

Simulation of Defibrillation

Scientific Computing & Imaging Institute
Harvard Medical School
Children's Hospital, Boston
Stanford Medical School
Primary Children's Medical Center



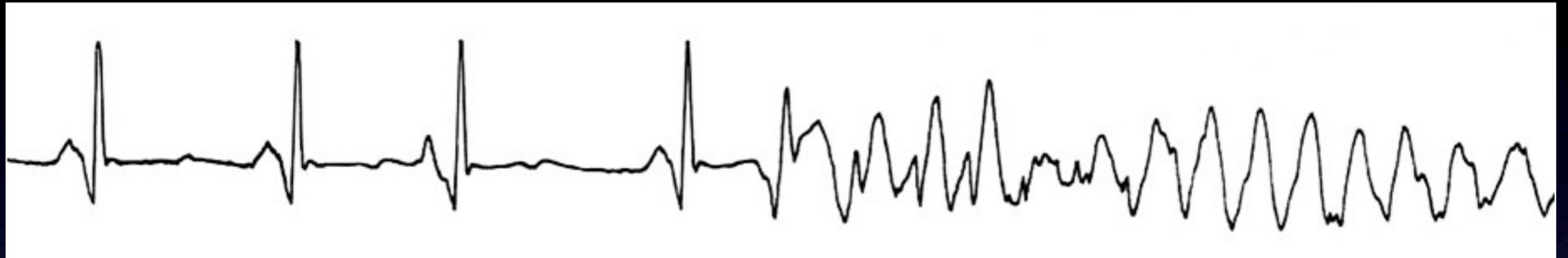
Normal Heart Beat

Fibrillation



Normal Heart Beat

Fibrillation

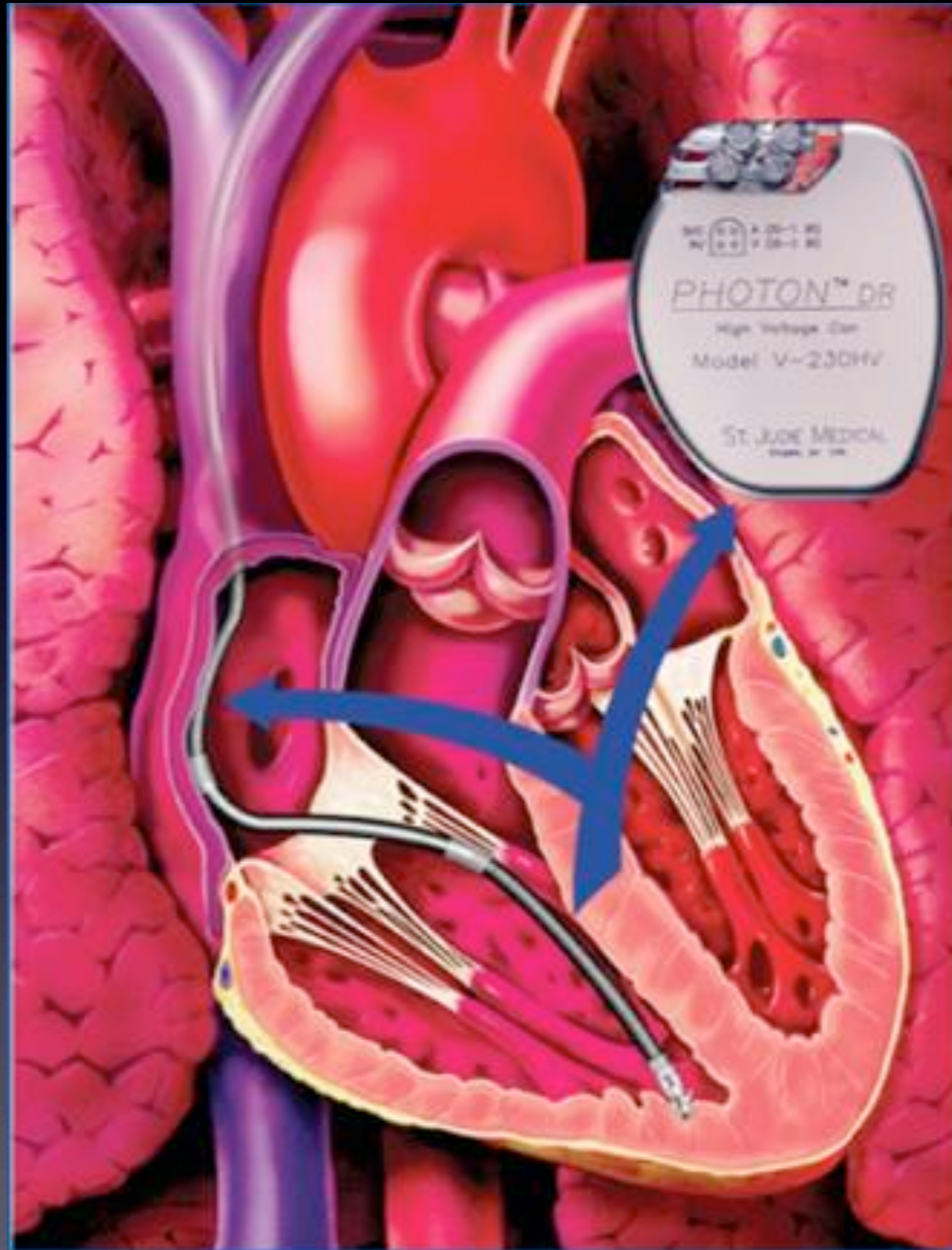


Fibrillation

Electric Shock

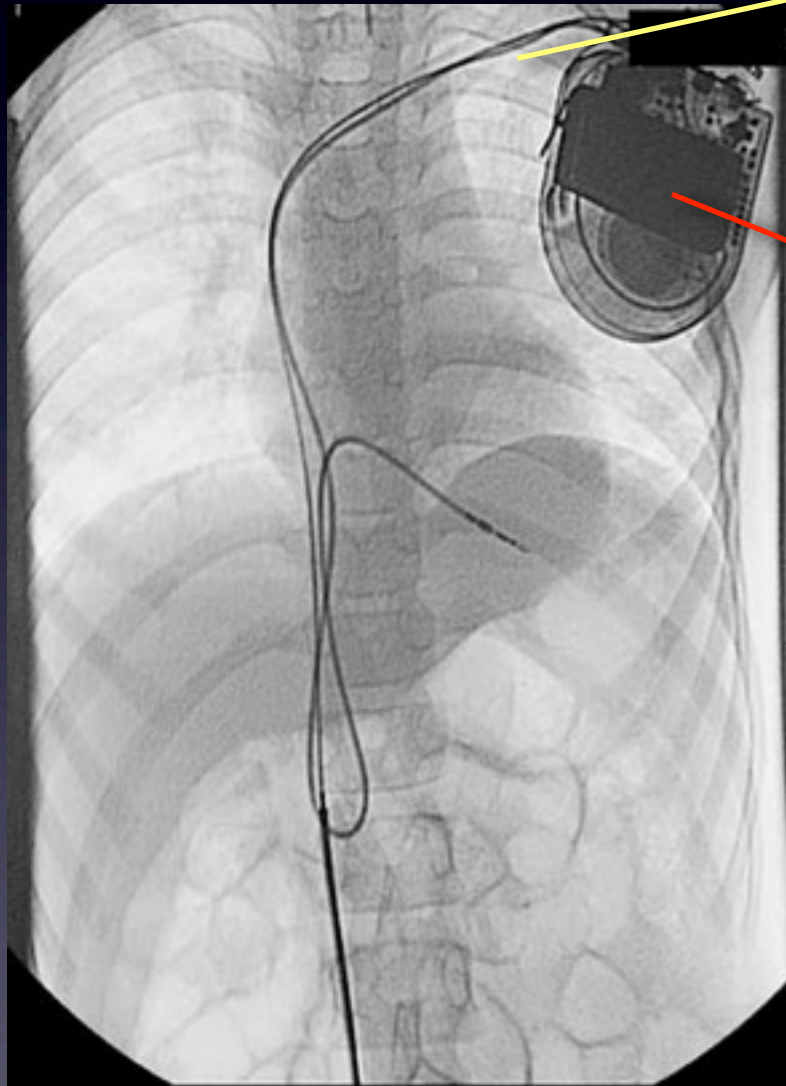
Normal Heart Beat



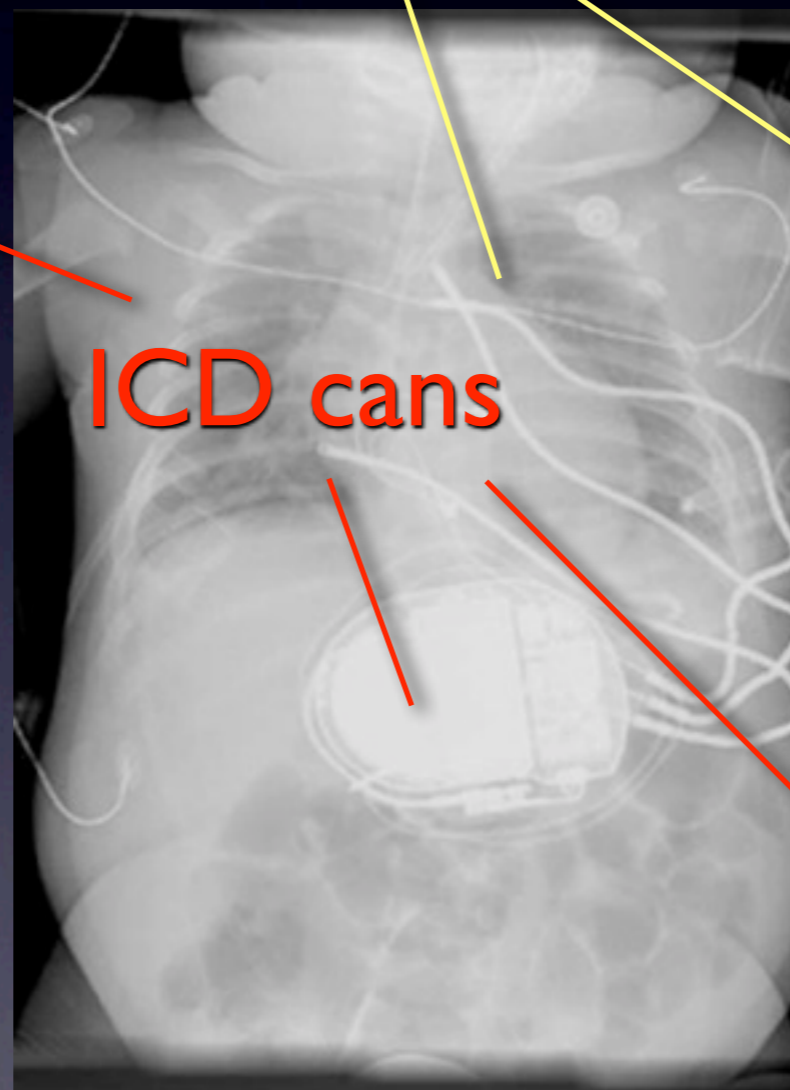


Defibrillators in Pediatric Patients

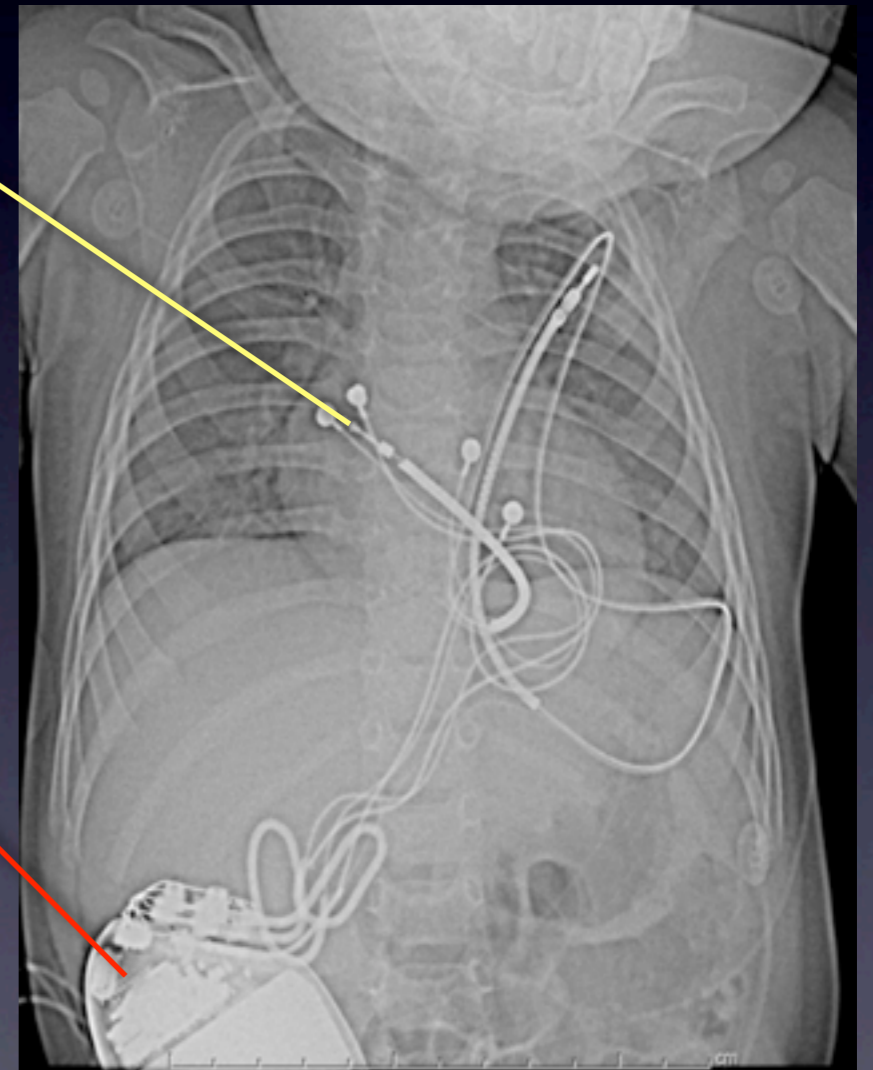
ICD leads



Gasparini, JCE, 2005



Stephenson, JCE, 2006



Children's Hospital Boston

Something Doctors Need



Simulated Solution to Defibrillation

Information underlying cardiac disease

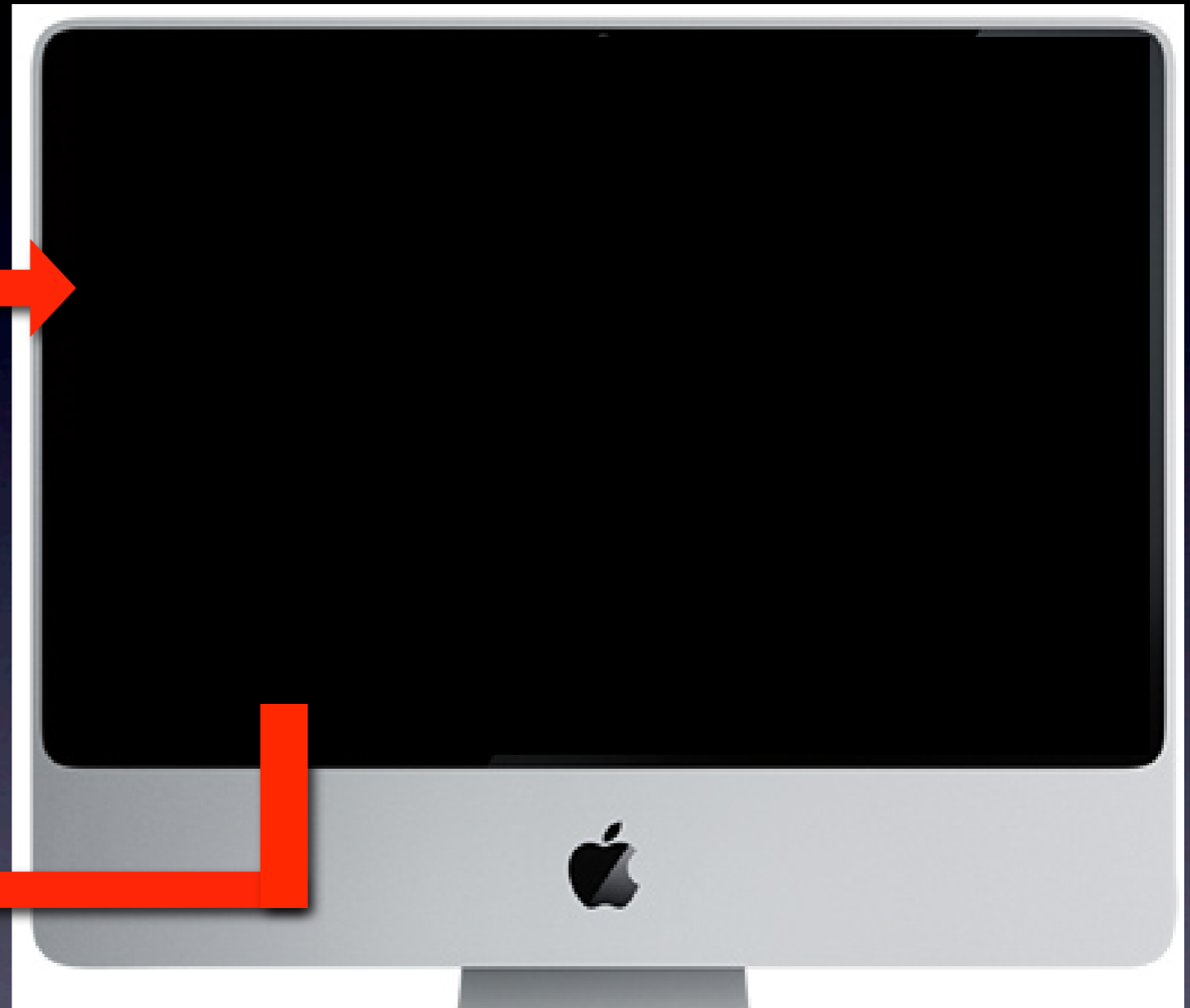
Patient specific anatomy

Existing implanted leads

Accessible locations

Patient growth

Predicted Defibrillation thresholds and lead locations



Simulated Solution to Defibrillation

Information underlying cardiac disease

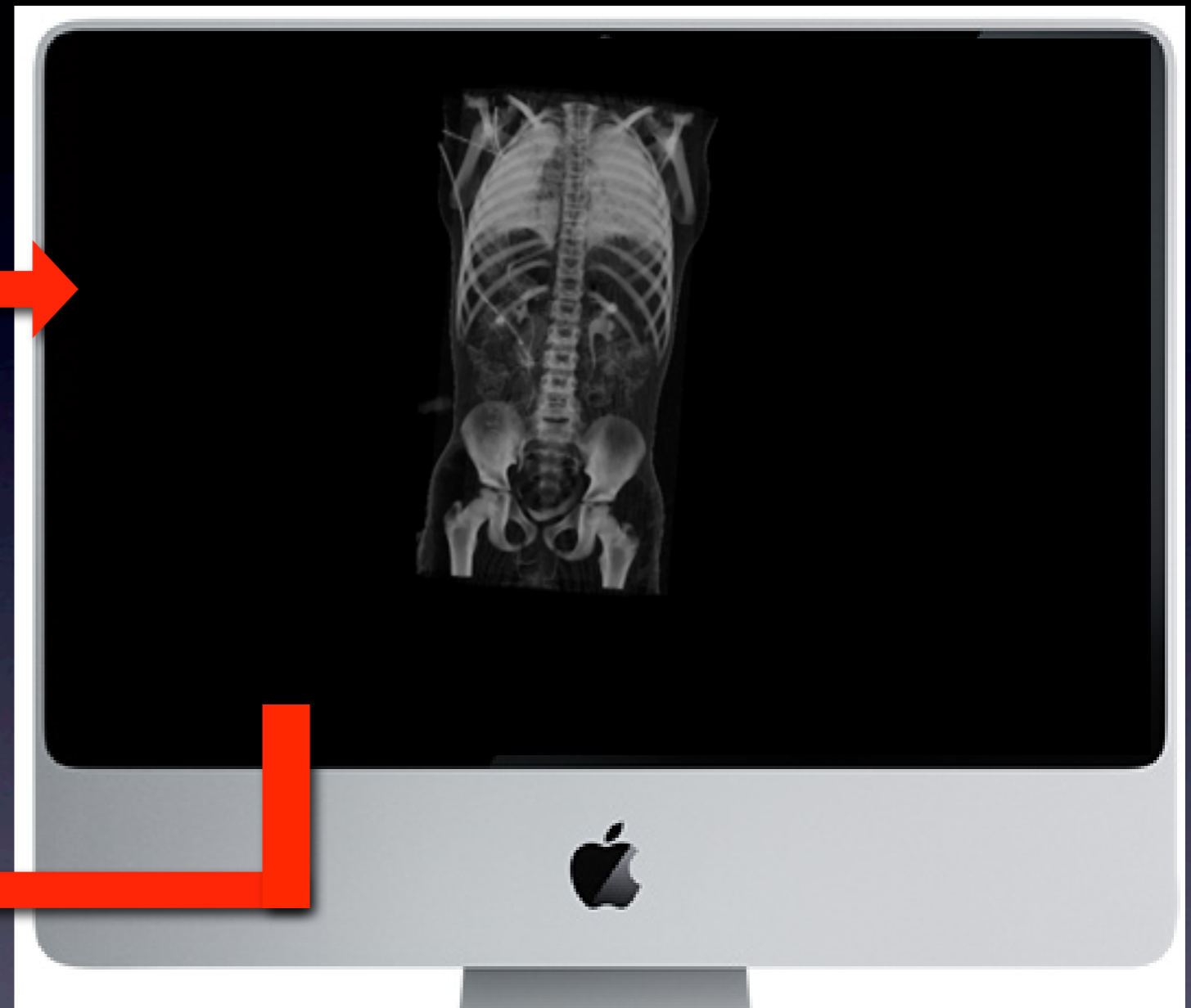
Patient specific anatomy

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Accessible locations

Patient growth

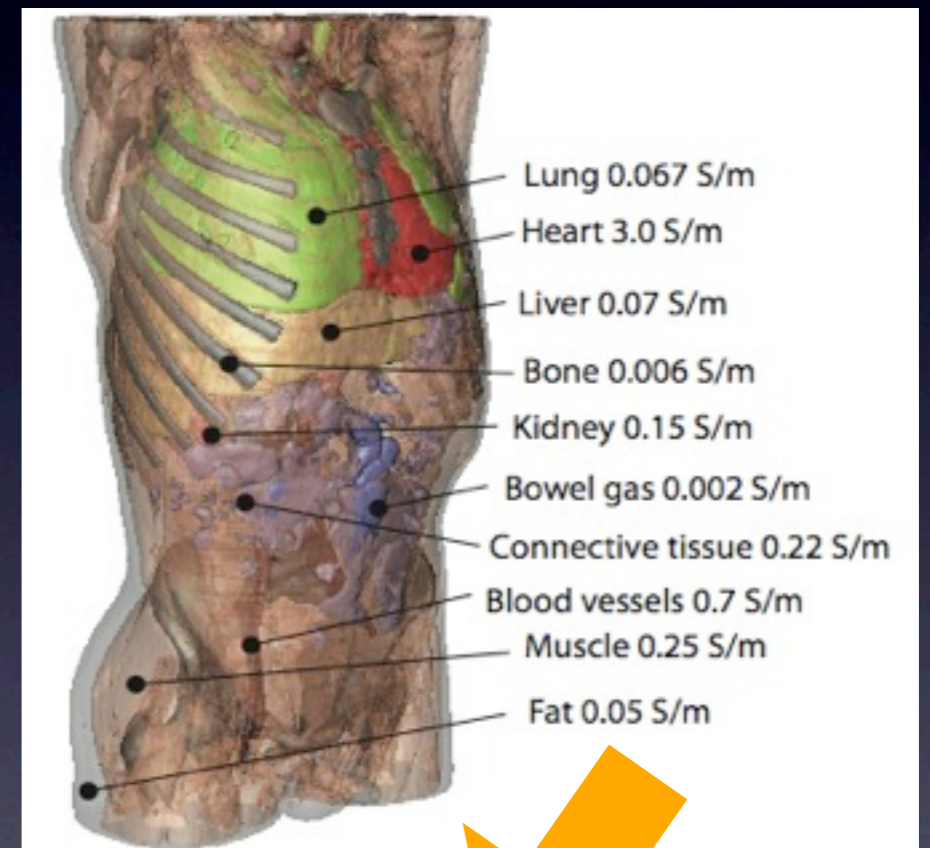
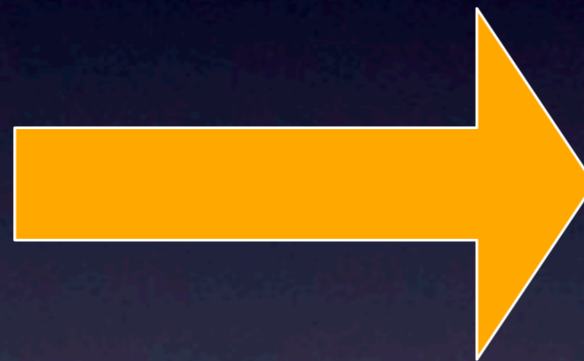
Predicted Defibrillation thresholds and lead locations



Our Pipeline: Segmentation

CT/MRI images

Geometric models of human torsos



Generated with
our Seg3D software



Database of torso models

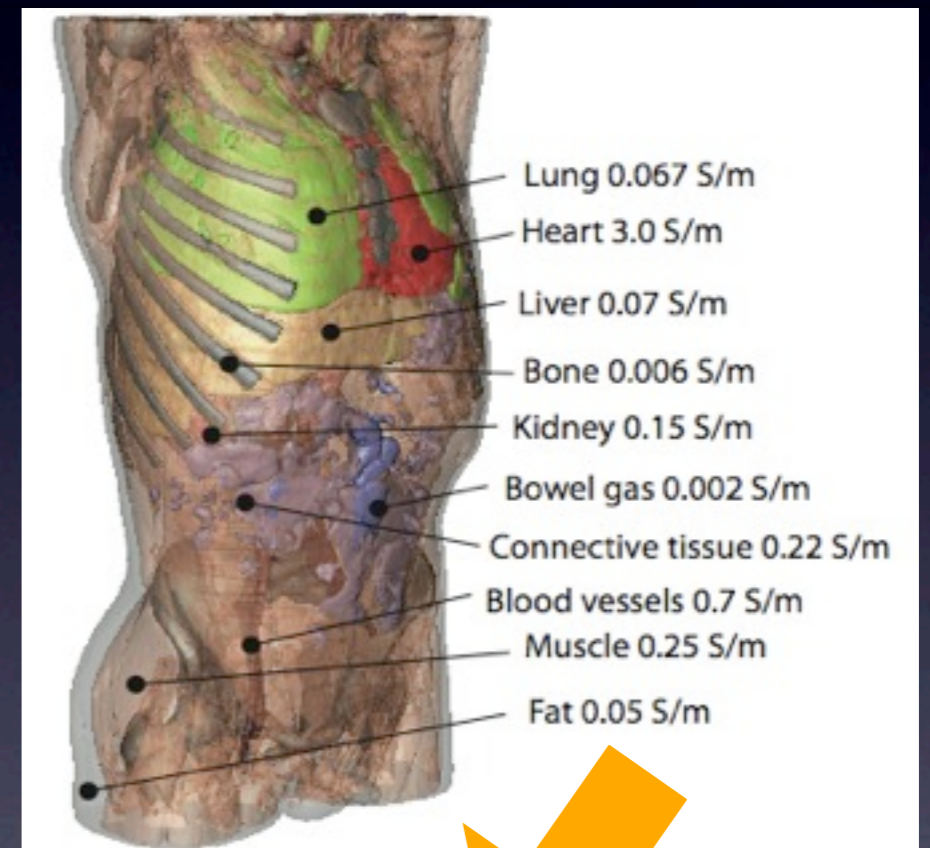
Our Pipeline: Segmentation

CT/MRI images



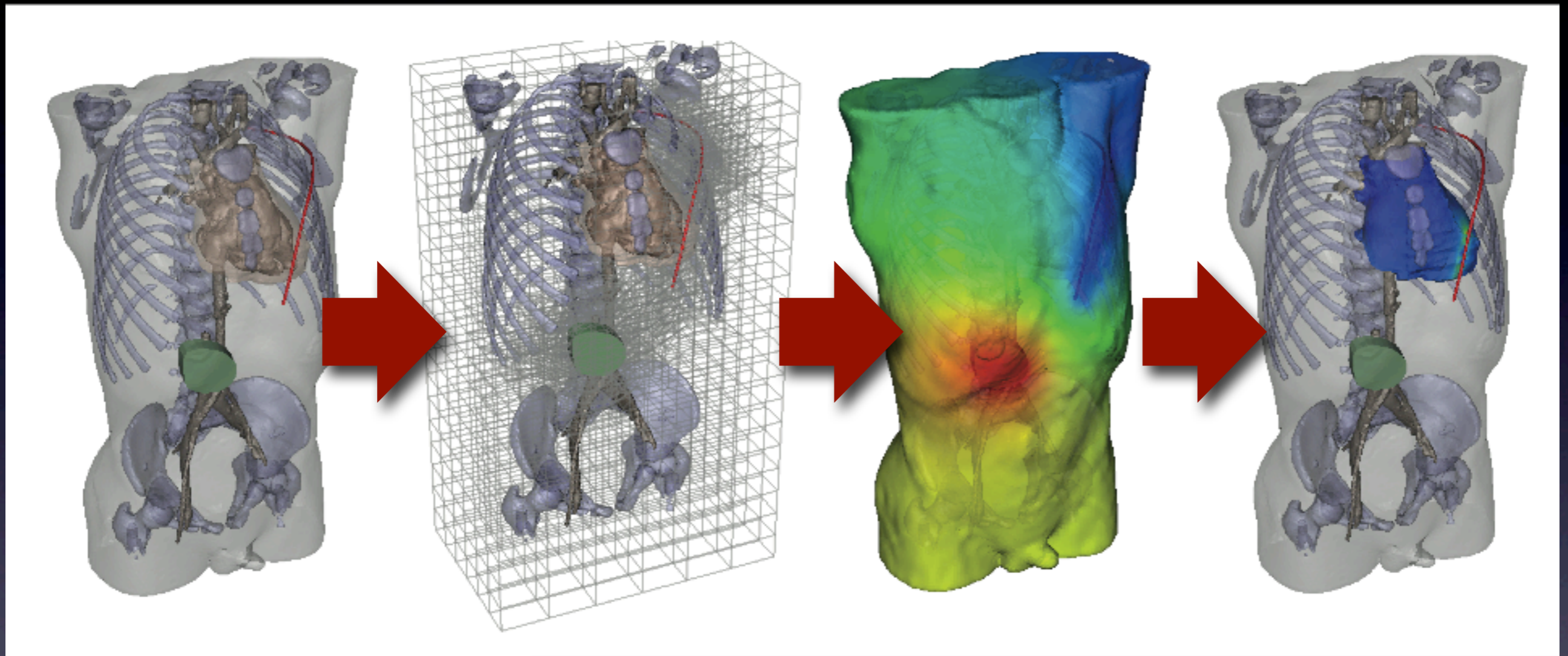
Generated with
our Seg3D software

Geometric models of
human torsos



Database of torso models

Our Pipeline: Model Generation



Place electrode leads

Build hex/tet mesh

Solve potentials using FEM

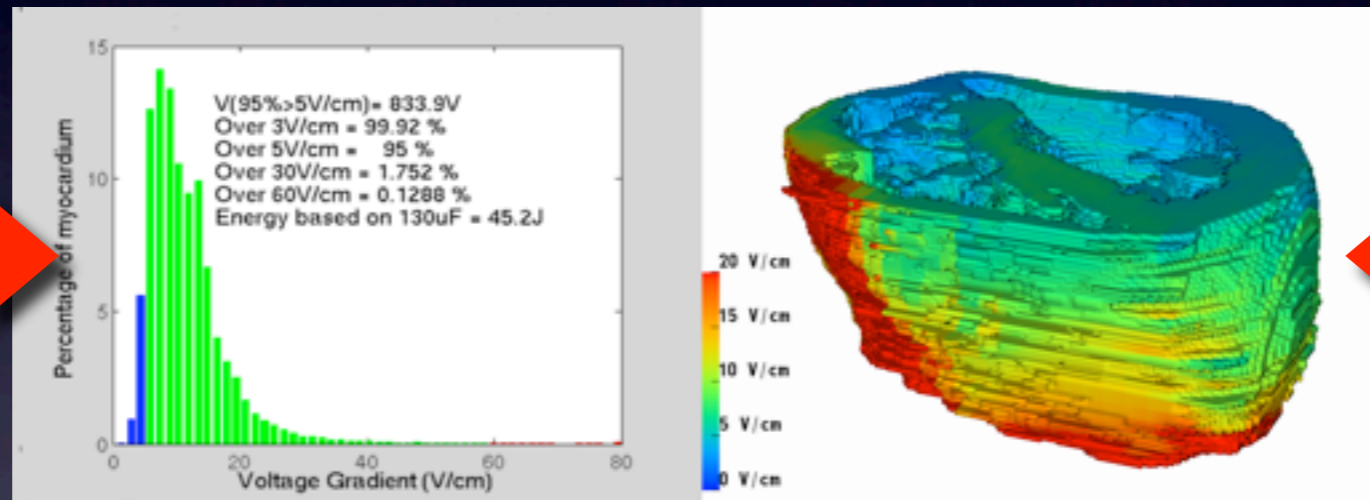
Evaluate electric field strength

Performed with SCIRun

Our Pipeline: Evaluate DFT

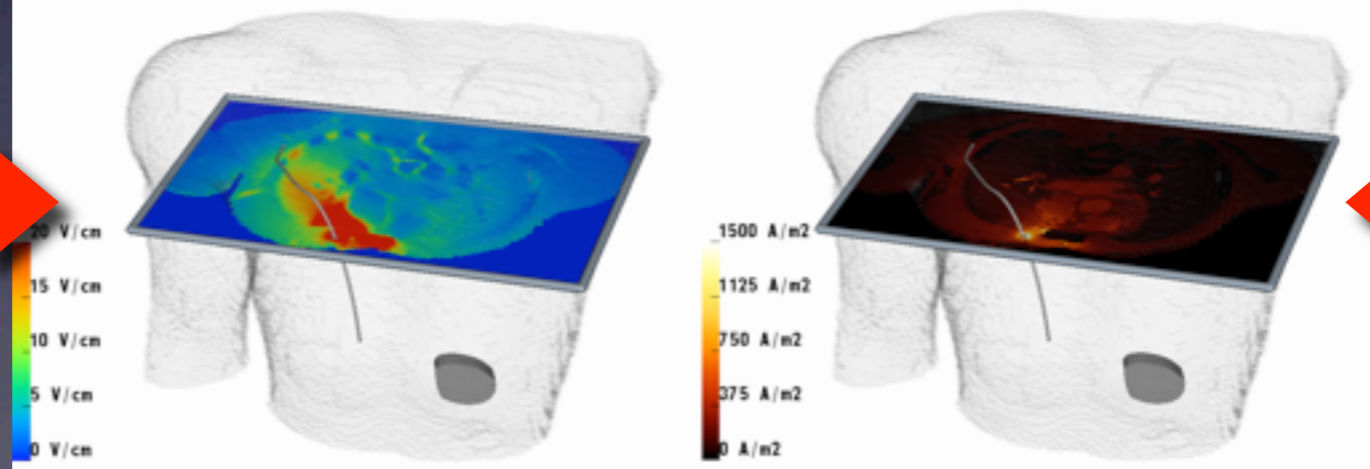
Critical mass hypothesis: > 95 % of the ventricular myocardium electric field 5 V/cm considered effective

Histogram
field strength



Electric field
within the heart

Electric field



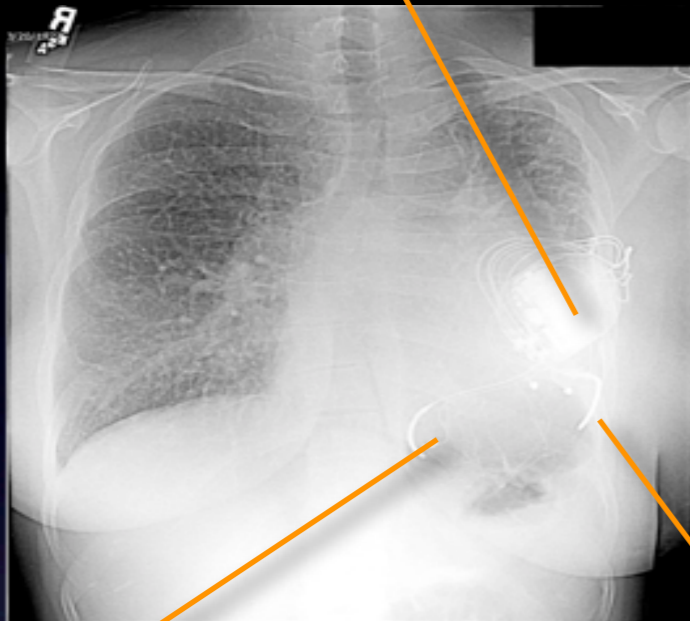
Current
density

Some Validation



Multiple lead configuration

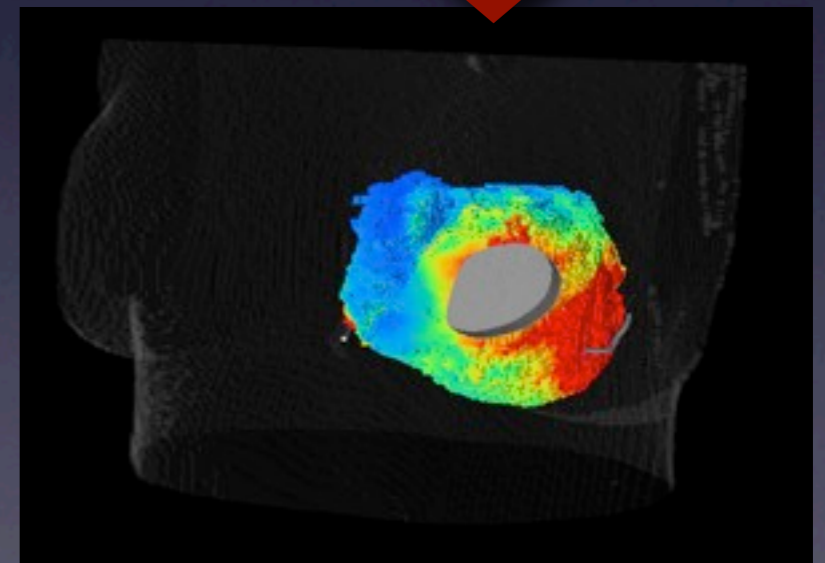
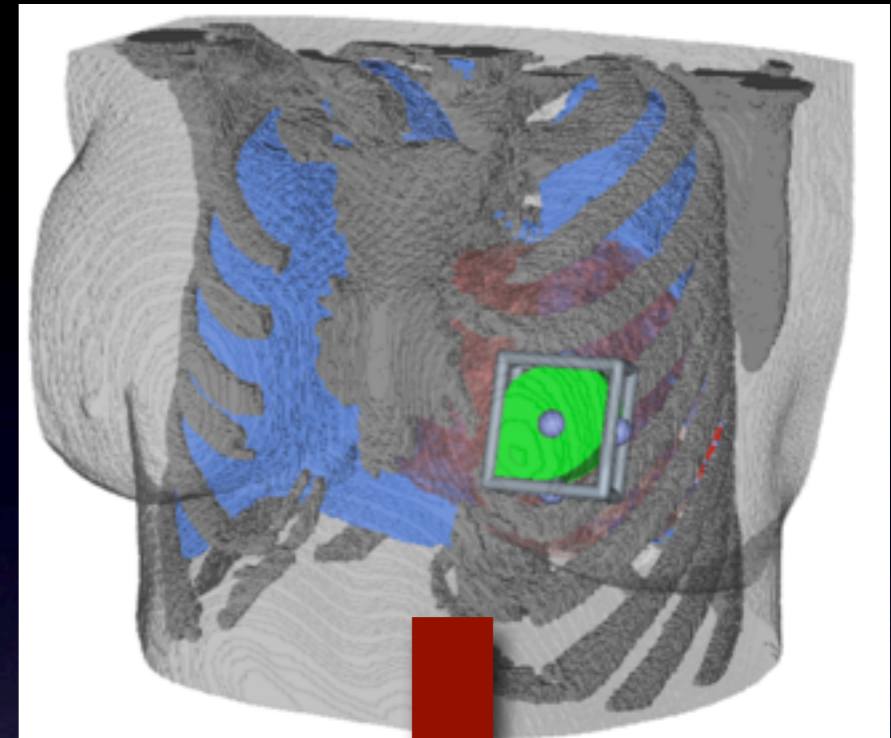
ICD can



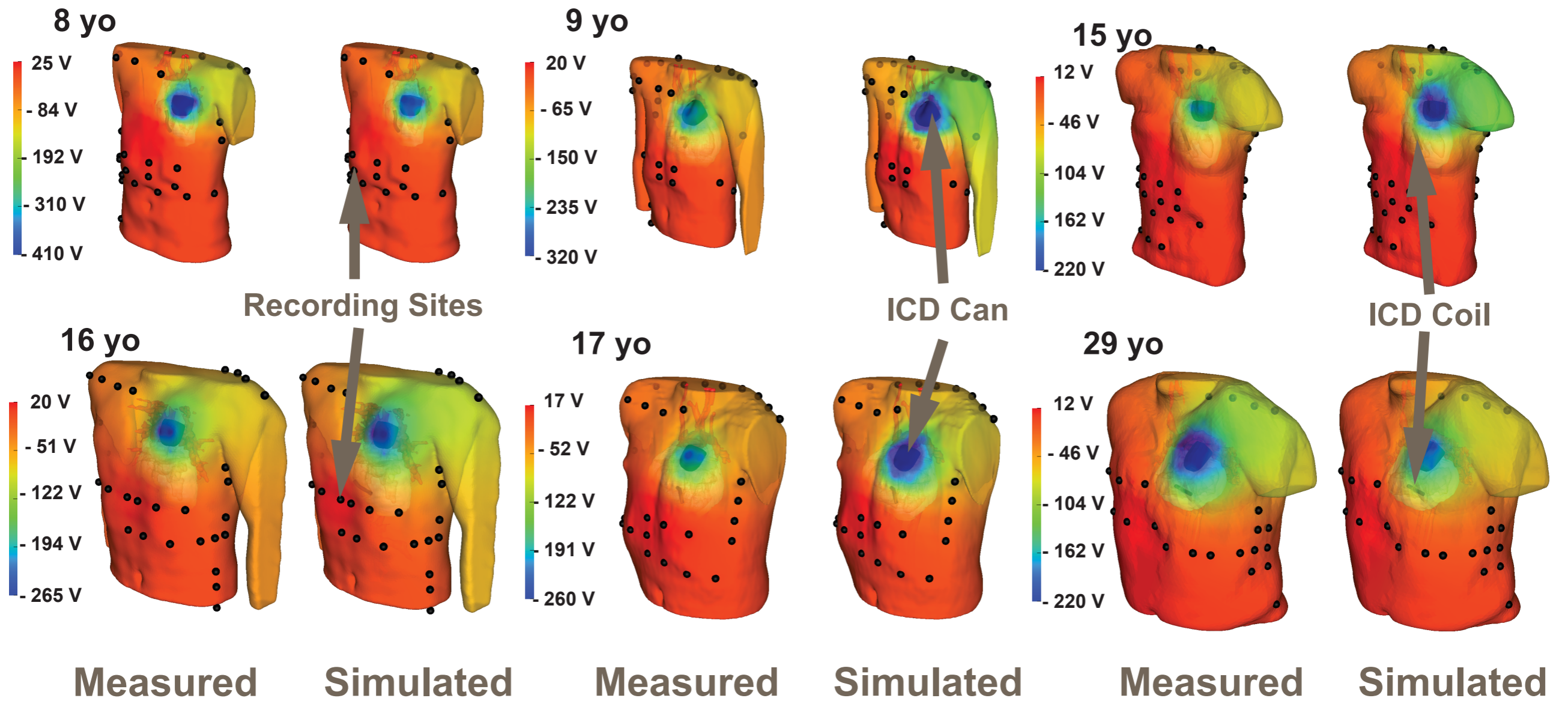
right lead

left lead

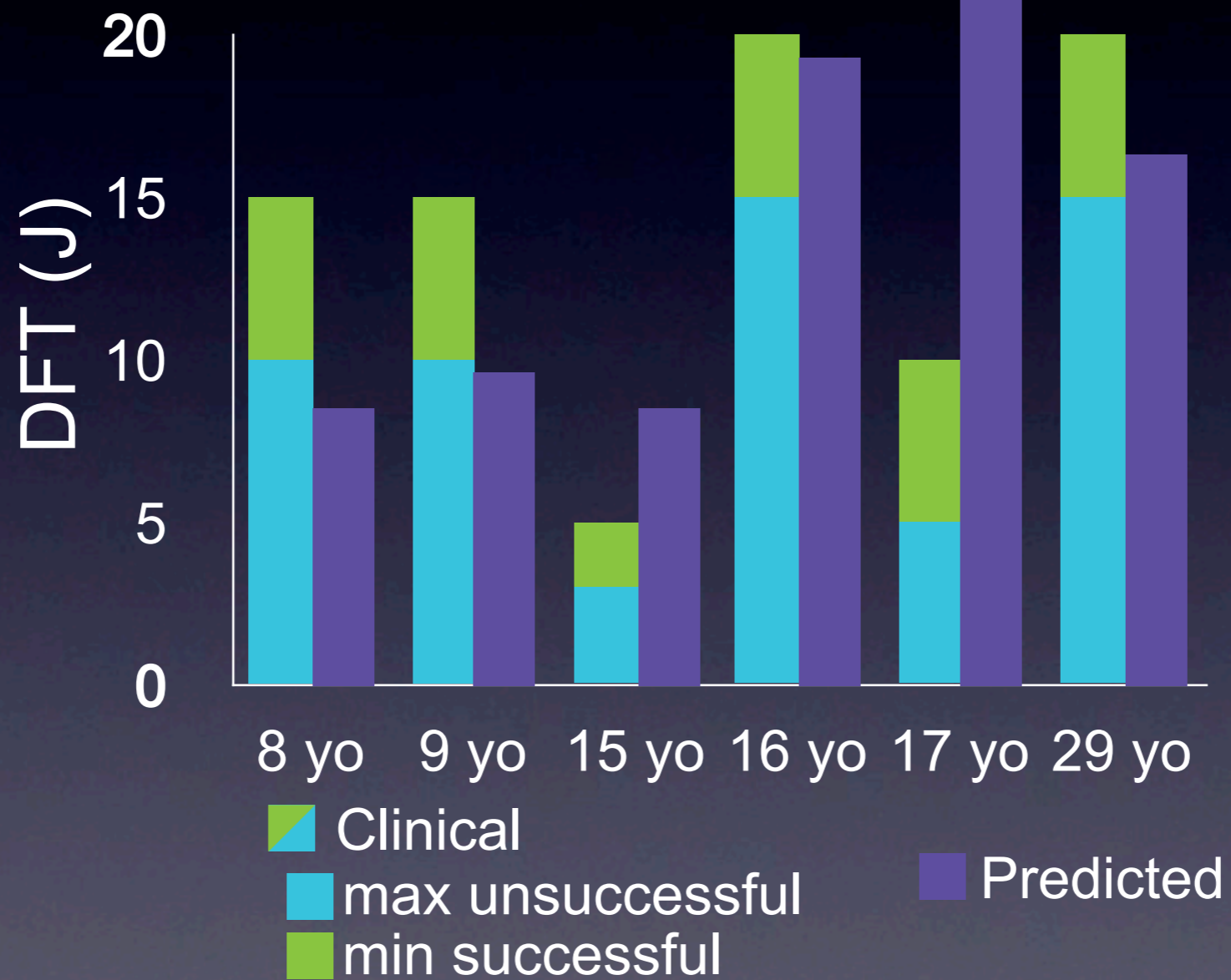
Model create from CT-scan



Polarity of leads	Predicted DFT (J)	Clinical DFT(J)
Can + right lead → left lead	66.2	Not Tested
Can → left lead + right lead	118.9	Not Tested
Can + left lead → right lead	24.0	20
Inactive Can: left lead → right	47.5	> 35



DFT Comparisons

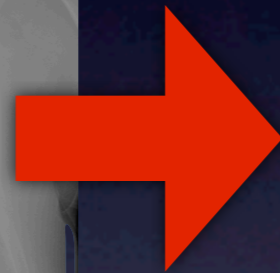
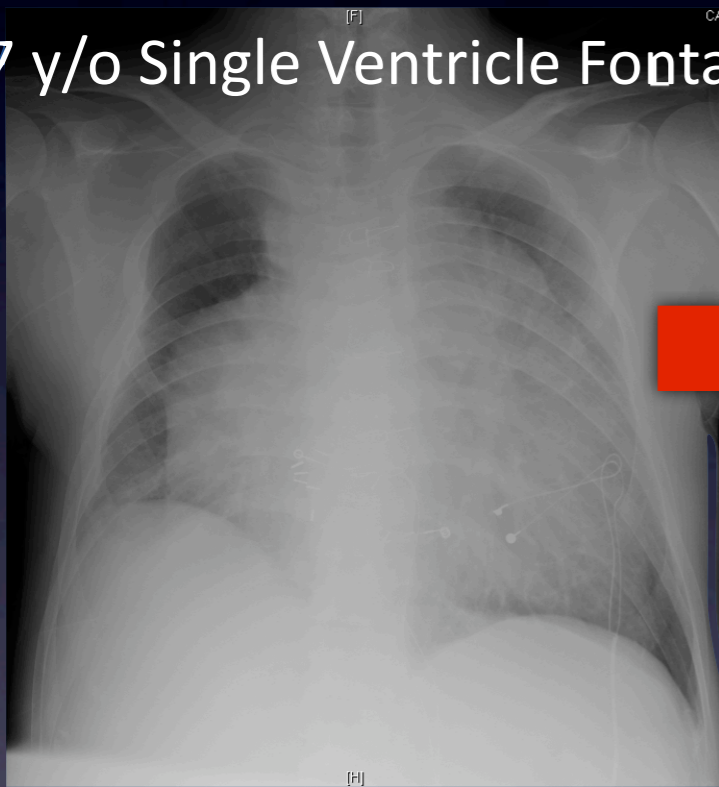


Some Applications



Patient Specific ICD Treatment

27 y/o Single Ventricle Fontan



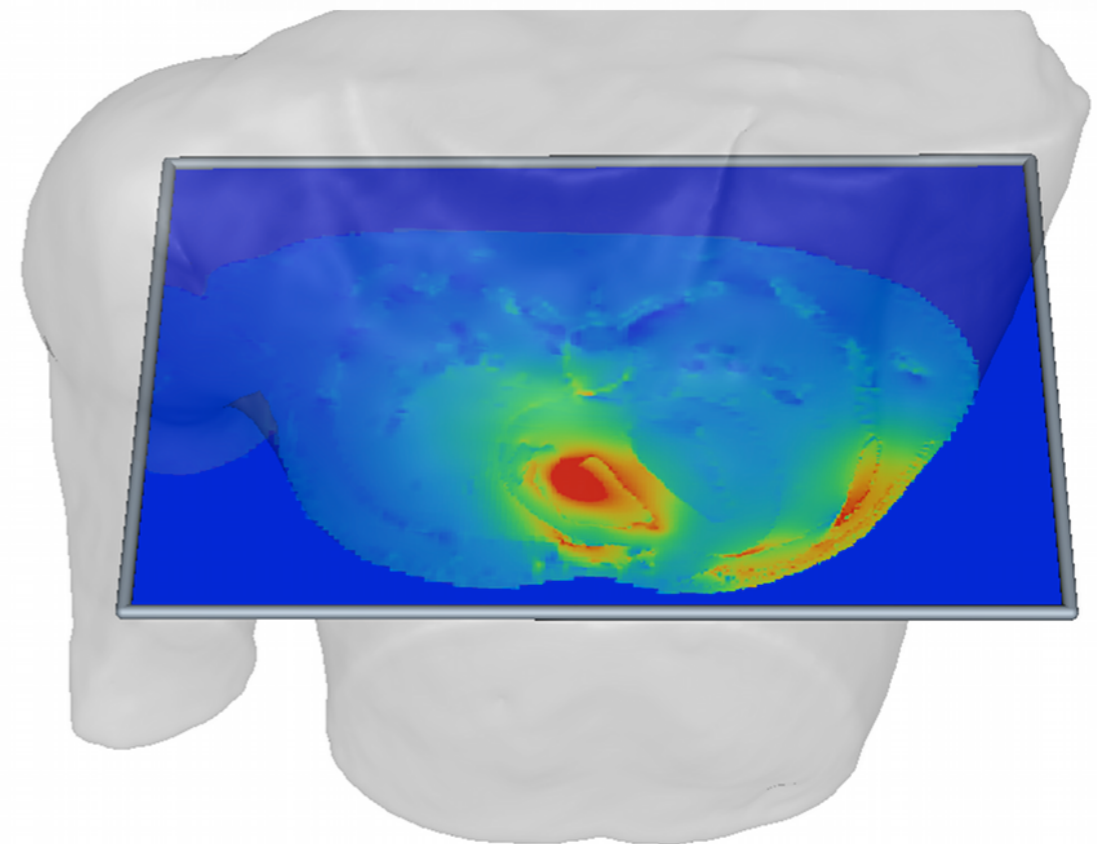
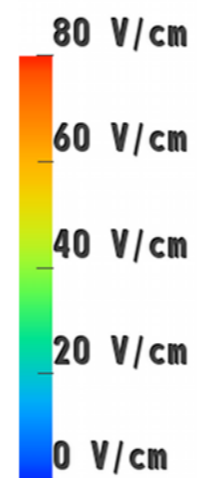
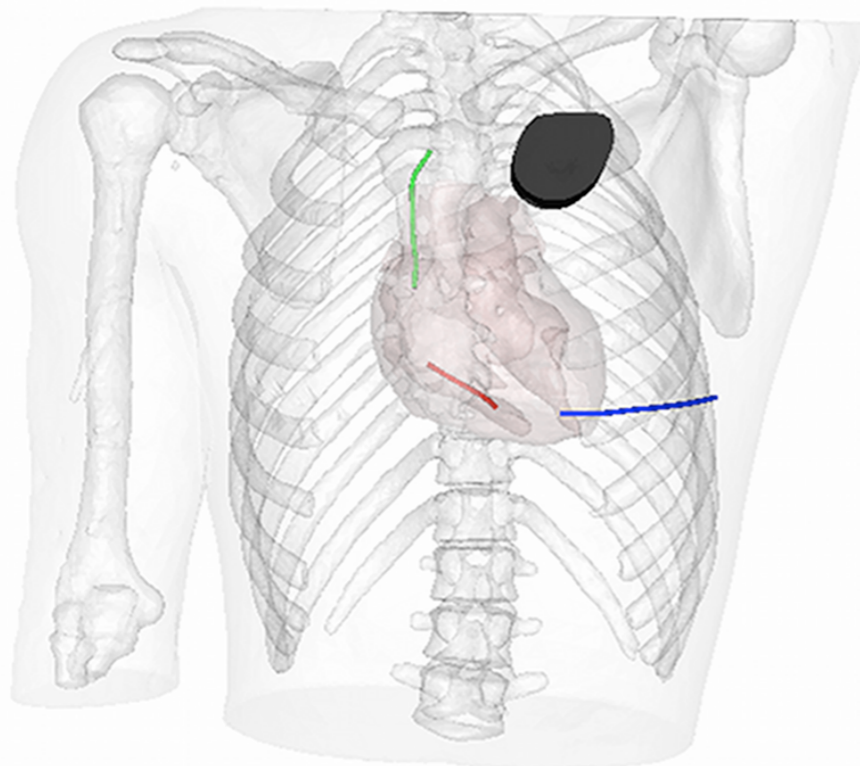
Simulation
Pipeline



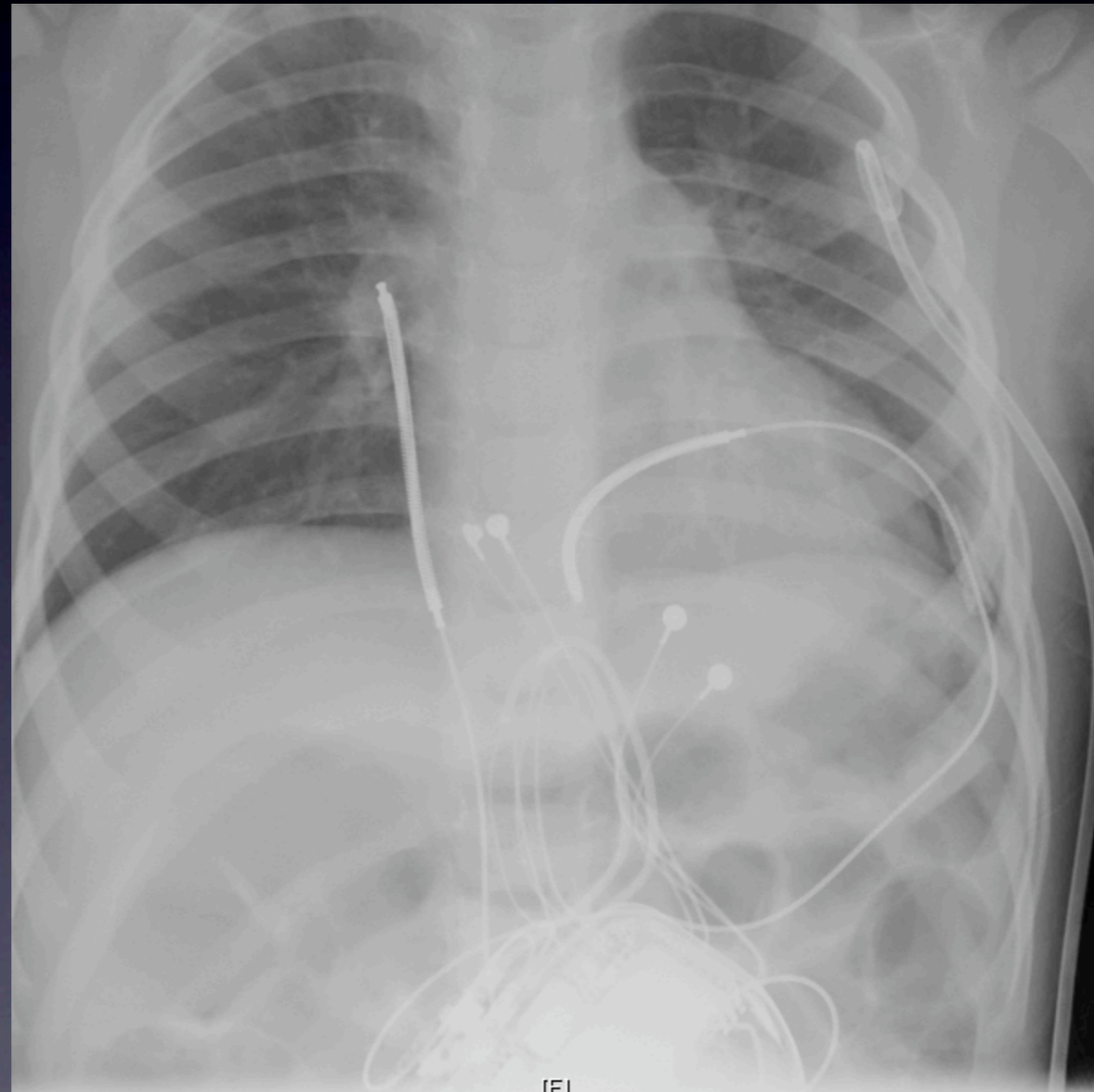
Placement with
Minimal DFT

Subcutaneous Electrode Placements

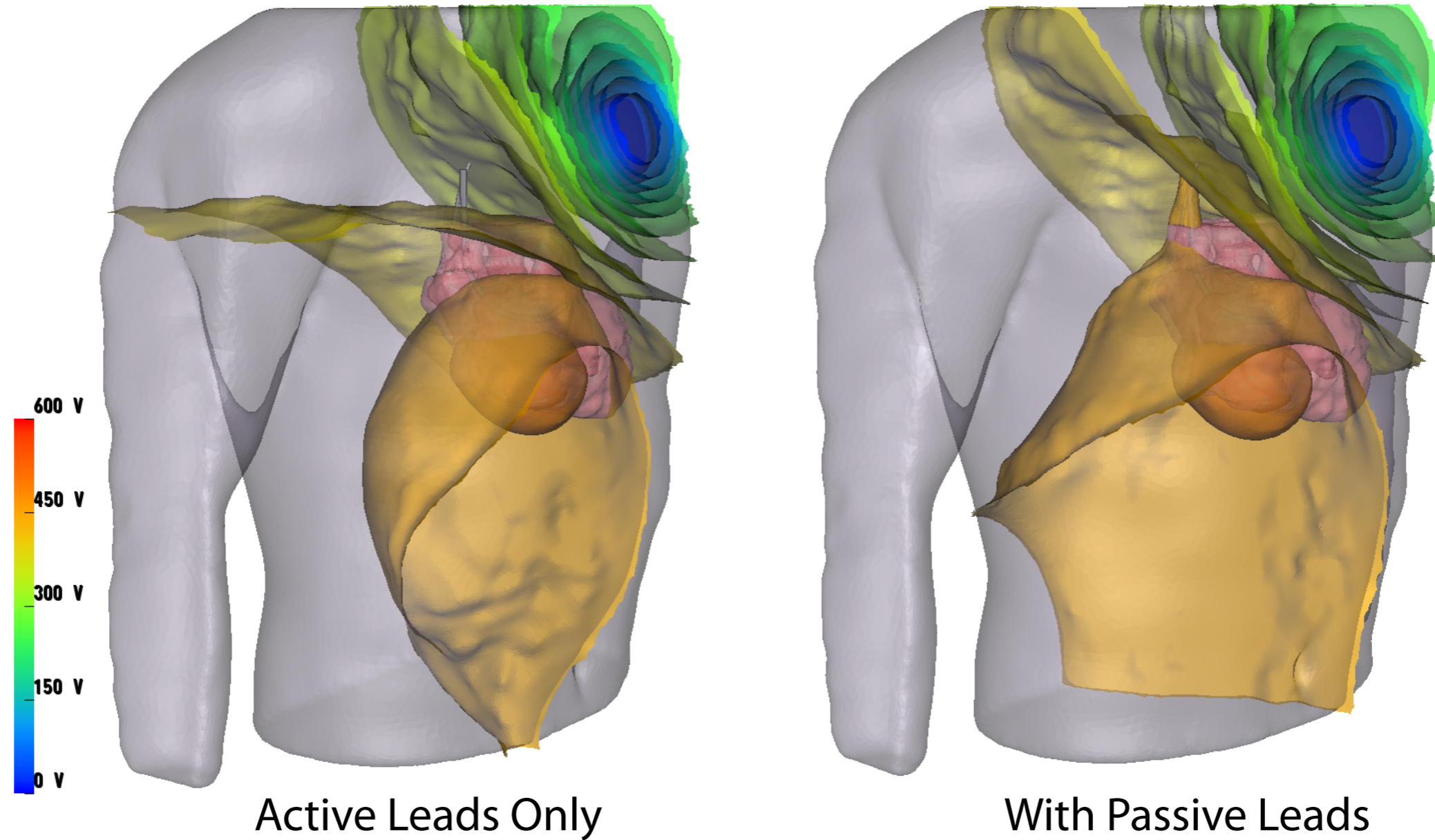
Electrode Placement



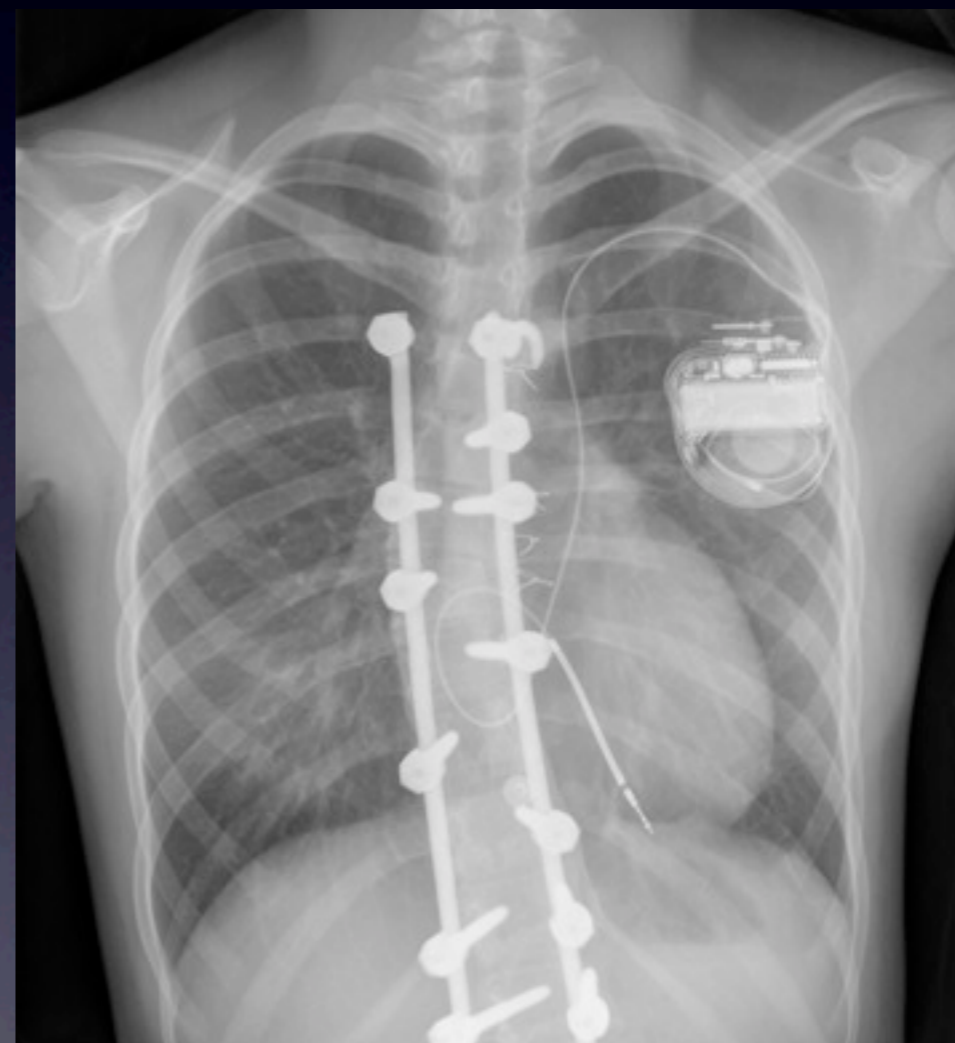
Effects of Abandoned Leads



Effects of Abandoned Leads

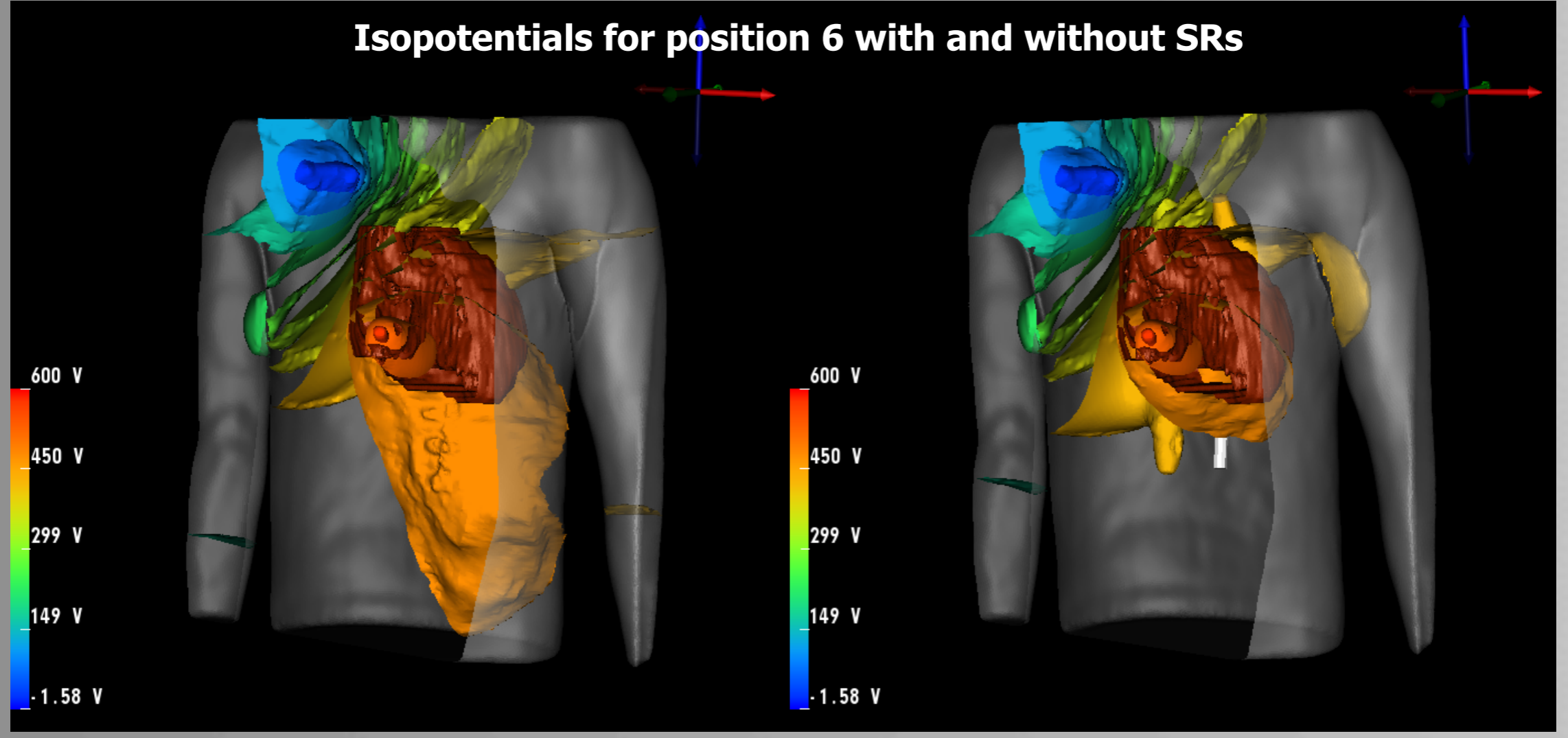


Effects of Spinal Rods



Effects of Spinal Rods

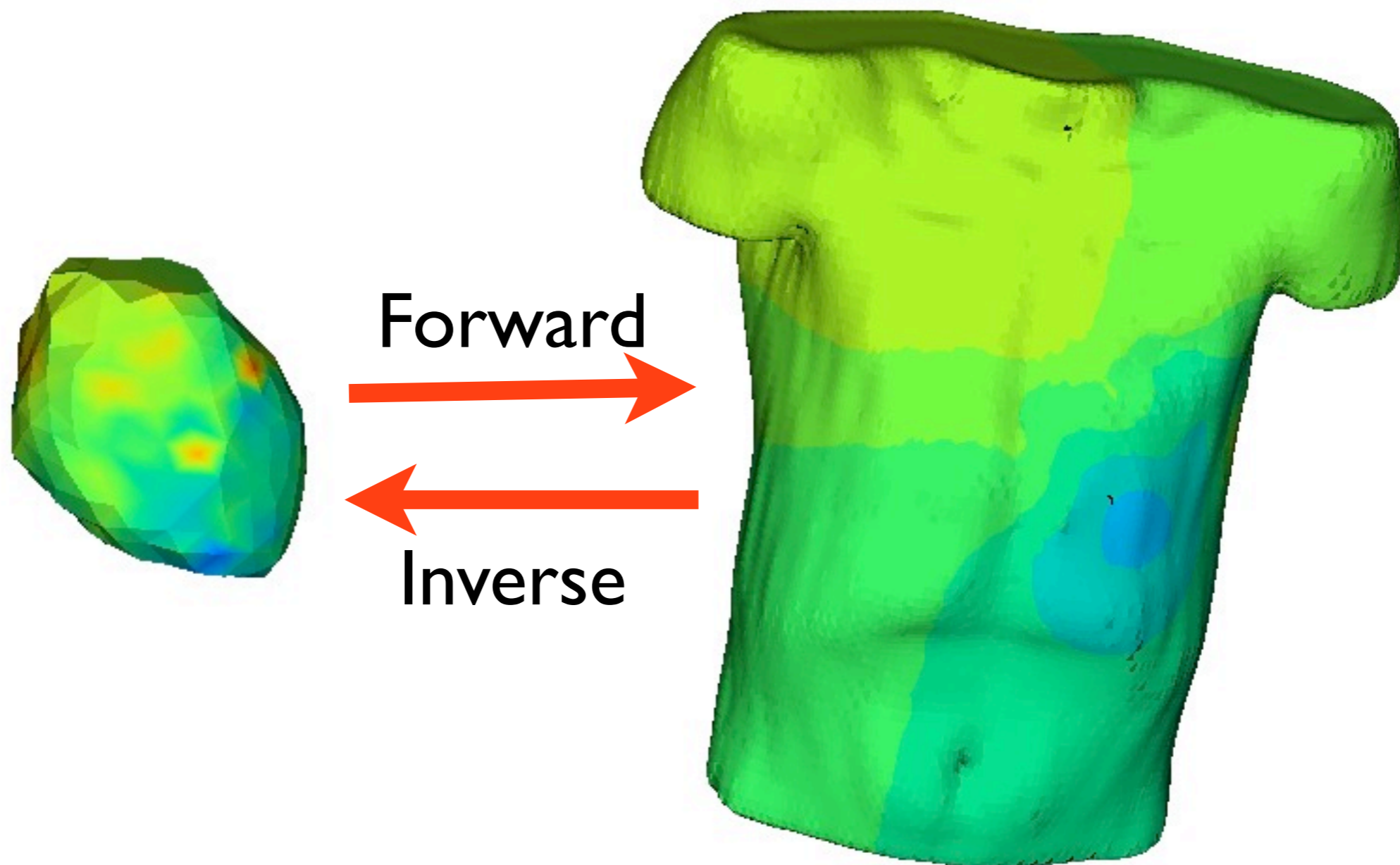
Isopotentials for position 6 with and without SRs



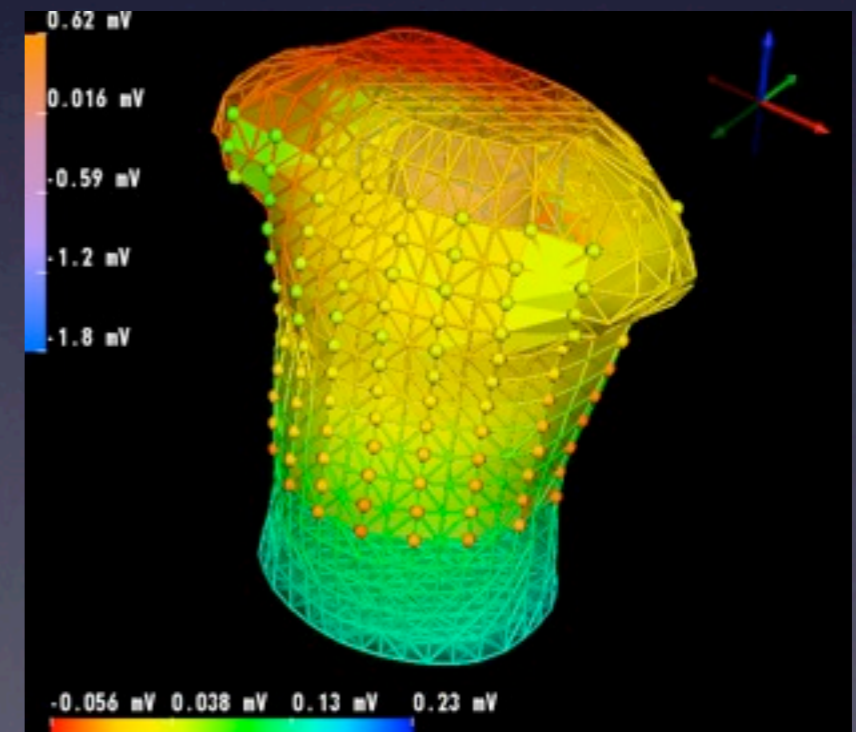
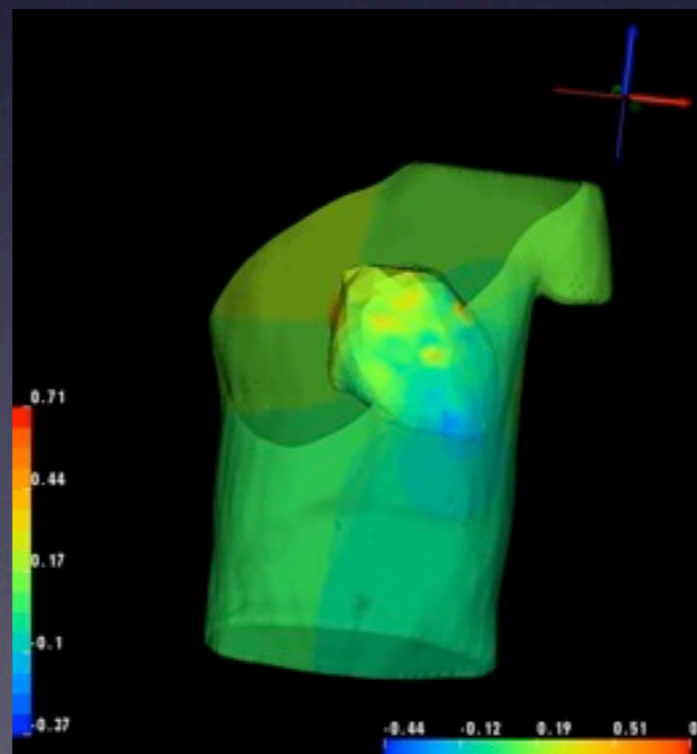
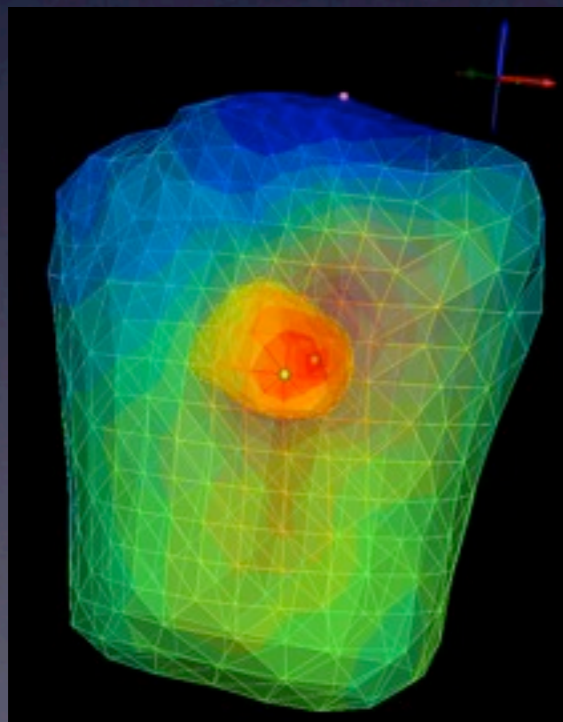
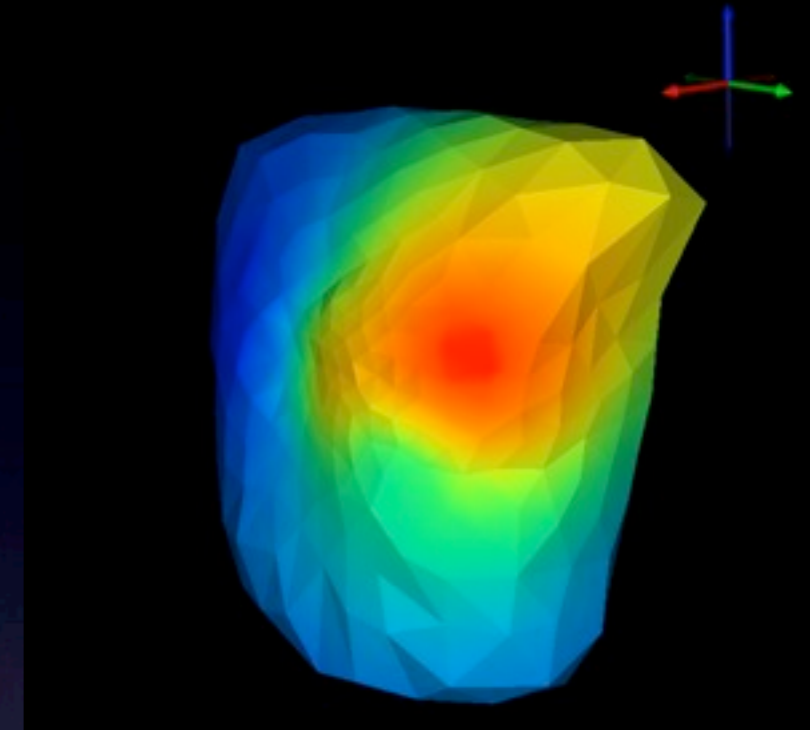
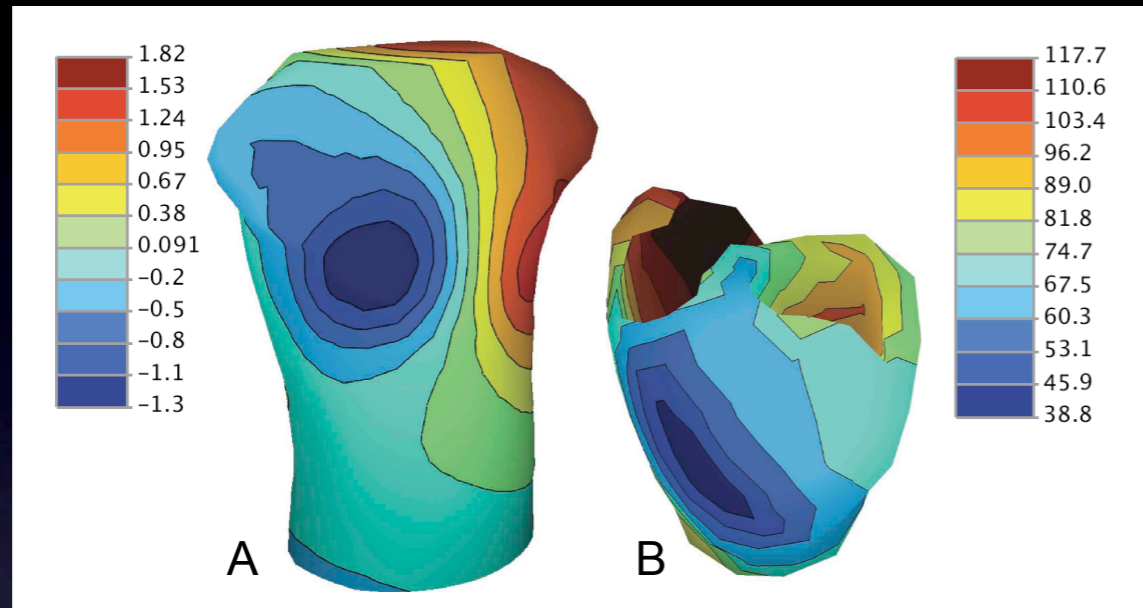
Something New

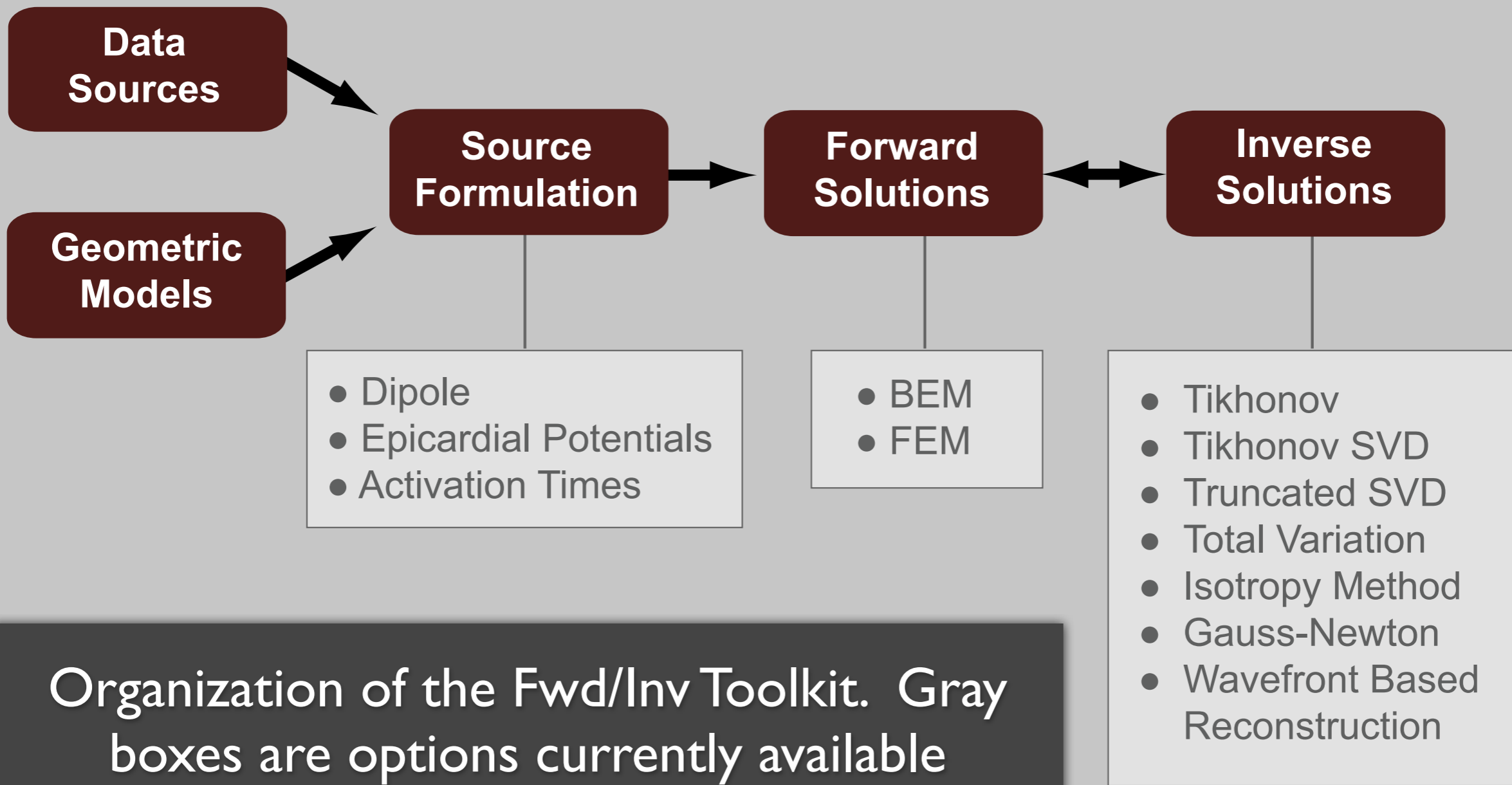


Forward Inverse Problems



Fwd/Inv Toolkit





Organization of the Fwd/Inv Toolkit. Gray boxes are options currently available

Some Demos

