The University of Texas at Austin
Department of Astronomy
College of Natural Sciences

Brown Dwarfs in the era of the Nancy Grace Roman Space Telescope

Matthew De Furio

NSF Astronomy & Astrophysics Postdoctoral Fellow

Roman Galactic Plane Survey Definition Committee

Roman Space Telescope is on schedule!

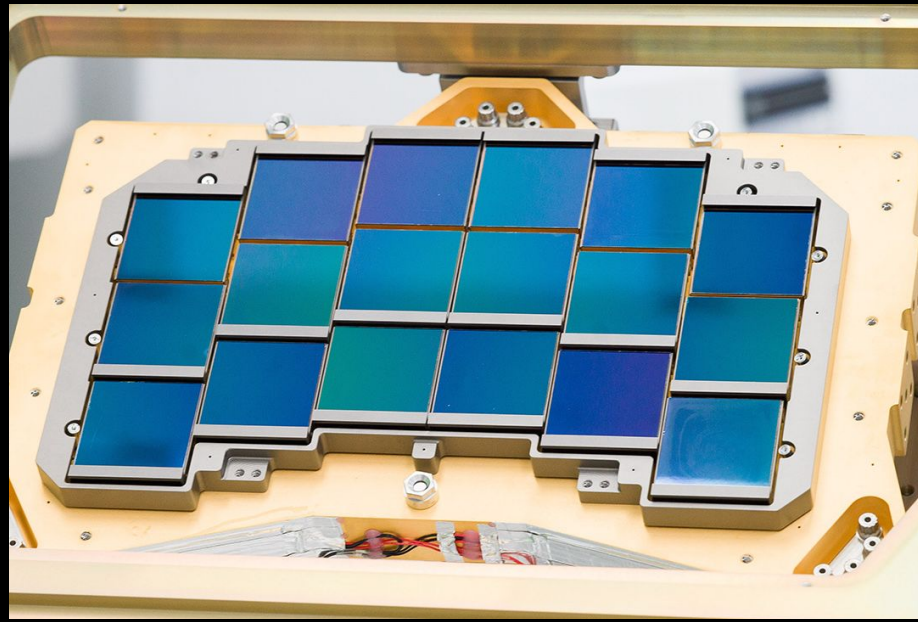
- Launch scheduled 30 October 2026, no later than May 2027
- 2.4 m primary mirror (same as Hubble)
- Operating across 0.48 - 2.3 μm
- Coronagraph Instrument is tech demo with 3 months of time in first 1.5 years
- Wide Field Instrument (WFI) is main instrument

Credit: NASA/Chris Gunn

Matthew De Furio

Roman Wide Field Instrument

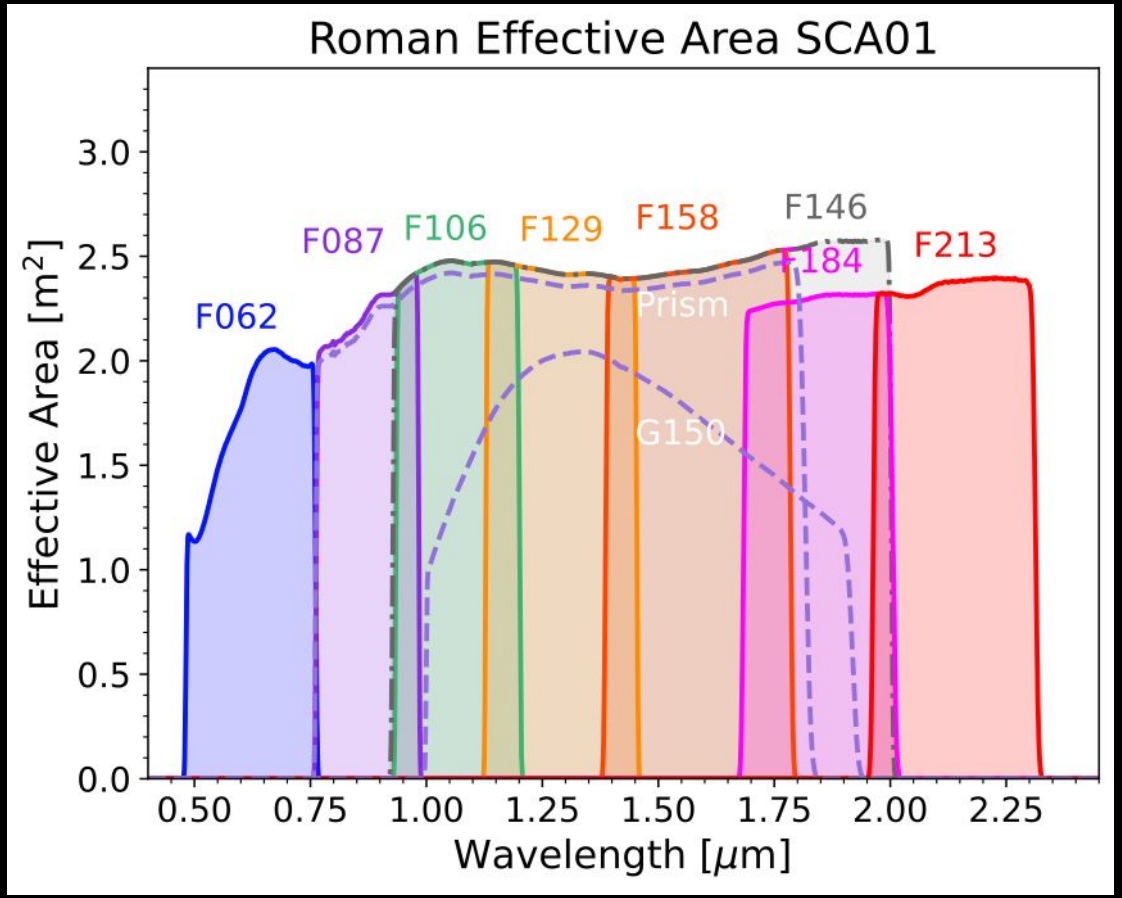
- Imaging: 0.48 - 2.3 μm
- Spectroscopy:
  - Prism (R~100): 0.75 - 1.8 μm
  - Grism (R~600): 1.0 - 1.93 μm
- Field of view: 0.8°x0.4° (0.281 deg^2, ~200x HST WFC3/IR)
- Plate scale: 0.11”/pixel



Credit: NASA/Goddard

Credit: Space Telescope Science Institute

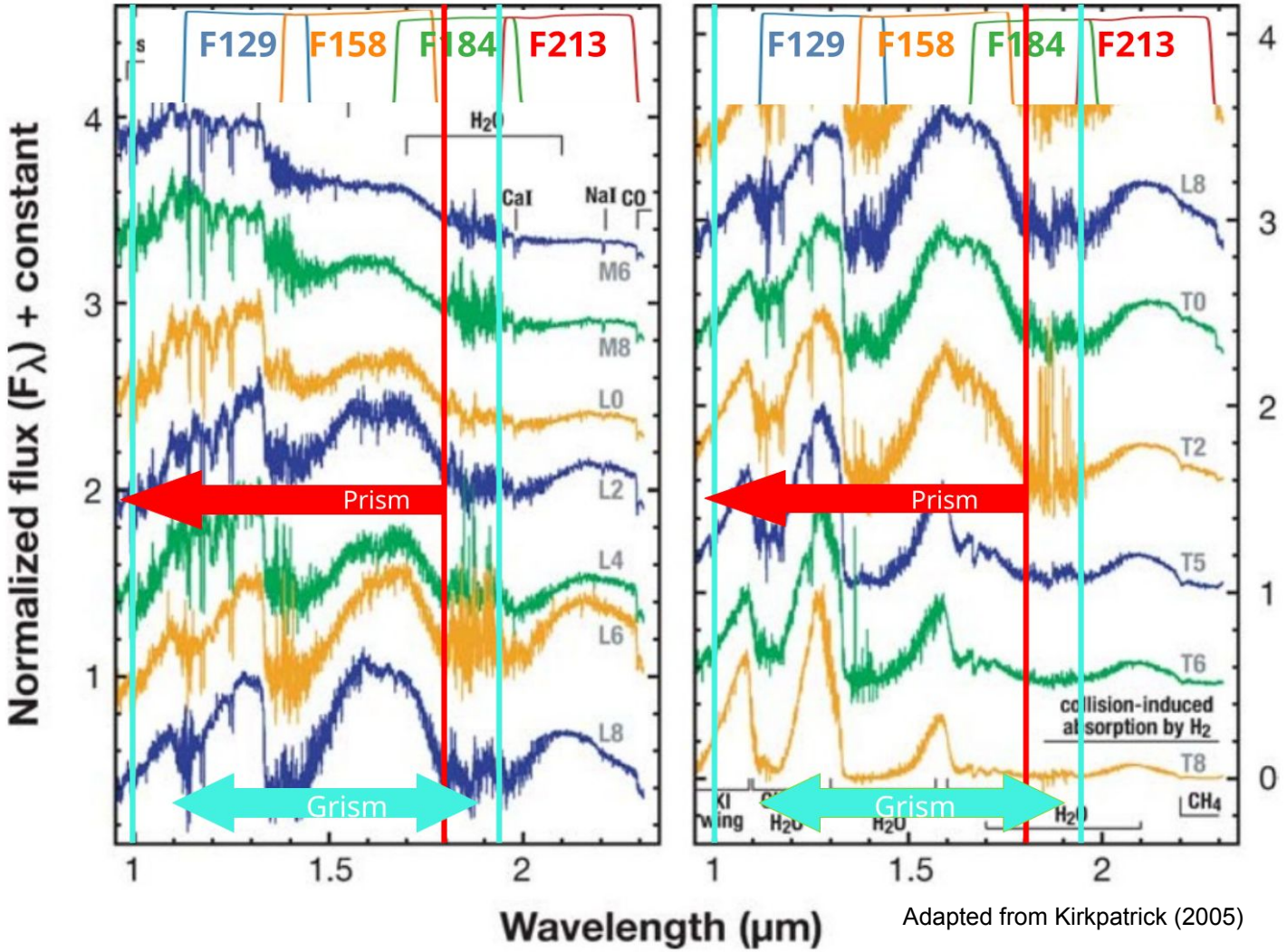
Roman Wide Field Instrument



Matthew De Furio

Roman Wide Field Instrument

Filter	F062	F087	F106	F129	F158	F184	F213	F146
Wavelength (microns)	0.48-0.76	0.76-0.98	0.93-1.19	1.13-1.45	1.38-1.77	1.68-2.00	1.95-2.30	0.93-2.00
1 hr, Point	27.97	27.63	27.60	27.60	27.52	26.95	25.64	28.01
1 hr, r50=0.3"	26.70	26.38	26.37	26.37	26.37	25.95	24.71	26.84
57s, Point $m(AB)_{m(Vega)}$	24.77 24.62	24.46 23.97	24.46 23.81	24.43 23.48	24.36 23.08	23.72 22.17	23.14 21.32	25.37 24.36
57s, r50=0.3"	23.53	23.23	23.26	23.24	23.24	22.76	22.23	24.22



Adapted from Kirkpatrick (2005)

Core Community Surveys (CCS)

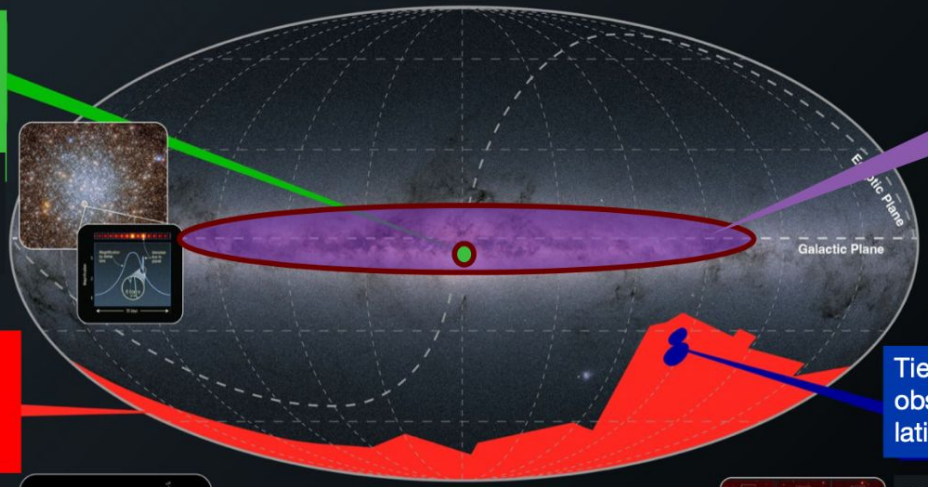
Example implementation of Core Community Surveys (CCS)

~< 15 min cadence observations over few deg^2 towards Galactic bulge

Galactic Bulge Time Domain Survey

Galactic Plane Survey (Early Definition)

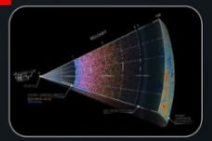
~ 700 deg^2 in four bands (J, H, H/K, K)



Wide area (thousands of deg2) survey including multiband imaging and slitless spectroscopy

Tiered, multiband time domain observations of ~10s of deg^2 at high latitudes with slitless spectroscopy

High Latitude Wide Area Survey



High Latitude Time Domain Survey

ROMAN SPACE TELESCOPE

Core Surveys

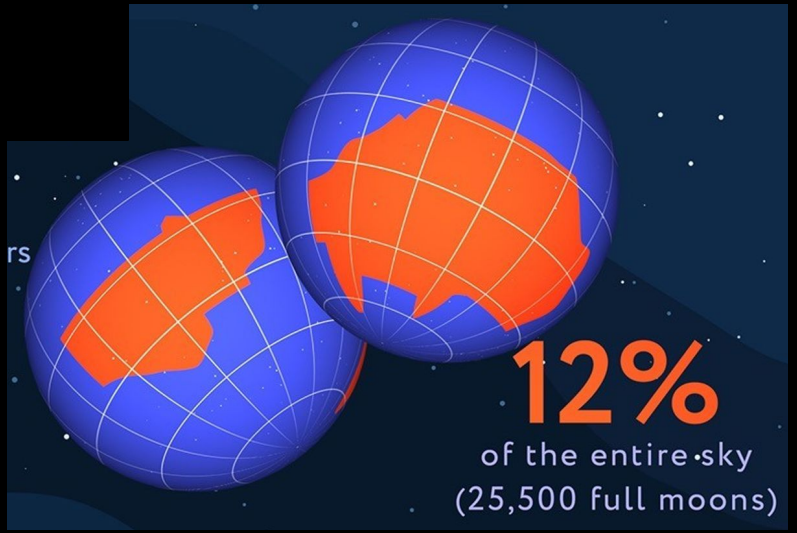
Roman Space Telescope's larger view and fast survey speeds will unveil the evolving universe in ways that have never been possible before.

Matthew De Furio

High Latitude Wide Area Survey

High Latitude Wide Area Survey

- Covers 12% of the sky
- Allocated 520 days
- Medium tier: 2415 deg^2, YJH + Grism, 2 passes for imaging separated by 4-6 months, 4 passes for grism
- Wide tier: 2702 deg^2, H-band, 6 passes
- Wide and medium tiers: ~ 26.5 mag(AB) in YJH-bands
- Deep achieves ~ 1 mag deeper (19 deg^2)
- Ultra-deep achieves ~ 2 mag deeper (5 deg^2)

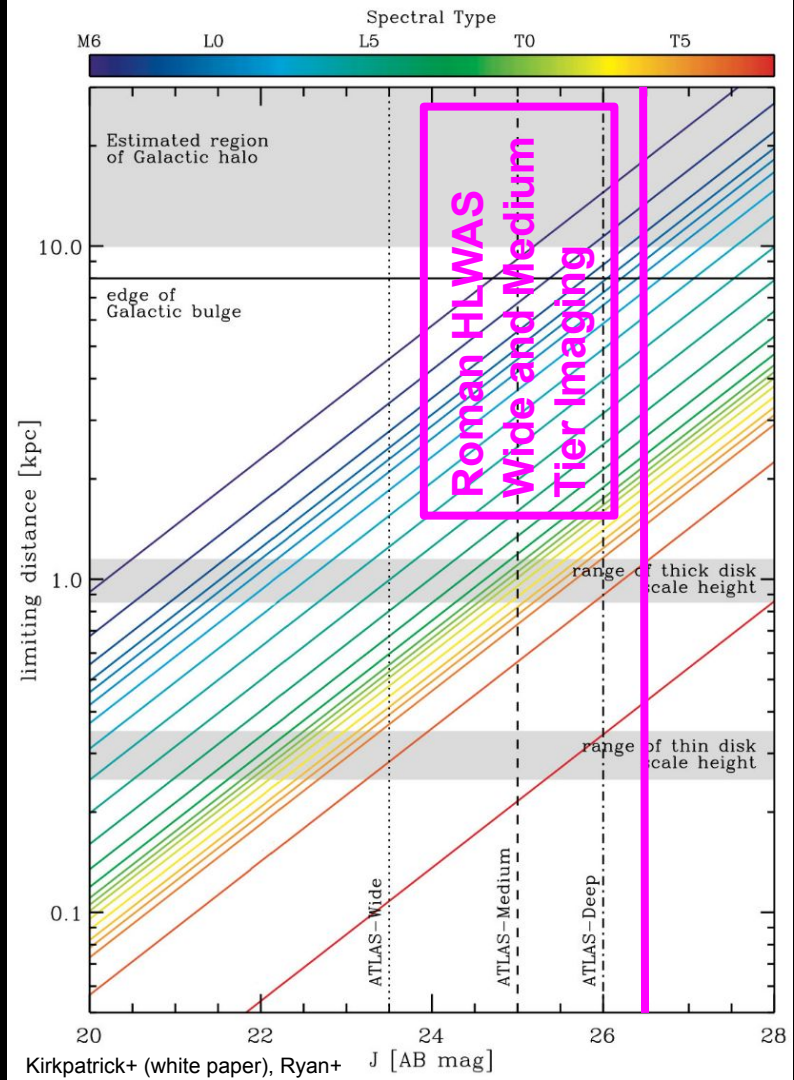


Credit: NASA's Goddard Space Flight Center

Some Estimates

- Wide and medium tier imaging:
  - Late-T out to ~ 400 pc, past thin disk
  - mid-T out to ~ 1 kpc, past thick disk
  - late-M, early-L out to ~ 10 kpc, into the Galactic halo
  - Ryan+17: ~ 65,000 L-dwarfs in 2,000 deg^2

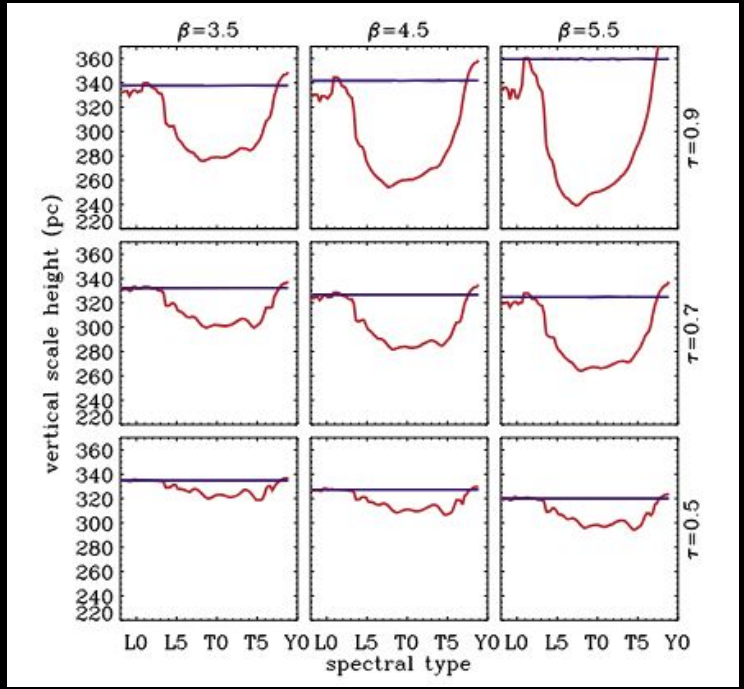
    → ~ 165,000 in 5100 deg^2
- 1 WISE0855 per volume with r = 2.3 pc, expect 1 new WISE0855 detection in H-band



Kirkpatrick+ (white paper), Ryan+

Galactic Star Formation History

- Large sample size gives strong constraint on vertical velocity dispersion
- Velocity dispersion gives scale height
- Scale heights as a function of spectral type with known cooling test star formation history of the Galaxy and IMF



Credit: Ryan et al. (2017)

Brown Dwarf Metallicity

- HLWAS plans grism observations across 1-1.93μm
- CIA of H_2 impacts beyond ~ 1μm
- L-subdwarfs will be easiest
- T-subdwarfs harder unless use K-band
- F213 operates across 1.95-2.3 μm
- K-band used in Deep field (19 deg^2) of HLWAS, but not wide fields or HLTDS

see Zhang, Lodieu, Zhang talks

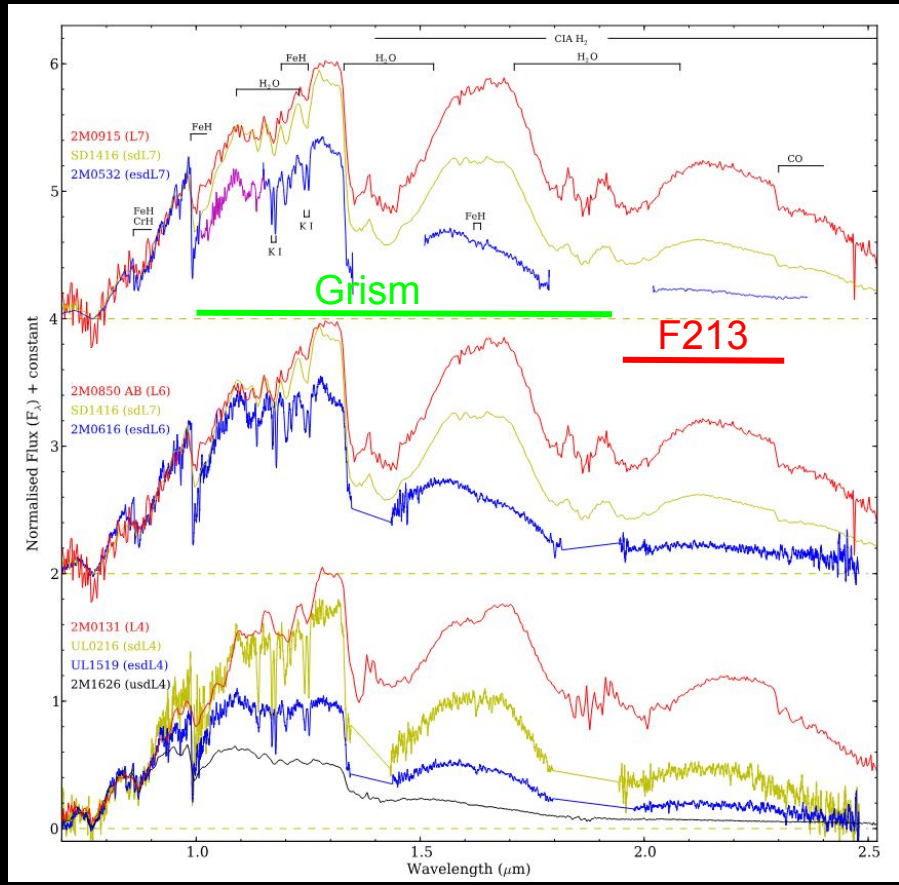


Image credit: Zhang et al. (2017)

Galactic Bulge Time-Domain Survey

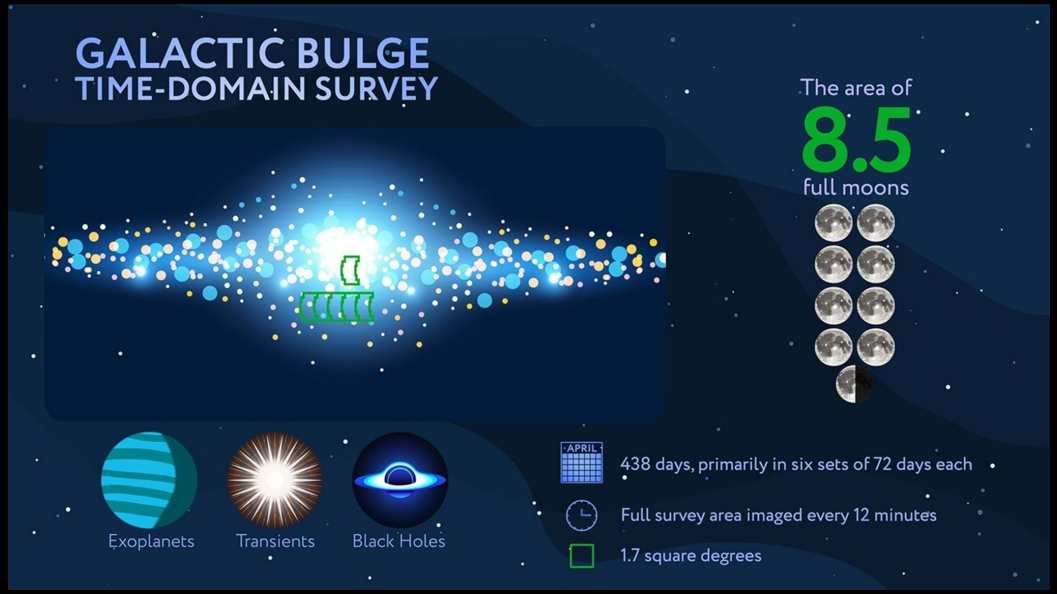


Image credit: NASA's Goddard Space Flight Center

Microlensing

- Six fields in Galactic Bulge
- Brown dwarfs (bound and unbound) will be detected as the lens to other stars
- Brown dwarfs quickly orbiting background star → causes a wobble in signal (xallarap effect)

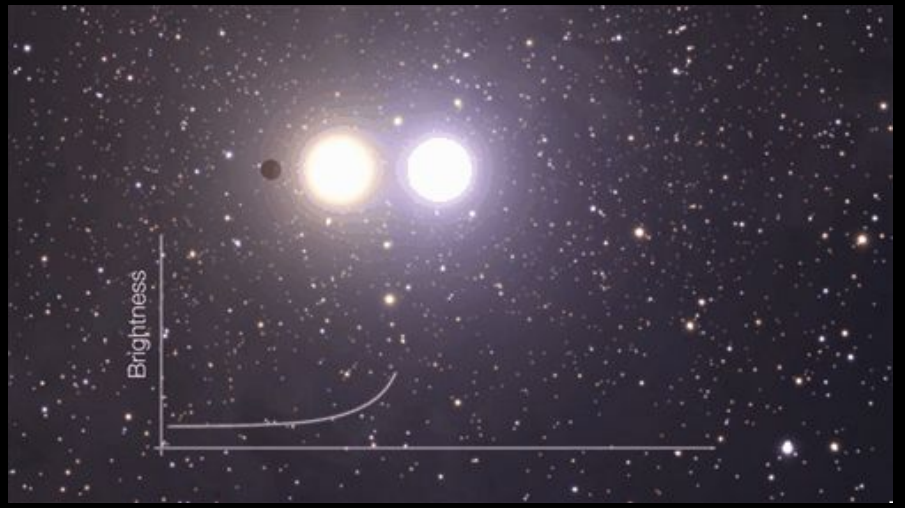


Image credit: European Southern Observatory

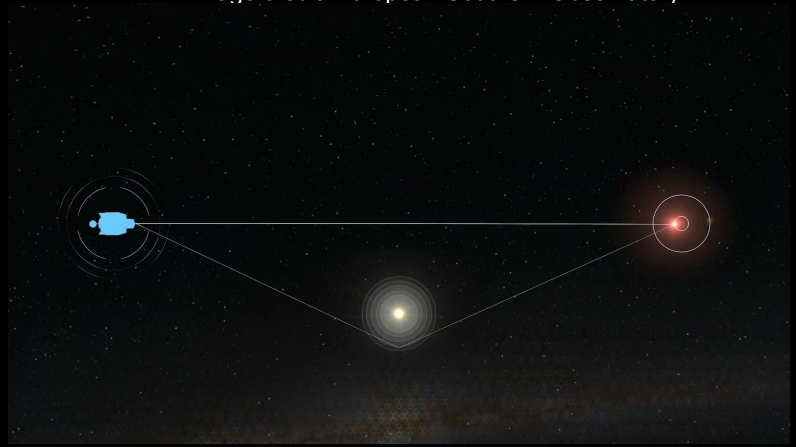
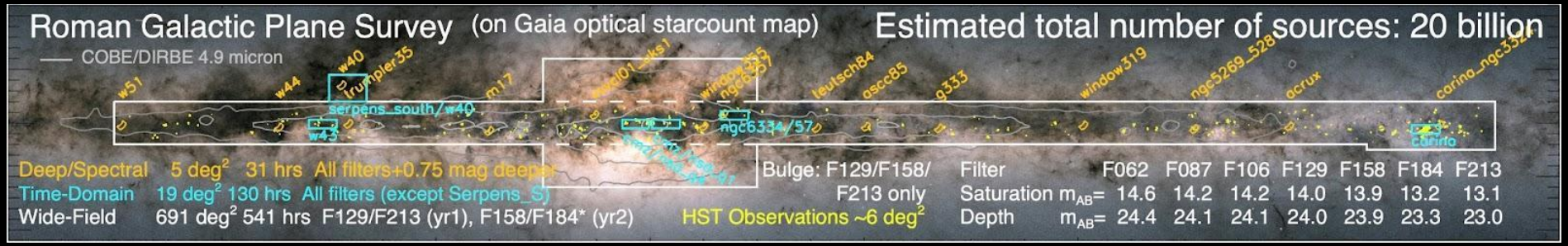


Image credit: NASA's Goddard Space Flight Center

Galactic Plane Survey

(Early-Definition General Astrophysics Survey)



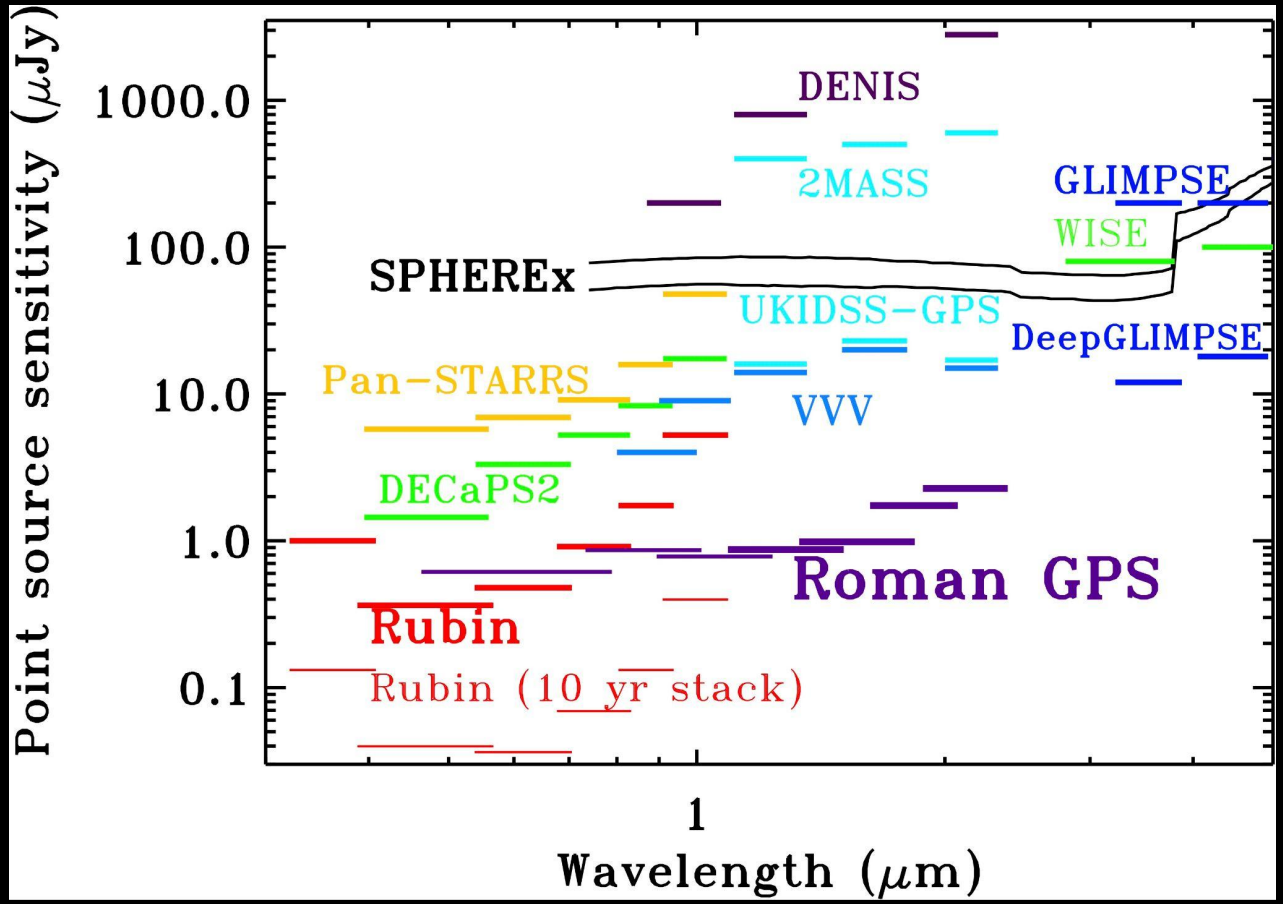
Wide-field: majority of program, J, H, H/K, and K imaging 1 min/field, two passes per field with two filters, expanded around the Bulge, 2-3 mag shallower than HLWAS

Time-Domain: Six subregions, all filters, Nuclear Stellar Disk and Central Molecular Zone, Carina, W43, NGC 6334, NGC 6357, and Serpens South

Deep/Spectral: Fifteen pointings, 4x longer integrations than wide-field, with grism and prism observations, range of Galactic environments, deep imaging/prism in W40

Matthew De Furio

Proposed Survey Depth

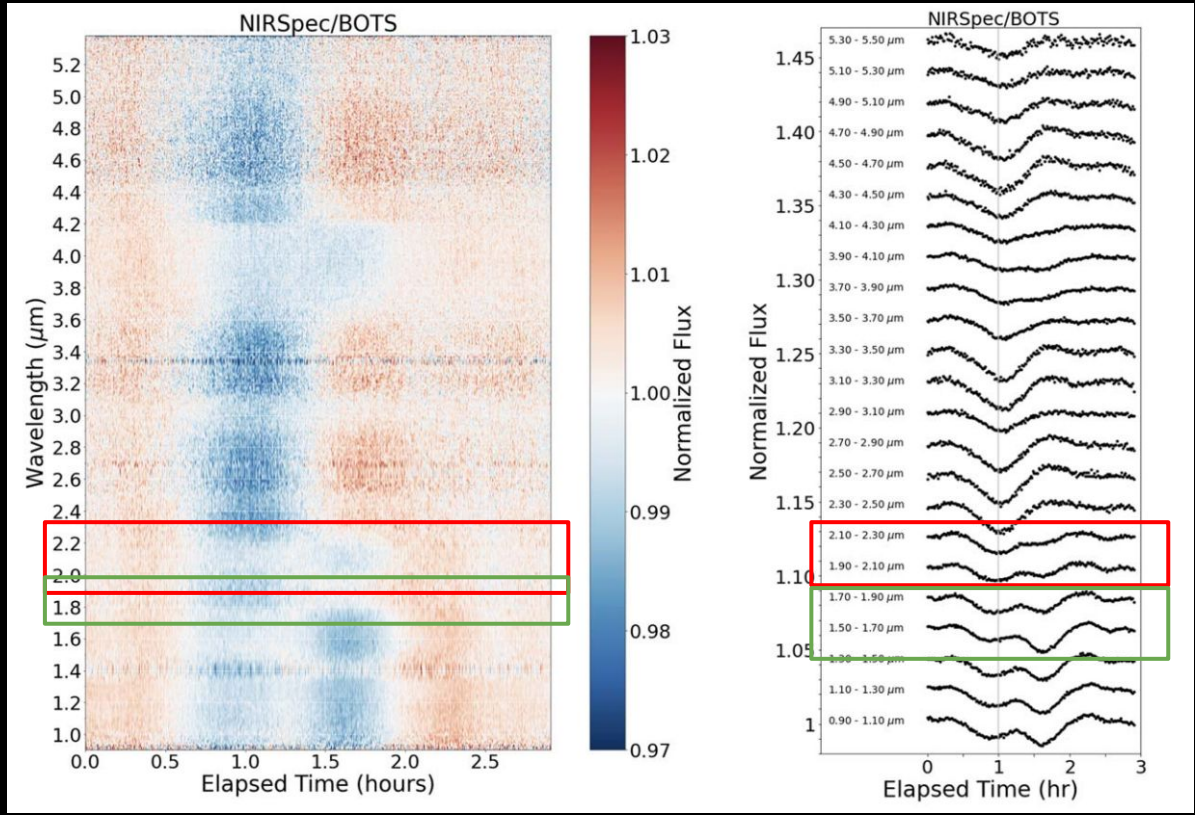


Matthew De Furio

Brown Dwarf Variability

see Miles-Páez, Bull, Manjrawala, Oliveros-Gomez talks

- Time-domain fields target Galactic Bulge and SFRs
- High cadence: F213 imaging every 11.3 min for 8 hours, W43 in F184 (overlap Subaru GPS)
- Low cadence: F213 imaging hourly with higher spaced intervals out to ~ 3 days
- HLTDS across NIR
- Evolution of atmosphere, weather features, rotation rates



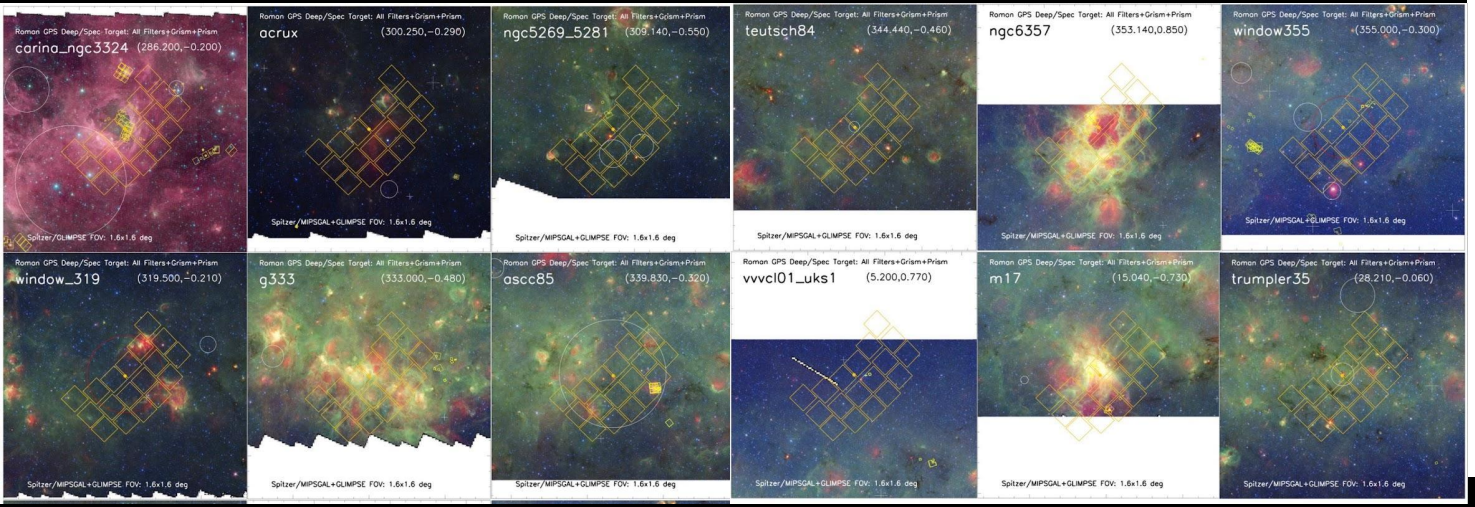
Matthew De Furio

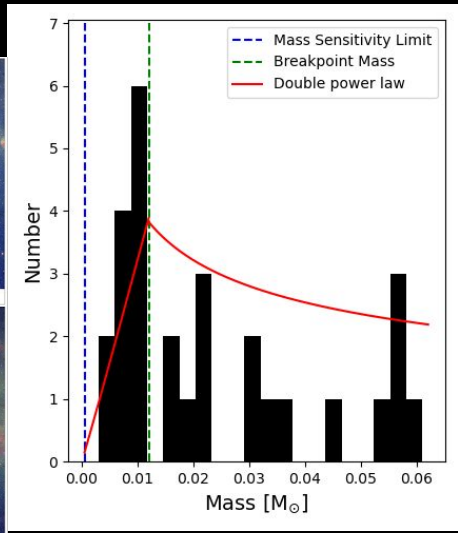
McCarthy et al. (2025)

Brown Dwarfs in Different Galactic Environments

see Almendros-Abad, Alves de Oliveira, Muzic, Rom, Tsilia, Zapatero Osorio talks

- 14 deep fields go 4x deeper than wide-field and performs grism/prism observations
- Targets many SFRs and open clusters
- Explore the low-mass IMF in many regions
- Adds additional astrometric measurements to previous archival programs (e.g. HST)



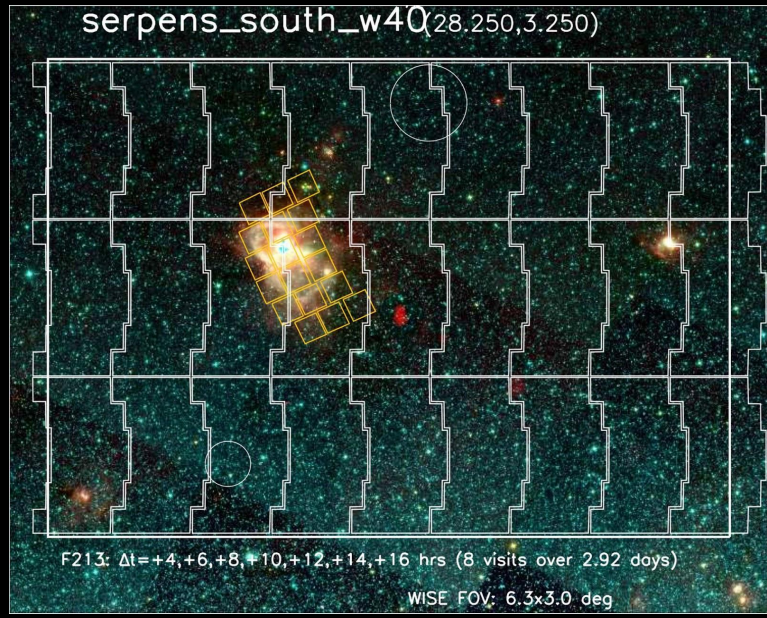


De Furio et al. (2025)

Special Case of W40

see Almendros-Abad, Alves de Oliveira, Muzic, Rom, Tsilia, Zapatero Osorio talks

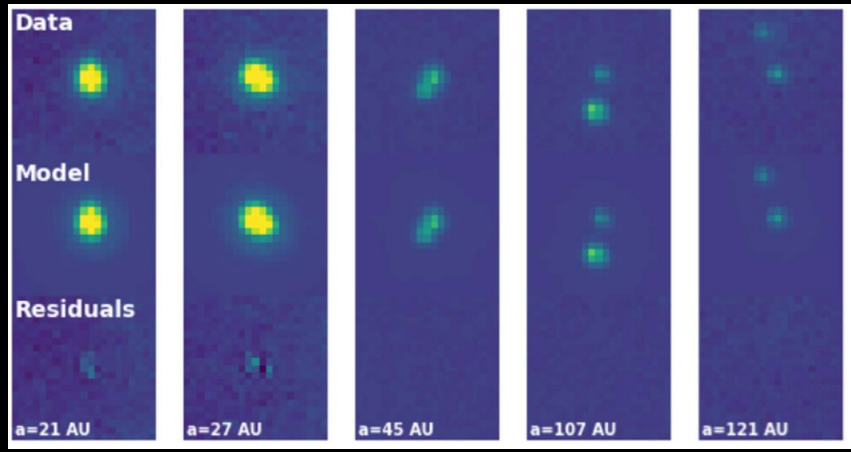
- Closest (440 pc) young SFR in the Galactic Plane
- Plan very deep imaging and prism observations
- 1 hour in JHK and 1 hour with prism with two rolls
- Sensitive to 1 Mj object in imaging
- Sensitive to 3 Mj object in prism spectra
- Demonstration of long spectroscopic exposures and how severe bleeding may be
- Also hourly time domain target with F213



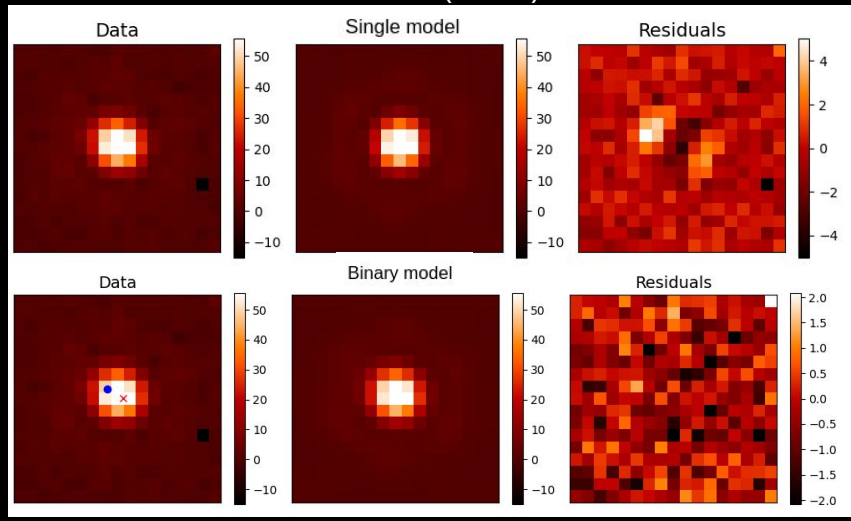
Matthew De Furio

Brown Dwarf Multiplicity

- Plate scale = 0.11”/pixel
- Resolve down to ~ 100 mas or 10 au at 100 pc, 100 au at 1 kpc
- If 0.1% of field BDs have a companion > 0.1” → 100 new companions to BDs, new insights to BD multiple formation



De Furio et al. (2022)

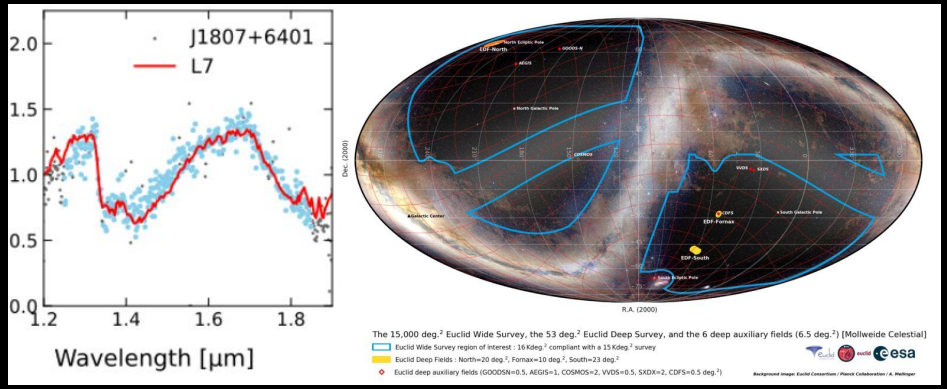


De Furio et al. (in press)

see Dupuy talk

Synergy with other Surveys

- **Euclid** has wide survey (14,000 deg^2, YJH limit ~ 24 mag (AB)) and Galactic Bulge component, wider but shallower than Roman
- **Rubin** full sky coverage (ugrizy down to 23 mag) will detect many brown dwarfs outside the field of view of Roman HLWAS, sample SEDs from ~ u to H for candidate selection (e.g. crucial for young brown dwarfs in star-forming regions +extinction)
- **ULTIMATE-Subaru** (narrow and medium bands across 1-2.5μm, Ks~22 mag(AB), GPS 60 deg^2, FOV = 14'x14', planned for 2028)
- **Spitzer, WISE, HST, JWST, Gaia, etc.**
- All program overlaps help improve measurements of ***proper motions*** and ***parallaxes***



Mohandasan et al. (2025)

Rubin LSST:
Single exposure, ten year stack AB mag

u: 23.9, 26.1 mag

g: 25.0, 27.4 mag

r: 24.7, 27.5 mag

i: 24.0 , 26.8 mag

z: 23.3, 26.1 mag

y: 22.1, 24.9 mag

see Domínguez-Tagle, Martín, Mohandasan, Muñoz-Torres, Sedighi, Zerjal talks

Matthew De Furio

Ways for you to get involved

- Cycle 1 Call for Proposals for General Astrophysics Surveys coming in Fall 2025
- 25% of time in first 5 years for General Astrophysics Surveys
- Roman not operating like HST or JWST, proposals must be larger surveys
- Will not have call for proposals every year

Join the Roman Science Forum, Roman Science Collaboration, and relevant Working Groups (e.g. external synergies, software)

Conclusions

- Roman imaging and spectroscopy operates across wavelengths where brown dwarfs have significant absorption features
- Current design of core community surveys will find > 10^5 L-dwarfs
- HLWAS will go deepest and may detect halo brown dwarfs
- Galactic Plane Survey will allow for mass function characterization across many environments and more
- Science fields such as Galactic star-formation rates, low metallicity brown dwarfs, variability, multiplicity, etc. will be greatly expanded ***WITHOUT*** a dedicated brown dwarf observing program

You could design the next large brown dwarf survey with Roman!