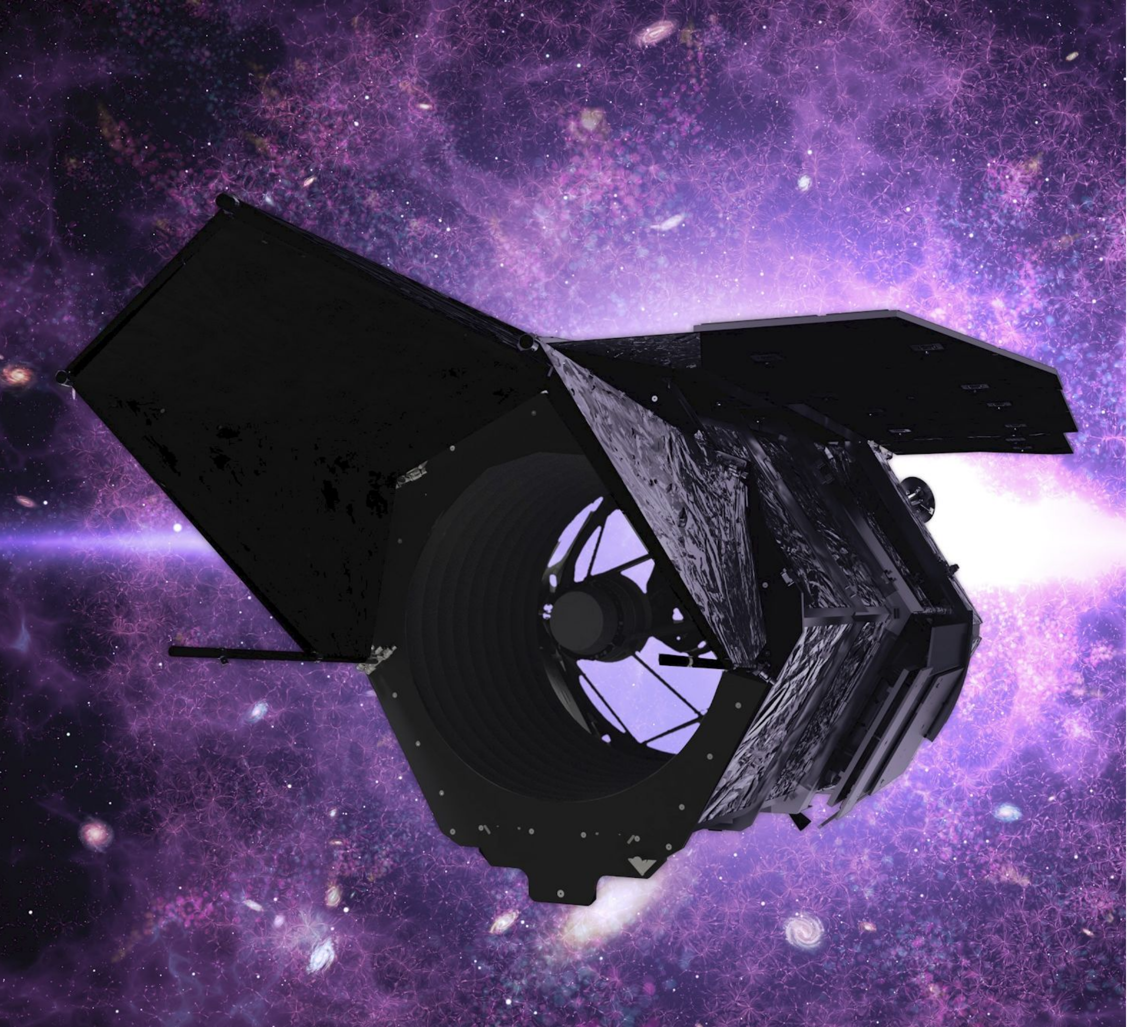


Image Credit: GSFC/SVS; For more Roman updates see: Akeson + (2019) [arXiv: 1902.05569]

Update on the Nancy Grace Roman Space Telescope

Kris Pardo

Jet Propulsion Laboratory, California Institute of Technology

High Latitude Survey
Science Investigation Team
https://www.roman-hls-cosmology.space/

Jet Propulsion Laboratory
California Institute of Technology

Overview of the Nancy Grace Roman Space Telescope

- Hubble resolution with 100x the field of view
- Top priority of the 2010 Astronomy & Astrophysics Decadal Survey
- 2.4 m mirror + wide-field imager + coronagraph
- Main science goals include: investigating Dark Energy & searching for planets
- Sensitive to NIR wavelengths.
- Nominal 5 year mission

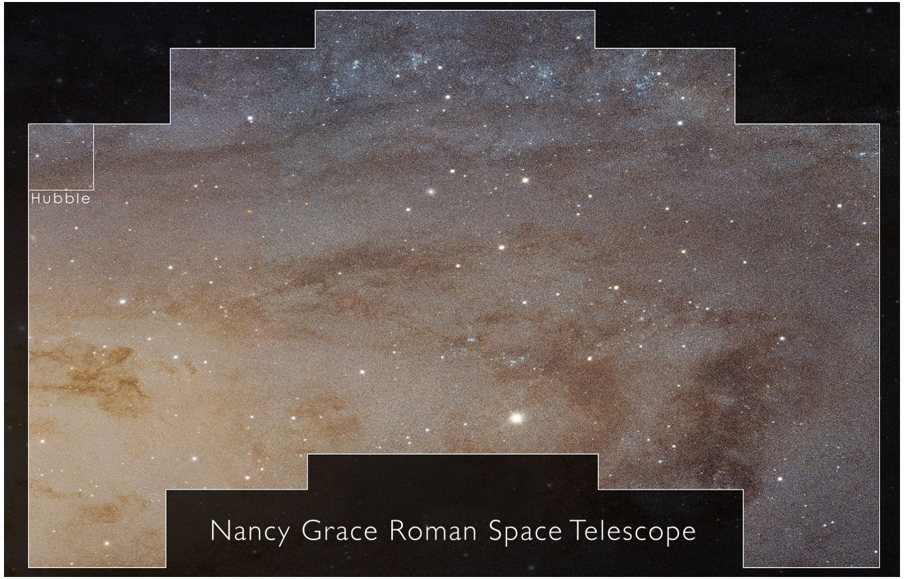
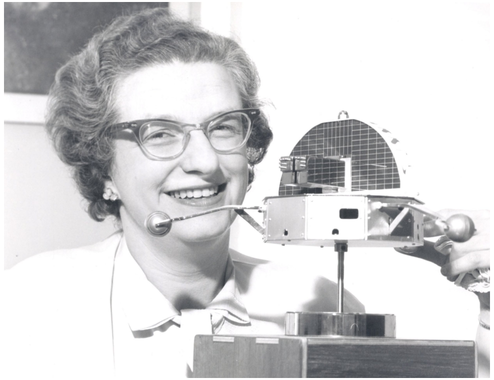


Image Credit: GSFC/SVS

Nancy Grace Roman

- NASA's First Chief Astronomer
- Her research focused on stellar spectroscopy, although she made contributions to many different subfields in observational astronomy.
- She built the space astronomy program at NASA (including making Hubble happen!) and is responsible for NASA's policy of making all data public.
- If you want to learn more about Nancy Grace Roman, please check out:
    - Dominic Bedford's Roman Space Telescope Virtual Series Lecture: "Is Nancy Grace Roman the Most Influential Person You've Never Heard Of?"



NASA and Roman Space Telescope team

Roman Space Telescope Instruments

Two main instruments.

- Wide Field Imager with 7 imaging filters and 2 grism/prism filters
- Coronagraph

Roman Space Telescope Imaging Capabilities							
Telescope Aperture (2.4 meter)		Field of View (45′x23′; 0.28 sq deg)		Pixel Scale (0.11 arcsec)		Wavelength Range (0.5-2.0 μm)	
Filters	**R062**	**Z087**	**Y106**	**J129**	**H158**	**F184**	**W146**
Wavelength (μm)	0.48-0.76	0.76-0.98	0.93-1.19	1.13-1.45	1.38-1.77	1.68-2.00	0.93-2.00
Sensitivity (5σ AB mag in 1 hr)	28.5	28.2	28.1	28.0	28.0	27.5	28.3

Roman Space Telescope Spectroscopic Capabilities				
	Field of View (sq deg)	**Wavelength (μm)**	**Resolution**	**Sensitivity (AB mag) (10σ per pixel in 1hr)**
Grism	0.28 sq deg	1.00-1.93	435-865	20.5 at 1.5 μm
Prism	0.28 sq deg	0.75-1.8	70-170	23.5 at 1.5 μm

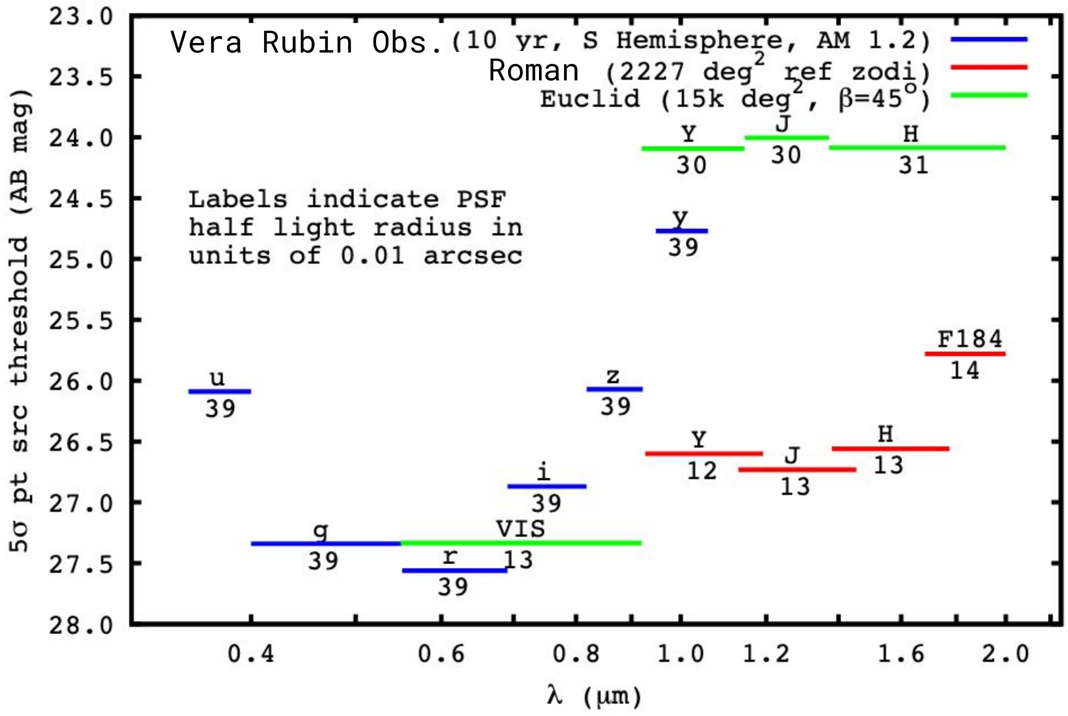
Roman Space Telescope Coronagraphic Capabilities					
	Wavelength (μm)	**Inner Working Angle (arcsec)**	**Outer Working Angle (arcsec)**	**Detection Limit***	**Spectral Resolution**
Imaging & Spectroscopy	0.5-0.8	0.15 (exoplanets) 0.48 (disks)	0.66 (exoplanets) 1.46 (disks)	10^{-9} contrast (after post-processing)	~50

NASA/GSFC

Roman Space Telescope Instruments

Two main instruments.

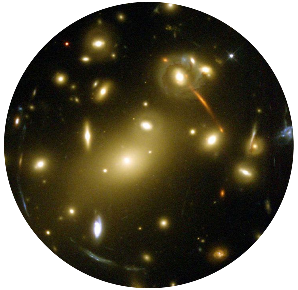
- Wide Field Imager with 7 imaging filters and 2 grism/prism filters
- Coronagraph



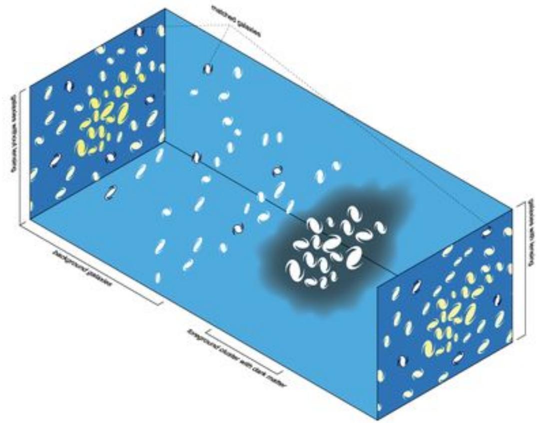
Spergel et al. (2015)

Reminder of the observables we're looking for

Galaxy Positions



Galaxy Cluster Counts

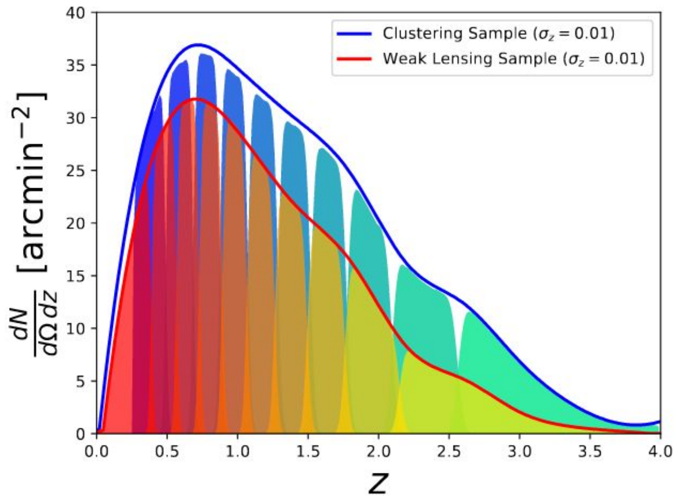


Weak Lensing
(i.e. galaxy shapes)

Type 1a supernovae
(i.e., standard candles)

Roman High Latitude Survey Overview

- Should include both imaging and spectroscopic surveys.
- Currently notionally envisioned as a 2000 deg sq survey
- Should constrain dark energy using: galaxy clustering, weak lensing, baryon acoustic oscillations + redshift space distortions, and cluster measurements
- Currently should account for ~⅓ of total mission time.
- Final survey parameters will be fully defined after the first results of the upcoming surveys like the Vera Rubin Observatory, DESI, Euclid, SPHEREx, etc. in order to be maximally scientifically impactful

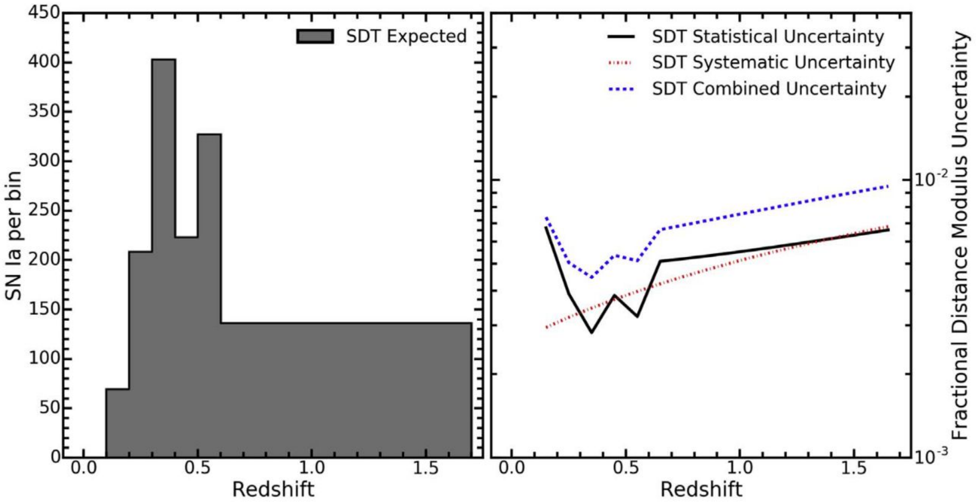


Optimistic Number Density of Galaxies as a function of redshift for the HLS [Eifler et al. 2020]

See Eifler et al. (2020) [arXiv:2004.05271], and https://www.roman-hls-cosmology.space/ for more details

Roman Supernovae Survey Overview

- Should have a 5 day cadence over 2 years.
- Should have 2 different fields of varying sizes and depths.
- Expected to discover almost 9000 supernovae up to redshift 1.7



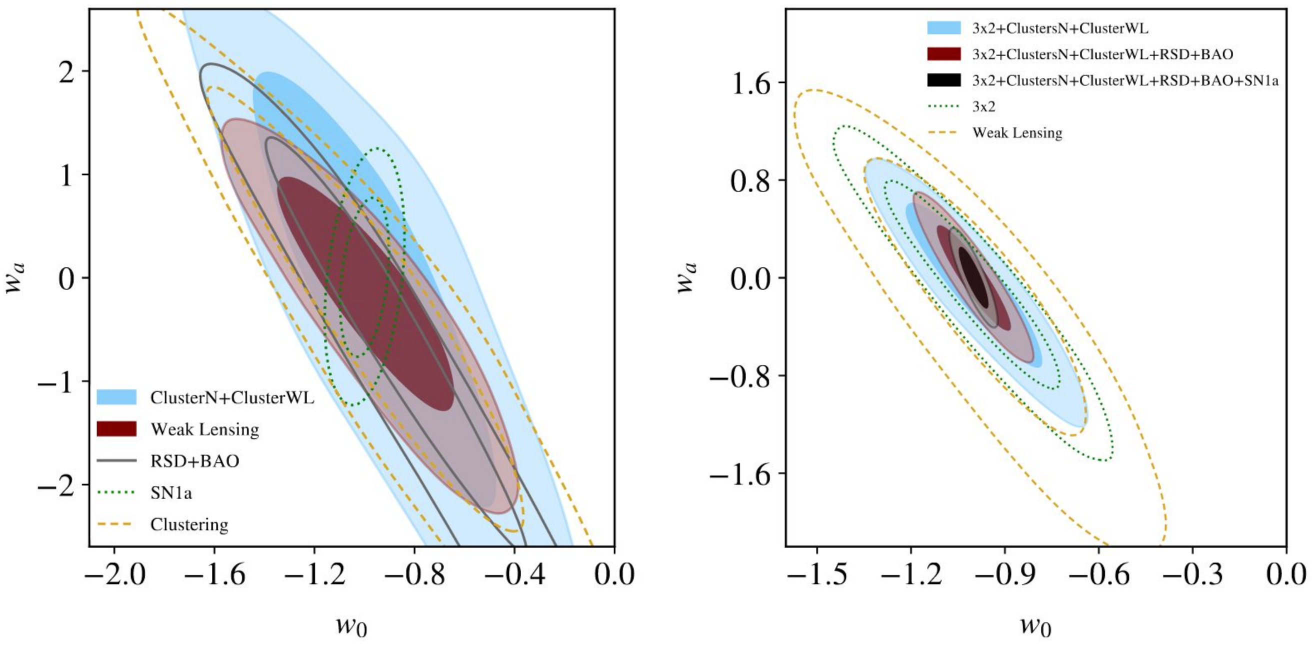
Expected Number of Observed Supernovae (left) & Distance Modulus Uncertainty (right) vs. Redshift [Hounsell et al. 2018]

See Hounsell et al. (2018) [arXiv:170201747] for more details.

Constraints on Dark Energy from the HLS + SNe Surveys

$$P = w\rho c^2$$

$$w = w_0 + \frac{z}{1+z} w_a$$



See Eifler et al. (2020) [arXiv:2004.05271], and https://www.roman-hls-cosmology.space/ for more details

But this isn’t the only cosmological science possible!

- General Observer Program should allow for a wide range of possible observations!
  - E.g., a survey of Andromeda.
  - 25-30% of Nominal 5 year Mission should be devoted to GO programs.
- The Exoplanet Microlensing Survey is also an option...

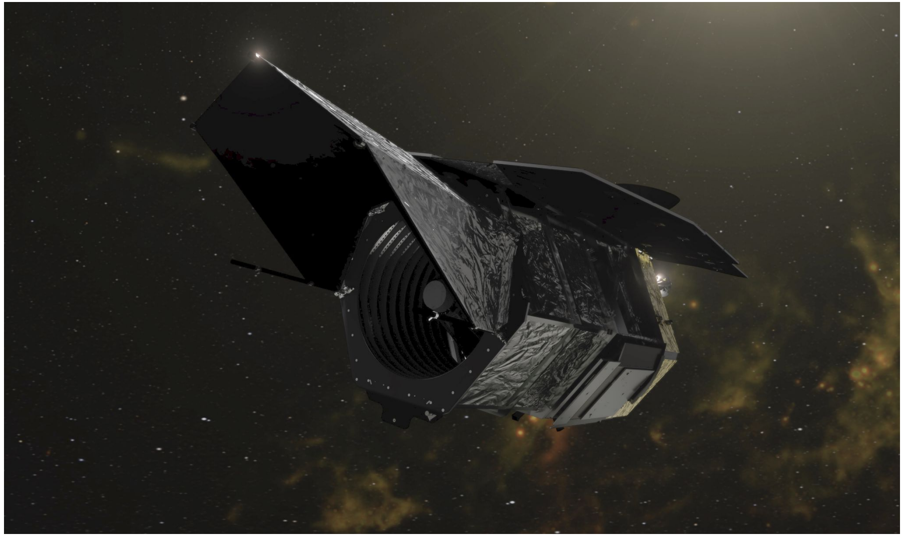


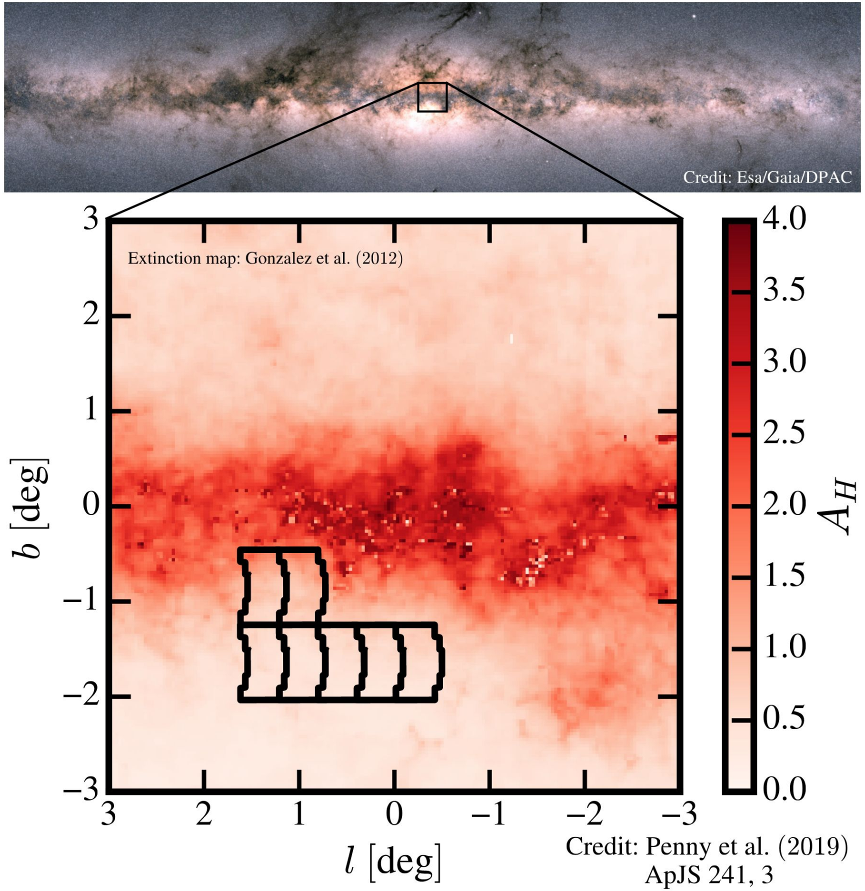
Image Credit: GSFC/SVS;   For more on the general observer programs see: Akeson + (2019) [arXiv: 1902.05569]

Roman's Exoplanet Microlensing Survey Basics

- Will monitor 10^8 stars

- Astrometry will be excellent -- single image precision will be comparable to *Gaia.*

- Will take 41,000 images of each star over 5 years



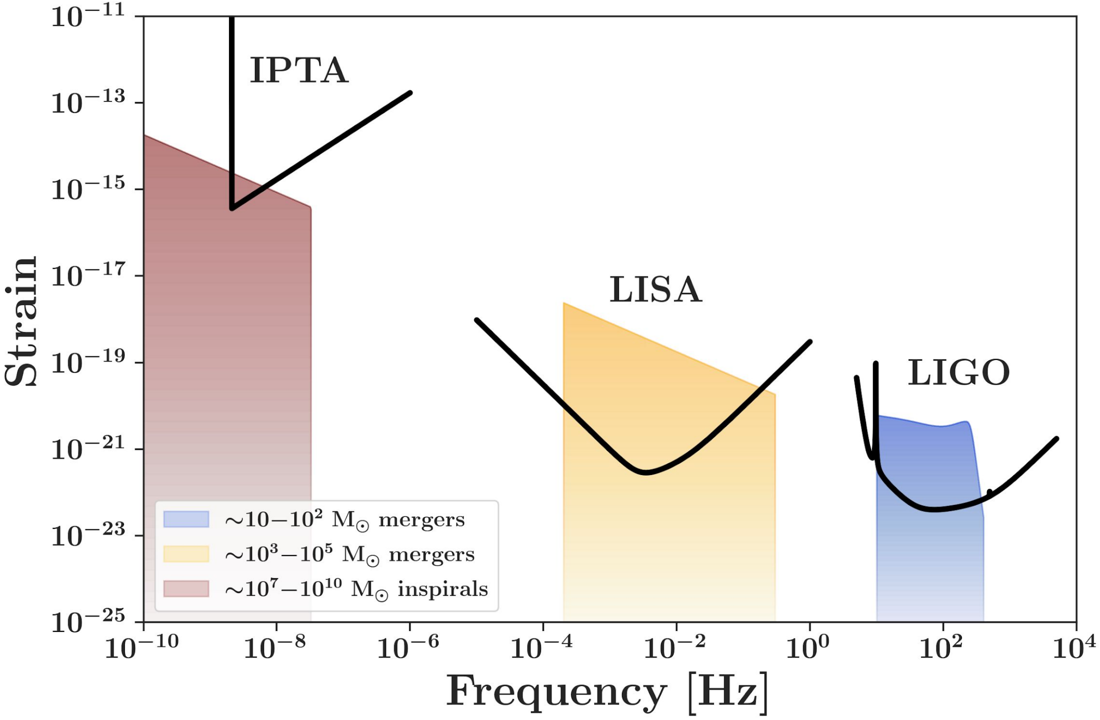
See Penny et al. (2019) [arXiv:1808.02490] and for more details.

Gravitational Wave Detection with Photometric Surveys

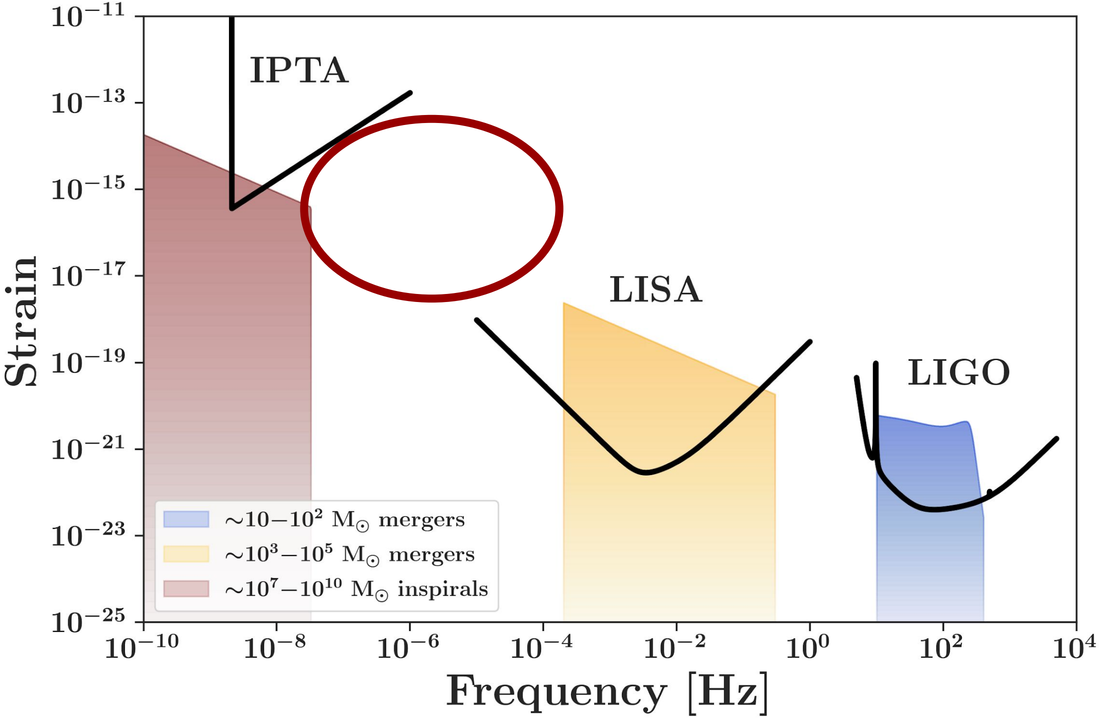
Paper led by Yijun (Ali) Wang;
also in collaboration with Tzu-Ching Chang & Olivier Doré

Published in PRD [arXiv:2010.02218]

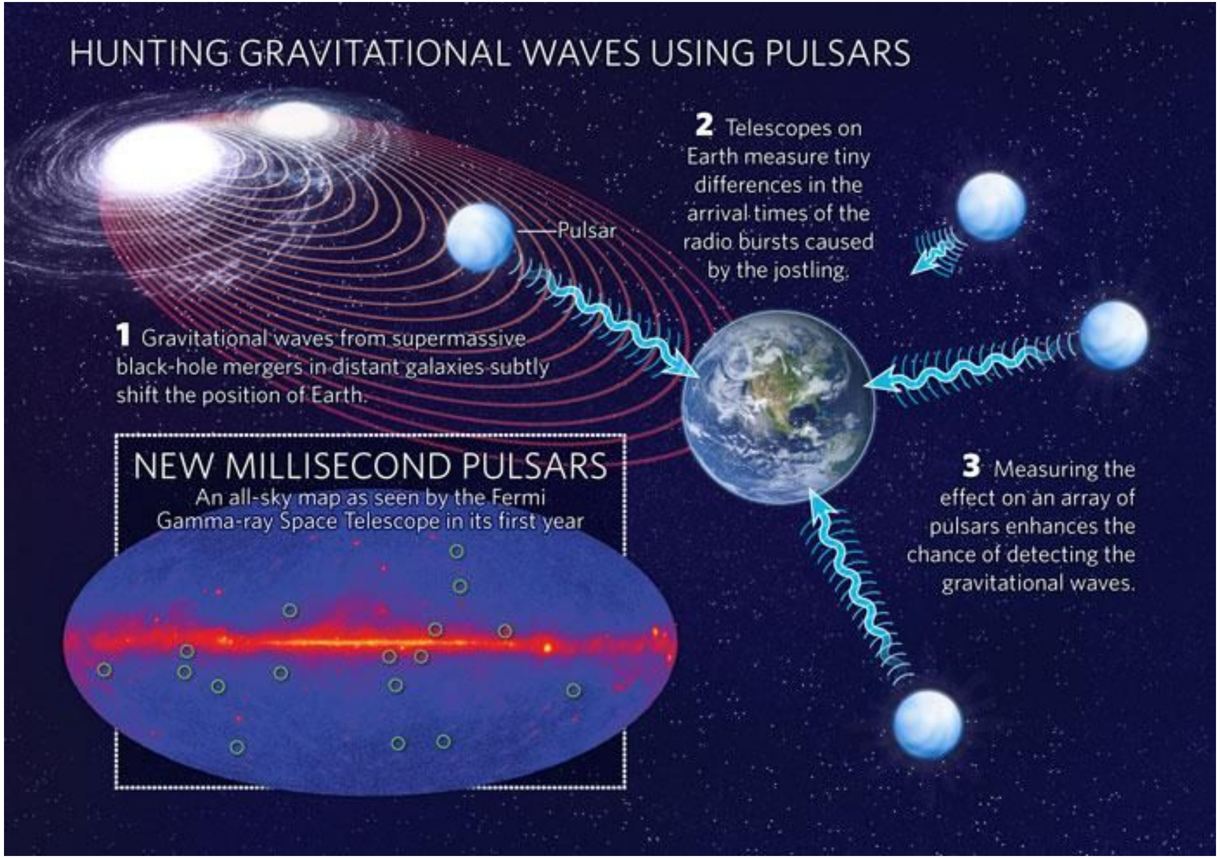
The Gravitational Wave Spectrum



The Gravitational Wave Spectrum

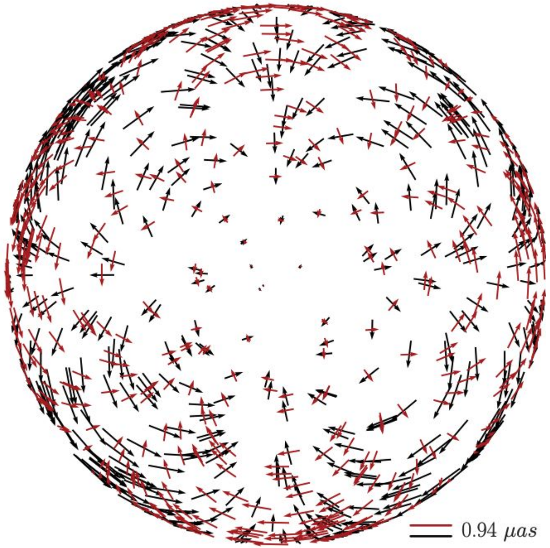


PTAs & supermassive black holes



NASA/DOE/Fermi LAT

Observing GWs with stellar parallax



Wang, Pardo, et al. (2021)

What is the Roman microlensing survey's sensitivity?

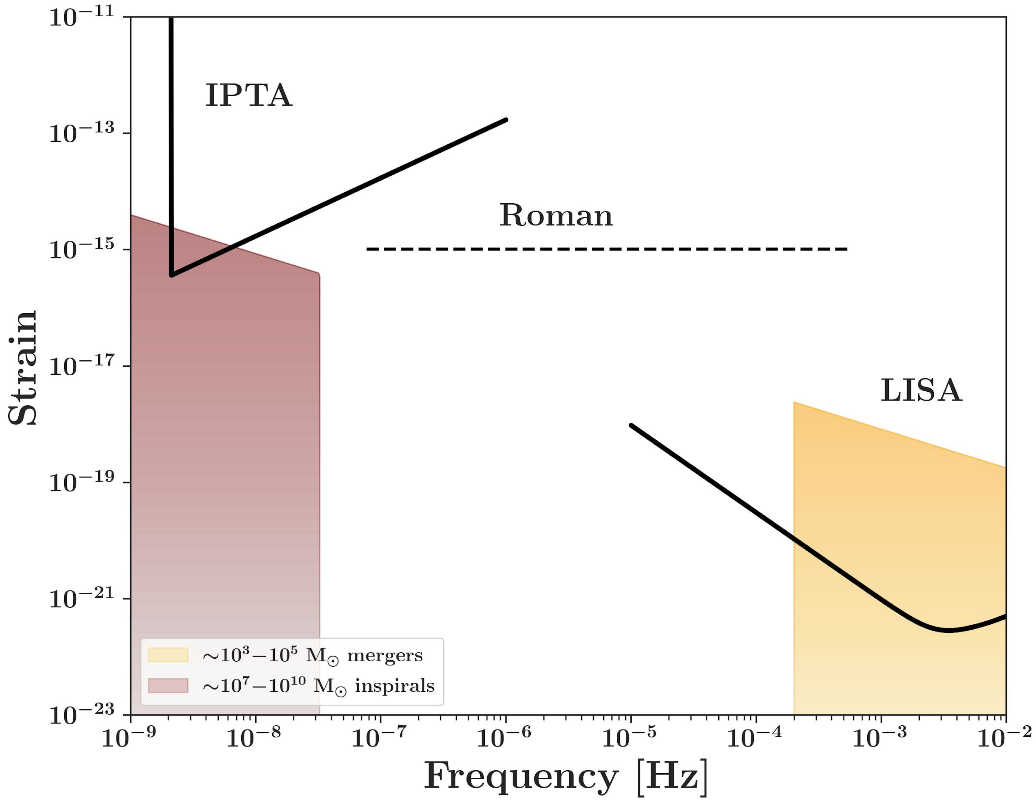
Sensitivity:

Astrometric precision

$$h \sim \frac{\sigma_\theta}{\sqrt{N_s N_m}}$$

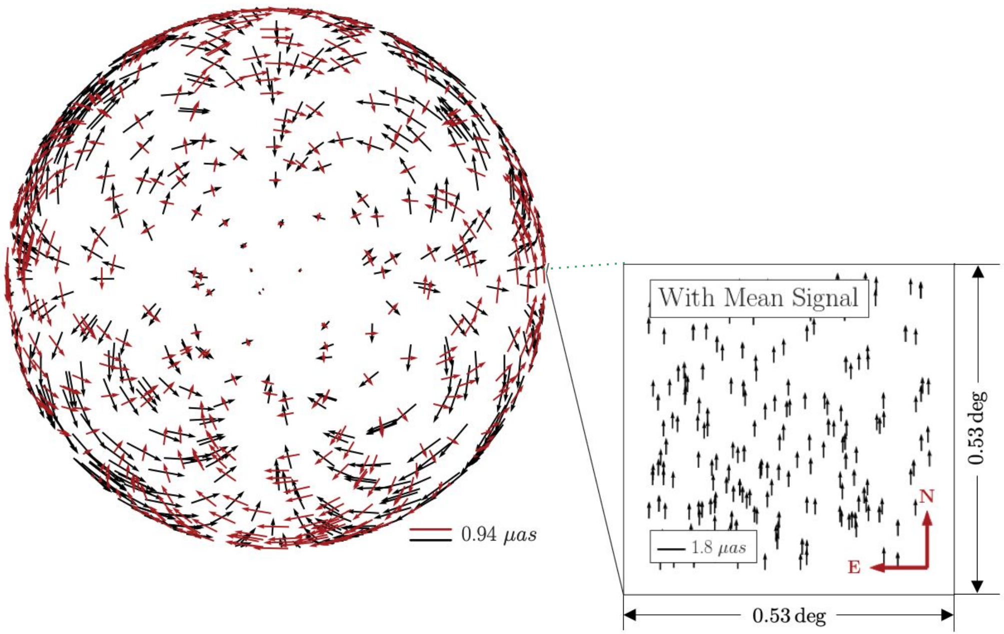
Signal (single binary):

$$h \sim (\pi f)^{2/3} \frac{\mathcal{M}_c^{5/3}}{D_L}$$



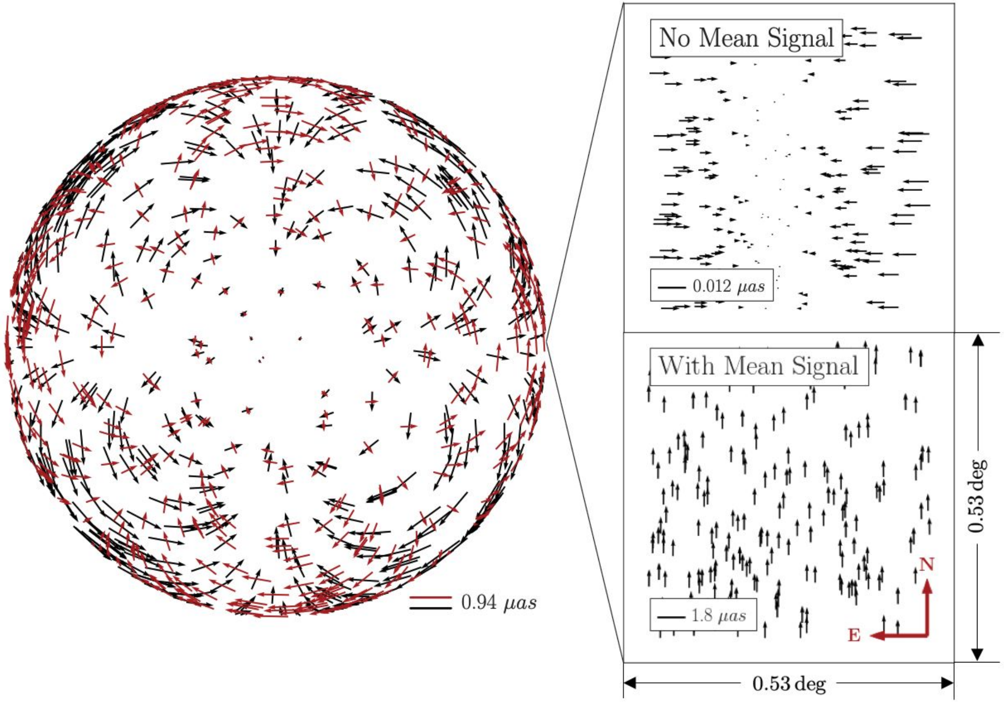
Wang, Pardo et al. (2021)

But, what signal can we realistically measure?



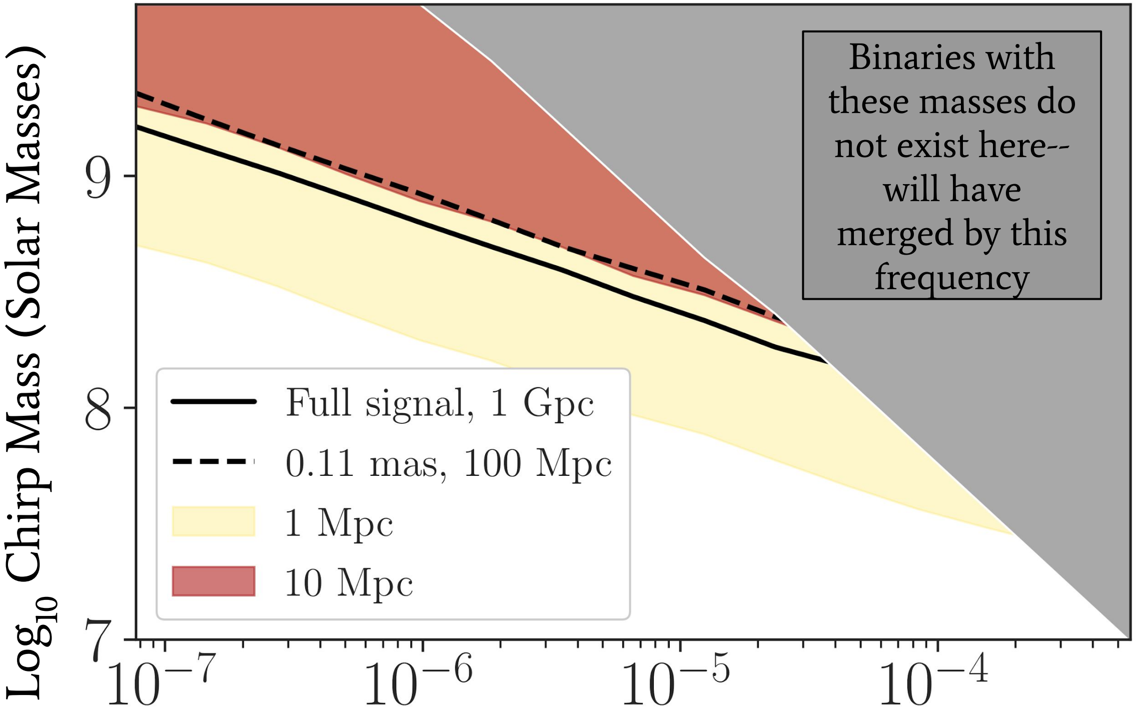
Wang, Pardo, et al. (2021)

But, what signal can we realistically measure?



Wang, Pardo, et al. (2021)

What sorts of systems will Roman detect?

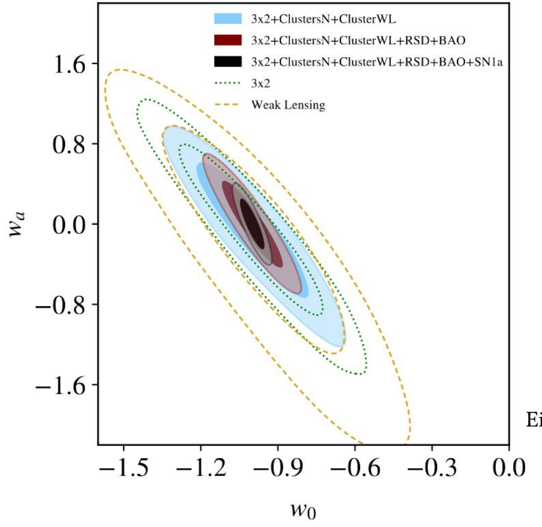


$$h \sim (\pi f)^{2/3} \frac{\mathcal{M}_c^{5/3}}{D_L}$$

Wang, Pardo, et al. (2021)

Conclusions

- The Roman Space Telescope should help us measure dark energy even more precisely.
- It should also be able to detect gravitational waves in a band that is not covered by any current or future experiment.



Eifler et al. (2020)