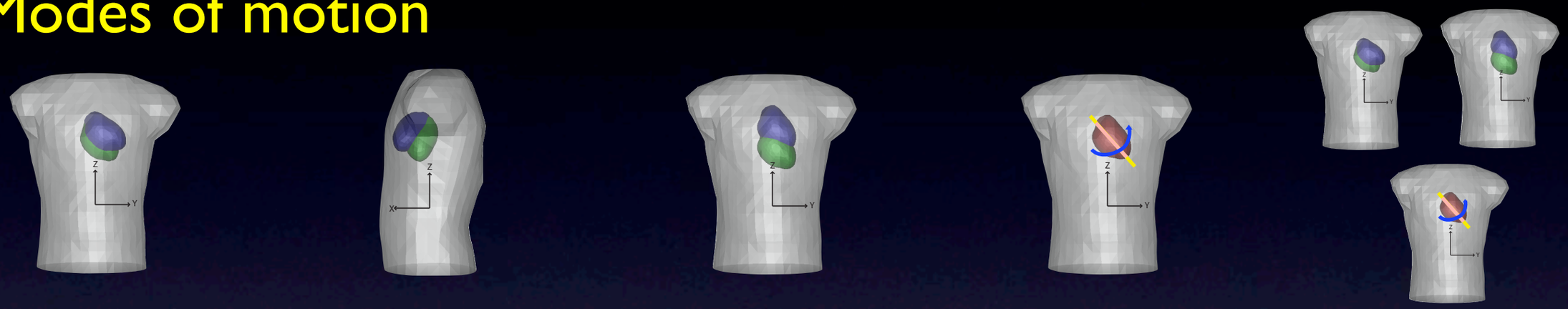
gPC-SC / Monte Carlo



400 times speed up

False Positive

Modes of motion



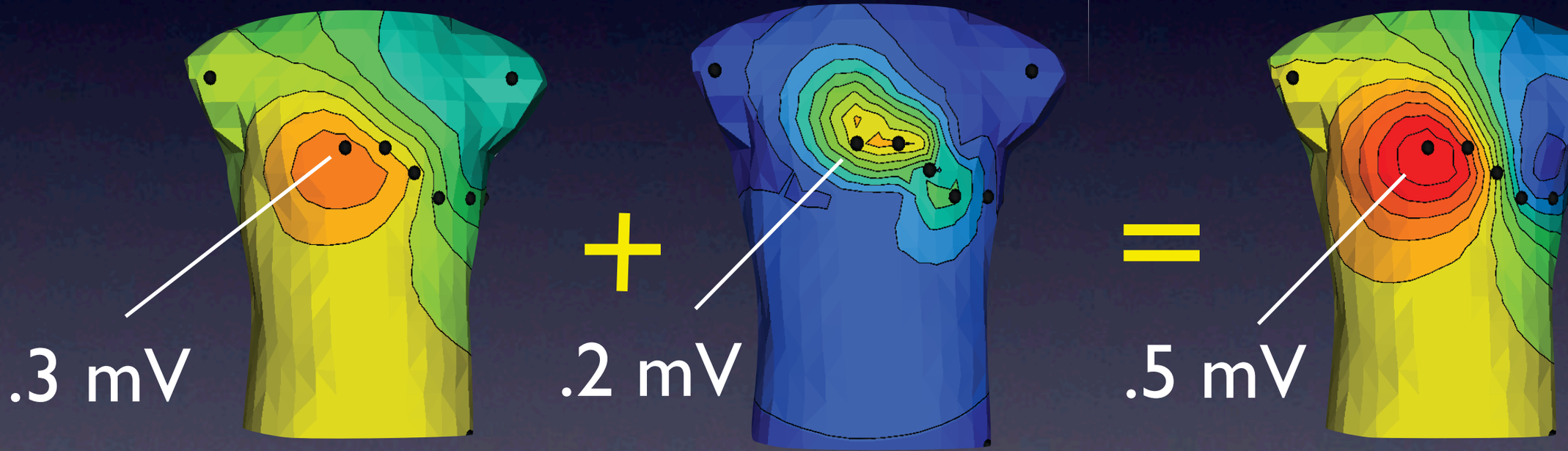
Standard Deviation

Results

Healthy Potentials

STD

Ischemic Potentials



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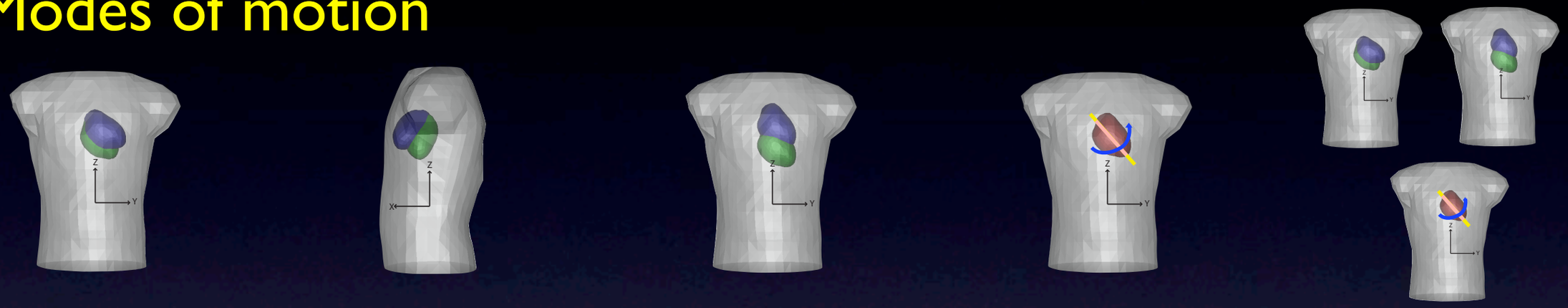
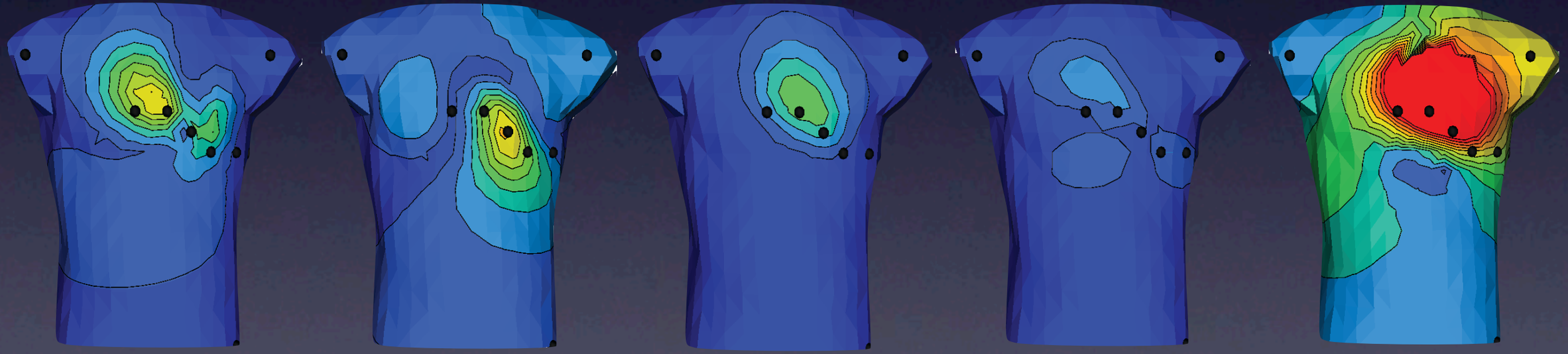
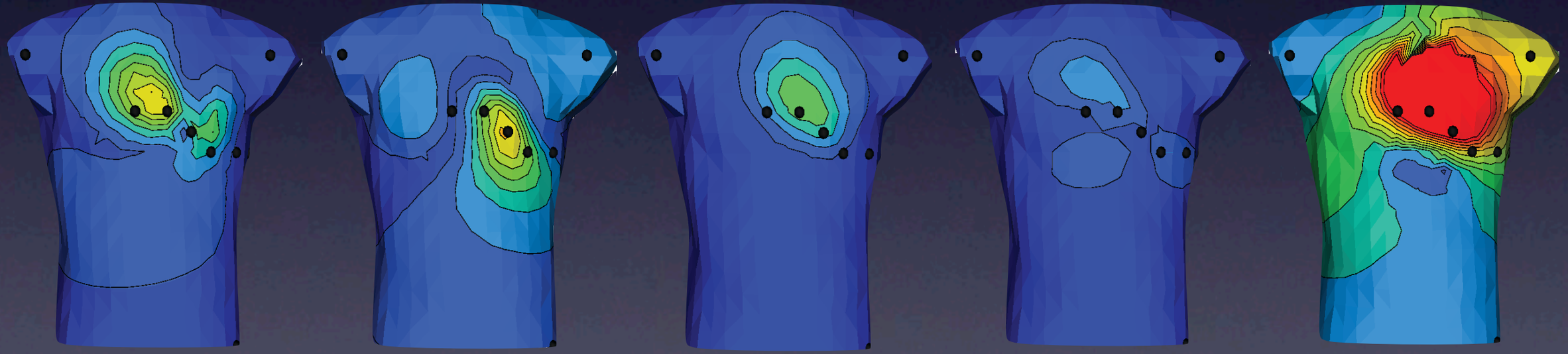




Standard Deviation

0 0.12 0.25 0.38 0.5 mV

Modes of motion



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