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ANALYSIS TOOLS

Slides taken from the 15th Synthesis Imaging Workshop by Ylva Pihlstr.m

science.nrao.edu/science/meeFngs/2016/15th-synthesis- imaging-workshop/SIW2016_Pihlstrom.pdf

Visualizing

- Imaging will create a spectral line *cube*, which is 3-dimensional: RA, Dec and Velocity.

- With the cube, we usually visualize the information by making 1-D or 2-D projections:
  - Line profiles (1-D slices along velocity axis)
  - Channel maps (2-D slices along velocity axis)
    - 'Movies' can be formed from the channel maps
  - Moment maps (integration along the velocity axis)
  - Position-velocity plots (slices along spatial dimension)

- 3-D rendering programs also exist

Visualizing 3-D

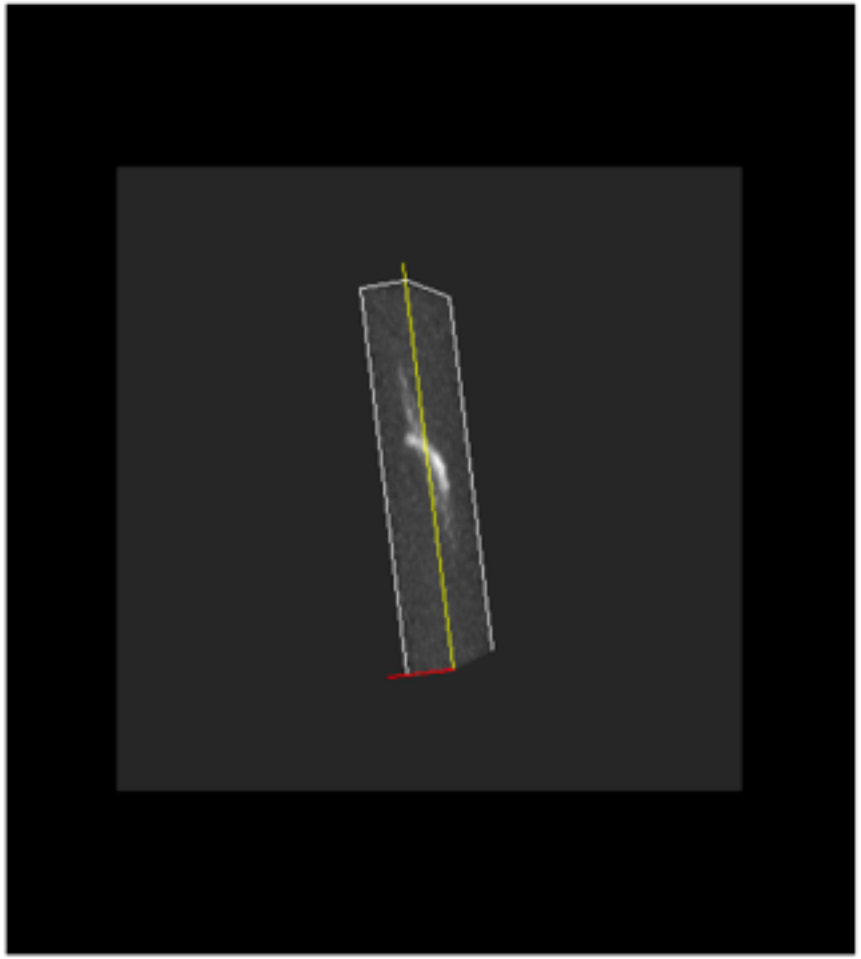
Some software allows 3-D visualization of cubes:

SAOimage DS9:

http://ds9.si.edu/site/Home.html

Karma package:

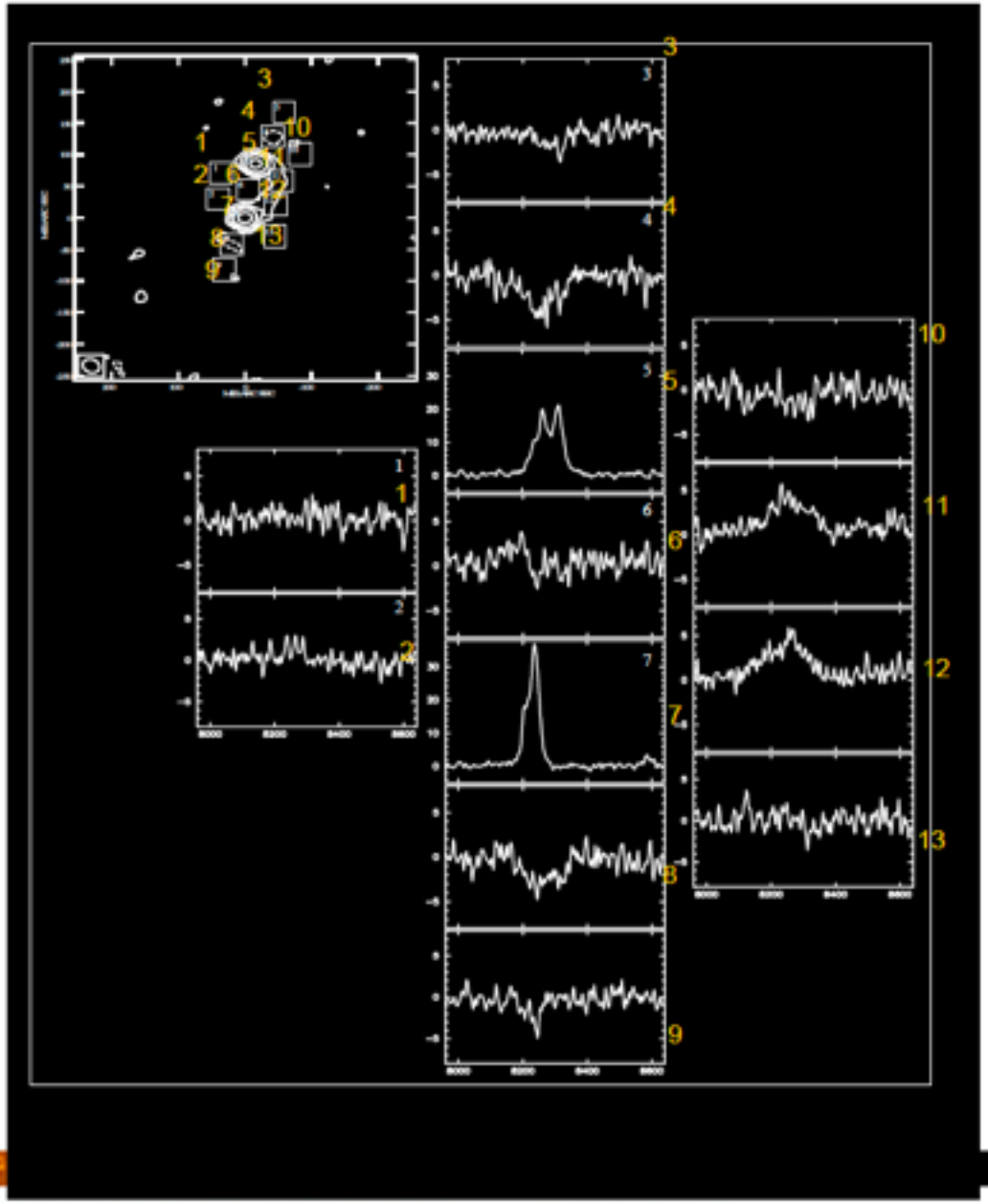
http://www.atnf.csiro.au/computing/software/karma/



Karma package; L. Matthews

1-D line profiles

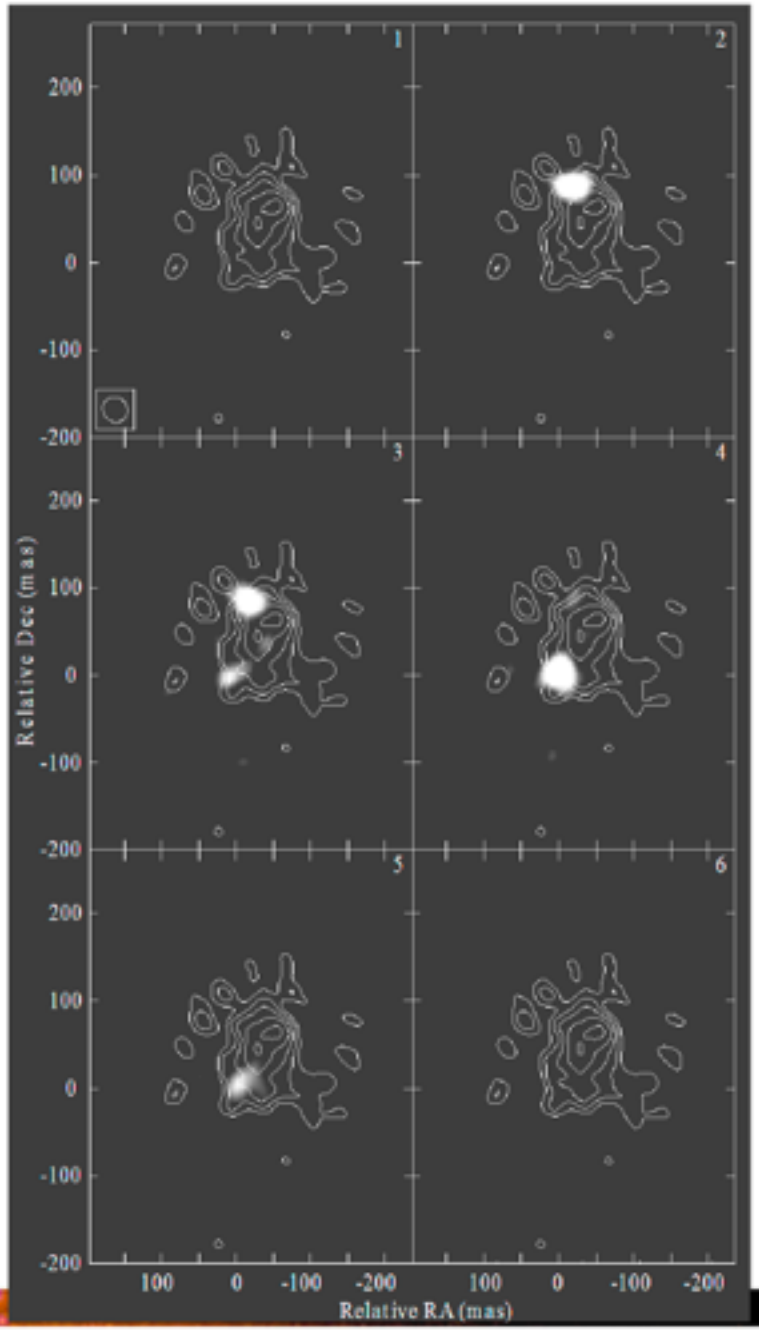
- Line profiles show changes in line shape, width and depth as a function of position.
- Can give information of relative position of features (absorption in front)
- Velocity width



EVN+MERLIN 1667 MHz OH maser emission and absorption spectra in a luminous infrared galaxy (IIIZw35).

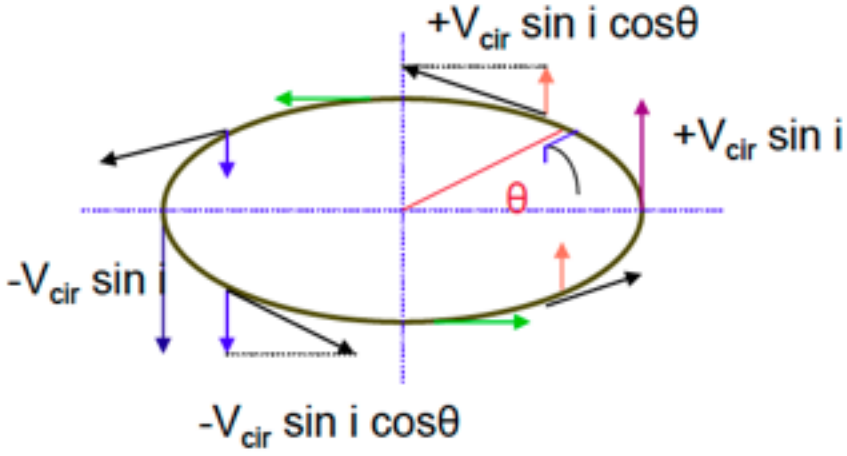
2-D channel maps

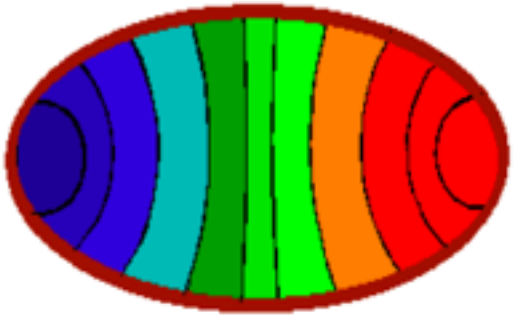
- Channel maps show how the spatial distribution of the line feature changes with frequency/velocity.
- Information about kinematics.



Contours continuum emission, grey scale 1667 MHz OH line emission in IIIZw35.

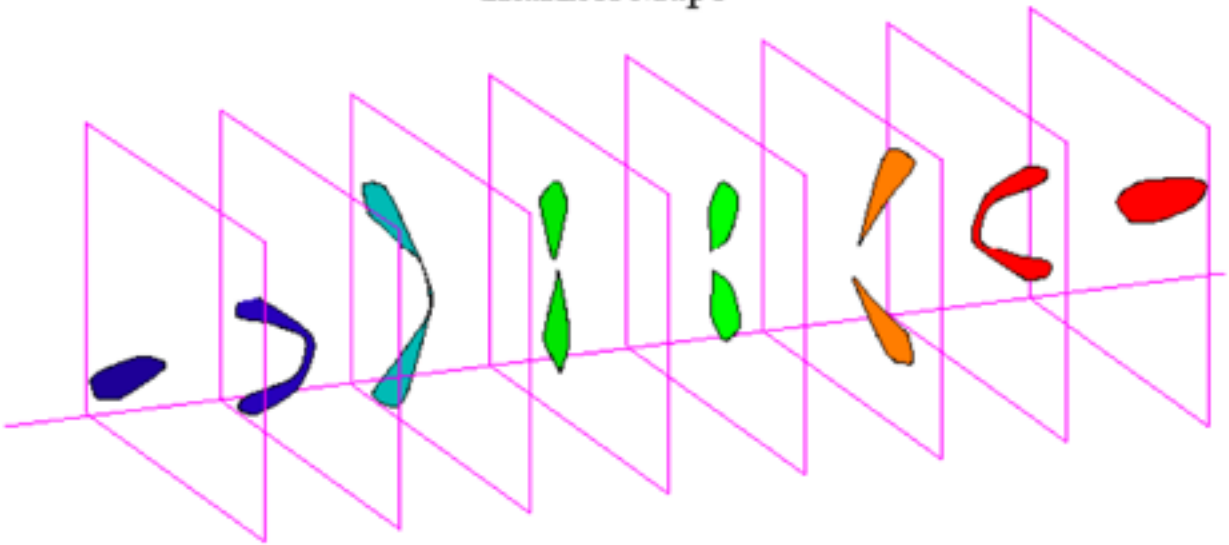
Rotating disk model





Mean Velocity Field

Channel Maps

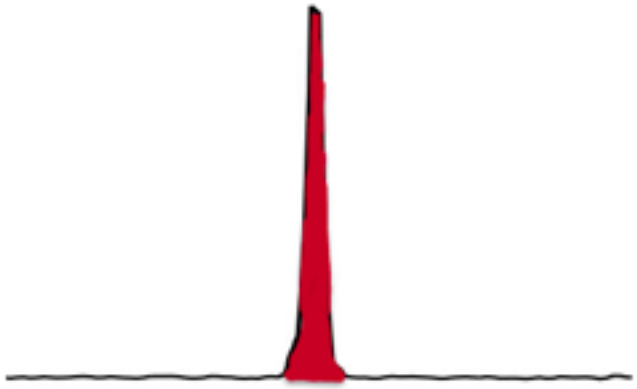


Moment analysis

- You might want to derive parameters such as integrated line intensity, centroid velocity of components and line width - all as functions of positions. Estimate using the *moments* of the line profile:

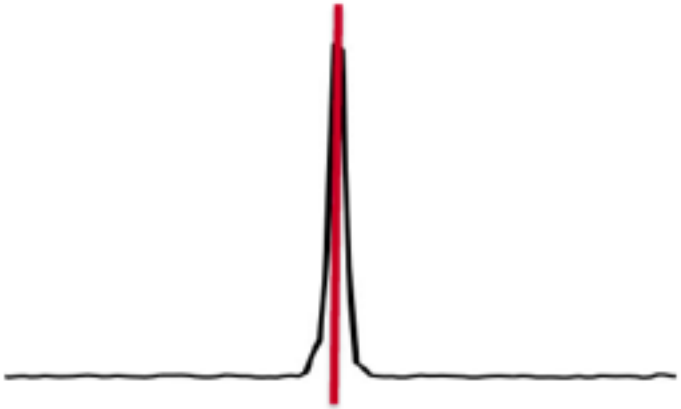
- Integrated intensity

$$\text{Moment } 0 = \int S_v dv$$



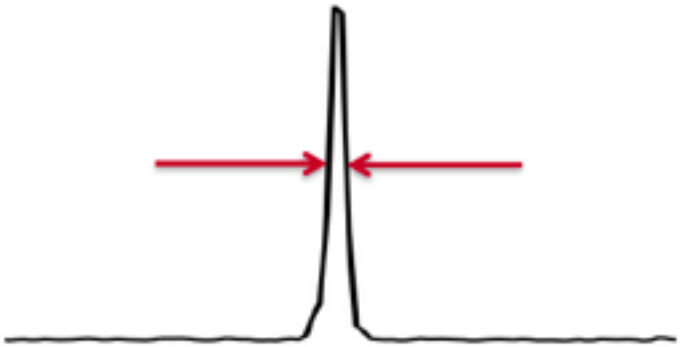
- Intensity weighted velocity

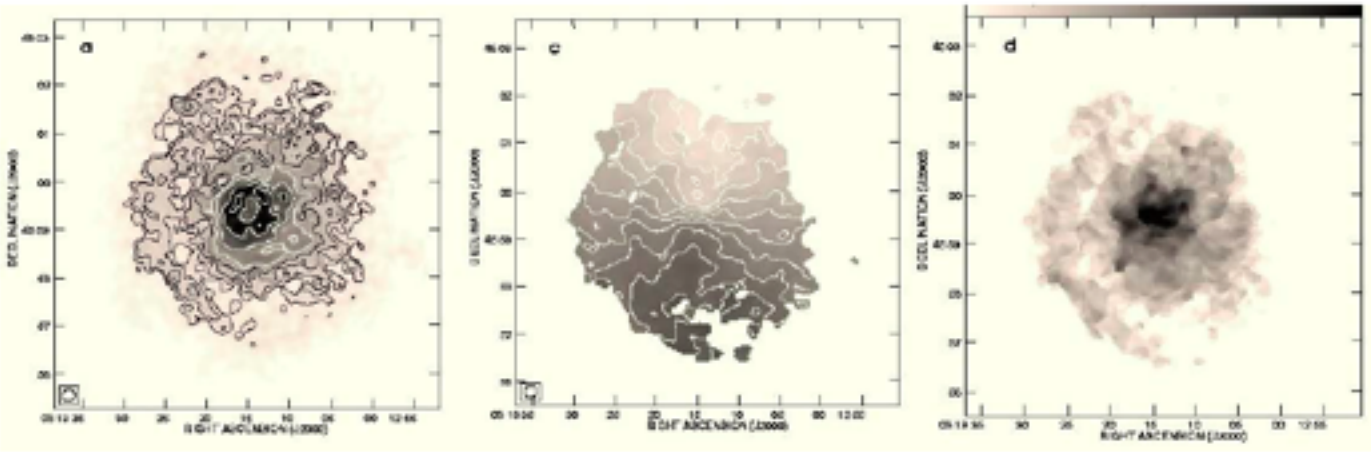
$$\text{Moment 1} = \langle V \rangle = \frac{\int S_v v dv}{\int S_v dv}$$



- Intensity weighted velocity dispersion

$$\text{Moment 2} = \langle V^2 \rangle^{1/2} = \sqrt{\frac{\int S_v (v - \langle V \rangle)^2 dv}{\int S_v dv}}$$





Moment 0
Total intensity

Moment 1
Velocity field

Moment 2
Velocity dispersion

- Moments sensitive to noise so clipping is required
- Higher order moments depend on lower ones so progressively noisier.

XMOM, MOMNT/immoments

Image Analysis of TWHydra

- Using the CASA guides: https://casaguides.nrao.edu/index.php/First_Look_at_Image_Analysis

- Using the CASA guides: https://casaguides.nrao.edu/index.php/TWHydraBand7_Imaging_4.5#Image_Analysis

Moment 0

```
os.system("rm -rf sis14_twhya_n2hp.mom0")
immoments("sis14_twhya_n2hp.image",
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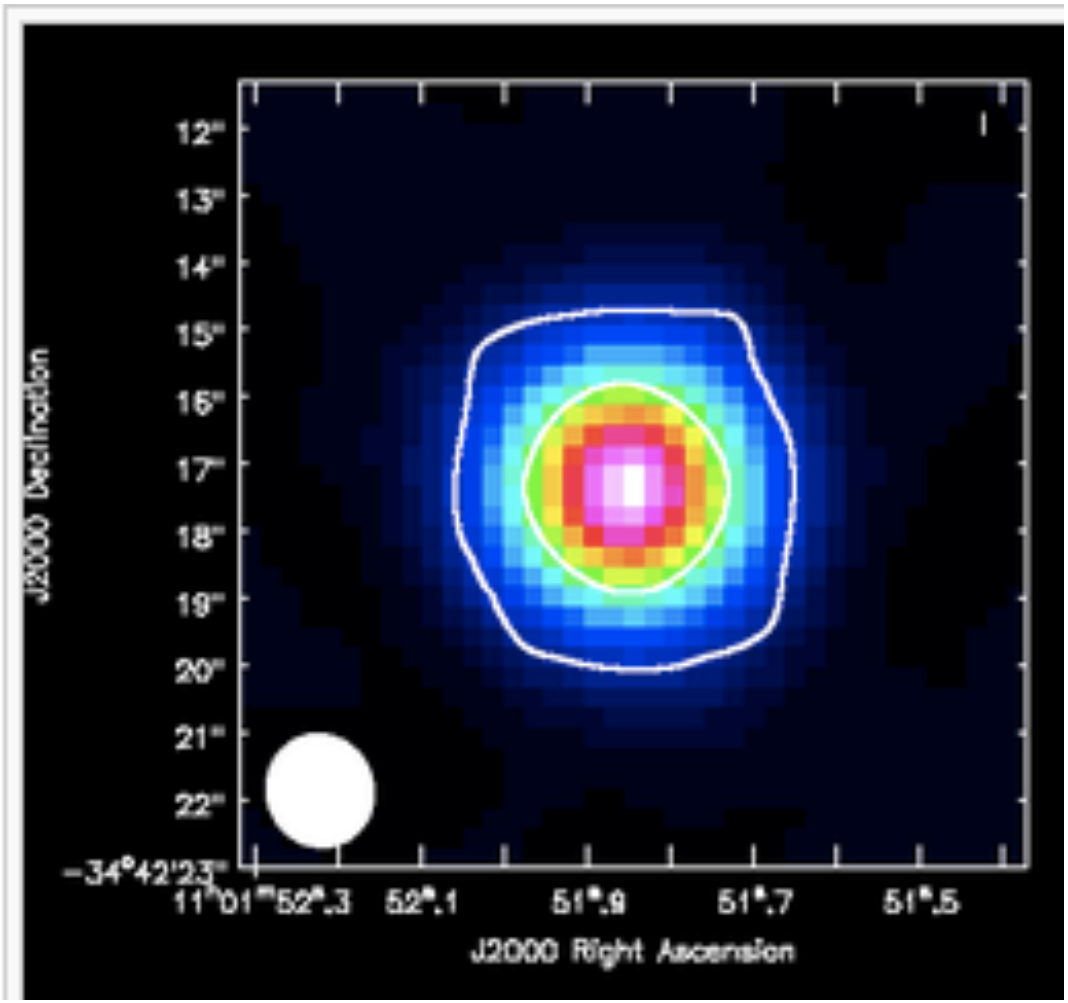
includepix=[20e-3,100],
chans="4~12", moments=0)
```



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Moment 1

```
os.system("rm -rf sis14_twhya_n2hp.mom1")
immoments("sis14_twhya_n2hp.image",
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chans="4~12", moments=1)
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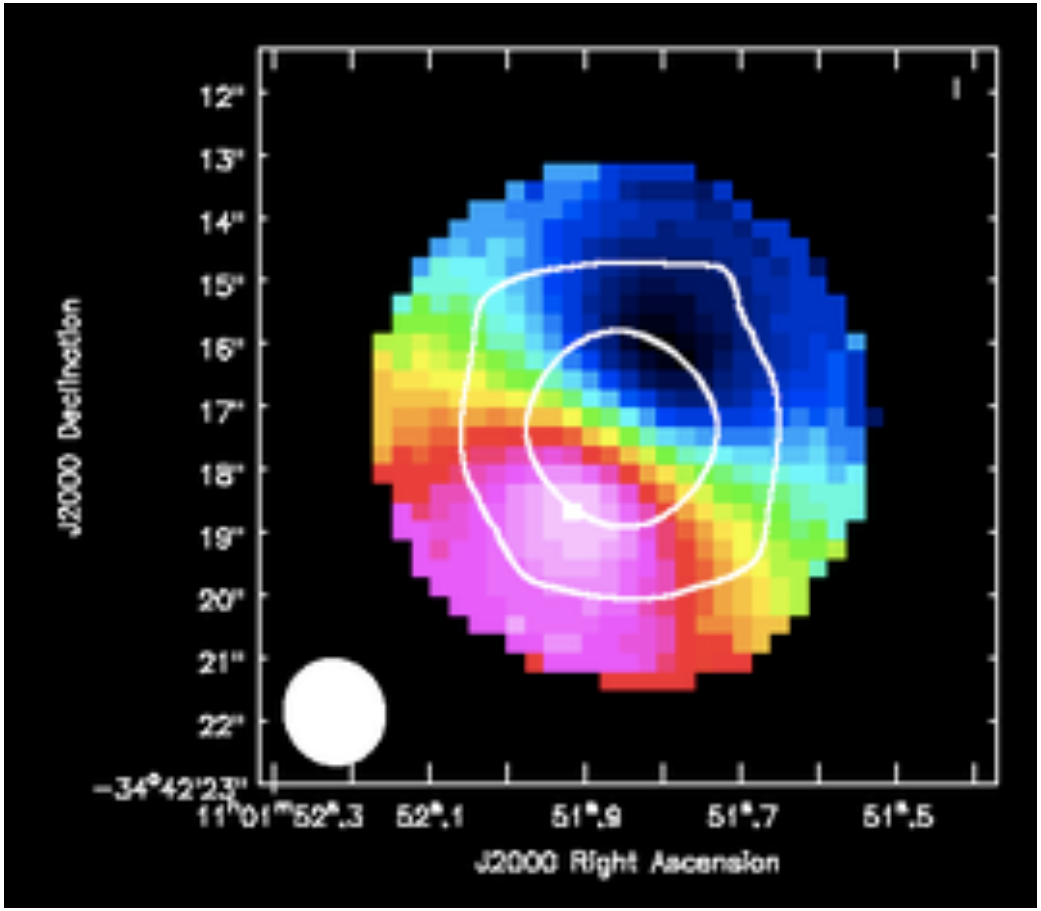

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Moment 2

```
os.system("rm -rf sis14_twhya_n2hp.mom1")
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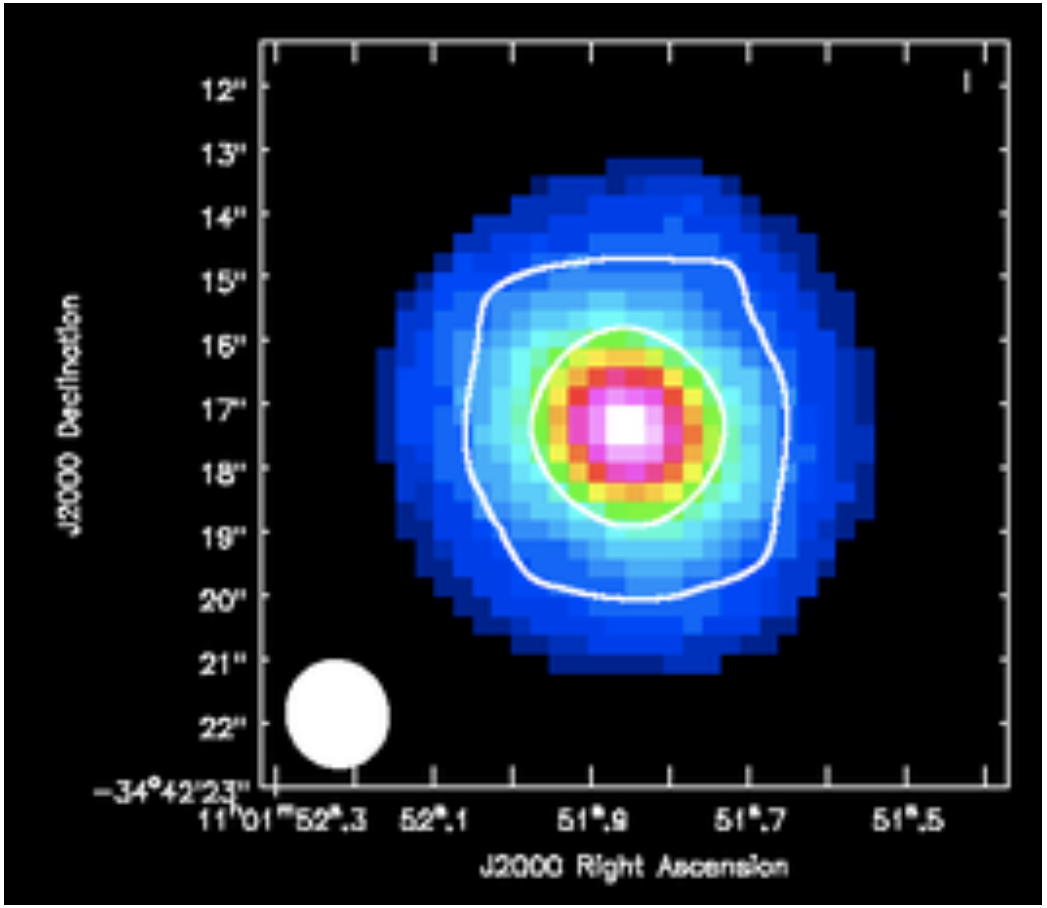
includepix=[40e-3,100],
chans="4~12", moments=2)
```



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Links

https://casa.nrao.edu/docs/cookbook/

Image analysis chapter:

https://casa.nrao.edu/docs/cookbook/casa_cookbook007.html

CASA toolkit:

https://casa.nrao.edu/docs/CasaRef/image.moments.html