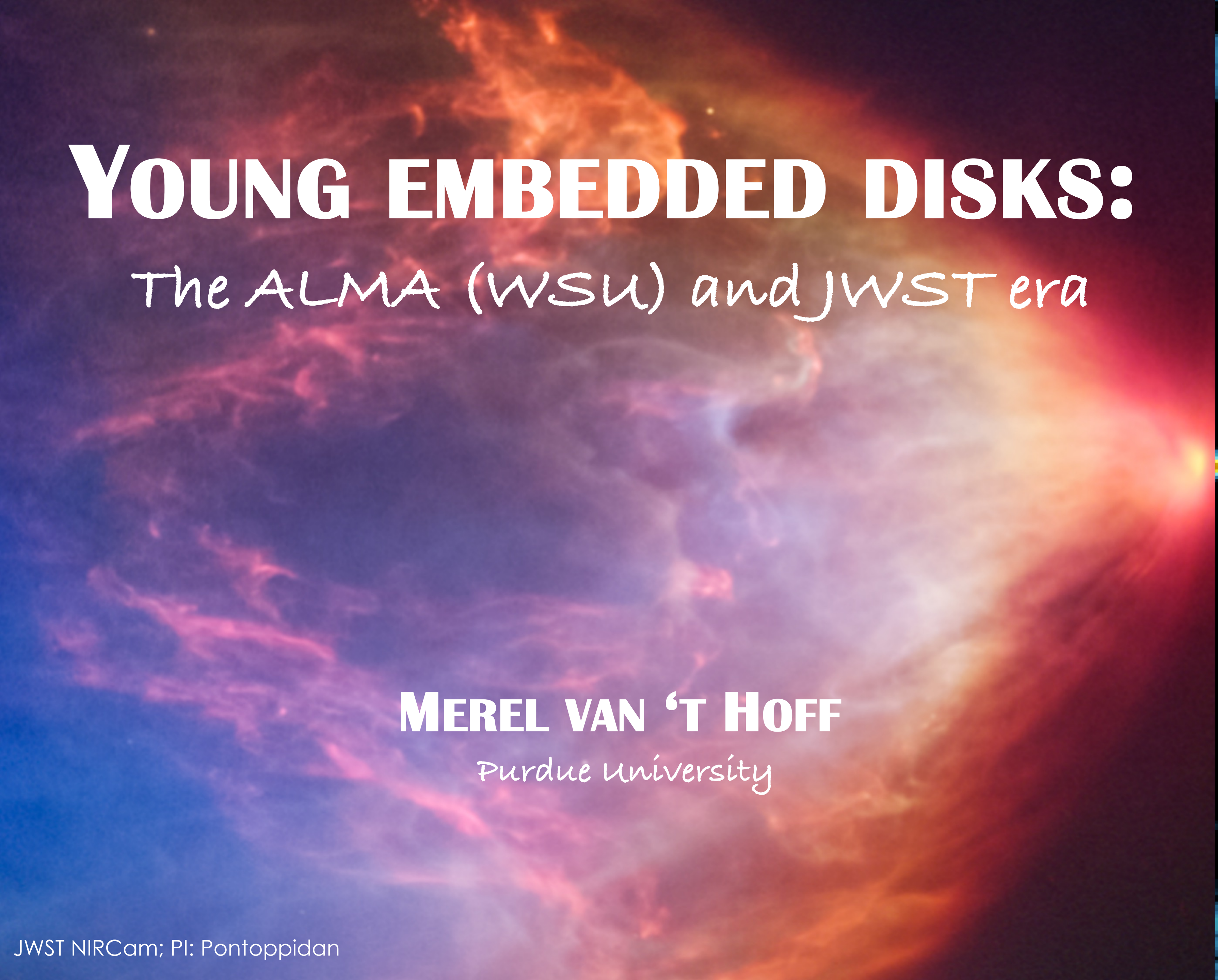


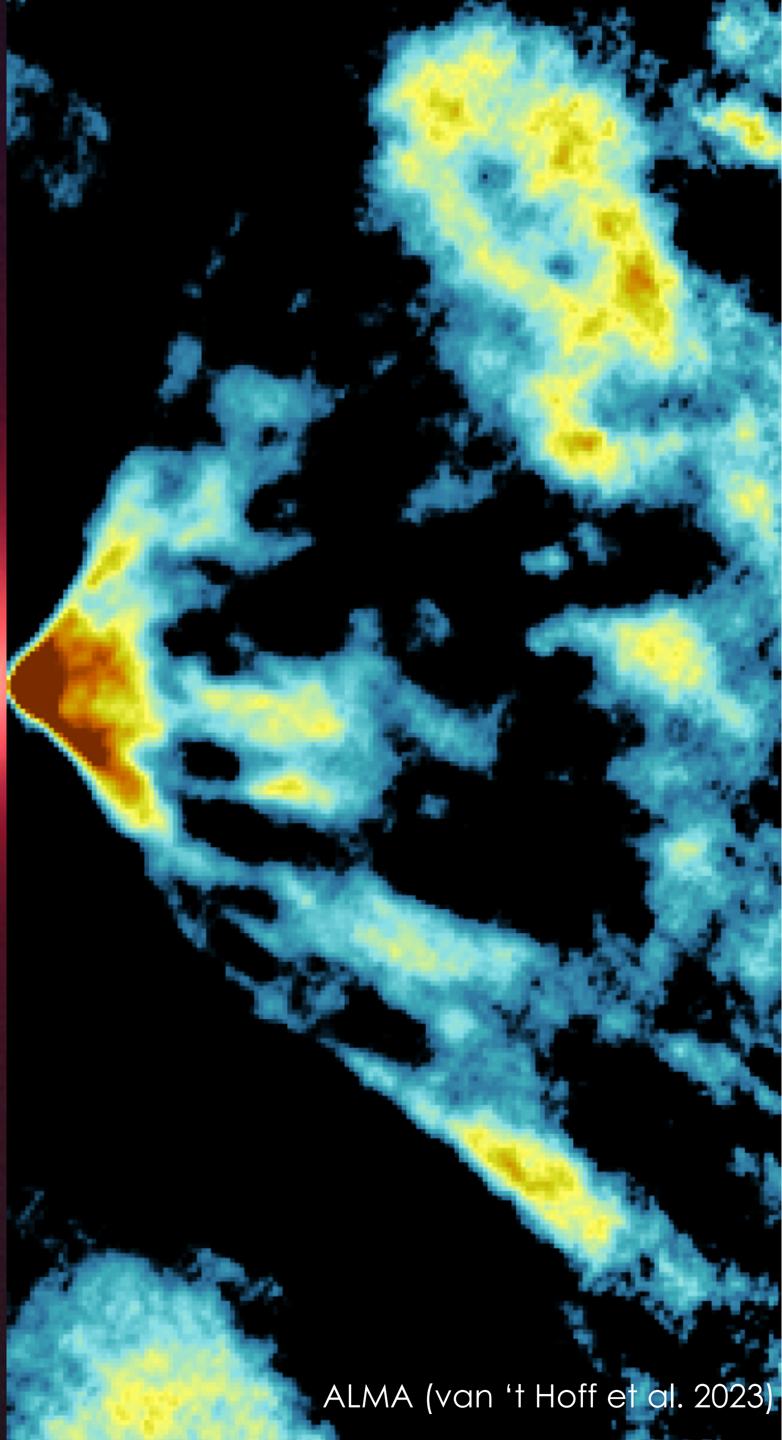
Young embedded disks:

The ALMA (WSU) and JWST era

Merel van 't Hoff

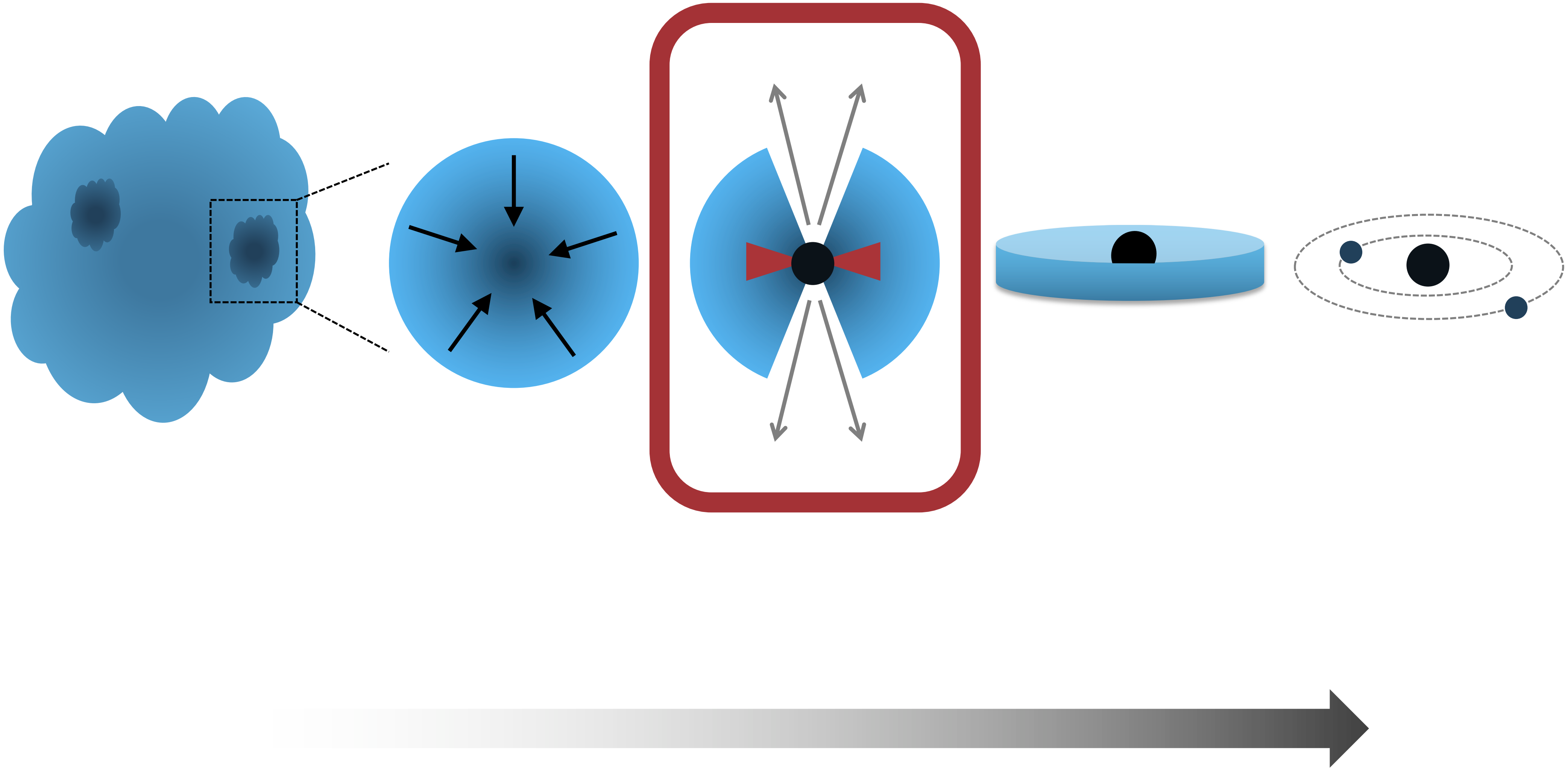
Purdue University

JWST NIRCam; PI: Pontoppidan



ALMA (van 't Hoff et al. 2023)

Young embedded disks



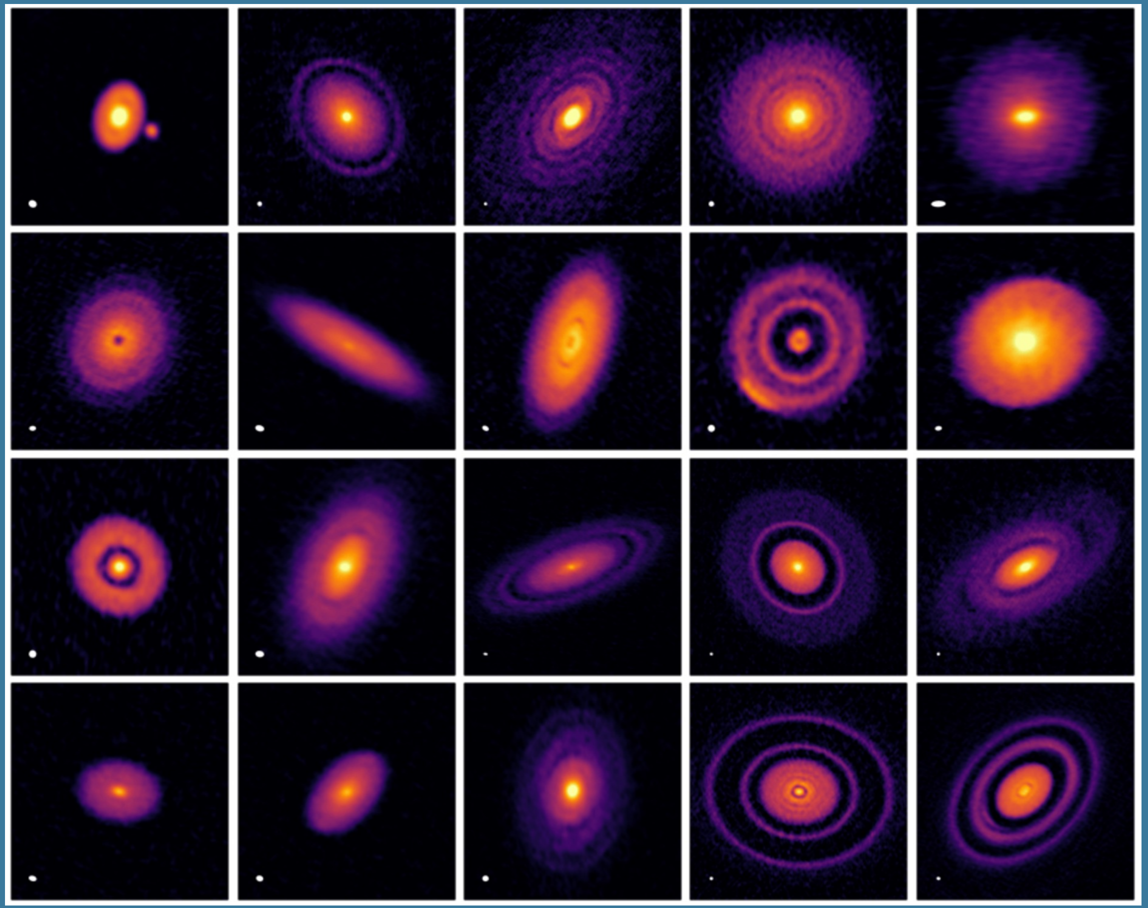
ALMA

ALMA WSU

JWST

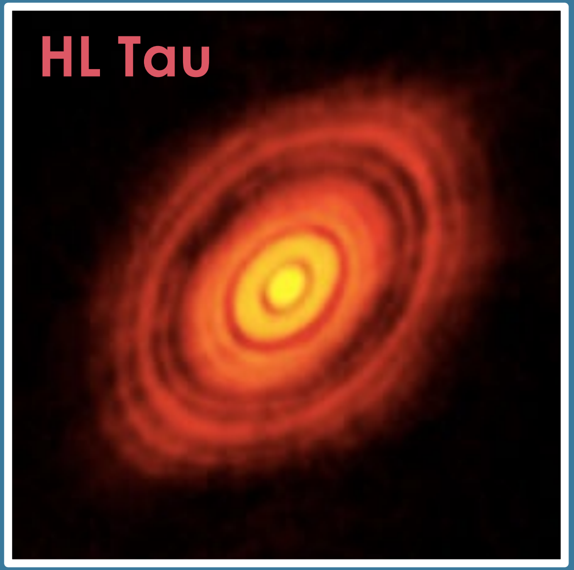
CONTINUUM

Are dust substructures common in young disks?

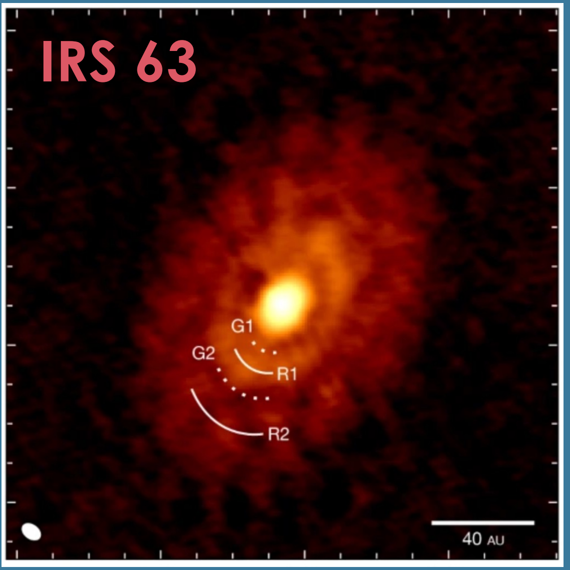


Mature protoplanetary disks (DSHARP)

Andrews et al. 2020



ALMA Partnership 2015



Segura-Cox et al. 2020

Young embedded disks

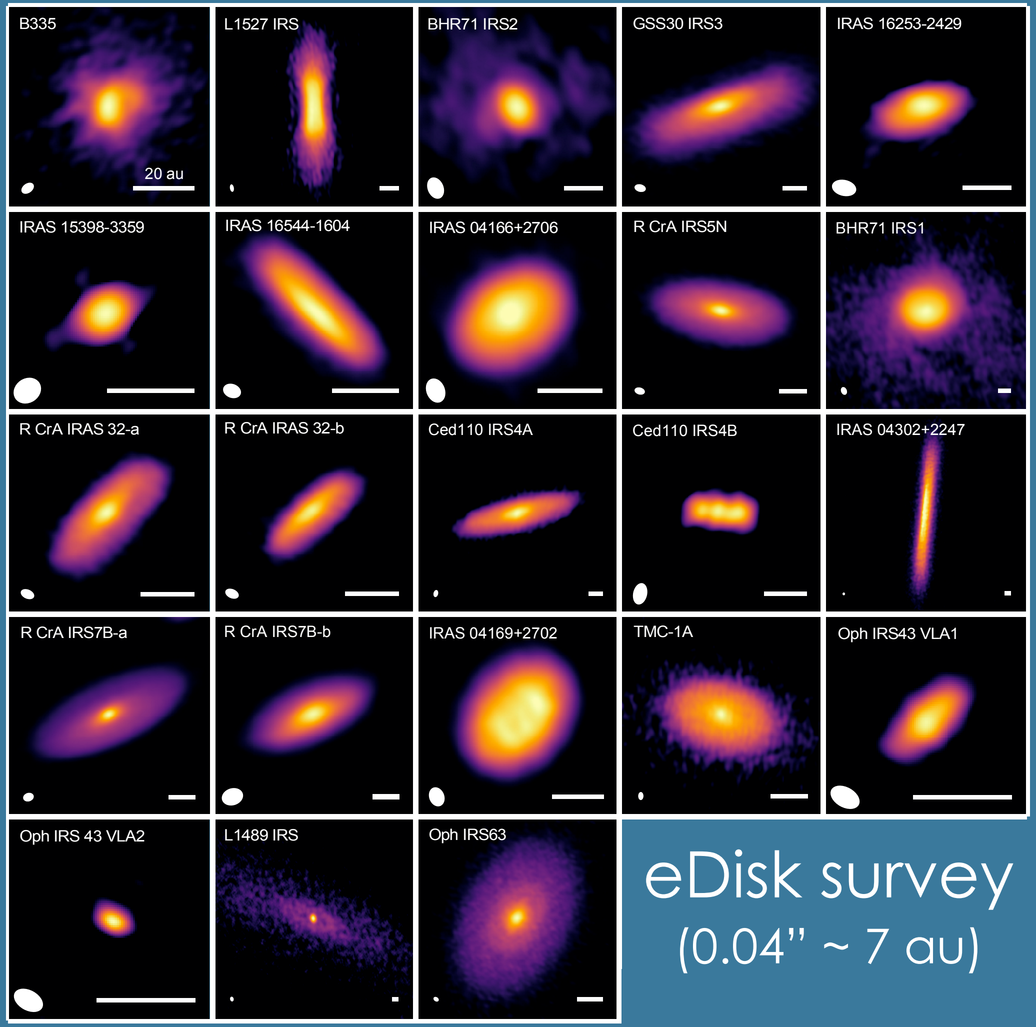
ALMA

ALMA WSU

JWST

Continuum

Are dust substructures common in young disks?



eDisk survey
(0.04" ~ 7 au)

Ohashi, …, van 't Hoff et al. 2023

Maybe not…
… but dust may be optically thick
… but eDisk is biased toward edge-on disks

If not, substructures may form quickly once Class 0 and I protostars evolve into Class II.
(see also Nazari et al. 2024)

Most common structure:
Asymmetry along the disk minor axis,
Suggest optically thick vertically extended disk, so dust not settled toward midplane.

ALMA

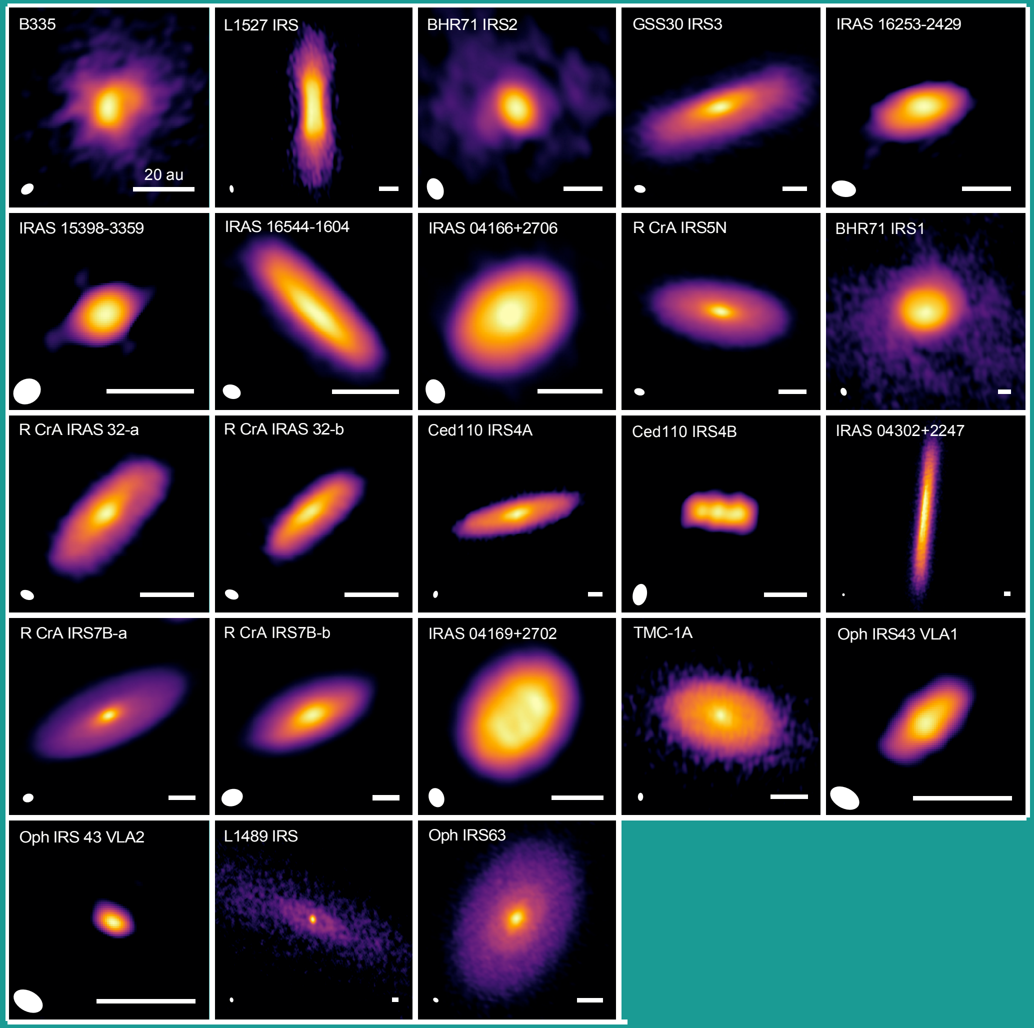
ALMA WSU

JWST

ALMA

Continuum

Are dust substructures common?



≥ 4.8x (for 2x BW correlation) increase in continuum imaging speed

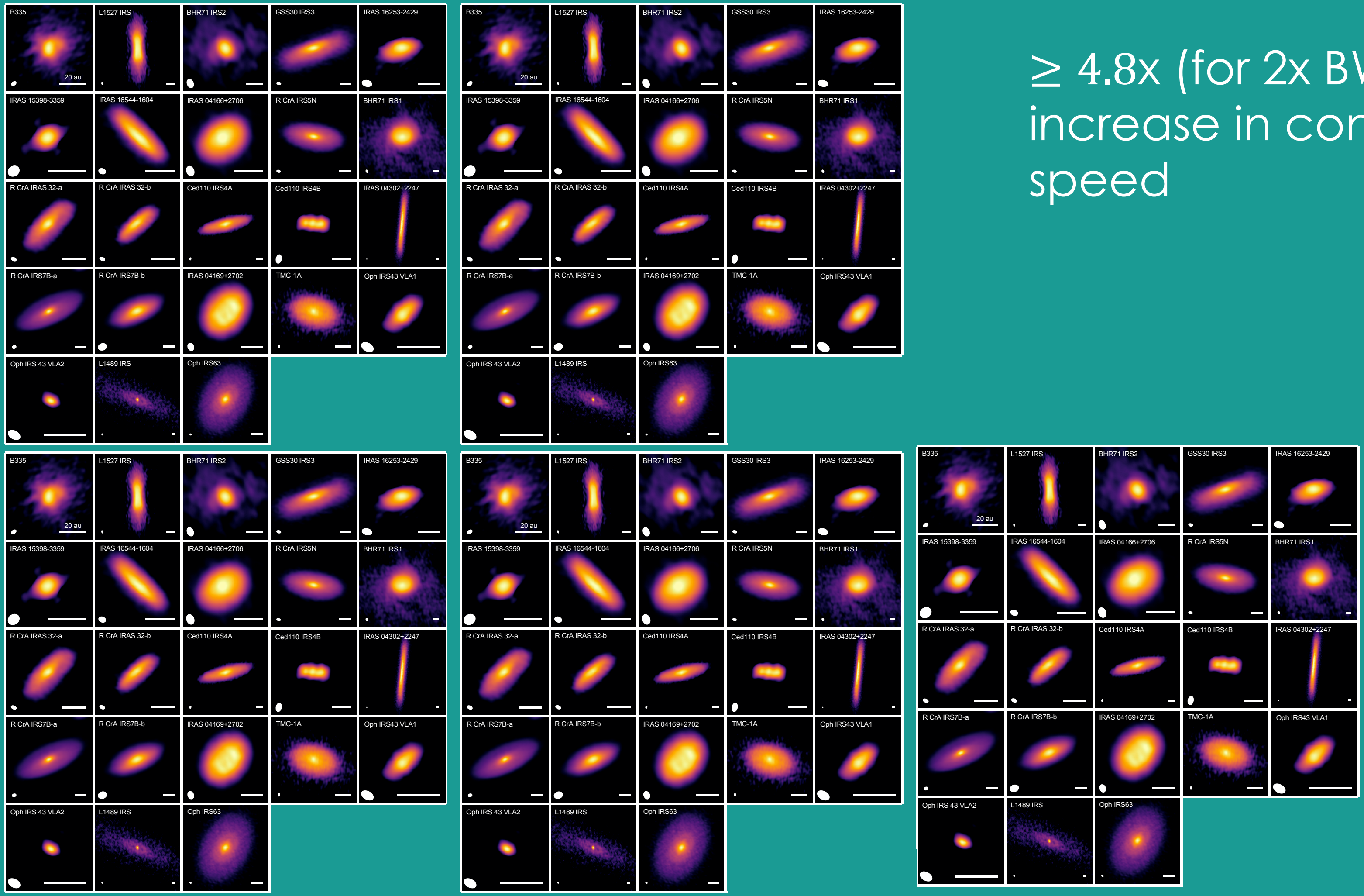
ALMA WSU

JWST

ALMA

Continuum

Are dust substructures common?



≥ 4.8x (for 2x BW correlation) increase in continuum imaging speed

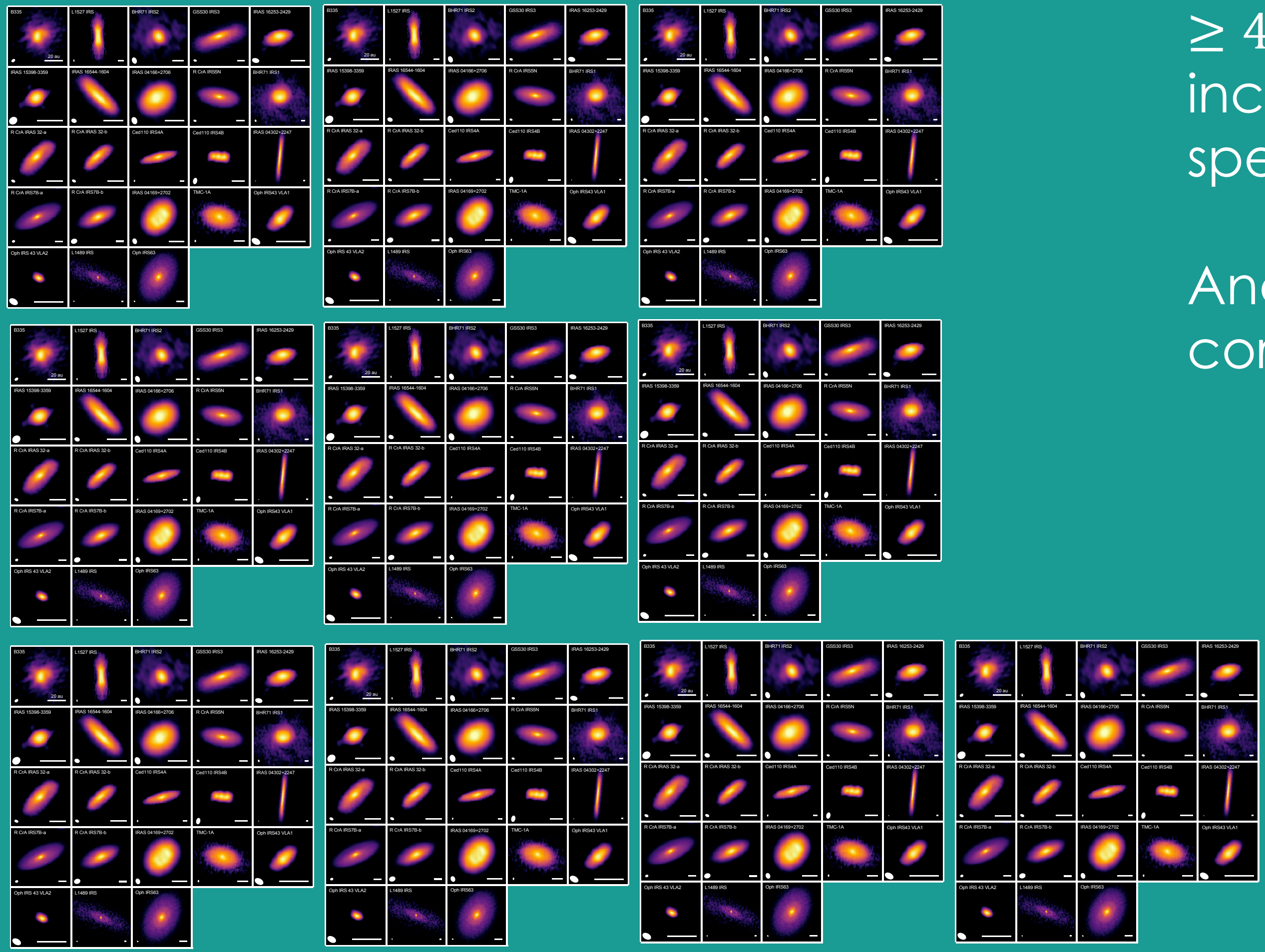
ALMA WSU

JWST

ALMA

Continuum

Are dust substructures common?



≥ 4.8x (for 2x BW correlation) increase in continuum imaging speed

Another 2x increase for 4x BW correlation

ALMA WSU

JWST

ALMA

ALMA WSU

Continuum

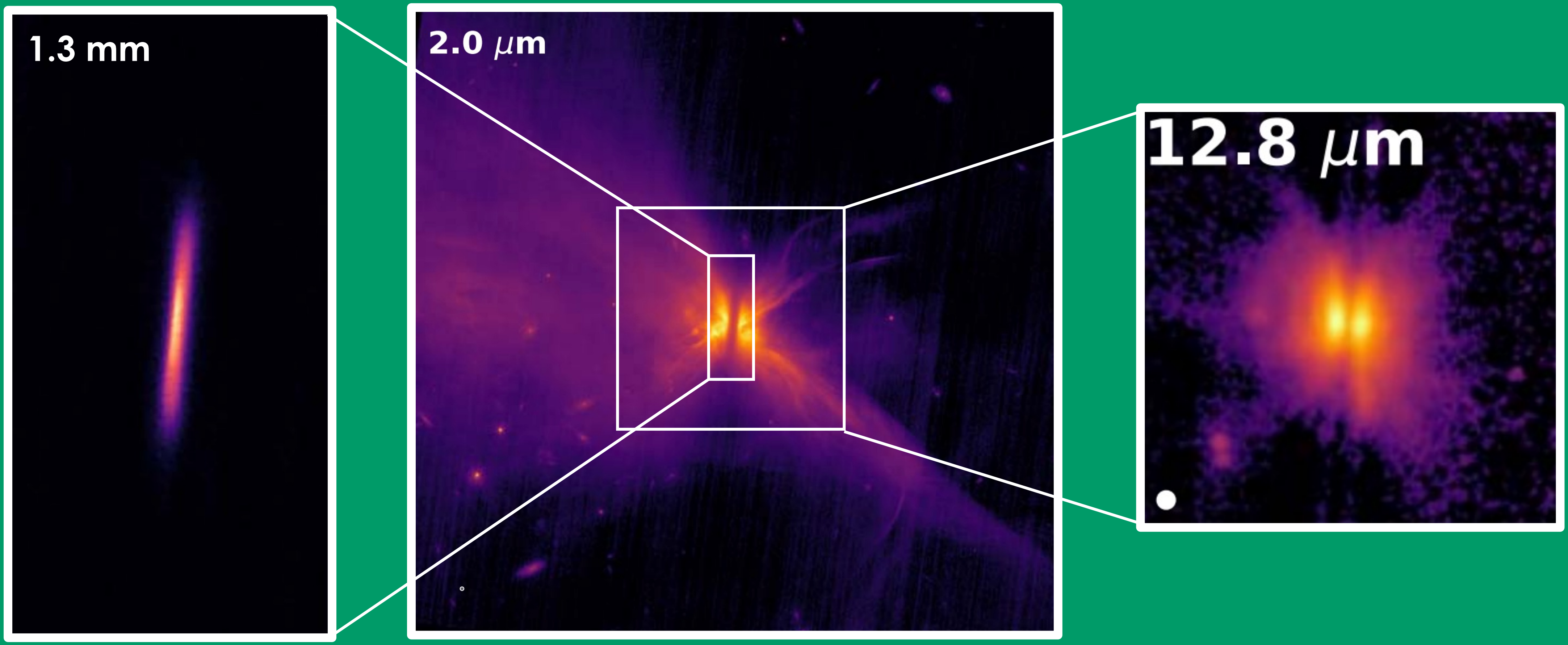
Disk structure

Asymmetry in scattered light suggest tilted inner disk

JWST

ALMA: thermal emission

JWST: scattered light



eDisk: Lin et al. 2023

Villenave et al. 2024

ALMA

ALMA WSU

Continuum

Dust composition

JWST

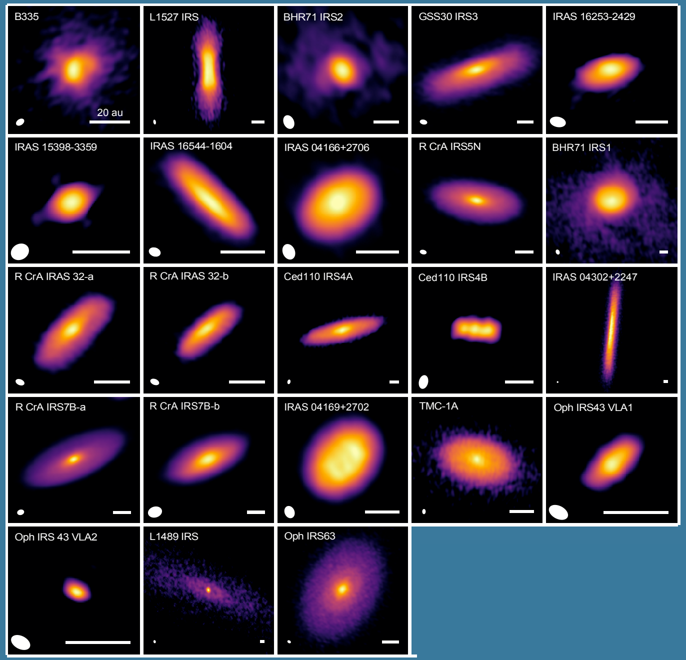
JWST MIRI spectrum can be decomposed into contributions from different minerals

Continuum

Dust in young disks

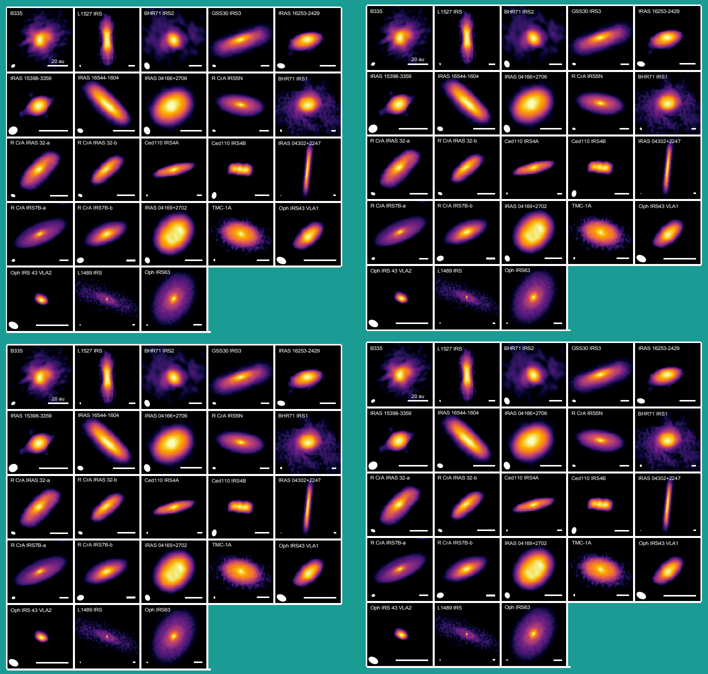
ALMA

Substructures not common in young disks



ALMA WSU

Study much larger disk sample

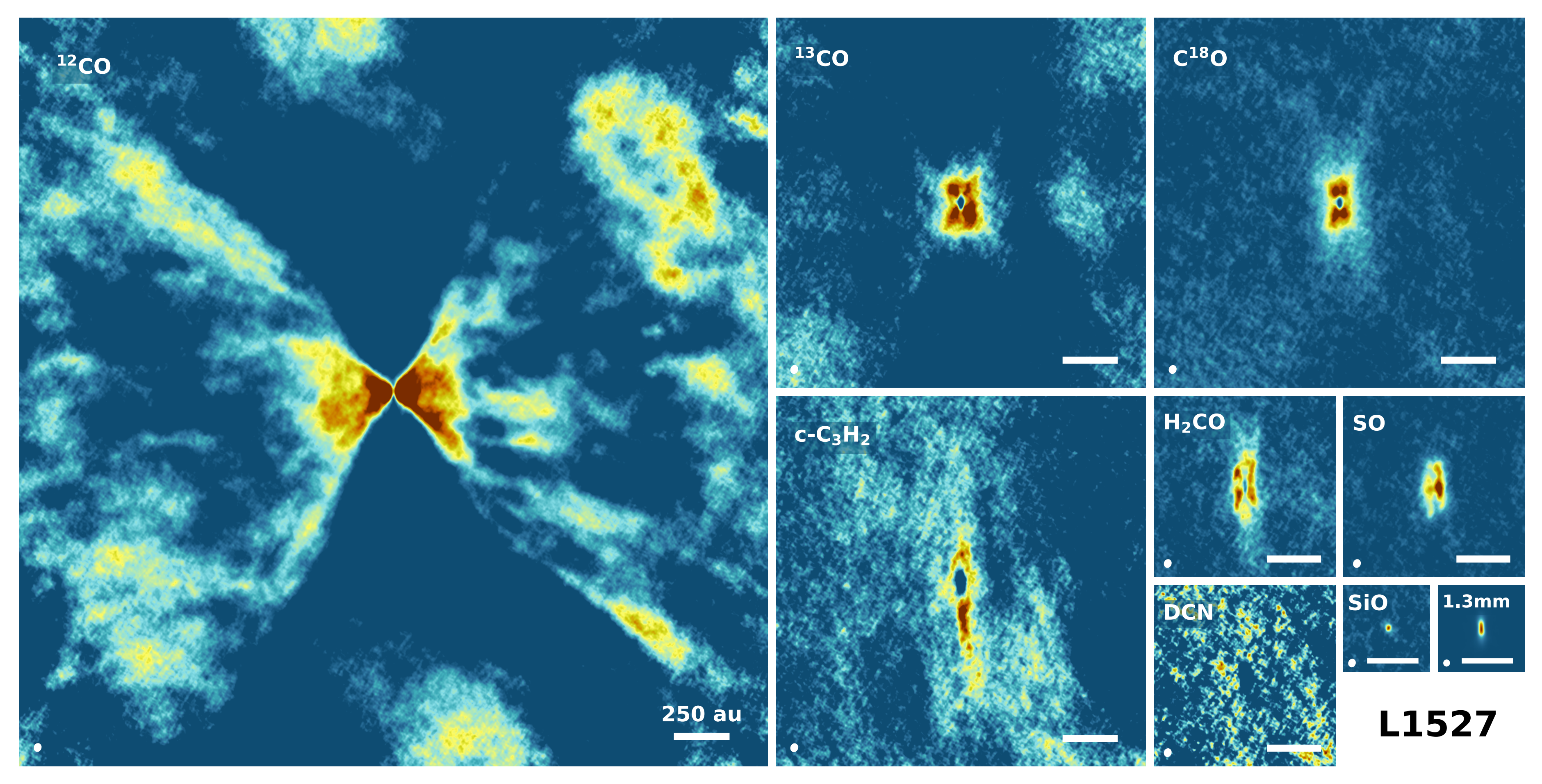


JWST

Complemenatary info on structure and composition

Molecular lines

Physical and chemical structure of young disks



eDisk: van 't Hoff et al. 2023

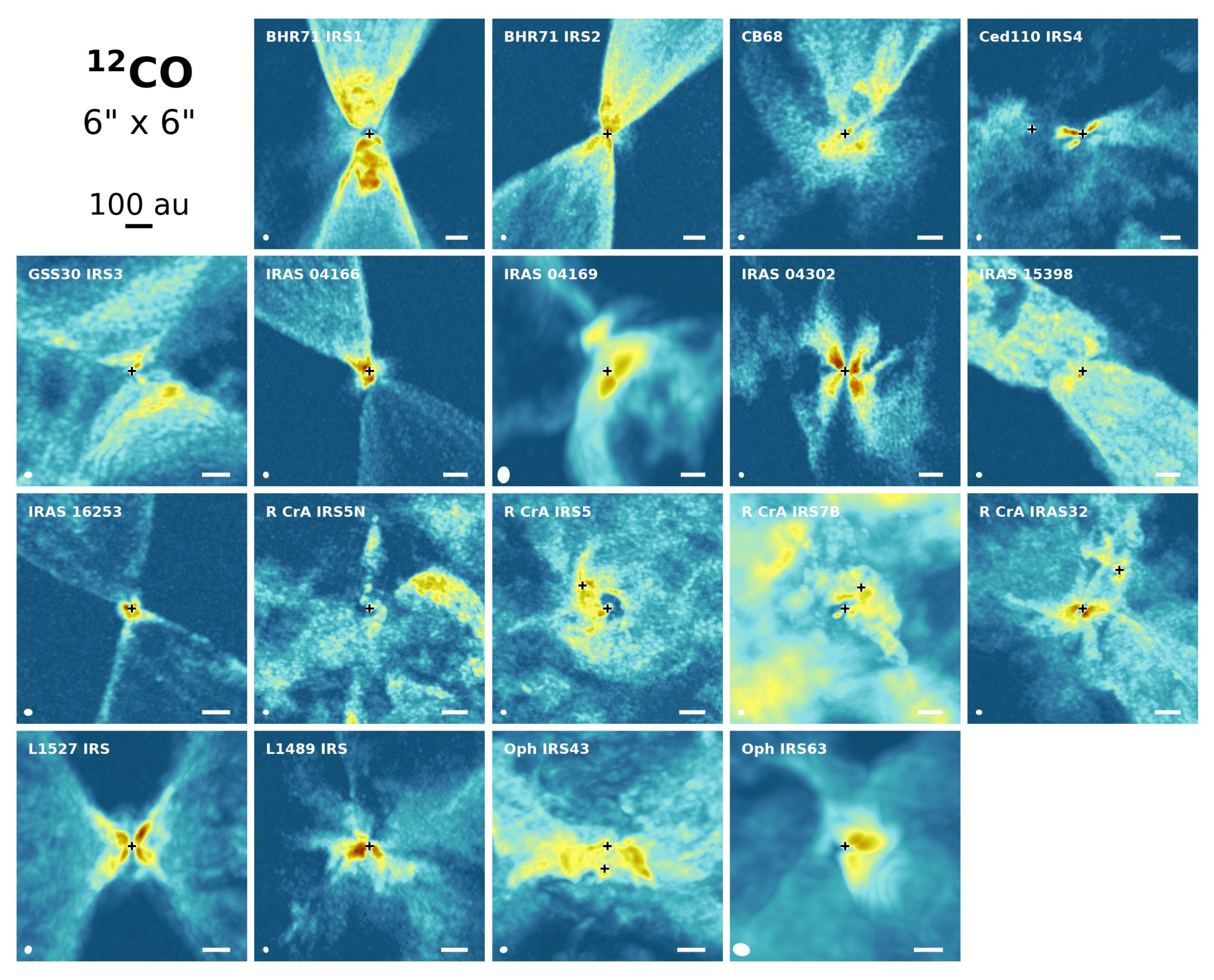
ALMA

ALMA WSU

JWST

Molecular lines

Physical and chemical structure of young disks



^{12}CO mainly traces outflows

eDisk: Sharma et al. subm

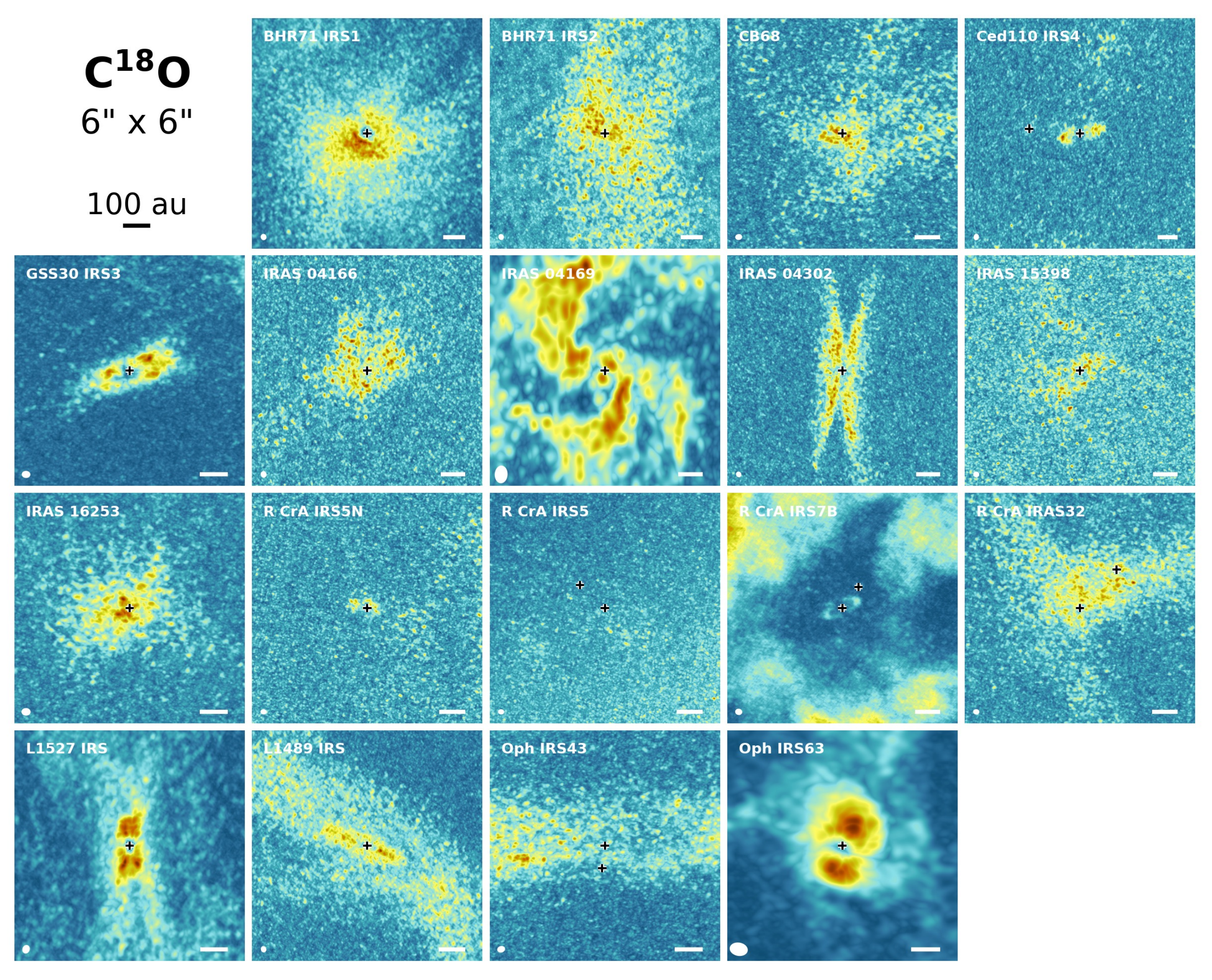
ALMA

ALMA WSU

JWST

MOLECULAR LINES

Physical and chemical structure of young disks



$C^{18}O$ mainly traces disk (and some envelope)

eDisk: Sharma et al. subm

ALMA

ALMA WSU

JWST

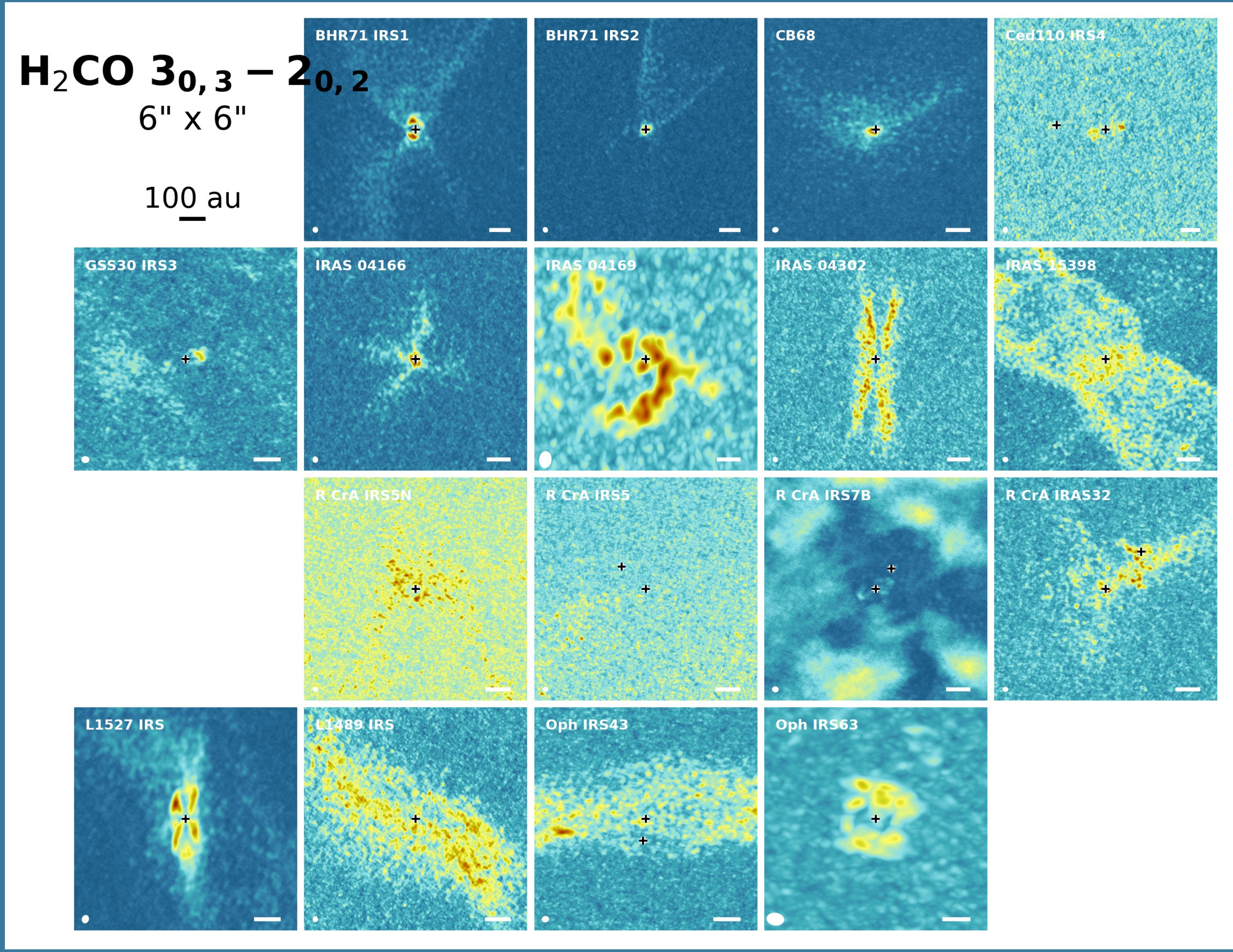
Molecular lines

Physical and chemical structure of young disks

ALMA

ALMA WSU

JWST

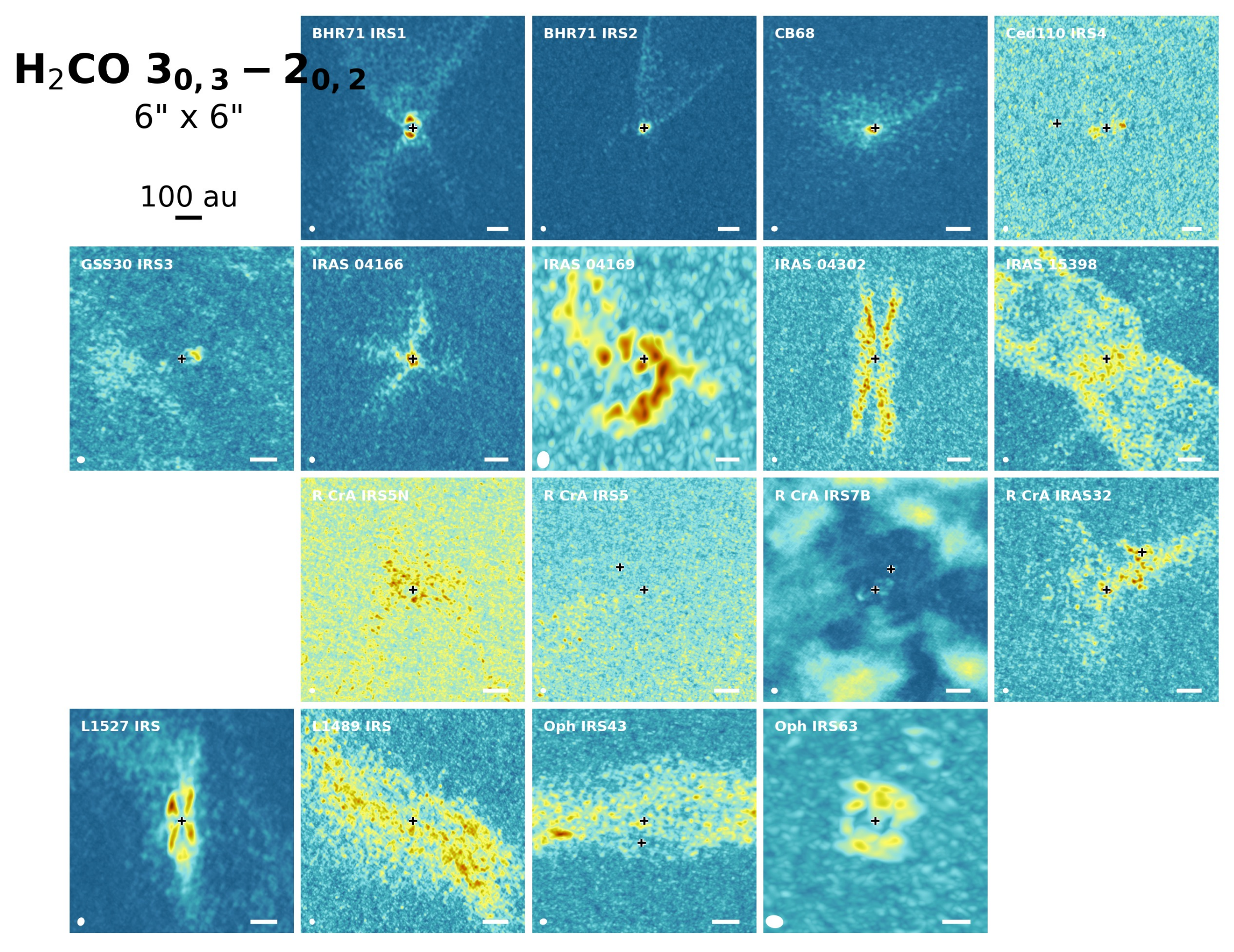


H_2CO can trace different components

eDisk: Sharma et al. subm

Molecular lines

Physical and chemical structure of young disks

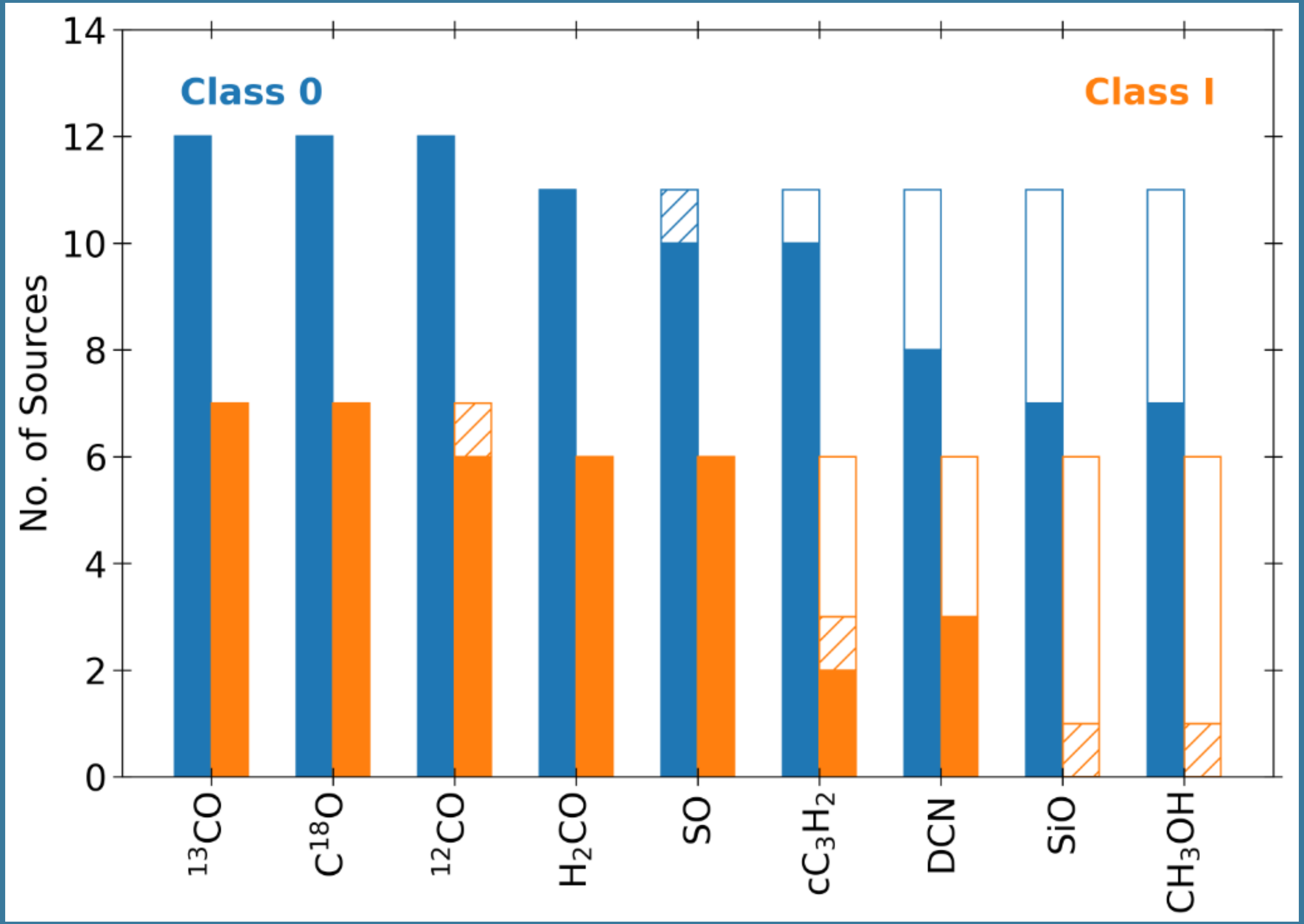


Up to a factor $\sim\sqrt{2}$ to $\sim\sqrt{3}$ deeper

eDisk: Sharma et al. subm

Molecular lines

Physical and chemical structure of young disks



eDisk: Sharma et al. subm

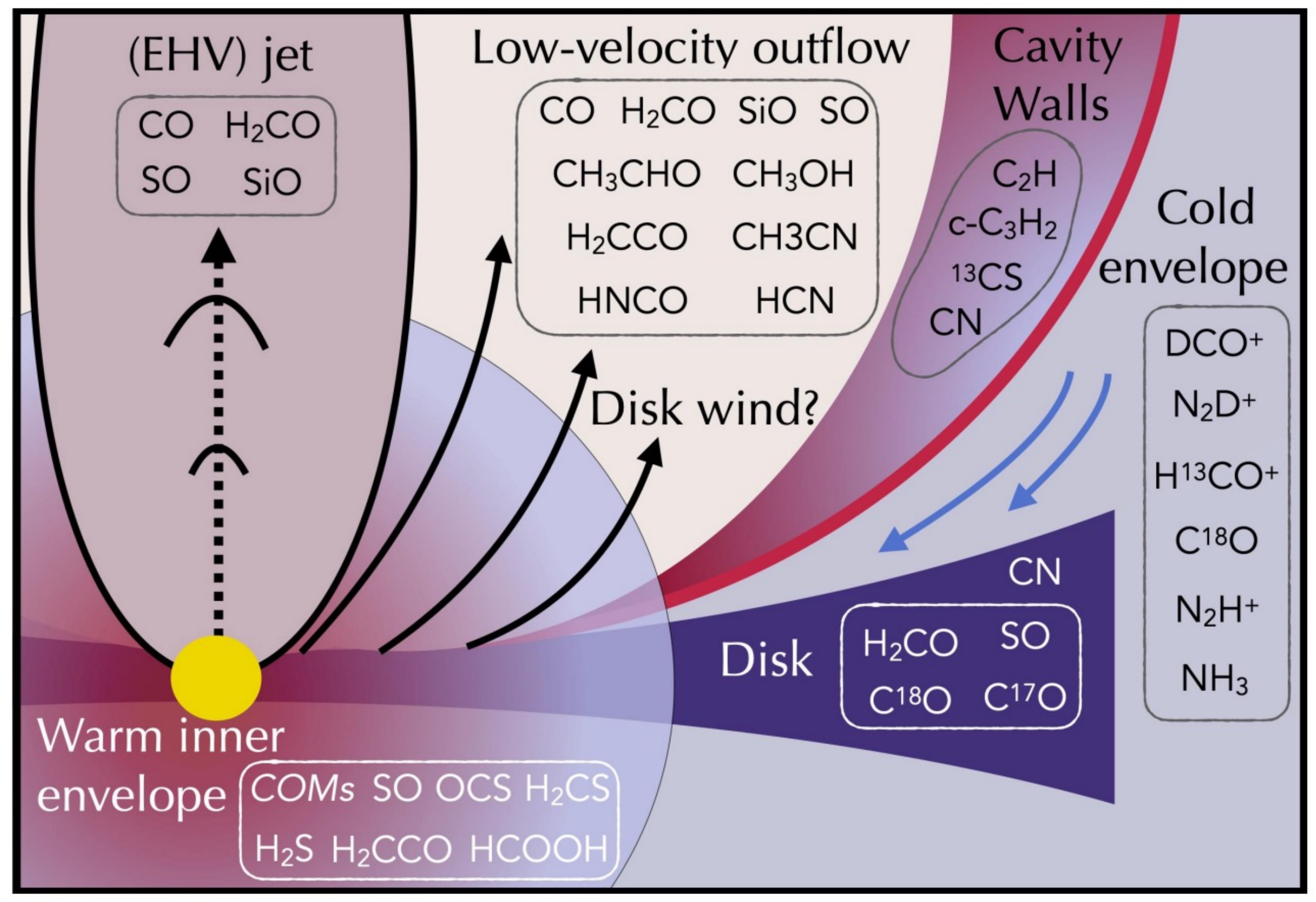
ALMA

ALMA WSU

JWST

Molecular lines

Physical and chemical structure of young disks



6 different programs:
27 species
(incl. isotopologues)

Tychoniec et al. 2021

ALMA

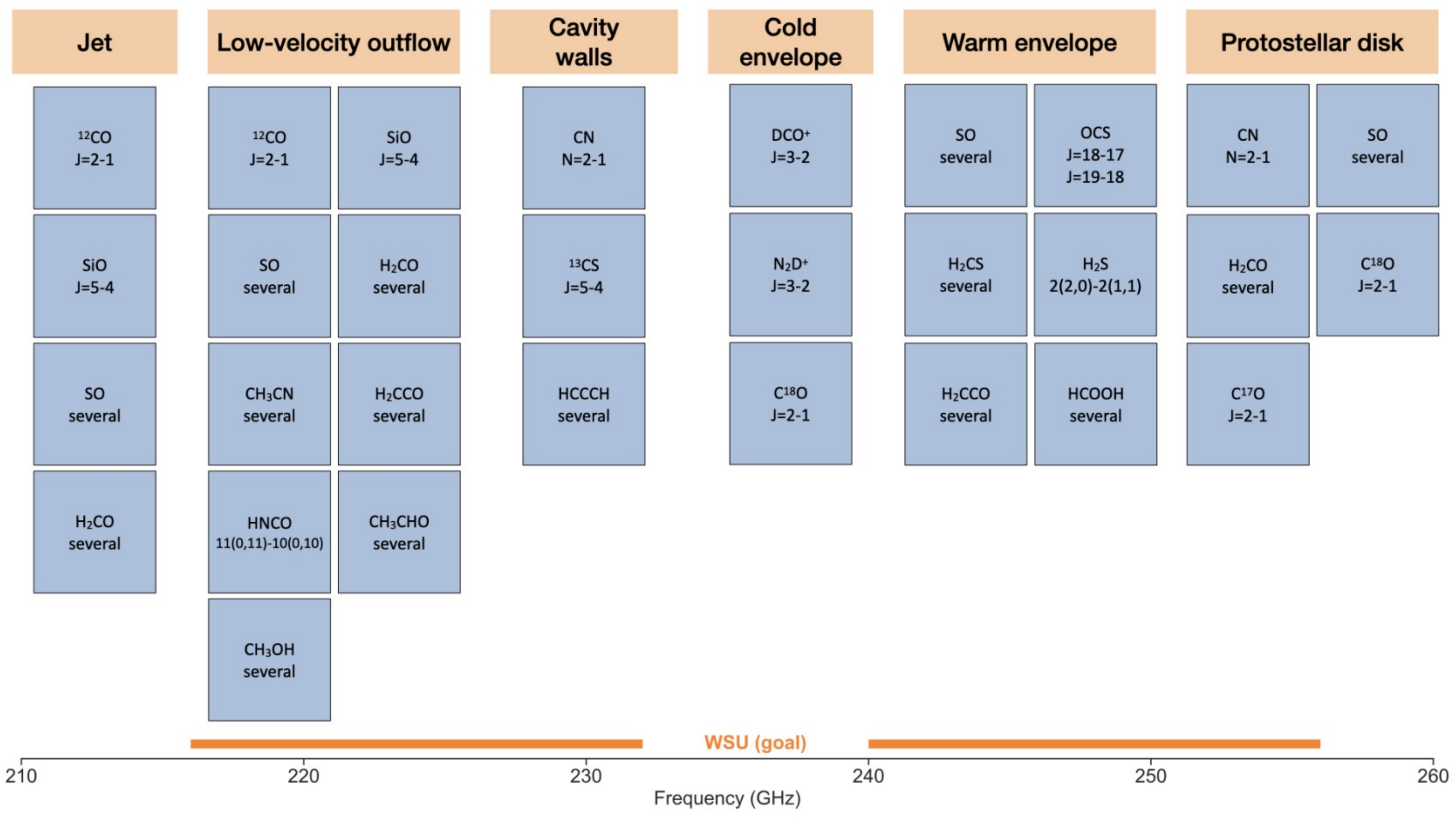
ALMA WSU

JWST

ALMA

Molecular lines

Physical and chemical structure of young disks



All these species (and more) in one tuning

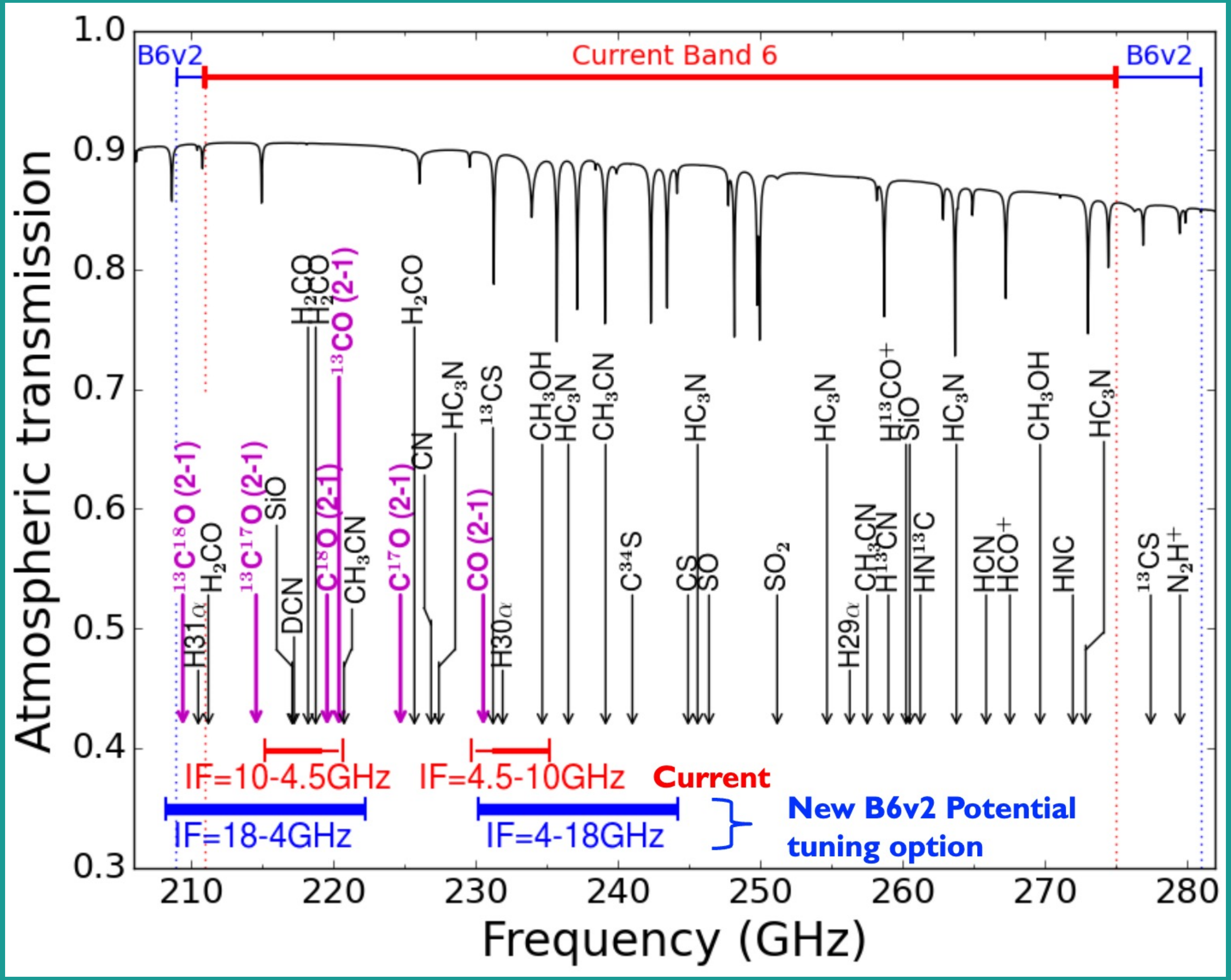
Carpenter et al. 2022

ALMA WSU

JWST

Molecular lines

Physical and chemical structure of young disks



New Band 6 will cover $^{13}C^{18}O$ and N_2H^+

ALMA

ALMA WSU

JWST

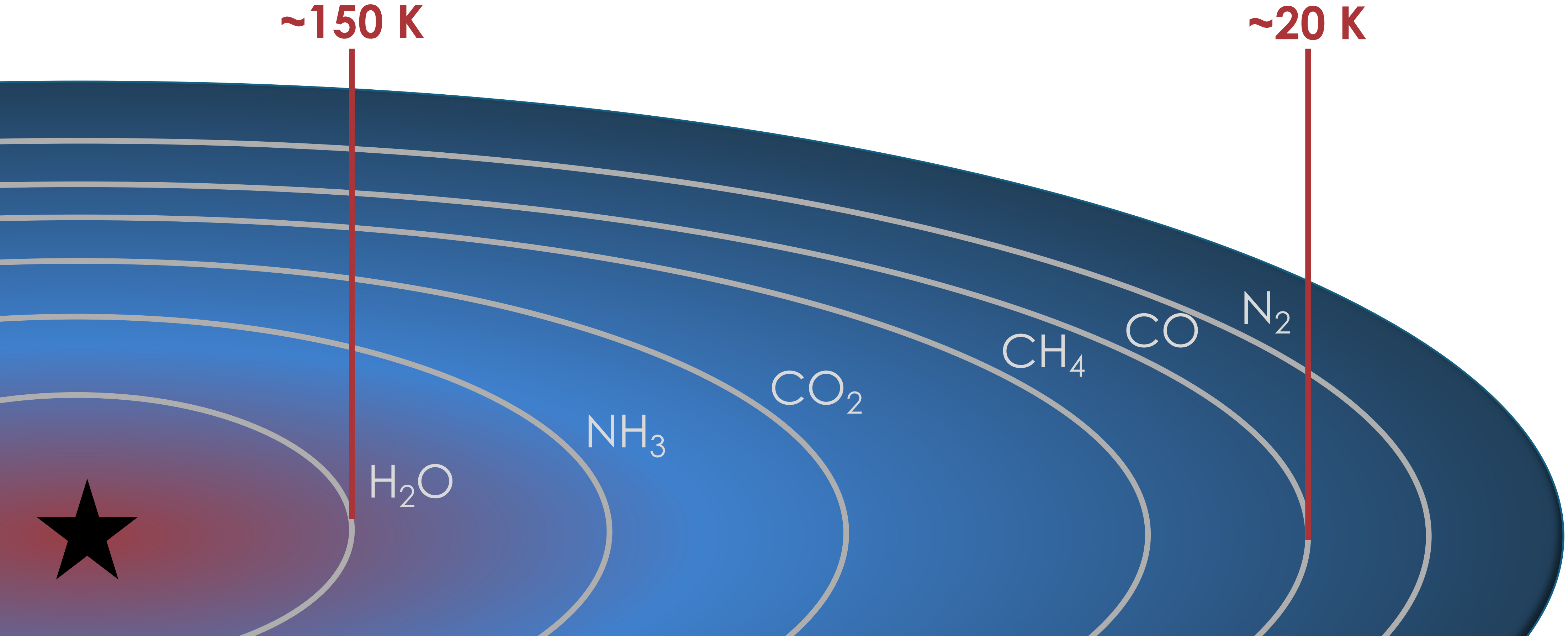
Molecular lines

Temperature structure

ALMA

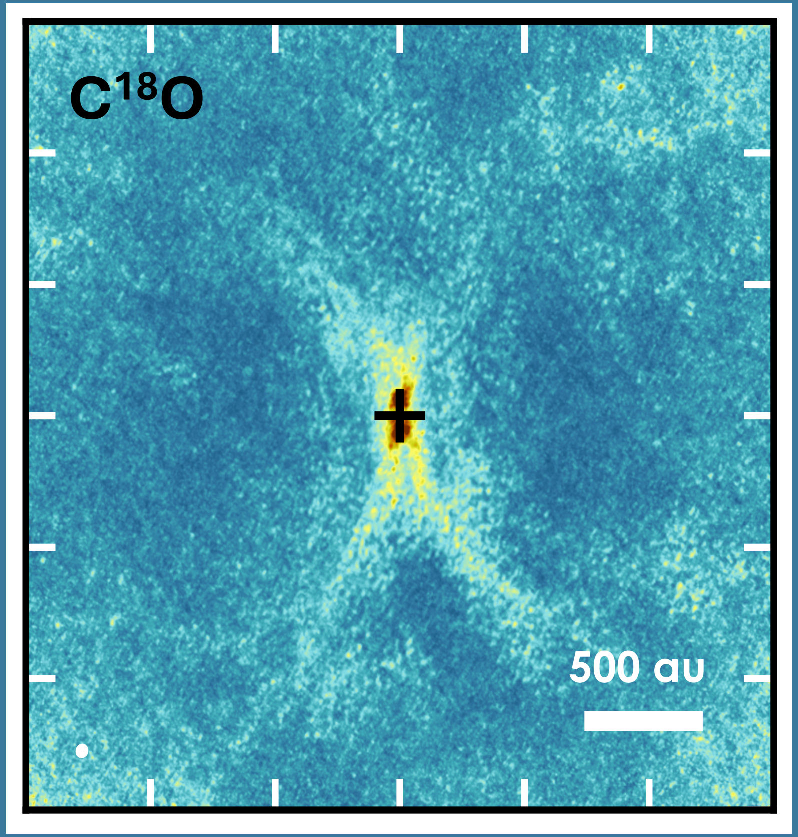
ALMA WSU

JWST



Molecular lines

Temperature structure



eDisk: van 't Hoff et al. 2023

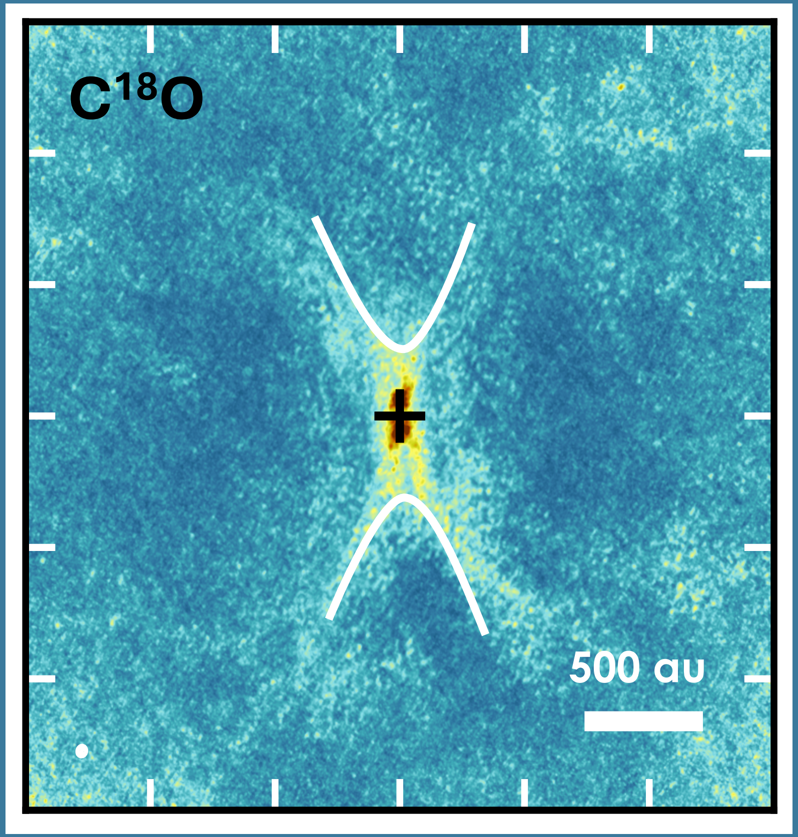
ALMA

ALMA WSU

JWST

Molecular lines

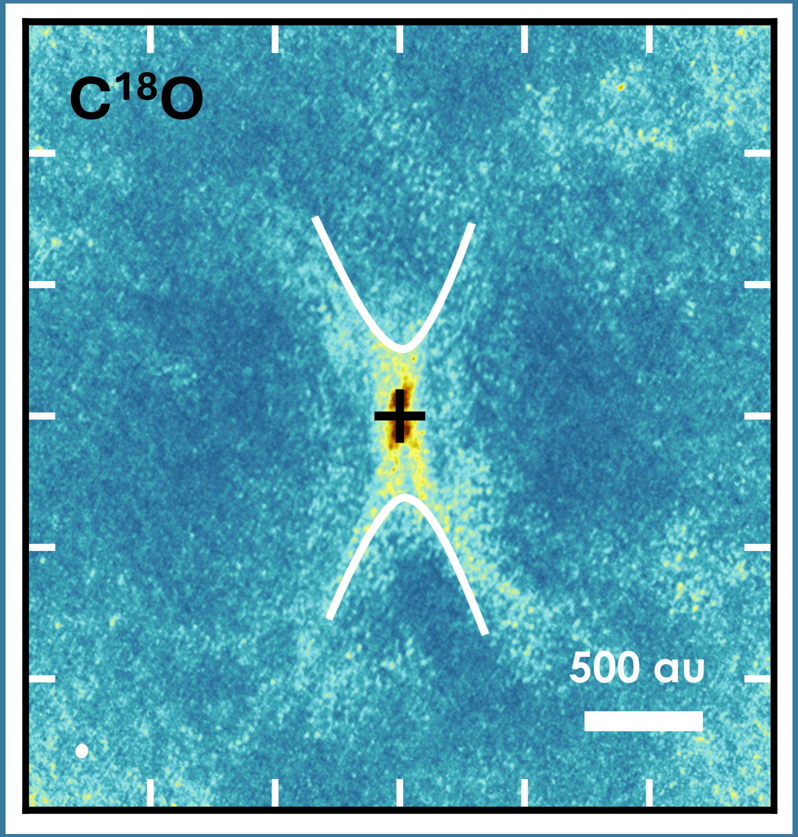
Temperature structure



eDisk: van ‘t Hoff et al. 2023

Molecular lines

Temperature structure



eDisk: van 't Hoff et al. 2023

CO snowline outside the disk:
Disk warmer than ~20 K

See also van 't Hoff et al. 2018, 2020

ALMA

ALMA WSU

JWST

Molecular lines

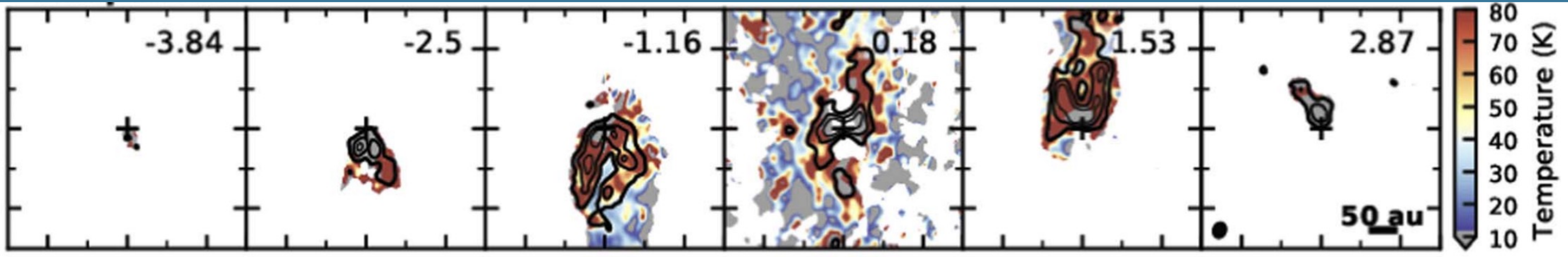
Temperature structure

ALMA

ALMA WSU

JWST

Temperature in velocity channels from the ratio of two H_2CO transitions



eDisk: van 't Hoff et al. 2023

Molecular lines

Temperature structure

- Increased imaging speed (~2.2x) will make it easier to do
  - Deeper observations
  - Higher resolution observations
  - Larger samples
  - Observations of different transitions from a molecule in different Bands

- Increased bandwidth will allow more temperature probes to be observed simultaneously

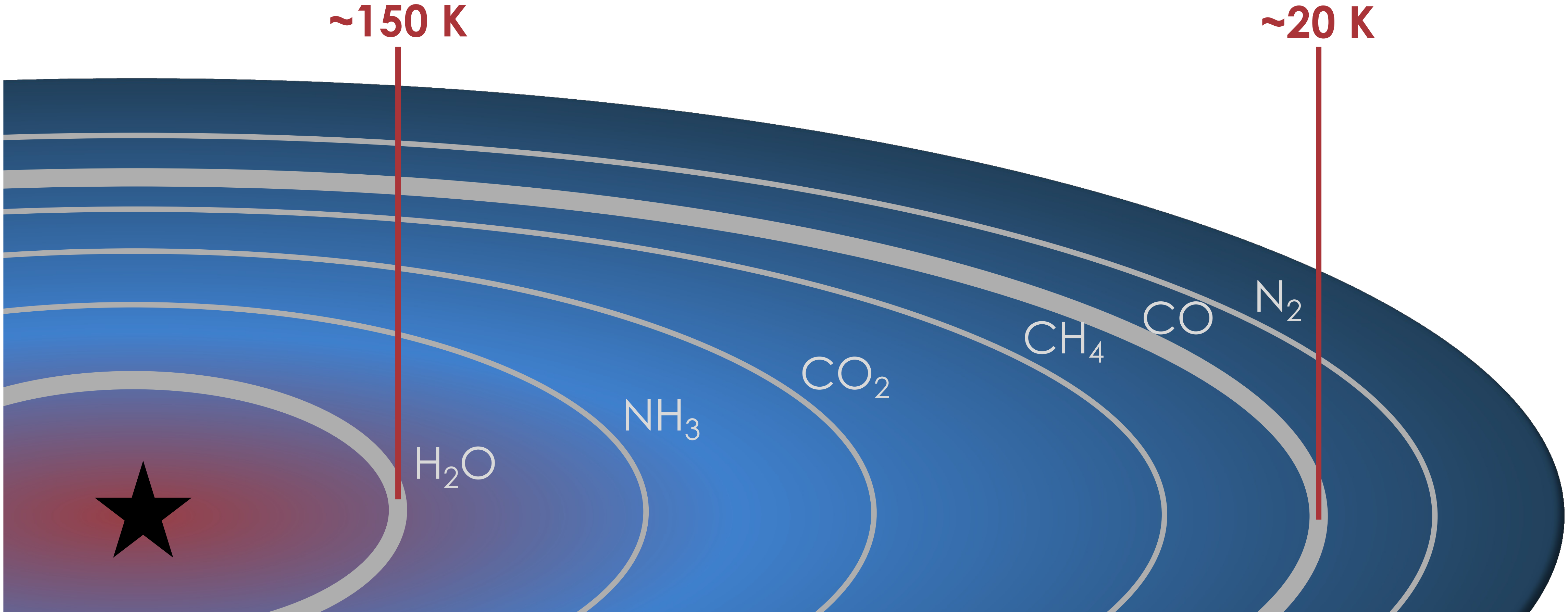
ALMA

ALMA WSU

Molecular lines

Temperature structure

JWST



ALMA

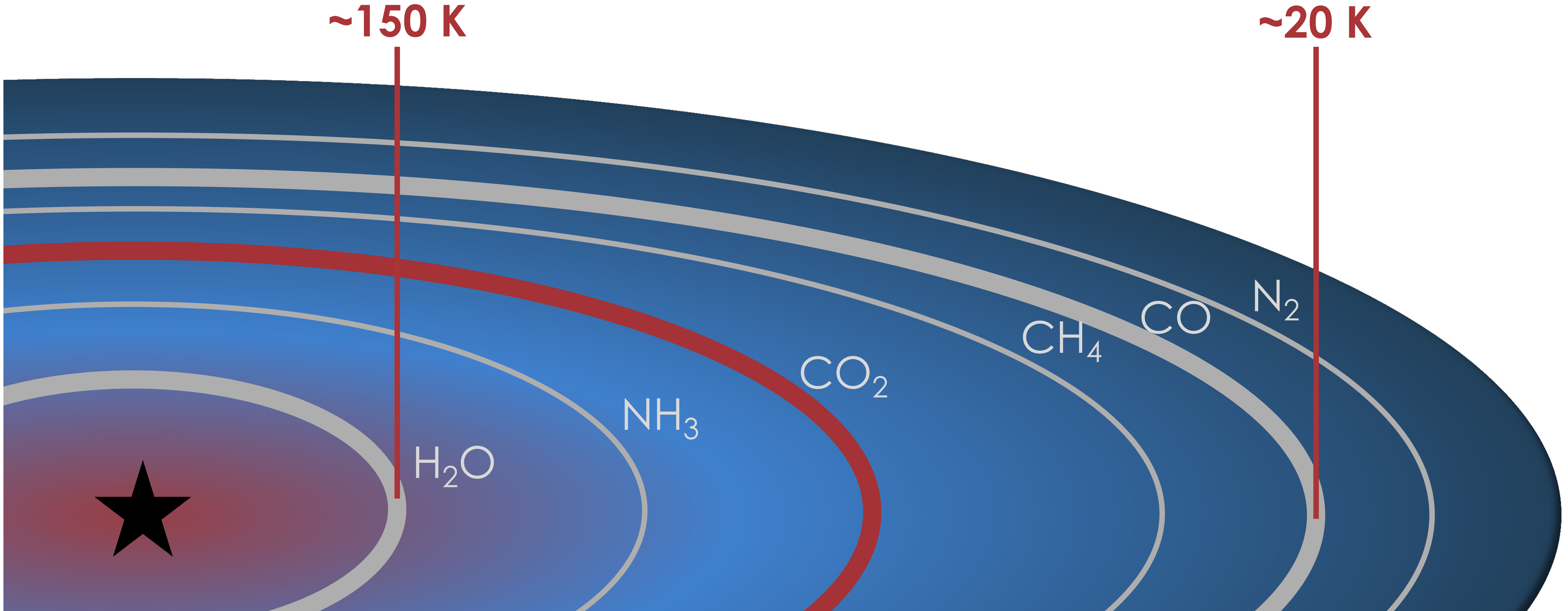
ALMA WSU

Molecular lines

Temperature structure

JWST

Kaçan et al. in prep.



ALMA

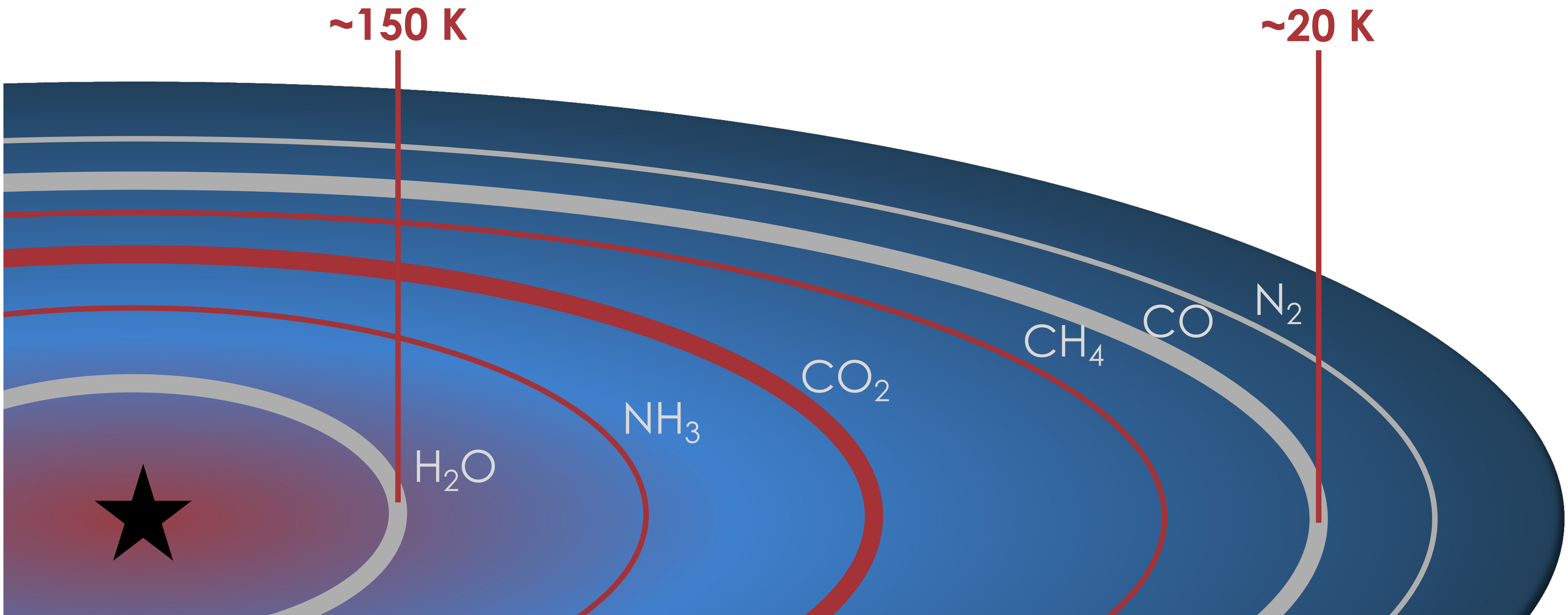
ALMA WSU

MOLECULAR LINES

JWST

Temperature structure

Kaçan et al. in prep.

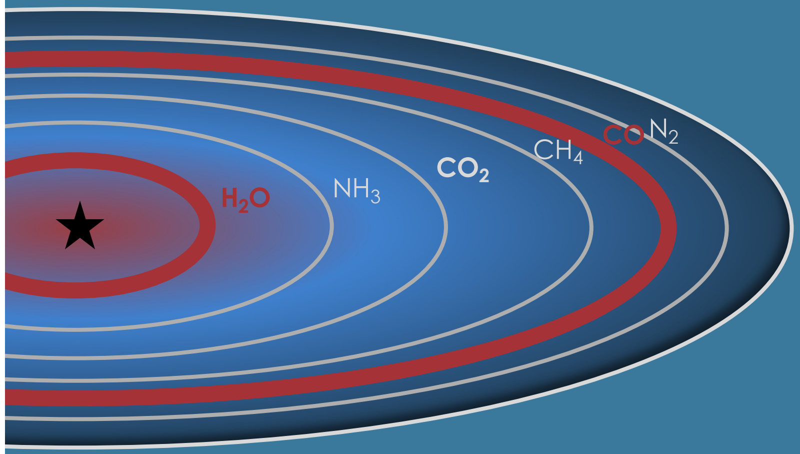


Molecular lines

Physical and chemical structure of young disks

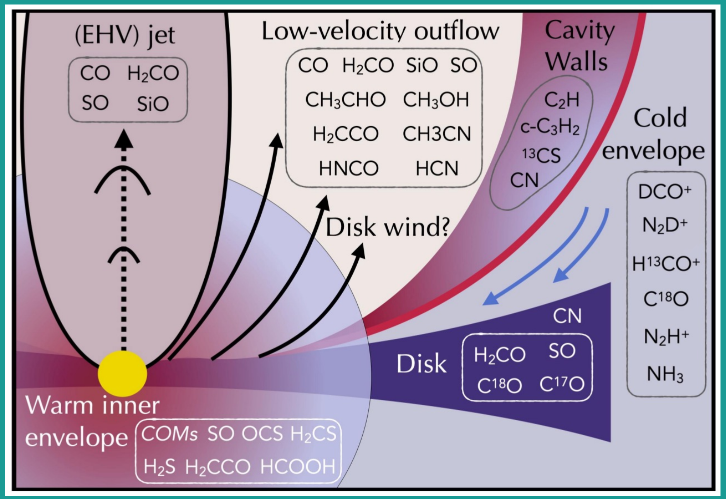
ALMA

Young disks traced by $C^{18}O$; Too warm for CO ice



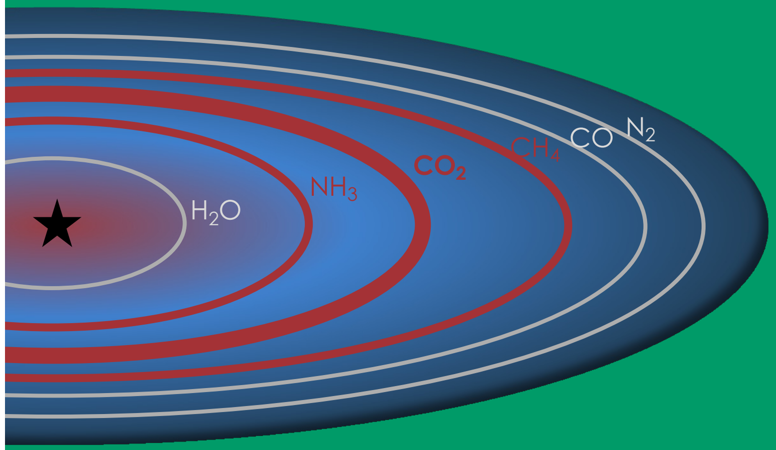
ALMA WSU

Study many tracers simultaneously



JWST

Complementary info on molecules without rotational transitions



Molecular lines

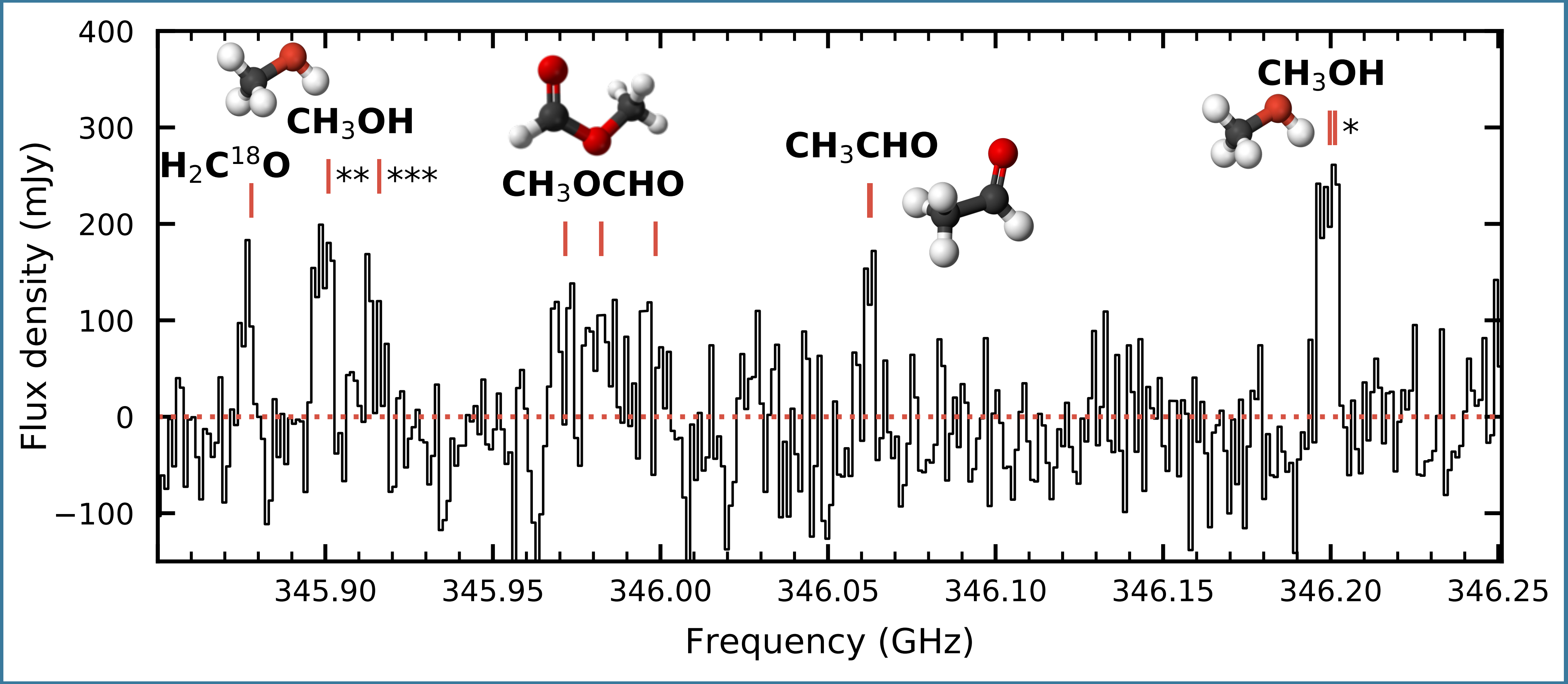
Chemical complexity

ALMA

ALMA WSU

JWST

V883 Ori (1 minute with ALMA)

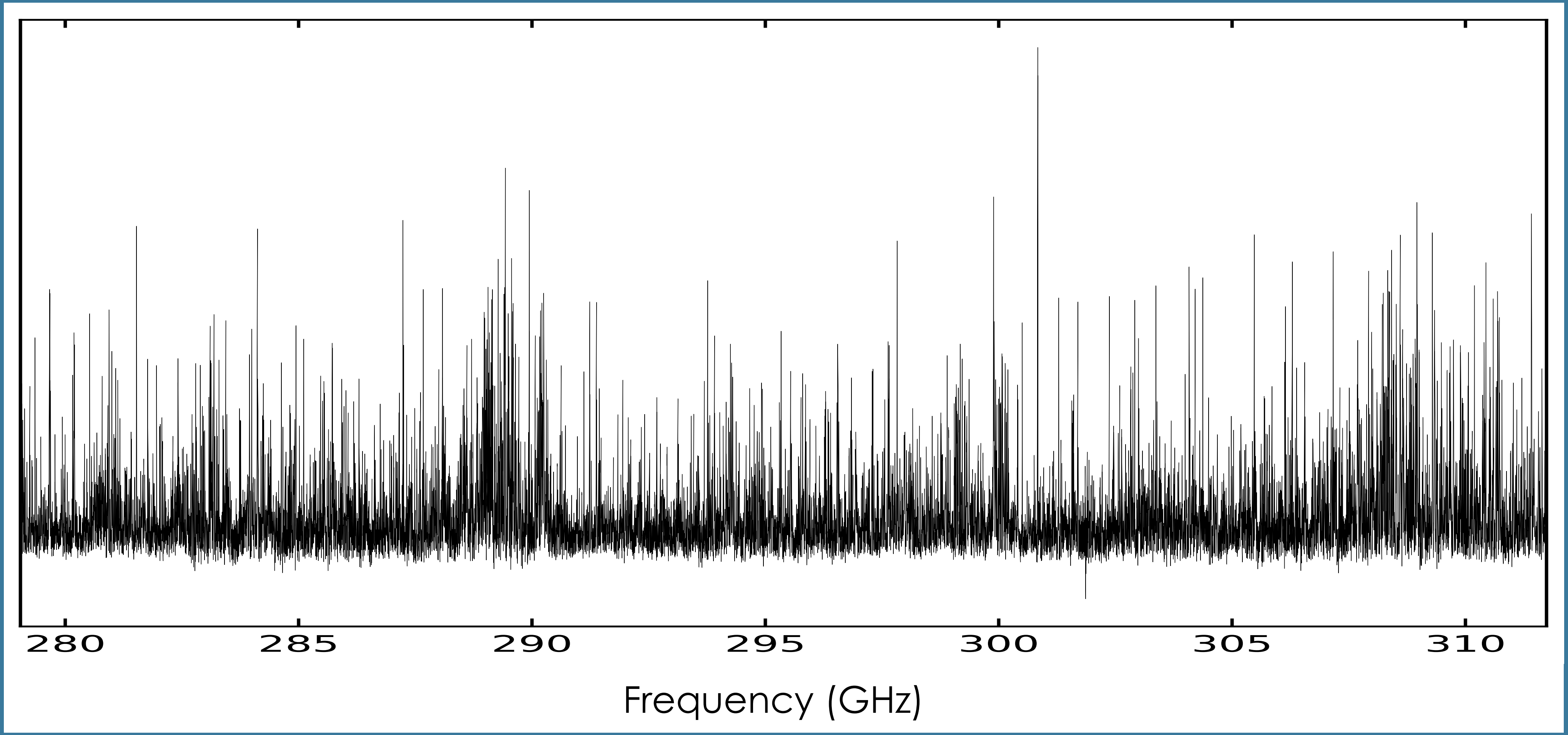


van 't Hoff et al. 2018 (see also Lee et al. 2019; Yamato et al. 2024; Jeong et al. 2024)

Molecular lines

Chemical complexity

V883 Ori with COMPASS Large Program (PI: Jes Jørgensen)



ALMA

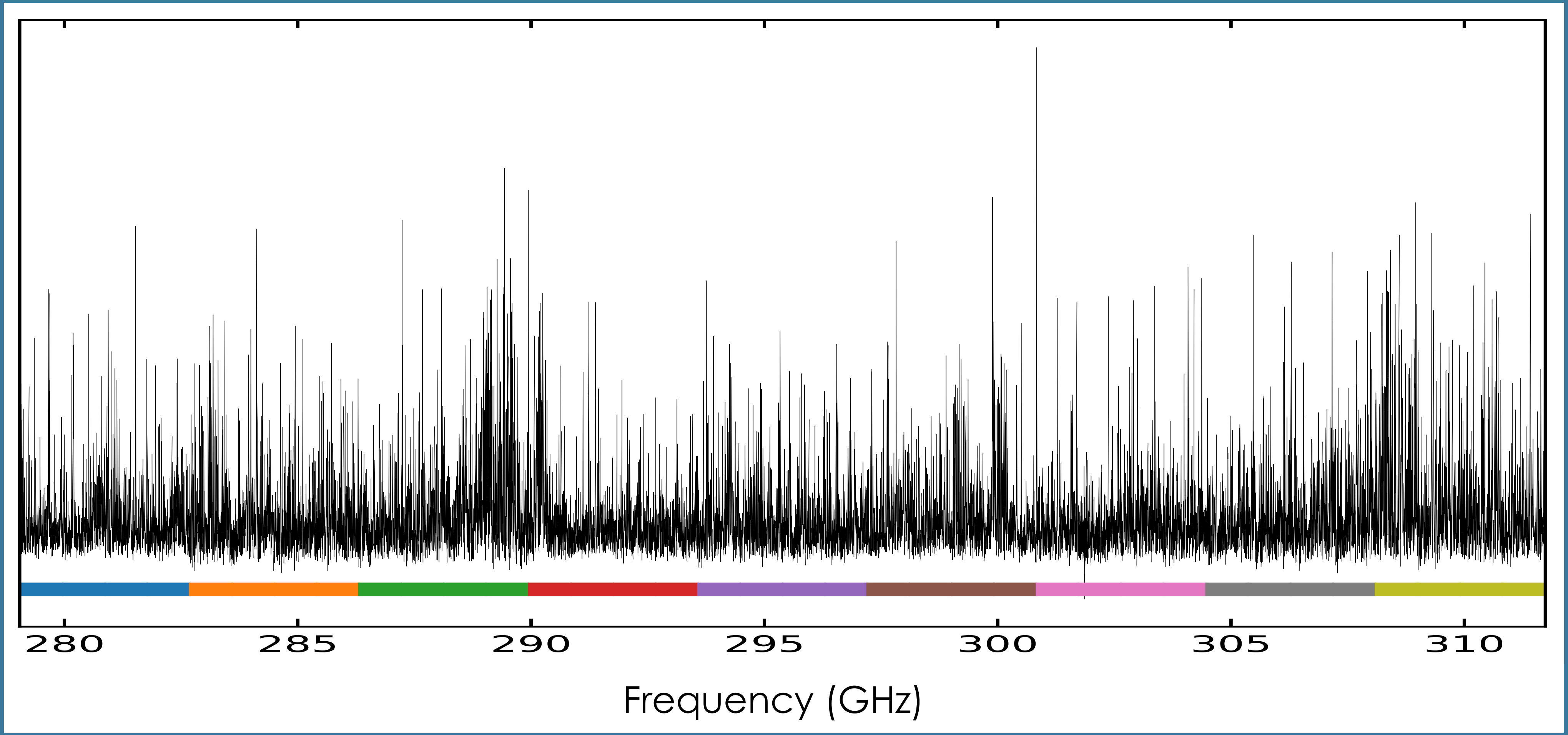
ALMA WSU

JWST

Molecular lines

Chemical complexity

V883 Ori with COMPASS Large Program (PI: Jes Jørgensen)



ALMA

ALMA WSU

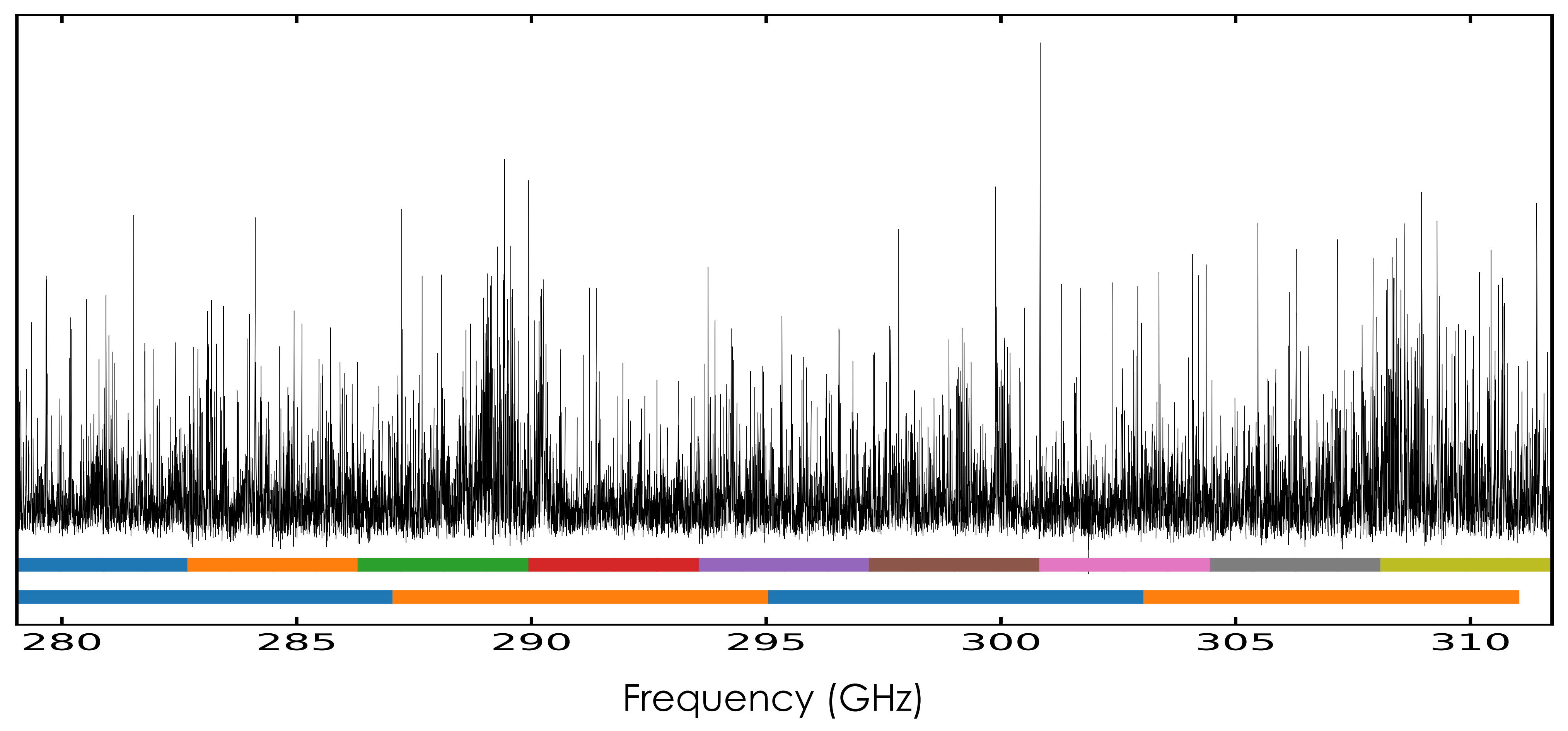
JWST

ALMA

Molecular lines

Chemical complexity

V883 Ori with COMPASS Large Program (PI: Jes Jørgensen)



ALMA WSU

JWST

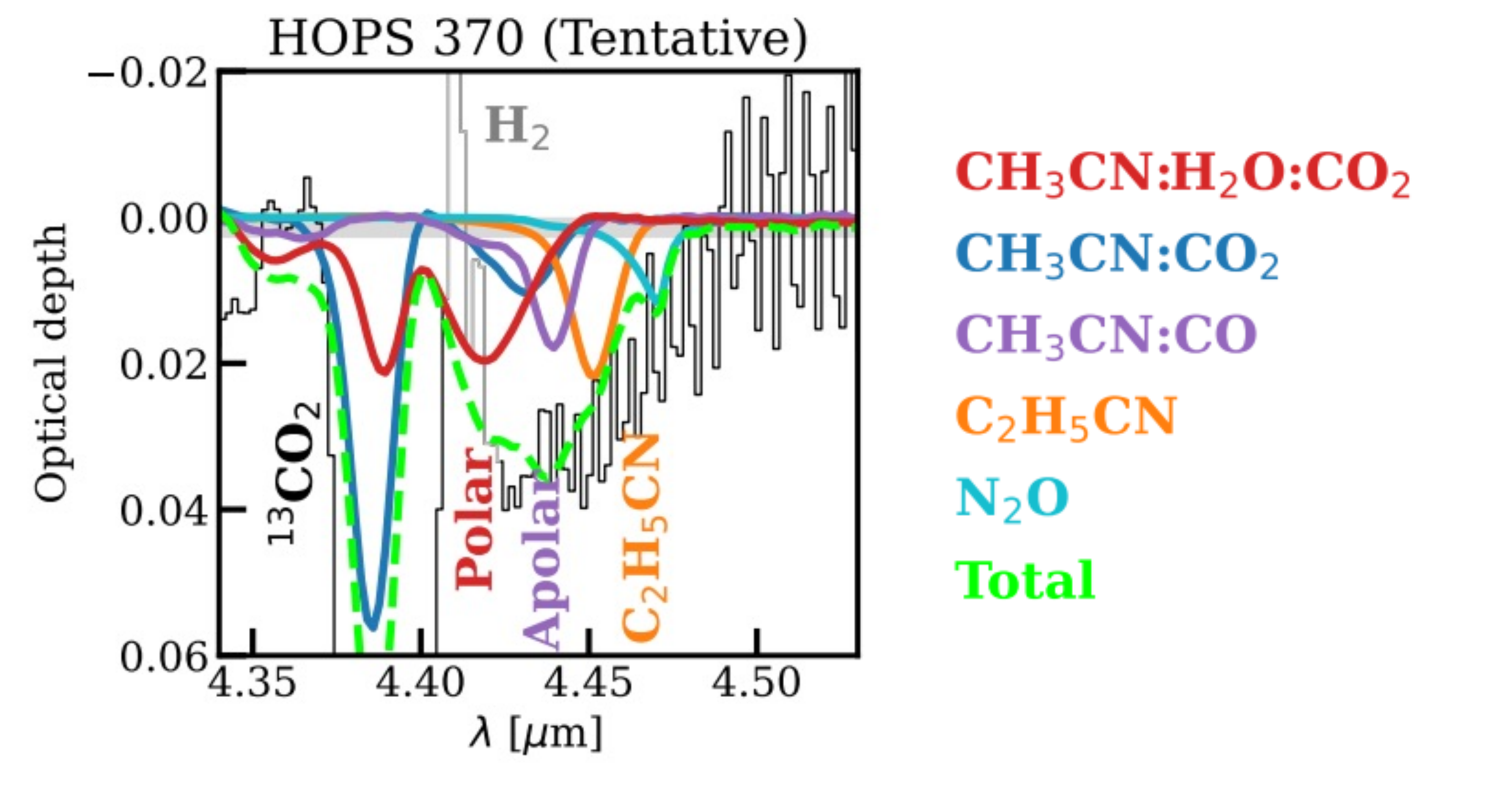
ALMA

ALMA WSU

JWST

Molecular lines

Chemical complexity



Complementary COMPASS JWST program to study ice composition in the envelope

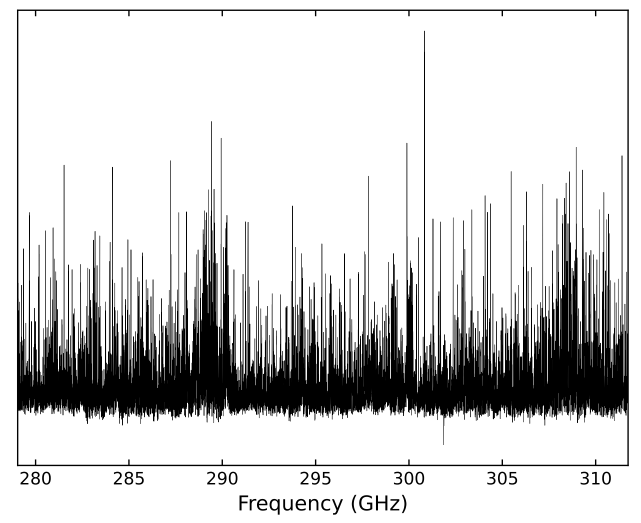
Nazari et al. 2024

Molecular lines

Chemical complexity in young disks

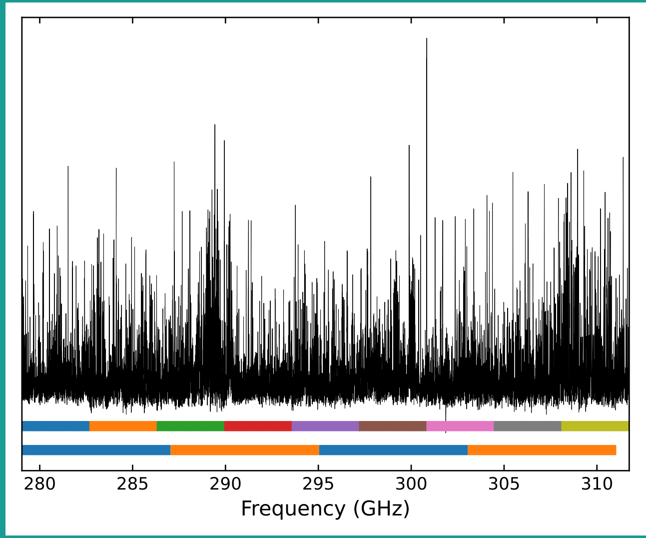
ALMA

High level of chemical complexity in young disks, but mostly frozen out



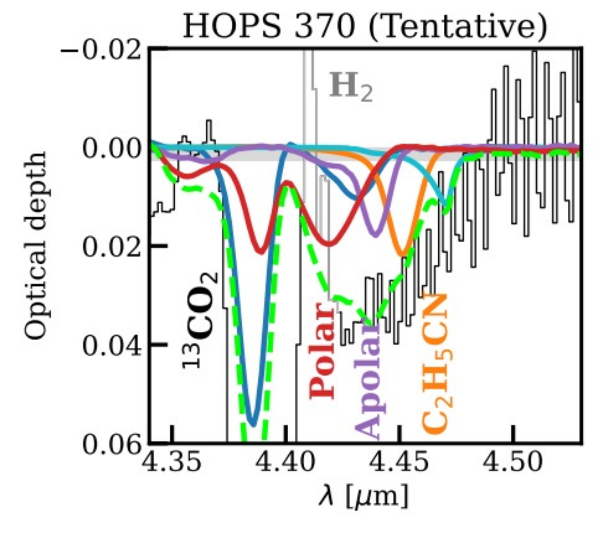
ALMA WSU

Much more efficient to study



JWST

Complemenatary info on chemical complexity in ice

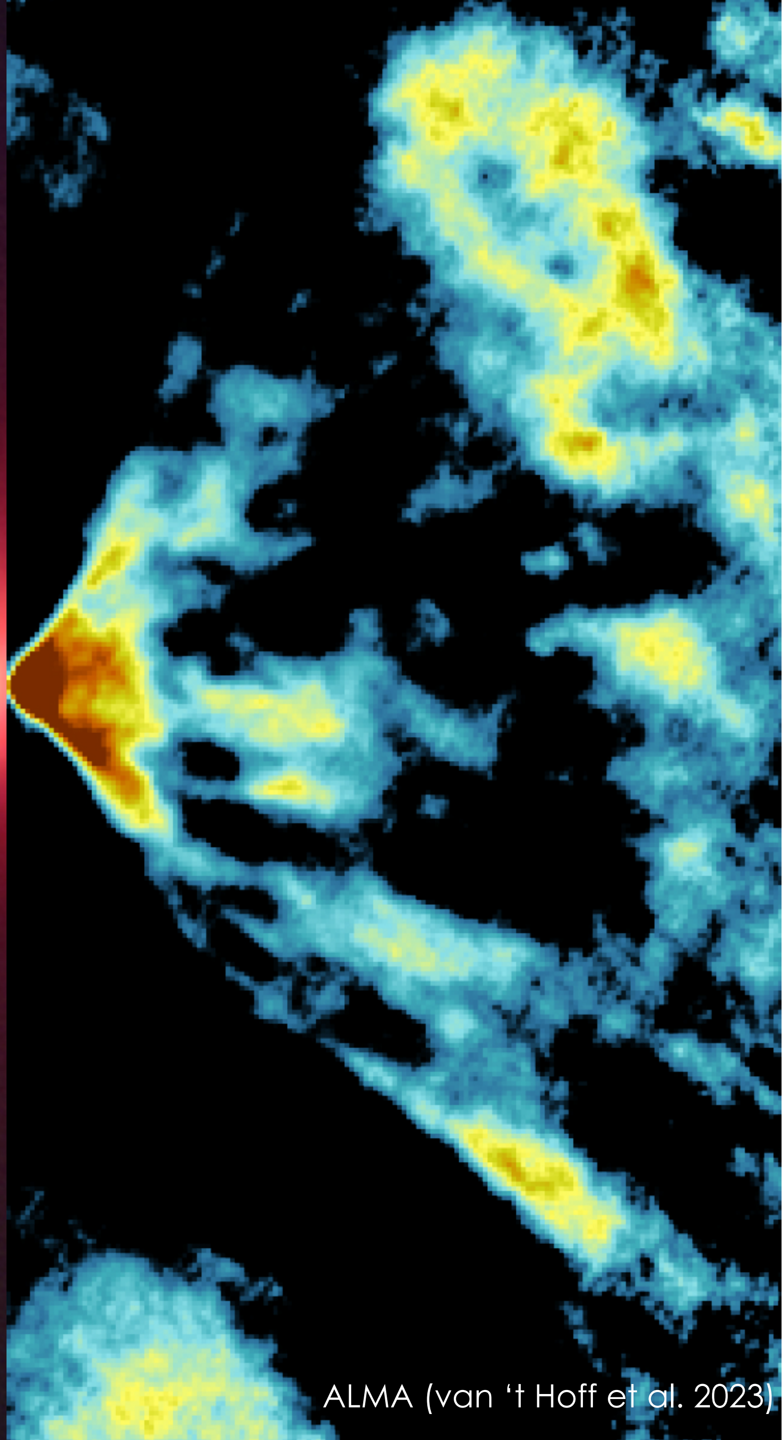


Young embedded disks:

The ALMA (WSU) and JWST era

We have only scratched the surface!

JWST NIRCam; PI: Pontoppidan



ALMA (van 't Hoff et al. 2023)