



# CARTA 3: Cube Analysis and Rendering Tool for Astronomy

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# CARTA

## Cube Analysis and Rendering Tool for Astronomy

Project: ASIAA, IDIA, NRAO, U Alberta

Webpage: <https://cartavis.org>

Github: <https://github.com/CARTAVIS>

Goal: To build a high performance, versatile image for large data cubes and image in astronomy

Use cases:

- CASA viewer replacement (excluding interactive clean and visibility display)
- Archive interface for images from SKA precursors, ALMA, NRAO SRDP
- Stand alone analysis tool
- Scriptable interface (publication ready images, interaction for analysis)
- Collaborative tool

Current release version 3.0 (release date Aug 23, 2022)





# CARTA on cartavis.org



HOME FEATURES GALLERY ROADMAP INSTALLACIÓN TEAM ABOUT



## CARTA

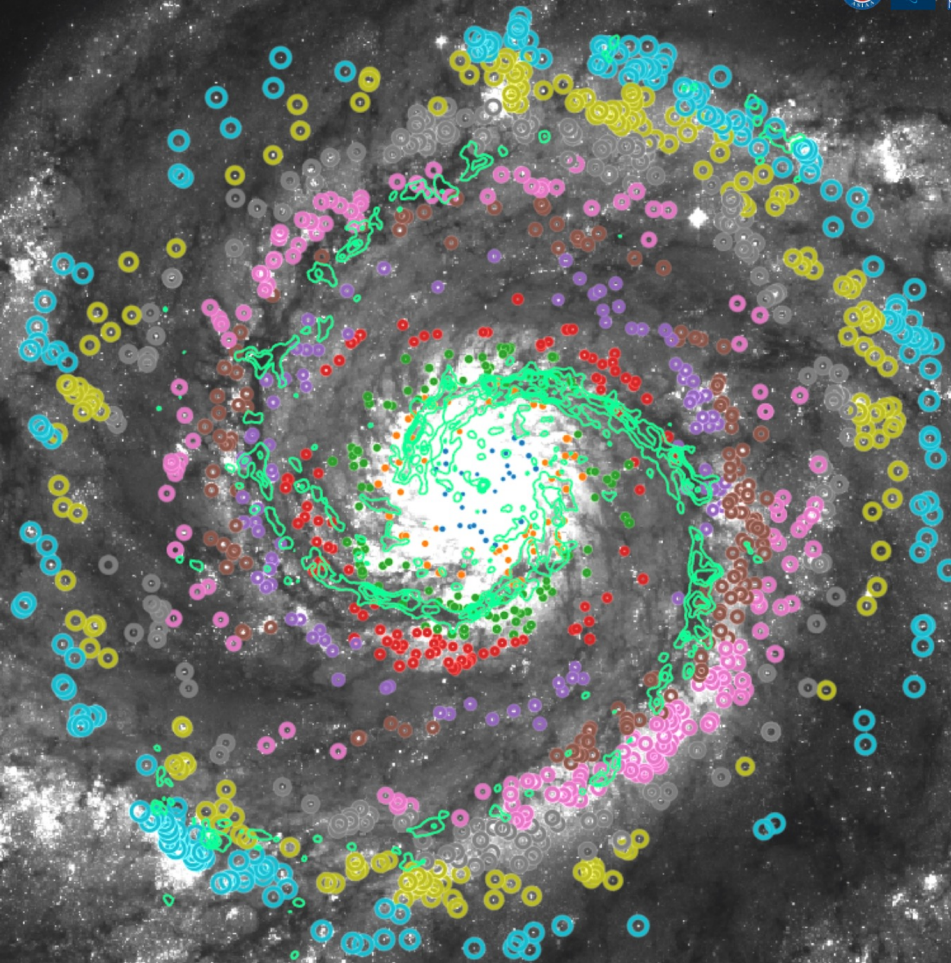
Cube Analysis and Rendering Tool for Astronomy, is a next generation image visualization and analysis tool designed for ALMA, VLA, and SKA pathfinders.

Installation

User Manual

Helpdesk

**NEW** [The CARTA v3.0 release is now available](#)



# System Requirements

## From catravis.org “Obtaining CARTA”:

v3.0-beta.3

Supported operating systems:

- Ubuntu Linux: 18.04 LTS (Bionic Beaver), 20.04 LTS (Focal Fossa)
- Red Hat Enterprise Linux: 7, 8
- macOS: 10.15 (Catalina), 11 (Big Sur), 12 (Monterey)

### Site deployment

### Packages

Ubuntu RHEL7 CentOS7 RHEL8 AlmaLinux macOS

Ubuntu 18.04 and 20.04 packages are available [from our PPA](#).

```
sudo add-apt-repository ppa:cartavis-team/carta
sudo apt-get update
sudo apt install carta-beta
```

To start CARTA, please refer to the user manual [How to Run CARTA](#).

### Stand-alone application

macOS Electron Desktop Ubuntu Linux Applmage Red Hat Linux Applmage

The Red Hat Linux Applmage does not require root access. You simply download, extract, and run it. It uses your default web browser to display the CARTA graphical interface. The Applmage has been tested to run on Red Hat Enterprise Linux (RHEL) 7 and 8, as well as CentOS 7 and AlmaLinux 8.

#### Installation:

Either click the Download button below or run:

```
wget https://github.com/CARTAVIS/carta/releases/download/v3.0.0-beta.3/CARTA-v3.0.0-beta.3-redhat.tgz
```

Extract the tarball:

```
tar -xzf CARTA-v3.0.0-beta.3-redhat.tgz
```

#### Operation:

To start CARTA, please refer to the user manual [How to Run CARTA](#).

Note: If you wish to run the Applmage inside a Docker container, or you system has trouble with FUSE, please prefix with the following environment variable:

```
APPIMAGE_EXTRACT_AND_RUN=1 ./CARTA-v3.0.0-beta.3-redhat.AppImage
```

## Browsers: from [carta.readthedocs.io](https://carta.readthedocs.io) “How to run CARTA?”:

Please note that the CARTA GUI is run in the web browser environment. The supported browsers are:

- Google Chrome (tested with v91)
- Firefox (tested with v89)
- Safari (tested with v14.1)

Other browsers might be supported but they are not tested.

#### Warning

At the moment, there is a layout issue with the Safari browser, which affect usability and user experience significantly. macOS users should try to avoid using Safari to run CARTA.

#### Note

CARTA requires WebGL in order to render images properly. WebGL2 is also required to render catalog overlay properly. Please ensure WebGL and WebGL2 are enabled in your browser.



Note: system/browser must be support webGL 2.0

If not, then CARTA widget will pop up, but image display will be single color  
Test URL:

<https://get.webgl.org/webgl2/>

May require upgrade or downgrade of video card driver



# CARTA on github.com/CARTAvis



## CARTAvis

<https://cartavis.org/> [support@carta.freshdesk.com](mailto:support@carta.freshdesk.com)

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- Packages
- People
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### Pinned

**carta** Public

To CARTA users, this repo holds the CARTA release packages. Please use this repo to log bugs and feature requests. These will be triaged by the development team and prioritised as necessary in the ...

☆ 11

### Repositories

Find a repository... Type Language Sort

- carta-backend** Public  
Source code repository for the backend component of CARTA, a new visualization tool designed for the ALMA, the VLA and the SKA pathfinders.  
C++ ☆ 14 🍴 3 🕒 82 🔗 6 Updated 4 hours ago
- carta-frontend** Public  
Source code repository for the frontend component of CARTA, a new visualization tool designed for the ALMA, the VLA and the SKA pathfinders.  
TypeScript ☆ 14 🍴 4 🕒 196 (1 issue needs help) 🔗 5 Updated 8 hours ago
- carta-backend-ICD-test** Public

### People

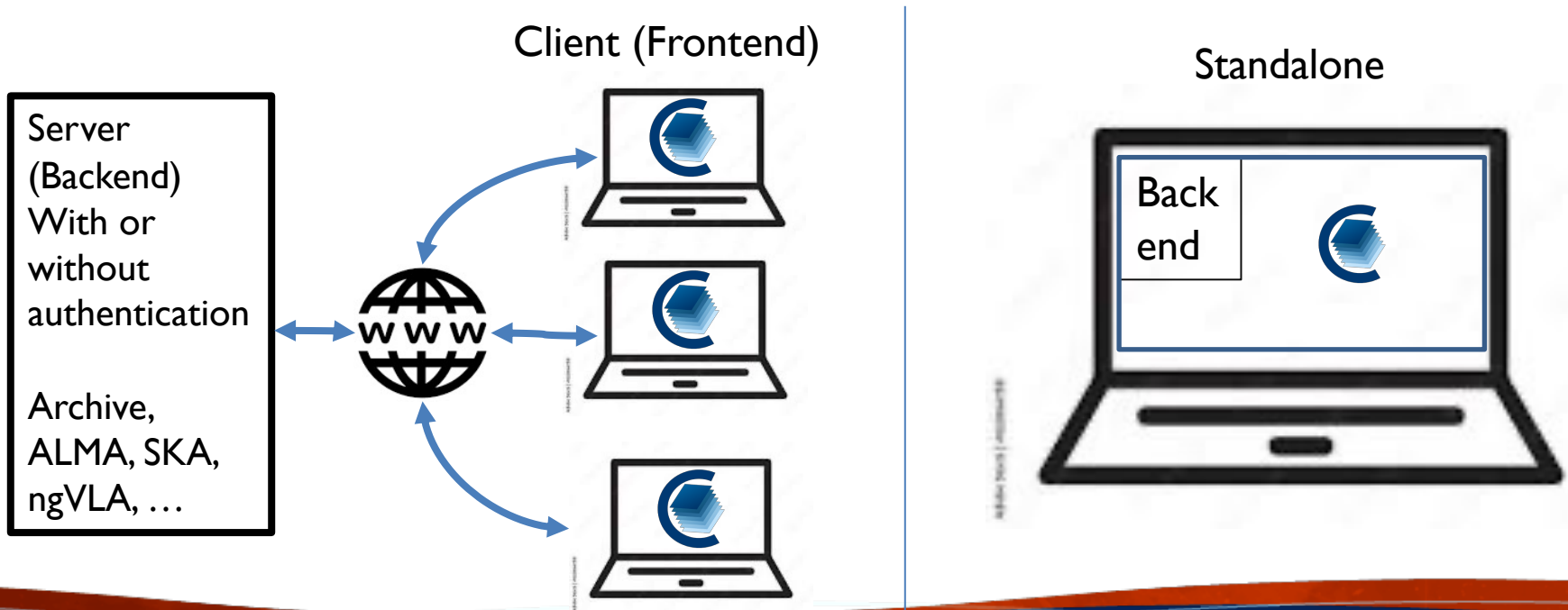
This organization has no public members. You must be a member to see who's a part of this organization.

### Top languages

- C++ Python TypeScript
- JavaScript Shell

# CARTA architecture

- A focus is on the performance for large datasets (1 TB loads in seconds)
  - Memory efficient image loading
  - Parallelization and GPU-accelerated rendering
  - Progressive and responsive update of spectral profile
  - Tiled image rendering
- Image formats: CASA, fits, gzipped fits, MIRIAD, HDF5 image (cube)
- OS: MacOS, Ubuntu, RHEL
- CARTA is built as a server-client infrastructure, launched separately or in a stand-alone version in a single instance





# CARTA Features

## Viewing:

- Image rendering with (global) min/max clipping, scaling functions and color maps
- Image panning, zooming, etc.
- Multi-panel
- Hardcopy
- Image/region saving
- Image blinking
- Image WCS matching spatially and spectrally
- Contours with different generators, colors, color maps
- Catalog overlays
- Setting of rest frequency
- Vector overlays
- Complex image display
- LEL image arithmetic before display
- Generating computed polarization quantities (eg. linear polarization intensity) of a Stokes cube on the fly
- Setting a new rest frequency when saving a subimage

# CARTA Features

## Tools/Analysis:

- Regions: rotating box, ellipses, polygons, line, point, polyline
- Spatial (X,Y) and spectral (Z) profiles
- Spectral profiles can convert spectral axis labels (velocity, frequency, wavelength)
- Histogram
- Image/Region Statistics
- Stokes analysis widget
- Moment generator
- pV diagram
- Spectral line labelling
- Spectral smoothing
- Distance measuring tool
- Intensity conversion
- 2D Gaussian fitting of sources in image
- Line and polyline region spectral profiler

# CARTA Features

## Other:

- Server-client infrastructure for remote image access
- Server authentication
- Tiled rendering for performance
- Docking and Preferred layouts and layout saving
- Scripting is under active development

# CASAvviewer vs CARTA

Gaps relative to CASAvviewer (green: CARTA development underway; black: future CARTA development; red: likely not implemented in CARTA)

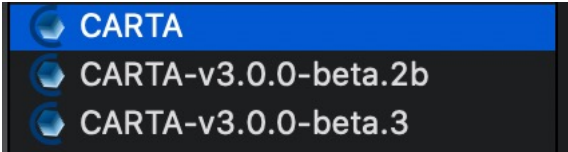
- **Complete set of fitting tools** → spectral: multiple Gaussians and Lorentzians already available with continuum polynomial; spatial: 2D Gaussian fit
- Source finder tool
- **Spectral profile error bar plotting** (MUSE/optical feature in CASA)
- **Image annotation** → v4
- profile annotation
- Rotated cube view (input as ra-dec-channel, view as ra-channel vs dec)
- Scalable output (SVG or PDF)
- **Creation of multi-channel plots** → v4
- Regions that extend across spectral and stokes planes
- Histogram fitting
- **Markers** → they have not been widely used in the CASAvviewer
- **Interactive clean** → CASA will develop a visualization tool independent of CARTA
- Full support of CRTF → was not even supported by the CASAvviewer
- **Save/reload states** → v4
- **Share states** → v4



# CARTA – Start

MacOX installed stand-alone:

`carta` (or click the icon in the Applications folder)



Linux or remote (beta version needs to be downloaded from [cartavis.org](http://cartavis.org) first):

(base) jott@Desktop ~> `CARTA-v3.0.0-redhat7.ApplImage --no_browser`

```
touch: cannot touch "/Users/jott/.local/share/icons/hicolor/.xdg-icon-resource-dummy": No such file or directory
```

```
[2022-04-04 14:49:41.290] [info] Writing to the log file: /Users/jott/.carta-beta/log/carta.log
```

```
[2022-04-04 14:49:41.290] [info] /tmp/.mount_CARTA-9Qe8SC/bin/carta_backend: Version 3.0.0-beta.2b
```

```
[2022-04-04 14:49:41.296] [info] Serving CARTA frontend from /tmp/.mount_CARTA-9Qe8SC/share/carta/frontend
```

```
[2022-04-04 14:49:41.296] [warning] Port 3002 is already in use. Trying next port.
```

```
[2022-04-04 14:49:41.296] [warning] Port 3003 is already in use. Trying next port.
```

```
[2022-04-04 14:49:41.297] [warning] Port 3004 is already in use. Trying next port.
```

```
[2022-04-04 14:49:41.297] [warning] Port 3005 is already in use. Trying next port.
```

```
[2022-04-04 14:49:41.297] [warning] Port 3006 is already in use. Trying next port.
```

```
[2022-04-04 14:49:41.297] [warning] Port 3007 is already in use. Trying next port.
```

```
[2022-04-04 14:49:41.297] [info] Listening on port 3008 with top level folder /, starting folder /lustre/aoc/sciops/jott/pipeline/calibrationtest/L-band.
```

```
The number of OpenMP worker threads will be handled automatically.
```

```
[2022-04-04 14:49:41.297] [info] CARTA is accessible at http://146.88.3.182:3008/?token=ec1836fc-2cd7-468d-9744-a1ac3e8cc995
```

→ Copy and past this URL in your local browser (VPN connection needed if outside NRAO)

`carta --no_browser` at NRAO will launch v2.0 (3.0 not installed yet)

# File loading

The screenshot displays the CARTA v3 (2022) software interface. A 'File Browser' window is open, showing a directory path of 'Users > jott > Documents > CARTA > demo'. The file list contains the following entries:

Filename	Type	Size	Date
fft-cube.im	CASA	251.0 MB	26 May 2021
fft.test	CASA	4.4 MB	26 May 2021
IRC10216.36GHzcont.image.fits	FITS	368.6 kB	29 Sep 2020
IRC10216_HC3N.cube_r0.5.image	CASA	19.4 MB	5 Jan 2020
IRC10216_HC3N.cube_r0.5.image-copy	CASA	19.4 MB	18 Mar 2020
IRC10216_HC3N.cube_r0.5.image.fits	FITS	18.7 MB	18 Mar 2020
IRC10216_HC3N.cube_r0.5.image.mir	Miriad	19.3 MB	18 Mar 2020
m82-car-2000.fits	FITS	4.0 MB	18 Mar 2020
m82-tan-2000.fits	FITS	4.0 MB	18 Mar 2020
NGC628_dss.fits	FITS	371.5 kB	9 Nov 2020
NGC628_galex.fits	FITS	371.5 kB	9 Nov 2020
NGC_628_CUBE-bin3.image	CASA	79.8 MB	9 Nov 2020
NGC_628_CUBE.image	CASA	251.0 MB	9 Nov 2020
NGC_628_NA_CUBE_THINGS.copy.fits	FITS	247.7 MB	26 May 2021
NGC_628_NA_CUBE_THINGS.copy.mir	Miriad	243.3 MB	26 May 2021
NGC_628_NA_CUBE_THINGS.copy.mir-manipulated	Miriad	243.3 MB	26 May 2021

The 'File Information' panel for the selected file 'IRC10216.36GHzcont.image.fits' displays the following metadata:

```
Name = IRC10216.36GHzcont.image.fits
HDU = 0
Shape = [300, 300, 1, 1]
Number of channels = 1
Number of polarizations = 1
Coordinate type = Right Ascension, Declination
Projection = SIN
Image reference pixels = [151, 151]
Image ref coords = [09:47:57.3820, +013.16.40.6600]
Image ref coords (deg) = [146.989 deg, 13.278 deg]
Pixel increment = -0.4", 0.4"
Pixel unit = Jy/beam
Celestial frame = FK5, J2000
Spectral frame = LSRK
Velocity definition = RADIO
Restoring beam = 2.81862" X 1.53258", -19.1115 deg
```

Below the file browser, two panels illustrate the 'No file loaded' state. The left panel shows a folder icon and the text 'No file loaded' with the instruction 'Load a file using the menu'. The right panel shows a folder icon, the text 'No file loaded', and the instruction 'Load a file using the menu'.

# Help

**? = help menu**

**1) Navigation**

- Pan image: click
- Pan image (inside region): middle-click
- Pan image (inside region): ⌘ cmd, click
- Zoom image: mouse-wheel

**2) Regions**

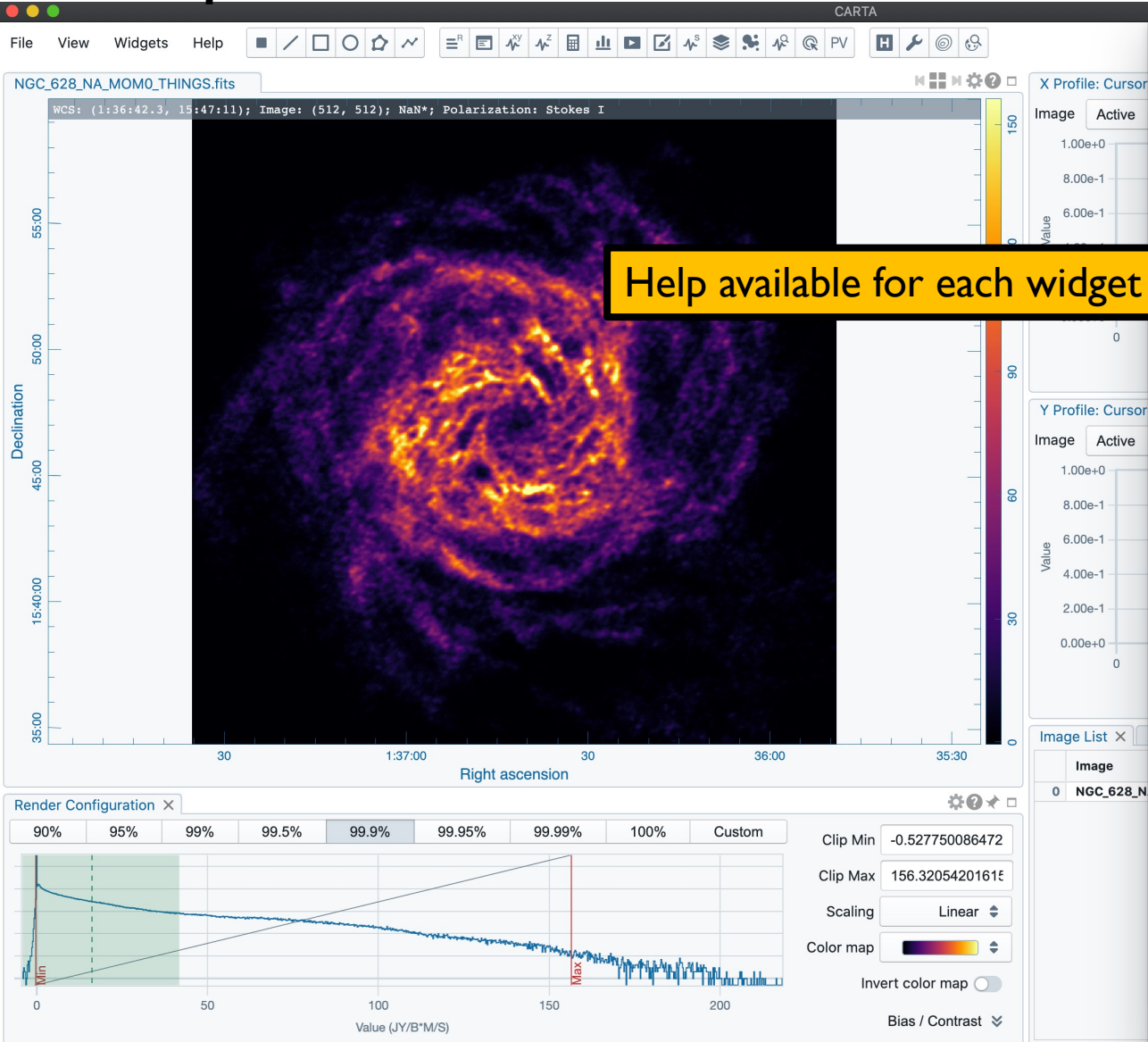
- Toggle region creation mode: C
- Toggle current region lock: L
- Unlock all regions: ⬆ shift, L
- Delete selected region: del
- Delete selected region: backspace
- Deselect region/Cancel region creation: esc
- Switch region creation mode: ⌘ cmd
- Symmetric region creation: ⬆ shift
- Region properties: double-click

**3) Frame controls**

- Next image: ⌘ alt, ]
- Previous image: ⌘ alt, [
- Next channel: ⌘ alt, ↑ up
- Previous channel: ⌘ alt, ↓ down
- Next Stokes cube: ⌘ alt, ⬆ shift, ↑ up

Layers	Matching	Channel	Polarization
NGC_628_NA_MOM	R	XY	R
		0	Stokes I

# Help



## Image View

The image viewer widget serves as the core component of CARTA. It allows you to visualize images in rasters and in contours. Region of interests can be defined interactively with the image viewer and subsequent image analysis can be performed with other widgets. Catalogue files can be loaded and visualized in the image viewer with the Catalogue widget.

Images can be loaded via **File -> Open image** (will close all loaded image first). You may load multiple images via **File -> Append image**. All images are loaded as raster by default. Contour layers can be further generated via the contour configuration dialog.

Information of world coordinates and image coordinates at the cursor position is shown at the top of the image viewer. To freeze/unfreeze the cursor position, press **F** key.

### Image tool buttons

A set of tool buttons is provided at the bottom-right corner when hovering over the image viewer. You may use these buttons to

- Select a source from catalog overlay
- Create regions
- Change image zoom scale
- Trigger WCS matching
- Change grid overlay reference frame
- Enable/disable grid lines and coordinate labels
- Export image

#### Catalog selection

##### Create region

##### Pan and select mode

##### Zoom in

##### Zoom out

##### Zoom to fit screen resolution



##### Export image

##### Toggle labels

##### Toggle grid

##### Overlay coordinate

##### WCS matching

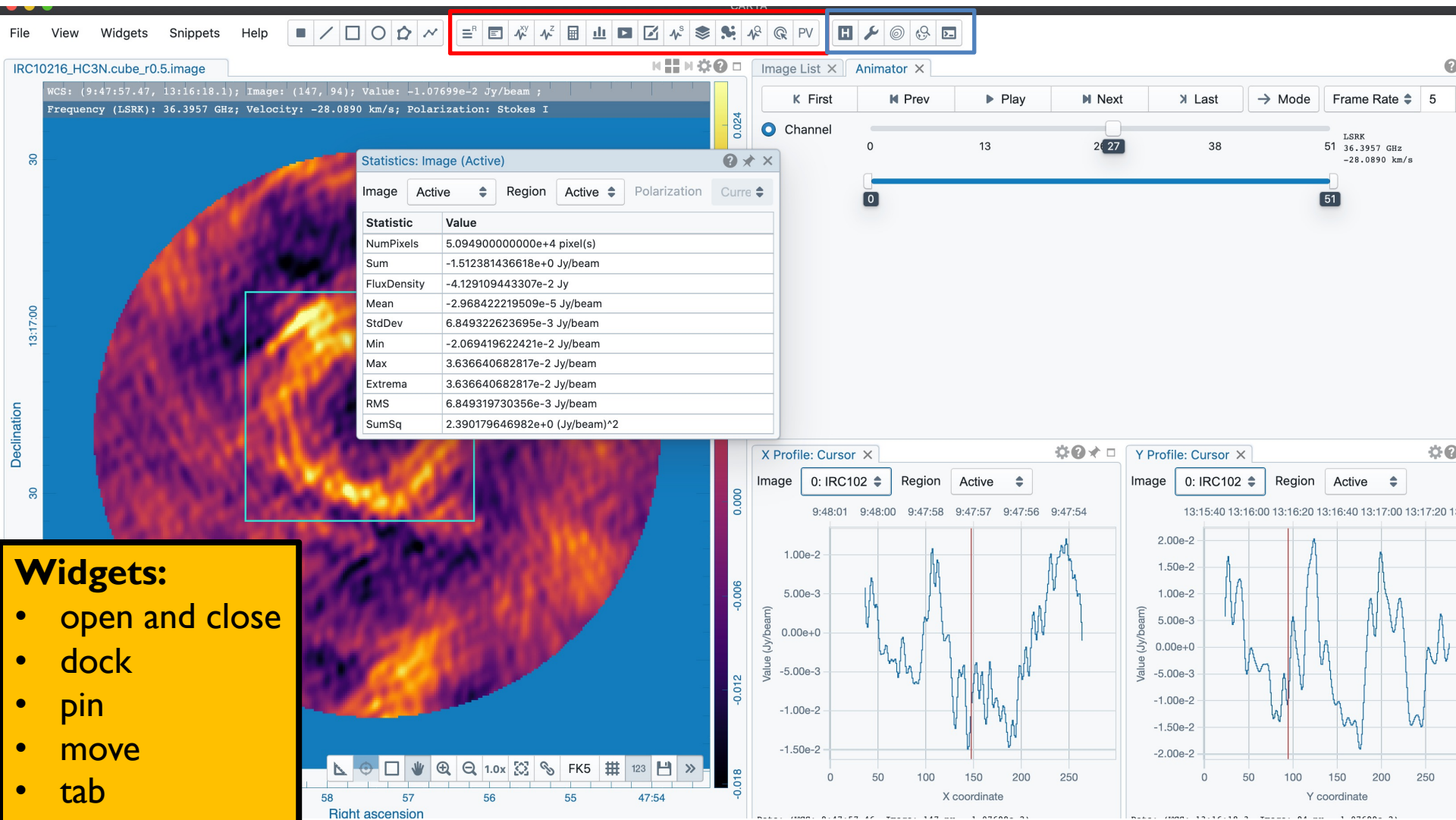
##### Zoom to fit image view

### Zoom and pan

Zoom actions can be triggered in different ways. The most common one is to use mouse and scroll wheel. By scrolling up, image is zoomed in, while by scrolling down, image is zoomed out. Alternatively, you may use the tool buttons at the bottom-right corner of the image viewer to zoom in, zoom out,



# Widgets



- Widgets:**
- open and close
  - dock
  - pin
  - move
  - tab
  - rearrange
  - resize
  - float

# Widgets

The screenshot displays the CARTA v3 (2022) software interface. The main window shows a radio galaxy image with a color scale on the right ranging from 0 to 150 Jy/B/M/S. A 'Render Configuration' window is open at the bottom, showing a histogram of the image data and various settings for clipping, scaling, and color mapping. A 'Y Profile' window is also open, showing a line plot of the image data along a specific axis. A yellow box with black text is overlaid on the Y Profile window, containing the following text:

**Widgets:**

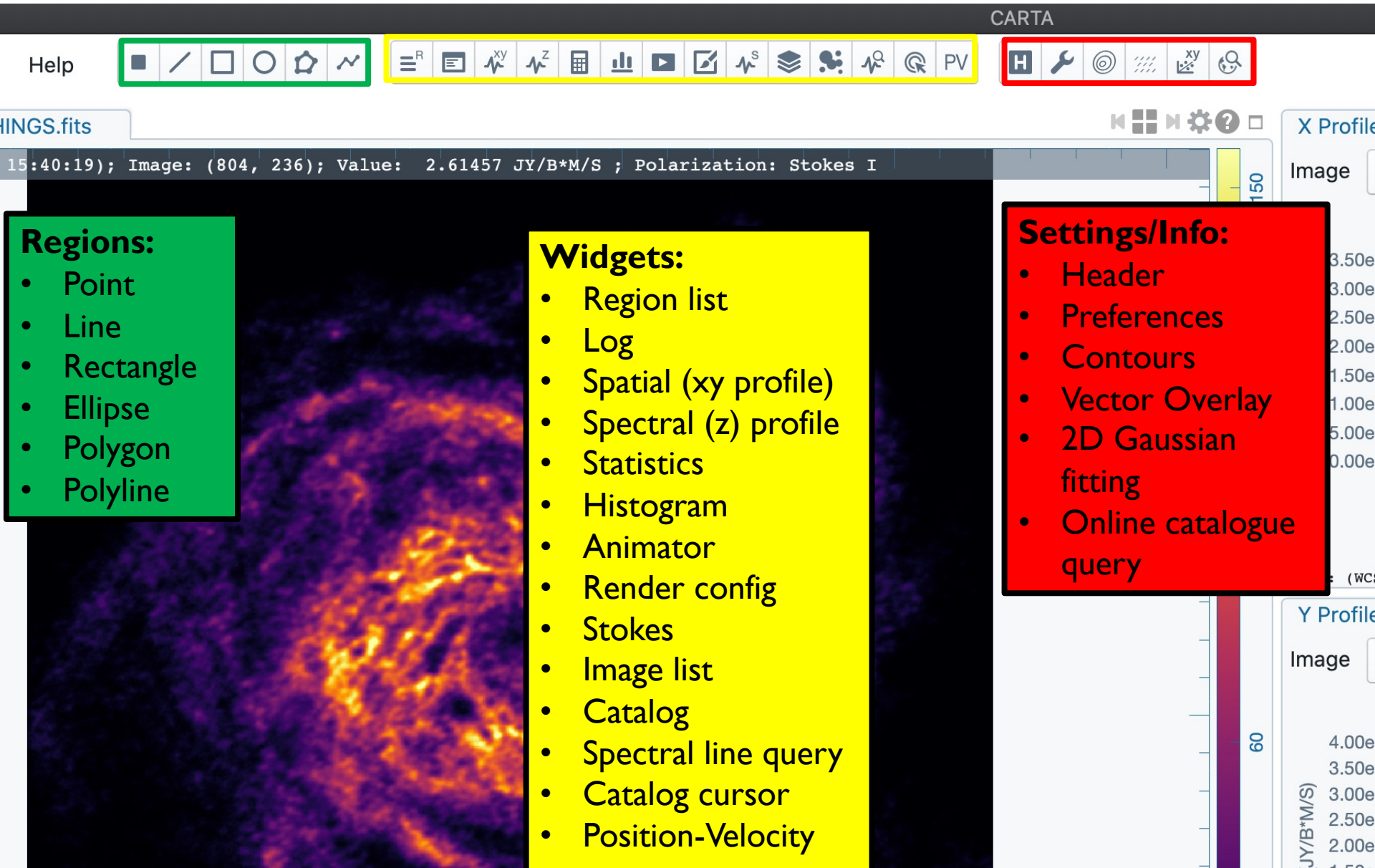
- Pre-defined layouts
- Layouts can be saved and restored
- Or defined for startup

The 'Render Configuration' window includes a histogram of the image data, with a green shaded area indicating the 'Clip Min' and a red vertical line indicating the 'Clip Max'. The histogram shows the distribution of values in Jy/B/M/S, with a peak around 150. The 'Clip Min' is set to -0.527750086472 and the 'Clip Max' is set to 156.3205420161. The 'Scaling' is set to 'Linear' and the 'Color map' is set to a rainbow color map. The 'Invert color map' option is unchecked. The 'Bias / Contrast' setting is also visible.

The 'Y Profile' window shows a line plot of the image data along a specific axis. The x-axis is labeled 'Y coordinate' and ranges from 0 to 1000. The y-axis is labeled 'Value (JY/B/M/S)' and ranges from 0.00e+0 to 1.60e+2. The plot shows a complex, multi-peaked structure. A red vertical line is positioned at approximately Y=500. The 'Image' and 'Region' tabs are active.

The 'Existing Layouts' menu is open, showing a list of layouts: Default, Cube View, Cube Analysis, Continuum Analysis, and test. The 'test' layout is highlighted in blue.

# Widgets



## Regions:

- Point
- Line
- Rectangle
- Ellipse
- Polygon
- Polyline

## Widgets:

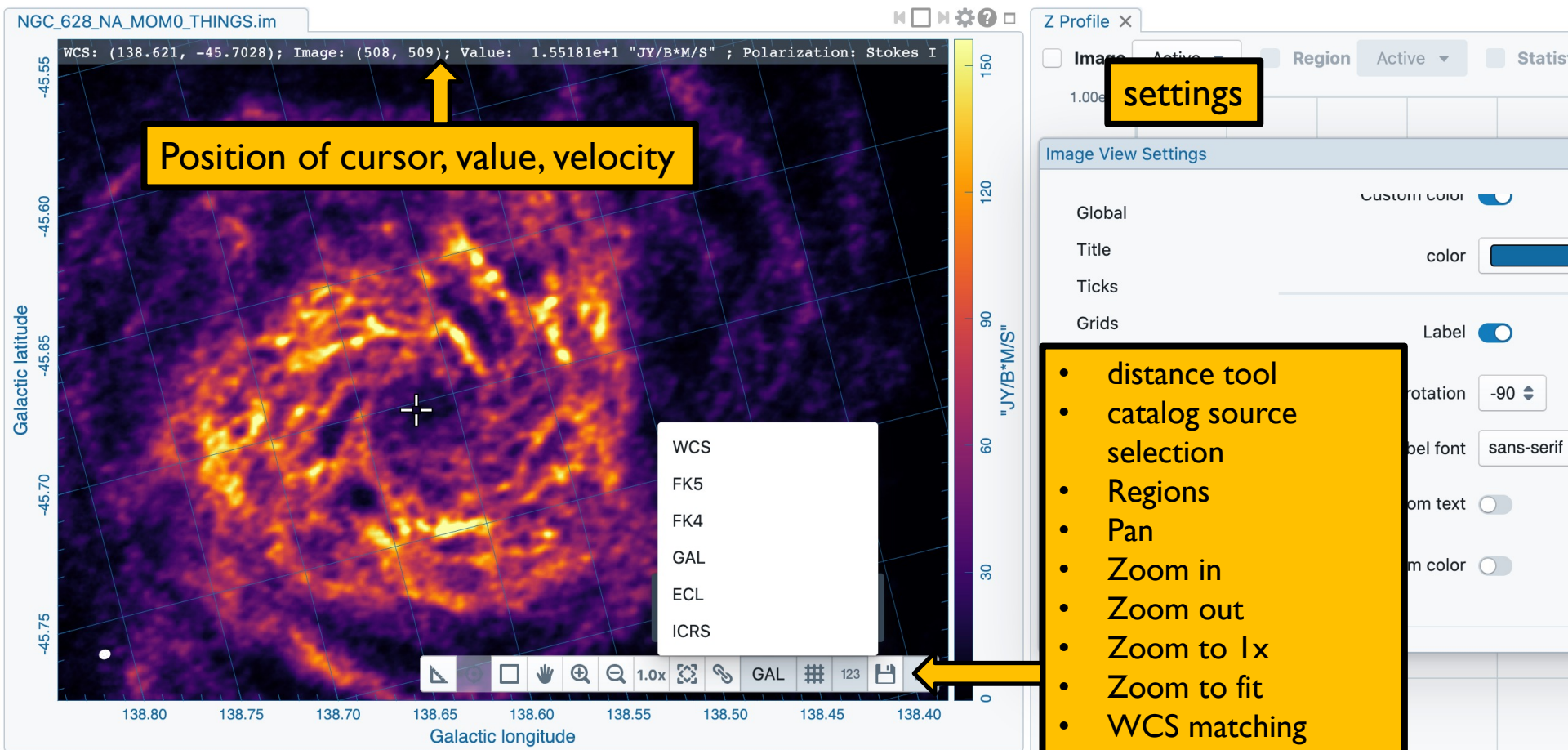
- Region list
- Log
- Spatial (xy profile)
- Spectral (z) profile
- Statistics
- Histogram
- Animator
- Render config
- Stokes
- Image list
- Catalog
- Spectral line query
- Catalog cursor
- Position-Velocity

## Settings/Info:

- Header
- Preferences
- Contours
- Vector Overlay
- 2D Gaussian fitting
- Online catalogue query



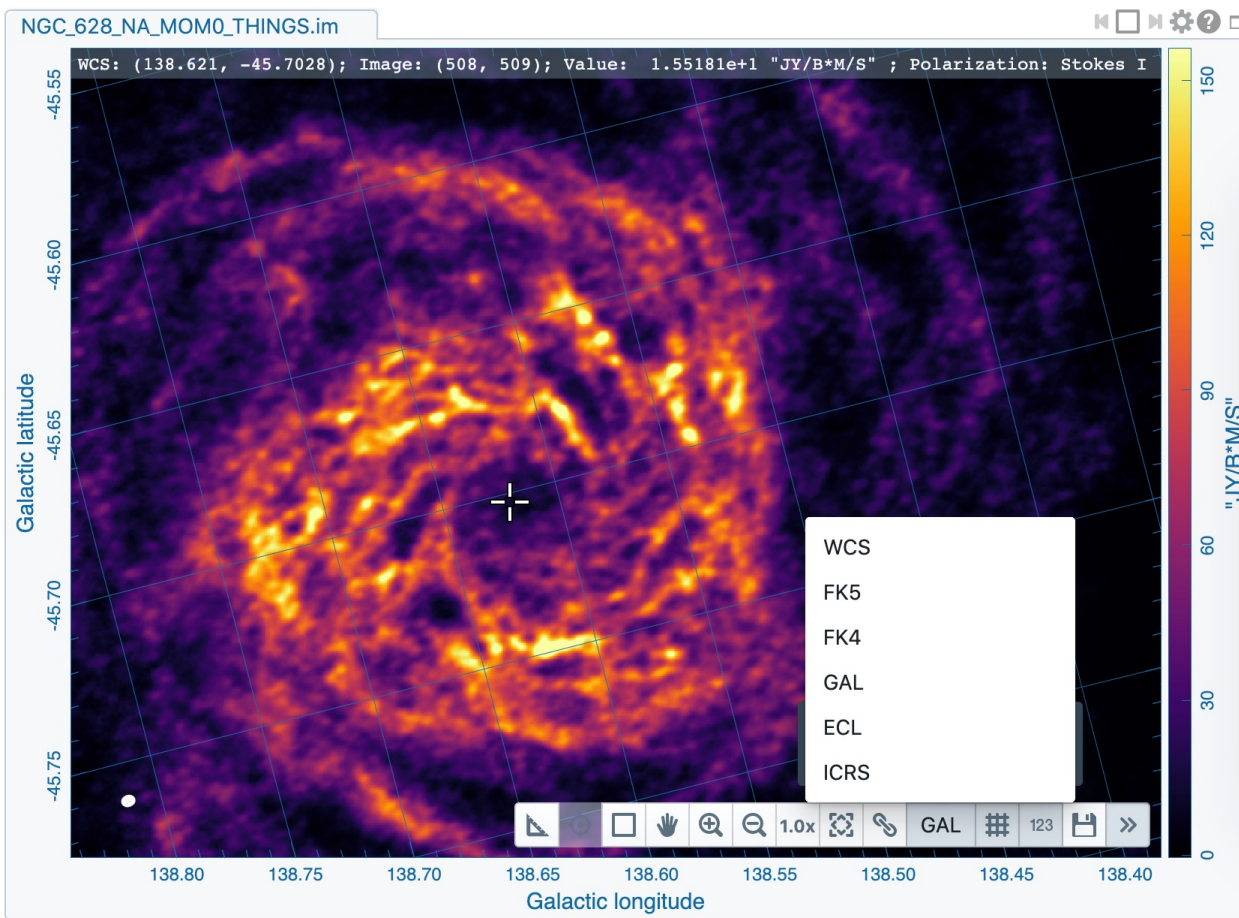
# Image display widget



- distance tool
- catalog source selection
- Regions
- Pan
- Zoom in
- Zoom out
- Zoom to 1x
- Zoom to fit
- WCS matching
- Overlay coordinate
- Grid
- Labels
- Export



# Image display widget



Z Profile X

Image Active  Region Active  Status

1.00e+0

Image View Settings

- Multi panel display
- Overlay of different coordinate grids
- Beam display
- Color wedge
- Distance measuring tool

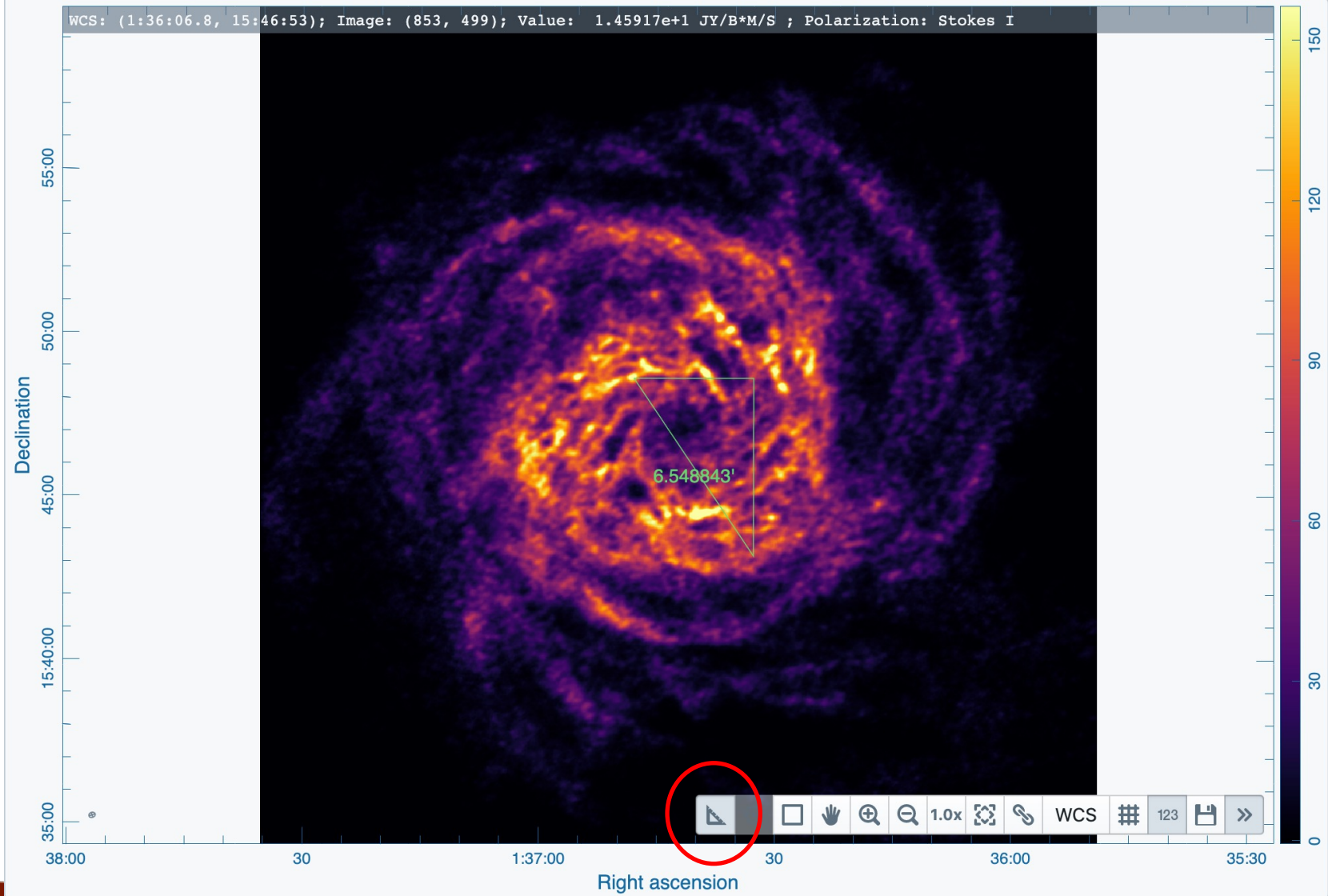
Colorbar Label custom text

Beam Label custom color

Conversion

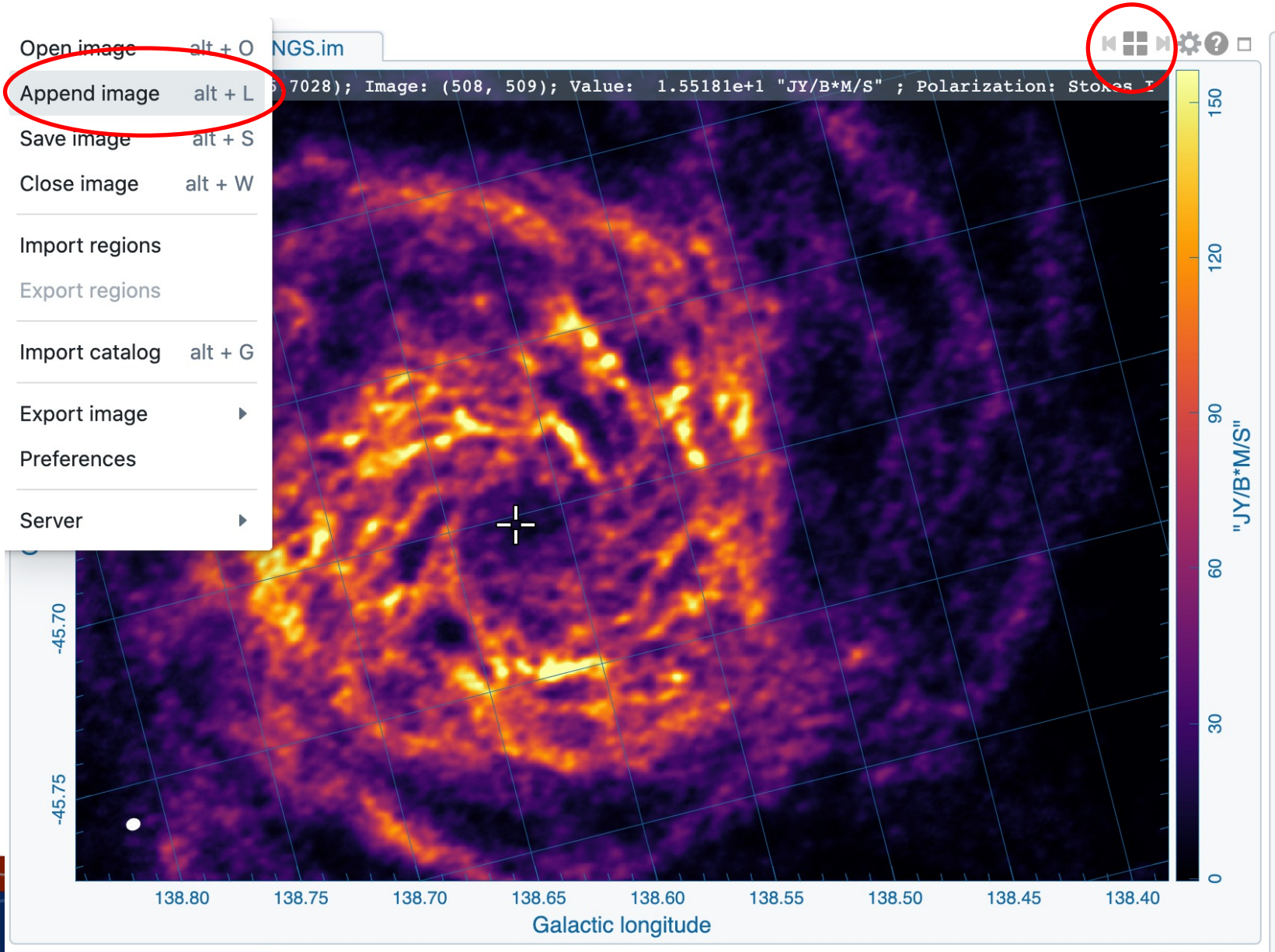
4.00e-1

# Distance Measurement





# Image display widget - multipanel



# Image display widget - multipanel

NGC\_628\_NA\_MOM1\_THINGS.fits

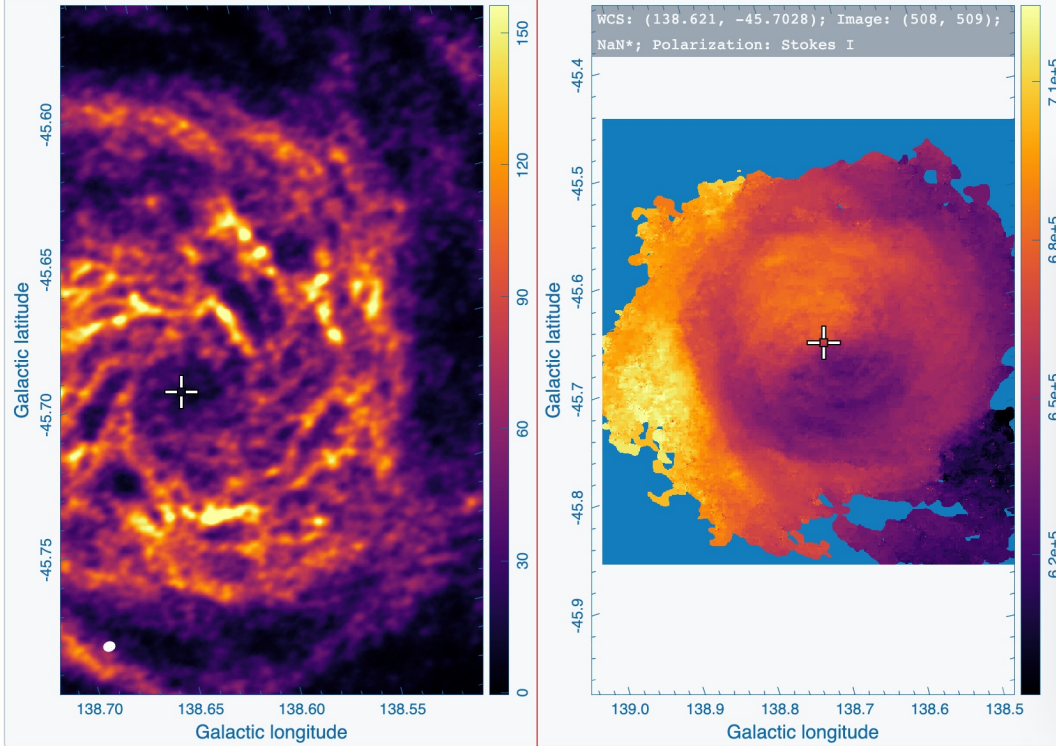


Image	Layers	Matching	Channel	Polarization
0 NGC_628_NA_MOM	R	XY R	0	Stokes I
1 NGC_628_NA_MOM	R	XY R	0	Stokes I

Image View Settings

Global

Enable multi-panel

Title

Ticks Multi-panel mode

Grids Columns (Maximum)

Border Rows (Maximum)

Axes Overlay color

Numbers Tolerance (%)

Labels Labelling

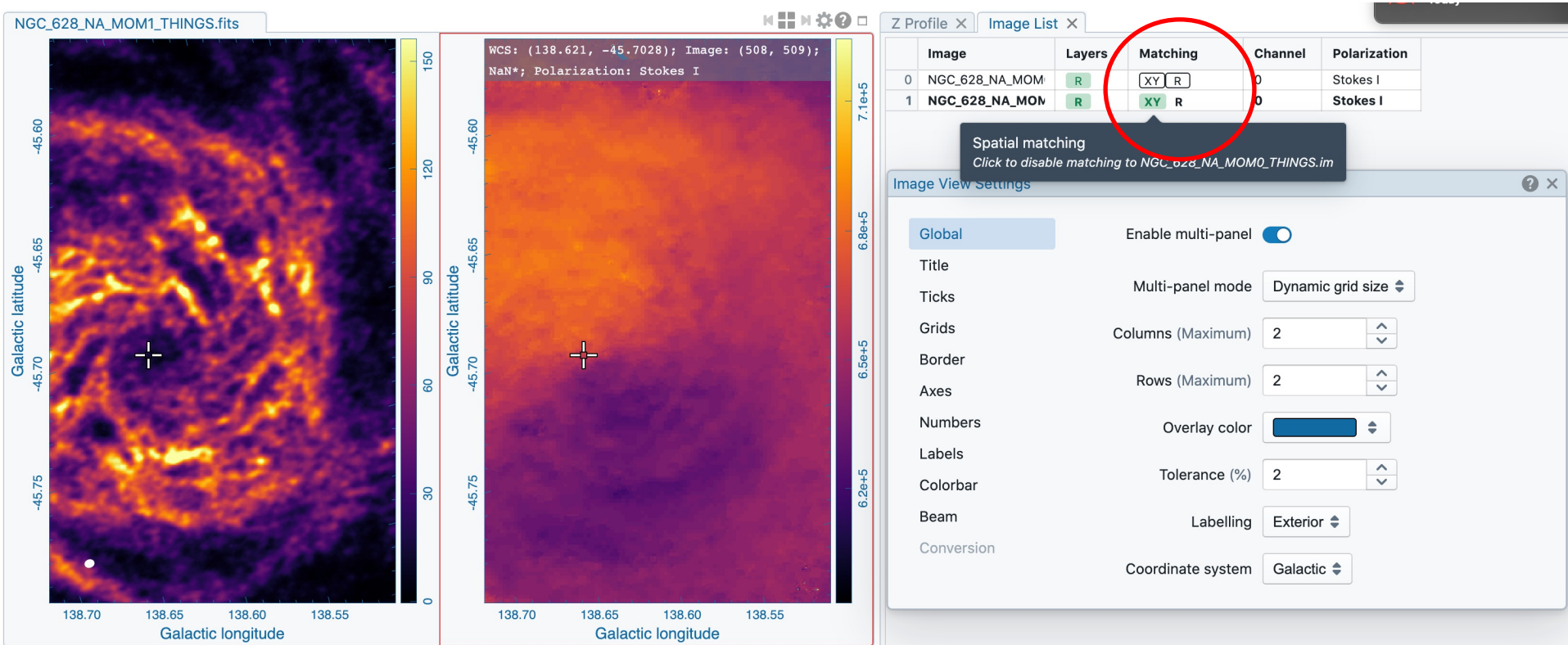
Colorbar

Beam

Conversion Coordinate system

# Image display widget - multipanel

WCS image registration will align coordinates of different images  
Master is outlined; aligned images in green  
Alignment in XY (spatial) and/or Z (spectral), and or R (color scale)





# Cursor Widget

Align WCS first to see multiple image values

The screenshot displays the CARTA software interface with three astronomical images of NGC 628. A cursor is positioned at the center of the images. The 'Image List' table shows the following data:

Image	Layers	Matching	Channel	Polarization
0 NGC_628_NA_MOM	R	XY   R	0	Stokes I
1 NGC_628_NA_MOM	R	XY R	0	Stokes I
2 NGC_628_NA_CUBE	R	XY Z R	29	Stokes I

The 'Cursor Info' window displays the following data for the selected image (Image 2):

Image	Value	WCS	XY (World)	XY (Image)	Z	Channel	Polarization
0 NGC_628_N...	1.02394e+2 JY/B*M/S	GAL...	138.613 -45.7517	550.551 398.686	NaN	0	Stokes I
1 NGC_628_N...	6.31224e+5 METR/SEC	GAL...	138.613 -45.7517	550.551 398.686	NaN	0	Stokes I
2 NGC_628_...	1.81849e-4 JY/BEAM	GAL...	138.613 -45.7517	550.551 398.686	FELO- 660528.5...	29	Stokes I

The 'Cursor Info' window also displays the following data for the selected image (Image 2):

WCS: (138.613, -45.7517); Image: (551, 399);  
 Value: 1.81849e-4 JY/BEAM ; FELO-  
 HEL (): 660528.5503 ; Polarization: Stokes I

The profile plots show the following data:

Y Profile: Value (Y/BEAM) vs Y coordinate. Data: (WCS: -45.7516, Image: 399 px, 1.81849e-4)

Z Profile: Value (Y/BEAM) vs FELO-HEL. Data: (660528.550, 1.82e-4)



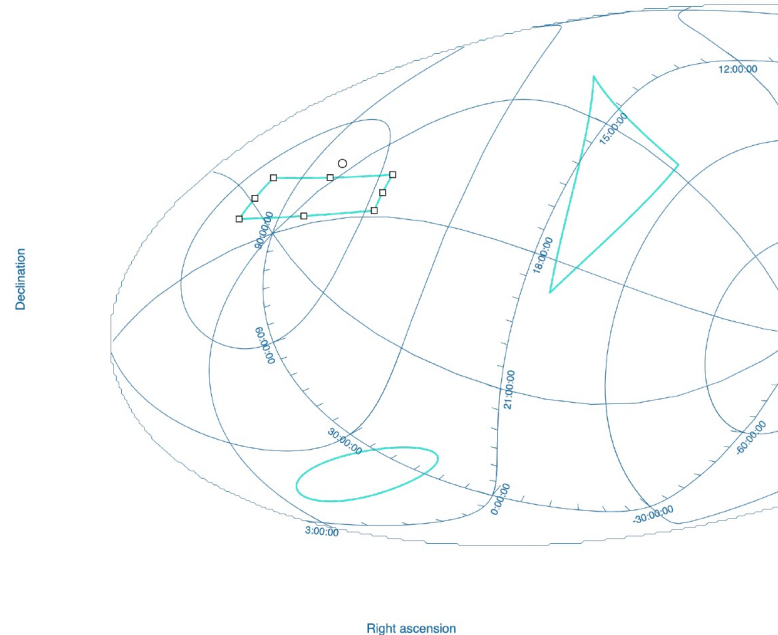
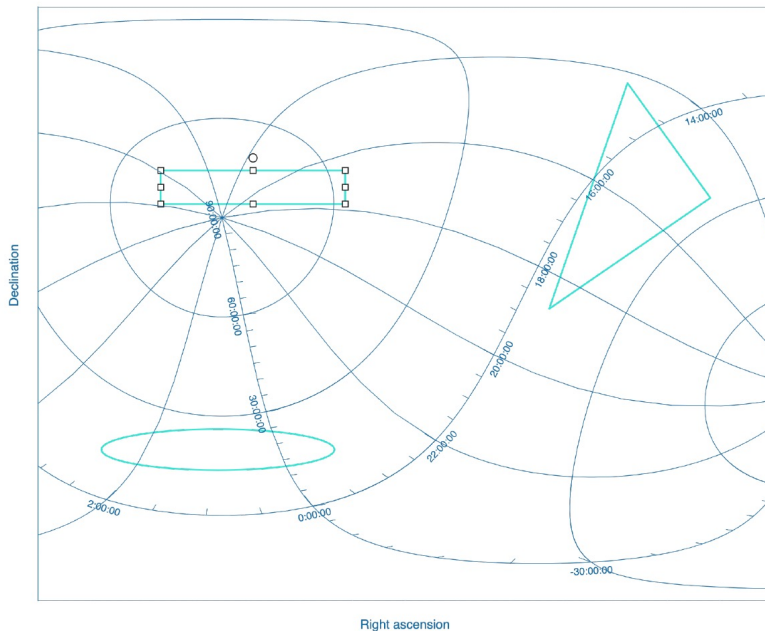
# CARTA

Projection handling:

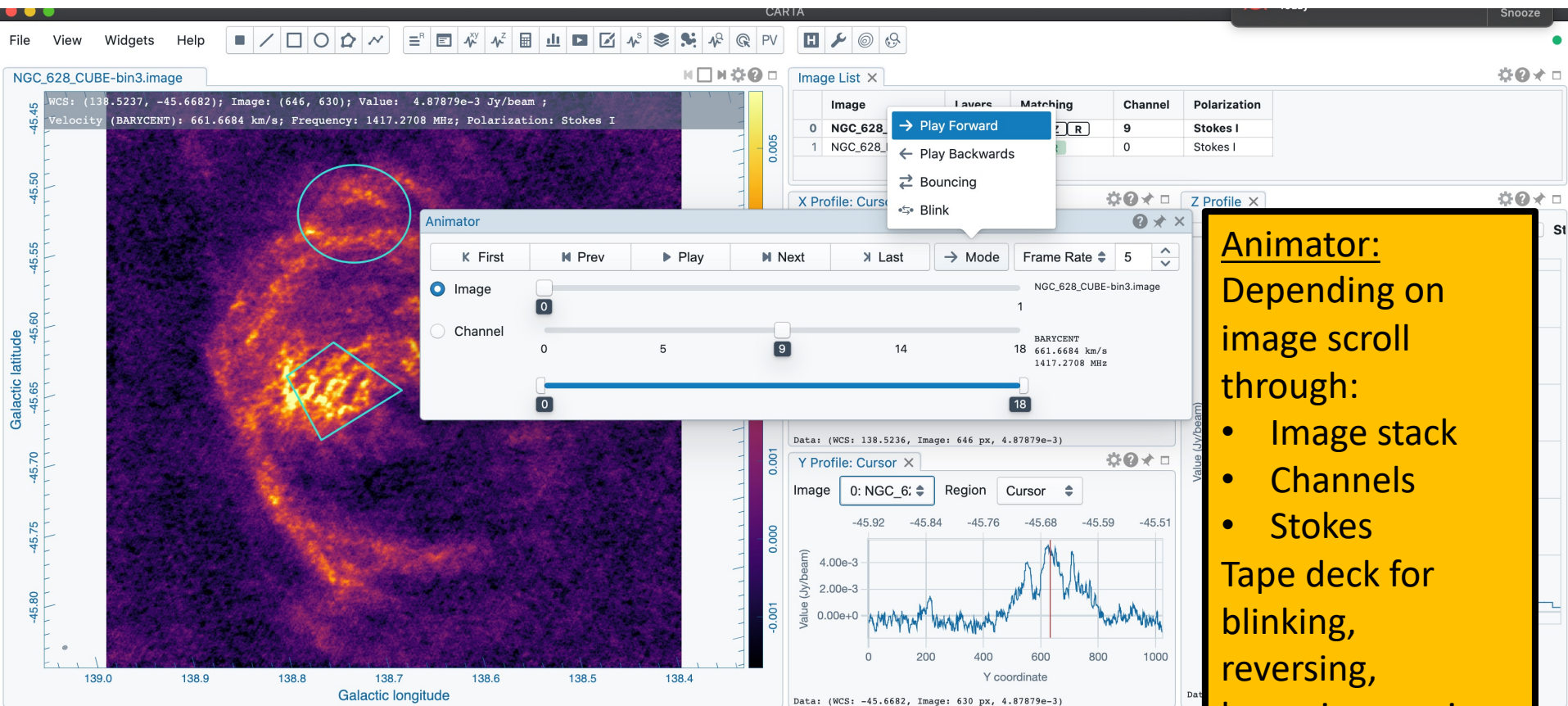
To avoid regridding, WCS matching shifts and rotates the image to the master image  
This produces a small error for large fields, only visible in blinking  
But images are projected correctly when overlaid as contours

Spectral matching: Nearest interpolation

Regions: They project correctly when moving across the sky in different coordinate systems



# Animator



**Animator:**  
Depending on image scroll through:

- Image stack
- Channels
- Stokes

Tape deck for blinking, reversing, bouncing movies

# Rendering

## Selection of

- Color maps
- Scaling/transfer function (shown as overlay)
- Per plane or per cube scaling
- Global scaling through the image list widg
- Bias/Contrast

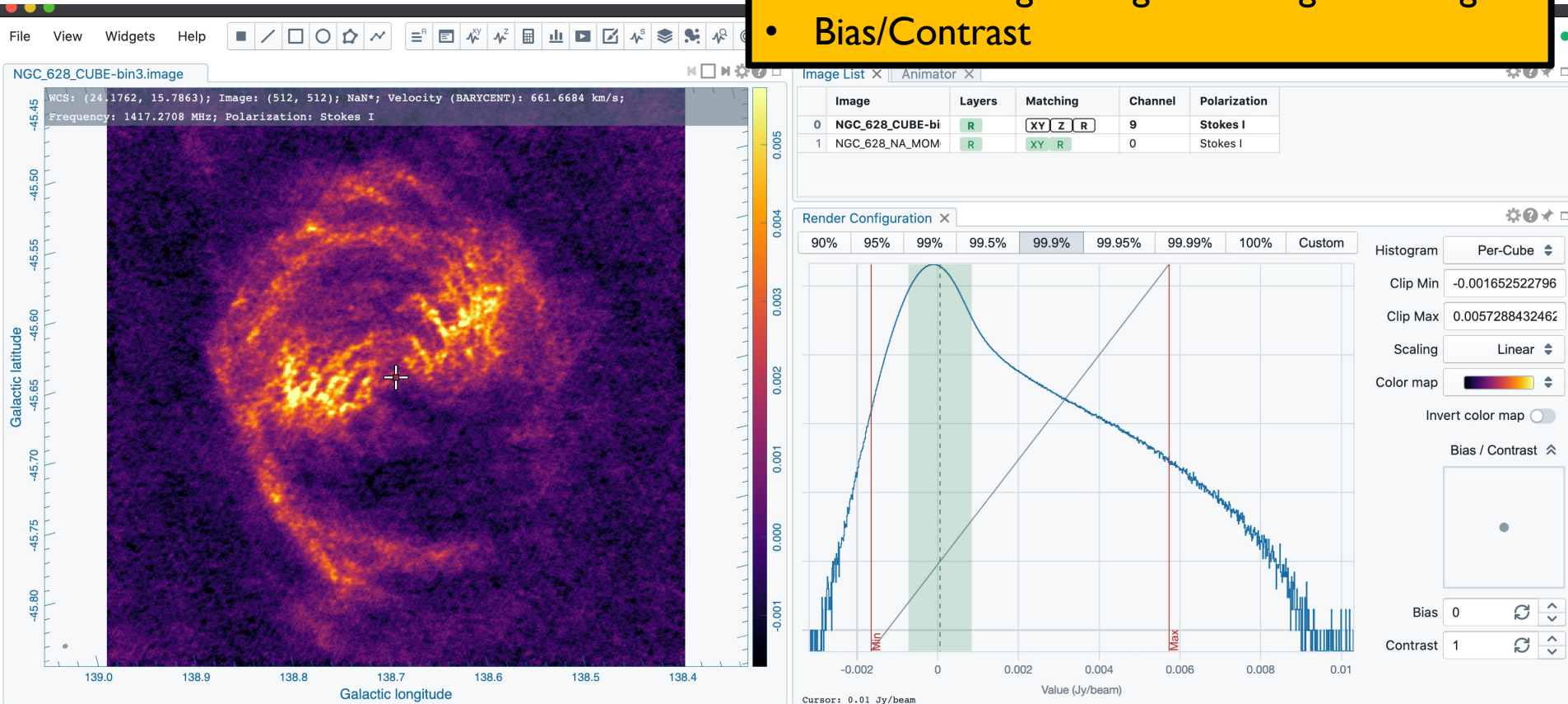


Image statistics, setting the cuts manually or by percentage or by values

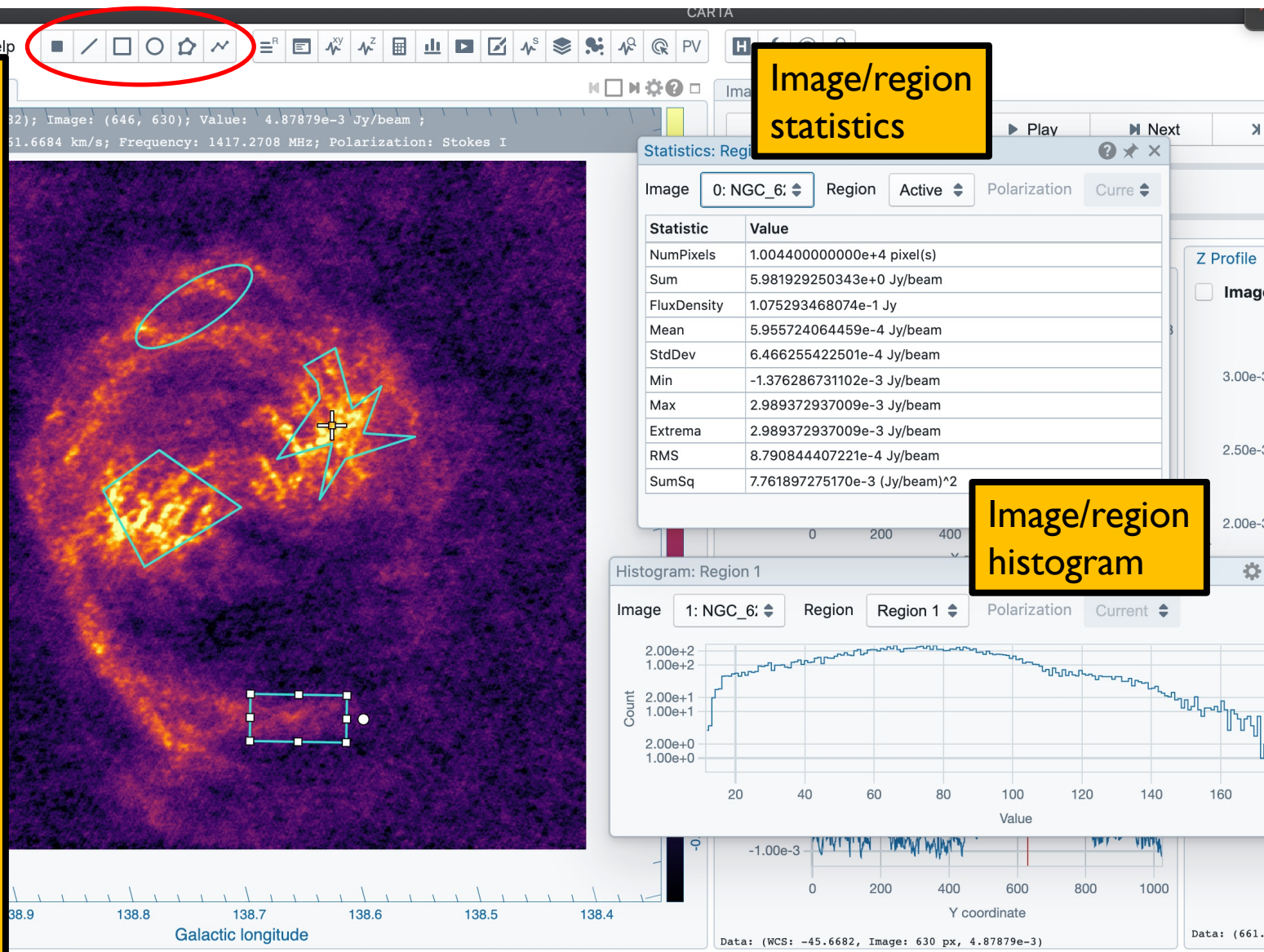


# Regions

Regions can be created (point, line, rectangle, ellipse, polygon, polyline), deleted, rotated, moved, resized. They are properly projected when moved

Save/load in CASA CRTF or DS9 format

Analysis can be done on selected regions (line and polyline for profiles, pV)



Image/region statistics

Image/region histogram

# Set new rest frequency

The screenshot displays the CARTA v3 software interface. On the left, a radio image of IRC10216\_HC3N is shown with a color scale from -0.018 to 0.024. The image is centered on a crosshair. The axes are labeled 'Right ascension' (47.54 to 01) and 'Declination' (16:00 to 30). The top status bar shows WCS information: (9:47:57.47, 13:16:46.2); Image: (147, 164); Value: -1.3649e-2 Jy/beam; Frequency (LSRK): 36.3957 GHz; Velocity: -28.0890 km/s; Polarization: Stokes I.

On the right, the 'Image List' panel shows a table with columns: Image, Layers, Matching, Channel, Polarization. The table contains one entry: 0 IRC10216\_HC3N.ci R XY Z R 27 Stokes I. Below this, the 'Image List Settings' panel is open, showing 'Matching: Rest Frequency', 'Source: 0: IRC10216\_HC3...image (Active)', and 'Rest frequency: 36.392319999 GHz'. A yellow box highlights the 'Image list setting' text.

At the bottom, the 'Z Profile' panel is open, showing a plot of 'Value (Jy/beam)' vs '[LSRK] Frequency (GHz)'. The plot shows a step-like function with a peak around 36.3957 GHz. The y-axis ranges from -2.00e-2 to 8.00e-2. The x-axis ranges from 36.393 to 36.398. A red vertical line is positioned at the peak. The plot is titled 'Z Profile' and has controls for 'Image', 'Region', 'Statistic', and 'Polarization'. The data point at the peak is: Data: (36.395730 GHz, -1.36e-2).



# Saving subimages

Select portion of image  
(assign new rest frequency if desired)

The screenshot displays the CARTA v3 interface. On the left, a radio image of IRC10216\_HC3N.cube\_r0.5.image is shown with a blue rectangular selection box. The image axes are labeled with Right ascension (9:48:00 to 47:54) and Declination (13:17:00 to 16:00). A File Browser window is open in the center, showing a list of files. The selected file is IRC10216\_HC3N.cube\_r0.5.image. The File Browser window has a 'Save Image' tab selected, and the 'Save Image' panel is visible on the right. The 'Save Image' panel shows the source as IRC10216\_HC3N.cube\_r0.5.image, the region as 1 (RECTANGLE), the range unit as Frequency (GHz), and the range from 36.39235438064446 GHz to 36.39873012520509 GHz. The 'Drop degenerate axes' option is checked. Below the File Browser window, two panels are visible, both with the message 'No catalog file loaded' and 'Load a catalog file using the menu'.

Filename	Type	Size
fft-cube.im	CASA	251.0 MB
fft.test	CASA	4.4 MB
IRC10216.36GHzcont.image.fits	FITS	368.6 kB
IRC10216_HC3N.cube_r0.5.image	CASA	19.4 MB
IRC10216_HC3N.cube_r0.5.image-copy	CASA	19.4 MB
IRC10216_HC3N.cube_r0.5.image.fits	FITS	18.7 MB
IRC10216_HC3N.cube_r0.5.image.mir	Miriad	19.3 MB
m82-car-2000.fits	FITS	4.0 MB
m82-tan-2000.fits	FITS	4.0 MB
NGC628_dss.fits	FITS	371.5 kB
NGC628_galex.fits	FITS	371.5 kB
NGC_628_CUBE-bin3.image	CASA	79.8 MB
NGC_628_CUBE.image	CASA	251.0 MB
NGC_628_NA_CUBE_THINGS.copy.fits	FITS	247.7 MB
NGC_628_NA_CUBE_THINGS.copy.mir	Miriad	243.3 MB
NGC_628_NA_CUBE_THINGS.copy.mir-manipulated	Miriad	243.3 MB

Save Image File Information Header

Source IRC10216\_HC3N.cube\_r0.5.image

Region 1 (RECTANGLE)

Range unit Frequency (GHz)

LSRK

Range from 36.39235438064446 (GHz)

Range to 36.39873012520509 (GHz)

Drop degenerate axes

IRC10216\_HC3N.cube\_r0.5.image CASA

No catalog file loaded  
Load a catalog file using the menu

No catalog file loaded  
Load a catalog file using the menu

# Contours

• Match the coordinates for multiple images

The screenshot displays the software interface for handling astronomical data. On the left, three panels show different stages of contour processing on the same data: a raw image, a color-coded intensity map, and a final image with overlaid contours. The central panel shows a color map with a crosshair cursor and associated WCS information: `WCS: (138.613, -45.7517); Image: (551, 399); Value: 6.31224e+5 METR/SEC; Polarization: Stokes I`. To the right, the 'Image List' table shows the following data:

Image	Layers	Matching	Channel	Polarization
0	NGC_628_NA_MOM	R	0	Stokes I
1	NGC_628_NA_MOM	XY R	0	Stokes I
2	NGC_628_NA_CUBE	XY Z R	29	Stokes I

The 'Matching' column for images 1 and 2 is circled in red. Below the table, the 'Contour Configuration' panel is visible, showing a plot of 'Value (METR/SEC)' vs 'Value (METR/SEC)' with various levels and a 'Generate' button. The 'Parameters' section includes: Min: 5.933e+5, Max: 7.246e+5, N: 9, and Scaling: Linear.

Append multiple images

Contour overlay:  
Create contours in various ways: percentage, min max, scaling, direct input, etc. The contour levels are shown on an image histogram and can be edited  
Styling allow color map as well as constant color



# Contours

CARTA

File View Widgets Help

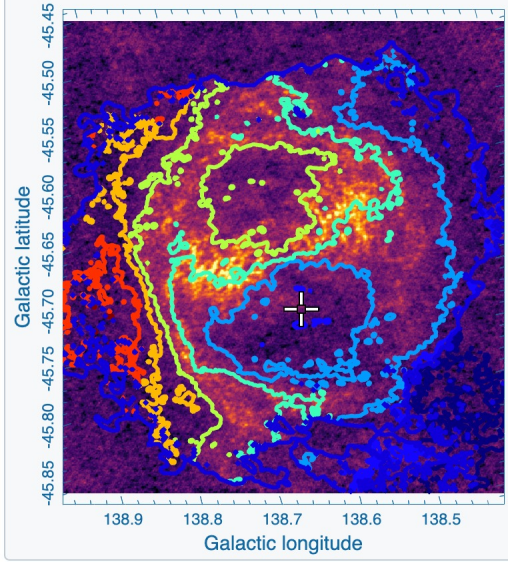
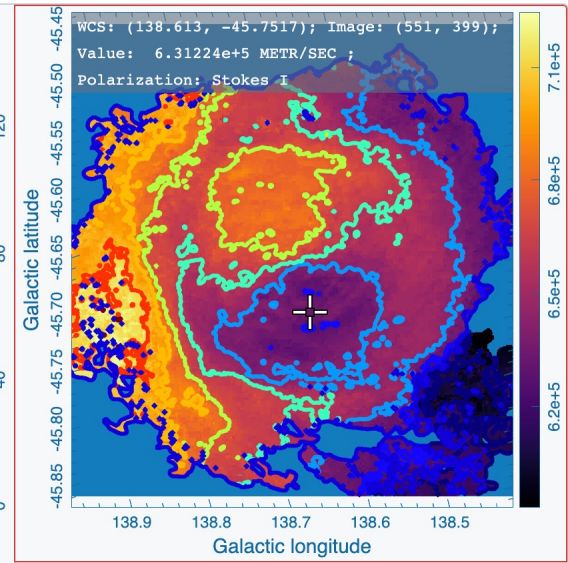
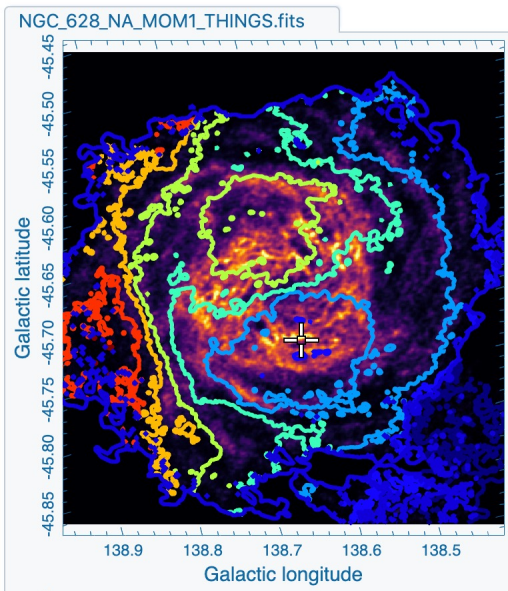


Image List x Animator x

Image	Layers	Matching	Channel	Polarization
0 NGC_628_NA_MOM	R	X R	0	Stokes I
1 NGC_628_NA_MOM	R C	X R	0	Stokes I
2 NGC_628_NA_CUBE	R	Y Z R	29	Stokes I

X Profile: Cursor x

Image Active

Data: (WCS: 138.6126, Image: 0)

Y Profile: Cursor x

Image Active

Data: (WCS: -45.7516, Image: 0)

### Contour Configuration

Data: NGC\_628\_NA\_MOM1\_THINGS.fits

Source:

Levels: Configuration Styling

Thickness: 3

Dashes: NegativeOnly

Color Mode: Color-mapped

Color Map:

Bias: 0

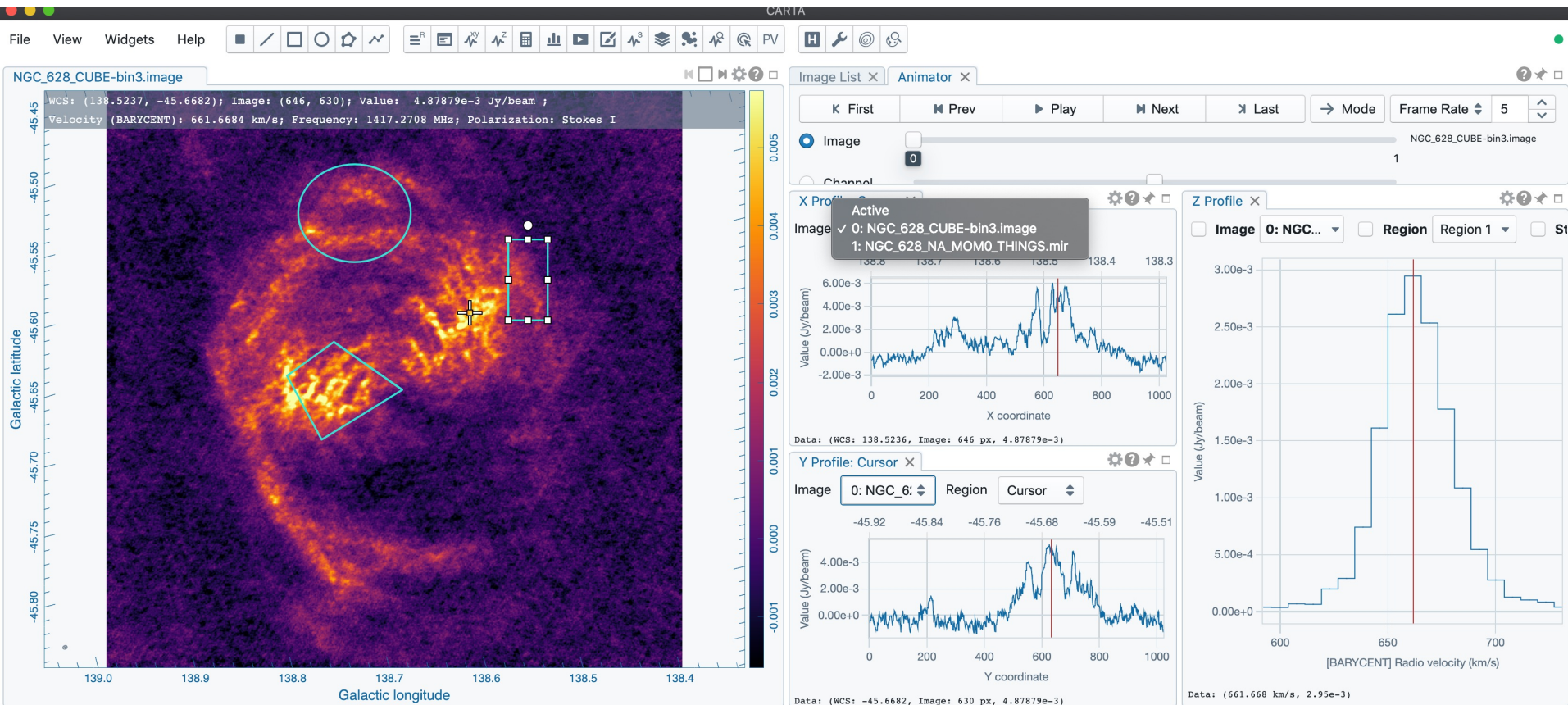
Contrast: 1

Color:

Clear Apply Close

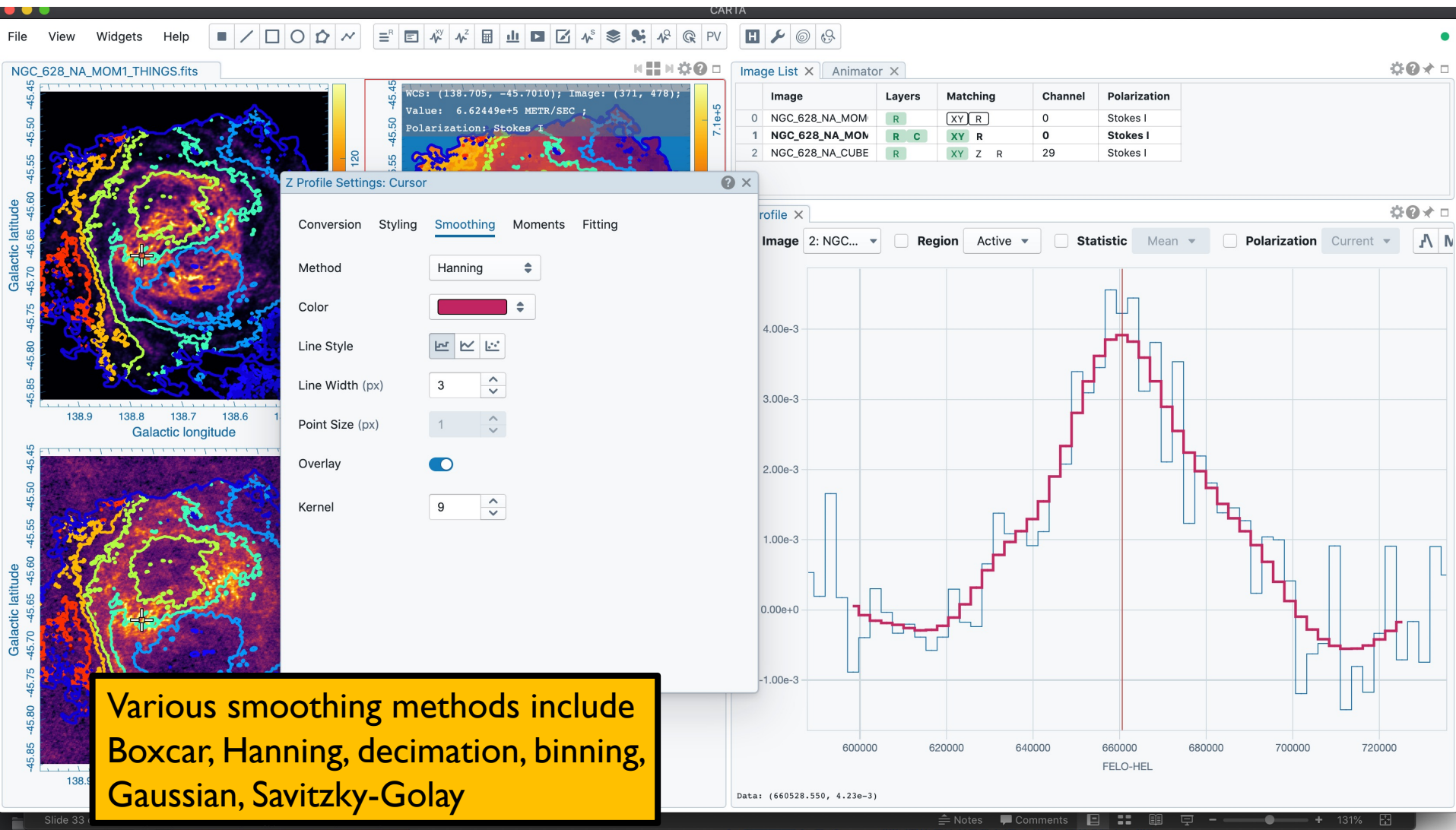
# Profiles

- Spatial/Spectral profile: Line shape can be changed (color, steps/connect/points), spectral smoothing; data can be saved as ascii
- Marker is the position of the cursor/animator (freeze with 'f')
- Selection of region and image in each widget
- For spectral profile, regions can be selected, as well as statistics, axis labels (velocity, frequency, channel, wavelength, ..)
- 3D Position is marked by a red vertical line





# Spectral smoothing



# Moment maps

Spectral selection can be done interactively, including clip. Images can be saved

The screenshot displays the CARTA v3 software interface. On the left, there are three panels showing moment maps for NGC 628. The top-left panel shows the 'moment.weighted\_coord' map with a color scale from -0.001 to 0.005. The top-right panel shows another moment map with a color scale from 0.06 to 0.12. The bottom-left panel shows a zoomed-in view of a region with WCS coordinates (138.4836, -45.6577) and a value of 6.65597e+2 km/s, with a color scale from 650 to 670. The right side of the interface features an 'Image List' table, a 'Z Profile' plot, and a 'Z Profile Settings: Cursor' dialog box.

Image	Layers	Matching	Channel	Polarization	
0	NGC_628_NA_CUBE	R	XY Z R	29	Stokes I
1	NGC_628_NA_CUBE	R	XY R	0	Stokes I
2	NGC_628_NA_CUBE	R	XY R	0	Stokes I

**Z Profile Settings: Cursor**

- Conversion: Styling Smoothing **Moments** Fitting
- Image (0: NGC\_628\_...): 0: NGC\_628\_...
- Region (Image): Active
- Coordinate: FELO-HEL (Native WCS)
- System: [Dropdown]
- Range: From 638082.3 To 687531.7
- Mask: None
- Range (JY/BEAM): From 0 To 1
- Moments: 0 x 1 x
- Generate**

**Z Profile**

- Image: 0: NGC\_628\_...
- Region: Active
- Statistic: Mean
- Polarization: Current

The Z Profile plot shows a histogram of the data with a red line representing the mean profile. The x-axis is labeled 'FELO-HEL' and ranges from 600,000 to 720,000. The y-axis represents intensity. A vertical red line is positioned at approximately 660,000.

# Spectral line labeling

Based on splatalogue, select line strength, frequency range and redshift

The screenshot displays the CARTA v3 software interface for spectral line labeling. The main window shows a spectral plot with intensity on the y-axis (ranging from 0.00e+0 to 8.00e-3) and frequency on the x-axis (ranging from 600,000 to 720,000 MHz). A red line represents the selected spectral line, and a blue line represents the rest of the spectrum. The plot is labeled 'FELO-HEL' and 'Data: (660528.550, 5.12e-3)'. Two vertical lines are marked: 'H-atom 2S1/2 F=1-0' at approximately 656,281 MHz and 'H&beta: H(209) beta:' at approximately 706,528 MHz.

The 'Spectral Line Query' dialog box is open, showing a list of lines with columns for Name, Species, Chemical Name, Shifted Frequency, Rest Frequency, and Rest Frequency. The 'Velocity (km/s)' is set to 660. The 'Spectral Profiler' section shows 'spectral-profiler-0' and buttons for 'Filter', 'Reset', 'Plot', and 'Clear'.

The 'Image List' table shows the selected image and its properties:

Image	Layers	Matching	Channel	Polarization
0 NGC_628_NA_CUBE	R	XY Z R	29	Stokes I
1 NGC_628_NA_CUBE	R	XY R	0	Stokes I
2 NGC_628_NA_CUBE	R	XY R	0	Stokes I



# Spectral Line Fitting

Autodetection of line for initial fitting parameters (can also be set manually).  
Fit region can be selected in spectrum or entered directly  
Options: multiple Gaussians, Lorentzians

The screenshot shows the CARTA software interface. On the left, there are two panels: the top one shows a zoomed-in view of the spectral data with axes for Galactic latitude and longitude, and the bottom one shows a zoomed-in view of the fitted spectral line with axes for Galactic latitude and longitude. The main panel on the right is titled "Z Profile Settings: Cursor" and contains the following settings:

- Conversion: Styling, Smoothing, Moments, **Fitting**
- Data source: NGC\_628\_NA\_CUBE\_THINGS.fits
- Profile function: Gaussian
- Auto detect:  w/ cont.  auto fit
- detected 1 component.
- Components: 1
- Center: 655353
- Amplitude: 0.00552114277778110
- FWHM: 15526.650876000058
- Continuum: None
- Fitting result: (empty box)

Buttons at the bottom include "Reset", "Fit", "View log", and a "residual" toggle.





# Spectral Line Fitting

The screenshot displays the CARTA software interface for spectral line fitting. The main window shows a spectral plot of FELO-HEL intensity versus wavelength (600000 to 680000). A Gaussian fit is overlaid on the data, and a vertical line marks the Helium 2S1/2-1-0 transition at approximately 655353. The 'Z Profile Settings: Cursor' dialog box is open, showing the fitting parameters for the detected component.

Image	Layers	Matching	Channel	Polarization
GC_628_NA_CUBE	R	XY Z R	29	Stokes I
GC_628_NA_CUBE	R	XY R	0	Stokes I
GC_628_NA_CUBE	R	XY R	0	Stokes I

**Z Profile Settings: Cursor**

Conversion Styling Smoothing Moments **Fitting**

Data source: NGC\_628\_NA\_CUBE\_THINGS.fits

Profile function: Gaussian

Auto detect:  w/ cont.  auto fit

detected 1 component.

Components: 1

Center: 655353

Amplitude: 0.00552114277778110

FWHM: 15526.650876000058

Continuum: None

Fitting result:

```

Component #1
Center = 655547.431446 (undefined)
Center Error = 250.777555 (0.038%)
Amplitude = 0.005615 (JY/BEAM)
Amplitude Error = 0.000124 (2.215%)
FWHM = 23108.497573 (undefined)
FWHM Error = 602.595058 (2.608%)
Integral = 138.116075 (JY/BEAM * undefin
Integral Error ~ 3.077627 (2.228%)
    
```

Buttons: Reset Fit View log residual

# Spectral Line Fitting

The screenshot displays the CASA software interface for spectral line fitting. The main window shows a radio image of NGC 628 with a cursor positioned at approximately 1:37:00 RA and 15:40:00 Dec. The 'Z Profile Settings' panel is active, showing the following parameters:

- Data source: NGC\_628\_CUBE.image
- Profile function: Gaussian
- Auto detect:  w/ cont.  auto fit
- Components: 2
- Center: 705
- Amplitude: 0.001
- FWHM: 5
- Continuum: None

The 'Fitting result' section displays the following parameters for Component #1:

- Center = 704.602400 (km/s)
- Center Error = 0.720620 (0.102%)
- Amplitude = 0.001960 (Jy/beam)
- Amplitude Error = 0.000534 (27.232%)
- FWHM = 5.439166 (km/s)
- FWHM Error = 1.734660 (31.892%)
- Integral = 0.011350 (Jy/beam \* km/s)
- Integral Error = 0.003117 (27.460%)

The 'Z Profile' panel shows a plot of Value (Jy/beam) versus [BARYCENT] Radio velocity (km/s). The plot displays a histogram of the data with a fitted Gaussian curve. The peak of the curve is at approximately 704.6 km/s. The plot also shows a secondary peak at approximately 705 km/s. The 'Z Profile' panel includes the following settings:

- Image: 0: NGC...
- Region: Active
- Statistic: Mean
- Polarization: Current

The 'Animator' panel shows the image being displayed, with the following settings:

- Image: NGC\_628\_CUBE.image
- Channel: 38
- Frame Rate: 5

The 'Render' panel shows the image being rendered at 90% zoom. The 'Histogram' panel shows the distribution of the data, with the following settings:

- Histogram: Per-Channel
- Clip Min: -0.002317636260
- Clip Max: 0.007166723976
- Scaling: Linear
- Color map: [Color bar]

# Position-Velocity

CARTA

File View Widgets Help

NGC\_628\_NA\_MOM0\_THINGS.fits

WCS: (1:36:50.8, 15:41:32); Image: (429, 286); Value: 9.36201e+1 JY/B\*/M/S ; Polarization: Stokes I

X Profile: Region #1

Image Active Region Active

Value

1.00e+0  
8.00e-1  
6.00e-1  
4.00e-1  
2.00e-1  
0.00e+0

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

PV Generator

Generate PV image

Image (1: NGC\_628\_N... 1: NGC\_628\_NA\_I

Region (Region 1) Region 1

Average Width (px) 3

Generate

Value

1.00e+0  
8.00e-1  
6.00e-1  
4.00e-1  
2.00e-1  
0.00e+0

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Y coordinate

Image List X Animator X Region List X

Image	Layers	Matching	Channel	Polarization
0 NGC_628_CUBE.ima	R	XY Z R	0	Stokes I
1 <b>NGC_628_NA_MOM</b>	R	<b>XY</b> R	0	<b>Stokes I</b>
2 NGC_628_CUBE_pv.	R	XY R	0	Stokes I
3 NGC_628_NA_MOM	R	XY R	0	Stokes I

Declination

42:00 44:00 46:00 48:00 15:50:00 52:00

Right ascension

10 1:37:00 50 40 30 20 36:10

Declination

42:00 44:00 46:00 48:00 15:50:00 52:00

Right ascension

10 1:37:00 50 40 30 20 36:10

[BARYCENT] Radio velocity (km/s)

630 640 650 660 670 680 690

OFFSET (arcmin)

-4 -3 -2 -1 0 1 2 3 4

[BARYCENT] Radio velocity (km/s)

0.001 0.004

-2790 -2800 -2810 -2820 -2830 -2840 -2850

OFFSET (arcmin)

-4 -3 -2 -1 0 1 2 3 4

Render Configuration X

90% 95% 99% 99.5% 99.9% 99.95% 99.99% 100% Custom

Clip Min -0.527750086472

Clip Max 156.3205420161E

Scaling Linear

Color map

Invert color map

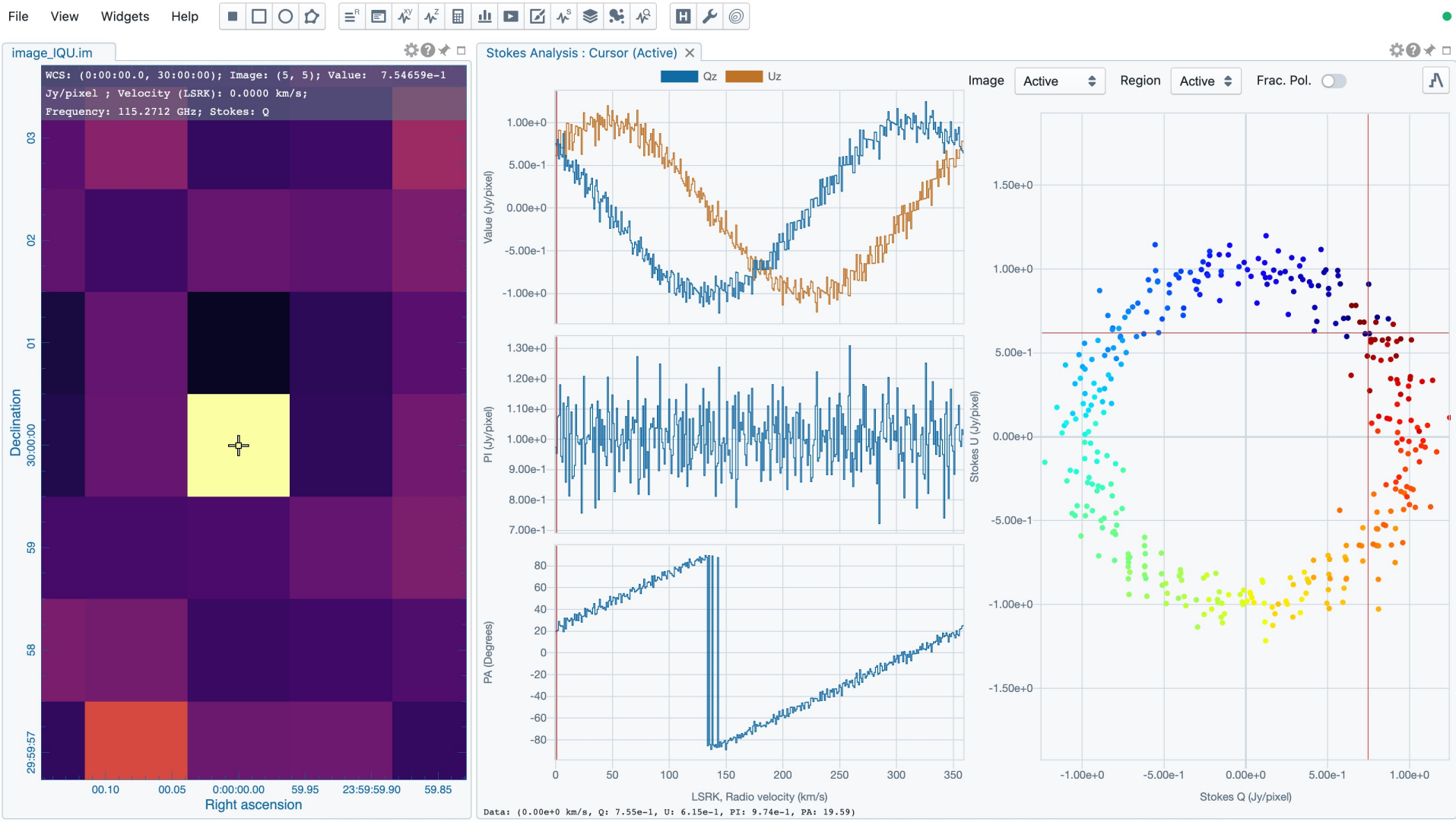
Bias / Contrast

Value (JY/B\*/M/S)

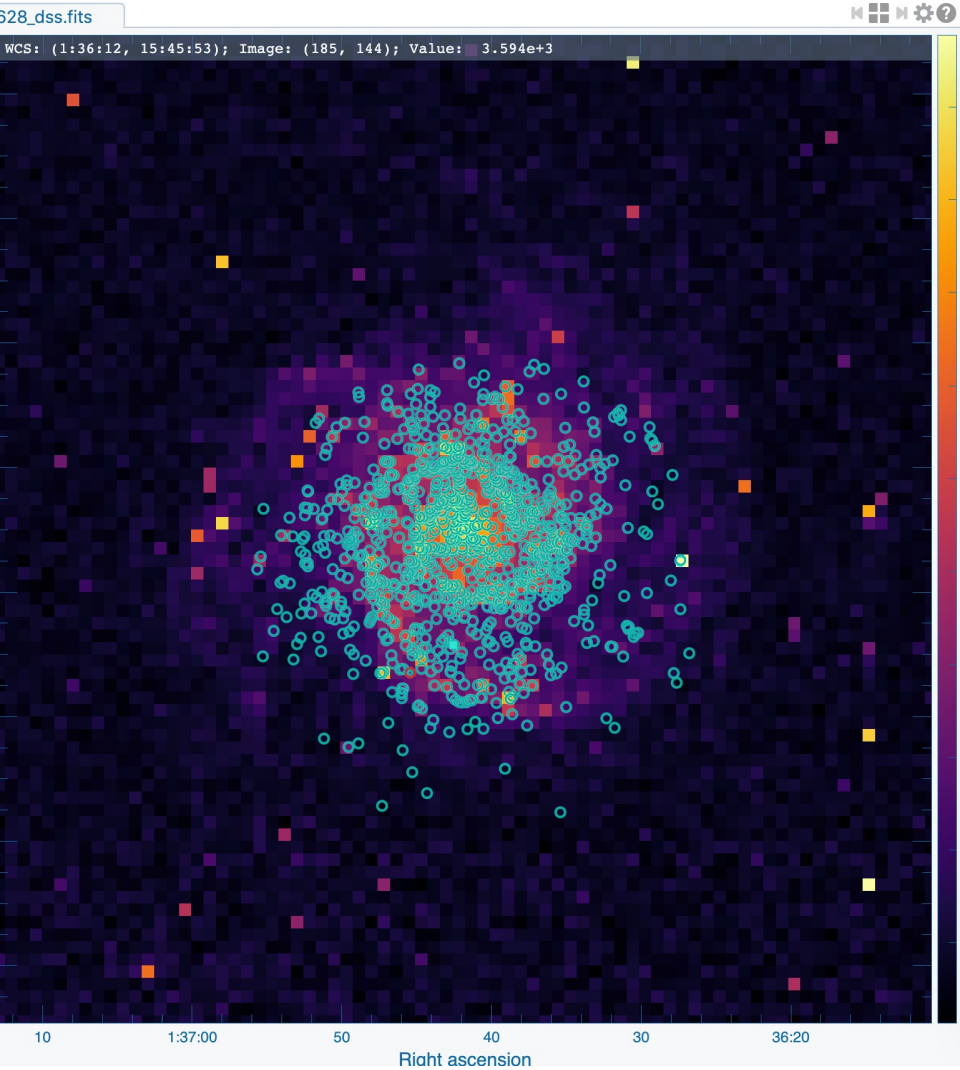
0 50 100 150 200



# CARTA – Stokes Analysis Widget



# CARTA – Catalog tool



Catalog : SIMBAD\_ICRS\_24.1698\_15.7629\_0.39603062065956496deg

File 1 System FK5

Size Color Orientation

Name	Unit	Type	Display	Description
56 vlsr		double	<input type="checkbox"/>	velocity in Local Standard of Rest r...
57 main_id		string	<input checked="" type="checkbox"/>	Main identifier for an object
58 otype_txt		string	<input type="checkbox"/>	Object type
59 ra	deg	double	<input checked="" type="checkbox"/>	Right ascension
60 dec	deg	double	<input checked="" type="checkbox"/>	Declination
61 dist	arcsec	double	<input type="checkbox"/>	Distance to the center coordiante (...)
62 RA_HMS	H:M:S	string	<input type="checkbox"/>	RA in sexagesimal format (H:M:S, c...

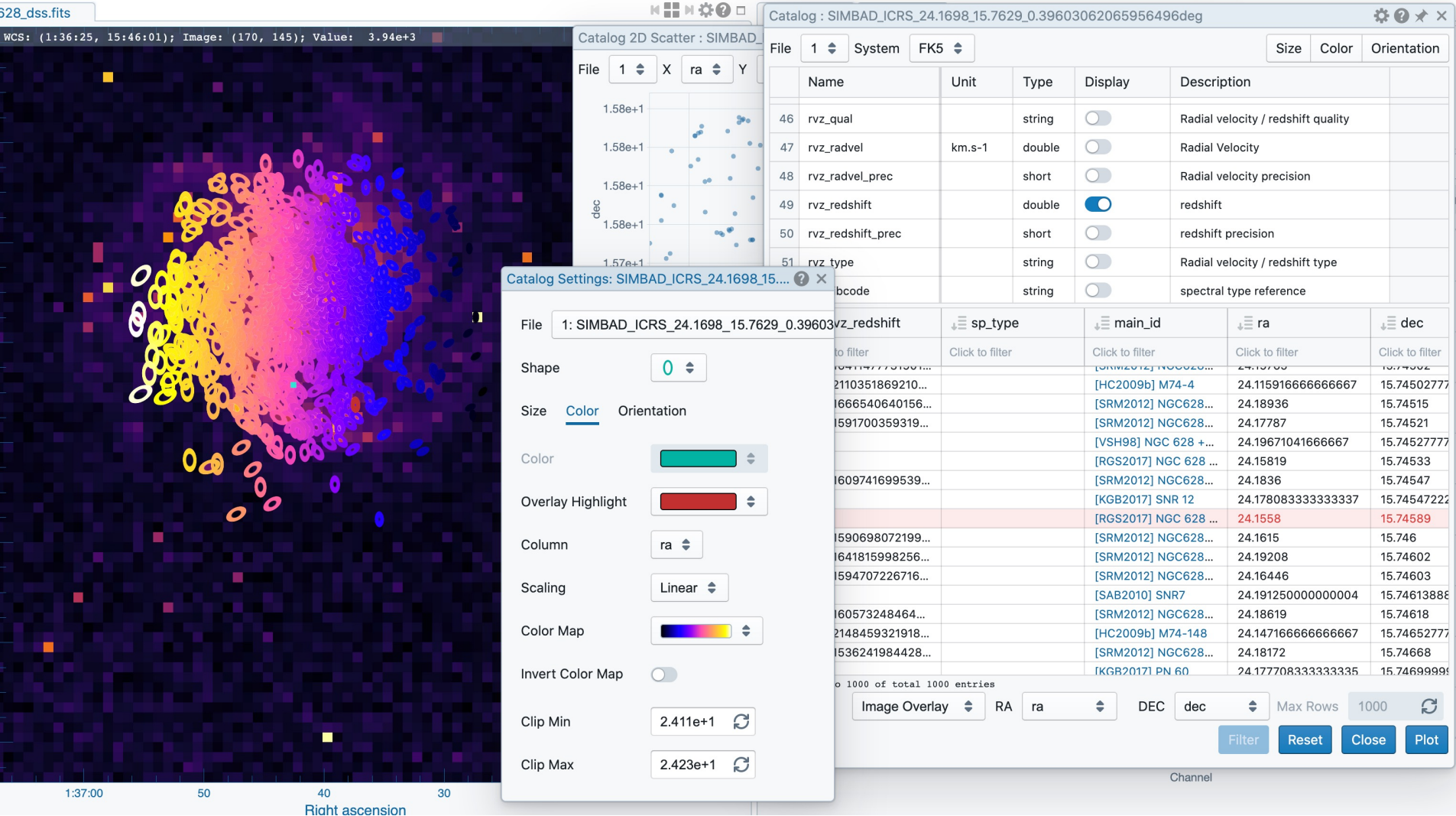
main_id	ra	dec
Click to filter	Click to filter	Click to filter
[SRM2012] NGC628...	24.115916666666667	15.745027777777778
[HC2009b] M74-4	24.115916666666667	15.745027777777778
[SRM2012] NGC628...	24.18936	15.74515
[SRM2012] NGC628...	24.17787	15.74521
[VSH98] NGC 628 + ...	24.196710416666667	15.745277777777776
[RGS2017] NGC 628 ...	24.15819	15.74533
[SRM2012] NGC628...	24.1836	15.74547
[KGB2017] SNR 12	24.178083333333337	15.745472222222222
[RGS2017] NGC 628 ...	24.1558	15.74589
[SRM2012] NGC628...	24.1615	15.746
[SRM2012] NGC628...	24.19208	15.74602
[SRM2012] NGC628...	24.16446	15.74603
[SAB2010] SNR7	24.191250000000004	15.746138888888888
[SRM2012] NGC628...	24.18619	15.74618
[HC2009b] M74-148	24.147166666666667	15.746527777777777
[SRM2012] NGC628...	24.18172	15.74668
[KGB2017] PN 60	24.177708333333335	15.746999999999999

Showing 1 to 1000 of total 1000 entries

Histogram X ra Y dec Max Rows 1000

Filter Reset Close Plot

# CARTA – Catalog tool





# CARTA – Catalog tool

The screenshot displays the CARTA software interface with the following components:

- Main View:** A star field plot titled "NGC628\_dss.fits" showing a cluster of stars. The axes are Right ascension (45 to 30) and Declination (42:00 to 52:00). A red arrow points to a star at approximately RA 44:45, Dec 42:15. A yellow arrow points to a star at approximately RA 31:00, Dec 48:00.
- Catalog Panel:** A table titled "Catalog : SIMBAD\_ICRS\_24.1740\_15.7835\_0.7413236287209521deg". It lists columns: Name, Unit, Type, Display, and Description. The table contains 6 rows of data.
- Catalog Histogram:** A histogram titled "Catalog Histogram : SIMBAD\_ICRS\_24.1740\_15.7835\_0.7413236287209521deg" showing the distribution of Right Ascension (ra). The x-axis ranges from 2.42e+1 to 2.42e+1, and the y-axis is Count (0 to 8000). A red vertical line is at approximately 2.42e+1.
- Catalog 2D Scatter:** A scatter plot titled "Catalog 2D Scatter : SIMBAD\_ICRS\_24.1740\_15.7835\_0.7413236287209521deg" showing the relationship between Right Ascension (ra) and Declination (dec). The x-axis is rvz\_redshift (0.00e+0 to 2.50e-3) and the y-axis is dec (1.57e+1 to 1.58e+1). A blue arrow points to a red dot at approximately rvz\_redshift 1.50e-3, dec 1.58e+1.

# CARTA – Catalog tool

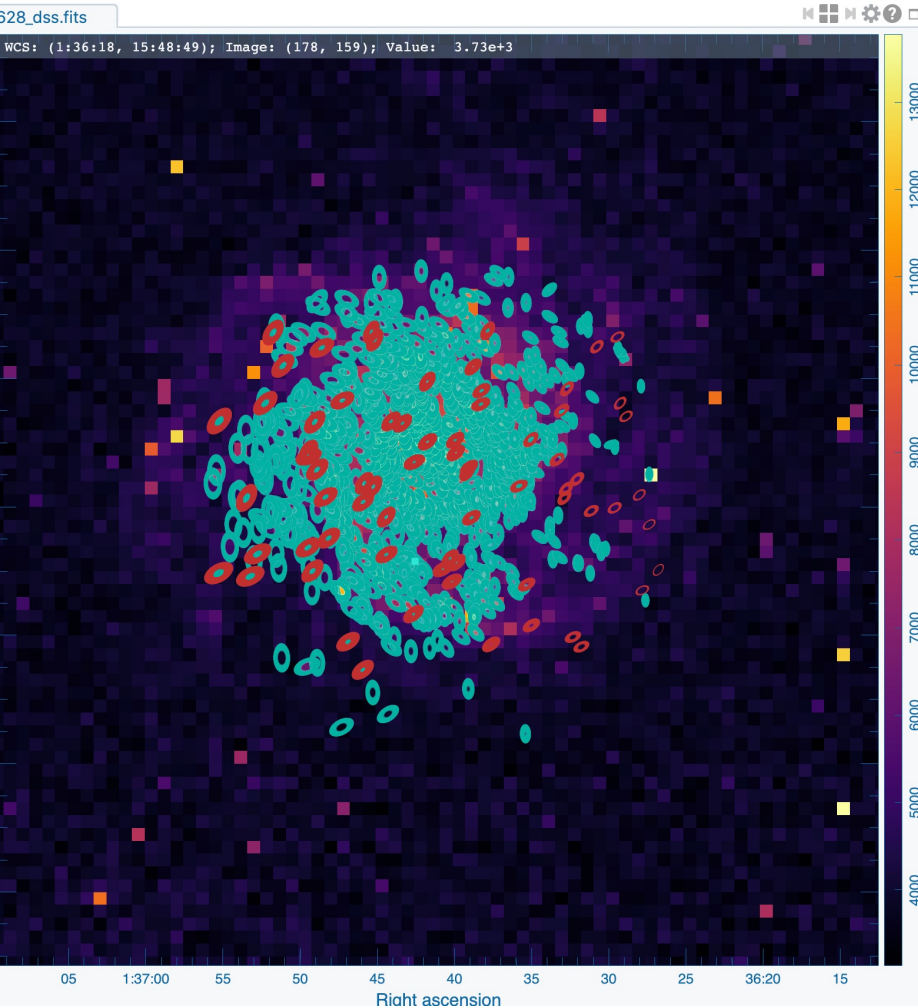


Image List | Animator | Catalog: SIMBAD\_ICRS\_24.1698\_15.7629\_0.5150007572809944deg

File 1 System FK5 Size Color Orientation

Name	Unit	Type	Display	Description
1	coo_bibcode	string	<input type="checkbox"/>	Coordinate reference
2	coo_err_angle	deg	<input type="checkbox"/>	Coordinate error angle
3	coo_err_maj	mas	<input type="checkbox"/>	Coordinate error major axis

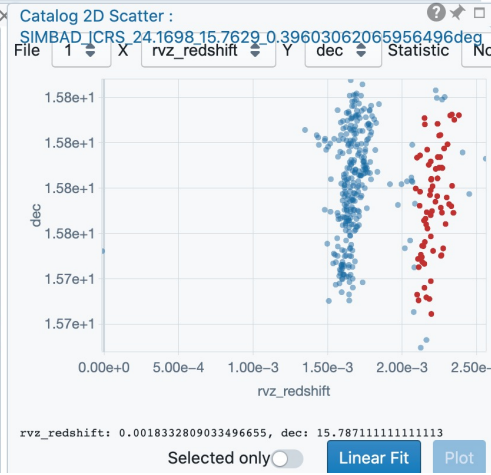
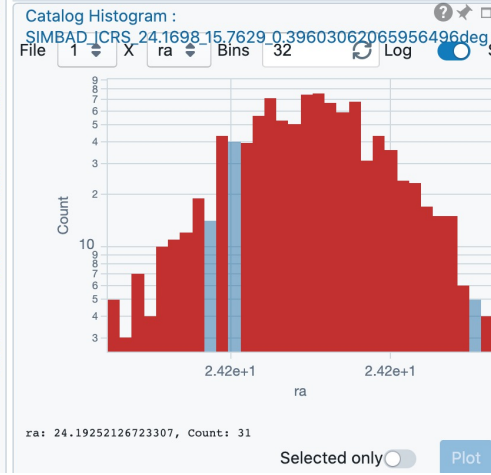
  

rvz_redshift	sp_type	main_id	ra	dec
Click to filter	Click to filter	Click to filter	Click to filter	Click to filter
0.002194925641232...		[HC2009b] M74-19	24.191416666666666	15.724388888888889
0.00207692547720...		[HC2009b] M74-94	24.206458333333333	15.72525
		[SAB2010] SNR5	24.203750000000003	15.726222222222223
		[CHP2004] J013651...	24.213333333333334	15.727500000000004
		[HC2009b] M74-124	24.178416666666667	15.729222222222222
		[YZ1 2016] 257	24.17337	15.73002

Showing 1 to 1000 of total 1000 entries

2D Scatter X rvz\_redsl Y dec Max Rows 1000

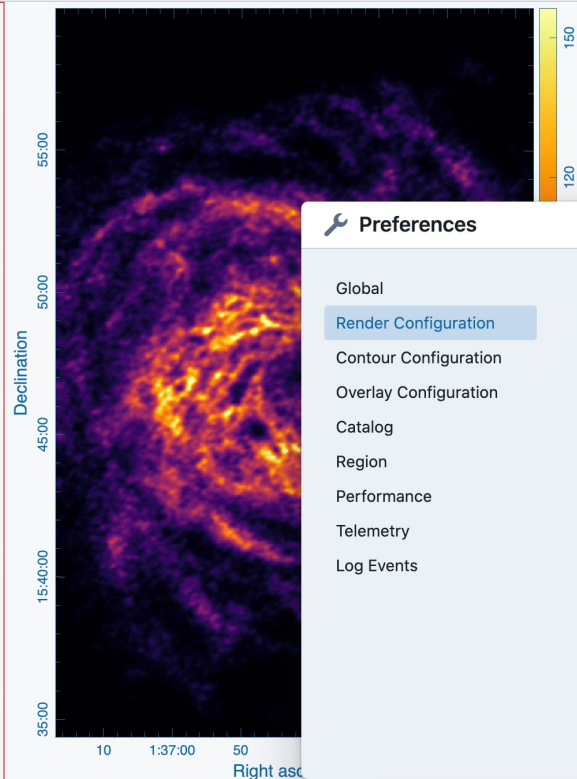
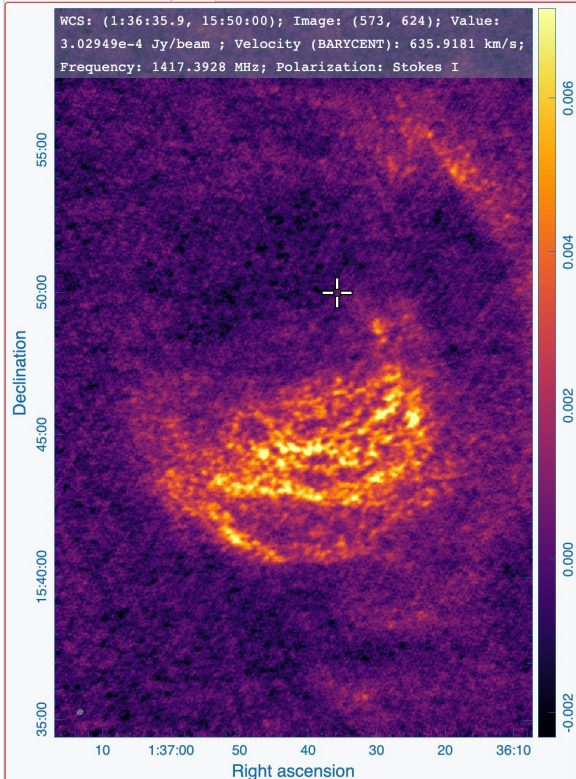
Filter Reset Close Plot



# Preferences

File View Widgets Snippets Help [Icons]

NGC\_628\_CUBE.image [Icons] Animator x [Icons]



Animator x

K First Prev Play Next Last Mode Frame Rate 5

Image 0 1 NGC\_628\_CUBE.image

Channel 0 14 29 38 43 57 BARYCENT 635.9181 km/s 1417.3928 MHz

### Preferences

- Global
- Render Configuration**
- Contour Configuration
- Overlay Configuration
- Catalog
- Region
- Performance
- Telemetry
- Log Events

Default Scaling: Linear

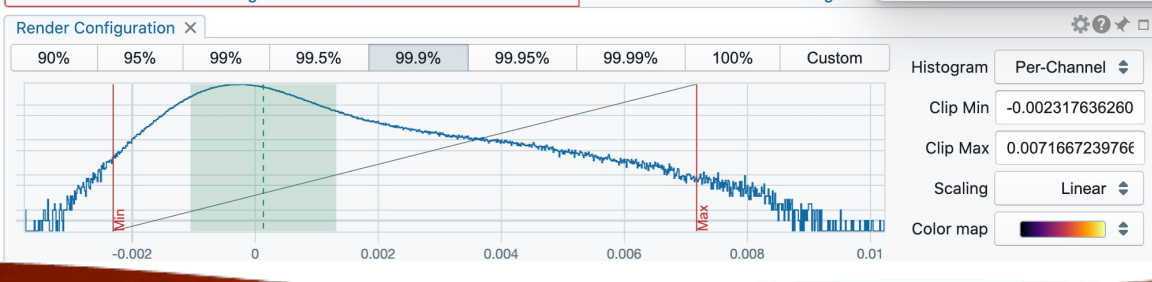
Default Color Map: [Color Bar]

Default Percentile Ranks: 99.9%

NaN Color: [Blue Box]

Smoothed Bias/Contrast:

Restore defaults Close





# Python scripting in progress/Code snippet

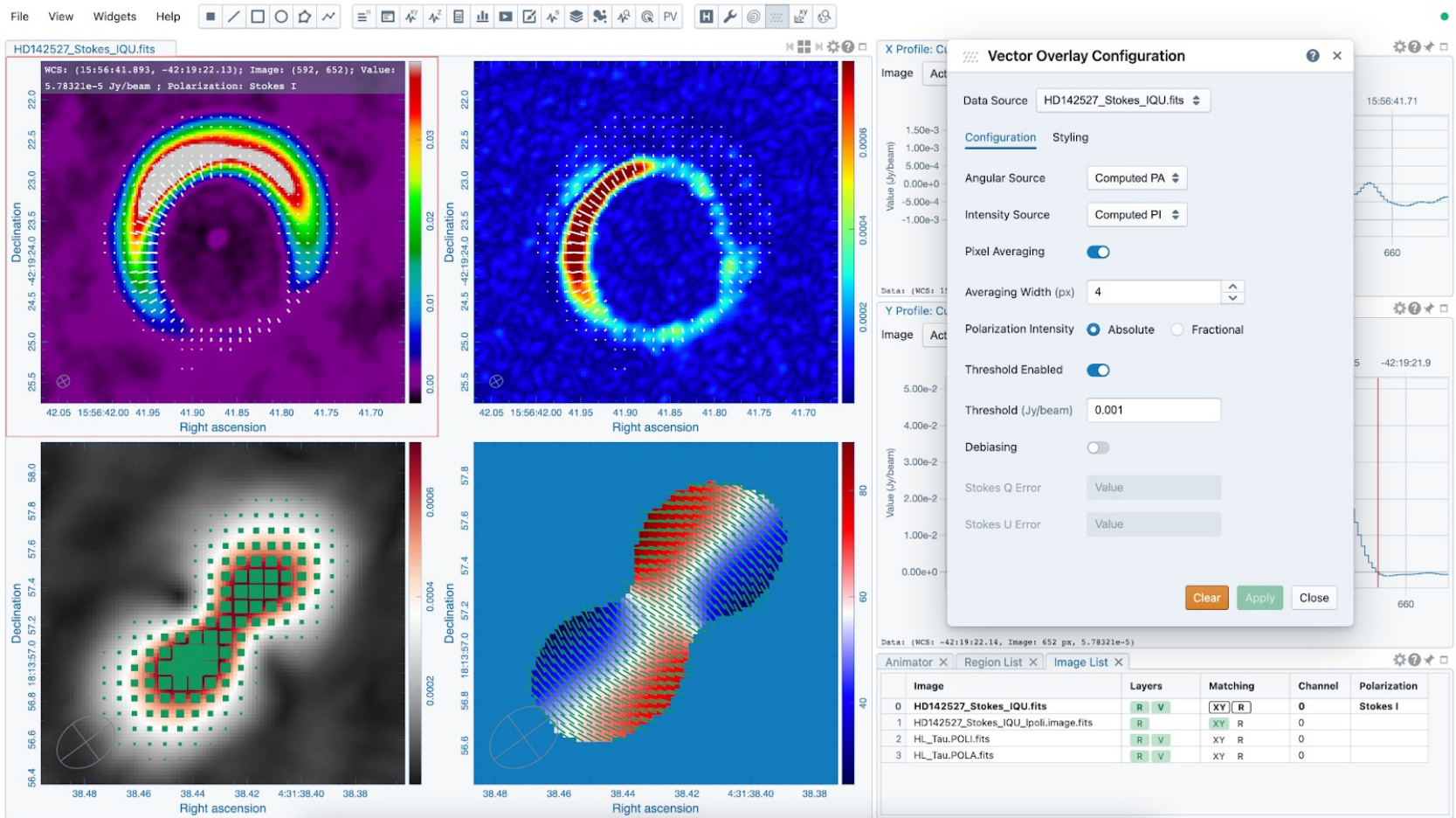
The screenshot displays the CARTA v3 (2022) software interface. At the top, a navigation menu shows 'Examples' and 'Tutorial' tabs. The 'Tutorial' tab is active, displaying a list of sections: '01. Basics', '02. Functions', and '03. Loading images'. A 'Create new snippet' button is visible below the 'Examples' tab.

In the center, an 'Edit code snippet' window is open, showing Python code for loading images. The code includes comments and function calls like `carta.showSplashScreen()`, `await carta.delay(1000)`, and `app.hideSplashScreen()`. Below the code editor are buttons for 'Execute', 'New', 'Delete', 'Save', and 'Close'.

On the right, a 'Preferences' window is open, showing settings for 'Global', 'Render Configuration', 'Contour Configuration', 'Overlay Configuration', 'Catalog', 'Region', 'Performance', 'Telemetry', and 'Log Events'. The 'Global' section is selected, showing options for 'Theme' (Light), 'Enable Code Snippets' (checked), 'Auto-launch File Browser' (checked), 'File List' (Filter by file content), 'Initial Layout' (Default), 'Initial Cursor Position' (Tracking), and 'Initial Zoom Level' (Zoom to fit). There are also 'Restore defaults' and 'Close' buttons.

At the bottom, two panels are visible, each displaying a folder icon and the text 'No catalog file loaded' with the instruction 'Load a catalog file using the menu'.

# Vector field rendering



# LEL image loading (mathematical expressions)

The screenshot displays the CARTA v3 software interface. The main window shows a FITS image with a color scale from 0 to 4.1. The image contains several bright spots. The axes are labeled 'Right ascension' and 'Declination'. A 'Render Configuration' window is open at the bottom, showing a histogram of the image values and a color map. A 'File Browser' window is open in the foreground, displaying a list of FITS files in the directory 'Users > kswang > carta\_image\_pool > set\_dice'. The file 'dice\_one.fits' is selected. The 'File Information' panel shows the following details:

```
Name = dice_one.fits
HDU = 0
Data type = double
Shape = [101, 101]
Coordinate type = Right Ascension, Declination
Projection = SIN
Image reference pixels = [320.75, 320.75]
Image reference coords = [06:12:53.8000, +017:59:22.1000]
Image ref coords (deg) = [93.2242 deg, 17.9895 deg]
Pixel increment = -0.03", 0.03"
Pixel unit = Jy/beam
Celestial frame = ICRS
Restoring beam = 0.150481" X 0.108465", 11.5153 deg
RA range = [06:12:54.262, 06:12:54.472]
DEC range = [+17:59:12.507, +17:59:15.507]
```

The 'Image arithmetic' window is also open, showing the expression `"dice_four.fits" + "dice_one.fits"`. A dropdown menu is open, showing options for 'List filtering' and 'Image arithmetic'. The 'Load expression' button is highlighted.



# Complex-valued images

The screenshot displays the CARTA v3 software interface. The main window shows a complex-valued image with a color scale ranging from -0.019 to 0.024. The image is titled "AMPLITUDE('complex.image')". The metadata for this image is as follows:

```

MCS: (1:20:15.5, 19:55:19); Images: (28, 22);
Value: 5.17845e-3;
Frequency (LSRK): 1000.0000 MHz;
Velocity: 88671.0087 km/s; Polarization: Stokes I
    
```

The File Browser window is open, showing a list of files in the directory "Users > kswang > set\_QA\_e2e\_v2". The file "complex.image" is selected, and its metadata is displayed in the File Information panel:

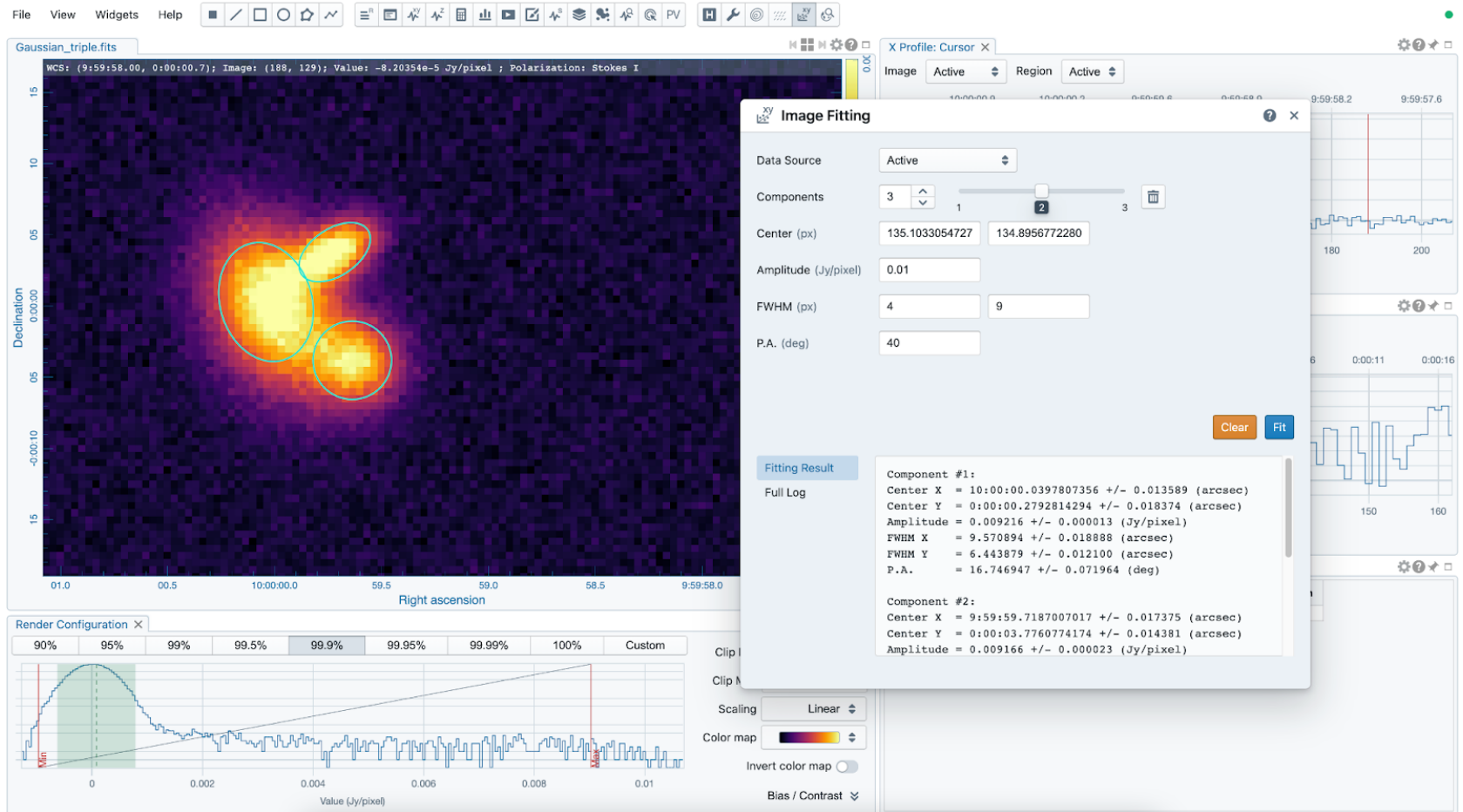
```

Name = complex.image
Data type = Complex
Shape = [100, 100, 1, 10]
Number of channels = 10
Number of polarizations = 1
Coordinate type = Right Ascension, Declination
Projection = SIN
Image reference pixels = [51, 51]
Image reference coords = [01:20:00.0000, +020.00.00.0000]
Image ref coords (deg) = [20 deg, 20 deg]
Pixel increment = -10", 10"
Celestial frame = FK5, J2000
Spectral frame = LSRK
Velocity definition = RADIO
RA range = [01:19:25.207, 01:20:35.503]
DEC range = [+19.51.39.779, +20.08.09.788]
Frequency range = [1.0000, 1.9000] (GHz)
Velocity range = [88671.0087, -101338.2957] (km/s)
Stokes coverage = FIT
    
```

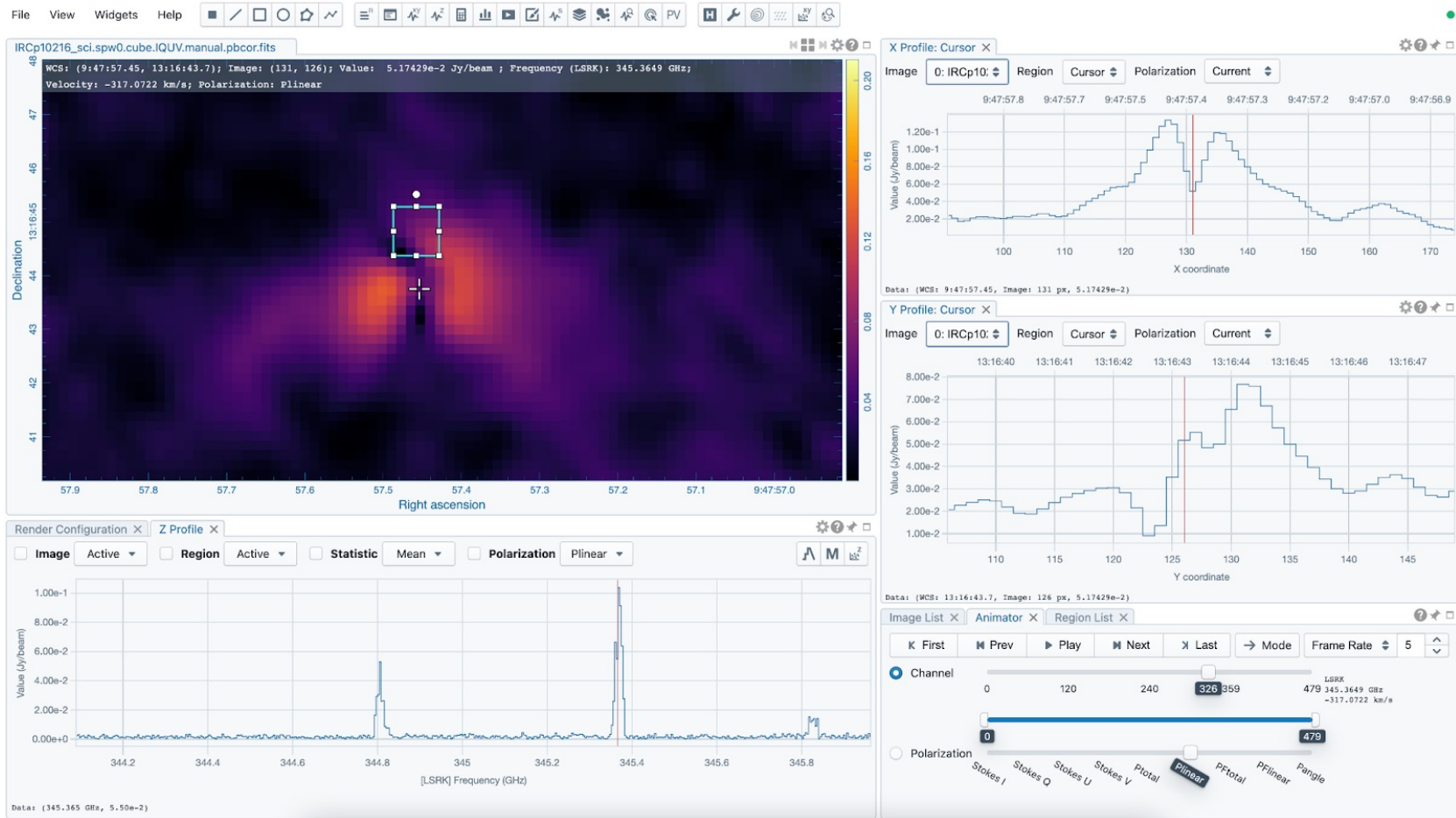
The Image List window shows the following images:

Image	Layers
0 AMPLITUDE('complex.image')	R
1 PHASE('complex.image')	R
2 REAL('complex.image')	R
3 IMAG('complex.image')	R

# 2D Gaussian Fitting

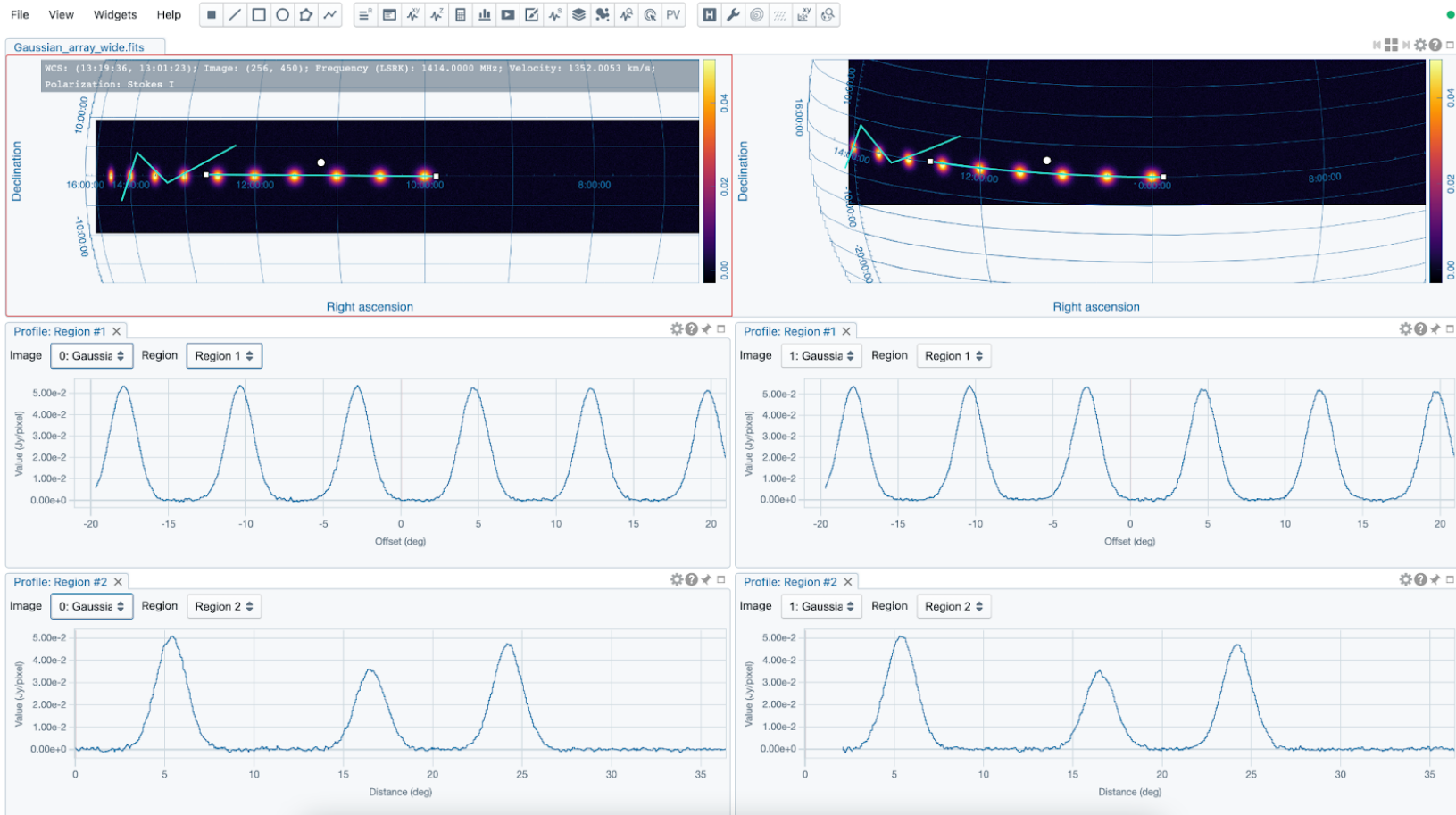


# Calculation of polarization quantities (like linear polarization intensity, polarization angle) from Stokes IQUV cube



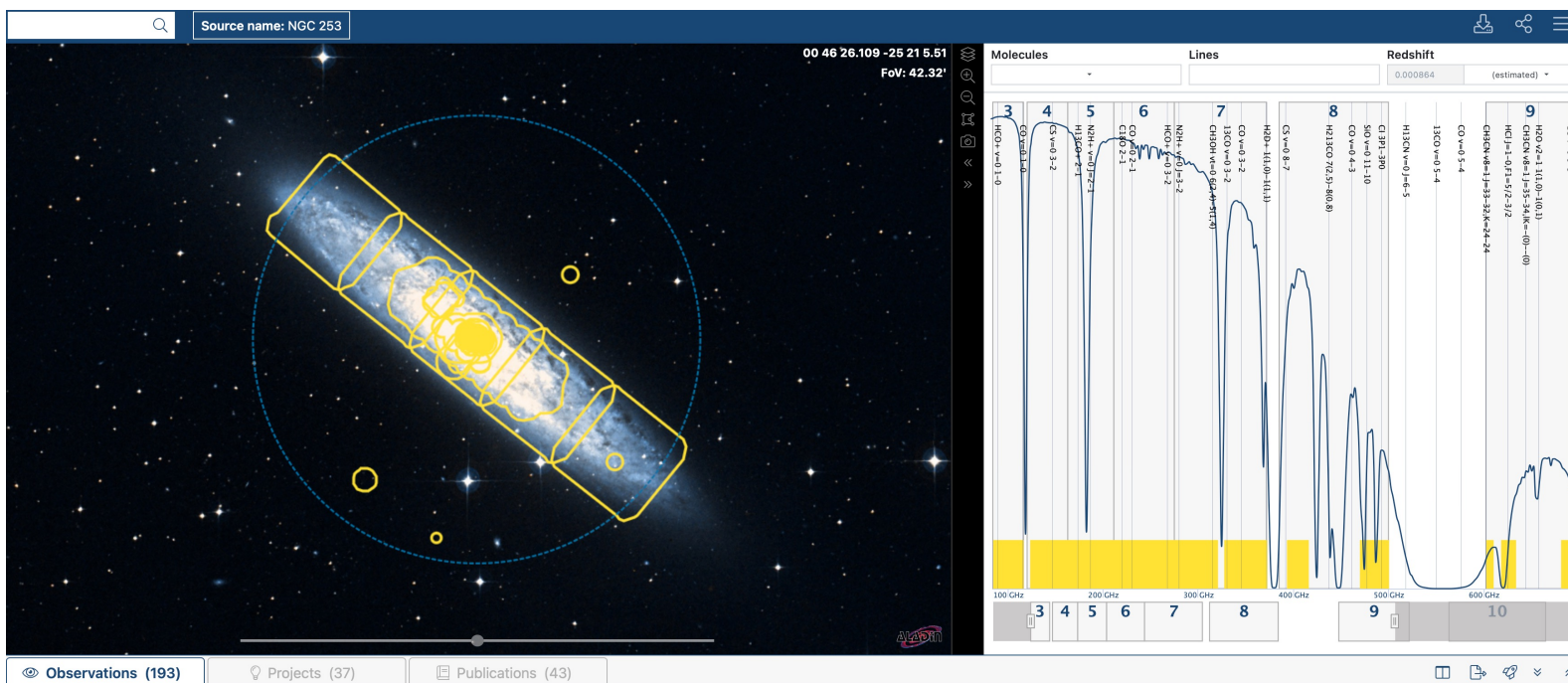


# Line and Polyline spatial profiles





# Remote Visualization of products in the ALMA Science Archive using CARTA



Click on "preview" icon

	Project code	ALMA source name	Ra	Dec	Band	Cont. sens.	Frequency support	Release date	Publications	Ang. res.	Min. vel. res.	Array	Mosaic	Max. reco. scale	FOV	Scientific category	Science keyword	In
			h:m:s	d:m:s		mJy/beam				arcsec	km/s			arcsec	arcsec			s
	2018.1.01321.S	NGC_253	00:47:33.000	-25:17:16.994	6	2.6269	217.05..233.81GHz	2020-01-04	9	5.026	0.736	7m	mosaic	30.416	362.436	Local Universe	Spiral galaxies, Giant ...	3
	2018.1.01321.S	NGC_253	00:47:47.067	-25:14:42.344	6	2.4902	217.05..233.81GHz	2020-01-04	9	5.012	0.736	7m	mosaic	29.519	362.436	Local Universe	Spiral galaxies, Giant ...	3
	2018.1.01321.S	NGC_253	00:47:04.869	-25:22:25.674	6	2.5089	217.05..233.81GHz	2020-01-04	9	5.042	0.736	7m	mosaic	30.047	362.436	Local Universe	Spiral galaxies, Giant ...	3
	2017.1.00161.L	ngc253	00:47:33.231	-25:17:16.203	4	0.0301	143.26..159.09GHz	2020-01-06	4	1.082	1.862	12m	mosaic	12.288	72.613	Galaxy evolution	Galaxy chemistry, Gia...	8
	2017.1.00161.L	ngc253	00:47:33.228	-25:17:16.132	4	0.0266	135.96..151.79GHz	2020-01-06	4	1.101	1.953	12m	mosaic	12.859	76.217	Galaxy evolution	Galaxy chemistry, Gia...	9
	2018.1.00162.S	ngc253	00:47:33.281	-25:17:17.680	5	0.2480	166.36..182.10GHz	2020-01-07	4	6.608	1.879	7m		48.557	57.292	Galaxy evolution	Galaxy chemistry, Gia...	9
	2018.1.01321.S	NGC_253	00:48:01.106	-25:12:07.874	6	2.6693	217.05..233.81GHz	2020-01-07	9	5.012	0.736	7m	mosaic	29.558	362.864	Local Universe	Spiral galaxies, Giant ...	3
	2018.1.00596.S	NGC_253	00:47:39.857	-25:15:33.714	6	0.0878	217.90..232.90GHz	2020-01-08	1	0.268	0.318	12m	mosaic	4.223	97.598	Local Universe	Spiral galaxies, Giant ...	6
	2018.1.00162.S	ngc253	00:47:33.281	-25:17:17.680	5	0.1956	169.71..185.45GHz	2020-01-09	4	6.382	1.845	7m		39.966	56.211	Galaxy evolution	Galaxy chemistry, Gia...	1'
	2017.1.00161.L	ngc253	00:47:33.232	-25:17:16.237	4	0.0258	146.91..162.74GHz	2020-01-13	4	0.999	1.820	12m	mosaic	12.190	70.936	Galaxy evolution	Galaxy chemistry, Gia...	7
	2018.1.00294.S	NGC253	00:47:33.067	-25:17:18.525	7	0.0329	315.27..330.69GHz	2020-01-14	0	0.312	1.768	12m		4.578	18.029	Active galaxies	Starbursts, star forma...	3
	2017.1.00161.L	ngc253	00:47:33.310	-25:17:18.519	7	0.8577	338.00..353.92GHz	2020-01-15	4	2.755	0.857	7m	mosaic	25.100	69.560	Galaxy evolution	Galaxy chemistry, Gia...	3





# Remote Visualization of products in the ALMA Science Archive using CARTA

The screenshot displays the ALMA Science Archive interface for source NGC 253. The top left shows the source name and coordinates. The main panel features a spectral plot with various molecular lines labeled, such as CO, HCN, and SiO. A red box highlights a CARTA icon in the bottom right of the plot area, with a red arrow pointing to a text box that reads: "Click on CARTA Icon to visualize remotely (i.e., without having to download!)". Below the plot is a table of observations with columns for resolution, array, mosaic, scale, FOV, scientific category, and science keyword.

res.	Min. vel. res.	Array	Mosaic	Max. reco. scale	FOV	Scientific category	Science keyword
0.736	7m	mosaic	30.416	362.436	Local Universe	Spiral galaxies, Giant ...	3
0.736	7m	mosaic	29.519	362.436	Local Universe	Spiral galaxies, Giant ...	3
0.736	7m	mosaic	30.047	362.436	Local Universe	Spiral galaxies, Giant ...	3
1.862	12m	mosaic	12.288	72.613	Galaxy evolution	Galaxy chemistry, Gia...	8
1.953	12m	mosaic	12.859	76.217	Galaxy evolution	Galaxy chemistry, Gia...	9
1.879	7m		48.557	57.292	Galaxy evolution	Galaxy chemistry, Gia...	9
0.736	7m	mosaic	29.558	362.864	Local Universe	Spiral galaxies, Giant ...	3
0.318	12m	mosaic	4.223	97.598	Local Universe	Spiral galaxies, Giant ...	6
1.845	7m		39.966	56.211	Galaxy evolution	Galaxy chemistry, Gia...	1
1.820	12m	mosaic	12.190	70.936	Galaxy evolution	Galaxy chemistry, Gia...	7
1.768	12m		4.578	18.029	Active galaxies	Starbursts, star forma...	3
0.857	7m	mosaic	25.100	69.560	Galaxy evolution	Galaxy chemistry, Gia...	3





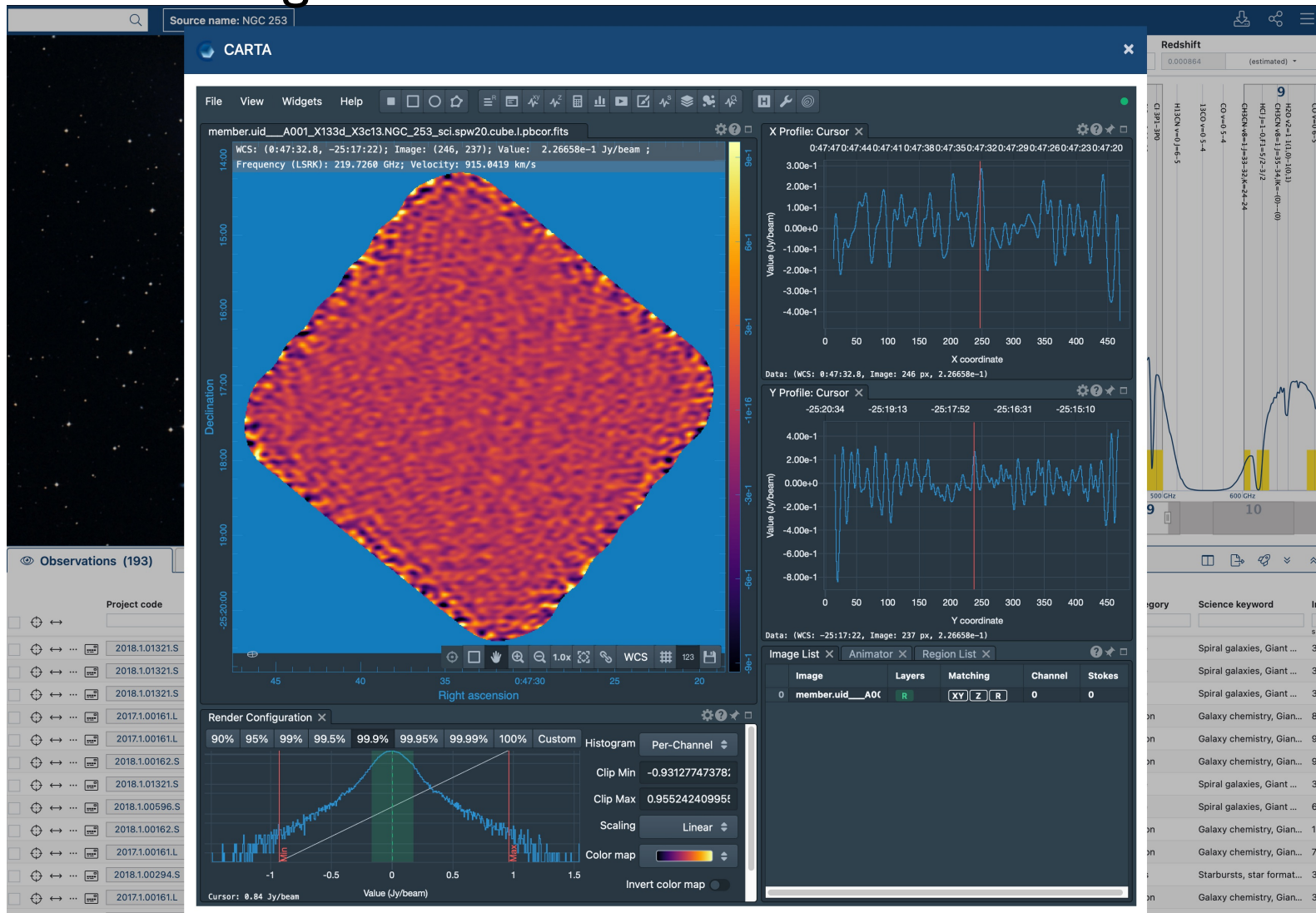


# Remote Visualization of products in the ALMA Science Archive using CARTA

The screenshot displays the CARTA 2.0.0 (4 Jun 2021) interface. The main window shows a dark sky image with a grid overlay. A central dialog box displays the CARTA logo and the text "CARTA 2.0.0 (4 Jun 2021) Cube Analysis and Rendering Tool for Astronomy". Below this, a status bar indicates "Connecting to server wss://carta.almascience.nrao.edu/vf1cftksd2fa4yuo0ajpp4mb failed." The interface includes several panels: "Observations (193)" on the left with a list of project codes; "X Profile: Cursor" and "Y coordinate" plots; a "Redshift" plot on the right showing a spectrum; and "Image List", "Animator", and "Region List" panels at the bottom. The status bar at the very bottom shows parameters: "ngc253 00:47:33.235 -25:17:16.328 7 0.6243 281.44..297.07GHz 2020-01-16 4 3.939 0.992 7m mosaic 30.020 65.735 Galaxy evolution Galaxy chemistry, Gian...".



# Remote Visualization of products in the ALMA Science Archive using CARTA





# Remote Visualization of products in the ALMA Science Archive using CARTA

The screenshot displays the CARTA interface. At the top left, there is a search bar and a '+ 1 tab-subfilter' button. The main area is split into three panels: a large image of a galaxy with yellow contours, a spectral plot showing various molecular lines, and a table of observations. A red arrow points from the 'NEW: Explore and download' button in the spectral plot to the 'Select dataset' label. Another red arrow points from the 'OLD: Explore and download' button to the 'Then go on "Explore and download"' label. The table below shows a list of observations for the source NGC253.

Project code	ALMA source name	Ra	Dec	Band	Cont. sens.	Frequency support	Release date	Publications	Ang. res.	Min. vel. res.	Array	Mosaic	Max. reco. scale	FOV	Scientific category
2011.0.00172.S	NGC253	00:47:33.146	-25:17:17.498	3	0.1049	99.91..115.74GHz	2013-06-19	14	2.701	2.530	12m	mosaic	28.891	98.703	Active galaxies
2011.0.00172.S	NGC253	00:47:33.130	-25:17:17.808	3	0.0458	85.69..101.32GHz	2013-08-28	14	1.323	2.890	12m	mosaic	13.611	109.127	Active galaxies
2012.1.00108.S	NGC253	00:47:33.414	-25:17:17.634	3	0.4806	99.76..115.70GHz	2015-03-31	4	7.767	2.531	7m	mosaic	68.156	178.609	Active galaxies
2012.1.00108.S	NGC253	00:47:33.149	-25:17:17.628	3	0.0442	99.82..115.64GHz	2015-04-25	4	0.740	2.532	12m	mosaic	15.592	99.039	Active galaxies
2013.1.00191.S	NGC253	00:47:34.225	-25:17:23.805	6	0.2794	216.06..233.61GHz	2015-08-27	4	5.152	2.488	7m	mosaic	31.671	66.279	Active galaxies
2013.1.00099.S	NGC253	00:47:33.134	-25:17:19.680	7	0.0768	350.54..365.46GHz	2015-09-12	3	0.332	3.203	12m	mosaic	2.898	16.265	Active galaxies
2013.1.00099.S	NGC253	00:47:33.134	-25:17:19.680	7	0.5939	350.48..365.52GHz	2015-10-07	3	0.547	3.202	7m	mosaic	19.215	27.883	Active galaxies
2012.1.00108.S	NGC253	00:47:33.130	-25:17:17.808	3	0.0270	85.69..101.32GHz	2015-12-23	4	0.699	2.889	12m	mosaic	8.427	108.877	Active galaxies
2013.1.00099.S	NGC253	00:47:33.134	-25:17:19.680	6	0.2741	217.04..235.46GHz	2016-01-05	3	5.013	2.633	7m	mosaic	33.053	44.120	Active galaxies

Select dataset

Then go on "Explore and download"





# Remote Visualization of products in the ALMA Science Archive using CARTA

CARTA v1.4 | CARTA - Cube Ar | CARTA - Cube Ar | Survey of missi | CARTAVIS - GitHu | ALMA Science Ar | ALMA Science Ar | Alma Request Ha | CARTA

almascience.eso.org/rh/submission

## ALMA Request Handler

Anonymous User: Request #2154992946764 ✓  
Request Title: [click to edit](#)

Download Selected

readme  product  auxiliary  raw  raw (semipass)  external

Project / OUSet / Executionblock	File	Size	Accessible	Actions
Request 2154992946764		3 GiB		
Project 2017.1.00161.L				
Science Goal OUS uid://A001/X1284/Xf2d				
Group OUS uid://A001/X1284/Xf2e				
Member OUS uid://A001/X1284/Xf2f				
SB ngc253_b_04_TM1				
<input checked="" type="checkbox"/> readme	<a href="#">member.uid_A001_X1284_Xf2f.README.txt</a>	3 KiB	✓	
<input checked="" type="checkbox"/> product	<a href="#">2017.1.00161.L_uid_A001_X1284_Xf2f_001_of_001.tar</a>	3 GiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw0.cube.l.manual.mask.tgz</a>	720 KiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw0.cube.l.manual.pb.fits.gz</a>	133 MiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw0.cube.l.manual.pbcor.fits</a>	527 MiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw1.cube.l.manual.mask.tgz</a>	720 KiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw1.cube.l.manual.pb.fits.gz</a>	130 MiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw1.cube.l.manual.pbcor.fits</a>	527 MiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw2.cube.l.manual.mask.tgz</a>	720 KiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw2.cube.l.manual.pb.fits.gz</a>	120 MiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw2.cube.l.manual.pbcor.fits</a>	527 MiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw3.cube.l.manual.mask.tgz</a>	720 KiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw3.cube.l.manual.pb.fits.gz</a>	119 MiB	✓	
<input type="checkbox"/> product	<a href="#">member.uid_A001_X1284_Xf2f.ngc253_sci.spw3.cube.l.manual.pbcor.fits</a>	527 MiB	✓	
<input checked="" type="checkbox"/> auxiliary	<a href="#">2017.1.00161.L_uid_A001_X1284_Xf2f_auxiliary.tar</a>	210 MiB	✓	
<input type="checkbox"/> raw	<a href="#">2017.1.00161.L_uid_A002_Xd10f82_Xd1a.asdm.sdm.tar</a>	134 GiB	✓	
<input type="checkbox"/> raw	<a href="#">2017.1.00161.L_uid_A002_Xd12f5c_Xad8f.asdm.sdm.tar</a>	129 GiB	✓	
Member OUS uid://A001/X1284/Xf31				
SB ngc253_b_04_7M				
<input type="checkbox"/> readme	<a href="#">member.uid_A001_X1284_Xf31.README.txt</a>	3 KiB	✓	
<input type="checkbox"/> product	<a href="#">2017.1.00161.L_uid_A001_X1284_Xf31_001_of_001.tar</a>	1 GiB	✓	
<input type="checkbox"/> auxiliary	<a href="#">2017.1.00161.L_uid_A001_X1284_Xf31_auxiliary.tar</a>	561 MiB	✓	
<input type="checkbox"/> raw	<a href="#">2017.1.00161.L_uid_A002_Xc6d2f9_X3fc.asdm.sdm.tar</a>	4 GiB	✓	





# Remote Visualization of products in the ALMA Science Archive using CARTA

The screenshot displays the CARTA v1.4 web interface. The main window shows a spectral line image with a central bright spot. The axes are labeled 'Right ascension' (horizontal) and 'Declination' (vertical). The image is titled 'member.uid\_\_A001\_X1284\_Xf2f.ngc253.spw0.cube.l.manual.pbcor.fits'. The WCS information is: (0:47:22.99, -25:16:38.1); Image: (850, 466); Value: 2.48483e-3 Jy/beam\*; Frequency (LSRK): 130.5345 GHz; Velocity: -1930.1892 km/s.

Two profile plots are shown on the right side:

- X Profile: Cursor**: Shows the intensity profile along the X-axis. The X-axis is labeled 'X coordinate' and ranges from 0 to 600. The Y-axis is labeled 'Value (Jy/beam)' and ranges from 0.00e+0 to 2.50e-2. A sharp peak is visible at approximately X=300.
- Y Profile: Cursor**: Shows the intensity profile along the Y-axis. The Y-axis is labeled 'Y coordinate' and ranges from 0 to 500. The Y-axis is labeled 'Value (Jy/beam)' and ranges from 0.00e+0 to 4.00e-2. A sharp peak is visible at approximately Y=300.

At the bottom left, there is a 'Render Configuration' panel with a histogram and various settings:

- Render Configuration: 90%, 95%, 99%, 99.5%, 99.9%, 99.95%, 99.99%, 100%, Custom
- Histogram: Per-Channel
- Scaling: Linear
- Color map: (Color bar)
- Invert color map: (Off)
- Clip Min: -0.0041573
- Clip Max: 0.0145616

At the bottom right, there is an 'Image List' panel with a table:

Image	Layers	Matching	Channel	Stokes
0 member.uid__A001_>	R	XY Z	0	0

# SRDP image archive

version: 4.1.0



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	Project	Longitude	Latitude	Band	Sp Resolution	Beam Axis Ratio	File Name
 	VLASS1.1	0h2m28.328s	-36°30'0.000"	S	2.520	2.554	VLASS1.1.ql.T01t01.J000228-363000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h2m30.256s	-37°30'0.000"	S	2.460	1.975	VLASS1.1.ql.T01t01.J000230-373000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h2m32.282s	-38°30'0.000"	S	2.486	1.534	VLASS1.1.ql.T01t01.J000232-383000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h2m34.411s	-39°30'0.000"	S	2.621	1.270	VLASS1.1.ql.T01t01.J000234-393000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h7m24.984s	-36°30'0.000"	S	2.518	2.440	VLASS1.1.ql.T01t01.J000724-363000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h7m30.769s	-37°30'0.000"	S	2.455	1.881	VLASS1.1.ql.T01t01.J000730-373000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h7m36.847s	-38°30'0.000"	S	2.502	1.462	VLASS1.1.ql.T01t01.J000736-383000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS1.1	0h7m43.233s	-39°30'0.000"	S	2.645	1.224	VLASS1.1.ql.T01t01.J000743-393000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits



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version: 4.1.0

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Show 25 of 52948 Images

### Launch Workflow Task on: VLASS1.1

**User Email (required):**

**Request Description:**

**Destination Directory:**  Specify directory (must be logged in & staff)


**Create tar file:**  Return results as a tar file

**Visualize with CARTA:**  Visualize Images with CARTA


Project	Longitude	Latitude	Band	Sp Resolution	Beam Axis Ratio	File Name
VLASS1.1	0h2m28.328s	-36°30'0.000"	S	2.520	2.554	VLASS1.1.q1.T01t01.J000228-363000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h2m30.256s	-37°30'0.000"	S	2.460	1.975	VLASS1.1.q1.T01t01.J000230-373000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h2m32.282s	-38°30'0.000"	S	2.486	1.534	VLASS1.1.q1.T01t01.J000232-383000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h2m34.411s	-39°30'0.000"	S	2.621	1.270	VLASS1.1.q1.T01t01.J000234-393000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h7m24.984s	-36°30'0.000"	S	2.518	2.440	VLASS1.1.q1.T01t01.J000724-363000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h7m30.769s	-37°30'0.000"	S	2.455	1.881	VLASS1.1.q1.T01t01.J000730-373000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h7m36.847s	-38°30'0.000"	S	2.502	1.462	VLASS1.1.q1.T01t01.J000736-383000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
VLASS1.1	0h7m43.233s	-39°30'0.000"	S	2.645	1.224	VLASS1.1.q1.T01t01.J000743-393000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits

# SRDP archive

\$Rev: 75523 \$



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## Request #996152768 by Anonymous User

Image Processing Request

— *Initializing request...*

### Requested Projects / OUSets / Executionblocks

Project / OUSet / Executionblock	File	Size
----------------------------------	------	------

Please wait; requested datasets list under construction....

Data entities 1-1 of 1

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# SRDP archive

File View Widgets Help

VLASS1.1.q1.T01t01.J000232-383000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits

WCS: (0:02:32.24, -38:29:59); Image: (1861, 1861); Value: -8.56652e-5 Jy/beam

Declination

Right ascension

X Profile: Cursor

Value (Jy/beam)

X coordinate

Data: (WCS: 0:02:32.24, Image: 1861 px, -8.56652e-5)

Y Profile: Cursor

Value (Jy/beam)

Y coordinate

Data: (WCS: -38:29:59, Image: 1861 px, -8.56652e-5)

Image List

Image	Layers	Matching	Channel	Stokes
0 VLASS1.1.q1.T01t01	R	XY R	0	0

Render Configuration

90% 95% 99% 99.5% 99.9% 99.95% 99.99% 100% Custom

Value (Jy/beam)

Clip Min -0.000523917148

Clip Max 0.000546530008

Scaling Linear

Color map

Invert color map

Bias / Contrast

Session timer: 58m 56s



# CARTA

**Development for v4 (release in 2023, but beta versions with subset of features will be available sooner):**

- Save, restore state
- Share states
- Interactive position-velocity plots
- 2D image fitting
- RGB image blender
- Spatial profile fitting
- Histogram improvements with custom parameters
- Image annotation
- Channel maps
- Scripting interface

Later:

- Volume (3D) rendering
- Improved Profile, histogram, and image fitting tools
- Source finder
- Transposed cubes
- Image smoothing
- VR integration (IDaVie)

# CARTA

- CARTA is the new visualization tool, actively developed for radio image formats (but can be used for any fits image [cube]). It replaces the CASAviewer that is not supported anymore.
- Performance and architecture of CARTA are ideal for displaying large images hosted locally (VLA, ALMA, ...) or remotely (SKA, ngVLA, VLASS, ...)
- Almost all CASAviewer functionality is now available in CARTA v3, it is now a good time to switch over
- CARTA is integrated in the ALMA and NRAO/SRDP archives
- Python scripting is under active development
- For questions, comments, suggestions, please contact the CARTA helpdesk [support@carta.freshdesk.com](mailto:support@carta.freshdesk.com)
- CARTA homepage: [cartavis.org](http://cartavis.org)



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