

Verification of a Defibrillation Simulation Using Internal Electric Fields in a Human Shaped Phantom

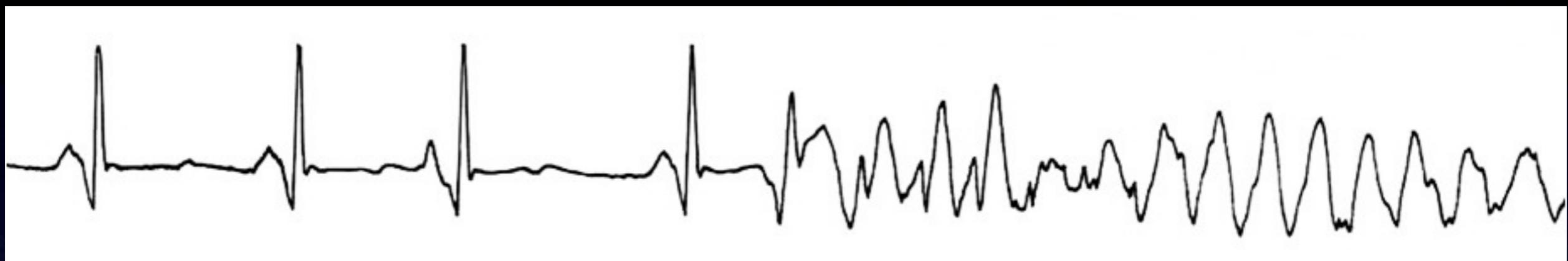
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Division of Pediatric Cardiology, University of Utah



Fibrillation

Normal Heart Beat



Fibrillation

Fibrillation

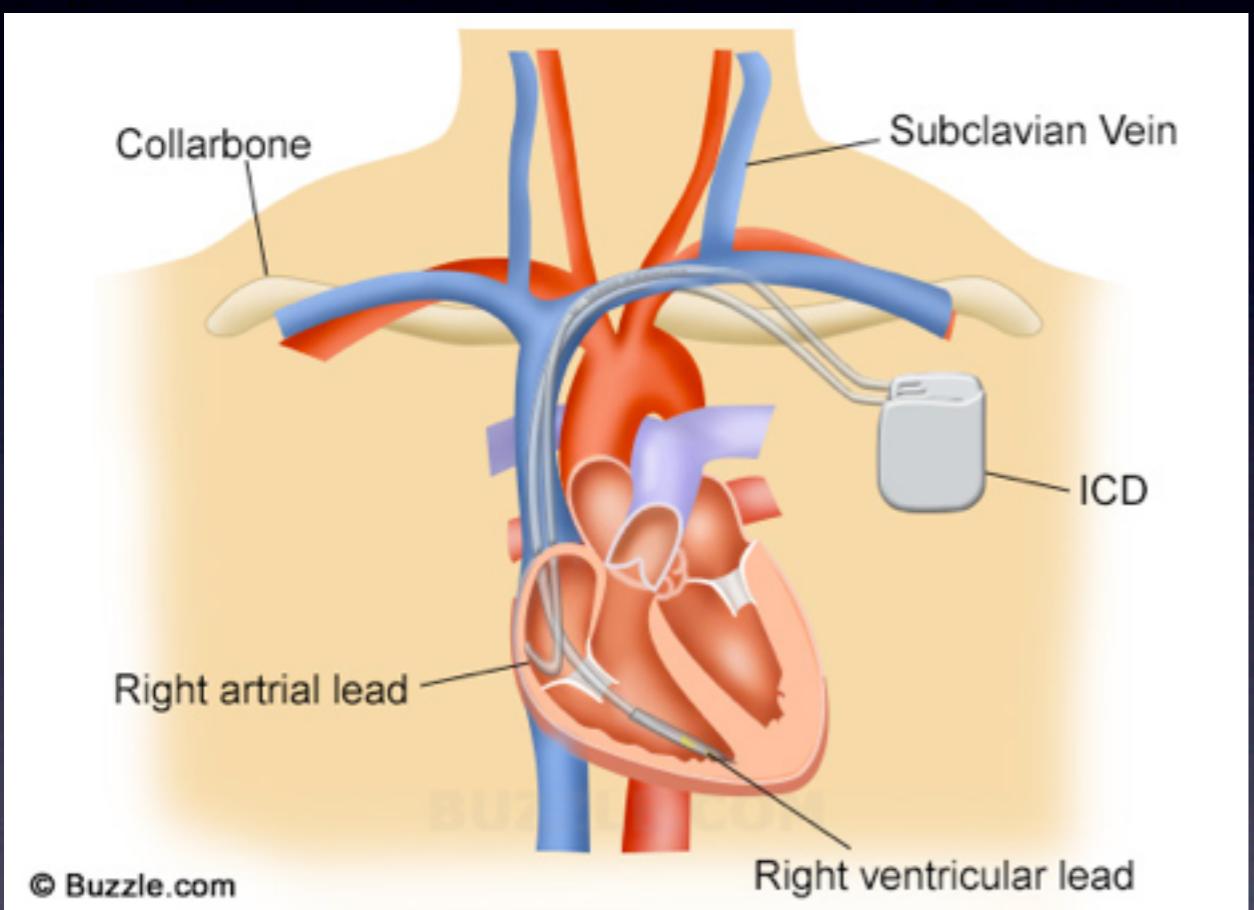
Electric Shock

Normal Heart Beat



Defibrillation

Implantable Cardioverter Defibrillator- ICD



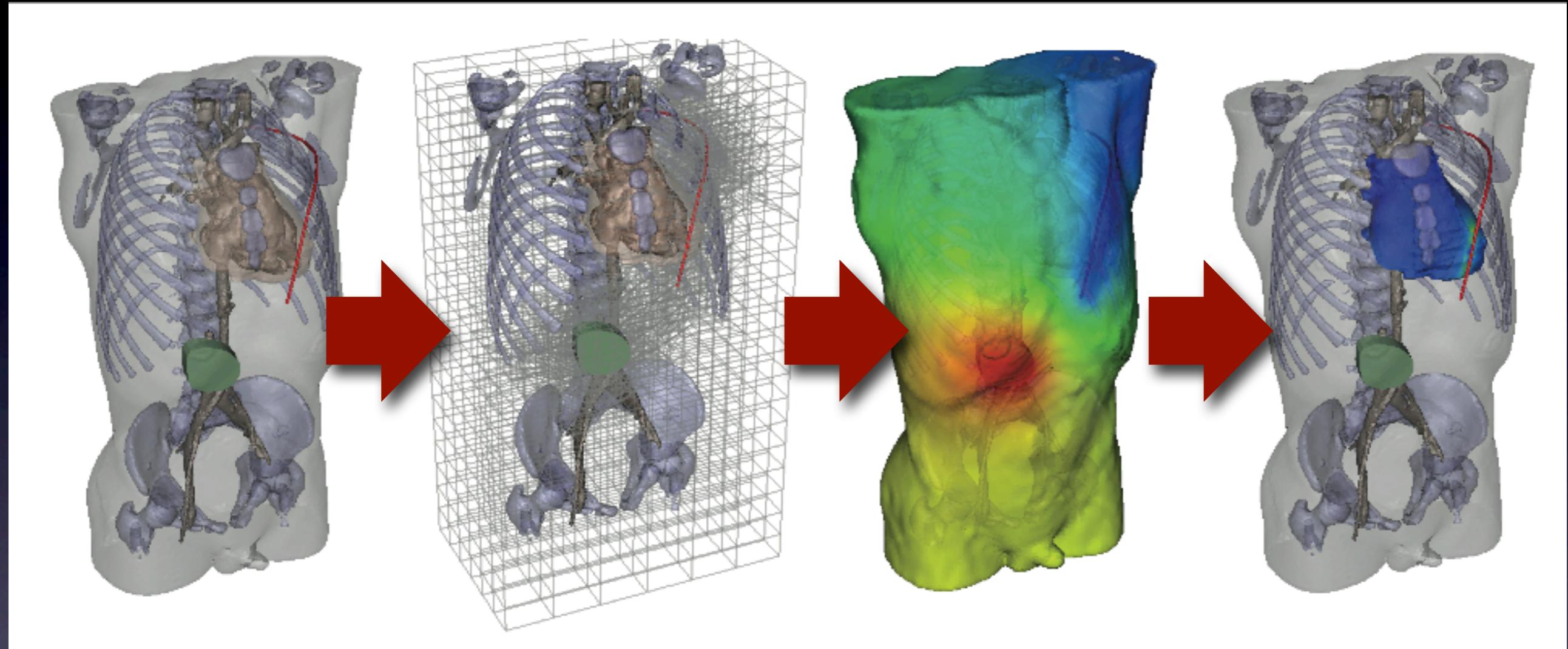
<http://www.buzzle.com/>

Automatic External Defibrillator- AED



<http://www.wtamu.edu/>

Our Pipeline: Model Generation



Place electrode
leads

Build hex/tet
mesh

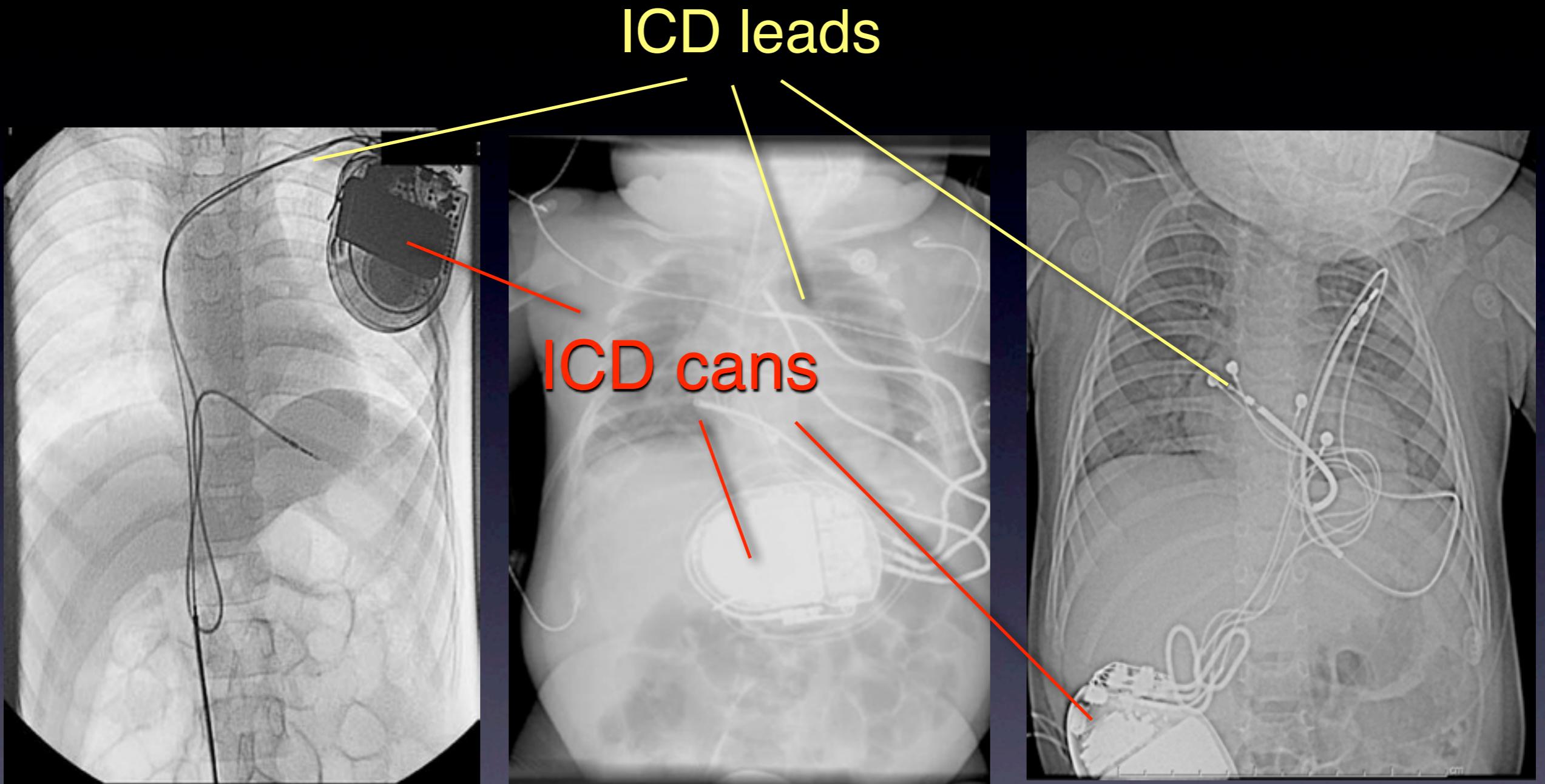
Solve potentials
using FEM

Evaluate electric
field strength

Performed with SCIRun



Pediatric Defibrillation



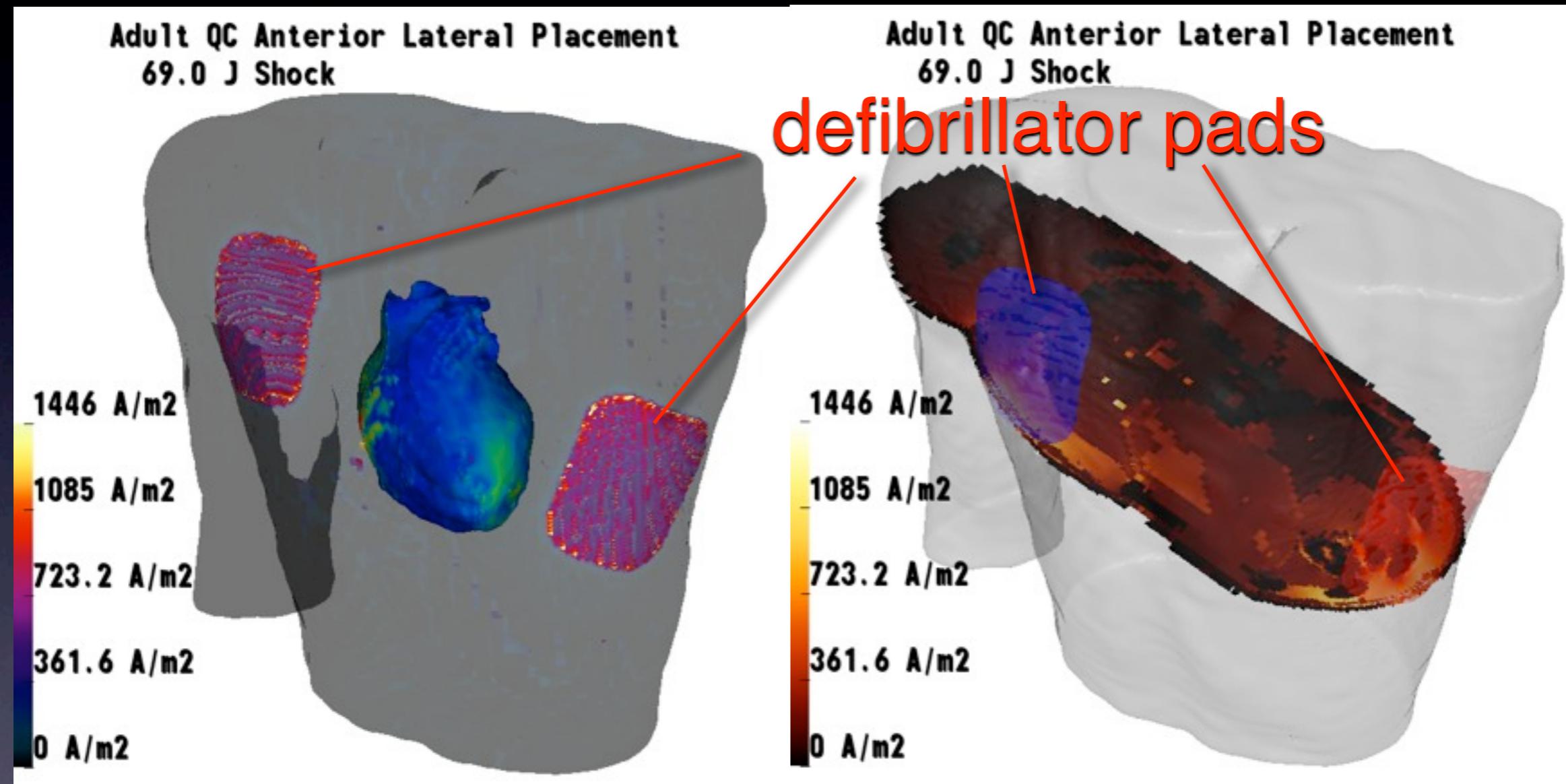
Gasparini, JCE, 2005

Stephenson, JCE, 2006

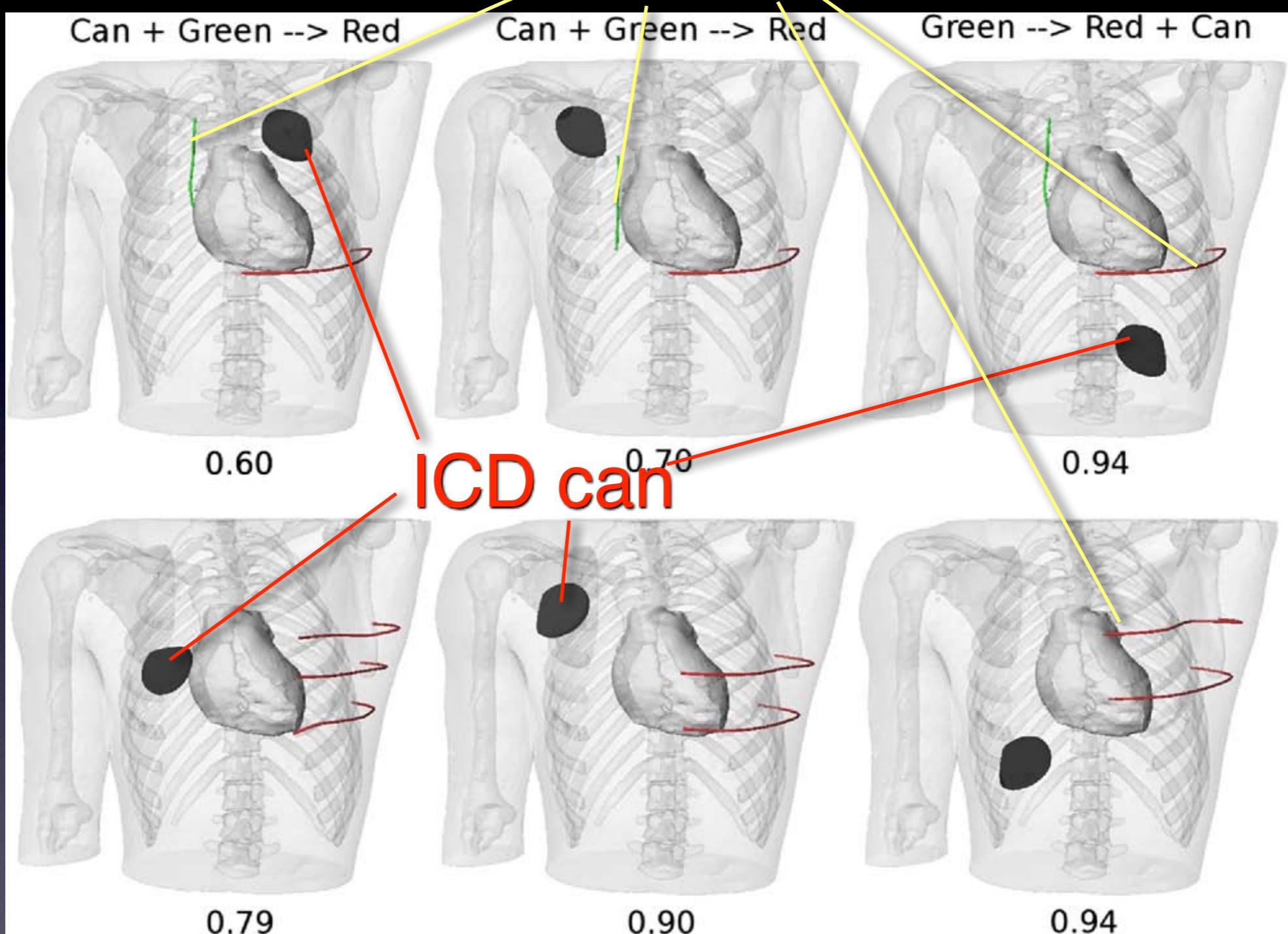
Children's Hospital Boston

Jolley M, et al. Heart Rhythm J 2008;5(4):565--572

External Defibrillation

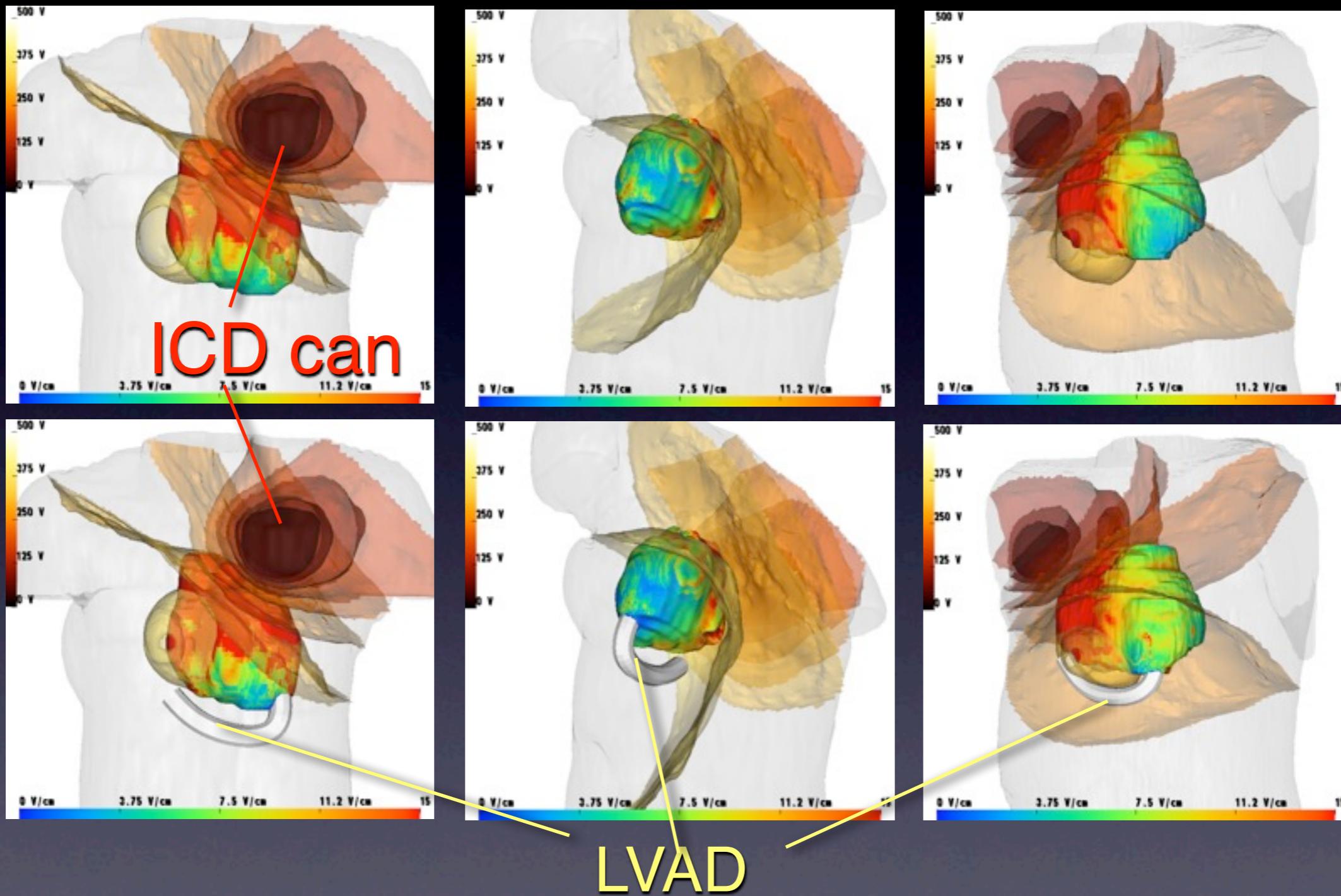


New ICD Configurations



Jolley M, et al. Heart Rhythm J May 2010;7(5):692–698

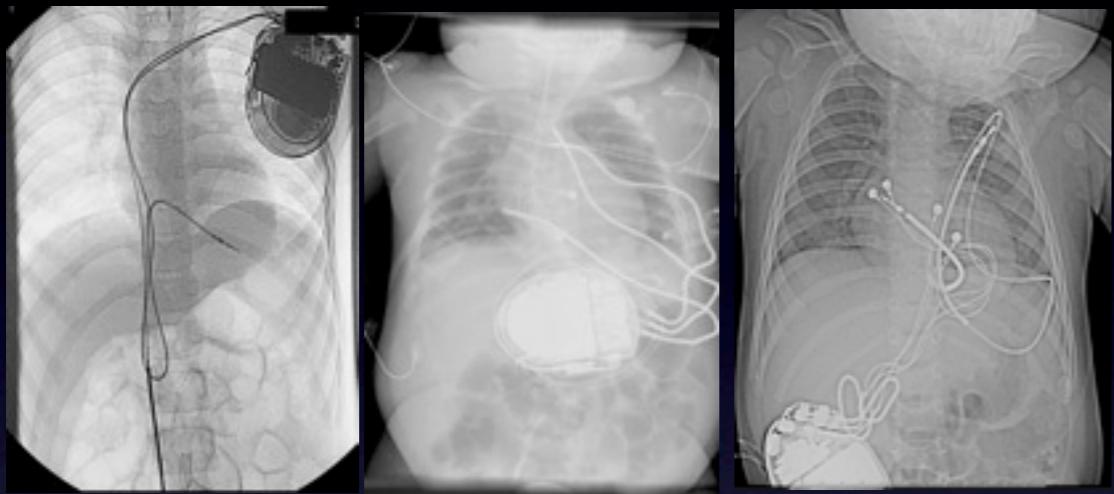
Stray Metal in Torso



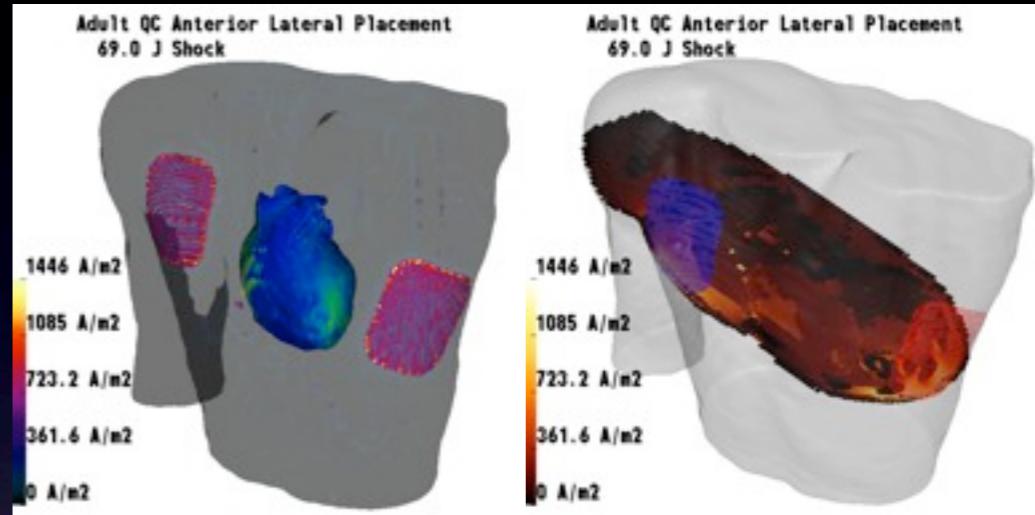
Pilcher T, et al. In American Heart Association, Scientific Sessions. November 2013

Simulation Applications

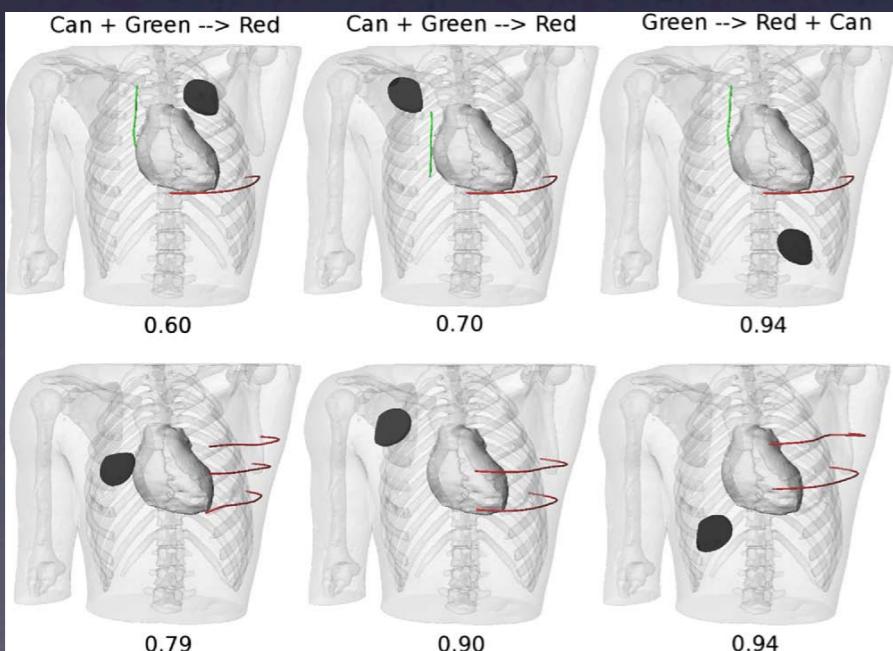
Pediatric Defibrillation



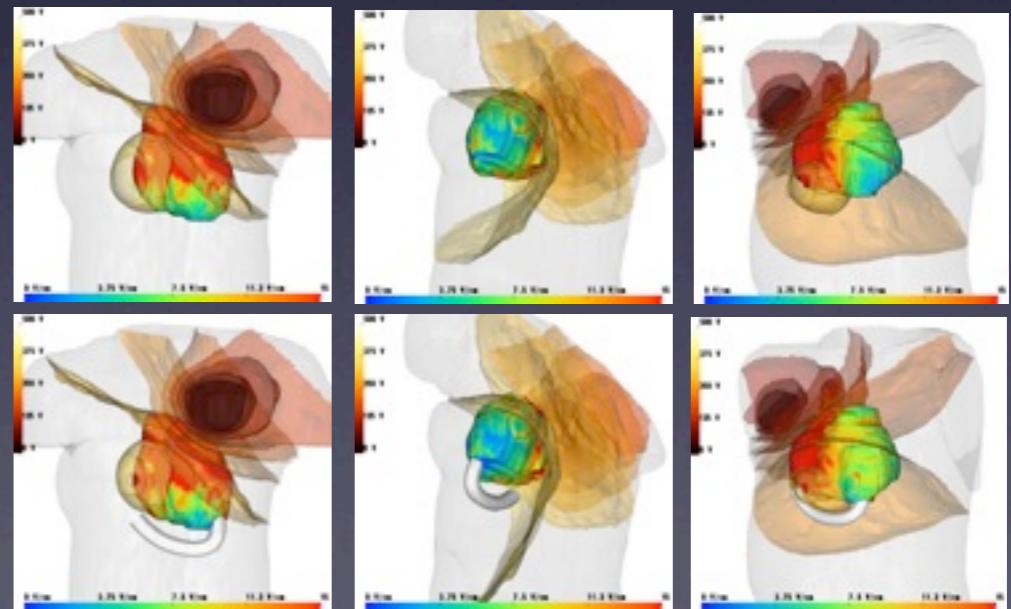
External Defibrillation



New Configurations



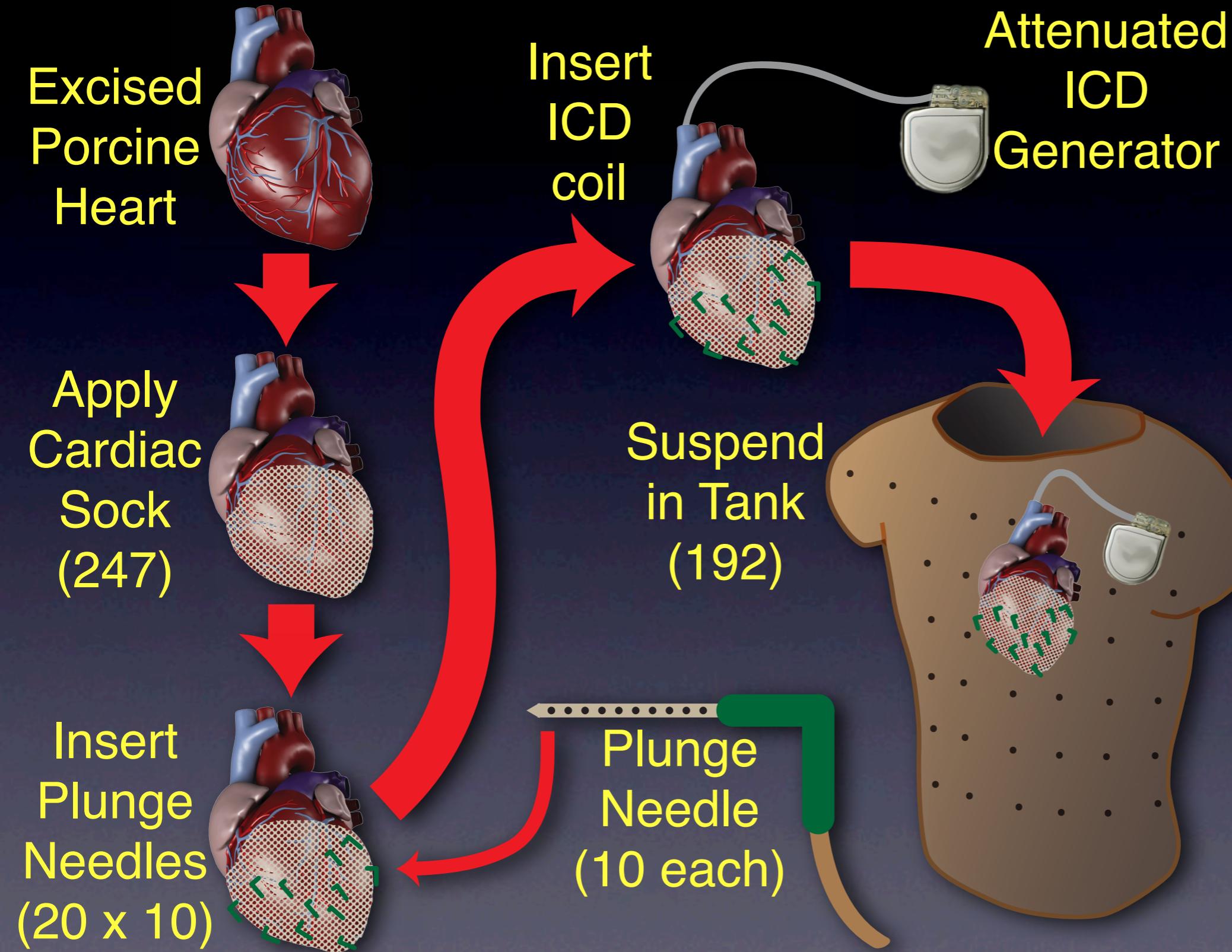
Stray Metal



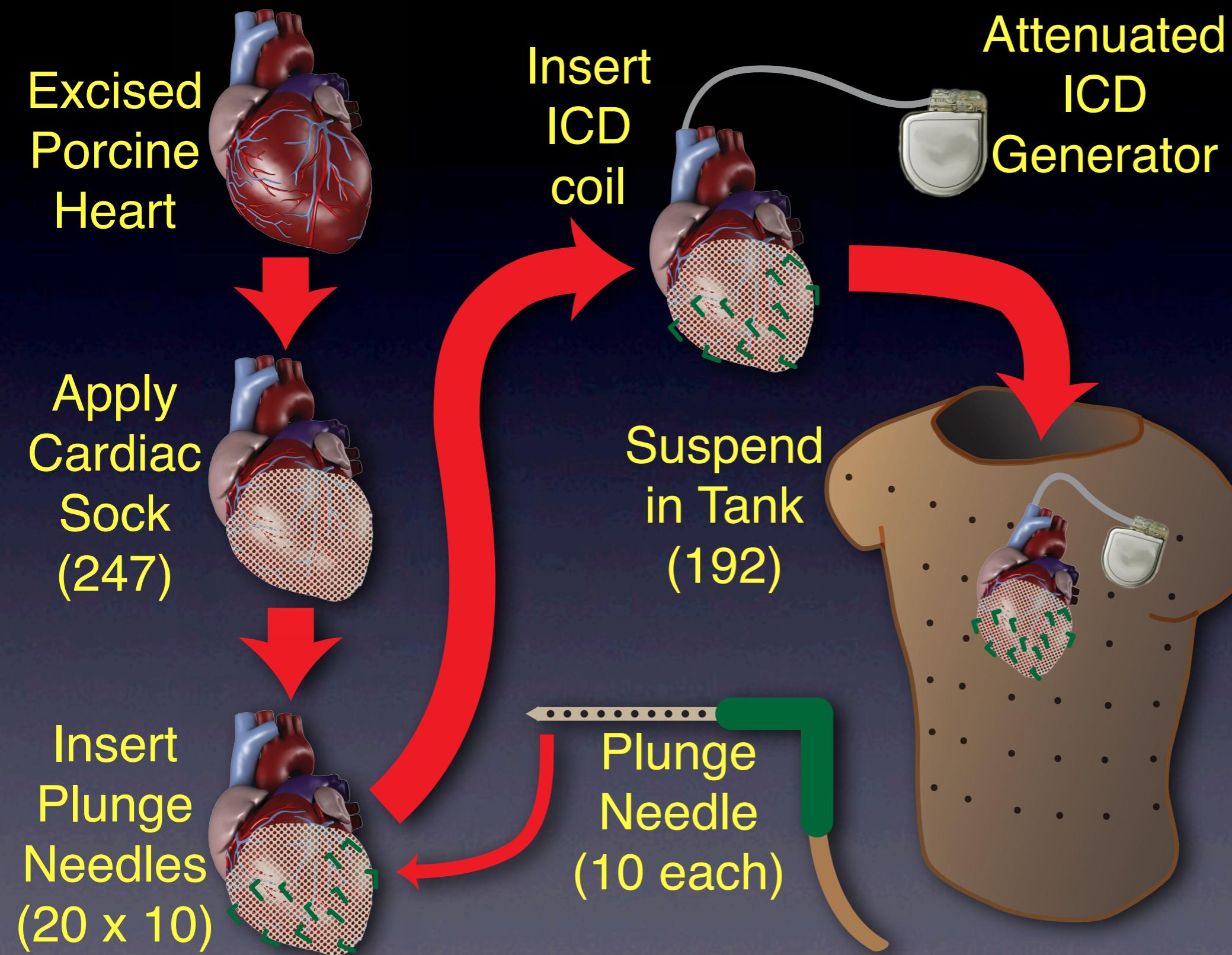
Goal:

Verification using a torso tank setup

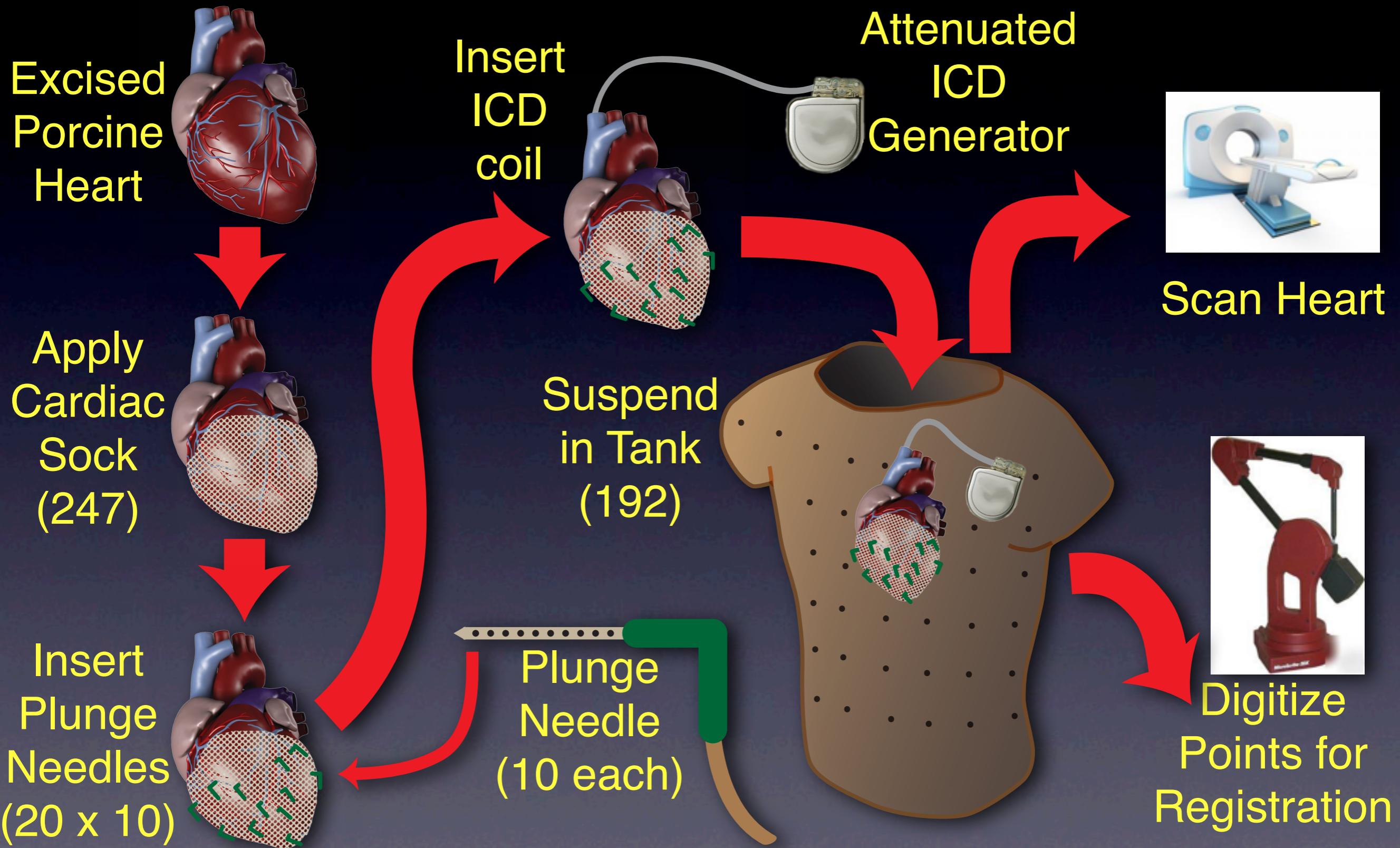
Tank Experiments



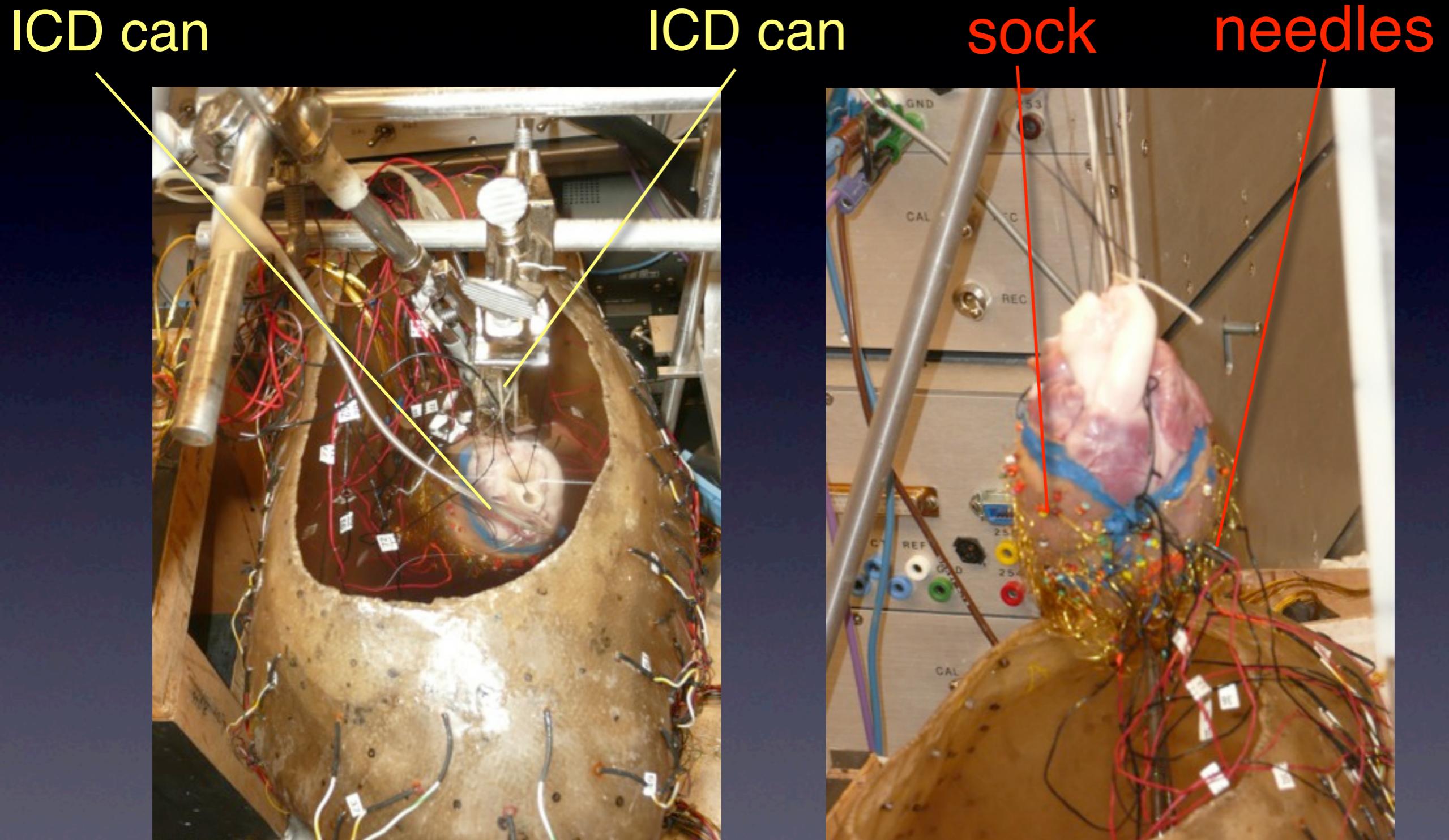
Tank Experiments



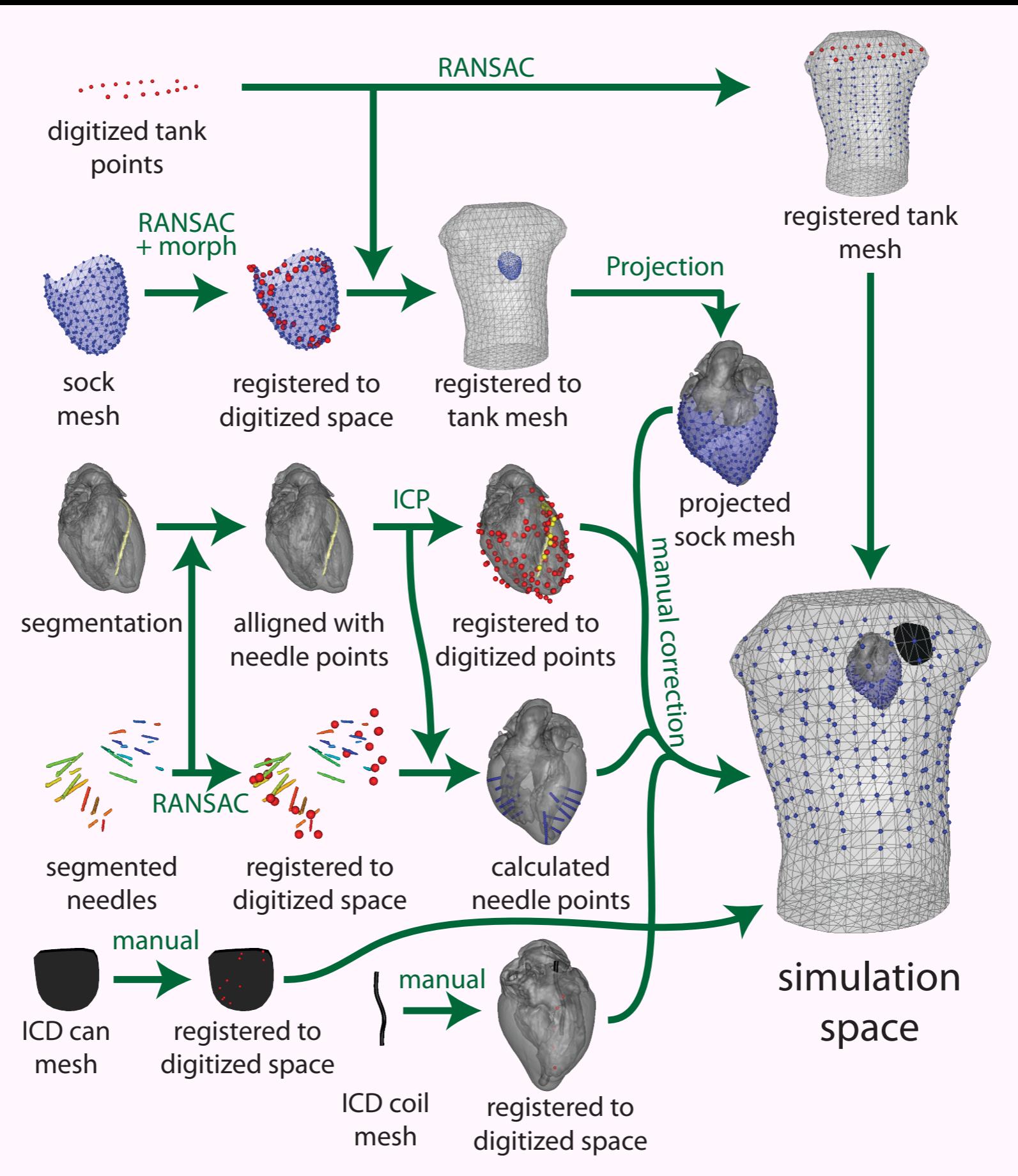
Tank Experiments



Tank Experiments



Registration



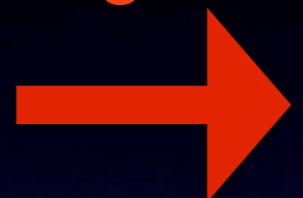
Simulation

MRI Scan



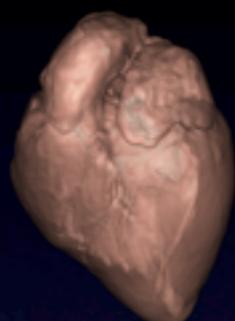
Segment

Seg3D

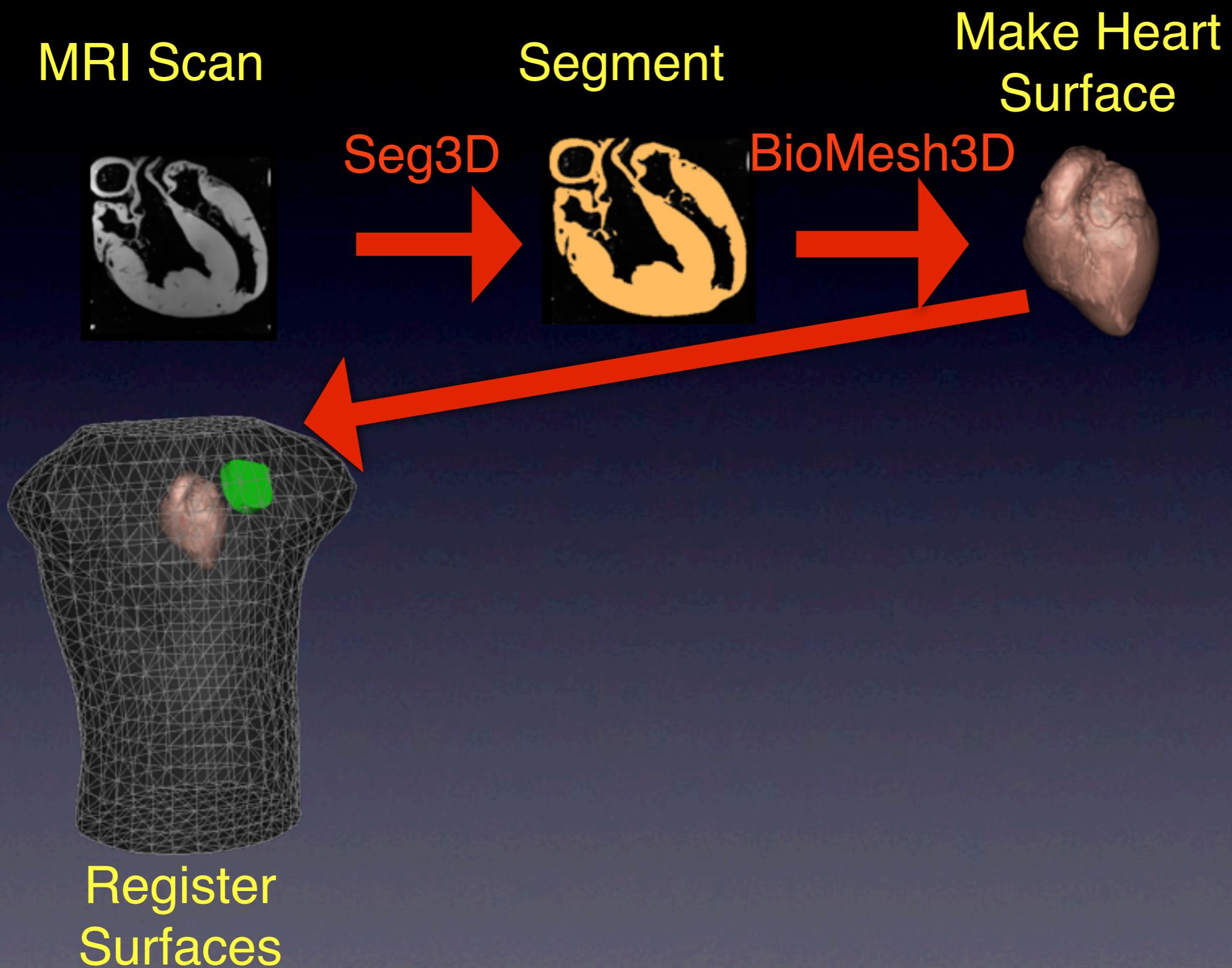


Make Heart
Surface

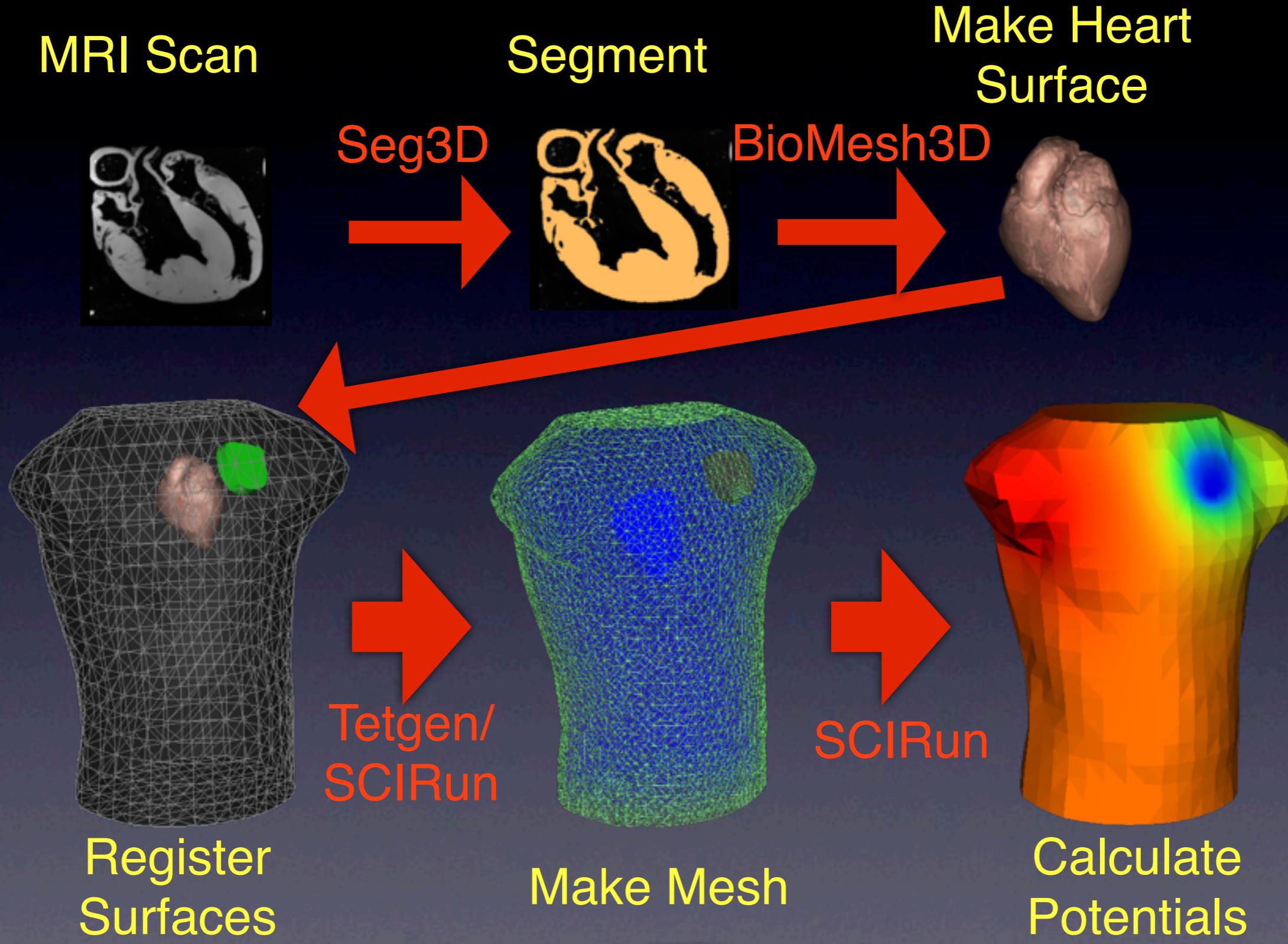
BioMesh3D



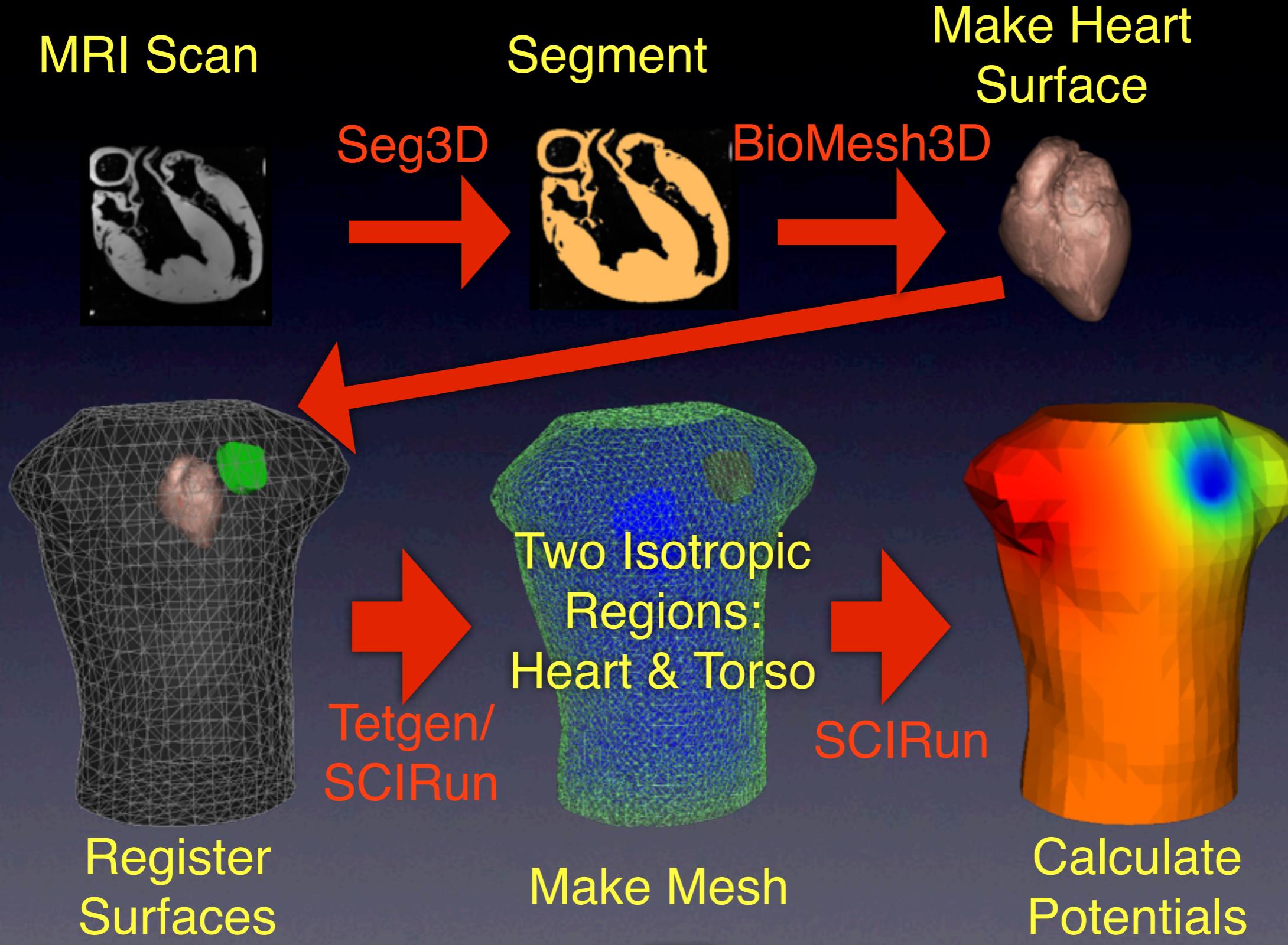
Simulation



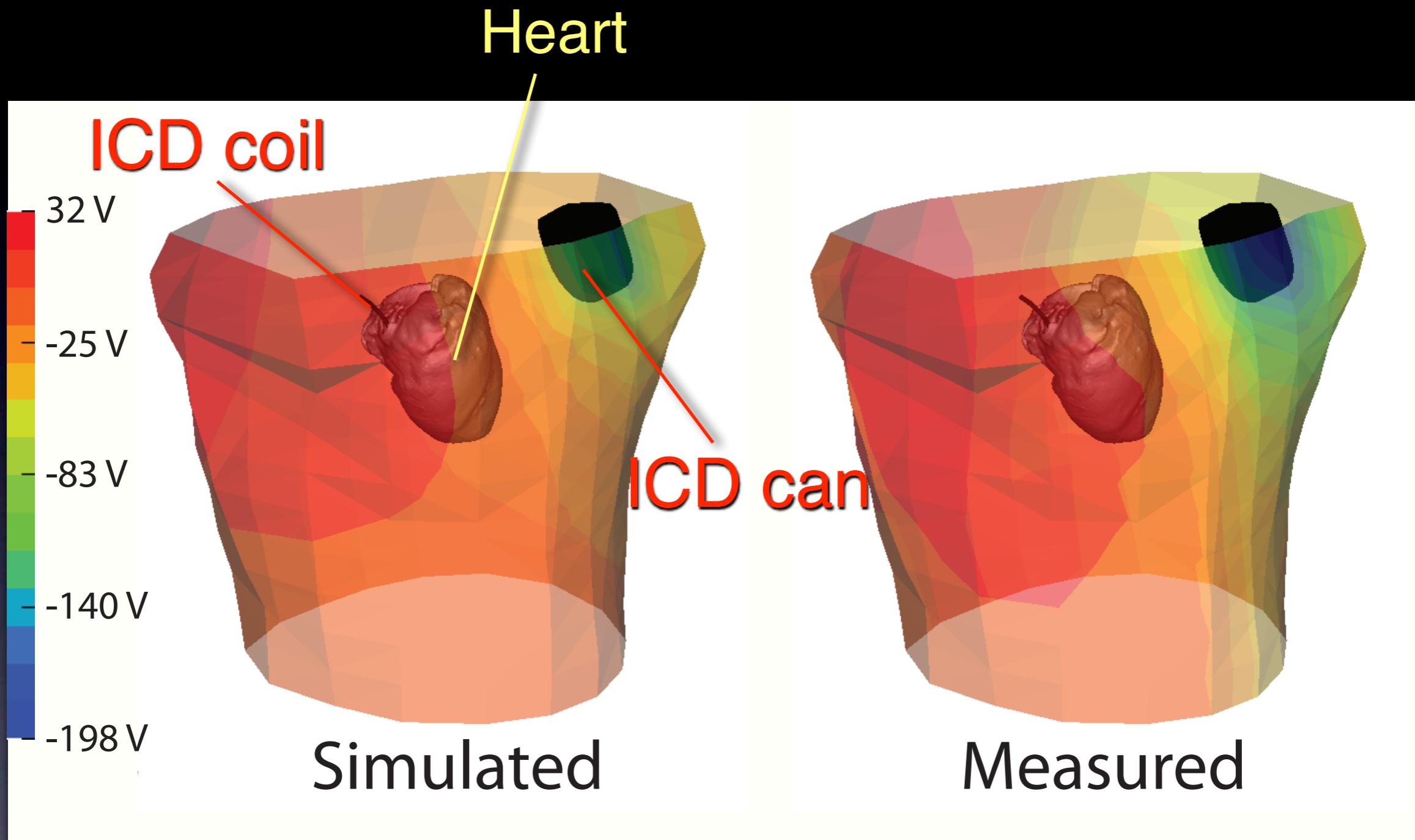
Simulation



Simulation

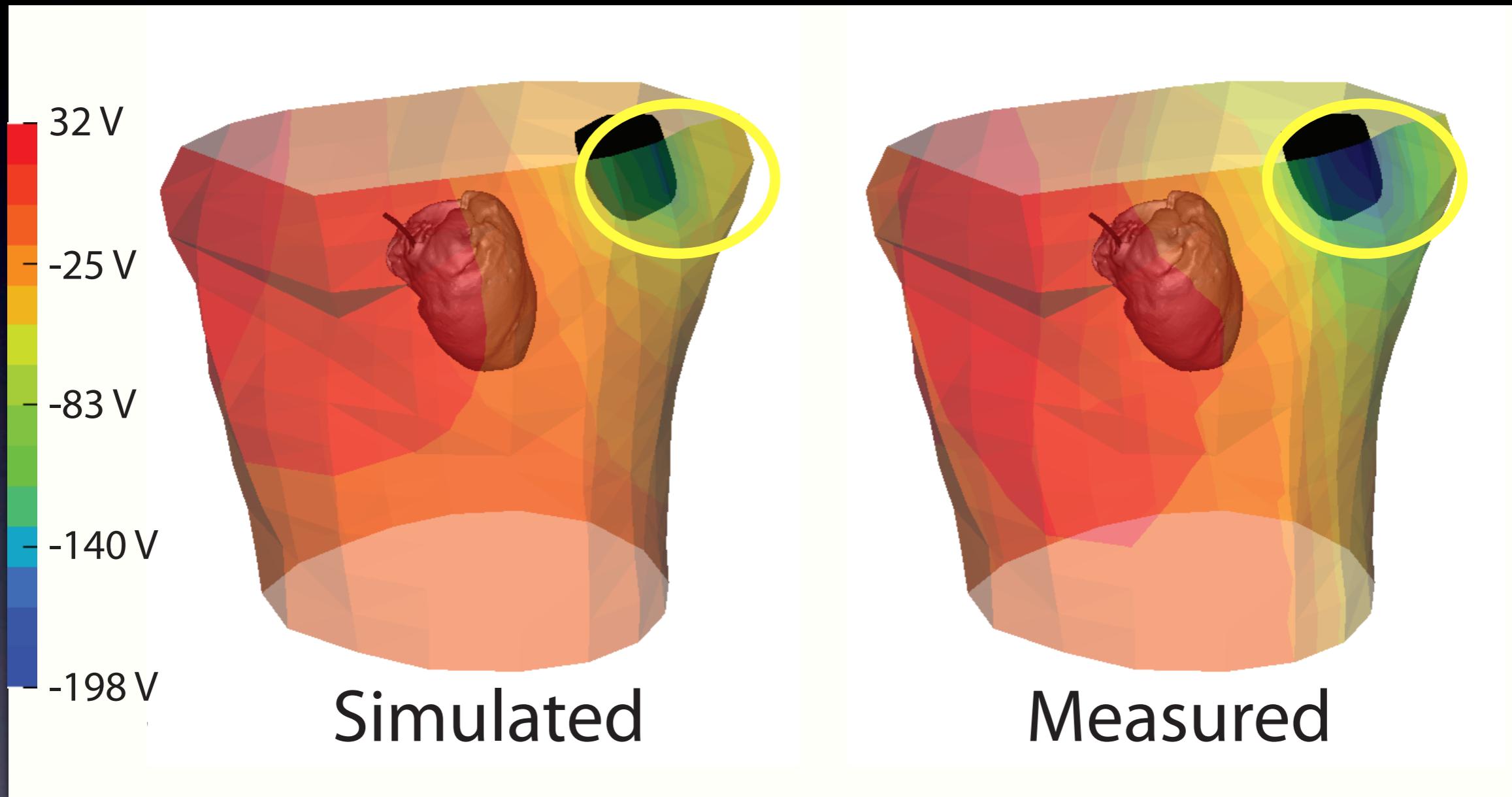


Tank Surface



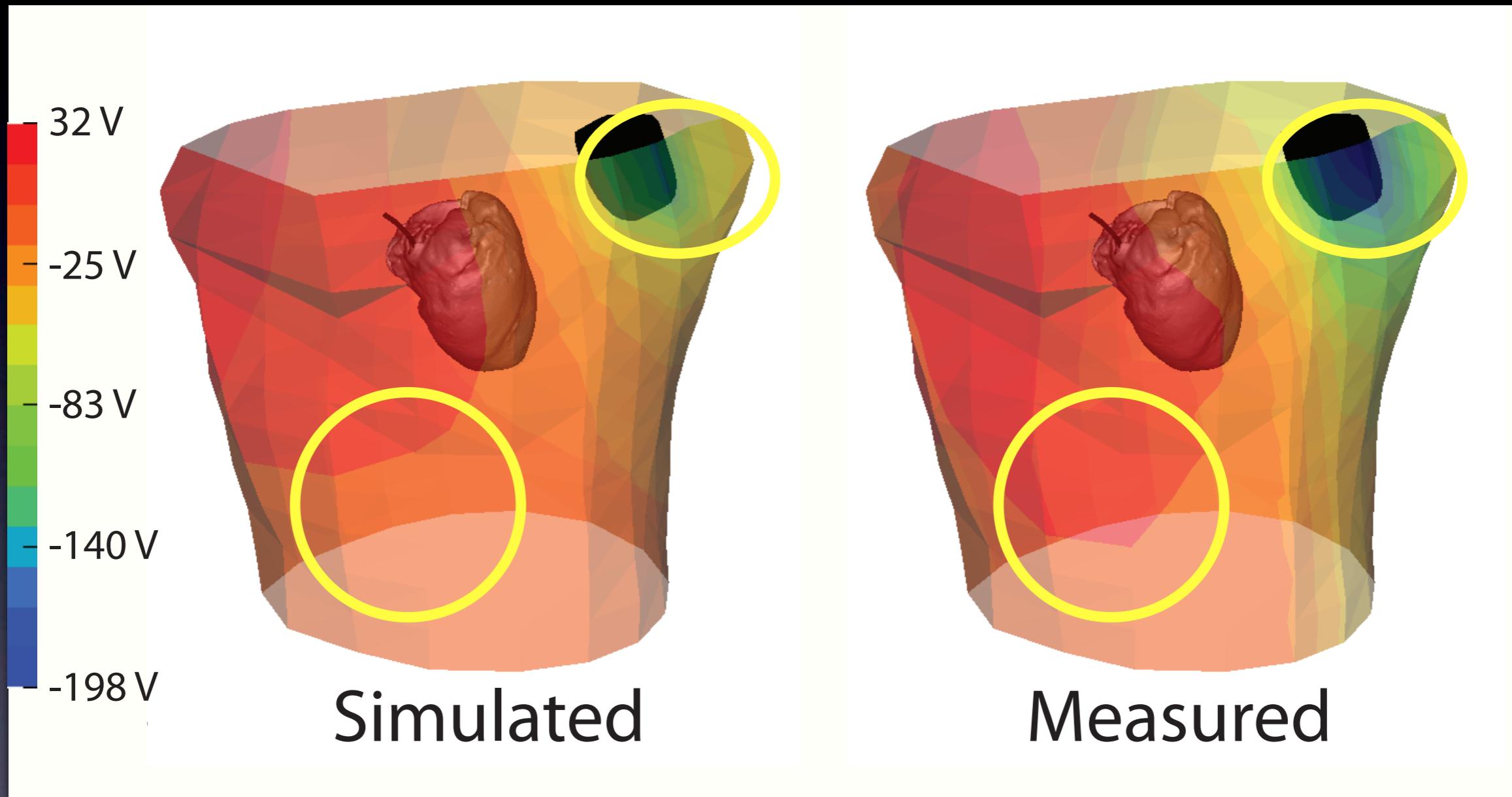
$$\rho=0.91, \bar{E}=23 \text{ V}, RE=28 \%$$

Tank Surface



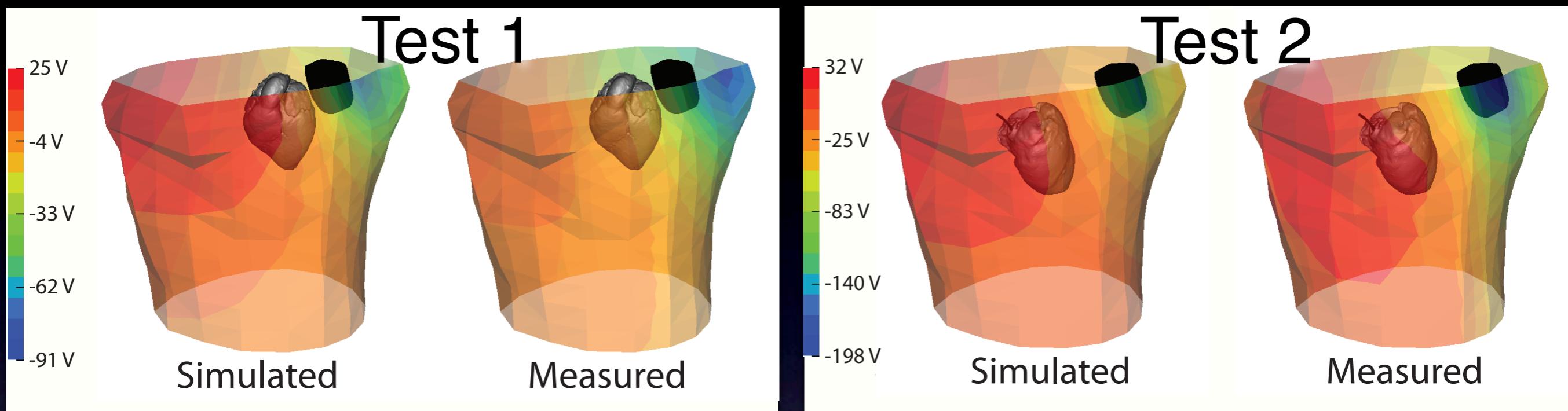
$$\rho=0.91, \bar{E}=23 \text{ V}, \text{RE}=28 \%$$

Tank Surface



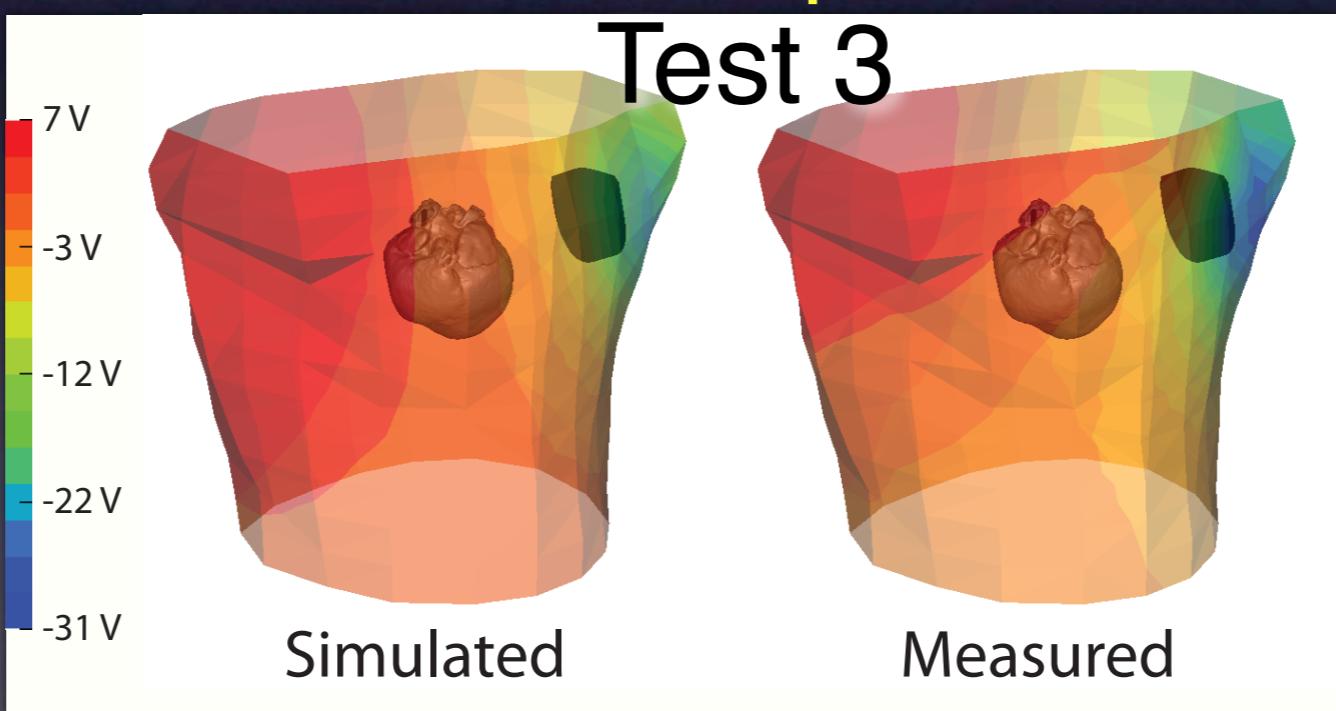
$$\rho=0.91, \bar{E}=23 \text{ V}, \text{RE}=28 \%$$

Tank Surface



$\rho=0.83$, $\bar{E}=12$ V, $RE=31$ %

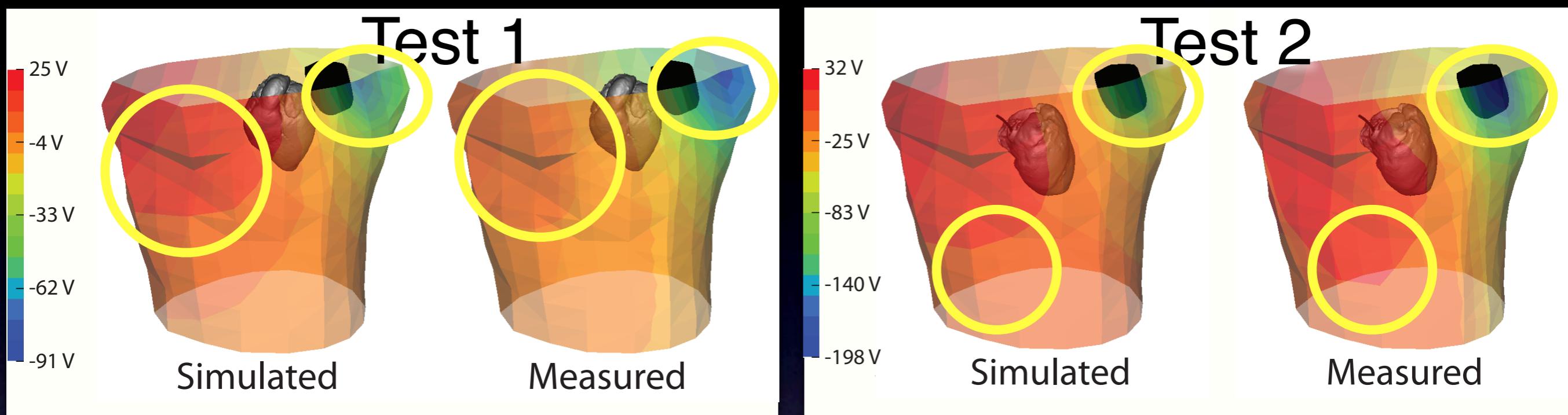
$\rho=0.91$, $\bar{E}=23$ V, $RE=28$ %



$\rho=0.88$, $\bar{E}=3.9$ V, $RE=23$ %

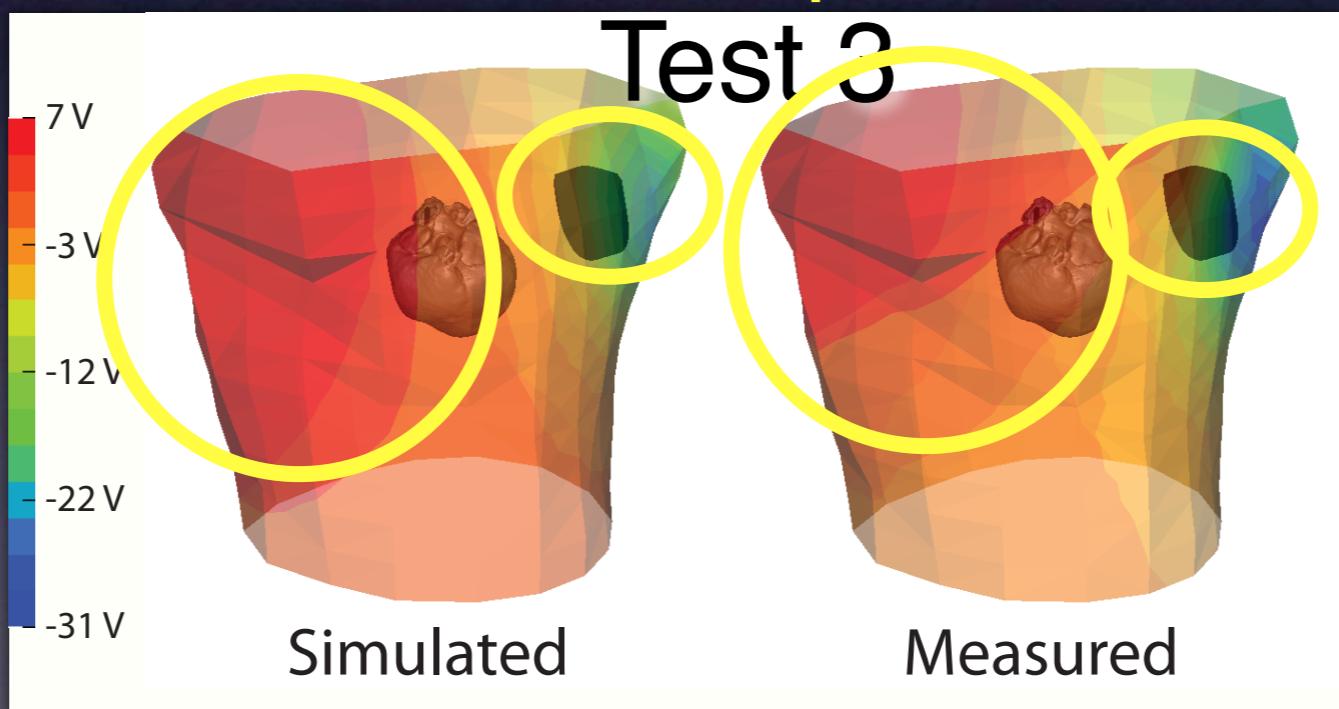


Tank Surface



$\rho=0.83$, $\bar{E}=12$ V, RE=31 %

$\rho=0.91$, $\bar{E}=23$ V, RE=28 %

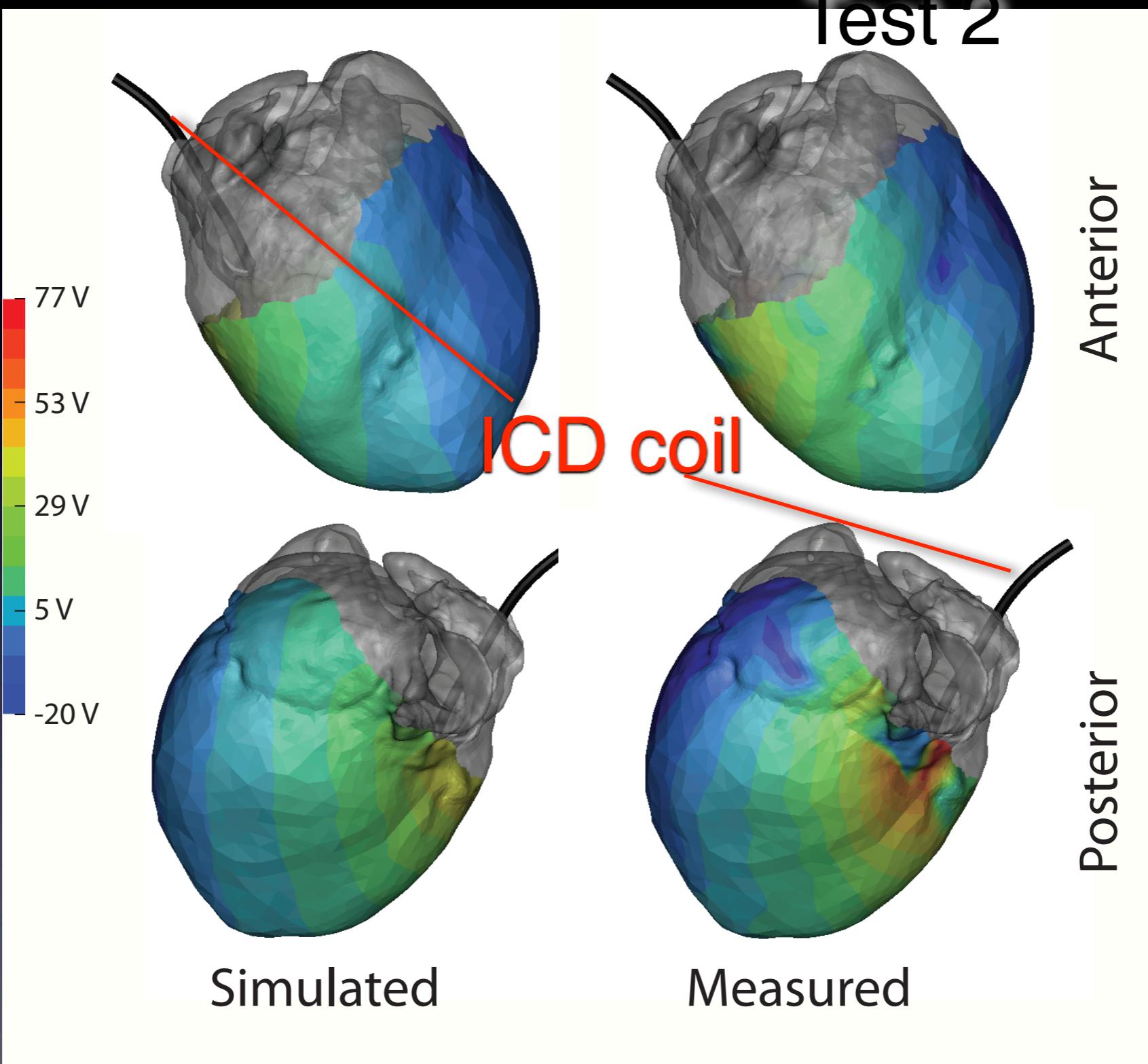


$\rho=0.88$, $\bar{E}=3.9$ V, RE=23 %



Cardiac Surface

Test 2

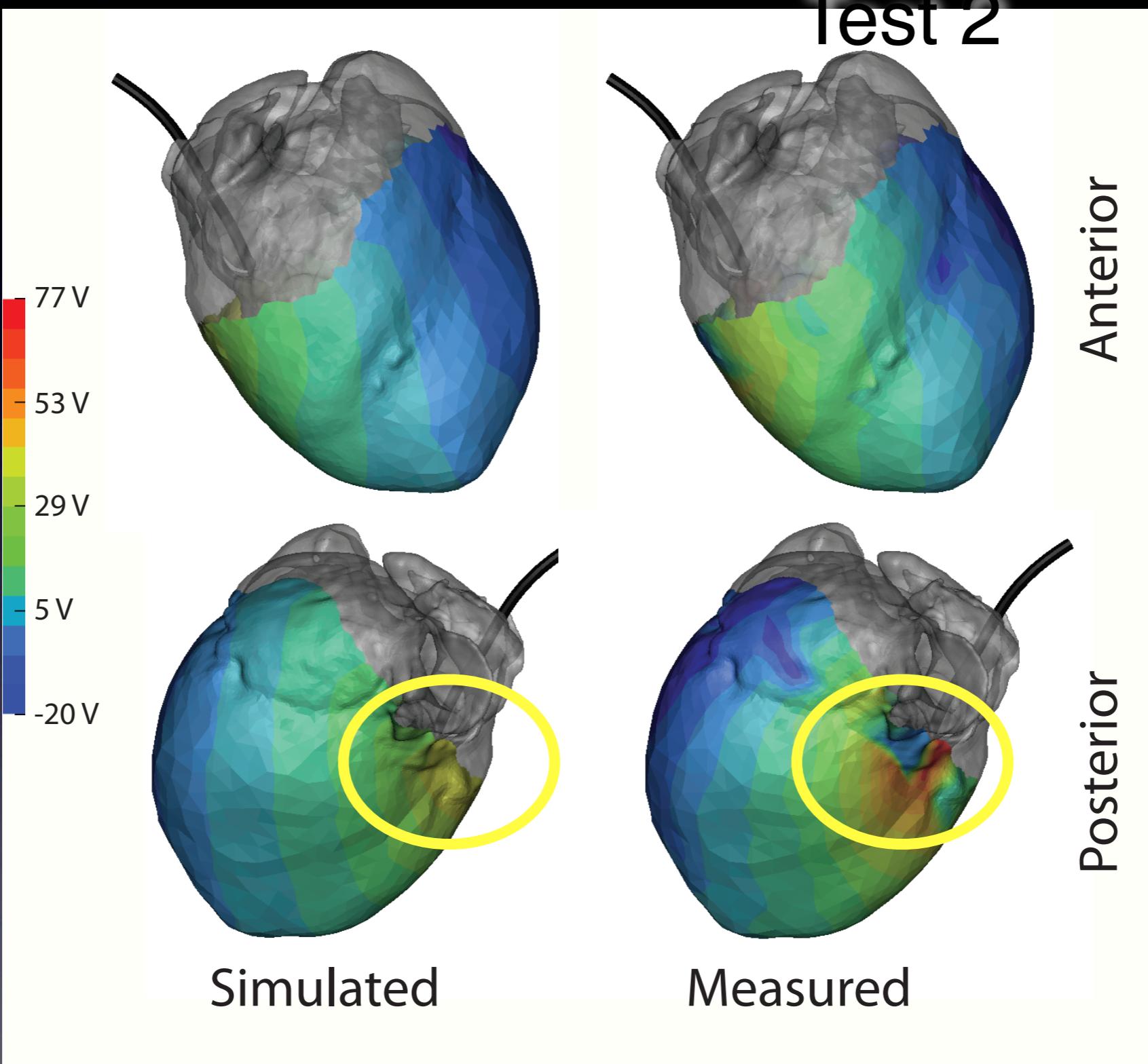


$\rho=0.85, \bar{E}=10 \text{ V}, \text{RE}=30\%$



Cardiac Surface

Test 2

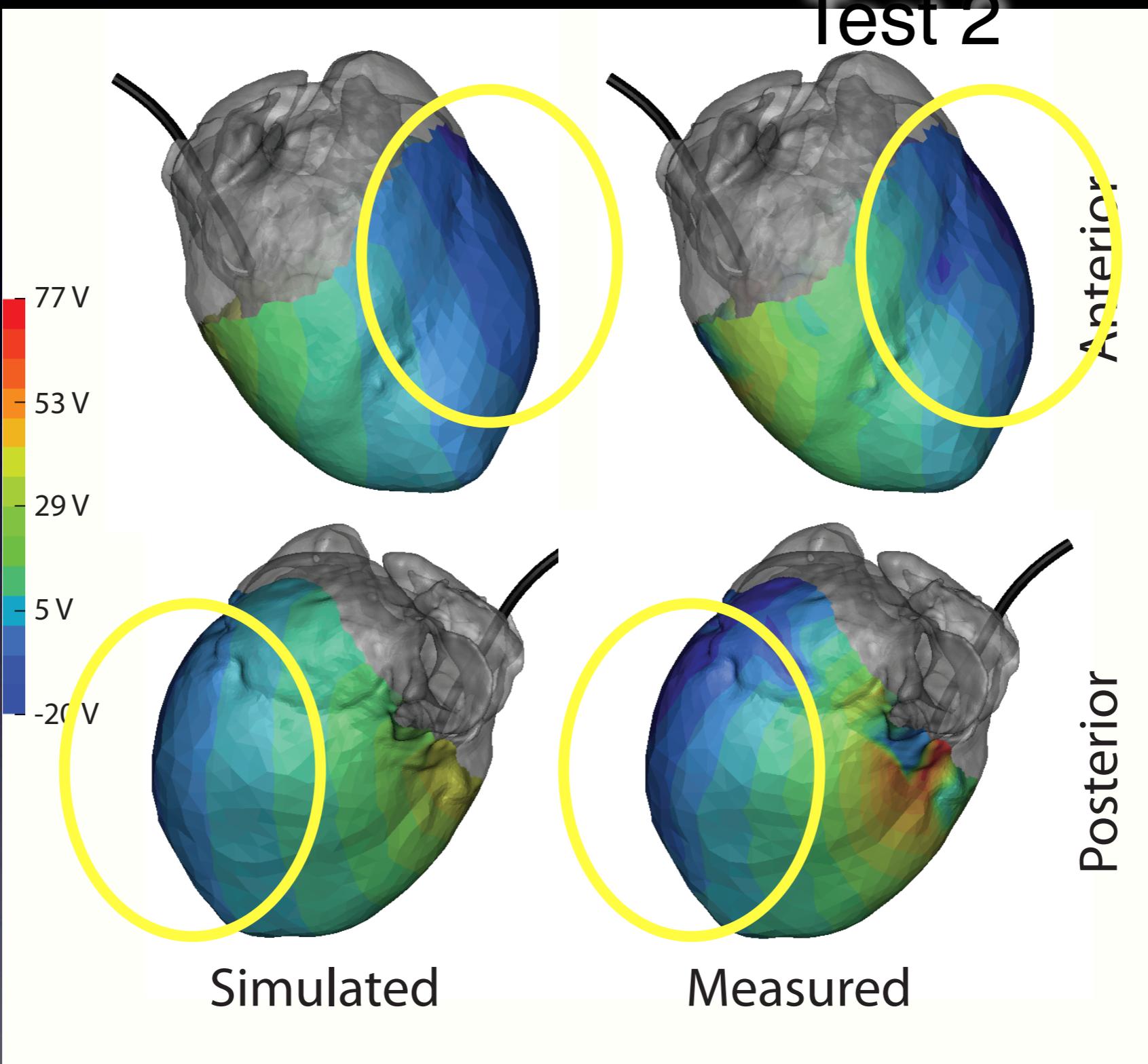


$\rho=0.85, \bar{E}=10 \text{ V}, \text{RE}=30\%$



Cardiac Surface

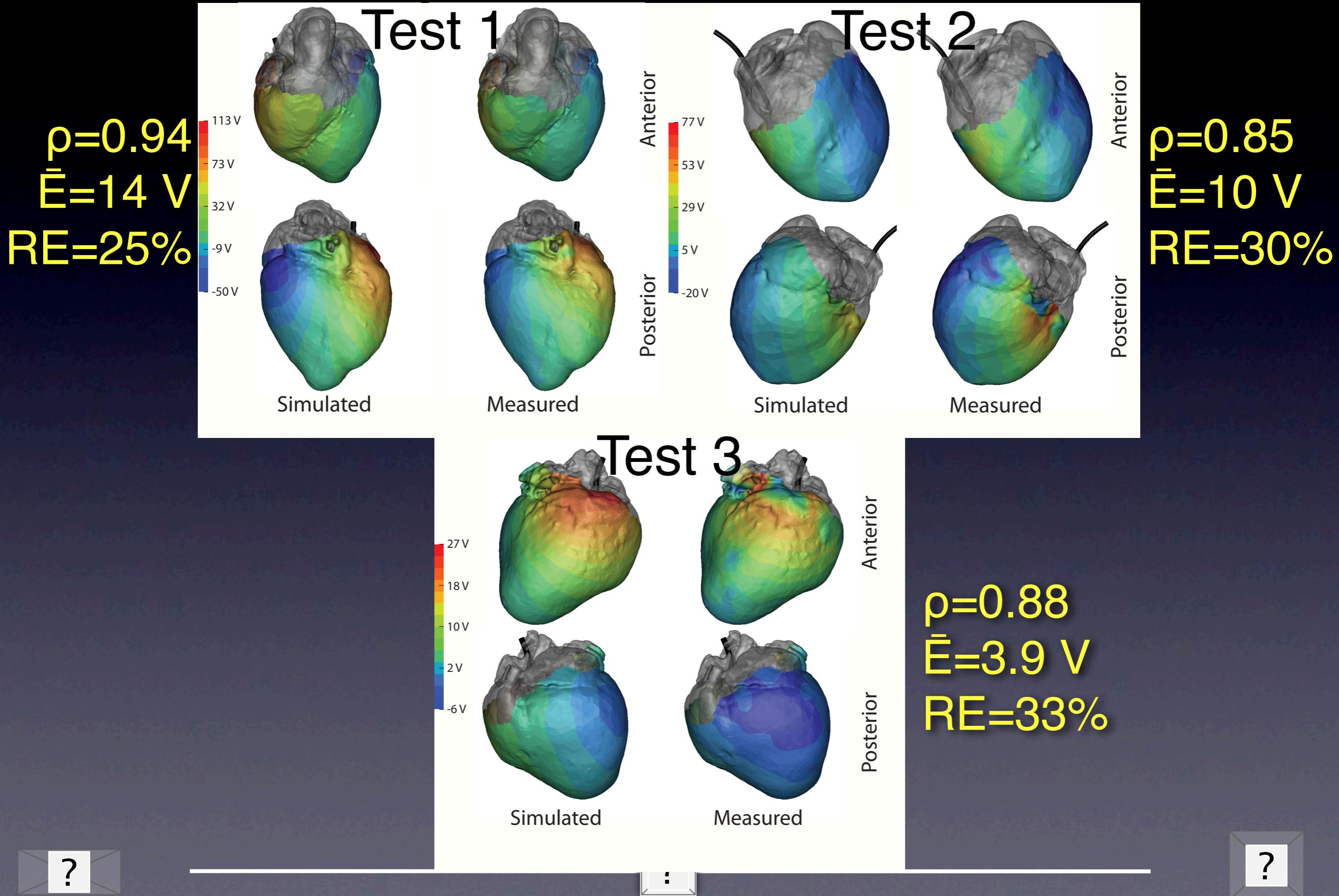
Test 2



$$\rho=0.85, \bar{E}=10 \text{ V}, RE=30\%$$



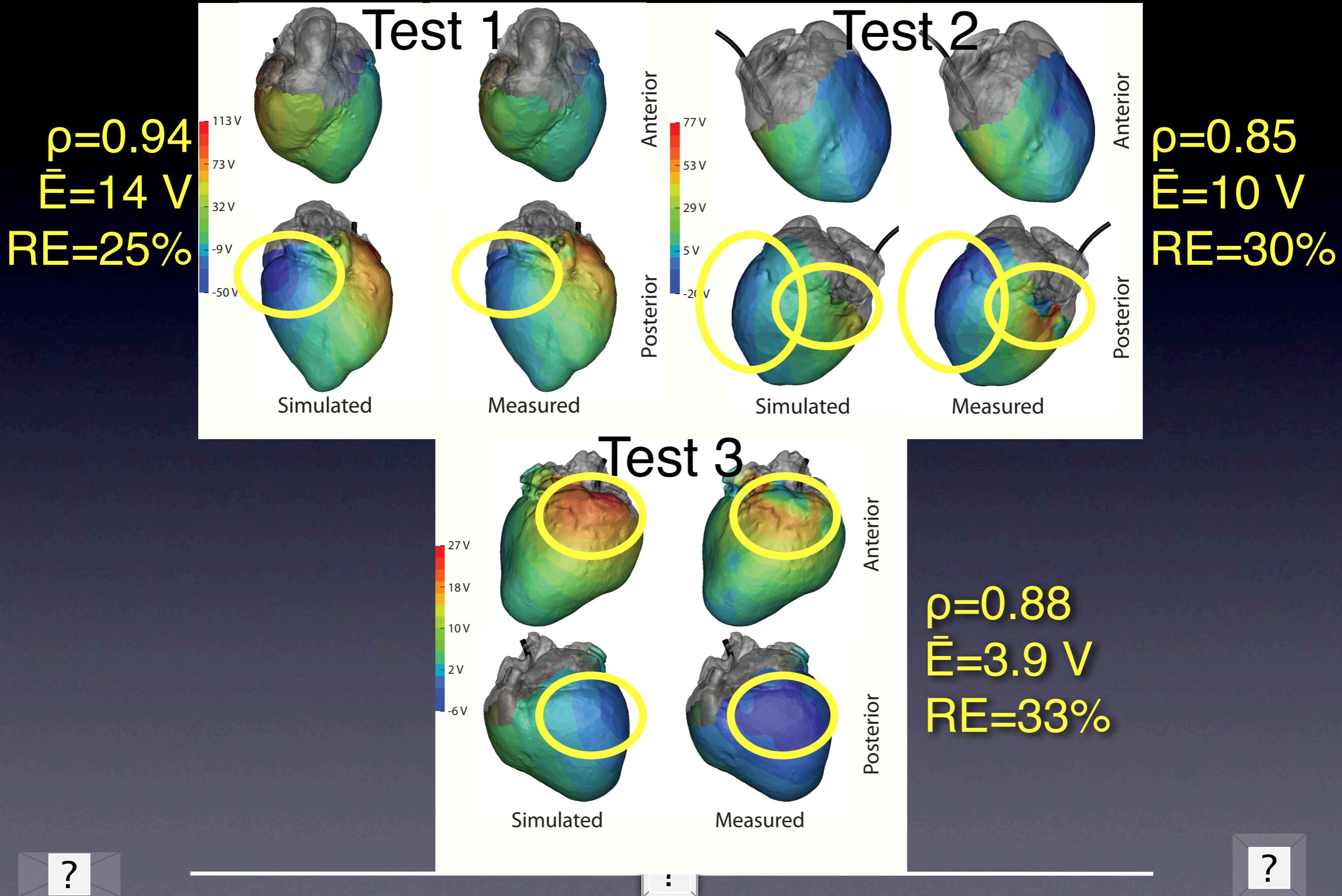
Cardiac Surface



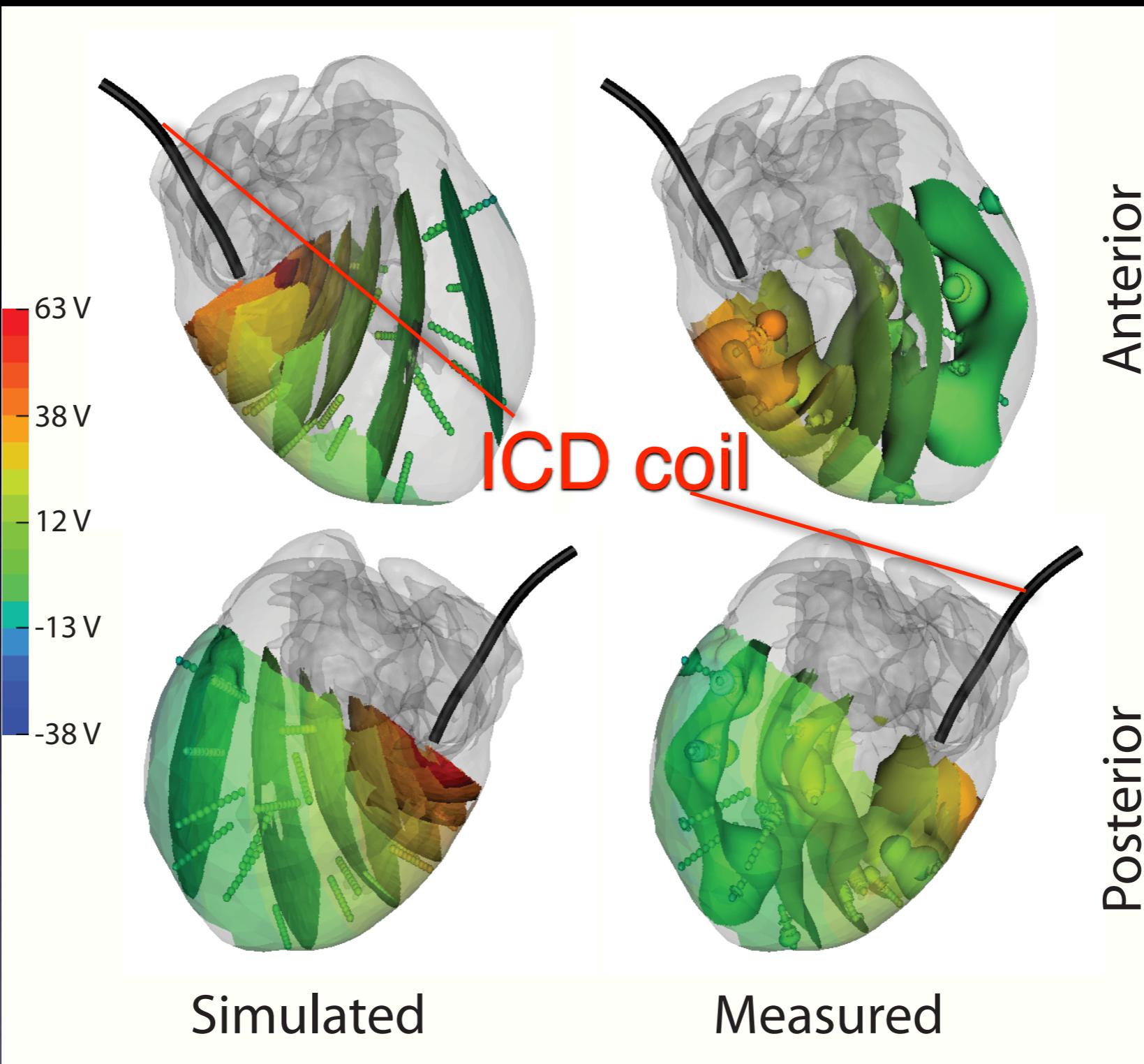
?

?

Cardiac Surface



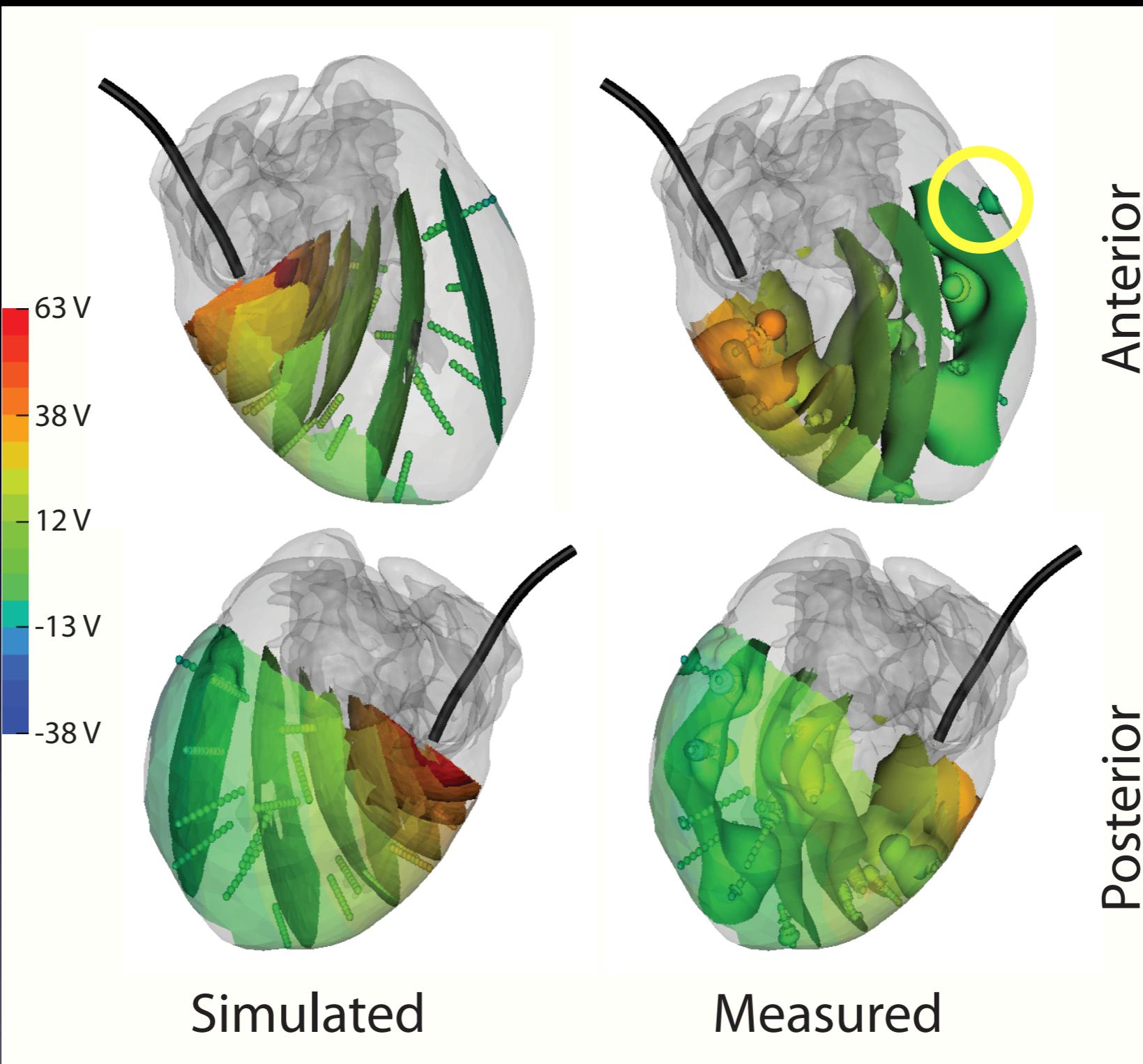
Cardiac Volume



$\rho=0.87$, $\bar{E}=12$ V, RE=26%



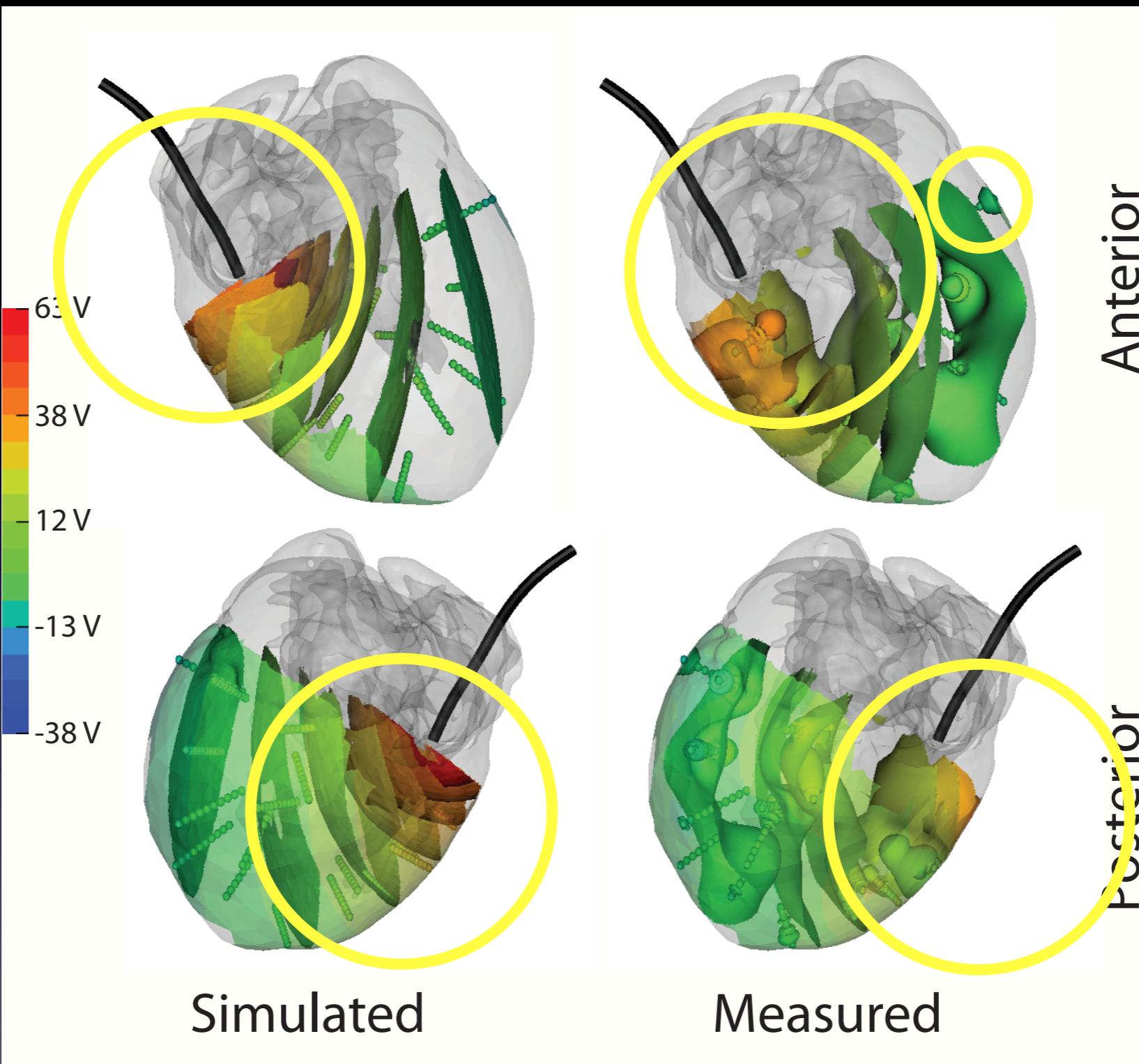
Cardiac Volume



$\rho=0.87$, $\bar{E}=12$ V, RE=26%



Cardiac Volume

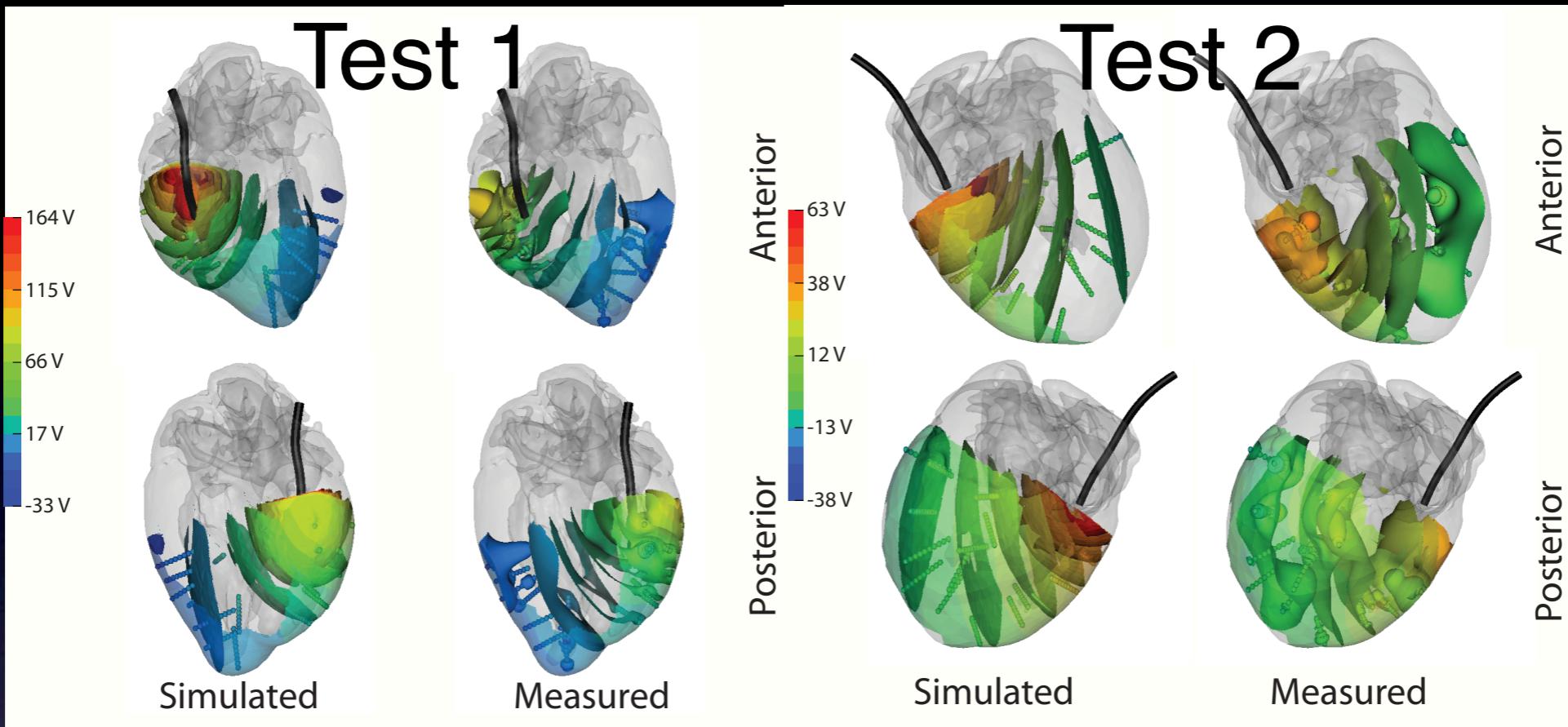


$\rho=0.87$, $\bar{E}=12$ V, RE=26%



Cardiac Volume

$p=0.91$
 $\bar{E}=14 \text{ V}$
 $RE=28\%$

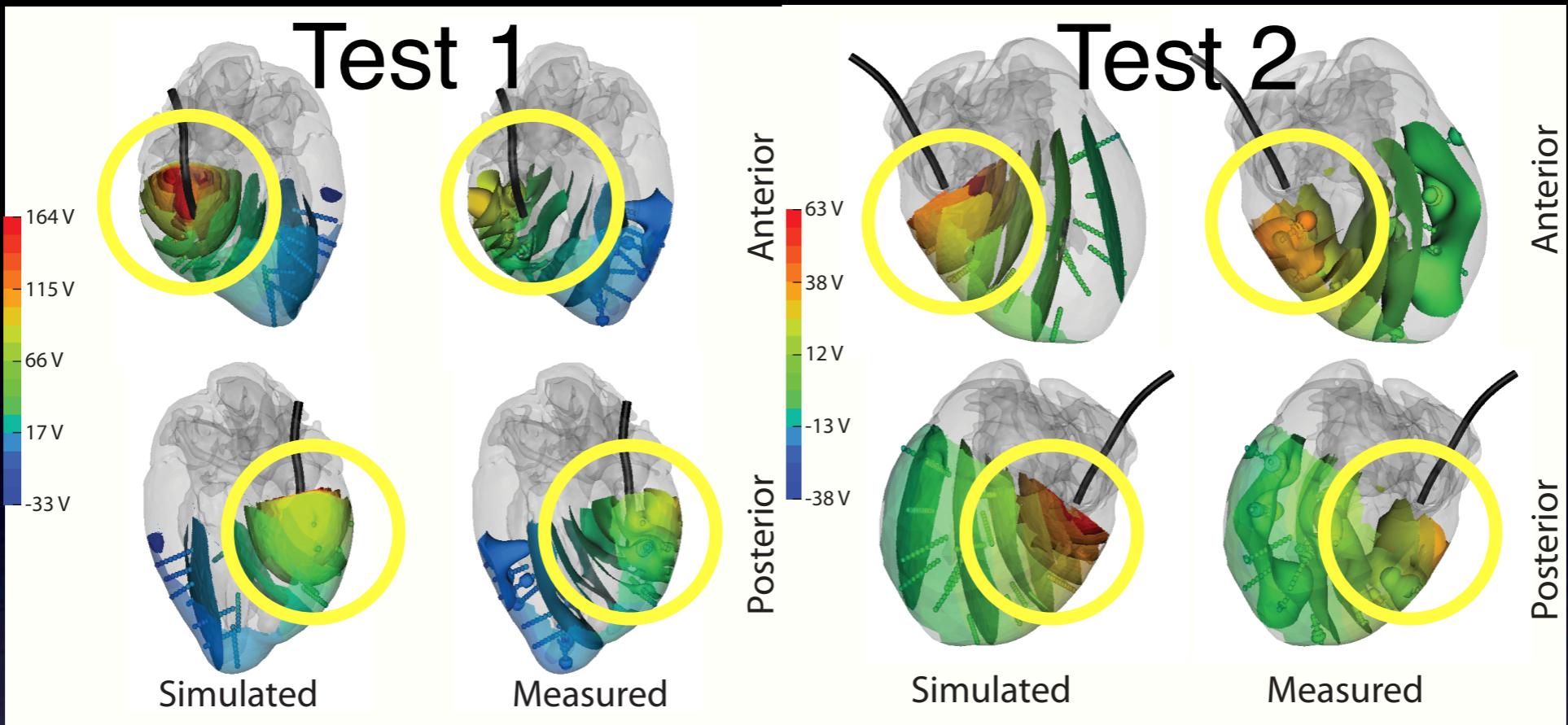


$p=0.96$
 $\bar{E}=2.8 \text{ V}$
 $RE=8.2\%$



Cardiac Volume

$p=0.91$
 $\bar{E}=14 \text{ V}$
 $RE=28\%$



$p=0.96$
 $\bar{E}=2.8 \text{ V}$
 $RE=8.2\%$

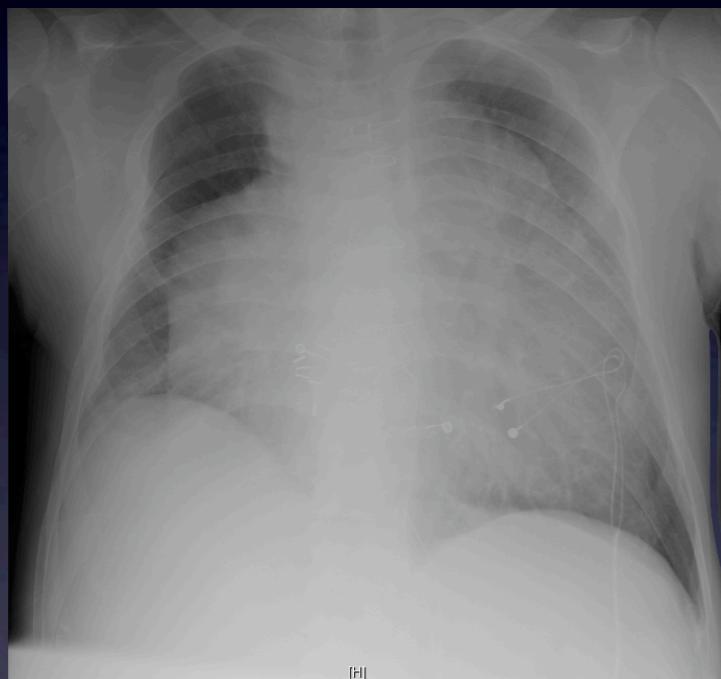


Conclusions

Experiments Verify our Simulation

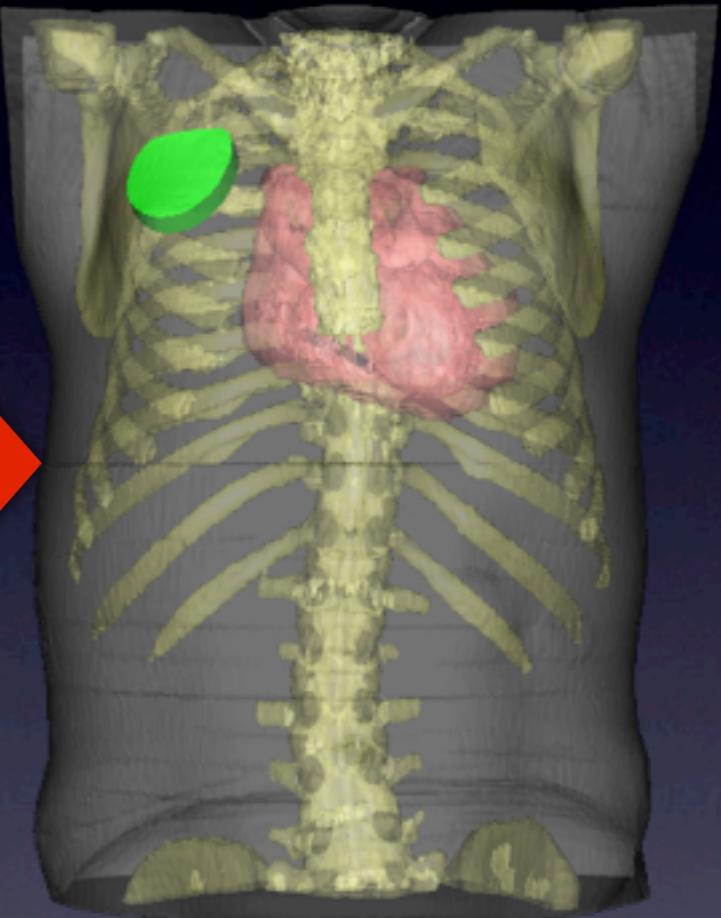
Likely Errors: Conductivity & Registration

Patient Specific ICD Treatment



Scan of Patient

Simulation
Pipeline



Placement with
Minimal DFT

Acknowledgements

Advisor

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