

# Understanding the Youngest Protostars

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GSMT SWG Meeting

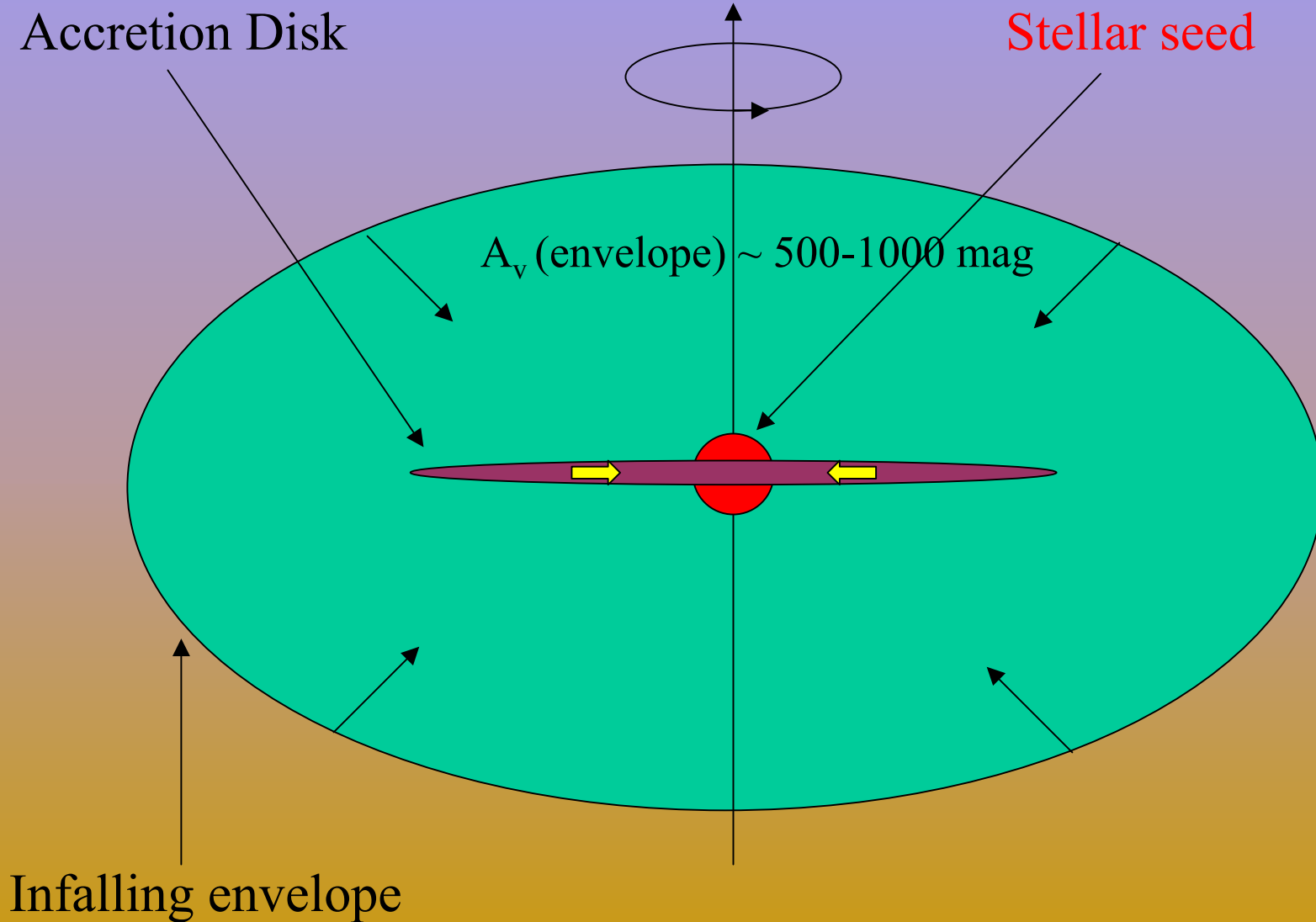
Honolulu, HI

12 February, 2004

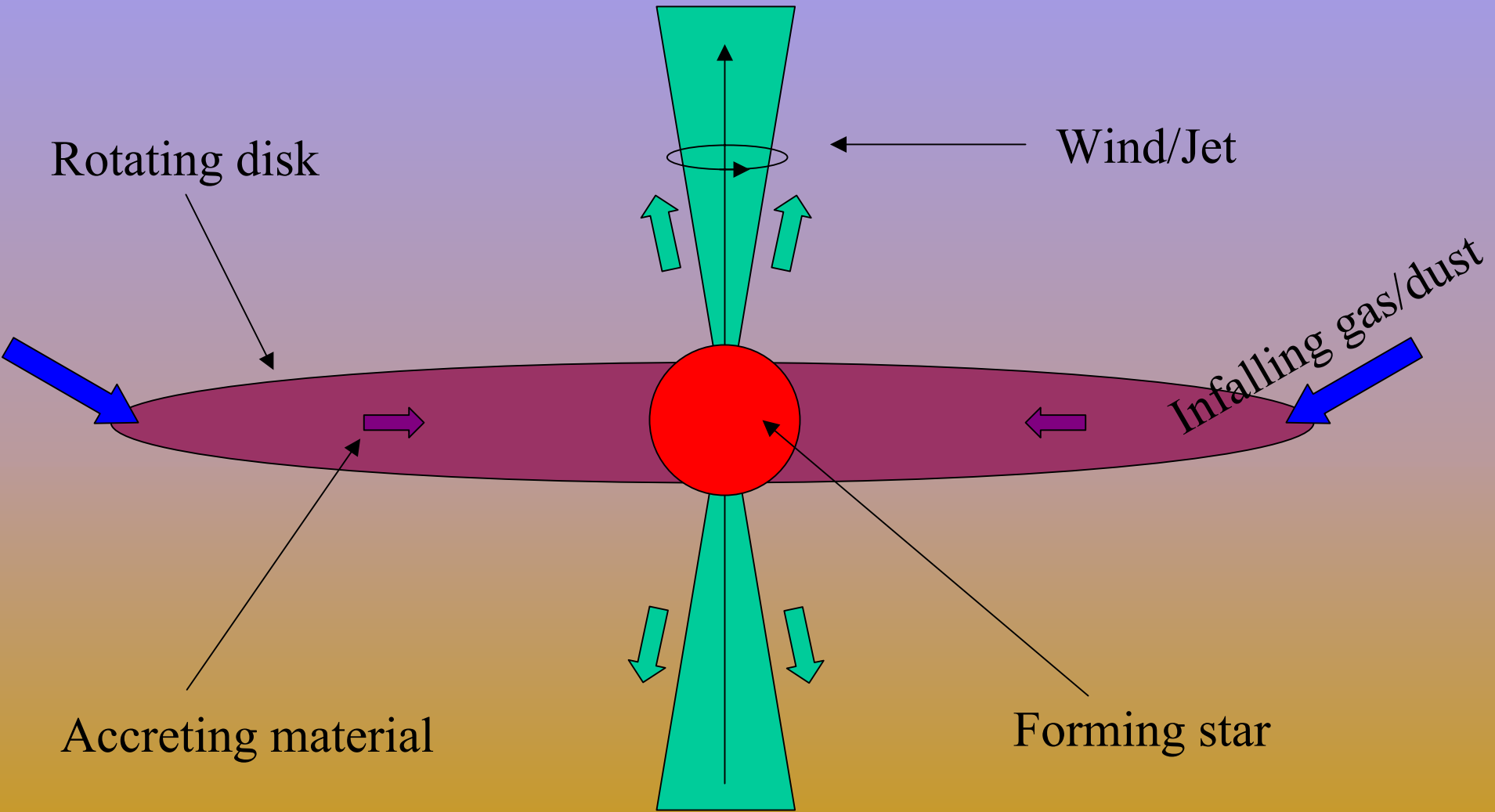
# Key Questions: JWST DRM

- How do star-disk systems evolve from protostellar cores?
- When and how are collimated outflows launched?
- When and how do binary stars form?
- What determines the final mass of a star?
  - Initial conditions in the protostellar core?
  - Feedback from forming star-disk-wind system?

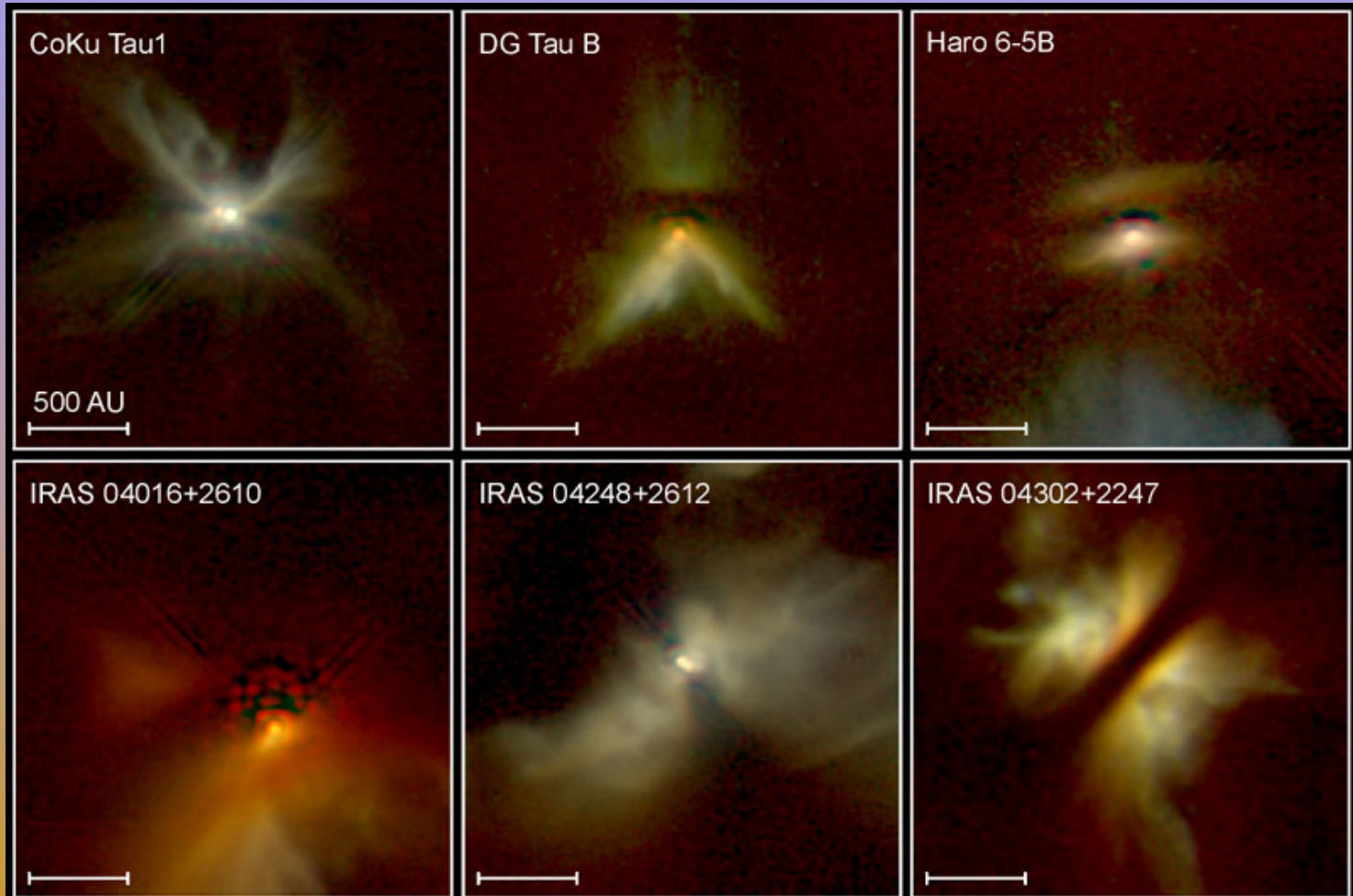
# Forming the Star-Disk System



# Building a Star



# Disks and Envelopes Around Young Stars



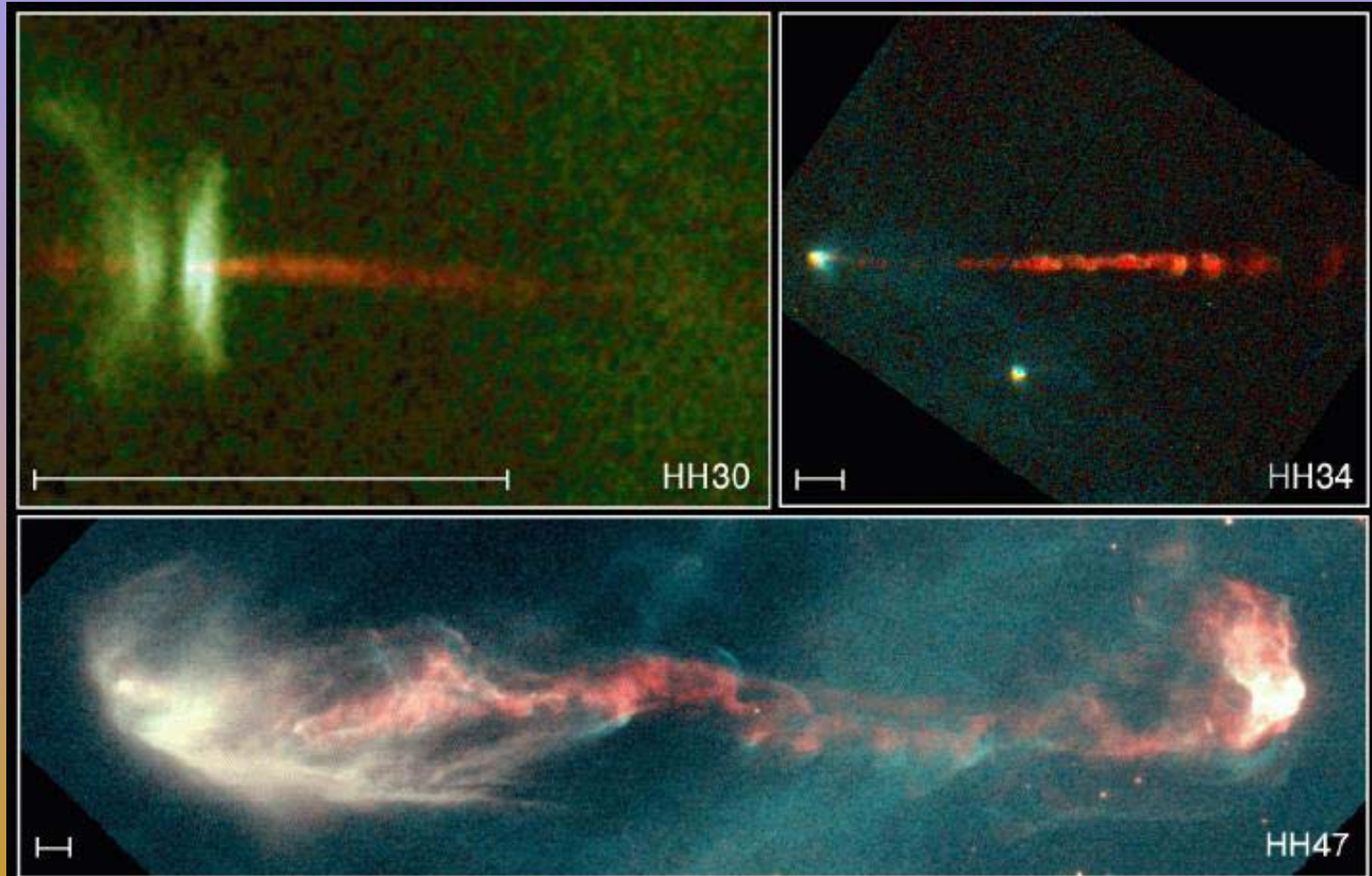
**Young Stellar Disks in Infrared**

**HST • NICMOS**

PRC99-05a • STScI OPO

D. Padgett (IPAC/Caltech), W. Brandner (IPAC), K. Stapelfeldt (JPL) and NASA

# Accretion Disks and Stellar Jets



## Jets from Young Stars

HST • WFPC2

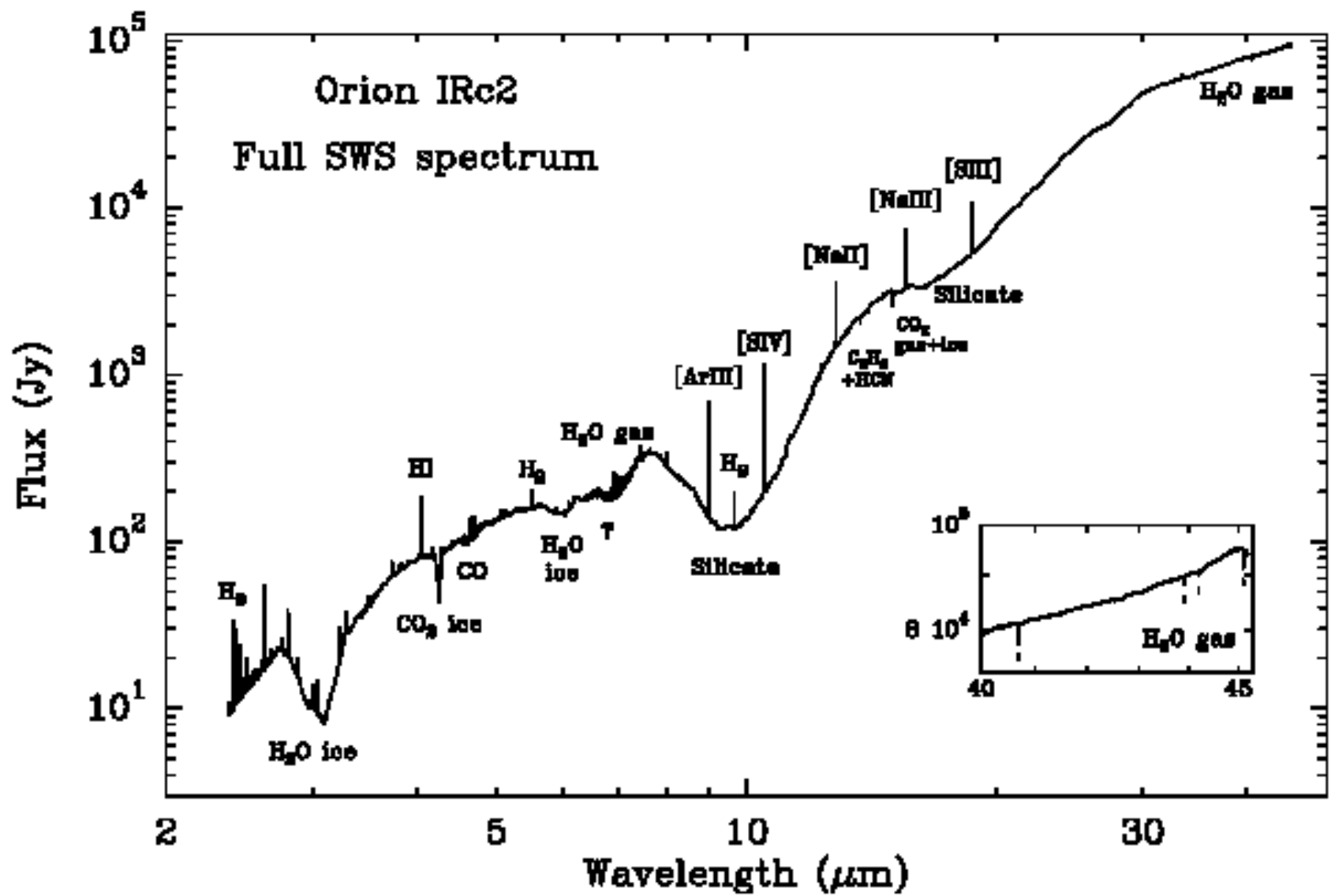
PRC95-24a • ST Scl OPO • June 6, 1995

C. Burrows (ST Scl), J. Hester (AZ State U.), J. Morse (ST Scl), NASA

# JWST Role

Exploit mid-IR sensitivity to:

- Obtain deep images and diagnose
  - Envelope morphology,  $T$ ,  $\rho$
  - Location of companions: disk or fragmentation origin
  - Reprocessed radiation at shock-heated wind-envelope interface
    - Estimate wind energy input and mass outflow rate
  - Jet structure (records past accretion episodes)
- Obtain moderate resolution spectra and diagnose
  - Emission lines arising from shocks at envelope-disk interface
    - Estimate envelope mass accretion rate via models
    - Are masses of embedded stars related to envelope  $dM/dt$ ?



# JWST DRM Proposal

- Use SIRTf survey to identify  $\sim 100$  cores within 1 kpc
  - Span a range of luminosity and (presumed) stellar mass
- Obtain images and spectra
  - Spatial resolution  $\sim 300$  mas or 50 AU at 150 pc
  - Thermal emission map
  - H<sub>2</sub> map for jets
  - R  $\sim 3000$  spectra for shock diagnostics
- Time to execute program
  - Narrow and broad-band imaging: 30 days
  - Moderate resolution spectroscopy: 25 days

# JWST Advantages

- Low thermal background leading to high sensitivity for low surface brightness features
- Full wavelength coverage
  - Enables use of broad range of emission line diagnostics ( $\text{H}_2$ ,  $\text{H}_2\text{O}$ , atomic features)

# GSMT Role

- Exploit higher spectral resolution
  - Typical emission and absorption line features have widths of several km/s ( $R \sim 100,000$ )
- Exploit higher angular resolution
  - Angular resolution at  $10\mu\text{m}$  is 60 mas:  $\sim 10\text{AU}$  at 150 pc
    - Typical disk size: 100 AU
    - Typical envelope size: 1000 AU
- Exploit collecting area to (partially) compensate for higher emissivity

# GSMT Science Program

- Use  $R \sim 10^5$  spectra to:
  - Map  $T(r)$ ,  $\rho(r)$ ,  $v(r)$  along line of sight to star-disk system
  - Derive mass accretion rate
  - Link  $dM/dt$  to mass of forming star
- Obtain spatially-resolved spectra for nearby star-disk-envelope systems
  - Map  $T(r)$ ,  $\rho(r)$ ,  $v(r)$  along multiple LOS
- Obtain broad- and narrow- band images
  - Deduce envelope and wind morphologies
  - Deduce wind energy input
  - Diagnose accretion episodes from jet morphology

# GSMT Advantages

- High spectral resolution matched to intrinsic line widths and typical velocities at  $d \sim 100\text{-}1000$  AU
- High angular resolution well-matched to dimensions of disk-envelope system

# Needed Simulations/Calculations

- Computation of limiting surface brightness vs wavelength for GSMT and JWST
  - Use common assumptions for detector performance
  - Use a range of emissivity values for GSMT
- Comparison with computed envelope infall models: continuum + line predictions

# Comparing a 30m GSMT with a 6.5m JWST

