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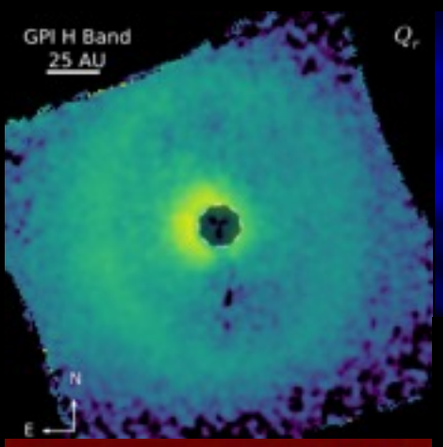
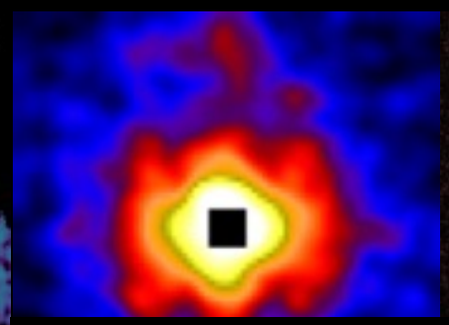
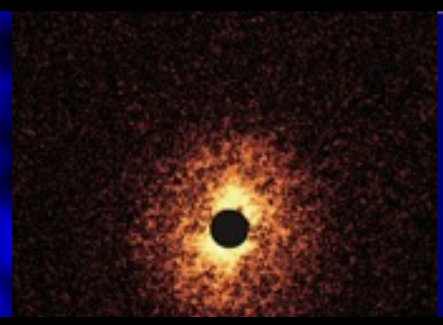
SHADOWS CAST ON THE TRANSITION DISK OF HD 135344B

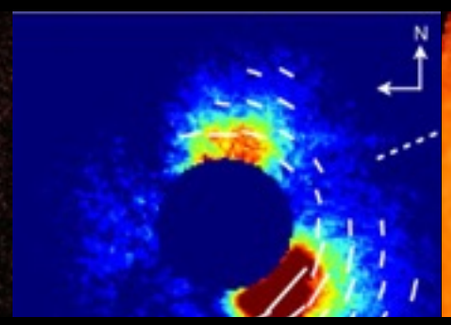
CARSTEN DOMINIK, HENNING AVENHAUS, MICHIEL MIN, JOS DE BOER, CHRISTIAN GINSKI, HANS MARTIN SCHMID, ATILLA JUHASZ, MYRIAM BENISTY AND THE SPHERE CONSORTIUM

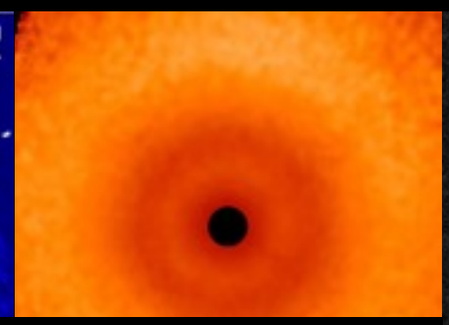
RESOLVING PLANET FORMATION IN THE ERA OF ALMA AND **EXTREME AO**

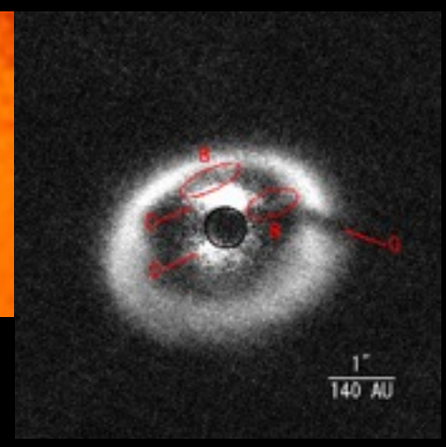


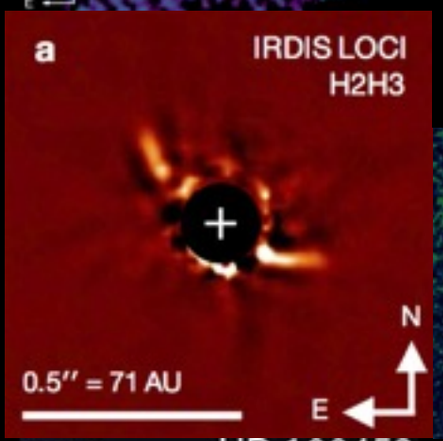


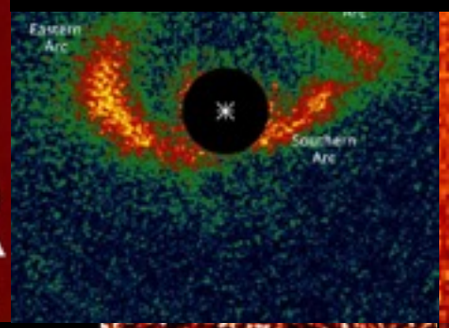


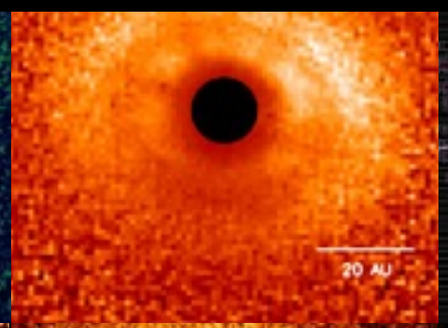


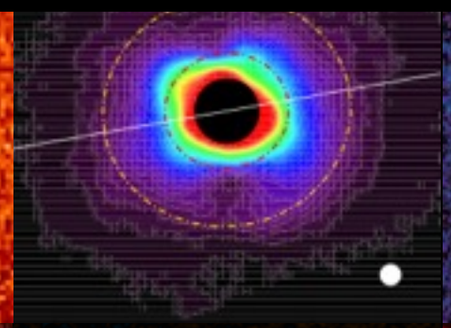


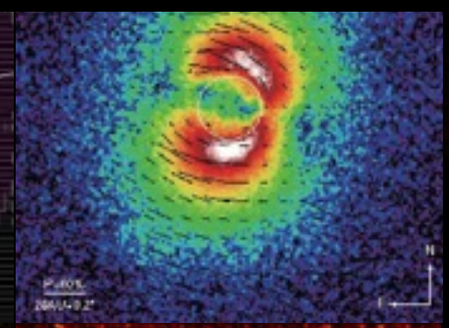


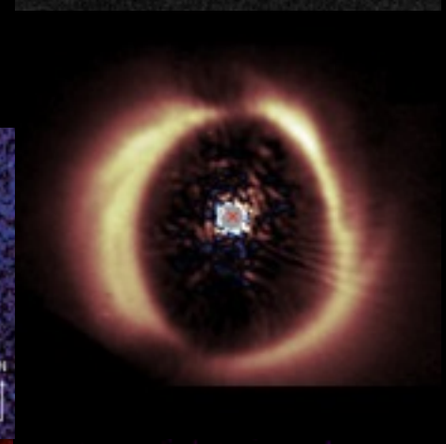


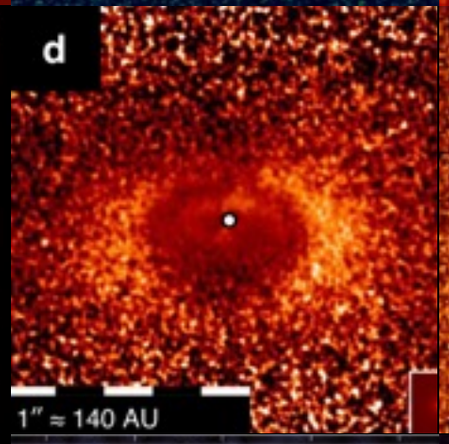


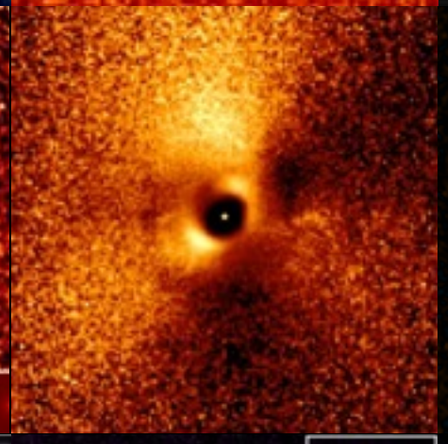


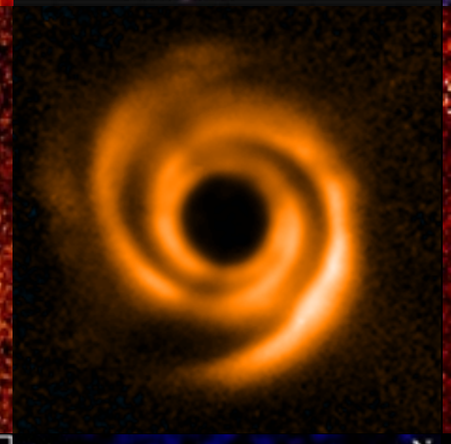


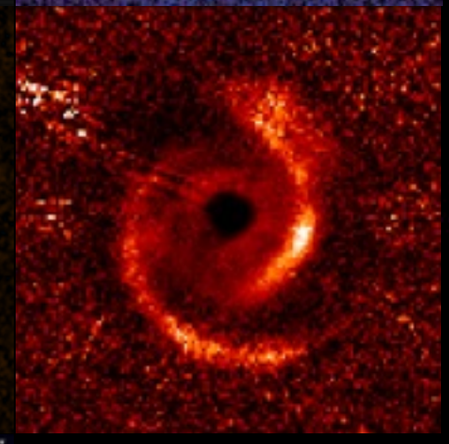


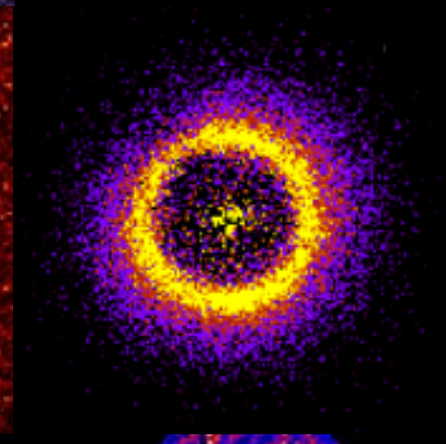


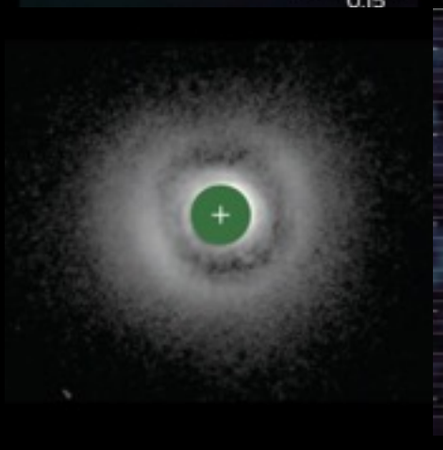


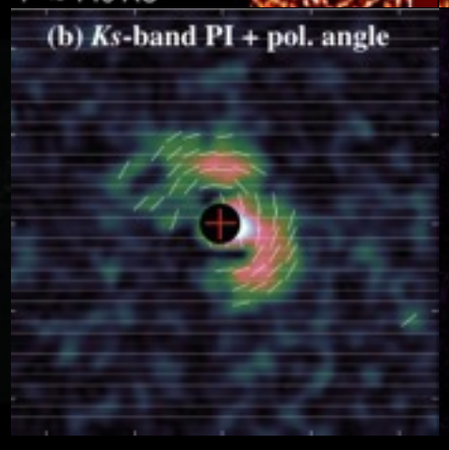


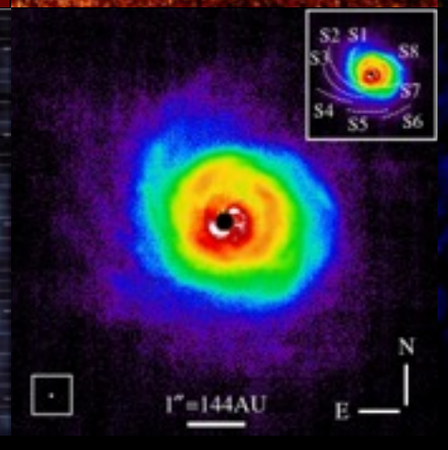


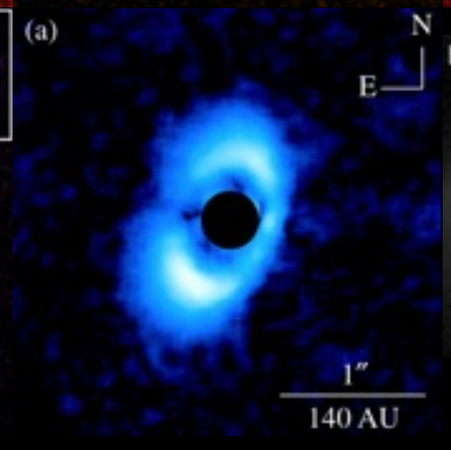


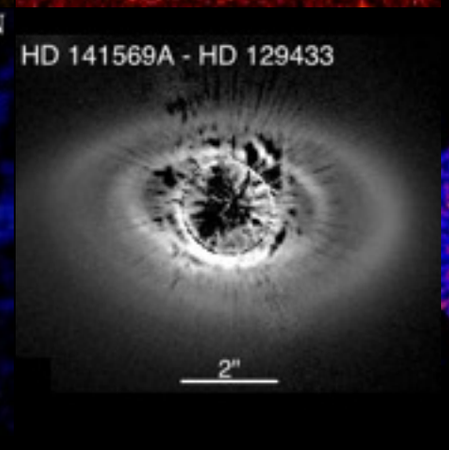


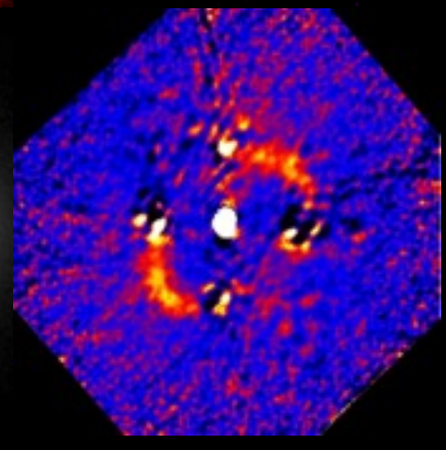




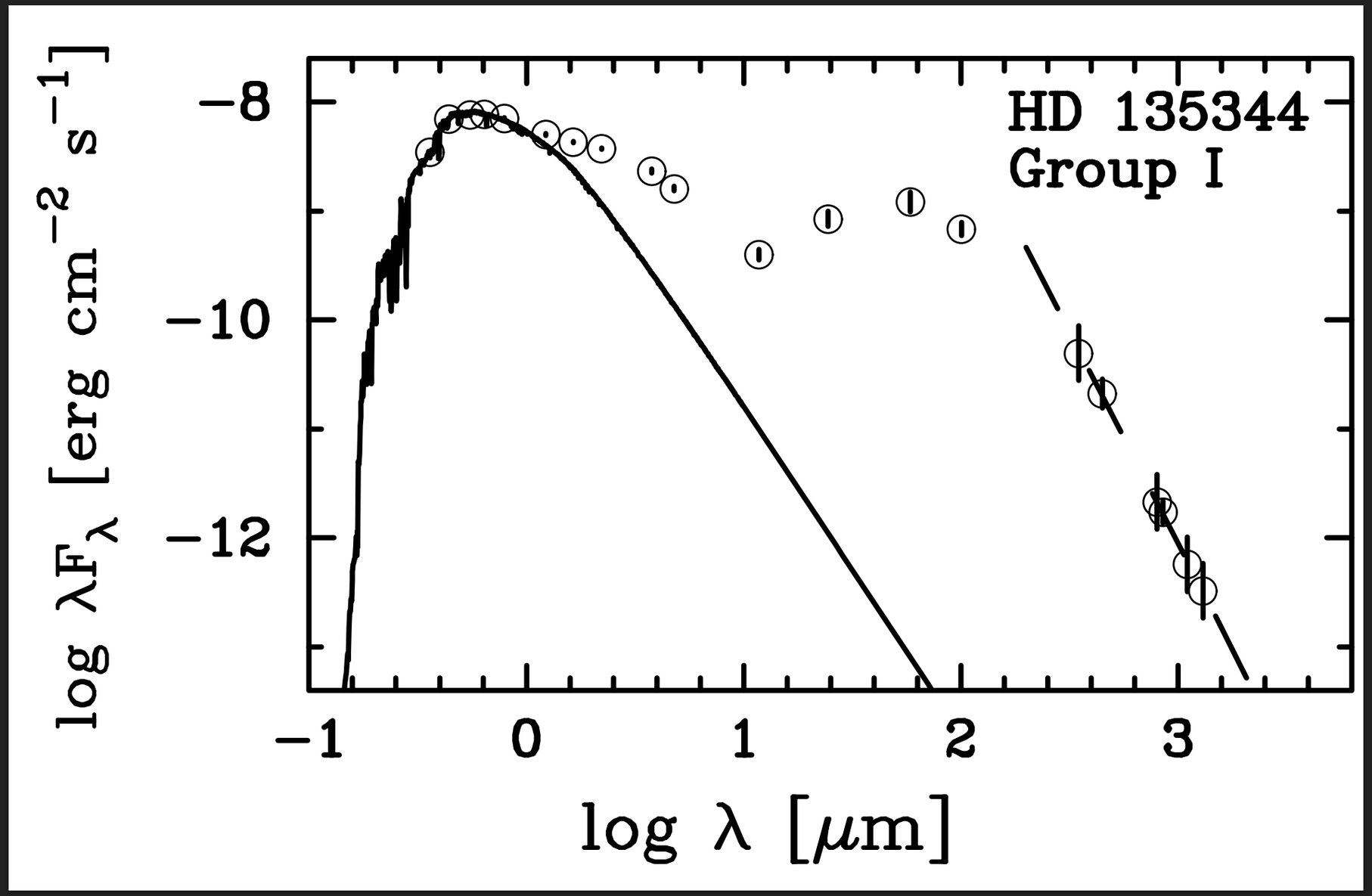






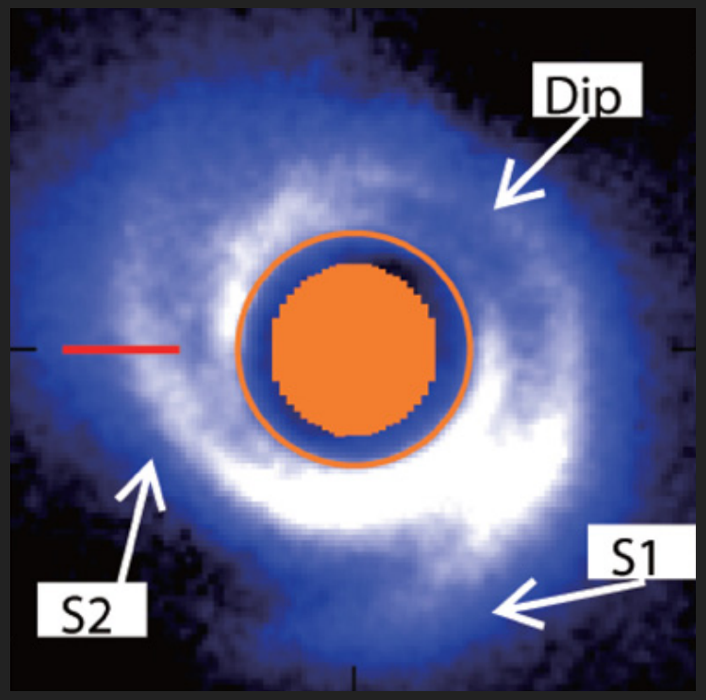


THE HD 135344B TRANSITION DISKS

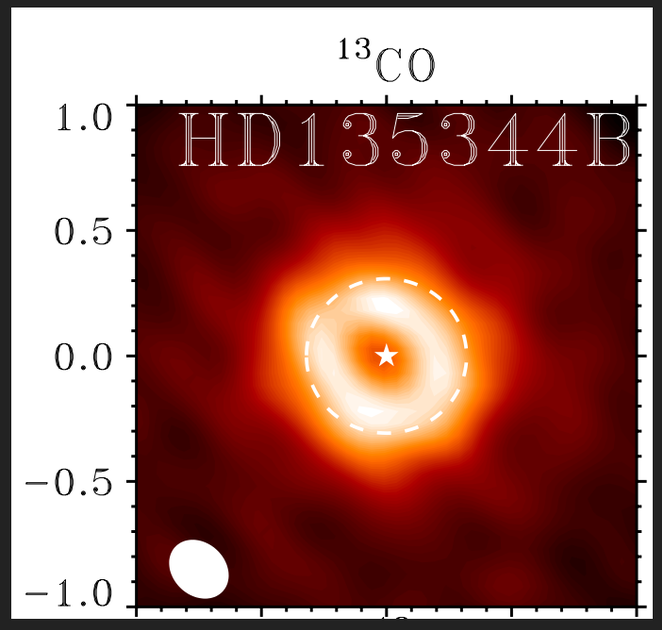


e.g. Acke et al. 2004, Brown et al. 2007, Maaskant et al. 2013, Carmona et al. 2014

CAVITY AND SPIRAL ARMS: SIGNPOSTS FOR PLANET FORMATION?

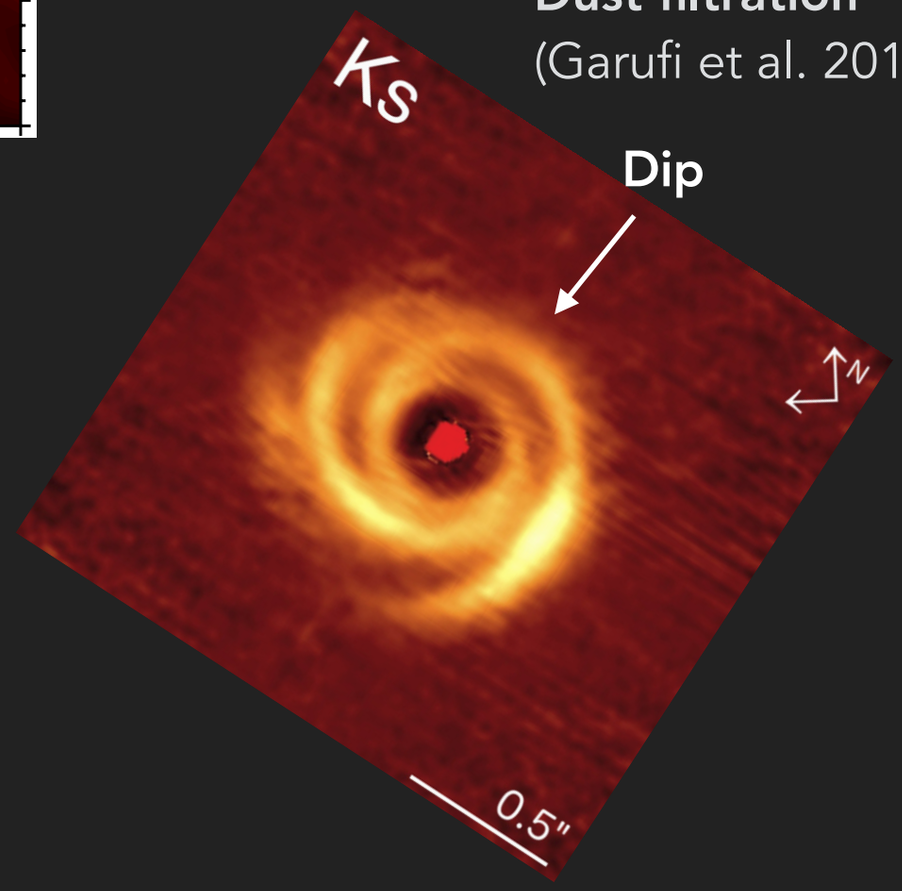


Spiral arms resolved
(Muto et al. 2012)

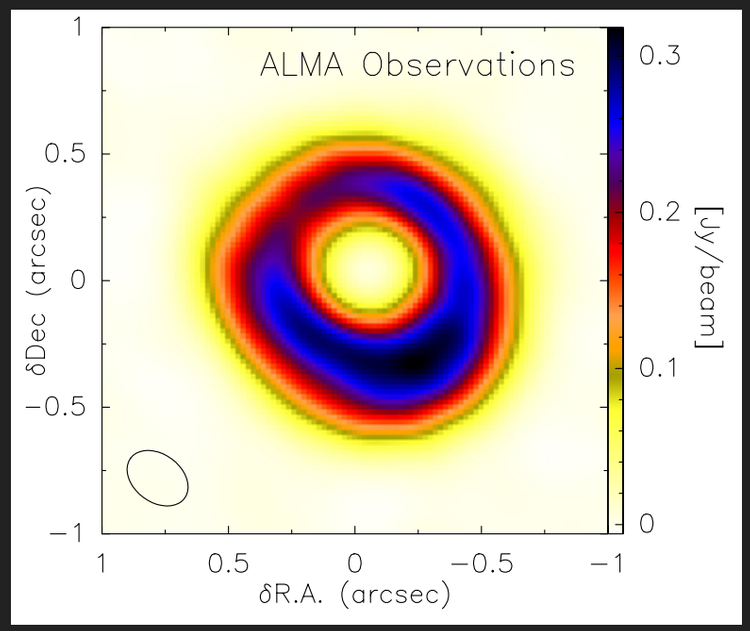


ALMA CO isotopologs
cavity = 30 au, δΣ ~ 10^{-4}
(van der Marel et al. 2016)

VLT/NACO PDI
cavity = 28 au
Dust filtration
(Garufi et al. 2013)



ALMA band 9
dust continuum
cavity = 60 au
(Perez et al. 2014)



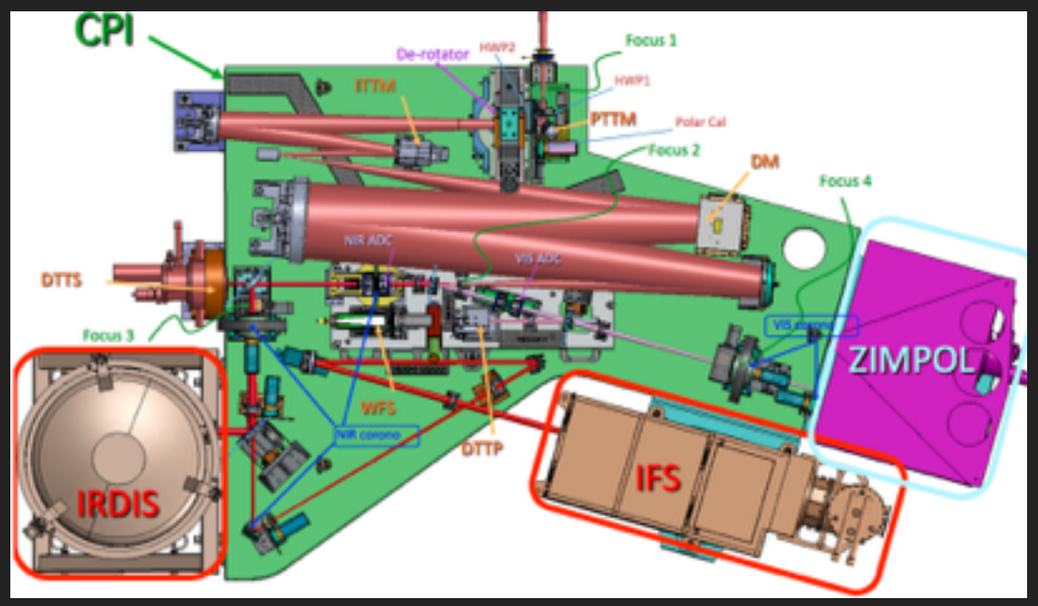
See next talk by Nienke van der Marel

SPECTRO-POLARIMETRIC HIGH-CONTRAST EXOPLANET RESEARCH

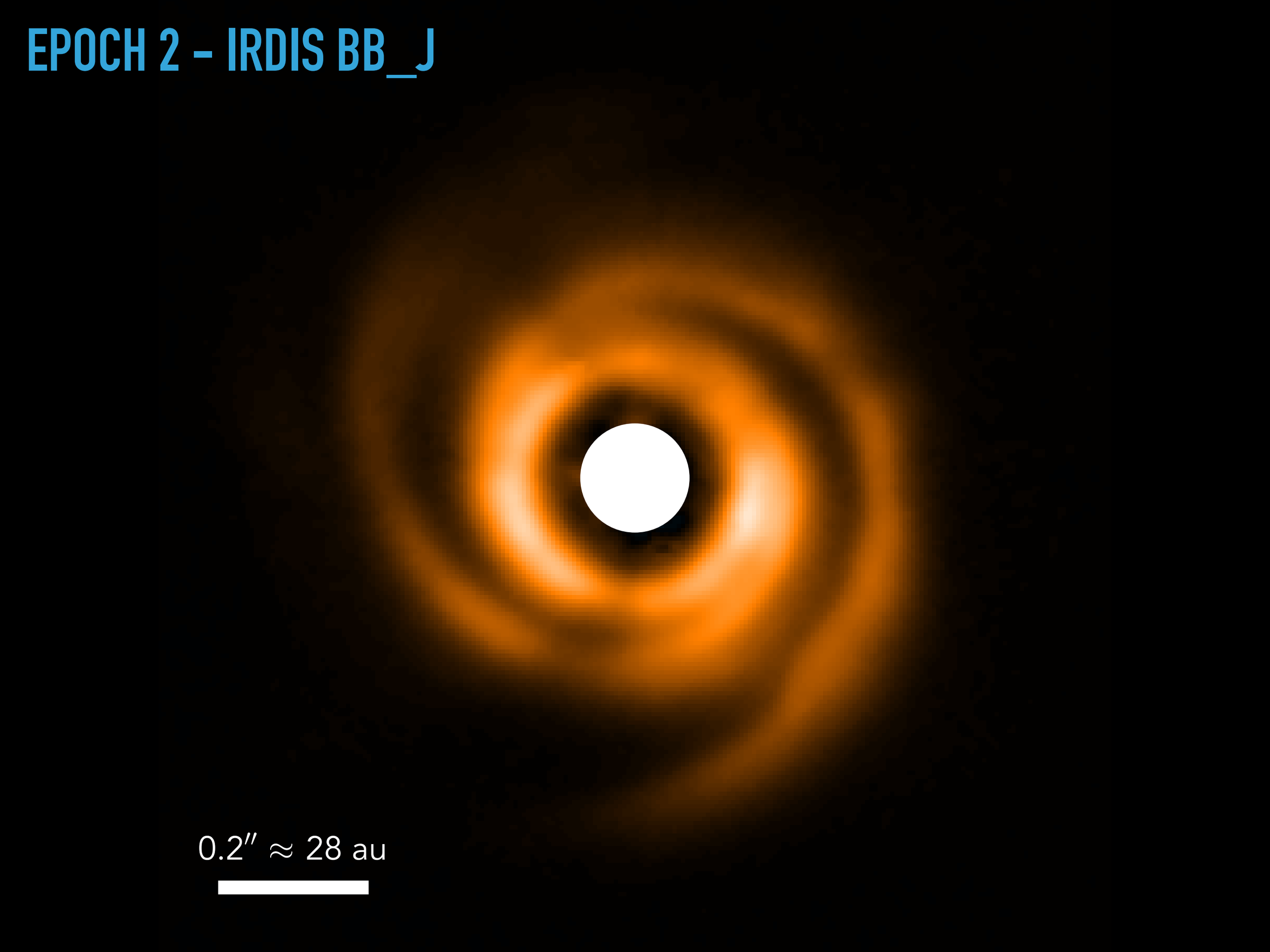
- Polarimetric differential imaging (PDI)
- ZIMPOL R′ and I′ (epoch 1)

  70 min, resolution = 30 mas, coronagraph = no
- IRDIS BB_J (epoch 2)

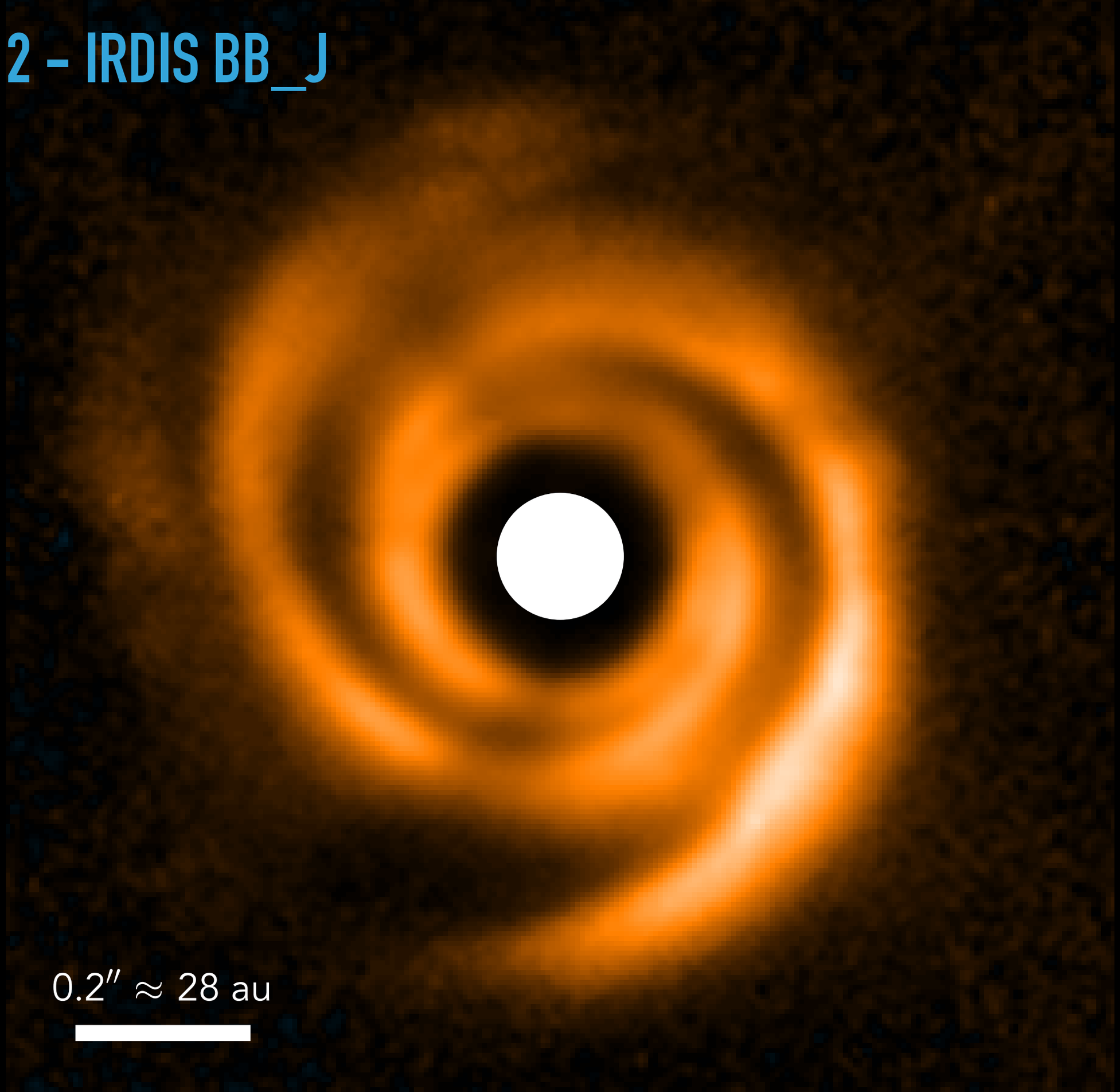
  80 min, resolution = 40 mas, coronagraph = 80 mas
- 1 month between epoch 1 and 2



EPOCH 2 – IRDIS BB_J

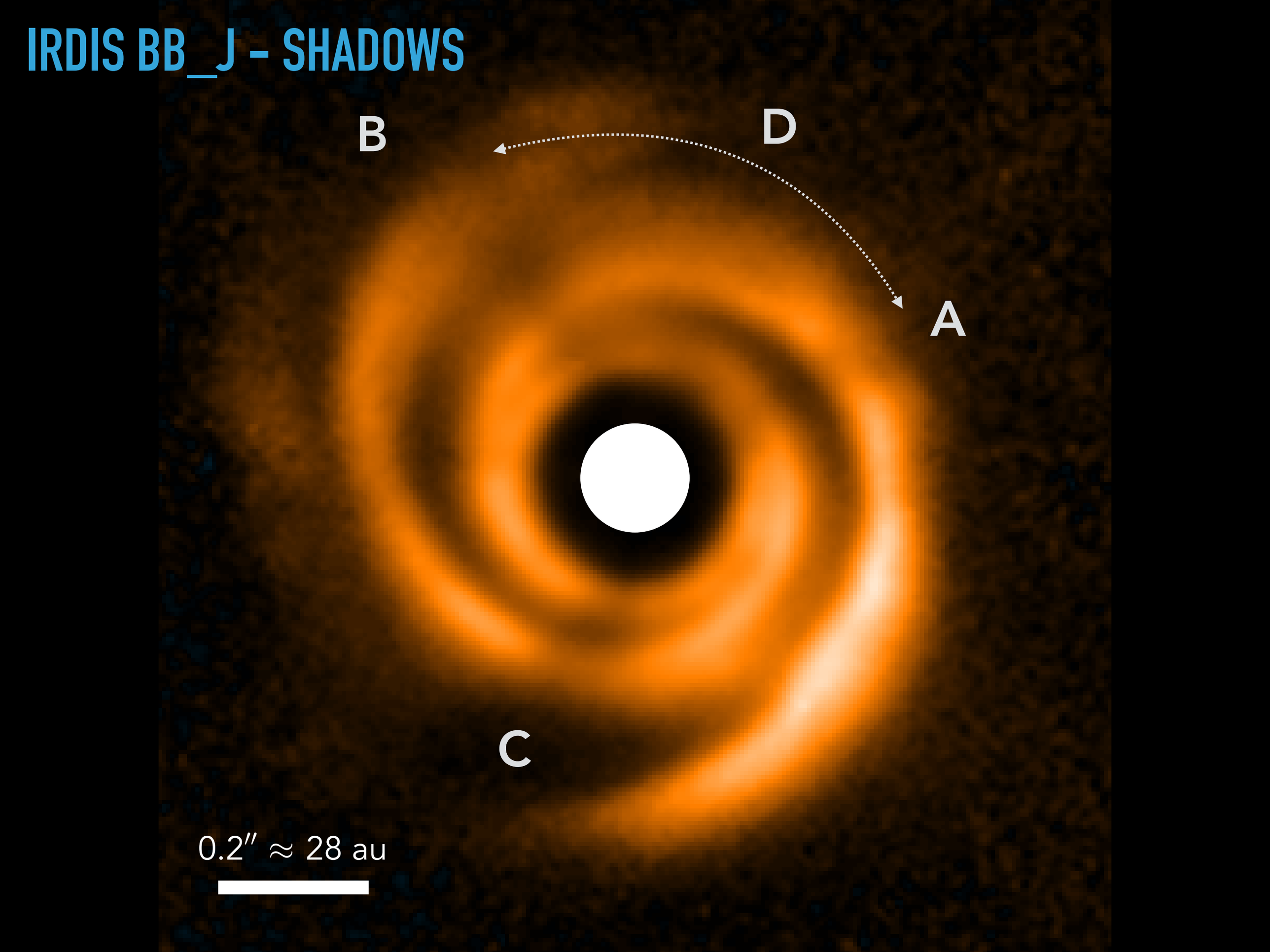


EPOCH 2 – IRDIS BB_J

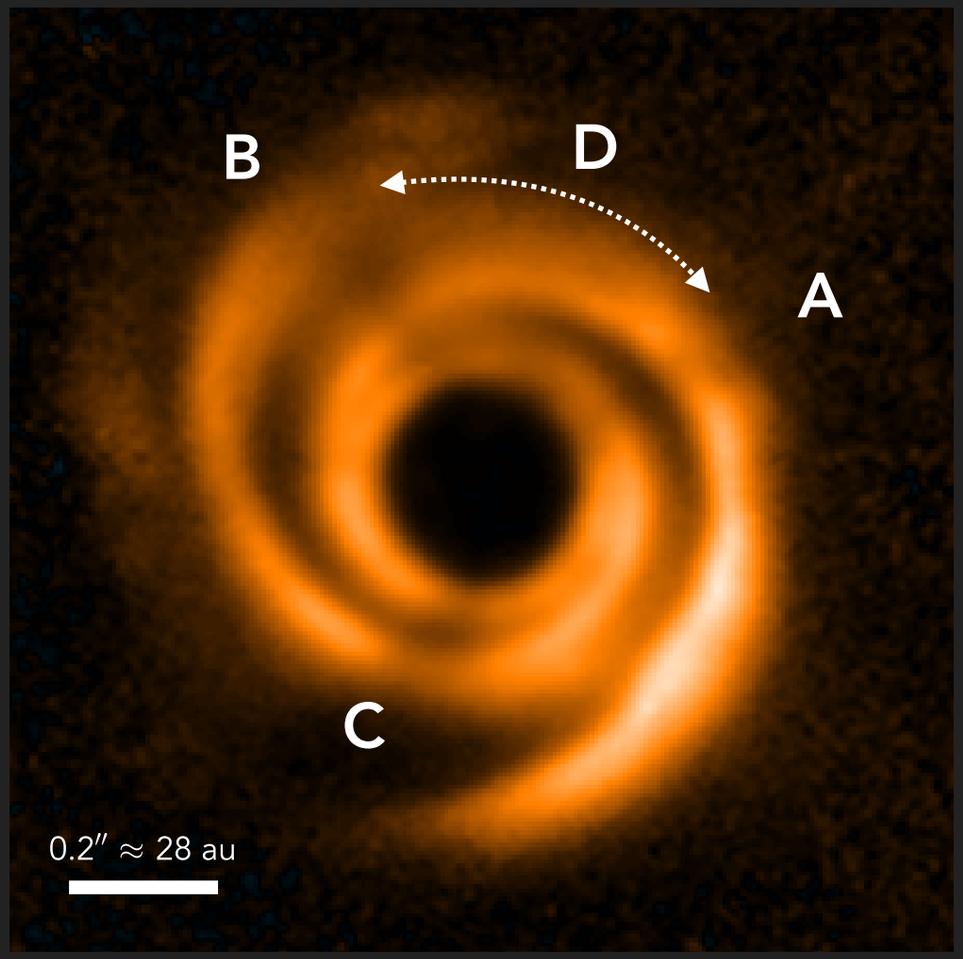


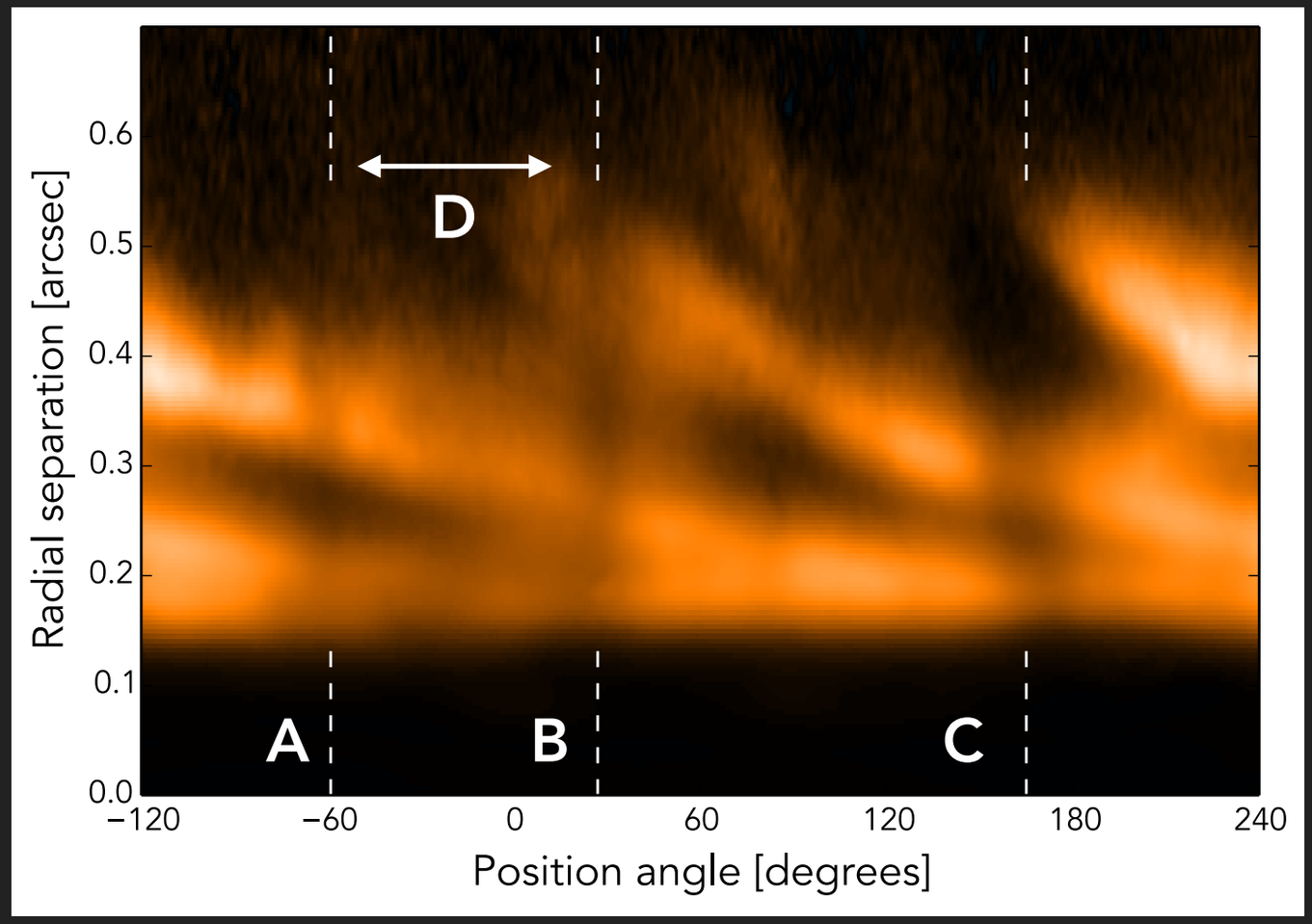
0.2″ ≈ 28 au

IRDIS BB_J – SHADOWS



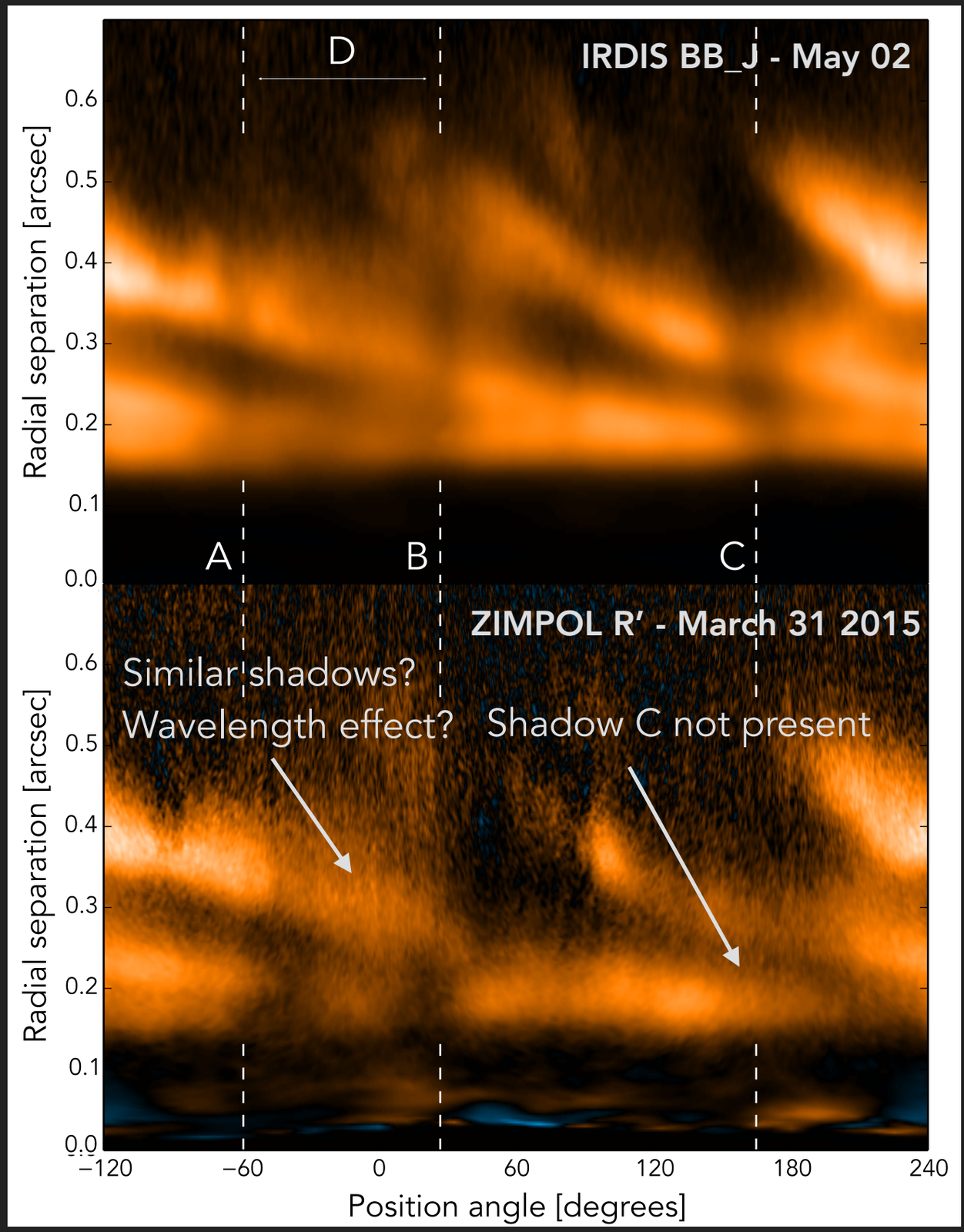
POLAR PROJECTION: VERTICAL SHADOW FEATURES



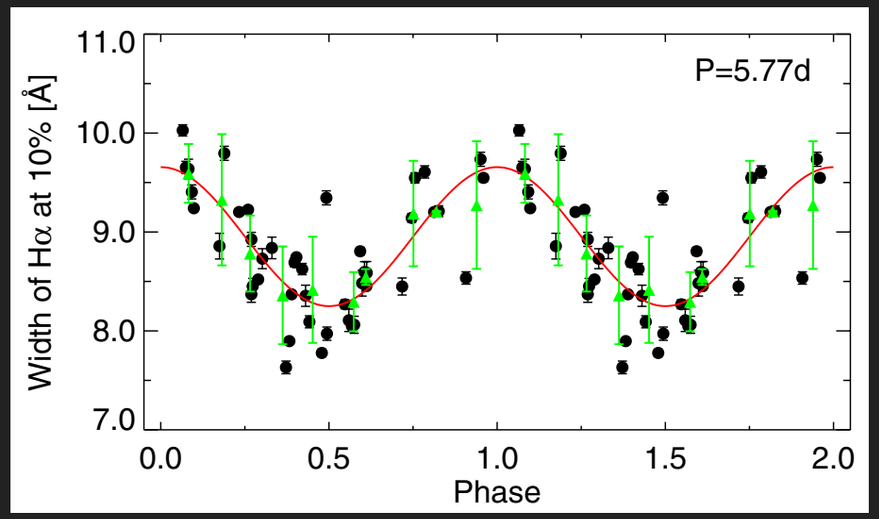


IRDIS BB_J May 02 2015

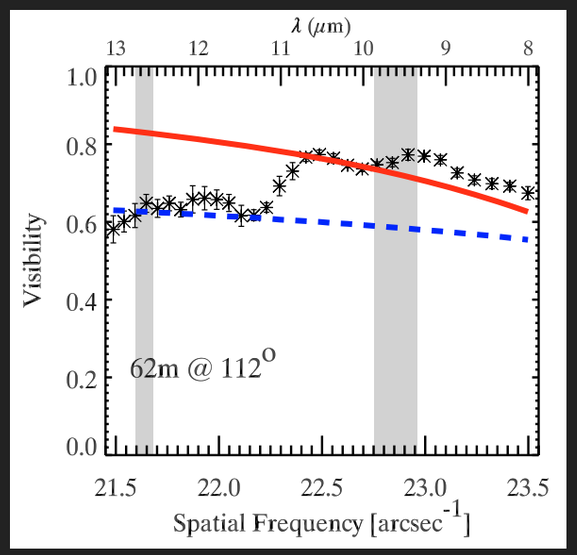
ONE MONTH EARLIER…



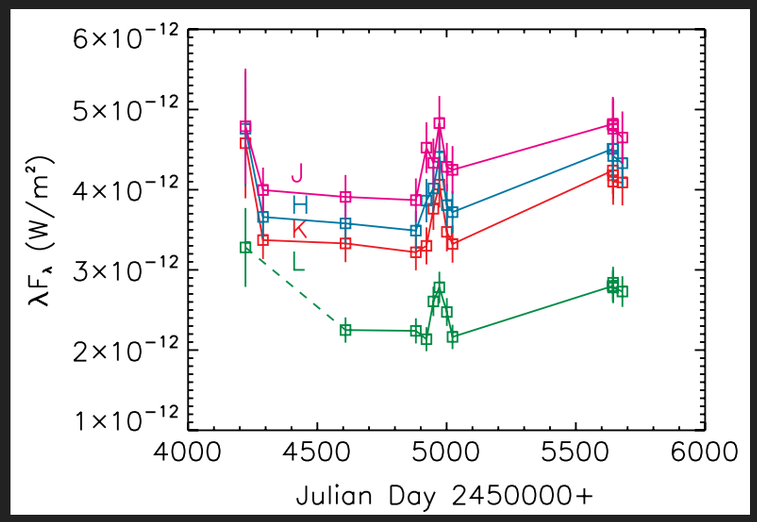
WHAT IS HAPPENING IN THE INNERMOST DISK REGIONS?



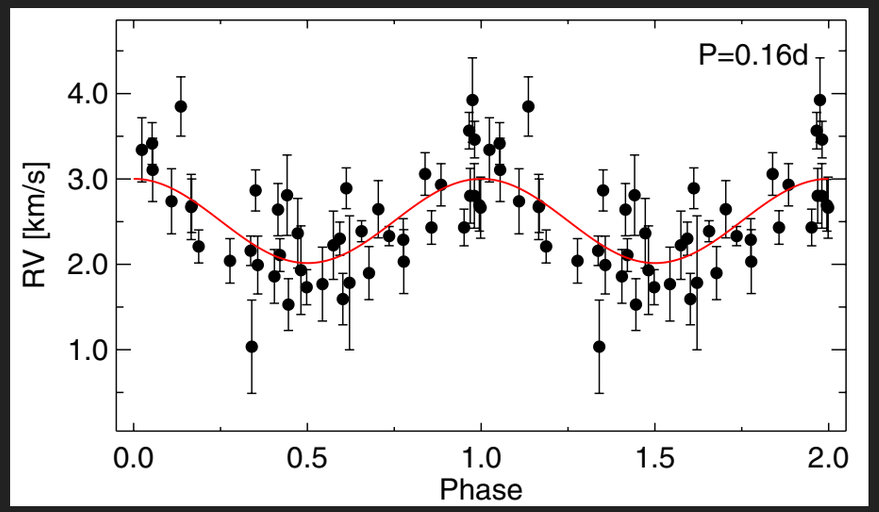
Stellar H_α variability
(Muller et al. 2011)



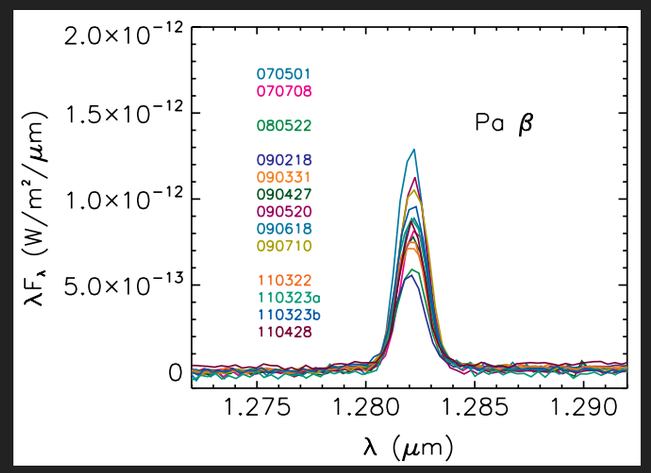
Possible misaligned inner disk
(Fedele et al. 2008)



Photometric variability
(Sitko et al. 2013)

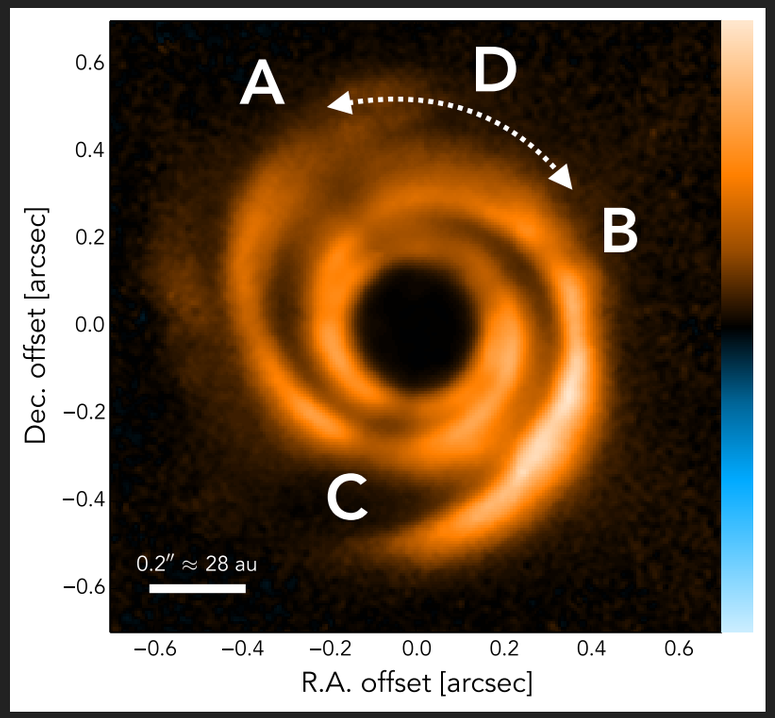


Stellar rotation
(Muller et al. 2011)

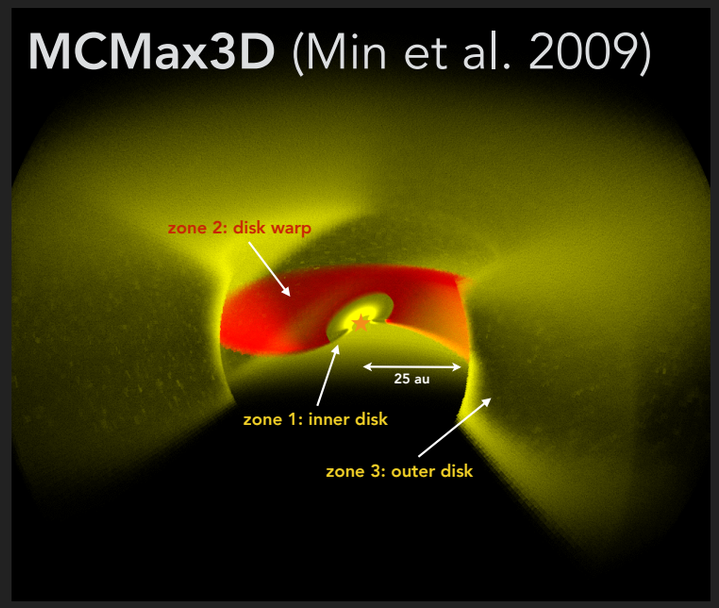


Stellar accretion = 10^{-8} $M_\odot$/yr
(Sitko et al. 2013)

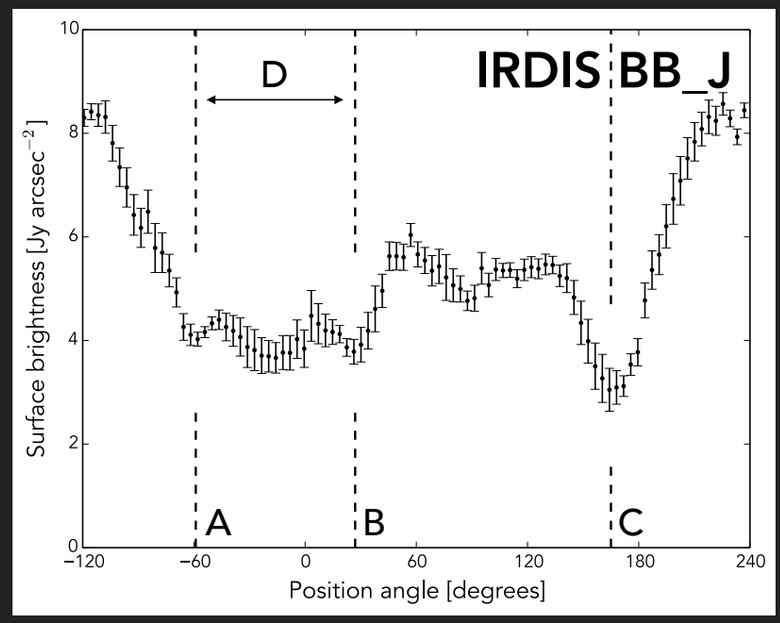
RADIATIVE TRANSFER: SHADOWS FROM A WARPED DISK



IRDIS BB_J Qphi



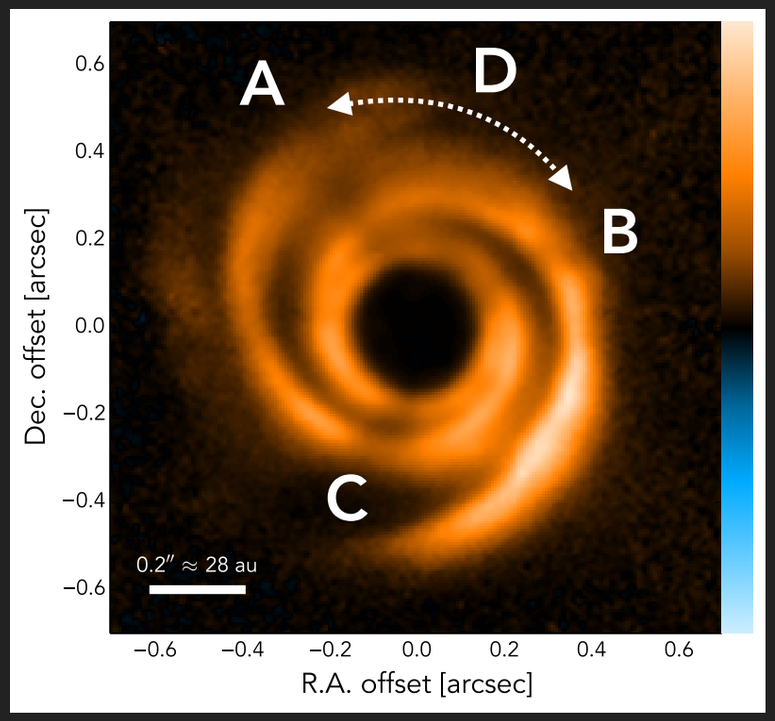
1. Misaligned inner disk
2. Warped disk region (cavity)
3. Outer disk



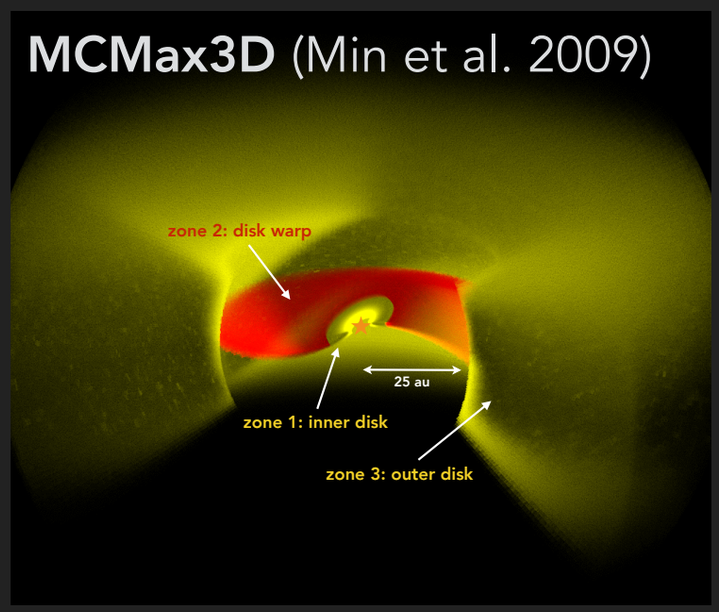
Radial integrated surface brightness

see also HD 142527 (Marino et al. 2015)

RADIATIVE TRANSFER: SHADOWS FROM A WARPED DISK

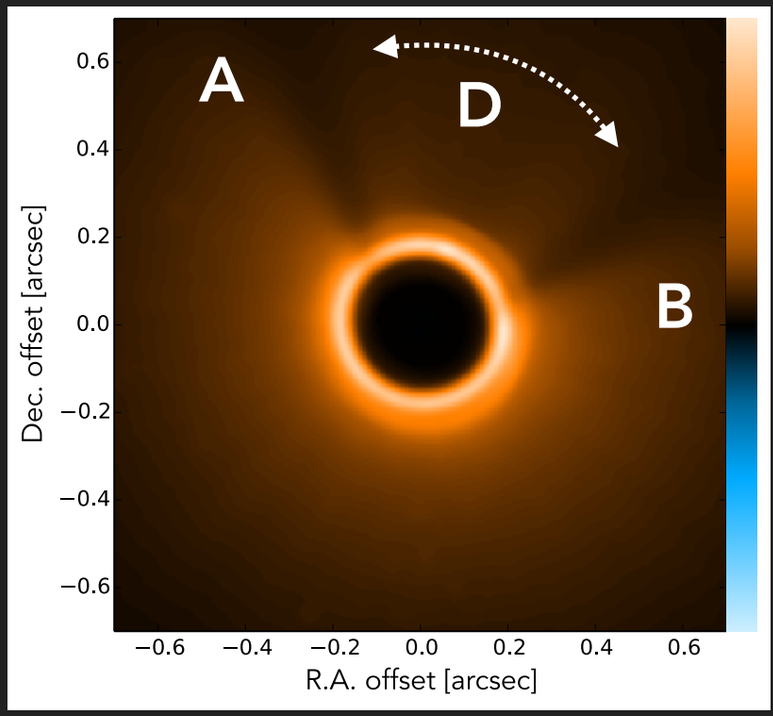


IRDIS BB_J Qphi



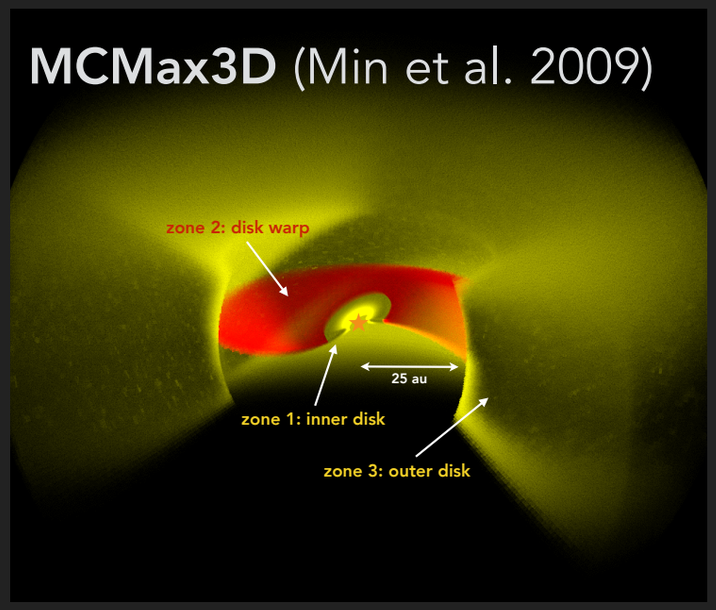
1. Misaligned inner disk
2. Warped disk region (cavity)
3. Outer disk

1. Shadow A+B = misaligned inner disk
2. Shadow D = disk warp

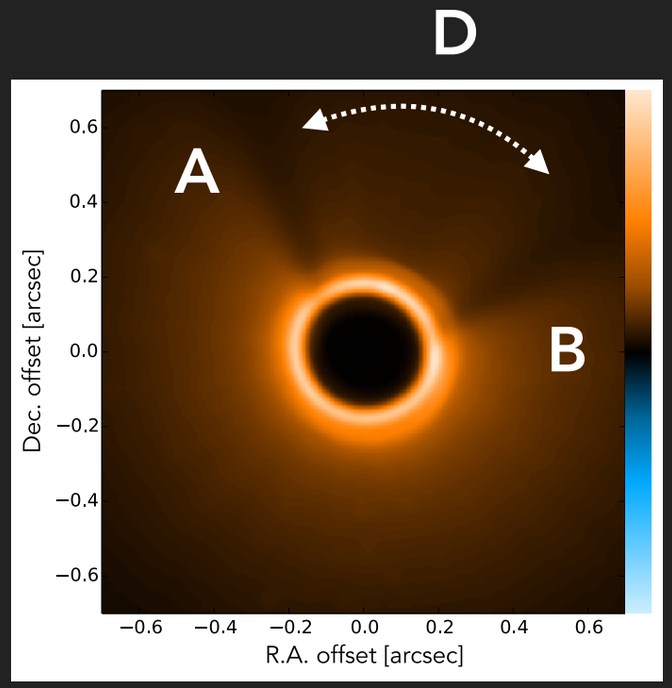


MCMax3D BB_J Qphi

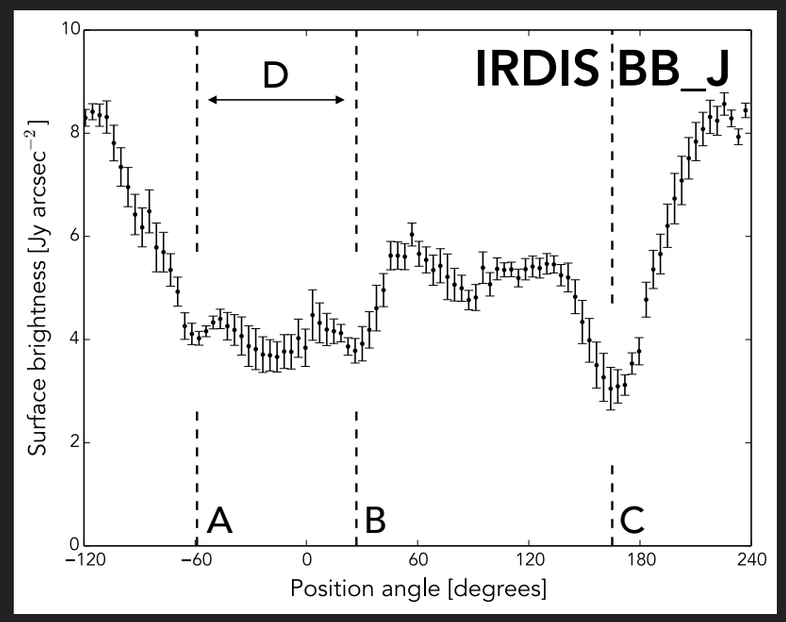
RADIATIVE TRANSFER: SHADOWS FROM A WARPED DISK

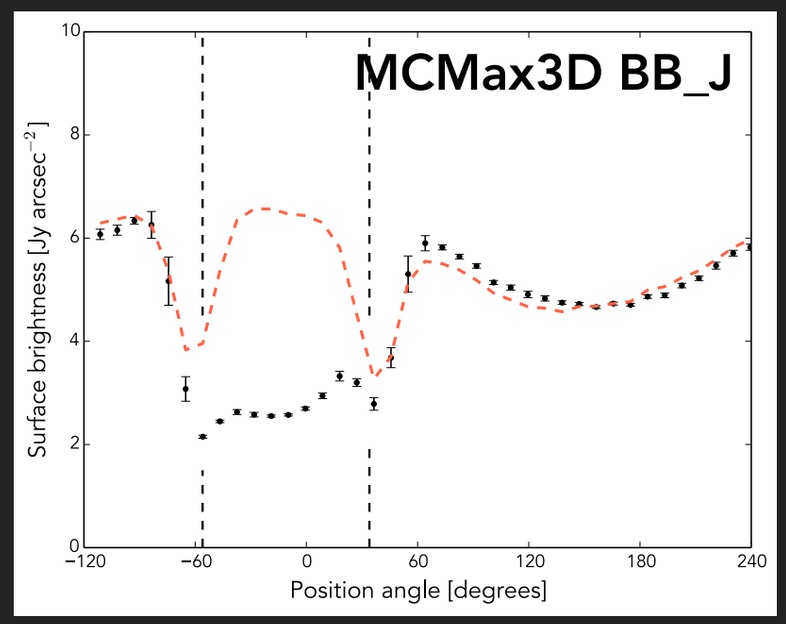


1. Misaligned inner disk
2. Warped disk region (cavity)
3. Outer disk



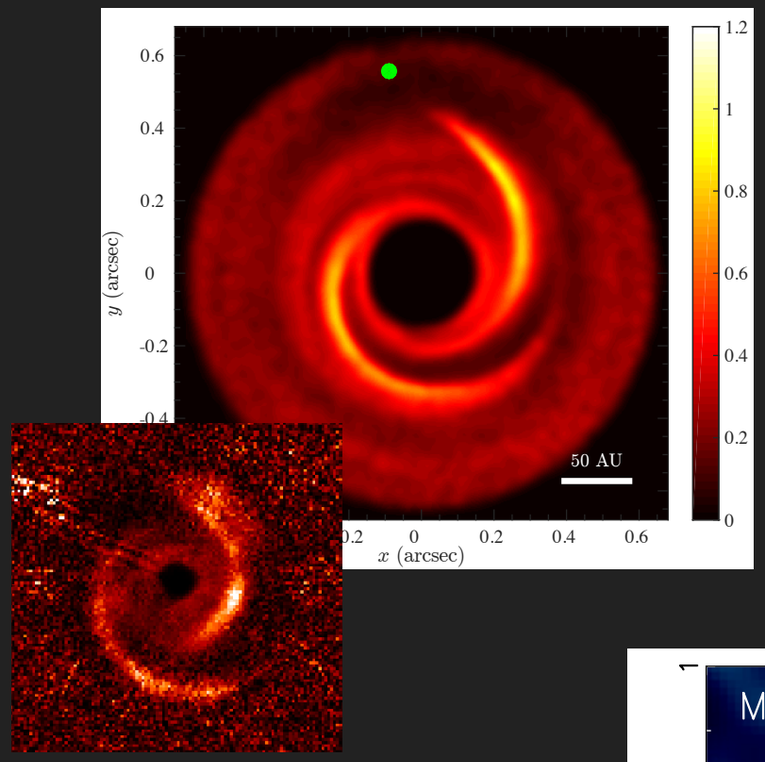
MCMax3D BB_J Qphi

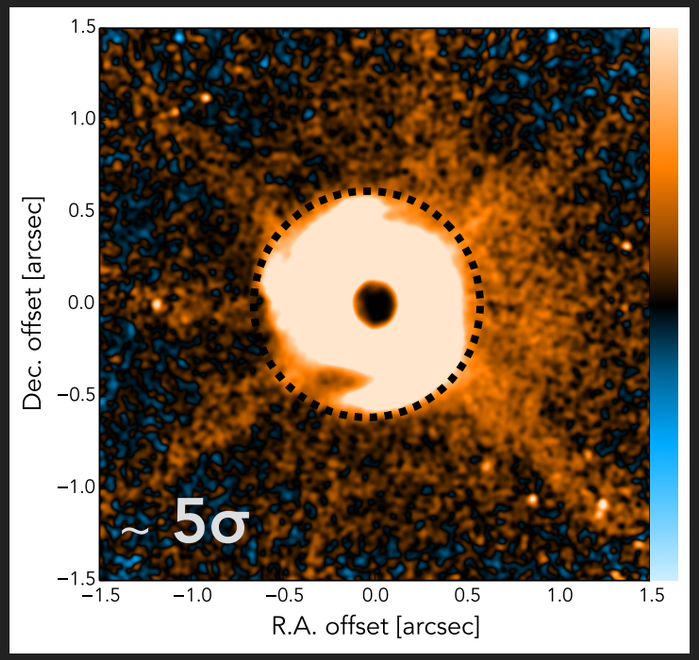




A PLANETARY ORIGIN OF THE SPIRAL ARMS?

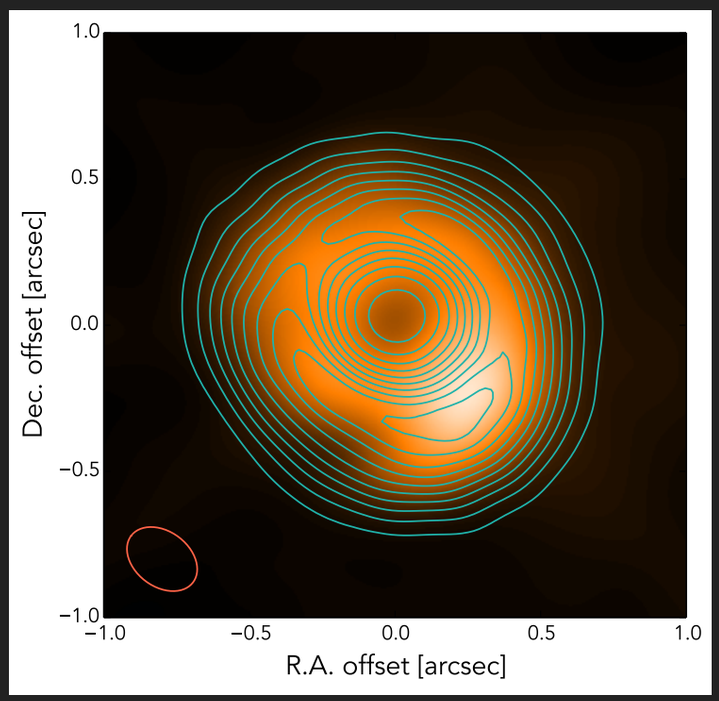
Massive planet in the outer disk
(Dong et al. 2015)



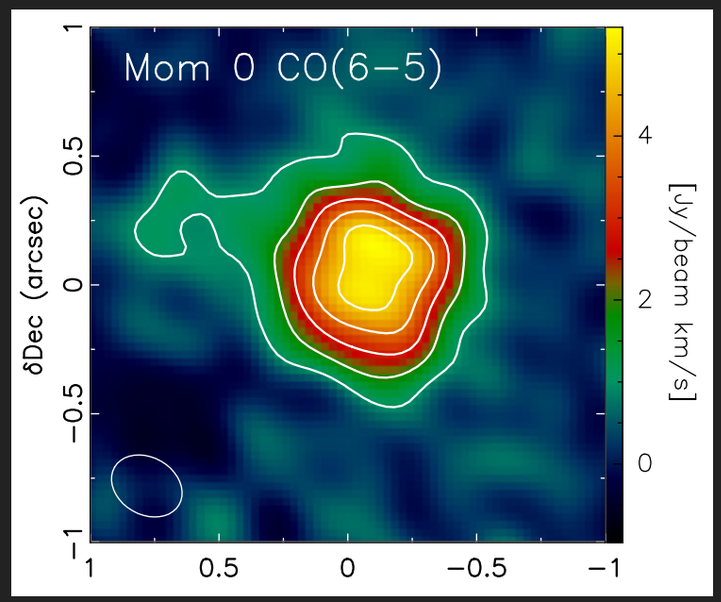


IRDIS BB_J Q_φ
hard stretch, r^2-scaled

IRDIS BB_J (ALMA resolution)
ALMA band 9 (contours)
Spiral perturbation?



ALMA compact CO disk
(Perez et al. 2014)



CONCLUSIONS

- VLT/SPHERE PDI observations show multiple reductions in surface brightness
- Interpretation: shadows cast by the innermost disk region
  - Disk warp, accretion flow, inner disk instability/perturbation, asymmetric disk wind, circumplanetary disk, …?
- Monitoring of the shadows has the potential to provide new insight into variable/transient phenomena in the inner disk, well beyond the reach of SPHERE

THANK YOU