

CARTA

Cube Analysis and Rendering Tool for Astronomy

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- Driver for CARTA
- CARTA
- CARTA in the ALMA Science Archive
- Stand-alone CARTA
- Practice with continuum image
- Practice with cube

Credits to Kazi Rygl, Elisabetta Liuzzo, et al.
I-TRAIN #12: CARTA tutorial
EU ALMA school (presentation, materials)

Why use CARTA?

- Many fits visualization tools in the market ([link here](#)) (DS9, QFitsView, Aladin, APLpy, fv, CARTA, ...)
- CARTA was made to address the interferometric data context
 - Continuum
 - Spectral cubes
 - Full polarization
 - Flux extraction
 - Spectral fitting
 - Momentum maps (integrated flux, velocity, velocity dispersion)
 - Position-velocity diagrams
 - Built to deal with heavy data (eg, 1TB cubes, parallelization)
 - FITS or HDF5
 - Can be used directly from the ALMA Science Archive



CARTA

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

Ubuntu/RedHat/MacOS

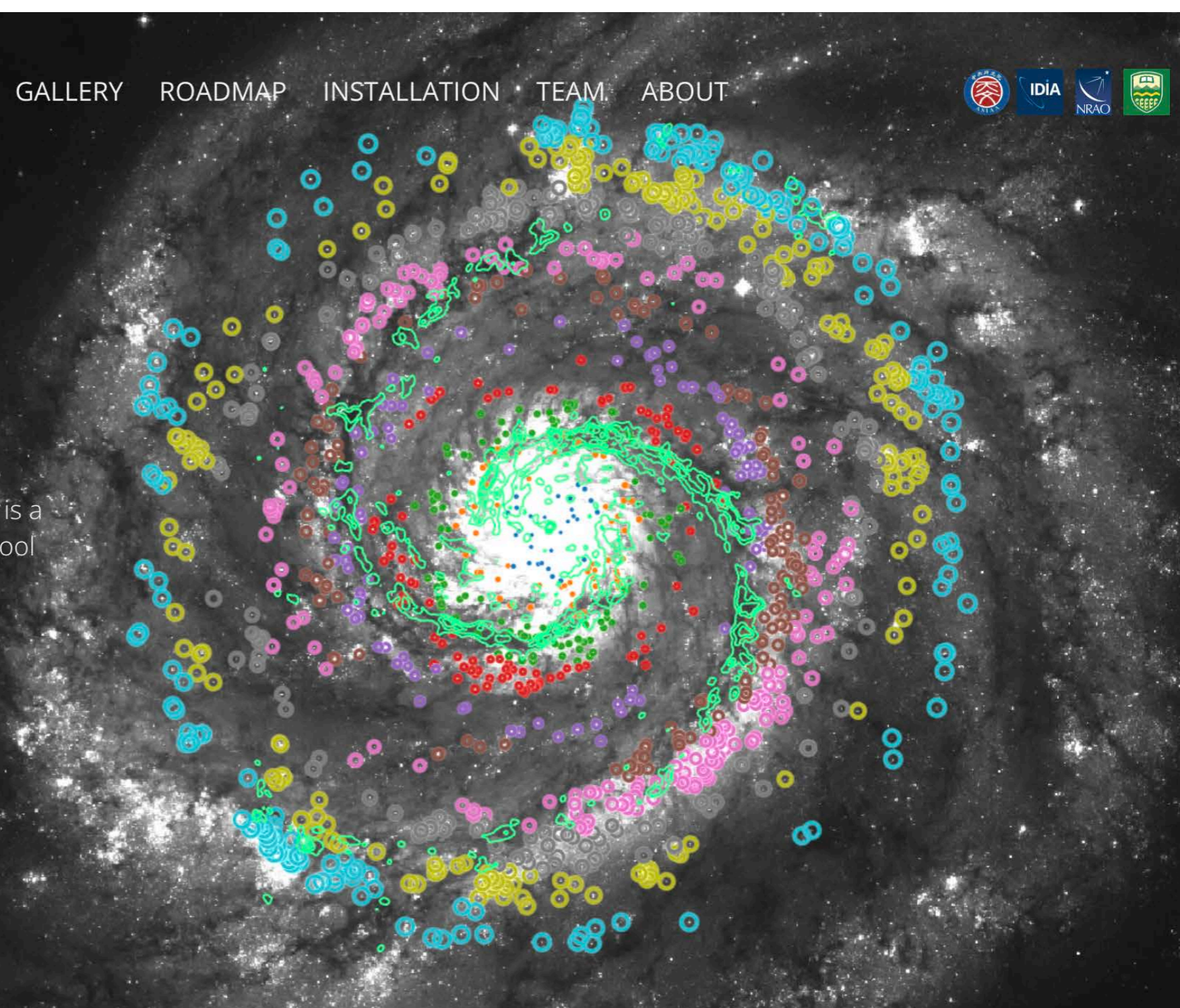
[Installation](#)

[User Manual](#)

[Helpdesk](#)

New release: v4.1

January 2024



Working with CARTA in the ASA

- No need to download data
- No need to install CARTA
- Can open multiple ASA images and overlay these
- Save png but not FITS to disk

Working with CARTA on your device

- Slightly bigger interface
- Save FITS/png to disk
- Can load locally stored data and overlay these
- Can load your regions/catalogs

Using CARTA in the ASA <https://almascience.eso.org/aq/>

Search Source name: HD 142527 Remove filters 1 column filter active Explore and download

15 56 41.867 -42 19 23.78 FoV: 3.08' VO

Protoplanetary disk HD 142527

Molecules Lines Redshift
-1.70072: estimated

Observations (6) Projects (18) Publications (36)

Band: 6 Remove tab filters

	Project code	ALMA source name	RA h:m:s	Dec d:m:s	Band	Cont.sens. mJy/beam	Frequency support	Release date	Publications	Ang.res.
<input type="checkbox"/>	2011.0.00465.S	HD 142527	15:56:41.887	-42:19:23.341	6	0.1041	218.464..232.442 GHz	2013-08-06	12	0.597
<input type="checkbox"/>	2013.1.00305.S	HD_142527	15:56:41.874	-42:19:23.656	6	0.0315	219.501..232.892 GHz	2016-10-31	2	0.208
<input type="checkbox"/>	2015.1.01353.S	HD_142527	15:56:41.874	-42:19:23.670	6	0.0380	219.501..232.892 GHz	2017-03-29	5	0.765
<input checked="" type="checkbox"/>	2015.1.01353.S	HD_142527	15:56:41.873	-42:19:23.680	6	0.0255	219.501..232.892 GHz	2018-10-03	5	0.266
<input type="checkbox"/>	2018.1.01172.S	HD_142527	15:56:41.871	-42:19:23.749	6	0.0366	219.529..235.482 GHz	2020-12-12	1	0.487
<input type="checkbox"/>	2018.1.00475.S	HD_142527	15:56:41.850	-42:19:24.198	6	0.0233	219.061..232.132 GHz	2023-08-16	0	0.560

Previews hovering the mouse over the 5th icon

Search Source name: HD 142527 Remove filters 1 column filter active Explore and download

15 56 41.867 -42 19 23.78 FoV: 3.08'
VO

Molecules
Lines
Redshift

Previews for HD_142527

ALMA ari_l

[README](#)

SPW 0: 219.501..219.618GHz, 70.557 kHz, XX YY

[member.uid_A001_X2fe_X465.HD142527_C18O.pbcor.fits](#) 6 GB

Band: 6

Frequency type: line

Frequency range: 219.501..219.618

Frequency resolution: 70.557 kHz

Continuum sensitivity: 0.026

Line sensitivity 10km/s (estimate): 0.48 mJy/beam@10km/s

Line sensitivity native (estimate): 0.12 uJy/beam@native

Polarizations: XX YY

Array: 12m

SPW 1: 220.339..220.457GHz, 70.557 kHz, XX YY

[member.uid_A001_X2fe_X465.HD142527_13CO.pbcor.fits](#) 6 GB

Band: 6

Frequency type: line

Frequency range: 220.339..220.457

Frequency resolution: 70.557 kHz

Continuum sensitivity: 0.026

Line sensitivity 10km/s (estimate): 0.48 mJy/beam@10km/s

Release date	Publications	Ang.res.
2013-08-06	12	0.597
2016-10-31	2	0.208
2017-03-29	5	0.765
2018-10-03	5	0.266
2020-12-12	1	0.487
2023-08-16	0	0.560

CARTA icon

Search Source name: hd 142527 Remove filters Explore and download

Download Open legacy Request Handler Login

Category	Name	Size
Project (1)	member.uid__A001_X2fe_X465.ari_I.HD_142527_sci.spw2_220398MHz.12m.cube.l.pbcor.fits (external, external/ari_I)	7 GB
Group ObsUniSet (1)	member.uid__A001_X2fe_X465.ari_I.HD_142527_sci.spw2_220398MHz.12m.cube.l.mask.fits.g... (external, external/ari_I)	7 MB
Member ObsUniSet (1)	member.uid__A001_X2fe_X465.ari_I.HD_142527_sci.spw0_1_2_3_226092MHz.12m.cont.l.mask.... (external, external/ari_I)	8 kB
Source (1)	member.uid__A001_X2fe_X465.ari_I.README.txt (external, external/ari_I)	3 kB
Collection (2)	member.uid__A001_X2fe_X465.ari_I.HD_142527_sci.spw1_230545MHz.12m.mfs.l.mask.fits.gz (external, external/ari_I)	8 kB
Array (1)	2015.1.01353.S_uid__A001_X2fe_X465_external_ari_I_001_of_001.tar (external)	30 GB
File type (5)	member.uid__A001_X2fe_X465.ari_I.hifa_image.weblog.tgz (external, external/ari_I)	20 MB
File class (6)	member.uid__A001_X2fe_X465.HD142527_CO.pbcor.fits (external, product)	6 GB

File Details:

- Band: 6
- Frequency range: 230.479..230.596
- Frequency resolution: 70.557 kHz
- Line sens. (10km/s): 0.474mJy/beam
- Line sens. (native): 0.121uJy/beam
- Polarizations: XX YY
- Array: 12m

CARTA icon

Open legacy Request Handler

The screenshot shows the ALMA archive interface for source 'hd 142527'. A red arrow points to the 'Open legacy Request Handler' button in the top navigation bar. Below, a table lists various data files. A detailed view of a file is shown, including a spectral plot and technical parameters. A green box highlights the 'CARTA icon' in the detailed view.

Project (1)	Name	Size
Group ObsUniSet (1)	member.uid__A001_X2fe_X465.ari_I.HD_142527_sci.spw2_220398MHz.12m.cube.l.pbcor.fits	7 GB
Member ObsUniSet (1)	member.uid__A001_X2fe_X465.ari_I.HD_142527_sci.spw2_220398MHz.12m.cube.l.mask.fits.g...	7 MB
Source (1)	member.uid__A001_X2fe_X465.ari_I.HD_142527_sci.spw0_1_2_3_226092MHz.12m.cont.l.mask....	8 kB
Collection (2)	member.uid__A001_X2fe_X465.ari_I.README.txt	3 kB
Array (1)	member.uid__A001_X2fe_X465.ari_I.HD_142527_sci.spw1_230545MHz.12m.mfs.l.mask.fits.gz	8 kB
File type (5)	2015.1.01353.S_uid__A001_X2fe_X465_external_ari_I_001_of_001.tar	30 G
File class (6)	member.uid__A001_X2fe_X465.ari_I.hifa_image.weblog.tgz	20 M
	member.uid__A001_X2fe_X465.HD142527_CO.pbcor.fits	6 GB

File Details:

- Band: 6
- Frequency range: 230.479..230.596
- Frequency resolution: 70.557 kHz
- Line sens. (10km/s): 0.474mJy/beam
- Line sens. (native): 0.121uJy/beam
- Polarizations: XX YY
- Array: 12m

CARTA previews for fits files in Product

ALMA Request Handler Login

Anonymous User: Request #2165002684535 ✓
Request Title: [click to edit](#)

Download Selected

readme product auxiliary raw raw (semipass) external

Project / OUSet / Executionblock	Updated	File	Size	Accessible	Actions
Request 2165002684535			46 GB		
Project 2015.1.01353.S					
Science Goal OUS uid://A001/X2fe/X463					
Group OUS uid://A001/X2fe/X464					
Member OUS uid://A001/X2fe/X465	2020-07-10				
SB HD_14252_a_06_TE					
<input checked="" type="checkbox"/> readme		member.uid_A001_X2fe_X465.README.txt	15 kB	✓	
<input checked="" type="checkbox"/> product		2015.1.01353.S uid_A001_X2fe_X465_001_of_001.tar	46 GB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_13CO.flux.fits.gz	2 GB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_13CO.image.fits	7 GB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_13CO.pbcor.fits	7 GB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_C18O.flux.fits.gz	2 GB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_C18O.image.fits	7 GB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_C18O.pbcor.fits	7 GB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_CO.flux.fits.gz	2 GB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_CO.image.fits	7 GB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_CO.pbcor.fits	7 GB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_cont.flux.fits.gz	1 MB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_cont.image.fits	4 MB	✓	
<input type="checkbox"/> product		member.uid_A001_X2fe_X465.HD142527_cont.pbcor.fits	4 MB	✓	

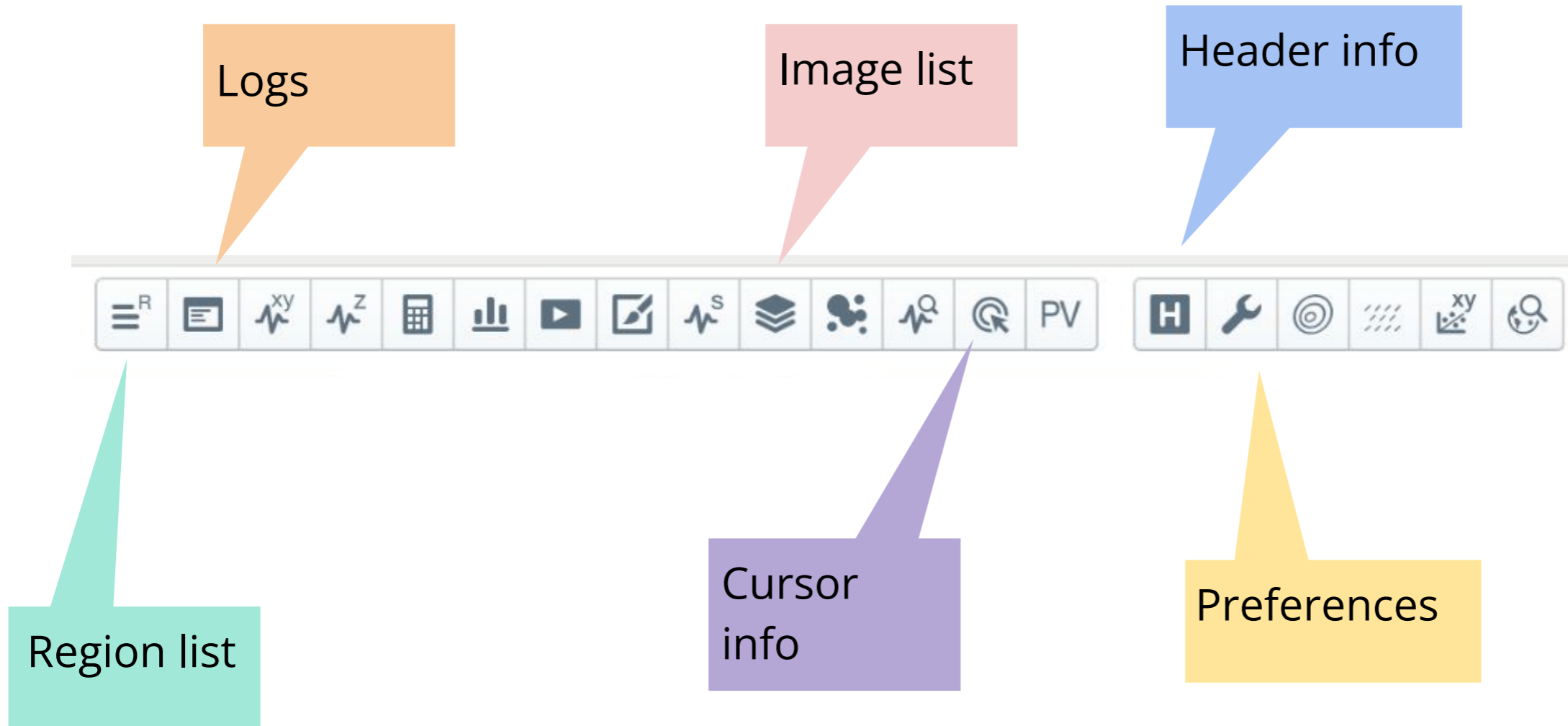
CARTA icons

Open CARTA in a new tab

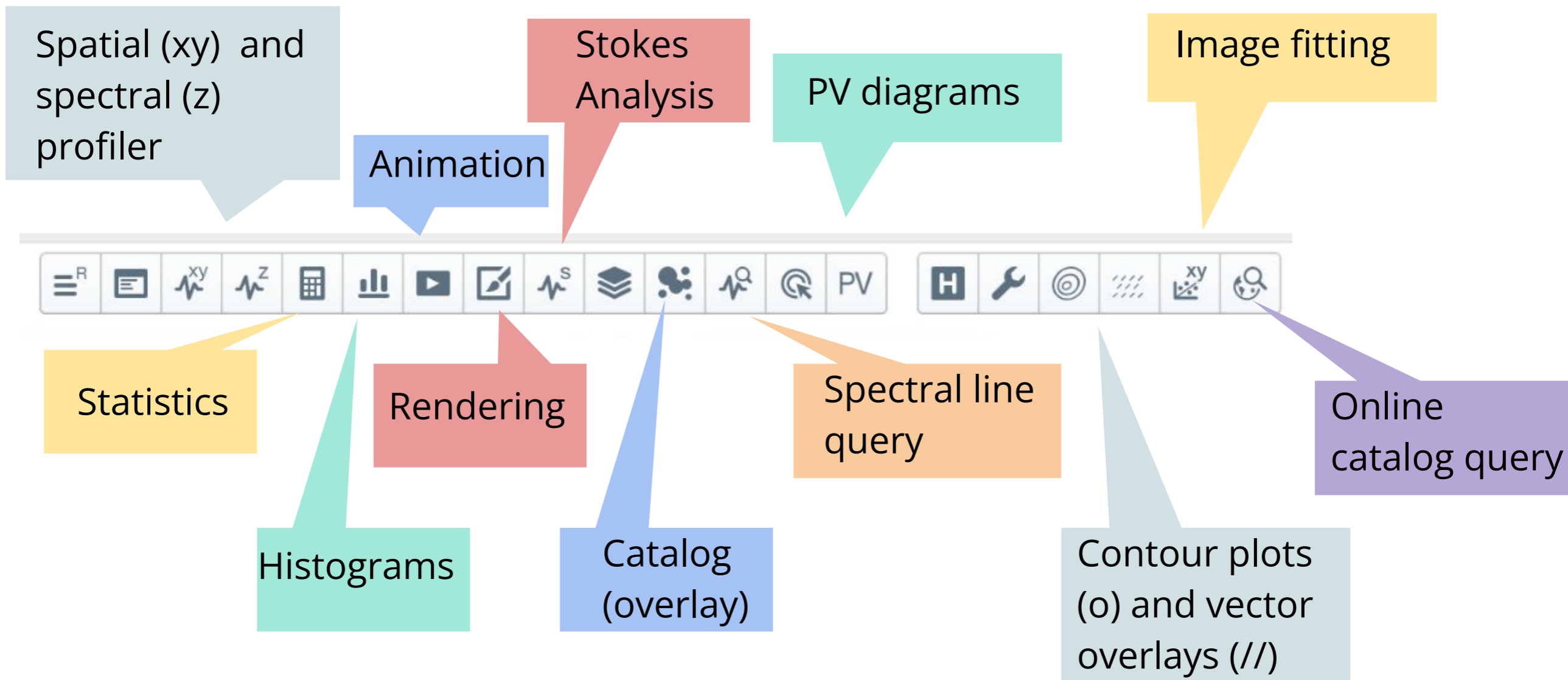
The screenshot shows the CARTA software interface. At the top, there is a menu bar with 'File', 'View', 'Widgets', and 'Help'. Below the menu is a toolbar with various icons for navigation and analysis. A red box highlights a specific set of icons in the toolbar, including a square, a circle, a star, a line, and a magnifying glass. The main display area shows a radio astronomy image of a source, with a color scale on the right ranging from -0.1 to 0.1 Jy/beam. The image is centered on a region of interest, with a cursor visible. Below the image, there are several panels: 'X Profile: Cursor', 'Y Profile: Cursor', 'Render Configuration', and 'Image List'. The 'Render Configuration' panel shows a histogram of the data with a 'Clip min' of -0.18050949058 and a 'Clip max' of 0.199529092745. The 'Image List' panel shows a table with columns for 'Image', 'Layers', 'Matching', and 'Channel'.

Image	Layers	Matching	Channel
0 member.uid__A00'	R	XY Z R	0

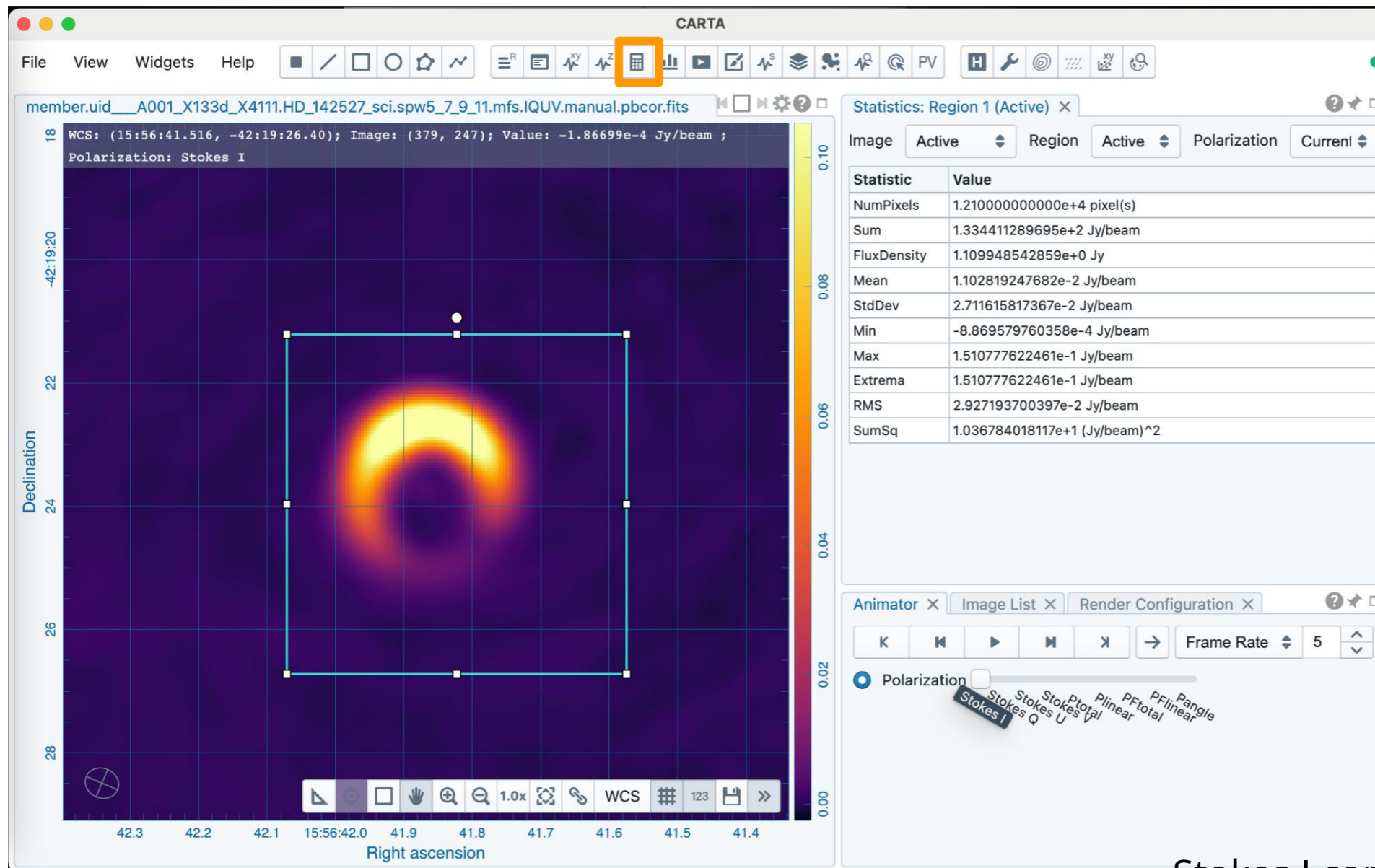
Auxiliary Widgets - basics



Analysis Widgets - more info



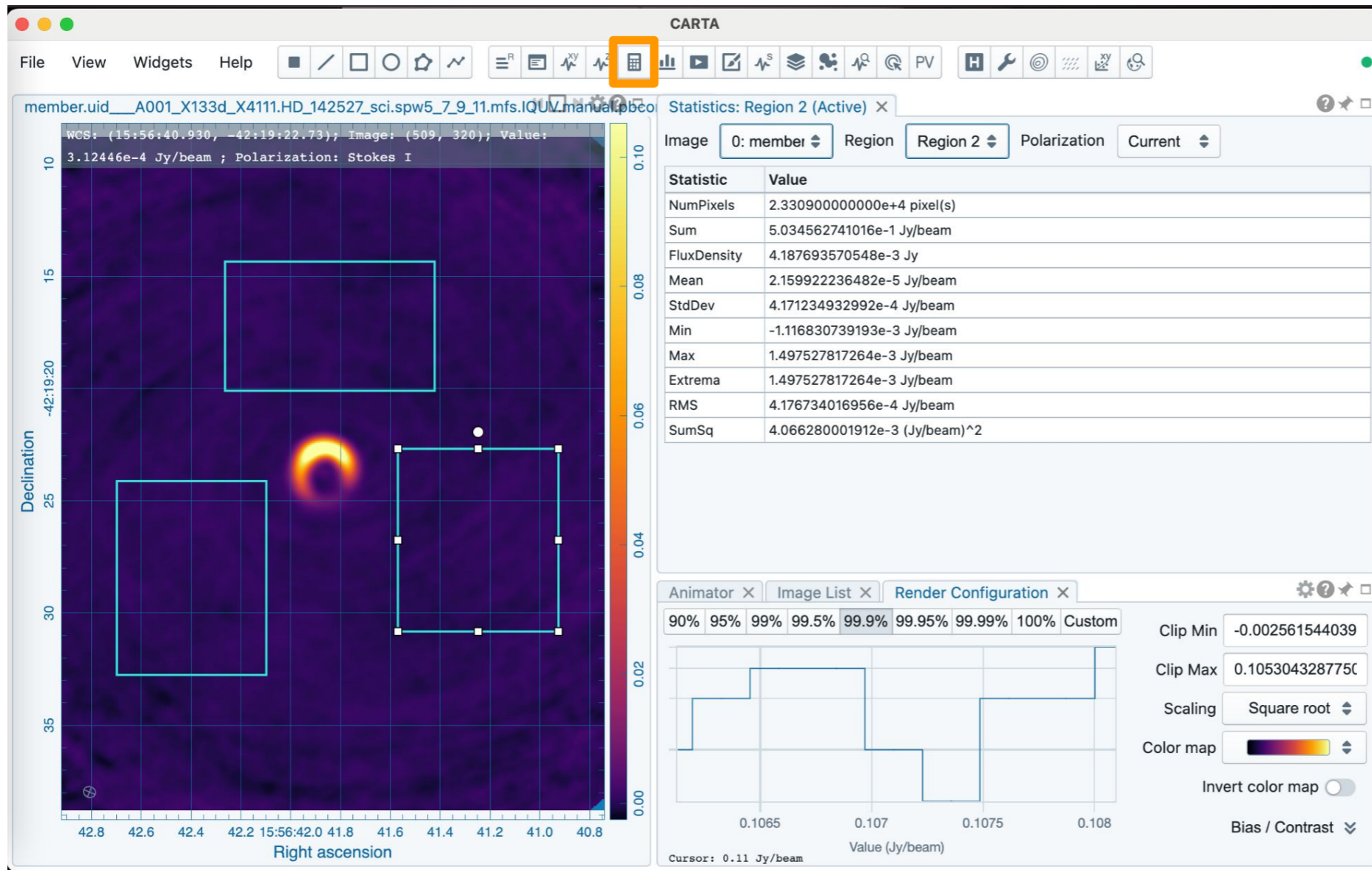
Statistics widget - Peak flux and flux density



For getting the peak of the target emission, use a Region on the Target.

Stokes I continuum map, HD 142527

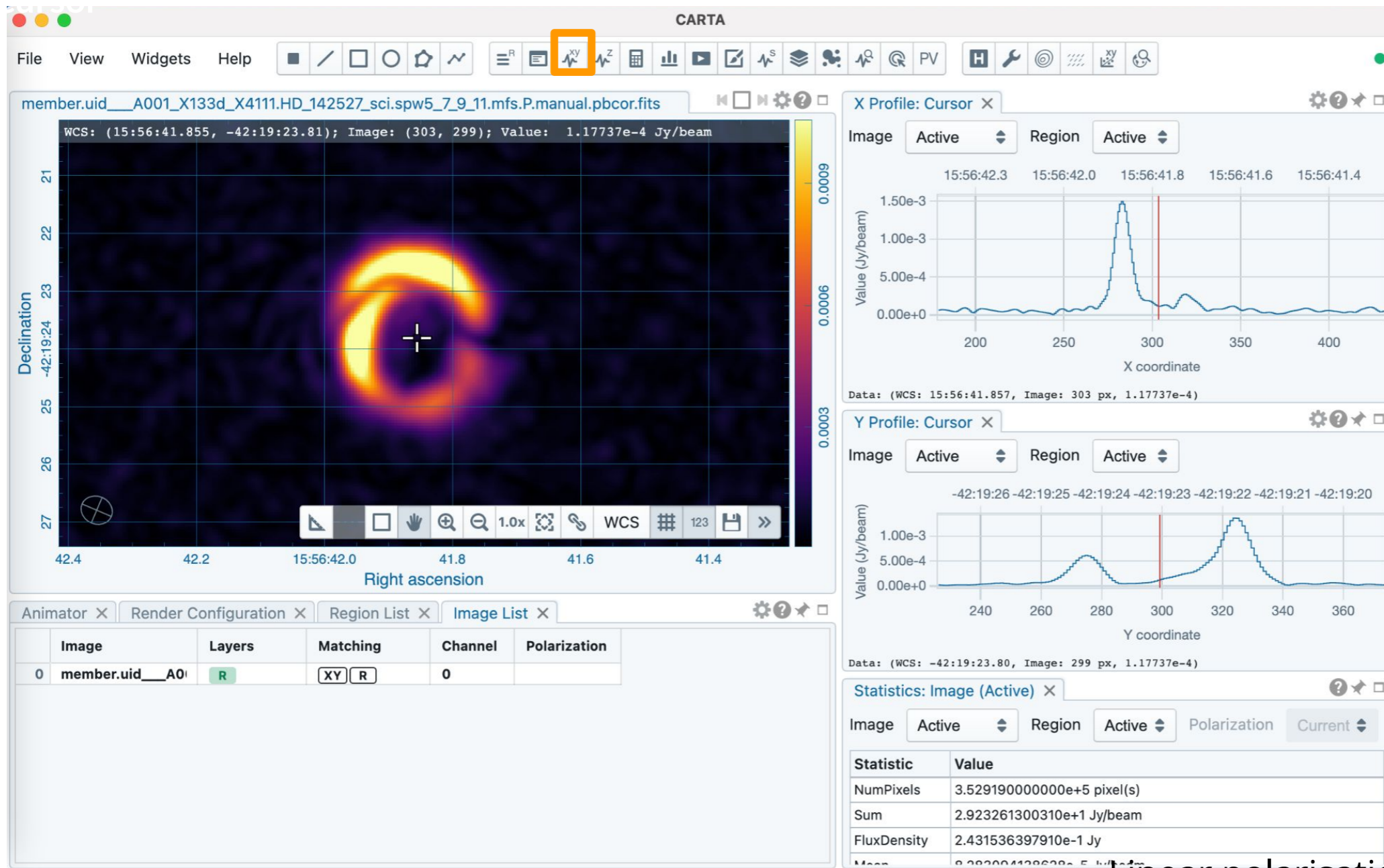
Statistics widget - rms



For getting the RMS noise of the map, use a few Regions excluding the Target and image edges (higher noise) and get the mean RMS.

Stokes I continuum map, HD 142527

Spatial profiler - fix position with "F"



Linear polarisation map, HD 142527

Size



File View Widgets Help

WCS: (15:56:42.082, -42:19:34.77); Image: (253, 80); Value: $-2.28297e-3$ Jy/beam ;
Frequency (LSRK): 230.5356 GHz; Velocity: 3.0887 km/s; Polarization: Stokes I

Decination

8.957595"

Distance measurement
Click to create geodesic curves.
Double Click to open the settings.

Right ascension

X Profile: Cursor X

Image Active Region Active Polarization Current

15:56:43.223 15:56:42.321 15:56:41.420 15:56:40.518

Value (Jy/beam)

2.00e-2
1.50e-2
1.00e-2
5.00e-3
0.00e+0
-5.00e-3

X coordinate

Data: (WCS: 15:56:42.082, Image: 253 px, $-2.28297e-3$)

Render Configuration X Image List X Region List X Animator X

K First Prev Play Next Last Mode Frame rate 5

Channel 0 12 24 36 49 LSRK 230.5356 GHz 3.0887 km/s

Polarization Stokes I Stokes Q Stokes U Stokes V Ptotal Plinear PFtotal PFlinear Pangle

Contours overlay

member.uid__A001_X133d_X4111.HD_142527_sci.spw7.cube.IQUV.manual.pbcors.fits

WCS: (15:56:41.957, -42:19:22.26);
Image: (281, 330); Value: 1.45402e-1 Jy/beam ;
Frequency (LSRK): 230.5356 GHz;
Velocity: 3.0887 km/s; Polarization: Stokes I

Decination

Right ascension

Decination

Right ascension

Contour Configuration

Data member.uid__A001_X133d_X4111.HD_142527_sci.spw7.cube.IQUV.manual.pb

source

Levels Configuration Styling

Histogram Per-channel

Value (Jy/beam)

Generator percentages-ref.value Generate

Parameters Reference 1.999e-1 N 8

Upper (%) 100 Lower (%) 20

Image	Layers	Matching	Channel	Polarization
0 member.uid__A00	R	XY Z R	24	Stokes I
1 member.uid__A001	R C	XY R	0	Stokes I

Practice (5min + 2min Q&A)

- *eso137-0.continuum.image.pbcor
 - Flux density (compare it with total sum and size in beams)
 - Peak flux
 - rms
- Same with *eso137-0.CO21.image.pbcor, but in different channels
- Use different type of regions
- Try out the distance/size widget
- Overlay continuum contours onto the CO(2-1) cube

Contours overlay



The screenshot shows the CARTA software interface. On the left, two panels display astronomical data. The left panel shows a raw image with red contours overlaid. The right panel shows the same data with 'Isocontours multiples of rms' overlaid. Below these panels is a table with the following data:

Image	Layers	Matching	Channel	Polarization
0 member.uid__A00	R	XY Z R	24	Stokes I
1 member.uid__A001	R C	XY R	0	Stokes I

On the right side, the 'Contour Configuration' panel is open. It features a 'Levels' tab (highlighted in cyan), a histogram of the data, and a 'Generator' dropdown set to 'percentages-ref.value'. The 'Parameters' section includes a 'Reference' value of 1.999e-1, 'N' set to 8, 'Upper (%)' at 100, and 'Lower (%)' at 20. A red arrow points to the histogram, and another red arrow points to the 'XY' checkbox in the table below.

Play with these!

Spectral analysis: click spectral profiler, drag it

The screenshot displays the CARTA software interface for spectral analysis. At the top, a toolbar contains various icons, with the 'Spectral profiler' icon (a waveform with a 'z') highlighted by a red box. A tooltip for this icon reads: "Spectral profiler Drag to place docked widget Click to place a floating widget".

The main interface features several panels:

- Top Left:** A coordinate display showing WCS: (15:56:41.107, -42:19:11.99) and Image: (469, 535). Below this is a plot of Declination (y-axis, -42:19:20 to -42:19:25) versus [LSRK] Frequency (GHz) (x-axis, 230.51 to 230.56). A red vertical line is positioned at approximately 230.535 GHz.
- Top Right:** A plot of X coordinate (x-axis, 200 to 600) versus Value (Jy/beam) (y-axis, -1.50e-2 to 1.50e-2). A red vertical line is at approximately 460 pixels.
- Center:** A 'Z Profile' window, highlighted with a red border. It shows a plot of Value (Jy/beam) (y-axis, -4.00e-3 to 4.00e-3) versus [LSRK] Frequency (GHz) (x-axis, 230.51 to 230.56). The plot shows a complex signal with a prominent peak at the red vertical line. The window includes controls for Image (Active), Region (Active), Statistic (Mean), and Polarization (Current).
- Bottom Left:** A control panel with buttons for 'K First', 'Prev', 'Play', 'Next', and 'Last'. It also includes a 'Frame rate' slider set to 5. Below these are sliders for 'Channel' (0 to 49) and 'Polarization' (0 to 49). The 'Channel' slider is currently set to 24, and the 'Polarization' slider is set to 0. The text 'LSRK 230.5356 GHz 3.0887 km/s' is displayed.
- Bottom Right:** A plot of Y coordinate (x-axis, 0 to 500) versus Value (Jy/beam) (y-axis, -1.00e-2 to 0.00e+0). A red vertical line is at approximately 460 pixels.

At the bottom right, a data label reads: "Data: (WCS: -42:19:12.00, Image: 535 px, -1.68213e-3)".

Moments: settings in z profile

The screenshot displays the CARTA software interface. The main window shows a spectral line plot with a Z Profile panel on the right. The Z Profile panel includes a plot of Value (Jy/beam) vs. [LSRK] Frequency (GHz) and a settings icon (gear) highlighted by a red arrow. A red box highlights the 'Z Profile Settings: Region #1 (Active)' window, which has tabs for Conversion, Styling, Smoothing, Moments, and Fitting. The 'Moments' tab is selected, showing the following settings:

- Coordinate: Frequency (GHz)
- System: LSRK
- Intensity unit: Jy/beam
- Secondary info:

The Z Profile plot shows a peak at approximately 230.5356 GHz with a value of 1.62e-2 Jy/beam. The X Profile and Y Profile panels are also visible, showing Value vs. X coordinate and Value vs. Y coordinate respectively.

Moments: settings in z profile

The screenshot displays the CARTA interface with two 'Z Profile Settings' windows. The background window shows a spectral plot with a Gaussian fit. The foreground window, 'Z Profile Settings: Region #1 (Active)', has the 'Fitting' tab selected. It shows the following settings:

- Coordinate: Frequency (GHz)
- System: LSRK
- Intensity unit: Jy/beam
- Secondary info:

The second window, 'Z Profile Settings: Region #2 (Active)', also has the 'Fitting' tab selected. It shows the following settings:

- Data source: member.uid__A001_X2fb_X44c.eso137-0.CO21.imag
- Profile function: Gaussian
- Auto detect: w/ cont. Auto fit
- detected 1 component.
- Components: 1
- Center: 226.97435176138734
- Amplitude: 0.00408469020319013
- FWHM: 0.011358089602111932
- Continuum: None
- Fitting result:
Component #1
Center = 227.016934 (GHz)
Center Error = 0.000673 (0.000%)
Amplitude = 0.031427 (Jy/beam)
Amplitude Error = 0.000787 (2.505%)
FWHM = -0.050619 (GHz)

Spectral profile: Moments available

Available moments

- 1: Mean value of the spectrum
- 0: Integrated value of the spectrum
- 1: Intensity weighted coordinate
- 2: Intensity weighted dispersion of the coordinate
- 3: Median value of the spectrum
- 4: Median coordinate
- 5: Standard deviation about the mean of the spectrum
- 6: Root mean square of the spectrum
- 7: Absolute mean deviation of the spectrum
- 8: Maximum value of the spectrum
- 9: Coordinate of the maximum value of the spectrum
- 10: Minimum value of the spectrum
- 11: Coordinate of the minimum value of the spectrum

The screenshot shows the 'Z Profile Settings: Region #1 (Active)' dialog box. It has tabs for Conversion, Styling, Smoothing, Moments, and Fitting. The 'Moments' tab is active. Annotations include:

- Choose Region:** Points to the 'Region (Region 1)' dropdown menu.
- Select with the cursor:** Points to the 'Range (GHz)' input fields.
- Choose frequency range:** Points to the 'From' and 'To' fields in the 'Range (GHz)' section.
- Choose Mask:** Points to the 'Mask' dropdown menu.
- Peak flux:** Points to the 'Range (Jy/beam)' input fields.
- put 3xrms:** Points to the 'Moments' list, specifically to the '3' moment.
- Choose Moments:** Points to the 'Moments' list.

Position Velocity diagrams



File View Widgets Help

member.uid__A001_X133d_X4111.HD_142527_sci.spw7.cube.IQUV.manual.pbcor.fits

WCS: (15:56:41.350, -42:19:32.13); Image: (415, 132); Value: -4.56408e-3 Jy/beam ;
 Frequency (LSRK): 230.5356 GHz; Velocity: 3.0887 km/s; Polarization: Stokes I

contours of moment 0.

PV Generator

Image (0: member.uid__... 0: member.uid__A001_X133d_X

PV cut (Region 2) Region 2

Average width 3

Coordinate Frequency (GHz)

System LSRK

Range (GHz) From 230.5067 To 230.5635

Axes order X-axis: Spatial, Y-axis: Spectral

Keep previous PV image(s)

Preview region Image

Preview rebin (px) XY 1 Z 1

Preview cube size (MB) 69.12

Start preview Generate

Image	Layers	Matching	Channel	Polarization
0 member.uid__A001_X133d_X4111.HD_142527_sci.spw7.cube.IQUV.manual.pbcor.fits	R	XY Z R	24	Stokes I
1 member.uid__A001_X133d_X4111.HD_142527_sci.spw7.cube.IQUV.manual.pbcor.fits	R C	XY R	0	Stokes I

Practice (5min + 2min Q&A)

- *eso137-0.CO21.image.pbcor
- Obtain different moment maps playing with different Z profile settings
- Extract fluxes
- Extract different PV diagrams

- cartavis.org
- [I-TRAIN #12: CARTA tutorial](#)
- [EU ALMA school \(presentation, materials\)](#)
 - Exercises on spectral line fitting
 - Catalogue interfaces
 - Polarization imaging analysis
- Comrie, Wang, Hsu, et al., (2018)
<https://ui.adsabs.harvard.edu/abs/2021zndo...3377984C/abstract>