

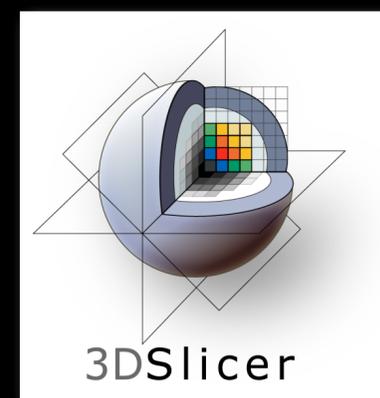
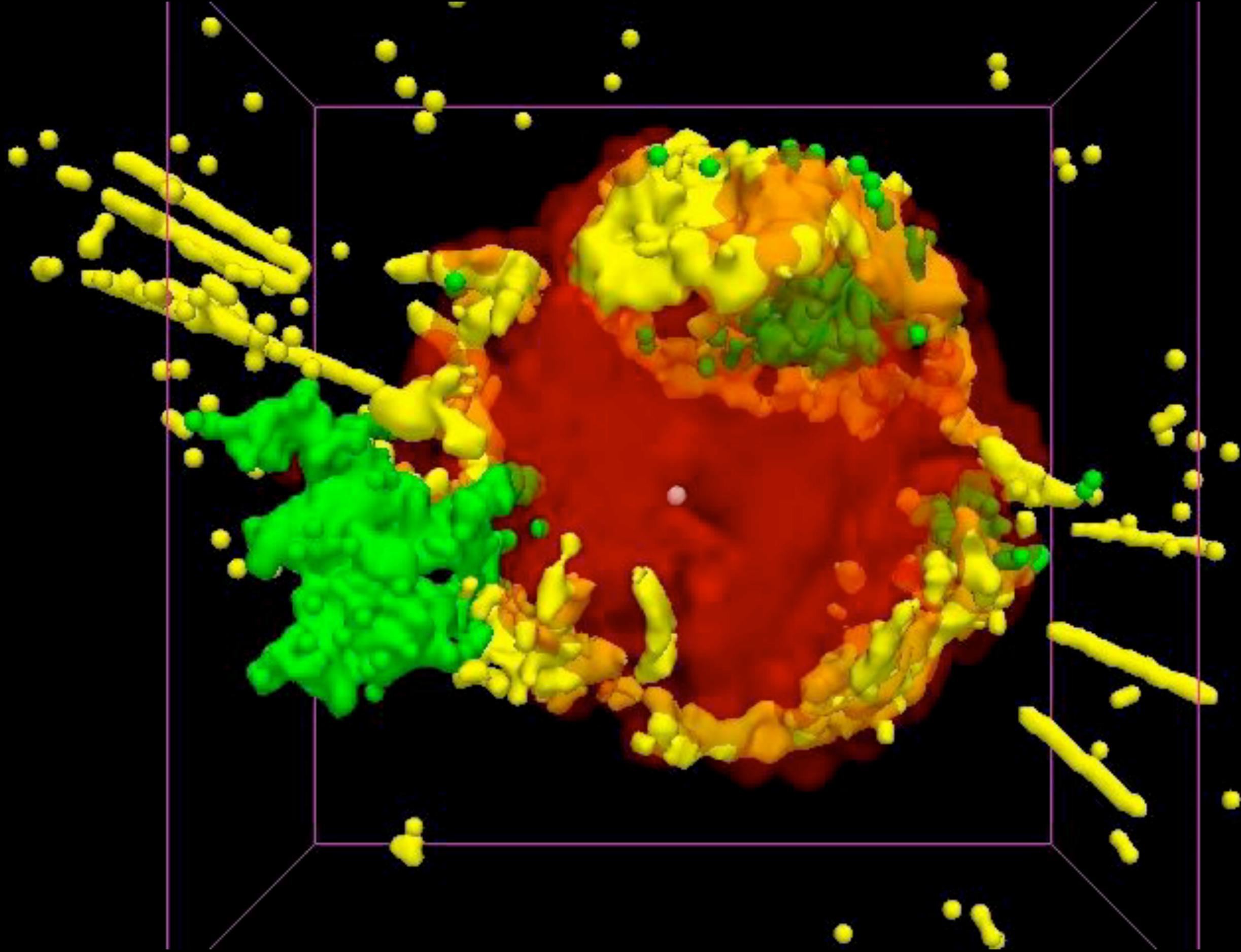
PERCEPTION, COGNITION, AND EFFECTIVENESS OF VISUALIZATIONS WITH APPLICATIONS IN SCIENCE AND ENGINEERING

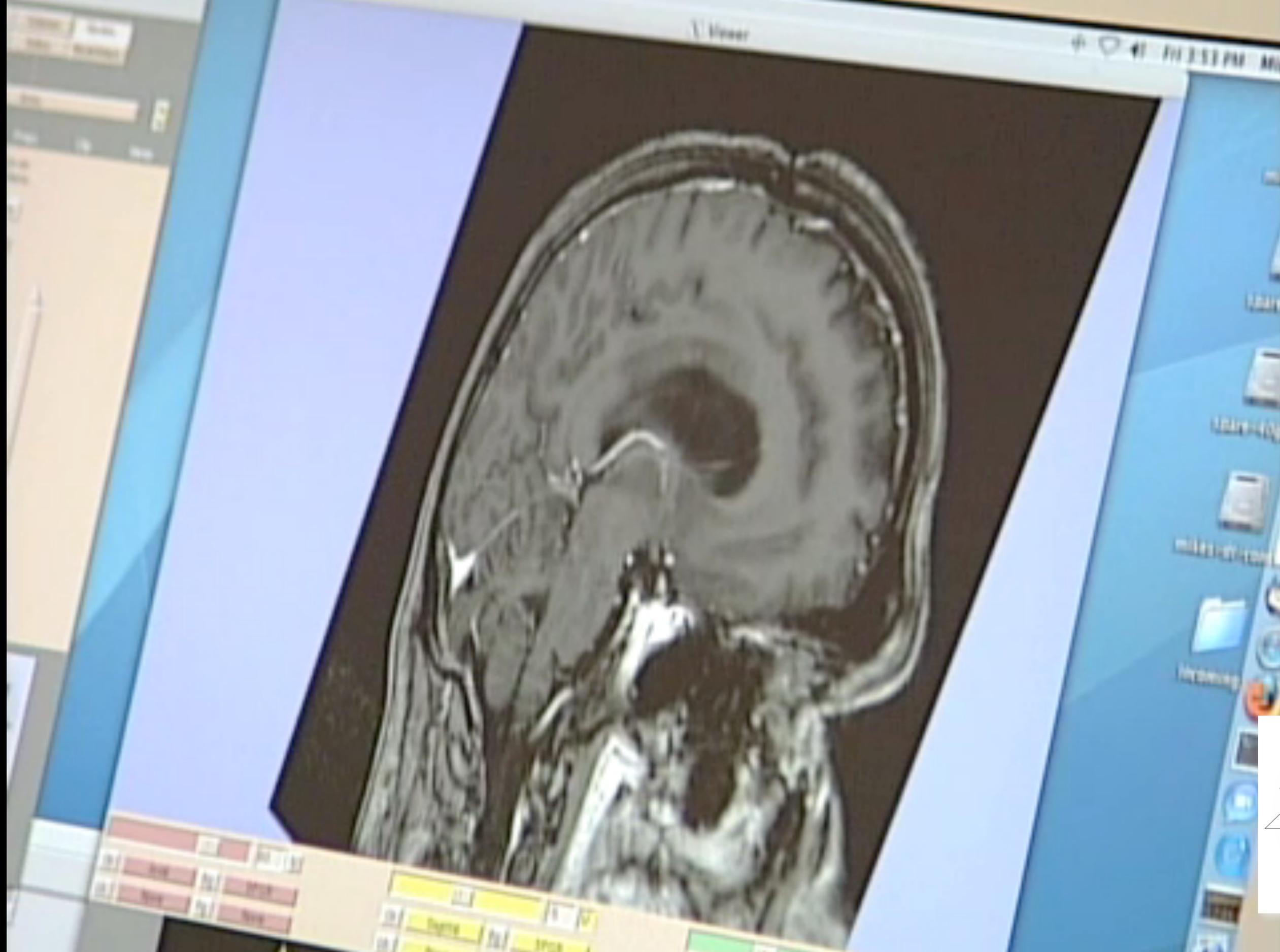
Michelle Borkin

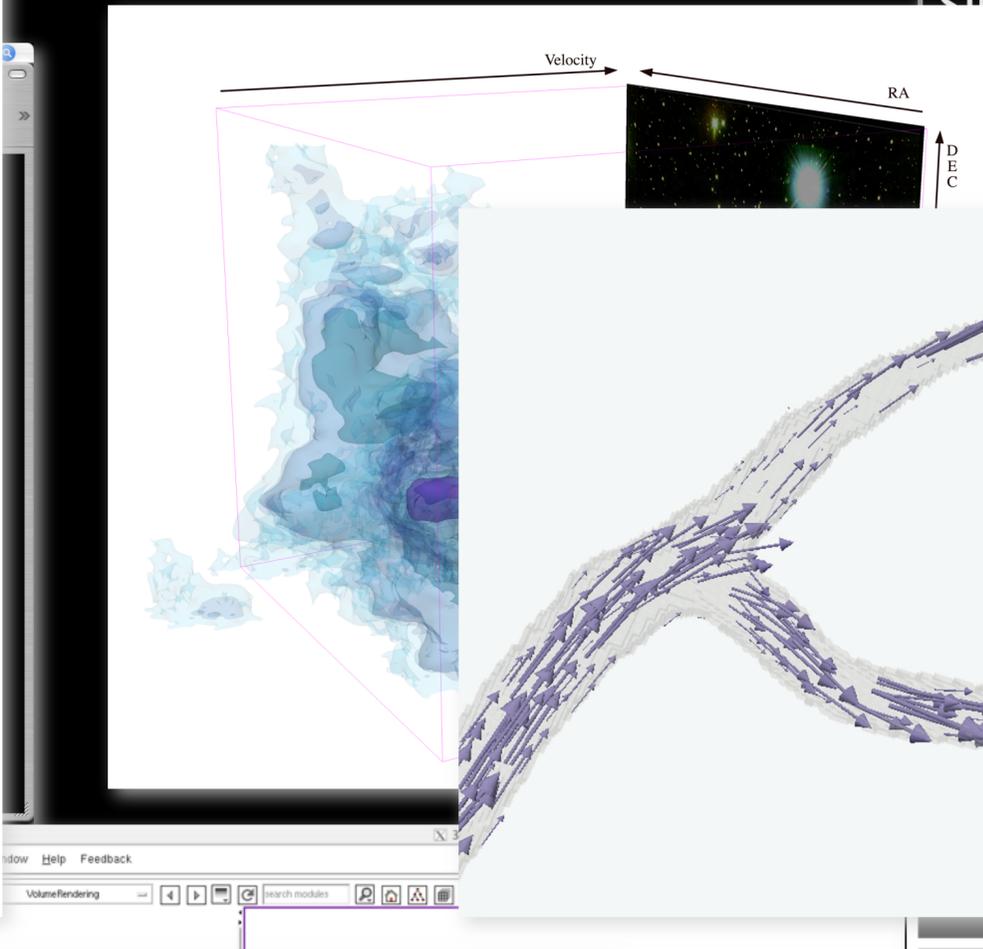
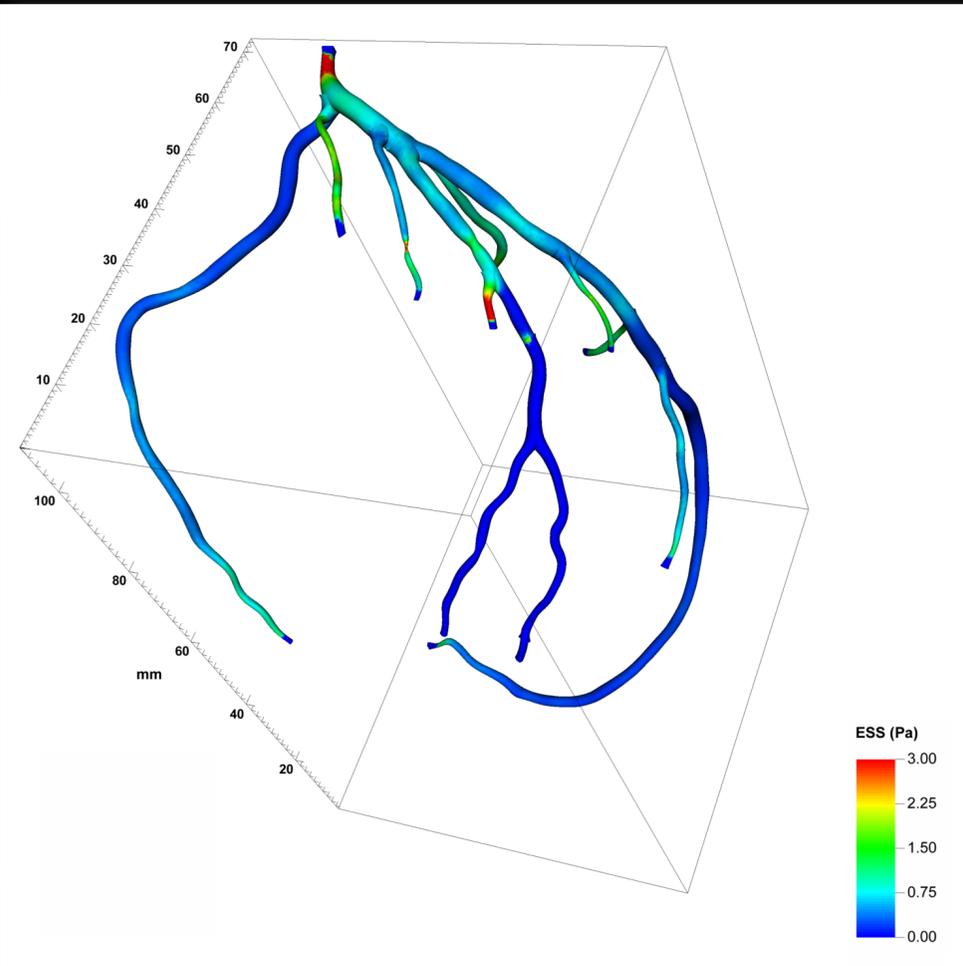
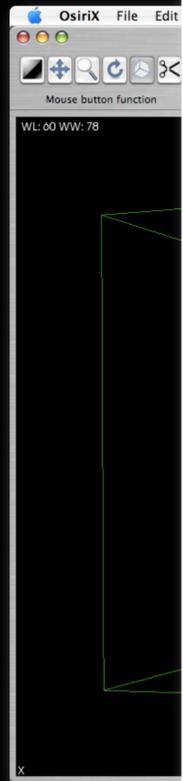
(University of British Columbia & Harvard University)

CPSC 547, UBC - September 24, 2014

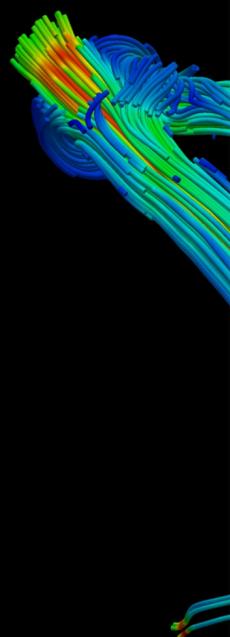
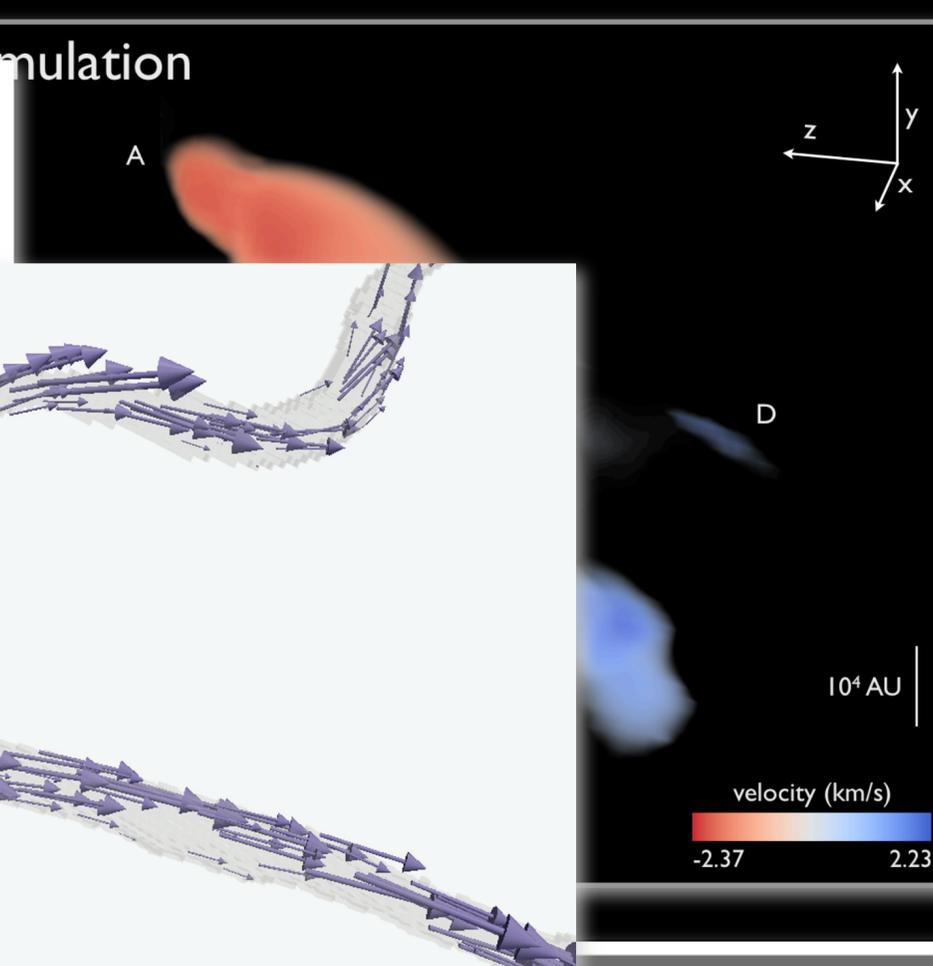








Simulation



Data Collection

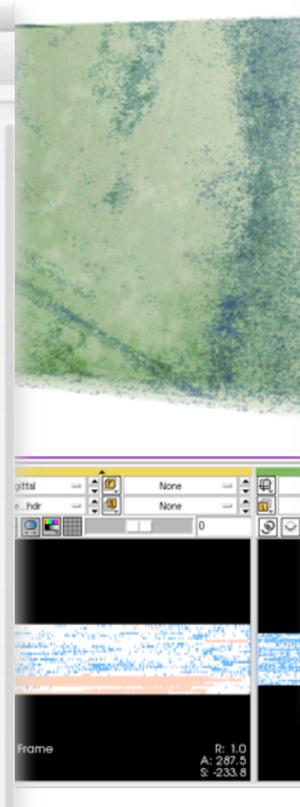
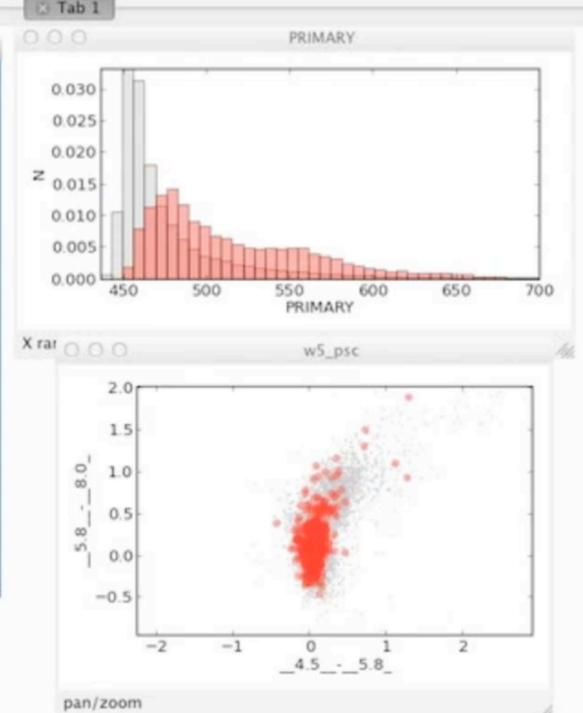
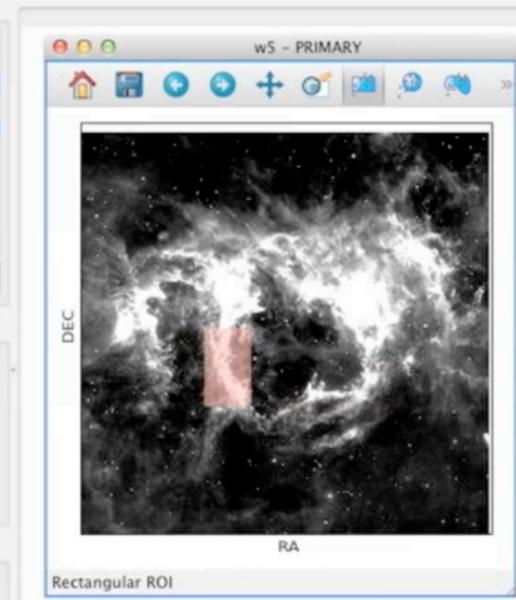
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w5.1	
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Plot Layers - Image Widget

- w5.1
- w5

Plot Options - Image Widget

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Attribute: PRIMARY



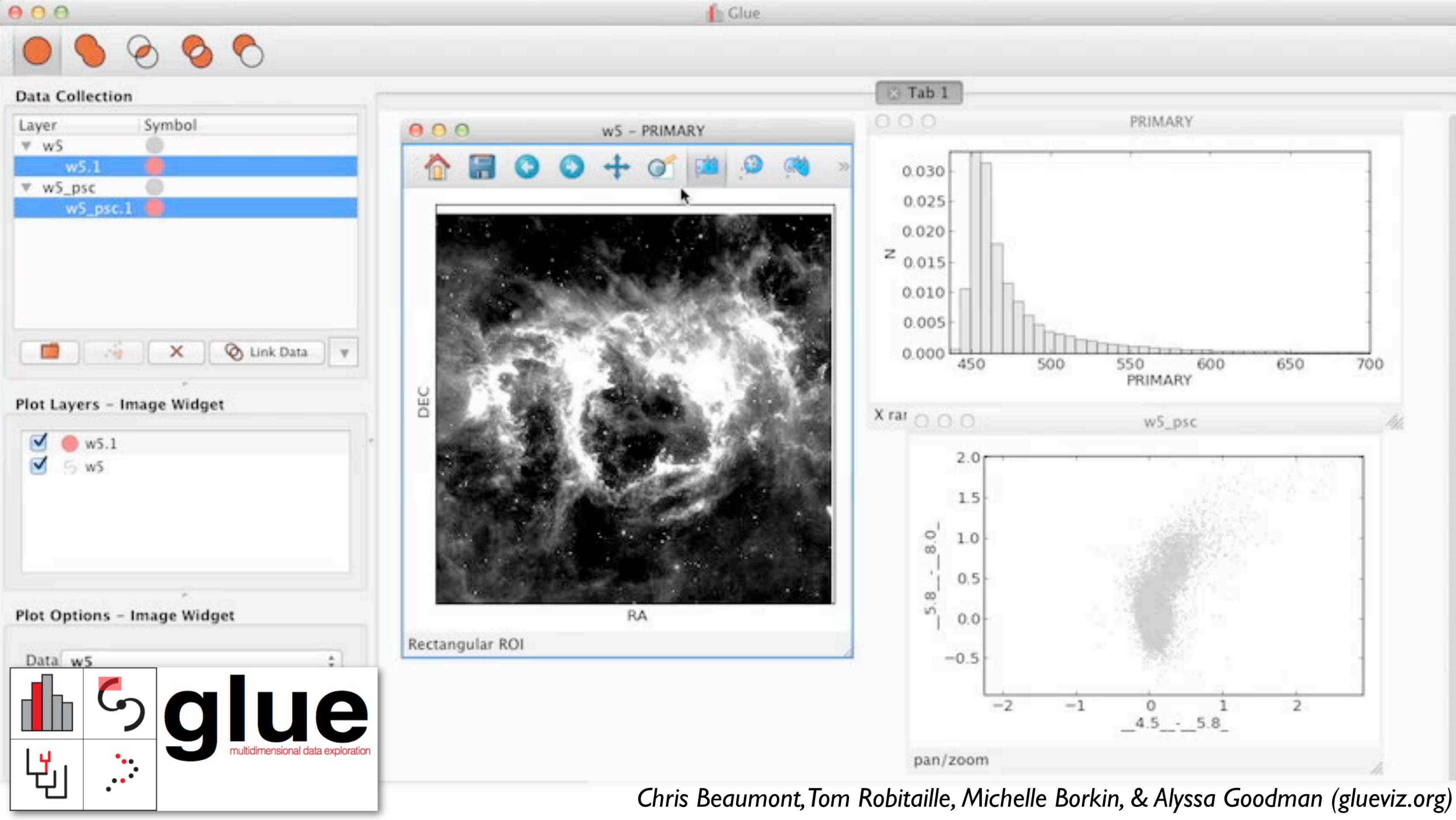
Diagram

Belt Chart Donut Chart Flow Chart Illustration (or Rendering)

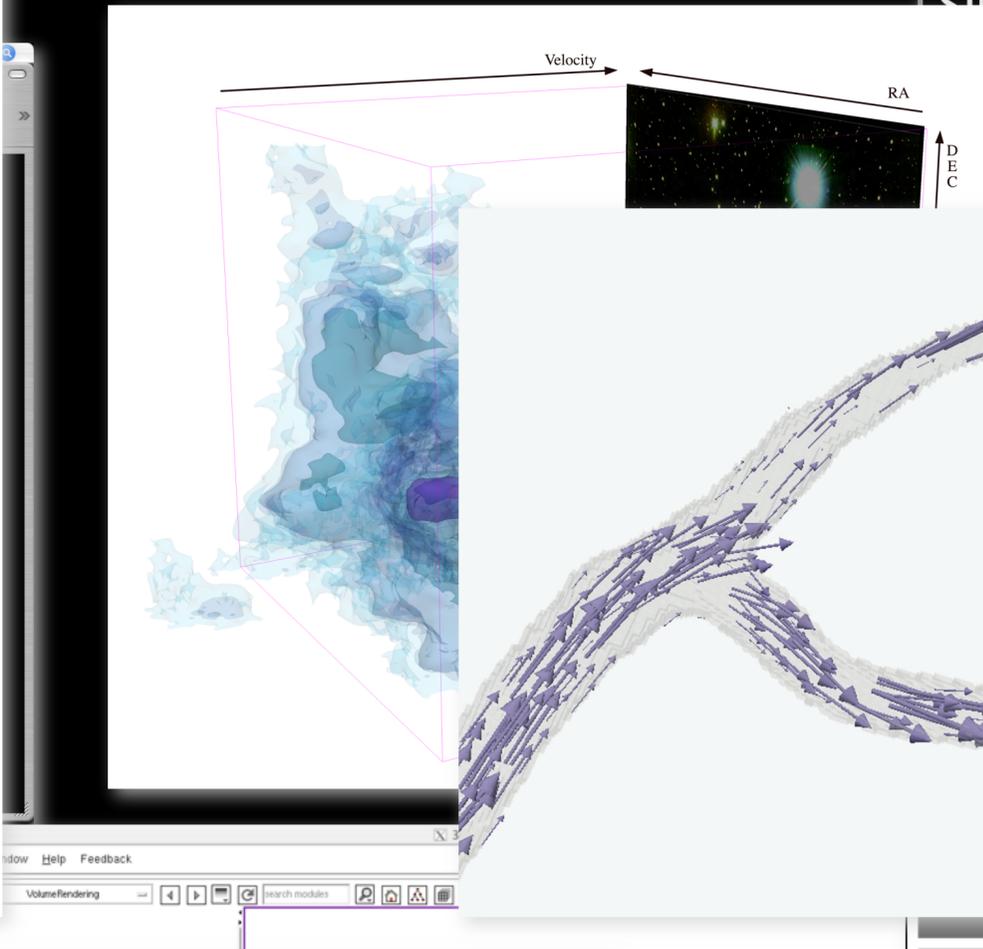
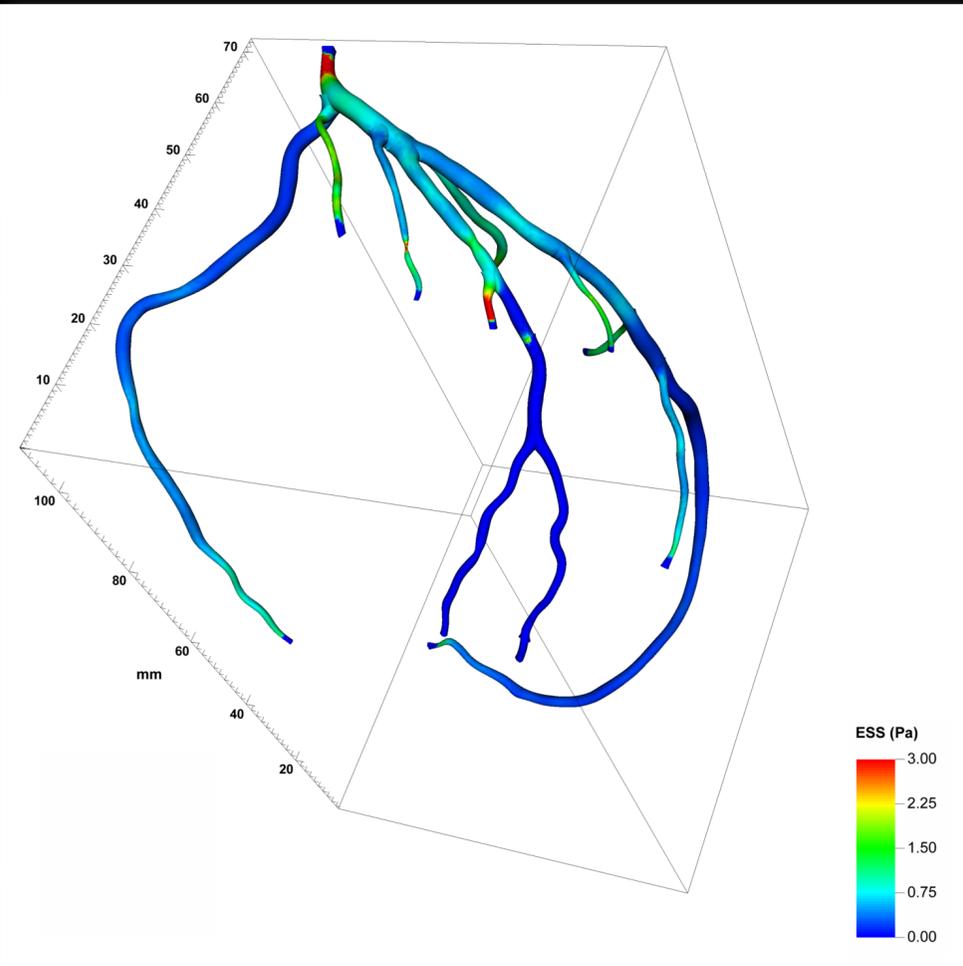
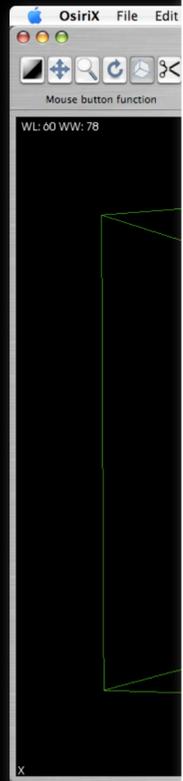
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blastall
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meminfo
Hinfaa.phr
Hinfaa.psq
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A_B

Timeline
B D E
1995 2000 2005

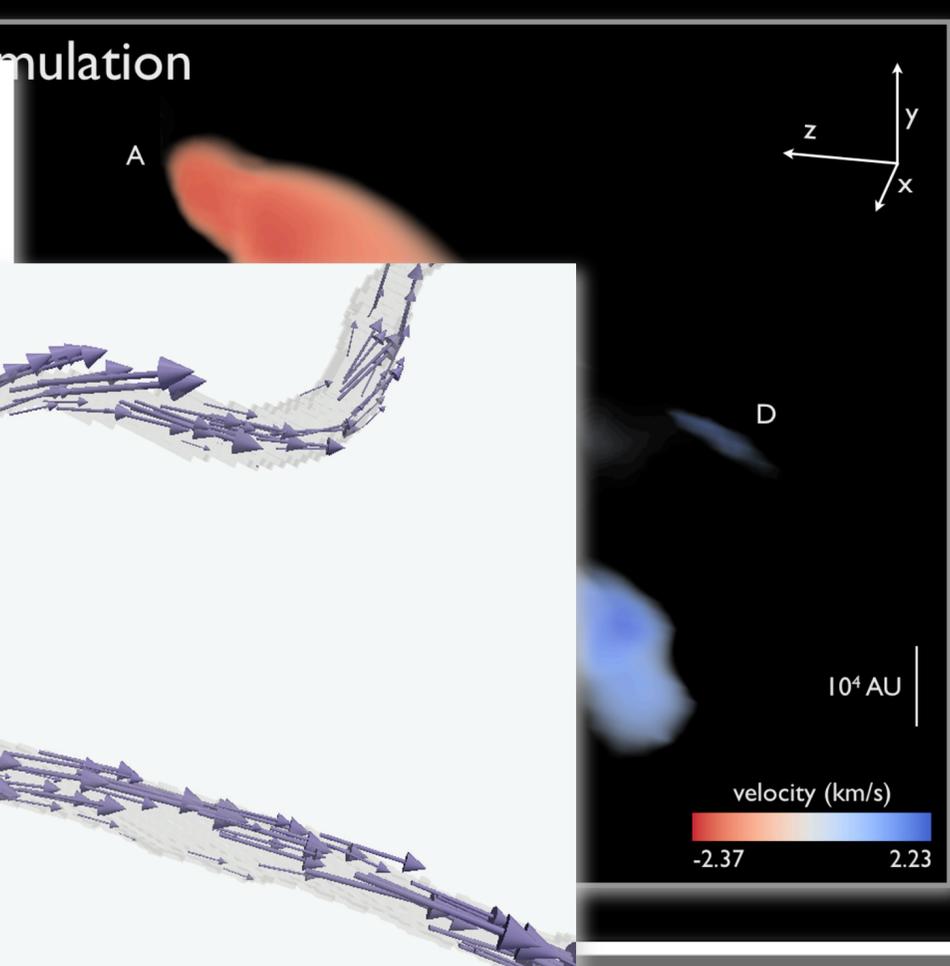
Venn Diagram
A B



Chris Beaumont, Tom Robitaille, Michelle Borkin, & Alyssa Goodman (glueviz.org)



Simulation



Data Collection

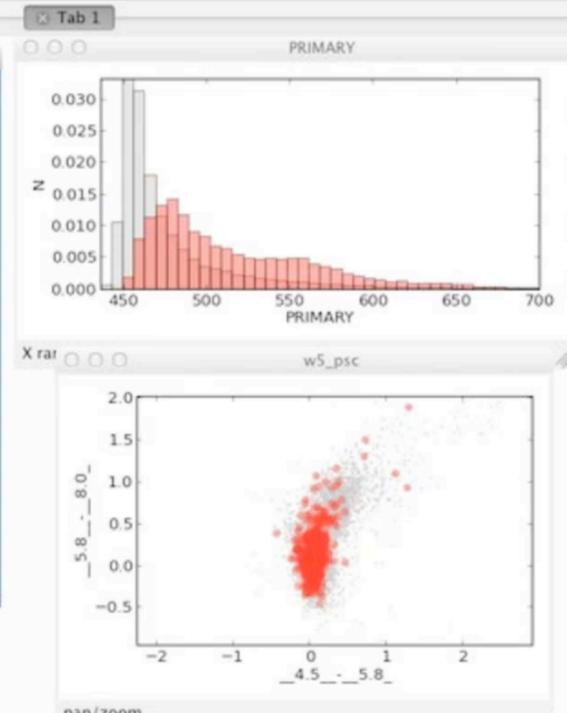
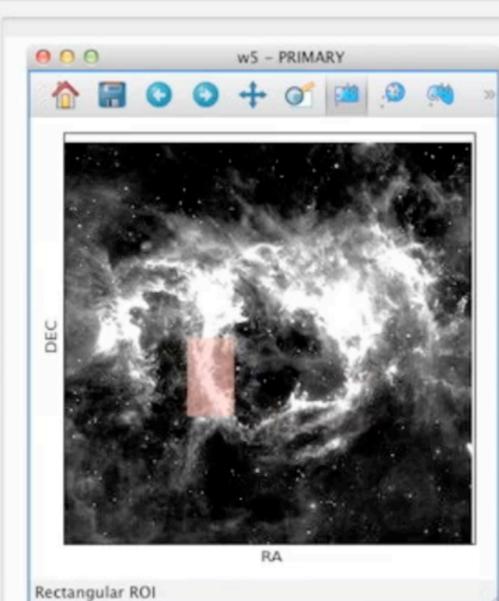
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w5.1	
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Plot Layers - Image Widget

- w5.1
- w5

Plot Options - Image Widget

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Attribute: PRIMARY



Frame
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A: 287.5
S: -233.8

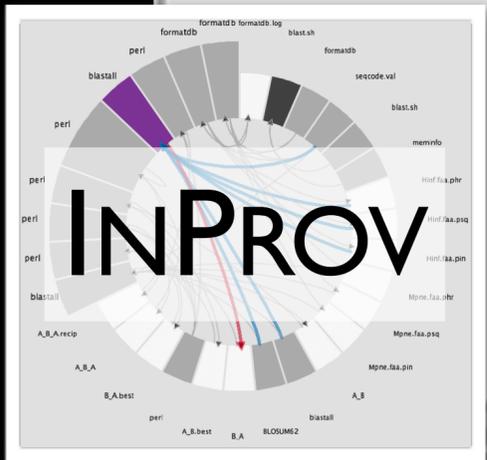
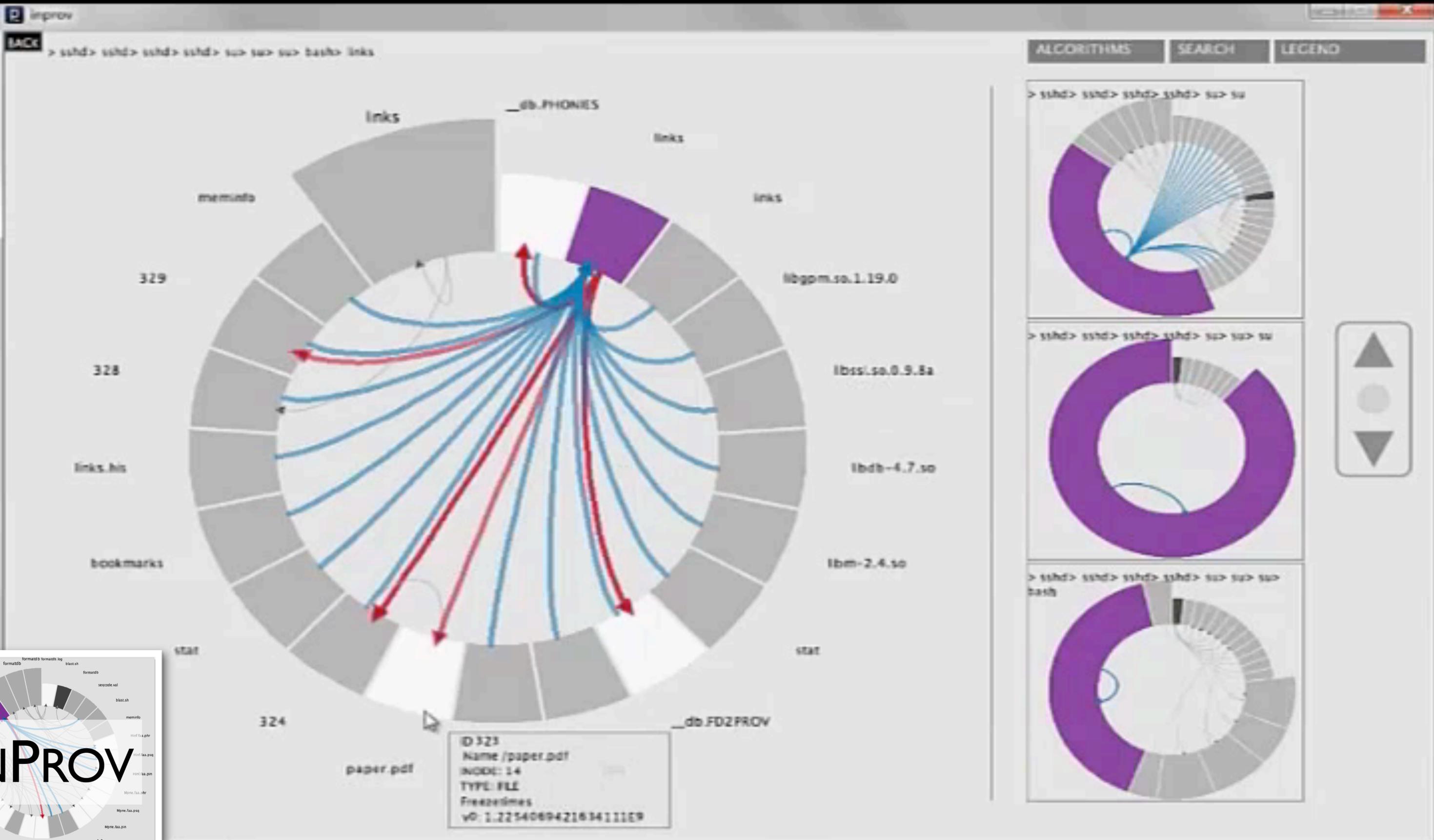
Diagram

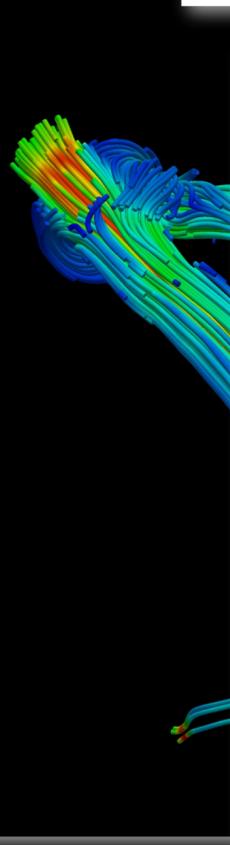
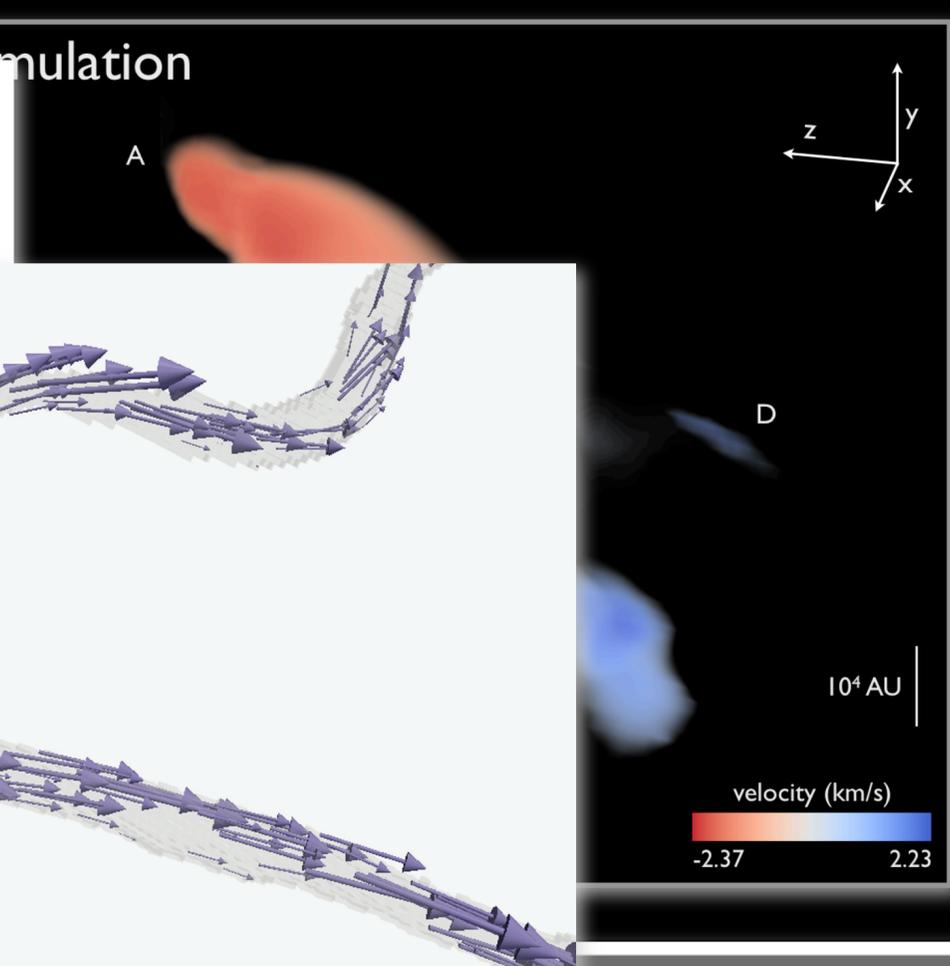
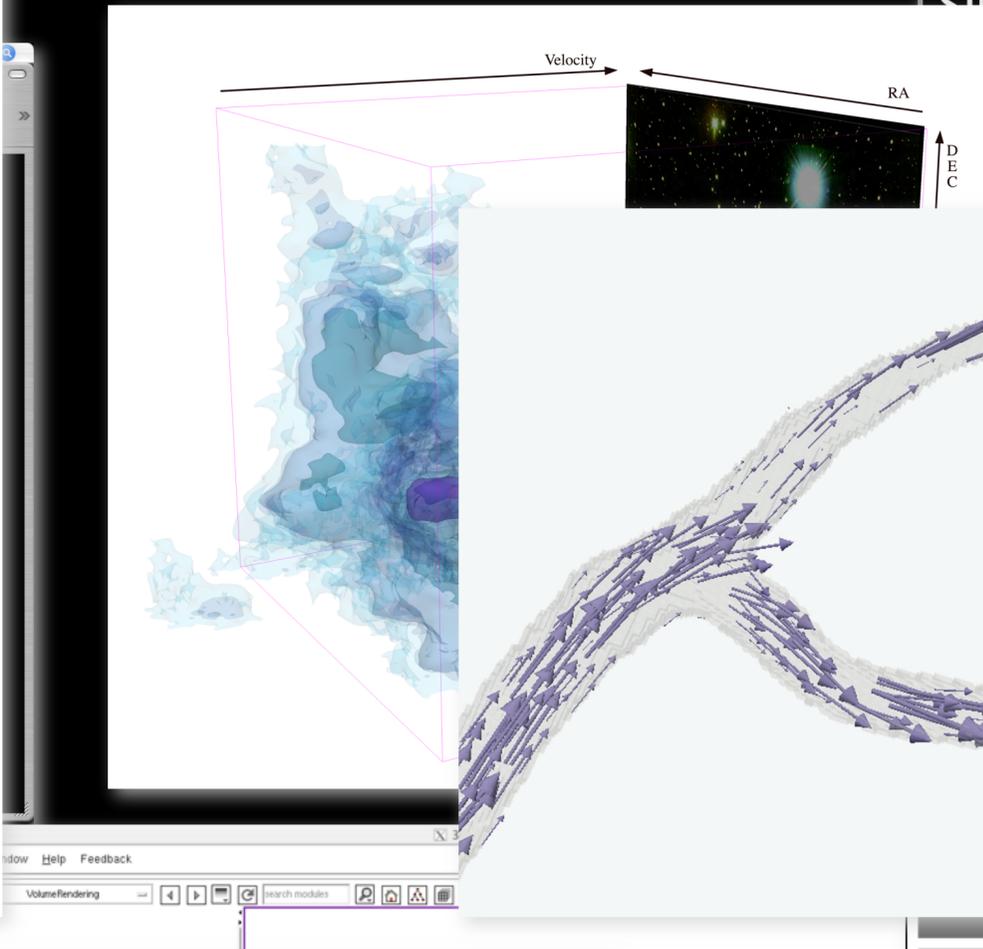
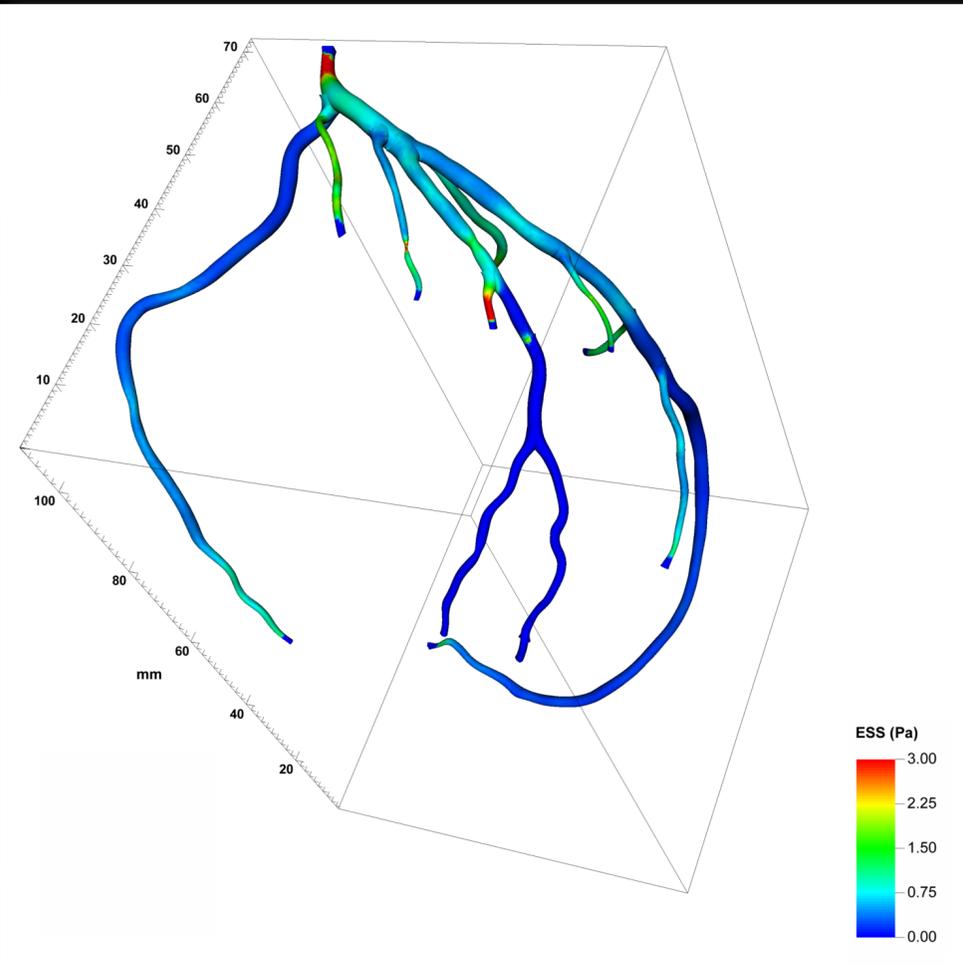
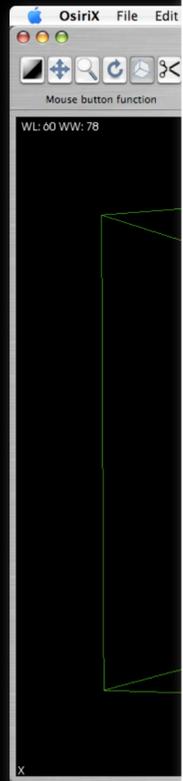
Belt Chart Donut Chart Flow Chart Illustration (or Rendering)

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blastall
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perli
perli
blastall
A_B.recip
A_B.A
B_A.best
perli
A_B.best B_A BLOSUM62
blastall
seacode.val
blast.sh
meminfo
Hinfaa.phr
Hinfaa.psq
Hinfaa.pin
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Mpne.faa.psq
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A_B

Timeline
B D E
1995 2000 2005

Venn Diagram
A B





Data Collection table with columns Layer and Symbol. Includes Plot Layers and Plot Options sections.

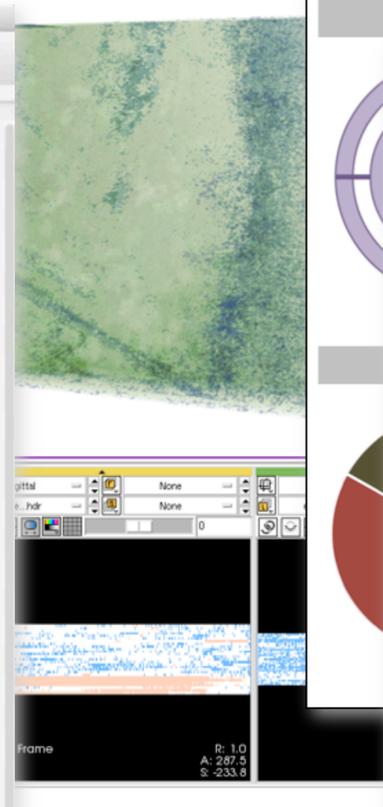
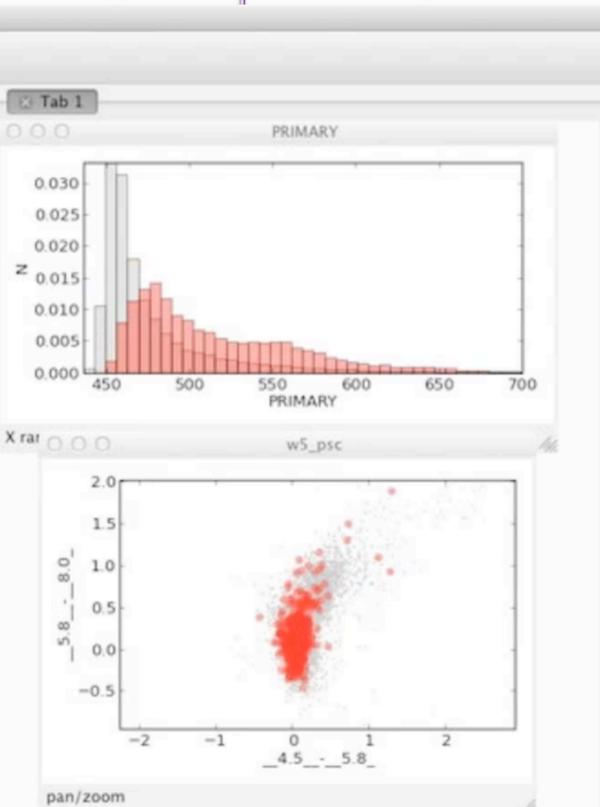
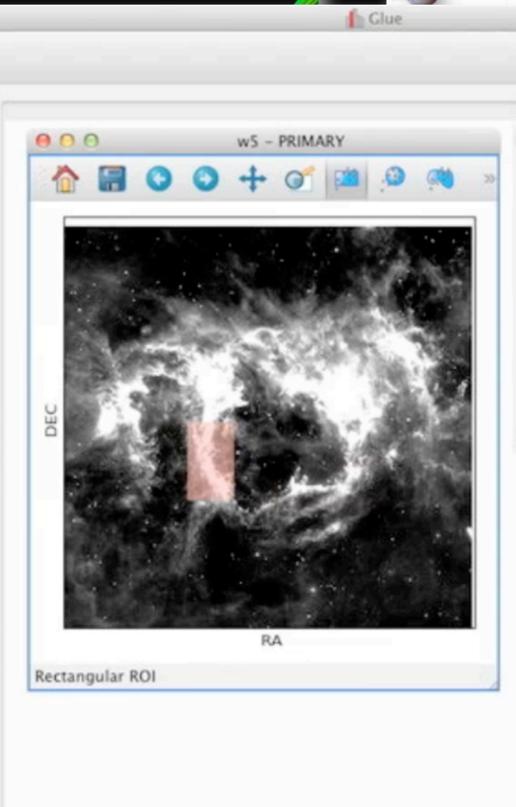
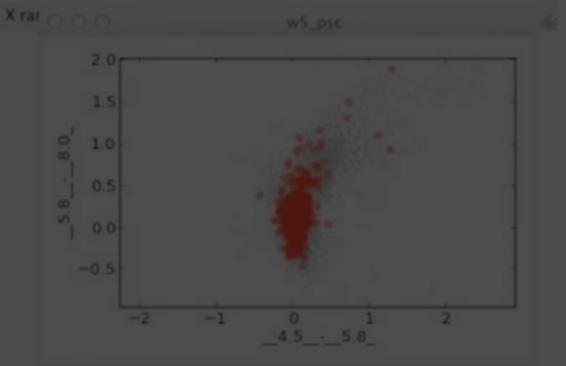
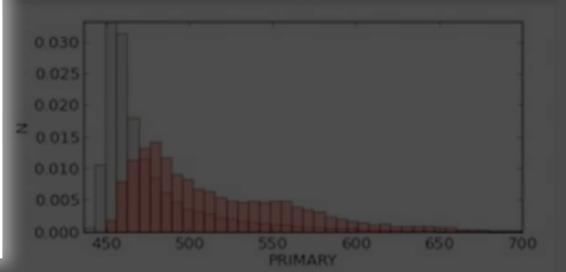
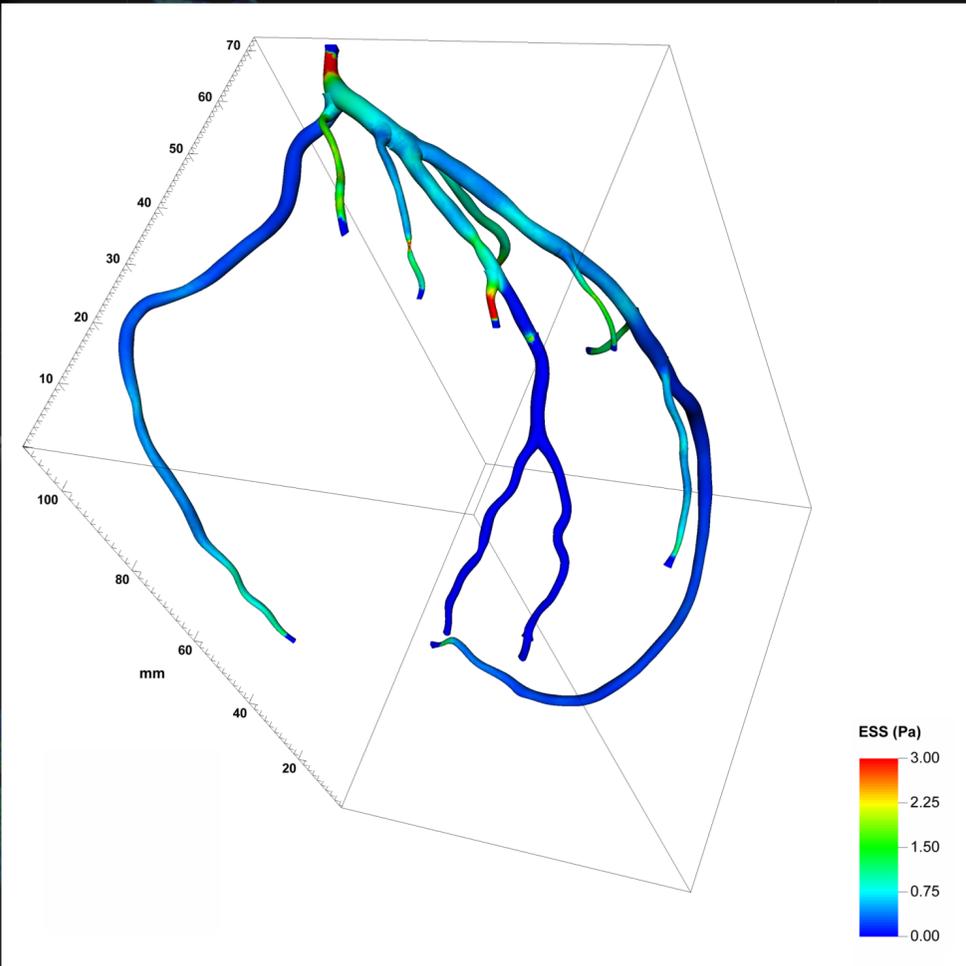


Diagram section containing a circular flow chart, a timeline, and a Venn diagram.

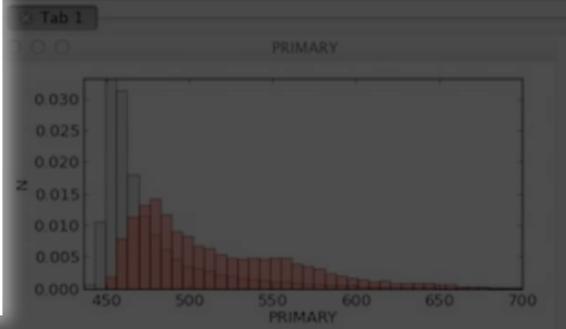
OsiriX File Edit Format 2D Viewer 3D Viewer ROI Plugins Window Help
 3D Reconstruction
 Volume Rendering WL/WV: Other CLUT: Spectrum Opacity: Logarithmic Inverse
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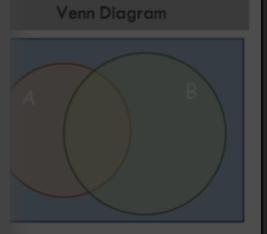
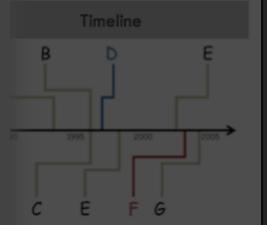
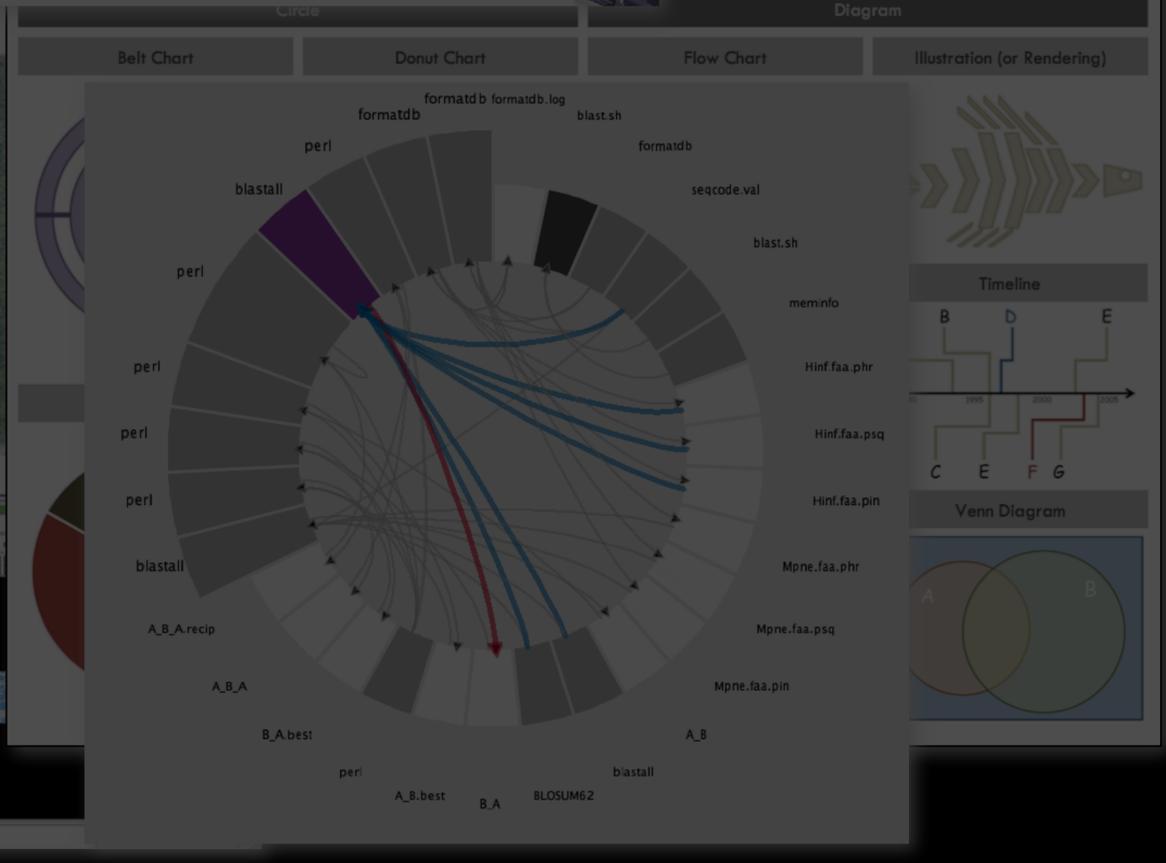
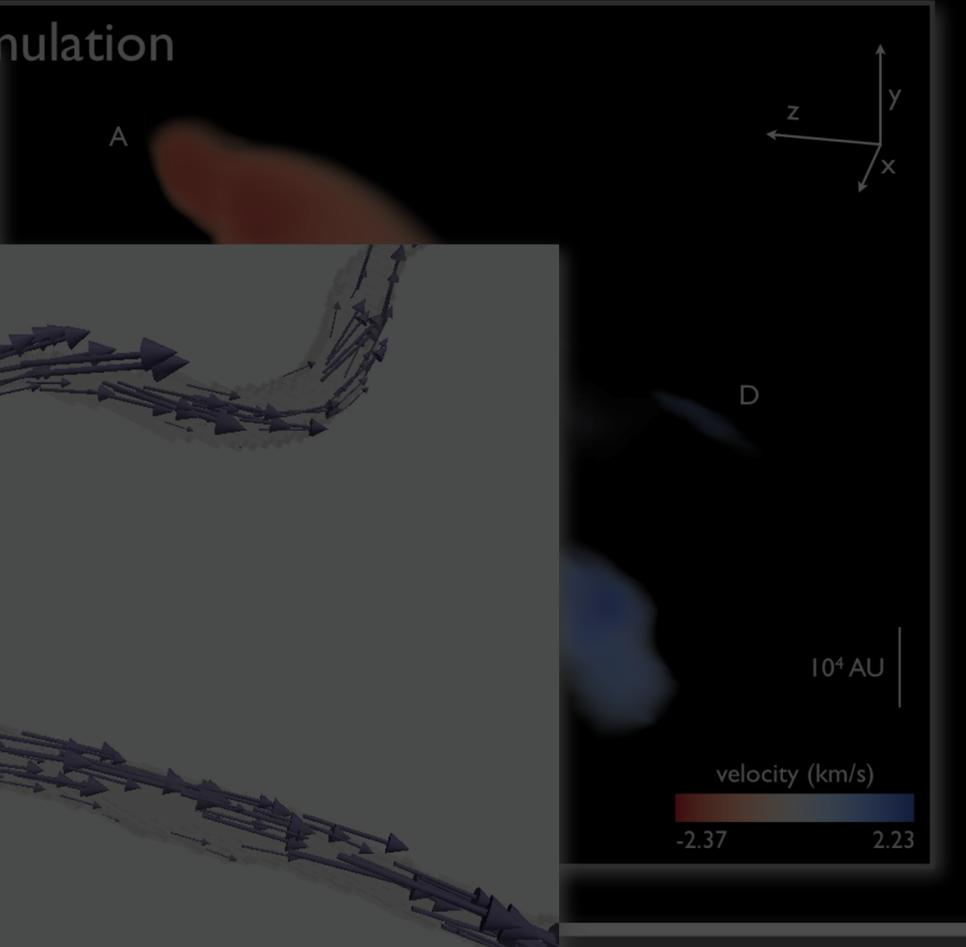
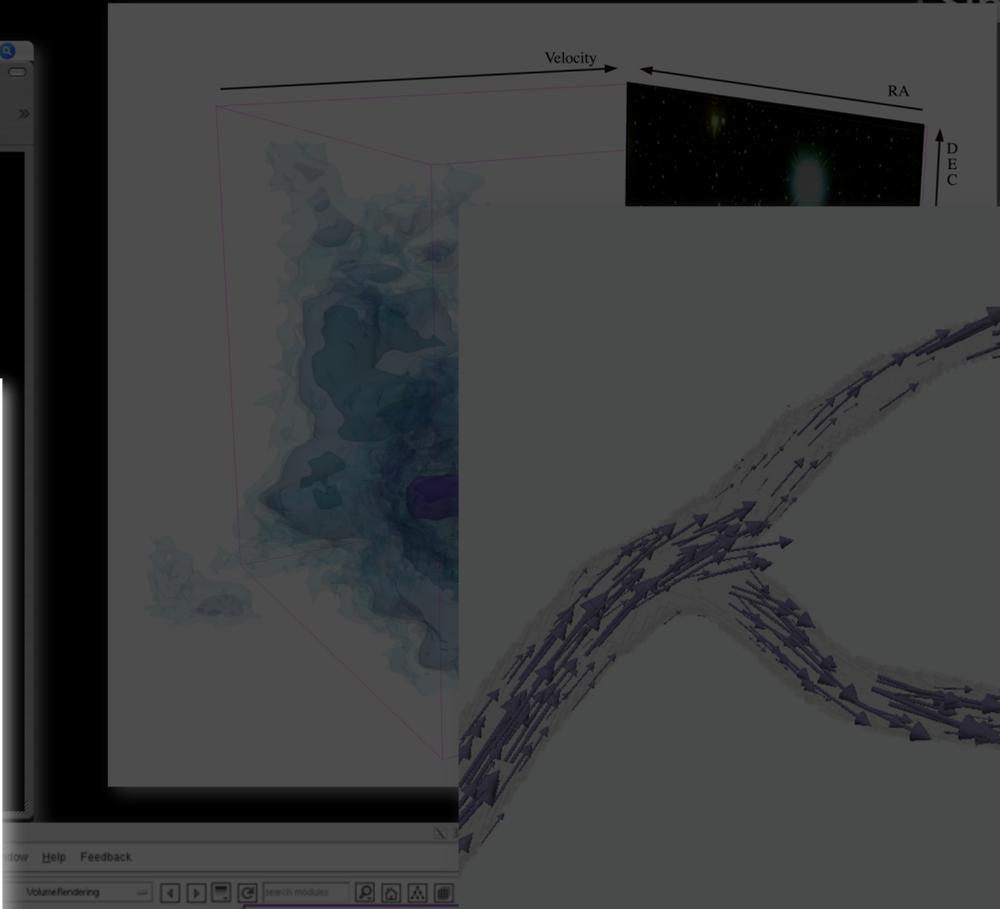
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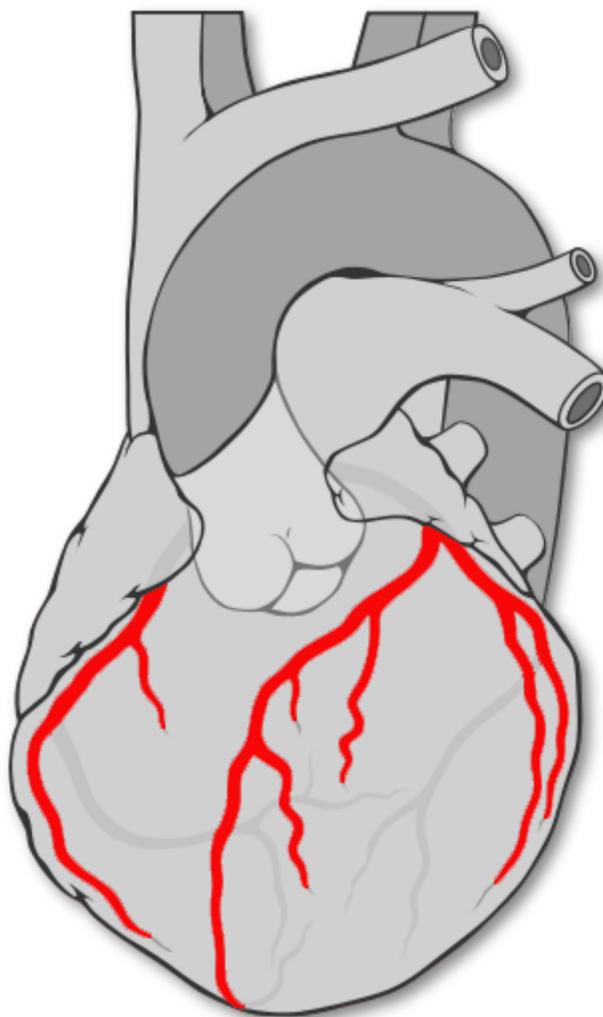
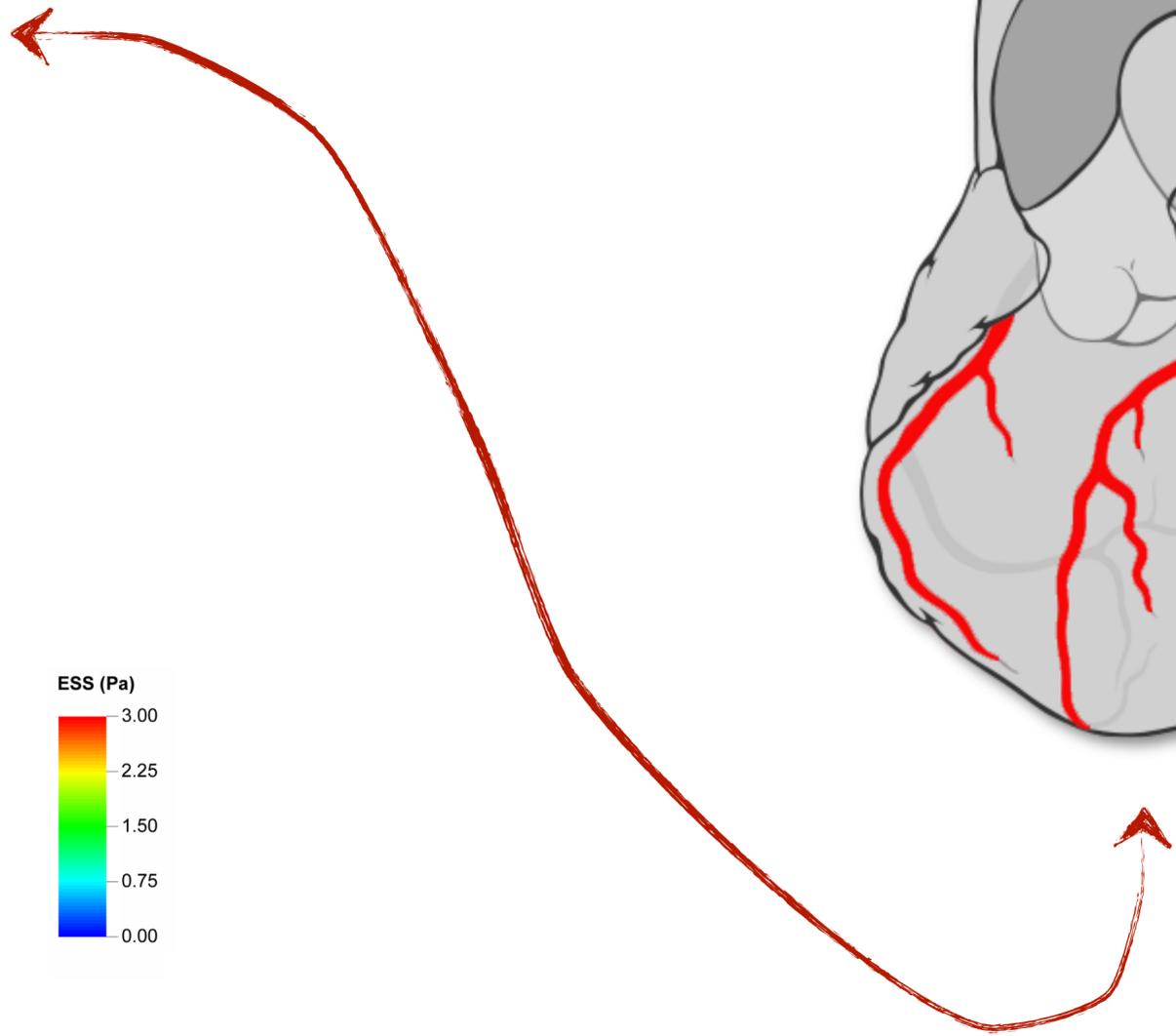
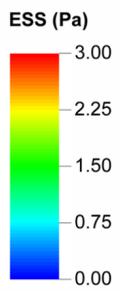
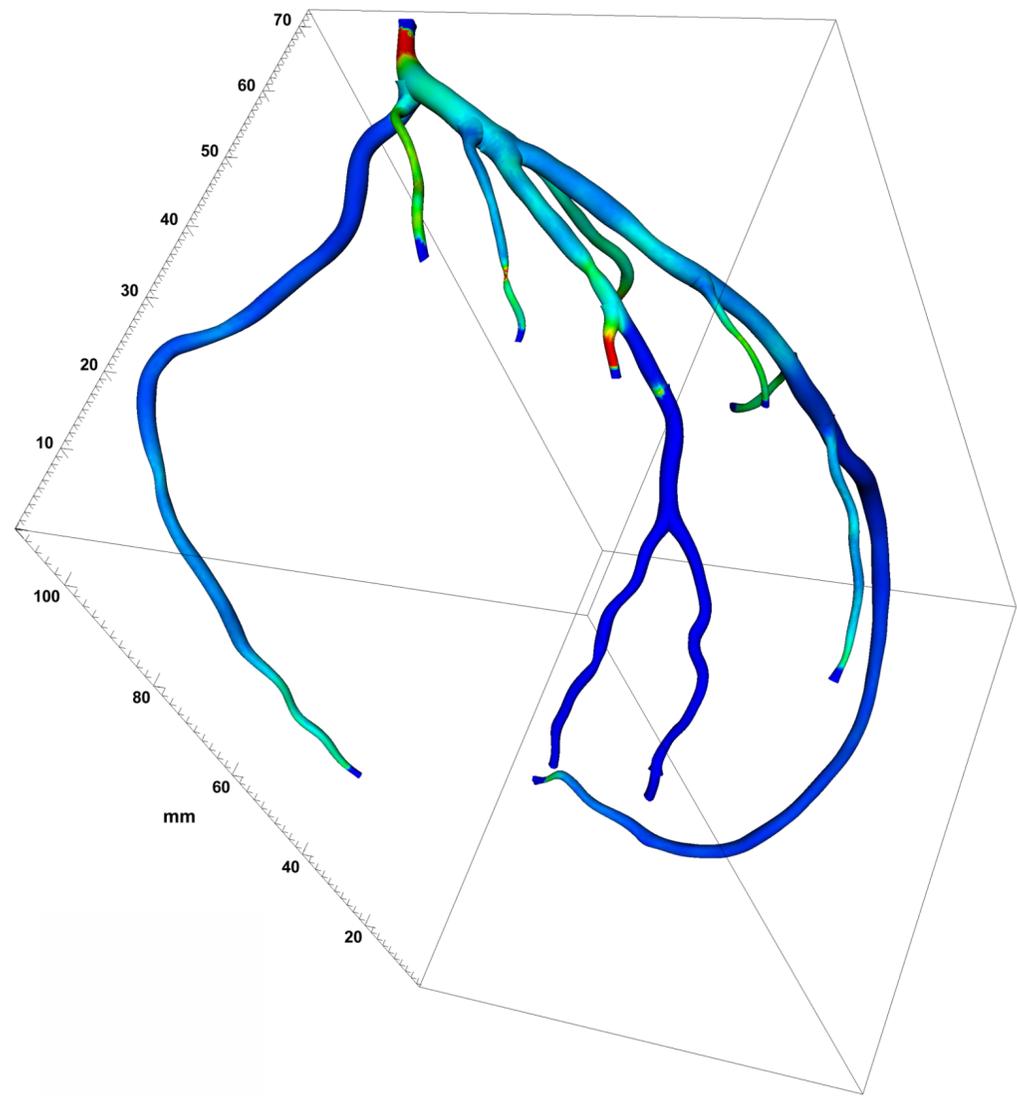
Plot Layers - Image Widget
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 wS

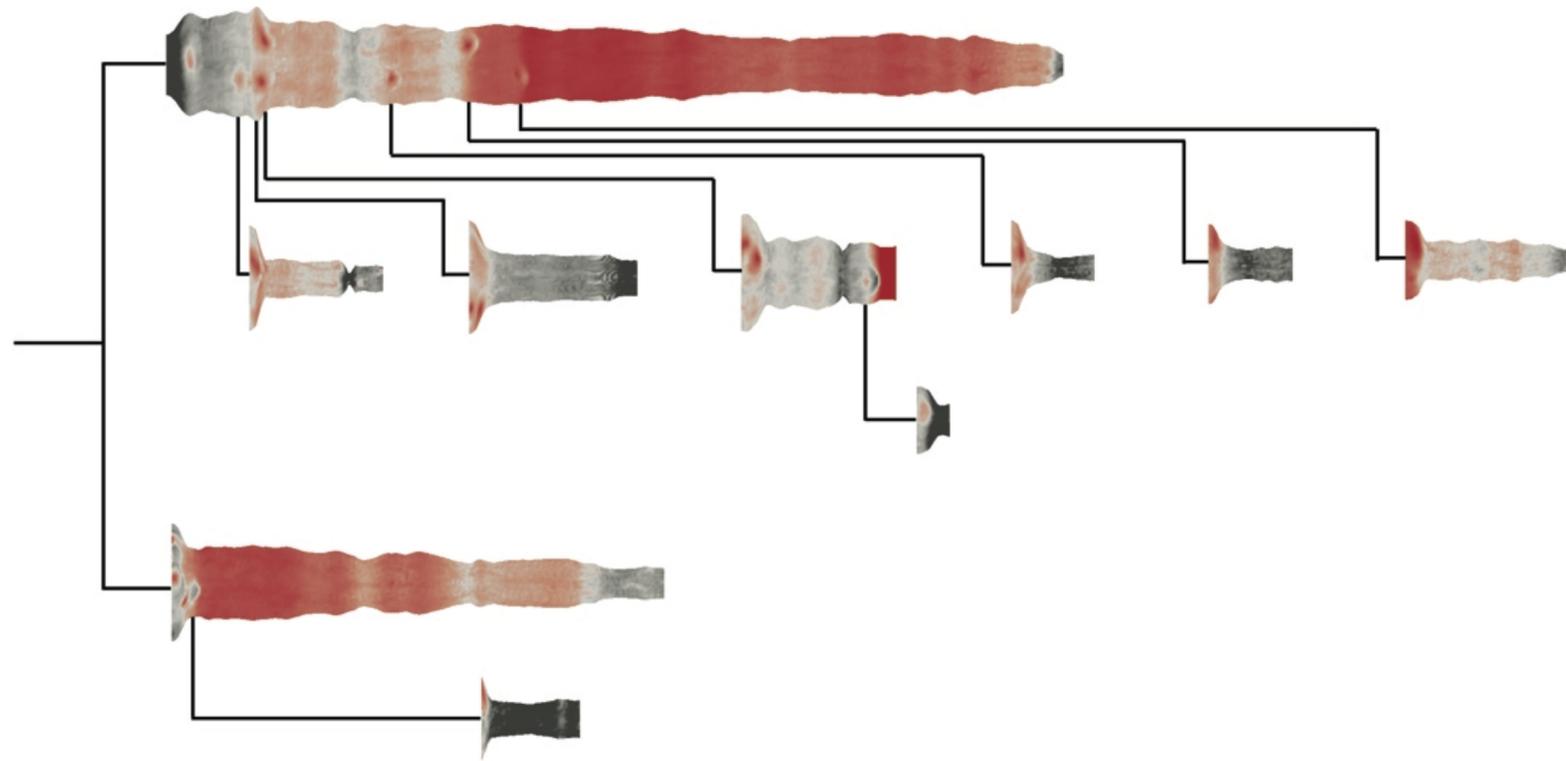
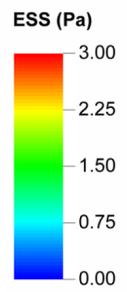
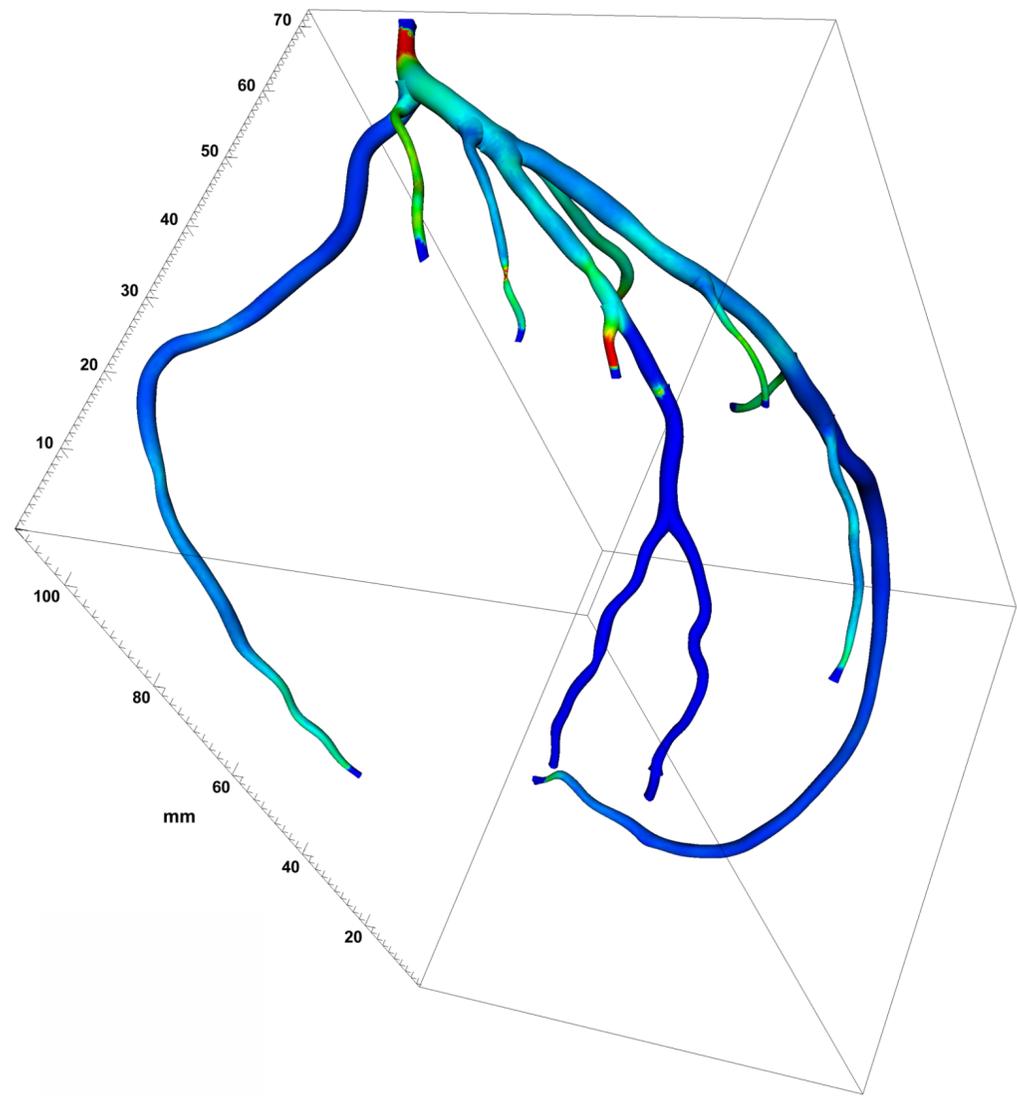
Plot Options - Image Widget
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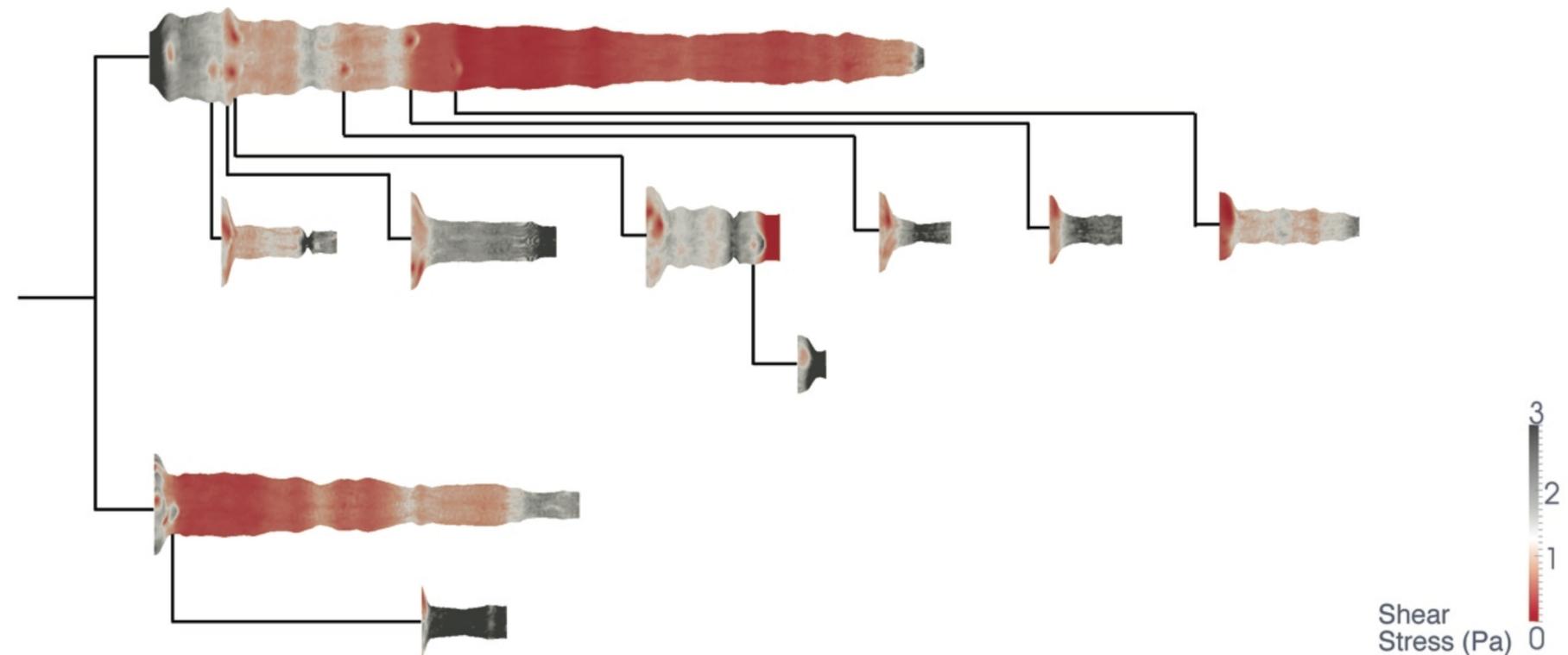
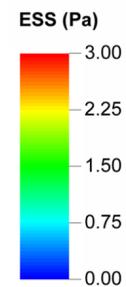
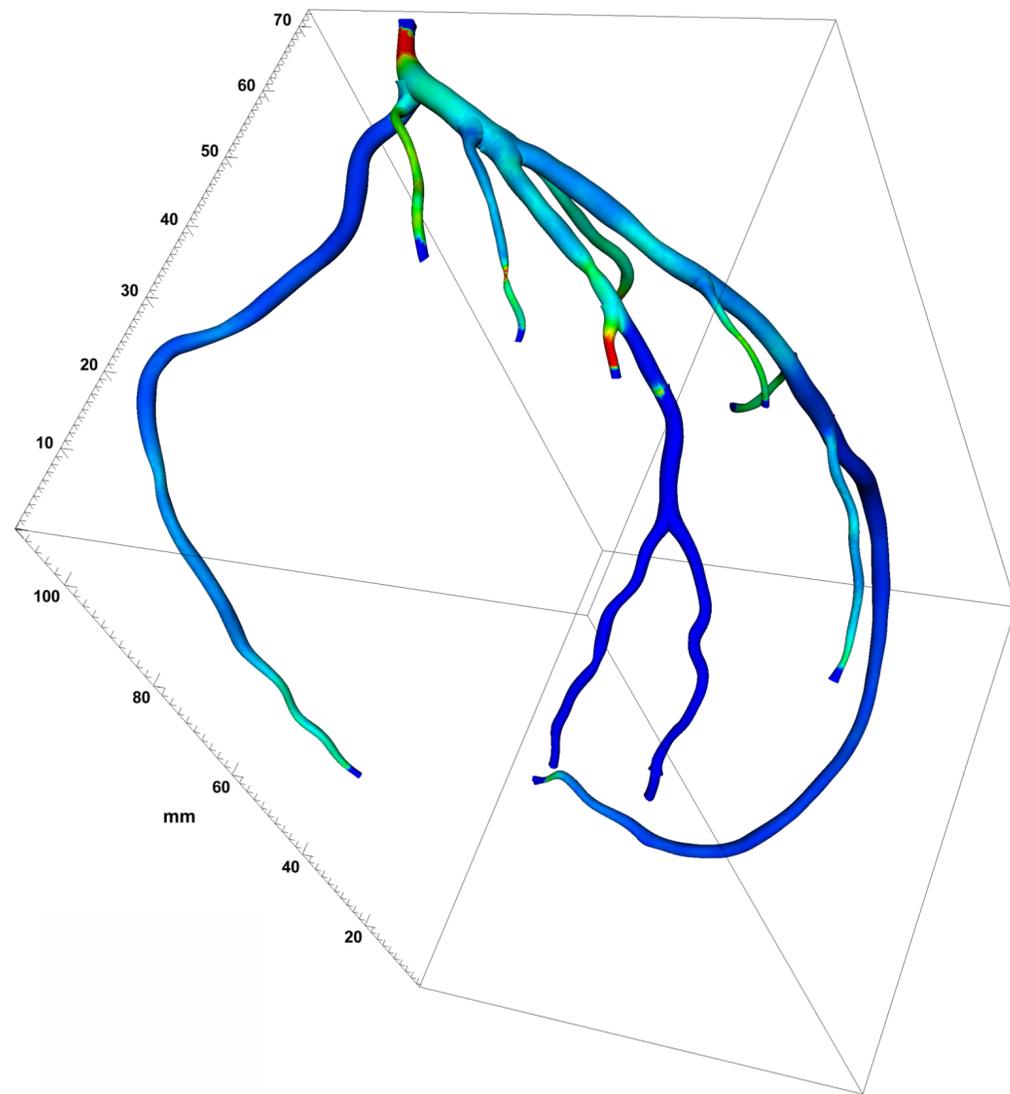


Frame
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 A: 287.3
 S: -233.8







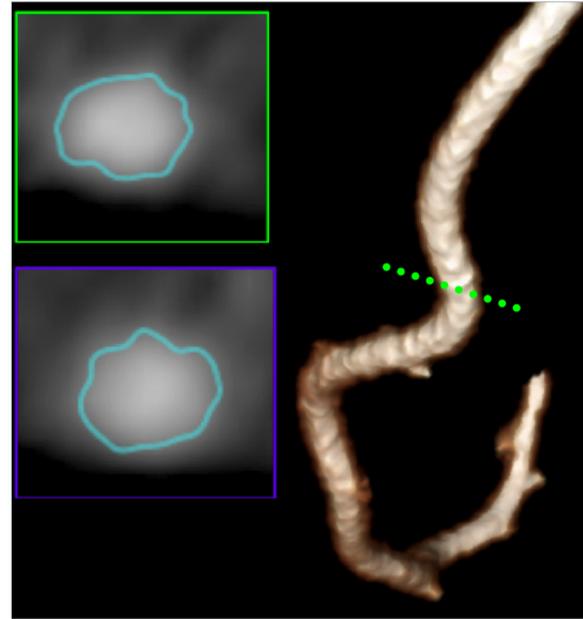


*Michelle Borkin, Krzysztof Gajos, Amanda Peters, Dimitris Mitsouras, Simone Melchionna,
Frank Rybicki, Charles Feldman, & Hanspeter Pfister,
“Evaluation of Artery Visualizations for Heart Disease Diagnosis” (IEEE TVCG / InfoVis 2011)*

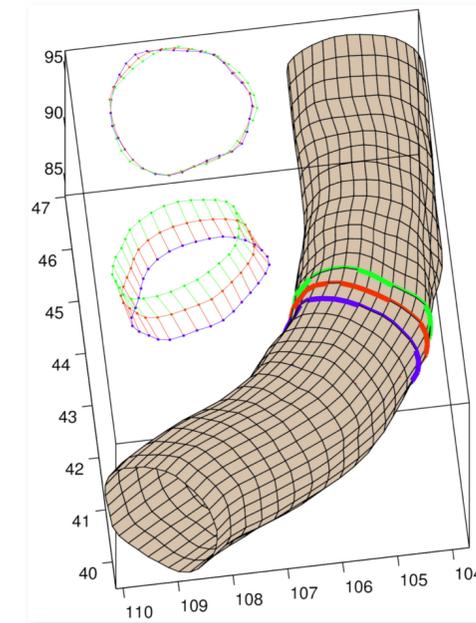
NON-INVASIVE DIAGNOSIS



Obtain patient CT data



Segment arteries

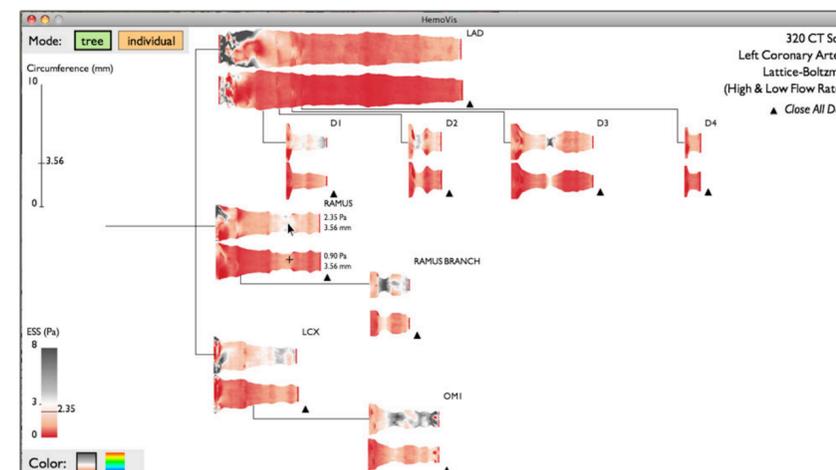


Generate patient geometries

Patient specific
blood flow simulation



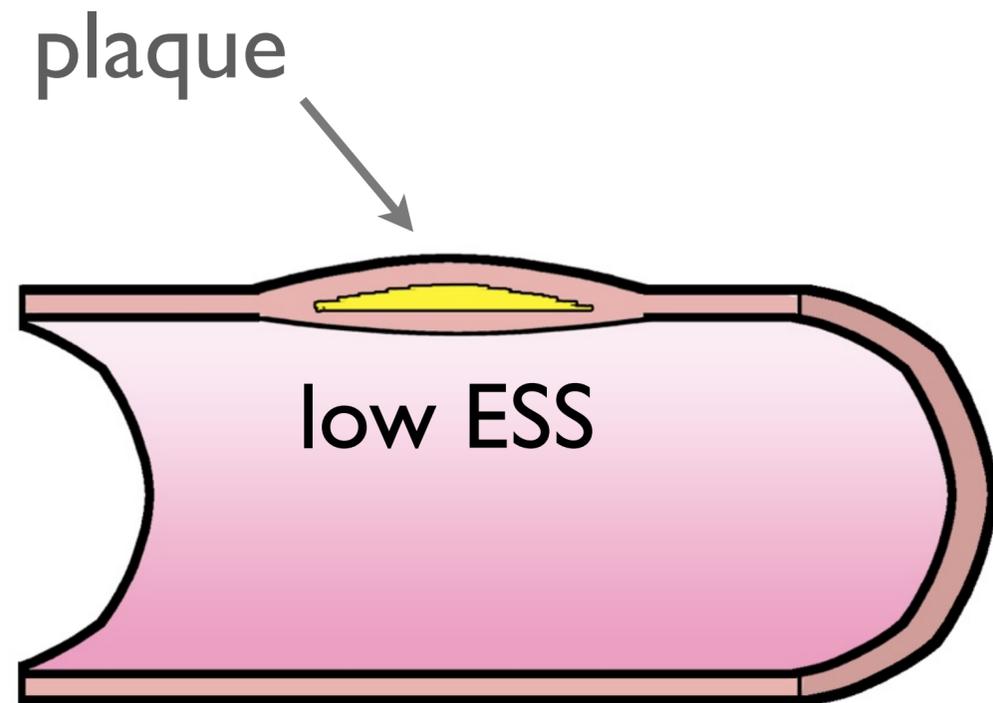
Visualize and
analyze data



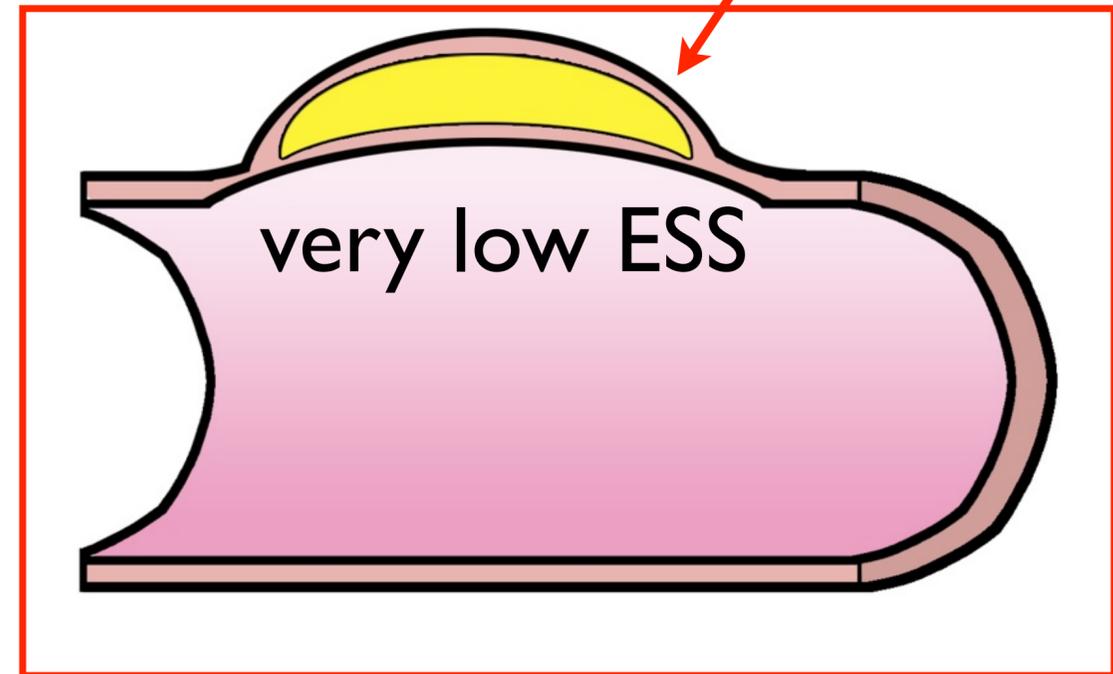
Clinical decision



DATA

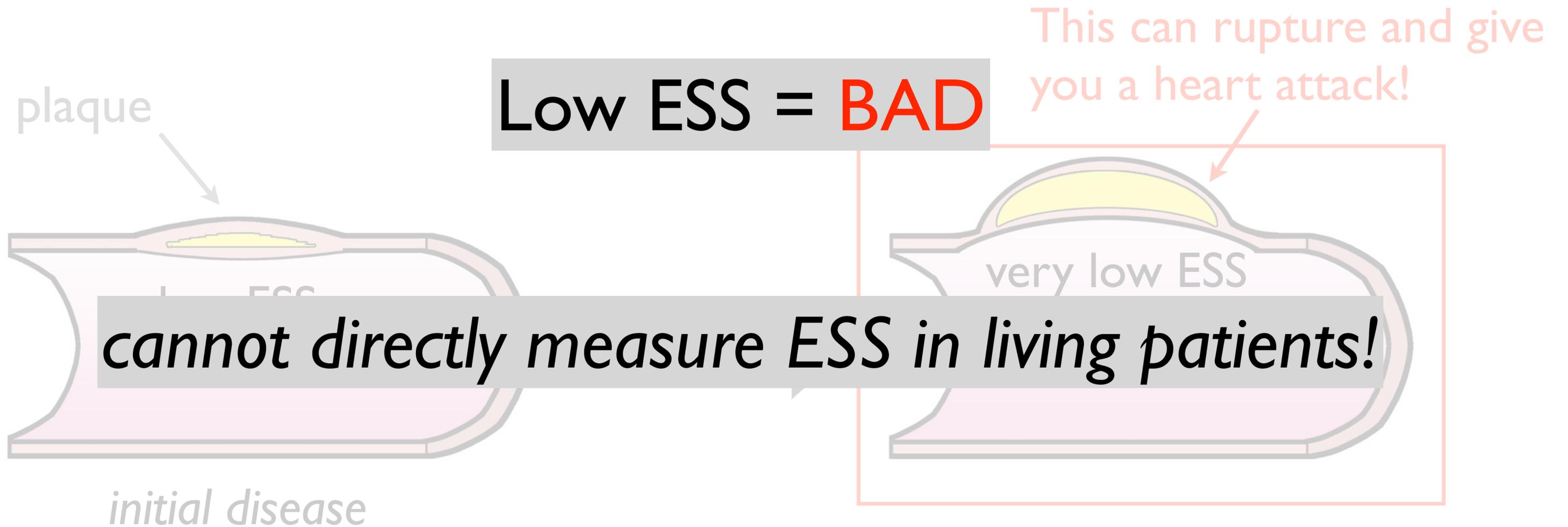


initial disease

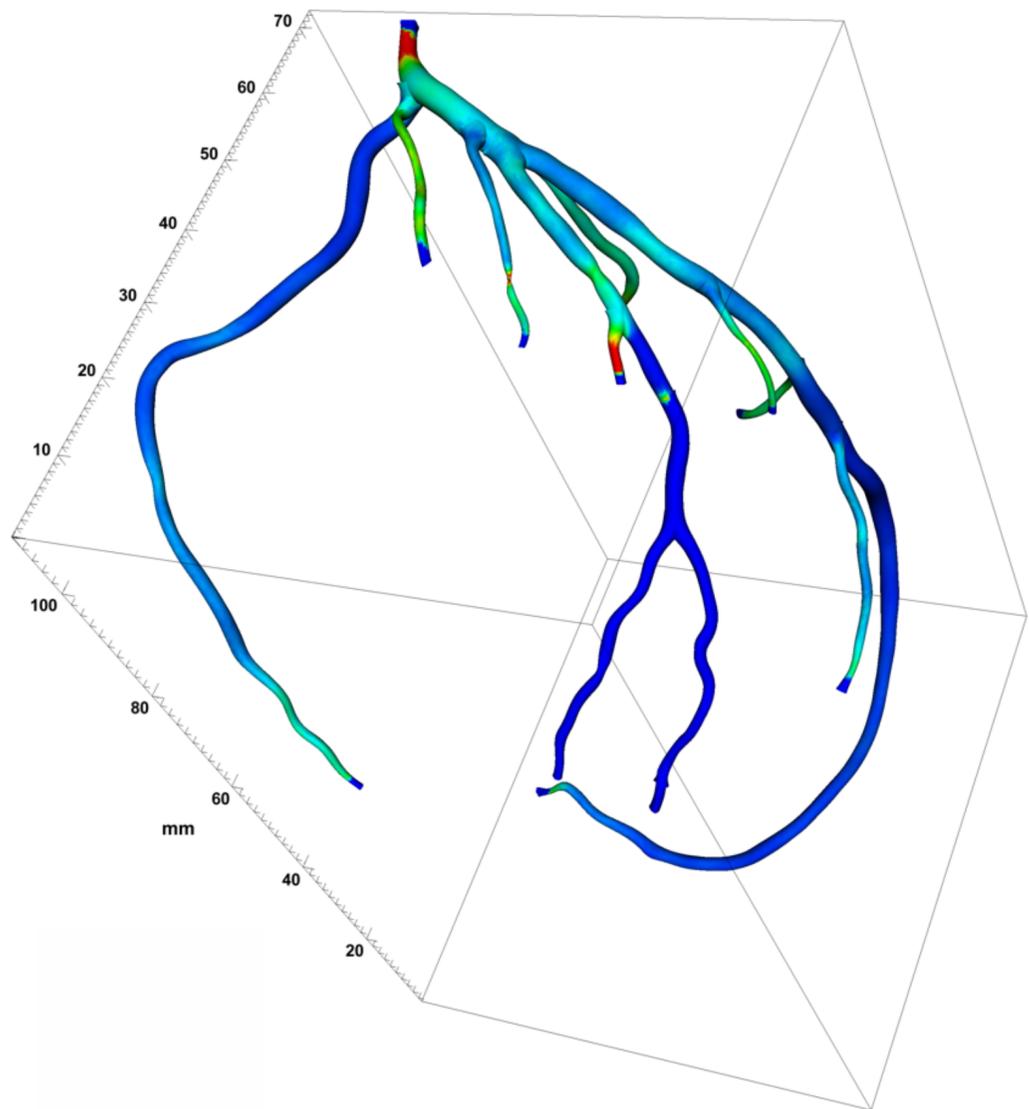


ESS = endothelial shear stress
(i.e., frictional force from blood flow)

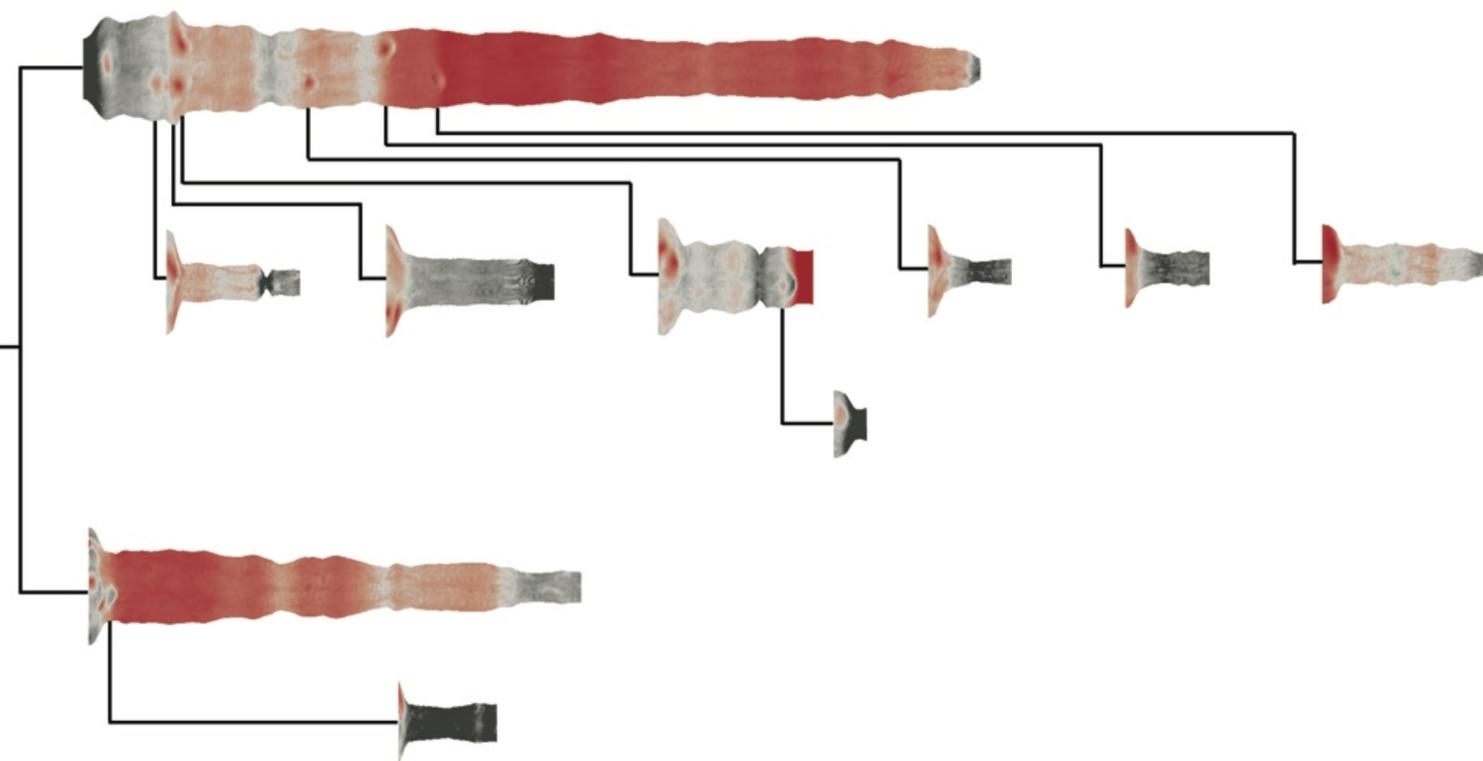
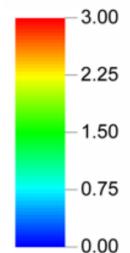
DATA



ESS = endothelial shear stress
(i.e., frictional force from blood flow)



ESS (Pa)



Shear Stress (Pa)



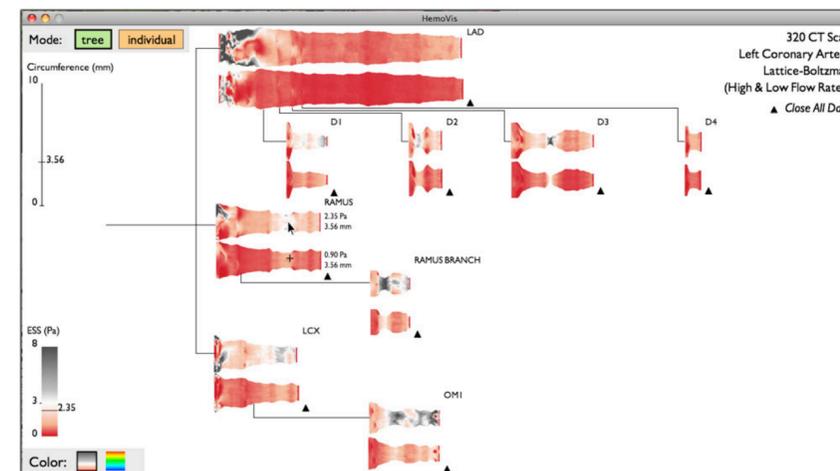
FORMATIVE QUALITATIVE STUDY

- Semi-structured interviews
- 10 medical doctors and researchers
- Brigham & Women's Hospital (Boston, MA)

Clinical decision



Visualize and analyze data

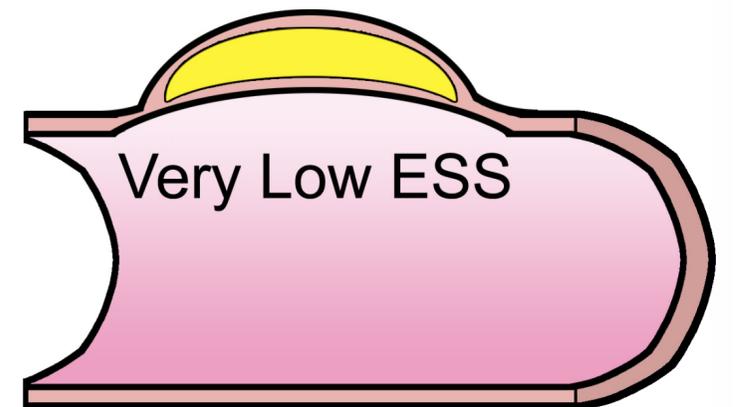


TASK TAXONOMY

TASK	ABSTRACTION
-------------	--------------------

TASK TAXONOMY

TASK	ABSTRACTION
“Identify regions of low ESS”	find extrema



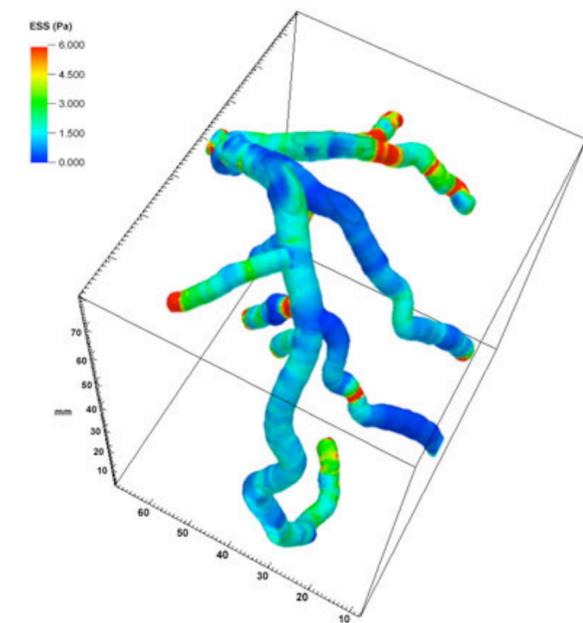
TASK TAXONOMY

TASK	ABSTRACTION
“Identify regions of low ESS”	find extrema
“Identify stenosis or blockage”	find extrema



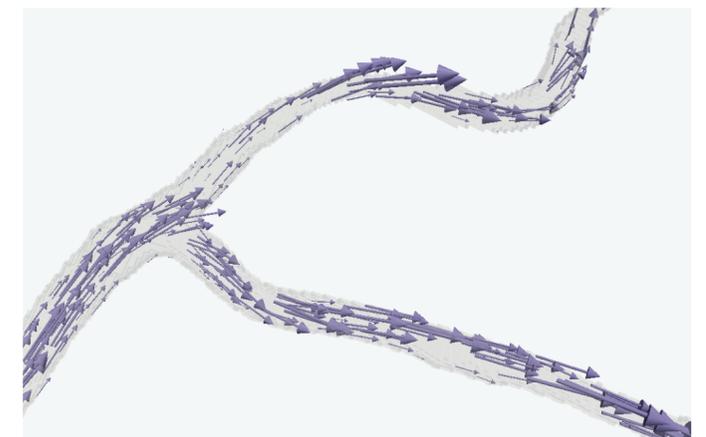
TASK TAXONOMY

TASK	ABSTRACTION
“Identify regions of low ESS”	find extrema
“Identify stenosis or blockage”	find extrema
“View all ESS data for patterns”	cluster



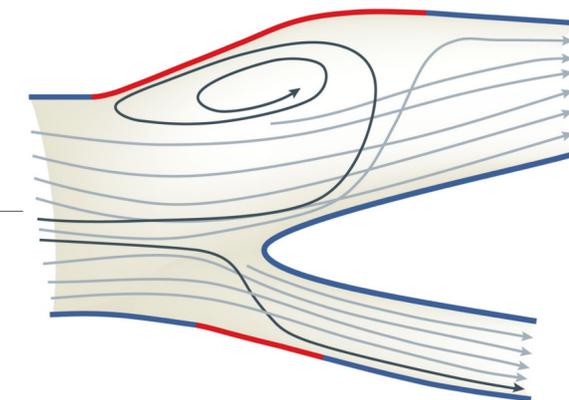
TASK TAXONOMY

TASK	ABSTRACTION
“Identify regions of low ESS”	find extrema
“Identify stenosis or blockage”	find extrema
“View all ESS data for patterns”	cluster
“Study blood flow velocity patterns”	find anomalies



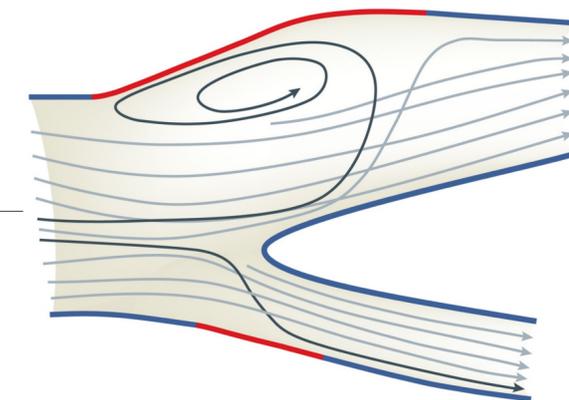
TASK TAXONOMY

TASK	ABSTRACTION
“Identify regions of low ESS”	find extrema
“Identify stenosis or blockage”	find extrema
“View all ESS data for patterns”	cluster
“Study blood flow velocity patterns”	find anomalies
“Identify regions of blood recirculation”	find anomalies



TASK TAXONOMY

TASK	ABSTRACTION
“Identify regions of low ESS”	find extrema
“Identify stenosis or blockage”	find extrema
“View all ESS data for patterns”	cluster
“Study blood flow velocity patterns”	find anomalies
“Identify regions of blood recirculation”	find anomalies
“Investigate other physical variables of blood flow”	find anomalies



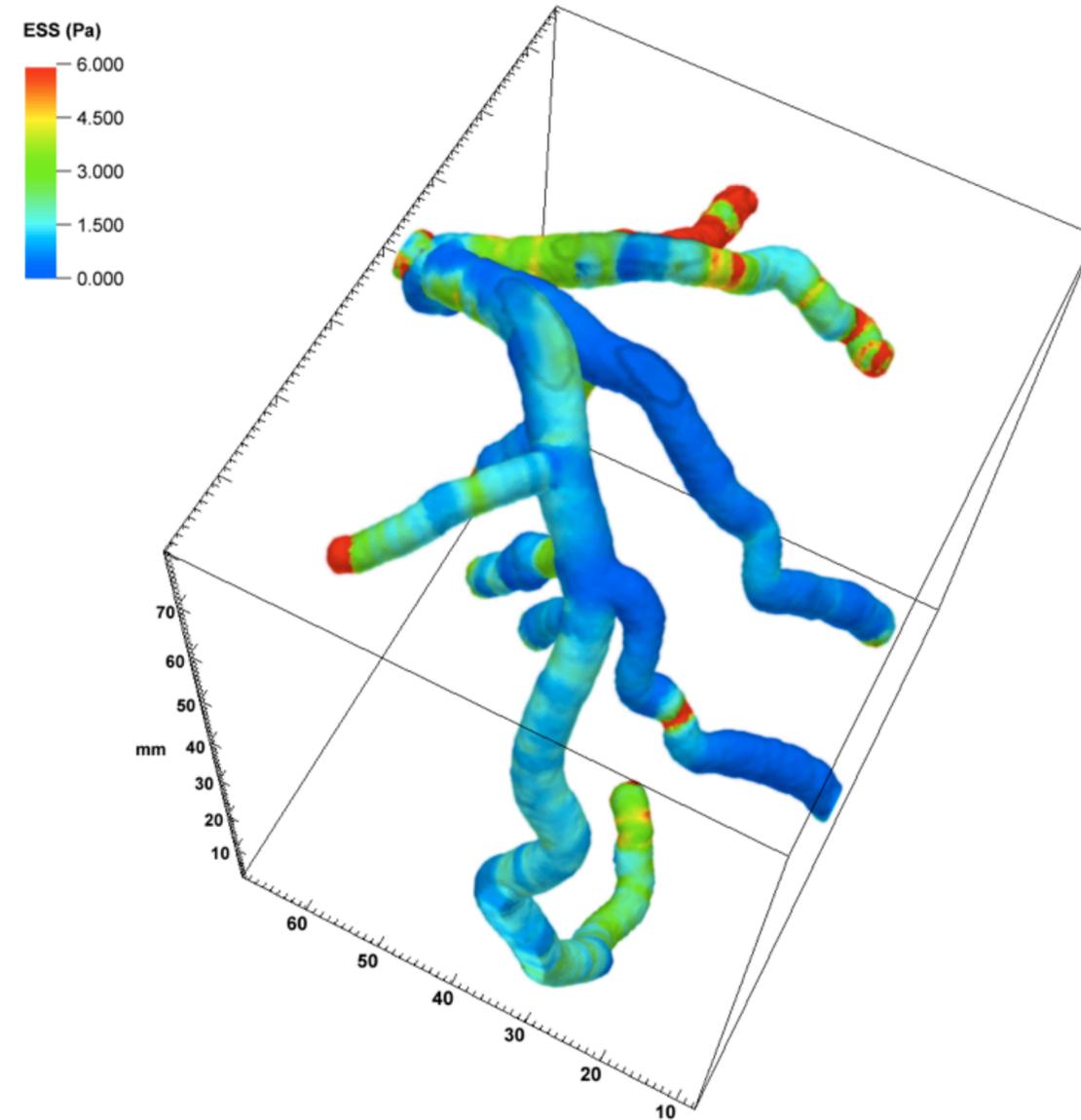
TASK TAXONOMY

TASK	ABSTRACTION	CLINICAL	RESEARCH
“Identify regions of low ESS”	find extrema	X	X
“Identify stenosis or blockage”	find extrema	X	X
“View all ESS data for patterns”	cluster	X	X
“Study blood flow velocity patterns”	find anomalies		X
“Identify regions of blood recirculation”	find anomalies		X
“Investigate other physical variables of blood flow”	find anomalies		X

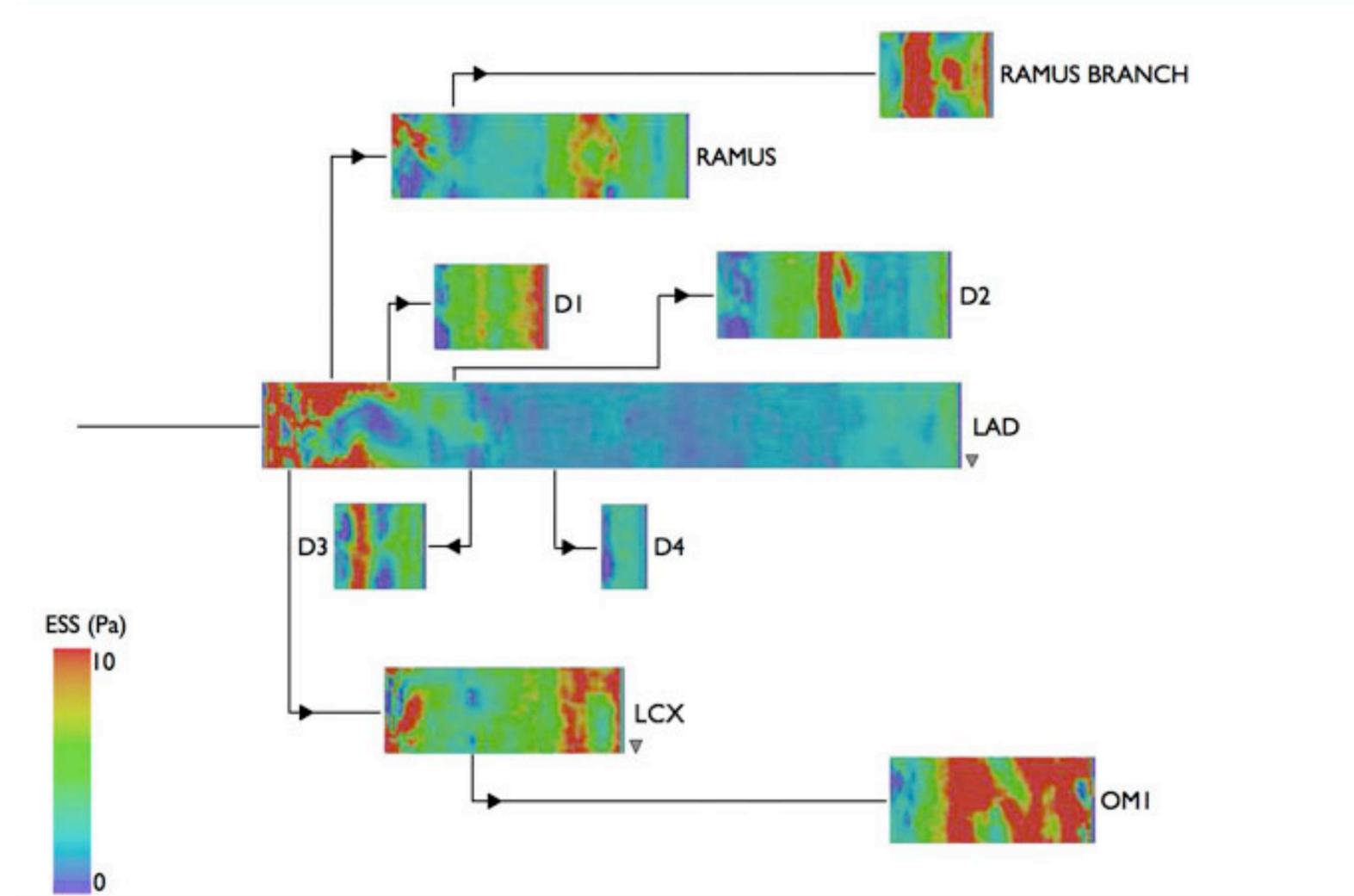
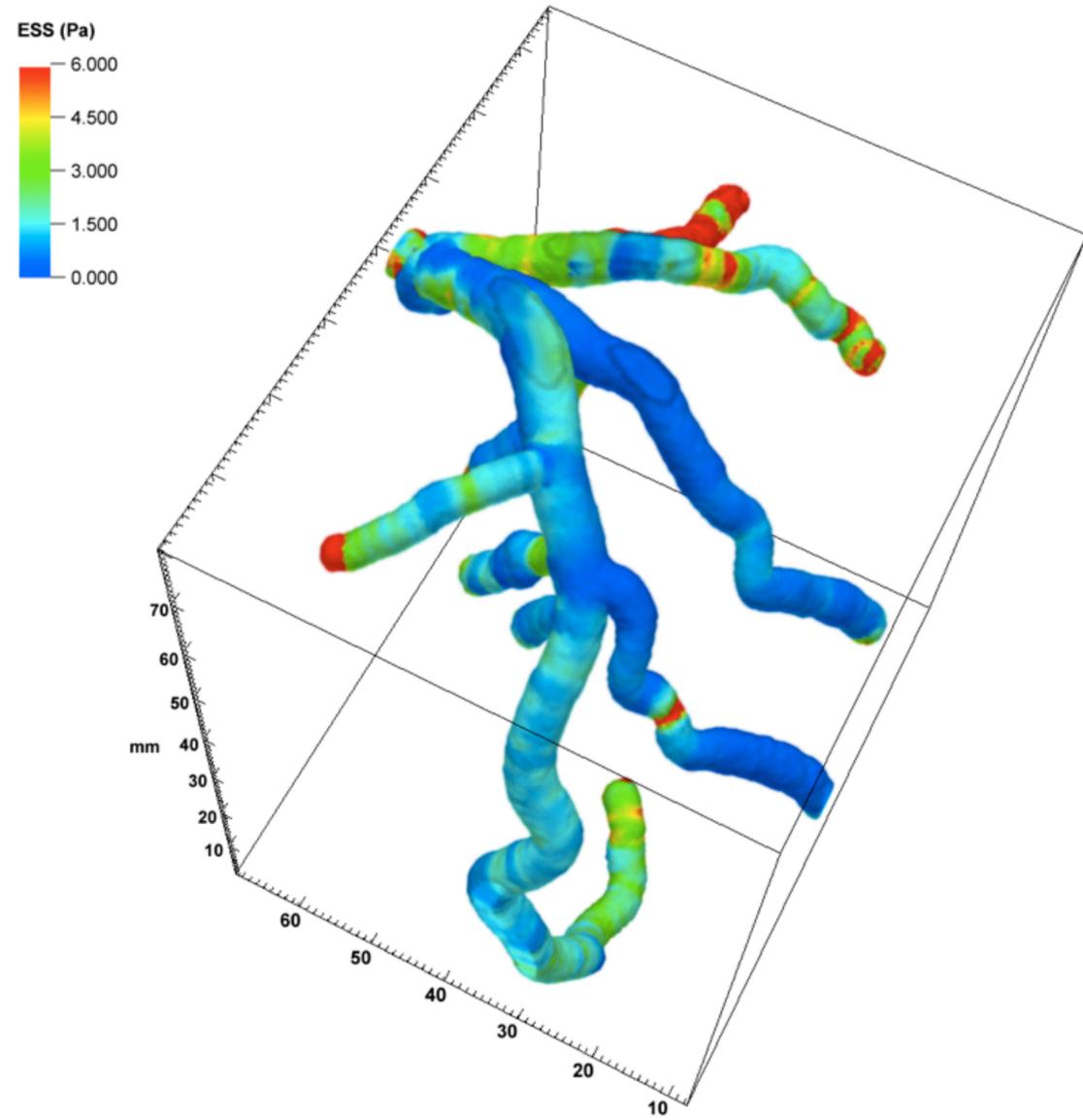
TASK TAXONOMY

TASK	ABSTRACTION	CLINICAL	RESEARCH
“Identify regions of low ESS”	find extrema	X	X
“Identify stenosis or blockage”	find extrema	X	X
“View all ESS data for patterns”	cluster	X	X
“Study blood flow velocity patterns”	find anomalies		X
“Identify regions of blood recirculation”	find anomalies		X
“Investigate other physical variables of blood flow”	find anomalies		X

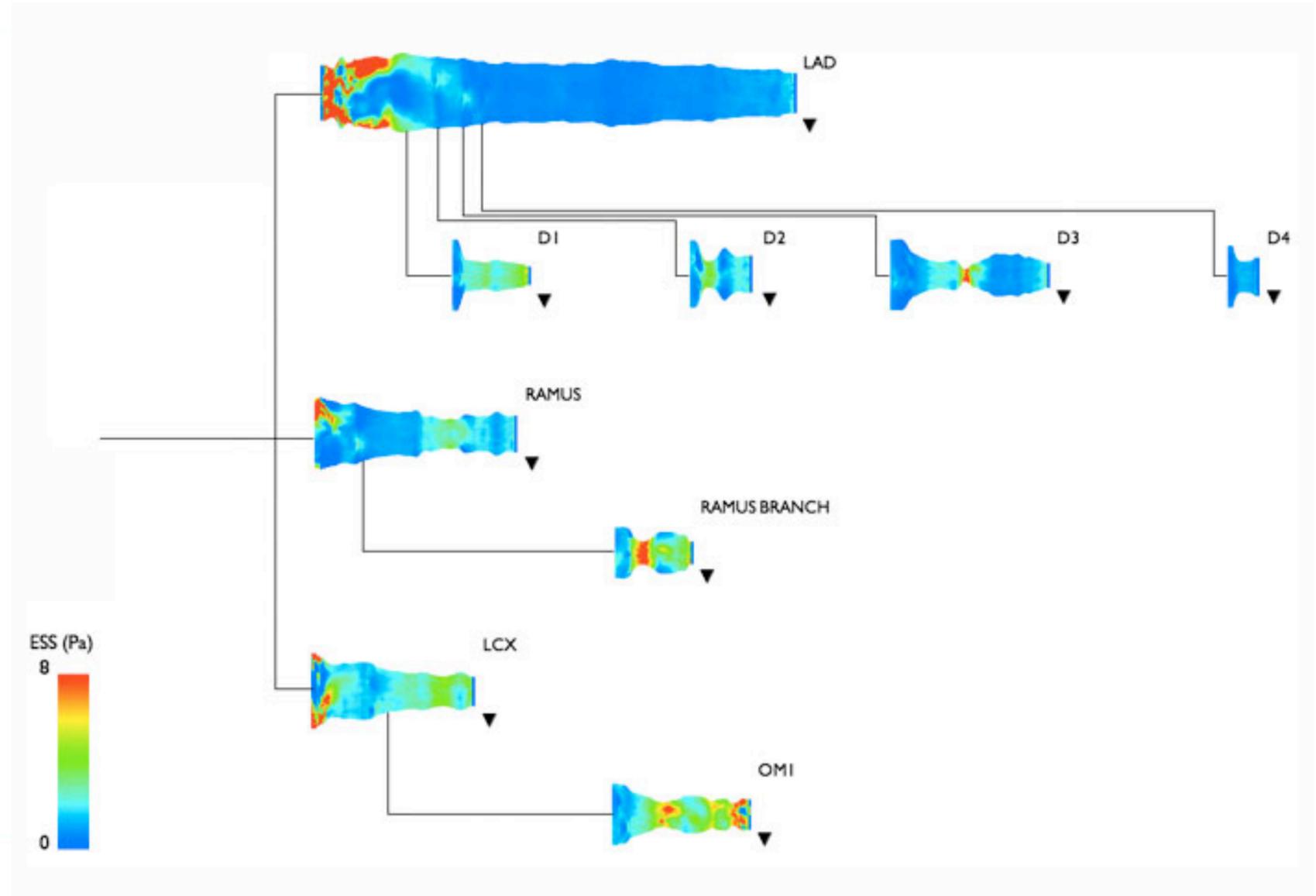
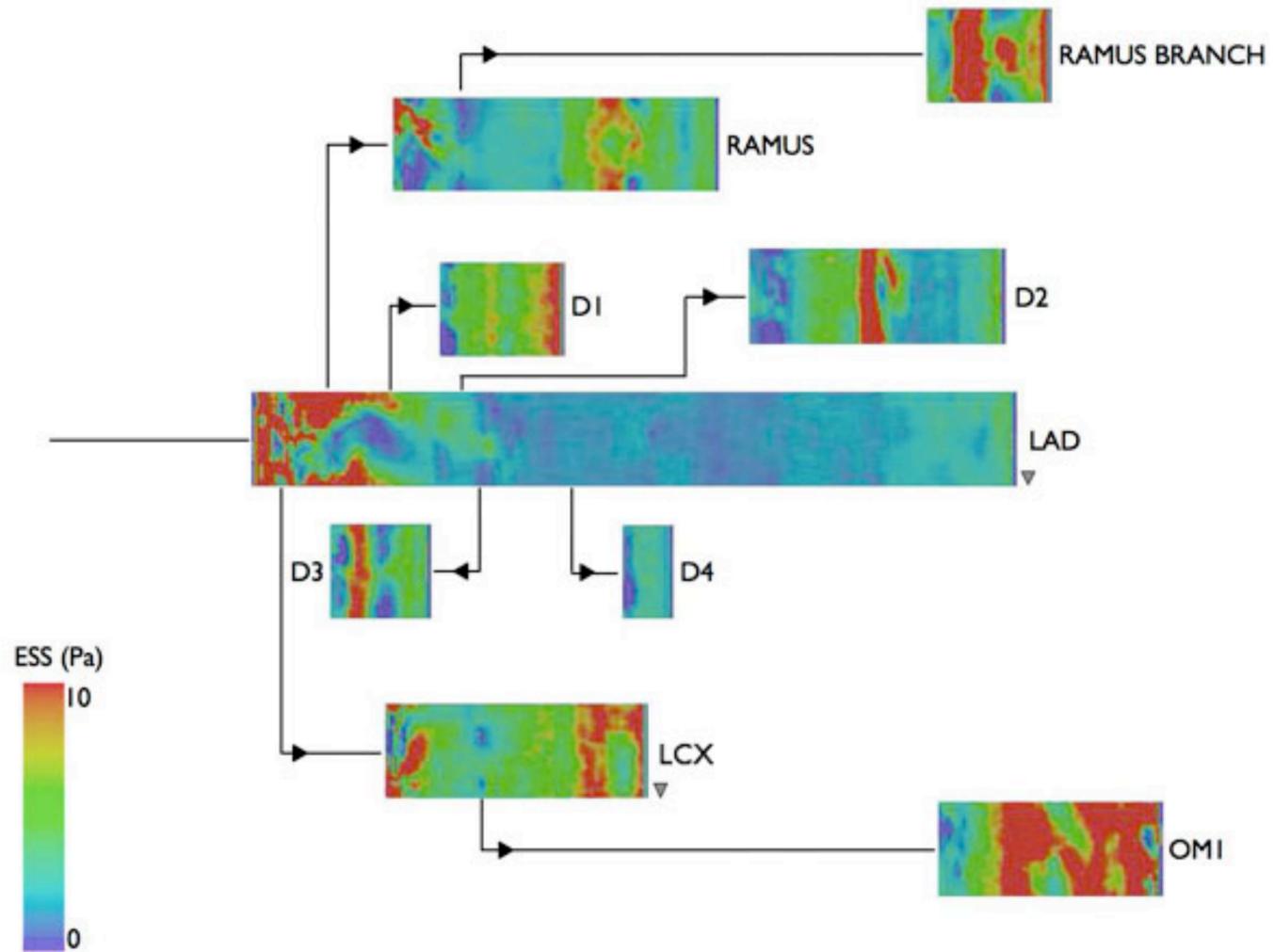
3D vs. 2D

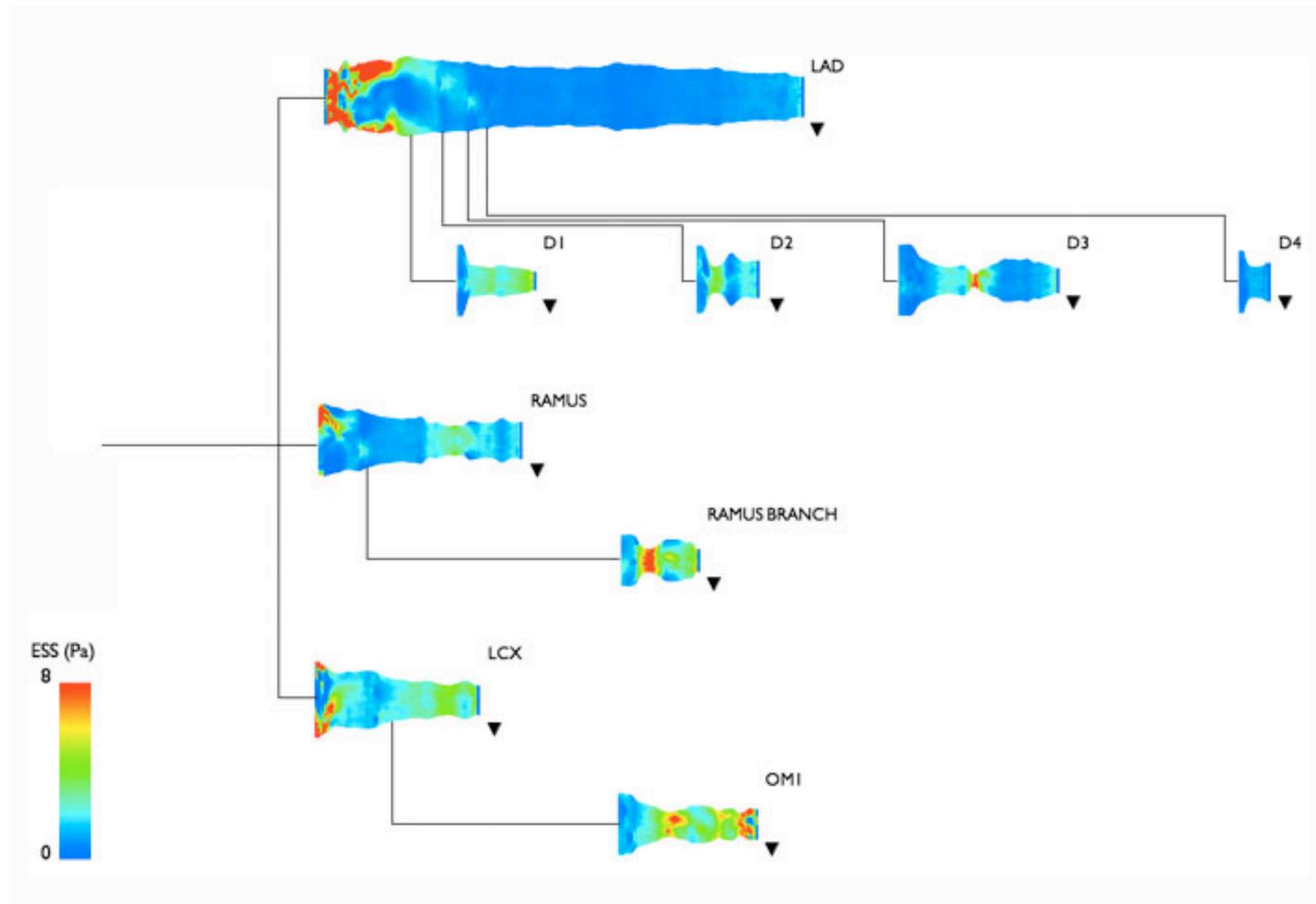


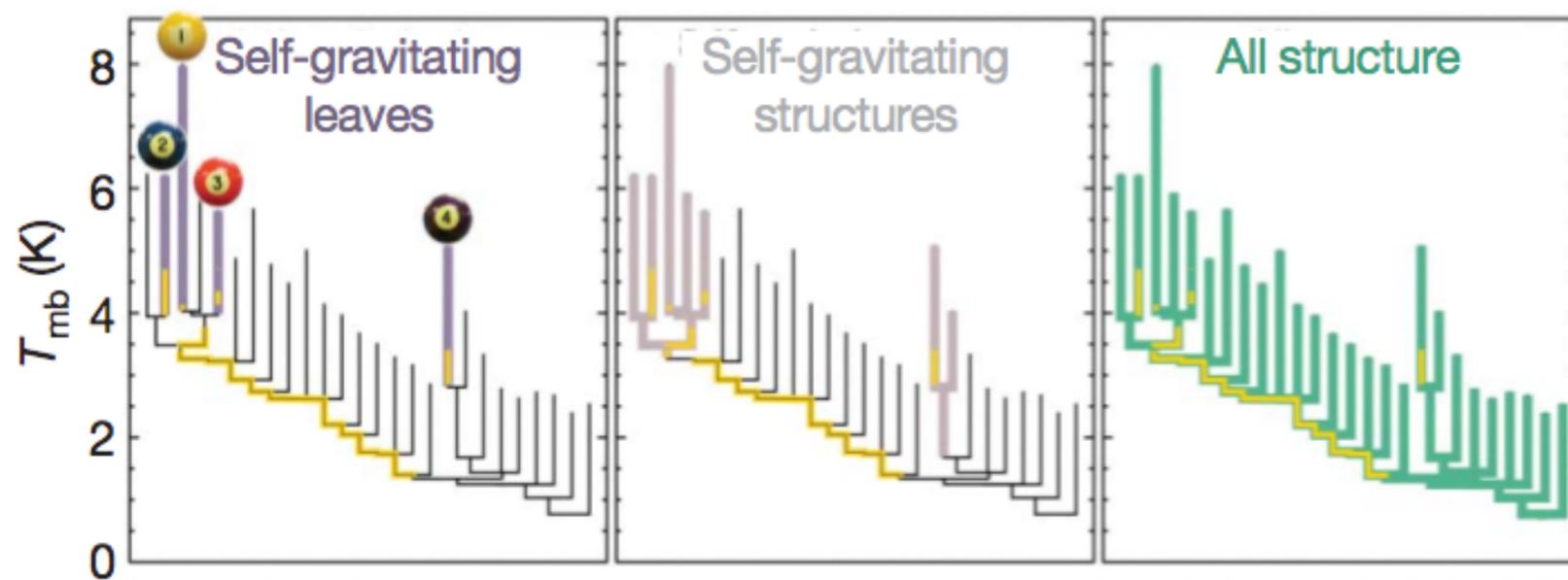
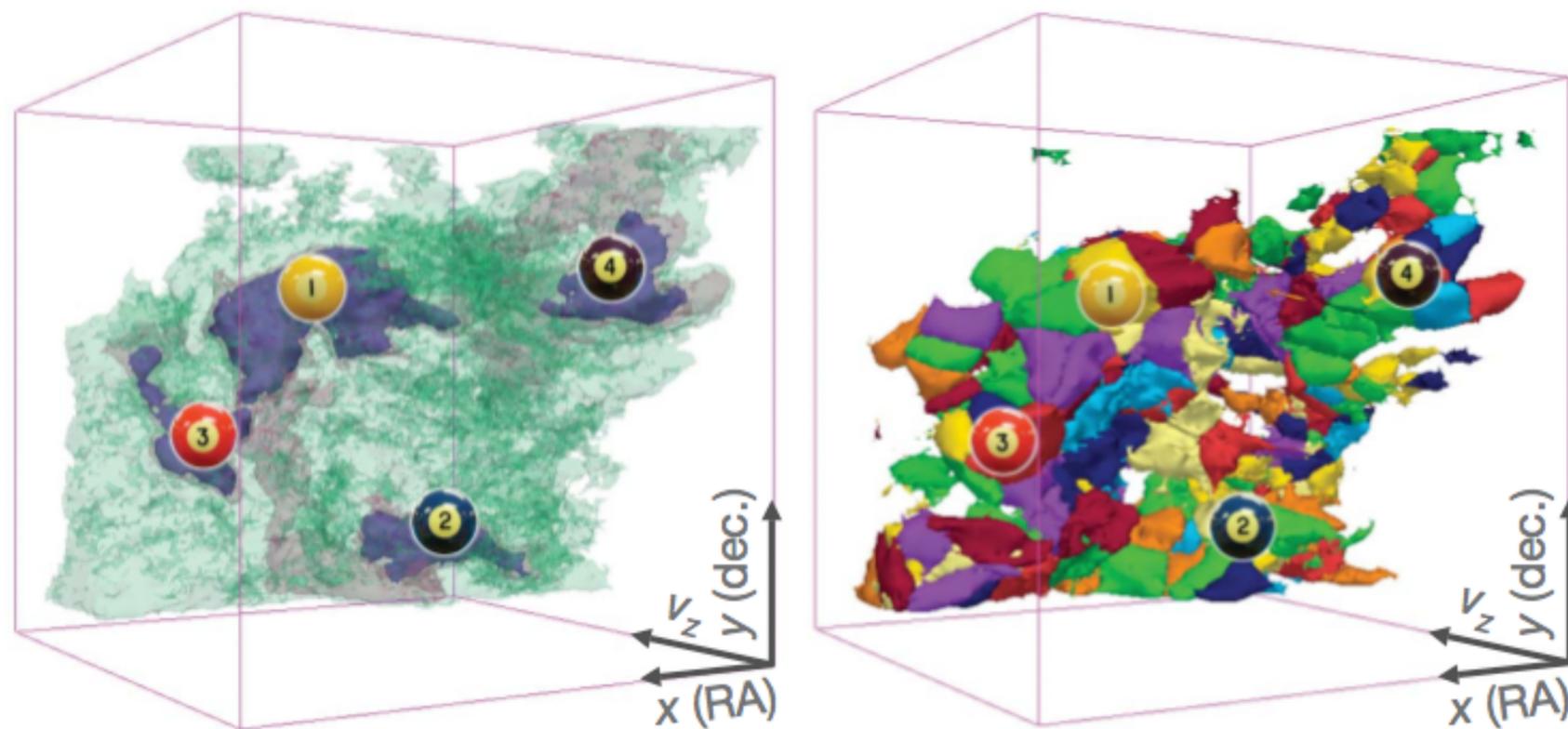
3D vs. 2D

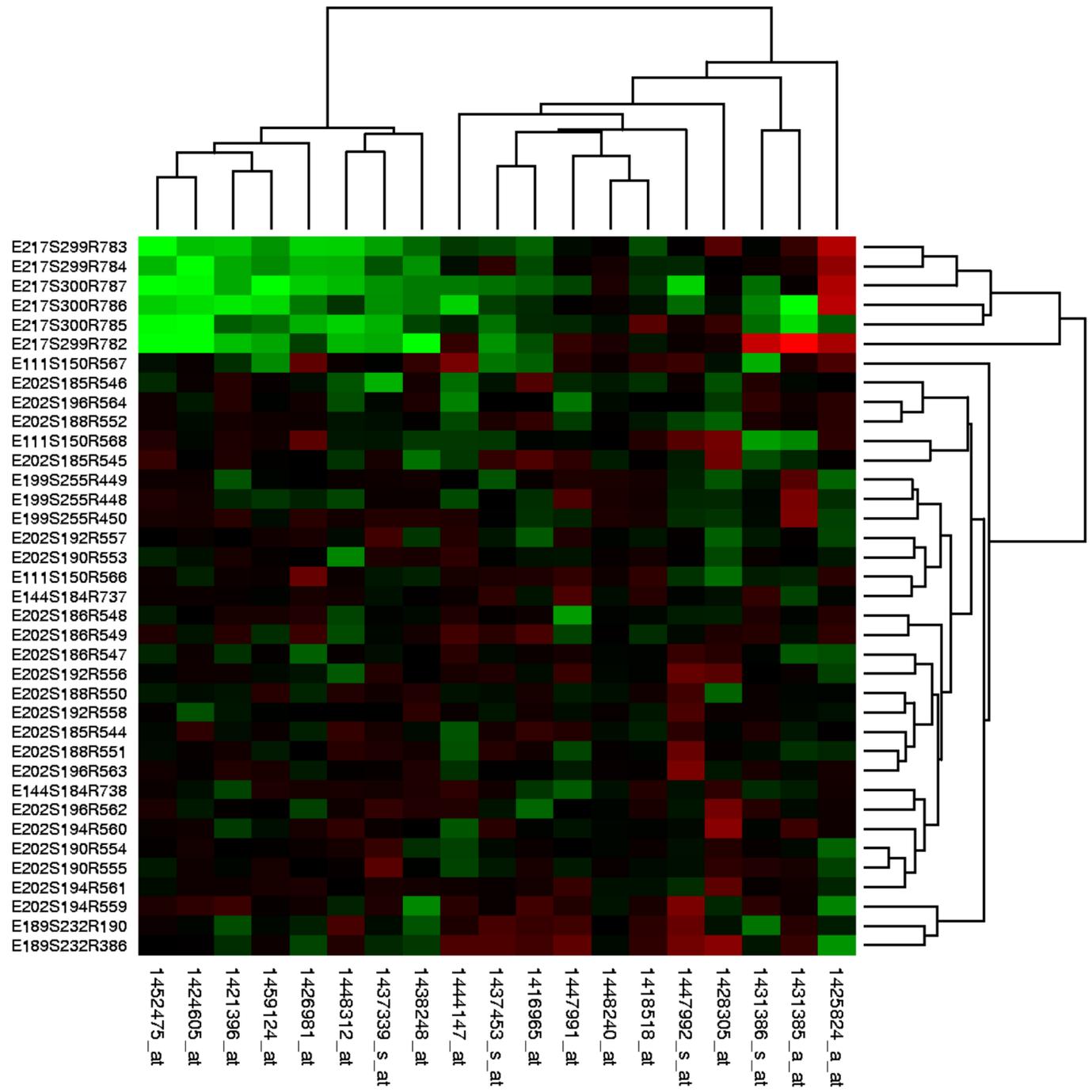


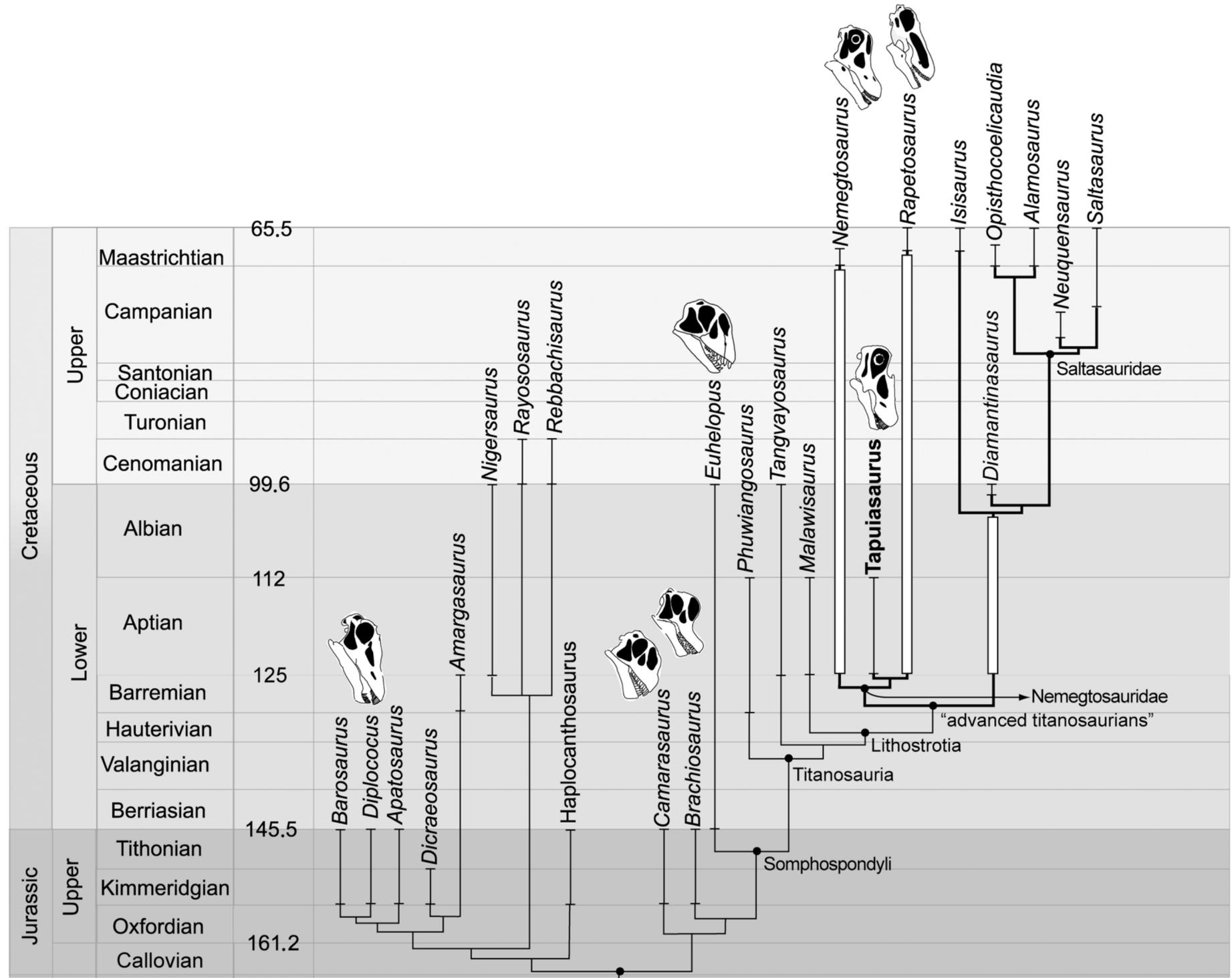
LAYOUT AND PROJECTIONS





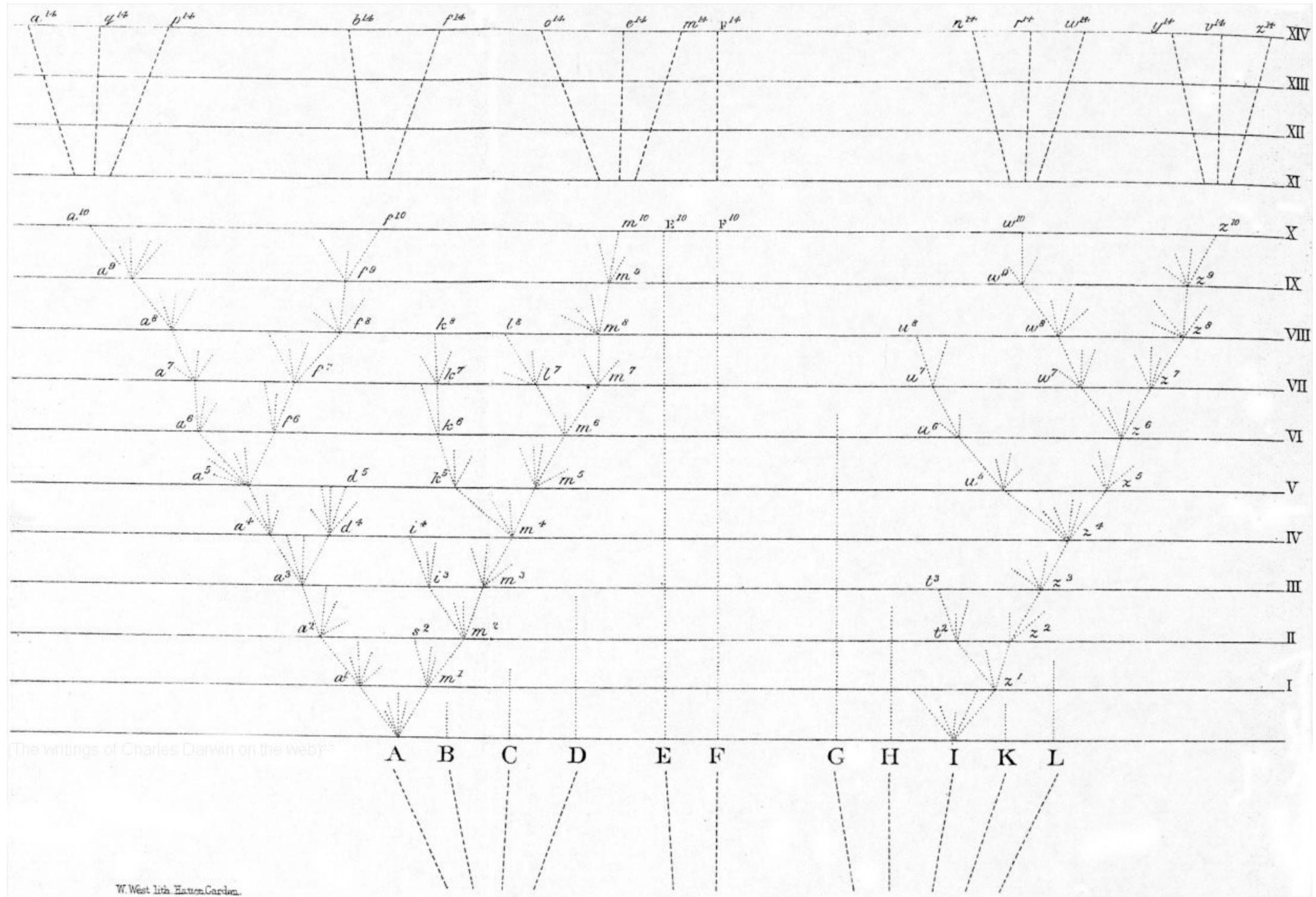




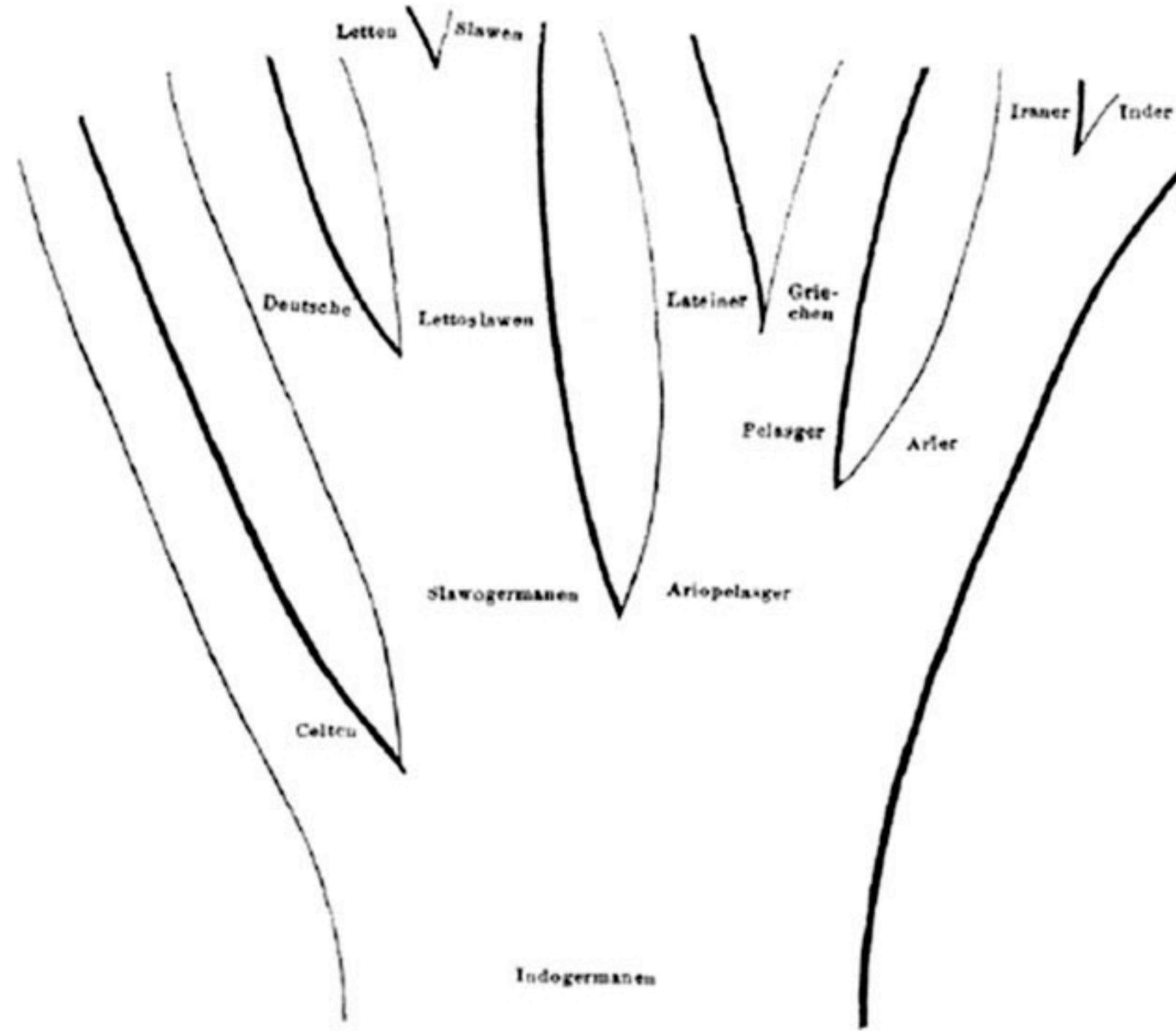


basal eusauropods ← Neosauropoda

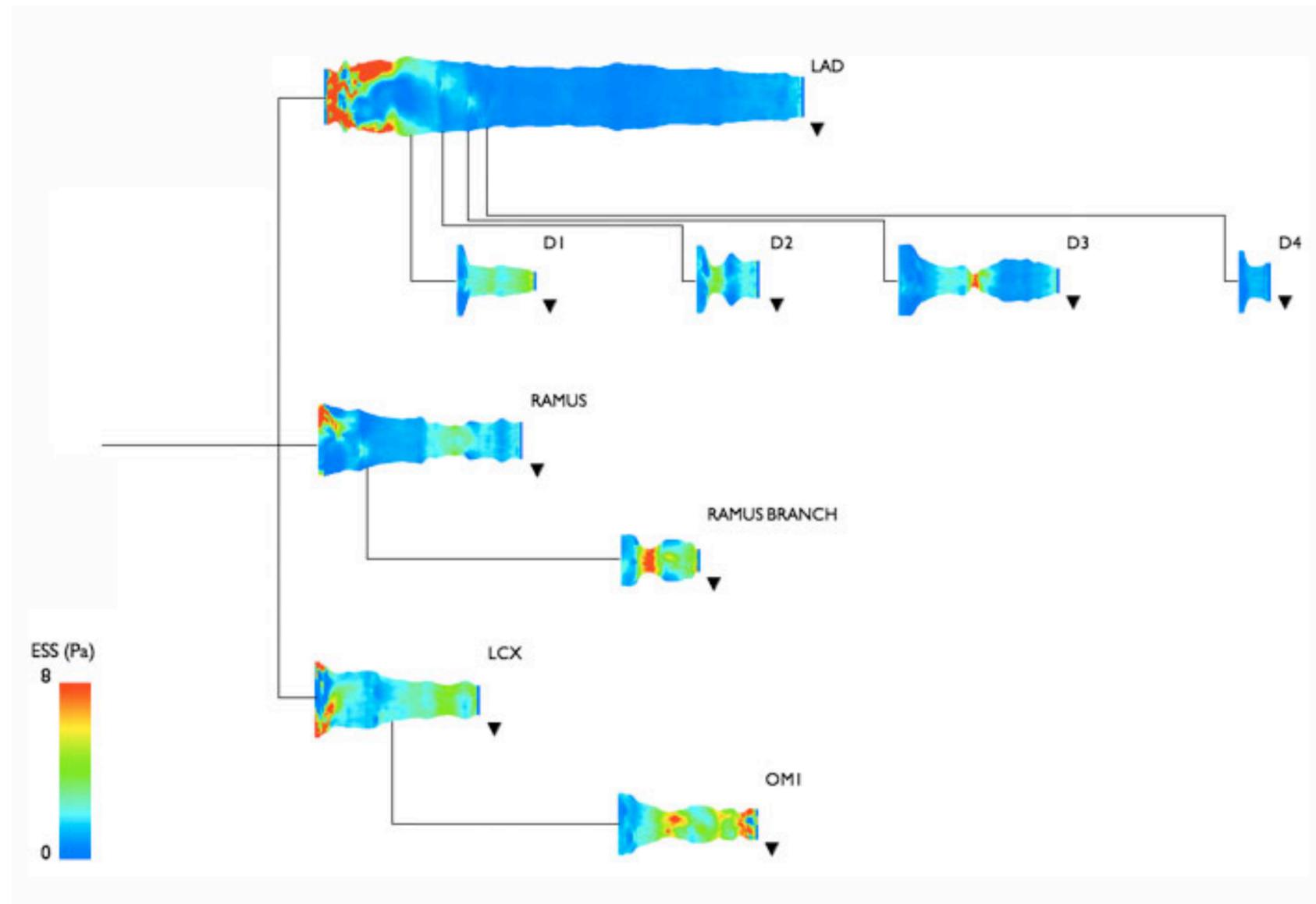
Authors: A. Carvalho, P. Nascimento & C. Riccomini



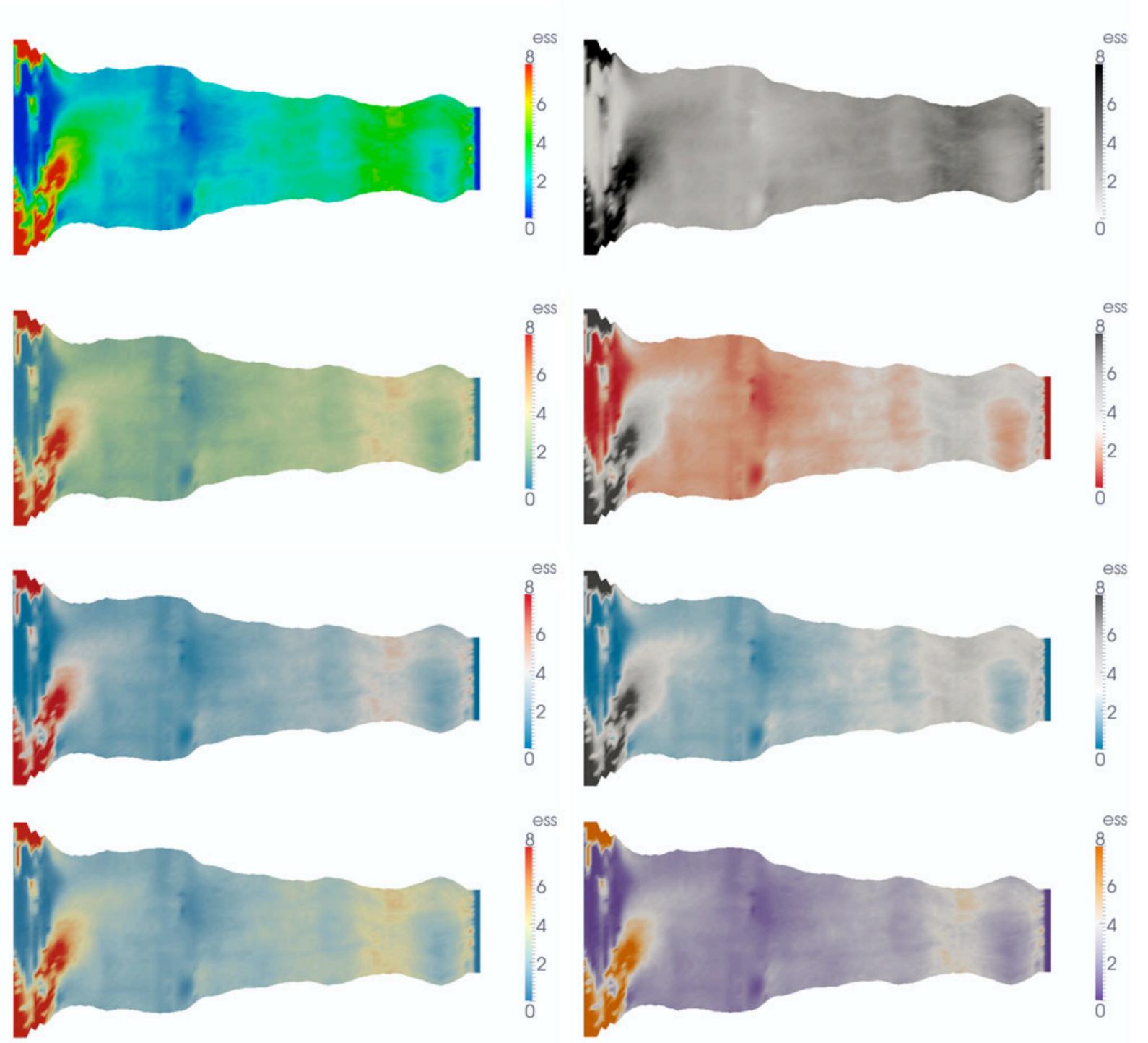
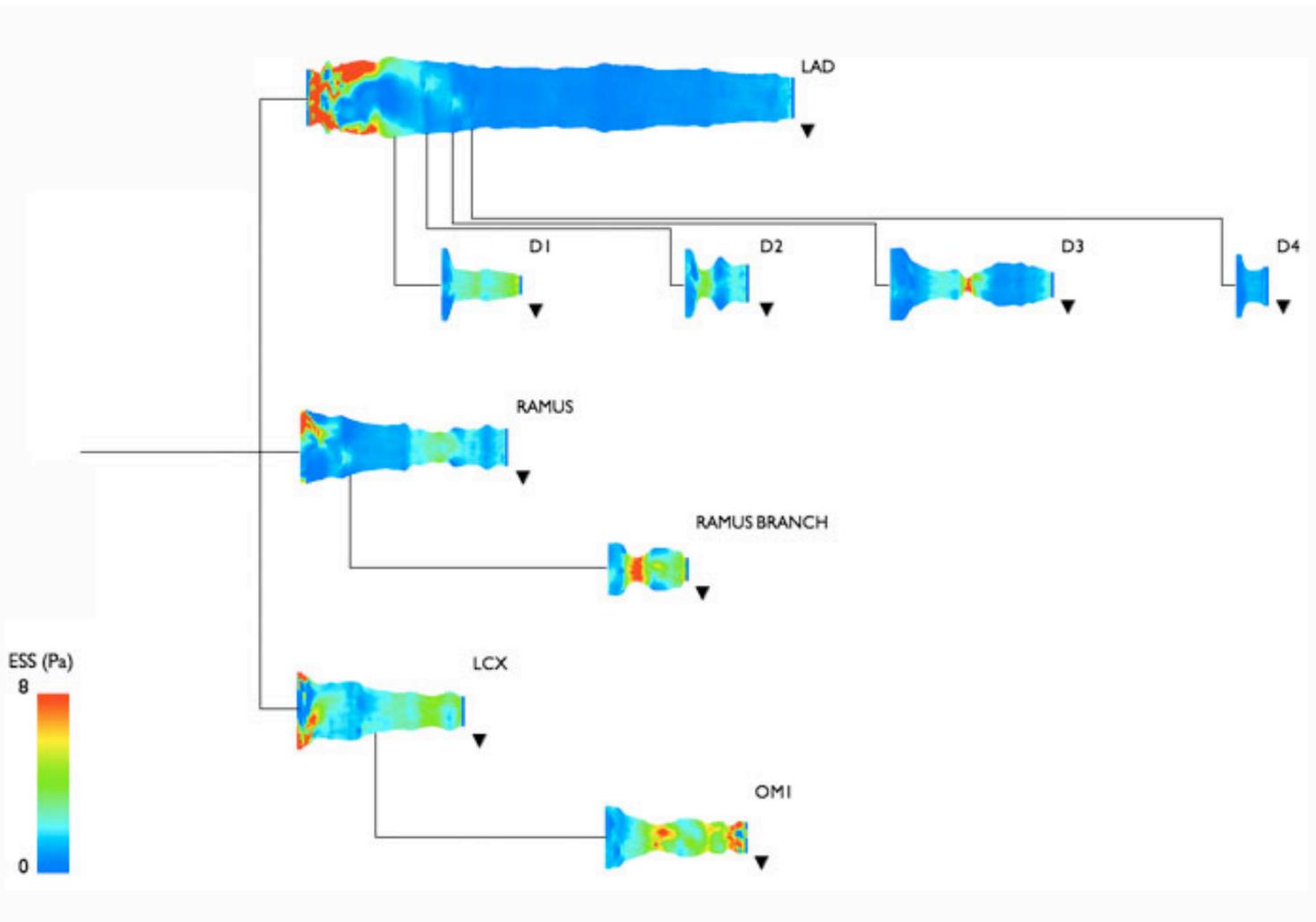
The writings of Charles Darwin on the web



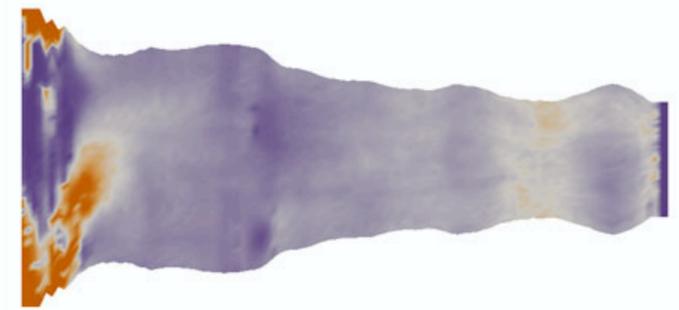
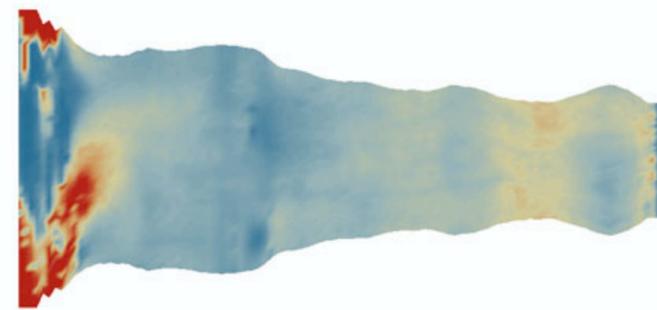
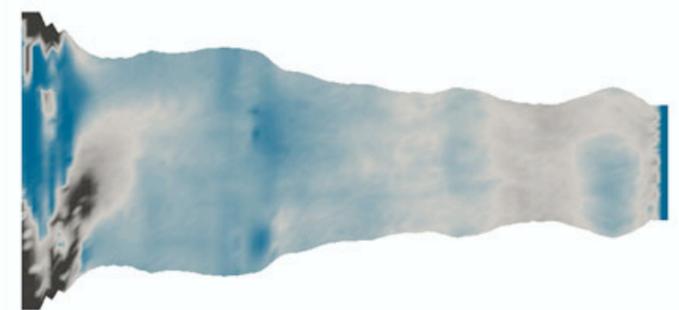
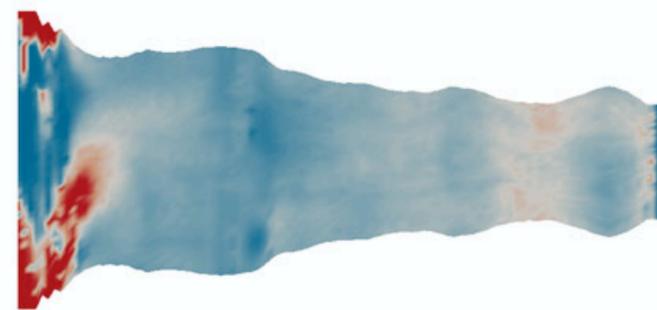
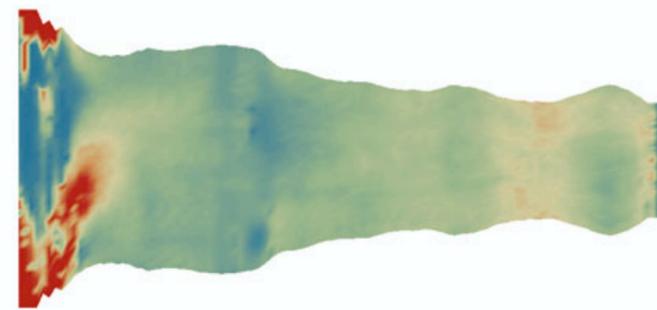
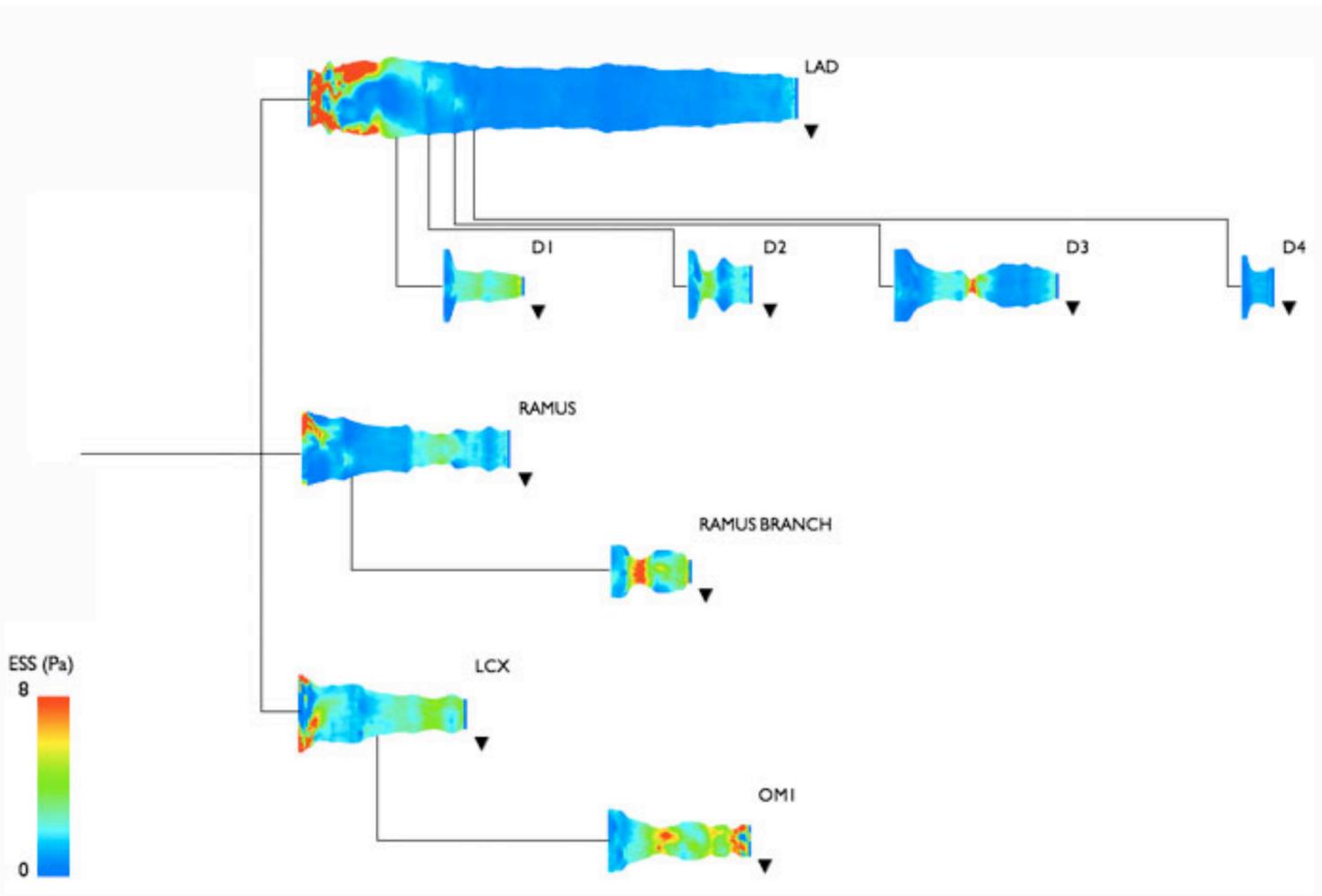
Sonneberg, den 15. Aug. 1853.



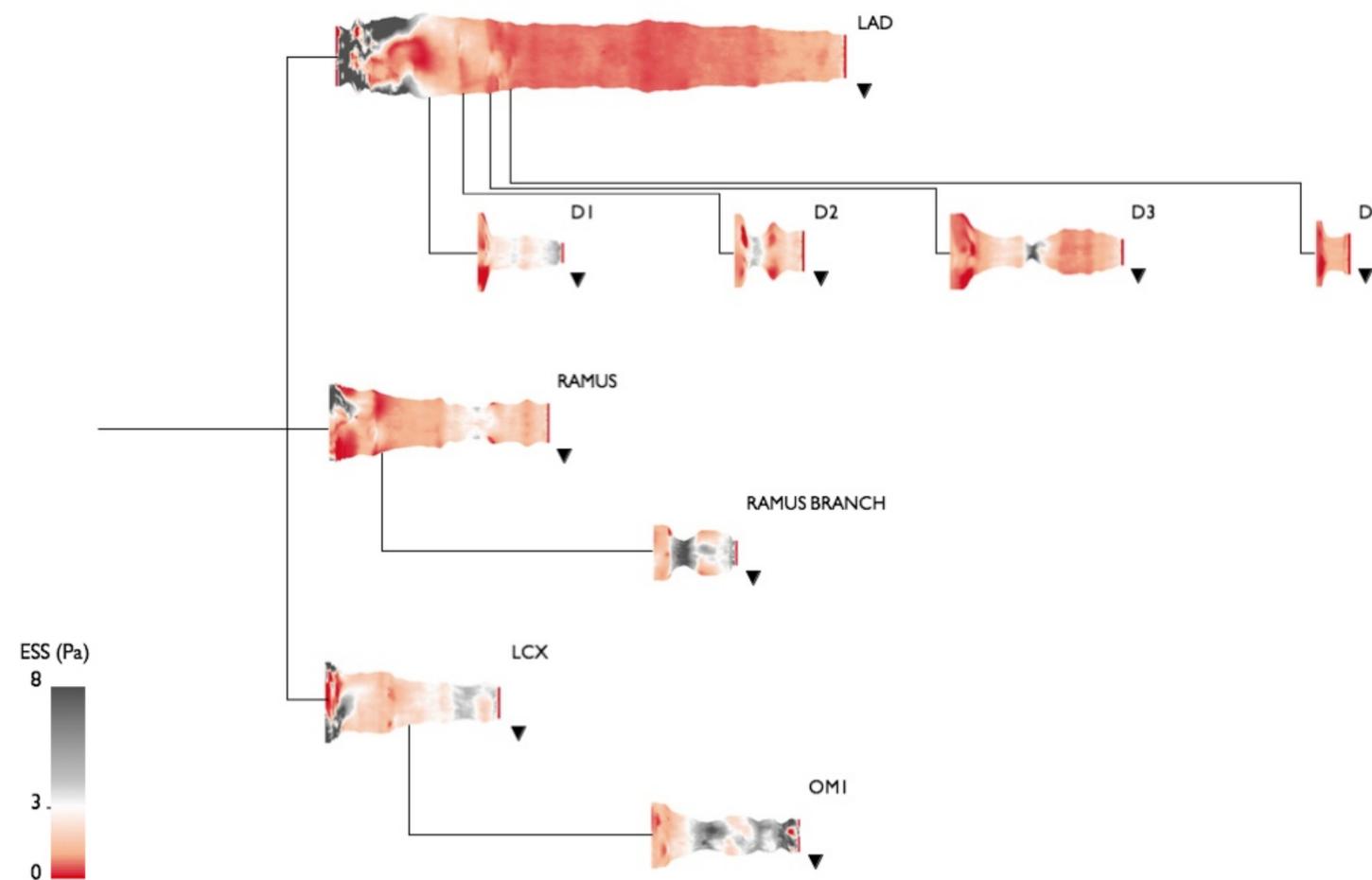
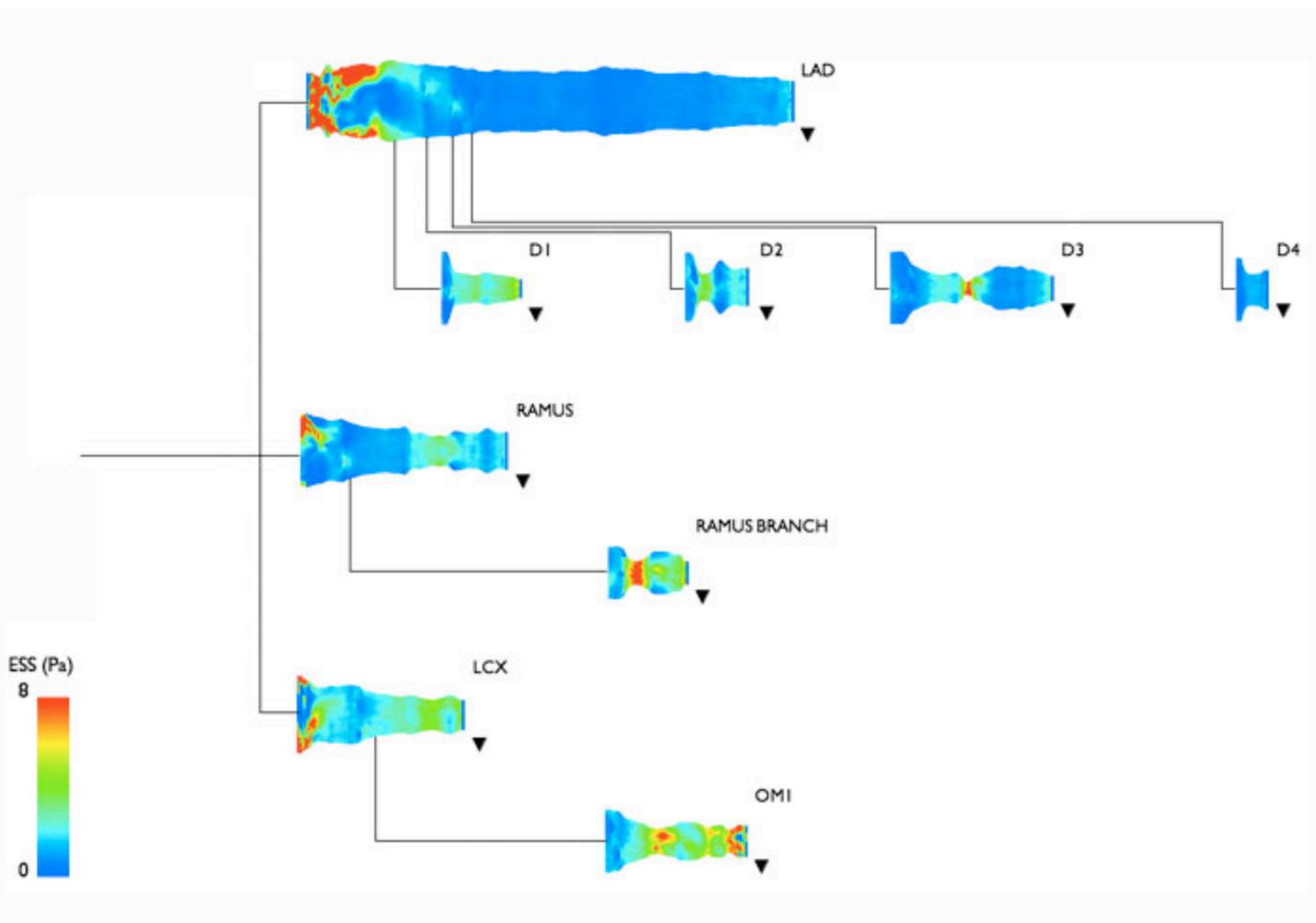
COLOR



COLOR



COLOR



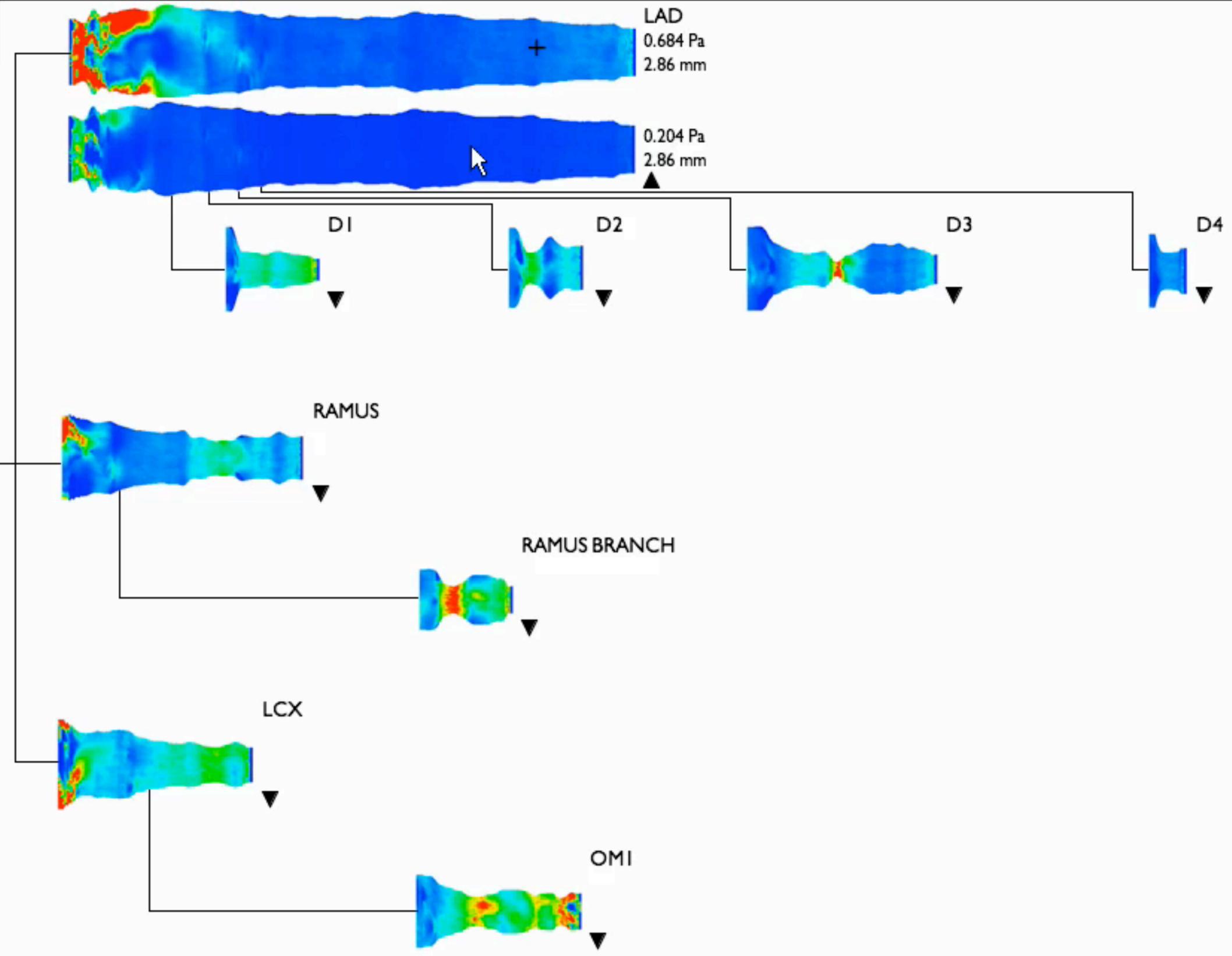
Mode: **tree** individual

Circumference (mm)

3.5
2.860
0

ESS (Pa)
8
0 0.204

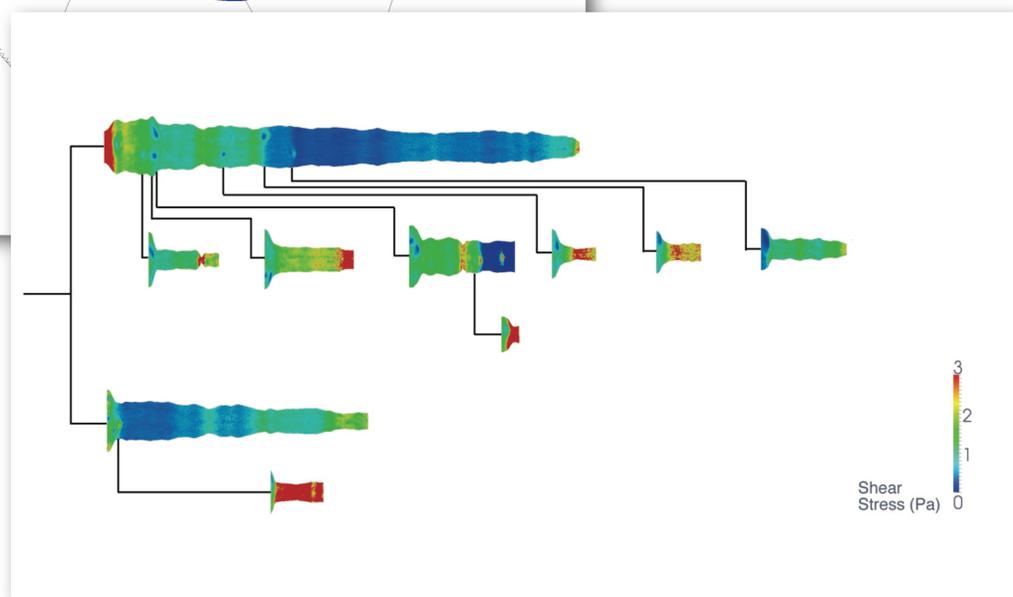
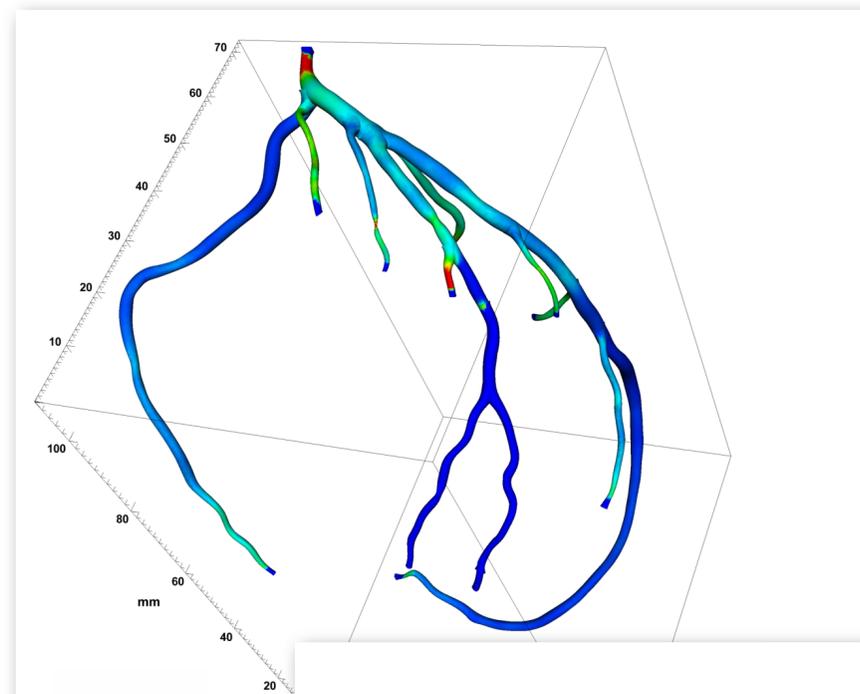
Color:



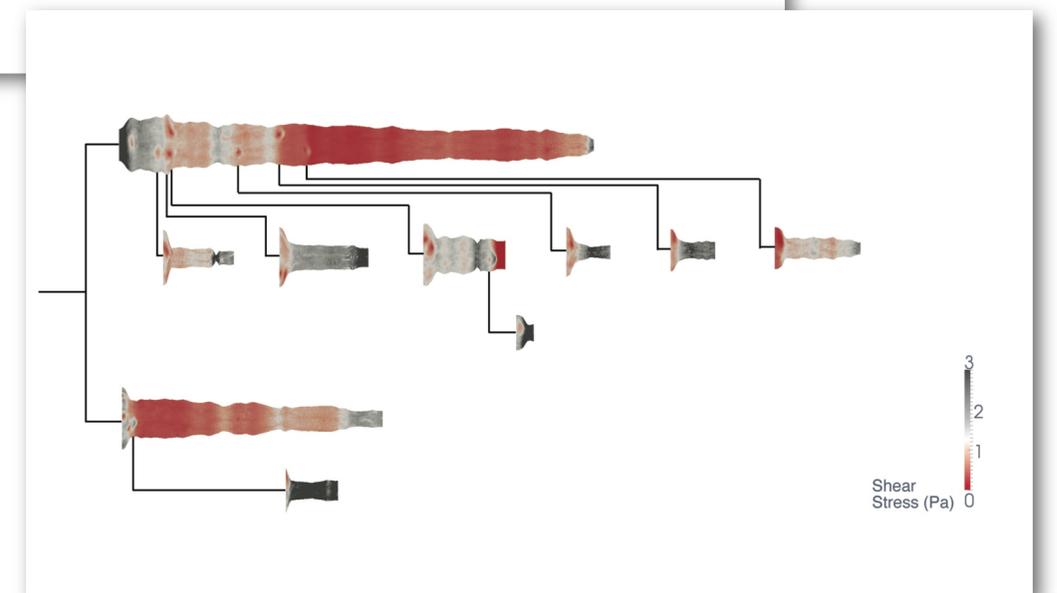
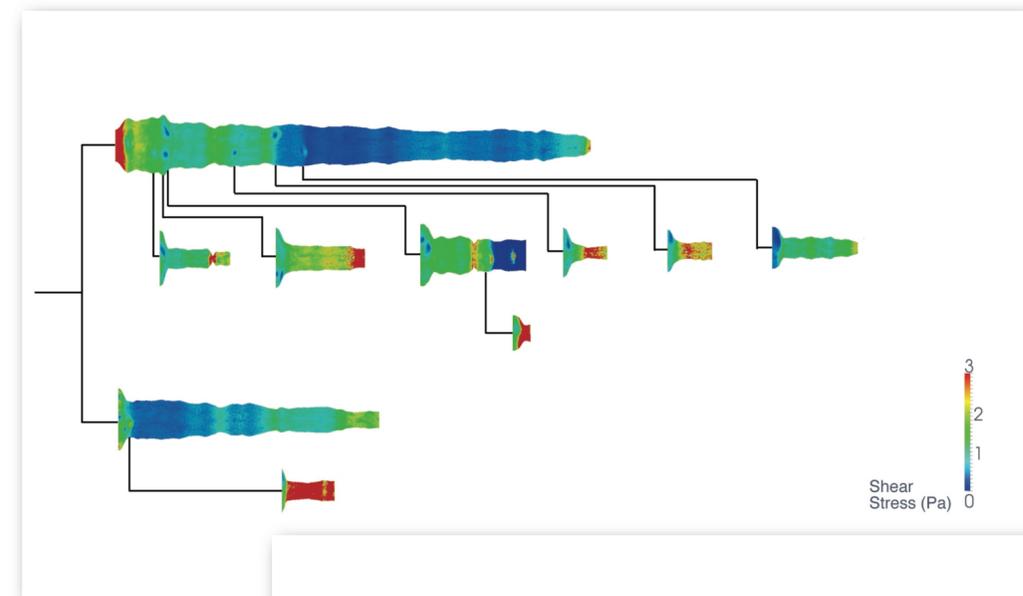
320 CT Scan
Left Coronary Artery
Lattice-Boltzman
(High & Low Flow Rates)
▼ *Open All Data*

QUANTITATIVE STUDY: GOALS

3D vs. 2D

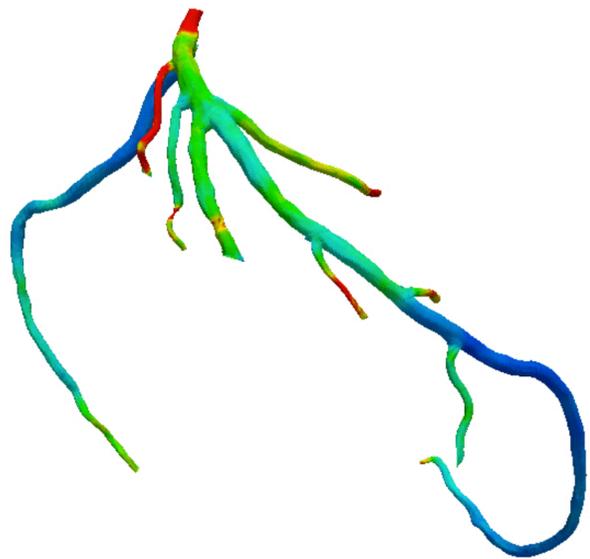


rainbow vs. diverging

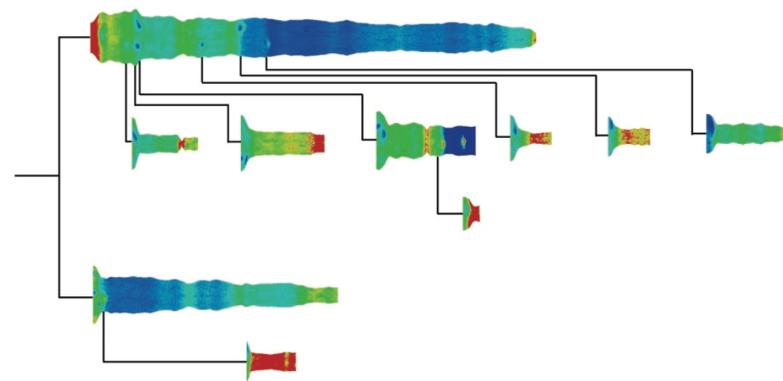


QUANTITATIVE STUDY

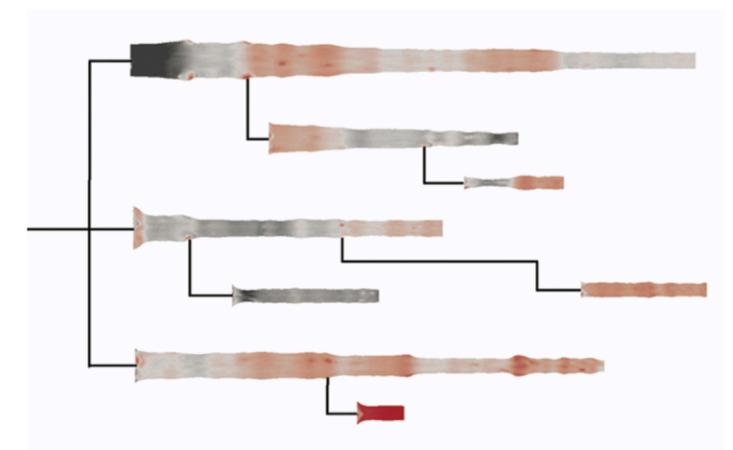
- 21 Harvard Medical students (12 women and 9 men)
- Mixed within-subject and between-subject design:
 - *within* = dimensionality of representation (2D or 3D)
 - *between* = color mapping (rainbow or diverging)



e.g., Participant A

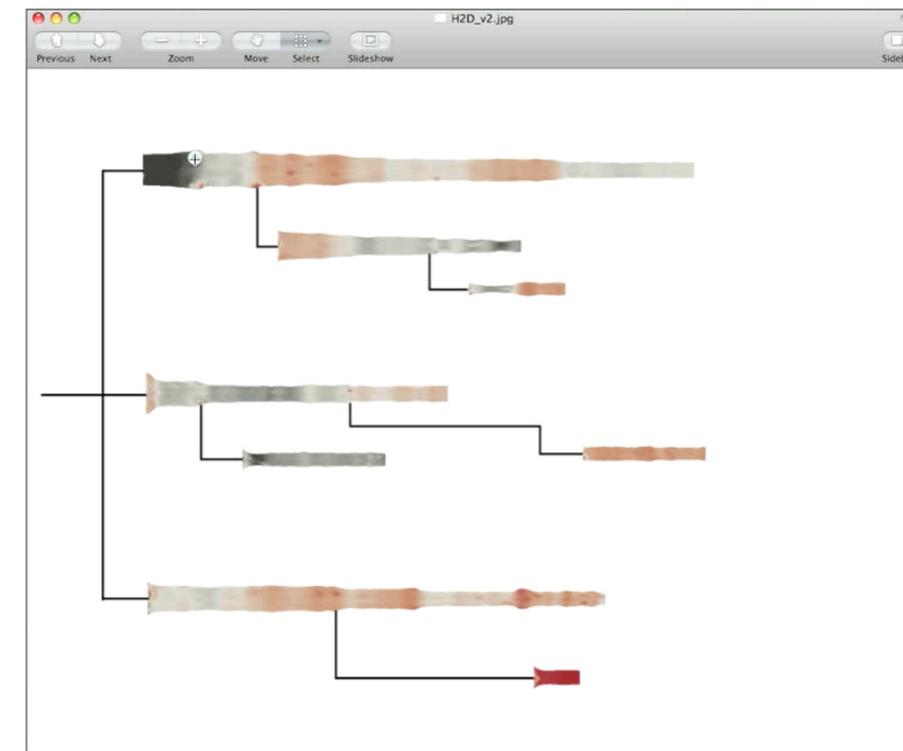
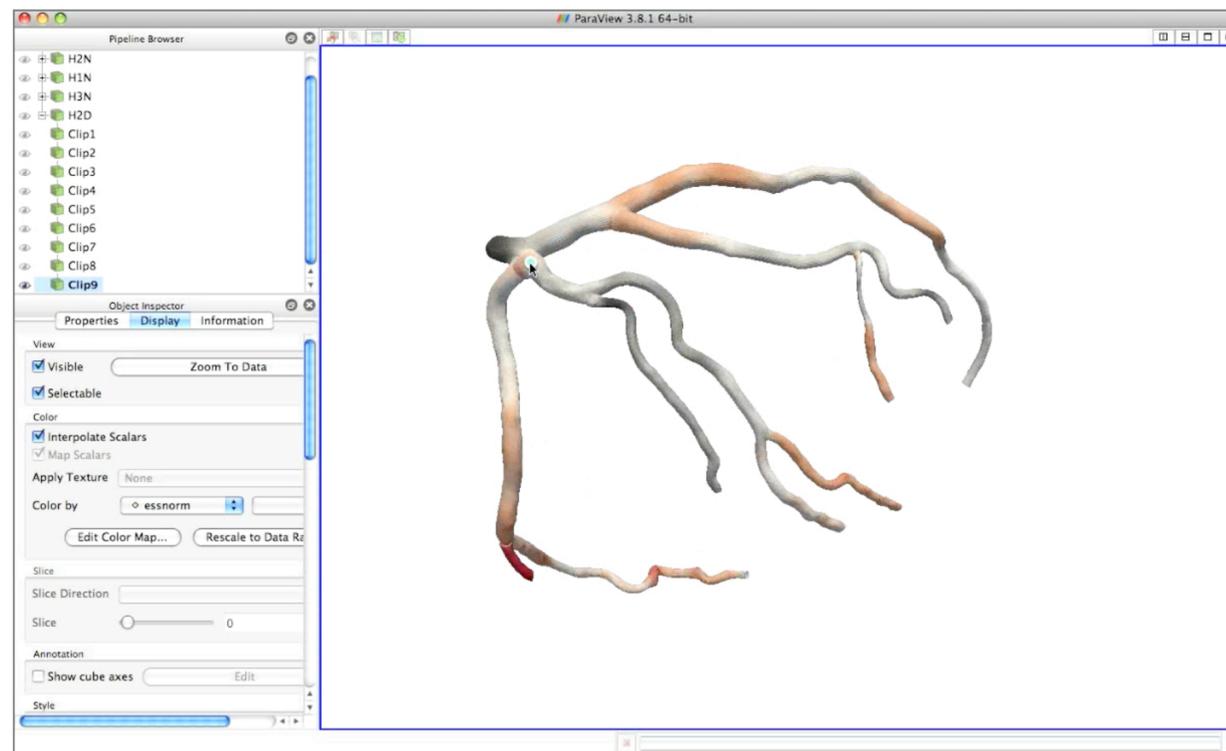


e.g., Participant B

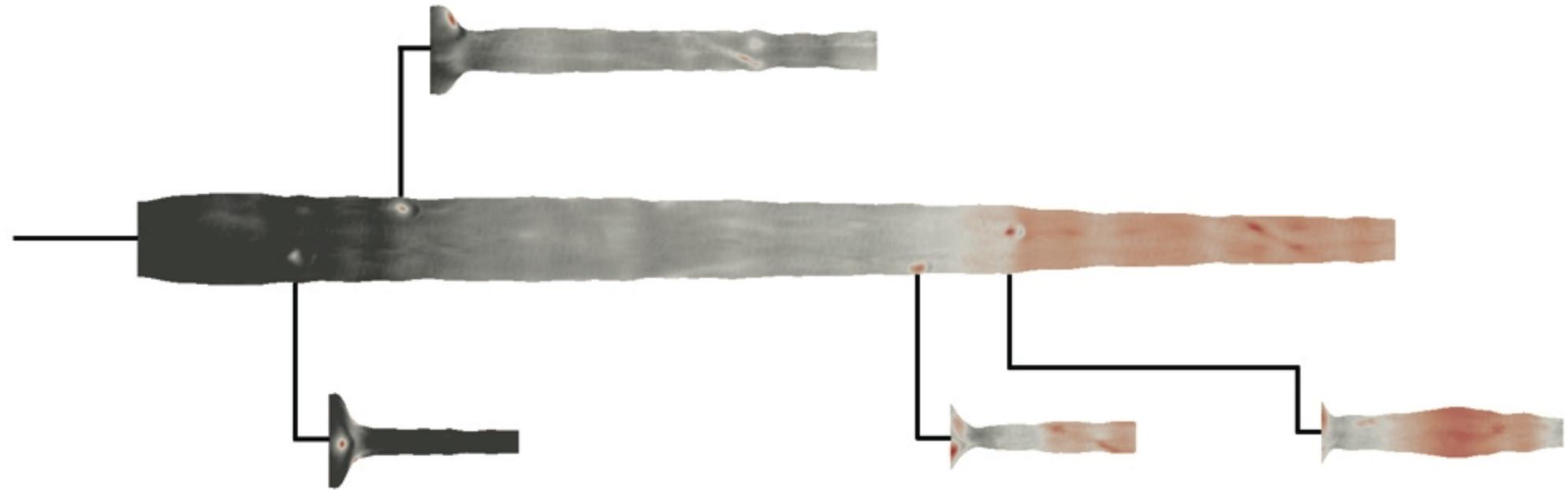
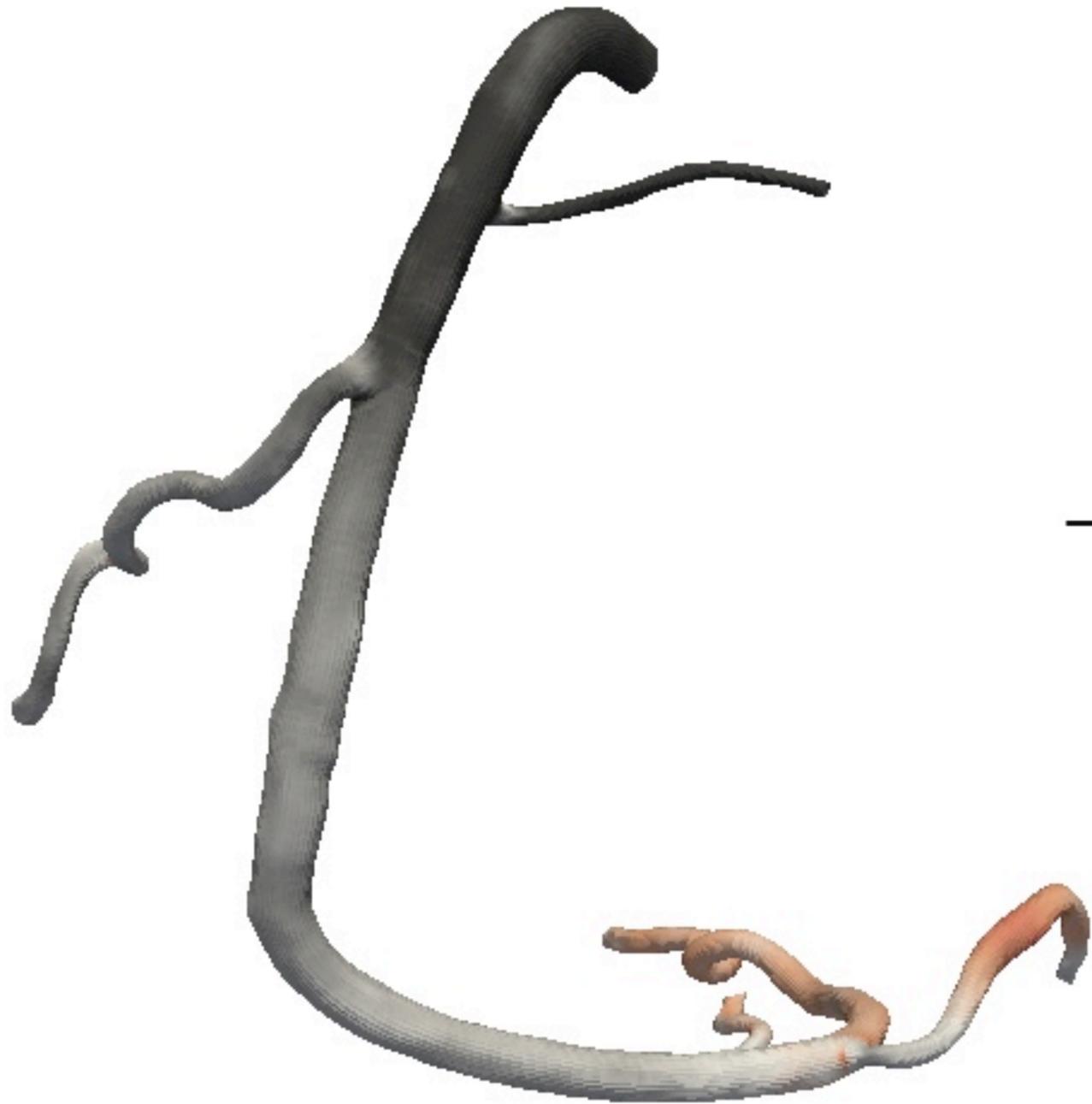


QUANTITATIVE STUDY

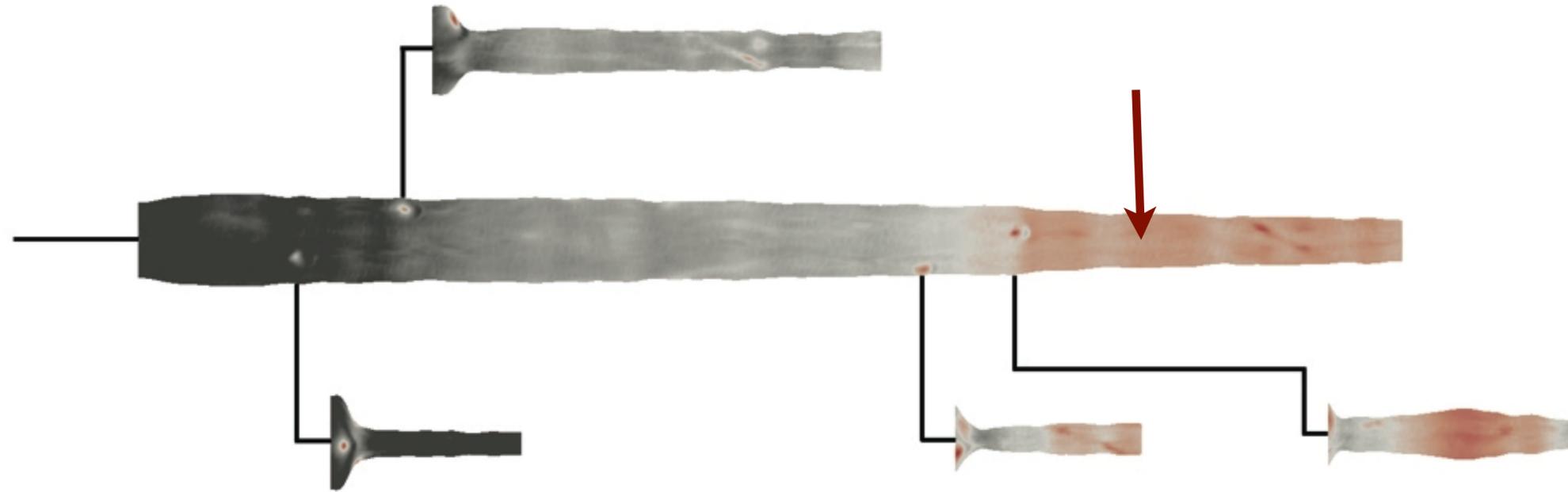
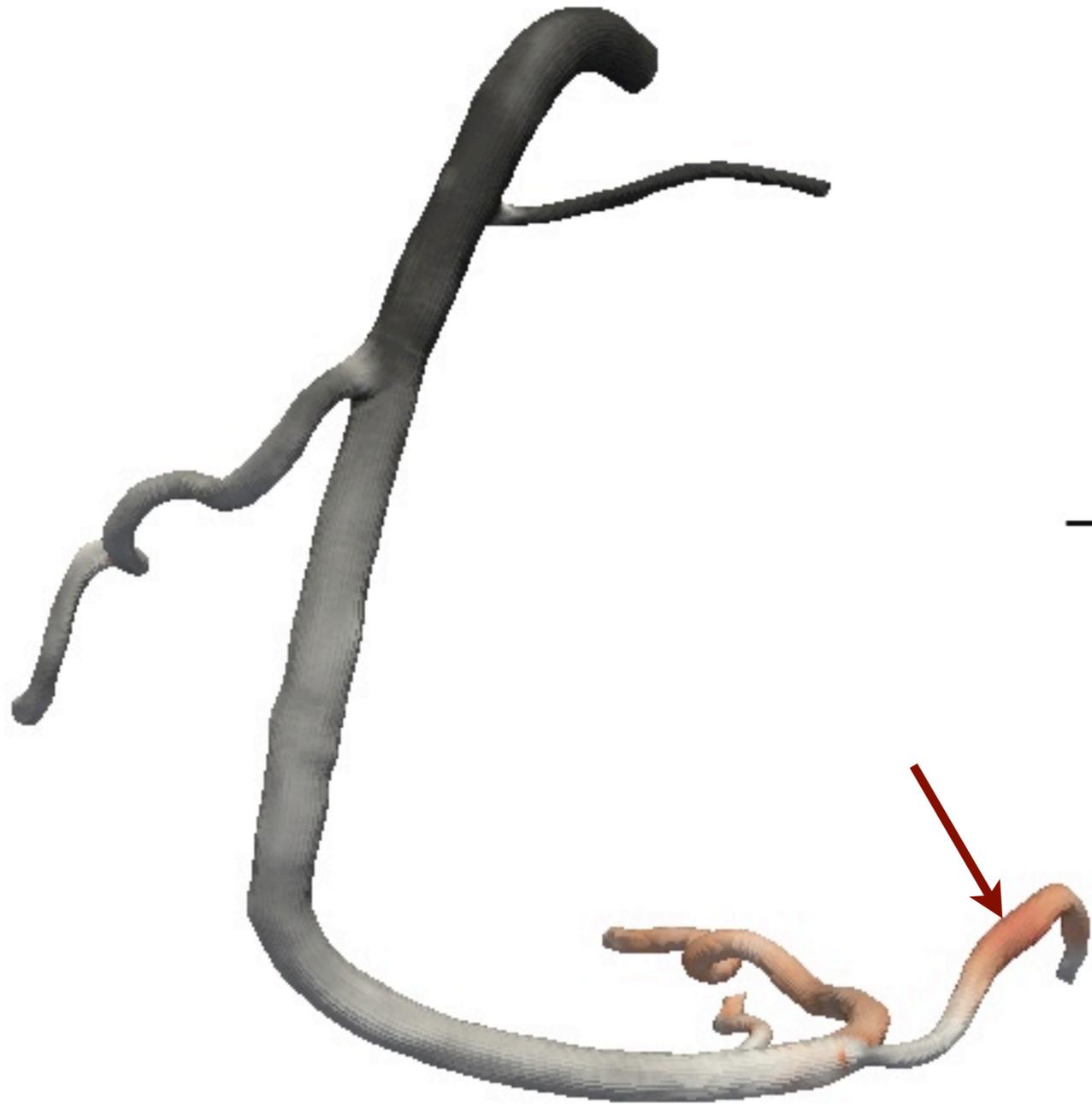
- Dependent measures:
 - fraction of low ESS regions identified
 - number of false positives (i.e., non-low ESS regions identified as low ESS)
 - time to complete a diagnosis



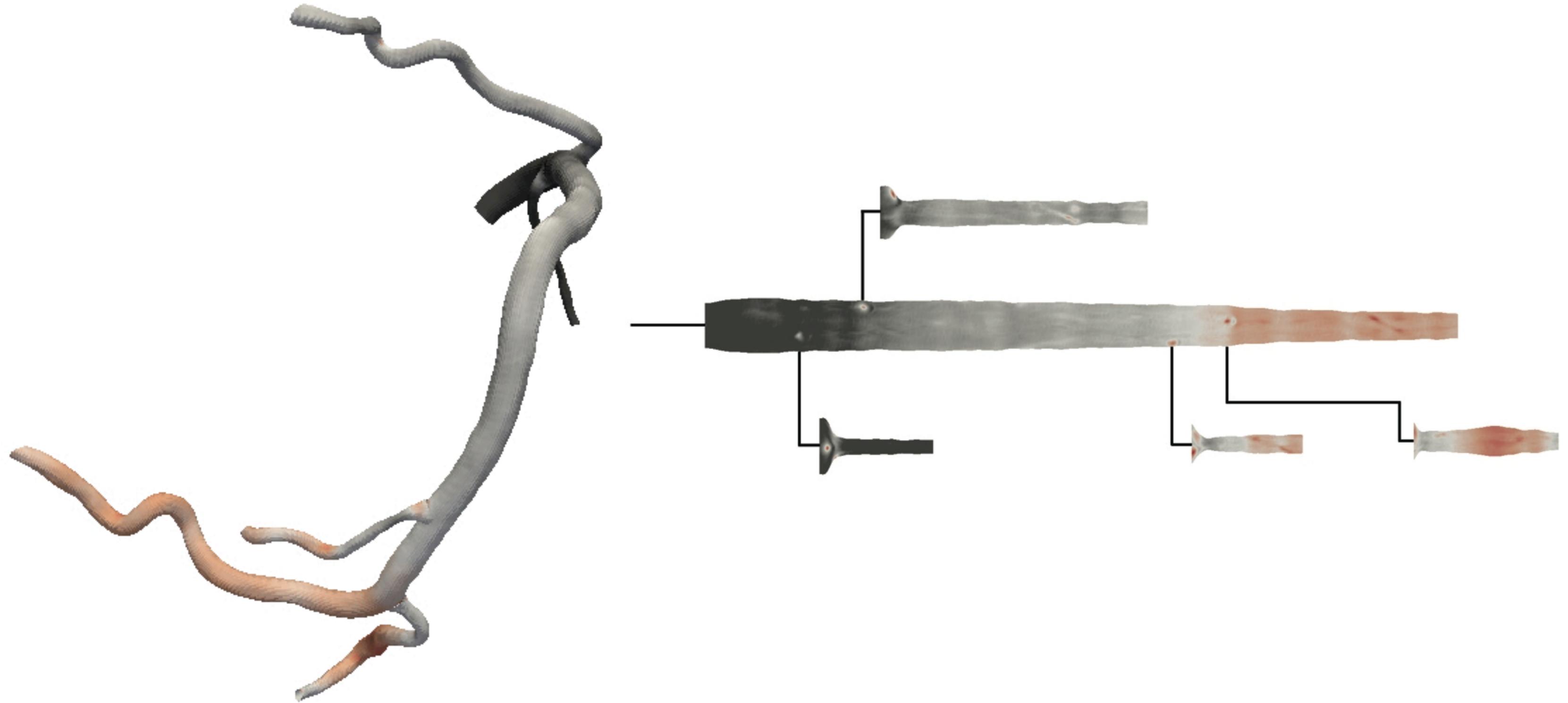
QUANTITATIVE STUDY



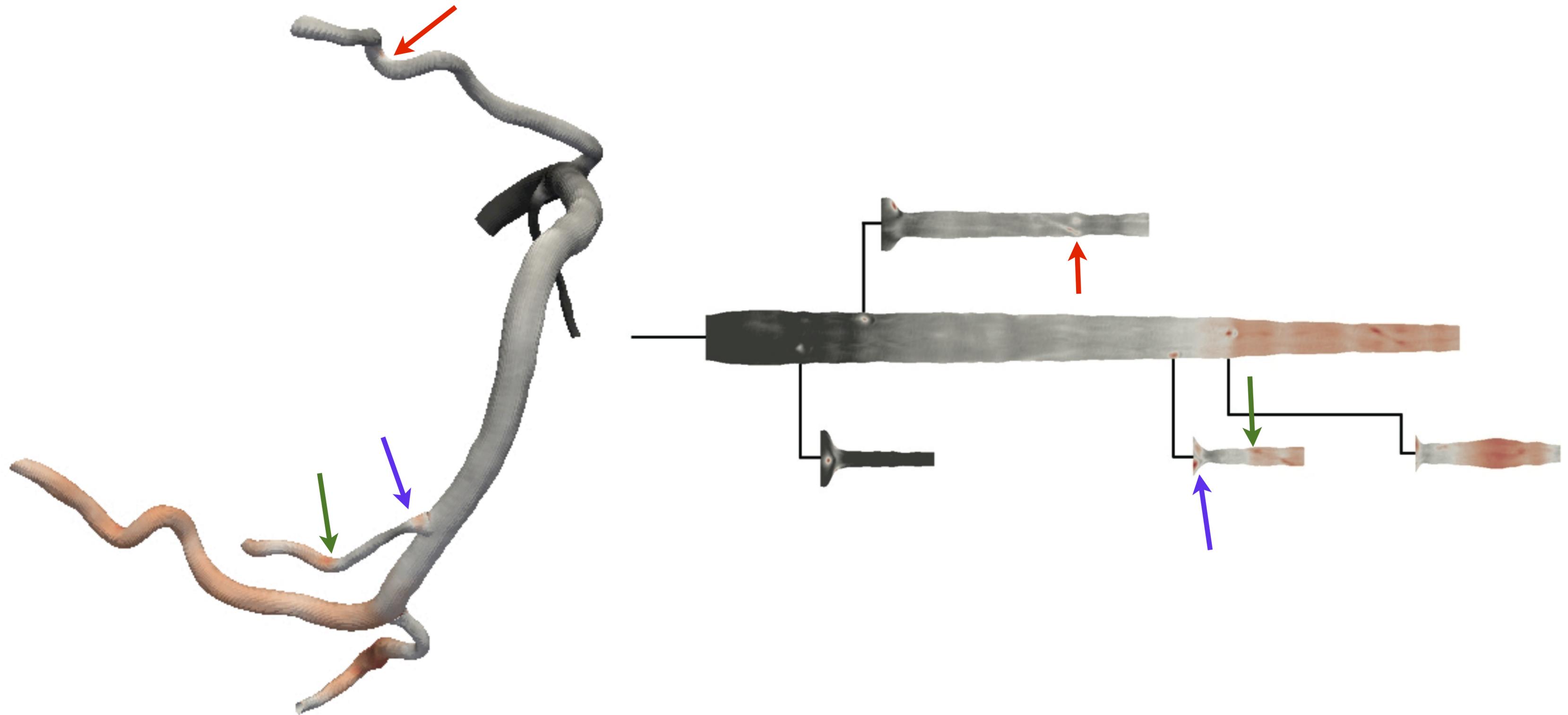
QUANTITATIVE STUDY



QUANTITATIVE STUDY



QUANTITATIVE STUDY

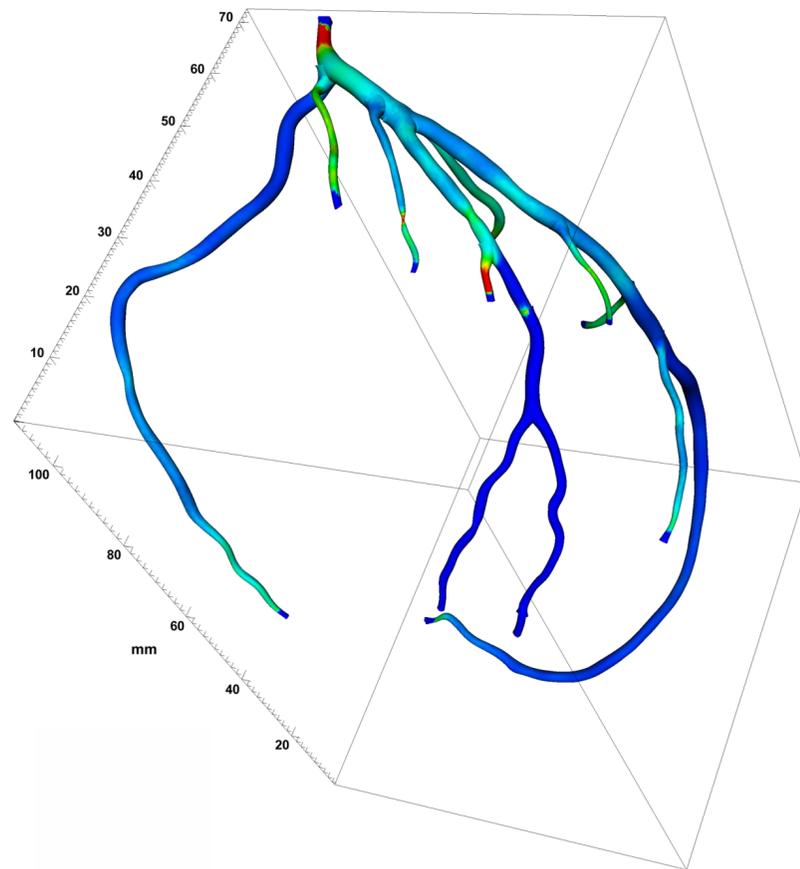


RESULTS

ACCURACY

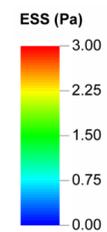
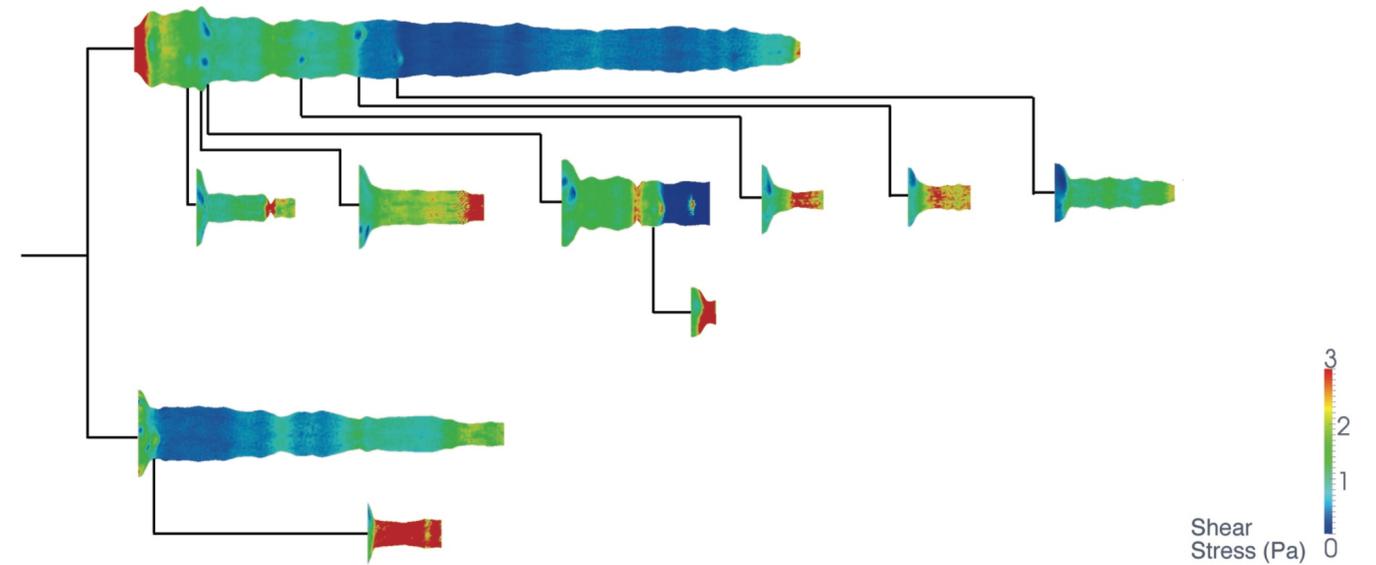
Strong effect of **dimensionality** on accuracy

39%



How many low ESS regions found?

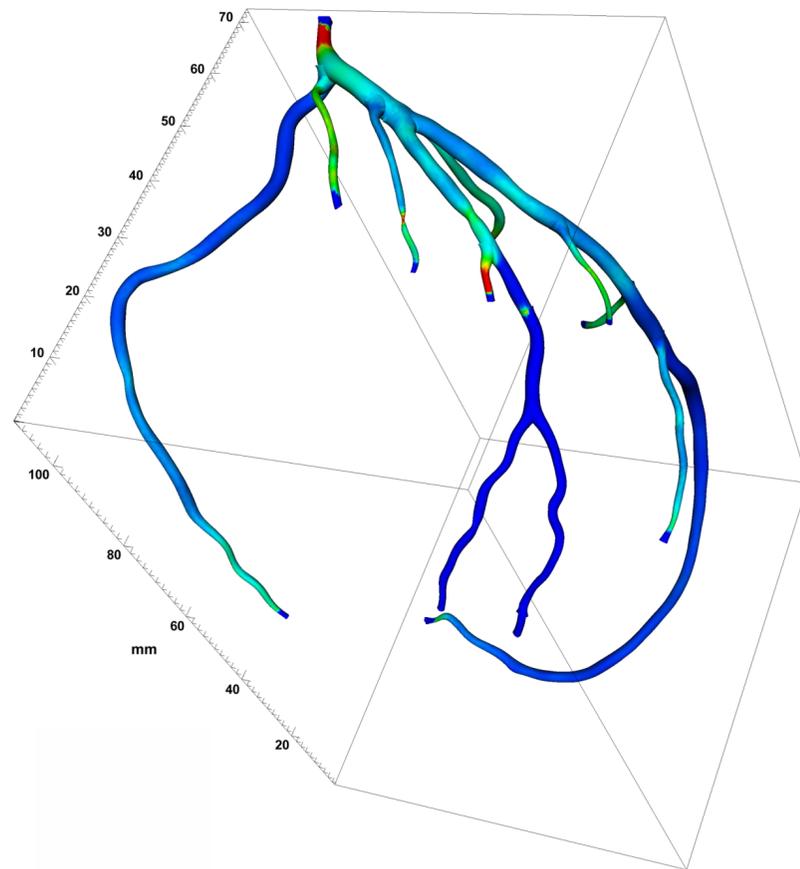
62%



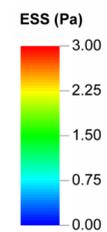
ACCURACY

Strong effect of **dimensionality** on accuracy
...as well as **color**

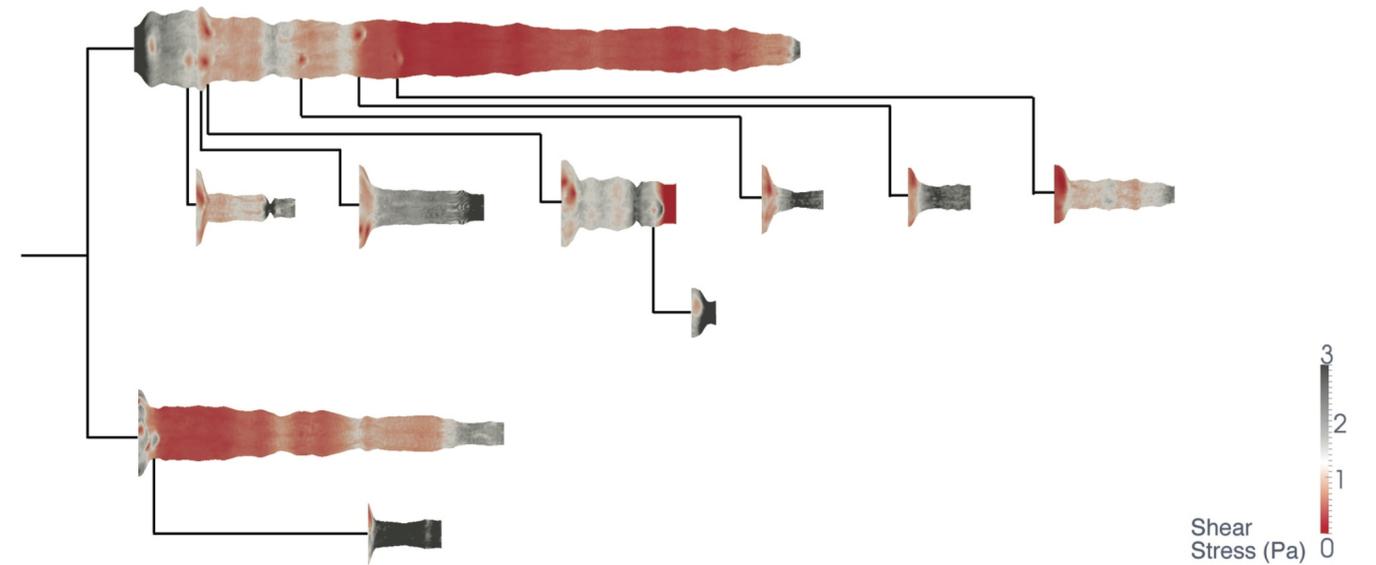
39%



How many low ESS
regions found?



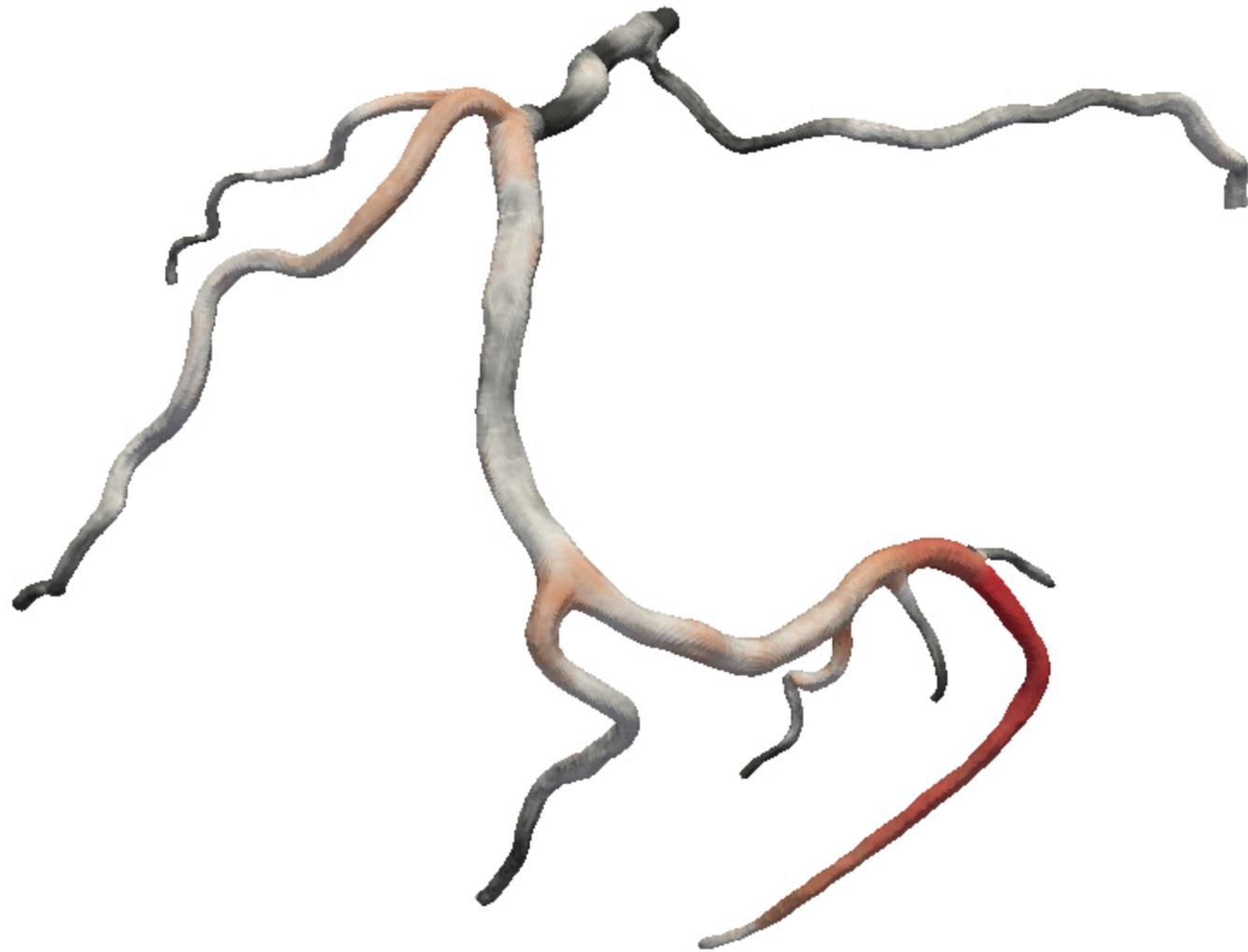
91%



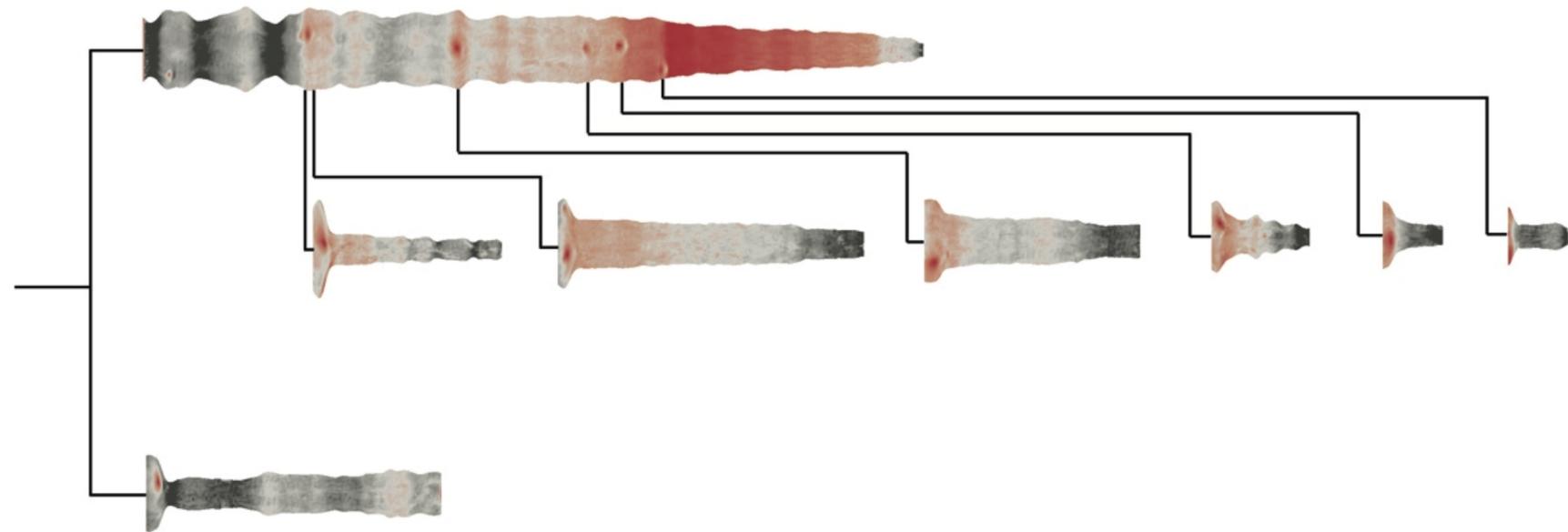
EFFICIENCY

Participants more **efficient** in **2D**.

5.6 sec/region



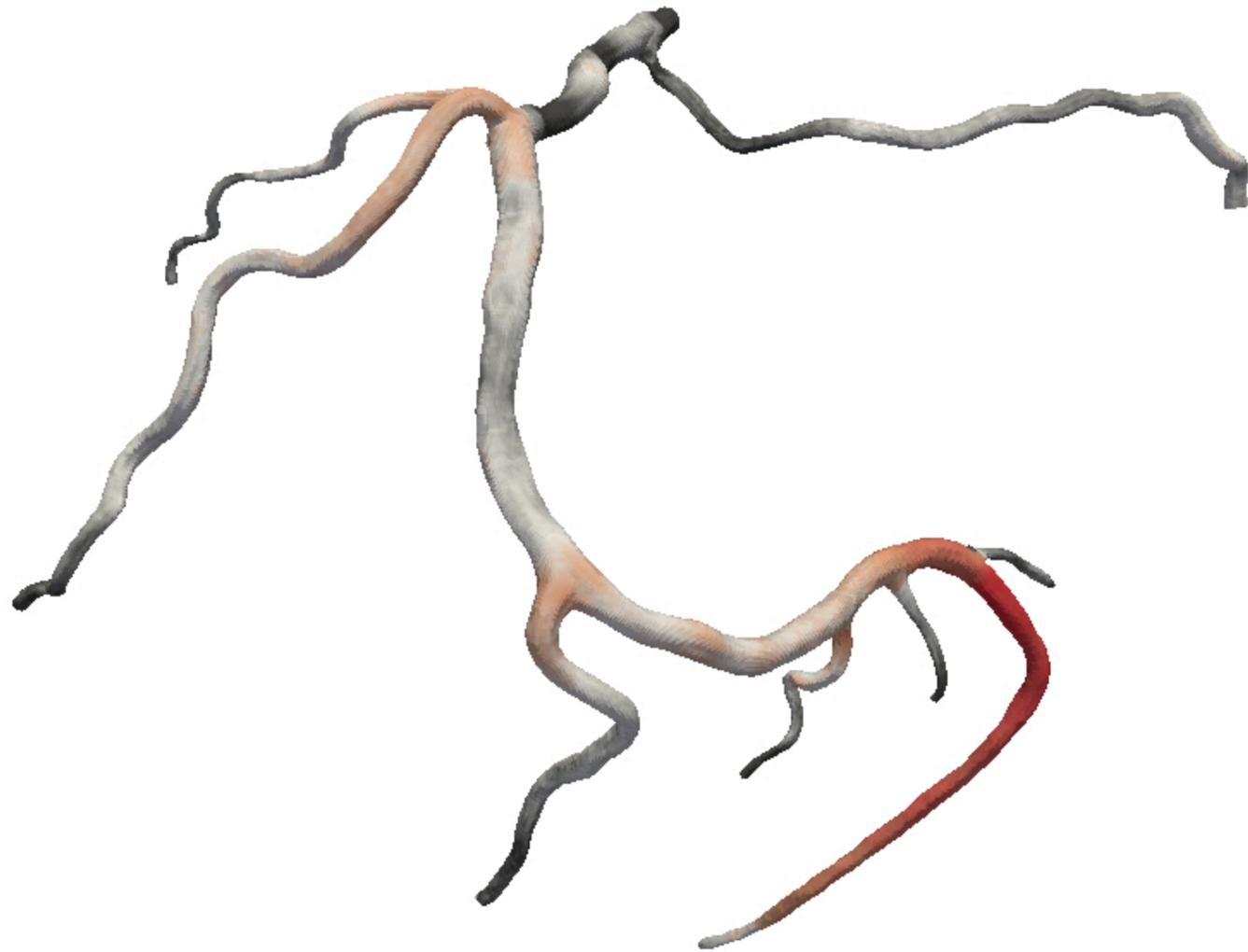
2.4 sec/region



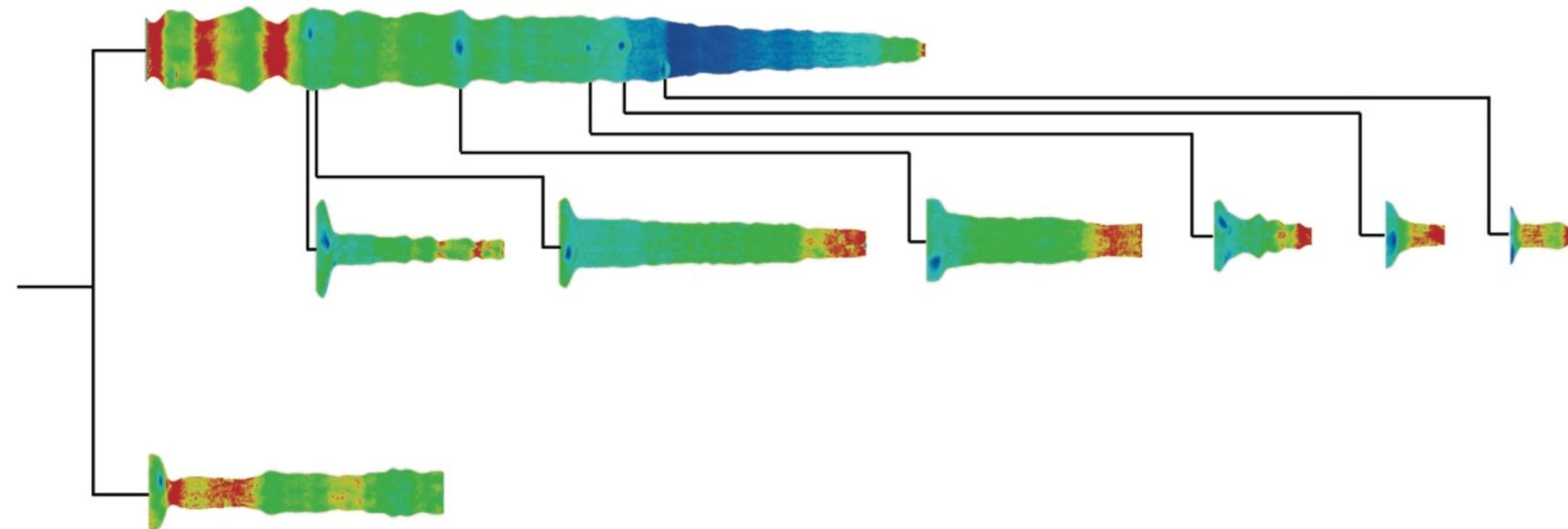
EFFICIENCY

Participants more **efficient** in **2D**.

5.6 sec/region



2.6 sec/region

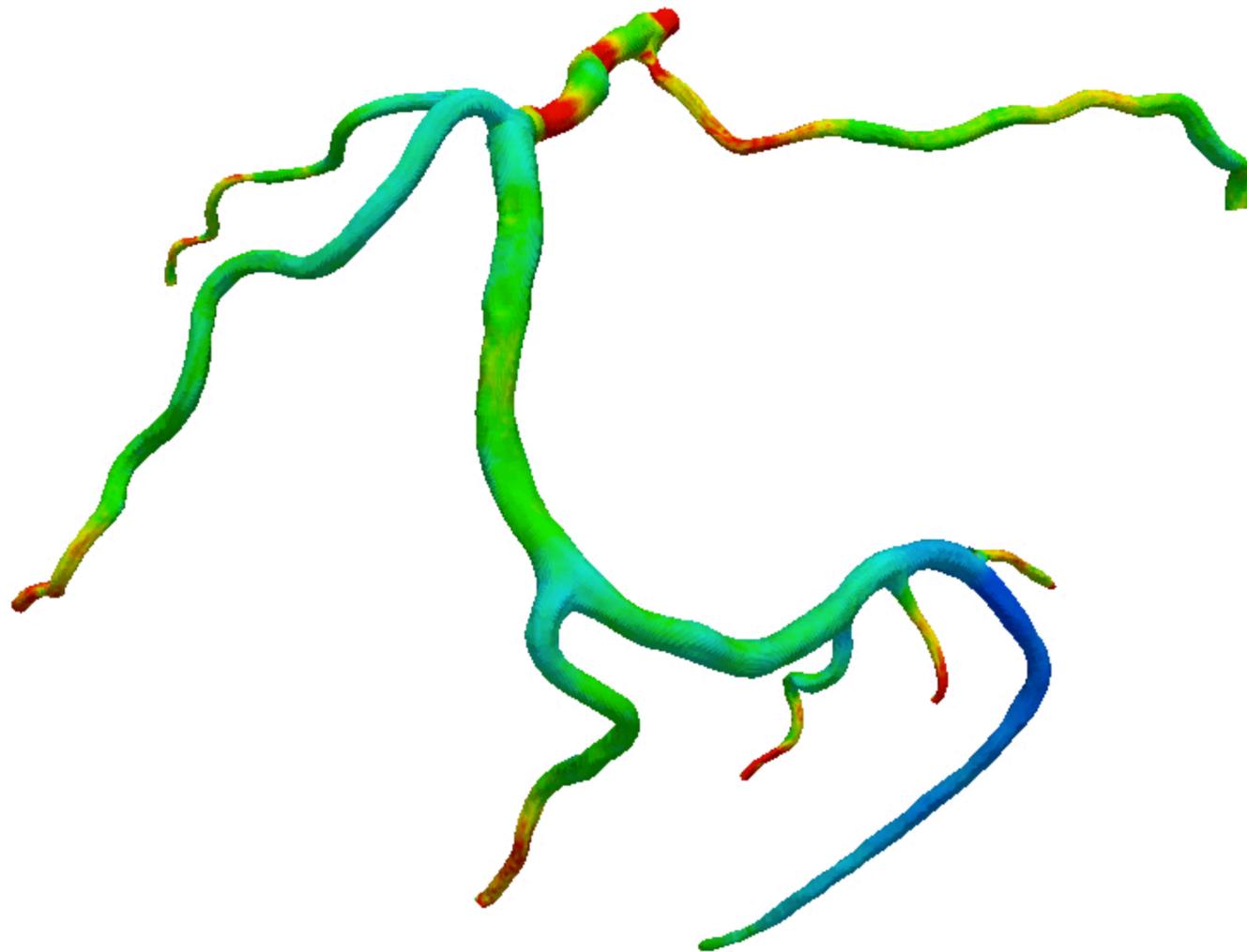


EFFICIENCY

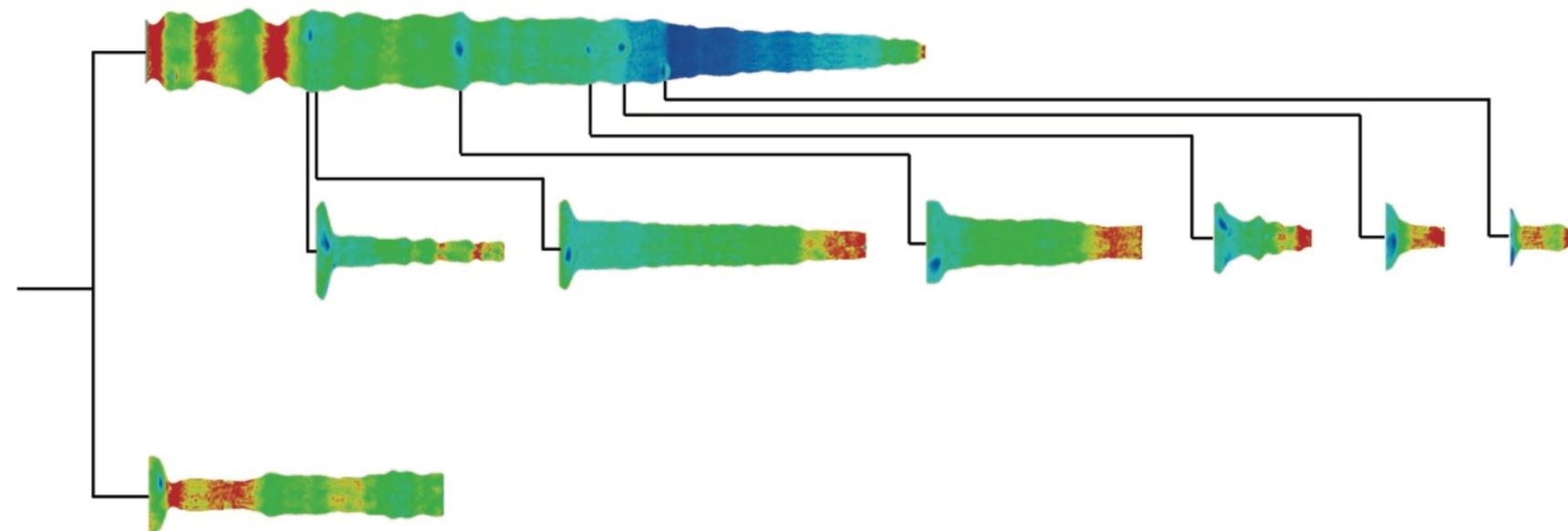
Participants more **efficient** in **2D**.

Rainbow color map has greater effect on efficiency in 3D.

10.2 sec/region



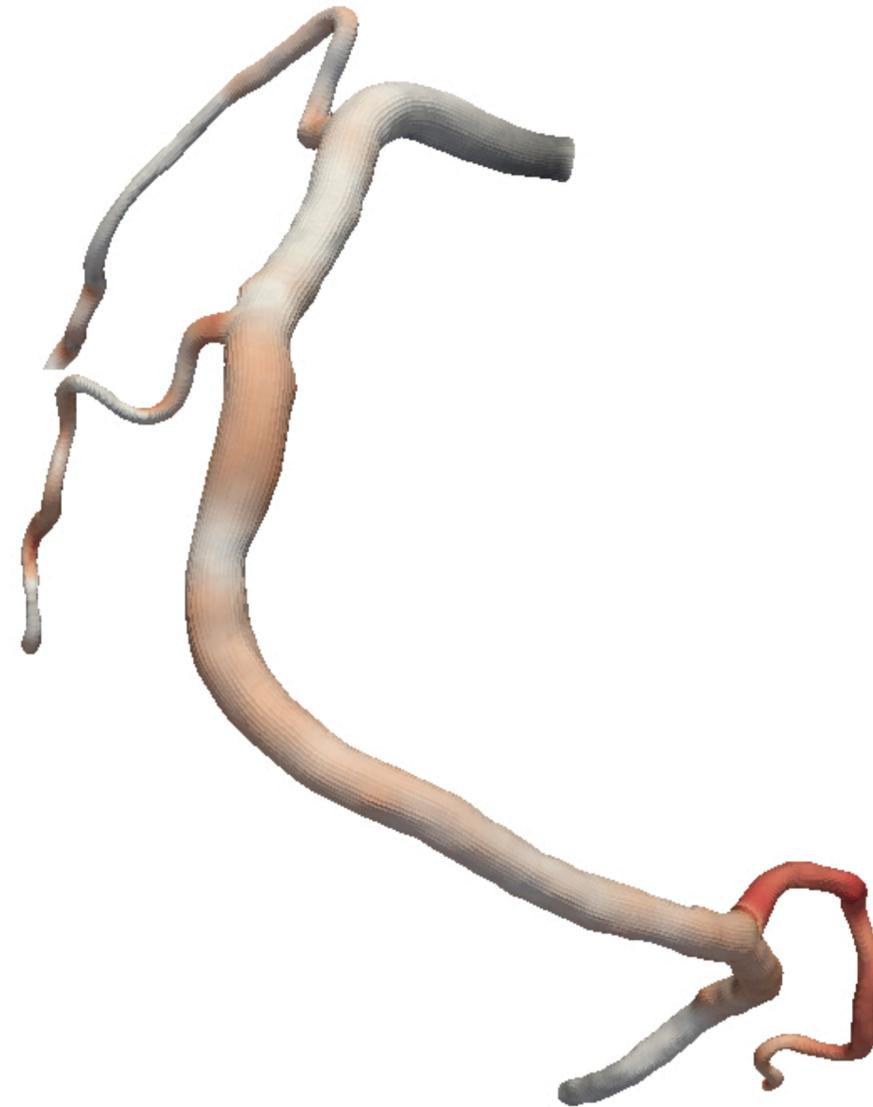
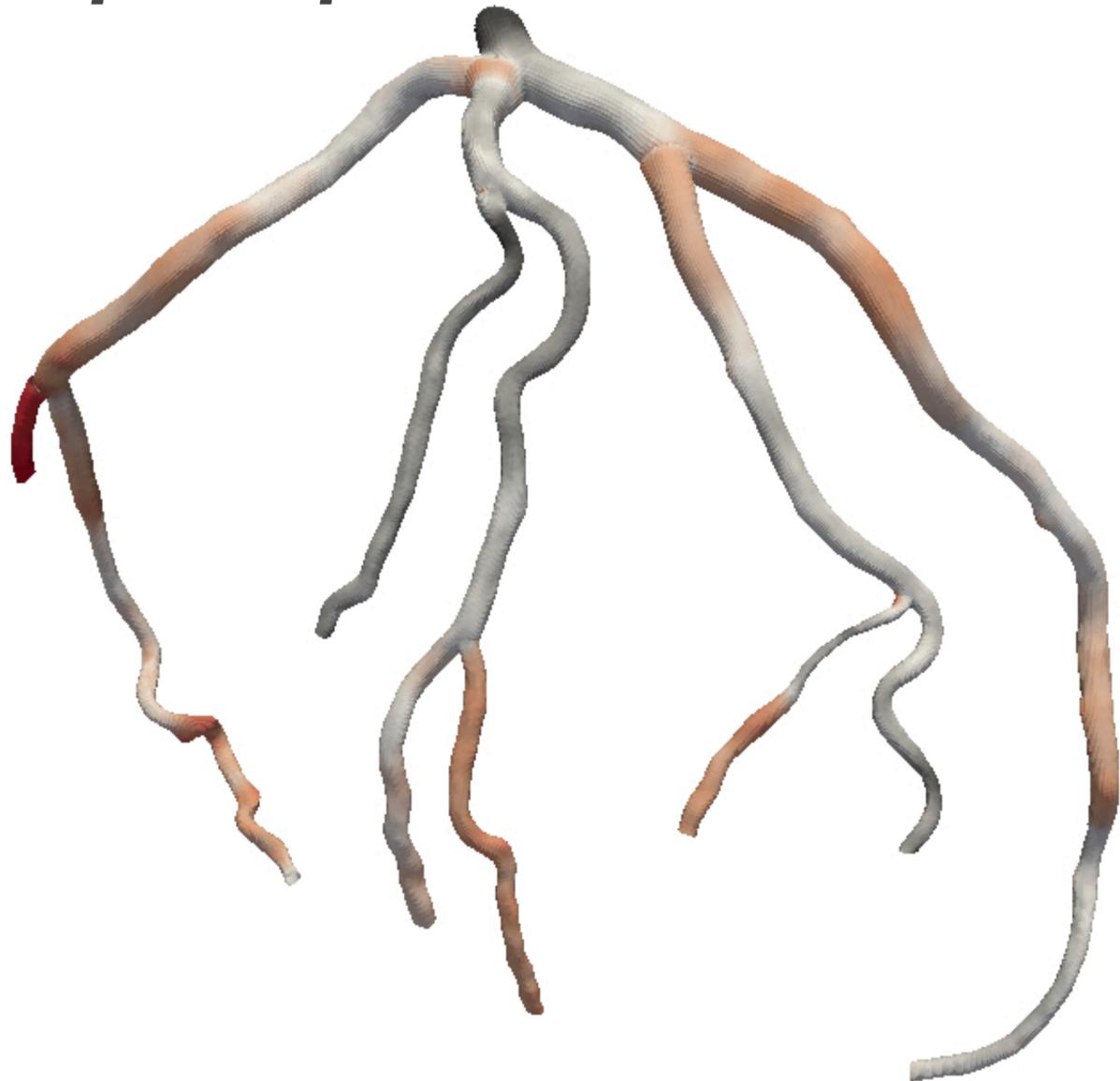
2.6 sec/region



COMPLEXITY

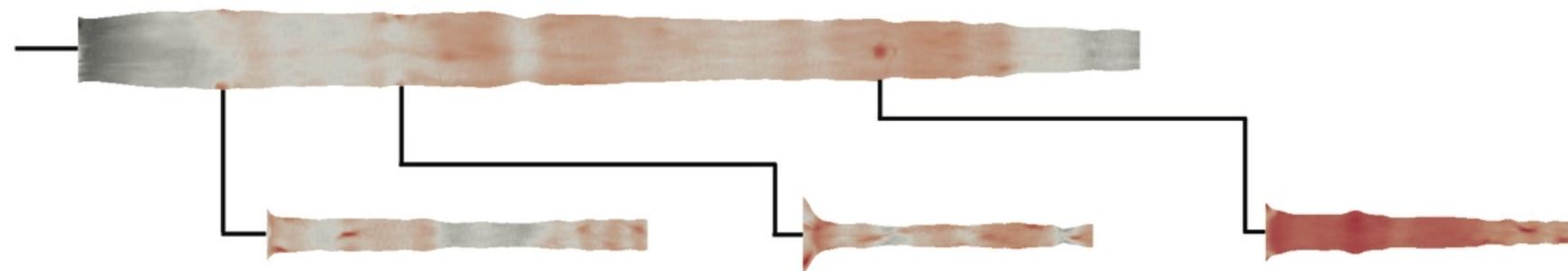
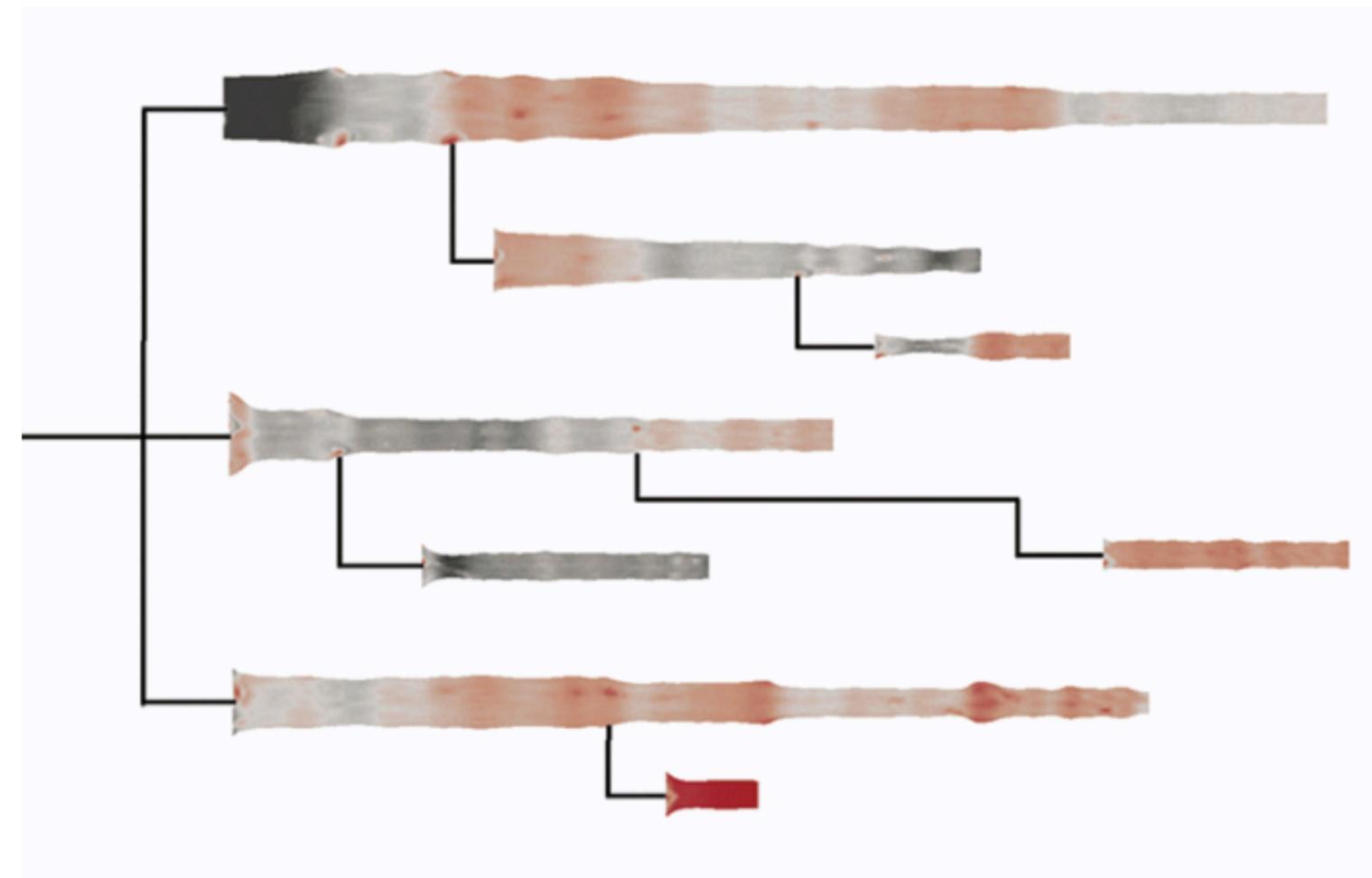
Accuracy decreases with increased data complexity in 3D

participants less accurate



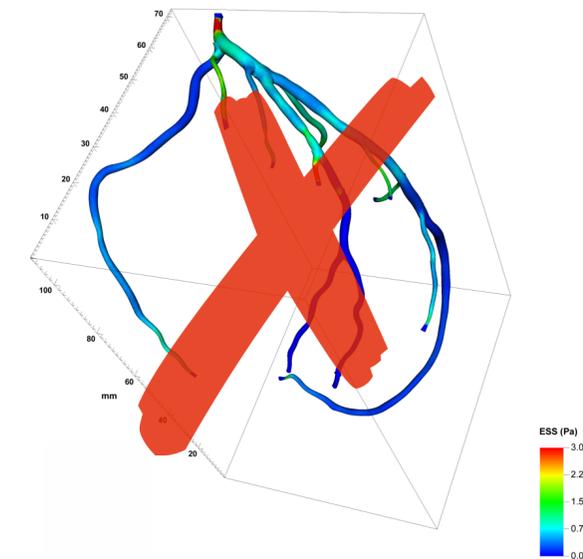
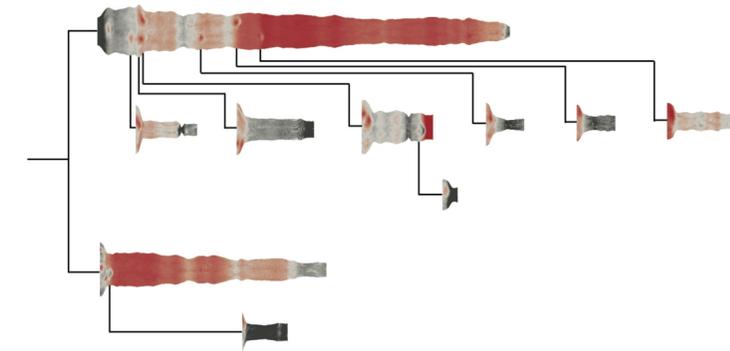
COMPLEXITY

Accuracy decreases with increased data complexity in 3D
(not true in 2D!)



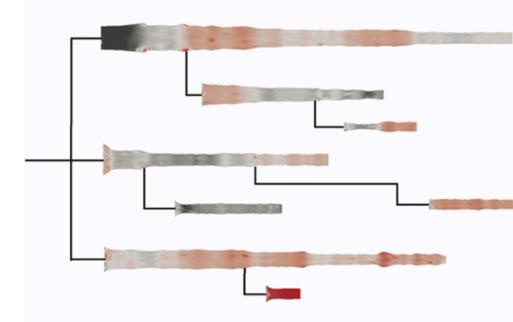
FINDINGS SUMMARY

- Even for 3D spatial data, a **2D** representation is
 - ▶ more **accurate** for spatial tasks
 - ▶ more **efficient** for spatial tasks
- Rainbow color map
 - ▶ is **not accurate** and **not efficient**
 - ▶ has adverse effects even greater in 3D

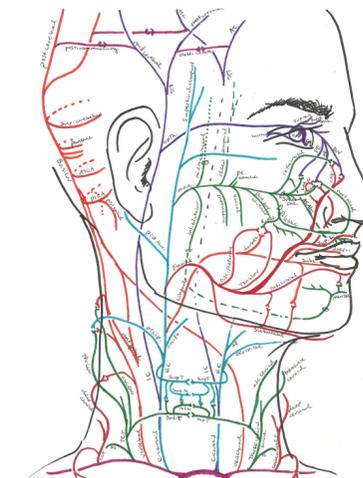
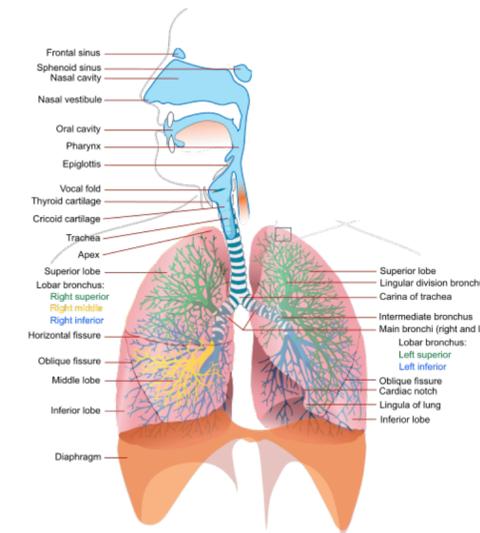


FINAL REMARKS

- 3D representation is still essential for surgical planning



- 2D tree diagram applicable to other applications



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