STAR FORMATION

&

DATA VISUALIZATION

at the

HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS

presented by Alyssa Goodman at HHSF14, MPIA Heidelberg, June 2014

AFFINITY DETAILS (LIVE, ONLINE)

Here	Slide	Talk			Visualization	Universe-> Galaxies	Galactic Structure	Galaxies-> GMCs	GMCs-> "Filaments"	"Filaments" -> Cores	Feedback	Cores-> Disks & Structure	Disks-> Stars + Planets	Making Exoplanets	Young Stars	*Rad Xfer*	*Chemistry*	*Dust*	*Gas (ppv)*	*Simulation/ Comparison*
			Xue-Ning	**Bai**	0	0	0	0	0	0	0	0	0.75	0.25	0.25	0.25	0.25	0.5	0.5	1
			Cara	**Battersby**	0	0	0.5	0.75	1	0	0.5	0	0	0	0	0	0	0.5	0.5	0.5
			Chris	**Beaumont**	1	0	0	0.25	0.75	0.25	0.75	0	0	0	0	0.25	0	0.25	0.75	0.75
			Til	**Birnstiel**	0.25	0	0	0	0	0	0	0	1	0.75	0	0.25	1	1	0.25	0.75
			Michelle	**Borkin**	1	0	0	0	0.5	0	0.5	0	0	0	0	0	0	0	0.5	0.25
			Hope	**Chen**	0.5	0	0.25	0.25	1	0.75	1	0.25	0	0	0	0.5	0	1	0.75	0.25
			Michael	**Dunham**	0	0	0	0	0	0	1	0	0.25	0	1	0	0.25	0.75	0.75	0.25
			Andrea	**Dupree**	0	0	0	0	0	0	0	0	0	0.25	1	0.25	0	0	0	0.75
			Chris	**Faesi**	0.25	0	0	1	0.75	0.75	0.5	0.5	0	0	0	0.25	0	0	0.75	1
			Jan	**Forbrich**	0	0	0	0	0	0	0.75	0.25	0.25	0	1	0	0	0	0.75	0
			Alyssa	**Goodman**	1		0.25	0.5	1	1	1	0.75	0	0	0	0.25	0.25	0.75	1	0.75
			H. Moritz	**Günther**	0	0	0	0	0	0	0.75	0	0	0	1	0.5	0	0	0.75	0.25
			Joseph	**Hora**	0	0	0	0	0.25	0.25	1	0	0	0	0	0	0	0.5	0	0
			Eric	**Keto**	0	0	0	0	0	0.75	0.75	0.75	0.5	0	0	1	0.75	0	0.75	1
			Lars	**Kristensen**	0	0	0	0	0	0.25	0.75	0.25	0.5	0.25	0	0.75	0.75	0.5	0.5	0.25
			Charles	**Lada**	0	0	0	1	1	1	0.75	0.75	0.75	0	0.75	0	0	1	0.5	0
			Walker	**Lu**	0.75	0	0	0	0.5	0.75	0.25	0	0	0	0	0	0	0	1	0.25
			Maxwell	**Moe**	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
			Phil	**Myers**	0	0	0	0	1	1	0.25	1	0.5	0	0.25	0	0.25	0	1	0.75
			Dylan	**Nelson**	0.75	1	0.25	0.5	0.25	0	0	0	0	0	0	0.25	0.25	0.25	0.25	1
			Ignazio	**Pillitteri**	0	0	0	0	0	0	0	0	0	0	1	0.25	0	0	0	0
			Mark	**Reid**	0	0	1	0.25	0.25		0.25	0.25	0	0	0.75	0	0	0	0.75	0.5
			Tom	**Rice**	0.5	0	0	0.75	0.75	0	0	0	0	0	0	0	0.25	0	1	0.5
			Anthony	**Stark**	0	0.25	1	0.75	0.25	0	0	0	0	0	0	0	0	0	0.75	0
			Sarah	**Willis**	0	0	0	0.75	0	0	0.25	0.25	0	0	0	0	0	0.75	0	0
			David	**Wilner**	0	0	0	0	0	0.25	0.25	0.75	1	0.75	0	0.25		1	0.75	0.25
			Scott	**Wolk**	0	0	0	0	0	0	0.25	0	0.75	0.25	1	0	0	0	0	0
			Karin	**Öberg**	0	0	0	0					1	0.5		0.25	1	0.75	0.25	0.5
			Sum	***Totals***	6	1	3	7	9	7	12	6	7	3	9	5	5	10	15	12
					Visualization	Universe-> Galaxies	Galactic Structure	Galaxies-> GMCs	GMCs-> "Filaments"	"Filaments" -> Cores	Feedback	Cores-> Disks & Structure	Disks-> Stars + Planets	Making Exoplanets	Young Stars	*Rad Xfer*	*Chemistry*	*Dust*	*Gas (ppv)*	*Simulation/ Comparison*

Feedback

PPV data

Sims comparison

https://docs.google.com/spreadsheets/d/1je5cOXxJl5lBrfB5p-UDXa4iLhLP96ALkT-S7_KScqY/pubhtml

Star Formation

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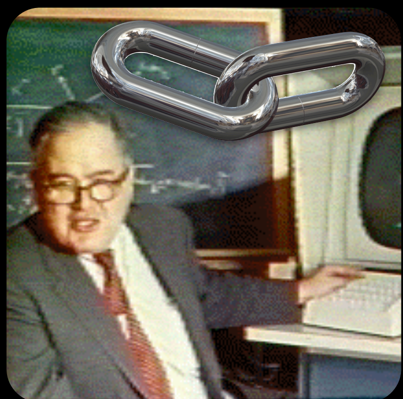
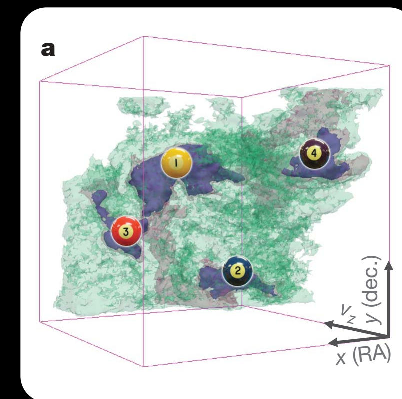
LINKING VISUALIZATION & UNDERSTANDING IN ASTRONOMY

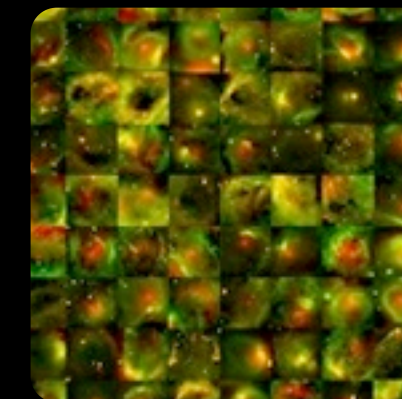
ALYSSA A. GOODMAN
HARVARD-SMITHSONIAN
CENTER FOR ASTROPHYSICS

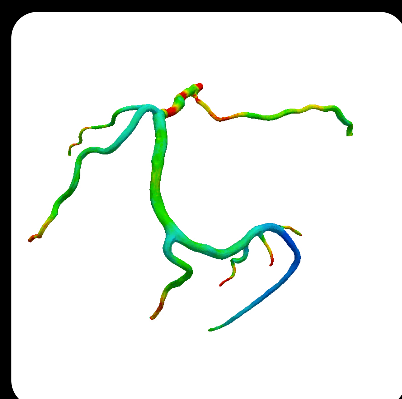
http://www.astrobetter.com/linking-visualization-and-understanding-in-astronomy-aas223

VISUALIZING VISUALIZATION



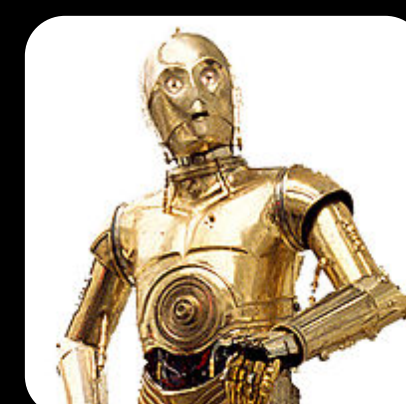






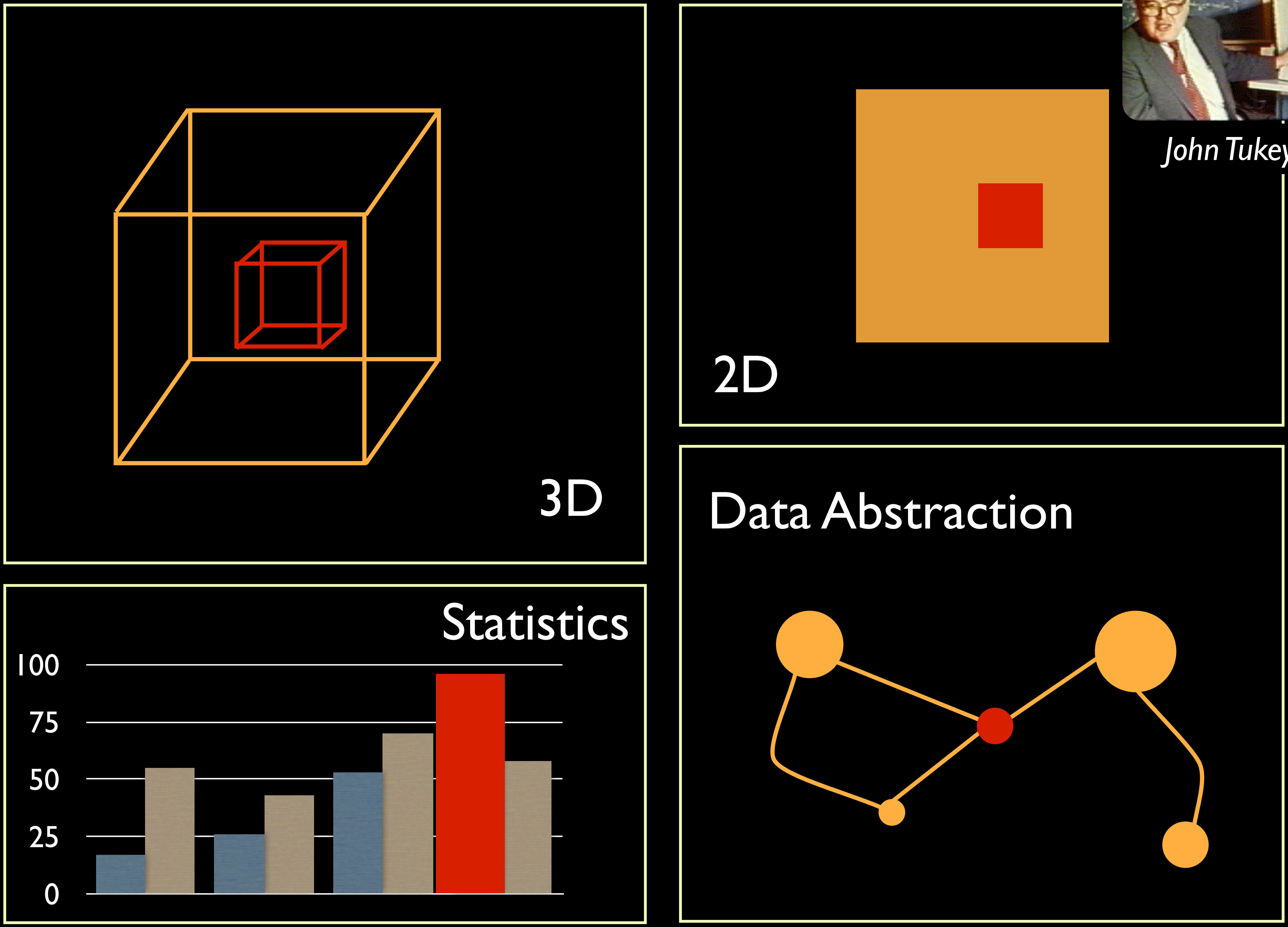
glue

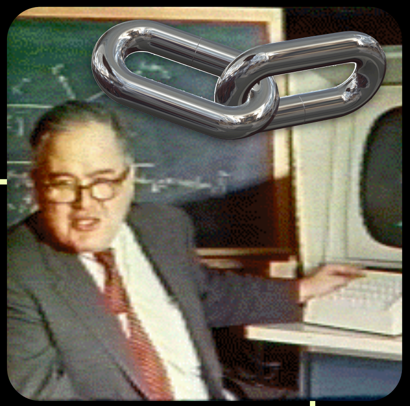
multidimensional data exploration



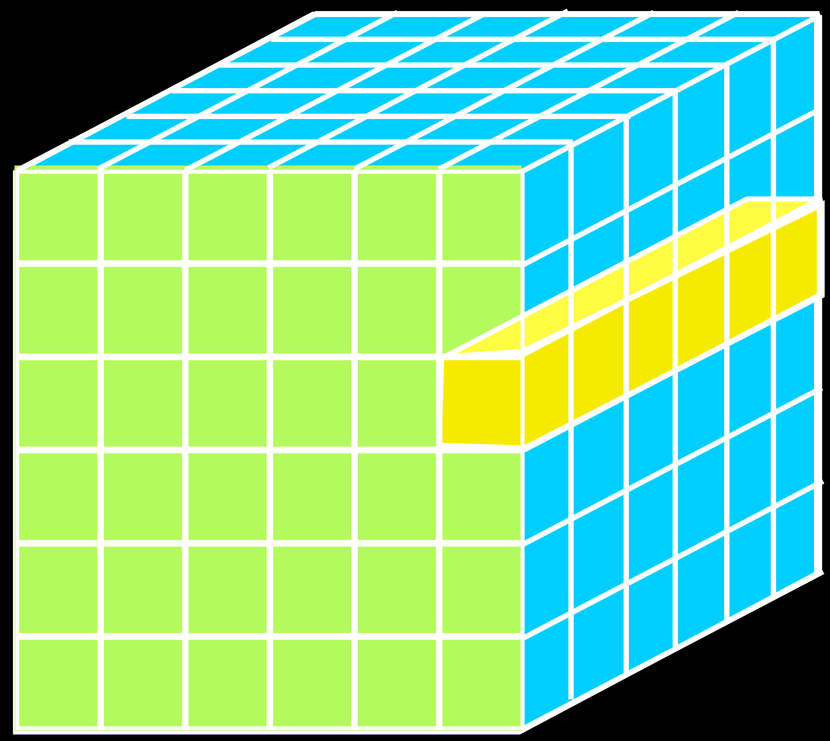
ADS ALL SKY SURVEY

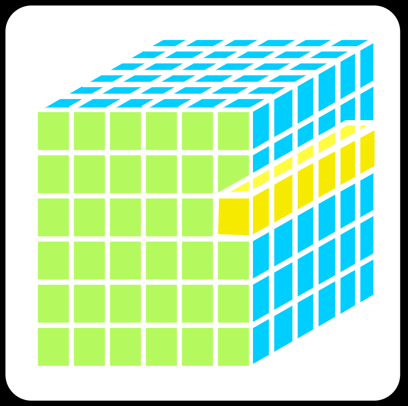
LINKED VIEWS OF HIGH-DIMENSIONAL DATA





figure, by M. Borkin, reproduced from Goodman 2012, "Principles of High-Dimensional Data Visualization in Astronomy"





"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"

2009

3D PDF

INTERACTIVE PPV CUBES IN A "PAPER"

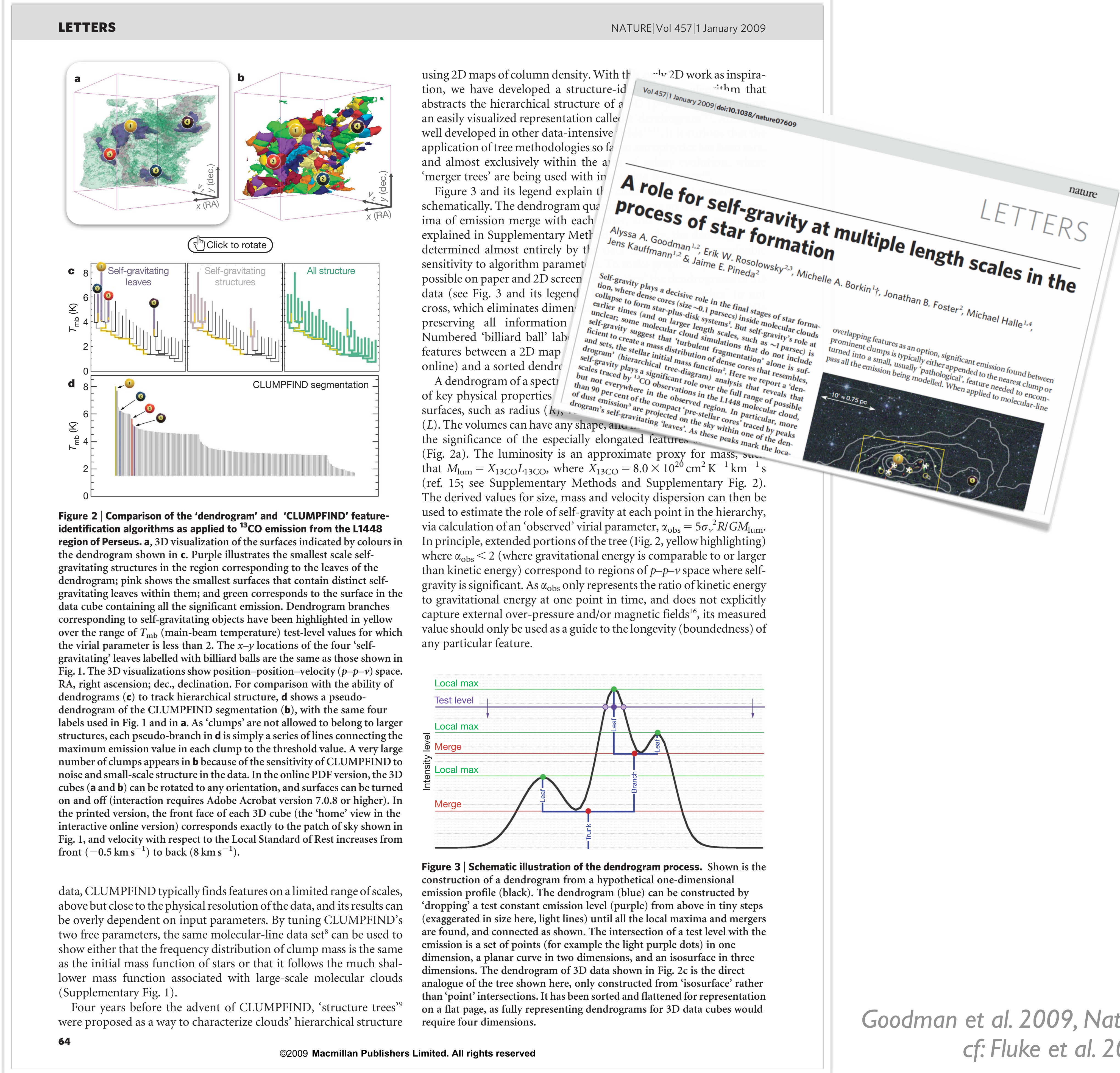


Figure 2 | Comparison of the 'dendrogram' and 'CLUMPFIND' feature-identification algorithms as applied to ^{13}CO emission from the L1448 region of Perseus. a, 3D visualization of the surfaces indicated by colours in the dendrogram shown in **c**. Purple illustrates the smallest scale self-gravitating structures in the region corresponding to the leaves of the dendrogram; pink shows the smallest surfaces that contain distinct self-gravitating leaves within them; and green corresponds to the surface in the data cube containing all the significant emission. Dendrogram branches corresponding to self-gravitating objects have been highlighted in yellow over the range of T_{mb} (main-beam temperature) test-level values for which the virial parameter is less than 2. The x–y locations of the four 'self-gravitating' leaves labelled with billiard balls are the same as those shown in Fig. 1. The 3D visualizations show position–position–velocity (p–p–v) space. RA, right ascension; dec., declination. For comparison with the ability of dendrograms (**c**) to track hierarchical structure, **d** shows a pseudo-dendrogram of the CLUMPFIND segmentation (**b**), with the same four labels used in Fig. 1 and in **a**. As 'clumps' are not allowed to belong to larger structures, each pseudo-branch in **d** is simply a series of lines connecting the maximum emission value in each clump to the threshold value. A very large number of clumps appears in **b** because of the sensitivity of CLUMPFIND to noise and small-scale structure in the data. In the online PDF version, the 3D cubes (**a** and **b**) can be rotated to any orientation, and surfaces can be turned on and off (interaction requires Adobe Acrobat version 7.0.8 or higher). In the printed version, the front face of each 3D cube (the 'home' view in the interactive online version) corresponds exactly to the patch of sky shown in Fig. 1, and velocity with respect to the Local Standard of Rest increases from front (-0.5 km s^{-1}) to back (8 km s^{-1}).

data, CLUMPFIND typically finds features on a limited range of scales, above but close to the physical resolution of the data, and its results can be overly dependent on input parameters. By tuning CLUMPFIND's two free parameters, the same molecular-line data set[8] can be used to show either that the frequency distribution of clump mass is the same as the initial mass function of stars or that it follows the much shallower mass function associated with large-scale molecular clouds (Supplementary Fig. 1).

Four years before the advent of CLUMPFIND, 'structure trees'[9] were proposed as a way to characterize clouds' hierarchical structure using 2D maps of column density. With th… 2D work as inspiration, we have developed a structure-id… …ithm that abstracts the hierarchical structure of a… an easily visualized representation calle… well developed in other data-intensive… application of tree methodologies so fa… and almost exclusively within the a… 'merger trees' are being used with in…

Figure 3 and its legend explain th… schematically. The dendrogram qua… ima of emission merge with each… explained in Supplementary Meth… determined almost entirely by th… sensitivity to algorithm paramete… possible on paper and 2D screen… data (see Fig. 3 and its legend… cross, which eliminates dimen… preserving all information… Numbered 'billiard ball' lab… features between a 2D map… online) and a sorted dendro…

A dendrogram of a spectr… of key physical properties… surfaces, such as radius (R)… (L). The volumes can have any shape, and… the significance of the especially elongated features… (Fig. 2a). The luminosity is an approximate proxy for mass, such that $M_{lum} = X_{13CO}L_{13CO}$, where $X_{13CO} = 8.0 \times 10^{20}$ cm^2 K^{-1} km^{-1} s (ref. 15; see Supplementary Methods and Supplementary Fig. 2). The derived values for size, mass and velocity dispersion can then be used to estimate the role of self-gravity at each point in the hierarchy, via calculation of an 'observed' virial parameter, $\alpha_{obs} = 5\sigma_v^2 R/GM_{lum}$. In principle, extended portions of the tree (Fig. 2, yellow highlighting) where $\alpha_{obs} < 2$ (where gravitational energy is comparable to or larger than kinetic energy) correspond to regions of p–p–v space where self-gravity is significant. As α_{obs} only represents the ratio of kinetic energy to gravitational energy at one point in time, and does not explicitly capture external over-pressure and/or magnetic fields[16], its measured value should only be used as a guide to the longevity (boundedness) of any particular feature.

Figure 3 | Schematic illustration of the dendrogram process. Shown is the construction of a dendrogram from a hypothetical one-dimensional emission profile (black). The dendrogram (blue) can be constructed by 'dropping' a test constant emission level (purple) from above in tiny steps (exaggerated in size here, light lines) until all the local maxima and mergers are found, and connected as shown. The intersection of a test level with the emission is a set of points (for example the light purple dots) in one dimension, a planar curve in two dimensions, and an isosurface in three dimensions. The dendrogram of 3D data shown in Fig. 2c is the direct analogue of the tree shown here, only constructed from 'isosurface' rather than 'point' intersections. It has been sorted and flattened for representation on a flat page, as fully representing dendrograms for 3D data cubes would require four dimensions.

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nature LETTERS

A role for self-gravity at multiple length scales in the process of star formation

Alyssa A. Goodman[1,2], Erik W. Rosolowsky[2,3], Michelle A. Borkin[1]†, Jonathan B. Foster[2], Michael Halle[1,4], Jens Kauffmann[1,2] & Jaime E. Pineda[2]

Self-gravity plays a decisive role in the final stages of star formation, where dense cores (size ~0.1 parsecs) inside molecular clouds collapse to form star-plus-disk systems[1]. But self-gravity's role at earlier times (and on larger length scales, such as ~1 parsec) is unclear; some molecular cloud simulations that do not include self-gravity suggest that 'turbulent fragmentation' alone is sufficient to create a mass distribution of dense cores that resembles, and sets, the stellar initial mass function[2]. Here we report a 'dendrogram' (hierarchical tree-diagram) analysis that reveals that self-gravity plays a significant role over the full range of possible scales traced by ^{13}CO observations in the L1448 molecular cloud, but not everywhere in the observed region. In particular, more than 90 per cent of the compact 'pre-stellar cores' traced by peaks of dust emission[3] are projected on the sky within one of the dendrogram's self-gravitating 'leaves'. As these peaks mark the loca-

overlapping features as an option, significant emission found between prominent clumps is typically either appended to the nearest clump or turned into a small, usually 'pathological', feature needed to encompass all the emission being modelled. When applied to molecular-line

Goodman et al. 2009, Nature, cf: Fluke et al. 2009

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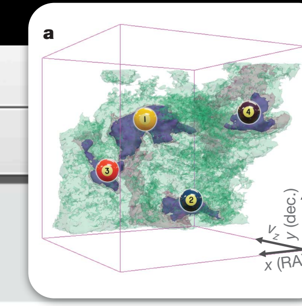

LETTERS

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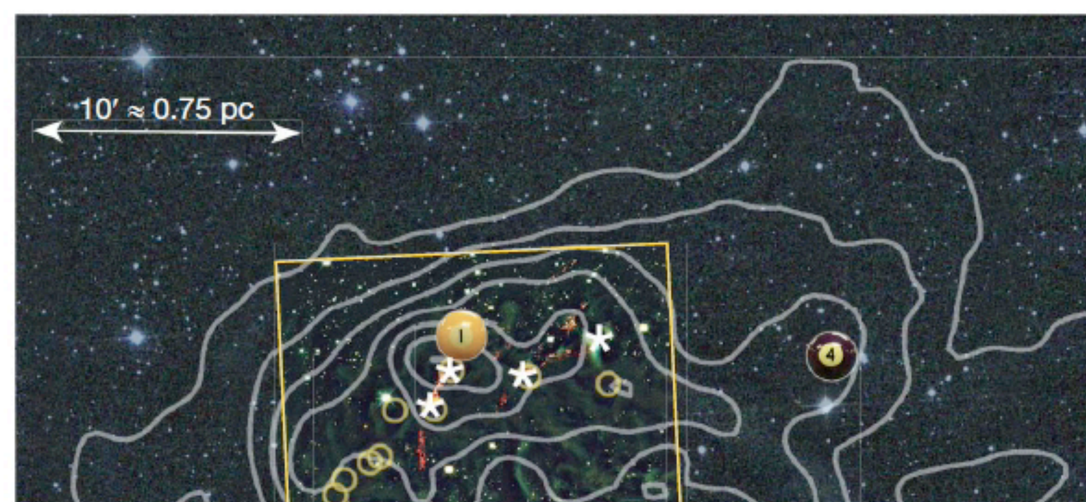
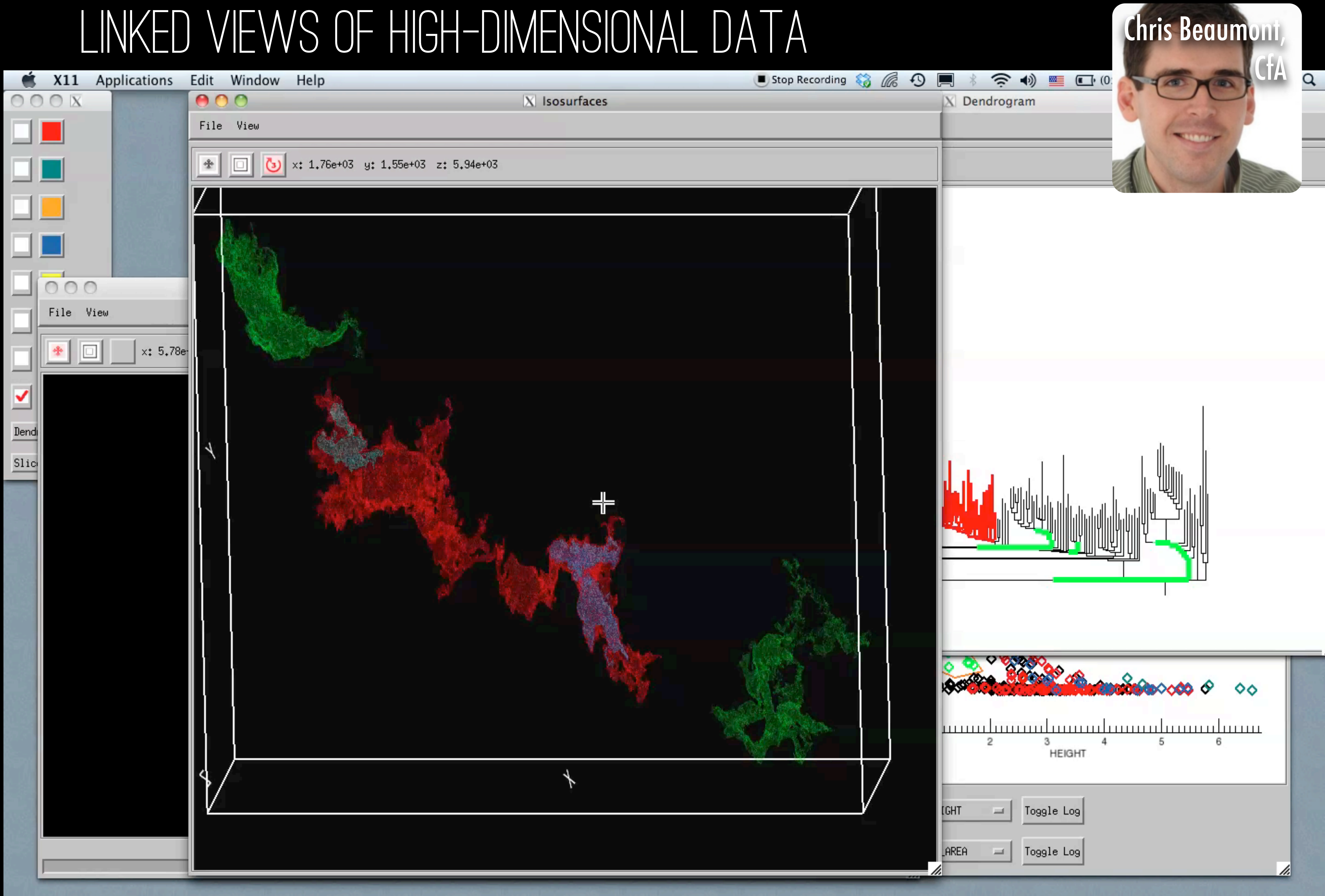
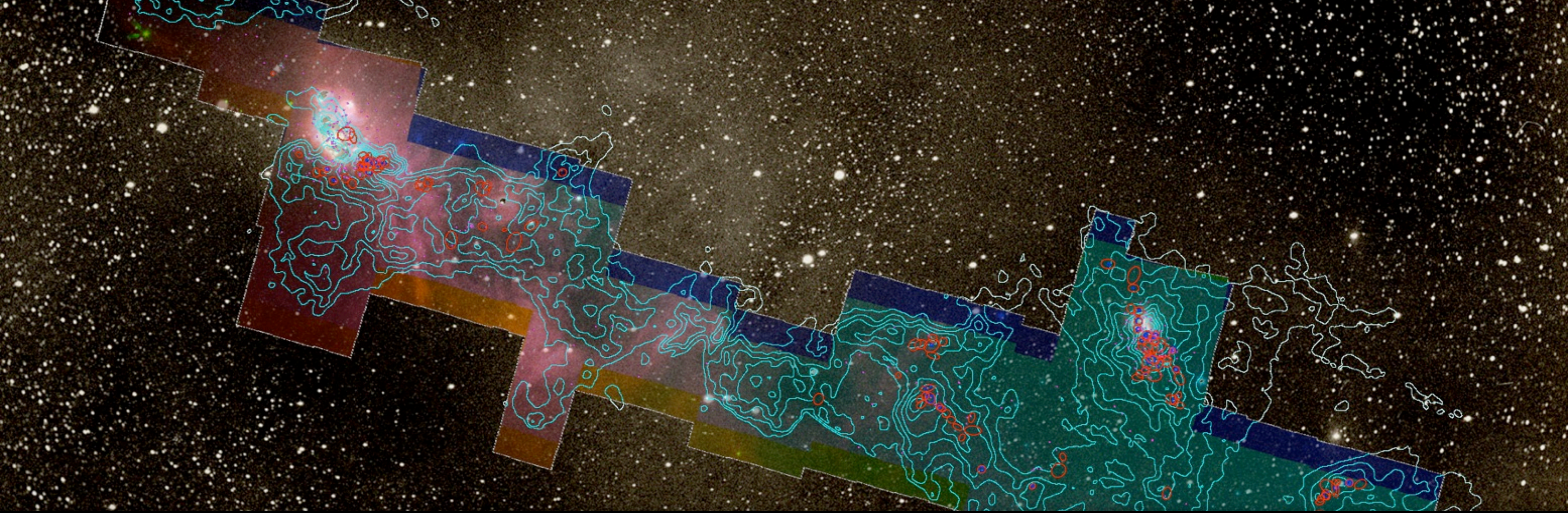
overlapping features as an option, significant emission found between prominent clumps is typically either appended to the nearest clump or turned into a small, usually 'pathological', feature needed to encompass all the emission being modelled. When applied to molecular-line



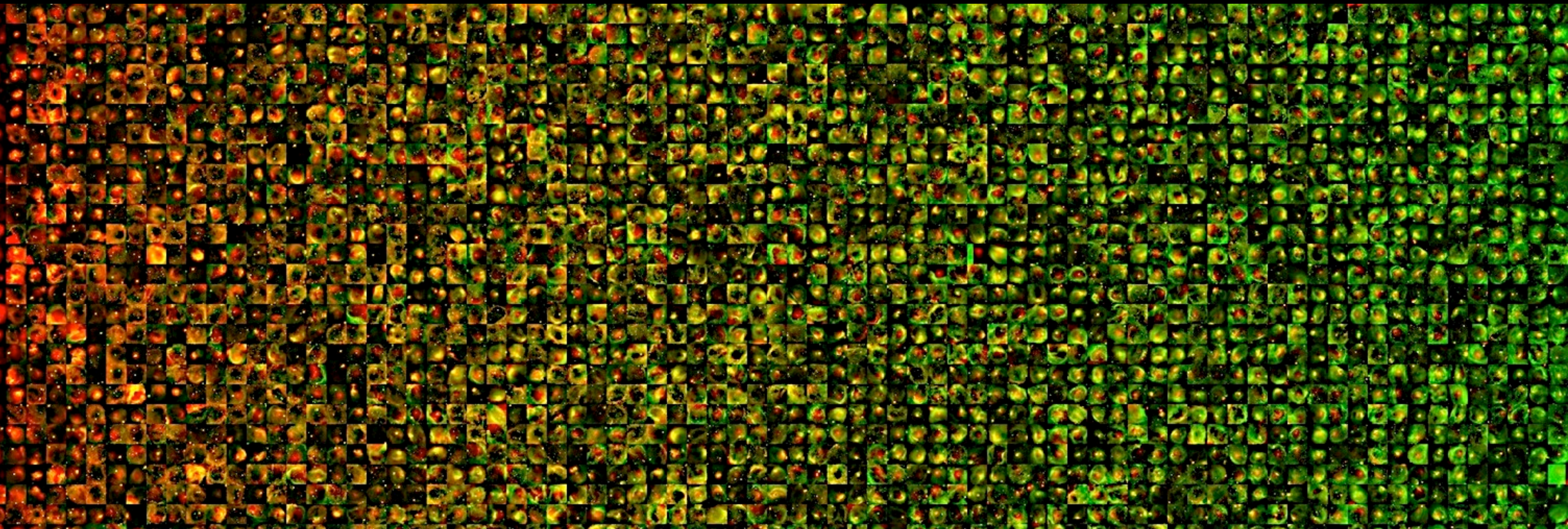
LINKED VIEWS OF HIGH-DIMENSIONAL DATA



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

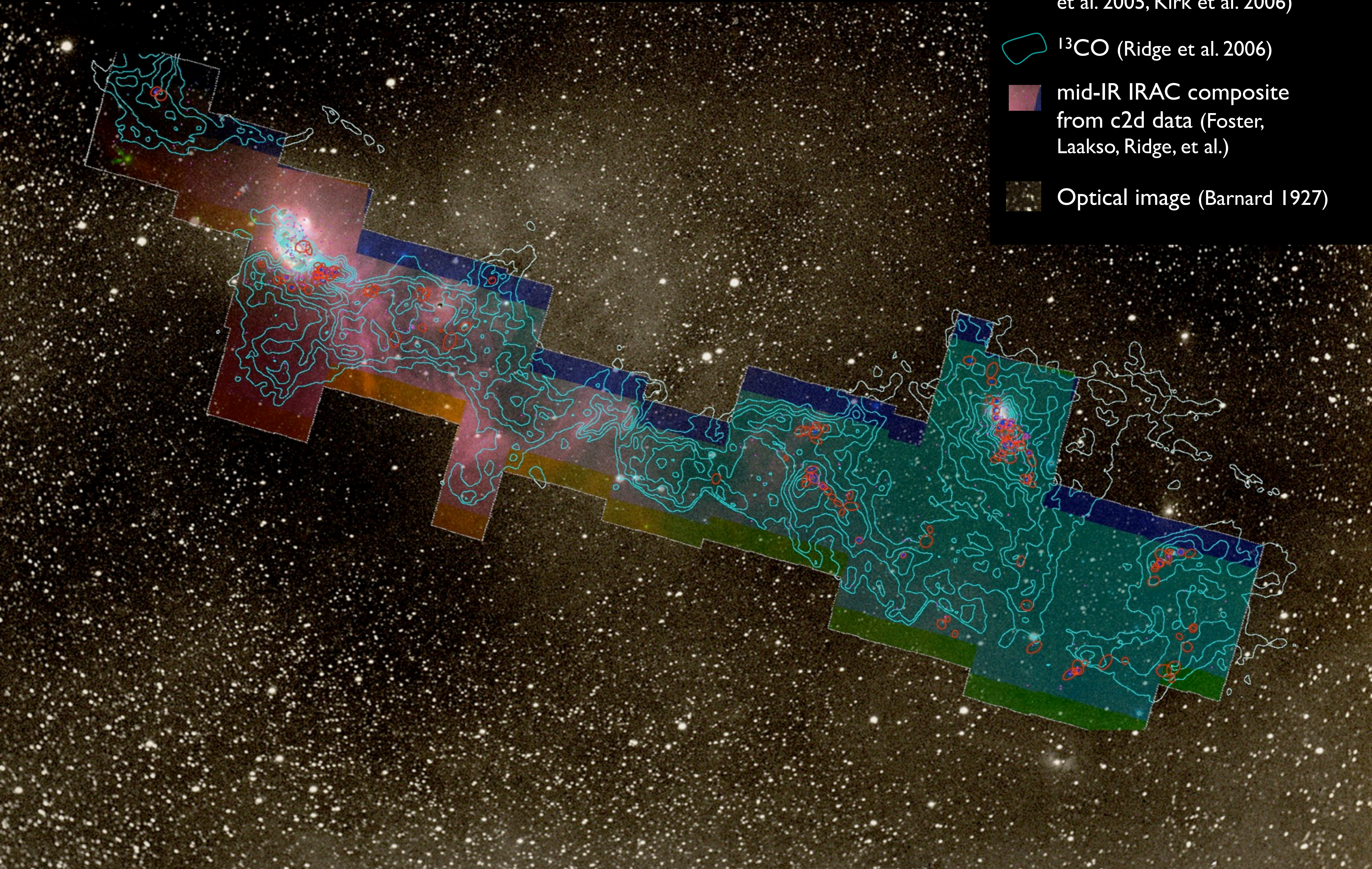


WIDE DATA & BIG DATA



WIDE DATA

COMPLETE



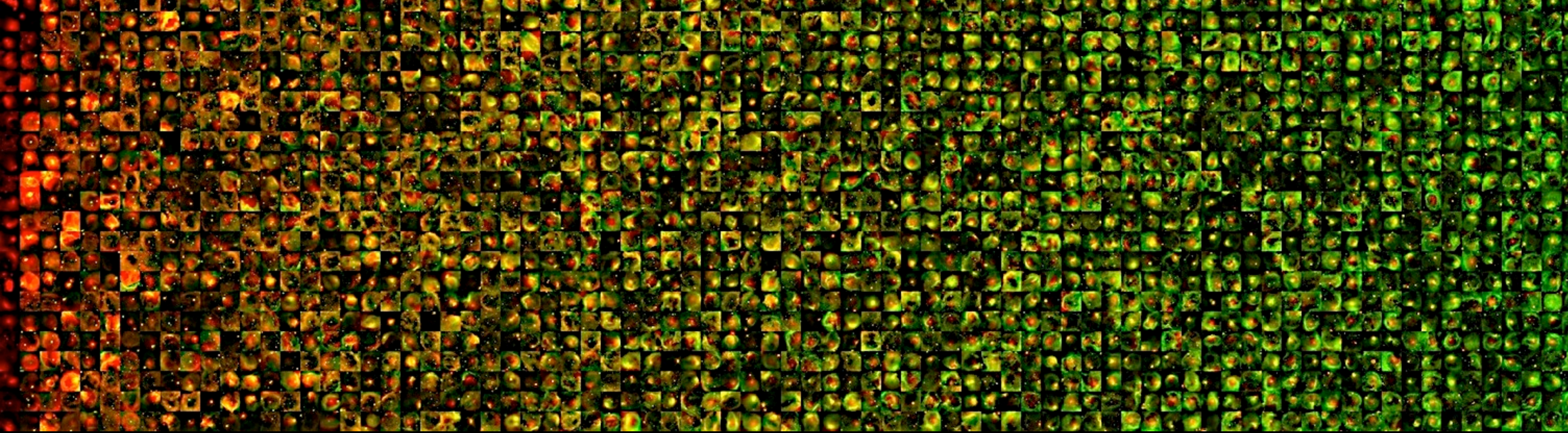
mm peak (Enoch et al. 2006)

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

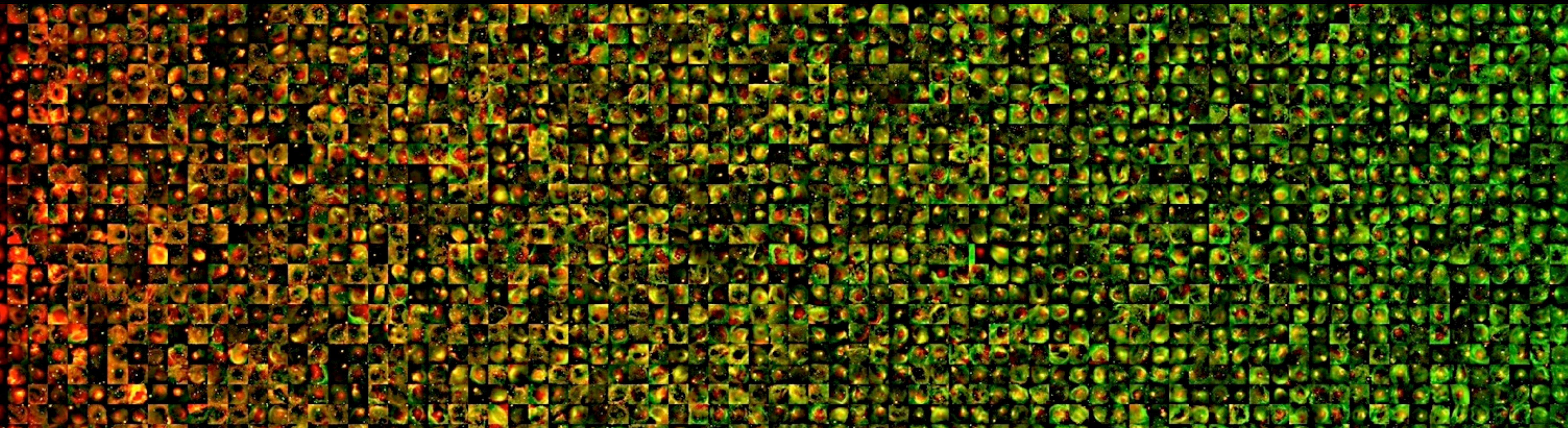
^{13}CO (Ridge et al. 2006)

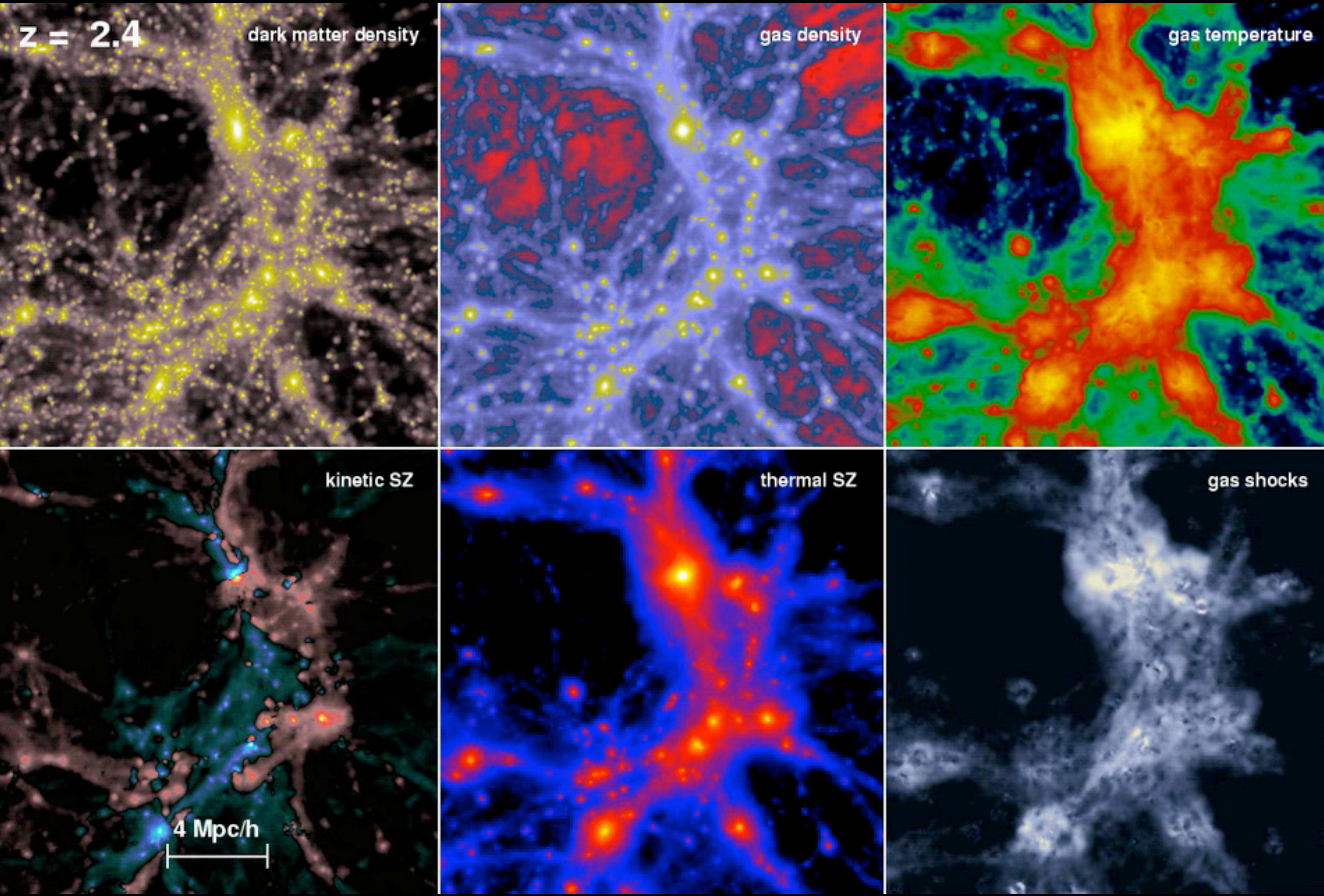
mid-IR IRAC composite from c2d data (Foster, Laakso, Ridge, et al.)

Optical image (Barnard 1927)



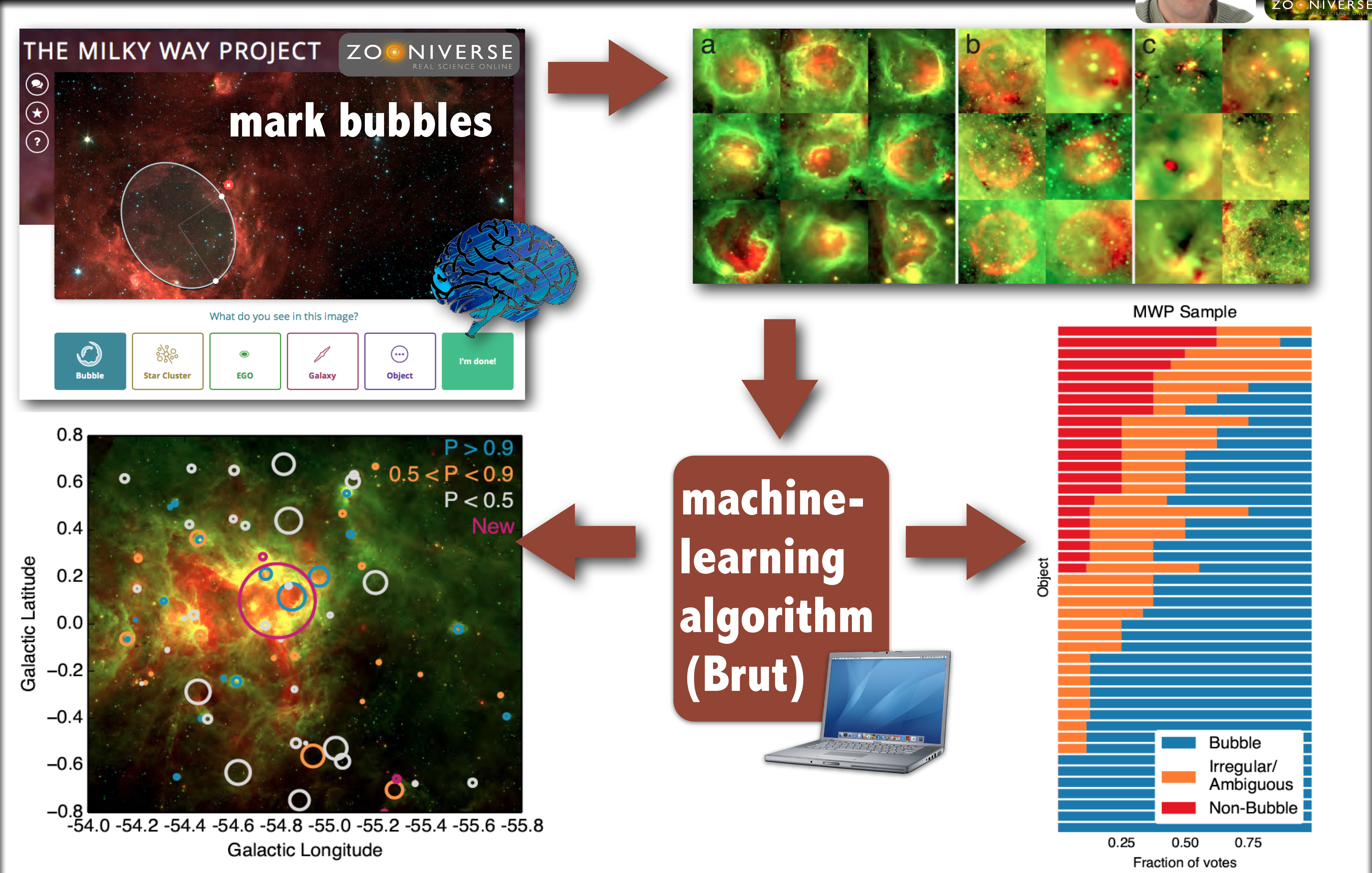
BIG AND WIDE DATA





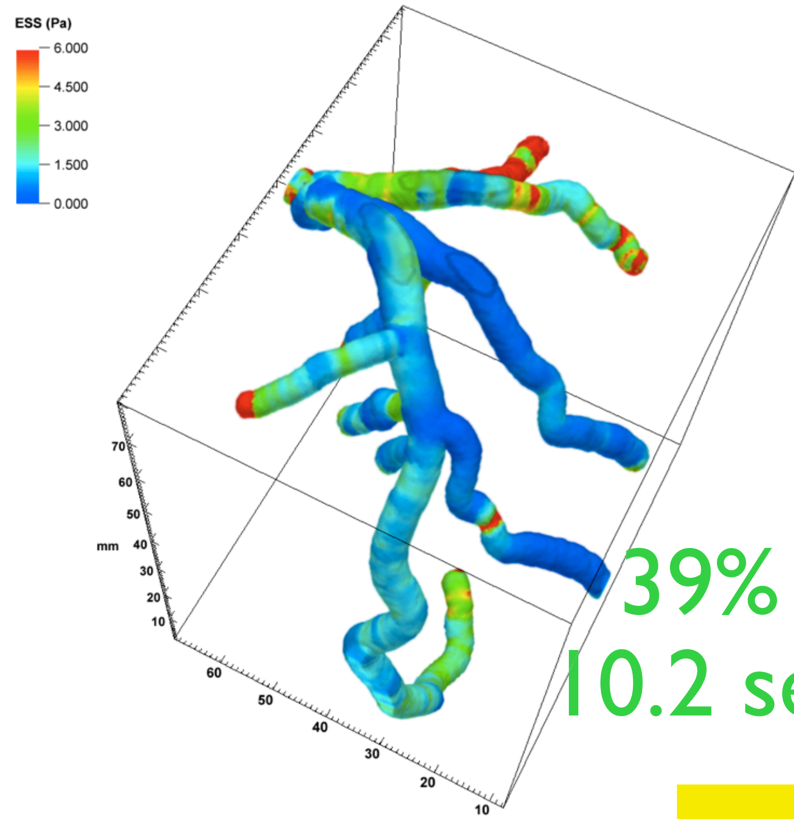
Movie: Volker Springel, formation of a cluster of galaxies

BIG DATA AND "HUMAN-AIDED COMPUTING"



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*

DIMENSIONALITY AND COLOR



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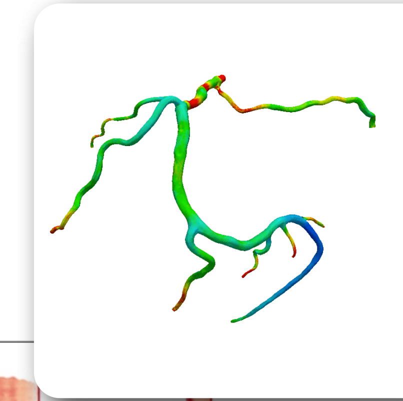
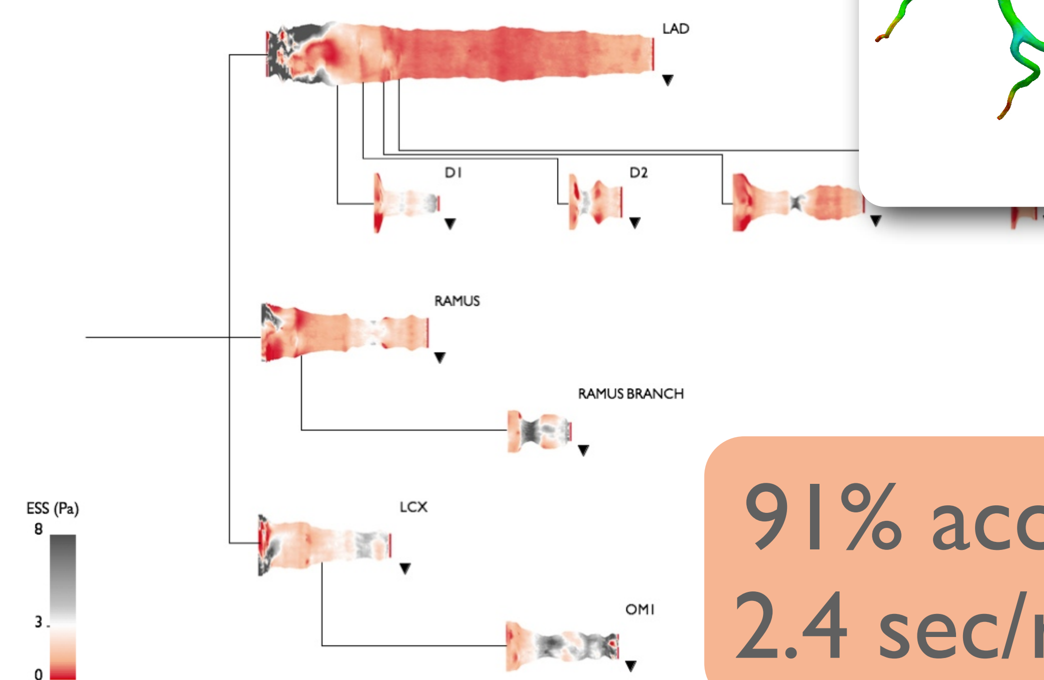
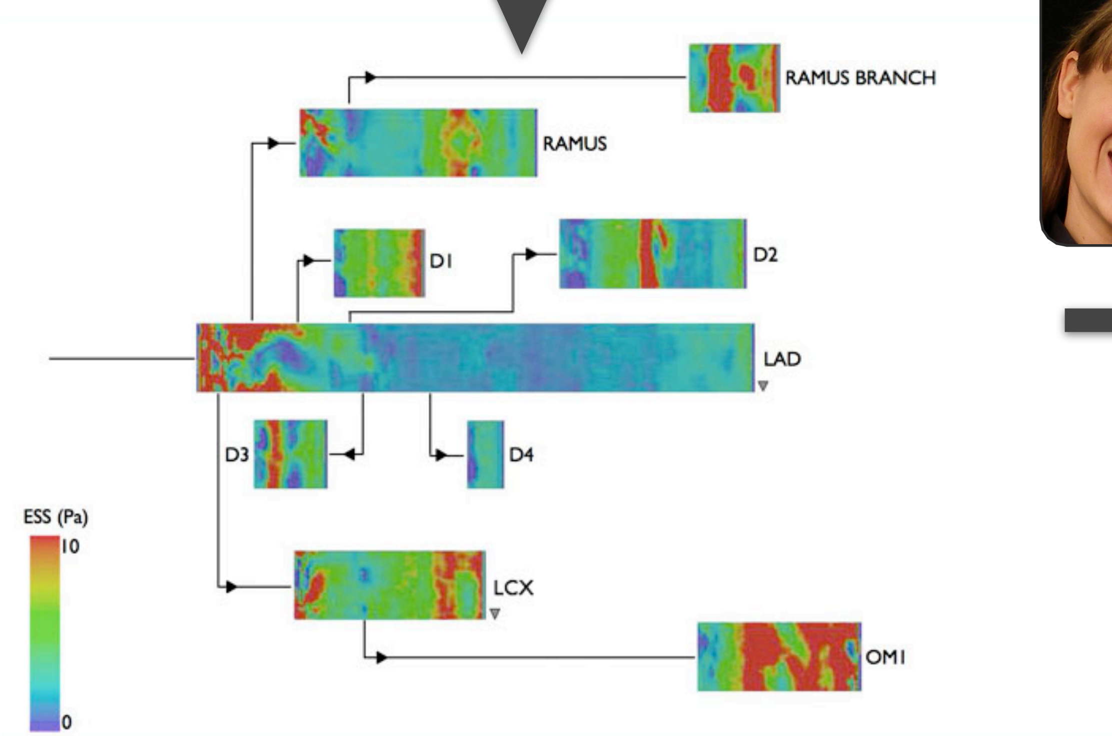
10.2 sec/region

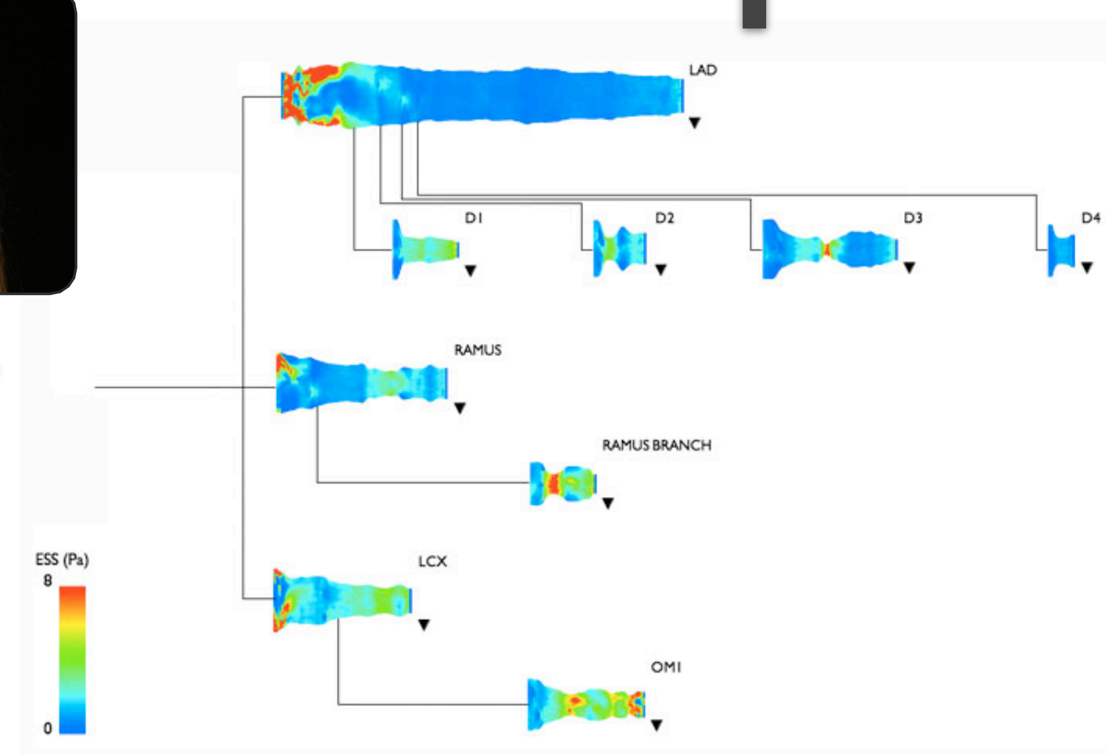




91% accurate
2.4 sec/region

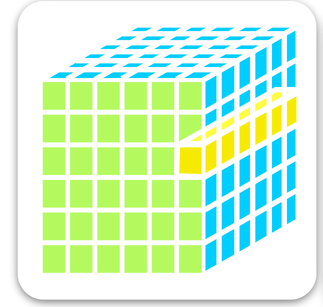
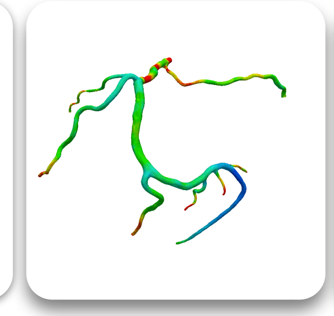
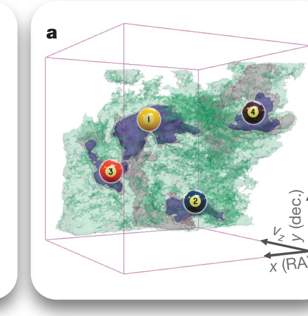
see Michelle Borkin's talk

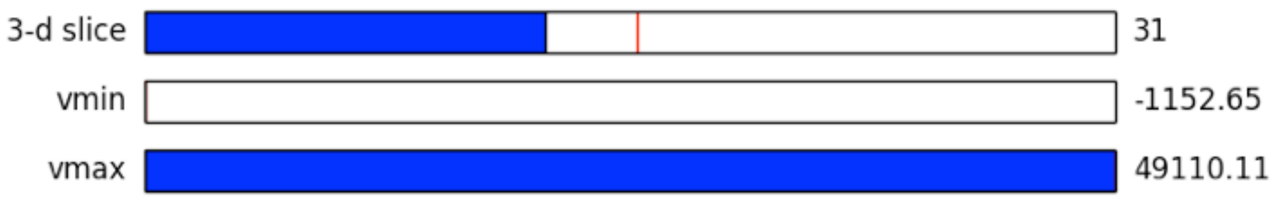




Borkin et al. 2011
cf. colorbrewer2.org

ASTRONOMICAL TREES
(LINKED VIEWS OF DENDROGRAMS)

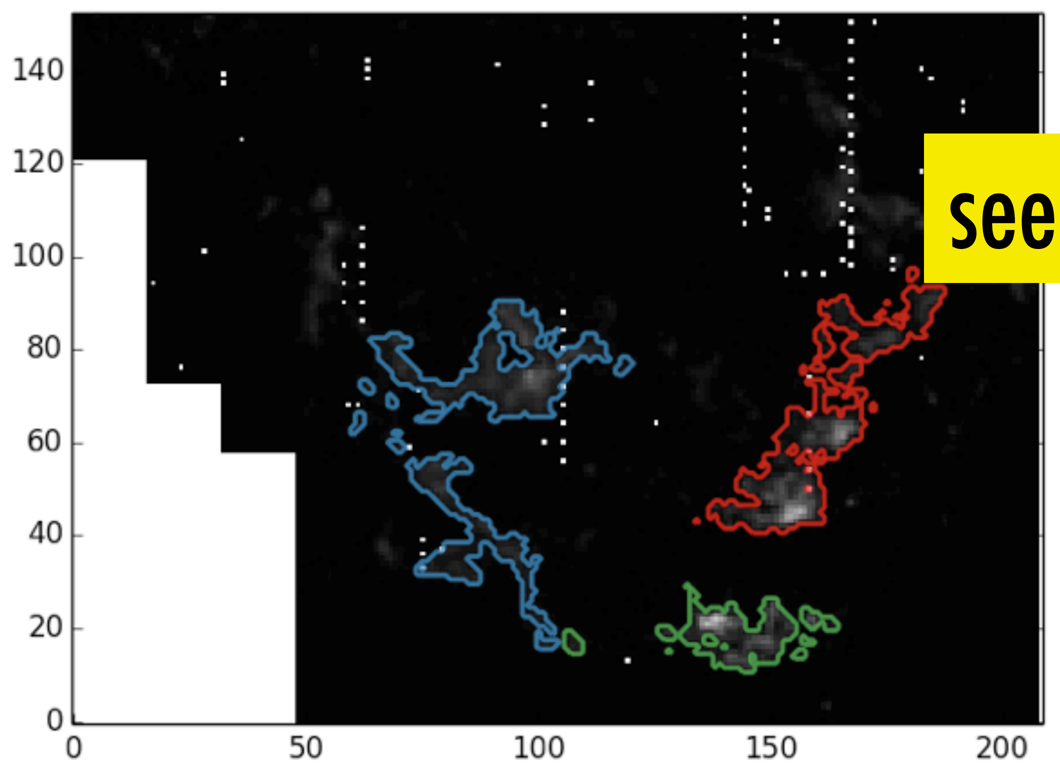




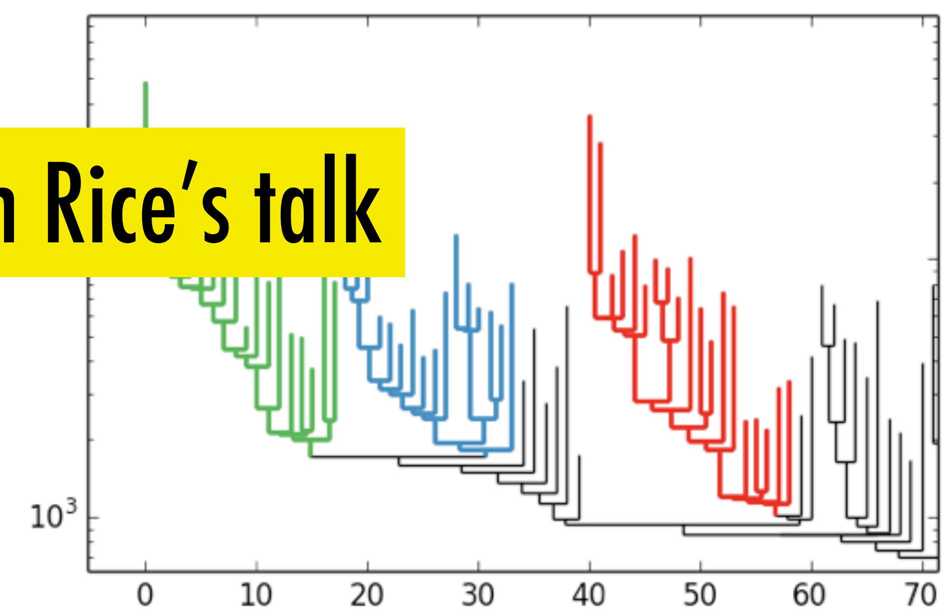


Selected structure: 48

Selected structure: 157

Selected structure: 58

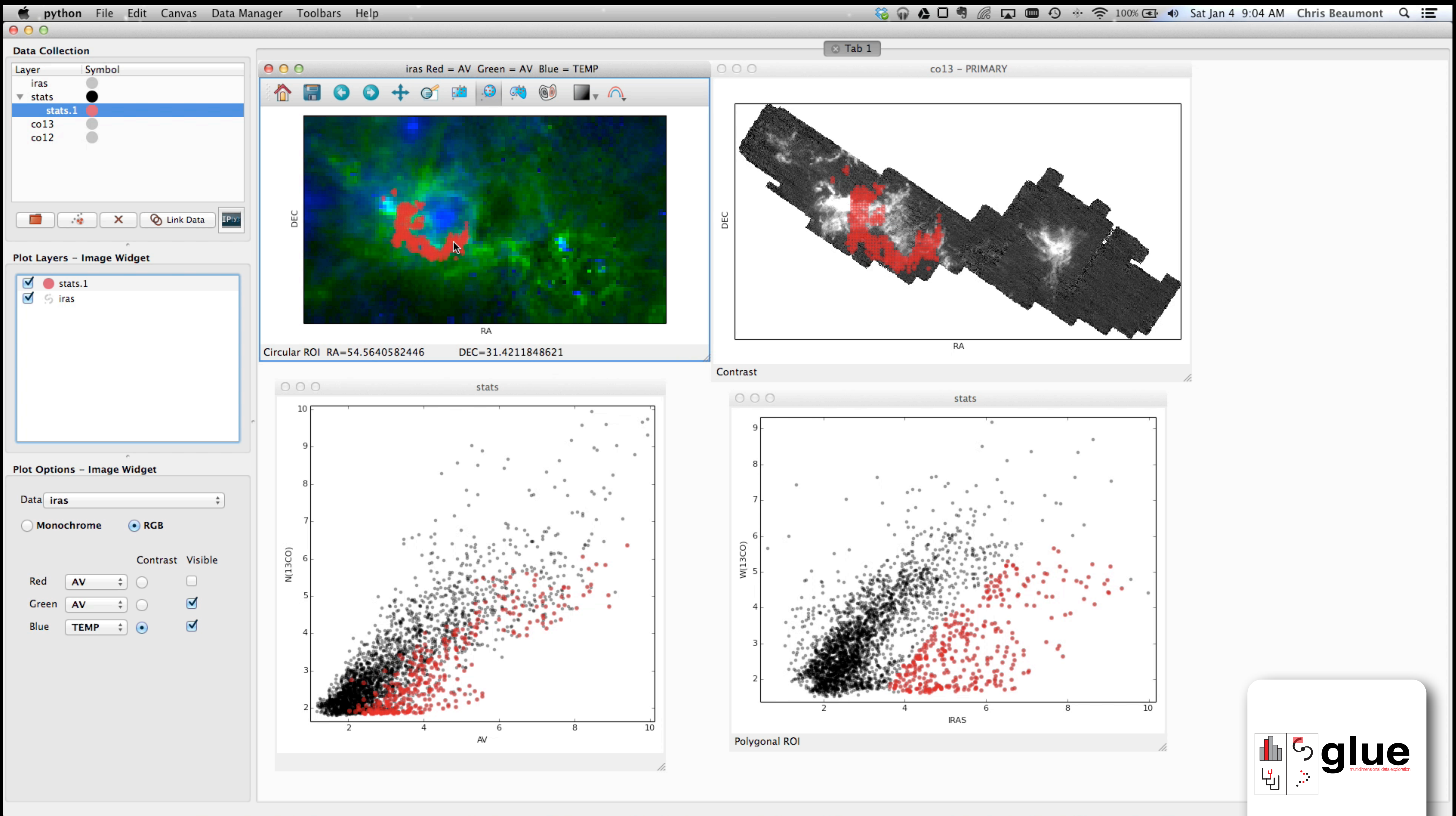




see Tom Rice's talk

LINKED VIEWS OF HIGH-DIMENSIONAL DATA

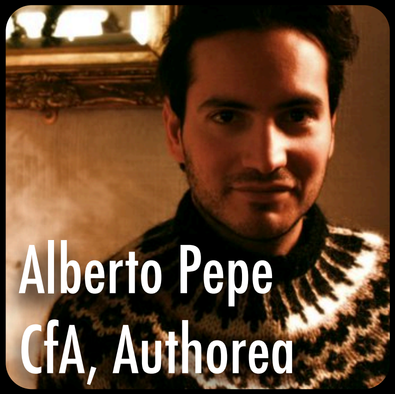
GLUE

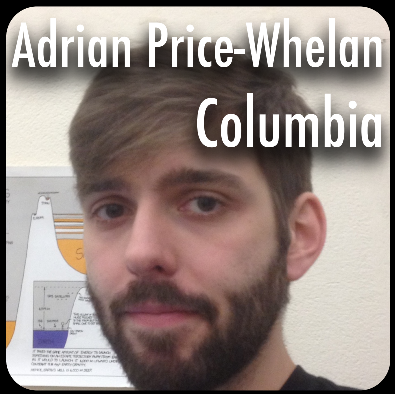


Beaumont, w/Goodman, Robitaille & Borkin

"THE STORY & THE SANDBOX"

(GLUE:D3PO:AUTHOREA)





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Beyond Galileo

Josh Peek, Alberto Pepe   + Add author

In the last portion of *Sidereus Nuncius*, Galileo reported his discovery of **four objects** that appeared to form a straight line of stars near **Jupiter**. The first night, he witnessed a line of three little stars close to Jupiter parallel to the ecliptic; the following nights brought different arrangements and another star into his view, totaling four stars around Jupiter. (Galilei 1618) Throughout the text, Galileo gave illustrations of the relative positions of Jupiter and its apparent companion stars as they appeared nightly from late January through early March 1610. The fact that they changed their positions relative to Jupiter from night to night, but always appeared in the same straight line near Jupiter, brought Galileo to deduce that they were four bodies in orbit around Jupiter. On January 11 after 4 nights of observation he wrote:

> "I therefore concluded and decided unhesitatingly, that there are three stars in the heavens moving about Jupiter, as Venus and Mercury round the Sun; which at length was established as clear as daylight by numerous subsequent observations. These observations also established that there are not only three, but four, erratic sidereal bodies performing their revolutions round Jupiter...the revolutions are so swift that an observer may generally get differences of position every hour." (Galilei 1610)

glue   D3PO   Au Authorea

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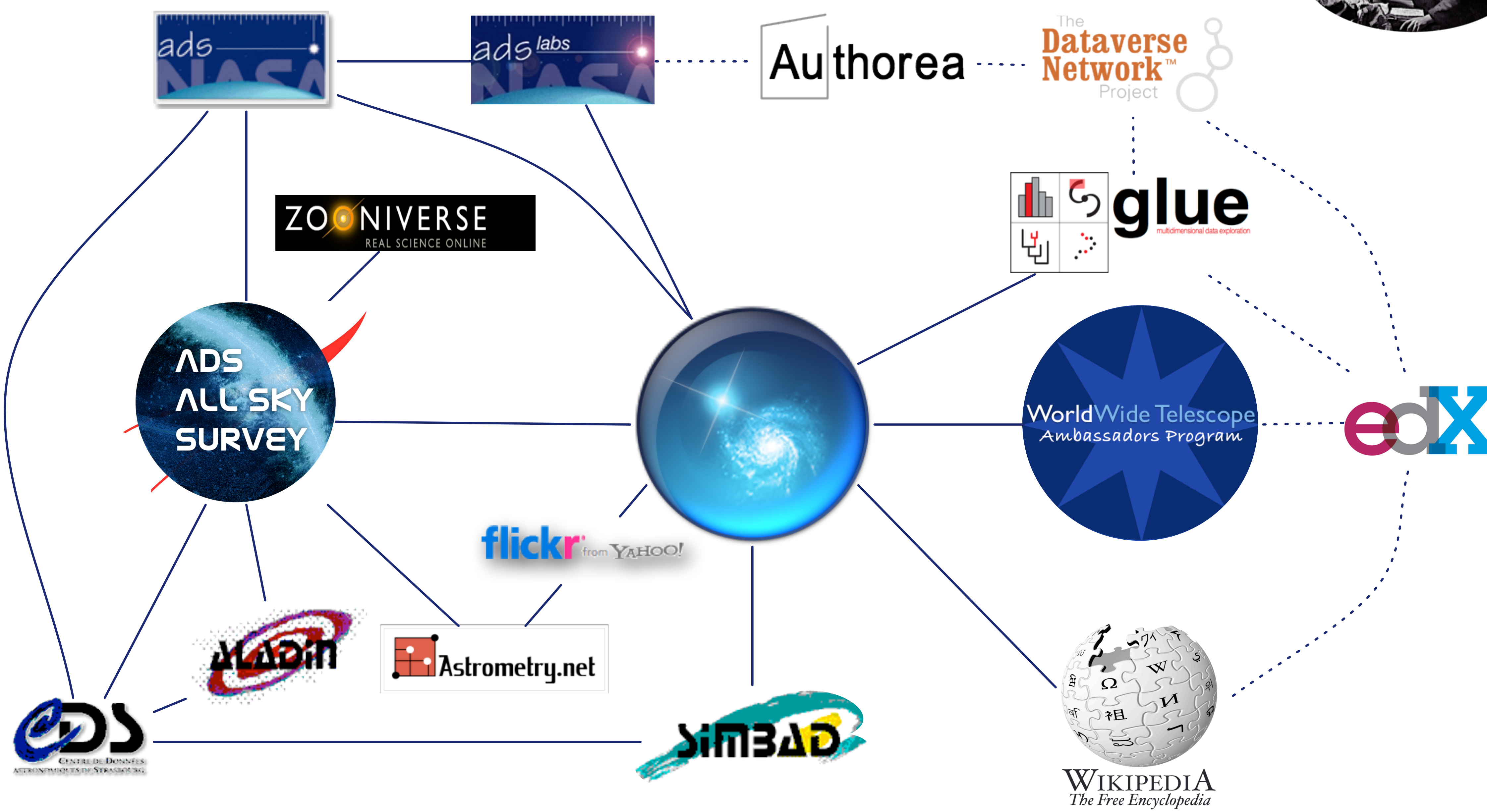
Linking scientific data, publications, and communities



https://www.cfa.harvard.edu/~agoodman/seamless/

Supported by Microsoft Research, NSF, NASA, Harvard, Smithsonian

Made possible by MANY collaborators, listed at projects.iq.harvard.edu/seamlessastronomy

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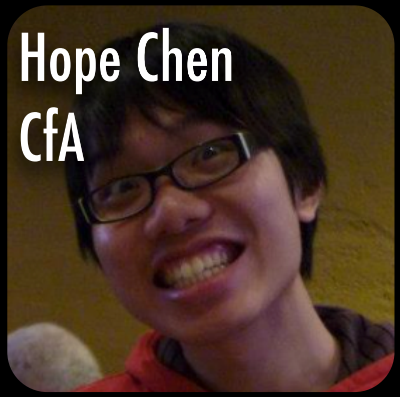

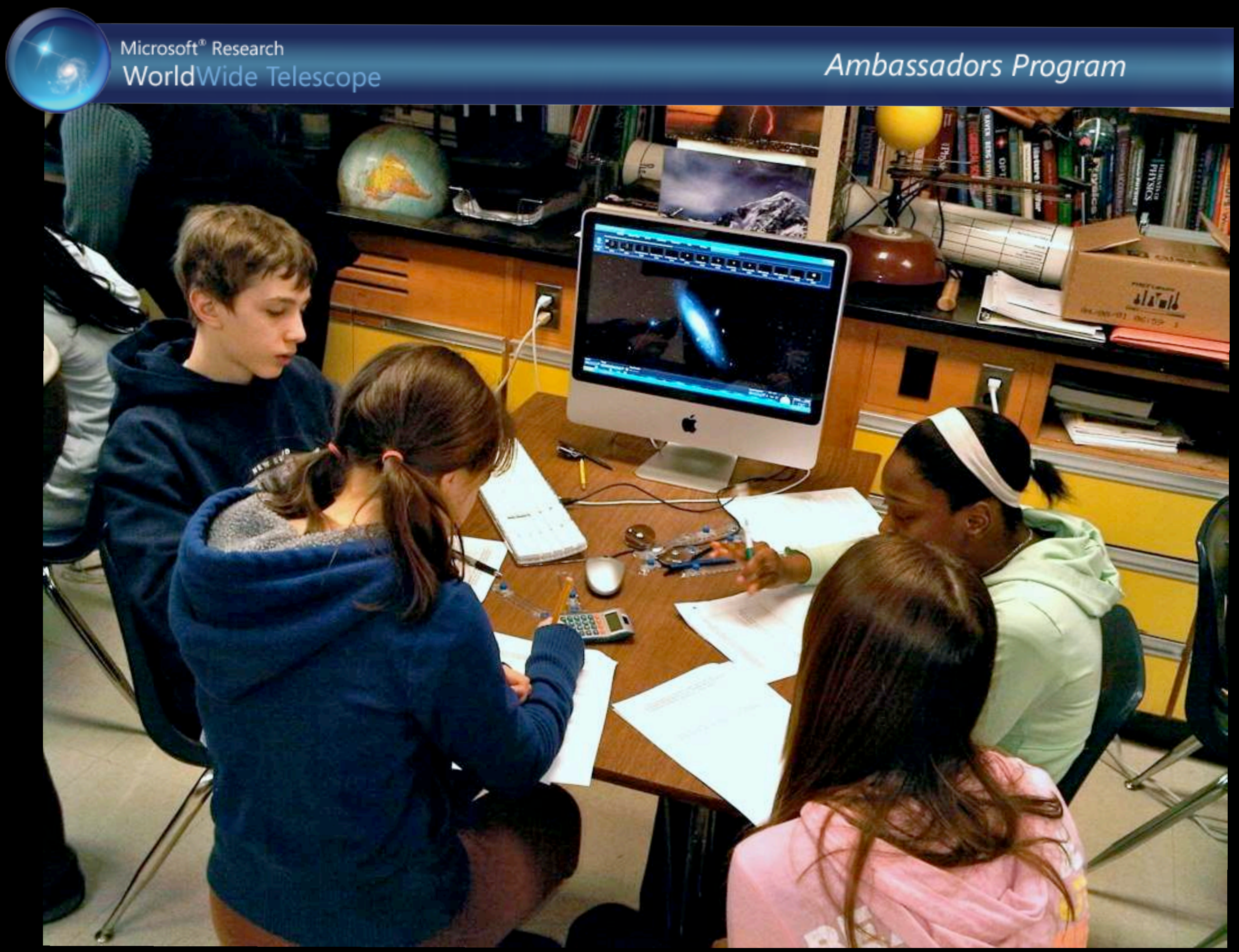

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COMPLETE Data Available

Center on Perseus | Center on Ophichus | Center on Serpens

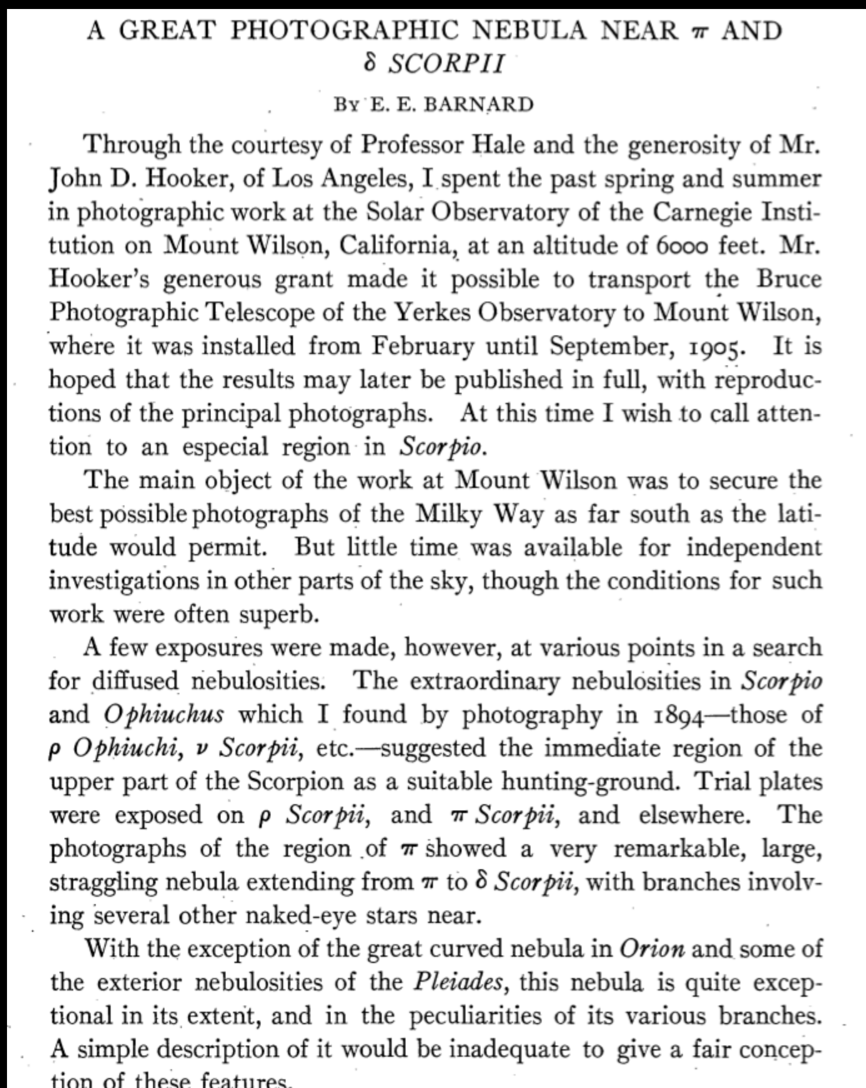
Full-Cloud Data (Phase I, All Data Available)

Dataset	Show	Perseus	Ophiuchus	Serpens	Link
GBT: HI Data Cube	☑	√	√	∅	Data
IRAS: Av/Temp Maps	☑	√	√	√	Data
FCRAO: 12CO	☑	√	√	√	Data
FCRAO: 13CO		√	√	√	Data
JCMT: 850 microns	☑	√	√	∅	Data
Spitzer c2d: IRAC 1,3 (3.6,5.8 μm)	☑	√	√	√	Data
Spitzer c2d: IRAC 2,4 (4.5,8 μm)	☑	√	√	√	Data
CSO/Bolocam: 1.2-mm	☑	√	∅	∅	Data
Spitzer MIPS: Derived Dust Map	☑	√	∅	∅	Data
Targeted Regions (Phase II, Some Data Not Yet Available)					
CTIO/Calar Alto: NIR (J,H,Ks)	☑	√	√	∅	Data
IRAM 30-m: N2H+ and C18O	☑	√	∅	∅	Data
IRAM 30-m: 1.1-mm continuum	☑	√	∅	∅	Data
Megacam/MMT: r,i,z images	☑	√	∅	∅	Data
Catalogs & Pointed Surveys					
NH3 Pointed Survey	☐	√	∅	∅	Data
YSO Candidate list (c2d)	☐	√	√	√	Data

A great photographic nebula near pi and delta Scorpii.

Barnard, E. E.

Astrophysical Journal, 23, 144-147 (1906)
Published in Mar 1906
DOI: 10.1086/141311



A GREAT PHOTOGRAPHIC NEBULA NEAR π AND δ *SCORPII*

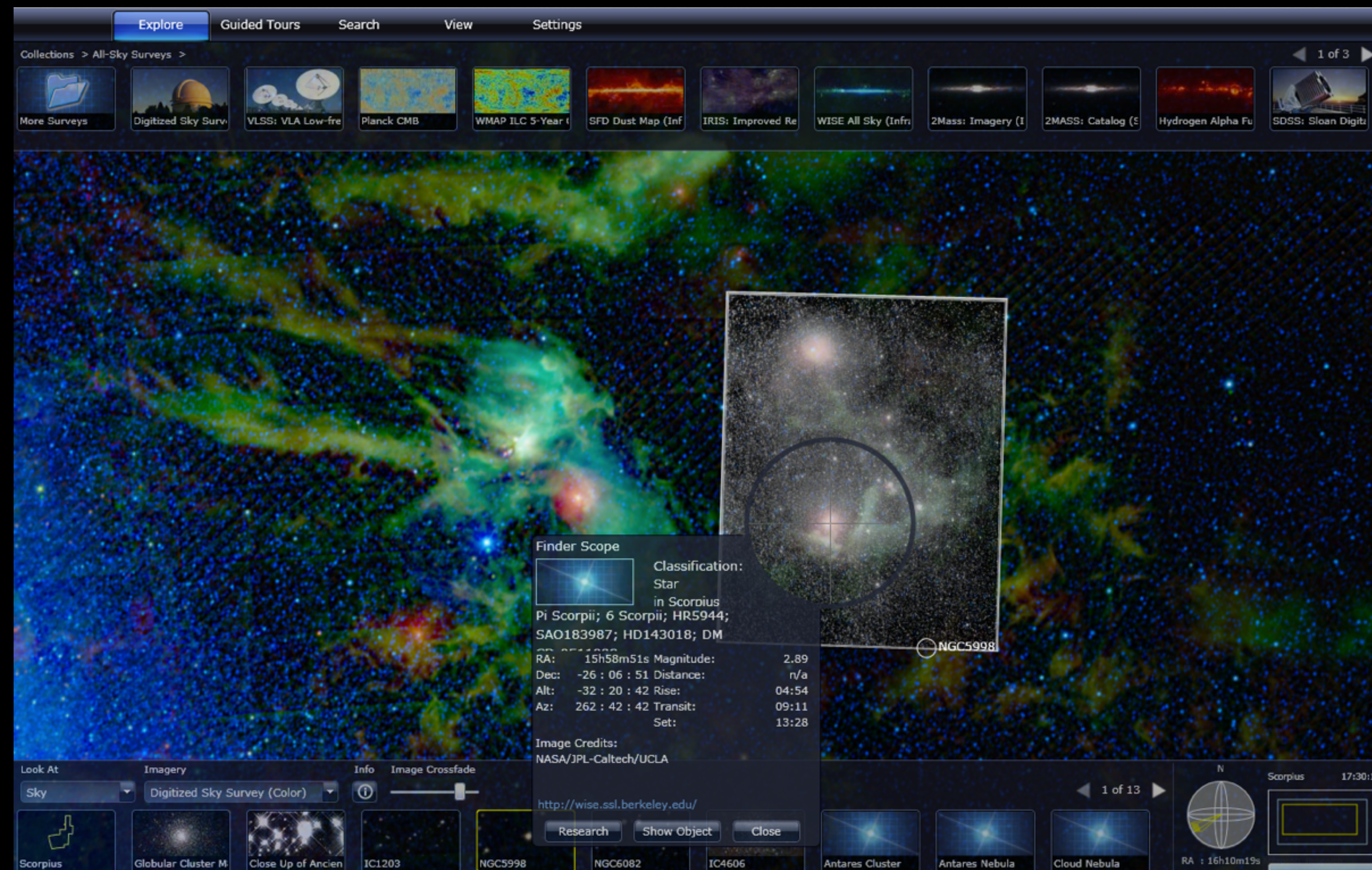
By E. E. BARNARD

Through the courtesy of Professor Hale and the generosity of Mr. John D. Hooker, of Los Angeles, I spent the past spring and summer in photographic work at the Solar Observatory of the Carnegie Institution on Mount Wilson, California, at an altitude of 6000 feet. Mr. Hooker's generous grant made it possible to transport the Bruce Photographic Telescope of the Yerkes Observatory to Mount Wilson, where it was installed from February until September, 1905. It is hoped that the results may later be published in full, with reproductions of the principal photographs. At this time I wish to call attention to an especial region in *Scorpio*.

The main object of the work at Mount Wilson was to secure the best possible photographs of the Milky Way as far south as the latitude would permit. But little time was available for independent investigations in other parts of the sky, though the conditions for such work were often superb.

A few exposures were made, however, at various points in a search for diffused nebulosities. The extraordinary nebulosities in *Scorpio* and *Ophiuchus* which I found by photography in 1894—those of ρ *Ophiuchi*, ν *Scorpii*, etc.—suggested the immediate region of the upper part of the Scorpion as a suitable hunting-ground. Trial plates were exposed on ρ *Scorpii*, and π *Scorpii*, and elsewhere. The photographs of the region of π showed a very remarkable, large, straggling nebula extending from π to δ *Scorpii*, with branches involving several other naked-eye stars near.

With the exception of the great curved nebula in *Orion* and some of the exterior nebulosities of the *Pleiades*, this nebula is quite exceptional in its extent, and in the peculiarities of its various branches. A simple description of it would be inadequate to give a fair conception of these features.



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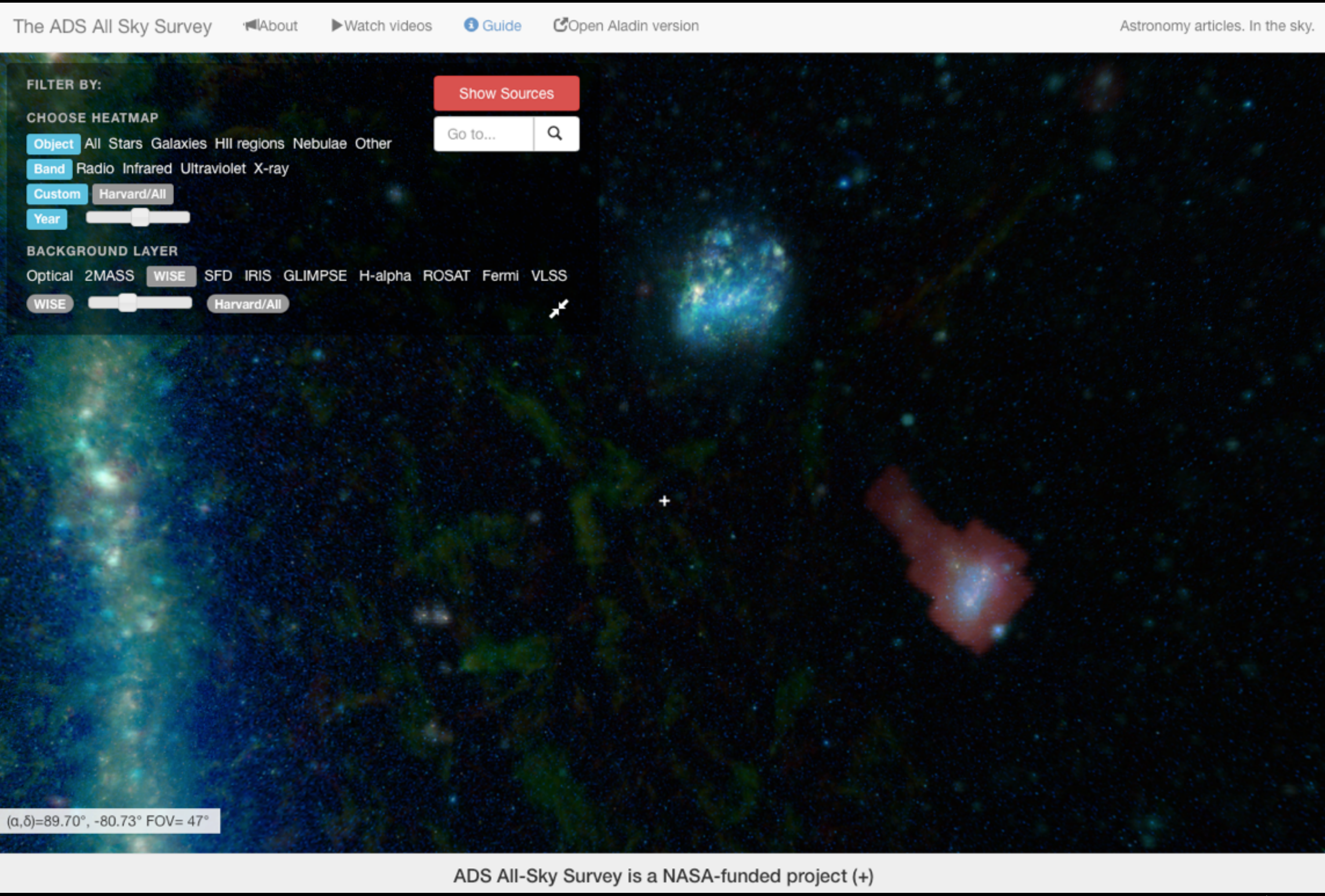
%2b(Page%3a%2b2%3b%2bImage%3a%2b1)%26imageurl%3dhttp%3a%2f%2fwww.adsass.org%2foldastro%2fdata%2f1906ApJ....23..144B-002-001.png%26credits%3dADS%2bAll%2bSky%2bSurvey%26creditsUrl%3dhttp%
%2fadsass.org%26ra%3d239%26y%3d948%26x%3d756%26rotation%3d179.892%26dec%3d-25.06%26thumb%3d%26wtml%3dtrue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WISE Harvard/All
(α,δ)=89.70°, -80.73° FOV= 47°
ADS All-Sky Survey is a NASA-funded project (+)

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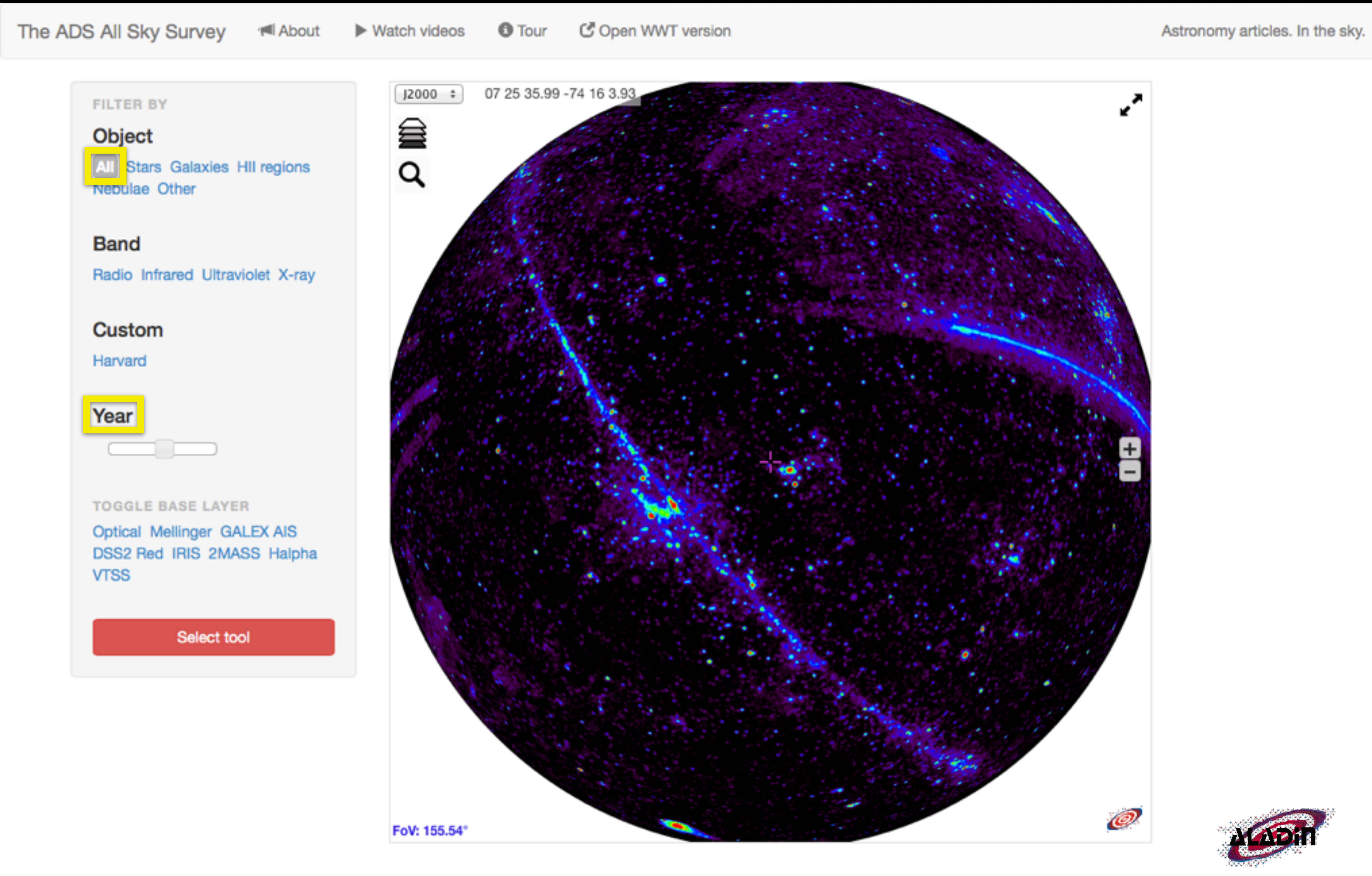
here is a 180-degree heatmap of article density on all kinds of objects, on the Sky, over all time



let's zoom in (on Ophiuchus)

The ADS All Sky Survey | About | Watch videos | Tour | Open WWT version | Astronomy articles. In the sky.

FILTER BY

Object

All Stars Galaxies HII regions Nebulae Other

Band

Radio Infrared Ultraviolet X-ray

Custom

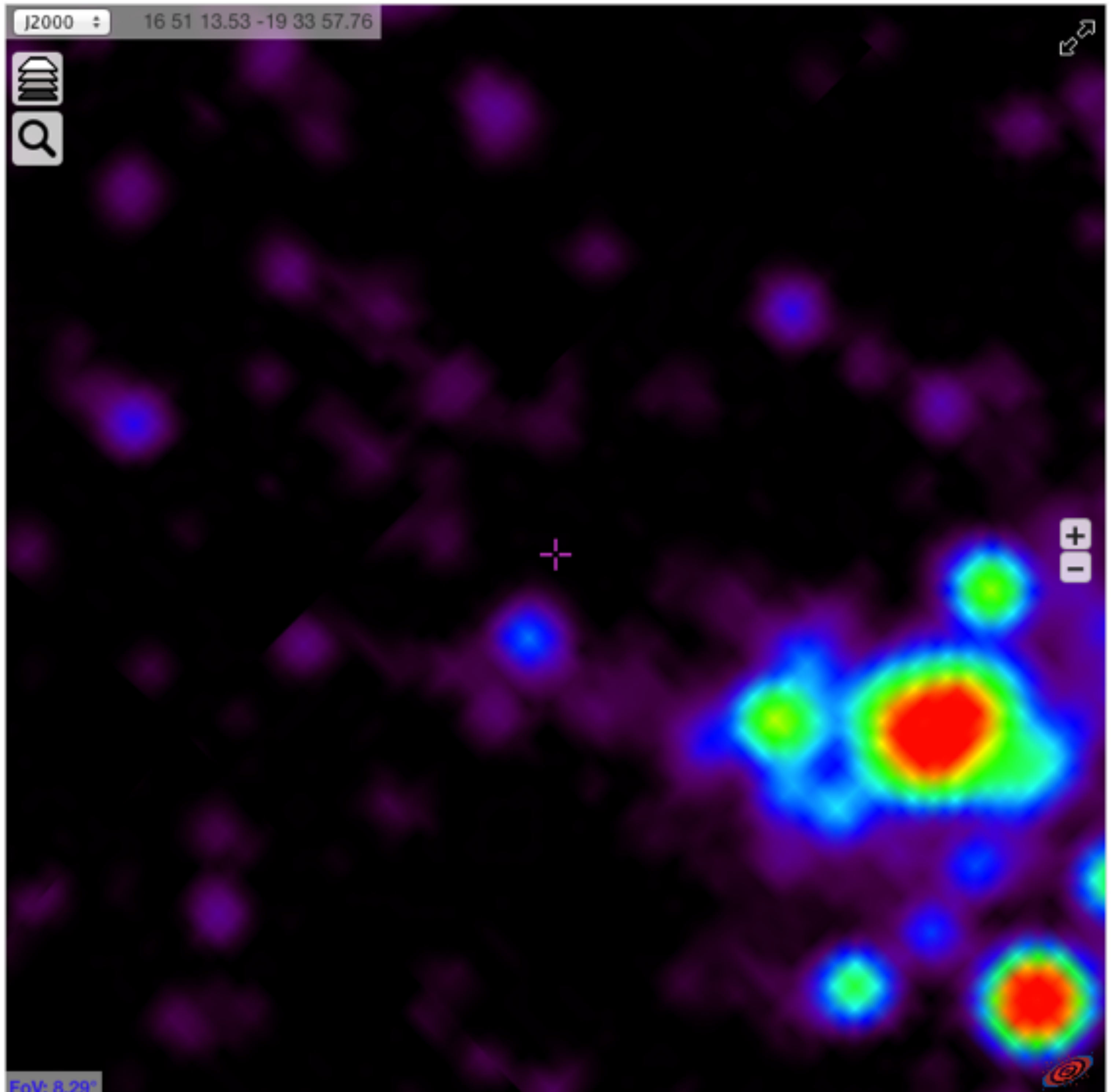
Harvard

Year

TOGGLE BASE LAYER

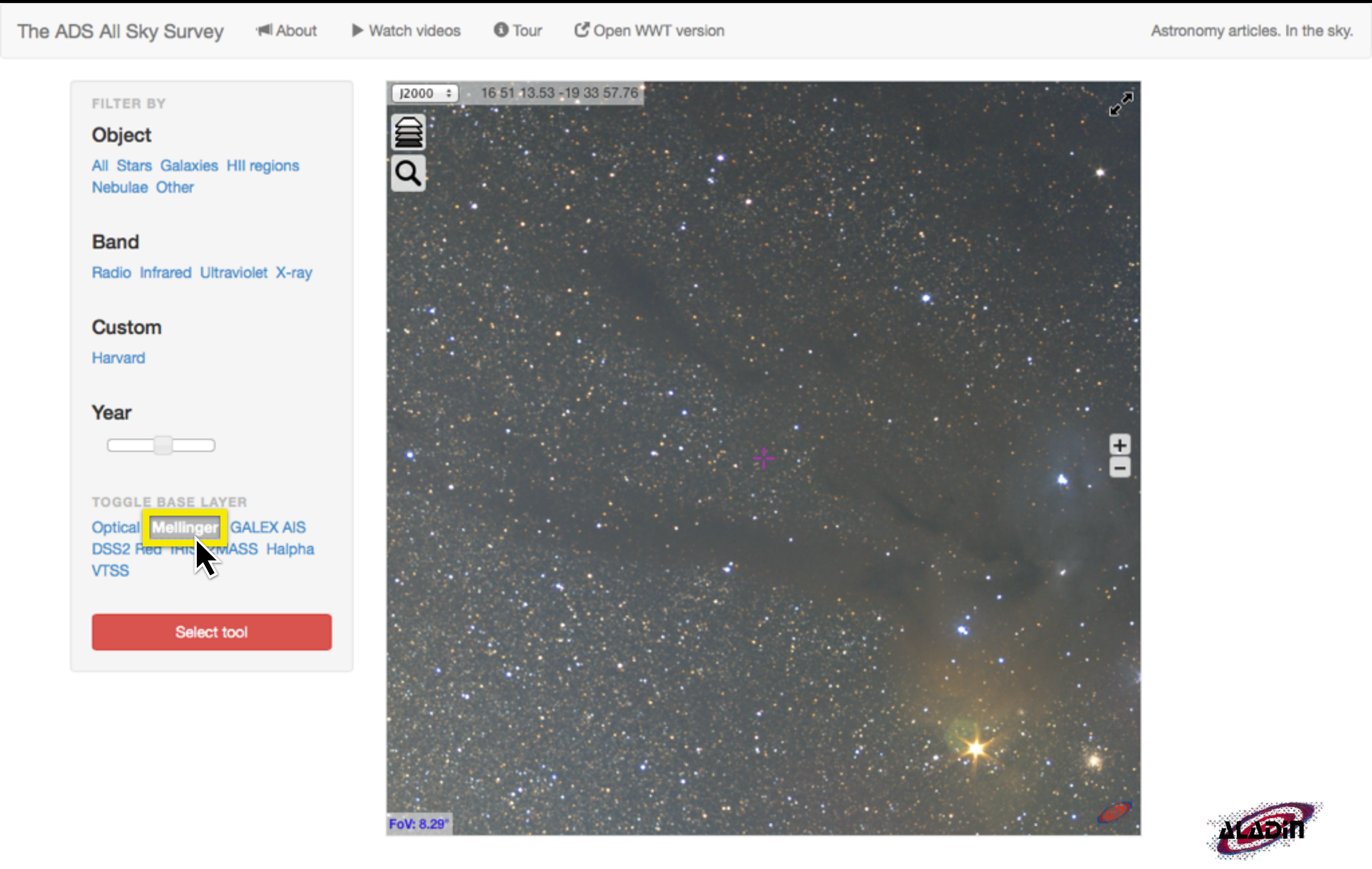
Optical Mellinger GALEX AIS DSS2 Red IRIS 2MASS Halpha VTSS

Select tool

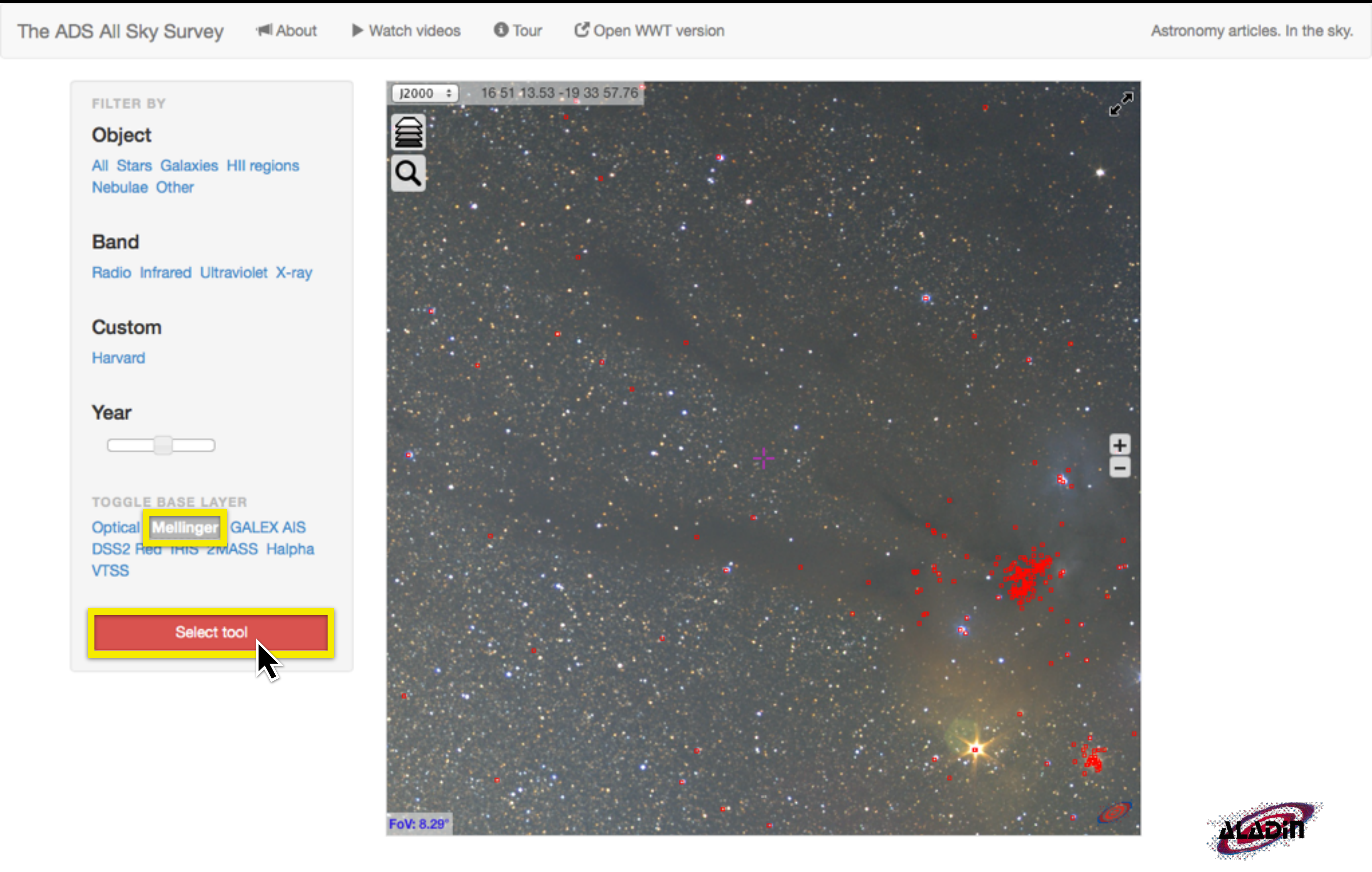


now, let's toggle on the "Mellinger" view of the Sky

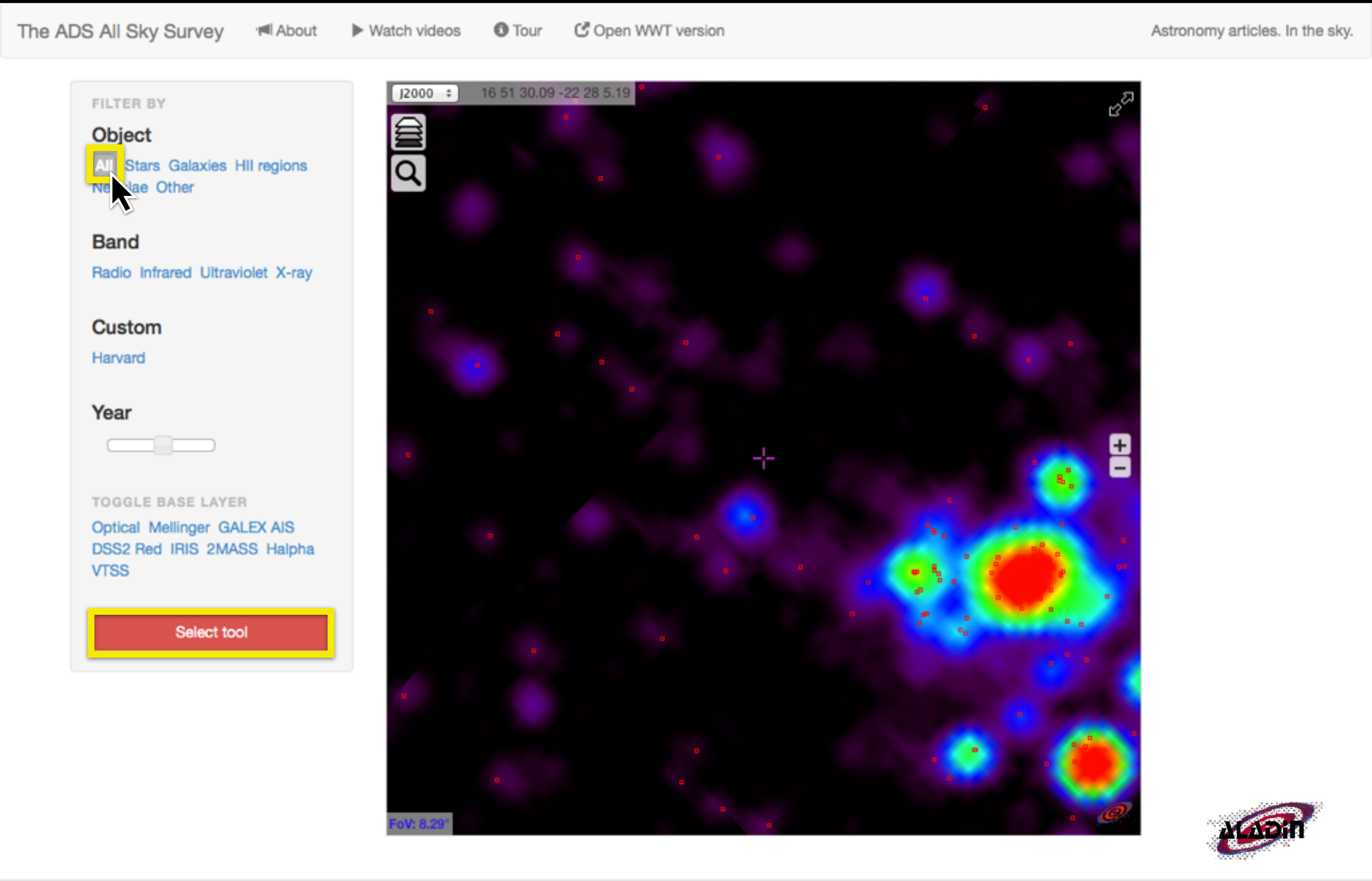
...to see a nice optical image of Ophiuchus



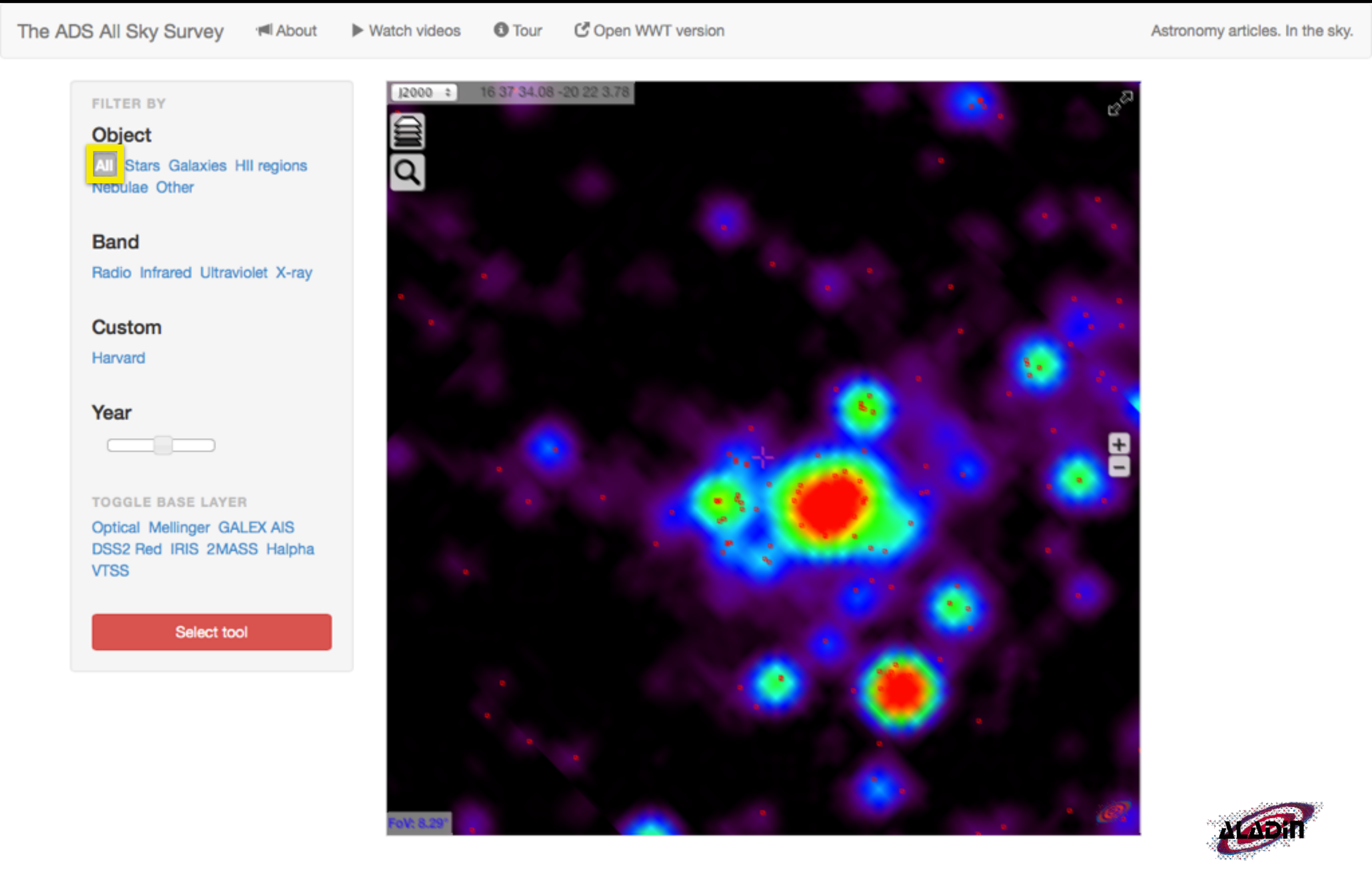
to add markers for SIMBAD sources, we can click the Select Tool



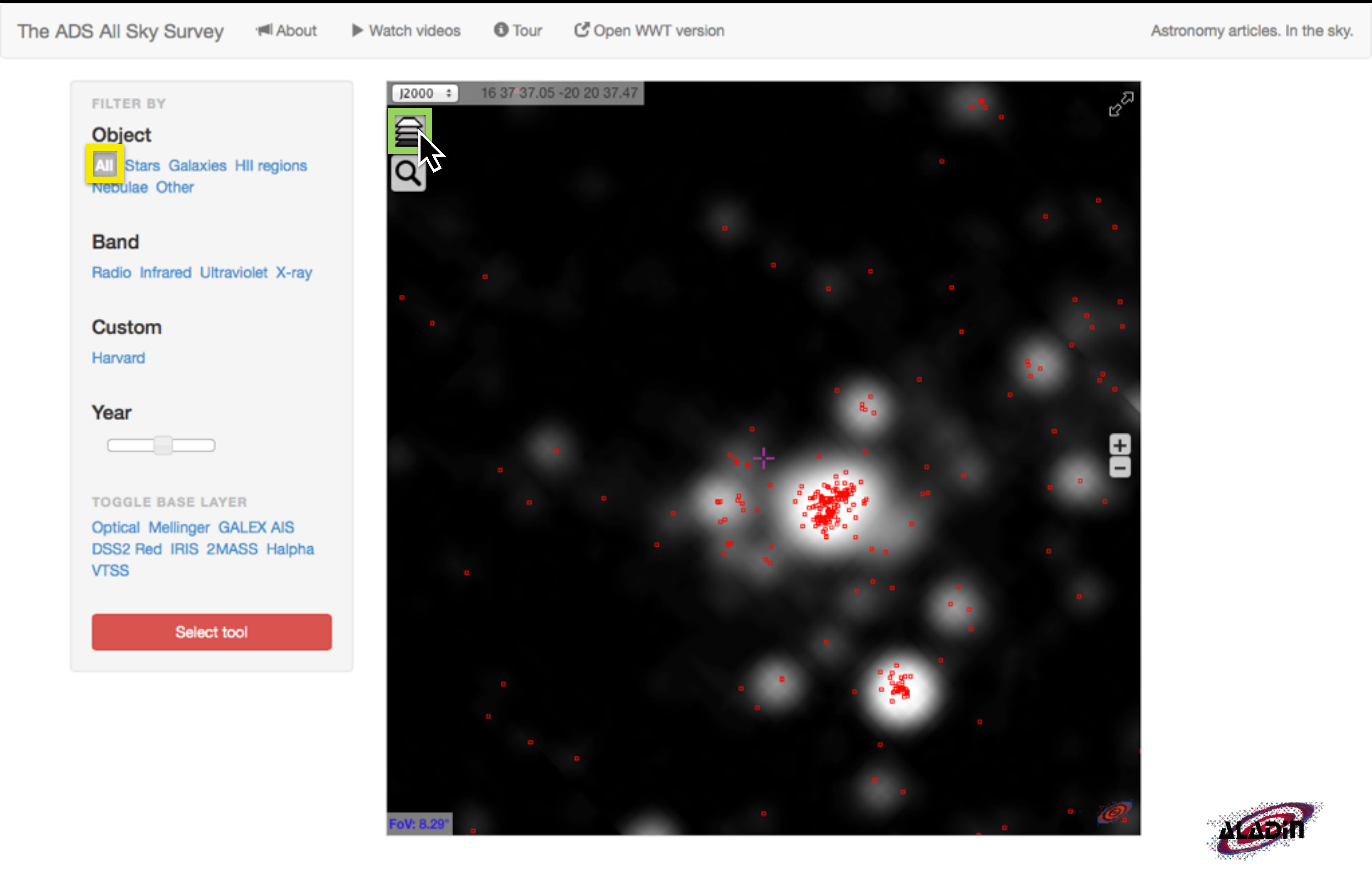
now, if we re-select "All," we see sources on article distribution



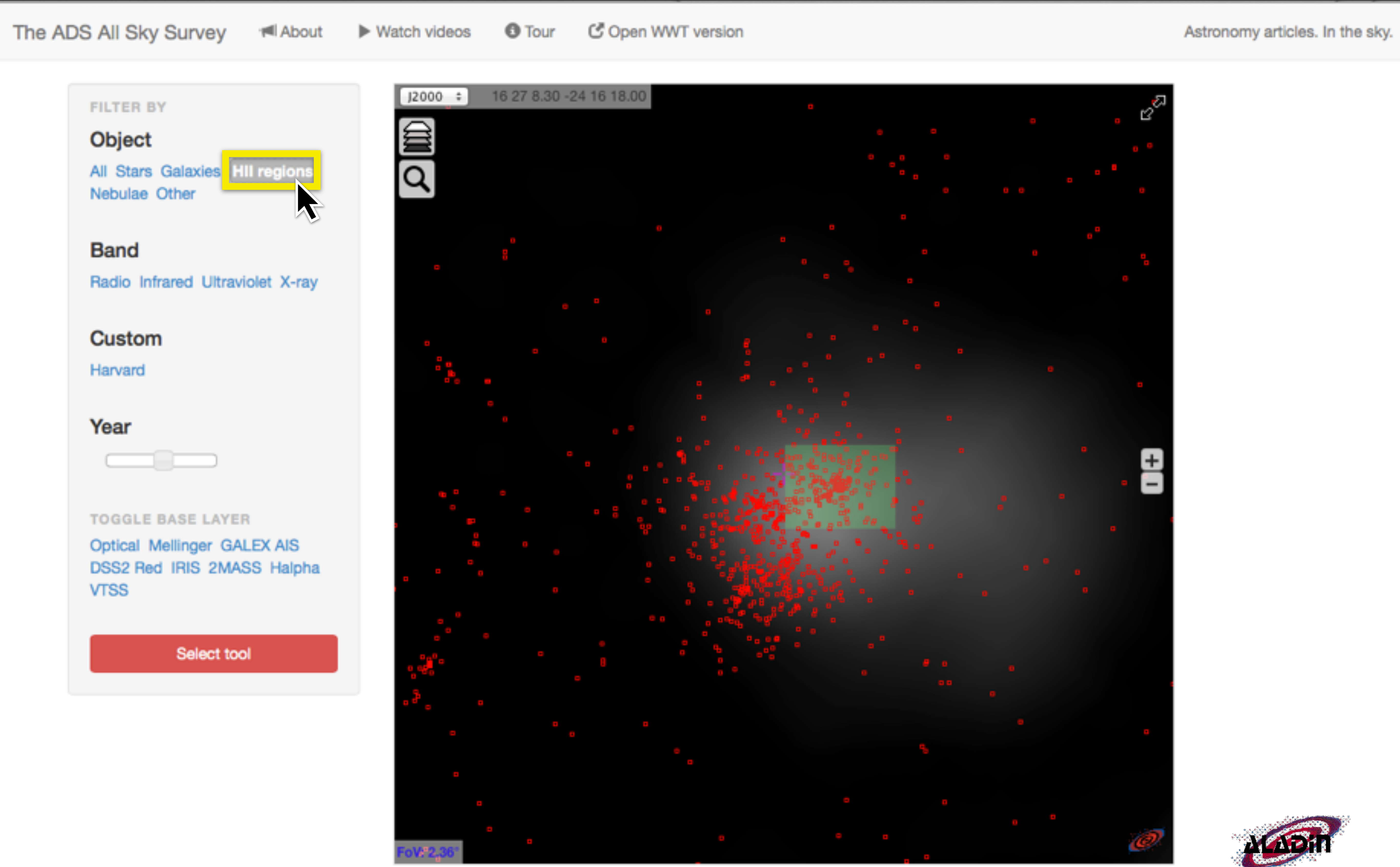
panning over a bit, we can center our region of interest



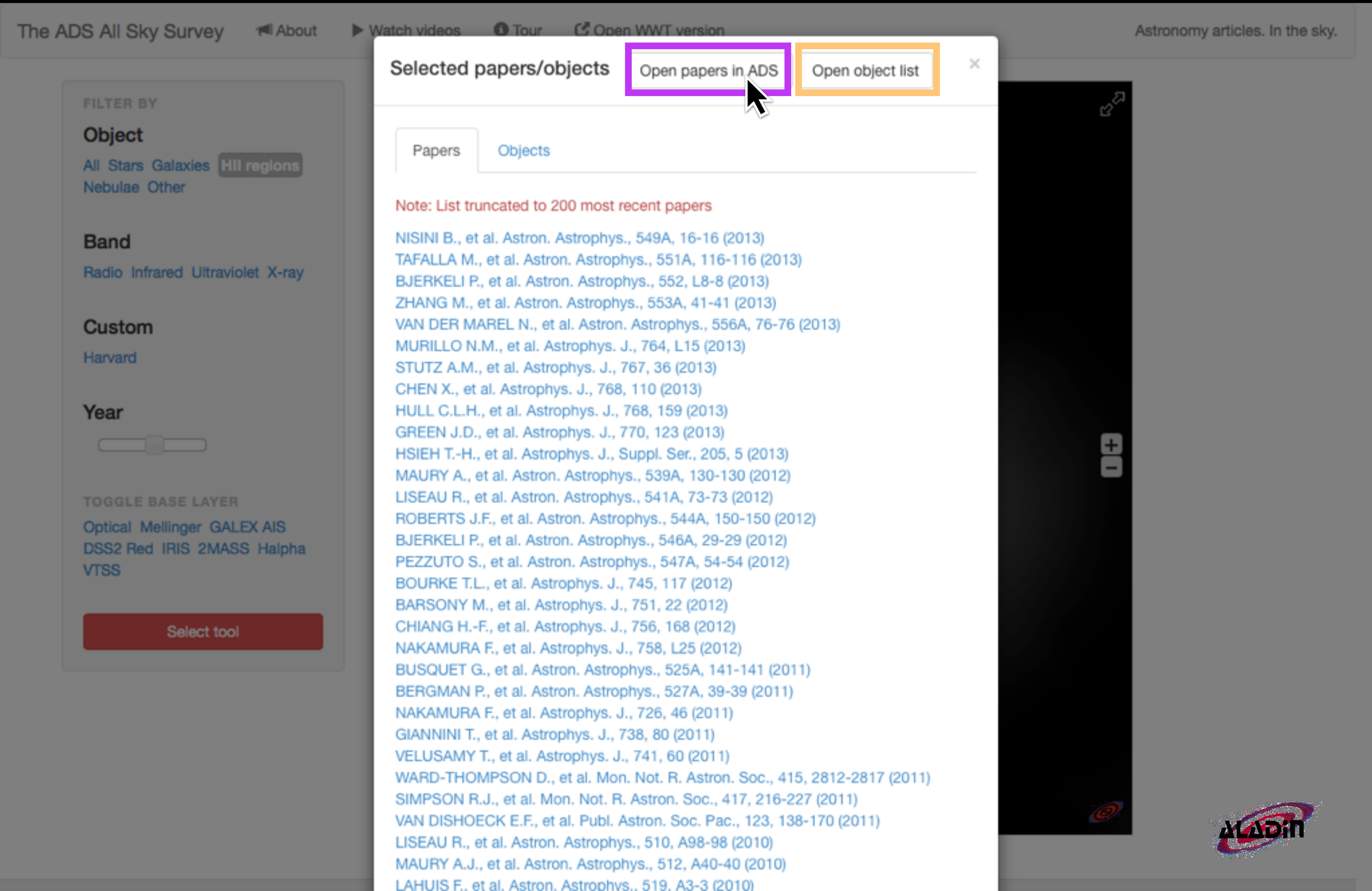
let's change the color table from rainbow to greyscale to make sources more apparent



let's look now at the distribution of articles about "HII regions" and *select* an area we're curious about



when we *release* the selection rectangle, we get a pop-up list of papers (ADS) mentioning these objects, or a list of the objects (CDS/SIMBAD) we highlighted



selecting "Open Papers in ADS" opens the paper list in ADS Labs

(From here, we can filter the list more, and more. e.g. clicking "SIMBAD Objects" lets us see particular objects in context on the Sky in WWT or Aladin.)

ADS Labs
Streamlined Search

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Advanced query - *Advanced Search* ***200 results*** More

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Authors
- Andre, P (20)
- van Dishoeck, E (17)
- Smith, M (14)
- Ward-Thompson, D (14)
- Jorgensen, J (12)

Keywords

Data

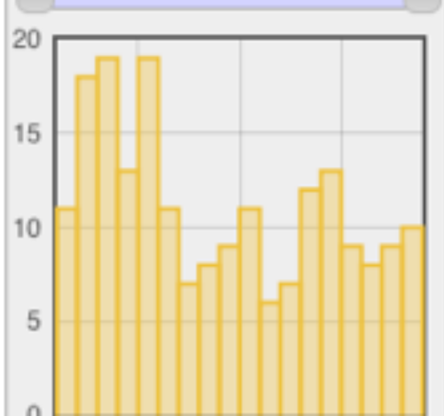
SIMBAD Objects

Vizier Tables

Refereed status

Dates

from 1996 to 2013



1. 2013A&A...556A..76V [E F L X D R S U]
Outflow forces of low-mass embedded objects in Ophiuchus: a quantitative comparison of analysis methods
van der Marel, N.; Kristensen, L. E.; Visser, R.; Mottram, J. C.; *and 2 coauthors*

2. 2013ApJ...770..123G Cited by 12 [E F L X R C S U]
Embedded Protostars in the Dust, Ice, and Gas In Time (DIGIT) Herschel Key Program: Continuum SEDs, and an Inventory of Characteristic Far-infrared Lines from PACS Spectroscopy
Green, Joel D.; Evans, Neal J., II; Jørgensen, Jes K.; Herczeg, Gregory J.; *and 17 coauthors*

3. 2013ApJ...768..159H Cited by 21 [E F L X R C S U]
Misalignment of Magnetic Fields and Outflows in Protostellar Cores
Hull, Charles L. H.; Plambeck, Richard L.; Bolatto, Alberto D.; Bower, Geoffrey C.; *and 21 coauthors*

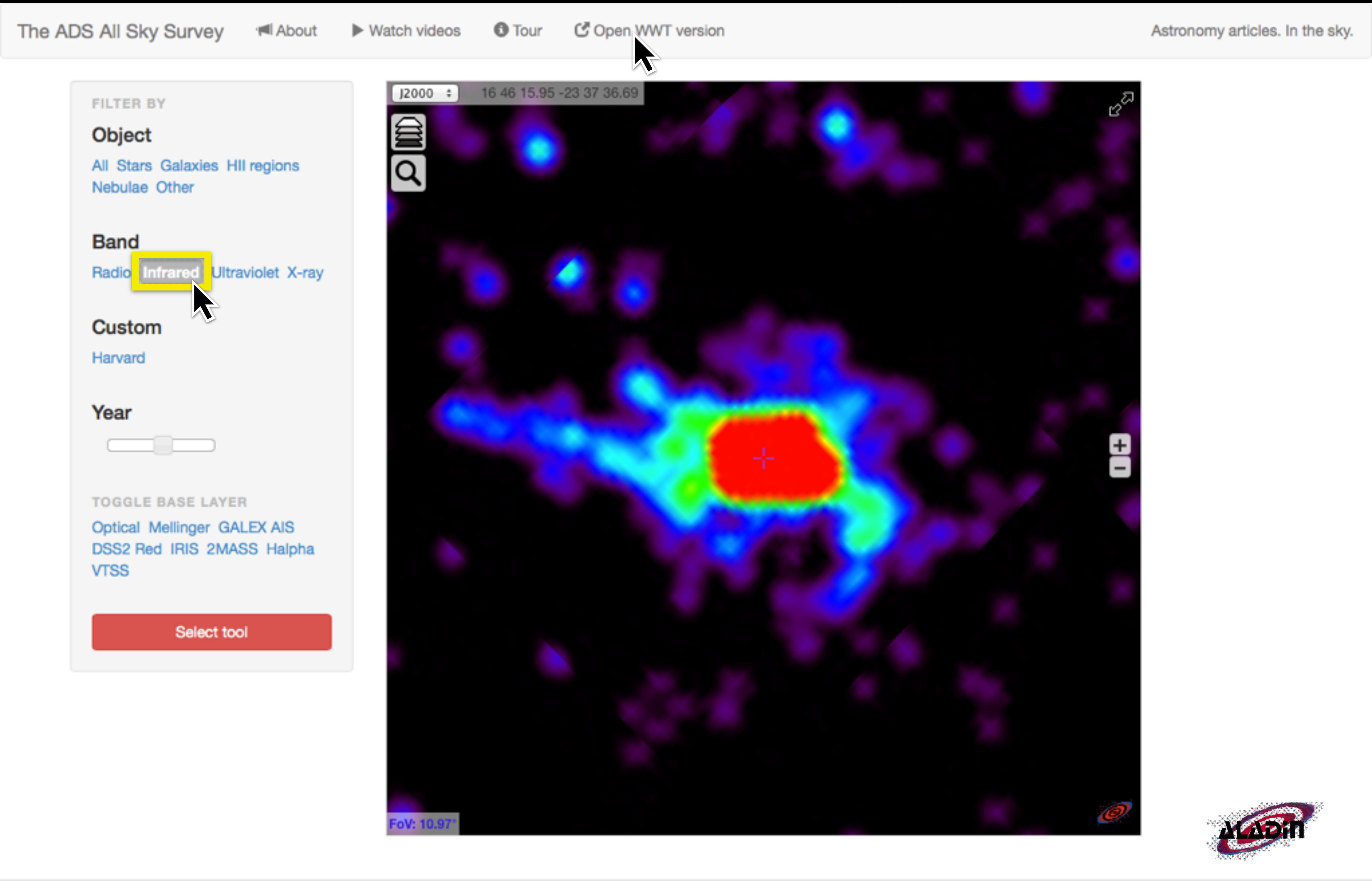
4. 2013ApJ...768..110C Cited by 6 [E F L X R C S U]
SMA Observations of Class 0 Protostars: A High Angular Resolution Survey of Protostellar Binary Systems
Chen, Xuepeng; Arce, Héctor G.; Zhang, Qizhou; Bourke, Tyler L.; *and 7 coauthors*

5. 2013A&A...553A..41Z [E F L X D R S U]
Proper motions of molecular hydrogen outflows in the ρ Ophiuchi molecular cloud
Zhang, M.; Brandner, W.; Wang, H.; Gennaro, M.; *and 5 coauthors*

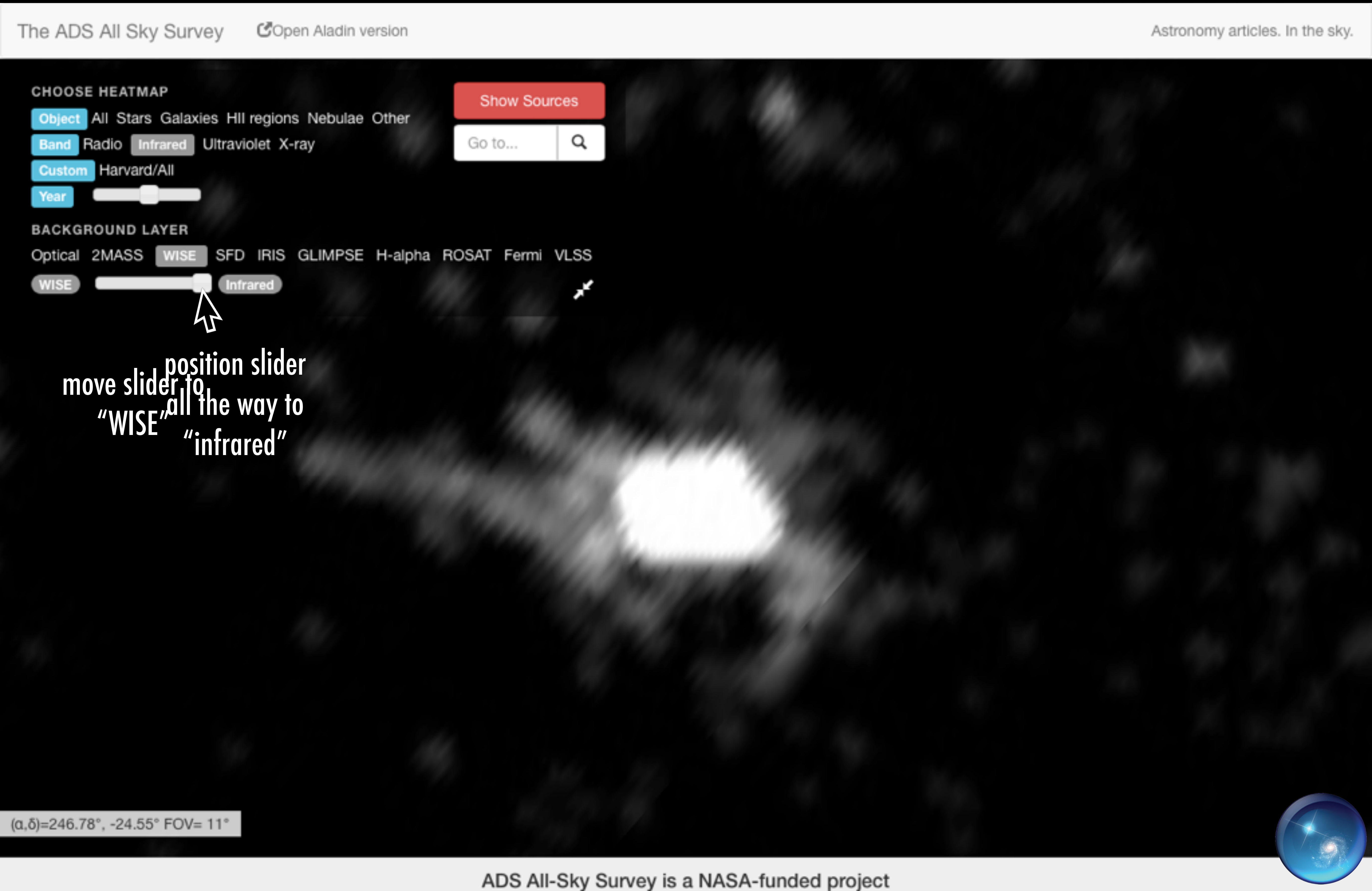
6. 2013ApJ...767...36S Cited by 6 [E F L X D R C S U]
A Herschel and APEX Census of the Reddest Sources in Orion: Searching for the Youngest Protostars
Stutz, Amelia M.; Tobin, John J.; Stanke, Thomas; Megeath, S. Thomas; *and 12 coauthors*

7. 2013A&A...552L...8B Cited by 2 [E F X R C S U]
Physical properties of outflows. Comparing CO- and H2O-based parameters

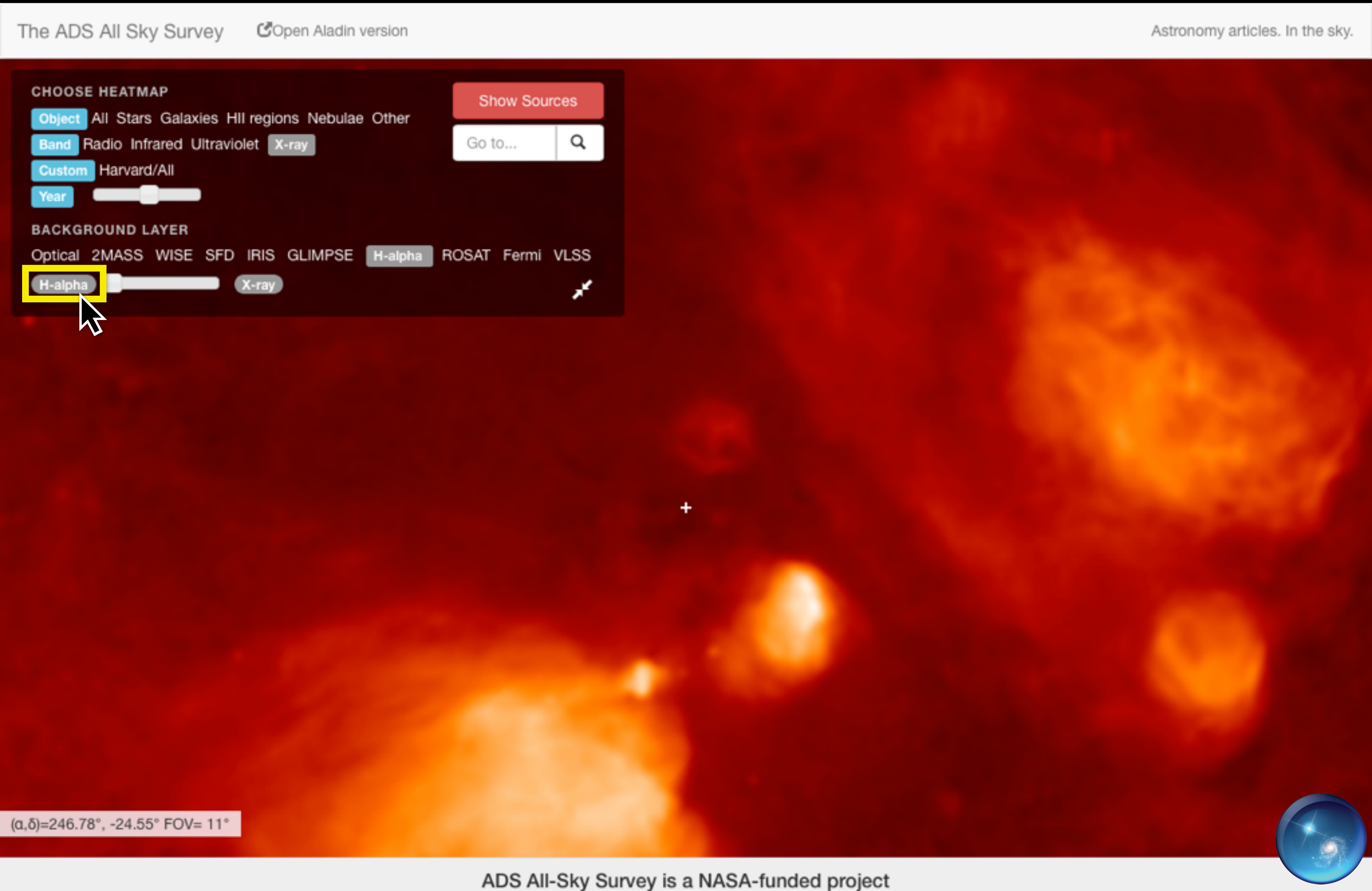
let's try "Open WWT Version," so we can see this same view in WWT, and use a transparency slider



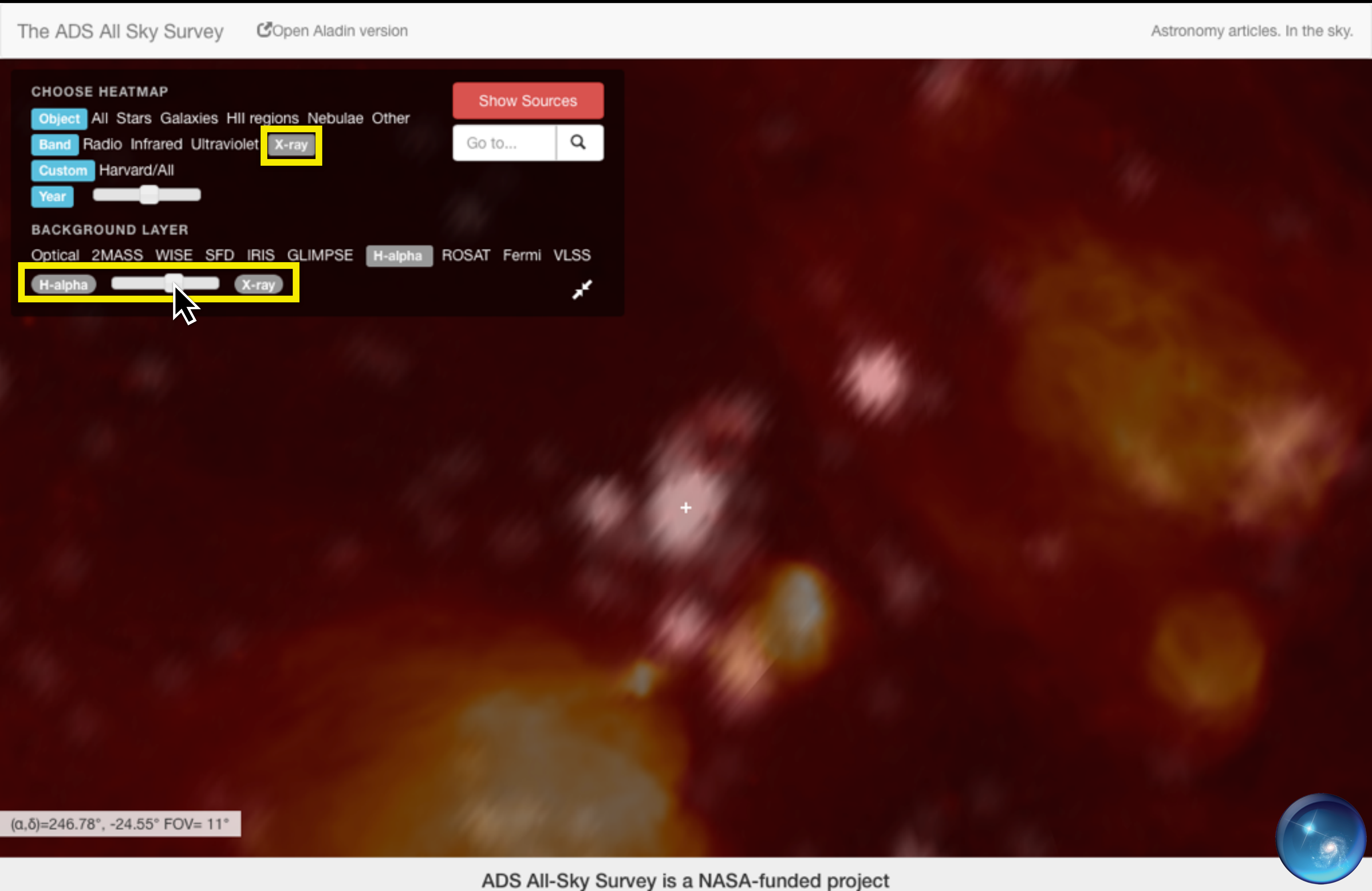
let’s try the transparency (layer) slider in WorldWide Telescope



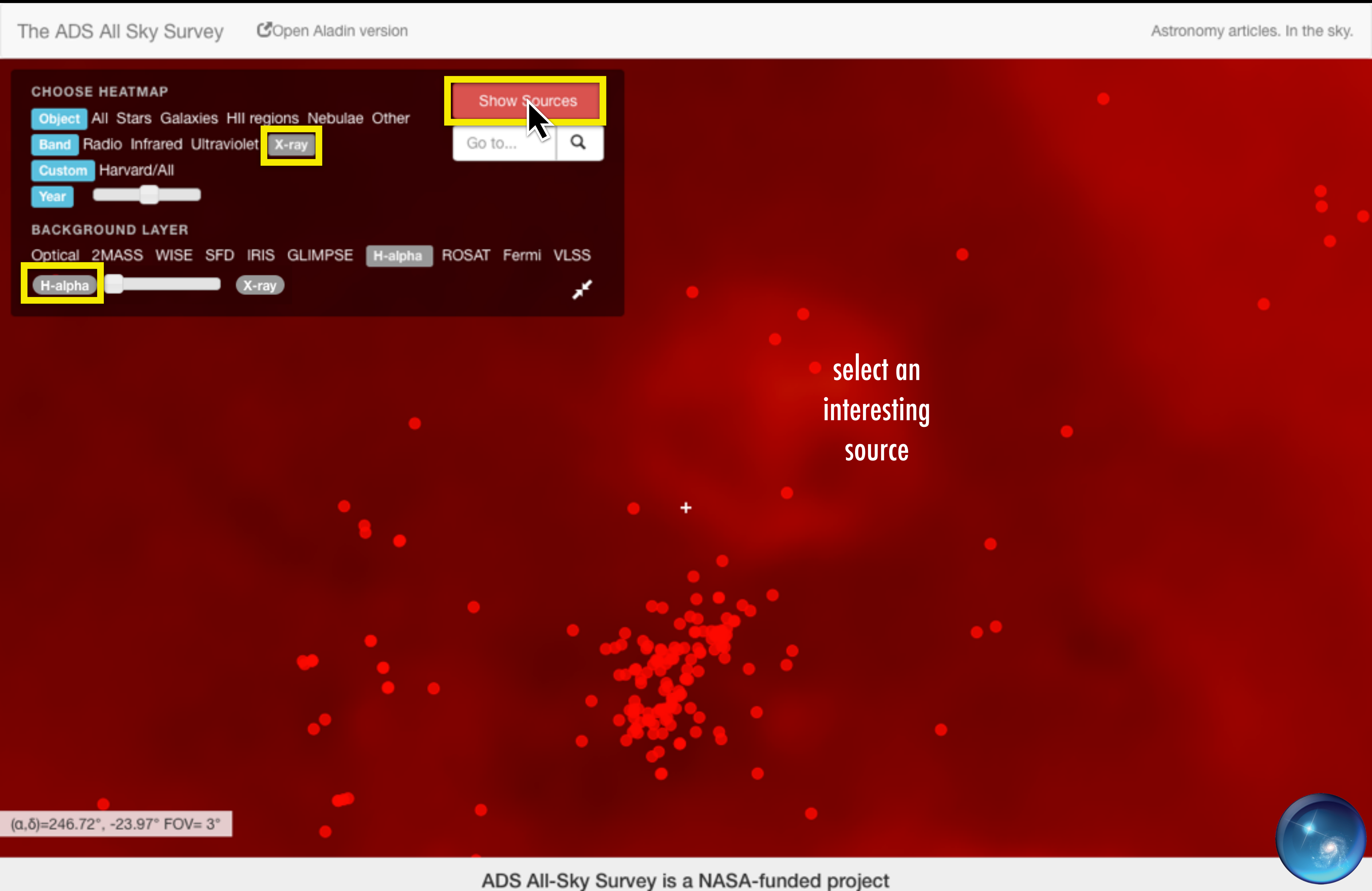
dust is nice, but we're curious about HII regions, let's change view to H-alpha



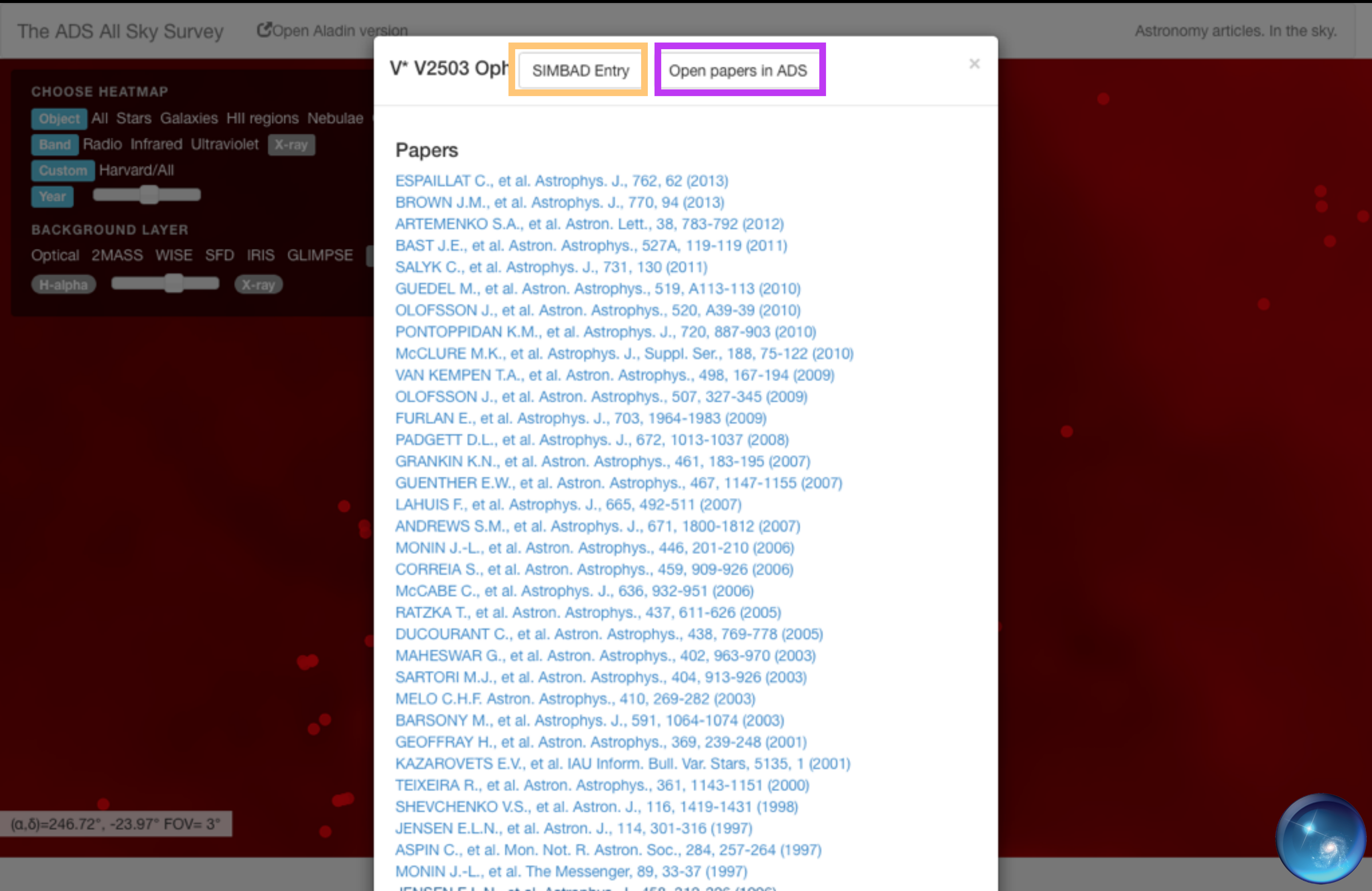
now we want to find X-ray observations and see if any are near the HII regions,
so we can slide between H-alpha and X-ray



now let’s zoom in, and try “Show Sources” to see what the SIMBAD X-ray sources really are



and, we can have plenty of information on the source, via CDS/SIMBAD or via ADS.



Credits

funding **NASA ADAP** program

PI: Alyssa **Goodman**, Harvard-CfA

Co-I: Alberto **Pepe**, Harvard-CfA & Authorea

Co-I: August **Muench**, Smithsonian-CfA

with

Alberto **Accomazzi**, Smithsonian Institution, NASA/ADS

Christopher **Beaumont**, Harvard-CfA

Thomas **Boch**, CDS Strasbourg

Jonathan **Fay**, Microsoft Research

David **Hogg**, NYU, astrometry.net

Alberto **Conti**, NASA/STScI, Northrup Grumman