1. Science aim/goal

Determine the timescales and amplitudes of episodic accretion in protostellar envelopes and circumstellar disks.

2. (i) Scientific Importance:

There is a decades-old debate as to the means by which roughly solar-mass stars build up their main-sequence masses. Accretion from a protostellar envelope via a circumstellar disk may decline smoothly with time, or it may occur primarily via episodic bursts of accretion, where the luminosity of a protostar increases by more than an order of magnitude for a brief time compared to its formation timescale (Audard et al. 2014). Episodic accretion events also heat distant regions of protoplanetary disks; they may have affected the chemistry of the early Solar System, including the makeup of comets and meteoroids. Constraining the importance of episodic accretion requires estimating the frequency and duration of such outbursts. **Episodic accretion events are best detected via far-IR monitoring of entire star-forming regions.** This is where the spectral energy distributions of embedded protostars peak and where the observed fluxes of protostars are best correlated with their accretion luminosities, but there has been limited monitoring at far-IR wavelengths (e.g., Billot et al. 2012). No sufficiently large-scale far-IR monitoring is planned before 2025.

(ii) Measurements Required:

Far-IR photometry of **a large sample** of YSOs is required. To estimate the frequency of accretion outbursts at high confidence, of order 10^4 YSOs need to be monitored (Hillenbrand & Findeisen 2015); this is roughly what is available in the nearest 1 kpc. With Herschel, 90% of the Orion protostars had 70 µm flux densities greater than 0.1 Jy. Scaled from the 420 pc distance of Orion to the 1000 pc of interest here, this corresponds to a **sensitivity** of 20 mJy. **Calibration accuracy** of 10% is required to distinguish between real outbursts and lower-amplitude variability. Good **angular resolution** is needed to avoid confusion. If one YSO in an unresolved system begins an outburst, the fractional increase in flux from the system will be reduced compared to that of a resolved YSO, but any detection can be investigated further with higher-resolution facilities. Systems with more than two components inside 5000 AU (5 arcsec at 1 kpc) are rare, so we require an angular resolution of 5 arcsec. If **mapping speed** is comparable to Herschel's PACS/SPIRE parallel mode (~0.8 deg^2/hr based on the Gould Belt Survey), the ~60 deg^2 of star-forming regions inside 1 kpc can be mapped in ~75 hr, which may be divided among several key programs.

(iii) Uniqueness to 10µm to few mm wavelength facility:

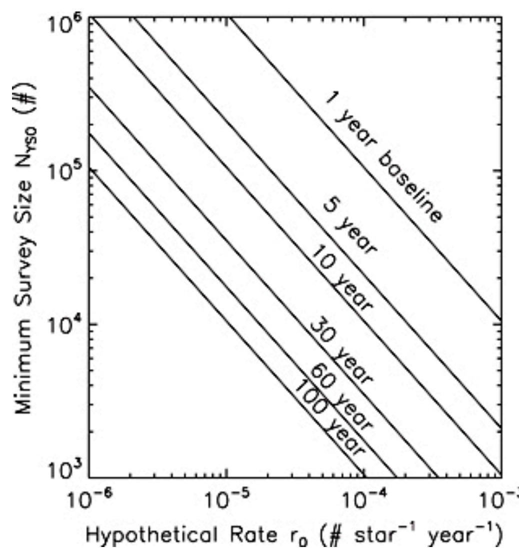
Other facilities operating at shorter wavelengths can trace YSO variability, but these observations probe a variety of mechanisms, including geometric effects. Far-IR time series are best for tracing real variations in the accretion luminosity, which give the most complete understanding of how accretion rates change during YSO evolution.

(iv) Longevity/Durability:

Other existing and planned facilities over the next 15 years can reach wavelengths at the edges of the far-IR, but at reduced sensitivity. These may address the question of outburst frequency with lower precision than a far-IR surveyor. While ALMA and SOFIA, for example, are effective tools for follow-up of outbursting sources, their limited fields of view and significant overheads make them inefficient in discovering new outbursts.

3. Figure:

For various time baselines, the plot shows the survey size N_{YSO} needed to constrain a particular outburst rate r_0 to within a factor of two at 90% confidence. The survey size is that needed to have a 90% chance of detecting enough events to establish the constraint. For likely outburst rates, monitoring of ~10^4 YSOs is needed if the time baseline is 5–10 years. From Hillenbrand & Findeisen (2015).



4. Table:

Parameter	Unit	Required value	Desired Value	Comments
Wavelength/band	μm	50–300	30–500	Protostar SEDs peak ~100 μm
Number of targets		1000	10000	See 2.ii.
Survey area	deg.^{2}	10	60	Lower value is just Orion; larger covers ~1 kpc regions
Angular resolution	arcsec	5	2	See 2.ii.
Spectral resolution	Δλ/λ	–	–	–
Bandwidth		–	–	–
Continuum Sensitivity (1 σ)	μJy	2000	200	Not a limiting factor
Spectral line sensitivity (1 σ)	W m^{-2}	–	–	–
Signal –to-noise		10	100	See 2.ii.
Dynamic range		–	–	–
Field of Regard		–	–	–
Cadence	yr	1	0.1	1 yr for major outbursts; 0.1 yr for lower-level variability
Mission lifetime	yr	5	10	Needed for good statistics

5. Key references: Billot et al. (2012, ApJ, 753, L35); Audard et al. (2014, PPVI review); Hillenbrand & Findeisen (2015, ApJ, 808, 68)