Copy images (if you will run CARTA on our machines):

```
cp -r ../../archive/DRT2023/TW_hydra/*.fits ./
```

Copy images (if you will run CARTA on your machine):

```
scp -r *strwname*@almaportal.strw.leidenuniv.nl:/almastorage/allegro/data/projects/KS3uzQKR/analysis/*strwname/TW_hydra/TWhya_2016.1.00229.S_C18O.fits .
```

```
scp -r *strwname*@almaportal.strw.leidenuniv.nl:/almastorage/allegro/data/projects/KS3uzQKR/analysis/*strwname/TW_hydra/TWhya_2016.1.00229.S_cont.fits .
```

EUROPEAN ARC
ALMA Regional Centre || Allegro

INTRODUCTION TO

CARTA

ALMA Data Reduction Training Day

Megan Lewis

ALMA Local Expertise Group (Allegro)

EUROPEAN ARC
ALMA Regional Centre || Allegro

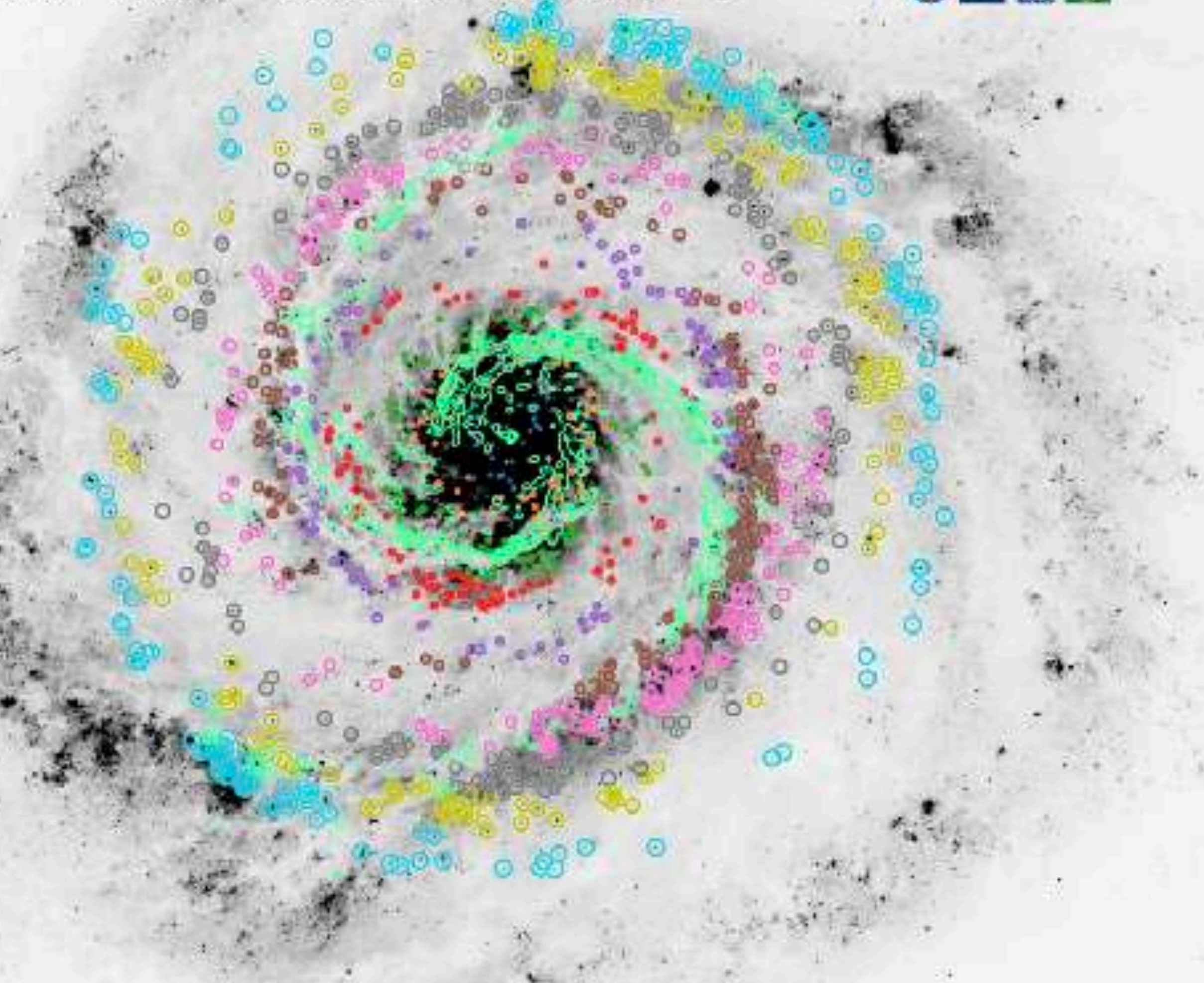
Leiden Observatory
October 23, 2024

HOME FEATURES GALLERY ROADMAP INSTALLATION TEAM ABOUT

https://cartavis.org/

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 release: v4
September 2023.

CARTA on the ALMA Science Archive

- No need to install CARTA
- No need to download data
- Can open multiple images
- Can save work in PNG format (not FITS)
- May get disconnected

Working with CARTA on your computer

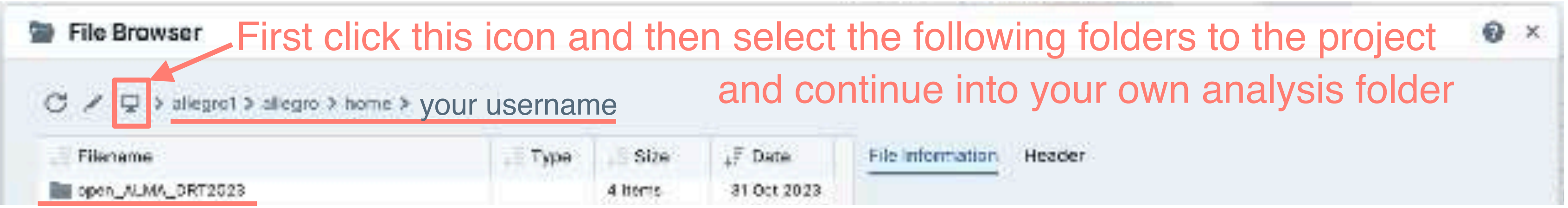
- Can customize panels and preferences
- Data must be downloaded locally
- Can open multiple images
- Can save work in FITS & PNG formats
- Does not time out

Using CARTA on the archive

- Go to the ALMA Science Archive: https://almascience.eso.org/aq/
- Query for Member ous ID: uid://A001/X87d/Xb3d
  - Alternatively, query for project ID: 2016.1.00229.S
    frequency range: 219 to 220 GHz
- Select the one observation that is returned and click on Explore & Download button
- Click on the CARTA button next to the continuum file
  member.uid___A001_X87d_Xb3d.TW_Hya_sci.spw19_23_25_27_29.**cont**.I.pbcor.fits
- Click on the CARTA button next to the cube corresponding to spw 27
  member.uid___A001_X87d_Xb3d.TW_Hya_sci.**spw27**.cube.I.pbcor.fits
- You now have two CARTA sessions open (one for the continuum, one for the line cube)
- You can append the line cube image in the continuum session and work in one session

Using CARTA on the Allegro computers

- Open a CARTA session on the Allegro machine assigned to you, following the instructions in the User's Guide at https://bit.ly/AllegroDRT23-guide



Using CARTA on the Allegro computers

- You can use two different datasets:
  - The results of the tutorial work today:
    - Continuum file: sis14_twhya_cont.image
    - Append the line cube we created in the imaging session: twhya_n2hp.image
  - A different TWhya dataset with higher spectral resolution in the archive folder
    - Load the continuum file: TWhya_2016.1.00229.S_cont.fits
    - Append the line cube: TWhya_2016.1.00229.S_C18O.fits
    - Note that you may need to copy this dataset to your analysis folder first
      > cp -r ../../archive/DRT2023/TW_hydra/***.fits** analysis_tools/.

→ I will be using this higher resolution dataset in the demo today

- If you prefer to work on your laptop and have CARTA installed, you can download the data at https://bit.ly/AllegroDRT23-data

EUROPEAN ARC
ALMA Regional Centre || Allegro

Live Demo + tutorial

1. Open CARTA
2. Open the continuum file
3. Append the line cube
4. Change the layout: View > Layouts > Existing Layouts > Cube Analysis
5. Match the coordinate systems in the Image List tab
6. Select the continuum image, switch the viewer to single panel if it is in multi panel, and play with how it is displayed using Render Configuration tab

Live Demo + tutorial

7. Create a region excluding the main continuum source and rename it ‘noise’
   -> Get an estimate for the noise in the continuum image
   -> Get an estimate for the noise in the cube (explore how the noise varies in different channels using the Animator tab)
8. Delete the ‘noise’ region (select region & click delete or back button)
9. Create a new region covering the central area where there is emission and rename this new region ‘disk’
10. Select the line cube in the image list tab and make sure the cube and ‘disk’ region are selected in the Spectral Profiler widget

Live Demo + tutorial

11. Play with the Spectral Profiler:
    - -> zoom in to regions of the spectrum where there is a line
    - -> click on parts of the line to see the image of that channel
    - -> Use the Animator to go through the channel maps of the line cube
12. Make moment 0, 1, and 8 maps covering the line of interest (remember to match their coordinates to the reference continuum image)
    - -> Play with excluding emission levels below a certain threshold (e.g. 3 sigma) using the noise estimate from before
13. Create contours for the continuum and moment 1 image using two different colours and save the image as a figure
    - -> Modify the look of the figure by clicking File > Preferences, as well as the settings wheel at the top of the viewer

Live Demo + tutorial

14. Create two new regions:

    -> One covering the redshifted emission, rename it ‘red’

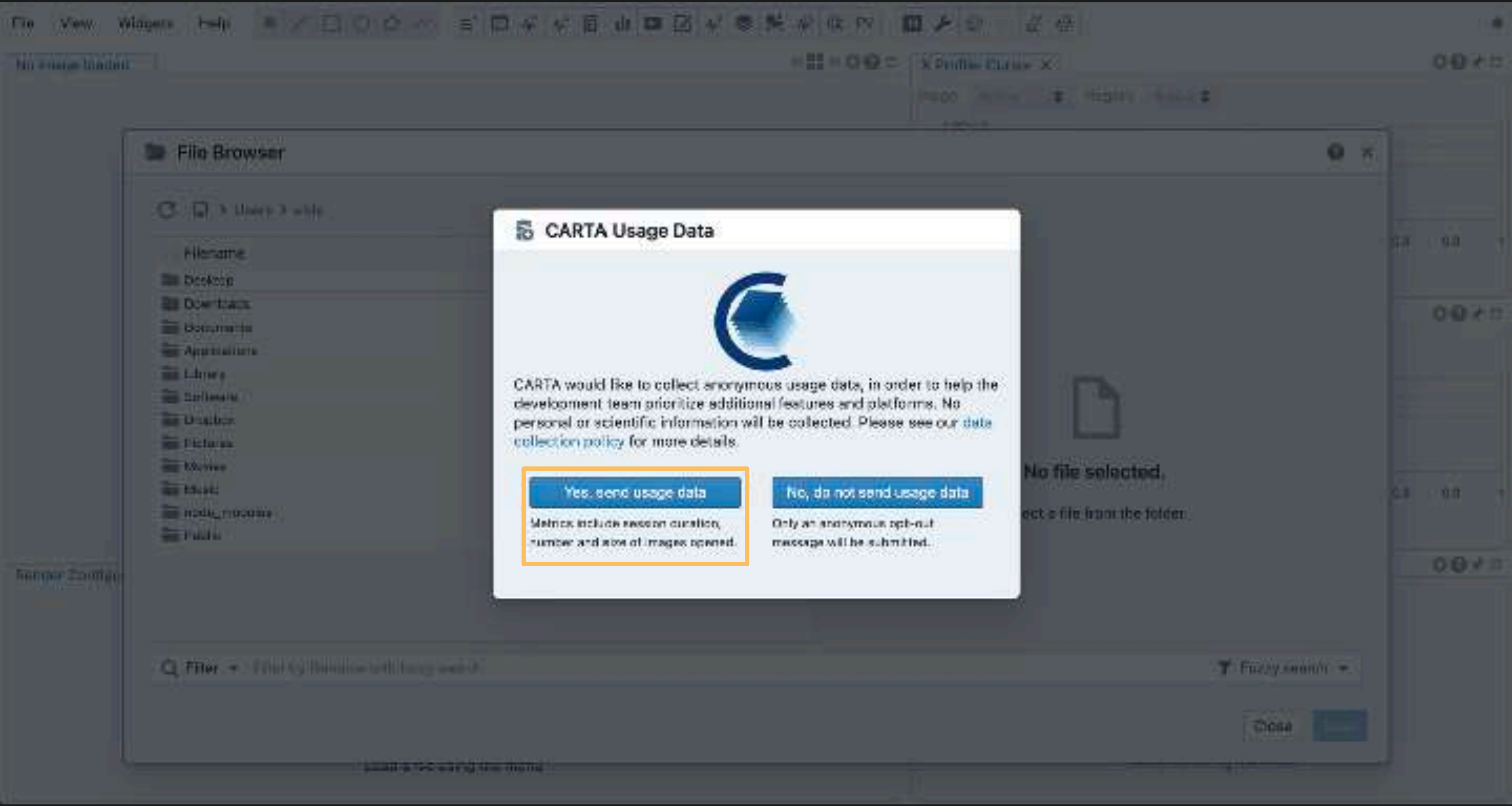
    -> One covering the redshifted emission, rename it ‘blue’

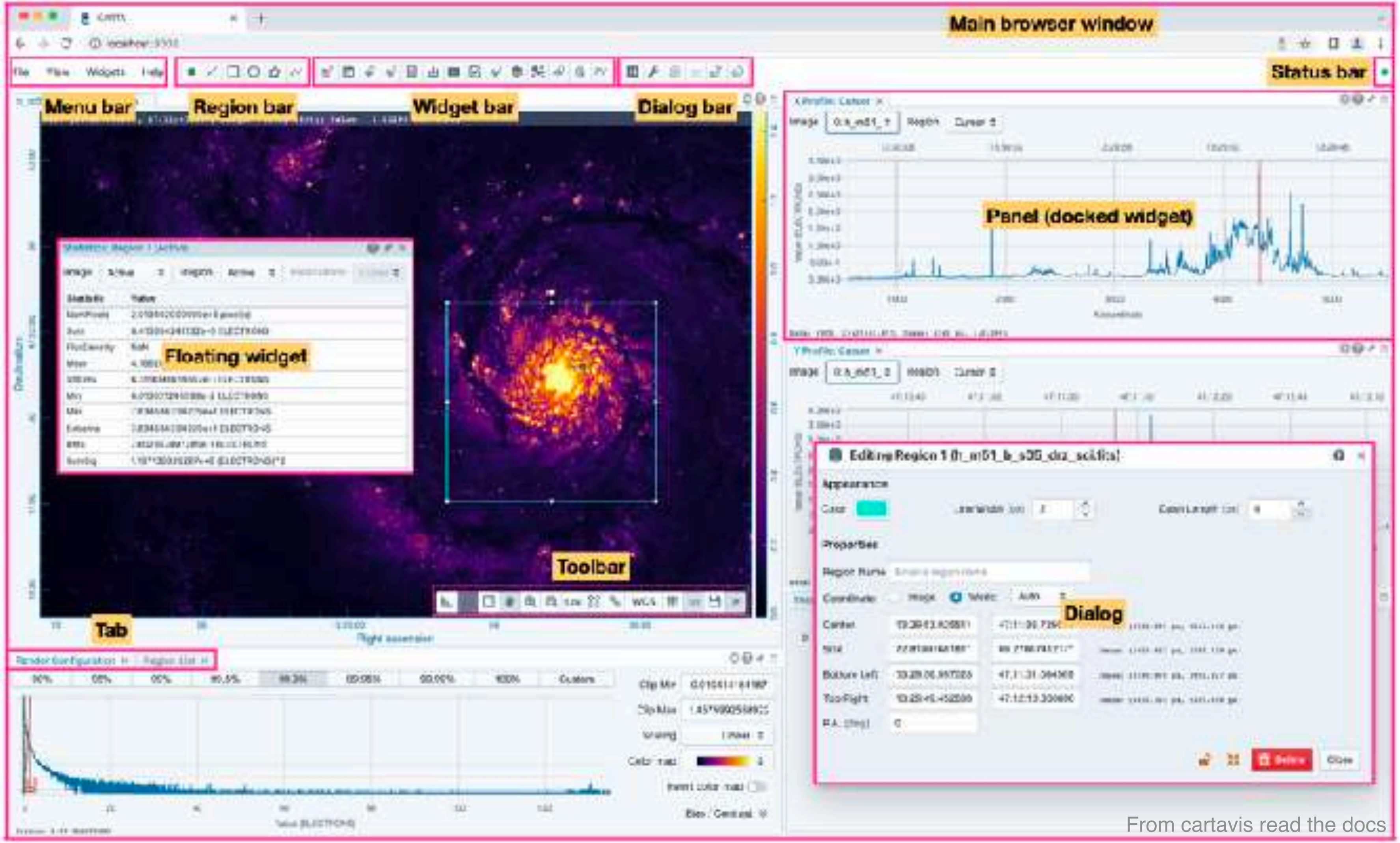
15. Visualise the emission over the three regions (red, blue, disk) in the Spectral Profiler by ticking the ‘Region’ box at the top and selecting the regions

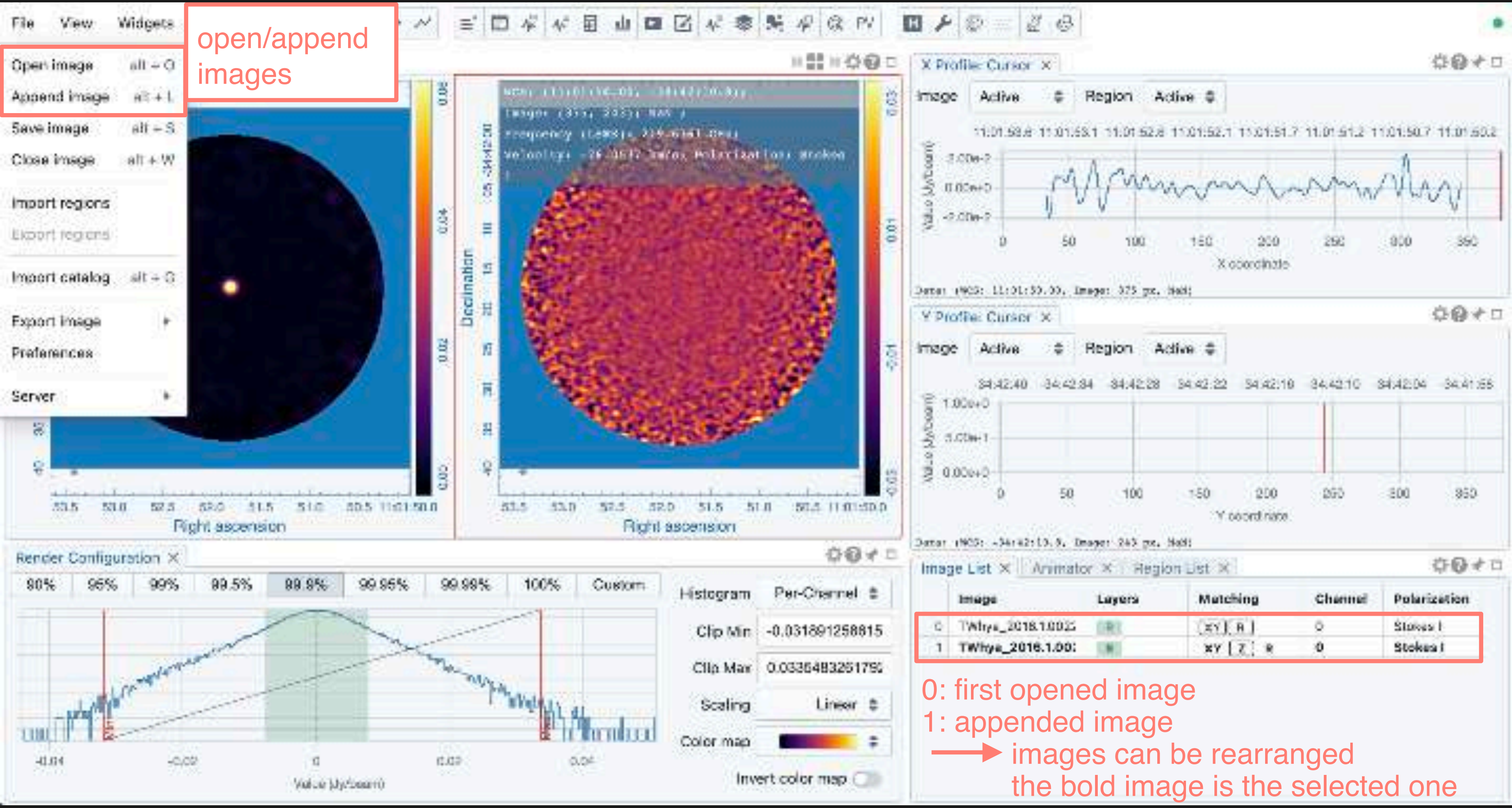
    -> Play with the different statistics shown

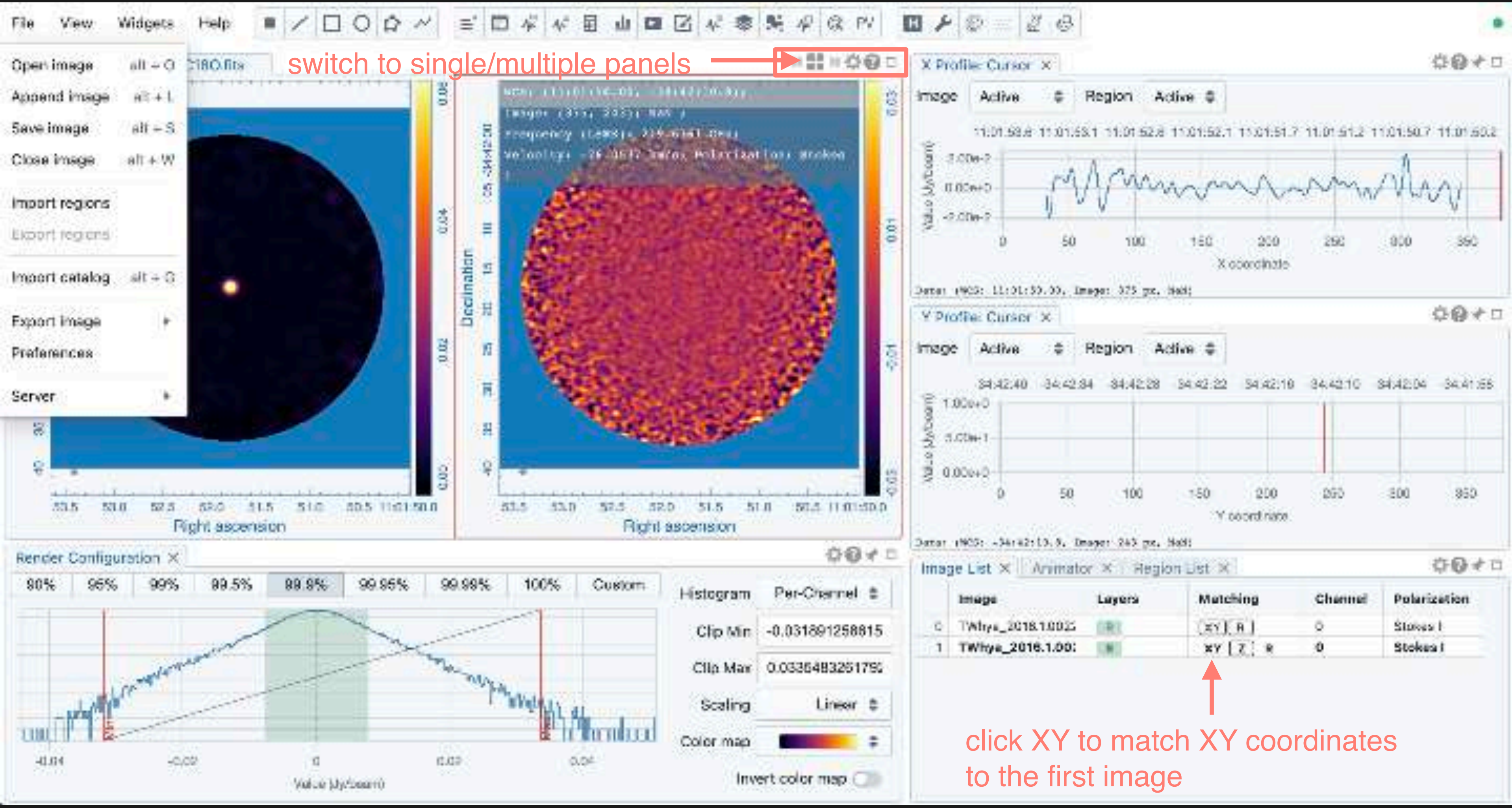
16. Fit the emission line profile of the redshifted emission and the blueshifted emission with Gaussian profiles (note the central velocities)
17. Save a new sub-cube (both spatial and spectral) that only includes the disk region and the line of interest as a new FITS file
18. Append this new smaller cube & create a PV diagram for a cut across the strongest velocity gradient

    -> Remember that you first need to create a line region across the gradient

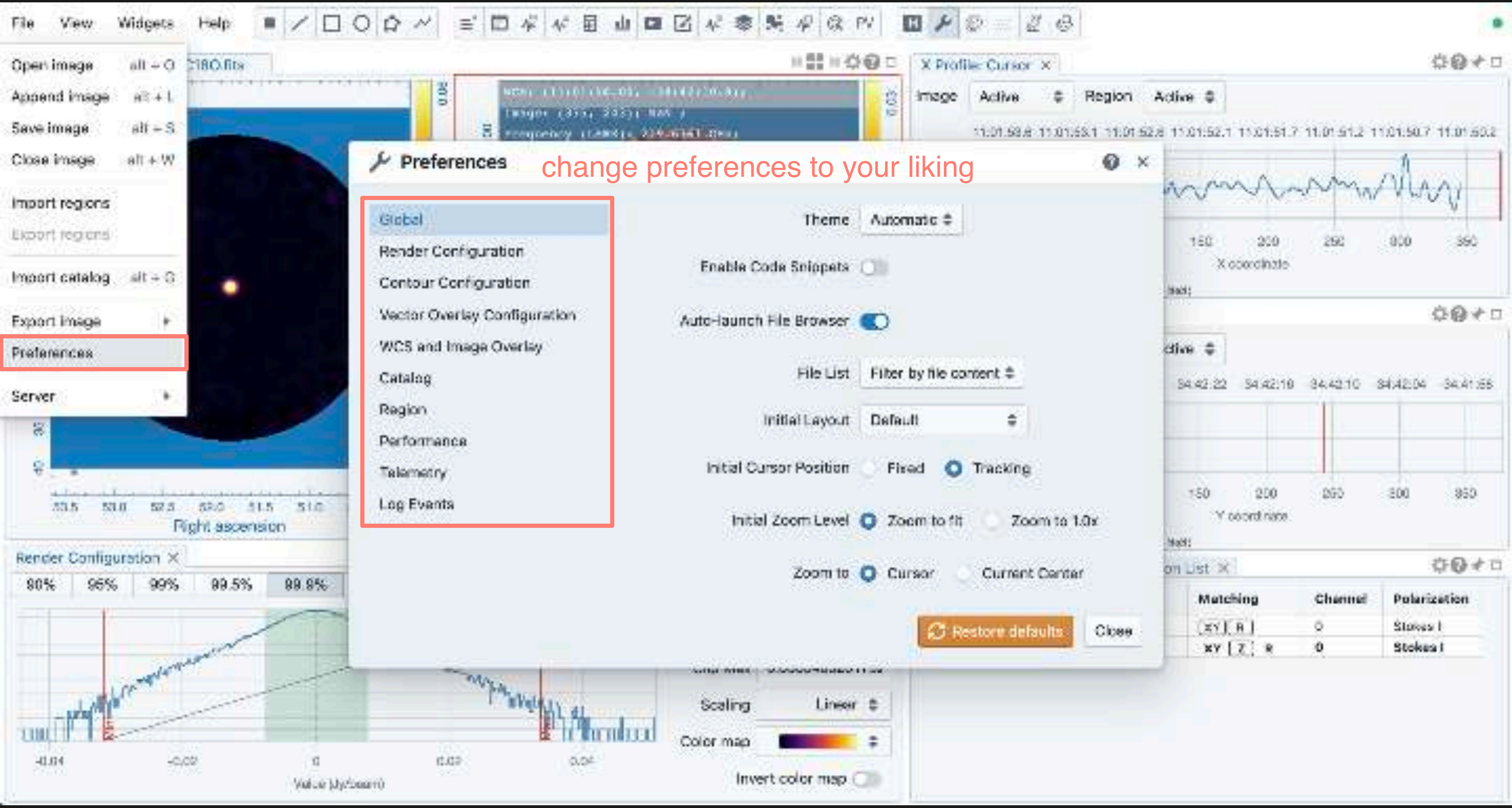

File Browser
CARTA Usage Data
CARTA would like to collect anonymous usage data, in order to help the development team prioritize additional features and platforms. No personal or scientific information will be collected. Please see our data collection policy for more details.
Yes, send usage data
Metrics include session duration, number and size of images opened.
No, do not send usage data
Only an anonymous opt-out message will be submitted.
No file selected.
Filter
Close


Main browser window
Status bar
Menu bar
Region bar
Widget bar
Dialog bar
Panel (docked widget)
Floating widget
Toolbar
Dialog
Tab
From cartavis read the docs

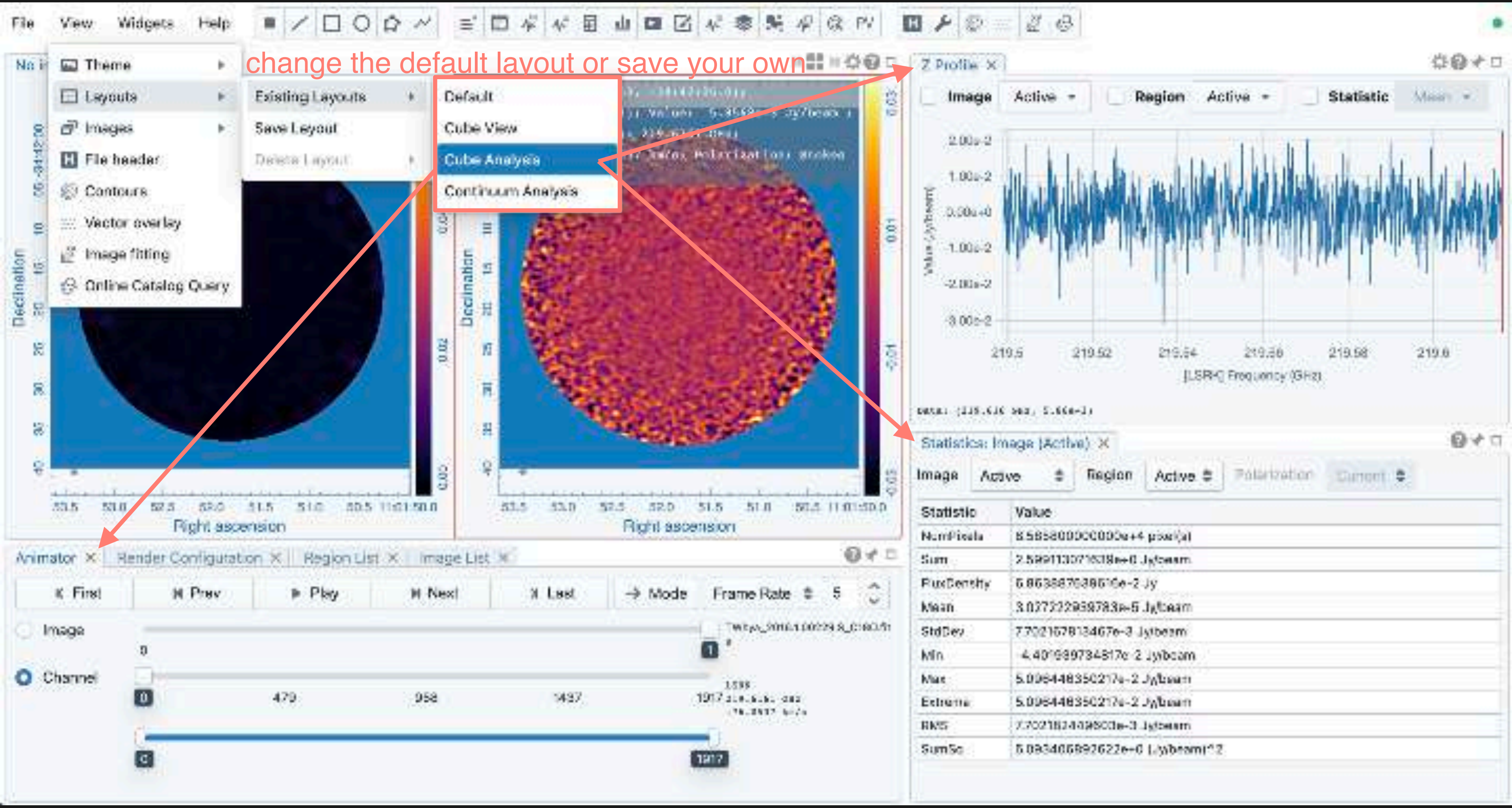

File
View
Widgets
Open image alt + O
Append image alt + L
Save image alt + S
Close image alt + W
Import regions
Export regions
Import catalog alt + G
Export image
Preferences
Server
open/append images
X Profile: Cursor
Image Active
Region Active
X coordinate
Y Profile: Cursor
Y coordinate
Right ascension
Declination
Render Configuration
90%
95%
99%
99.5%
99.9%
99.95%
99.99%
100%
Custom
Histogram Per-Channel
Clip Min -0.031891258815
Clip Max 0.0326483261792
Scaling Linear
Color map
Invert color map
Value (Jy/beam)
Image List
Animator
Region List
Image
Layers
Matching
Channel
Polarization
0 TWhya_2016.1.00:
1 TWhya_2016.1.00:
Stokes I
0: first opened image
1: appended image
images can be rearranged
the bold image is the selected one



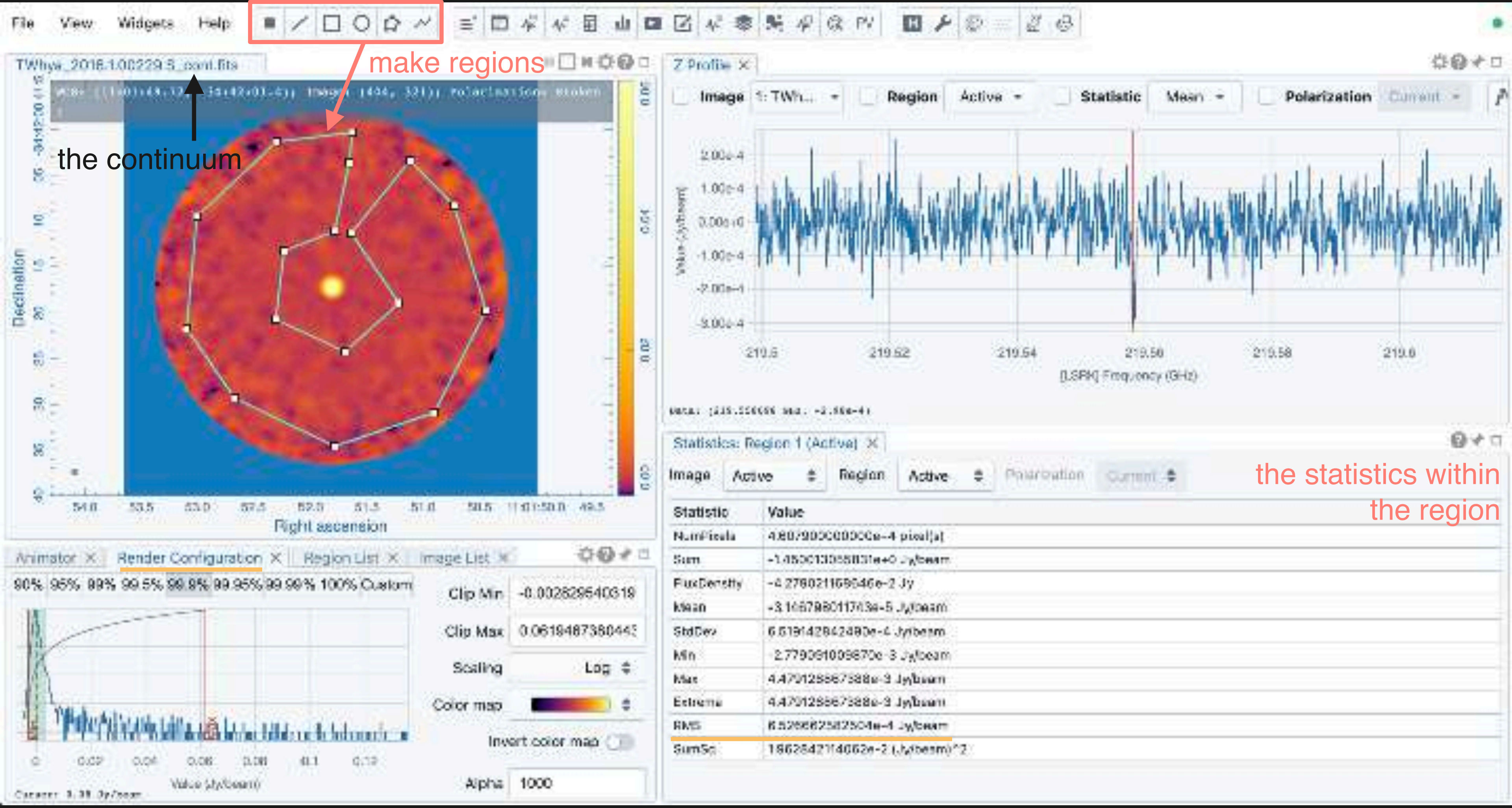
switch to single/multiple panels
click XY to match XY coordinates
to the first image



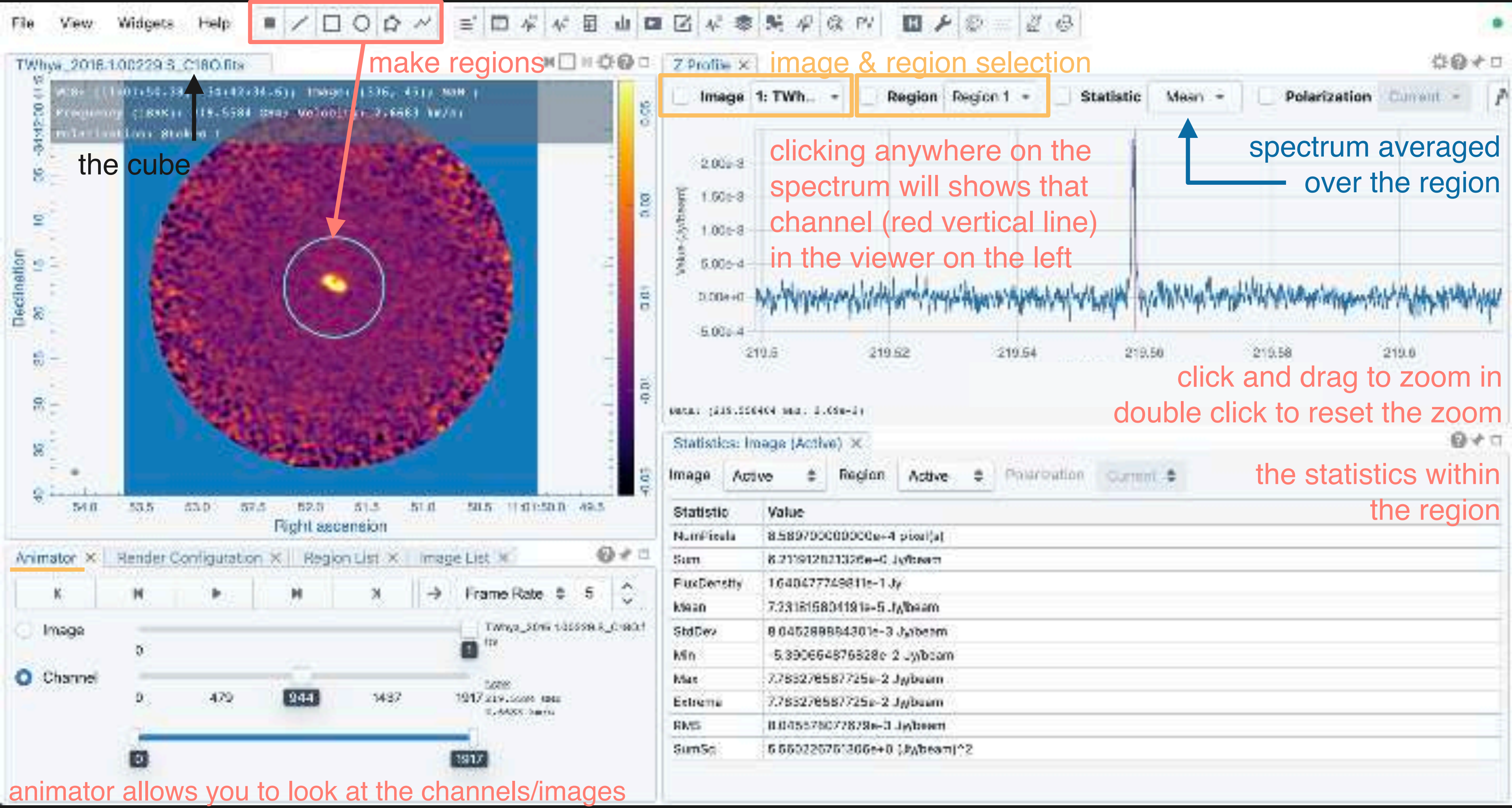
change preferences to your liking
File
View
Widgets
Help
Open image
Append image
Save image
Close image
Import regions
Export regions
Import catalog
Export image
Preferences
Server
Preferences
Global
Render Configuration
Contour Configuration
Vector Overlay Configuration
WCS and Image Overlay
Catalog
Region
Performance
Telemetry
Log Events
Theme
Automatic
Enable Code Snippets
Auto-launch File Browser
File List
Filter by file content
Initial Layout
Default
Initial Cursor Position
Fixed
Tracking
Initial Zoom Level
Zoom to fit
Zoom to 1.0x
Zoom to
Cursor
Current Center
Restore defaults
Close
X Profile: Cursor
Image
Active
Region
Active
X coordinate
Y coordinate
Render Configuration
90%
95%
99%
99.5%
99.9%
Right ascension
Scaling
Linear
Color map
Invert color map
Matching
Channel
Polarization
Stokes I

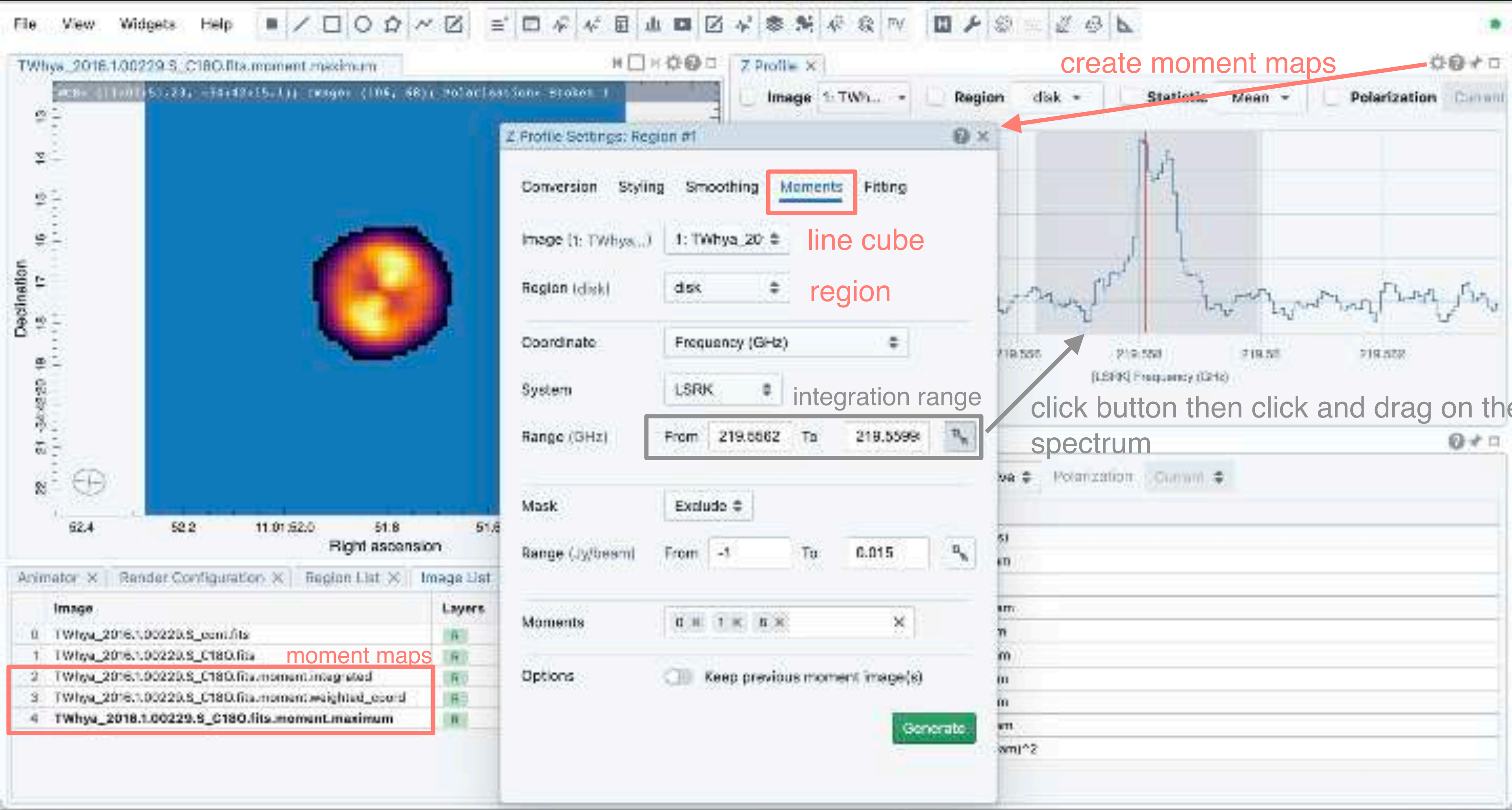


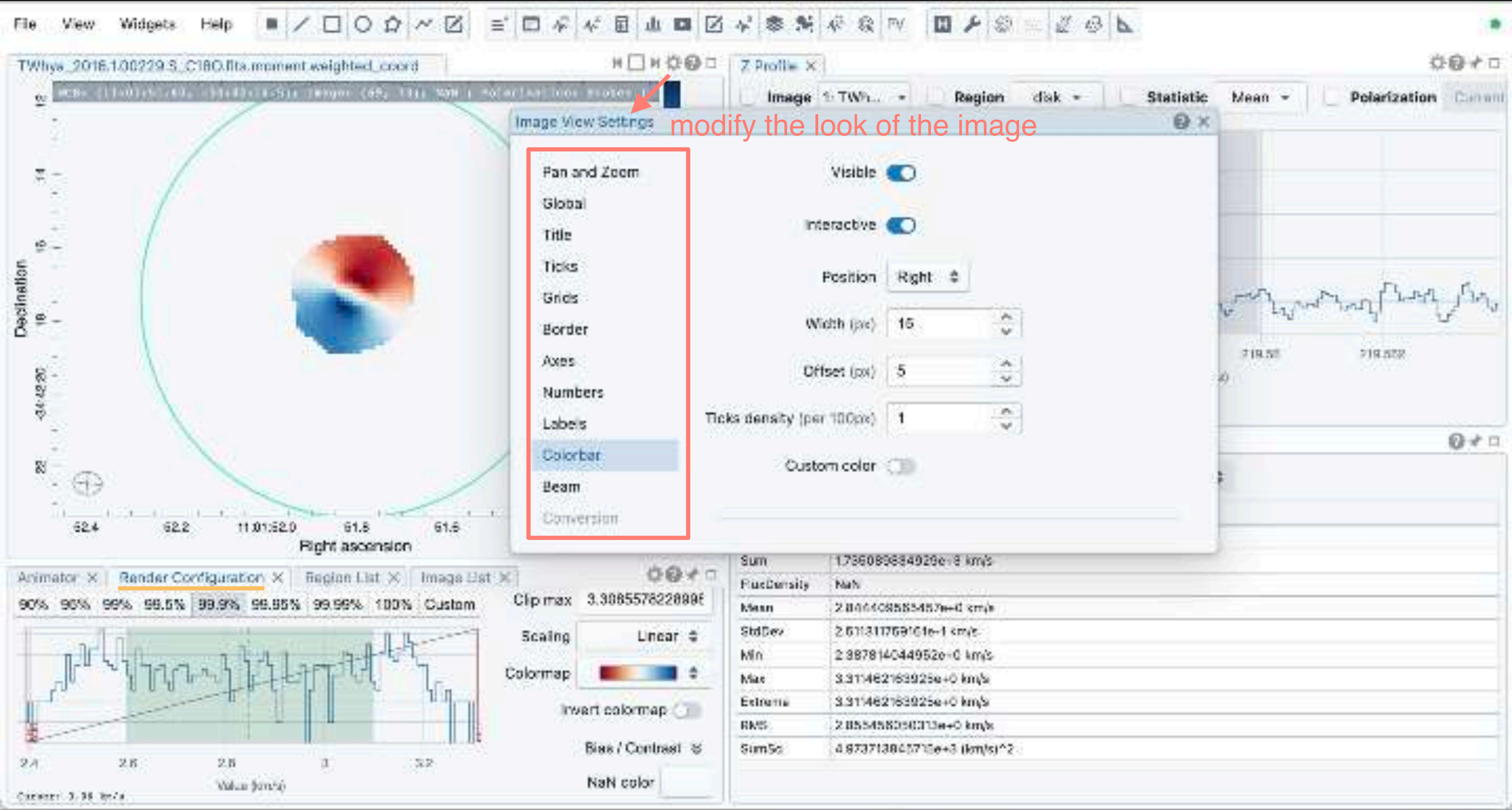
change the default layout or save your own
File
View
Widgets
Help
Theme
Layouts
Images
File header
Contours
Vector overlay
Image fitting
Online Catalog Query
Existing Layouts
Save Layout
Delete Layout
Default
Cube View
Cube Analysis
Continuum Analysis
Z Profile
Image
Active
Region
Active
Statistic
Right ascension
Declination
[LSRK] Frequency (GHz)
Statistics: Image (Active)
Statistic
Value
NumPixels
Sum
FluxDensity
Mean
StdDev
Min
Max
Extrema
RMS
SumSq
Animator
Render Configuration
Region List
Image List
First
Prev
Play
Next
Last
Mode
Frame Rate
Image
Channel

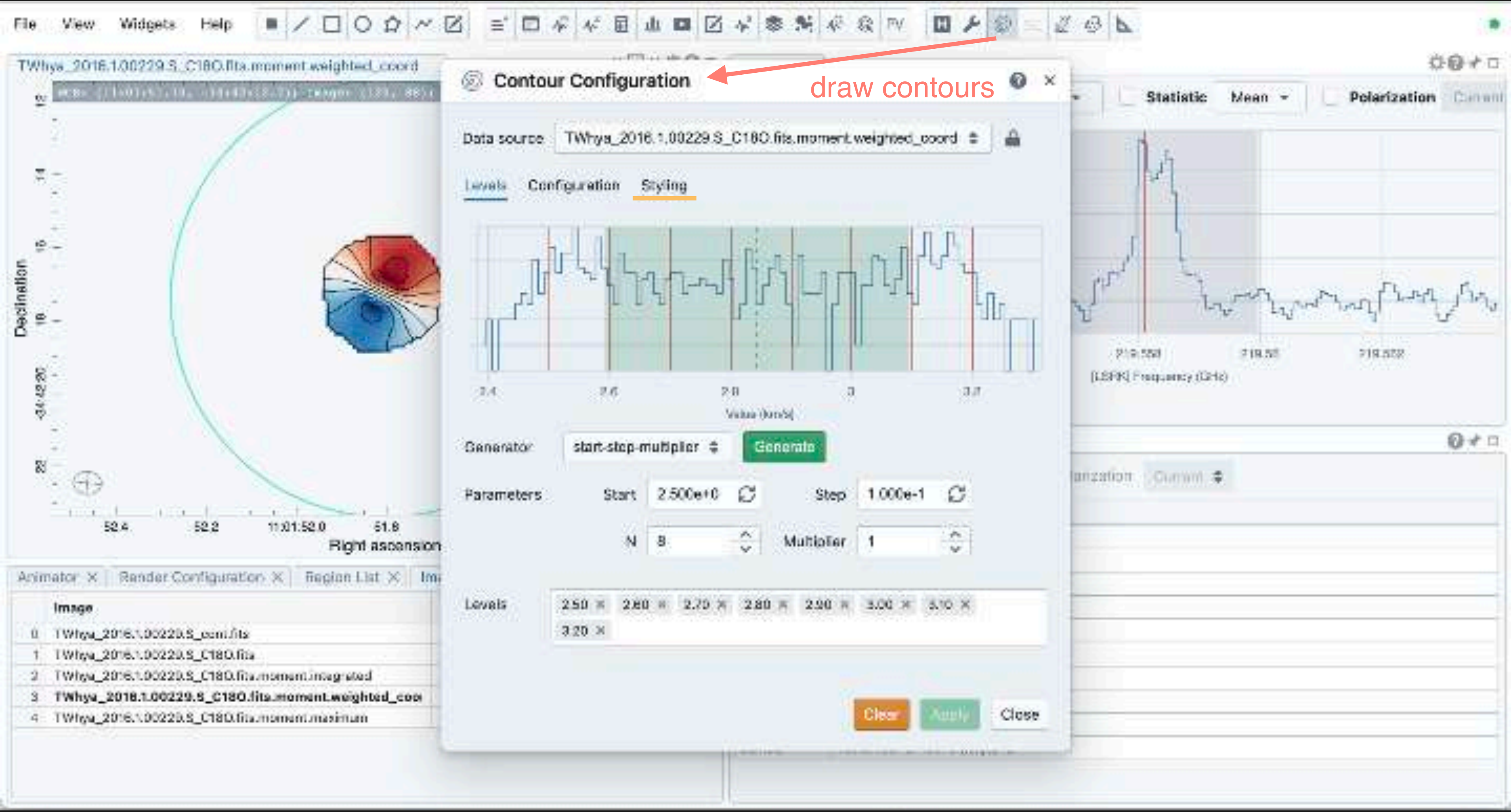


File
View
Widgets
Help
make regions
the continuum
Declination
Right ascension
Z Profile
Image
Region
Active
Statistic
Mean
Polarization
[LSRK] Frequency (GHz)
Statistics: Region 1 (Active)
the statistics within the region
Statistic
Value
NumPixels
Sum
FluxDensity
Mean
StdDev
Min
Max
Extrema
RMS
SumSq
Animator
Render Configuration
Region List
Image List
Clip Min
Clip Max
Scaling
Log
Color map
Invert color map
Alpha
1000
Value (Jy/beam)

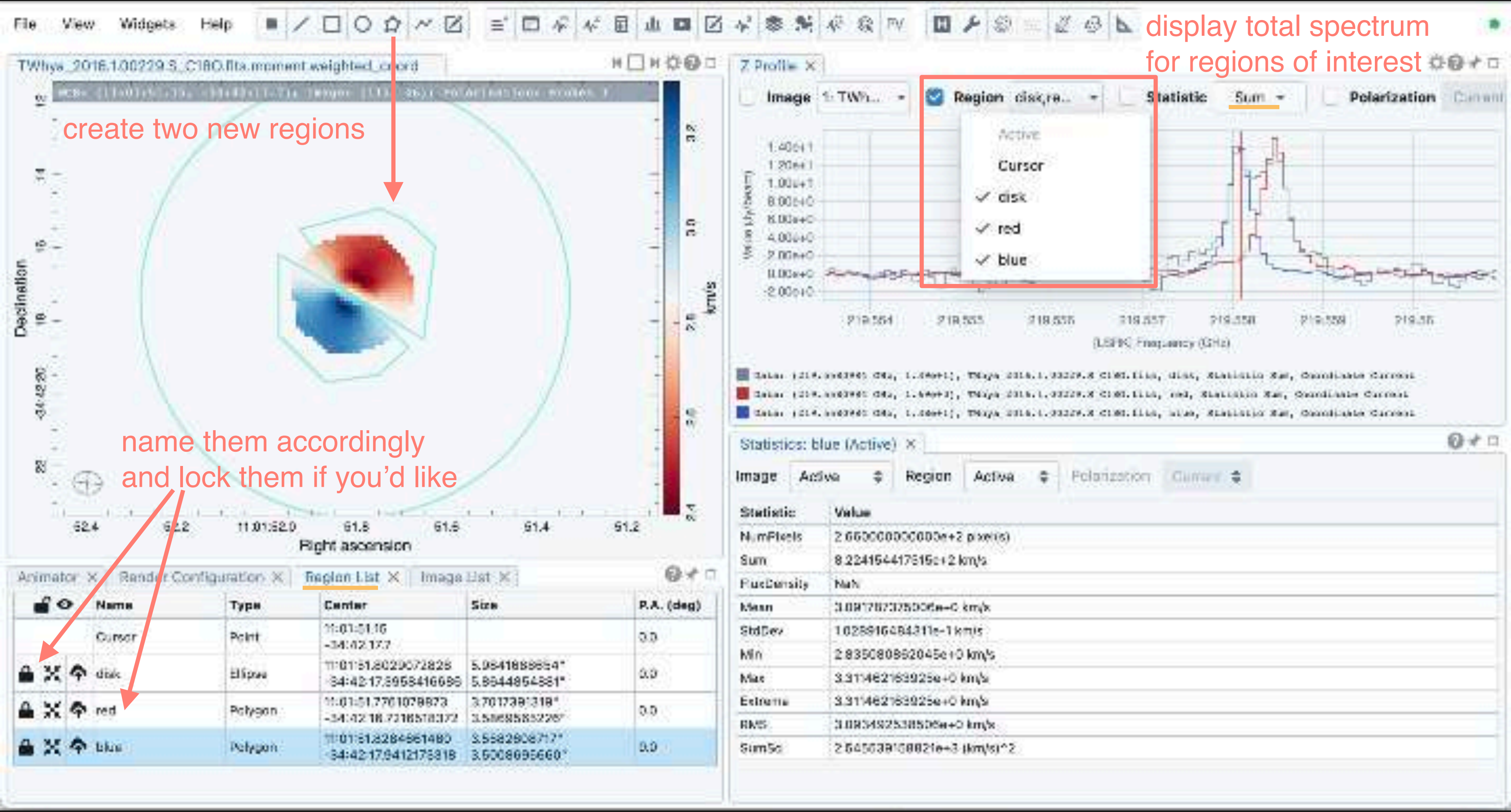

make regions
image & region selection
the cube
clicking anywhere on the spectrum will shows that channel (red vertical line) in the viewer on the left
spectrum averaged over the region
click and drag to zoom in
double click to reset the zoom
the statistics within the region
animator allows you to look at the channels/images


create moment maps
line cube
region
integration range
click button then click and drag on the spectrum
moment maps
Z Profile Settings: Region #1
Conversion
Styling
Smoothing
Moments
Fitting
Image (1: TWhya...)
Region (disk)
Coordinate
Frequency (GHz)
System
LSRK
Range (GHz)
From
219.5662
To
219.5599
Mask
Exclude
Range (Jy/beam)
-1
0.015
Moments
Options
Keep previous moment image(s)
Generate
Right ascension
Declination
Animator
Render Configuration
Region List
Image List
Image
Layers
TWhya_2016.1.00229.S_cont.fits
TWhya_2016.1.00229.S_C18O.fits
TWhya_2016.1.00229.S_C18O.fits.moment.integrated
TWhya_2016.1.00229.S_C18O.fits.moment.weighted_coord
TWhya_2016.1.00229.S_C18O.fits.moment.maximum
Z Profile
Statistic
Mean
Polarization
[LSRK] Frequency (GHz)

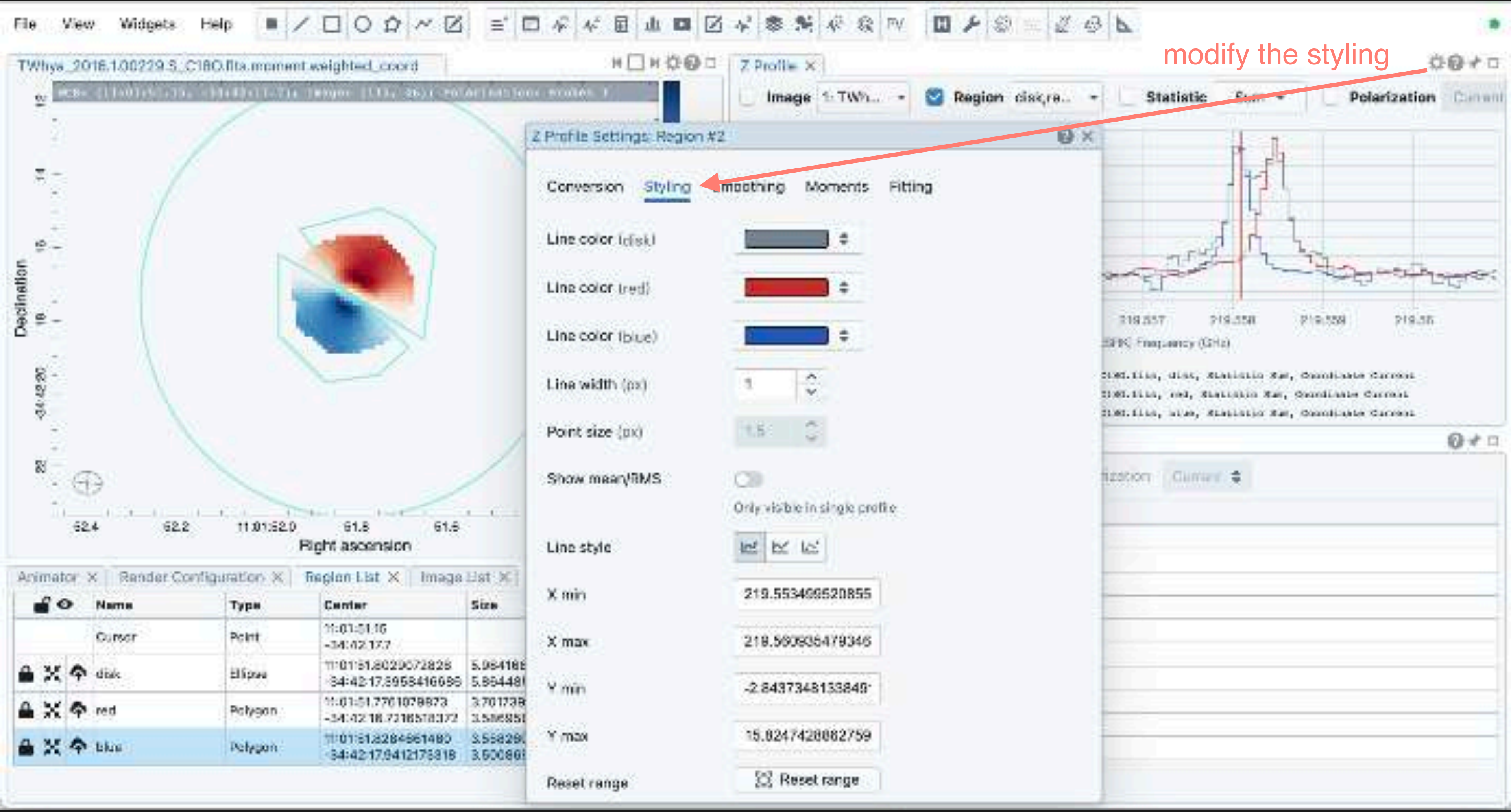

File
View
Widgets
Help
Z Profile
Image
Region
Statistic
Mean
Polarization
Image View Settings
modify the look of the image
Pan and Zoom
Global
Title
Ticks
Grids
Border
Axes
Numbers
Labels
Colorbar
Beam
Conversion
Visible
Interactive
Position
Right
Width (px)
15
Offset (px)
5
Ticks density (per 100px)
1
Custom color
Declination
Right ascension
Animator
Render Configuration
Region List
Image List
90%
95%
99%
99.5%
99.9%
99.95%
99.99%
100%
Custom
Clip max
Scaling
Linear
Colormap
Invert colormap
Bias / Contrast
NaN color
Sum
FluxDensity
NaN
Mean
StdDev
Min
Max
Extrema
RMS
SumSq

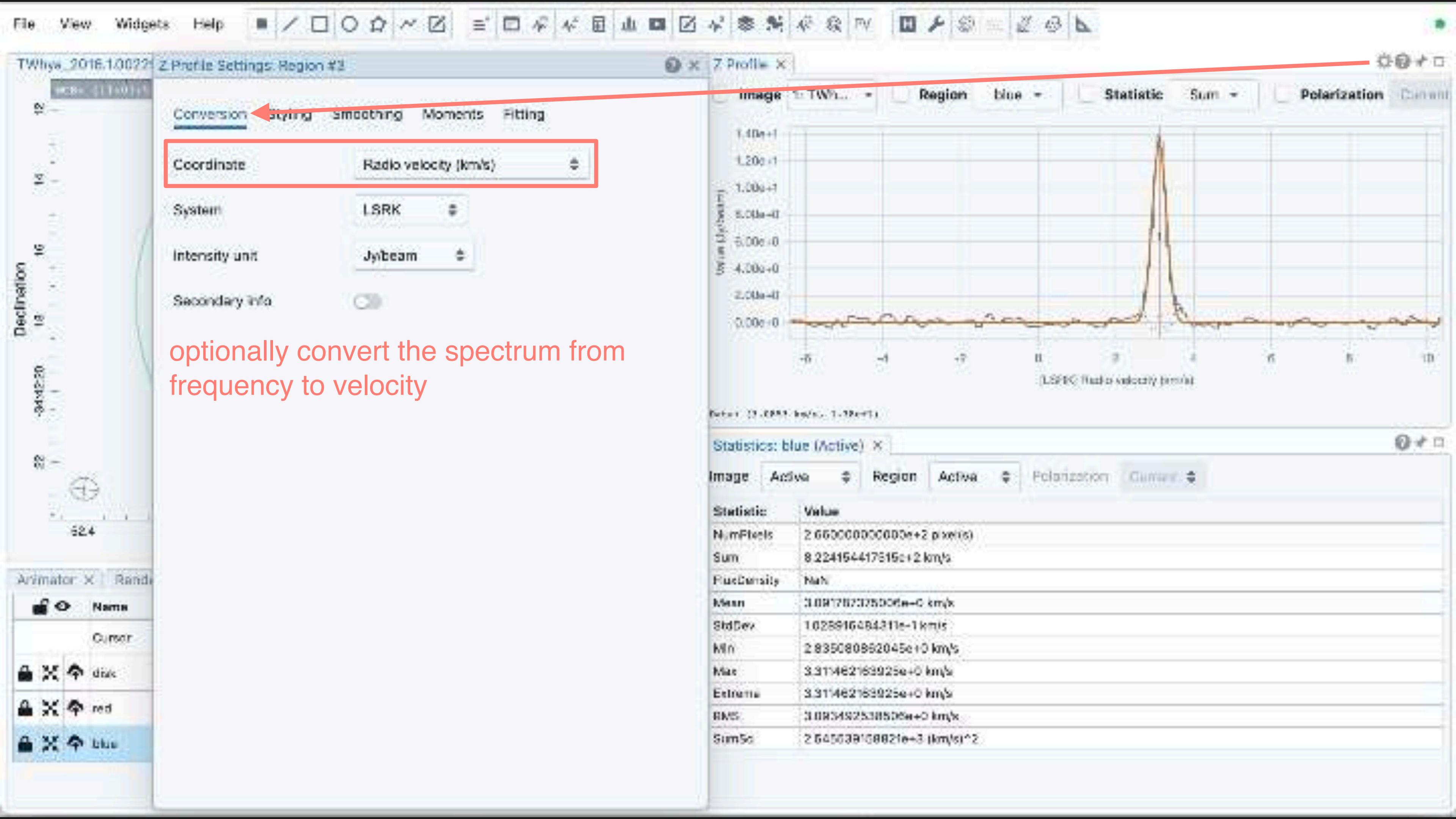

File
View
Widgets
Help
TWhya_2016.1.00229.S_C18O.fits.moment.weighted_coord
Contour Configuration
draw contours
Statistic
Mean
Polarization
Data source
TWhya_2016.1.00229.S_C18O.fits.moment.weighted_coord
Levels
Configuration
Styling
Generator
start-step-multiplier
Generate
Parameters
Start
2.500e+0
Step
1.000e-1
N
8
Multiplier
1
Levels
2.50
2.60
2.70
2.80
2.90
3.00
3.10
3.20
Clear
Apply
Close
Declination
Right ascension
52.4
52.2
11:01:52.0
51.8
Animator
Render Configuration
Region List
Image
TWhya_2016.1.00229.S_cont.fits
TWhya_2016.1.00229.S_C18O.fits
TWhya_2016.1.00229.S_C18O.fits.moment.integrated
TWhya_2016.1.00229.S_C18O.fits.moment.weighted_coord
TWhya_2016.1.00229.S_C18O.fits.moment.maximum


File
View
Widgets
Help
Open Image alt + O
Append Image alt + L
Save Image alt + S
Close Image alt + W
Import Regions
Export Regions
Import Catalog alt + G
Export Image
Open Workspace
Save Workspace
Preferences
Server
Resolution
Normal (100%) alt + E
High (200%)
Highest (400%)
save image
Z Profile
Image
Region
Statistic
Sum
Polarization
[LSRK] Frequency (GHz)
km/s
Right ascension
Animator
Render Configuration
Region List
Image List
Image
Layers
Matching
Channel
Statistics: Image (Active)
Image
Active
Region
Active
Polarization
Statistic
Value
NumPixels
Sum
FluxDensity
Mean
StdDev
Min
Max
Extrema
RMS
SumSq

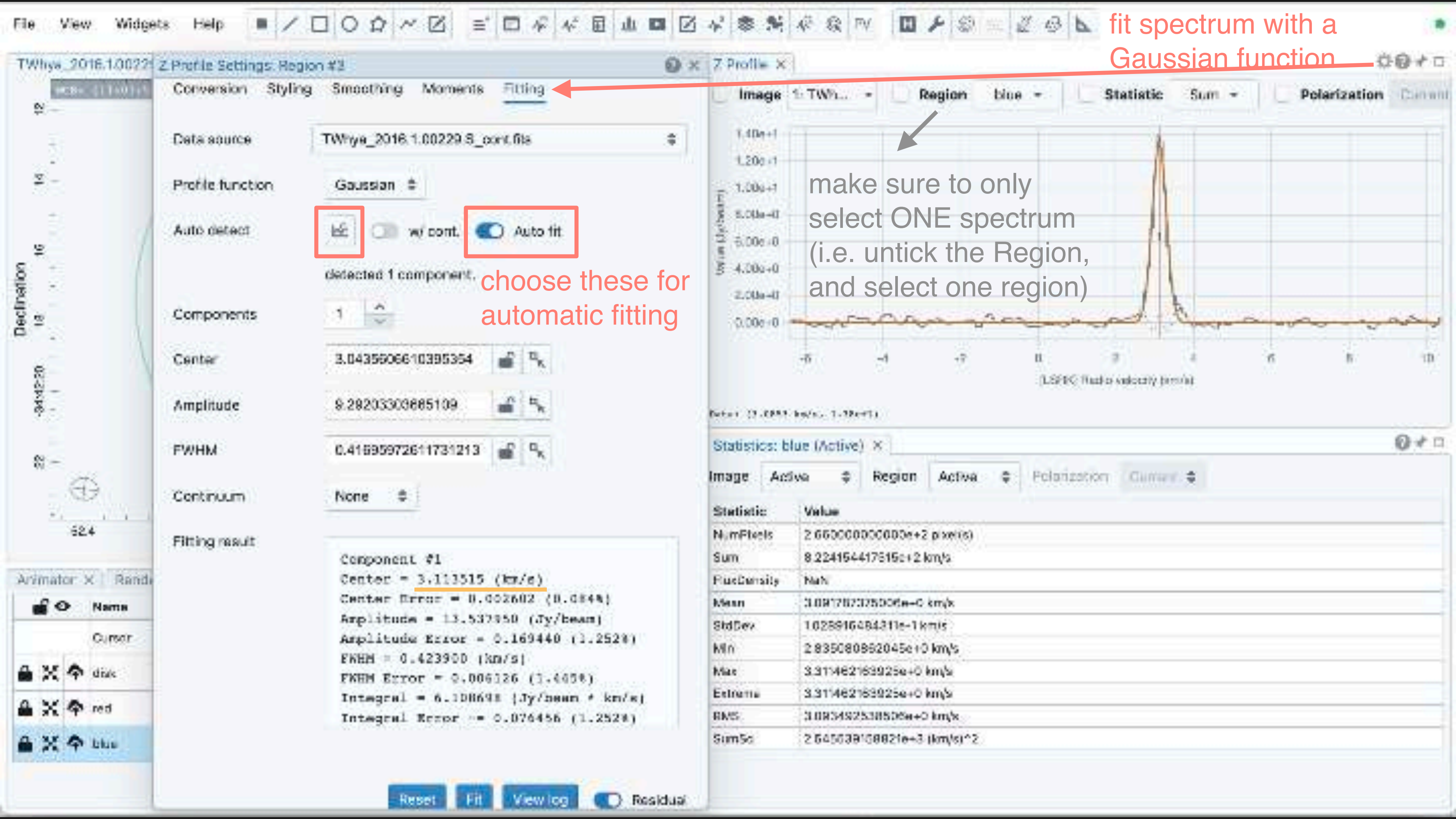


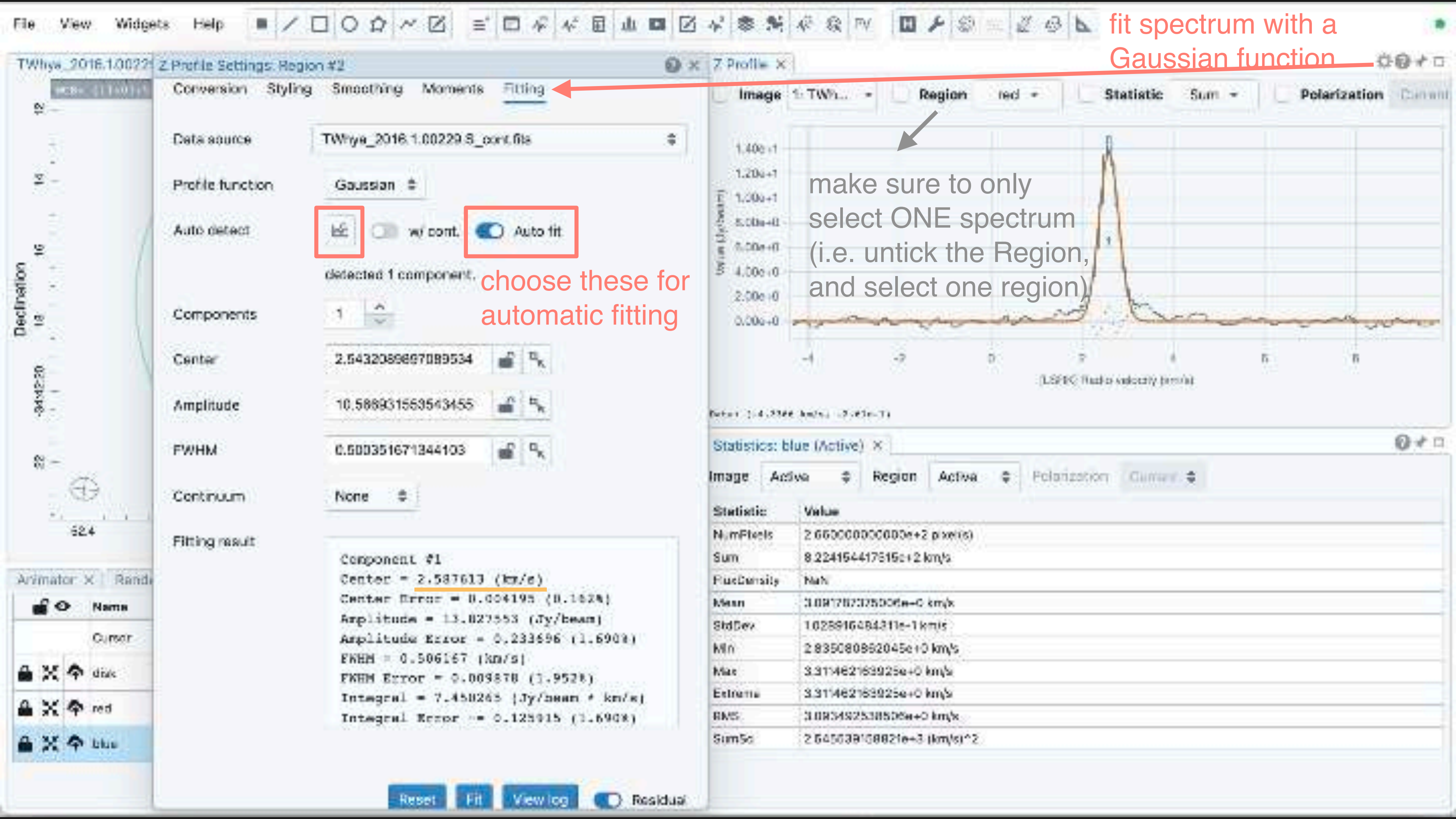
display total spectrum
for regions of interest
create two new regions
name them accordingly
and lock them if you'd like
Region
Active
Cursor
disk
red
blue
Statistics: blue (Active)
Statistic
Value
NumPixels
Sum
FluxDensity
Mean
StdDev
Min
Max
Extrema
RMS
SumSq
Name
Type
Center
Size
P.A. (deg)
Cursor
Point
disk
Ellipse
red
Polygon
blue
Polygon
Right ascension
Declination


modify the styling
File
View
Widgets
Help
Z Profile
Image
Region
Statistic
Polarization
Z Profile Settings: Region #2
Conversion
Styling
Smoothing
Moments
Fitting
Line color (disk)
Line color (red)
Line color (blue)
Line width (px)
Point size (px)
Show mean/RMS
Only visible in single profile
Line style
X min
219.553499520855
X max
219.560935479346
Y min
Y max
15.8247428862759
Reset range
Reset range
Declination
Right ascension
Animator
Render Configuration
Region List
Image List
Name
Type
Center
Size
Cursor
Point
disk
Ellipse
red
Polygon
blue
Polygon

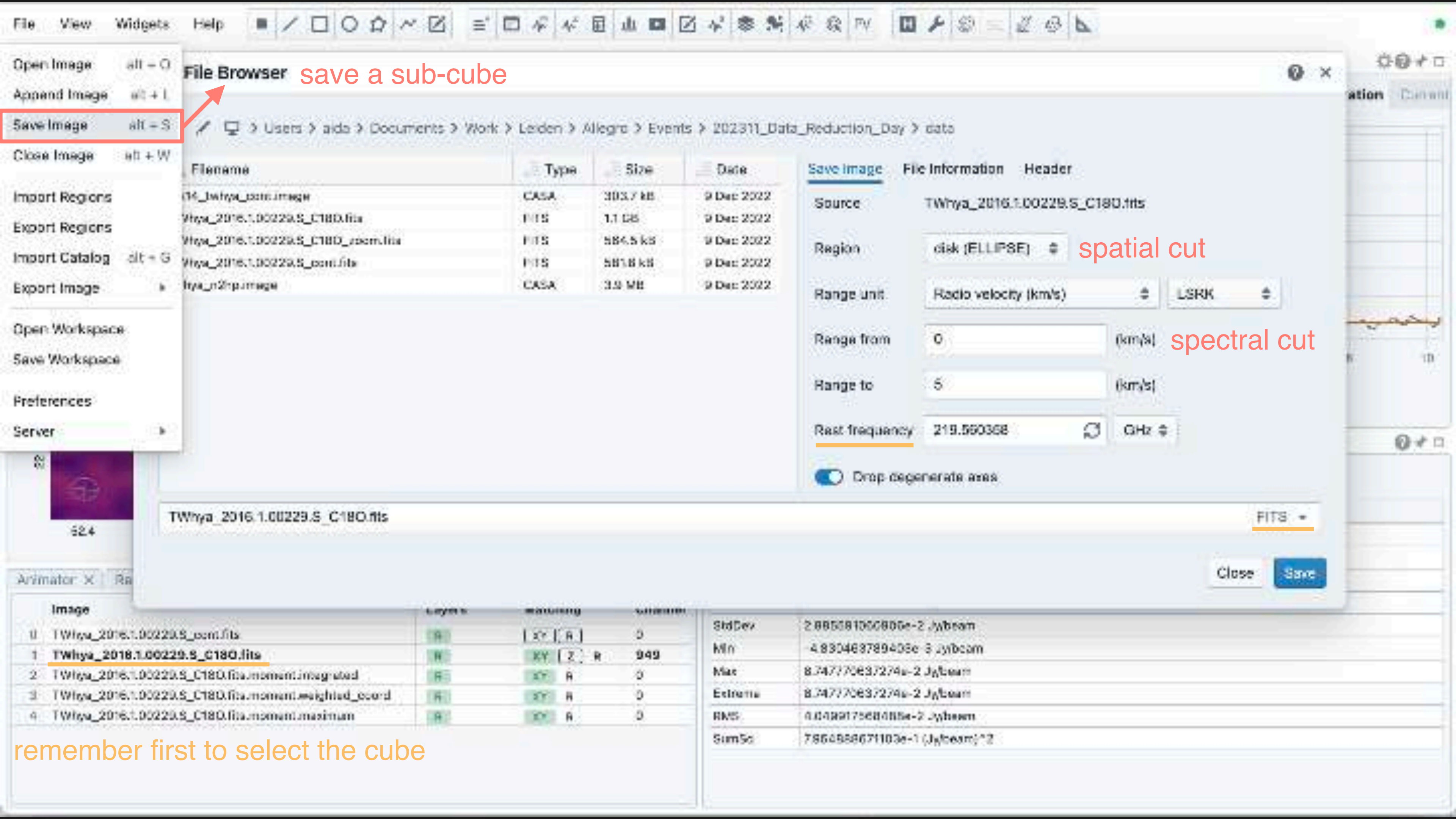


File
View
Widgets
Help
Z Profile Settings: Region #3
Conversion
Styling
Smoothing
Moments
Fitting
Coordinate
Radio velocity (km/s)
System
LSRK
Intensity unit
Jy/beam
Secondary info
optionally convert the spectrum from frequency to velocity
Z Profile
Region
blue
Statistic
Sum
Polarization
Statistics: blue (Active)
Image
Active
Region
Active
Polarization
Statistic
Value
NumPixels
Sum
FluxDensity
NaN
Mean
StdDev
Min
Max
Extrema
RMS
SumSq
Declination
Animator
Name
Cursor
disk
red
blue

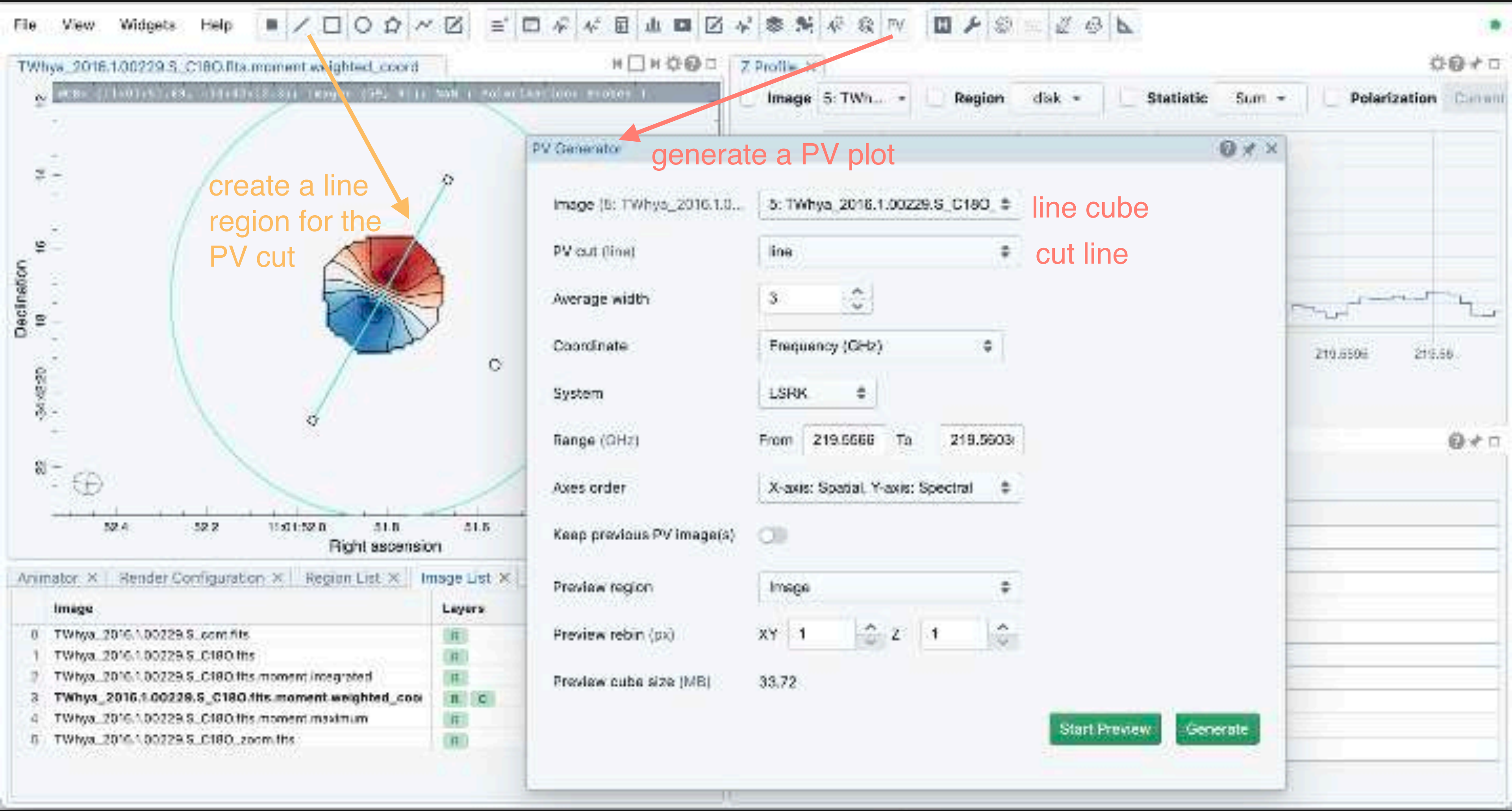

fit spectrum with a Gaussian function
make sure to only select ONE spectrum (i.e. untick the Region, and select one region)
choose these for automatic fitting
Z Profile Settings: Region #3
Conversion
Styling
Smoothing
Moments
Fitting
Data source
TWhya_2016.1.00229.S_cont.fits
Profile function
Gaussian
Auto detect
w/ cont.
Auto fit
detected 1 component.
Components
1
Center
3.0435506610395354
Amplitude
9.28203303885109
FWHM
0.41695972611731213
Continuum
None
Fitting result
Component #1
Center = 3.113515 (km/s)
Center Error = 0.002682 (0.086%)
Amplitude = 13.537350 (Jy/beam)
Amplitude Error = 0.169440 (1.252%)
FWHM = 0.423900 (km/s)
FWHM Error = 0.006126 (1.445%)
Integral = 6.108698 (Jy/beam * km/s)
Integral Error = 0.076456 (1.252%)
Reset
Fit
View log
Residual
Z Profile
Image
Region
blue
Statistic
Sum
Polarization
Statistics: blue (Active)
Image
Active
Region
Active
Polarization
Statistic
Value
NumPixels
Sum
FluxDensity
NaN
Mean
StdDev
Min
Max
Extrema
RMS
SumSq
Animator
Name
Cursor
disk
red
blue
File
View
Widgets
Help

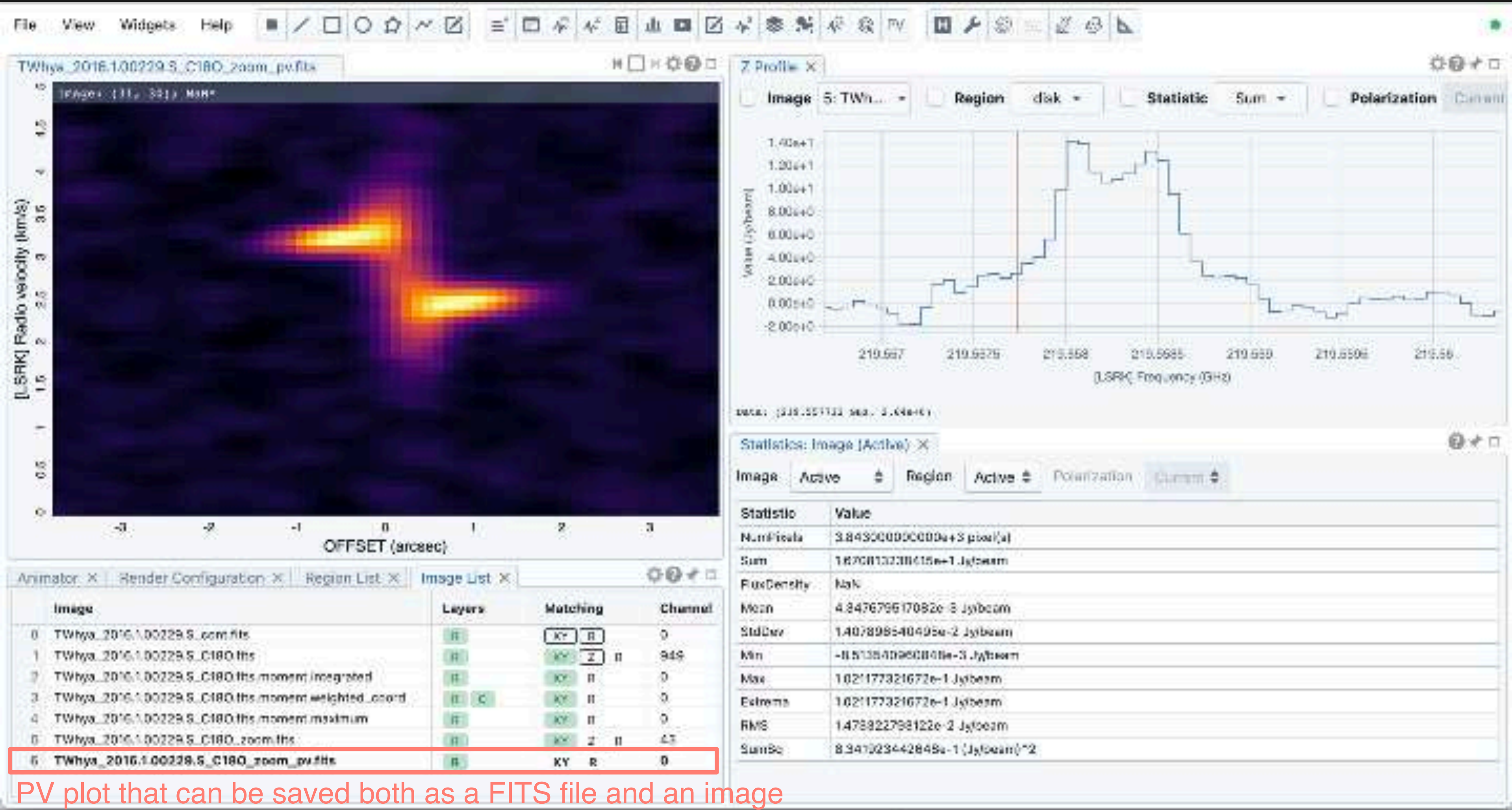


fit spectrum with a Gaussian function
make sure to only select ONE spectrum (i.e. untick the Region, and select one region)
choose these for automatic fitting
Z Profile Settings: Region #2
Conversion
Styling
Smoothing
Moments
Fitting
Data source
Profile function
Gaussian
Auto detect
w/ cont.
Auto fit
detected 1 component.
Components
Center
Amplitude
FWHM
Continuum
None
Fitting result
Component #1
Center = 2.587613 (km/s)
Reset
Fit
View log
Residual
Z Profile
Image
Region
red
Statistic
Sum
Polarization
Statistics: blue (Active)
Active
Statistic
Value
NumPixels
Sum
FluxDensity
Mean
StdDev
Min
Max
Extrema
RMS
SumSq
Animator
Name
Cursor
disk
red
blue



File
View
Widgets
Help
Open Image alt + O
Append Image alt + L
Save Image alt + S
Close Image alt + W
Import Regions
Export Regions
Import Catalog alt + G
Export Image
Open Workspace
Save Workspace
Preferences
Server
File Browser
save a sub-cube
Users > aida > Documents > Work > Leiden > Allegro > Events > 202311_Data_Reduction_Day > data
Filename
Type
Size
Date
Save Image
File Information
Header
Source TWhya_2016.1.00229.S_C18O.fits
Region disk (ELLIPSE)
spatial cut
Range unit Radio velocity (km/s)
LSRK
Range from 0 (km/s)
spectral cut
Range to 5 (km/s)
Rest frequency 219.560358 GHz
Drop degenerate axes
TWhya_2016.1.00229.S_C18O.fits
FITS
Close
Save
Animator
Image
TWhya_2016.1.00229.S_C18O.fits
remember first to select the cube


create a line region for the PV cut
generate a PV plot
line cube
cut line
PV Generator
Image [5: TWhya_2016.1.0...
5: TWhya_2016.1.00229.S_C18O
PV cut (line)
line
Average width
3
Coordinate
Frequency (GHz)
System
LSRK
Range (GHz)
From
219.5666
To
219.5603
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]
33.72
Start Preview
Generate
Right ascension
Declination
Image List
Image
Layers



PV plot that can be saved both as a FITS file and an image