2019 UCAT Summer Student Program Progress Report 2019.08.30 NTHU

Searching For Young Proto-Planetary Disks

Student: 吳冠賢 Kuan-Hsien Wu (NTHU)

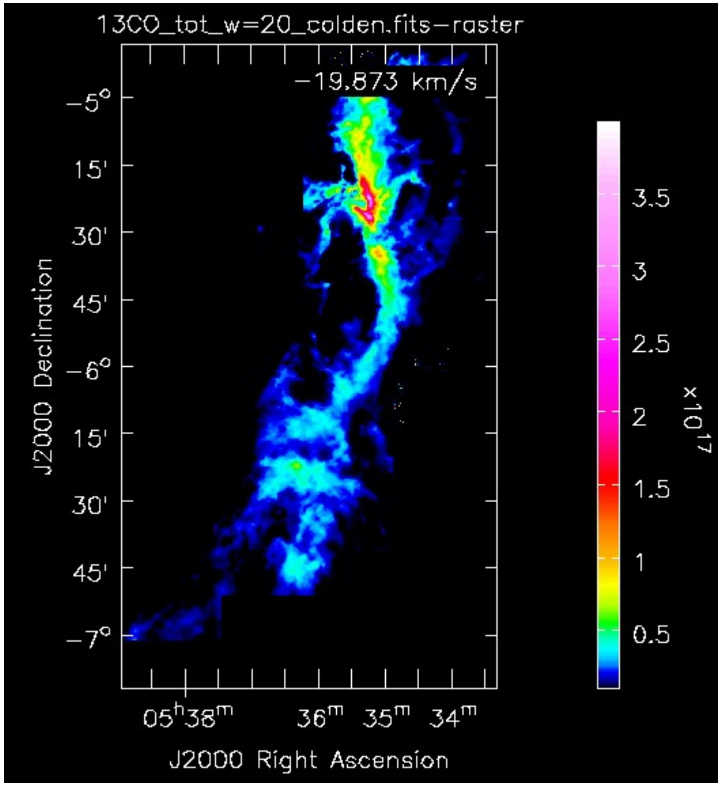
Adviser: 賴詩萍 Shih-Ping Lai (NTHU)

國立清華大學
NATIONAL TSING HUA UNIVERSITY

P1 - 20190708 ~ 20190719

Basic ISM knowledge and Data Manipulation

- Region - Orion A (molecular cloud)
  - Dust Continuum
    - Dust Alpha, Beta Map
    - Dust Column Density Map
  - Molecular Line
    - 12CO (J 1-0), 13CO (J 1-0), C18O (J 1-0)
      - Moment Map (mom0 & mom1)
    - 12CO Excitation Temperature Map
    - 13CO, C18O Column Density Map

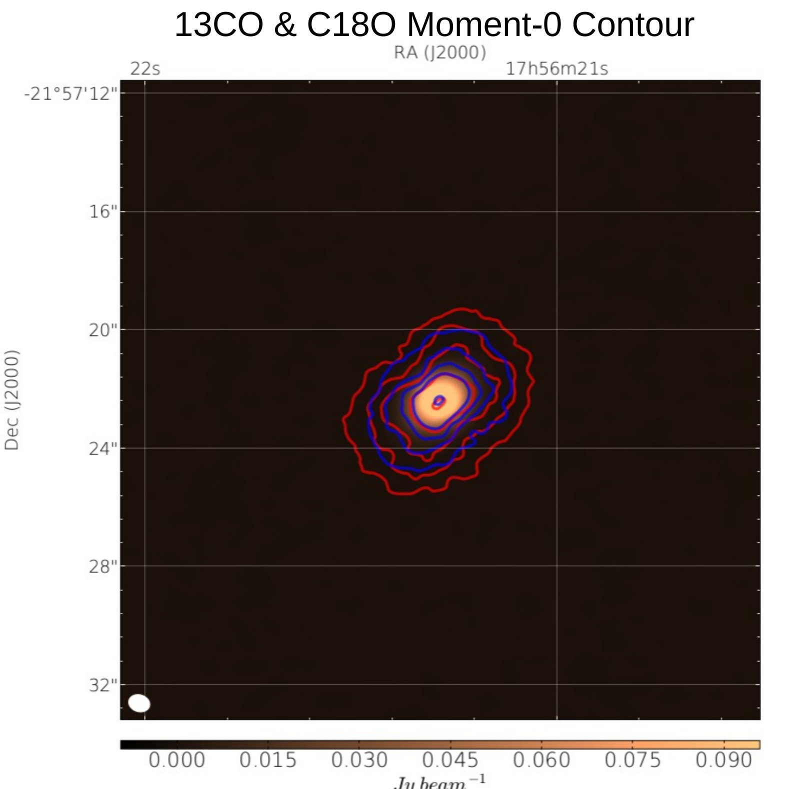


- Data
  - Dust Continuum: Herschel Space Observatory
  - Molecular Line: Nobeyama Radio Observatory (NRO-45m)

P2 - 20190722 ~ 20190802

Making PV Diagrams and Moment Maps

- Target – HD163296
  - Molecular Line
    - 12CO (J 1-0), 13CO (J 1-0), C18O (J 1-0)
    - 230.53 GHz, 220.40 GHz, 219.56 GHz
  - Moment Maps
    - Moment-0 Maps
    - Moment-1 Maps
  - PV Diagrams
    - Position Velocity Diagrams
    - Fitting with Keplerian Motion to Find Stellar Mass

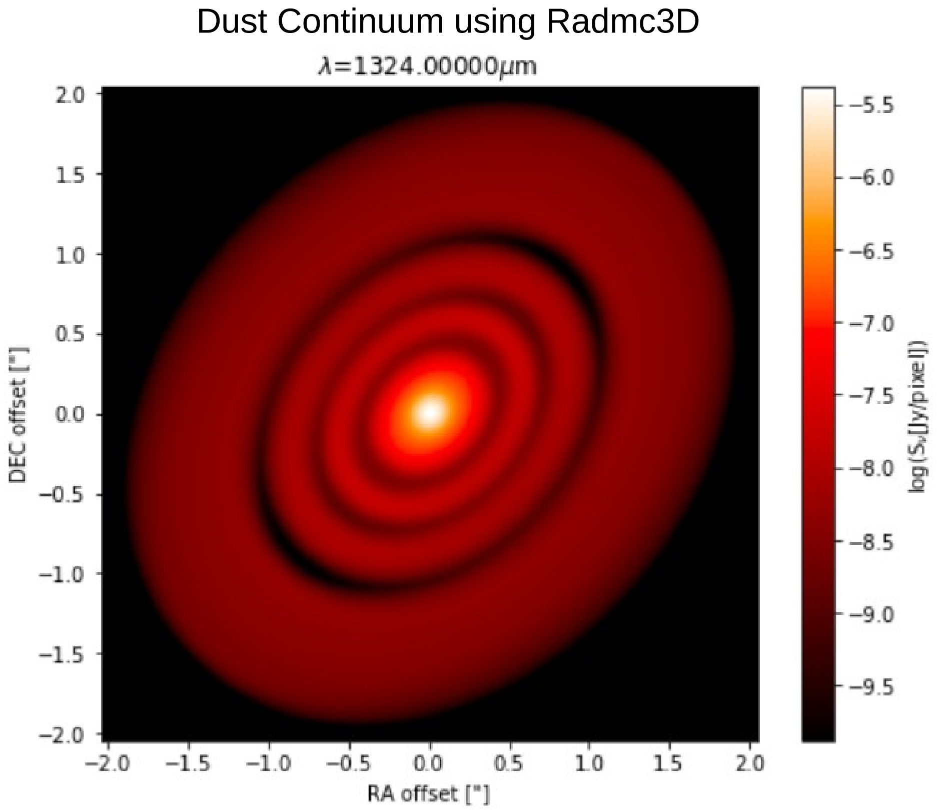


- Data
  - ALMA Cycle 0 (Band 6)

P3 - 20190803 ~ 20190816

Learning RADMC3D Simulation

- Target – HD163296
  - Radmc3D Modeling
    - PPDisk Model
    - Dust Density Dist.
    - Dust Temperature
    - Gas Temperature
    - Gas Velocity Field
    - SED of HD163296
  - Dust Continuum
  - Line Emission 12CO (J 3-2)



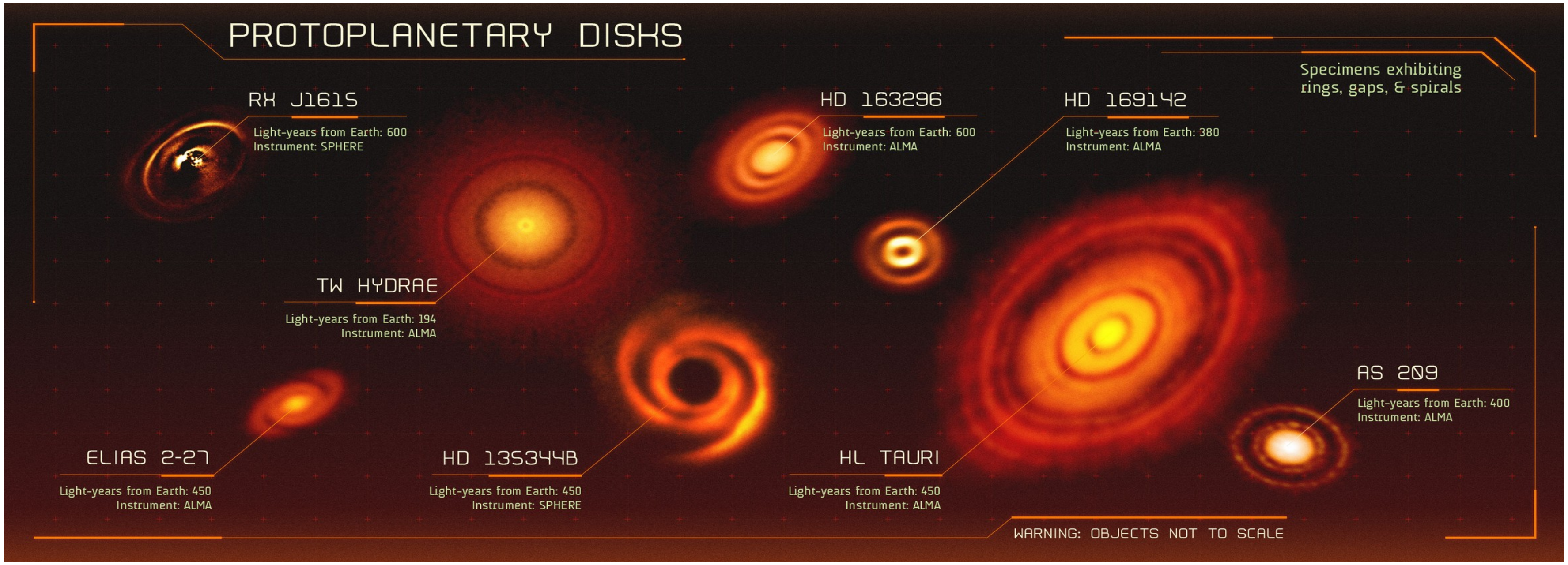
20190819 ~ 20180830

Modeling and Comparing with Observation

- Target – HD163296
  - Radmc3D Modeling
    - Band6 Dust Continuum
    - CO 3-2 Line Emission
  - Comparison with Observation Data
  - Parameters and Equations From
    - Isella et al. (2016) Review Paper
    - Isella et al. (2016) Supplementary
    - Rosenfeld et al. (2013)
- Data
  - Band6 Continuum: ALMA Fits Archive (2013.1.00601.S)
  - CO 3-2 Line Emission: ALMA SV Data

HD163296 Info

- **RA(FK5):** 17h53m20.606374s
- **Star Class:** Herbig Ae/Be star
- **Spectral Type:** A1Vep C
- **Star Mass:** 2.3 solar mass
- **Star Radius:** 1.66 solar radius
- **Star Temperature:** 9330 K
- **DEC(FK5):** -21d56m57.379724s
- **Distance to us:** 122 pc
- **Inclination Angle:** 42 deg
- **Position Angle:** 132 deg
- **Gap Location:** 60, 100, 160 AU



CREDIT: https://www.quantamagazine.org/stellar-disks-reveal-how-planets-get-made-20180521/

Rosenfeld et al. (2013)

Radmc3D model setup

- **Column Density Dist. (Dust, Molecules, Gas)**

$$\Sigma(r) = \Sigma_c (r/r_c)^{-\gamma} \exp[-(r/r_c)^{2-\gamma}]$$

- **Density Dist. (Dust, Molecules, Gas)**

$$\rho(r,\phi) = \frac{\Sigma(r)}{H(r)\sqrt{2\pi}} \exp\left[\frac{-z^2}{2H_p^2}\right]$$

$$H(r) = 16\,AU\,(r/150\,AU)^{1.35}$$

$$T_a(r,z) = T_{a,0}(\sqrt{r^2+z^2}/r_0)^{-q_a}$$

$$T_m(r) = T_{m,0}(r/r_0)^{-q_m}$$

$$z_q(r) = z_{q,1}(r/r_1)^{q_z} e^{-(r/r_2)^2}$$

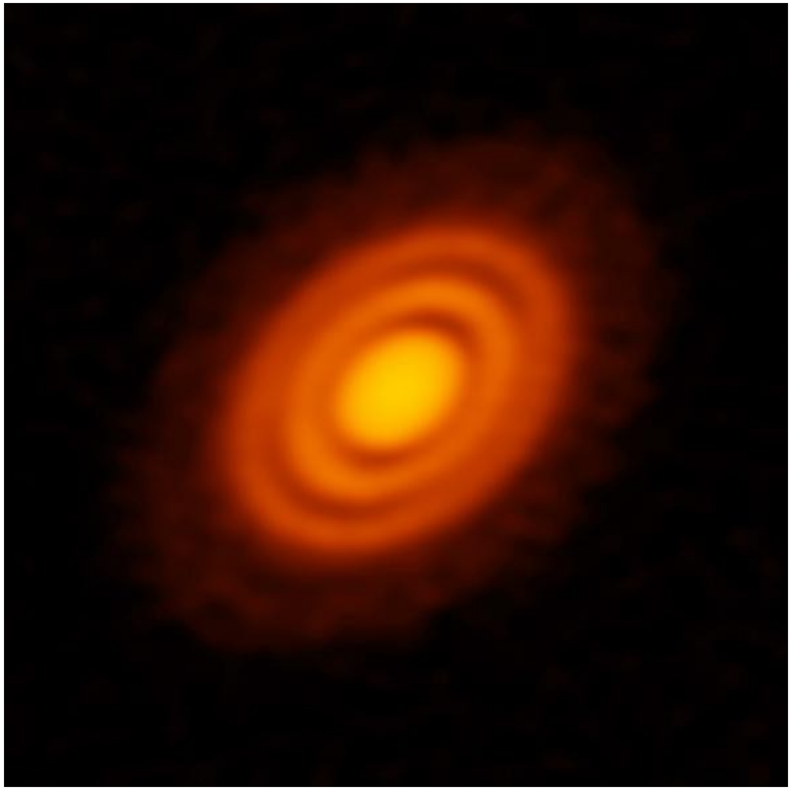
- **Temperature Dist. (Dust, Gas)**

$$T(r,z) = \begin{cases} T_a(r,z) + [T_m(r) - T_a(r,z)]\left(\cos\frac{\pi z}{2z_q(r)}\right)^{2d(r)}, & \text{if } |z| < z_q(r) \\ T_a(r,z), & \text{otherwise.} \end{cases}$$

Radmc3D model setup

- **Dust Opacity**
  - Most Various Parameter
  - Input Dust Opacity in different wavelength
- **Gas Velocity**
  - Assuming Keplerian Motion
- **Gas Turbulence**
  - Assuming No Turbulence
- **Gas Species**
  - Assuming there is Only CO, H2
- **Gas Abundance**
  - Assuming [CO]/[H2] is universal constant
- **Ring Gap**
  - There is one Degeneracy:
    - Wider Gap -> More Depletion (Use This One)
    - Narrower Gap -> Less Depletion

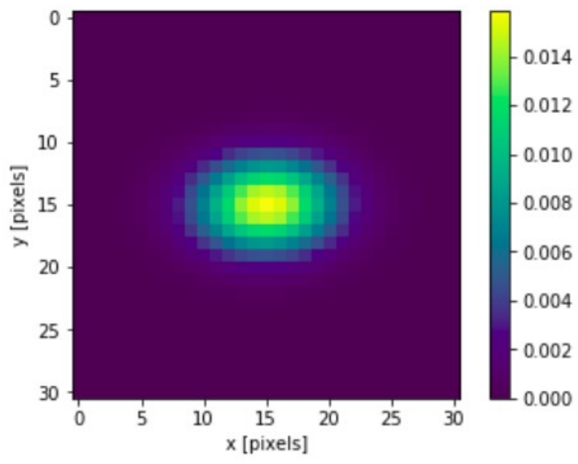
Dust Continuum



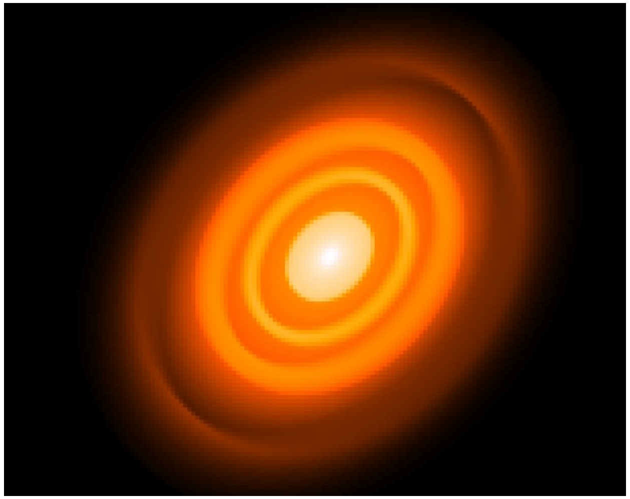
CREDIT: ALMA (ESO/NAOJ/NRAO); A. Isella; B. Saxton (NRAO/AUI/NSF)

Radmc3d Image Manipulation

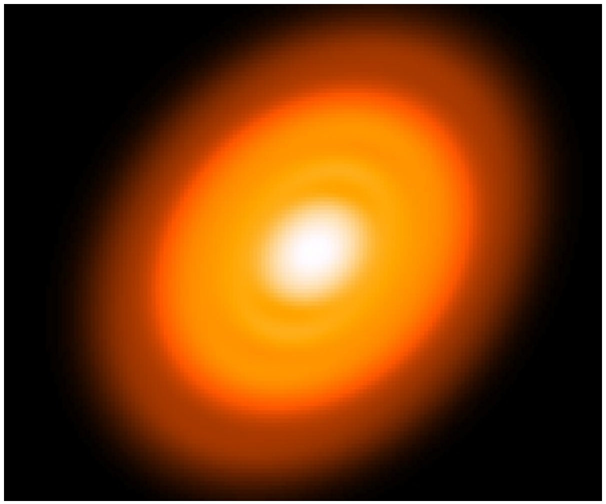
- **Convert Pixel to Beam**
  - Unit: Jy/Pixel -> Jy/Beam
- **Beam Convolution**
  - Use Observational Beam to Convolve Images
  - Input FWHM [Major, Minor], Position Angle



BEFORE



AFTER

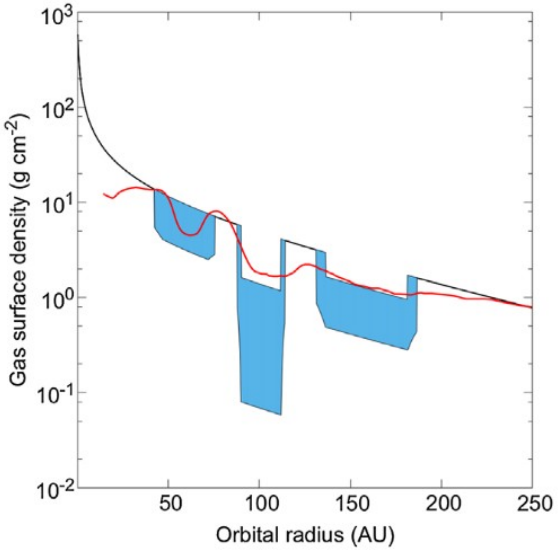


Calculate Dust/Gas Column Density

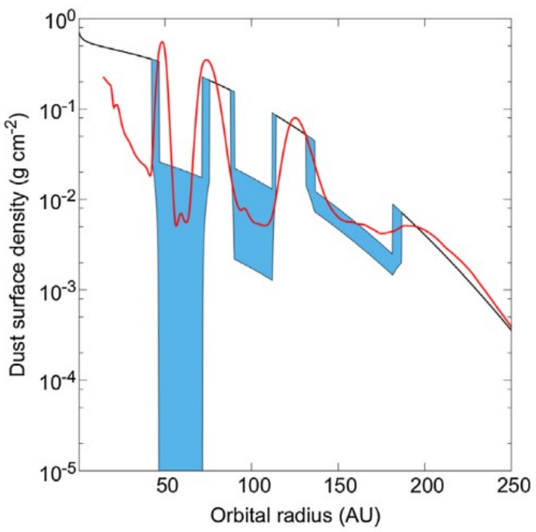
Isella et al. (2016)

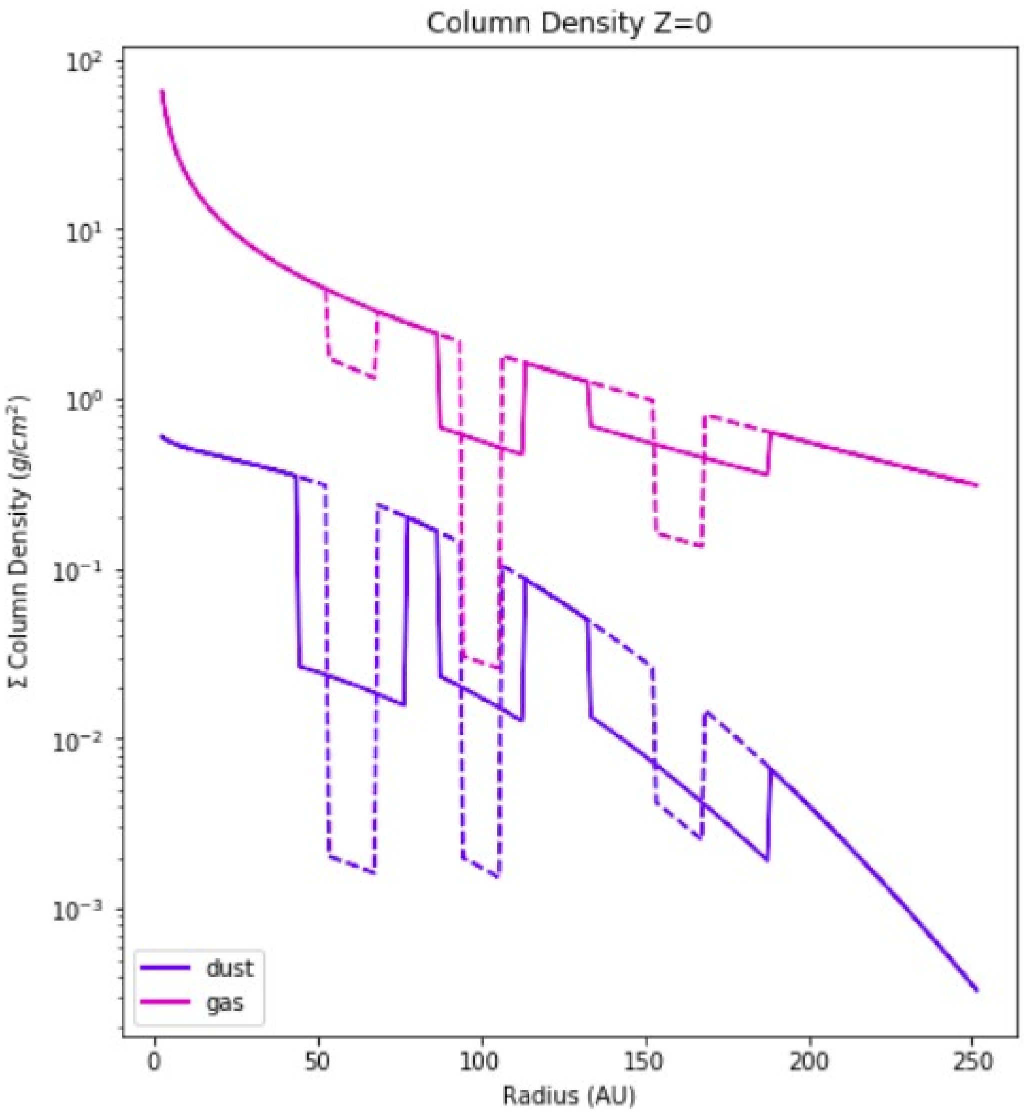
This work

Gas

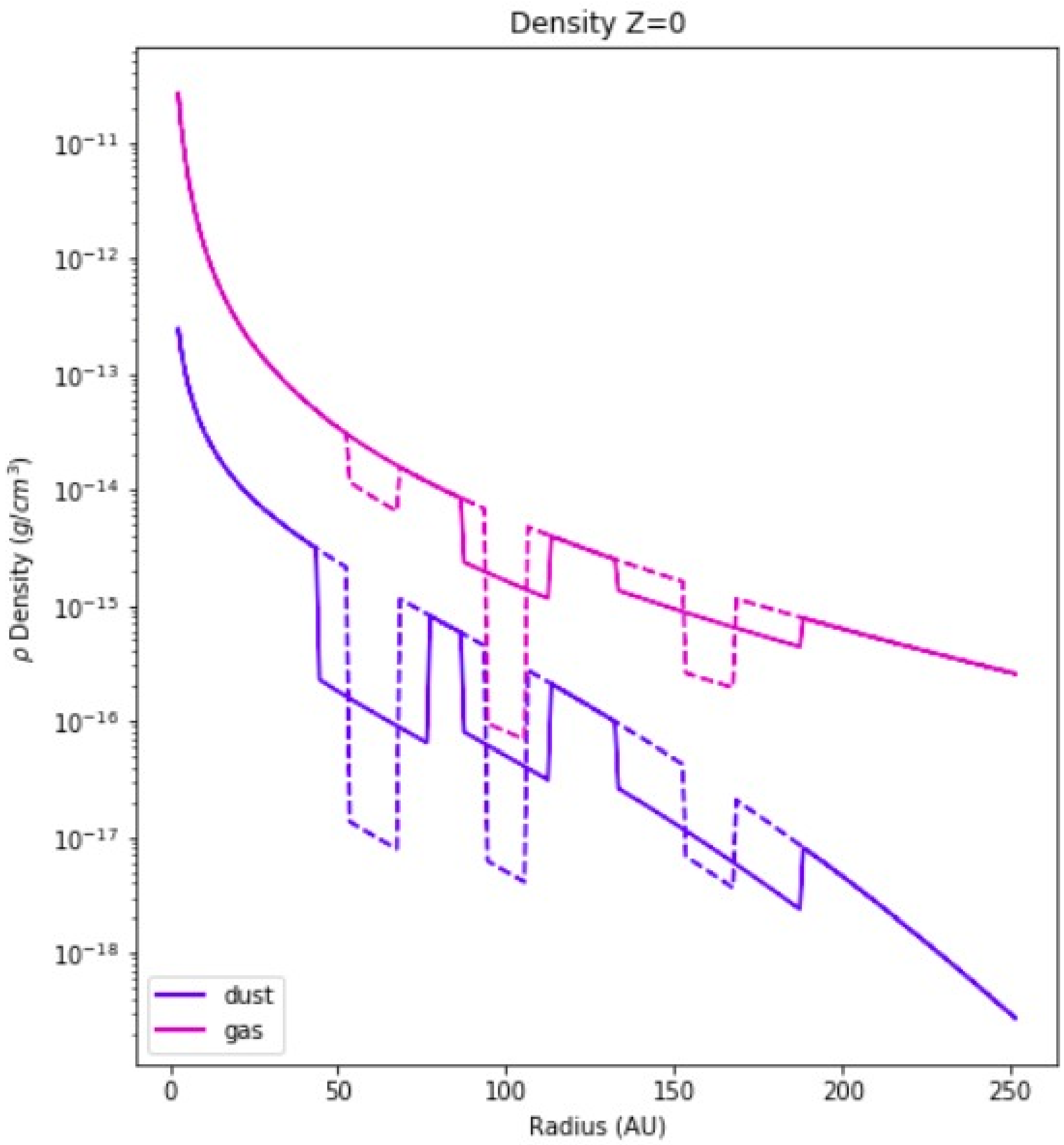


Dust



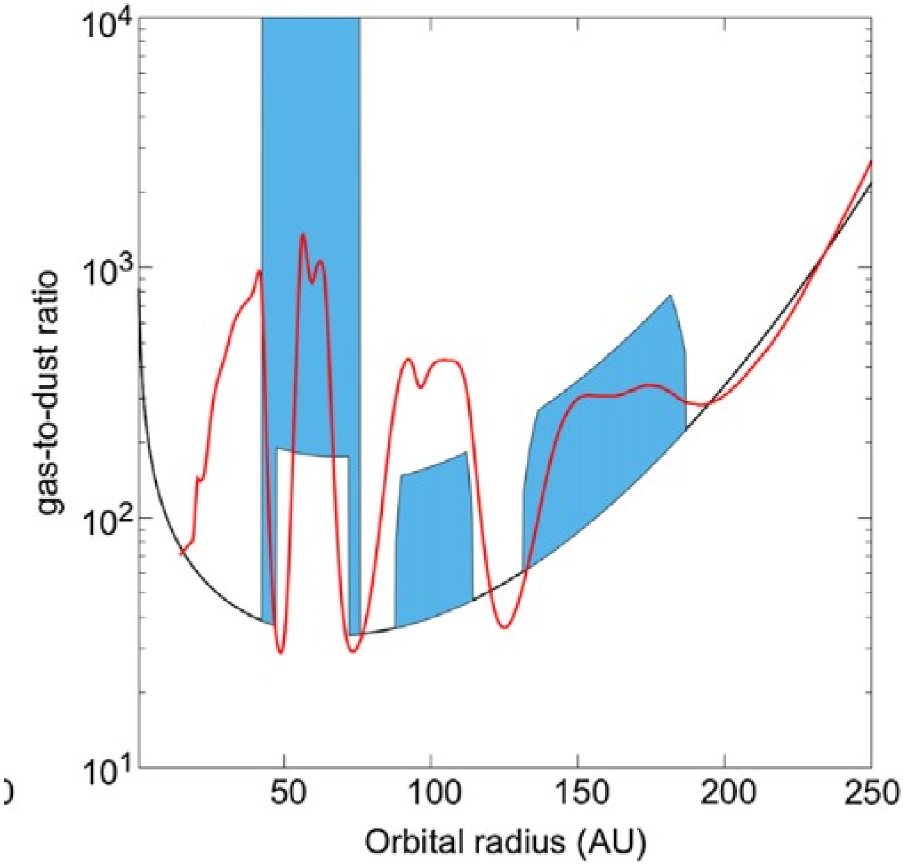


Calculate Dust/Gas Density

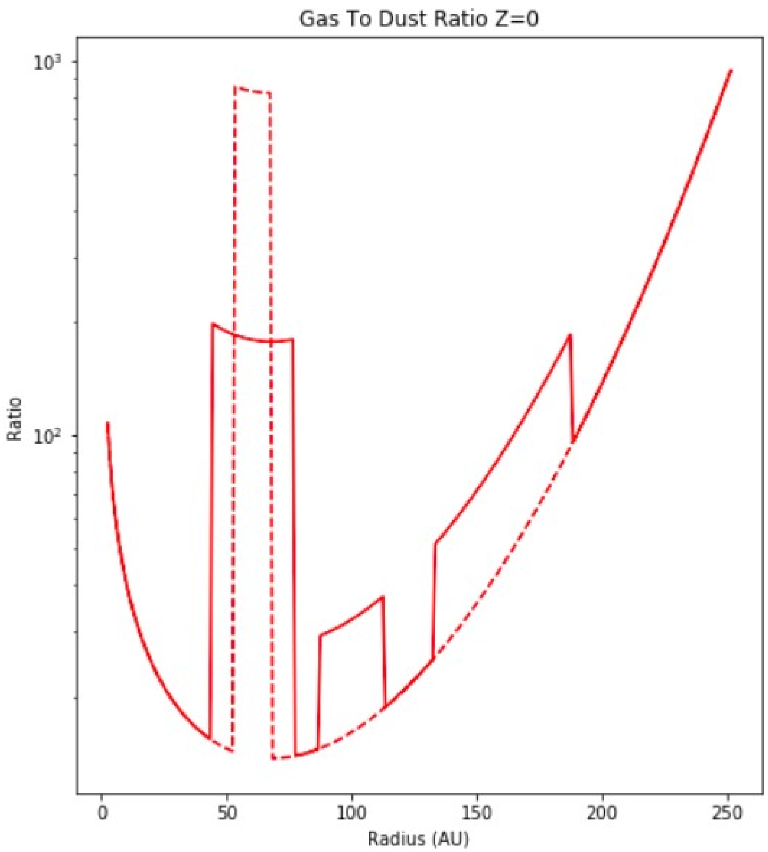


Calculate Gas to Dust Ratio

Isella et al. (2016)

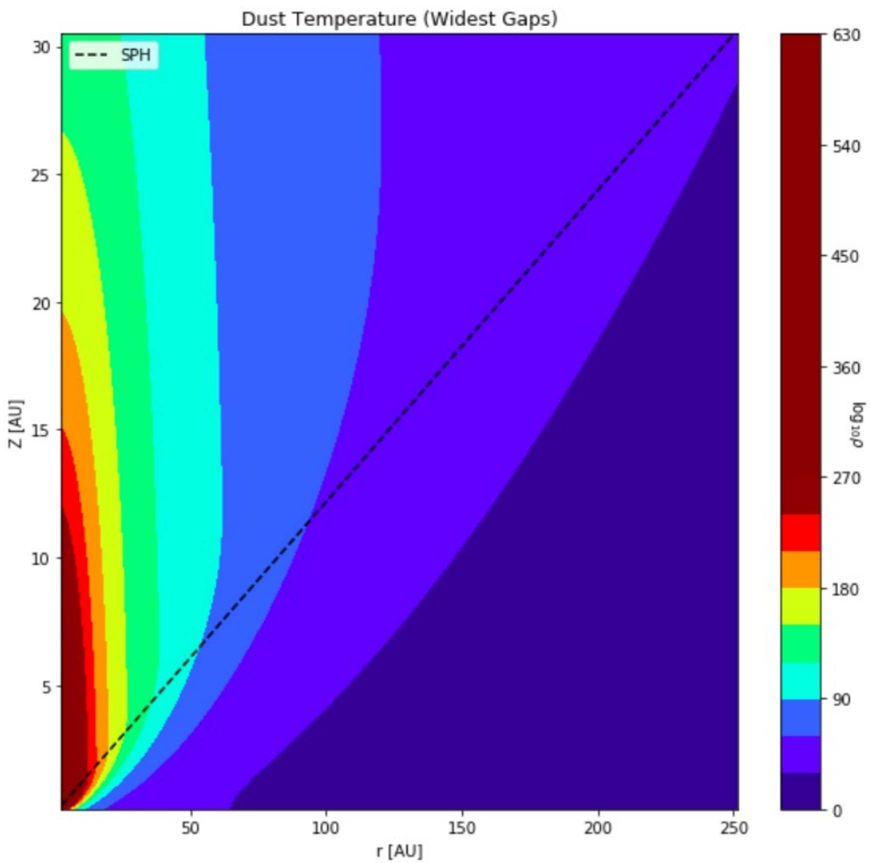


This work

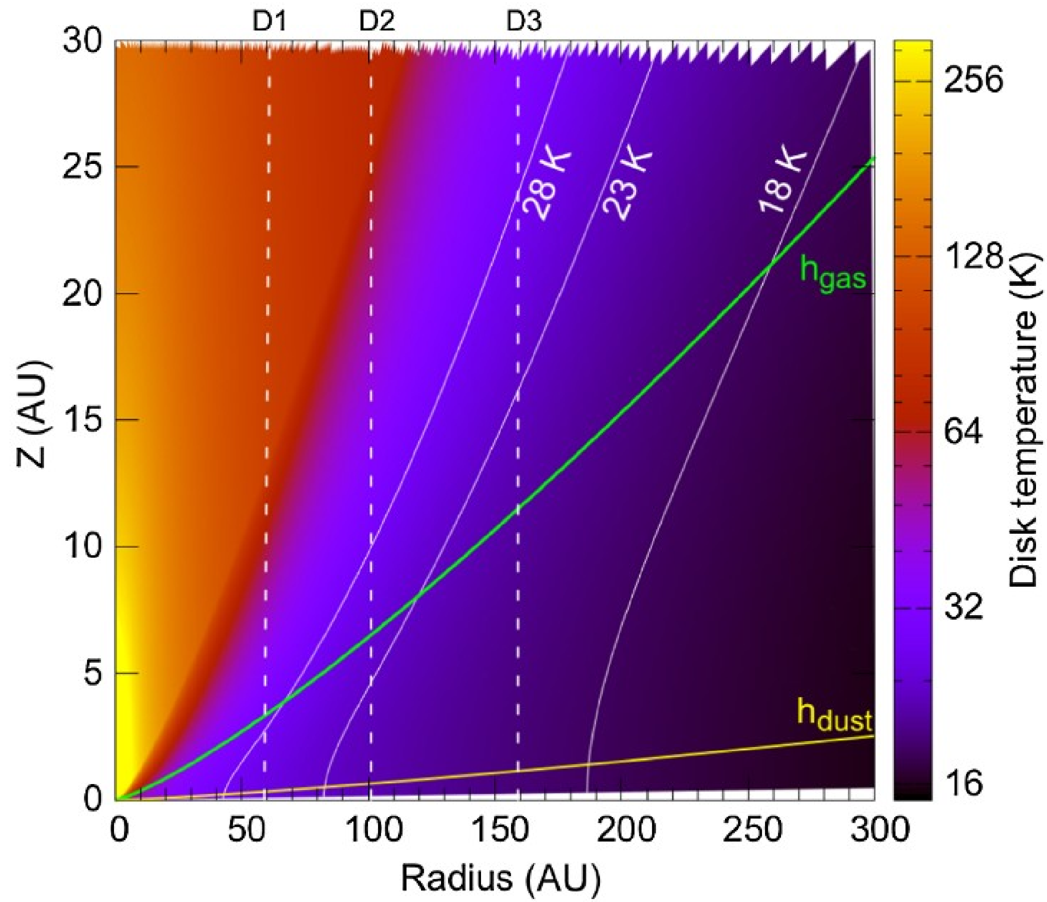


Calculate Temperature Dist.

This Work



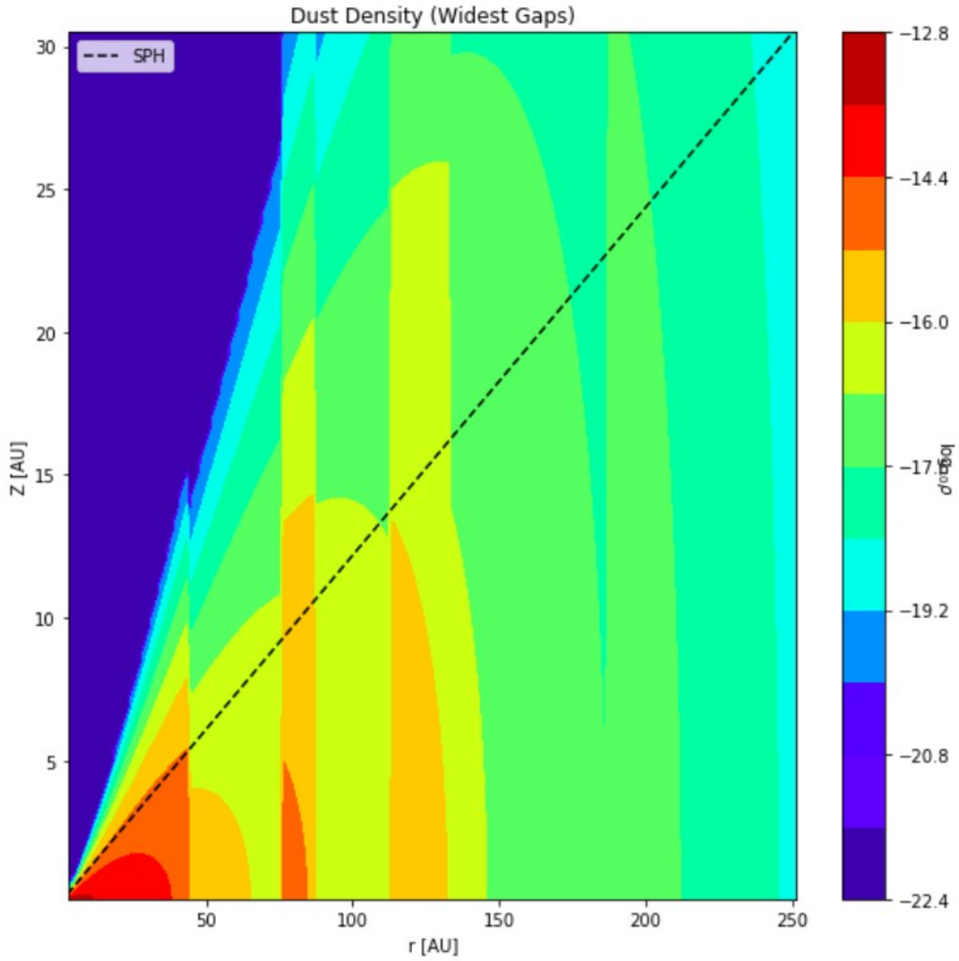
Observation



Isella et al. (2016)

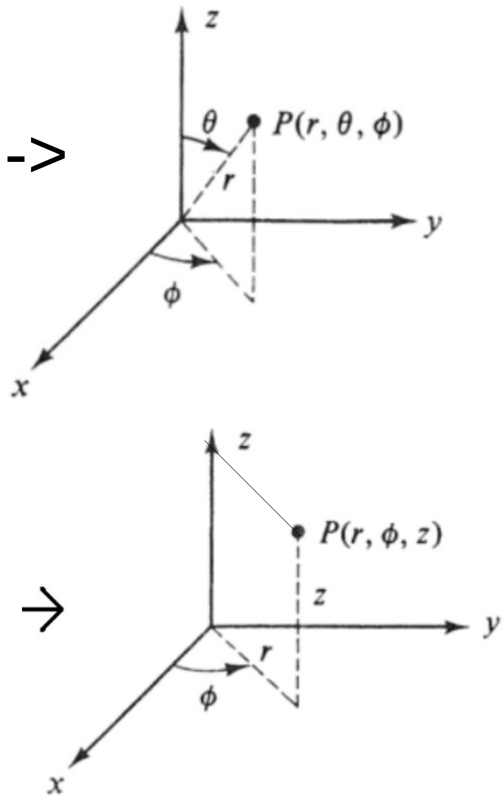
Calculate Dust Density Dist.

Dust Density



SPH ->

CYL →



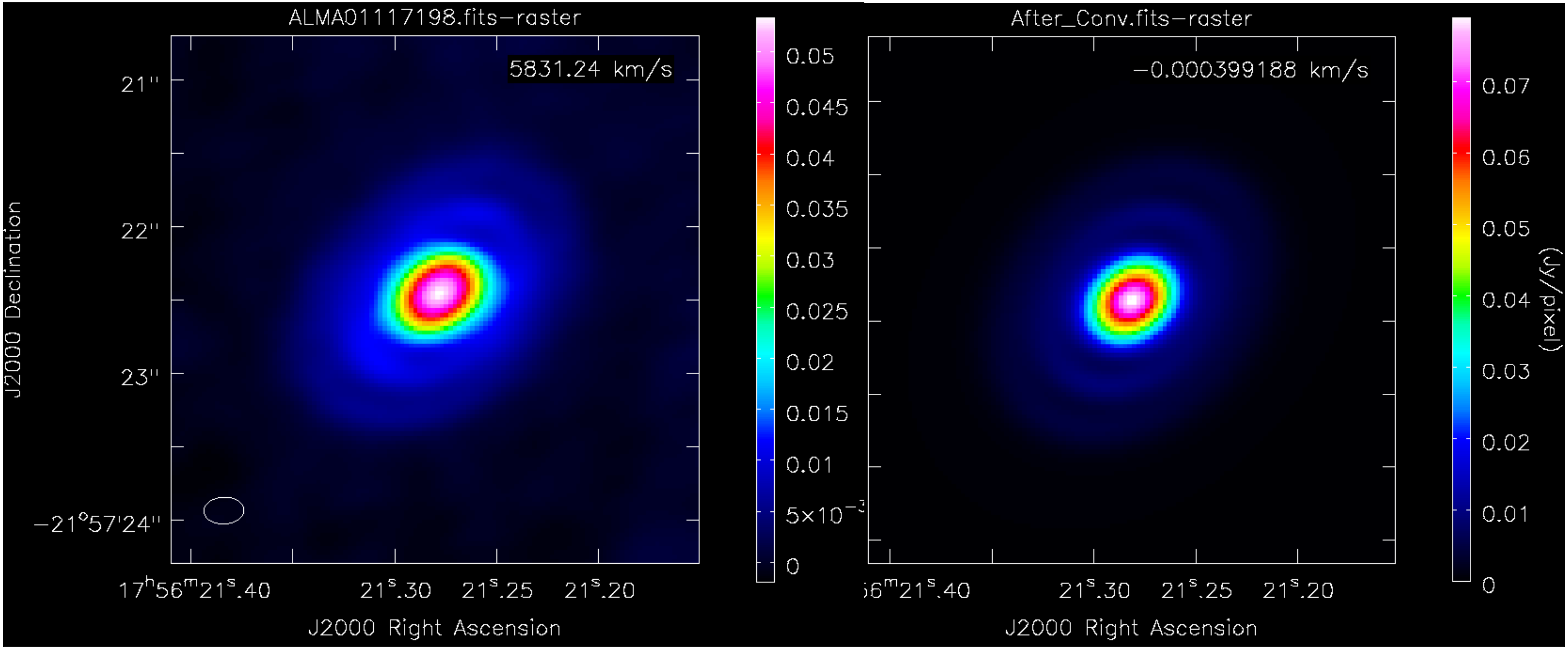
Credit:
http://www.learningaboutelectronics.com/Articles/Spherical-to-cylindrical-coordinate-converter-calculator.php

Due to technical problem, this work uses **spherical coordinate** not **cylindrical coordinate** that was used in (Isella et al. 2016)

Band6 Dust Continuum

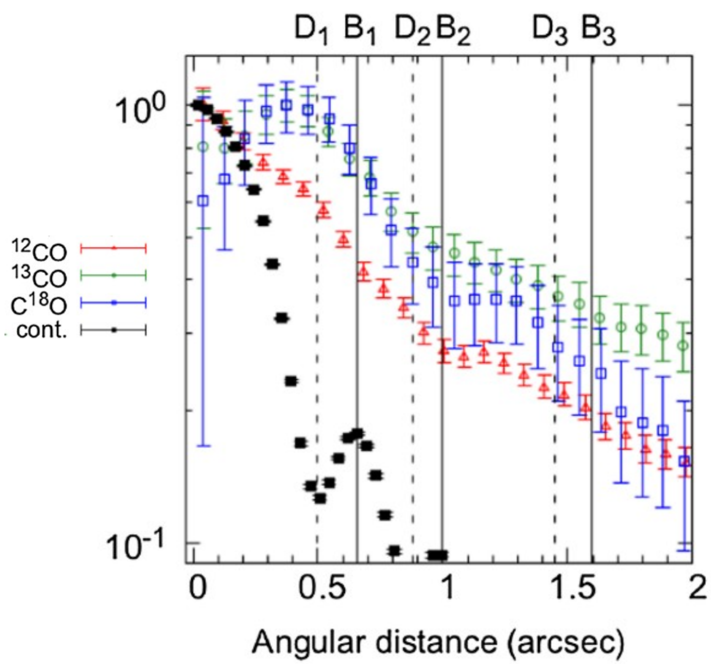
Isella et al. (2015)

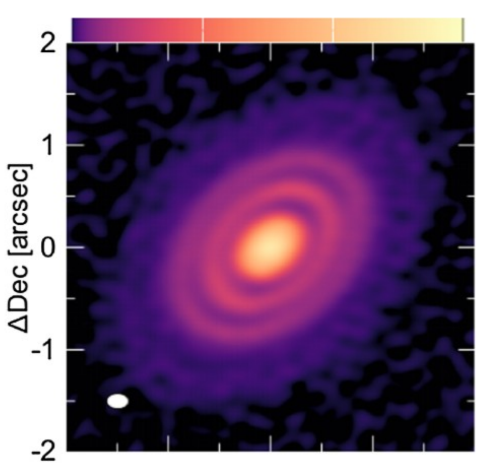
Observation | Simulation



Band6 Dust Continuum

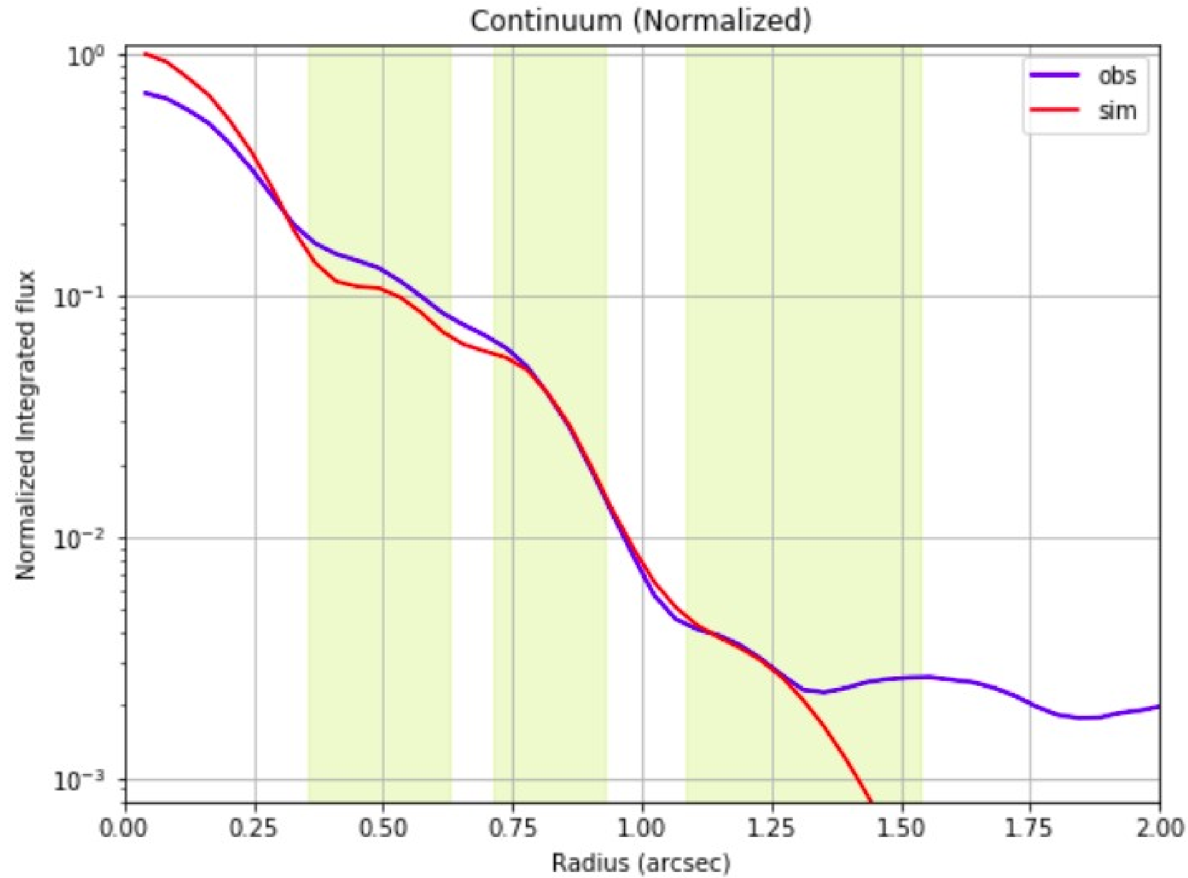
Isella et al. (2016)





This work

Elliptical Accumulated Intensity

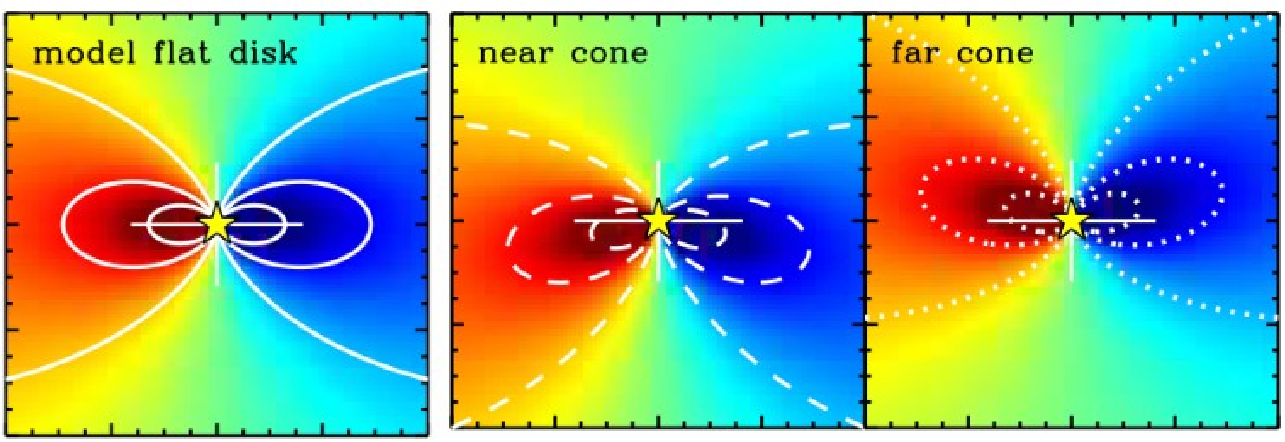


Rosenfeld et al. (2013)

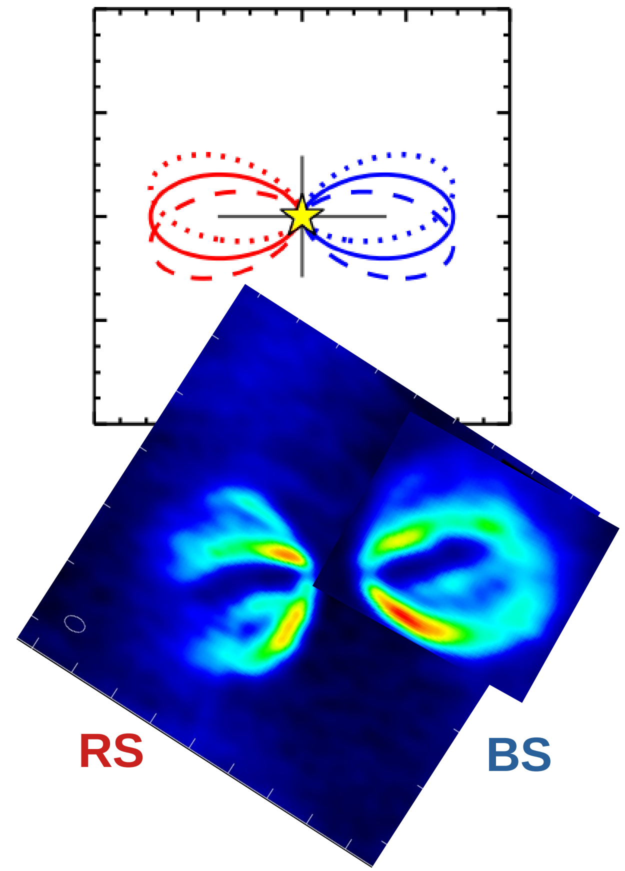
CO 3-2 Line Emission

- Double Cone Model
  - Observed Velocity Changes Due to Inclination
  - Actually Observed Different Part of Disk

Observed At Identical Velocity Channel

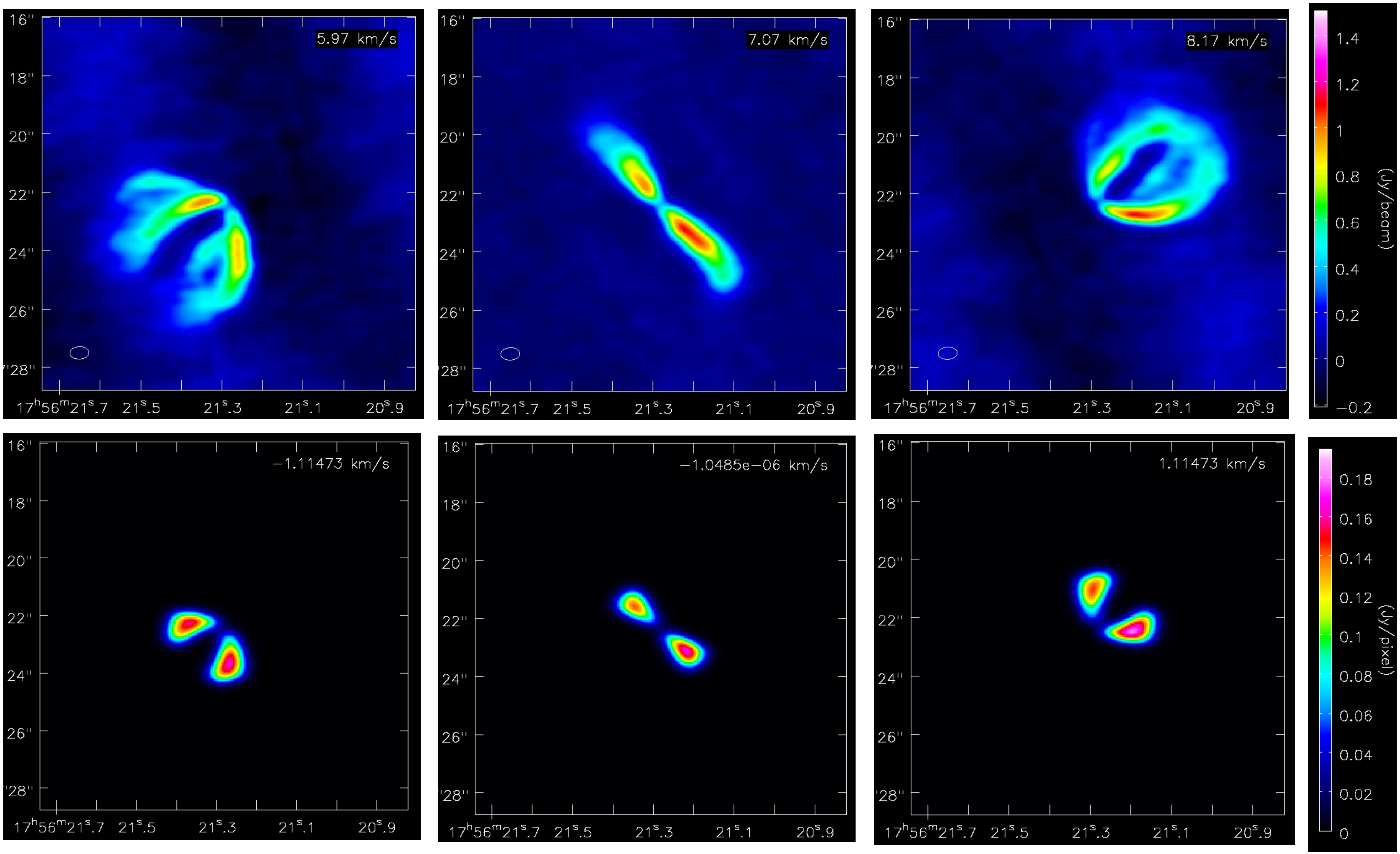


white line, white dashed line, and white dot line indicates same velocity contour



CO 3-2 Line Emission

Observation



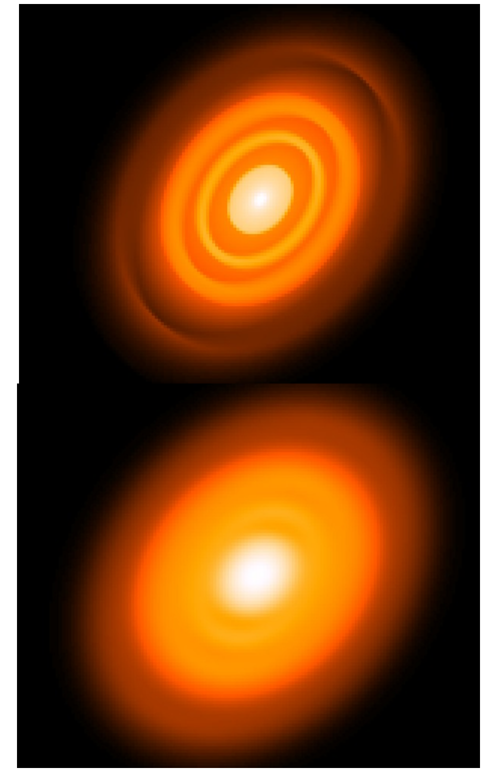
Simulation

Discussion

- How to Improve Simulation ?
  - (1) Try Different Opacity Sets
  - (2) Try Different Velocity Sets
    - For this simulation, all assuming in Keplerian motion
    - In Rosenfeld et al. (2013), they provide other velocity sets

- Why not seeing Double-Cone In Simulation ?
  - (1) Modeling Scale isn’t Large Enough
  - (2) Velocity Turbulence may be needed. Since providing Wider Velocity Distribution, It may help to Separate Near Cone and Far Cone Apart.

Work Progress Revisit



- Target – HD163296
  - Radmc3D Modeling
    - Band6 Dust Continuum
    - CO 3-2 Line Emission
  - Comparison with Observation Data
  - Parameters and Equations From
    - Isella et al. (2016) Review Paper
    - Isella et al. (2016) Supplementary
    - Rosenfeld et al. (2013)
- Data
  - Band6 Continuum: ALMA Fits Archive (2013.1.00601.S)
  - CO 3-2 Line Emission: ALMA SV Data

Thanks for Listening

Any Questions?