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Ku-band Galactic Reconnaissance Survey

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- Large Area Surveys - One of the cornerstones of astronomy
- Most radio Surveys have so far been carried out at low frequency (ν < 5GHz)

- High frequency radio surveys are expensive….

Time required for a radio survey

$$t_{survey} = N_{pointings} \times t_{each\ pointing}$$

$$N \text{ scales as } \nu^2, \; t \text{ scales as } \frac{1}{S^2}$$

KuGARS

- First Galactic Plane Survey to explore the sub-arcsecond and sub-mJy regime at 14 GHz
- Focused at uncovering high frequency (>10GHz) radio emitters

- Survey Aims
  - To discover and characterise the population of steep positive spectrum objects in the Galaxy
  - To detect and identify Hypercompact (HC) HII regions out to the edge of the Milky Way

- **Project Goals:**
  - Develop a data reduction pipeline for KuGARS data.
  - Detect and identify Hypercompact HII regions in KuGARS.
- **Auxiliary Goals**:
  - Investigate modifications to standard procedures for On the Fly Mapping
  - Detect the 14.4GHz H_2CO line, CH_3OH and OH masers and Radio Recombination lines from H81α to H74α

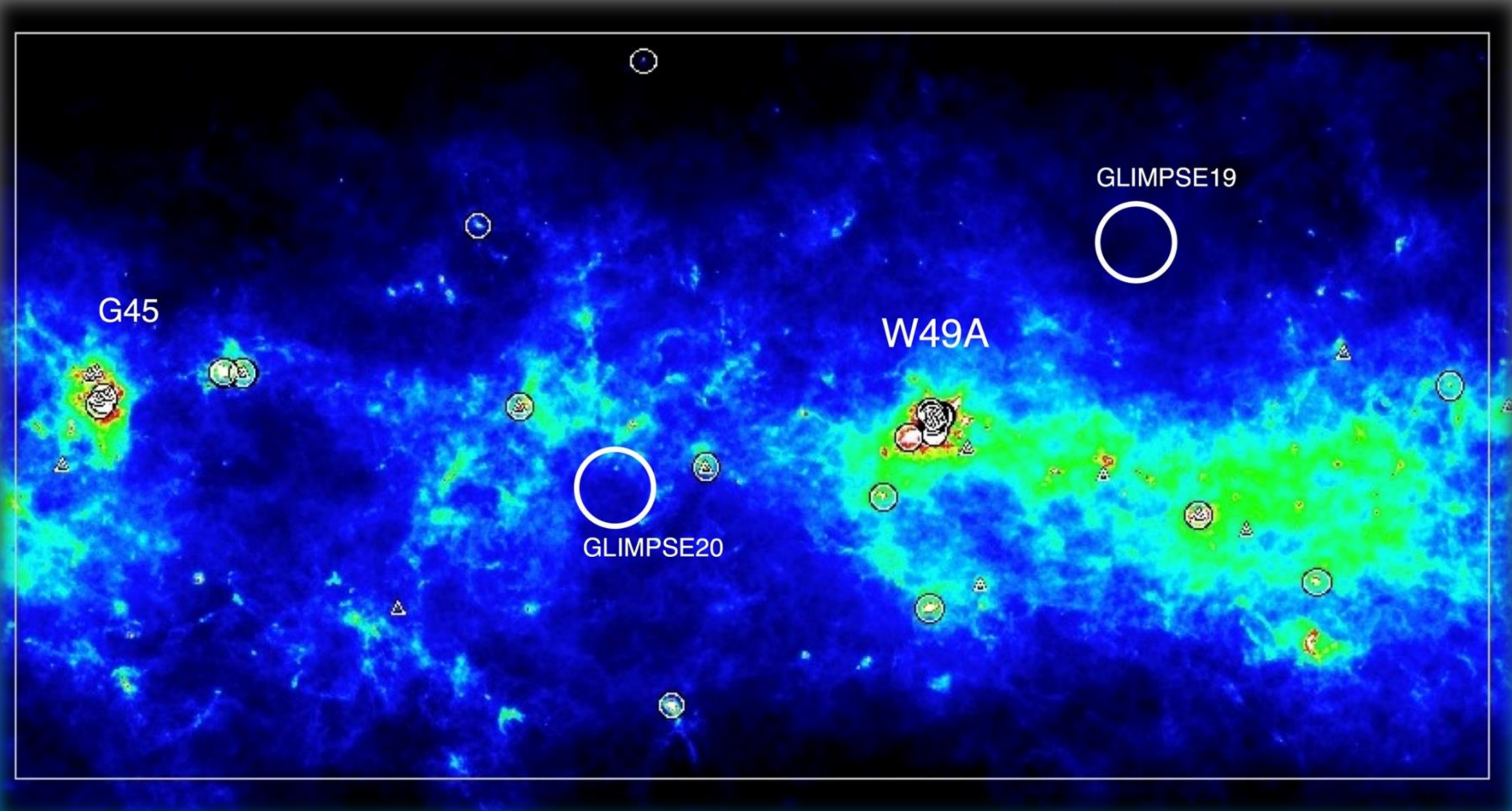
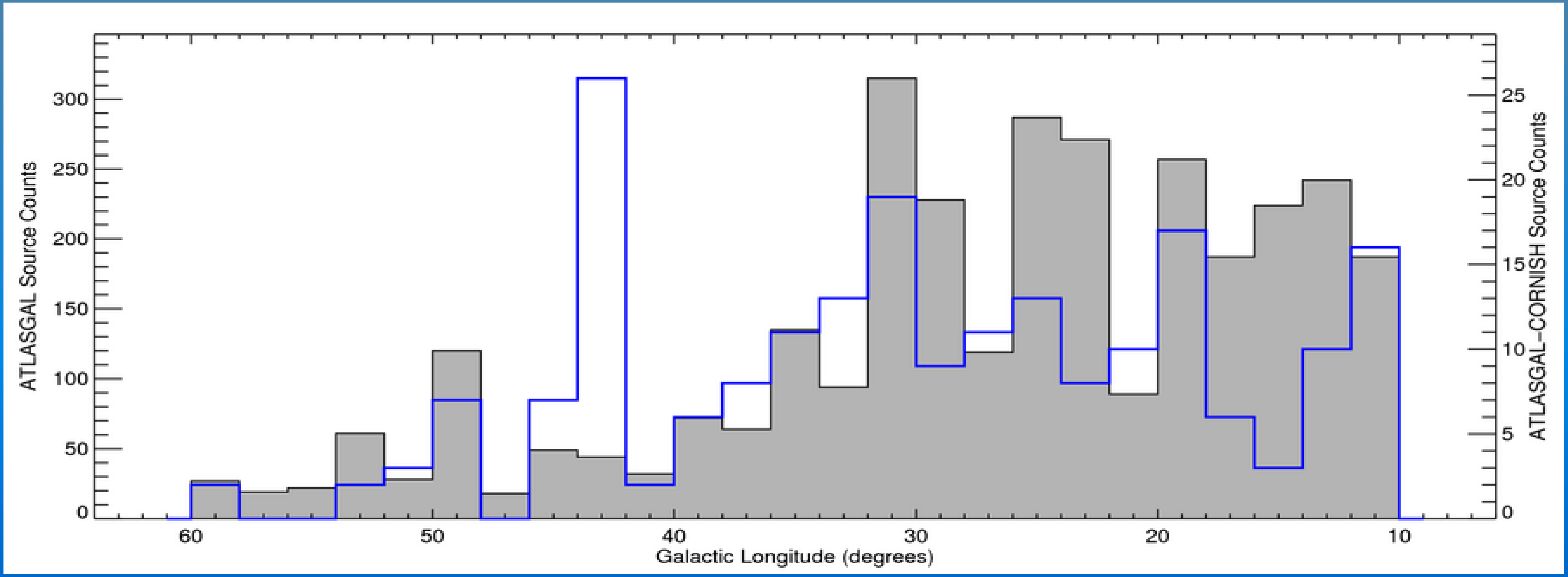


Figure 1: Herschel Hi-GAL 250 μm image of the l=42–46 region. CORNISH UC HIIs are indicated by circles and AMGPS CH3OH masers by triangles over 250 μm Hi-GAL colour-scale. The box shows the 4°×2° region that was mapped. Regions of interest are indicated by text labels.

W49A

- This Radio Continuum source was discovered by Westerhout (1958)
- W49A is an active star forming region (D = 11.4 kpc)

 -One of the most Luminous Star forming regions in the galaxy



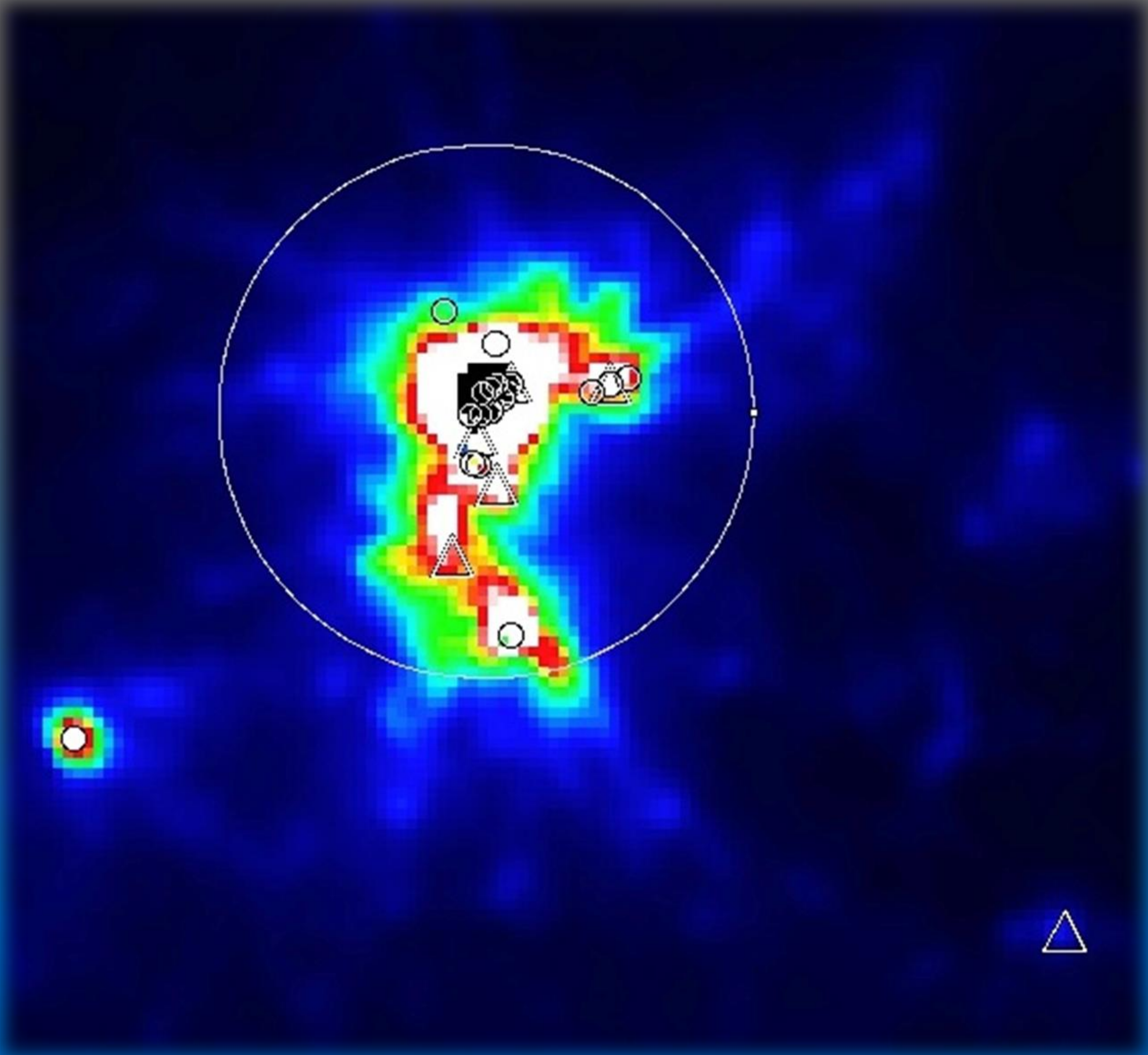


Figure 3: A close-up of the W49A complex. UC HIIs and CH3OH masers are indicated as before. The large circle represents the primary beam from De Pree et al’s 1997 W49A study. Note that the colour-scale stretch is different between these two figures.

HII Regions

- Youngest and most compact HII regions offer a window to peer into the early development of massive star formation
- HII regions reflect the interaction between the UV radiation from the nascent massive star and its environment
- The classes most closely linked to star formation are the smallest, densest and presumably the Youngest stages (i.e. Compact, Ultra Compact and Hypercompact HII regions)

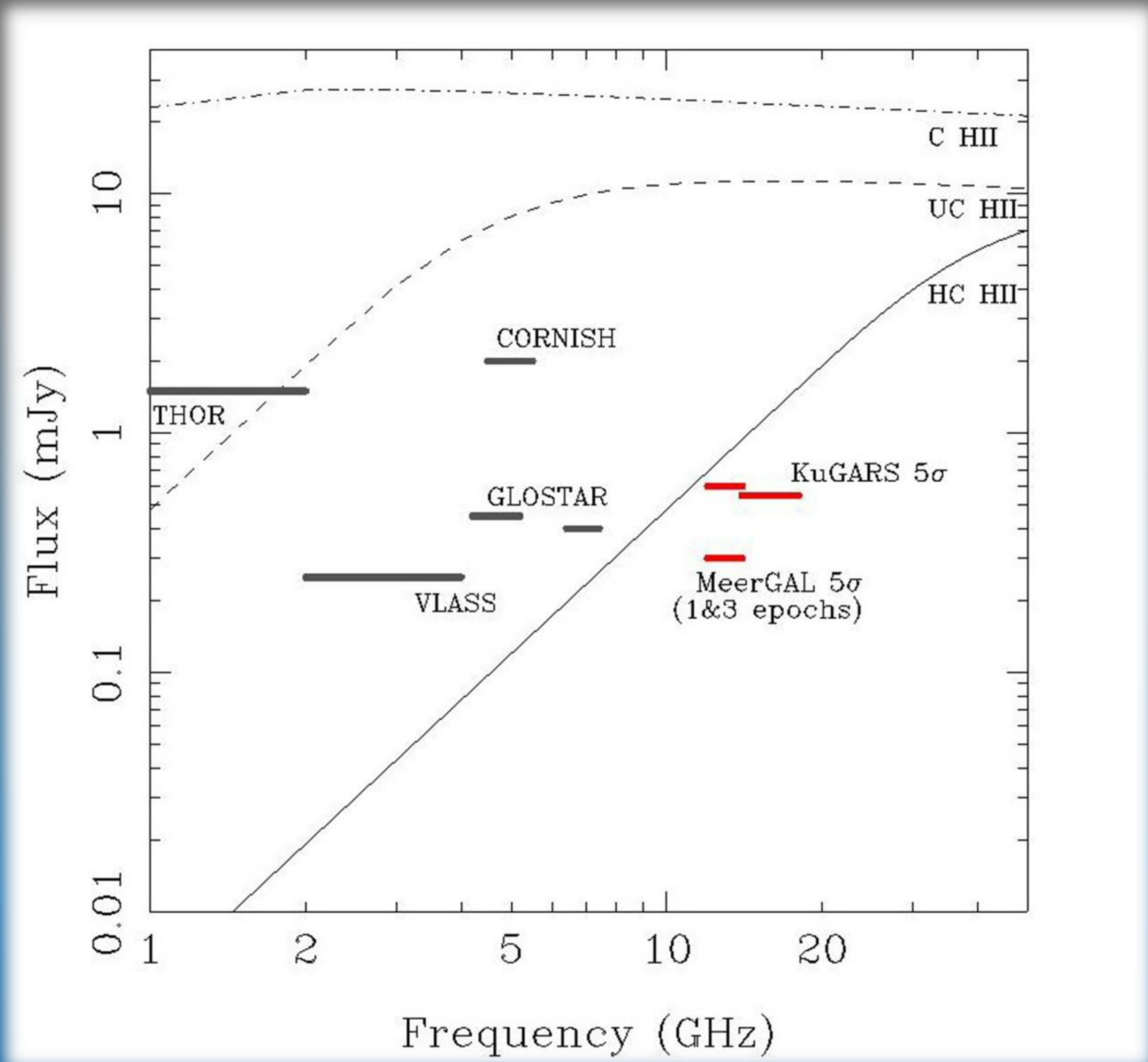


Figure 4: Left: Theoretical spectra of homogenous isothermal HII regions at a distance of 20 kpc. Solid, dashed and dot-dashed lines show spectra for hypercompact, ultracompact and compact HII regions respectively (with diameters 0.005, 0.05 & 0.5 pc and typical emission measures as given in Kurtz 2005). 5 continuum sensitivities for KuGARS, CORNISH, GLOSTAR (5 & 8 GHz bands) and VLASS-Galactic are indicated.

Observation Technique – On the Fly Mapping (OTFM)

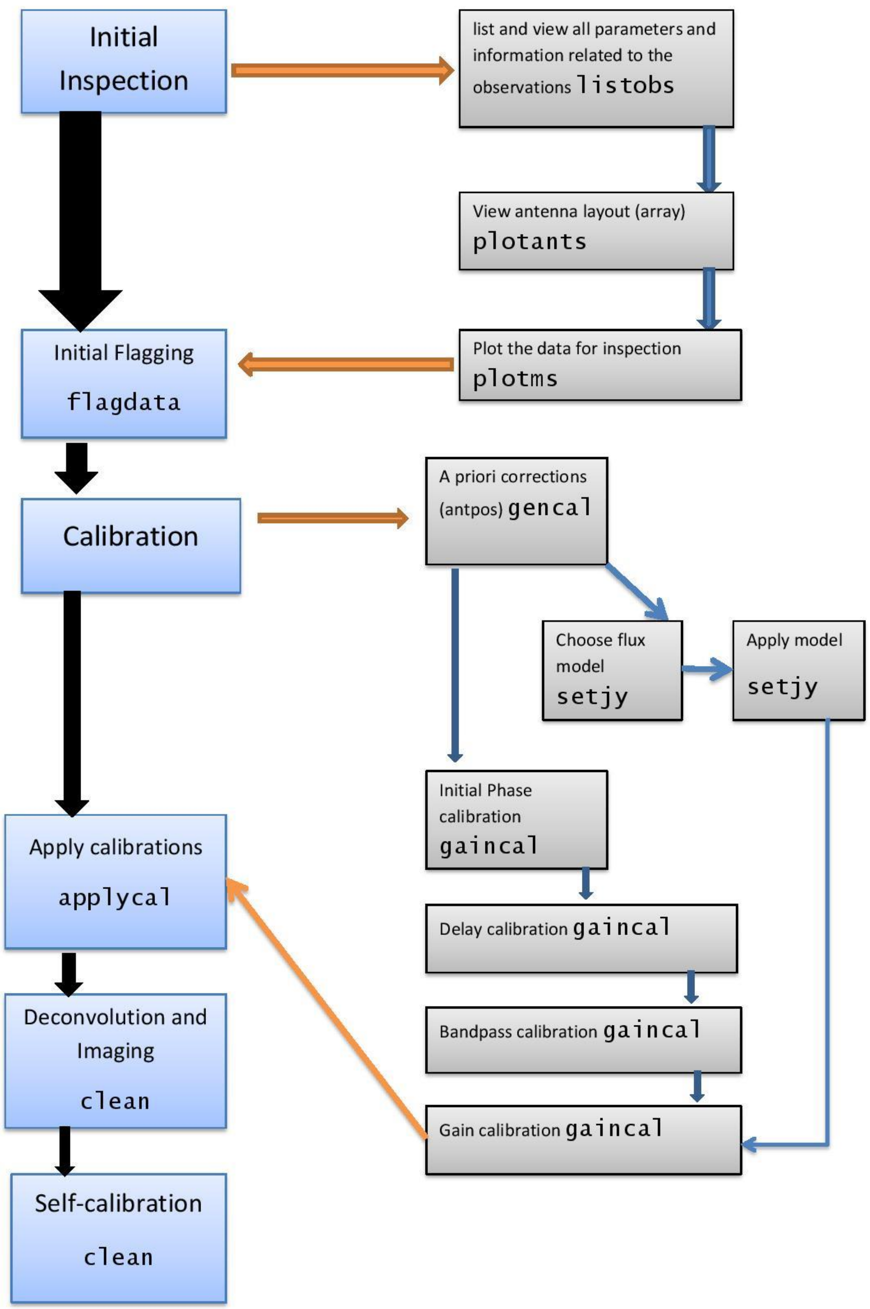
- Standard methods => step and integrate or "point and shoot"

- OTFM => telescope is driven smoothly and rapidly across a field while data and antenna position information are recorded continuously

- Advantages:
  - Telescope overhead is reduced significantly
  - Properties of the atmosphere and the system (antenna pointing, calibration… etc) change less

Data reduction – CASA

- The data reduction is done in the Common Astronomy Software Applications (CASA) package
- CASA (written in python) has been developed to reduce and analyse data obtained from new radio telescopes such as ALMA and the VLA
- The data are stored in Measurement sets (ms) which are reduced in CASA



Initial Inspection
list and view all parameters and information related to the observations listobs
View antenna layout (array) plotants
Plot the data for inspection plotms
Initial Flagging flagdata
Calibration
A priori corrections (antpos) gencal
Choose flux model setjy
Apply model setjy
Initial Phase calibration gaincal
Delay calibration gaincal
Bandpass calibration gaincal
Gain calibration gaincal
Apply calibrations applycal
Deconvolution and Imaging clean
Self-calibration clean

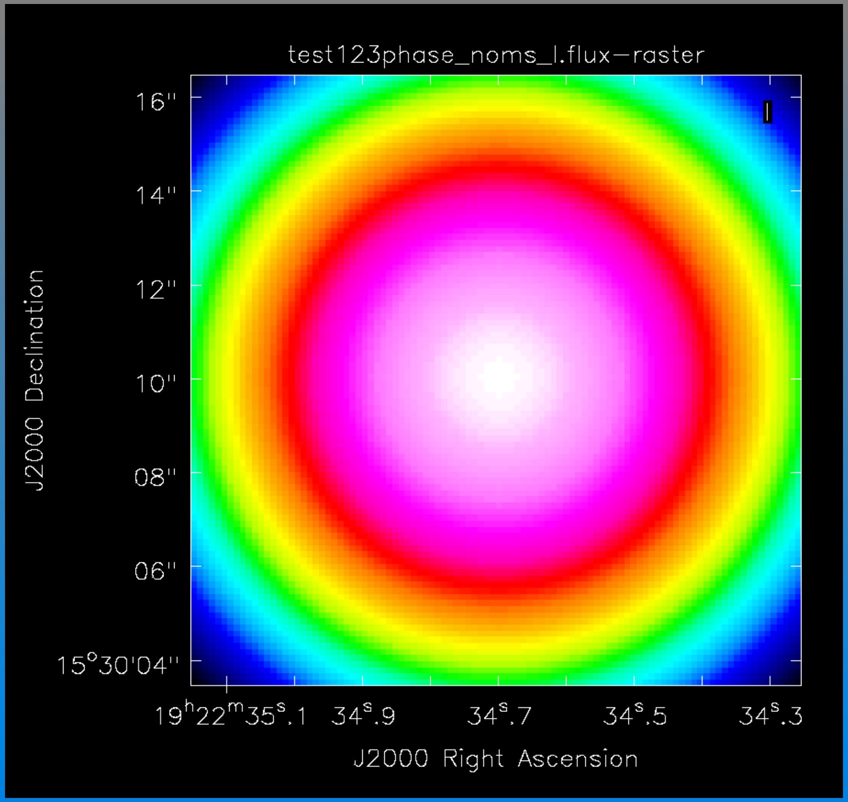
Typical parameters in the KuGARS data

KuGARS (single ms)

- Spw = 44
- Fields = 563
- Sources = 23652
- 10 Spectral line spectral windows (varying properties)
- 34 Continuum Spectral windows
  - chanWid = 2MHz
  - BW = 128MHz
  - #Chans = 64

The NOT so typical features....

Standard



OTFM

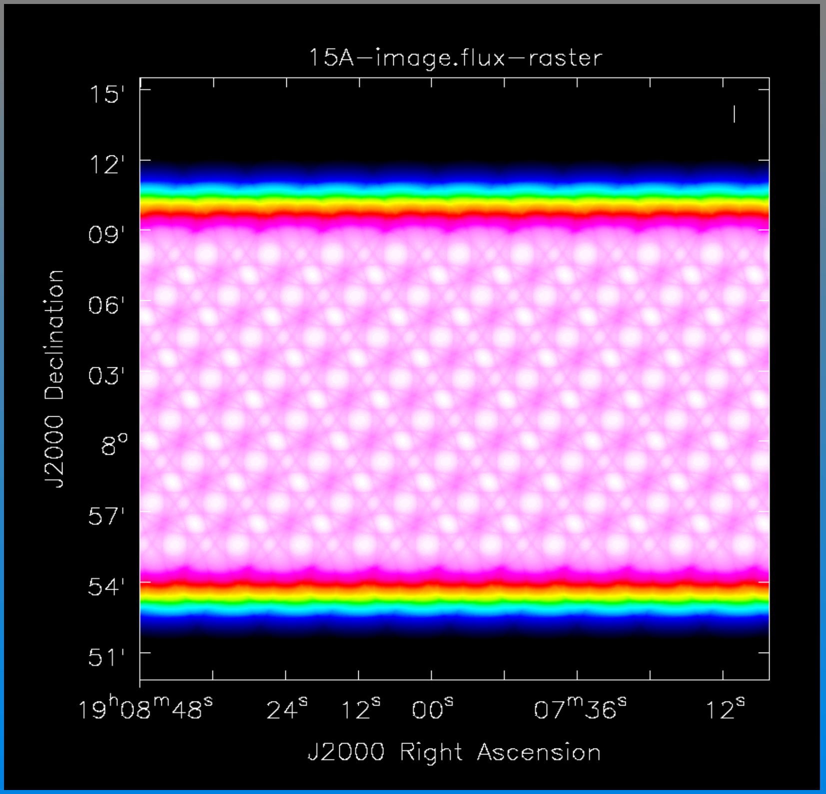
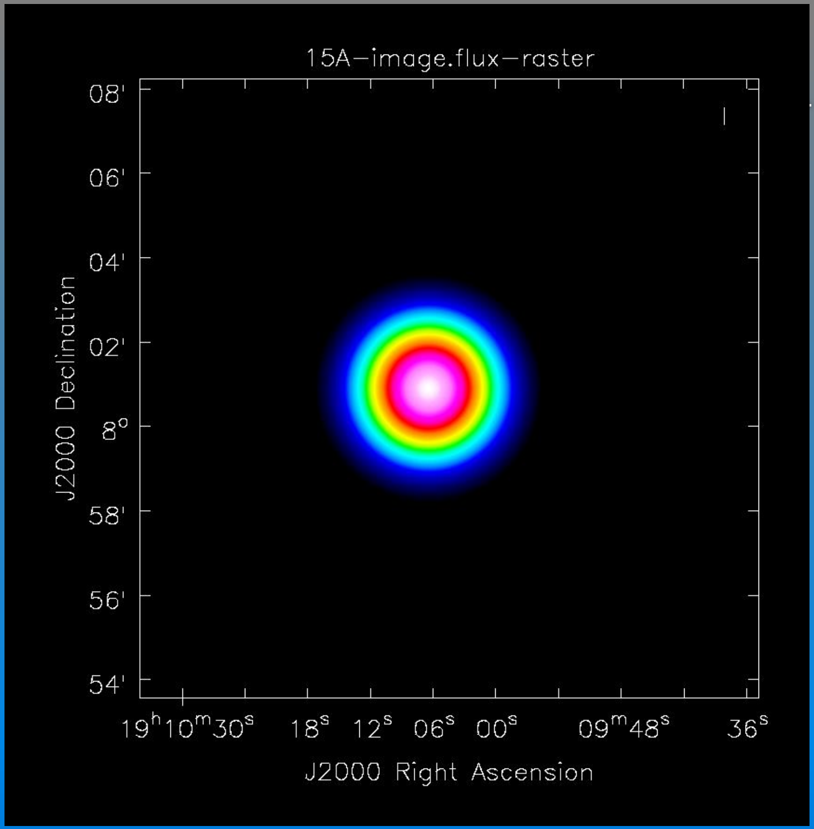


Figure 6: Comparison between the beam of a standard pointing (left) and the beam of on the fly map pointing (right).

Single OTFM scan



High resolution – small image size

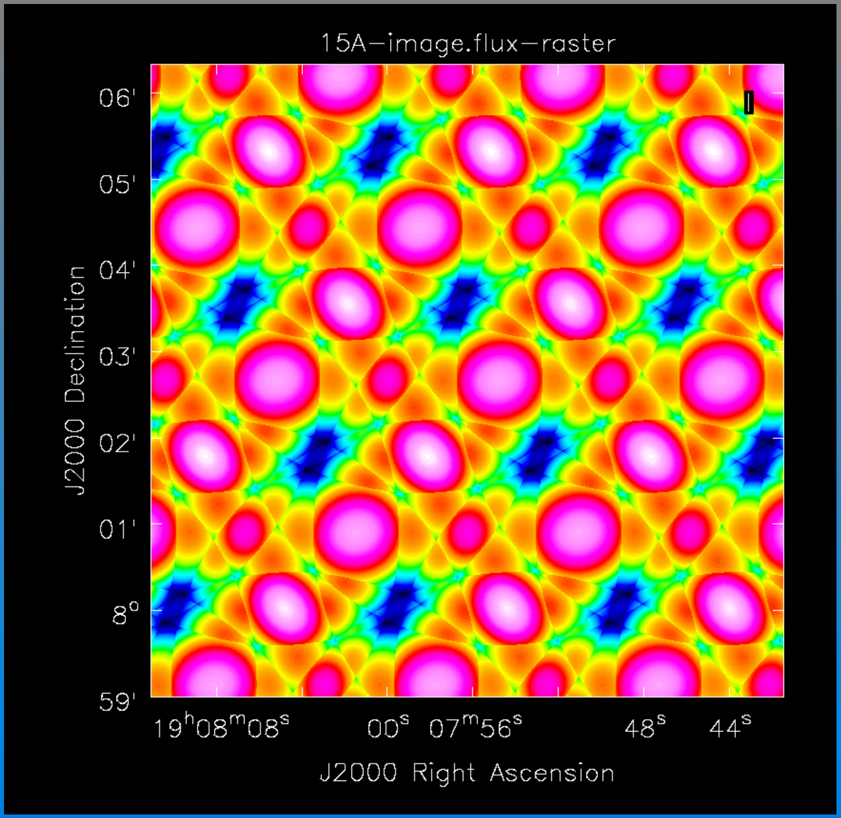


Figure 7: Left image shows the beam of a single scan in an OTFM stripe - the image to the right shows the beam of several scans morphed together

Phasecenter off/Wrong

Phasecenter correct

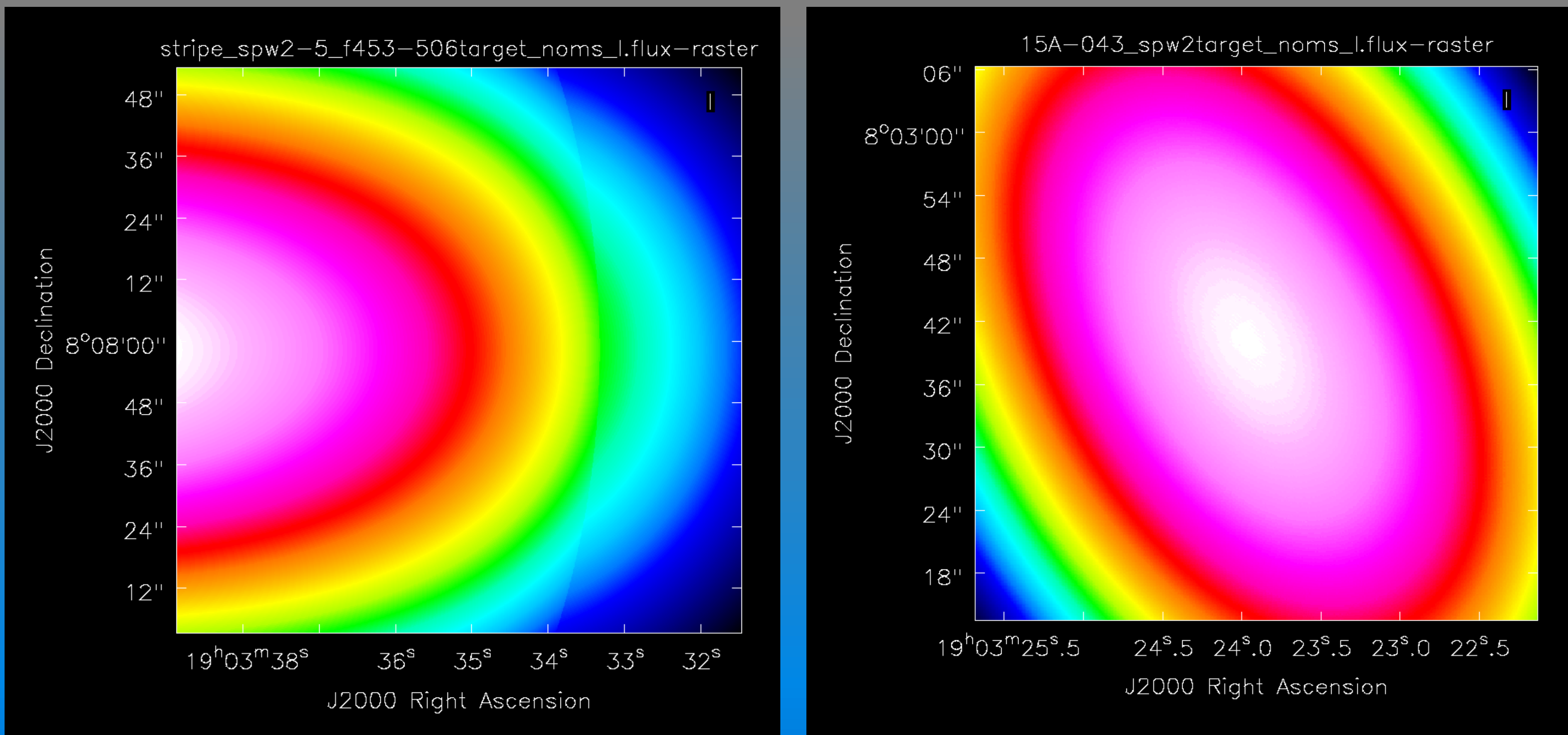
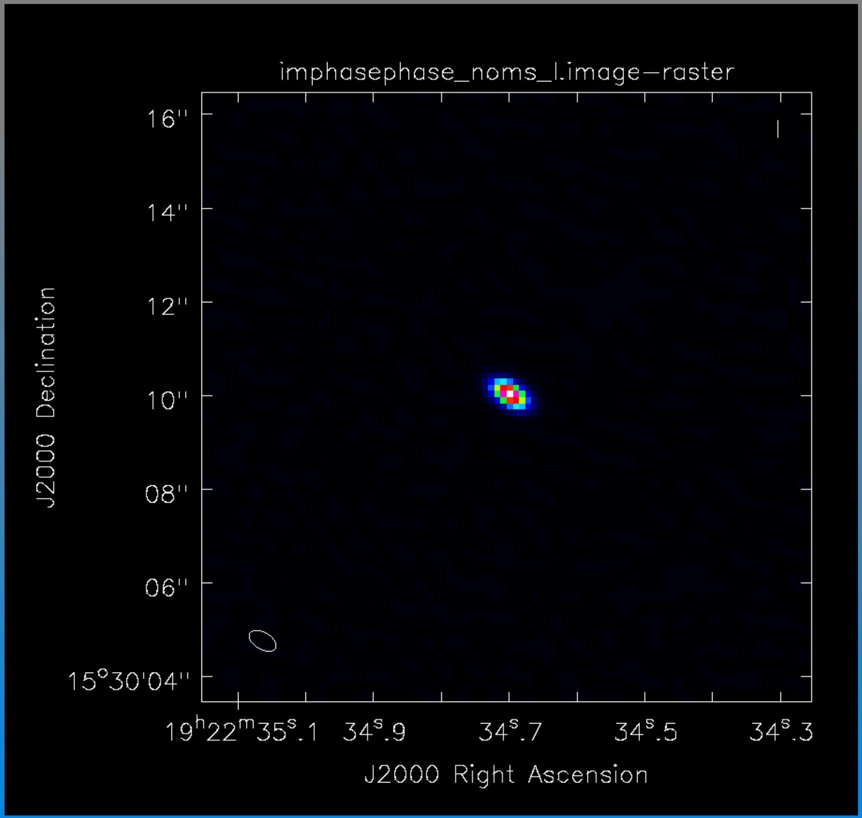


Figure 8: An offset phasecenter (left) compared with a correctly set phasecenter (right)



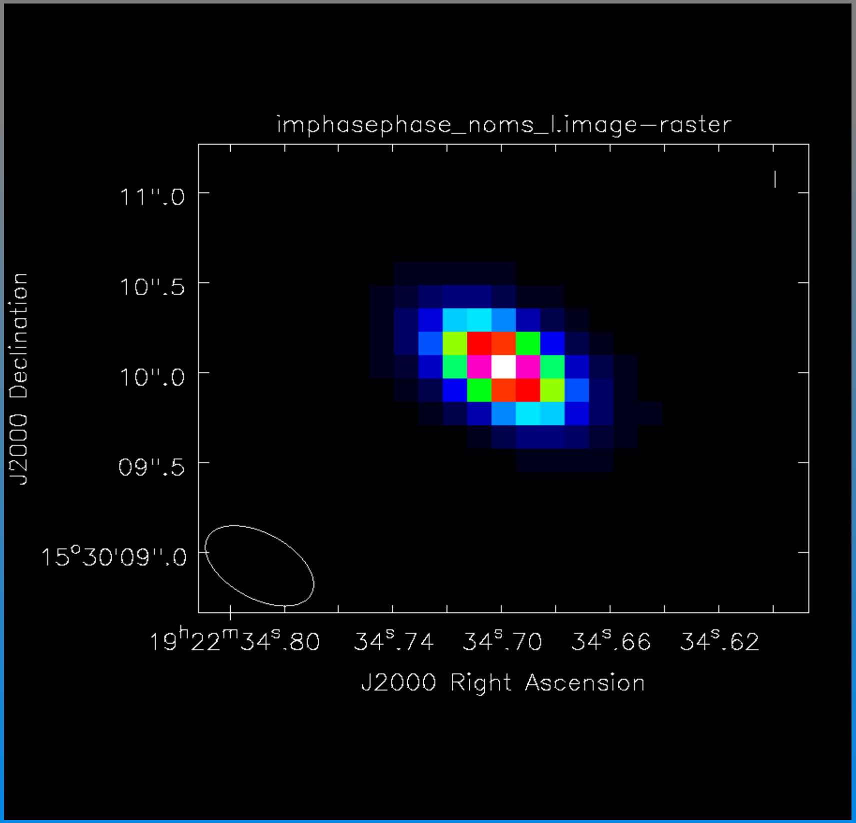


Figure 9: Image of J1922+1530, the phase Calibrator used in the KuGARS data reduction

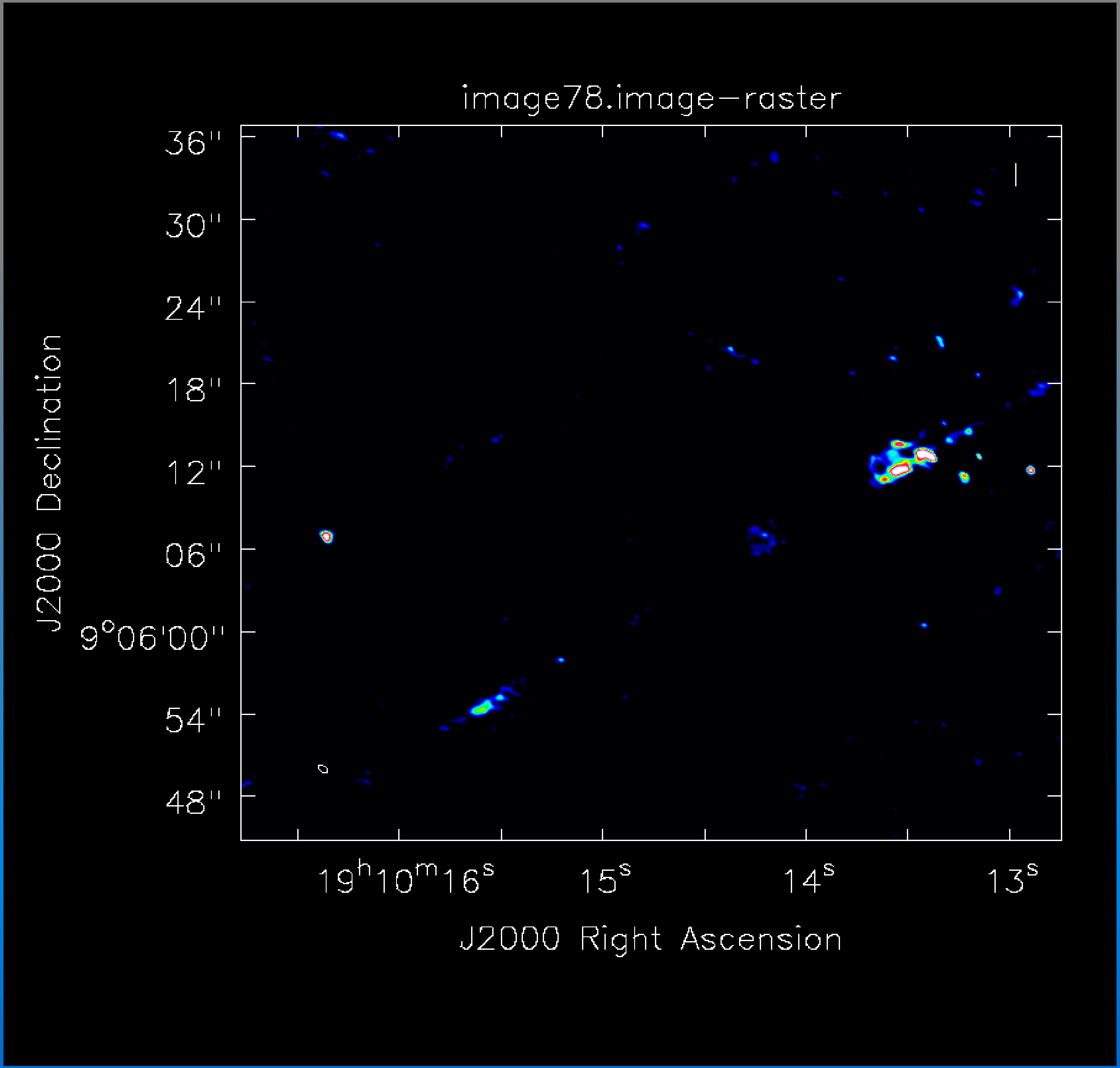
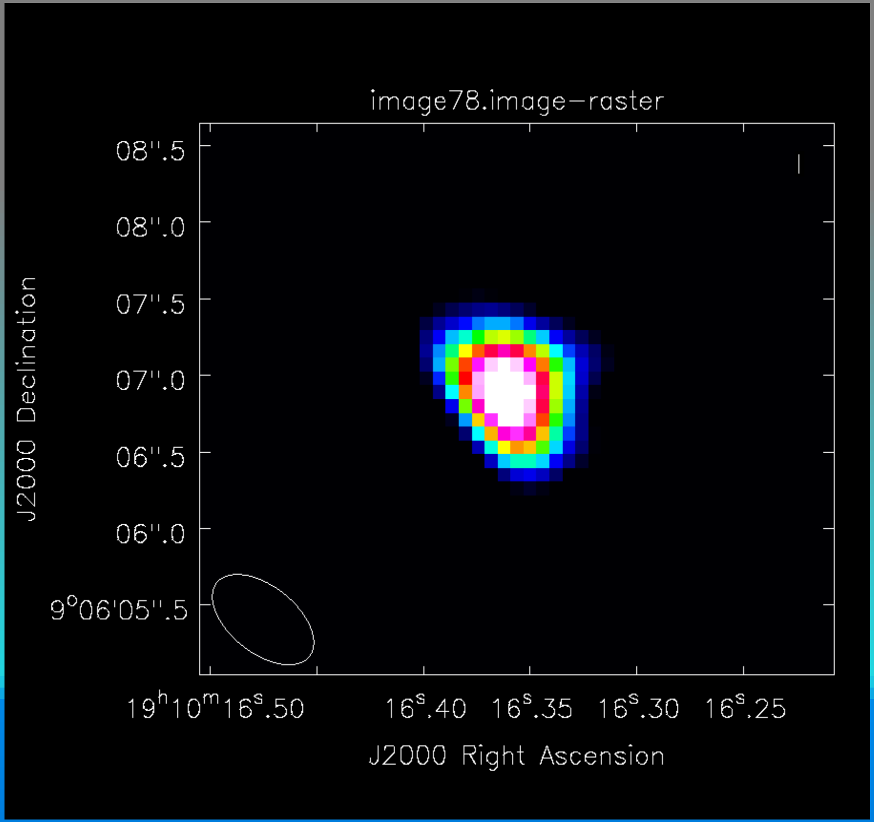


Figure 10: KuGARS - Single Spectral window map of W49A



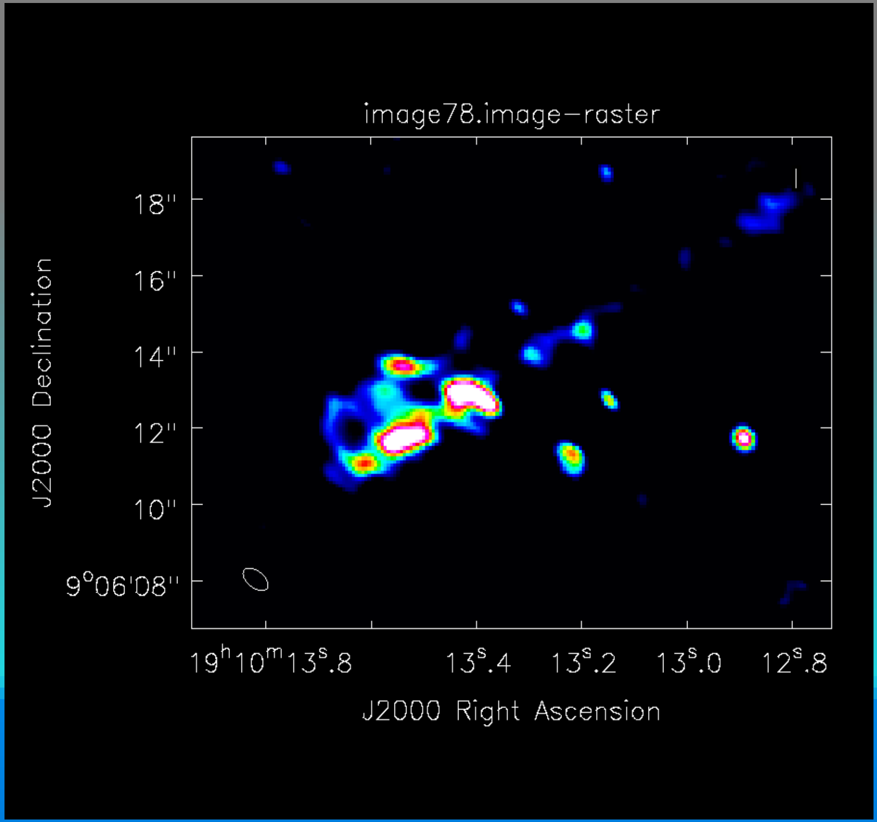


Figure 11: KuGARS – zoom in of W49A's Central "ring"

Summary

- Large area surveys often have an impact far beyond their original expectations and conceived wavelengths
- KuGARS has potential for new and unexpected discoveries
- High frequency surveys, such as KuGARS will through increasing the observational record make a formidable contribution to piecing together a coherent theory of massive star formation
- Data load too heavy to all be done by hand
- Further work, calculation of resolved spectral indices across W49A

Thank you for your attention!

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