Adventures in High Angular Resolution Astrophysics

Mike Sitko

SSI/CEPS - 27/4/2016

How do planetary systems form & evolve?

1. Look at “baby” planetary systems
2. look at mature planetary systems

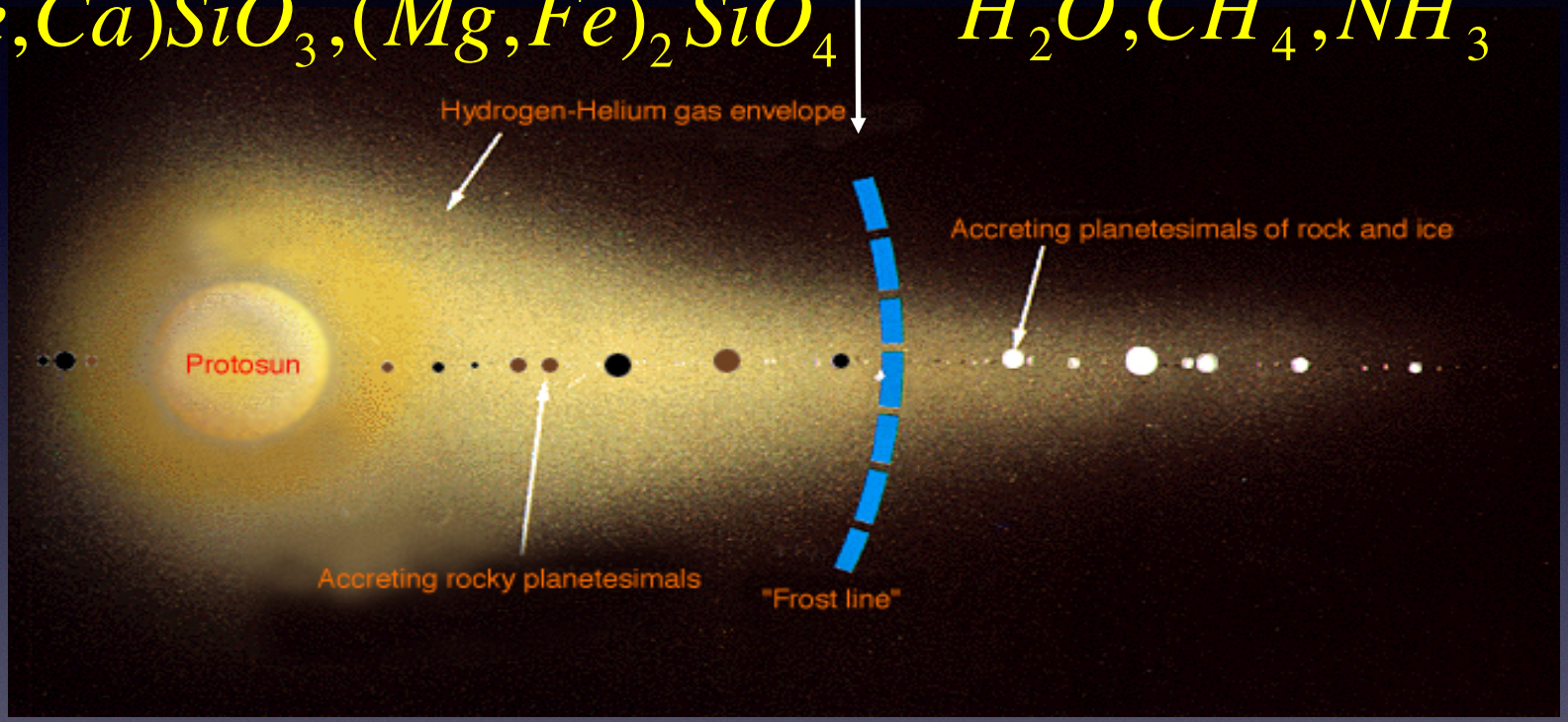
Beyond the “frost line” ice can condense, allowing more massive planets to form

Silicates: Pyroxenes, Olivines

$(Mg,Fe,Ca)SiO_3, (Mg,Fe)_2SiO_4$

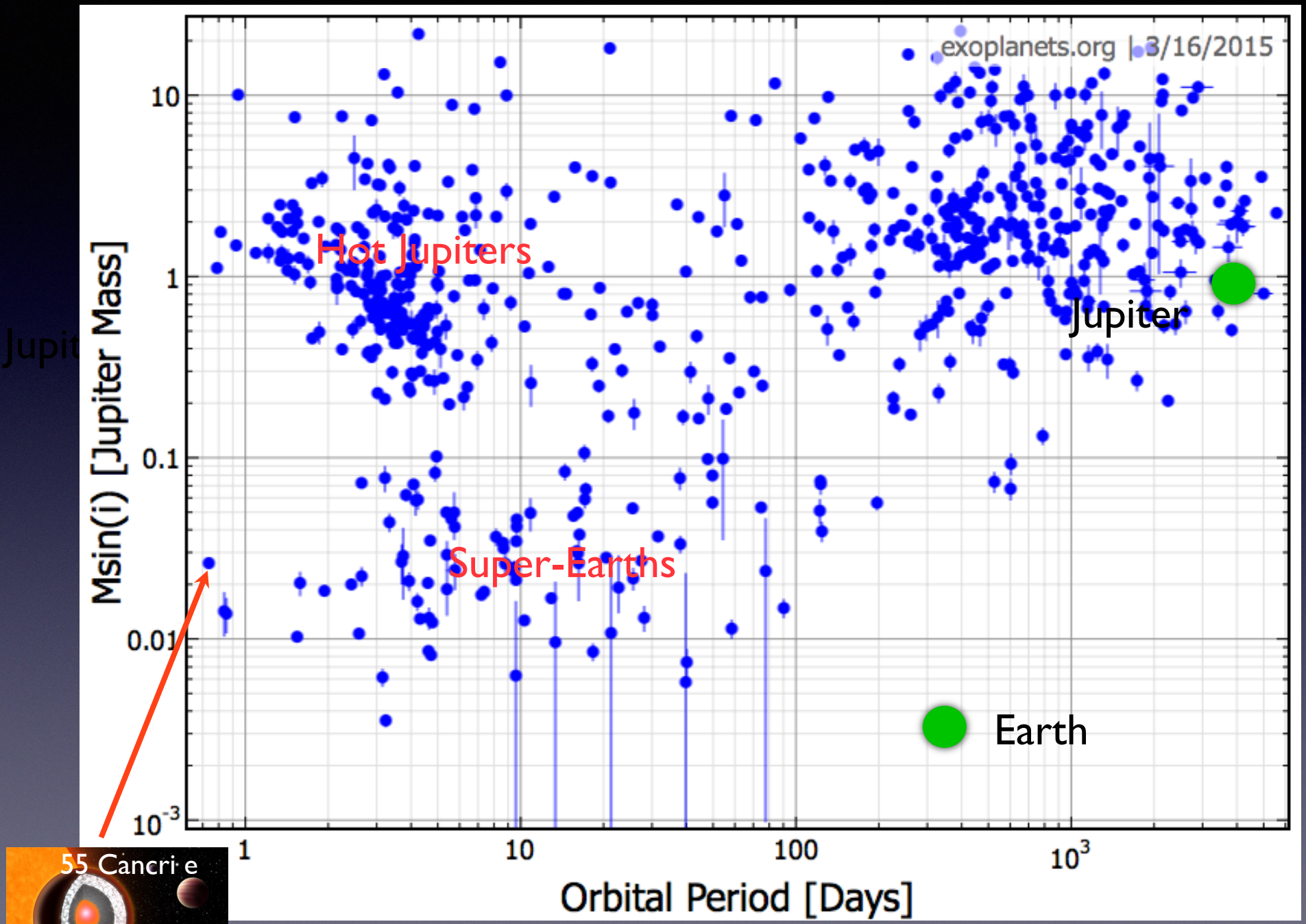
Volatile Ices

H_2O, CH_4, NH_3



Refractories (rock, metal)

volatiles (ices & gas) and refractories


exoplanets.org | 3/16/2015
Hot Jupiters
Super-Earths
Jupiter
Earth
Msin(i) [Jupiter Mass]
Orbital Period [Days]
10
1
0.1
0.01
10^{-3}
1
10
100
10^3

55 Cancri e

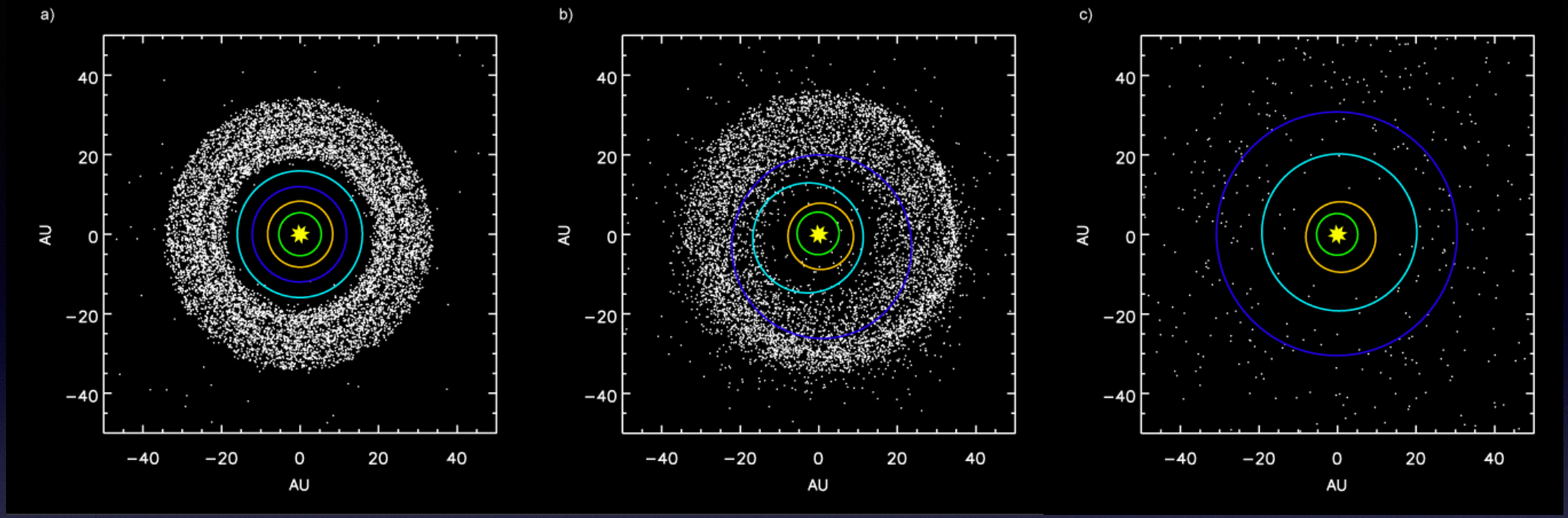
Okay, where did all the “Hot Jupiters” come from?

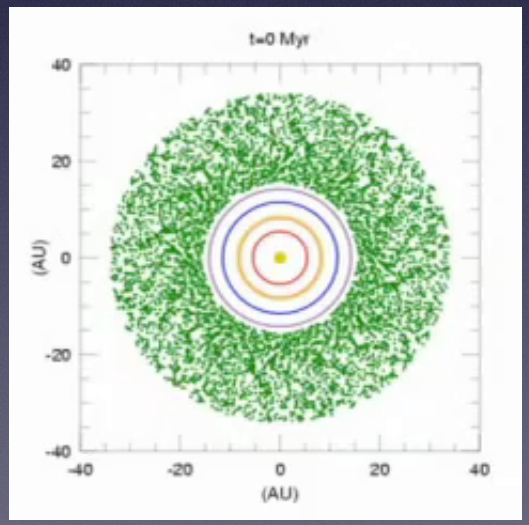
Cannot form inside the snow/frost line

Formed further out & migrated - planet-disk drag

A nice “little” (8 MB) of one example, by Phil Armitage, U Colorado

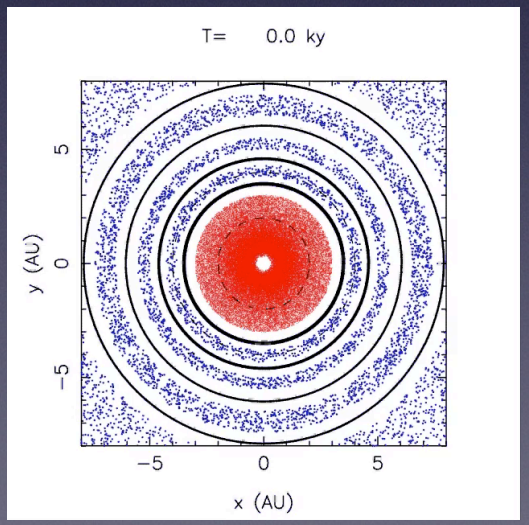
Also, planetary migration



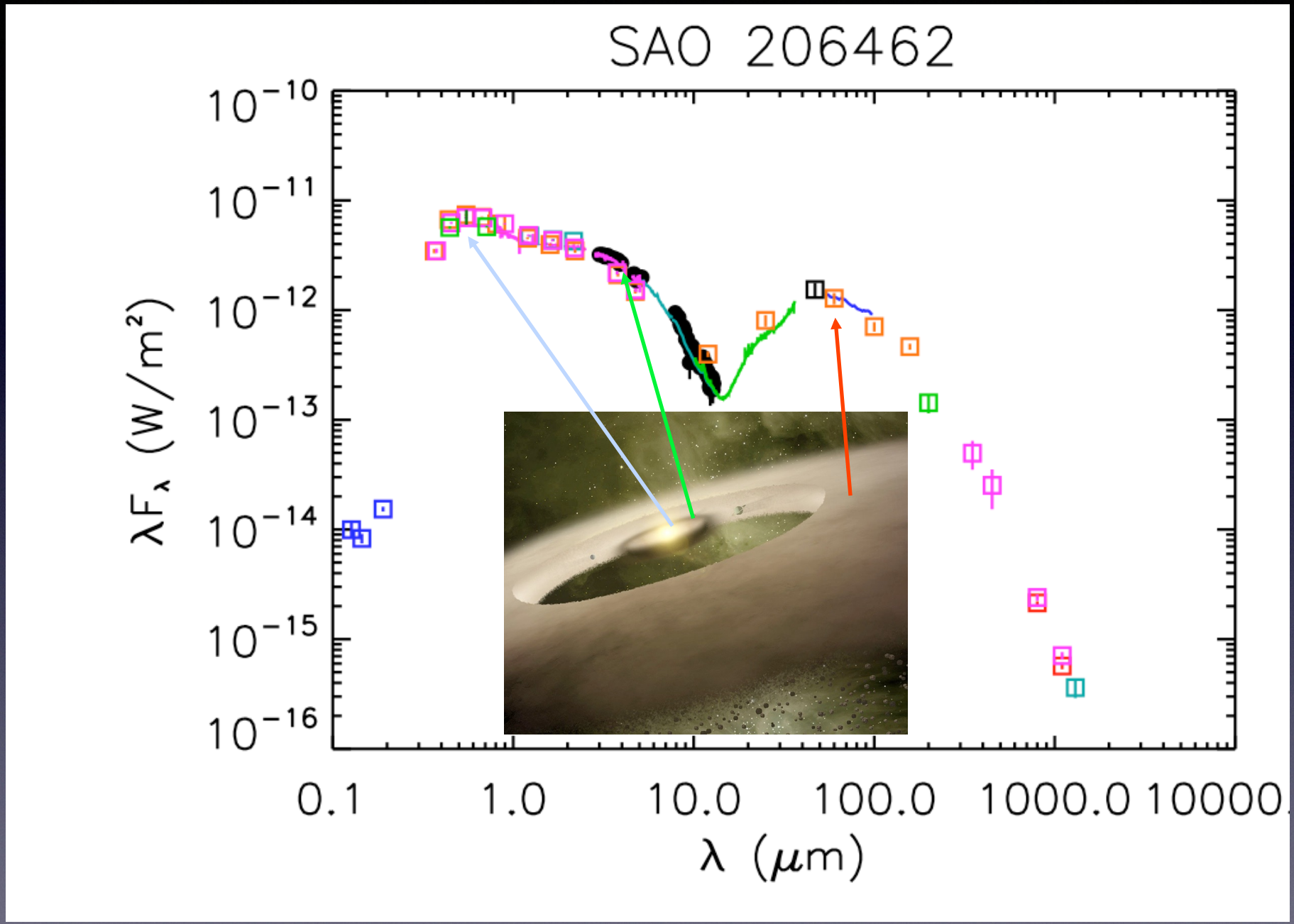


“Nice Model”

“Grand Tack”



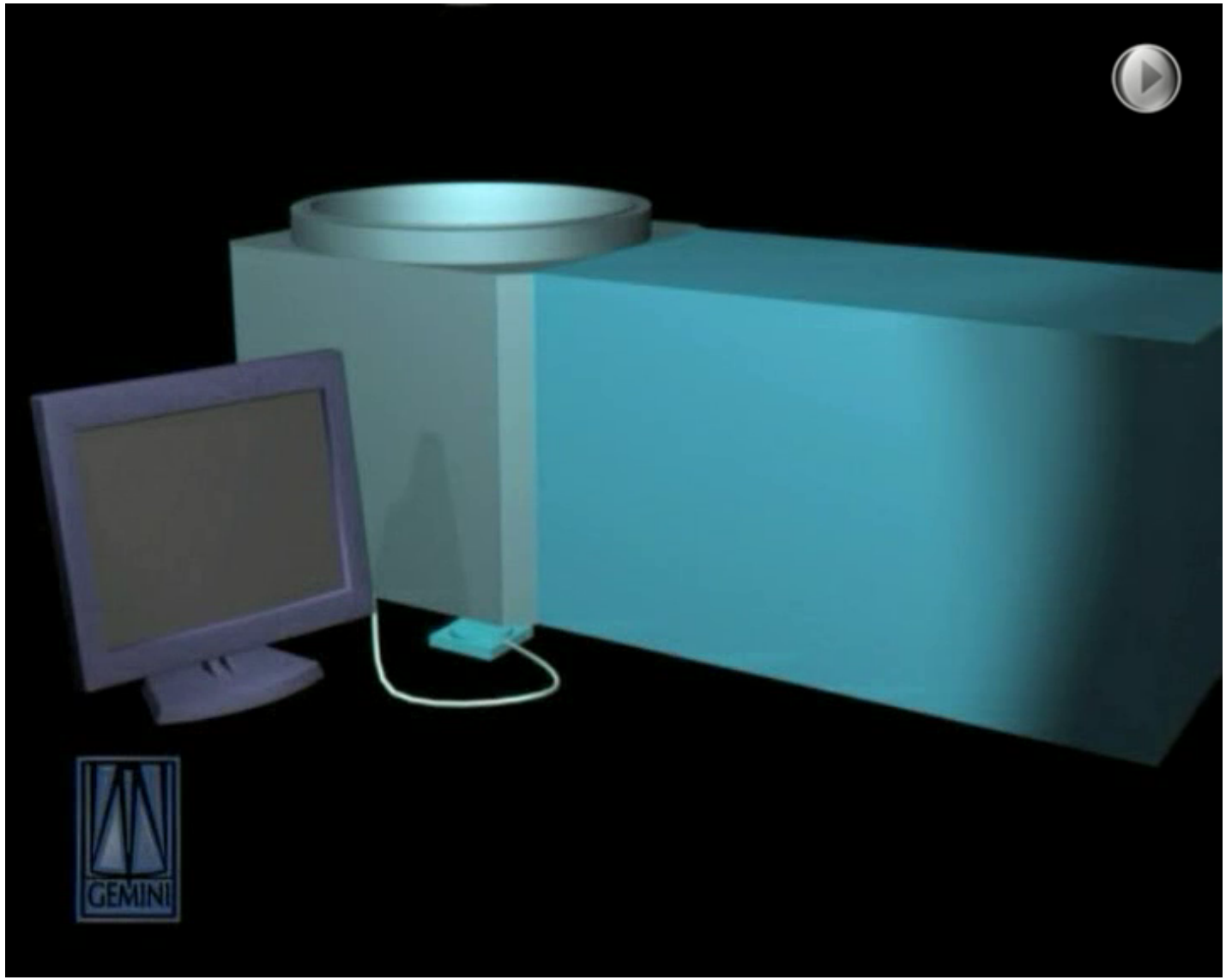
“Pre-Transitional Disks”

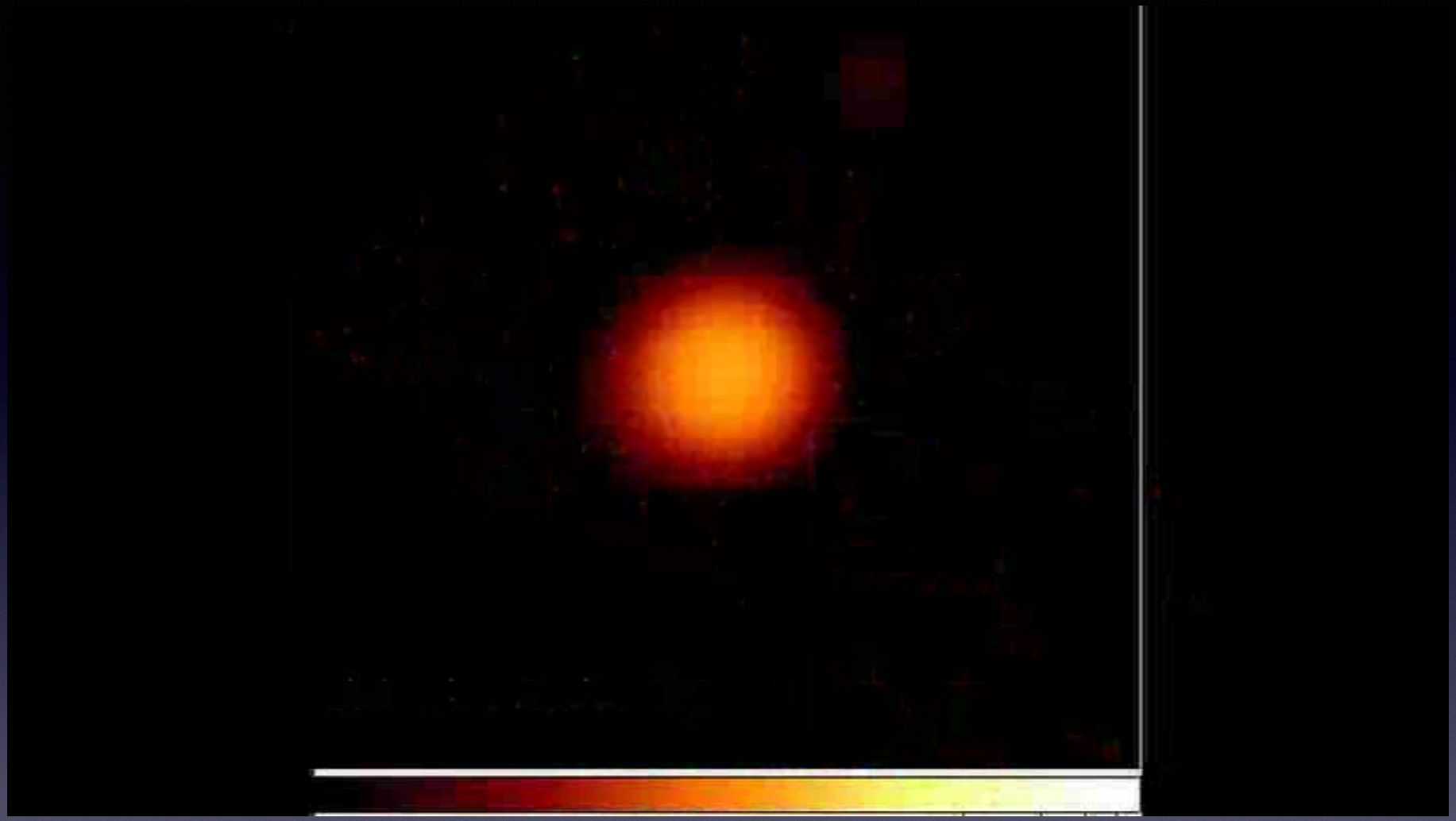


High Angular Resolution Astrophysics:

- Direct Imaging
- Interferometry

Adaptive Optics





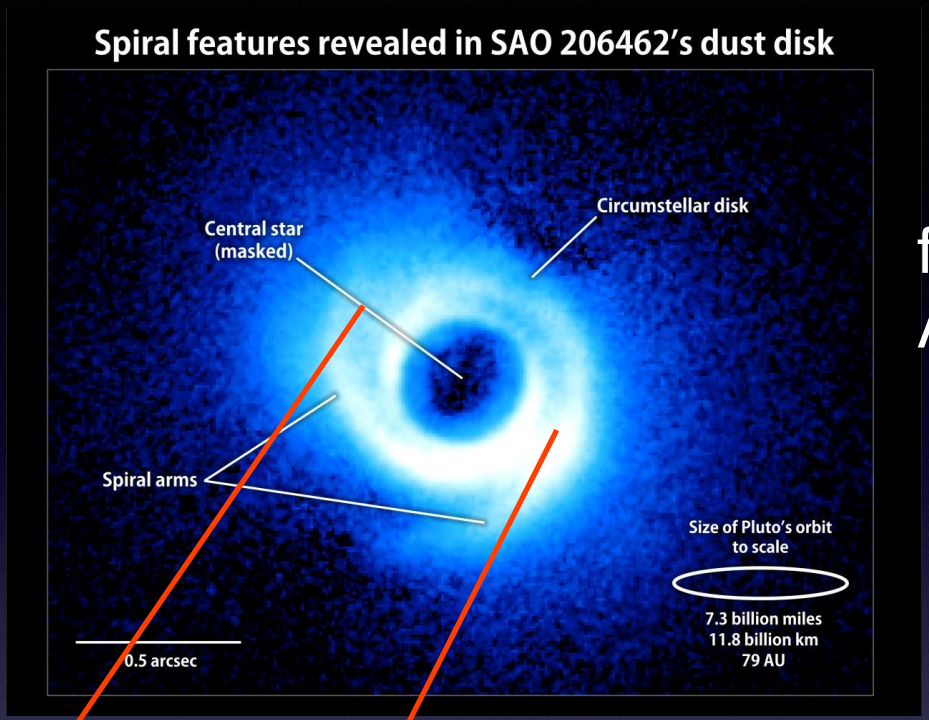
In actual operation....

Subaru High Contrast Instrumentation

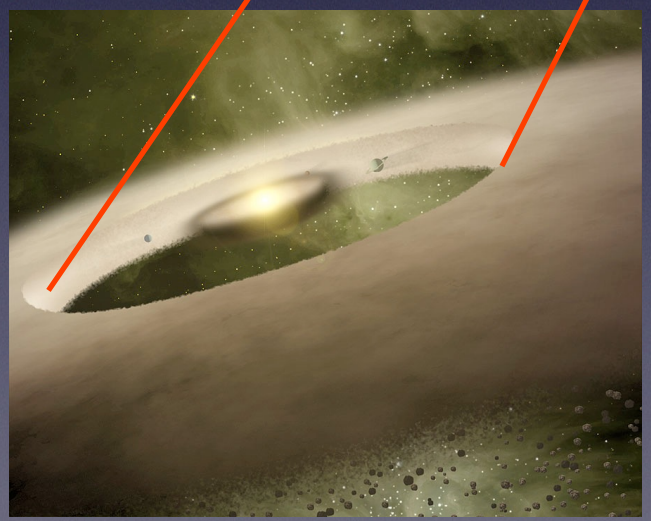
Strategic Exploration of Exoplanets and Disks with Subaru

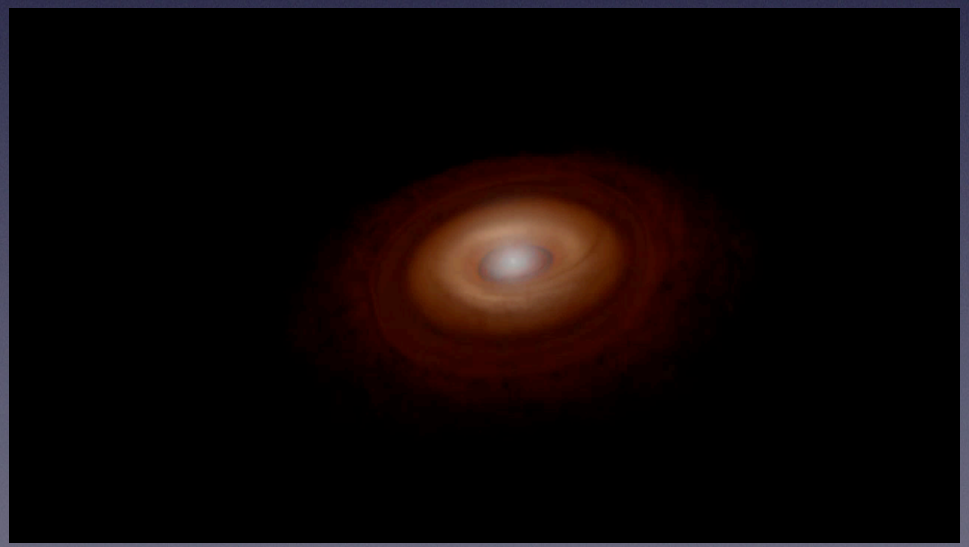
Subaru – 8.2 m telescope
AO 188
Classical Lyot Coronagraph
HiCIAO – NIR Science camera
Direct Imaging
Simultaneous Differential Imaging
Polarization Differential Imaging
Modes can be combined

SAO 206462

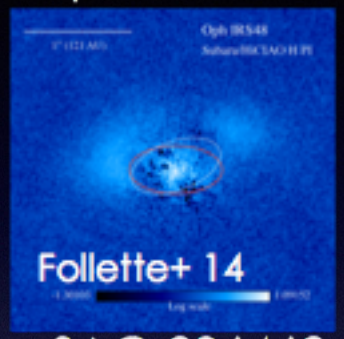


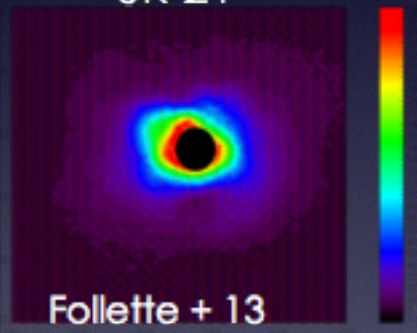
from Muto et al.2012, ApJL, 748, L22





This is what we see

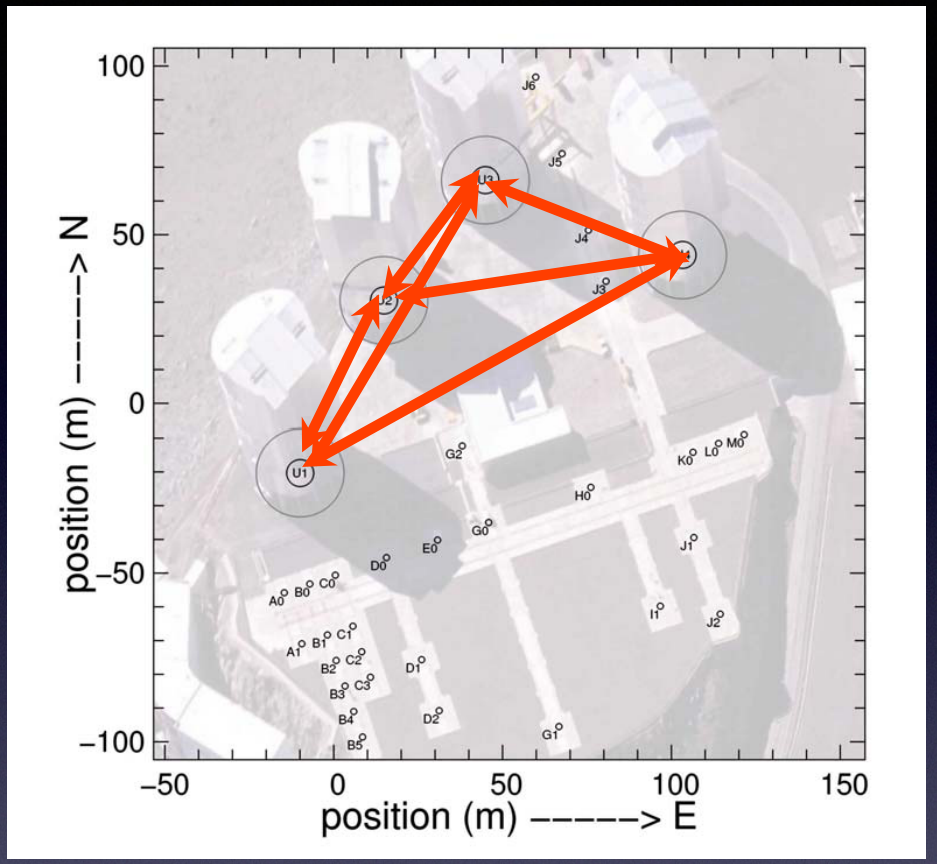


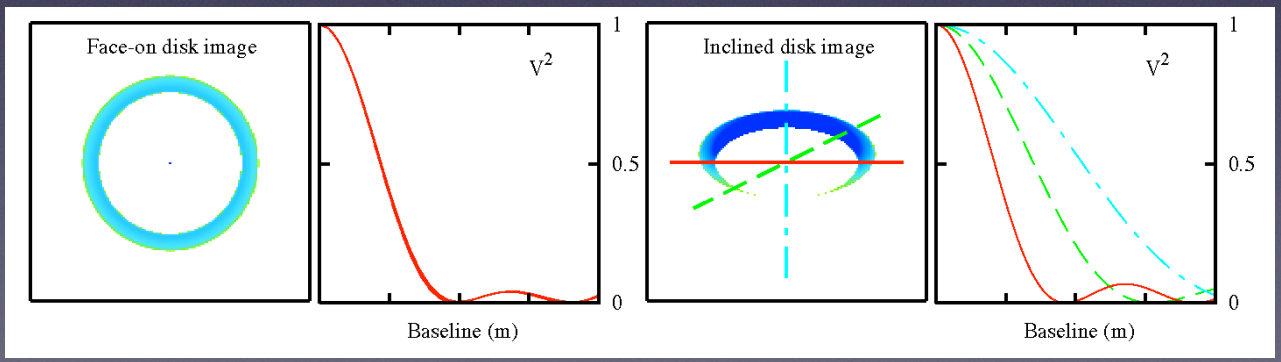


Inner Disk Structure from Interferometry

Very Large Telescope Interferometer - VLTI

Largest baseline 130 m.

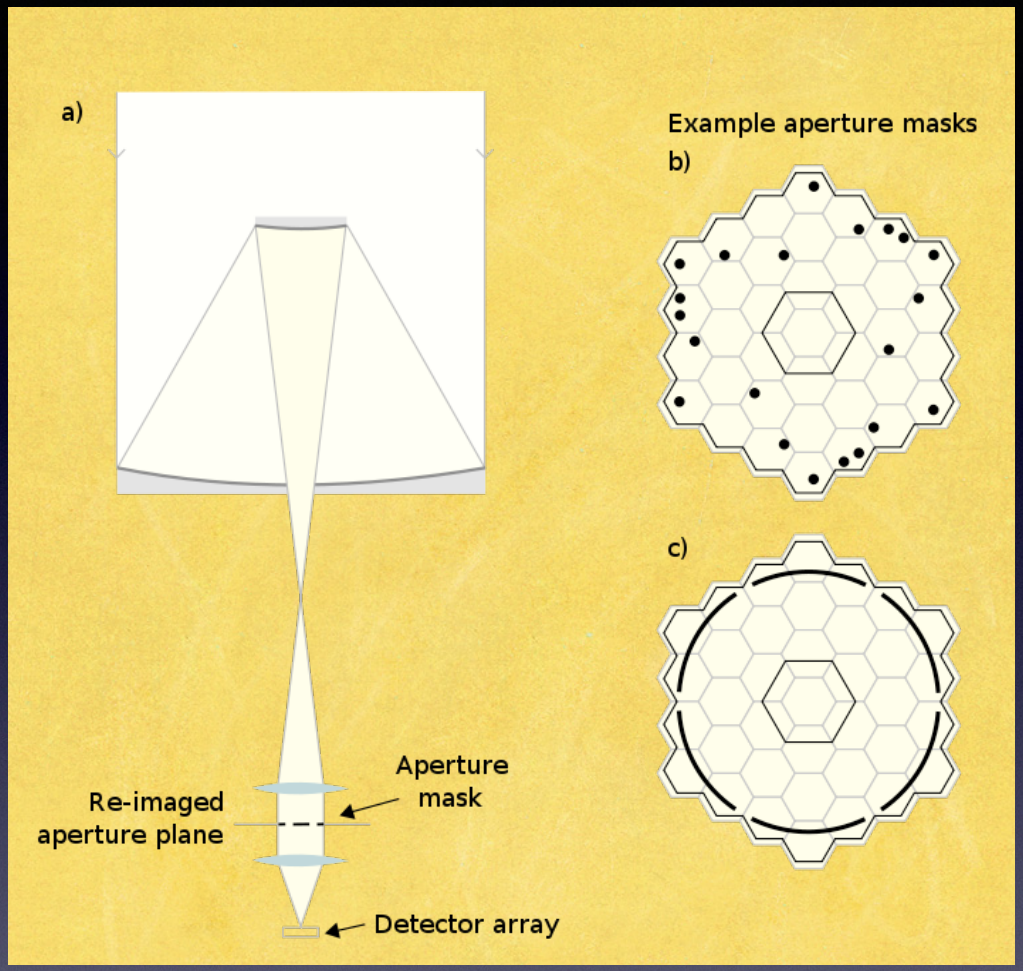




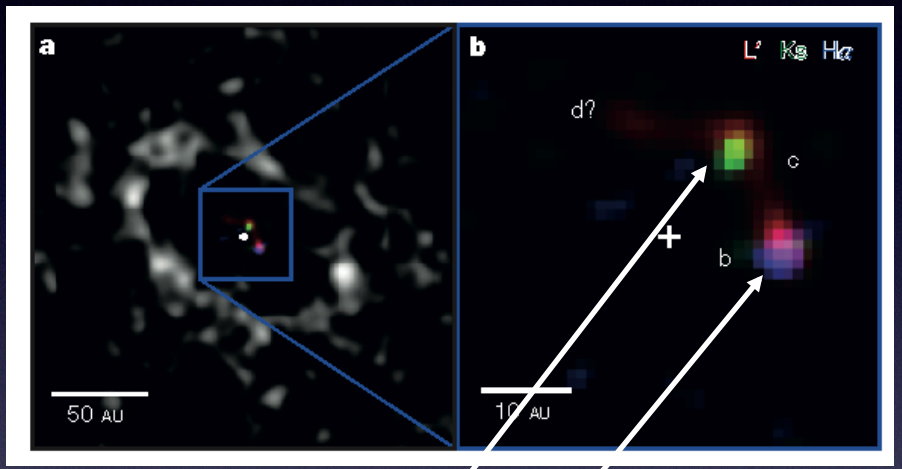
Spatial resolution - a few milli-arcsec

http://www.youtube.com/watch?v=u5GzsdwdnWM

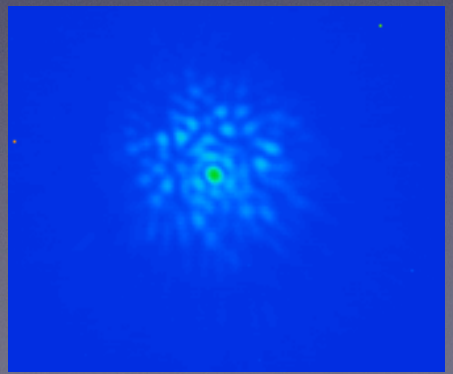
Non-Redundant Sparse Aperture Mask Interferometry



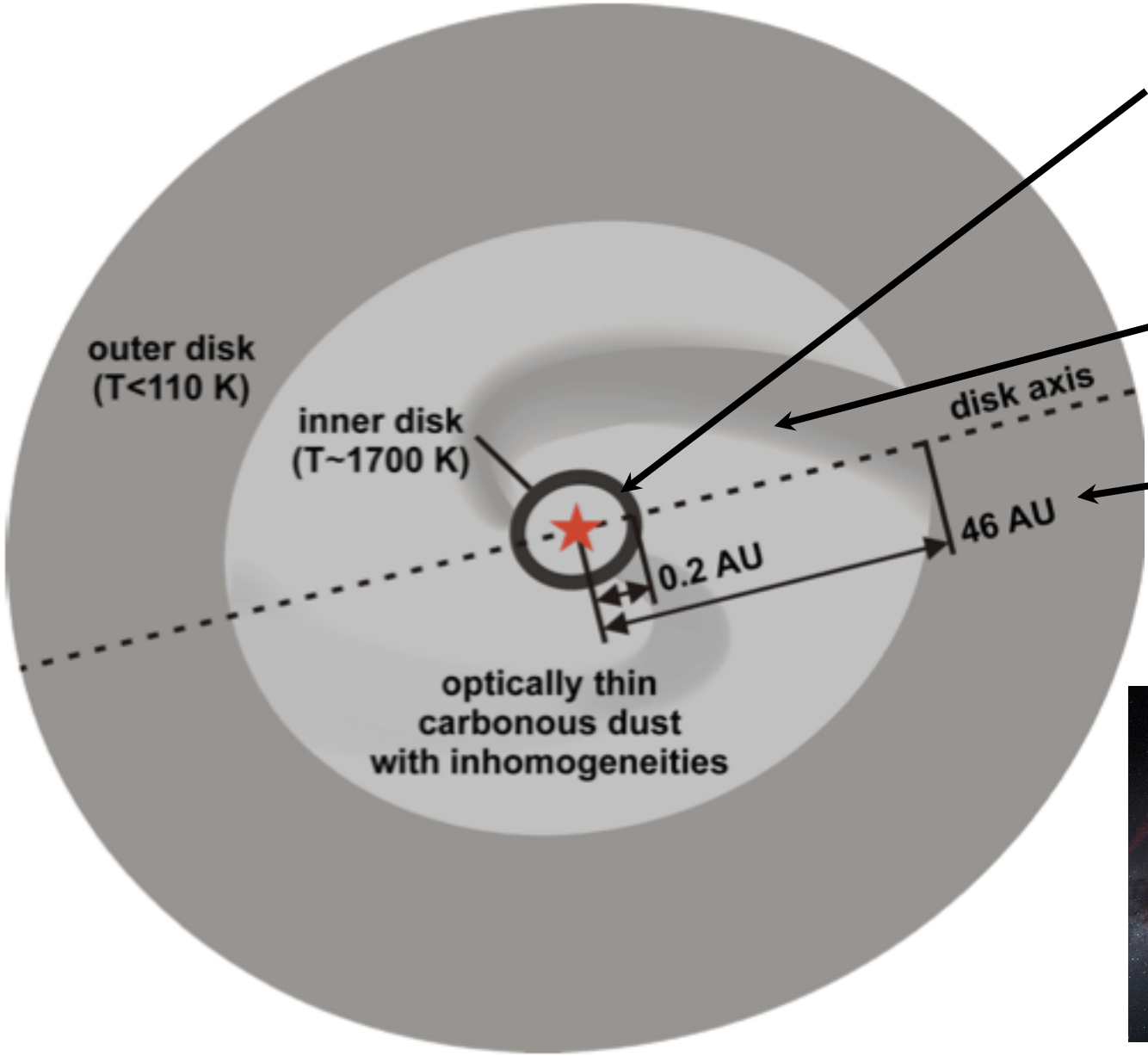
Sallum & Follette 2015



Protoplanets in a disk



V1247 Ori, a Gapped Pre-Transitional Disk

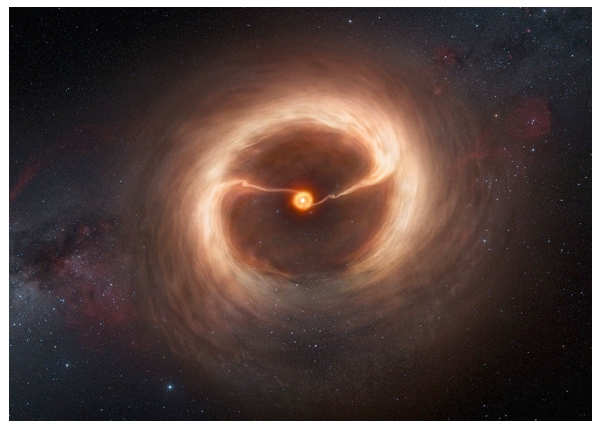


VLTI
Keck Interf.

Keck SAM

Gemini Speckle

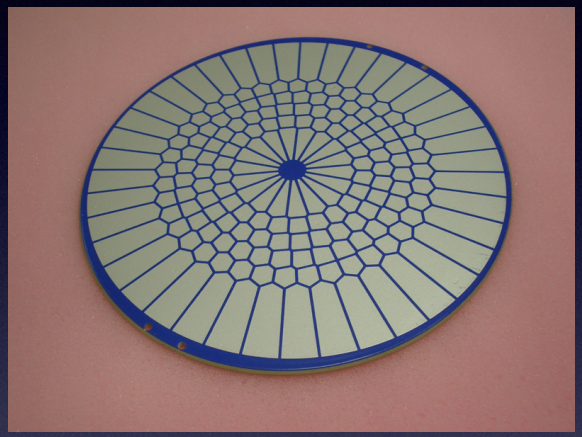
(like HD 142527)



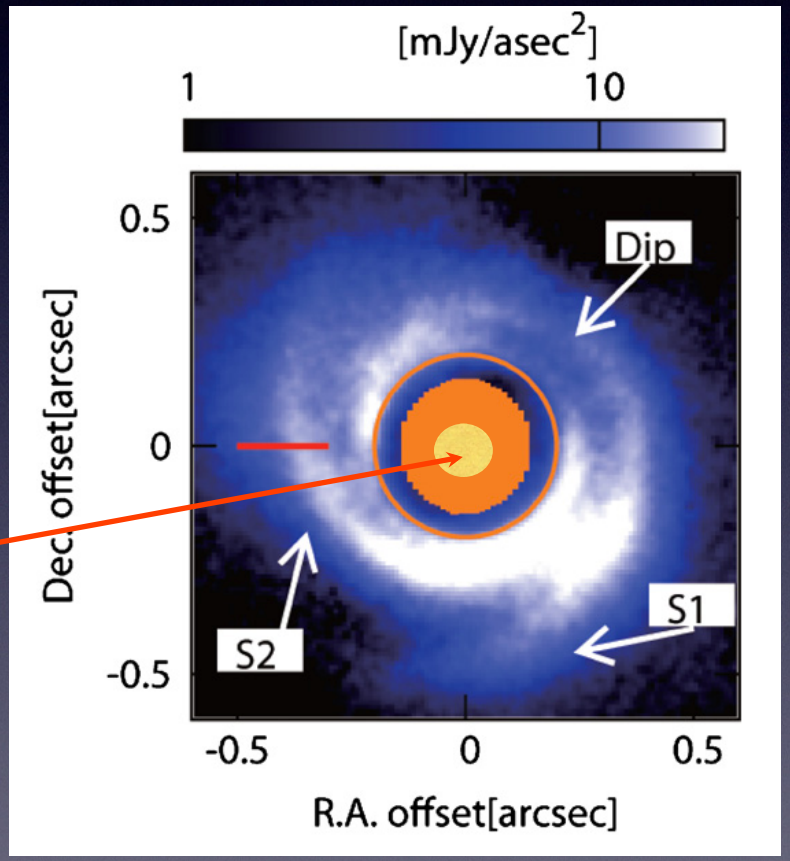
from Kraus et al. 2013, ApJ, 768, 80

The New Reality!

"Extreme Adaptive Optics"

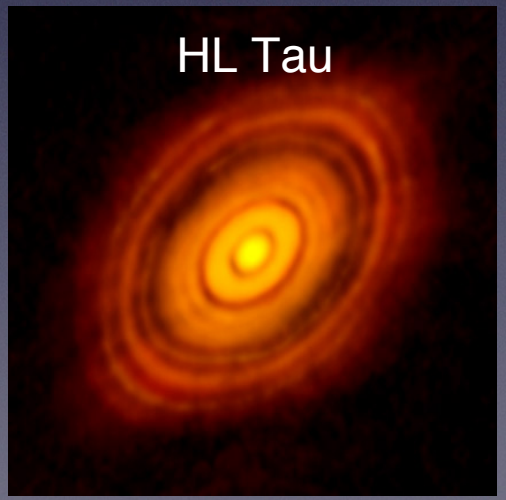


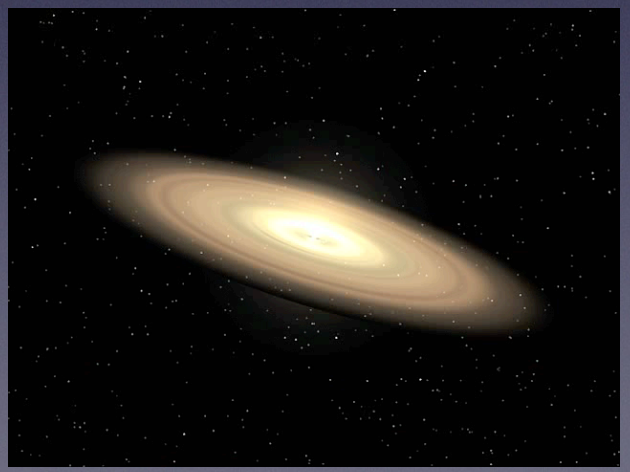
Subaru Telescope
SCExAO
Apodized Spot



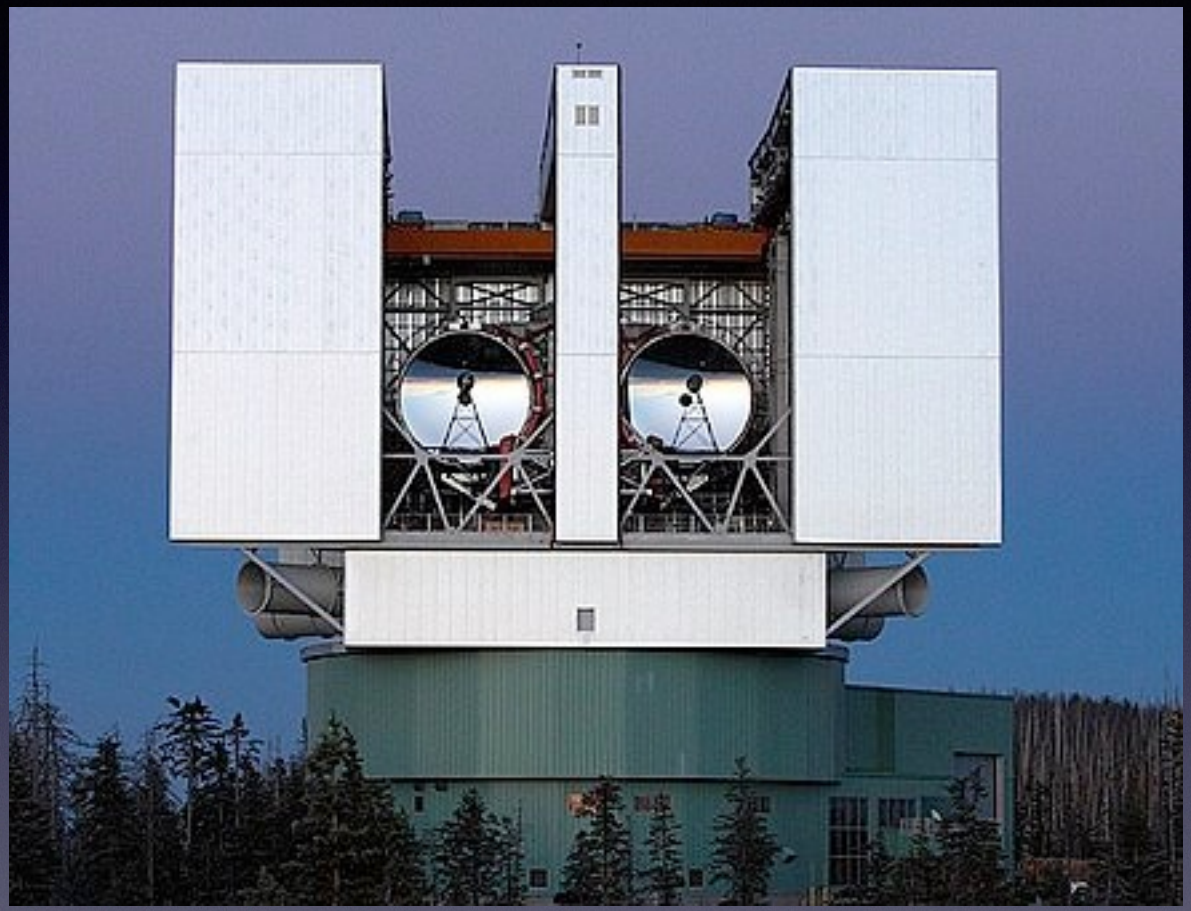
Also SPHERE (VLT), GPI (Gemini)

Atacama Large Millimeter/submillimeter Array (ALMA)





Large Binocular Telescope
Mt. Graham, Arizona



Expected spatial resolution ~0.01 arcsec