Dust extinction variations unveiled by the Roman Galactic Plane Survey

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Roman Galactic Plane Survey
Definition Committee Report

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Contributors:

Numerous colleagues have contributed to this report, as will be noted throughout the document, but the committee would like to specifically highlight three groups of contributors:

(1) the authors of white papers and science pitches described in this report[1],
(2) the participants and Scientific Organizing Committee of the *Roman Galactic Plane Survey Community Workshop*[2] held online on Feb 11-13, 2025, and
(3) the participants, Local Organizing Committee, and Scientific Organizing Committee of the *Galactic Science with the Nancy Grace Roman Space Telescope* workshop held at Yerkes Observatory on June 13-15, 2024.[3,4]

Copies of contributed presentations, manuscripts, and minutes of numerous discussion groups may be found in the links below. The Definition Committee was extremely grateful for the interest and support of our colleagues and for their many contributions to this survey, and it is our hope that the program presented here will provide data of value for science programs for many decades to come.

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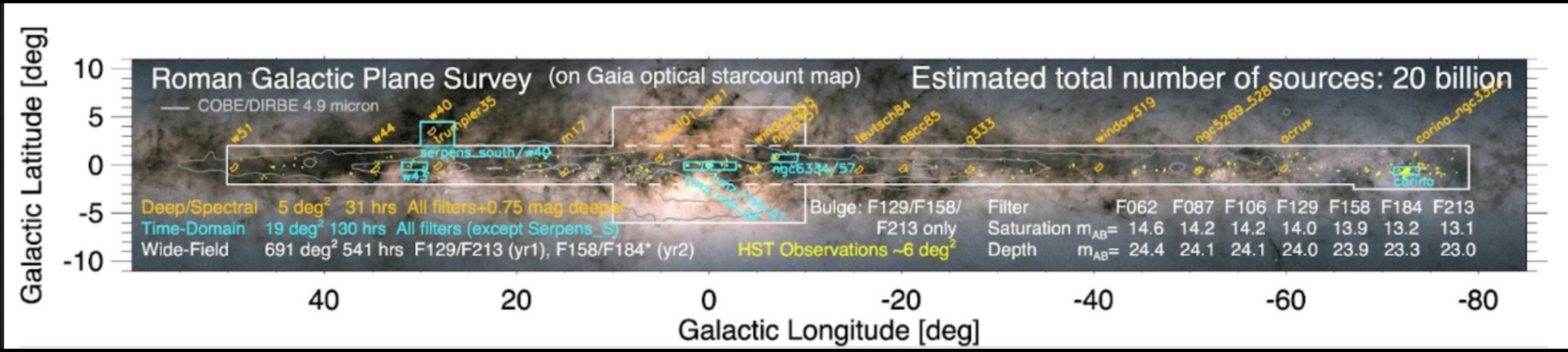
[1] https://stsci.app.box.com/s/4wchza9b8q3nmajaqazkuzb5kxhkmqbc
[2] https://outerspace.stsci.edu/display/GPSCW/Galactic+Plane+Survey+Community+Workshop+Home
[3] https://sites.google.com/cfa.harvard.edu/romanyerkes/home
[4] https://tinyurl.com/roman-yerkes-discussions

The Roman Galactic Plane Survey

https://science.nasa.gov/mission/roman-space-telescope/galactic-plane-general-astrophysics-survey

~20B Sources !

The Survey in a Nutshell

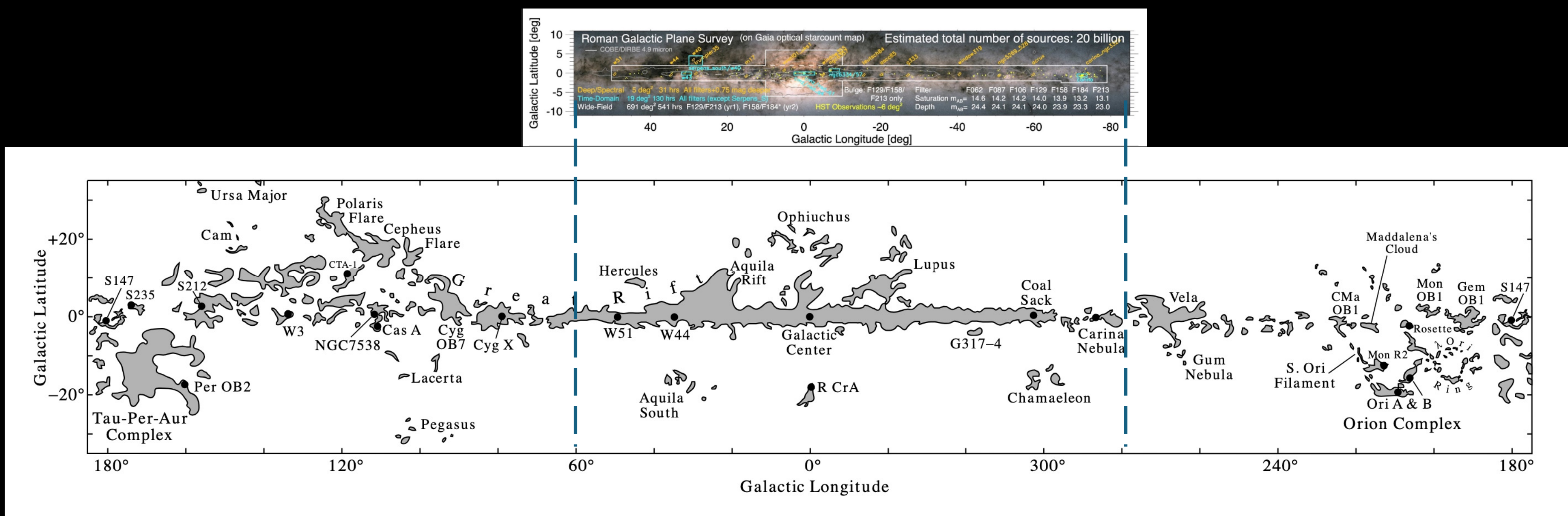


Wide-field mapping - 691 deg², 541 hours	**Time-domain - 19.1 deg², 130 hours**	**Deep-field/Spectroscopic - 4.8 deg², 30 hours**
Covering a large, continuous portion of the Galactic plane (Galactic latitude |*b*|<2 deg and Galactic longitude *l* = 50.1 - 281 deg) with higher latitude extensions for the bulge, Serpens South/W40 star formation region, and Carina	Six fields including the full Nuclear Stellar Disk (NSD) and Central Molecular Zone (CMZ)	Fifteen pointings over a wide range of extinction, diffuse emission, stellar density, and populations
Four filters: F129, F159, F184, F213	Seven filters: F062, F087, F106, F129, F158, F184, F213	Seven filters: F062, F087, F106, F129, F158, F184, F213
	Repeat observations in one or more filters with cadences from ~11 minutes to weeks	Longer exposure times (with respect to time-domain element) and grism and prism observations

Dust Extinction as a Probe of Star and Planet Formation

→ The community showed extensive interest in studying dust with Roman: WP06, SP04, SP10, SP22, SP23, SP33, SP35, SP39, SP43

→ What is *trash* (cfr., attenatuation) for somebody is *gold* (cfr. dust evolution) for somebody else…

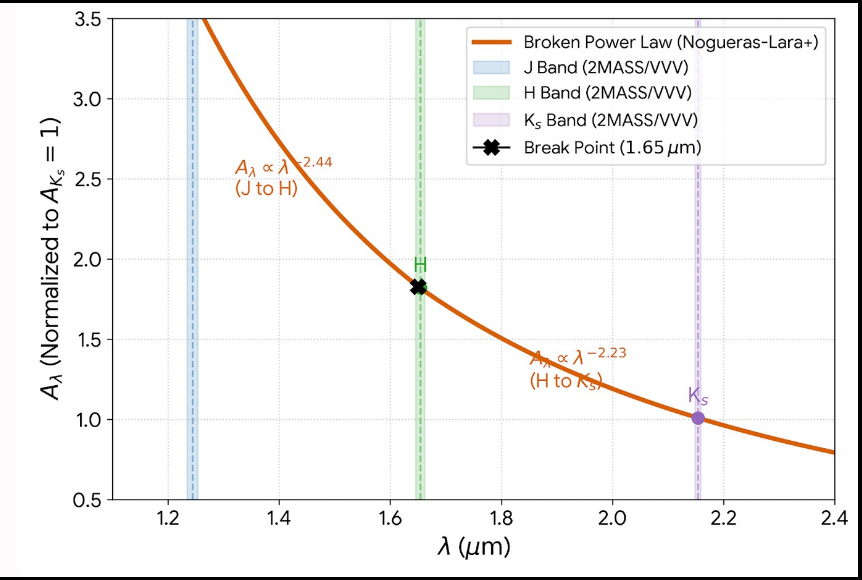


Dame et al. 2011

Line-Of-Sight Variations of the NIR Dust Extinction Curve: Star Formation Regions and the Galactic Center

Several findings, e.g.:

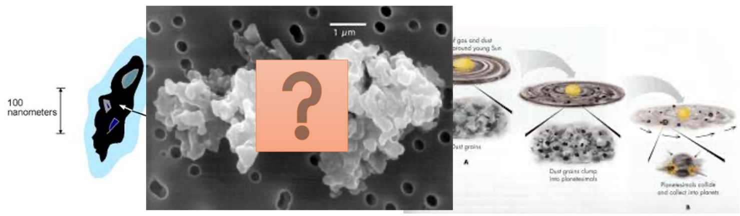
- Indebetouw et al. (2005) and Nishiyama et al. (2009) reported a *flattening* beyond 3 μm
- Nogueras-Lara et al. (2019) found a similar behavior between JH (1.27 - 1.65 μm, α ~ 2.43) and HK (1.65 - 2.16 μm, α ~2.23).



Nogueras-Lara et al. 2019

Dust Evolution & Grain Growth

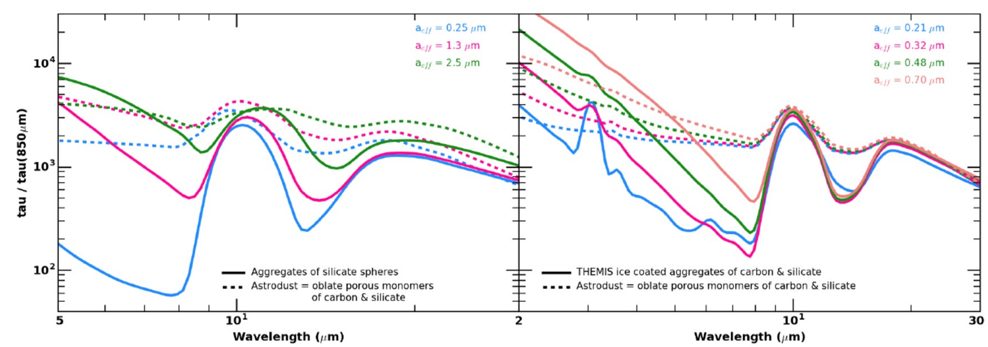
ISM **PROTOPLANETARY SYSTEMS**



e.g. MRN 1977: $n(a) \sim a^{-3/5}$
For silicates: $a_{max} \sim 0.25$ µm

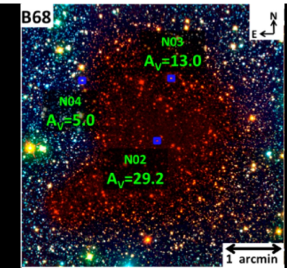
- **a ~ from a few µm to ~1 mm:**
- **10 – 20 µm silicate feature**
- **β from sub-mm/mm observations**

No Ice Mantles | Dust + Ice Mantles



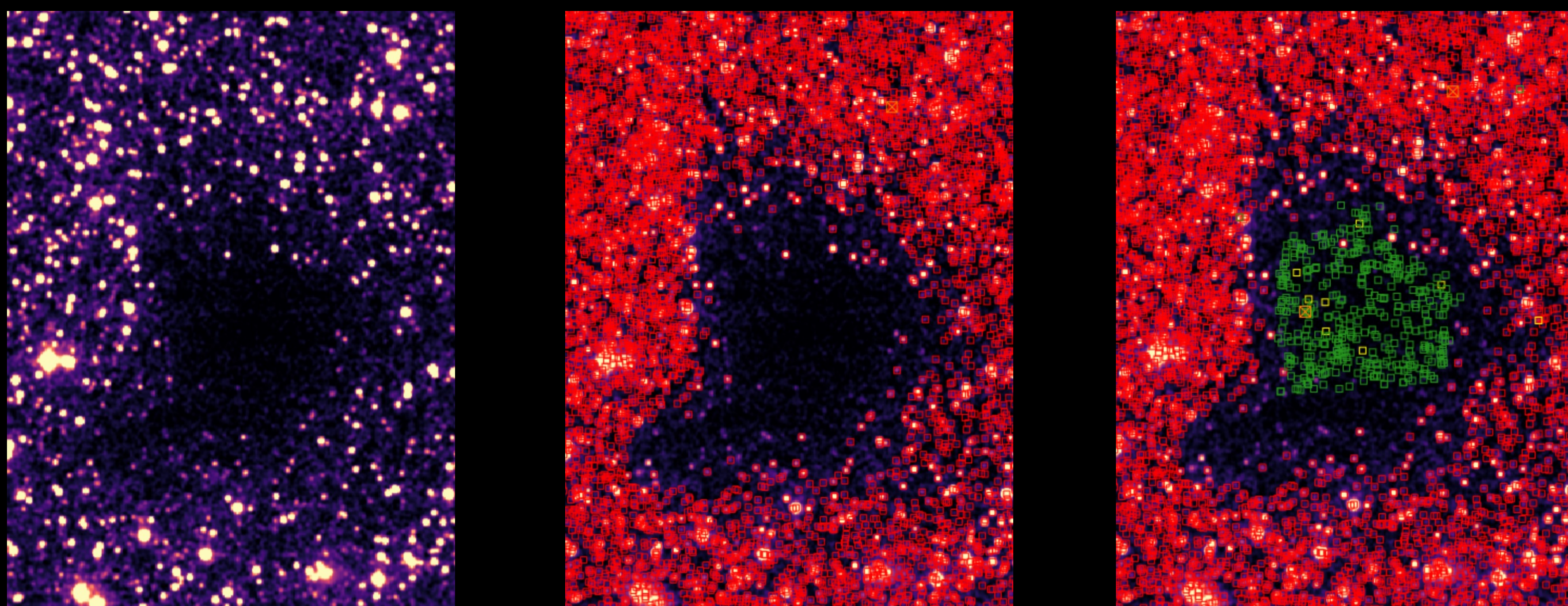
AstroDust | THEMIS

Advantages of Roman GPS/WFI Observations
Ex: B68 (d = 150 pc, A_K = 0.5 → 3 mag)

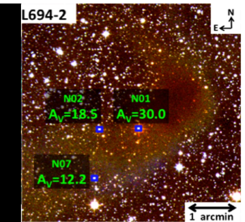


JWST/NIRSPec: 0.3 M/deg^2 ⟷ Roman/WFI: 100 M/deg^2

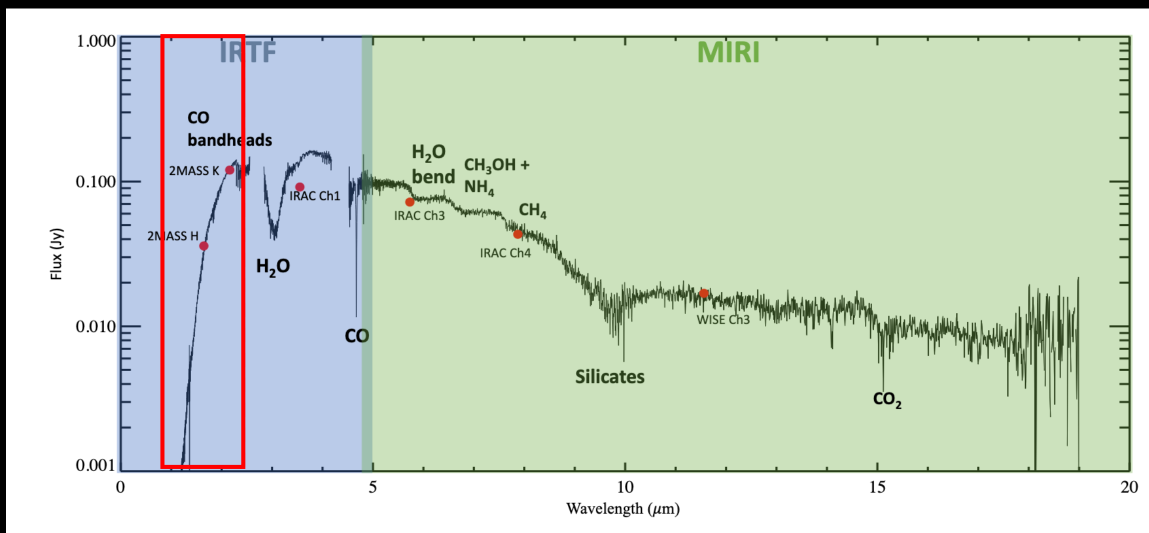
8’



- Background image: 2MASS K-band
- Red: Gaia DR3
- Green: NIRSPec targets



Challenges of Roman GPS/WFI Observations:
Ex: L694-2 (d = 250 pc, A_k = 1 → 3 mag) – JWST #2331



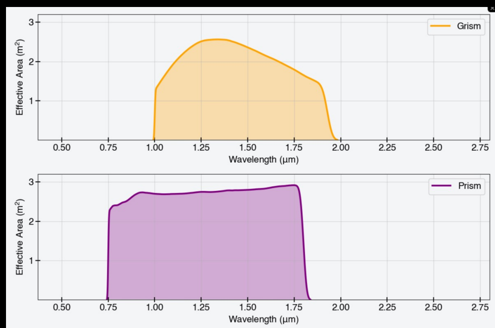
To derive the dust extinction curve:

- Use stellar models library
- Extinguish stellar models with dust extinction curve

1. 77 stellar models (cfr. PHOENIX library)
2. 5 dust extinction models (no broken power-law)

T_e, log g, [Fe/O]

RGPS/WFI: 4 filters & 3 parameters … 4 parameters (and even 5 for a broken power-law) if we let the slope of the extinction curve vary !



- The RGPS will enable great science
- Deriving dust extinction curves towards low-extinction ($A_k < 0.2 – 0.3$ mag) might be relatively easy
- *However* studies of the extinction curve towards high-A_k lines of sight may result in substantial challenges
- The RGPS spectroscopic high-A_k fields may provide the needed leverage and normalization *if* spectra recovery in crowded regions is possible

Summary

Wavelength Range	**Key Feature**	**Primary Line Carrier**	**Diagnostic Target**	**Typical Spectral Type**
J-Band	1.083 micron	He I	Winds, Temperature	O, B, Be, YSOs
	1.097 micron	CN band	Luminosity Class	K - M (Giants vs. Dwarfs)
	1.282 micron	Pa-beta	Temperature	B, A, F (Emission in YSOs)
	1.243 / 1.252 micron	K I	Gravity, Temp	M, L, T Dwarfs
H-Band	1.50--1.75 micron	Brackett Series	Temperature	B, A, F (Emission in Be)
	1.558--1.619 micron	CO (delta_v = 3)	Temp, Gravity	K, M, L (Strong in supergiants)
	1.672-1.675 micron	Al I	Temperature	K, M