

worldwidetelescope.org

Big DATA

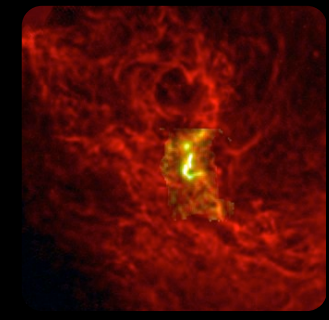
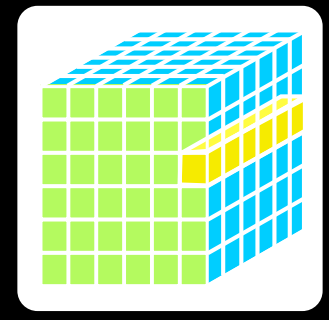
versus

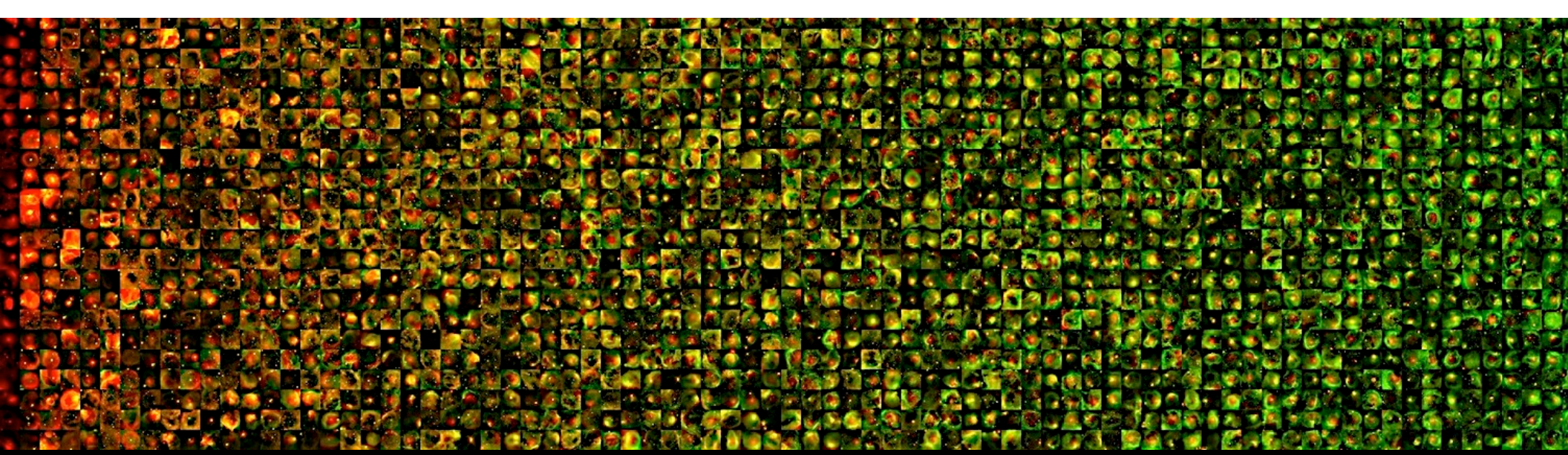
Wide DATA



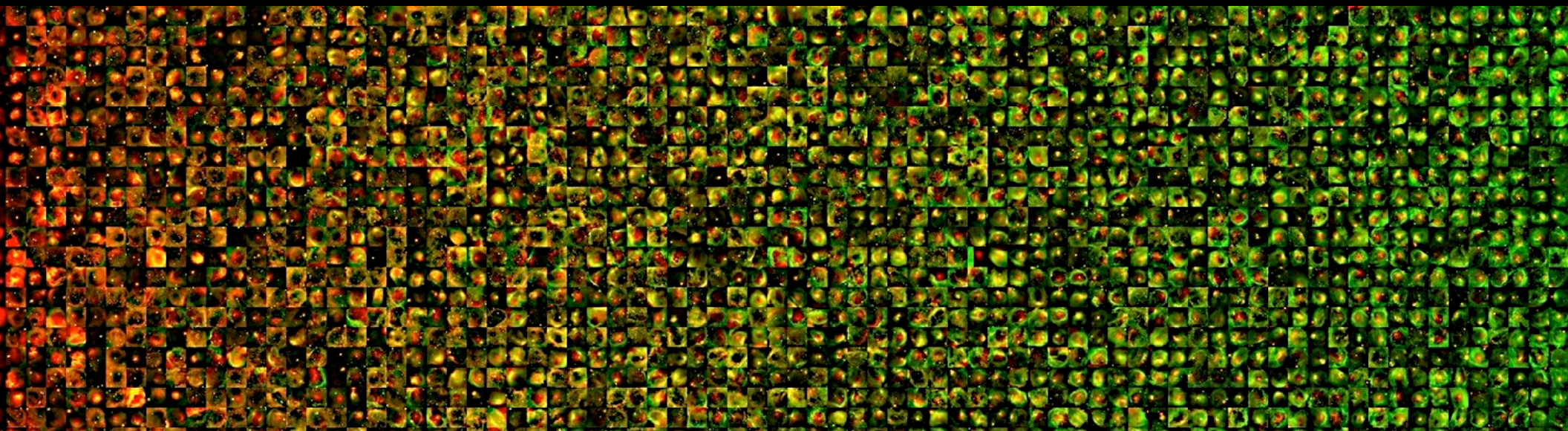
DATA SCIENCE TOOLS

RESOLUTION
CONTEXT
BIG DATA
WIDE DATA
DIMENSIONALITY
LINKED VIEWS
INTERACTION





BIG DATA, WIDE DATA



Use Layer Manager to Control User Settings



Name My Location

Lat 37:47:15 Alt 0 m

Lng -123:35:23

View From This Location

2015/02/11 04:40:33

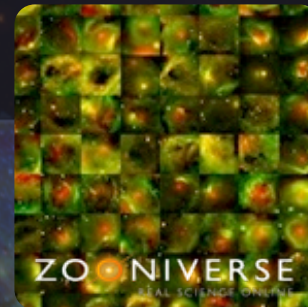
Real Time



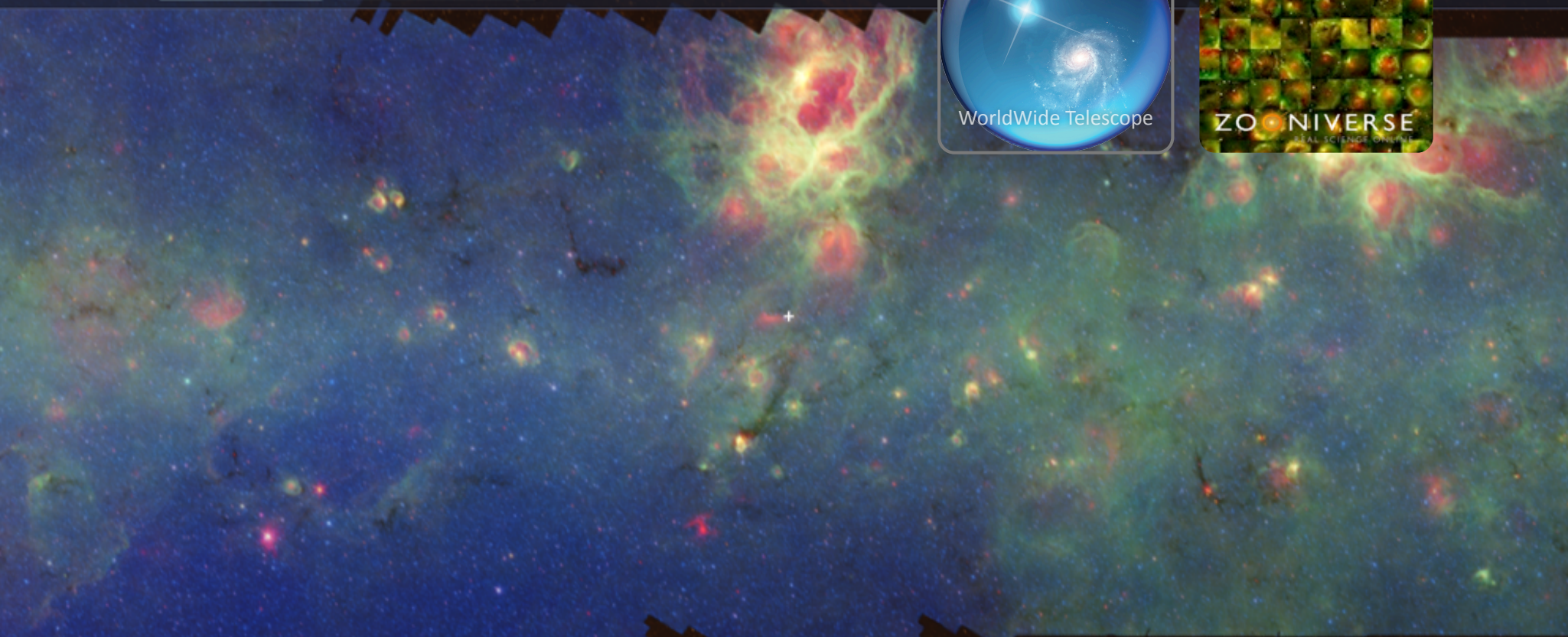
Galactic Plane Mode



WorldWide Telescope



ZOONIVERSE
REAL SCIENCE ONLINE



Look At: Sky Imagery: Digitized Sky Survey (Color) Image Crossfade: [Slider]

Tracking: GLIMPSE/MIPSGAL 1 of 3

Scorpius 03:10:14

RA: 17h28m14s

- Pismis 24 and
- NGC6334
- NGC6357
- NGC6374
- NGC6383
- NGC6396
- NGC6404
- Lesath
- Shaula
- HR6397
- HR6405

BIG DATA AND "HUMAN-AIDED COMPUTING"

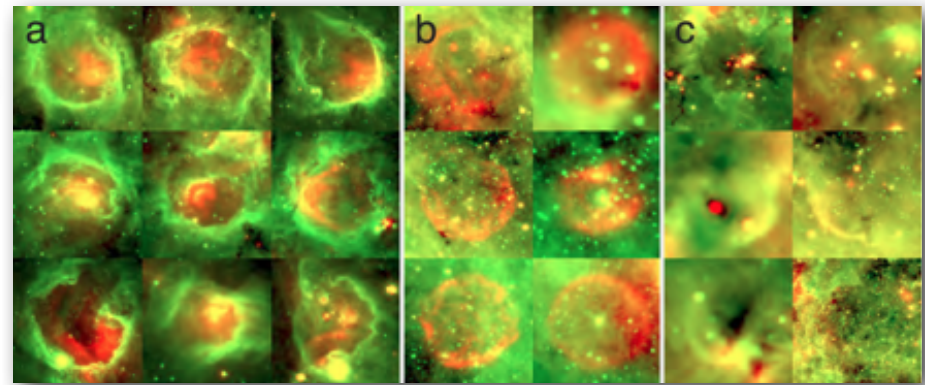
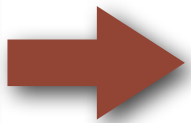


THE MILKY WAY PROJECT ZOONIVERSE REAL SCIENCE ONLINE

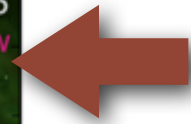
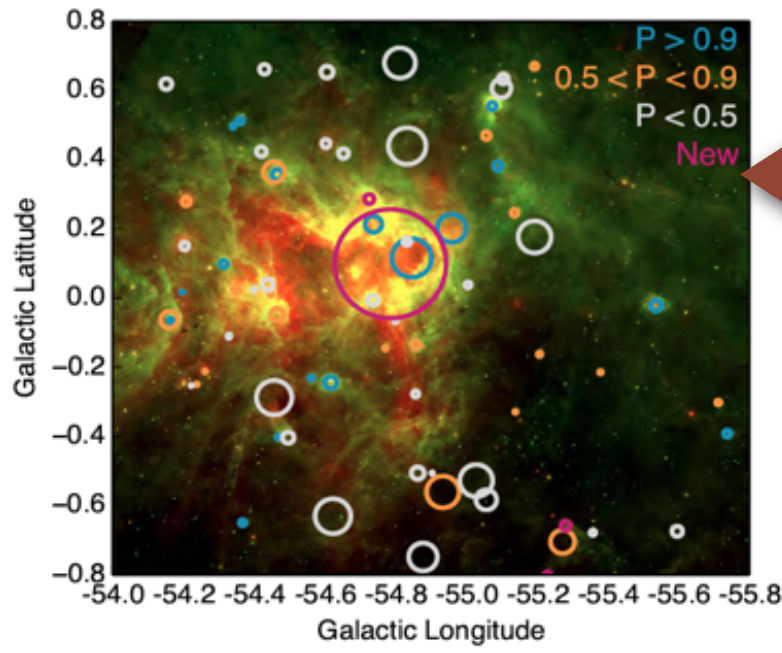
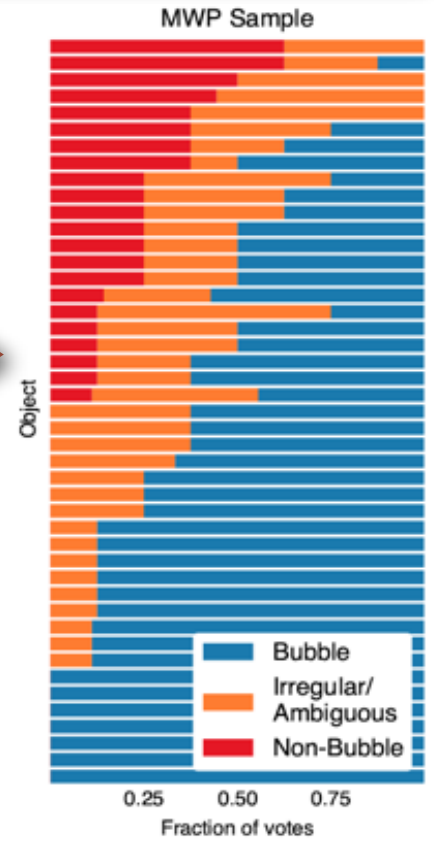
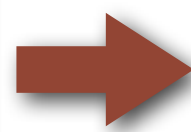
mark bubbles

What do you see in this image?

Bubble Star Cluster EGO Galaxy Object I'm done!

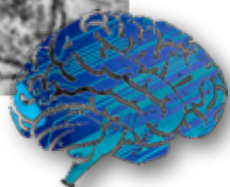
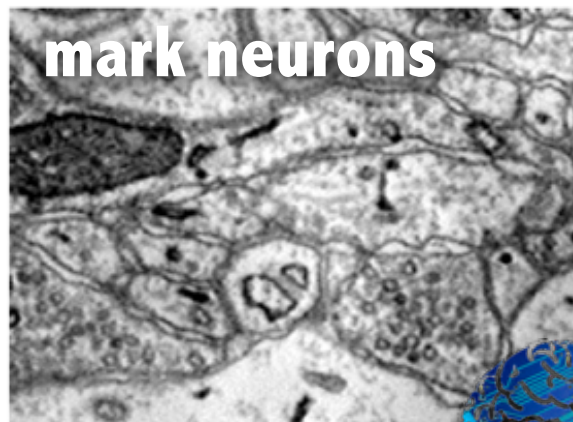


machine-learning algorithm (Brut)

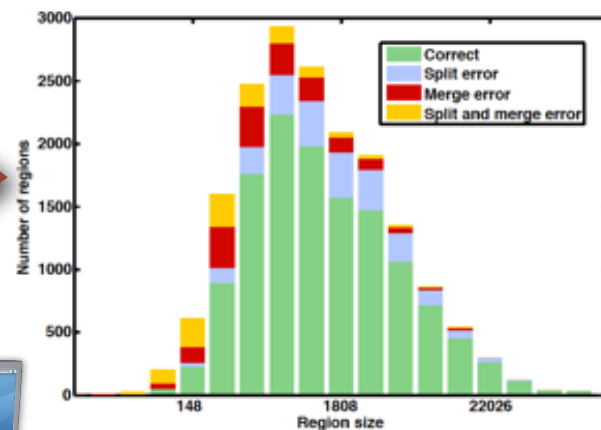
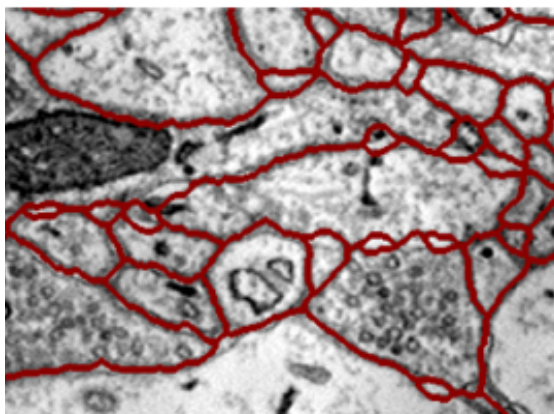


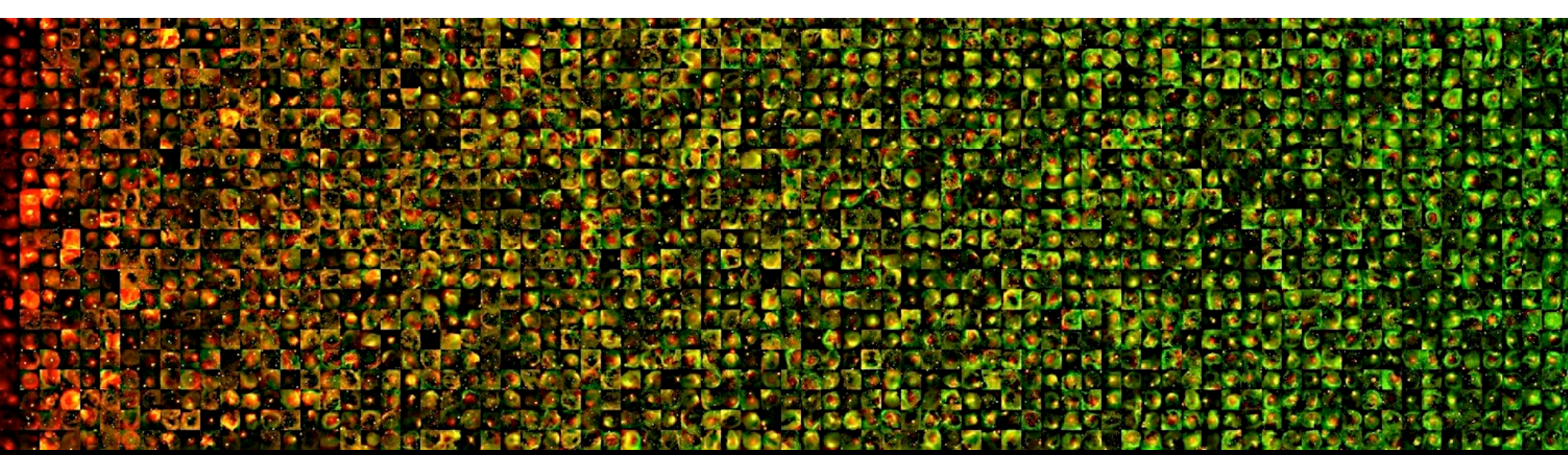
example here from: **Beaumont**, Goodman, Kendrew, Williams & Simpson 2014; based on **Milky Way Project** catalog (Simpson et al. 2013), which came from **Spitzer/GLIMPSE** (Churchwell et al. 2009, Benjamin et al. 2003), cf. Shenoy & Tan 2008 for discussion of HAC; astroml.org for machine learning advice/tools

BIG DATA AND "HUMAN-AIDED COMPUTING"

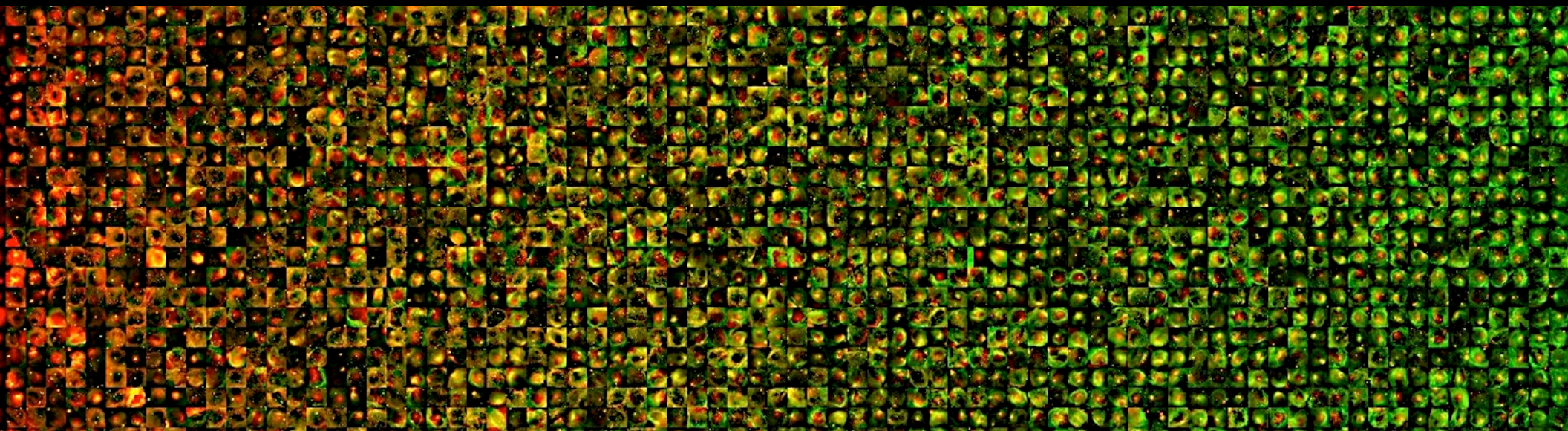


machine-learning algorithm (RF+CRF)

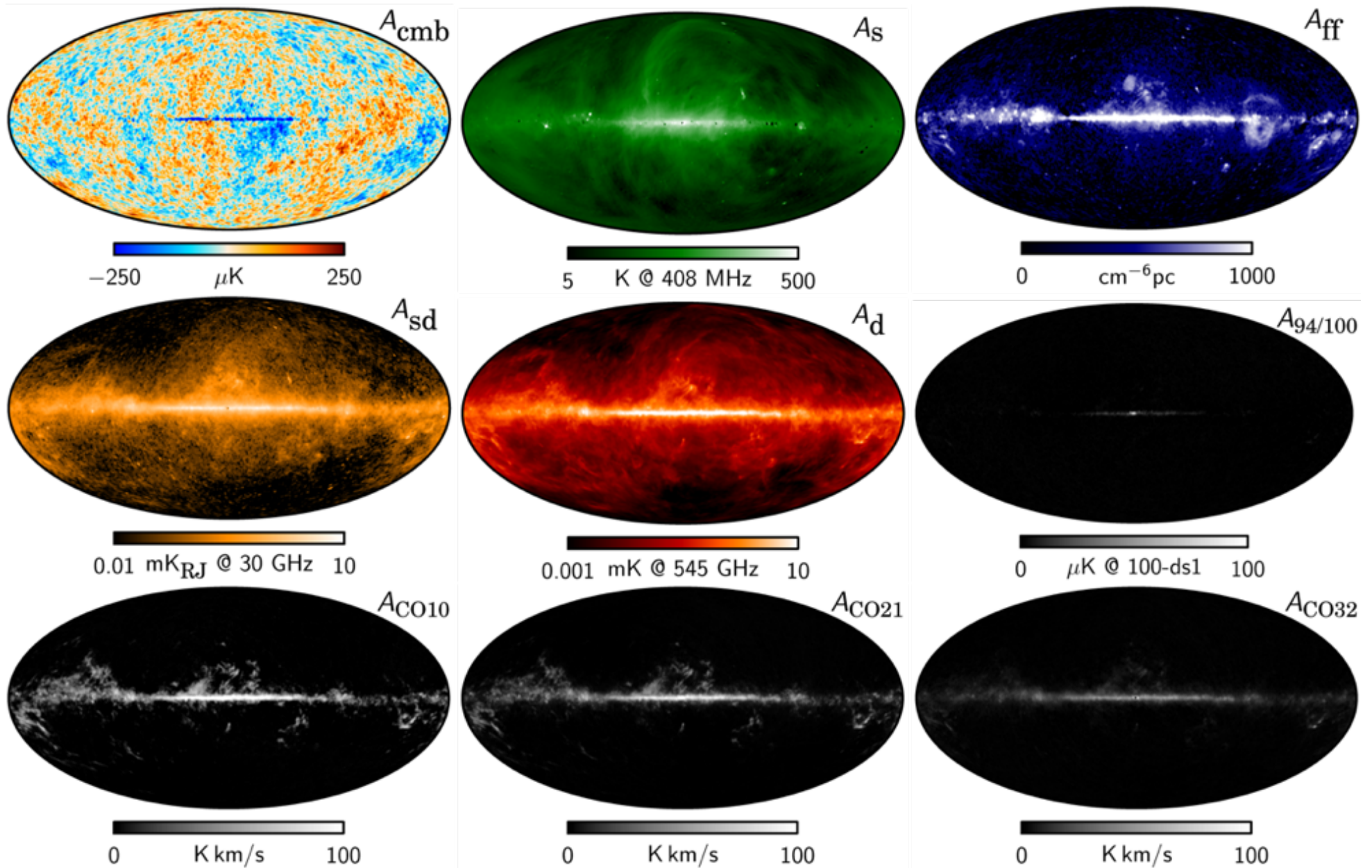




BIG DATA, WIDE DATA





WIDE DATA




WIDE DATA

COMPLETE

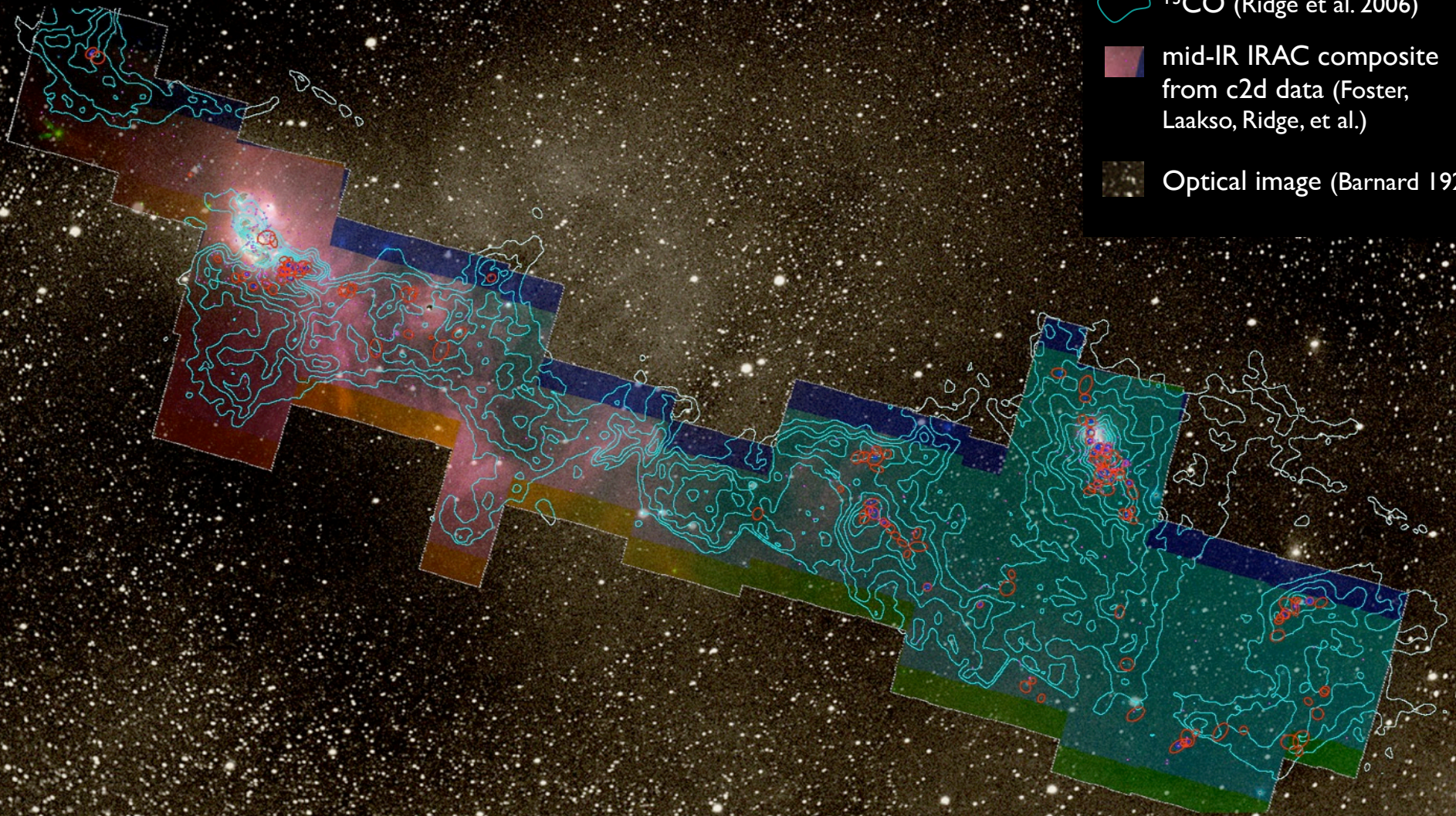
 mm peak (Enoch et al. 2006)

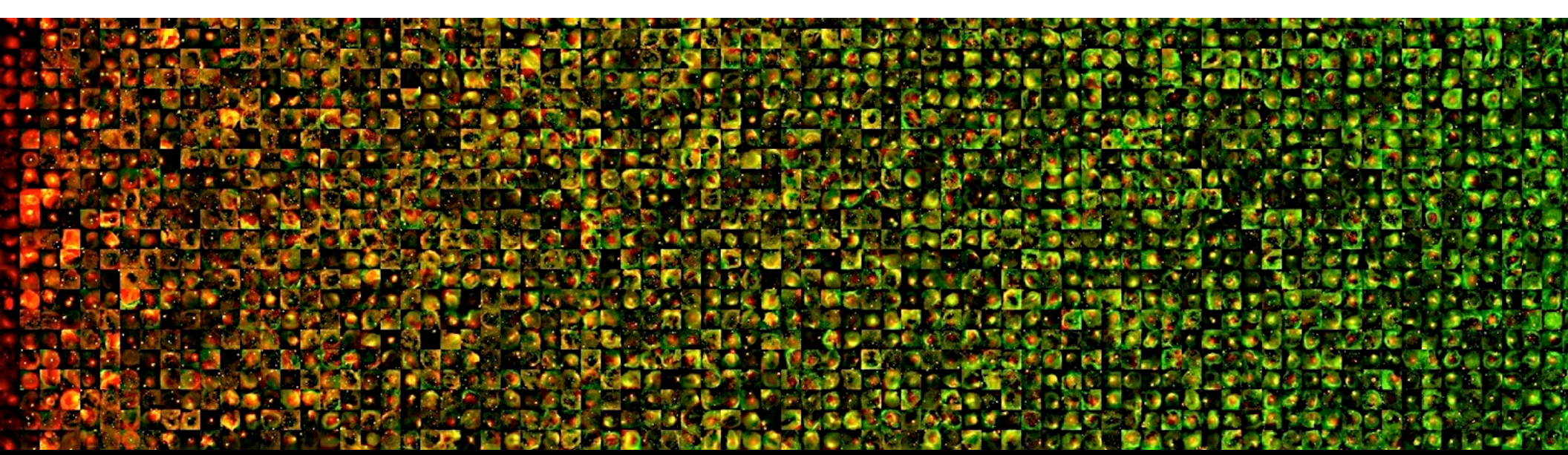
 sub-mm peak (Hatchell et al. 2005, Kirk et al. 2006)

 ^{13}CO (Ridge et al. 2006)

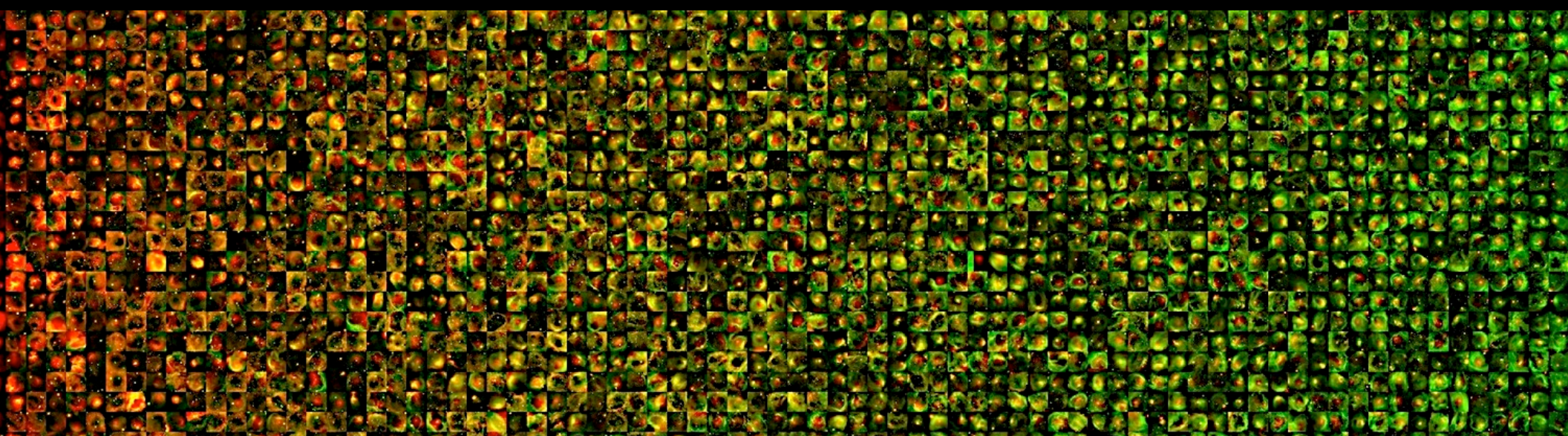
 mid-IR IRAC composite from c2d data (Foster, Laakso, Ridge, et al.)

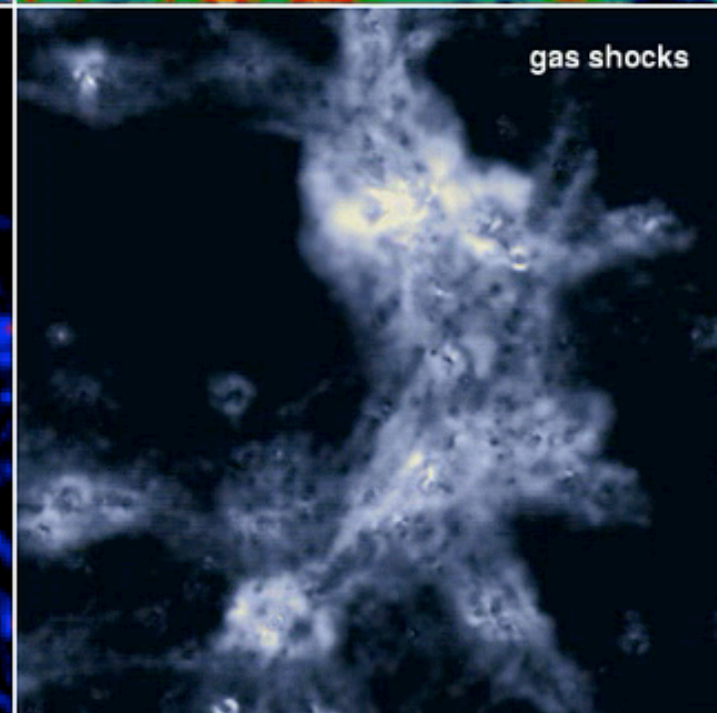
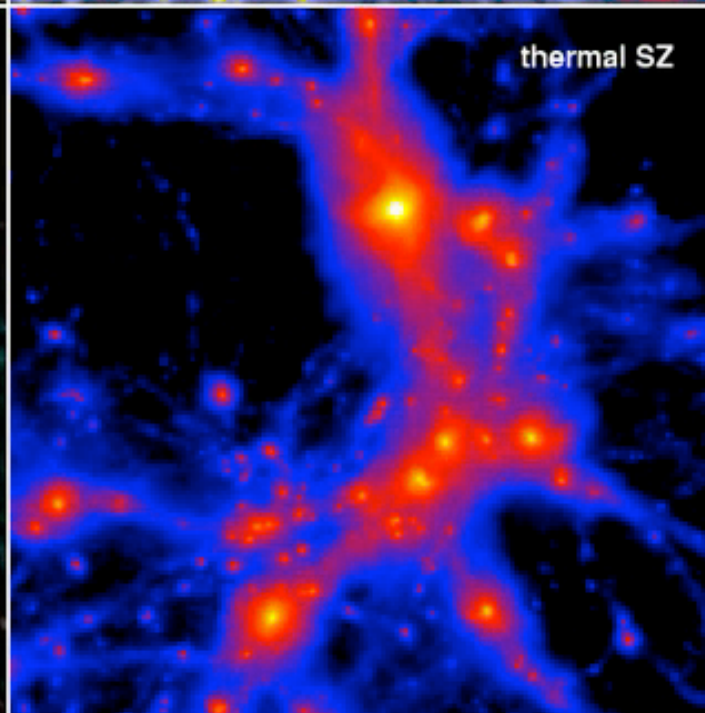
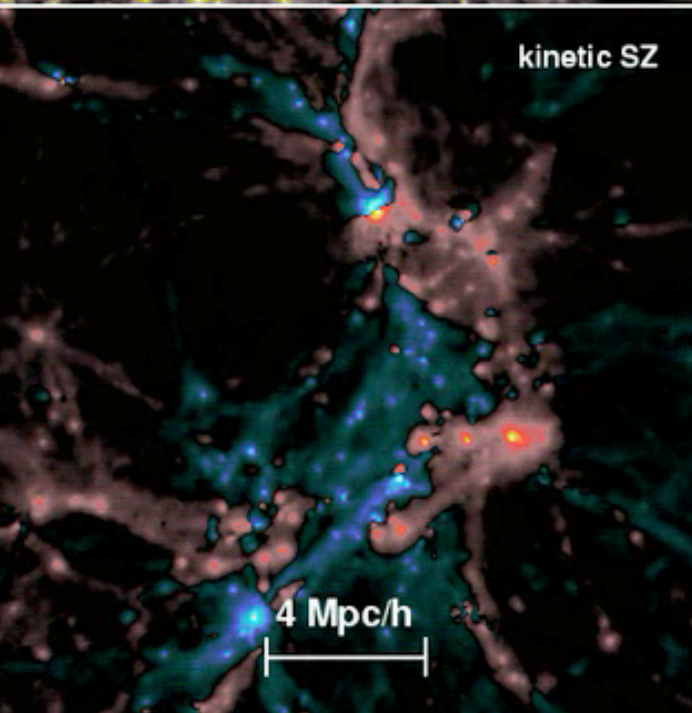
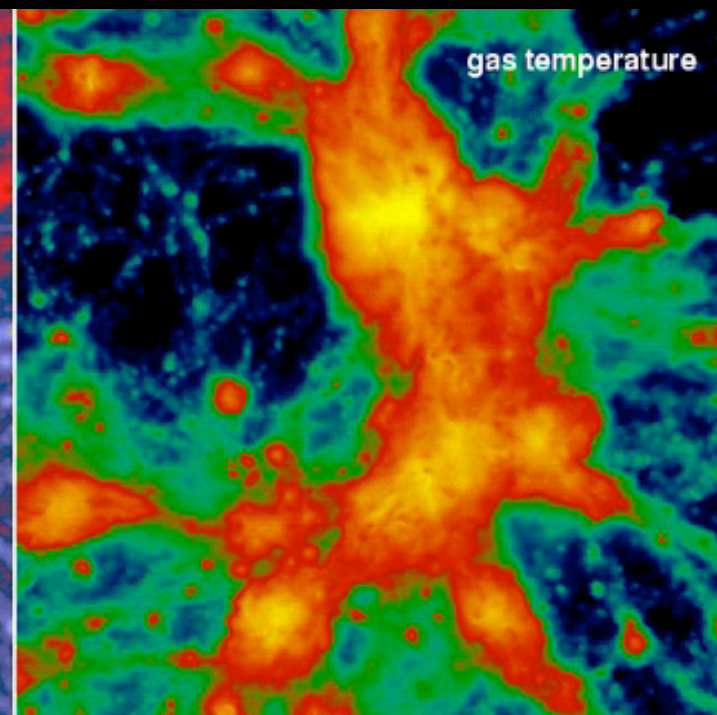
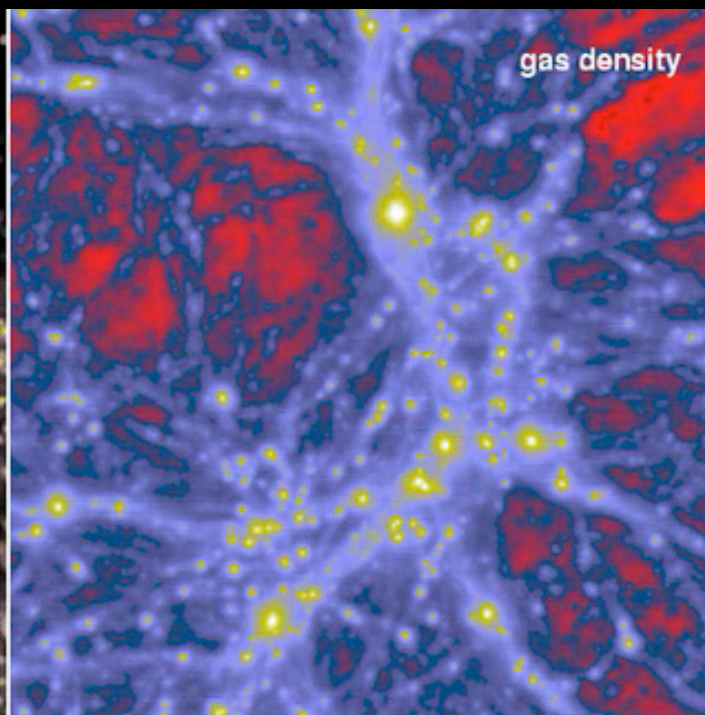
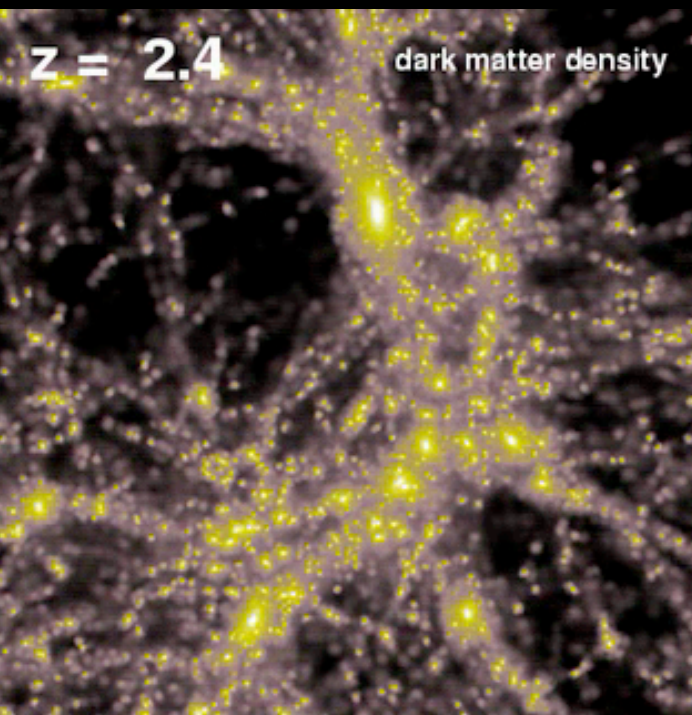
 Optical image (Barnard 1927)





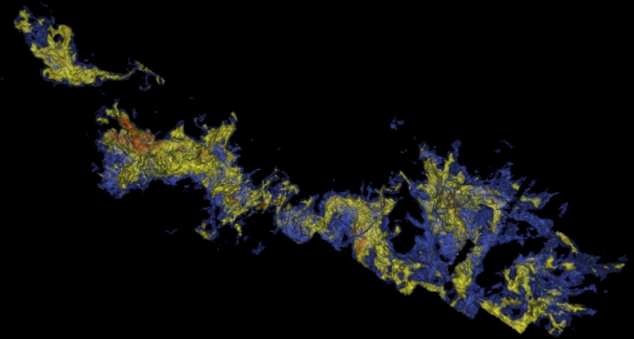
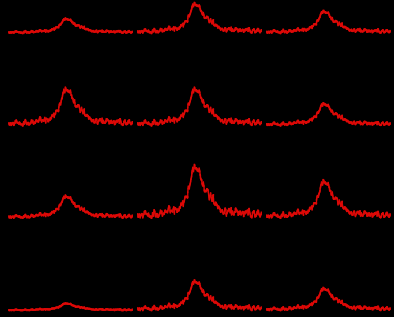
BIG AND WIDE DATA



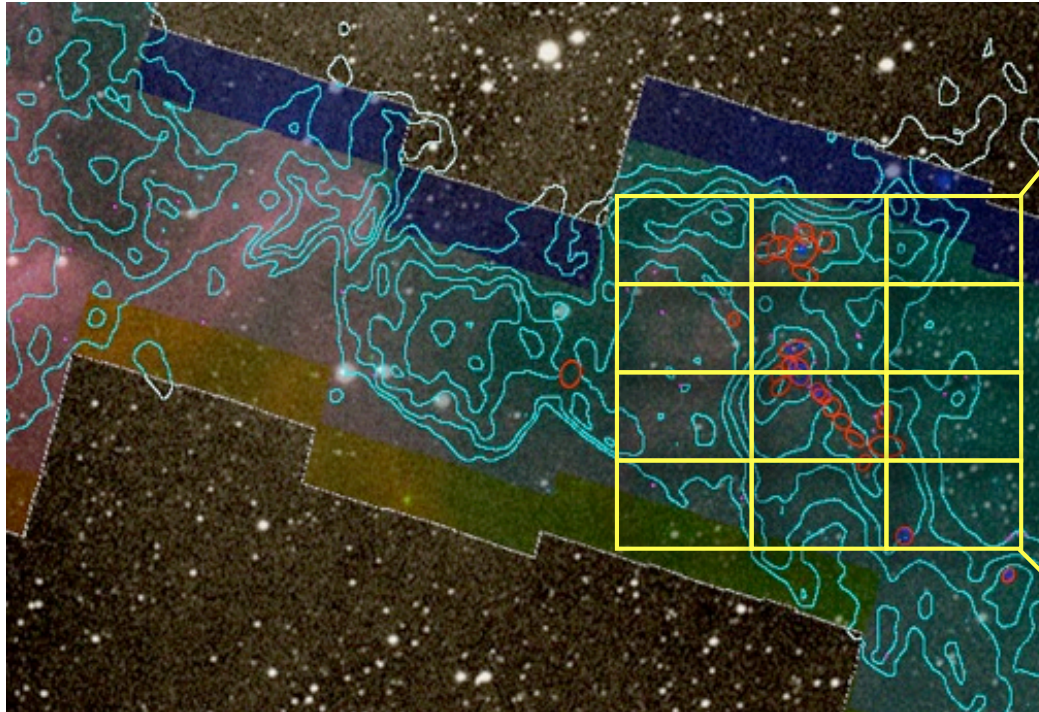
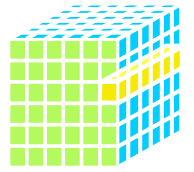


Movie: Volker Springel, formation of a cluster of galaxies. Millenium Simulation requires 25TB for output.

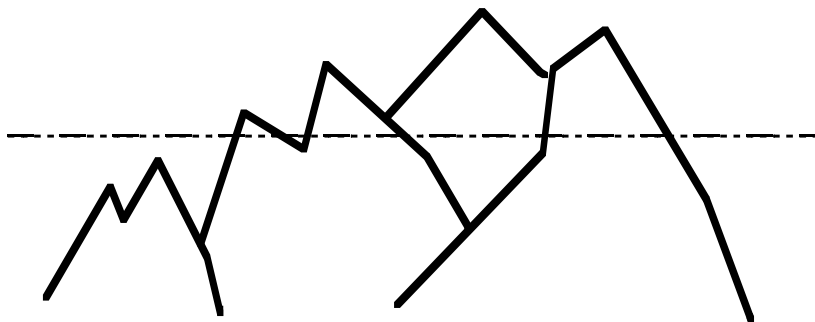
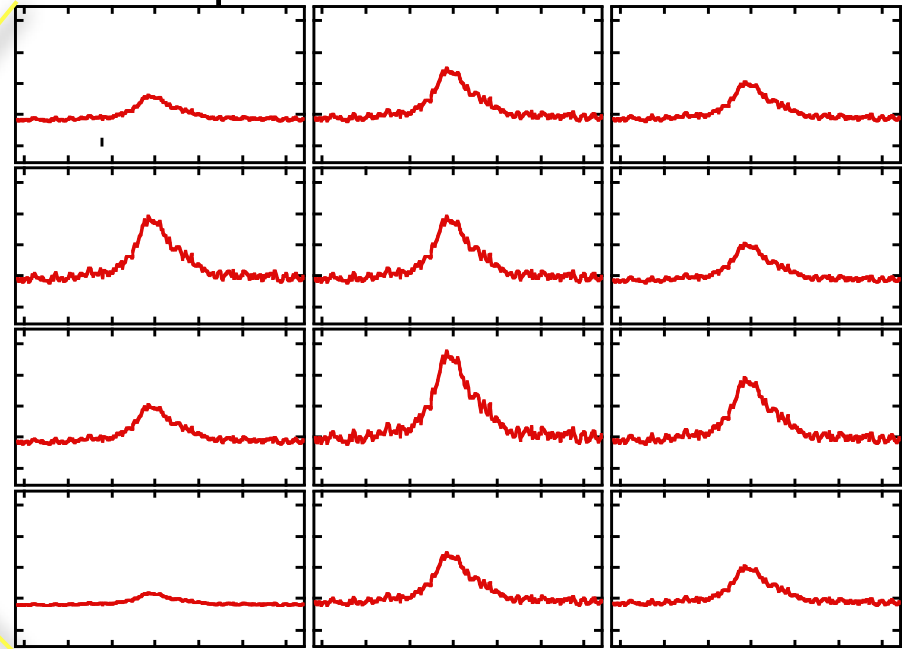
ADDING A THIRD DIMENSION



THIRD DIMENSION OFTEN HIDDEN



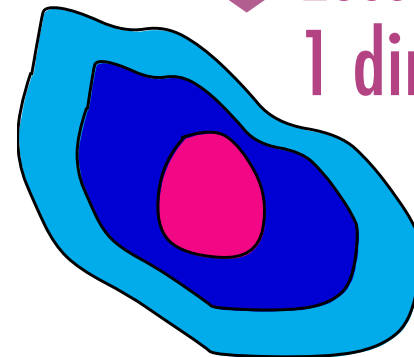
Spectral Line Observations



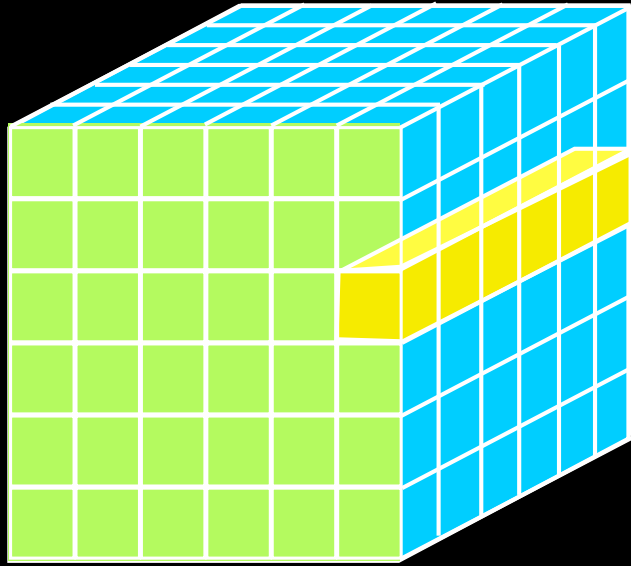
Mountain Range



No loss of information



Loss of 1 dimension



"DATA, DIMENSIONS, DISPLAY"






1D: Columns = "Spectra", "SEDs" or "Time Series"

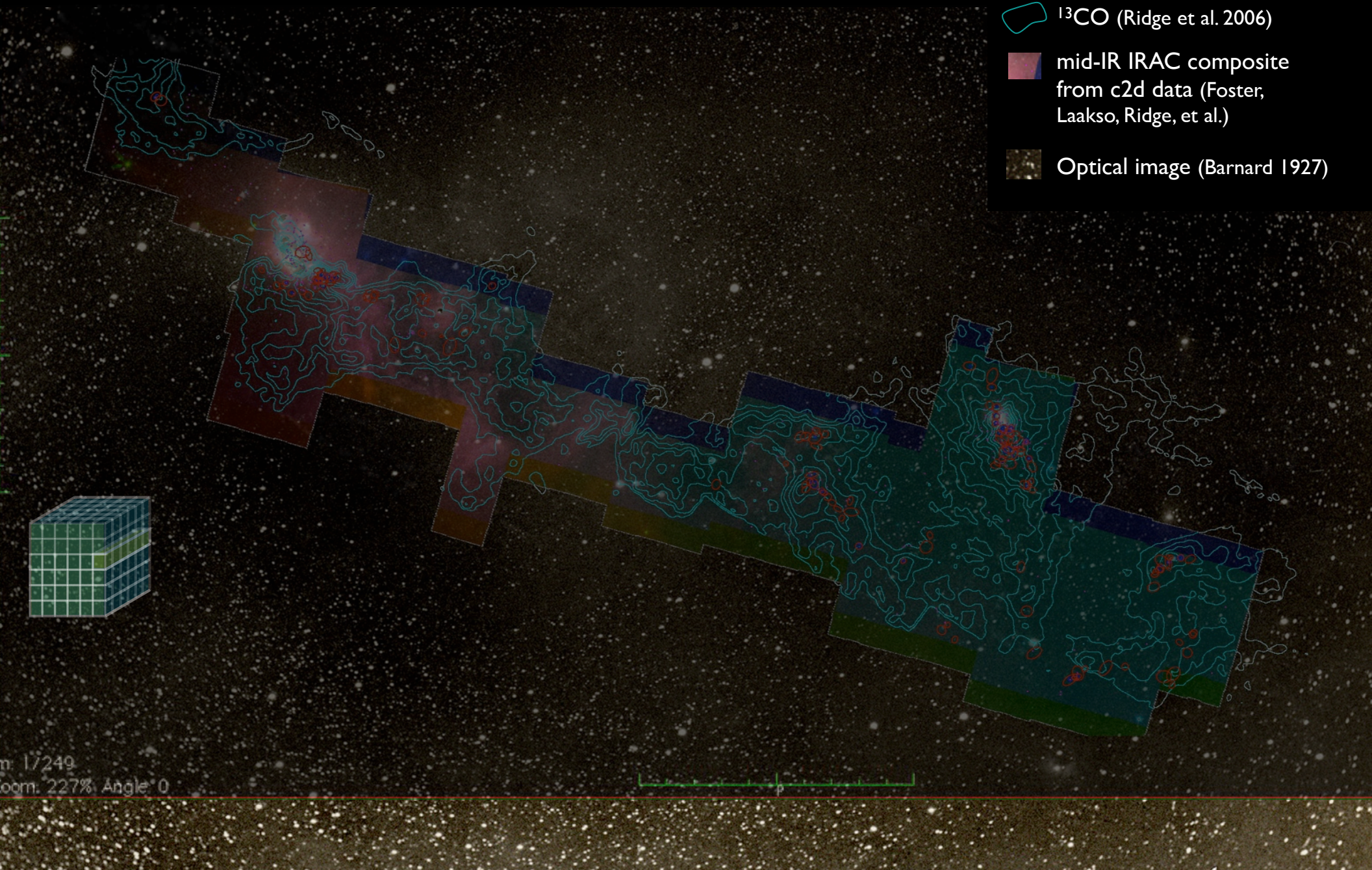
2D: Faces or Slices = "Images"

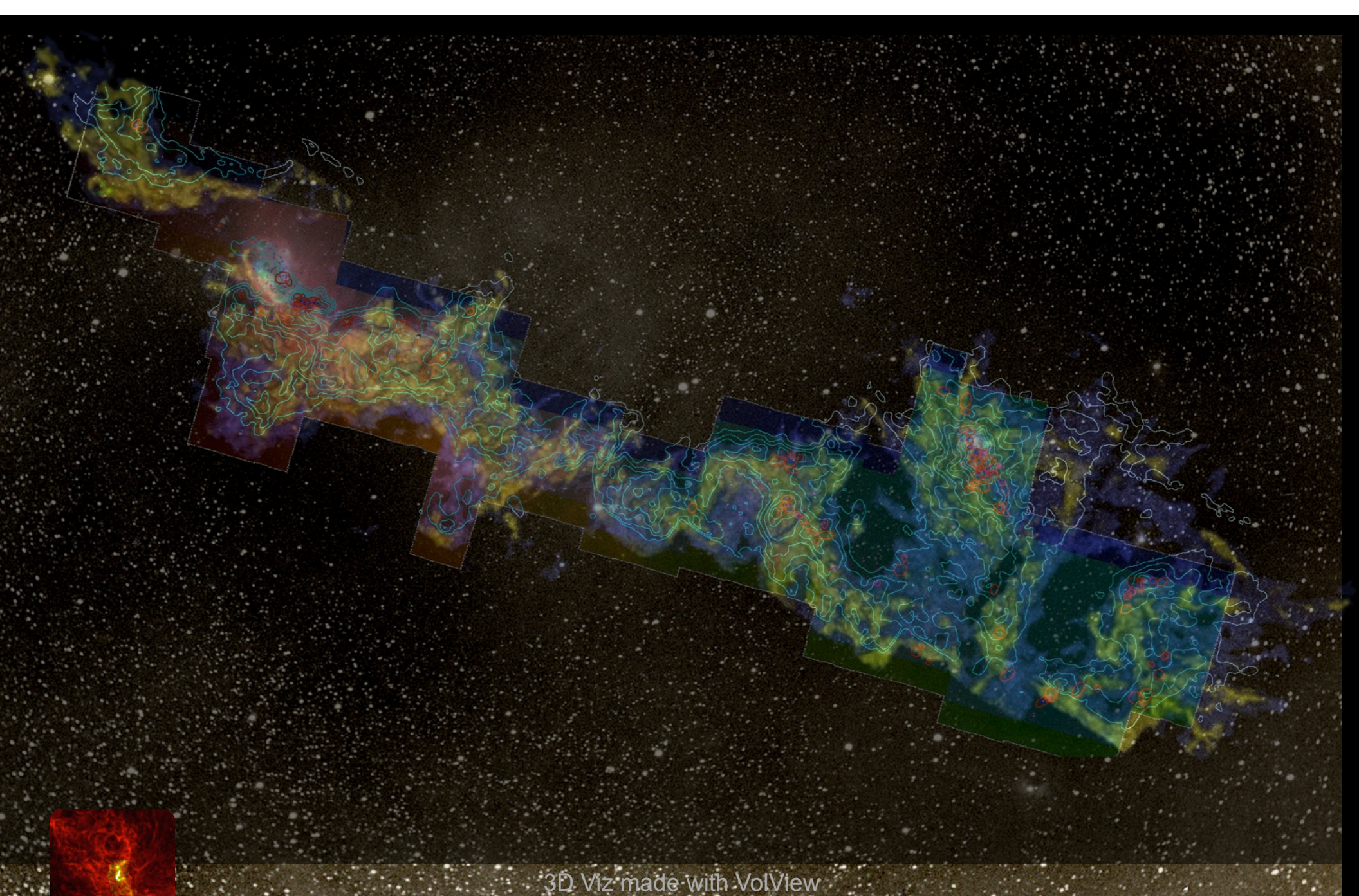
3D: Volumes = "3D Renderings", "2D Movies"

4D: Time Series of Volumes = "3D Movies"

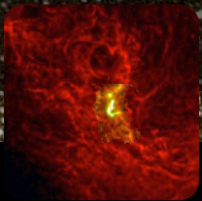
WIDE DATA, "IN 3D"

-  mm peak (Enoch et al. 2006)
-  sub-mm peak (Hatchell et al. 2005, Kirk et al. 2006)
-  ^{13}CO (Ridge et al. 2006)
-  mid-IR IRAC composite from c2d data (Foster, Laakso, Ridge, et al.)
-  Optical image (Barnard 1927)





3D Viz made with VolView



Astronomical**Medicine**@**iig**

COMPLETE

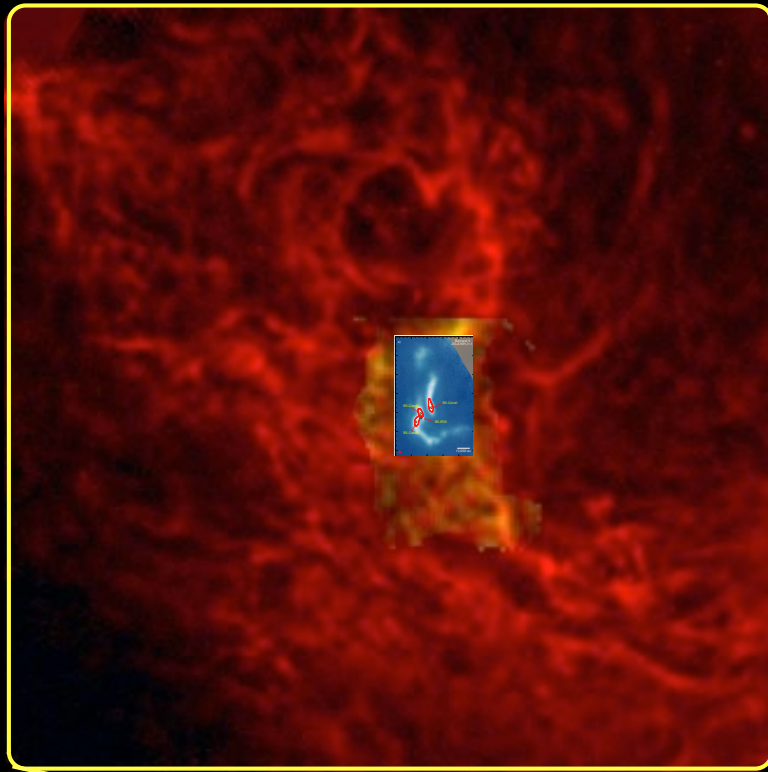
Big + **COMPLETE** was
wide in 2006

GAS GBT Ammonia Survey of **All** the Cores in Perseus
(Rachel Friesen & Jaime Pineda, PIs + 20 co-Is)

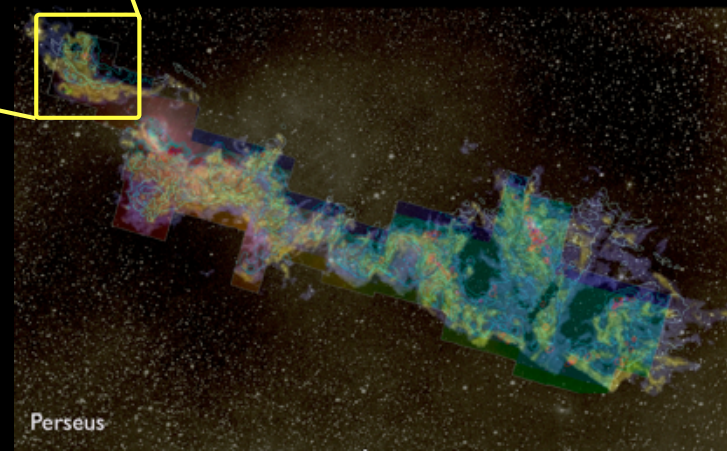
+ **MASSES** SMA Survey of **All** the Outflows in Perseus
(Mike Dunham, PI + 10 co-Is)

are **Big** now...

but, let's talk **wide** for a few minutes..



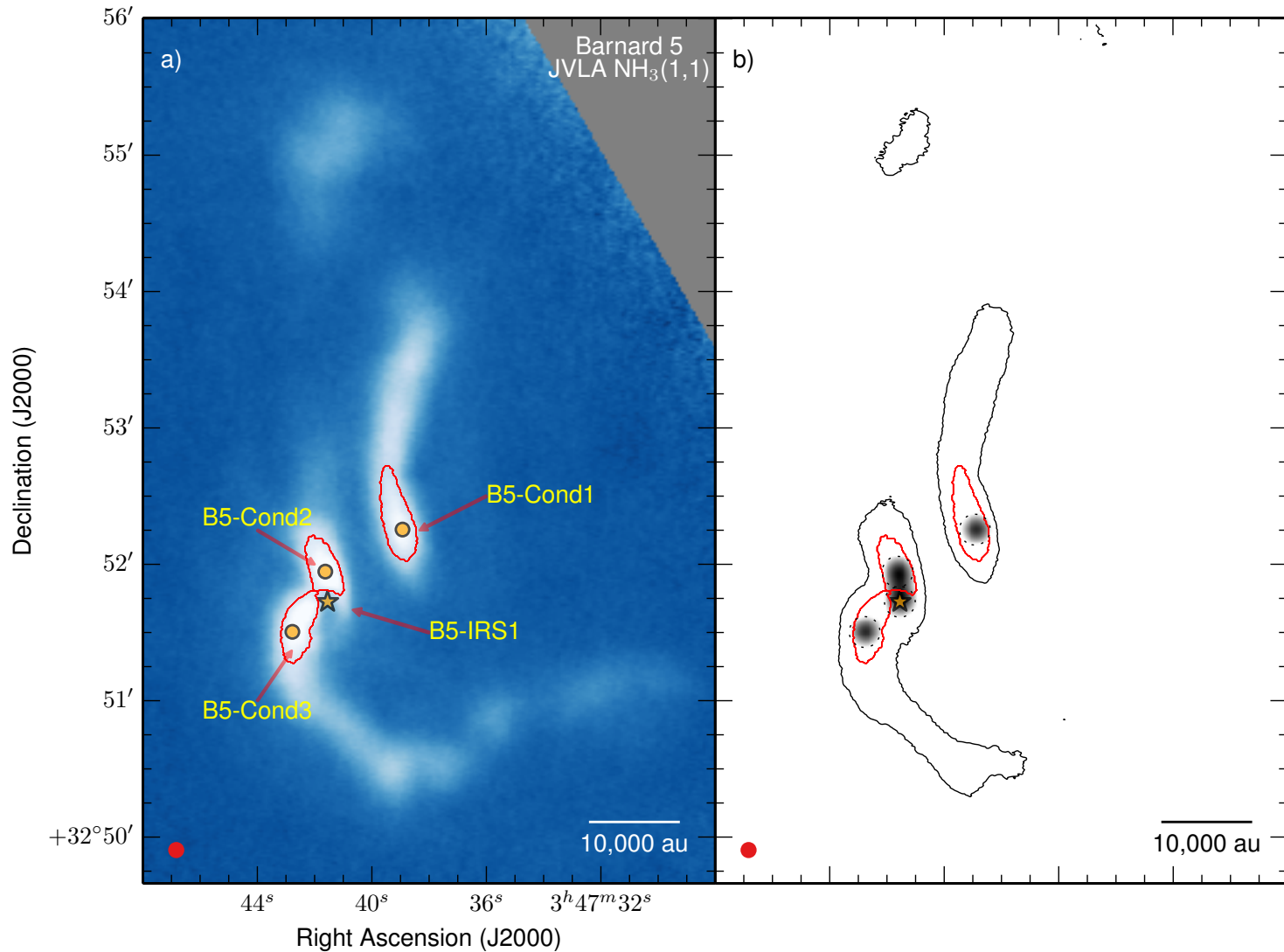
"B5"



30-year story of (Coherent) Dense Cores: Myers & Benson 1983, Goodman et al. 1998, Pineda et al. 2010, 2011, 2015

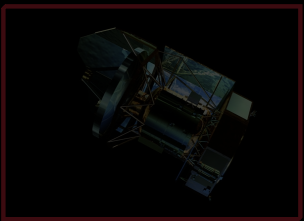
SUPER HIGH-RESOLUTION

SHOWS THAT STARS FORM IN FRAGMENTING FILAMENTS (NOT IN BORING BLOBS)

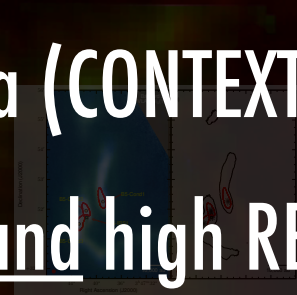


SUPER-WIDE DATA

SHOW THAT FILAMENTS CONTINUE FROM PC SCALES INTO CORE INNARDS?!



Wide data (CONTEXT) gives the discovery...
but it's derived from BIG surveys and high RESOLUTION data sets



blue =VLA ammonia (high-density gas); green=GBT ammonia (lower-res high-density gas); red=Herschel 250 micron continuum (dust)

RESOLUTION

CONTEXT

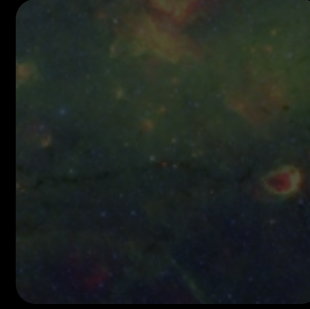
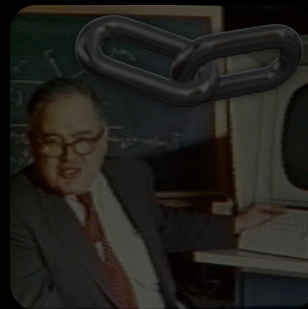
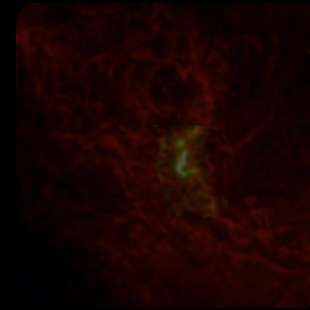
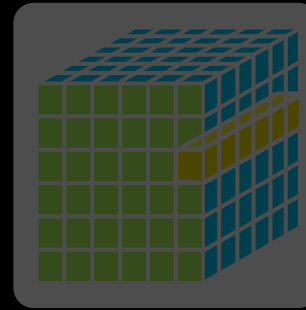
BIG DATA

WIDE DATA

DIMENSIONALITY

LINKED VIEWS

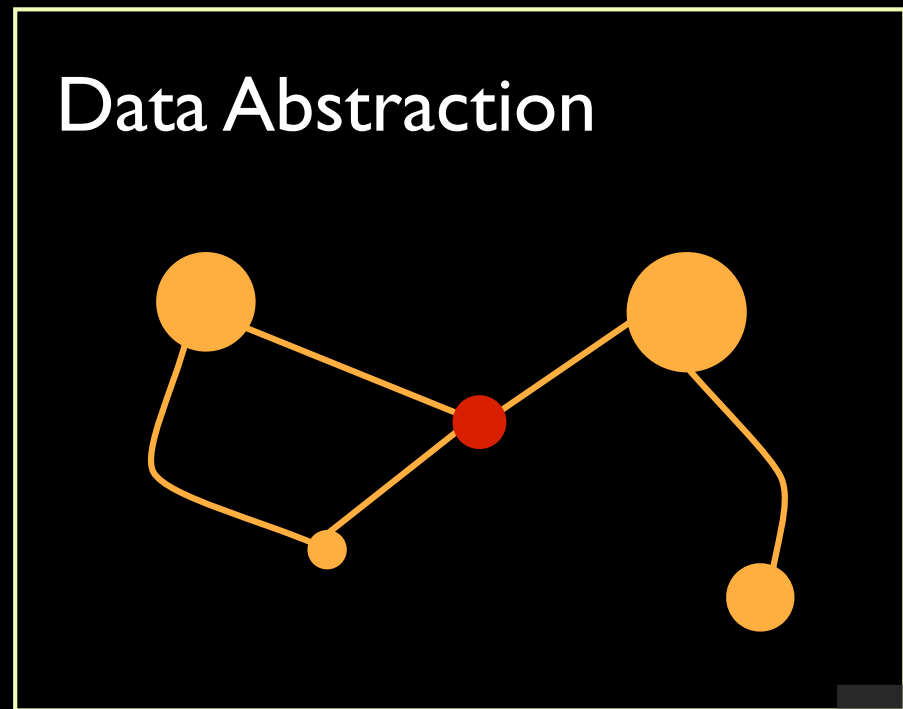
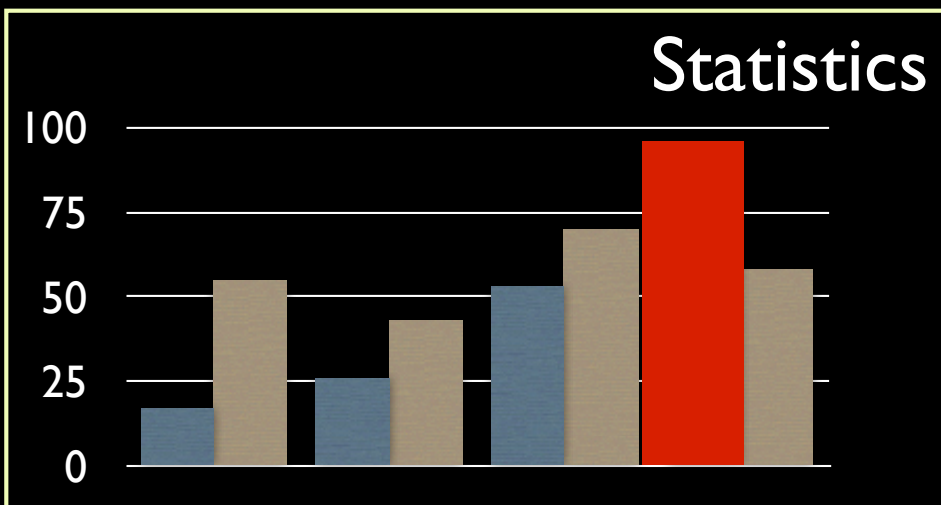
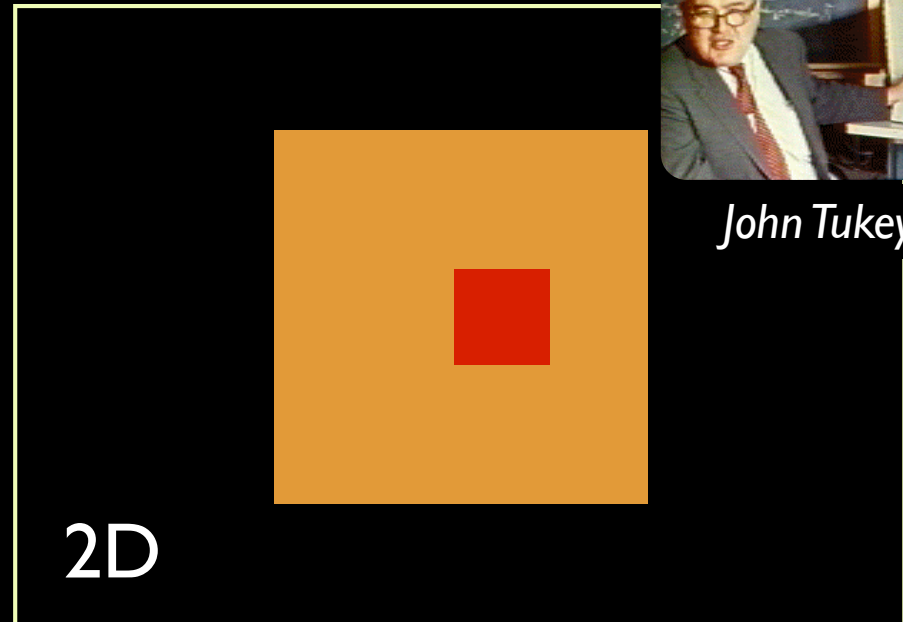
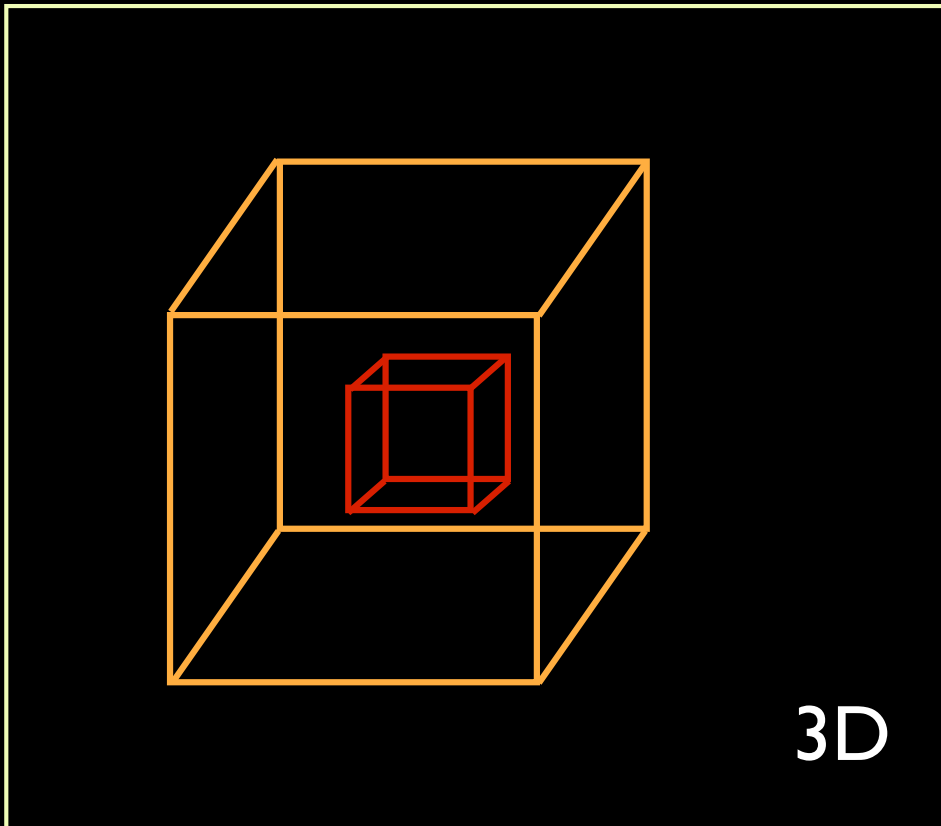
INTERACTION



LINKED VIEWS OF HIGH-DIMENSIONAL DATA



John Tukey



DATADESK (EST. 1986)

QuickTime Player File Edit View Share Window Help Stop Recording (1:38) Wed 4:46 PM Alyssa Goodman

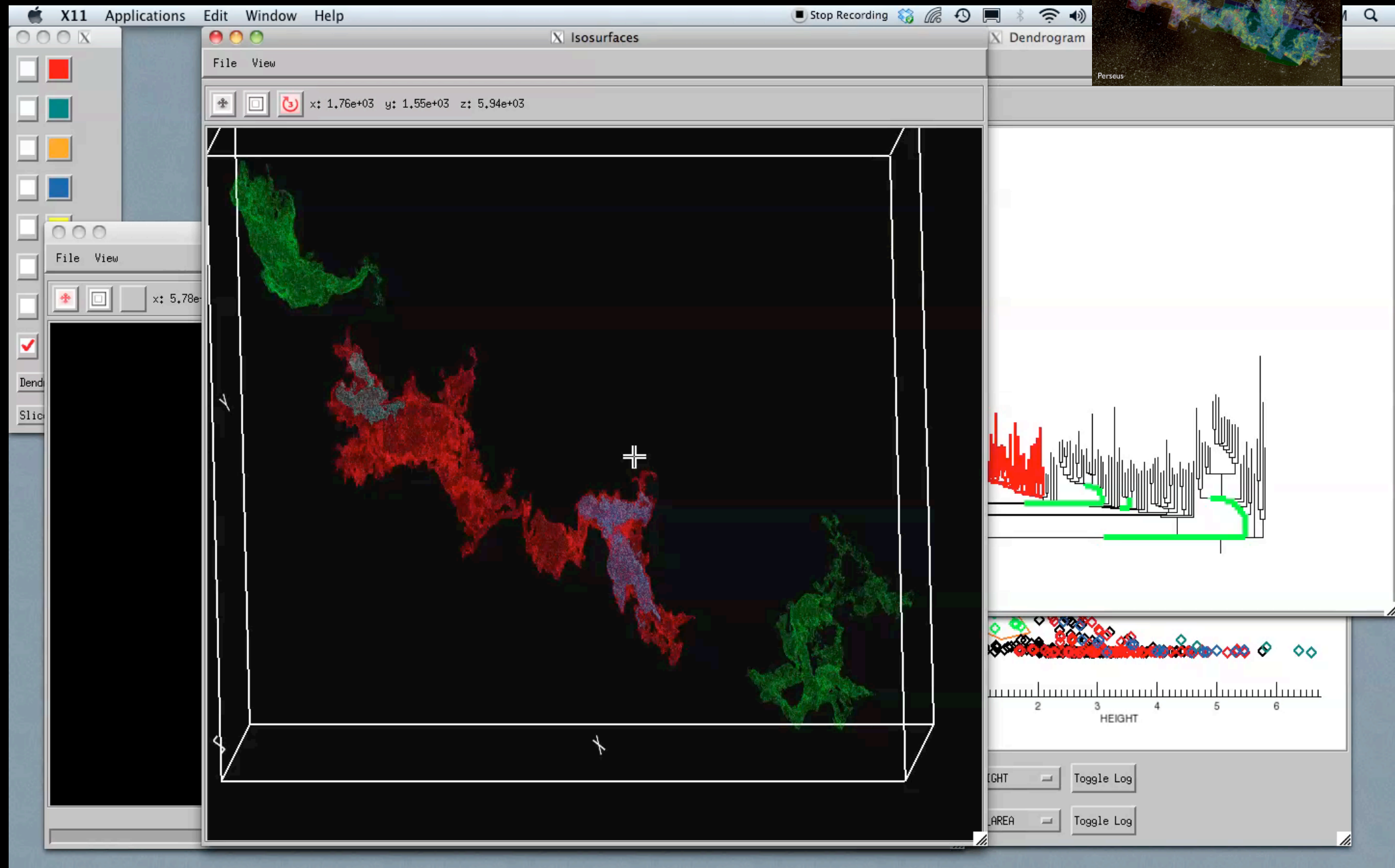
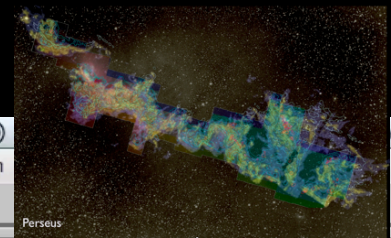
Data Desk® 6.2.1 - final.per.dd

The interface displays several data visualization windows:

- logN2mass Histogram**: Histogram of logN2mass (0.04 to 0.84).
- logNiras Histogram**: Histogram of logNiras (-0.25 to 0.95).
- logn13 Histogram**: Histogram of logn13 (-1.625 to 0.375).
- lgN/IN2 Plot**: Scatter plot of lgNiras vs logN2mass.
- l13/IN2 Plot**: Scatter plot of l13 vs logN2mass.
- T_IRAS/N_IR Plot**: Scatter plot of T_IRAS vs N_IRAS.
- N_t/N_2 Plot**: Scatter plot of N_13CO_best vs N_2MASS.
- N_IRAS Histogram**: Histogram of N_IRAS (0.0 to 9.0).
- v13 Histogram**: Histogram of v13 (-1.0 to 9.0).
- Dec/mRA Plot**: Color-coded spatial plot of Dec vs minRA, showing the Perseus region.
- fw hm13 Histogram**: Histogram of fw hm13 (0.2 to 4.2).
- N_13CO_best Histogram**: Histogram of N_13CO_best (-1 to 19).

Tools and UI elements include a toolbar with navigation and editing tools, a color palette, and a dock at the bottom with icons for RA, Dec, Tint12x, TintGau..., Ta12, v12, fw hm12, Tint13x, Tint12, TintGau..., Tint13, Ta13, v13, fw hm13, flux60, flux100, T_IRAS, N_IRAS, N_2MA..., logn13, and logN2m... A purple DataDesk logo is also present on the left side.

LINKED VIEWS OF HIGH-DIMENSIONAL DATA



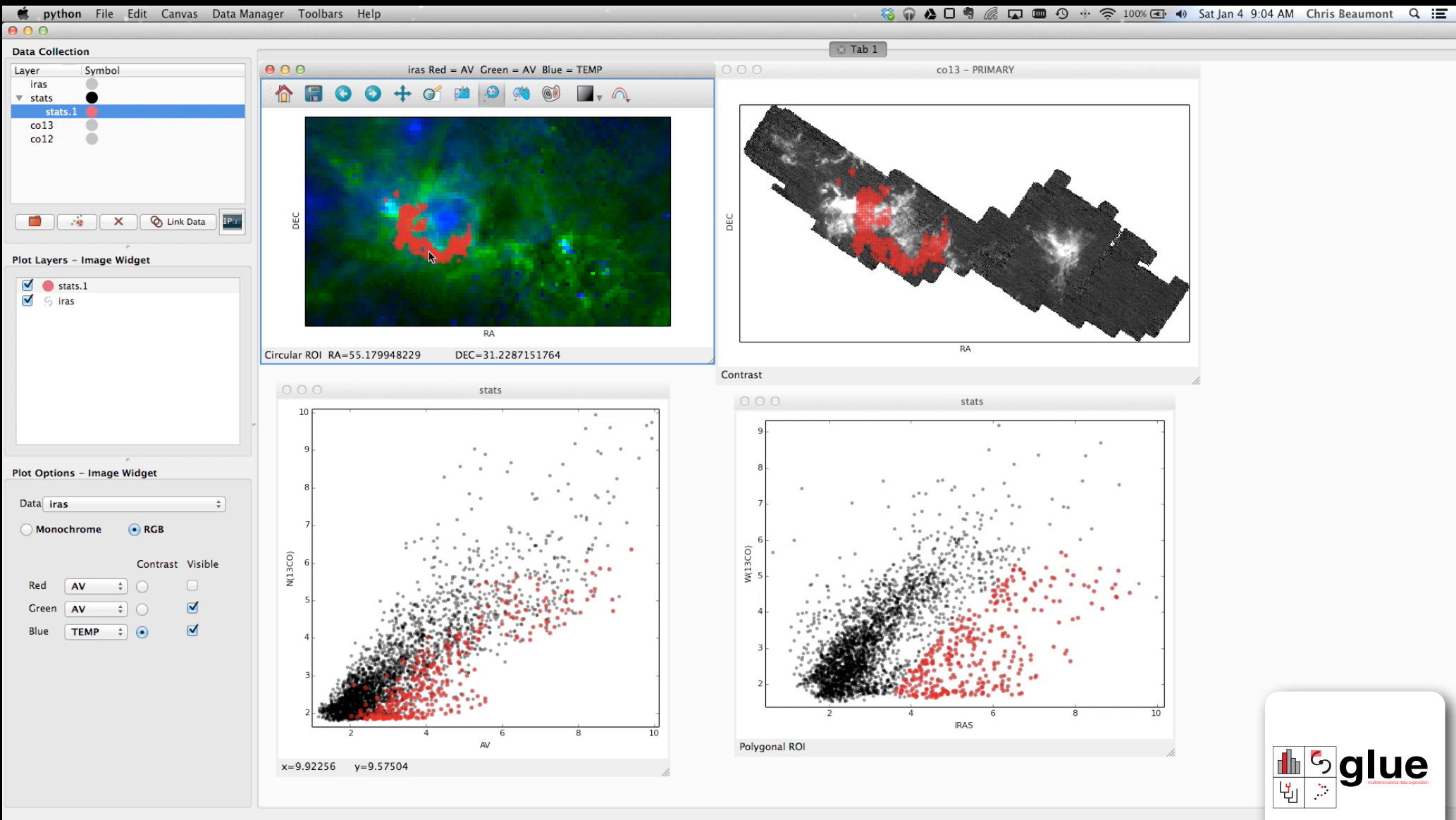
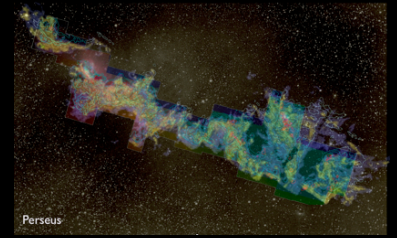
Video & implementation: Christopher Beaumont, Harvard→Counsyl;
inspired by AstroMed work of Douglas Alan, Michelle Borkin, AG, Michael Halle, Erik Rosolowsky

GREAT. BUT THAT WAS ALL FROM ONE DATA FILE.

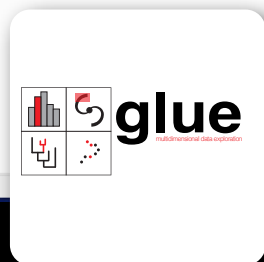
(AND IT WAS IN SOFTWARE THAT COSTS \$1000.)

LINKED VIEWS OF HIGH-DIMENSIONAL DATA (IN PYTHON)

GLUE



Christopher Beaumont, w/A. Goodman, T. Robitaille & M. Borkin




LINKED, INTERACTIVE VIEWS OF **Big**

Wide DATA ...AND LITERATURE

**Once upon a time (2012), in an
enchanted castle (in Bavaria)**

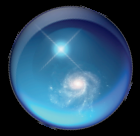
**...at a conference about
“The Early Phases of Star Formation”**



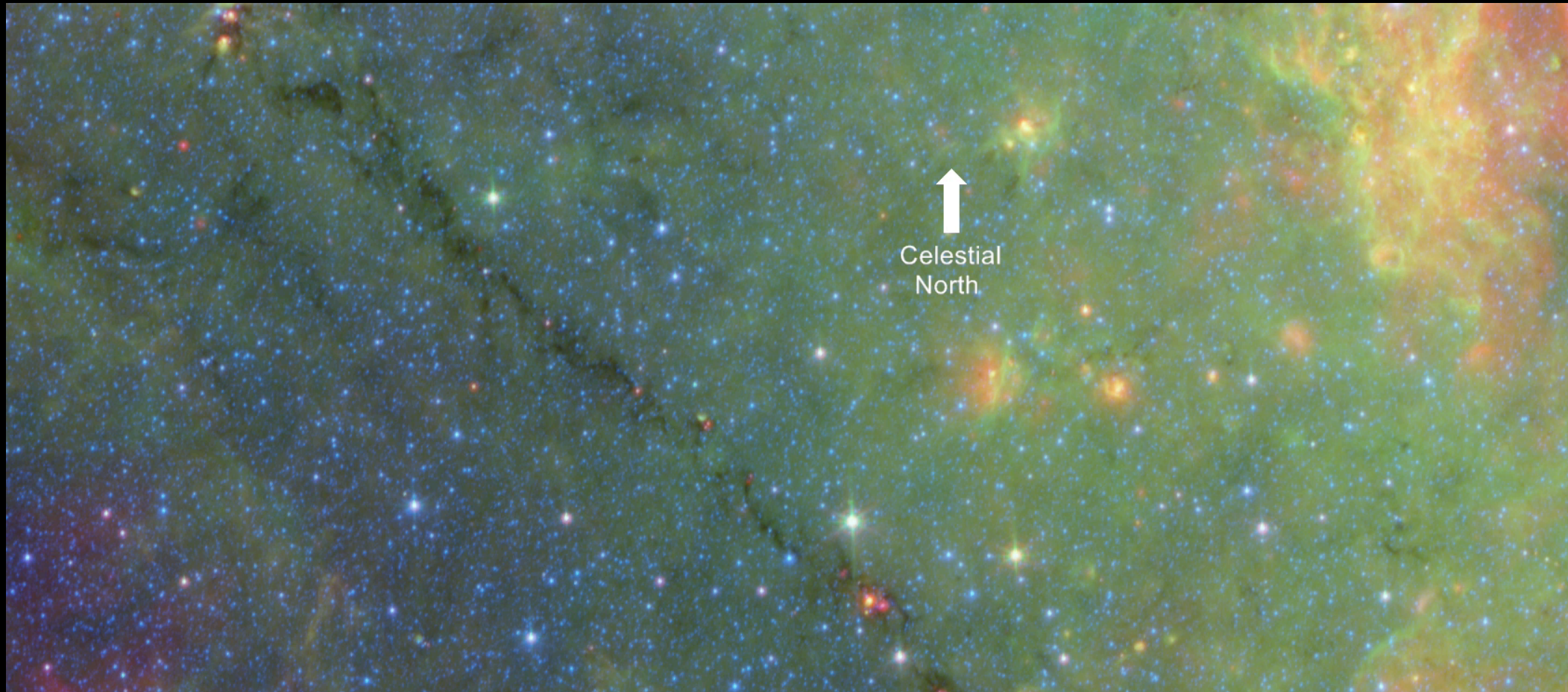


Andi Burkert asked a question:
Is Nessie “parallel to the Galactic Plane”?

No one knew.

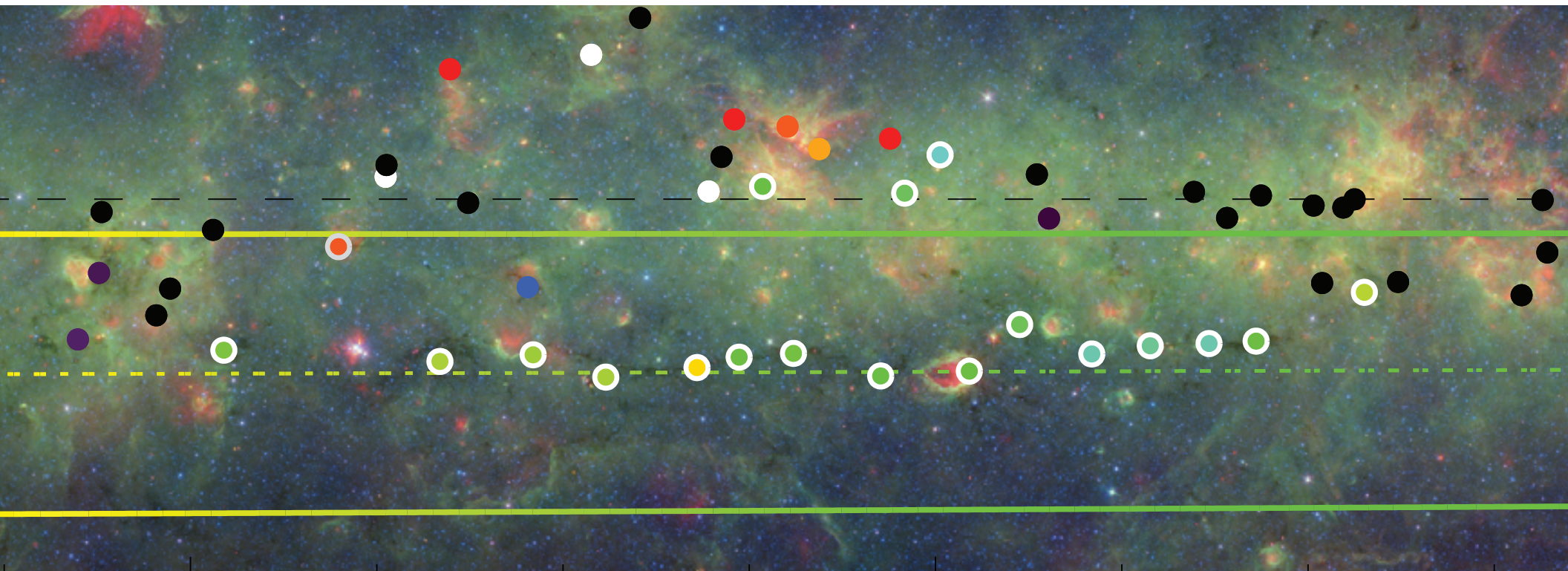


WorldWide Telescope (easy access to **Big** & **Wide** data) to the rescue...



Yes, parallel to the plane...and much longer than had been realized.
But why not at Zero of Latitude (**b=0**)?

Great long story you don't get to hear now—ask me at lunch...

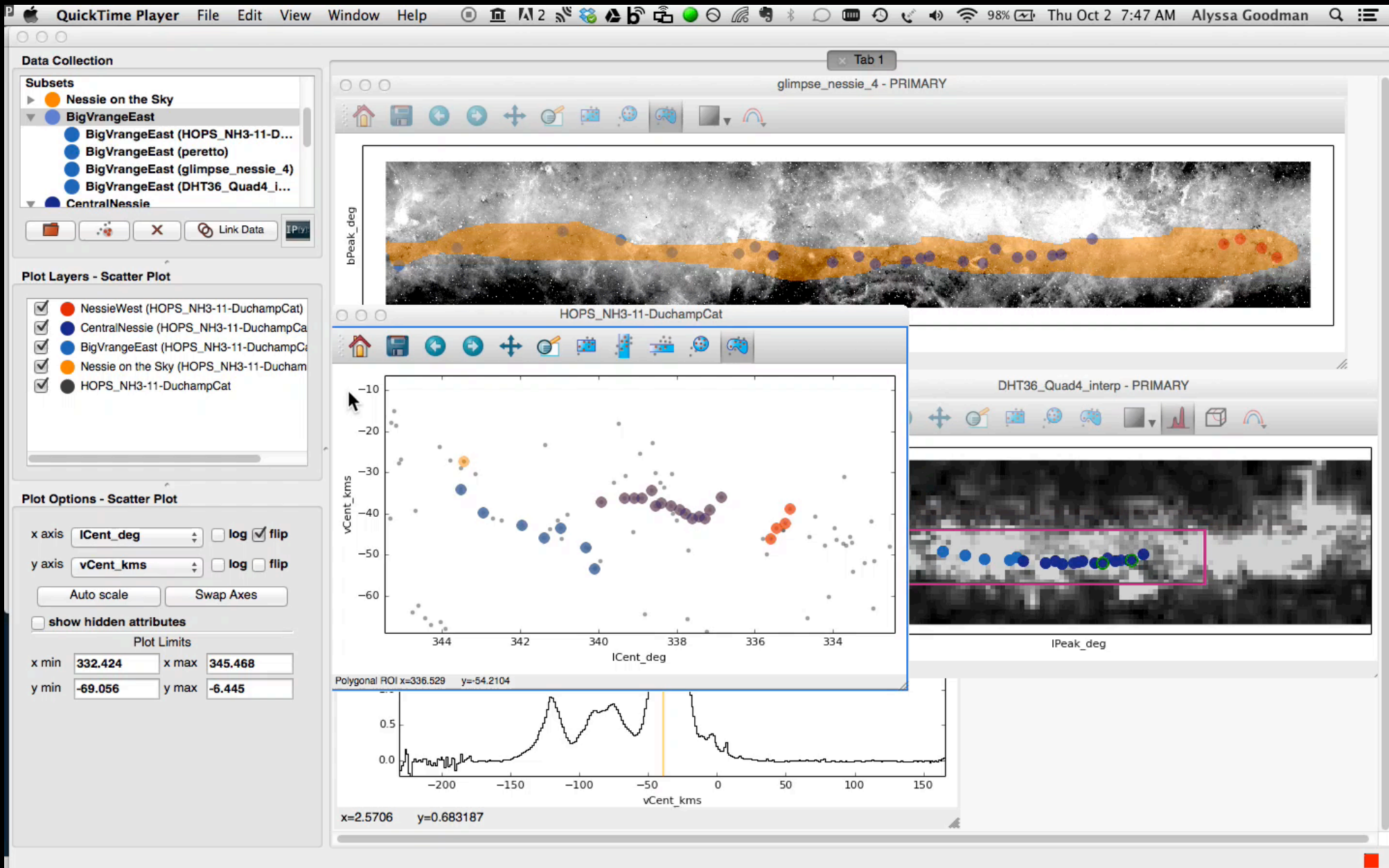


How do we know
the velocities?

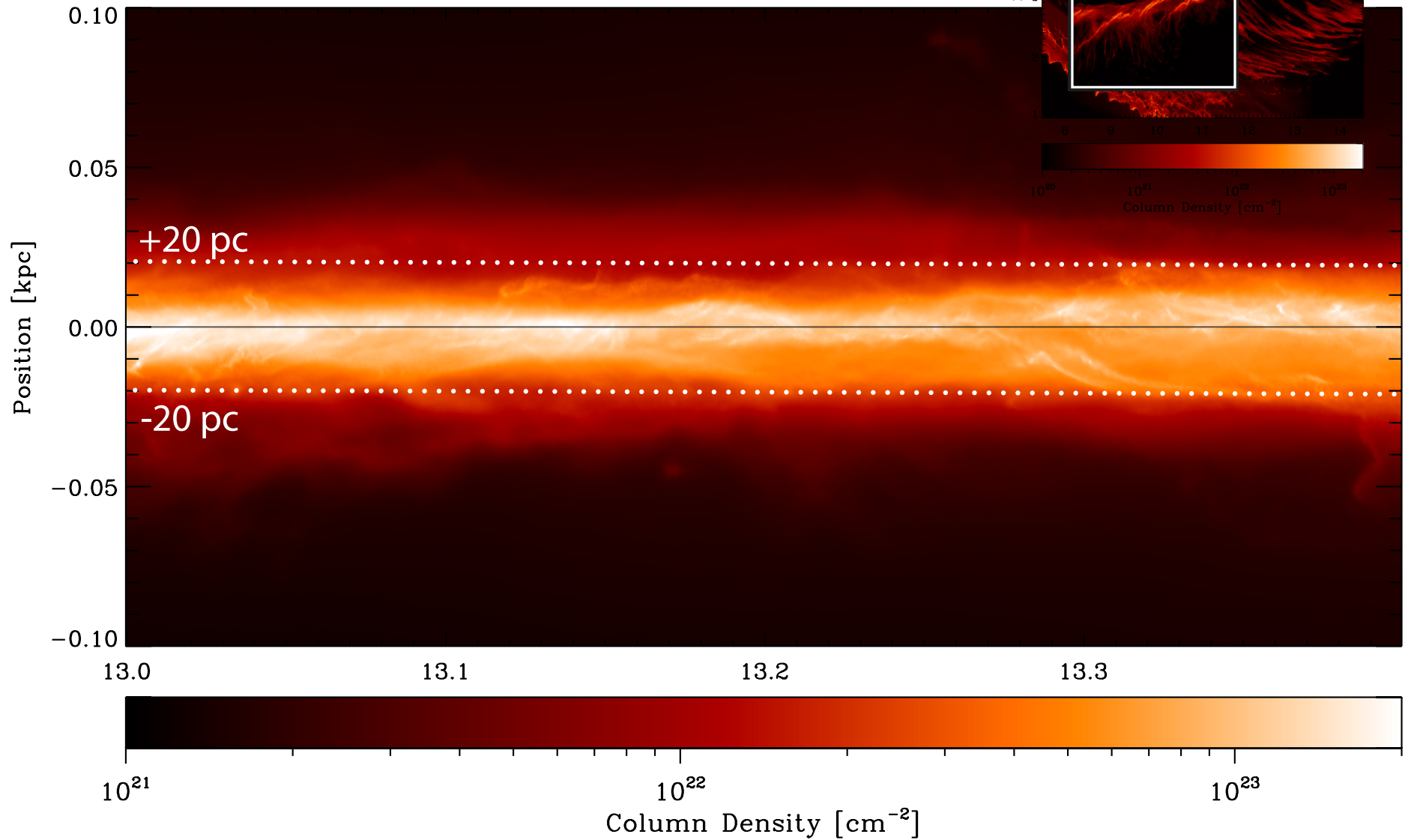
...eerily precisely...



NESSIE IN GLUE



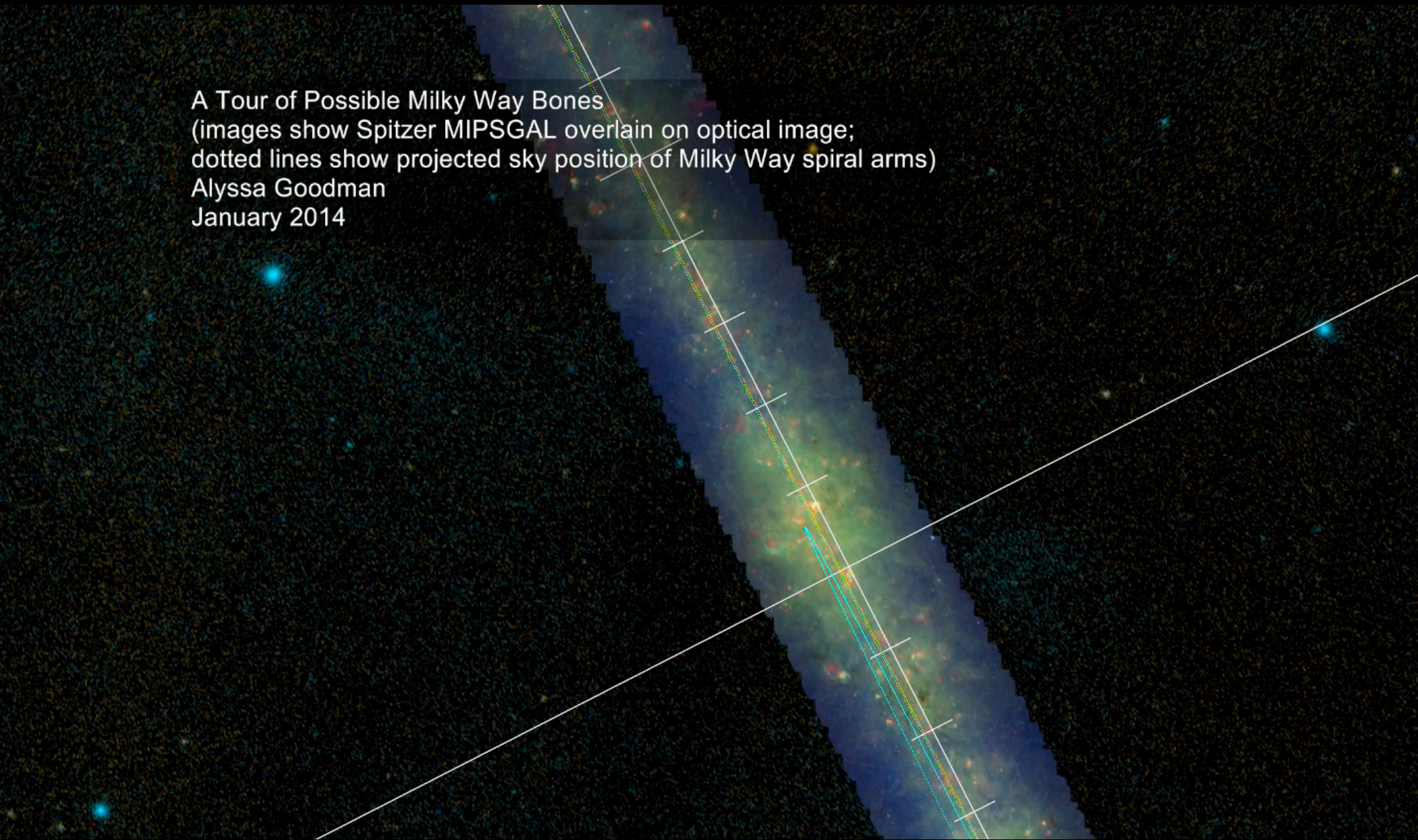
2014 Simulation



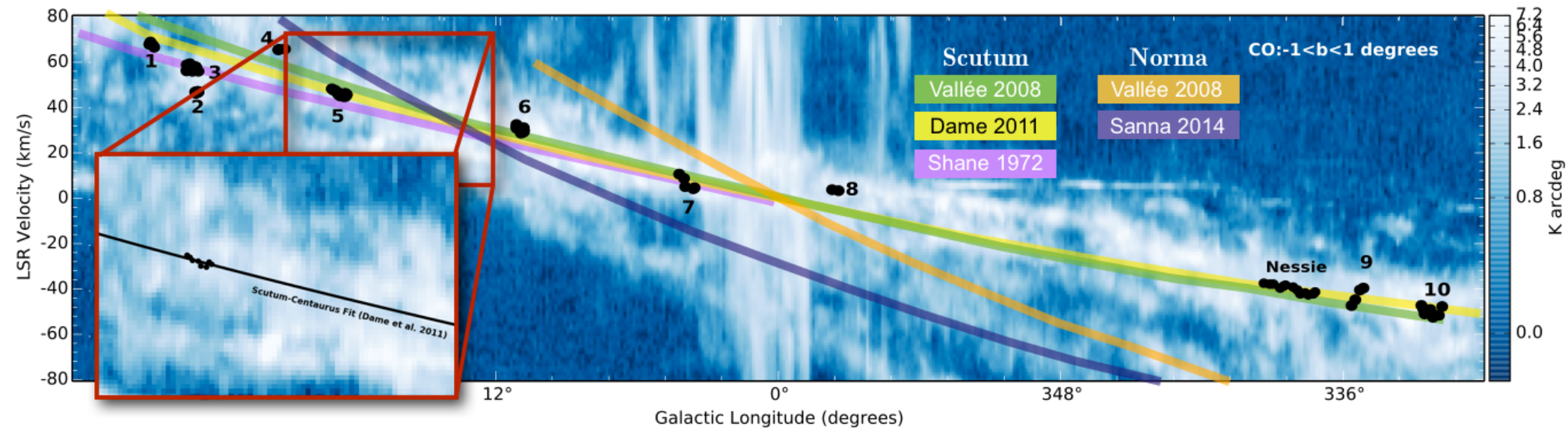
Smith et al. 2014, using AREPO (hydro+chemistry, imposed potential, no B-fields, no local (self-)gravity, no feedback)

WWT USED TO SEARCH FOR MORE OF THE "SKELETON"

A Tour of Possible Milky Way Bones
(images show Spitzer MIPS GAL overlay on optical image;
dotted lines show projected sky position of Milky Way spiral arms)
Alyssa Goodman
January 2014



6 OUT OF 10 BONE CANDIDATES LOOK EXCELLENT IN "3D" (POSITION-POSITION-VELOCITY SPACE)



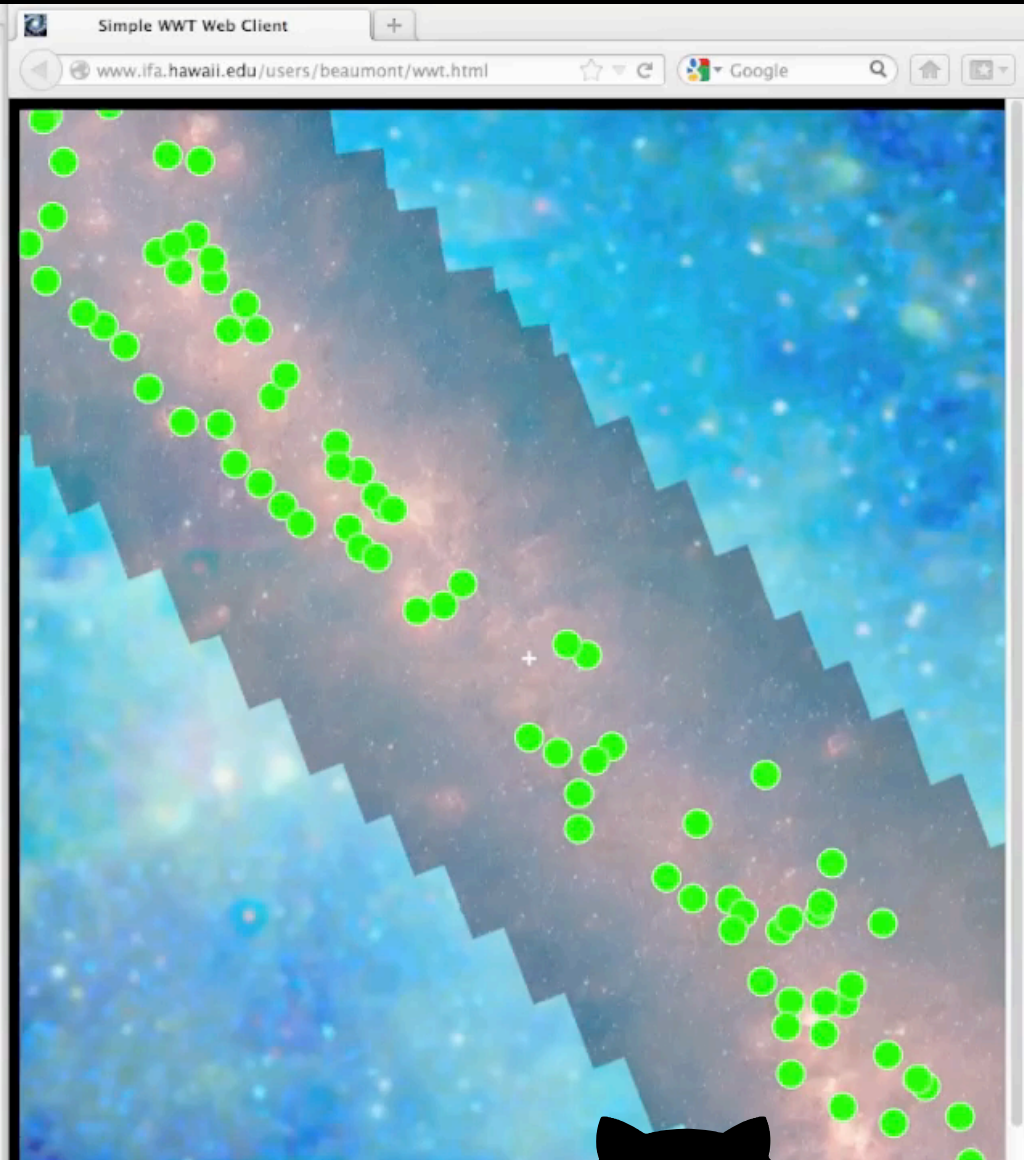
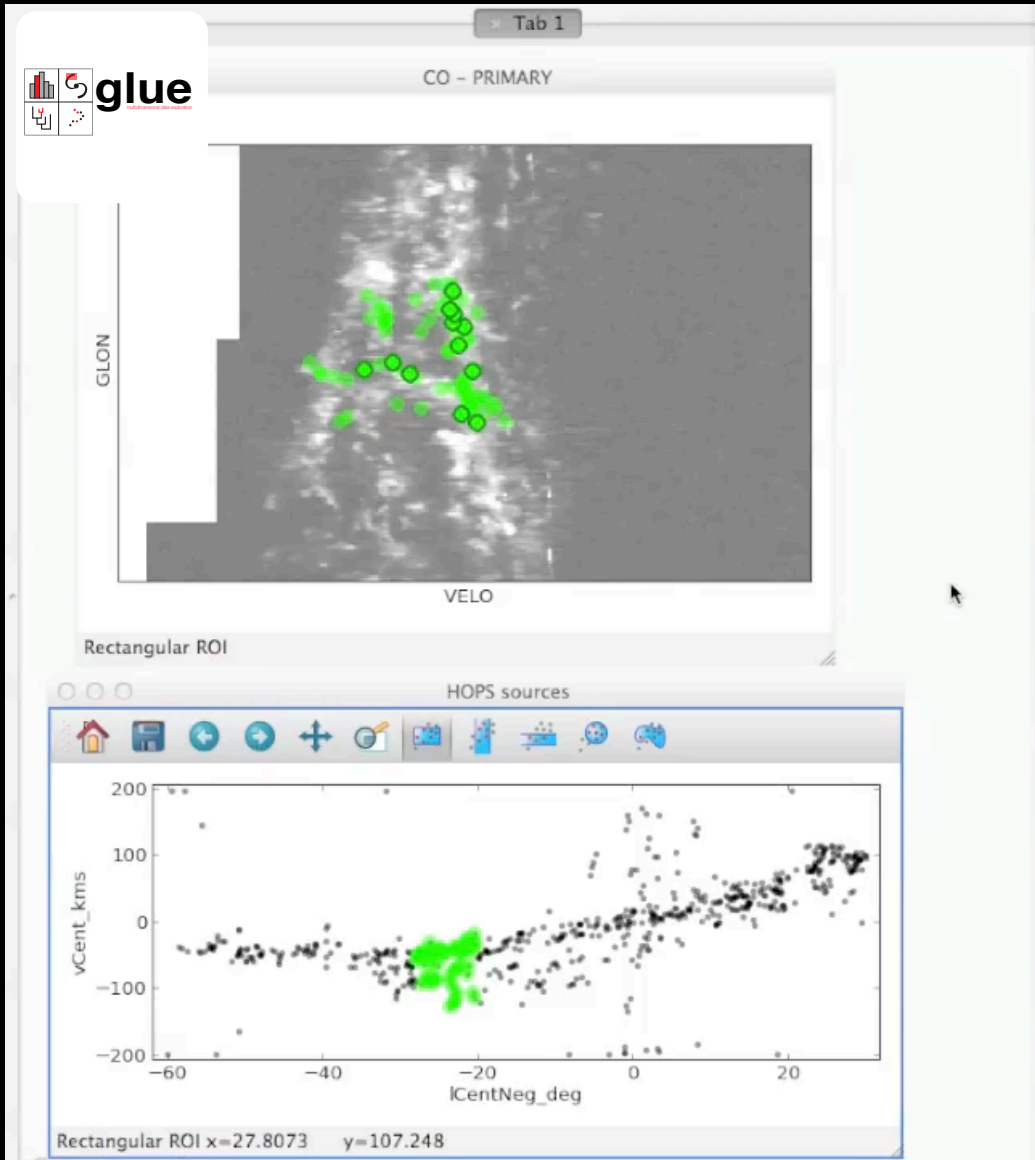
Blue image in the background shows CO position-velocity diagram based on Dame et al. 2001

The Skeleton of the Milky Way

Catherine Zucker, Alyssa Goodman, Cara Battersby

“We present the first evidence of additional bones in the Milky Way Galaxy, arguing that Nessie is not a curiosity but one of several filaments that could potentially trace Galactic structure.”

tinyurl.com/galaxyskeleton



WorldWide Telescope: **OpenWWT**

LINKED, INTERACTIVE VIEWS OF **Big**

Wide DATA ...AND LITERATURE

The logo for the ADS All-Sky Survey features the text "ADS ALL SKY SURVEY" in white, bold, sans-serif capital letters. The text is arranged in three lines: "ADS" on the top line, "ALL SKY" on the middle line, and "SURVEY" on the bottom line. The text is centered within a blue circular background. A red, curved, swoosh-like graphic element cuts across the circle from the bottom-left to the top-right.

ADS ALL SKY SURVEY

[View in Aladin](#) • [View in WorldWide Telescope](#) • [Demo Videos](#)

Finder Scope

Classification: Spiral Galaxy
Constellation: Andromeda
Names: M31

Name: M31	RA: 00h42m	Rise: 17:58
Information	Dec: +41 16' 00"	Transit: 03:40
Imagery	Alt: 35 39'	Set: 13:19

Set as Background Imagery
Set as Foreground Imagery

Research Show Object Bing Q

WorldWide Telescope Web Client

Andromeda Galaxy - Wikipedia, the free encyclopedia

Classification: Spiral Galaxy
Constellation: Andromeda
Names: Andromeda Galaxy, M31, Messier 31, NGC 206, M32, M110

RA: 00h42m29s	Rise: 18:24
Dec: +41 17' 03"	Transit: 04:07
Alt: 30 48' 47"	Set: 13:46
Az: 317 20' 25"	

Image Credit: Don J. McCrady

Research Show Object Bing Q

WorldWide Telescope Web Client

Andromeda Galaxy - Wikipedia, the free encyclopedia

Object Query Results

Look At: sky

Imagery: digitized sky survey color

Tracking: M31

1 of 2

Andromeda 01:50:29

RA: 00h42m42s
Dec: +41 16' 00"

WorldWide Telescope Web Client

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WorldWide Telescope: Data ↔ Literature

Web or Windows: "right-click"

ADS All-Sky survey on Al... ADS All-Sky survey on Wo... Untitled SIMBAD basic query result Advanced query - Advanc...

www.adsass.org/wwt/?ra=345.42886923995724&dec=56.80696913940664&fov=118.07887634625072&layer=harvard

The ADS All Sky Survey [Open Aladin version](#) Astronomy articles. In the sky.

CHOOSE HEATMAP

Object All Stars Galaxies HII regions Nebulae Other

Band Radio Infrared Ultraviolet X-ray


Custom Harvard/All

Year

BACKGROUND LAYER

Optical 2MASS WISE SFD IRIS GLIMPSE H-alpha ROSAT

Optical Harvard/All



$(\alpha, \delta) = 83.66^\circ, -5.39^\circ$ FOV = 17°

ADS All-Sky Survey is a NASA-funded project



Region: In Perseus and Taurus

ads
NASA

$\alpha(2000) 3h 38m 14s, \delta(2000) +31^{\circ} 25'$
 $\alpha(1875) 3h 30m 30s, \delta(1875) +31^{\circ} 00'$

Area
In Perseus and Taurus

Galactic Coordinates
 $127^{\circ}, -18^{\circ}$

Scale
1 cm = 18'.2 or 1 in = 46'.2

Chart Plate & Chart
Table Text

enlarge [+] printable PDF



Bar-p1-p1003_sm
Bernard's Image of Perseus
www.library.gatech.edu/pep

December 10

astrometry.net
Hello, this is the blind astrometry solver. Your results are: (RA, Dec) center: (54.3096782184, 31.420266374) degrees Orientation: 5.2134589764 deg E of N Pixel scale: 18.516371997 arcsec/pixel Your field contains: NGC 1465 IC 1985 C Per / Ask o Per 40Per 42Per NGC 1333 IC 348 IC 2003 View in World Wide Telescope — If you would like to have other images solved, please submit them to the astrometry.group.



Explore Guided Tours Search View Settings

collections > All Sky Surveys > Open Collections > Perseus

ADS ALL SKY SURVEY

Explore Guided Tours Search View Settings

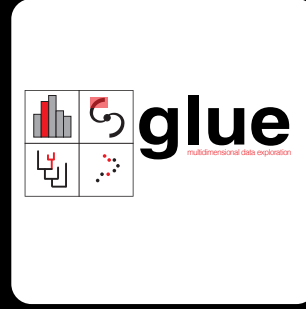
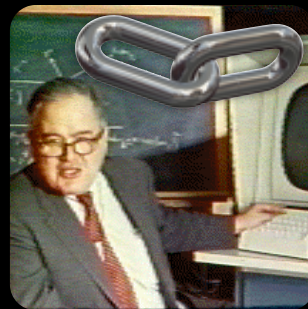
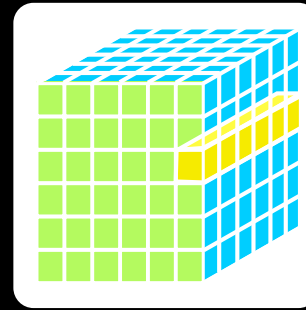
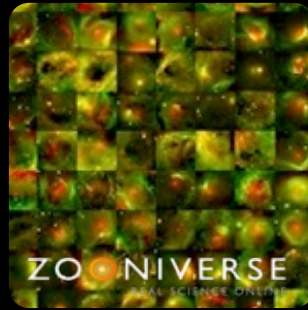
collections > Open Collections > Bar-p1-p1003_sm > Perseus

Look At Imagery Info Image Crossfade

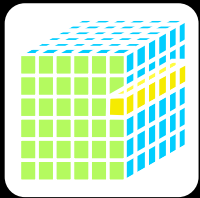
Perseus NGC 1333 California Nebula IC348, IC 348 IC1911 IC1880 IC1985 IC1876 IC1960

DATA SCIENCE TOOLS

RESOLUTION
CONTEXT
BIG DATA
WIDE DATA
DIMENSIONALITY
LINKED VIEWS
INTERACTION



TOOLS



WWT will be fully open-source on GitHub in 2015.

Dataverse & Authorea links to WWT...



Glue is funded by NASA/JWST.

On the horizon: CARTA/NRAO (visualizer for big cubes)



Interactivity in 3D, especially for “big data” is “an opportunity” ...



ADSASS will be linked to AAS/IOP Astrolmage Explorer + WWT.



“oldAstronomy” will extend ADSASS beyond optical, via Zooniverse.

Big DATA

versus

Wide DATA

WIDE DATA IN WWT

ipac

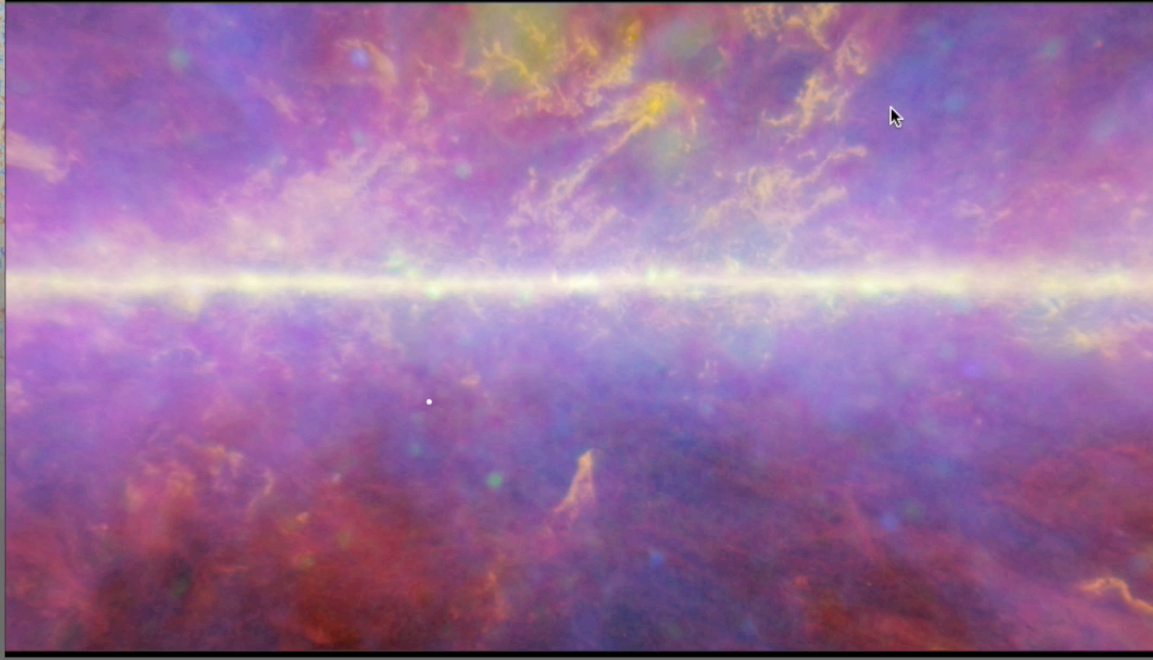
PLANCK

U.S. DATA CENTER AT IPAC

ABOUT NEWS GALLERY FOR RESEARCHERS



Interactive Planck Data Viewer (WorldWide Telescope)



- Galactic Plane Mode
- Galactic Grid
- Equatorial Grid
- Constellation Figures

Background

Planck Thermal Dust

Our Milky Way galaxy is filled with sooty particles of

Foreground

Planck Dust & Gas

A composite view of our Milky Way displays a

planck.ipac.caltech.edu/wwt