

HLIS



roman-hlis-cosmology.caltech.edu



github.com/Roman-HLIS-Cosmology-PIT



Forecasts for Weak Lensing Cosmology with Nancy Grace Roman Space Telescope

Presenter: Kaili Cao (The Ohio State University)

28th International Conference on Particle Physics and Cosmology (COSMO-25), October 13, 2025

HIGH-LATITUDE WIDE-AREA SURVEY



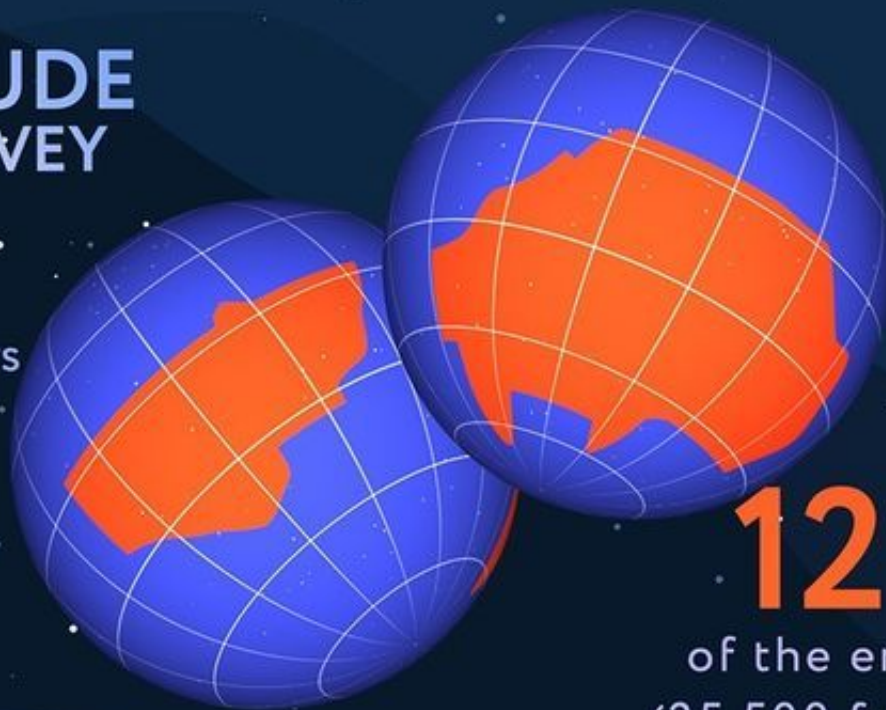
520 days over five years



Exposure times from
11 to 150 minutes



5,100 square degrees



12%

of the entire sky
(25,500 full moons)



Dark Energy



Dark Matter



Galaxies



Solar System

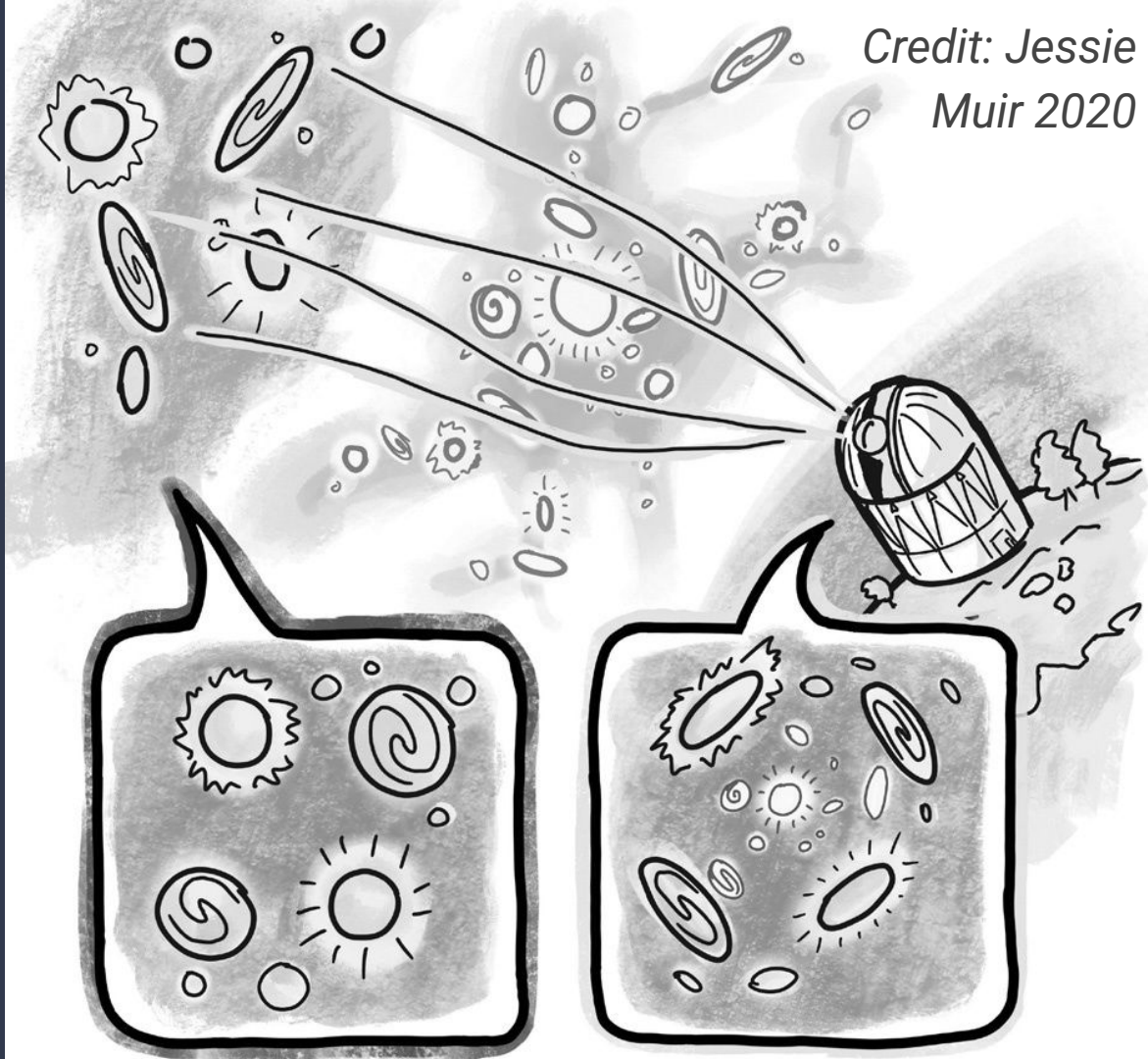


Milky Way

*Credit: NASA's
Goddard Space
Flight Center*

Weak Gravitational Lensing

Our Project Infrastructure Teams (PIT) is building the infrastructure to make use of the gravitational lensing probe to understand the dark universe.



Roman Weak Lensing: From Pixels to Cosmology

Roman images (“pixels”)

Coaddition → Combined images

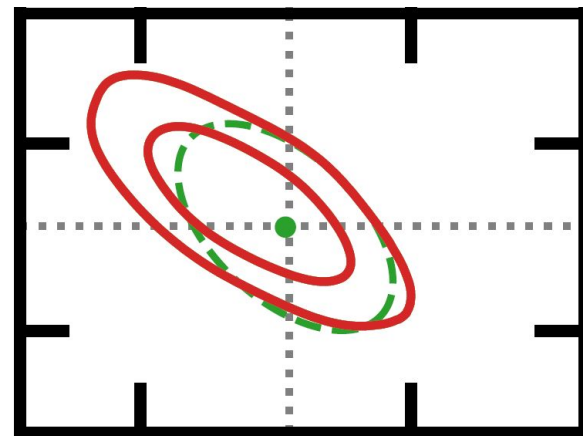
Shape measurements → Catalog
→ Summary statistics

Inference → Cosmological
parameters (“cosmology”)

*Right: Part of Figure 4 from Cao et al.
2025c, in prep. (will appear on arXiv in
a few weeks).*

Just an example:

Ω_m 0.32
0.31



Quick caption

*Red solid: Markov chain
Monte Carlo*

*Green dashed: Maximum
a posteriori + Fisher*

*Gray dotted: truth values
for simulated data*

σ_8

Inference Relies on Theoretical Prediction



COCOA

COBAYA-COSMOLIKE JOINT ARCHITECTURE

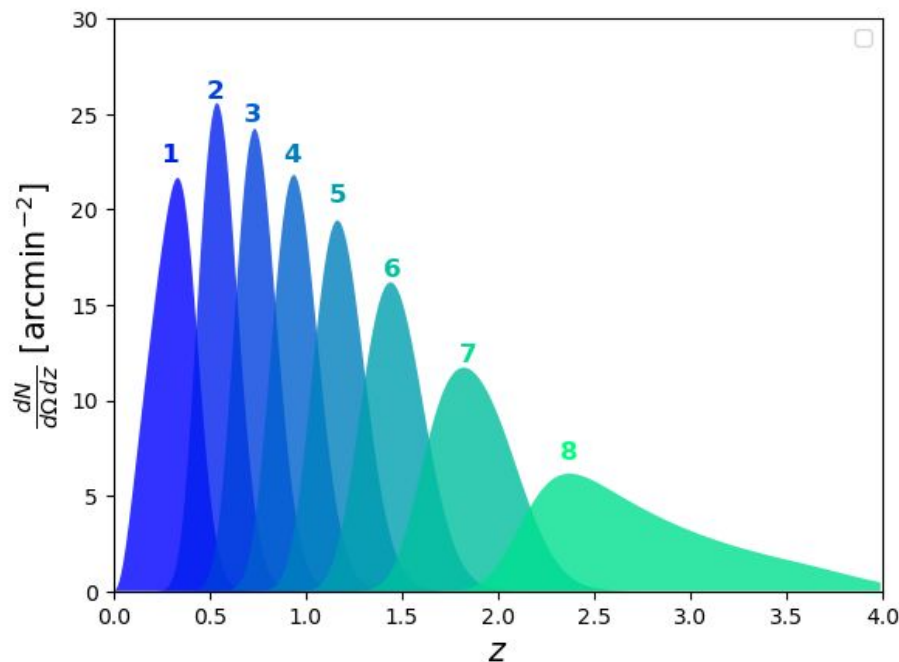
Weak Lensing Observables: 3×2pt

Three two-point correlation functions:

Cosmic shear: autocorrelation of galaxy **shapes**

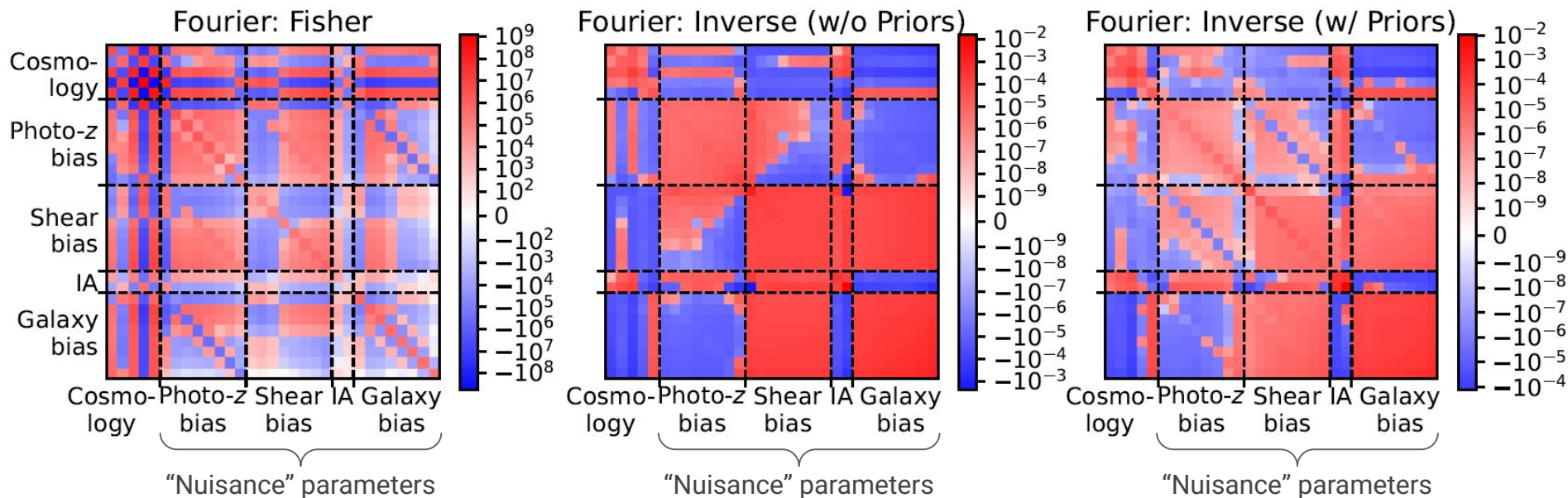
Galaxy-galaxy lensing (GGL):
cross-correlation of galaxy **shapes**
and galaxy **positions**

Galaxy clustering: autocorrelation of galaxy **positions**



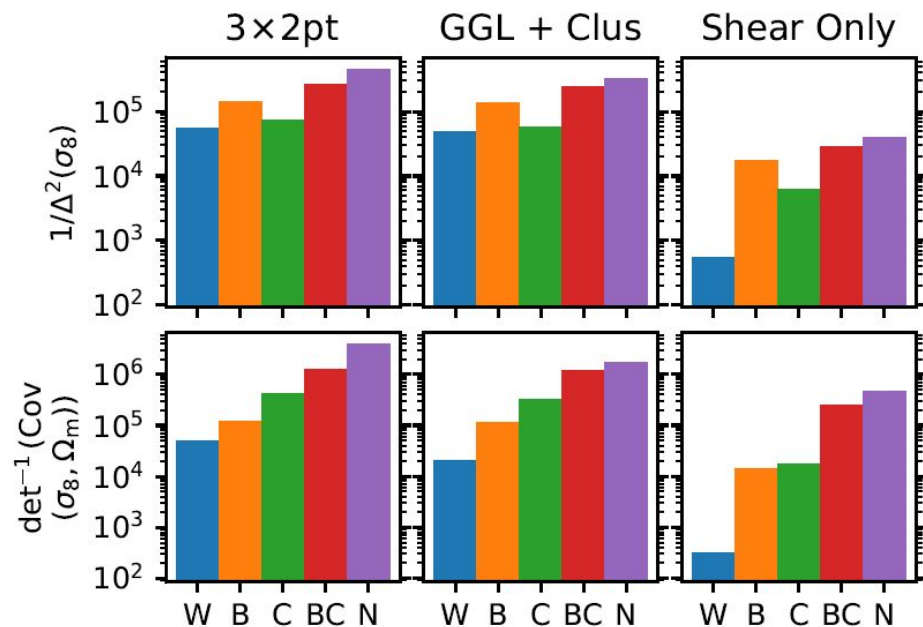
Credit: Haley Bowden

Fisher Forecasts for Constraining Power



Above: Figure 3 from Cao et al. 2025c, in prep. (will appear on arXiv in a few weeks).

Constraining Power from Different Probes



W: infinitely wide priors on all (i.e., both cosmological and “nuisance”) parameters

B: benchmark priors on photo- z bias (Δz ; 0.002) and shear bias (m ; 0.005)

C: infinitely narrow priors on other studied cosmological parameters (n_s , Ω_b , and h_0)

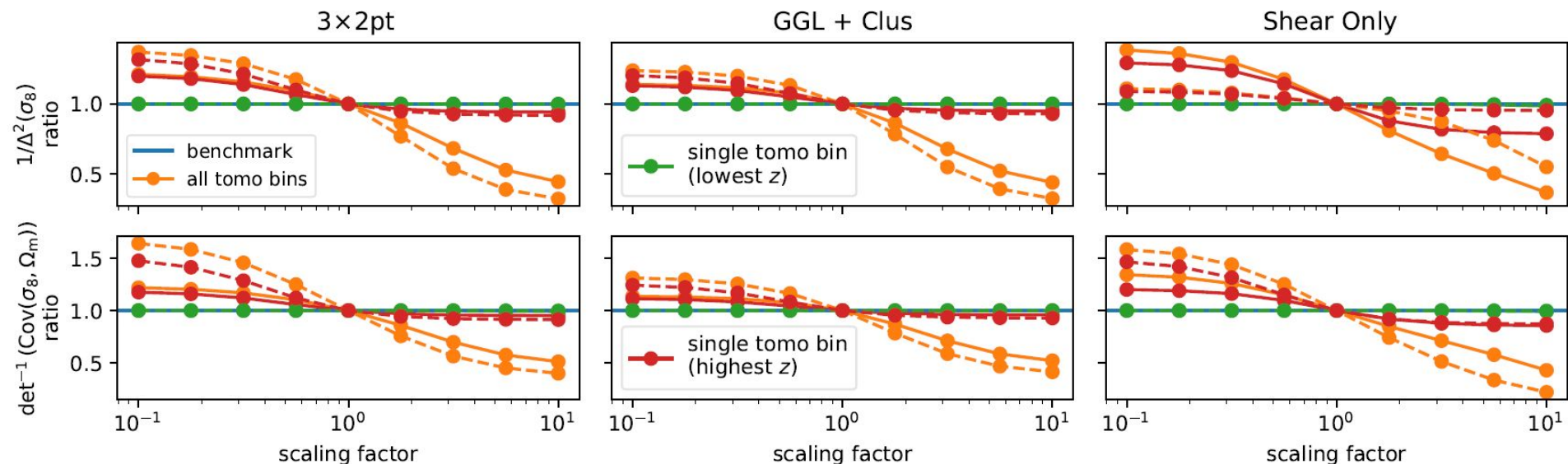
BC: benchmark priors on Δz and m (B) + infinitely narrow priors on n_s , Ω_b , and h_0 (C)

N: infinitely narrow priors on all parameters other than σ_8 , Ω_m , and galaxy bias (b)

Above: Figure 6 from Cao et al. 2025c, in prep. (will appear on arXiv in a few weeks).

Impact of Rescaled Priors on Shear Biases

Solid curves: w/o external cosmology; dashed curves: w/ external cosmology.



Above: Figure 12 from Cao et al. 2025c, in prep. (will appear on arXiv in a few weeks).

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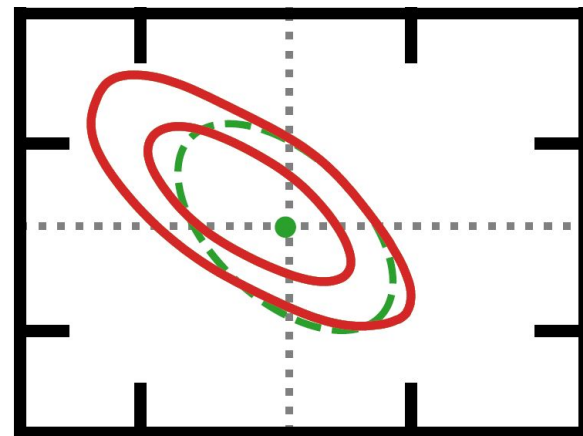
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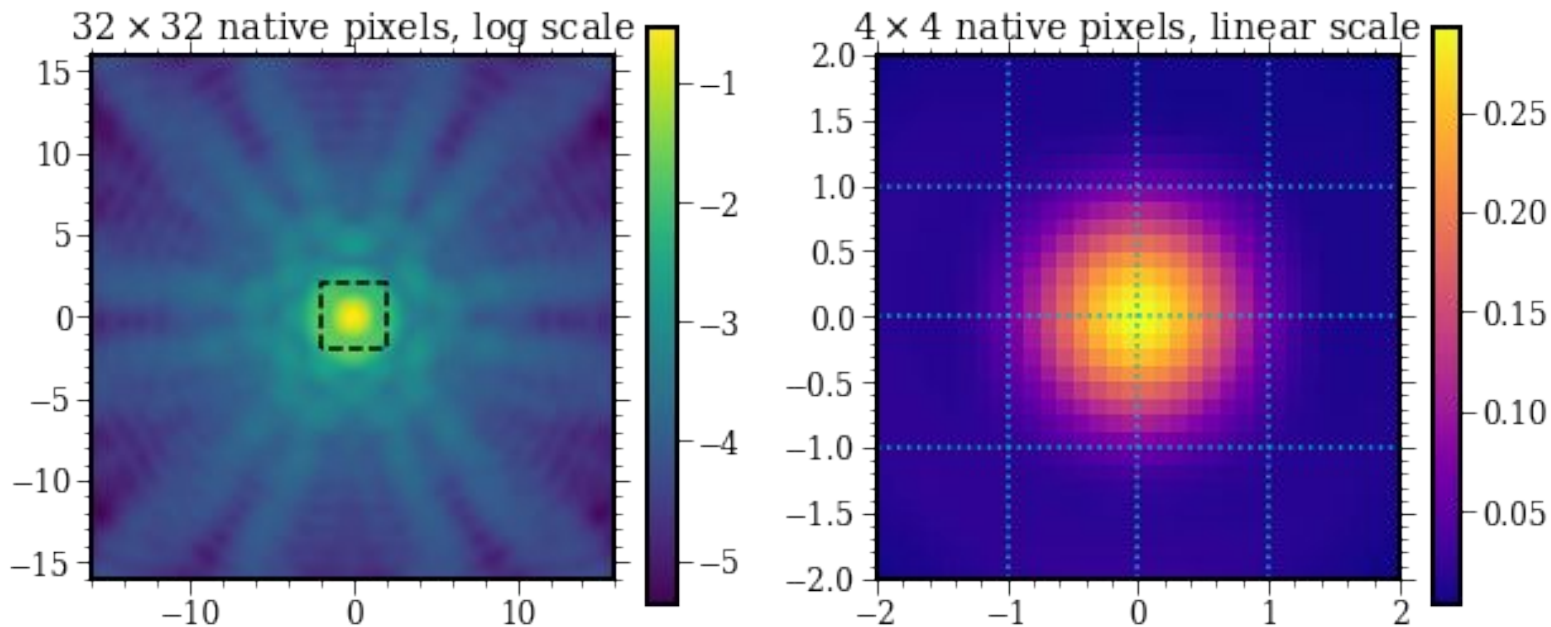
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σ_8

Challenge: We Need Oversampled Images

Roman point spread function (PSF) is stable and narrow (undersampled).

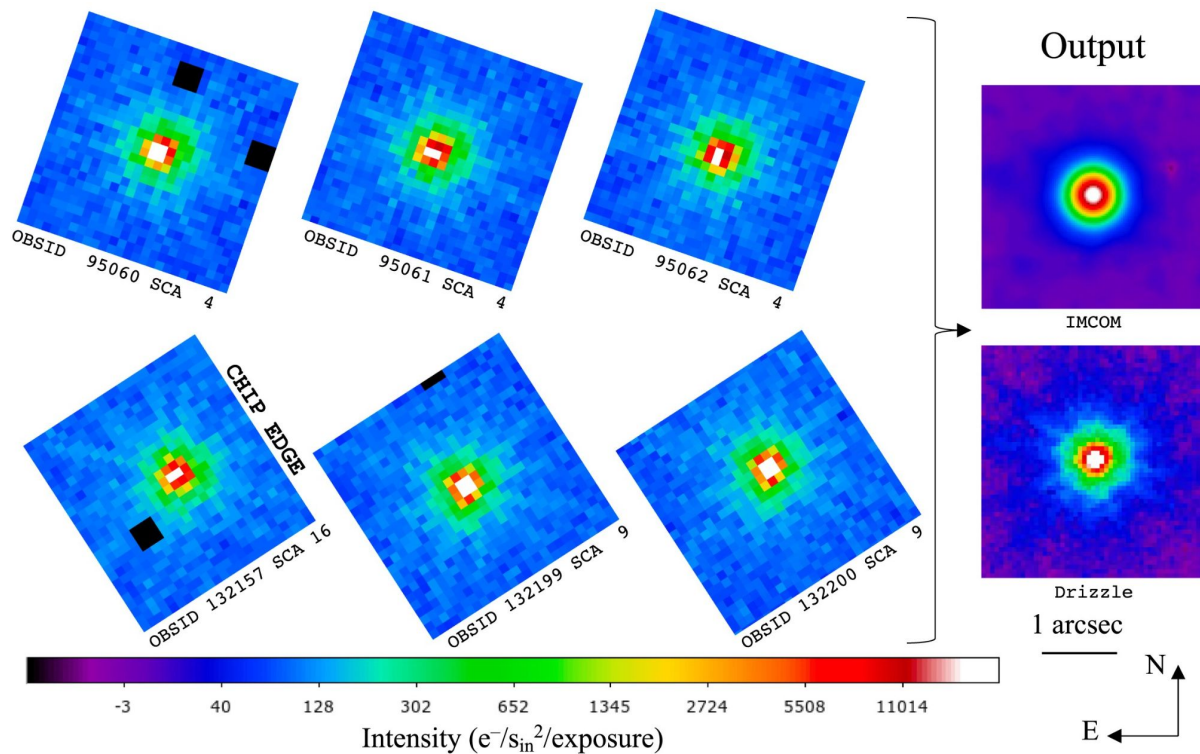


Solution: IMCOM (IMage COMbination)

Typically, there are 3 dithers $\times$ 2 passes for each pointing.

IMCOM provides control over both PSF and noise in coadded images.

Right: Figure 9 from Hirata et al. 2024



New Solution: **Fast** IMCOM (Cao 2025, in prep.)

Algorithm	Traditional IMCOM	Fast IMCOM
Strategy	Single-step matrix inversion	Two-step: regrid then coadd
Est. Compute Cost	~100M core-hours	< 10M core-hours
Est. Storage	~1.5 PB	~0.2 PB
Noise Properties	Random realizations	Semi-analytic model
Survey Optimization	Unclear	Enabled

Note: The Fast IMCOM proof-of-concept paper will appear on arXiv next week.

Forecasts for Roman Weak Lensing: Takeaways

The Nancy Grace Roman Space Telescope is poised to provide unprecedented weak gravitational lensing data with its [High Latitude Imaging Survey \(HLIS\)](#).

Weak lensing observables include three [two-point correlation functions \(3×2pt\)](#): cosmic shear, galaxy-galaxy lensing, and galaxy clustering.

Control over [systematics](#) is crucial for realizing Roman HLIS's full potential.

To overcome the difficulty of undersampling, images will be coadded using [IMCOM](#). A more efficient algorithm, [Fast IMCOM](#), is under development.

Presenter: Kaili Cao (The Ohio State University; email: cao.1191@osu.edu).