

# 5–12 pc resolution ALMA imaging of gas and dust in the obscured compact nucleus of IRAS 17578-0400

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w/ Susanne Aalto, Sabine König, and the HIDDeN ([hidden-nuclei.org](http://hidden-nuclei.org)) team

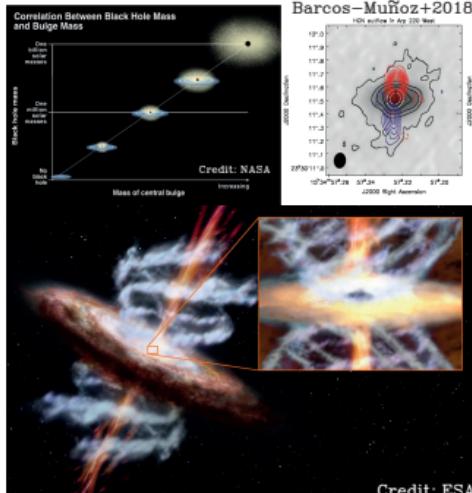
Chalmers University of Technology



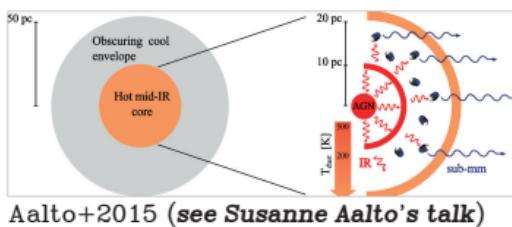
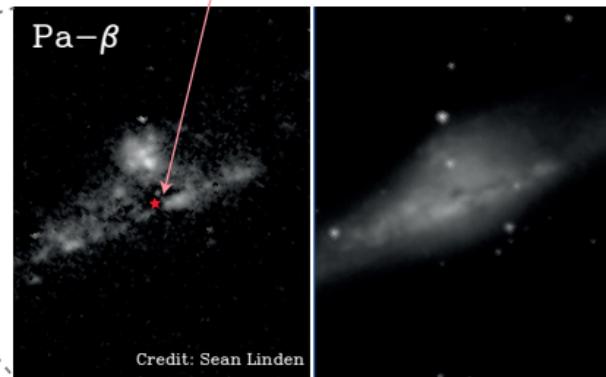
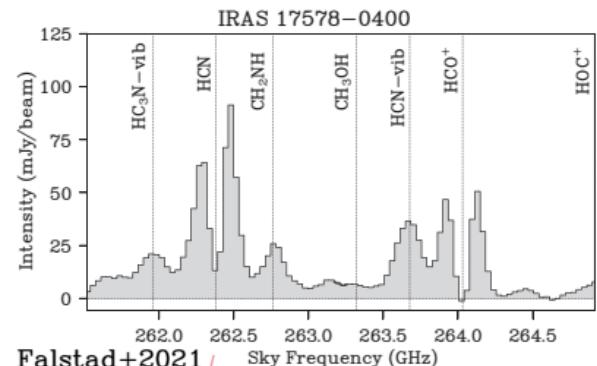
15 March 2023 @ IAUS378, Haifa

What are CONs and why they matter

# What are compact obscured nuclei (CONs) and IRAS 17578-0400



- $L_{\text{IR}}: 2.3 \times 10^{11} L_{\odot}$  (a LIRG)
- HCN-VIB:  $1.5 \times 10^4 L_{\odot}$ ,  $4.8 L_{\odot} \text{ pc}^{-2}$
- Very obscured,  $N_{\text{H}_2} > 10^{24-25} \text{ cm}^{-2}$
- Has a companion ~ interaction?
- 79 micron OH absorption doublet
  - 30km/s redshifted
- A newly discovered CON
- CONquest survey (Falstad+2021)



Background  
○

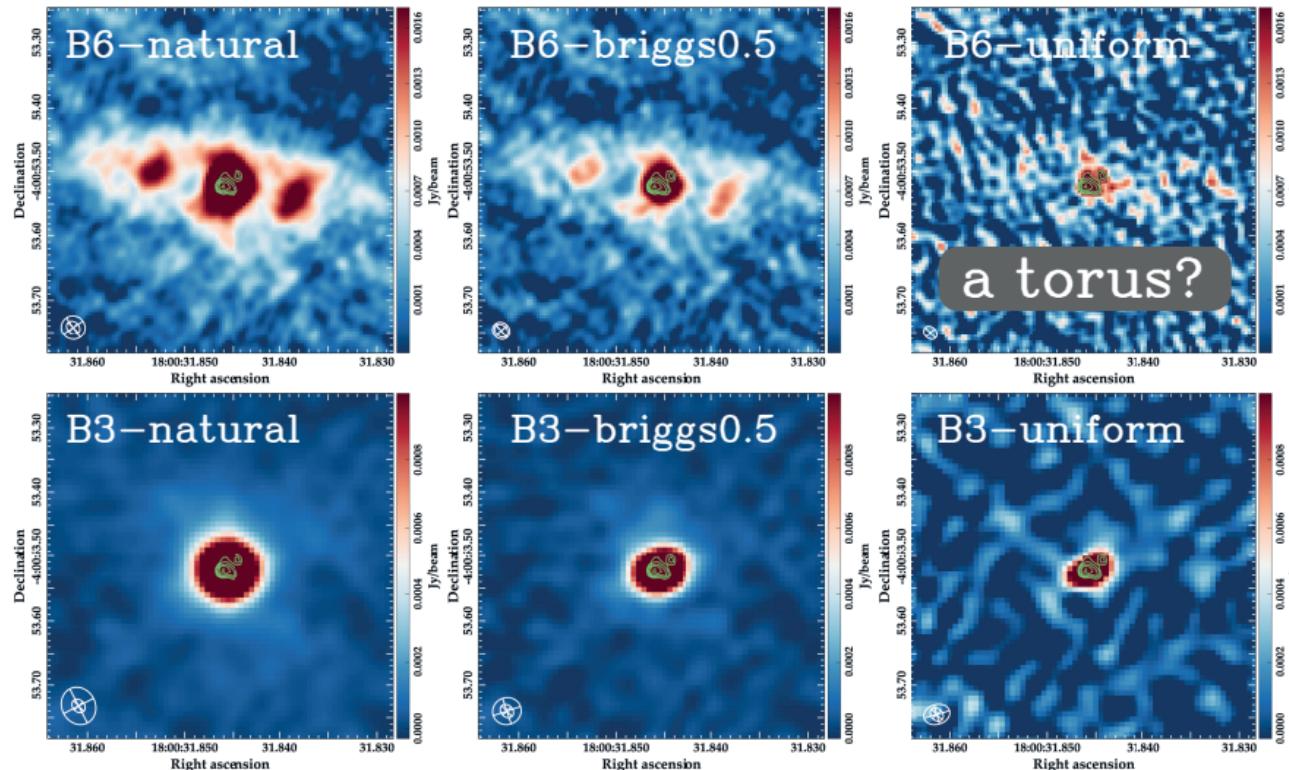
CONfirm  
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kinematic model  
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CONclusions: the structure of the CON  
○○

Puzzle pieces from the new CONfirm data

## Band 3 (B3~104GHz) and Band 6 (B6~257GHz) continuum structure



Background

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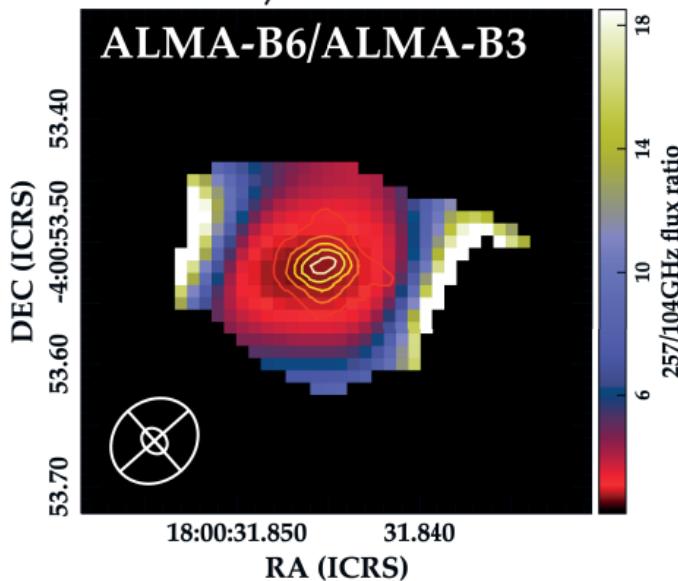
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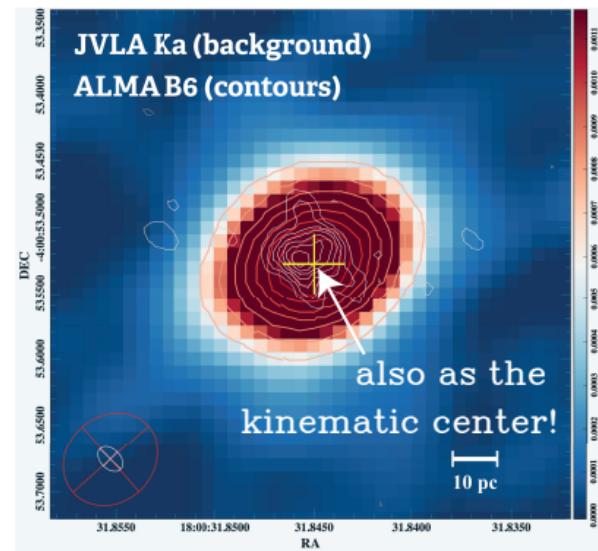
Puzzle pieces from the new CONfirm data

# We see a dust torus? (center of torus – kinematics and radio center)

~ 6 thermal ratio, lower  
ALMA B6/B3 ratio inward

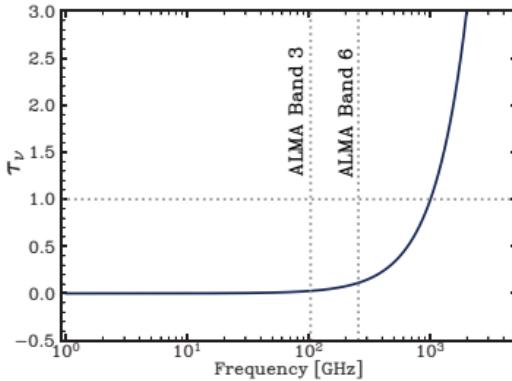
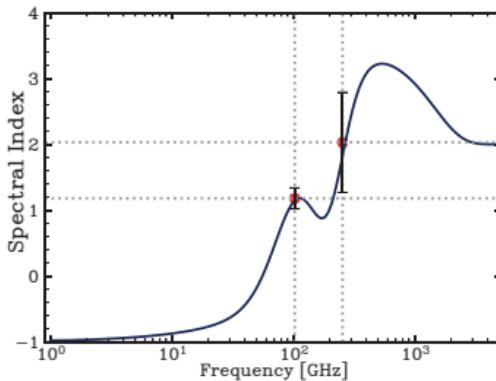
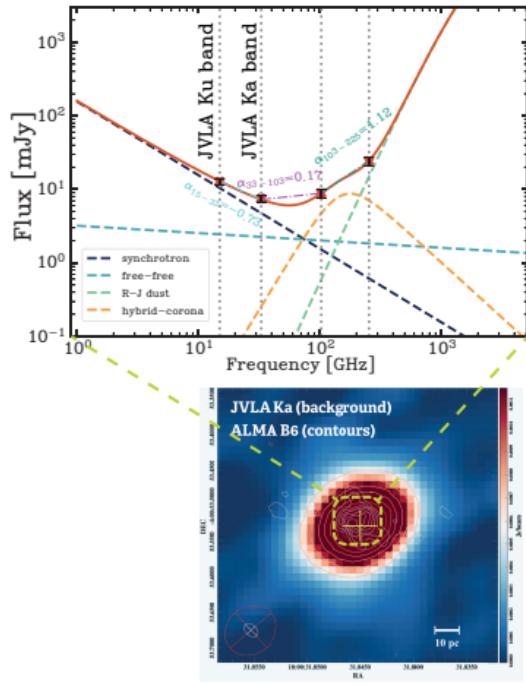


JVLA Ka band radio continuum peaks  
between two B3 dust components in



Puzzle pieces from the new CONfirm data

# Radio to mm continuum: hybrid-corona + 1mm optically thin dust?



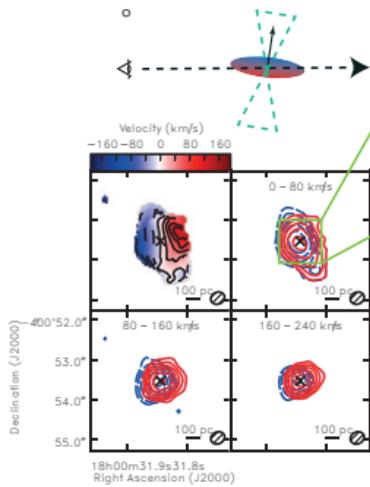
Continuum of inner  $\sim 10$  pc nuclear region:

- Unusually high ALMA B3 (103GHz) flux;
- Flat spectral index in ALMA B3 ( $\sim 1.2$ );
- Optically thick dust can not explain the spectral index;
- Synchrotron+free-free+dust can not explain the SED;
- Hybrid-corona component is needed, peaking  $\sim 150$ GHz;
- Optically thin at ALMA B6 ( $\sim 0.3$ );

Puzzle pieces from the new CONFIRM data

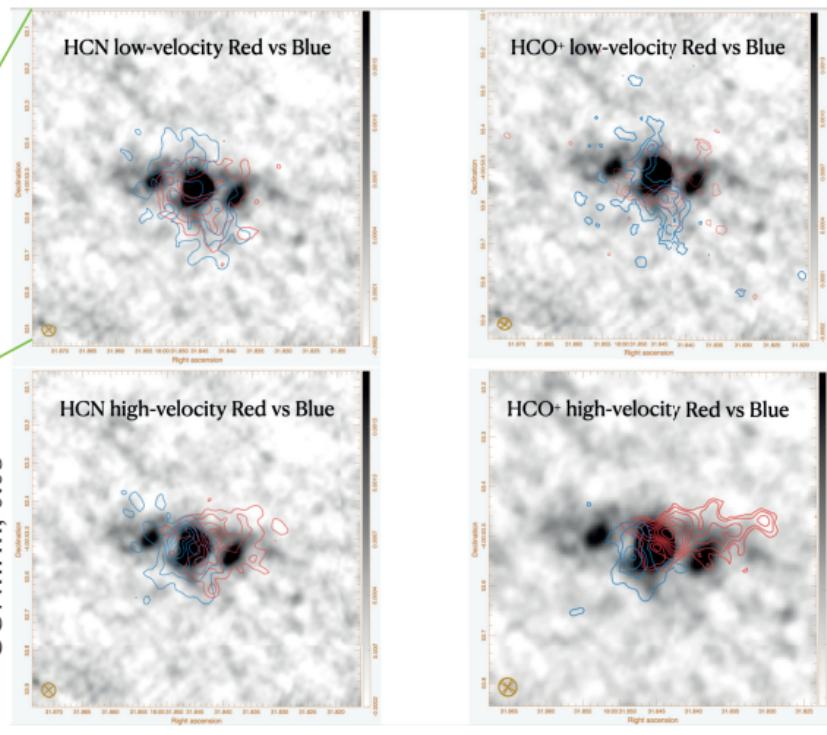
# HCN and HCO<sup>+</sup> structure: edge-on disk with collimated outflow

- Low velocity HCN/HCO<sup>+</sup>
  - collimated outflow
  - almost edge-on disk
    - low projected velocity
  - strong on the south



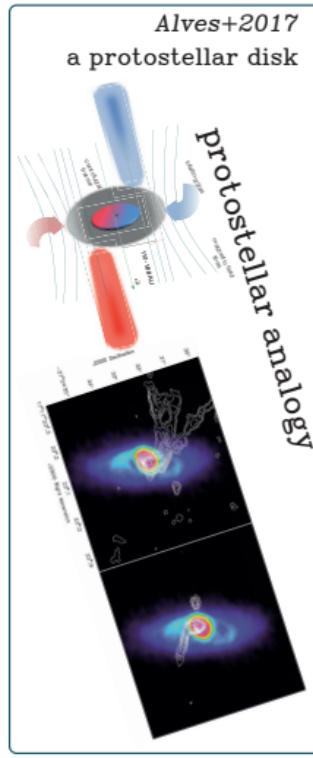
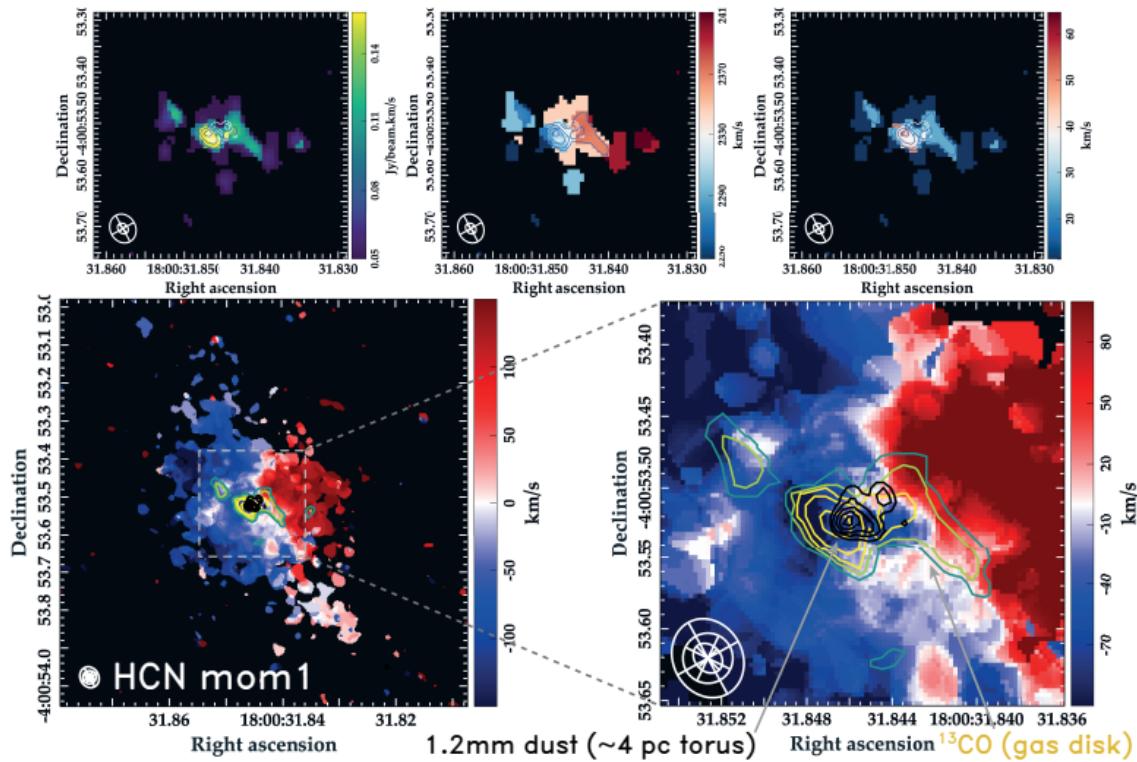
Falstad+2021 (CONquest, 0.35'')

CONFIRM, 0.03''



#### Puzzle pieces from the new CONfirm data

$^{13}\text{CO}$ , launching site of the (disk-driven?) outflow? Asymmetrical tails.



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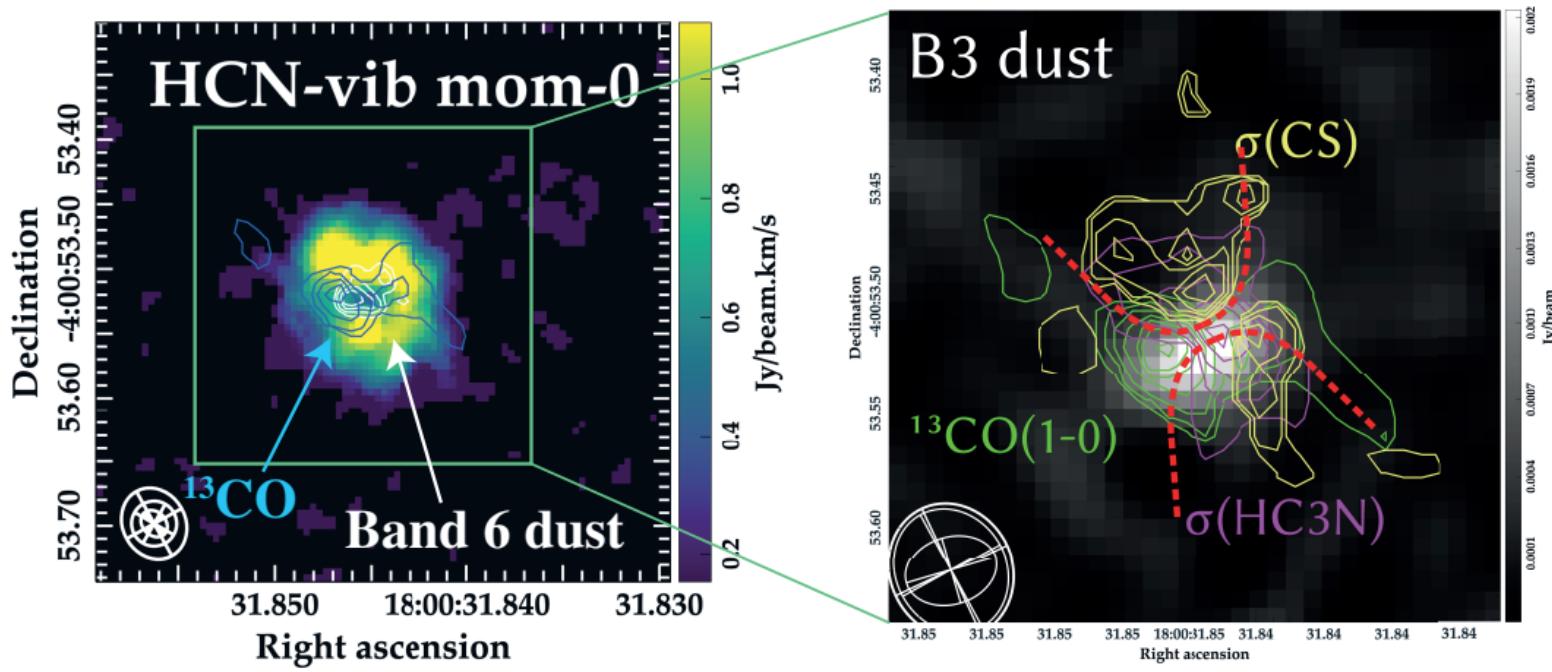
CONFIRM  
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kinematic model  
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CONclusions: the structure of the CON  
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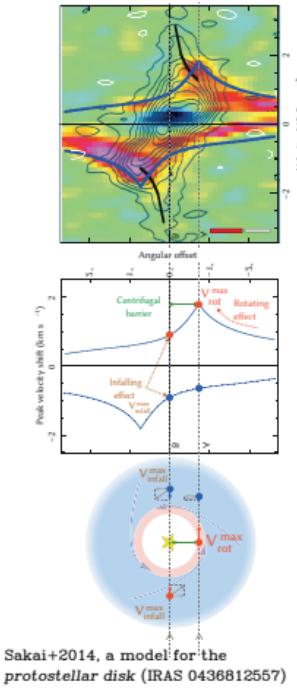
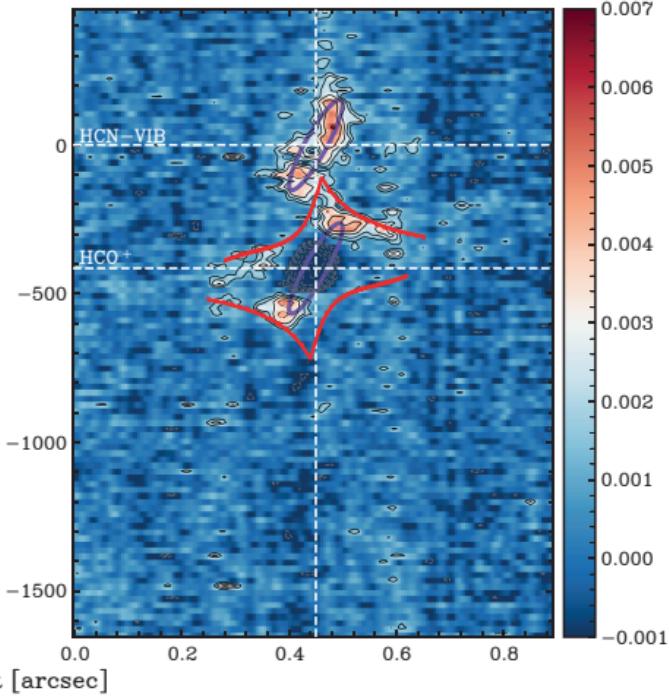
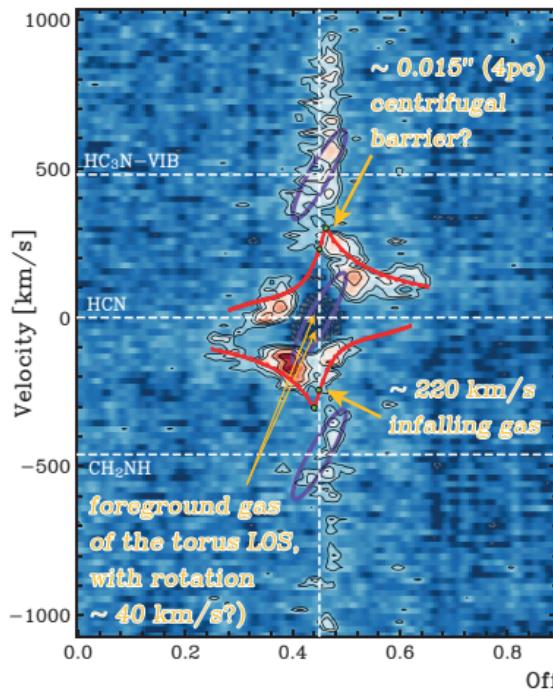
Puzzle pieces from the new CONFIRM data

HCN-VIB: circled around, and peaks at the base of the molecular outflow



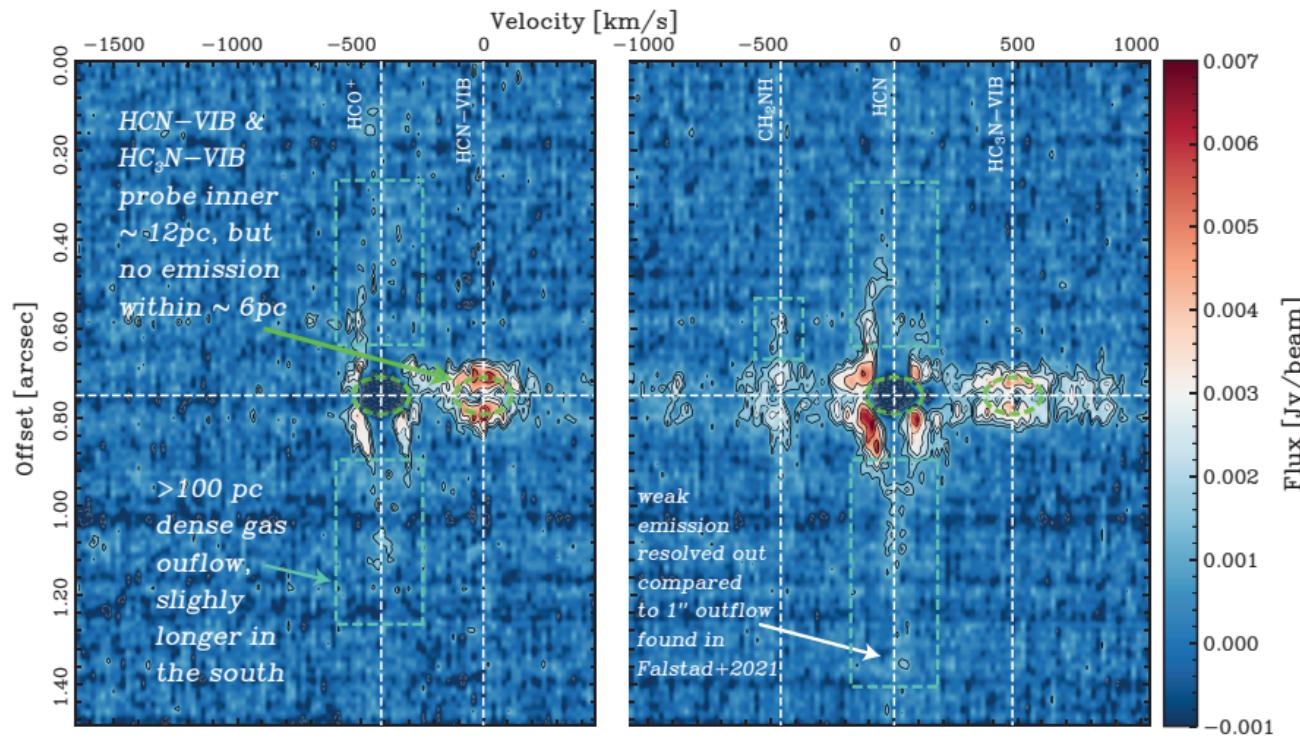
Putting the puzzle pieces together

## Dissecting the data: a flared, infalling, rotating disk



Putting the puzzle pieces together

## Dissecting the data: How about the outflows? Minor axis PV diagrams.

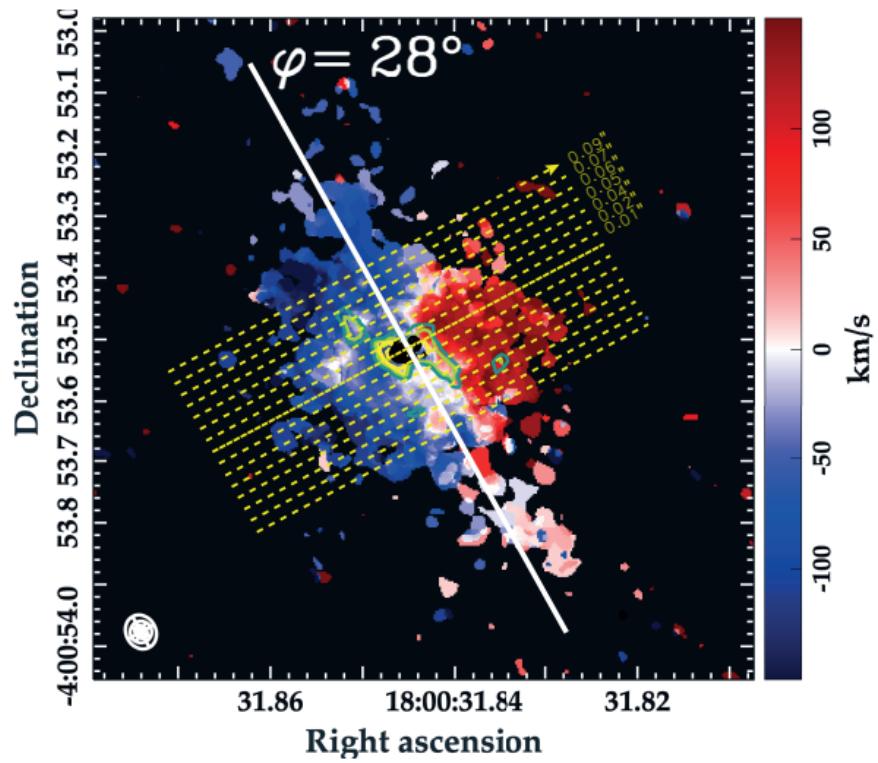


Background

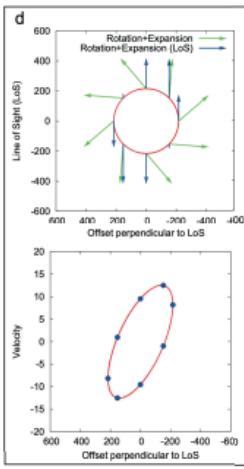
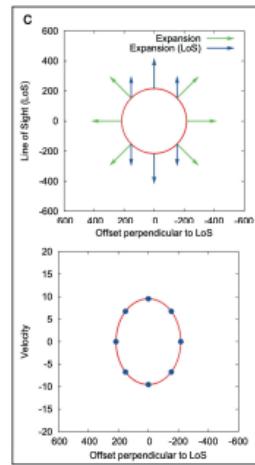
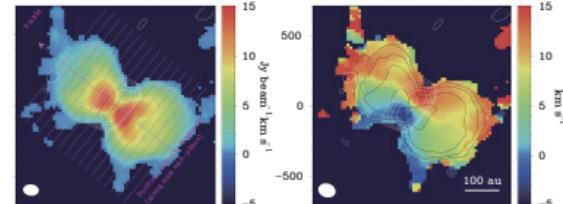
Putting the puzzle pieces together

CONfirm  
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# Dissecting the data: Cutting the PV from the parallel axis

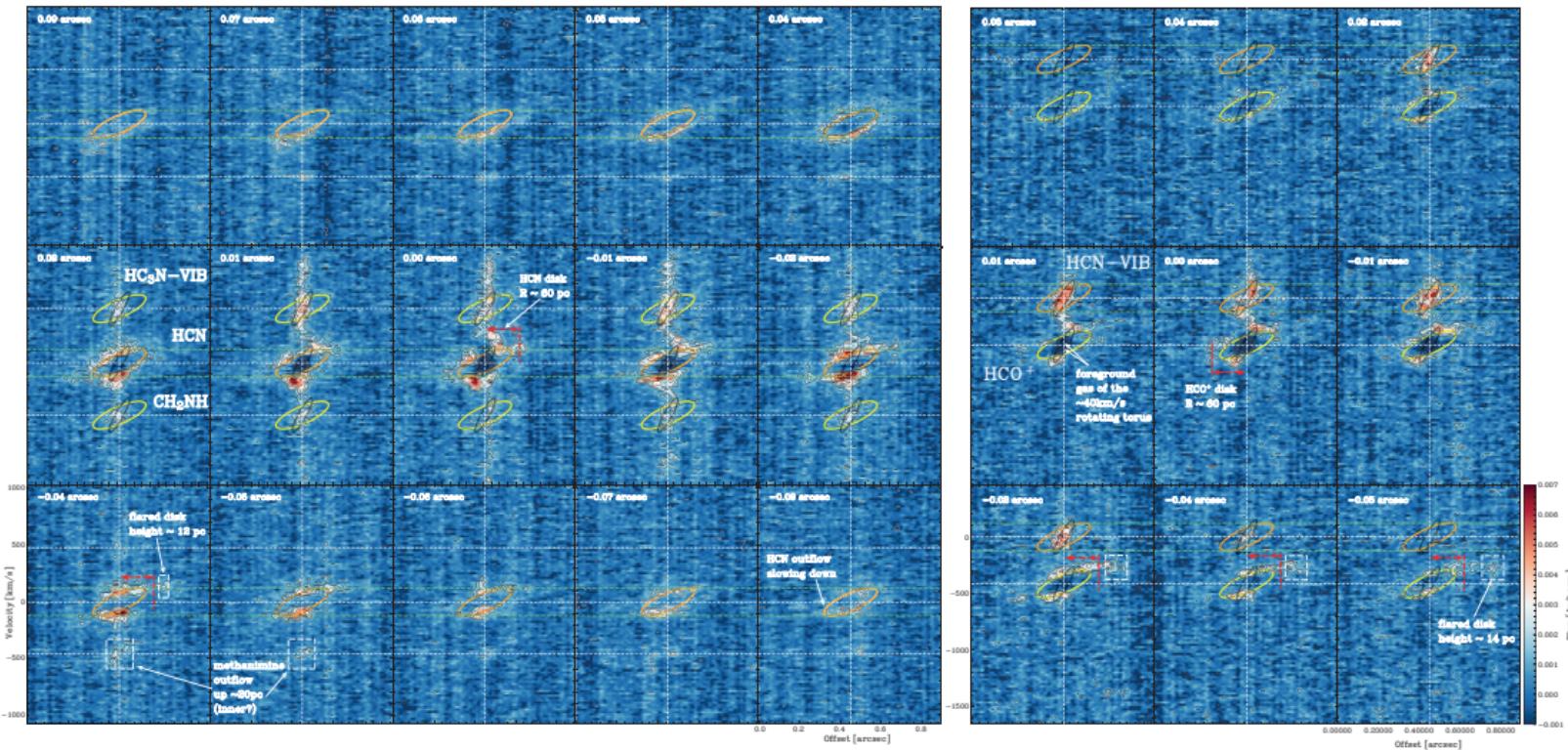


Hirota+2017, disk–driven rotating outflow  
in a young stellar object

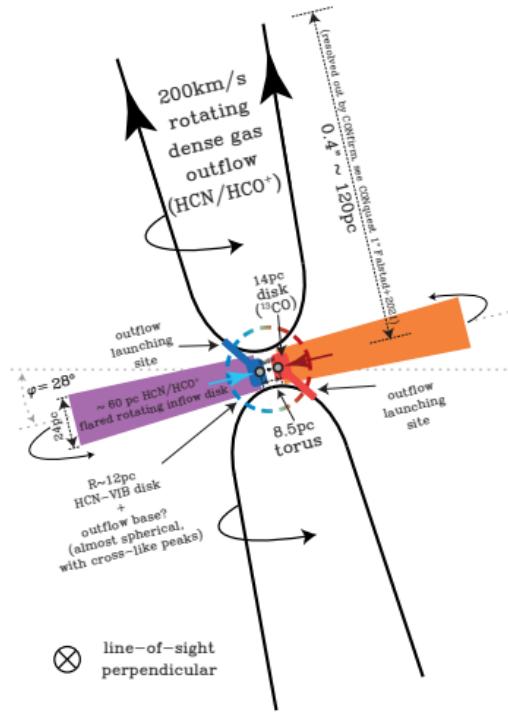


Putting the puzzle pieces together

## Dissecting the data: PV analysis - rotating outflows &amp; the flared disk



# What we found with the $\lesssim 10$ pc resolution ALMA data?



- A duty torus with roughly 4pc radius
- Growing B3/B6 ratio inwards:  $\tau_{1.2\text{mm}} \sim 0.3$ ? (hybrid–corona?)
- In-band spectra index + radio fluxes  $\rightarrow N_{\text{H}_2} \sim 10^{24.5} \text{ cm}^{-2}$
- $^{13}\text{CO}$  disk (radius  $\sim 7$  pc) with asymmetrical tails in blue and red
  - Launching region of the outflow?
  - The scales of the tails: launching bases of the outflow?
- HCN–VIB circled around with 12 pc radius
  - Peaks at the disk and the bases of the outflow
- Large-scale HCN/HCO<sup>+</sup> rotating disk with  $\sim 60$  pc radius
  - Flared (thicker outside,  $\sim 24$  pc thick)
  - Infalling (fast emission  $\sim 200$  km/s), and rotating ( $\sim 300$  km/s)
  - Rotating absorption  $\sim 40$  km/s (in front of torus?)
  - Central figural barrier  $\sim 4$  pc?  $\rightarrow$  SMBH mass of  $\sim 8 \times 10^7 M_\odot$
  - Disk driven?
- Collimated  $>120$  pc outflow traced by HCN and HCO<sup>+</sup>,
  - Rotating at  $\sim 200$  km/s
  - Very little slowing-down

# Thank you for your attention!

## Questions?