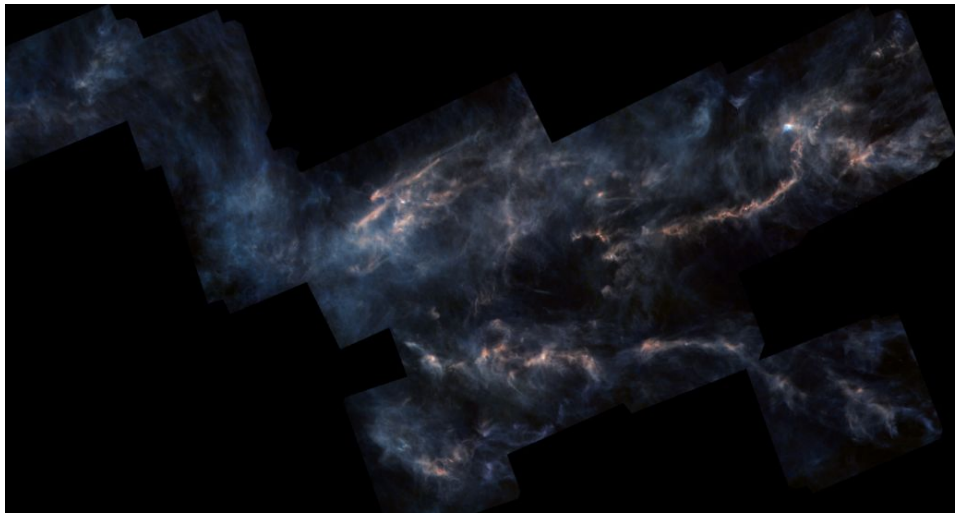
Mosaicking and Total Power
(EA ALMA Data Analysis Workshop 2024)

Members: Tae Keon Kim, Jyun-Heng Lin, Piyali Saha, Suphakorn Suphapolthaworn, Himanshu Tyagi

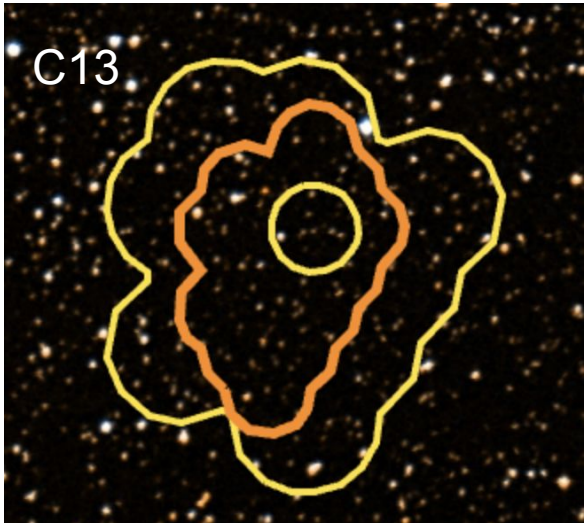
Why Mosaicking is required??

To study the extended targets…such as molecular clouds, galaxies etc.

M100



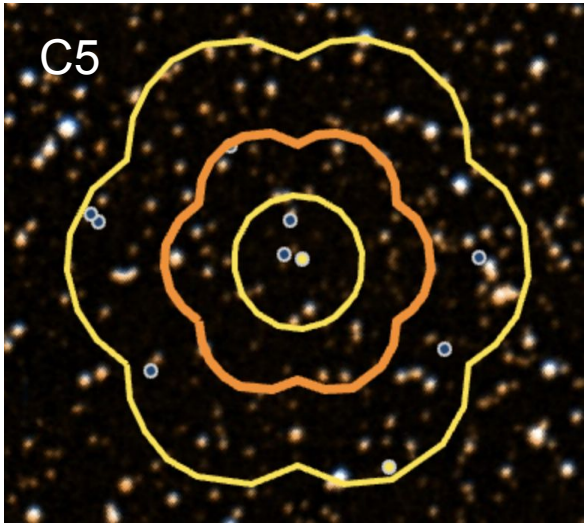
Taurus

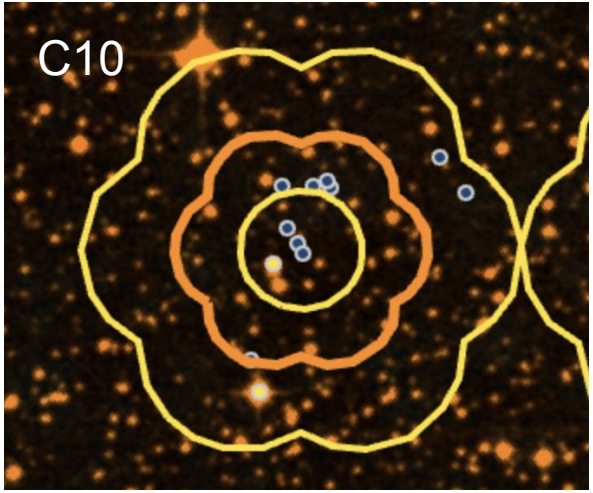


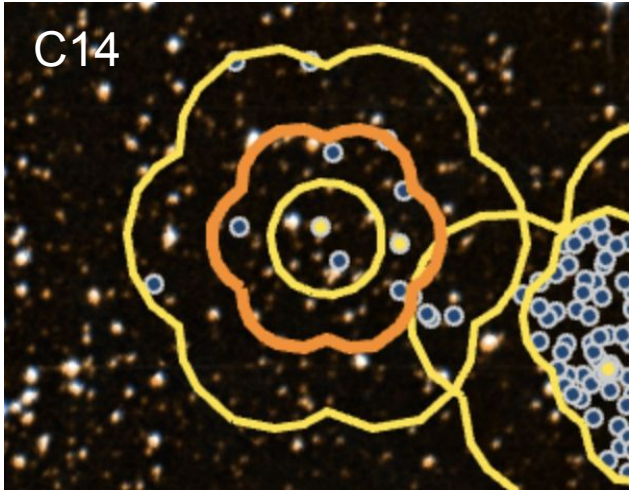
Data: ALMA Archive data

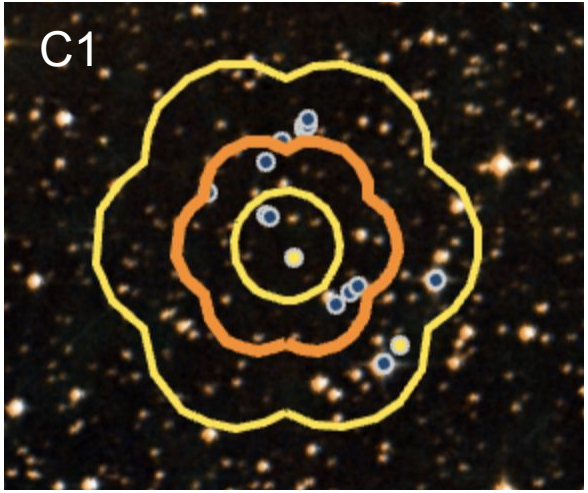
PI: Peretto, Nicolas

Frequency: Band 3, 90.62 GHz



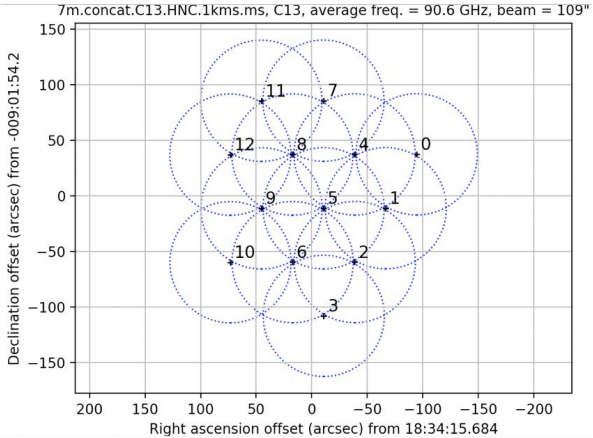




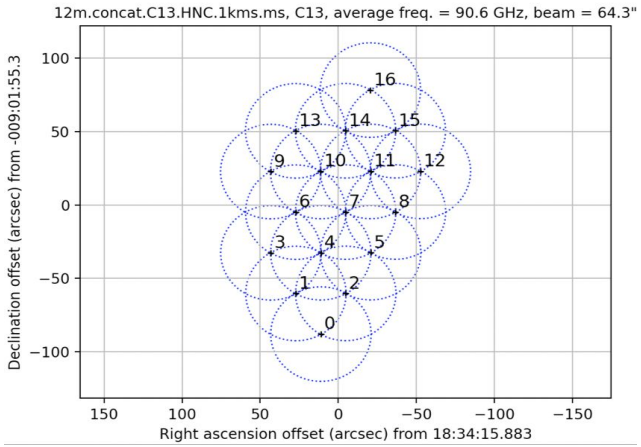


C13

7m

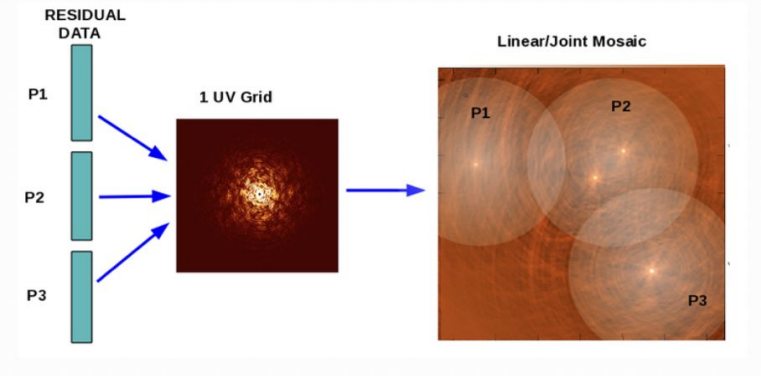


12m



Mosaics are done following Nyquist criteria to have a uniform noise

Joint mosaic——>



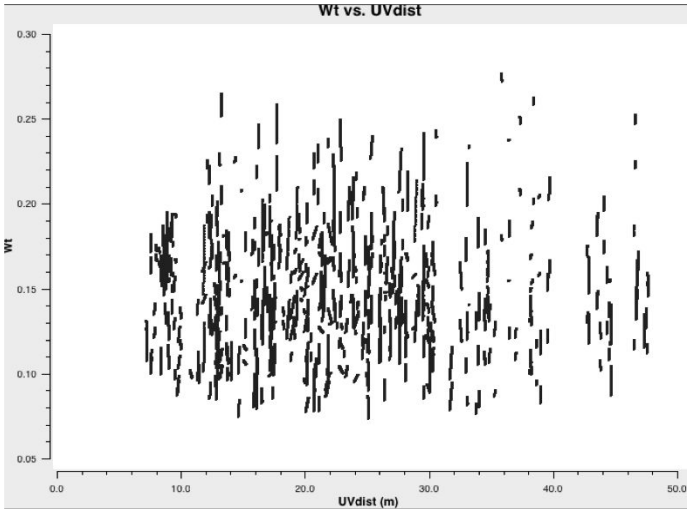
Combining the 12-m and 7-m images using casatask—> ‘concat’

Check the weights and concatenate the data

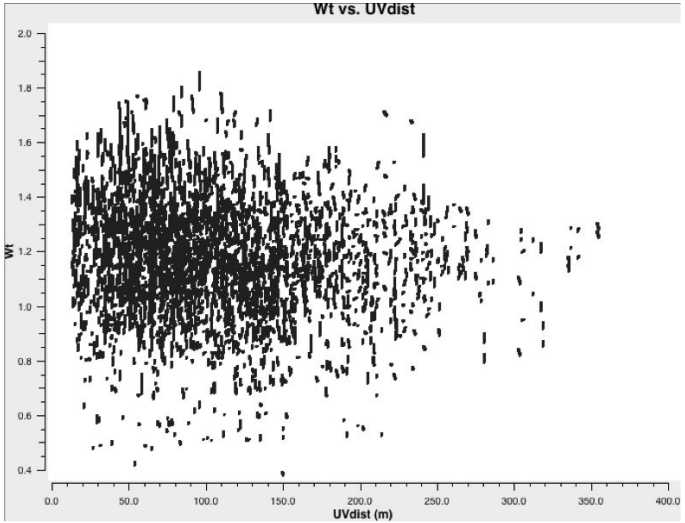
Weight—>proportional to 1/sigma^2

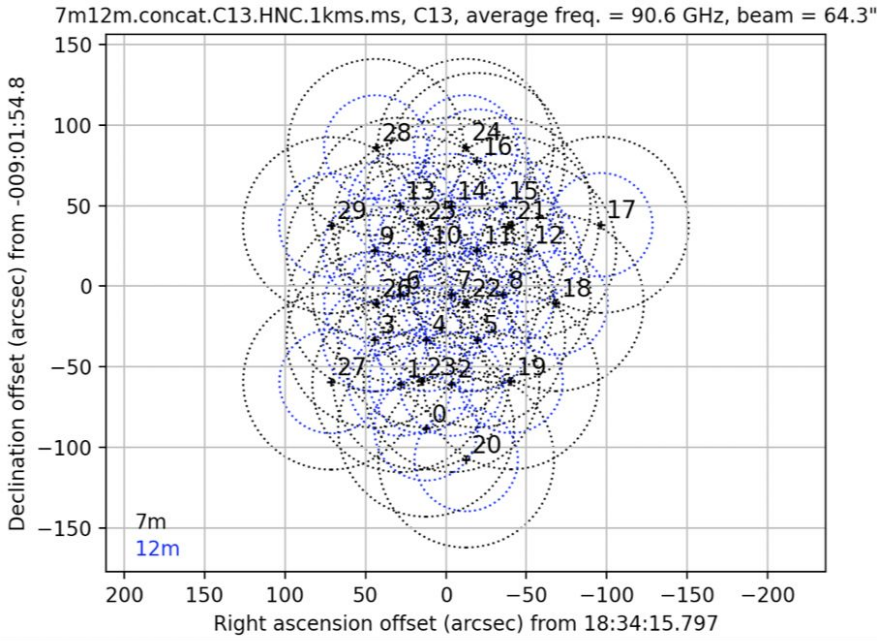
$$\sigma_{ij}(Jy) = \frac{2k}{\eta_q \eta_c A_{eff}} \sqrt{\frac{T_{sys,i} T_{sys,j}}{2\Delta\nu_{ch} t_{ij}}} \times 10^{26},$$

7m

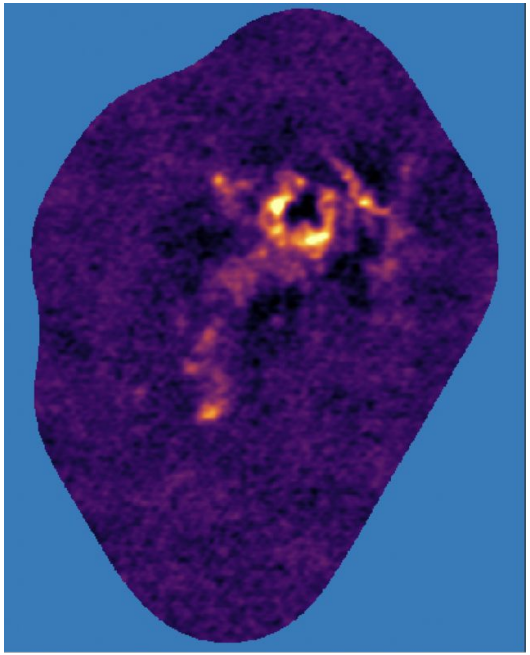


12m



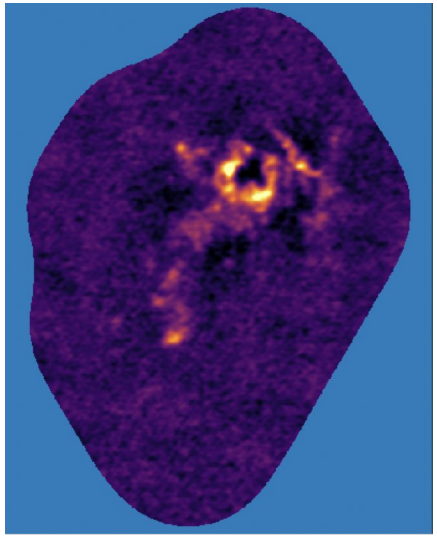


Combined 12-m and 7-m mosaic



Cube @ 60 km/s

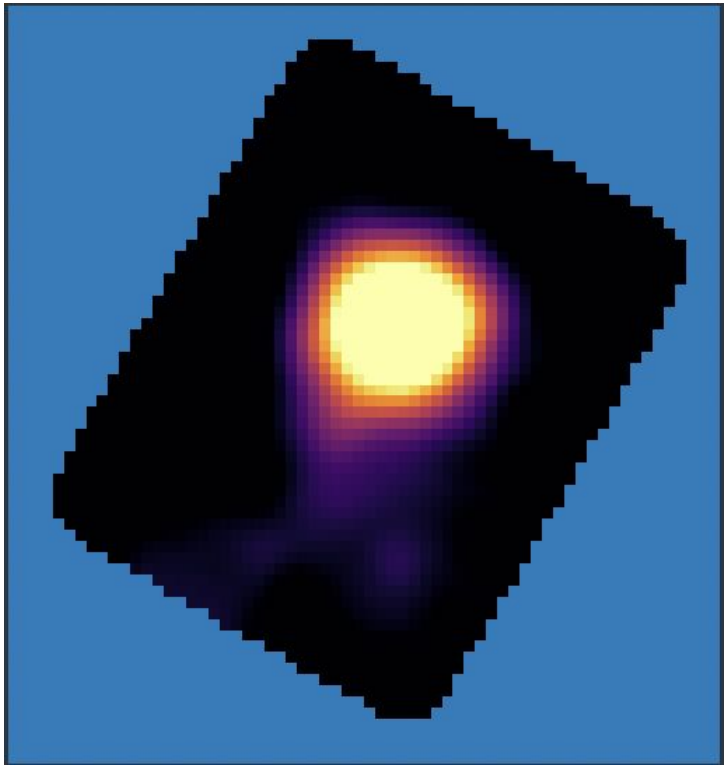
Missing flux from large-scale



12m+7m image (3.5”X2.6”)

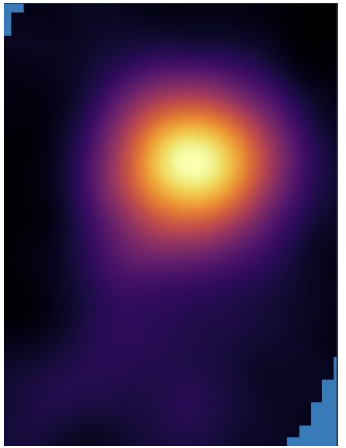
casatask
‘imregrid’

+

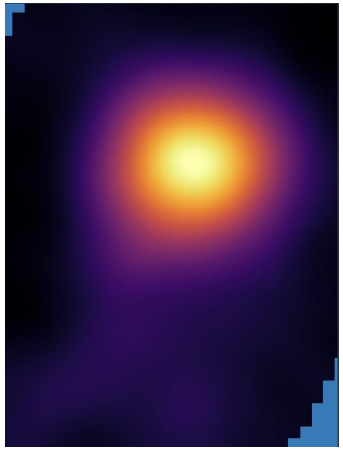


Total power image (71”X71”)

=



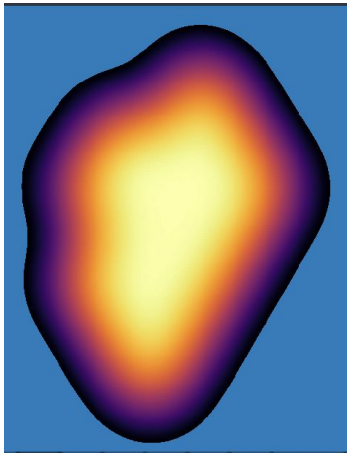
Regridded image (TP)



Regridded image (TP)

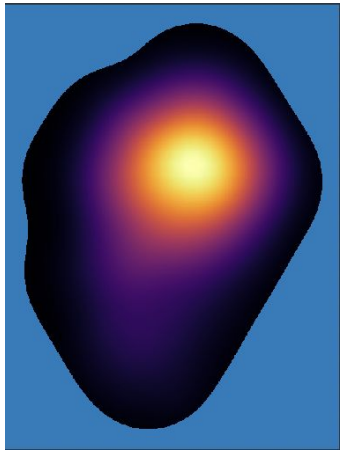
×

casatask
‘immath’



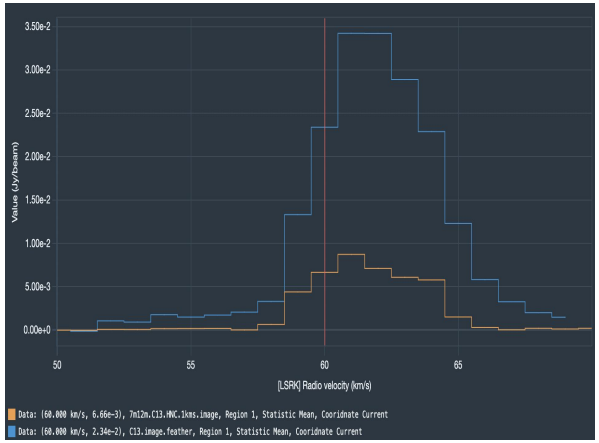
primary beam response (12m+7m)

=



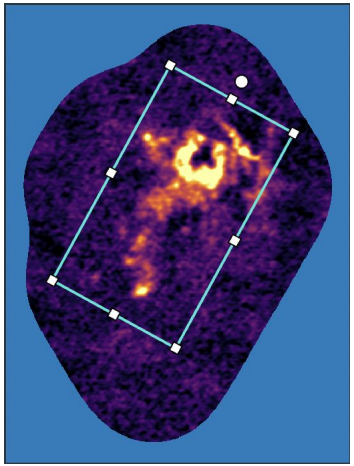
+

casatask
‘feather’

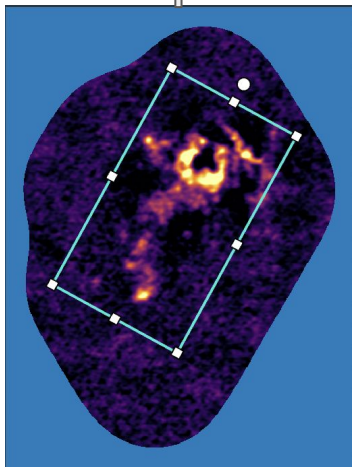


Comparison of the flux before and after feathering

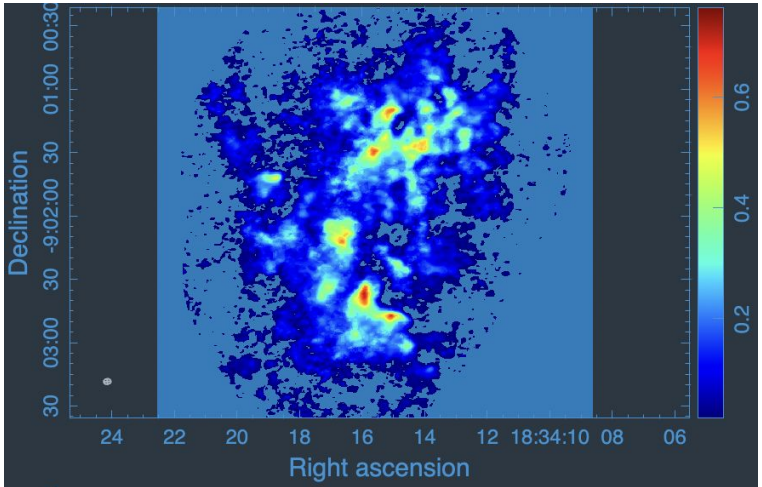
=



Feathered image

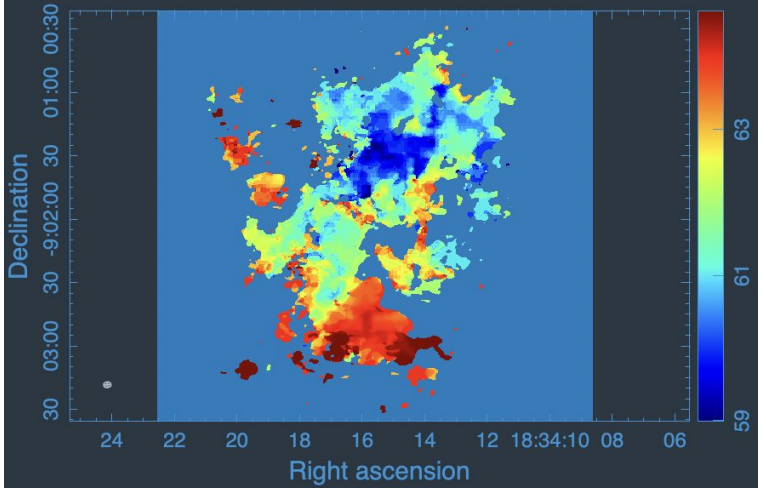


12m+7m mosaic



← Moment 0 map

Casatask→immoment



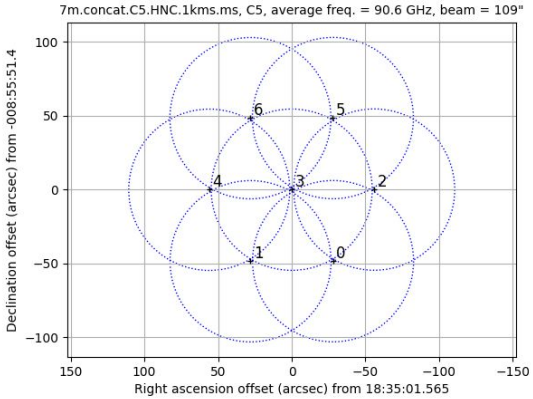
← Moment 1 map

Exercise: C5 & C10

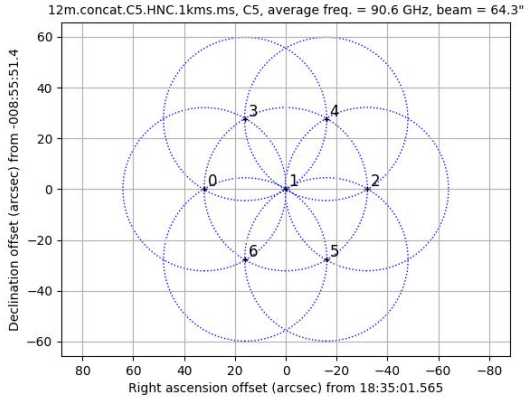
C 5

FOV of Mosaic

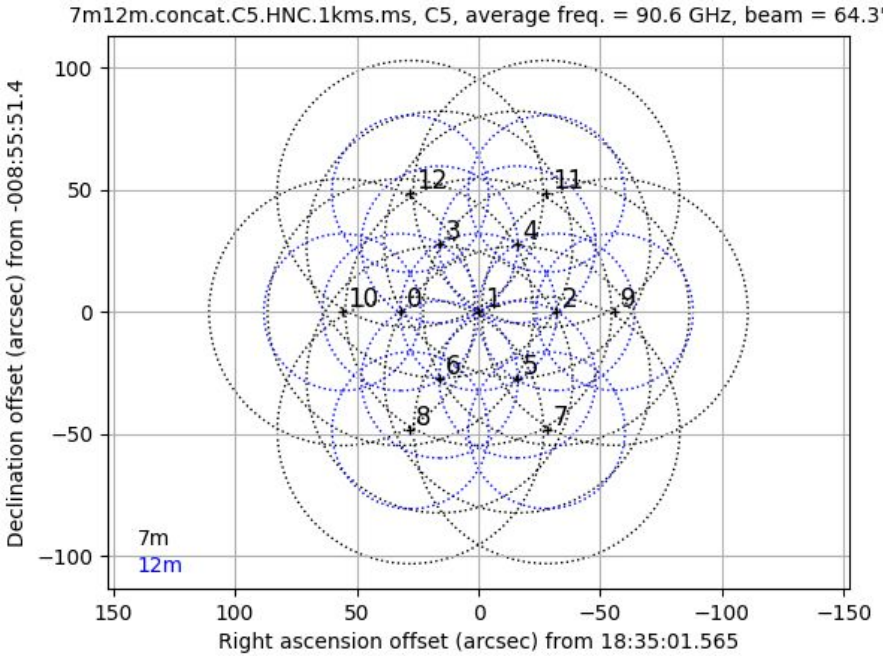
7-m



12-m



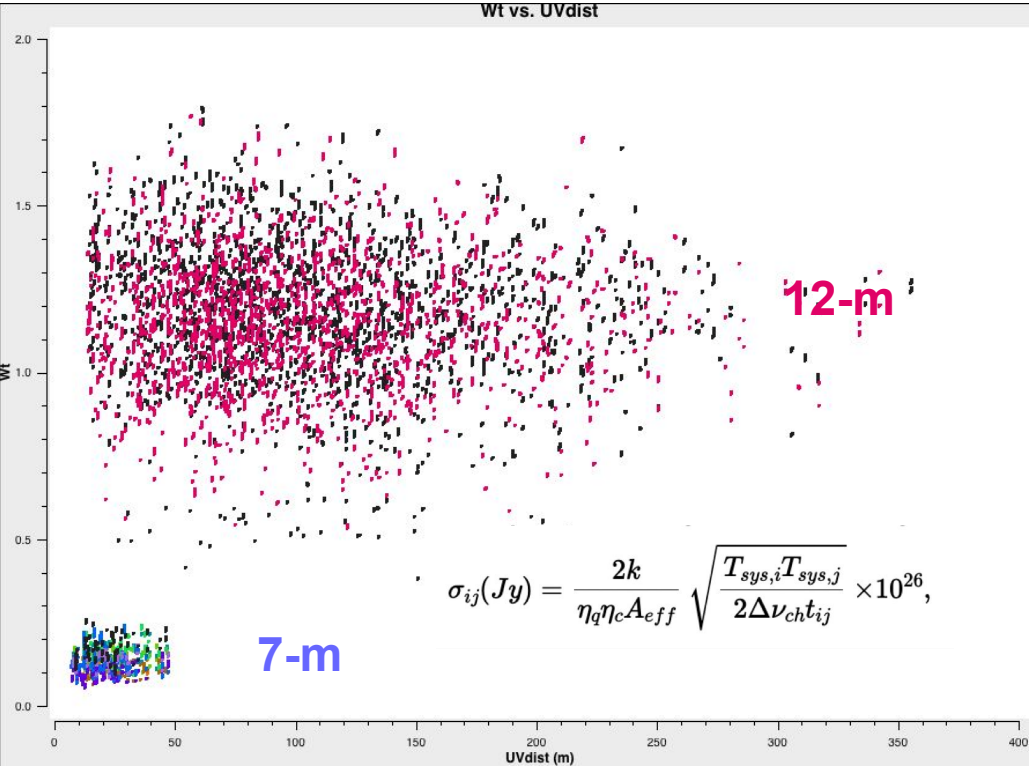
FOV of Concatenated Mosaic



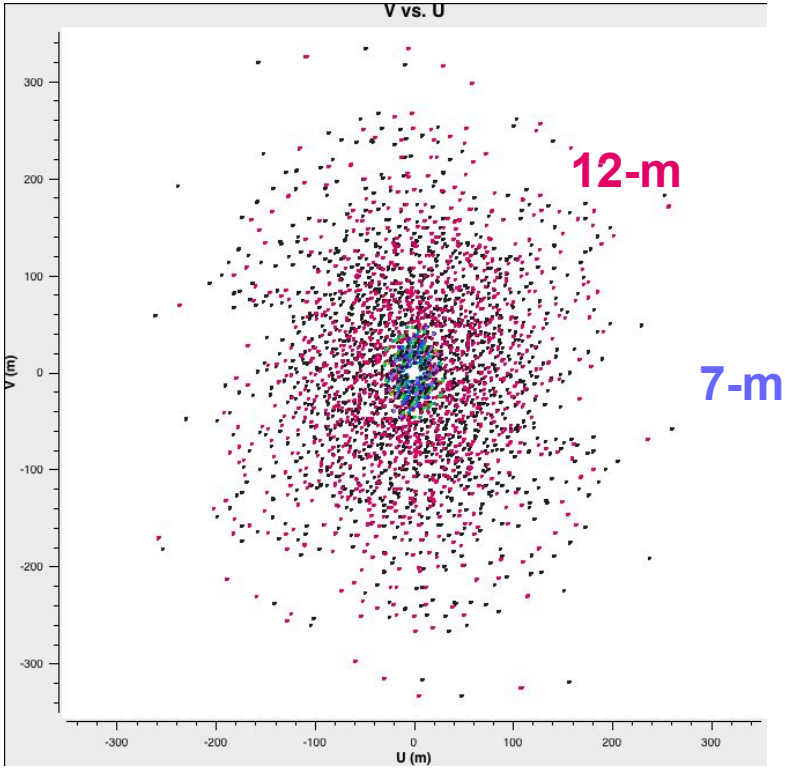
7m12m

C 5

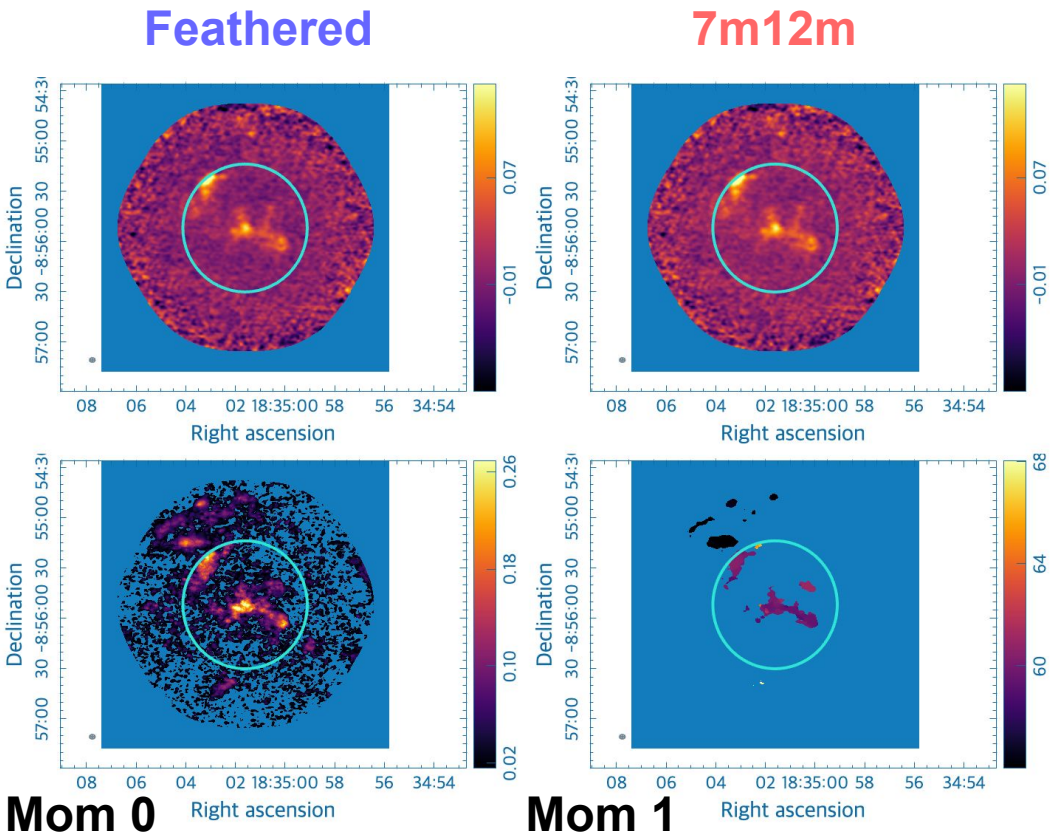
Weight vs UV distance

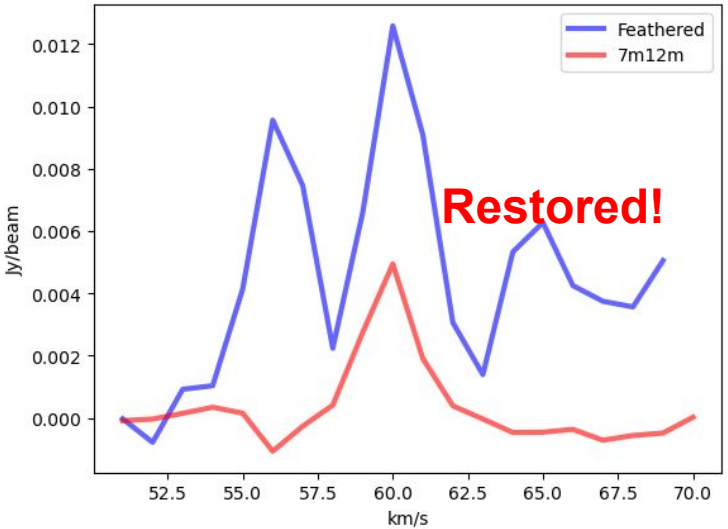


UV Coverage



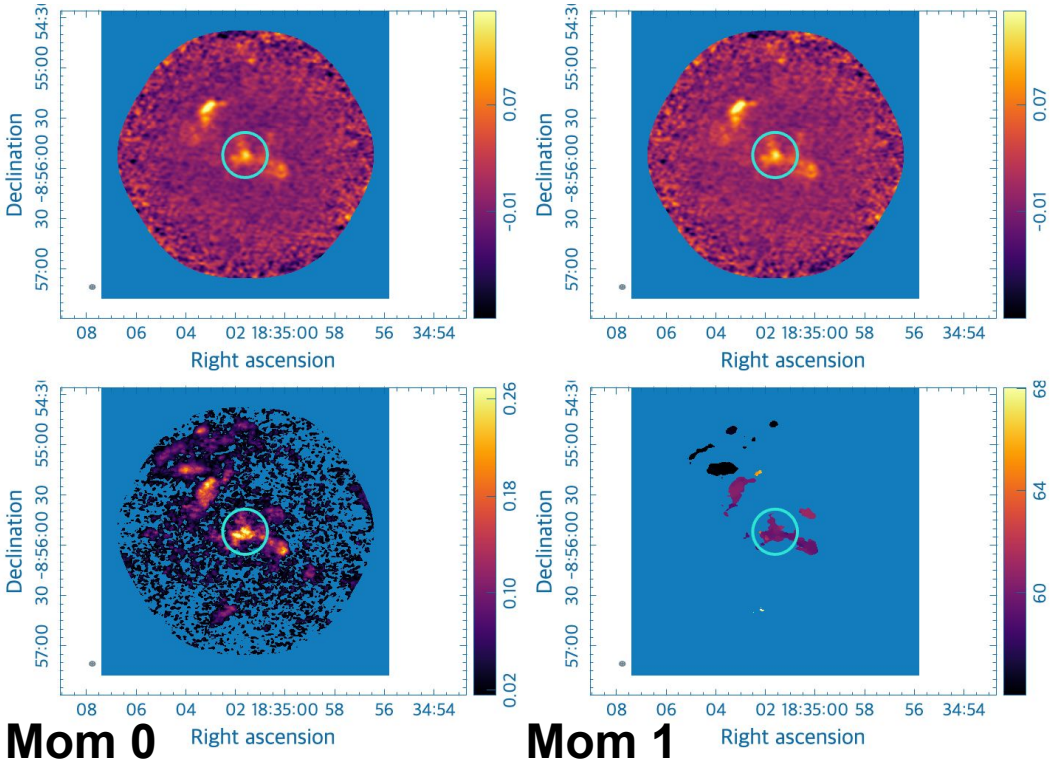
C 5


Feathered
7m12m
Declination
Right ascension
Mom 0
Mom 1

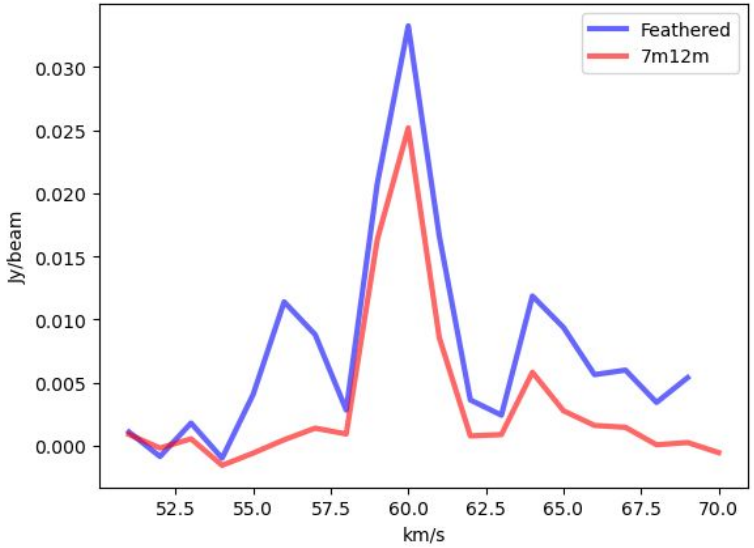

Feathered
7m12m
Restored!
Jy/beam
km/s

C 5

Feathered **7m12m**

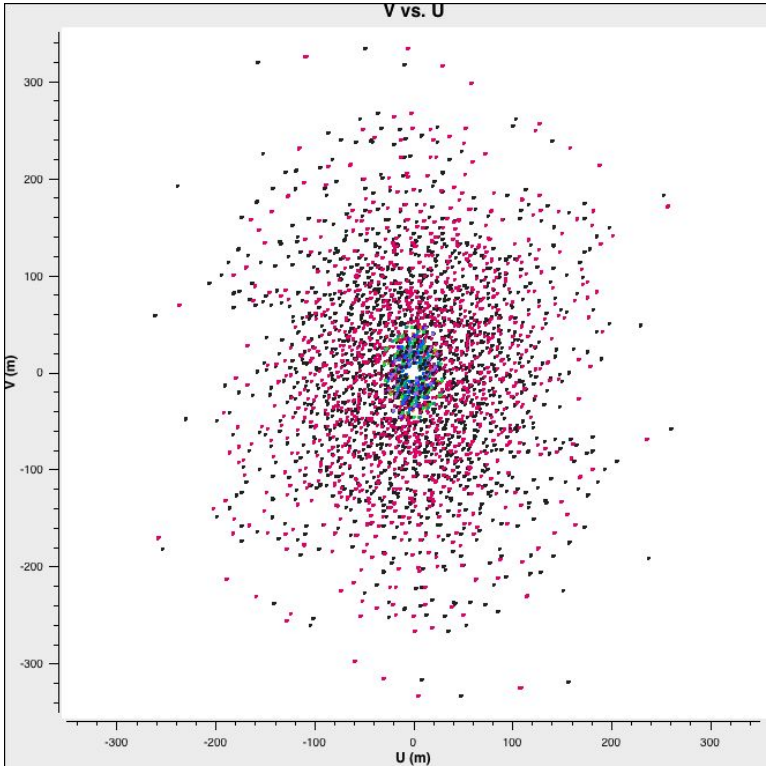


Sensitivity of **compact source** is **not much restored** with combining total power

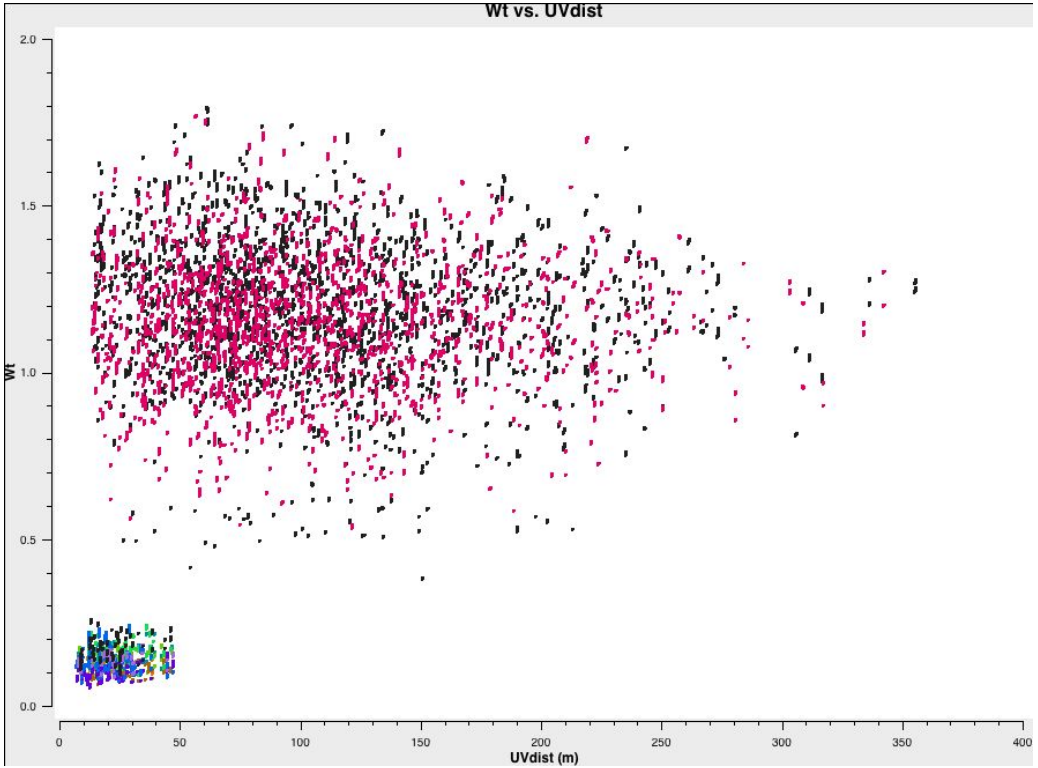


C10

UV plane



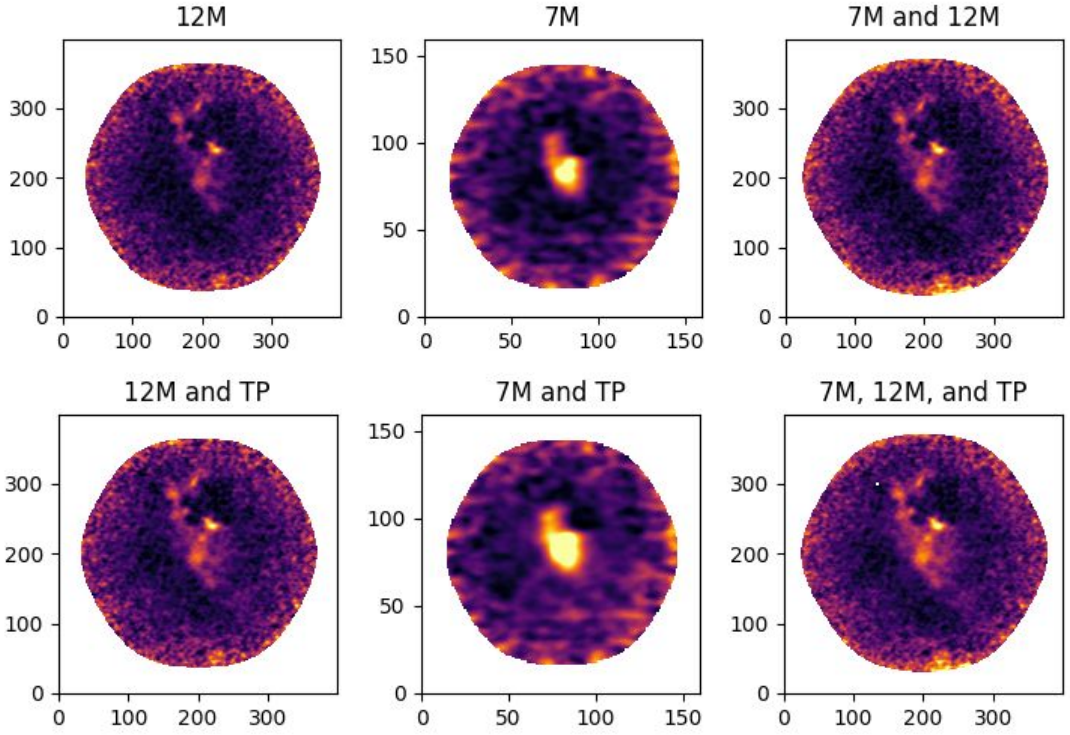
Wt v.s. UVdist



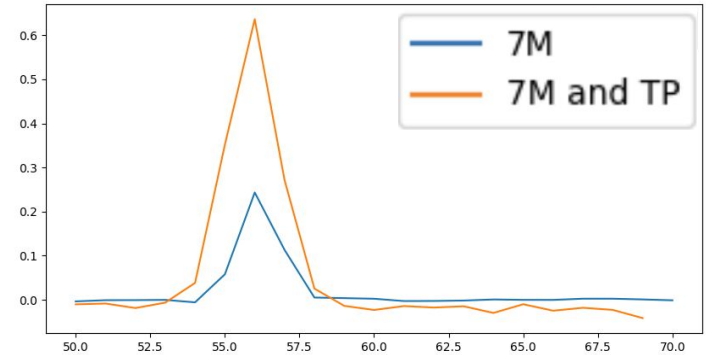
C10

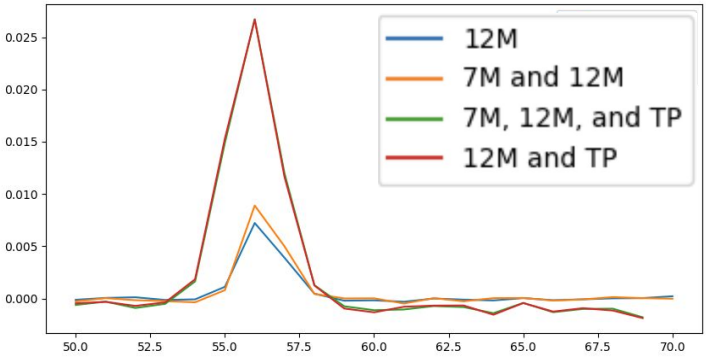
- Since there are no extended structure, it didn't change a lot when adding 7M data.

moment 0



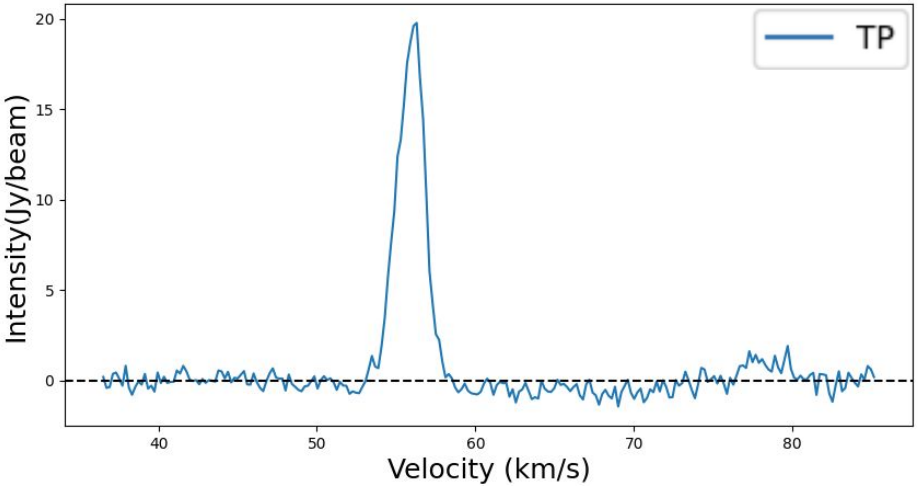
Combination data spectra





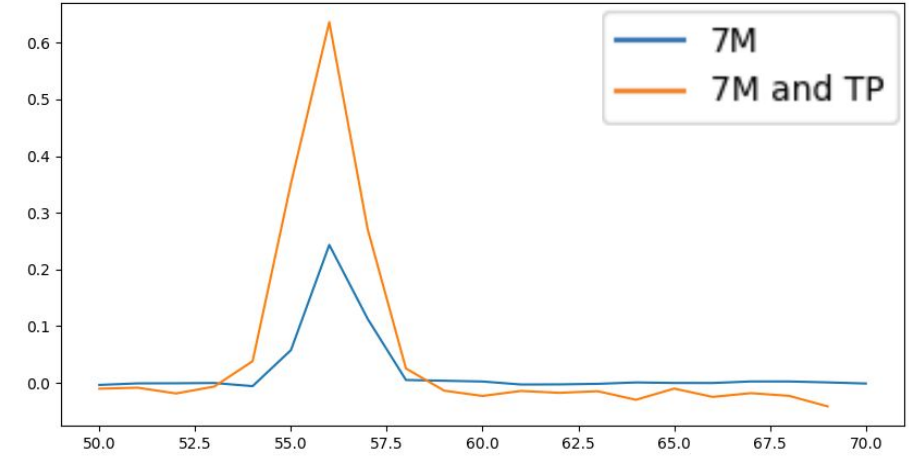
C10

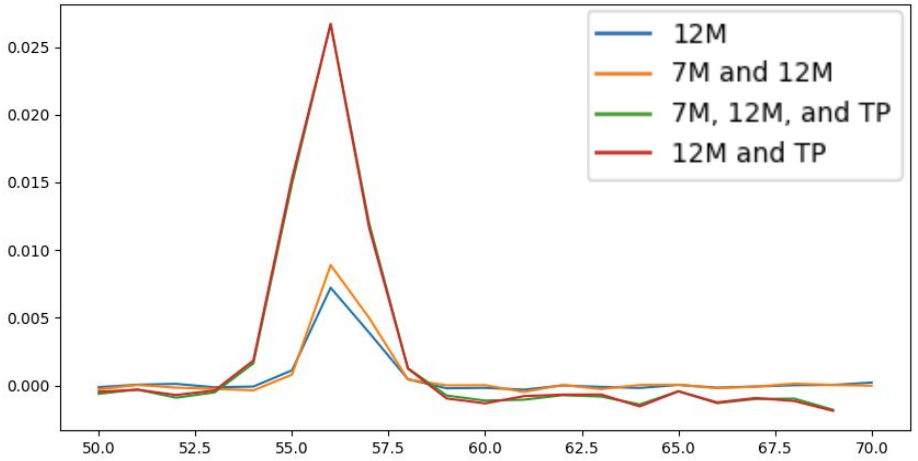
TP spectra



The baseline of TP data has been **over subtracted** in ALMA pipeline, so there are some negative value in around 60~75 km/s.

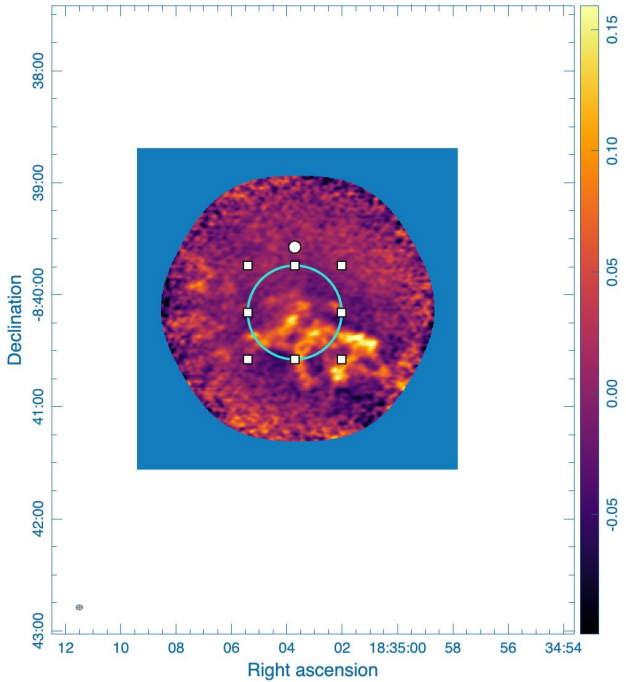
Combination data spectra

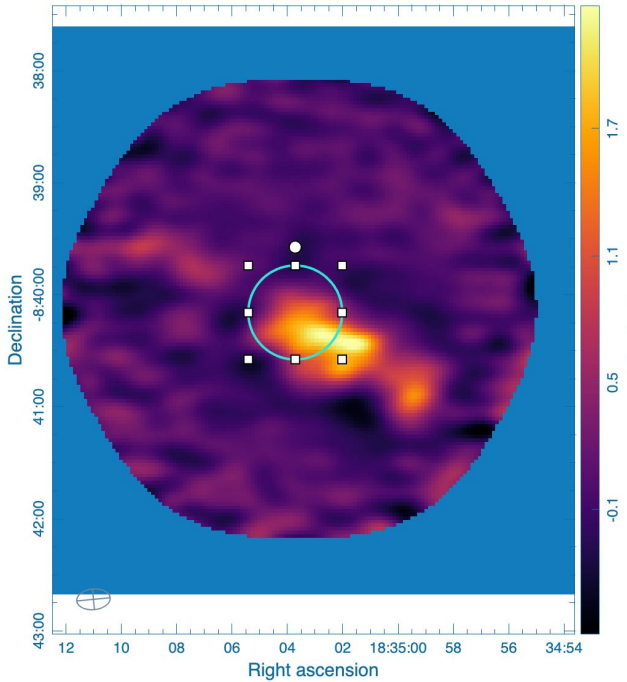


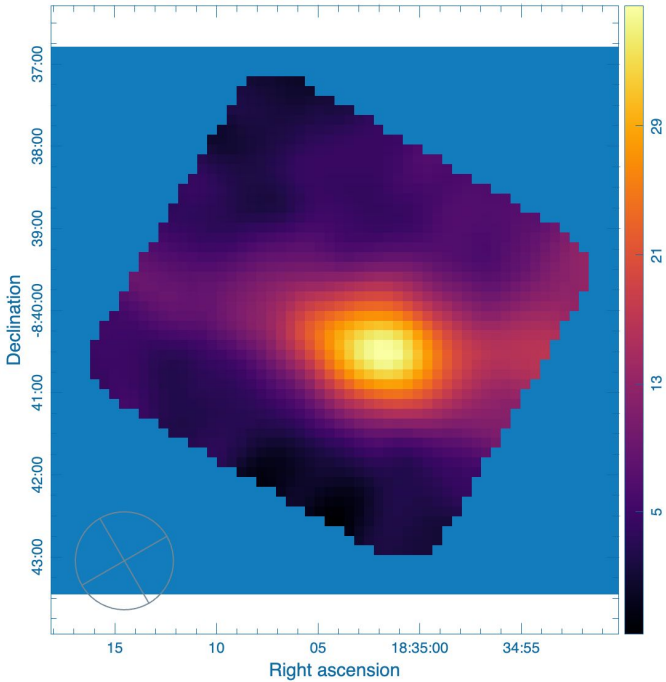


Effects of Tweaking the Parameters Using C14 and C1

12m vs 7m vs TP

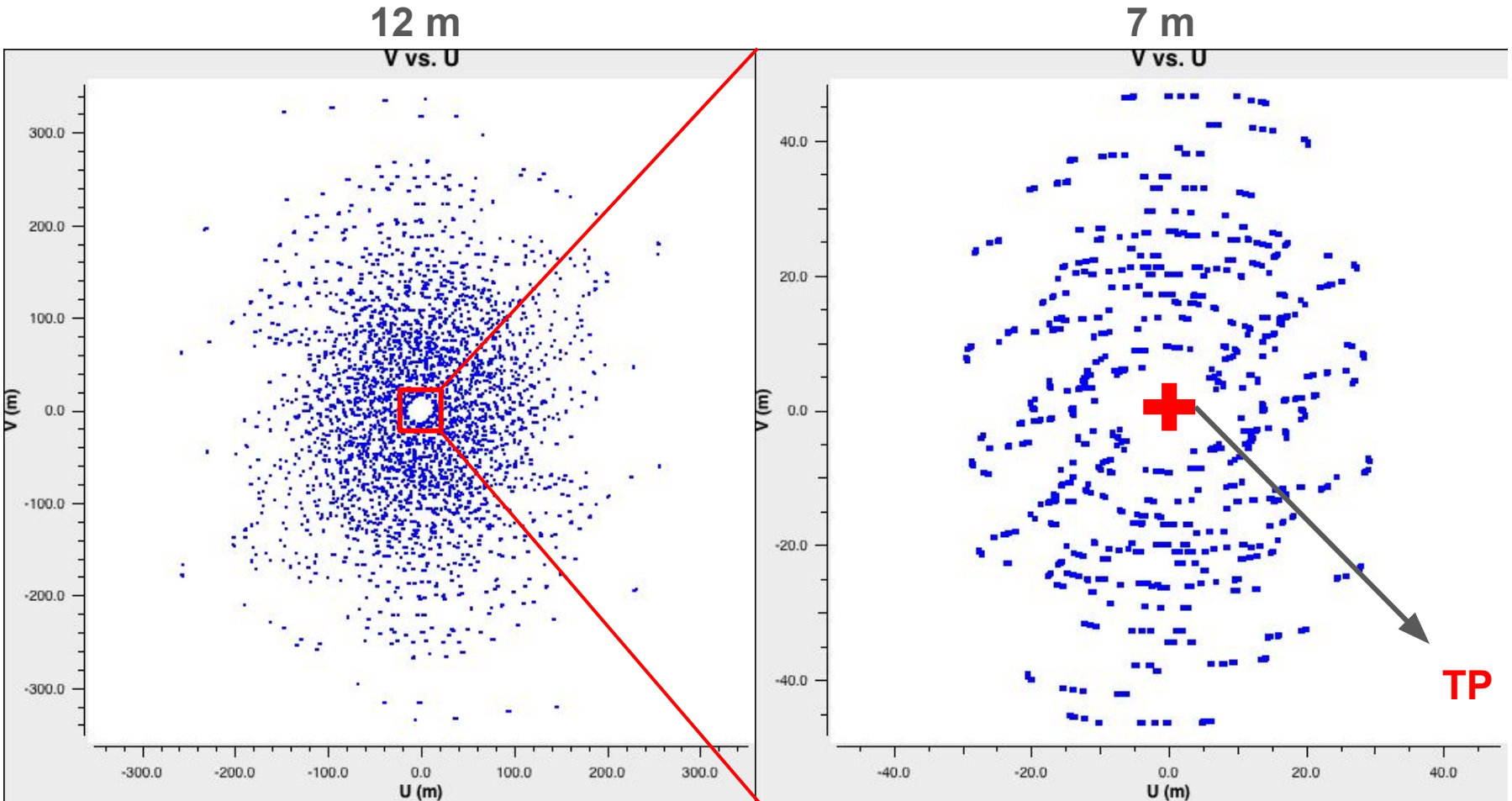






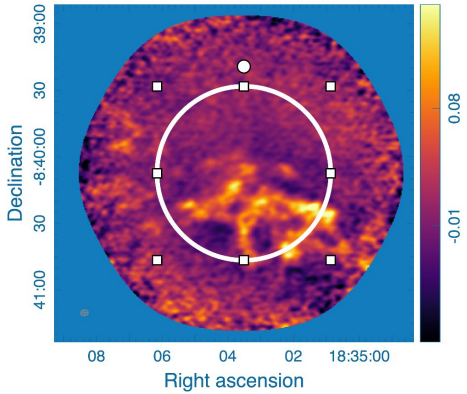
Missing Flux!

How 7m and TP can help in flux recovery?

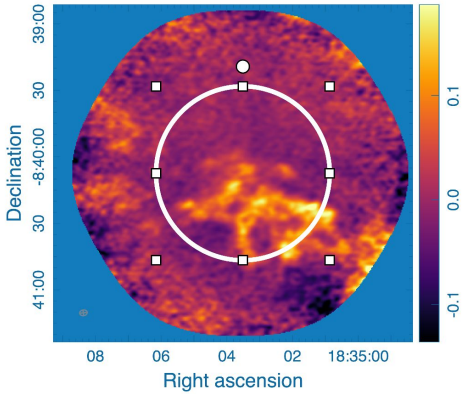


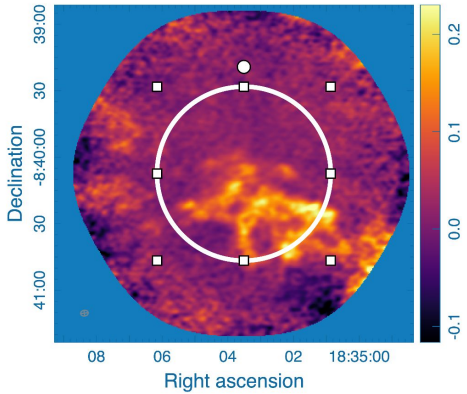
Combining 12m+7m+TP retrieves the missing flux

12 m

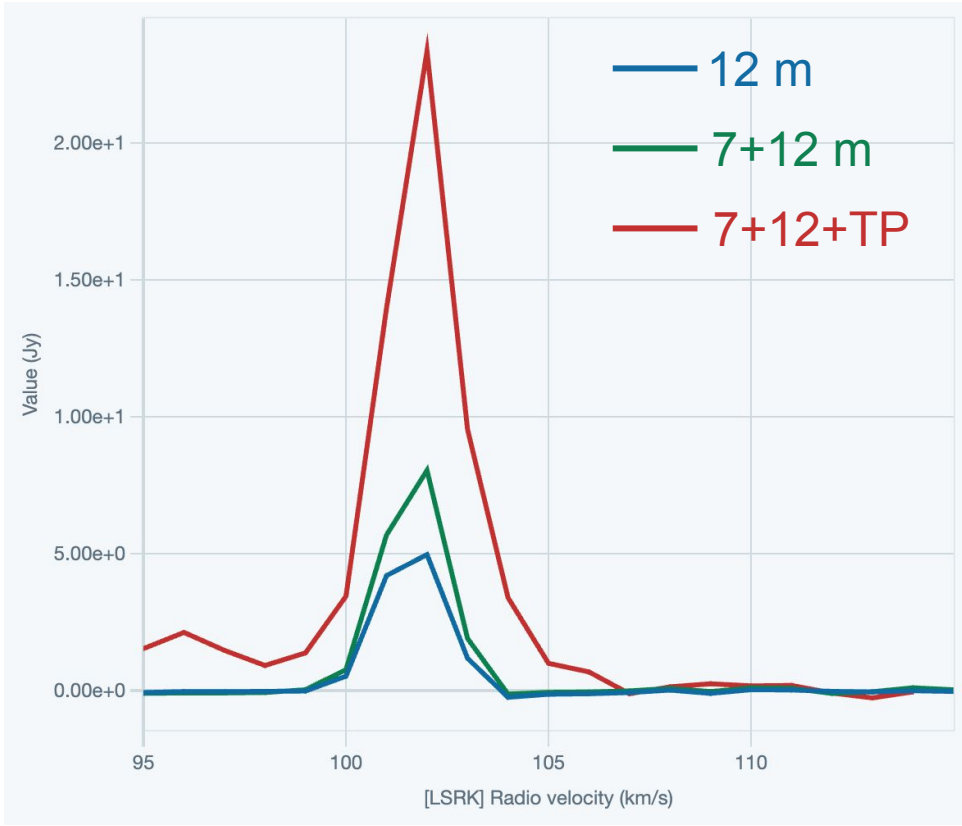


7+12 m





7+12+TP

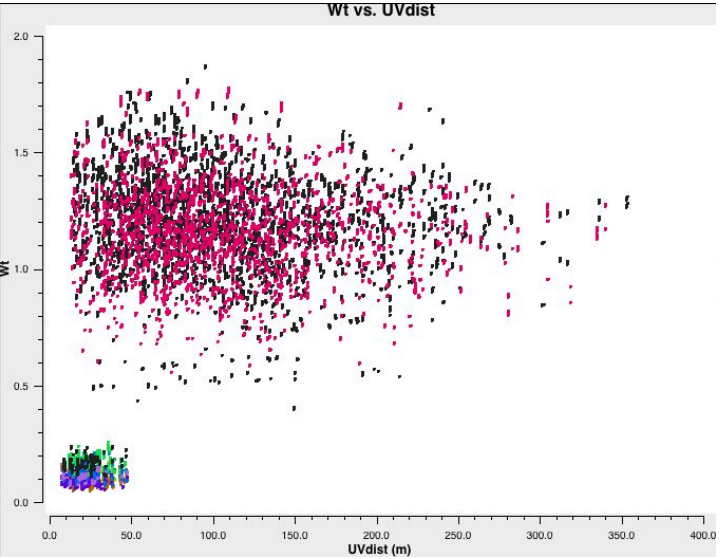


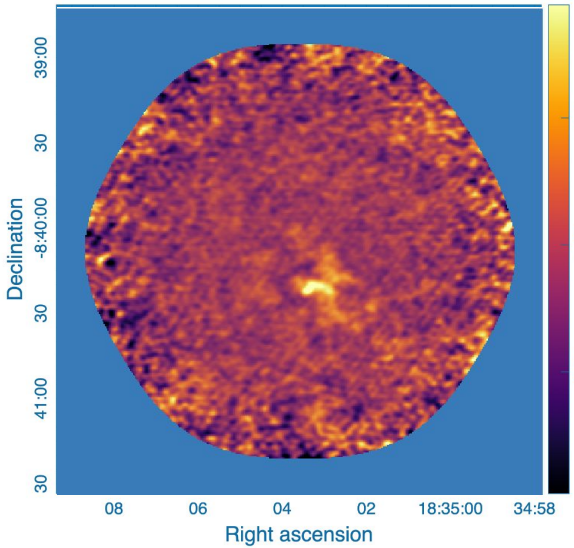
Effects of weighting proportion

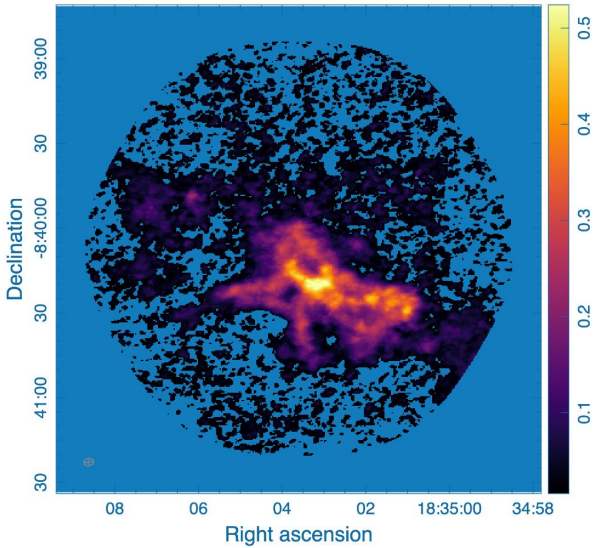
$$\sigma_{ij}(Jy) = \frac{2k}{\eta_q \eta_c A_{eff}} \sqrt{\frac{T_{sys,i} T_{sys,j}}{2\Delta\nu_{ch} t_{ij}}} \times 10^{26}$$

$$\frac{1}{\sigma^2} \Longrightarrow \frac{7m}{12m} = \frac{7^4}{12^4} \times \frac{t_{int,7}}{t_{int,12}}$$

Weighting in correct proportion



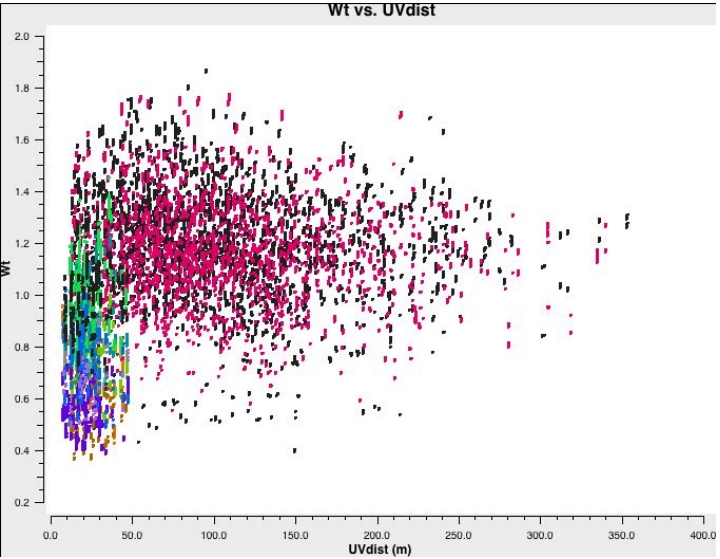


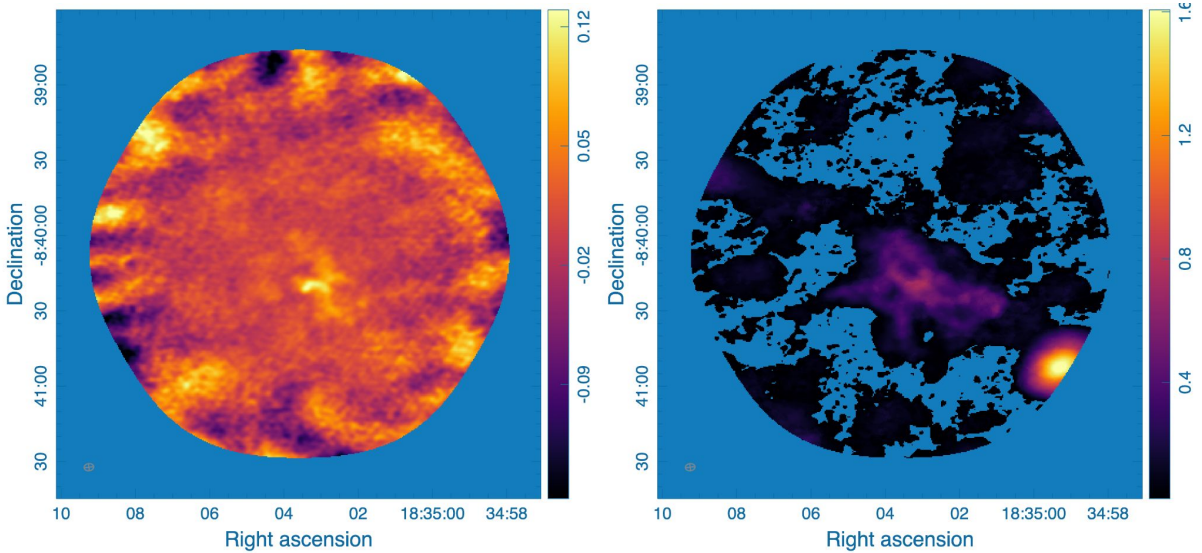


rms (Jy/beam) in a channel = 0.0075

Restoring beam = 3.45575" X 2.5596"

Effects of increasing 7m weight

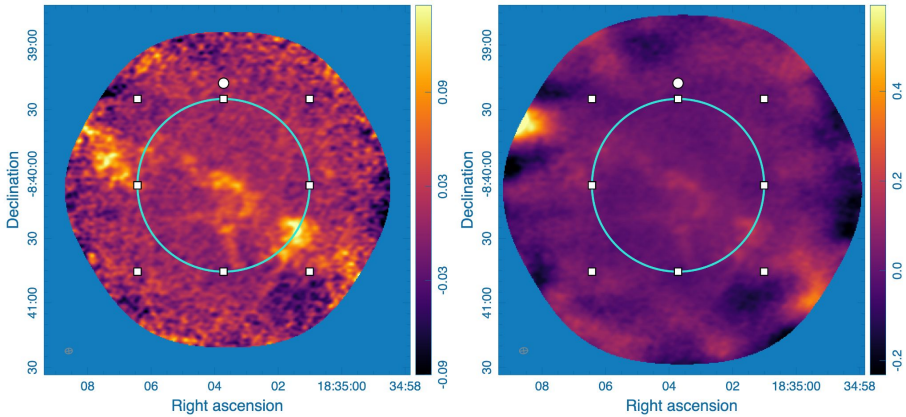




rms (Jy/beam) in a channel = 0.0110

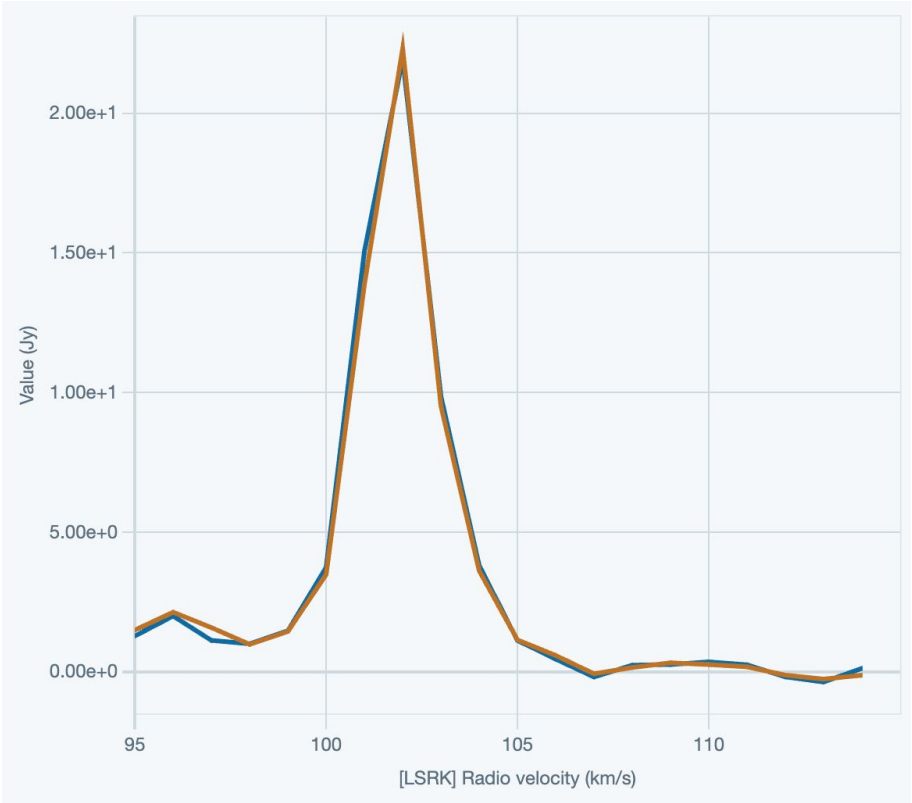
Restoring beam = 3.84613" X 2.83431"

Effects of increasing 7m weight on Spectrum



Correct Weighting

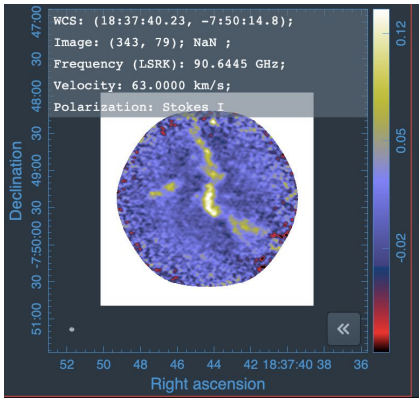
Increased Weighting



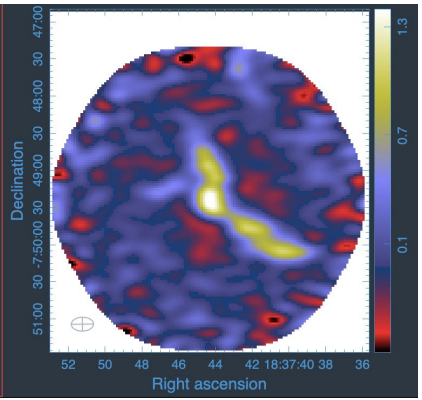
*source: C1

Combined effects of increased 7m weight + improper image size

12m-only mosaic

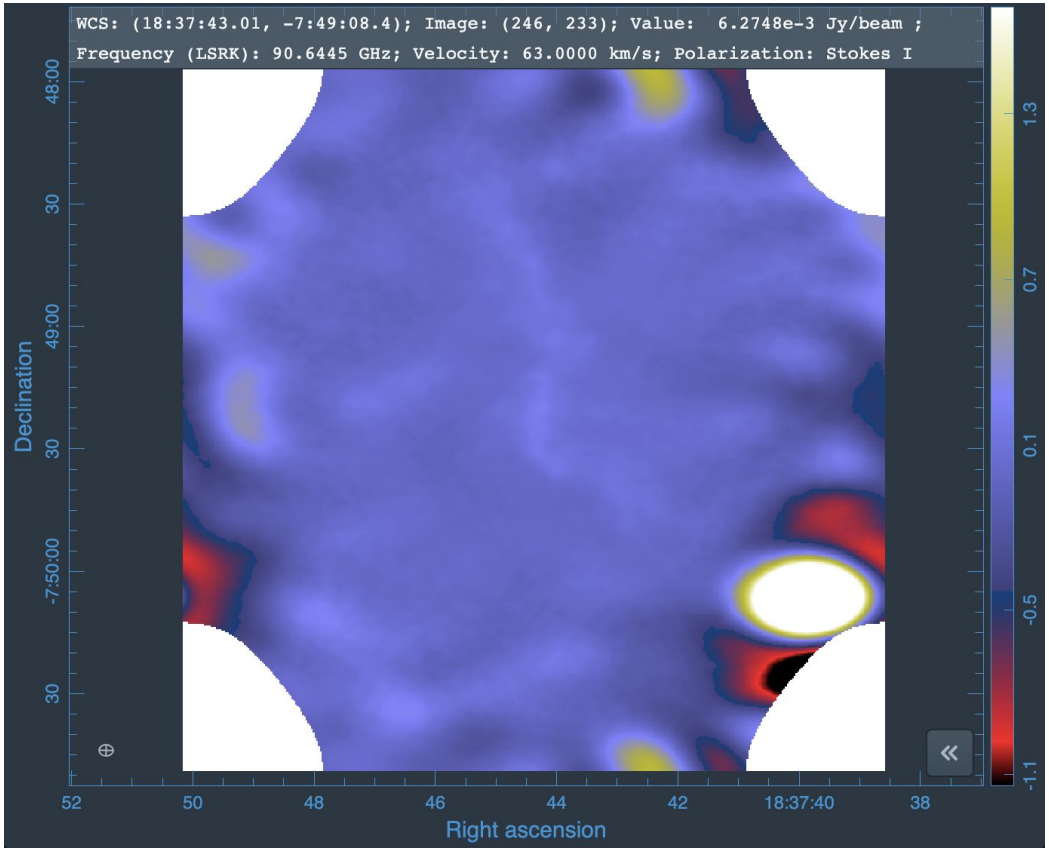


7m-only mosaic



spatially matched

cube @ 63 km/s



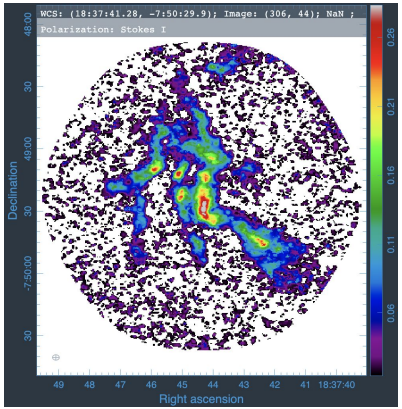
12m+7m+TP

(also visible in 12m+7m)

*source: C1

Effects of PB correction on feathering

Traditional method

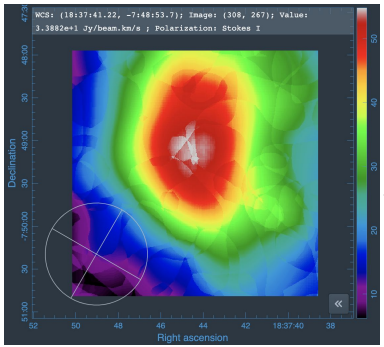


Int image

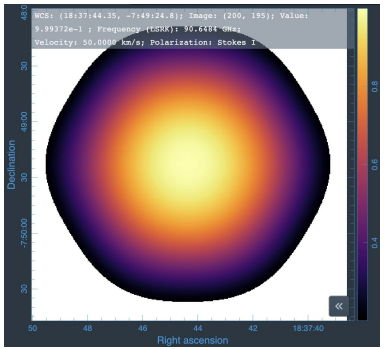
(12m, 7m, or 12m+7m)

Not yet PB corrected

feather

+ (

TP image

x 

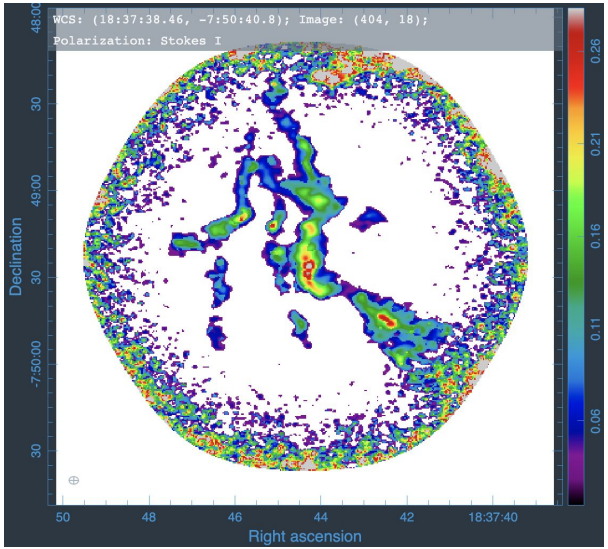
Int PB response)

divide

Int PB response

(for PB correction)

Feathering – what we tried

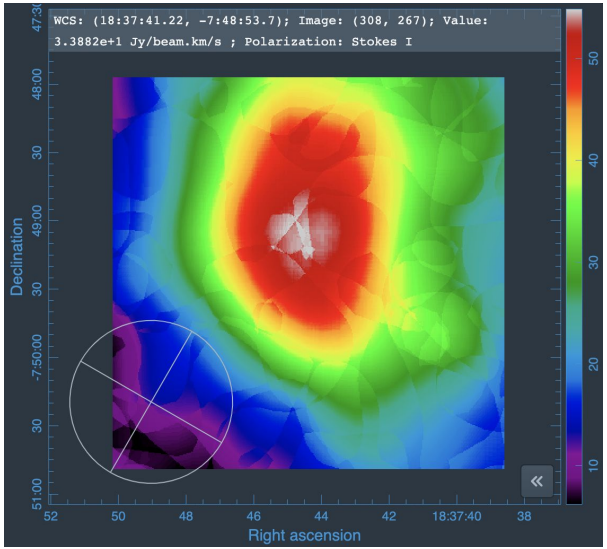


Int image
(12m, 7m, or 12+7)

PB corrected

feather

+



TP image

cube @ 62 km/s

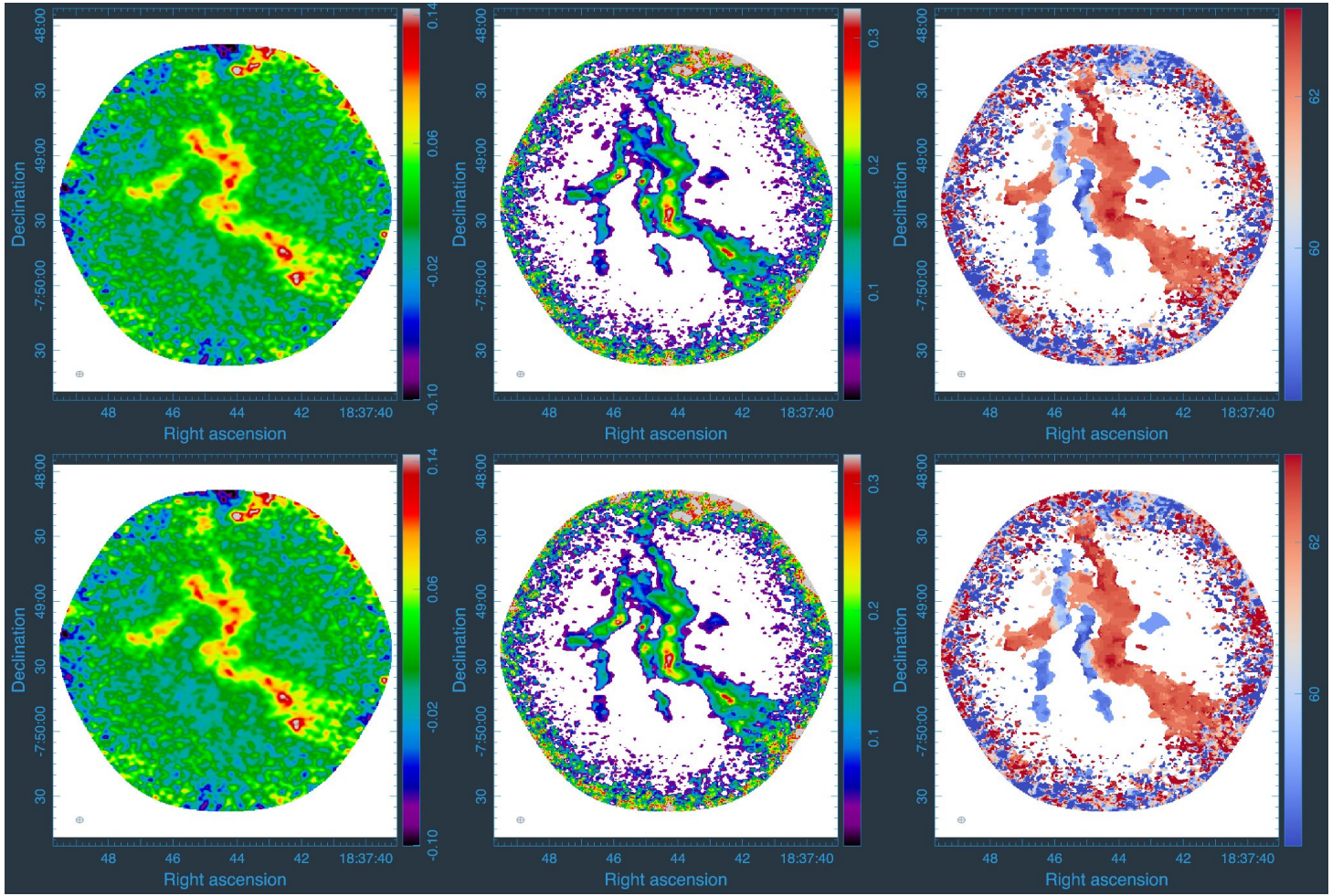
moment 0

moment 1

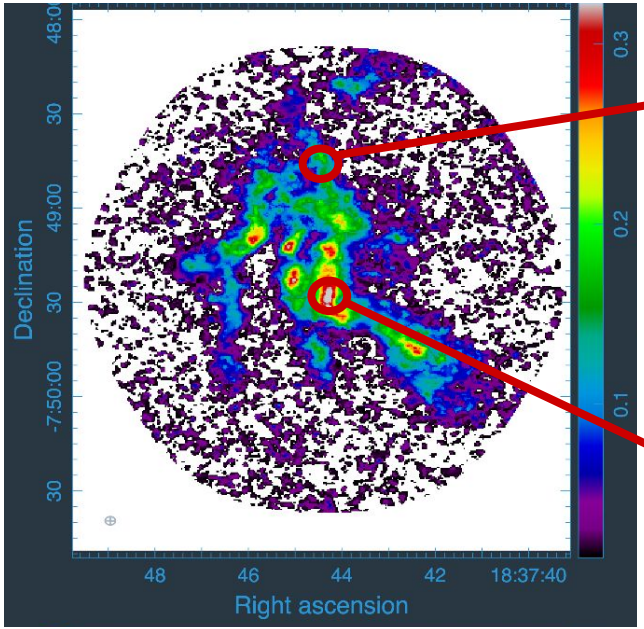
Traditional method

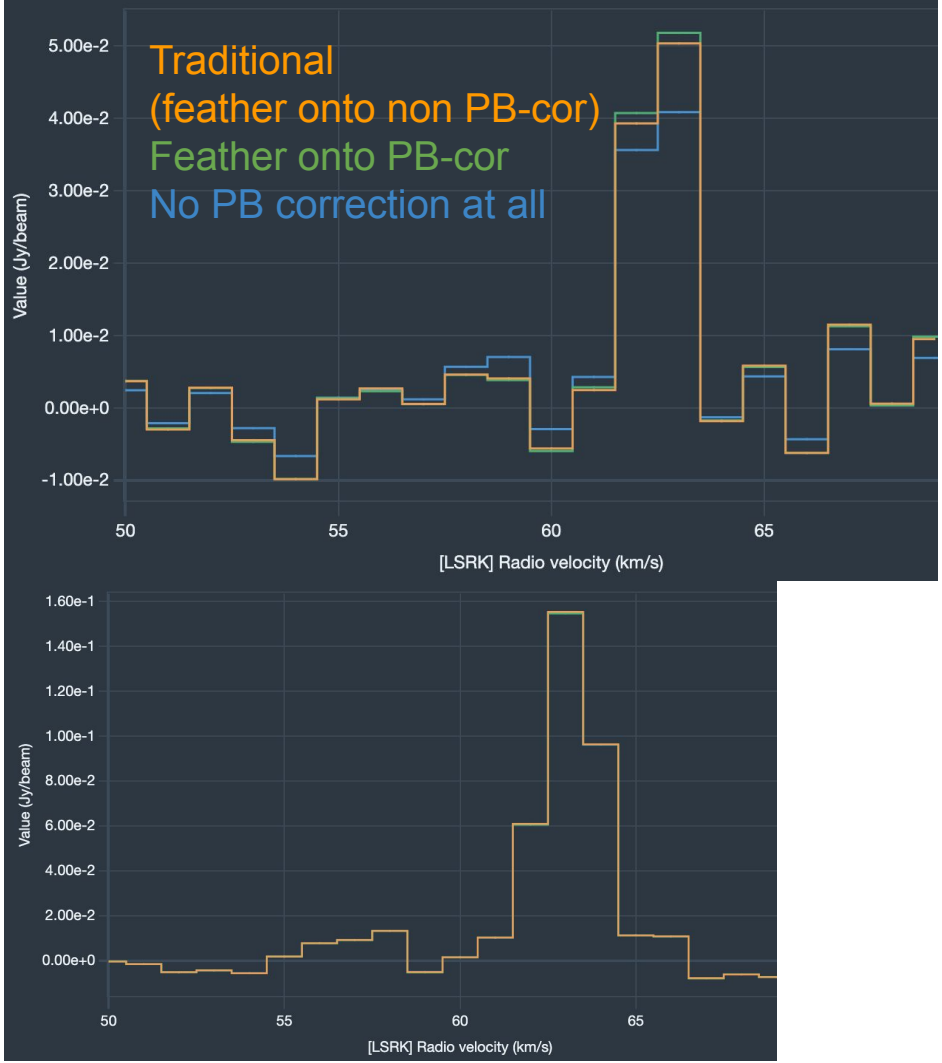
(+final PB corrected)

Feather onto PB-corrected image



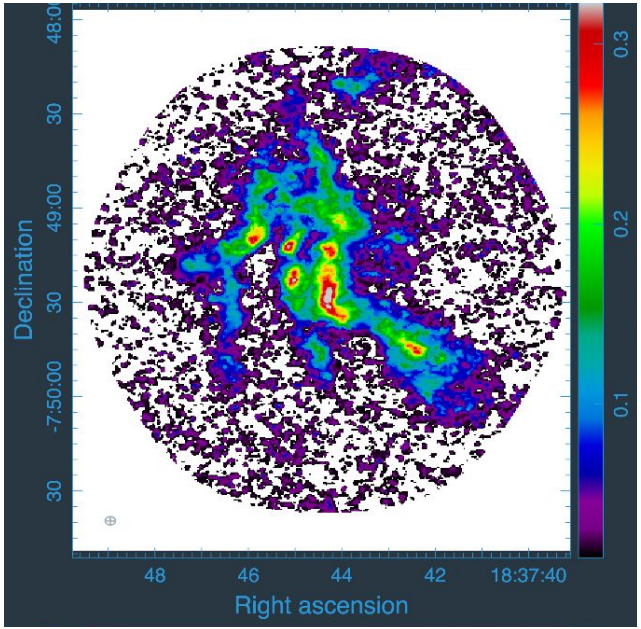
Differences: spectra

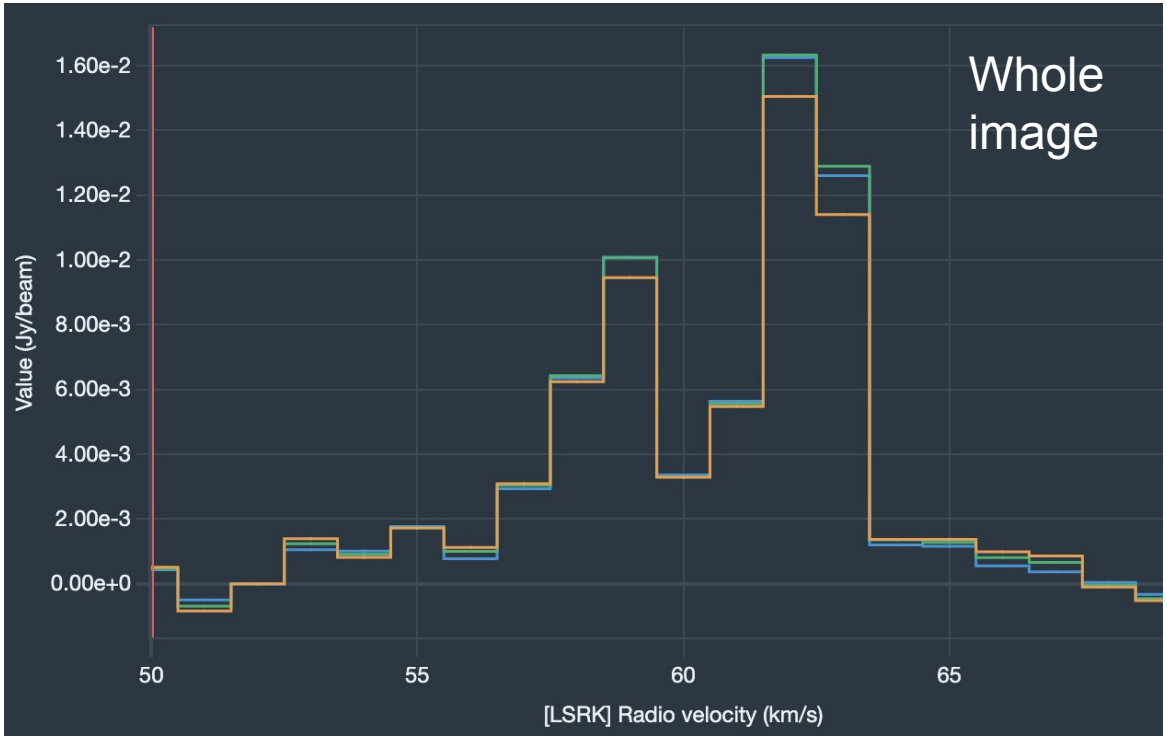




Differences: spectra

Traditional
(feather onto non PB-cor)
Feather onto PB-cor
No PB correction at all





Conclusions

- Joint mosaic and combination with total power to recover emissions from extended structures
- Effects of various parameters: image sizes, weighting, primary beam correction
- Cautions when combining images (e.g., TP baseline)
- It is not necessary to do the data combination and feather if there are no extending structure.

Some useful CASA commands

Visibilities: concat, plotms, au.plotmosaic, tclean
Images: immath, imregrid, feather, immoments, imsubimage

CO(1–0) in M100

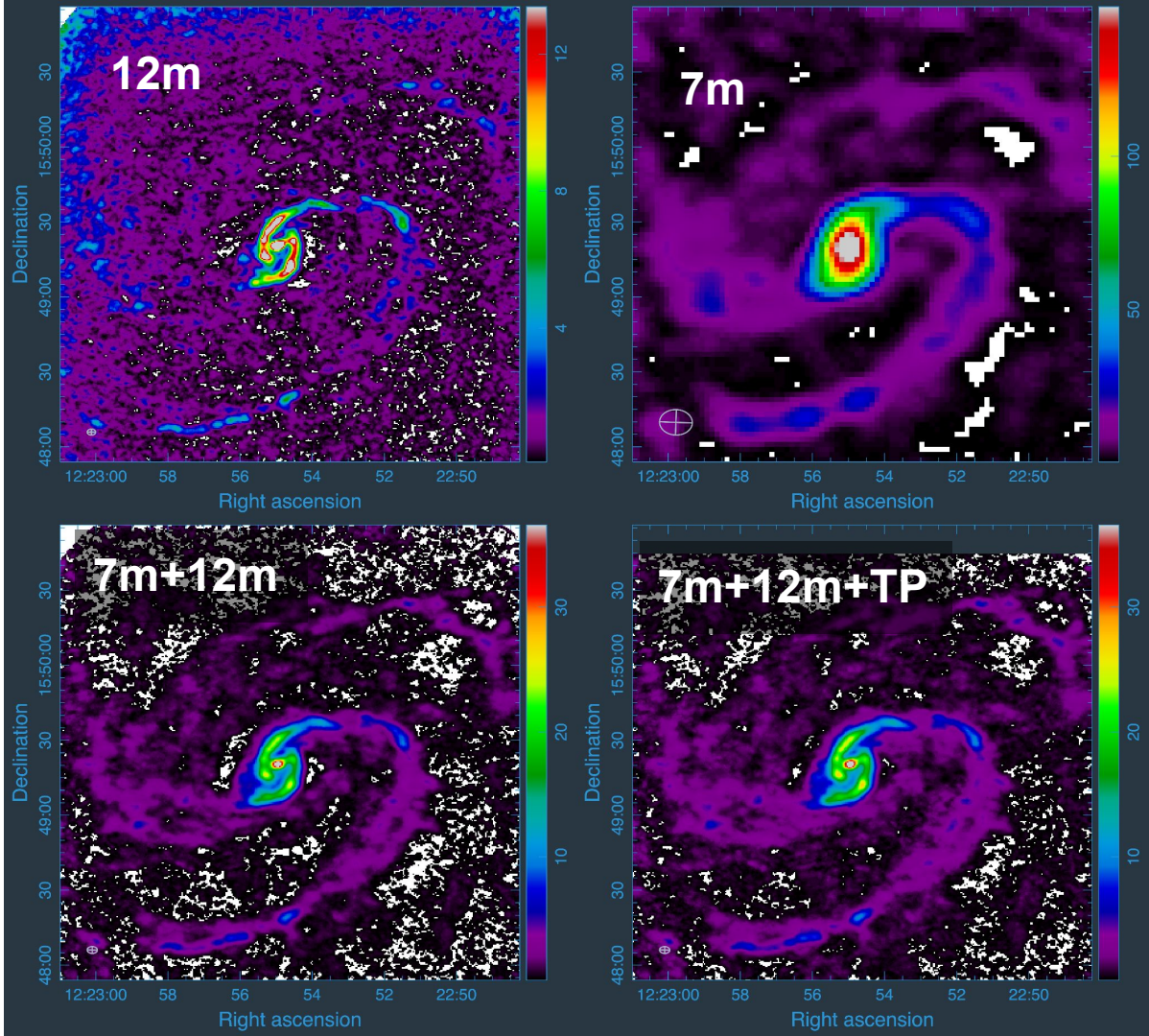
$n_{\mathrm{crit,\ CO}} \sim 10^{3}\ \mathrm{cm}^{-3}$

$n_{\mathrm{crit,\ HNC}} \sim 3 \times 10^{5}\ \mathrm{cm}^{-3}$

→ the data we presented

(T = 20 K, using coefficients from LAMDA database)

(Schoier+05)



mom0