

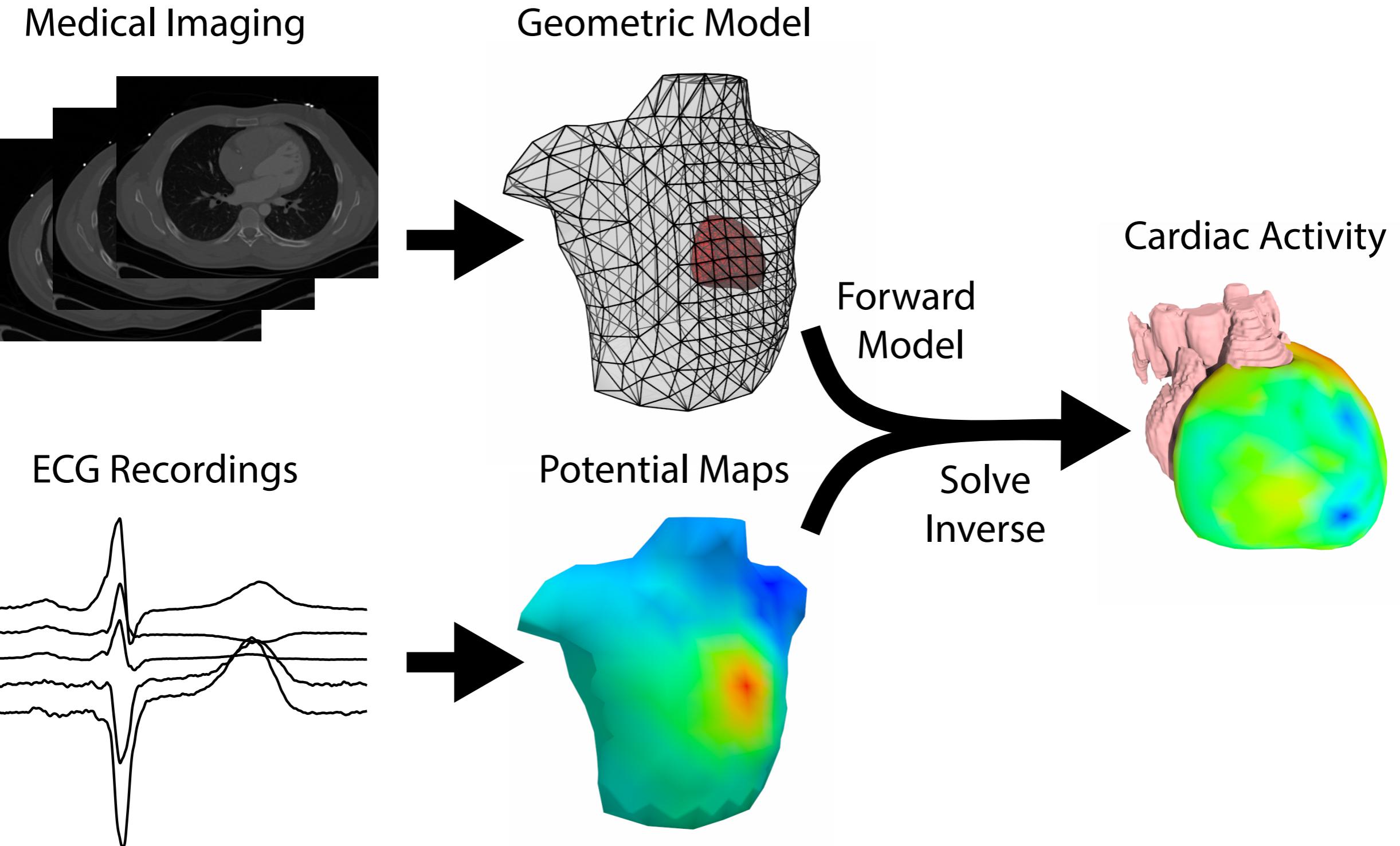
# Effect of Segmentation Variation on ECG Imaging

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Peter van Dam, Dana Brooks, Rob MacLeod

University of Utah  
Inria Bordeaux Sud Ouest  
Radboud Nijmegen University  
Northeastern University

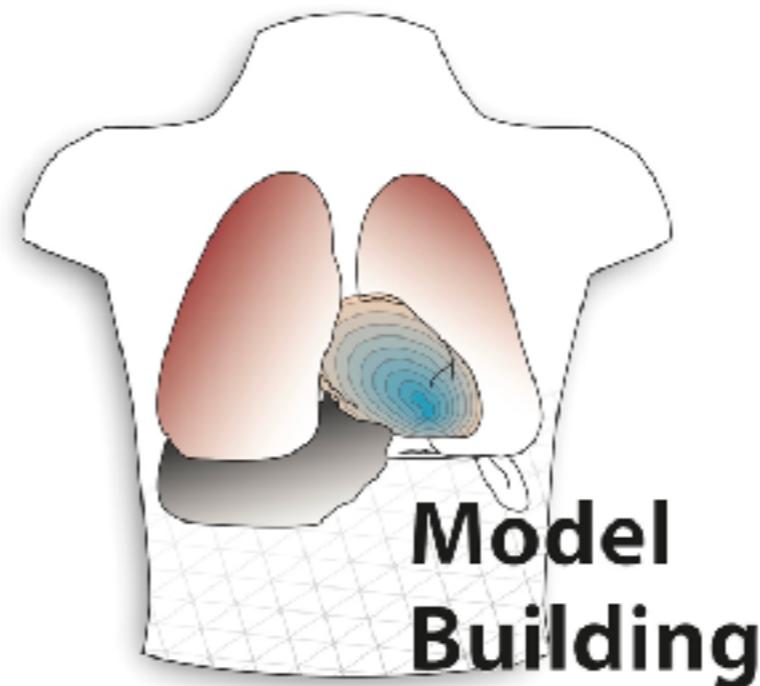


# ECG Imaging

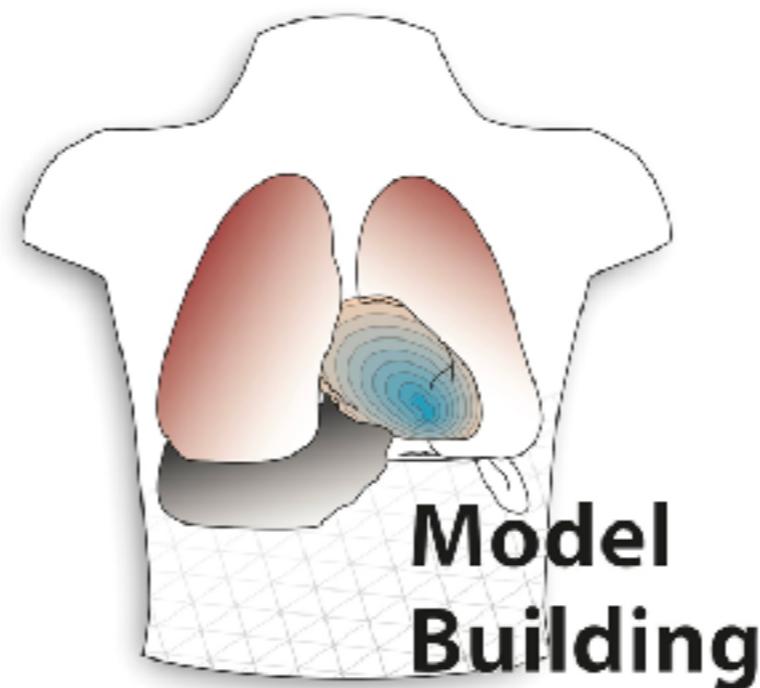


# CEI: Modeling Error Workgroup

(Consortium for ECG Imaging)



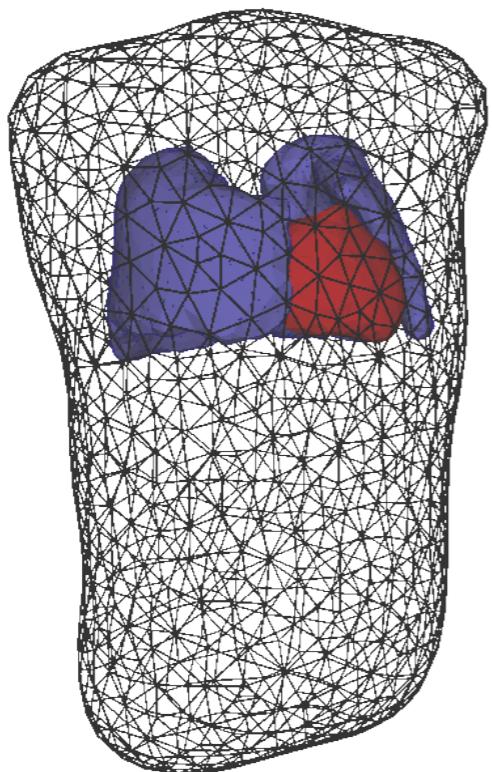
# CEI: Modeling Error Workgroup (Consortium for ECG Imaging)



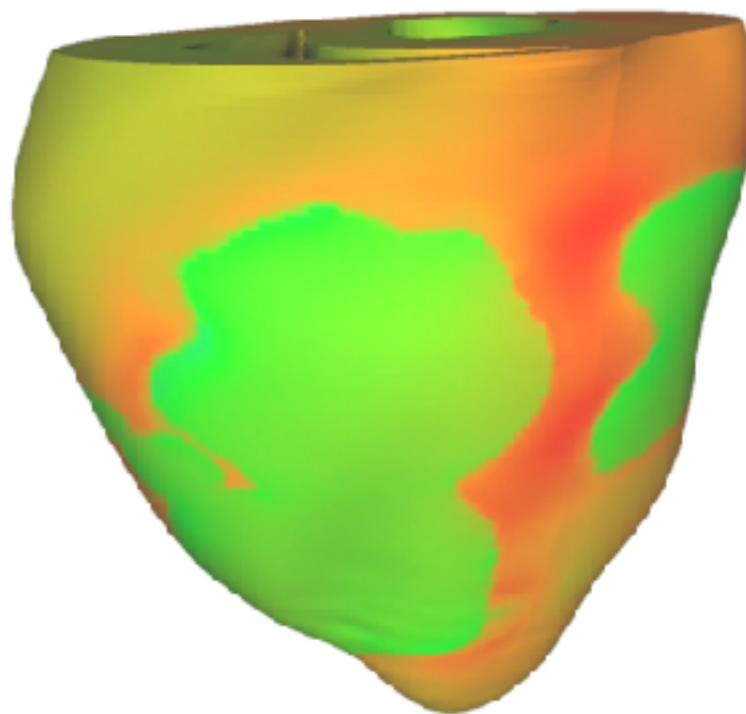
Quantify the effects of error

# Origins of Error

Geometry

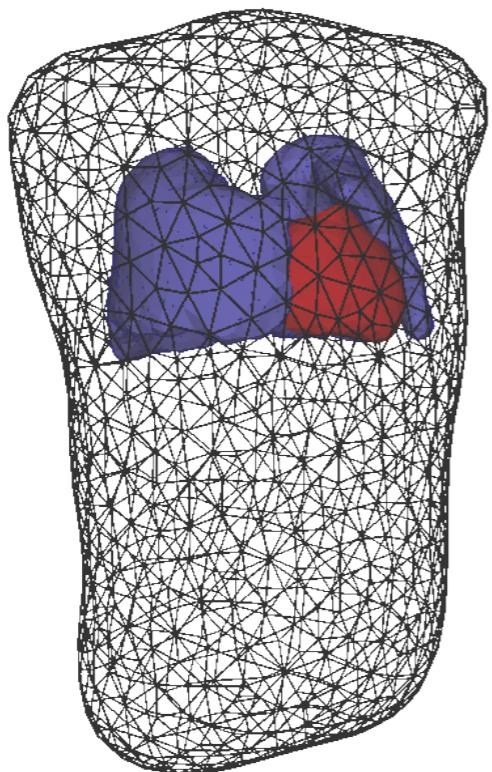


Sources

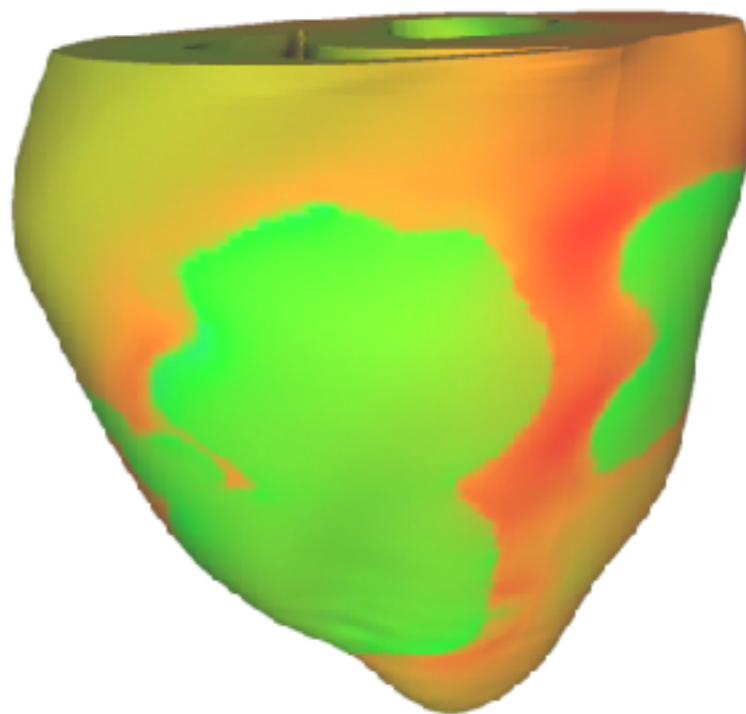


# Origins of Error

Geometry

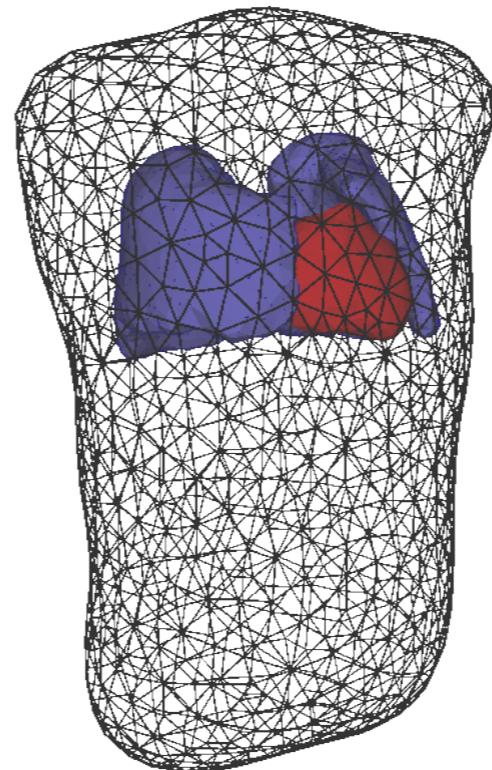


Sources



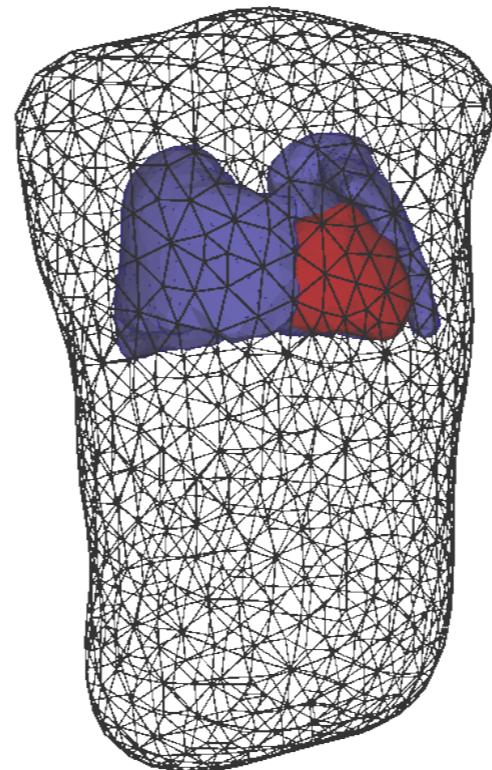
# Origins of Error

## Geometry



# Origins of Error

## Geometry



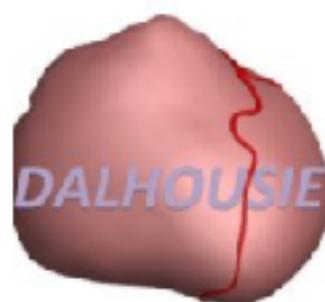
## Segmentation

# Segmentation Error



# Data Collection

The screenshot shows a web browser window titled "Covalc" with a secure connection to "challenge.kitware.com". The URL in the address bar is <https://challenge.kitware.com/#phase/57c76241cad3a51cc66c7e60>. The page title is "CEI Model Building > Stage 1: Dalhousie Segmentation". On the left, there's a "OVERVIEW" section with a "DALHOUSIE" logo featuring a red heart shape and the word "DALHOUSIE" in blue. On the right, there's a user profile for "Jess Tate" with a gear icon.



This phase is to upload the segmentation of torso, ventricles, left lung, and right lung from the Dalhousie CT scan. Four files will need to be submitted simultaneously:

- LLung.nrrd - left lung
- RLung.nrrd - right lung
- Torso.nrrd - Torso surface (everything in the torso should be 1)
- Ventricles.nrrd - Ventricular Myocardium (with endo and epicardial surfaces)

Each file will need to be of the same image size and spacing as the original CT scan (512x512x54, 0.7422x0.7422x3). Select all of the files when in the file finder dialogue. Your submission will be compared to a "Ground Truth" which is just one of the possible segmentations, so do not worry what your scores or metrics are, but if they are not calculated (it may take several minutes), or if there is an error, you will need to resubmit the segmentations. If you wish to, you can create an empty file (nrrd of the same size with all zeros) to skip one of the tissues. Once all the participants submit a segmentation of each of the tissues, we will create a common segmentation to use for the next stage.

Download test dataset

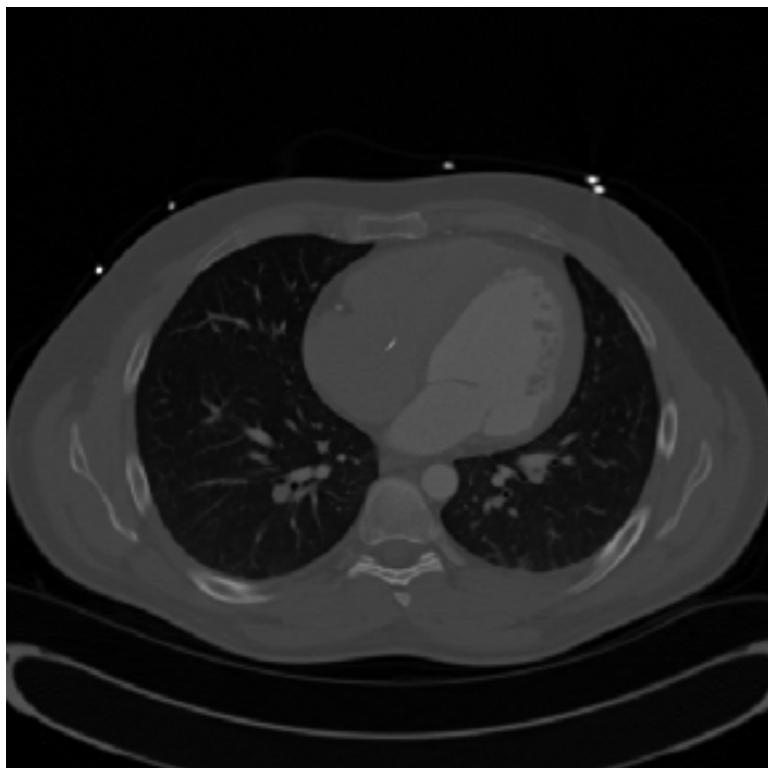
Download ground truth data

Submit your results

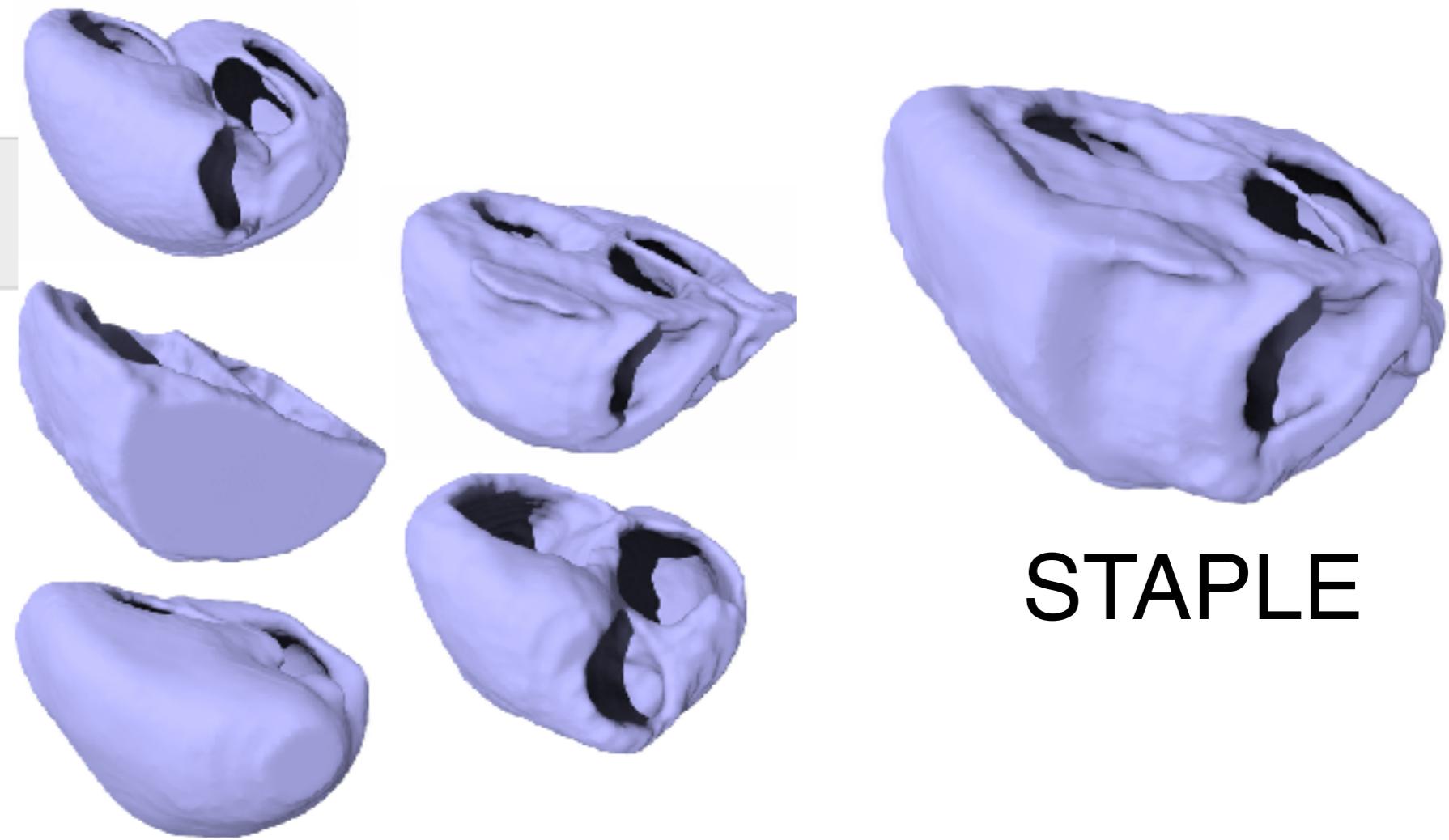
# Segmentations



the EDGAR  
Time Signal Catalog



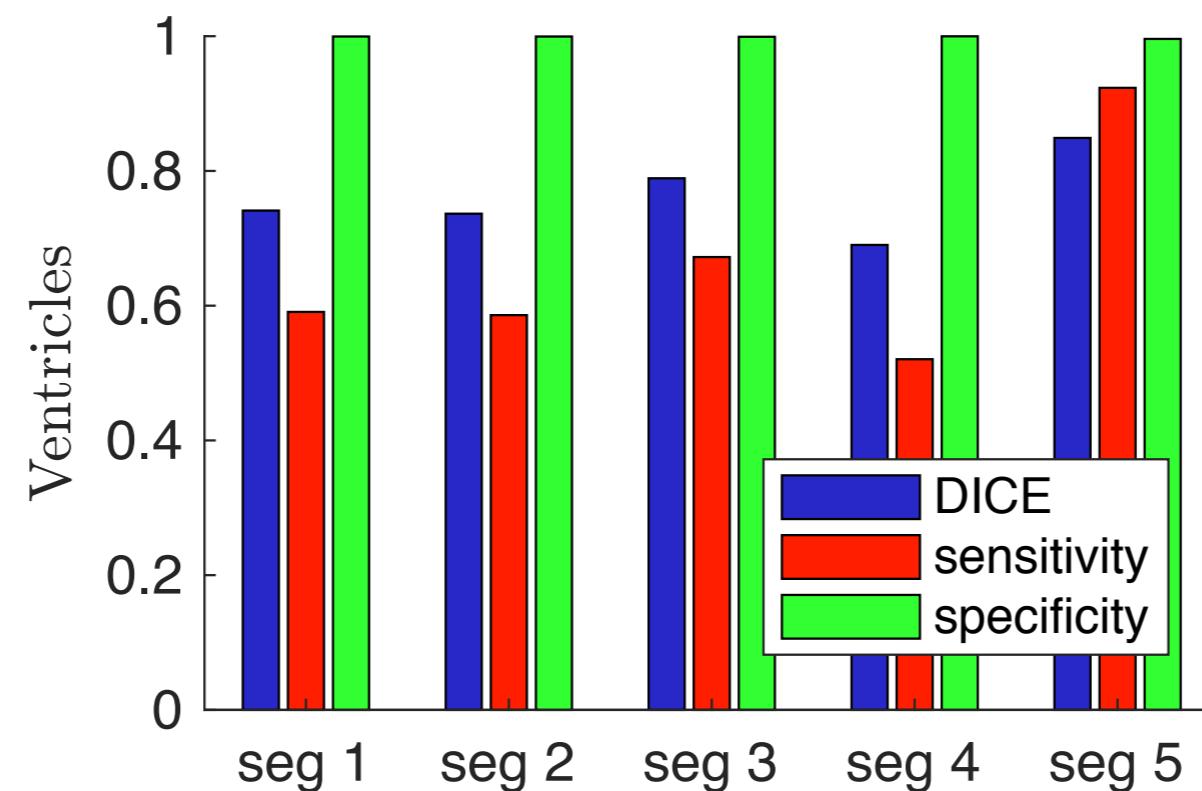
CT scan



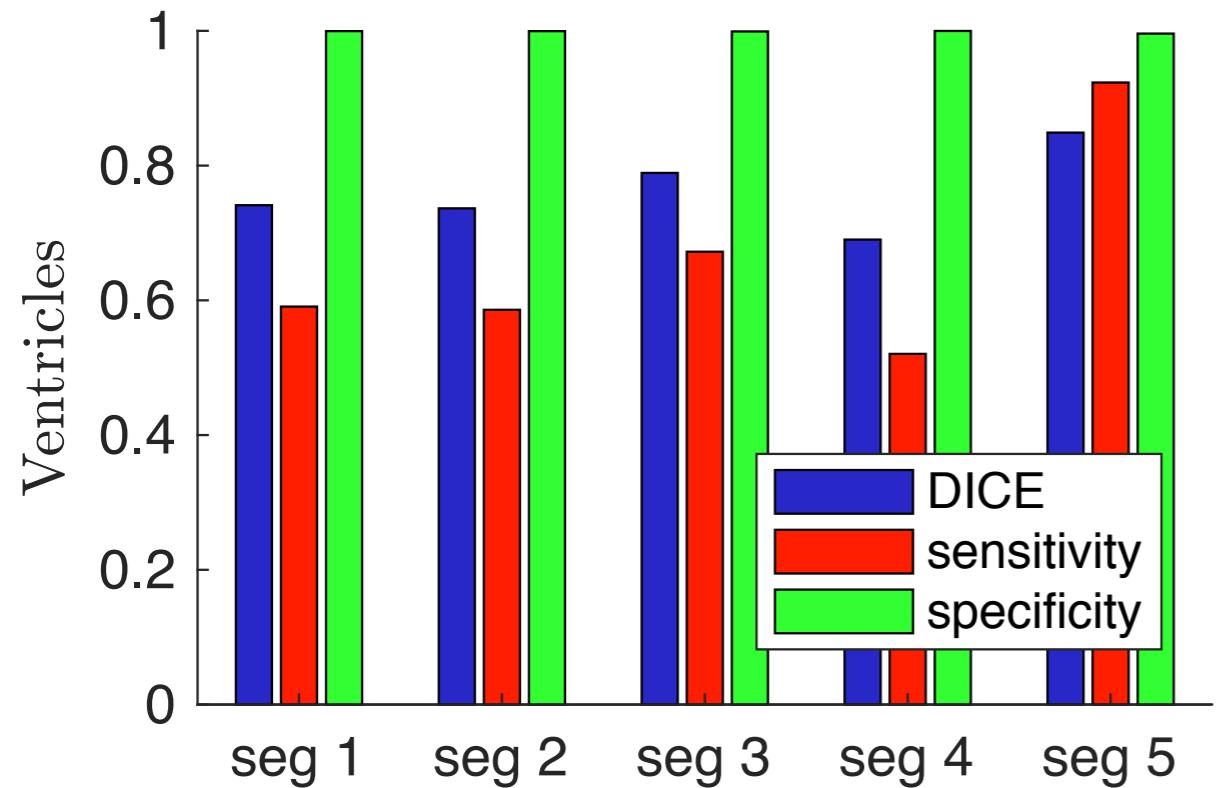
Covalic

STAPLE

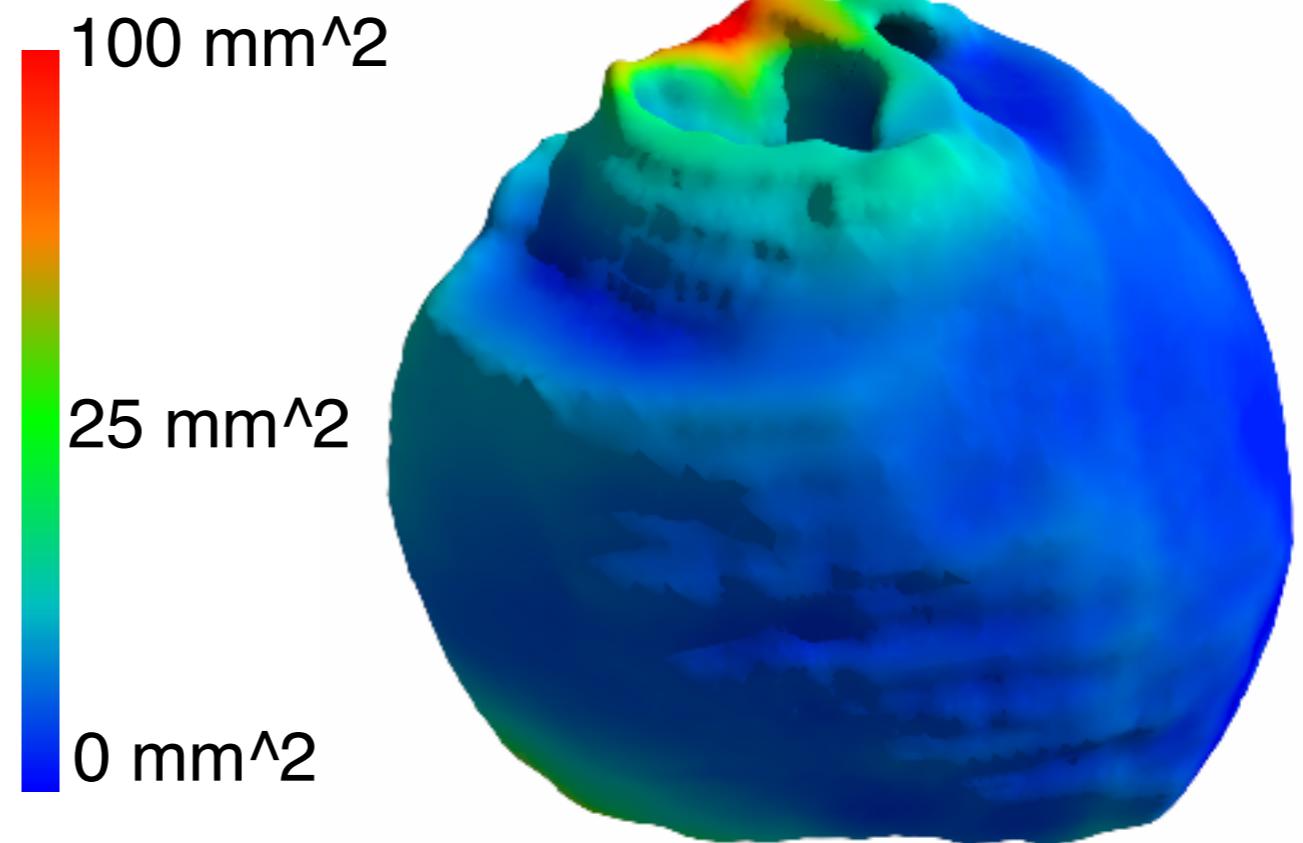
# Segmentation Variation



# Segmentation Variation



Variance of  
min distance



# Quantify the effect of segmentation variation on ECGI solutions

Covalic



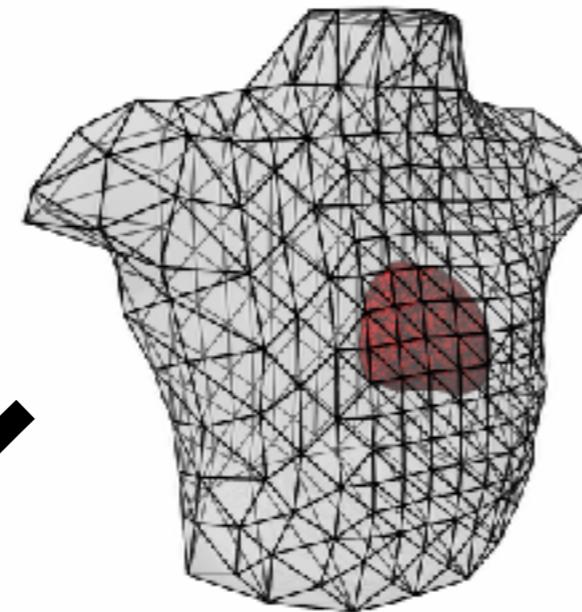
Segmentation



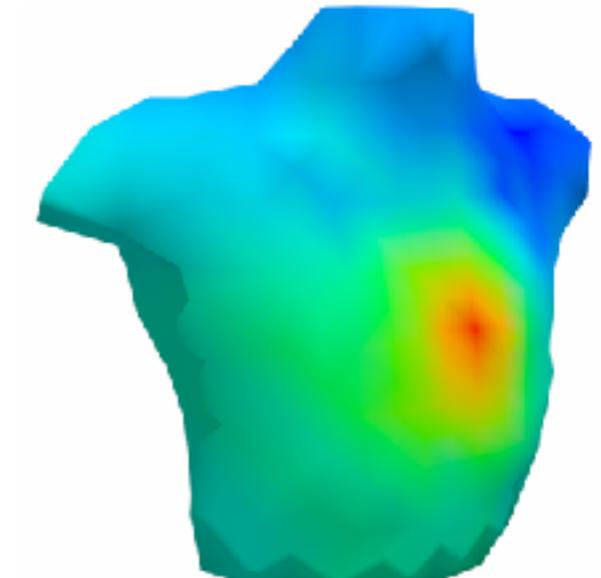
Heart Mesh

# ECGI pipeline

x6

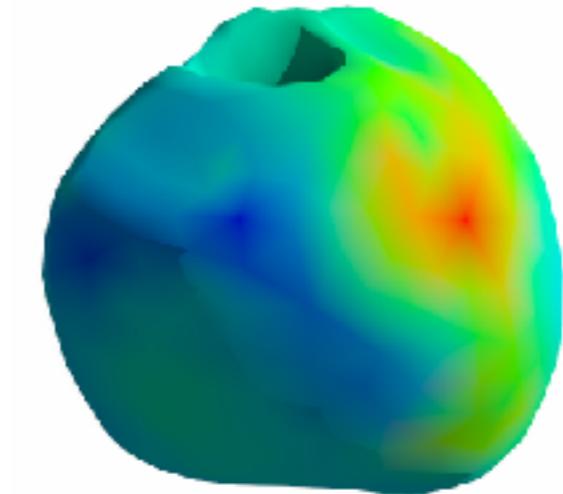
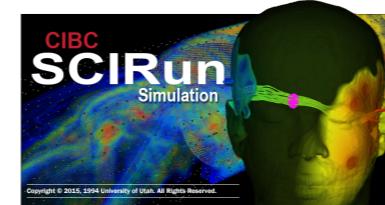


Torso Mesh



BSPM

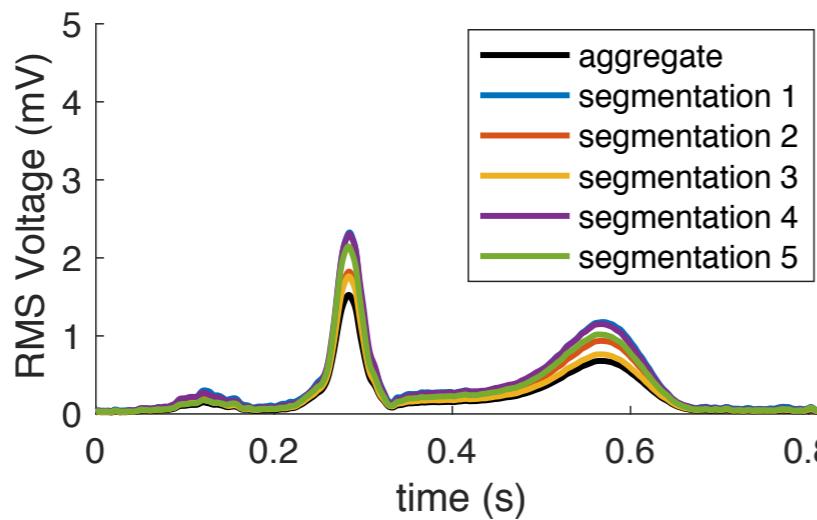
Forward  
Matrix



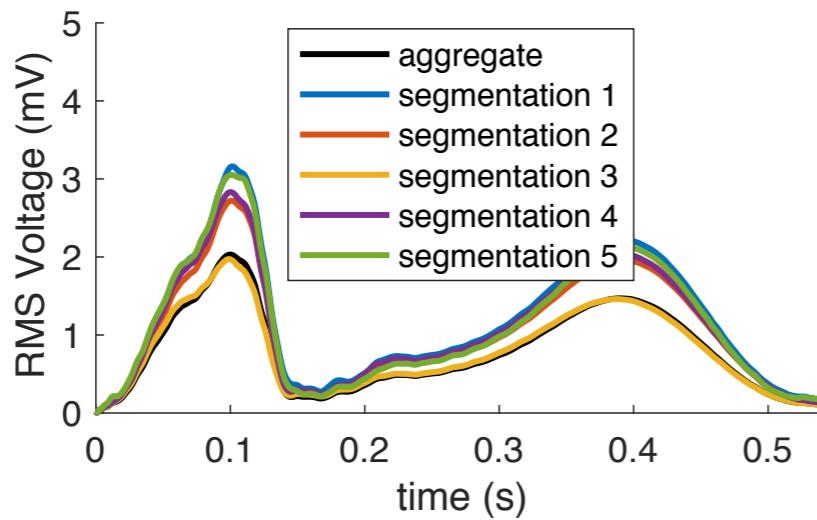
ECGI

# Variance Over Time

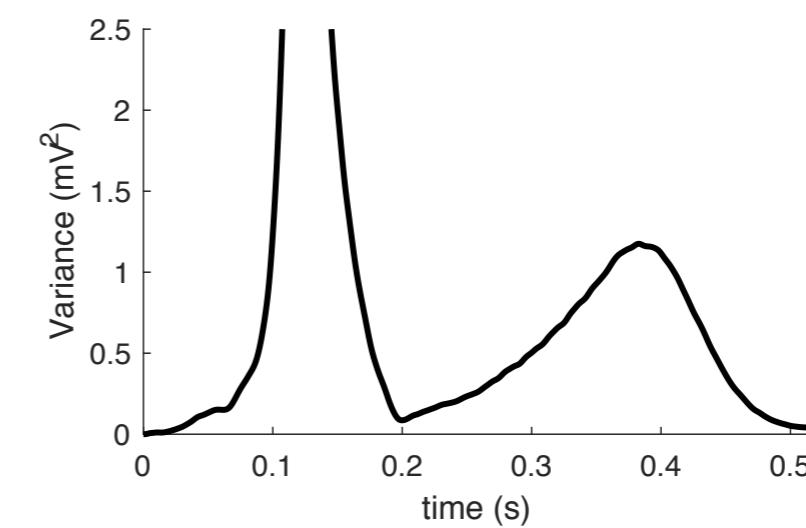
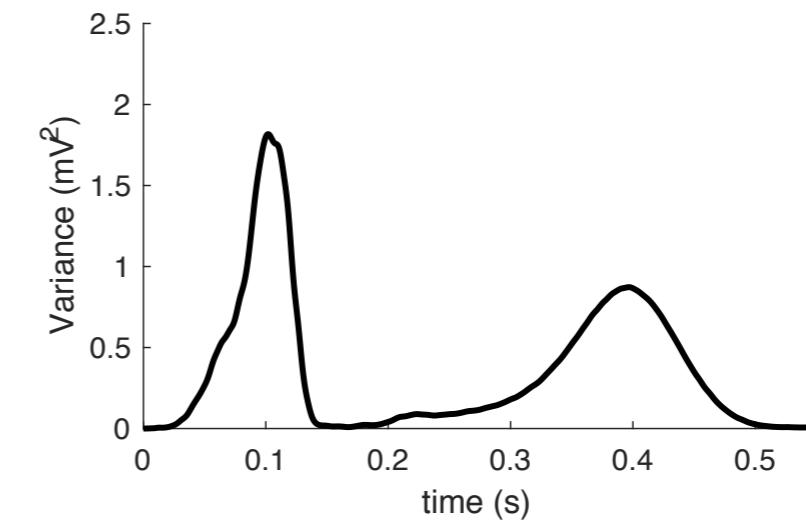
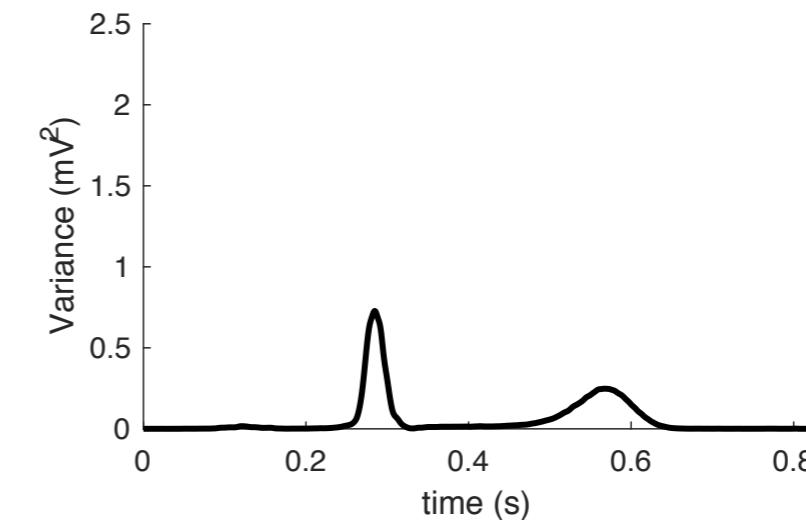
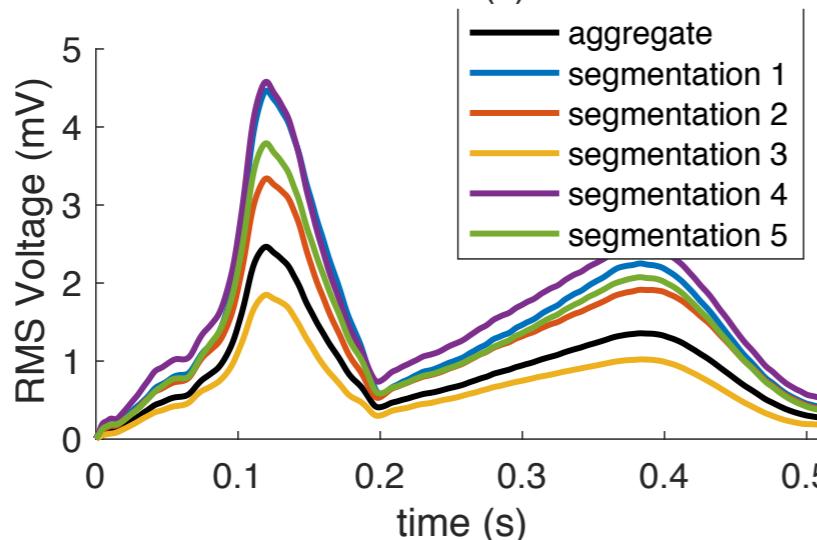
Sinus



LV stim

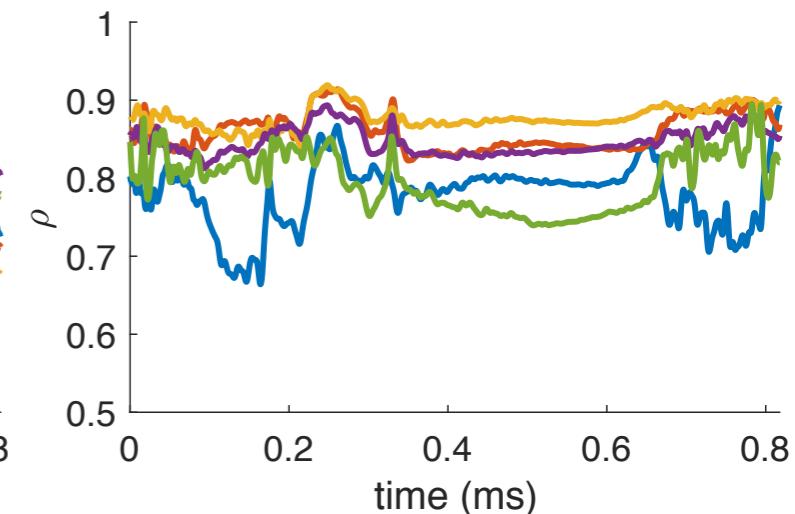
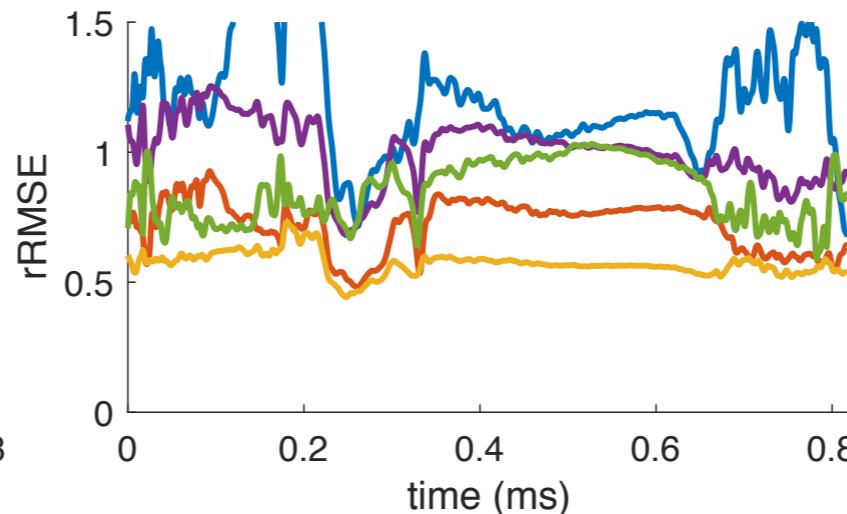
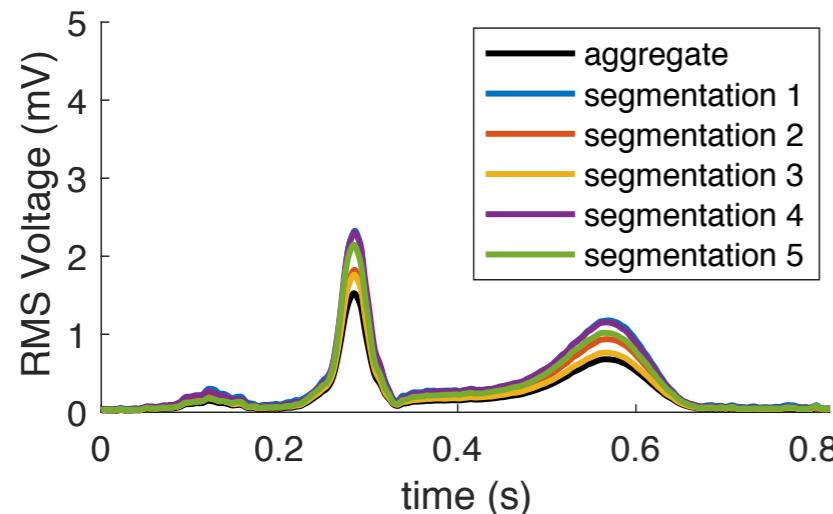


RV stim

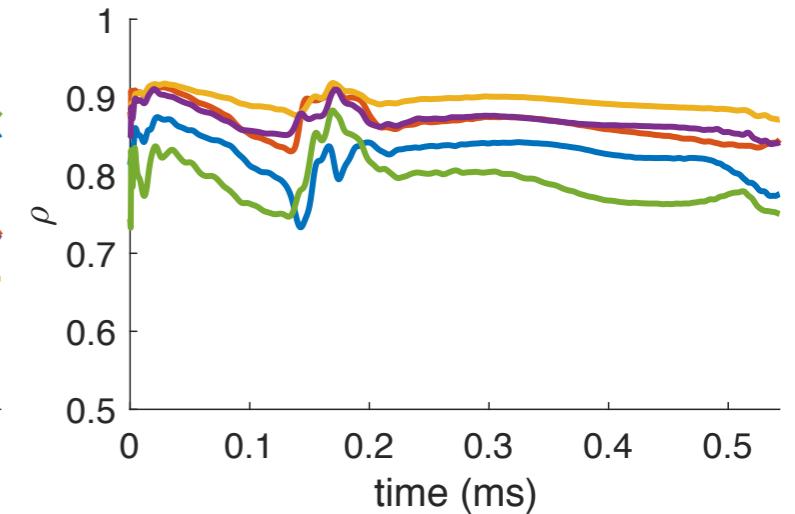
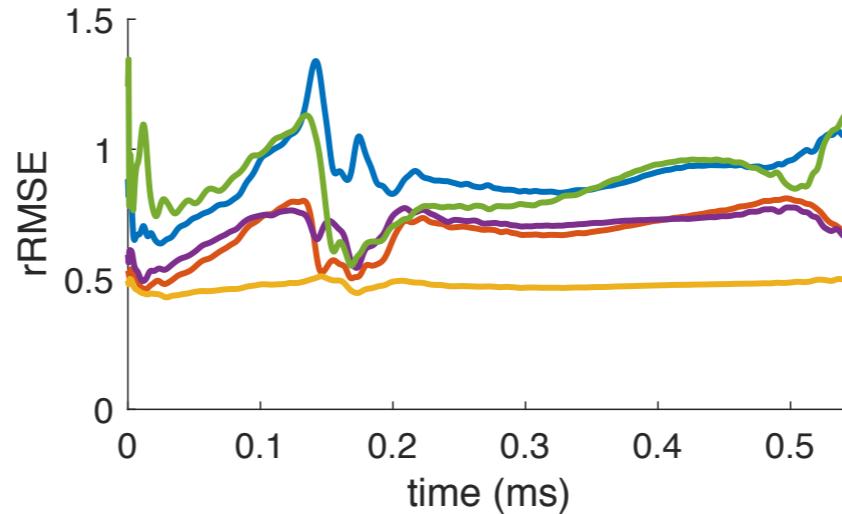
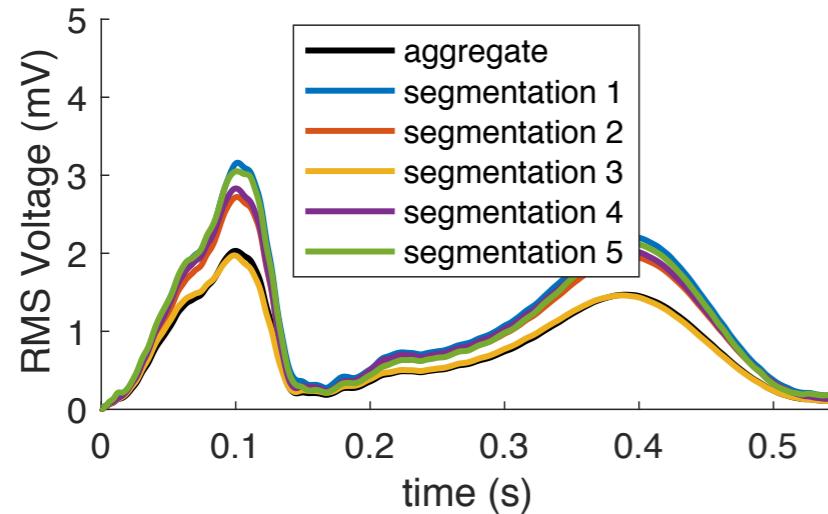


# Variation Over Time

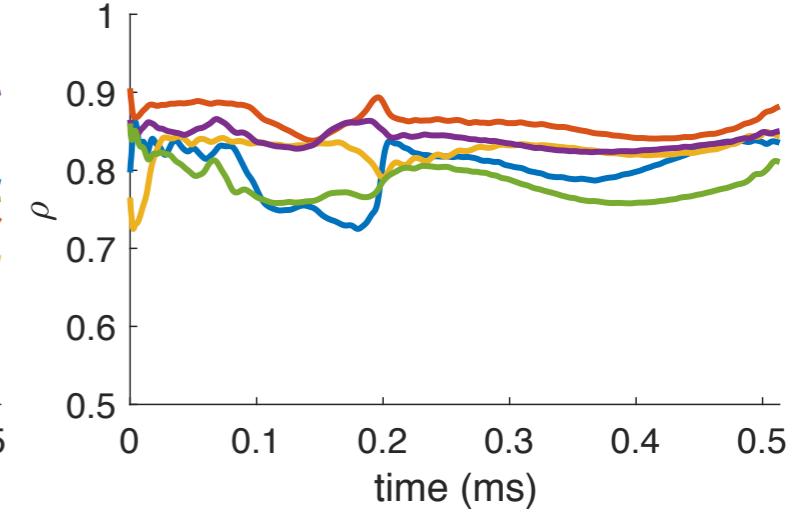
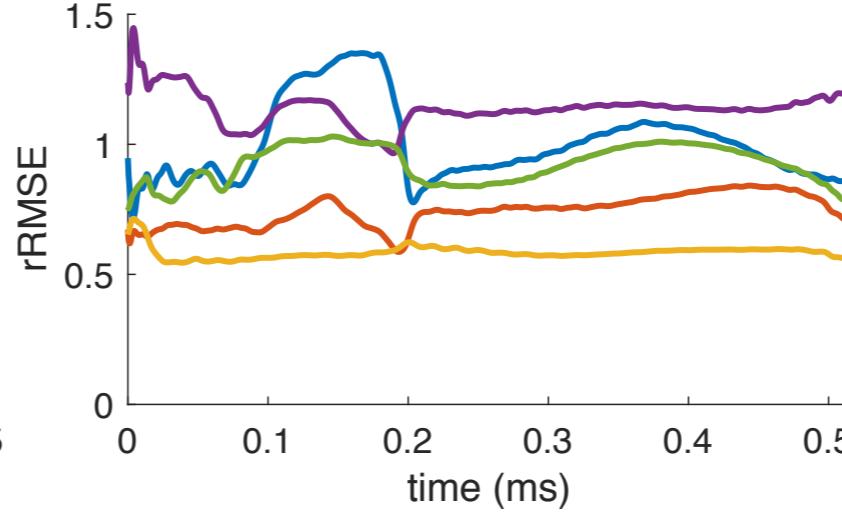
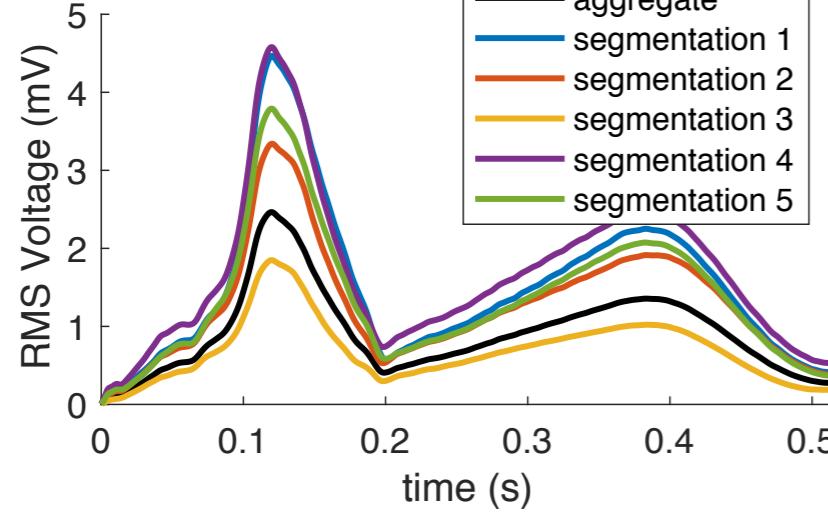
Sinus



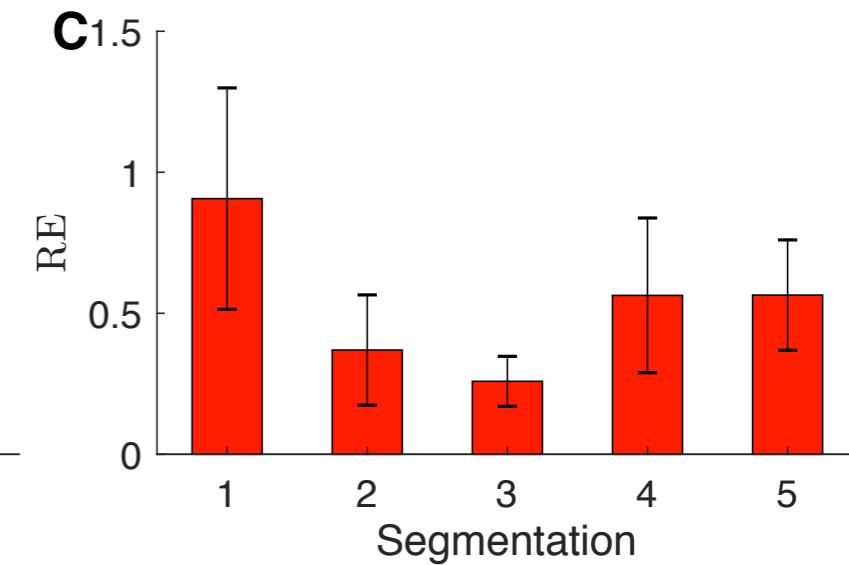
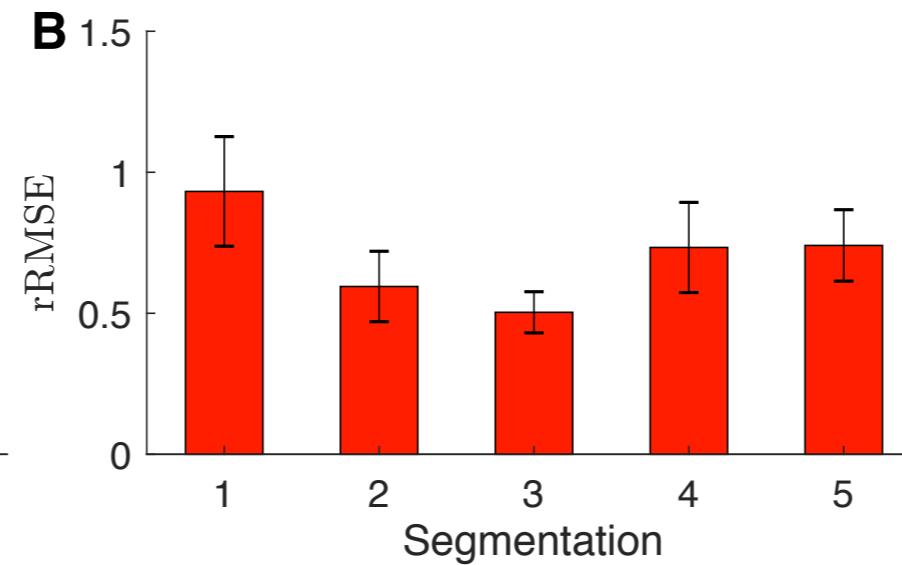
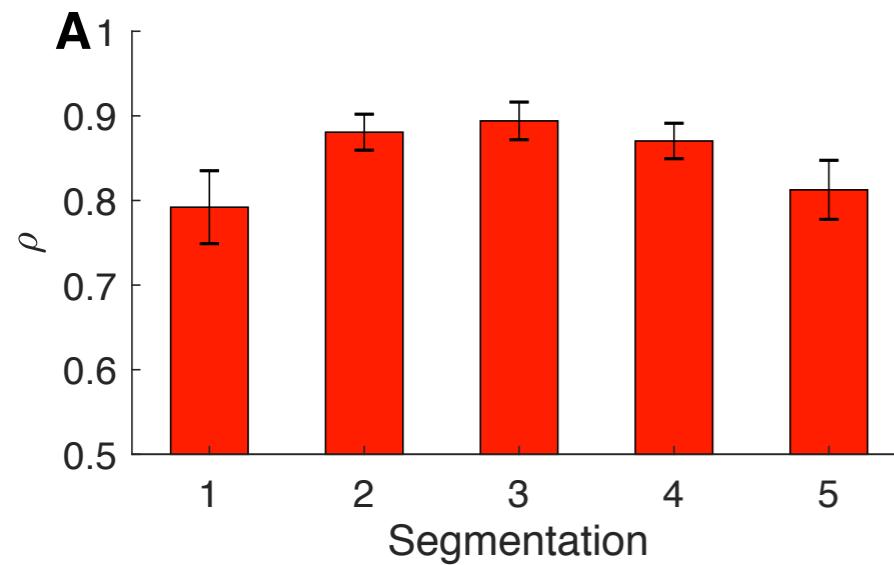
LV stim



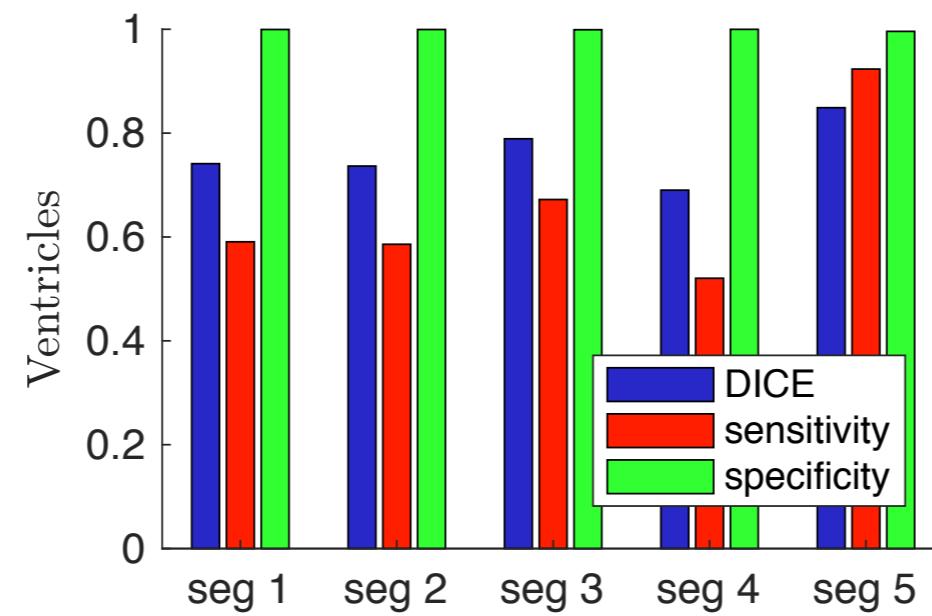
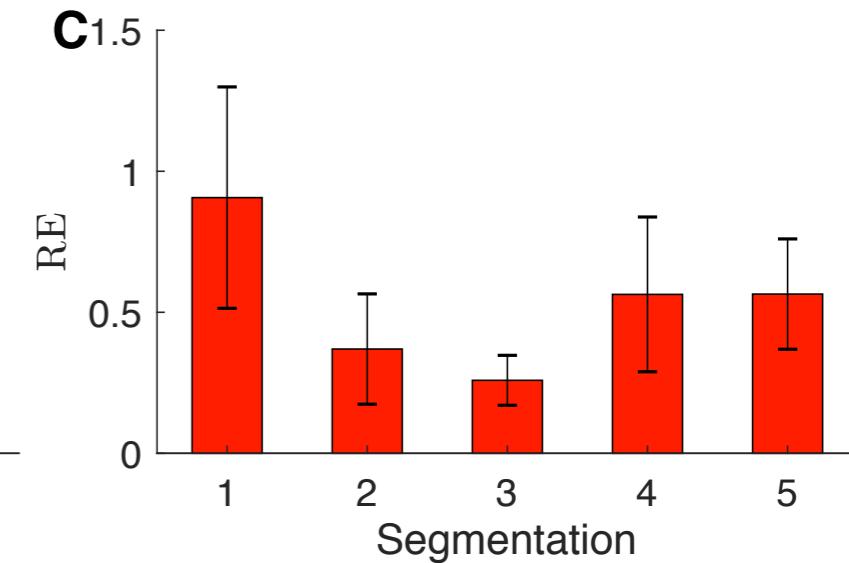
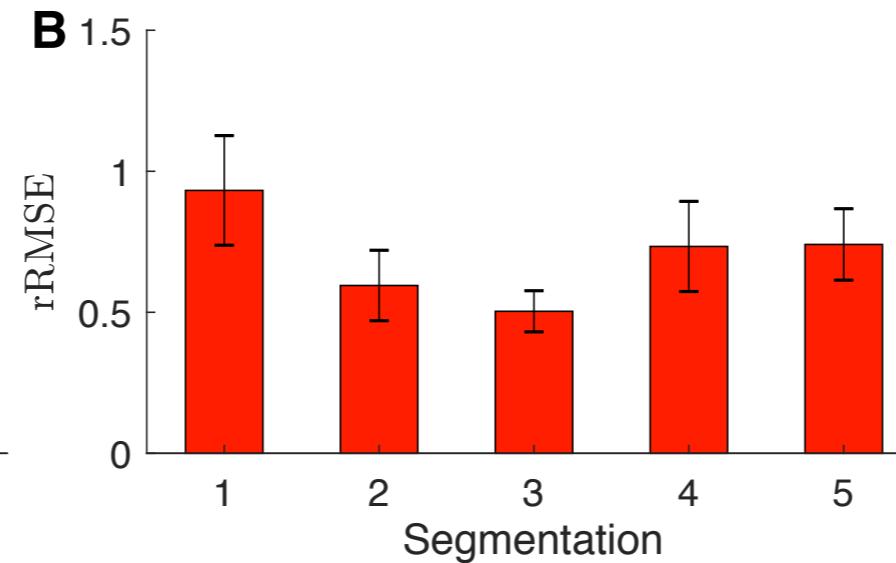
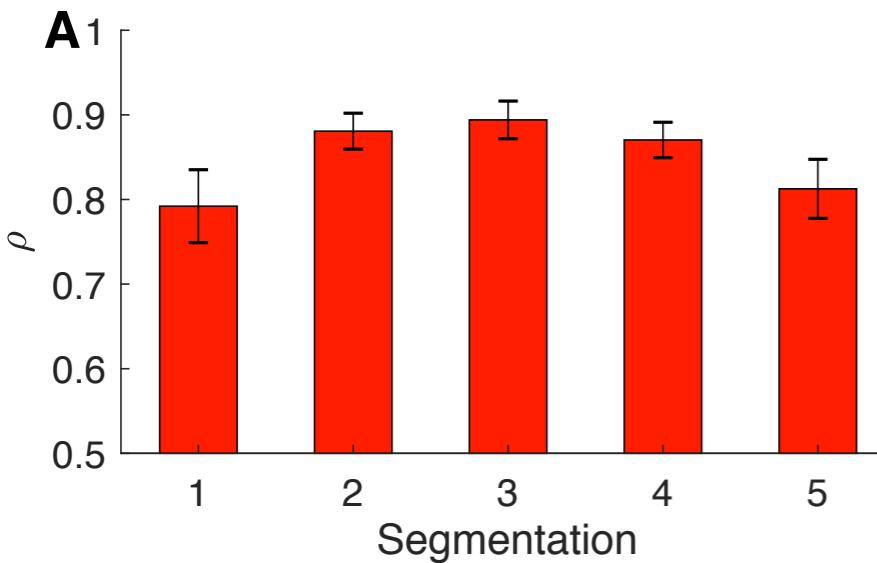
RV stim



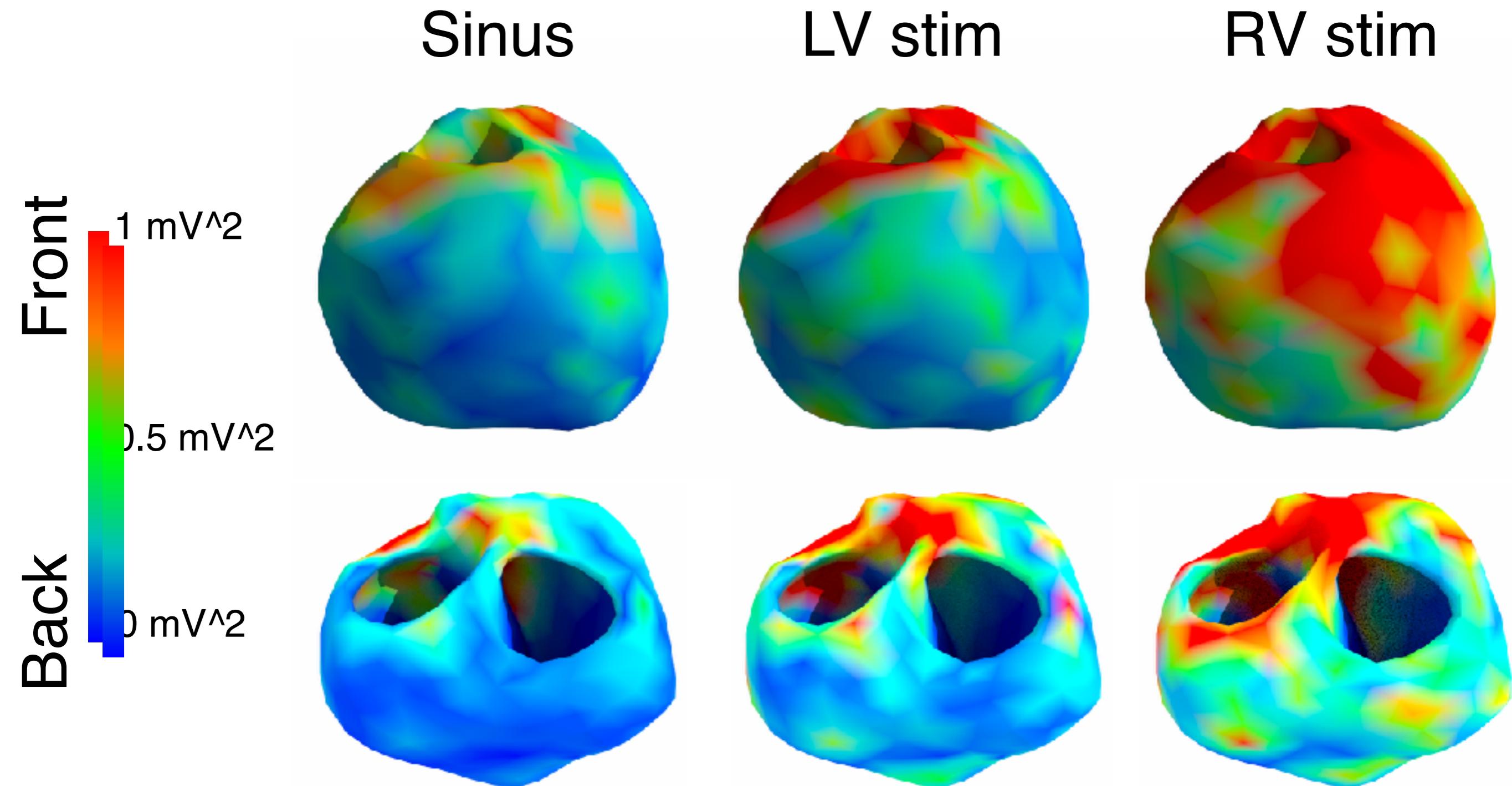
# Total Error



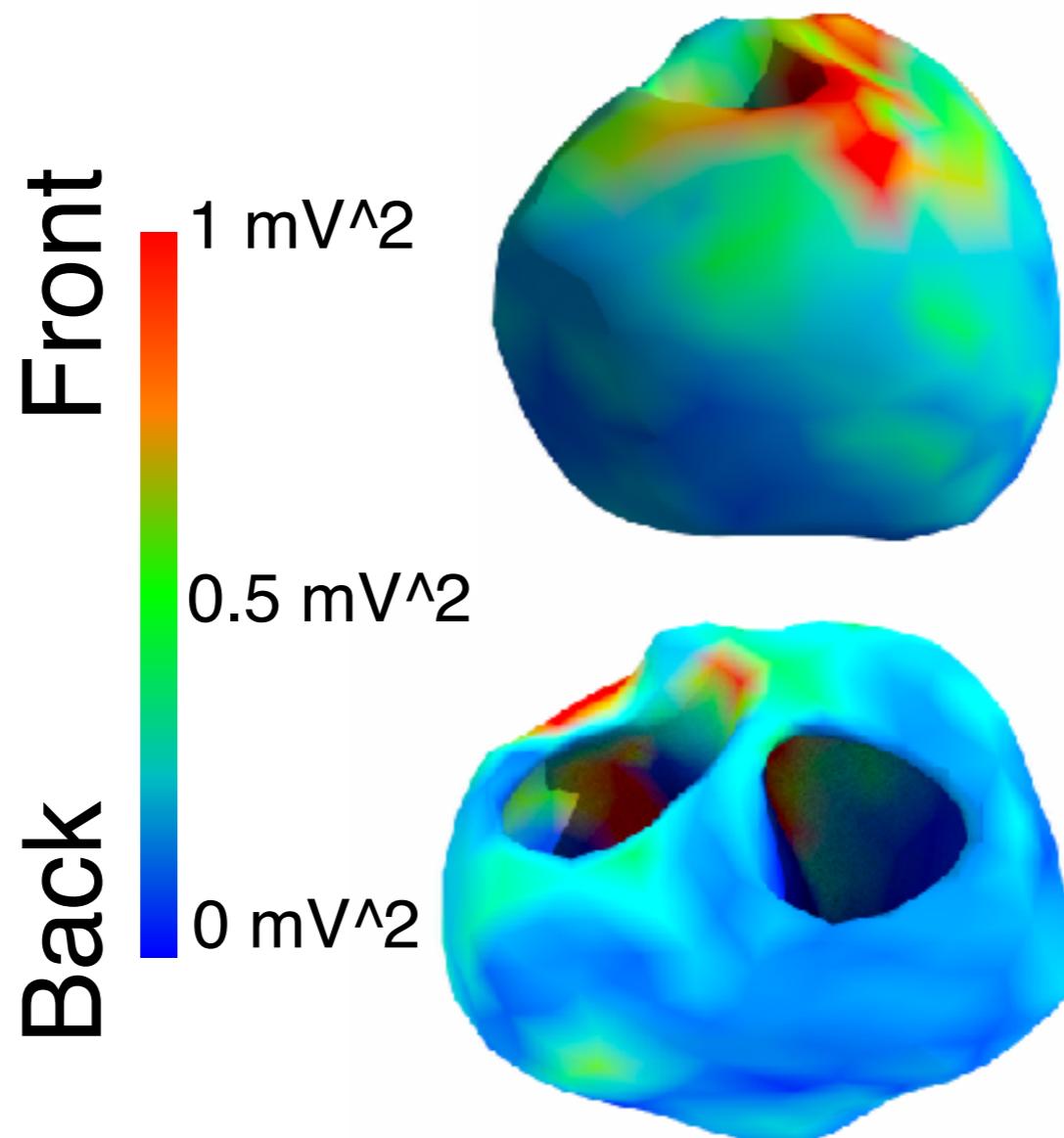
# Total Error



# Locations of High Variance



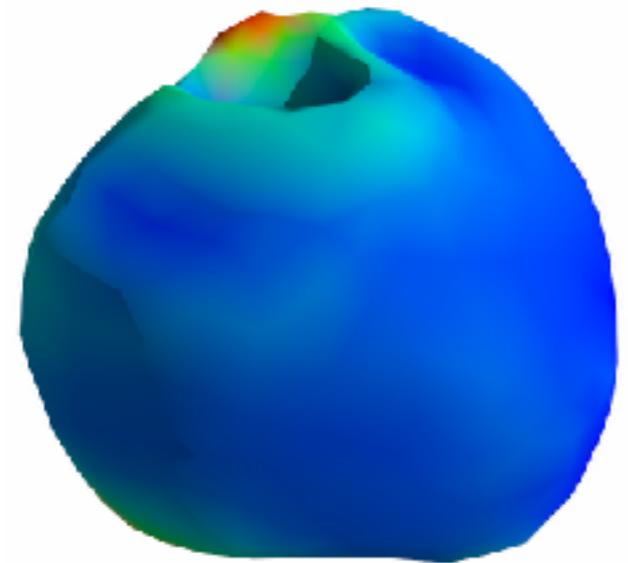
# Variance of Solutions and Meshes



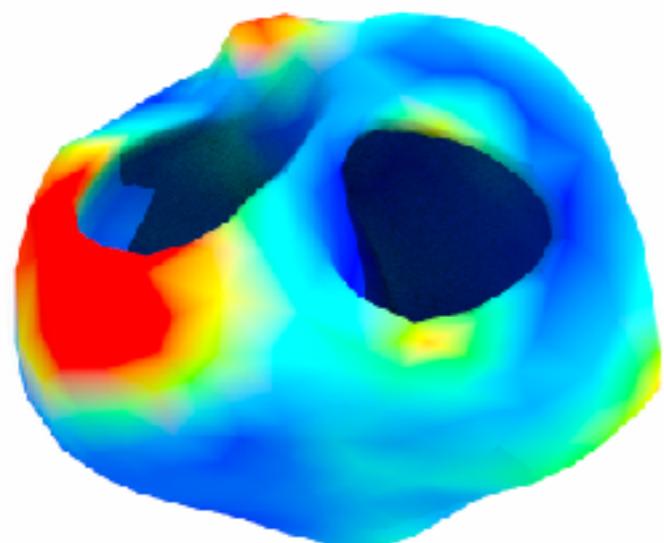
Solution Variance

# Variance of Solutions and Meshes

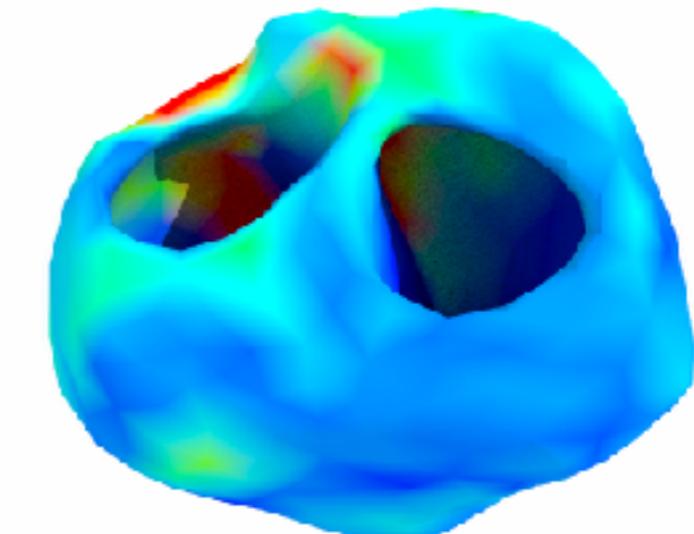
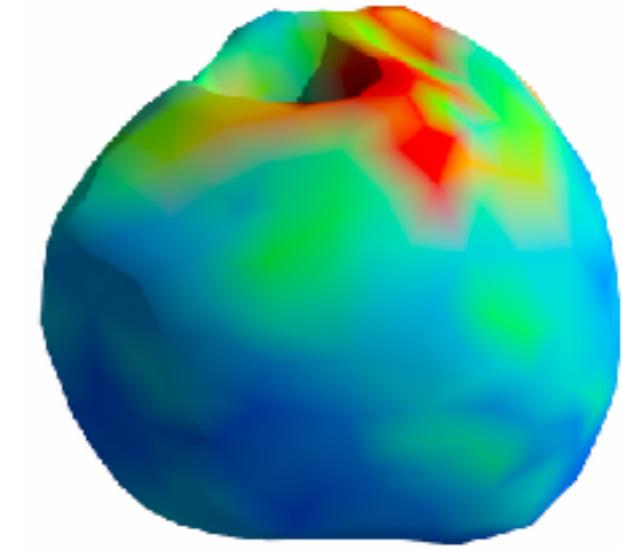
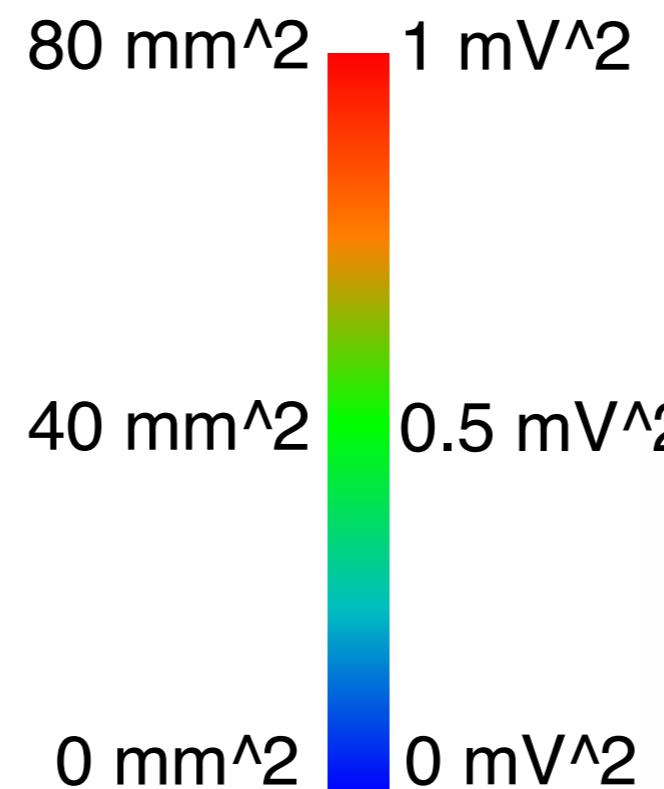
Front



Back



Mesh Variance



Solution Variance

ECGI can be  
sensitive to  
segmentation errors

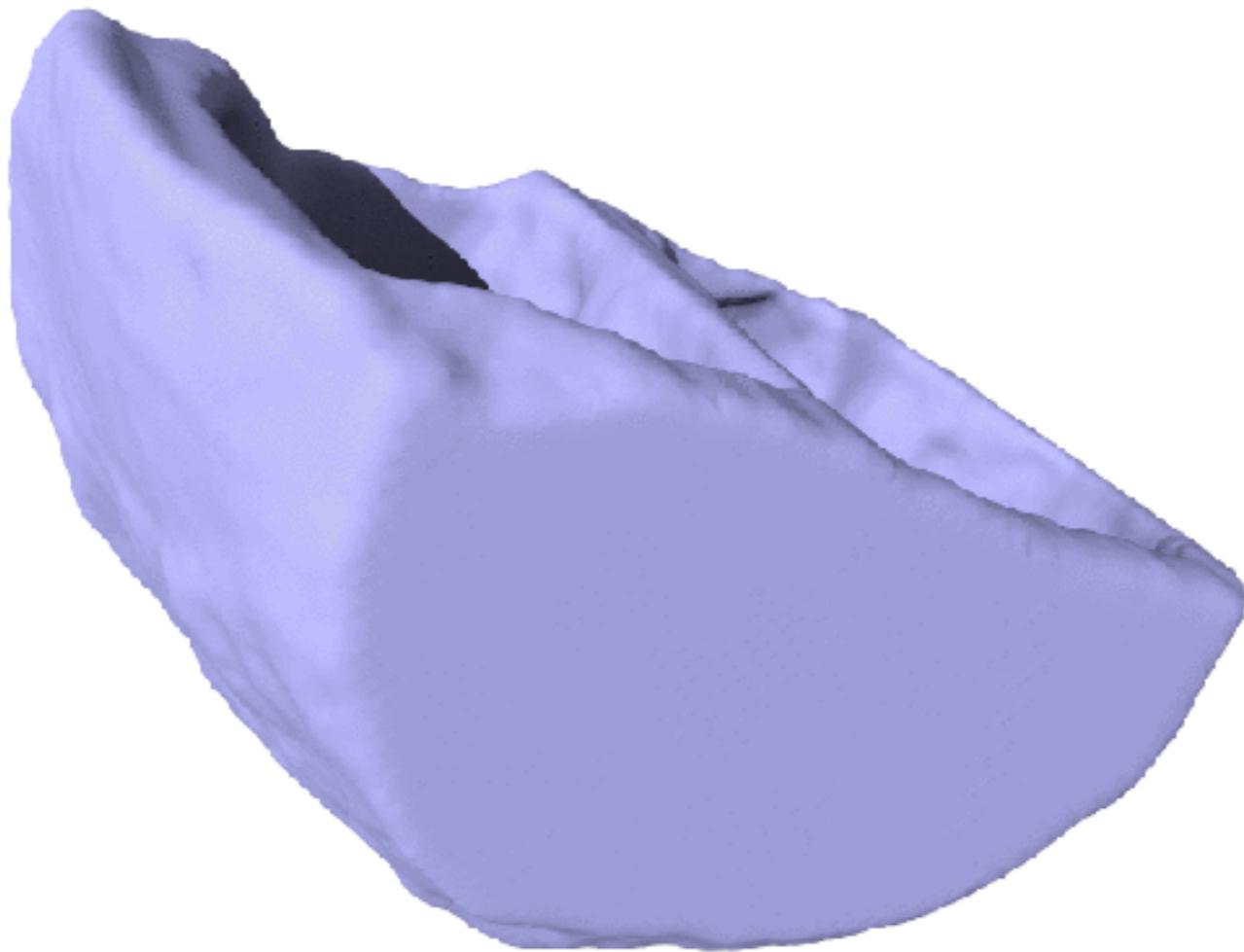
# High variance in ECGI solution corresponds to high variance in Segmentation

High variance in ECGI solution  
corresponds to high variance  
in Segmentation

Anterior region is more  
sensitive to segmentation  
variation

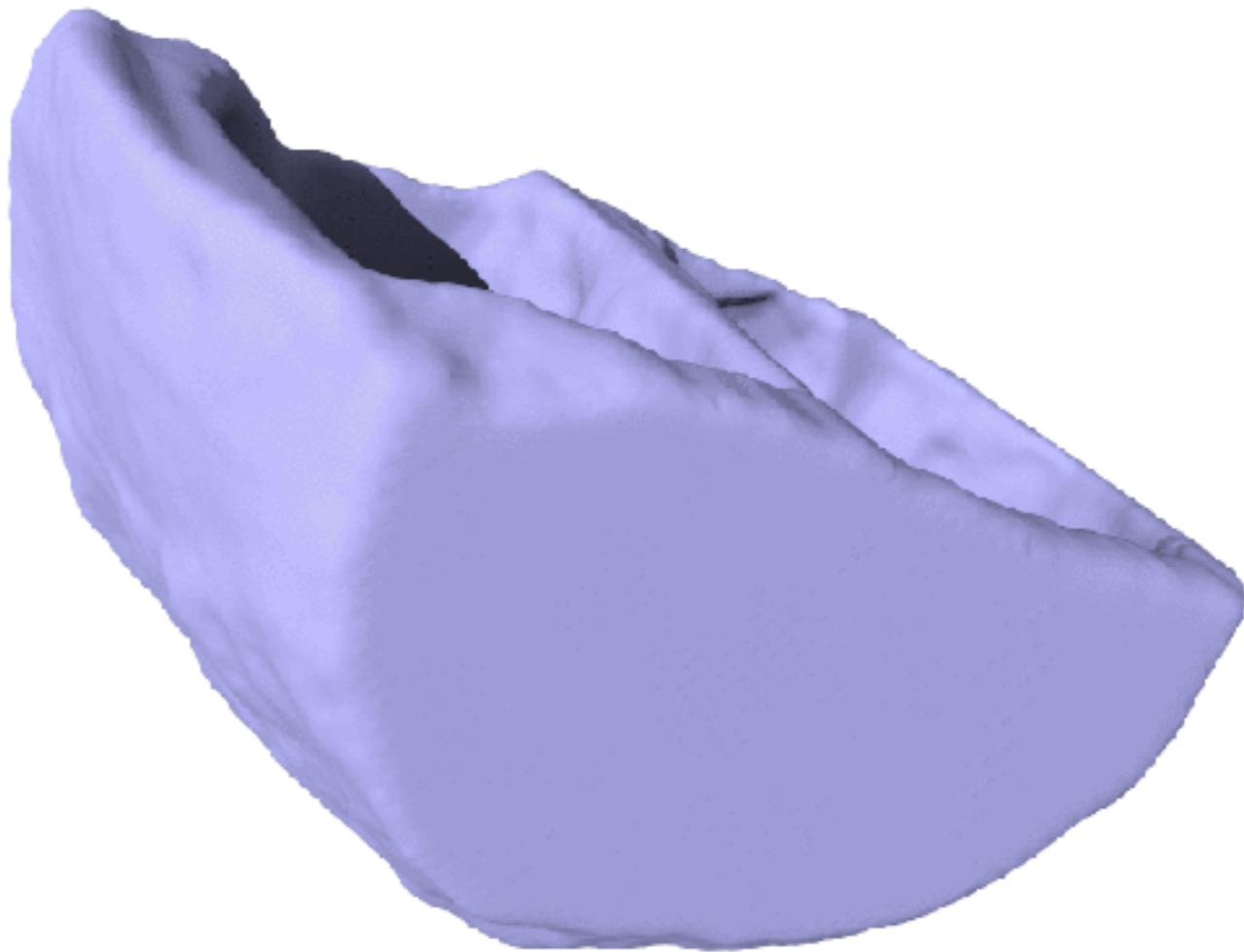
# What's Next?

## Shape Analysis

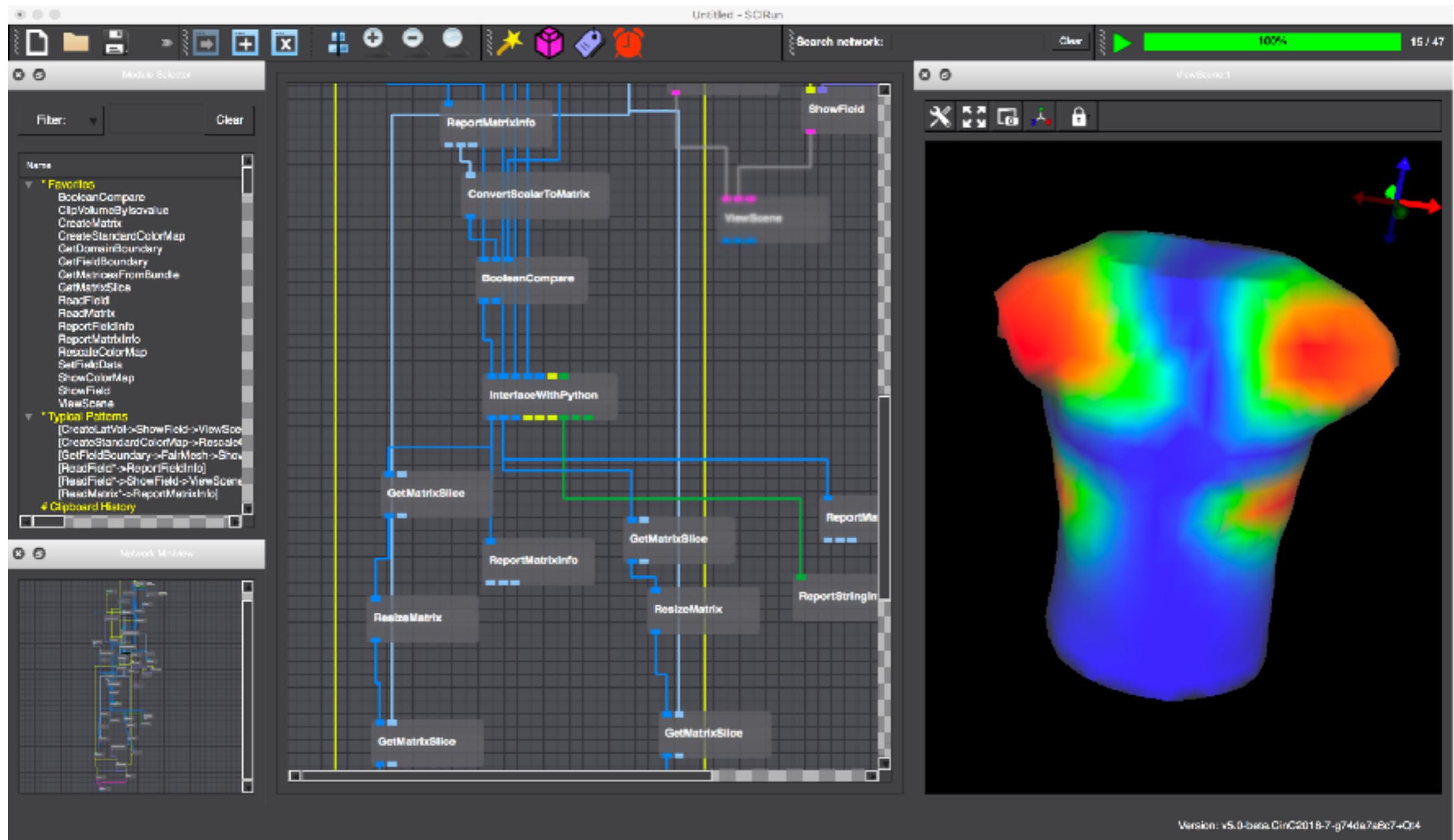


# What's Next?

## Shape Analysis



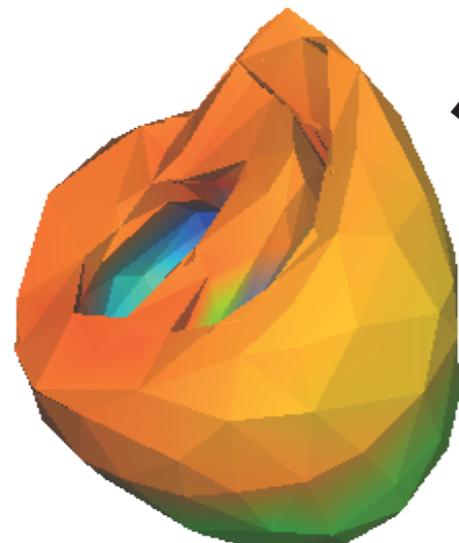
# What's Next?



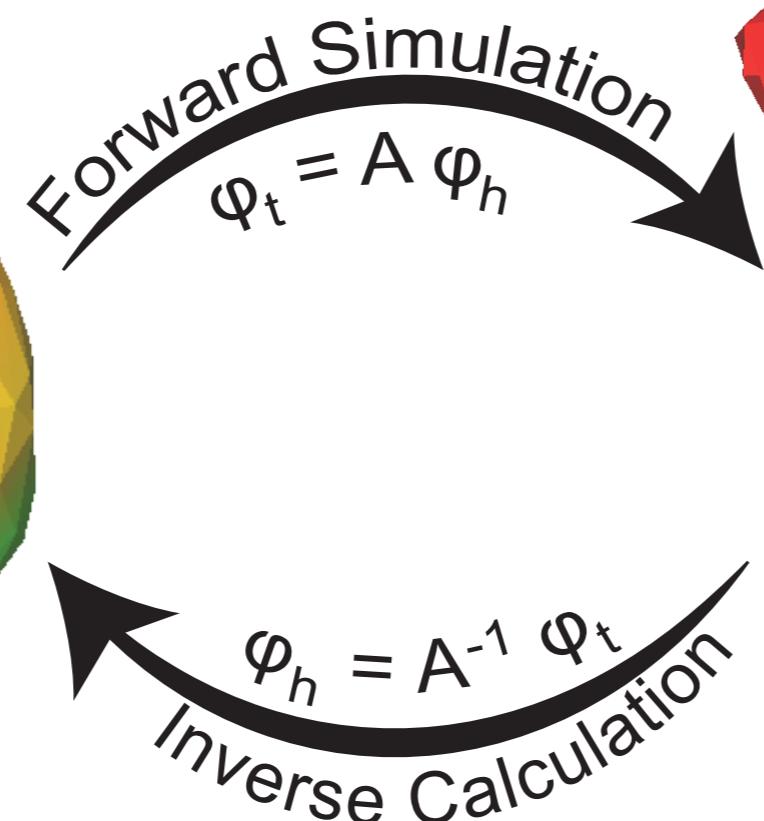
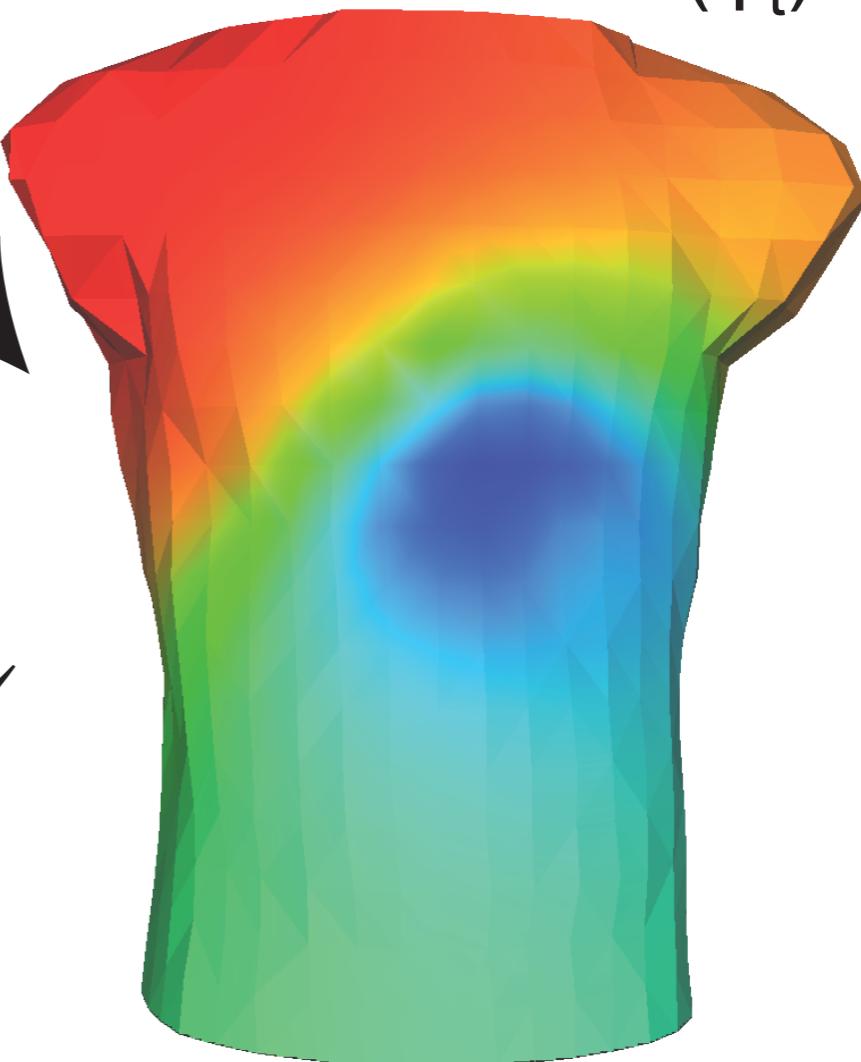
## Uncertainty Quantification

# Improve ECGI

Heart Potentials ( $\varphi_h$ )



Torso Potentials ( $\varphi_t$ )



## Quantify Uncertainty

# Acknowledgements

## People

Jaume Coll-Font  
Sandesh Ghimire

## Data Submissions

Wilson Good  
Nejib Zemzemi  
Sophie Giffard-Roisin  
Eric Perez-Alday  
Peter van Dam

## Clinical Data

John Sapp and Milan Horáček and  
Dalhousie University

## Support

Center for Integrative Biomedical Computing  
NIGMS NIH P41 GM103545-18

Consortium for ECG Imaging ([ecg-imaging.org](http://ecg-imaging.org))



# More Submission Needed

<https://challenge.kitware.com/>

The image data for a nrrd file is a stream of numbers. The order of the data should iterate x first, then y, then z. If the data is a 3D matrix  $M$  of size  $nx$  by  $ny$  by  $nz$ , the data array ( $D$ ) should match to the matrix index ( $M[i, j, k]$ ) as:

$$D[i*nx*ny + j*nx + k] = M[i, j, k]$$

assuming zero based indexing and  $i, j, k$  are the indices for the  $x, y, z$  directions respectively. Make sure that the data type field in the header matches the value that the data will be written in. Now to write the file, write the header string, with a new line at the end, then write the data.

If there are questions, do not hesitate to [ask](#).

## Stage 2: Mesh Generation

With this stage we will quantify differences in meshing techniques used by different groups. We will be making the meshes based of an average of the submissions from Stage 1, therefore, we will have more details on this stage at a later time.

## Stage 3: Forward Transform Matrix

With this stage we will quantify differences in techniques of calculating the forward matrix for ECG used by different groups. Again, we will base this calculation on a common input from the submissions from Stage 2, therefore, we will have more details on this stage at a later time.

### PHASES FOR THIS CHALLENGE +

- ① [Stage 1: Dalhousie Segmentation](#) ≡
- ① [Stage 1: Auckland Segmentation](#) ≡
- ① [Stage 1: Nijmegen Segmentation](#) ≡