Ambitious Goal: Image Key Stages of Planet Formation

- Planet formation is one of the most exciting fields in astronomy
- Connects star formation with exoplanets
  - How to explain exoplanet demographics, architectures
  - Detect young giant planets themselves
- Robust theory & simulation efforts are underway
- Benefits from a range of facilities
  - Poised for many advances with VLTI/MATISSE, ALMA, GPI/SPHERE, ELTs
- We expect complexity beyond what ALMA and single apertures can ever resolve
What are the relevant spatial scales?

- 24µm thermal emission from small dust grains
- Circumplanetary accretion disk
  - 0.03 AU = 0.2 milliarcseconds
- For nearby star-forming regions, d~100pc
- Gaps 5AU
  - ~50 milliarcseconds
- Full disk 80AU ~0.8"

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Top-level Science Requirements (abbreviated)

- Resolve “Hill-sphere” size region of Jupiter at 1 AU (0.03 AU)
  - for nearby star forming region (140pc) \(\rightarrow 0.2\) milliarcseconds
- Sensitivity to thermal emission
  - for 300K grains \(\rightarrow\) mid-IR (10 microns)
- Angular Resolution of up to 0.2 milliarcseconds (TBD)
  - For 10\(\mu\)m \(\rightarrow\) requires 10km baselines
  - For 3\(\mu\)m \(\rightarrow\) requires 3km baselines
- Sensitivity to see a circumplanetary disk and even planets themselves
- Very complex scenes.. 200x200 pixel imaging
- SECONDARY: imaging AGN dust tori, mass loss, stellar surfaces…
Planet Formation Imager

Architecture

• Basics
  – Mid-infrared key science, 3-13 μm
  – Up to 7 km baselines
  – 2m minimum telescope diameter for NIR fringe tracking
    • Natural guide star AO is sufficient for YSO case
    • 4meter telescope gives better margin
  – 8m maximum telescope diameter to maintain at least 0.25” field of view
  – N>10 telescopes due to complex imaging

• Technology Developments Needed
  – Inexpensive 3m class telescopes (*COST DRIVER*)
  – Sensitive fringe tracking demonstration
  – Kilometric baselines w/ delay lines, beam transport, high throughput
  – Beam combiners for N>10 telescopes
  – Low-cost operations model
The “Planet Formation Imager” Project

planetformationimager.org