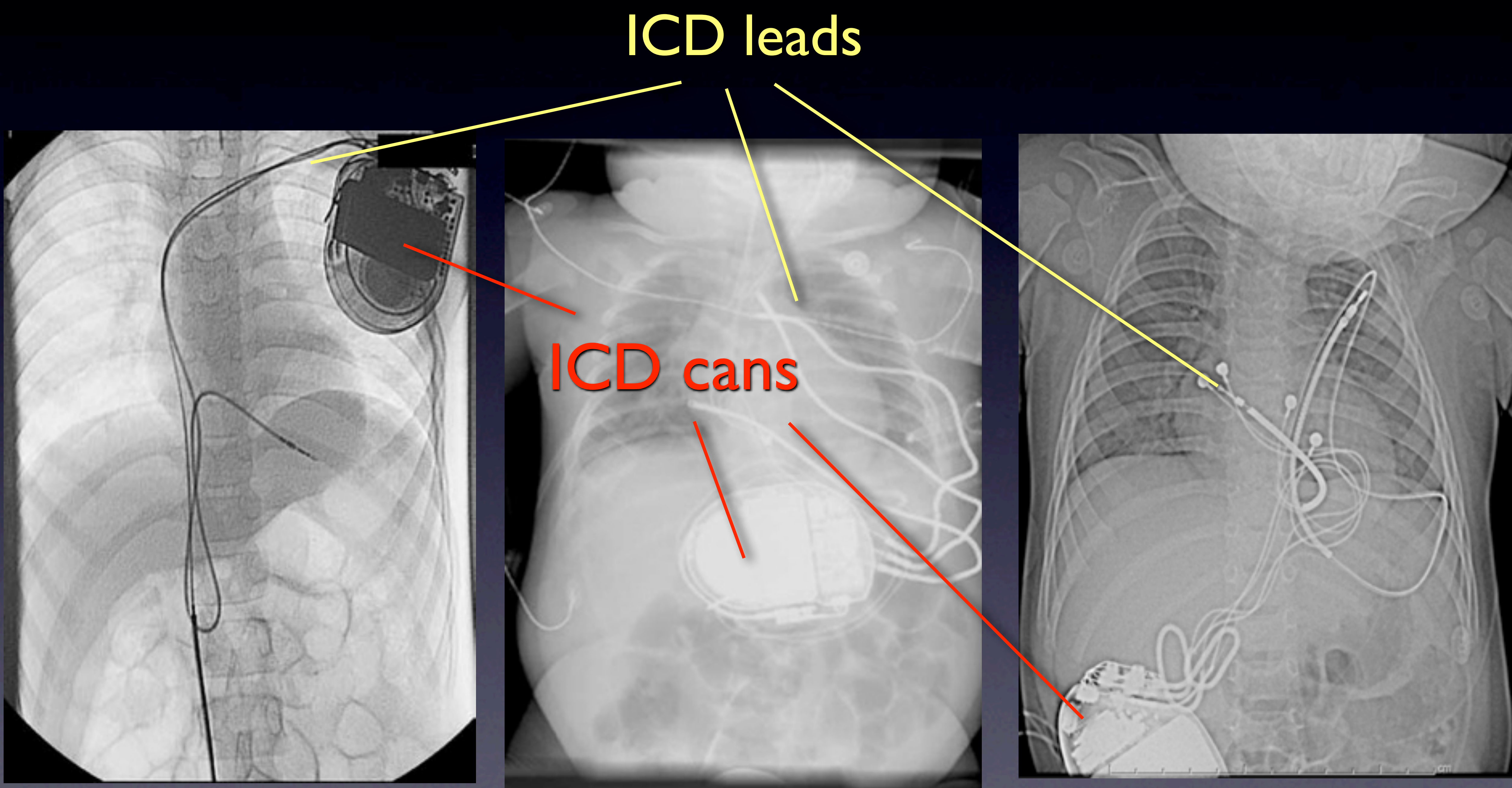
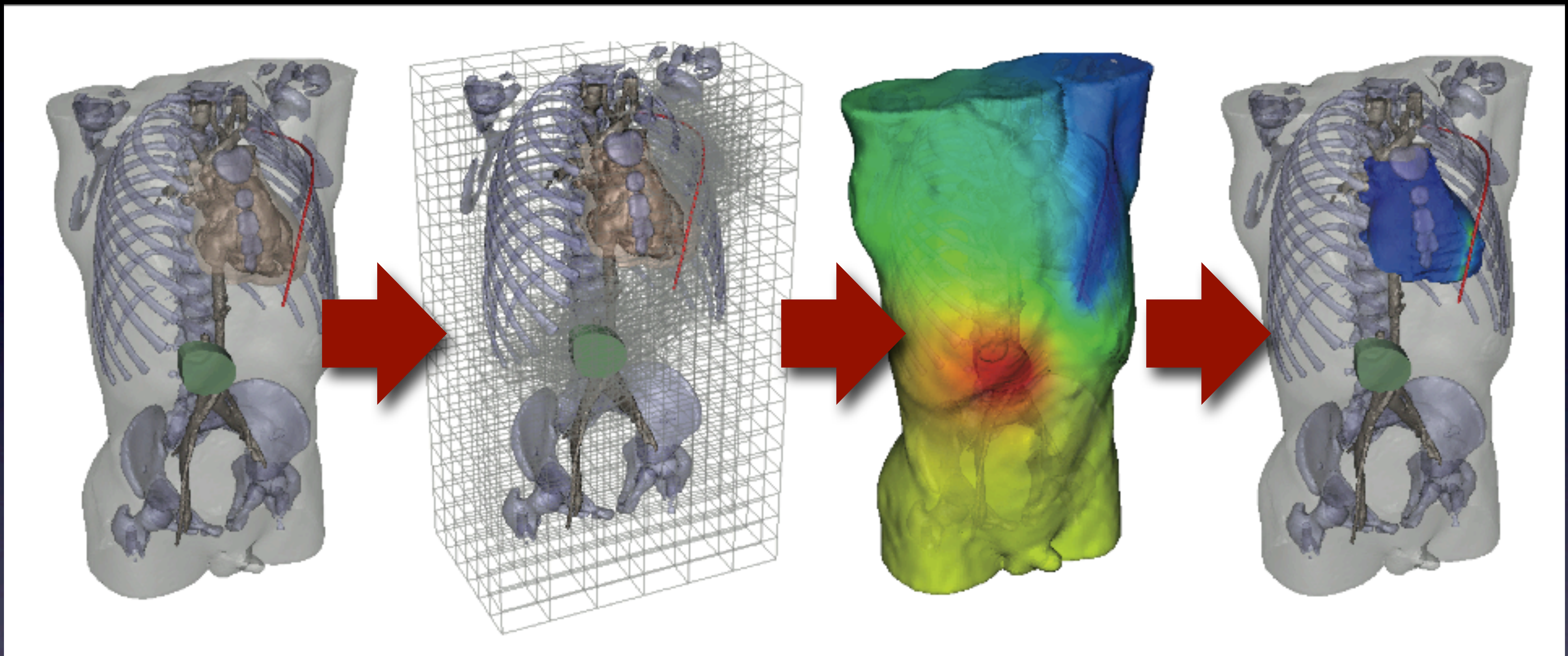
Defibrillators in Pediatric Patients



Gasparini, JCE, 2005 | Stephenson, JCE, 2006 | Children's Hospital Boston

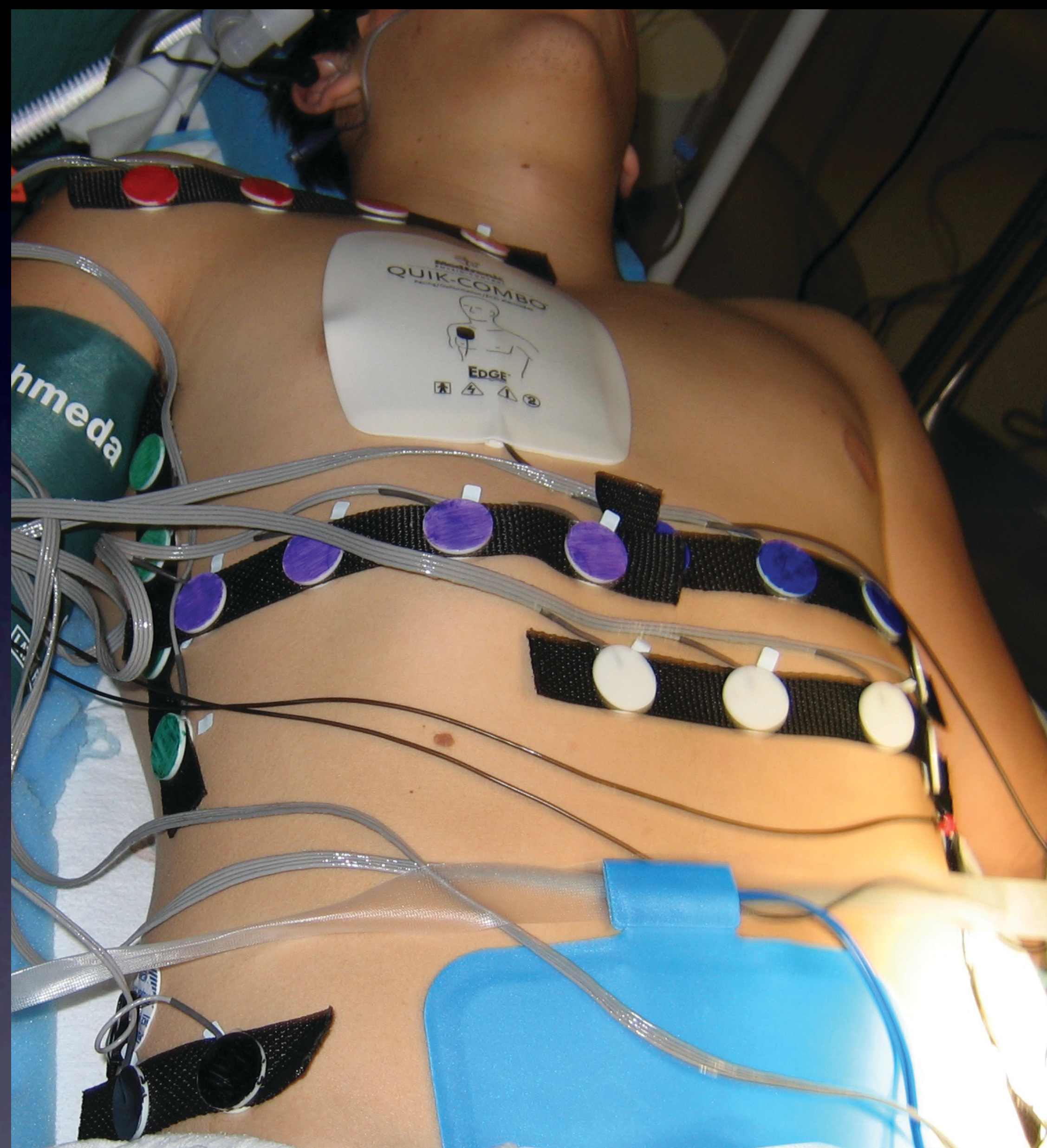


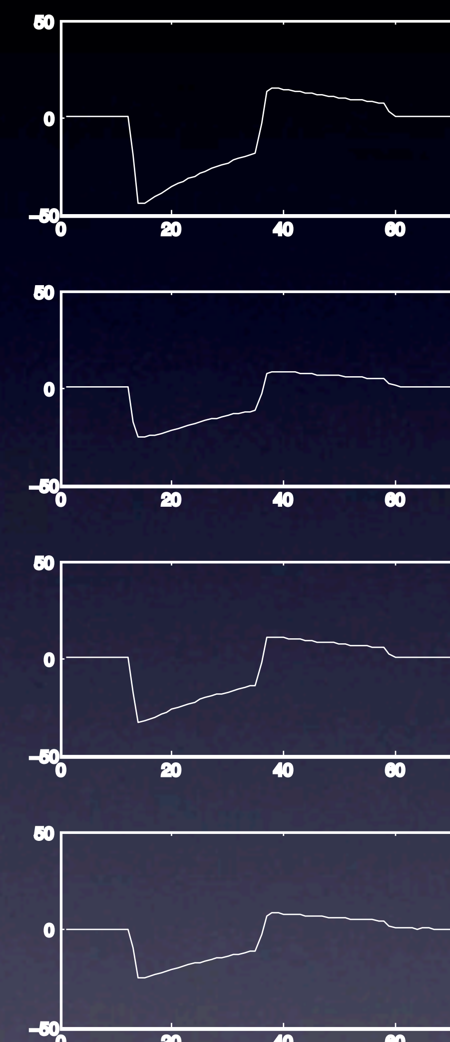
Place electrode leads

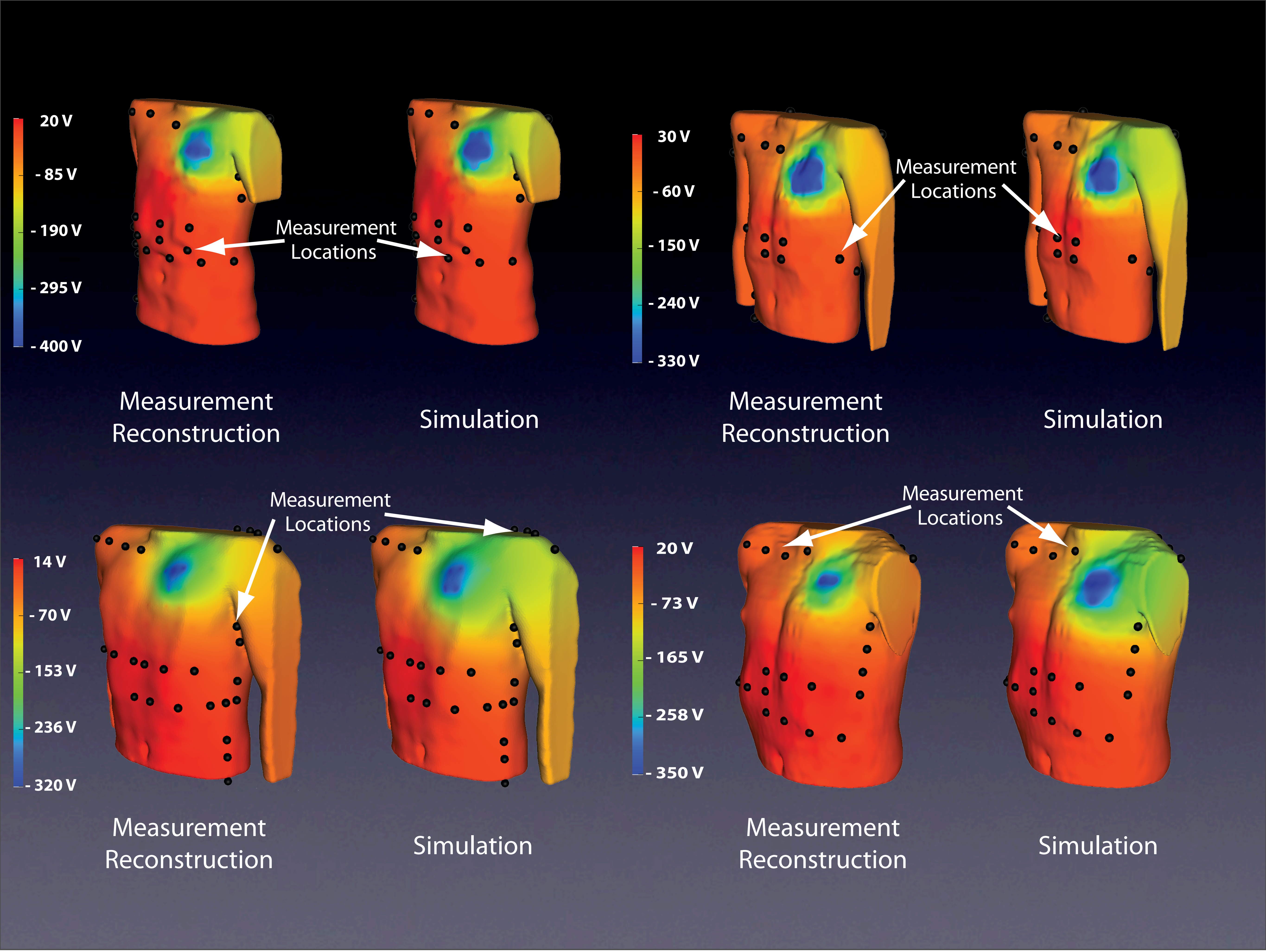
Build hexahedral mesh

Solve potentials using FEM

Evaluate electric field strength


QUIK-COMBO
EDGE


50
0
-50
0
20
40
60
50
0
-50
0
20
40
60
50
0
-50
0
20
40
60
50
0
-50
0
20
40
60


20 V
- 85 V
- 190 V
- 295 V
- 400 V
Measurement
Locations
Measurement
Reconstruction
Simulation
30 V
- 60 V
- 150 V
- 240 V
- 330 V
Measurement
Locations
Measurement
Reconstruction
Simulation
14 V
- 70 V
- 153 V
- 236 V
- 320 V
Measurement
Locations
Measurement
Reconstruction
Simulation
20 V
- 73 V
- 165 V
- 258 V
- 350 V
Measurement
Locations
Measurement
Reconstruction
Simulation

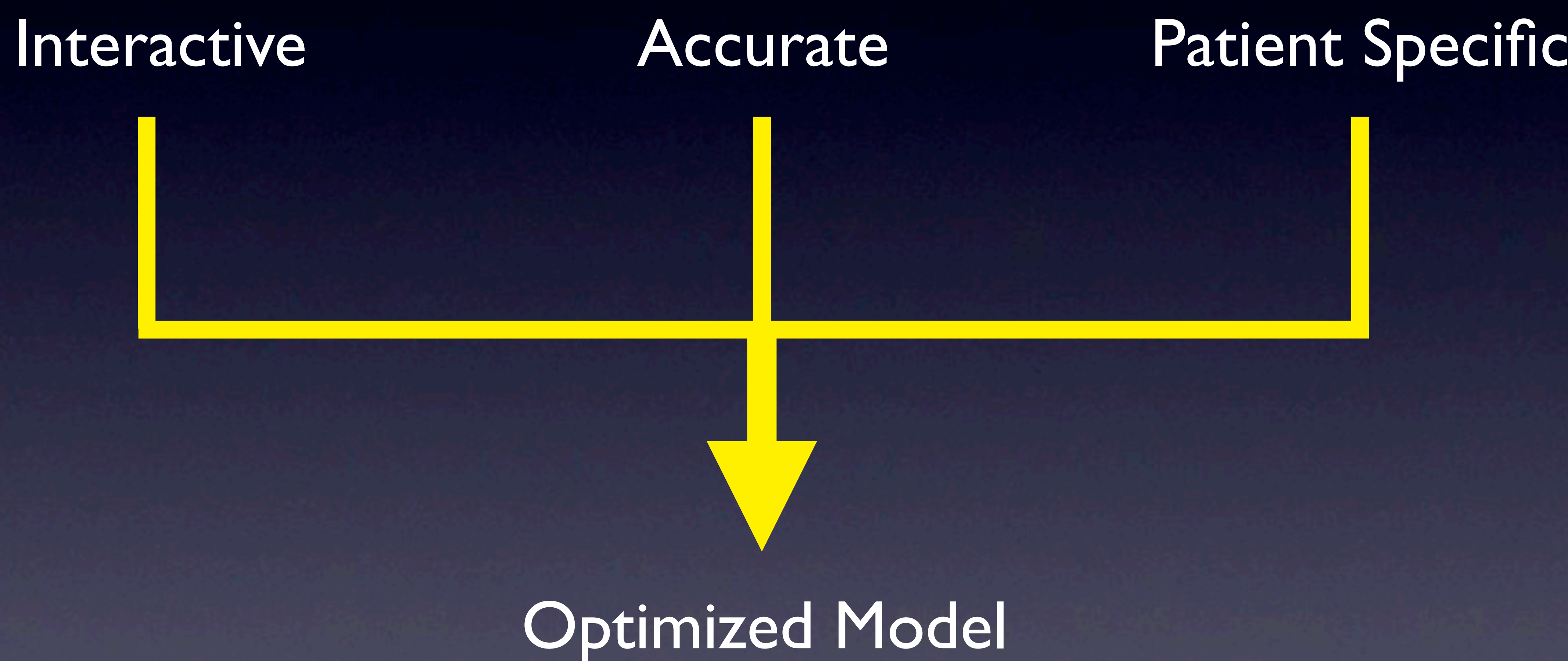
Clinical Viability

Interactive

Accurate

Patient Specific

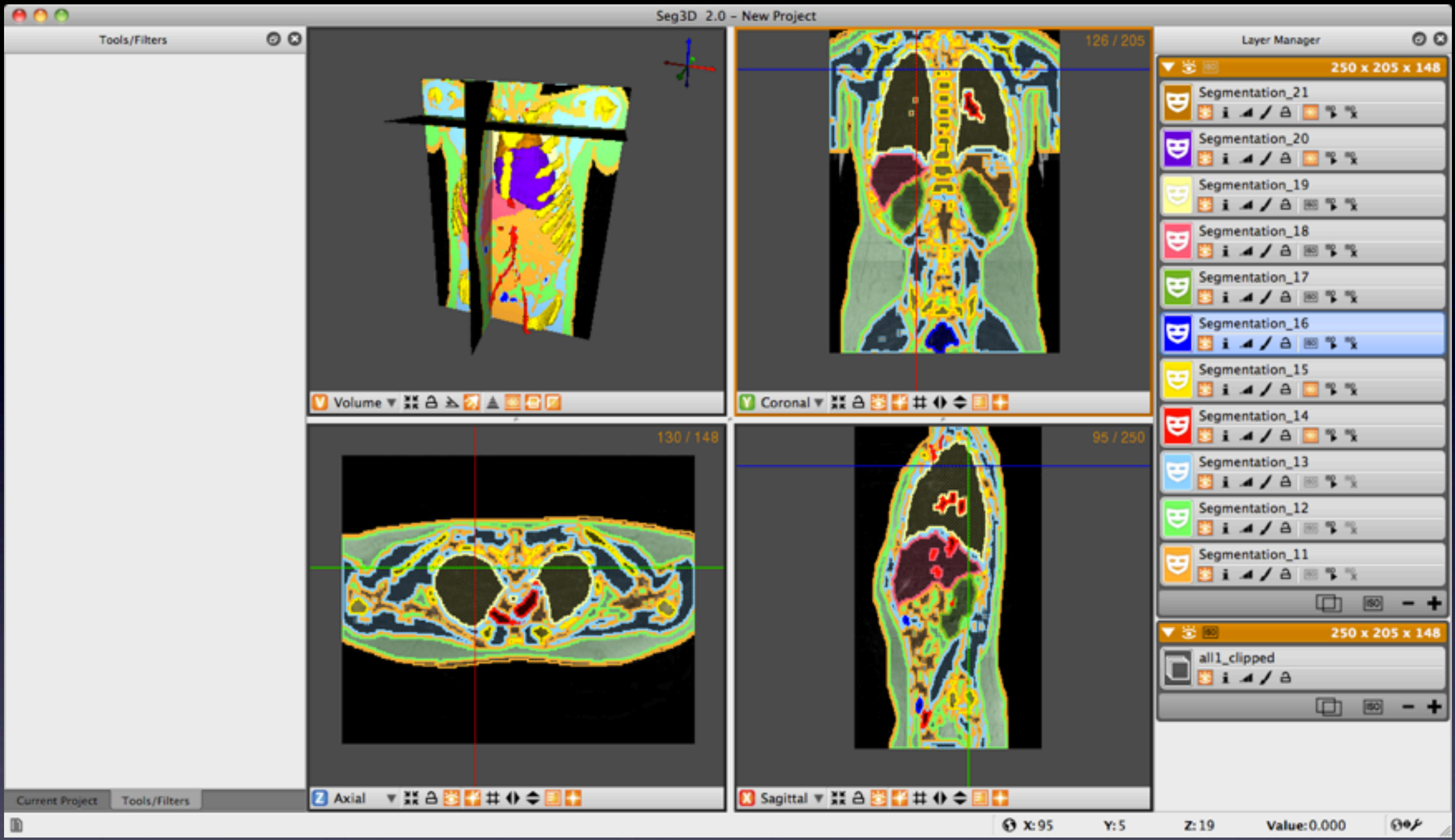
Clinical Viability



Validation Studies

Model Complexities

Parameter & Process Optimization


Seg3D 2.0 – New Project
Tools/Filters
Layer Manager
250 x 205 x 148
Segmentation_21
Segmentation_20
Segmentation_19
Segmentation_18
Segmentation_17
Segmentation_16
Segmentation_15
Segmentation_14
Segmentation_13
Segmentation_12
Segmentation_11
250 x 205 x 148
all1_clipped
Volume
Coronal
126 / 205
Axial
130 / 148
Sagittal
95 / 250
Current Project
Tools/Filters
X: 95
Y: 5
Z: 19
Value: 0.000

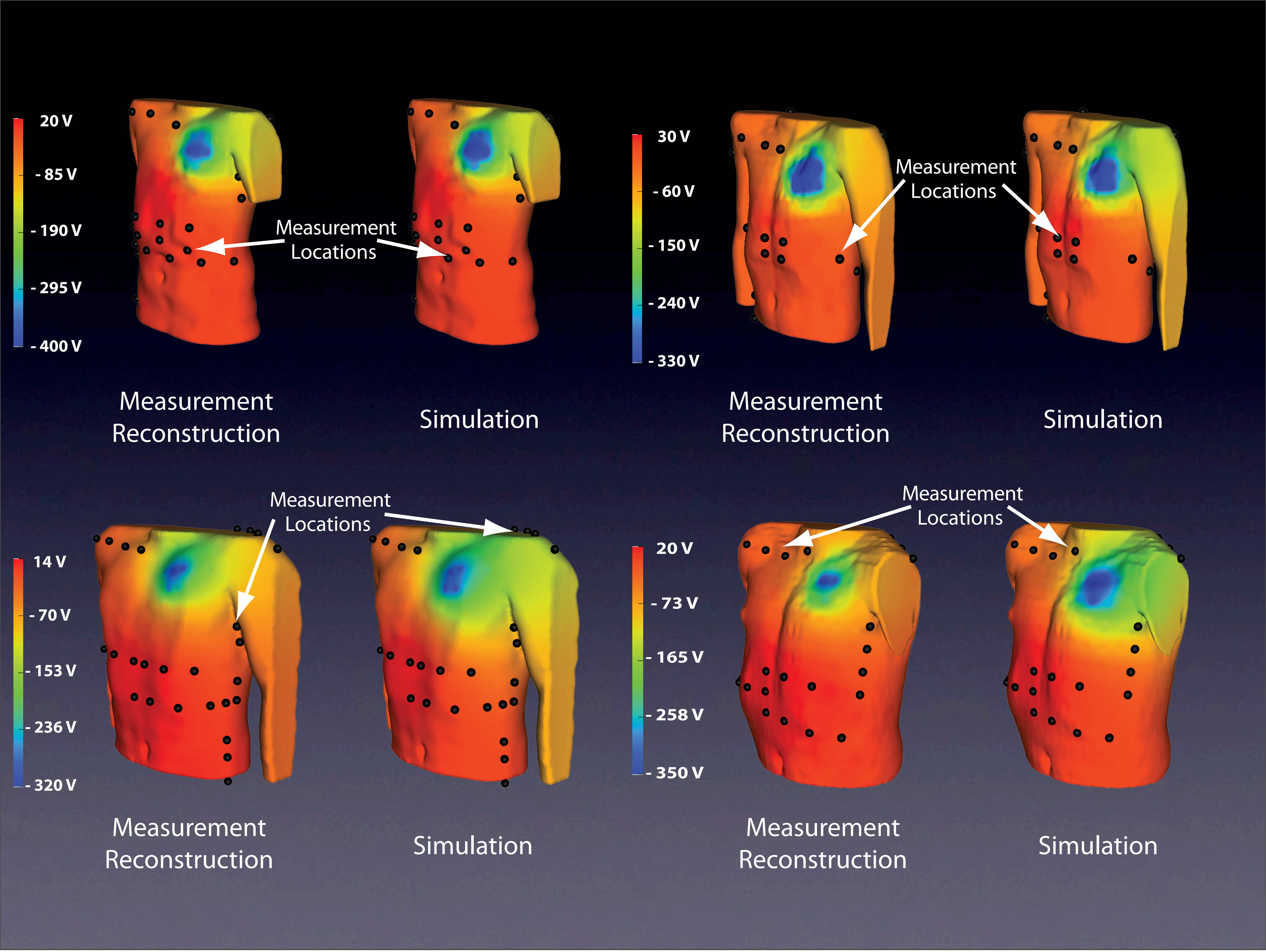
~ 40 hr

Automatic Segmentation

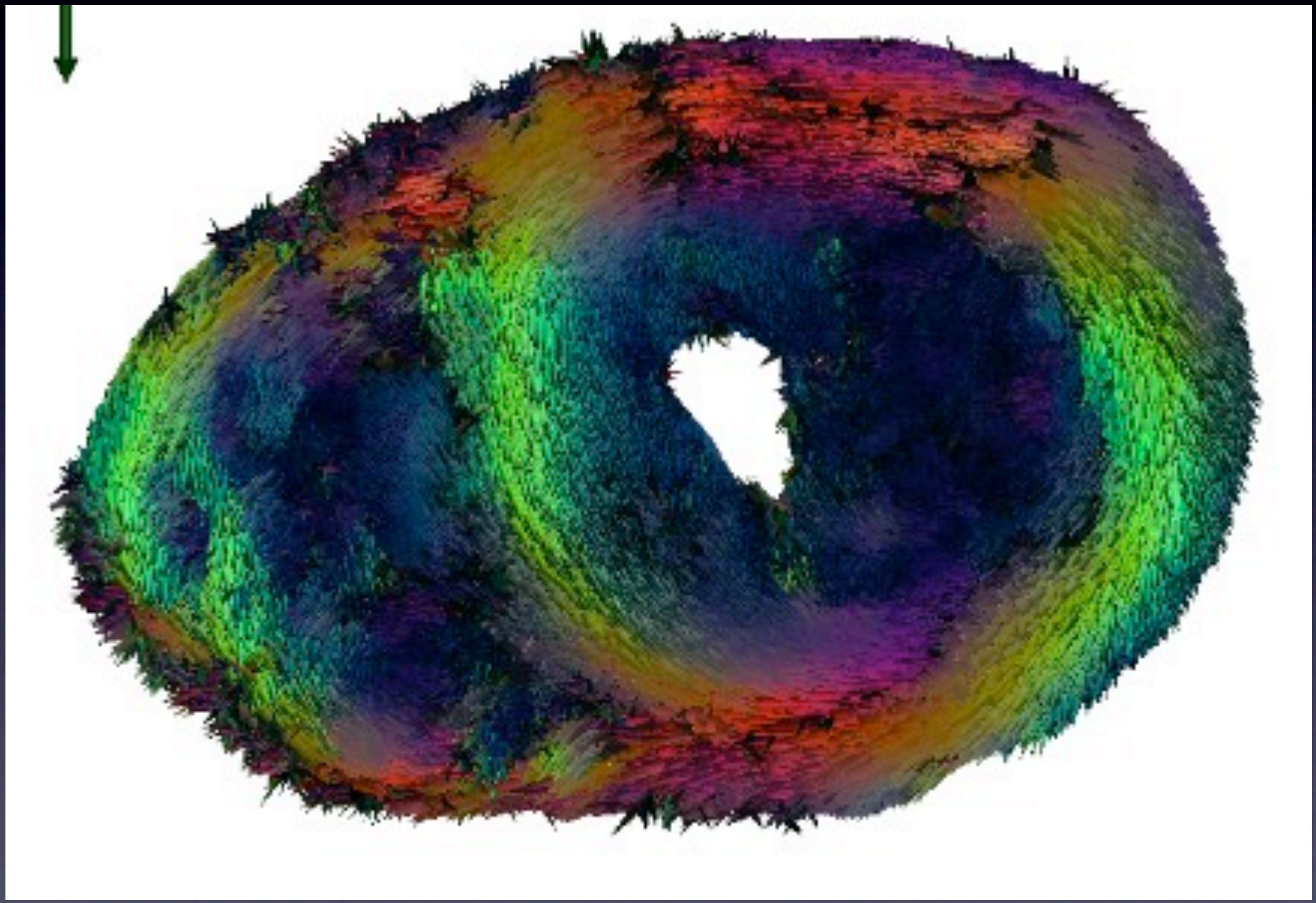
Smarter Filters

Better Scans

Complexities


20 V
- 85 V
- 190 V
- 295 V
- 400 V
Measurement
Locations
Measurement
Reconstruction
Simulation
30 V
- 60 V
- 150 V
- 240 V
- 330 V
Measurement
Locations
Measurement
Reconstruction
Simulation
14 V
- 70 V
- 153 V
- 236 V
- 320 V
Measurement
Locations
Measurement
Reconstruction
Simulation
20 V
- 73 V
- 165 V
- 258 V
- 350 V
Measurement
Locations
Measurement
Reconstruction
Simulation

Anisotropy



Passive anisotropic
model

Passive anisotropic
model

SCIRun

Passive anisotropic
model

SCIRun

bottlenecks/problems:

Passive anisotropic model

SCIRun

bottlenecks/problems:

Model generation

Passive anisotropic model

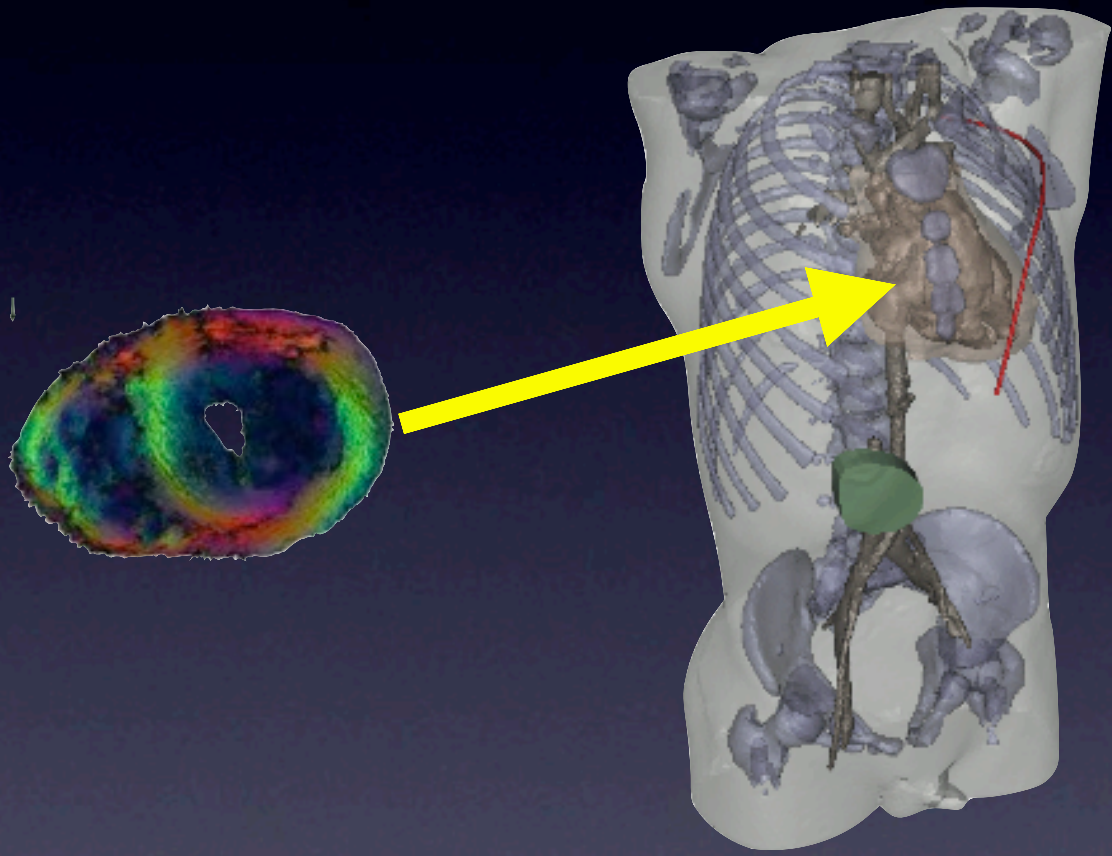
SCIRun

bottlenecks/problems:

Model generation

Fiber data

Fiber Mapping



Geometry Morphing

Vector/Tensor Morphing and Interpolation

Active cardiac model

CARP

CHASTE

Active cardiac model

CARP

CHASTE

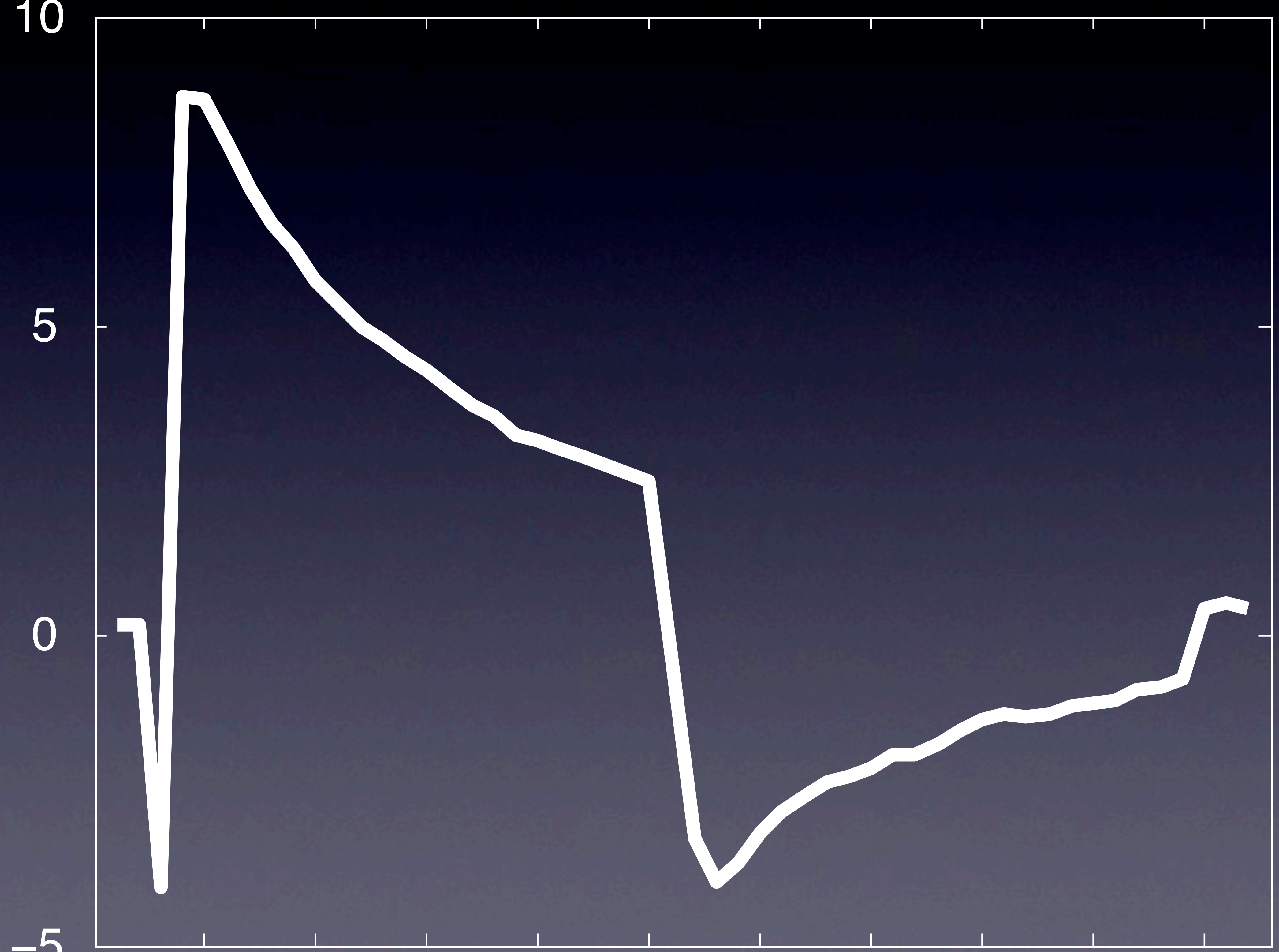
bottlenecks/problems:

Model generation

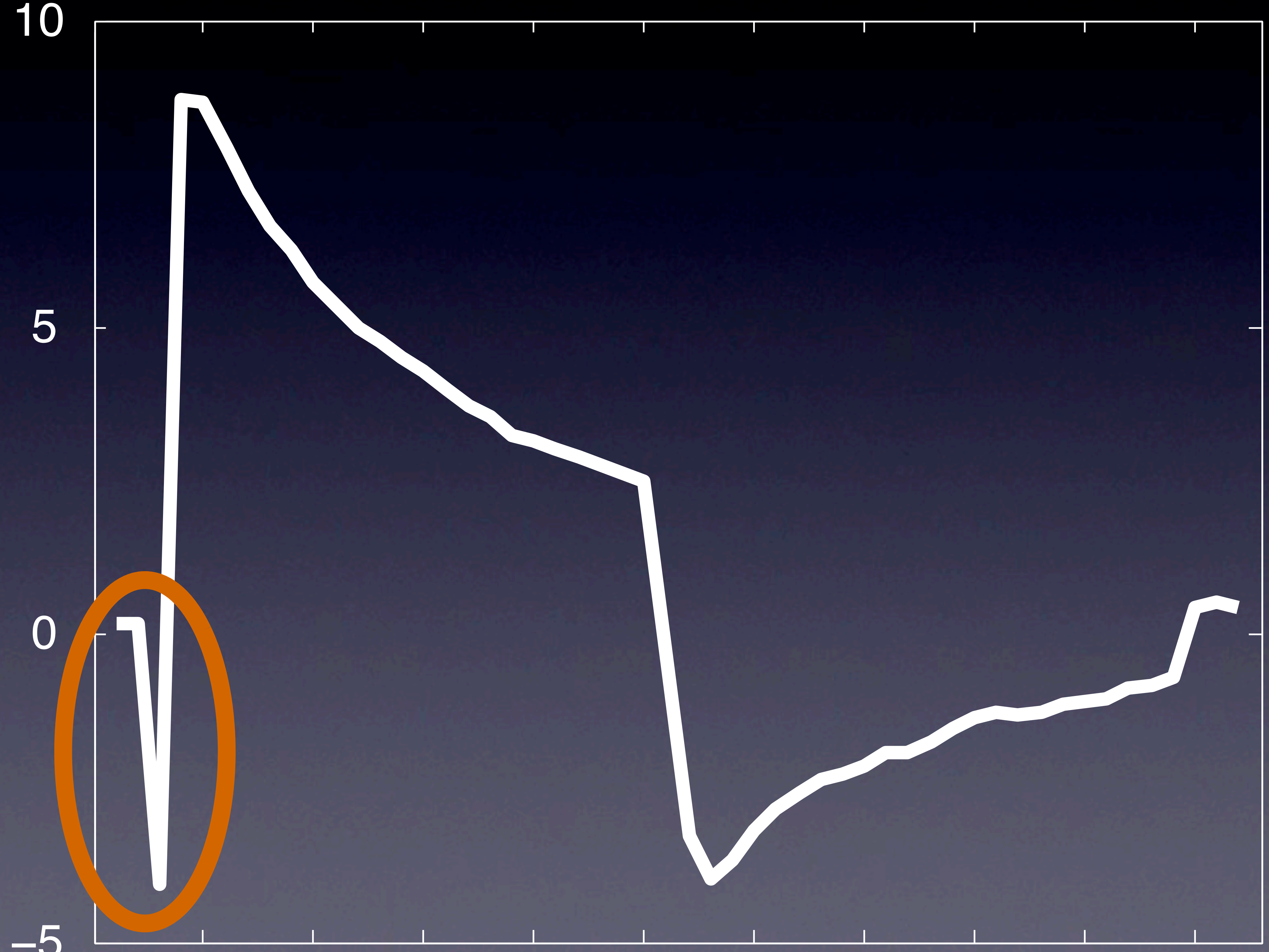
Visualization

Isolated heart models

Capacitance?



Capacitance?



Potentials in the frequency domain

$$\nabla \cdot [(\sigma + j\omega\epsilon_0\epsilon_r \nabla\varphi] = 0$$

Potentials in the time domain

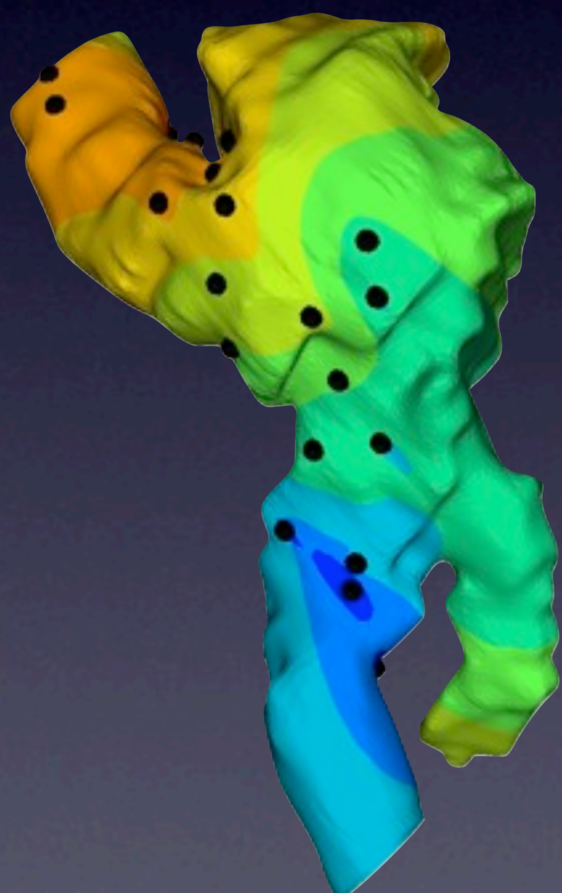
$$\nabla \cdot \left[\left(\sigma + \epsilon_0\epsilon_r \frac{\delta}{\delta t} \right) \nabla\varphi \right] = 0$$

Stoykov etal. IEEE Trans in Biomed, Vol. 4 No. 8 p.763 2002

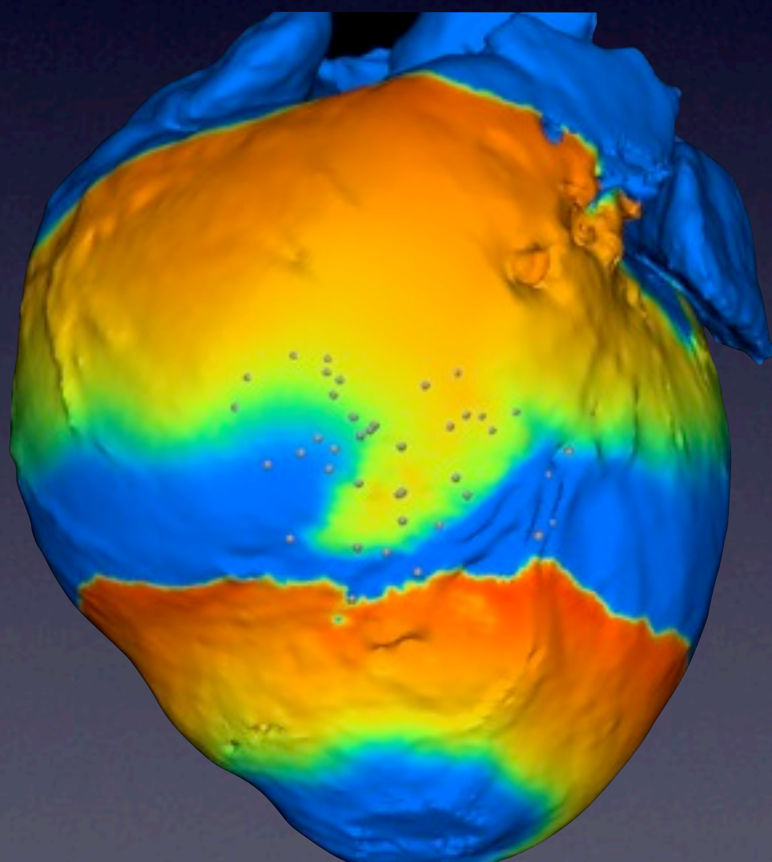
Support for complex data

Modification of solvers

Activation Simulations



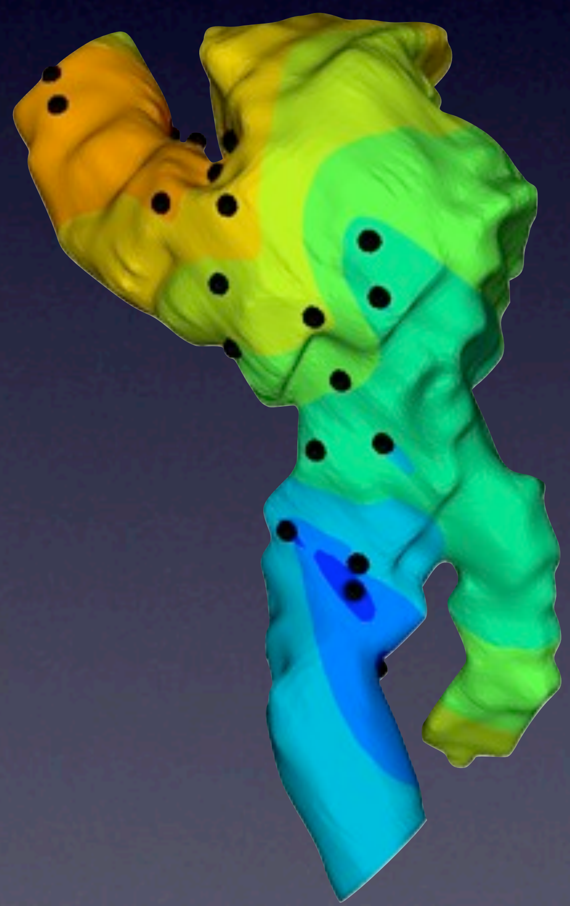
Help develop ablation strategies



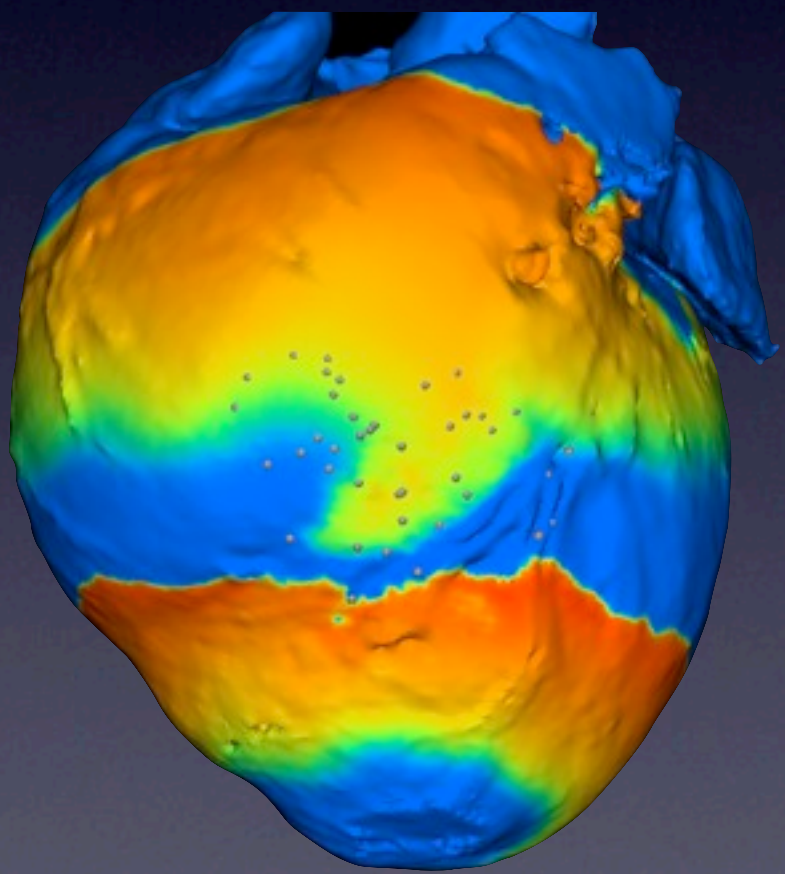
Identify areas for potential reentry

Activation Simulations

Activation Map of
Left Atrium



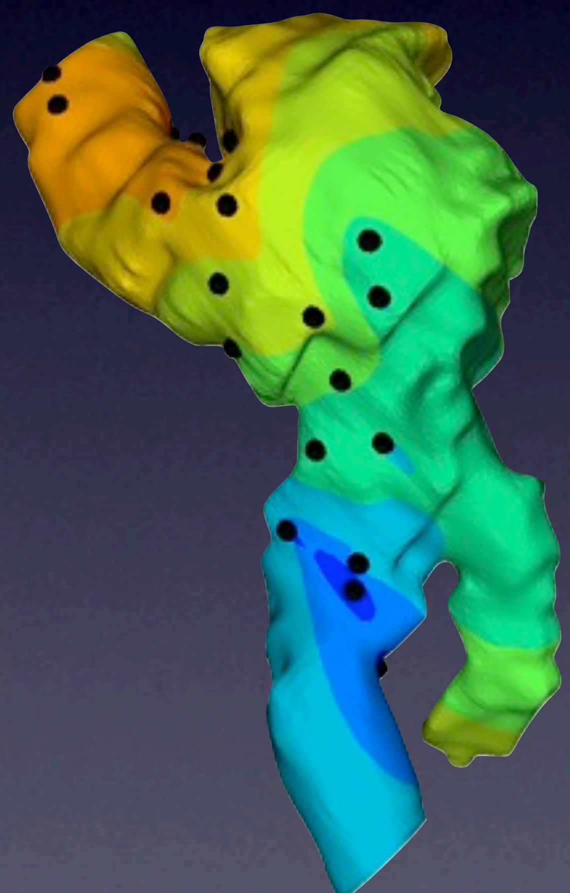
Help develop
ablation strategies



Identify areas for
potential reentry

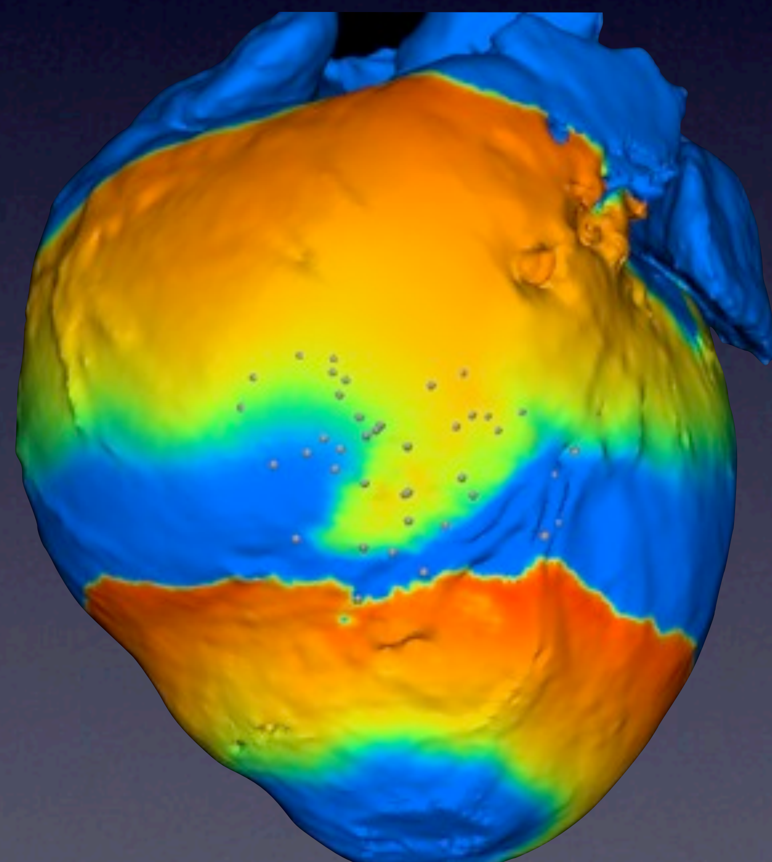
Activation Simulations

Activation Map of Left Atrium



Help develop ablation strategies

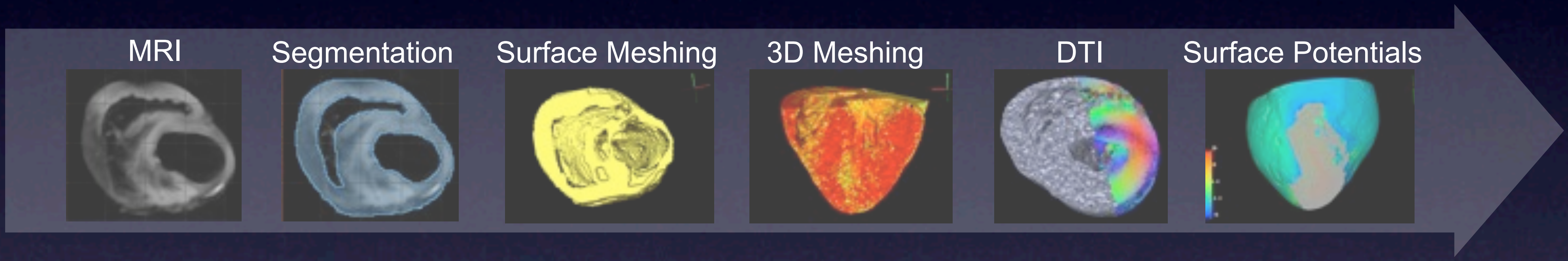
Transmembrane Potentials of infarcted heart



Identify areas for potential reentry

Not there yet

- Highly technical patient specific modeling pipeline



- Prohibitive time to run models

Days to weeks

- Models lack realism and validation

Solutions

Speed up simulations

Simplifications
Technical improvements

Improve accuracy

Cell Model
Geometry
Fiber Direction
Conductivity

Accuracy

Increase accuracy without increasing computational costs

Better geometry

- Multi-Material models
- Conformal Meshing
- Adaptive refinement
- Higher order elements

Validation

- Subject specific models
- Clinical Collaborations

Accuracy

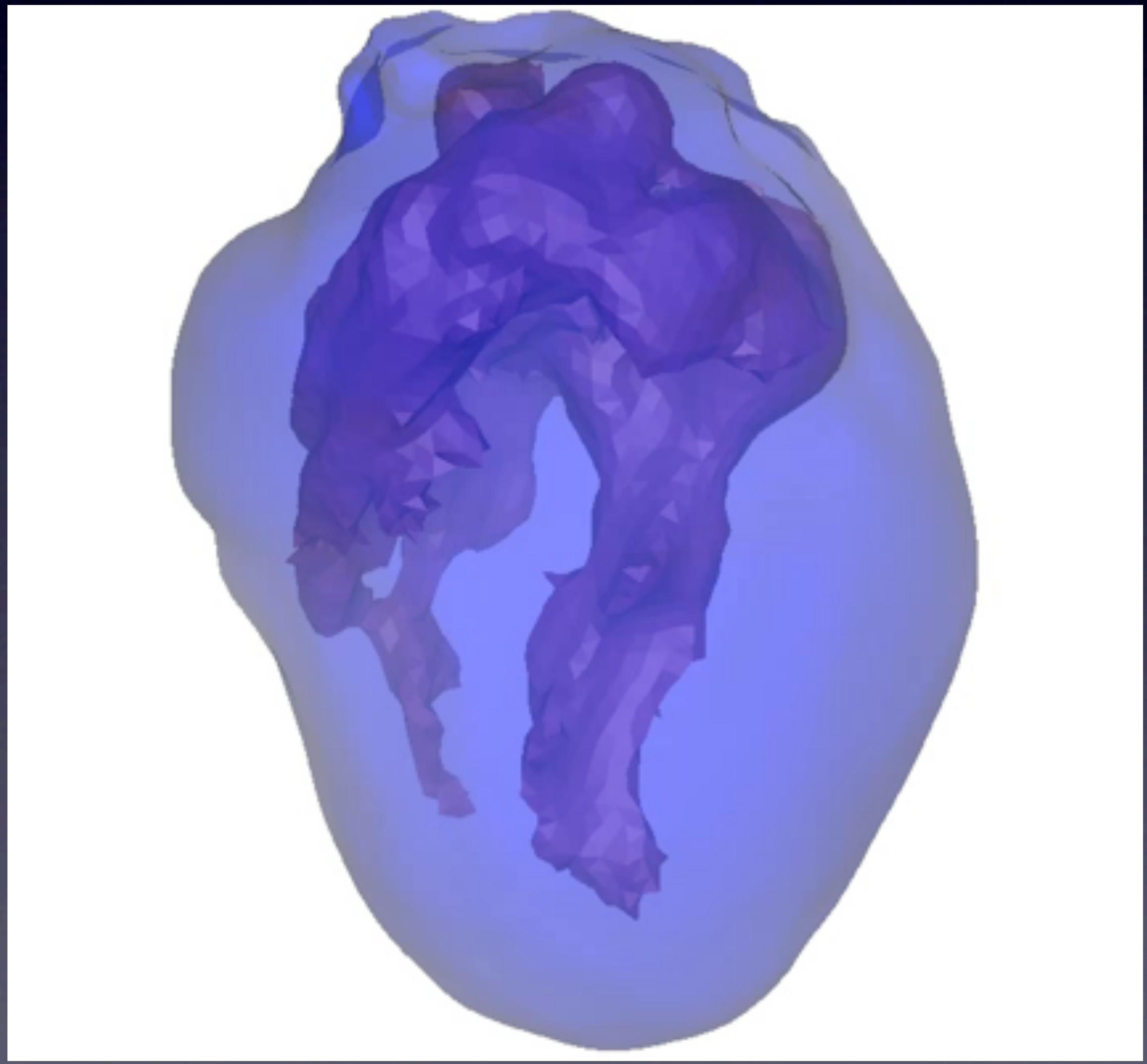
Increase accuracy without increasing computational costs

Better geometry

- Multi-Material models
- Conformal Meshing
- Adaptive refinement
- Higher order elements

Validation

- Subject specific models
- Clinical Collaborations



Speed Up

Decreasing computation time
without losing accuracy

GPUs

MPI

Server/Client

HDF5

Speed Up

Decreasing computation time
without losing accuracy

GPUs

MPI

Server/Client

HDF5

Technical Challenges

- Memory limits large models
- Avoid gathering and scattering
- Elliptical solvers for GPUs
- Support for unstructured grid

Speed Up

Decreasing computation time
without losing accuracy

GPUs

MPI

Server/Client

HDF5

MPI -Message passing interface

- More efficient parallel algorithms

Speed Up

Decreasing computation time
without losing accuracy

GPUs

MPI

Server/Client

HDF5

Very large computers as servers

- More practical for clinical settings
- Give practitioners client software

Speed Up

Decreasing computation time
without losing accuracy

GPUs

MPI

Server/Client

HDF5

How do we handle very large data sets

- Newer file formats
- Streaming an blocking techniques

Other Ideas

- How do more efficiently solve patient specific models?