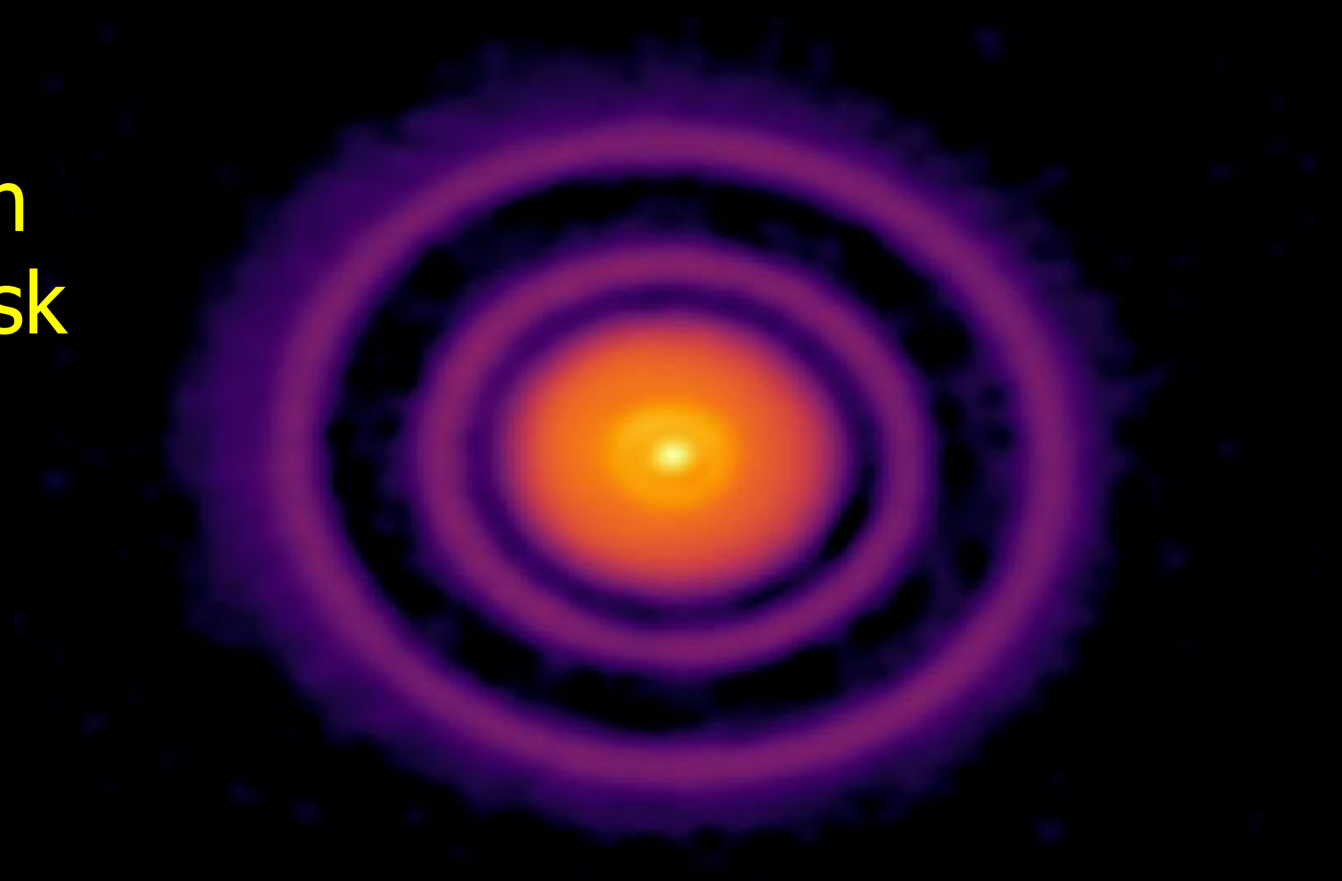
ALMA data reduction with AS 209 protoplanetary disk



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Target & Observations

- Target

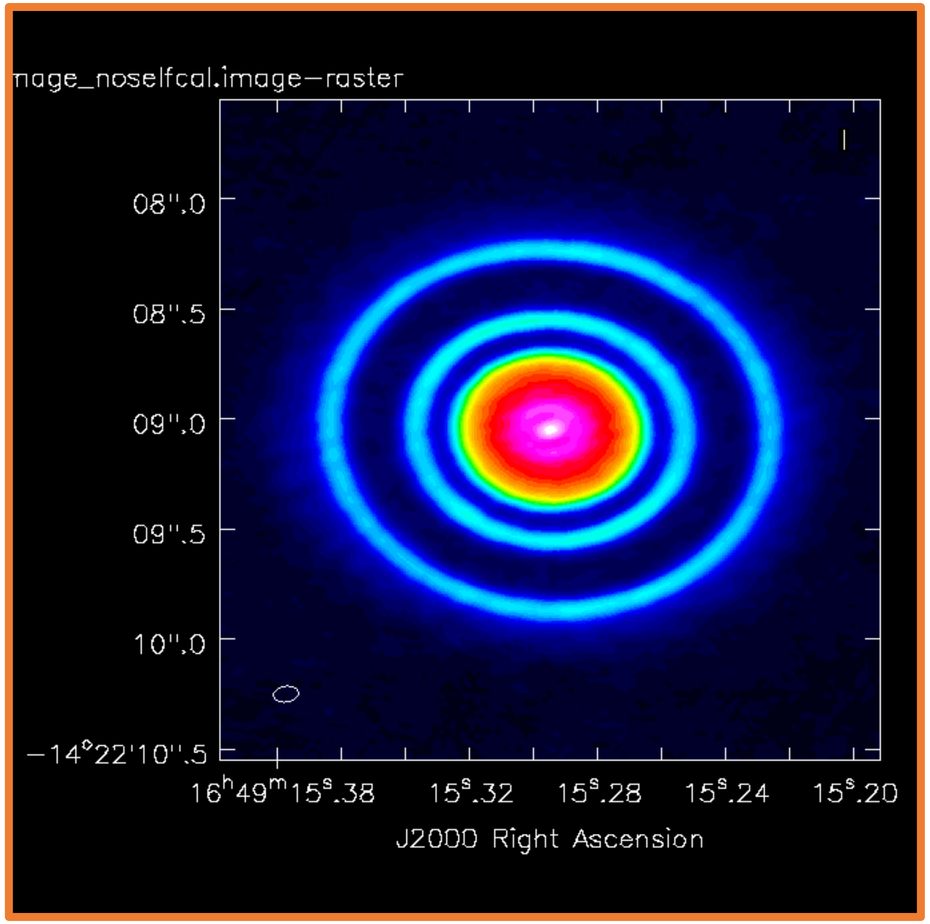
  : AS 209 (T Tauri disk at Ophiuchus star-forming region)

- Observation (DSHARP)

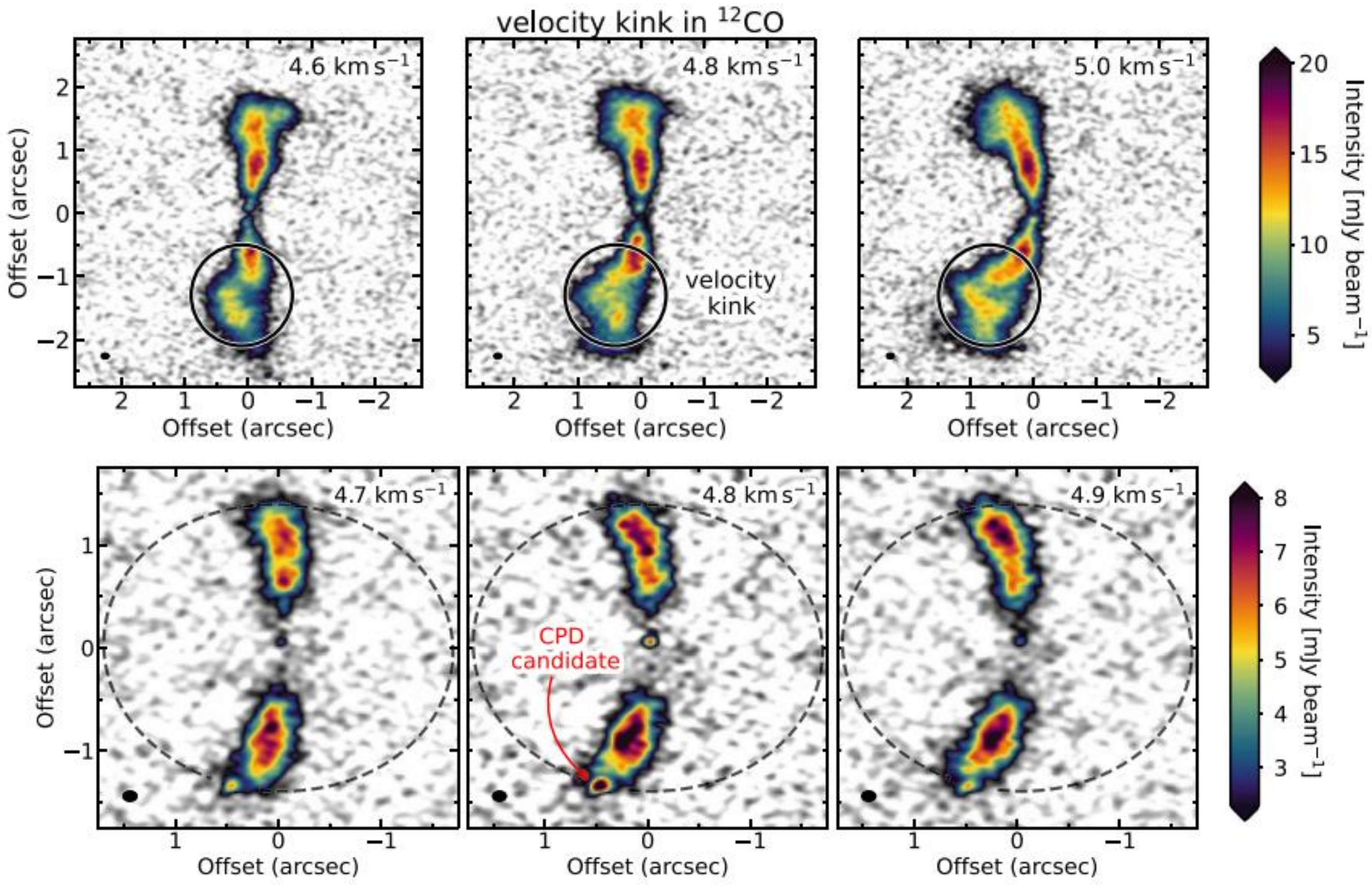
  : ALMA Band 6 (~ 230GHz)

  Dust continuum observations

  CO J = 2 → 1 line observations



Introduction



Velocity kink structure

in ^{12}CO channel maps!

CPD candidate

in ^{13}CO channel maps!

Bae et al. (2022)

Goals

- 1. From continuum data

  → Improve the image quality by self-calibration while minimizing the resolution loss.

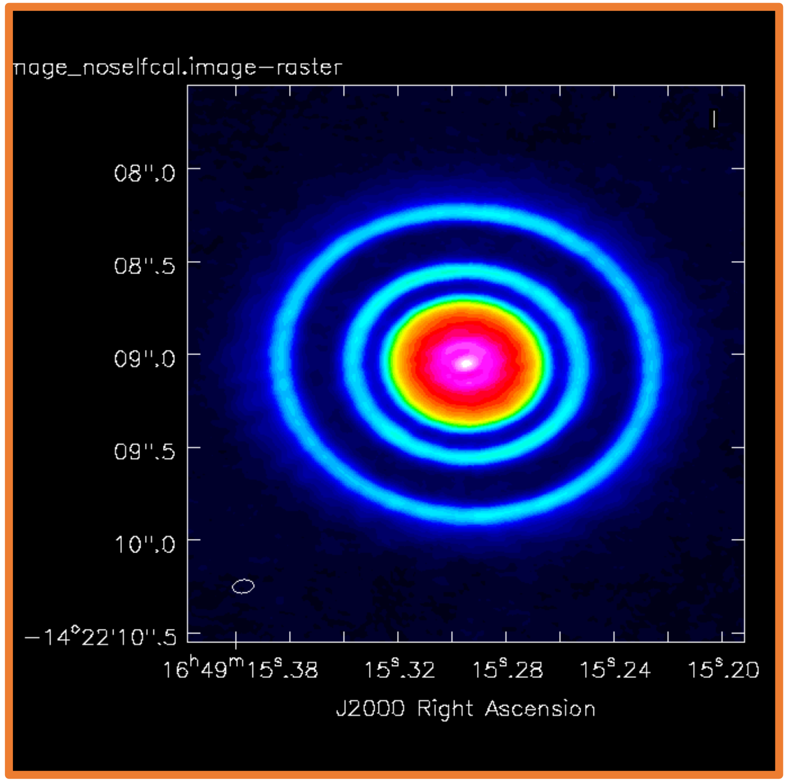
- 2. From CO line data

  → Find the signature of the planet formation.

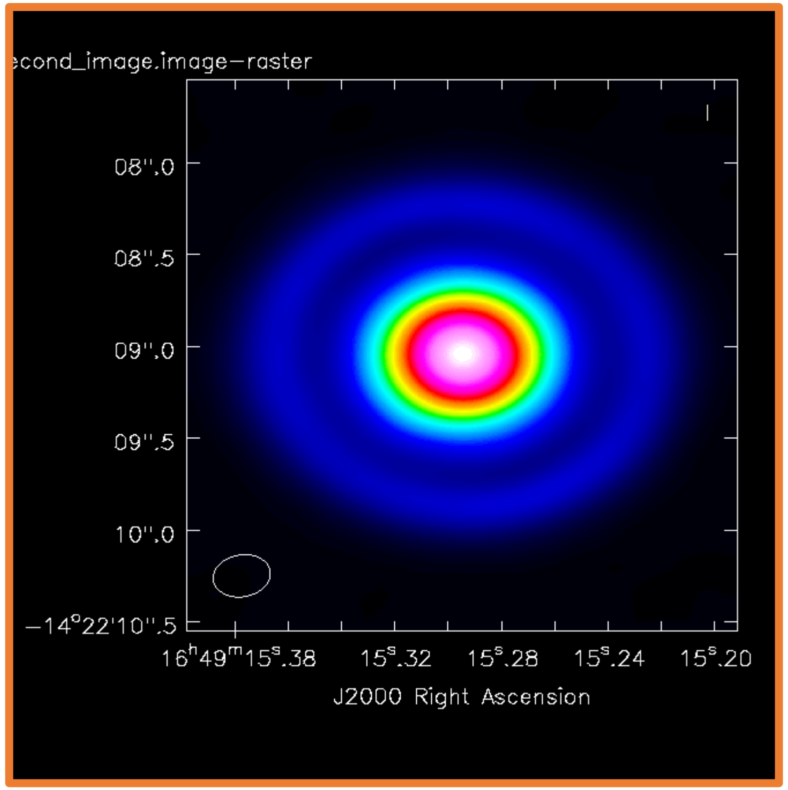
  (velocity kink, Circum-planetary disk candidate)

Continuum : Self-calibration

First Trial: Self-calibration with total measurement set



Non-self-calibrated image



Self-calibrated image

- Gaincal
  solint= 30s
- Extended UV-distance datasets are flagged out!

Continuum : Self-calibration

Measurement set data structure

Data sets	Maximum UV distance	Spw
Oberg	650 m	0~2, 3~8
Fedele	2800 m	8~9, 10~11
Andrew (Compact)	1100 m	12~16
Andrew (Extended)	10700 m	17~20, 21~24

Continuum : Self-calibration

Second Trial: Self-calibration with split measurement sets

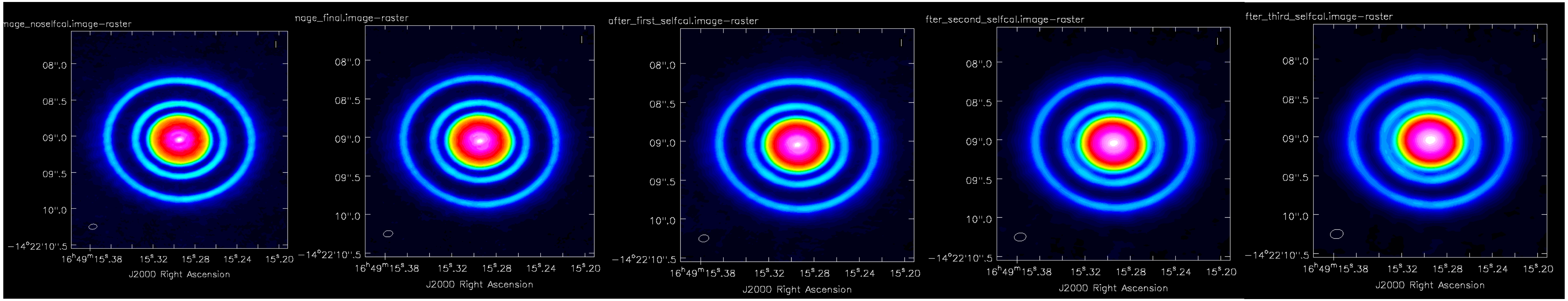
- Oberg + Fedele, Compact, Extended → Youngwoo
- Oberg, Fedele + Compact, Extended → Dong Hyeok
- Oberg + Fedele + Compact + Extended → Youngwoo
- Oberg, Fedele + Compact, Extended → Adarsh

60s → 30s → 15s phase calibration + amplitude calibration

First case: peak SNR increases, Third case: peak SNR decreases

Continuum : Self-calibration

Third Trial: Self-calibrate combined datasets with lower SNR cut



Non-self-calibrated	Only self-cal with split MS	After first self-cal	After second self-cal	After third self-cal
	Self-cal Oberg (60s→ 30s→15s)	solint= 900s minsnr = 1.5	solint= 360s minsnr = 1.5	solint= 180s minsnr = 1.5
Peak SNR = 530	Peak SNR = 616	Peak SNR = 508	Peak SNR = 561	Peak SNR = 623

Continuum : Summary

In our case, it was always a tradeoff between resolution and image quality

If we improve the image quality, the resolution gets worse,

and if we preserve the resolution, we could not improve the image dramatically

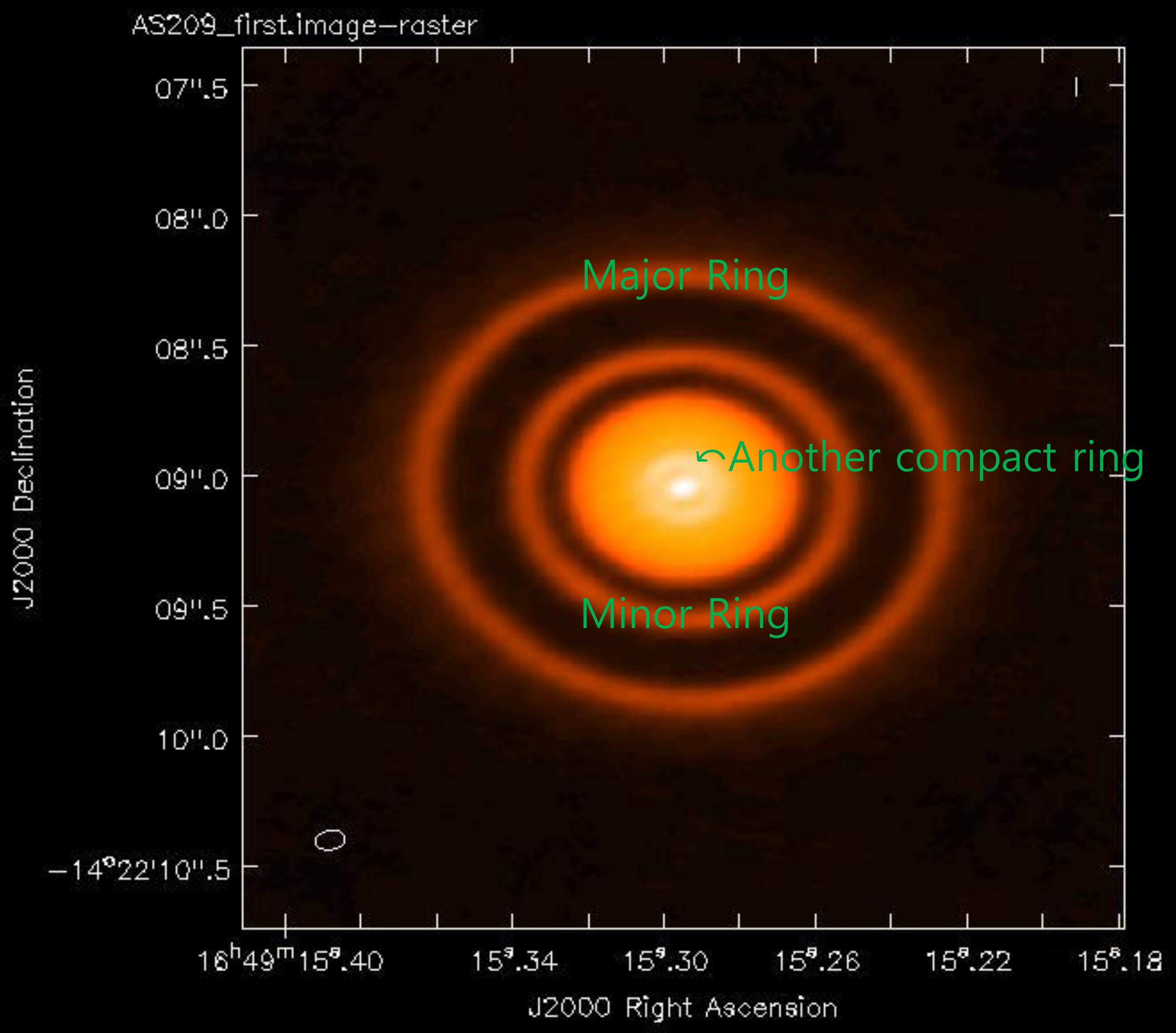
First Look of **AS209**

Max value of *UV dist* was *~10700m*
-> resolution *~0.03"*
-> *cell* size *~0.006"*

FOV of 12m-antenna with 230 GHz *~27"*
-> *imsize* = FOV/cell *~4500*

SNR of first image *~440*

Some substructures had appeared

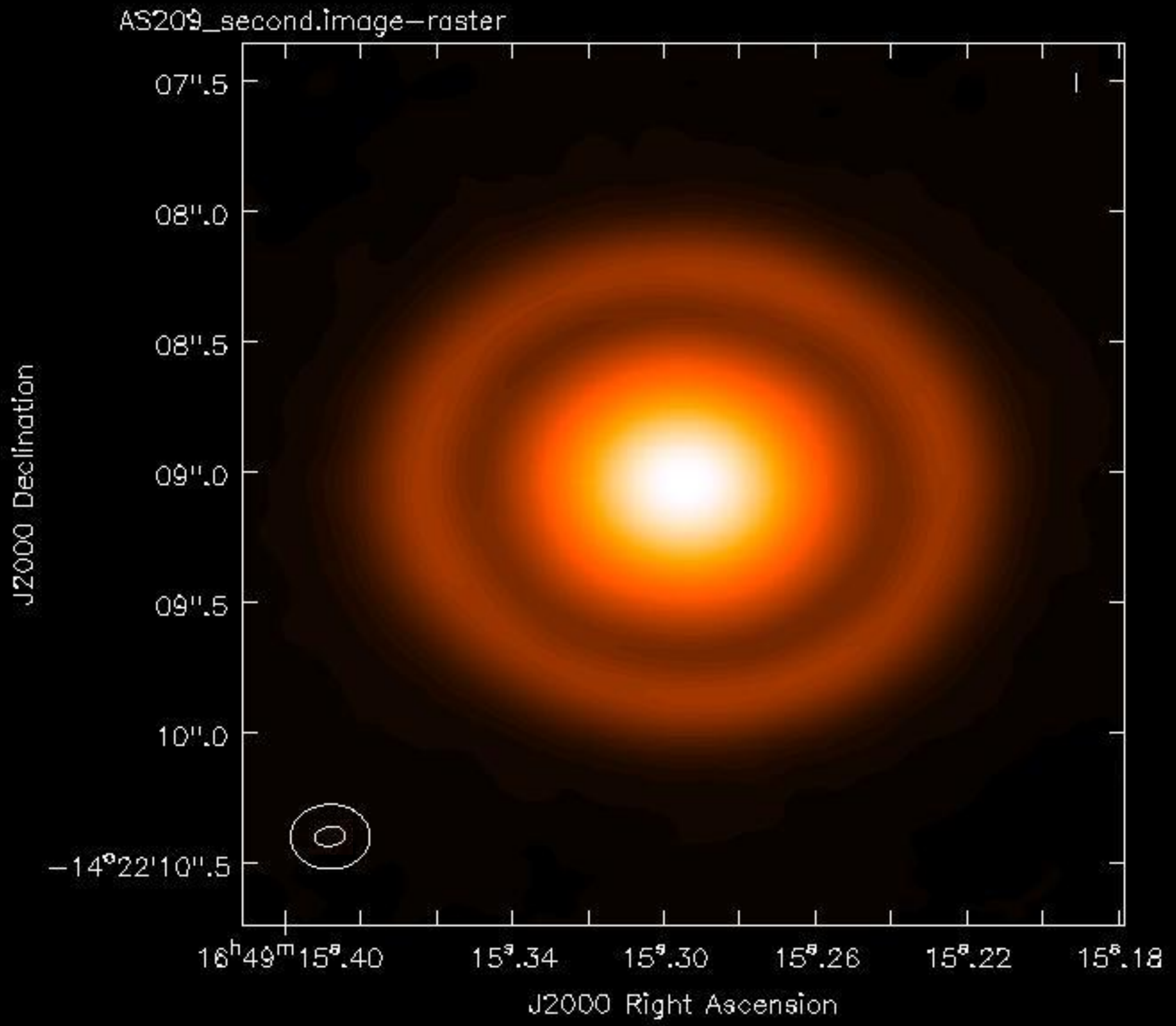


First Look of **AS209**

Try to calibrate phase with model itself
to improve the SNR.

-> A lot of solutions had flagged (hundreds of)
-> And it takes too long time to *gaincal*
(in my local, 30 min)
-> Beam size increase surprisingly.

We considering that a lot of solutions that containing log-baseline data has flagged out



Presenter : Dong-Hyeok Koh

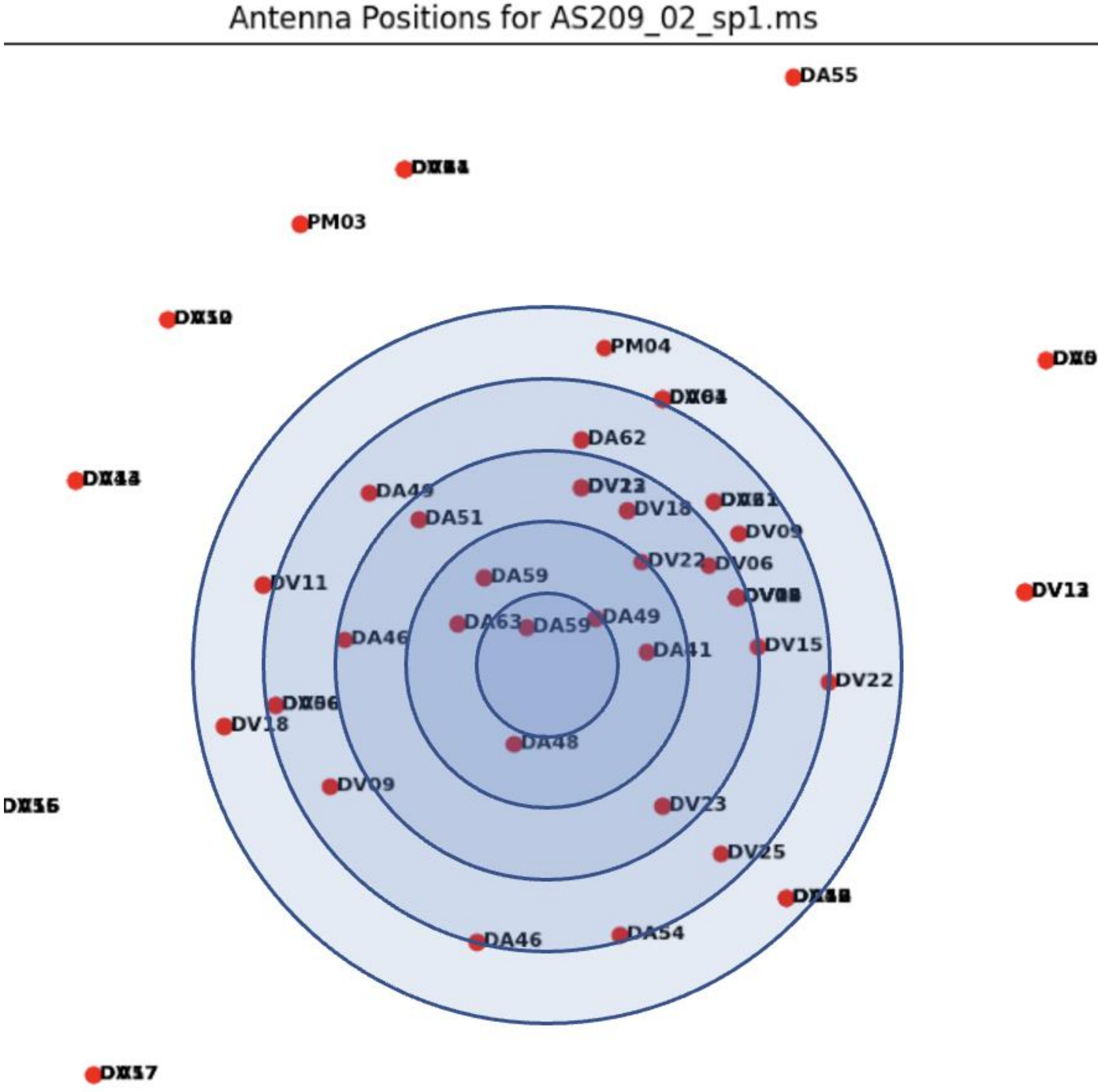
Selection of *Refant* of **AS209**

This data contain several (*~7*) observation with different antenna configuration

We want to give abundant *Refant* candidates base on their UV positions.

Refant="DA59, DA49, DA48, DA63, DA41, DV22"

-> It did not improve the image quality, but we had used these *Refant* ever since.



Presenter : Dong-Hyeok Koh

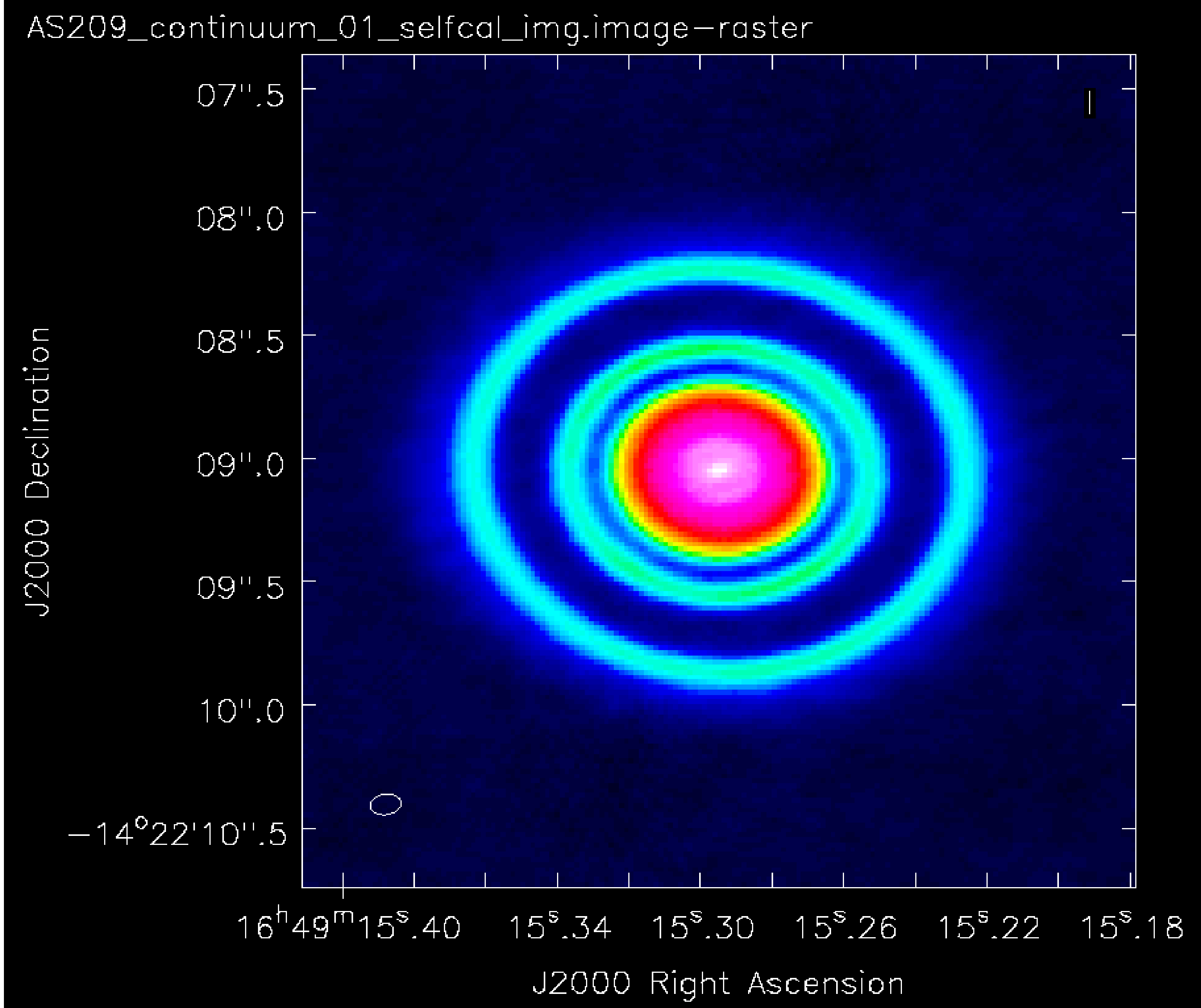
Calibration Options of **AS209**

We can use some options during *gaincal* to save long-baseline solution.

We tried to give option, *minsnr=2*

It was most powerful between all, but it took too much time.
(It is still running!
Notice that right image is not final.

SNR *~559* (highest, so far)



Presenter : Dong-Hyeok Koh

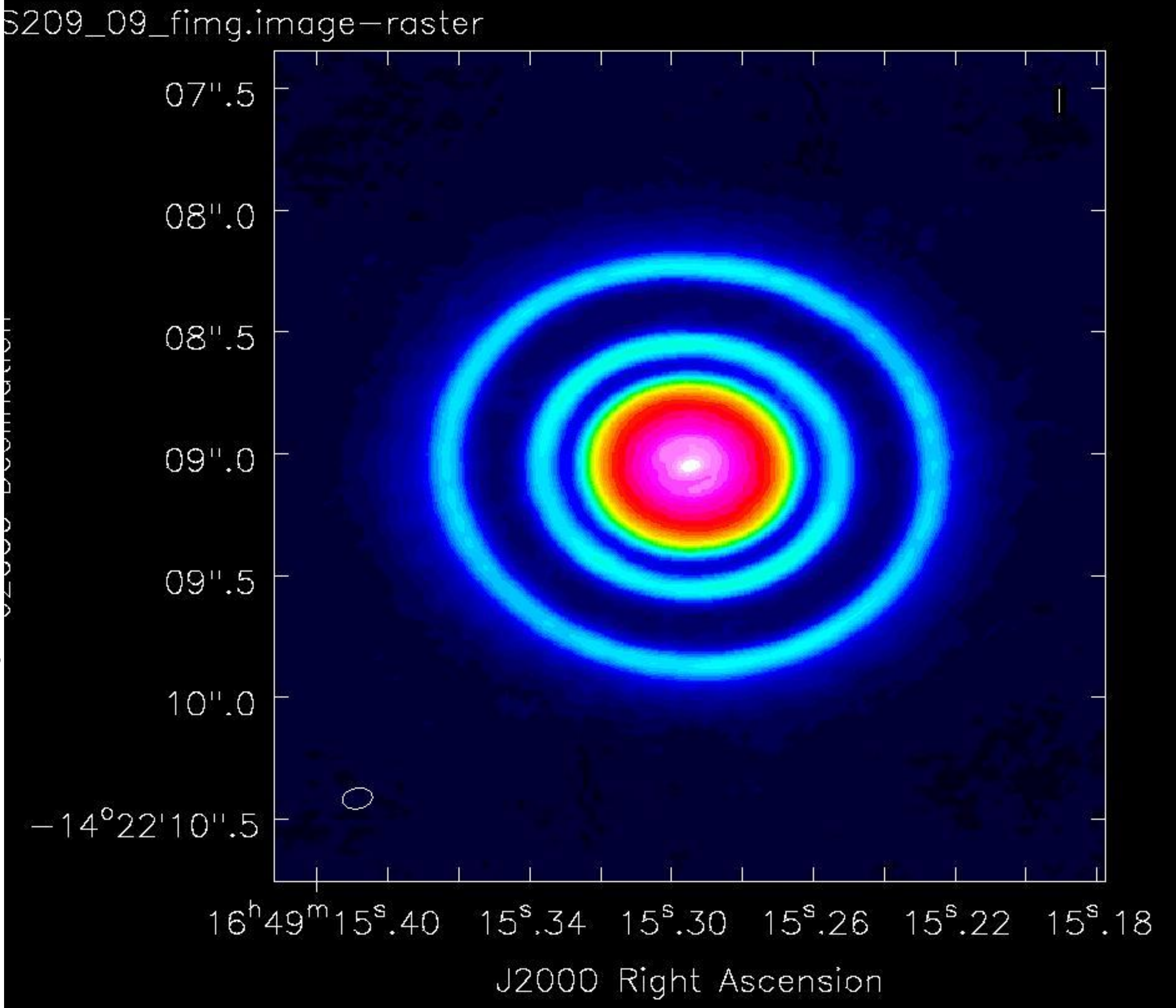
Spliting Observtions of **AS209**

Data containing 7 observations with different UV distance.
We can split them in compact/large UV data sets

-Data of Oberg&Fedele (compact UV) :
Try selfcal

-Data of Andrews (large UV):
DONNOT try selfcal

-> SNR was improved factor of 1.13
(best case, so far)



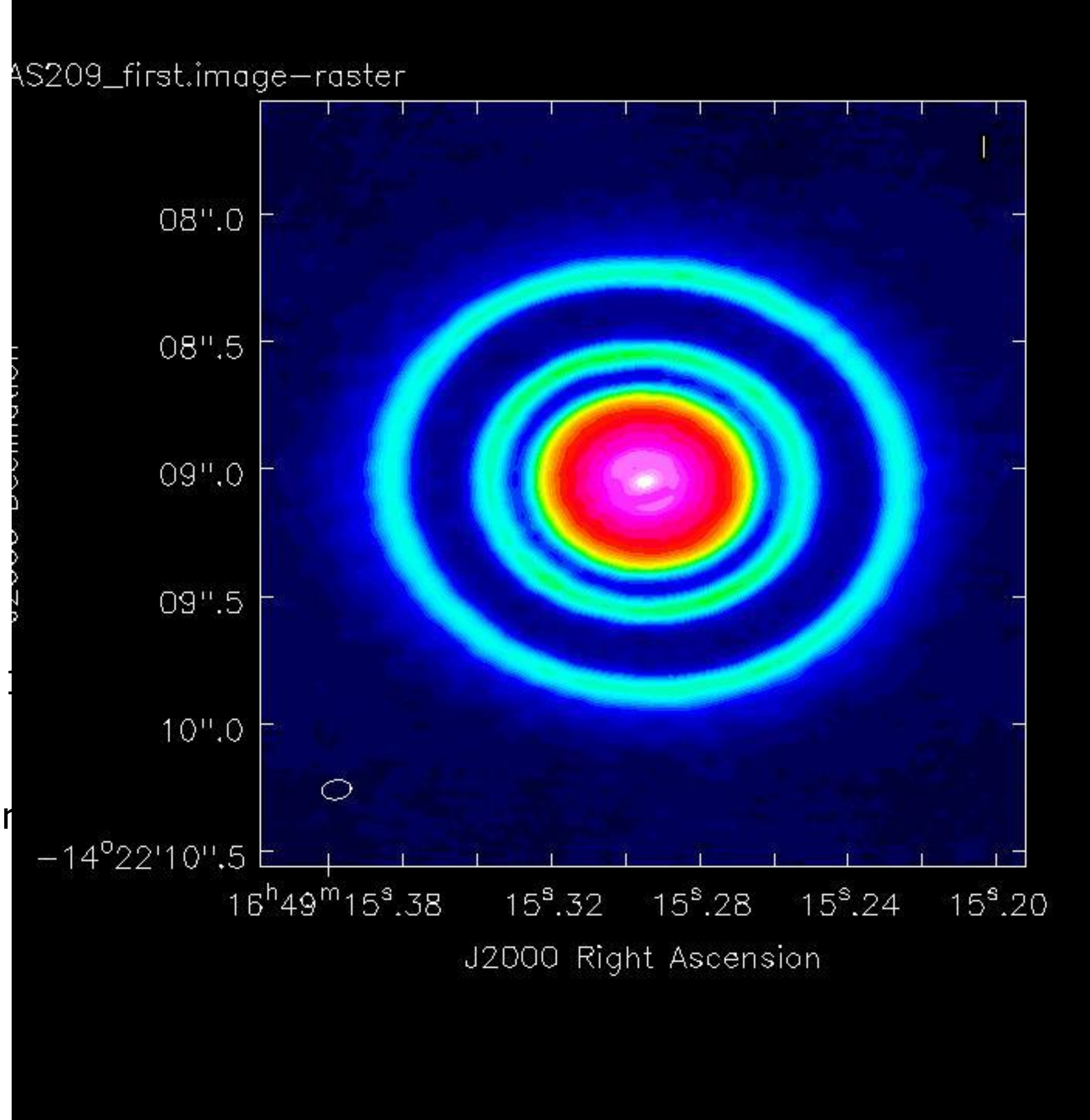
Presenter : Dong-Hyeok Koh

Spliting Observtions of **AS209**

We try this method giving more care about :

fine cleaning (iterations of 1000 -> 500 -> 200 -> 1
phasecal with solint=(inf - 300s - 200s)

But we can improve under the factor of 1.13, so far

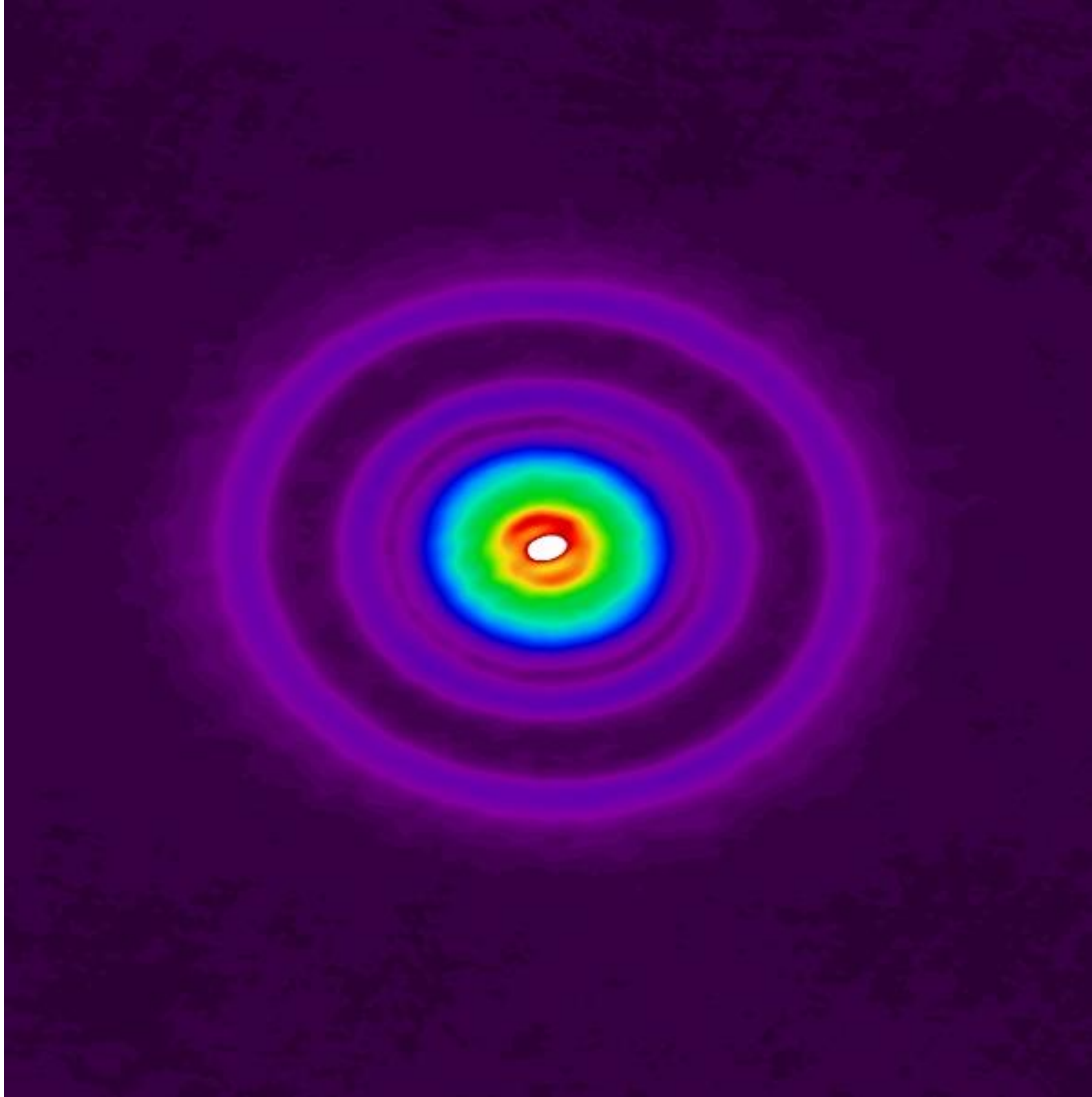


Final Image of **AS209**

We consider that it was really hard to apply the self-calibrations on the data which containing compact substructure.

We are expecting improvement b setting option, *minsnr=2* (but it still yet)

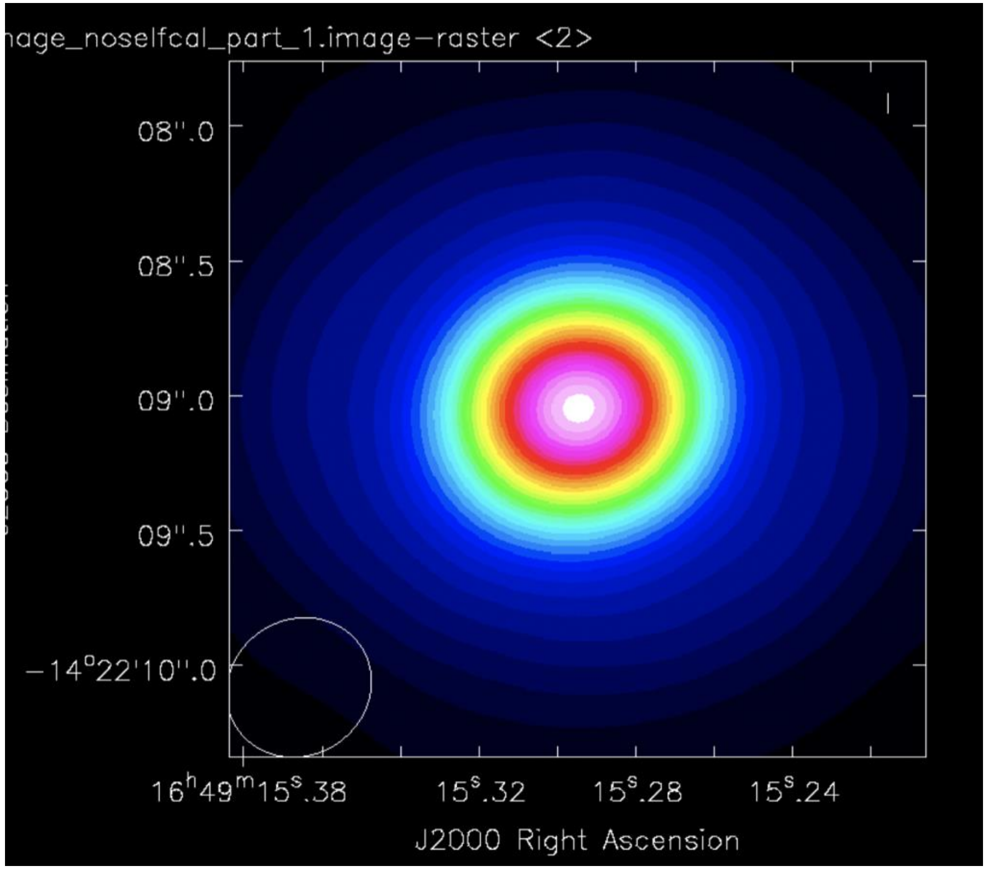
The SNR was improved factor of 1.13 by split method.



Self-calibrating dust continuum

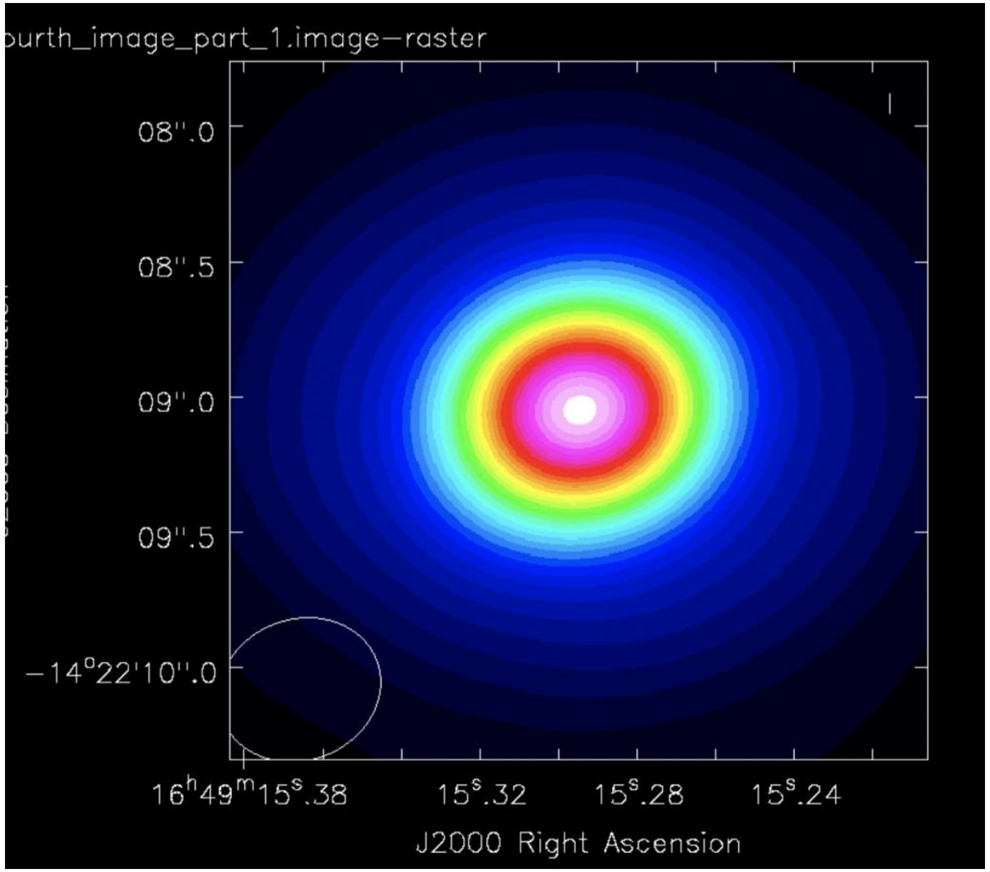
- ✤ I personally split the archival observations (from PIs: karinoberg and dfedele, hereafter Part-1) and current observations (from PI: sandrews, hereafter Part-2).

- ✤ The figure on the right shows the dust continuum map of Part-1 without self-calibration.



Self-calibrating dust continuum

- ✤ The figure is updated to show results after self-calibration of Part-1 data.
- ✤ I tried different self-calibrations techniques and setting but without significant improvement or gain.
- ✤ I note for AS209 archival observations in DSHARP data, I do not see any significant improvement.

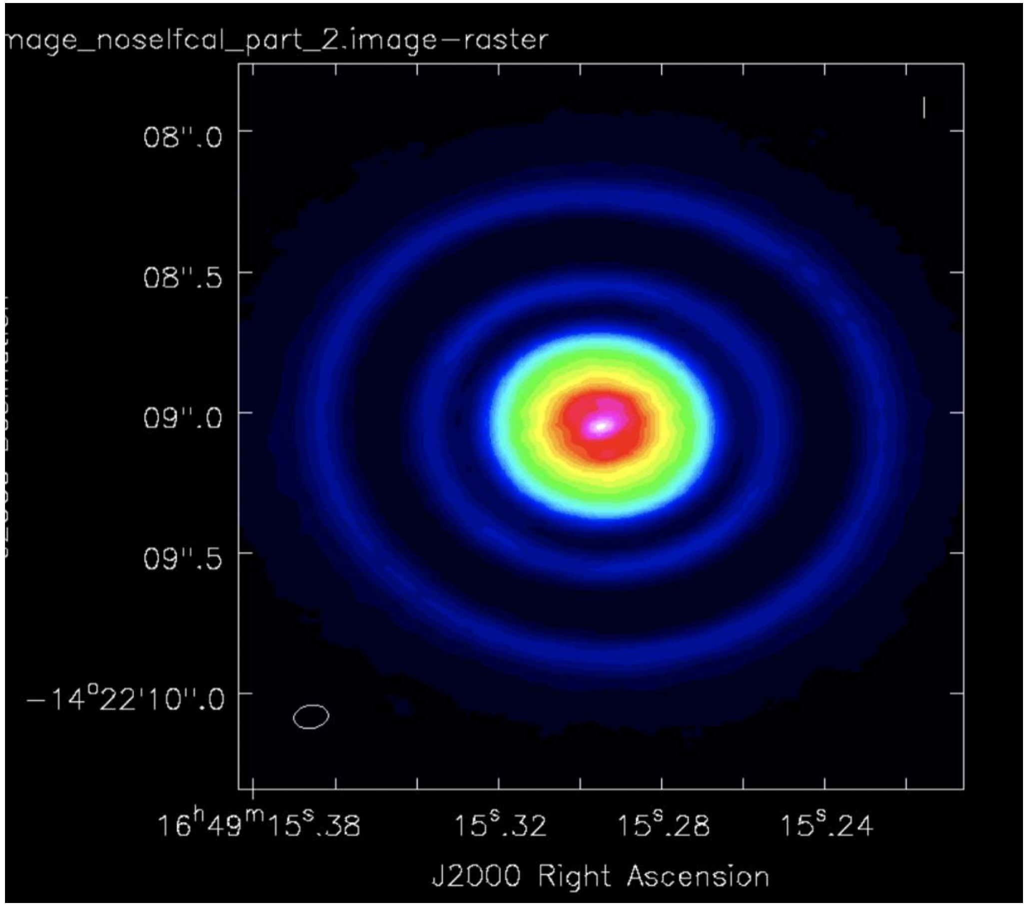


Self-calibrating dust continuum

✤ The figure on the right shows long baseline Part-2 data for AS209.

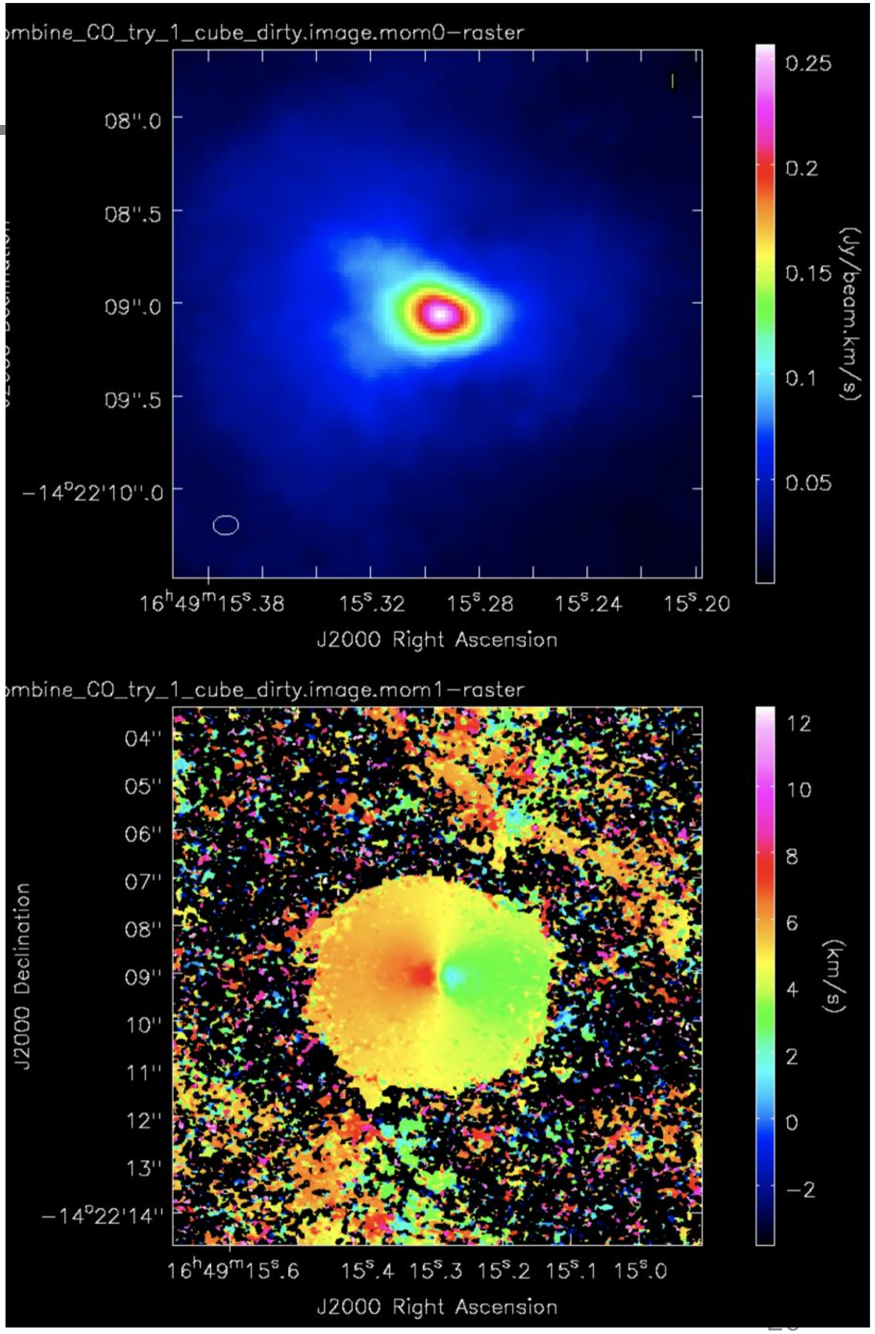
✤ The protoplanetary disk structure is clearly visible (compared to Part-1) because of angular resolution.

✤ I tried self-calibration on Part-2 data but I find that while the gain increases significantly, but we lose structure information.



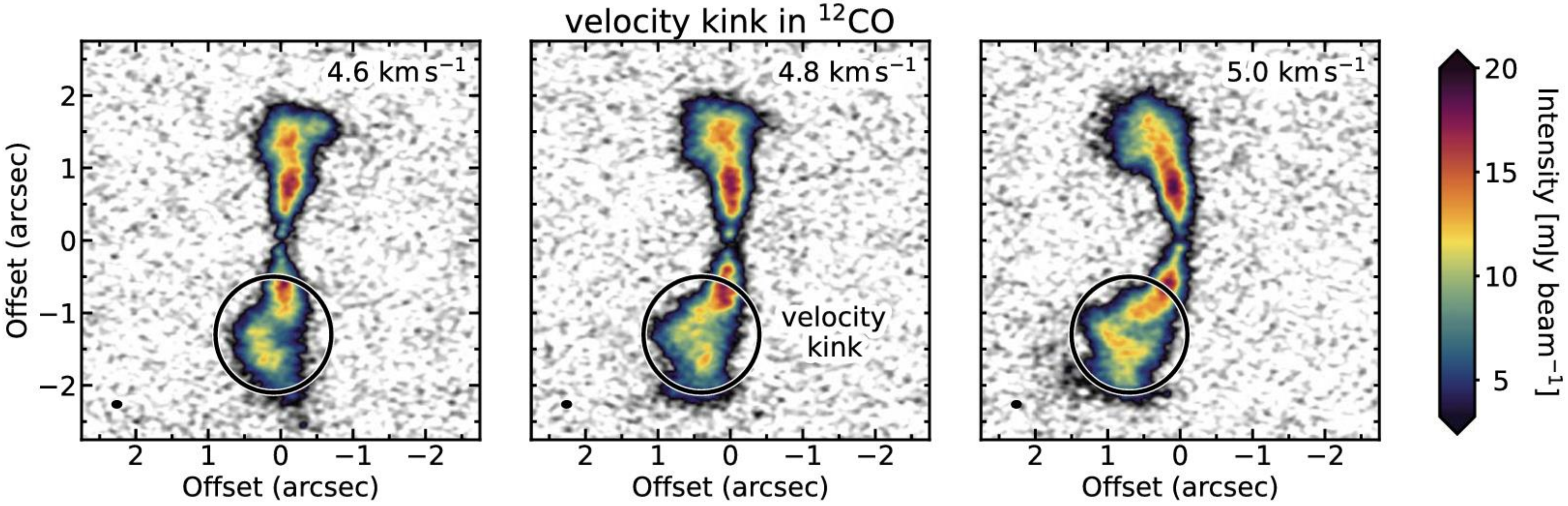
Making a ^{12}CO map for AS 209

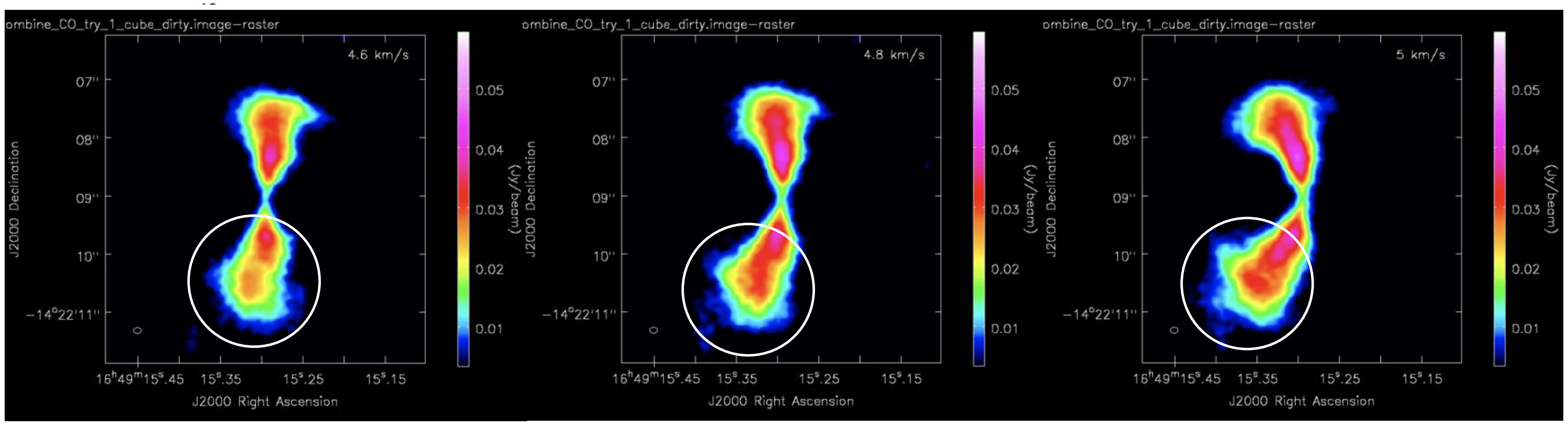
- ✤ We obtain 12CO (J=2->1) spectral observations of AS209 from DSHARP as well as MAPS large ALMA programs.
- ✤ We use the observations to test the effects of image concatenation and deconvolution on combined images.
- ✤ We show here the moment-0 and moment-1 maps for 12CO (J=2->1) observations from the combined dataset.
- ✤ Unfortunately, due to the long cleaning time required for data cubes, we could not produce individual maps from the MAPS survey for comparison.



Making a ^{12}CO map for AS 209

- We did manage to compare our velocity map with Bae et al. 2022. We note that we do see the kink even in our dirty map.

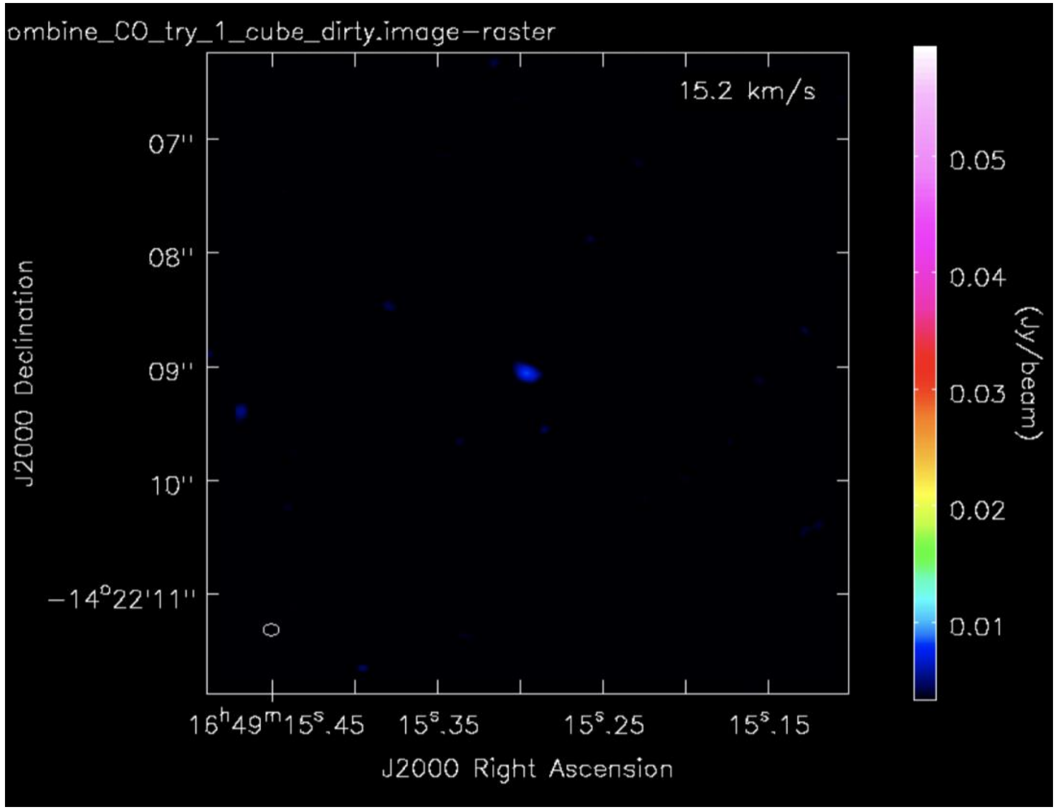




Making a ^{12}CO map for AS 209

- We report a faint 6- detection of a line centered at 230.526GHz.

  Need to explore further. Any guesses?



Main Project Summary

- ✤ We learned about the effects of self-calibration on ALMA continuum data and spectral cube.
- ✤ The AS209 protoplanetary disk data is good for practicing self-calibration on both dust continuum maps and spectral line observations.
- ✤ Self-calibration did not impact the SNR of short baseline observations, while it was not required for long-baseline observations.
- ✤ We show 12CO (J=2->1) velocity maps consistent with Bae et al. 2022.
- ✤ We would like to compare other spectral data with Bae et al. 2022. Since the cleaning process takes a painfully long time, we could not finish our analysis on time.

Thank you

This team would like to extend its gratitude to all the ALMA Summer School organizing committee.

And special thanks to Dr. Aran Lyo for helping us all the way through.