



U.S. DEPARTMENT OF
ENERGY



**UNIVERSITY OF
CALIFORNIA**



BERKELEY LAB

Bringing Science Solutions to the World



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High Dimensional Visualization

E. Wes Bethel, LBNL

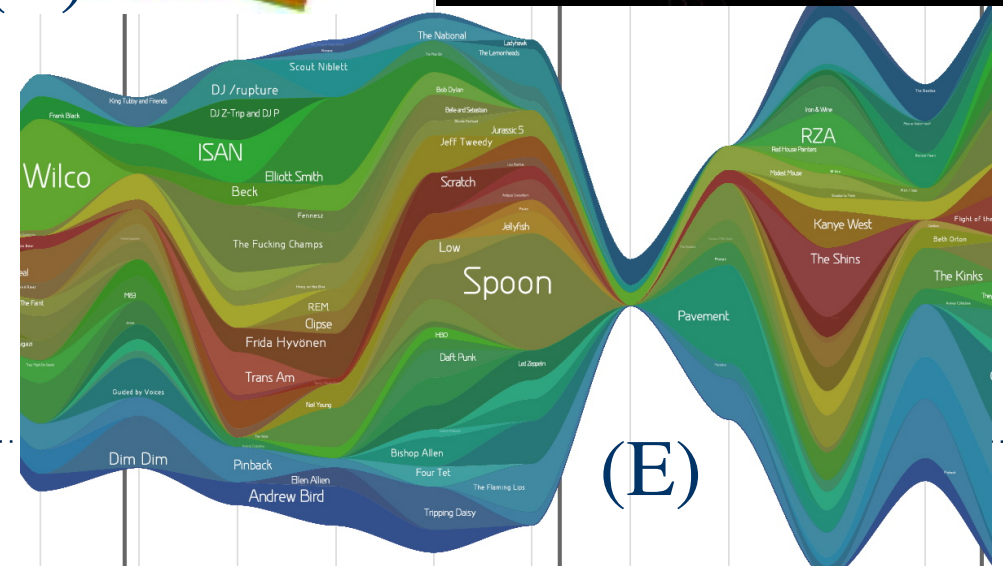
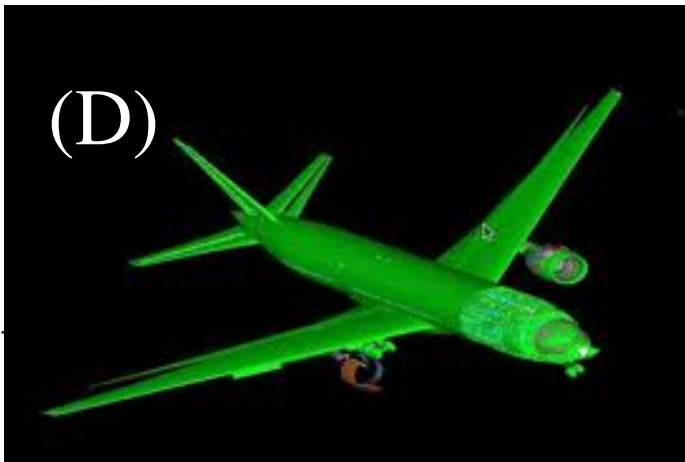
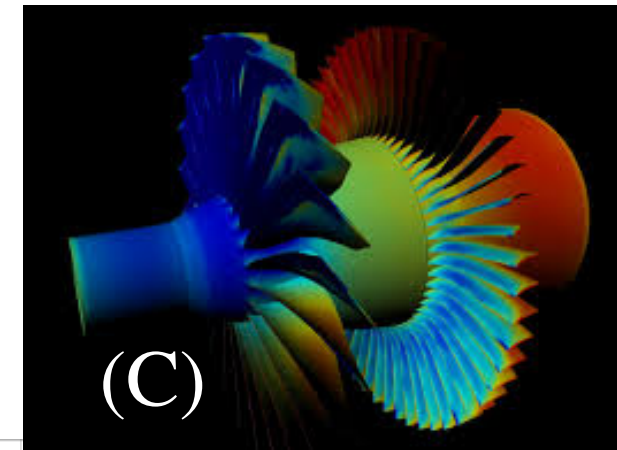
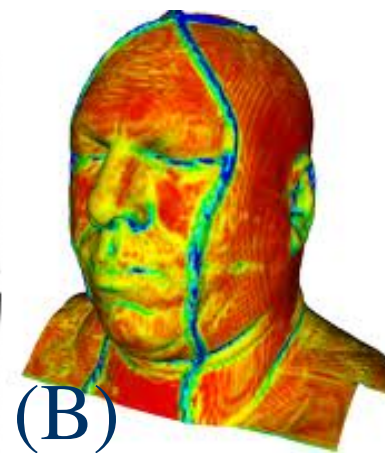
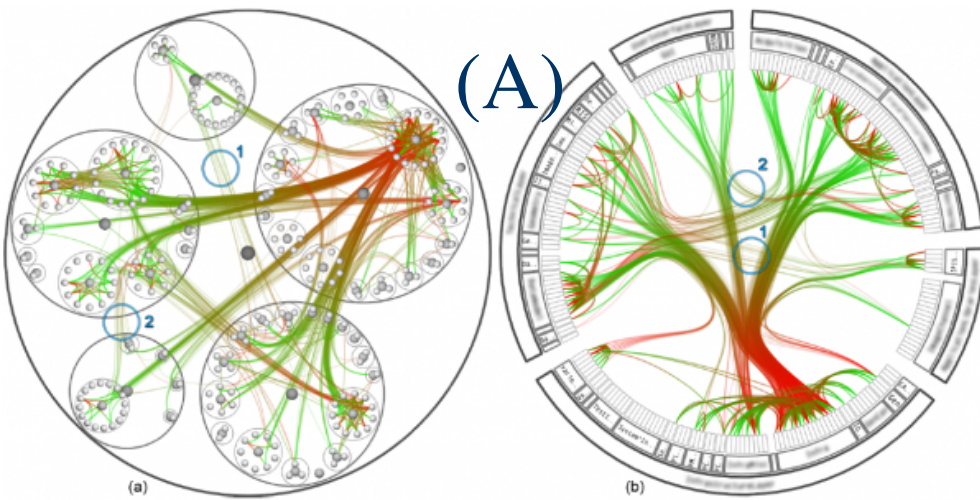
Machine Learning for Jet Physics

11 Dec 2017

Berkeley, CA, USA

SciVis vs InfoVis

“it’s infovis when the spatial representation is chosen, and it’s scivis when the spatial representation is given”

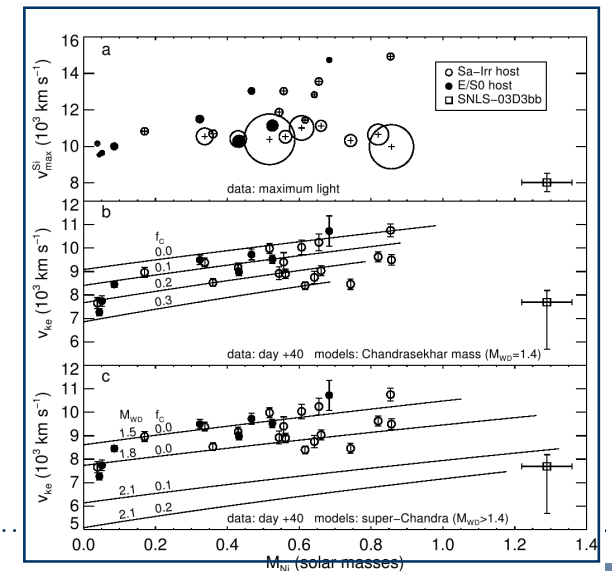
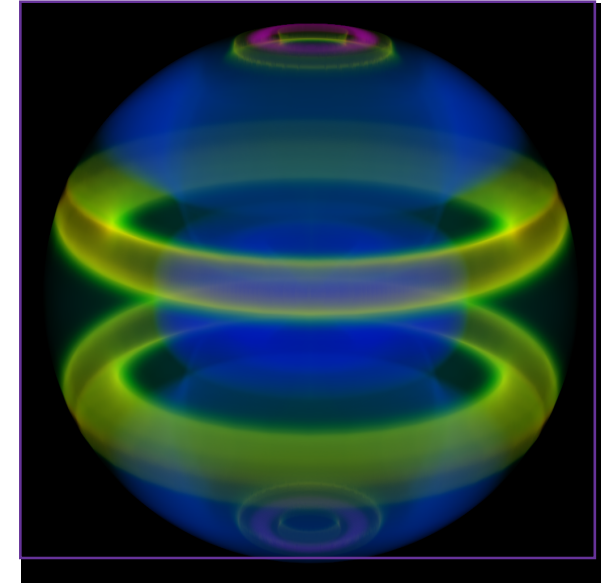


3 Primary Uses of Visualization

Analytical – you know what you’re looking for

Exploratory – you have no idea what you’re looking for

Presentation – you’ve found something and want to show it to someone else

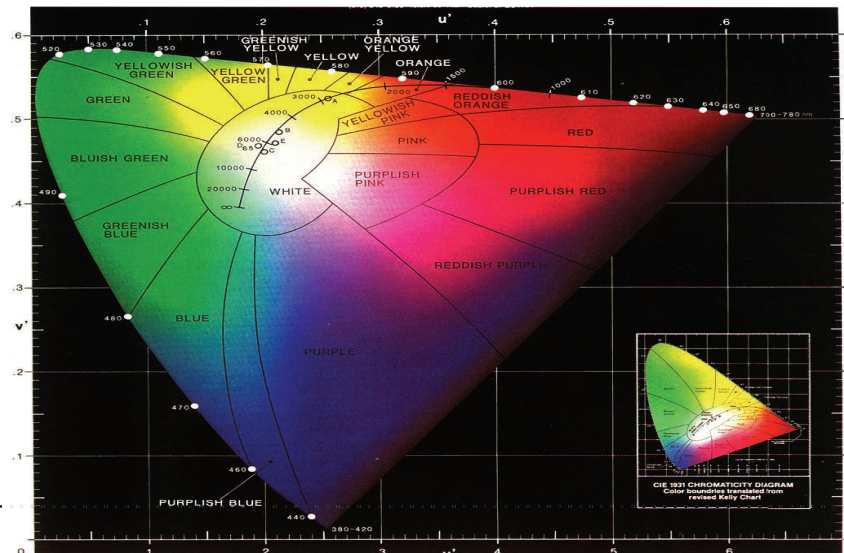


Elements of Visualization

Space – pixels on the screen, conveying information through shape, promixity, and spatial relationships

Time – animations to show temporal evolution

Color

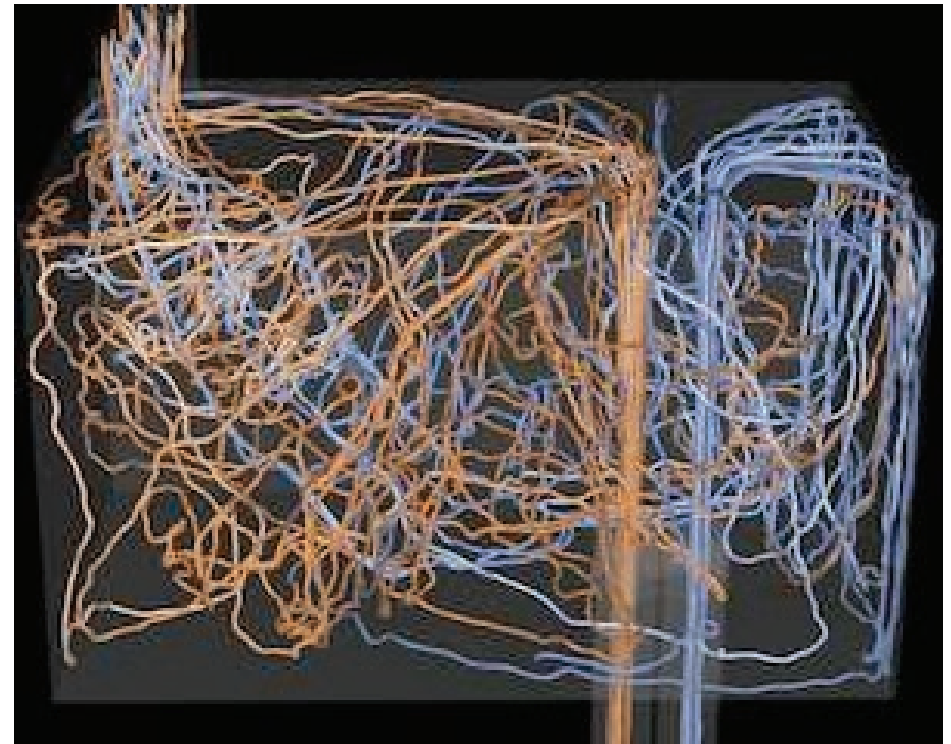
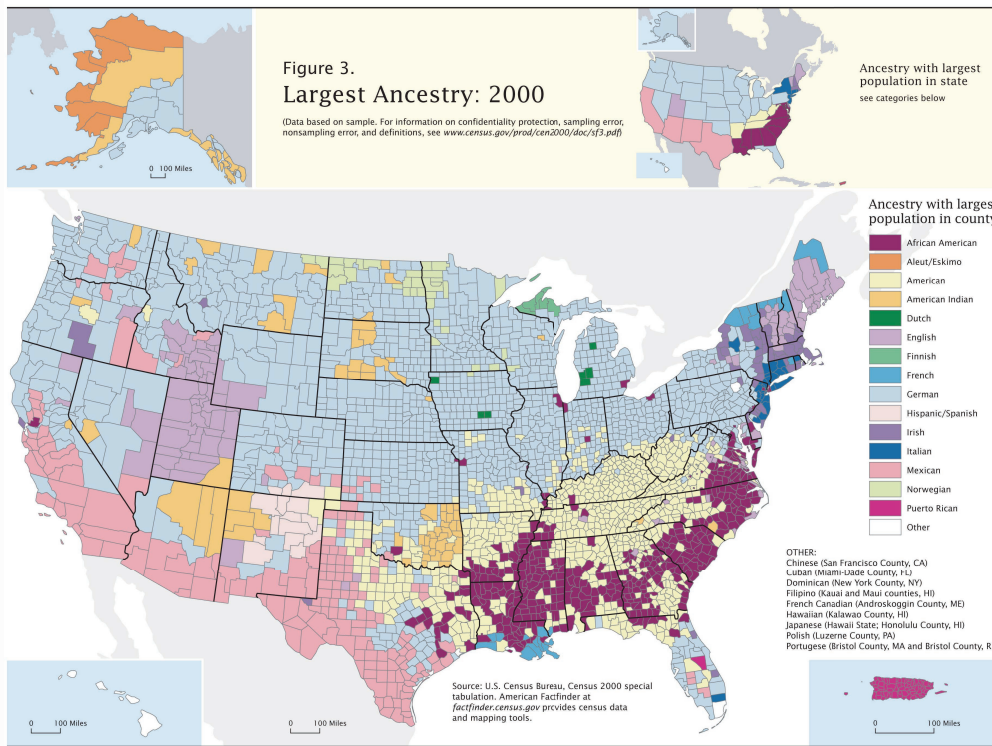


Color



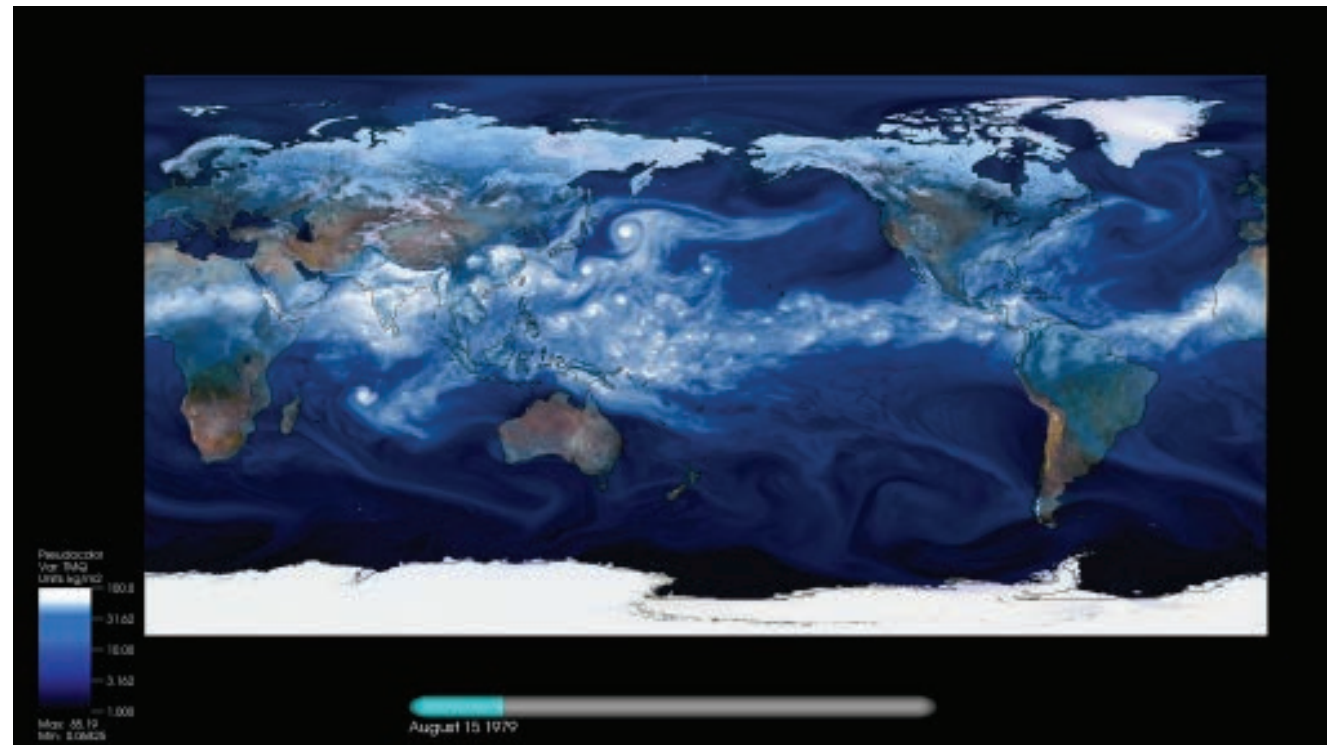
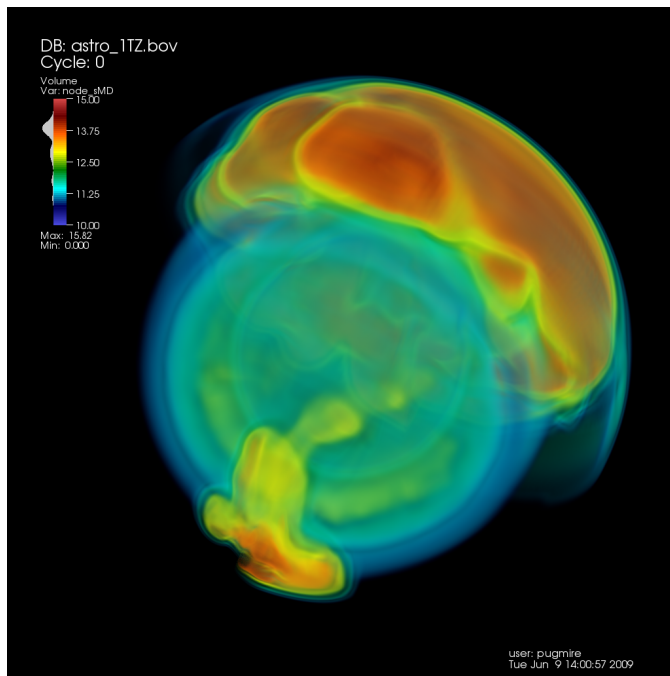
How Color is Used in Visualization

■ Labeling, set membership



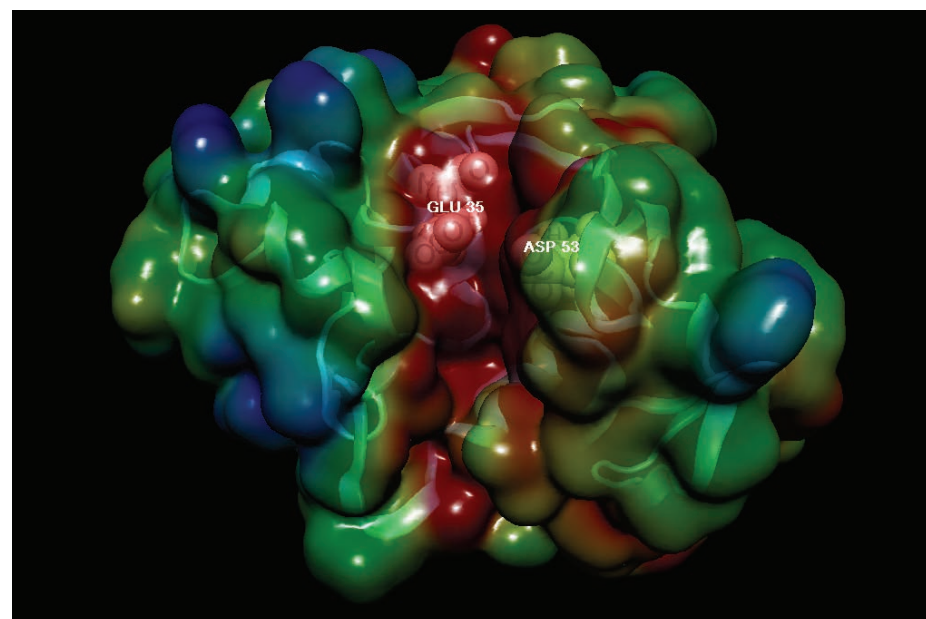
How Color is Used in Visualization

- Indication of measurement



How Color is Used in Visualization

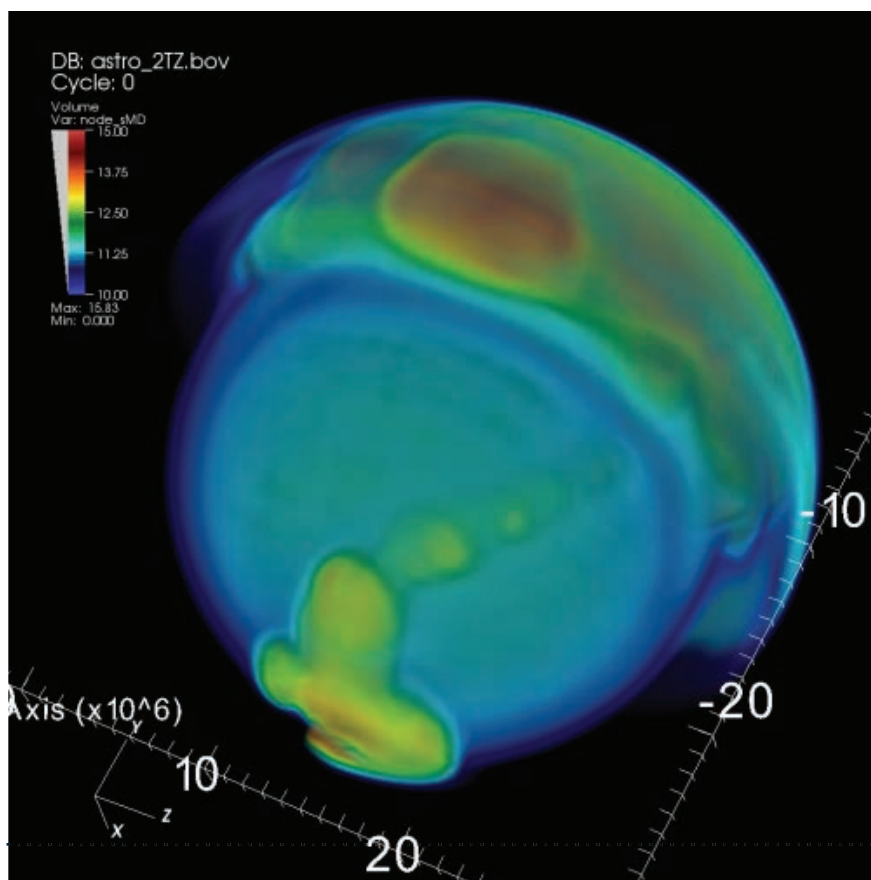
- To enliven, or decorate



Transfer Functions

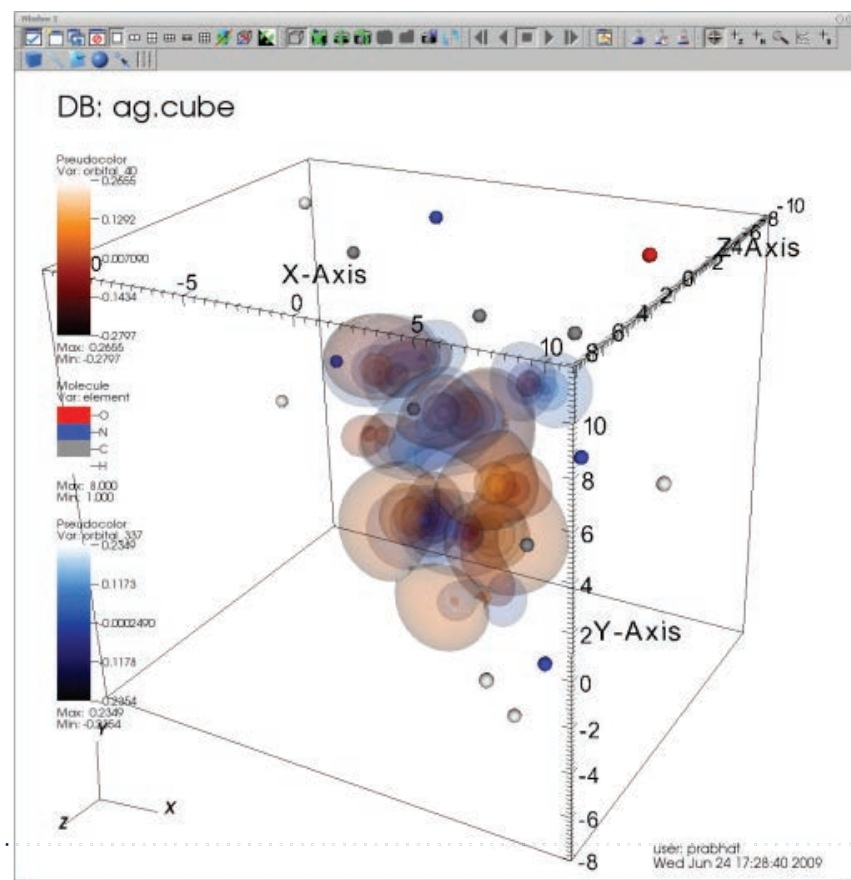
1D

color = f(scalar, map)

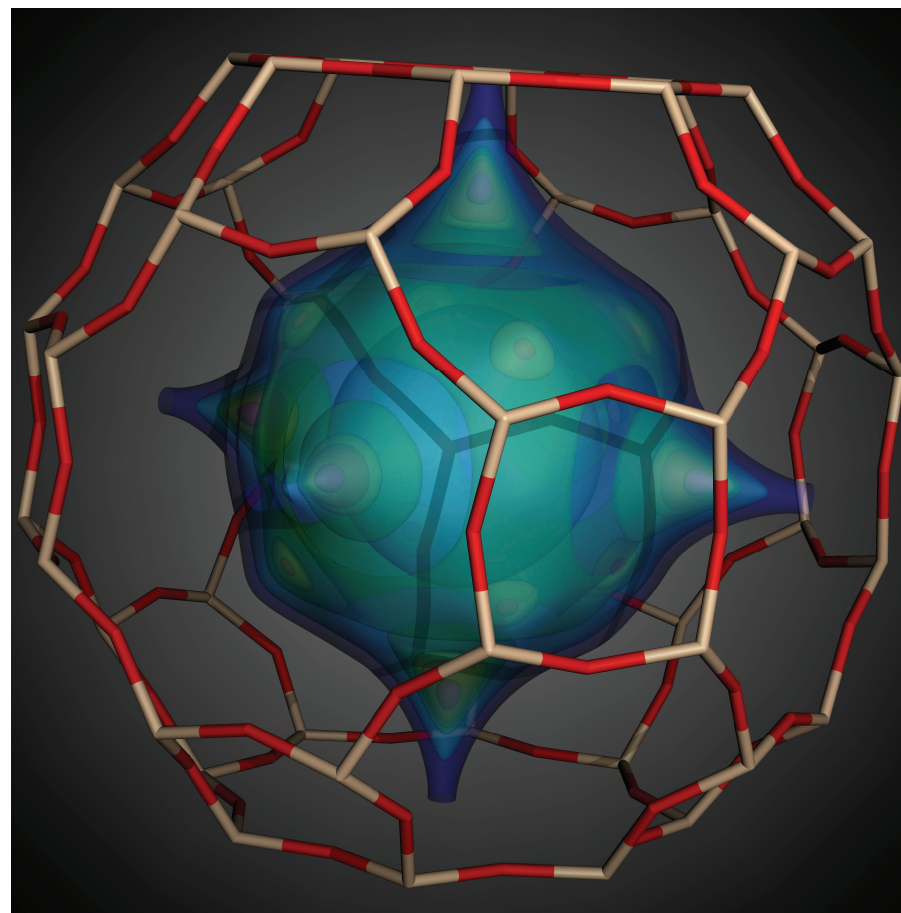
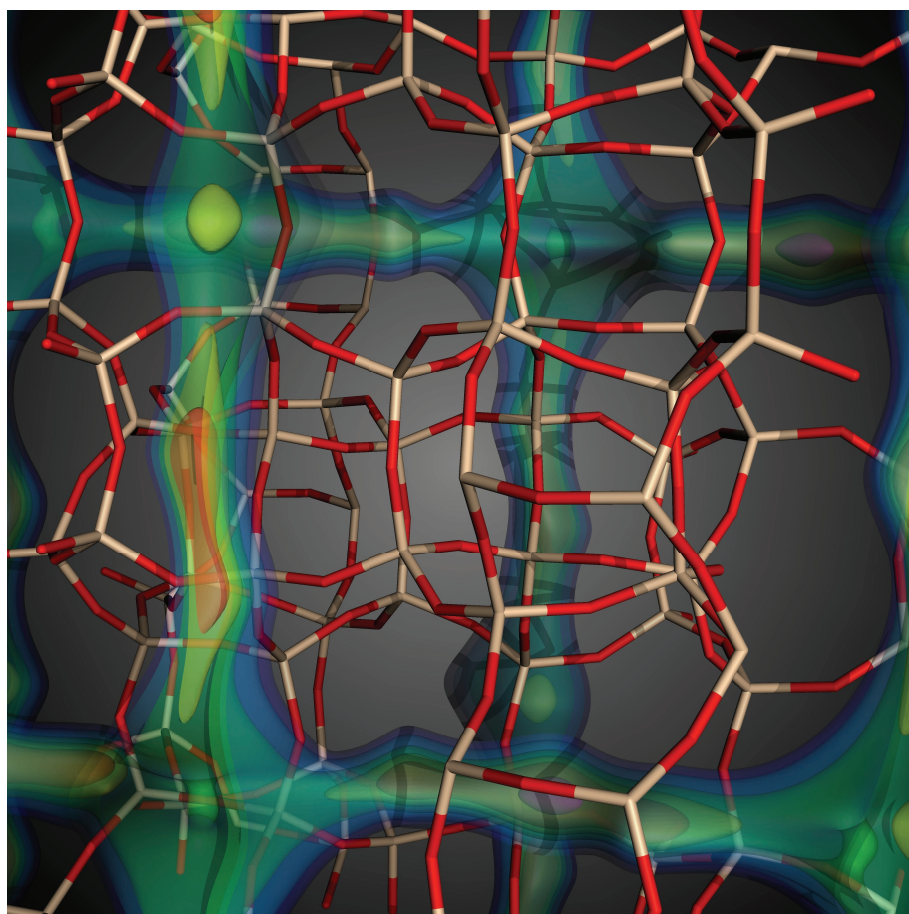


2D

color = f(scalar1, map1, scalar2, map2)



Mixing Metaphors: Color indicating both a label and a measurement

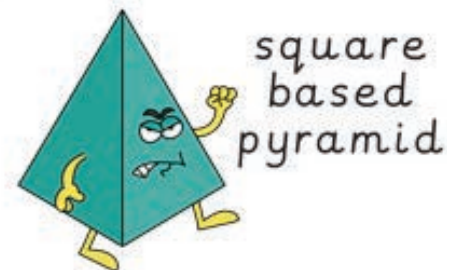
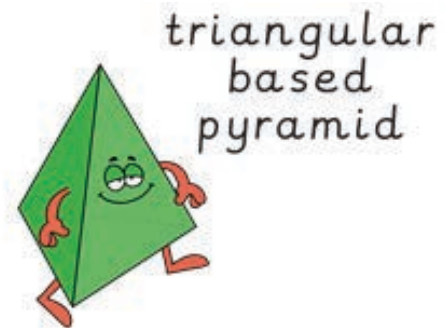
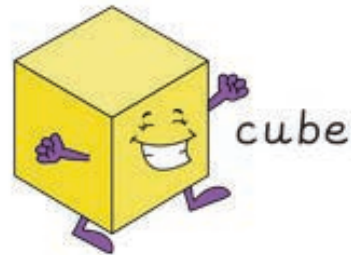


Molecular structure and composition, and energy landscape.

Image courtesy Richard L. Martin (LBNL).

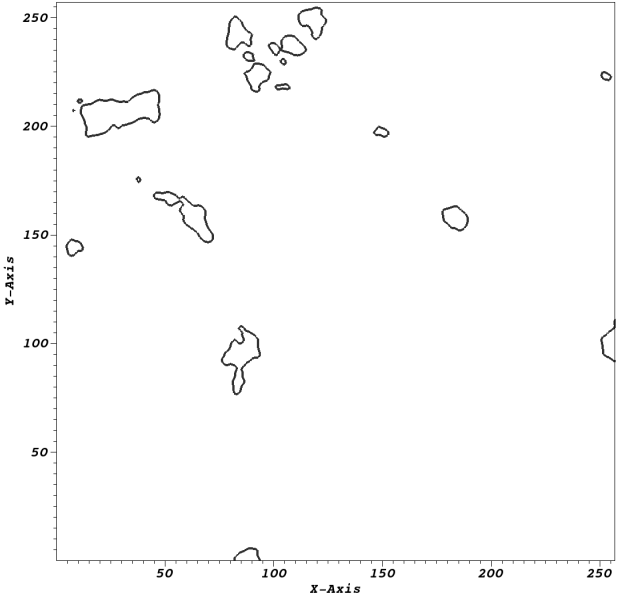
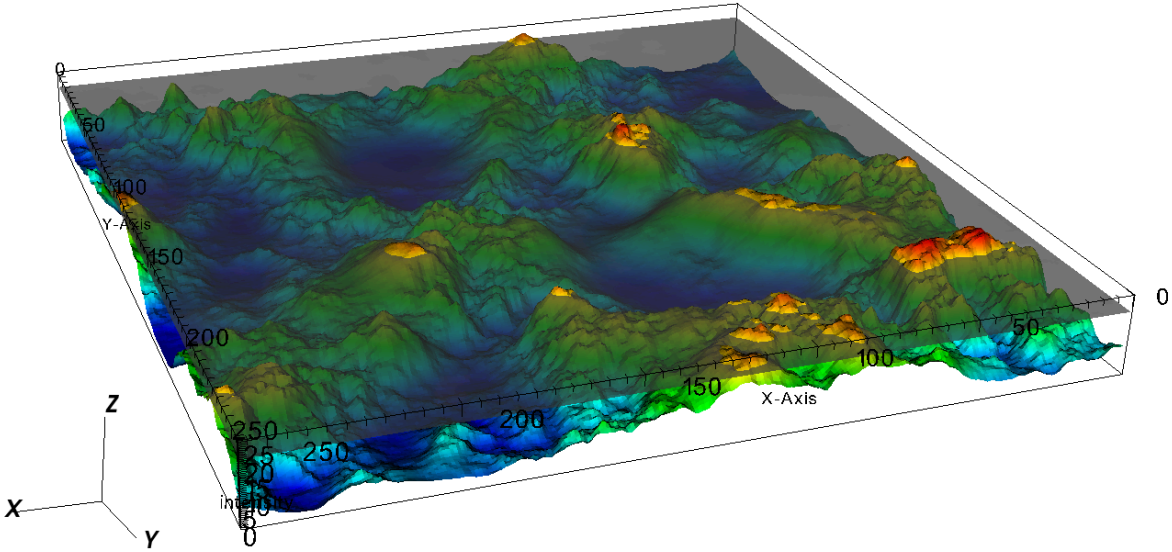
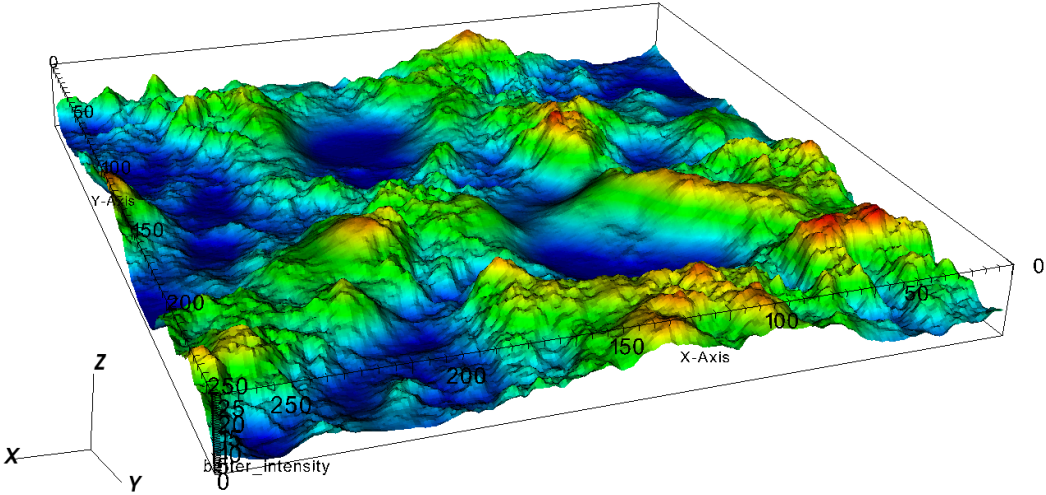
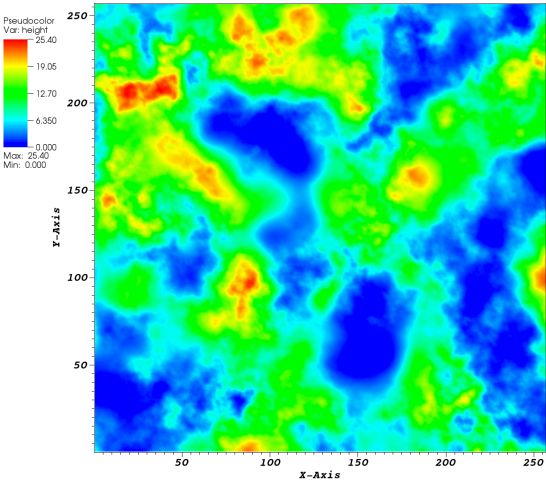
Space

3D Shape Word Mat



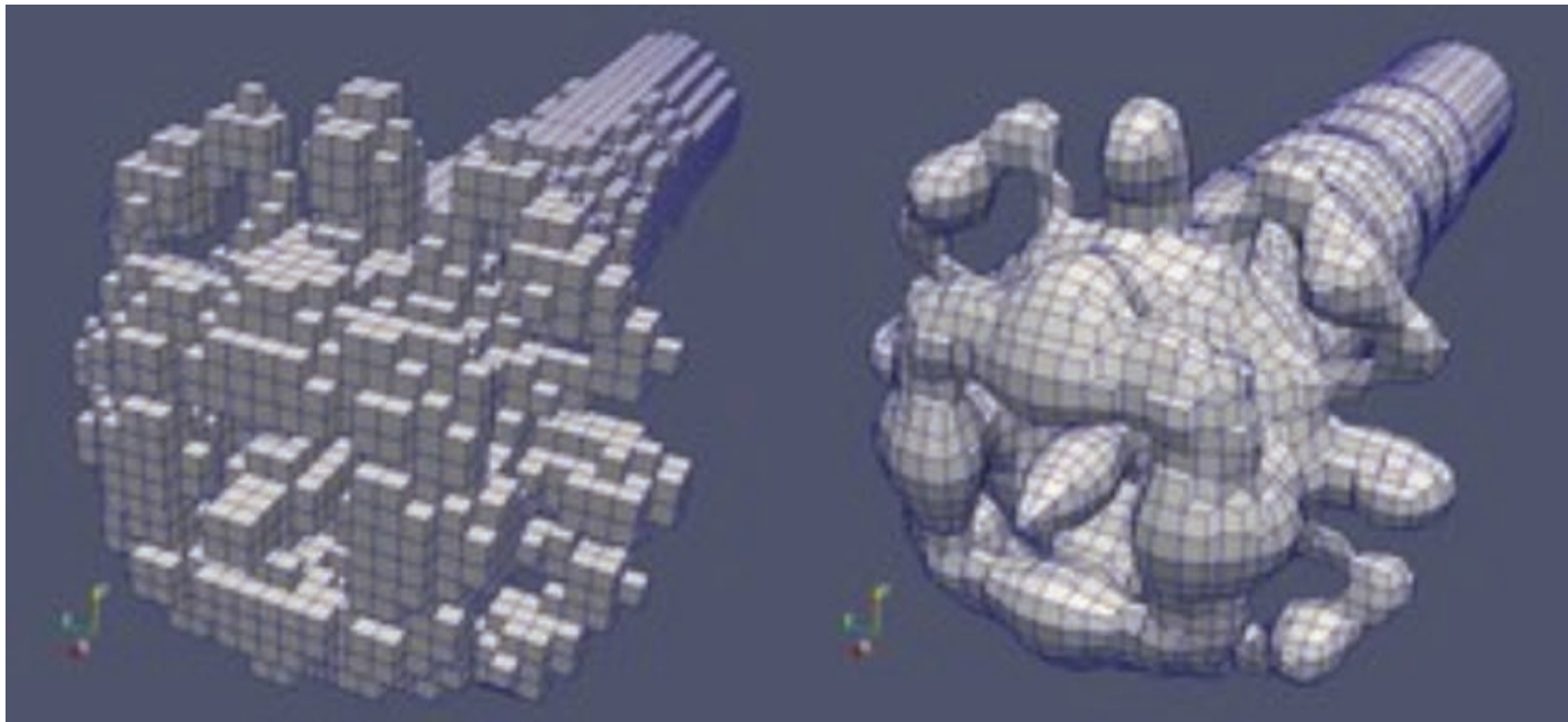
 ©Teacher's Pet 2014 www.tpet.co.uk

Contours in 2D



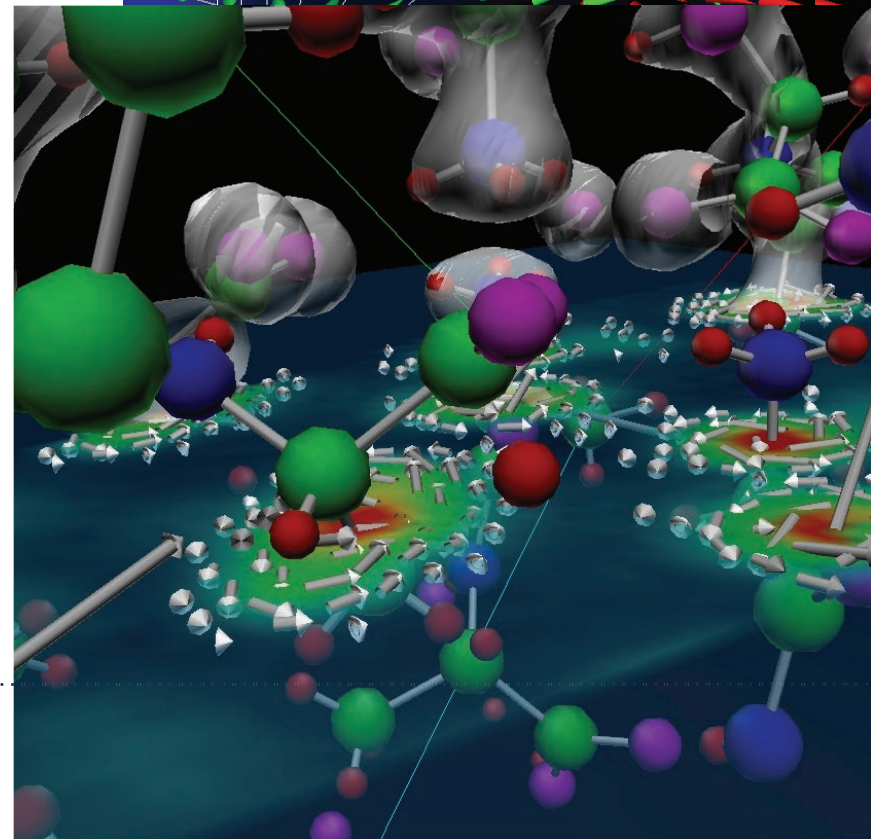
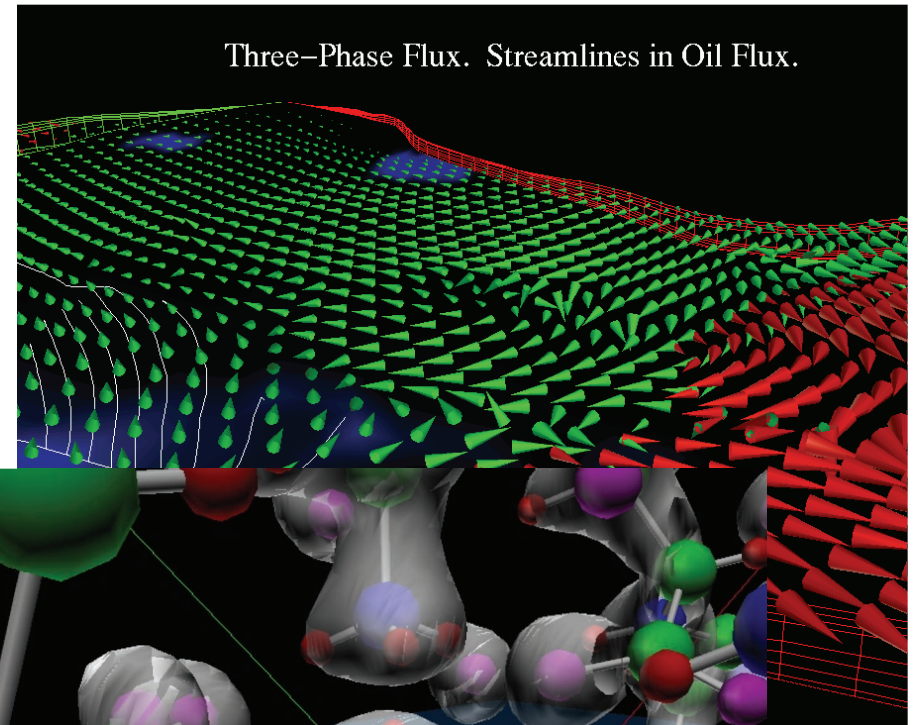
Contours in 3D

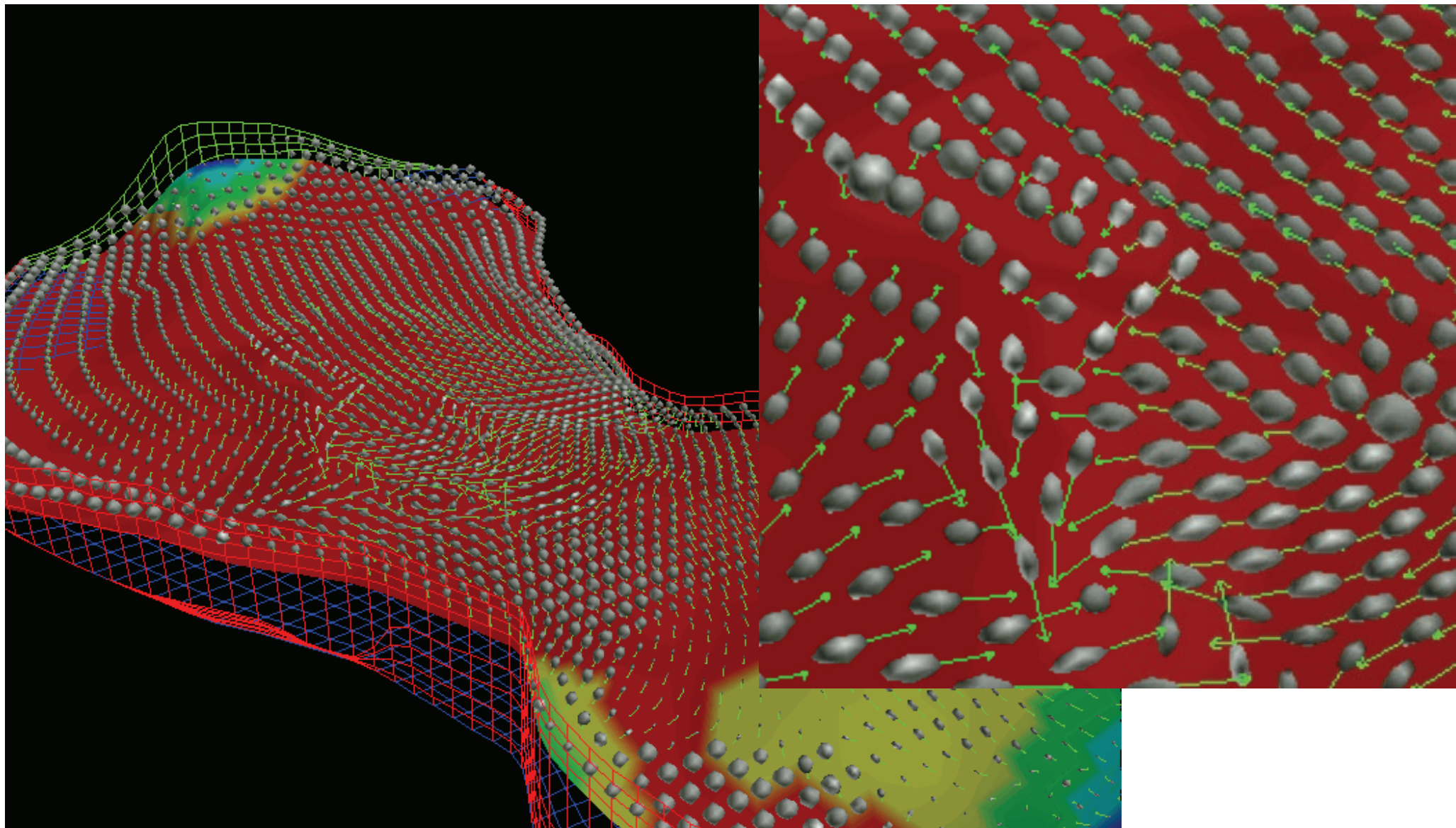
- Cuberille: can give the appearance of a contour
- Isosurface: is a contour surface



Vector Fields: Glyph-based methods

- Basic idea:
 - Foreach grid point, draw a glyph that indicates something about the vector field.
- Good for:
 - Small datasets
 - Well-behaved data





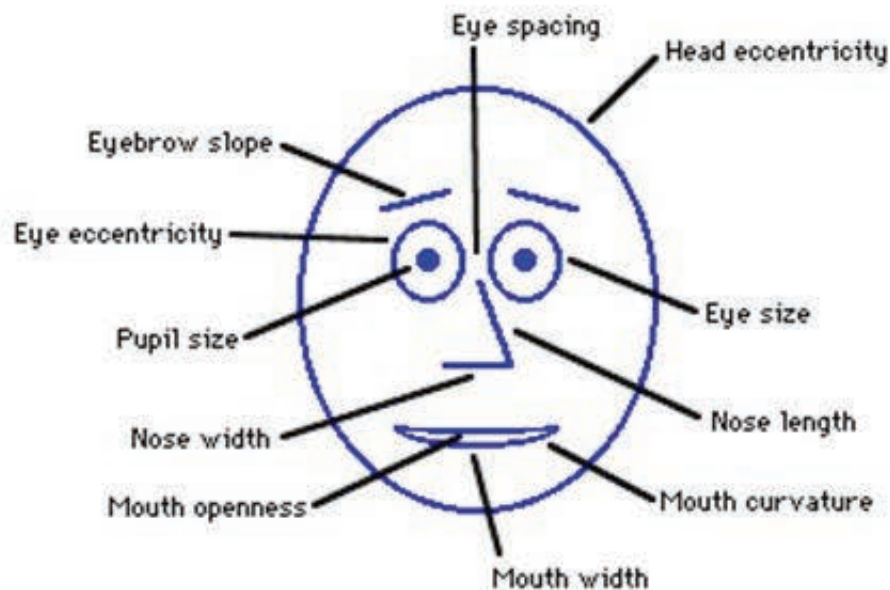
3 spatial dimensions, false-colored slice of V1

At each grid point:

- vector field direction/magnitude of V2 (x,y,z)
- Ellipsoid: R1=V3, R2=V4, orientation is V5 (x,y,z)

Chernoff Faces

Encode different variables' values in characteristics of human face



Chernoff-Faces [Che 73, Tuf 83]

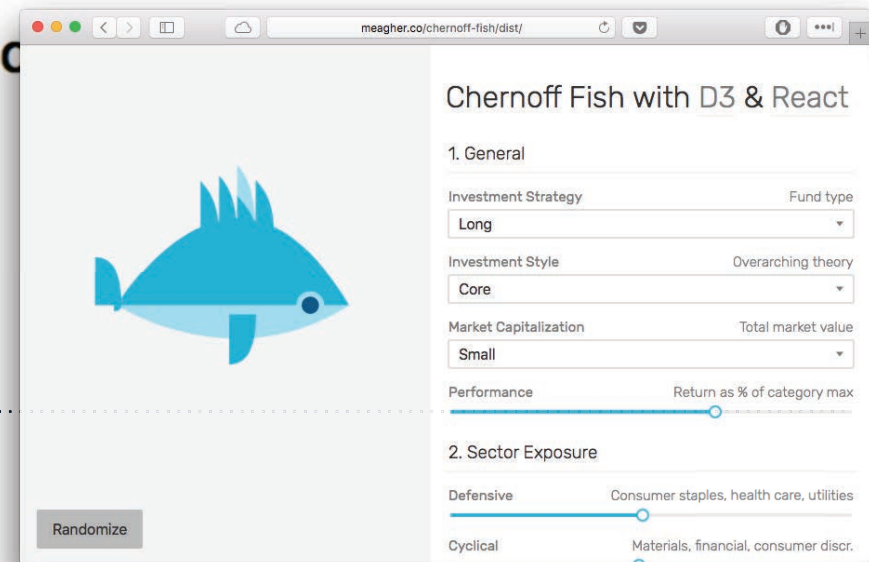
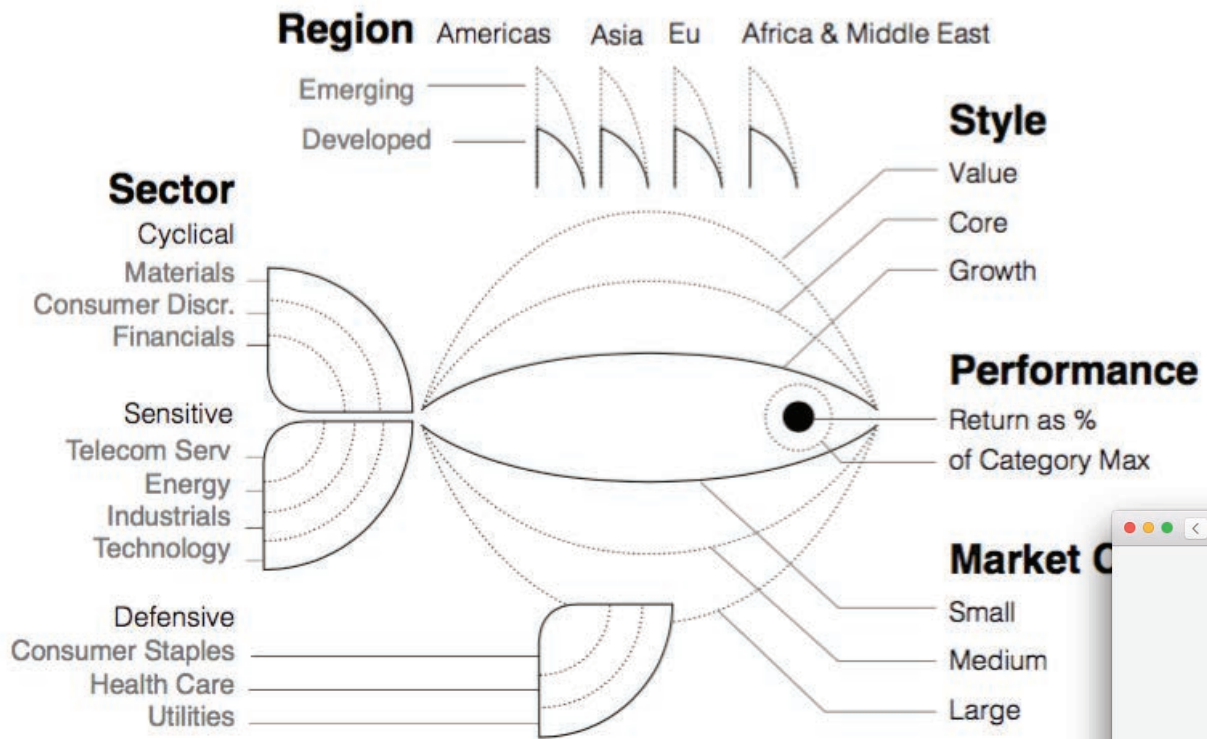


Fun applets: <http://www.cs.uchicago.edu/~wiseman/chernoff/>
<http://hesketh.com/schampeo/projects/Faces/chernoff.html>

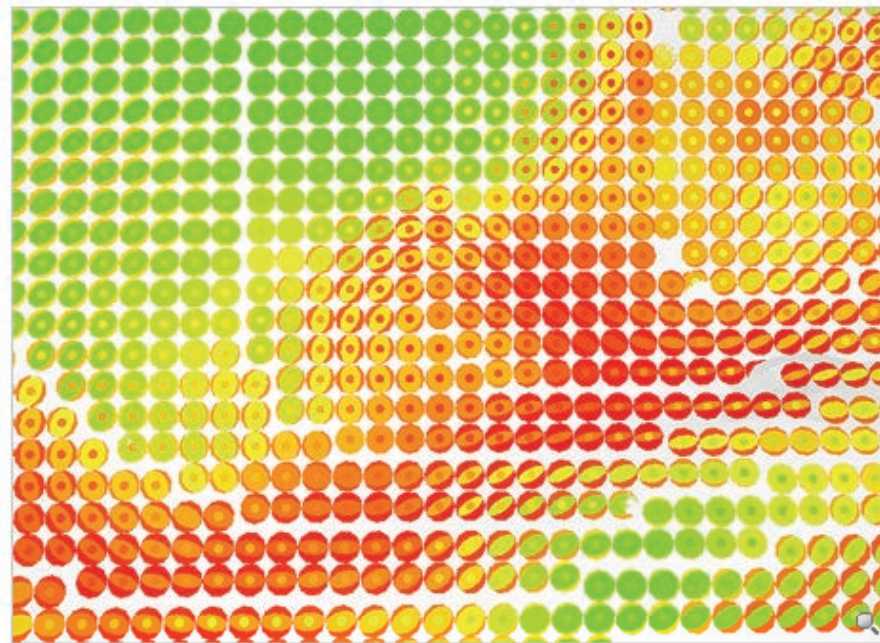
Chernoff "Fishes"

Fund Characteristics Legend

Detailed Sector Information



More Glyph-based Visualization



Correlation Visualization for Structural Uncertainty Analysis

T. Pfaffelmoser, R. Westermann, *International Journal of Uncertainty Quantification IJUQ* Pfaffelmoser, 2013.

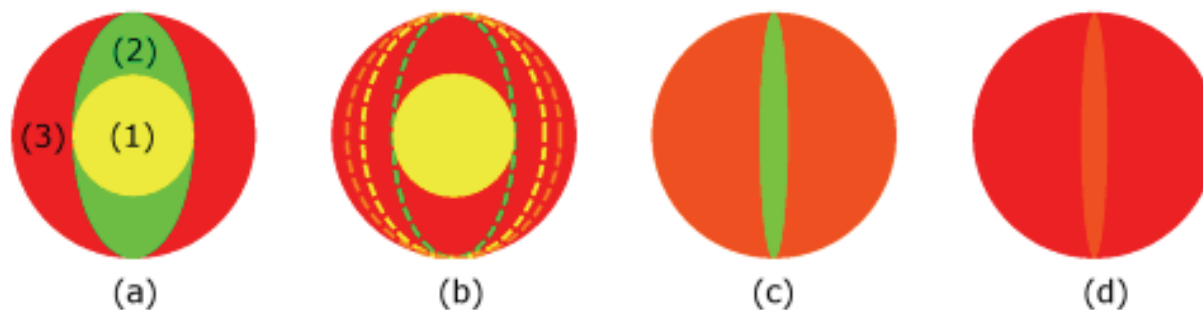
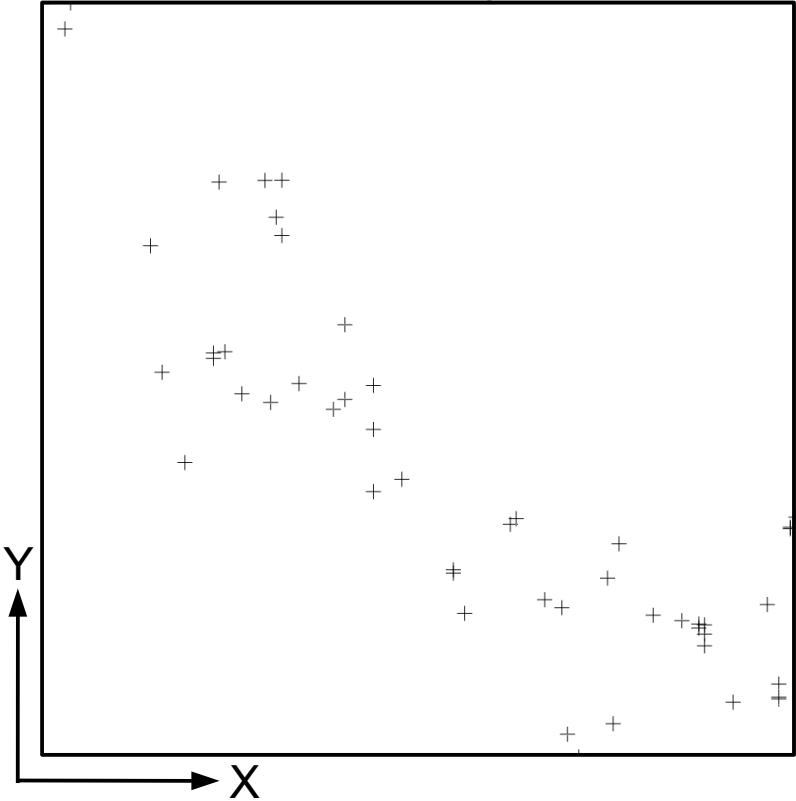


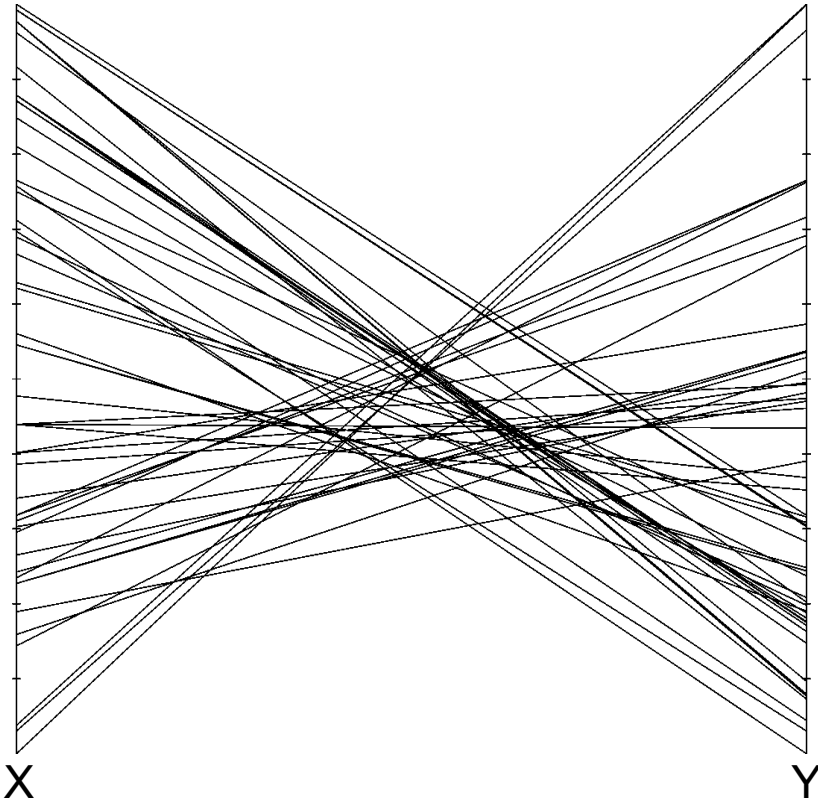
FIG. 5: In (a) the used correlation glyph is shown. Absolute correlation strengths are mapped from $[0, 1]$ to $[\text{red} \rightarrow \text{green}]$ for surface normal (1), first (2) and second (3) principal tangential correlation directions in three zones. (b) Geometry of zone (2) visualizes the correlation ratio between the two tangential direction. (c) Glyph for high contrast tangential correlation values 0.9 (2) and 0.1 (3) is shown. (d) Glyph for low contrast tangential correlation values 0.09 (2) and 0.01 (3) is shown.

Parallel Coordinates Plots

2D Scatter-plot

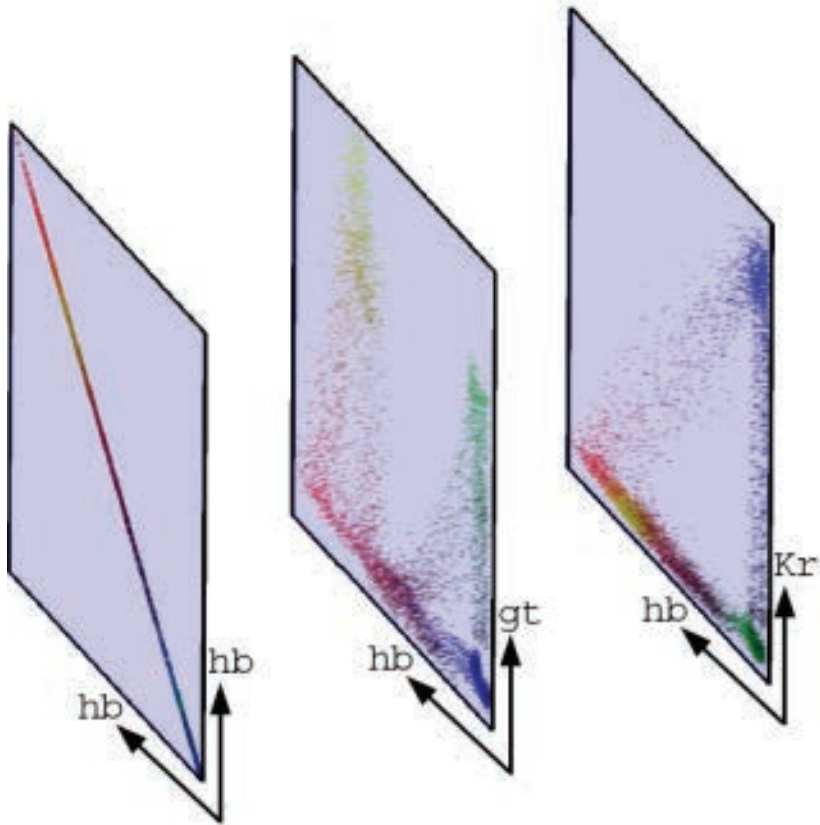


Parallel Coordinates



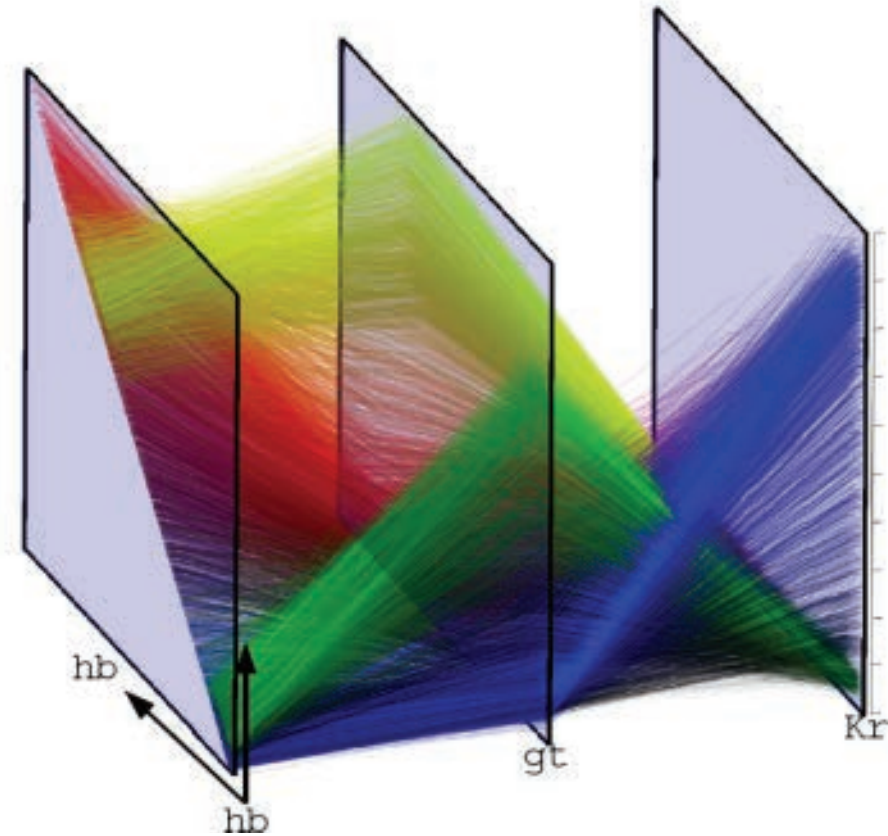
Parallel Coordinates Plots, ctd.

Series of 2D Scatter-Plots

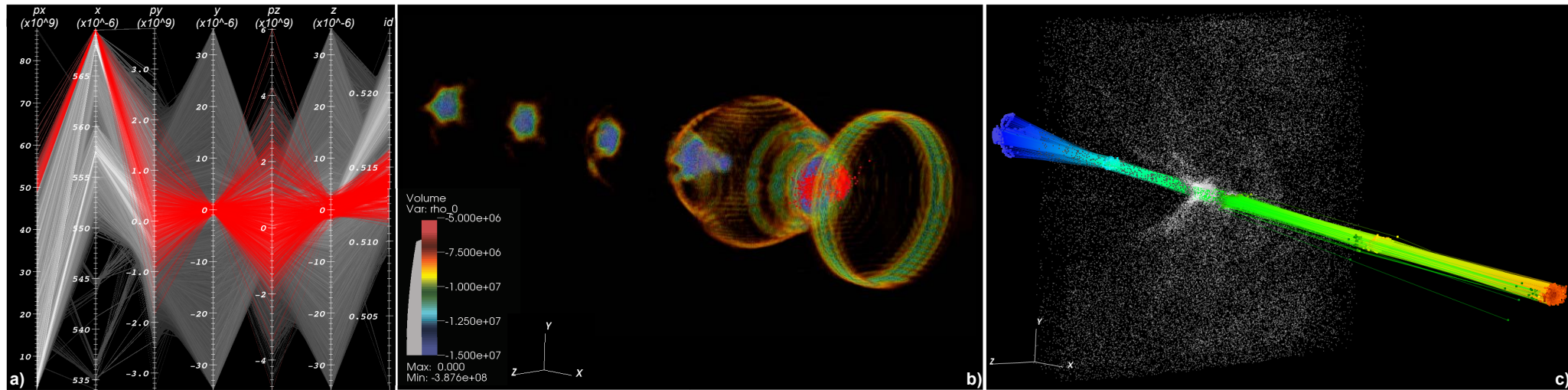


Connect
corresponding
points

3D Parallel Coordinates



Parallel Coordinates Interface for Subset Selection – High Energy Particles in LWFA



3D example. High velocity bunch selected (left), shown in 3D context (middle). All particles of that bunch traced over time (right), color shows increasing acceleration along trace.

Rübel et al., 2008. High Performance Multivariate Visual Data Exploration for Extremely Large Data. Supercomputing 2008.

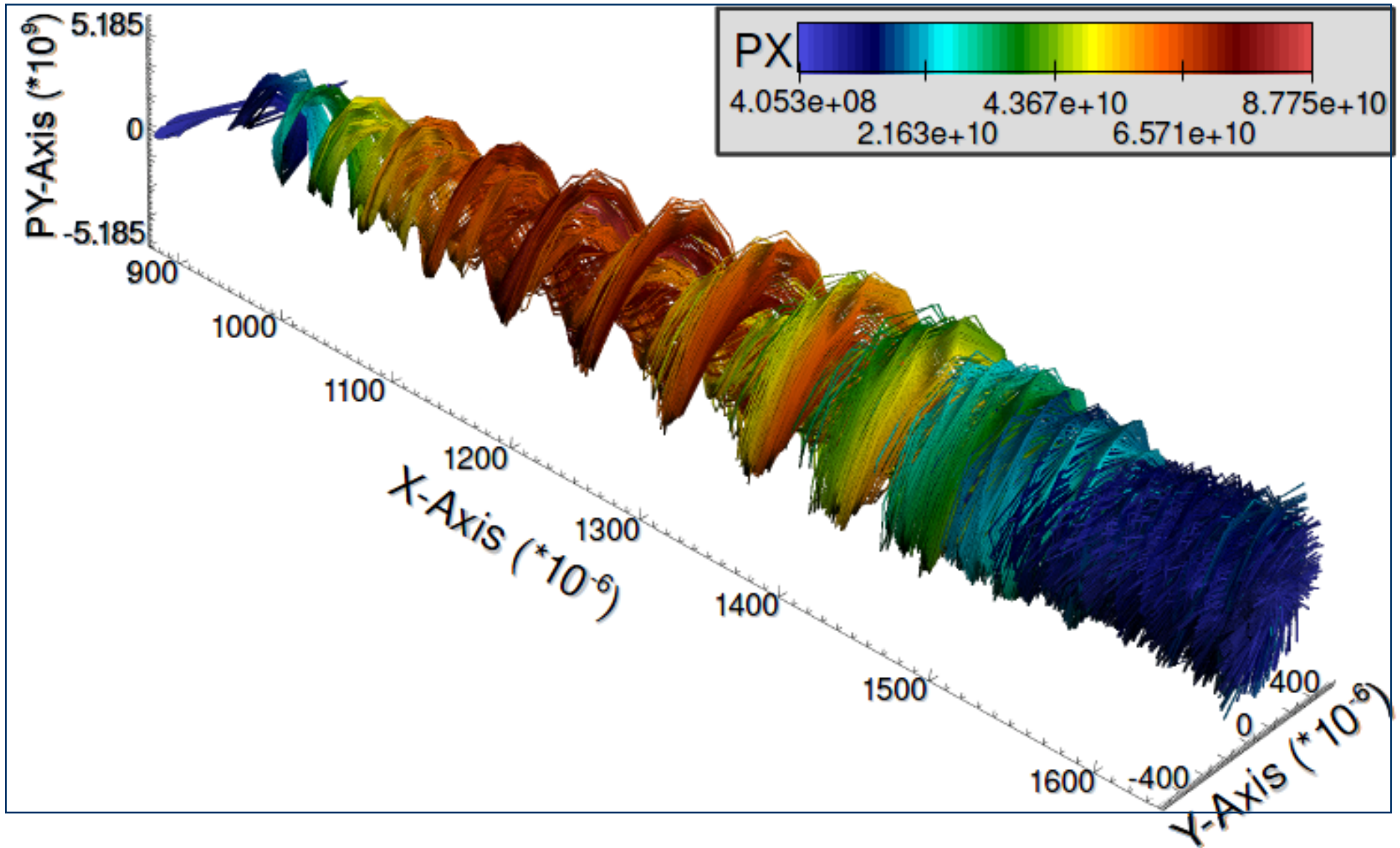
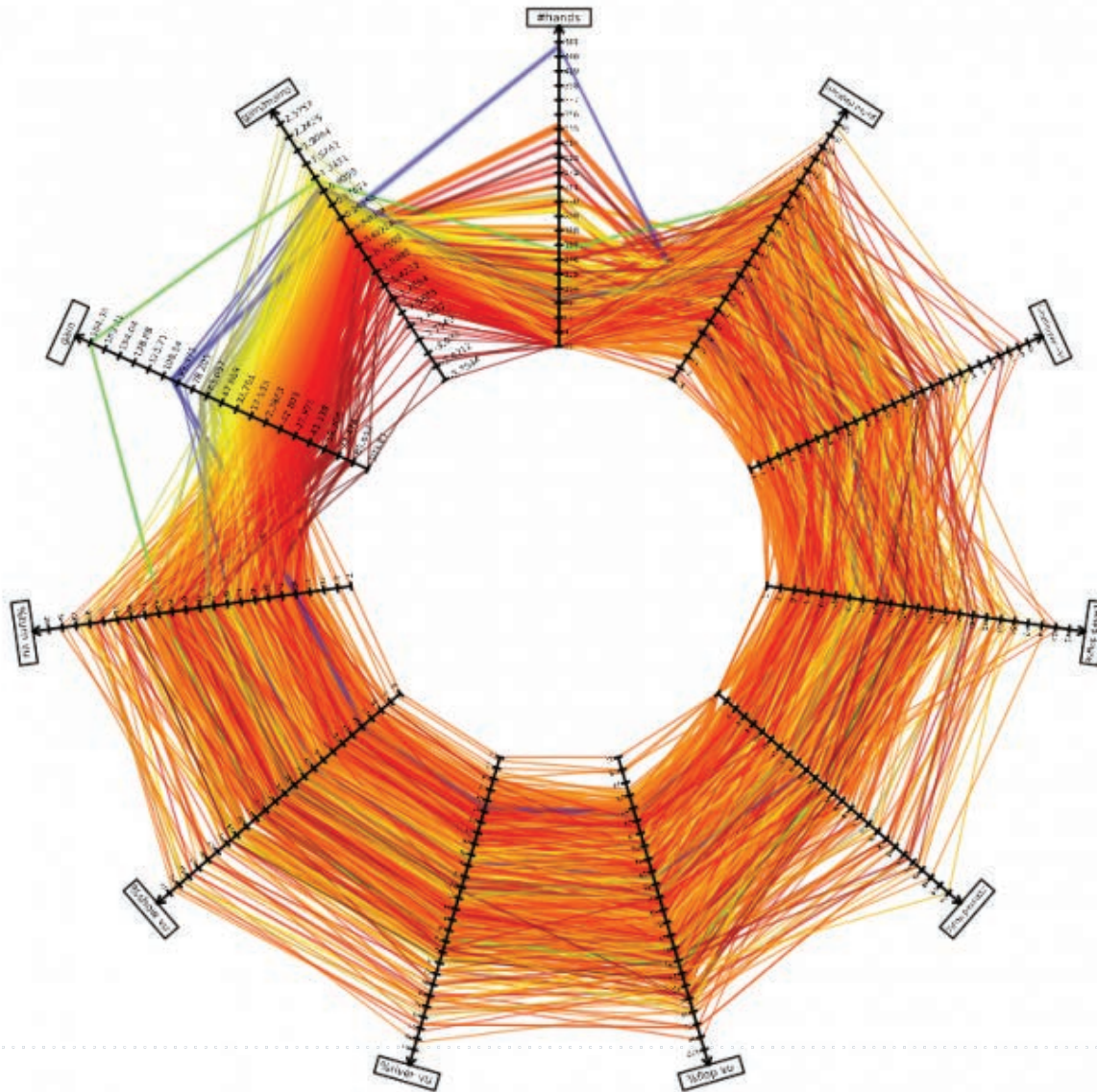


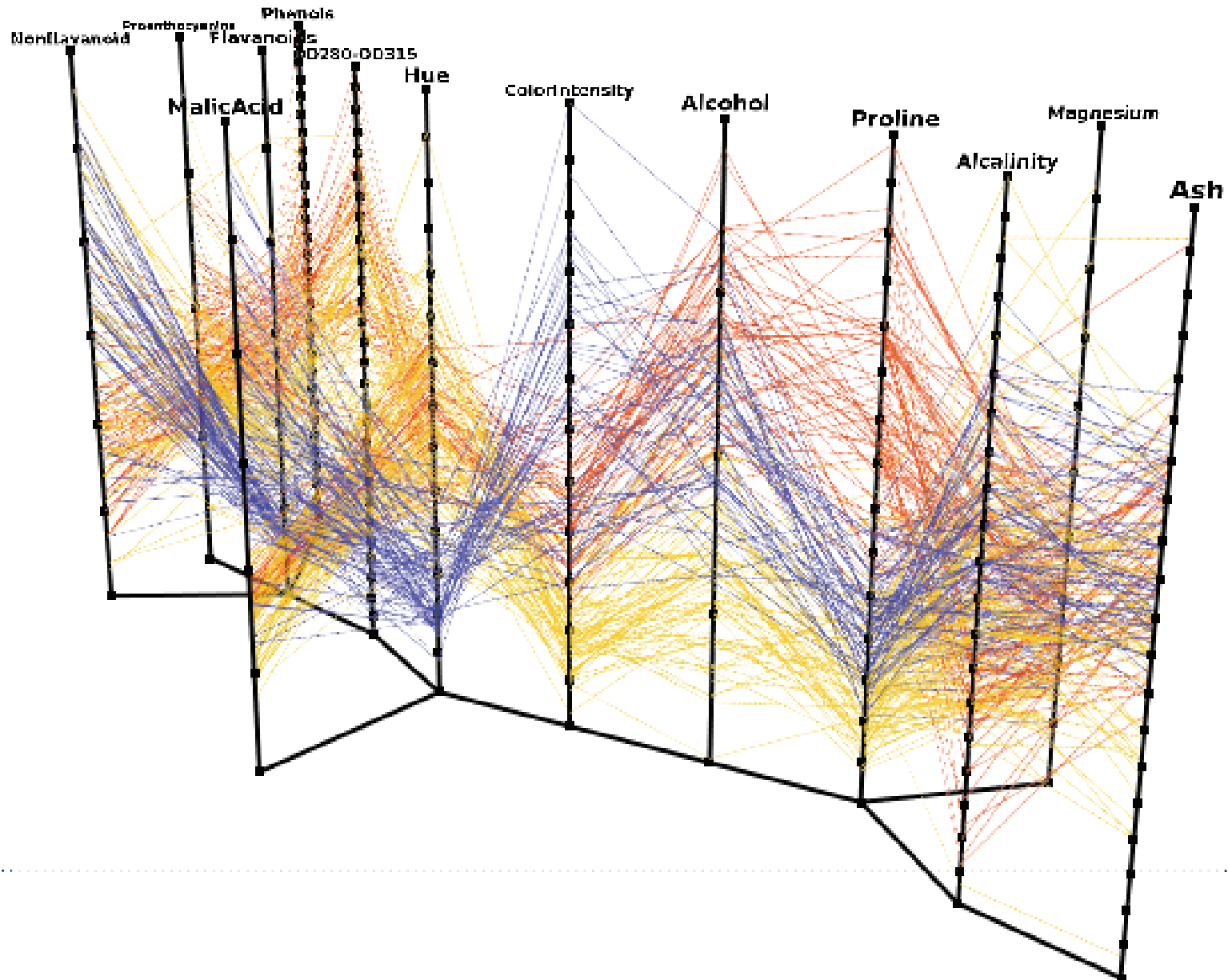
Image courtesy: O. Ruebel, C. Geddes (LBNL)

O. Ruebel, et al., "High Performance Multivariate Visual Data Exploration for Extremely Large Data." SC08, Austin TX, November, 2008. LBNL-716E

Parallel Coordinates Plots: Radial Layout



Parallel Coordinates: 3D Partition

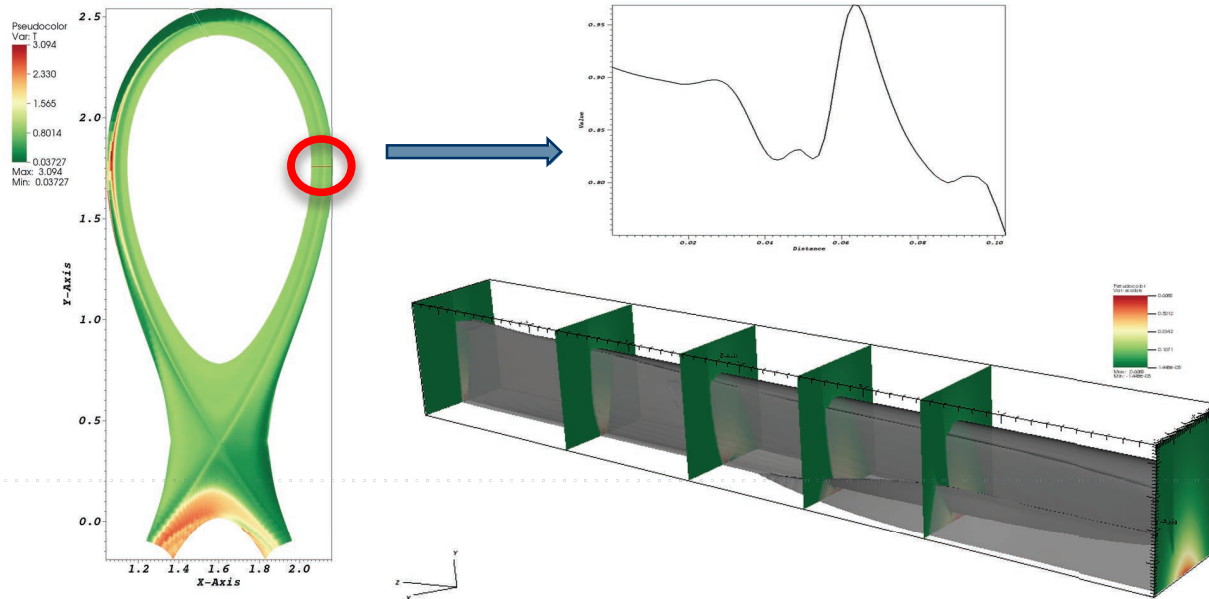
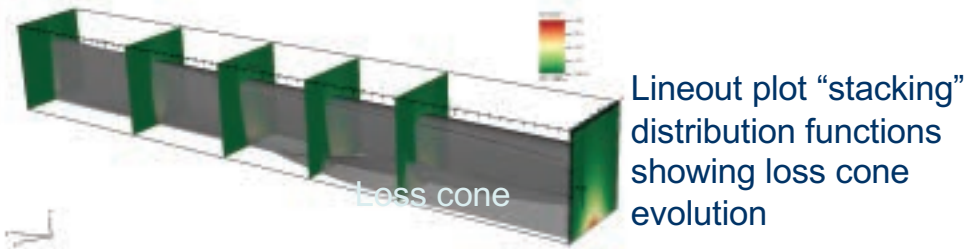
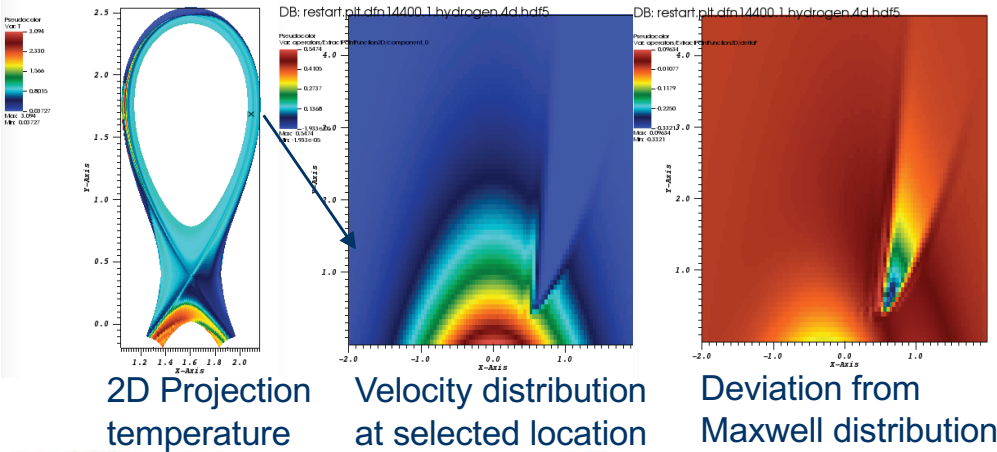


Visualization of Simulations in 4D Phase Space (COGENT/Chombo)

G.H. Weber, B. Van Straalen

Approach & Progress

- Develop new visualization methods for 4D/6D phase space based on
 - Derived fields (bulk/random velocity, temperature, similarity to distribution) to project to 2D/3D
 - Multiple coordinated views/brushing & linking to explore 4D/6D phase space
 - Glyphs showing velocity distribution
- Distributed prototype implementation to code development teams as part of VisIt distribution
 - Ability to read one level 4D Chombo files
 - Projection to 2D/3D and extract distribution functions
 - Brushing & linking via VisIt Python macros



Humpback Whale Swim Path

Encoding temporal data in a spatial format

