# Molecules with ALMA at Planet-forming Scales (MAPS) II: CLEAN Strategies for Synthesizing Images of Molecular Line Emission in Protoplanetary Disks

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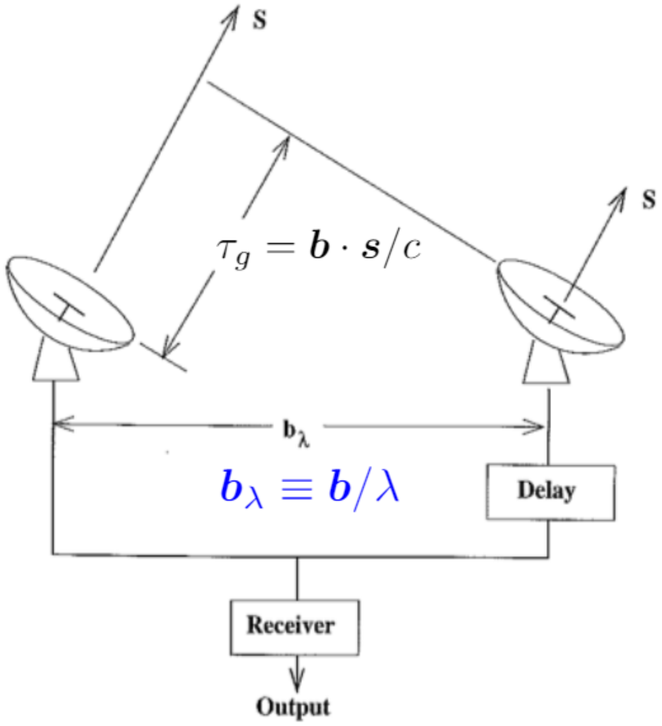
# Two-element interferometer




Fringe pattern changes as the Earth rotates

Assumptions:
Monochromatic point source with two identical antennas.

Cross-correlation:

$$R_{xy}(\tau) = \langle x(t)y(t-\tau)\rangle$$

⬇

$$R_{xy}(\boldsymbol{s}) = A(\boldsymbol{s})F\cos(2\pi\boldsymbol{b}_\lambda\cdot\boldsymbol{s})$$

Cross-spectrum power density:

$$S_{xy}(\nu) = X(\nu)Y^*(\nu)$$

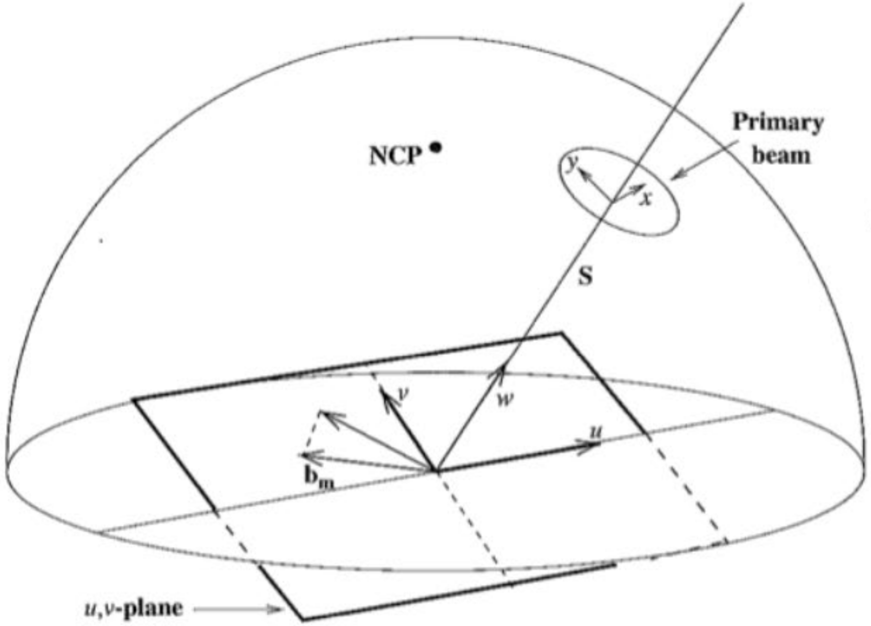
⬇

$$\boxed{S_{xy}(\boldsymbol{s}) = A(\boldsymbol{s})F_\nu\exp\left(\mathrm{i}2\pi\boldsymbol{b}_\lambda\cdot\boldsymbol{s}\right)}$$

$S$ gives the fringe amplitude and phase.

Cited by Xuening's slides

# UV Plane




$$\boldsymbol{b}_{ij,\lambda} = u\boldsymbol{e}_u + v\boldsymbol{e}_v + w\boldsymbol{e}_w$$

$$\sigma = x\boldsymbol{e}_u + y\boldsymbol{e}_v$$

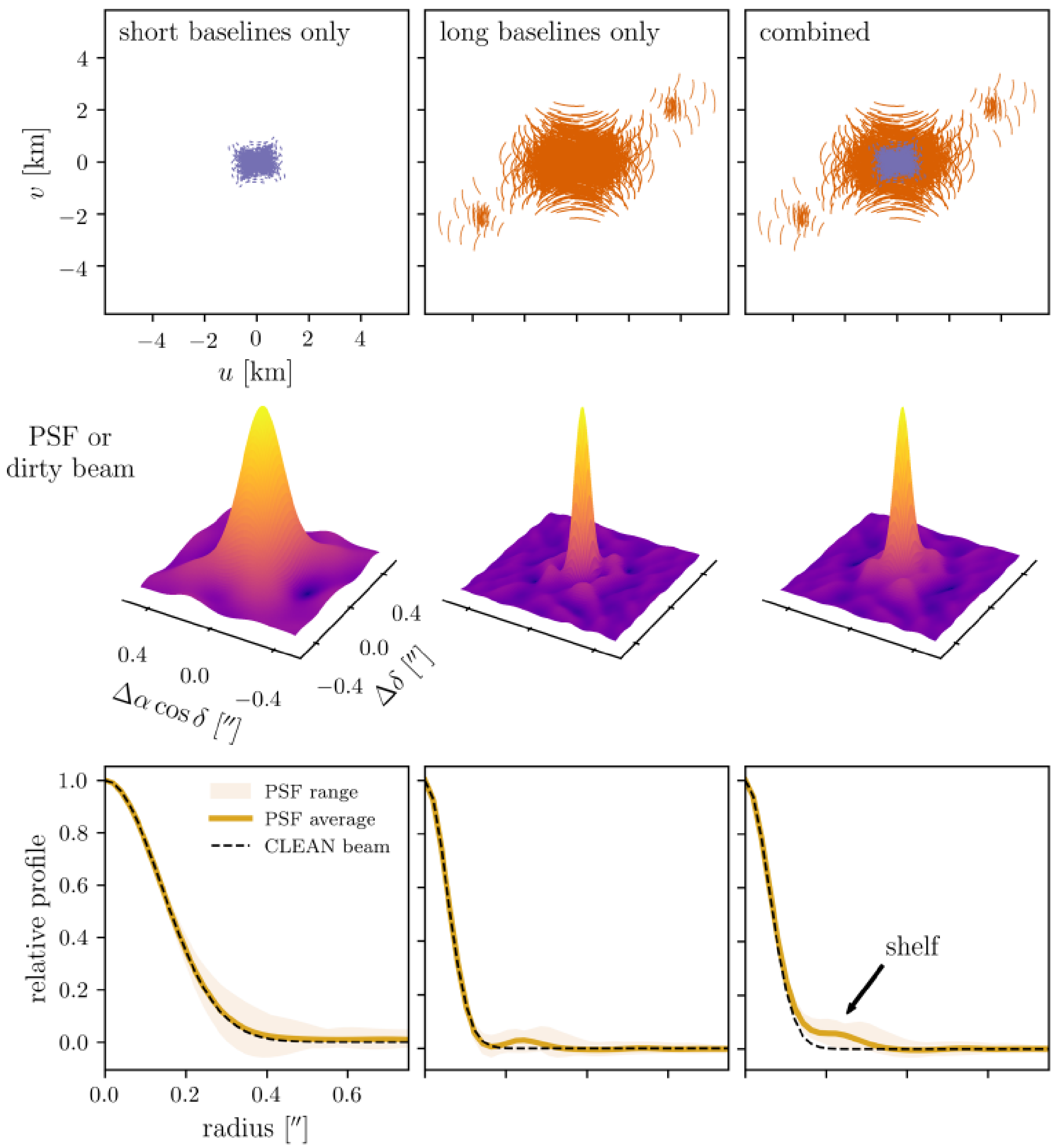
$$V_{ij} \equiv \int \mathcal{A}(\sigma) B_\nu(\sigma) \exp\left(2\pi i \boldsymbol{b}_{ij,\lambda} \cdot \sigma\right) d\Omega$$

$$\Rightarrow \quad V(u,v) = \int \mathcal{A}(x,y) B_\nu(x,y) \exp\left[\mathrm{i}2\pi(ux+vy)\right] dxdy$$

Cited by Xuening's slides

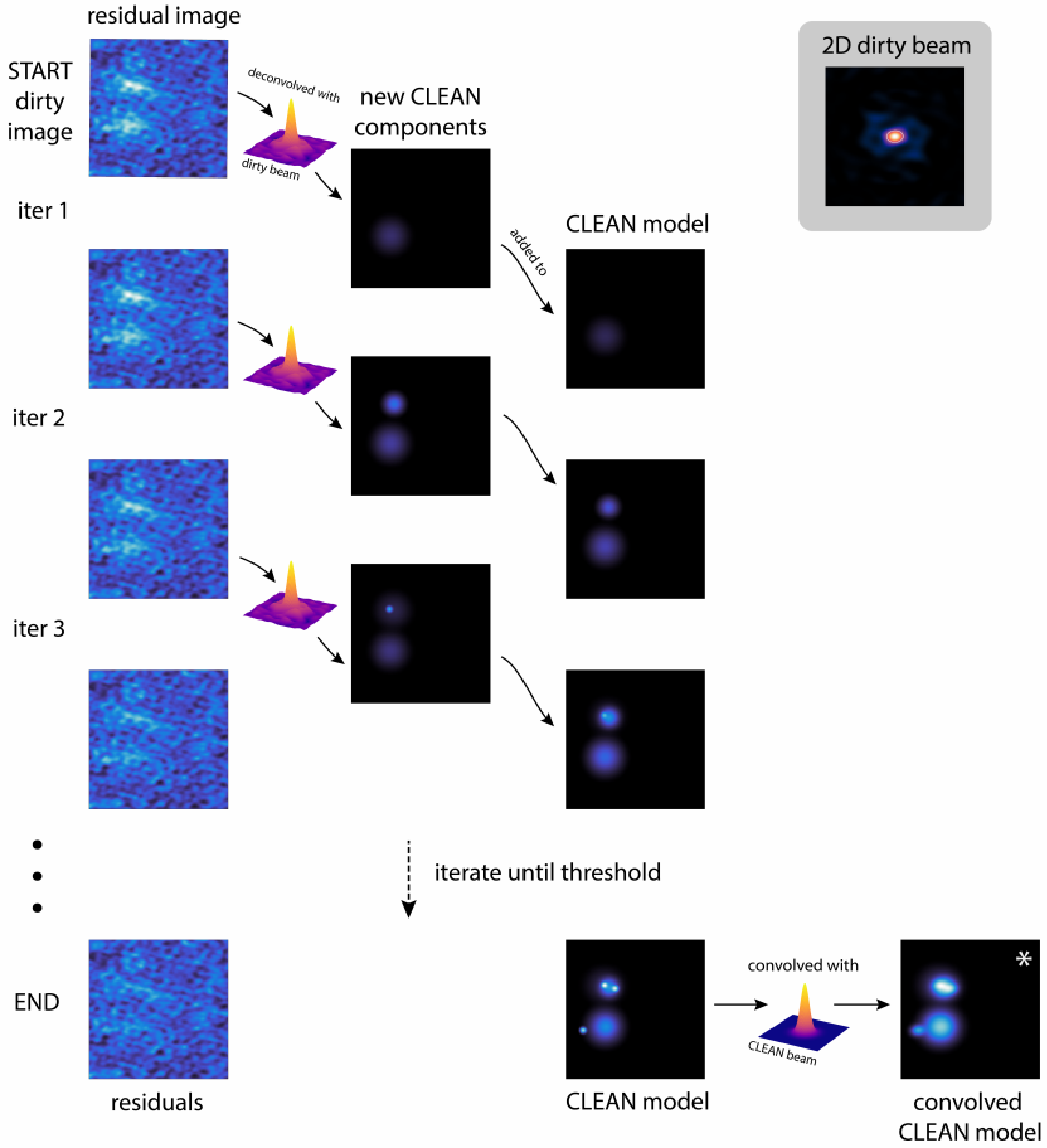
# PSF Function

- See Oberg et al. (2021) for ALMA detailed parameters
- Combined -> Higher Resolution and Sensitivity
- Combined -> Shelf (We don’t want)

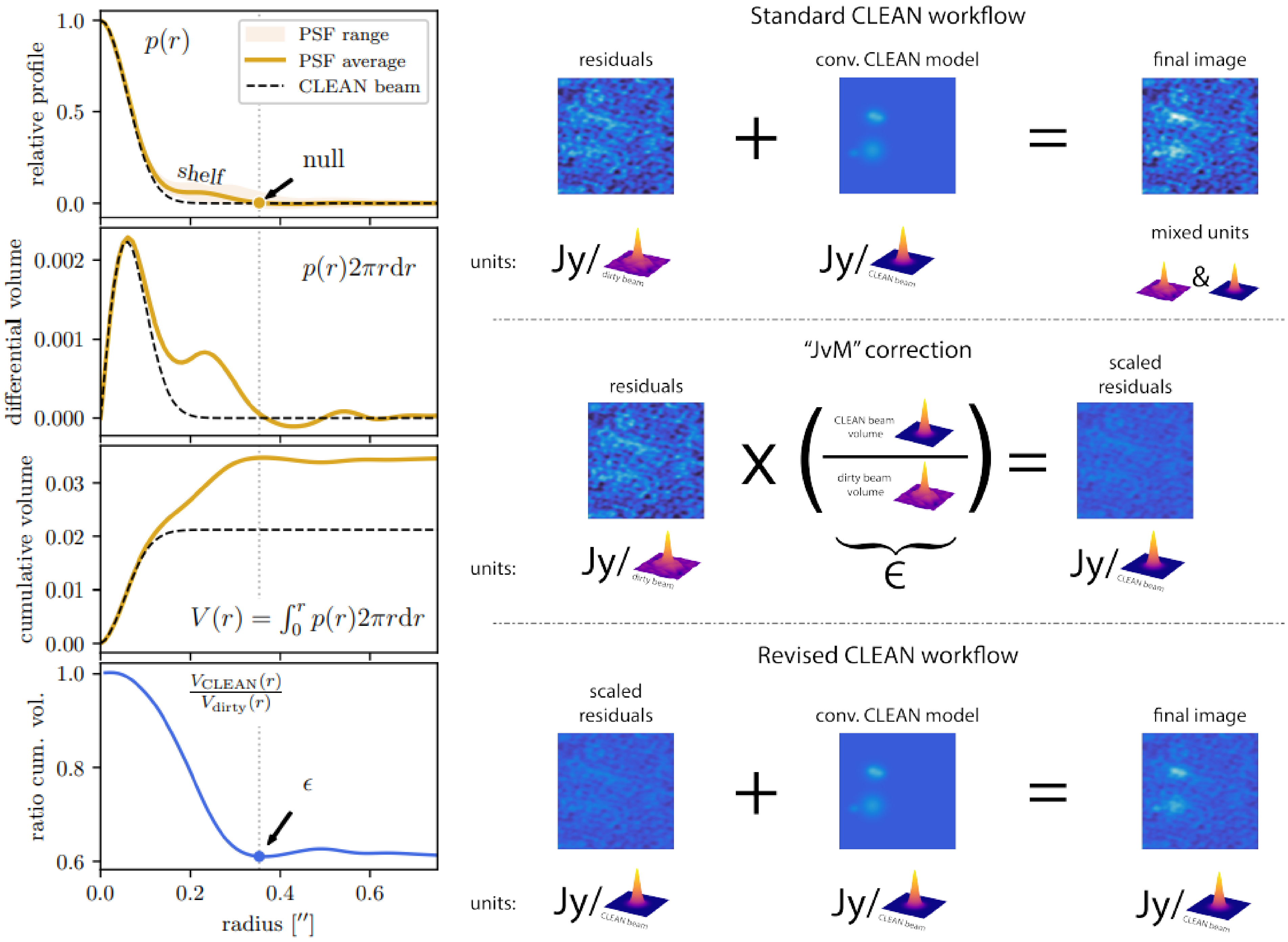


# CLEAN Algorithm

- S1: Find the maximum in residual image
- S2: Deconvolved-> CLEAN components
- S3a: CLEAN += new CLEAN components
- S3b: residual image -= dirty image for the new CLEAN components
- S4: If maximum in residual image > threshold, go to S1, else, stop



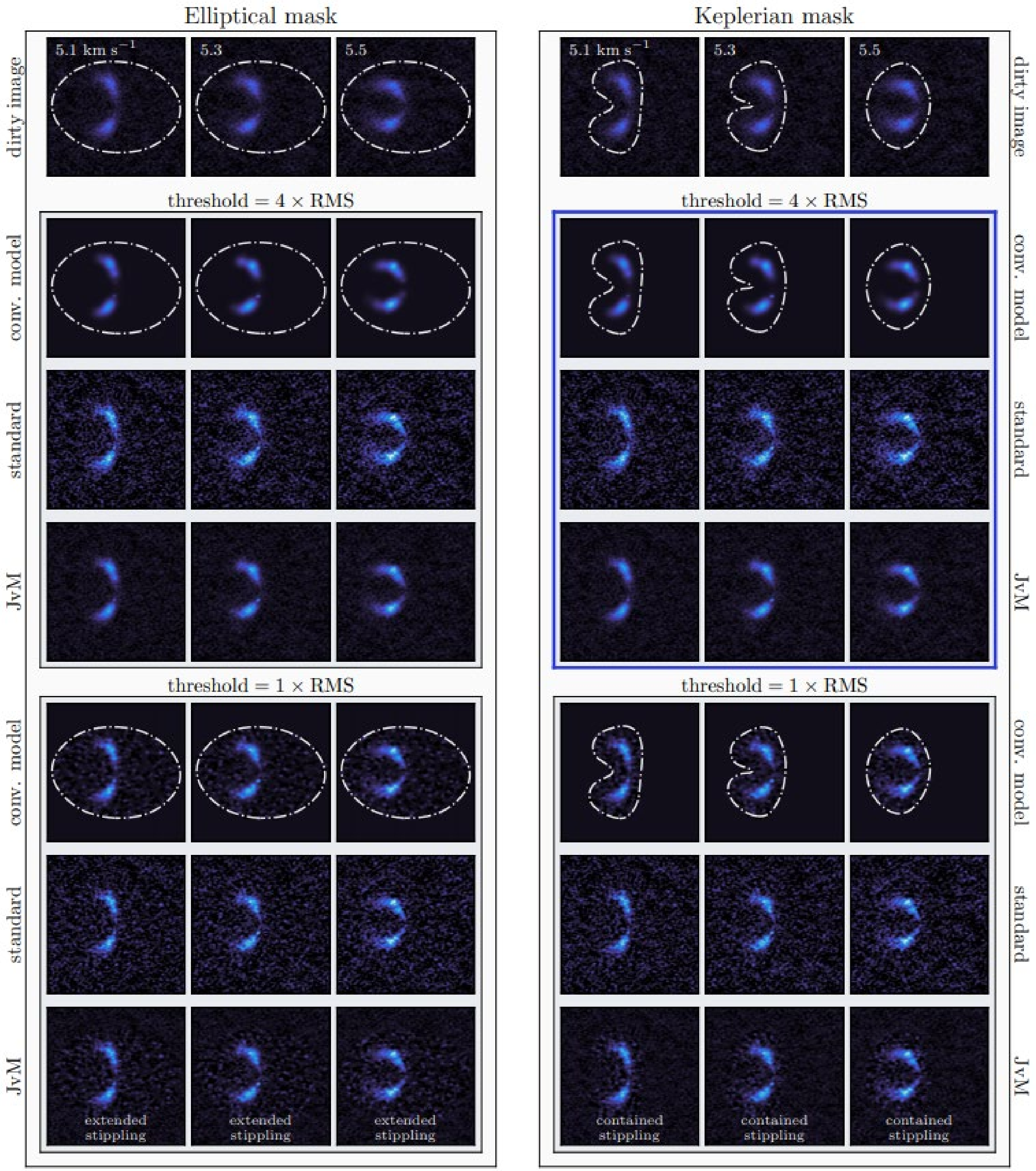
# Shelf Problem and JvM Correction



# Masking

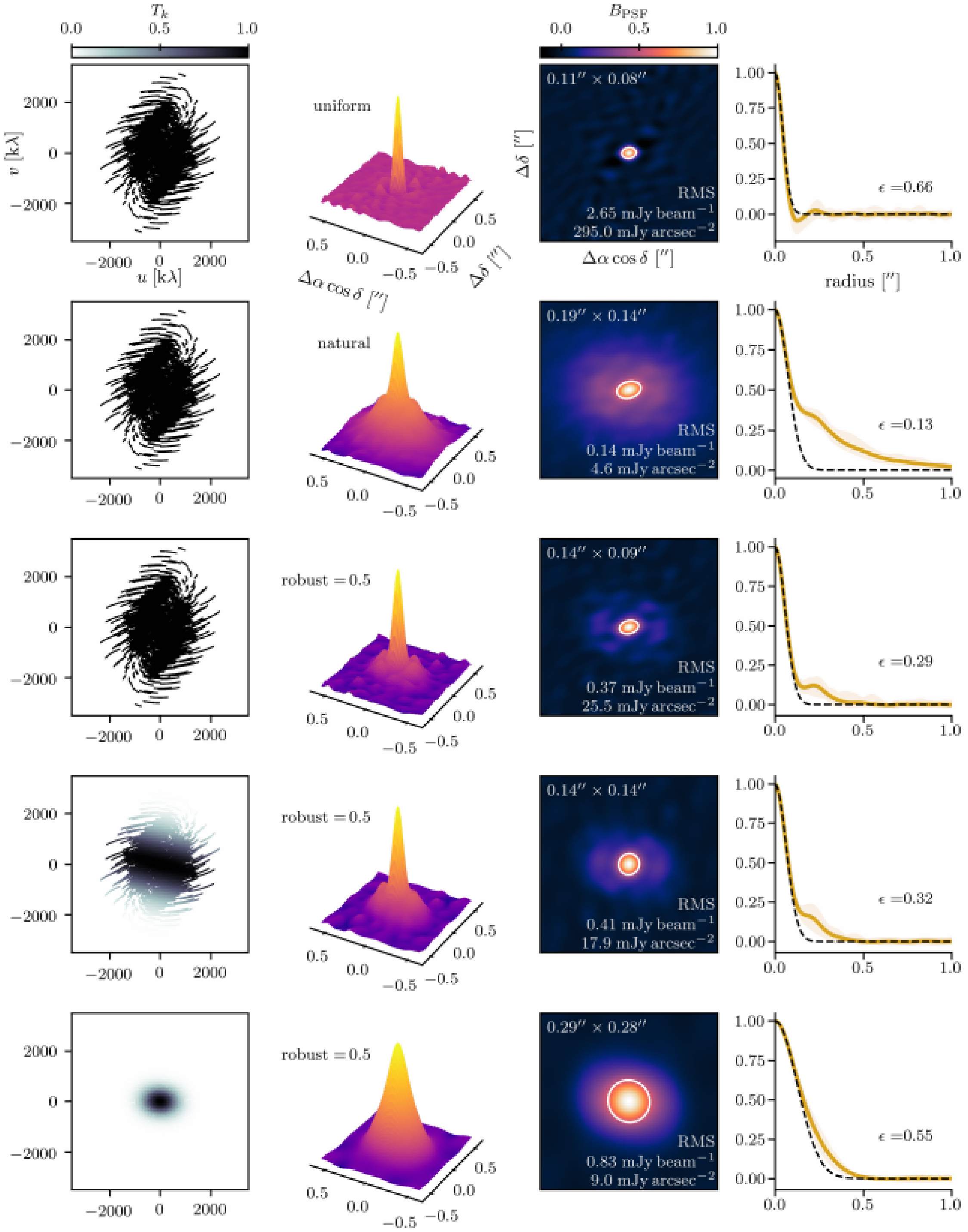
- Well designed mask

-> Low probability to add components to clean model erroneously

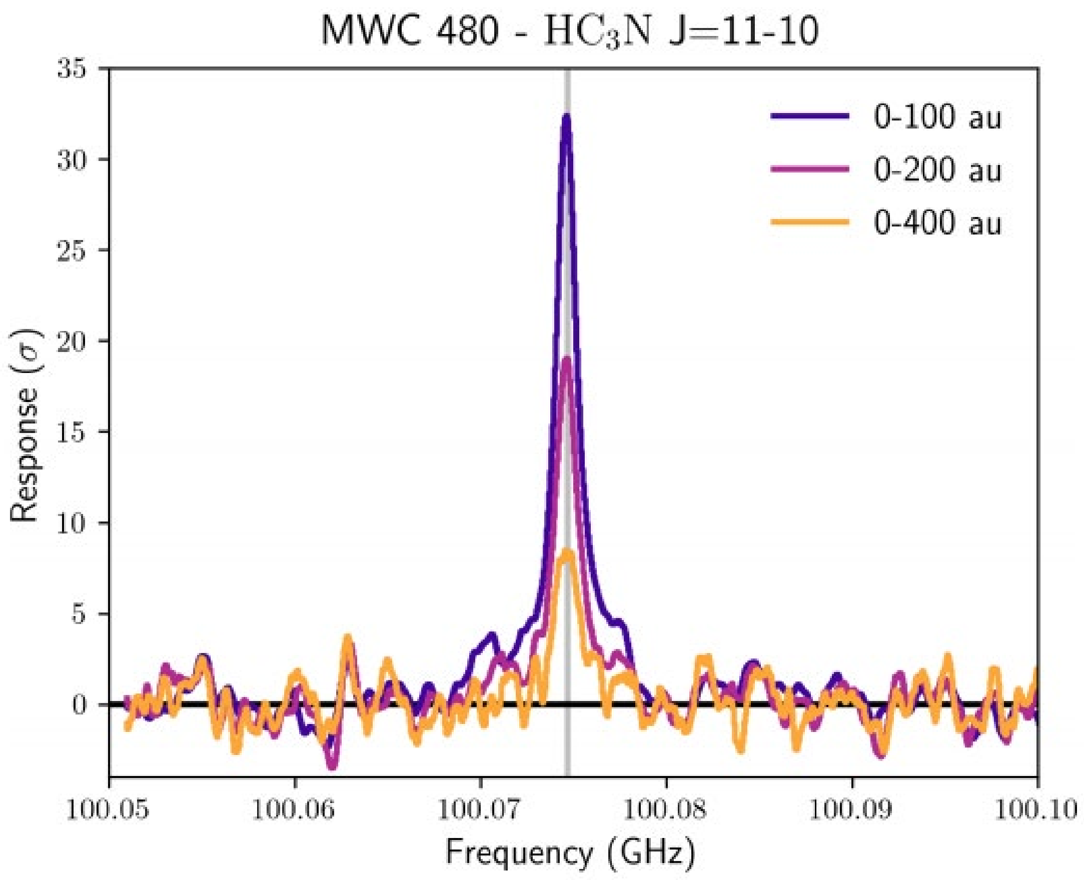


# Weighting and Tapering

- Weighting and tapering could directly affects the shape of dirty beam



# SNR



MWC 480 - $HC_3N$ J=11-10
0-100 au
0-200 au
0-400 au
Response ($\sigma$)
Frequency (GHz)
35
30
25
20
15
10
5
0
100.05
100.06
100.07
100.08
100.09
100.10

# Summary

- Main target: Clean the dirty image so that the following work could continue
- JvM to correct the last step of the standard CLEAN method
- Keplerian masks, weighting and tapering for better results

# Questions I would ask If I were audience

- How do they deal with noise when fitting?
- Details for three kinds of weighting?
- Is there a better way than JvM to correct shelf?