2020 ALMA Summer School

Project 5: Magnetic fields in the early stages of massive star forming dark cloud G28.34+0.06-MM1
(Liu et al. 2020, ApJ, 895, 142)

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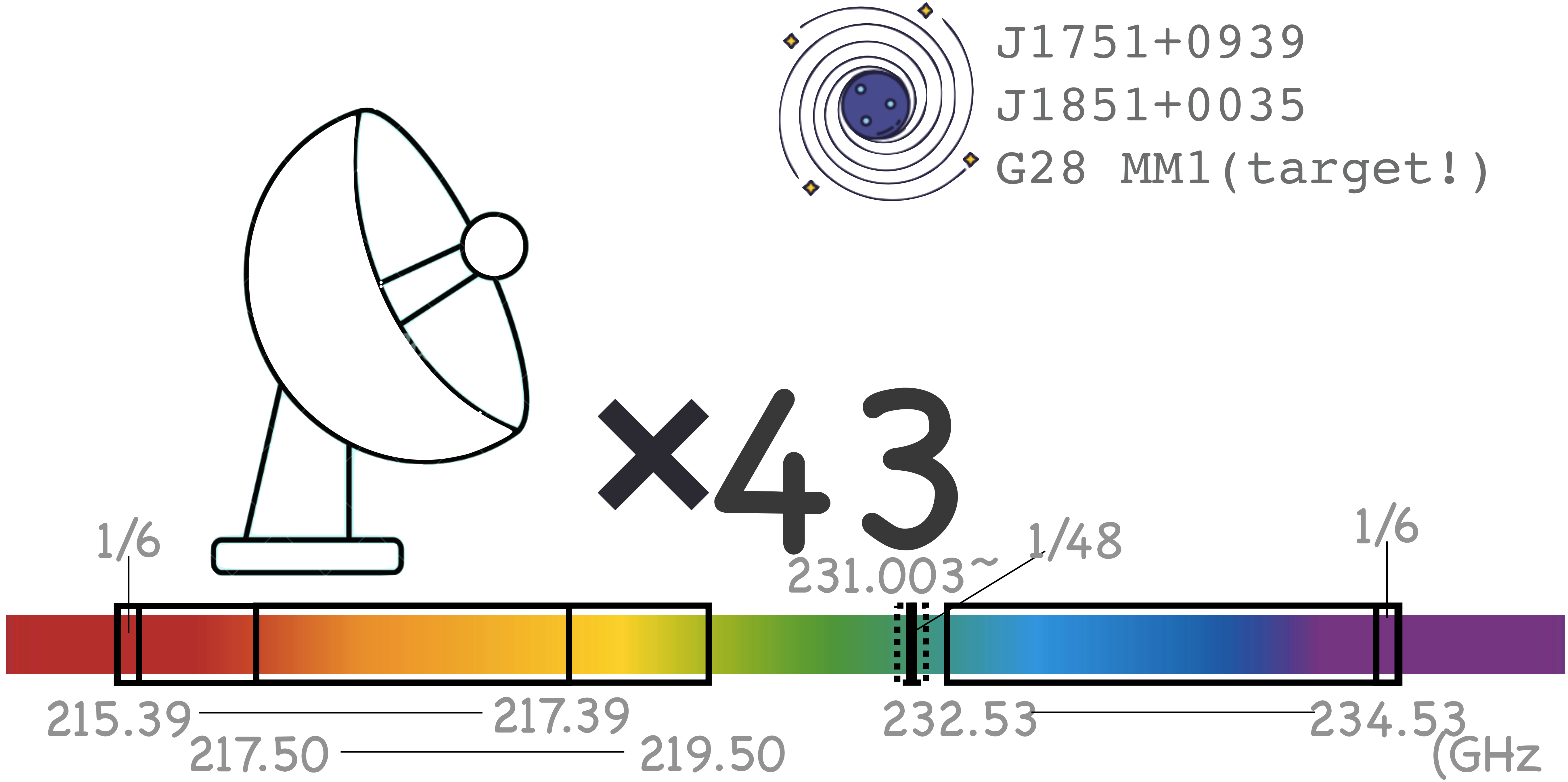
Source

- G28.34+0.06: IRCS (infrared dark cloud, the early phase of massive star formation)
- Distance: ~4.8 kpc
- Three prominent clumps: MM1, MM4, and MM9
- MM1: warmer (~ 30 K) than MM4 and MM9 and is associated with an IR-bright protostellar source

Listobs('Group5')



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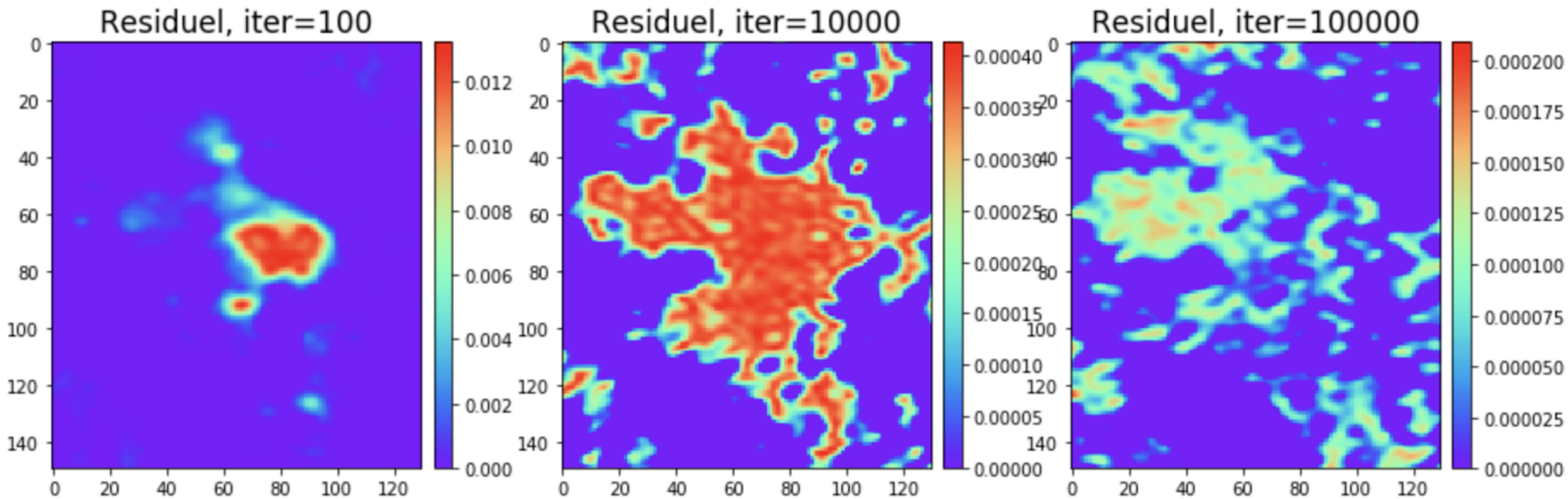
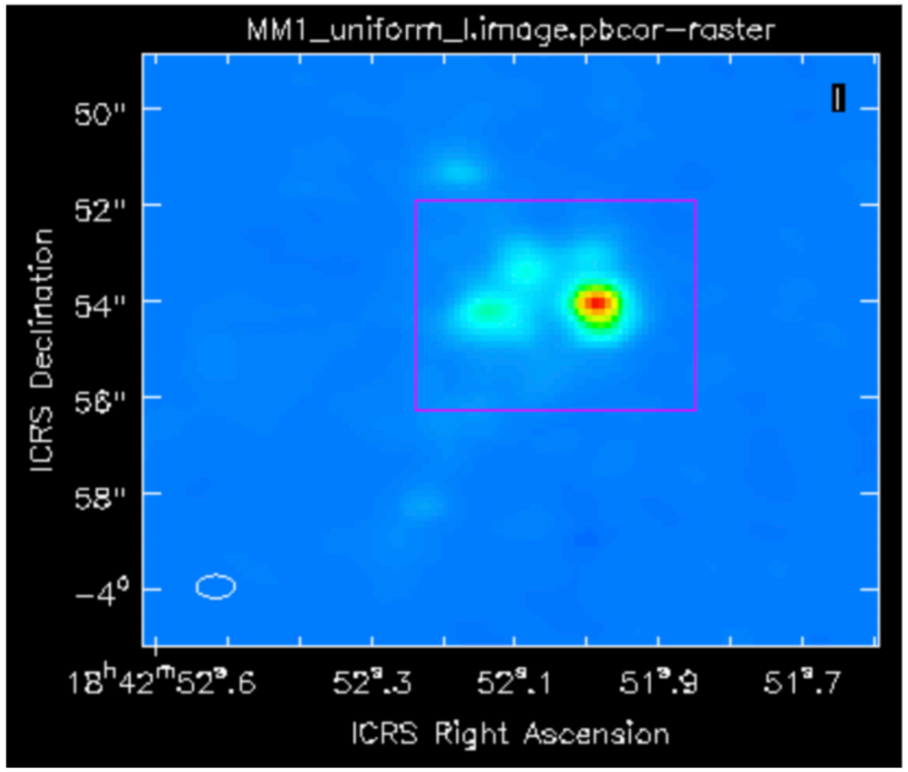
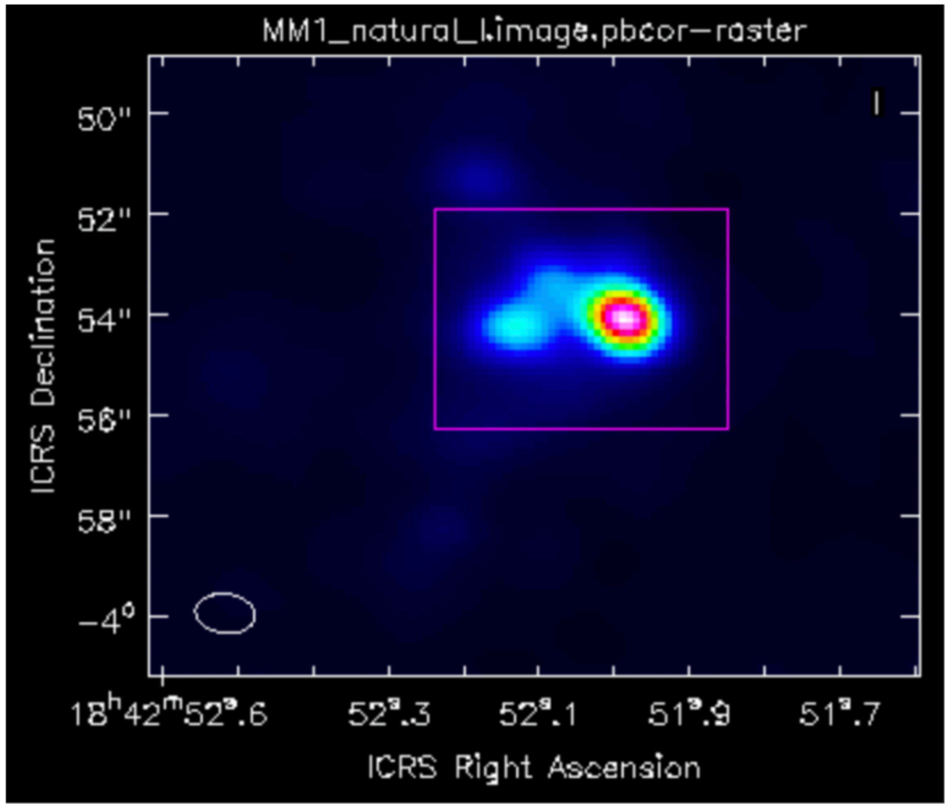


Weight factor

uniform



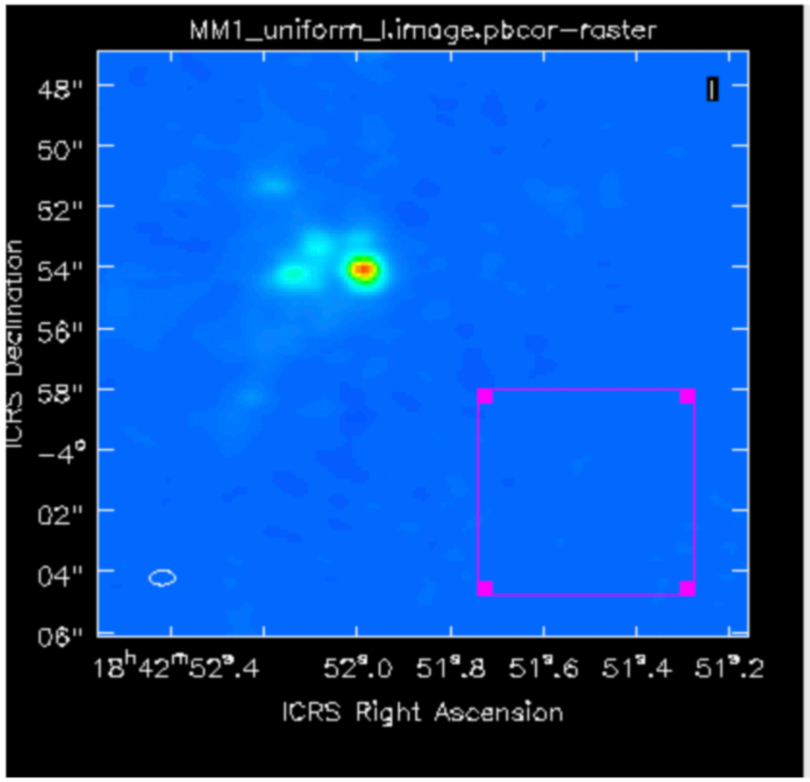
natural



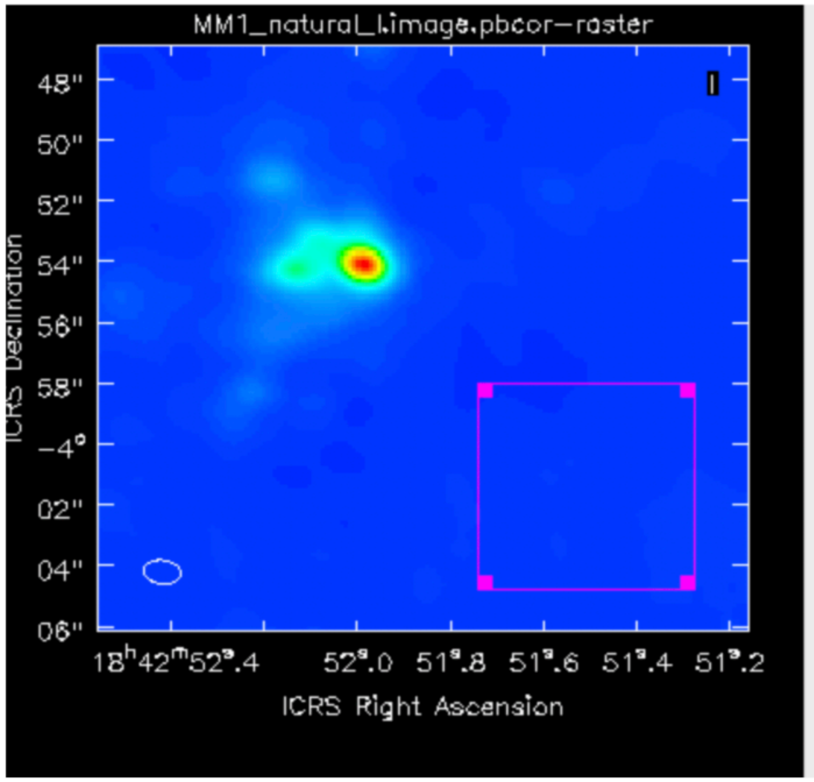
Maximum: 1.4e-01 **1.8e-01**

Weight factor

uniform

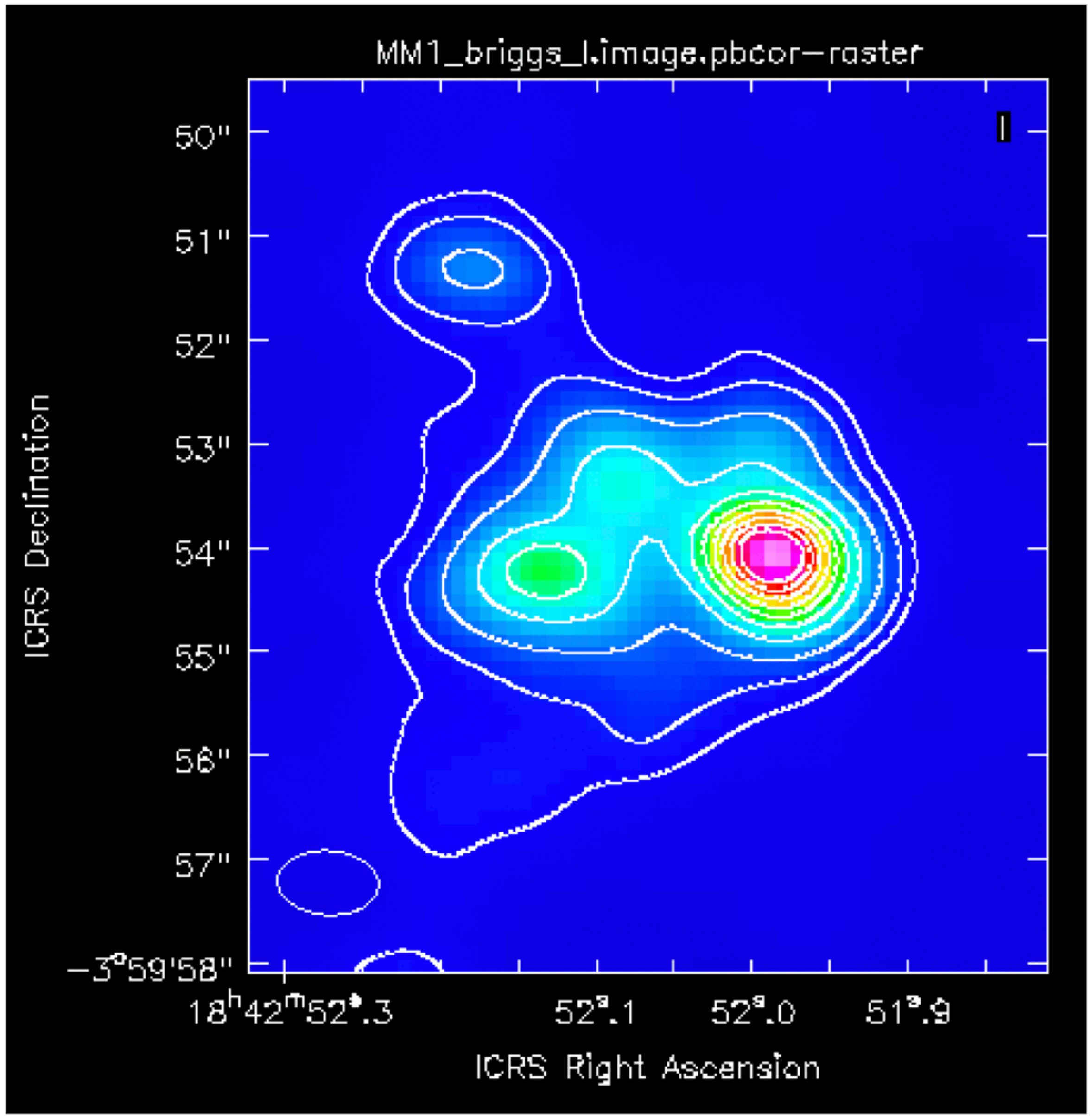


natural

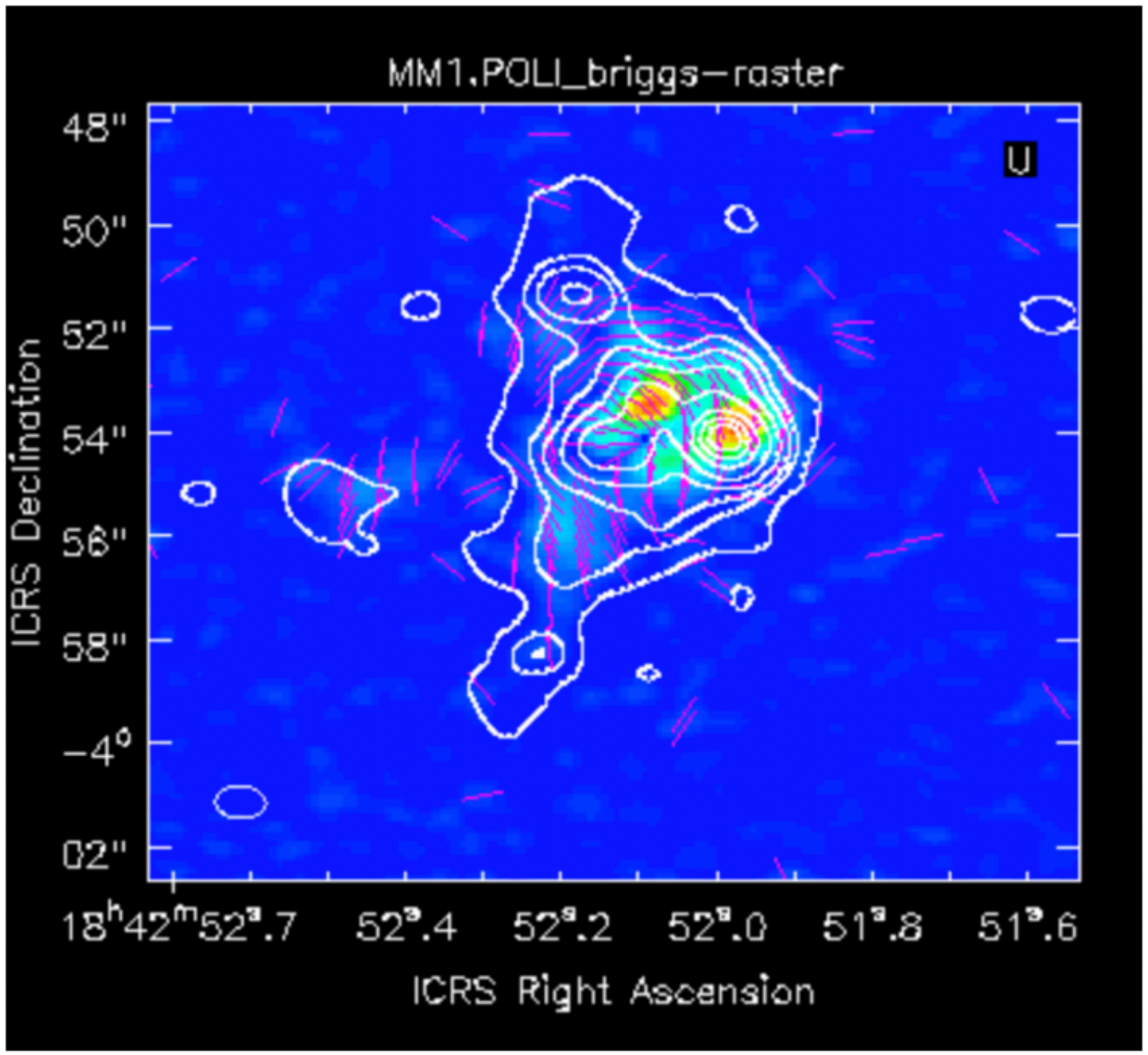


	uniform	natural
Maximum:	1.4e-01	**1.8e-01**
rsm:	2.4e-04	**5.6e-04** ?

Dust Continuum map of MM1

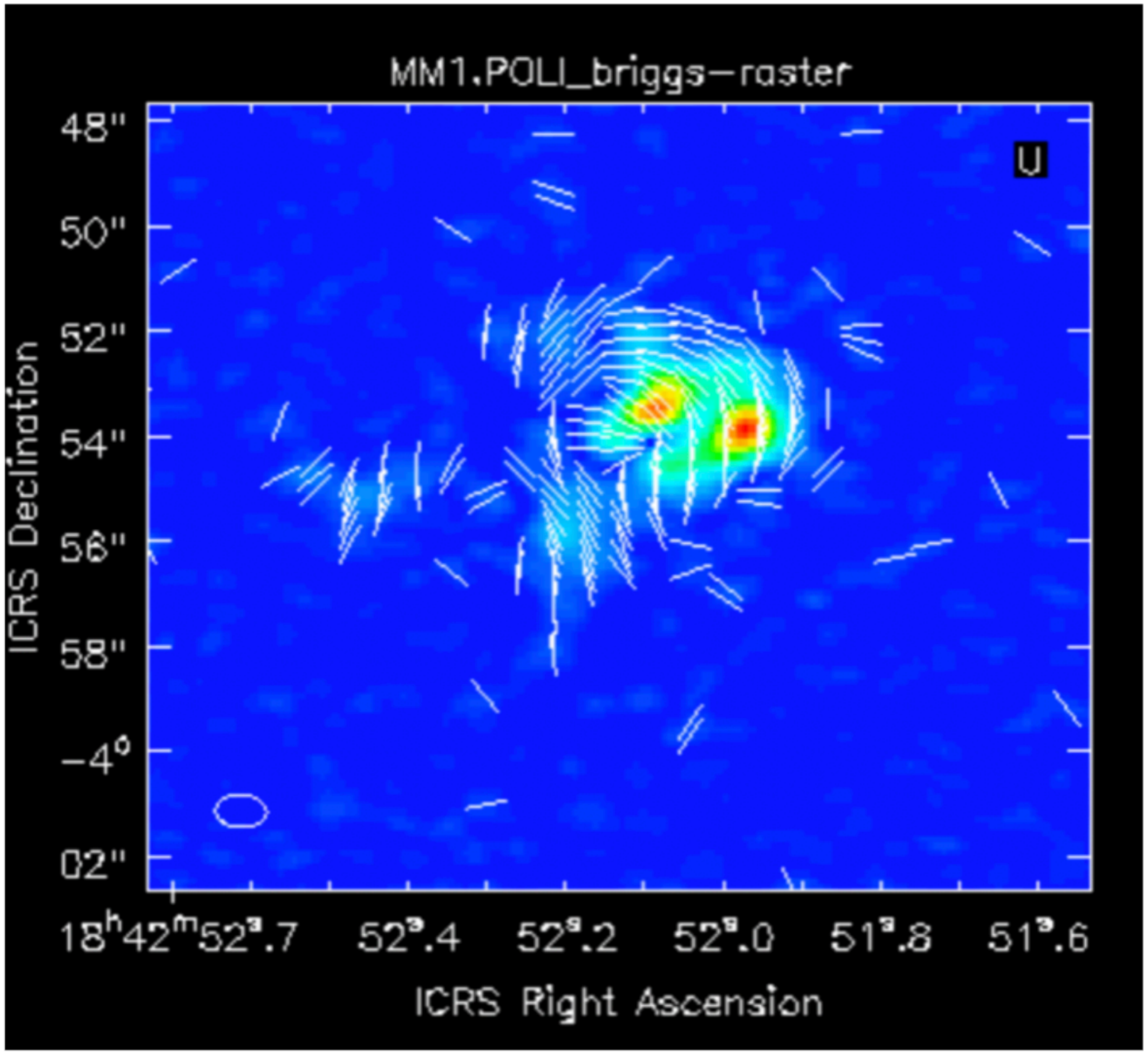


Polarization map of MM1



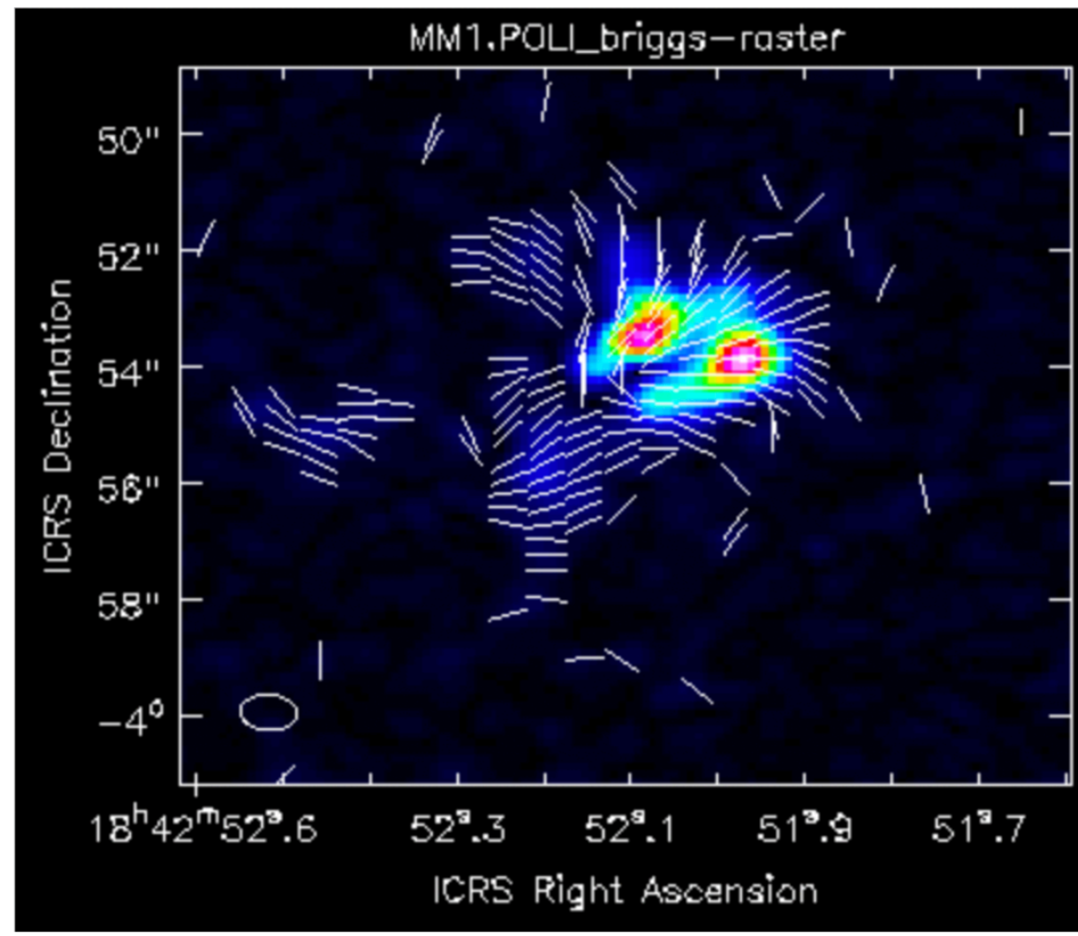
1. Direction of polarized light indicate the alignment of Dust particle
   -> Magnetic field

Polarization map of MM1



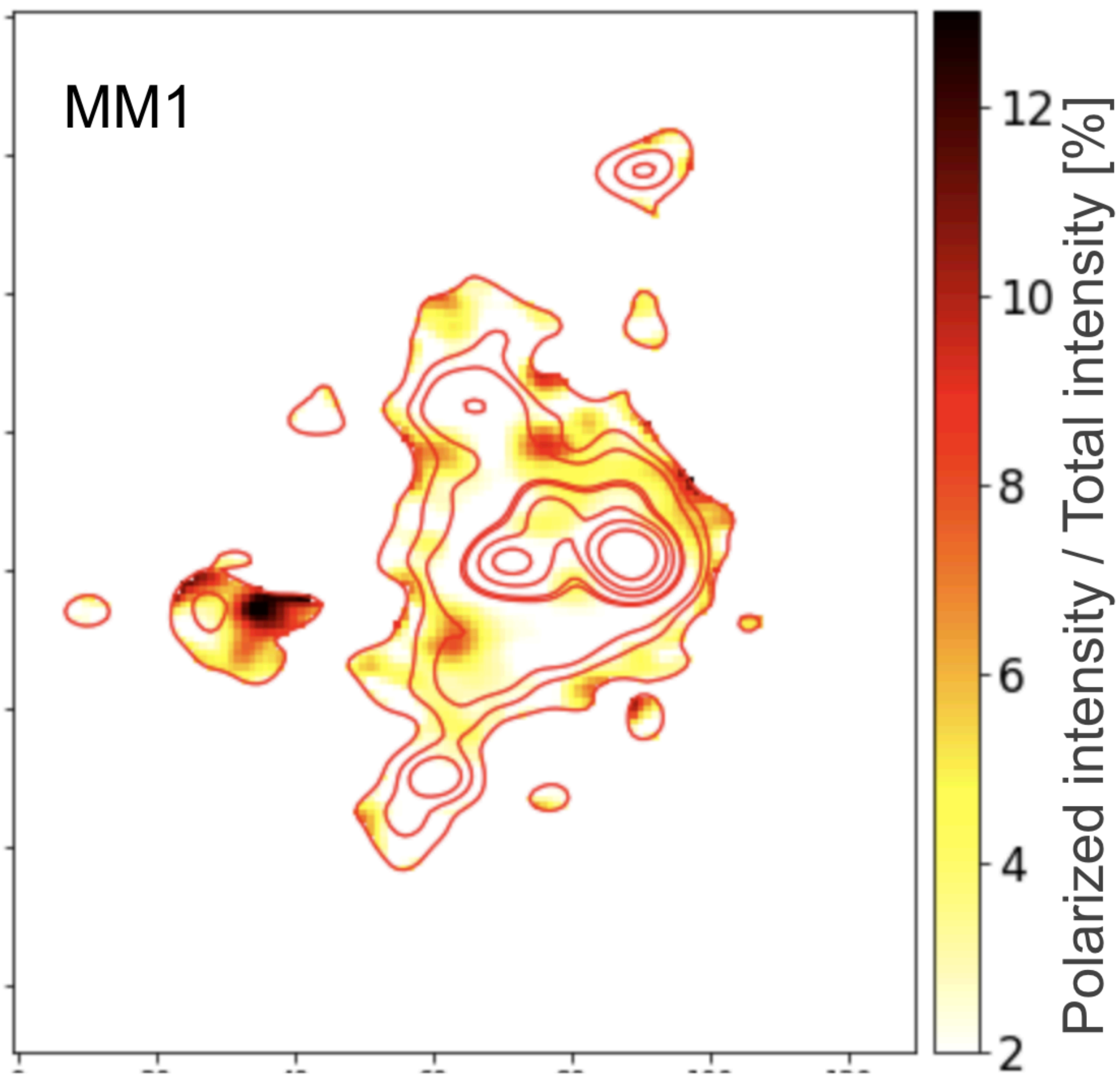
electric field direction

1. Decreasing polarized emission fraction with increasing Stokes I intensities in MM1



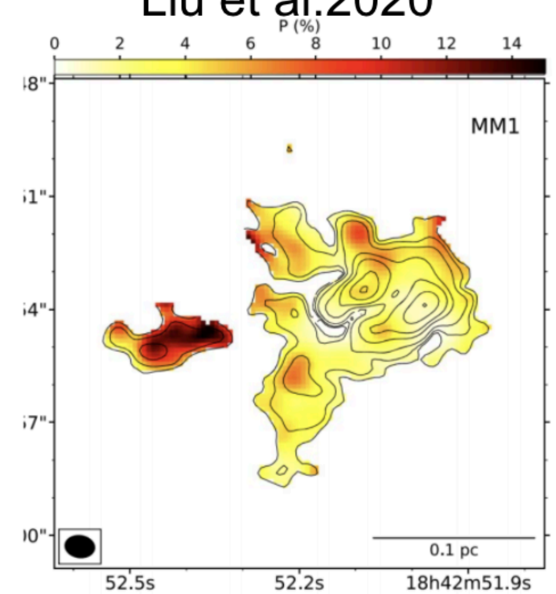
magnetic field direction

Polarization fraction map of MM1

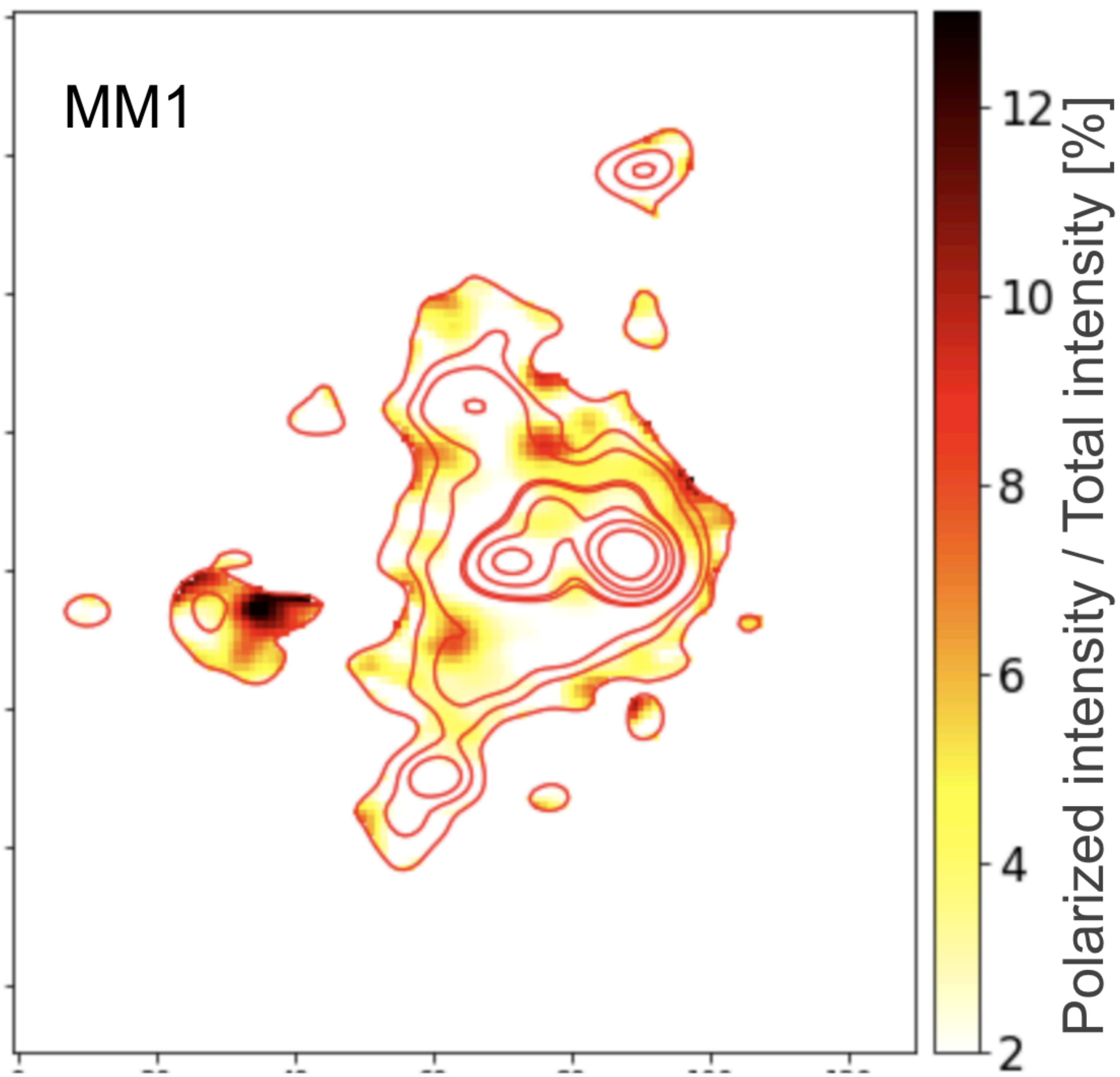


1. Decreasing polarized emission fraction with increasing Stokes I intensities in MM1

Liu et al.2020



Polarization fraction map of MM1



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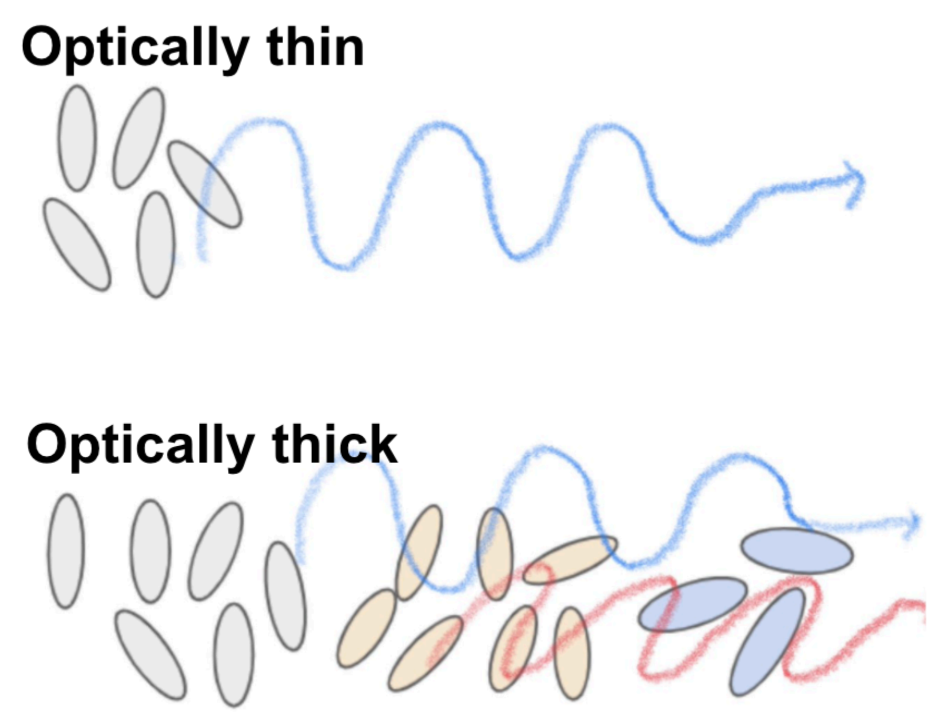
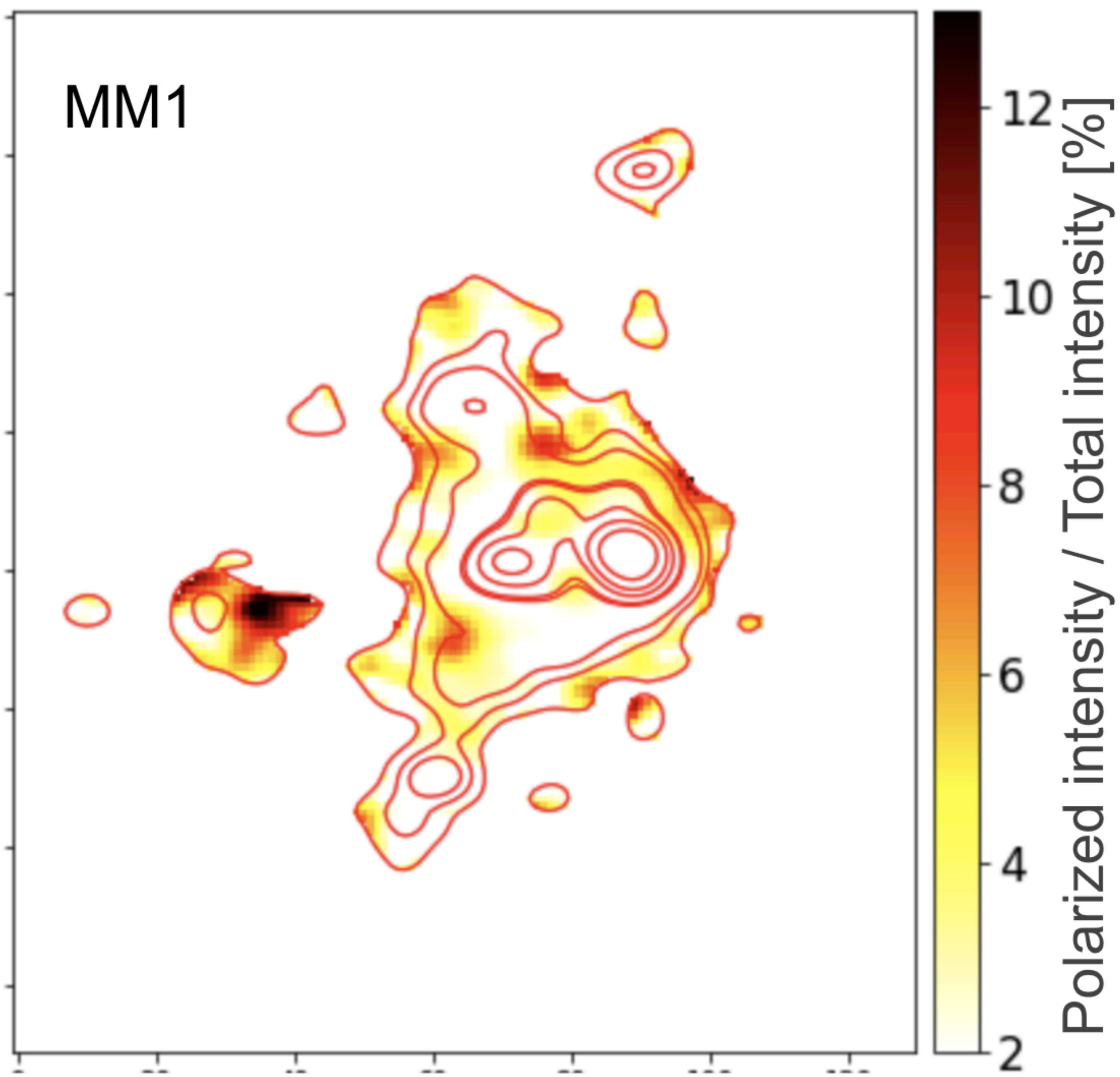


Polarization fraction map of MM1



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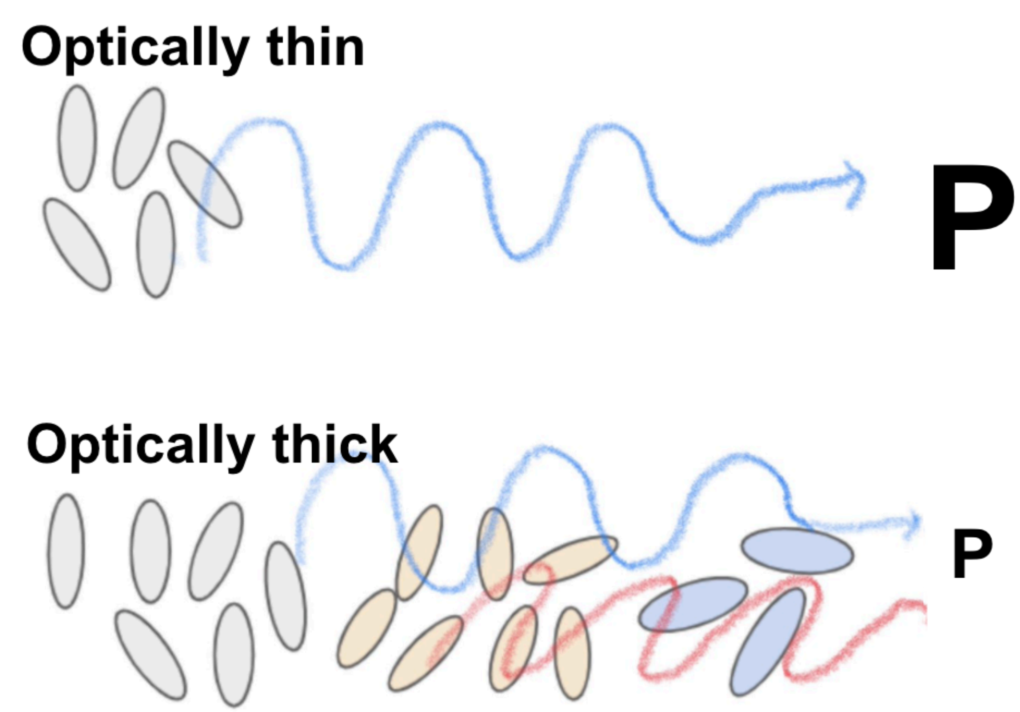
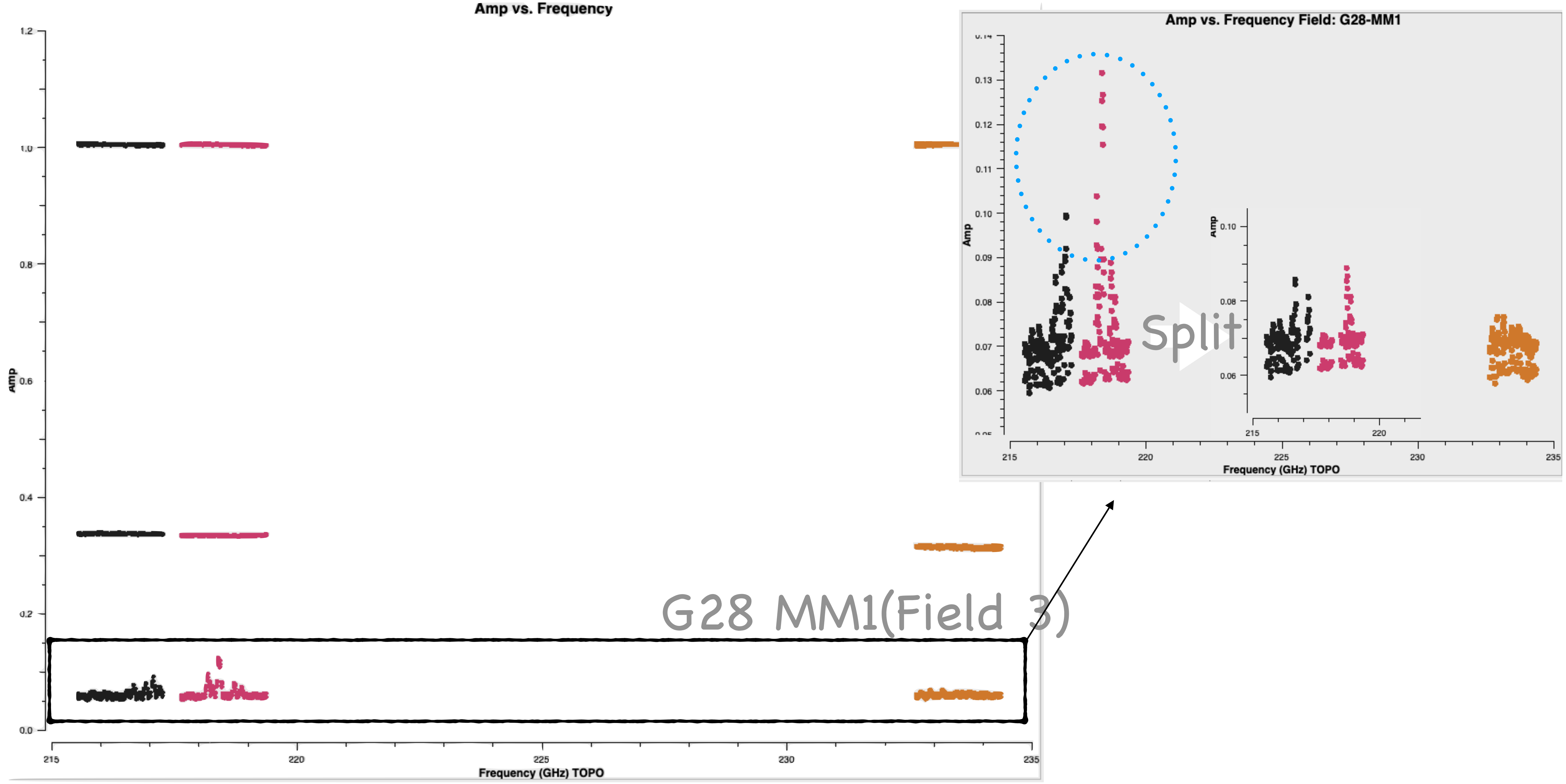
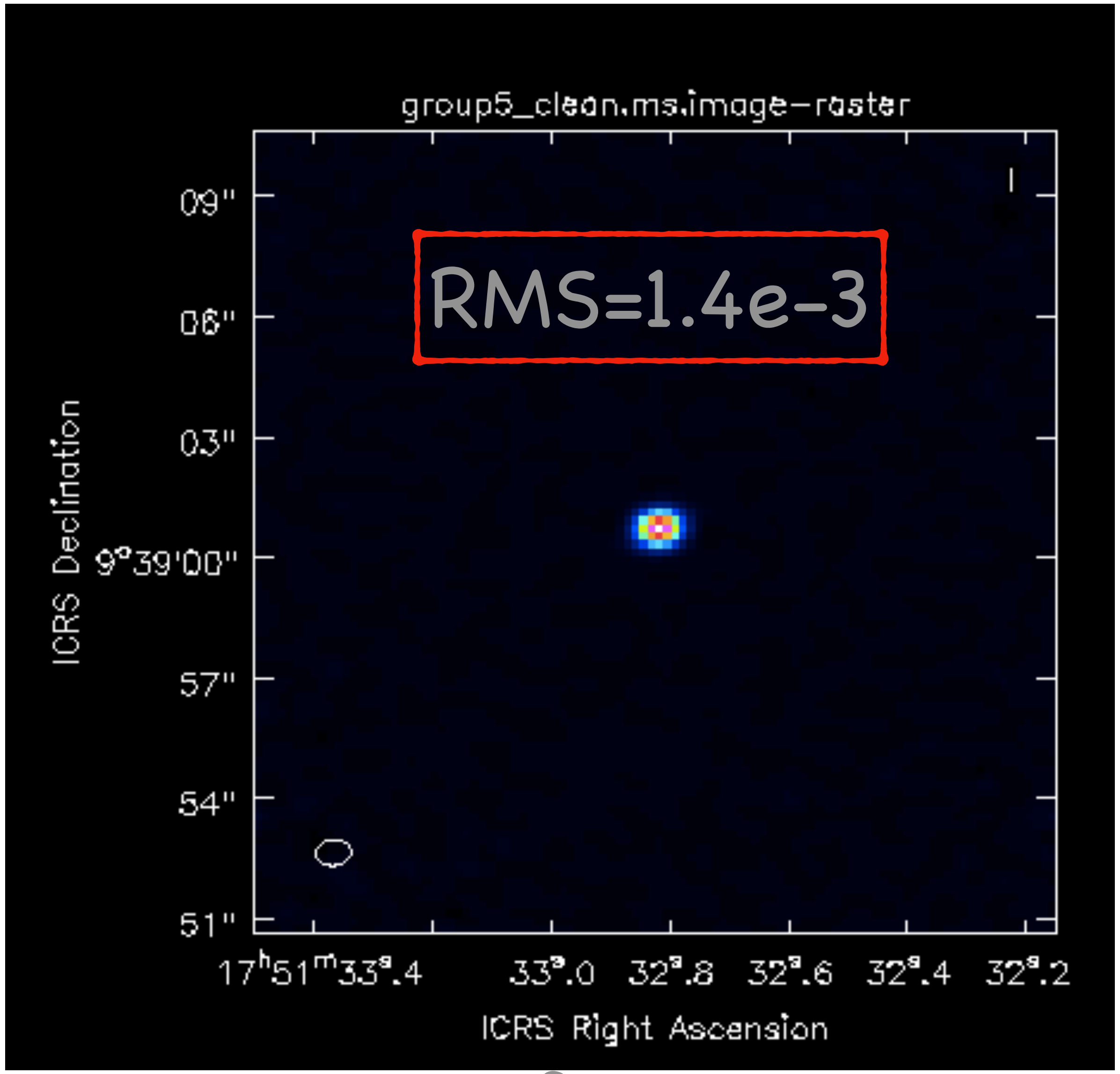


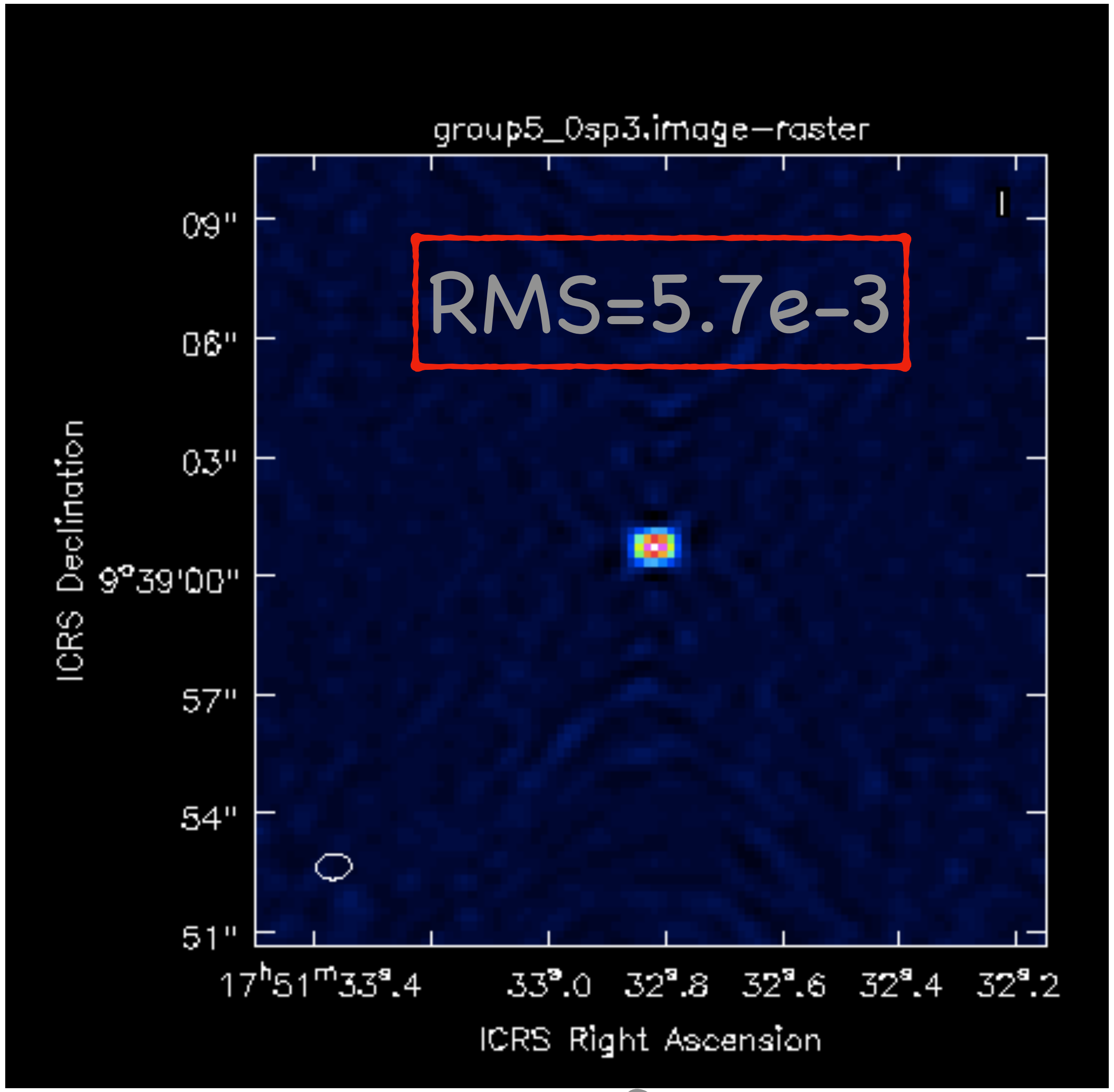
Continuum analysis



Continuum analysis

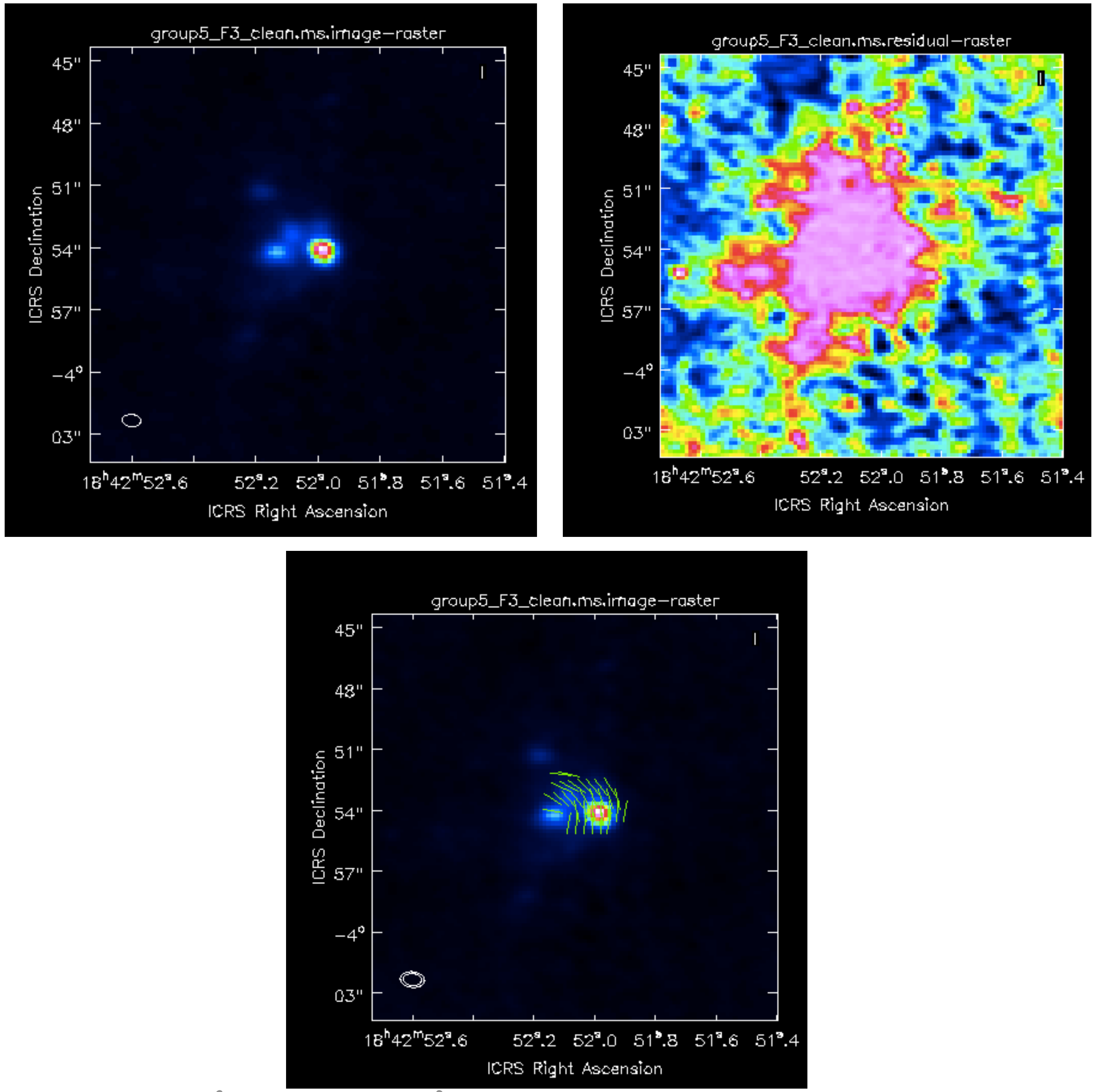


Before



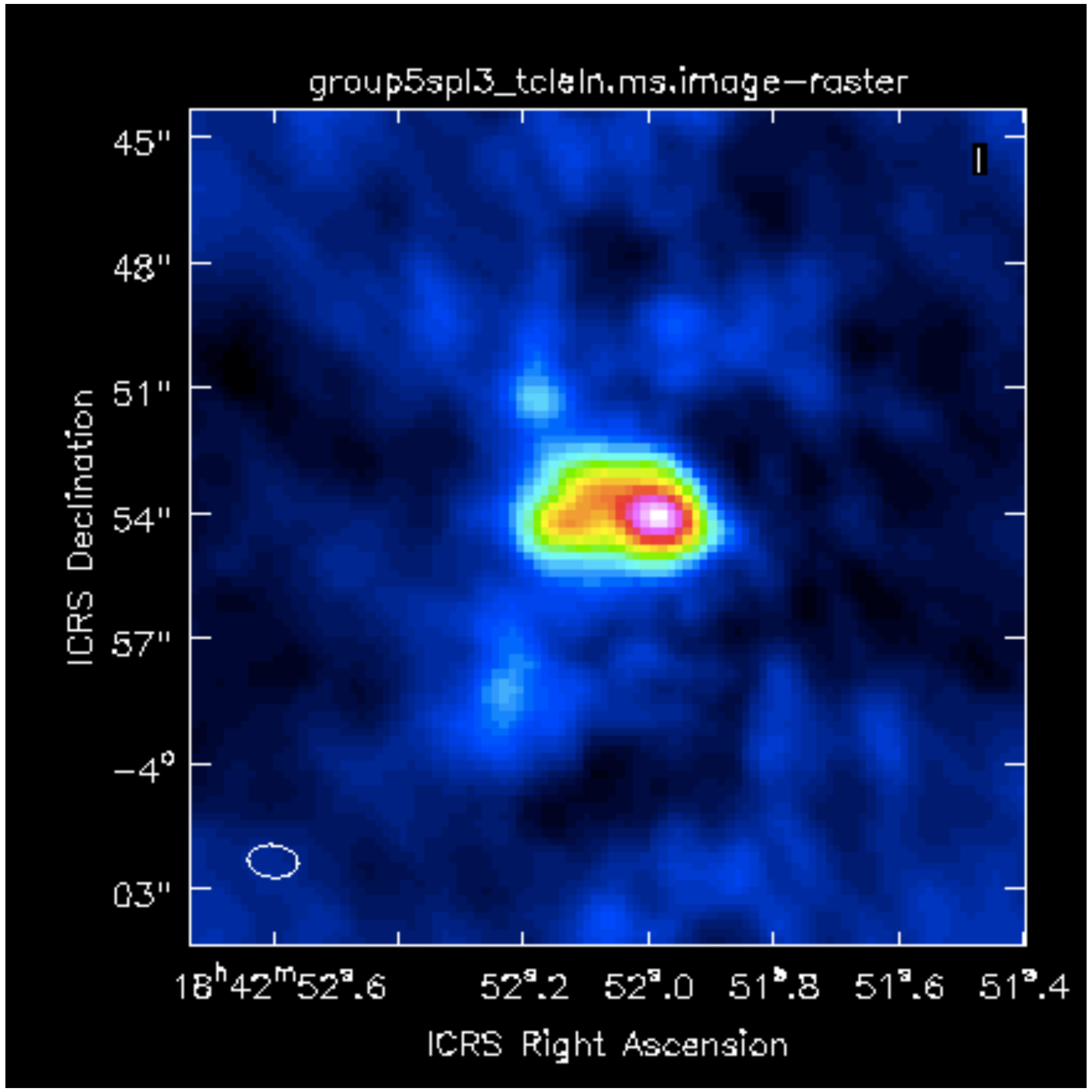
After

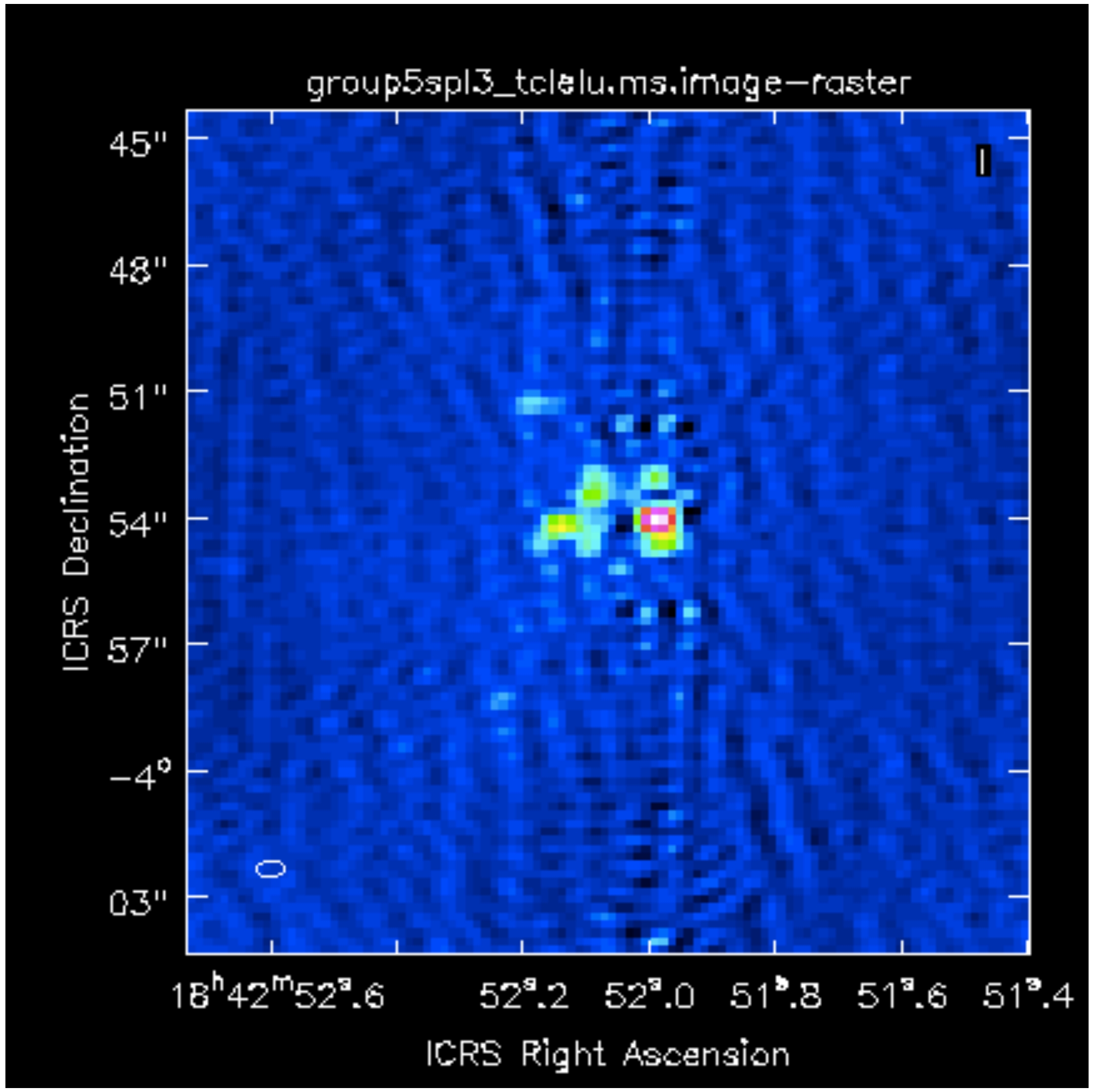
Continuum analysis



Field3(target) continuum images

Continuum analysis



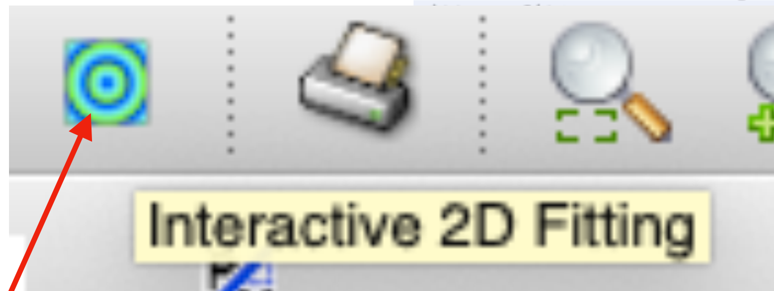


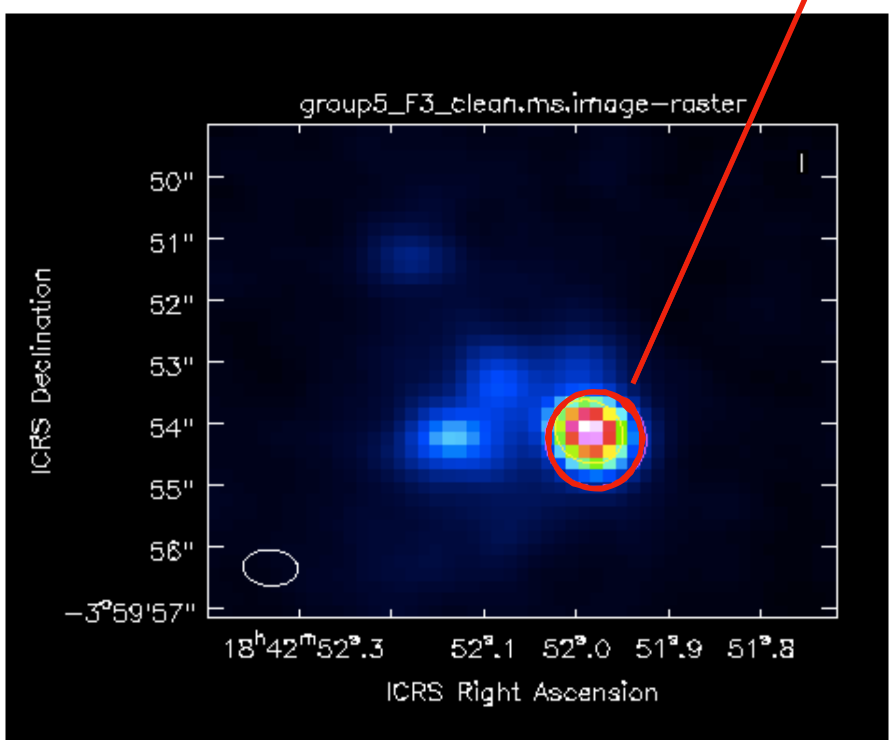
Weighting

Natural vs uniform

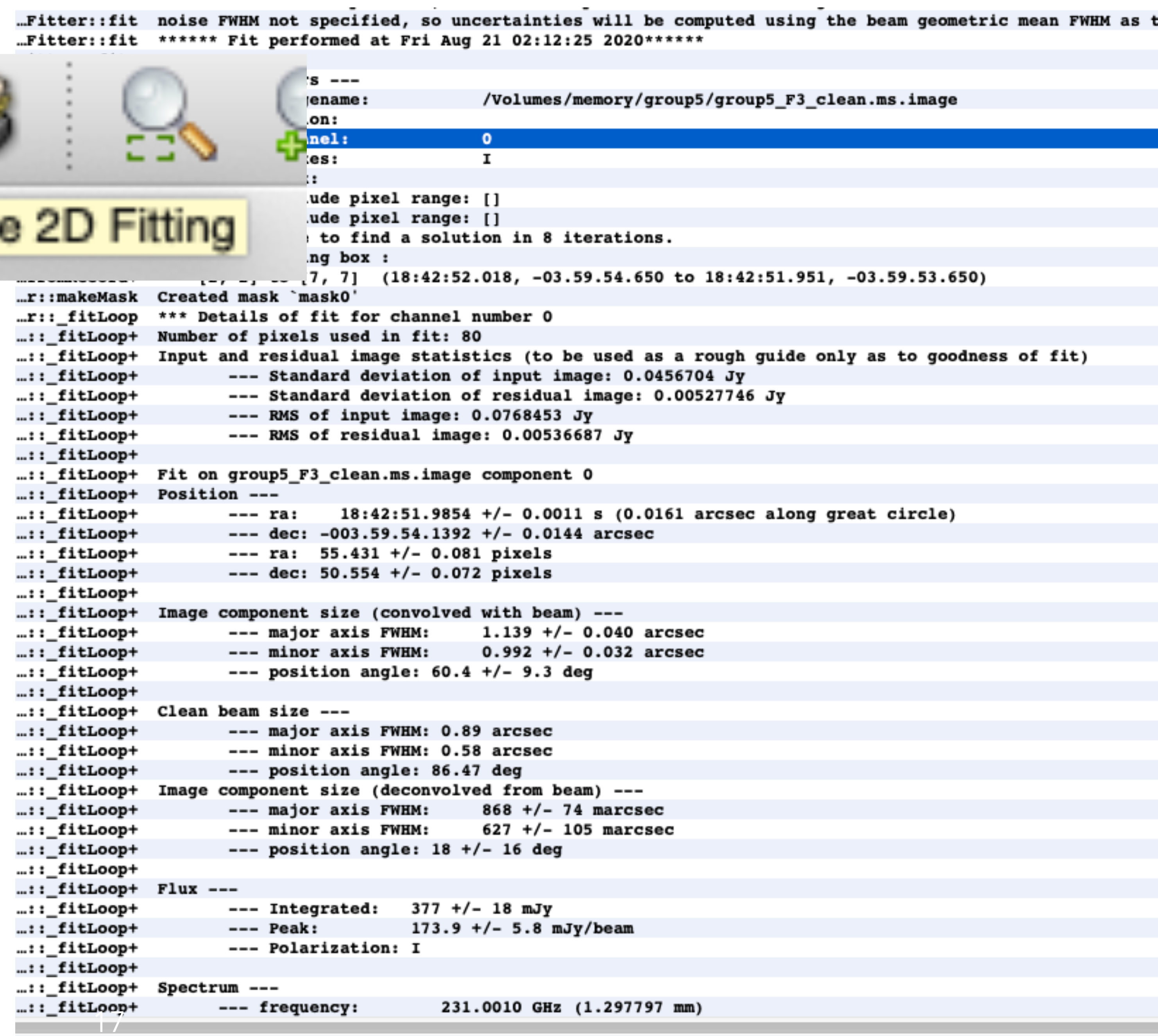
Better RMS

Continuum analysis



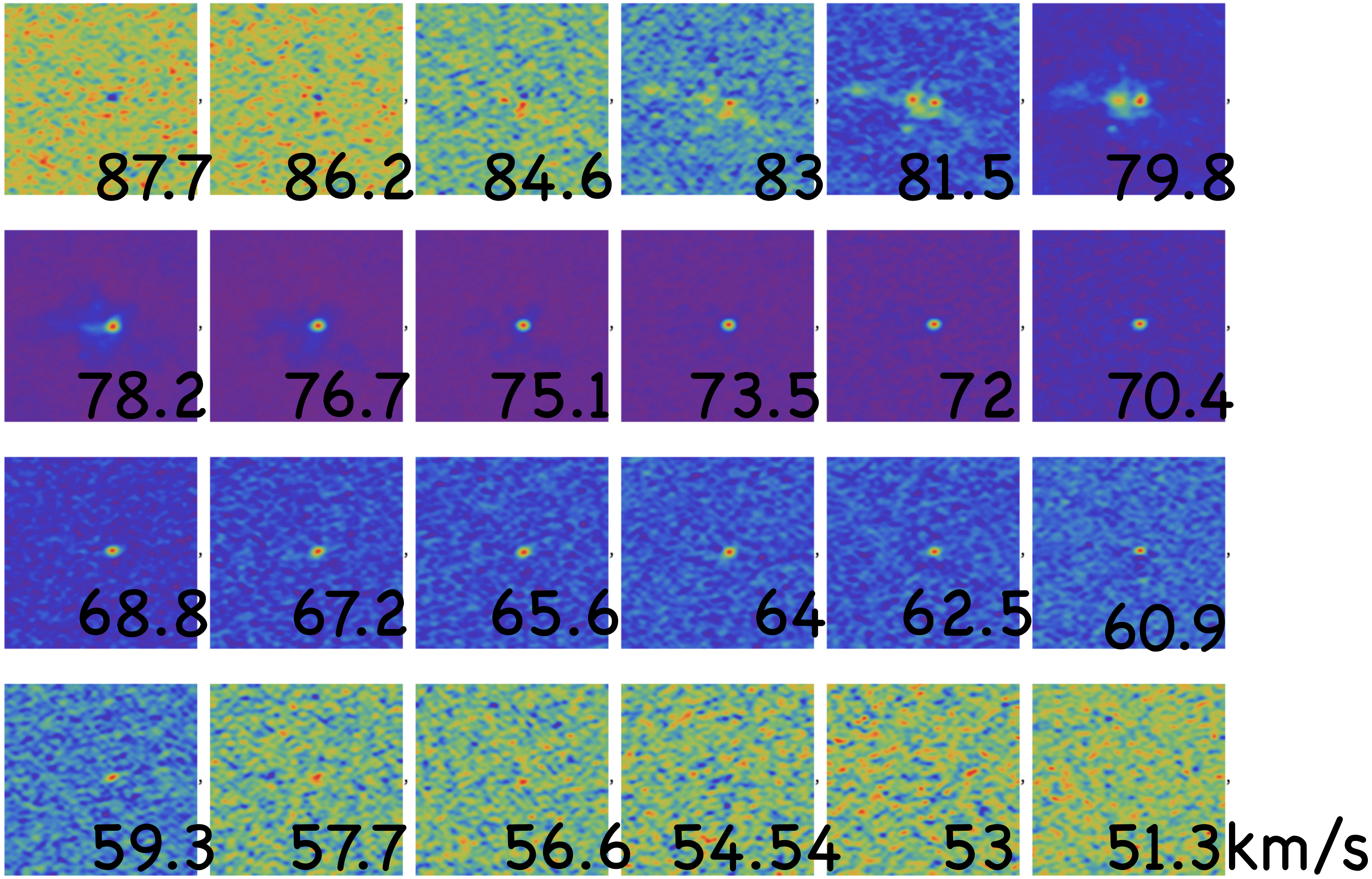


2D Fitting



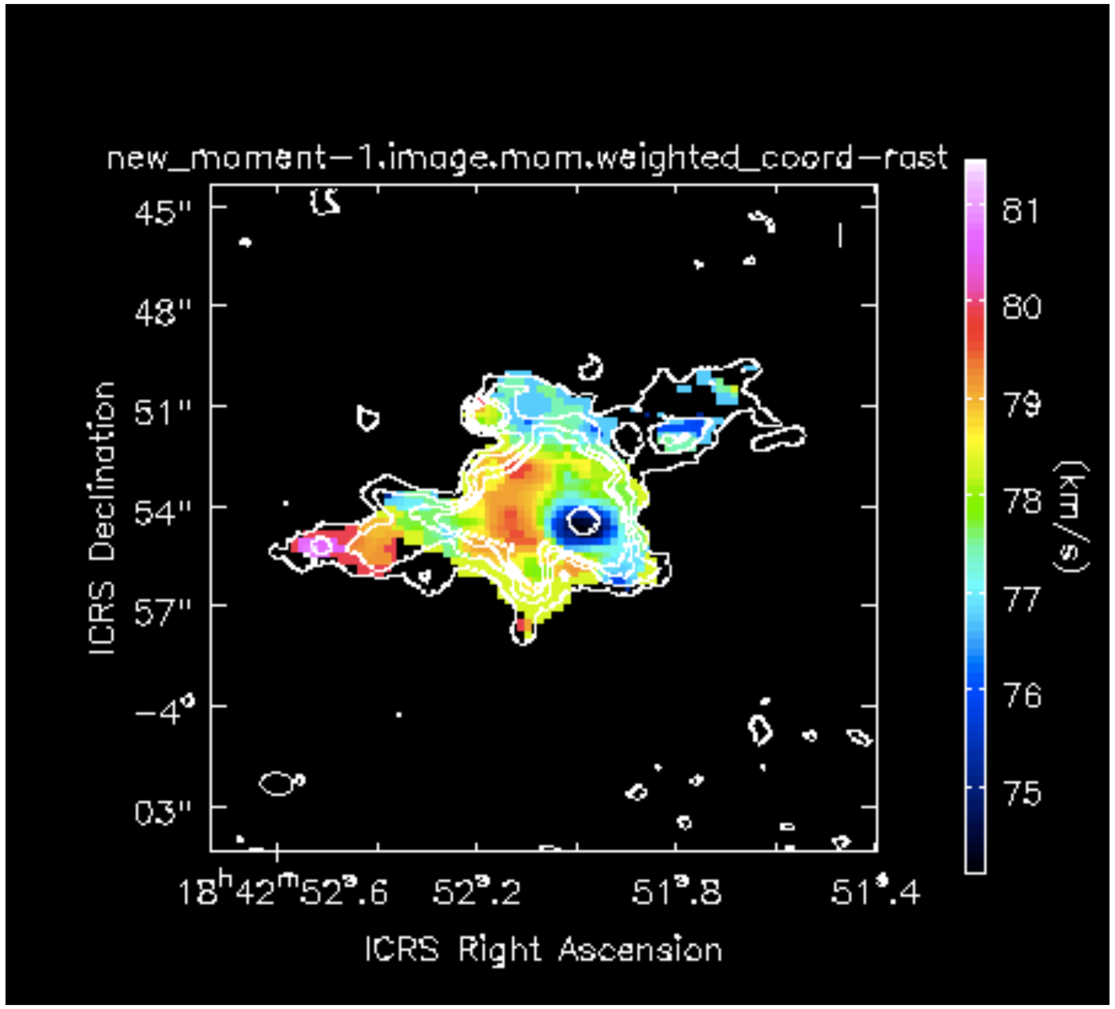
```
…Fitter::fit  noise FWHM not specified, so uncertainties will be computed using the beam geometric mean FWHM as the
…Fitter::fit  ****** Fit performed at Fri Aug 21 02:12:25 2020******

              s ---
              ename:                 /Volumes/memory/group5/group5_F3_clean.ms.image
              on:
              nel:                   0
              es:                    I
              :
              ude pixel range: []
              ude pixel range: []
              to find a solution in 8 iterations.
              ng box :
              7, 7]   (18:42:52.018, -03.59.54.650 to 18:42:51.951, -03.59.53.650)
…r::makeMask  Created mask `mask0'
…r::_fitLoop  *** Details of fit for channel number 0
…::_fitLoop+  Number of pixels used in fit: 80
…::_fitLoop+  Input and residual image statistics (to be used as a rough guide only as to goodness of fit)
…::_fitLoop+         --- Standard deviation of input image: 0.0456704 Jy
…::_fitLoop+         --- Standard deviation of residual image: 0.00527746 Jy
…::_fitLoop+         --- RMS of input image: 0.0768453 Jy
…::_fitLoop+         --- RMS of residual image: 0.00536687 Jy
…::_fitLoop+
…::_fitLoop+  Fit on group5_F3_clean.ms.image component 0
…::_fitLoop+  Position ---
…::_fitLoop+         --- ra:    18:42:51.9854 +/- 0.0011 s (0.0161 arcsec along great circle)
…::_fitLoop+         --- dec: -003.59.54.1392 +/- 0.0144 arcsec
…::_fitLoop+         --- ra:  55.431 +/- 0.081 pixels
…::_fitLoop+         --- dec: 50.554 +/- 0.072 pixels
…::_fitLoop+
…::_fitLoop+  Image component size (convolved with beam) ---
…::_fitLoop+         --- major axis FWHM:     1.139 +/- 0.040 arcsec
…::_fitLoop+         --- minor axis FWHM:     0.992 +/- 0.032 arcsec
…::_fitLoop+         --- position angle: 60.4 +/- 9.3 deg
…::_fitLoop+
…::_fitLoop+  Clean beam size ---
…::_fitLoop+         --- major axis FWHM: 0.89 arcsec
…::_fitLoop+         --- minor axis FWHM: 0.58 arcsec
…::_fitLoop+         --- position angle: 86.47 deg
…::_fitLoop+  Image component size (deconvolved from beam) ---
…::_fitLoop+         --- major axis FWHM:     868 +/- 74 marcsec
…::_fitLoop+         --- minor axis FWHM:     627 +/- 105 marcsec
…::_fitLoop+         --- position angle: 18 +/- 16 deg
…::_fitLoop+
…::_fitLoop+  Flux ---
…::_fitLoop+         --- Integrated:   377 +/- 18 mJy
…::_fitLoop+         --- Peak:         173.9 +/- 5.8 mJy/beam
…::_fitLoop+         --- Polarization: I
…::_fitLoop+
…::_fitLoop+  Spectrum ---
…::_fitLoop+        --- frequency:        231.0010 GHz (1.297797 mm)
```

Line analysis

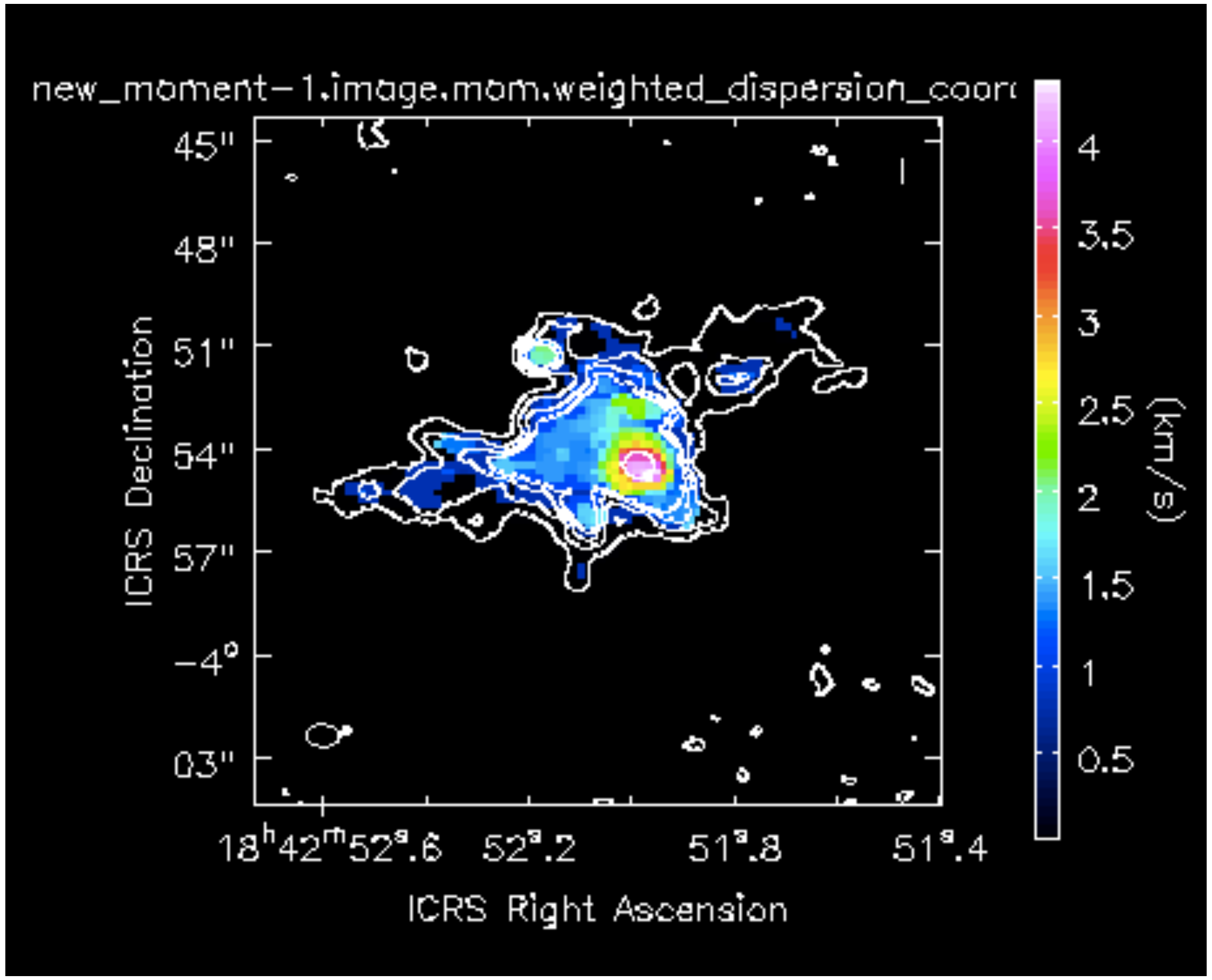


Channel map

Line analysis

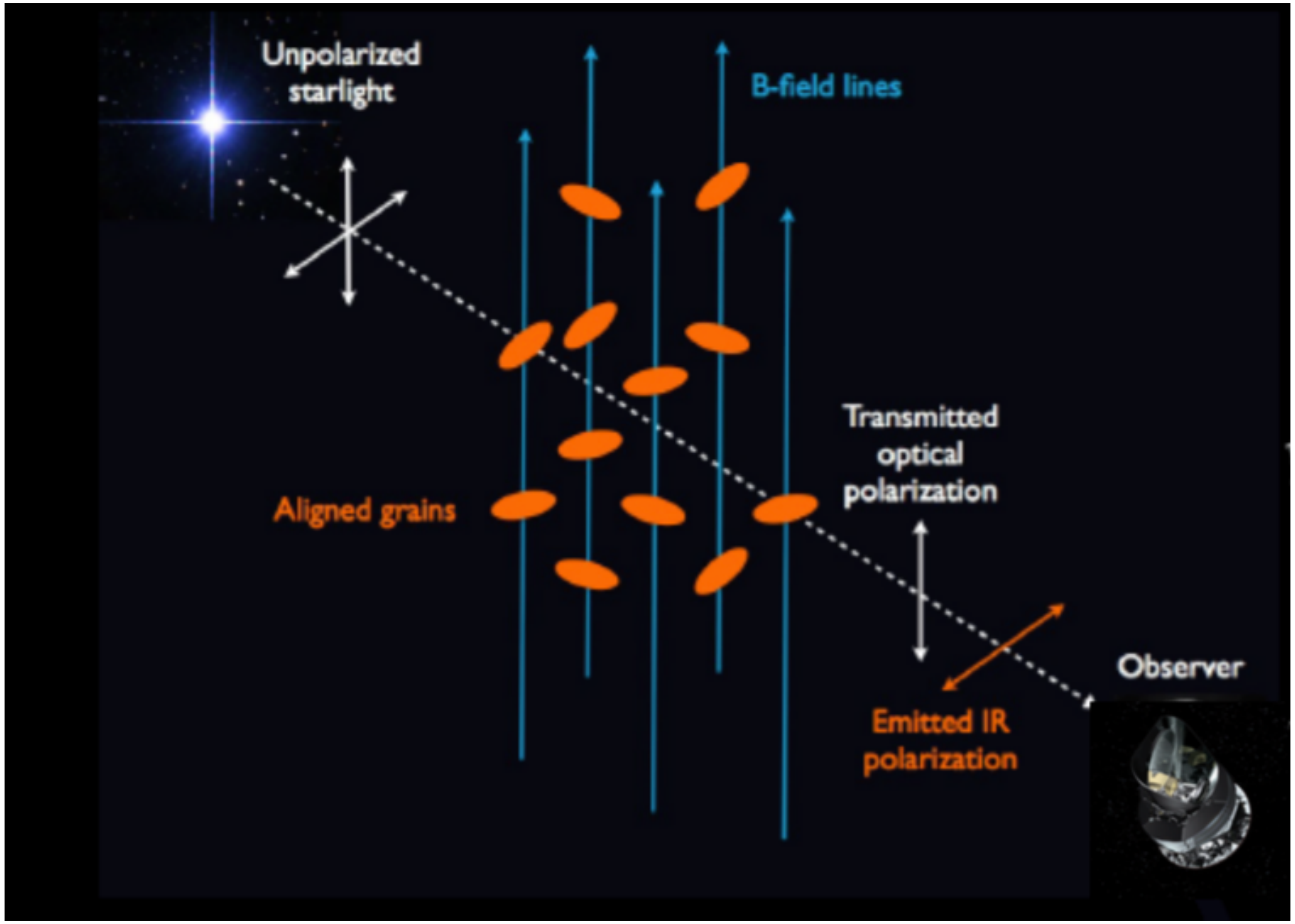


Velocity map



Velocity dispersion map

Dust polarization



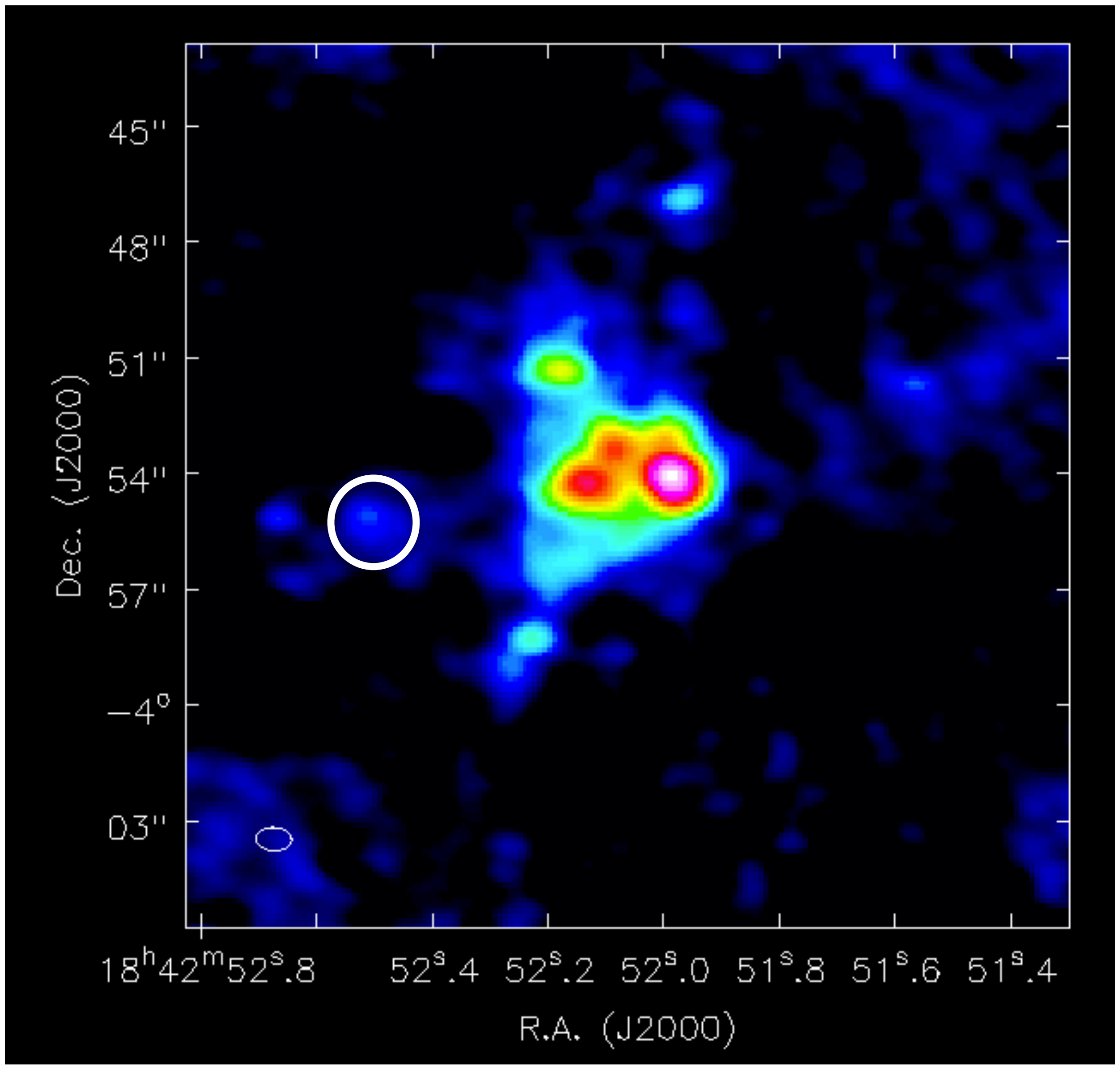
- Dust grains are anisotropic.
- Dust grains align (statistically) with their long axis perpendicular to the magnetic field orientation.
- Dust emission (extinction) is perpendicular (parallel) to the magnetic field.

Observations

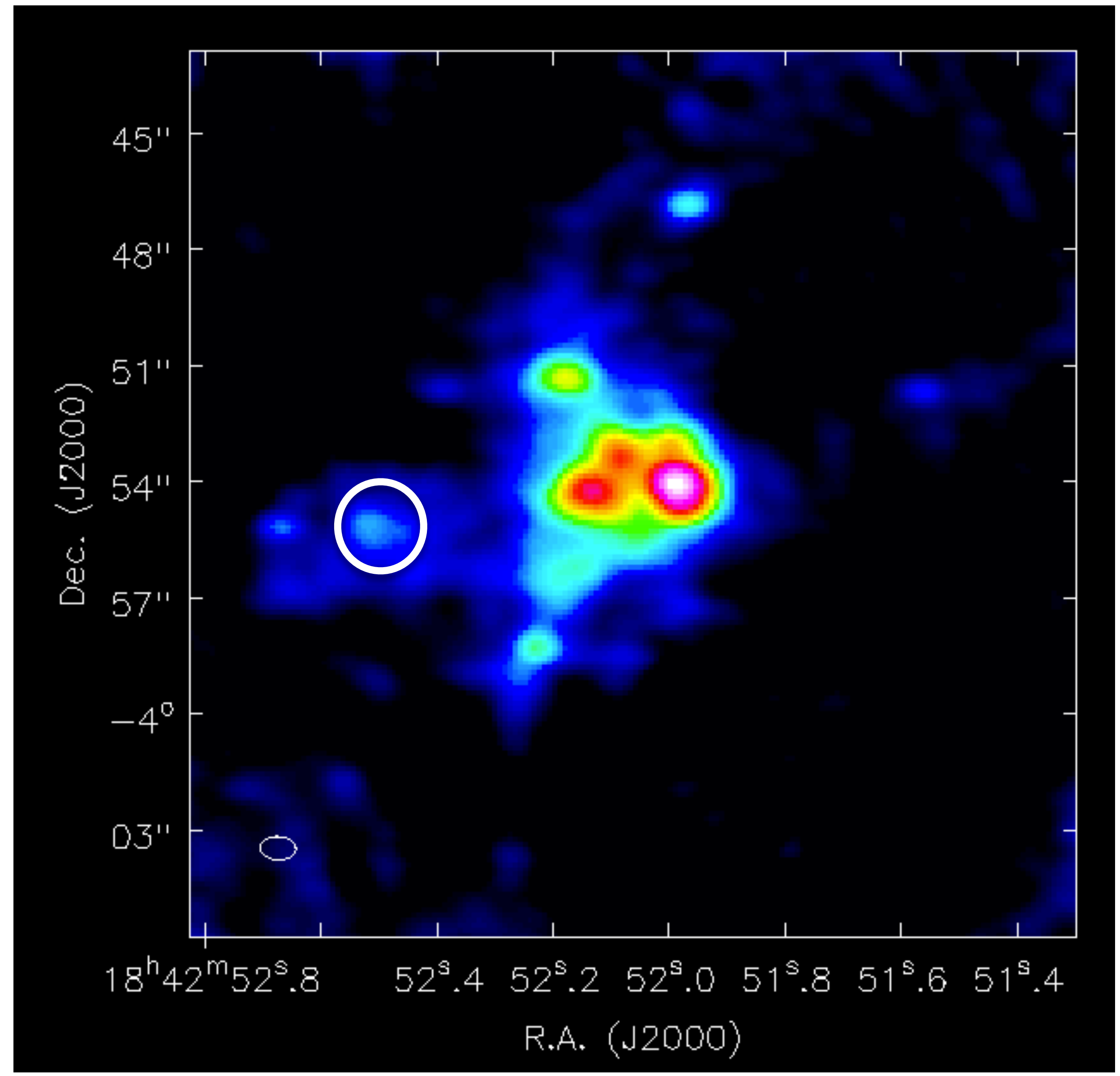
- April, 2017 (Cycle 5, PI: Zhang) & June, 2018 (Cycle 6, PI: Zhang)
- C43-3 configuration
- Band 6: 230 GHz dust continuum in the full polarization mode & OCS (19-18), CO (2-1), 13CS (5-4), and N2D+ (3-2)
- Angular resolution: ~ 0.6" (~0.02 pc)
- 2-iterations of phase-only self calibration on the continuum data
- Using the CASA task "*TCLEAN*" with Briggs weighting (robust = 0.5)
- Obtain the Stokes *I, Q, U* maps of dust continuum and the molecular line cube of OCS (19-18)

Self calibration

A cleaned image

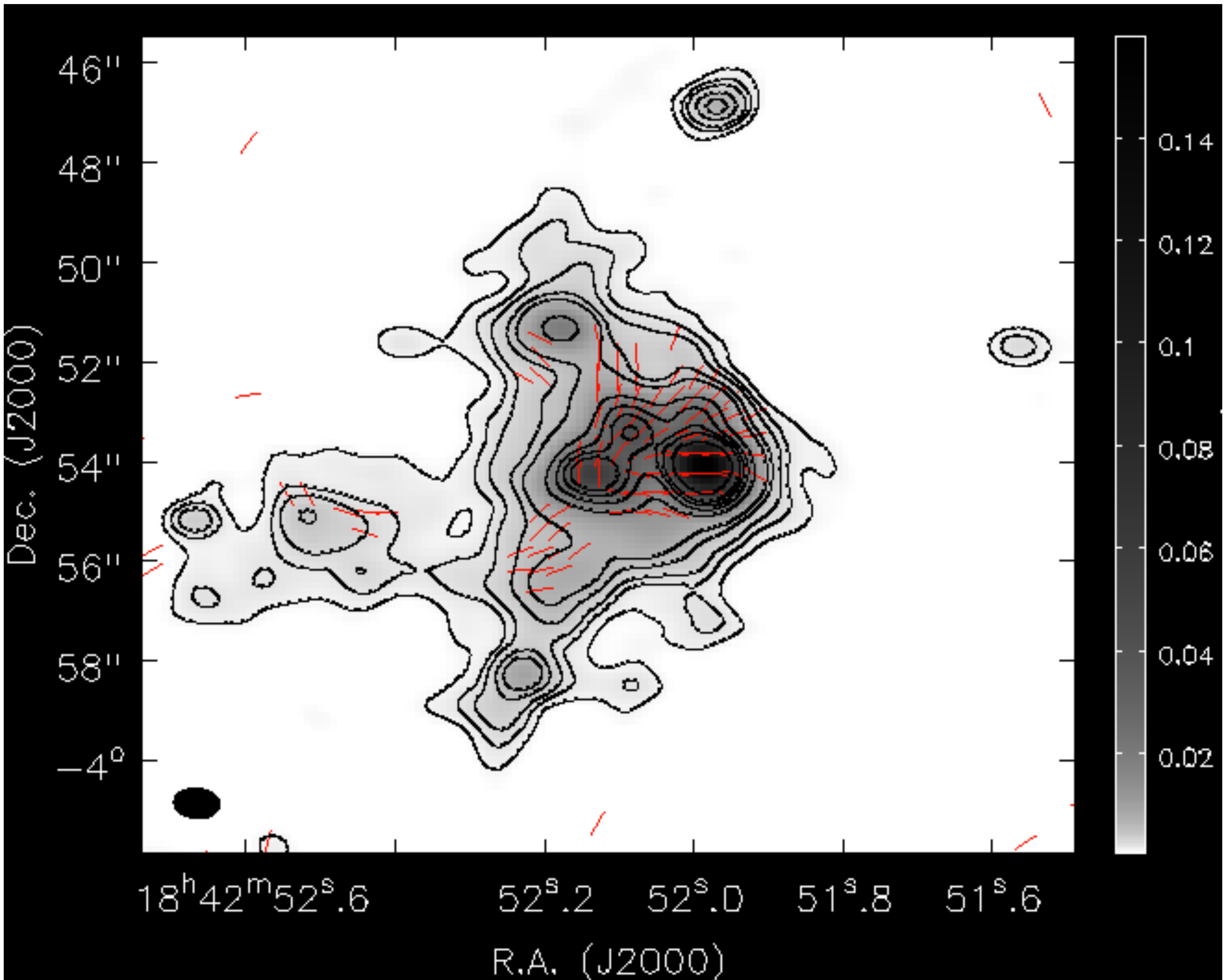


A cleaned image after two-iteration self calibration



- rms noise decreases by ~34% after two-iteration self calibration.

Dust continuum and magnetic orientation map



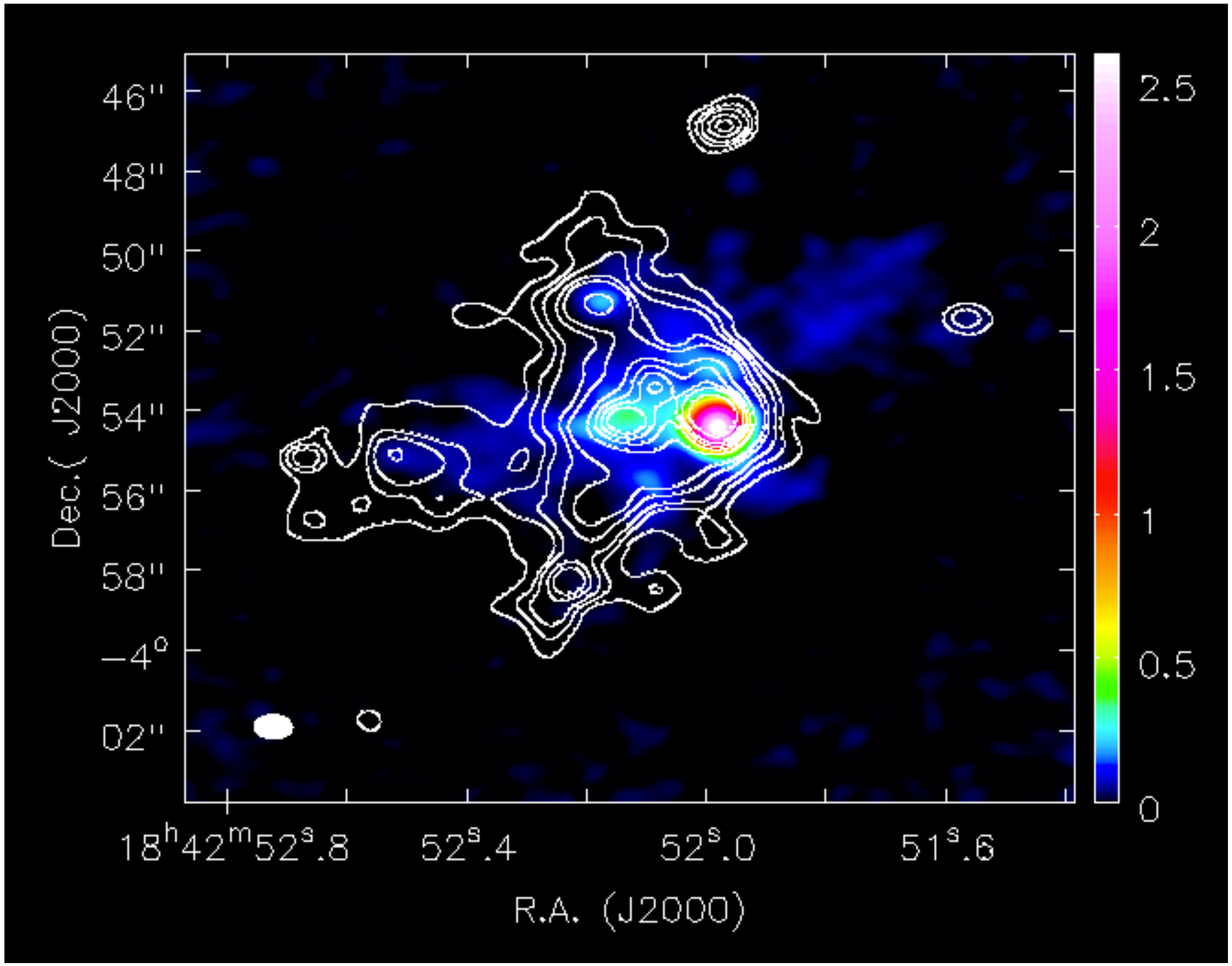
Dust continuum emission

- dominated by a major core
- resolved into several condensation structures (~ 15 cores)
- using the CASA task "*IMFIT*" to characterize the dense structures such as coordinates, flux, FWHM

Magnetic field in MM1

- The plane-of-sky magnetic field orientation can by derived rotating the orientation of the observed linear dust polarization by 90 degree.
- Well resolved and shows a radical pattern
- The magnetic field in MM1 might be dragged toward the center by gravity.
- Clear trend of decreasing polarization percentage (*P*) with increasing Stoke *I* are seen in MM1.

Molecular line: OCS (19-18)



- similar emission morphology and present the strongest emission mostly near the dust continuum peaks.

Thank you :-)