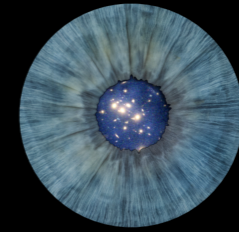
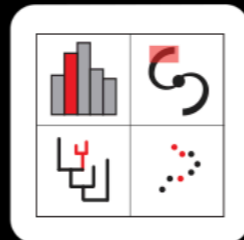
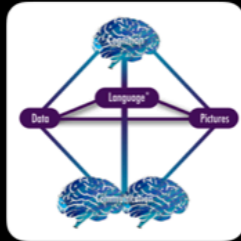
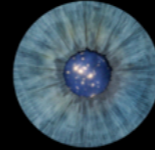


SEEING MORE OF THE UNIVERSE



SEEING MORE OF THE UNIVERSE



Explore

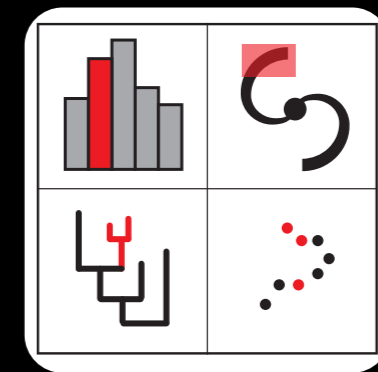
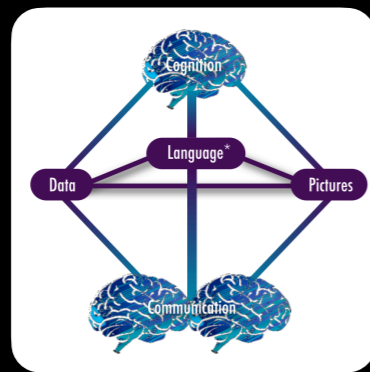
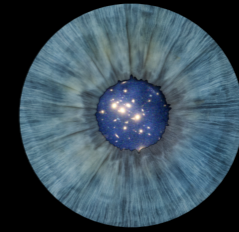
Explain

FIND THE FULL
SERIES ON



TINYURL.COM/
10QVIZVIDEOS

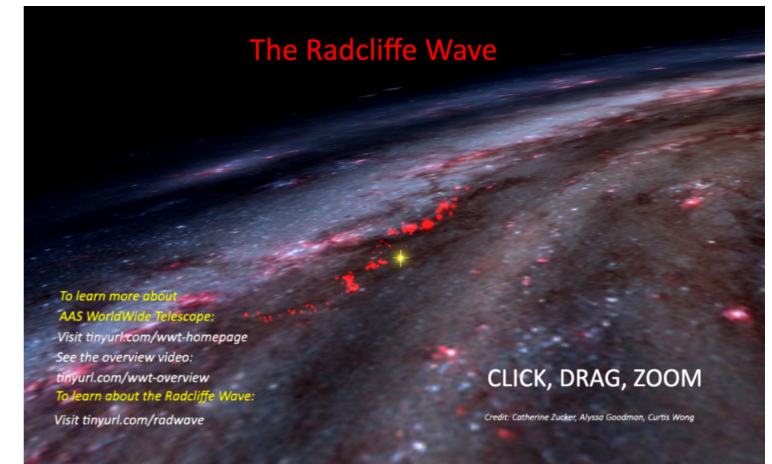
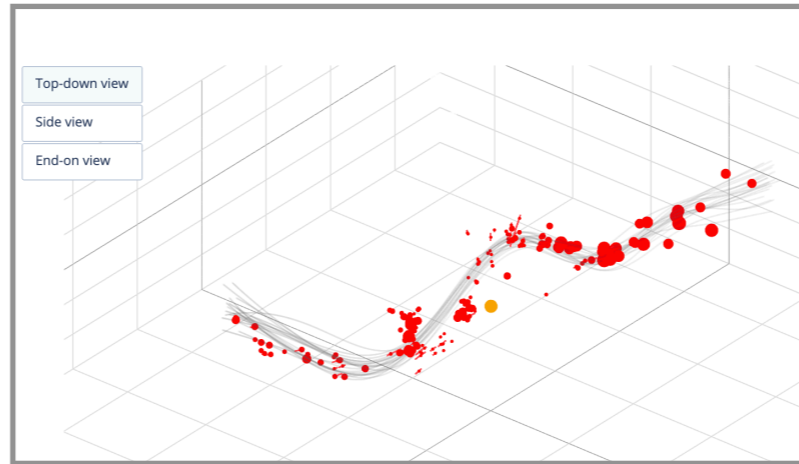
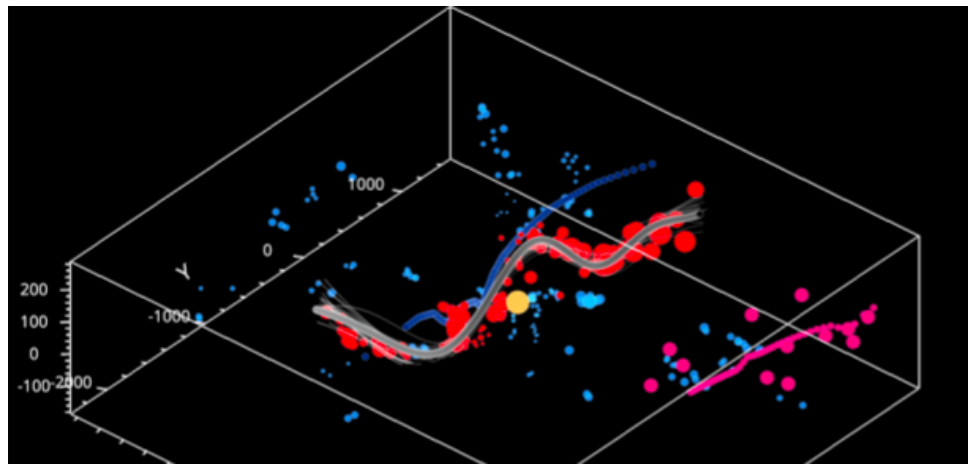
SEEING MORE OF THE UNIVERSE IN 20 MIN

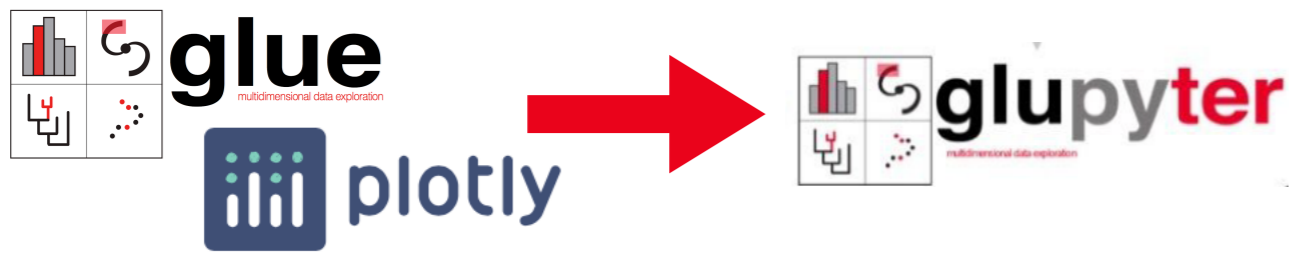


Explore

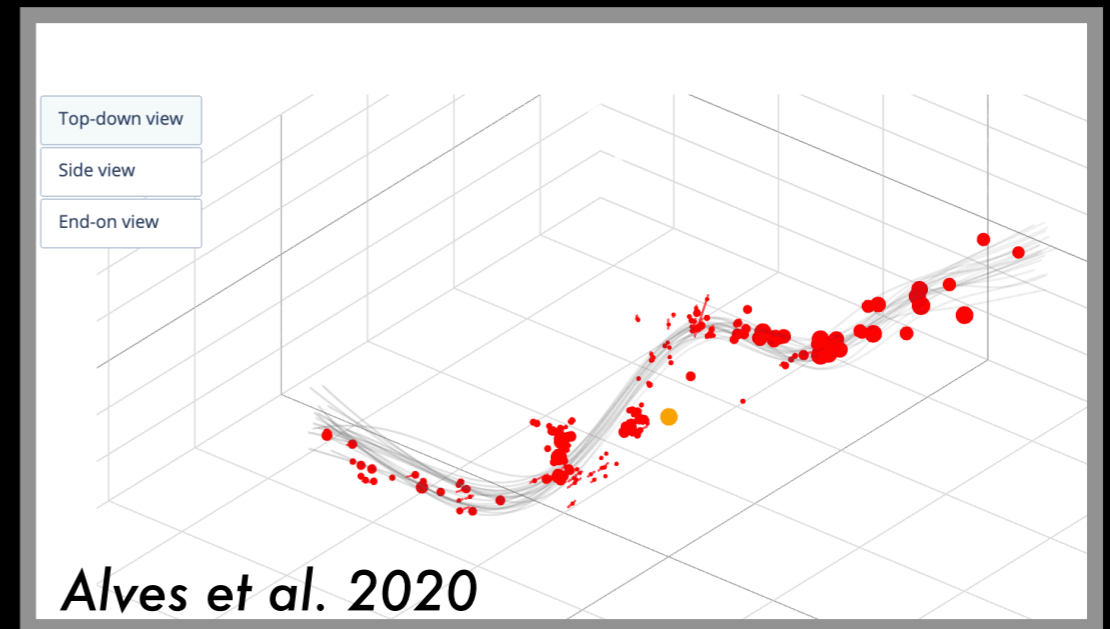


Explain

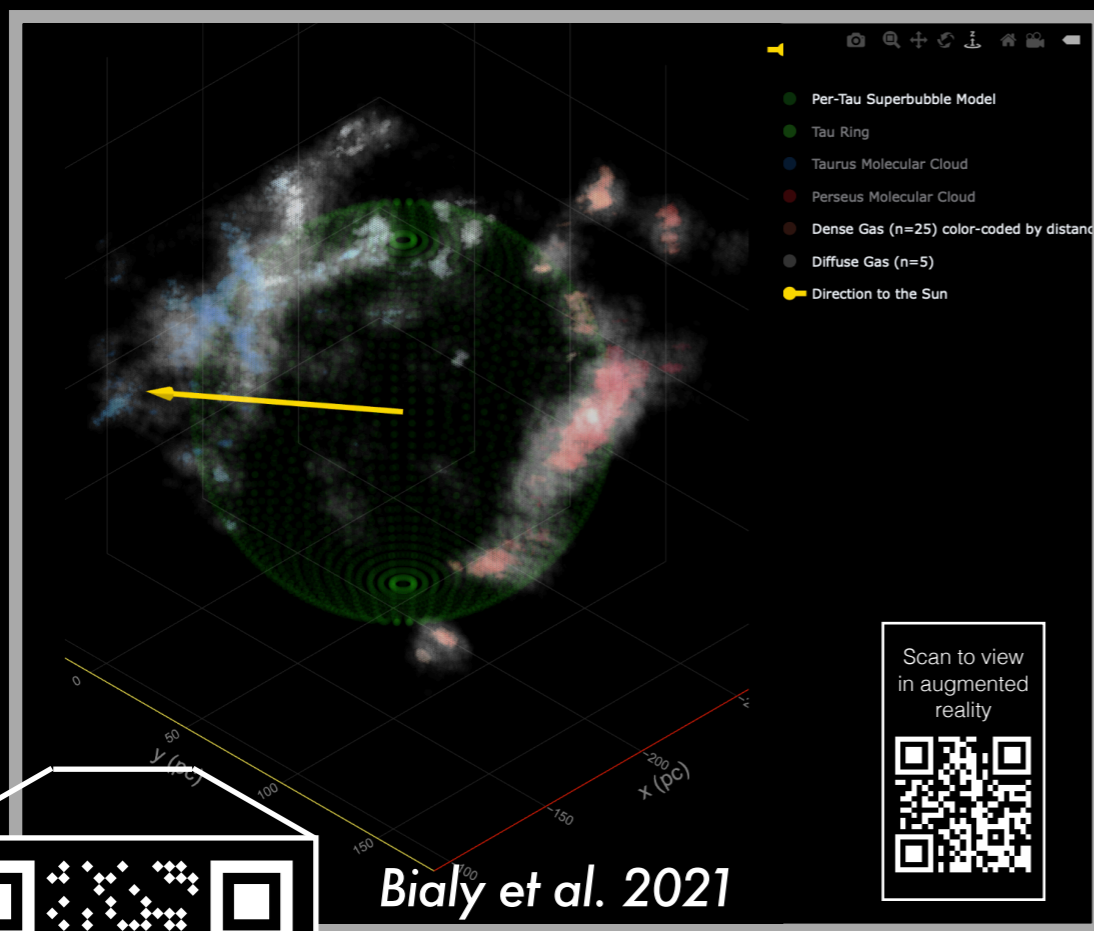




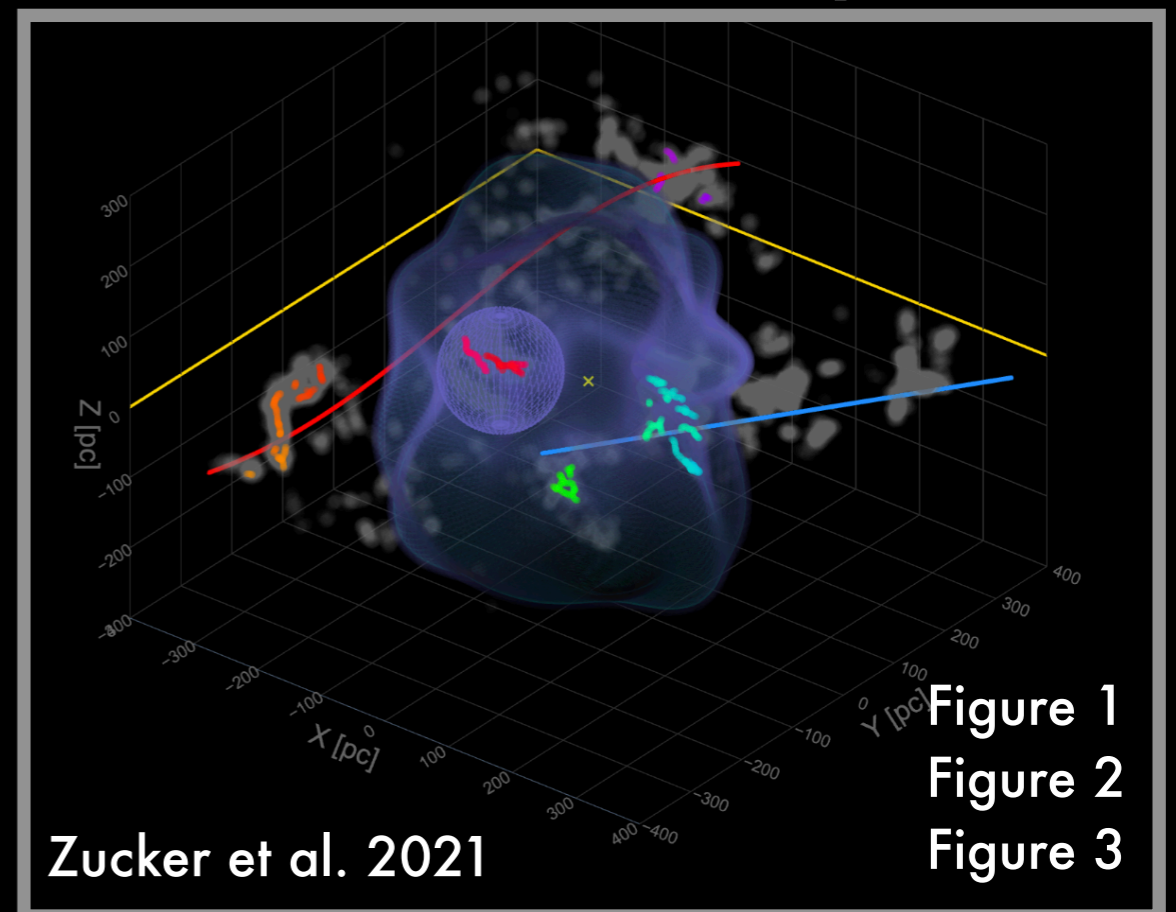
João will show you...



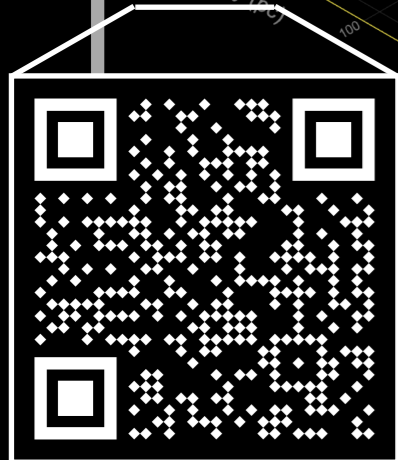
Shmuel showed you



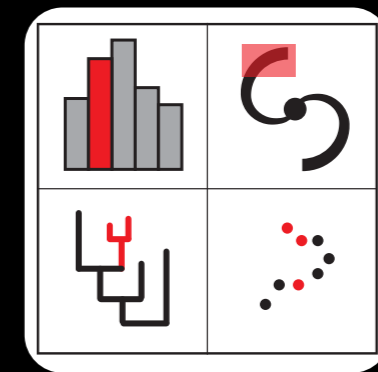
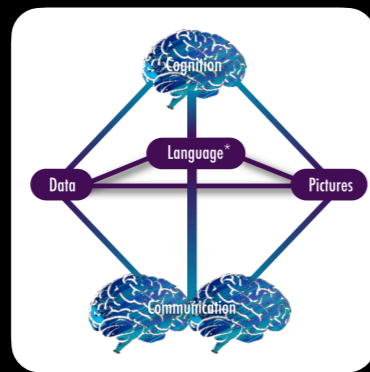
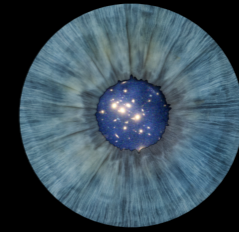
Catherine will show you...



Later: Merge Cube



SEEING MORE OF THE UNIVERSE IN 20 MIN



Explore



Explain

WIDE DATA DISCOVERY: THE RADCLIFFE WAVE

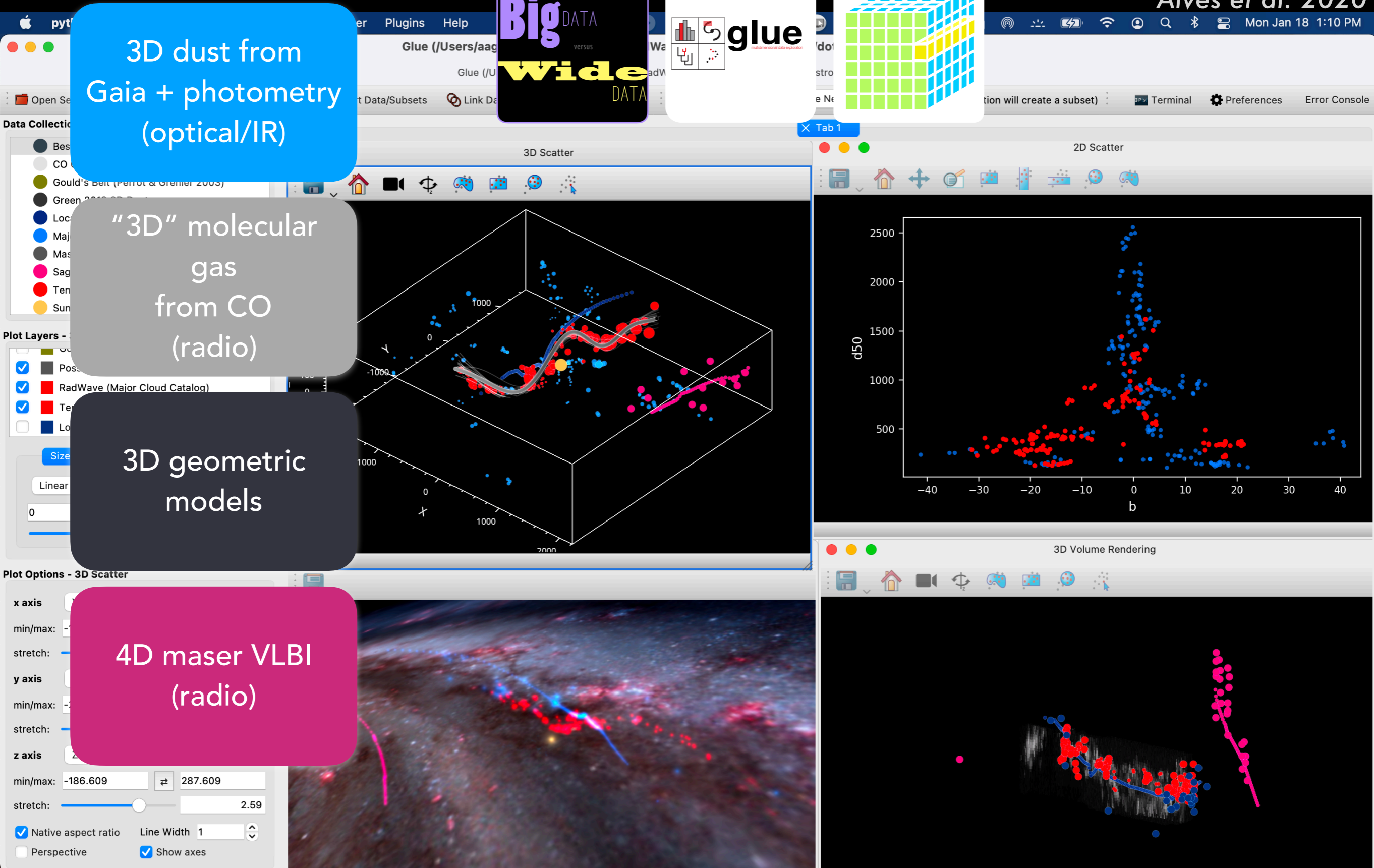
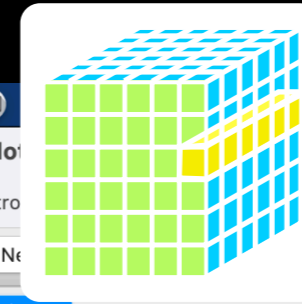
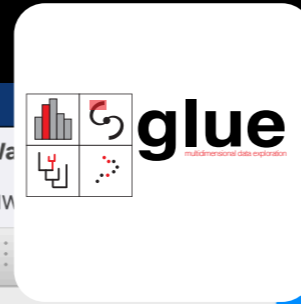
Alves et al. 2020

3D dust from
Gaia + photometry
(optical/IR)

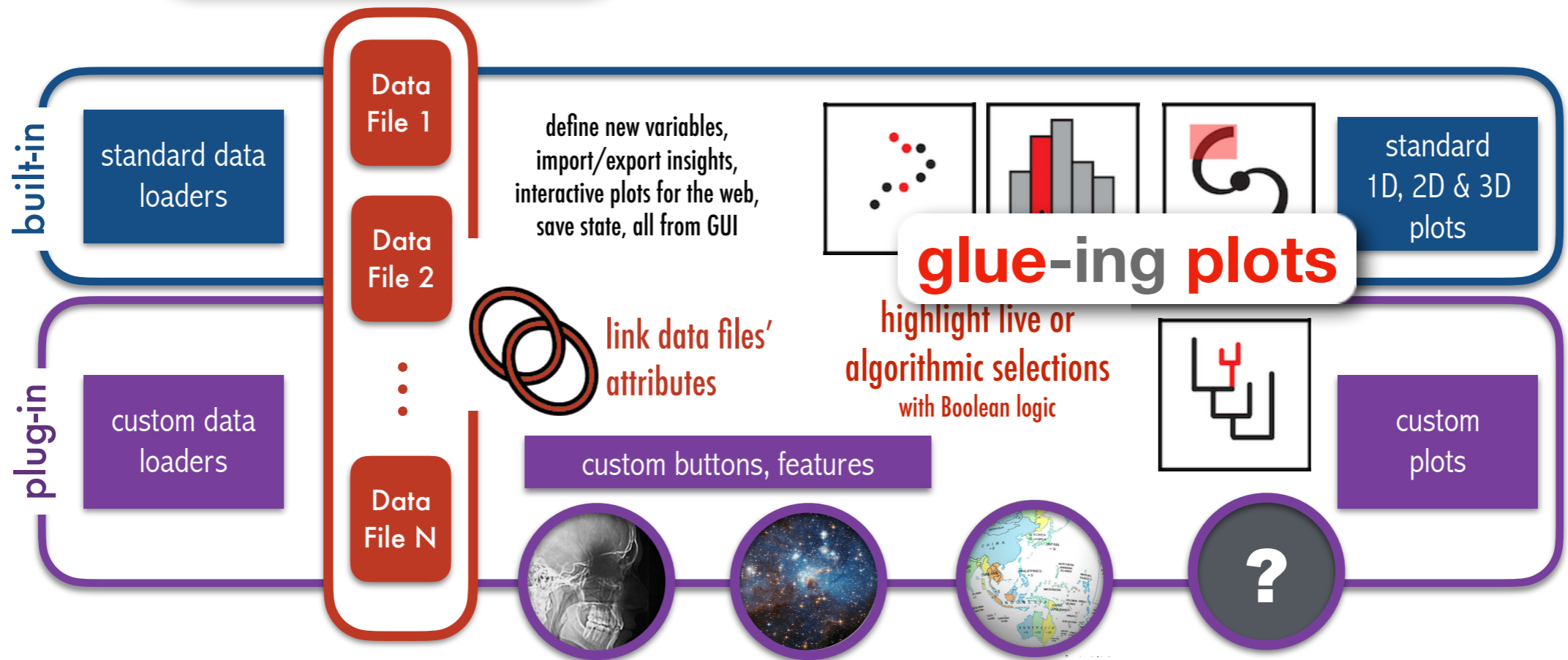
"3D" molecular
gas
from CO
(radio)

3D geometric
models

4D maser VLBI
(radio)



glue-ing data



+options

user config.py file
(loaders, colors, plot types, +)



access to all matplotlib functions
through built-in IPython terminal



run & interact with glue from
Jupyter notebook & other tools

glue-ing tools



DEMO: 5 steps to revealing a wispy veil in 3D

1. “glue” data sets to each other
2. drag data sets to visualize
3. inspect cubes with 2D sliders
4. adjust color
5. inspect cubes as (superimposed) 3D volumes

+ bonus—comparison with traditional views & sliders

sample ALMA (spectral-line) data cubes courtesy of Jorma Harju

Find out more about glue, and download for free, at glueviz.org

No merging of data sets—just glue them.



The screenshot shows the Glueviz application window. The menu bar at the top includes 'python', 'File', 'Edit', 'View', 'Canvas', 'Data Manager', 'Plugins', and 'Help'. The title bar reads 'Glue' and the user name 'Jorma Harju' is visible. The sidebar on the left contains three panels: 'Data Collection' with a list of data sets ('meth_cube_hdrfixed' and 'onh2d_cube_hdrfixed'), 'Plot Layers', and 'Plot Options'. The main plot area is currently empty and contains the text 'Drag Data To Plot'. The system tray at the top right shows the date and time as 'Tue May 29 10:39 PM' and the battery level at '79%'.

An ALMA core

Just drag to visualize, e.g. series of 2D "channel maps."



The screenshot shows the Glue software interface. At the top is a macOS-style menu bar with 'python' and menus for 'File', 'Edit', 'View', 'Canvas', 'Data Manager', 'Plugins', and 'Help'. Below this is a toolbar with various icons and a status bar showing 'Tue May 29 10:39 PM Alyssa A Goodman'. The main interface is divided into three vertical panels on the left: 'Data Collection', 'Plot Layers', and 'Plot Options'. The 'Data Collection' panel contains a list of data items: 'meth_cube_hdrfixed' (selected) and 'onh2d_cube_hdrfixed'. The 'Plot Layers' and 'Plot Options' panels are currently empty. The central plot area is a large white space with the text 'Drag Data To Plot' centered in a large, light gray font. A tab labeled 'Tab 1' is visible at the top of the plot area.

An ALMA core

Adjust so each tracer is a different color.



python File Edit View Canvas Data Manager Plugins Help

Open Data Export Data/Subsets Link Data IPython Terminal Open Session Export Session Add/edit arithmetic attributes Selection Mode: Preferences

Data Collection

Data

- meth_cube_hdrfixed
- onh2d_cube_hdrfixed

Subsets

Plot Layers - 2D Image

- meth_cube_hdrfixed (PRIMARY)

attribute: PRIMARY

limits: Custom Arcsinh

0 1.1412

color/opacity: [red color bar] Sync

contrast/bias: [sliders] Reset

Plot Options - 2D Image

General Limits Axes

mode: One color per layer

aspect: Square Pixels

reference: meth_cube_hdrfixed

x axis: Right Ascension

y axis: Declination

Vrad Show real coordinates

4300.0 m/s

2D Image

methanol

2D Image

o-NH₂D

Create 3D views...

python File Edit View Canvas Data Manager Plugins Help
Glue
Open Data Export Data/Subsets Link Data IPython Terminal Open Session Export Session Add/edit arithmetic attributes Selection Mode: Preferences

Data Collection

Data

- meth_cube_hdrfixed
- onh2d_cube_hdrfixed

Subsets

Plot Layers - 2D Image

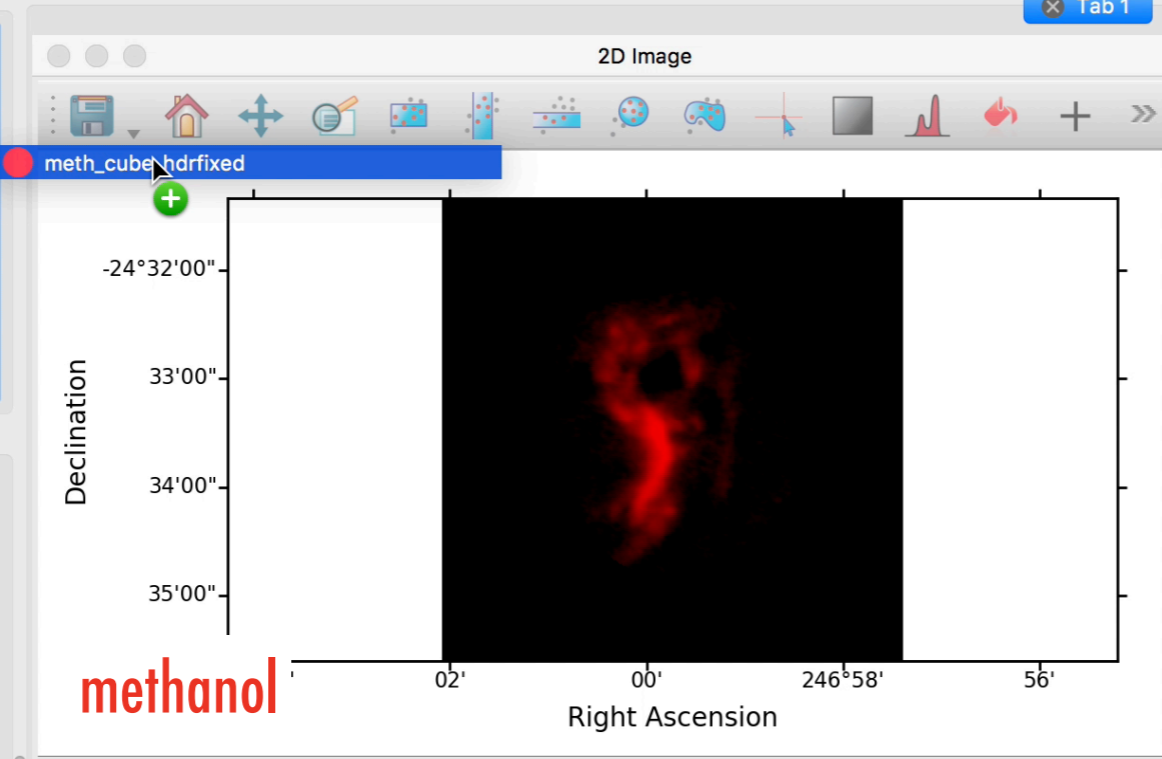
- onh2d_cube_hdrfixed (PRIMARY)

attribute: PRIMARY
limits: Min/Max, Arcsinh
color/opacity: [blue bar] [slider]
contrast/bias: [slider] [Reset]

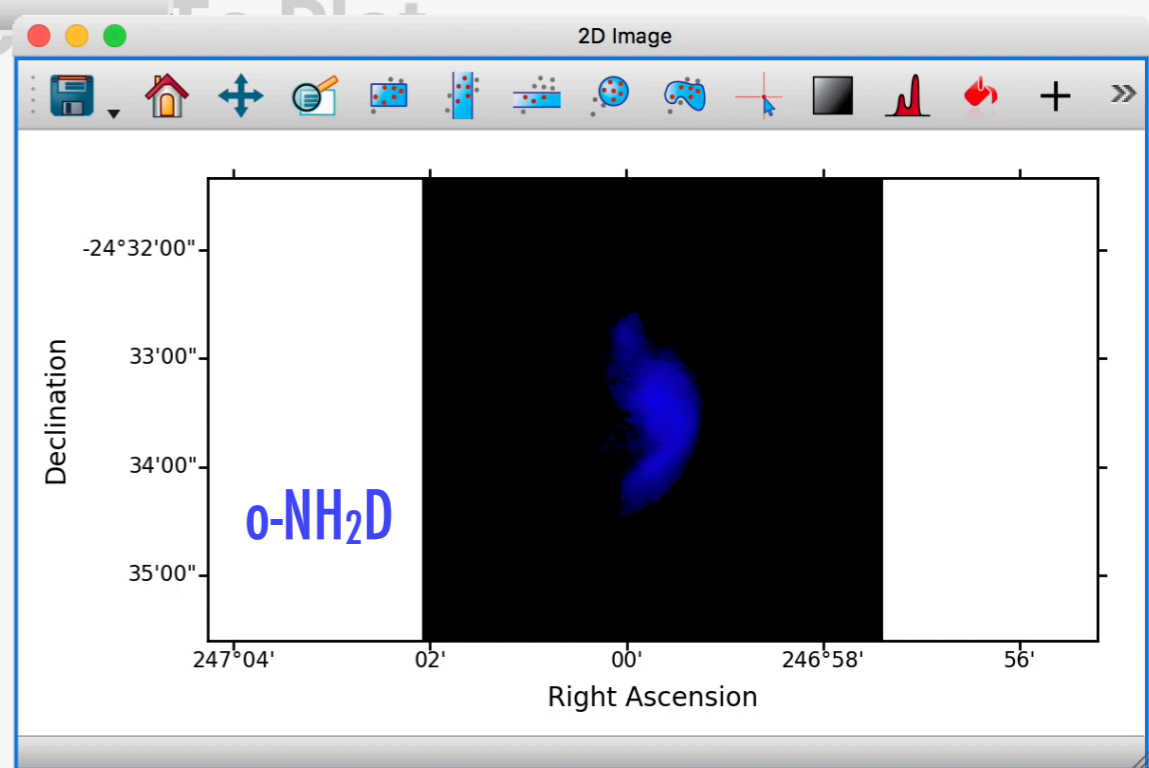
Plot Options - 2D Image

General Limits Axes

mode: One color per layer
aspect: Square Pixels
reference: onh2d_cube_hdrfixed
x axis: Right Ascension
y axis: Declination
Vrad: Show real coordinates
4200.0 m/s

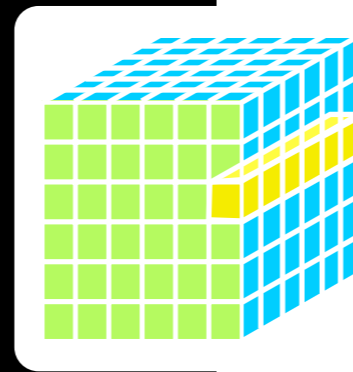


...see clearly
"veil" of
wind-blown
methanol.

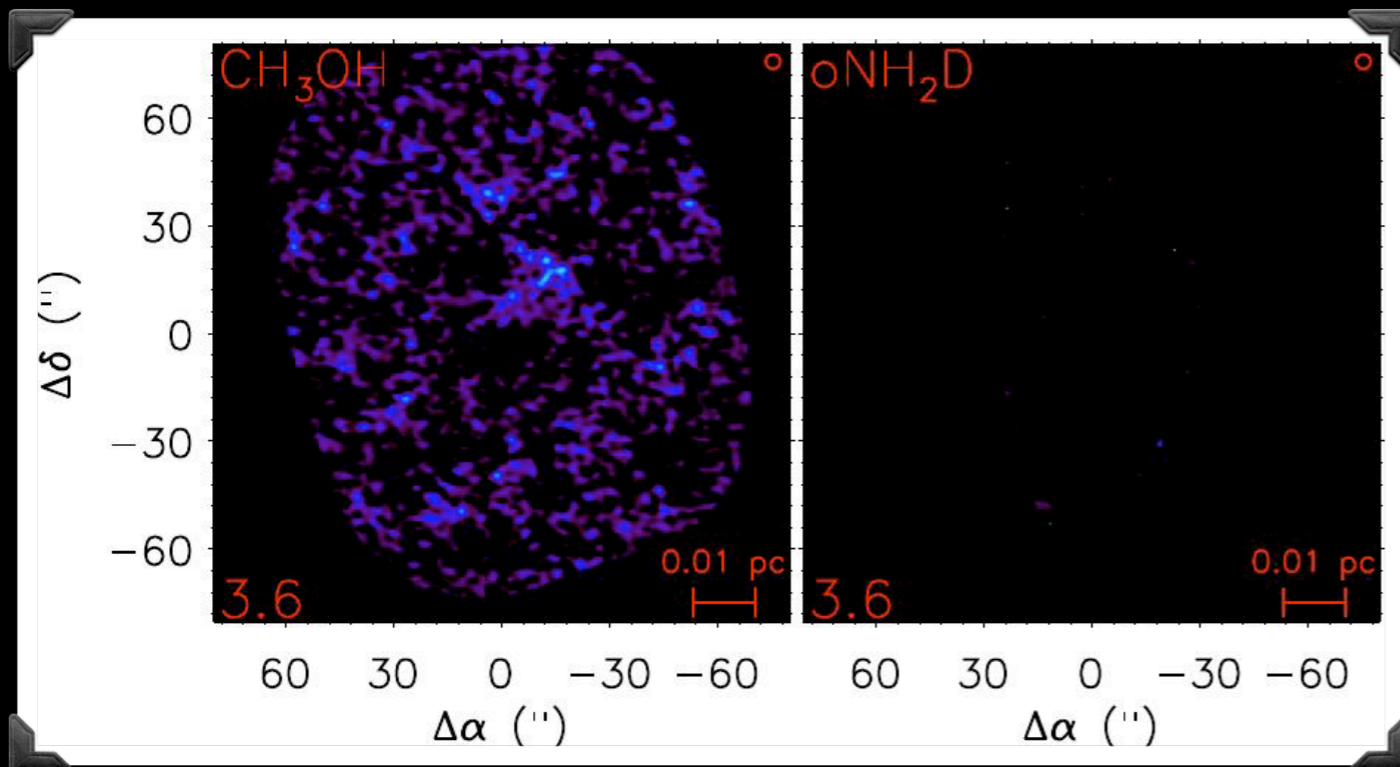


COMPARISON

traditional **rainbow**
channel maps



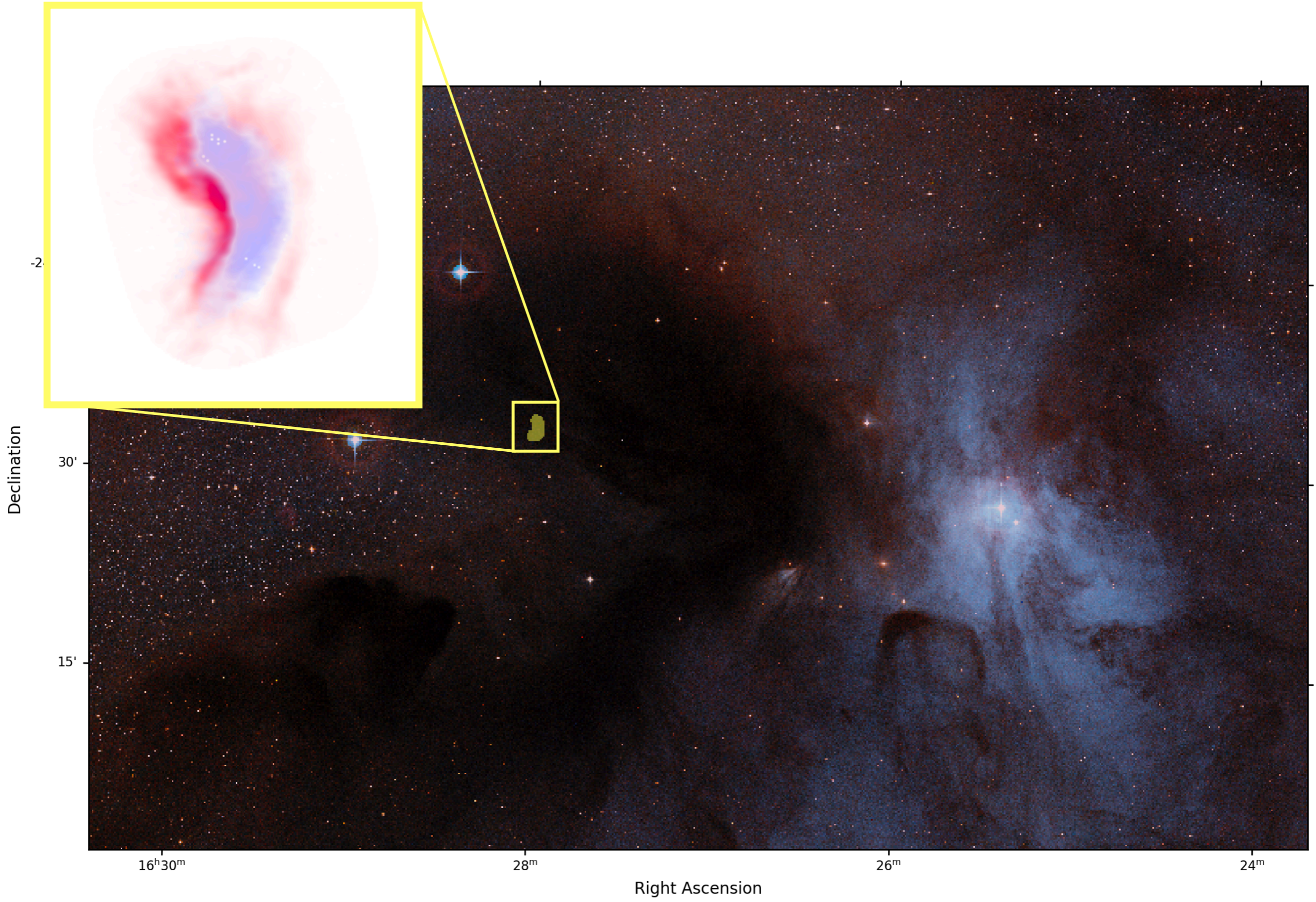
glue
volume visualization

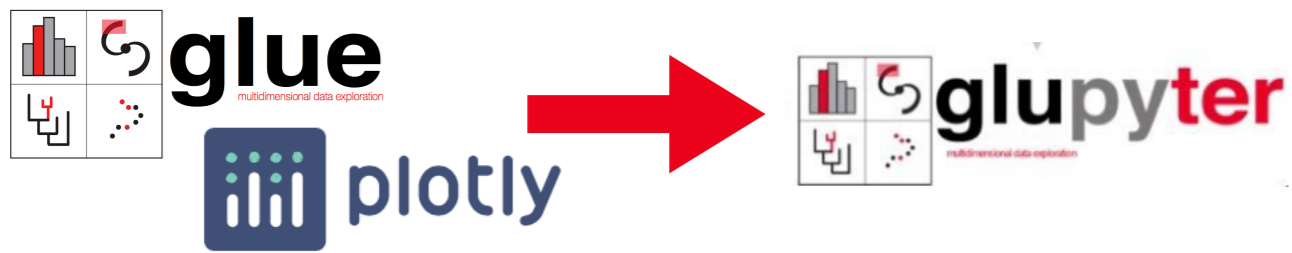


result: happy unicorns

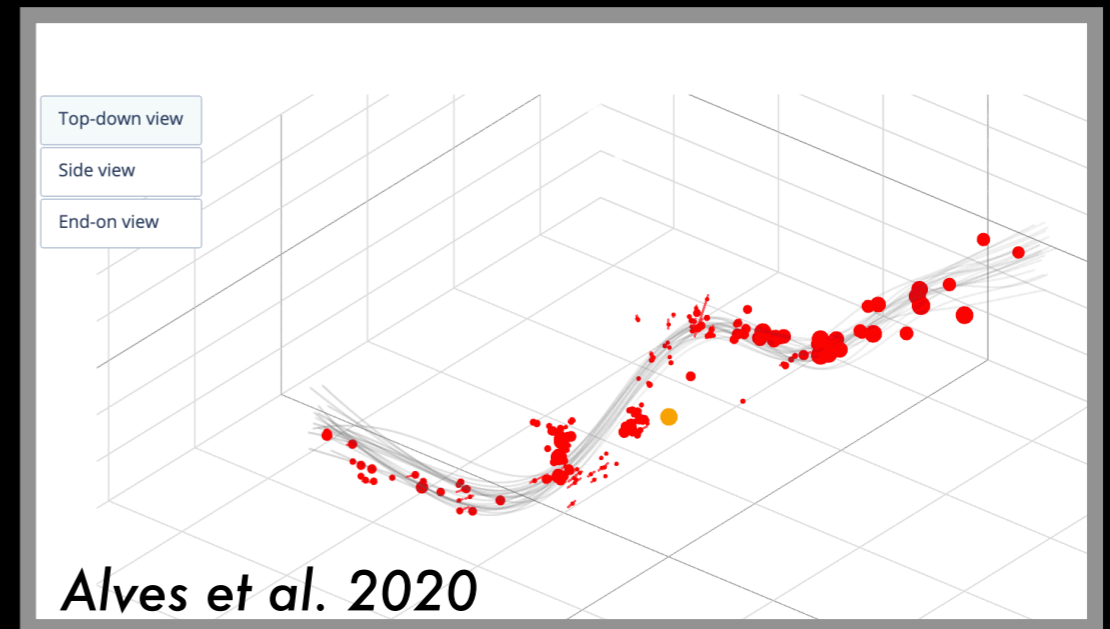


result: previously unknown phenomenon
(veil of emission) revealed

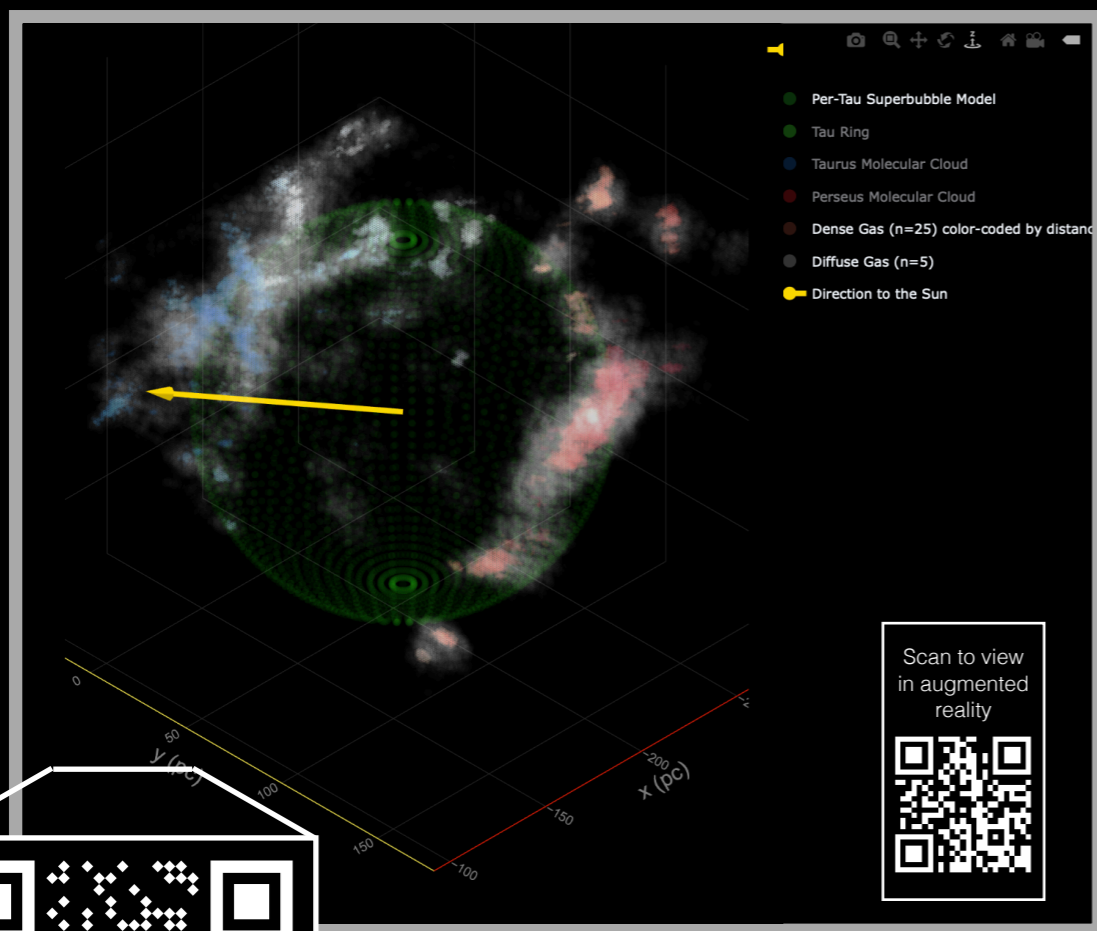




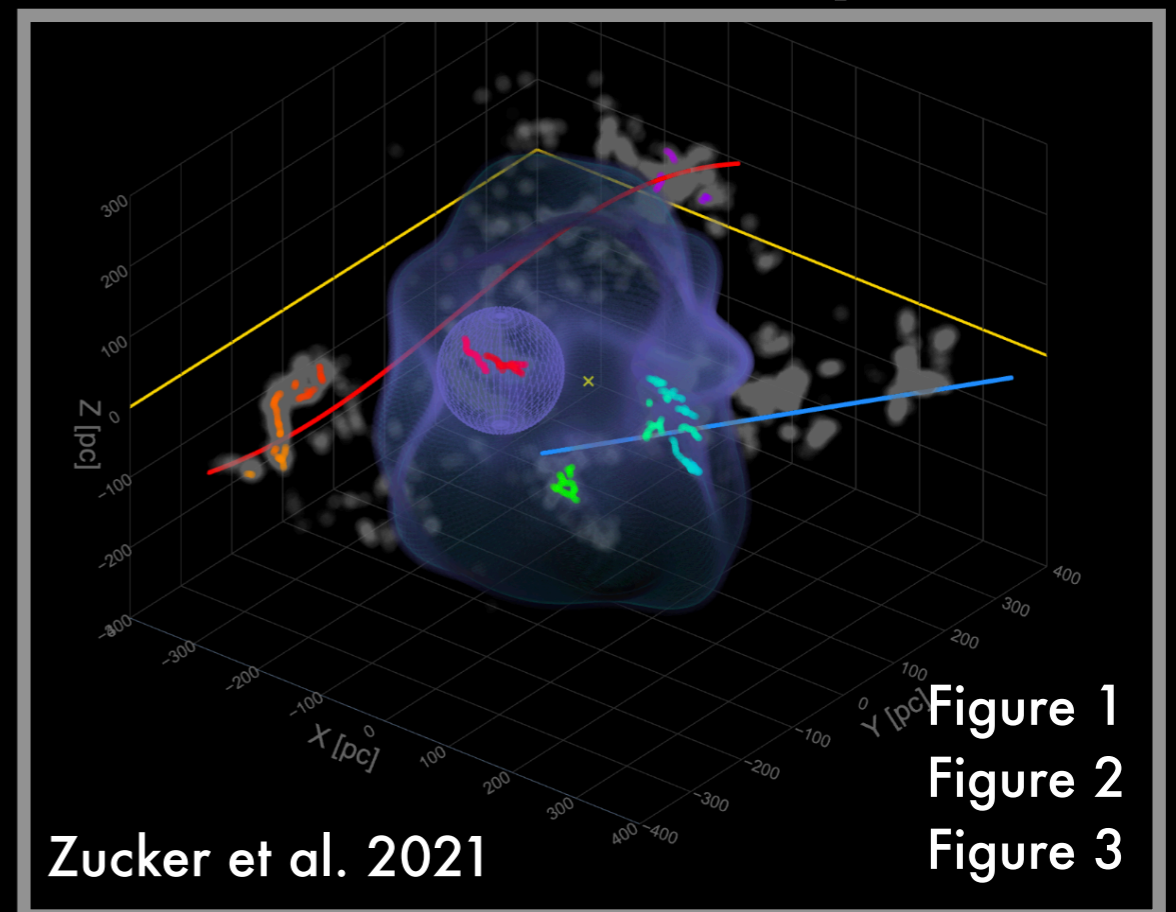
João will show you...



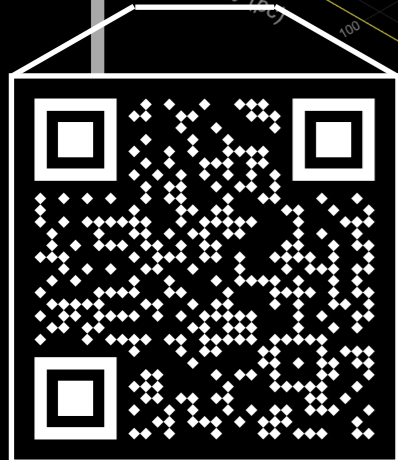
Shmuel showed you

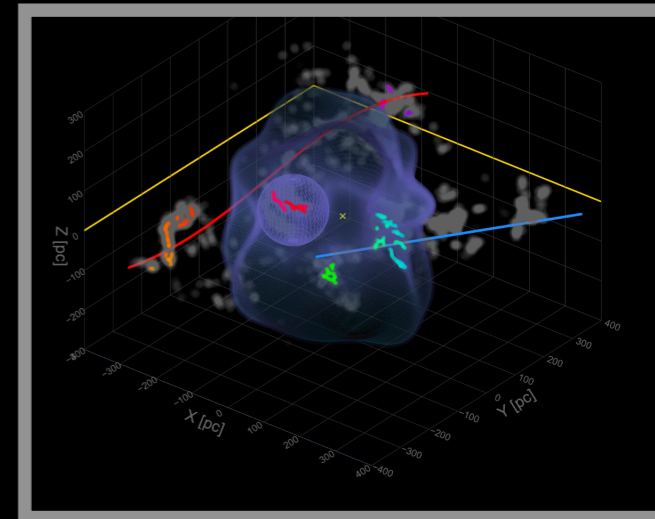
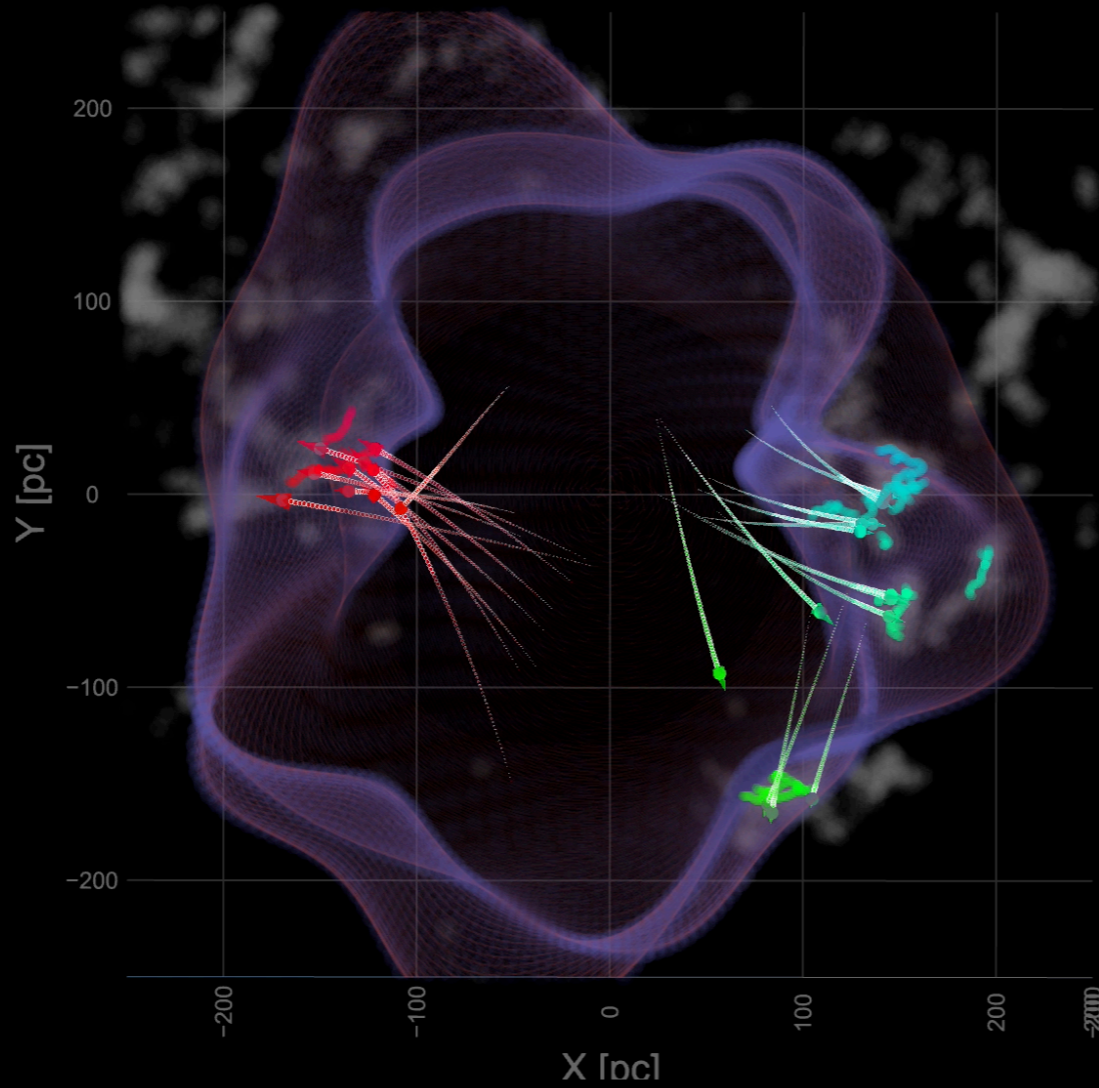


Catherine will show you...



Soon... Merge Cube





Jump to -16 Myr

Jump to -15 Myr

Jump to -14 Myr

Jump to -10 Myr

Jump to -6 Myr

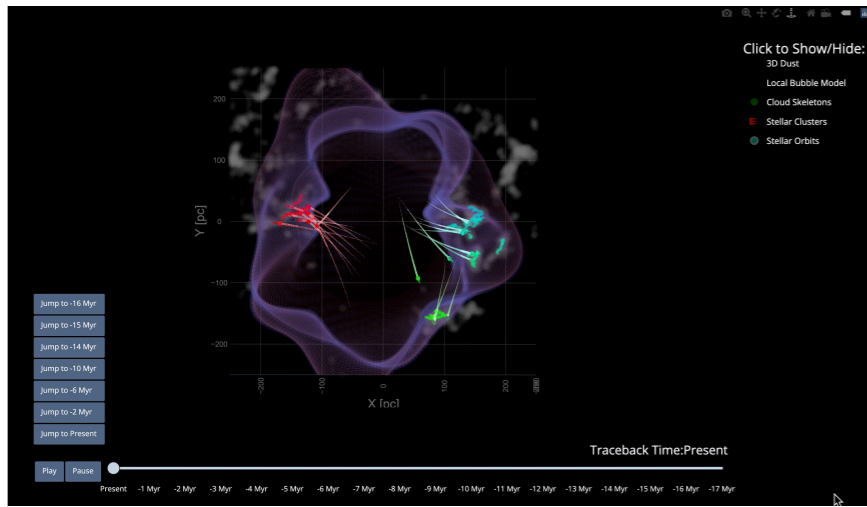
Jump to -2 Myr

Jump to Present

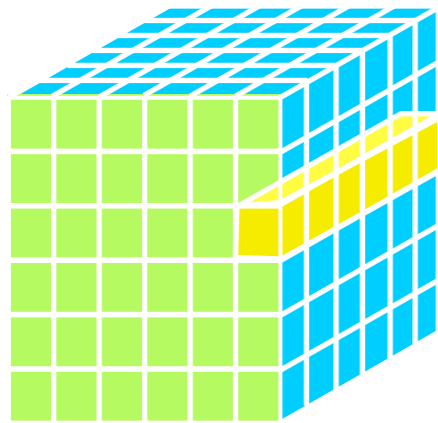
Traceback Time:Present

Play Pause

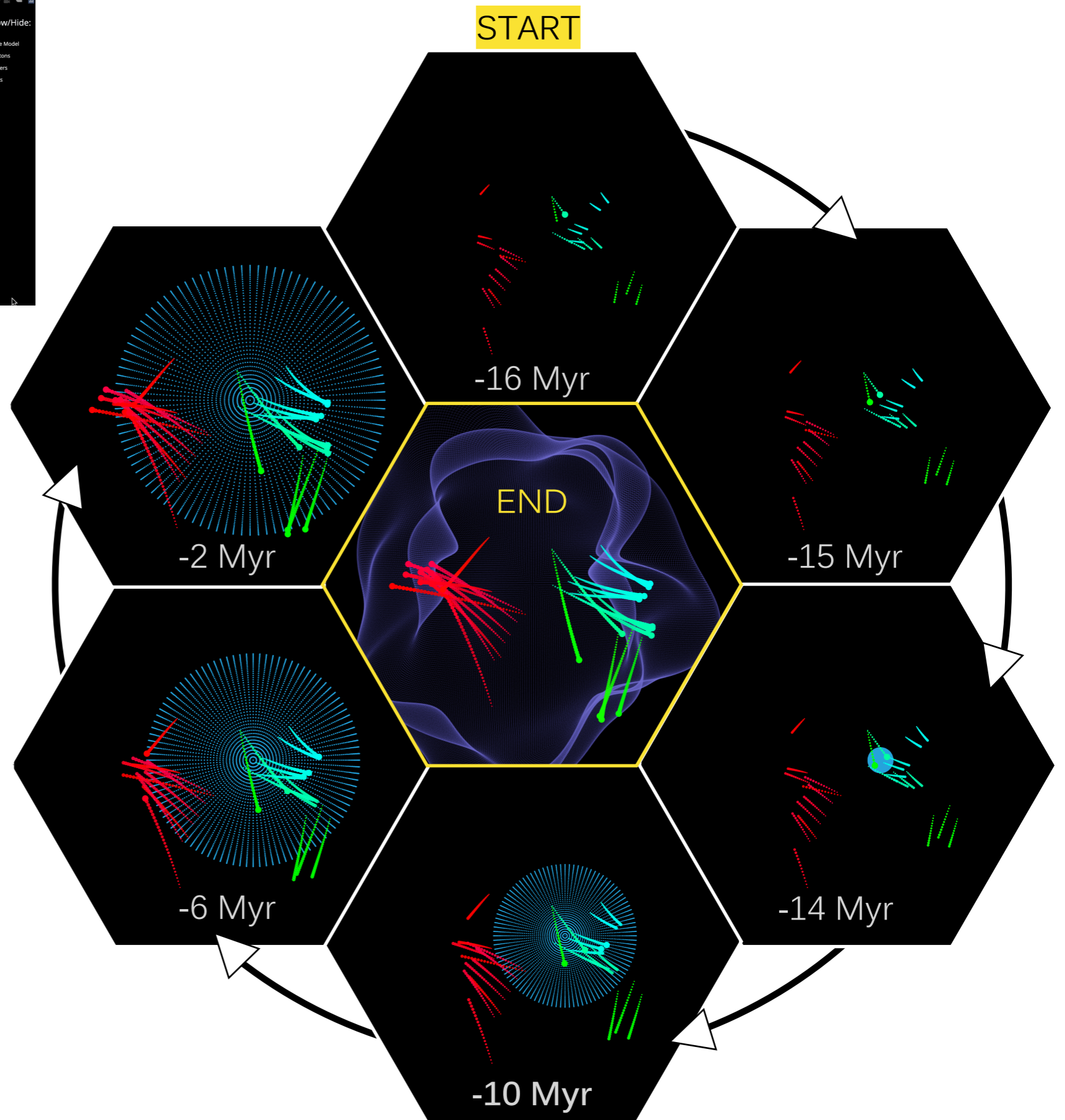
Present -1 Myr -2 Myr -3 Myr -4 Myr -5 Myr -6 Myr -7 Myr -8 Myr -9 Myr -10 Myr -11 Myr -12 Myr -13 Myr -14 Myr -15 Myr -16 Myr -17 Myr



"DATA-DIMENSIONS-DISPLAY"

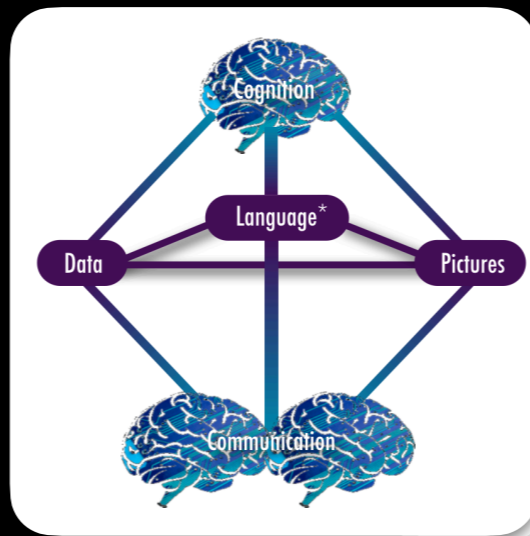


& PUBLISHING...

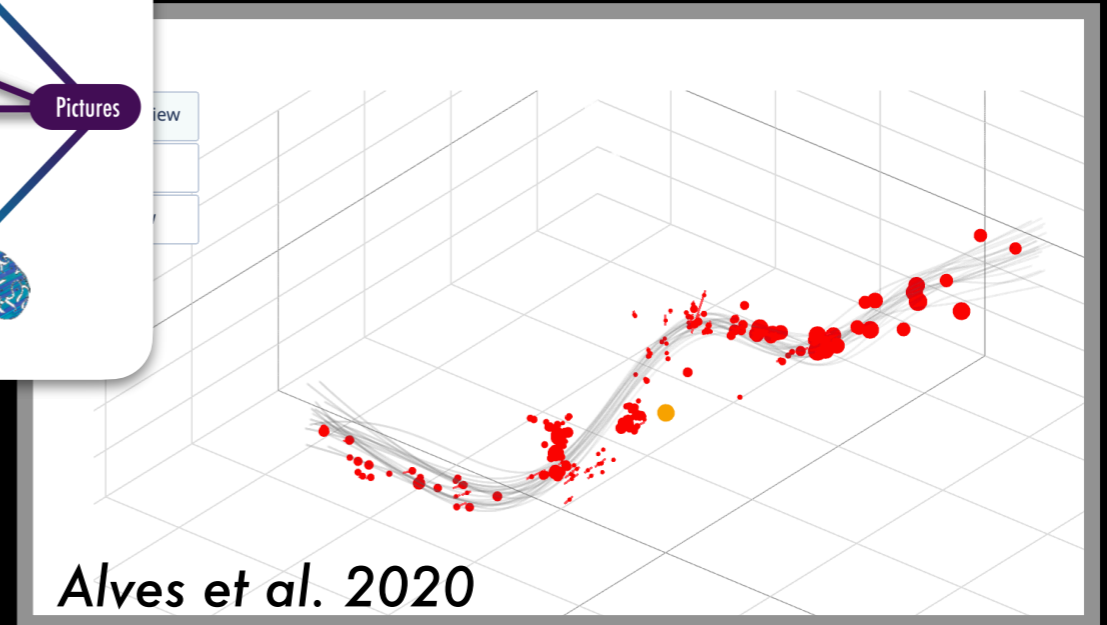




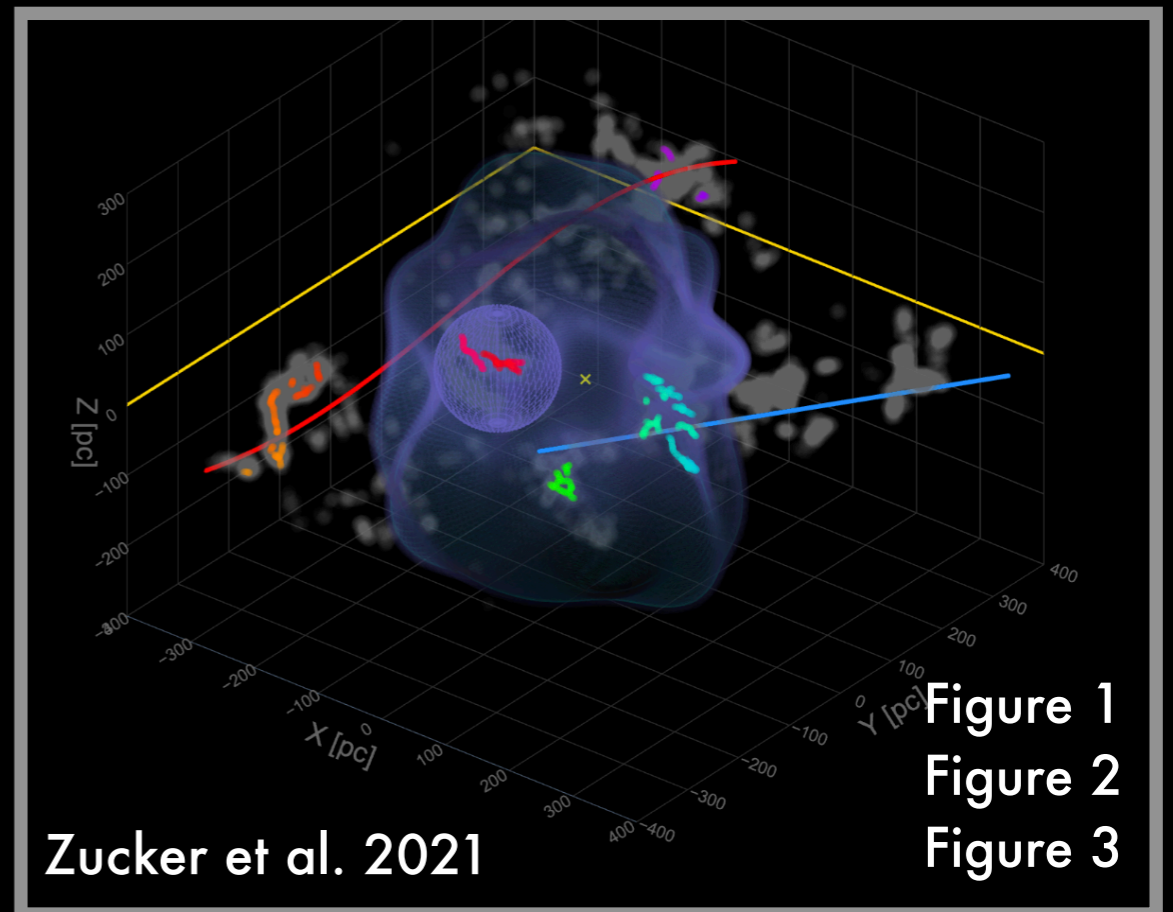
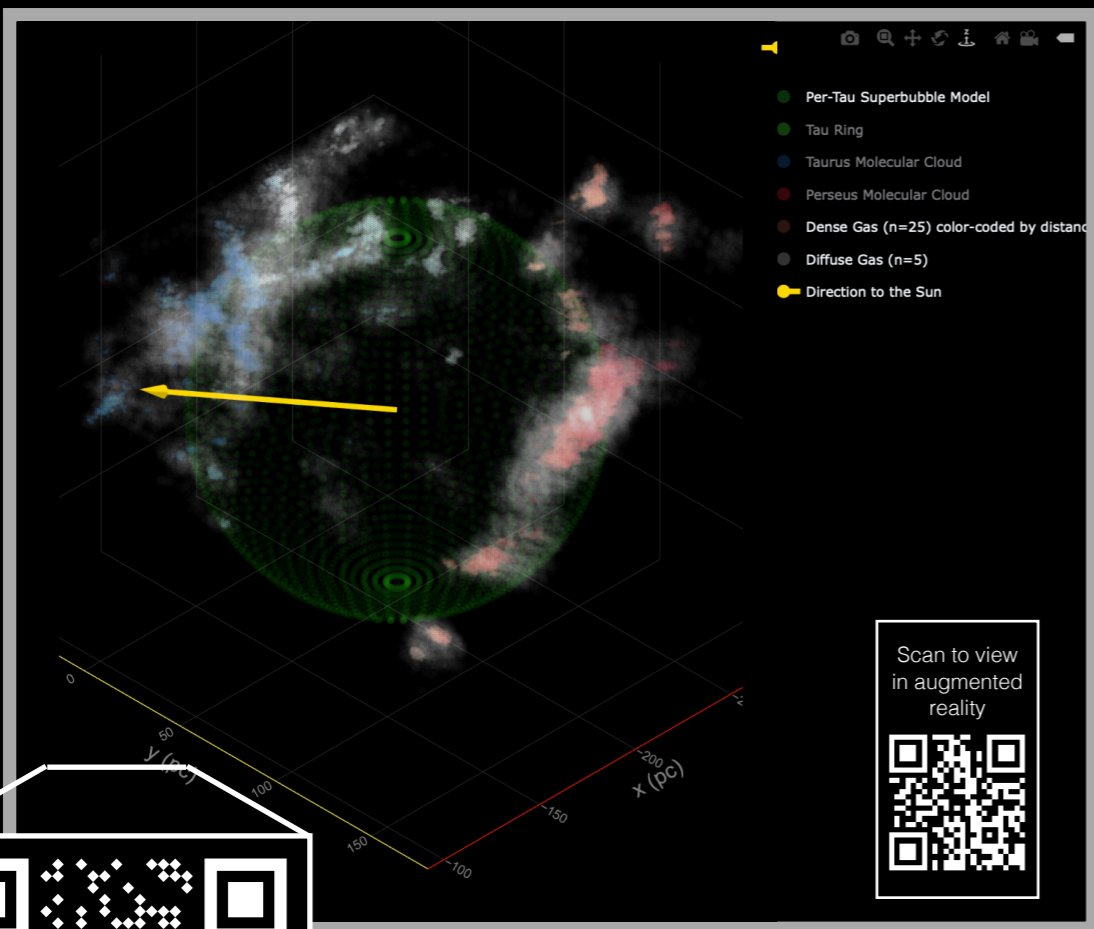
Shmuel showed you



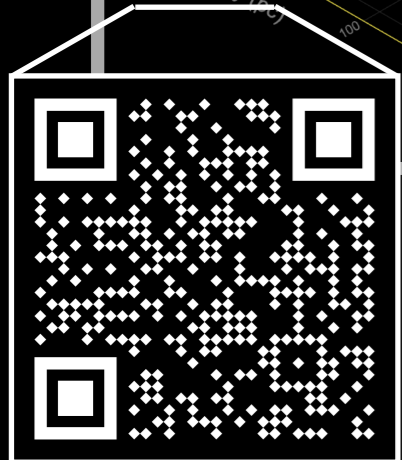
João will show you...



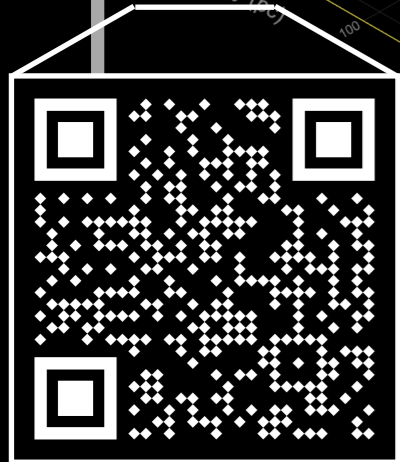
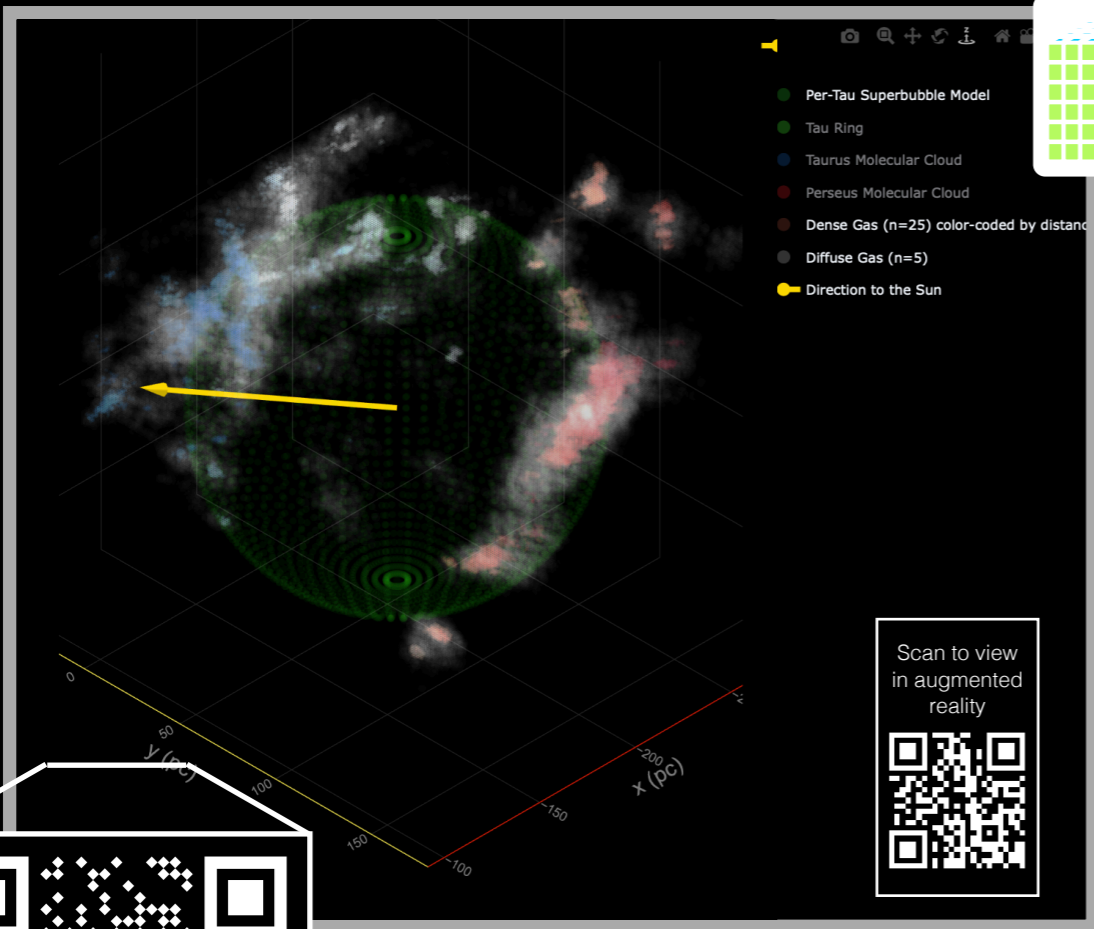
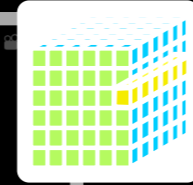
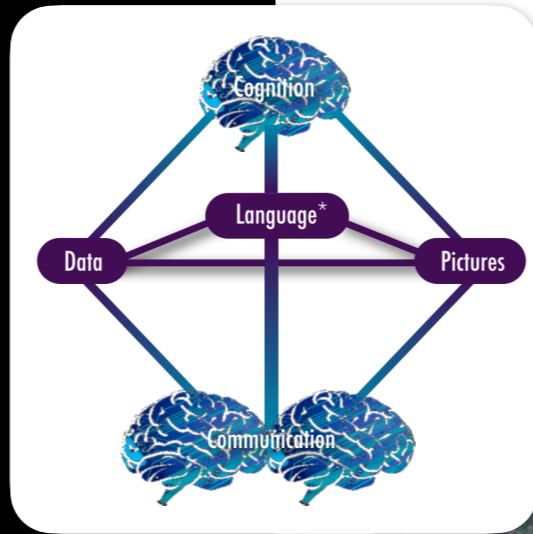
Catherine will show you...



Bonus: Merge Cube



PUBLISHING'S INTERACTIVE CUTTING-EDGE & (AUGMENTED) FUTURE



Now: Merge Cube

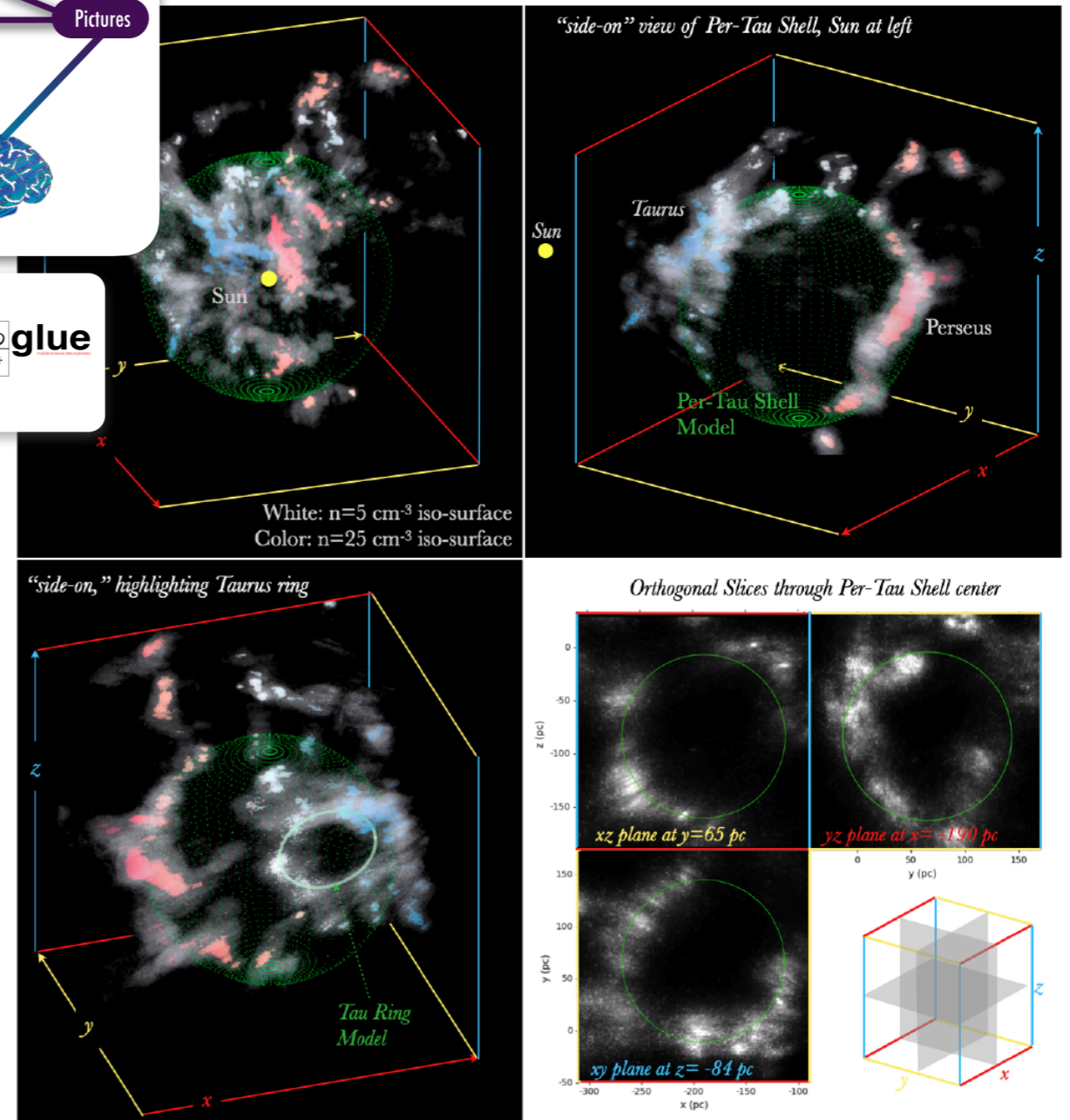


FIG. 2.— 3D^a b views of the Per-Tau shell (see Fig. 5 for more visualizations). Plotted are density iso-surfaces at levels $n = 5 \text{ cm}^{-3}$ (grey) and $n = 25 \text{ cm}^{-3}$ (color), overlaid with our spherical shell model, radius $R_s = 78 \text{ pc}$, distance from the sun $d = 218 \text{ pc}$. The $n = 25 \text{ cm}^{-3}$ surfaces are colored by distance from the sun (blue-to-red). Upper-left: View from the sun (compare with Fig. 1). Upper-right: A side view of the region. Perseus and Taurus and their diffuse envelopes are arranged on two opposing sides of the Per-Tau shell. Lower-left: Another side view emphasizing the Tau Ring. The ellipse is the Tau Ring model (Appendix B). Lower-right: 2D density slices along the xy , xz , yz planes. All planes intersect at shell's center. In all panels xyz are the Heliocentric Cartesian Galactic Coordinates.

^aFor an interactive version of this figure visit https://faun.rc.fas.harvard.edu/czucker/Paper_Figures/sbiay/pertau_superbubble.html.

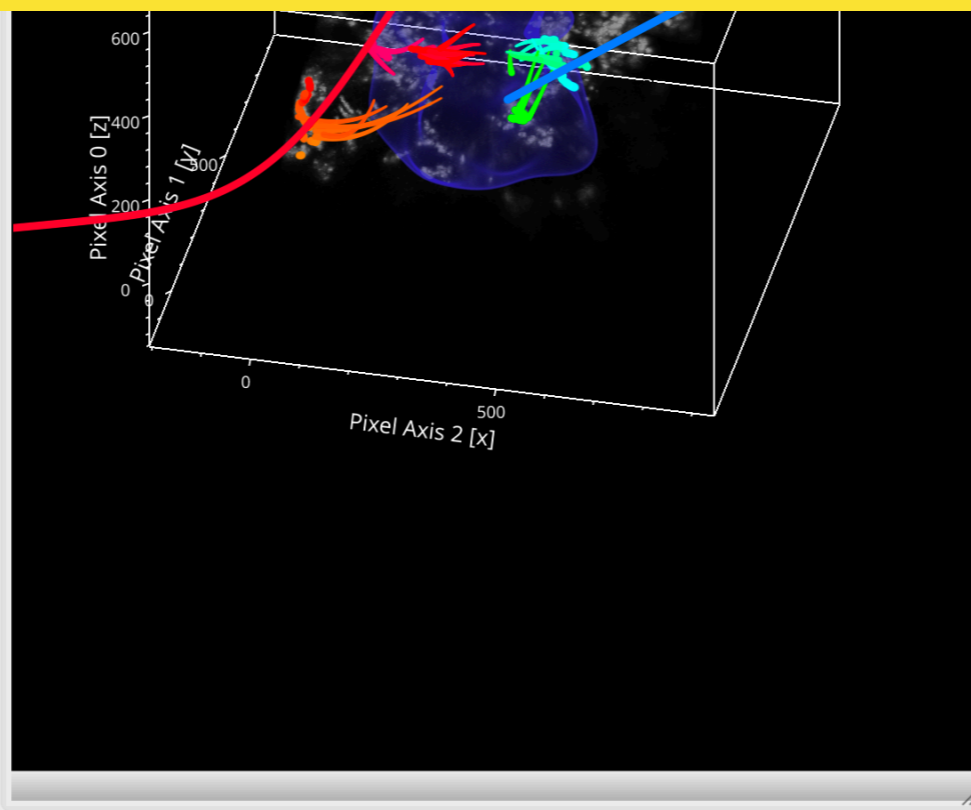
^bFor Augmented Reality (AR), scan the QR code

Live demo, using the New Frontier Catherine will explain tomorrow.

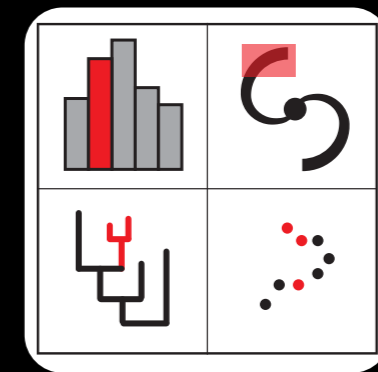
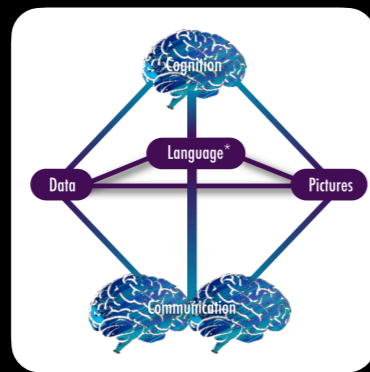
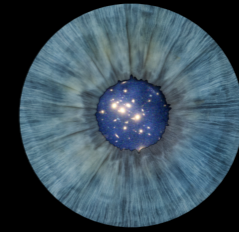
The screenshot shows the top portion of a software interface. At the top is a menu bar with options: Open Session, Export Session, Import Data, Export Data/Subsets, Link Data, χ^2 Arithmetic attributes, Active Subset: None/Create New, (the next selection will create a subset), Terminal, Preferences, and Error Console. Below the menu bar is a 'Data Collection' panel on the left with a list of data items: 3D_Dust_Leike_2020, Local_Bubble_Model_Pelgrims_2020[HDU1], Radcliffe_Wave_Model_Alves_2021, Split_Model_Lallement_2019, 3D_Molecular_Cloud_Skeletons_Zucker_2021[HDU1], and Stellar_Orbit_Tracebacks. Below this is a 'Subsets' section. To the right of the data collection panel is a '3D Volume Rendering' window showing a dark space with some faint structures. Further right is an 'Earth/Planet/Sky Viewer (WWT)' window displaying a colorful, streaky visualization of a celestial object.

**TOP SECRET, REALLY— PLEASE DO NOT SHARE—BEING SUBMITTED TO NATURE in a few days
Zucker, Goodman, Alves, Bialy, Foley, Finkbeiner, Speagle, Großschedl, Swiggum, Burkert 2021.**

This screenshot shows the control panels of the software. At the top is a 'Fixed' dropdown menu and a horizontal slider. Below the slider is a button labeled 'Center view on layer'. At the bottom is the 'Plot Options - Earth/Planet/Sky Viewer (WWT)' panel, which includes several dropdown menus: Mode (set to 'Milky Way'), Frame (set to 'Galactic'), Longitude (set to 'l'), Latitude (set to 'b'), and Distance (set to 'd'). There is also a 'pc' option at the bottom of the distance menu.



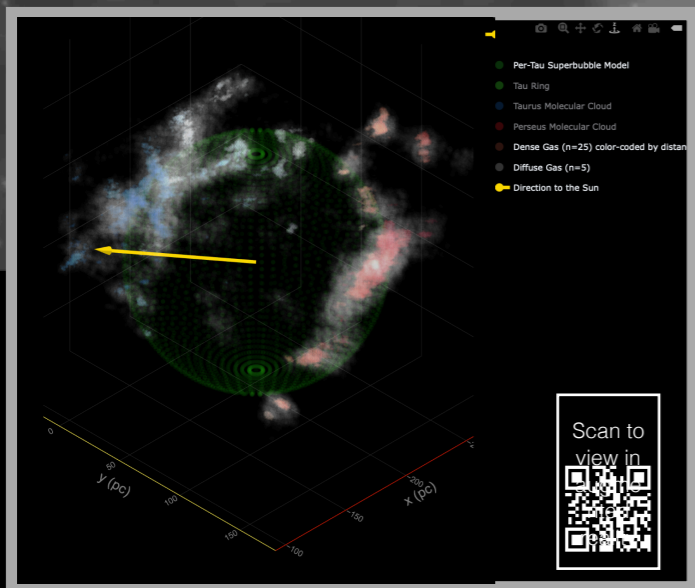
SEEING MORE OF THE UNIVERSE IN 20 MIN



Explore

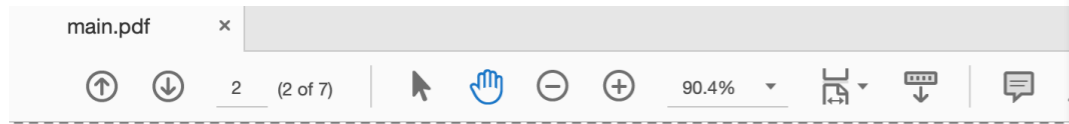


Explain

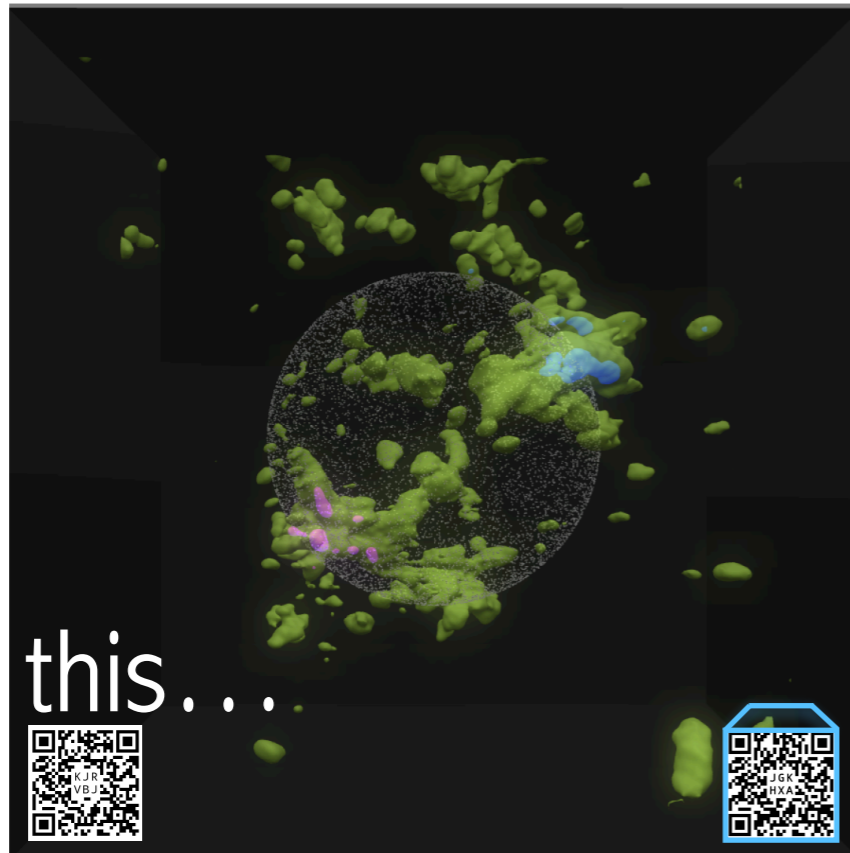


explanatory "Per-Tau Shell" video by Jasen Chambers,
for release with Bialy et al. (ApJL) & Zucker et al. 2021 (ApJ)

PUBLISHING'S INTERACTIVE CUT (AUGMENTED) FUTURE



2



scan this...

...see this

AUGMENTED REALITY
PROPOSED TO NSF
11-2020

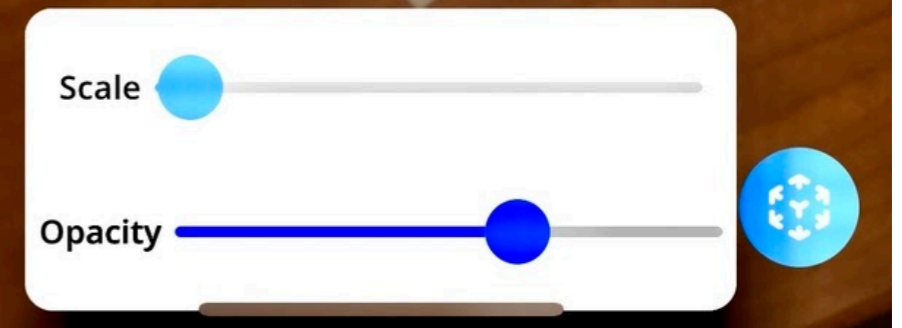
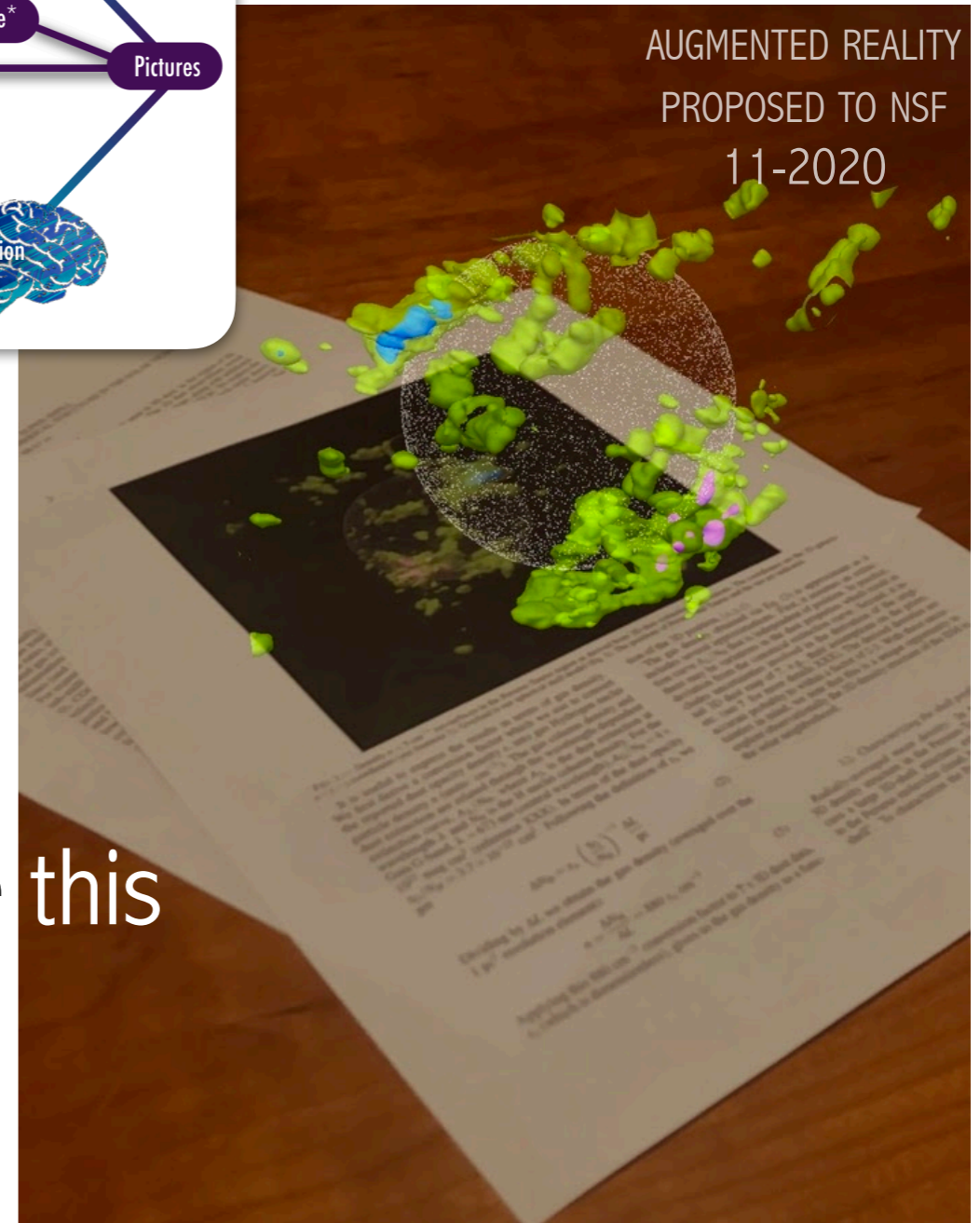
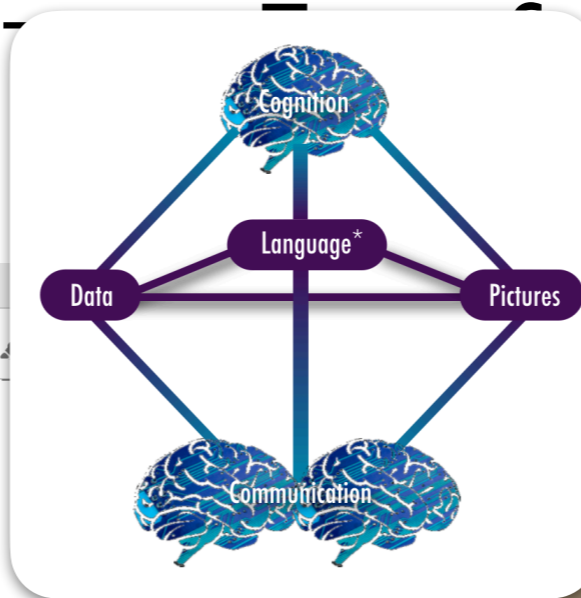


FIG. 1.— Density $n = 5 \text{ cm}^{-3}$ iso-surfaces in the Perseus-Taurus region as derived from 3D-dust extinction observations. The coordinates are the 3D galactic $x-y-z$ coordinates (see footnote 1). Overlaid is our spherical shell model (Eq. 5). The positions of Perseus and Taurus and the sun are indicated.

It is useful to express the results in terms of gas density. We first derive a conversion factor which we use to convert the reported dust opacity density s , into gas Hydrogen nuclei particle density n (units: cm^{-3}). The gas column density and dust extinction are related through the wavelength-dependent extinction curve, A_λ/N_H , where A_λ is the dust extinction at wavelength λ and N_H is the H nuclei column density. For the Gaia G-band, $\lambda = 673 \text{ nm}$ (central wavelength), $A_G/N_H = 4 \times 10^{22} \text{ mag cm}^2$ (reference XXX). In terms of the dust opacity $\tau_G/N_H = 3.7 \times 10^{-22} \text{ cm}^2$. Following the definition of s_x we get

$$\Delta N_H = s_x \left(\frac{\tau_G}{N_H} \right)^{-1} \frac{\Delta L}{\text{pc}}. \quad (2)$$

Dividing by ΔL we obtain the gas density (averaged over the 1 pc^3 resolution element):

$$n = \frac{\Delta N_H}{\Delta L} = 880 s_x \text{ cm}^{-3}. \quad (3)$$

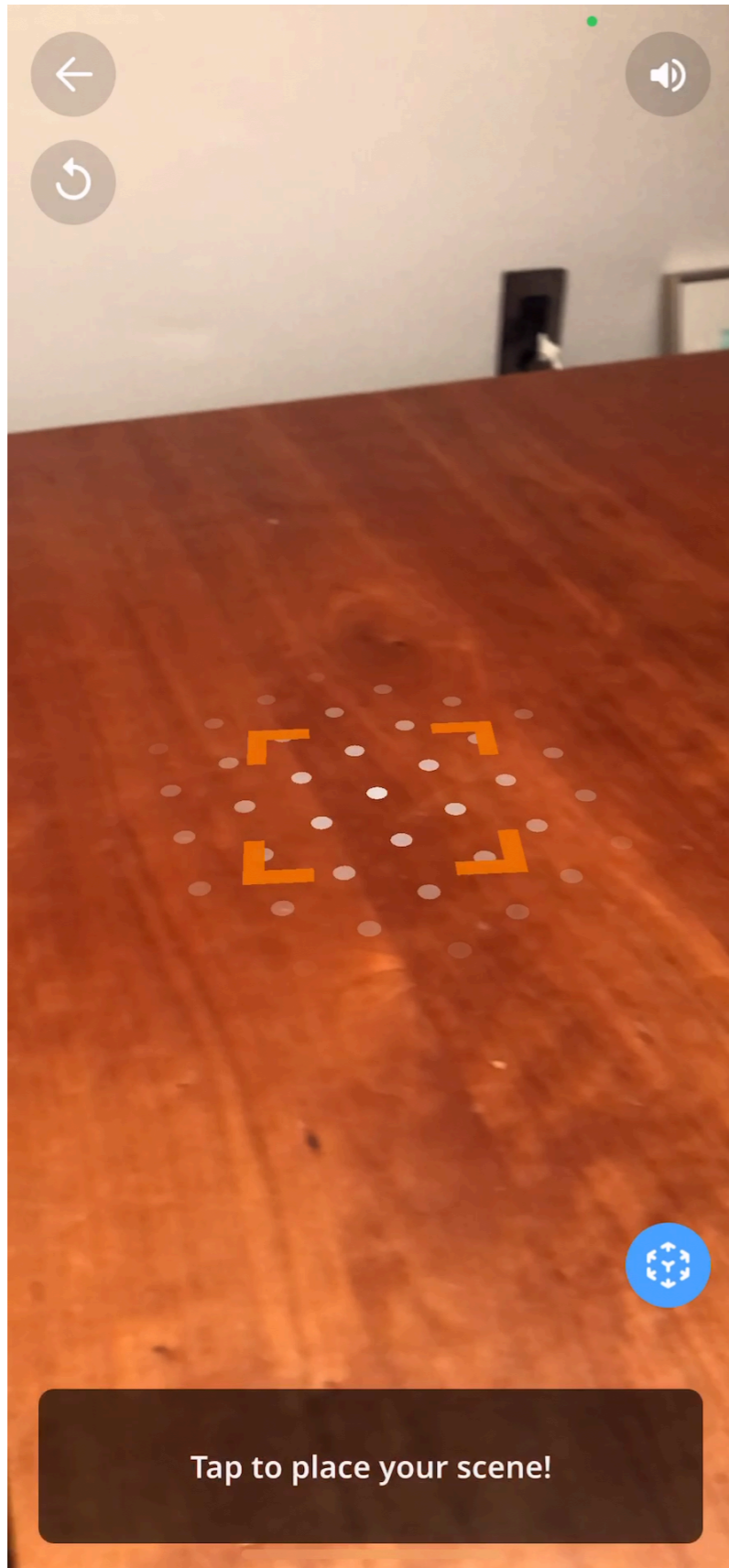
tion of the 3D position, (x, y, z) .

The gas density obtained via Eq. (3) is approximate as it includes several approximations. First, it assumes an extinction curve A_λ/N_H that is independent of position. In practice, there may be variations in the dust properties which result in deviation from the canonical extinction curve. Second, it includes uncertainties involved in the derivation of the original 3D dust map of ?, e.g., their assumptions on the priors, etc. (see ? for more details XXX). The derived densities are accurate probably to within a factor of 2-3. With these uncertainties in mind, we note that this is a unique opportunity to explore observationally the 3D density structure of the ISM in the solar neighborhood.

3.2. Characterizing the shell profile

Radially-averaged mean density: In §4 we explore the 3D density structure in the Perseus-Taurus region, and discuss a large 3D-shell structure, extending from the Taurus

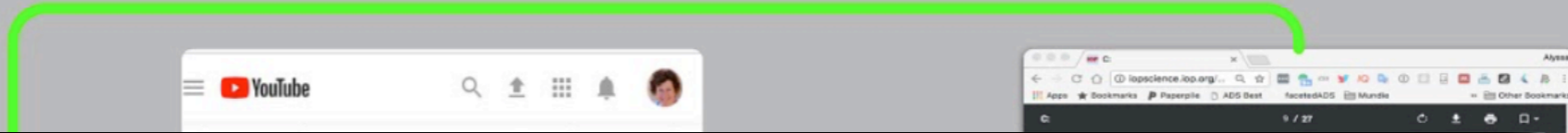
PUBLISHING'S INTERACTIVE CUTTING-EDGE & (AUGMENTED) FUTURE



DATA,
CODE,
COLLABORATION



DATA-DRIVEN STORYTELLING



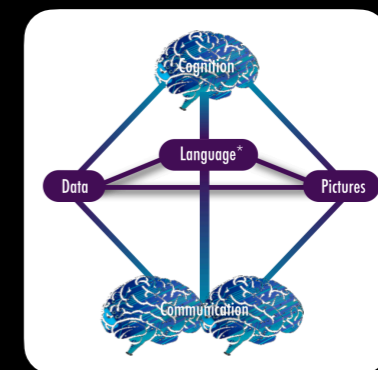
This is all possible, and happening now.

Not for everyone, though.

see *“New Thinking on, and with, Data Visualization”*
(Goodman, Borkin & Robitaille arxiv.org/abs/1805.11300)

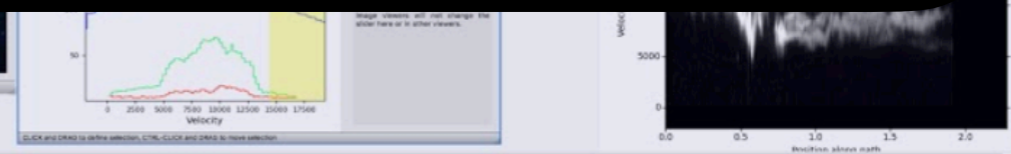
Learn more in our next episode...

“CONNECTING DATA, LANGUAGE AND PICTURES”



collaborative
software
development

plug-in
architecture



EXPLORATION



EXPLANATION

