

# Searching for Planets in Young Disks

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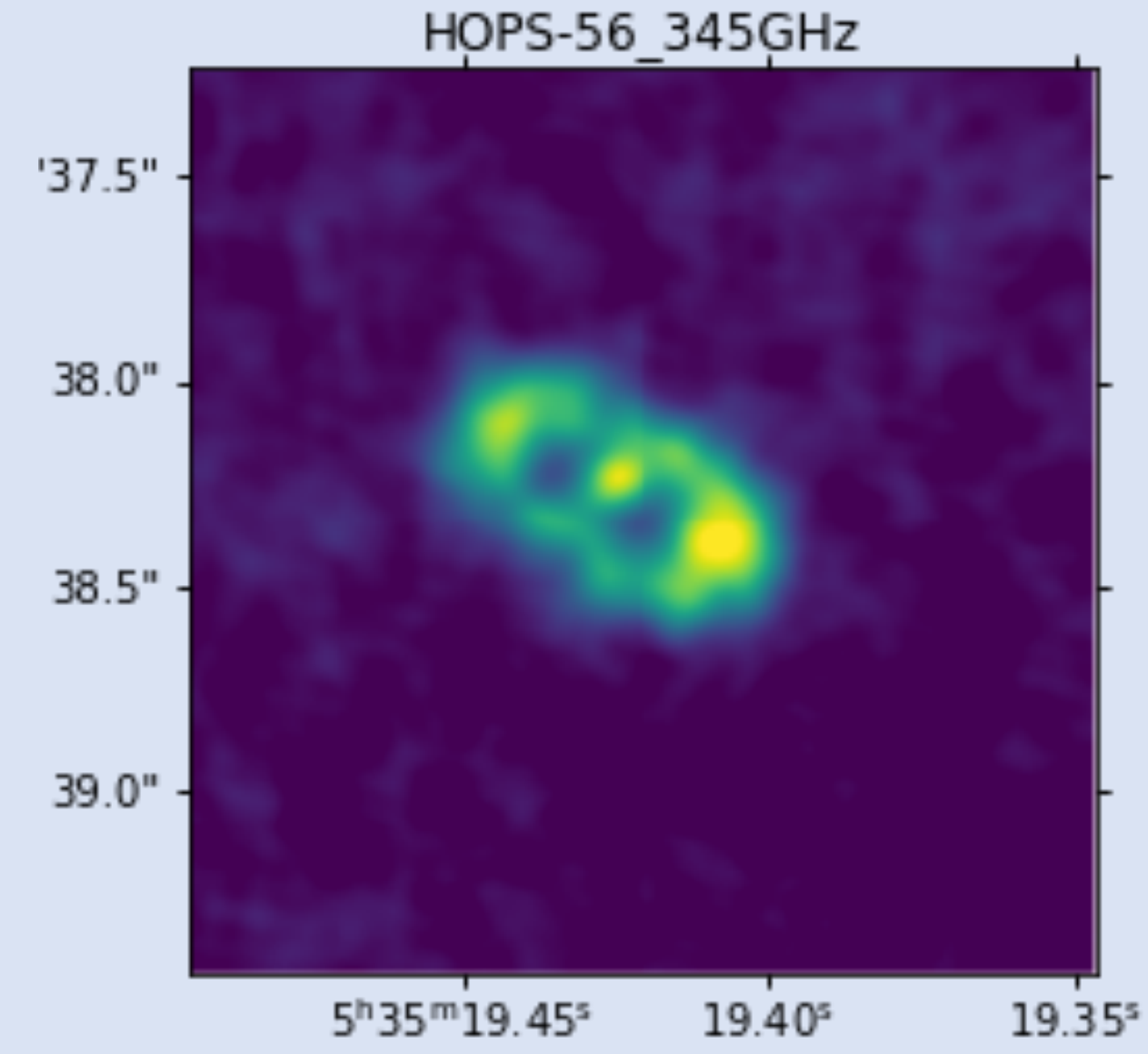
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## Background

### Existing Problems:

- Timescale for planet formation theory
- Structures found in 2 Myr-old disks suggest planets form early, unclear how early



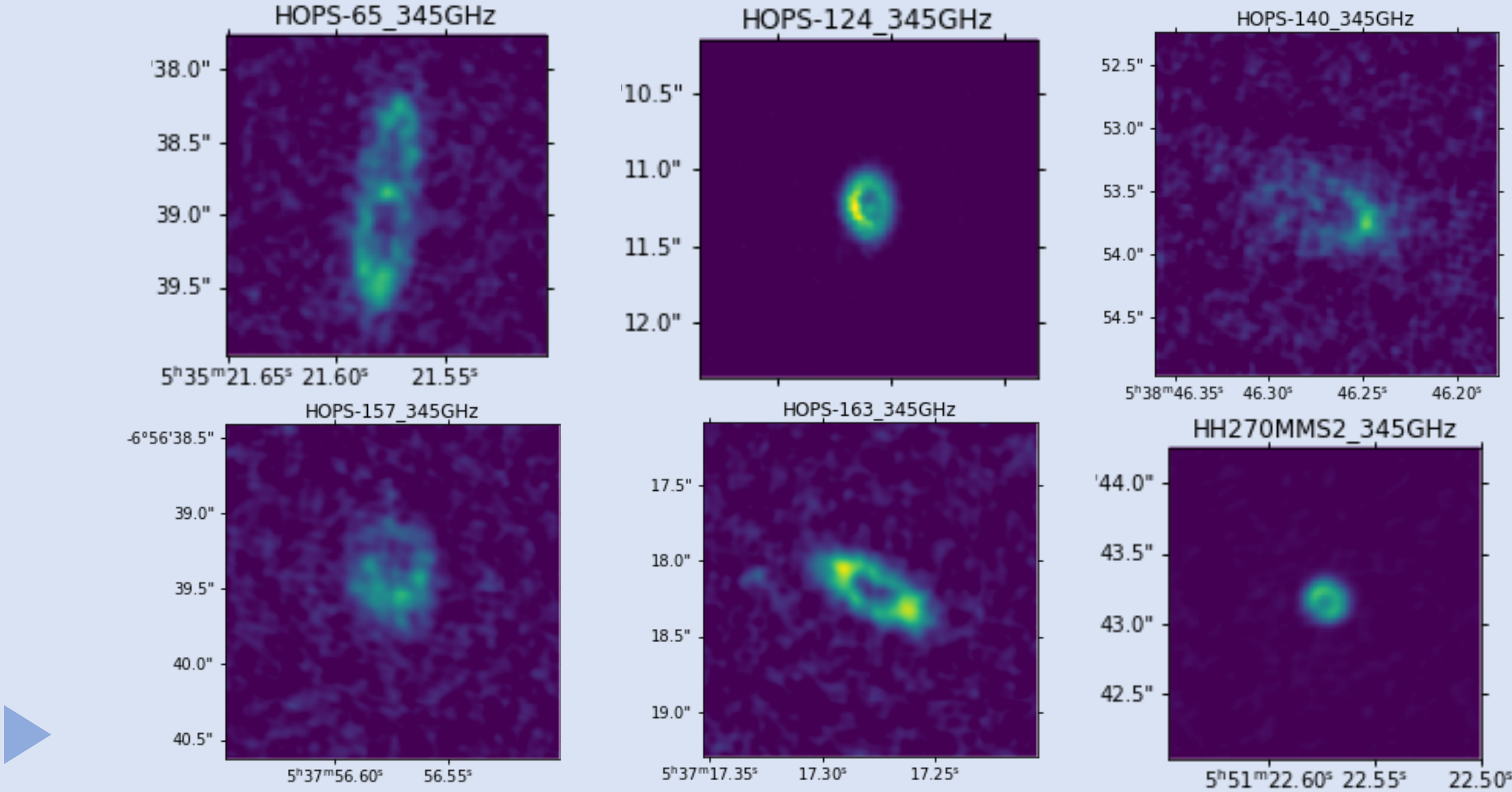
### Young Disks around 1 Myrs old:

- Some show “dark ring”
- New planets or companion stars may be born inside

### ALMA and VLA data:

- ALMA shows the disks
- VLA shows the free-free emission from objects

Young disks with gaps from ALMA



## Methods

- Compare ALMA and VLA images to find potential objects and their flux (energy)

- Transfer flux to bolometric luminosity

$$L = F * D^2$$

$$L \propto v^{-0.1} \quad \text{or} \quad L \propto v^{0.56}$$

$$\log(L_{4.1cm}) = (-2.66 \pm 0.06) + (0.91 \pm 0.06)\log(L_{bol})$$

- Find mass with assumed age and measured flux by using 8 evolutionary tracks. They are used to show relationship between mass, age and bolometric luminosity of the objects

- Incorporate errors from flux measurement and third equation above by using Monte Carlo Method



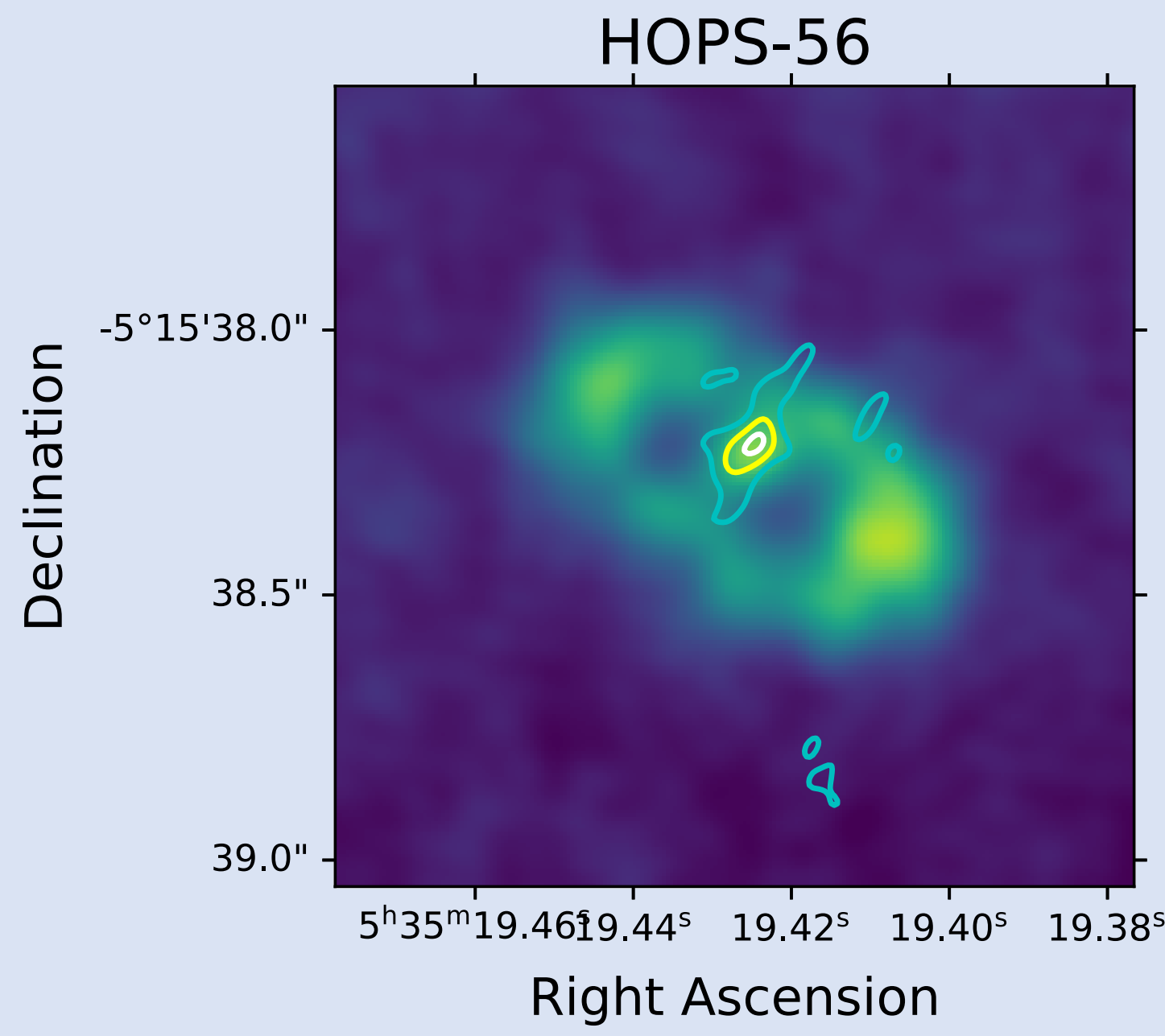
No clear evidences for potential objects inside the dark gap of 7 sources

The mass of companion should be no more than  $0.55 M_{\odot}$

## Results

### 1 Sources showing interesting structures

- HOPS-157
- But not clear for evidence of planets
- 3RMS of the data is used for those with no detections

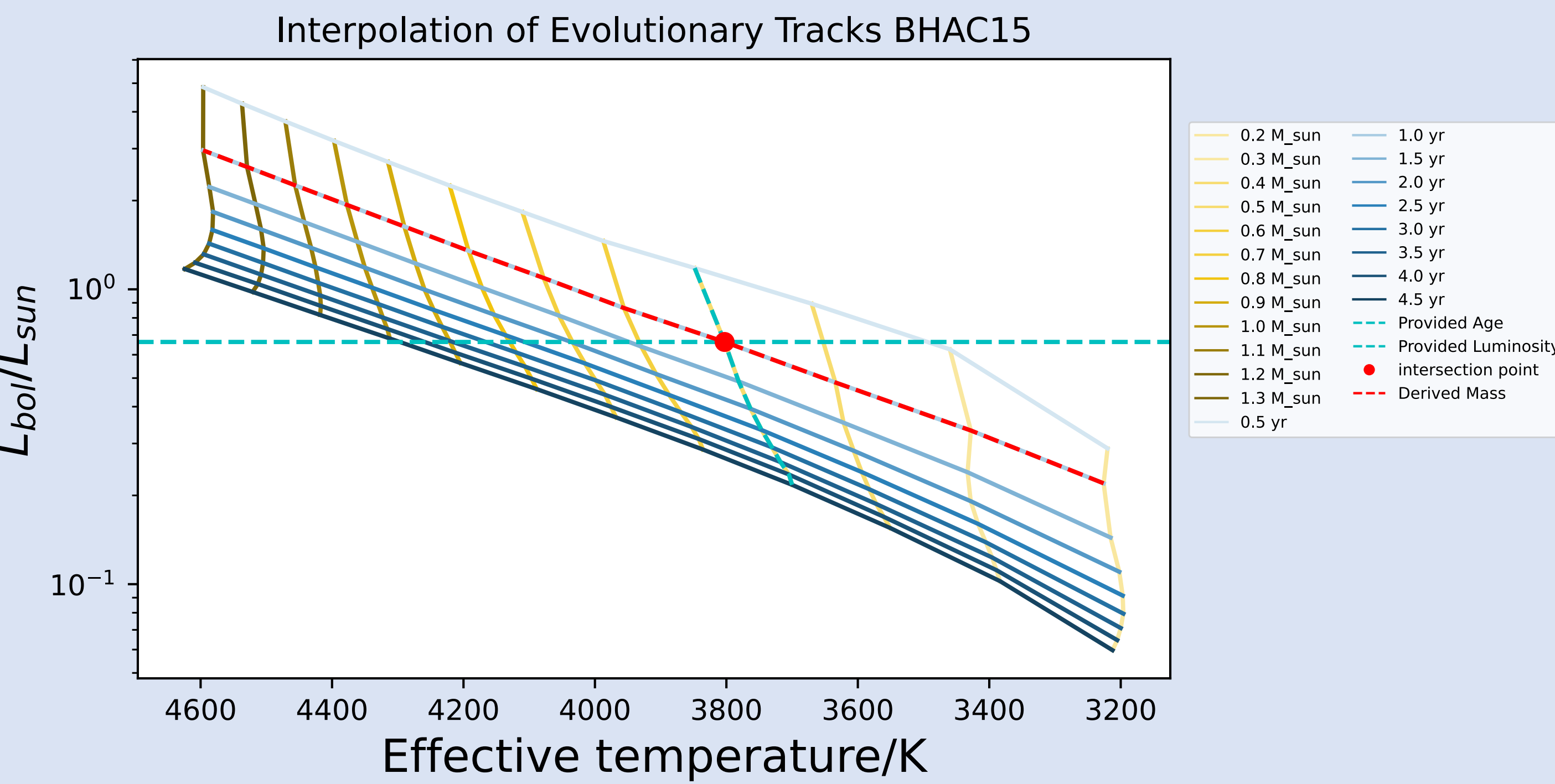


### 2 Finding mass by evolutionary tracks

- Done for all 7 sources
- Assumed age at 0.5Myr and 1 Myr

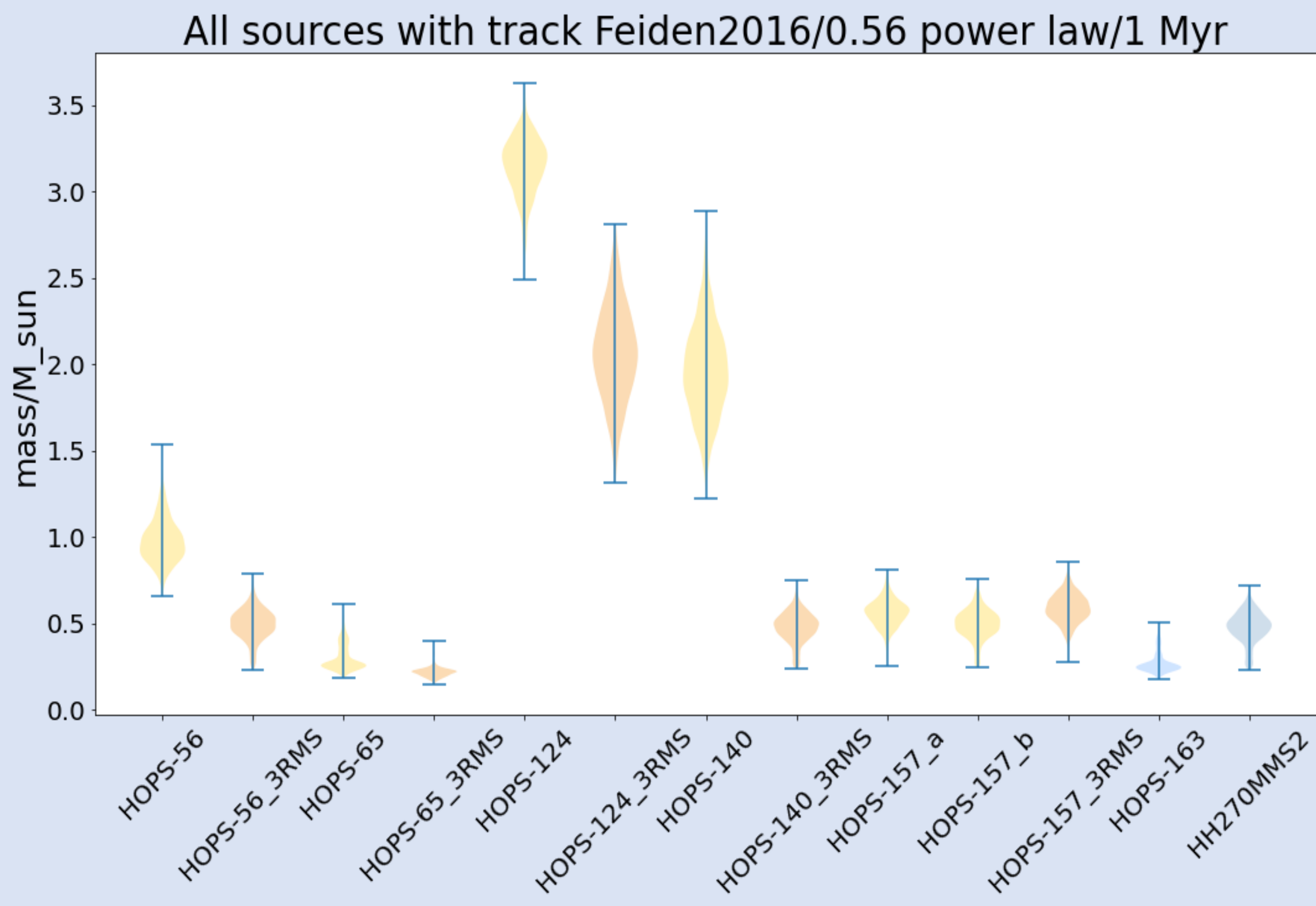
HOPS-157 –ALMA background with VLA contours

Evolutionary tracks and the process to find mass



### 3 Incorporating errors to calculated mass

- Primary star
- 3RMS for planets



Masses for all sources and their errors

## References

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• Segura-Cox D M, Looney L W, Tobin J J, et al. The VLA Nascent Disk and Multiplicity survey of Perseus protostars (VANDAM). V. 18 candidate disks around Class 0 and I protostars in the Perseus molecular cloud[J]. The Astrophysical Journal, 2018, 866(2): 161.