

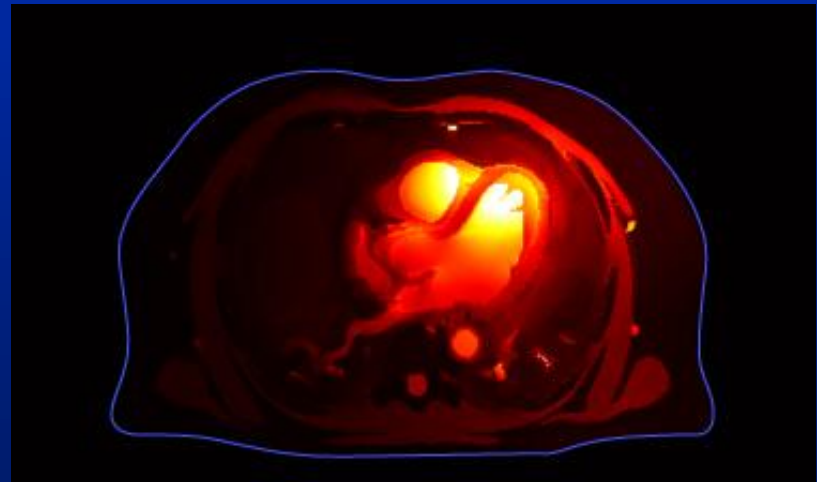
Evaluation of Reconstructed Images of Regional Lung Changes Using a Model

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Question?

How do regional changes in lung resistivity appear in images using a model for the forward data?

Model Used

ECG gated MRI image

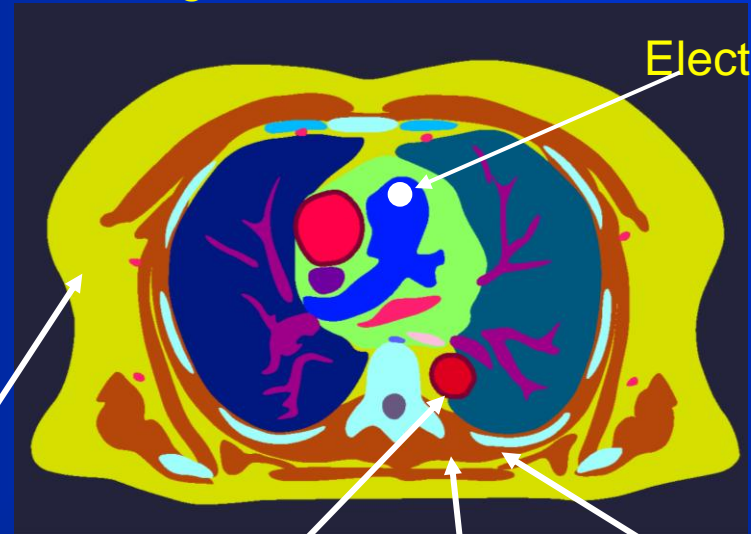
Each 50 ms during cardiac cycle



5 mm slices

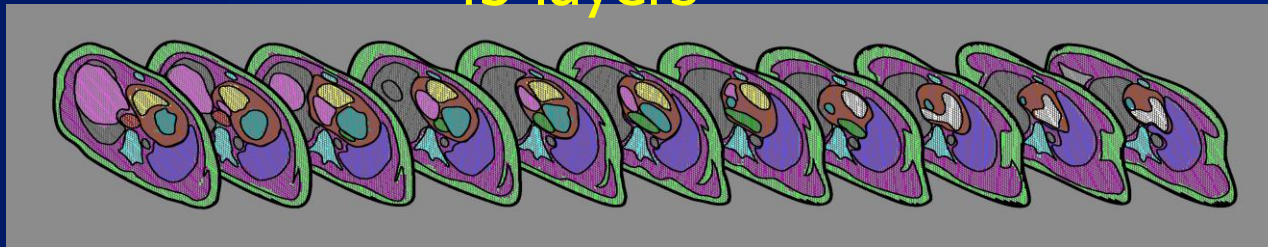
Segmentation

Using Abode Illustrator

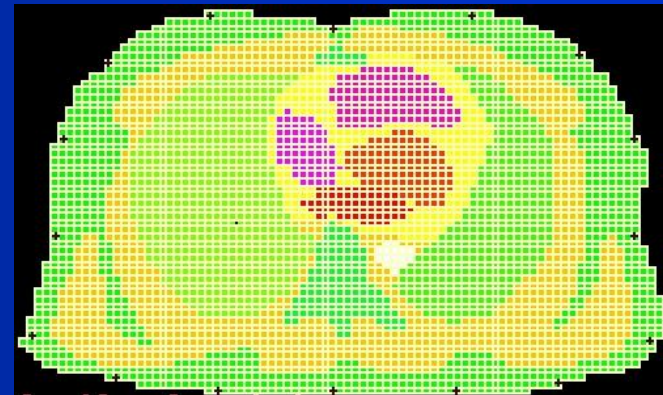


Fat: 2000 Ωcm Aorta: 150 Ωcm Rib: 2000 Ωcm
Muscle: 400 Ωcm

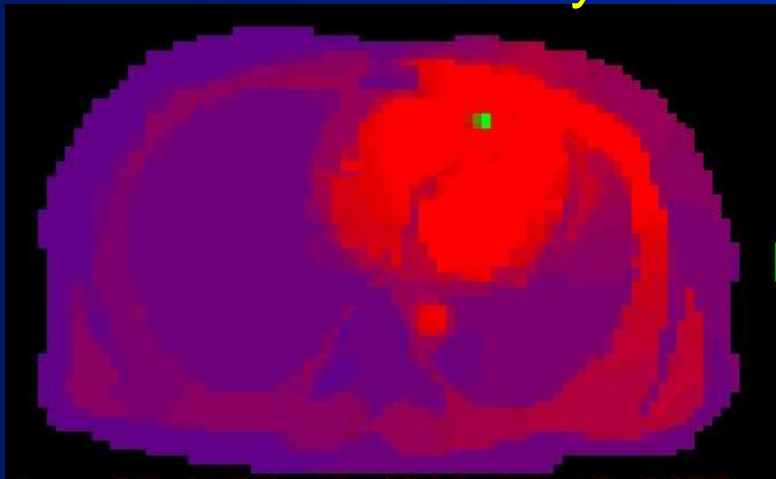
43 layers



Low or high resolution meshing?



Low resolution
Current Density



216 000 elements
10 x 3.7 x 4.2 mm

High resolution
Current Density



3.8 million elements
5 x 1.5 x 1.5 mm

A Friendly GUI for Model Creation and Analysis

MIND EIT Forward Solver (MEFS) is a MATLAB based graphic user interface software package that provides a forward solution for the Sheffield electrode arrangement

MIND EIT Forward Solver (MEFS)

Choose a model

Create Model...

Select From Model Catalog

EITfwd
EITfwdLean

Model Info

end-diastole model at end
with 16 electrodes placed

Apply

Replicate An Existing Model

Existed Model Browse Apply

Model Name: Save As: Browse

Apply Cancel Next

Modified Lung Regions

Model Scaling

Model Scaling: 0%

Linear Scaling: 0%

Apply Cancel

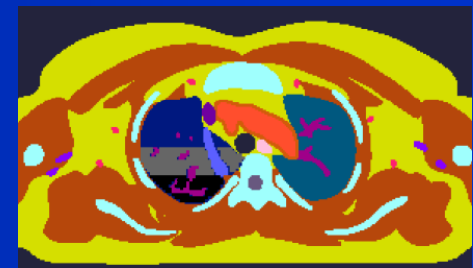
Back Next

Tissue Palette

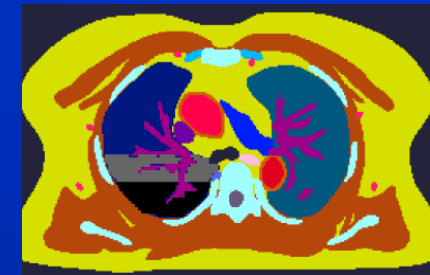
Air	Jg Vein	Brach/Sub Vein	SVC	IVC	Spinal Cord	Asc aorta	Aortic Arch	Desc aorta
Carotid Art	Brach/Sub Art	Other Blood	Azygous Vein	RA	RV	Pulm Art	Pulm Vein	LA
LV	Skel M long	Skel M cross	Myocardium	Heart fat	R Lung	L Lung	Fat	Esophagus
Cartilage	Liver	Kidney	PTrunk	Spleen	Stomach	Esophagus	Diaphragm	Aortic Wall
Opt A	Opt B							

Eraser Mode
R: Nan
G: Nan
B: Nan

Apply Cancel



Level 10



Level 16



Level 27



Level 33



Modified two posterior lung regions

Modify Tissue Resistivity?

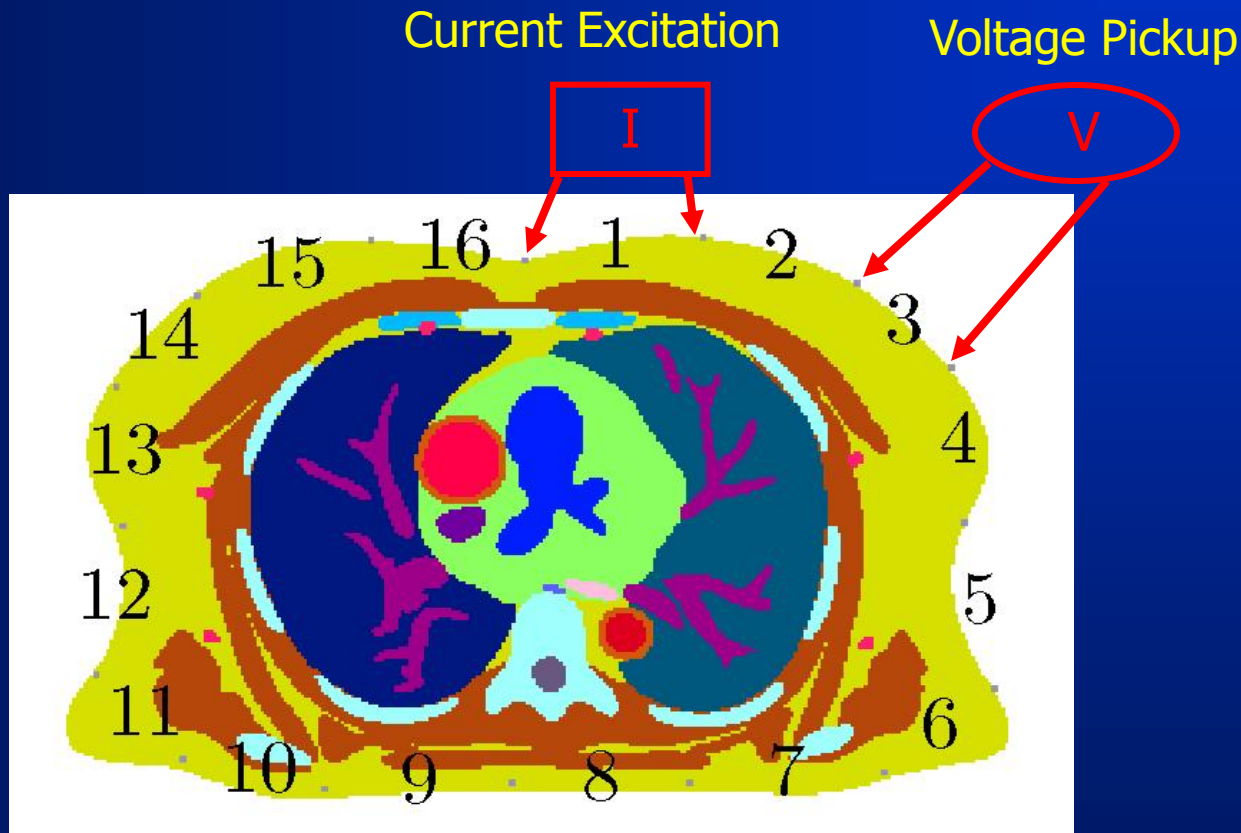
Resistivity Setting (ohm-cm)

Tissue	Rho(x)	Rho(y)	Rho(z)	Label
pulmonary vein	168	168	168	16
left atrium	150	150	150	17
left ventricle	150	150	150	18
skeletal muscle long axis	225	225	225	19
skeletal muscle across sectional	400	400	400	20
heart muscle	250	250	250	21
HEART FAT	2000	2000	2000	22
right lung	1400	1400	1400	23
left lung	1400	1400	1400	24
fat	2000	2000	2000	25
bone	2000	2000	2000	26
cartilage	2000	2000	2000	27

Resistivity Setting (ohm-cm)

Tissue	Rho(x)	Rho(y)	Rho(z)	Label
bone	2000	2000	2000	26
cartilage	2000	2000	2000	27
liver	600	600	600	28
kidney	600	600	600	29
pulmonary trunk	150	150	150	30
spleen	150	150	150	31
stomach	400	400	400	32
esophagus	400	400	400	33
diaphragm	400	400	400	34
aortic wall	250	250	250	35
option a	1000	1000	1000	36
option b	2200	2200	2200	37

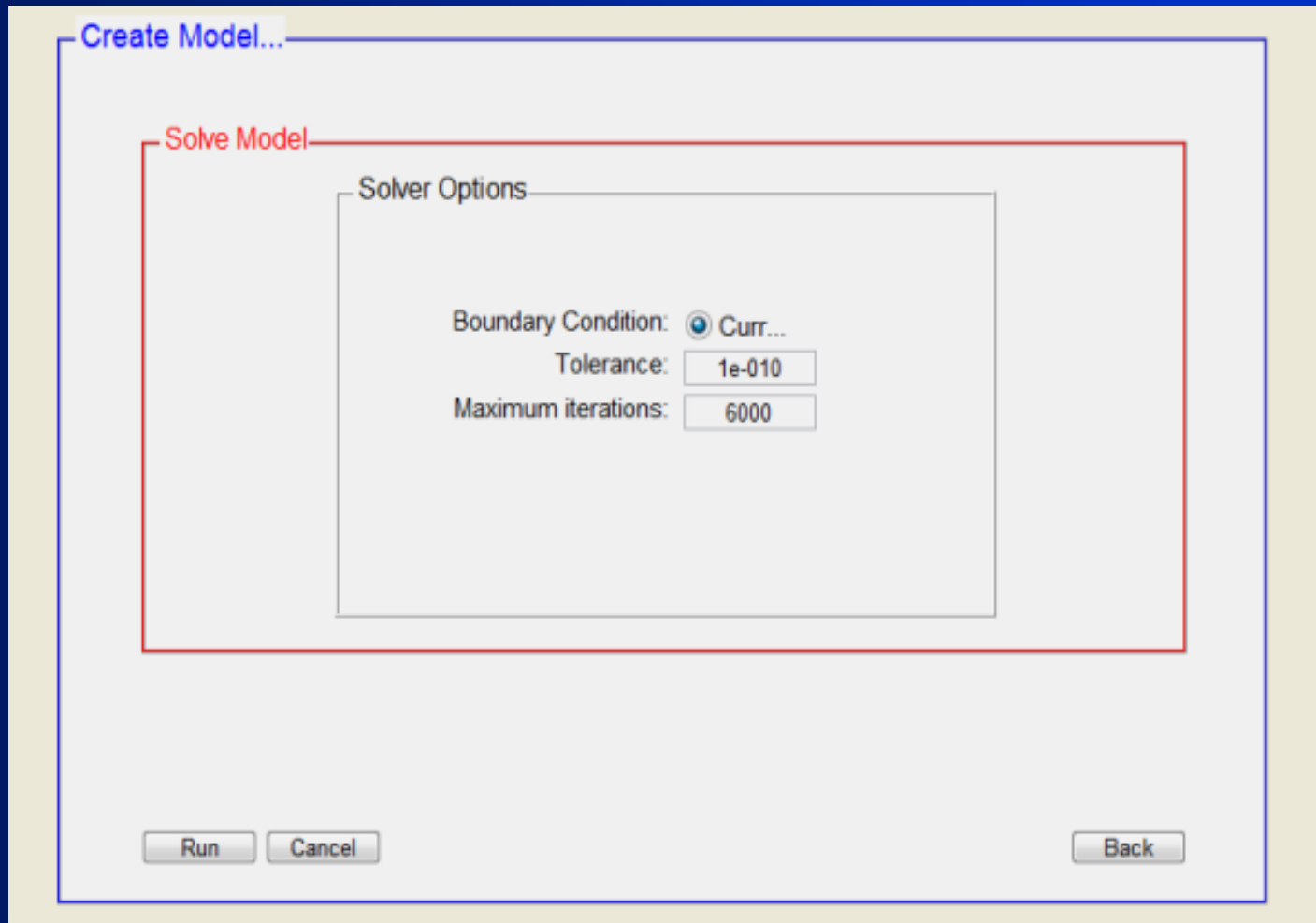
16 Electrodes at Mid-Thorax



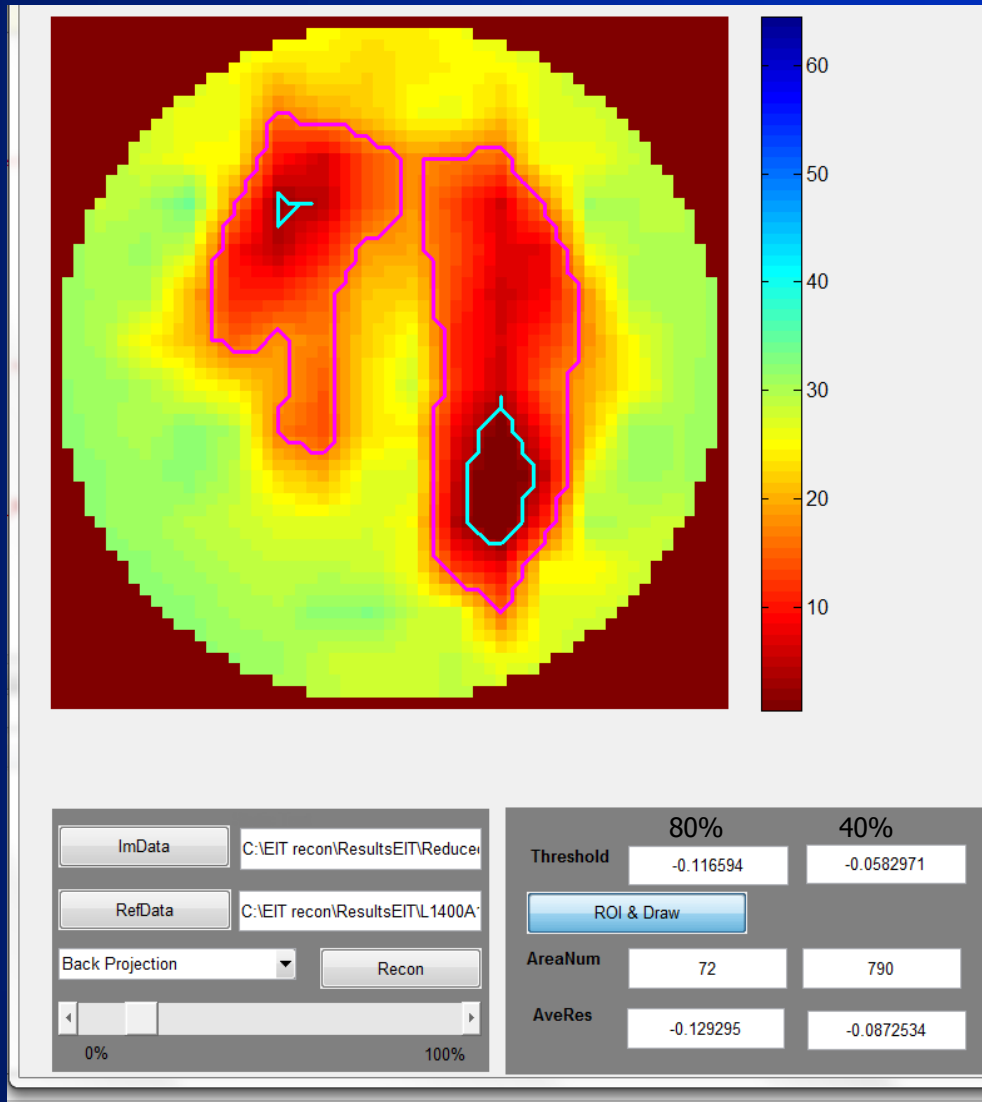
The model was solved 16 times for each unique current excitation

MIND EIT Forward Solver (MEFS)

RUN



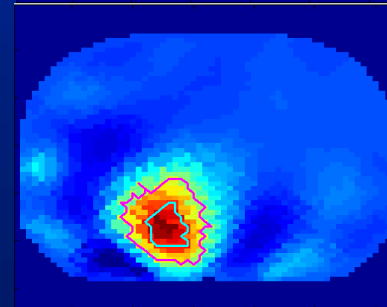
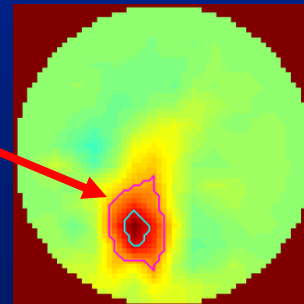
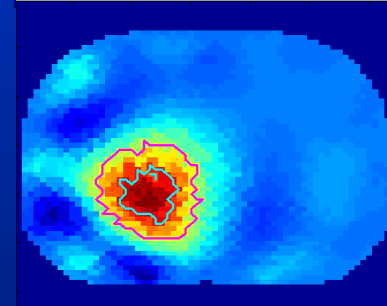
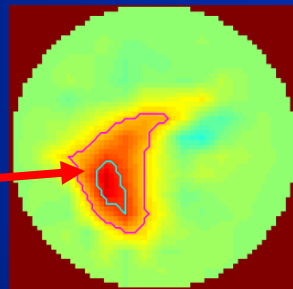
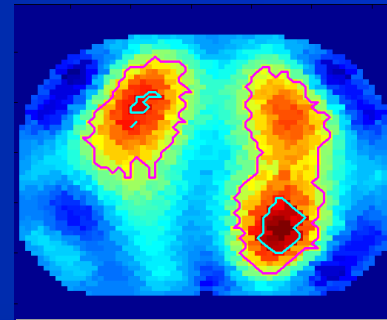
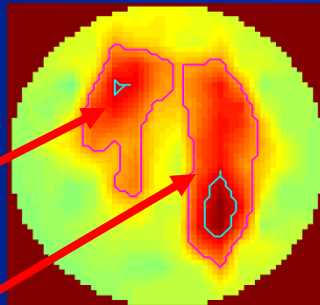
Analysis Screen



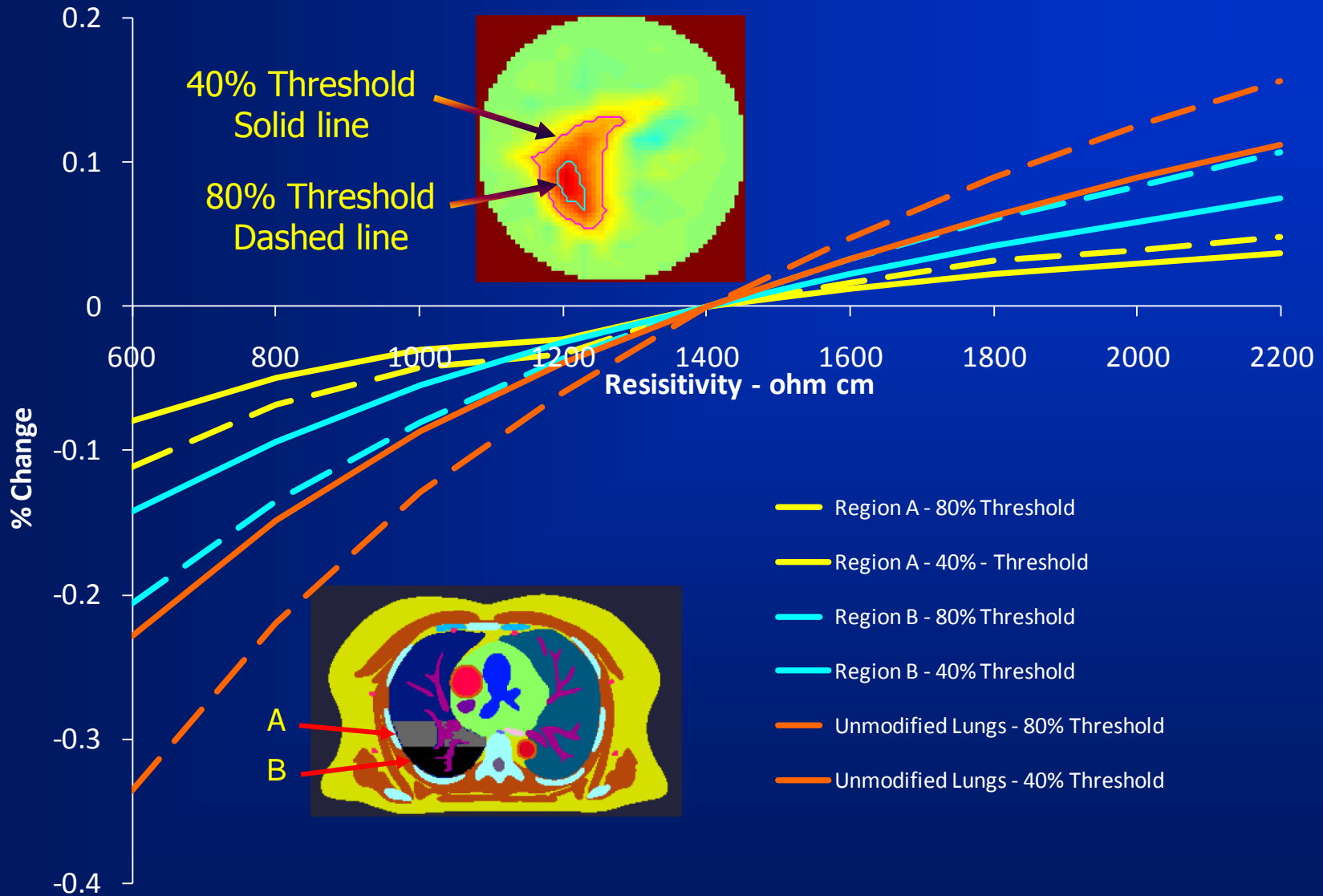
Example with each lung area changed to 1000 ohm-cm

Sheffield

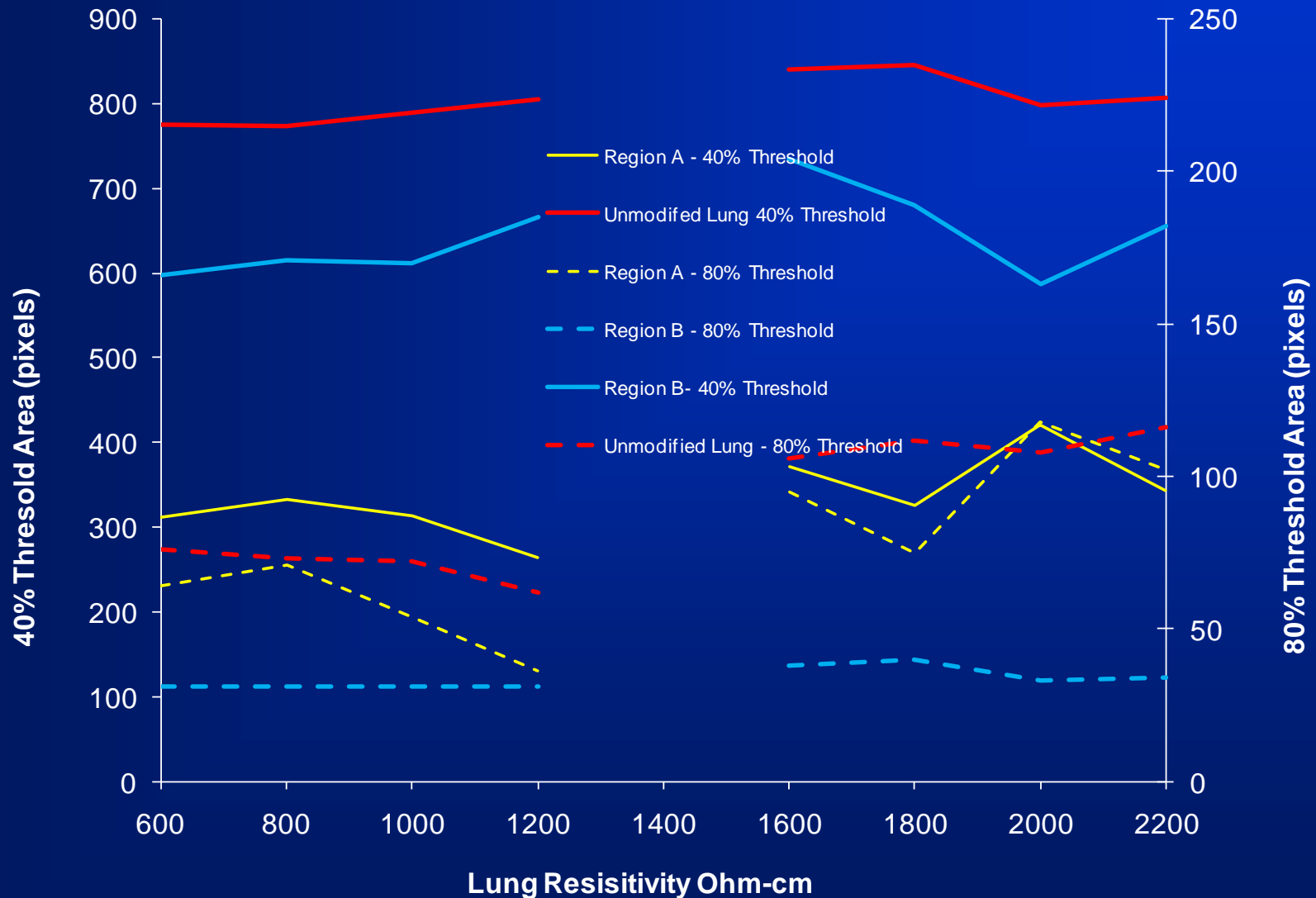
GREIT



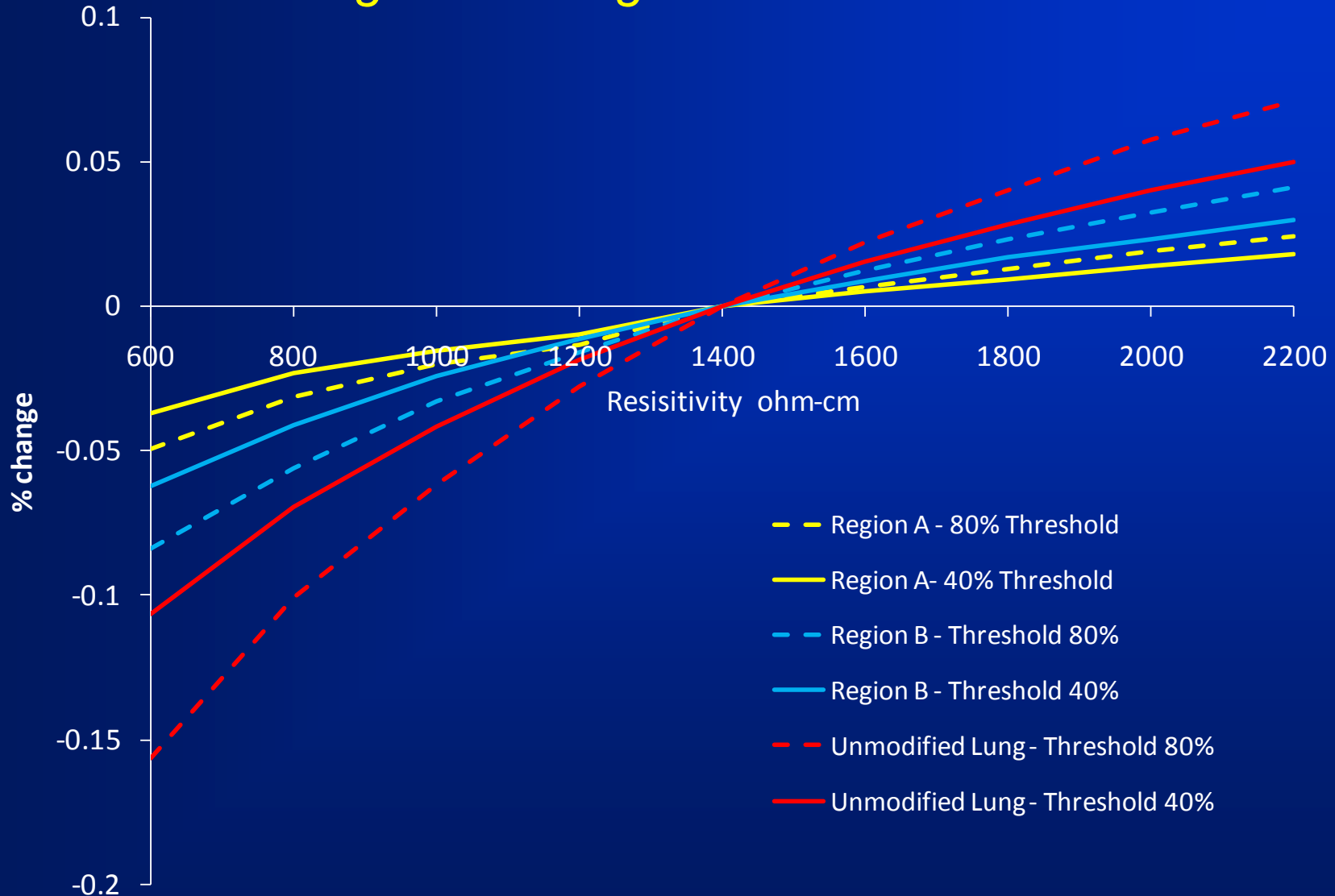
Results from Changing Lung Resistivity from 600 to 2200 ohm-cm using Sheffield Algorithm



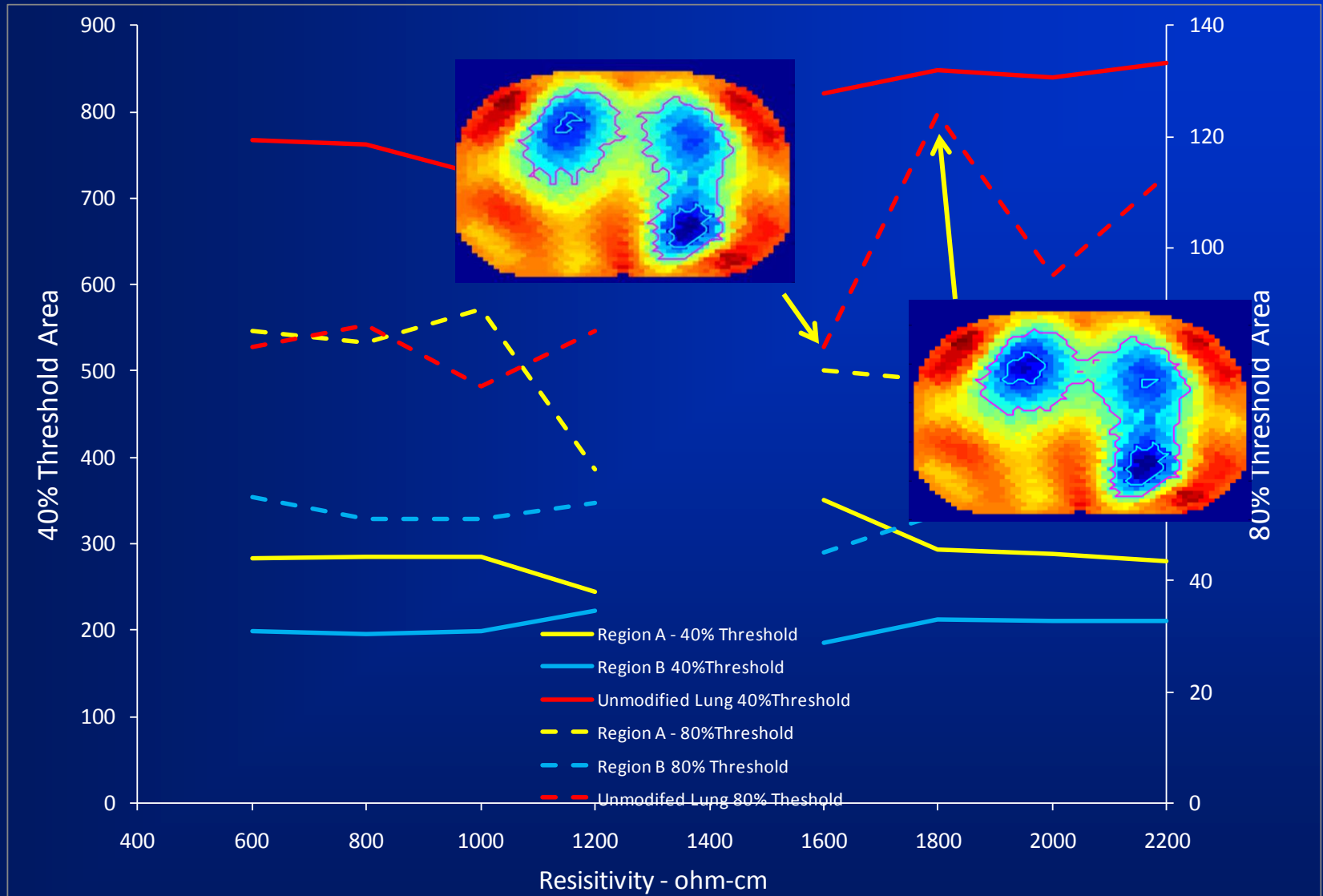
Area change using the Sheffield Algorithm as a % of Max for Condition



Results from Changing Resistivity from 600 to 2200 ohm-cm using GREIT Algorithm



Area change using the GREIT Algorithm as a % of Max for Condition



Conclusion

MEFS offers a software package that is easily to used, which can quantitatively evaluate various EIT reconstruction algorithms

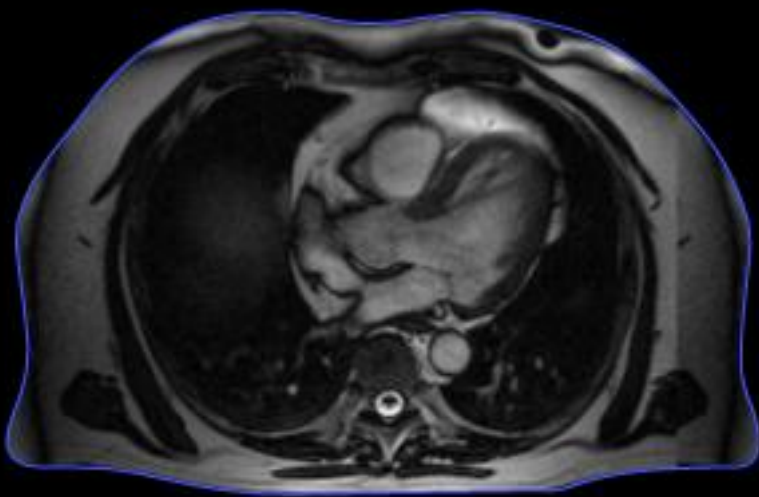
An aerial photograph of the Oshkosh, Wisconsin, airport taken from the International Space Station. The image shows the airport's runways, taxiways, and surrounding landscape, including fields and some buildings. The text "Thanks for Listening" is overlaid in yellow on the upper portion of the image.

Thanks for Listening

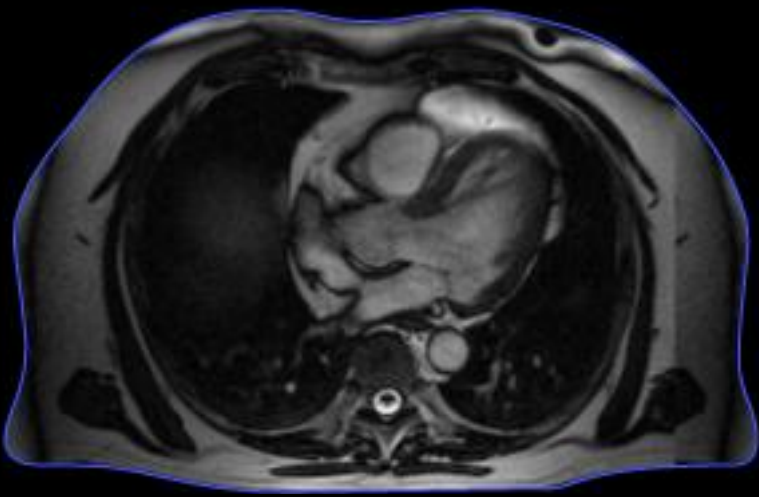
The Oshkosh WI, Airport from the International Space Station

Comparison of electrode locations: sensitivity

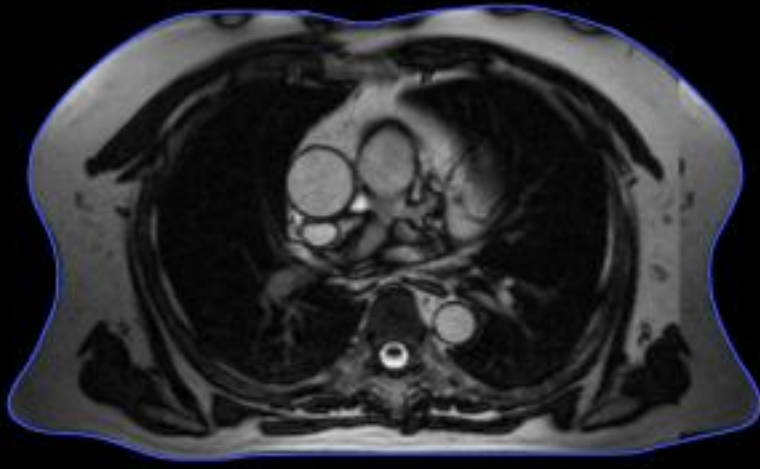
RV



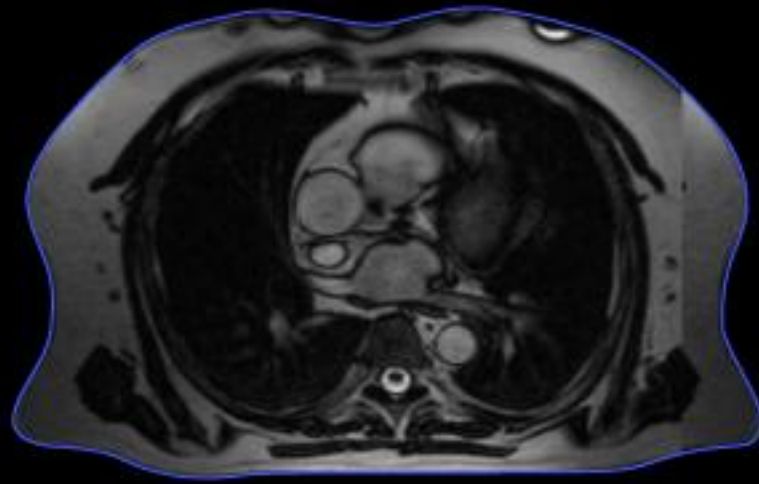
RV coil



localizer



RA



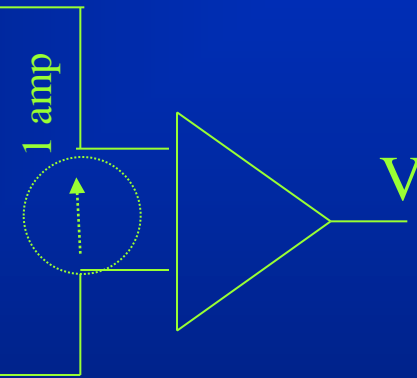
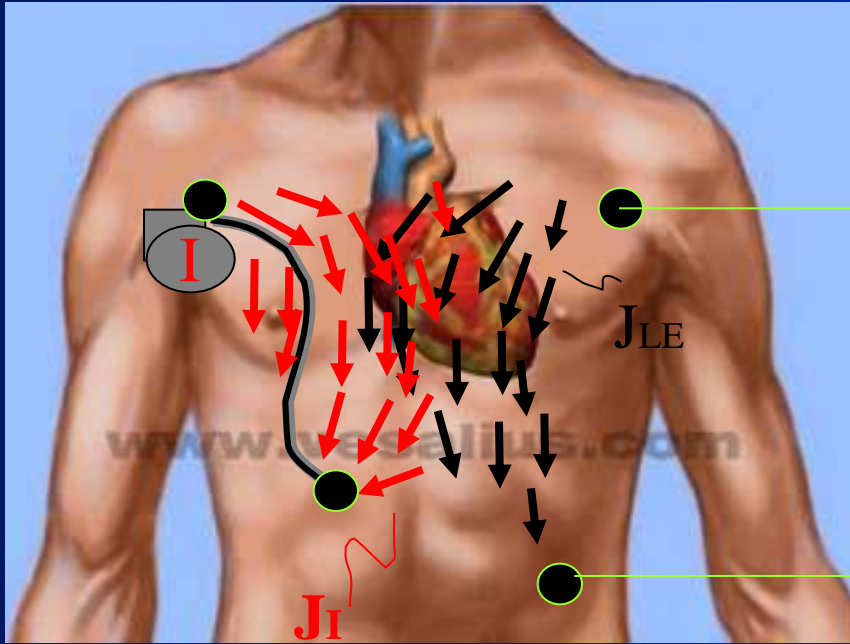
LVCV

Lead Field Theory

J_I : lead field of injected current
 J_{LE} : lead field of pickup electrodes

J_I may be obtained in a computer model

J_{LE} may be obtained by reciprocity in a computer model.



$$Z_t = \frac{V}{I}$$

Otto Schmitt first to propose:

Then mathematically proven by Geselowitz in 1971.

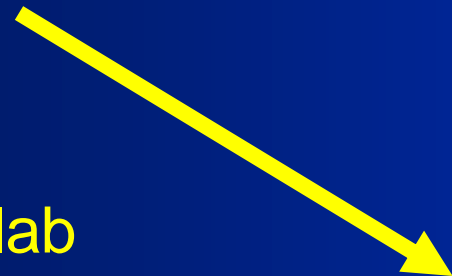
$$Z = \int \rho \underbrace{J_{LE} \cdot J_I}_{\text{Sensitivity distribution}} dv$$

Sensitivity distribution

Sensitivity Analysis

$$Z = \int \rho \mathbf{J}_{LE} \cdot \mathbf{J}_I \, dv$$

Matlab



air	0.00000000	ohms	0.00 %
Jugular vein	0.02236529	ohms	0.03 %
brachiocephalic, subclavian vein	0.30973676	ohms	0.44 %
sup. vena cava	0.01750516	ohms	0.02 %
inf. vena cava	0.00440736	ohms	0.01 %
spinal cord	0.02196743	ohms	0.03 %
ascending aorta	0.04345968	ohms	0.06 %
aortic arch	0.11498361	ohms	0.16 %
descending aorta	0.06885995	ohms	0.10 %
carotid arteries	0.00000000	ohms	0.00 %
brachiocephalic, subclavian arteries	0.19739194	ohms	0.28 %
other arterial blood	0.17940933	ohms	0.25 %
azygous vein	0.00527963	ohms	0.01 %
right atrium	0.03346155	ohms	0.05 %
right ventricle	0.11870241	ohms	0.17 %
pulmonary artery	0.00000000	ohms	0.00 %
pulmonary vein	0.93691461	ohms	1.33 %
left atrium	0.23355130	ohms	0.33 %
left ventricle	3.77208881	ohms	5.36 %
skeletal muscle long axis	20.13149520	ohms	28.59 %
skeletal muscle across sectional	0.00000000	ohms	0.00 %
heart muscle	8.41862416	ohms	11.96 %
HEART FAT	4.00992003	ohms	5.69 %
right lung	0.09421865	ohms	0.13 %
left lung	13.83721035	ohms	19.65 %
fat	15.87351760	ohms	22.54 %
bone	1.41879010	ohms	2.01 %
cartilage	0.04330071	ohms	0.06 %
liver	0.03599823	ohms	0.05 %
kidney	0.00000000	ohms	0.00 %
pulmonary trunk	0.20376950	ohms	0.29 %
spleen	0.01136754	ohms	0.02 %
stomach	0.01261023	ohms	0.02 %
esophagus	0.03332739	ohms	0.05 %
diaphragm	0.20868111	ohms	0.30 %

GRAND TOTAL Z: 70.41 ohms.