

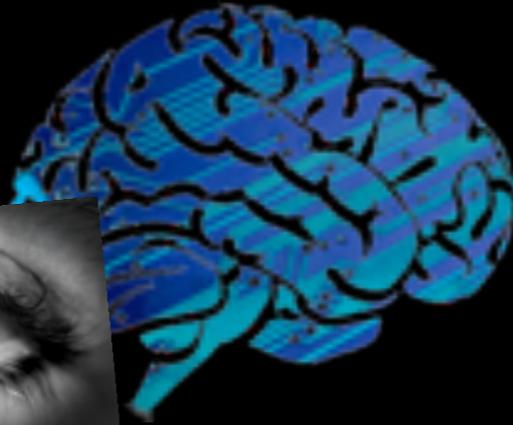
worldwidetelescope.org

Big Data

versus

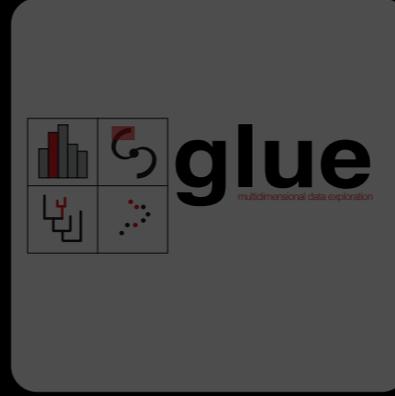
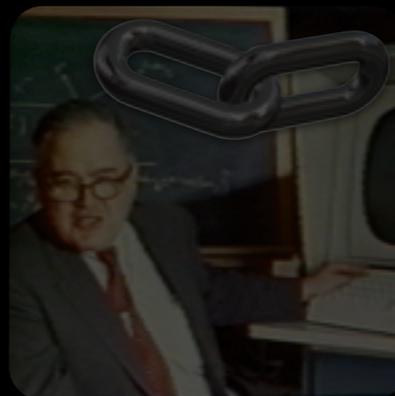
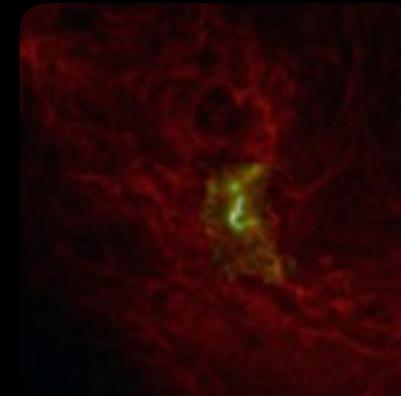
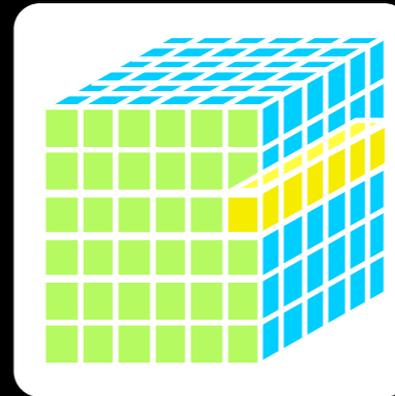
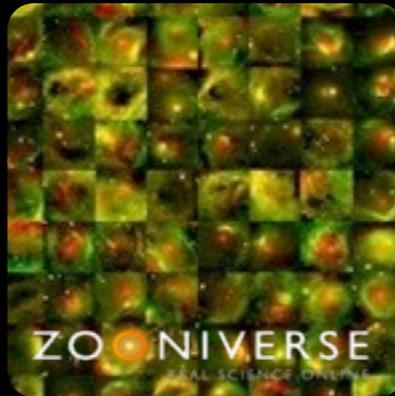
Wide

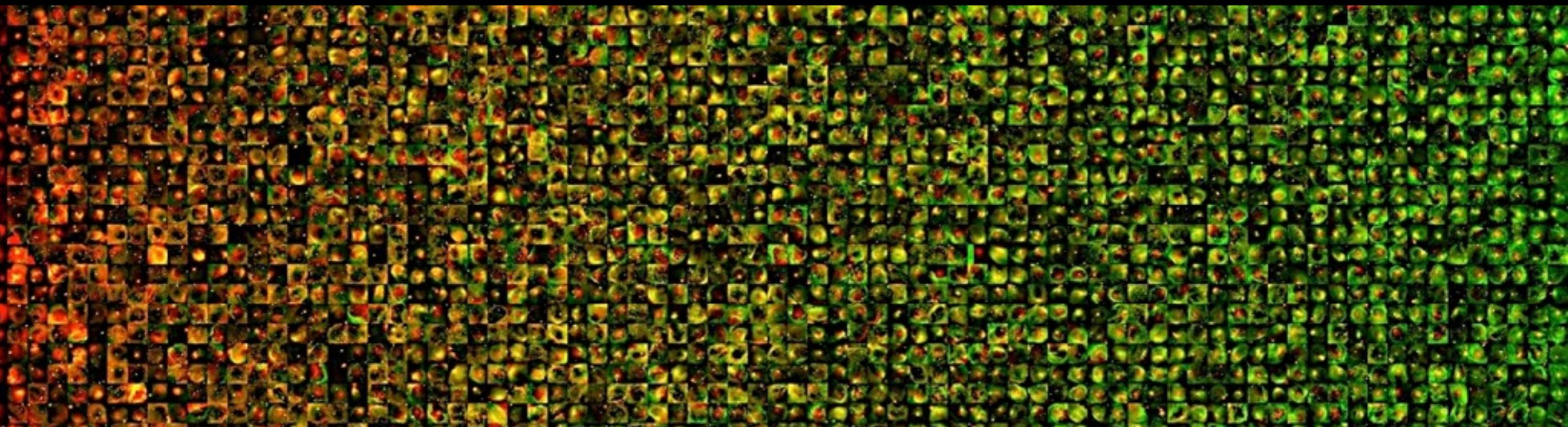
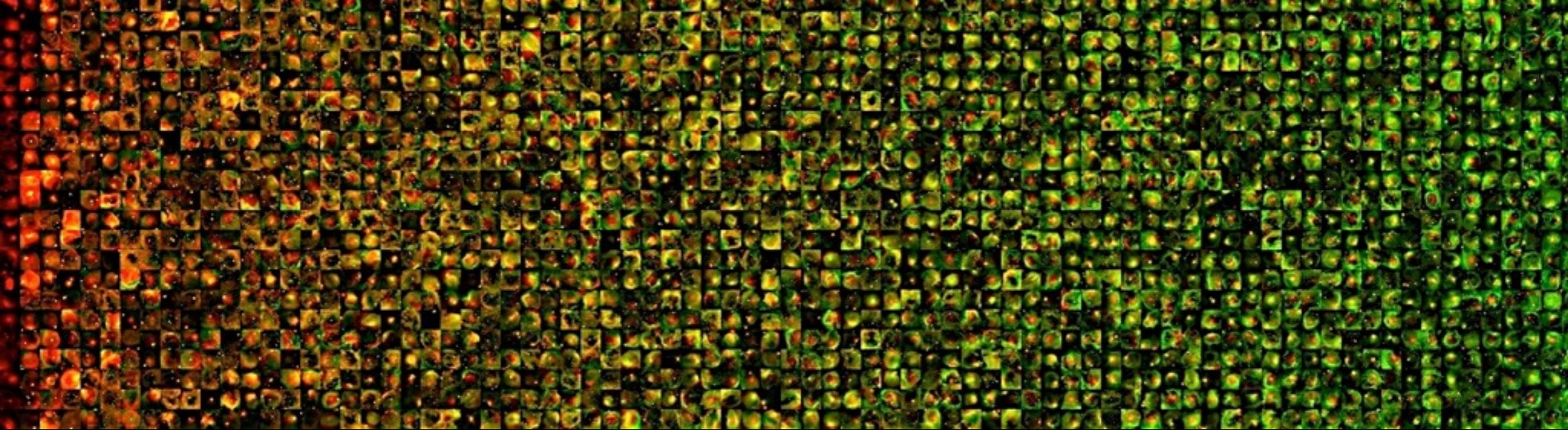
Data



Data Science Tools

Resolution
Context
Big Data
Wide Data
Dimensionality
Linked views
Interaction





Use Layer Manager to Control User Settings



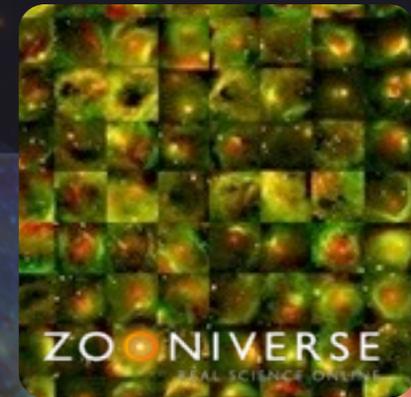
Name My Location
Lat 37:47:15 Alt 0 m
Lng -123:35:23
View From This Location

2015/02/11 04:40:33
Real Time
Now

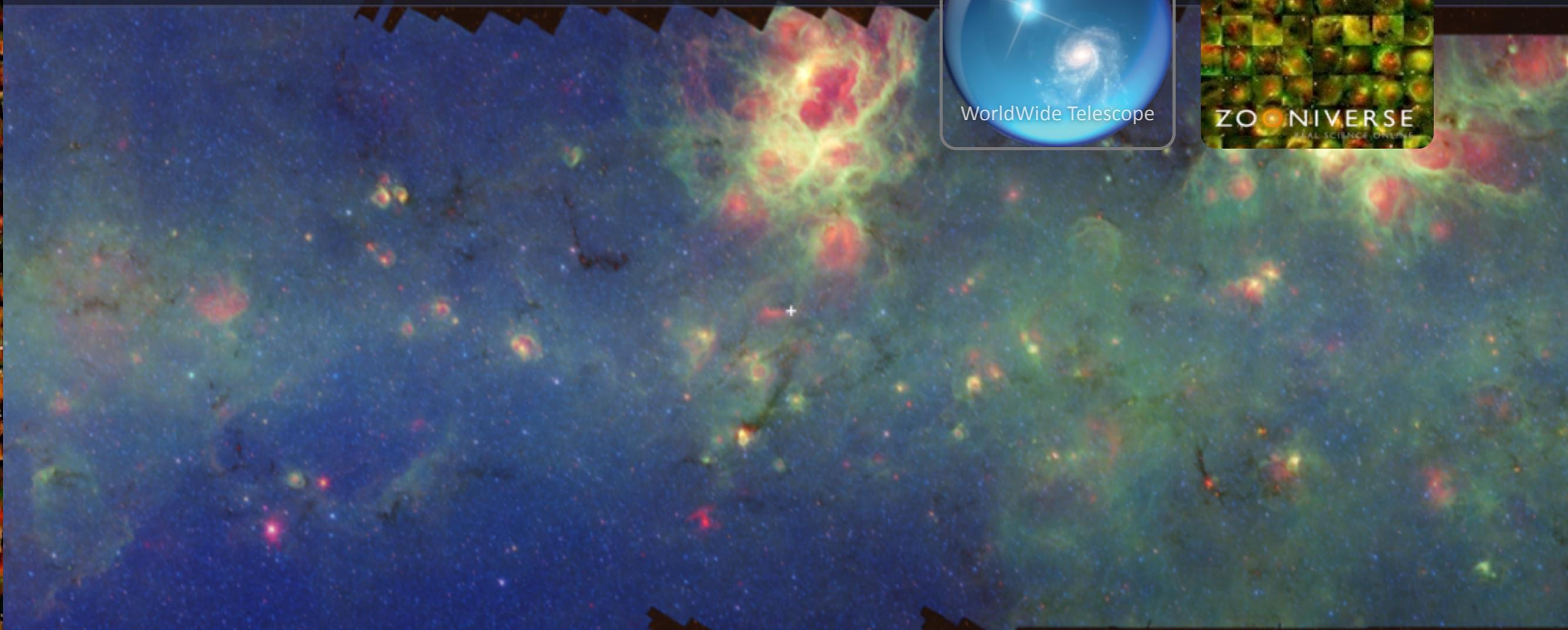
Galactic Plane Mode



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

DIG DATA and Human-Aided Computing

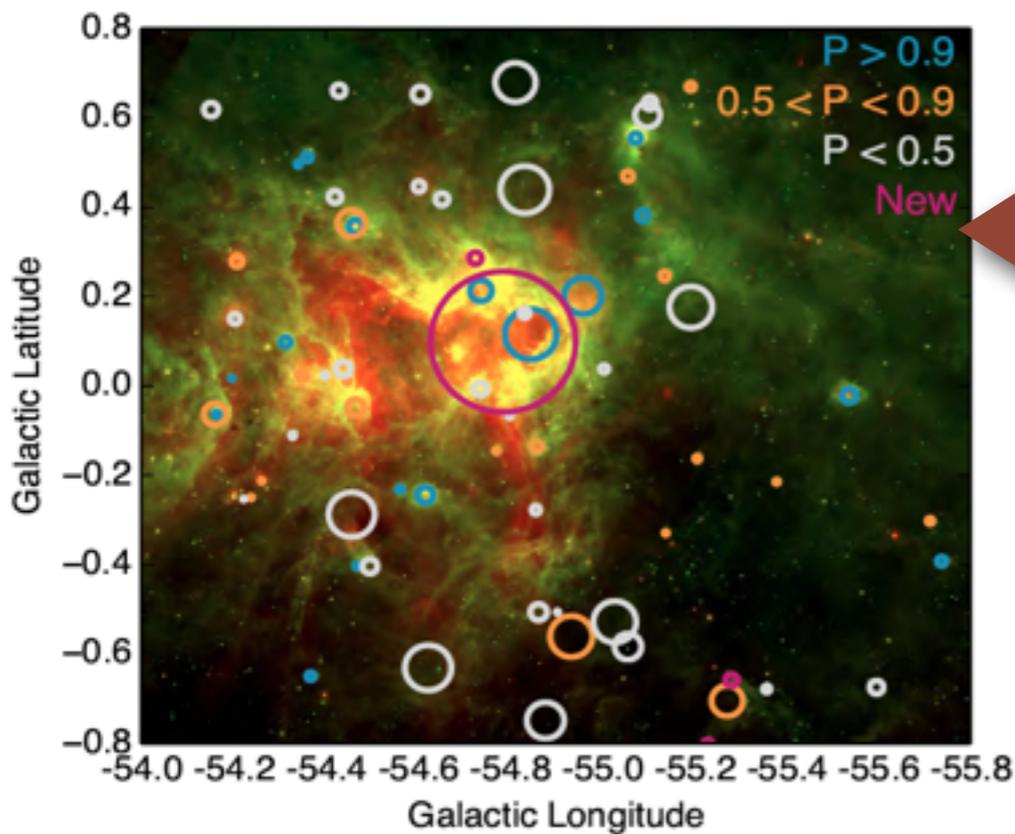
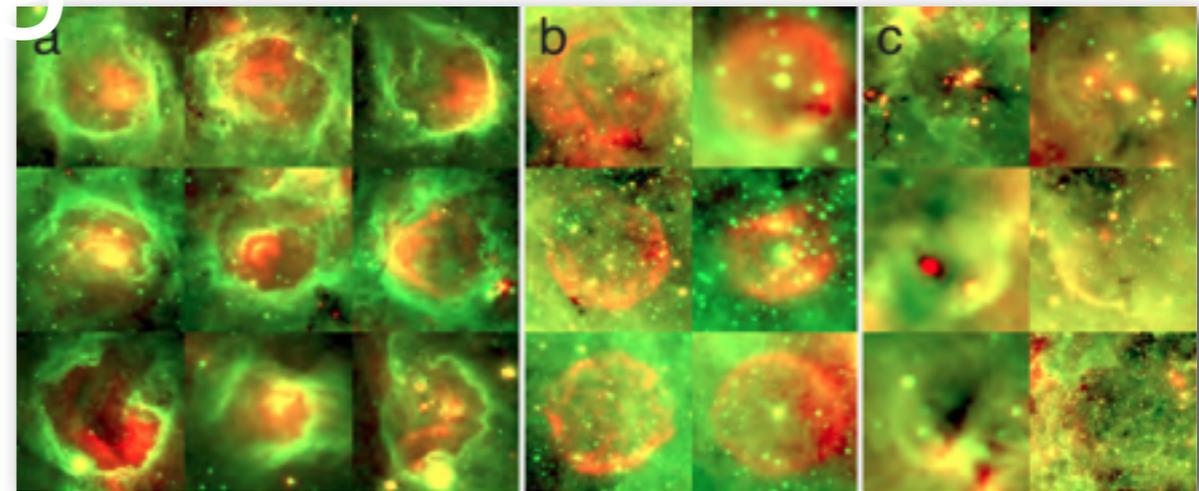


THE MILKY WAY PROJECT ZOONIVERSE REAL SCIENCE ONLINE

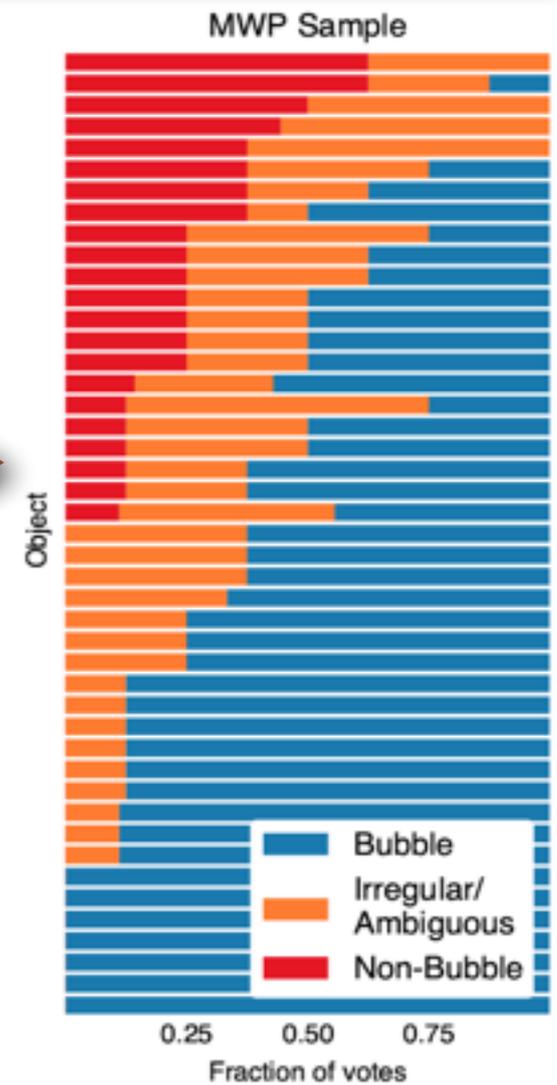
mark bubbles

What do you see in this image?

Bubble Star Cluster EGO Galaxy Object I'm done!

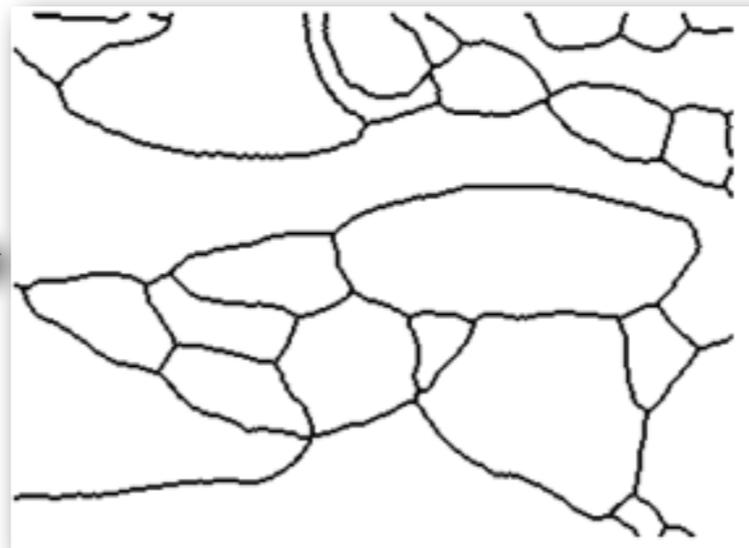
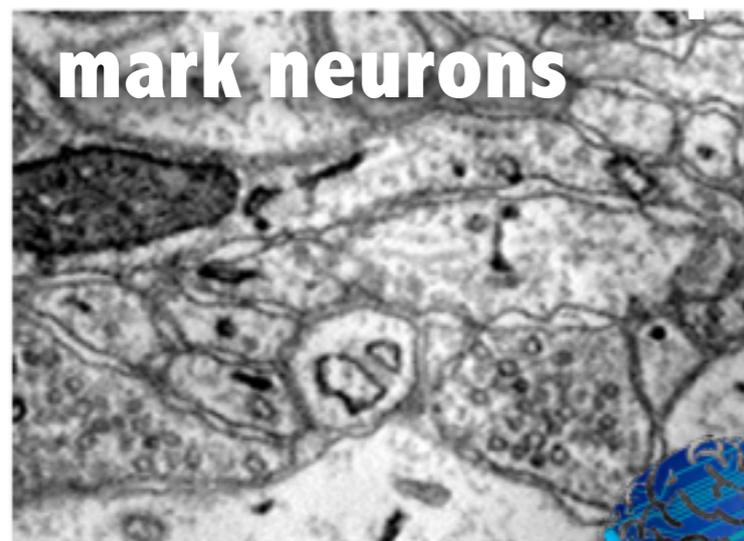


machine-learning algorithm (Brut)

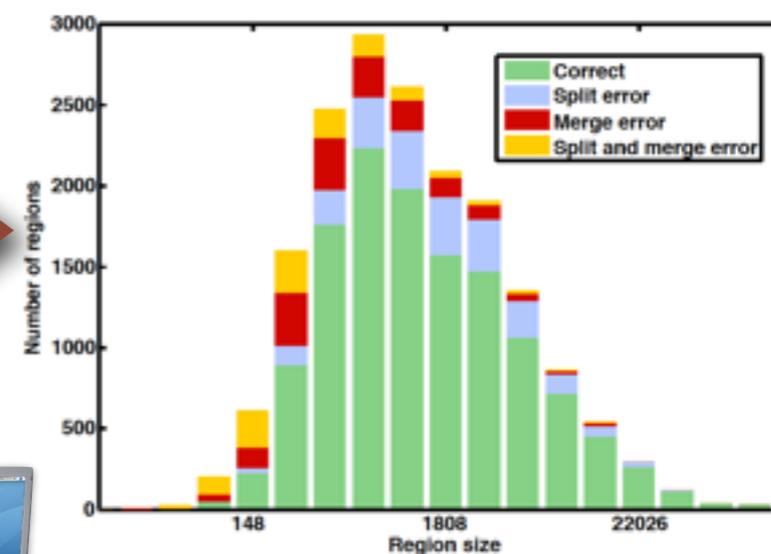
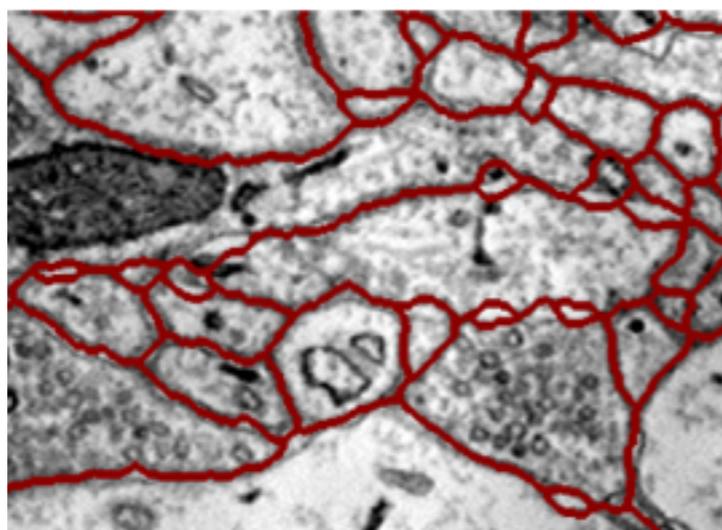


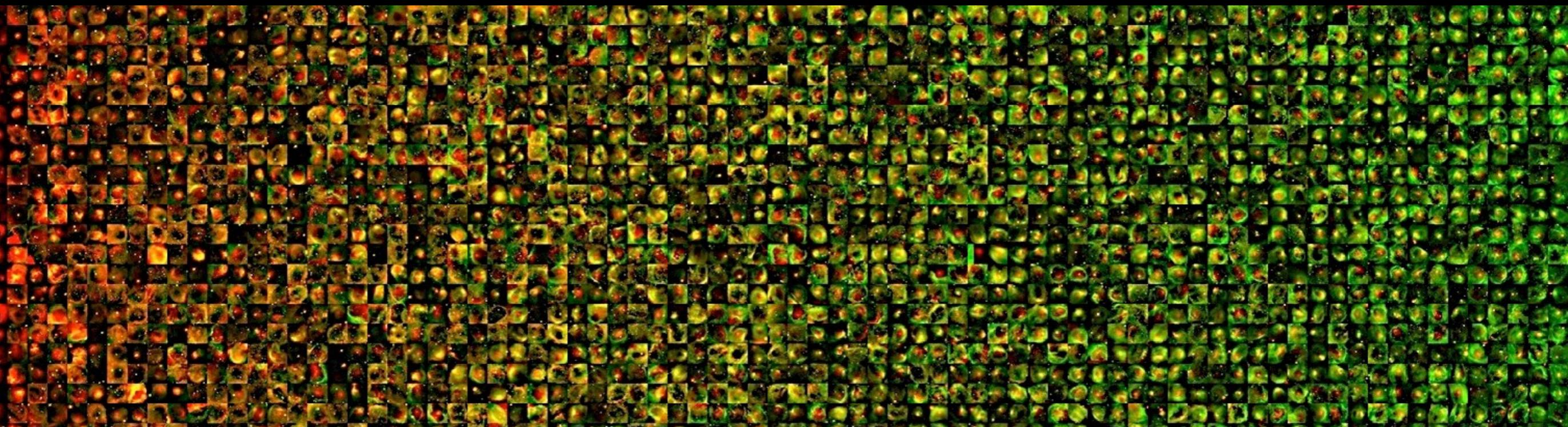
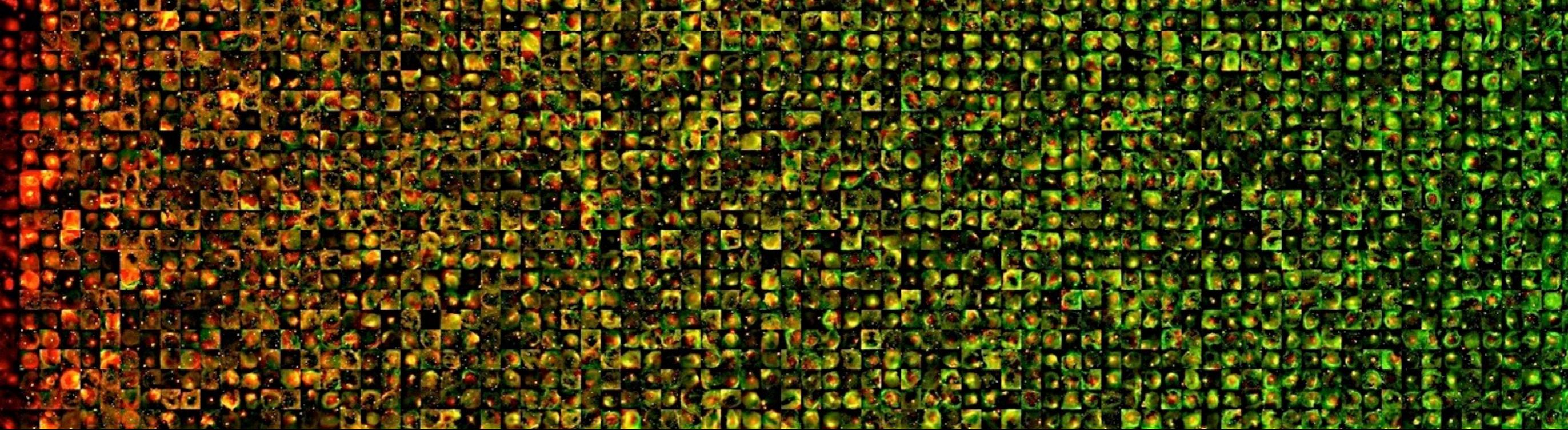
example here from: Beaumont, Goodman, Kendrew, Williams & Simpson 2014; based on Milky Way Project catalog (Simpson et al. 2013), which came from Spitzer/GLIMPSE (Churchwell et al. 2009, Benjamin et al. 2003), cf. Shenoy & Tan 2008 for discussion of HAC; astroml.org for machine learning advice/tools

BIG DATA and Human-Aided Computing

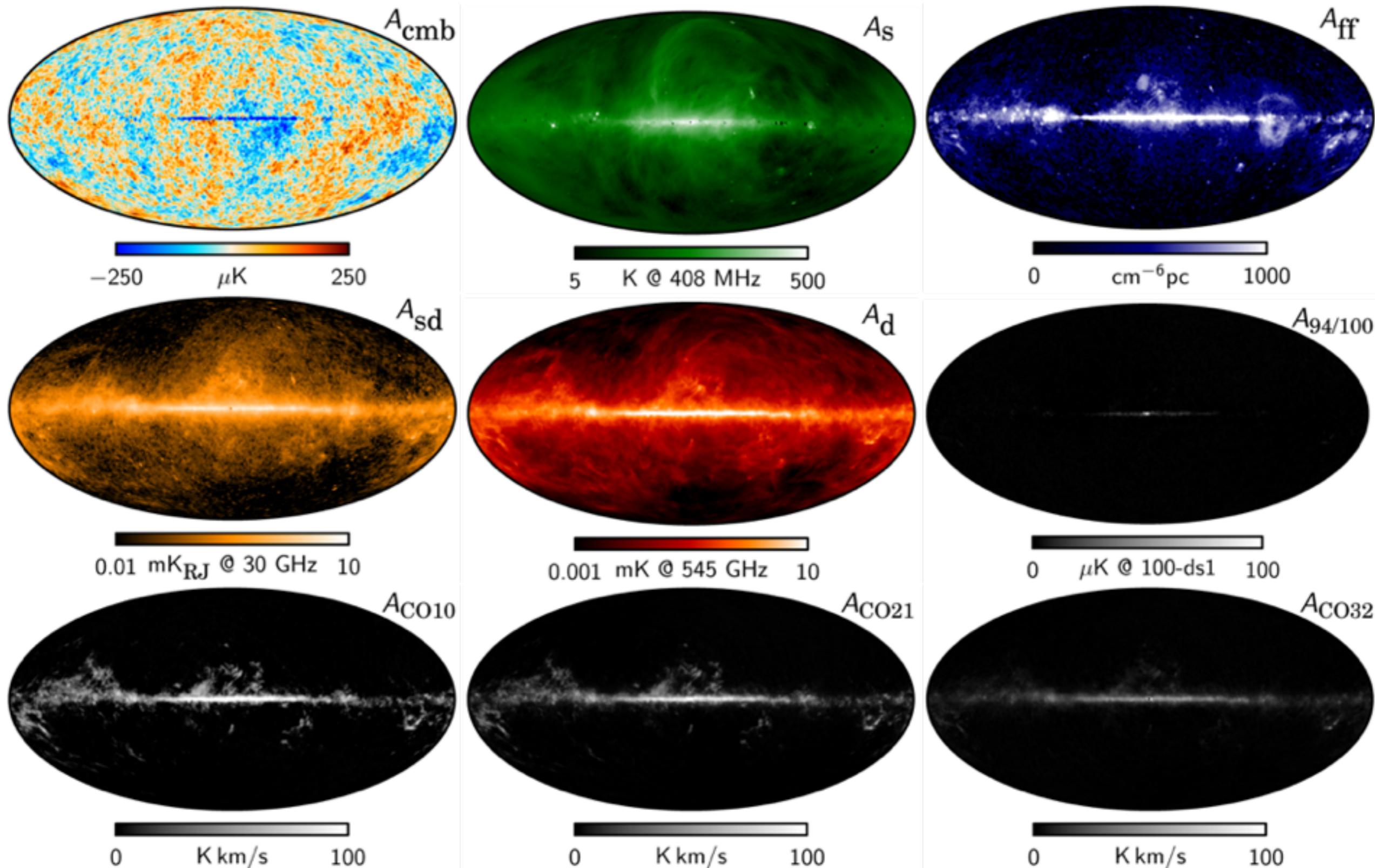


machine-learning algorithm (RF+CRF)





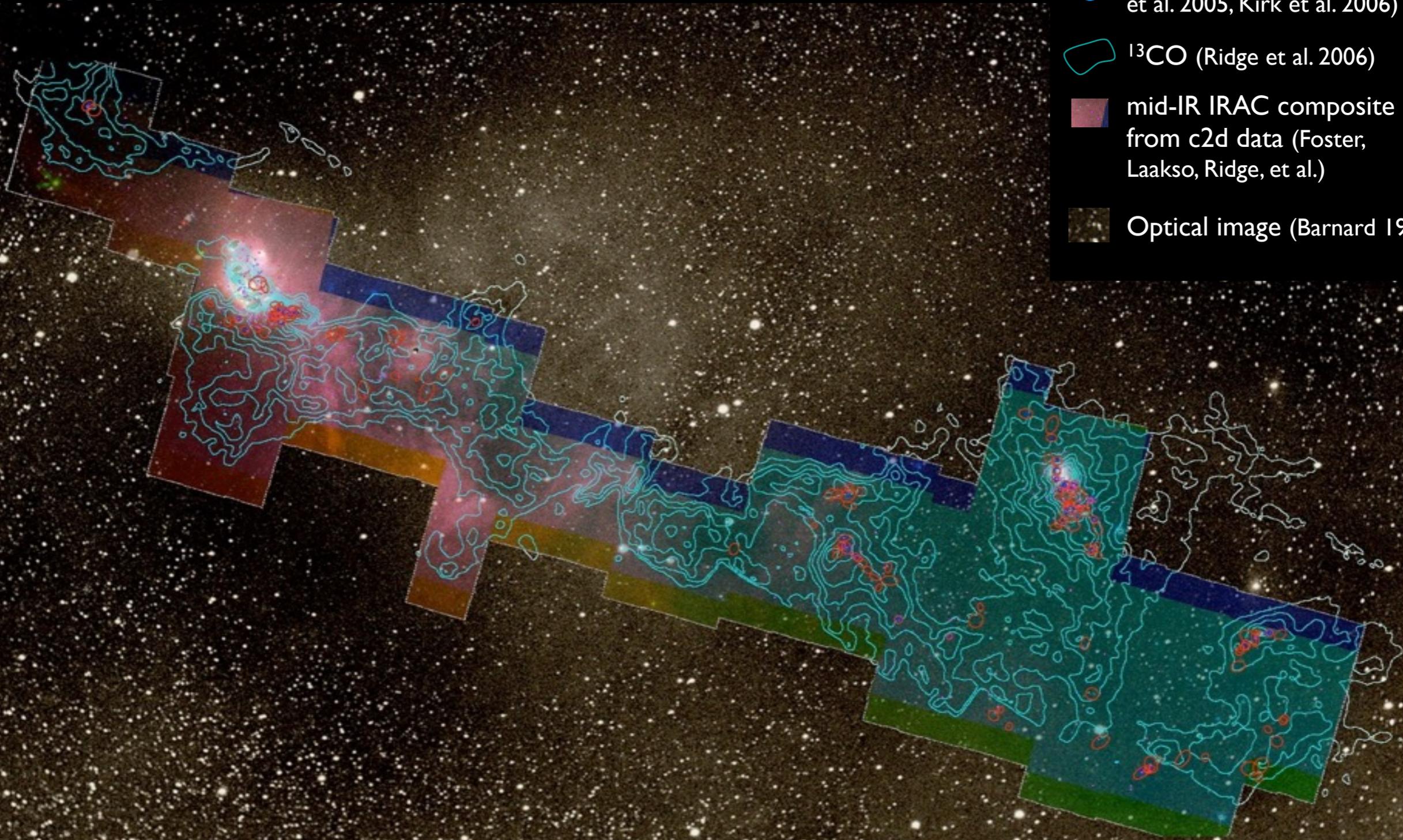
Wide Data

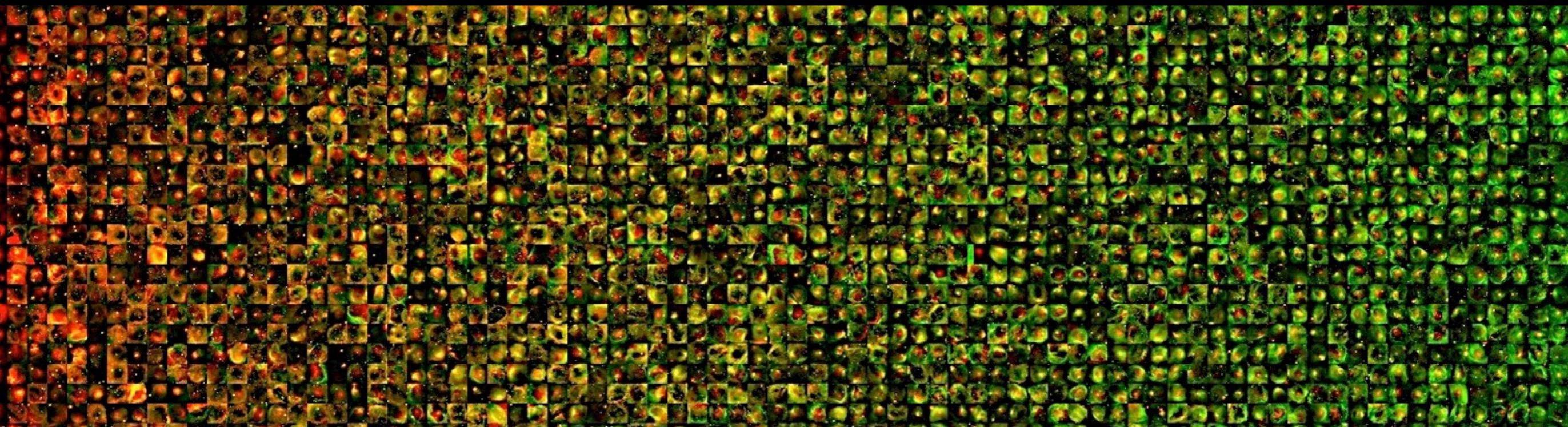
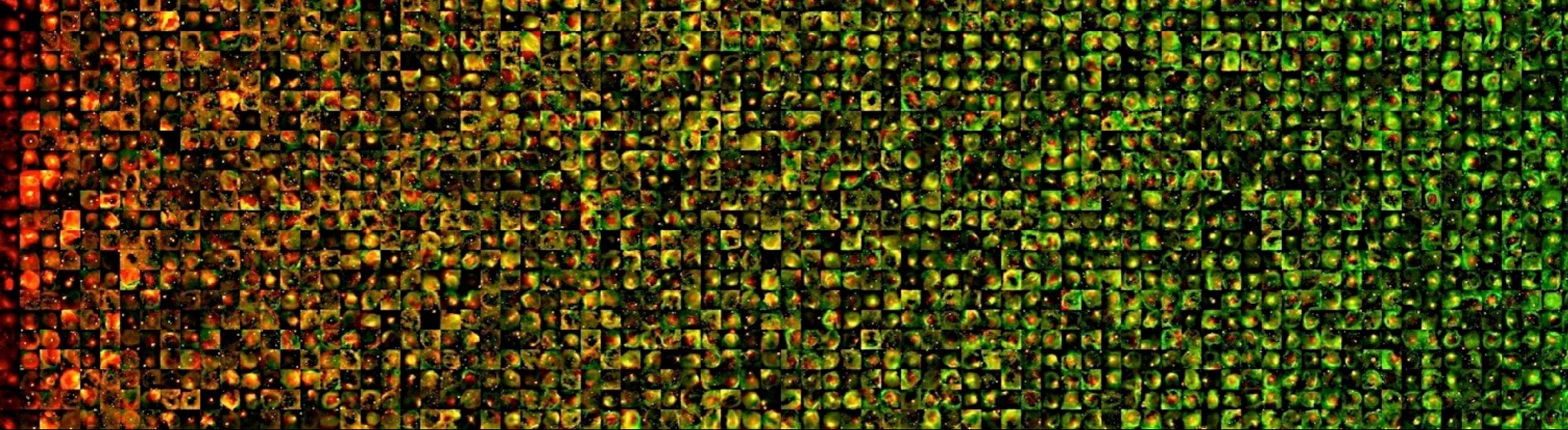


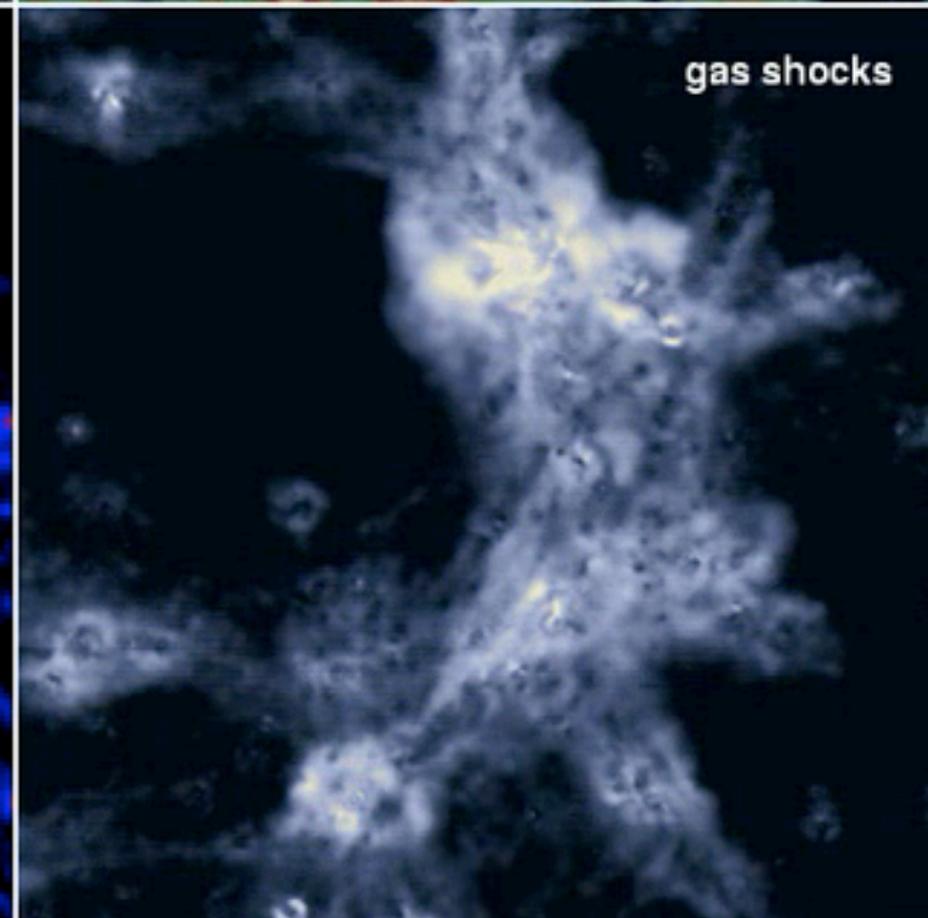
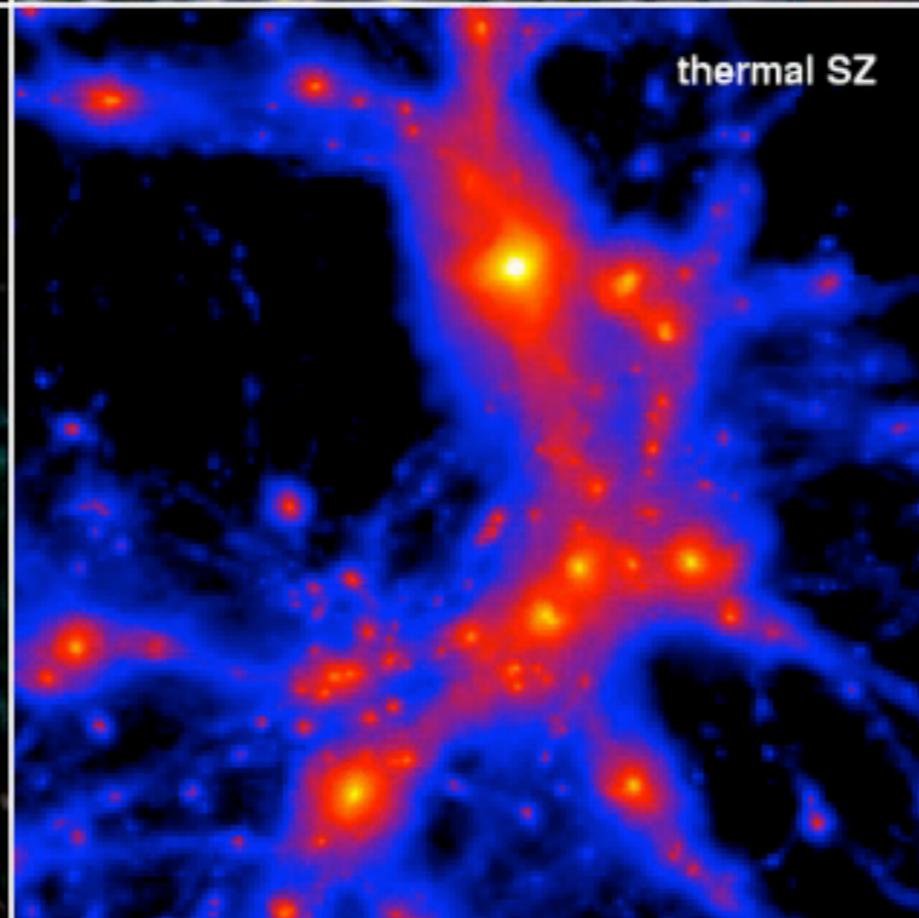
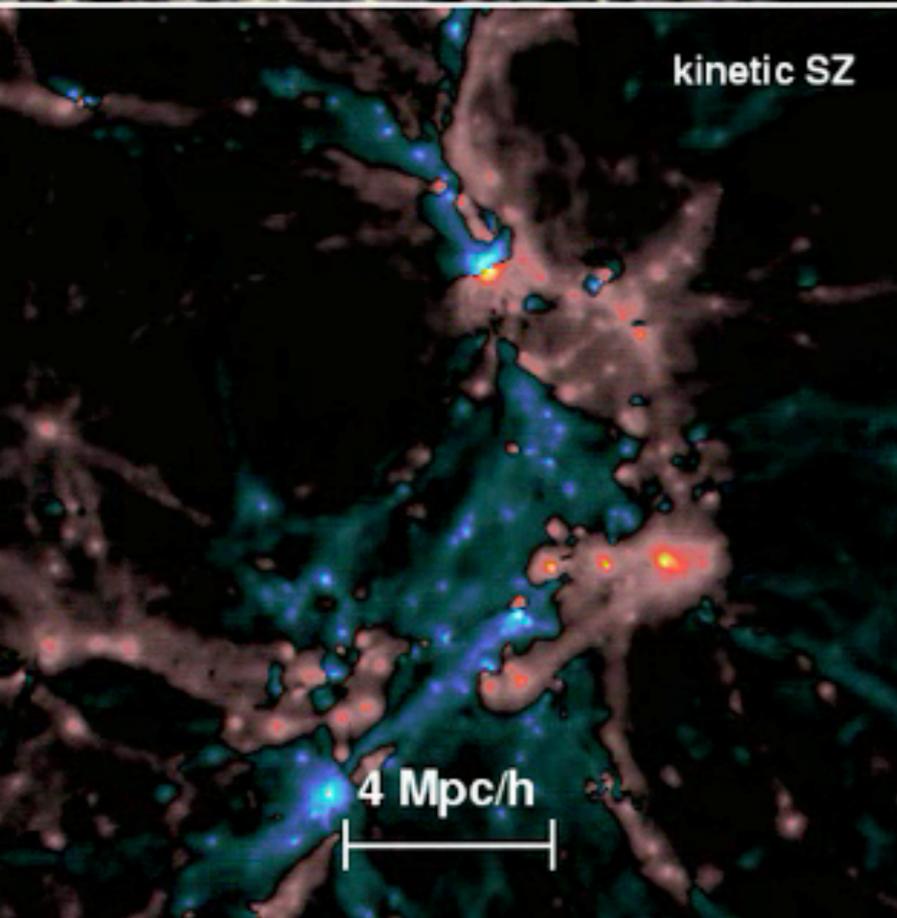
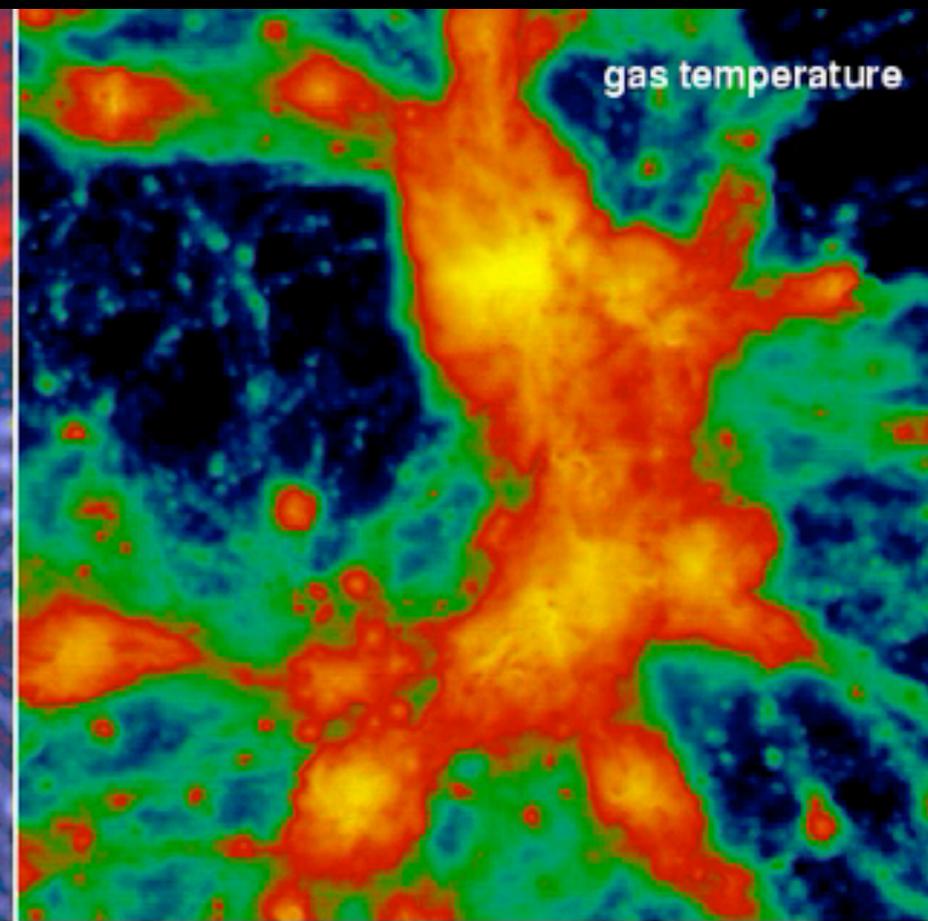
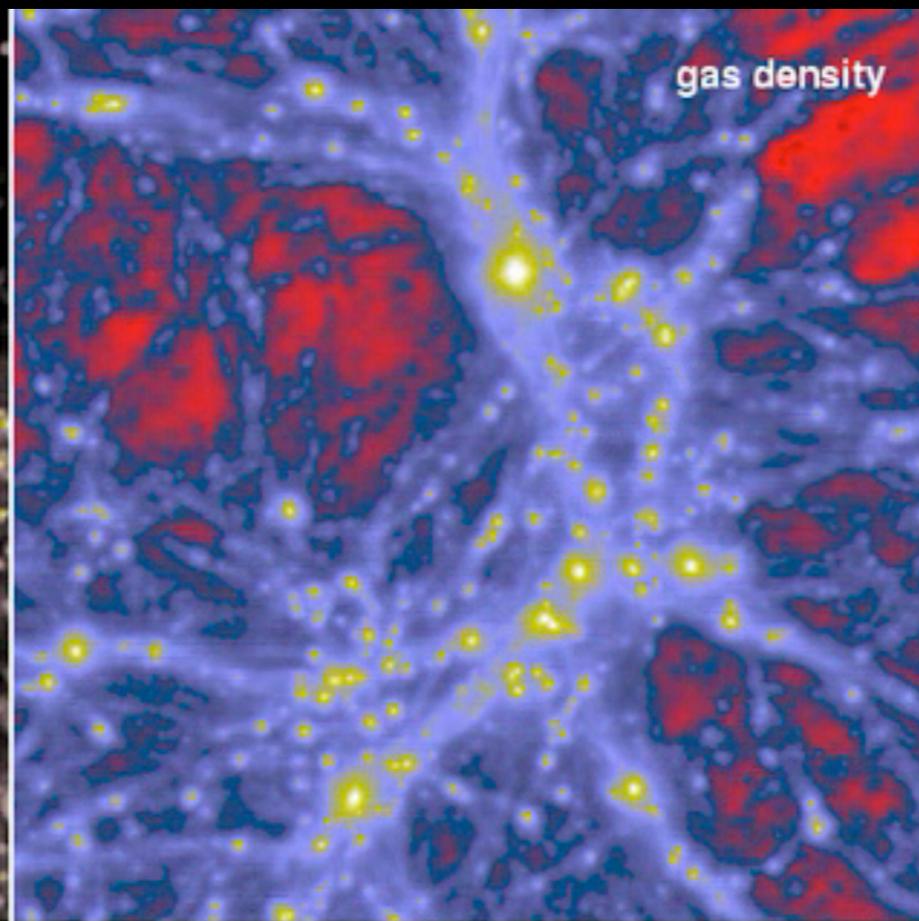
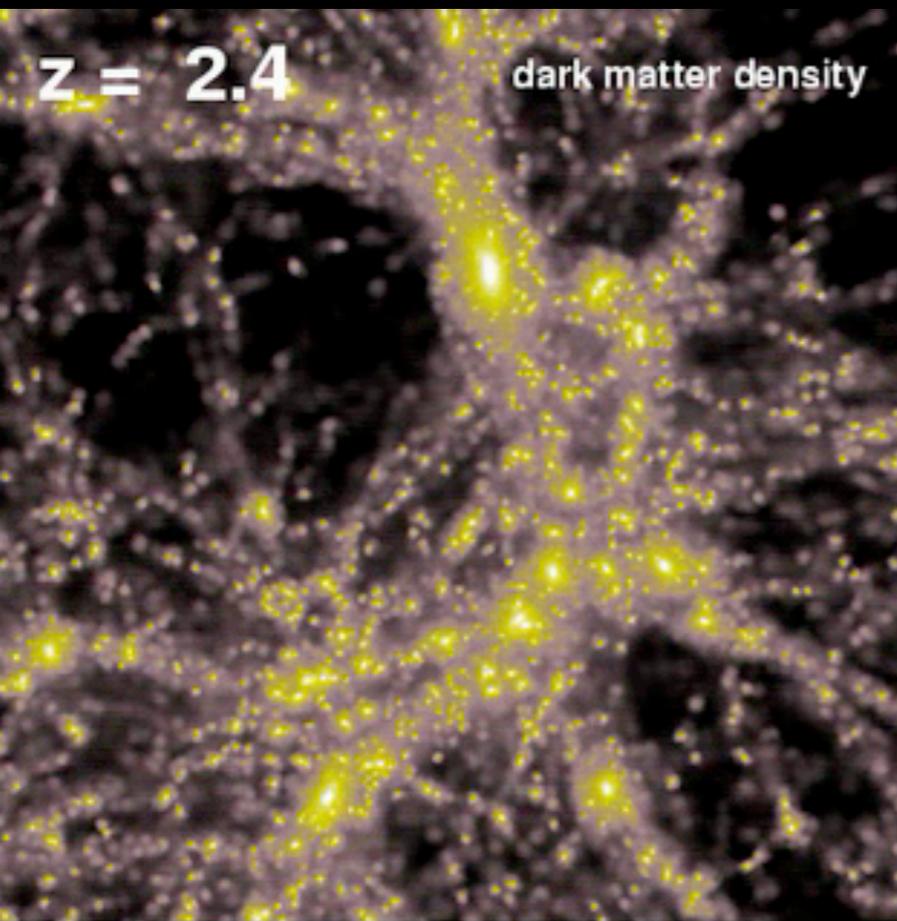
Wide Data

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)

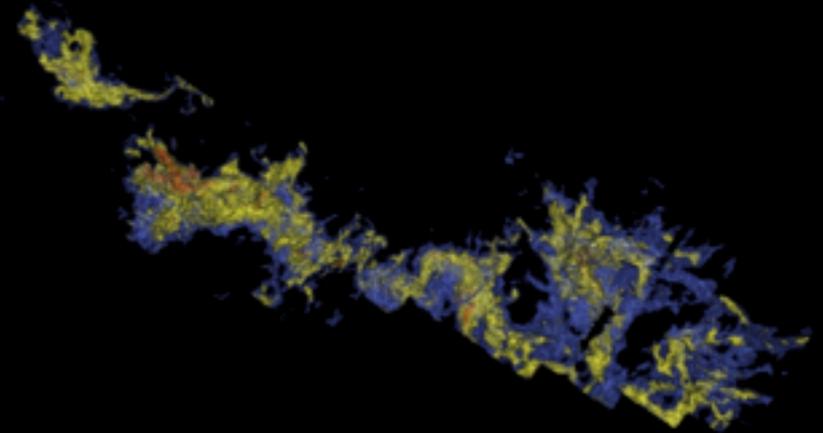
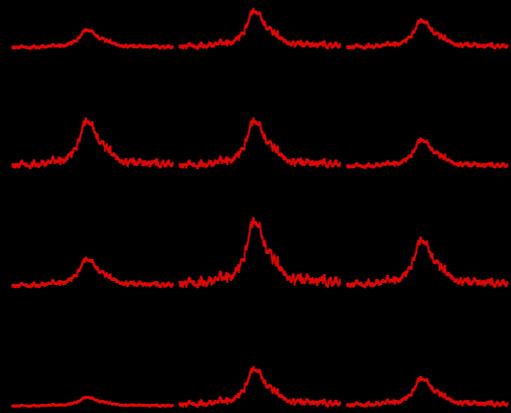




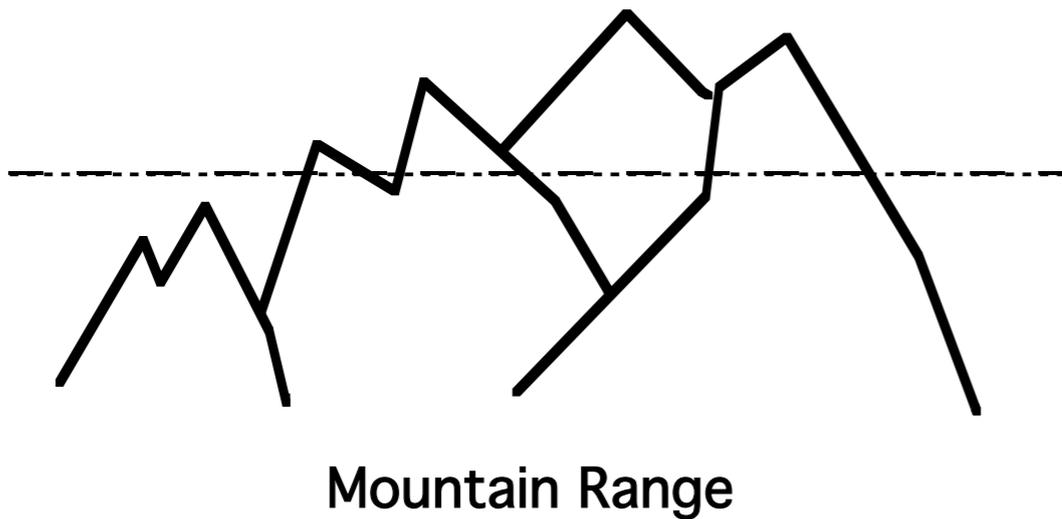
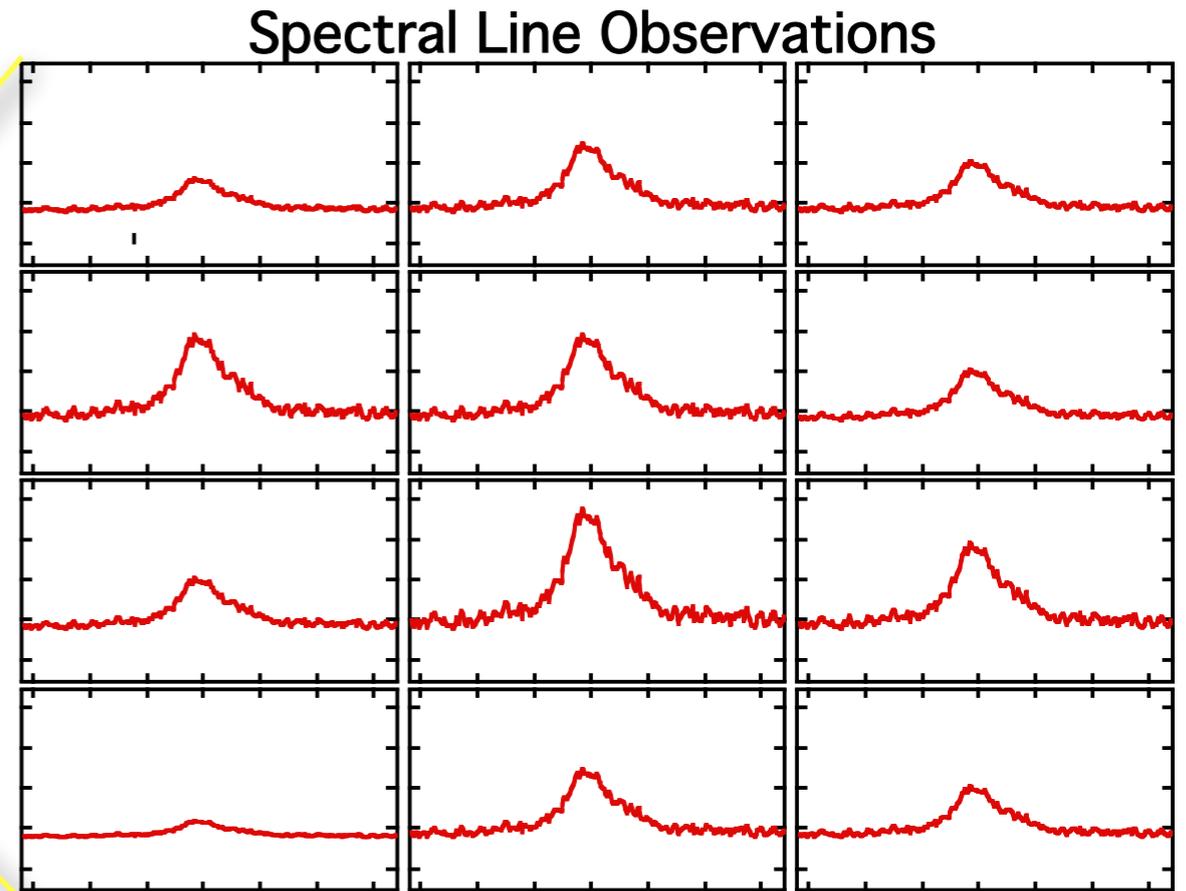
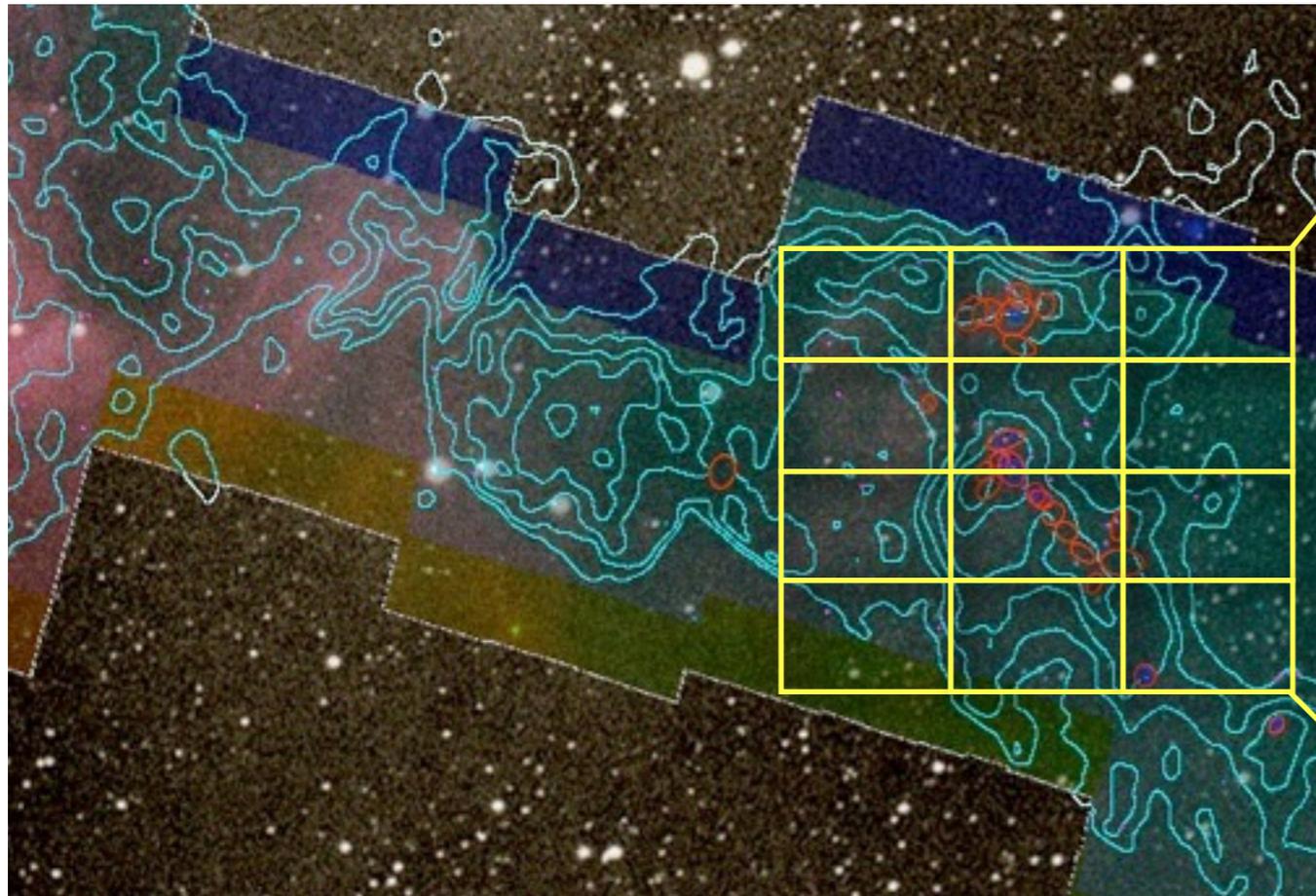
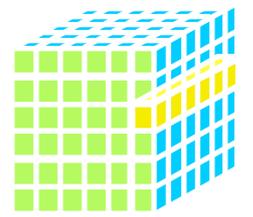


Movie: Volker Springel, formation of a cluster of galaxies. Millenium Simulation requires 25TB for output.

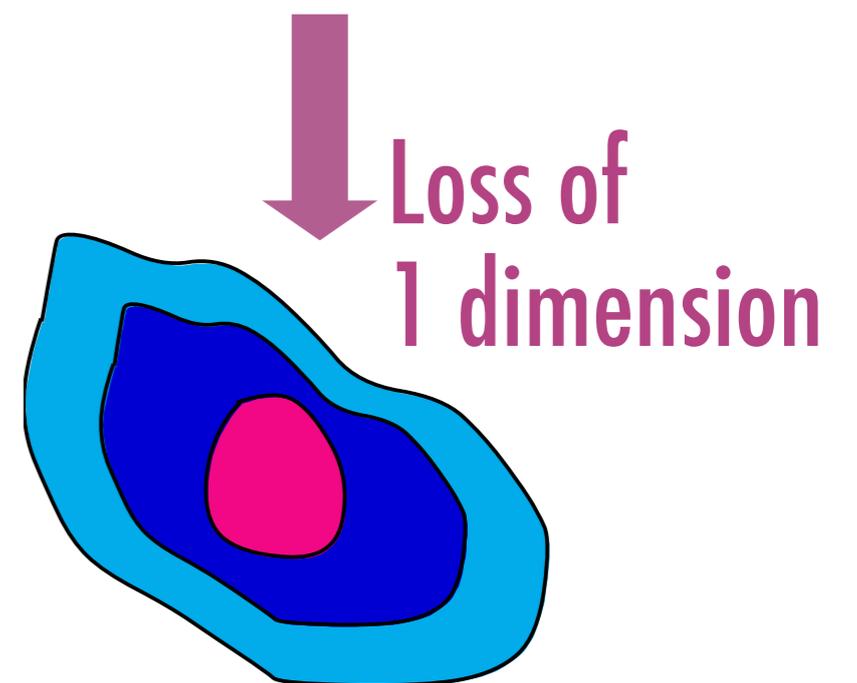
Adding A third Dimension

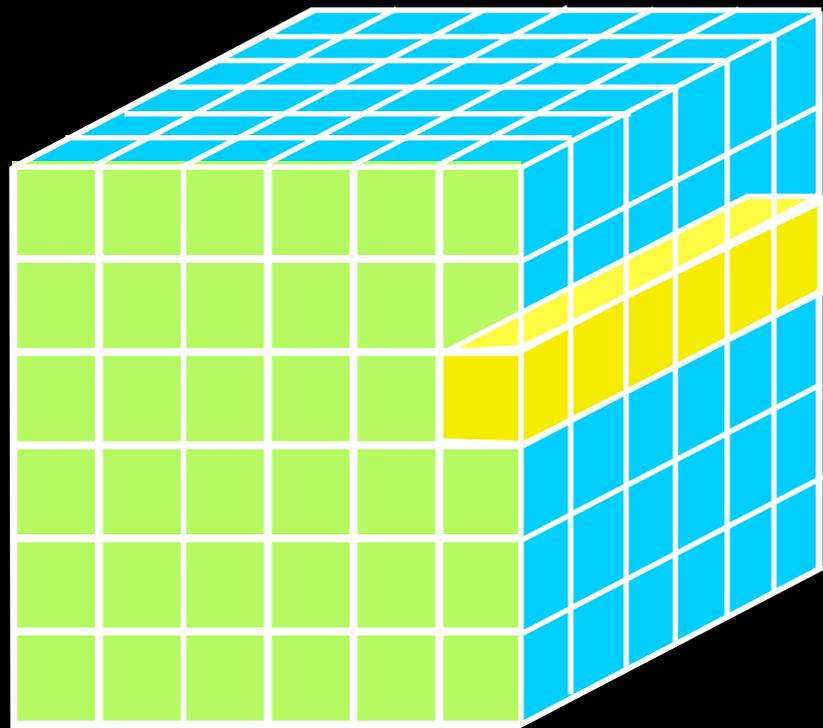


third dimension often hidden



No loss of information





“Data, Dimensions, Display”

1D: Columns = “Spectra”, “SEDs” or “Time Series”

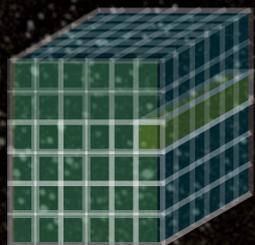
2D: Faces or Slices = “Images”

3D: Volumes = “3D Renderings”, “2D Movies”

4D: Time Series of Volumes = “3D Movies”

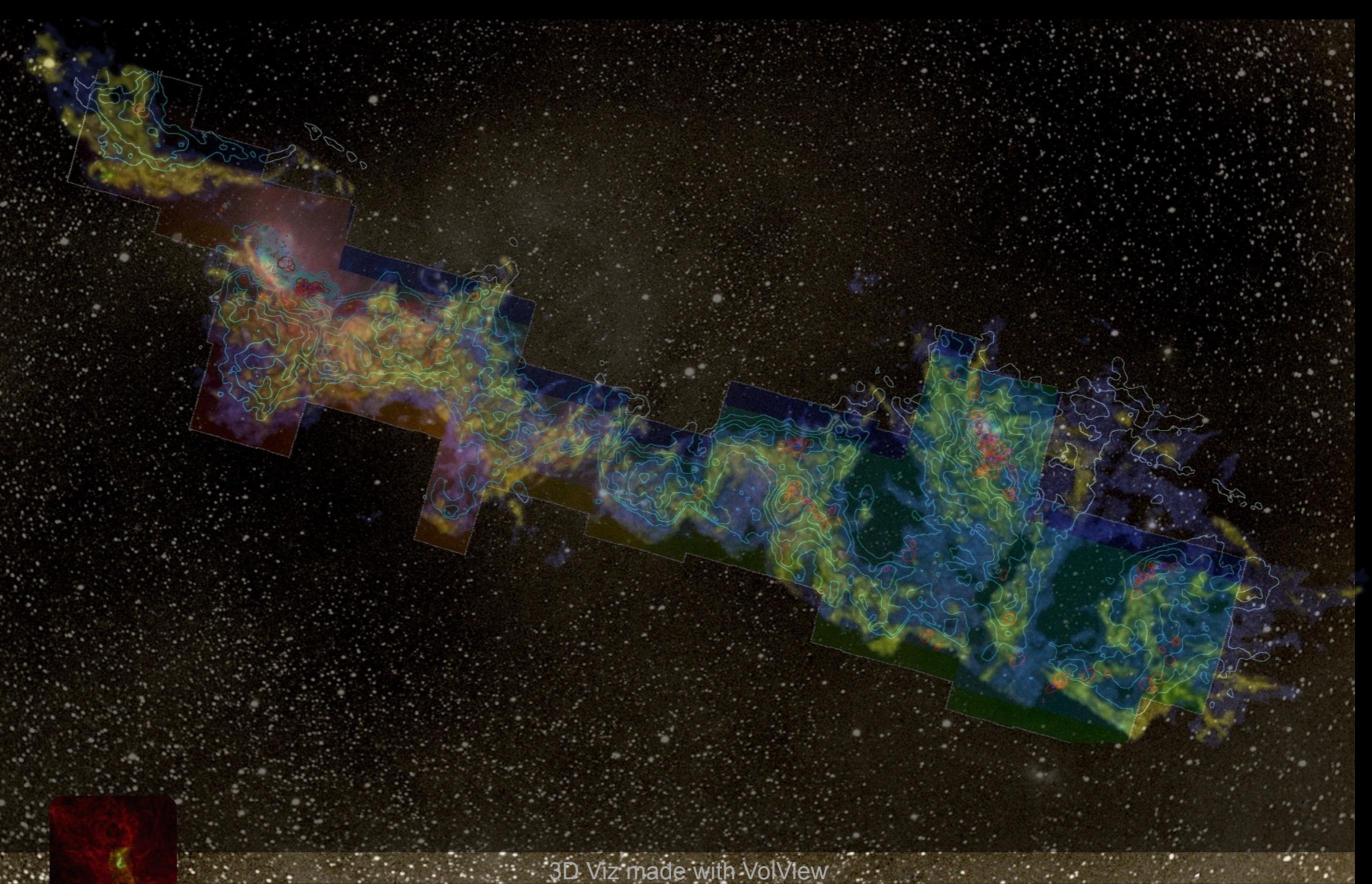
Wide Data, “In 3D”

-  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)



m: 17249
Zoom: 227% Angle: 0





3D Viz made with VolView

AstronomicalMedicine@iig

COMPLETE

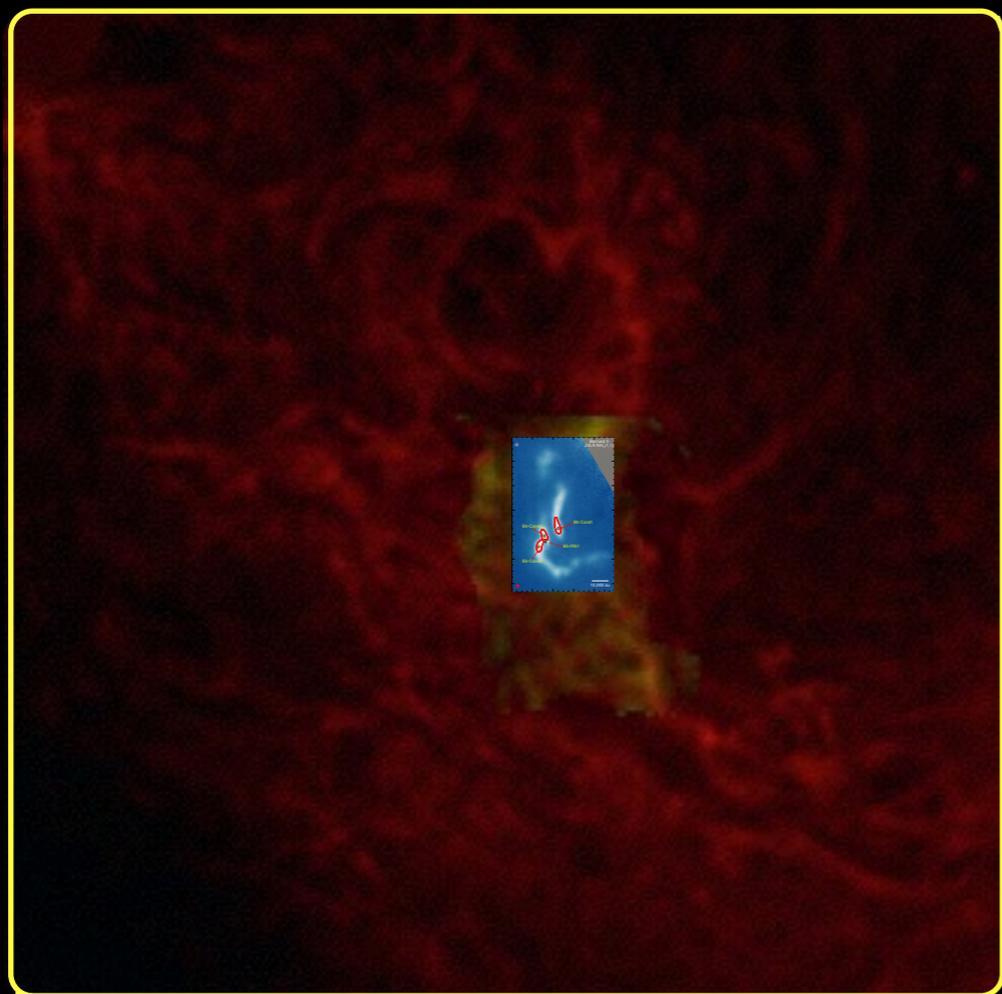
Big + **COMPLETE** was
wide in 2006

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

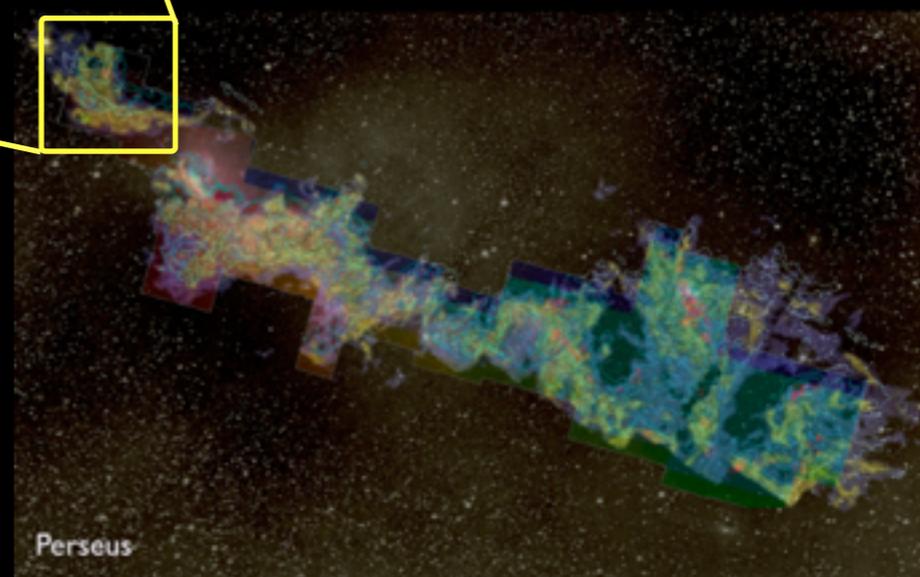
+ **MASSES** SMA Survey of **All** the Outflows in Perseus
(Mike Dunham, PI + 10 co-Is)

are **Big** now...

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



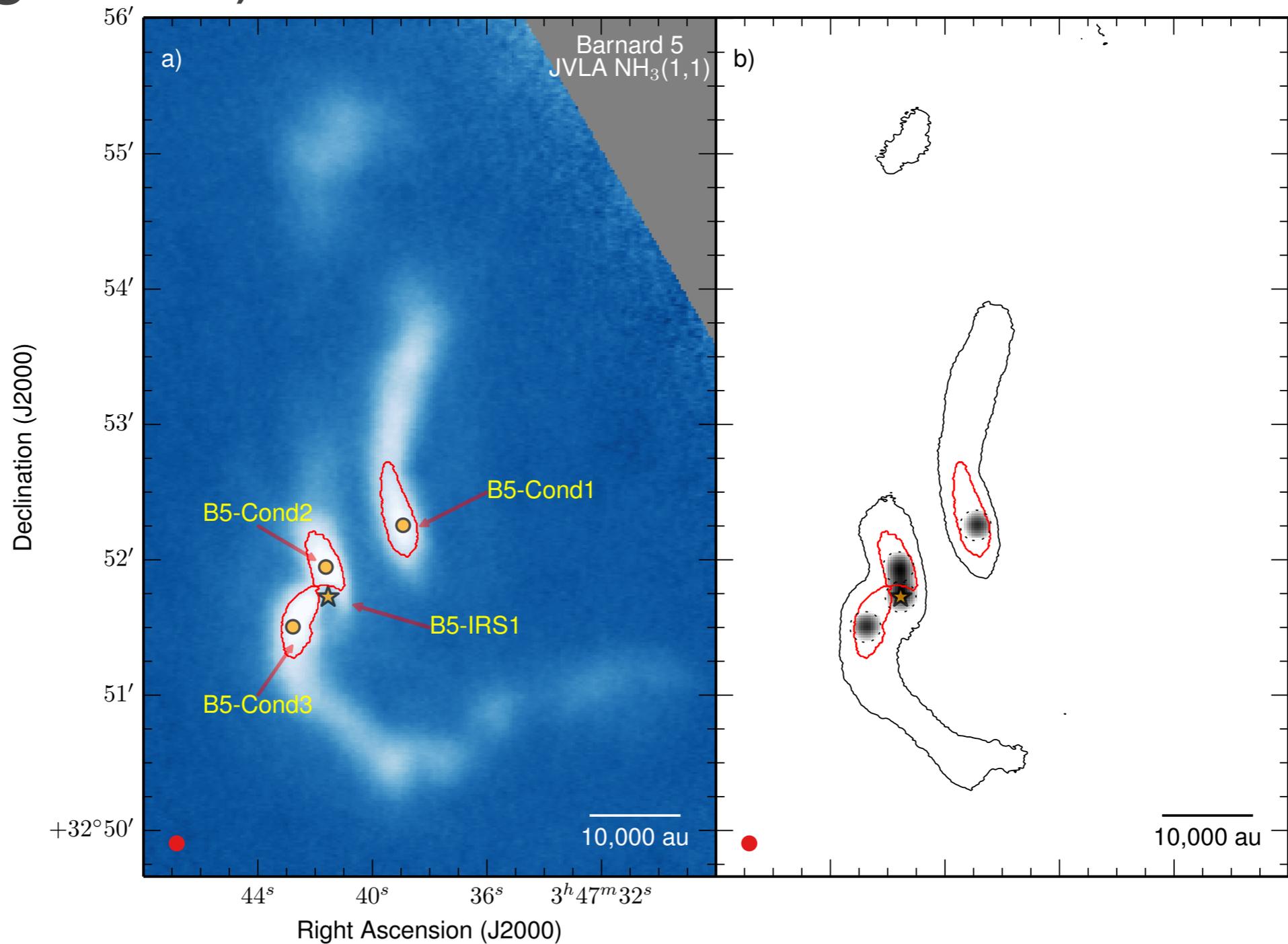
“B5”



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

Superhigh-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?!

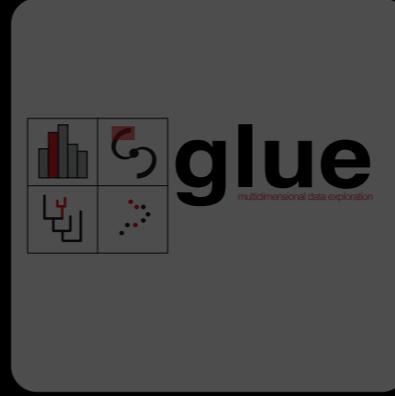
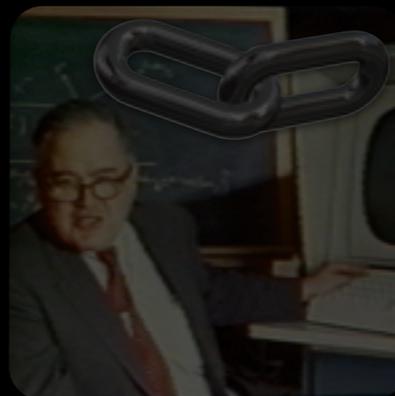
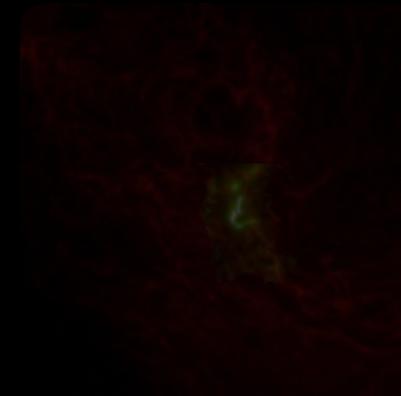
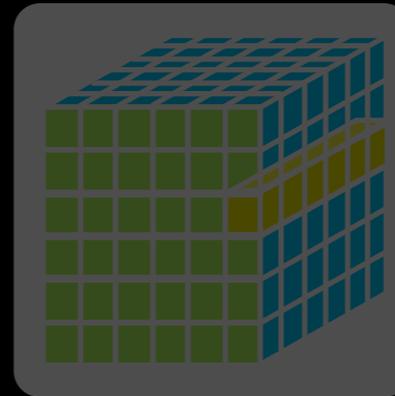


Wide data (CONTEXT) gives the discovery...
but it's derived from BIG surveys and high RESOLUTION data sets



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

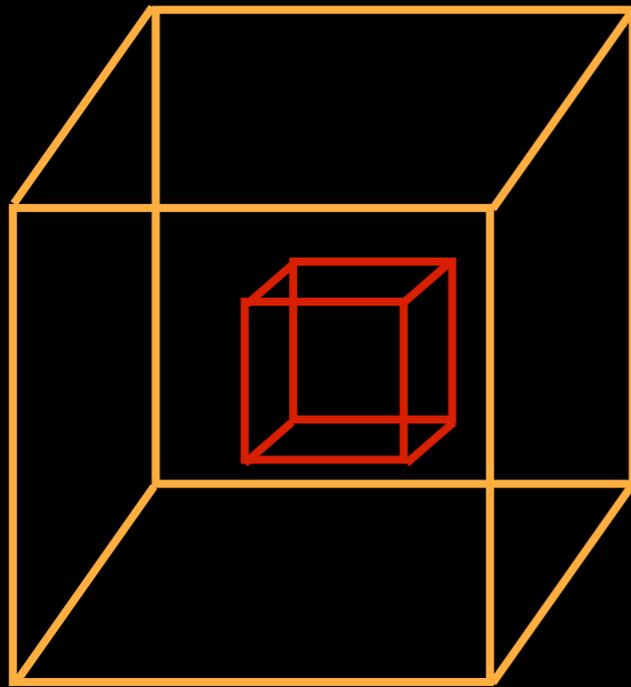
Resolution
Context
Big Data
Wide Data
Dimensionality
Linked views
Interaction



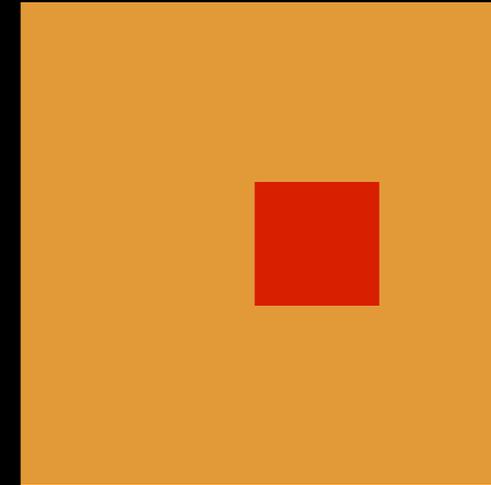
Linked Views of High-dimensional Data



John Tukey

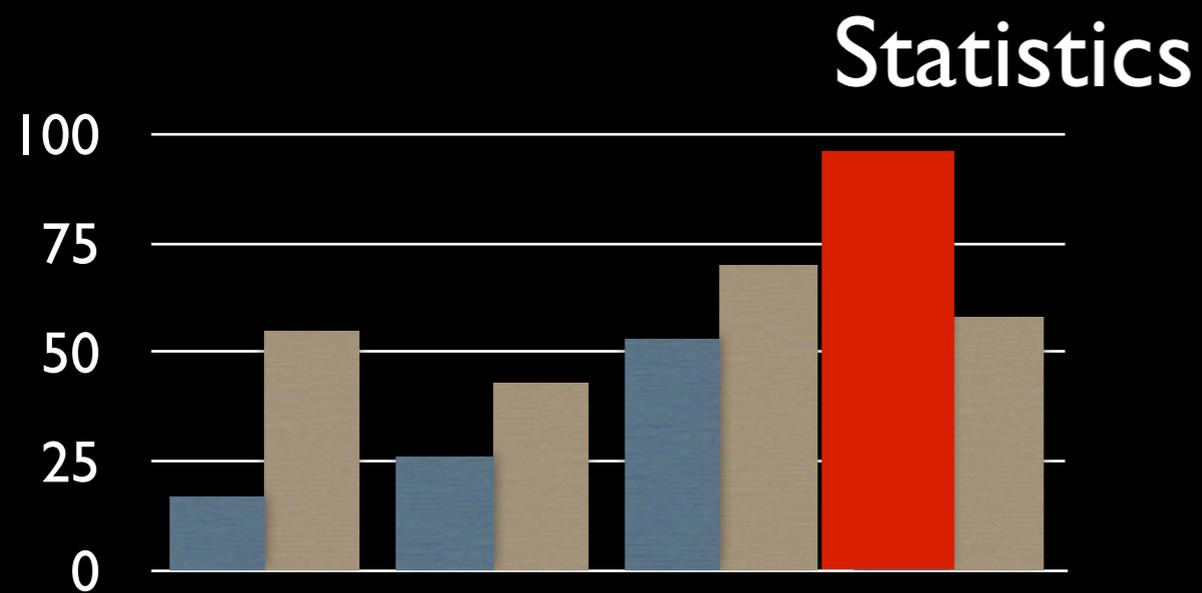
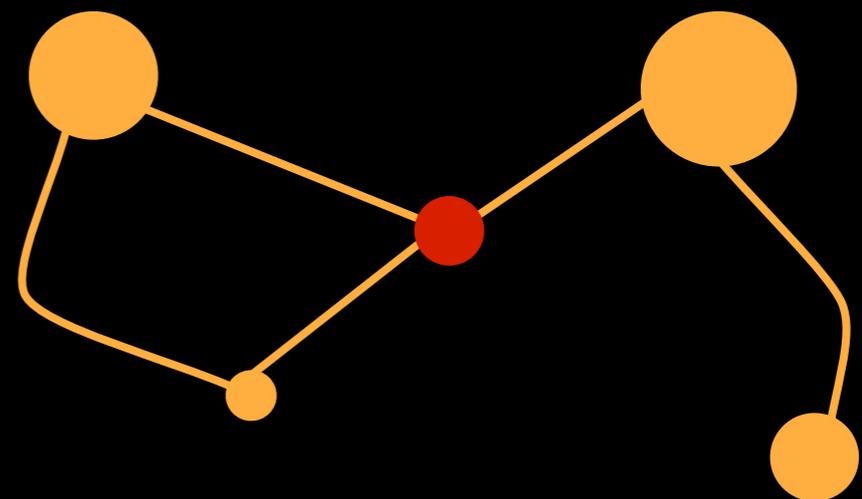


3D

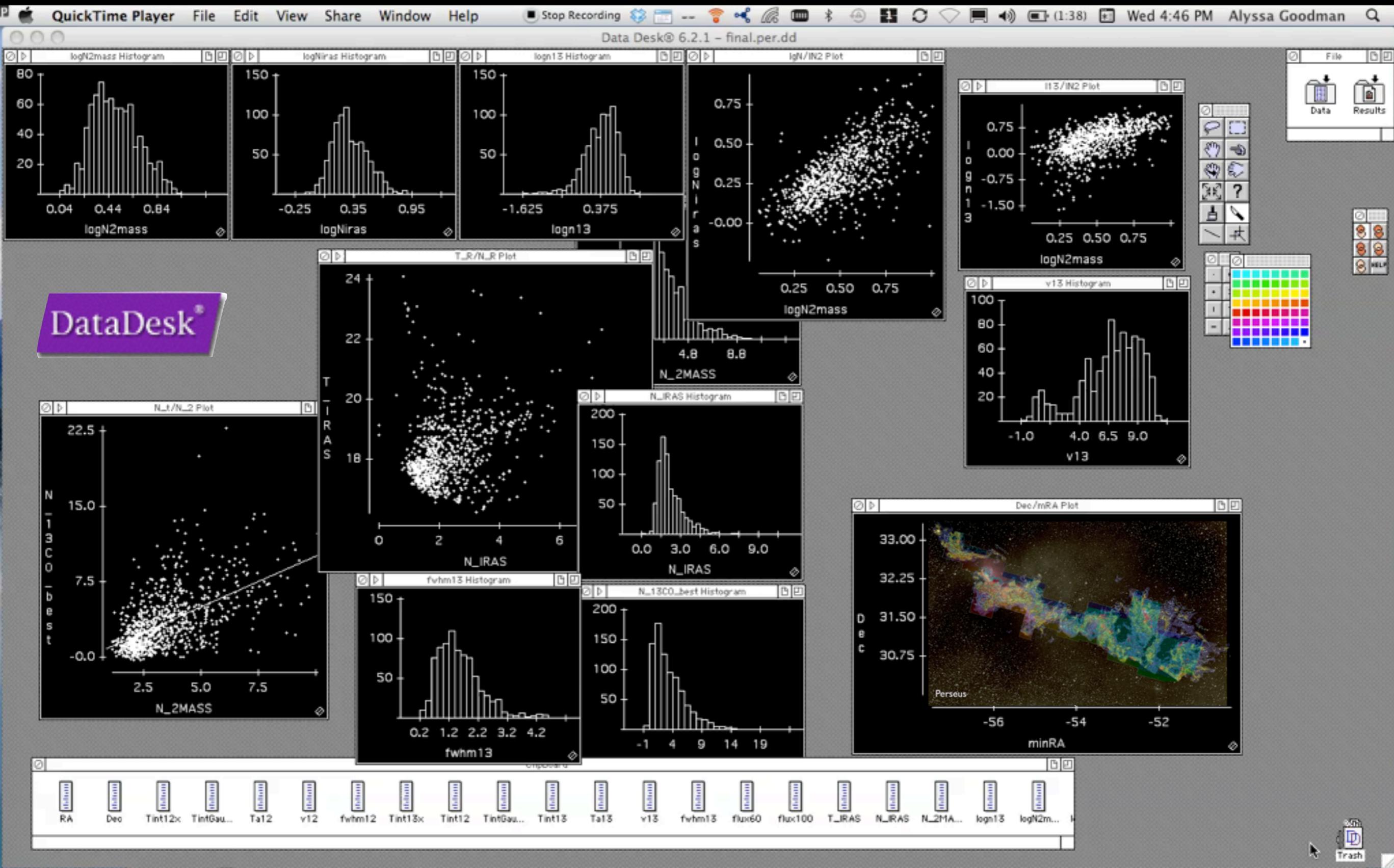


2D

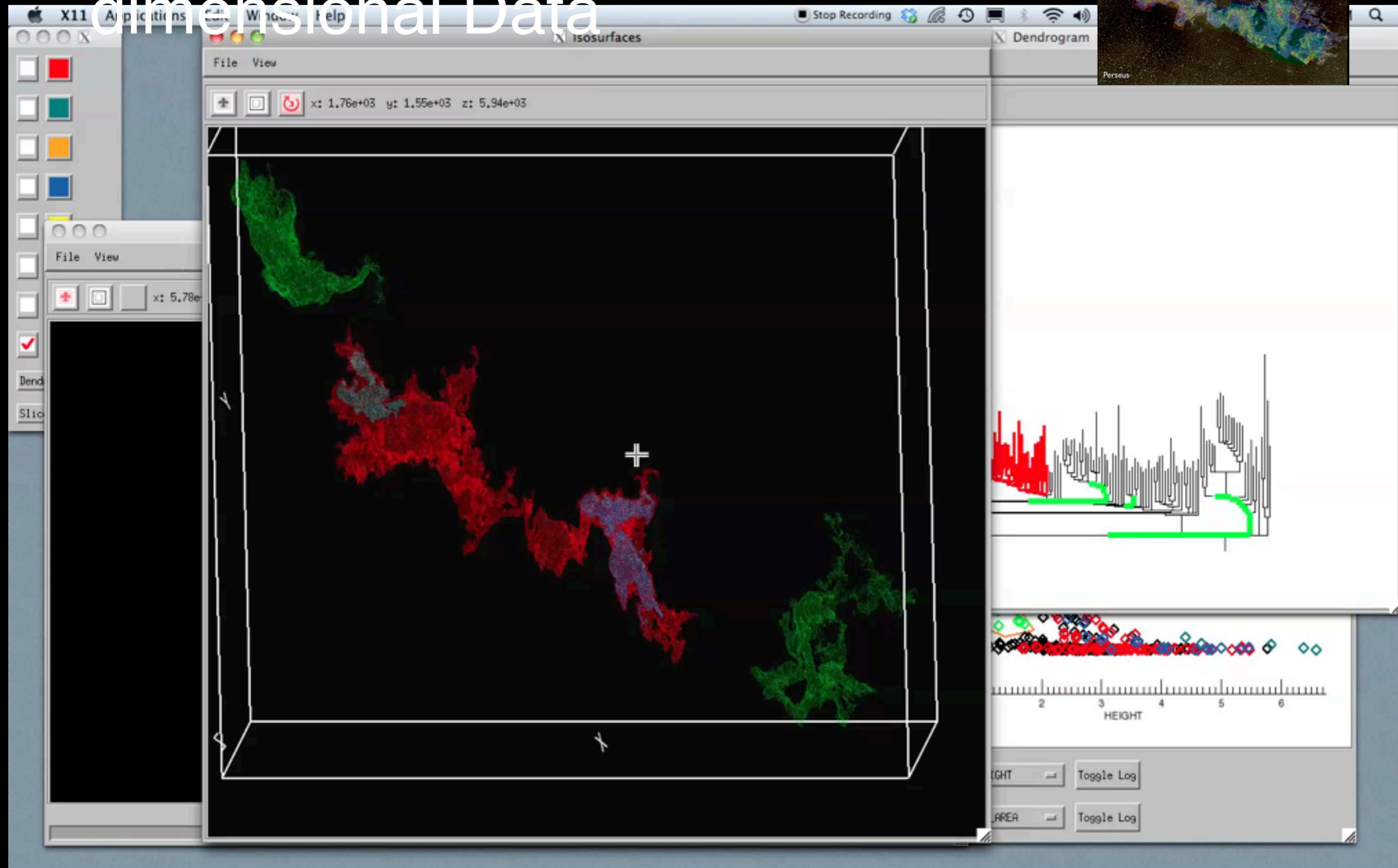
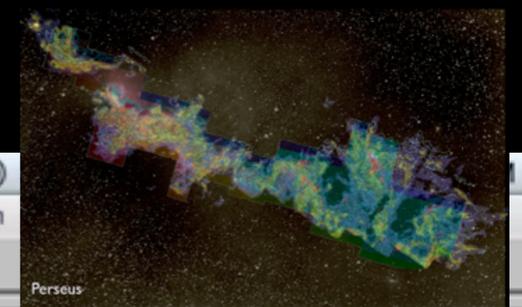
Data Abstraction



DataDesk (est. 1986)



Linked Views of High-dimensional Data

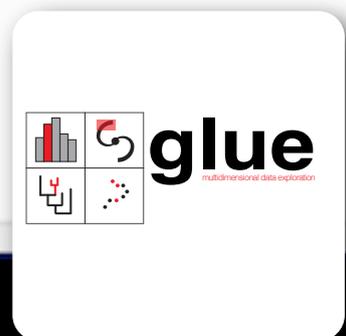
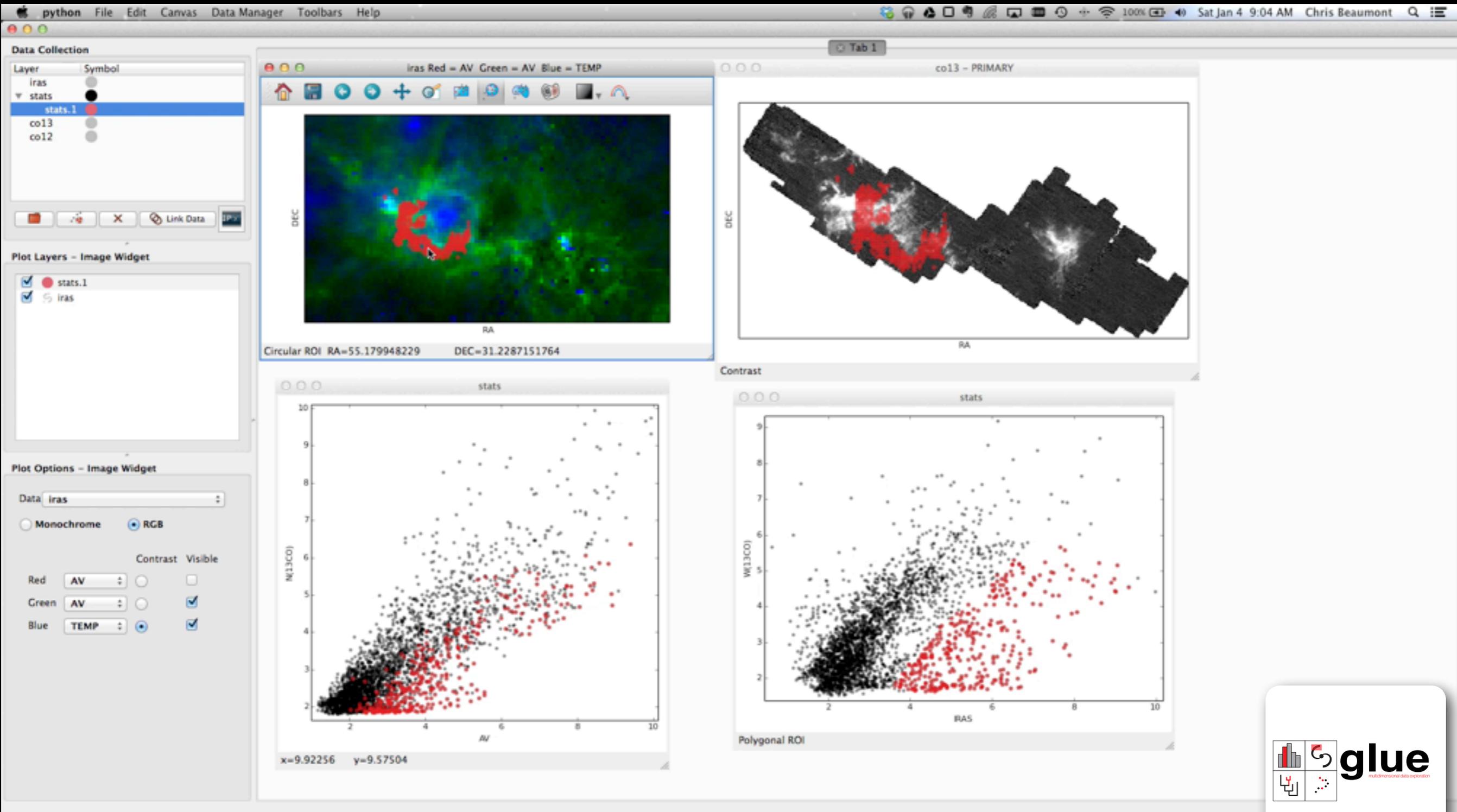
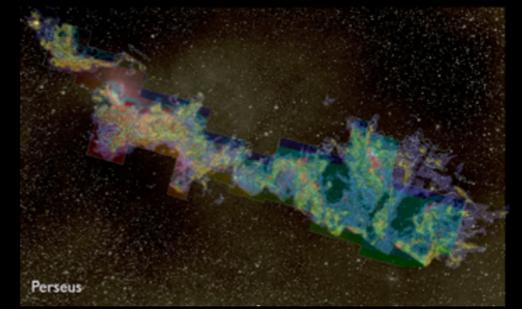


Video & implementation: Christopher Beaumont, Harvard→Counsyl;
inspired by AstroMed work of Douglas Alan, Michelle Borkin, AG, Michael Halle, Erik Rosolowsky

great. but that was all from one
(And it was in ~~software~~ ^{data file} that costs
\$1000.)

Linked Views of High-dimensional Data (in Python)

Glue



Linked, interactive views of

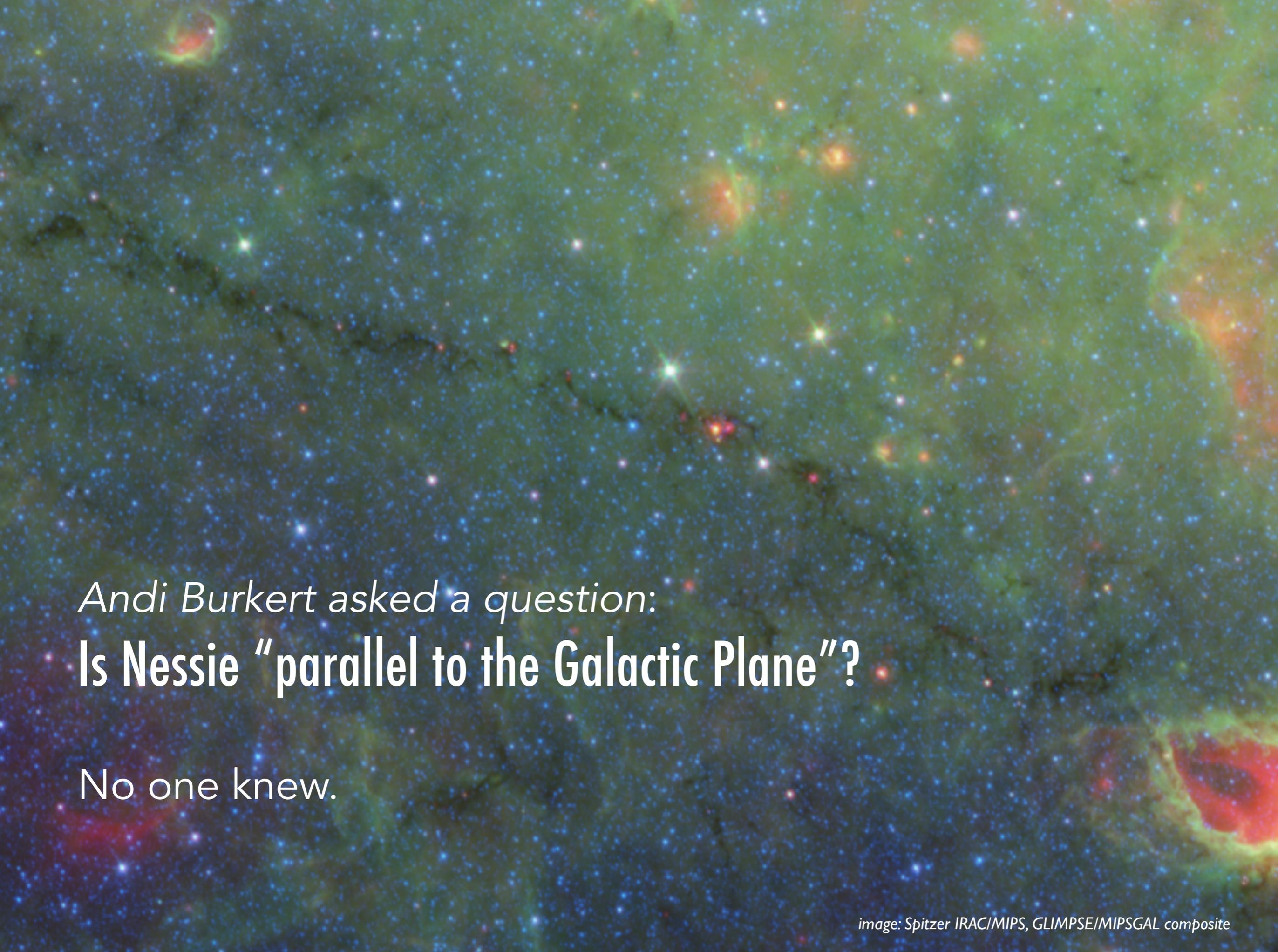
Big

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”**



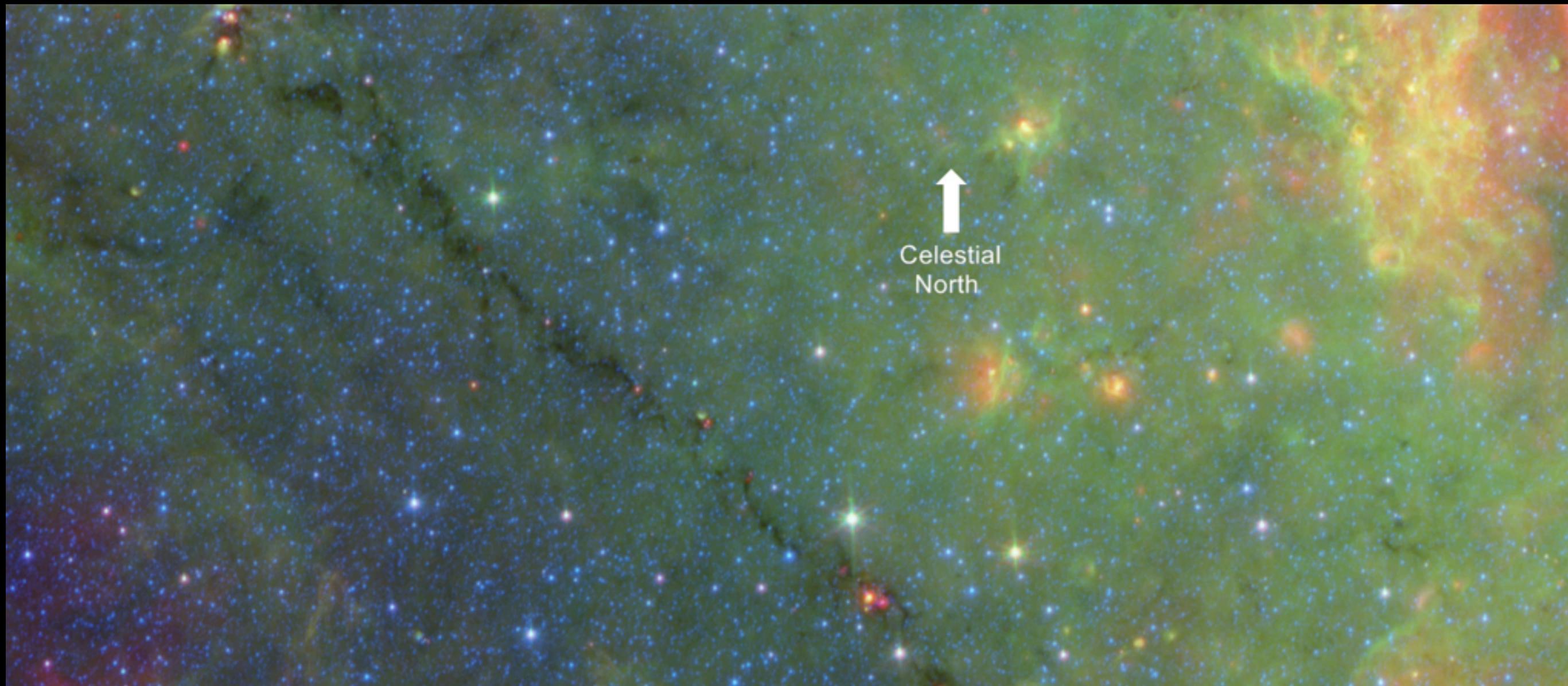


Andi Burkert asked a question:
Is Nessie “parallel to the Galactic Plane”?

No one knew.

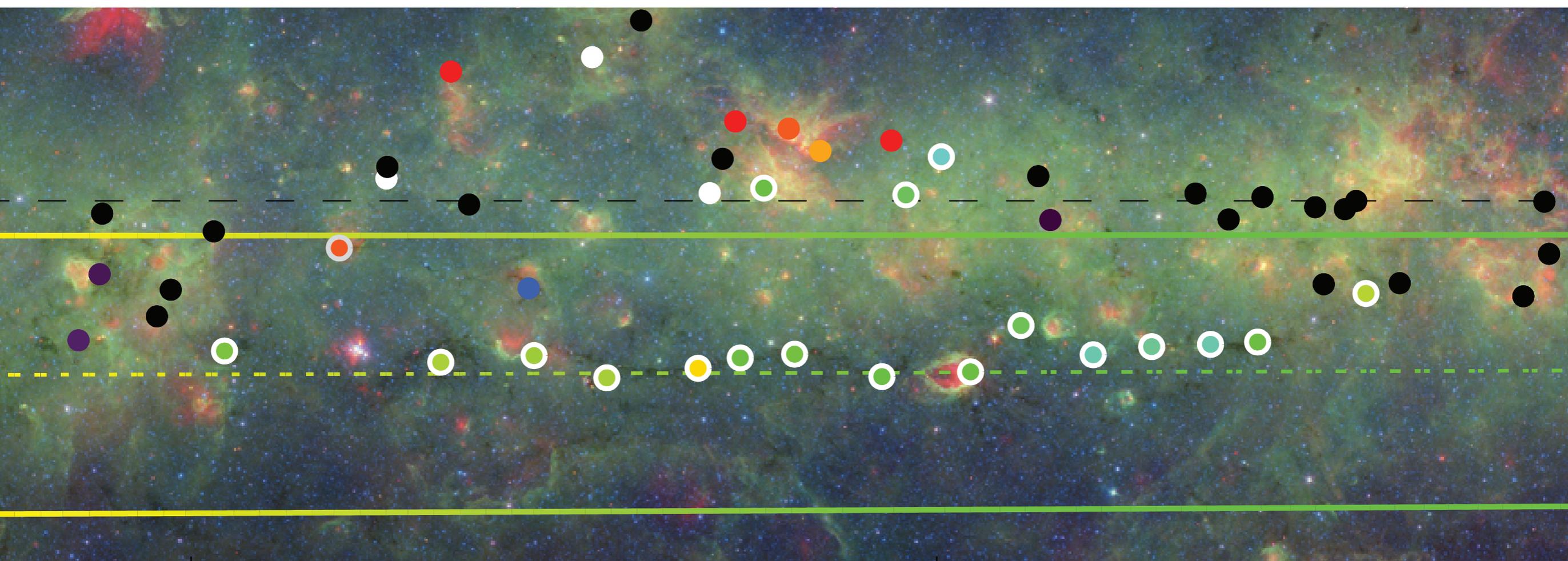


WorldWide Telescope (easy access to **Big** & **Wide** data) to the rescue...



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...

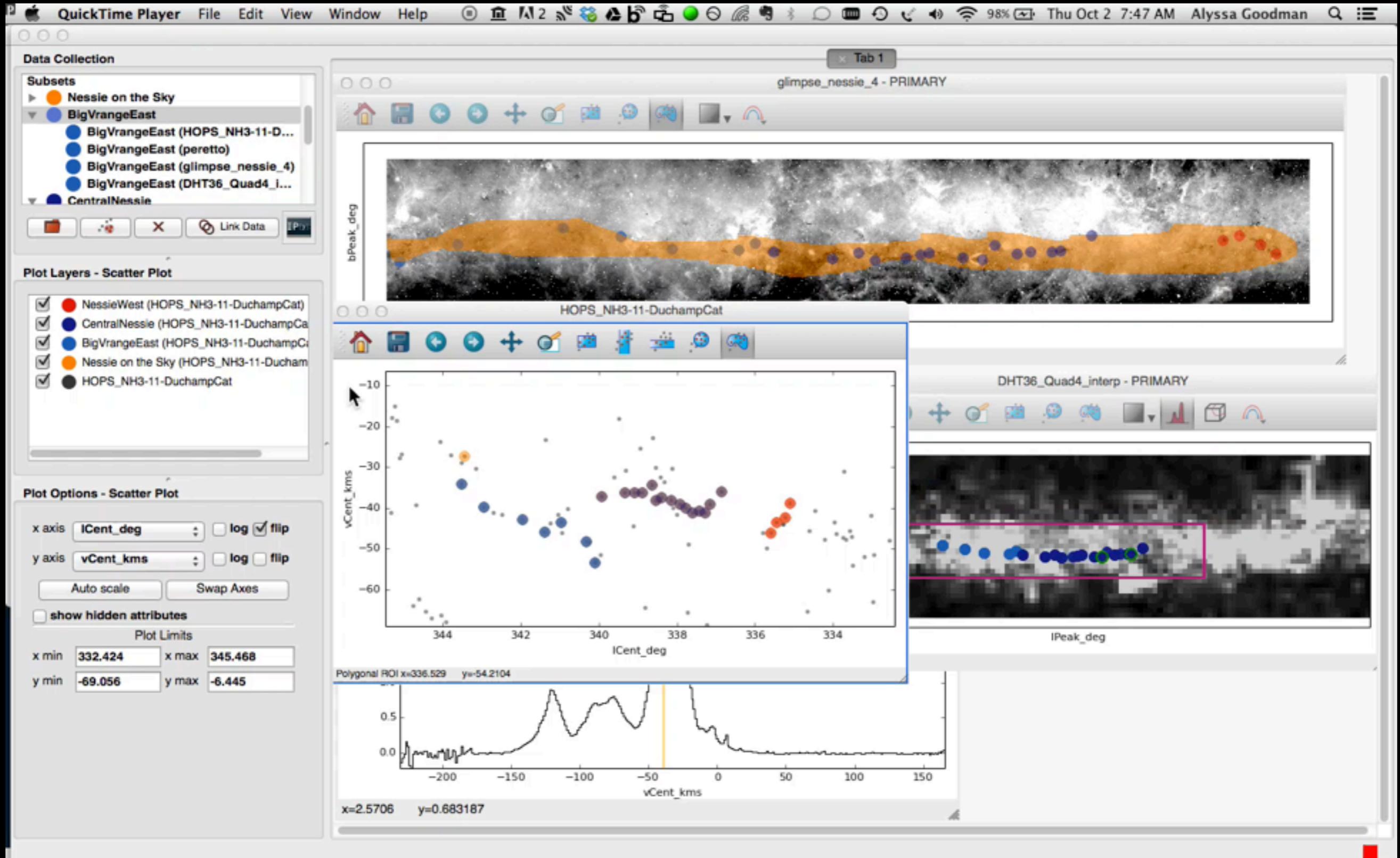
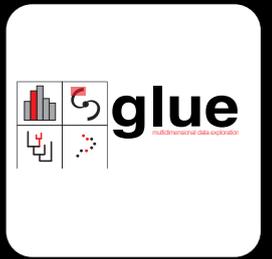


How do we know
the velocities?

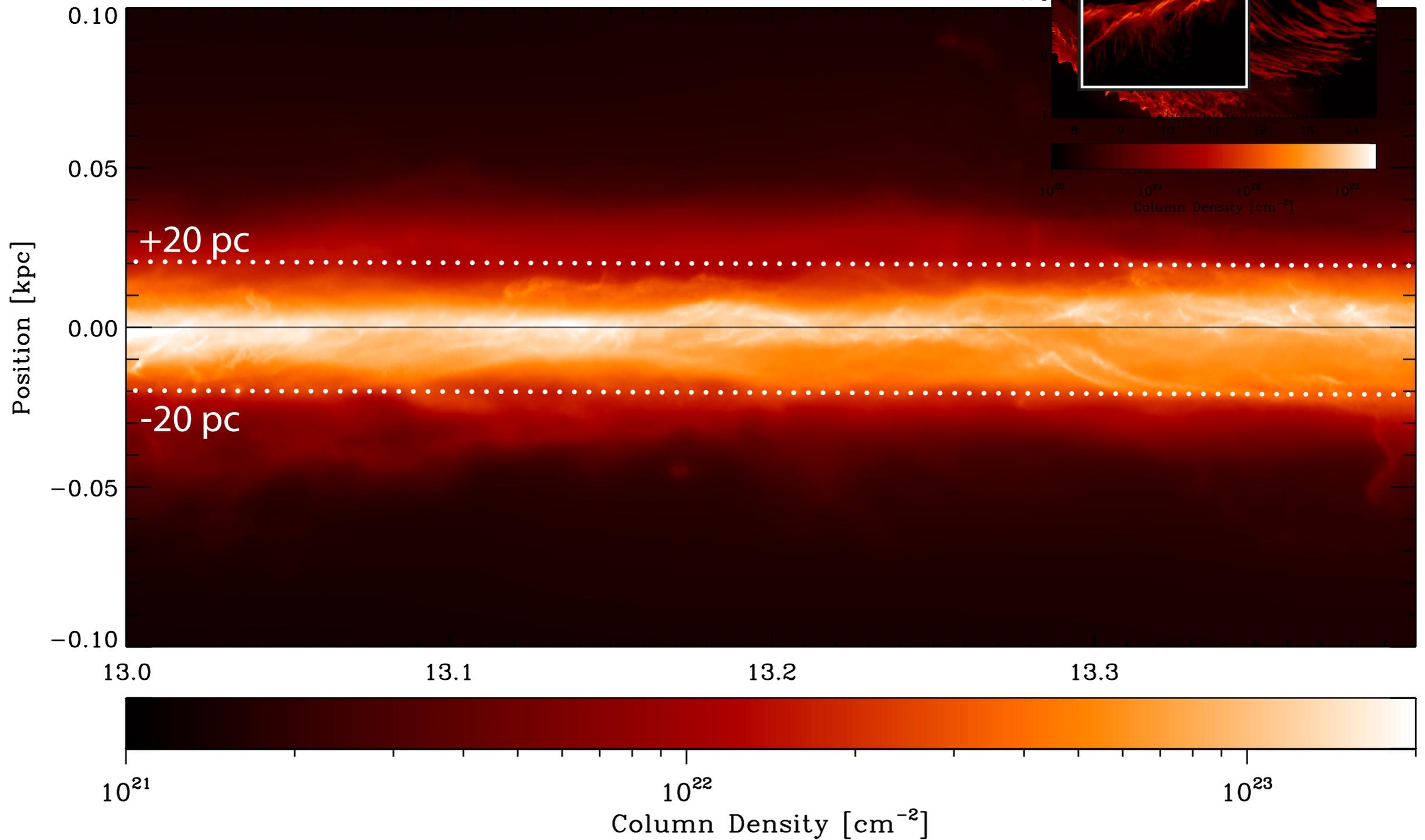
...eerily precisely...



Nessie in Glue



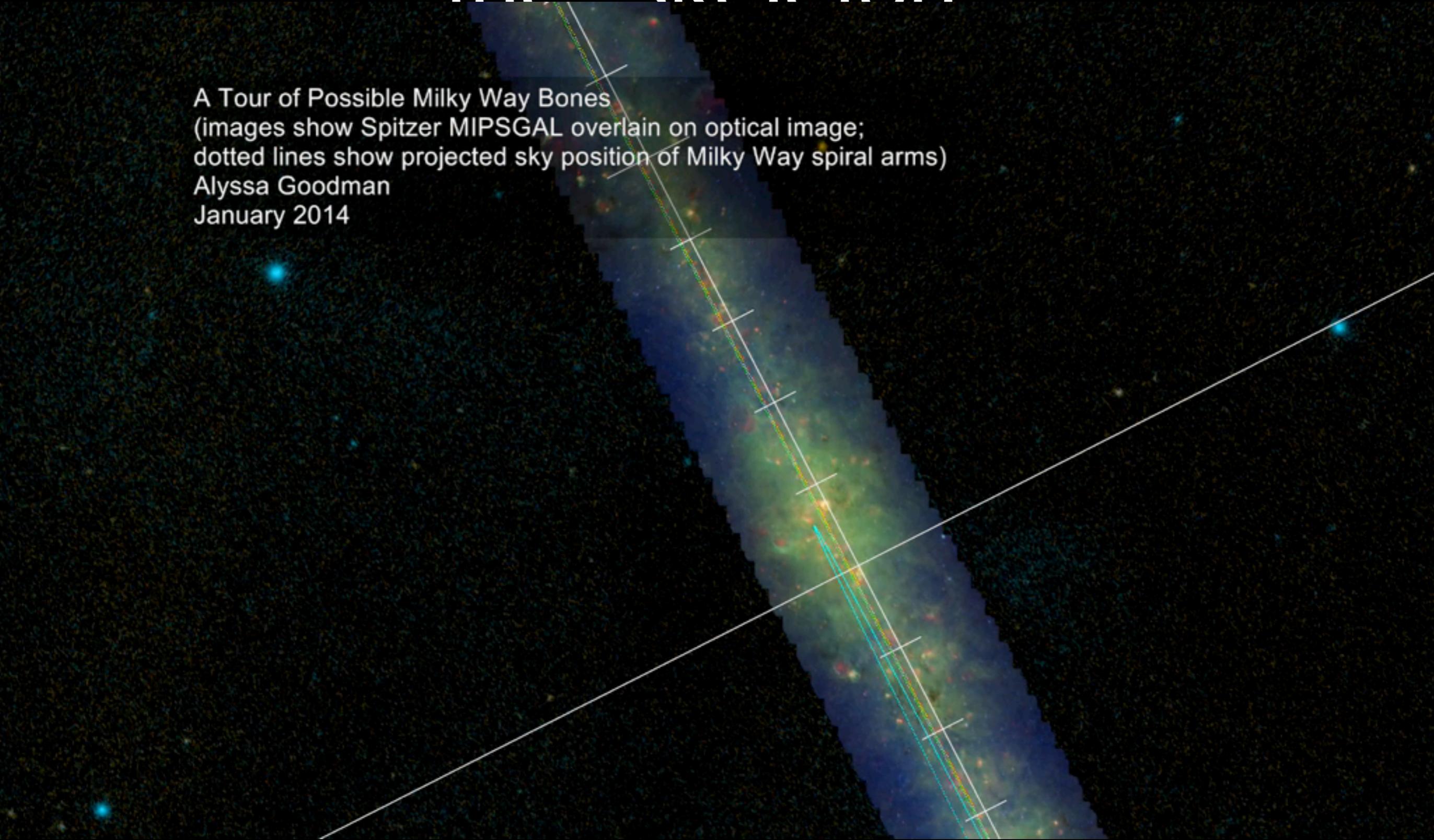
2014 Simulation



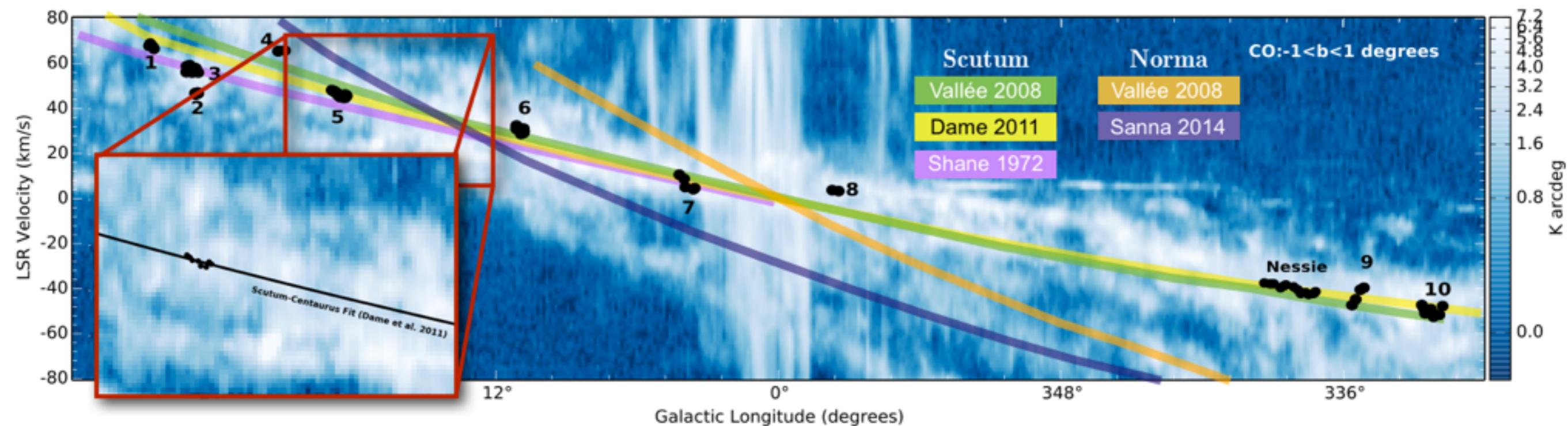
Smith et al. 2014, using AREPO (hydro+chemistry, imposed potential, no B-fields, no local (self-)gravity, no feedback)

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)



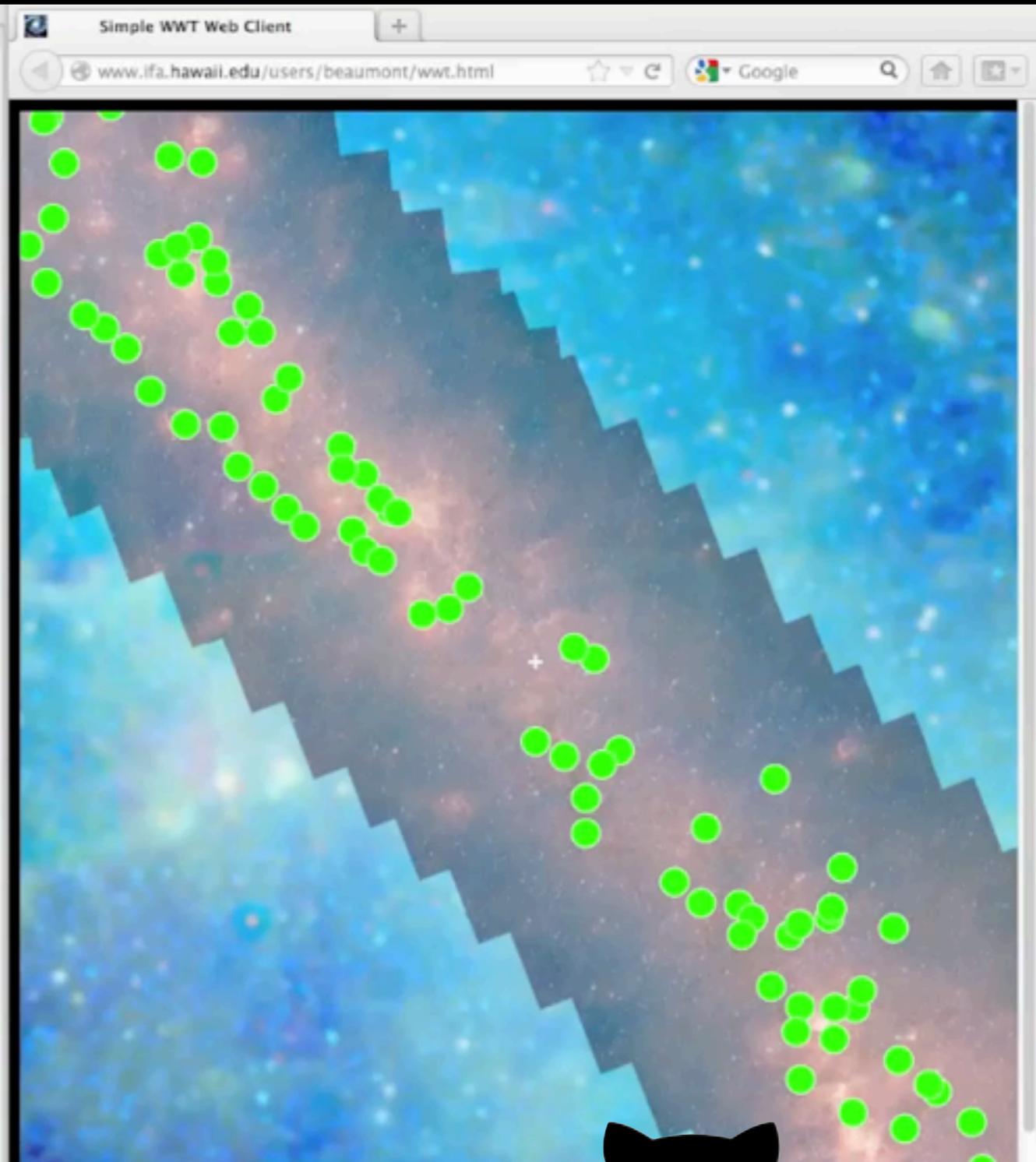
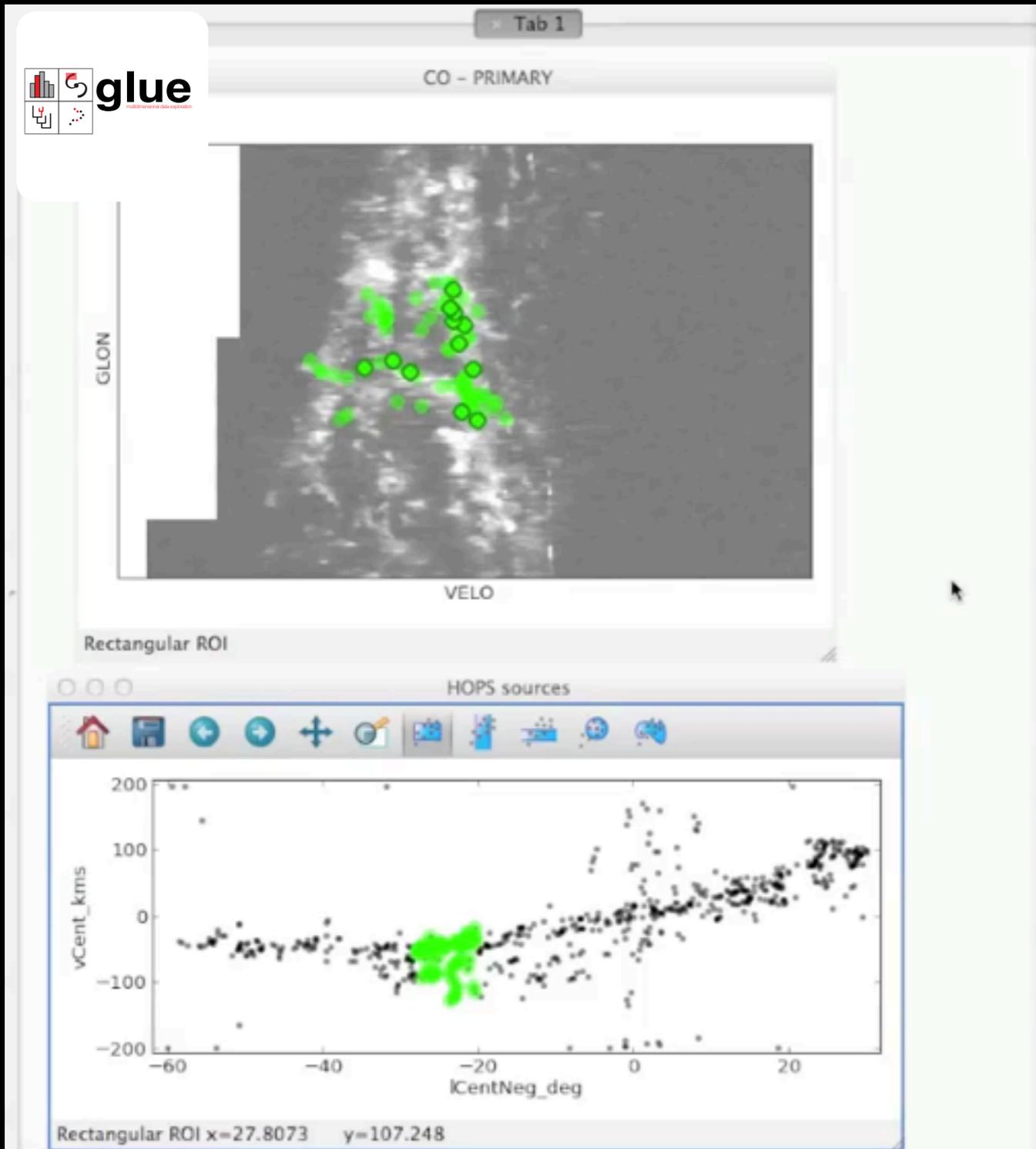
Blue image in the background shows CO position-velocity diagram based on Dame et al. 2001

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



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



Finder Scope

Classification: Spiral Galaxy
 Constellation: Andromeda
 Names: M31

Name: M31	RA: 02m42s	Dec: 41° 56'	Mag: 3.4
Information	17:58	03:40	13:19
Imagery	13:02		

Set as Background Imagery
 Set as Foreground Imagery

Research Show Object

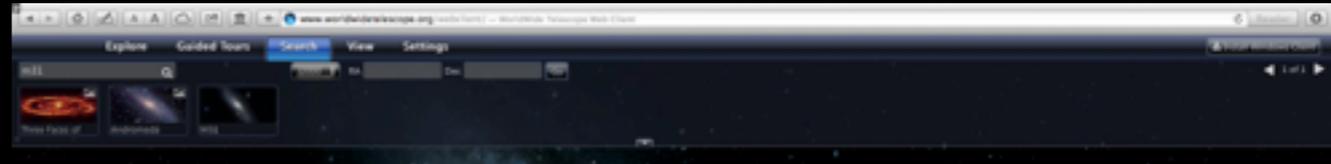
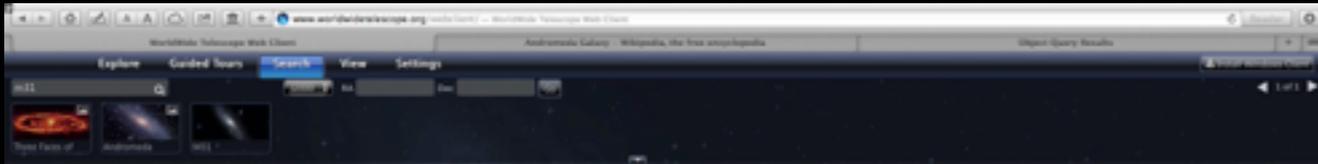


DS Article

Classification: Spiral Galaxy
 Constellation: Andromeda
 Names: Andromeda Galaxy, M31, Messier 31, NGC 204, M32, M110

RA: 02m42s	Dec: 41° 56'	Mag: 3.4
Dec: +41 57 03	Transit: 04:07	
Alt: 30 46 47	Set: 13:46	
Az: 337 20 25		

Image Credit: Don J. McCreedy



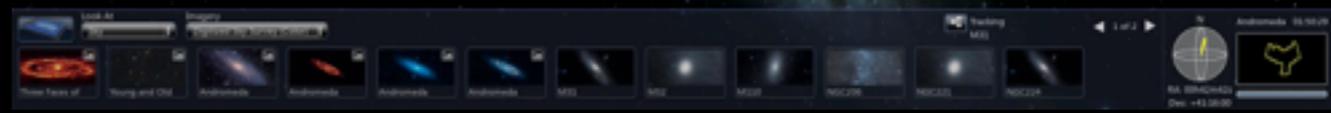
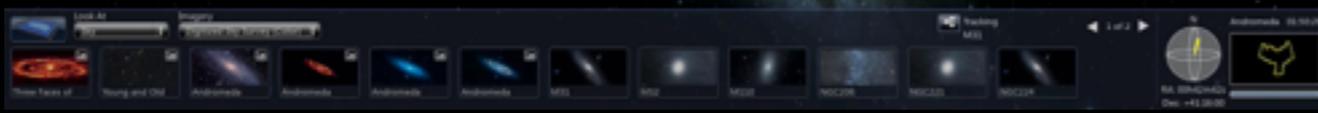
MBAD Data

Wikipedia

Classification: Spiral Galaxy
 Constellation: Andromeda
 Names: Andromeda Galaxy, M31, Messier 31, NGC 204, M32, M110

RA: 02m42s	Dec: 41° 56'	Mag: 3.4
Dec: +41 57 03	Transit: 04:07	
Alt: 30 46 47	Set: 13:46	
Az: 337 20 25		

Image Credit: Don J. McCreedy



WorldWide Telescope: Data ↔ Literature

Web or Windows: "right-click"



ADS All-Sky survey on Al... ADS All-Sky survey on Wor... 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 [Slider]

BACKGROUND LAYER

Optical 2MASS WISE SFD IRIS GLIMPSE H-alpha ROSAT

Optical [Slider] Harvard/All

Show Sources

Go to... [Search]

ADS ALL SKY SURVEY

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

ADS All-Sky Survey is a NASA-funded project



Region: In Perseus and Taurus

ads
NASA

α (2000) 3h 38m 14s, δ (2000) +31° 25'

α (1875) 3h 30m 30s, δ (1875) +31° 00'

Area
In Perseus and Taurus

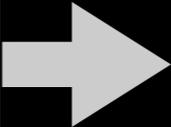
Galactic Coordinates
127°, -18°

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

Chart
Table

Plate & Chart
Text

enlarge [+]
printable PDF



Bar-p0003_sm
Bernard's image of Perseus,
www.library.queensu.ca/spot...

December 1

1

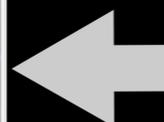
astrometry.net

Hello, this is the blind astrometry solver.
Your results are: (RA, Dec) center:
(54.3096782184, 31.43264374) degrees
Orientation: 5.2104989764 deg E of N
Pixel scale: 18.56371997 arcseconds
Your field contains: NGC 1465 IC 1985 C
Per / Ask o Per 42Per 42Per NGC 1333
IC 348 IC 3003 View in WorldWide
Telescope: — If you would like to have
other images solved, please submit
them to the astrometry.group.



Explore Guided Tours Search View Settings

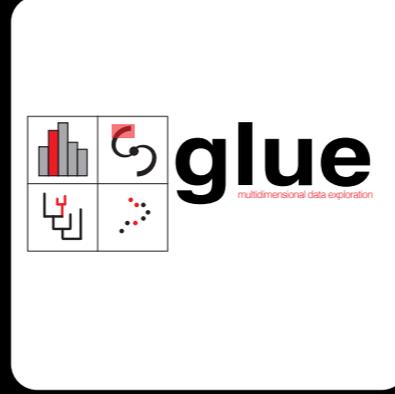
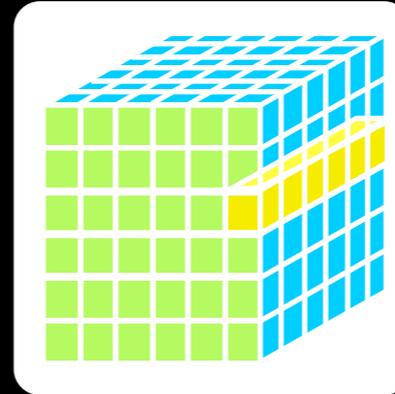
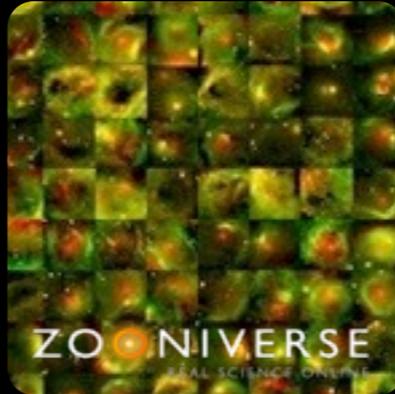
ADS ALL SKY SURVEY



Explore Guided Tours Search View Settings

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.

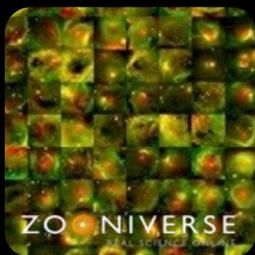
On the horizon: CARTA/NRAO (visualizer for big cubes)



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

WWWT

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