1. Science aim/goal (provide a high-level statement in 140 characters or less):

Measure the star formation efficiency (SFE, in % per year) of gas outside the Milky Way by counting young stellar objects (YSOs). Construct star formation (SF) laws with direct tracers and study the environmental dependence of SFE.

2. (i) Scientific Importance:

The SFE, which is the ratio of the star formation rate (SFR) to the gas mass, reflects how efficiently gas gets converted into young stars. The SF process is a key component of galaxy evolution, consuming the gas at different rates depending on environment, modifying the structure and composition of the ISM through its radiative and mechanical feedback, enriching galaxies with new elements, and driving some of those metals into the circum-galactic medium through SF-powered galactic fountains.

The empirical extragalactic kpc-scale relations (relatively constant SFE of 1% per free-fall time, Leroy+2008) and the pc-scale relations measured in the Milky Way (large scatter in molecular gas SFE, relatively constant SFE in dense gas, strong environmental dependence, Evans+2014) are difficult to reconcile within a common framework. Comprehensive models unifying the two perspectives are needed, which can explain the SF itself, the pc-scale feedback and turbulence processes that determine the dense gas distribution and result in the kpc-scale relations (Kennicutt & Evans 2012). Validating these models requires observations of the star formation rate (SFR) and gas surface densities at pc-scale resolution over molecular cloud (MC) scales (100 pc). Studies that can directly measure the SFR on MC scales by directly counting mass in young stellar objects (YSOs) are limited to local clouds. A breakthrough in this field could be achieved by extending the level of spatial detail and coverage to a large sample of regions in nearby galaxies. With ALMA and SKA, we have the opportunity to observe interstellar gas at sub-arcsec resolution. However, the resolution of MIR-FIR observations necessary to trace early stage YSOs and ISM dust is still lagging. Spatial resolution matching that of ALMA and SKA (~1") is required to understand the star formation process.

(ii) Measurements Required:

Direct observations of the SF process are required to understand the SFE, by characterizing YSOs, rather than relying on poorly calibrated indirect tracers of SF (e.g., Hα and 24 μm). The feedback from young stars onto the surrounding ISM, over a range of physical parameters (density, metallicity, Hubble type, etc.) must also be observed.

UVOIR observations (HST, JWST, WFIRST) can trace the evolved stages of SF (classes II and III). The mass of earlier stage (class 0 and early class I) YSOs can only be characterized in the MIR- FIR (10-500 μm), which samples the peak of the black-body dust emission (mm-emission covers only the Rayleigh-Jeans tail and does not allow for a determination of temperature and mass). In order to characterize YSOs in the Local Group, the photometric observations must achieve pc-scale resolution, corresponding to 1" (5 pc at M31/M33, 0.2 pc in the LMC) at ~100 μm (peak of the SED). The HI and H_2 can be observed with ALMA and SKA. However, MIR-FIR dust emission is a better tracer of H_2 gas at low metallicity, where CO is photo-dissociated due to lack of dust shielding. This also advocates for comparable resolution between ALMA, SKA and the FIR Surveyor.

To understand the feedback processes that set the SFE, spectroscopic observations of cooling lines tracing the energetics ([C II] 158 μm; [O I] 63 μm; [O III] 52 and 88 μm; [N II] 122 and 205 μm), and FIR lines tracing shocks and turbulence dissipation regions (H_2, high-J CO, H_2O lines between 10-500 μm) are crucial. High spectral resolution (R>100,000) is required to resolve the line-width of ISM lines. Both wide-field (MC scale - 100 pc) and pc-scale resolution are required to understand SF regions as a whole, sample the physical parameters governing the SF processes (density, surface density, dynamics, radiation field), and characterize YSOs and feedback processes within MCs.

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

The early stages of SF that are best correlated to the gas reservoir can only be characterized between 10 μm and 500 μm where YSOs have the most energy output. Additionally, atomic cooling lines and shock/TDR tracers occur in the MIR-FIR.

(iv) Longevity/Durability:

HST, JWST, EELT, and WFIRST will provide catalogs of Class I, II and III YSOs in nearby galaxies. The early stage of SF will only be measured in the MIR-FIR at pc-scale resolution (not achieved by Herschel and SOFIA). Overlap with mm-cm-wave interferometers (ALMA, NOEMA, SKA) is required to complement the measurements of HI and H_2 gas reservoir for SF. Together, these facilities will provide a complete view of the star formation process in nearby galaxies. The FIR Surveyor will provide the missing spectral diagnostics to complement the view of the gas reservoir and SF activity.

3. Figure: See Appendix

4. Table:

Parameter	Unit	Required value	Desired Value	Comments
Wavelength/band	μm	10-500 μm	10-500 μm	
Number of targets		40	100	Galaxies in LVL, KINGFISH, THINGS
Survey area	deg.^{2}	5 arcmin	10 arcmin	Per galaxy; 100-200 pc in the LMC
Angular resolution	arcsec	1"	1"	At 100 μm (peak of SED)
Spectral resolution	$\Delta\lambda/\lambda$	100,000	200,000	Resolve 1.5-3 km/s turbulence motions
Bandwidth	300 km/s			
Continuum Sensitivity (1 σ)	MJy/sr	0.5 MJy/sr	0.1 MJy/sr	To detect 0.005 Mo/pc2 in the dust surface density
Spectral line sensitivity (1 σ)	K	0.01 K	0.005K	in 3 km/s wide channels