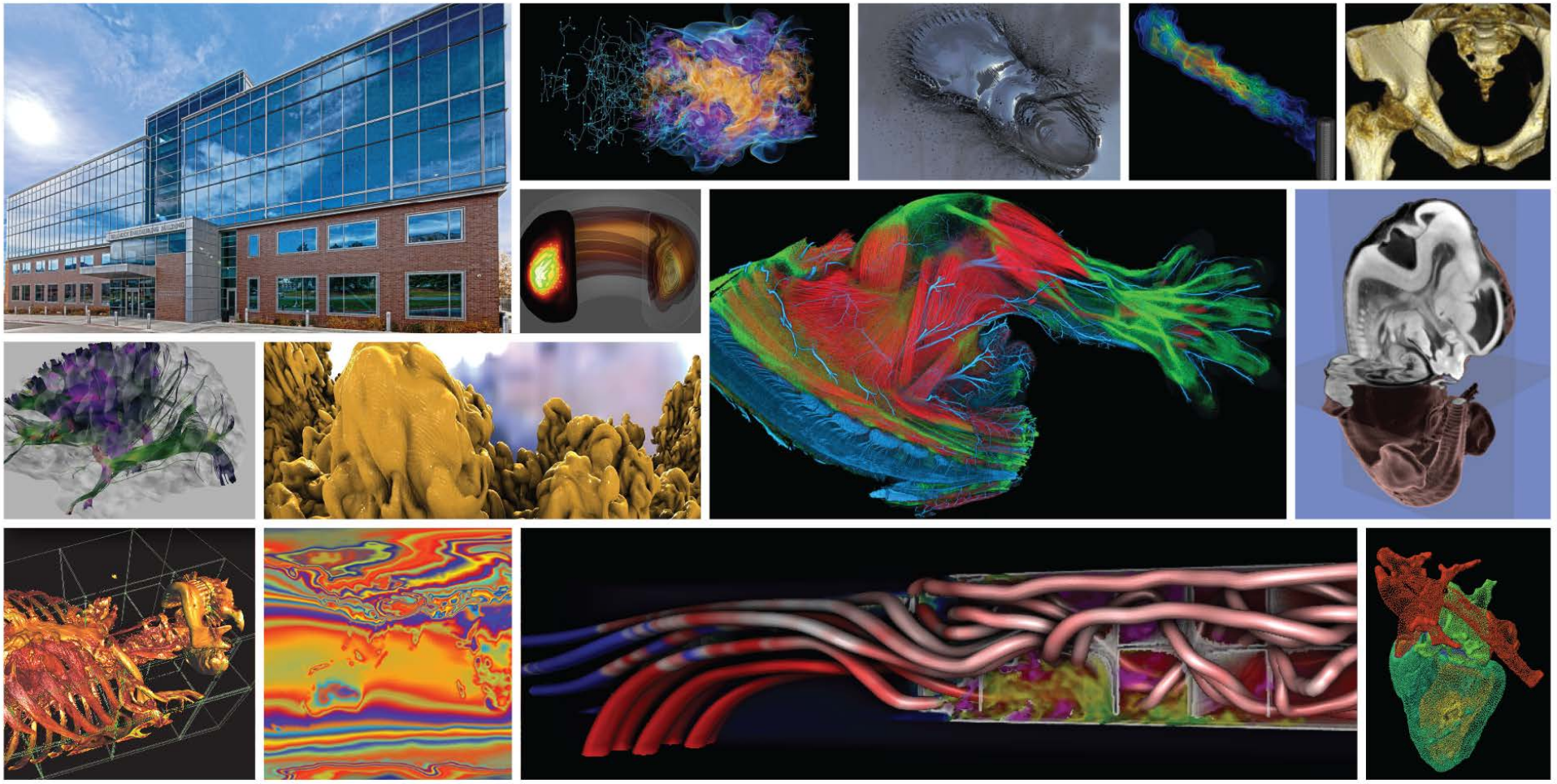
Large-Scale Visual Analysis



Chris Johnson
Scientific Computing and Imaging Institute
University of Utah

History of Computer Graphics in Utah

1, 2. David Evans /Ivan Sutherland
-Founded CS Dept at the UofU in 1968
-Ivan Sutherland - Turing award
-Founded Evans & Sutherland Company

3. John Warnock
-Worked at Evans & Sutherland
-Founded Adobe
-Hidden Line Removal Algorithm
-Helped invent Postscript @ Adobe

4. Tom Stockham
-Known for work in Signal Processing
-Helped to invent the CD Player

5. Ed Catmull
-Worked at Lucas Film
-Co-Founded Pixar
-President of Disney Animation Studios
-Chair of CoE External Advisory Board

6. Alan Kay
- Personal Computer
-Turing Award Winner
-Object Oriented Languages

7. Jim Kajyia
-VP Research at Microsoft

8. Jim Clark
-Founded SGI, Netscape, Healtheon
- Work in Geometry Pipelines

9. Jim Blinn
-Invented Blinn-Phong Shading Model

10. Nolan Bushnell
-Invented Pong
-Founded Atari

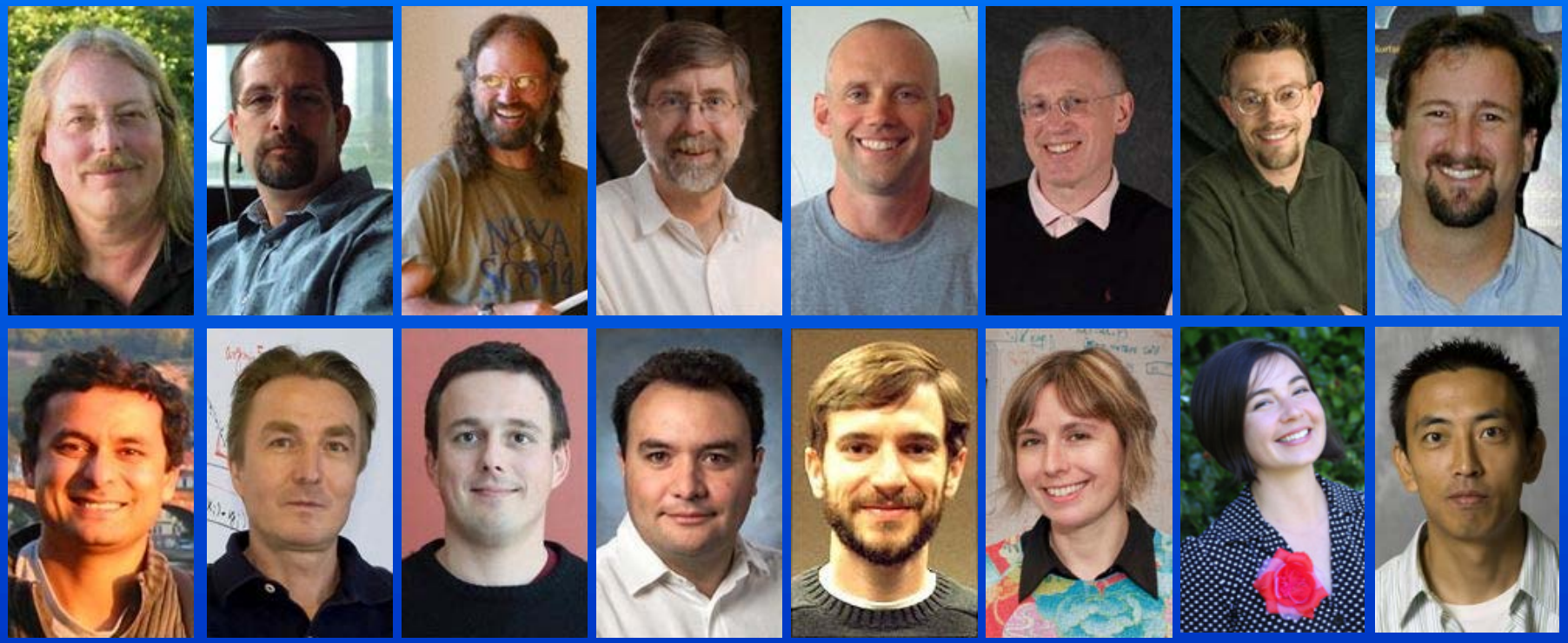
11. Henri Gouraud
-Invented Gouraud Shading Model

12. Allen Ashton
-Word Perfect
-My CFO Founder

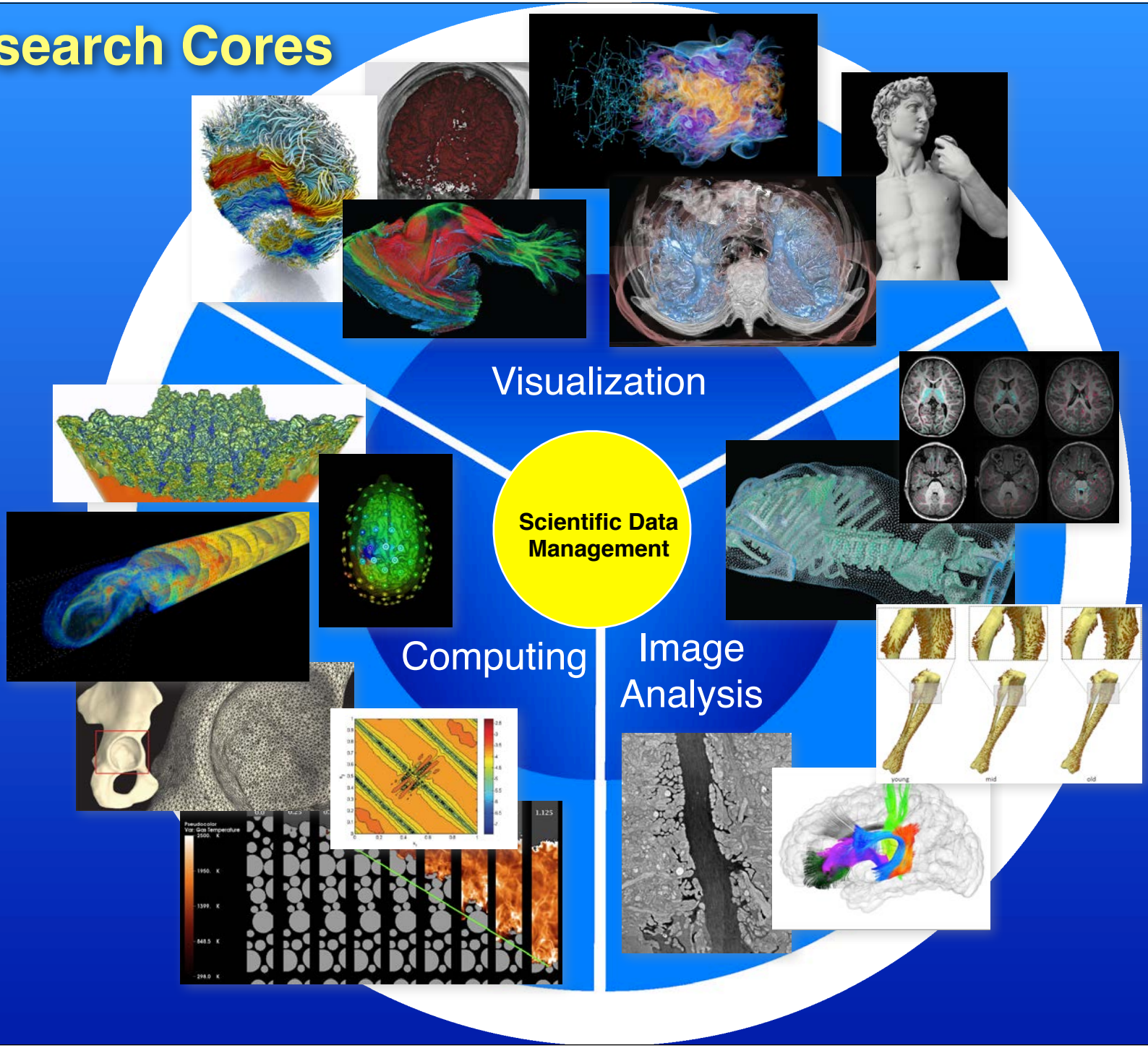
13. Bui Tuong Phong
-Invented Phong Reflection and Shading Models

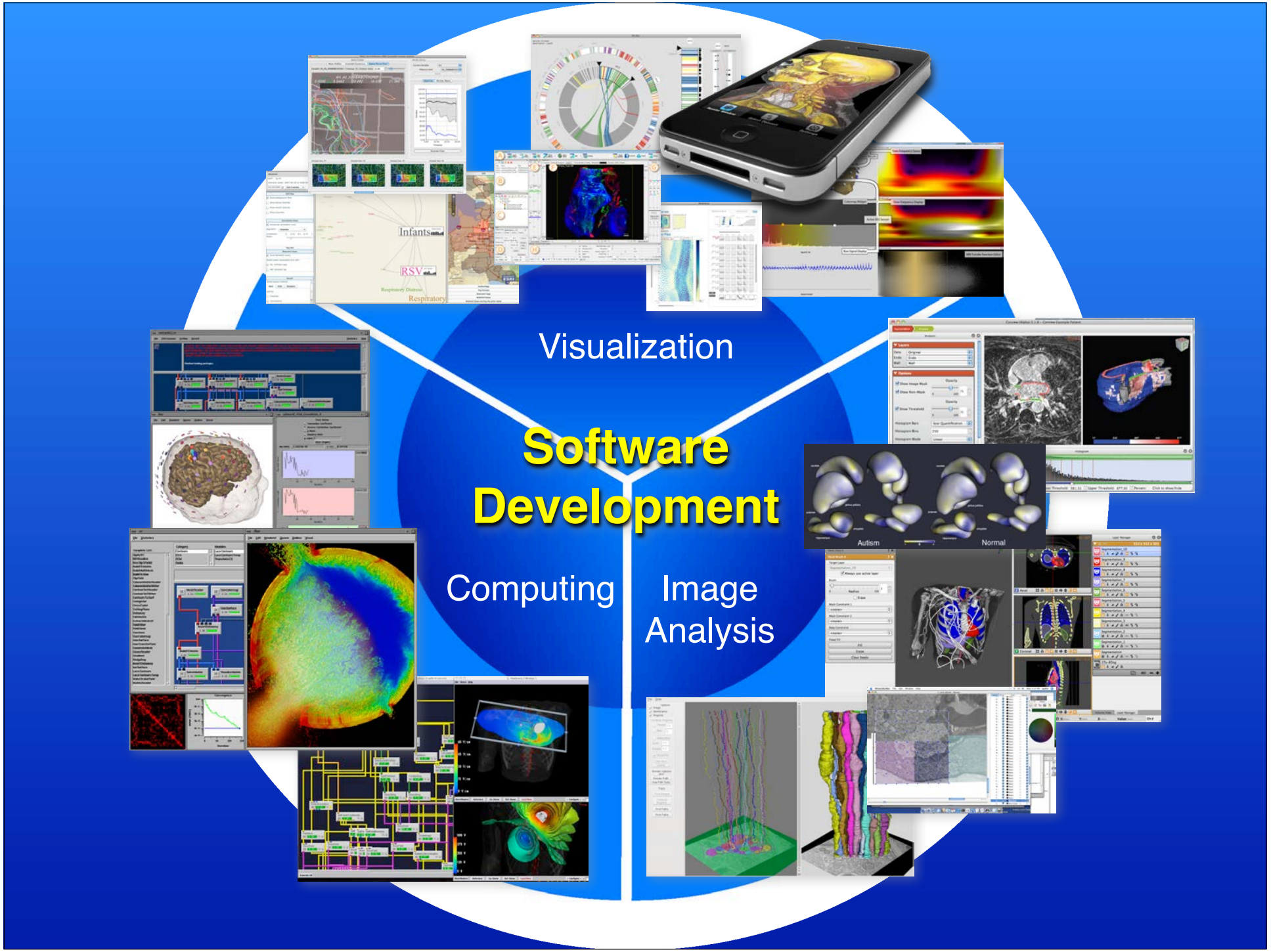
SCI
www.sci.utah.edu

SCI Institute Faculty



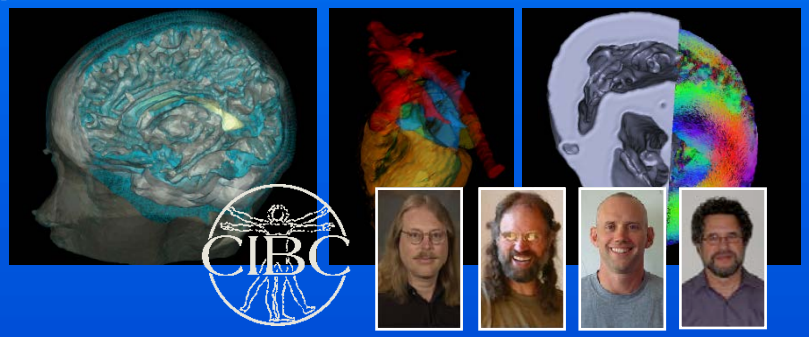
Research Cores




Visualization
Software Development
Computing
Image Analysis
Infants
RSV
Respiratory
Autism
Normal

Centers We Direct

NIH/NIGMS Center for Integrative Biomedical Computing



Utah Center for Neuroimage Analysis

UTAH Center for Computational Earth Sciences

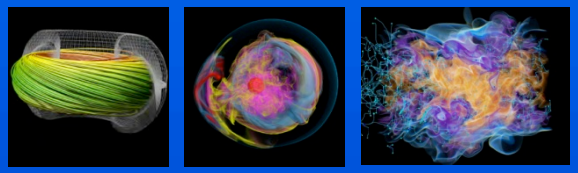
Center for Extreme Data Management, Analysis, and Visualization

CEDMAV

National Centers We are Affiliated With

SDAV

Scalable Data Management, Analysis and Visualization



NIH NAMIC

NIH NAMIC

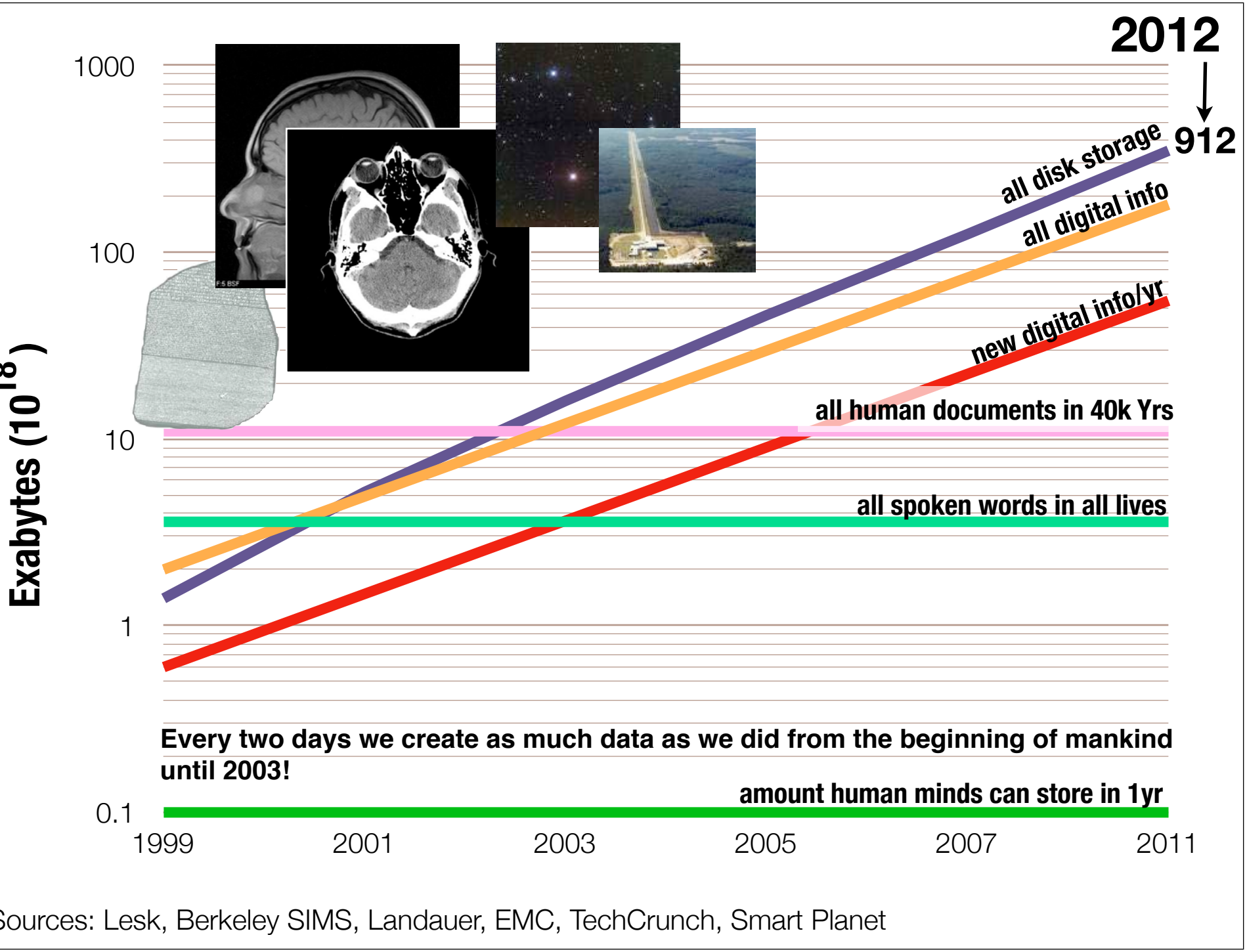
KAUST

IAMCS
Institute for Applied Mathematics and Computational Science

CDC Decision-Support for Infectious Disease Epidemiology

EXACT

Center for Exascale Simulation of Combustion in Turbulence



Sources: Lesk, Berkeley SIMS, Landauer, EMC, TechCrunch, Smart Planet

How Much is an Exabyte?



How many trees does it take to print out an Exabyte?

1 Exabyte = 1000 Petabytes = could hold approximately
500,000,000,000,000 pages of standard printed text

It takes one tree to produce **94,200** pages of a book

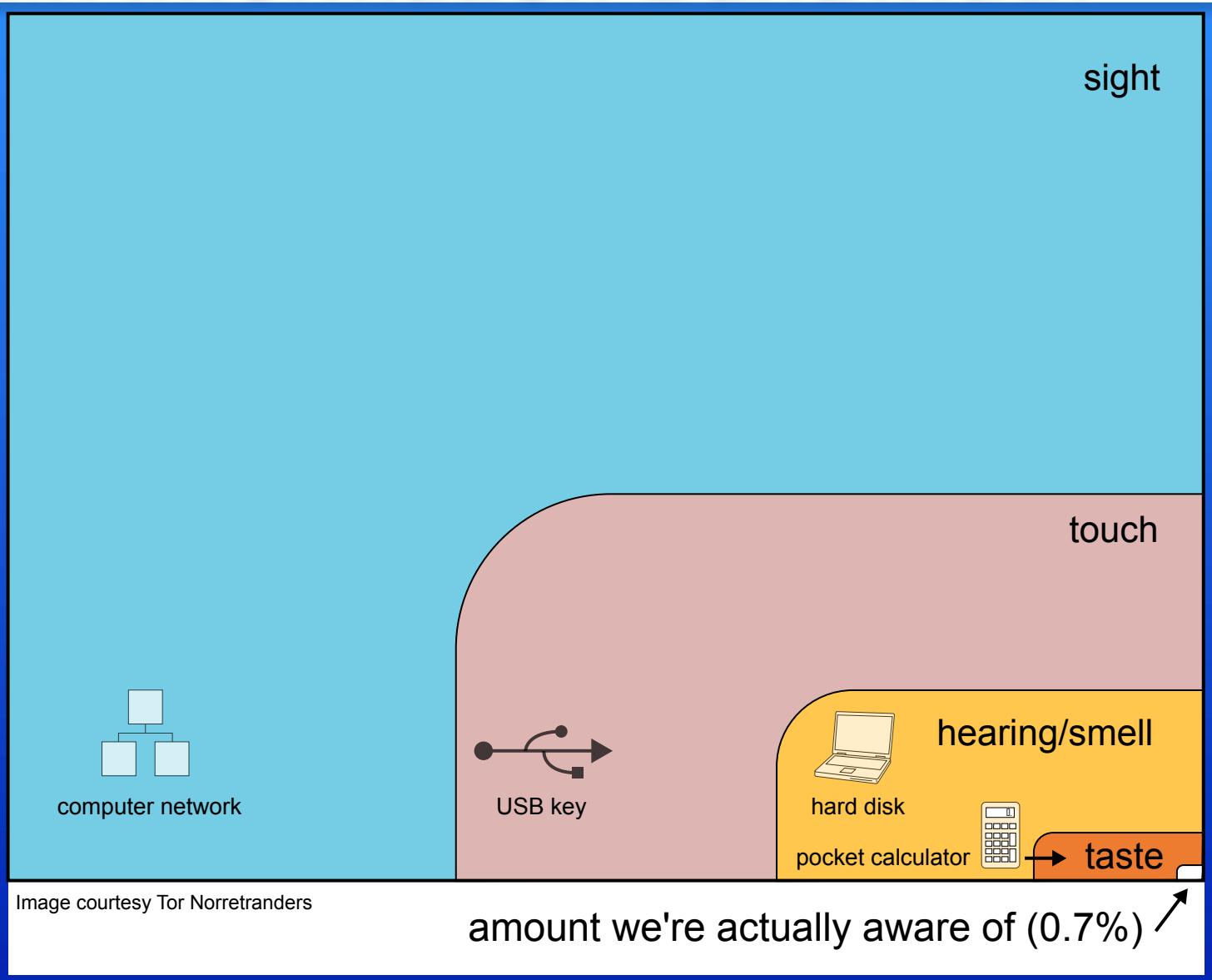
Thus it will take **530,785,562,327** trees to store an Exabyte of data

In 2005, there were **400,246,300,201** trees on Earth

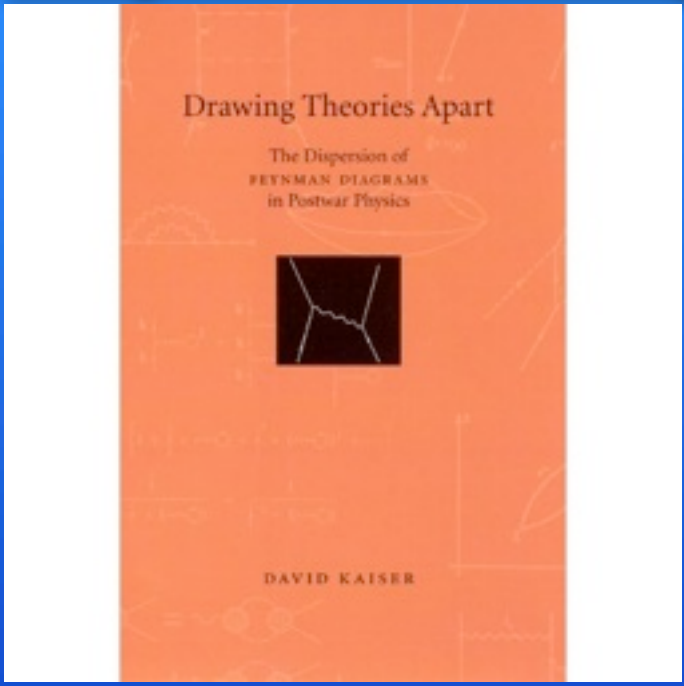
We can store **.75** Exabytes of data using all the trees on the entire planet.

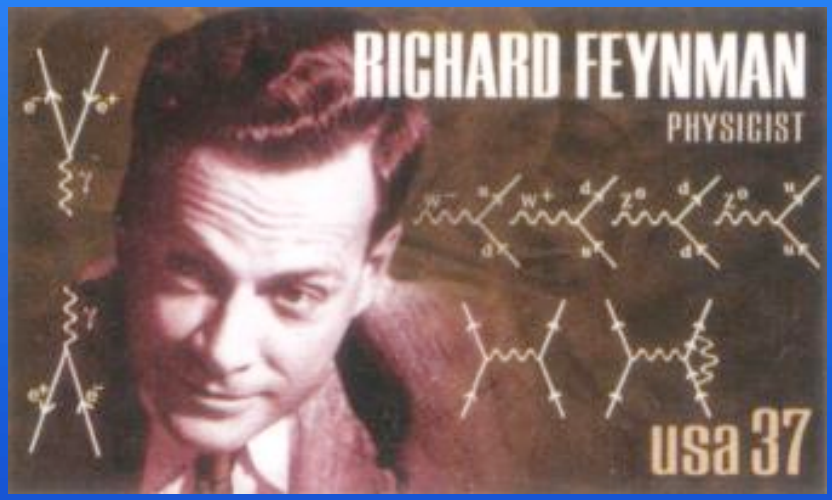
Sources: http://www.whatsabyte.com/ and http://wiki.answers.com

Brain Information Bandwidth



Feynman Diagrams

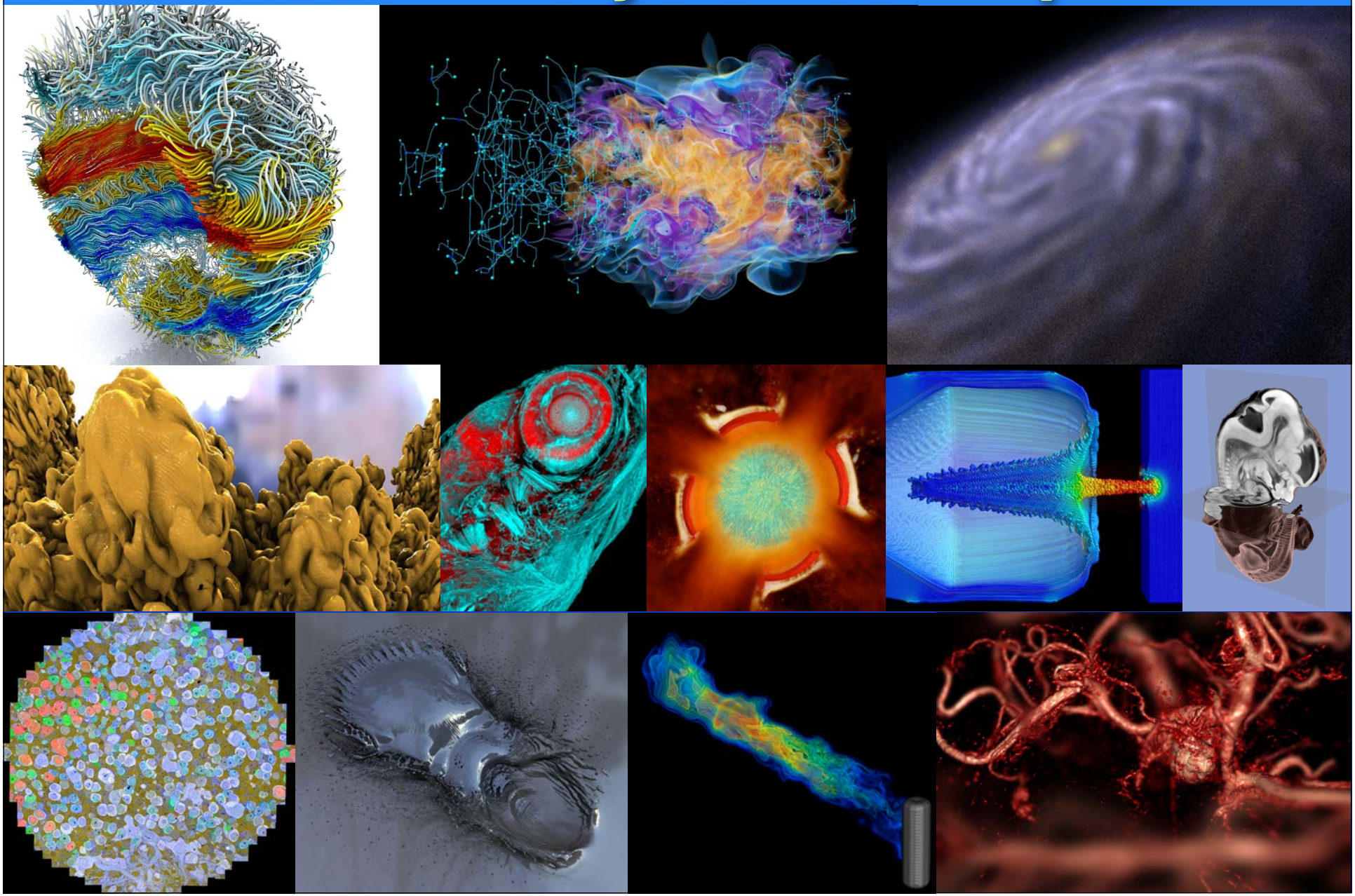


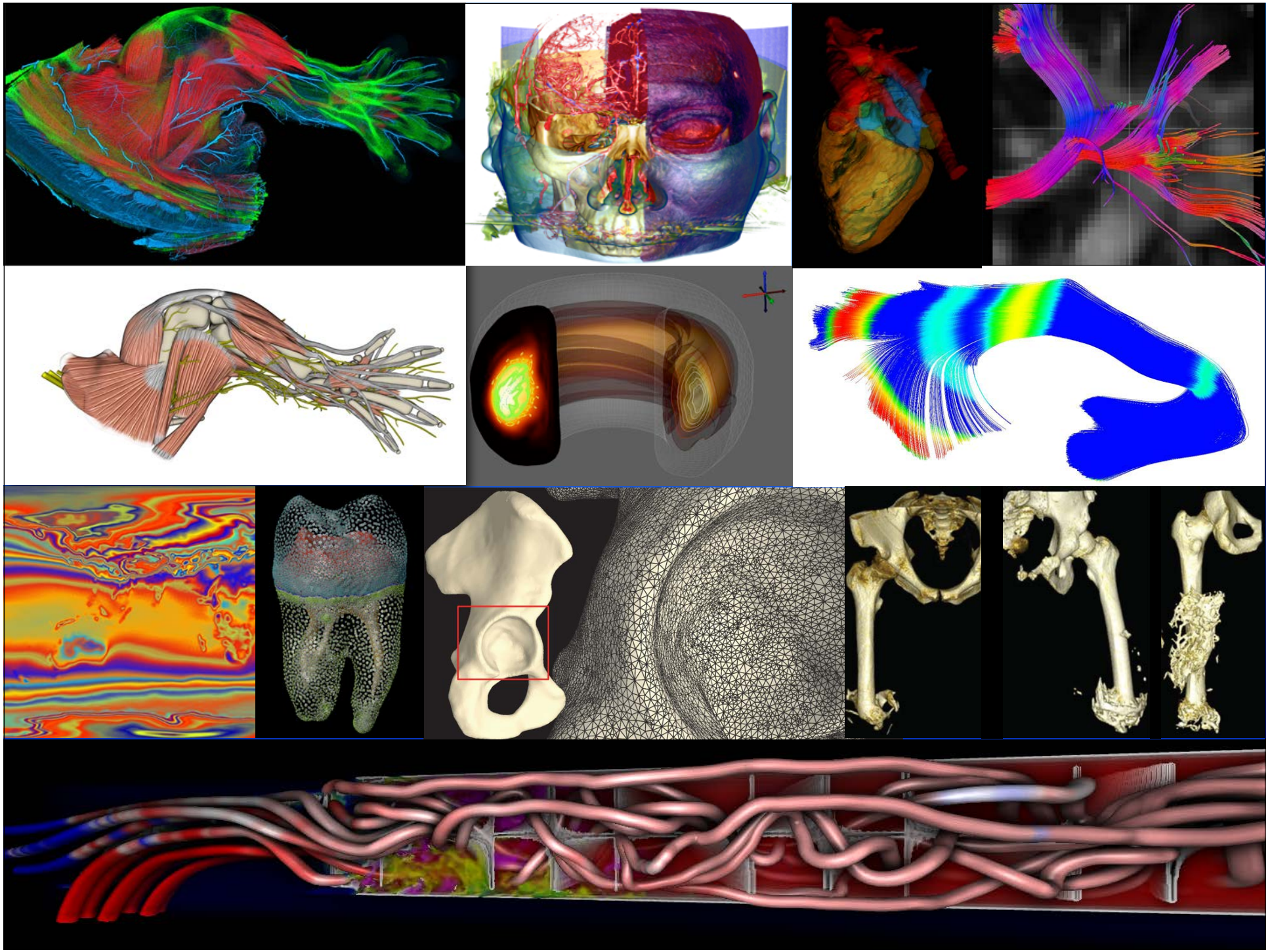


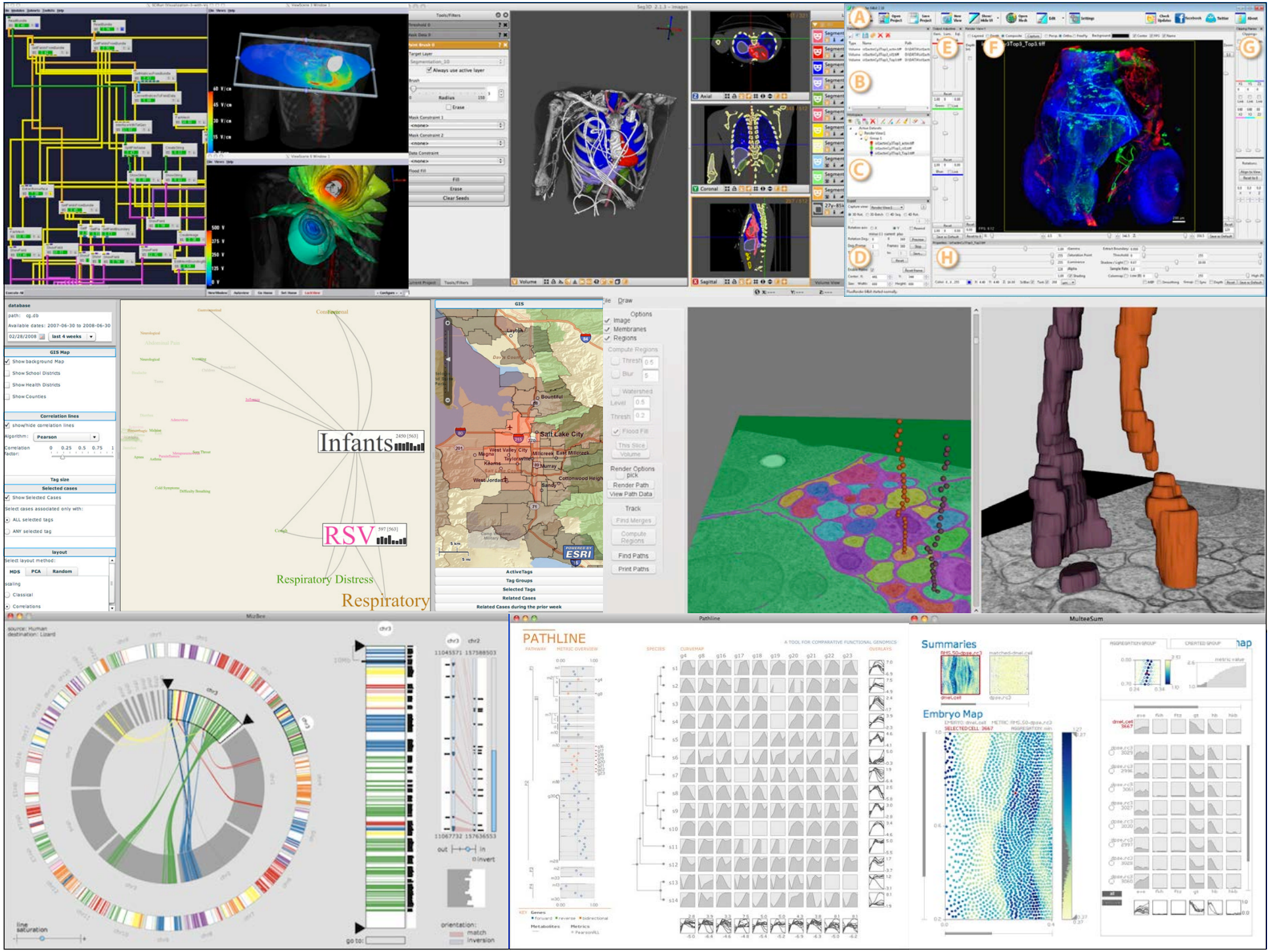
Feynman: “What I am really try to do is bring birth to clarity, which is really a half-assedly thought-out-pictorial semi-vision thing. I would see the jiggle-jiggle-jiggle or the wiggle of the path. Even now when I talk about the influence functional, I see the coupling and I take this turn - like as if there was a big bag of stuff - and try to collect it in away and to push it. It's all visual. It's hard to explain.”

James Gleick, The Life and Science of Richard Feynman, Vintage Books, New York, 1992.

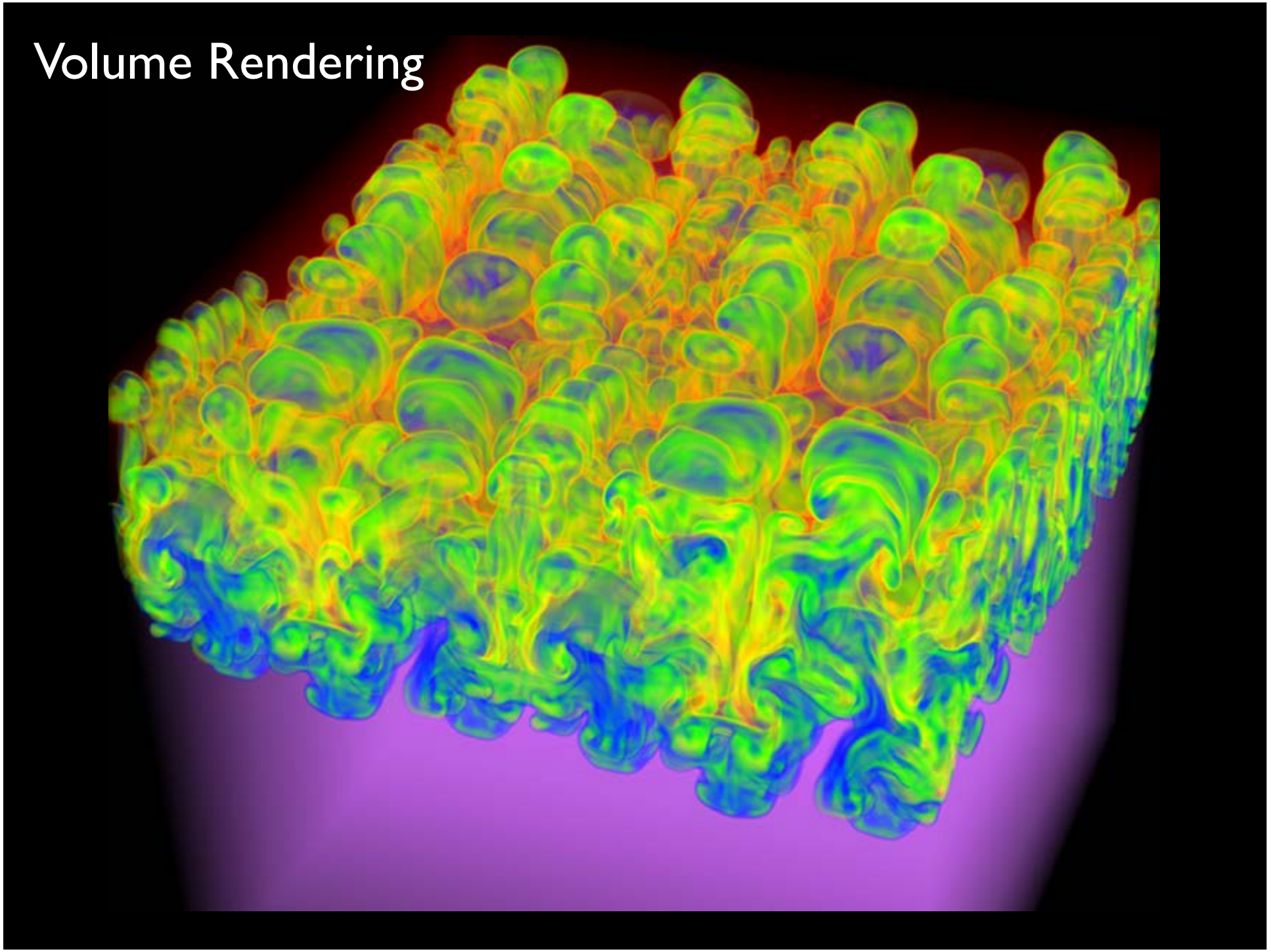
New Visual Analysis Techniques



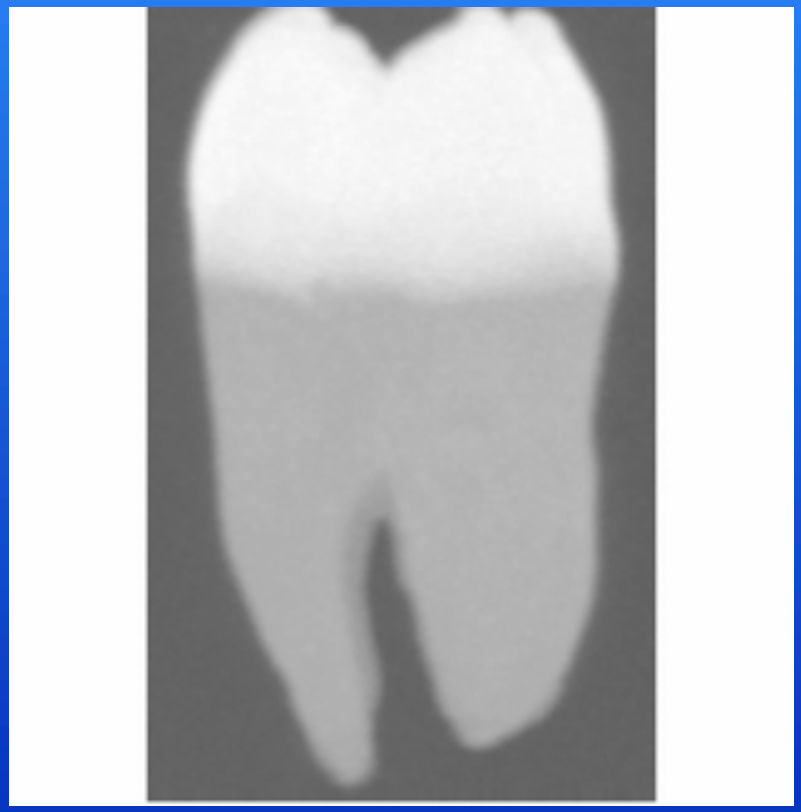



Infants
RSV
Respiratory Distress
Respiratory
PATHLINE
Summaries
Embryo Map

Volume Rendering



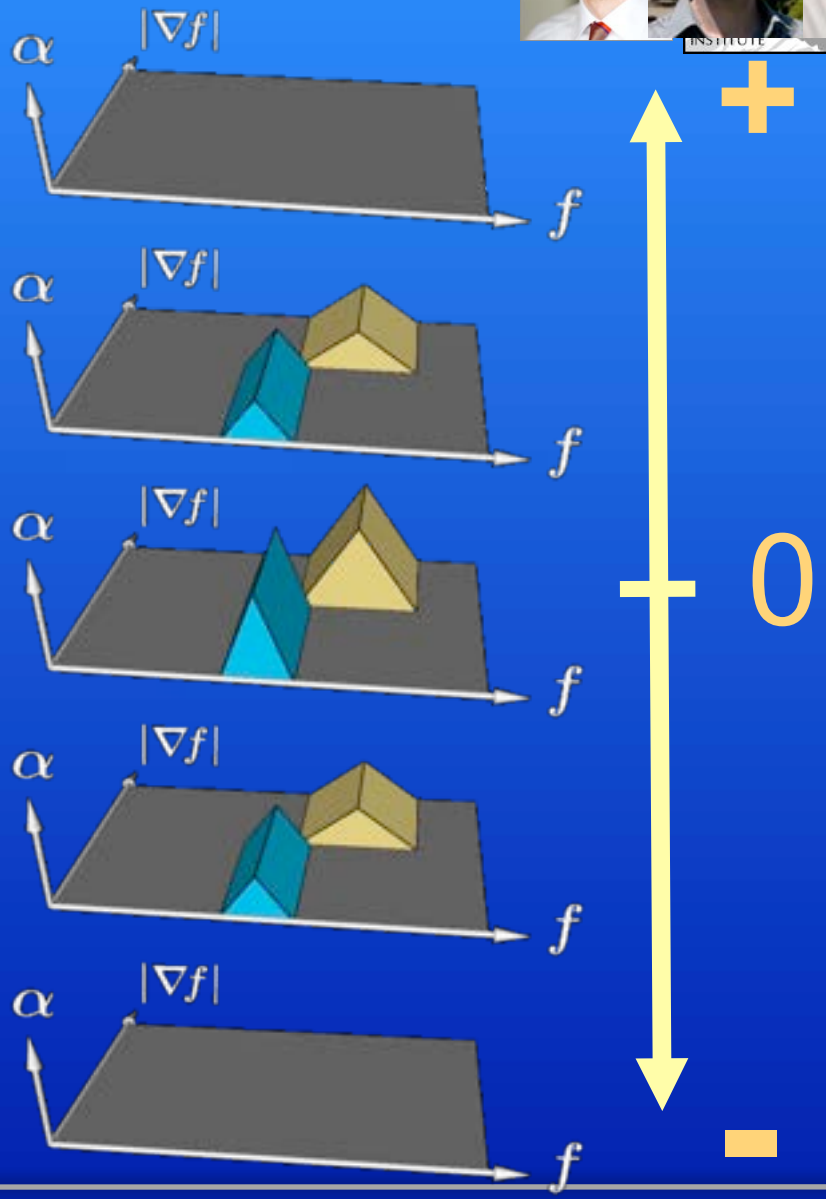
Volume Rendering



Maximum Intensity Projection (MIP)

Full Volume Rendering

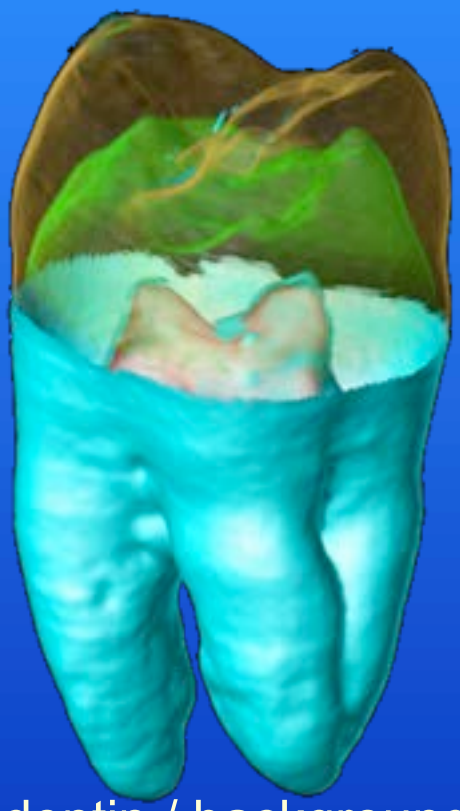
Multi-Dimensional Transfer Function



RGB $\alpha(f, |\nabla f|, D^2_{\widehat{\nabla f} f} f)$

Volume Rendering

enamel / background



dentin / background

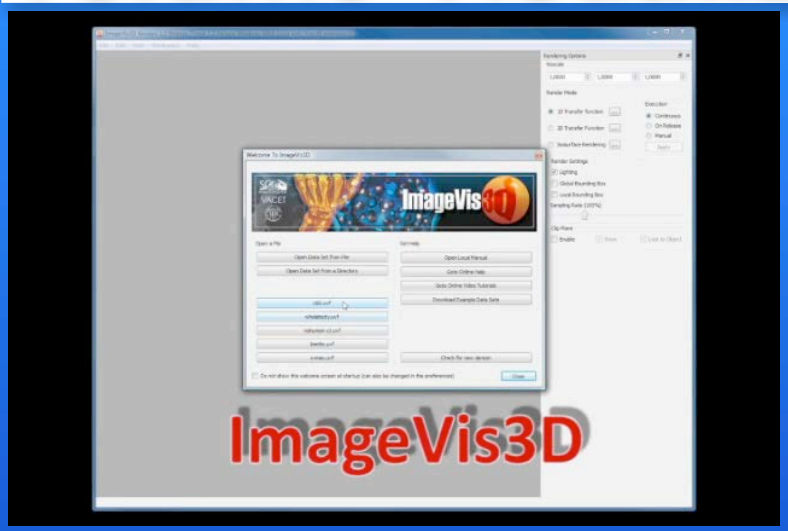
dentin / enamel

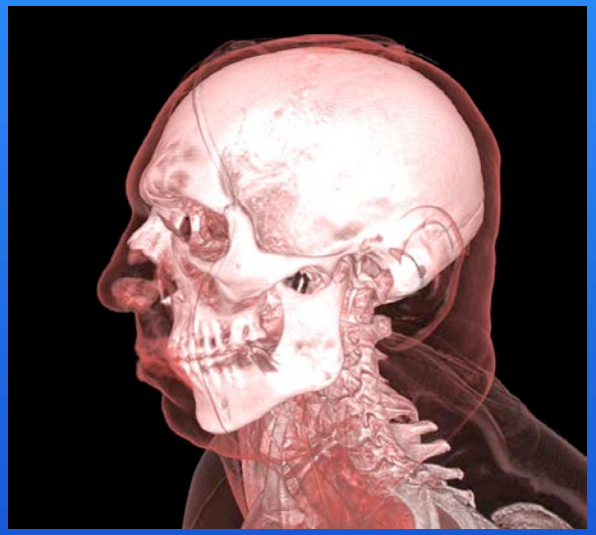
dentin / pulp

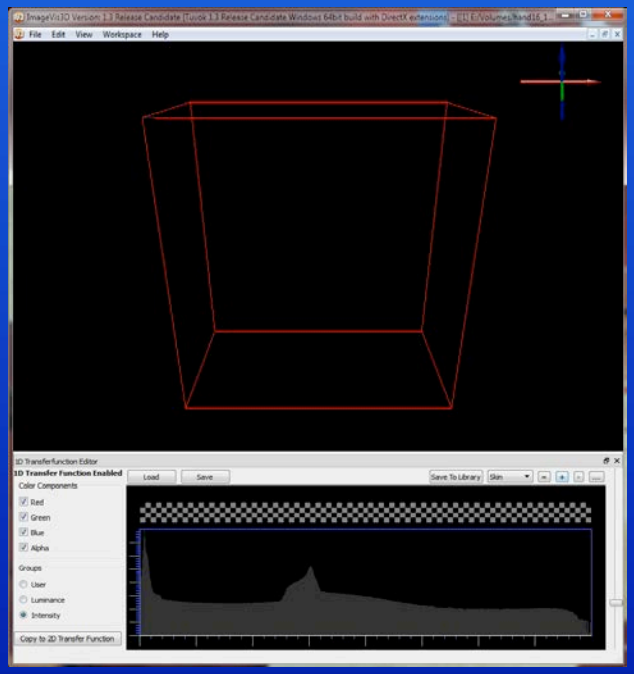
1D: not possible

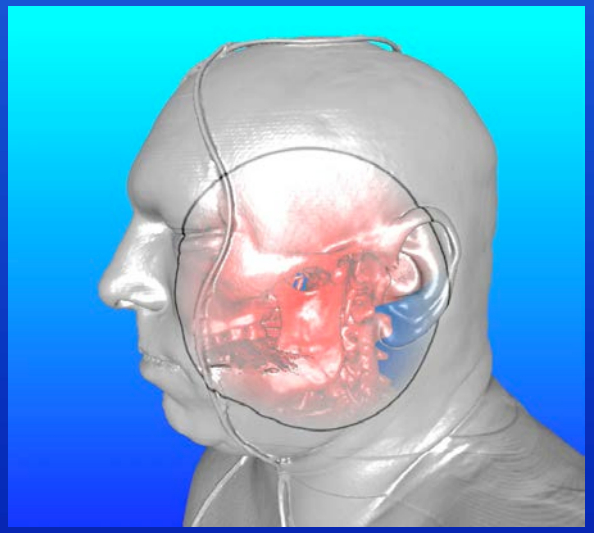
2D: specificity not as good

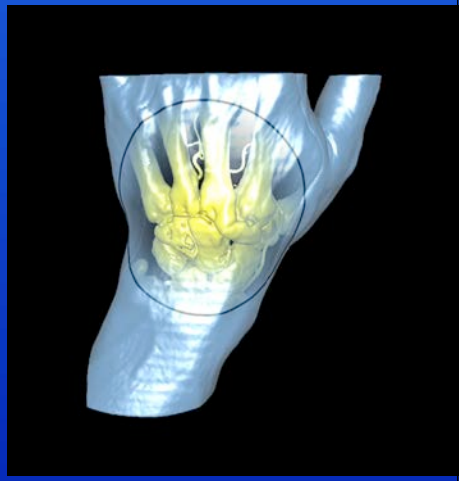
Volume Visualization





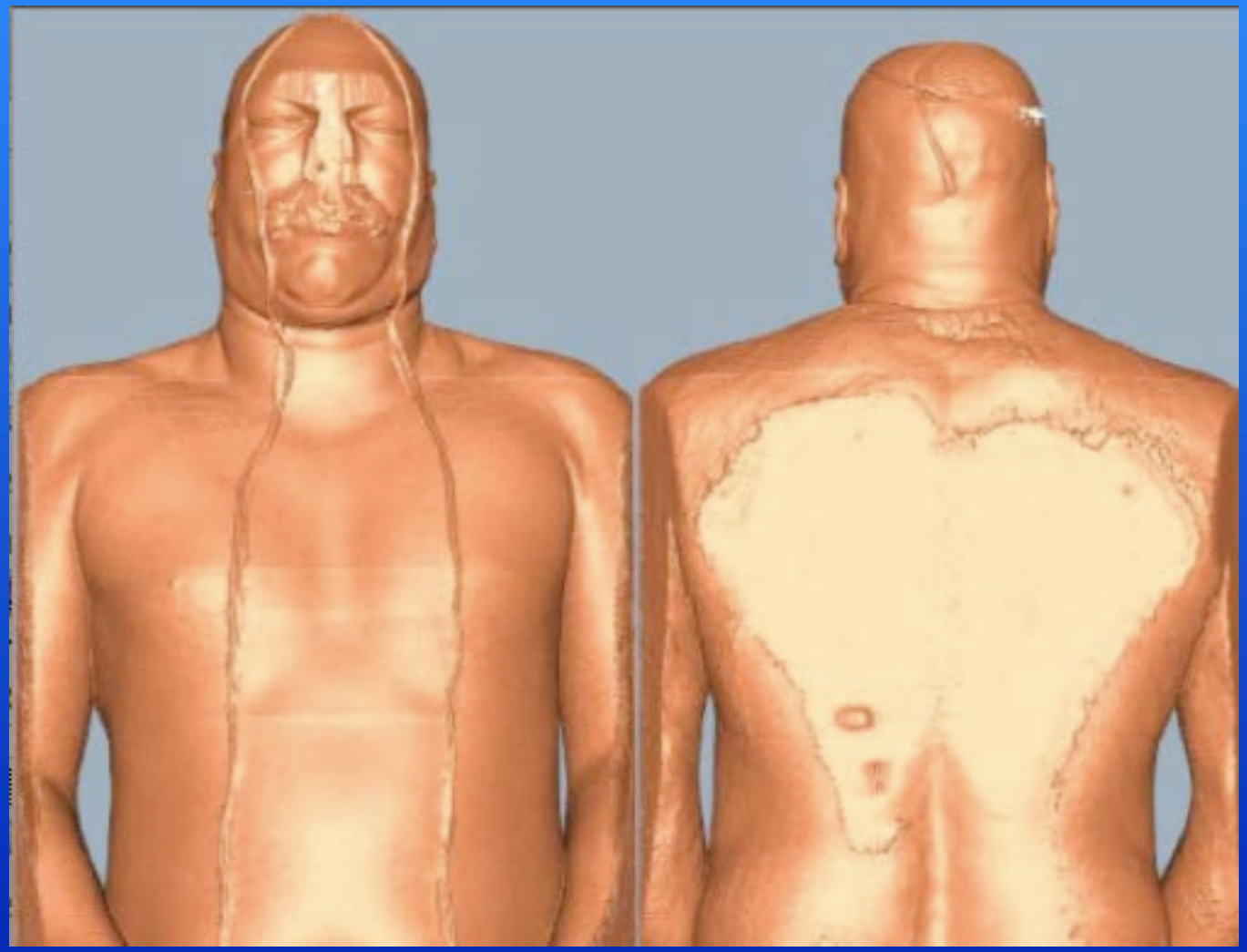






Scientific Computing and Imaging Institute, University of Utah

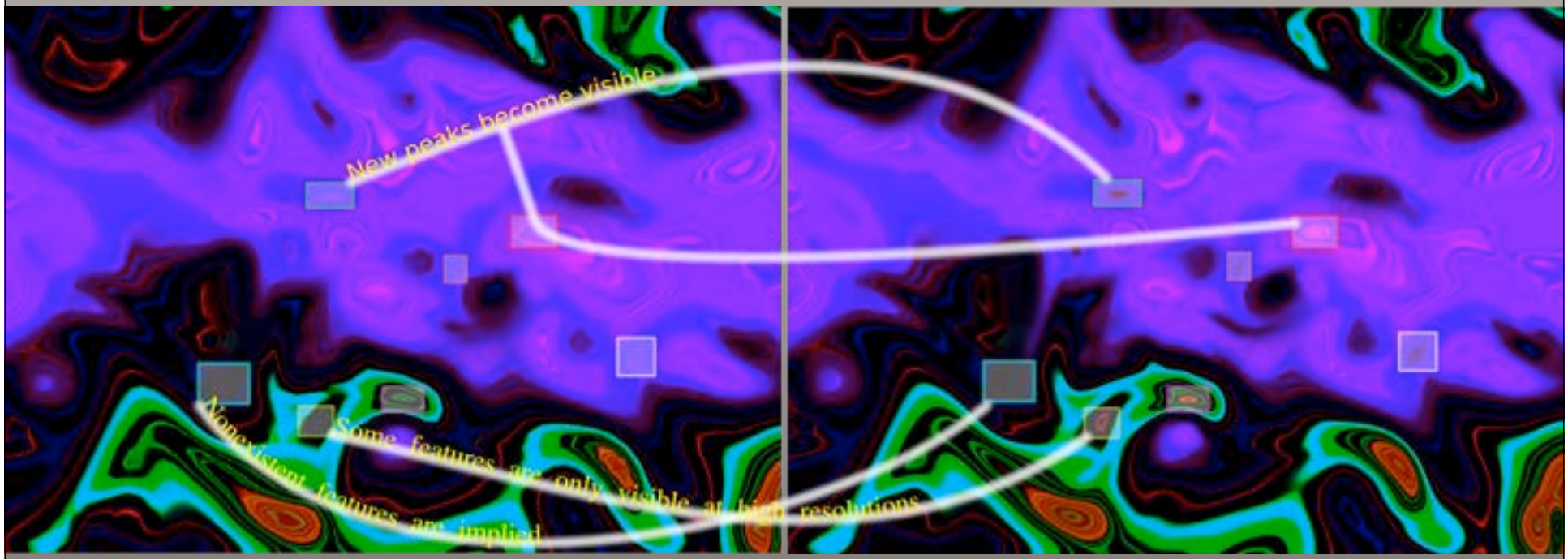
NIH Visible Male



Visible Human - High Resolution

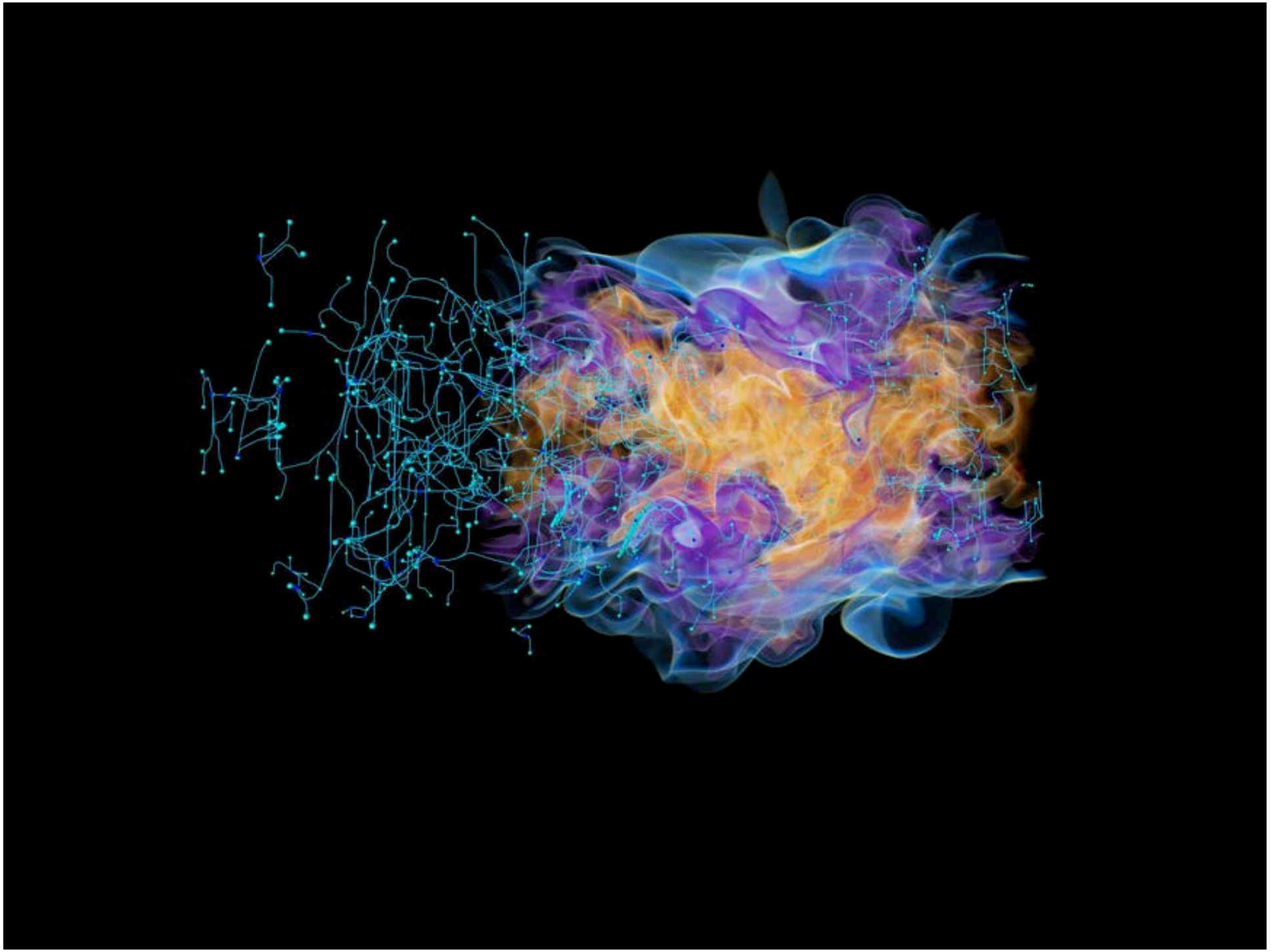
The Need for High Resolution Visualization

"…the data show for the first time how detailed transport and chemistry effects can influence the mixing of reactive scalars. It may be advantageous to incorporate these effects within molecular mixing models. It is worth noting that at present it is impossible to obtain this type of information any other way than by using the type of highly resolved simulation performed here."
Jacqueline Chen, Sandia National Laboratories



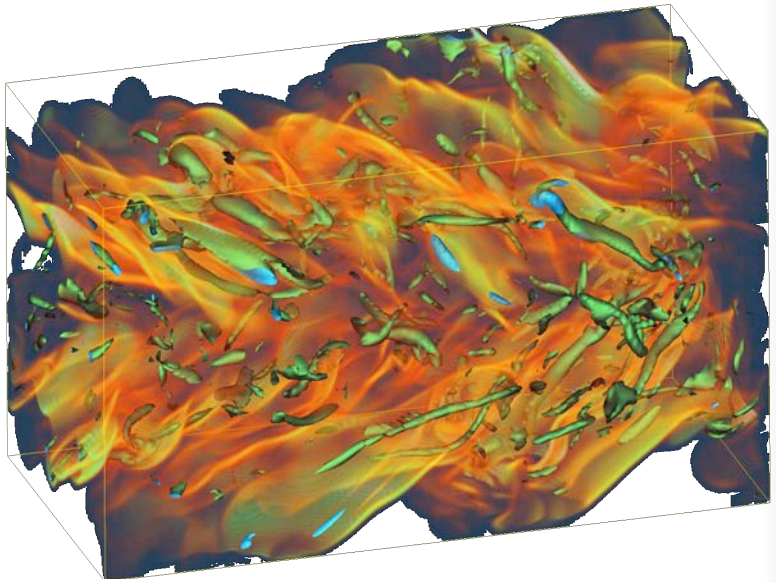
Lower Resolution

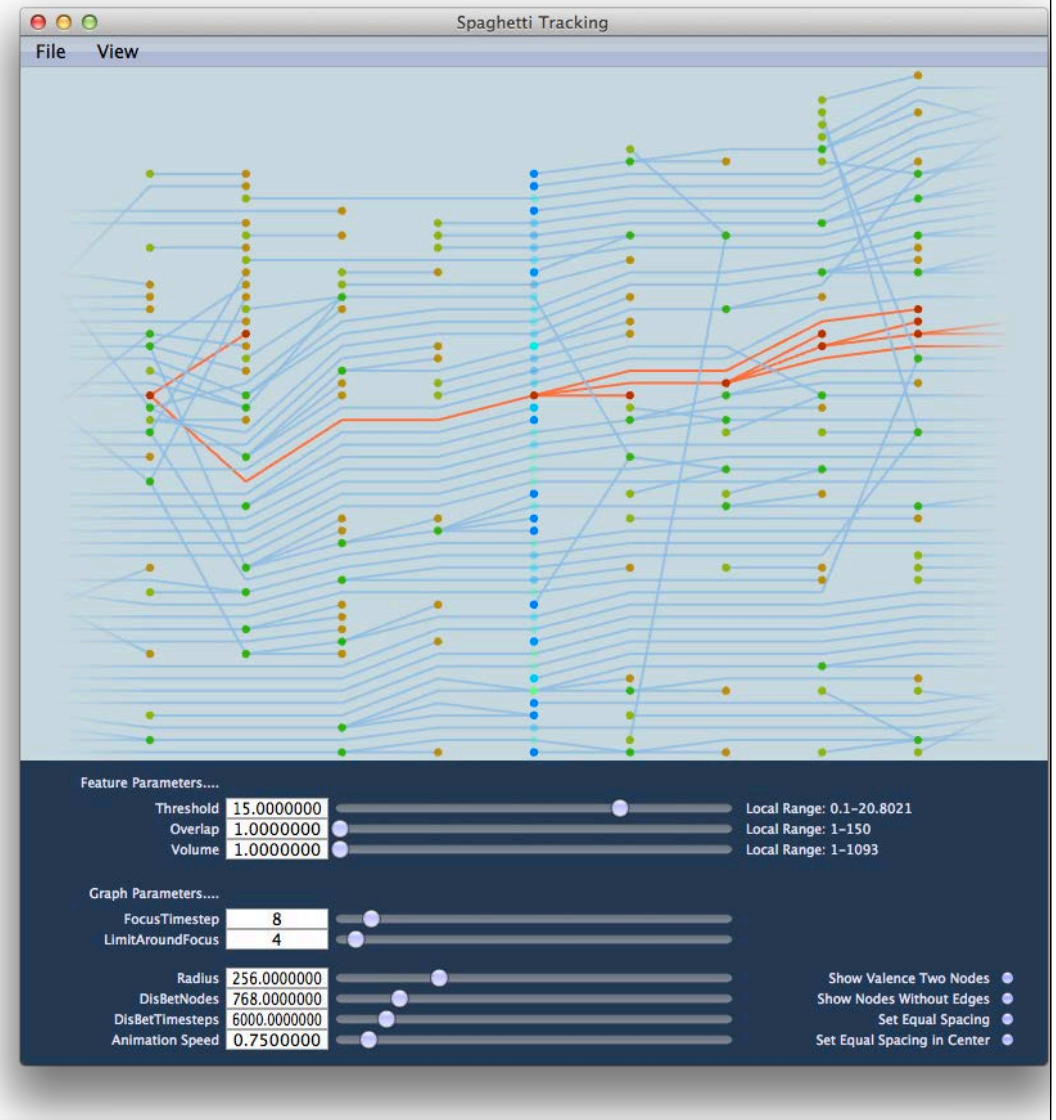
High Resolution



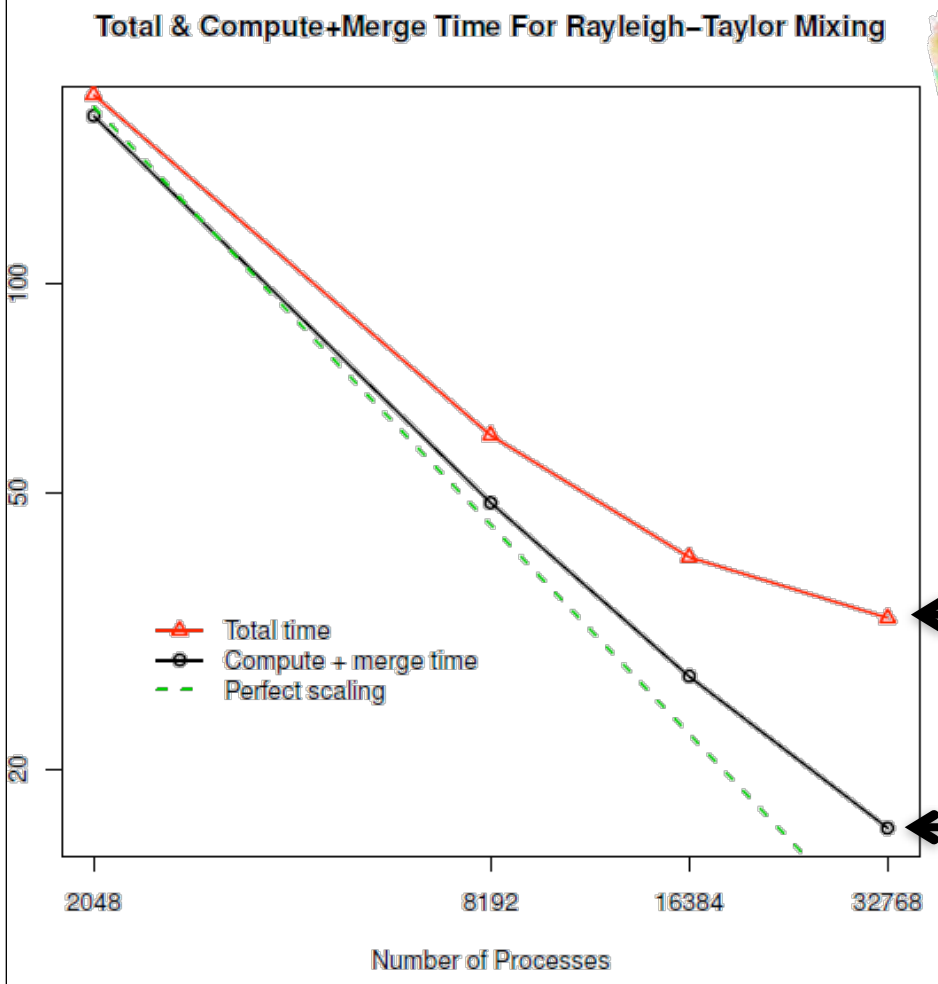
Topological Analysis of Massive Combustion Simulations

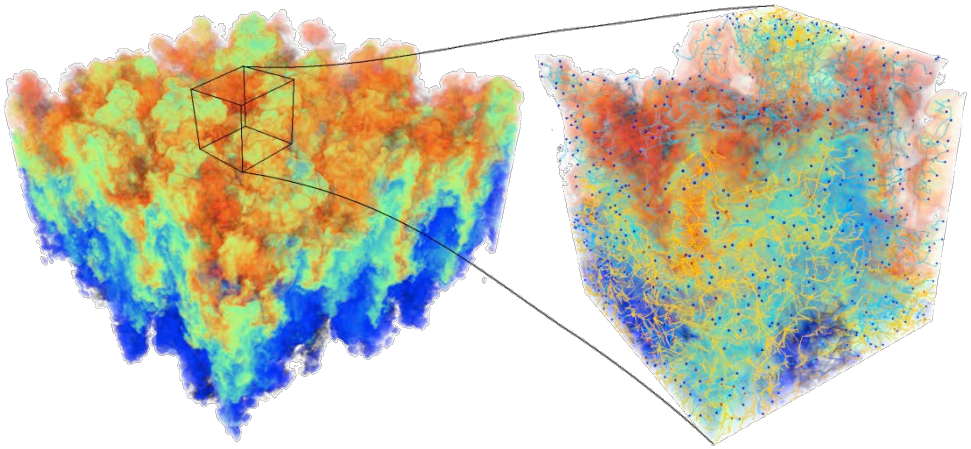
- Non-premixed DNS combustion (J. Chen, SNL): Analysis of the time evolution of extinction and reignition regions for the design of better fuels





New Parallel Topological Computations Achieve High Performance at Scale

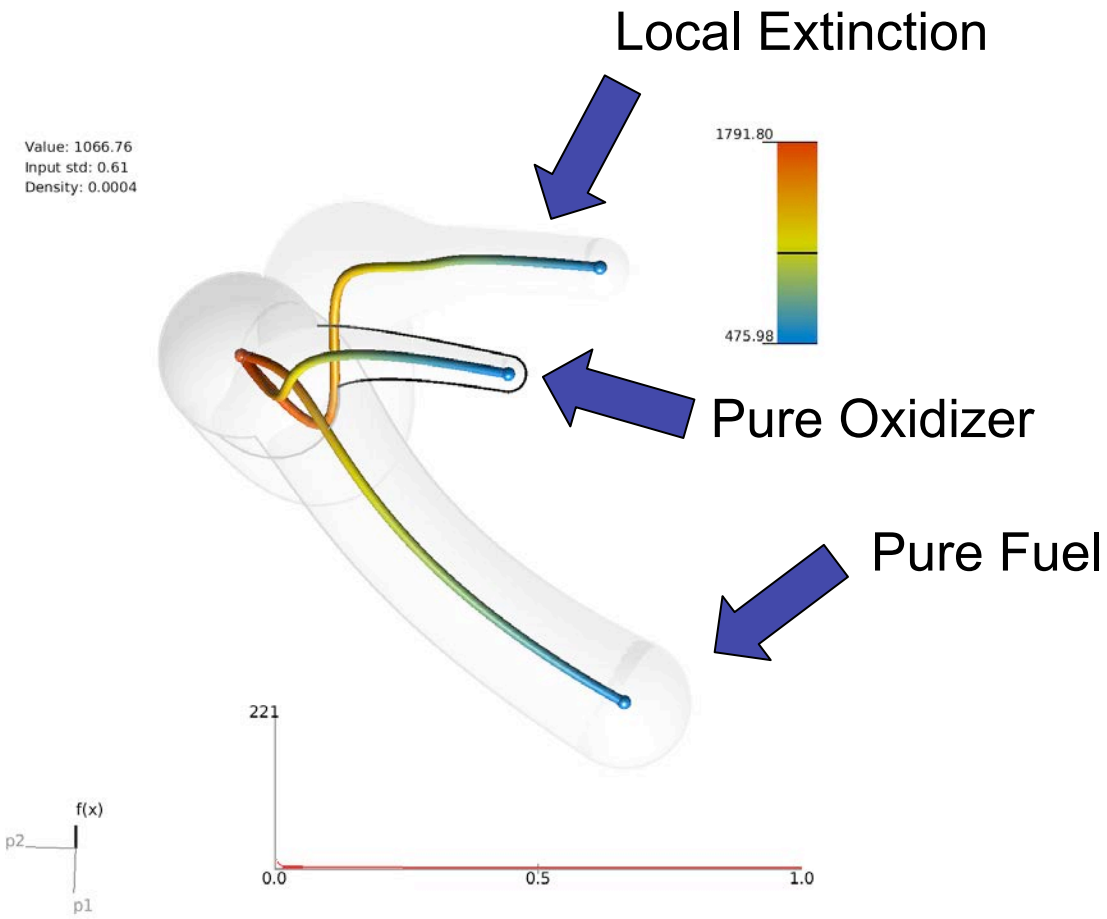


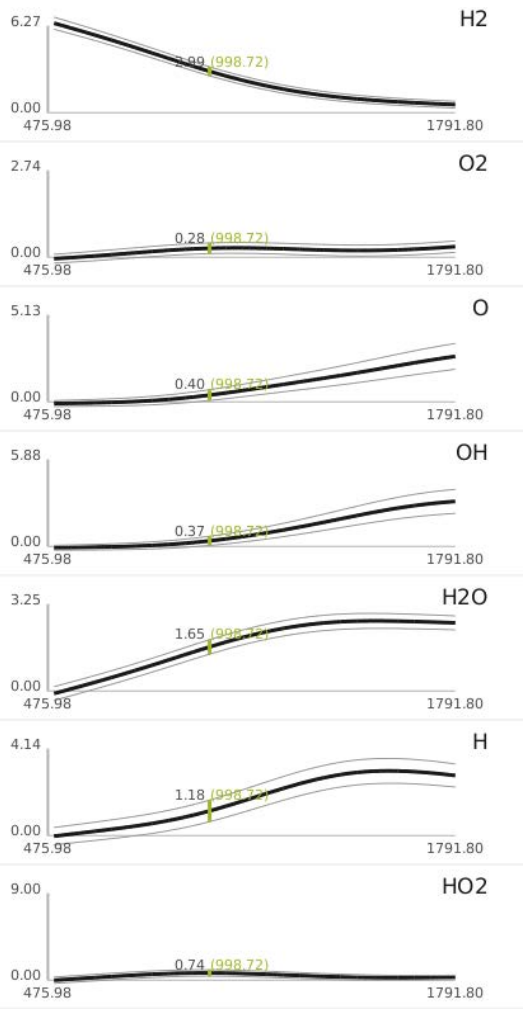


Computation + I/O

Pure Computation

Visualization of 10D Combustion Simulation of Jet CO/H2-Air Flames





10 dimensional data set describing the heat release wrt. to various chemical species in a combustion simulation

Analysis of Combustion Simulations

Combustion Simulation of Jet CO/H2-Air Flames

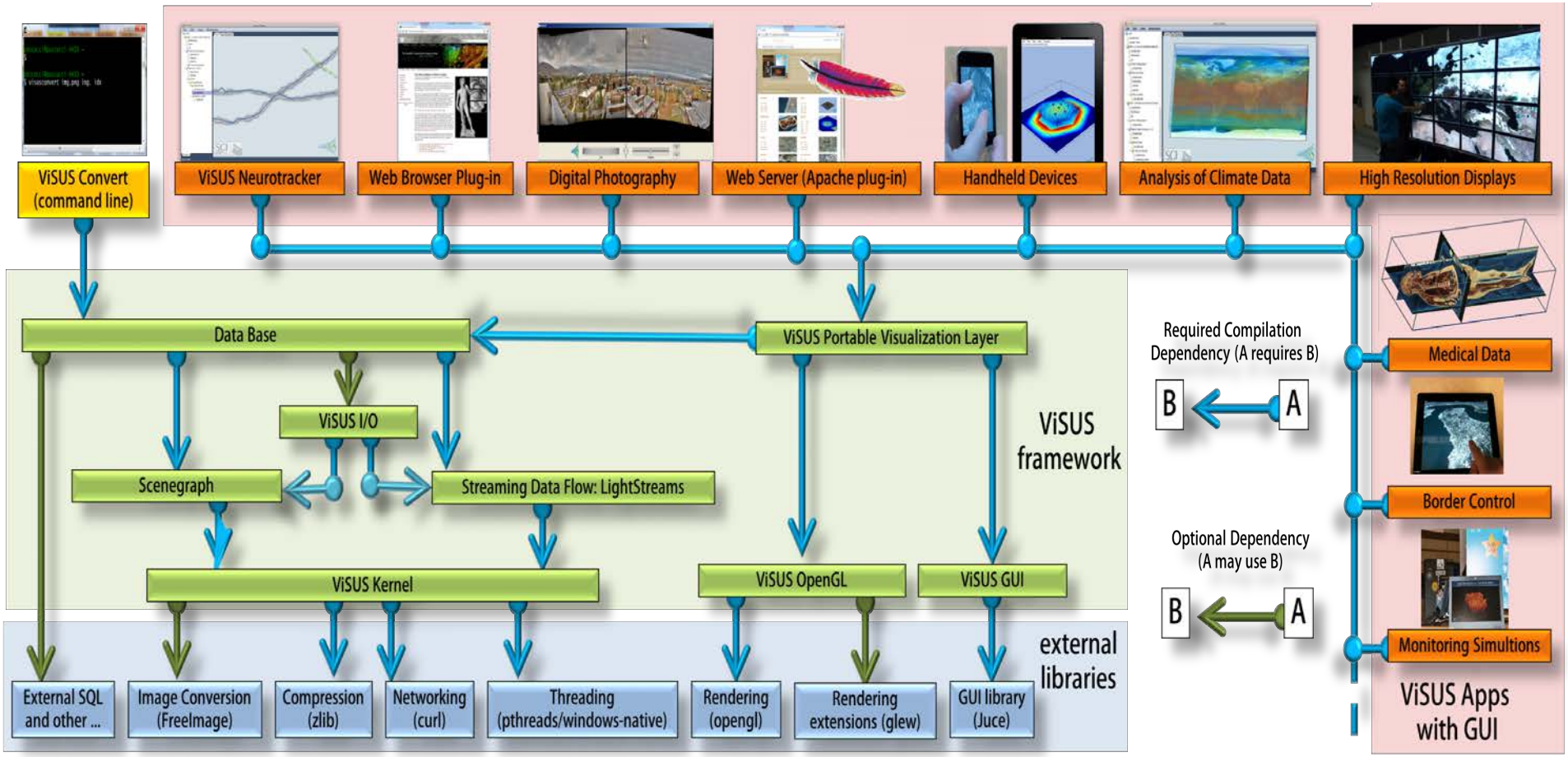
Input: Composition of 10 chemical species

Output: Temperature

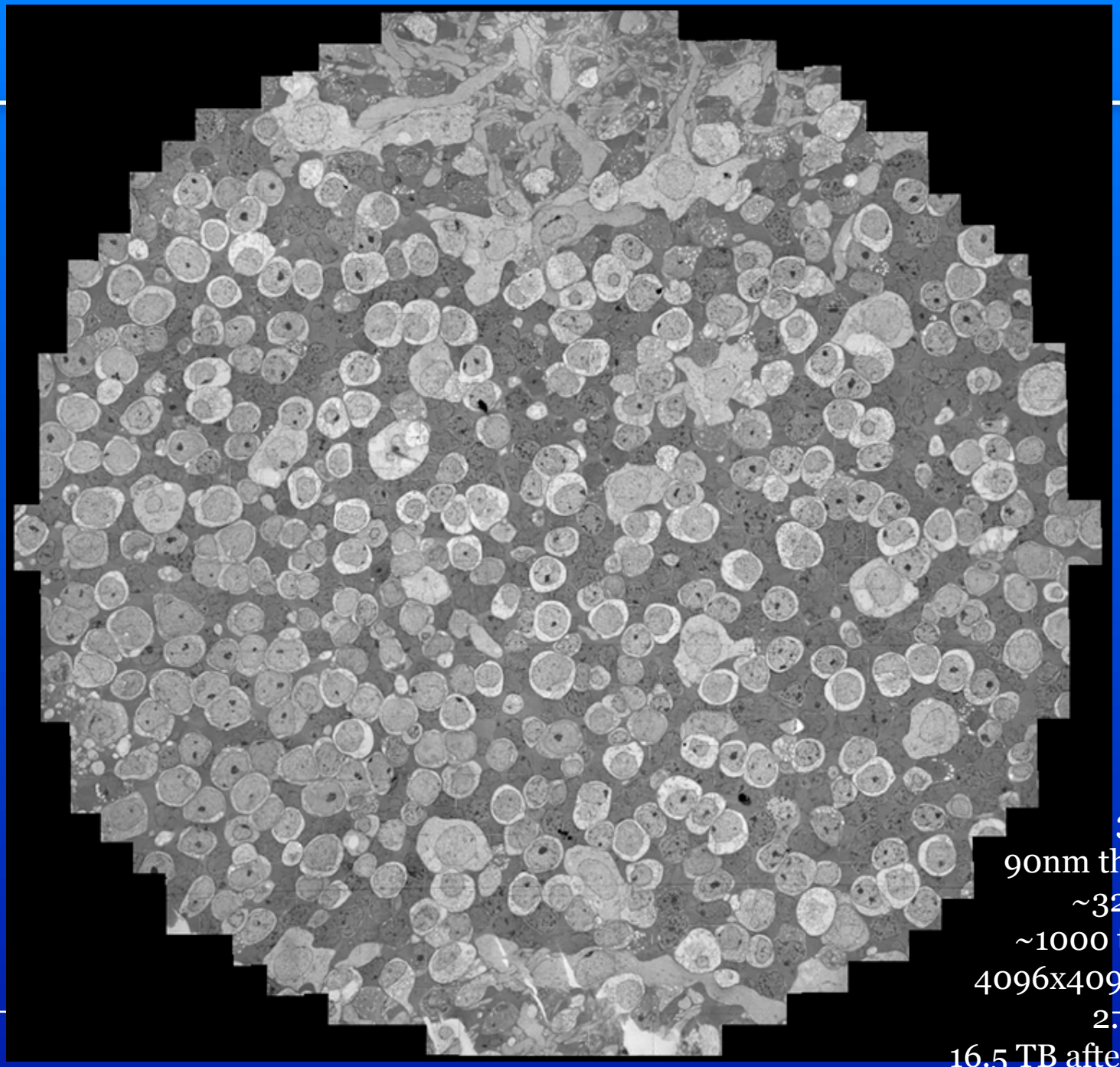
Michelangelos David

Michelangelos David - Part 2

ViSUS Framework for Scalable Data



Large Scale Galaxy Simulation

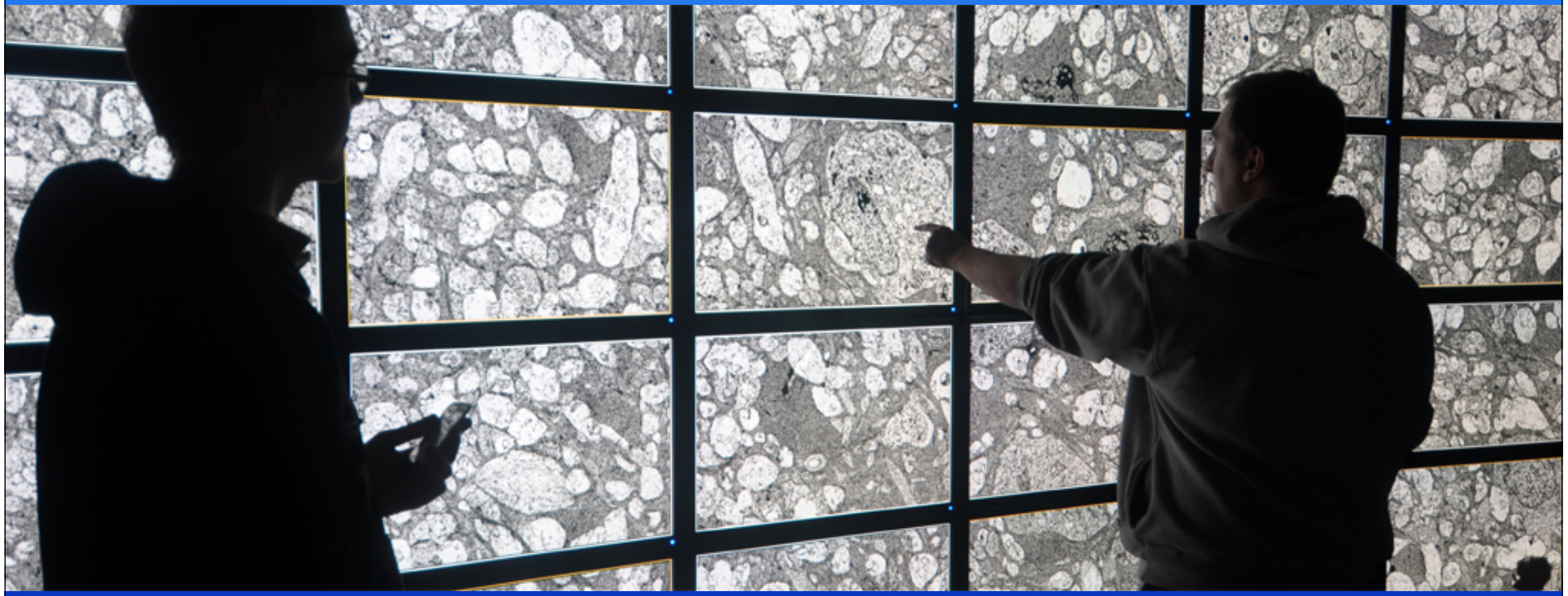


341 Sections
90nm thick sections
~32GB/Section
~1000 tiles/section
4096x4096 pixels/tile
2.18 nm/Pixel
16.5 TB after processing

Antony van Leeuwenhoek (1632-1723)

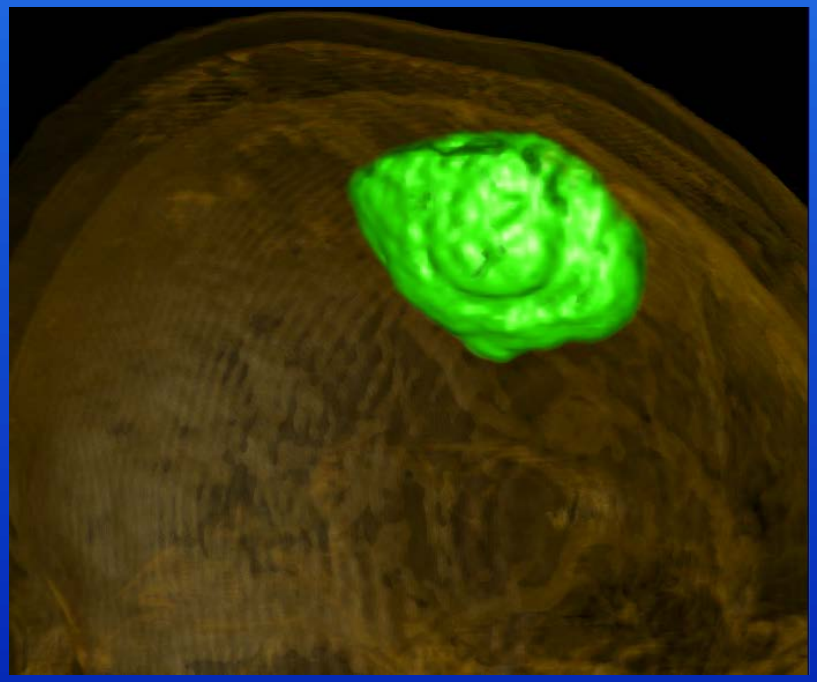
. . . my work, which I've done for a long time, was not pursued in order to gain the praise I now enjoy, but chiefly from a craving after knowledge, which I notice resides in me more than in most other men. And therewithal, whenever I found out anything remarkable, I have thought it my duty to put down my discovery on paper, so that all ingenious people might be informed thereof.

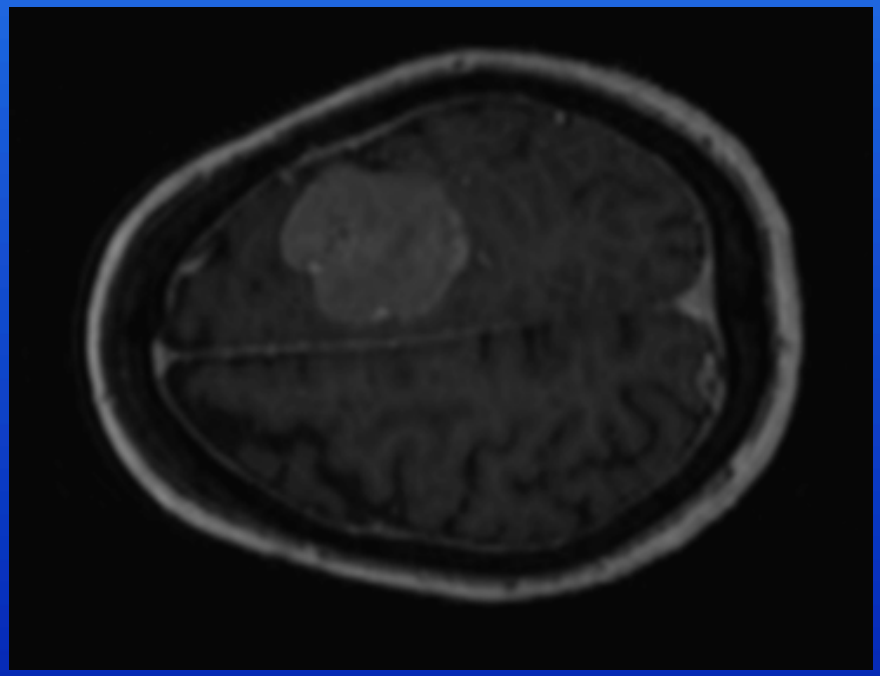
Antony van Leeuwenhoek. Letter of June 12, 1716



Uncertainty Visualization

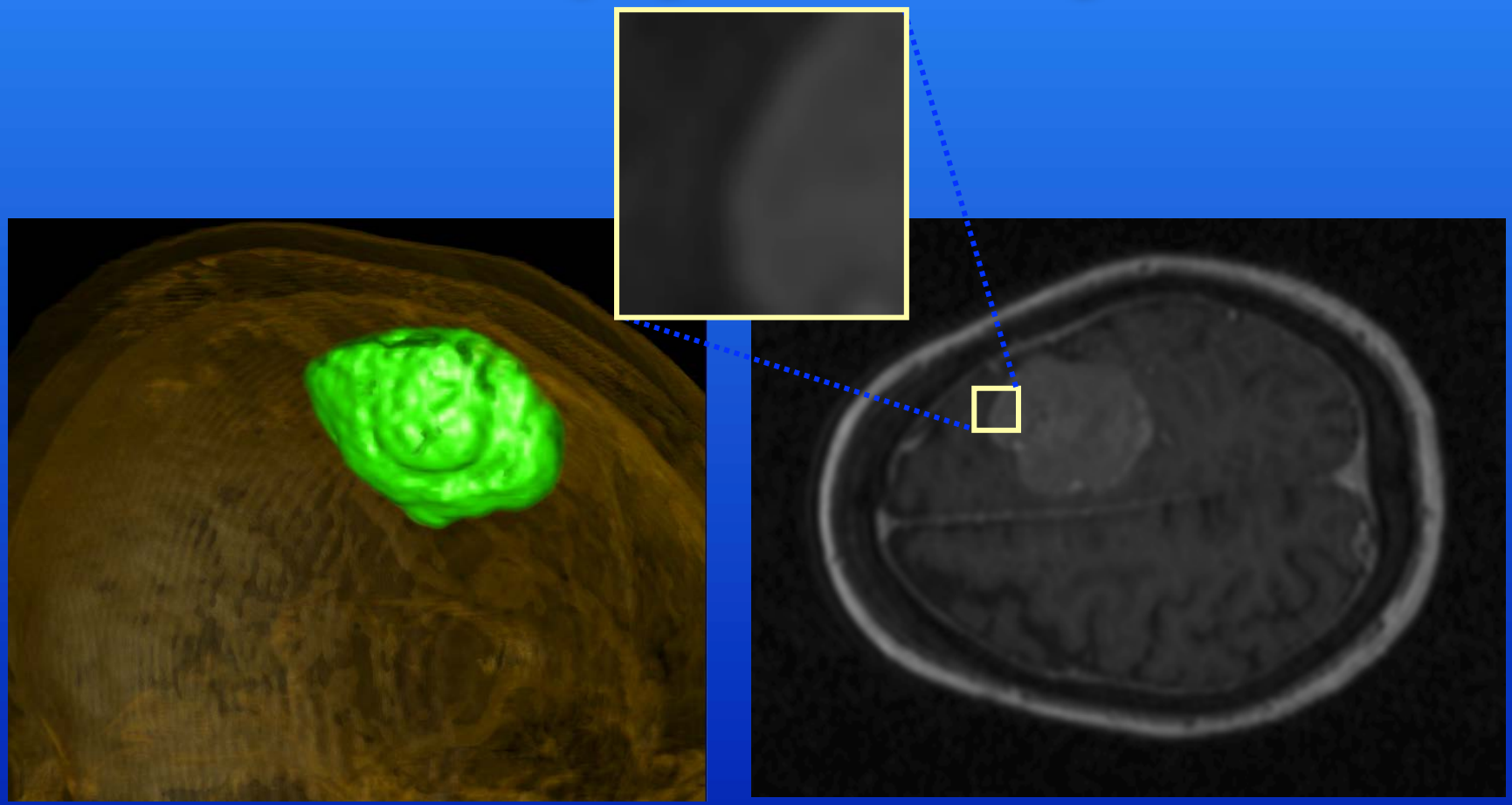
When is the last time you've seen an error bar in a 3D visualization?





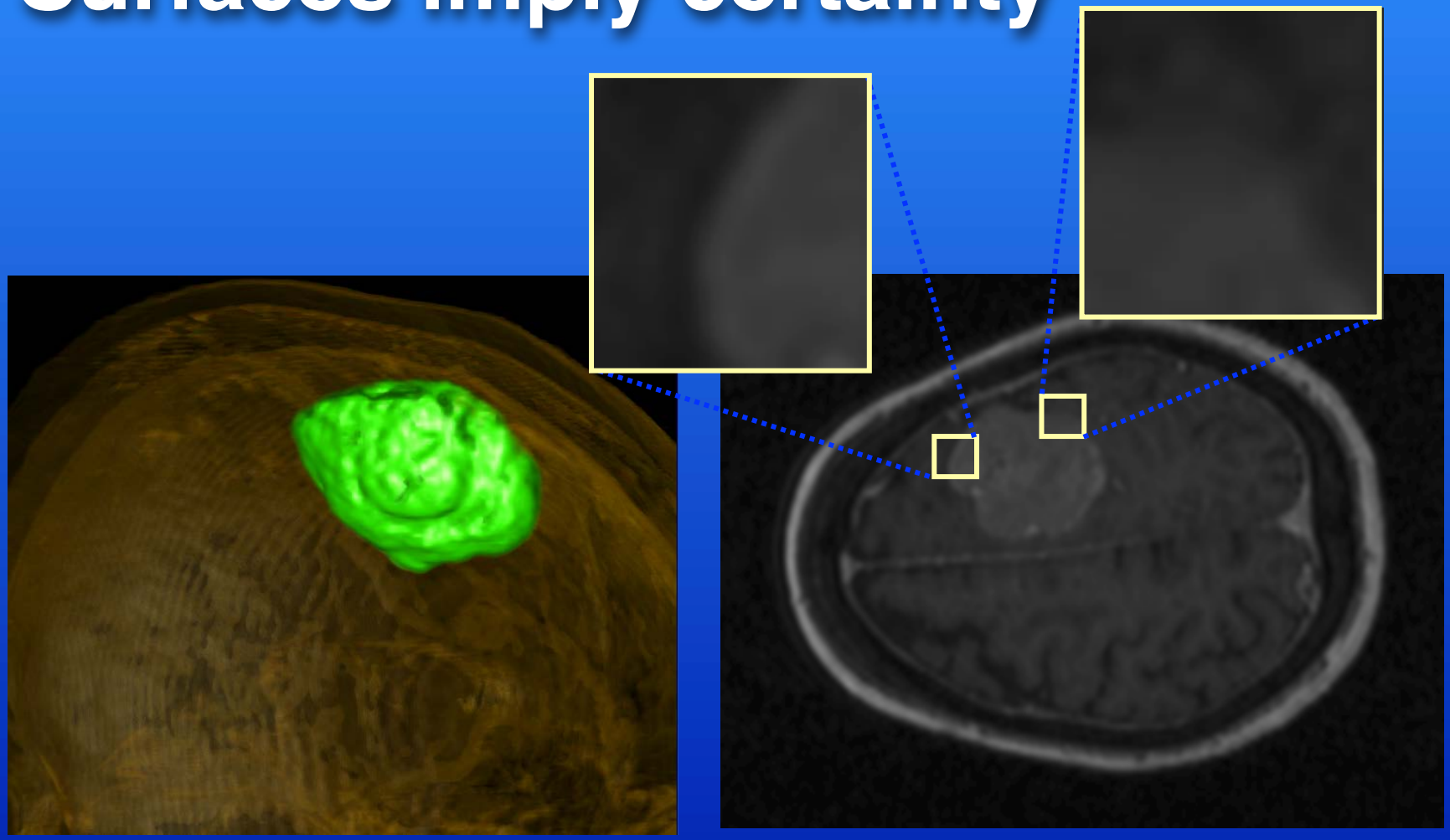
Uncertainty Visualization

Surfaces imply certainty



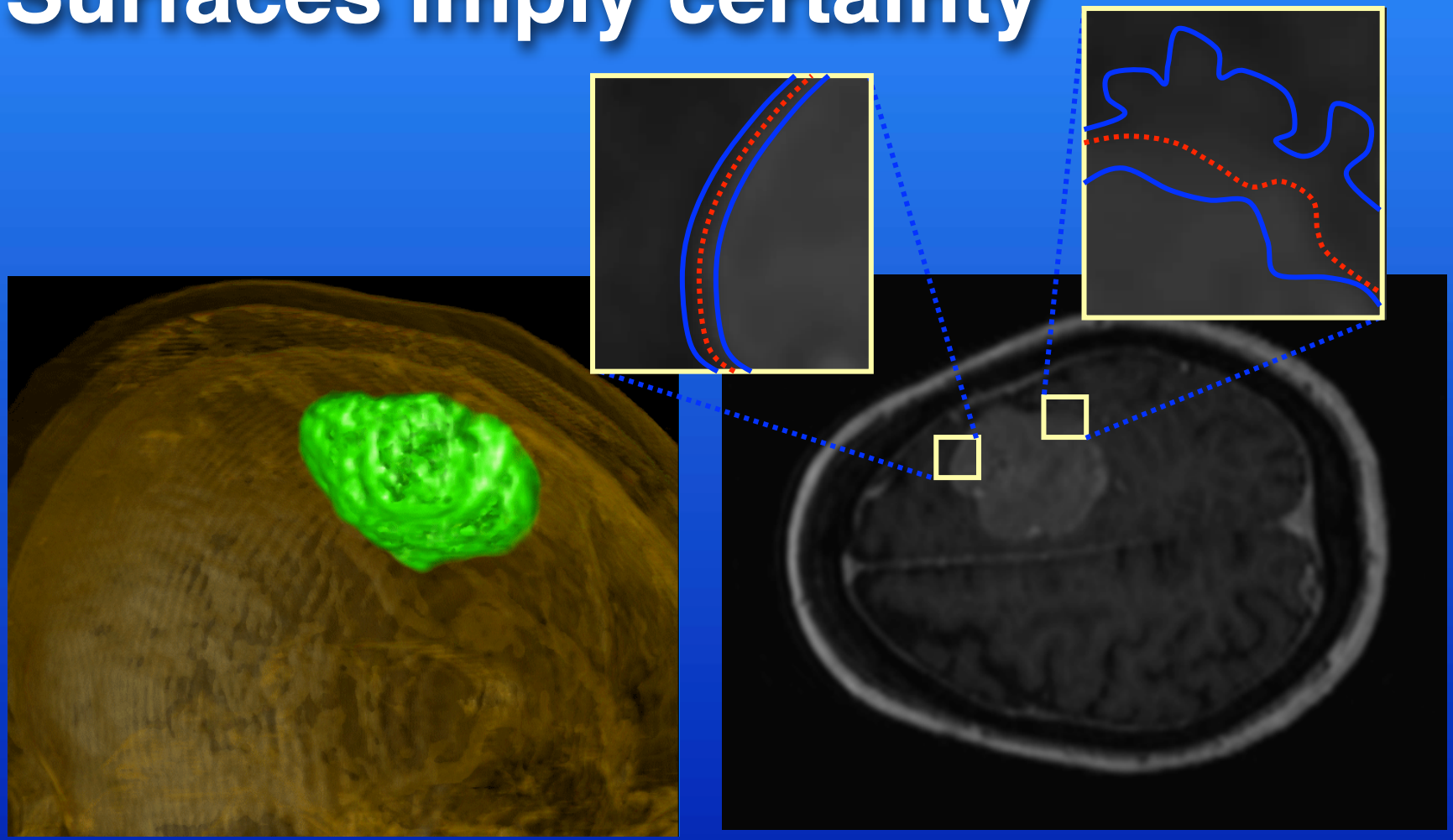
Uncertainty Visualization

Surfaces imply certainty



Uncertainty Visualization

Surfaces imply certainty



Topological Uncertainty

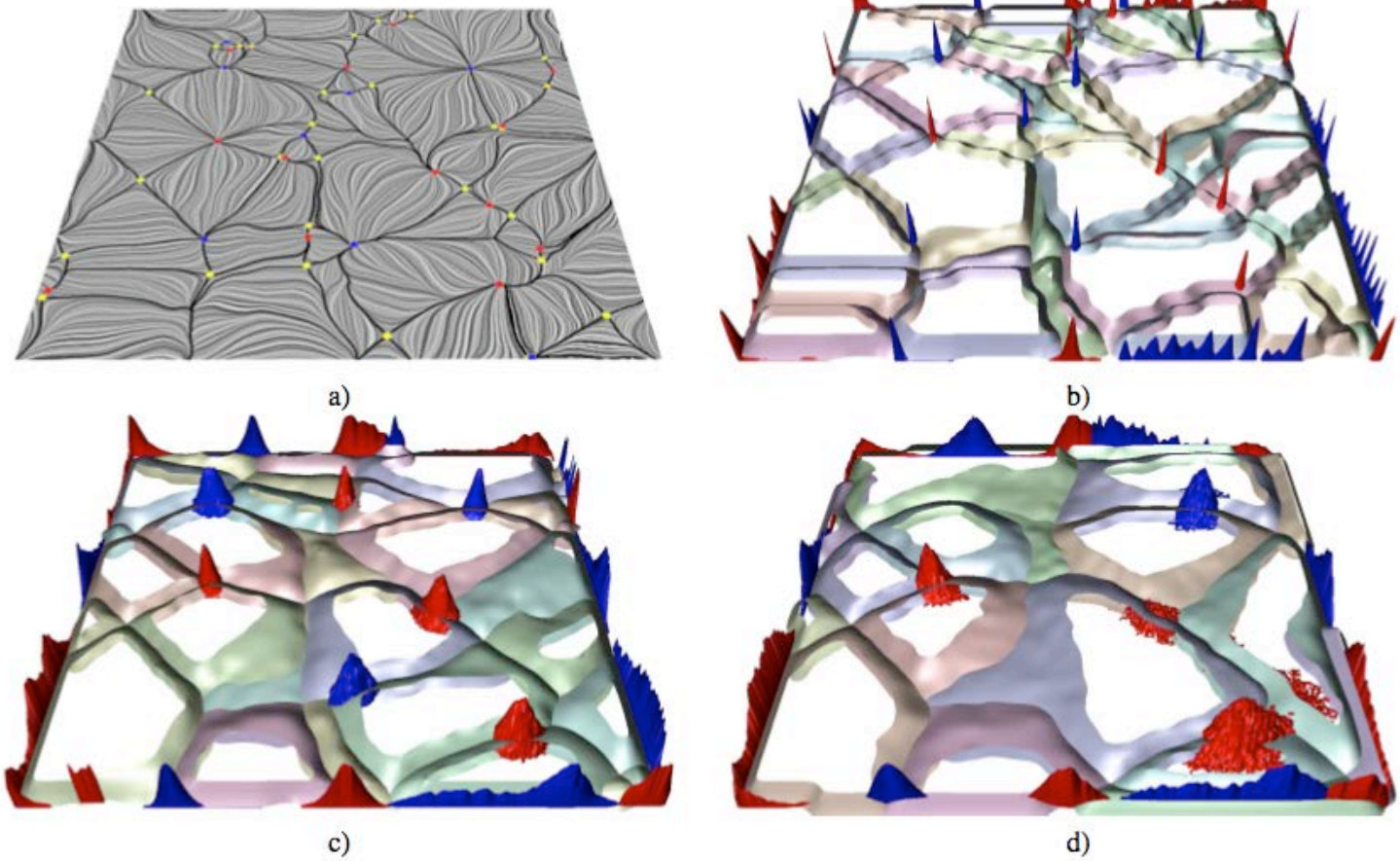
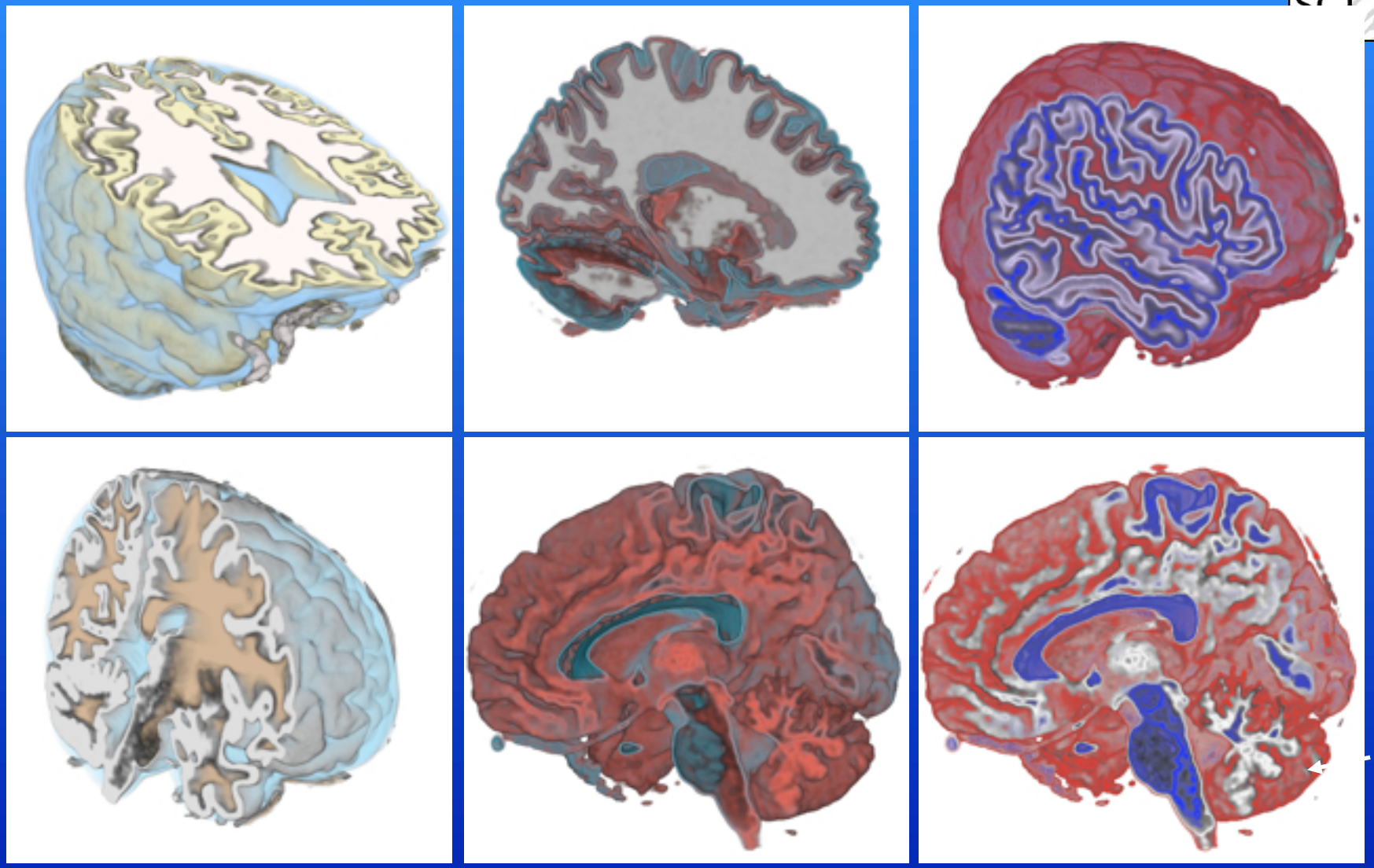


Figure 6: *Increasing the uncertainty of a random vector field: a) certain topology of mean vector field; b)* $\|\mathbf{T}\|_F = 0.2$*; c)* $\|\mathbf{T}\|_F = 2.0$*; d)* $\|\mathbf{T}\|_F = 5.0$.

M. Otto, T. Germer, H.C. Hege, H. Theisel. Uncertain 2D Vector Field Topology. In *CGF*, 29(2), 2010.

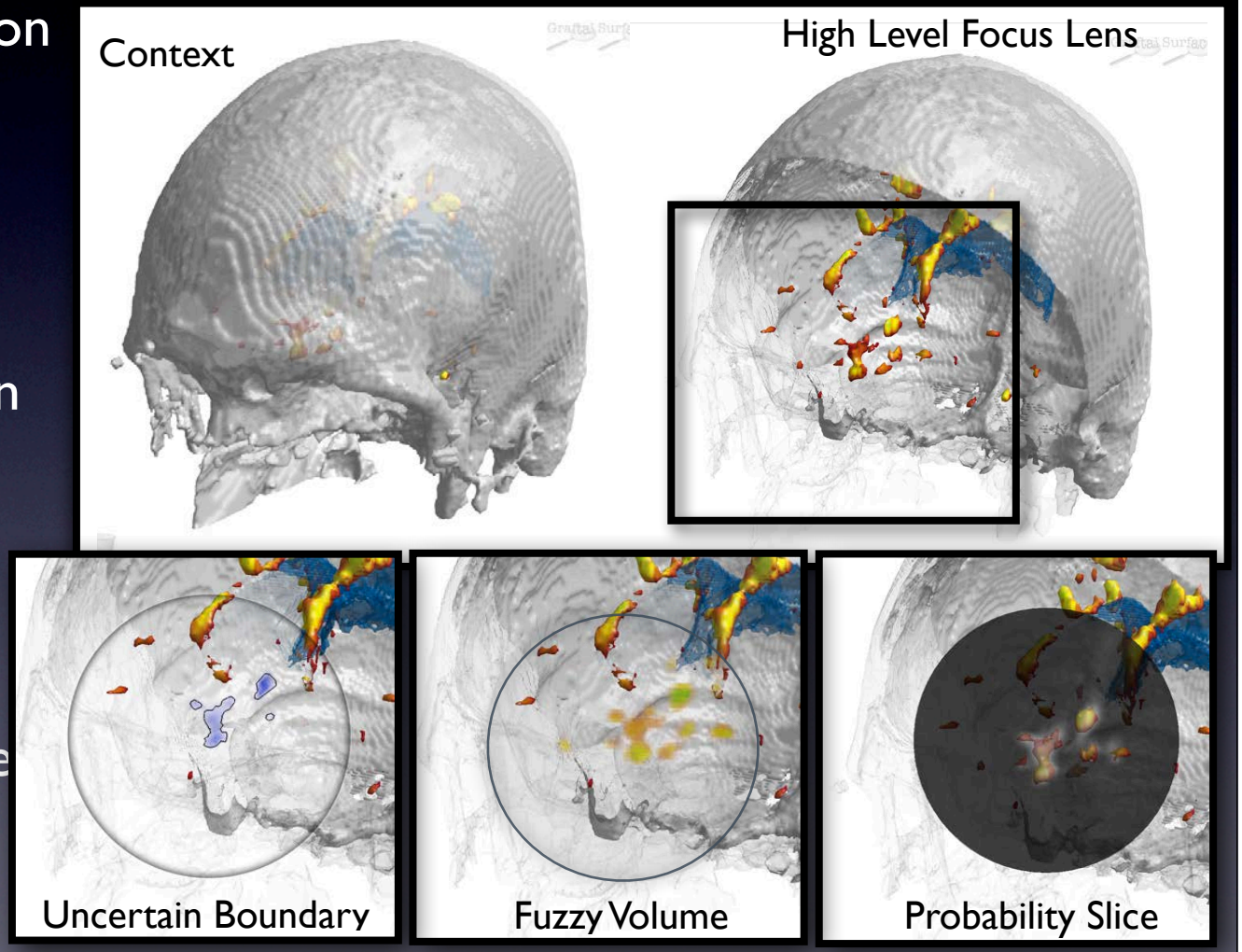
Visualizing Uncertainty



Fuzzy Sensitivity Confidence

QuizLens: A Multi-lens approach for uncertainty exploration

- Global information important for qualitative evaluation & context
- Local information necessary for quantitative understanding
- Interchangeable lenses to explore various data characteristics



The SCI Institute

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Productivity Machines

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Acknowledgements

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DOE SciDAC and NETL
NSF
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KAUST

More Information

www.sci.utah.edu

crj@sci.utah.edu