

WorldWide Telescope

Microsoft
Research

The Art of Numbers Data Visualization in the 21st Century



The Art of Numbers

Empirical and Mathematical Reasoning 19. The Art of Numbers: The Visual Display of Information

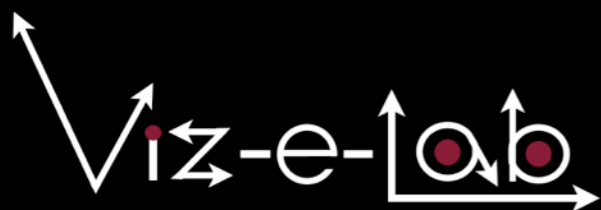
Professor Alyssa A. Goodman (Astronomy)

Course website

Duration: 05:30

*What kind of
credentials are
those??*

Alyssa A. Goodman
Harvard University (HCO+IIC)
Smithsonian Astrophysical Observatory
Scholar-in-Residence, WGBH







IMG_4705



IMG_4661



4268



IMG_4130



IMG_4129



IMG_4128



y fun this was!



IMG_3343



IMG_3343



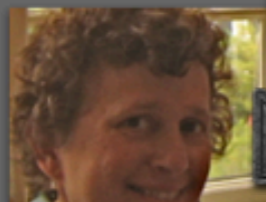
IMG_3338



3251



IMG_3238



View



Confirm Name



Edit



Rotate



Flag



Hide



Slideshow



Book



Calendar



Card



MobileMe



Facebook



Flickr



Email



Set Desktop



iWeb



iDVD





19 out of 22?

Relative Strengths



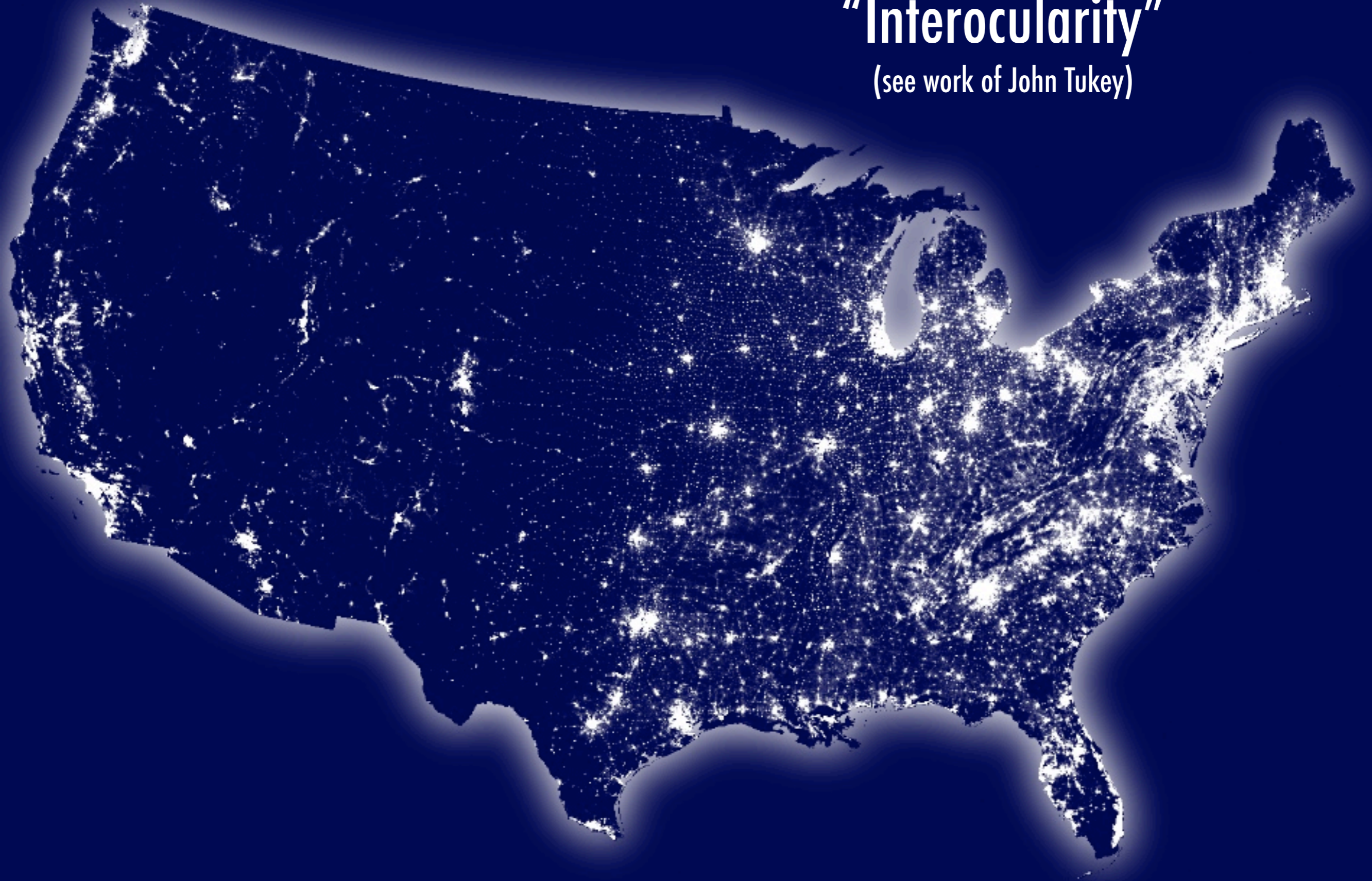
Pattern Recognition
Creativity



Calculations

"Interocularity"

(see work of John Tukey)



What...

...is easier now than before?

fast computation, animation, 3D

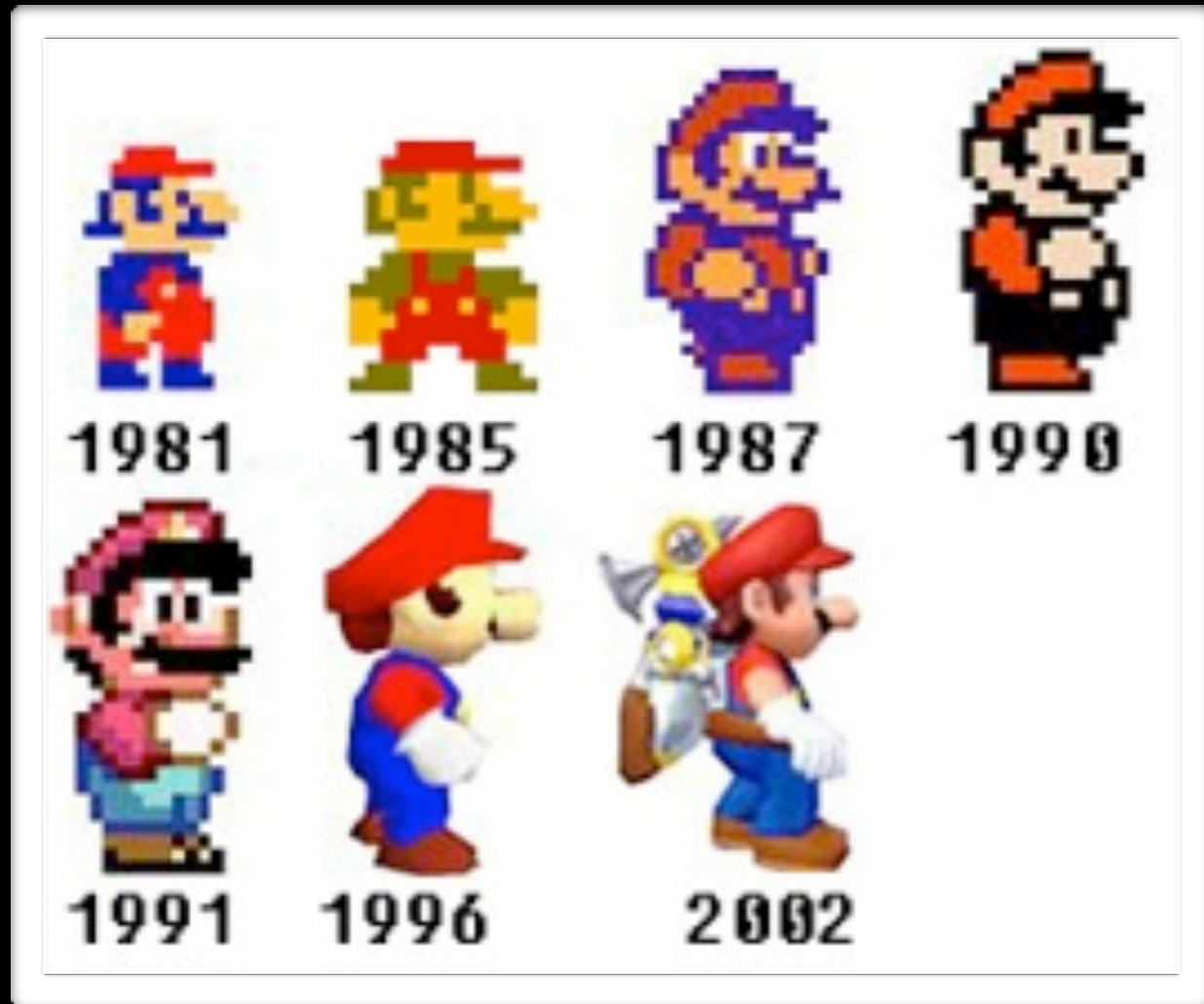
...was easier before than now?

craftsmanship

...should be easier in the future?

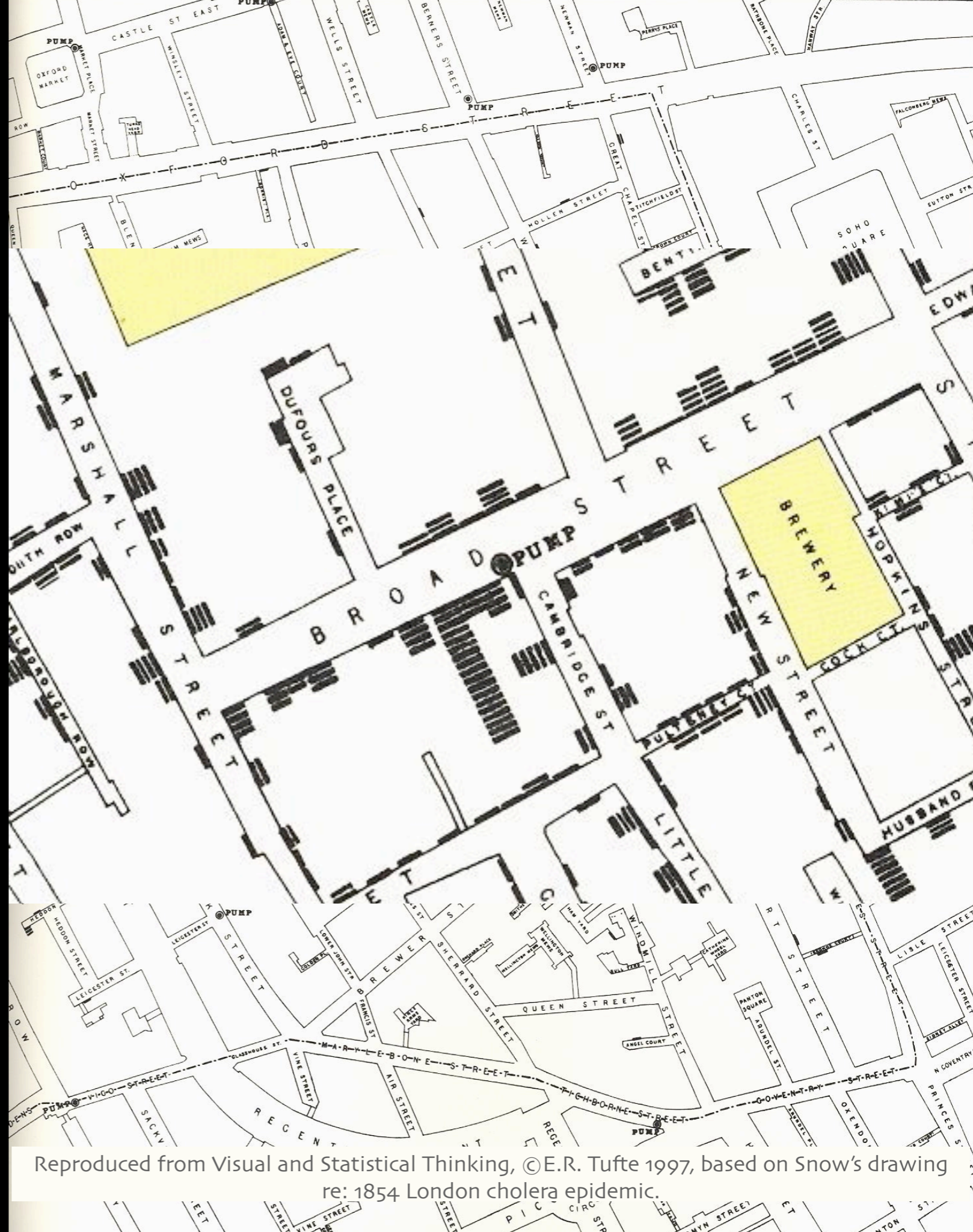
modular craftsmanship, linked views

"Easier"



2011

Craftsmanship (in 1854)



Reproduced from Visual and Statistical Thinking, © E.R. Tufte 1997, based on Snow's drawing re: 1854 London cholera epidemic.

Craftsmanship (in 1854)

Displaying
“high-dimensional” data

with

“multi-functioning
graphical elements”



Reproduced from Visual and Statistical Thinking, © E.R. Tufte 1997, based on Snow's drawing re: 1854 London cholera epidemic.

Data • Dimensions • Display

Craftsmanship (in 1854)

Displaying
“high-dimensional” data

with

“multi-functioning
graphical elements”



Reproduced from Visual and Statistical Thinking, © E.R. Tufte 1997, based on Snow's drawing re: 1854 London cholera epidemic.

What Computers Can Let us Craft (2008)

Elements...

- ✓ Maps
- ✓ Tables
- ✗ Graphs
- ✓ Charts
- ✓ Illustrations
- ✓ Combinations

Live Scoreboard | Celtics.com

SCOREBOARD

DEN	116	WAS	72	POR	97	PHI	46	MIL	34	DAL	26-11	LAL	25-11
CHA	119	BOS	79	NJN	70	SAS	52	UTA	34	SAC	14-21	SEA	9-27
FINAL		2:34	4th	0:50	4th	Halftime	5:36	2nd	10:00				10:00

COURTSIDE LIVE

19-16 STANDINGS

Fouls 1, Full 4, :20

02:46

1 2 3 4 OT T

18	17	24	13		72
18	19	26	16		79

Fouls 1, Full 3, :20

30-5 STANDINGS

COURTSIDE LIVE | BOX SCORE | PLAY-BY-PLAY | Highlights | Watch the Game | Listen to the Game

WAS SELECT: ○ ALL ● ACTIVE 5

PLAYER NAME	PTS	REB	AST	F
Daniels, Antonio	7	2	8	0
Steuenson, DeSha	11	3	4	2
Jamison, Antawn	18	10	0	3
Butler, Caron	14	3	1	3
Haywood, Brenda	12	5	0	3
Blatche, Andray	3	5	0	3
Mason, Roger	3	1	1	5
Songaila, Darius	2	1	1	2
Young, Nick	2	0	0	0
Pecherou, Oleksiy	0	1	0	0
Arenas, Gilbert				
McGuire, Dominic				

BOS SELECT: ○ ALL ● ACTIVE 5

PLAYER NAME	PTS	REB	AST	F
Rondo, Rajon	4	2	2	2
Allen, Ray	16	6	3	2
Garnett, Kevin	21	6	6	3
Pierce, Paul	16	4	2	3
Perkins, Kendrick	9	3	1	3
House, Eddie	5	6	3	1
Allen, Tony	4	4	0	0
Davis, Glen	1	0	0	2
Posey, James	3	2	0	2
Pollard, Scott				
Scalabrino, Brian				
Powe, Leon				

TD Banknorth GARDEN

WIZARDS

CELTICS

WAS show: ● made shots ✓ X missed shots ✓

BOS show: ● made shots ✓ X missed shots ✓



What Computers (D3) Can Let us Craft (2012)

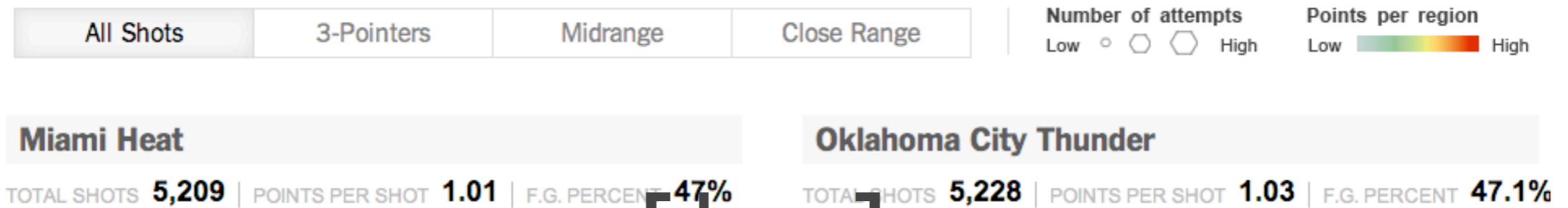
UPDATED June 12, 2012

N.B.A. FINALS

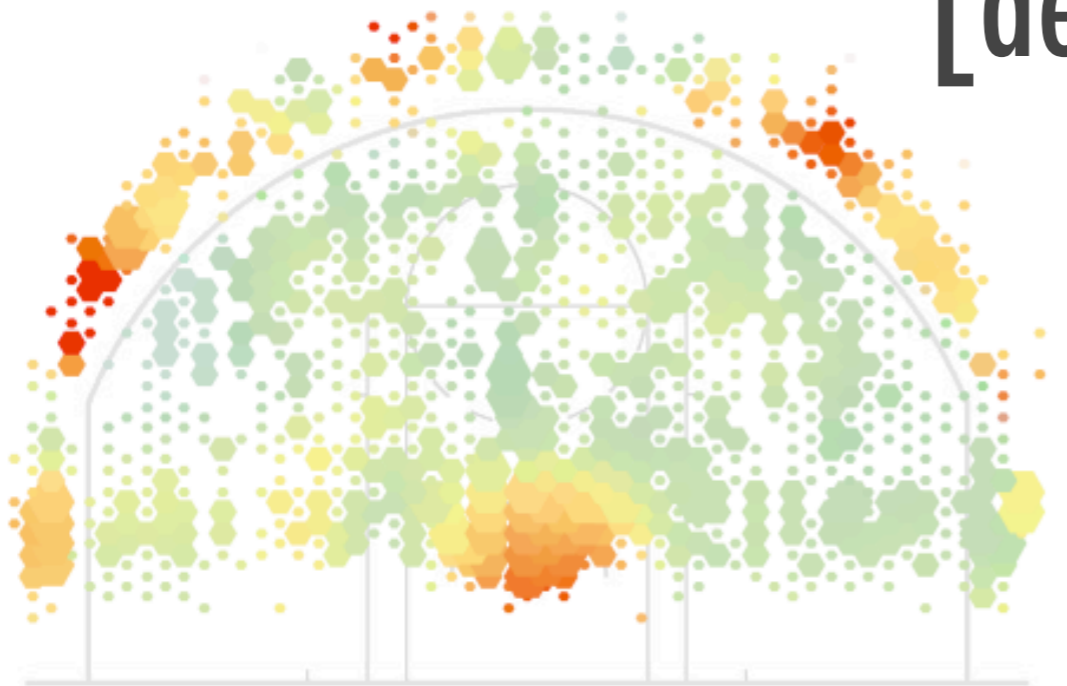
[f RECOMMEND](#) [TWITTER](#) [LINKEDIN](#) [SIGN IN TO E-MAIL](#) [SHARE](#)

Where the Heat and the Thunder Hit Their Shots

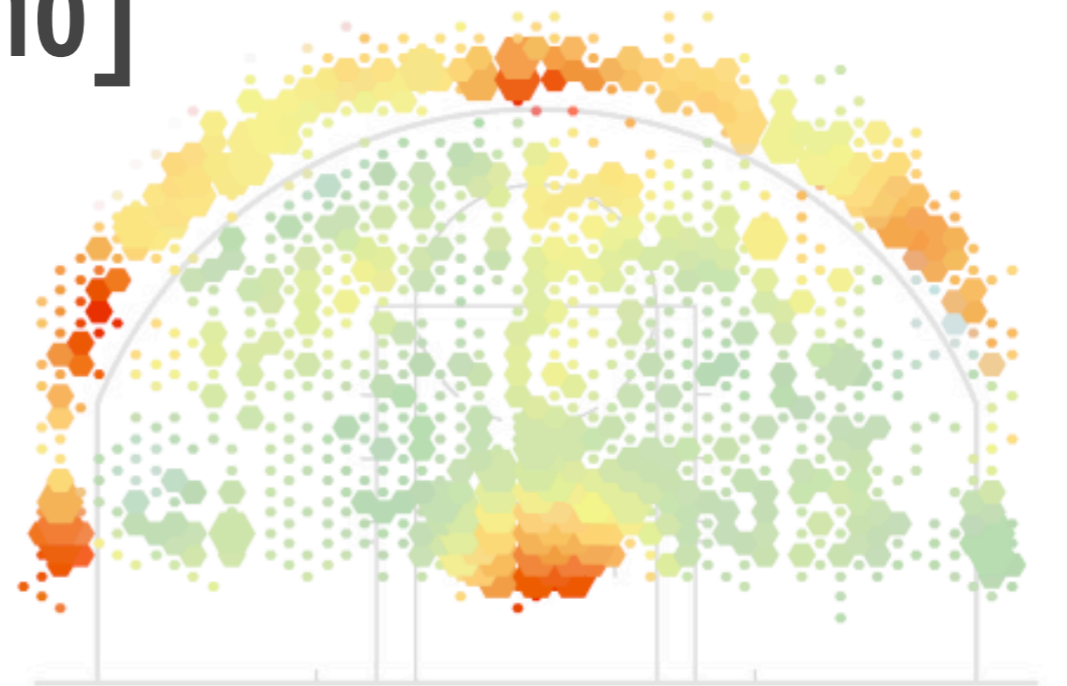
The shooting patterns for the players on the Miami Heat and the Oklahoma City Thunder reveal where they are most dangerous on the court. Below, compare each player's strengths using court maps and analysis by Kirk Goldsberry, a geography professor at Michigan State. [Related Article »](#)



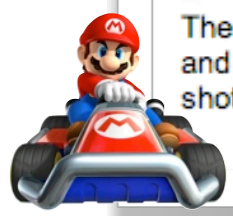
[demo]



The Heat rely on player positioning to create isolation plays for LeBron James and Dwyane Wade, often on the left side. The Heat take many fewer 3-point shots than the Thunder.



The Thunder are effective from almost any area on the court and shoot many more 3-point shots than the league average. Kevin Durant and James Harden are potent from the top of the arc.



What...

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craftsmanship

...should be easier in the future?

modular craftsmanship, linked views

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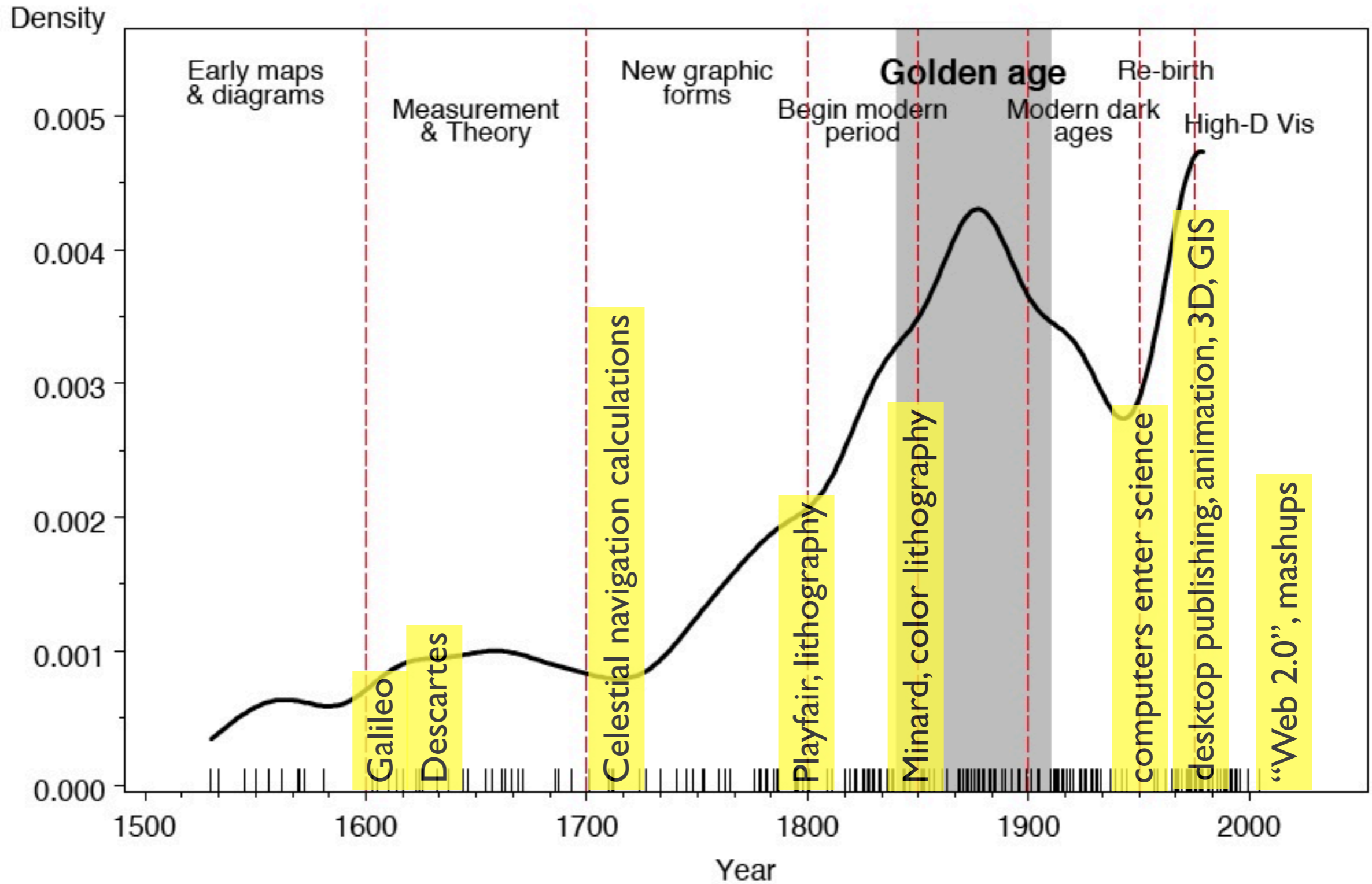
craftsmanship

...should be easier in the future?

modular craftsmanship, linked views

First, the past...

Milestones: Time course of developments



adapted from Friendly, "The Golden Age of Statistical Graphics," *Statistical Science*, 2009

Galileo



Galileo Galilei (1564-1642)



Sc. Principale.

Galileo Galilei, Familiare. Seruo della Ser. V. inuigilante
 do assiduo, et lo ogni spirito se essere no solo satisfatto
 aluano che non della letura di Mathematiche nelle Scuole
 di Padova,

Inuere diuere determinate di presentare al Sc. Principale
 l'occhio et il pensiero di giuamenti inestimabile di ogni
 negozio et in circa marittima o terrestre stimo di tenere per
 ste nuovi artificio ne l'ingegno segeto et uolere a disposizione
 di di ser. L'occhio conato dalle piu uide speculationi di
 prospettua in l'uantaggio di scoprire Legni et Vele dell' inimico
 di luce et di piu di tempo prima di gli scopri noi et distinguendo
 il numero et la qualita de i Vascelli giuocare le sue forze
 ballottarsi alla caccia et combattimento o alla fuga, o pure essi
 nella campagna aperta uedere et particolarmente distinguere ogni suo
 uento et propriamento.

Adi 7. di gennaio
 Giove si uede uero
 Adi 8. uero
 Adi 10. si uede in tale uisione
 Adi 13. si uede uero in Giove 4 stelle
 Adi 14. di agosto
 Adi 15. si uede in la pressi a 4 ora in uero la 4. ora di
 spante dalla 3. a coppia terra
 Lo spazio delle 3 uide uero non
 maggiore del diametro di 7. et e
 uero in linea retta.

7	* * * *	17	* * *
8	○ * * *	18	* ○ *
10	* * ○	19	* ○ * *
11	* * ○	19	* ○ * *
12	* ○ *	20	○ * ○ * ○
13	* ○ * *	21	... ○ *
15	○ * * * *	22	* ○ * *
15	○ * * *	22	* ○ * *
16	* ○ *	23	* ○ *
17	* ○ *	24	* ○ *

SIDERIUS NUNCIUS

On the third, at the seventh hour, the stars were arranged in this
 quence. The eastern one was 1 minute, 30 seconds from Jupiter
 the closest western one 2 minutes; and the other western one wa
 East * ○ * West

0 minutes removed from this one. They were absolutely on the
 same straight line and of equal magnitude.

On the fourth, at the second hour, there were four stars around
 Jupiter, two to the east and two to the west, and arranged precisely
 East * * ○ * * West

on a straight line, as in the adjoining figure. The easternmost wa
 distant 3 minutes from the next one, while this one was 40 second
 from Jupiter; Jupiter was 4 minutes from the nearest western one
 and this one 6 minutes from the westernmost one. Their magnitude
 were nearly equal; the one closest to Jupiter appeared a little smaller
 than the rest. But at the seventh hour the eastern stars were only
 30 seconds apart. Jupiter was 2 minutes from the nearer eastern
 East ** ○ * * West

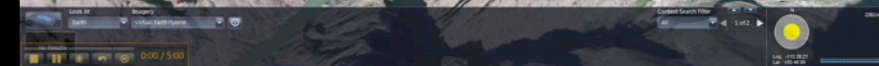
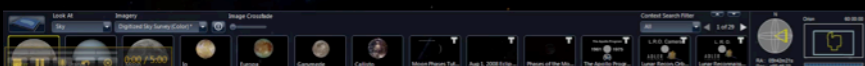
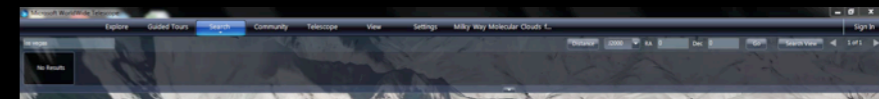
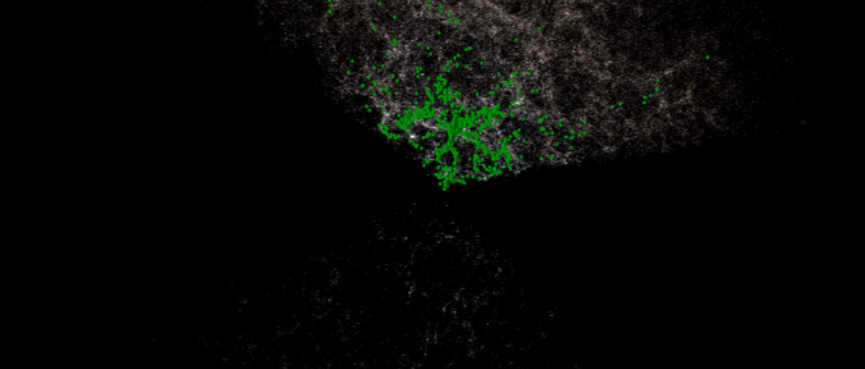
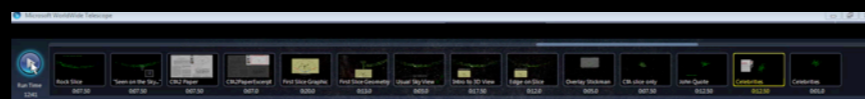
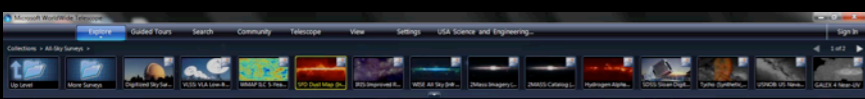
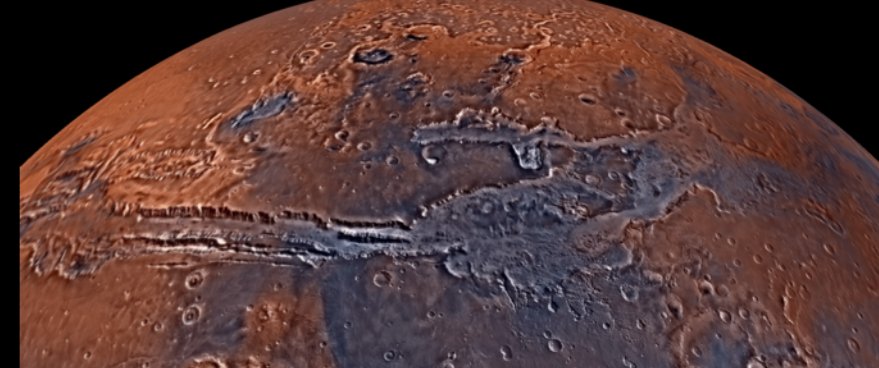
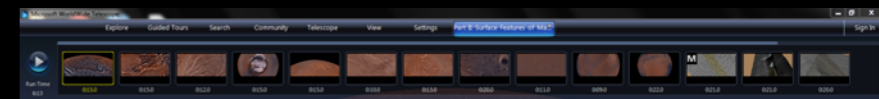
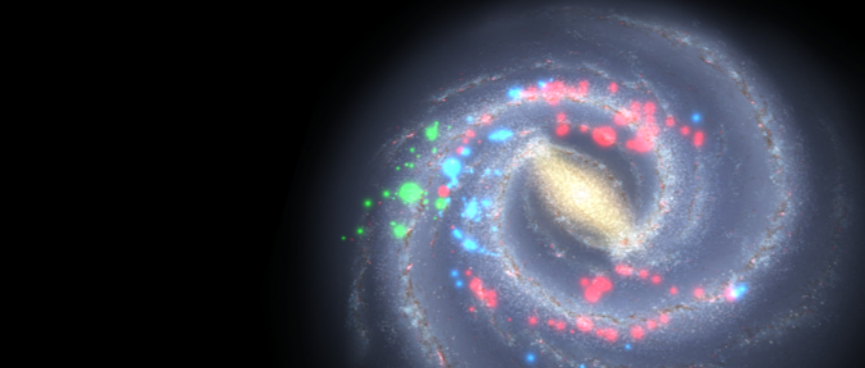
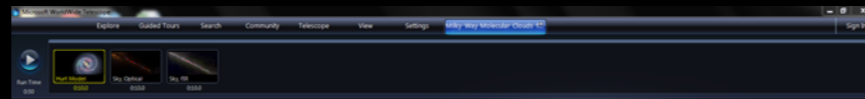
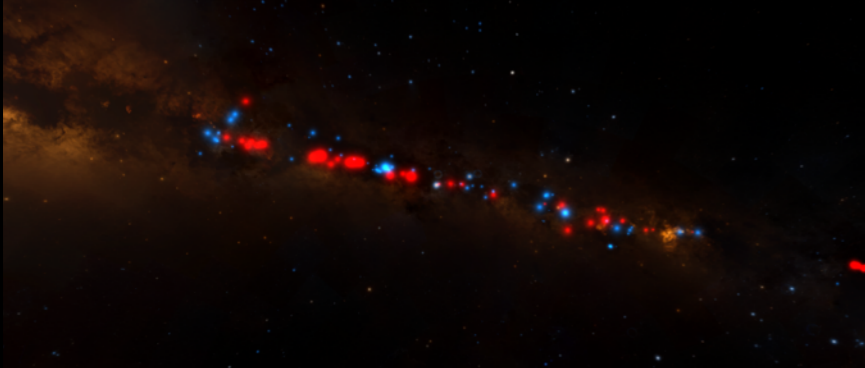
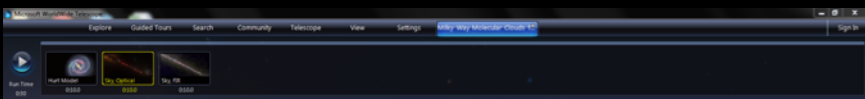
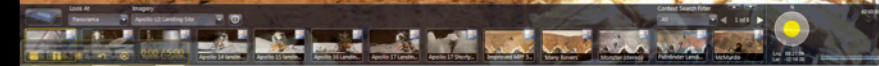
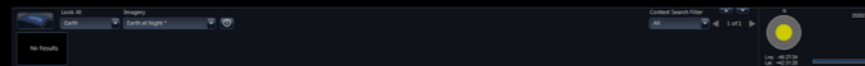
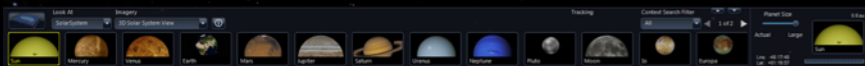
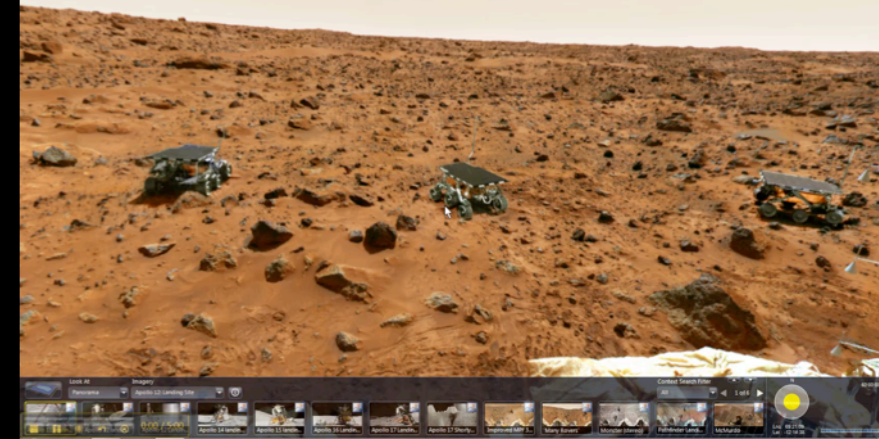
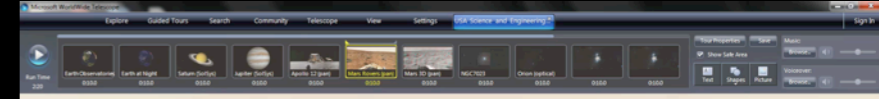
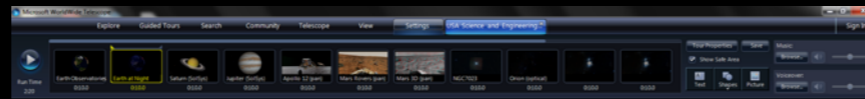
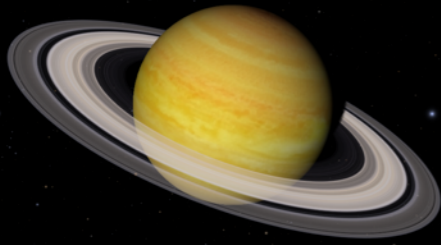
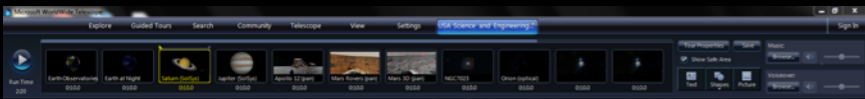
one, while he was 4 minutes from the next western one, and this
 one was 3 minutes from the westernmost one. They were all equal
 and extended on the same straight line along the ecliptic.

On the fifth, the sky was cloudy.

On the sixth, only two stars appeared flanking Jupiter, as is seen
 East * ○ * West

in the adjoining figure. The eastern one was 2 minutes and the
 western one 3 minutes from Jupiter. They were on the same straight
 line with Jupiter and equal in magnitude.

On the seventh, two stars stood near Jupiter, both to the east



Experience  at worldwidetelescope.org



WWT Ambassadors



WWT at Harvard



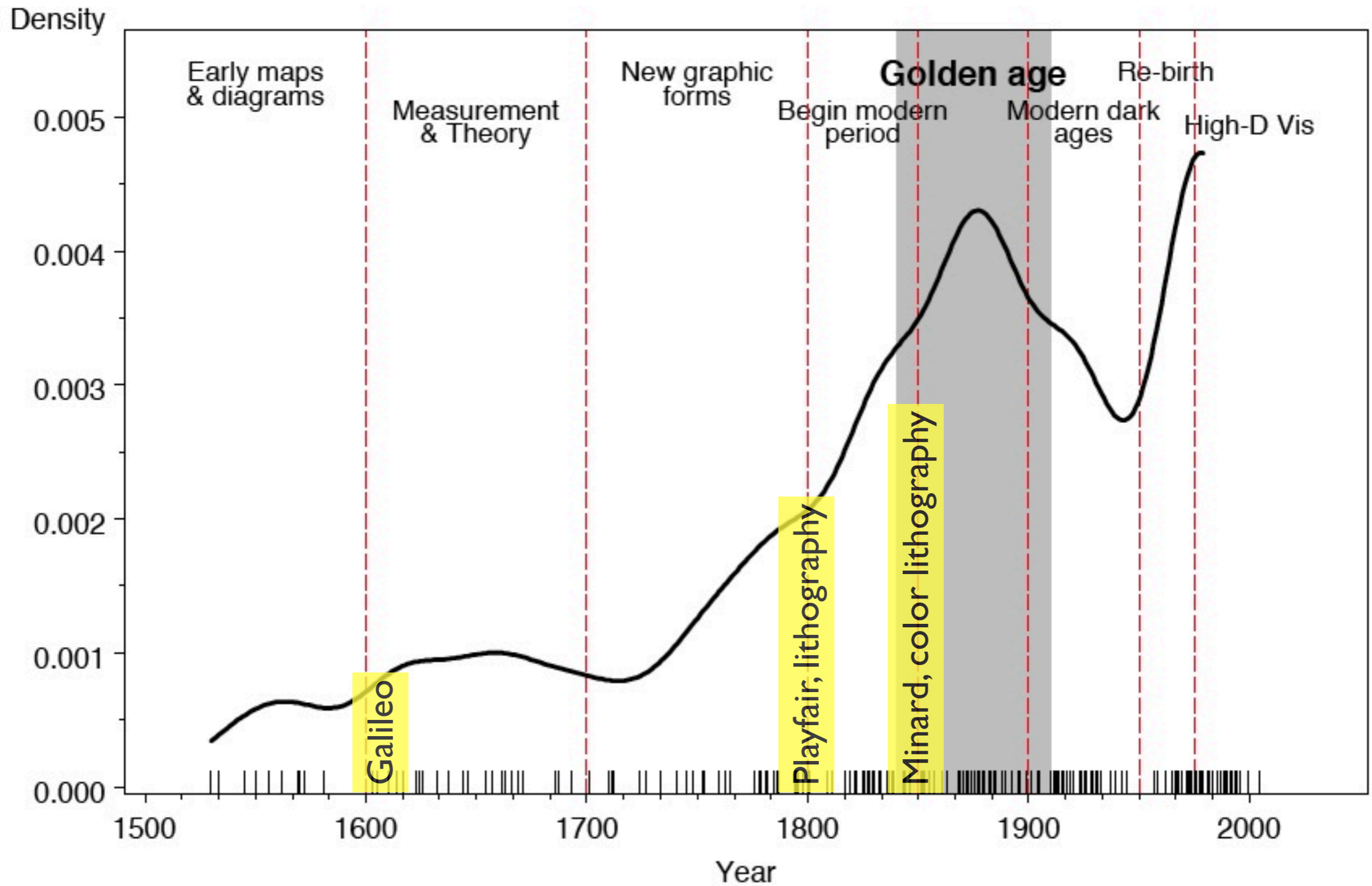
WWT in Research



"Tours"

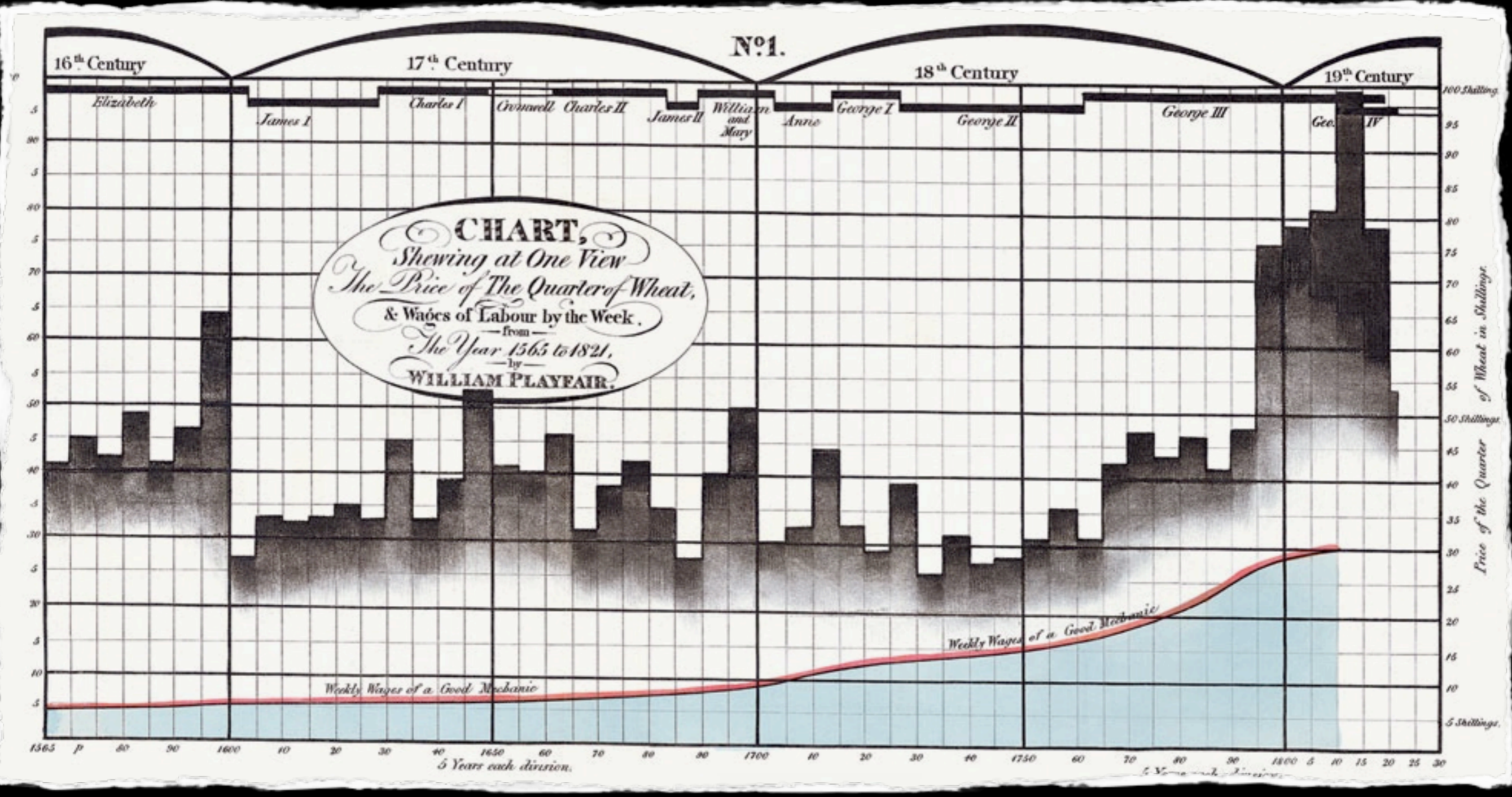


Milestones: Time course of developments

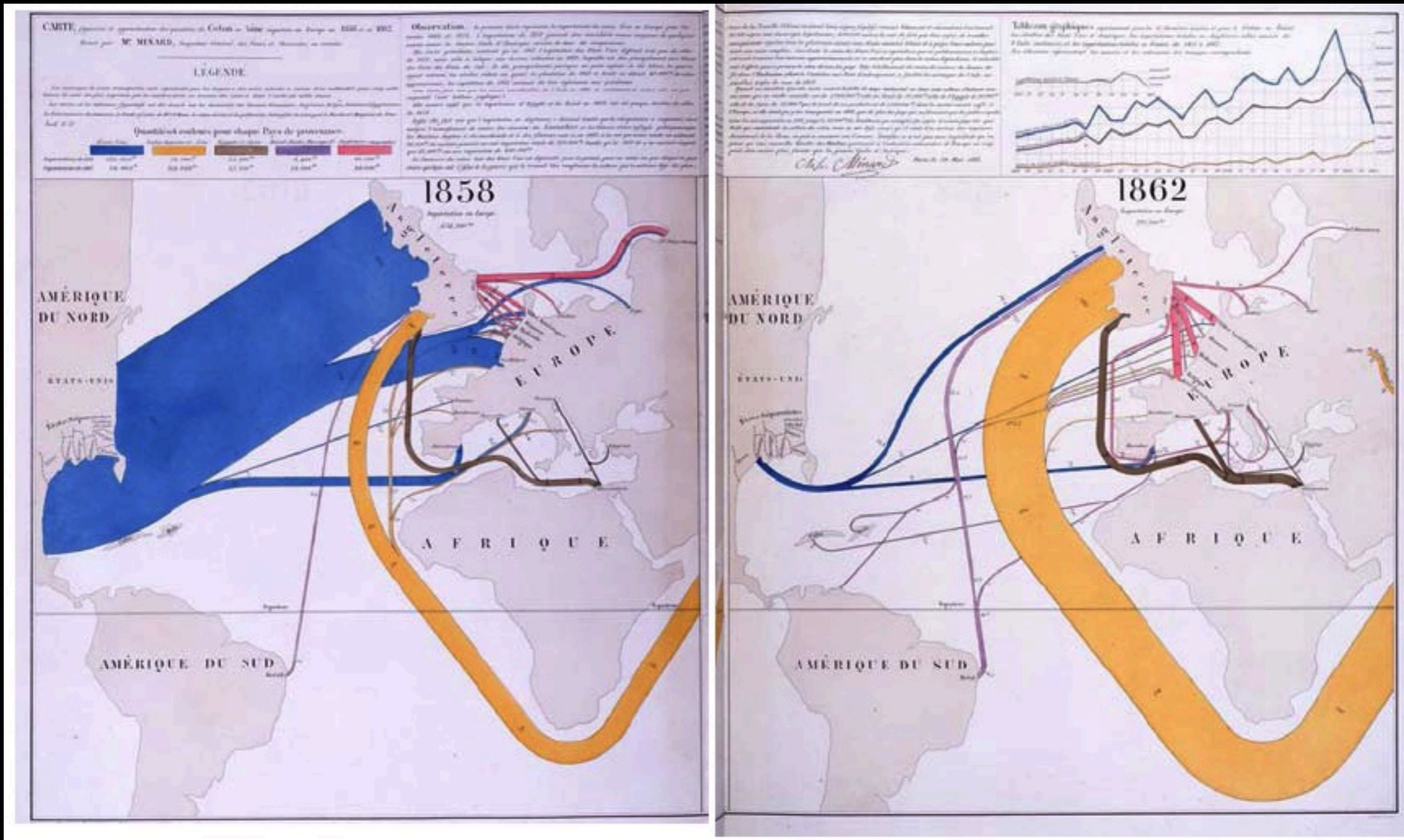


adapted from Friendly, "The Golden Age of Statistical Graphics," *Statistical Science*, 2009

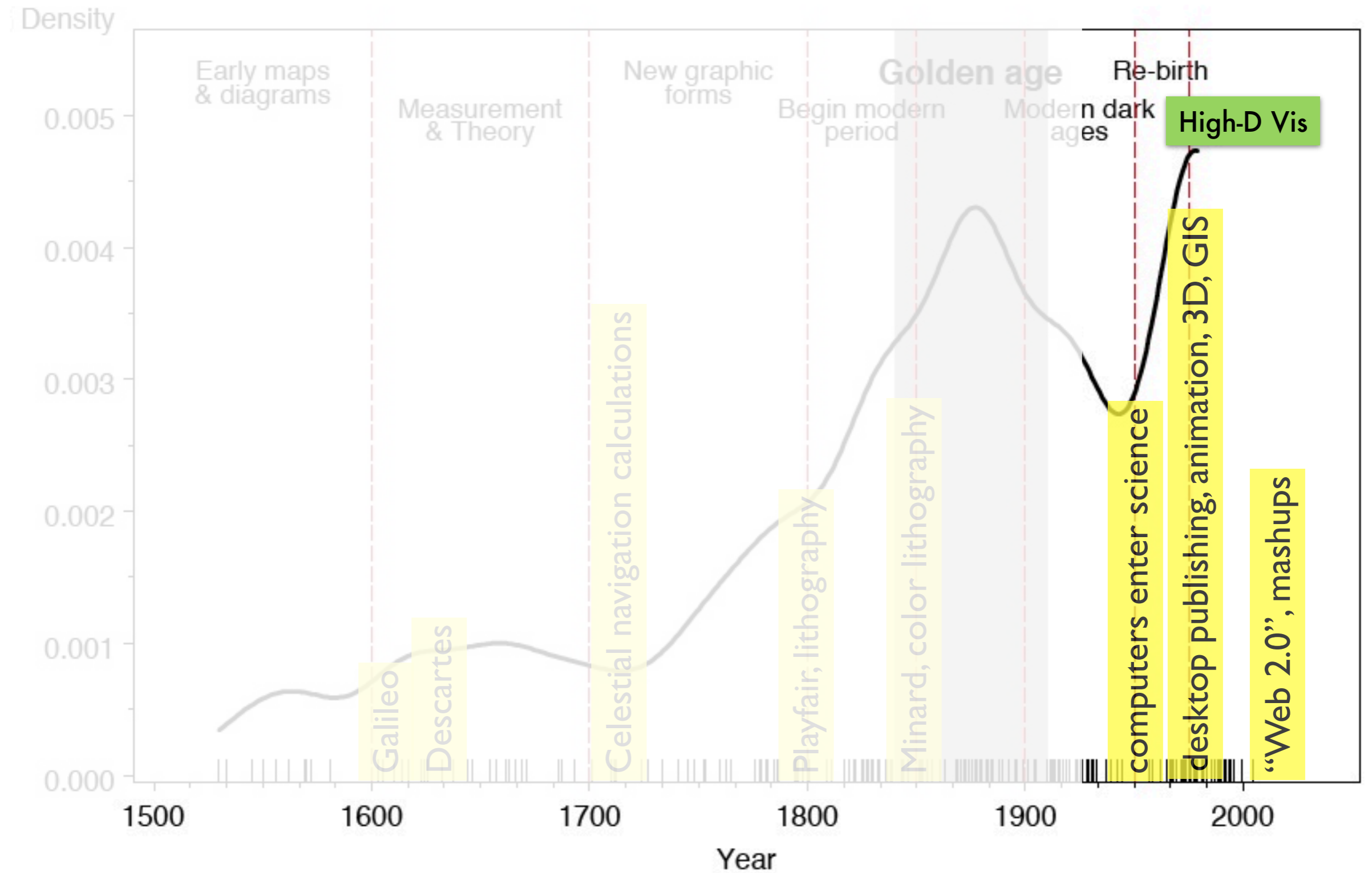
William Playfair (1759-1823)



Charles Joseph Minard, in color (1781-1870)



Milestones: Time course of developments

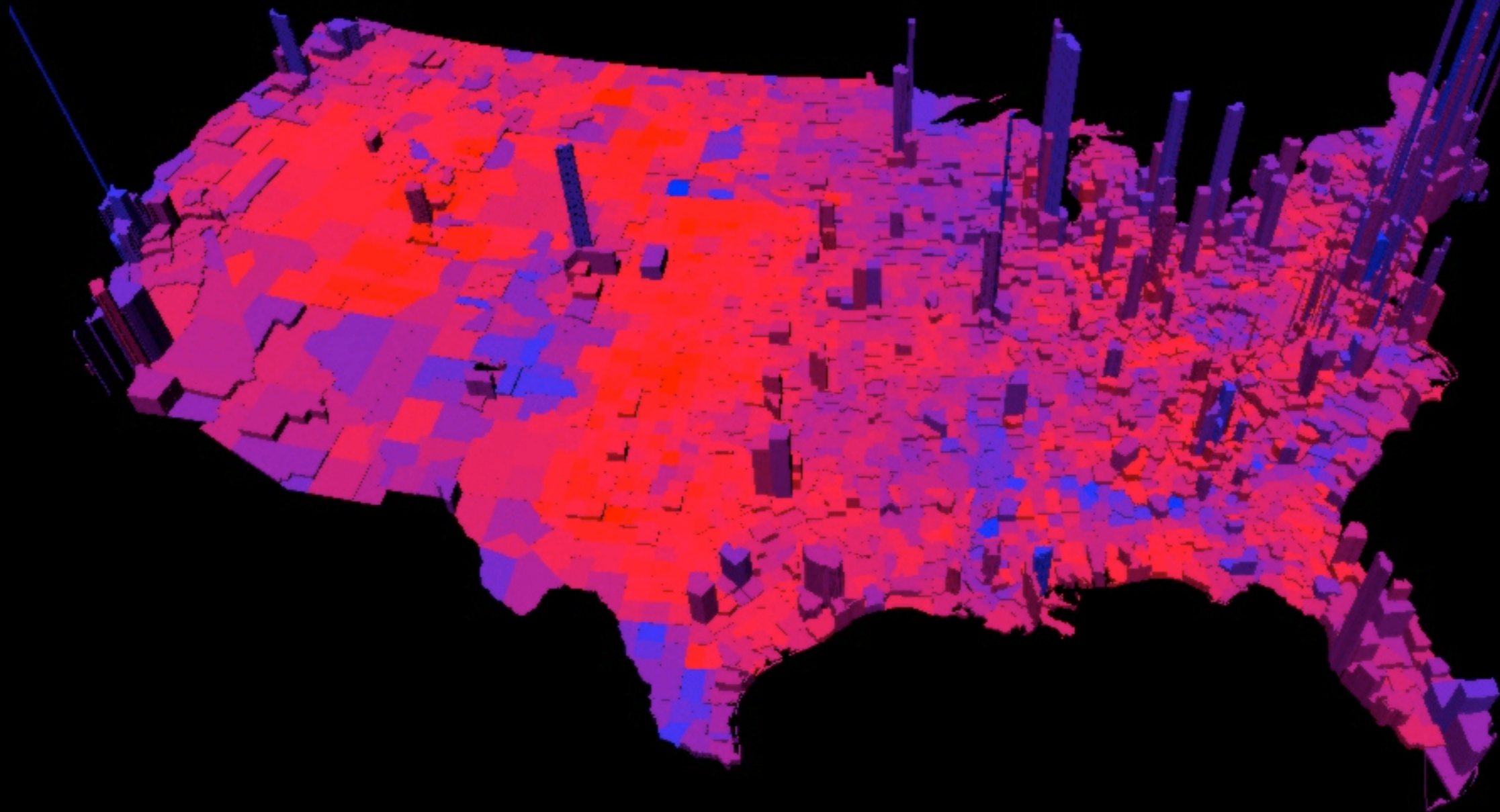


adapted from Friendly, "The Golden Age of Statistical Graphics," *Statistical Science*, in press (2008)

High-D Vis

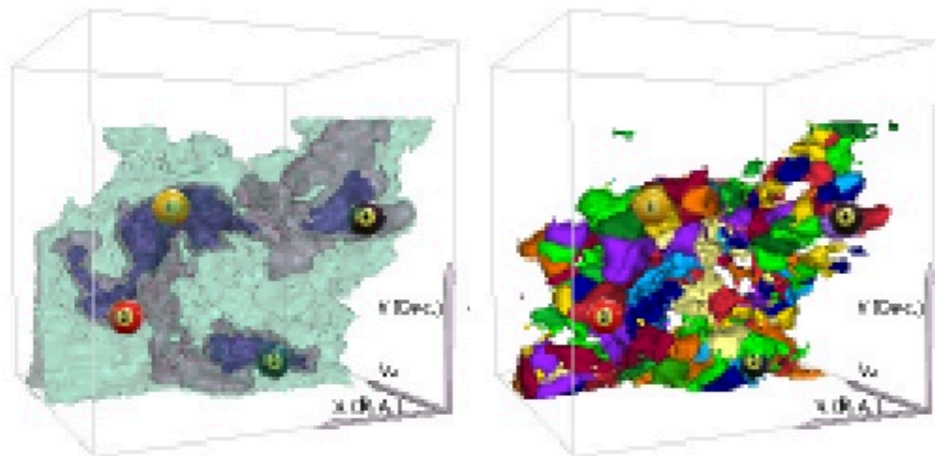
Data • Dimensions • Display

"High-dimensional" or "Multivariate" Data and High(er) Dimensional Displays

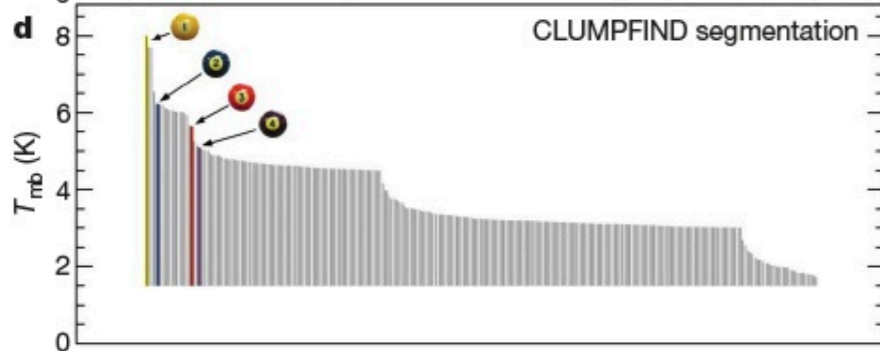
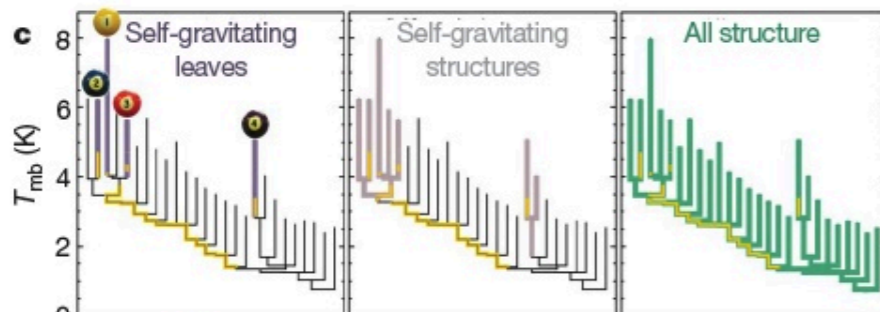


"High-dimensional" or "Multivariate" Data (Astronomy=Biology)

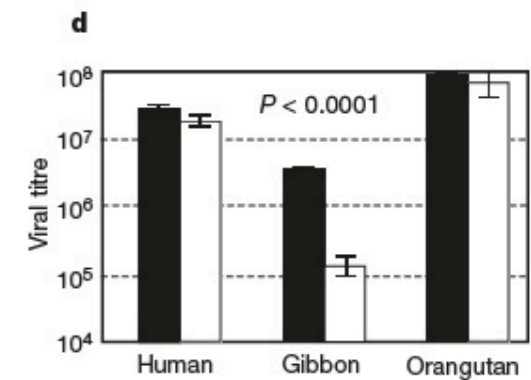
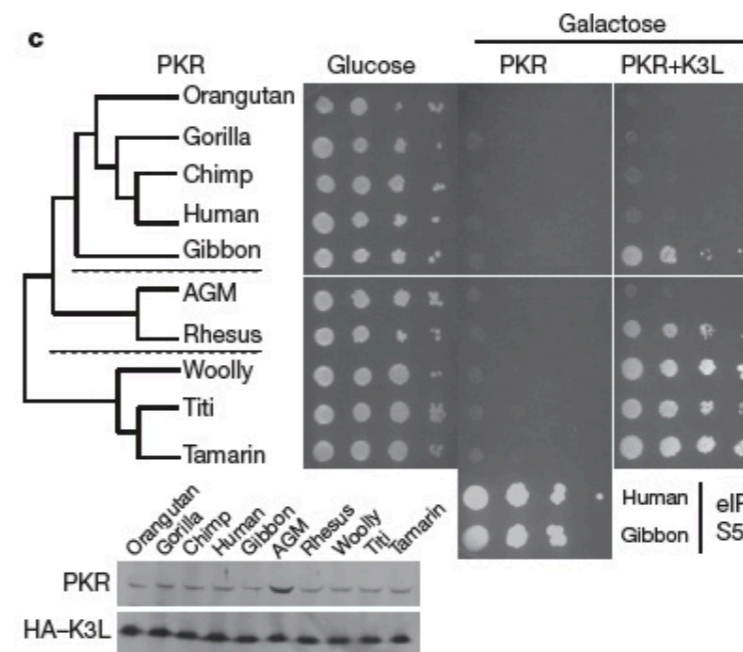
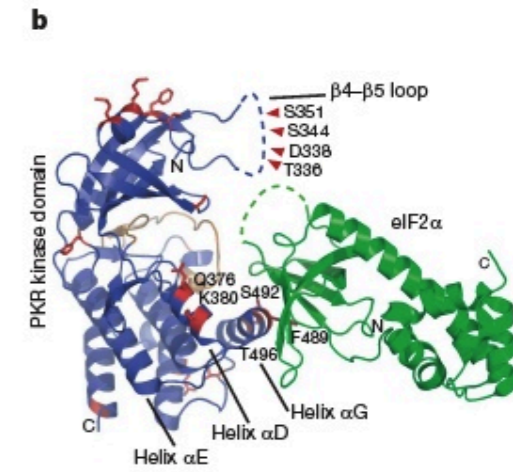
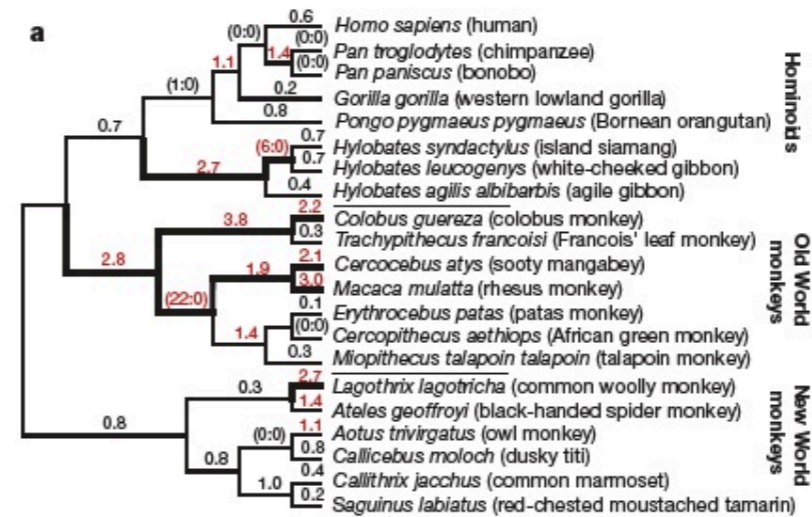
LETTERS



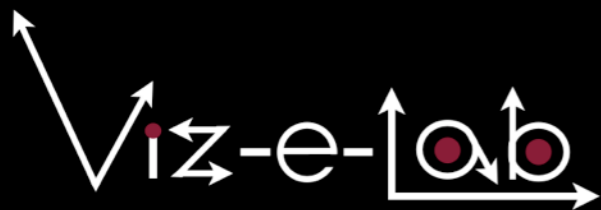
Click to rotate

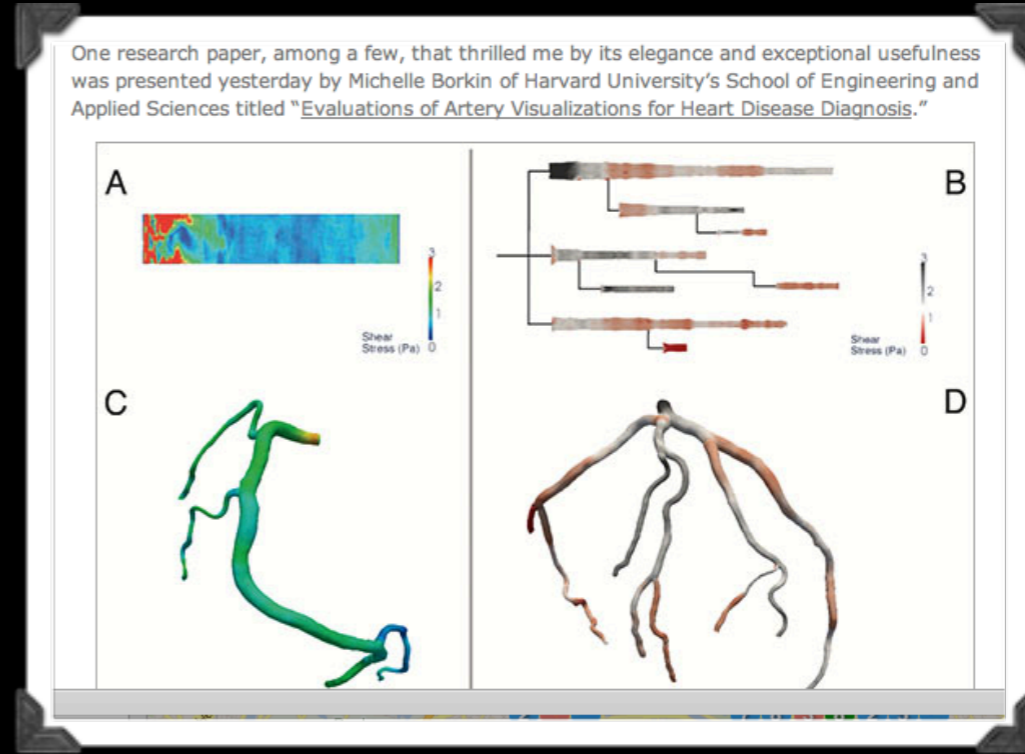
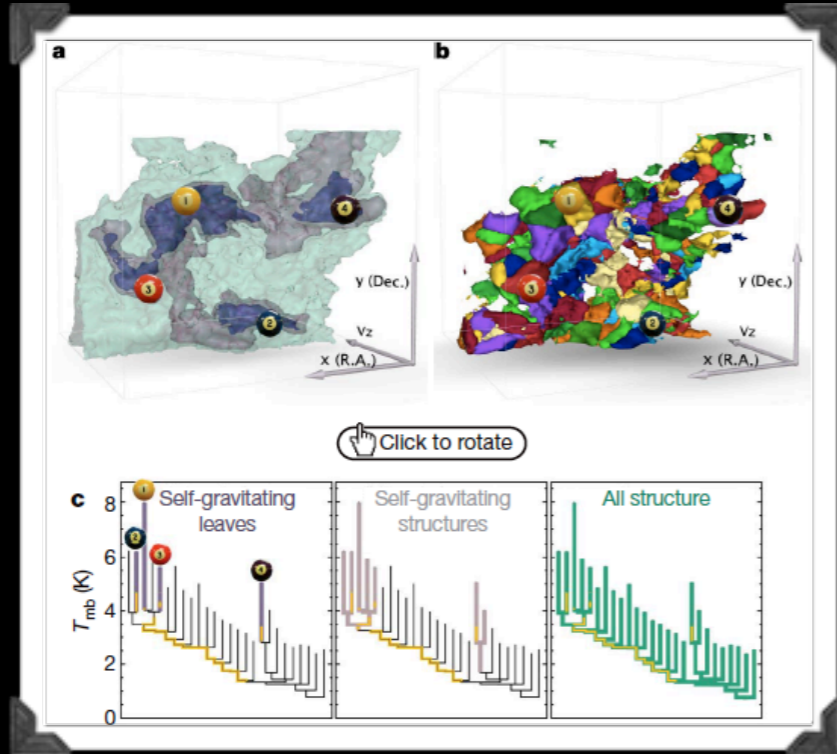


LETTERS

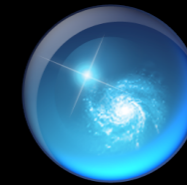


The Art of Numbers Data Visualization in the 21st Century





Viz-e-lab



The AstroMed (Back) Story



Themes	TED Conferences	TED
Speakers	TEDx Events	TED
Talks	TED Prize	
Translations	TED Fellows	

TED Fellows The TED Fellows Directory > Michelle Borkin 2009



Michelle Borkin is now a SEAS PhD Student, advised by Profs. Alyssa Goodman (Astronomy) and Hanspeter Pfister (SEAS), and IIC +AstroMed became the bases for the Viz-e-Lab



2011 Visual Business Intelligence

A blog by Stephen Few

Home About Consulting Workshops Courses Examples Library **Blog** Discuss

VisWeek 2011 – Award-Worthy Visualization Research

On Tuesday in this blog I expressed my frustration with VisWeek's information visualization research awards process. I don't want to leave you with the impression, however, that the state of information visualization research is bleak. Each year at VisWeek I find a few gems produced by thoughtful, well-trained information visualization researchers. They identified potentially worthy pursuits and did well-designed research that produced useful results. While puzzling over the criteria that the judges must have used when selecting this year's best paper, I spent a few minutes considering the criteria that I would use were I a judge, and came up with the following list with points totaling to 100:

Effectiveness (It does what it's supposed to do and does it well.) — 30 points

Usefulness (What it does addresses real needs in the world.) — 30 points

10 points

ses.) — 10 points

ew way.) — 10 points

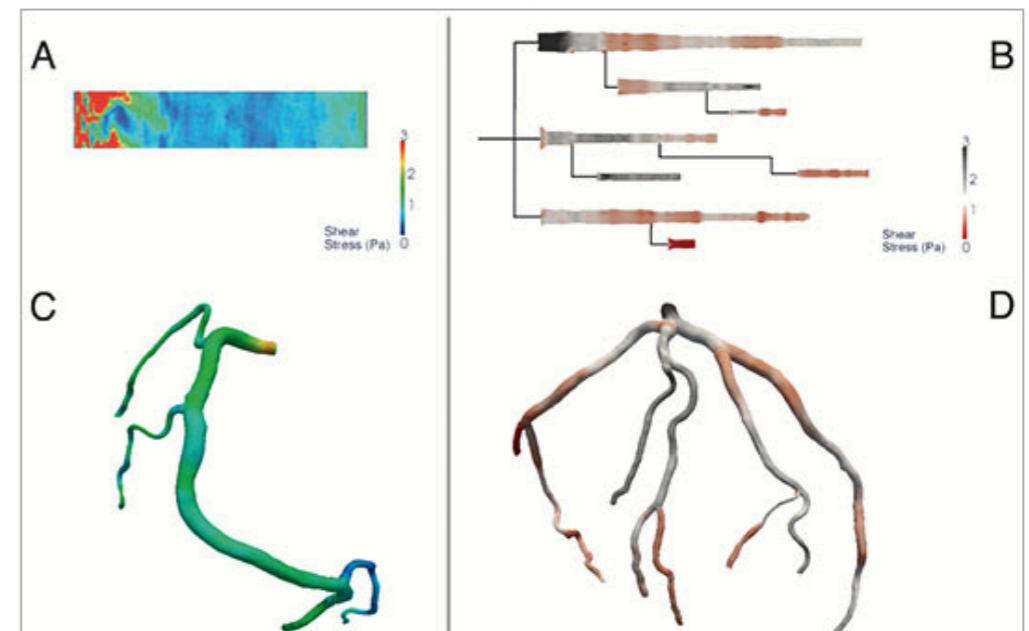
e.) — 10 points

to some degree, but this gives you an idea of the importance of each.

e by its elegance and exceptional usefulness

Harvard University's School of Engineering and

Applied Sciences titled "Evaluations of Artery Visualizations for Heart Disease Diagnosis."



TEDGlobal 2009

AstroMed09

The Inaugural Sydney International Workshop on Synergies in Astronomy and Medicine

14–16 December, 2009
The University of Sydney

Bio

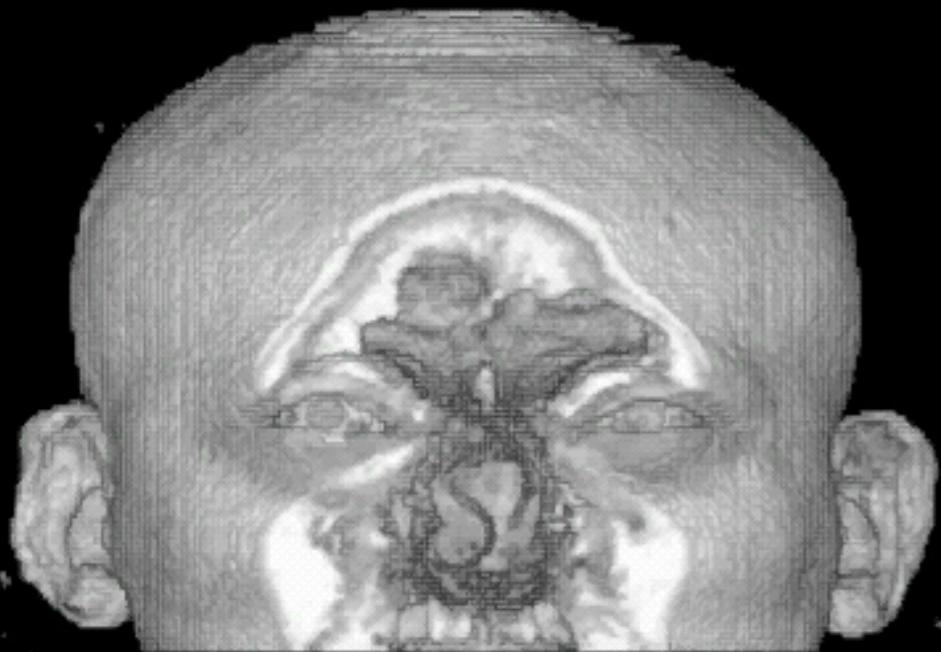
Michelle Borkin interdisciplinary and image analysis. She wrote her work on the application of astronomical data as part of the "AstroMed" Harvard's Initiative. She works with the development of tools to improve their effectiveness in multiple

serting a stent

to prevent a heart attack.

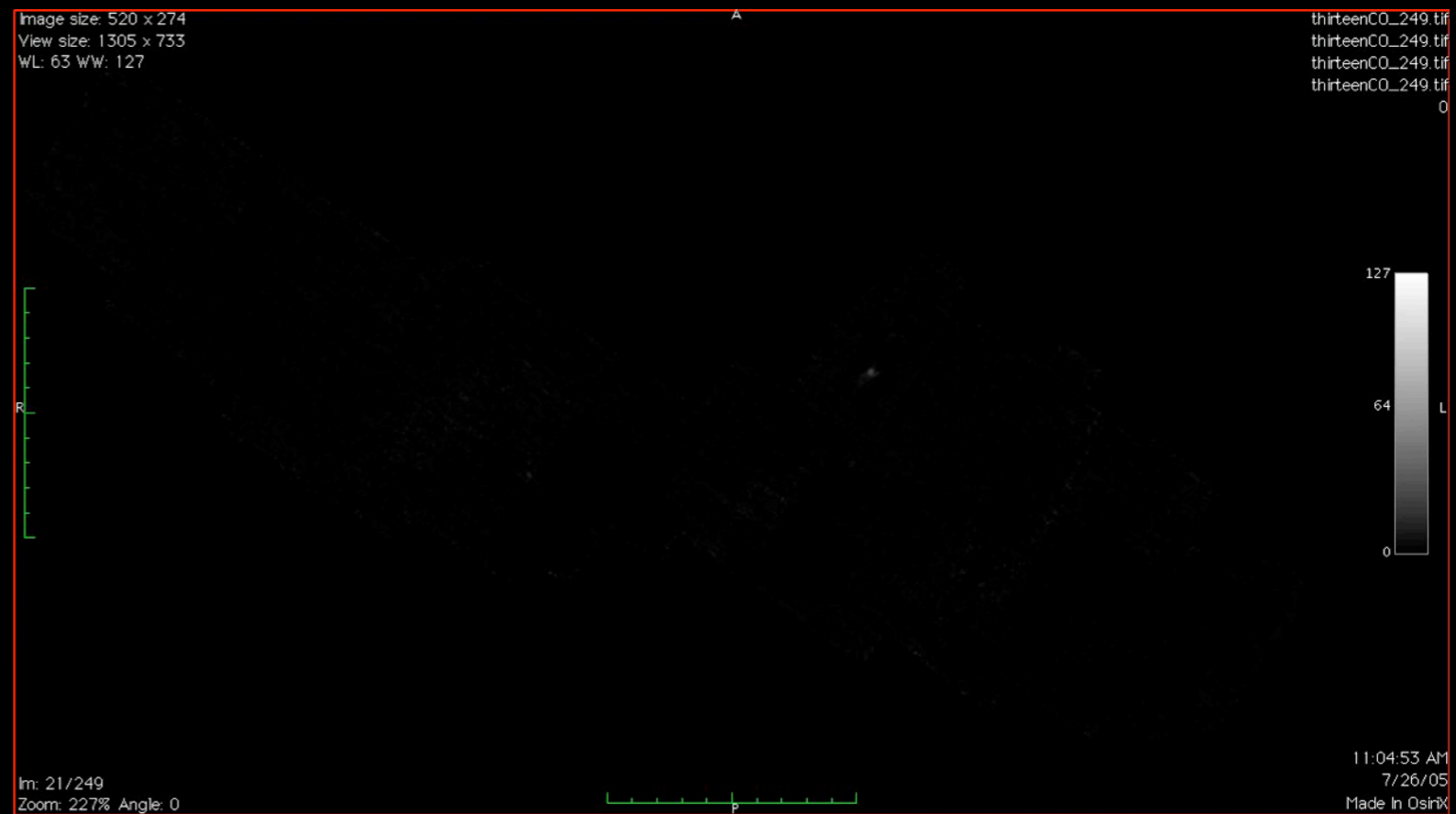
"Astronomical Medicine"

"KEITH"



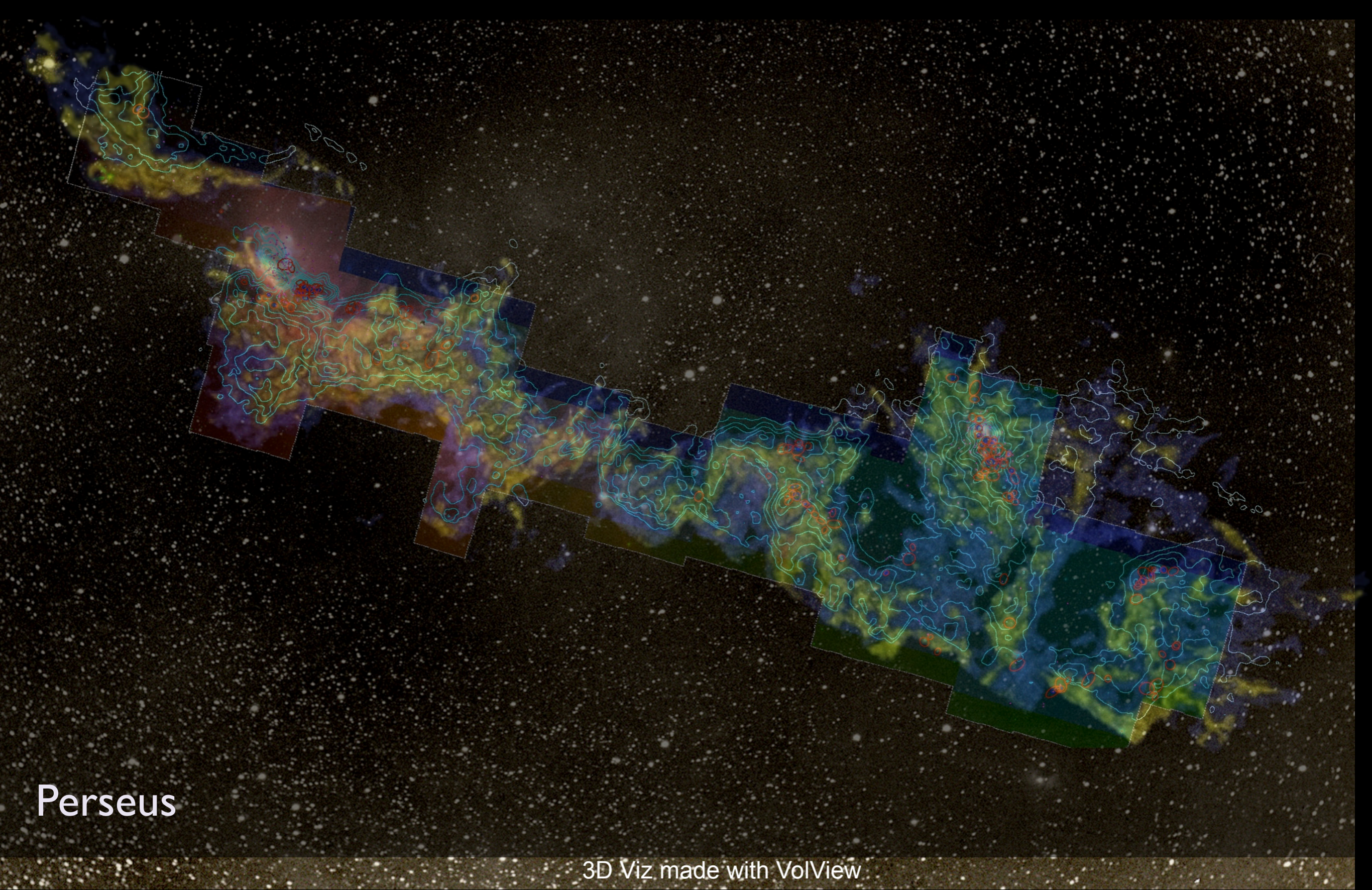
"z" is depth into head

"PERSEUS"



"z" is line-of-sight velocity

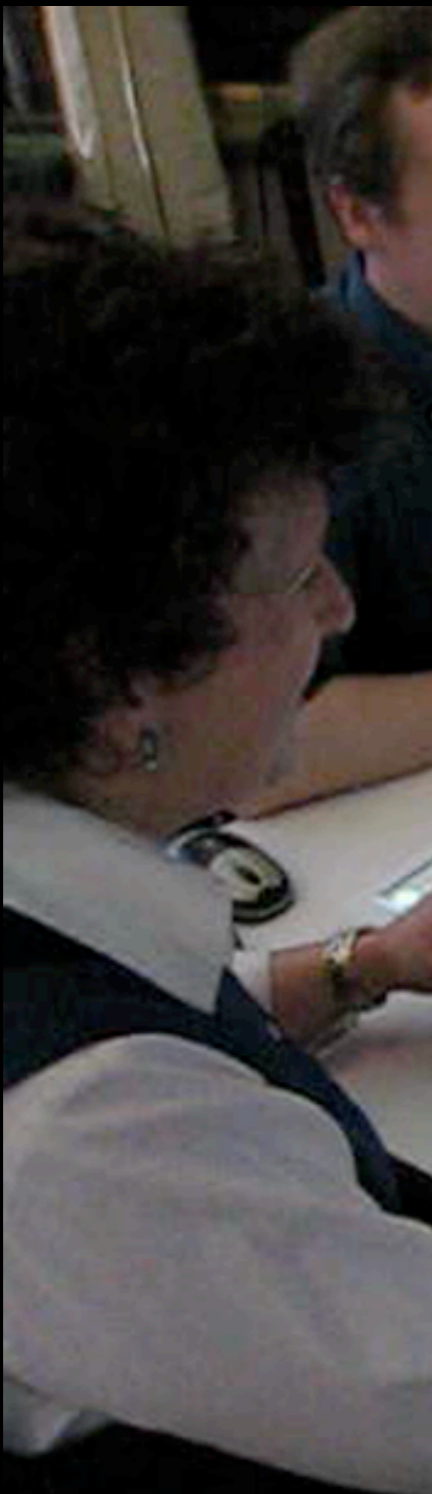
(This kind of "series of 2D slices view" is known in the Viz as "the grand tour")



Perseus

3D Viz made with VolView

Origins of the Viz-e-lab



Slideshow: Tabletop Computers *Continued*

By Meredith Ringel Morris

First Published December 2008

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[Del.icio.us](#) [Digg](#) [Slashdot](#)

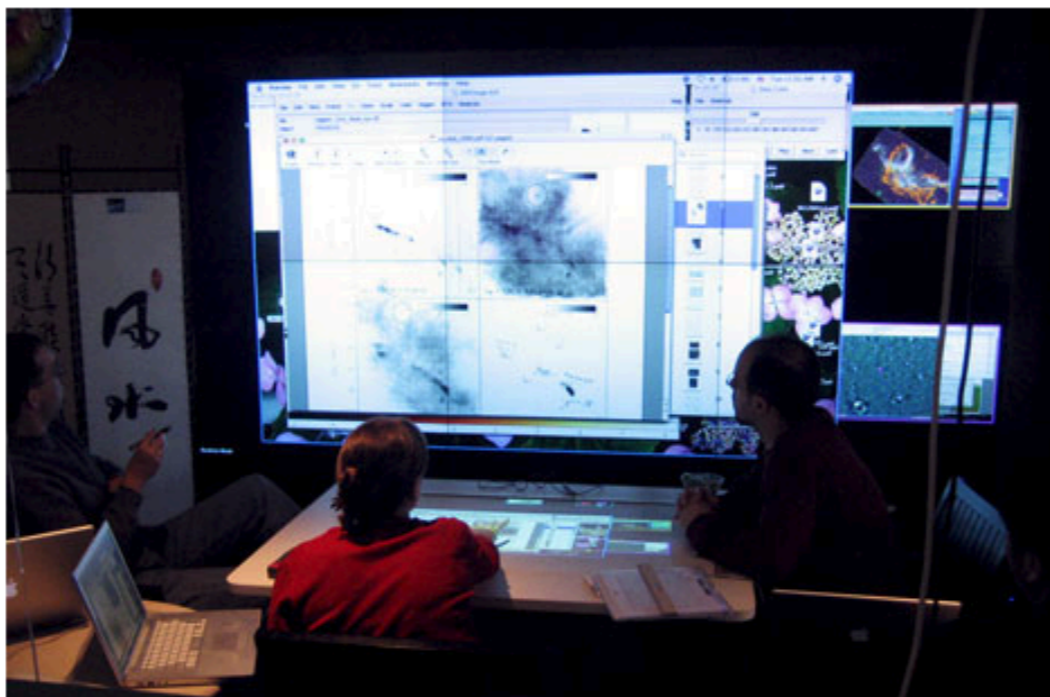
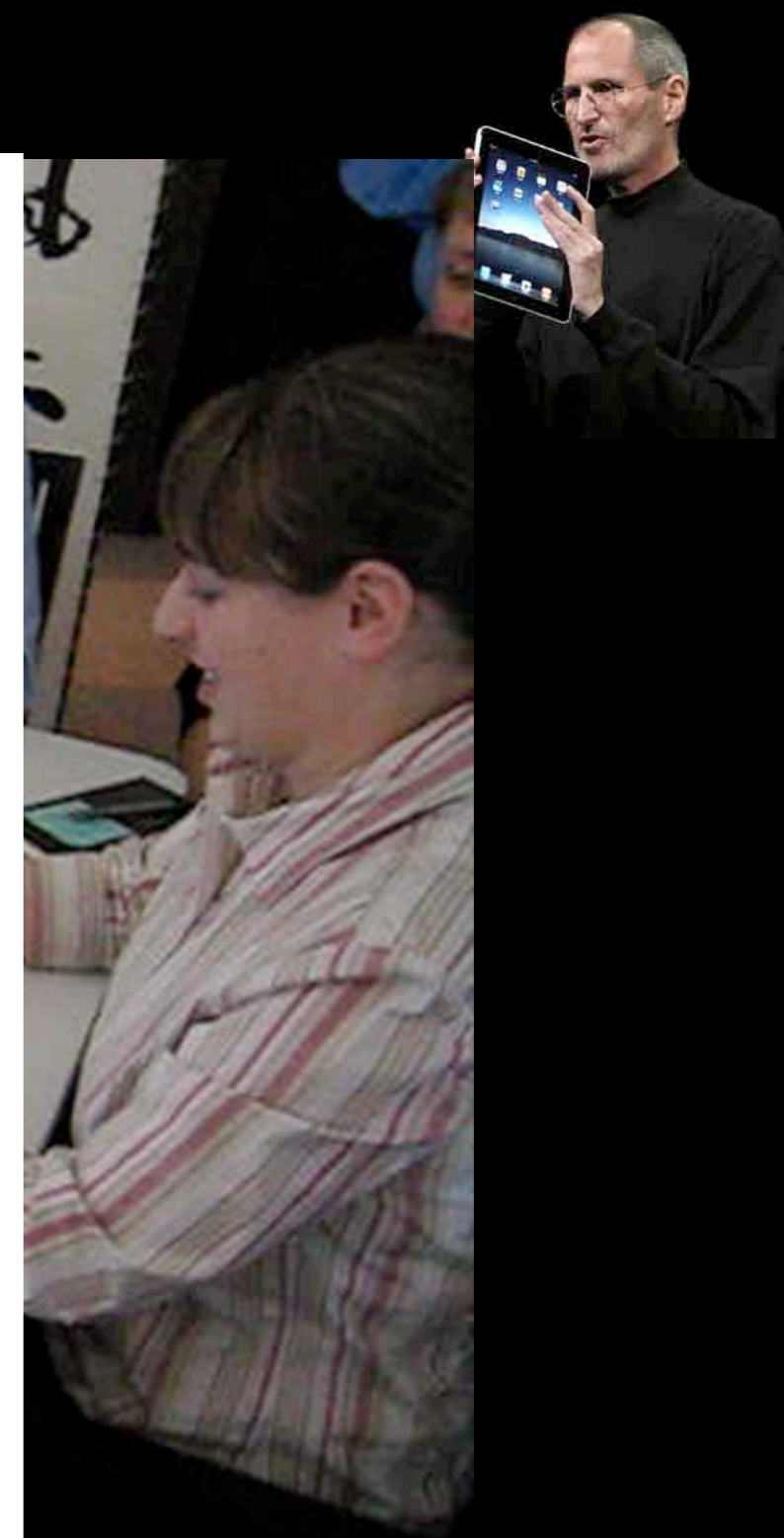


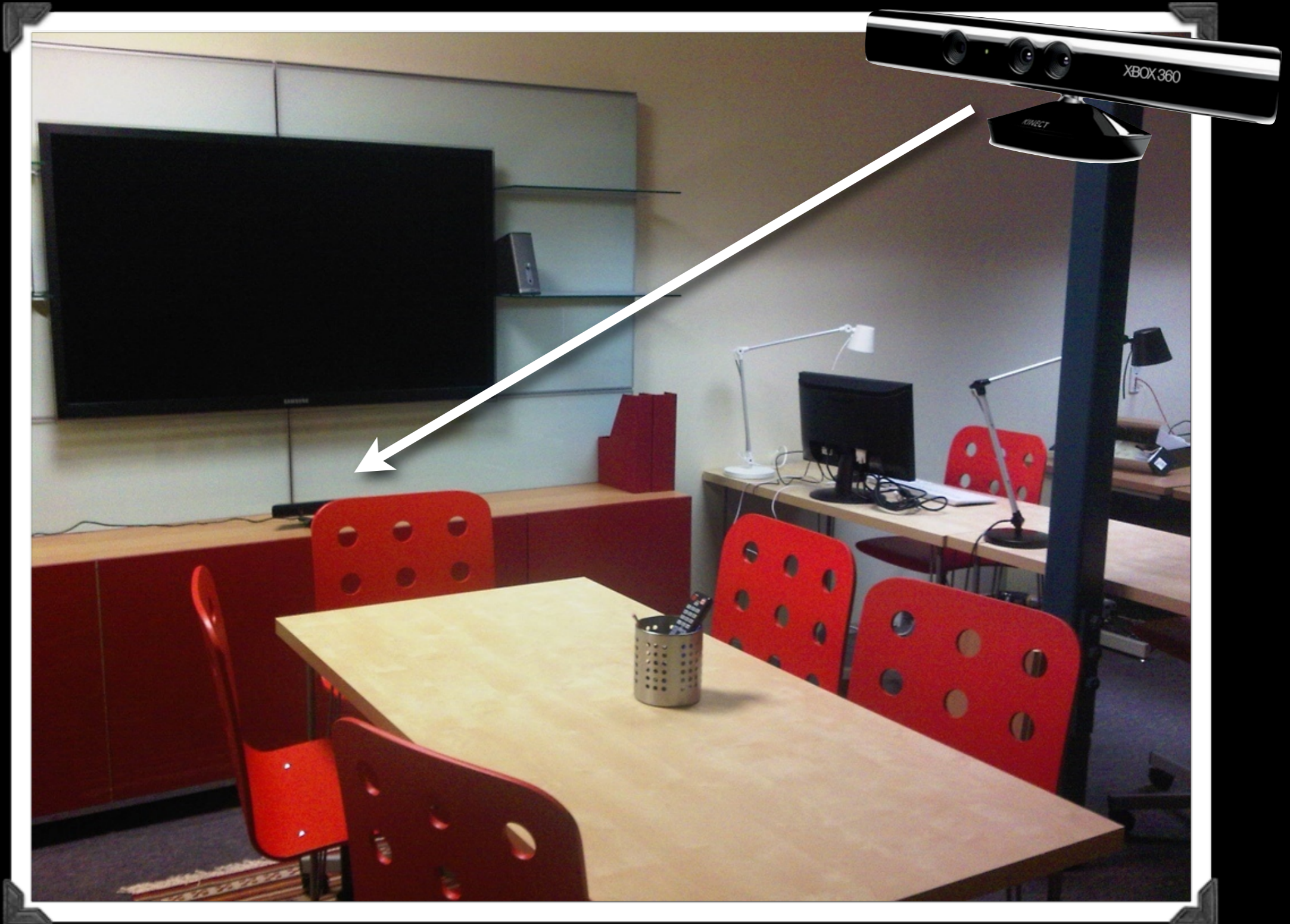
PHOTO: HAO JIANG, DANIEL WIGDOR, CLIFTON FORLINES, AND CHIA SHEN

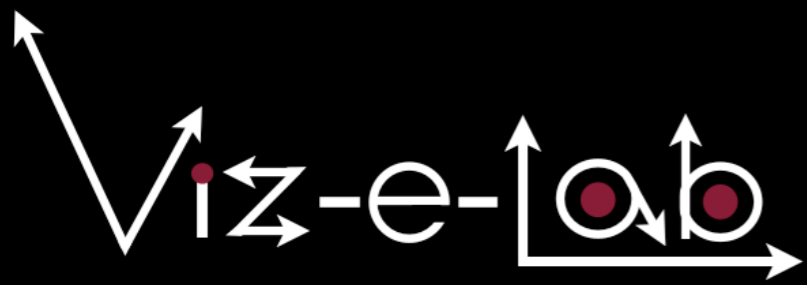
UBITABLE: Users can interact with surface computers through auxiliary devices, such as laptops, phones, and PDAs. The display on the auxiliary device can convey private or sensitive content to a single user, while group-appropriate content can appear on the tabletop display. Chia Shen and her colleagues at Mitsubishi Electric Research Laboratories, in Cambridge, Mass., have explored auxiliary interactions with surface computers in their UbiTable project, in which two people with laptops collaborate over a tabletop display. Recently, Shen expanded the UbiTable into an interactive room called the WeSpace. People can share data on their laptops with other people in the room, using both a table and a large display wall. Here, three Harvard University astrophysicists discuss radio and IR spectrum images using the WeSpace.



movie courtesy Daniel Wigdor, taken at MERL, Kendall Square, Cambridge, 2007

Viz-e-lab

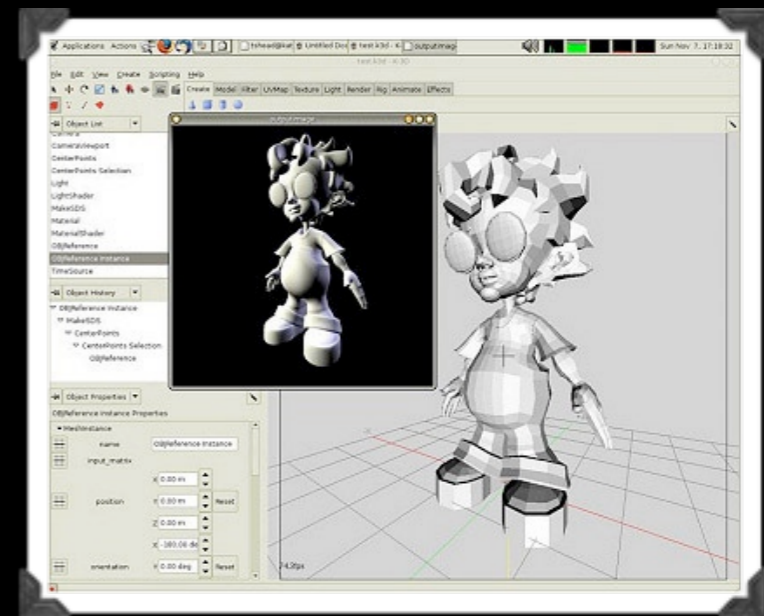
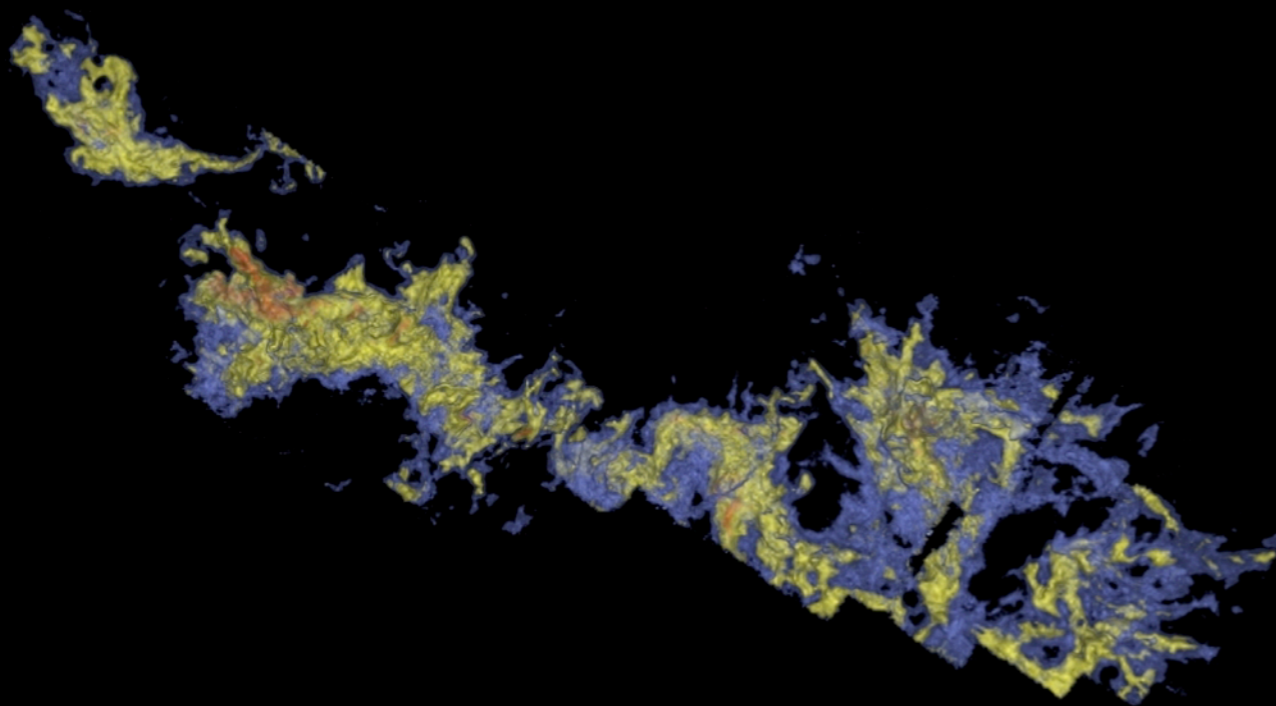


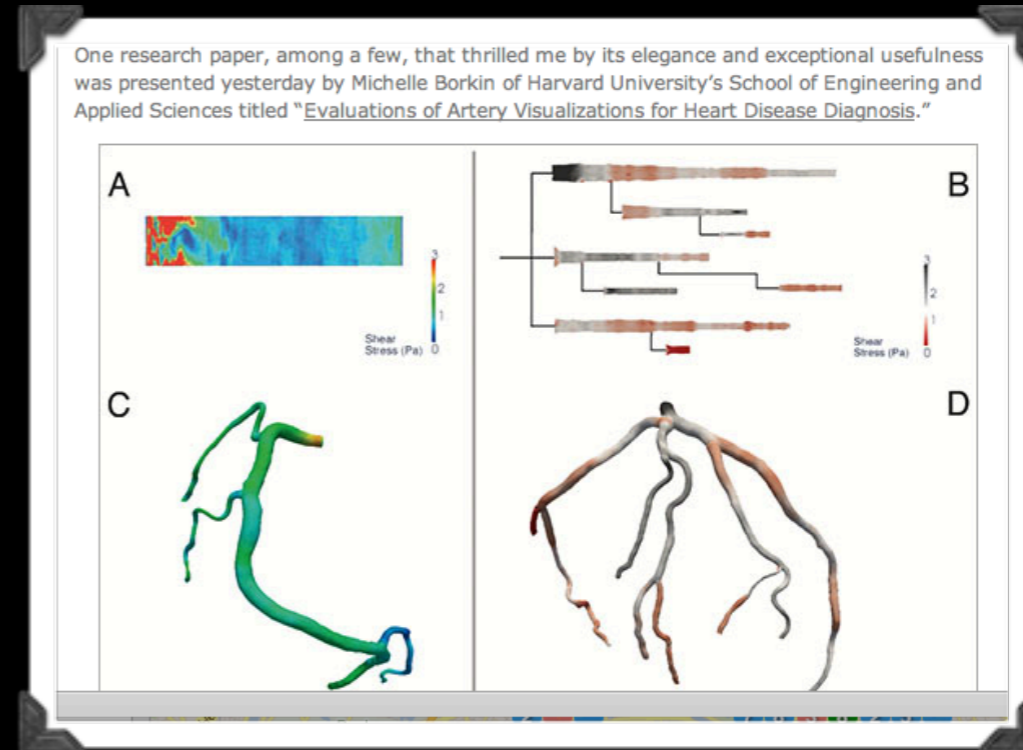
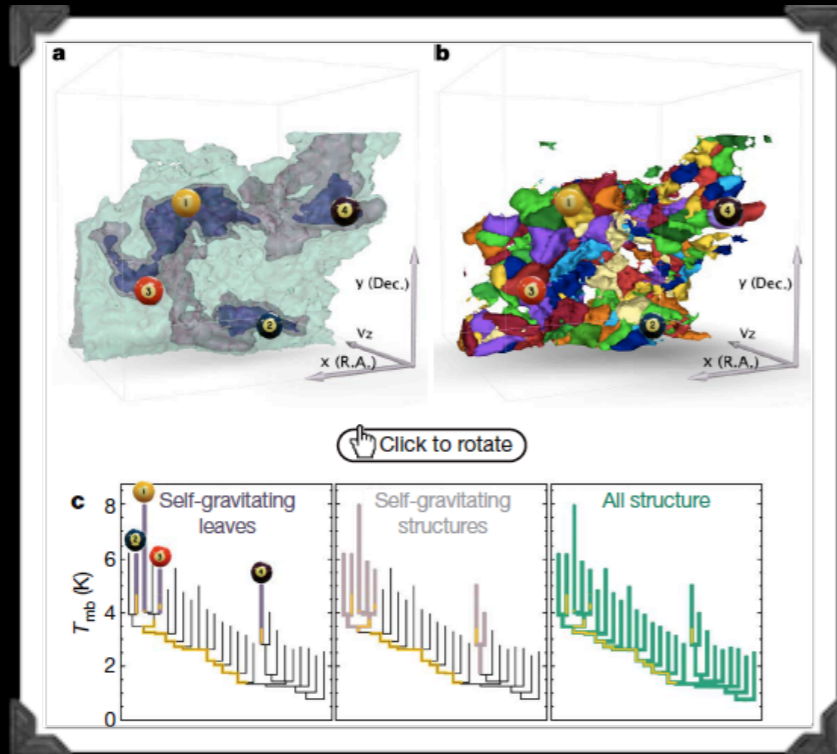


What's the **3D** “magnetic lasso”?

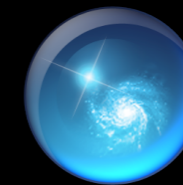
How do you use it with a mouse?

How can a human “steer” computer-aided selection?





Viz-e-lab



SEAMLESS ASTRONOMY
Linking scientific data, publications, and communities

ABOUT PROJECTS PEOPLE RESOURCES DATAVERSE

SEAMLESS ASTRONOMY

About

Data **Literature**

The Seamless Astronomy Group at the Harvard-Smithsonian Center for Astrophysics brings together astronomers, computer scientists, information scientists, librarians and visualization experts involved in the development of tools and systems to study and enable the next generation of online astronomical research.

Current projects include research on the development of systems that seamlessly integrate scientific data and literature, the semantic interlinking and annotation of scientific resources, the study of the impact of social media and networking sites on scientific dissemination, and the analysis and visualization of astronomical research communities. Visit our [project page](#) to find out more.

Latest Announcements

Introducing the Astronomy Dataverse

Latest Feed Items

@rahuldave there is a writeboard with my notes... More at next #seamlessastronomy next week.

Thanks to @astrobits and @astroknight06 for great summary <http://t.co/JWFTOCD> of our High-D Data Viz work! #ivox #seamlessastronomy

glue
multidimensional data exploration

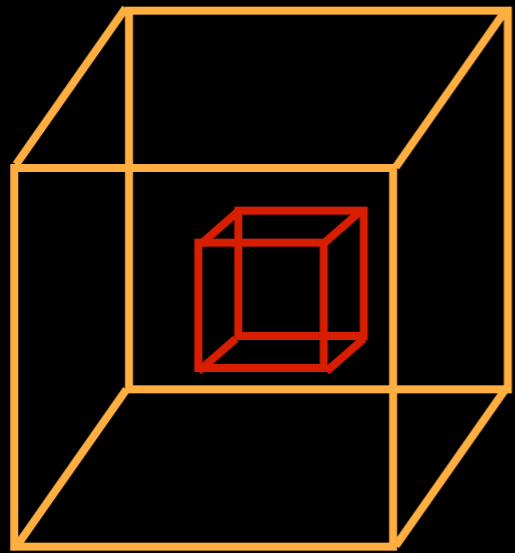
"Linked Views"

*Contextual,
High-Dimensional
View*

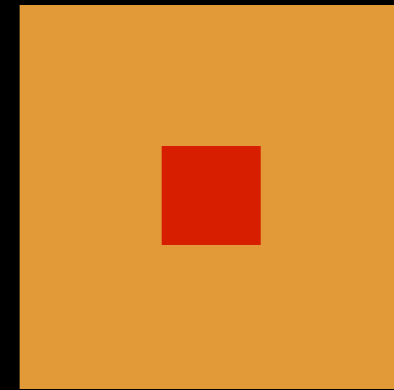
Link

*Flat,
Text-Based
View*

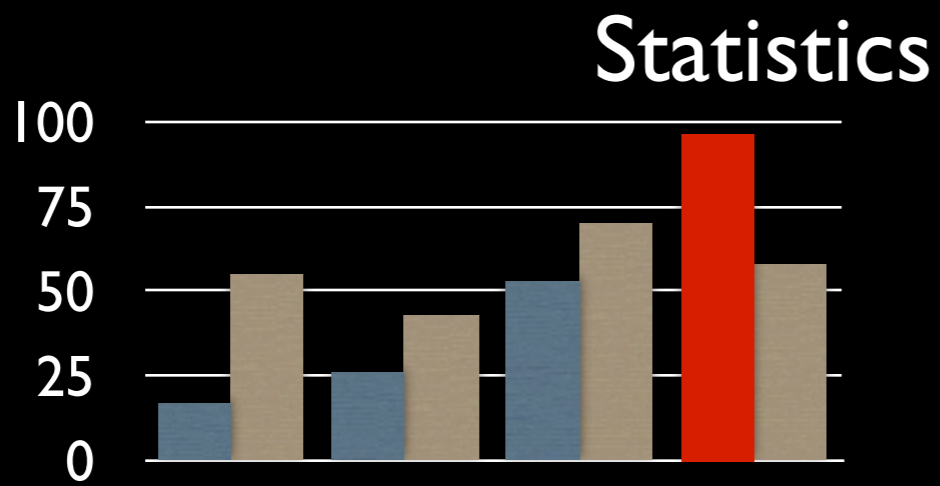
"Linked Views"



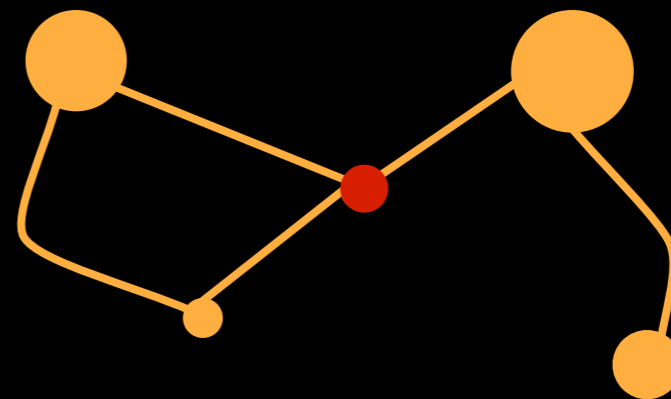
3D



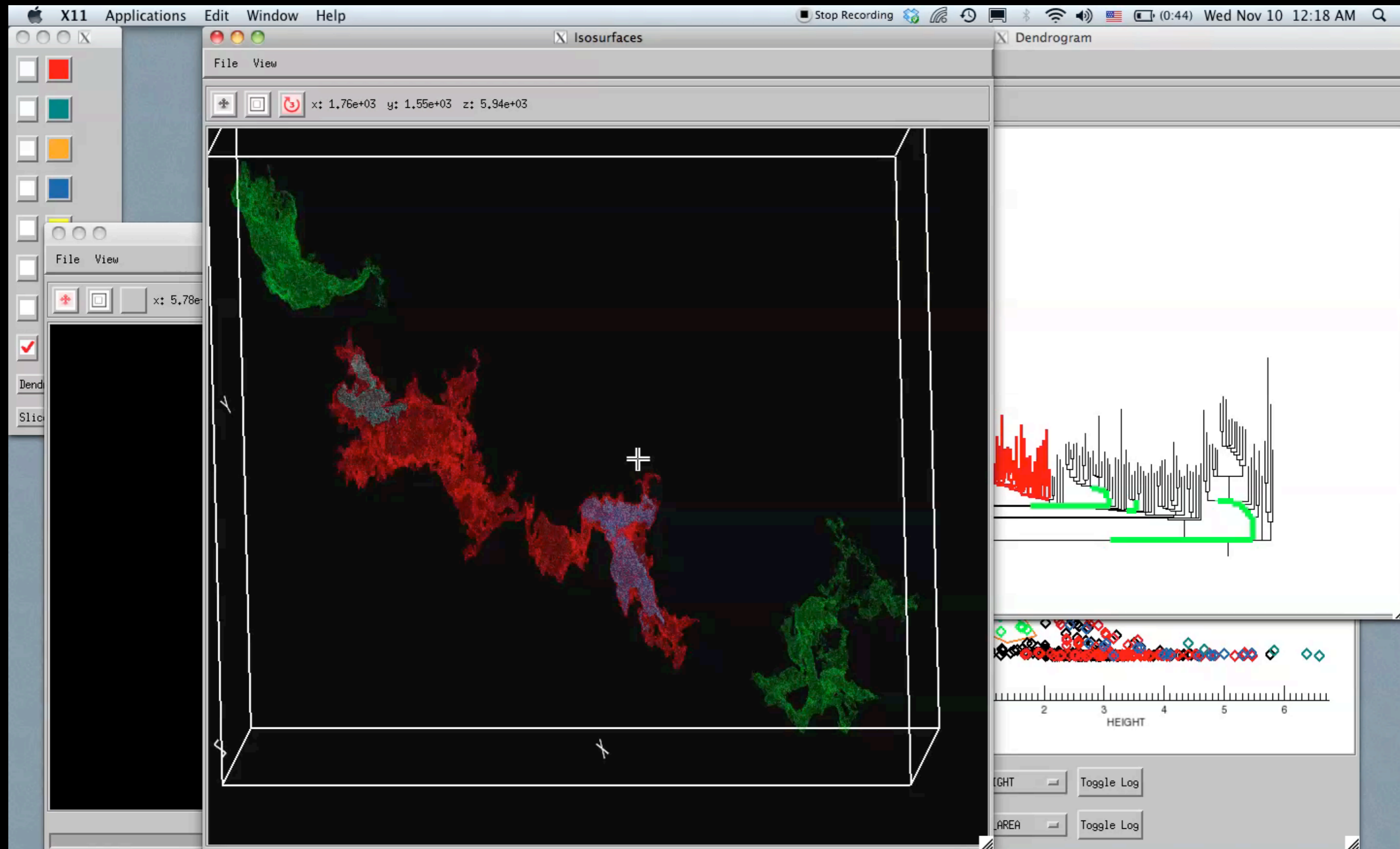
2D



Data Abstraction

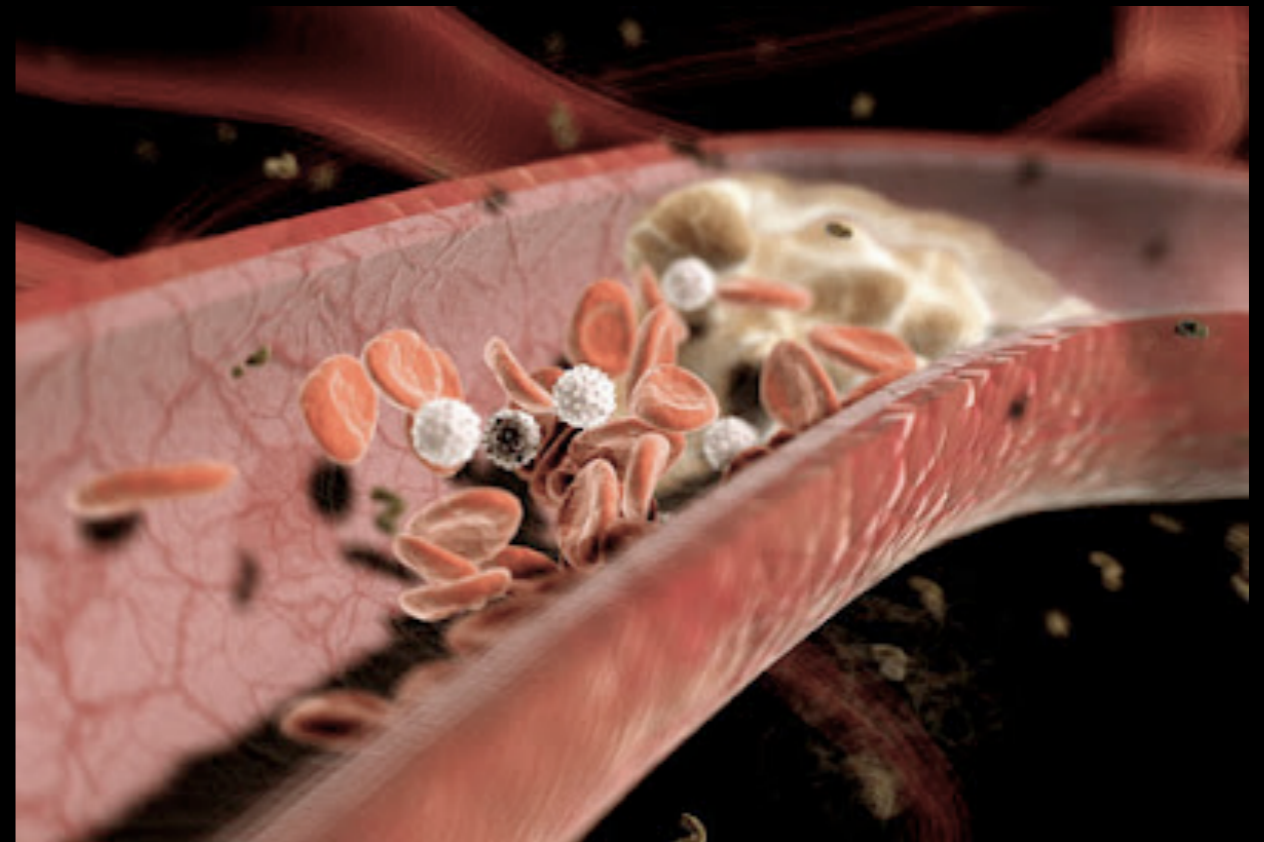


Linked Views



Video & implementation: Christopher **Beaumont**, CfA/UHawaii;
inspired by AstroMed work of Douglas Alan, Michelle Borkin, AG, Michael Halle, Erik Rosolowsky

The (Medical) Value of Linked Views...



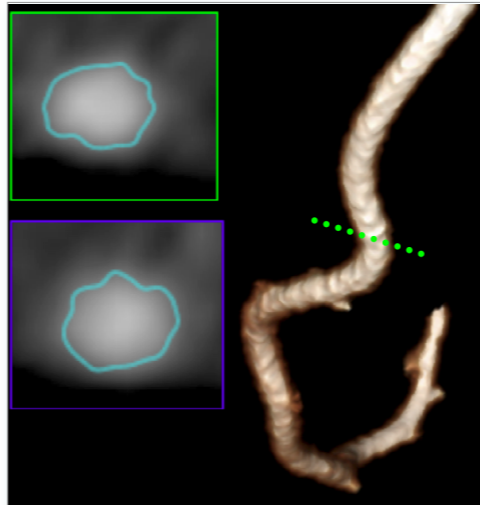
Michelle Borkin

*Harvard School of Engineering & Applied Science Ph.D. student,
supervised by Alyssa Goodman (Astronomer) & Hanspeter Pfister (Computer Scientist)*

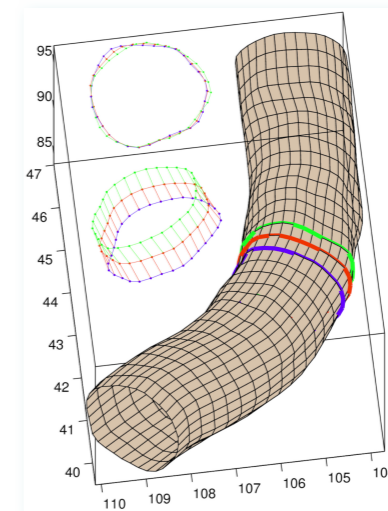
Patients Troubled Hearts, in 3D



Obtain patient CT data



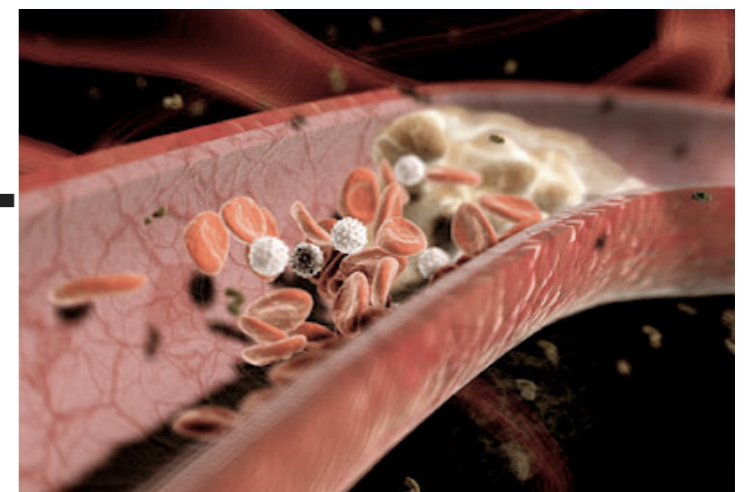
Segment arteries



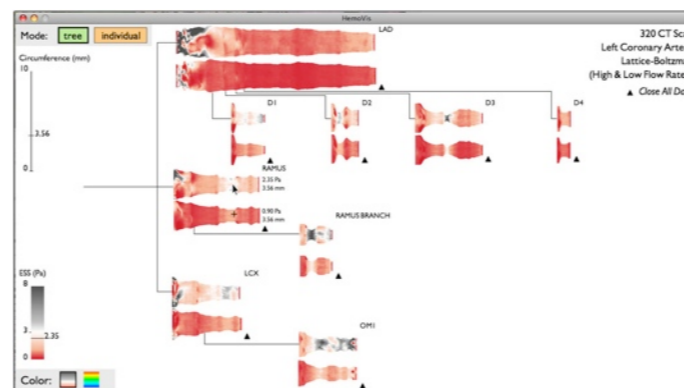
Generate patient geometries



Patient specific flow simulation



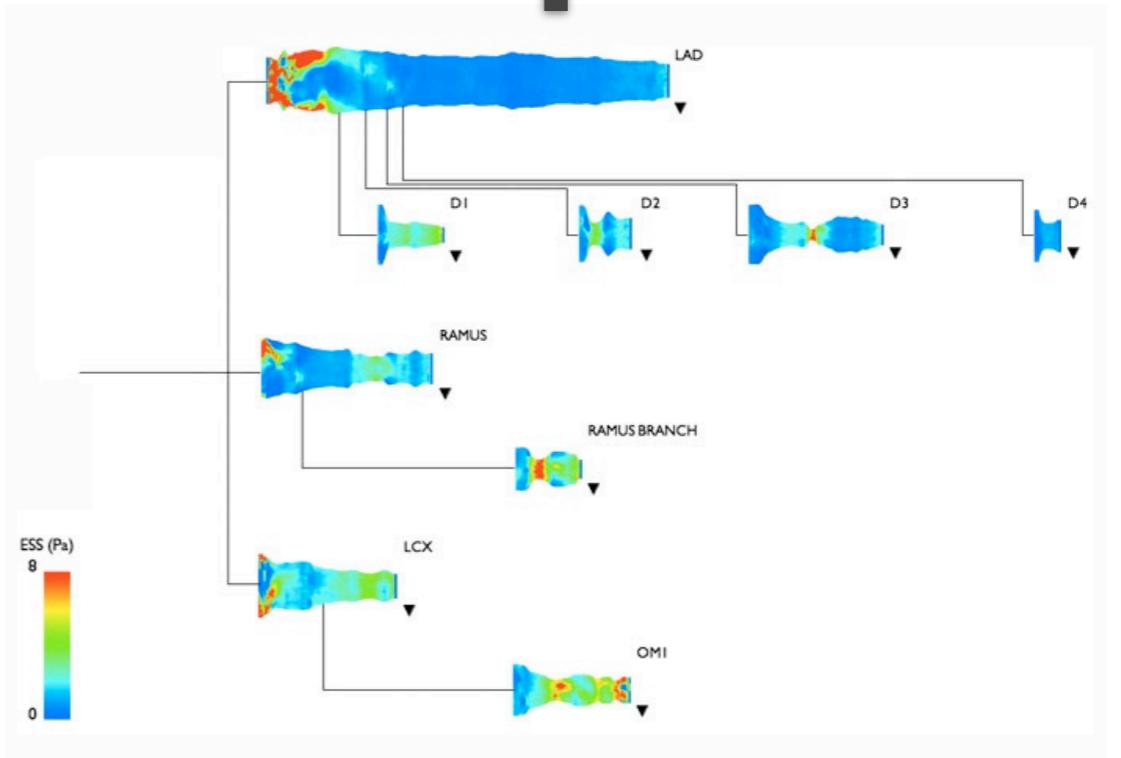
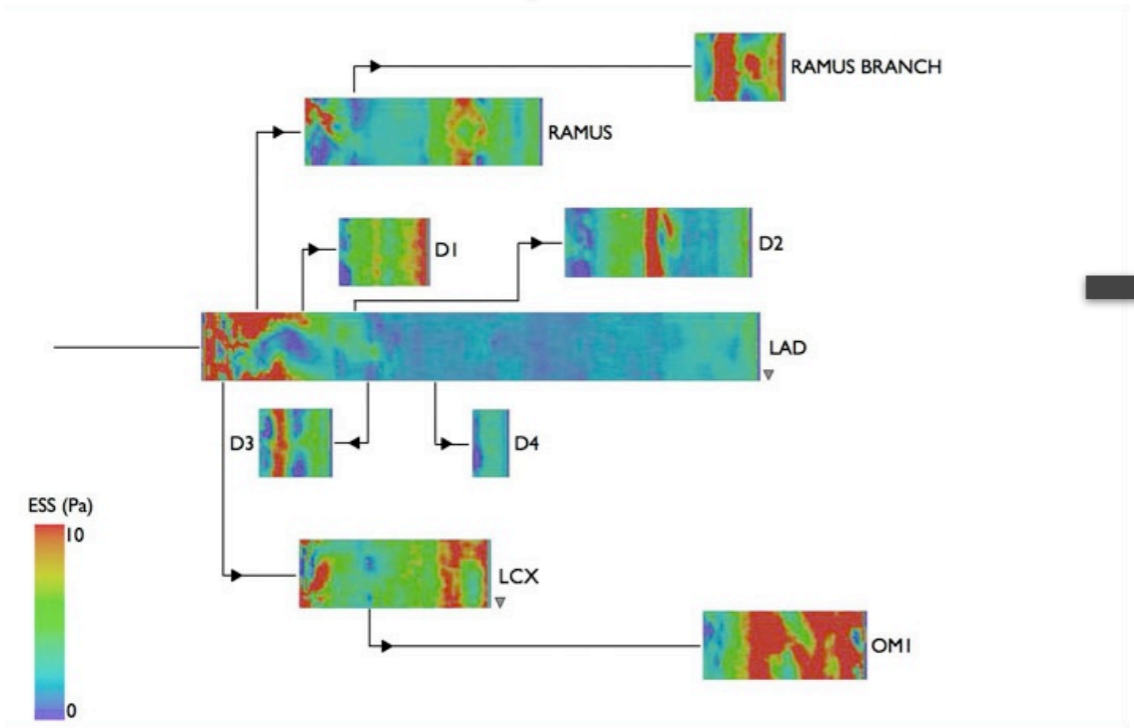
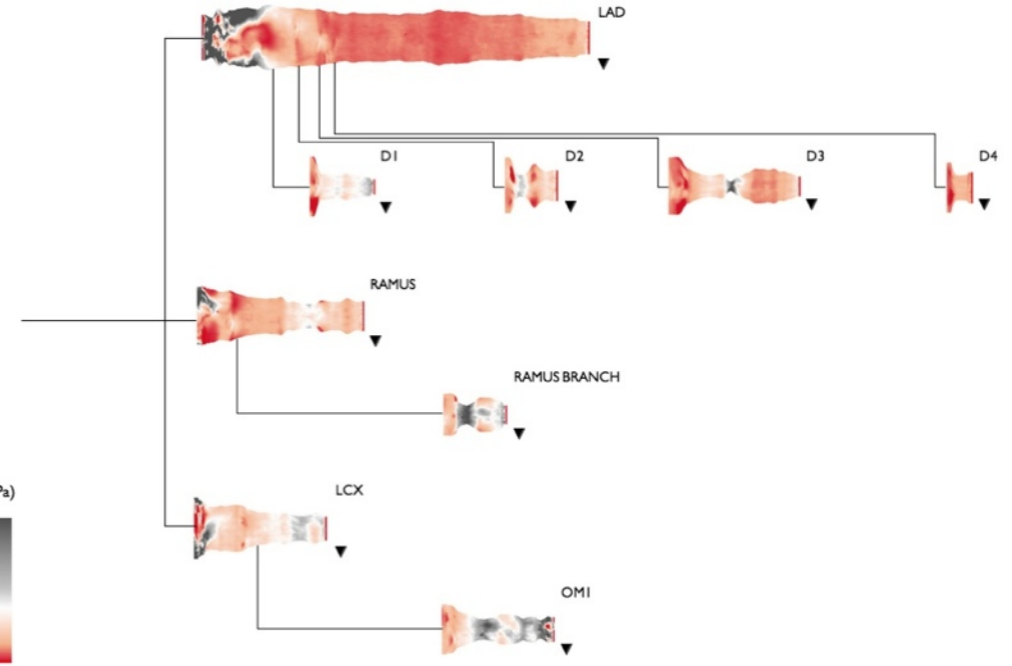
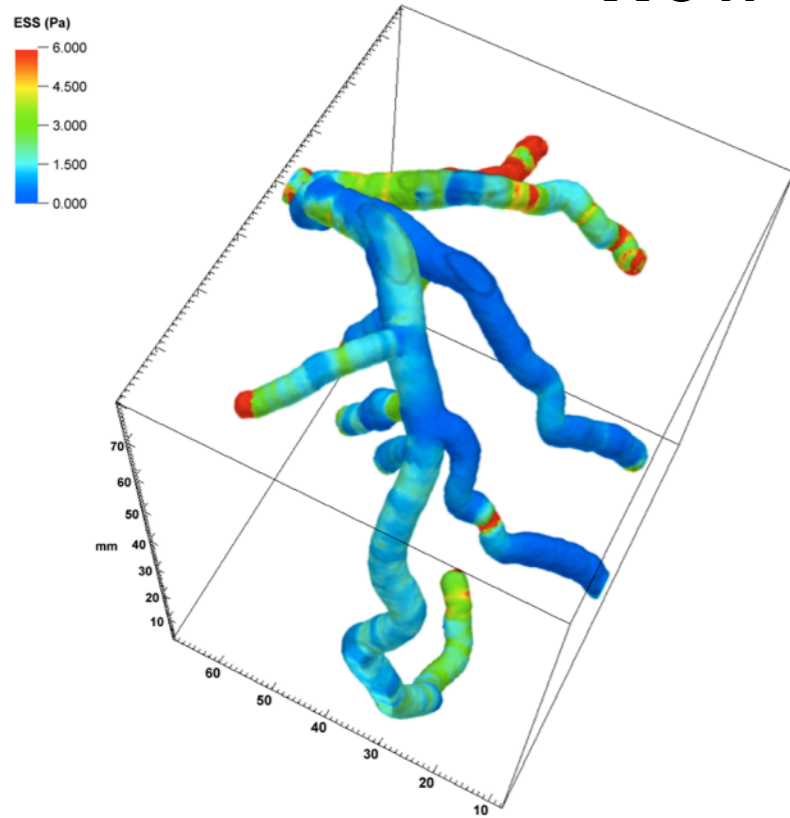
Visualize/analyze data



Clinical decision



How much does viz matter?



ACCURACY

Strong effect of **dimensionality** on accuracy

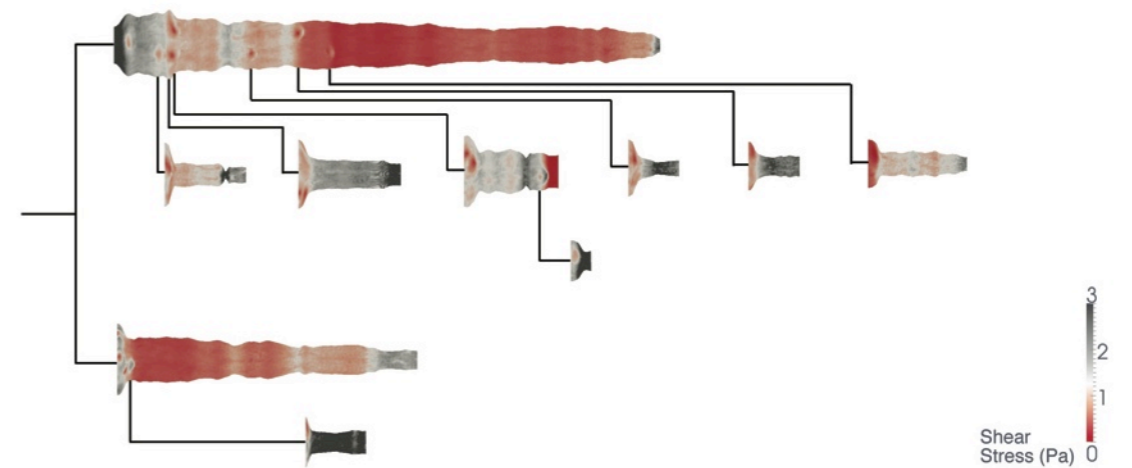
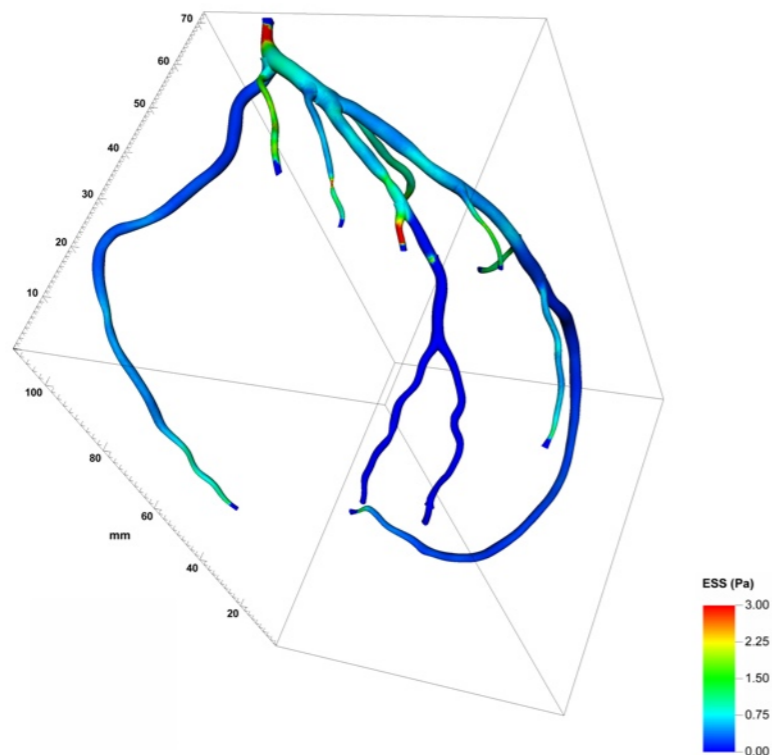
And strong effect of **color**...

39%

percent low ESS regions found

62%

91%



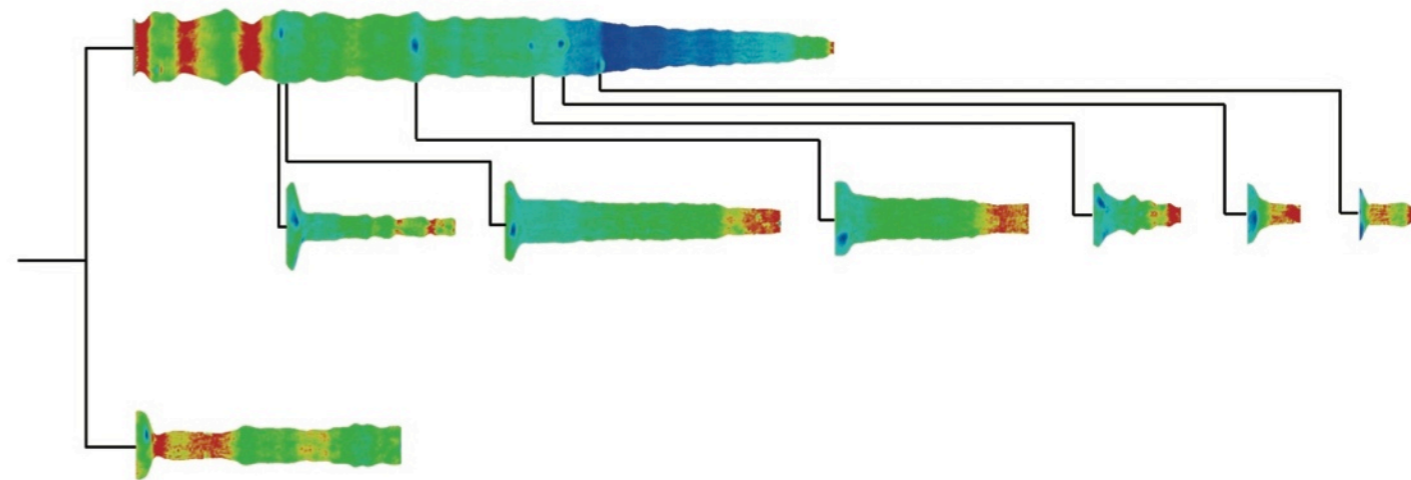
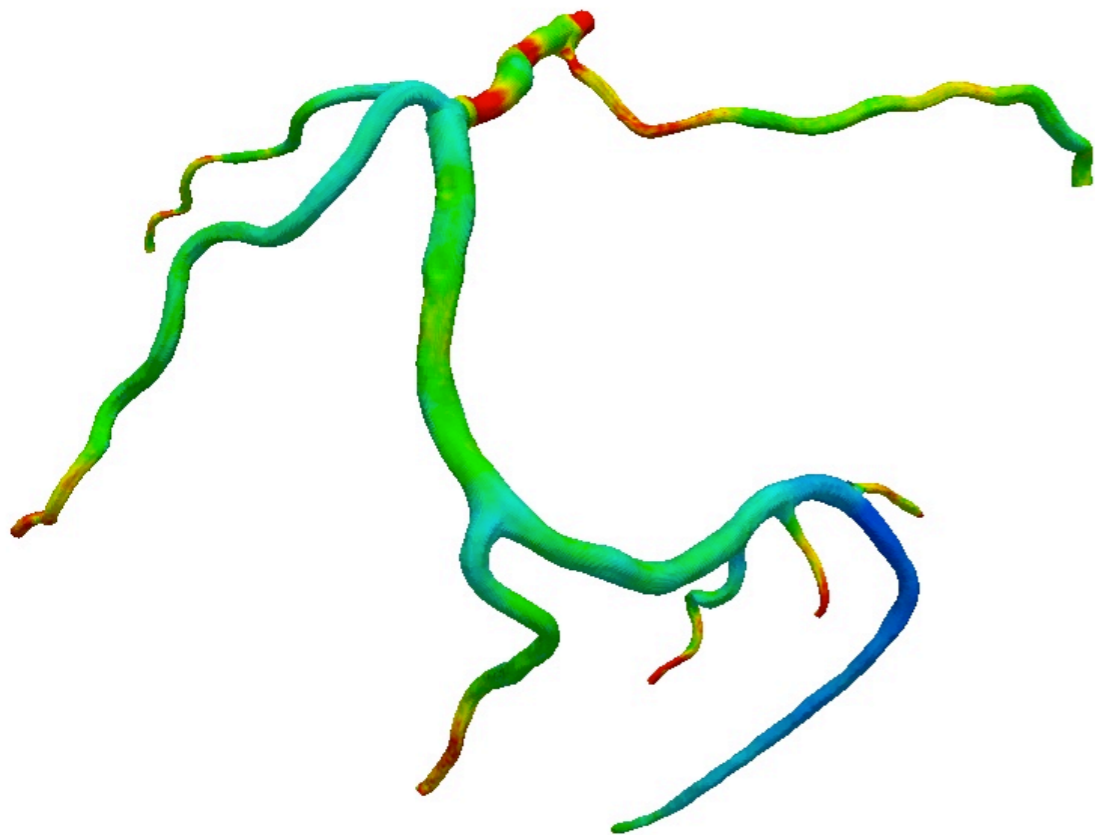
EFFICIENCY

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

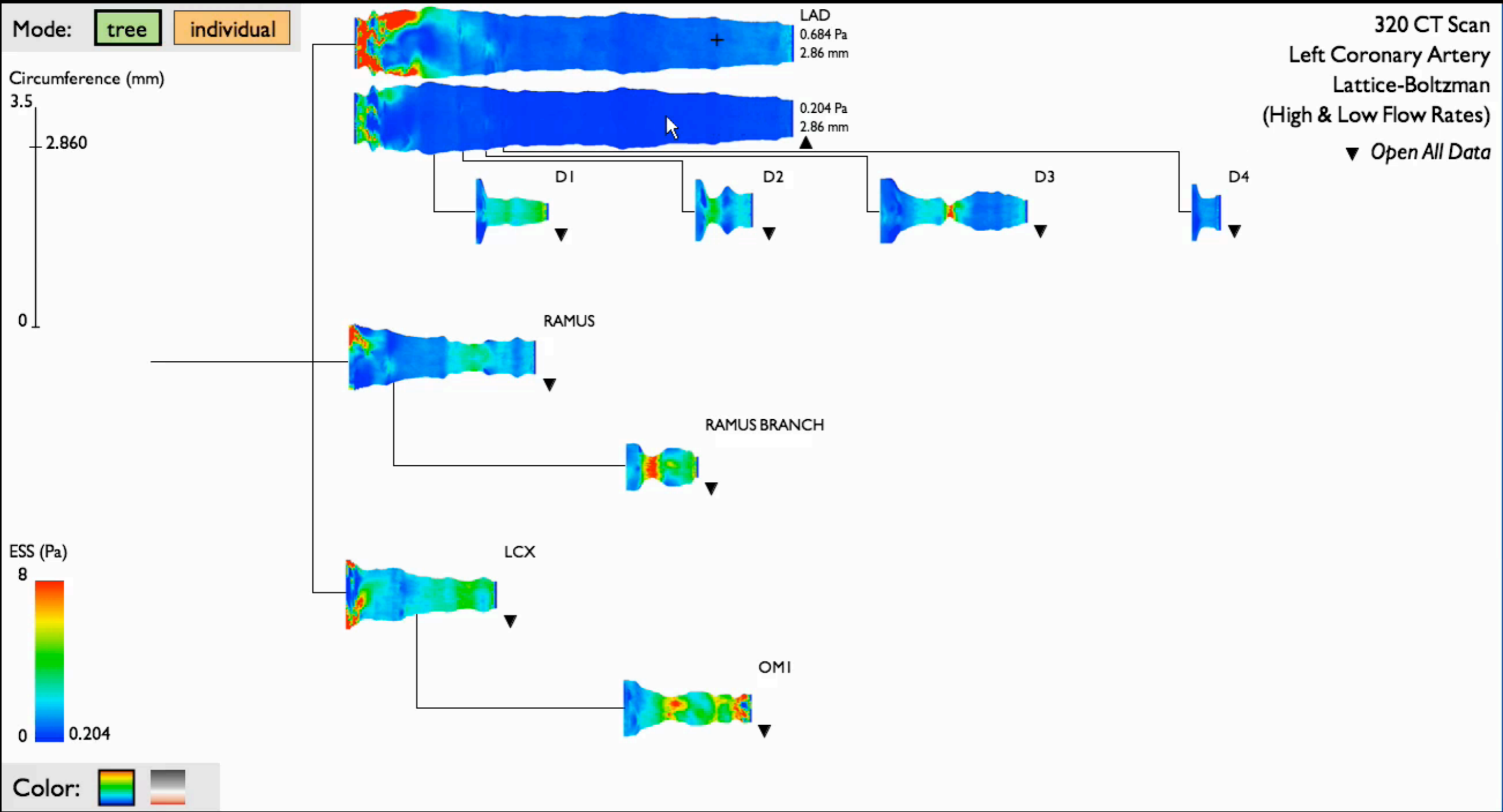
Rainbow color map has greater detriment in 3D.

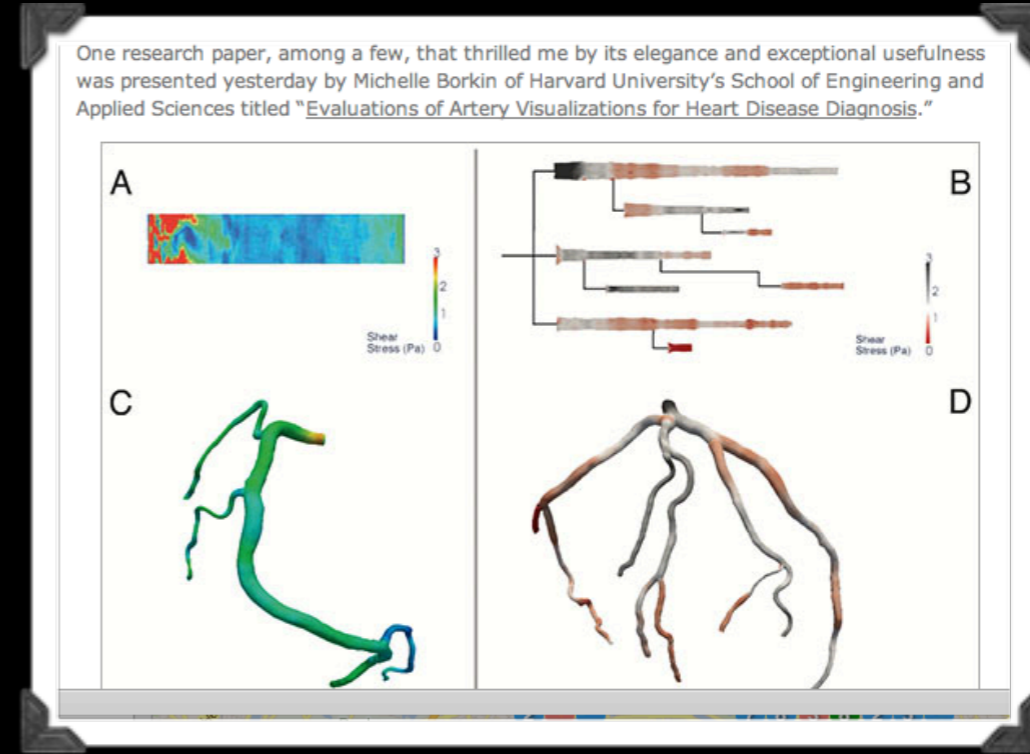
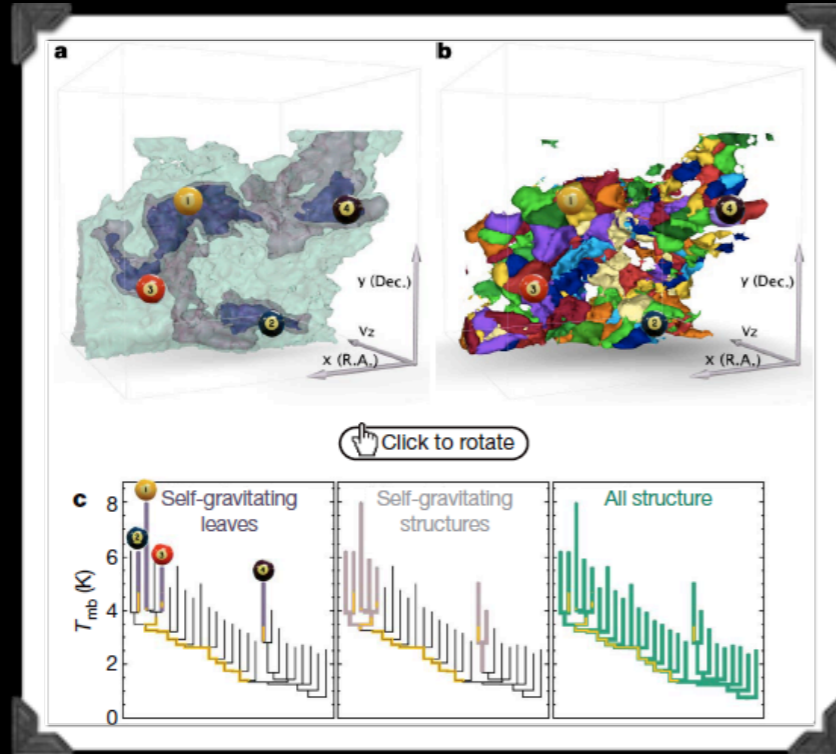
10.2 sec/region
5.6 sec/region

2.6 sec/region
2.4 sec/region

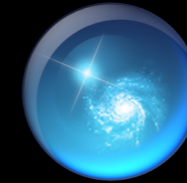


BUT—3D still essential for surgical planning.





Viz-e-lab



SEAMLESS ASTRONOMY
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ABOUT PROJECTS PEOPLE RESOURCES DATAVERSE

SEAMLESS ASTRONOMY

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Data **Researcher** **Literature**

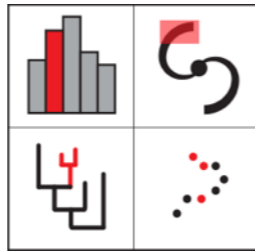
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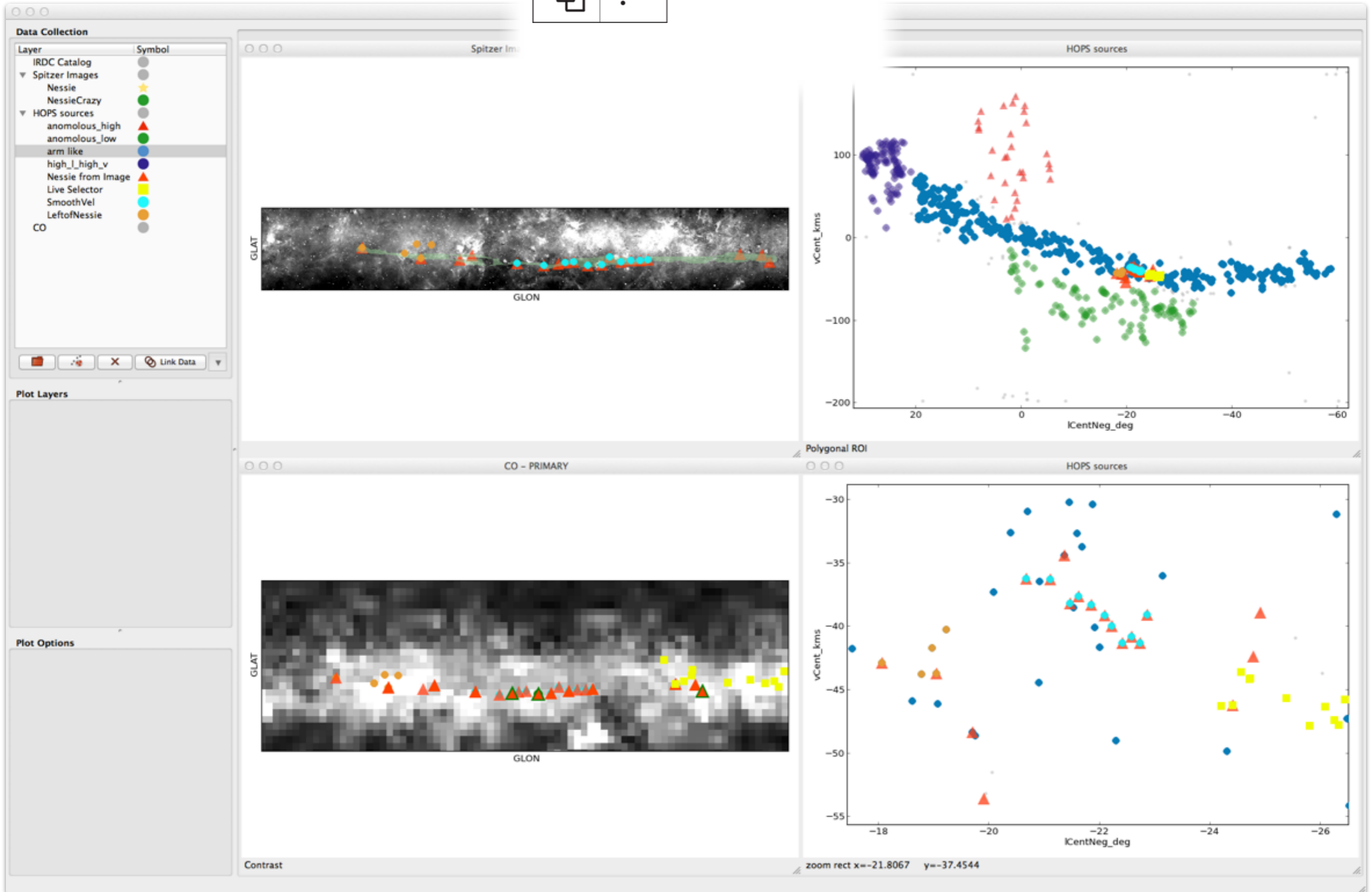
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glue
multidimensional data exploration



glue


multidimensional data exploration



Glue collaboration: **Beaumont**, Borkin, Goodman, Pfister, Robitaille

What is glue?

Glue 0.1 documentation > next index



Glue Documentation

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Glue Documentation
Indices and tables

Next topic
Installing Glue

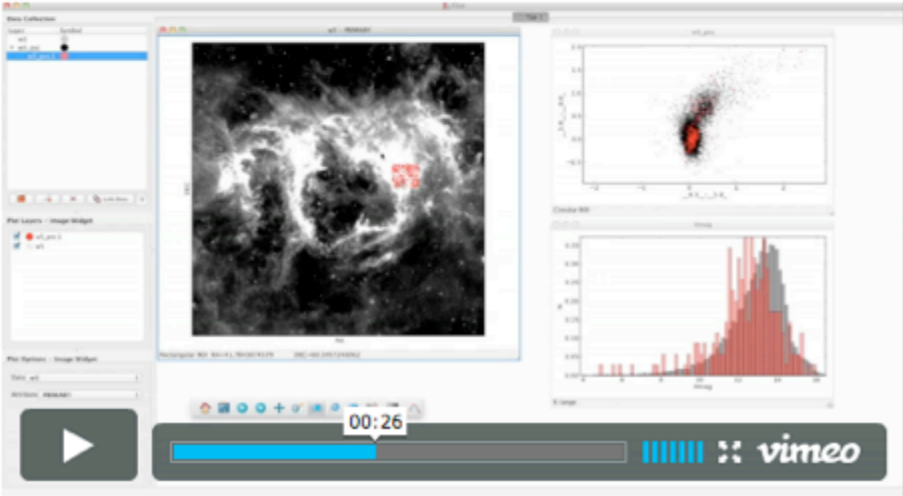
This Page
Show Source
Show on GitHub
Edit on GitHub

Quick search

Enter search terms or a module, class or function name.

Glue is a Python library to explore relationships within and among related datasets. Its main features include:

- **Linked Statistical Graphics.** With Glue, users can create scatter plots, histograms and images (2D and 3D) of their data. Glue is focused on the brushing and linking paradigm, where selections in any graph propagate to all others.
- **Flexible linking across data.** Glue uses the logical links that exist between different data sets to overlay visualizations of different data, and to propagate selections across data sets. These links are specified by the user, and are arbitrarily flexible.
- **Full scripting capability.** Glue is written in Python, and built on top of its standard scientific libraries (i.e., Numpy, Matplotlib, Scipy). Users can easily integrate their own python code for data input, cleaning, and analysis.



[the film!]

What...

...is easier now than before?

fast computation, animation, 3D

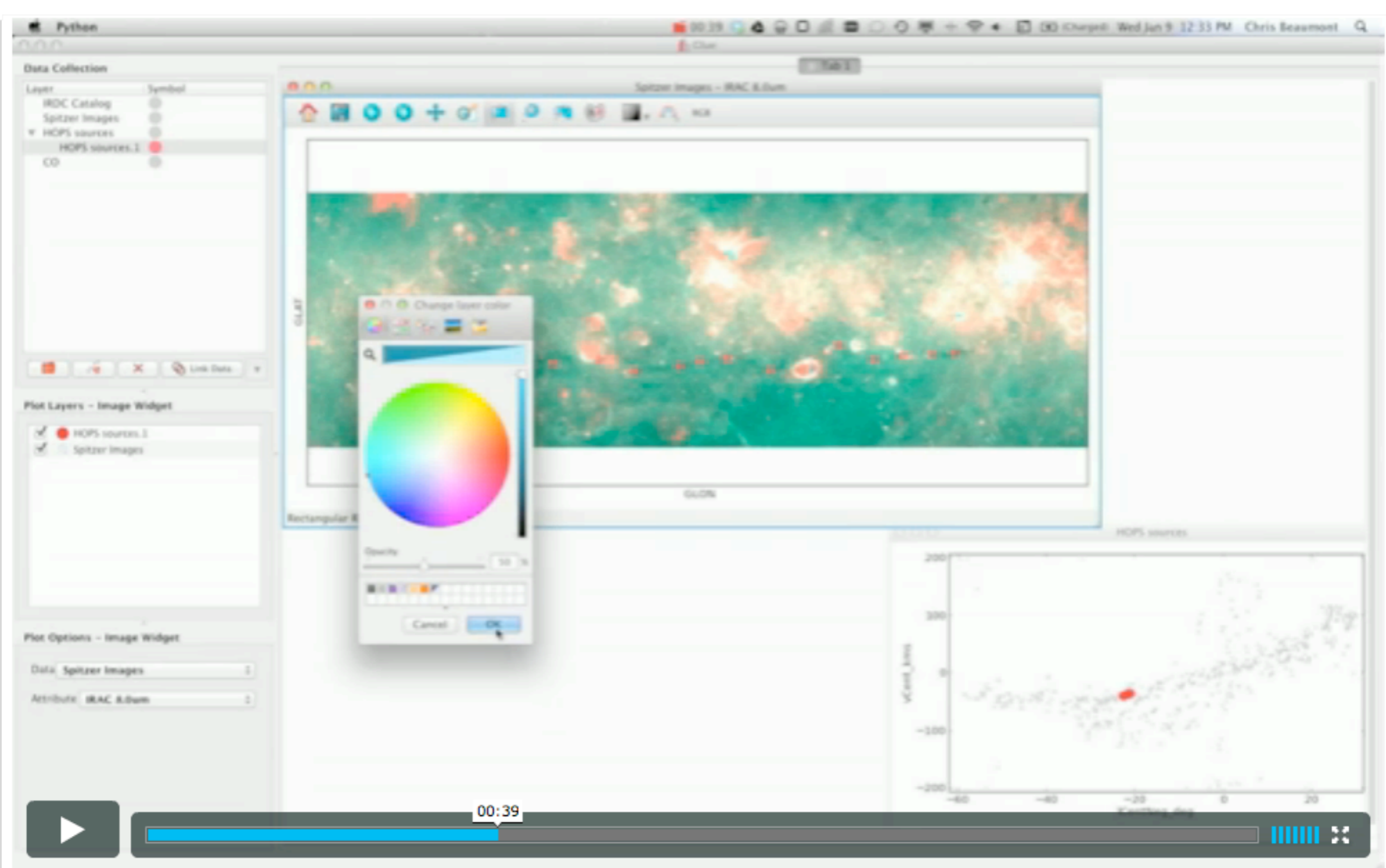
...was easier before than now?

craftsmanship

...should be easier in the future?

modular craftsmanship, linked views

“modular craftsmanship, linked views”

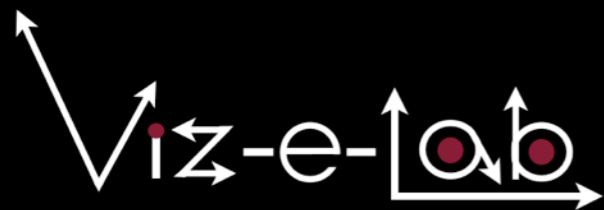


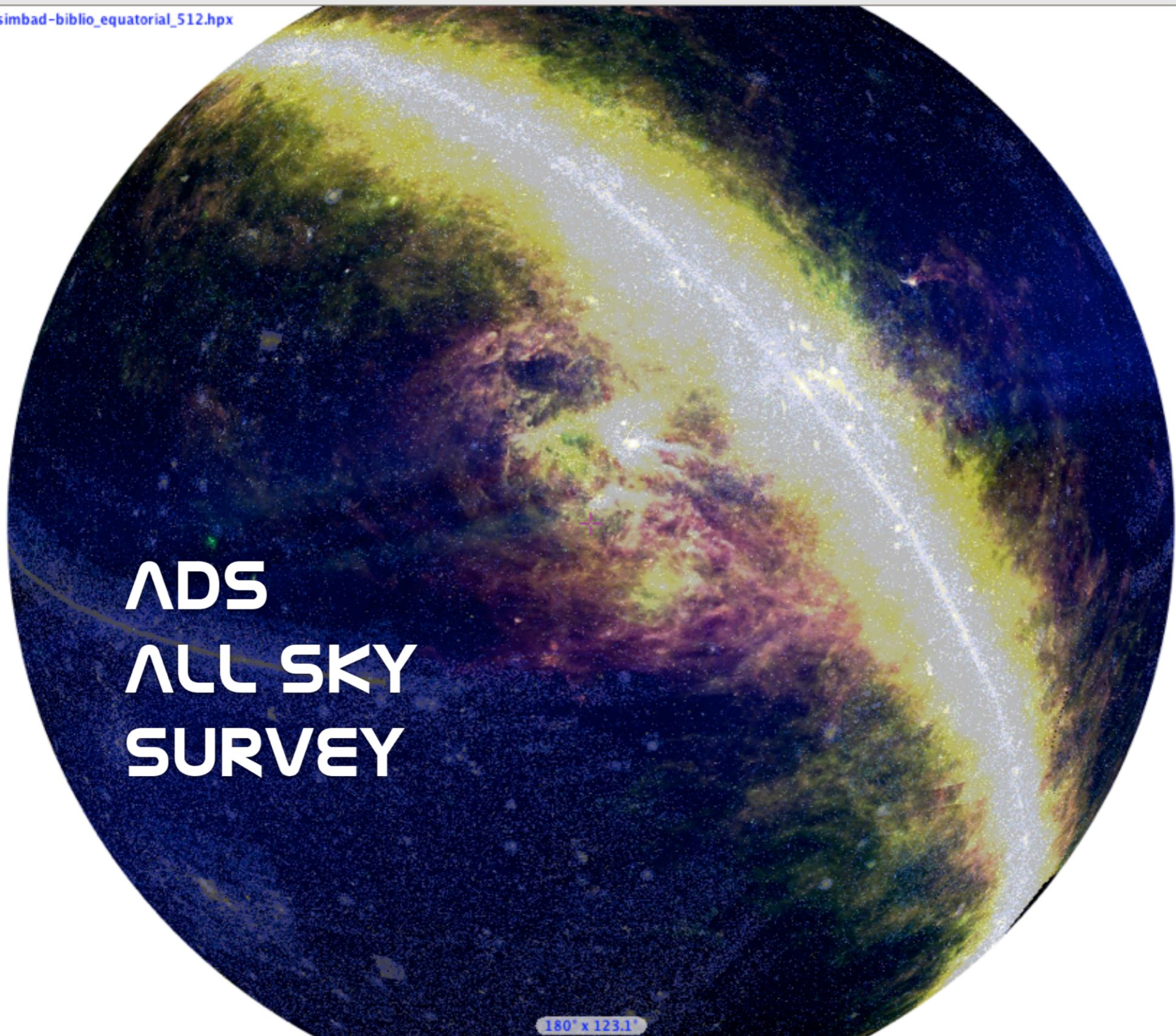
The screenshot displays a video player interface. The main content is a software window titled "Python" showing a data analysis application. On the left, a "Data Collection" panel lists layers: "IRDC Catalog", "Spitzer Images", "HOPS sources", "HOPS sources.1", and "CO". Below this is a "Plot Layers - Image Widget" section with checkboxes for "HOPS sources.1" and "Spitzer Images". Further down is a "Plot Options - Image Widget" section with dropdowns for "Data: Spitzer Images" and "Attribute: IRAC_8.0um". The central area features a large image plot titled "Spitzer Images - IRAC 8.0um" showing a colorful astronomical field. A "Change layer color" dialog box is open over the image, showing a color wheel and a "Density" slider. To the right of the image plot is a scatter plot titled "HOPS sources" with axes labeled "Vcent_kms" and "Position_deg". At the bottom of the video player, there is a play button, a progress bar at 00:39, and a volume icon. Below the video player, the video title "Glue Demo: World Wide Telescope" is displayed, along with the creator's name "Chris Beaumont", the upload time "1 month ago", and a "NOT YET RATED" badge.

Glue Demo: World Wide Telescope
from **Chris Beaumont** 1 month ago NOT YET RATED

<http://vimeo.com/57078802>

The Art of Numbers Data Visualization in the 21st Century





ADS ALL SKY SURVEY

180° x 123.1°

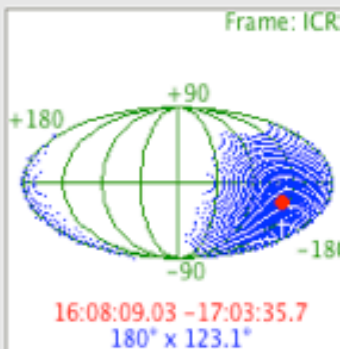
- select
- pan
- zoom
- dist
- phot
- draw
- tag
- filter
- cross
- rgb
- assoc
- crop
- cont
- mgls
- pixel
- prop
- del

IRAS-IRIS color

DSS colored

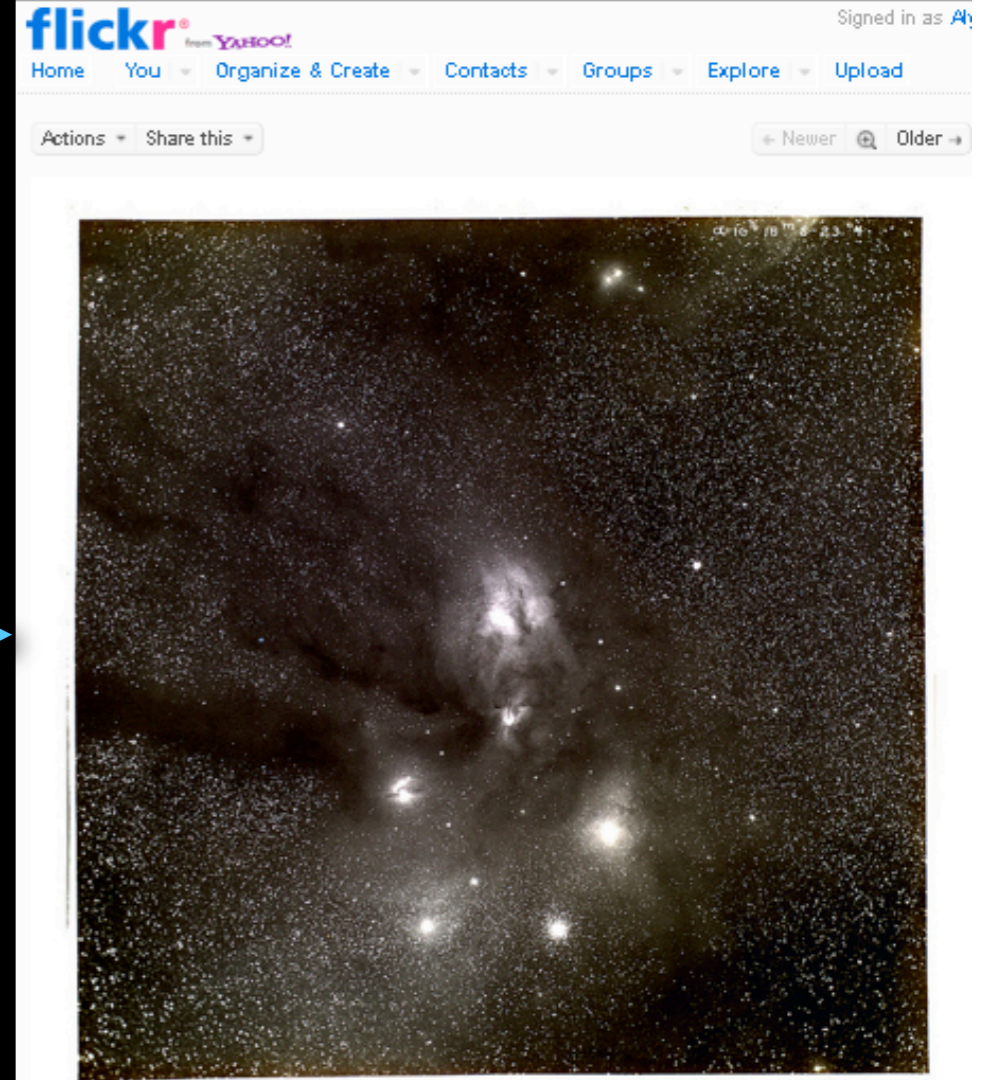
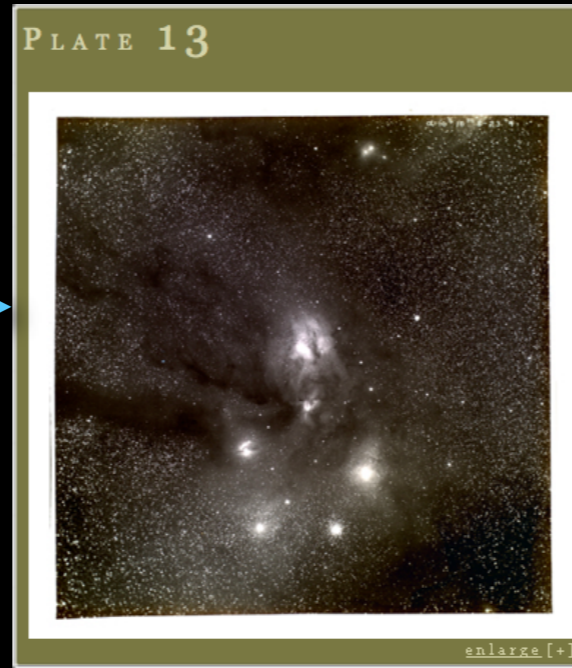
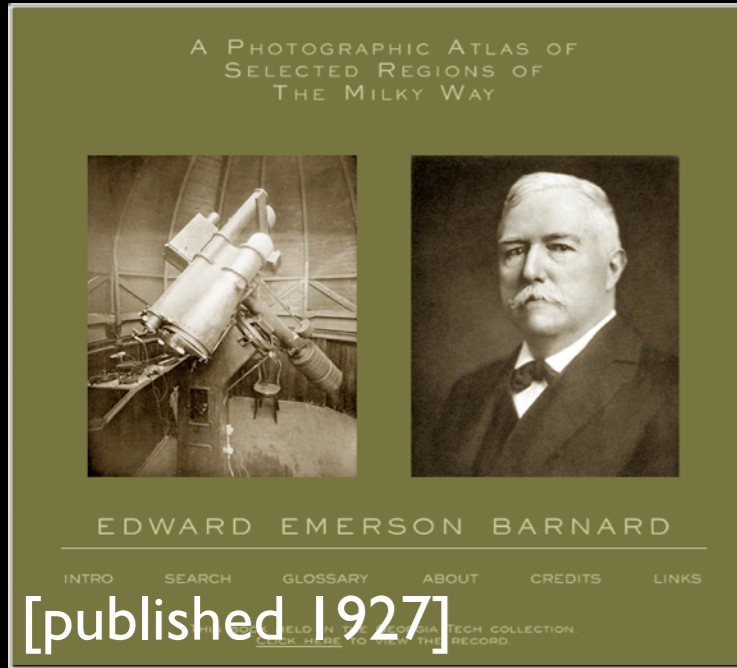
simbad-bibli

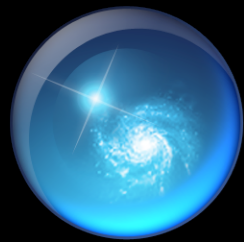
om 1/16x



ADSASS: History on the Sky

astrometry.net + flickr + WWT





Microsoft® Research WorldWide Telescope



Experience WWT at worldwidetelescope.org

The screenshot displays the WWT interface with a top navigation bar containing 'Explore', 'Guided Tours', 'Search', 'View', and 'Settings'. Below this is a 'Collections > All-Sky Surveys >' section with thumbnails for 'Digitized Sky Survey', 'VLSS: VLA Low-fre', 'WMAP ILC 5-Year', 'SFD Dust Map (Inf', 'IRIS: Improved Re', '2MASS: Two Micro', and 'Hydrogen Alpha Fu'. The main view shows a large galaxy with a 'Finder Scope' overlay. A 'Context bar' at the bottom shows 'NGC221' and 'M31'. A 'Context globe' on the right shows the current field of view. A 'Look At' dropdown is set to 'Sky', and a 'Look At' panel shows 'Andromeda' selected. A 'Finder Scope' window is open, displaying details for 'NGC224'.

Seamlessly explore imagery from the best ground and space-based telescopes in the world

Expert led tours of the Universe

Control time to study how the night sky changes

View and compare images from across the electromagnetic spectrum

Much more than "just" the sky at night! 3D features can take you to other planets, stars & galaxies.

Finder Scope links to Wikipedia, publications, and data, so you can learn more

Context bar shows items of interest in current field of view

Context globe shows where you're looking.

WorldWide Telescope Ambassadors



Upcoming Events

- [Dallin Elementary School Math & Science Night](#)
Mar. 28
- [Cambridge Science Festival Carnival](#)
Apr. 13
- [Cambridge Explores the Universe](#)
Apr. 20
- [Clarke Middle School, Lexington, MA](#)
Apr. 22 - May. 31

Explore WWT through hands-on demos at AAAS Family Science Days

Submitted by patudom on Feb. 15



WWT Ambassadors hosted a booth at the [AAAS Family Science Days](#) event in Boston. Many thanks to WWT Ambassadors Moha Azimlu, Zach Berta, Hope Chen, Ana Constantin, Chris Faesi, Jonathan Jackson, & Erin Lotridge for helping to make the WWT booth a great success!

This was a free event, open to the public.

Where: Hynes Convention Center, Boston

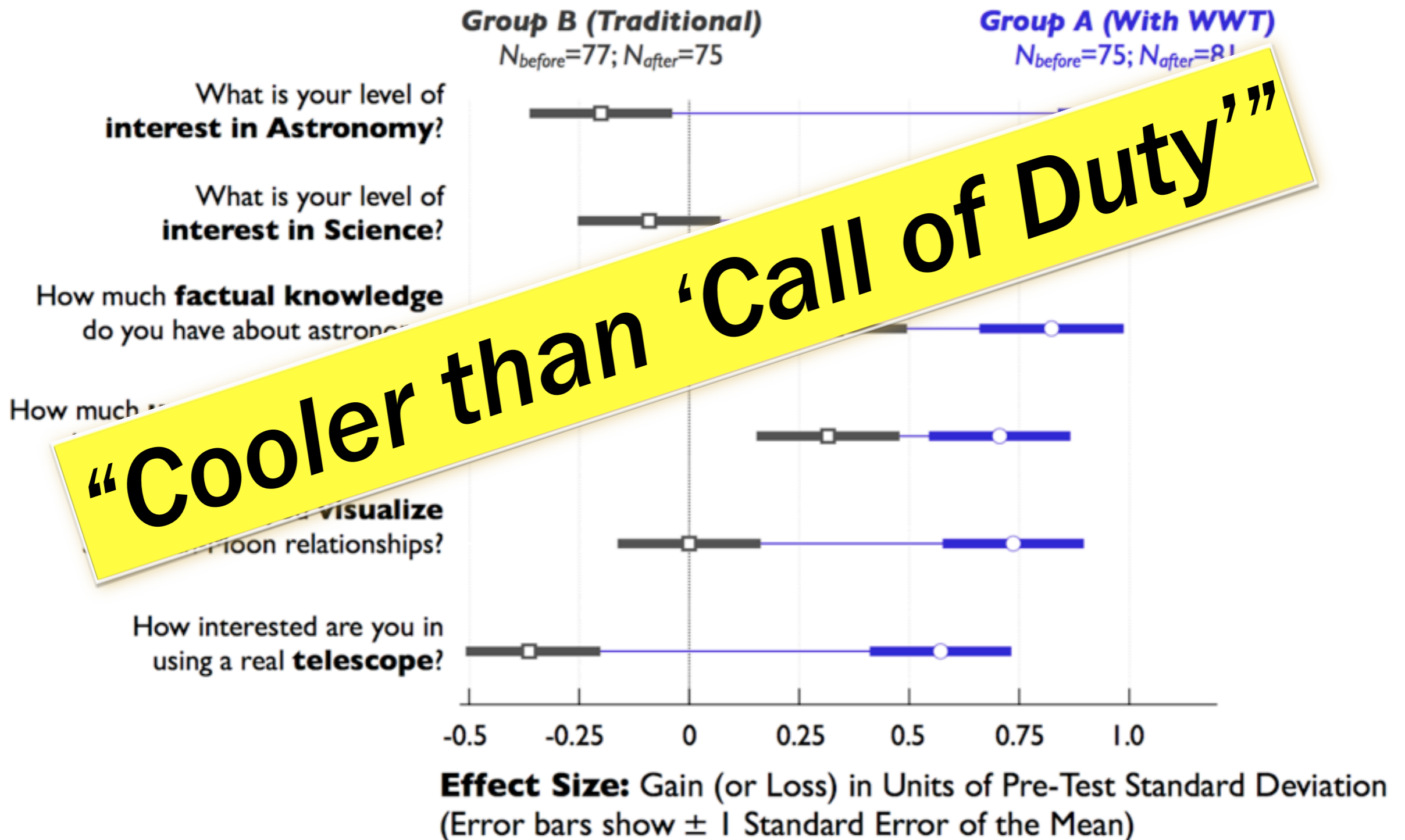
When: Saturday and Sunday, 2/16-2/17, 11am-5pm both days

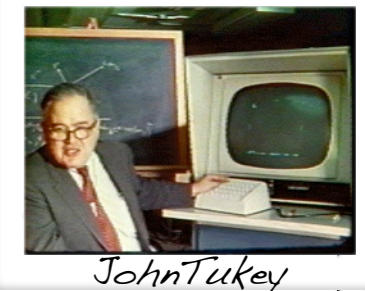
Login or register to post comments Read more

wwtambassadors.org



Gains in Student Interest and Understanding ("Traditional Way" vs "WWT Way")





Principles of high-dimensional data visualization in astronomy

A.A. Goodman*

Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA

Received 2012 May 3, accepted 2012 May 4

Published online 2012 Jun 15

Key words cosmology: large-scale structure – ISM: clouds – methods: data analysis – techniques: image processing – techniques: radial velocities

Astronomical researchers often think of analysis and visualization as separate tasks. In the case of high-dimensional data sets, though, interactive *exploratory data visualization* can give far more insight than an approach where data processing and statistical analysis are followed, rather than accompanied, by visualization. This paper attempts to chart a course toward “linked view” systems, where multiple views of high-dimensional data sets update live as a researcher selects, highlights, or otherwise manipulates, one of several open views. For example, imagine a researcher looking at a 3D volume visualization of simulated or observed data, and simultaneously viewing statistical displays of the data set’s properties (such as an x - y plot of temperature vs. velocity, or a histogram of vorticities). Then, imagine that when the researcher selects an interesting group of points in any one of these displays, that the same points become a highlighted subset in all other open displays. Selections can be graphical or algorithmic, and they can be combined, and saved. For tabular (ASCII) data, this kind of analysis has long been possible, even though it has been under-used in astronomy. The bigger issue for astronomy and other “high-dimensional” fields, though, is that no extant system allows for full integration of images and data cubes within a linked-view environment. The paper concludes its history and analysis of the present situation with suggestions that look toward cooperatively-developed open-source modular software as a way to create an evolving, flexible, high-dimensional, linked-view visualization environment useful in astrophysical research.