SUBBAND IMAGE RECONSTRUCTION
USING DIFFERENTIAL CHROMATIC REFRACTION

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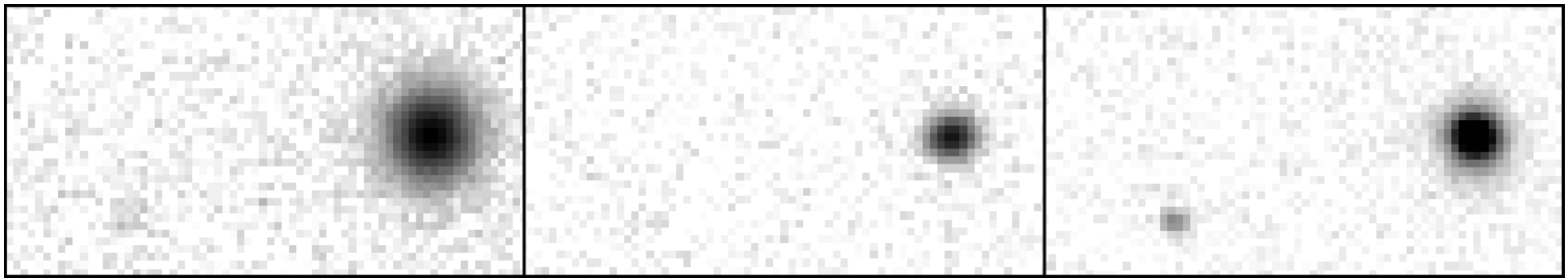
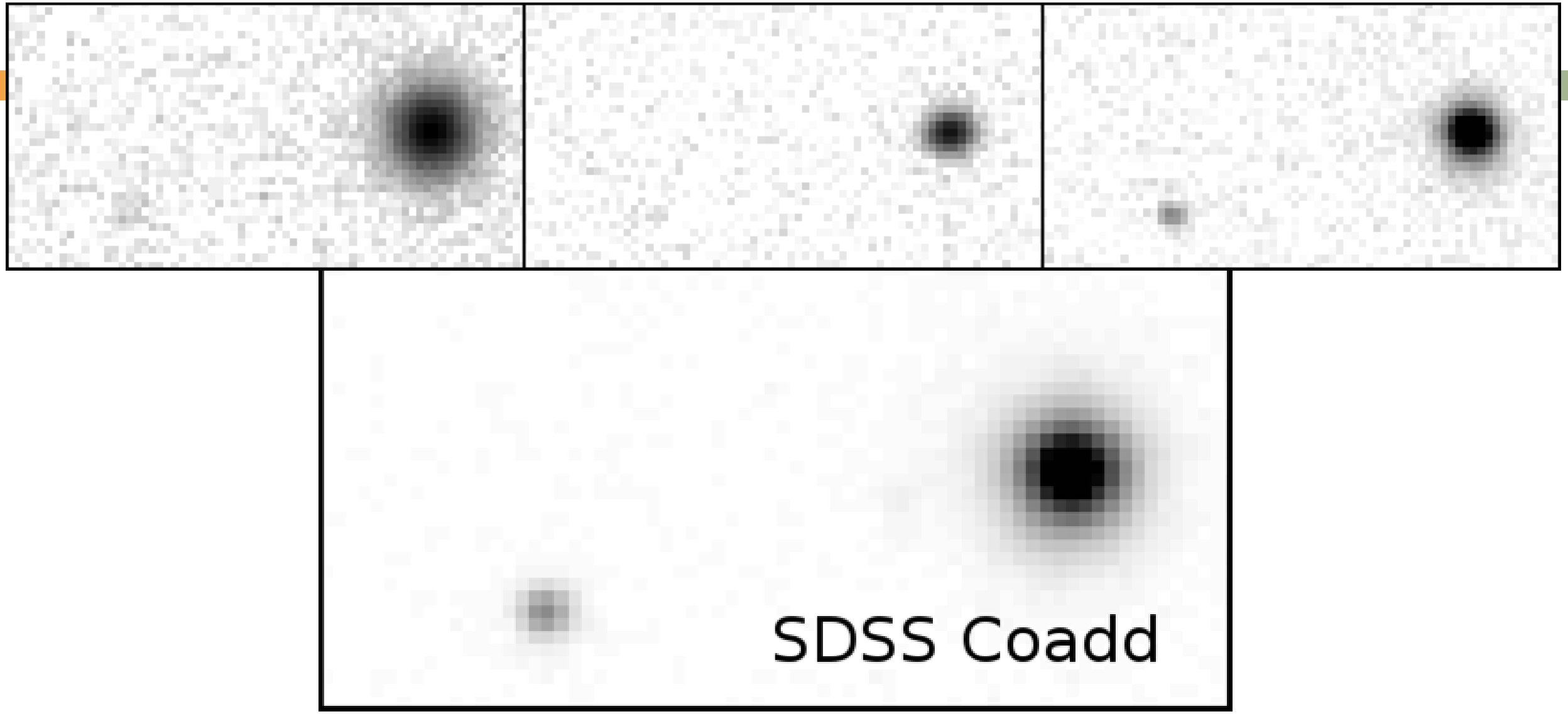
Multiple Exposures

- Each observation
  - Low signal-to-noise
  - Blurry
  - Variable quality

SDSS FRAMES




SDSS Coadd

Current Methods

- Brute-force summing of images is incorrect
- Lucky imaging uses only the best images
- Convolve to worst acceptable PSF & coadd

Throwing away a lot of information!

Simple Model

- Background image convolved with unknown point-spread function
- Plus the noise
- Solve for x and f_t?

$$y_t = f_t * x$$

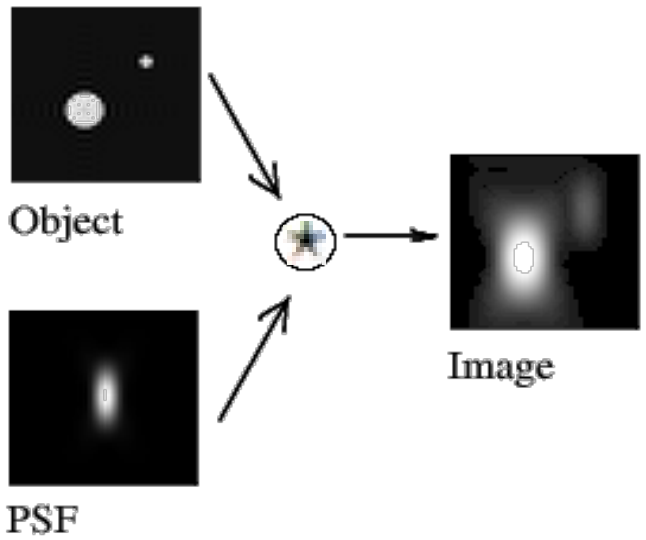


Image Deconvolution

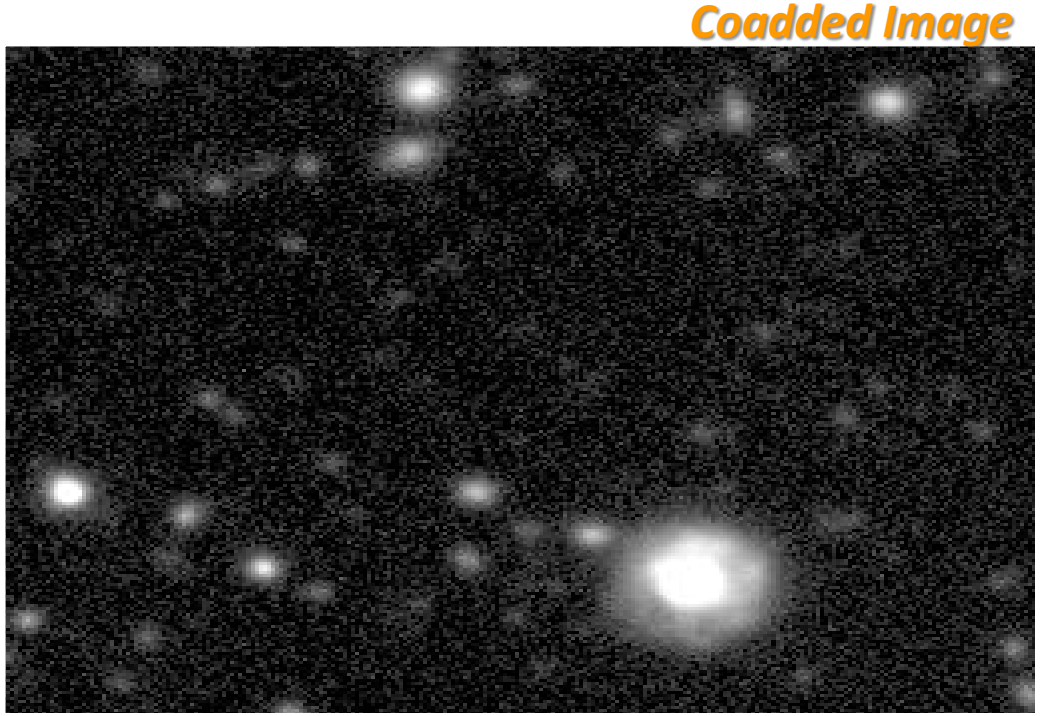
- Correcting Hubble's optics & R-L deconvolution
  - See *White (1994), Starck+ (1994), Lauer (1994, 2002), …*
- Now it's different with hundreds of exposures
  - With different PSFs

Priors & Likelihoods

- Stars are point sources
  - Regularization
- Modified likelihoods
  - Masking saturated & bad regions
  - Damped variants & robust stats
- Controlling convergence
  - Update clipping, …

Image behind the Atmosphere

- Coadding
  - Brings out faint sources
  - But blurs the images
- We solve for it
  - For high-res details



Lee+ (2014, 2017)

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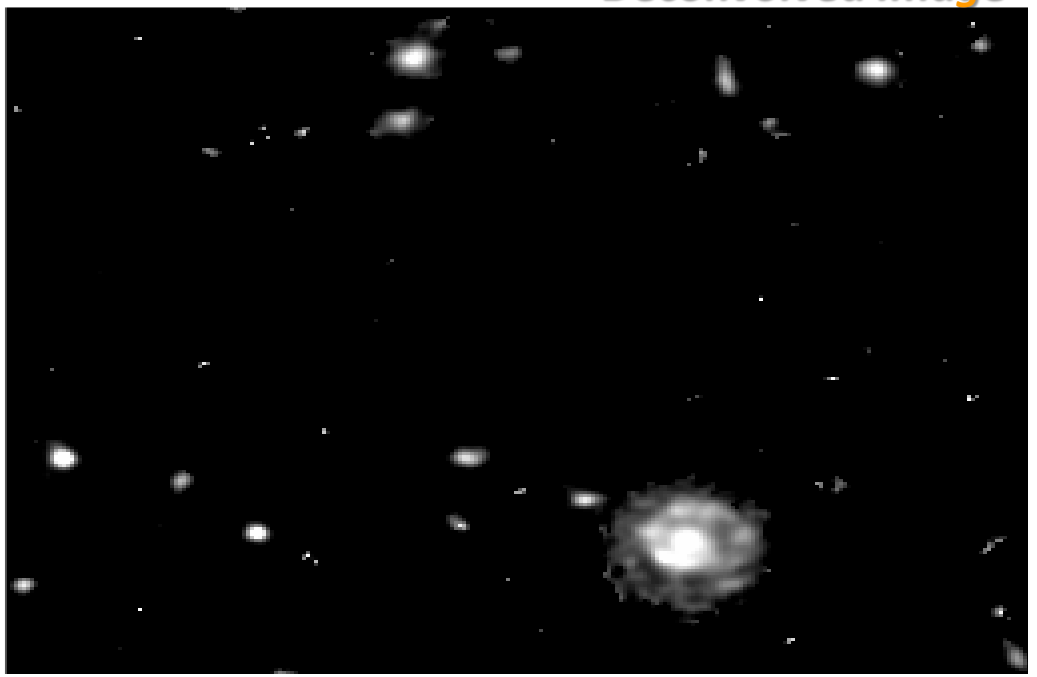

Lee+ (2014, 2017)

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Hubble Image

Lee+ (2014, 2017)

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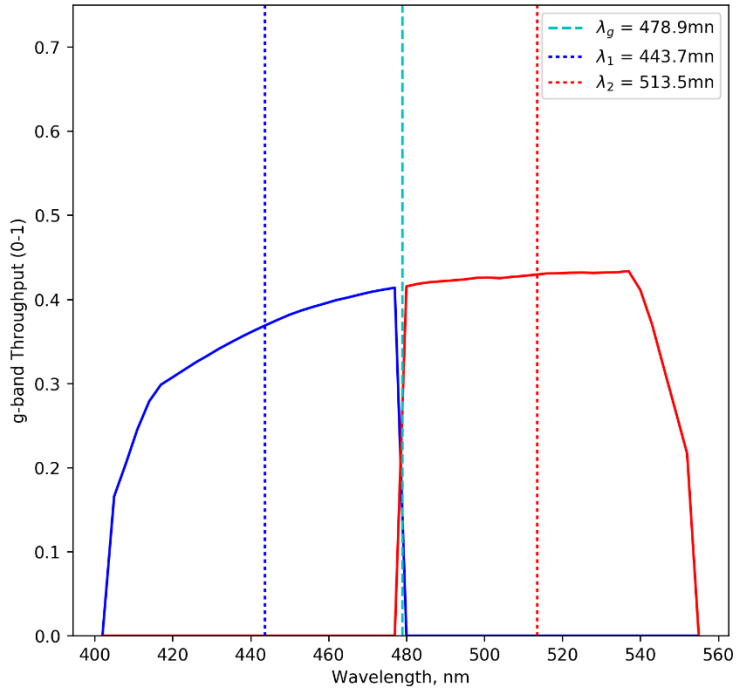
Lee+ (2014, 2017)

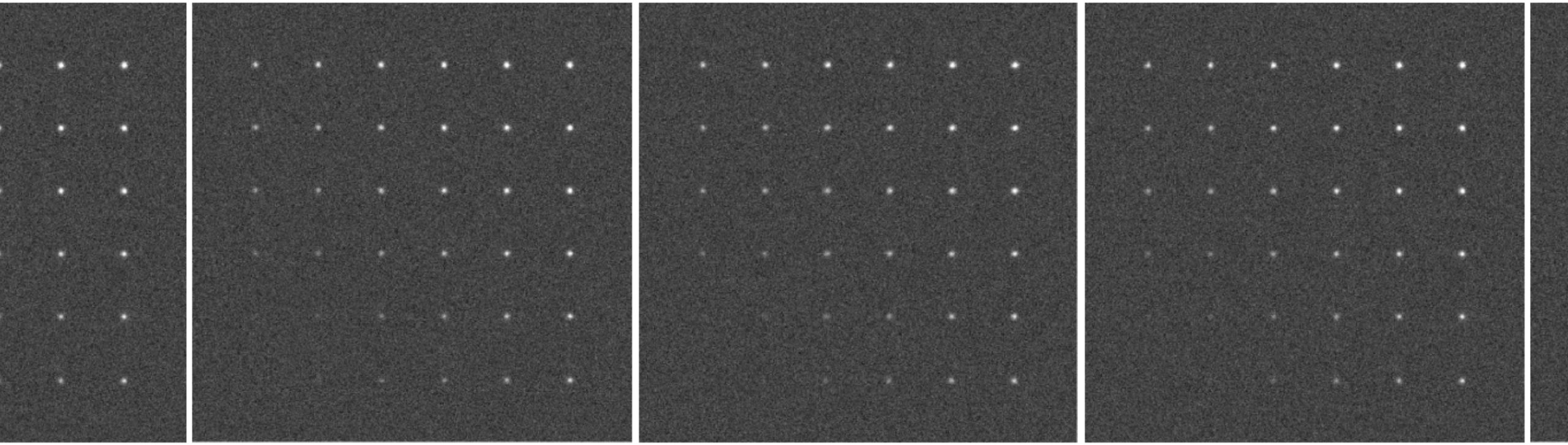
Subband Colors?

- Differential Chromatic Refraction
  - Known nonlinear physics
- New model
  - Subband filters
  - Subband images



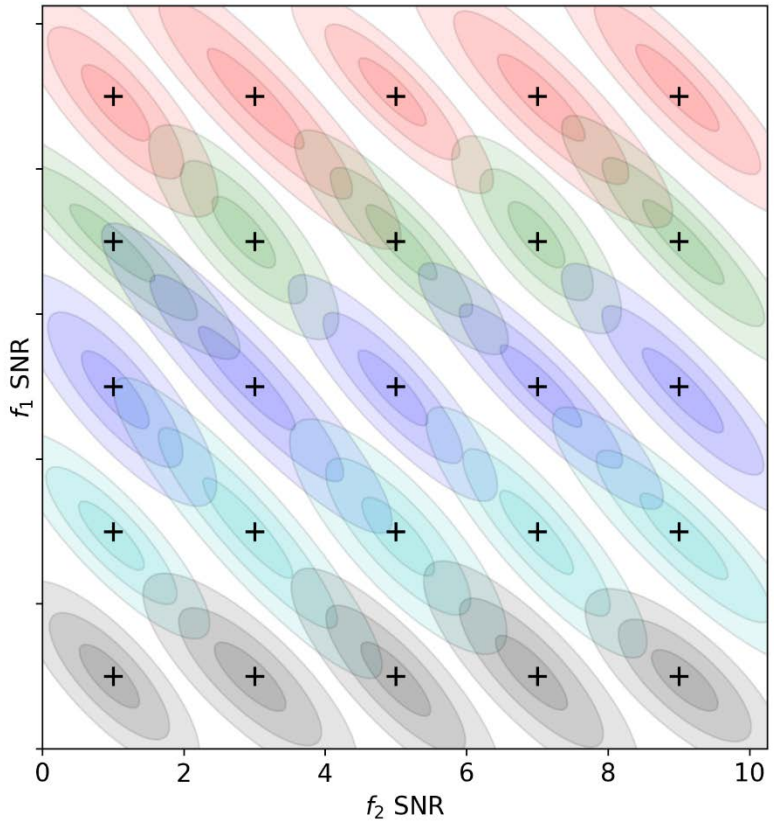
Simulated Stars

- Subband fluxes vary as fn of sky coordinates



Inferred Fluxes

- Signal-to-noise ratio – varying errors



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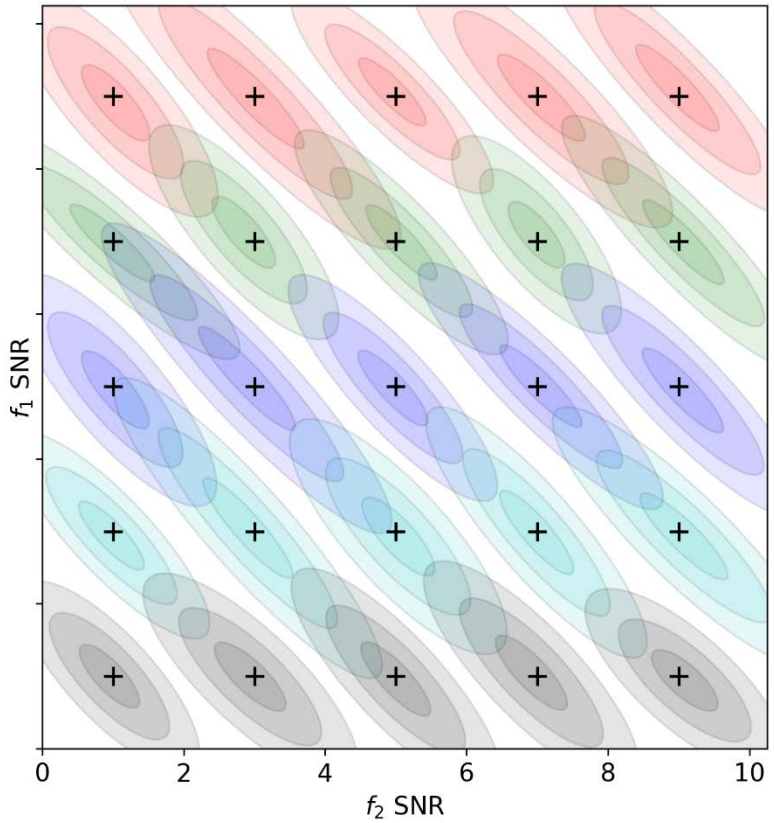
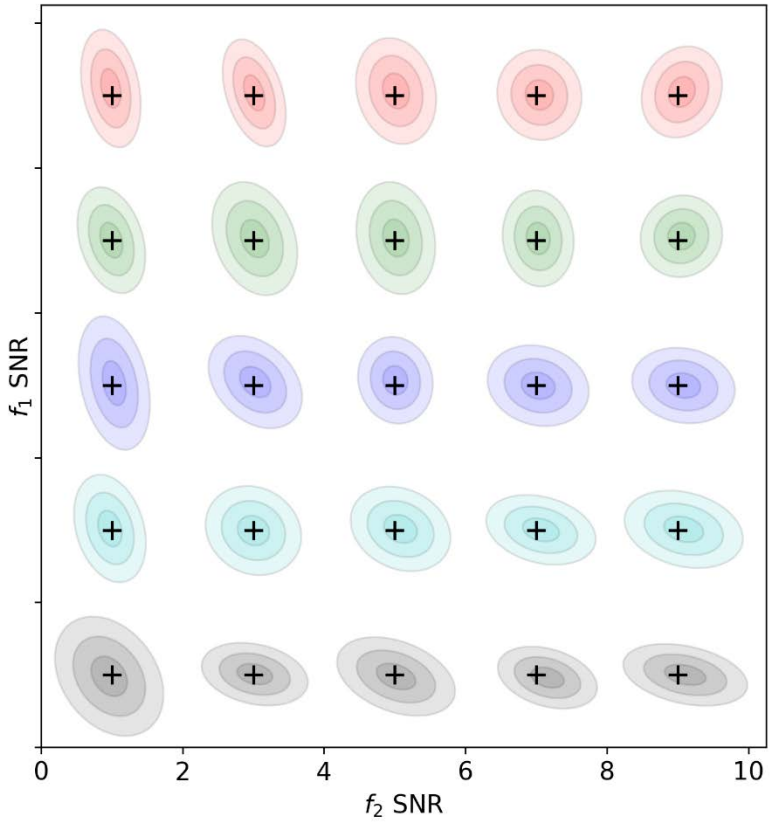
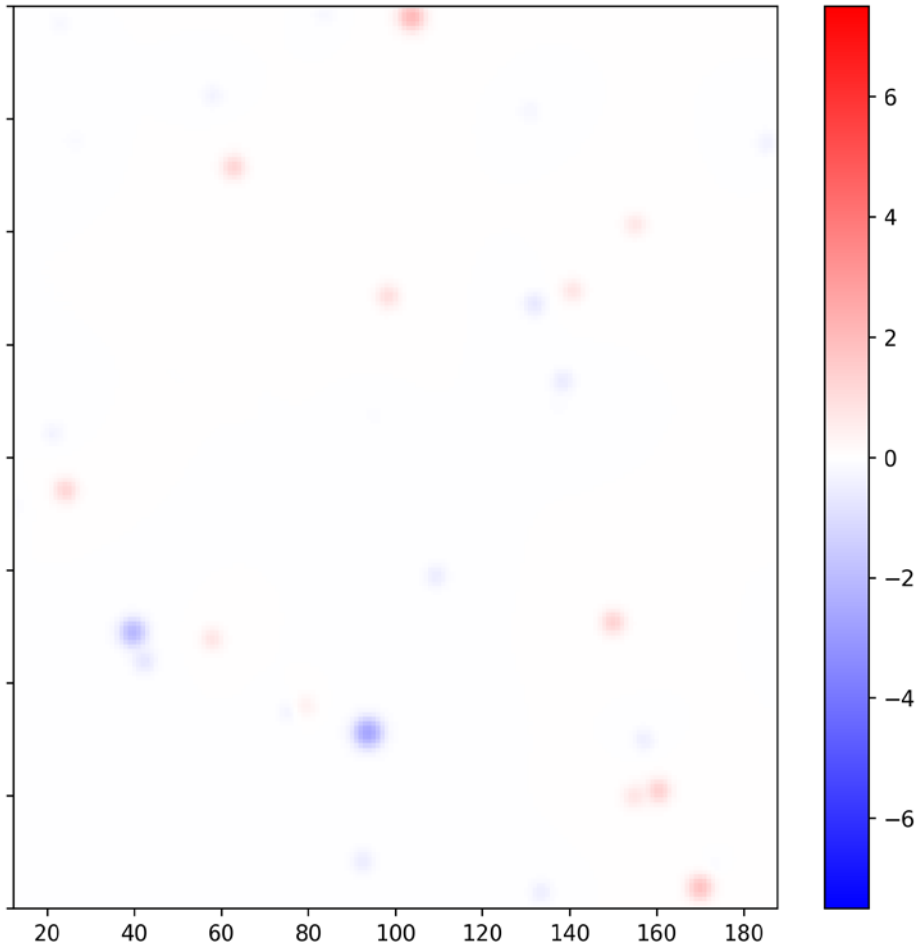
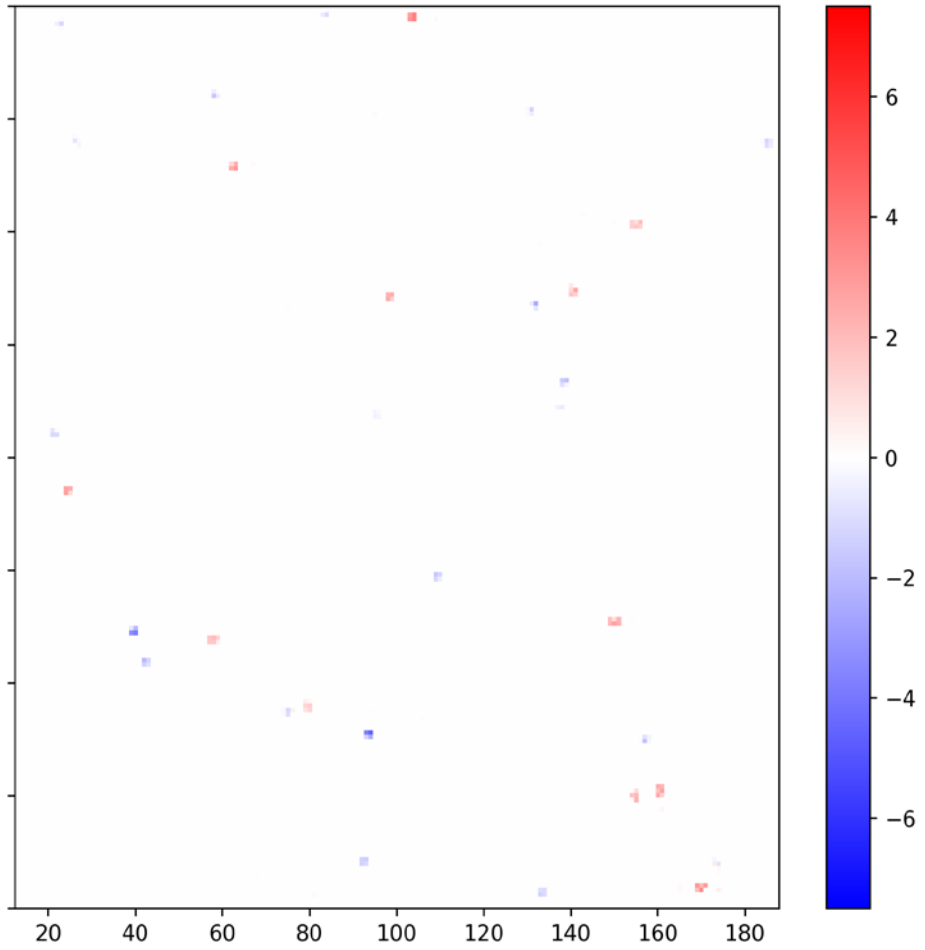


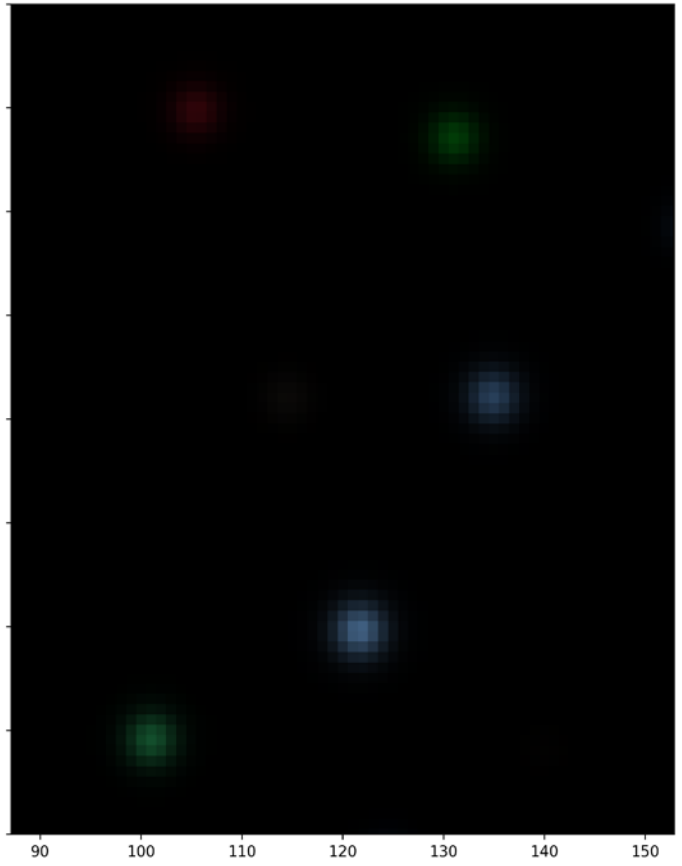


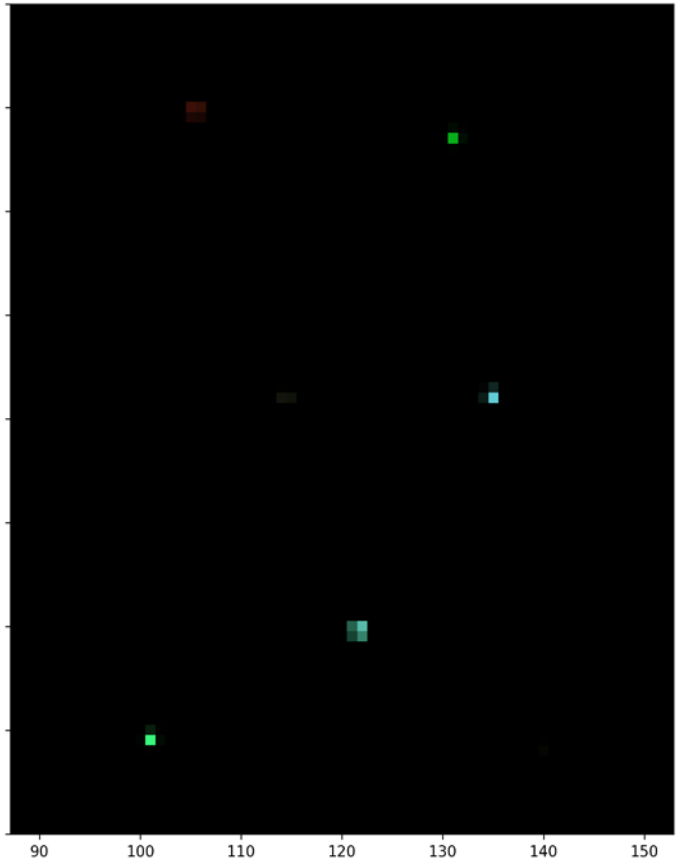
Inferred Images





Inferred


90
100
110
120
130
140
150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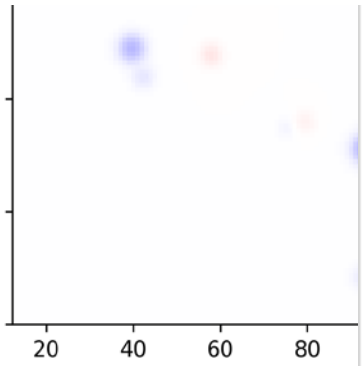
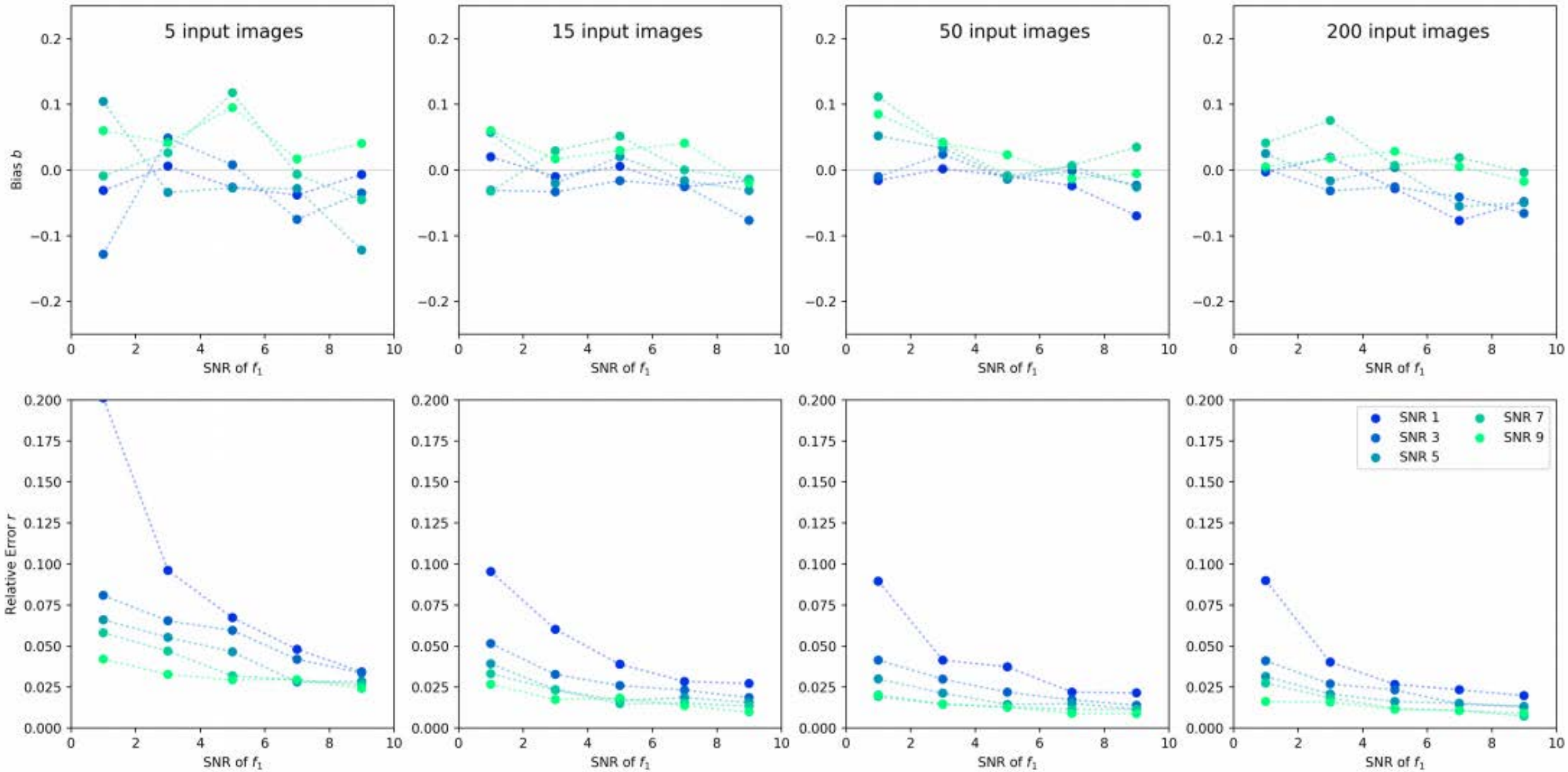
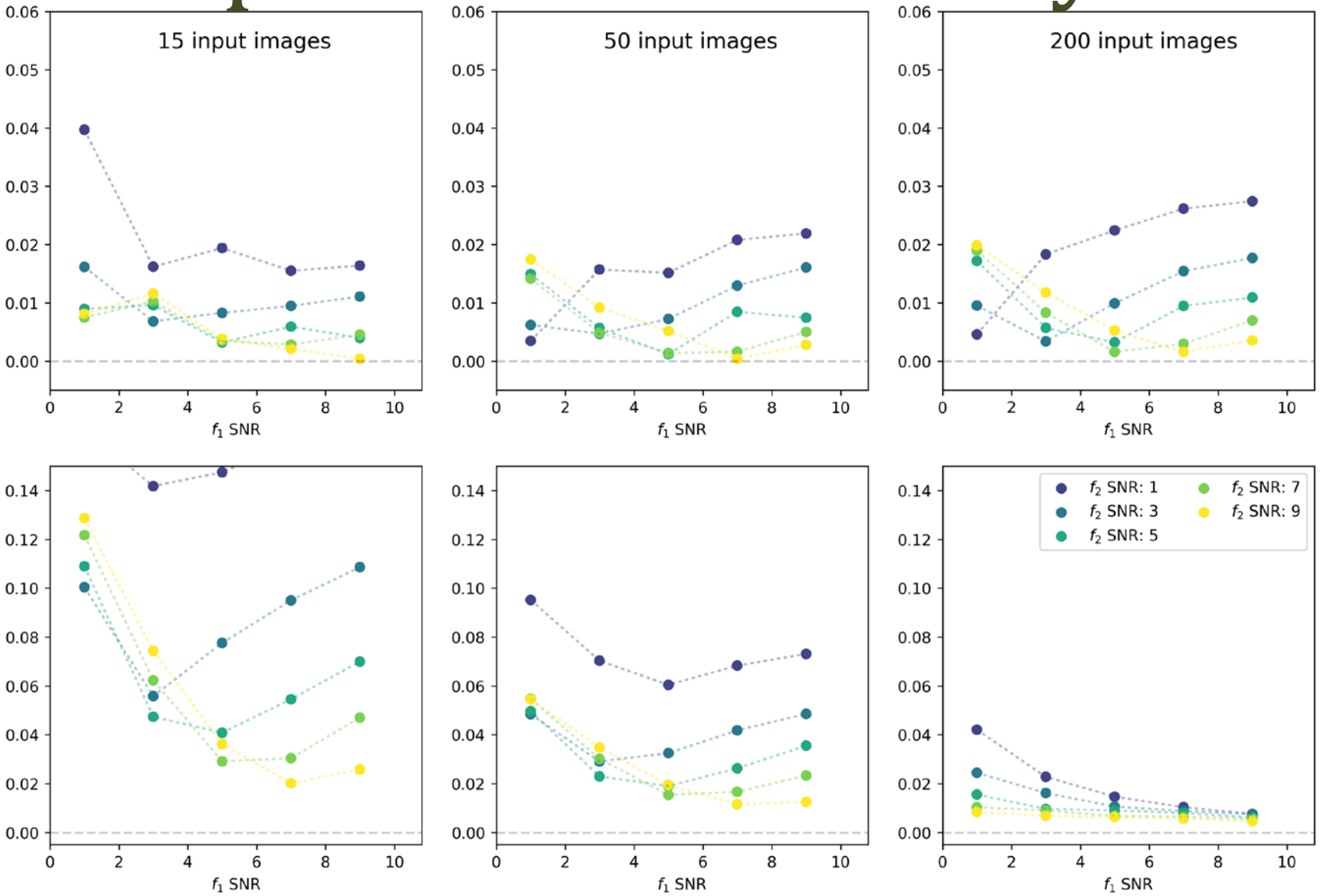

20
40
60
80


5 input images
15 input images
50 input images
200 input images
Bias b
Relative Error r
SNR of f_1
SNR 1
SNR 3
SNR 5
SNR 7
SNR 9

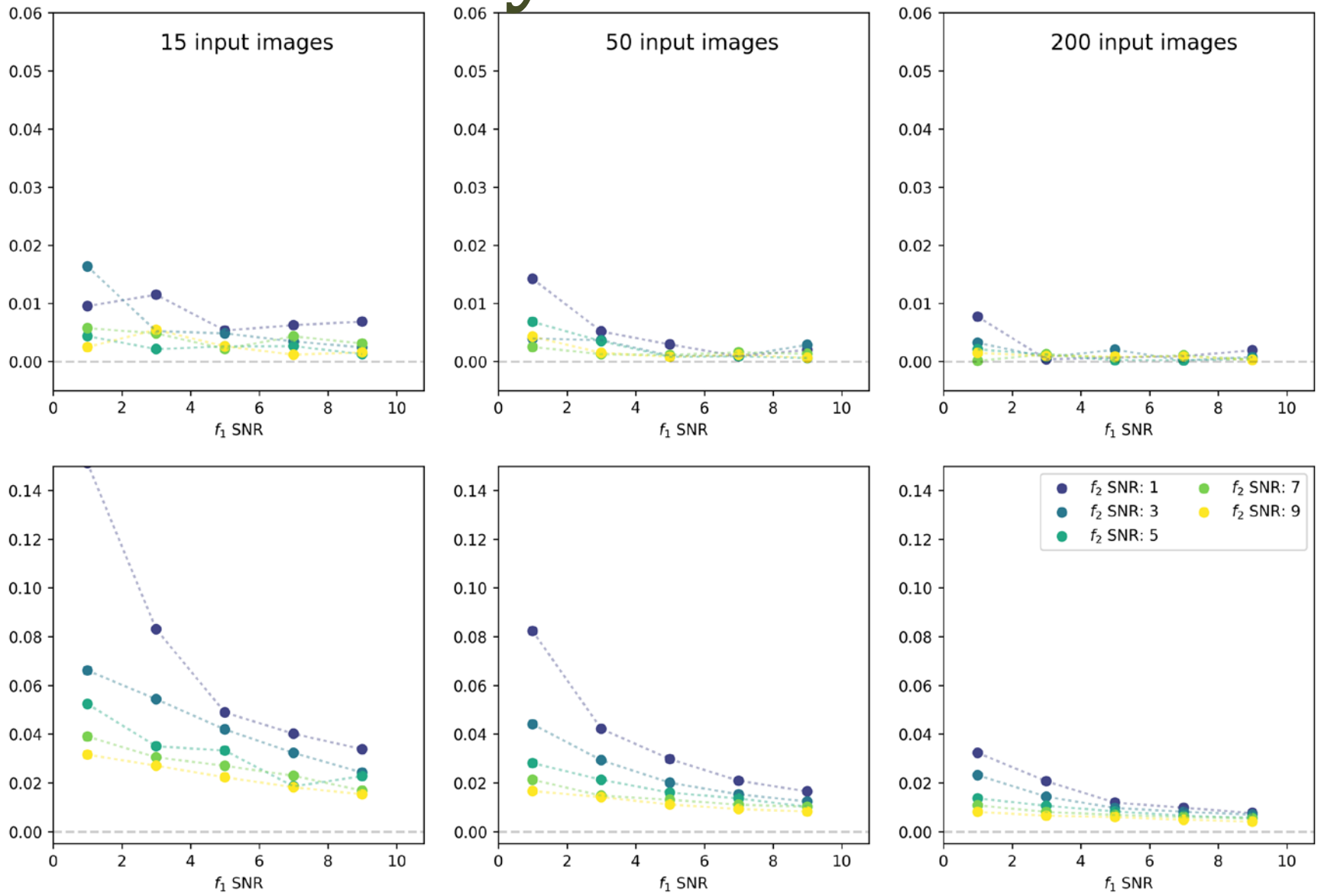
Improved Astrometry



coadd is biased

Improved Astrometry

new is unbiased



Summary

- Robust inference for hyper-resolution images
  - Time-domain observations provide breakthrough
- Subband color information accessible
  - Modeling the nonlinear optics of the atmosphere
- Improved astrometric uncertainties